#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
1	36063	3	0	0	0	0	Most of the conclusions mentioned in this chapter are derived from studies that employ the IPCC AR4 emission scenarios. In the light of IPCC AR5 and the new emission pathways therein, how valid are the IPCC AR4 emission scenarios for regional impact assessment studies? (Pradeep MUJUMDAR, Indian Institute of Science)	The SRES scenarios continue to be prominent in the literature. At the time of preparation of this draft there were few published studies relying on the new RCPs, but we expect the latter to be dominant in our assessment by the time of final publication. IPCC AR4 emissions scenarios remain valid. We will see what differences there are with the CMIP5/RCP runs, based on the evidence.
2	36064	3	0	0	0	0	Many of the studies whose results have been mentioned in this chapter employ single or only a few GCMs and a single scenario (e.g. lines 24-25, page 8) – how correct is it to base the conclusions, particularly for hydrological projections which the models are not very good at, on a single GCM and a single scenario? Model and scenario uncertainties, apart from that due to downscaling models, should be clearly mentioned while making strong claims on projections and related demands for mitigation and adaptation. (Pradeep MUJUMDAR, Indian Institute of Science)	These are good points. More and more published studies draw on multi-model and multi-scenario computations, but less ambitious studies remain frequent and potentially valuable. We will bear this comment in mind during revision. We continually emphasise uncertainties in the chapter.
3	37107	3	0	0	0	0	Too descriptive and the analysis on groundwater still too succint - while it should be an important component of this freshwater resources chapter. There are stil very few examples of groundwater resources behaviour vis-à-vis climate change in Africa., while quite a number of research and per review publications should have been used, including the recent attempt for groundwater mapping quantification in Africa, recently published by Environ. Res. Lett. 7 (2012) 024009 (7pp) with several authors: A M MacDonald1, H C Bonsor1, B ´E ´O Dochartaigh1 and R G Taylor2. (Salif Diop, UNEP - SAB - DEWA)	Due to the need to further shorten the chapter and many other important compartments and issues to cover, the groundwater analysis cannot be extended but will even to be shortened. New research and review papers on groundwater and climate (e.g. Taylor et al. 2012) is considered in SOD. The publication by MacDonald et al. does not include new insights on climate change impacts on groundwater.
4	37108	3	0	0	0	0	On freshwater resources assessment including climate change impacts, I suggest to the authors to carefully check the following link including regional examples and bilbligraphical references at the end of the various published reports by UNEP - See: http://www.unep.org/dewa/Assessments/Ecosystems/Water/tabid/6954/Default.aspx (Salif Diop, UNEP - SAB - DEWA)	Thank you, but due to lack of space wa cannot cite these references.
5	37109	3	0	0	0	0	Will recommend that the critical review analysis as undertaken in this chapter should consider cross-cutting with other integration and nexus such as: water/land/food and energy nexus. At the same time assessing the solution to freshwater resources and shortages due to climate change should be further assessed. In this regards, the 5th global environment report could assist authors in such exercise - see following weblink: http://www.unep.org/geo/geo5.asp (Salif Diop, UNEP - SAB - DEWA)	Chapter cross cutting boxes were introduced on energy and food.
6	37135	3	0	0	0	0	Throughout this chapter care must be taken to use the term 'vulnerability' (or 'vulnerabilities' and other variants) in a consistent manner. In some cases the term is (by context) taken to mean exposure to a hazard, whereas elsewhere the understood context is to mean a product of exposure versus adaptive capacity (Stephen Darby, University of Southampton)	We checked that carefully.
7	39309	3	0	0	0	0	An important, multiauthored and extensively reviewed overview on cryospheric components would be: UNEP (2007): Global outlook for ice & snow. UNEP/GRID-Arendal, Norway. This is a standard work of highest scientific level, probably still providing the best and most complete overview available including impact aspects. From this source it becomes clear that the impacts from continued warming in permafrost regions (high latitude/high alitude) could be serious (drainage patterns, slope instability). At mid-latitudes the changes in snowfall and glacier size will lead to a marked seasonal redistribution of water supply, which could be dramatic in regions where the warm season tends to be dry (or dryer than now). Such aspect should appear in the executive summary as they concern some of the most vulberably geo-/ecosystems. (Wilfried Haeberli, University of Zurich)	We have tried to avoid citing earlier assessments such as this UNEP overview, preferring to devote the available space to assessing the primary research literature.
8	39336	3	0	0	0	0	The FOD of chapter 3 is much improved than ZOZ by additional material and information (Liu Chunzhen, Ministry of Water Resources)	Thank you very much.
9	40541	3	0	0	0	0	Cite: Major, D. C., A. Omojola, M. Dettinger, R. T. Hanson, R. Sanchez-Rodriguez, 2011: Climate change, water, and wastewater in cities. Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network, C. Rosenzweig, W. D. Solecki, S. A. Hammer, S. Mehrotra, Eds., Cambridge University Press, Cambridge, UK, 113–143. (Cynthia Rosenzweig, NASA Goddard Institute for Space Studies/Columbia University)	Reference used
10	42474	3	0	0	0	0	This is nicely written chapter but I feel the chapter is narrowly focused on more integrated climate and crop modelling, pests and diseases. Considering wider implication and policy level implication from country and regional prospective, the focus needs to be broadened (Shahbaz Mushtaq, University of Southern Queensland)	This comment is baffling. It seems that it and the following seven (#10-#17) must be about some other chapter, perhaps Ch07 (Food production). The irrelevance of comments #18 and #19 to Ch03 also points in the same direction.
11	42475	3	0	0	0	0	The chapter fell short of discussing how future food security requirement would be met. It would be good to include discussions on: (Shahbaz Mushtaq, University of Southern Queensland)	This comment is baffling. It seems that it and the following seven (#10-#17) must be about some other chapter, perhaps Ch07 (Food production). The irrelevance of comments #18 and #19 to Ch03 also points in the same direction.
12	42476	3	0	0	0	0	o Size of investment needed to manage future food security, and who are the likely investor: Global funds such as IMG, WB or ADB, private entities or public-private partnerships) (Shahbaz Mushtaq, University of Southern Queensland)	This comment is baffling. It seems that it and the following seven (#10-#17) must be about some other chapter, perhaps Ch07 (Food production). The irrelevance of comments #18 and #19 to Ch03 also points in the same direction.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
13	42477	3	0	0	0	0	o Type of structural adjustment needed to manage regional food security considering economic, social and environmental outcomes. (Shahbaz Mushtaq, University of Southern Queensland)	This comment is baffling. It seems that it and the following seven (#10-#17) must be about some other chapter, perhaps Ch07 (Food production). The irrelevance of comments #18 and #19 to Ch03 also points in the same direction.
14	42478	3	0	0	0	0	o Regional relocation and transformation (briefly mention via one case study) (Shahbaz Mushtaq, University of Southern Queensland)	This comment is baffling. It seems that it and the following seven (#10-#17) must be about some other chapter, perhaps Ch07 (Food production). The irrelevance of comments #18 and #19 to Ch03 also points in the same direction.
15	42479	3	0	0	0	0	o Role of peri-urban agriculture and wastewater in meeting future food security challenges. (Shahbaz Mushtaq, University of Southern Queensland)	This comment is baffling. It seems that it and the following seven (#10-#17) must be about some other chapter, perhaps Ch07 (Food production). The irrelevance of comments #18 and #19 to Ch03 also points in the same direction.
16	42480	3	0	0	0	0	o Trade-offs between food security and environmental security (GHG reduction) via plantation when considering they will complete with both land, water and other resources. (Shahbaz Mushtaq, University of Southern Queensland)	This comment is baffling. It seems that it and the following seven (#10-#17) must be about some other chapter, perhaps Ch07 (Food production). The irrelevance of comments #18 and #19 to Ch03 also points in the same direction.
17	42481	3	0	0	0	0	Solid evidences of climate change on crops are presented (in some instance on experimental level). However, up-scaling these estimates to regional level to assess a more clear food security situation would be a challenge (Shahbaz Mushtaq, University of Southern Queensland)	This comment is baffling. It seems that it and the following seven (#10-#17) must be about some other chapter, perhaps Ch07 (Food production). The irrelevance of comments #18 and #19 to Ch03 also points in the same direction.
18	42482	3	0	0	0	0	There are heaps of repetitions for example see page 8 line 10-14 and page 5 line 18-20. I hope next draft will make sure there isn't any repetition (Shahbaz Mushtaq, University of Southern Queensland)	P8 L10-14 and P5 L18-20 are unrelated. This must refer to some other chapter.
19	42486	3	0	0	0	0	Some references are missing eg Park et al 2010 & 11 (Shahbaz Mushtaq, University of Southern Queensland)	Ch03 does not cite either of these sources.
20	42905	3	0	0	0	0	Please consider including discussion on the interaction between electricity generation (not limited to hydroelectric power) and water resources. As it takes water to produce electricity, e.g. coal-fired power and nuclear power, the way we generate electricity will affect water resources on the planet. Reference: http://www.rivernetwork.org/news/burning-our-rivers-water-footprint-electricity. In fact, electricity generation is partly a climatic factor because a warmer climate will lead to higher demand for energy for cooling. (Sai-ming Lee, Hong Kong Observatory)	Cooling of thermal power plants in SOD included in section 3.5.3.
21	43195	3	0	0	0	0	The synthesis on the freshwater resources changes in Chapter 3 of the IPCC report is generally successful and relatively complete. We can underline the quality and interest of the 3.4. Projected Hydrological Changes, 3.5. Impacts, Vulnerabilities, and Risks - for Human and Environmental Systems, 3.6. Adaptation and Managing Risks, 3.9. Research and Data Gaps and Frequently Asked Questions sections. However, the section 3.2 on the trends from the observations and measurements is incomplete and not sufficiently developed compared with other parts. The bibliography is incomplete. Indeed, the section of the measurements is limited to a summary of trends. However, in recent years, there are studies that have focused on methods other than the trend tests, using methods such as signal processing, such as wavelet analysis, to search modes of variability in hydrological and climate parameters in different hydrosystems in the world and thus investigate the relationships between hydrological variability and climate fluctuations. This work has highlighted the relationship between the flows variability and those of climate indices such as NAO, ENSO, PDO, but also a major discontinuity in the 70s. It therefore seems important to summarize thèse works. Moreover, in this observations and measurements section, the authors do nothing on satellite data, such as change in sea level, but also on the variability of the global reserve of water (surface water + soil moisture + groudwater, eg GRACE data). Many teams are working on these data, such as A. Cazenave at LEGOS in Toulouse. The 3.8. Water Management, Water Security, and Sustainable Development section is too short and does not justify a section and a title. Some sections or subsections are too short and should be grouped. There are a number of repetitions that could be avoided. (Benoit Laignel, University of Rouen)	We revised Section 3.2 a lot. As you say, we grouped short sections and reorganized some sections.
22	43373	3	0	0	0	0	In general I think the chapter has much improved as compared to the ZOD, in particular in terms of structure which is now much clearer and more consistent throughout the chapter. The section of observed impacts (3.2.) is now concentrating on this topic, as well as section 3.4 (projections), both of which have been mixed to some degree in the ZOD. (Christian Huggel, University of Zurich)	Thank you very much.
23	43496	3	0	0	0	0	Chapter 3 is well written with good consideration of the potential impacts of climate change and other environmental factors on the global freshwater resource. I have reviewed this chapter and chapter four and note the broad similarity in structure which is good as this helps the reader. However, it would be useful to standardise further on the next iteration. For example, sections covering similar aspects but in different chapters should have the same name, for example, in chapter 3 the title 'Adaptation and Managing Risks' is used, whilst for chapter 4, the title is 'Adaptation'. Also in chapter 3, there is a section 'Research and Data Gaps' whilst for chapter 4 this is called 'Emerging issues and key uncertainties'. In some sections, noted in the following comments, the outcomes of scientific studies are presented, but further work is needed to critique these to synthesise the findings. Some aspects of freshwater resources are underrepresented in the discussion. I have highlighted what I think is missing in the following comments. (Andrew Wade, University of Reading)	In general the section titles in chapter 3 are those given in a document entitled Agreed Reference Material for the IPCC Fifth Assessment Report, which was made available to all chapters at the outset of the drafting process.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
24	43497	3	0	0	0	0	I think it would be useful to have both an Executive Summary and a concluding section in each chapter. The former would be a standalone section that would give the reader the key points with a note regarding the strength of the evidence and/or the confidence in any projected changes (as done in chapter 3). The latter would be a broader summary of the whole chapter highlighting key outcomes and the current state of the science and policy. Each of the points made in the Executive Summary of chapter 3 needs to be detailed further. For example, as the summary may be read in isolation, then 'many regions' needs to be replaced with specifics, and 'several anthropogenic factors' needs to be replaced with a list of the factors. (Andrew Wade, University of Reading)	Following IPCC guidance, chapter 3 ends with a "standard" concluding section entitled Research and Data Gaps. Generalized expressions such as "many regions" are used in the ES either for brevity or because the state of the science requires a generalized assessment.
25	43498	3	0	0	0	0	There is relatively little consideration of lakes and wetlands in Chapter 3. This omission is not addressed by Chapter 4. Whilst data on wetlands is limited, a significant body of literature exists on the analyses of long-term lake data sets and experiments. The outcomes of these studies should be incorporated. A useful summary of the likely impacts of climate change on freshwater ecosystems can be found in Kernan et al. (Eds) 2010. Climate Change Impacts on Freshwater Ecosystems, Wiley-Blackwell, pp. 314. The book focuses on the direct impacts of climate change on freshwater ecosystems and indirect effects through changed hydrology and morphology, the interaction of eutrophication and climate change, the interaction of acid deposition and climate change, the distribution of persistent organic pollutants and mercury, and considers reference conditions, freshwater ecosystem restoration in the context of climate change, modelling catchment-scale responses and decision making. The book contains useful literature reviews and summarises likely impacts. For example the following are presented: summaries of stream temperature changes in Switzerland since 1965; the effects of a deeper thermocline consistent with A2 warming on nutrient concentrations, water temperature, oxygen content and phytoplankton in Lake Valkae-Kotinen, Finland , and field experiments looking at warming in lakes and mesocosms. (Andrew Wade, University of Reading)	The chapter is on freshwater resources not ecosystems, your comment was sent to the relevant chapter.
26	43499	3	0	0	0	0	Global groundwater resources remain poorly mapped. This is being addressed by the WHYMAP programme but uncertainty in the volume estimates of this resource remains and therefore the size of this buffer against changes in precipitation is unknown. Puri, S. & Aureli, A. 2005 Transboundary aquifers: a global program to assess, evaluate, and develop policy. Ground Water 43, 661–668. (doi:10.1111/j.1745-6584.2005.00100.x). (Andrew Wade, University of Reading)	In SOD addressed in section on research gaps (3.9).
27	43500	3	0	0	0	0	Chapter 3 does not consider the impacts of climate change on human health other than in terms of sewage systems. More frequent low flows will cause reduced dilution of pollutants entering surface waters and climate change may alter the distribution of disease vectors. There is recent evidence that malaria is decreasing. Gething et al. 2010. Climate change and the global malarial recession. Nature 465, 342-354. (Andrew Wade, University of Reading)	This is addressed in the Health Chapter.
28	43501	3	0	0	0	0	The potential impacts of climate change are tackled in turn, but two major research questions are will the changes be non-linear (i.e. if temperatures continue to rise will the response become proportionally worse), and how will all the effects integrate to affect the system (or catchment) response? These are major research gaps which are not noted in section 3.9. (Andrew Wade, University of Reading)	Yes, however, working group 2 focuses on the impacts of climate change, and the geophysical relationships between temperature and hydrological cycle should be handled by working group 1.
29	43585	3	0	0	0	0	This chapter is very comprehensive and generally well-written. I don't see any gaps in the writing other than those already flagged by the authors. (Cate Macinnis-Ng, University of Auckland)	Thank you.
30	44205	3	0	0	0	0	The chapter has a very small number of figures and most are of poor layout quality. I suggest to considerably increase the number of figures. (Georg Kaser, University of Innsbruck)	The number of figures and tables has been increased.
31	44448	3	0	0	0	0	Chapter ES: 4 out of 8 ES bullets are closely linked to WGI (Climate models project....water availability; water cycle intensification; more intense precipitation; glaciers melting). It will therefore be crucially important to maintain inter-working group consistency in these key findings We are, however, encouraged by the generally good referencing to the relevant WGI AR5 chapters. (Thomas Stocker, IPCC WGI TSU)	Agreed on the practical point (close coordination to ensure consistency and to keep repetition within reasonable bounds). However the intellectual, as opposed to the physical, divide between WG1 and WG2 seems to run through WG2 Ch03 in the present IPCC schema. It seems essential to us to summarize observed and projected changes in our "climatic drivers", so as to place the rest of our assessment of freshwater resources in a secure (and accessible) context.
32	44449	3	0	0	0	0	Section 3.2.1: combination of Observations and D&A. Please check and ensure consistency in D&A with Ch18 WGII and Ch10 WGI AR5. (Thomas Stocker, IPCC WGI TSU)	In WG2 Ch03 we are in close contact with WG2 Ch18 and will review the SOD of WG1 Ch10 carefully.
33	44450	3	0	0	0	0	Section 3.2.3: droughts/floods is a most critical section -- care is needed to ensure consistency with the WGI AR5 and SREX Chapter 3. In addition, there currently seems to be no consistent approach to cross-referencing to material from these two IPCC reports/chapters. (Thomas Stocker, IPCC WGI TSU)	All the text regarding WGI were collected to ensure aggrement.
34	44451	3	0	0	0	0	Section 3.3.1: The amount of material in here on Climatic Drivers could be reconsidered, as this is essentially material that is assessed in the WGI contribution to AR5 and the risk of overlap and inconsistency should be avoided to the extent possible. (Thomas Stocker, IPCC WGI TSU)	We will review section 3.3.1 with this comment in mind. A broad question that appears never to have been settled is where the boundary lies between the two working groups. Precipitation and evaporative demand are clearly atmospheric phenomena, but equally clearly they are hydrological phenomena. Some repetition of WG1 material is unavoidable for the purpose of providing context.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
35	44452	3	0	0	0	0	Section 3.3.1.1: Physical Basis, includes lots of WGI relevant material. While reference is made to Ch2 of WGI AR5 (Hartmann et al.), we wonder if all this material is appropriate. At least consistency needs to be carefully considered when providing quantitative assessment results, e.g., in Box1.1 which has its own assessment (based on one study) of the freshwater balance (fluxes, storage etc.). This is clearly a WGI assessment topic and overlap and inconsistency should be avoided to the extent possible. (Thomas Stocker, IPCC WGI TSU)	See annotation on comment #34.
36	44453	3	0	0	0	0	Section 3.3.1.2: This section deals with Uncertainty in the Climatic Drivers and refers once to Ch11 of WGI AR5, yet this reference seems not enough given that most of the section deals with forcing, climate variability etc. Improved cross-referencing to WGI chapters needed, and possible reconsideration of the appropriateness of this material in WGII (Thomas Stocker, IPCC WGI TSU)	See annotation on comment #34.
37	44454	3	0	0	0	0	Section 3.3.1.3: Projections includes mostly WGI relevant material. While reference is made to Ch12 of WGI AR5 (Collins et al.), we wonder if all this material is needed or if it could not be replaced simply leaving the reference. Overlap and inconsistency should be avoided to the extent possible. (Thomas Stocker, IPCC WGI TSU)	See annotation on comment #34.
38	44455	3	0	0	0	0	Section 3.3.1.4 Extremes - Rather than referring to Field et al. 2012 for SREX reference should be to Seneviratne, S.I., N. Nicholls, D. Easterling, C.M. Goodess, S. Kanae, J. Kossin, Y. Luo, J. Marengo, K. McInnes, M. Rahimi, M. Reichstein, A. Sorteberg, C. Vera, and X. Zhang, 2012: Changes in climate extremes and their impacts on the natural physical environment. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 109-230. (Thomas Stocker, IPCC WGI TSU)	We do not cite the reference now.
39	44456	3	0	0	0	0	Section 3.3.1.4 Extremes - In addition, updates from SREX (or citation of individual studies: Pall et al.) should be avoided here, and rather cross-reference to material in the WGI AR5 chapters should be added. (Thomas Stocker, IPCC WGI TSU)	See annotation on comment #34. This subsection is critically important for WG2 Ch03.
40	44457	3	0	0	0	0	Section 3.4 on Projected Hydrological Changes – some parts of this assessment drift into physical climate changes, with little reference to WGI AR5. One example is of this is in relation to Glaciers Mass Loss (with reference to Church et al). What about runoff, snowmelt etc. which could make reference to WGI Ch12? (Thomas Stocker, IPCC WGI TSU)	We will be inserting more cross-references to several WG1 chapters as we develop our SOD. (There are several already in the FOD.)
41	44458	3	0	0	0	0	Section 3.4.8: This section refers to AR4 (Trenberth et al., Chapter 3 WGI AR4) for projections of rainfall in Tibet Plateau. Please update this to the contributions from the WGI AR5, e.g., WGI Ch12 or Ch14. (Thomas Stocker, IPCC WGI TSU)	The section was updated with inputs from WGI.
42	44459	3	0	0	0	0	Section 3.4.9 Extremes (Floods, Drought) – includes an assessment of regional and global scale droughts and floods. Relevant WGI AR5 Chapters (including the SREX Chapter 3) need to be referred to as the primary basis here. For example, Chapter 3 of the SREX assesses floods in Europe and likewise provides a comprehensive discussion on drought indices. (Thomas Stocker, IPCC WGI TSU)	SREX were intensively referred but not comprehensively for AR5/WGI. We'll incorpolate in the next revision when final draft of AR5/WGI will be ready.
43	44460	3	0	0	0	0	Box 3.2 Case Study Himalayan Glaciers: Box should begin with available information from the WGI AR5 for the broader area of Central Asia, before going into the more specific assessment for the Himalayan glaciers provided here. Ensure there are no inconsistencies with the available information from Chapter 4 of WGI AR5. (Thomas Stocker, IPCC WGI TSU)	See annotation on comment #899. There is emerging evidence that glacier changes, and therefore their impacts, are strongly variable at sub-regional scale.
44	44461	3	0	0	0	0	Table 3.1 includes material on Detection/Attribution – please check and ensure consistency with WGI Ch10 and WGII Ch18 of AR5. (Thomas Stocker, IPCC WGI TSU)	See annotation on comment #32.
45	44462	3	0	0	0	0	Figure 3.3. Hydrological Cycle: please ensure that the numbers provided here are consistent with the corresponding values given in WGI AR5 Ch2. (Thomas Stocker, IPCC WGI TSU)	The figure has been deleted.
46	44463	3	0	0	0	0	Figure 3.4 is entirely a WGI figure – rather than using the Hawkins and Sutton study here, we suggest that you refer to Ch9/11/12 of WGI AR5 to refer to the assessment of different sources of (physical science) uncertainties in projections. (Thomas Stocker, IPCC WGI TSU)	See annotation on comment #34.
47	44464	3	0	0	0	0	Figure 3.10 on Himalayan Glaciers changes – ensure that information here is not inconsistent with any available information from the WGI AR5 assessment for the broader area of Central Asia. (Thomas Stocker, IPCC WGI TSU)	See annotation on comment #34.
48	44465	3	0	0	0	0	FAQ 3.1 – Finishes with a rather general statement “Floods and droughts will become more frequent”. In relation to floods especially, this is a considerably stronger statement then could be supported by the recent SREX (which is quoted earlier in the chapter). Actually, FAQ 3.2 of this Chapter immediately provides a contradictory statement: “There is a low confidence in projected changes in flood magnitude and frequency”. Please ensure consistency between these two FAQ’s and with the assessed literature. (Thomas Stocker, IPCC WGI TSU)	Accepted and the texts were revised
49	44586	3	0	0	0	0	Well written text where interesting toppics are made available to a broad audience. Nevertheless, the chapter does not appear as written from a single source. This is particularly true for sub-chapter 3.6 "Adaptation and Managing Risks". The term "Tipping point" should be mentioned and linked to freshawater resources/systems. Link to WGI. -- General comment: Please check spelling (English - American); USA - US- U.S.; modelling - modeling; run-off - runoff; ground water - groundwater; waste water - wastewater; USD - $ (Martina Flörke, University of Kassel)	"Tipping point" is not cited now, and we cite chapters in WGI. We revised typos.
50	45925	3	0	0	0	0	Authors have done tremendous amount of work in preparing a detailed FOD on this very important chapter for climate change impacts. In-depth review of available literature is presented in the FOD. Many times references to CMIP3 climate models and scenarios have been made; CMIP5 results are limited in the draft. As more CMIP5 results (publications) have become available recently (http://cmip.llnl.gov/cmip5/publications/allpublications), attempts should be made to include relevant CMIP5 publications in SOD. I see two major issues in FOD. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	See annotation on comment #409.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
51	45926	3	0	0	0	0	First major issue is: there is some kind of disconnect between this chapter and WGI (The Physical Basis) and even relevant chapters in WGII on regional climate projections. For example: in page 12 Line 37 to 40 talk about "…Inaccurate modeling of the atmospheric response to external forcing…". I am sure, several WGI and even WGII authors and reviewers would disagree with this comment. As a hydrologist (I am a hydrologist), we tend to focus on our few km^2 watershed, and then say global model does not provide accurate climate simulation results. Is it really the case? At regional scale natural climate variability play and important role, and often dominate over global climate change signal (see Kumar et al., (a) submitted to Journal of Climate). There is no reason why different climate simulations should synchronize in time to give accurate climate predications at regional/local (also see additional text provided in a separate PDF sheet). This is more true for IPCC type simulations where climate simulations starts in 1850 and only time series climate model knows is the external forcing, including green house gas emissions/concentrations, volcanic eruptions etc. A number of other factors e.g. initial conditions in the atmosphere, SST anomaly in the nearby oceans etc. affect regional climate (see additional text/figure provided in separate pdf sheet, along with references). (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	See annotation on comment #409.
52	45927	3	0	0	0	0	Second major issue is: treatment of emission scenarios e.g. A1B, A2, B1 etc. as a source of uncertainty. Given the climate policy inaction over the last 20 years [Jeff and Gilbert, 2012], and the lack of significant progress in the Rio+20 meeting this year [Nature Editorial, A first Step, June 2012], do we still believe that low emission scenarios e.g. RCP 2.6 is one of the possible pathway. I would suggest, instead of considering different scenarios as a source of uncertainty, a comparative results for high (e.g. RCP8.5) and low emissions scenario (RCP4.5) should be presented; so that policy makers see an advantages of one emission scenario compared to other. Reference is provided in the supplemental pdf sheet. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	See annotation on comment #409.
53	46435	3	0	0	0	0	Comments to Chapter 3 – Freshwater resources (Review of all the Chapter) (Rubén Piacentini, Institute of Physics Rosario (CONICET - National University of Rosario))	This is not for content of chapter 3.
54	46894	3	0	0	0	0	General comments on Chapter 3: Overall, there is clear recognition that dams can exacerbate impacts of climate change on freshwater resources. However, greater attention could be given to the specific impacts basins with or without dams can expect from climate change. A useful report to reference is "Climate change and the world's river basins: anticipating management options" (2007) Palmer et al, Front Ecol Environ (http://www.palmerlab.umd.edu/docs/Palmer_et_al_2007_Frontiers_Environ_Climate_ change_rivers.pdf). According to this report, due to changes in discharge and water stress, the area of large river basins in need of reactive or proactive management interventions will be much higher for basins impacted by dams than for basins with free-flowing rivers. In areas with increased water availability due to climate change, according to the report, "rivers surrounded by intense development and river reaches above dams may experience more severe floods and increased erosion; in addition, aquatic organisms (including exotics) may be more easily dispersed and water quality reduced because of increased sediment, nutrient, and pollutant flux (Nelson et al. in review). Reservoir lifespan could decrease because of increased sediment storage, further amplifying flood risks and, if reservoirs are near capacity, the risk of breaches or dam failure will be great. While dams have saved the lives of many people by preventing floods, dams at risk of failure under future scenarios may pose the greatest threats to humans, infrastructure, crops, and livestock." On the other end of the spectrum, "impounded rivers that lose water may not be able to maintain their channels as they become less dynamic, resulting in degraded aquatic habitats. If water levels fall, land–water connectivity will be reduced and upland vegetation, probably with a large proportion of exotics, will likely encroach on the originally water-filled channels. Reservoirs may lose even more water due to evaporation, with concomitant increases in water temperature and declines in water quality. There is also a risk of increased rates of water extraction in response to water scarcity, implying that even more rivers might run dry." Table 2 in this report also offers good management strategies that can be included for major dammed rivers in the Annex of Chapter 3. (Katy Yan, International Rivers)	We agree in part in the outcomes from that report. However, dams are only mentioned in our report as a way to adapt to climate change water scarcity in some regions, and not so much on the dam impacts on rivers.
55	47225	3	0	0	0	0	I am thankful to IPPC for the invitation to review the IPCC WGII AR5. I had planned to review a few chapters but unfortunately other commitments did not allow me to work for the time I had planned. I was able to review merely Chapter 3 – Freshwater Resources (hereinafter referred to Ch3). I believe that my comments can be useful because they refer to essential elements related to the logic of the report and the underlining philosophy, and provide key information currently missing in Ch3. [Note, my comments are written to form a coherent review with 10 sections rather than making a list of independent comments] I have not made a review for IPCC before. I am somewhat puzzled to read in the relevant "Charge to Reviewers" (hereinafter: CTR), on the one hand, "The IPCC procedures state that the Expert Review process shall be open, objective, and transparent, with a wide circulation…" and, on the other hand, "Please remember that all draft chapters are works in progress and are not to be cited or quoted, or further disseminated". The latter statement is made more emphatic in the "Expert Review Certification", in the phrase: "… all review materials are considered CONFIDENTIAL. Do not share the draft chapters with colleagues…". I am certainly respecting this term, but on the other hand it is self-evident that I have to quote phrases from the draft chapter, in order to make my review. In due time, with full respect to the principle of transparency (which I strongly endorse), this review may be made public, if necessary, and, thus, these quotations will become public, as well. (Demetris Koutsoyiannis, National Technical University of Athens)	The comment is not for content of chapter 3.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
56	47226	3	0	0	0	0	(Koutsoyiannis continued) 2. Completeness and balance According to the CTR, "We ask that expert reviewers evaluate chapters for accuracy, attention to key issues, completeness of intellectual coverage and of the literature assessed, clarity, and balance." In the Ch3 Draft I can see neither "completeness of intellectual coverage and of the literature assessed", nor "balance." But I hope my comments will help to achieve these. My comments are in full agreement with the purpose of the review process, since, according to the CTR, "The purpose of this review is to help ensure that the report provides a balanced and comprehensive assessment of the latest scientific findings associated with the approved outline." I will only present some examples of missing references to the recent literature, most of which stem from my experience as a Co-Editor of the Hydrological Sciences Journal (HSJ). In that capacity, I was happy to receive and approve a summary of the corresponding Freshwater Chapter of the IPCC AR4 (Kundzewicz et al., 2008). There was a formal Discussion of this article (Koutsoyiannis et al., 2009b) and a formal Reply to this Discussion (Kundzewicz et al., 2009). I find it self-evident that all three documents should have been read and quoted in Ch3 of the AR5, because they represent formal scientific publications related to AR4 and constitute discussions and suggestions made to be included in AR5. Currently, none is quoted. (Demetris Koutsoyiannis, National Technical University of Athens)	The comment is not for content of chapter 3.
57	47227	3	0	0	0	0	(Koutsoyiannis continued) In addition, HSJ has hosted a series of papers and discussions about the suitability of climate model projections for hydrological and freshwater management purposes. These include: (a) the original papers by Koutsoyiannis et al. (2008) and Anagnostopoulos et al. (2010); (b) the Editorial article by Kundzewicz and Stakhiv (2010); (c) the Opinion article by Wilby (2010); and (d) the Discussion paper by Huard (2011) and its Reply by Koutsoyiannis et al. (2011). All of these are perfectly relevant and absolutely essential for Ch3, but unfortunately none of these is currently cited. From other HSJ publications (and in addition to a few already cited in Ch3), I can certainly propose the following which are related to climate and freshwater of specific key basins: Di Baldassarre et al. (2011; future hydrology and climate in the River Nile basin); Wu (2010; Great Miami River); Hänggi and Weingartner (2011; Upper Rhine River); and Okruszko (2011; European wetlands). Last, but not least, I strongly propose for inclusion the work by Hirsch and Ryberg (2012), which is absolutely related to the theme of Ch3, as it is related to the investigation of possible changes in magnitude of floods across the USA (note that this, along with the ones mentioned in the previous paragraphs, have been the most read HSJ articles as listed in our web site, and were also heavily discussed informally). Relevant to the same issue, but from another journal, is the work by Lins and Cohn (2011). Some additional key references from other journals , which are related to the suitability of climate models, climate uncertainty, climate change impacts with special emphasis on freshwater, and climate adaptation issues, include the following: Whitfield (2012); Fildes and Kourentzes (2011); Ward et al. (2011); Kiem and Verdon-Kidd (2011); Burke (2011; note, this is newer than two Burke et al. papers already cited); Kundzewicz (2011); Stakhiv (2011); Stephens et al. (2010); Blöschl and Montanari (2010); Kundzewicz et al. (2010); Matthews and Wickel (2009); and Pittock (2009). The authors could find many more by inspecting the reference lists in each of the above. (Demetris Koutsoyiannis, National Technical University of Athens)	Due to space, we cannot cite all references which you recommended. However, some papers in HSJ which we think are important have been cited.
58	47228	3	0	0	0	0	(Koutsoyiannis continued) 3. "Will" Searching Ch3, I found 79 instances of the word "will", the first one being in the statement (in p. 2, l. 45): "Evapotranspiration will increase". This statement makes an interesting contrast with what is mentioned in following sections, i.e. (p. 5, l. 32-40): "Trend estimations for global evapotranspiration are still not compelling due to high uncertainties in global research results. … On a global scale, evaporation increased from the early 1980s up to the late 1990s but not thereafter … [S]o far no fundamental physical-based explanation has been provided for the so called 'evaporation paradox'". This example could make the authors think that "will" may not be a proper expression from a scientific point of view; it implies a naïve and oversimplified view on complex hydroclimatic processes. Even from a literal, rather than philosophical, point of view, I guess the authors do not mean "will" but rather "is projected to". Thus, I suggest locating all appearances of "will" and replacing them accordingly. Likewise, the authors may also wish to inspect and replace 24 and 18 additional appearances of "would" and "expected to", respectively. There have been several discussions about this issue. We read in IPCC reports and sometimes in journal papers (see e.g. Huard, 2011 and Koutsoyiannis et al., 2011), and we hear very often in conferences that the IPCC and, more specifically the climate models used by IPCC, do not provide predictions (let alone certainties about the future) but merely projections. Whatever the difference in semantics of these terms may be, clarity, consistency, precision and honesty, which are desirable or even necessary in the scientific language, demand not to use "will". The importance of this remark becomes higher, as it has been questioned that climate models are "ready for prime time" in water resources management applications (Kundzewicz and Stakhiv, 2010; Koutsoyiannis et al., 2008, 2011; Anagnostopoulos et al., 2010). Furthermore, since the authors of Ch3 rely on results given by others, i.e. climate modellers, who admit that their models do not simulate well processes related to hydrology (cf. Koutsoyiannis et al., 2008), it would be unfair for the Ch3 authors to assume more responsibility for possible wrong "projections" than they really have. By using "will" they actually proceed further than climate modellers, assigning the projections a degree of credibility which they certainly lack. (Demetris Koutsoyiannis, National Technical University of Athens)	We take the point made here and will review our use of unqualified "will". Dr. Koutsoyiannis may be interested in the following from Mastrandrea et al,. 2010 (cited in comment #60), p2 point 5: "Consider that, in some cases, it may be appropriate to describe findings for which evidence and understanding are overwhelming as statements of fact without using uncertainty qualifiers." The example from P2 L45 relies on this guidance, while the statement at P5 L32-40 is about observations rather than projections.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
59	47229	3	0	0	0	0	(Koutsoyiannis continued) 4. "Evidence" and "confidence" Another related issue that needs to be clarified is the use of the term "evidence" when the authors speak about future states, for example, in their statement (p. 2, l. 44-45): "Climate models project both increases and decreases of available water at the regional scale (high agreement, robust evidence)." In my view, it is unclear what "robust evidence" refers to. I can imagine three different cases: a. It refers to what the models predict, i.e., there is evidence that the models make these projections. In this case, the word evidence is unnecessary or even wrong: we cannot call "evidence" the information about what those models project; models provide just their outputs. b. It refers to the future water availability. This case is even worse: there cannot be evidence about the future for the complex hydroclimatic system. Only the future, when it becomes present, will offer the evidence. c. It refers to something that has already occurred, in a degree. In this case the word "evidence" is relevant, but the first part of the statement, "Climate models project both increases…" is irrelevant. (Demetris Koutsoyiannis, National Technical University of Athens)	We would argue rather that model outputs can constitute evidence. The weight to be given to them requires critical assessment, but to limit "evidence" to hard facts, already realized, would make assessments of possible futures impossible.
60	47230	3	0	0	0	0	(Koutsoyiannis continued) 4. Similar problems I had with other parts of the Executive Summary, which I do not list here (because they are of the same type), except one (p. 3, l. 14-15): "Hydrological impacts of climate change on humans and freshwater ecosystems increase with increasing greenhouse-gas emissions (limited evidence, high confidence)." Here I was not able to understand how limited evidence can result in high confidence. To clarify this, I consulted the relevant IPCC Guidance Note (Mastrandrea, 2010) which, inter alia, says (p. 1): "The AR5 will rely on two metrics for communicating the degree of certainty in key findings: • Confidence in the validity of a finding, based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgment) and the degree of agreement. Confidence is expressed qualitatively. • Quantified measures of uncertainty in a finding expressed probabilistically (based on statistical analysis of observations or model results, or expert judgment)." On the other hand it says (p. 2): • "For findings with high agreement and robust evidence, present a level of confidence or a quantified measure of uncertainty. • For findings with high agreement or robust evidence, but not both, assign confidence or quantify uncertainty when possible. Otherwise, assign the appropriate combination of summary terms for your evaluation of evidence and agreement (e.g., robust evidence, medium agreement)." Based on these (in particular, the last point) I do not think that, in IPCC terms, limited evidence can be consistent with high confidence. Furthermore, it is remarkable that none of the Executive Summary points contain any quantification of uncertainty. (Demetris Koutsoyiannis, National Technical University of Athens)	"limited" is a semi-quantitative (ordinal) measure of amount of evidence, while "[high] confidence" is a two-word summary of the author team's assessment of the evidence.
61	47231	3	0	0	0	0	(Koutsoyiannis continued) 5. Bias I always had the impression that IPCC texts are characterized by bias: they present any evidence in a manner as catastrophe-friendly as possible. I found the following quotation (p. 3 l. 1-3) to be a characteristic example of this type: "Intense precipitation events will become more frequent (high confidence) and droughts will become more frequent (low to medium confidence, medium evidence). The observed intensification of heavy precipitation events is very likely to be anthropogenic. Climate models, however, do not simulate the observed intensification correctly, so that projections may be biased low. Simulated changes in the incidence of droughts are regionally very variable". If climate models do not simulate something correctly, then their results are incorrect, not biased. Even if one wants to use the more polite expression "bias" instead of "error" or "incorrect result", then what is the reason to assume that they are "biased low" rather than "biased" or "biased high"? Looking at the supporting analysis in [3.3.1.4], the only relevant statement is: "For example the GCMs do not simulate the observed intensification adequately." This does not give any justification for the phrase "biased low". Actually, even the phrase "do not simulate the observed intensification" in both quotations is biased per se. A more neutral and accurate phrase would be "do not simulate the observed precipitation extremes". An even better formulation can be taken from the work by Stephens et al. (2010), whose abstract includes the following statements: "The character of liquid precipitation (defined as a combination of accumulation, frequency, and intensity) over the global oceans is significantly different from the character of liquid precipitation produced by global weather and climate models. … However, these models produce precipitation approximately twice as often as that observed and make rainfall far too lightly. This finding reinforces similar findings from other studies based on surface accumulated rainfall measurements. The implications of this dreary state of model depiction of the real world are discussed." Such "dreary state" undermines also other statements in Ch3, which should be modified accordingly; for example (p. 1 l. 46-48): "Reliable surface water supply is likely to decrease in many regions because of decreases in snow/ice storage and groundwater recharge, degradation of water quality, and more variable streamflow due to more variable precipitation." In addition to the reference to precipitation, which is poorly modelled, the above statement is another example of a biased statement. I guess water supply is also likely to increase in many other regions, so why mention only the case where it is likely to decrease? (Demetris Koutsoyiannis, National Technical University of Athens)	A bias is a particular, well-understood kind of error. It is quite wrong to assume that "biased" means or implies "incorrect". If it can be quantified, it can be corrected with ease; if not, the biased source of information can nevertheless be evaluated with due caution. For example, relying on model simulations of the past, we say that the models' projections "may be" biased low; there is no question of an assumption here.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
62	47232	3	0	0	0	0	(Koutsoyiannis continued) 6. Can climate "cease to change"? There is another point in the Executive Summary worth commenting for a different reason (p. 3, l. 8-9): "Glaciers would continue to lose mass even if the climate were to cease to change…" The statement is misleading. Climate never ceases to change. Furthermore, melting glaciers constitute climate changing conditions themselves, and in turn would induce other changes. Perhaps the authors imply here that climate change is only anthropogenic, but this is not consistent even with the AR5 FOD Glossary, according to which (p. 3): "Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use." 7. Society vs. infrastructure I believe that statements like the following (p. 3, l. 37-39): "storm surges, floods, debris flows, and droughts … demand the changes for human society in the way how to manage water resources" are inaccurate as, by putting the emphasis on the society, they hide the fact that such changes are mainly dealt with by engineering means, i.e. by infrastructure development (Koutsoyiannis, 2011a). Such changes are not necessarily dictated by projected climate changes, but are necessary to resolve existing problems (e.g. Sivakumar, 2011), which have their reasons in demographic and environmental changes, rather than climatic changes (Koutsoyiannis et al., 2009a). On the other hand, I must commend the authors for not exclusively promoting the so-called 'soft path' (Gleick, 2002) which is certainly insufficient to resolve existing problems; for example, I agree with their statement (p. 33; l. 15-16): "Adaptation measures, which involve a combination of 'hard' infrastructural and 'soft' institutional actions, can be helpful in reducing the vulnerability." (Demetris Koutsoyiannis, National Technical University of Athens)	Climate can indeed cease to change in a thought experiment. The statement to which the reviewer objects is correct, not misleading.
63	47233	3	0	0	0	0	(Koutsoyiannis continued) 8. Hydropower I think that several aspects related to hydropower are not presented objectively. First of all, I do not believe that the following extract is correct (p. 38, l. 50-52): "It was estimated that ethanol from corn and from switch grass requires much more water than other renewable energy sources for the same amount of energy produced, except for hydropower where water is lost from reservoirs [by] evaporation (Jacobson, 2009)." Hydropower, which does not consume water for the production of energy but only transforms its dynamic energy into electric energy, cannot consume more water than the production of ethanol for the same amount of energy produced. I have seen the original source (Jacobson, 2009), as well as the one referenced in it (Torcellini, 2003). My impression is that they have counted the entire amount of evaporation. In fact, however, part of this amount, or in some places, depending on the local climate, all of it, is replenished by rainfall over the reservoir area. In such cases, the correct practice is to use the net evaporation, i.e. the difference of evaporation minus precipitation, over the reservoir area. An alternative approach would be to use the difference of evaporation from the reservoir minus the natural evapotranspiration (if the reservoir was not there). Certainly, neglecting the subtrahend in either of the cases results in overestimation of the actual losses. Interestingly, for the case of corn and switch grass, Jacobson (2009) considers in the calculation only the irrigation water (plus ethanol-factory water) requirement, thus subtracting from the total amount the water from rainfall, which, according to the data he gives, is the vast majority. Thus I am afraid the comparison here is biased against hydropower. Such bias may be present in other cases too, e.g. (p. 39, l. 17-18) "In particular, hydropower operation often leads to fast sub-daily discharge changes that are detrimental to the downstream river ecosystem ." This is true only in part, for two reasons. First, the natural flows are also characterized by substantial sub-daily (and over-daily) changes and ecosystems are familiar with changes. Second, modern hydropower operation rules have been adapted so as to take into account ecosystem health. The concept of ecological flow has already been implemented in most dams and the deliberate flooding of downstream areas is among the measures being studied for future implementation. The authors may wish to consult Koutsoyiannis (2011a) about this. But the most important bias is related to hydropower features missing from Ch3 (i.e. not being mentioned at all in it). In particular, the development of renewable energy sources cannot be developed if they are not accompanied by hydropower. Renewables, such as wind and solar energy, are highly variable and unpredictable, and thus their exploitation requires energy storage. Hydropower with reversible turbines (implementing pumped storage schemes) is the only available and proved technology for large-scale energy storage (Koutsoyiannis, 2011a; Koutsoyiannis et al., 2009a). (Demetris Koutsoyiannis, National Technical University of Athens)	We agree that the Torcellini (2003) estimate of water consumption for hydropower production may be an overestimation. At least in semi-arid areas, this might not so much be an effect of un-accounted for evapotranspiration in the case of soil instead of open-water, but of the fact that reservoirs serve multiple purposes. Therefore, the sentence on p.38, l 50-52 will be reformulated. Regarding ecological impacts of dams and how they can be decreased by optimal management: A balanced discussion of this is unfortunately not possible in our chapter, due to space constraints. We believe, however, that it is not possible to manage reservoirs in a way that leads to insignificant impacts (e.g. regarding migratory fish). Regarding the last three sentences of the comment, these considerations are outside the scope of the chapter but are to be made in Working Group III.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
64	47234	3	0	0	0	0	(Koutsoyiannis continued) 9. Trends and Hurst However, among the information missing from Ch3, the most important, in my view, is the complete absence of any reference to the Hurst-Kolmogorov (HK) behaviour (Hurst, 1951; Kolmogorov, 1940), also termed the Hurst phenomenon, long-term persistence, or the scaling behaviour, which is quite relevant to hydroclimate (Koutsoyiannis, 2003, 2006, 2011b). Instead, the authors discuss extensively "trends" in several phenomena, e.g.: "Changes in global precipitation are observed and simulated by multiple General Circulation Models GCM …, but global trends cannot be determined. Linear trends for global averages from different datasets (e.g. GHCN, GPCP, GPCC, PREC/L, CRU, etc) during 1901–2005 are statistically insignificant" (p. 5, l. 17-20). "Certain trends in total precipitation and precipitation extremes are observed, for example in South China where increases in dry days and a prolongation of dry periods have been detected" (p. 5, l. 24-26). "Trend estimations for global evapotranspiration are still not compelling due to high uncertainties in global research results. There is still little literature on observed trends in evapotranspiration, whether actual or potential … On a global scale, evaporation increased from the early 1980s up to the late 1990s but not thereafter … Fu et al. (2009) point out that the magnitude of changes and importance of each of the causes varies from region to region. They conclude that so far no fundamental physical-based explanation has been provided for the so called 'evaporation paradox'" (p. 5, l. 32-40). "Robock et al. (2005) observed an increasing long-term trend in soil moisture content during summer for stations with the longest records" (p. 5, l. 47-48). "[R]egional down and upward trends in soil moisture have been calculated for China, where the trend to more severe soil moisture droughts has been experienced ... Such findings in drought trends and severity need to be taken carefully, as … PDSI and other methods give diverging results for droughts" (p. 5, l. 51-53). "Stahl et al. (2010) investigated streamflow data across Europe reporting a decreasing trend in stream flow for southern and eastern regions, and generally an increasing runoff trend elsewhere, particularly in northern latitudes. In the Nordic countries, the overall picture shows a trend towards increased streamflow annual values" (p. 6, l. 33-36). "In the USA, a significant statistical increasing trend of streamflow was detected for the Mississippi and Missouri regions, whereas a decreasing trend in total runoff was found for the Pacific Northwest and South Atlantic-Gulf regions" (p. 6, l. 33-35-38). "Analysis of global discharges based on model-simulated runoff ratio during 1948-2004 … revealed that only about one third of the top 200 rivers… showed statistically significant trends, namely rivers recording downward runoff trends … and only 19 having an upward discharge trend" (p. 6, l. 38-42). (Demetris Koutsoyiannis, National Technical University of Athens)	We are aware that a trend, identified for example by linear regression against time, need not constitute a climatic change. Trends can and do appear in the output of random-number generators.But to show that a detected trend is inconsistent with natural variability of the phenomenon being studied is a major statistical challenge. We think that consistency with expectations (derived from an understanding of the climatic forcing) has evidentiary value even when the possible range of purely natural variation is not well quantified.
65	47235	3	0	0	0	0	(Koutsoyiannis continued) 9. Trends and Hurst "in terms of heavy precipitation there are more locations and studies that show an increasing trend over the late 20th century than those recording a decrease" (p. 7, l. 14-16). "Cunderlik and Ouarda, (2009) reported a change on flood frequency on snowmelt floods … over the last three decades with significant trends at 20% of stations in SE Canada towards decreasing magnitudes, whereas increasing peak flows were recorded in NW Canada. In contrast, there is no evidence of widespread trends in extreme floods based on daily river discharge of 139 Russian gauge stations" (p. 7, l. 18-22) "Similarly, statistical analysis of annual maximum stream flows in the USA at 30-yr (1959-1988) and 50-yr (1939-1988) timeframes do not prove any significant trend…, probably showing the inability to detect any trend based on short term flow series" (p. 7, l. 22-24). "In Northern-Western Europe, there is a higher number of gauge stations showing a significant upward trends in flood magnitude and frequency, covering W, S and central Germany…, the Meuse river and its tributaries (except Geul River…). In contrast, in E and NE Germany and in the Czech Republic …, a slight decrease in winter flood occurrence and no change in summer flooding was reported ... In South-western Europe, there is no evidence on generalized trend on annual flow maxima… although regional discrimination shows a decreasing trend on flood frequency in the Pyrenees, a flood magnitude decreases in the Alps region, in relation with earlier snowmelt processes. British rivers showed significant positive trends in high-flow indicators primarily in maritime-influenced, upland catchments in the north and west of the UK … although in previous studies those changes were not so obvious" (p. 7, l. 26-37). (Demetris Koutsoyiannis, National Technical University of Athens)	1: See response to comment 64. 2: The difficulty experienced by Dr. Koutsoyiannis in conforming to the constraints of this spreadsheet is comparable with the difficulty experienced by the chapter authors in addressing his comments, and is further evidence that the spreadsheet is not an adequate medium for the purposes of the review.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
66	47236	3	0	0	0	0	(Koutsoyiannis continued) 9. Trends and Hurst "In Asia, flood discharge of the lower Yangtze region shows an upward trend in the last 40 years …, and both upward and downward trends were identified in a 40-yr record of four selected river basins of the northwestern Himalaya ... In the Amazon region, large floods have been registered in the main channel of the Amazon river and its tributaries, including the July 2009 flood considered one of the highest in 106 years of record of the Rio Negro at Manaus… In Africa, there is no evidence of flood magnitude changes during the 20th Century" (p. 7, l. 39-46). "In the U.S., droughts are becoming more severe in some regions, but there are no clear trends for North America as a whole" (p. 8, l. 9-10). "In general terms, the SREX Chapter report (2012) concluded that there is medium confidence that since the 1950s some regions of the world have experienced more intense and longer droughts … but also opposite trends exist in other regions" (p. 8, l. 21-25). While this information is, no doubt, useful, there are also missing key references, some of which have been already mentioned in section 2 above. For example, in terms of the trends in floods in the USA, the missing reference to the more comprehensive USGS studies for USA by Hirsch and Ryberg (2012) and Lins and Cohn (2011) is characteristic. Even more important is the missing big picture. The big picture is consistent with the Hurst-Kolmogrov behaviour. More specifically, trends, like the above quoted, which differ in sign in different time periods or in different locations adjacent in space, are none other than manifestations of the HK behaviour (Hamed, 2008). The Hurst-Kolmogorov behaviour has now been recognized even in the physics literature (e.g. Halley, 2009; Eichner et al., 2003) as well as in the climate literature (e.g. Halley and Kugiumtzis, 2011; Mann, 2011). Given that the discovery of this behaviour has been pioneered by a hydrologist (Hurst, 1951) it would be a pity if it is not referred to in Ch3 (cf. also Koutsoyiannis et al., 2009b, who criticized AR4 for not incorporating HK in the AR4 Freshwater chapter). Once the HK behaviour is recognized, then the significance of trends is dramatically affected (Koutsoyiannis, 2003; Cohn and Lins, 2005; Hamed, 2008). Unfortunately, in the standard literature the statistical significance of trends is mostly assessed by typical statistical tests that assume independence it time. This is a wrong assumption and the results are equally wrong. Therefore, I suggest that reference to statistical significance in Ch3 should be made with extreme care and only mentioned if the original source has used proper methodology, recognizing the temporal dependence in hydroclimatic processes. (Demetris Koutsoyiannis, National Technical University of Athens)	1: See responses to comments 64 and 65.
67	47237	3	0	0	0	0	(Koutsoyiannis continued) 10. Some notes on figures Hydrology, the science of water on earth, is a quantitative science. Most figures comply with this fact. An exception is Fig. 3-2; what it depicts is too far from quantitative information. Perhaps even the qualitative information cannot be correct: When there is low degree of confidence in detection, how is it possible that the degree of confidence in attribution is high? On the other hand, Fig. 3.5 wants to depict decomposition of variance into contributions from three sources of uncertainty (internal uncertainty, model uncertainty, scenario uncertainty). Such decompositions rely on a linear view of science which is incorrect. (A Mexican colleague gives the following example—well-understood in Mexico—to illustrate the fallacy of linear decomposition into different contributions: If someone is being machine-gunned by two people at the same time, it is objectively impossible to quantify the contribution of each killer to that person's death, since the result would be the same, even in the absence of one of the two killers). (Demetris Koutsoyiannis, National Technical University of Athens)	A. Figure 3-2 is part of a WG2-wide effort to convey information on detection and attribution in a uniform visual format, and its axes are deliberately semi-quantitiative to reflect the extreme difficulty of making quantitative assessments of most of the hydrological impacts of climatic change. B. It is not expected that all parts of the graph will be occupied with equal or high frequency. C.We do not accept the proposition that contributions to total variance are not linearly separable as in Figure 3.4 (not 3.5).
68	47238	3	0	0	0	0	(Koutsoyiannis continued) References: Anagnostopoulos, G. G., D. Koutsoyiannis, A. Christofides, A. Efstratiadis, and N. Mamassis, A comparison of local and aggregated climate model outputs with observed data, Hydrological Sciences Journal, 55 (7), 1094–1110, 2010. Blöschl, G., and A. Montanari, Climate change impacts - throwing the dice?, Hydrological Processes, 24(3), 374-381, 2010. Burke, E. J., Understanding the sensitivity of different drought metrics to the drivers of drought under increased atmospheric CO2, Journal of Hydrometeorology, 12(6), 1378-1394, 2011. Cohn, T. A., and H. F. Lins, Nature's style: Naturally trendy, Geophysical Research Letters, 32(23), art. no. L23402, 2005. Cunderlik, J. M., and T. B. M. J. Ouarda, Trends in the timing and magnitude of floods in Canada. Journal of Hydrology, 375 (3-4), 471-480, 2009. Di Baldassarre, G., M. Elshamy, A. van Griensven, E. Soliman, M. Kigobe, P. Ndomba, J. Mutemi, F. Mutua, S. Moges, J.-Q. Xuan, D. Solomatine, and S. Uhlenbrook, Future hydrology and climate in the River Nile basin: a review, Hydrological Sciences Journal, 56(2), 199-211, 2011. Eichner J. F., E, Koscielny-Bunde, A. Bunde, S. Havlin and H.-J. Schellnhuber, Power-law persistence and trends in the atmosphere: A detailed study of long temperature records, Phys Rev E, 68, 046133, 2003. Fildes, R., and N. Kourentzes, Validation and forecasting accuracy in models of climate change, International Journal of Forecasting, 27(4), 968-995, 2011. Fu, G., S. P. Charles and J. Yu: A critical overview of pan evaporation trends over the last 50 years, Clim. Change, 97, 193–214, 2009. Gleick, P. H., Soft water paths, Nature, 418, 373, 2002. Halley, J. M., Using models with long-term persistence to interpret the rapid increase of earth's temperature, Physica A: Statistical Mechanics and its Applications, 388 (12), 2492-2502, 2009. Halley, J. M., and D. Kugiumtzis, Nonparametric testing of variability and trend in some climatic records, Climatic Change, 107 (3-4), 267-276, 2011. Hamed, K. H., Trend detection in hydrologic data: The Mann-Kendall trend test under the scaling hypothesis, Journal of Hydrology, 349(3-4), 350-363, 2008. Hänggi, P., and R. Weingartner, Inter annual variability of runoff and climate within the Upper Rhine River basin, 1808–2007, Hydrological Sciences Journal, 56(1), 34–50, 2011. Hirsch, R. M., and K. R. Ryberg, Has the magnitude of floods across the USA changed with global CO2 levels?, Hydrological Sciences Journal, 57 (1), 1-9, 2012. Huard, D., A black eye for the Hydrological Sciences Journal, Discussion of "A comparison of local and aggregated climate model outputs with observed data", by G. G. Anagnostopoulos et al., Hydrological Sciences Journal, 56(7), 1330–1333, 2011. Hurst, H. E., Long term storage capacities of reservoirs, Trans. Am. Soc. Civil Engrs., 116, 776-808, 1951. (Demetris Koutsoyiannis, National Technical University of Athens)	They are references.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
69	47239	3	0	0	0	0	(Koutsoyiannis continued) References: Jacobson, M.Z., Review of solutions to global warming, air pollution, and energy security, Energy and Environmental Science, 2 (2), 148-173, 2009. Kiem, A. S., and D. C. Verdon-Kidd, Steps toward "useful" hydroclimatic scenarios for water resource management in the Murray-Darling Basin, Water Resources Research, 47, W00G06, doi: 10.1029/2010WR009803, 2011. Kolmogorov, A. N., Wienersche Spiralen und einige andere interessante Kurven in Hilbertschen Raum, Dokl. Akad. Nauk URSS, 26, 115-118, 1940. Koutsoyiannis, D., Climate change, the Hurst phenomenon, and hydrological statistics, Hydrological Sciences Journal, 48 (1), 3–24, 2003. Koutsoyiannis, D., Nonstationarity versus scaling in hydrology, Journal of Hydrology, 324, 239–254, 2006. Koutsoyiannis, D., Scale of water resources development and sustainability: Small is beautiful, large is great, Hydrological Sciences Journal, 56 (4), 553–575, 2011a. Koutsoyiannis, D., Hurst-Kolmogorov dynamics and uncertainty, Journal of the American Water Resources Association, 47 (3), 481–495, 2011b. Koutsoyiannis, D., A. Christofides, A. Efstratiadis, G. G. Anagnostopoulos, and N. Mamassis, Scientific dialogue on climate: is it giving black eyes or opening closed eyes? Reply to "A black eye for the Hydrological Sciences Journal" by D. Huard, Hydrological Sciences Journal, 56 (7), 1334–1339, 2011. Koutsoyiannis, D., A. Efstratiadis, N. Mamassis, and A. Christofides, On the credibility of climate predictions, Hydrological Sciences Journal, 53 (4), 671–684, 2008. Koutsoyiannis, D., C. Makropoulos, A. Langousis, S. Baki, A. Efstratiadis, A. Christofides, G. Karavokiros, and N. Mamassis, Climate, hydrology, energy, water: recognizing uncertainty and seeking sustainability, Hydrology and Earth System Sciences, 13, 247–257, 2009a. Koutsoyiannis, D., A. Montanari, H. F. Lins, and T.A. Cohn, Climate, hydrology and freshwater: towards an interactive incorporation of hydrological experience into climate research—DISCUSSION of "The implications of projected climate change for freshwater resources and their management", Hydrological Sciences Journal, 54 (2), 394–405, 2009b. Kundzewicz, Z. W., Nonstationarity in water resources – Central European perspective, Journal of the American Water Resources Association, 47(3), 550-562, 2011. Kundzewicz, Z. W., Y. Hirabayashi and S. Kanae, River floods in the changing climate—Observations and projections, Water Resources Management, 24(11), 2633-2646, 2010. Kundzewicz, Z. W., L. J. Mata, N. W. Arnell, P. Döll, B. Jimenez, K. Miller, T. Oki, Z. Şen and I. Shiklomanov, The implications of projected climate change for freshwater resources and their management, Hydrological Sciences Journal, 53(1), 3–10, 2008. Kundzewicz, Z. W., L. J. Mata, N. W. Arnell, P. Döll, B. Jimenez, K. Miller, T. Oki and Z. Şen, Water and climate projections—Reply to discussion "Climate, hydrology and freshwater: towards an interactive incorporation of hydrological experience into climate research", Hydrological Sciences Journal, 54(2), 406-415, 2009. Kundzewicz, Z. W., and E. Z. Stakhiv, Are climate models "ready for prime time" in water resources management applications, or is more research needed? Hydrological Sciences Journal, 55(7), 1085–1089, 2010. Lins, H. F., and T. A. Cohn, Stationarity: wanted dead or alive? Journal of the American Water Resources Association, 47(3), 475-480, 2011. (Demetris Koutsoyiannis, National Technical University of Athens)	They are references.
70	47240	3	0	0	0	0	(Koutsoyiannis continued) References: Mann, M. E., On long range dependence in global surface temperature series, Climatic Change, 107 (3), 267-276, 2011. Mastrandrea, M. D., C. B. Field, T. F. Stocker, O. Edenhofer, K. L. Ebi, D. J. Frame, H. Held, E. Kriegler, K.J. Mach, P. R. Matschoss, G.-K. Plattner, G. W. Yohe, and F. W. Zwiers, Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties, Intergovernmental Panel on Climate Change (IPCC), 2010 (<http://www.ipcc.ch>; <http://193.194.138.236/pdf/supporting-material/uncertainty-guidance-note.pdf>). Matthews, J., and A. J. Wickel, Embracing uncertainty in freshwater climate change adaptation: A natural history approach, Climate and Development, 1(3), 269-279, 2009. Okruszko, T., H. Duel, M. Acreman, M. Grygoruk, M. Flörke, and C. Schneider, Broad-scale ecosystem services of European wetlands — overview of the current situation and future perspectives under different climate and water management scenarios, Hydrological Sciences Journal, 56(8), 1501–1517, 2011. Pittock, J., Lessons for climate change adaptation from better management of rivers, Climate and Development, 1(3), 194-211, 2009. Robock, A., M. Mu, K. Vinnikov, I. V. Trofimova and T. I. Adamenko,: Forty five years of observed soil moisture in the Ukraine: No summer desiccation (yet), Geophys. Res. Lett., 32, L03401, 2005. Sivakumar, B., Water crisis: From conflict to cooperation – an overview, Hydrological Sciences Journal, 56 (4), 531-552, 2011. Stahl K., H. Hisdal, J. Hannaford, L. Tallaksen, H. Van Lanen, E. Sauquet, S. Demuth, M. Fendekova, J. Jordar, Streamflow trends in Europe: evidence from a dataset of near-natural catchments, Hydrology and Earth System Sciences, 14, 2367- 2382, 2010. Stakhiv, E. Z., Pragmatic approaches for water management under climate change uncertainty, Journal of the American Water Resources Association, 47(6), 1183-1196, 2011. Stephens, G. L., T. L'Ecuyer, R. Forbes, A. Gettlemen, J.-C. Golaz, A. Bodas-Salcedo, K. Suzuki, P. Gabriel and J. Haynes , Dreary state of precipitation in global models, J. Geophys. Res., 115, D24211, doi:10.1029/2010JD014532, 2010. Torcellini, P., N. Long, and R. Judkoff, Consumptive water use for US power production, National Renewable Energy Laboratory, U.S. Department of Energy, 2003 (www.nrel.gov/docs/fy04osti/33905.pdf). Ward, J. D., A. D. Werner, W. P. Nel, and S. Beecham, The influence of constrained fossil fuel emissions scenarios on climate and water resource projections, Hydrology and Earth System Sciences, 15, 1879-1893, 2011. Whitfield, P. H., Floods in future climates: a review, Journal of Flood Risk Management, 2012. Wilby, R. L. () Evaluating climate model outputs for hydrological applications–Opinion, Hydrological Sciences Journal, 55 (7), 1090–1093, 2010. Wu, S.-Y., Potential impact of climate change on flooding in the Upper Great Miami River Watershed, Ohio, USA: a simulation-based approach, Hydrological Sciences Journal, 55(8), 1251-1263, 2010. (Demetris Koutsoyiannis, National Technical University of Athens)	They are references.
71	48038	3	0	0	0	0	Overall a thorough treatment of the literature on freshwater ecosystems and water resources. Perhaps a greater emphasis on the research and data gaps would be helpful - in particular the uncertainty in translating the GCMs into predicted changes in streamflow and ground-surface water interactions. (Nick Bond, Griffith University)	Thank you.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
72	48257	3	0	0	0	0	In Chapter 3, in the drought section, neither the recent devastating drought of the South West US or the Colorado wildfires are mentioned (Malini Nair, Indian Institute of Science)	The chapter is not intended to review single events except for the case study boxes which is not the case.
73	48260	3	0	0	0	0	The topics of evapotranspiration, runoff, drought, rivers, groundwater requires more geographical coverage especially from Asia and Australia (Malini Nair, Indian Institute of Science)	coverage depends on publications, Australia is covered well with respect to groundwater. We can include more findings from China e.g. Zhai et al. (drought, runoff), Fischer et al. (drought, rivers), Tao et al. (runoff), ... Some new senteces were added to cover these regions.
74	48263	3	0	0	0	0	Figure 3.8 and Figure 3.9 redraw (Malini Nair, Indian Institute of Science)	They have been redrawn.
75	48977	3	0	0	0	0	I thought the chapter focussed a lot on negative aspects of anthropogenic climate change for the hydrological cycle, while positive aspects were often ignored (although not completely). (Richard Betts, Met Office Hadley Centre)	Perhaps, but see also FAQ 3.5 (P43 L34-43). You are right but the assessment reflects what has been written.
76	48978	3	0	0	0	0	The chapter gives the impression that anthropogenic climate change is the only climate-related issues facing freshwater resources. However, understanding and quantification of natural climate variability is also very important for adaptation. I suggest that the authors provide more information on natural variability, especially in the context of adaptation. (Richard Betts, Met Office Hadley Centre)	In the SOD we will try to focus more on setting assessed impacts in the context of natural variability. However we note that IPCC assessments derive their raison d'être from the UN Framework Convention on Climate Change, and therefore that an emphasis on searching for signals of anthropogenic climate change is hardly surprising.
77	50010	3	0	0	0	0	1) Overall -- In preparing the 2nd-order draft, the chapter team should prioritize making each section of the chapter a polished, comprehensive treatment of topics considered. From these sections, the chapter team is then encouraged to maximize the utility of its findings, ensuring that they are robust, compelling, and nuanced. Themes to consider informing in constructing findings include decisionmaking under uncertainty, risks of extreme events and disasters, avoided damages, and limits to adaptation. To these ends, the chapter team has prepared a solid 1st-order draft. In an effort to inform further chapter development, I provide some general and specific comments below. (Katharine Mach, IPCC WGII TSU)	Thank you very much. We revised the draft a lot.
78	50011	3	0	0	0	0	2) Highlighting key findings -- In developing the 2nd-order draft, the chapter team should continue presenting key findings across the sections of the chapter, using calibrated uncertainty language to characterize its degree of certainty in these conclusions. In this way, a reader of the chapter will be able to understand how the literature reviews and syntheses in the chapter sections--the traceable accounts--support the conclusions of the chapter, especially those presented in the executive summary. Additionally, identification of key findings throughout the chapter will further enable the author team to increase specificity and nuance in characterizing key trends and determinants in the context of the executive summary, so that the richness of assessment in the underlying chapter sections fully carries through to the summary statements of the chapter in the executive summary. (Katharine Mach, IPCC WGII TSU)	We revised and used calibrated uncertainty language carefully.
79	50012	3	0	0	0	0	3) Usage conventions for calibrated uncertainty language -- Where used, calibrated uncertainty language, including summary terms for evidence and agreement, levels of confidence, and likelihood terms, should be italicized. In addition to incorporating these terms directly into sentences, the author team may find it effective to present them, as already done, parenthetically at the end of sentences or clauses. Casual usage of the reserved uncertainty terms should be avoided, as has been flagged in some specific comments throughout the chapter. (Katharine Mach, IPCC WGII TSU)	We italicized calibrated uncertainty language, and casual usage of them was avoided.
80	50013	3	0	0	0	0	4) Summary terms for evidence and agreement -- The chapter team is encouraged to revisit statements for which a summary term is provided for evidence, but not for agreement. In such cases, the author team should consider characterizing agreement as well. Additionally, there may be statements for which the author team could present only a level of confidence, without summary terms for evidence and/or agreement. The TSU would be happy to discuss evidence and agreement further with the author team, if exploring the framework for treatment of uncertainties in this regard would be of use. (Katharine Mach, IPCC WGII TSU)	We used summary terms for both evidence and agreement.
81	50014	3	0	0	0	0	5) Specificity of described observations and projections -- The author team is encouraged to continue presenting observed and projected impacts and trends with high levels of specificity and conciseness. Aspects to consider presenting include the following: relevant time periods, geographic areas, etc. for observations; relevant time frames, scenarios for climate change or socio-economic development, geographic regions, or other assumptions for projections; and discussion of key driving factors where ranges of outcomes are presented. (Katharine Mach, IPCC WGII TSU)	We specified observed and projected impacts.
82	50015	3	0	0	0	0	6) Conditional constructions -- The chapter team may wish to consider further use of conditional constructions that explicitly separate a given physical change from its corresponding conditional outcome. Such constructions may particularly be of use in presenting impacts for ecological, human, and social-ecological systems, as well as response strategies. (Katharine Mach, IPCC WGII TSU)	We considered further use of conditional constructions as much as possible.
83	50016	3	0	0	0	0	7) Coordination across the Working Group 2 contribution -- In developing the next draft of the chapter, the author team should consider treatment of topics not only in this chapter, but also across the report as a whole. For each topic, the chapter team should ensure that treatment here is reduced to the essence of what is relevant to the chapter, with cross-references made to other chapters as appropriate, also minimizing overlap in this way. (Katharine Mach, IPCC WGII TSU)	We checked other chapters in WG2 and cited some chapters which we think were related to this chapter.
84	50017	3	0	0	0	0	8) Harmonization with the Working Group 1 contribution to the AR5 -- At this stage of chapter drafting, the author team should carefully consider the working group 1 contribution. Wherever climate, climate change, climate variability, and extreme events are discussed, the chapter team should ensure that their treatment is harmonized with the assessment findings of working group 1. (Katharine Mach, IPCC WGII TSU)	We checked chapters in WG1 and cited some chapters which we think were related to this chapter.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
85	52143	3	0	0	0	0	" The present chapter is very important because water is life. Climate change can convert a monsoon fed region into an arid one which necessitates more and more anthropogenic involvement in utilization of groundwater and bore wells. Both the activities can render a population helpless having less and less water for urban and rural use in the near future. Some attention needs to be focussed on the crisis of water management under such circumstanc 1. How realistic is the assessment of current and future risks; 2. What are the options proposed for managing risks and 3. How options can be adapted by the population in crisis (Shelley Bhattacharya, Visva Bharati University)	We added the contents as much as possible.
86	52638	3	0	0	0	0	Generally there is very little actual information and discussion on biological systems and the effects on them. A positive general point is the attempt to estimate risks for these systems as well as how adaptation and management in other areas (e.g. terrestrial) affects freshwater systems and vice versa. However, without the biological base/context for this it becomes difficult to evaluate how appropriate these risks and effects are. A separate section on research and data gaps is also very positive, but once again biological focus is lacking. Although the literature on ecological effect of climate change on freshwater ecology is poor, some relatively new papers are dealing with this issue from an European perspective . The EU Research Program, WISER (www.wiser.eu), mainly dealing with the implementation of the Water Framework Directive in Europe, has published some papers on the climate change issue. Jeppesen et al. (2009) and Jeppesen et al. (2011) are dealing with phosphorous and nitrogen runoff respectively and the effects on the ecological state of lakes. Jeppesen et.al (2010) is discussing impacts of climate change on lake fish communities. Suggested additional refernces: Jeppesen, E. et al. (2009) Climate change effects on runoff, catchment phosphorus loading and lake ecological state, and potential adaptations. Journal of Environmental Quality, 38, 1931-1940. Jeppesen, E. et al. (2011) Climate change effect on nitrogen loading from catchment in Europe: implications for nitrogen retention and ecological state of lakes and adaptations- Hydrobiologia, 663, 1-21. Jeppesen, E. et al. (2010) Impacts of climate warming on lake fish community structure and potential effects on ecosystem function. Hydrobiologia, 646, 73-90. (Else Marie Løbersli, Norwegian directorate for nature management)	This comment was missed during consideration of the review of the FOD. Chapter 3 now has a Cross-chaper Box on interactions between freshwater systems and vegetation.
87	52640	3	0	0	0	0	A biological understanding of the system is necessary for development and evaluation of adaptation and management strategies. Statements such as «Water utilities must enhance their capacity to cope with the impacts of climate change and other human pressures in the future by increasing resilience and reliability» (p. 35 l. 19-20) need to be put in a context where the factors making the system resilient or not resilient in the present or the future are explicitly stated, estimated and/or discussed (depending on the status of data available at this point). It is simply not possible to develop strategies for resilient water utilities until we know the biological background for this resilience (or lack thereof). (Else Marie Løbersli, Norwegian directorate for nature management)	The section has been rewritten.
88	54399	3	0	0	0	0	GENERAL COMMENTS: I would like to thank the authors for a very interesting and enjoyable FOD. When considering the expert review comments received on your chapter and the next round of revisions, I suggest several overall priorities. (1) Keep in mind that the preparation of the SOD is the time to ensure that each section of the chapter presents a comprehensive treatment of relevant literature, and that the Executive Summary presents findings that capture the key insights that arise from the chapter assessment. (2) This is also the time to focus on distilling the chapter text, not just fine-tuning wording but editing with a critical eye to improving quality by making discussions succinct and synthetic, while still being comprehensive. (3) Cross-chapter coordination is also important at this stage, as it should now be possible to identify topics that overlap with other chapters and to coordinate with other chapter teams to minimize that overlap. (4) Cross-Working Group coordination is important as well, and relevant chapter sections should cross-reference chapters from the other Working Groups, particularly in the case of statements about changes in mean or extreme climate conditions that are assessed in the contribution of Working Group I. (5) Continue to look for opportunities for the creation of figures that synthesize across results from the literature. (Michael Mastrandrea, IPCC WGII TSU)	Thank you very much.
89	54400	3	0	0	0	0	EXECUTIVE SUMMARY: The author team has made a good start on the Executive Summary, including clear attention to providing traceable accounts (see separate comment on this) and calibrated uncertainty language. For the SOD, I suggest considering ways to increase the specificity of the findings in the Executive Summary (see specific comments on this). There may also be opportunities to add additional findings as the chapter assessment matures. In addition, please consider the overall use of calibrated uncertainty language in the Executive Summary. Currently, evidence and agreement are used for the first two bold findings, while confidence and evidence are used for the rest. Assignments of evidence are generally paired with a level of agreement, which together may form the basis for a level of confidence. I suggest either moving to presentation of levels of confidence on their own (with the description of underlying evidence and agreement appearing in the corresponding chapter text), or presenting agreement/evidence assignments as a basis for confidence wherever possible (e.g., high confidence based on high agreement, medium evidence). Finally, to add a further consideration, likelihood language also appears in the nonbold text in some paragraphs, and it appears that in some cases the nature of the evidence assessed in the chapter (e.g., model projections) would provide a basis for findings to be assigned likelihood language (and thus ranges of probability of occurrence) in the context of providing information about the range of possible future outcomes. See specific comments on this point. We in the TSU are available to discuss all of these issues as well, if that would be of use. (Michael Mastrandrea, IPCC WGII TSU)	We revised executive summary including clear attention.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
90	54401	3	0	0	0	0	TRACEABLE ACCOUNTS: The author team has made a good start to providing traceable accounts for assessment findings and highlighting the location of those traceable accounts in the Executive Summary. There are some cases where improvements could be made, which I have included in comments associated with specific findings and chapter sections. In general, I would recommend the author team continue to strengthen the linkages between the Executive Summary findings and the corresponding chapter text. One approach would be providing some explanation of the calibrated uncertainty language used in the Executive Summary (with the adjustments suggested in my ES comment) in the corresponding chapter section(s) where the traceable account appears for each finding. For example, in situations where confidence in a finding is not high (or evidence is not robust), it would be useful to understand why the author team has made this judgment--what are the factors that limit confidence (or available evidence). In situations where confidence is high and/or where likelihood language is employed, what is the evidence that forms the basis for these assignments. Succinct descriptions in the chapter text of this type will both highlight the basis for ES findings and help explain the author team's assessment of the literature. We in the TSU are also available to discuss these issues if that would be of use. (Michael Mastrandrea, IPCC WGII TSU)	Calibrated language used when relevant.
91	54910	3	0	0	0	0	The author team should update the reference list and remove citation inconsistencies between in text citations and full citations given in the reference list. Please see supplementary document named WG2AR5-Chap3_Reference Checks.pdf at https://ipcc-wg2.gov/AR5/author/FOD/SuppMat (Monalisa Chatterjee, IPCC WGII TSU)	Thank you.
92	48966	3	1	1	11	33	As a general point, there are several instances where observed or projected changes (or lack of change) are quantified without giving a time period over which the change (or lack of change) was observed or projected. Such time periods should be included. (Richard Betts, Met Office Hadley Centre)	The omission of dates, as also the omission in some places of geograhical information, is dictated by the the pressure to reduce chapter length.
93	46399	3	1	6	1	12	The number of contributing authors is higher in some chapters. In this chapter it may result into insufficient coverage of literature from large regions (e.g. former Soviet Union, Indian subcontinent, South America, etc. …) which is published in reliable sources in local languages. This may particularly affect information on trends and specific regional climates and hydrological regimes. Such knowledge may not be publishable in high rated international journals or these are just not accessible to local authors, but it is essential for the credibility of the IPCC report. Wouldn't it be possible to include contributing authors from these areas to cover such information even at this late stage of work? (Jan Szolgay, Slovak University of Technology)	This comment seems reasonable until one considers the number of possible local languages. In chapter 3 we have coverage of most European languages, including Russian; Chinese; and Japanese. Our only major gap is in languages of the Indian subcontinent, but most colleagues in that region publish in English.
94	49030	3	2	16	2	16	Please replace "by changing river flows." with "not only by increased water temperatures but also by altered flow regimes, water levels and extent and timing of inundation." cut from page 29 line 39-40. (Oyvind Christophersen, Climate and Pollution Agency)	Will be done if space permits.
95	38237	3	2	26	2	30	Executive Summary. "Water quality changes have been linked to increases in temperature or pluvial precipitation ... However, it is still difficult to clearly link them to climate change due to several anthropogenic confounding factors. Despite this, projections under climate change scenarios show (…) that there is a risk of deterioration of water quality, notably impacting upon the cost of the safe supply of water for municipal purposes." My question is: Does this deterioration of water quality hold true at the regional scale? If so, could you compare the impact upon the cost of the safe supply of water for municipal purposes in wetter regions vs. drier regions? (Abdalah Mokssit, Direction de la Météorologie Nationale (DMN))	No I can´t. Because to reply this question there is need to have data for an specific location on the different composition of water pollution as contamination is site specific this should be done at least for each basin (dry or humid) and then estimate the treatment costs for the safe supply. The sum of al this would be the comparison you are requesting, but I am afraid there is no available data for such comparison.
96	50018	3	2	42	0	0	Executive Summary -- In subsequent work on the executive summary, there are several aspects of development for the author team to consider further: 1st, where a level of confidence is presented with a summary term for evidence, the author team should further consider providing a summary term for agreement. Alternatively, in some cases, for example where confidence is high and evidence is robust, it may be possible to present a level of confidence without also presenting the corresponding summary terms for evidence and agreement. 2nd, please note that the summary terms for evidence are limited, medium, and robust evidence. 3rd, throughout the executive summary, the author team may wish to enhance specificity, indicating further relevant complexities, such as where, when, why conclusions hold. (Katharine Mach, IPCC WGII TSU)	We revised executive summary including clear attention.
97	39044	3	2	42	3	30	I was a little confused at the difference between the formal, defined expressions of confidence (i.e. high confidence, medium confidence, etc) and undefined expressions of confidence, particularly in the Executive Summary. For example, on P3, line 10 it is stated that "mass loss will probably accelerate". The bold heading for this paragraph indicates high confidence. In contrast, on P3, line 22, it is stated that bioenergy crops "may have negative impacts", yet the bold heading also states high confidence. To my mind, "probably" indicates more confidence than "may have", but this sits at odds with the precisely defined "high confidence" for both of these statements. (Daniel Kingston, University of Otago)	Deleted "probably" at P3 L10.
98	40785	3	2	42	3	30	The executive summary deals with future changes only, with no mention of the present observations. No information on damage costing is given (Michel Petit, CGIET rue de Bercy)	Good point. We added present observations.
99	44587	3	2	42	3	30	A statement with regards to climate change adaptation and mitigation is missing in the Executive Summary. In order to adapt to climate change impacts, flexible, integrated, multi-sectoral solutions are needed. Both, climate change mitigation and adaptation are associated with costs, a major rethink in terms of governmental and govenance structures, and behavioral changes. (Martina Flörke, University of Kassel)	The ES now contains a subsection on adaptationa nd mitigation.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
100	46400	3	2	42	3	30	Few statements concerning expected changes in the Executive summary are too general and spatially not localized. A local administrator or decision maker may not be able to decide whether and how these concern his region (e.g. that models predict increases and decreases is too obvious, how may one decide if a region is wet, etc.). Wouldn't it be possible to include some geographical localization into messages which are important for adaptation into the ES? (Jan Szolgay, Slovak University of Technology)	Confidence about regional-scale assessments is typically less than at the drainage-basin scale of many published studies and the global or continental scales at which climate models yield larger samples with more degrees of freedom. Moreover, being regionally specific in a comprehensive way would require an amount of space that is not available in the Executive Summary.
101	48964	3	2	42	3	30	The Executive Summary focusses almost entirely on model projections of the future - it should include more on observations. (Richard Betts, Met Office Hadley Centre)	See annotation on comment #98
102	50019	3	2	44	2	47	It might be helpful for the reader to define "available water" slightly more, in the context of this finding. Additionally, if "likely" on line 47 is being used per the uncertainties guidance for authors (reflecting a probabilistic basis for its assignment), it should be italicized. Casual usage of this reserved likelihood term should be avoided. (Katharine Mach, IPCC WGII TSU)	The word has been deleted.
103	42381	3	2	44	2	48	Modify this paragraph to read as follows: "Climate models PROVIDE CONTRADICTORY RESULTS FOR available water at the regional scale, WITH SOME MODELS PROJECTING INCREASES WHERE OTHER MODELS PROJECT DECREASES (high agreement, robust evidence). Evapotranspiration SHOULD increase, and average annual runoff is generally projected to increase at high latitudes and in the wet tropics and to decrease in most dry tropical regions. Reliable surface water supply is likely to CHANGE because of CHANGES IN THE AMOUNT AND VARIABILITY OF PRECIPITATION, snow/ice storage and groundwater recharge, AND CHANGES of water quality." Rationale: For contradictory results from models, see IPCC AR4 WG1, Chapter 11, Third panel in Figures 11-2, 11-5, 11-9 and 11-12. For papers that indicate there may be increased water supply, see Arnell (2004), Oki and Kanae (2006), Alcamo et al. (2007), van Vuuren et al. (2011), Arnell et al. (2011), Goklany (2009a, 2009b, 2012a). (Indur Goklany, Independent)	The paragraph has been deleted.
104	39240	3	2	44	2	49	Something can be said on mid-latitudes ? (Eric Martin, Meteo-France)	The paragraph has been deleted.
105	43502	3	2	44	2	49	Within chapter 3, the authors note that evapotranspiration may not increase as plant stomata will remain closed for longer. The authors note on page 5, line 32 that the estimations of trends in global evapotranspiration are not compelling, so perhaps the statement on page 2, line 44 that 'Evapotranspiration will increase' is too strong. (Andrew Wade, University of Reading)	The paragraph has been deleted.
106	49815	3	2	44	2	49	There is no evidence .that precipiation is increadsing, or that it is more or less vigorous than usually takes place, or that it is influenced by greenhouse gase emissions. (Vincent Gray, Climate Consultant)	The paragraph has been deleted.
107	52823	3	2	44	2	49	The title is self explanatory. Rather, it is confusing. does not summarize the content of the envisaged changes. I see no coherent explanation thermal growth / evapotranspiration and runoff relationships. This report is adressed to very different readers. (Juan Jose Neiff, CONICET - UNIVERSIDAD NACIONAL DEL NORDESTE)	The paragraph has been deleted.
108	54365	3	2	44	2	49	This is an example where the specificity of the finding could be improved. Section 3.5.1 provides further relevant details, including some regional information about changes in availability, information about other drivers of change in availability, and information on avoided impacts, all of which might contribute to a more information-rich bold finding. In addition, regarding the traceable account for this finding, some of the sections currently cited cover relevant topics but do not seem directly linked to the finding (e.g., 3.4.4, 3.4.6, 3.4.7, 3.4.9, parts of 3.5), and the line of sight could be focused as the finding is revised to more clearly point readers to the most relevant sections. Also, the linkage to the discussion of changes in evapotranspiration could be improved, as the discussion in section 3.4.2 appears to be more nuanced than what is currently captured in this finding. There is also relevant discussion in section 3.2.2 (and some overlap between the discussions in these sections). (Michael Mastrandrea, IPCC WGII TSU)	The paragraph has been deleted.
109	37131	3	2	44	3	30	It would be more logical to order the sequence of bullet points in the 'Executive Summary' in rank order of 'confidence' (or alternatively by a qualitative judgement of the significance of the impact) (Stephen Darby, University of Southampton)	At present the logic of the ordering is that the paragraphs of the ES proceed from the physical science towards the human consequences.
110	36065	3	2	45	2	45	The statement 'Evapotranspiration will increase' in the Executive Summary (Page 2, line 45) is rather too generic and should be included only with its caveats, as has been done in Section 3.4.2 (which is also referred in the Executive Summary). This is particularly so since the authors mention that no physical explanation can yet be provided for the so-called 'evaporation paradox' (Page 5, line 40). The first paragraph of Executive Summary should also mention that there exist uncertainties associated with the projections. (Pradeep MUJUMDAR, Indian Institute of Science)	The paragraph has been deleted.
111	45928	3	2	45	2	45	"Evapotranspiration will increase …". In kumar et al. (c) [submitted Journal of Geophysical Research, Fig. 11] we show that global average land evapotranspiration does not increases with increasing temperature in RCP 8.5 scenarios; land evapotranspiration becomes limited by the available water (precipitation increase). Please consider revising this result. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	The paragraph has been deleted.
112	45929	3	2	51	2	52	"Wet region will get wetter and dry region will get drier". In kumar et al. (c) (submitted Journal of Geophysical Research) we found that " … despite increases in precipitation, the land surface transitions to a drier state (water-limited) in the 21st century." See Section 4.0 in the above referred paper. Further investigation is being carried out. Also, the result "Wet region will get wetter and dry region will get drier" is in contrast with the results on page 16, Line 22 -24 in this chapter; where authors (Serrat-Capdevila et al., 2011) conclude that increase in growing season length will lead to increased atmospheric demand and subsequently decrease in groundwater recharge and streamflow. Please consider revising this result in view of new findings. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	Clarified by adding "atmospheric": "The atmospheric water cycle is expected to … .". See annotation on comment #116.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
113	50020	3	2	51	2	52	The statement that "wet regions will get wetter and dry regions will get drier" is presented with a high degree of implied certainty, as a factual statement, yet this presentation seems somewhat at odds with the caveats raised in the 3rd sentence of the paragraph. The chapter team may wish to consider further qualification of the statement, reflecting more of the complexities referred to, as appropriate. (Katharine Mach, IPCC WGII TSU)	Substituted "are expected to" for "will". See annotation on comment #116.
114	42382	3	2	51	2	53	The first sentence seems to be contradicted by the last one. Modify this paragraph to read as follows: "ALTHOUGH the water cycle is PROJECTED to intensify (high agreement, medium evidence), that is, wet regions will get wetter and dry regions will get drier, THIS is at odds with EMPIRICAL evidence that land-surface evaporation and wind speed have been decreasing." See, e.g., Robock et al. (2005); Roderick and Farquhar (2002, 2004; 2005); Liu et al. (2004); Shenbin et al. (2006); Roderick et al. (2009a, 2009b); Hoffman et al. (2011); Jovanovic et al. (2008). (Indur Goklany, Independent)	We prefer the alterations in response to comments #112, #113 and #116 to that suggested here.
115	52824	3	2	51	2	53	This paragraph contains a hypothesis that is expressed as a statement. If it's just a guess, if not supported by scientific demonstration, convincing, I understand that it is best to avoid this comment. (Juan Jose Neiff, CONICET - UNIVERSIDAD NACIONAL DEL NORDESTE)	See annotations on comments #112 and #113.
116	54366	3	2	51	2	53	This is another example where the specificity of the finding could be improved. How has the water cycle intensified to date? In what ways is the water cycle expected to intensify in the future? What characteristics are projected to change and are there quantitative projections of the magnitude of these changes? Do projections provided the basis for quantifying the likelihood of different possible outcomes? In addition, regarding the traceable account for this finding, it appears that section 3.3.1.3 is meant instead of 3.3.1.2. Also, it would be very useful to explain further the interplay between the available (sometimes "puzzling") observational evidence (described in 3.2.2) and the physical understanding and model projections that lead to conclusions about future changes. (Michael Mastrandrea, IPCC WGII TSU)	These questions are too detailed to be addressed in the Executive Summary. However the second sentence now clarifies the meaning of "intensify": "That is, the quantity (precipitation minus evaporation) is expected to become more postive in wet regions and more negative in dry regions." Reference to 3.3.1.3 substituted for reference to 3.3.1.2. See annotations on comments #112 and #113.
117	49029	3	2	52	2	52	Consider to replace the phrase "is at odds" with language that are easier for the readers to understand. (Oyvind Christophersen, Climate and Pollution Agency)	Changed to "conflicts".
118	42383	3	3	1	0	0	Insert a new paragraph here that reads as follows: "Net global population at risk of water shortage is likely to decline due to climate change. Corollaries to this are that the net global population at risk would be higher under a low emission pathway and that a greater population would be at risk of water shortage under the 2 degree C scenario than a 4 degree C scenario." See Arnell (2004), Oki and Kanae (2006), Alcamo et al. (2007), van Vuuren et al. (2011), Arnell et al. (2011), Goklany (2009a, 2009b, 2012a). Their results are also consistent with the patterns from IPCC AR4 WG1, Chapter 11, Third panel in Figures 11-2, 11-5, 11-9 and 11-12, which indicate increased precipitation in the more heavily populated areas of the world (China, India and Southeast Asia). (Indur Goklany, Independent)	This very interesting claim will be considered in detail. On first inspection the maps cited from AR4 WG1 Ch11, and also Figures 11-15 and 11-17, constitute mixed rather than strong support for the claim. We have no means of tracing several of the suggested references.
119	52825	3	3	1	3	4	If we have no evidence, if we have no scientific proof ... better not to issue this risky comment (Juan Jose Neiff, CONICET - UNIVERSIDAD NACIONAL DEL NORDESTE)	We consider our calibrated language and traceable account (to 3.3.1.4) appropriate as it stands.
120	48965	3	3	1	3	5	The bullet point on intense precipitation should mention that, despite an observed intensification of heavy precipitation events, the reported increaese in flood disasters may be explained in terms of increasing exposure of people and economic assets [3.2.3] (page 7 lines 17-18) (Richard Betts, Met Office Hadley Centre)	Second sentence now ends "… anthropogenic, although their impacts are also magnified by increasing exposure of people and economic assets."
121	54367	3	3	1	3	5	These statements related to the frequency of intense precipitation events may also be a candidate where projections provide the basis for quantifying the likelihood of possible outcomes, in coordination with findings originating in relevant chapters of the Working Group I contribution. In terms of the statement on droughts, the discussion in the chapter text needs to be developed further to provide adequate support for this finding. In addition, the chapter text mentions projections of increased drought frequency for specific regions, not globally, and this is not communicated clearly in the Executive Summary text. (Michael Mastrandrea, IPCC WGII TSU)	We think that "regionally very variable" is a clear summary of the chapter text. Added 3.4.9 to the traceable account.
122	48967	3	3	2	3	2	"The observed intensification of heavy precipitation events" - over what period? (Richard Betts, Met Office Hadley Centre)	Added "in recent decades".
123	47163	3	3	2	3	3	The sentence can be confusing. The link between anthropogenic activities being the cause of 'heavy precipitation' needs to be better articulated. (Keith Nichols, Caribbean Community Climate Change Centre)	See annotation on comment #120. The sentence appears particularly clear to us, and we do not think extra detail would be appropriate for the Executive Summary.
124	35260	3	3	4	3	4	As I understand it the term drought here refers to meteorological drought. I therefore suggest to specify this. (Hege Hisdal, Norwegian Water Resources and Energy Directorate)	Done.
125	50021	3	3	4	3	4	The author team could consider specifying further how the simulations vary across specific regions. (Katharine Mach, IPCC WGII TSU)	The region-to-region variations suggest low confidence at least as much as real variability, and so we prefer not to highlight particular regions in the Executive Summary.
126	42384	3	3	6	0	0	Insert a new paragraph here that reads as follows: "Global population at risk of water shortage is substantialy more sensitive to socioeconomic factors (population and economic and agricultural development) than to climate change." See Arnell (2004), Alcamo et al. (2007), van Vuuren et al. (2011), Arnell et al. (2011), Goklany (2009a, 2009b, 2012a). (Indur Goklany, Independent)	This comparative assessment may or may not be correct, but in either case is more suitable for treatment in Ch19 (Emergent risks and key vulnerabilities) or perhaps Ch13 (Livelihoods and poverty). We have no means of tracing several of the suggested references.
127	42385	3	3	7	0	0	Insert a new paragraph that addresses global trends in socioeconomic impacts of droughts and floods. This should address not only economic losses but also deaths and death rates from such events. For global deaths and death rates it ought to note that they have declined by (a) 99.97% and 99.99% since the 1920s for drought and (b) 98.6% and 99.6% since the 1930s for floods (see Goklany 2009c, 2012a). This is based on data from the international disaster database (EM-DAT). (Indur Goklany, Independent)	The paragraph has change and now is referring only to general trends.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
128	37132	3	3	7	3	7	In some regions 'spring' has no real significance (e.g. tropical, high altitude, glaciers) (Stephen Darby, University of Southampton)	Deleted "peak meltwater flows coming earlier in spring and".
129	35427	3	3	7	3	12	This statement needs care and possible revision to be fully clear. If precipitation in a region does not change, the annual average river discharge will not change, whether or not the glaciers retreat. Yes, the fraction of flow that comes from MELTWATER runoff may change. But here the issue is about seasonality of discharge, especially in areas where summer rainfall is low. (David Vaughan, British Antarctic Survey)	Altered "yields" to "yield of stored glacier ice".
130	44199	3	3	7	3	12	The ExSum comments in WG should be cross checked with the respective findings and statements in WG1 SOD (Georg Kaser, University of Innsbruck)	We will collate the cryospheric parts of our assessment carefully with WG1 Ch04 (Cryosphere).
131	54369	3	3	7	3	12	It would be useful to consider refinements to the wording of the nonbold text here, as the corresponding chapter text provides more information about the timing of some of the changes described that currently is not captured here. Phrases such as "will probably accelerate" and the statements about snowfall and meltwater production do not give a sense of the magnitude of the described change, its timing, or whether these are global trends or trends with more regional patterns. In addition, the chapter text includes statements assigned calibrated uncertainty language that do not link to the Executive Summary text directly, and further harmonization would be useful. (Michael Mastrandrea, IPCC WGII TSU)	As at comment #116, we think that the balance between the short summary statement here and the detail available by tracing the traceable account is appropriate. In particular, if the ES were to echo all the calibrated language in the chapter text it would lose the character of a summary.
132	52830	3	3	9	0	0	at the end of the sentence I recommend to add ..response times <between decades and centuries> (Herbert Lang, ETH Zürich)	Altered "long response times" to "response times of decades to centuries".
133	52673	3	3	10	0	0	One climate change impact study to satisfy an UNFCC `s requirement has shown that El Niño processes increase snowfall on the Andes Cordillera, between 29º S and 40º S. Further, observations show that snowfall is increasing in the Antarctica, adversely impacting the Emperor penguin population because heavy snowing cover lying eggs impeding hatching. Severe population reduction has been reported. Warmer Antarctic Ocean feeds more absolute humidity into the atmosphere, increasing snowfall. Therefore, the paragraph should be amended. REFERENCE: Argentina´s First National Communication to UNFCC. (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	Altered "annual accumulation" to "and, in almost all regions, the annual accumulation". The cited reference is incomplete and not accessible to us.
134	52831	3	3	10	0	0	accelerate < prior to a decline >. (Herbert Lang, ETH Zürich)	Clarified the scope of the statement by altering "rate of actual mass loss" to "actual rate of mass loss per unit area of ice".
135	48968	3	3	10	3	10	"probably" - should this be given a calibrated likelihood estimate such as "likely", "very likely" etc? (Richard Betts, Met Office Hadley Centre)	Deleted "probably".
136	48969	3	3	10	3	11	Over what future time period are these changes expected? (Richard Betts, Met Office Hadley Centre)	The changes are expected over the entire period during which the temperature rises, or until sub-freezing temperatures are no longer experienced. We do not think it necessary to be explicit about this.
137	50022	3	3	10	3	11	Where the chapter team uses "will probably" and "will" on these lines, assignment of calibrated uncertainty language, to characterize the author team's degree of certainty in the statements, could be considered. (Katharine Mach, IPCC WGII TSU)	In using "will" without qualification, we are relying on advice from Mastrandrea et al. 2010, Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties, p2 point 5: "Consider that, in some cases, it may be appropriate to describe findings for which evidence and understanding are overwhelming as statements of fact without using uncertainty qualifiers."
138	48970	3	3	14	3	15	It should be pointed out in the Executive Summary that increasing CO2 concentrations also affect the hydrological cycle through its influence on plant transpiration as well as through climate change. (Richard Betts, Met Office Hadley Centre)	Agree. Executive summary was revised a lot.
139	52826	3	3	14	3	16	At least in Large rivers of America, there is no evidence or factual information showing that the natural variability of river flow was modified as a result of increased emissions. Nor was it shown the sensitivity of organisms to hydrological fluctuations. By contrast, some reports/articles(Neiff et al. (1985) and Casco et al. 2010) shows that forests are very tolerant river flow. Similar information were produced for the Amazon (Junk & Piedade) info variability. Neiff et al. (2009) showed that fish in the Paraná floodplain adjust their populations to hydrological variability. (Juan Jose Neiff, CONICET - UNIVERSIDAD NACIONAL DEL NORDESTE)	This part of the ES refers to future impacts.
140	43503	3	3	14	3	18	What evidence is there that climate change will have a greater impact on river flow than human withdrawls and dams? I can not see any presented in the chapter so far. (Andrew Wade, University of Reading)	Fig. 9, lines 22 ff, in section 3.5.5
141	54371	3	3	14	3	18	Here is an example where the bold finding could be more specific. The positive correlation between climate change and the magnitude of impacts is fairly clear, but can further insights be communicated? For example, what is the potential for avoiding impacts under lower emissions scenarios? What adaptation needs remain even under lower emissions scenarios? Regarding the traceable account for this finding, the rationale for the assignment of limited evidence is not clear, given the assignment of high confidence and the likelihood statements in the nonbold text (see also my general comment on evidence/agreement). In addition, while other likelihood statements appear in section 3.5.5, those mentioned here do not, and further harmonization would be useful. (Michael Mastrandrea, IPCC WGII TSU)	Modified in SOD.
142	41986	3	3	15	0	0	For consistency, the "confidence" factor should be presented before the "evidence" factor (Nathan L. Engle, 2011-2012 AAAS Science and Technology Policy Fellow)	accepted, and changed it.
143	37133	3	3	15	3	15	Reverse order of 'limited evidence, high confidence' for consistency with other bullets (Stephen Darby, University of Southampton)	accepted, and revised.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
144	50023	3	3	15	3	18	Several clarifications could be considered for these lines. 1st, where the chapter team says "changing river flow" on line 16, it could be beneficial to further specify the changes relevant. 2nd, is it possible to characterize the mentioned avoided damages and adaptation costs referred to on line 17-18? Finally, if "very likely" on line 15 and "likely" on line 16 are being used per the uncertainties guidance for authors (reflecting a probabilistic basis for their assignment), the terms should be italicized; casual usage of these reserved likelihood terms should be avoided. (Katharine Mach, IPCC WGII TSU)	Modified in SOD.
145	48971	3	3	16	3	18	Is climate change really likely to be stronger than direct anthropogenic influences? What about human influences on the Aral Sea - will anthropogenic climate change have such severe impacts? If so, over what time period? What about where human management has brought flow rates of major rivers under control, such as the Nile or Colorado? I am not convinced that the evidence supports this statement. Maybe the authors are referring to global scales rather than local scales - but even then I'm not sure that "likely" is appropriate. I'm not sure we'd have high enough confidence in the climate model projections underpinning the studies in Table 3-2 to warrant this likelihood statement. (Richard Betts, Met Office Hadley Centre)	Reference is to fractions of affected global land areas (Fig. 9, lines 22 ff, in section 3.5.5).
146	42386	3	3	17	3	18	Delete the sentence on this line. Rationale: see comments on page 3, lines 6 and 7. (Indur Goklany, Independent)	We do not agree.
147	48973	3	3	17	3	18	I don't think it is correct to say that "a low-emission pathway will avoid damage costs and costs of adaptation". Firstly, even a low-emission pathway such as RCP2.6 is projected to give some further warming, so presumably this implies that some damage costs and adaptation needs are probably unavoidable. Secondly, future damages and adaptation needs are not certain, although they are possible or even probable. I'd suggest re-wording this as "a low-emission pathway could reduce the likelihood of damage costs and the need for adaptation." (Richard Betts, Met Office Hadley Centre)	We agree with the suggestion for rewording.
148	48972	3	3	18	3	18	This bullet refers to section 3.4 and 3.5 as supporting evidence, but those sections are very large and it is hard to find the specific information relevant to this point. Specific sub-section numbers should be used. (Richard Betts, Met Office Hadley Centre)	We agree and consider if this is possible.
149	54373	3	3	20	3	24	Here is another example where further specificity in the finding would be helpful. Which approaches are meant in the bold finding? What types of negative effects from hydropower are meant? In which regions or under what conditions can afforestation reduce water resources? (Michael Mastrandrea, IPCC WGII TSU)	No space for further elaboration in ES but elaborated in section 3.7.2.1 to which referral has been made.
150	45930	3	3	21	3	24	Here all carbon emission reduction approaches: bio-energy, hydropower, and afforestation are shown to have negative impacts on water resources. Please also suggest some carbon emission reduction approaches, which will have positive impacts on water resources. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	will be reformulated to point out positive impact of decreased thermal power production and increased wind and solar power.
151	50024	3	3	22	3	22	It would be preferable to indicate more specifically the "negative effect" relevant here. (Katharine Mach, IPCC WGII TSU)	No space for further elaboration in ES but elaborated in section 3.7.2.1 to which referral has been made.
152	44642	3	3	22	3	23	see above in general comments about hydropowers (Sarka D. Blazkova, T.G. Masaryk Water Research Institute)	Where is comment?
153	48974	3	3	23	3	24	But afforestation (or avoided deforestation) may also be important for maintaining precipitation levels - a wealth of modelling studies suggest this, by authors such as Foley, Bonan, Lean, Nobre, Sampaio and many others (Richard Betts, Met Office Hadley Centre)	Discussed in cross-chapter box on active vegetation.
154	52832	3	3	24	0	0	.... water resources (3.7.2.1.) < however will reduce flood risks (Herbert Lang, ETH Zürich)	For SOD, the part of ES as well as section 3.7.2.1 was reformulated to show not only negative effects of mitigation measures but also positive ones. Positive impact on flood risk mentioned in section 3.7.2.1.
155	52833	3	3	26	0	0	.... temperature < and> / or pluvial precipitation (Herbert Lang, ETH Zürich)	Accepted. Please note that the whole text was restructured and shortened so this change although made may not appear on the final version.
156	49031	3	3	26	3	26	Replace the scientific term "pluvial" with easier to understand language (Oyvind Christophersen, Climate and Pollution Agency)	accepted, we do not use the term now.
157	54372	3	3	27	3	28	It would be useful to specify which confounding factors are meant. (Michael Mastrandrea, IPCC WGII TSU)	Accepted. Please note that the whole text was restructured and shortened so this change although made may not appear on the final version.
158	50025	3	3	28	3	29	The summary terms for evidence and agreement on these lines should be italicized. (Katharine Mach, IPCC WGII TSU)	accepted, and revised.
159	48071	3	3	33	0	0	It would be good to start this section by stating that water is a medium through which many impacts of climate change will be experienced, including in sectors well beyond 'freshwater resources' e.g. energy, agriculture and transport (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	noted and added.
160	49555	3	3	35	0	0	I do not think this sentence requires a citation. It is common sense! (Amithirigala Jayawardena, International Centre for Water Hazard and Risk Management (ICHARM))	Yes, but literarily quoted from the reference.
161	36021	3	3	35	3	40	This is one massive run-on sentence that rambles enough that it should be split into two or more ideas/sentences (Michael Brewer, NOAA)	accepted and revised.
162	50026	3	3	36	3	36	The author team may consider if "any" could be interpreted as overstated here--simply "changes" could be an option to consider. (Katharine Mach, IPCC WGII TSU)	accepted and revised.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
163	48975	3	3	36	3	38	The text says "any changes in the climate system and hydrological cycles… as illustrated in Figure 3-1". But despite the correct referral to "any changes" here, the current version of Figure 3-1 is rather over-simplified and only focusses on one particular aspect of changes in the climate system and hydrological cycles, namely anthropogenic radiative forcing by GHGs. A more comprehensive, full-system figure is needed here (I am pleased to see the authors' note that the figure will be newly-developed later, and would support a figure that includes other anthropogenic drivers of hydrological change such as land cover changes and plant physiological responses to changes in atmospheric composition, as well as natural variability) (Richard Betts, Met Office Hadley Centre)	accepted and revised.
164	42387	3	3	37	0	0	Substitute "change" for "increase". Rationale: In many places risks could be reduced. See, e.g., comments on page 3, line 1. (Indur Goklany, Independent)	accepted and revised.
165	48976	3	3	37	3	37	Changes in the climate system and hydrological cycles also have a potential to decrease the risks of water-related hazards. (Richard Betts, Met Office Hadley Centre)	accepted and revised.
166	48175	3	3	39	3	39	poor grammar: "in the way how to manage" (David Sauchyn, University of Regina)	accepted and revised.
167	45931	3	3	40	3	40	"…. water is a localized resource…". I think water is a regionalized/basin scale resources. Stream flow is the integrated response of basin scale hydrologic characteristics e.g. precipitation, evapotranspiration, and ground water recharge. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	accepted and revised.
168	37134	3	3	47	3	52	This passage of text does not include natural climate variability and other system changes (e.g. natural geomorphic changes) as one of the multiple additional stressors. In all cases the passage might be made more useful by including specific examples. (Stephen Darby, University of Southampton)	accepted, and revised the paragraph a lot.
169	36020	3	3	50	0	0	Change "options" to "lessons". We learn lessons. We have and create options. (Michael Brewer, NOAA)	noted and revised
170	52834	3	3	50	0	0	"…. in this sense, < some> adaptation options …" (Herbert Lang, ETH Zürich)	noted and revised
171	43577	3	3	50	3	52	The last sentence of this paragraph is vague and sweeping but not informative. Provide more detail or examples to indicate how overcoming previous water supply and quality issues will inform appropriate approaches to solving climate change water issues. Otherwise delete. (Cate Macinnis-Ng, University of Auckland)	noted and revised
172	47966	3	3	50	3	52	Ancient solutions to water crises may be of little value for the current globalised, economic crisis plagued world (Jaroslav Mysiak, Fondazione Eni Enrico Mattei; and Euro-Mediteranean Center for Climate Change)	noted and revised
173	48980	3	4	1	4	16	Are the conclusions of AR4 supported by the more recent SREX report? In at least one case (drought) I think the conclusions were different in SREX, ie: lower confidence on drought increases than AR4 (Richard Betts, Met Office Hadley Centre)	noted and revised
174	42389	3	4	3	0	0	Substitute "were" for "are". This ought to be in the past tense. (Indur Goklany, Independent)	accepted and revised.
175	49556	3	4	3	0	0	What is the quantification of 'very high confidence' or 'high confidence'? (Amithirigala Jayawardena, International Centre for Water Hazard and Risk Management (ICHARM))	please refer AR4.
176	37136	3	4	3	4	3	Whwen discussing/summarising the findings from AR4, care is needed with the selection of verb tenses. The use of 'are' here might be understood to mean that AR5 takes these findings still to stand (Stephen Darby, University of Southampton)	accepted and revised.
177	50027	3	4	3	4	3	As calibrated uncertainty language, "very high confidence" or "high confidence" should be italicized. (Katharine Mach, IPCC WGII TSU)	accepted and revised.
178	45932	3	4	5	4	5	"……, local increases or decreases ……"See my comment for chapter 3, page 2, line 40. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	yes, but precipitation and temperature are discussed here.
179	37137	3	4	8	4	10	This is a statement of process, not climate impact. Rephrase. (Stephen Darby, University of Southampton)	It is a quote from AR4.
180	42390	3	4	16	0	0	Please check if this statement is accurate. I don't recall this. Please provide precise reference. In any case, this statement would have been a stretch in 2007, considering Oki and Kanae (2006), Arnell (2004), and Alcamo et al. (2007). It would be an even greater stretch today considering that additional studies have indicated that climate change should reduce the net global population at risk of water shortage (Arnell et al. 2011; van Vuuren et al. 2011; Goklany 2009a, 2009b, 2012a). (Indur Goklany, Independent)	Yes. It is literalily from Executive summary of Chapter 3, WGII, AR4.
181	44588	3	4	16	0	0	Is this a general statement? (Martina Flörke, University of Kassel)	Yes. It is literalily from Executive summary of Chapter 3, WGII, AR4.
182	48979	3	4	16	4	16	Does this statement refer to past or projected future changes, or both? (Richard Betts, Met Office Hadley Centre)	Future.
183	41987	3	4	17	0	0	It might be more impactful if the authors explain what the AR5 adds to this AR4 'high-confidence list' so that the reader can quickly see what we have gained in understanding over the past 5 years. In this same spirit, update us on whether any of these AR4 conclusions have been made more or less robust over the past 5 years. (Nathan L. Engle, 2011-2012 AAAS Science and Technology Policy Fellow)	Yes, but ES in AR5 is not yet fixed. We'll follow your suggestion in the final phase.
184	42391	3	4	18	0	0	Insert "projected" before "future" so that readers may not misconstrue them to be predictions. (Indur Goklany, Independent)	accepted and revised.
185	52674	3	4	22	0	0	What it means "terrestrial water"? ¿ Is it the integration of surface and underground water? Clarification is needed. (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	All the water over land is called terrestrial water.
186	43174	3	4	23	4	23	The word "Sector" may be replace with "Sectors" (GHAZANFAR ALI, GLOBAL CHANGE IMPACT STUDIES CENTRE (GCISC))	We deleted this sentence.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
187	46010	3	4	35	0	0	Section 3.2: Regarding attribution, I don't know if WGI-AR5 report includes it, but it may be useful in this section to make reference to a study of extreme weather (Peterson et al., 2012) published in the Bulletin of the American Meteorological Society and commented in the NY Times (Gillis 2012). Six events from 2011 were studied and concluded that some of them could be attributed to global warming. For exampkle, they concluded that global warming made the severe heat wave that afflicted Texas last year 20 times as likely as it would have been in the 1960s. Also that the extremely warm temperatures in Britain last November were 62 times as likely because of global warming. However, they also concluded that the amount of rain falling in Thailand last year , while heavy, was not particularly unusual by historical standards, and that “climate change cannot be shown to have played any role in this event” (one of the most striking weather events of recent years). More important was farm fields given way to factories in the floodplains of major rivers. This is reported as the first time that individual extreme events are attributed to climate change and has been described as both exciting and controversial. (Luis E. Garcia, World Bank)	Each of the six studies forming part of Peterson et al. 2012 were considered as potential references for chapter 3, but none "made the cut". Pall et al. 2011 (Nature, 470, 382-385) was selected instead as a subject for more detailed assessment.
188	39337	3	4	35	11	30	Section 3.2 is focused on Detection and Attribution for observed changes in hydrological systems, such as precipitation, runoff and streamflow, groundwater, water quality, soil erosion and sediment load. It is seems that presentation in 3.2.7 and 3.2.8 is not related to the topics of 3.2. Meanwhile in the 3.2.1 there is lack of assessment of trends, detection and attribution of climate change on water use and availability and water management as human systems. Suggest: (1) to add some relevant content in the 3.2.1 and related material in 3.2.7 and 3.2.8 as well or (2) to delete 3.2.7 and 3.2.8 (3) to summarize and evaluate the knowledge and existed problems in the field of detection and attribution in hydrological systems introduced in 3.2.2; 3.2.3; 3.2.4; 3.2.5 and 3.2.6. (Liu Chunzhen, Ministry of Water Resources)	Impacts of climatic change on water use, water availability and water management are "mediated" through impacts on soil moisture, runoff, groundwater recharge, and so on. End-to-end attribution, from anthropogenic climatic change to hydrological impacts, is still uncommon in the literature, and the further step from hydrological impacts to impacts on human systems has yet to generate a significant amount of research.
189	46401	3	4	37	4	52	It also could be stressed, that despite of the very large number of papers dealing with trends, there is no consistent methodology and accepted hypothesis testing framework for trends attribution which would include evidence of consistency, evidence of inconsistency, and provision of confidence statement (Merz et al. (2012)). See in B. Merz, S. Vorogushyn, S. Uhlemann, J. Delgado, and Y. Hundecha: More efforts and scientific rigour are needed to attribute trends in flood time series. Hydrol. Earth Syst. Sci., 16, 1379-1387, 2012 doi:10.5194/hess-16-1379-2012 (Jan Szolgay, Slovak University of Technology)	Merz et al.recast the IPCC formulation of attribution in the context of flood frequency analysis. Interesting as it is, their work does not break fundamentally new ground, but we will try to emphasize the underdeveloped state of hydrological methods for the attribution of trends.
190	43374	3	4	39	0	0	Section 3.2.1: I think this paragraph provides a good overview, including some potential and limitations of the current state of detection and attribution (D&A) studies in hydrology. However, I'm not sure whether a main limitation lies in the insufficient integration of climate and hydrological (impact) models. In my understanding, hydrology is the field of impacts where this integration has been achieved best, as compared to other impact fields. Rather, I think that a main limitations stems from insufficient understanding of drivers or confounding factors that make it difficult to detect a climatic signal in a hydrological observation (especially due to other anthropogenic activities, such as land-use etc). Furthermore, I recommend to revise lines 39-42. Detection, as defined by the IPCC GPGP (Hegerl et al 2010), is 'only' the process of demonstrating that a system has changed in some defined statistical sense and does not necessarily need to show that (part of) the trend is not due to non-climatic anthropogenic changes. However, I recognize that there may be some need for clarification on that, on the level of the whole AR5, and suggest we'll have a cross-chapter discussion with chapter 18 (latest during LAM3). (Christian Huggel, University of Zurich)	The section has been revised and now conforms with the usage recommended by Hegerl et al. 2010.
191	50028	3	4	40	4	40	Does the author team here specifically mean "anthropogenic climate change"? (Katharine Mach, IPCC WGII TSU)	Inserted "anthropogenic" before "climate change".
192	48176	3	4	41	4	42	If natural variability of the water cycle is caused by natural climate variability, and climate varies systematically (quasi-periodic cycles), then why is the water cycle necessarily random? There consistent modes of variability in the water cycle; seasonal of course, but also related to ENSO for example. (David Sauchyn, University of Regina)	Altered to "random or quasiperiodic variability".
193	49557	3	4	48	0	0	This is true, but how does this statement compare with similar statements in IPCC AR4 ? (Amithirigala Jayawardena, International Centre for Water Hazard and Risk Management (ICHARM))	This does not seem to call for an alteration.
194	50029	3	4	49	4	49	It may be clearest to specify here what is meant by "the purpose" (presumably attribution to anthropogenic climate change). (Katharine Mach, IPCC WGII TSU)	Altered to "the purpose of attributing hydrologic impacts to anthropogenc climate change".
195	43375	3	4	50	4	50	Schiermeier is not a scientific paper (rather a report by a journal staff writer) and I do not recommend this citation therefore. (Christian Huggel, University of Zurich)	As noted in the text, Schiermeier is only a placeholder. It will be replaced.
196	48259	3	4	50	4	52	The sentence beginning with " In the meantime ", is slightly controversial (Malini Nair, Indian Institute of Science)	We do not agree.
197	42392	3	4	51	4	52	Please add that it should be noted that "to be consistent with climatic changes that are in turn attributable to anthropogenic or other forcing" is not the same as having actually attributed it to anthropogenic climate change. It should also be noted that not all anthropogenic climate change is due to emissions of well-mixed greenhouse gases (e.g., CO2, CH4, N2O). This could have policy implications. (Indur Goklany, Independent)	The suggested addition would be repetitive. That the two are not the same is implied by the structure of the sentence. We do not think this is the place for a remark along the lines of the second sentence of the comment.
198	47967	3	5	0	0	0	Table 3.1 and Figure 3.2 deserve a carefull revision. The impact of climate change detected with medium-confidence might be excluded fro the analysis as they may imply low confidence in attribution. (Jaroslav Mysiak, Fondazione Eni Enrico Mattei; and Euro-Mediteranean Center for Climate Change)	We are not sure what kind of revision is being suggested. Assigning different degrees of confidence to both detection and attribution is fundamental to the emerging science of "D and A".

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
199	43410	3	5	1	0	0	A seperate section on Mountains is recommended in Chapter 5 of the AR 5 as has also been duely recognized by Rio+20 outcome document. Mountains occupy 24% of the global land surface area and are home to 12% of the world's population. About 10% of the world's population depends directly on the use of mountain resources for their livelihoods and wellbeing, and an estimated 40% depends indirectly on them for water, hydroelectricity, timber, biodiversity and niche products, mineral resources, recreation, and flood control. In Asia, the Hindu Kush–Himalaya (HKH) range spans more than 4.3 million km2 having the most snow and ice outside of the polar regions. Ref: Schild, A and E, Sharma (2011) Sustainable Mountain Development Revisited. Mountain Research and Development, Vol 31, No 3. More reference for the climate vulnerabillity and adaptation on the Himalaya region needs to be cited. References are: 1) Bajracharya, SR; Shrestha, B (eds) (2011) The status of glaciers in the Hindu Kush-Himalayan region. Kathmandu: ICIMOD http://www.icimod.org/publications/index.php/search/publication/775. 2) Gurung, DR; Amarnath, G; Khun, SA; Shrestha, B; Kulkarni, AV (eds) (2011) Snow-cover mapping and monitoring in the Hindu Kush-Himalayas. Kathmandu: ICIMOD http://www.icimod.org/publications/index.php/search/publication/774. 3) Bolch, T., Kulkarni, A., Kaab, A., Huggel, C., Paul, F., Cogley, J.J.G., Frey, H., Kargel, J.S., Fujita, K., Scheel, M., Bajracharya, S. and Stoffel, M. (2012) The State and Fate of Himalayan Glaciers. Science Vol 336, 20 April 2012. 4) Tse-ring K; Sharma, E; Chettri, N; Shrestha, A (eds) (2010) Climate change vulnerability of mountain ecosystems in the Eastern Himalayas; Climate change impact an vulnerability in the Eastern Himalayas – Synthesis report. Kathmandu: ICIMOD. http://books.icimod.org/uploads/tmp/icimod-climate_change_vulnerability_of_mountain_ecosystems_in_the_eastern_himalayas.pdf (David Molden, International Centre for Integrated Mountain Development (ICIMOD))	This comment seems to be in the wrong place.
200	52827	3	5	12	6	25	The discussion relating to floods and droughts is correct. The writing is very honest and shows the impossibility of separating the effects of emissions, for those changes due to natural climate variability. (Juan Jose Neiff, CONICET - UNIVERSIDAD NACIONAL DEL NORDESTE)	Thank you. But this comment seems to be in the wrong place.
201	45973	3	5	15	0	0	Section 3.2.2. Changes in snow cover (as for example briefly discussed in Chapter 1, p.24, line 44-53) should be discussed here. The next section (3.2.3) appears to discuss snow cover only in relation to streamflow. (Rutger Dankers, Met Office Hadley Centre)	Inserted: Changes in snowfall are similarly contradictory as in precipitation, while changes in terms of the start and end of the snow melt season can be strongly linked to the atmospheric warming. Due to increases in warming, a shortening of the snowfall season is observed. This is underlined with the significant shortening and the continuous shift towards an earlier start and even earlier ending of the snow melt season which is observed for most parts of the Northern Hemisphere (Takala et al., 2009; Tedesco et al., 2009).
202	48177	3	5	15	6	15	This section seems to be catchall for all freshwater that is not either runoff or groundwater. Then why are snow and ice not included? Permafrost is frozen ground which may or may not contain water; therefore, ground ice the more appropriate terminology. (David Sauchyn, University of Regina)	We use the terms as given by WGI
203	39328	3	5	15	6	21	This section needs some rewriting to flow better and to pass whatever idea the authors intended to pass. It goes from theory to observations to expectations not fullfilled. I think it will be very confusing to the non-specialist. (Maria Assuncao Silva Dias, University of Sao Paulo)	Revisions and a shortening of the texts are envisaged, but I guess most non-specialists won't read it anyway.
204	47245	3	5	15	7	10	The lack of reference to loss of tropical glaciers in the Andes and the implications for human populations in the highlands, for development prospects due water stress and lost development opportunities (tourism, for example),is an unfortunate oversight in this chapter, particularly considering the vast literature documenting the lost of glaciers, like Chacaltaya in Bolivia. This needs to be urgently addressed for the next draft of this chapter. Someacademic references to consider- Ramírez, Edson; Francou, Bernard; Ribstein, Pierre; Descloitres, Marc; Guérin, Roger; Mendoza, Javier; Gallaire, Robert; Pouyaud, Bernard; Jordan, Ekkehard. Small glaciers disappearing in the tropical Andes: a case-study in Bolivia: Glaciar Chacaltaya (16° S). Journal of Glaciology, Volume 47, Number 157, March 2001 , pp. 187-194(8) or Tropical climate change recorded by a glacier in the central ... (n.d.). Retrieved from http://www.ibcperu.org/doc/isis/7078.pdf (Juan Hoffmaister, Third World Network)	Inserted in text: Almost all small tropical glaciers in the Andes are shrinking at serious rates since the 1980s (Ramirez et al., 2001).
205	50030	3	5	16	0	0	Section 3.2.2. For material in this section, the author team may wish to further consider and cross-reference findings from the working group 1 contribution to the 5th assessment report. Additionally, the chapter team may also consider cross-references to the special report on extremes. (Katharine Mach, IPCC WGII TSU)	some cross-references have been added.
206	49558	3	5	17	0	0	If global trends cannot be determined, what is the justification for substantiating global warming? (Amithirigala Jayawardena, International Centre for Water Hazard and Risk Management (ICHARM))	Global trends cannot be determined, but regional trends and tendencies can!!! These can further be attributed to changes in atmospheric circulation, and hence to regional warming.
207	49559	3	5	17	0	0	Contradictory views! (Amithirigala Jayawardena, International Centre for Water Hazard and Risk Management (ICHARM))	See response to #206.
208	39345	3	5	17	5	18	This is a poorly worded sentence. Are you suggesting models capture all observed variability, if so that is incorrect. e.g. models possibly underestimate anthropogenic contribution Zhang et al Nature 2007 (Gareth S Jones, Met Office)	text revised
209	45933	3	5	17	5	20	I think changes in only regional precipitation has been observed. Global average land precipitation trend, during 20th century, is insignificant in both models and observation (see Kumar et al. (b) submitted to Journal of Climate). Reference is provided in separate pdf sheet. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	accepted, but we cannot cite this reference due to lack of space.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
210	46402	3	5	17	10	13	Although it is almost impossible, very time consuming and tiresome to prepare a good global overview on observed changes with respect to all variables tackled in the report, some additional effort would be probably useful here to give more consistent messages based on literature on various regions of the world. In the evaluation the spatial scales of the analyzed phenomena should be more consistently recognized and their territorial/regional representativeness evaluated. This part of the report may be considered as crucial, since with the growing number and length of series quite a number of studies were published in the literature, which would deserve thorough evaluation foer signals. Moreover information published in reliable sources in local languages on trends and specific regional climates and hydrological regimes is not covered in the report so far, therefore I would recommend to attempt to extend the coverage at least from international sources. This problem could be also solved by taking abroad contributing authors with regional responsibility – e.g. for former Soviet Union, India etc.. I came across a number of studies not listed in the literature of the Chapter, which could contribute to messages in this subchapter. For the case they have not been used for the conclusions here, I include a few references: China: Hydrol. Process. 26, 1050–1061 (2012), DOI: 10.1002/hyp.8180 Hydrol. Process. 26, 2294–2306 (2012), DOI: 10.1002/hyp.8348 Water Resour Manage (2011) 25:677–689, DOI 10.1007/s11269-010 9720-y Water Resour Manage (2011) 25:677–689, DOI 10.1007/s11269-010-9720-y Journal of Hydrology 388 (2010) 350–356 Hydrol. Process. 23, 2045–2055 (2009), DOI: 10.1002/hyp.7334 Journal of Hydrology (2008) 353, 215– 227 India Int. J. Climatol. (2012), DOI: 10.1002/joc.3483 Iran DESERT, Online at http://jdesert.ut.ac.ir, DESERT 16 (2011) 49-60 Water Resources Management , Volume 26, Number 8 (2012), 2219-2232, DOI: 10.1007/s11269-012-0011-7 Australia Hydrol. Process. 25, 1659–1675 (2011), DOI: 10.1002/hyp.7928 Mediterranean: Int. J. Climatol. 32: 1537–1557 (2012) DOI: 10.1002/joc.2372, Hydrol. Earth Syst. Sci. Discuss., 9, 6689–6713, 2012 , doi:10.5194/hessd-9-6689-2012, Int. J. Climatol. 32: 900–919 (2012)DOI: 10.1002/joc.2313, Int. J. Climatol. (2012) DOI: 10.1002/joc.3549 Int. J. Climatol. 32: 1310–1325 (2012), DOI: 10.1002/joc.2353 Europe: Int. J. Climatol. 32: 1295–1309 (2012), DOI: 10.1002/joc.2351 Int. J. Climatol. (2012) DOI: 10.1002/joc.3542 Journal of Hydrology 388 (2010) 131–143 Journal of Hydrology (2008) 361, 227– 239 Int. J. Climatol. 29: 1369–1380 (2009), DOI: 10.1002/joc.1781 Int. J. Climatol. 29: 1294–1311 (2009), DOI: 10.1002/joc.1777 Int. J. Climatol. (2008), DOI: 10.1002/joc.1784 Argentina Int. J. Climatol. (2012), DOI: 10.1002/joc.3541 USA Journal of the American Water Resources Association, (JAWRA) 1-11. DOI: 10.1111/j.1752-1688.2011.00535.x Journal of Hydrology 452–453 (2012) 259–281 (Jan Szolgay, Slovak University of Technology)	We agree, hence some regional changes have been included, but the text is already too long and needs shortening, rather than enlarging it with more example regions…
211	50031	3	5	19	5	19	Where the author team states that "global trends cannot be determined," it is not completely clear how global-level findings, for example pertaining to extremes of precipitation, compare. Does the chapter team here mean that not all changes are happening in the same direction on a global basis? (Katharine Mach, IPCC WGII TSU)	text revised
212	48981	3	5	20	5	21	I don't think that the use of "found" is appropriate here, as Gosling et al (2011) is a modelling study of future projections. "Found" implies a real observation. I think "projected" or "simulated" would be more accurate. (Richard Betts, Met Office Hadley Centre)	changed to: "projected"
213	39045	3	5	20	5	22	Gosling et al (2011, HESS) used pattern scaled scenarios: this means that year 2100 projections of precipitation were scaled back to the present day as a direct funtion of changing global mean temperature - so the methods used pre-determined that there would be an increasing magnitude of change in precipitation through the 21st century. See Todd et al 2011, Uncertainty in climate change impacts on basin-scale freshwater resources – preface to the special issue: the QUEST-GSI methodology and synthesis of results, Hydrology and Earth System Sciences, 15, 1035-1046, for a descrption of the scenario generation method used by Gosling et al. 2011. (Daniel Kingston, University of Otago)	noted, but not changed
214	50032	3	5	24	5	24	For this statement in particular, the chapter team could cross-reference the findings of the special report on extremes and of the working group 1 contribution to the 5th assessment report. (Katharine Mach, IPCC WGII TSU)	accepted, and we cite the chapter in WG1 in this section.
215	46895	3	5	24	5	26	Could also add the example of Ethiopia: "Spring and summer rains in parts of Ethiopia have declined by 15-20% since the mid-1970s." ("A Climate Trend Analysis of Ethiopia" (2012), Chris Funk et al, FEWSNET/USAID) (Katy Yan, International Rivers)	included (might be shortened/deleted due to text space requirements!)
216	45934	3	5	26	5	26	Also mention about increasing precipitation trend in certain areas e.g. eastern United States (Kumar et al., 2009; Kumar et al. (b) submitted to Journal of Climate). Reference is provided in separate pdf sheet. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	I didn't consider the references because we already have enough on precipitation and no more space available in the paragraph.
217	37138	3	5	28	4	30	Too brief, needs expansion (Stephen Darby, University of Southampton)	I think it's enough considering the other factors.
218	39346	3	5	28	5	30	Why does an increase in water holding capacity lead to more drought events? (Gareth S Jones, Met Office)	according to Kundzewicz et al. (2007)
219	45935	3	5	28	5	30	Please see my comment on Chapter 3, Page 2, Line 45, and Line 51. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	I didn't consider the references because we already have enough on precipitation and no more space available in the paragraph.
220	49032	3	5	30	5	30	Change order of the two references (Oyvind Christophersen, Climate and Pollution Agency)	changed order of them
221	50033	3	5	33	5	34	For these statements, the chapter team could consider using calibrated uncertainty language per the guidance for authors to characterize the uncertainties and the available literature. (Katharine Mach, IPCC WGII TSU)	text revised
222	48982	3	5	36	5	38	I believe changes in anthropogenic aerosol concentrations were also suggested as playing some role in changes in evaporation, eg: Roderick and Farquhar 2002/2003? (Richard Betts, Met Office Hadley Centre)	yes, due to the scattering of light. we added the information
223	37139	3	5	38	4	38	past 50 years' - be absolutely specific about the period that this 'the past 50 years' refers to (means 1962-2012 at time of reviewing) (Stephen Darby, University of Southampton)	changed accordingly
224	42483	3	5	39	9	40	Good points. However, some crop models such as APSIM can handle change in the management strategies. Nonetheless, solid socio-economic data would necessary to model behavioural changes in more integrated crop models (Shahbaz Mushtaq, University of Southern Queensland)	accepted, but we deleted the sentence.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
225	45936	3	5	40	5	40	What is “evaporation paradox”? Please explain. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	brief definition is now included
226	44638	3	5	41	0	0	Please explain the "evaporation paradox" in more detail. (Martina Flörke, University of Kassel)	brief definition is now included
227	39046	3	5	41	5	41	McVicar et al (2012) is missing from the reference list (Daniel Kingston, University of Otago)	accepted and added it
228	50034	3	5	41	5	41	It would be helpful to further clarify what is meant by "evaporation paradox"--the previously discussed trends from the 1980s to the present? (Katharine Mach, IPCC WGII TSU)	see #225/226
229	37140	3	5	42	4	44	Add details of the specific dates that the reviewed trends refer to (Stephen Darby, University of Southampton)	added: 1950-2000
230	50035	3	5	45	5	45	Where the author team uses the word "attributable," has attribution occurred in a formal sense? If not, it may be preferable to use an alternative word. (Katharine Mach, IPCC WGII TSU)	changed to "linked"
231	37141	3	5	46	4	46	Sentence does not make sense (Stephen Darby, University of Southampton)	The sentence was deleted.
232	40685	3	5	46	6	2	Droughts events (and especially soil moisture drought events) develop slowly in time (and space), therefore any trend analysis should be performed on very long time series. Consequently, the 57 year period used by Wang et al. (2011) seems a rather short period for drought trend analysis (Vidal et al., 2010). Vidal, J.-P., Martin, E., Franchistéguy, L., Habets, F., Soubeyroux, J.-M., Blanchard, M. & Baillon, M. (2010) Multilevel and multiscale drought reanalysis over France with the Safran-Isba-Modcou hydrometeorological suite. Hydrology and Earth System Sciences, 14(3), 459-478. doi: 10.5194/hess-14-459-2010 Wang, A., Lettenmaier, D. P. & Sheffield, J. (2011) Soil moisture drought in China, 1950-2006. Journal of Climate, 24(13), 3257-3271. doi: 10.1175/2011JCLI3733.1 (Jean-Philippe Vidal, Irstea)	this is correct, but the results by Wang et al (2011) fit good in the context of the text .
233	37142	3	5	48	4	50	Common approaches to simulate...' BUT remote sensing is not a simulation tool, and PDSI is likewise just a metric. Needs rephrasing (Stephen Darby, University of Southampton)	revised: we changed simulate to "determine"
234	37143	3	5	52	4	52	where a trend to more severe..' (not replacing 'the' with 'a') In any event this is too vague. Give specific details of the trend (Stephen Darby, University of Southampton)	revised to: "more severe soil moisture droughts (in duration, severity and frequency) has been experienced at 37% of the land area "
235	37144	3	6	1	6	1	Replace 'hot' with 'temperature' (Stephen Darby, University of Southampton)	The sentence was deleted.
236	37145	3	6	4	6	4	Is the word 'steadily' really meant here? It seems most unlikely to me that this is the case - is the loss in fact occurring at a constant rate or not? (Stephen Darby, University of Southampton)	changed to: at constant or increasing rates
237	48983	3	6	4	6	4	Does this mean *all* glaciers, or most, or some? How well-observed are glaciers at the global scale - what proportion are monitored? Are any gaining mass? (Richard Betts, Met Office Hadley Centre)	revised to: "many"
238	43376	3	6	4	6	9	I recommend revision of this paragraph of cryosphere changes. It looks like written in a hurry and has not a clear focus, and not a clear structure. As a suggestion, observed changes across different cryosphere components could be mentioned, followed by a statement on D&A. If a specific example/region is highlighted (in this case southern South America) it should be clear why this example is chosen. Furtermore, in line 6, I recommend to be specific about the type of external forcing (anthropogenic?). (Christian Huggel, University of Zurich)	revised the paragraph a lot.
239	49033	3	6	4	6	9	Please consider to include a sentence about how glacier melting is dependent upon elevation, and how this affects the dynamics of the glacier as an entity. (Oyvind Christophersen, Climate and Pollution Agency)	included it
240	39310	3	6	4	6	12	This section must be improved (as noted already in the text). Continental ice sheets and glaciers should be clearly discriminated (their role in the climate system is different). The formation of new lakes in high-mountain regions should be mentionned as an important impact of atmospüheric warmin and glacier retreat. An important reference would be: Frey, H., Haeberli, W., Linsbauer, A., Huggel, C. and Paul, F. (2010): A multi level strategy for anticipating future glacier lake formation and associated hazard potentials. Natural Hazards and Earth System Science 10, 339-352. The connection between active-layer depth and soil humidity in permafrost areas (Tibet!) or permafrost degradation and the stability of steep slopes should be mentionned. UNEP (2007; see general comment on chapter 3) provides important information. Recent overviews on permafrost in high mountains are: (a) Haeberli, W., Noetzli, J., Arenson, L., Delaloye, R., Gärtner-Roer, I., Gruber, S., Isaksen, K., Kneisel, C., Krautblatter, M. and Phillips, M. (2011): Mountain permafrost: Development and challenges of a young research field. Journal of Glaciology 56 (200; special issue), 1043-1058. (b) Harris, C., Arenson, L.U., Christiansen, H.H., Etzelmüller, B., Frauenfelder, R., Gruber, S., Haeberli, W., Hauck, C., Hoelzle, M., Humlum, O., Isaksen, K., Kääb, A., Kern-Lütschg. M.A., Lehning, M., Matsuoka, N., Murton, J.B., Nötzli, J., Phillips, M., Ross, N., Seppälä, M., Springman, S.M. and Vonder Mühll, D. (2009): Permafrost and climate in Europe: Monitoring and modelling thermal, geomorphological and geotechnical responses. Earth-Science Reviews 92, 117-171. (Wilfried Haeberli, University of Zurich)	partly included
241	37146	3	6	5	6	5	Term 'substantial' is too vague. Define. (Stephen Darby, University of Southampton)	The paragraph was revised a lot.
242	52471	3	6	5	6	5	the statement "very likely" here could do with qualification (e.g. as shown by a number of studies in the WG1 report"; as written it looks like it is attributed to one paper although this is in fact the WG1 report. (Peter Falloon, Met Office Hadley Centre)	The paragraph was revised a lot.
243	35428	3	6	6	0	0	Please reference WGI Ch4, and probably not Comiso, 2013! (David Vaughan, British Antarctic Survey)	Accepted and changed.
244	48178	3	6	6	6	6	Indicate that these trends are declining. (David Sauchyn, University of Regina)	included
245	48984	3	6	6	6	7	Why is Arctic sea ice relevant to this chapter? Is it a fresh water resource? (Richard Betts, Met Office Hadley Centre)	section has been revised
246	40301	3	6	7	6	7	Update: J J Day, J C Hargreaves, J D Annan and A Abe-Ouchi 2012 Sources of multi-decadal variability in Arctic sea ice extent Environ. Res. Lett. 7 034011 (doi:10.1088/1748-9326/7/3/034011) (John Sweeney, National University of Ireland Maynooth)	not included

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
247	52835	3	6	8	0	0	....- margin- should be substituted by < length and area > (Herbert Lang, ETH Zürich)	changed accordingly
248	43228	3	6	11	0	0	Text related to 'permafrost' should appear before text related to Glacier changes (Muhammad Zia ur Rahman Hashmi, Global Change Impact Studies Centre)	agreed, we moved the section
249	47971	3	6	11	0	0	It is estimated that there are more than 2000 million hectares of permafrost in the planet, which store approximately 450000 and 70000 millions of tons of carbon and methane, respectively. The release of this amount of organic material will produce gases concentrations large enough to spark an unprecedented chain reaction (Mernia 2008). These processes are not well represented in the global climate models and their effects could not be included in the projections of future climates. Thresholds for irreversible climate change could be reached earlier than projected. (Sergio Castellari, Centro Euro-Mediterraneo sui Cambiamenti Climatici)	partly integrated
250	52675	3	6	11	0	0	Although the impact of the Andean permafrost melting is by far less important than that of the larger permafrost areas in the Northern Hemisphere, more information is needed (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	partly integrated
251	52836	3	6	11	0	0	Much work on permafrost has been performed in Switzerland by W.Haeberli et al ! (Herbert Lang, ETH Zürich)	changed as see above
252	48179	3	6	11	6	11	This one short sentence is a seriously inadequate review of climate change impacts on permafrost. Despite rapid changes in the Andes, alpine permafrost is a very small fraction of the earth's permanently frozen ground. Most of it is in the circumpolar region of the North Hemisphere where degradation of permafrost in response to global warming is extensive and well documented. (David Sauchyn, University of Regina)	changed as see above
253	45972	3	6	11	6	12	Chapter 1, page 24, line 44-53 discusses observations on permafrost/frozen ground and refers to [WGI-4]. Please ensure consistency (Rutger Dankers, Met Office Hadley Centre)	not done yet
254	52837	3	6	14	0	0	This part on precipitation seems to me quite weak and needs complete revision, preferably based on WG I report (Herbert Lang, ETH Zürich)	We revised the paragraph a lot.
255	36070	3	6	14	6	14	The statement 'Changes in precipitation are attributed mainly to warming of the atmosphere which causes changes in circulation characteristics' is rather generic. Following this, precipitation would have only increased (since warming is consistent and temperatures are reported to be only increasing) forcing streamflow to increase everywhere as well (except in cases where evapotranspiration also increases, in which case streamflow may remain unchanged). However, precipitation, both at global and regional scales, show a lot more variability and no generic conclusion can be made about changes or trends in precipitation. Similarly, which some rivers report increasing flows, others have decreasing trends in flows (Page 6, Section 3.2.3). This needs to be discussed here. (Pradeep MUJUMDAR, Indian Institute of Science)	partly included, text revised
256	39347	3	6	14	6	15	This is too simplistic it implies that the attribution of observed precipitation changes is mostly to any global warming. Lambert 2004 suggested that shortwave heating has a bigger influence than longwave heating on precipitation due to radiative effects and not "changes in circulation". (Gareth S Jones, Met Office)	partly included, text revised
257	36069	3	6	14	6	21	In the context of precipitation, detection of volcanic influence in global precipitation has also been formally established (Gillett, N. P., A. J. Weaver, F. W. Zwiers, and M. F. Wehner (2004), Detection of volcanic influence on global precipitation, Geophys. Res. Lett., 31, L12217, doi:10.1029/2004GL020044) – this can be cited. Also, other than just whether anthropogenic forcing has contributed to changes in precipitation, it needs to be mentioned whether the model-predicted signals over or underestimate the observed precipitation changes, and to quantify the anthropogenic contributions. (Pradeep MUJUMDAR, Indian Institute of Science)	noted, it is partly mentioned in the text
258	43229	3	6	14	6	21	whole paragraph related to attribution of precipitation changes may be moved to page 5 at line 27 (Muhammad Zia ur Rahman Hashmi, Global Change Impact Studies Centre)	we moved this section up
259	44883	3	6	14	6	21	This block is confusing. What is the main statement? Warming of the atmosphere causes changes in circulation and that way changes in precipitation. On the other hand, changes in precipitation affect also the energy budget of the atmosphere and thereby atmospheric dynamics. And why should precipitation react only to sulfate aerosol particles? I agree that anthropogenic aerosol particles affect precipitation stronger than black carbon or greenhouse gases, but it is not only sulfate aerosol particles. Any anthropogenic particles that can act as CCN can affect precipitation, even if it doesn't contain any sulfate! Zhang et al. 2007 finds obviously something different than anybody else. What makes their study so different? (Sabine Wurzler, LANUV NRW)	partially revised

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
260	46403	3	6	14	6	21	This paragraph may be moved to page 5 line 27 in order to have precipitation at one place in this subchapter. A few lines on precipitation extremes could also be added to it, since these are of special interest with respect to floods. The relationship between seasonal precipitation changes and changes in atmospheric circulation may also be of interest to be touched. The spatial representativeness of the conclusions taken form studies cited in this paragraphs would also deserve a comment. Kysely (2008)(Int. J. Climatol. (2008), DOI: 10.1002/joc.1784) discussed in these respects trends in multiple characteristics of heavy precipitation over the area of the Czech Republic. His analysis partly supported an emerging global picture of prevailing positive trends in precipitation extremes over the mid-latitudinal land areas of the Northern Hemisphere in winter. However he pointed out, that the cut-off between the western and eastern parts of the Czech Republic in many precipitation characteristics, including the trends in wintertime indices of precipitation extremes, may indicate that the pattern of changes is more complex and less coherent in eastern than in western Europe. Therefore he also concluded, that the differences between winter and summer on the one hand and the transition seasons on the other highlight the need for involving spring and autumn into studies of temporal changes of climatic variables, to avoid simplified views. He has also shown that trends in heavy precipitation at Prague-Klementinum, the most frequently analysed long-term station in the Czech Republic [and the only one available in continental-scale analyses within the European Climate Assessment (ECA) project and related activities], are particularly unrepresentative for a wider area. (Jan Szolgay, Slovak University of Technology)	we moved this section up, the rest is noted.
261	48180	3	6	15	6	16	Delete “it is found that” (David Sauchyn, University of Regina)	accepted and deleted
262	46011	3	6	15	6	21	This paragraph seems to include some contradictions and may be confusing. Perhaps it could be clarified? (Luis E. Garcia, World Bank)	see above
263	37329	3	6	17	0	21	Here you mentioned two opposite conclusions on global mean precipitation. I would suggest indicating the relative confidence of each of study so that readers can understand relative significance of these conclusions. (So Kazama, Tohoku University)	partially revised
264	37147	3	6	17	6	18	Avoid qualitative terminology ('most'; 'small'; etc) (Stephen Darby, University of Southampton)	We deleted this sentence.
265	39047	3	6	17	6	18	but there will be large scales in regional-to-local precipitation (e.g. Gosling et al. 2011, HESS) (Daniel Kingston, University of Otago)	changed accordingly
266	45937	3	6	17	6	18	“Most climate models.. a small increase in global mean precipitation”. During 20th century global mean precipitation trend is insignificant, most CMIP5 climate models show a slightly negative global mean precipitation trend (Kumar et al. (b) submitted to Journal of Climate). Reference is provided in separate pdf sheet. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	partially revised
267	39348	3	6	18	6	21	Should mention that Zhang 2007 suggests that the models substantially underestimate observed trends. (Gareth S Jones, Met Office)	included
268	50036	3	6	19	6	21	It would be helpful to specify the timeframe relevant to the statement. (Katharine Mach, IPCC WGII TSU)	included
269	50037	3	6	24	0	0	Section 3.2.3. For material in this section, the author team may wish to further consider and cross-reference findings from the working group 1 contribution to the 5th assessment report. Additionally, the chapter team may also consider cross-references to the special report on extremes. (Katharine Mach, IPCC WGII TSU)	Both being considered.
270	48985	3	6	26	6	42	Over what time period(s) were these changes seen? (Richard Betts, Met Office Hadley Centre)	Periods covered by each work added.
271	40686	3	6	26	6	51	Giuntoli et al. (2012) performed a trend analysis on streamflow in France, based on a benchmark network of 220 stations over the period 1968-2008. They found a significant decrease of mean and low flow in the South of the country. However, such a trend is not robust when looking at different periods (1948-1988 and 1948-2008) for a subset of long time series, unlike the correlation with large-scale climate indices (NAO, AMO and weather types). Giuntoli, I., Renard, B., Vidal, J.-P., Bard, A. (2012) Low flows in France and their relationships with large scale climate indices. Journal of Hydrology, submitted. (Jean-Philippe Vidal, Irstea)	Only those records with clear climate change link were collected and cited.
272	45938	3	6	26	6	51	Effect of land use/cover change on stream-flow is not adequately presented. For example: Zhang and Schilling (2006) have attributed increase in low flows in the Mississippi river basin to the land use change (Agricultural expansion; also see Kumar et al., 2009). Yang et al. (2009) have presented effect of Urbanization on the urban runoff. Reference is provided in separate pdf sheet. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	Zhang and Schilling 2006 added and the problem on land use was further developed in the text.
273	52472	3	6	26	6	51	in this section, please make it clear (if possible) which studies looking at streamflow trends included, or separated out human modified vs "unmodified" basins. Clearly the impacts (and drivers of change) could be very different. If this is not possible, then please add a statement to say the studies include both types of basin. (Peter Falloon, Met Office Hadley Centre)	The distintion was improved and cited in each case.
274	50038	3	6	29	6	51	The author team may wish to specify further the time frames relevant to some of the examples provided in this passage, for example on line 29, lines 33-38, and lines 49-51. Additionally, if "more likely than not" is being used as calibrated uncertainty language (reflecting a probabilistic basis for its assignment), it should be italicized; casual usage of the term should be avoided. (Katharine Mach, IPCC WGII TSU)	Time frames of stream records were added.
275	36071	3	6	30	6	40	These lines merely mention about hydrological trends in runoff in some important rivers across the world. However, whether such trends are indeed because of human-induced greenhouse gas emissions and anthropogenic climate change, and how much is the contribution of human-induced climate change to the hydrological trends needs to be determined. As the authors mention (Section 3.2.1) - ‘a documented hydrological trend, however, is not necessarily a detected impact of climate change’. (Pradeep MUJUMDAR, Indian Institute of Science)	This was addressed in the new text.
276	37148	3	6	35	6	36	Annual and seasonal timescales referred to in same sentence. Confusing. (Stephen Darby, University of Southampton)	Changed the sentence

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
277	44589	3	6	36	0	0	Additional statistical analyses focussing on the USA which should be mentioned here: Hirsch, R.M., and Ryberg, K.R. 2012: Has the magnitude of floods across the USA changed with global CO2 levels? Hydrological Sciences Journal, v. 57, no, 1, p. 1-9. (Martina Flörke, University of Kassel)	Thanks, but due to lack of space we can not cite it.
278	36072	3	6	42	6	42	'Decreases in river discharge may be argued to have a strong human influence whereas increases in annual streamflow are more likely than not dominated by climate'. What is meant by 'human influence' and 'climate' respectively is not clear. Also, what is the physical explanation behind this statement? (Pradeep MUJUMDAR, Indian Institute of Science)	This was changed.
279	52838	3	6	43	0	0	" ..... human influence < by irrigation > ...." (Herbert Lang, ETH Zürich)	It was precised in the new text.
280	48181	3	6	46	6	46	the wording should be "and even suppressed" (David Sauchyn, University of Regina)	Changed and revised it
281	39241	3	6	46	6	47	"an even suppress" incorrect ? "anthopogenic emissions" : should be replaced by "increased atmospheric carbon dioxide concentration" (Eric Martin, Meteo-France)	Changed and revised it
282	43580	3	6	47	6	51	This sentence is unclear. Has the contribution of canopy transpiration decline to river discharge decline been detected or modelled? Or perhaps both? (Cate Macinnis-Ng, University of Auckland)	Changed and revised it
283	46405	3	6	50	6	50	Reference to Betts et al is missing in the literature. (Jan Szolgay, Slovak University of Technology)	accepted and revised.
284	43579	3	6	50	6	51	I didn't find Betts et al. 2007 in the reference list (Cate Macinnis-Ng, University of Auckland)	accepted and revised.
285	52473	3	6	50	6	51	there are other papers on this issue which should be cited and the last one I mention disagrees with Gedney's findings to some extent (Huntington 2008), plus see WG2 chapter 4 p14 lines 40-50 and p24 line 38 to p25 line 36. papers e.g: Felzer, B. S., T. W. Cronin, J. M. Melillo, D. W. Kicklighter, and C. A. Schlosser (2009), Importance of carbon-nitrogen interactions and ozone on ecosystem hydrology during the 21st century, J. Geophys. Res., 114, G01020, doi:10.1029/2008JG000826. ; Alkama, R., M. Kageyama, and G. Ramstein (2010), Relative contributions of climate change, stomatal closure, and leaf area index changes to 20th and 21st century runoff change: A modelling approach using the Organizing Carbon and Hydrology in Dynamic Ecosystems (ORCHIDEE) land surface model, J. Geophys. Res., 115, D17112, doi:10.1029/2009JD013408; Huntington, T.G., 2008, CO2-induced suppression of transpiration cannot explain increasing runoff: Hydrological Processes, v. 22, p. 311-314. (Peter Falloon, Met Office Hadley Centre)	This problem is addressed in the text, but opinions are contradictory and very controversial. There are not field measurements that can confirm this. However, all these ideas and debate has been included in the text.
286	48986	3	6	51	6	51	Changes in land cover may also be important as a driver of changes in large-scale evapotranspiration (Richard Betts, Met Office Hadley Centre)	This is cited now.
287	48182	3	6	53	6	53	'in' not 'on' (David Sauchyn, University of Regina)	accepted and revised.
288	35261	3	7	3	7	3	It is suggested to add the reference Wilson et al. (2010) as this study covers the whole Nordic region and the earlier timing of snowmelt is one of the main conclusions in the study. The sentence should then be changed to: …Clow,2010) in the Nordic countries (Wilson et al., 2010) including Finland (Korhonen and Kuusisto, 2010) and in ..... (Hege Hisdal, Norwegian Water Resources and Energy Directorate)	Wilson reference added
289	50039	3	7	3	7	4	For the examples on this line, it would be preferable to specify the time frame as done on line 2. Additionally, the chapter team could consider using calibrated uncertainty language per the guidance for authors to characterize the lack of "significant evidence" described on line 4. (Katharine Mach, IPCC WGII TSU)	Can not be translated to uncertainty lenguague in that case.
290	45974	3	7	3	7	5	In Canada, a tendency towards earlier snowmelt floods has more recently been observed by Cunderlik and Ouarda (2009). Contrary to what the text on line 4-5 suggests, they found significant trends in the magnigude of the snowmelt flood at almost a fifth of the 160 stations analysed, most of these negative (see also line 18-20). Similar results have been found by e.g., Burn et al. 2010 (Burn, D. H., Sharif, M. and Zhang, K. (2010), Detection of trends in hydrological extremes for Canadian watersheds. Hydrological Processes, 24: 1781–1790. doi:10.1002/hyp.7625.) (Rutger Dankers, Met Office Hadley Centre)	The text have been changed according to the suggested changes.
291	45975	3	7	3	7	5	Shiklomanov et al. (2007) also found a significant shift to an earlier spring snowmelt runoff peak in Russian rivers, which has been confirmed by other studies (e.g., Tan et al., 2010). (Shiklomanov, A. I., R. B. Lammers, M. A. Rawlins, L. C. Smith, and T. M. Pavelsky (2007), Temporal and spatial variations in maximum river discharge from a new Russian data set, J. Geophys. Res., 112, G04S53, doi:10.1029/2006JG000352. Tan, A., J. C. Adam, and D. P. Lettenmaier (2011), Change in spring snowmelt timing in Eurasian Arctic rivers, J. Geophys. Res., 116, D03101, doi:10.1029/2010JD014337.) (Rutger Dankers, Met Office Hadley Centre)	Both references were added in the new text.
292	45976	3	7	4	7	4	In upstream portions of the major tributaries of the Mackenzie River, de Rahm et al. (2008) found significantly earlier trends in the timing of spring break-up of river ice of around 1 day per decade over the period 1970-2002. (L.P. de Rham, T.D. Prowse, B.R. Bonsal (2008), Temporal variations in river-ice break-up over the Mackenzie River Basin, Canada, Journal of Hydrology, 349, 441-454, DOI: 10.1016/j.jhydrol.2007.11.018.) (Rutger Dankers, Met Office Hadley Centre)	Cite added
293	35262	3	7	8	7	8	It is suggested to refer to a study of trends in snow water equivalent that illustrates the importance of elevation on snow conditions under chanign temperature and precipation conditions. Skaugen, T., Stranden, H.B., Saloranta, T. (2012) Trends in snow water equivalent in Norway (1931-2009). Hydrology Research 43 (3), p. 489-499, doi: 10.2166/nh.2012.109 (Hege Hisdal, Norwegian Water Resources and Energy Directorate)	This is too specific for this manuscript.
294	45939	3	7	8	7	10	Some regions e.g. Midwestern United States has shown increasing trend in low flow, which occurs late summer to early Fall (see Novotny and Stefan, 2007; Kumar et al., 2009). (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	Not necesarily related to climate change.
295	44601	3	7	12	7	24	Include reference Kundzewicz 2012: Changes in Flood Risk in Europe (Martina Flörke, University of Kassel)	The reference is now included.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
296	43504	3	7	12	7	46	Land cover change is likely over the 30 to 50 years periods for which floods have been analysed and it would be difficult to separate the effects from a climate driver. To help determine the impacts of climate on river flows, it would be useful to separate studies that have looked at catchments, where trends have been found, that have experienced land cover change (e.g. urbanisation) or changes in storage due to impoundments from those that with little human influence. (Andrew Wade, University of Reading)	The text indicates which studies used near natural catchments. Most of the references cited used such type of catchments to avoid human interference.
297	46012	3	7	12	7	52	This section about floods includes several contradictory statements. Or what look like statements. Perhaps it would be useful to clarifiy that this is what the literature reports and that in fact, it includes contradictory reports. Maybe if this section were ended (after lines 48 to 52) with a quote to what it says about floods in SREX (IPPC 2012) it would be useful to avoid confusion. (Luis E. Garcia, World Bank)	These aspects were clarify in this version and more relevance was put to works with clear statements (with uncertainty lenguage) regarding flood trends.
298	46404	3	7	12	8	25	In this part also problems at what scales and how do climate variability and land cover change impact on flooding and droughts could be shortly mentioned especially with respect to the conclusions taken or illustrated by the studied cited therein. A widely cited discussion is given in Bloeschl et al., (2007) (Günter Blöschl, Sandra Ardoin-Bardin, Mike Bonell, Manfred Dorninger, David Goodrich, Dieter Gutknecht, David Matamoros, Bruno Merz, Paul Shand, Jan Szolgay: At what scales do climate variability and land cover change impact on flooding and low flows? Invited commentary. Hydrological Processes 21 (9), pp. 1241-1247in DOI: 10.1002/hyp.6669,) which certainly could be worth to be cited in the chapter. In particular one could add a few words of caution to the spatial interpretation of the analysis of changes in floods (droughts) extremity and frequency contained therein. In the interpretation of the evidence of changes in regimes of extremes from the literature it could be stressed that since data and results derived by their analysis never can exhaustively represent the hydrological environment, heterogeneity and scale effects have to be respected in the interpretation. The question how to interpret messages from measurements and models across a range of spatial and temporal scales is particularly important with respect to extremes. There are a number of complications with this process – the information at the larger scales tends not to be as detailed as that in the local studies and it is not always known how one can upscale local information. Moreover there is a lot of variability at all scales. There is a general notion that hydrological events have become more extreme in recent years as flagged out by recent exceptional events. However, a causal interpretation needs to be treated with caution as extreme events tend to cluster into groups of several years. Also, there may exist biases both towards and against the apparent occurrence of more extreme events. One of the potential biases is a tendency for selecting catchments with recent extremes for hydrological analyses of change while not examining catchments where such extremes have not occurred recently. (Bloeschl et al., (2007)). (Jan Szolgay, Slovak University of Technology)	The new text addresses this problem in a short way, and the high uncertainty associated to short records to distinguish between climate trend and natural decadal climate variability.
299	45980	3	7	13	7	46	Australia is missing from this analysis, in spite of the extreme flood events in recent years. A preliminary study on trends in Australian flood data using 491 stations with minor anthropogenic influences and with annual maximum flood records of length between 30 and 97 years found approximately 30% of stations with a statistically significant trend at the 10% significance level, which were in a downward direction in southern parts of the Australian continent and an upward direction in the northern regions (Ishak et al., 2010 - it may be worth checking if there is a follow-up to this study). (Ishak, E.H., A. Rahman, S. Westra, A. Sharma & G. Kuczera (2010): Preliminary Analysis of Trends in Australian Flood Data. World Environmental and Water Resources Congress, American Society of Civil Engineers (ASCE), Providence, Rhode Island, USA, doi:10.1061/41114(371)14.) (Rutger Dankers, Met Office Hadley Centre)	The reference is now included.
300	48987	3	7	16	7	18	I think the SREX may also be worth citing here (Richard Betts, Met Office Hadley Centre)	Accepted. SREX is now cited.
301	45977	3	7	21	7	22	Although Semonov (2011) reported an increase in flooding events in the first decade of the 21st century in several Russian river basins, including the Volga and Ob. (V. A. Semenov (2011): Climate-related changes in hazardous and adverse hydrological events in the Russian rivers. Russian Meteorology and Hydrology 36, 124-129, DOI: 10.3103/S1068373911020075.) (Rutger Dankers, Met Office Hadley Centre)	Yes, I agree. However, going to one decade scale doesn't mean anything in relation to the general trend.
302	40302	3	7	24	7	54	Comment: Trend analysis is extremely complex and cannot be simplified in this way. Starting dates and finsihing dates are crucial and region wide comparisons as quoted in this section are gross simplifications which may be misleading. Many sysudies have similar end dates, but unless there is a common start date the establishmen tof a trend is fraught with difficulty, even over very small regions. (John Sweeney, National University of Ireland Maynooth)	Yes, that is a problem but there is not any general paper that coves all world regions and over same temporal framework.
303	48988	3	7	26	7	27	This sentence would be clearer if the reader was reminded what kind of trends were detected by Stahl et al, or pointed back to the text where this was discussed. (Richard Betts, Met Office Hadley Centre)	The sentence was deleted.
304	35263	3	7	26	7	37	This paragraph needs to be reformulated. It is not true that overall in Europe trends on peak flows follow a similar pattern to the onec detected by Stahl et al. (2010) for annual stream flows. For example, the trend (or rather abcence of trends) in peak flow found in Wilson et al. (2010) for the Nordic countries, i.e. northern Europe, both regarding spring snowmelt floods and autumn rain floods do not correspond with what is stated in this paragraph. The magnitude in autumn and spring floods show no systematic trend and no systematic regional pattern. (Hege Hisdal, Norwegian Water Resources and Energy Directorate)	I agree. The paragraph is now changed completely and reference to Stahl et al. 2010 deleted.
305	36073	3	7	26	7	37	Merely discusses statistical trends in flood magnitude. Whether these trends are indeed because of anthropogenic greenhouse gas emissions and what fraction of these changes are due to human-induced climate change or due to local interventions need to be analyzed/mentioned. (Pradeep MUJUMDAR, Indian Institute of Science)	It is now mention now, and the high uncertainty to address short (50yr) records to analyse flood trends.
306	48072	3	7	26	7	37	See also studies by Wilby e.g. Wilby, R.L. 2006. When and where might climate change be detectable in UK river flows? Geophysical Research Letters, 33, L19407. (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	Thanks. Only references dealing with global and regional trends are cited.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
307	50040	3	7	26	7	37	For examples in this paragraph, the chapter team could consider further characterizing the relevant time frame. (Katharine Mach, IPCC WGII TSU)	Accepted and changed.
308	52474	3	7	36	7	37	was the difference between these studies due to different methods, or different time periods analysed? Please make this clear in the text. (Peter Falloon, Met Office Hadley Centre)	The sentence was re-written.
309	40571	3	7	39	0	0	The devastating flood in Chao Phraya River basin in the last year 2011 may be one of the best observed impacts and the following article may be cited: Daisuke Komori, Shinichirou Nakamura, Masashi Kiguchi, Asako Nishijima, Dai Yamazaki, Satoshi Suzuki, Akiyuki Kawasaki, Kazuo Oki and Taikan Oki. 2012. Hydrological Research Letters 6, 41–46. DOI: 10.3178/HRL.6.41. (Toshiyuki Nakaegawa, Meteorological Research Institute)	The text was intended to address trends not individual floods.
310	45979	3	7	39	7	39	For Yangtze River, see also Zhang et al. (2009). A similar trend has been observed in the lower reaches of the Pearl River (Zhū Jiāng) further south (Piao et al., 2010). In the arid, continental Tarim basin in western China and other areas in the northwest the number of flood events has risen sharply due to glacier melting and more rapid snowmelt (Shi et al., 2007). (Zhang, Z., Zhang, Q., Xu, C., Liu, C. & Jiang, T. (2009): Atmospheric moisture budget and floods in the Yangtze River basin, China. Theoretical and Applied Climatology, 95, 331-340, doi:10.1007/s00704-008-0010-z. Piao, S., Ciais, P., Huang, Y., Shen, Z., Peng, S., Li, J., Zhou, L., Liu, H., Ma, Y., Ding, Y., Friedlingstein, P., Liu, C., Tan, K., Yu, Y., Zhang, T. & Fang, J. (2010): The impacts of climate change on water resources and agriculture in China. Nature, 467, 43-51, doi:10.1038/nature09364. Shi, Y., Shen, Y., Kang, E., Li, D., Ding, Y., Zhang, G. & Hu, R. (2007): Recent and Future Climate Change in Northwest China. Climatic Change, 80, 379-393, doi:10.1007/s10584-006-9121-7. (Rutger Dankers, Met Office Hadley Centre)	This was inclued in the table.
311	36022	3	7	39	7	46	I did not see any mention of the affect of the 3-Gorges dam and the narrative does not make clear whether the upstream impact of this was considered when looking at 40-year streamflow. This would be a critical issue to address in work or assessment of this area. (Michael Brewer, NOAA)	The paragraph only addresses climate change detection and attribution. That could be considered in future impacts.
312	45978	3	7	40	7	41	I believe Bhutiyani et al. (2008) mostly found a significant increase in the number of high-magnitude flood events in the past 4 to 5 decades. They also found evidence of a decreasing contribution of glaciers to the river discharge during winter as well as monsoon season since the 1990s. (Rutger Dankers, Met Office Hadley Centre)	I checked and changed.
313	43402	3	7	47	7	47	In the Himalayas, significant hydrological hazards like floods are caused by glacier melt-supplied lake expansion and outburst (Yao et al. 2011; Cui et al. 2010; ICIMOD 2011). Scientists have identified 34 such glacial lakes on the northern slopes of the Himalayas, and 20 outburst floods have been recorded in the past 50 years. In addition, the risks of glacial-terminus lake outburst floods (GLOF) intensify with glacial retreat, which can pose serious dangers to people and habitats (Cui et al. 2010). Glacial retreat also induces glacial-water-fed lake expansion floods (GLEF) which looms large on pastures and livestock in the catchment (Morton 2011, Cui et al. 2010, Bajracharya and Mool 2009). (see: Yao, T. D., L. G. Thompson, V. Musbrugger, Y. M. Ma, F. Zhang, X. X. Yang & D. Joswiak. 2011. Together with the Arctic and the Antarctic, the Tibetan Plateau In UNESCO-SCOPE-UNEP Policy Briefs Series. Third Pole Environment, ed. A. Persic. France: ITC Grigny; Cui, P., C. Dang, Z. Cheng & K. M. Scott (2010) Debris Flows Resulting From Glacial-Lake outburst Floods in Tibet, China. Physical Geography, 31, 508-527; Bajracharya, S. and P. Mool (2009) Glaciers, glacial lakes and glacial lake outburst floods in the Mount Everest region, Nepal Ann. Glaciol., 50, 81-86; ICIMOD (2011) Glacial lakes and glacial lake outburst floods in Nepal. Kathmandu: ICIMOD; Morton, K (2011) Climate Change and Security at the Third Pole, Survival, 53-1, 121-132 (David Molden, International Centre for Integrated Mountain Development (ICIMOD))	GLOFs are not addressed in this part of the text.
314	48989	3	7	48	7	48	The text says "several" studies but only cites two - to my mind, two is not enough to count as "several". Are there any more? (Richard Betts, Met Office Hadley Centre)	Changed to Recent studies.
315	39349	3	7	48	7	50	Need more than two studies to support "several " claim (Gareth S Jones, Met Office)	We deleted this sentence.
316	39350	3	7	48	7	50	Not sure Pall 2011 study (for England/Wales) is a good example increase in floods in regions across northern hemisphere. England/Wales is not very big! (Gareth S Jones, Met Office)	Yes, just live to refer to "some regions".
317	39351	3	7	48	7	50	It would be useful to put some confidences on these statements. e.g. Pall 2011 says it is "very likely" that there is a "substantial" "increased flood risk". (Gareth S Jones, Met Office)	included very likely.
318	36074	3	7	49	7	50	'anthropogenic greenhouse gas emissions have increased the risk of floods' is rather a generic statement as the study referred (Pall et al., 2011) conducts the analysis only on a particular flood event in a particular region (Europe) of the world. Also, Min et al., 2011 show that the current climate models underestimate changes in extreme rainfall of the global land areas – this is an important finding and must be mentioned. (Pradeep MUJUMDAR, Indian Institute of Science)	It is now referred as some studies suggest that….
319	39352	3	7	50	7	52	What is the confidence in the studies claims and how much was the "higher probability"? 1%, 10% 100%? (Gareth S Jones, Met Office)	The portion is about 20%, but it is only one study, so better to leave in generic.
320	48990	3	7	51	7	51	I'd say "not possible" rather than "difficult". (Richard Betts, Met Office Hadley Centre)	changed to not possible.
321	52676	3	7	53	0	0	The environmental, social and economic importance of GLOFs suggests to include some pertinent information in this and successive lines. REFERENCE: Carey M.-Living and dying with glaciers: People´s historical vulnerability to avalanches and outburst floods, in Peru. Global and Planetary Change, Elsevier 2004. Kuroiwa J..- Understanding Natural Disasters Page 6, Disaster Reduction, Lima, Peru, 2004 (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	GLOFs are not addressed in this part of the text.
322	52677	3	8	1	0	0	Although Regional Chapter 27: Central and South America would include more information on droughts, the worldwide importance of this region´ s commodities production suggests to include some more updated information. (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	The text on droughs is shortened because it was addressed in chapter 2 WGI.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
323	35264	3	8	1	8	25	Droughts: There is a need to distinguish between meteorological droughts (lack of precipitation - PDSI is normally regarded as a meteorological drought index), agricultural droughts (soil moisture deficit) and hydrological droughts (river flow and groundwater droughts). The trends in the different types of droughts are different as meteorological droughts reflect the trends in precipitation dry spells whereas agricultural and hydrological droughts are a result of the combined effect of preciptation deficits and high temperatures (and in cold climates also influenced by the snow storage and snowmelt). This should be explained and it should be made clear what type of drought that is actually studied in the differnt papers referred to. (Hege Hisdal, Norwegian Water Resources and Energy Directorate)	A sentence was added for clarificaiton.
324	35265	3	8	1	8	25	It would be useful to add areference here to Stahl et al. (2010) who conclude that: Low flows have decreased in most regions where the lowest mean monthly flow occurs in summer, but vary for catchments which have flow minima in winter and secondary low flows in summer. This indicates that hydrological summer droughts in Europe have become more severe in regions that experience the lowest river flows during the summer. (Hege Hisdal, Norwegian Water Resources and Energy Directorate)	Most local references are now deleted.
325	48991	3	8	1	8	25	This section refers to PDSI a fair bit, but isn't PDSI less reliable for higher temperatures? I believe that is the key conclusion of work by Sheffield and Wood (eg: papers cited in this chapter) (Richard Betts, Met Office Hadley Centre)	This is added as well latest paper by Sheffield et al 2012.
326	43581	3	8	2	0	0	Define PDSI (Cate Macinnis-Ng, University of Auckland)	The word has been defined.
327	50041	3	8	2	8	2	It would be helpful to clarify the units relevant to the described increase in extent--in terms of land surface affected? Then, 12% was the value relevant to the 1970s, or the overall increase has been something between 12 and 30%? It would be beneficial to clarify this further. (Katharine Mach, IPCC WGII TSU)	This was changed.
328	48183	3	8	2	8	3	The correct reference is Dai et al., 2004. The AR5 report of WG I cautions that these results are not considered robust in the context of subsequent studies. (David Sauchyn, University of Regina)	Corrected
329	36023	3	8	3	0	0	Is "aridity" the word you intend to use? It refers to consistent dryness, not sporatic drought (Michael Brewer, NOAA)	Agree. Changed
330	36024	3	8	7	0	0	It might be a stretch to sell an analysis for central-southern Europe as strong based on only 9 stations across all of Europe (Michael Brewer, NOAA)	Most local references are now deleted.
331	36075	3	8	8	8	9	'Exceptional winter low precipitation in the UK gave rise to unprecedented dry conditions in Spring 2012' – reference for this statement needs to be cited. (Pradeep MUJUMDAR, Indian Institute of Science)	Deleted this statement.
332	40687	3	8	8	8	9	Similarly to the UK, exceptional low winter precipitation in France gave rise to unprecedentedly dry soil moisture conditions in both spring 2011 and 2012 (Soubeyroux et al., 2012). These events follow other recent strong soil moisture drought events (Vidal et al., 2010, 2012). Soubeyroux, J.-M., Kitova, N., Blanchard, M., Vidal, J.-P., Martin, E. & Dandin, P. (2012) Characterizing meteorological and soil moisture droughts in France in a climate change context. Results and applications from the ClimSec project.. La Météorologie, accepted. Vidal, J.-P., Martin, E., Franchistéguy, L., Habets, F., Soubeyroux, J.-M., Blanchard, M. & Baillon, M. (2010) Multilevel and multiscale drought reanalysis over France with the Safran-Isba-Modcou hydrometeorological suite. Hydrology and Earth System Sciences, 14(3), 459-478. doi: 10.5194/hess-14-459-2010 Vidal, J.-P., Martin, E., Kitova, N., Najac, J. & Soubeyroux, J.-M. (2012) Evolution of spatio-temporal drought characteristics: validation, projections and effect of adaptation scenarios. Hydrology and Earth System Sciences, accepted. (Jean-Philippe Vidal, Irstea)	Agree. Changed
333	50042	3	8	8	8	9	The citation supporting this example should be clarified. (Katharine Mach, IPCC WGII TSU)	Statement deleted.
334	43230	3	8	21	0	0	Please define SREX here (Muhammad Zia ur Rahman Hashmi, Global Change Impact Studies Centre)	It is defined in the volume.
335	50043	3	8	21	8	21	As calibrated uncertainty language, "medium confidence" should be italicized. (Katharine Mach, IPCC WGII TSU)	accepted and revised.
336	39353	3	8	24	8	25	The detection study didn't seperate the different external forcing factors so could only conclude that "a significant influence of anthropogenic emissions of greenhouse gasses and sulphate aerosols in the production of this drying trend" (Gareth S Jones, Met Office)	The statement was deleted.
337	48992	3	8	24	8	25	Give the specific name of the configuration of the Hadley GCM (eg: I expect Burke et al used HadCM3 - but please check!) (Richard Betts, Met Office Hadley Centre)	This was deleted.
338	41988	3	8	28	0	0	The groundwater section is begging for a call for more impacts-focused research, like several of the other impacts sections that already have these statements. Same comment goes for the subsequent section on water quality. (Nathan L. Engle, 2011-2012 AAAS Science and Technology Policy Fellow)	This section is about observations not impacts.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
339	45852	3	8	28	8	45	Groundwater may be climate independent to a degree. Recent World Bank report (June 2012) 'Managing the Invisible: Understanding and Improving Groundwater Governance'. All the following text in this comment is extracted from the WB (2012) report: Climate change will have an impact on all components of the hydrological cycle and result in changes in the seasonal and geographical distribution of water on the planet. Climate change may negatively impact groundwater resources in case of changes in groundwater recharge due to changing river discharge or rainfall patterns. Climate change may also lead to an increased pressure on groundwater resources in case of reduced availability of surface water resources. But groundwater also has a unique potential to adapt to climate change – primarily as a result of its buffering potential against increased climate variability. ... Furthermore, climate change is introducing costs and risks that are hard to manage, including increased demand for groundwater and reduced recharge, with consequent heightened risk of conflict. Disputes have also started to emerge between states over transboundary aquifers. ....the ability to use groundwater “on credit” is a major advantage when facing increasing climate variability; however, it also poses a significant hazard to the sustainability of the resource if not governed effectively. A balance between meeting short-term needs and long-term utilization (and ecosystem demands) must be established. ....Groundwater has a unique potential for climate change adaptation. ....Groundwater reserves provide a first rate buffer against climate variability and any associated decline in other water sources, and will play an increasing role where aridity is on the increase. In addition, groundwater’s typically delayed response to climatic variability and its protection from evaporation means that it provides a water source that is itself naturally protected from increased variability under climate change. However, any compromised quantity and quality of groundwater resources may erode its advantages. .... Climate change will put additional stress on groundwater resources. For example, progressive reduction of the Himalayan glaciers is expected to lead first to a surge, then a decline, in associated base flows in the main Ganges tributaries, with consequent impacts on the extensive aquifer systems underlying the Ganges basin. Table 12. Ten Institutional Design Propositions for Complex (Ground) Water Governance Systems and Climate Change Adaptation Institutional Design Proposition Explanation 1) Clearly defined boundaries Defining the boundaries of the resource system and of	This section is about observations not impacts; reference may be referred to in section 3.6.
339.2	45852	3	8	28	8	45	those authorized to use it can be thought of as a first step in organizing for collective action (Ostrom, 1993). When confronted with social and physical challenges (e.g. the impacts of climate change on groundwater), it is important to clarify who is affected by this problem and who has the responsibility, capacities, access to resources and information to deal with it (Huntjens et al., 2012). 2) Equal and fair (re-distribution of risks, benefits and costs) Those who receive the highest proportion of the water also pay approximately the corresponding share of the fees (Ostrom, 1993). Within the context of climate change, or other external disturbances, it is important that stakeholders at risk are given opportunities to participate in reshaping and reducing the risks to which they are projected to be exposed. This requires engagement with, and strong representation of, groups likely to be highly affected or especially vulnerable (Huntjens et al., 2012). 3) Collective choice arrangements Most individuals affected by operational rules can participate in modifying them (Ostrom, 2005). In large-scale resource systems it is important to enhance the participation of those involved in making key decisions about the system, e.g. on how to adapt to climate change (Huntjens et al., 2012). 4) Monitoring and evaluation Monitors who actively audit CPR conditions and appropriator behavior are accountable to the appropriator and/or are the appropriator themselves (Ostrom, 1993). Additionally, it is also important to monitor and evaluate decision-making and the development and implementation of policies (Huntjens et al., 2012). An important measure is to have agencies at least review the impacts of their policies and other interventions (Huntjens et al., 2012). The process of monitoring and evaluation serves to adjust the course of action and motivate those driving the processes. Actions and objectives can then be adjusted based on reliable feedback from the monitoring programs and improved understanding (Nyberg, 1999). 5) Graduated sanctions Appropriators who violate rules are likely to receive graduated sanctions (depending on the seriousness and context of the offense) from other appropriators, from officials accountable to these appropriators, or from both (Ostrom, 1993). 6) Conflict prevention and resolution mechanisms Appropriators have rapid access to low-cost, local arenas to resolve conflicts among appropriators or between appropriators and officials (Ostrom, 1993). In complex water governance systems we can also observe a	

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
339.3	45852	3	8	28	8	45	number of conflict prevention mechanisms, such as timing and careful sequencing, transparency, trust-building, and sharing of (or clarifying) responsibilities (Huntjens et al., 2012). 7) Minimal recognition of rights to organize The rights of appropriators to devise their own institutions are not challenged by external governmental authorities (Ostrom, 1993). 8) Nested enterprises / polycentric governance The design of robust systems of common pool resources that are larger and more dynamic (as in the case of transboundary river basins or groundwater systems) and also involve multiple stakeholders is characterized by the presence of governance activities organized in multiple layers of nested enterprises (Ostrom, 2005). Nested enterprises are functional units to overcome the weakness of relying on either just large-scale or only small-scale units to govern complex resources systems. 9) Robust and flexible processes Institutions and policy processes that continue to work satisfactorily when confronted with social and physical challenges but, at the same time, are capable of changing (Huntjens et al., 2012). Building trust and reciprocity are important elements of a robust and flexible process (Huntjens et al., 2012). Robustness of a water governance system may be enhanced by cross-sectoral policy integration or mainstreaming climate adaptation, because it reduces the incidence of large adverse side-effects and feedbacks or maladaptation (Dovers and Hezri, 2010). 10) Policy learning Policy and institutional adjustments based on commitment to dealing with uncertainties, deliberating alternatives and reframing problems and solutions (Huntjens et al., 2012). Specific references: Ostrom, E. (1993) Design principles in long-enduring irrigation institutions, Water Resour. Res., 29(7), 1907–1912, doi:10.1029/92WR02991. Ostrom, E. (2005) Understanding Institutional Diversity: Princeton University Press. Nyberg, B. 1999. An introductory guide to adaptive management for project leaders and participants, January 1999. Huntjens, P., Lebel, L., Pahl-Wostl, C., Camkin, J., Schulze, R. & Kranz, N. (2012) Institutional design propositions for the governance of adaptation to climate change in the water sector. Global Environmental Change, 22 (2012) 67–81. (Bradley Hiller, World Bank)	
340	36025	3	8	30	8	37	Need to make specific that this is a global overview (Michael Brewer, NOAA)	Is already specified.
341	45895	3	8	30	8	37	The paragraph is largely based on studies published by only a few authors who are lead authors or review editors of the chapter at the same time - this could decrease credibility. I doubt that the shares of groundwater used for irrigation, households and manufacturing can be estimated with such a high accuracy. The paragraph also lacks linkages to previous and other chapters: Groundwater recharge is related to precipitation, temperature, evapo(-transpi-)ration and river discharge. In previous chapters the impact of climate change on these processes is discussed. The section should try to relate to this. In its present form the paragraph does not relate much to climate change. The style is different from the previous chapters. (Roland Barthel, Helmholtz Centre for Environmental Research - UFZ)	Section will be reformulated and moved the section to 3.5.1.
342	45898	3	8	30	8	45	The whole section does not give the impression as if it would be based on a thorough review of the literature. Recently a couple of review papers on climate change and groundwater were published. These are missing here. They include many more case studies. For example: Green et al. Journal of Hydrology Volume 405, Issues 3–4, 5 August 2011, Pages 532–560. Barthel et al. (2012) Water Resources Management Volume 26, Number 7 (2012), 1929-1951, DOI: 10.1007/s11269-012-0001-9 list more case studies and review papers on groundwater and climate change. (Roland Barthel, Helmholtz Centre for Environmental Research - UFZ)	Green et al. do not provide information on observed climate change impacts on groundwater. Review papers Green et al. and Taylor et al. (2012) cited in 3.4.6 SOD.
343	48993	3	8	37	8	37	How significant a depletion is 4,500 km3? Eg: what percentage of total (or available) groundwater, or what percentage of the amount used per year, for example? (Richard Betts, Met Office Hadley Centre)	Numbers already provided in paragraph.
344	37149	3	8	39	8	40	This is interesting. The human actions referred to are described as not being related to climate change. Elsewhere in the chapter it is recognised that activities such as withdrawals (and choices about crop types etc) may very well be modulated by climate change, albeit perhaps in complex ways that are more or less direct. My point here is that there should be some recognition here of the role that climate change may play in affecting the anthropogenic components of the hydrological balance - there is a feedback at work (Stephen Darby, University of Southampton)	Text was reformulated with respect to the anthropogenic component.
345	45896	3	8	39	8	40	a) that fact that only few studies investigated the relation between groundwater level changes and climate change does not prove that there is no or little relation between the two b) withdrawal rates and climate change may be related, thus an indirect relation be groundwater levels and climate change may exist, c) it should be mentioned that existing groundwater monitoring networks are not suitable for assessing the impact of climate change as most groundwater observation wells were installed to monitor the impact of human activity and/or are situated close to rivers and thus influenced by changes in discharge. A meaningful evaluation of climate change impacts on groundwater levels is thus neither possible nor was it done in a globally representative way. The two sentences should be rephrased to acknowledge that we just know little about this. Currently the paragraph reads as if direct climate change impacts on groundwater would be negligible - which can't be the case, given the dependence of groundwater levels on climate. A paper that deals with the evaluation of long term groundwater level data would for example be Stoll et al. Hydrology and Earth System Sciences, Volume 15, Issue 12, 2011, Pages 3861-3875 (Roland Barthel, Helmholtz Centre for Environmental Research - UFZ)	Stoll et al. was taken into account, and section was reformulated.
346	36076	3	8	40	8	41	What is 'attribution to climatic changes' is not clear. IPCC AR4 WGI Chapter 9 requires formal establishment of cause of an observed climate change for attribution. Decrease of discharge of groundwater-fed springs, consistent with precipitation decreases cannot be attributed to human-induced climate change, since precipitation may vary because of natural variability of climate alone, or because of other causes like volcanic activities or solar irradiance. (Pradeep MUJUMDAR, Indian Institute of Science)	Refer to 3.2.1 where we explain that in hydrology, end-to-end-attribution but only partial attribution to changes in climatic drivers is done.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
347	45897	3	8	40	8	45	The two examples seem to be picked rather arbitrarily. Again, it should be pointed out that only few (and foremost local) studies have tried to establish a relation between climate change and groundwater (levels). The two mentioned case studies do not show or prove any significant (on a global level) findings. (Roland Barthel, Helmholtz Centre for Environmental Research - UFZ)	Reforumlated.
348	43506	3	8	48	9	6	I think it would be worth mentioning in the Executive Summary that it is difficult to separate the direct effects of climate drivers on water quality from other environmental controls, such as land cover and management, deposition, water usage and effluent inputs. (Andrew Wade, University of Reading)	Accepted as it is similar to #157. It was also added to the tet the indirect effects of climate change on water quality.
349	52464	3	8	48	9	6	In fact there have been reported changes in surface water coloration due to changed inputs of terrestrially derived dissolved organic carbon. This will affect not only biotic processes (relevant to Ch. 4) but also water quality for human use. The topic is touched upon however on p. 9, line 38. (Dag Hessen, Univeristy of Oslo)	No need to take action, as mentioned by the reviewer the query is considered later in the text page 9 line 38.
350	50044	3	8	50	8	50	The chapter team could consider assigning calibrated uncertainty language, such as summary terms for evidence and agreement, to characterize the information available. (Katharine Mach, IPCC WGII TSU)	Accepted when appropriate
351	43505	3	8	50	10	13	I have emailed a copy of a deliverable from the Eurolimpacs project as supporting material, filename 'Del301_PositionPaper.pdf'. This deliverable provides a summary of outcomes from the project which focused on an assessment of the impacts of climate change on freshwater ecology. The outcomes are also presented in the book by Kernan et al. (2010). The full reference for the book is given in my third comment on chapter 3. (Andrew Wade, University of Reading)	The Eurolimpacs report was used and referenced.
352	39329	3	9	1	9	32	In the first paragraph changes are solely attributed to changing temperature and rainfall/evaporation. Then in the third paragraph pollution is introduced. Pehaps in the first paragraph there should ba a warning that pollution would be considered also. (Maria Assuncao Silva Dias, University of Sao Paulo)	The reason to present it like this is that the first papers reported have attributed their finding to temperature or rainfall and not to pollution. Later it is reported that for some studies this might be also the case.
353	36077	3	9	3	9	4	Is there a physically based relationship to explain the association between increasing atmospheric temperature and observed water quality changes? For example, how does the hydraulic retention time in a lake change with global temperature rise? (Pradeep MUJUMDAR, Indian Institute of Science)	So far it have not come to my notice studies assesing how the hydraulic retetion time in a lake is modify because of the water temperature only because of rainfall.
354	48184	3	9	4	9	4	hydraulic or hydrologic? (David Sauchyn, University of Regina)	hydrologic, the text was modified. Please note that the text has recieved final editing and had to be shortened so your comment although accepted might not be contained in the final version.
355	44590	3	9	11	0	0	"Numerous studies…" Include some references here. (Martina Flörke, University of Kassel)	As we have severe space constraints I had to condense reference in one place as a same paper might be reporting different pollutants/causes.
356	37150	3	9	11	9	11	Numerous studies…' Cite some of them (Stephen Darby, University of Southampton)	As we have severe space constraints I had to condense reference in one place as a same paper might be reporting different pollutants/causes.
357	39263	3	9	11	9	11	"tis" should be "this" (XIAOSHENG QIN, Nanyang Technological University)	accepted and revised.
358	50045	3	9	11	9	11	The author team might consider providing an example citation for the described "numerous studies." (Katharine Mach, IPCC WGII TSU)	As we have severe space constraints I had to condense reference in one place as a same paper might be reporting different pollutants/causes.
359	37151	3	9	12	9	12	Define 'shallow' lakes (Stephen Darby, University of Southampton)	The text was rewritten in such a way that shallow lakes are not longer mentioned.
360	43507	3	9	12	9	12	Why are shallow lakes more vulnerable? No evidence is cited. Climate change can affect deep lakes through an increase in the temperature of the hypolimnion. This temperature increase will cause a reduction in oxygen concentration in bottom waters, especially in summer. (Andrew Wade, University of Reading)	Because of their complete mixed properties as they have a lower amount of water. The definition of shallow lakes requested on #359 could have respond to this but in the final text due to space constraints was not included.
361	50046	3	9	14	9	15	The chapter team could consider indicating the general decades over which the studies took place--spanning the 19XXs through 20YY, for example? (Katharine Mach, IPCC WGII TSU)	Accepted and included at the begining of the section.
362	50047	3	9	16	9	53	Calibrated uncertainty language (levels of confidence) on these lines should be italicized: please check lines 16, 18, 22, 23, 25, 27, 39, 48, 53. (Katharine Mach, IPCC WGII TSU)	Done when it was appropriate.
363	36078	3	9	18	9	18	'Eutrophication, resulting from higher nutrient contents sometimes associated with climate variability' – what is meant by 'climate variability' is not clear. Does it also include human-induced climate change, or natural internal variability of climate, or external natural causes? (Pradeep MUJUMDAR, Indian Institute of Science)	The texts rephrased as "eutrophication conditions associated with warmer temperatures, lower hydraulic retention times or higher nutrient loads". Please note that due to space constraints the text had to be shortened and hence your comment not reflected on it.
364	50048	3	9	24	9	27	The author team might specify the relevant time frame for this statement. (Katharine Mach, IPCC WGII TSU)	The period in which the observation are made is now included in a figure.
365	44602	3	9	26	9	27	metals and metalloids (Martina Flörke, University of Kassel)	Accepted. Please note that the whole text was restructured and shortened so this change although made may not appear on the final version.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
366	44367	3	9	34	9	44	Other relevant papers concerning the impacts of climate change on rivers are : Whitehead, P.G. , Willby, R.L. , Battarbee, R.W. , Kernan, M. & Wade, A.J. 2009. A review of the potential impacts of climate change on surface water quality. Hydrological Sciences Journal, 54(1): 101-123. Whitehead, P.G., Wade, A.J. & Butterfield, D. 2009. Potential impacts of climate change on water quality and ecology in six UK rivers. Hydrology Research, 40(2-3): 113-122. (Ibáñez Carles, IRTA)	Reviewed and reference introduced when were relevant to the final text.
367	46406	3	9	34	9	44	With respect to water temperature changes there is a paper on the Danue, which might be of interest: Pavla - HALMOVÁ, Dana - MIKLÁNEK, Pavol - ONDERKA, Milan - PEKÁR, Ján - ŠKODA, Peter. Is the Water Temperature of the Danube River at Bratislava, Slovakia, Rising?. In Journal of Hydrometeorology. ISSN 1525-755X, 2008, vol. 9, issue 5, pp. 1115-1122. The abstract says> This paper aims to reveal the annual regime, time series, and long-term water temperature trends of the Danube River at Bratislava, Slovakia, between the years 1926 and 2005. First, the main factors affecting the river's water temperature were identified. Using multiple regression techniques, an empirical relationship is derived between monthly water temperatures and monthly atmospheric temperatures at Vienna (Hohe Warte), Austria, monthly discharge of the Danube, and some other factors as well. In the second part of the study, the long-term trends in the annual time series of water temperature were identified. The following series were evaluated: 1) The average annual water temperature (To) (determined as an arithmetic average of daily temperatures in the Danube at Bratislava), 2) the weighted annual average temperature values (To) (determined from the daily temperatures weighted by the daily discharge rates at Bratislava), and 3) the average heat load (Zt) at the Bratislava station. In the long run, the To series is rising; however, the trend of the weighted long-term average temperature values, To , is near zero. This result indicates that the average heat load of the Danube water did not change during the selected period of 80 yr. What did change is the interannual distribution of the average monthly discharge. Over the past 25 yr, an elevated runoff of "cold" water (increase of the December–April runoff) and a lower runoff of "warm" water (decrease of the river runoff during the summer months of June–August) were observed. (Jan Szolgay, Slovak University of Technology)	Accepted. The reference is cited.
368	50049	3	9	35	9	36	It would be helpful to clarify further what is meant by "the variations observed in rivers are all considered negative." (Katharine Mach, IPCC WGII TSU)	Text changed as lowering water quality.
369	52475	3	9	35	9	44	these papers are potentially relevant here: Howden, NJK, Burt, TP, Worrall, F, Whelan, MJ & Bieroza, MZ. 'Nitrate concentrations and fluxes in the River Thames over 140 years (1868 - 2008): are increases irreversible?', Hydrological Processes, 24, (pp. 2657-2662), 2010. 10.1002/hyp.7835; Macleod C.J.A., Falloon P.D., Evans R., and Haygarth P.M. 2012. The Effects of Climate Change on the Mobilization of Diffuse Substances from Agricultural Systems. Advances in Agronomy 115, 41-47 (Peter Falloon, Met Office Hadley Centre)	Papers were reviwed and reference when they resulted pertinent to the text.
370	37084	3	9	42	0	0	Reference Arheimer et al. Does not deal with semiarid hydrology (Christophe Cudennec, Agrocampus Ouest)	Moved to the right place.
371	50050	3	9	47	9	52	For these examples, the chapter team could consider further indicating the relevant time frames and geographic areas as appropriate. (Katharine Mach, IPCC WGII TSU)	The information was included in the figure of observed and projected impacts.
372	45899	3	9	47	9	54	The whole section is not very convincing. A small number of precipitation/temperature-related impacts on groundwater quality are mentioned. The interpretation of the significance of the mentioned studies with respect to general tendencies of climate change impacts on groundwater quality is left to the reader. Many other conditions and examples could be mentioned (e.g. decreasing groundwater recharge might lead to less mobilization of contaminants from the unsaturated zone, or extreme precipitation after long dry periods might lead to more mobilization of contaminants ...). The choice of examples seems arbitrary and incomplete. I think it would be wise to mention that the impact of climate change on groundwater is hardly studied and understood yet. The section in chapter 3.4.7 (page 21 lines 26 to 45) covers the same topic and is much better! It seems to be written by different authors. (Roland Barthel, Helmholtz Centre for Environmental Research - UFZ)	A mention on the limited studies for groundwater is made on the text, and as well at the begining of the section where it is mentioned that most studies are for surface water. This might not be reflected in the final text due to lack of space but addressed in research needs.
373	36026	3	9	53	0	0	Refers to high and low income countries. Elsewhere in the document you refer to them as developed and developing. Need to keep consistency. (Michael Brewer, NOAA)	Note taken
374	50051	3	10	2	10	13	The chapter team might consider assigning calibrated uncertainty language to characterize these general conclusions, per the guidance for authors. Additionally, it could be helpful to specify further what is meant by "observed trends" on line 9--observed trends in what? (Katharine Mach, IPCC WGII TSU)	(1) sentences calibrated; and, (2) Replaced with "if the observed trends on the deterioration of the quality of water continue"
375	39330	3	10	9	3	11	Sentence needs a bit mor explanation... I can´t really understand what is the point . (Maria Assuncao Silva Dias, University of Sao Paulo)	Rephrased
376	46013	3	10	9	10	13	Conclusion (d) seems not clear to me. Perhaps a little explanation as to why this is, could help. (Luis E. Garcia, World Bank)	Rephrased
377	37153	3	10	16	0	0	This is a comment on the whole of Section 3.2.6: Throughout this section there is an implicit conflation of very different terms. Specifically, the term sediment 'loads', 'yields', 'flux' are used seemingly interchangeably. My understanding would be while 'load' and 'flux' both refer to the mass of sediment transported by a river (though non-experts may not understand the use of flux), there is no direct relationship between changing sediment load/flux (measured at a specific, local, point in the river network) and sediment 'yield', which refers specifically to the sediment load (normalised by drainage area) at the basin outlet. This is not just a matter of semantics. Loads can go up and down over time, but the effects of changes in loads on yields is very hard to predict due to transfers of sediments between storages in the river network. The entire section therefore needs close editing to be specific about what is being described, and to avoid unnecessary confusion. (Stephen Darby, University of Southampton)	Good comment!. Look for detail editing on the section.
378	43508	3	10	16	11	13	Sediments are also a vector for pollutants, such as phosphorus. (Andrew Wade, University of Reading)	I agree. Noted

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
379	43377	3	10	18	0	0	Section 3.2.6.: the section provides interesting information on soil erosion. I recommend integrating some reference to bedrock erosion in mountain regions. See chapter 18, section 18.3.1.3 for some literature references on this topic. Especially in high mountains changes in erosion rates, related to shrinkage of glaciers and permafrost, have been detected over the past decades. A few studies will be published over the next couple of months. Furthermore I recommend to include the topic of landslides. As discussed with Gerardo Benito, I'm willing to contribute text on that (post-FOD). (Christian Huggel, University of Zurich)	This to be discussed with chapter members.
380	37152	3	10	18	10	27	See comments above in relation to p8 lines 39-40. This paragraph refers to 'non-climatic' drivers such as vegetation changes and conservation measures that may either be a natural response to climate change or indeed a possible means of adapatation. So the reference to 'non-climatic' drivers unhelpfully simplifies the complex. The distinction is also contradicted implicitly by statements made later in the same paragraph (Stephen Darby, University of Southampton)	I agree. The paragraph has been changed.
381	37331	3	10	38	0	51	Ono et al.(2011) have mentioned increase of risk of sedimentation deposition in reservoirs of Japan. Also this makes decrease of water storage capacity for water supply. (K. Ono, T. Akimoto, L. N. Gunawardhana, S. Kazama, and S. Kawagoe, Distributed specific sediment yield estimations in Japan attributed to extreme-rainfall-induced slope failures under a changing climate, Hydrology and Earth System Science, Vol.15, pp.197-207, 2011.) (So Kazama, Tohoku University)	Interesting paper, that this refers to future changes not to observed ones that can be attributed to climate change.
382	39331	3	10	38	10	41	is it really climate change or climate variability? (Maria Assuncao Silva Dias, University of Sao Paulo)	Climate change is fine. It is refered to impacts of global warming.
383	36027	3	10	38	10	51	Again, I did not see any mention of the 3-Gorges dam when looking at the sediment load in the Yangtze (Michael Brewer, NOAA)	Why should 3-gorges be mention?. Not understand this point.
384	36080	3	10	38	10	51	Effects of climate change on sedimentation are discussed based on studies which are all specific to particular regions. This must be acknowledged and generic conclusions based on this must be avoided. Also, more evidence of climate change in tropical cyclones is sought. (Pradeep MUJUMDAR, Indian Institute of Science)	Agree. Changed.
385	36079	3	10	39	10	39	It is not clear what is 'contemporary sediment transport'. (Pradeep MUJUMDAR, Indian Institute of Science)	Changed them
386	50052	3	10	41	10	43	The chapter team could consider using calibrated uncertainty language, such as summary terms for evidence and agreement, to characterize the evidence described on lines 41 and 43. (Katharine Mach, IPCC WGII TSU)	accepted and revised.
387	46896	3	11	3	11	4	Should use updated study by Yao Tandong ("Different glacier status with atmospheric circulations in Tibetan Plateau and surroundings" (2012), Yao, T., et al. Nature Clim. Change, http://www.nature.com/news/tibetan-glaciers-shrinking-rapidly-1.11010) (Katy Yan, International Rivers)	The section is not in cryospheric changes, and the cite gives a % of glacial retreat on the region where sediment production estimates were analyzed.
388	44200	3	11	7	0	0	Editorial: An instead of Aan (Georg Kaser, University of Innsbruck)	accepted and revised.
389	39264	3	11	7	11	7	"Aan" should be "An" (XIAOSHENG QIN, Nanyang Technological University)	accepted and revised.
390	48258	3	11	7	11	7	An instead of A (Malini Nair, Indian Institute of Science)	accepted and revised.
391	44591	3	11	7	11	8	"An increasing trend… of the large Asian rivers Yangtze River.." Any other river or just the Yangtze? (Martina Flörke, University of Kassel)	The sentence was changed.
392	36081	3	11	10	11	10	How is the soil erosion rate determined for the last 364 years? The span is beyond instrumental records – was any form of climate reconstruction used for generating the data? (Pradeep MUJUMDAR, Indian Institute of Science)	This was changed.
393	39265	3	11	10	11	13	Please check the units of soil erosion rate. Is it mm/yr or m/yr? (XIAOSHENG QIN, Nanyang Technological University)	The sentence and reference was deleted.
394	50053	3	11	11	11	11	For the statement on this line, it would be helpful to clarify if this change has been attributed to climate change in a formal sense, as implied by "due to climate change." (Katharine Mach, IPCC WGII TSU)	This was clarified.
395	52678	3	11	16	0	25	These two paragraphs are very important in decision making. Their appropriate expansion is a must and should incorporate the importance of "virtual water" and its value as an externality (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	unfortunately, the subsection was dropped, however, virtual water is discussed under the context of adaptation option in 3.6.1
396	43509	3	11	16	11	19	The section on water use and availability is limited though I note the text which states the section will be devloped. A discussion of the work by Vorosmarty et al 2000 would seem appropriate. This paper is already in the reference list. (Andrew Wade, University of Reading)	unfortulately the subsection was dropped.
397	39332	3	11	16	11	31	should this very short sections be mantained? (Maria Assuncao Silva Dias, University of Sao Paulo)	accepted and dropped.
398	47968	3	11	27	11	30	The statement about increasing trend of drought events with significant socioeconomic impacts should be somehow qualified. Discuss the quality of recorded drought--related impact data and growing population (Jaroslav Mysiak, Fondazione Eni Enrico Mattei; and Euro-Mediteranean Center for Climate Change)	This section has been deleted.
399	36082	3	11	46	11	46	More suitable to replace 'precipitable water' with 'total precipitable water' to avoid confusions with convective fractions of precipitable water. (Pradeep MUJUMDAR, Indian Institute of Science)	Our usage is unambiguous in context and conforms with the AMS Glossary of Meteorology.
400	52679	3	11	49	0	0	Physically-wise, the water vapour ´ s atmosphere capacity depends on its temperature. Further, the qualification strongly is misleading and shall be cancel out. To obviate any doubt, the suggestion is to amend the first phrase in line 49, to read as follows: " The atmosphere water vapour storage capacity depends on its temperature" (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	We do not think that this would improve clarity.
401	37333	3	11	49	0	51	Please consider to rewrite this part. (So Kazama, Tohoku University)	This comment offers no guidance on how to rewrite.
402	48261	3	11	50	3	50	Clausius-Clapeyion description is too technical without follow up explanation in Appendix (Malini Nair, Indian Institute of Science)	The only technical term, specific humidity, is explained at L47. We could delete "the Clausius-Clapeyron description of", but that would be a disservice to more technical readers without assisiting less technical readers.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
403	36085	3	12	0	0	0	In Box 3-1, 'Evapotranspiration' instead of 'Evaporation' would be more correct. (Figure 3-3 also mentions 'evapotranspiration' instead of 'evaporation'). (Pradeep MUJUMDAR, Indian Institute of Science)	Done.
404	36087	3	12	0	0	0	Section 3.3.1.2: the scale issues that arise when using climate models for regional hydrological impact assessment studies, especially variability of precipitation within a climate model grid box and the related uncertainties need to be discussed in greater details. (Pradeep MUJUMDAR, Indian Institute of Science)	Downscaling is discussed briefly at P13 L2-3. We have expanded that sentence.
405	36083	3	12	1	12	1	'precipitable water has increased on average' – in this context, reference to articles Santer et al., 2007 (Santer, B. D., C. Mears, F. J. Wentz, K. E. Taylor, P. J. Gleckler et al. (2007), Identification Of Human Induced Changes In Atmospheric Moisture Content, Proc. Natl. Acad. Sci. USA, 104, 15248–15253) and Santer et al., 2009 (Santer, B. D., Taylor, K. E., Gleckler, P. J., Bonfils, C., Barnett, T. P., Pierce, D. W. et al. (2009), Incorporating model quality information in climate change detection and attribution studies. Proc. Natl. Acad. of Sci. USA, 106(35), 14778-14783) can be included. (Pradeep MUJUMDAR, Indian Institute of Science)	Hartmann et al. 2013 cite Santer et al. 2007 (the more relevant of the two suggested citations).
406	48995	3	12	4	12	5	Rather than just saying that CO2 exerts a physiological control on plants affecting transpiration, it would be clearer to say what direction this effect is on transpiration (higher CO2: reduced transpiration). A cross-reference to Chapter 4 section 4.2.4.4 would probably be useful here. (Richard Betts, Met Office Hadley Centre)	Changed "control" to "reduction", with further rewording to make the sentence less conditional, and a citation of Betts et al. 2007 (see comment #422).
407	36084	3	12	13	12	15	Box 3-1: It is much more convenient to express the statement in the form of a mathematical equation. (Pradeep MUJUMDAR, Indian Institute of Science)	We agree, but in avoiding equations we have our less technical readers in mind.
408	36086	3	12	19	12	19	'surface water balance is simply the sum of precipitation, evaporation and runoff' – the statement is not correct (since balance refers to an equation, and not a sum). Instead, ''surface water balance simply considers precipitation, evaporation and runoff' would be more appropriate. (Pradeep MUJUMDAR, Indian Institute of Science)	Whether the balance is the equation or just the right-hand side of the equation (the change of storage) is a matter of usage. We prefer the second usage.
409	45940	3	12	37	12	41	See my general comment for Chapter 3. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	This refers to comments #50, #51 and #52. We could not find the PDF sheet mentioned by the reviewer in #51 and #52. #50: We intend to rely on CMIP5 rather than CMIP3 to the extent possible. #51: "inaccurate modelling of the atmospheric response to external forcing" is simply an expanded version of "[climate] model uncertainty", which is clear in the context; the reviewer seems to have understood it as "inaccurate modelling of the hydrological response to atmospheric forcing". #52: How to present uncertain futures to policymakers is a question separate from that being addressed here, namely how to isolate the main sources of uncertainty.
410	43175	3	13	0	0	0	Under 3.3.1.3, information regarding Glaciers Response to changing climatic condition may be added (GHAZANFAR ALI, GLOBAL CHANGE IMPACT STUDIES CENTRE (GCISC))	Section 3.3.1.3 is about the atmosphere. Implications for the cryosphere are touched on at L16-17 and L23, but this is not the place for a discussion of impacts on glaciers.
411	39048	3	13	2	13	3	although previous research has shown that downscaling-related uncertainty is generally smaller than that relating to inter-GCM uncertainty: Prudhomme & Davies, 2009, Assessing uncertainties in climate change impact analyses on the river flow regimes in the UK. Part 2: future climate, Climatic Change, 93, 197-222) (Daniel Kingston, University of Otago)	We now cite Prudhomme, C., and H. Davies, 2009, Assessing uncertainties in climate change impact analyses on the river flow regimes in the UK. Part 2: future climate, Climatic Change, 93, 197-222.
412	45981	3	13	2	13	3	See e.g. Hagemann et al. (2011). The use of hydrological models adds further uncertainty as models are often tuned to present-day conditions. (Hagemann, Stefan, Cui Chen, Jan O. Haerter, Jens Heinke, Dieter Gerten, Claudio Piani, 2011: Impact of a Statistical Bias Correction on the Projected Hydrological Changes Obtained from Three GCMs and Two Hydrology Models. J. Hydrometeor, 12, 556–578. doi: http://dx.doi.org/10.1175/2011JHM1336.1) (Rutger Dankers, Met Office Hadley Centre)	Hagemann et al. attribute most of the uncertainty identified by their bias correction to the GCMs rather than to the hydrological models.
413	44592	3	13	3	0	0	is the drainage-basin scale the only scale of interest? (Martina Flörke, University of Kassel)	Deleted "at the drainage-basin scale".
414	45983	3	13	6	0	0	Section 3.3.1.3: If possible, update with results from CMIP5 (Rutger Dankers, Met Office Hadley Centre)	We will update from the SOD of WG1 Ch12.
415	50054	3	13	6	0	0	Section 3.3.1.3. For material in this section, the author team may wish to consider and cross-reference the findings of the working group 1 contribution to the 5th assessment report. (Katharine Mach, IPCC WGII TSU)	Collins et al. 2013 IS the WG1 contribution.
416	44593	3	13	10	0	0	Do the authors refer to CMIP3 or CMIP5? (sounds like CMIP5) (Martina Flörke, University of Kassel)	We will update from the SOD of WG1 Ch12.
417	50055	3	13	11	13	11	Do other citations or chapter sections contain information supporting the findings presented here? (Katharine Mach, IPCC WGII TSU)	We will update from the SOD of WG1 Ch12, with particular attention to their calibrated language.
418	35429	3	13	16	0	0	Except that warming on Antarctic Peninsula is as high as most of the Arctic. (David Vaughan, British Antarctic Survey)	Added "south of the Antarctic Peninsula" after "Antarctica".
419	45941	3	13	18	13	19	See my comment on Chapter 3, Page 2, Line 45 and 51. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	See response to comment #112.
420	50056	3	13	18	13	34	For these examples, the chapter team could consider further indicating its degree of certainty in the statements with use of calibrated uncertainty language. Additionally, would it be beneficial to further qualify the statements provided on lines 18-19 and 30? Finally, is it possible to provide citations supporting the statements on lines 29-34? (Katharine Mach, IPCC WGII TSU)	A. We will update from the SOD of Ch12, but we are reluctant to add calibrated language of our own where it is not found in Collins et al. 2013. B. Annotation A also applies to L18-19 and L30. C. We now cite Collins et al., 2013 at L29.
421	39049	3	13	26	13	26	1900-1929 is a strange and uncommon baseline to use - parhaps some comment could be made to highlight or further explain this? (Daniel Kingston, University of Otago)	Added "the first 30-year period available in the observations".

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
422	48996	3	13	28	13	28	I think there should be some mention of the effect of CO2 physiological effects on projected future hydrological changes here, as the effects of this on simulated runoff projections have been quantified and appear to be significant. One relevant paper is Betts, R.A., Boucher, O., Collins, M., Cox, P.M., Falloon, P.D., Gedney, N., Hemming, D.L., Huntingford, C., Jones, C.D., Sexton, D.M.H., and Webb, M.J., 2007: Projected increase in continental runoff due to plant responses to increasing carbon dioxide. Nature, 448, 1037-1041 although this does not use CMIP3 or CMIP5 projections. A more recent paper looking at this effect in a climate model ensemble using an SRES scenario has recently been submitted by Wiltshire et al, I can provide a copy to the authors. There are other papers also showing significant effects in other models, eg: Gerten et al, Bala et al. (Richard Betts, Met Office Hadley Centre)	Section 3.3.1.3 is a digest of hydrologically essential findings from WG1. However at P12 L5 we now cite Betts et al. 2007 (see comment #406). Betts, R.A., Boucher, O., Collins, M., Cox, P.M., Falloon, P.D., Gedney, N., Hemming, D.L., Huntingford, C., Jones, C.D., Sexton, D.M.H., and Webb, M.J., 2007, Projected increase in continental runoff due to plant responses to increasing carbon dioxide, Nature, 448, 1037-1041.
423	39050	3	13	29	13	29	"fairly clear" is a bit vague - can you be more precise? (Daniel Kingston, University of Otago)	"fairly clear" is a deliberately vague assessment of the text of Collins et al. 2013.
424	45982	3	13	29	13	34	Please add references for these claims (Rutger Dankers, Met Office Hadley Centre)	See annotation C on comment #420.
425	45942	3	13	31	13	33	These results should be presented in view of observed uncertainty in 20th century climate simulations (Kumar et al. (b) submitted to Journal of Climate). Also see my comment in Chapter 26, Page 7, Line 47 (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	We consider the introduction at L29 to be a sufficient acknowledgement of uncertainty.
426	45943	3	13	34	13	34	Do greater evaporative demand results into lesser water availability? Please clarify. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	The answer depends on the meaning of "water availability". But here we are simply summarizing projections of the climatic drivers, not exploring hydrological impacts.
427	45984	3	13	37	0	0	Section 3.3.1.4: If possible, update with results from CMIP5 (Rutger Dankers, Met Office Hadley Centre)	This update is in progress, based on Kharin et al. 2012 (Journal of Climate, submitted).
428	50057	3	13	37	0	0	Section 3.3.1.4. For material in this section, the author team may wish to consider further and cross-reference the findings of the working group 1 contribution to the 5th assessment report. (Katharine Mach, IPCC WGII TSU)	We will cross-check the WG1 SOD. But it is essential that readers of our chapter should have an explicit assessment of projected changes in the extremes of climatic drivers of hydrology.
429	44884	3	13	37	14	6	Talking about precipitation extremes and projections for 2081 to 2100: you should also mention how confident those trends are. (Sabine Wurzler, LANUV NRW)	We will include assessments of confidence when updating this section for the SOD.
430	47164	3	13	41	13	42	It would be good to provide a better explanation for this phenomenon. "Emptying" does not really explain this. (Keith Nichols, Caribbean Community Climate Change Centre)	The reason is the projected increase in precipitable water. The verb "empty" is an attempt to demystify the science for general consumption. The sentence has been rearranged for greater clarity.
431	36088	3	13	43	13	43	'Another reason....most heavy thundertstorms' – reference for this reasoning/statement is sought. (Pradeep MUJUMDAR, Indian Institute of Science)	Text rearranged to clarify that this second reason is also from Collins et al. 2013.
432	39266	3	13	45	13	46	Please list the country or study region for the statement. (XIAOSHENG QIN, Nanyang Technological University)	Changed "Annual maxima" to "Globally, annual maxima".
433	36089	3	13	45	13	50	Projections for 2081-2100 are mentioned. However, it would be worthwhile to include a discussion on how the rainfall extremes are likely to vary in the near future (next 3 to 4 decades). Also, since extreme rainfall impacts will have severe impacts locally, scale issues while modelling extreme climate drivers (especially rainfall) needs to be discussed. (Pradeep MUJUMDAR, Indian Institute of Science)	We will address the first of these points directly from Kharin et al. 2012 (an update of Kharin et al. 2007). It wil be harder to offer an assessment of the second point. Sample sizes are intrinsically small in the study of extremes, and reliability is inversely proportional to both the duration and the spatial extent considered.
434	36091	3	14	0	0	0	Title of Section 3.4.1: One title out of the three alternative titles mentioned need to be chosen. (Pradeep MUJUMDAR, Indian Institute of Science)	Title is now "New Ways of Estimating Future Changes".
435	36092	3	14	0	0	0	Section 3.4.1: In the context of regional hydrological impact assessment studies from multiple GCMs and scenarios and modelling of related uncertainties, references to some recent works post IPCC AR4 namely those of Ghosh and Mujumdar, 2007 (Ghosh, S. and P. P. Mujumdar (2007), Nonparametric Methods for Modeling GCM and Scenario Uncertainty in Drought Assessment, Water Resources Research, 43, W07405, doi:10.1029/2006WR005351) and Mujumdar and Ghosh, 2008 (Mujumdar, P. P. and S. Ghosh (2008), Modeling GCM and scenario uncertainty using a possibilistic approach: Application to the Mahanadi River, India, Water Resources Research, 44, W06407, doi:10.1029/2007WR006137) can be included. (Pradeep MUJUMDAR, Indian Institute of Science)	Due to lack of space, we can not cite them.
436	48262	3	14	0	15	0	Hydrological impact Models of South Asia by R. Srinivasan, Sandhya Rao and N H Ravindranath (Malini Nair, Indian Institute of Science)	We have not been able to locate this incompletely-referenced source.
437	45985	3	14	1	14	2	Strictly speaking, Pall et al. (2011) found that the floods that took place in England and Wales in 2000 were substantially more likely to occur in their models when the effect of climate change due to anthropogenic emissions in the past century was included. (Rutger Dankers, Met Office Hadley Centre)	The reviewer's precis of Pall et al. 2011 is correct. We think that our assessment, though shorter, is also correct.
438	35266	3	14	4	14	6	As this paragraph is about projected changes it is suggested to move the paragraph to Sectio 3.4 (Hege Hisdal, Norwegian Water Resources and Energy Directorate)	Added "meteorological" before "droughts" at P14 L4 to clarify that these projections are projections of climatic drivers (and so that the paragraph is where it ought to be).

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
439	40688	3	14	4	14	6	Examples of longer and more frequent droughts in Europe are given by Vidal and Wade (2009) for the UK and Vidal et al. (2012) for France. Vidal, J.-P. & Wade, S. D. (2009) A multimodel assessment of future climatological droughts in the United Kingdom. International Journal of Climatology, 29(14), 2056-2071. doi: 10.1002/joc.1843 Vidal, J.-P., Martin, E., Kitova, N., Najac, J. & Soubeyroux, J.-M. (2012) Evolution of spatio-temporal drought characteristics: validation, projections and effect of adaptation scenarios. Hydrology and Earth System Sciences, accepted. (Jean-Philippe Vidal, Irstea)	Vidal et al. 2012 now cited: Vidal, J.-P., Martin, E., Kitova, N., Najac, J. and Soubeyroux, J.-M., 2012, Evolution of spatio-temporal drought characteristics: validation, projections and effect of adaptation scenarios, Hydrology and Earth System Sciences, 16, 2935–2955.
440	54368	3	14	4	14	6	As mentioned in the context of the executive summary of findings, this text requires further development, in coordination with relevant assessment in the Working Group I contribution. Please clarify whether there is medium confidence in the projections of longer and more frequent droughts in the regions mentioned, and also whether the alternative is no change in droughts or less frequent droughts. Further details of the range of possible outcomes would be very helpful, perhaps supplemented by a figure communicating regional details. (Michael Mastrandrea, IPCC WGII TSU)	We discuss droughts in sections 3.2.3 (observations) and 3.4.9 (projections). This paragraph is only about projected changes in a climatic driver (meteorological drought). We will try to rationalize the organization of our assessment of droughts (and of floods).
441	43510	3	14	9	14	26	I am unsure if land cover and management and population growth are included in the scenarios referred too. Changes in land cover and management and population growth may have a greater impact on water resources than climate alone. (Andrew Wade, University of Reading)	Population and GDP are included in new SSPs but not land use change. New text will be added.
442	48997	3	14	9	14	26	I think that anthropogenic land cover change should be discussed as a non-climatic driver of hydrological change here, through the effects it has on evapotranspiration and runoff. I see it is mentioned later in section 3.4.2 (page 16 line 11) (Richard Betts, Met Office Hadley Centre)	New text on land use change will be added.
443	53872	3	14	9	14	26	The section doesn't really discuss any non-climate drivers despite the heading. Land Use, Land Cover Change, Population, ag nutrients are critical. In the case of water, these are really important and in many regions are far more important than climate change right now. (Bradley Udall, University of Colorado)	Text reformulated.
444	45944	3	14	11	14	12	See my general comment on Chapter 3, major issue # 2. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	Our sentence does not contradict your comment.
445	48073	3	14	11	14	18	Is this paragraph saying that climate and socio-economic scenarios have been de-coupled at the global scale? The paragraph could be clearer, also recognising that local socio-economic scenarios can be different to those at the global scale. (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	1) To a certain extent. 2) Paragraph will be reformulated.
446	50058	3	14	15	14	26	It would be beneficial to clarify the relevance of this material to chapter 3 or to reduce or delete it. (Katharine Mach, IPCC WGII TSU)	Modified in SOD.
447	40689	3	14	31	0	0	Table 3-2 comment: two relevant references could be added to Table 3-2: (1) Vidal et al. (2012) considered the effect of choosing among the A2, AIB and B1 emissions scenario on the projections of spatio-temporal drought characteristics over France. In the B1 scenario, the dramatic increase in all characteristics (duration, magnitude, area) is limited compared to the other scenarios; (2) Vidal and Wade (2009) found that the increase in the number and the magnitude of extreme drought events over a catchment in Scotland (but not for a catchment in Southern England) is limited by considering the B2 scenario compared to the A2 scenario (multi-GCM ensemble mean). Vidal, J.-P. & Wade, S. D. (2009) A multimodel assessment of future climatological droughts in the United Kingdom. International Journal of Climatology, 29(14), 2056-2071. doi: 10.1002/joc.1843 Vidal, J.-P., Martin, E., Kitova, N., Najac, J. & Soubeyroux, J.-M. (2012) Evolution of spatio-temporal drought characteristics: validation, projections and effect of adaptation scenarios. Hydrology and Earth System Sciences, accepted. (Jean-Philippe Vidal, Irstea)	Vidal et al. 2012 was reviewed but found not suitable for inclusion in Table 3.2 due to lack of "simple" numbers that could be put in the table.
448	37154	3	14	31	14	36	The basis for the assertion that 'it is more helpful to compare hydrological changes that may occur under different future GHG emissions scenarios' should be clarified/justified (Stephen Darby, University of Southampton)	The justification is in the clause "for supporting decisions on climate mitigation". See annotation on comment #449.
449	45945	3	14	33	14	35	"…… to compare hydrologic changes …. under different GHG emissions scenarios". This is a very good point. I am arguing the same in my general comment on Chapter 3, major issue # 2. (Sanjiv Kumar, Center for Ocean-Land-Atmosphere Studies)	See annotation on comment #448.
450	37334	3	14	36	0	0	table3-2 and page20 line 45-47, Groundwater temperature is also an important quality parameter found to be vulnerable under changing climate (potential to increase 1.0-4.3°C by the 2100 under different emission scenarios as estimated by Gunawardhana and Kazama 2012, Global and Planetary Change, Vol 86-87, pp 66-78). (So Kazama, Tohoku University)	Due to lack of space, we can not add.
451	44594	3	14	43	0	0	"Preparing Future Changes" sounds a little bit odd. A reference to Haddeland et al. 2011 and the multi-model comparison carried-out in the EU-WATCH project should be included as this model intercomparison was a novum. Haddeland, I., D.B. Clark, W. Franssen, F. Ludwig, F. Voß, N.W. Arnell, N. Bertrand, M. Best, S. Folwell, D. Gerten, S. Gomes, S.N. Gosling, S. Hagemann, N. Hanasaki, R. Harding, J. Heinke, P. Kabat, S. Koirala, T. Oki, J. Polcher, T. Stacke, P. Viterbo, G.P. Weedon, and P. Yeh, 2011, Multimodel Estimate of the Terrestrial Global Water Balance: Setup and First Results, J. Hydrometeor., 12, 869–884, doi: 10.1175/2011JHM1324.1 A note to the ongoing ISI-MIP could be included, too. (Martina Flörke, University of Kassel)	Title will be changed. Haddeland reference will be included.
452	46014	3	14	43	15	54	Section 3.4: Maybe it should be clarified that some authors take the so-called standard methodology (line 46) with a grain of salt because of the many uncertainties involved (see for example Maslin and Austin 2012, Kundzewics and Stakhiv 2010, Yu et al 2012, Rodriguez-Iturbe and Valdes 2011, Stakhiv 2011). Regarding projections, there is much work going on and the HydroPredict events every two years are an example (http://web.natur.cuni.cz/hydropredict2012/). The Water Partnership Program (WPP) and the Water Unit at the World Bank organized a workshop last November (publication pending) which concluded that there is currently no consensus on how to approach planning and hydrologic design of water resources projects under climate change uncertainty. In collaboration with other organizations are working towards creating a basis to inform the selection of a set of practical working tools useful for adaptation to climate change of water-related projects at different stages. These tools are also envisioned taking into account the information and institutional deficiencies of many developing countries and will also encompass also the engineering, economic, and financial considerations. (Luis E. Garcia, World Bank)	These comments relate to making projections for water management purposes. The aim of section 3.4.1 is to discuss approaches to the estimation of potential impacts - not necessarily for adaptation. The introductory section will make this more clear.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
453	46407	3	14	43	15	54	This text on methodological issues of modelling is very informative, but compared with other parts of Chapter 3 dealing with methodological issues, a bit lengthy, detailed and maybe too specific for an average reader. I would recommend to shorten it and to concentrate just on the uncertainties which must be respected when reading messages on scenario based modelled impacts. In this respect I am a bit afraid, that the question of model building, parametrisation/calibration is undervalued in the discussion here when compared to the uncertainty arising from climate scenarios. We have to accept, that our models are grey boxes (even most of the grid based semi-distributed and distributed models) depending on calibration on past data. This problem is widely discussed, a Central European perspective is given in Hlavčová, Kamila - Szolgay, Ján - Kohnová, Silvia - Horvát, Oliver: The limitations of accessing impacts of land use changes on runoff with a distributed model: case study of the Hron River. In: Biologia. - ISSN 0006-3088. - Vol. 64, No. 3 (2009), s. 589-593 with respect to spatial heterogeneity of catchment properties. As also discussed in Bloeschl et al. (2007) (Günter Blöschl, Sandra Ardoin-Bardin, Mike Bonell, Manfred Dorninger, David Goodrich, Dieter Gutknecht, David Matamoros, Bruno Merz, Paul Shand, Jan Szolgay: At what scales do climate variability and land cover change impact on flooding and low flows? Invited commentary. Hydrological Processes 21 (9), pp. 1241-1247in DOI: 10.1002/hyp.6669,) Hlavcova et al (2009) showed, that catchment systems include a multitude of processes that interact to various degrees and at present we cannot properly conceptualise the interactions in our models feedback loops topresent and future states of catchments. Such feedbacks are certainly not well understood especially with regard to the future climate (e.g. land surface soil moisture feedbacks associated with climate effects, feedbacks associated with soil erosion/depletion and soil formation related to climate, feedbacks to changes in albedo, surface roughness, infiltration; soil evolution with changes in vegetation zones, etc.) Some of these feedbacks may be very important for assessing the impact of climate change flows various scales. The present models structures and parameters do not usually include any information on potential feedbacks of the future hydrologic systems to climate changes. These facts should be communicated to the user and reader in this subchapter. (Jan Szolgay, Slovak University of Technology)	Agree. The paragraphs will be revised to incorporate more recent literature on the effect of model structure as well as parameterisation on uncertainty in projected impacts.
454	53873	3	14	43	15	54	This section is a nice overview. There has been some pushback that these methods lack 'actionable science', however. I've included a series of references which call into question the value of these approaches, see below. At the very least some acknowledgement of these issues needs to be made within this chapter. Perhaps the logical place is in section 3.6.5, Dealing with Uncertainty. References: Kerr, R. A. (2011a) Time to Adapt to a Warming World, But Where's the Science? Science, 334, 2. --- (2011b) Vital Details of Global Warming are Eluding Forecasters. Science, 334, 2. Kiem, A. S. & D. C. Verdon-Kidd (2011) Steps toward "useful" hydroclimatic scenarios for water resource management in the Murray-Darling Basin. Water Resources Research, 47. ---. 2009. Informing decisions in a changing climate. Washington, D.C.: National Academies Press. Nature Editorial Board (2010) Validation Required. Nature 463, 1. Water Utility Climate Alliance. 2009. Options for Improving Climate Modeling to Assist Water Utility Planning for Climate Change. ed. C. A. Joseph Barsugli, Joel Smith, Jason Vogel, 146. ---. 2010. Decision Support Planning Methods: Incorporating Climate Change Uncertainties into Water Planning. ed. M. L. Edward Means III, Jennifer Daw, Laurna Kaatz, Marc Waage, 113. (Bradley Udall, University of Colorado)	Useful references, but relevant to adaptation and decision making (3.6.5) - we will incorporate them there. See response to #452.
455	37335	3	14	45	0	0	What is the meaning of "very" in this sentence? (So Kazama, Tohoku University)	the word will be deleted.
456	37336	3	14	46	0	0	"now-standard", should it be corrected as "new-standard". (So Kazama, Tohoku University)	no, but the sentence will be rephrased.
457	42605	3	14	53	14	54	The following reference is a good example of modelling climate change impact on runoff across very large regions using large number (all available) of GCMs - Chiew et al. (2009) Estimating climate change impact on runoff across south-east Australia: method, results and implications of modelling method. Water Resources Research, 45, W10414. (Francis Chiew, Commonwealth Scientific and Industrial Research Organization - Land and Water)	Will be added to the list.
458	37330	3	15	0	0	0	please consider to reword the "locations and studies". (So Kazama, Tohoku University)	Where is this?
459	42606	3	15	4	15	7	The last sentence is directly supported by the reference Chiew et al. (2009) Influence of global climate model selection on runoff impact assessments, Journal of Hydrology, 379, 172-180 (this reference is already in the current reference list for the chapter). (Francis Chiew, Commonwealth Scientific and Industrial Research Organization - Land and Water)	Will add to the reference list.
460	42485	3	15	8	15	9	line 8&9 repetition (Same as page 14 line 19-20) … For example, whilst projected changes in crop productivity in China are uncertain, even within a single emissions scenario, irrigation has significant 9 adaptation potential (Piao et al., 2010). (Shahbaz Mushtaq, University of Southern Queensland)	not in this section - wrong reference.
461	48074	3	15	9	15	20	Note that the delta method is a form of bias correction (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	yes, but the term 'bias correction' is increasingly used to mean some method of adjusting climate model output, in contrast to the delta method. The text will be rephrased.
462	48076	3	15	9	15	20	The wider point here is to ask whether RCMs are believable. This can be tested for the past, but that is not a guarantee for the future. (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	Agree.
463	48075	3	15	14	15	16	It is unclear why this is the case - is the future simulation also adjusted? (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	We will rephrase.
464	37337	3	15	30	0	38	Please explain what kinds of model parameters are considered. It will be helpful for a clear understanding. (So Kazama, Tohoku University)	The model parameters will depend on the models used, so this would not be useful - but the section is being rephrased.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
465	45986	3	15	30	15	31	This assumption adds further uncertainty. Merz et al. (2011) found that the impact on simulated runoff of assuming time invariant parameters can be very significant. (Merz, R., J. Parajka, and G. Blöschl (2011), Time stability of catchment model parameters: Implications for climate impact analyses, Water Resour. Res., 47, W02531, doi:10.1029/2010WR009505.) (Rutger Dankers, Met Office Hadley Centre)	Thanks for the useful reference.
466	46143	3	15	30	15	31	The problem of non-stationarity is an issue that worries water resources and hydrologic engineering practitioners. See for example Milly et al., (2008) and Olsen et al., (2010). (Luis E. Garcia, World Bank)	See response to comment #452.
467	45987	3	15	30	15	38	This section discusses parameter uncertainty in hydrological models, but ignores model structural uncertainty. Bae et al. (2011 - already cited) for example, found major differences in runoff change under the same climate change simulations, dependent on the model that was used, as well as the method for calculating PET. Similarly, hydrological models do not commonly incorporate the effect of CO2 on plant evapotranspiration, but this has been shown to change projections of runoff, see e.g. Betts et al. (2007 - cited before but not included in the references) (Betts et al. (2007): Projected increase in continental runoff due to plant responses to increasing carbon dioxide. Nature 448, 1037-1041 (30 August 2007) | doi:10.1038/nature06045) (Rutger Dankers, Met Office Hadley Centre)	We will revise the section to include structural uncertainty.
468	40303	3	15	32	15	32	Bastola, S., Murphy, C. and Sweeney, J. (2011) Evaluation of the transferability of hydrological model parameters for simulations under changed climatic conditions. Hydrology and Earth System Sciences, 8, 5891- 5915 (available at http://www.hydrol-earth-syst-sci-discuss.net/8/5891/2011/hessd-8-5891-20...) (John Sweeney, National University of Ireland Maynooth)	Thanks for the useful reference.
469	40304	3	15	35	15	35	Even with a relatively large multi climate model based approach , the role of hydrological model parameter and structural uncertainty can be considerable. (Bastola, S., Murphy, C., Sweeney, J (2011) Role of hydrological model uncertainty in climate change impact studies, Advance in water Resources, 34, 5, 562-576. (John Sweeney, National University of Ireland Maynooth)	Thanks for the useful reference.
470	42607	3	15	35	15	38	The statement attributed to Vaze et al. (2010) is not strictly correct. The Vaze et al. paper concludes that for changes in mean annual rainfall up to 10-15%, calibrated rainfall-runoff models are generally sufficiently robust for climate change impact on runoff predictions. But, in south-eastern Australia, where the recent climate has been drier and the projections indicate a drier future, there is good reason for calibrating models against the more recent data for future predictions. (Francis Chiew, Commonwealth Scientific and Industrial Research Organization - Land and Water)	We will rephrase this.
471	36093	3	15	40	15	49	The 'top-down' approach mentioned appears interesting, however, that it was not further pursued in other related studies in the next few years is curious. What are the implications in this procedure and how it is superior to the standard practice need to be discussed. (Pradeep MUJUMDAR, Indian Institute of Science)	We do not say this - we will rephrase the text to avoid misinterpretation.
472	46144	3	15	40	15	54	Other approaches have also been proposed. For example, An expansion of the concept of ''robust decision making,'' coupled with existing analytical tools and techniques, has been proposed as the basis for a new approach advocated for planning and designing water resources infrastructure under climate uncertainty. This approach calls for the suite of decision rules and evaluation principles used for project justification to be aligned to be more compatible with the implications of a highly uncertain future climate trajectory, so that the hydrologic effects of that uncertainty are correctly reflected in the design of water infrastructure (Stakhiv, 2011). (Luis E. Garcia, World Bank)	See response to comment #452.
473	46145	3	15	40	15	54	Another example proposes a flexible framework for combining information from climate models with the best features of 'bottom-up' (or vulnerability-led) approaches towater management. A management process that could evolve with changing circumstances. It provides an example of how relatively simple adjustments to the way water managers set about making decisions and gathering information could improve resilience to climate change. Crucially, their method is appropriate for the type of information that climate scientists currently provide, if society is prepared to monitor and manage emerging climate risks (Brown et al., 2011). The suggested framework is only feasible if other support systems are in place, such as well-designed, well-maintained and continuously funded monitoring networks (Wilby 2011). (Luis E. Garcia, World Bank)	See response to comment #452.
474	46146	3	15	40	15	54	Some report that some experts contest that climate models were not originally conceived to solve adaptation problems and that palaeohydrological evidence could do a better job of testing system performance under extreme conditions that have actually occurred (Kundzewics and Stakhiv, 2010). Wilby (2011) reports that others assert that water management is already in crisis in large parts of the developing world, and that the imperative is not uncertainty about the future, but the certainty of present scarcity. (Luis E. Garcia, World Bank)	See response to comment #452.
475	48077	3	15	49	15	49	More widely suitable because it get to the level of the impact domain. (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	We will rephrase.
476	48078	3	15	49	15	54	Note that this method is intensive in terms of model runs. (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	we will make this point.
477	44641	3	15	50	15	54	This paragraph should continue according to the abstract of the paper that the method enables a quick appraisal also for the case when new scenarios become available. (Sarka D. Blazkova, T.G. Masaryk Water Research Institute)	we will make this point.
478	54361	3	16	3	0	0	Section 3.4.2: Please consider revisions to this section that more clearly link its discussion to the first finding of the Executive Summary, which mentions evapotranspiration. That ES finding states that evapotranspiration will increase, while the discussion here is more nuanced, and it would be helpful to understand more clearly how the discussion in this section leads to the conclusion highlighted in the ES. (Michael Mastrandrea, IPCC WGII TSU)	changes have been made in the ES and in the chapter, to better point out the details.
479	48999	3	16	3	16	36	I suggest cross-referencing with Chapter 4 section 4.3.2.4 would be useful here. (Richard Betts, Met Office Hadley Centre)	Due to lack of space we can not cite it.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
480	48998	3	16	10	16	11	Good to see the effect of CO2 concentration on canopy conductance mentioned. However this statement should be supported by references. (Richard Betts, Met Office Hadley Centre)	noted, it is supported by one reference.
481	46408	3	16	13	16	17	This text repeats statements given on page 5 , line 36 to 40. (Jan Szolgay, Slovak University of Technology)	accepted, deleted
482	50059	3	16	17	16	17	It would be helpful to further specify what the "paradox" is for a reader unfamiliar with it. (Katharine Mach, IPCC WGII TSU)	the whole paragraph has been deleted, as it is already stated in section 3.2.
483	36094	3	16	21	16	22	In the context of stomatal openings influencing river runoff by controlling evapotranspiration, reference to Gedney et al. (2006) (Gedney, N., P. M. Cox, R. A. Betts, O. Boucher, C. Huntingford and P. A. Stott, (2006), Detection of a direct carbon dioxide effect in continental river runoff records. Nature 439, 835-838) can be included. (Pradeep MUJUMDAR, Indian Institute of Science)	included the reference.
484	37338	3	16	28	0	0	PET has not been defined before. (So Kazama, Tohoku University)	included the full words.
485	50060	3	16	28	16	28	What the acronym on this line stands for should be indicated explicitly. (Katharine Mach, IPCC WGII TSU)	included the full words.
486	40690	3	16	28	16	36	Kay and Davies (2008) compared the temperature-based Oudin formula with a version of the Penman–Monteith formula, with inputs from five GCMs and eight RCMs over the UK, in both present and future climate. They found that both methods lead to quite different changes in PET for the end of the century under the A2 emissions scenario, with no method giving systematically higher changes than the other, depending on the month of the year and the location. Ekström et al. (2007) compared the Blaney-Criddle and Penman-Monteith formulas for a case study in North-West England, with inputs from the HadRM3H RCM in both present and future climates. They found that the Blaney-Criddle formulation lead to much smaller changes that the Penman-Monteith formula. Ekström, M., Jones, P. D., Fowler, H. J., Lenderink, G., Buishand, T. A. & Conway, D. (2007) Regional climate model data used within the SWURVE project 1: projected changes in seasonal patterns and estimation of PET. Hydrology and Earth System Sciences, 11(3), 1069-1083. doi: 10.5194/hess-11-1069-2007 Kay, A. L. & Davies, H. N. (2008) Calculating potential evaporation from climate model data: A source of uncertainty for hydrological climate change impacts. Journal of Hydrology, 358(3-4), 221-239. doi: 10.1016/j.jhydrol.2008.06.005 (Jean-Philippe Vidal, Irstea)	partly included.
487	45988	3	16	28	16	36	See also Bae et al. (2011 - already cited) (Rutger Dankers, Met Office Hadley Centre)	included the reference.
488	39051	3	16	34	16	35	Out of the 30 GCM and PET method combinations (6 PET methods, 5 GCMs) investigated by Kingston et al (2009, Geophysical Research Letters), 27 resulted in an increase in arid areas, three did not. (Daniel Kingston, University of Otago)	Yes, interesting results, but we this part has to be shortened, so we leave it out.
489	49000	3	16	34	16	35	What is the confidence in this projection of increased arid areas at 2 degrees? It seems to be only one study. Also it seems a rather vague statement - how much of an increase in arid areas is projected in that study? (Richard Betts, Met Office Hadley Centre)	text was not revised on this issue.
490	45989	3	16	39	0	0	Section 3.4.3: permafrost is not discussed at all (Rutger Dankers, Met Office Hadley Centre)	accepted and the section is totally revised.
491	45990	3	16	39	0	0	Section 3.4.3: this section may benefit from projections that will be produced within the framework of the ISI-MIP project (http://isi-mip.org/), based on CMIP5 climate projections. (Rutger Dankers, Met Office Hadley Centre)	noted, due to lack of space, wa can not cite it.
492	50061	3	16	39	0	0	Section 3.4.3. For material in this section, the chapter team may wish to consider further and cross-reference the findings of the working group 1 contribution to the 5th assessment report. (Katharine Mach, IPCC WGII TSU)	noted, Ch4 WGI is cited.
493	39311	3	16	41	16	52	Permafrost is missing - see general remarks on chapter 3 (Wilfried Haeberli, University of Zurich)	accepted and the section is totally revised.
494	36095	3	16	46	16	46	What is the nature of the relationship between decreasing soil moisture and increasing risk of extreme hot days? A brief mention on this is sought. (Pradeep MUJUMDAR, Indian Institute of Science)	accepted and the section is totally revised.
495	50062	3	16	48	16	49	The timeframe for the described doubling could be clarified, along with the relevant geographic area (a global result?). (Katharine Mach, IPCC WGII TSU)	accepted and the section is totally revised.
496	49001	3	16	48	16	52	Over what time period(s) were these changes projected? (Richard Betts, Met Office Hadley Centre)	accepted and the section is totally revised.
497	50063	3	17	1	0	0	Section 3.4.4. For material in this section, the chapter team may wish to consider further the findings of the working group 1 contribution to the 5th assessment report. (Katharine Mach, IPCC WGII TSU)	The chapter team member (G. Cogley) responsible for section 3.4.4 is also a contributing author in WG1 Ch04. Liaison between the two chapters will continue.
498	43378	3	17	5	0	0	Section 3.4.4.1: This is a concise and well balanced paragraph. My only suggestion is to include some more references. Section 3.4.4.2: Similarly, as for the previous section, my impression is that this is a well-balanced piece of text that adequately reflects the current state in this field. (Christian Huggel, University of Zurich)	Thank you. We will consider adding references, but the chapter is already too long (by two thirds).
499	52680	3	17	5	19	0	The WG 2 `s attribution, calls for a reference on GLOFs Their importance so recommends. (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	Glacer-lake outburst floods are discussed in Box 3-2, at P42 L6-10.
500	52839	3	17	13	0	0	" There have been published analyses and results based on field studies in the European Alps prior to 1990 dealing with the information content of various meteorological variables with view to glacier melt and runoff, which might be useful to advance forward in these problems (inter alia : Lang,H. and Braun,L.1990: On the information content of airtemperature with view to melt rate determination. IAHS Publ.no. 190, 347 - 354)" (Herbert Lang, ETH Zürich)	There is an enormous literature on temperature-index modelling of surface ablation on glaciers. Regrettably, we cannot afford more citations than the two at P17 L6.
501	47021	3	17	15	0	0	"has yet to be attempted". Please check if the following publication is already in this direction: Kotlarski, S., Jacob, D., Podzun, R. and Paul, F. (2010): Representing glaciers in a regional climate model. Climate Dynamics, 34 (1), 27-46. (Frank Paul, University of Zurich)	Now cited in a revised sentence: Kotlarski, S., Jacob, D., Podzun, R. and Paul, F., 2010, Representing glaciers in a regional climate model. Climate Dynamics, 34 (1), 27-46.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
502	44201	3	17	15	17	18	A series of papers discussion downscaling improvements have appeared recently: e.g. HOFER, M., et al. 2010. Empirical-statistical downscaling of reanalysis data to high-resolution air temperature and specific humidity above a glacier surface (Cordillera Blanca, Peru). Journal of Geophysical Research-Atmospheres, 115 and MÖLG, T. & KASER, G. 2011. A new approach to resolving climate-cryosphere relations: Downscaling climate dynamics to glacier-scale mass and energy balance without statistical scale linking. Journal of Geophysical Research, 116, D16101 but also others. A statement supported by one or the other reference may be useful to show where the way meay go in near future. (Georg Kaser, University of Innsbruck)	Mölg and Kaser 2011 now cited in a revised sentence: Mölg, T., and G. Kaser, 2011, A new approach to resolving climate-cryosphere relations: Downscaling climate dynamics to glacier-scale mass and energy balance without statistical scale linking, Journal of Geophysical Research, 116, D16101.
503	48185	3	17	16	17	18	Use of climate model data is challenging only if the climate data are used directly from GCMs. Line 6 on page 19 states that “GCM scenarios always need to be downscaled before they can be used as input of hydrological models”. (David Sauchyn, University of Regina)	This comment is slightly out of focus. Direct use of GCM output produces wrong glaciological results. What is challenging is the necessary sub-grid-scale parameterization. Changed "The task" at P17 L15 to "At present, sub-grid-scale parameterization".
504	48186	3	17	23	17	23	Is it appropriate to use a reference dated 2013? (David Sauchyn, University of Regina)	Yes. This is just a placeholder for AR5 WG1 Ch13.
505	39312	3	17	23	17	32	The mentionned change in water supplyand the formation of new lakes can be directly applied to hydropower production and future development of new hydropower potential. Reference: Terrier, S., Jordan, F., Schleiss, A.J., Haeberli, W., Huggel, C. and Künzler, M. (2011): Optimized and adapted hydropower management considering glacier shrinkage scenarios in the Swiss Alps. Proceedings of the International Symposium on Dams and Reservoirs under Changing Challenges - 79th Annual Meeting of ICOLD, Swiss Committee on Dams, Lucerne, Switzerland (Schleiss, A. & Boes, R.M., Eds), Taylor & Francis Group, London, 497 - 508. (Wilfried Haeberli, University of Zurich)	We do not think we can afford a reference on water supply in addition to Huss 2011.
506	47022	3	17	26	0	0	"warming climate": please avoid the use of warming climate or climate warming as it is physical non-sense (you cannot warm climate). Please use higher or increasing temperatures (Frank Paul, University of Zurich)	Reworded.
507	47023	3	17	26	0	0	When you refer with 'glaciers shrink' not only to extent (area) but also to thickness (volume loss), this is not entirely true. For large glaciers the contribution to runoff will first increase as they will lose a lot of volume by down-wasting (surface coming to lower elevations) without changing their size substantially. The shift of the peak will only occur after the glacier is much smaller (in size). See also L36 ff on this page where this is actually explained. (Frank Paul, University of Zurich)	Our generalized statements about relative contribution and the seasonal shift are correct; we do not mention quantitative details such as the time required for the shift to become noticeable. In fact we use "shrink" to refer to reduction of area, but loss of volume and mass is of course entailed as well. (We understand "When" to mean "If" here, that is, it is German wenn.)
508	50064	3	17	26	17	28	Given the description on line 27, the chapter team could consider using calibrated uncertainty language to characterize its degree of certainty in the shift. (Katharine Mach, IPCC WGII TSU)	"one of the most reliably expected" altered to "expected with very high confidence as a".
509	44202	3	17	28	17	32	Additional useful papers: KOBOLTSCHNIG, G. R., SCHÖNER, W., ZAPPA, M. & HOLZMANN, H. 2007. Contribution of glacier melt to stream runoff: if the climatically extreme summer of 2003 had happened in 1979. Annals of Glaciology, 46, 303-308. and KOBOLTSCHNIG, G. R., SCHÖNER, W., ZAPPA, M., KROISLEITNER, C. & HOLZMANN, H. 2008. Runoff modelling of the glacierized Alpine Upper Salzach basin (Austria): multi-criteria result validation. Hydrological Processes, 22, 3950-3964. The first one maybe better in the next section (lines 34 - 35) (Georg Kaser, University of Innsbruck)	Koboltschnig et al. 2007 now cited at P17 L35: Koboltschnig, G.R., W. Schöner, M. Zappa, C. Kroisleitner and H. Holzmann, 2007, Contribution of glacier melt to stream runoff: if the climatically extreme summer of 2003 had happened in 1979, Annals of Glaciology, 46, 303-308.
510	48187	3	17	29	17	31	Yes “the relative importance of high-summer glacier meltwater can be substantial” but mostly in small alpine basins and once the winter snowpack has ablated. In larger basins, and where snow tends to persist at high elevation (in the mid-latitude Andes and Rockies for example) the relative contribution of glacier melt water tends to quite a bit less, except perhaps during hot dry summers. (David Sauchyn, University of Regina)	The work of Huss 2011 tends to contradict this point. Moreover, by glaciological definition the snow is transient. It is that part of the frozen water that fails to survive the summer.
511	50065	3	17	30	17	42	For the statements on lines 30-32 and 41-42, the chapter team should consider indicating the relevant climate/socio-economic scenarios as appropriate. (Katharine Mach, IPCC WGII TSU)	Scenarios now identified at P17 L32.
512	48188	3	17	39	17	44	These studies, from China and Europe, project peak meltwater in a future decade. Studies from the America cordillera, on the hand, suggest that the ‘meltwater dividend’ has past (see Baraer, et al. 2012; Journal of Glaciology) (David Sauchyn, University of Regina)	See annotation on comment #897. It appears that some clarification of the concept of peak meltwater is needed. Given the assumptions in the text, and plausible rates of change, there will be a peak later than the starting date for any choice of the starting date.
513	54362	3	17	42	17	44	It would be helpful to explain the basis for this assignment of medium confidence a bit further. Is confidence not high because of uncertainty in the timing of the peak across assessed literature (whether that peak occurs this century), or because the literature does not cover all inhabited glacierized regions? Providing a bit more information about the reasons why confidence is not high would be helpful here. (Michael Mastrandrea, IPCC WGII TSU)	Sentence now begins "Pending further regional-scale investigations, there is … ."
514	36096	3	17	44	17	44	It would be worthwhile to briefly mention what the current ‘meltwater dividend’ implies in terms of water availability or flooding/droughts. (Pradeep MUJUMDAR, Indian Institute of Science)	As far as we are aware, these implications have not yet been considered in detail in the literature.
515	39052	3	17	46	17	46	what is a "real glacierized basin"? (Daniel Kingston, University of Otago)	Deleted "In real glacierized basins,".
516	48189	3	17	46	17	46	‘real’ as opposed to virtual? (David Sauchyn, University of Regina)	Deleted "In real glacierized basins,".
517	48190	3	17	49	17	50	Is Peru’s Cordillera Blanca the only exception to the conclusion reached at the end of the previous paragraph, or perhaps declining meltwater production is more widespread? (David Sauchyn, University of Regina)	This point will be considered during revision for the SOD, with particular attention to the need for clarity about what a decline in meltwater production might imply.
518	46015	3	17	49	17	51	See also Vergara et al., 2011. (Luis E. Garcia, World Bank)	We were unable to locate this incomplete reference in either Geobase or Web of Science.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
519	54363	3	17	49	17	51	As in the previous paragraph, it would be helpful to explain the reasons for the assignment of "medium" here, although in this case it is not clear why "evidence" is used rather than "confidence" as before. If "evidence" is intended, it is expected to be paired with a level of agreement as well, which together could be used as the basis for an assignment of confidence. (Michael Mastrandrea, IPCC WGII TSU)	We have dropped the calibrated language and substituted "moderately reliable evidence". If all assignments by IPCC authors of confidence, evidence and agreement were to be accompanied by more detailed explanation, as suggested here, the extra bulk would require a significant reduction of the scope of the assessment. This would much diminish the usefulness of the calibrated-language formalism, which offers IPCC author teams a way to summarize their assessments succinctly.
520	52840	3	18	3	0	0	Add : < The coefficients of variation of glacier summer runoff in the European Alps for example show a minimum in river basins with a glacierization between 30 and 50 % (H.Roethlisberger and H.Lang , 1987, in Glacio- fluvial Sediment Transfer, Edit. by A.M.Gurnell and M.J.Clark, 1987, John Wiley&Sons Ltd.) (Herbert Lang, ETH Zürich)	With space at a premium, we do not feel able to cite this older source.
521	45991	3	18	6	0	0	Section 3.4.5: this section may benefit from projections that will be produced within the framework of the ISI-MIP project (http://isi-mip.org/), based on CMIP5 climate projections. (Rutger Dankers, Met Office Hadley Centre)	Agree - we will use ISI-MIP results (if published in time) in the next version.
522	48191	3	18	6	0	0	This is a relatively brief overview of climate change impacts on runoff and streamflow considering the proportion of the world's population that depends on surface water supplies, plus "a very large number of assessments of the impact of climate change on runoff and streamflow have been published". This section should contain more information about temperature-driven shifts in the timing and magnitude of peak flows; this is the most robust projection of climate change impacts on runoff. Also the shift in water between seasons has significant implications for water use and management. (David Sauchyn, University of Regina)	We will expand the discussion of changes in timing.
523	50066	3	18	6	0	0	Section 3.4.5. For material in this section, the author team may wish to consider further and cross-reference the findings of the working group one contribution to the 5th assessment report. (Katharine Mach, IPCC WGII TSU)	Will do.
524	44595	3	18	8	18	12	Has been outlined already in section 3.4. (Martina Flörke, University of Kassel)	We will rephrase the introduction.
525	40570	3	18	16	0	0	What does "a high-resolution global model" mean? Nakaegawa et al. (2012) used a 20-km mesh AGCM simulation and 15-member 60-km mesh AGCM simulations in order to force a 0.5-degree global river routing model. In many studies, the horizontal resolution is high for the river routing model, but that of GCM used is very coarse: 100 km to 300 km. Therefore, the following article may be cited here: Nakaegawa, T, A. Kitoh, and M. Hosaka, 2012: Discharge of major global rivers in the late 21st century climate projected with the high horizontal resolution MRI-AGCMs -overview-. Hydrological Processes. accepted. (Toshiyuki Nakaegawa, Meteorological Research Institute)	We will add the reference and clarify the text.
526	54364	3	18	17	18	18	Particularly once the multi-GCM results are available, are any differences in patterns/magnitudes of change identifiable across the higher and lower emissions scenarios, indicating the potential for avoided impacts under the lower emission scenario compared to the higher scenario? If so, these elements would be useful to describe here as well. (Michael Mastrandrea, IPCC WGII TSU)	We discuss avoided impacts in Table 3.2 and section 3.5.1, and we will use any RCP-based results if they are available.
527	48192	3	18	19	18	20	Runoff is projected to decrease also in most dry sub-tropical regions. (David Sauchyn, University of Regina)	we will mention this.
528	43231	3	18	23	0	0	Adjust text spaces (Muhammad Zia ur Rahman Hashmi, Global Change Impact Studies Centre)	editorial.
529	48195	3	18	23	18	27	Perhaps Tang and Lettenmaier 2012 could be cited once rather than three times in these two sentences. (David Sauchyn, University of Regina)	Agree - we will rephrase.
530	36097	3	18	24	0	38	'Relationship between change in temperature and change is runoff is approximately linear' and 'catchments runoff may either increase or decrease' – these two statements might contradict each other depending on the region under consideration. Since temperatures are increasing, the first statement cannot explain why runoffs may decrease. The statements in lines 26-27, page 18 are overly generalized. Precipitation and in turn, river flows show wide variability from one region to another and modelling hydrological changes based on impacts of climate change involve a lot of uncertainties because of scale differences and use of hydrological models. The caveats of the analyses mentioned need to be discussed. (Pradeep MUJUMDAR, Indian Institute of Science)	We will rephrase the text.
531	42608	3	18	24	18	27	The following references support the sentence. Chiew et al. (2006) Precipitation elasticity of streamflow in catchments across the world, In: Climate Variability and Change - Hydrological Impacts, IAHS Press, Wallingford, United Kingdom, Publication Number 308, pp. 256-262. Chiew FHS (2006) Estimation of rainfall elasticity of streamflow in Australia. Hydrological Sciences Journal, 51, 613-625. (Francis Chiew, Commonwealth Scientific and Industrial Research Organization - Land and Water)	Thanks for the references.
532	48193	3	18	25	18	25	What is the exceptional response due to in some dry regions? Do small increases in temperature result in increased to decreased runoff? (David Sauchyn, University of Regina)	The text will be rephrased to make this more clear.
533	48194	3	18	26	18	27	The concluding sentence requires some explanation. What is the mechanism for this non-linear response? (David Sauchyn, University of Regina)	The text will be rephrased to make this more clear.
534	49002	3	18	34	18	34	"Figure 3-6 shows changes…." this should be "….shows projected changes". ie: make clear these are model projections (Richard Betts, Met Office Hadley Centre)	We revised the paragraph.
535	39053	3	18	37	18	38	Instances of consistent response of runoff in the studies mentioned in this paragraph occur where there is a strong meltwater signal in changing future runoff - i.e. where temperature driven changes in meltwater production (relatively consistent between GCMs) is great enough to mask precipitation driven changes in river flow (relatively inconsistent between GCMs). (Daniel Kingston, University of Otago)	we will rephrase the text on timing.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
536	49004	3	18	39	18	39	Differences in evaporation simulated by the hydrological model can also make an important difference, see for example Betts, R.A., Arnell, N.W., Boorman, P., Cornell, S.E., House, J.I., Kaye, N.R., McCarthy, M.P., McNeall, D., Sanderson, M.G., and Wiltshire, A.J. (eds.), in press: Climate change impacts and adaptation: an Earth system view. Understanding the Earth System: Global Change Science for Application. . Cambridge University Press, Cambridge, pp. (I can provide a copy of this if required) (Richard Betts, Met Office Hadley Centre)	We will include model structural uncertainty (referring explicitly to evaporation) in the revised section.
537	37339	3	18	46	0	51	Please explain climate change effects on snowfall at different elevation levels. For example, Gunawardhana & Kazama (2012) showed that the exponential rate of frost day decrease for 1°C winter warming in lower-elevation areas of the Tagliamento River basin in Italy is approximately three-fold (262 %) higher than that in higher-elevation areas, revealing that snowfall in lower-elevation areas will be more vulnerable under a changing climate. Gunawardhana & Kazama (2012), A water availability and low-flow analysis of the Tagliamento River discharge in Italy under changing climate conditions. Hydrol. Earth Syst. Sci., 16, 1033–1045. (So Kazama, Tohoku University)	We will add this information.
538	49003	3	18	46	18	46	"pattern of future change" should be "…pattern of projected future change" ie: make clear these are model projections (Richard Betts, Met Office Hadley Centre)	same as #534.
539	48196	3	18	48	18	49	Re increased accumulation (of snow?) in response to increases in precipitation at high latitudes; how does this represent a shift in the timing of streamflows? (David Sauchyn, University of Regina)	text to be rephrased to be made more clear.
540	36099	3	19	0	0	0	Section 3.4.6: Since groundwater is more affected by local human interventions like water withdrawals or pollutant discharge or modification of infiltration characteristics of the surface, it is very difficult to segregate the impacts of human-emission-induced climate change or natural variability or local effects in the observed/projected groundwater changes. This aspect may need to be discussed. (Pradeep MUJUMDAR, Indian Institute of Science)	Therefore, in this section about impacts, all studies are model-based. No space to discuss this.
541	44596	3	19	1	0	0	The groundwater section is rather long and should be shortened according to other (sub-)sections. (Martina Flörke, University of Kassel)	Shortened
542	49560	3	19	1	0	0	Groundwater - There is a recent finding by researchers from the University College in London and the British geological Survey about the presence of a large underground aquifer in Africa. Is this information substantiated or discounted? I think reference should be made to this finding. (Amithirigala Jayawardena, International Centre for Water Hazard and Risk Management (ICHARM))	The study achieved a certain quantification but it has been know before that large aquifers do exist in Africa. Regarding climate change, the study does not contribute an important finding.
543	48197	3	19	1	19	0	What is the rational for giving much more attention to groundwater than to surface water? (David Sauchyn, University of Regina)	Since AR4, for which only few studies on groundwater could be evaluated, there has been a tremendous increase in studies.
544	45901	3	19	15	19	17	What do the percentages refer to? Changes of what in relation to what? (Roland Barthel, Helmholtz Centre for Environmental Research - UFZ)	Deleted.
545	52681	3	19	17	0	0	Please check the figures indicating the aquifer ´s decline. (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	Deleted.
546	45900	3	19	17	19	18	Absolute changes of groundwater level in [m] are meaningless if not associated with type and properties (confined, unconfined, shallow, deep, spec. Storage etc.) of the respective aquifers (see Barthel, 2011 19,3: 525–546. DOI: 10.1007/s10040-010-0693-y (Roland Barthel, Helmholtz Centre for Environmental Research - UFZ)	Deleted due to space constraints.
547	52828	3	19	19	19	24	These forecasts are inconsistent, are a gross simplification of reality. Many other environmental factors can determine completely different results (quality and quantity of sediment transported by the river, for example) (Juan Jose Neiff, CONICET - UNIVERSIDAD NACIONAL DEL NORDESTE)	Comment not clear, does not seem to refer to paragraph p. 19 line 20-25.
548	45902	3	19	22	19	22	I don't understand the last part of this sentence. In what way and why? This part of the sentence does not seem to have any reference. (Roland Barthel, Helmholtz Centre for Environmental Research - UFZ)	Last part of sentence is elaborated in next sentence.
549	46016	3	19	27	19	38	Maybe it would be of interest to add that Rodriguez-Iturbe and Valdes (2011) presented a relatively simple framework to understand and predict ecosystem changes due to climate change in dryland and wetlands. The framework is based on two fundamental principles: That rainfall should be trated stochastically because random fluctuations in rainfall have large impacts on the seasonal distribution of soil moisture available to plants; and that a tradeoff exists between resource use/availability and mitigating the cost of resources use. (Luis E. Garcia, World Bank)	Reference not found.
550	43511	3	19	29	19	30	The sentence noting that 'deeper roots and increased vegetation cover generally decrease total runoff but also tend to increase the total runoff that becomes groundwater recharge' needs supporting evidence. This is provided by Wilcox and Huang (2010) and Buttle (2011), though in large, semi-arid catchments groundwater recharge may increase with decreased vegetation cover due to surface water ponding and enhanced infiltration (LeBlanc et al., 2008). Leblanc MJ, Favreau G, Massuel S, Tweed SO, Loireau M, Cappelaere B. 2008. Land clearance and hydrological change in the Sahel: SW Niger. Global and Planetary Change 61, 135-150. Buttle, JM. 2011. Streamflow response to headwater reforestation in the Ganaraska River basin, southern Ontario, Canada, HYDROLOGICAL PROCESSES 25(19): 3030-3041, DOI: 10.1002/hyp.8061. Wilcox BP. Huang Y. 2010. Woody plant encroachment paradox: Rivers rebound as degraded grasslands convert to woodlands. Geophysical Research Letters 37, L07402, doi:10.1029/2009GL041929. (Andrew Wade, University of Reading)	Deleted due to space constraints.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
551	43583	3	19	30	19	31	The text states that leaf area is modelled to decrease in a warmer climate in Australia. This is inconsistent with the observed pattern of woody thickening throughout Australia and across semi-arid regions of the globe. See Macinnis-Ng, C., Zeppel, M., Williams, M., Eamus, D. (2011) Applying a SPA model to examine the impact of climate change on GPP of open woodlands and the potential for woody thickening. Ecohydrology, 4: 379-393 and references cited there-in. We postulate that extra soil moisture remaining in the soil due to water savings associated stomatal responses to rising CO2 stimulate additional plant growth, indicating the the role of climate change in driving woody thickening (increasing density of strubs and trees in the landscape). Whatever the cause of woody thickening, it causes an increase (not decrease) in leaf area across the landscape as grasslands are converted to woodlands. What type of model is predicting leaf area will decrease in a warmer climate? It is not consistent with analysis of areal photos and other approaches. For instance, see Fensham, RJ, Fairfax, RJ and Archer, R 2005, 'Rainfall, land use and woody vegetation cover in semi-arid Australian savannah', Journal of Ecology, vol. 95, pp 596-606. I argue that leaf area is not decreasing across the landscape and I therefore question whether groundwater recharge will increase (especially if rainfall is decreasing). See chapter 4 page 39 lines 5-13 (Cate Macinnis-Ng, University of Auckland)	The model is described in McCallum et al. 2010. Reformulated in SOD andmoved to new cross-chapter box between chapters 3 and 4 on the effect of cc-related vegetation change on water flows.
552	43176	3	19	42	19	45	The referred study shows that an indirect impact of Cliamte change on ground water recharge can occur in irrigated areas with increased water requirement due to increased potential evapotranspiration and longer growing period. Whereas, the study cited below shows shorter growing period due to global warming instead of longer growing period. Iqbal, M. M., M. A. Goheer and A. M. Kahn (2009) 'Climate Change Aspersions on Food Security of Pakistan', Science Vision, 15 (No. 1): 15-23. It is suggested that this may kindly be verified (GHAZANFAR ALI, GLOBAL CHANGE IMPACT STUDIES CENTRE (GCISC))	Longer growing periods could be due to multicropping that becomes possible in a warmer climate.
553	48198	3	19	43	19	45	An increase in irrigation return flow assumes that more irrigation water is required and is applied with no improvements in the efficiency of the irrigation system. Experience in many regions shows that increased water requirements have resulted in increased water use efficiency and decreased return flows. Also the longer growing period and increased PET may result in increased water consumption, again resulting in decreased return flows. (David Sauchyn, University of Regina)	What you write is possible, but with constant or only somewhat decreasing irrigation efficiency, return flows would increase. Shortened anyway to to space constraints.
554	48199	3	19	47	19	48	Putting "due to changes in groundwater recharge" and "together with groundwater recharge" in the same sentence is repetitious. (David Sauchyn, University of Regina)	reformulated.
555	43512	3	19	51	19	53	These lines are unclear and need to be rewritten please. (Andrew Wade, University of Reading)	Deleted due to space restrictions.
556	45903	3	19	51	19	53	The sentence is a bit weird: a) by definition, in a water table aquifer the water table can rise freely. In case a river is present, a new equilibrium will be established. b) reaching the soil surface is a result of rising freely and thus it cannot be said that rising is impossible. (Roland Barthel, Helmholtz Centre for Environmental Research - UFZ)	Deleted due to space restrictions.
557	36100	3	19	53	19	54	'For each meter....approximately 40m' – the meaning of this sentence is not clear. What is referred to as 'freshwater' here? (Pradeep MUJUMDAR, Indian Institute of Science)	reformulated.
558	44597	3	19	53	19	54	Confusing description. (Martina Flörke, University of Kassel)	reformulated.
559	45904	3	19	53	20	1	The relation between sea-level and the depth to the freshwater-seawater interface, known as the Ghyben-Herzberg relationship was published as early as 1888/1901 and not by Werner et al. In 2012 for the first time. (Roland Barthel, Helmholtz Centre for Environmental Research - UFZ)	Certainly, but it makes sense to cite Werner for a recent and accessible overview on sea water intrusion.
560	36101	3	20	0	0	0	Section 3.4.7: In the context of modelling impacts of human-induced climate change on river water quality and water quality extremes, references to the works of Rehana and Mujumdar, 2012 (Rehana, S. and Mujumdar, P. P. (2012), Climate change induced risk in water quality control problems, Journal of Hydrology, 444 - 445, 63-77) and Towler and Rajagopalan, 2010 (Towler, E., B. Rajagopalan, E. Gilleland, R. S. Summers, D. Yates, and R. W. Katz (2010), Modeling hydrologic and water quality extremes in a changing climate: A statistical approach based on extreme value theory, Water Resour. Res., 46, W11504) can be included. (Pradeep MUJUMDAR, Indian Institute of Science)	Information considered
561	50067	3	20	5	20	10	The chapter team could consider indicating the relevant time frames for these statements. (Katharine Mach, IPCC WGII TSU)	deleted
562	48200	3	20	7	20	9	Delete 'in' before 'within' and 'with' before 'lower' (David Sauchyn, University of Regina)	Done
563	43177	3	20	10	20	10	Sentense 'Found be slow' be changed either 'Found to be slow' or 'Found slow' or with some other appropriate word (GHAZANFAR ALI, GLOBAL CHANGE IMPACT STUDIES CENTRE (GCISC))	Done
564	48201	3	20	19	20	19	Delete "Regarding vulnerability of coastal groundwater" because this is the subject of this entire long paragraph. In fact, the space given to this subject seems excessive when impacts on runoff and streamflow are treated briefly. (David Sauchyn, University of Regina)	Done. Section will be shortened.
565	48202	3	20	22	20	22	'in' not 'into' (David Sauchyn, University of Regina)	reformulated.
566	45905	3	20	25	20	33	I think it doesn't make sense to use the (model based) case study from the upper Nile to prove something that is known since centuries and forms a well-known part of the hydrological cycle and the principles of groundwater-surface water interaction. Groundwater discharges into rivers and thus a decrease in groundwater recharge will lead to a decrease in discharge. The last sentence in this paragraph is incomprehensible. The whole paragraph needs reconsideration and rewriting. (Roland Barthel, Helmholtz Centre for Environmental Research - UFZ)	The study achieved to quantify a somewhat indirect effect of future decrease in groundwater on river flow. To non-hydrologists, the link between groundwater and surface water impacts of climate change is not very clear.
567	52682	3	20	38	0	49	Again, from the WG 2 responsibility some information on natural and human induced underground water pollution is needed. The implementation of the MDGs so require. Maybe this reference pertains to paragraph 3.4.7 (page 20, line 38 to 49, but. Could also be included under sub-paragraph on page 21, Lines 26-45 (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	MDG mentioned in 3.5.4. Please note that because the text was considerably shortened your comment might not be included in the final version.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
568	43513	3	20	38	20	49	A suggested reference to support this statement is Wilby RL, Whitehead PG, Wade AJ, Butterfield D, Davis RJ, Watts G. 2006. Integrated modelling of climate change impacts on water resources and quality in a lowland catchment: River Kennet, UK. Journal of Hydrology, 330(1-2), 204-220. (Andrew Wade, University of Reading)	Note taken, reference added
569	50068	3	20	46	20	46	As calibrated uncertainty language, "high confidence" should be italicized. (Katharine Mach, IPCC WGII TSU)	accepted and revised.
570	43178	3	21	7	21	9	The sentense started from "This requires…….. climate change" does not expalin adequatly what author wants to convey and may please be rephrased for the sake of clearity. (GHAZANFAR ALI, GLOBAL CHANGE IMPACT STUDIES CENTRE (GCISC))	Rephrased
571	43514	3	21	18	21	24	Model simulations suggest a range of responses for within river nutrient concentrations to climate change depending on the type of river-system and the nutrient form considered. Winter in-stream phosphorus concentrations may increase through greater wash-in of phosphorus attached to sediment in agricultural areas and peri-urban areas. A reduction in-stream phosphorus concentrations may also occur during autumn and winter months as point-sources are diluted (Whitehead et al., 2009). Whitehead PG, Wade AJ, Butterfield D. 2009 Potential impacts of climate change on water quality and ecology in six UK rivers. Hydrology Research 40(2-3): 113–122. Geology is also a key control on the flow response of catchments to changes in precipitation. In Denmark, summer runoff is expected to increase in predominantly groundwater fed streams and decrease in streams with greater inputs from surface and near-surface inputs. In both cases, instream nutrient concentrations were simulated to change by 10% or less due to changes in hydrology alone (Andersen et al., 2006). Andersen Hans Estrup; Kronvang Brian; Larsen Soren E.; et al. 2006. Climate-change impacts on hydrology and nutrients in a Danish lowland river basin, SCIENCE OF THE TOTAL ENVIRONMENT 365(1-3), 223-237, DOI: 10.1016/j.scitotenv.2006.02.036. (Andrew Wade, University of Reading)	Reference considered
572	49005	3	21	19	21	20	For a modelling study of future projections, I don't think it is appropriate to say "it was found that … will decrease" - this implies a higher degree of confidence than is probably justified, especially since this study is probably using the UKCIP02 projections which do not explore uncertainty in the future projections. (Richard Betts, Met Office Hadley Centre)	Rephrased
573	43515	3	21	19	21	24	Recent work by Bowes et al. (2012) has suggested that residence time, rather than nutrient concentrations, might be the main control on algal growth. Bowes MJ, Gozzard E, Johnson AC, Scarlett PM, Roberts C, Read DS, Armstrong LK, Harman SA, Wickham HD, 2012. Spatial and temporal changes in chlorophyll-a concentrations in the River Thames basin, UK: Are phosphorus concentrations beginning to limit phytoplankton biomass? SCIENCE OF THE TOTAL ENVIRONMENT 426, 45-55, DOI: 10.1016/j.scitotenv.2012.02.056. (Andrew Wade, University of Reading)	Paper assessed and used for contribution to adaptation options. It is not on climate change observations.
574	42484	3	21	19	21	48	Good work. I believe more research along the same line is needed to identify vulnerable households and level of intervention required to reduce vulnerability etc. (Shahbaz Mushtaq, University of Southern Queensland)	Thanks
575	50069	3	21	43	21	45	For this conclusion, the author team should consider using calibrated uncertainty language to characterize its degree of certainty in the statement. (Katharine Mach, IPCC WGII TSU)	Used when appropriate
576	50070	3	21	48	0	0	Section 3.4.8. For material in this section, the author team may wish to consider further and cross-reference the findings of the working group 1 contribution to the 5th assessment report. (Katharine Mach, IPCC WGII TSU)	Not found any section dealing with soil erosion.
577	43379	3	21	50	0	0	Section 3.4.8: As for section 3.2.6 I recommend to include some material on landslides. I would be willing to contribute some text if necessary. (Christian Huggel, University of Zurich)	No much on future changes.
578	48203	3	21	53	21	53	What does 'their' refer to - the areas of the world? What aspect of vulnerability and adaptive capacity – practices and policies to prevent soil erosion? Be more specific. (David Sauchyn, University of Regina)	The sentence was deleted.
579	52683	3	21	54	0	0	After climate change add a comma followed by te following text: "associated to other environmental stresses, " etc. One example is given in page 22, line 10 (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	Accepted and added
580	37155	3	21	54	21	54	The use of the word 'deteriorate' may be misunderstood to mean 'decline'. Suggest replacing the term with the word 'increase' (Stephen Darby, University of Southampton)	Word deleted.
581	43584	3	21	54	21	54	The phrase 'climate change will deteriorate soil erosion' is unclear. Perhaps 'climate change will exacerbate soil erosion' is a better way of saying it. (Cate Macinnis-Ng, University of Auckland)	The sentence was deleted.
582	37332	3	22	2	0	3	Same as above.In Japan, the exponential relationship found between sediment yield and catchment average probability of slope failure attributed to extreme precipitation indicates that the sediment yield may substantially increase with increasing probability of slope failure. (Ono et al., 2011 Distributed specific sediment yield estimations in Japan attributed to extreme-rainfall-induced slope failures under a changing climate. Hydrol. Earth Syst. Sci., 15, 197–207). (So Kazama, Tohoku University)	Thanks for the comment.
583	49006	3	22	2	22	2	"Likely" is used - is this use of calibrated language intended? If so, how is the likelihood level arrived at here? (Richard Betts, Met Office Hadley Centre)	Changed.
584	44598	3	22	2	22	20	Names of models are not given in any other text, thus should be omitted here, too. (Martina Flörke, University of Kassel)	Changed.
585	50071	3	22	2	22	47	For statements on this page, for example on lines 3-15, 22-30, and 45-47, the chapter team should consider indicating relevant climate/socio-economic scenarios as appropriate. Additionally, if "likely" on line 2 is being used as calibrated uncertainty language per the guidance for authors (reflecting a probabilistic basis for its assignment), it should be italicized; casual usage of this reserved likelihood term should be avoided. (Katharine Mach, IPCC WGII TSU)	Most papers are not directly related to IPCC scenarios. Calibrated language is now italized.
586	36028	3	22	11	22	12	There is a lot more detail in the sentence descriging TUGS and HydroTrend than for any other product or result in the secion or chapter. I suggest pulling some of the detail in this sentence to make it consistent with other references. (Michael Brewer, NOAA)	This was changed.
587	49007	3	22	17	22	17	rising CO2 can also promote vegetation growth (Richard Betts, Met Office Hadley Centre)	Thanks.
588	48204	3	22	22	22	22	Tibetan (David Sauchyn, University of Regina)	Changed.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
589	47024	3	22	23	0	0	glacial melting: please use melting glaciers, with glacial we refer to periods of the last glacial maximum and before rather than to contemporary glaciers. (Frank Paul, University of Zurich)	Changed.
590	36029	3	22	34	22	35	Much more detail in descrigin the Scholz et al models than in the rest of the section. I recommend removing some of the detail to make it consistent with the discussion of other citations. (Michael Brewer, NOAA)	Explanation was reduced.
591	44599	3	22	45	0	0	GCMs model (Martina Flörke, University of Kassel)	Changed.
592	39313	3	22	50	0	0	Somewhere in this section the increasing flood hazard from new lakes in deglaciating mountain regions should be mentionned. Possible references: (a) Haeberli, W., Clague, J.J., Huggel, C. and Kääb, A. (2010): Hazards from lakes in high-mountain glacier and permafrost regions: Climate change effects and process interactions. Avances de la Geomorphología en España, 2008-2010, XI Reunión Nacional de Geomorphología, Solsona, 439-446. (b) Künzler, M., Huggel, C., Linsbauer, A. and Haeberli, W. (2010): Emerging risks related to new lakes in deglaciating areas of the Alps. In: J.-P. Malet, T. Glade, N. Casagli (eds) Mountain Risks: Bringing Science to Society. Proceedings of the 'Mountain Risk' International Conference, 24-26 November 2010, Firenze, Italy, CERG Editions, Strasbourg, France, 453-458. (Wilfried Haeberli, University of Zurich)	Glacier lake outburst floods are discussed at P42 L6-10.
593	50072	3	22	52	0	0	Section 3.4.9. For material in this section, the author team may wish to consider further and cross-reference the findings of the working group 1 contribution to the 5th assessment report. (Katharine Mach, IPCC WGII TSU)	accepted and will be incorpolated with the final draft of WGI
594	43380	3	22	53	0	0	Section 3.4.9: The SREX should be referenced (Christian Huggel, University of Zurich)	accepted and revised.
595	43516	3	22	53	22	54	Groundwater flooding can also be important. (Andrew Wade, University of Reading)	We do not have enough literature on water logging associated with anthropogenic climate change.
596	48079	3	22	53	23	19	Note that most studies focus on runoff changes and do not use hydraulic models to compute changes in water levels. See Darch and Jones 2010 or Darch and Jones 2012 for examples of the latter: Darch, G.J.C. and Jones, P.D. 2010. From sensitivity to scenarios: assessing future flood risk through the application of climate model output in operational hydrological-hydraulic models. Proceedings of the British Hydrological Society's Third International Symposium, 'Role of Hydrology in Managing the Consequences of a Changing Global Environment', Newcastle University, 19-23 July 2010. Darch, G.J.C. and Jones, P.D. 2012 in press. Design flood flows with climate change: method and limitations, Proceedings of the Institute of Civil Engineers: Water Management. (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	water level is significantly prone to be altered associated with river works and dependent on socio economic scenario and adaptation measures, and we could not include here due to space limitation.
597	47770	3	22	53	24	23	It is surprising that the section on water-related hazards only briefly mentions glacial lake outburst floods (GLOFs) without explaining them in detail. GLOFs threaten populations worldwide. They have killed tens of thousands in Peru (Carey, 2010, In the Shadow of Melting Glaciers: Climate Change and Andean Society, Oxford University Press). In the Himalaya the threat seems to grow and is receiving increasing attention since IPCC AR4, and thus there ought to be an update on the state of the literature, not glossing over it. For much of the newer literature, see here: http://glaciers.uoregon.edu/bibliography.html (Mark Carey, University of Oregon)	Glacier lake outburst floods are discussed at P42 L6-10.
598	43179	3	22	54	23	2	"A change in the cliamte physically changes many of the factors affecting floods (e.g., precipitation, snow cover, soil moisture content, sea level, glacila lake condion) and thus may consequently change the characteristics of flood" does not expalin adequatly what author wants to convey and may please be rephrased for the sake of clearity. (GHAZANFAR ALI, GLOBAL CHANGE IMPACT STUDIES CENTRE (GCISC))	accepted and the sentence was intensively revised.
599	42609	3	23	4	23	11	This paragraph contradicts the third paragraph in the Executive Summary. (Francis Chiew, Commonwealth Scientific and Industrial Research Organization - Land and Water)	accepted and the sentence was intensively revised.
600	45992	3	23	7	23	9	Veijalainen et al. (2010), using a model more suited to local conditions, produced results for Finland that, at large scale, are very similar to those of Dankers & Feyen (2008, 2009) and Hirabayashi et al. (2008) (Rutger Dankers, Met Office Hadley Centre)	Thanks. The sentence addresses more regional conditions
601	48205	3	23	8	23	10	What accounts for these opposing findings concerning flood frequency? (David Sauchyn, University of Regina)	accepted and the sentence was intensively revised.
602	35267	3	23	10	23	10	Before the last sentece in the paragraph it is suggested to add the following sentence: In a detailed study for Norway in Northern Europe (Lawrence and Hisdal, 2011) show that an increase in annual maximum floods can be sexpected in rivers that today are dominated by rain floods and adecrease in annual maximum floods can be expected in rivers that are dominated by spring snowmelt floods. Ref: Lawrence, D., Hisdal, H. (2011). Hydrological projections for floods in Norway under a future climate. NVE Report no. 2011-5, 47 pp - to be found at: http://webby.nve.no/publikasjoner/report/2011/report2011_05.pdf (Hege Hisdal, Norwegian Water Resources and Energy Directorate)	noted but the sentence was totally revised considering all the comments received to this part.
603	40305	3	23	13	23	13	Insert: "and Irish " after UK. (Ref.)Bastola, S., Murphy, C., Sweeney, J. (2011) The sensitivity of fluvial flood risk in Irish catchments to the range of IPCC AR4 climate change scenarios. Science of the Total Environment, 409, 5403-5415. (John Sweeney, National University of Ireland Maynooth)	noted but the sentence was totally revised considering all the comments received to this part.
604	43517	3	23	13	23	19	Samuels et al. (2009) examined the effect of extreme rainfall events on the water resources of the River Jordan and Wade et al (2010) made an assessment by coupling a GCM-RCM output and a hydrological model to simulate flows in the upper Jordan. Samuels R, Rimmer A, Alpert P. 2009. Effect of extreme rainfall events on the water resources of the Jordan River. Journal of Hydrology 375, 513-523. Wade AJ, Black E, Brayshaw D, El-Bastawesy M, Holmes PAC, Butterfield D, Nuimat S, Jamjoum K. 2010. A model-based assessment of the effects of projected climate change on the water resources of Jordan. Philosophical Transactions of the Royal Society A, 368, 5151-5172. (Andrew Wade, University of Reading)	noted but the sentence was totally revised considering all the comments received to this part.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
605	45993	3	23	13	23	19	More recent studies can be included in this section, although it remains true that projections of changes in flood risk are sparse in some regions of the world. For UK, e.g. Kay & Jones (2011); in the Elbe basin, Hatterman et al. (2008) projected a shift in the occurrence of flood events from early spring to early winter due to less retention of runoff in snow; Rhine basin, Hurkmans et al. (2010) and Te Linde et al. (2010), Te Linde et al. (2011) also include projections of expected annual damage; French rivers: Ducharne et al. (2011), Moatar et al. (2010), Quintana- Seguí et al. (2011); some studies have been performed in India although few have been peer-reviewed, but see e.g. Asokan & Dutta (2008) for a modelling study of the Mahanadi River in central-east India who found a tendency to increasingly intense floods with a projected increase in September peak runoff of 38% in the period 2075-2100; Japan: e.g. Sayama et al. (2008), Dairaku et al. (2008); Nóbrega et al. (2011) produced scenarios for the Rio Grande Basin in southern Brazil, one of the main tributaries of the Paraná River; finally, a number of studies have looked at the Nile and include projections for the flood season, e.g. Beyene et al. (2010), Soliman et al. (2009), Elshamy et al. (2009). My knowledge of the literature on this topic is probably not exhaustive (Rutger Dankers, Met Office Hadley Centre)	noted but the sentence was totally revised considering all the comments received to this part.
606	40572	3	23	16	0	0	These articles may be suitable for the references in this section. Kwak, Y., K. Takeuchi, K. Fukami, and J. Magome 2012: A new approach to flood risk assessment in Asia-Pacific region based on MRI-AGCM outputs. Hydrological Research Letters 6, 70–75.doi: 10.3178/HRL.6.70; Kure, S., and T. Tebakari 2012: Hydrological impact of regional climate change in the Chao Phraya RiverBasin, Thailand. Hydrological Research Letters 6, 53–58. DOI: 10.3178/HRL.6.53 (Toshiyuki Nakaegawa, Meteorological Research Institute)	noted but the sentence was totally revised considering all the comments received to this part.
607	40573	3	23	16	0	0	For South America, the following article may be cited, which includes the future river discharge projections. Kitoh, A., S. Kusunoki, and T. Nakaegawa, 2011: Climate change projections over South America in the late 21st century with the 20 and 60 km mesh Meteorological Research Institute atmospheric general circulation model (MRI-AGCM). Journal of Geophysical Research, 116, D06105. (Toshiyuki Nakaegawa, Meteorological Research Institute)	noted but the sentence was totally revised considering all the comments received to this part.
608	40574	3	23	16	0	0	For the middle East, the following article may be cited: Akio Kitoh, Akiyo Yatagai and Pinhas Alpert: “First super-high-resolution model projection that the ancient “Fertile Crescent” will disappear in this century”, Hydrological Research Letters, Vol. 2, pp.1-4, (2008) . (Toshiyuki Nakaegawa, Meteorological Research Institute)	noted but the sentence was totally revised considering all the comments received to this part.
609	40575	3	23	16	0	0	Thirty-year daily precipitation changes in the future climate in Japan is investigate by Ishihara (2010a,2010b): Koji Ishihara: “Assessment for the 30-Year Daily Precipitation Change due to Global Warming Using Regional Frequency Analysis”, Hydrological Research Letters, Vol. 4, pp.30-34, (2010) . Koji Ishihara: “Quantifying the Uncertainty Range of 30-Year Daily Precipitation Change due to Global Warming Using Regional Frequency Analysis”, Hydrological Research Letters, Vol. 4, pp.90-94, (2010) . (Toshiyuki Nakaegawa, Meteorological Research Institute)	We let WGI to handle the changes in precipitation.
610	40576	3	23	17	0	0	The following article may be one of the best ones for Africa: T. Nakaegawa, C. Wachana, and KAKUSHIN Team-3 Modeling Group. First impact assessment of hydrological cycle in the Tana River basin, Kenya, under a changing climate in the late 21st Century. Hydrological Research Letters., Vol. 6, pp.29-34, (2012) . (Toshiyuki Nakaegawa, Meteorological Research Institute)	noted but the sentence was totally revised considering all the comments received to this part.
611	50073	3	23	21	23	21	As calibrated uncertainty language, "low confidence," "limited evidence," and "low agreement" should be italicized. (Katharine Mach, IPCC WGII TSU)	accepted and revised.
612	48206	3	23	21	23	22	There is a discrepancy between the low confidence assigned here to evidence for earlier peak flows in snowmelt-fed rivers and the higher confidence (‘consistent patterns’) on page 18, lines 46-47. (David Sauchyn, University of Regina)	noted but the sentence was totally revised considering all the comments received to this part.
613	43381	3	23	21	53	22	This is a rather awkward statement. The low confidence is only due to the term 'magnitude' in the sentence. Rather I suggest a stronger and more relevant statement, such as: there is high [to be checked] confidence that peak flows in snow and glacier fed rivers will shift toward earlier periods of the season. (Christian Huggel, University of Zurich)	noted but the sentence was totally revised considering all the comments received to this part.
614	43180	3	23	24	23	26	This sentense may be revised to make it complete as there might be some word missing in it. (GHAZANFAR ALI, GLOBAL CHANGE IMPACT STUDIES CENTRE (GCISC))	accepted and the paragraph was completely revised.
615	48080	3	23	24	23	26	Evapotranspiration can also influence the timing and magnitude of some floods (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	noted. The assessment cannot adress such kind of details.
616	49008	3	23	26	23	26	Add "although this can be partly offset by decreased transpiration due to rising CO2 concentrations". One possible paper to cite in support of this is Betts, R.A., Boucher, O., Collins, M., Cox, P.M., Falloon, P.D., Gedney, N., Hemming, D.L., Huntingford, C., Jones, C.D., Sexton, D.M.H., and Webb, M.J., 2007: Projected increase in continental runoff due to plant responses to increasing carbon dioxide. Nature, 448, 1037-1041, although there are others by, eg: Gerten et al, Bala et al. (Richard Betts, Met Office Hadley Centre)	accepted. Please see the cross-chapter box on vegetation and water cycle
617	44600	3	23	28	23	53	Please make sure that all acronyms are listed in a list of abbreviations and acronyms. (Martina Flörke, University of Kassel)	accepted and revised.
618	48081	3	23	28	23	53	This paragraph could do with some critique of GCMs (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	accepted and the paragraph was completely revised.
619	43232	3	23	29	23	33	define the Abbreviations used here (Muhammad Zia ur Rahman Hashmi, Global Change Impact Studies Centre)	accepted and revised.
620	39267	3	23	33	23	33	Perhaps it is good to explain "CDD". (XIAOSHENG QIN, Nanyang Technological University)	accepted and revised.
621	43518	3	23	33	23	33	CDD is not defined. (Andrew Wade, University of Reading)	accepted and revised.
622	48207	3	23	43	23	43	Where are these ‘areas’? Identify them. (David Sauchyn, University of Regina)	We revised the section a lot.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
623	40691	3	24	1	24	14	Vidal et al. (2012) found highly significant increases in various spatio-temporal characteristics (duration, area, magnitude) of meteorological and agricultural droughts over France throughout the 21st century. Results were consistent across an ensemble of experiments with varying emissions scenarios, GCMs and downscaling methods. Vidal, J.-P., Martin, E., Kitova, N., Najac, J. & Soubeyroux, J.-M. (2012) Evolution of spatio-temporal drought characteristics: validation, projections and effect of adaptation scenarios. Hydrology and Earth System Sciences, accepted. (Jean-Philippe Vidal, Irstea)	noted but the sentence was totally revised considering all the comments received to this part.
624	36103	3	24	16	24	23	Definition of hydrological drought should be a robust one, taking into consideration the probability distribution of the streamflow. The analysis results may vary depending on drought definitions, as well as regions of study. This needs to be discussed here. (Pradeep MUJUMDAR, Indian Institute of Science)	noted but the sentence was totally revised considering all the comments received to this part.
625	49009	3	24	16	24	23	How many models are these projections based on - just a few, or many? Given earlier comments in the chapter about different model projections of precipitation being an important source of uncertainty, I suggest it is important to be clear about whether projected changes in drought are a multi-model consensus or just one model. (Richard Betts, Met Office Hadley Centre)	noted but the sentence was totally revised considering all the comments received to this part.
626	48208	3	24	20	24	21	The sentence beginning “Some regions” is vague. How are these results different then those reported in the preceding sentence? Where is northern North America – Canada? What is the reference for these projections? Elsewhere in AR5, there are projections of increased precipitation and runoff for northern North America. (David Sauchyn, University of Regina)	noted but the sentence was totally revised considering all the comments received to this part.
627	35268	3	24	22	24	23	The last sentence here is confusing. Do you hre refer to meteorological droughts? Hydrological droughts caused by precipitation stored as snow and ice will continue to occur in the "frost season" as long as temperatures continue to stay below zero. (Hege Hisdal, Norwegian Water Resources and Energy Directorate)	noted but the sentence was totally revised considering all the comments received to this part.
628	35269	3	24	23	24	23	It is suggested to add areference to a detailed study of projected meteorological, soil moisture and hydrological droughts in Norway where it is shown that even in regions where precipitation will increase and precipitation dry spells will not increase, more severe soil moisture and hydrological summer droughts can be expected because of increases in evapotranspiration. Ref: Wong, W.K., Beldring, S., Engen-Skaugen, T., Haddeland, I. and Hisdal, H. (2011) Climate Change effects on spatiotemporal patterns of hydroclimatological summer droughts in Norway. J. Hydrometeor., 12, 1205-1220, doi: 10.1175/2011JHM1357.1 (Hege Hisdal, Norwegian Water Resources and Energy Directorate)	noted but the sentence was totally revised considering all the comments received to this part.
629	47933	3	24	26	0	0	A clear discussion on allocation issues is missing here - interesting discussions re: allocation for cultural flows is occuring in Australia and is relevant in terms of determining availability of water resource see "Cultural flows: Culture, identity and ecology" (2006) this is also relevant for seciton on Adaptation options (pg 29, line 8) (Ameyali Ramos Castillo, United Nations University - Institute of Advanced Studies)	Due to lack of space, we can not treat.
630	48082	3	24	28	0	0	Section 5.3.1 does not include much on conflicts or allocation issues (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	Due to lack of space, we can not treat.
631	48083	3	24	28	0	0	A section on reservoirs would be useful (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	Due to lack of space, we can not treat.
632	36104	3	24	30	24	34	These are rather overly generalized conclusions, especially keeping in mind that changes in precipitation and river flows are highly uncertain and widely varying from region to region, following no uniform trends. (Pradeep MUJUMDAR, Indian Institute of Science)	We deleted the paragraph.
633	42393	3	24	30	25	8	See comments on the Executive Summary , page 3, lines 1 and 6. (Indur Goklany, Independent)	See #118
634	46897	3	24	32	24	34	Decline in glacier volumes and precipitation of snow would not only impact mountain cities but also communities, towns and cities downstream (e.g., Tibetan glaciers feed rivers in India and Bangladesh). (Katy Yan, International Rivers)	This point is touched on at the end of Box 3-2.
635	52684	3	24	38	0	0	After the comma, read “as characterized by”, instead of “as characterized”. (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	accepted and revised.
636	52685	3	24	39	0	0	Further, in line 39, instead of “pollution” reads “quality” (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	We revised the sentence.
637	47771	3	24	39	24	40	Add the Andean region to the list of areas with the greatest threat of water security. Chevallier, P., Pouyaud, B., Suarez, W. and Condom, T.: 2011, Climate Change Threats to Environment in the Tropical Andes: Glaciers and Water Resources, Regional Environmental Change 11, S179-S187. Vergara, W. et al.: 2007, Economic Impacts of Rapid Glacier Retreat in the Andes, EOS, Transactions, American Geophysical Union 88, 261-268. (Mark Carey, University of Oregon)	Due to lack of space, we can not cite it.
638	48084	3	24	39	24	41	Adaptive capacity varies greatly between these regions and some cope ok (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	In the section, adaptive capacity is not treated.
639	50074	3	24	49	25	5	For these conclusions, the chapter team should consider using calibrated uncertainty language to characterize its degree of certainty in the statements. Additionally, as a much more specific point, is "small" an appropriate descriptor on line of page 25, given that it seems the subsequent example suggests a reduction of impacts by 47%? (Katharine Mach, IPCC WGII TSU)	we will try this.
640	42394	3	25	6	25	8	Add to the end of this sentence, the following: "that is, fewer people would be water stressed if climate change increases." Alternatively, Replace the entire sentence with the following: "Fewer people would be water stressed if climate change increases (Arnell et al. 2011; van Vuuren et al. 2011)." (Indur Goklany, Independent)	we will rephrase the sentence, but the proposed rewording does not represent accurately the conclusions of Arnell et al 2011.
641	45906	3	25	11	25	33	Again (see my comment on page 8, line 30 to page 8 line 37) this section is entirely based on studies by the lead author and the review editor. This might decrease credibility in particular as a global groundwater recharge estimation is something very difficult to accomplish and many people might question the conceptual foundations. Which were the four scenarios / GCM output combinations used to produce the data shown in figure 3-8? (Roland Barthel, Helmholtz Centre for Environmental Research - UFZ)	Scenarios shown in Fig. 3.8.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
642	49010	3	25	13	25	14	What is the level of confidence in increased precipitation variability causing reduced reliability of surface water? Changes in mean precipitation are confidently expected, but changes in variability about this mean are (I think) less confidently projected aren't they? This statement needs a source to back it up - probably the appropriate chapter and section in the WG1 report. (Richard Betts, Met Office Hadley Centre)	Although we do not answer the first question directly, we do use the calibrated-language adjective "likely". Kharin et al. 2012 (Climatic Change, Changes in temperature and precipitation extremes in the CMIP5 ensemble, submitted) offers the most direct means of assessing changes in the variability of precipitation. Refer to section 3.3.1.4.
643	36105	3	25	13	25	17	These are very generalized and obvious statements. It would instead be worthwhile to provide a worldmap showing regions where, based on analysis of data till the current time, the groundwater withdrawals remain well below the recharge. (Pradeep MUJUMDAR, Indian Institute of Science)	The statements are not so obvious for non-hydrologists. Such a map would be interesting but does not exist. As IPCC authors, we can only summarize existing research.
644	37156	3	25	13	25	26	In this paragraph the term 'vulnerability' is used in a very specific way that differs from its use elsewhere both in Chapter 3 and elsewhere in the AR5. Consistency should be maintained throughout - or flagged very carefully where it is impossible to avoid, for example as here when reviewing a specific paper (Stephen Darby, University of Southampton)	In the study of Döll (2009) referred to here, vulnerability is precisely formulated according to the definition of AR 4 WGII as 'a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity'.
645	50075	3	25	13	25	26	"likely" on lines 13 and 17, "unlikely" on line 26 -- If being used as calibrated uncertainty language per the guidance for authors (reflecting a probabilistic basis for assignment), these terms should be italicized; casual usage of the likelihood terms should be avoided. (Katharine Mach, IPCC WGII TSU)	reformulated.
646	43181	3	25	19	25	21	The sentense "In the A2 (B2) ….resourcse of atleast 10%" is a bit confusing and need to be rephrased (GHAZANFAR ALI, GLOBAL CHANGE IMPACT STUDIES CENTRE (GCISC))	reformulated.
647	36030	3	25	19	25	22	The discussion of Doll 2009 uses parentheses to show the opposite of what is being discussed. I recommend removing these. They are not used anywhere else in the chapter and have been identified as the least effective way of showing an opposing idea by people who worry about whether people understand something written. (Michael Brewer, NOAA)	In parentheses are the results for emissions scenario B2..
648	37663	3	25	26	0	0	I think this section needs to include the concrete analysis provided in the work of Roy. Add(?): Roy et al (Roy et al., 2012) quantifies how combined ground water use with changes in perception, due to climate change, will negatively affect water availability among U.S. counties through 2050. [Roy, S.B., L. Chen, E.H. Girvetz, E.P. Maurer, W.B. Mills, and T.M. Grieb, 2012 Projecting Water Withdrawal and Supply for Future Decades in the U.S. under Climate Change Scenarios, Environmental Science & Technology, 46 (5), 2545-2556 DOI: 10.1021/es2030774] (George Backus, Sandia National Laboratories)	Reference has been reviewed.
649	50076	3	25	36	0	0	Section 3.5.2. As can be supported by the literature, this section should be further developed. (Katharine Mach, IPCC WGII TSU)	accepted and the section is totally revised.
650	53874	3	25	36	25	44	This section really needs some cites. Note that some have indicated plant stomatal closures with higher CO2 counteract, at least to a point, the need for additional ET water use by plants. The US. Synthesis and Assessment Product on water and other issues (4.3, I think) may have some material on this. I would suggest additional research here would be fruitful. (Bradley Udall, University of Colorado)	accepted and the section is totally revised.
651	43519	3	25	38	25	38	The text seems general. Could this be strengthened by adding further references? As well as irrigation, agriculture can also rely on flood waters to bring in new sediment and nutrients to areas where farmers plant crops on the floodplain, for example the Ganges–Brahmaputra Delta. (Andrew Wade, University of Reading)	accepted and the section is totally revised.
652	49011	3	25	38	25	38	Need a source for the statement on increased variability in precipitation, eg: WG1 report. Also assign a confidence level to the statement on increased variability. (Richard Betts, Met Office Hadley Centre)	accepted and the section is totally revised.
653	52686	3	25	41	0	0	After rainfall and before temperature, add snowmelt. In fact in many dry and desert regions, with low precipitation rates, snowmelt allows agricultural activities (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	accepted and the section is totally revised considering all the comments to this section.
654	44603	3	25	47	0	0	Climate change does not only impact hydropower generation, cooling water requirements for thermal power plants are influenced, too. References: USA: Feeley III, T. J. , Skone, T. J., Stiegel, G. J., McNemar, A., Nemeth, M., Schimmoller, B., Murphy, J. T. & Manfredo, L. 2008: Water: a critical resource in the thermoelectric power industry. Energy 33, 1–11. ; Europe: Flörke, M., Bärlund, I, Kynast, E. (2012). Will climate change affect the electricity production sector? A European study. Journal of Water and Climate Change, 3(1), 44-54.; USA and Europe: - Michelle T. H. van Vliet, John R. Yearsley, Fulco Ludwig, Stefan Vogele, Dennis P. Lettenmaier, and Pavel Kabat. 2012: Vulnerability of US and european electricity supply to climate change. Nature Climate Change. (Martina Flörke, University of Kassel)	References have been reviewed. Section extended to cover impacts on thermal power production.
655	46898	3	25	47	0	0	Section 3.5.3: add to this section something like the following: A recent World Bank ESMAP report (2011) states that "heavy reliance on hydropower creates significant vulnerability to climate change and is a feature that many low- and middle-income countries have in common." The report summarizes the impacts on the hydropower sector as: "reduced firm energy, increased variability, and increased uncertainty." It warns that "long-lifespan infrastructure, such as hydropower plants, is generally less adaptable to changes in actual facilities whereas short-lifespan infrastructure can be replaced in the long term as the climate changes." And in order to "increase the flexibility of the system and its resilience to more variable climatic conditions," the report recommends "an adaptation response may require a policy decision to diversify away from hydropower." Citation: "Climate Impacts on Energy Systems, Key Issues for Energy Sector Adaptation" (2011), Jane Ebinger and Walter Vergara (http://www.esmap.org/esmap/sites/esmap.org/files/DocumentLibrary/E-Book_Climate%20Impacts%20on%20Energy%20Systems_BOOK_resized.pdf). (Katy Yan, International Rivers)	beyond the scope of "impacts"

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
656	46899	3	25	47	0	0	Section 3.5.3: also add to this section more on the impact of climate on the financial viability of hydropower projects. For instance, among the major hydropower projects in design or being planned for the Zambezi River in southern Africa, the financial risk of climate change was considered only for the Kafue Gorge Lower Dam (International Finance Corporation 2011). IFC's financial analysis used power generation and project cost information from previous technical and economic analysis. Their results indicated that the differences between future emission scenarios have a significant impact on the operations, and therefore the financial viability of the Kafue Gorge Lower project. Among four alternatives considered, only the maximum power scenario was projected to yield acceptable returns to investors, with an internal rate of return in excess of 20%. None of the scenarios exceeded the average annual generation needed to satisfy investor requirements. Citation: Beilfuss, 2012, pending. (Katy Yan, International Rivers)	econonomic aspects covered in chapter 10.
657	48085	3	25	47	0	0	Cooling water is also very important e.g. the problems with power production in Europe in 2003? drought (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	Section will be widened to cover impacts on thermal power production.
658	35270	3	25	47	26	15	It is suggested to add findings from two studies: (1) one on climate change effects on the electricity market in Europe: Ref: Golombek, R., Kittelsen, S.A.C., and Haddeland, I. (2012), Climate change: impacts on electricity markets in Western Europe, Climatic Change, 357-370, doi:10.1007/s10584-011-0348-6. (2) Climate change effects on hydropower in the Nordic and Baltic region Ref: Thorsteinsson, T and Björnsson, H. (2011) Climate Change and Energy Systems - Impacts, Risks and Adaptation in the Nordic and Baltic countries, TemaNord 2011:502, pp 226 - to be found at: http://www.norden.org/en/publications/publikationer/2011-502 (Hege Hisdal, Norwegian Water Resources and Energy Directorate)	econonomic effects covered in chapter 10.
659	46017	3	25	47	26	15	Section 3.5.3 Water for Energy Power Production: This section deals with hydropower. However, the water energy nexus goes beyond hydropower and is attracting much attention (see for example Webber 2012). Several US national organizations are working on that (like the Argonne National Laboratory, Brookhaven National Laboratory, Electric Power Research Institute, Idaho National Laboratory, Lawrence Berkeley National Laboratory, Los Alamos National Laboratory, National Renewable Energy Laboratory, Sandia National Laboratory). The Water Unit and others at the World Bank are also embarked on that theme. Perhaps it would be useful to review how the impacts of climate change are being considered in these studies. (Luis E. Garcia, World Bank)	Section will be widened to cover impacts on thermal power production.
660	46409	3	25	47	26	15	The following info may be useful for this part. In Slovakia J. Szolgay, K. Hlavčová, P. Dušička in their paper Climate Change and Hydroenergetic Potential in Slovakia (The Environment (Životné prostredie) ISSN 0044-4863. Vol. 38, No. 5 (2004), s. 257-261 (In Slovak)) studied the changes of the hydroenergetic potential of the country in several pilot basins, which represented various types of runoff generation and water use using GCM scenarios and scenarios, that were analogous with the behaviour of the hydro-meteorological system during warm periods in the past. Discussion on adaptation strategies with respect to the hydroenergetic potential stressed the need for future conflict solving between the need for storage expansion and new environmental flow requirements under seasonally redistributed decreasing runoff conditions. (Jan Szolgay, Slovak University of Technology)	Lack of command of Slovak Language among lead authors prevents review.
661	53875	3	25	47	26	15	It seems that either this section needs to be expanded to include water for power plant cooling needs, or the title of the section should be changed to indicate this is solely for hydropower. There are a variety of issues with cooling water for power plants including the impacts of higher streamflow temperatures on the ability of thermo-electric plants to operate during high temperature, low streamflow times as would occur in late fall, and during drought. In recent years there have been a number of instances when power production has either been shut down or curtailed because of violations of operating licence terms for allowable streamflow temperatures. I believed this occurred during the European heatwave of 2003 and during some of the recent droughts in the SE of the US. (Bradley Udall, University of Colorado)	Section will be widened to cover impacts on thermal power production.
662	39314	3	25	49	26	15	An example of a study about the possible integration of potential new lakes in deglaciating high-mountain regions for hydropower production is provided: Terrier, S., Jordan, F., Schleiss, A.J., Haeberli, W., Huggel, C. and Künzler, M. (2011): Optimized and adapted hydropower management considering glacier shrinkage scenarios in the Swiss Alps. Proceedings of the International Symposium on Dams and Reservoirs under Changing Challenges - 79th Annual Meeting of ICOLD, Swiss Committee on Dams, Lucerne, Switzerland (Schleiss, A. & Boes, R.M., Eds), Taylor & Francis Group, London, 497 - 508. (Wilfried Haeberli, University of Zurich)	Due to lack of space I have focuss only on water services; the issues on agriculture/energy and water should be considered in more detail in the corresponding chapters. If the other sectors do not take care to dimensionate their water problem we can only mention as a problem in the present chapter and no need for references for that.
663	40692	3	25	49	26	15	For the Ariège catchment in the French Pyrenees, Paiva et al. (2010) found a 20% decrease of hydropower production together with an increase in internnual variability between 1973-2004 and 2015-2045, based on projections from 11 GCMs under the A1B emissions scenario. Paiva, R. C. D., Collischonn, W., Schettini, E. B. C., Vidal, J.-P., Hendrickx, F. and Lopez, A. (2010) The Case Studies, in Modelling the Impact of Climate Change on Water Resources (eds F. Fung, A. Lopez and M. New), John Wiley & Sons, Ltd, Chichester, UK. doi: 10.1002/9781444324921.ch6 (Jean-Philippe Vidal, Irstea)	Reference considered.
664	46900	3	26	1	26	2	Hydropower generation is also affected by higher temperatures (which lead to higher evaporation rates), and by increased sediments flowing into a reservoir. See for example the recent Asian Development Bank study. "Climate Risk and Adaptation in the Electric Power Sector" (http://www.adb.org/publications/climate-risk-and-adaptation-electric-power-sector). This section should also include language on the importance of incorporating climate change scenarios into the design and operation of hydropower dams, and the necessity of moving beyond "stationarity" in hydrological modeling (see "Stationarity Is Dead: Whither Water Management?" (2008), P. C. D. Milly et al., Science, http://www.hydroreform.org/node/4014) (Katy Yan, International Rivers)	Sensitivity to temperature and sediment flux added.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
665	47772	3	26	1	26	2	The current statement about" Hydropower production is affected by changes in the annual average river discharge as well as by seasonal flow shifts and daily flow variability" should be amended to note that hydropower production is also significantly affected by electricity demands, markets, water rights, technologies, and stakeholder demands/actions. The statement as it stands seems odd, as if water management plays no part. The paragraph itself goes on to contradict the oepning statement when it refers to reservoir capacity. On line 14, before the sentence starting with "Economic assessment procedures . . ." you might add the following sentence: Efforts to increase hydropower generation can require increased exploitation and reservoir management of the diminishing water supplies under climate change and glacier shrinkage, thereby leading to local conflicts over water management (Carey, M., French, A. and O'Brien, E.: 2012, Unintended Effects of Technology on Climate Change Adaptation: An Historical Analysis of Water Conflicts below Andean Glaciers, Journal of Historical Geography 38, 181-191). (Mark Carey, University of Oregon)	Here we focus on climatic drivers. The latter part of the comment refers to impact of hydropower on freshwater, which is covered in section 3.7.2.1
666	37340	3	26	6	0	0	the meaning of the “lower and earlier spring flood” is not clear. Please explain compared to what basis that the flood will be lower. (So Kazama, Tohoku University)	Compared to a cooler climate, but this should be clear as we talk about impact of climate change.
667	46901	3	26	14	26	15	Add language on whether these procedures have been implemented, and if not, the need to apply these procedures. (Katy Yan, International Rivers)	Deleted here, as this is discussed in chapter 10.
668	48086	3	26	23	26	23	Optimal measures may not be robust... (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	The term "proper" is used instead of optimal, please note that the text was considerably shortened and your comment might not be included in the final text.
669	52687	3	26	24	0	0	The following additional is suggested: The increasing worldwide urbanization trend will put more stress on municipal water services (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	Note taken
670	53876	3	26	29	0	0	I don't understand the purpose of this first sentence. (Bradley Udall, University of Colorado)	Rephrased
671	48087	3	26	33	0	0	It is important to note that a reduction in resource does not necessarily translate into a reduction of water available for use (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	Note taken
672	36107	3	26	35	26	35	‘will result in a different situation’ – with respect to what is it going to be different is not clear. (Pradeep MUJUMDAR, Indian Institute of Science)	Rephrased
673	40693	3	26	37	26	39	Under the UKCP09 probabilistic climate change projections, the mean annual flow is expected to decrease over most of the UK, with negative median values of all monthly changes except in winter over the western and northern mountainous areas (Christierson et al., 2012). Furthermore the results indicate a high likelihood of a significant decline in summer flows. Christierson, B. v., Vidal, J.-P. & Wade, S. D. (2012) Using UKCP09 probabilistic climate information for UK water resource planning. Journal of Hydrology, 424-425, 48-67. doi: 10.1016/j.jhydrol.2011.12.020 (Jean-Philippe Vidal, Irstea)	The whole section on the UK conditions was removed from the text due to space constraints.
674	50077	3	26	38	26	39	Where the chapter team says "up to 30%" is it possible to specify the lower bound of the range more specifically? (Katharine Mach, IPCC WGII TSU)	1-32% added, but the whole idea was removed from the final text due to space constraints.
675	48088	3	26	41	26	42	Reference? These are large changes. A ~1% increase in household demand was anticipated in the CC:DEW study. (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	Environment Agency: 2001, Water Resources for the Future: A Strategy for England and Wales, Environment Agency: Bristol. Please note that the whole paragraph was removed from the final text due to space constraints.
676	37341	3	26	43	0	44	Please explain why the ecological services going to need 5% increase in water supply by 2025 than today. Perhaps it would be better if you can mention what kind of ecological services are talking here. (So Kazama, Tohoku University)	This is the increased fix as target by the UK Environment Agency. Please note that the whole paragraph was removed from the final text due to space constraints.
677	36108	3	26	46	26	47	‘Recalculations....16% for another’ – a reference to the statement should be included. (Pradeep MUJUMDAR, Indian Institute of Science)	The whole paragraph was removed from the text due to space constraints.
678	43520	3	26	47	26	48	A new paragraph is needed at line 48 otherwise it seems that the general comments on water utilities is related to the UK case and there are no glaciers in the UK. (Andrew Wade, University of Reading)	Note taken
679	48089	3	26	48	0	0	Note that water utilities typically already have sophisticated procedures for balancing supplies and demand (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	Note taken and rephrased accordingly
680	48090	3	26	48	0	0	Demand management should be added to the list (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	Water demand when modified by climate change factors has been mentioned.
681	50078	3	26	50	27	31	For the statements, the author team could consider assigning calibrated uncertainty language to characterize its degree of certainty in the statements, also with further reference to previous sections of the chapter. (Katharine Mach, IPCC WGII TSU)	These sentences are not refering to projects but to results when a situation has happened, there is no calibration to make in there.
682	40306	3	27	3	27	3	A thid factor is abstraction changes. These may arise due to technological changes (e.g. leakage reduction) or demand changes (due to demography). Mixes of these with climate change are required to be considered for effective adaptation (Hall, J and Murphy, C. (2010) Vulnerability analaysis of future public water supply under changing climate conditions: a case study of the Moy catchment, Western Ireland. Water Resource Management 24(13), 3527-3545. (John Sweeney, National University of Ireland Maynooth)	Note Taken; reference used and added

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
683	47972	3	27	8	0	0	Generally, there have been more rainy periods (with strong runoff) and longer drought periods in recent years. This provides more nutrients, which combined with higher temperatures implies more primary productivity of algae, enhanced turbidity and organic matter content in waters. All these conditions undermine water quality. (Sergio Castellari, Centro Euro-Mediterraneo sui Cambiamenti Climatici)	Already mentioned on item c) on the same list
684	46018	3	27	12	27	15	As an example: "LakeAtitlan, one of the most important lakes not only in Central America but in the whole world, is facing serious problems with increasing water pollution. Over the last several decades, the uncontrolled nutrient input into the lake has lead to high P levels and low N:P ratios, initiating cyanobacterialblooms. The first bloom occurred in December of 2008, followed by more extensive bloom in October 2009. The blooms are formed by cyanobacteria from the rare planktic Lyngbya hieronymusii/birgei/robusta complex. Based on the species morphology, the Atitlan population corresponds to L. robusta and this is the first case of reported bloom of this species worldwide." (Rejmánková et al., 2011). (Luis E. Garcia, World Bank)	This is interesting, but in order to cite it in the observation sections the study should be send to IPCC as part of grey literature if it is as result of climate change and not to anthopogenic conditions.
685	47973	3	27	19	0	0	The low dilution capacities of the rivers must lead countries to set new rules to regulate discharge, for industrial and domestic activities, into water sources. To this end each entity should carry out hydrological, hydrogeological, economic and social studies, to know well the conditions of each river basin and ensure the quality of waters, as the effects of climate change increase. (Sergio Castellari, Centro Euro-Mediterraneo sui Cambiamenti Climatici)	This was included on the adaptation measures table 3-3, information improvement.
686	52688	3	27	22	0	23	Add North America in the listing on Arsenic in water. USA and Mexico have about 20 million affected with “arseniferous diseases”, like cancer. REFERENCE: The Atlas of Water, Earthscan UK 2003 (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	Reference reviewed and included but because of space limit the text regarding this aspect had to be removed and with it the reference.
687	36109	3	27	22	27	25	references to all the results reported should be included. (Pradeep MUJUMDAR, Indian Institute of Science)	Added
688	52689	3	27	32	0	0	Add item e), reading Increased sea water and freshwater mixing, because of SLR and sea water advection, enhanced by ocean to coast winds, would adversely affect freshwater take-up in estuaries and rivers (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	Added. Please note the text was shortened and you comment might not be reflected in.
689	36110	3	27	33	27	36	while discussing vulnerability of groundwater resources, it may be mentioned that though groundwater may currently be less vulnerable as compared to surface water resources, yet, when once it gets polluted, it is much more difficult to remediate the groundwater reservoir than to treat surface water bodies. (Pradeep MUJUMDAR, Indian Institute of Science)	Note taken and comment added to the final text.
690	43521	3	27	33	27	36	Due to longer residence times then groundwater pollution will likely take longer to clean-up than that in surface water. For example, nitrate in groundwater in UK chalk catchments is estimated to remain for 60-80 years (Jackson et al. 2008). Jackson BM, Browne CA, Peach D, Wade AJ, Wheater HS. 2008. Nitrate transport in Chalk catchments – monitoring, modelling and policy implications. Environmental Science and Policy, 11, 125-135. (Andrew Wade, University of Reading)	Thanks for the comment, the text was rephrased but the reference was not used.
691	48091	3	27	38	0	0	A UK Water Industry Research report has recently been published examining climate change implications for water treatment: Arkell, B., Cox, B., Daldorph, P., Darch, G., Fawcett, D., Wade, S., and Whitehead, P. 2011. Climate Change Implications for Water Treatment: Volume 1 – Overview Report. UK Water Industry Research, London. (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	Reference included
692	52690	3	27	53	0	0	It might be useful to mention the peculiar and increasing water pollution resulting from drugs (medicines and else) being injected into surface waters, directly or through human and animal fluids. Agrochemicals are also affecting freshwater sources. REFERENCE: Control of water pollution from agriculture. FAO Corporate Document Repository (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	Nothing related to climate change has been reported on this although it mignt be an issue to consider in the future.
693	46019	3	28	8	28	8	Reference (WHO-UNICEF, 2006): There should be more recent data? (Luis E. Garcia, World Bank)	UNICEF-WHO 2012 information was used.
694	43522	3	28	9	28	10	What were the key findings of NACWA (2009) and Zwolsman et al (2010)? (Andrew Wade, University of Reading)	The list of impacts or proposal for adaptation is summarized on text; in the sense of "findings" these cannot be considered as such.
695	48092	3	28	12	0	0	See also: Arkell, B., Cambridge, A., Darch, G., Jeal, G., Jones, P., McSweeney, R., Kilsby, C., Osborn, T. and Ravnkilde, K. 2011. Climate Change Modelling for Sewerage Networks. Report Ref. No. 10/CL/10/15. United Kingdom Water Industry Research, London. (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	Need to review the paper
696	36111	3	28	12	28	30	The set of statements written are useful to ensure sustainability of the environment in general. Are they the outcome of anthropogenic greenhouse gas emissions in particular? (Pradeep MUJUMDAR, Indian Institute of Science)	The text has been rephrsed to better reflect when this is the case.
697	50079	3	28	12	28	30	The chapter team should consider providing further citations for these statements. (Katharine Mach, IPCC WGII TSU)	Due to space consttraints references are cited in some parts of the paragraphs to not repeat as a same paper may be referring to different pollutants or causes of impacts.
698	43524	3	28	13	28	23	I would have thought that wetter conditions would have provided more water to dilute sewage effluent. (Andrew Wade, University of Reading)	Storm runff is not clean water as it seep pollutants fron agricultural fields and the urban environemnt, notably for certains types of pollutants. Storm runoff has not the same quality as rainfall.
699	53877	3	28	16	28	18	Citations would be nice for this sentence. I believe it is true. (Bradley Udall, University of Colorado)	Accepted and added
700	52691	3	28	17	0	0	Another important anthropogenic mechanism is the building “topography”. This should be added after “heat island effect”. (not heath island effect). REFERENCE: Chagnon S.A.(Jr) Recent Studies of urban effects on precipitation in USA. Bull. Am. Soc. 50 (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	The topography as external factor for urban floods was mentioned.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
701	37342	3	28	18	0	0	“heath island effect” should this be corrected as “heat island effect? (So Kazama, Tohoku University)	accepted and revised.
702	44604	3	28	18	0	0	"heath island effect" (Martina Flörke, University of Kassel)	accepted and revised.
703	43523	3	28	18	28	18	What is the 'heath island effect'? Is this the 'heat island effect'? (Andrew Wade, University of Reading)	accepted and revised.
704	48093	3	28	26	0	0	Other issues include septicity problems, blockages and first flush concentrations (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	Note taken.
705	43525	3	28	26	28	30	Similarly, dry weather conditions would reduce dilution of sewage effluent. (Andrew Wade, University of Reading)	Note taken.
706	48094	3	28	32	0	0	High and low flows can cause problems for waste water treatment works; higher temperatures can be beneficial. See UK Water Industry Research report due to be published shortly on this. (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	Note taken.
707	44605	3	28	32	28	39	Text could be integrated in first paragraph (page 28 line 3 to 10) (Martina Flörke, University of Kassel)	No it can the first part deals with sewers while the last one is for wastewater treatment plants, this has been clarified on the text to avoid misunderstanding.
708	53878	3	28	32	28	39	The U.S. has a reported $USD 1Trillion dollar need for water infrastructure investment over the next 30 to 50 years. Much of this is on the wastewater side. There is potentially an opportunity to invest these funds into climate-savvy systems. Already the US EPA has reach an agreement with Pittsburgh (?) on how to cost-effectively handle CSO events by building green infrastructure. I think there is at least an appreciation if not acknowledgement that you may not be able to build your way out of these problems given the magnitudes of expected future downpours. (Bradley Udall, University of Colorado)	No action taken as there is no a clear request.
709	42395	3	28	33	0	0	Replace "need to treat" with "should consider treating". Rationale: The current formulation is policy-prescriptive. (Indur Goklany, Independent)	Note taken.
710	43526	3	28	33	28	39	Is there any information on how changed temperatures will affect tertiary treatment using microbial activity? Presumably such treatment is temperature controlled in sealed vessels but some works are open to the atmosphere. (Andrew Wade, University of Reading)	So far,no reference in literature was found on this .
711	53879	3	28	42	29	29	This section highlights the huge disparity in needs and options between developed countries and developing countries. I pose a question: is it worth ever in the chapter trying to break the description and solution set to water problems into these two entities? Or is the solution set similar enough that they can be considered together? (Bradley Udall, University of Colorado)	This should be made at some point but normally it is difficult to produce a document accepted by all countries; a poor country if it is suffering from a drought will afford a very expensive option and might be willing to pay for it even more that a richer country.
712	43182	3	28	45	28	45	The word "terms" after word quality may be ommited (GHAZANFAR ALI, GLOBAL CHANGE IMPACT STUDIES CENTRE (GCISC))	Accepted, please note the final text has be shortened and your comment might have not be included on it.
713	50080	3	28	51	29	29	For these statements and examples, as appropriate the chapter team could consider using calibrated uncertainty language to characterize its degree of certainty, especially if further comment on the effectiveness of strategies is provided. (Katharine Mach, IPCC WGII TSU)	First the text was changed, secondly what does not meake sense is to use a calibrated language on this section.
714	41989	3	29	7	0	0	I recently published a study on the bridges and barriers to adaptation for municipal water systems that might be helpful here or in the latter adaptation section: Engle, Nathan L., 2012. Adaptation Bridges and Barriers in Water Planning and Management: Insight from Recent Extreme Droughts in Arizona and Georgia. Journal of the American Water Resources Association (JAWRA) 1-12. DOI: 10.1111／j.1752-1688.2012.00676.x. (Nathan L. Engle, 2011-2012 AAAS Science and Technology Policy Fellow)	The paper indeed was useful, it is cited now.
715	43404	3	29	7	29	0	This does not really do justice to adaptation options. The titles of the options are not necessarily self-explanatory, plus the list seems to be derived from authors’ own studies. I would suggest adding something specifically on agricultural water management, and here referring to the Comprehensive Assessment of Water Management in Agriculture. Even more specifically you could refer to growing more food with less water (increasing water productivity). References: 1) Molden, David, Oweis, T., Steduto, P., Bindraban, P., Hanjra, M. A., Kijne, J. 2010. Improving agricultural water productivity: between optimism and caution. Agricultural Water Management, 97(4):528-535. 2) CA, 2007. Water for food, water for life: A Comprehensive Assessment of Water Management in Agriculture. David Molden ed, London, UK; Colombo, Sri Lanka: Earthscan; IWMI. 645p.asd (David Molden, International Centre for Integrated Mountain Development (ICIMOD))	The adaptation measures for agriculture and industries, not considered in the first text are to be addressed by additional contributing authors.
716	46020	3	29	7	29	29	These actions are needed even without climate change (and not forgetting the effect of earthquakes). (Luis E. Garcia, World Bank)	The adaptation options more close linked to adaptation or mitigation are highlighted in the new table provided.
717	48095	3	29	16	0	0	Raises question of tariffs and full valuation of water (which would help justify further leakage reductions) (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	Tariffs were not mentioned especifically although economical tools were as they cannot be universally applied as there is no elasticity everywhere on the use of water.
718	48096	3	29	18	0	0	Also emerging sanitation safety planning (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	We revised the section a lot.
719	52693	3	29	20	0	0	Add the use of brackish water. It use in Italy and Israel has increase productivity in some solanaceaes, and olive trees (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	That is part of the water flex concept mentioned on item (a).
720	43183	3	29	27	29	27	The phrase " in which is the aim is to" may be replaced with "in which the aim is to" (GHAZANFAR ALI, GLOBAL CHANGE IMPACT STUDIES CENTRE (GCISC))	accepted and revised.
721	52692	3	29	29	0	0	The long list should include a new item l), informing on the nasty news that continuous potabilization brings water with remains of the chemicals used. This water has led to bladder cancer problems. (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	This comments is not related to climate change adaptation measures.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
722	42396	3	29	30	0	0	Add the following to the list of options: charging users for water used based on the cost of replacing the water, establishing property rights for water which would provide an incentive to conserve water, desalination, greater adoption of drought-resistant crops and precision agriculture (IPCC AR1 Resource Use and Management Subgroup Report; Goklany 2005, 2007b, 2007c, 2009b). (Indur Goklany, Independent)	Note taken
723	49012	3	29	32	29	44	Cross-reference with Chapter 4, which also covers freshwater ecosystems. (Richard Betts, Met Office Hadley Centre)	in SOD, cross-chapter box between chapter 3 and 4 on impact of flow regime changes on freshwater ecosystems.
724	43527	3	29	32	30	47	I do not wish to be accused of pushing the projects that I have worked on, but I do think that there is a lot of useful information in the book by Kernan et al. (2010) and a position paper produced by the EURO-LIMPACS project team to help. Also the work by Bowes et al. (2012) highlights the importance of river reach residence time in controlling algal biomass. See third comment on this chapter and the comment on Chapter 3, page 21, line 19. (Andrew Wade, University of Reading)	Reference considered.
725	52639	3	29	32	30	49	Positive and structurally clear that ecosystem effects have a separate section of the chapter. But the information provided could be expanded (both on established effects through empirical studies and predicted effects through theoretical modeling). , at the moment it is limited to water flow effects and fish species only. However effects on primary production and freshwater invertebrates, for example, have implications for the effects on fish species. In addition, other stressors are active (climate change or not climate change driven) and will work in concert with water flow. How are for example effects of increased pollution, water turbidity (due to e.g. increased sediment content in the water or increased primary production) or nutrient levels related to the effects of water flow?. There are several studies from Europe dealing with flow regime and response of freshwater organisms. Both hydrology and biology are complex, therefore relations between water flow alterartions and biotic changes are often qualitative rather than quantitative. But many studies, especially on fish, dealing with both water flow and temperature, describe ecological effects of hydrophysical changes relevant to those expected to result from climate change. Atlantic salmon is f.ex. frequently studied in regulated rivers in Norway. Evidence of of climate change effects on freshwater ecology is poor. On the othe hand, relations between hydrophysics and biology are known to an extent that make possible indications of future ecological effects given the prognoses for future hydrophysical changes related to climate. Given the scientific literature on this issue, the report should have more references to European studies and European conditions. If efficient management plans for freshwater ecosystems and associated species are to be developed, there is need for more detailed knowledge about the biological effects of both climate change and management strategies. Are such studies lacking? Should future effort into these questions be promoted? Furthermore, it is a positive intention to try and not duplicate a lot of the information in other chapters, but it would be more intuitive and structurally logical if all freshwater ecosystem effects were listed in this chapter. (Else Marie Løbersli, Norwegian directorate for nature management)	We agree with some of the suggestions but due to space constraints we need to focus.
726	46902	3	29	39	29	40	Consider adding a sentence: "For dammed rivers (more than 60% of the world's major rivers have been dammed), climate change will compound the consequences of already-altered flows." For evidence of this, see "Climate change and the world's river basins: anticipating management options" (2007) Palmer et al, Front Ecol Environ (http://www.palmerlab.umd.edu/docs/Palmer_et_al_2007_Frontiers_Environ_Climate_change_rivers.pdf). (Katy Yan, International Rivers)	done
727	50081	3	29	42	29	42	"likely" -- If being used as calibrated uncertainty language per the guidance for authors (reflecting a probabilistic basis for its assignment), the term should be italicized. Casual usage of this reserved likelihood term should be avoided. (Katharine Mach, IPCC WGII TSU)	italicized
728	44368	3	29	47	30	6	A study looking at freshwater fish extinctions form climate change and water withdrawl (Xenopoulos et al. 2005) projected that in rivers with reduced discharge, up to 75% of local fish biodiversity would be headed toward extinction by 2070 because of combined changes in climate ans water consumption. Xenopoulos, M.A., Lodge, D.M., Alcamo, J. et al. 2005. Scenarios of freshwater fish extinctions from climate change and water withdrawal. Global Change Biology 11: 1557-1564. (Ibáñez Carles, IRTA)	Xenopoulos et al. Relation between decrease of annual runoff and fish species number was used in the the study of Döll and Zhang 2010 which is already discussed in the section.
729	48036	3	29	48	0	0	statement that quantitative relationships between flow alteration and biotic changes (e.g. the review cited) overstates the situation. They are difficult to detect and few good examples, but there are still numerous published examples. The principle of the statement i think is sound however. (Nick Bond, Griffith University)	reformulated.
730	48037	3	29	49	0	0	See Bond et al (2011) for an example of a study in which hydrologic regimes are incorportated into SDM models.Bond, N. R., J. R. Thomson, P. Reich, and J. Stein. 2011. Using species distribution models to infer potential climate change-induced range shifts of freshwater fish in south-eastern Australia. Marine and Freshwater Research 62:1043–1061. (Nick Bond, Griffith University)	Cannot be cited due to space restrictions.
731	50082	3	29	52	29	54	Does the author team mean that this result also pertains across climate/socio-economic scenarios considered? If so, it could be helpful to indicate this within the parentheses. (Katharine Mach, IPCC WGII TSU)	Only climate model uncertainty considered in study. But we will describe the uncertainties of projected changes relating to emission scenarios, climate models, downscaling and impact models more clearly and focused at the beginning of section 3.4, so that reader can understand that results could probably be extended to different emissions scenarios, too.
732	40577	3	30	0	0	0	The following article firstly assesses the flood-affected people at global scale: Hirabayashi, Y. and S. Kanae 2009: First estimate of the future global population at risk of flooding. Hydrological Research Letters 3, 6–9. (Toshiyuki Nakaegawa, Meteorological Research Institute)	The references have been updated

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
733	43528	3	30	1	30	6	Recent work by Post et al. (2012) has shown that unmanaged groundwater extraction, possibly in response to climate change, could have an impact on wetlands and river ecology in Tasmania. Post DA, Chiew FHS, Teng J, Viney NR, Ling FLN, Harrington G, Crosbie RS, Graham B, Marvanek S, McLoughlin R. 2012. A robust methodology for conducting large-scale assessments of current and future water availability and use: A case study in Tasmania, Australia, Journal of Hydrology 412-413, 233-245. (Andrew Wade, University of Reading)	Cannot be cited due to space restrictions.
734	50083	3	30	2	30	17	"likely" on lines 2 and 17 -- If being used as calibrated uncertainty language per the guidance for authors (reflecting a probabilistic basis for assignment), this term should be italicized; casual usage of the reserved uncertainty term should be avoided. (Katharine Mach, IPCC WGII TSU)	We deleted the sentence.
735	54948	3	30	8	30	9	"Wetlands … are endangered by extinction. … resulting in wetland extinction". The extinction of an ecosystem or habitat type is not a well-defined concept. Perhaps "collapse" is more appropriate here than extinction, although that term also requires a definition. (H. Resit Akcakaya, Stony Brook University)	We will keep the term extinction
736	50084	3	30	11	30	14	For this example, it would be helpful to clarify the mechanisms driving the substantial decline in population for a much smaller percentage loss of wetland area. (Katharine Mach, IPCC WGII TSU)	explained
737	50085	3	30	22	30	24	For this statement, the author team could consider referencing earlier chapter sections. (Katharine Mach, IPCC WGII TSU)	Suggestion not followed.
738	50086	3	30	29	30	31	For this statement, as appropriate the author team might consider indicating the relevant time frame for the projection. (Katharine Mach, IPCC WGII TSU)	Added the time frame
739	42398	3	30	49	0	0	Replace "absolute socioeconomic losses" with "economic losses in nominal or current dollars". (Indur Goklany, Independent)	The term was taken from SREX report.
740	43382	3	30	49	0	0	Section 3.5.6.: Especially the text on page 31 of this section should be improved in terms of clarity of the statement. I also suggest to mention the possible role of adaptation as a 'confounding' factor. There is a discussion whether risk reduction measures undertaken in the recent past have had a positive effect on loss and damage but quantitative data and statements (and even qualitative ones) are very difficult (see e.g. Neumayer, E. Barthel, F. 2011. Normalizing economic loss from natural disasters: a global analysis. Global Environmental Change, 21(1): p.13–24.) (Christian Huggel, University of Zurich)	Not sure what the comment means with confounding factor. If adaptation means construction of flood defense, dams, etc., and this is a confounding factor in the normalisation, I agree that to separate this on the quantification of losses is rather a dificult task.
741	50087	3	30	49	30	51	As calibrated uncertainty language, "high confidence" on line 49 and "high agreement" and "medium evidence" on line 51 should be italicized. (Katharine Mach, IPCC WGII TSU)	accepted and italicized them
742	42397	3	30	49	31	19	This section should also discuss trends in global deaths and death rates from such events. For global deaths and death rates, it ought to note that they have declined by 98.6% and 99.6% since the 1930s for floods (see Goklany 2009c, 2012a). This is based on data from the international disaster database (EM-DAT). (Indur Goklany, Independent)	Reliability of old statistics on damages are not good.
743	43233	3	30	52	0	0	change 'societ al' to 'societal' (Muhammad Zia ur Rahman Hashmi, Global Change Impact Studies Centre)	accepted and revised.
744	44606	3	30	52	0	0	societal factors (Martina Flörke, University of Kassel)	accepted and revised.
745	39268	3	30	52	30	52	"societ al factors" should be "societal factors". (XIAOSHENG QIN, Nanyang Technological University)	accepted and revised.
746	43234	3	31	3	0	0	here use of word 'dealing' looks inappropriate (Muhammad Zia ur Rahman Hashmi, Global Change Impact Studies Centre)	Changed.
747	48209	3	31	3	31	3	“dealing conclude on”? (David Sauchyn, University of Regina)	Changed.
748	37343	3	31	4	0	5	Kazama et al., (2009) found a significant linear relationship between the “Rate of increases in extreme rainfall” and “rate of increases in damage cost”. Such economical aspects of the flood may need to discuss. (So Kazama, Ayumu Sato, Seiki Kawagoe, Evaluating the cost of flood damage based on changes in extreme rainfall in Japan, Sustainability Science, Vol.4, Iss.1, pp.61-69, 2009.) (So Kazama, Tohoku University)	That is not a normal case.
749	50088	3	31	4	31	5	It would be helpful to clarify if the described trends in flood losses have been attributed to climate change. (Katharine Mach, IPCC WGII TSU)	It is now clarified.
750	50089	3	31	10	31	19	The chapter team could consider assigning calibrated uncertainty language to statements made here. Additionally, "robust evidence" on line 12, as calibrated uncertainty language, should be italicized. Also, it would be helpful to clarify further what is meant by the statement on line 13. (Katharine Mach, IPCC WGII TSU)	Thanks.
751	48210	3	31	13	31	13	More poor grammar: “cannot be attained as far as changes on peak flows are regionally detected” (David Sauchyn, University of Regina)	Thanks. Very constructive comment from a native speaker reviewer!
752	46903	3	31	15	31	18	Include in this section: "Floods can also be worsened by mismanagement of large dams and a lack of operating rules for managing flood releases from dams, as is the case in India." See "Before the Deluge, Coping with Floods in a Changing Climate" (2007), McCully and Thakkar, International Rivers (http://www.internationalrivers.org/files/attached-files/deluge2007_full.pdf). (Katy Yan, International Rivers)	This is not related to climate change. Flood impacts should be constrained to those related to climate extremes.
753	44607	3	31	16	0	0	What is meant by longitudinal loss data? (Martina Flörke, University of Kassel)	The expression was changed to "data on flood losses".
754	44608	3	31	18	0	0	What is meant by longitudinal impact analysis? (Martina Flörke, University of Kassel)	The expression was changed to "data on flood losses".
755	42399	3	31	21	0	0	Add a subsection on droughts which should discuss both economic losses as well as global deaths and death rates associated with such events. This should note that in the 20th century more people died from droughts than all other extreme weather events combined; however, global deaths and death rates from such events have declined 99.97% and 99.99% since the 1920s (see Goklany 2009c, 2012a). This is based on data from the international disaster database (EM-DAT). (Indur Goklany, Independent)	Sure that the mortality has decreased but not sure if the global statistics is reliable to that point.
756	43529	3	31	27	31	27	The 'etc.' needs to be expanded to make the text specific. (Andrew Wade, University of Reading)	done

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
757	43530	3	31	28	31	30	Tony Allen makes the point that the trade in virtual water may have prevented conflicts in an unplanned way and I think it would be useful to include this point in the discussion. Allan T. 2011. Virtual water: tackling the threat to our planet's most precious resource. I.B. Tauris, p. 47-53. (Andrew Wade, University of Reading)	Very good point, we included this part.
758	37664	3	31	30	0	0	Add to end of sentence: and" and nation-state instability (ODNI 2012)." [Office of the Director of National Intelligence (ODNI) 2012, Global Water Security: The Intelligence Community Assessment. Report ICA 2012-08, Washington, DC. Available at: www.dni.gov/nic/ICA_Global%20Water%20Security.pdf] (George Backus, Sandia National Laboratories)	included
759	46021	3	31	35	31	37	Maybe it would be useful to mention the Panama Canal as an example. Also, the El Niño 0f 1996 caused the imposition of ship draft restrictions. (see for example: http://www.thepanamanews.com/pn/v_12/issue_14/opinion_01.html; http://www.npr.org/templates/story/story.php?storyId=87851345; http://www.planetizen.com/node/50991; Mozejko, 2009) (Luis E. Garcia, World Bank)	noted, partly included.
760	44610	3	31	49	0	0	A lot of references cited in the text are not included in the reference list. Check spelling: USD and/or US$. Description of units: per year - /year - /yr. (Martina Flörke, University of Kassel)	accepted and revised.
761	36031	3	32	11	32	13	Opening sentence is unclear. I suggest a re-write for clarity. (Michael Brewer, NOAA)	changed
762	46904	3	32	11	32	13	Language here is extremely awkward and difficult to understand. Suggested rephrasing: "Adaptation measures are of utmost urgency to avoid the worst adverse impacts that will stem from changes in the hydrological system and to water resources (e.g., floods and droughts)." (Katy Yan, International Rivers)	yes, good suggestion, done
763	43531	3	32	13	32	14	Clarification is needed on whether the increases and decreases are both 10 to 40%. (Andrew Wade, University of Reading)	revised
764	50090	3	32	13	32	14	It would be helpful to specify the timeframe for this increase, as well as relevant geographic areas as appropriate. (Katharine Mach, IPCC WGII TSU)	takes too much space!
765	46905	3	32	14	32	15	Would be clearer if this was rephrased as: "These changes will have major impacts on the water resources, which will increase the vulnerability of communities, biodiversity, industry, and many types of infrastructure." (Katy Yan, International Rivers)	the sentence was rephrased
766	46906	3	32	17	32	18	There is also counter evidence that dike construction can be counterproductive: it often pushes flood impacts to areas downstream of dikes. It should not be considered "climate proofing" as dikes and flood-control structures can increase flood vulnerabililty by encouraging people to live in floodplains. Recommend revising this section to refer to "implementing low-regret flood-risk management programs" or similar language. See "Before the Deluge, Coping with Floods in a Changing Climate" (2007), McCully and Thakkar, International Rivers (http://www.internationalrivers.org/files/attached-files/deluge2007_full.pdf). (Katy Yan, International Rivers)	the sentence was rephrased.
767	52694	3	32	20	0	0	Cross reference with the Hyogo Plan of Action and the UN ISDR is necessary (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	cross reference has not been done.
768	43403	3	32	21	32	21	For example, Babel and Wahid (2008) reported that there are no viable generic solutions to the water vulnerability faced by the South Asian countries. Thus, for its major riverbasins, the recommendations available for reducing the water resources vulnerability must rely on a unique mix of policyinterventions and preferred routes for futurewater resources development. (David Molden, International Centre for Integrated Mountain Development (ICIMOD))	this has been included now.
769	43532	3	32	22	32	29	The possibilities for integrated water management strategies seem too general. Is it possible to be more specific using suggestions from the work cited? (Andrew Wade, University of Reading)	partly changed, see above.
770	52695	3	32	29	0	0	Add another reference Cooley H: “Water management in a changing climate” Also ECLAC Bulletins. REFERENCE: The World Water 2008-2009 (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	added it
771	45853	3	32	31	32	40	Definition of IWRM could be elaborated better here. Paragraph discusses its acceptance internationally but not its basic premises. IWRM is part of the Integrated Ecosystem Management approach. Synthesised extract from Hiller, B.T. (July 2012) PhD dissertation (unpublished): Integrated ecosystem management (IEM) represents an ecological approach to natural resource management (NRM) that aims to ensure productive and healthy ecosystems by integrating social, economic, physical, and biological needs and values (GEF-ADB, 2006). It accents the provisioning, regulating, cultural, and supporting services provided by biologically diverse systems (MEA 2005) and their connection to human well-being (Armsworth et al., 2007). IEM enables treatment of all elements of an ecosystem simultaneously to promote ecological and socioeconomic benefits via multidisciplinary examination of manifold facets of phenomena (Stocking, 2006; Scherr, 1999). Specific references: Armsworth, P.R., Chan, K.M.A., Daily, G.C., Ehrlich, P.R., Kremen, C., Ricketts, T.H. & Sanjayan, M.A., 2007, Ecosystem Service Science and the Way Forward for Conservation, Conservation Biology Vol. 21, No. 6: pp.1383–1384. Scherr, S.J., March 1999, Poverty environment interactions in agriculture: Key factors and policy implications, UNDP & EC expert workshop on Poverty and the Environment, Brussels, Jan 20 21, 1999, Revised March 1999. Stocking, 2006, The Evolution of Integrated Ecosystem Management as an Approach for Managing Natural Resources, Chapter 1 in Zehui, J., 2006, Integrated Ecosystem Management, Proceedings of the International Workshop, China. WRI (World Resources Institute), 2005, Millennium Ecosystem Assessment, Ecosystems and Human Well-being: Synthesis; Desertification Synthesis; Wetlands & Water Synthesis; Health Synthesis; Biodiversity Synthesis; World Resources Institute, Washington, DC. GEF ADB (Global Environment Facility Operation Program 12 & Asian Devpt Bank Team), 2006, Integrated Ecosystem Management as an Alternative Approach for the People’s Republic of China: A Post Workshop Perspective, Chapter 11 in Zehui, J., 2006, Integrated Ecosystem Management, Proceedings of the International Workshop, Beijing. (Bradley Hiller, World Bank)	partly acknowledged in text

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
772	46022	3	32	31	32	40	Maybe it would be useful to also mention that although nowadays practically no national, regional, or international organization fails to promote “some” IWRM concept, one must be careful with this type of conceptual tools. Some think that although we cannot say that we are for "disintegrated water resources management" instead of an integrated approach, it has been more difficult to use it in practical applications than in conceptual advocacy (see for example Biswas, 2008; Garcia, 2008; Hering and Ingold, 2012). (Luis E. Garcia, World Bank)	partly acknowledged in text
773	46410	3	32	31	32	40	The potential of IWRM is presented here in a rather positive optic. With reference to Biswas (2004 and 2008) a few words of caution could do no harm. The key points he stressed are, that while at a first glance, the concept of IWRM looks attractive, a deeper analysis brings out many problems The definition of IWRM continues to be amorphous. Despite of the manuals published both by the governmental and nongovernmental sector, and there is no general agreement on fundamental issues like what aspects should be integrated, how, by whom, or even if such integration in a wider sense is possible. The results of its application in a real world to improve water policy, program and projects at macro- and meso-scales have left much to be desired. Therefore, especially with respect to adaptation to CC, this concept may need to be substantially revised. This could be one of the messages of this chapter. Biswas, A.K.: Integrated Water Resources Management: A Reassessment, Water International, Volume 29, Number 2, Pages 248–256, June 2004 Biswas, A.K.: Integrated Water Resources Management: Is It Working? Water Resources Development, Vol. 24, No. 1, 5–22, March 2008 (Jan Szolgay, Slovak University of Technology)	partly acknowledged in text
774	43533	3	32	42	33	29	The discussion of integrated water management focuses on the response to climate change but population growth may be a greater driver of pressure on water resources. (Andrew Wade, University of Reading)	that's true, this is a good point, I integrated it into the introduction.
775	46023	3	32	42	33	30	I'm afraid this section might be misslabeled. More properly it could be labeled as "Requirement for Succesful (or adequate, or sustainable, or something like that); Water Resources Management". I don't think it is well matched with IWRM. Besides, lines 51 on page 32 to 29 on page 33 are statements without references. It may be useful to include references (for example in lines 24 to 26, page 33), unless these are statements made by the authors of this Chapter. (Luis E. Garcia, World Bank)	We revised the entire part.
776	43184	3	32	48	32	48	The word "Thus" may be follow by the word "The" (GHAZANFAR ALI, GLOBAL CHANGE IMPACT STUDIES CENTRE (GCISC))	revised
777	50091	3	33	7	33	7	It would be beneficial to specify what the acronym on this line stands for. (Katharine Mach, IPCC WGII TSU)	revised
778	36032	3	33	7	33	12	RBMP, RBM, and WFD acronyms are used without defining them. (Michael Brewer, NOAA)	we replaced the acronyms with the full words.
779	47970	3	33	12	33	15	The WFD abbr. Is not explained before. The 'a fundamental shift' highlighted in line 12 has yet to be realised (Jaroslav Mysiak, Fondazione Eni Enrico Mattei; and Euro-Mediteranean Center for Climate Change)	revised accordingly
780	48097	3	33	13	0	0	The uncertainty referred to, is this specific to climate change or more general? (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	more general to scientific projections, text revised.
781	41990	3	33	24	0	0	Citation for this statement? Also, I co-authored a paper that evaluated the tradeoffs and tensions in trying to implement both integrated and adaptive management of water resources, which is an important point to practitioners trying to plan for adaptation and resilience: Engle, N. L., O. R. Johns, M. Lemos, and D. R. Nelson. 2011. Integrated and adaptive management of water resources: tensions, legacies, and the next best thing. Ecology and Society 16(1): 19. [online] URL: http://www.ecologyandsociety.org/vol16/iss1/art19/. This might be helpful citation to include. (Nathan L. Engle, 2011-2012 AAAS Science and Technology Policy Fellow)	citation added.
782	43405	3	33	24	33	0	Reference missing (David Molden, International Centre for Integrated Mountain Development (ICIMOD))	citation added.
783	46907	3	33	24	33	26	This paragraph needs a citation and specific case study examples. (Katy Yan, International Rivers)	citation added.
784	44609	3	33	32	0	0	Title: Economic Costs (instead of economics costs) (Martina Flörke, University of Kassel)	accepted and revised.
785	46024	3	33	43	33	43	A problem are also discount rates. Any future costs or benefits 25-30 years in the future become nil when discounted to present value. (Luis E. Garcia, World Bank)	Will discuss
786	44174	3	33	43	33	46	In section 2.3.6 on Local Responses, it would be important to acknowledge that many of these capacities, human capital to access climate information and process it to be locally relevant, and capacities to access it, economic or social, are interlinked (Westerhoff, L, Juhola, S 2010. Science-policy linkages in climate change adaptation in Europe. International Journal of Climate Change Strategies and Management. 2:3, 222-241) (Sirkku Juhola, Aalto University)	Will see article and include as appropriate.
787	52696	3	33	46	0	0	Add Cooley H and P.H. Gleick. REFERENCE: Urban Water Use Efficiency and Lessons from USA Cities. The World Water 2008-2009. (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	Will see article and include as appropriate.
788	50092	3	33	49	33	51	As calibrated uncertainty language, "very likely" should be italicized. (Katharine Mach, IPCC WGII TSU)	accepted and italicized it.
789	50093	3	34	6	35	37	For some of the statements provided on this page, for example on lines 6-7, 22-23, 27-31 and 35-37, the author team should consider further indicating the relevant climate/socio-economic scenarios. Additionally, relevant time frames could potentially be indicated for lines 22-23 and 27-31. (Katharine Mach, IPCC WGII TSU)	Assessment was drafted as example of robust findings across multiple scenarios and details of specific scenarios were not included.
790	40307	3	34	9	34	9	The cited study (Tol) is acknowledged as having so many caveats it is of little use in decision making. It should be omitted as the insignificant %burden indicated (0.5-1.5% gdp by 2200) will be confusing for policymakers should it be repeated in the SPM. (John Sweeney, National University of Ireland Maynooth)	Will clarify in revison.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
791	37665	3	34	10	0	0	I think this section needs to include bottom-up as well as the top-down analyses Add(?): Sandia National Laboratories produced a bottom-up estimate of the economic risk and impacts of climate change-related to drought for each of the interconnected U.S. states through the year 2050 (Backus et al., 2012). Adaptation and economic costs are entwined in the study as industries act to limit the impacts. The study estimates the undiscounted cost of drought risk though 2050 at over one trillion U.S. dollars, with an employment loss of over seven million labor-years. [Backus, G., T. Lowry and D. Warren, 2012: The near-term risk of climate uncertainty among the U.S. states. Climatic Change, Online First 23 June 2012. Doi: 10.1007/s10584-012-0511-8] (George Backus, Sandia National Laboratories)	Will see article and include as appropriate.
792	52697	3	34	10	0	0	We should imagine the economic impact of the ongoing trend to charge the externalities in the commodities production. The concept of “virtual water” and its potential introduction in the international commerce should deserve a comment. It should be included under this paragraph. REFERENCE: Hoekstra A. Y. et al.-The Water Footprint Manual. Settng the Global Standard. Earthscan 2011 (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	Will see article and include as appropriate.
793	46025	3	34	17	34	17	(World Bank, 2006b): Could not find this reference in the list (Luis E. Garcia, World Bank)	The reference is not cited now.
794	44611	3	34	18	0	0	EACC project (full text of abbreviation) (Martina Flörke, University of Kassel)	Will do.
795	44612	3	34	20	0	0	these research (Martina Flörke, University of Kassel)	Will do.
796	37344	3	34	20	0	31	Same as above. Kazama et al., 2009 estimated the damage and adaptation cost for flooding in whole Japan. (So Kazama, Ayumu Sato, Seiki Kawagoe, Evaluating the cost of flood damage based on changes in extreme rainfall in Japan, Sustainability Science, Vol.4, Iss.1, pp.61-69, 2009.) (So Kazama, Tohoku University)	Will see article and include as appropriate.
797	43534	3	34	33	34	33	Need to define UNFCC. (Andrew Wade, University of Reading)	Will do.
798	36033	3	34	33	34	34	Opening sentence is only a sentence fragment. (Michael Brewer, NOAA)	Will Revise
799	44613	3	34	35	34	37	Rewrite this sentence. (Martina Flörke, University of Kassel)	Will do.
800	40694	3	34	52	35	4	The impact of theoretical adaptation scenarios to spatio-temporal drought characteristics has been studied by Vidal et al. (2012) for France and compared to the impact of mitigation scenarios. Vidal, J.-P., Martin, E., Kitova, N., Najac, J. & Soubeyroux, J.-M. (2012) Evolution of spatio-temporal drought characteristics: validation, projections and effect of adaptation scenarios. Hydrology and Earth System Sciences, accepted. (Jean-Philippe Vidal, Irstea)	we will look at this paper and assess the evidence.
801	44614	3	35	9	0	0	Henrique & Spraggs, replace & by and (Martina Flörke, University of Kassel)	accepted and replaced
802	48098	3	35	19	0	0	Resilience is sometimes interpreted as adapting for a 'worst case' but not no-regret. (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	We deleted the sentence.
803	50094	3	35	19	35	19	The logic of this statement, following from the previous statement, could be clarified. (Katharine Mach, IPCC WGII TSU)	We will rephrase and clarify.
804	44615	3	35	31	0	0	Stuart-Hill and Schultz, 2010 (Schultz is named Schulz in the reference list) (Martina Flörke, University of Kassel)	accepted and revised.
805	45854	3	35	37	35	46	A recent publication entitled 'AMCOW. 2012. Status report on the application of integrated approaches to water resources management in Africa' may provide some additional evidence from the literature related to the content of this paragraph. (Bradley Hiller, World Bank)	we will look at this report; thanks for the reference.
806	50095	3	35	38	35	38	The chapter team should consider using calibrated uncertainty language, such as summary terms for evidence and agreement, to characterize the evidence described on this line. (Katharine Mach, IPCC WGII TSU)	we will consider this.
807	44616	3	35	43	0	0	Arnell 2011a (Martina Flörke, University of Kassel)	it is Arnell (2011b) JAWRA.
808	47773	3	35	46	3	46	Add a sentence here (or to section 3.6.4) to recognize the following: Carey et al. (2012) demonstrate that the implementation of climate change adaptation measures to prevent glacial lake outburst floods in Peru's Cordillera Blanca lead to water conflicts because of the new water management strategies that were facilitated by technologies installed to prevent the floods. When water managers do not engage local communities in their adaptation to climate change, then policies may introduce new risks that exacerbate climate change impacts. (Carey, M., French, A. and O'Brien, E.: 2012, Unintended Effects of Technology on Climate Change Adaptation: An Historical Analysis of Water Conflicts below Andean Glaciers, Journal of Historical Geography 38, 181-191). (Mark Carey, University of Oregon)	thanks for the reference: it is a good example of unanticipated consequences of adaptation measures.
809	47934	3	35	49	0	0	See also: Crabbe, P., and Robin, M. (2006) Institutional adapatatio of water resrouce infrastructure to climate change in Eastern Ontario. In Climatic Change. 78(1):103-133; Holman, I.P., and Trawick, P., (2011) Developing Adaptive Capacity within groundwater abstraction management systems. In Journal of Environmental Management. 92(6): 1542-1549. (Ameyali Ramos Castillo, United Nations University - Institute of Advanced Studies)	the original section was dropped and replaced by a new section.
810	50096	3	35	49	0	0	Section 3.6.4. For this section, the chapter team should ensure a focus on freshwater resources. The adaptation chapters can be referenced to provide background information. Also, it would be helpful to increase the specificity of the last paragraph of the section, also ensuring a focus on limits. (Katharine Mach, IPCC WGII TSU)	the original section was dropped and replaced by a new section.
811	47969	3	36	0	0	0	The section 3.6.5. could bbe moved or integrated with the chapter 2. (Jaroslav Mysiak, Fondazione Eni Enrico Mattei; and Euro-Mediteranean Center for Climate Change)	Disagree; the material here is specific to water management.
812	44617	3	36	10	36	11	please correct: "…conditions have changed and are expected to change." (Martina Flörke, University of Kassel)	the original section was dropped and replaced by a new section.
813	37345	3	36	11	0	12	Please give some examples for the Autonomous adaptation measures. (So Kazama, Tohoku University)	the original section was dropped and replaced by a new section.
814	41991	3	36	19	0	0	See my comment for page 29, line 7. (Nathan L. Engle, 2011-2012 AAAS Science and Technology Policy Fellow)	the original section was dropped and replaced by a new section.
815	44618	3	36	22	0	0	Either Zwolsman at al. 2010 or not in reference list (Martina Flörke, University of Kassel)	the original section was dropped and replaced by a new section.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
816	37666	3	36	30	0	0	I think this section needs some concrete discussion what adaptation actually entails. Add(?): For the U.S., the cost and policy option available to the electric and water sectors due to the levels of drought implied by climate change are presented in Kelic et al. (2009).[Kelic, A., V. Loose, V. Vargas, and E. Vugrin, 2009: Energy and Water Sector Policy Strategies for Drought Mitigation. Report SAND 2009-1360, Sandia National Laboratories Albuquerque, NM. Available at: http://prod.sandia.gov/techlib/access-control.cgi/2009/091360.pdf DOI 10.2172/974886] (George Backus, Sandia National Laboratories)	the original section was dropped and replaced by a new section.
817	50097	3	36	33	36	33	Section 3.6.5. For this section, the chapter team should ensure a focus on freshwater resources. (Katharine Mach, IPCC WGII TSU)	We will make this explicit - all the examples are from water management.
818	43535	3	36	33	37	30	Section 3.6.5. 'Dealing with Uncertainty' reads as a summary of possible techniques at the moment. I suggest that this section needs further development to provide a critique of how to treat uncertainty. (Andrew Wade, University of Reading)	We will provide an assessment.
819	44619	3	36	42	0	0	Arnell 2011a or b? (Martina Flörke, University of Kassel)	it is Arnell (2011b) JAWRA.
820	44620	3	37	9	0	0	Henrique & Spraggs, replace & by and (Martina Flörke, University of Kassel)	accepted and replaced
821	44621	3	37	35	37	41	Text is rather general and hence should be integrated into introduction of section 3.6. (Martina Flörke, University of Kassel)	not moved
822	46026	3	37	36	37	38	The mention of IWRM in lines 36 and 38 seems out of place. (Luis E. Garcia, World Bank)	we revised the text accordingly
823	41992	3	38	2	0	0	World Bank has been cited several times, this being one of them. Why is there no reference to the 2010 World Development Report on Climate Change and Development? There is an entire chapter on water, land, and food systems. (Nathan L. Engle, 2011-2012 AAAS Science and Technology Policy Fellow)	good point, but we tried to keep not too many references.
824	52698	3	38	3	0	0	This line may be used to add a phrase along the following lines. One incentive to obviate maladaptation will be to see virtual water uses and evaluate them in the countries receiving commodities. The time should arrive when the externalities are included in the pricing of exports (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	we revised this part and included this option.
825	44622	3	38	4	38	7	The authors may refer to PROVIA, UNEP's Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (Martina Flörke, University of Kassel)	yes, good idea, it's added in the listing.
826	43536	3	38	19	38	27	There is the potential to allow controlled flooding of agricultural land to alleviate flooding in urban areas. (Andrew Wade, University of Reading)	very good point, we included it!
827	50098	3	38	40	38	42	For this statement, it would be helpful to indicate the relevant time frame, and potentially the relevant climate/socio-economic scenarios. (Katharine Mach, IPCC WGII TSU)	no time frame, number refer to afforestation of all areas suitable for afforestation according to CDM-AR.
828	46027	3	38	42	38	43	If true that when runoff decreases the carry-over from land of N, P and eroded material decreases with beneficial impacts on water quality of receiving water bodies, this may not always be the case. If runoff decreases (unless there is a substantial contribution from base flow), the streamflow also decreases and the concentration increases. (Luis E. Garcia, World Bank)	Agreed. Therefore, we wrote,"depending on local conditions"
829	37346	3	38	52	0	0	“be” should it change as “by”. (So Kazama, Tohoku University)	Accepted and changed.
830	43185	3	38	52	38	54	In this sentense "l" which stands for liter may be replaced with Liter for the sake of clearity (GHAZANFAR ALI, GLOBAL CHANGE IMPACT STUDIES CENTRE (GCISC))	Accepted and changed.
831	37347	3	38	53	0	54	“with 2400 l consumptive water use per 1 ethanol”, please reword this. Meaning is not clear. (So Kazama, Tohoku University)	l (Liter) replaced by m3.
832	50099	3	38	54	38	54	It would be helpful to further characterize the scenarios mentioned--scenarios of what? (Katharine Mach, IPCC WGII TSU)	not possible due to lack of space.
833	50100	3	39	9	39	10	For this described outcome, is it possible to specify the relevant timeframe or scenario used in the analysis? (Katharine Mach, IPCC WGII TSU)	not pertaining to a timeframe or scenario just chemical equilibrium considerations.
834	36034	3	39	10	0	0	As an example. The software used identifies the strings of et al and automatically puts them in italics. This is not a problem except in instances like this (and others throughout document) where the word is actually metals. (Michael Brewer, NOAA)	accepted and checked it
835	44623	3	39	10	0	0	metals (Martina Flörke, University of Kassel)	accepted and revised.
836	52699	3	39	14	0	0	Impacts of climate change mitigation also include the potential reduction of dangerous emissions, like those that bring hydrometeors (rain, snow, fog, dew, frost) acidification. Since the poorer quality of fossil fuels will increase the emission of sulphur, And this will exacerbate acidification of precipitations, etc (the well known case in China does not require more details), emphasis must be put in the local and regional effects of fuel economy (read: mitigation of emissions). Another new and critical issue is that of the shale oil and shale gas exploration and extraction. These activities will adversely affect underground water in deep reservoirs. Therefore paragraph 3.7.2.1 must report on these adverse trends in future water quality (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	But shale oil and gas are not mitigation actions.
837	43537	3	39	36	39	45	Measures put in place to reduce diffuse pollution fluxes from agriculture entering surface waters may increase GHG emissions. For example, emissions of N2O may increase from buffer strips designed to reduce NO3 fluxes to surface waters due to incomplete denitrification (Heftinget al. 2003). The trade-offs between the impacts on climate regulation and provision of good quality water need to be balanced. Hefting MM, Bobbink R, de Caluwe H. 2003. Nitrous oxide emission and denitrification in chronically nitrate-loaded riparian buffer zones. Journal of Environmental Quality 32(4), 1194-1203. (Andrew Wade, University of Reading)	Not covered due to space constraints.
838	36035	3	39	38	0	0	Need to identify the CC acronym before using (Michael Brewer, NOAA)	accepted and identified it.
839	44624	3	39	38	0	0	CC mitigation (Martina Flörke, University of Kassel)	accepted and identified it.
840	50101	3	39	50	39	54	It would be helpful to clarify if these statements are specific to their water sector--and if not, provide clearer linkage to water here. (Katharine Mach, IPCC WGII TSU)	the original section was dropped and replaced by a new section.
841	44625	3	39	51	0	0	Elasha (2010) not in reference list (Martina Flörke, University of Kassel)	the original section was dropped and replaced by a new section.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
842	44626	3	40	3	0	0	Bates (2008) (Martina Flörke, University of Kassel)	the original section was dropped and replaced by a new section.
843	52700	3	40	3	0	0	The right way to mentioned an IPCC Report or Technical Note is to refer the name and, in the bibliography, to write the authors. Therefore, the quotation in this page shall read IPCC Technical Paper VI- Clmate Change and Water, 2008) (Osvaldo Francisco Canziani, Academia Argentina de Ciencias Ambientales)	the original section was dropped and replaced by a new section.
844	48099	3	40	9	0	0	Another research gap relates to adaptation approaches (Geoff Darch, Atkins (Visiting Lecturer at UEA, Industrial Supervisor at UCL))	Thank you very much but we tried to include the adaptation approaches in 3.6 Adaptation and Managing Risks.
845	43538	3	40	9	40	39	I suggest two other research and data gaps. The first is the lack of knowledge regarding the extent of groundwater resources. The second is how to deal with uncertainty in the climate model outputs in terms of regional precipitation. Biased corrected precipitation is used in hydrological impact assessments but little consideration, in such impact studies, is typically taken of whether the climate simulators are representing the atmospheric processes sufficiently well to have good confidence in the simulation of precipitation, in particular the extreme events. A recent article by Pielke and Wilby (2012) noted some of the problems. Piekle RA, Wilby RL. 2012. Regional Climate Downscaling: What's the Point? Eos 93(5), 52-53. (Andrew Wade, University of Reading)	Description of ground water resources was added finally in the final governmental draft. Uncertainty in the climate model outputs are also described in the final governmental draft.
846	46028	3	40	9	40	39	Section 3.9 Research and Data Gaps: After all what was said in previous sections and pages, this section feels like a welcomed, sobering down to earth contribution. Again, no references so it must be from the authors of the Chapter. Perhaps would be worthwhile to add some of this to the Executive Summary and Conclusions of the Chapter. (Luis E. Garcia, World Bank)	Summary and conclusion is summerized in the Executive summary.
847	52641	3	40	9	40	39	Section 3.8, too little focus on biological systems (Else Marie Løbersli, Norwegian directorate for nature management)	Interactions between biological systems and water is described in Chapter 4, Terrestrial and inland water systems, but little statement was added in the final governmental draft.
848	37083	3	40	12	0	39	One main research challenge remains to establish references with synoptic spatial accounting of past hydroclimatic archived or reconstructed data in order to allow change assessments in the future. See the synoptic analysis within Tunisia: Slimani M., Cudennec C., Feki H., 2007. Structure du gradient pluviométrique de la transition Méditerranée–Sahara en Tunisie: déterminants géographiques et saisonnalité. Hydrological Sciences Journal, 52, 6, 1088-1102, doi: 10.1623/hysj.52.6.1088 - Baccour H., Slimani M., Cudennec C, 2012. Etude synoptique conjointe des structures spatiales de l'évapotranspiration et de variables climatiques corrélées en Tunisie. Hydrological Sciences Journal, 57, 4, 818-829, DOI: 10.1080/02626667.2012.672986. - Feki H., Slimani M., Cudennec C. Incorporationg elevation in rainfall interpolation in Tunisia using geostatistical methods. Hydrological Sciences Journal, in press. This should be addressed in Chapter 2 and potentially 22. This can also have impacts on bio and agricultural geography, thus potentially on people migrations within countries since ancestral adapatation to variability may not be robust any more over (rural) territories (para 7.3, 7.4, 9.3, 12.4). See also S. Vicente-Serrano and colleagues' publications on droughts. (Christophe Cudennec, Agrocampus Ouest)	Thank you very much. Regional studies are assessed in each regional chapter. Detecting past climate change in hydroclimatic record is mainly assessed by Working Group I.
849	40308	3	40	18	40	18	A specific mention of the need for better metadata is needed here also. Add 'arterial drainage' and 'instrumental changes' to the list on line 15. (John Sweeney, National University of Ireland Maynooth)	Yes, but issues of metadata is too technical and have lower priority to be included in the limited space.
850	45855	3	40	21	40	25	There appear relatively few results on holistic costing of natural capital related to water resources, let alone climate change impacts and adaptation options. (Bradley Hiller, World Bank)	Ecosystem services on freshwater resources are described in Chapter 4, Terrestrial and inland water systems.
851	49013	3	40	30	40	30	Add "although robustness of regional climate projections is still contrained by the realism of large-scale processes in driving GCMs" (or words to that effect). Ie: if GCM projection is no good then RCM cannot be better - rubbish in: rubbish out! (Richard Betts, Met Office Hadley Centre)	Thank you very much. The description was added in the final governmental draft.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
852	46411	3	40	33	40	33	The UNESCO Division of Water Sciences has initiated a working group on identifying the relative role of climatic variability and land cover change on floods and low flows as a function of spatial scale. The mandate of the working group was to summarise the state of the art of the subject, develop the key science questions, plan a five year research strategy for testing in HELP basins and other research experimental basins, and plan a series of workshops. The paper Günter Blöschl, Sandra Ardoin-Bardin, Mike Bonell, Manfred Dorninger, David Goodrich, Dieter Gutknecht, David Matamoros, Bruno Merz, Paul Shand, Jan Szolgay: At what scales do climate variability and land cover change impact on flooding and low flows? Invited commentary. Hydrological Processes 21 (9), pp. 1241-1247in DOI: 10.1002/hyp.6669,) summarised findings of a working group meeting held in Vienna to provide a road map of how to address these issues and act as a catalyst for motivating communication and targeted research. These are the conclusions of the paper, you may find some issues relevant to be put into the subchapter on Research gaps. 'To provide a road map of how to address the issues of climate variability and land cover change impact on flooding and low flows, the working group has singled out a number of specific research questions. These are given below for each of the themes discussed above. Change and methods of change analysis • What do various earth-sciences consider change? • How do they deal with it? • What are the results of agents of change on hydrological response, and time scales of change? • What are suitable methods of change analysis/detection? • When does the delta change approach (or incremental change approach) fail? Transitional climate regimes • How can one best use climate model results in view of the scale gap? • How does uncertainty propagate from climate to hydrological models? • How can analyses by the analogue method be combined with results from climate models? • If circulation patterns change – does this decrease/increase floods? • How can one relate changes of the mean atmospheric characteristics to changes of the extremes? Catchment processes and flow paths • How do land use change and climate variability modify flow pathways and storage? • What are the changes in soil structure due to vegetation changes (e.g. break down of fabric, mineralogy)? • What are the changes in the time scales, e.g., over what time scales does soil structure change occur in response to land cover change? • What is the resilience of soil hydraulic characteristics to change? • What is the recharge for different settings and how does it change with climate/land use changes? Feedbacks • How do floods and low flows change with time and what are the feedback mechanisms controlling them? • What feedbacks of land cover / climate impacts on water resources exist? • What are the positive and negative feedback loops? • How does the water balance affect runoff components (interactions between long and short time scales)? • What are the changes in the coupling between groundwater and surface water linked with land cover change? Heterogeneity and scaling • What percentage of catchment area can be changed to another land cover type before a significant change in the flood regime occurs? • How do changes in the hydraulic soil characteristics due to vegetation changes transfer to larger scales? • How can one upscale local information on soils, vegetation, groundwater and groundwater - surface water interactions to the scale of HELP basins (10000km²)? • What are integrative concepts of upscaling/downscaling in the context of impact analyses? • What is the relative role of climatic variability and land cover change on floods and low flows as a function of scale in different environments? Generalisation and potential of typologies • How can climate/rainfall, catchments, aquifers, soils and vegetation be classified (with a view on floods and low flows)? • What processes switch between regimes (in time, spatially)? • How to best overcome data scarcity to assess the impacts on the water resource due to land cover change and what are low cost options for measuring hydrological response at various scales? • What is the necessary network density to address a management problem such as the ecological consequences in a stream of catchment development? • What variables should be strategically collected that would more directly address impact on hydrological response?' (Jan Szolgay, Slovak University of Technology)	noted but hopefully some of the issues are illustrated in the concept of Figure 3-1.
853	35430	3	40	43	0	0	Suggest cross reference to FAQ in WGI Ch4 Are glaciers in mountainous areas dissppearing? (David Vaughan, British Antarctic Survey)	Thank you for this very worthwhile suggestion.
854	44203	3	40	43	0	0	Box 3-2 is well written and will improve with the assimilation of a series of recently published papers (Georg Kaser, University of Innsbruck)	Thank you.
855	43406	3	40	45	40	0	Include a rererence to Singh, SP; Bassignana-Khadka, I; Karky, BS; Sharma, E (2011) Climate change in the Hindu Kush-Himalayas: The state of current knowledge. Kathmandu: ICIMOD http://www.icimod.org/publications/index.php/search/publication/773 (David Molden, International Centre for Integrated Mountain Development (ICIMOD))	We will consider this source, but in general we try to focus on the primary research literature rather than on other assessments.
856	43407	3	40	48	40	0	Add that since the AR4, there has been efforts to improve the database, including studies on glaciers and ice: 1) Bajracharya, SR; Shrestha, B (eds) (2011) The status of glaciers in the Hindu Kush-Himalayan region. Kathmandu: ICIMOD http://www.icimod.org/publications/index.php/search/publication/775. 2) Gurung, DR; Amarnath, G; Khun, SA; Shrestha, B; Kulkarni, AV (eds) (2011) Snow-cover mapping and monitoring in the Hindu Kush-Himalayas. Kathmandu: ICIMOD http://www.icimod.org/publications/index.php/search/publication/774. 3) Bolch, T., Kulkarni, A., Kaab, A., Huggel, C., Paul, F., Cogley, J.J.G., Frey, H., Kargel, J.S., Fujita, K., Scheel, M., Bajracharya, S. and Stoffel, M. (2012) The State and Fate of Himalayan Glaciers. Science Vol 336, 20 April 2012. (David Molden, International Centre for Integrated Mountain Development (ICIMOD))	Bolch et al. 2012 will certainly be cited in the SOD. We will consider the ICIMOD reports, but in general we try to focus on the primary research literature rather than on other assessments.
857	44627	3	41	0	0	0	Box 3-2. unit per year is written as a-1 (Martina Flörke, University of Kassel)	Yes.
858	49014	3	41	14	41	14	Figure caption needs to include the references for studies shown in panel (a). Also I think an accompanying table with more detail would be useful. (Richard Betts, Met Office Hadley Centre)	The list of sources for this figure would add about one IPCC page to the chapter reference list, and a table would be similarly bulky. We will investigate the possibility of including it in AR5 as "Supplementary Material".
859	49561	3	41	29	0	0	mass loss of glacier ice in Himalayas in 2035: Please make sure the numbers are correct as there has been a blunder in IPCC AR4 related to this issue. (Amithirigala Jayawardena, International Centre for Water Hazard and Risk Management (ICHARM))	The numbers have been checked carefully.
860	49015	3	41	29	41	29	Say why 2035 is being mentioned - otherwise it seems a bit arbitrary. (Richard Betts, Met Office Hadley Centre)	Added a citation of Cruz et al. 2007 (AR4 WG2 Ch10).
861	36112	3	42	0	0	0	FAQ 3.1: The statements are rather general and the uncertainties and the variability in hydrological projections must be mentioned. (Pradeep MUJUMDAR, Indian Institute of Science)	FAQ was revised a lot.
862	43408	3	42	6	42	0	Include a reference to the following: ICIMOD (2011) Glacial lakes and glacial lake outburst floods in Nepal. Kathmandu: ICIMOD http://www.icimod.org/publications/index.php/search/publication/750 (David Molden, International Centre for Integrated Mountain Development (ICIMOD))	We will consider this source, but in general we try to focus on the primary research literature rather than on other assessments.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
863	50102	3	42	12	42	52	Calibrated uncertainty language used on this page should be italicized; please check lines 12, 38-39, 43, 44, 45, 50, 51, 52. Also, the chapter team should ensure that "likely" on line 12 and "very likely" on line 51 reflect a probabilistic basis for their assignment; casual usage of the reserved uncertainty terms should be avoided. (Katharine Mach, IPCC WGII TSU)	Changed "likely" to "expected" at P42 L12.
864	43409	3	42	17	42	0	Include the following reference: Rasul, G.: 2011, 'The Role of the Himalayan Mountain Systems in Food Security and Agricultural Sustainability in South Asia', International Journal of Rural Management 6, 95- 116. (David Molden, International Centre for Integrated Mountain Development (ICIMOD))	This paper is about the role of water from the mountains in the problem of agricultural production in the lowlands. It does not match well with the sentence, which already has a good supporting reference.
865	46436	3	42	17	42	18	In the sentence: "In the mountains, however, both dependence on and vulnerability to glacier meltwater can be of serious practical concern when measured per head of population.", please delete "and" after "on". (Rubén Piacentini, Institute of Physics Rosario (CONICET - National University of Rosario))	No. The suggested "dependence on vulnerability" would be meaningless.
866	46029	3	42	25	42	30	Good question but the answer is not enough for engineering design purposes. (Luis E. Garcia, World Bank)	FAQ was revised a lot.
867	39054	3	42	26	42	27	Is this increase in evapotranspiration referring to the global scale? If this is the case, I have no problem with this sentence. However, on a regional scale (as the preceding sentence refers to), evapotranspiration may only increase if there is water available to be evaporated. That is, there can be no increase in evapotranspiration in already water limited environments. (Daniel Kingston, University of Otago)	accepted and revised.
868	37157	3	42	27	42	27	The FAQ on water resources focuses on changes in average annual runoff, but arguably it is seasonal changes that are more pertinent to water resources. (Stephen Darby, University of Southampton)	accepted and revised.
869	46908	3	42	33	42	35	This section should include the recognition that human interventions such as dam mismanagement during extreme flood events can exacerbate flood impacts and damages. For examples, see the 2008 flooding events in Nepal and India (http://www.internationalrivers.org/node/1552), and the 2009 flooding events in the Philippines and India (http://www.internationalrivers.org/node/1363). This sectiomn could read "Floods are natural phenomena (which can be worsened by human interventions), defined as an above-average water level, that overflows onto land that is not usually submerged. Source of floods are intense rainfall, snow and ice-melt, combined rain and ice-melt, the breakdown or overtopping of dams, dikes and embankments, and the breakdown of natural dams (e.g. ice-dam lakes in glacial retreat regions, also known as glacial lake outbursts)." (Katy Yan, International Rivers)	Human and geophysically produced floods are not in the scope of this report.
870	44628	3	42	34	0	0	usage of & (Martina Flörke, University of Kassel)	Accepted and changed.
871	48211	3	42	34	42	34	Many floods are generated by combined rain and snowmelt (versus ice-melt). (David Sauchyn, University of Regina)	Agree. Changed
872	48212	3	42	36	42	37	Two instances of 'based on' in the same phrase. (David Sauchyn, University of Regina)	Agree. Changed
873	46437	3	42	37	42	38	With respect to the sentence: "As floods are rare hydrological events (frequency <1 flood in 10 years), the number of events from historical records is limited and their trends are difficult to establish", the frequency of less than 1 flood per decade is not applied in all regions (for example, to the Nilo river in Africa). Please, verify this sentence. (Rubén Piacentini, Institute of Physics Rosario (CONICET - National University of Rosario))	Agree. Changed
874	48213	3	42	39	42	39	due 'to' (David Sauchyn, University of Regina)	accepted
875	46438	3	42	41	42	43	Please, correct the word "disasters" by "disaster" in the following sentence: "Floods may have adverse effects on exposed and vulnerable elements (a predisposition to loss and damage) that entail social, economic, or environmental impacts, becoming a "natural disasters"." (Rubén Piacentini, Institute of Physics Rosario (CONICET - National University of Rosario))	accepted
876	44629	3	42	42	0	0	"…becoming a natural disasters" (Martina Flörke, University of Kassel)	accepted
877	48214	3	42	51	42	51	'in' not 'at' (David Sauchyn, University of Regina)	accepted
878	36114	3	43	0	0	0	FAQ 3.4: Some non-intensive technical alternatives suited for poorer countries must also be suggested. (Pradeep MUJUMDAR, Indian Institute of Science)	accepted and reflected in the revision
879	36115	3	43	0	0	0	FAQ 3.6: How cost effective is the 'no-regrets' option – this aspect needs to be discussed. (Pradeep MUJUMDAR, Indian Institute of Science)	A comment made on text
880	37158	3	43	2	43	18	I thought that the tone of this FAQ answer was somewhat polemical. The honest answer is 'who knows' - both drivers (population growth and climate change) are important and often compound each other. It seemed to me that the response was trying to argue for the primacy of climate change when that would be highly debatable (Stephen Darby, University of Southampton)	The FAQ answer clearly points out that there is no primacy of climate change but that the answer depends on region, compartment and type of stress.
881	53871	3	43	2	43	18	This section while good, leaves out an important point, namely that the water cycle is intrinsically part of the climate cycle because it is a primarly mechanism to redistribute heat. If we add additional energy to the climate system, the water cycle will change. This point is important to make because it explains WHY the changes to the hydrologic cycle are a global phenomenon under climate change. (Bradley Udall, University of Colorado)	This FAQ has been deleted.
882	43186	3	43	7	43	7	You may like to consider changing the word "Volume" with "Magnitude" (GHAZANFAR ALI, GLOBAL CHANGE IMPACT STUDIES CENTRE (GCISC))	Volume was replaced by amount. Magnitude would tend to suggest large-magnitude events to the more hasty reader.
883	50103	3	43	11	43	12	For this statement, the chapter team should also consider the role of exposure and vulnerability in determining the risks and impacts of flooding. (Katharine Mach, IPCC WGII TSU)	Would interrupt flow of thought.
884	46030	3	43	11	43	13	The discussion on page 7, lines 12 to 52 does not seem to fully support this statement. See also SREX (IPCC, 2012) and Peterson et al., 2012). (Luis E. Garcia, World Bank)	"in most areas of the globe "was deleted.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
885	36113	3	43	12	43	12	'increased risk of flooding in most areas of the globe due to increased occurrence of heavy rainfall' – this is again a rather general statement. Trends in extreme rainfall or flooding are not uniform across the globe, and the variability and the uncertainty associated should be mentioned. (Pradeep MUJUMDAR, Indian Institute of Science)	in most areas of the globe was deleted.
886	48215	3	43	12	43	12	Re "no other human stress", what about deforestation? (David Sauchyn, University of Regina)	Agreed. Reformulated.
887	44204	3	43	14	43	15	Geographical Names in capital letters (pleas echeck also in other references) (Georg Kaser, University of Innsbruck)	no geographical names here.
888	48216	3	43	15	43	15	Also, the success of adaptation efforts. (David Sauchyn, University of Regina)	Yes, but we thought of impacts before adaptaton.
889	46031	3	43	15	43	18	Is this an opinion? If so, it would be useful to say so. Otherwise, to include references. (Luis E. Garcia, World Bank)	No references in FAQs
890	50104	3	43	20	43	20	The chapter team should ensure a formulation for this question that avoids potential interpretation of policy prescription. (Katharine Mach, IPCC WGII TSU)	accepted and reflected in the revision
891	46909	3	43	20	43	32	This section should mention the benefits of "green water" compared to conventional water storage in dam reservoirs. As Swedish hydrologist Malin Falkenmark has shown, more freshwater is available as green water (in fields and plants) than as blue water (in rivers and lakes). Water can be stored through techniques that maintain soil humidity, underground in aquifers, in local ponds, and in small reservoirs. This sectoin should also explicitly reference "green infrastructure" as the necessary core of 21st century integrated water management approaches. For more information, see American Rivers' 2009 report, "Natural Security: How Sustainable Water Strategies are Preparing Communities for a Changing Climate," which is US-focused but has global relevance: http://www.americanrivers.org/assets/pdfs/reports-and-publications/natural-security-report.pdf.) Their benefits also include their cost-effectiveness and flexibility for communities dealing with the impacts of climate change. Their three key components include: - Protect healthy landscapes like forests and small streams that naturally sustain clean water supplies. - Restore degraded landscapes like floodplains and wetlands so they can better store flood water and recharge streams and aquifers. - Replicate natural water systems in urban settings, to capture rainwater for outdoor watering and other uses and prevent stormwater and sewage pollution. (Katy Yan, International Rivers)	accepted and reflected in the revision, even though the jargon "green water" is not explicitly used.
892	48217	3	43	21	43	22	The first sentence in FAQ 3.4 is not clear; it is too abstract. (David Sauchyn, University of Regina)	accepted and reflected in the revision
893	39341	3	43	23	43	52	1. The FAQ 3.6 seems very closely related to FAQ 3.4. Suggest to combine these two questions into 3.4 and to add a new question before FAQ 3.4 : What Policy makers need to know on the current studied results of climate change impact and future projection from climate scenarios to be used in their climate change adaptation options . Because climate change adaptation options reflect the state of knowledge in the area of climate change impact on water resources and the scientific level of future projection. (Liu Chunzhen, Ministry of Water Resources)	noted but we decided to keep these two FAQs separately.
894	48218	3	43	26	43	26	'natural resource management' in this instance is more specifically watershed and land use planning and management. (David Sauchyn, University of Regina)	accepted and reflected in the revision
895	50105	3	43	36	43	37	The chapter team should consider if further qualification of this statement would be beneficial. (Katharine Mach, IPCC WGII TSU)	The two instances of "will" altered to "are likely to".
896	35431	3	43	39	0	0	I'd like to see "shortlived/limited-duration/etc meltwater dividend" (David Vaughan, British Antarctic Survey)	Altered to acknowledge uncertainty in duration of the dividend.
897	48219	3	43	39	43	40	In some regions, the meltwater dividend already has occurred or is presently being realized; it is not a future prospect. (David Sauchyn, University of Regina)	The dividend is realized with respect to any given reference epoch, as long as the specific mass balance and the glacierized area are opposing linear functions of time after that epoch. The comment is probably accurate in many regions if the reference epoch is taken as the culmination of the Little Ice Age. We will try to accommodate this point by rewording.
898	52841	3	43	40	0	0	....the total yield of meltwater will < gradually diminish depending on percentage of glacierization, depth of ice streams and altitudinal distribution and range of glacier areas >. (Herbert Lang, ETH Zürich)	Substituting "gradually" for "eventually" would change the meaning of the statement, which is about the date of the inflection in the time series of total yield. The comment would no doubt be correct if we were discussing the rate of diminution after this date, but we are not.
899	46032	3	43	42	43	43	On this same page 43, lines 4 and 5 it is implied that some measures of water management put additional stress on freshwater systems. It seems contradictory. (Luis E. Garcia, World Bank)	Sentence changed to "More careful management can alleviate some stresses on water resources arising from climate change, for example by improving the seasonal distribution of water availability."
900	46439	3	43	42	43	43	Please, verify the words "a more positive effects", since in principle, if you include the word "a" then it must be "effect", in the following sentence: "Regions where water resources are heavily managed might experience a more positive effects, including improvement in seasonal availability of water, under climate change." (Rubén Piacentini, Institute of Physics Rosario (CONICET - National University of Rosario))	changed
901	48220	3	43	43	43	43	An increased seasonal availability of water is an 'improvement' only if it occurs in the season of highest water demand. In seasonal climates most of the demand is in summer. (David Sauchyn, University of Regina)	See annotation on comment #899.
902	50106	3	43	45	43	45	The chapter team might consider a more informative angle for this question. (Katharine Mach, IPCC WGII TSU)	No space available for this.
903	43539	3	43	45	43	52	Reducing per captia consumption of water would also be a "no-regrets" option. (Andrew Wade, University of Reading)	The FAQ was deleted.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
904	46033	3	43	49	43	52	I have some diffculties with this example: providing universal access to safe water. Assuming this were possible in the near future (even in developing countries), how does this guarantee that climate change will not stress populations in the future? Because of climate change this goal could not be achievable in the future. True, it may affect less people. But the goal of providing universal access to safe water is something that has to be sought, climate change or not. (Luis E. Garcia, World Bank)	Yes, you are right but having access to a safe water supply and sanitation reduces vulnerability to climate change. In that sense it is an adaptation option.
905	44630	3	44	0	65	0	References: revision of format is necessary (Martina Flörke, University of Kassel)	accepted and revised.
906	39338	3	66	0	0	0	The Tab.3-1 introduced studied results from 12 papers on detection and attribution of impacts of climate change on freshwater resources. In the table there are “Observed change” and “attributed to what” described. It will be perfect, if the applied method of detection and attribution for every example from these 12 papers to be involved in this table, e.g. which one uses end-to-end attribution, which one uses multi-step attribution and so on. (Liu Chunzhen, Ministry of Water Resources)	We will try to add parenthetical descriptions of the methods of attribution in the Attributed To column.
907	39342	3	66	0	0	0	1. The Tab.3-1 introduced studied results from 12 papers on detection and attribution of impacts of climate change on freshwater resources. In the table there are “Observed change” and “attributed to what” described. It will be perfect, if the applied method of detection and attribution for every example from these 12 papers to be involved in this table, e.g. which one uses end-to-end attribution, which one uses multi-step attribution and so on. (Liu Chunzhen, Ministry of Water Resources)	same with #906.
908	39354	3	66	0	0	0	Table 3-1: Attribution statements are too definitive. What is the actual estimated attributed contribution to observed change and the liklihood of the analysis? Min 2011 study [1] formally an attribution anthropogenic factors study and deduced greenhouses gases contributed to change, but didn't say by how much. (Gareth S Jones, Met Office)	Sources 1 and 2 are the only end-to-end attribution studies in the table. We might be able to extract such information as fractions of variance explained by linear regression from some of the others, but the methods and the endpoints of the attributions are so heterogeneous that quantitative information of the kind requested here might be more misleading than helpful.
909	42400	3	66	0	0	0	Expand this table to include social and economic impacts (including fatalities from droughts and floods).. (Indur Goklany, Independent)	It is unlikely that there will be space for an extra column about socioeconomic impacts, which in any case are not considered in most of the sources.
910	50107	3	66	0	0	0	Table 3-2. For the 3rd column, the chapter team could consider indicating the relevant time frame for projections as relevant. (Katharine Mach, IPCC WGII TSU)	included in second column.
911	36090	3	67	0	0	0	Table 3-2: The title needs to be diluted. ‘impacts of climate change on humans and ecosystems that could be avoided’ – Do the studies referred herein really establish that such changes could be avoided by reducing greenhouse gas emissions? (Pradeep MUJUMDAR, Indian Institute of Science)	Yes, indirectly.
912	42401	3	67	0	0	0	To this table, add changes in net global population at risk of water stress from Arnell et al. (2011) and van Vuuren et al. 2011) for the various scenarios. (Indur Goklany, Independent)	Due to lack of space we can not add them.
913	44631	3	67	0	0	0	Table 3-2: last column, Feyen et al. 2012 is not included in the list of references (Martina Flörke, University of Kassel)	Accepted and added
914	54370	3	67	0	0	0	Table 3-2: Many of these impacts are reduced by mitigation, but not avoided, and it would be useful to clarify this in the caption. (Michael Mastrandrea, IPCC WGII TSU)	avoided was replaced by reduced.
915	42402	3	68	0	0	0	See comment on page 29, line 30. (Indur Goklany, Independent)	Accepted
916	44632	3	68	0	0	0	Table 3-3: second row, second column: ".. support integrated water resources management (IWRM), …" (Martina Flörke, University of Kassel)	The table was revised a lot.
917	44633	3	68	0	0	0	Table 3-3: third row, second column: "…variations in influent quality and quality;…" (?) (Martina Flörke, University of Kassel)	The table was revised a lot.
918	44634	3	68	0	0	0	Table 3-3: fourth row, second column: "…tariffs (where there is eleasticity)" (?) (Martina Flörke, University of Kassel)	rephraded as "they result relevant to reduce consumption"
919	46910	3	68	0	0	0	Table 3-3: Include "green infrastructure" options under "Improve water management practices." Under this same objective, rephrase 2nd to last sentence on dam operation to reflect regions of greater water scarcity (and high density of dams) as well as regions of greater water availability, as follows: "In regions of both greater water availability and water scarcity due to climate change, reoperate dams in a way that increases the climate resilience of freshwater ecosystems and downstream communities through environmental flows strategies." (Katy Yan, International Rivers)	The table was revised a lot.
920	39340	3	68	0	69	0	1. The table 3-3 describes climate change adaptation options regarding freshwater from 7 objectives, all of them are true and some of them have been applied in current practice for policy makers and water managers to cope with multiple stresses from human and ecological systems. It seems that the listed options are too over-elaborate and there is lack of linkage of these adaptation options to observed impact in 3.2 and with projected hydrological changes presented in section 3.4 and particularly with main presented content in 3.6.1—3.6.6. I’d like to suggest revise and refine table 3-3 and move it to the end as conclusion and summary of this section to involve some key findings of 3.6 in this table, such as options of relative adaptive management in objective “Improve water management practices” and to add some measures of disaster risk management in the objective “Reduce impact of natural disasters”. (Liu Chunzhen, Ministry of Water Resources)	Table 3-3 is to be completed and better integrated and supported by the text. It had to be produced first in order to be discussed collectively by all the team.
921	42614	3	68	0	69	0	Table 3-3 with long list of references following. Please disaggregate into regional trends & recommendations, ideally with regional maps where appropriate, and coordinated with regional chapters. Not very useful to inform policy decisions in present form. (Jean Bogner, University of Illinois at Chicago (UIC))	Because of the lack of space the references have been consolidated; the options cannot be "regionalised" as regions are so big and varied that almost all option had to be included to address local needs. For regional recommendations please consult the regional chapters of the assessment.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
922	53899	3	68	0	69	0	Table 3-3: It would be useful to have a “reference column” on the left of the table (instead of aggregated reference list for the all source of information) so that readers can look up the source for specific cases just like your table 3-2. (Yuka Estrada, IPCC WGII TSU)	see repply below. In addition te complete reference provided at the end of the chapter allow people to select those of interest.
923	43540	3	68	3	68	0	Table 3-3. Is hydroponics included in the phrase 'improved irrigation efficiency'? Vegetation buffers may lower nutrient fluxes entering surface waters but they may also increase GHG emissions to the atmosphere. Further work is needed to look at the trade-offs. Does the idea of 'virtual water' have a role as a adaptation option, where crops are grown in areas with surplus water and exported to those with deficits. I think so. It is already happening. (Andrew Wade, University of Reading)	Hydrponics is included on the row related to the control of water pollution "Prevent pollution of water bodies through vegetative buffers"; for the one on virtual water no references assesing their role to address impacts on climate change were available.
924	44635	3	69	0	0	0	List of references, please correct: de Graaf, R. and van der Brugge, R. (2010) (Martina Flörke, University of Kassel)	accepted and corrected the reference
925	42403	3	70	0	0	0	Table 3-4 takes a very narrow view of adaptability, and what factors affect adaptability. These factors should include human capital and technological know-how. Technology, for instance, includes not just hardware solutions but software [including knowledge, agricultural technologies and practices that would conserve or recycle water, etc.; see comments on page 29, line 30, Goklany (2007b,). It should utilize technology, if appropriate, whether or not it is based on "traditional knowledge". (Indur Goklany, Independent)	the table was dropped from the draft.
926	43541	3	70	0	70	0	Table 3-4. Does 'technical capacity' also mean funding people to design and implement adaption mechanisms? If not, I suggest it should. I suggest that education and behavioural change should also be included as access mechanisms. (Andrew Wade, University of Reading)	the table was dropped from the draft.
927	36066	3	71	0	0	0	Figure 3-1 does not consider some ways of changes in hydrological variables, as has been observed. For example, Figure 3-1 only considers ‘Increasing Precipitation’, whereas - and this is important for regional studies on impact assessments – Section 3.2.2 clearly mentions that precipitation trends, both regional and global are not compelling. (Pradeep MUJUMDAR, Indian Institute of Science)	accepted and revised.
928	42388	3	71	0	0	0	I would recommend dropping this figure or footnoting it liberally. First, it should note that empirical evidence so far is not always consistent with this framework. Specifically, (A) There is no indication of more intense typhoons (or cyclones or hurricanes); see Maue (2011); Vecchi and Knutson (2011); (B) The text on pages 7 and 8 indicates that empirical data doesn't indicate a global increase in the magnitude and frequency of floods or droughts. Second, modify the box on typhoons to read, "changes in the frequency and magnitude of typhoons". Similarly, substitute "Change in" for "Increase of" in each box where that occurs. [Rationale: In many places risks could be reduced. See, e.g., comments on page 3, line 1.] Third, modify the "more frequent floods" box to read "changes in flood magnitude and frequency" [Rationale: IPCC AR4 WG1, Chapter 11, Third panel in Figures 11-2, 11-5, 11-9 and 11-12, all indicate that there will be changes, but in some areas some models indicate an increase in precipitation and in other areas there should be decreases, so in some areas flooding will be worse but in other areas it should be less. Similarly for droughts. Fourth, add a red box with the following text: "changes in water availability". [Rationale: See: Arnell (2004), Oki and Kanae (2006), Alcamo et al. (2007), van Vuuren et al. (2011), Arnell et al. (2011), Goklany (2009a, 2009b, 2012a).] (Indur Goklany, Independent)	noted and the figure was totally revised considering all the comments received
929	50108	3	71	0	0	0	Figure 3-1. For this figure, the chapter team should tie information provided to the findings and calibrated uncertainty language of the working group 1 contribution to the 5th assessment report. (Katharine Mach, IPCC WGII TSU)	noted but could not attribute proper calibrated language in time.
930	53900	3	71	0	0	0	Figure 3-1: It would be useful to have a brief description on what the different colors of boxes are indicating. Are the red boxes representing the impacts on society? Does “change in water use pattern” mean water use by humans or non-anthropogenic factors or both? Are there any feedback processes taken into account in this framework? Also, human activities such as pumping of the groundwater surely seem to interact with other components depicted in this figure, but they are not included in this framework. If they are excluded purposely, it would be helpful for readers to understand the main message of this figure better. (Yuka Estrada, IPCC WGII TSU)	noted and the figure was totally revised considering all the comments received
931	36067	3	72	0	0	0	In the title of Figure 3-2, why is it needed to categorically mention ‘observed (not projected)’? Detection and attribution analysis are always carried out only for observed data, using historical model runs. Projections are hence never used in them. (Pradeep MUJUMDAR, Indian Institute of Science)	Deleted "(not projected)".
932	36068	3	72	0	0	0	Out of the twelve studies mentioned in Figure 3-2 and Table 3-1, only two (Min et al., 2011 and Pall et al., 2011) use formal and robust fingerprint based detection and attribution (IPCC AR4, WGI, Chapter 9) techniques. Section 3.2.1 clearly mentions that ‘a documented hydrological trend, however, is not necessarily a detected impact of climate change’. Hence, hydrological trends consistent or correlated with climatic changes may not necessarily imply that the change is because of human-induced greenhouse emissions. How correct is it to include all other studies in this list, which does not perform a formal detection and attribution analysis following IPCC detection and attribution good practice guidelines? (Pradeep MUJUMDAR, Indian Institute of Science)	This is a very good question with broad (WG2-wide) implications. Robust end-to-end D+A algorithms are a frontier of statistical research, and are likely to remain few in number in the peer-reviewed impacts literature for some time. To rephrase the question, does it then follow that we ought not to assess multi-step attribution studies as providing evidence of impacts of climatic change? Does the same hold for even simpler "consistent-with" arguments? (Graham)
933	39355	3	72	0	0	0	Figure 3-2 This figure is poor. "degree in confidence in attribution" gives no indication of size of contribution to observed change. The Pall 2011 symbol suggests that England/Wales flooding is attributable to anthropogenic climate change, when in fact it is part of the risk that has been attributed with associated confidence limits. (Gareth S Jones, Met Office)	A. Figure 3-2 is part of a WG2-wide effort to convey information on detection and attribution in a uniform visual format, and its axes are deliberately semi-quantitiative to reflect the extreme difficulty of making quantitative assessments of most of the hydrological impacts of climatic change. B. The Pall et al. 2011 result is clarified, in our opinion adequately, in Table 3-1.

#	ID	Ch	From Page	From Line	To Page	To Line	Comment	Response
934	43578	3	72	0	0	0	Fig. 3-2. This is novel figure but I'm not sure what the take home message is other than there are more references on water quality than groundwater or extremes. More description/discussion of this figure in the text would make it more meaningful. (Cate Macinnis-Ng, University of Auckland)	We will try to add an explanatory sentence to section 3.2.1 (P4).
935	44636	3	72	0	0	0	Figure 3-2: please correct reference 12: Gascuel-Odoux et al. 2010 (Martina Flörke, University of Kassel)	accepted and corrected the reference
936	48994	3	72	0	0	0	Figure 3-2 assigns high confidence to detection of changes in water quality and medium-high confidence to attribution, but section 3.2.5 states (probably correctly) that little information is available on this (page 8 lines 50-51). Therefore the figure is not supported by the text. Also "very high" confidence is assigned to detection in the Pall et al study, and "high" confidence for attribution, but that study only looks at one event and quantifies the fraction of attributable risk as opposed to attribution of the event. Therefore I don't think such high confidence is warranted, unless further clarification is given. I suggest the figure needs revising to better reflect the text and underlying literature, and I suspect that confidence needs to be downgraded in several cases. (Richard Betts, Met Office Hadley Centre)	A. We will discuss this, but it does not necessarily follow from little information being available that the assignments in the figure are not supported by the text. B. We do not agree that our assessment of Pall et al. 2011 is unwarranted. It is a cutting-edge study with a value out of proportion to its scope. The reviewer's comment does, however, raise a methodological question: how far are we entitled to expect the outcome of a difficult but successful piece of work to carry over to an entire field of study? (Greenhouse radiation has hardly ever been measured, but we all "believe" in it.)
937	50109	3	72	0	0	0	Figure 3-2. For the legend in this figure, it would be helpful to label each symbol with the observed change (as outlined in column 1 of table 3-1). (Katharine Mach, IPCC WGII TSU)	A good suggestion. We will try to add condensed summaries of the material in column 1 of Table 3-1.
938	39339	3	73	0	0	0	Fig.3-3 illustrates the element of global hydrological fluxes with numerical values, from which the rate of water cycle variation over land and ocean could be found. Because these values of every element of global hydrological fluxes are synthesized from various sources, it is need to indicate the time period of these calculated value, such as from XXXX year to XXXX year in order to know their representative decades. (Liu Chunzhen, Ministry of Water Resources)	the figure was deleted
939	36098	3	75	0	0	0	Fig 3-5 shows grid point values of percentage of future river discharges. For adaptive policy implementations, these grid cell values need to be converted again at river discharge locations for particular rivers – hence, it would be more useful to include results of studies conducted on rivers individually instead of considering grid cell discharges across the globe. (Pradeep MUJUMDAR, Indian Institute of Science)	Yes, however, for engineering purposes, more regional studies will be more helpful. The figure is intended to illustrate overall pattern of the changes in river discharge globally.
940	53901	3	75	0	0	0	Figure 3-6: The visibility of this figure should be improved. (Yuka Estrada, IPCC WGII TSU)	we will do this.
941	36102	3	76	0	0	0	Fig 3-7: This is a rather complex figure where almost everything is connected to everything else. Which way does the arrow connecting 'Economic Development' and 'Water Quality' point to? 'Urban growth', 'Population growth', and 'Economic Development' should all be related to 'Land use and..pollution'. (Pradeep MUJUMDAR, Indian Institute of Science)	Accepted the figure was provided as response to a request.
942	36106	3	76	0	0	0	Fig 3-8 shows the results globally only for two climate models. How sensitive are these results to choice of climate models and scenarios? Do we expect a different vulnerability map if WCRP/CMIP5 data is used instead of WCRP/CMIP3? (Pradeep MUJUMDAR, Indian Institute of Science)	We do not know.
943	43582	3	76	0	0	0	Fig. 3-7. What do the different colours (arrows and other shapes) signify? (Cate Macinnis-Ng, University of Auckland)	Figure deleted.
944	53902	3	76	0	0	0	Figure 3-7: The legend to describe the different types of bubbles, and different colors needs to be provided. (Yuka Estrada, IPCC WGII TSU)	Figure deleted.
945	43542	3	76	0	76	0	Figure 3.7. I suggest that the arrow between economic development and climate conditions should be reversed as economic development affects the climate. There is no key to interpret the width or colour of the arrows. I suggest that irrigated agriculture is a type of land use and should be linked to the 'land-use...' bubble. (Andrew Wade, University of Reading)	Figure deleted.
946	35432	3	77	0	0	0	Figure 3-10 is likely to be similar but not identical to what's presented by WGI-Ch4 which does some more assessment across a range of sources. (David Vaughan, British Antarctic Survey)	As far as we are aware there are no plans in WG1 Ch04 to include anything quite as detailed and region-specific as WG2 Ch03 Figure 3-10.
947	36036	3	77	0	0	0	Figure 3-9's color scheme is hard to read. The subtle differences, especially in the yellow, are hard to see, especially when aras involved are small. (Michael Brewer, NOAA)	Color scheme changed.
948	44637	3	77	0	0	0	Figure 3-10: rather complex figure which is difficult to interpret and understand (Martina Flörke, University of Kassel)	We will try to add guidance on how to "read" the figure, either in the caption or the text.
949	50110	3	77	0	0	0	Figure 3-10. For panel A, would be helpful to clarify the interpretation of each red line--each corresponds to one study ? (Katharine Mach, IPCC WGII TSU)	Added "Each line represents one glacier."
950	53880	3	77	0	77	0	Figure 3-9 seems to mostly show areas where dams exist versus where they don't exist. For example, US West, Australian MDB have dams and are blue. Amazon, Congo NE Australia are red and have few dams. To me the implication is that the Blue areas will be impacted less than the red areas, but I don't think we can say this with any degree of confidence given the existing problems in the US West and MDB with their dams. I also am uncertain about using just one model for this image. (Bradley Udall, University of Colorado)	There is no comparative study using an ensemble of climate models and/or hydrology models. As written in the caption, blue area are those in which the impact of climate change is modelled to be significantly smaller that the historic impact of dams and reservoirs. It is not correct to interpret that blue areas will be impacted less by climate change than others.