Tables

Table SM23-1: Lists of countries in European regional groupings.

Table SM23-2: Projected changes of selected climate parameters and indices for 2071-2100 with respect to 1971-2000 spatially averaged for European sub regions for the A1B scenario. Numbers are based on 9 (indicated with *) and 20 (indicated with **) regional model simulations. The different numbers of simulations used is due to the limited data availability. The "*likely* range" defines the range of 66% of all projected changes around the ensemble median.

Table SM23-3: Projected changes of selected climate parameters and indices for 2071-2100 with respect to 1971-2000 spatially averaged for European sub regions based on RCP 4.5 and RCP 8.5. Numbers are based on 9 (RCP8.5) and 8 (RCP4.5) regional model simulations. The "*likely* range" defines the range of 66% of all projected changes around the ensemble median.

Table SM23-4: Projected changes of selected climate parameters and indices for 2071-2100 with respect to 1971-2000 spatially averaged for three alpine sub regions based on RCP 4.5 and RCP 8.5. Numbers are based on 9 (RCP8.5) and 8 (RCP4.5) regional model simulations. For Alpine North only 8 (RCP8.5) and 7 (RCP4.5) simulations are available. The "*likely* range" defines the range of 66% of all projected changes around the ensemble median.

Figures

Figure SM23-1: Figure SM23-1: Explanation of terminology for Tables SM23-2, SM23-3, and SM23-4 (tables adapted from Jacob et al., 2013). The figure depicts the range of projected climate change signals for several parameters/indices averaged over different sub regions towards the end of the 21st century shown in Tables 23-1 to 23-3. The range of projected changes is estimated on the basis of climate change projections of the A1B scenario (* for parameter based on 9 simulations, ** for parameter based on 20 simulations), RCP4.5 (8 simulations) and RCP8.5 (9 simulations). The different numbers of simulations used is due to the limited data availability. In a first step the climate change signals for each parameter/index were calculated for each individual model on its native model grid. In order to overlay the climate change information of the individual models with the five major sub regions (applied from Metzger et al 2005), the estimated climate change signals on the native model grids had to be remapped onto a unifying grid which allowed to spatially aggregate the estimated climate change signals for each of the sub regions and each of the models. For each parameter/index and sub region the resulting bandwidth of the ensemble of spatially-averaged climate change signals is categorized in the tables by providing the upper and lower boundary of the bandwidth of projected changes as well as the median. Moreover the central 66 percent of the projected changes are indicated as "likely range".

Figure SM23-2: Sub-regional classification of IPCC Europe region with three Alpine sub regions. Based on Metzger et al., 2005.

Table SM23-1. Lists of countries in European regional groupings

EU15	EU27	EEA (33)
Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.	Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom.	Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia. Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom

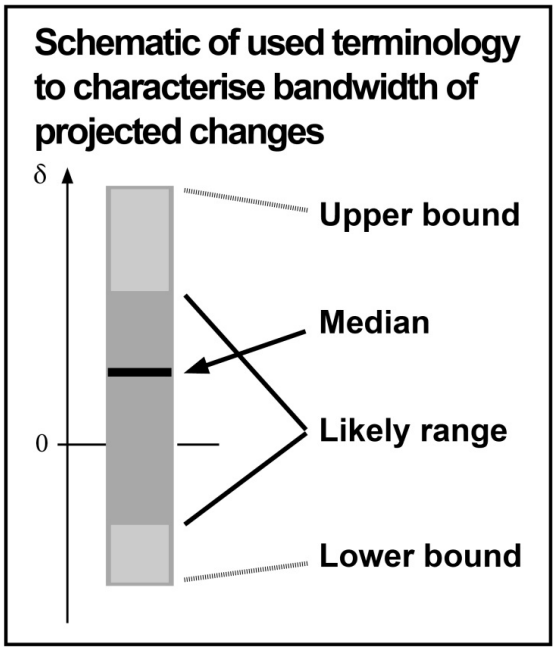

Figure SM23-1: Explanation of terminology for Tables SM23-2, SM23-3, and SM23-4 (tables adapted from Jacob et al., 2013). The figure depicts the range of projected climate change signals for several parameters/indices averaged over different sub regions towards the end of the 21st century shown in Tables 23-1 to 23-3. The range of projected changes is estimated on the basis of climate change projections of the A1B scenario (* for parameter based on 9 simulations, ** for parameter based on 20 simulations), RCP4.5 (8 simulations) and RCP8.5 (9 simulations). The different numbers of simulations used is due to the limited data availability. In a first step the climate change signals for each parameter/index were calculated for each individual model on its native model grid. In order to overlay the climate change information of the individual models with the five major sub regions (applied from Metzger et al 2005), the estimated climate change signals on the native model grids had to be remapped onto a unifying grid which allowed to spatially aggregate the estimated climate change signals for each of the sub regions and each of the models. For each parameter/index and sub region the resulting bandwidth of the ensemble of spatially-averaged climate change signals is categorized in the tables by providing the upper and lower boundary of the bandwidth of projected changes as well as the median. Moreover the central 66 percent of the projected changes are indicated as “likely range”.

Table SM23-1: Projected changes of selected climate parameters and indices for 2071-2100 with respect to 1971-2000 spatially averaged for European sub regions for the A1B scenario. Numbers are based on 9 (indicated with *) and 20 (indicated with **) regional model simulations. The different numbers of simulations used is due to the limited data availability. The "*likely* range" defines the range of 66% of all projected changes around the ensemble median. The definition of indices is described below.

A1B	Climate Parameters	Measure	Alpine	Southern	Northern	Continental	Atlantic
2071-2100 minus 1971-2000	**Mean annual temperature in K ****	***Median***	***3.4***	***3.6***	***3.8***	***3.3***	***2.5***
		Lower bound	2.8	2.3	3.2	2.1	1.9
		***Likely* in the range**	**3.1 to 4.5**	**3.3 to 4.1**	**3.5 to 5.0**	**2.8 to 4.5**	**2.1 to 3.5**
		Upper bound	5.4	5.5	5.8	5.7	4.7
	Frost days per year *	***Median***	***-50***	***-24***	***-54***	***-44***	***-24***
		Lower bound	-72	-34	-71	-56	-39
		***Likely* in the range**	**-57 to -38**	**-31 to -12**	**-55 to -40**	**-53 to -27**	**-34 to -15**
		Upper bound	-37	-12	-38	-26	-13
	Summer days per year *	***Median***	***14***	***48***	***7***	***32***	***21***
		Lower bound	4	33	3	21	9
		***Likely* in the range**	**11 to 20**	**33 to 51**	**5 to 14**	**22 to 41**	**16 to 32**
		Upper bound	21	51	27	43	34
	Tropical nights per year *	***Median***	***3***	***47***	***4***	***21***	***8***
		Lower bound	1	18	1	14	2
		***Likely* in the range**	**2 to 9**	**35 to 52**	**1 to 7**	**16 to 35**	**6 to 17**
		Upper bound	11	60	10	43	32
	Growing season length in days per growing season **	***Median***	***47***	***36***	***41***	***52***	***41***
		Lower bound	27	14	25	20	23
		***Likely* in the range**	**34 to 56**	**27 to 41**	**27 to 46**	**33 to 62**	**33 to 51**
		Upper bound	75	51	61	81	55
	Warm spell duration index in days per year *	***Median***	***57***	***91***	***67***	***42***	***44***
		Lower bound	46	67	37	26	29
		***Likely* in the range**	**51 to 84**	**85 to 112**	**47 to 96**	**37 to 69**	**35 to 72**
		Upper bound	126	144	119	94	125
	Cold spell duration index in days per year *	***Median***	***-5***	***-5***	***-6***	***-6***	***-5***
		Lower bound	-8	-8	-9	-9	-9
		***Likely* in the range**	**-5 to -4**	**-5 to -4**	**-8 to -5**	**-6 to -5**	**-6 to -4**
		Upper bound	-4	-3	-5	-4	-4
	Annual total precipitation in % **	***Median***	***6***	***-15***	***16***	***3***	***2***
		Lower bound	0	-24	4	-9	-11
		***Likely* in the range**	**4 to 9**	**-17 to -11**	**12 to 20**	**-1 to 5**	**-3 to 4**
		Upper bound	10	-7	28	10	7
	Annual total precipitation where RR>99p of 1971/2000 in % **	***Median***	***46***	***32***	***57***	***45***	***59***
		Lower bound	27	8	26	17	24
		***Likely* in the range**	**40 to 54**	**25 to 44**	**40 to 75**	**38 to 63**	**34 to 92**
		Upper bound	105	64	98	95	102

Table SM23-2: Projected changes of selected climate parameters and indices for 2071-2100 with respect to 1971-2000 spatially averaged for European sub regions based on RCP 4.5 and RCP 8.5. Numbers are based on 9 (RCP8.5) and 8 (RCP4.5) regional model simulations. The "*likely* range" defines the range of 66% of all projected changes around the ensemble median. The definition of indices is described below.

Scenarios	Climate Parameters	Measure	Alpine		Southern		Northern		Continental		Atlantic	
			RCP 4.5	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
2071-2100 minus 1971-2000	**Mean annual temperature in K**	***Median***	***2.4***	**4.6**	**2.0**	**4.2**	**2.9**	**5.2**	**2.1**	**4.1**	**1.7**	**3.2**
		Lower bound	1.8	3.8	1.9	3.8	2.0	4.1	1.6	3.6	1.3	2.5
		***Likely* in the range**	**1.9 to 3.4**	**3.9 to 6.0**	**1.9 to 2.7**	**3.9 to 5.4**	**2.0 to 4.2**	**4.1 to 6.2**	**1.6 to 3.2**	**3.7 to 5.2**	**1.4 to 2.1**	**2.7 to 3.6**
		Upper bound	3.6	6.3	3.2	5.7	4.3	6.5	3.2	5.3	2.9	4.2
	Frost days per year	***Median***	***-40***	***-70***	***-22***	***-43***	***-40***	***-68***	***-34***	***-62***	***-28***	***-40***
		Lower bound	-47	-93	-31	-51	-52	-93	-41	-73	-33	-60
		***Likely* in the range**	**-41 to -26**	**-85 to -57**	**-29 to -11**	**-51 to -23**	**-43 to -26**	**-83 to -60**	**-40 to -18**	**-65 to -50**	**-30 to -15**	**-50 to -26**
		Upper bound	-25	-55	-10	-22	-24	-58	-16	-46	-12	-21
	Summer days per year	***Median***	***8***	***19***	***27***	***54***	***4***	***13***	***20***	***37***	***11***	***24***
		Lower bound	3	10	21	43	2	5	11	27	6	17
		***Likely* in the range**	**4 to 14**	**12 to 24**	**25 to 33**	**46 to 60**	**2 to 16**	**6 to 22**	**13 to 24**	**30 to 46**	**6 to 14**	**22 to 28**
		Upper bound	18	25	37	67	23	28	28	49	33	38
	Tropical nights per year	***Median***	***1***	***4***	***20***	***45***	***1***	***1***	***9***	***22***	***3***	***7***
		Lower bound	0	1	7	23	0	0	2	11	0	3
		***Likely* in the range**	**1 to 3**	**2 to 5**	**11 to 24**	**25 to 57**	**0 to 5**	**1 to 3**	**9 to 27**	**17 to 31**	**1 to 5**	**3 to 12**
		Upper bound	8	6	41	58	7	13	30	37	18	17
	Growing season length in days per growing season	***Median***	***31***	***61***	***27***	***49***	***23***	***55***	***26***	***58***	***39***	***58***
		Lower bound	23	52	16	34	17	37	17	52	24	41
		***Likely* in the range**	**23 to 39**	**52 to 83**	**17 to 33**	**38 to 53**	**19 to 33**	**41 to 60**	**20 to 38**	**53 to 71**	**27 to 43**	**47 to 68**
		Upper bound	45	95	38	58	42	78	41	75	45	75

Warm spell duration index in days per year	***Median***	***34***	***96***	***34***	***124***	***35***	***82***	***23***	***73***	***20***	***65***
	Lower bound	26	73	28	90	22	64	16	52	17	46
	***Likely* in the range**	**29 to 55**	**77 to 136**	**32 to 69**	**98 to 177**	**23 to 42**	**75 to 114**	**18 to 42**	**58 to 93**	**20 to 31**	**49 to 87**
	Upper bound	69	162	83	186	63	130	54	106	55	102
Cold spell duration index in days per year	***Median***	***-5***	***-5***	***-5***	***-5***	***-7***	***-6***	***-6***	***-6***	***-5***	***-5***
	Lower bound	-7	-6	-6	-6	-8	-7	-7	-8	-6	-6
	***Likely* in the range**	**-7 to -4**	**-6 to -4**	**-5 to -3**	**-5 to -4**	**-8 to -6**	**-7 to -5**	**-7 to -4**	**-8 to -5**	**-6 to -3**	**-5 to -4**
	Upper bound	-3	-3	-3	-4	-4	-4	-3	-5	-2	-4
Annual total precipi-tation in %	***Median***	***4***	***11***	***-3***	***-11***	***10***	***22***	***9***	***10***	***1***	***4***
	Lower bound	3	4	-10	-23	7	17	0	0	-2	-2
	***Likely* in the range**	**3 to 7**	**6 to 13**	**-9 to 1**	**-19 to -3**	**8 to 17**	**18 to 32**	**1 to 12**	**4 to 18**	**-1 to 6**	**1 to 7**
	Upper bound	9	15	2	-1	21	33	13	24	8	9
Annual total precipi-tation where RR>99p of 1971/2000 in %	***Median***	***34***	***70***	***27***	***35***	***31***	***69***	***35***	***55***	***29***	***60***
	Lower bound	14	29	14	20	22	57	11	29	15	42
	***Likely* in the range**	**17 to 55**	**32 to 85**	**18 to 40**	**26 to 46**	**22 to 58**	**59 to 98**	**24 to 41**	**37 to 65**	**17 to 64**	**43 to 97**
	Upper bound	56	99	62	51	63	107	59	90	65	107

References

Karl, T.R., N. Nicholls, and A. Ghazi, 1999: CLIVAR/GCOS/WMO workshop on indices and indicators for climate extremes: Workshop summary. Climatic Change, 42, 3-7.

Peterson, T.C., and Coauthors: Report on the Activities of the Working Group on Climate Change Detection and Related Rapporteurs 1998-2001. WMO, Rep. WCDMP-47, WMO-TD 1071, Geneve, Switzerland, 143pp.

http://etccdi.pacificclimate.org/list_27_indices.shtml

Definition of Indices

Number of frost days: Annual count of days when TN (daily minimum temperature) < 0ºC.Let TN_{ij} be daily minimum temperature on day *i* in year *j*. Count the number of days where: $TN_{ij} < 0$ºC.

Number of summer days: Annual count of days when TX (daily maximum temperature) > 25ºC.Let TX_{ij} be daily maximum temperature on day *i* in year *j*. Count the number of days where: $TX_{ij} > 25$ºC.

Number of tropical nights: Annual count of days when TN (daily minimum temperature) > 20ºC.Let TN_{ij} be daily minimum temperature on day *i* in year *j*. Count the number of days where: $TN_{ij} > 20$ºC.

Growing season length: Annual (1st Jan to 31st Dec in Northern Hemisphere (NH)) count between first span of at least 6 days with daily mean temperature TG>5ºC and first span after July 1st of 6 days with TG<5ºC. Let TG_{ij} be daily mean temperature on day *i* in year *j*. Count the number of days between the first occurrence of at least 6 consecutive days with: $TG_{ij} > 5$ºC. and the first occurrence after 1st July of at least 6 consecutive days with: $TG_{ij} < 5$ºC.

Warm spell duration index: Annual count of days with at least 6 consecutive days when TX > 90th percentile. Let TX_{ij} be the daily maximum temperature on day *i* in period *j* and let $TX_{in}90$ be the calendar day 90th percentile centered on a 5-day window for the base period 1971-2000. Then the number of days per period is summed where, in intervals of at least 6 consecutive days: $TX_{ij} > TX_{in}90$

Cold spell duration index: Annual count of days with at least 6 consecutive days when TN < 10th percentile. Let TN_{ij} be the daily maximum temperature on day *i* in period *j* and let $TN_{in}10$ be the calendar day 10th percentile centered on a 5-day window for the base period 1971-2000. Then the number of days per period is summed where, in intervals of at least 6 consecutive days: $TN_{ij} < TN_{in}10$

Annual total precipitation in wet days: Let RR_{ij} be the daily precipitation amount on day *i* in period *j*. If *I* represents the number of days in *j*, then

$$PRCPTOT_j = \sum_{i=1}^{I} RR_{ij}$$

Annual total precipitation when RR > 99p: Let RR_{wj} be the daily precipitation amount on a wet day *w (RR ≥ 1.0mm)* in period *i* and let $RR_{wn}99$ be the 99th percentile of precipitation on wet days in the 1971-2000 period. If *W* represents the number of wet days in the period, then:

$$R99p_j = \sum_{w=1}^{W} RR_{wj} \text{ where } RR_{wj} > RR_{wn}99$$

Figure SM23-2: Sub-regional classification of IPCC Europe region with three Alpine sub regions. Based on Metzger et al., 2005.

Table SM23-3: Projected changes of selected climate parameters and indices for 2071-2100 with respect to 1971-2000 spatially averaged for three alpine sub regions based on RCP 4.5 and RCP 8.5. Numbers are based on 9 (RCP8.5) and 8 (RCP4.5) regional model simulations. For Alpine North only 8 (RCP8.5) and 7 (RCP4.5) simulations are available. The "*likely* range" defines the range of 66% of all projected changes around the ensemble median. The definition of indices is described above.

	Climate Para-meters	Measure	Alpine North		Alpine South		Eastern Mountains	
Scena-rios			**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
2071-2100 minus 1971-2000	**Mean annual tem-perature in K**	***Median***	***3.0***	***4.8***	***1.9***	***4.4***	***2.4***	**5.0**
		Lower bound	1.9	3.4	1.6	3.6	2.0	4.2
		***Likely* in the range**	**1.9 o 3.9**	**3.6 to 5.8**	**1.7 to 2.5**	**3.7 to 5.8**	**2.1 to 3.6**	**4.5 to 6.9**
		Upper bound	4.0	6.4	3.2	6.1	3.8	7.3
	Frost days per year	***Median***	***-42***	***-75***	***-35***	***-67***	***-33***	***-67***
		Lower bound	-55	-105	-43	-90	-44	-89
		***Likely* in the range**	**-45 to -30**	**-96 to -57**	**-39 to -23**	**-87 to -58**	**-40 to -22**	**-84 to -56**
		Upper bound	-28	-56	-21	-55	-18	-46
	Summer days per year	***Median***	***0***	***0***	***9***	***23***	***16***	***37***
		Lower bound	0	0	3	13	8	22
		***Likely* in the range**	**0 to 1**	**0 to 1**	**6 to 17**	**16 to 37**	**8 to 21**	**24 to 45**
		Upper bound	3	1	25	41	29	47
	Tropical nights per year	***Median***	***0***	***0***	***1***	***3***	***4***	***10***
		Lower bound	0	0	0	0	1	6
		***Likely* in the range**	**0**	**0**	**0 to 4**	**1 to 5**	**2 to 7**	**7 to 17**
		Upper bound	0	0	11	7	15	18
	Growing season length in days per growing season	***Median***	***35***	***64***	***28***	***62***	***27***	***58***
		Lower bound	20	40	23	49	23	53
		***Likely* in the range**	**22 to 38**	**46 to 84**	**26 to 35**	**54 to 90**	**23 to 39**	**55 to 81**
		Upper bound	53	104	40	93	48	88
	Warm spell duration index in days per year	***Median***	***43***	***89***	***29***	***101***	***30***	***105***
		Lower bound	27	64	23	64	27	85
		***Likely* in the range**	**29 to 47**	**73 to 132**	**23 to 51**	**70 to 138**	**29 to 82**	**89 to 171**
		Upper bound	61	155	64	163	86	171
	Cold spell duration index in days per year	***Median***	***-6***	***-5***	***-5***	***-5***	***-5***	***-5***
		Lower bound	-9	-7	-6	-6	-7	-6
		***Likely* in the range**	**-8 to -5**	**-6 to -4**	**-6 to -3**	**-6 to -4**	**-7 to -3**	**-6 to -4**
		Upper bound	-3	-3	-2	-4	-3	-4
	Annual total precipi-tation in %	***Median***	***9***	***21***	***3***	***5***	***1***	***7***
		Lower bound	3	6	-2	-2	-1	-4
		***Likely* in the range**	**5 to 12**	**8 to 25**	**-1 to 9**	**1 to 9**	**0 to 8**	**-2 to 14**
		Upper bound	13	28	10	12	11	14
	Annual total precipi-tation where RR>99p of 1971/2000 in %	***Median***	***54***	***89***	***35***	***54***	***29***	***51***
		Lower bound	14	27	9	18	10	38
		***Likely* in the range**	**19 to 61**	**33 to 129**	**9 to 43**	**21 to 73**	**16 to 41**	**39 to 65**
		Upper bound	88	139	62	80	79	90