Tables

Figures

Table SM24-1: Summary of key observed past and present annual mean temperature trends in Asian countries/regions.

Sub-region	Countries/Regions	Unit	Change (Period)	Reference
Central Asia	Kazakhstan	°C/10y	+0.31 (1936-2005)	Kryukova *et al*., 2009
	Kyrgyzstan	°C	+1.6 (1901-2000)	Iliasov *et al*., 2003
	Tajikistan	°C/10y	+0.1 to +0.2 (1940-2005)	Karimov *et al*., 2008
East Asia	Hong Kong	°C/10y	+0.12 (1885-2008), +0.16 (1947-2008), +0.27 (1979-2008)	Ginn *et al*., 2009
	Japan	°C/100y	+1.15 (1898-2010)	JMA, 2011
	China	°C/10y	0.09±0.017 (1900-2006), 0.26±0.032 (1954-2006), 0.45±0.13 (1979-2006)	Li *et al*., 2010
		°C/10y	+0.03 to +0.120 (1906-2005), +0.03 to +0.120 (1908-2007)	Ren *et al*., 2012
	South Korea	°C	+1.87 (1908-2008), +1.37 (1954-2008), +1.44 (1969-2008)	Kim *et al*., 2010
	Taiwan	°C/10y	+0.14 (1911-2009), +0.19 (1959-2009), +0.29 (1979-2009)	Hsu *et al*., 2011
North Asia	Mongolia	°C	+2.14 (1940-2005)	Dagvadorj *et al*., 2009
	Russia	°C	+1.29 (1907-2006), +1.33 (1976-2006)	Anisimov *et al*., 2008a
South Asia	Afghanistan	°C	+0.6 (1960-2008)	Savage *et al*., 2009
		°C/10y	+0.13 (1960-2008)	
	Bangladesh	°C/10y	+0.097 (1958-2007)	Shahid, 2010
	India	°C	+0.56 (1901-2009)	Attri and Tyagi, 2010
		°C/100y	+0.68 (1880-2000)	Lal, 2003
		°C/y	+0.0056 (1948-2008)	Ganguly, 2011
	Nepal	°C/y	+0.06 (1977-1994)	Shrestha *et al*., 1999
	Pakistan	°C	+0.57 (1901-2000), +0.47±0.21 (1960-2007)	Chaudhry *et al*., 2009
		°C/10y	+0.099 (1960-2007)	
	Sri Lanka	°C/y	+0.005 to +0.035 (1961-2000)	Iqbal, 2010
		°C/10y	+0.3 to +0.93 (1869-2007), +0.75 to +0.94 (1910-2007)	De Costa, 2008
Southeast Asia	The Philippines	°C	+0.648 (1951-2010)	PAGASA, 2011
		°C/y	+0.0108 (1951-2010)	
West Asia	Armenia	°C	+0.85 (1935-2007)	Gabrielyan *et al*., 2010
Tibetan Plateau		°C(°C/10y)	+1.8 (0.36/10y) (1961-2007)	Wang *et al*., 2008
		°C/10y	+0.447 (1962-2001)	Xu *et al*., 2008

Table SM24-2: Summary of key observed past and present annual mean precipitation trends in Asian countries/regions.

Sub-region	Countries/Regions	Unit	Change (Period)	Reference
Central Asia	Kazakhstan	No definite national trend. (1936-2005)		Kryukova *et al*., 2009
	Kyrgyzstan	mm	+23 (+6%) (1901-2000)	Iliasov *et al*., 2003
	Tajikistan *plains region	%	+8 (insignificant) (1940-2005)	Karimov *et al*., 2008
	*mountainous region	%	-3 (insignificant) (1940-2005)	Karimov *et al*., 2008
	Turkmenistan	mm/10y	+12 (1931-95)	MNPT, 2000
East Asia	Hong Kong	mm/10y	+25 (1885-2008)	Ginn *et al*., 2009
	Japan	No clear trend (1898-2008)		MEXT *et al*., 2009
	South Korea	%	+5.6 (2001-2008)	Kim *et al*., 2010
North Asia	Mongolia	mm/y	-0.1 to -2.0 (1940-2005)	Dagvadorj *et al*., 2009
	Russia	mm/10y	+7.2 (1976-2006)	Anisimov *et al*., 2008a
South Asia	Afghanistan	mm/m	-0.5 (1960-2008)	Savage *et al*., 2009
		%/10y	-2 (1960-2008)	
	Bangladesh	mm/y	+5.53 (1958-2007)	Shahid, 2010
	India	No significant national trend (1901-2009)		Attri and Tyagi, 2010
	Pakistan	mm	+61 (1901-2007), -156 (1901-54), +35 (1955-2007)	Chaudhry *et al*., 2009
	Sri Lanka	mm/y	-1.55 to -19.06 (1961-2000)	Iqbal, 2010
Southeast Asia	Indonesia *Brontas Catchment	mm/y	-1.23 to -24.25 (1955-2005)	Aldrian and Djamil, 2008
West Asia	Armenia	%	-6 (1935-2007)	Gabrielyan *et al*., 2010
Tibetan Plateau		mm/y	+0.614	Xu *et al*., 2008

Table SM24-3: Summary of projected changes for a variety of climate parameters.

Sub-region	T/P	Projected changes
Central and North (see WGI AR5 section 14.8.8)	T	Central: Similar warming magnitude in winter and summer. Northern: A stronger warming trend than the global mean trend during winter.
	P	Central: *Likely* increase Northern: *Very likely* increase. Central and Northern: *Likely* increase in extremes
East (see WGI AR5 section 14.8.9)	T	*Very likely* longer duration, more intense and more frequent heat waves/hot spells in summer and *very likely* decrease in frequency of very cold days
	P	Increase in summer precipitation over East Asia with an intensified East Asian summer monsoon (*medium confidence*) *Likely* increase over East Asia during the Meiyu-Changma-Baiu season in May to July and *very likely* increase in extremes over the eastern Asian continent in all seasons and over Japan in summer under RCP4.5 scenario (*low confidence*).
West (see WGI AR5 section 14.8.10)	T	*Very likely* that temperatures will continue to increase.
	P	Overall reduction (*medium confidence*)
South (see WGI AR5 section 14.8.11)	T	Increase (*high confidence*)
	P	Increase in summer monsoon precipitation (*medium confidence*)
Southeast (see WGI AR5 section 14.8.12)	T	*Very likely* increase with substantial subregional variations.
	P	Moderate increase in rainfall, except on Indonesian islands neighboring the Southeast Indian Ocean (*medium confidence*). Strong regional variations because of terrain.
T: Temperature, P: Precipitation		

Table SM24-4: Summary of key observed past and present climate change impacts in Asia.

Sub-Region	Countries/Regions (Area)	***Parameters:*** Observed changes	Period	References
Central Asia	Kazakhstan (Steppe region in north)	***Normalized Difference Vegetation Index (NDVI):*** Decline (browning)	1982-2008	De Jong *et al*., 2012
	Kazakhstan (Northern Tien Shan Mountains)	***Permafrost temperature at depths of 14-25 m:*** +0.3 to +0.6°C	1974-2004	Marchenko *et al*., 2007; Zhao *et al*., 2010
		Active layer thickness: +23%		
	Uzbekistan (Zerafshan River Basin)	***Water monthly discharge:*** Significant increases in spring and decreases in summer	1923-2006	Olsson *et al*., 2010
	Kazakhstan, Uzbekistan, Kyrgyzstan (Main lakes)	***Surface area change:*** -49.62% (Aral Sea), -75.7% (Balk hash) , -2.61% (Ebinur), -8.37% (Issyk-Kul) +5.85% (Zaysan), -9.18% (Bosten)	1975-2007	Bai *et al*., 2012
East Asia	East Asia north of 23ºN	***Tree growth:*** Tree-ring data suggests recent summer temperatures have exceeded those for warm periods of similar length over the past 1210 years.	800-2009	Cook *et al*.., 2013
	Japan (Upper part of Kurobe Dam, Toyama)	***Runoff:*** Decreased by 40 mm, slightly decreased and more in winter and spring, less in summer	1974-2004	Shinohara *et al*., 2009
	Japan (Multiple sites)	***Spring leafing and flowering:*** Earlier by < 3 days per decade	Last 60 years	Ogawa-Onishi and Berry, 2013
		Changes in species distributions: Northwards by < 126 km per decade	Last 50-70 years	
	Japan (Seas around Japan)	***Changes in species distributions:*** Northwards expansion of fish, corals and algae.	Recent decades	Nagai *et al*., 2011; Yamano *et al*., 2011; Tian *et al*., 2012.
	China (Shiyang River basin)	***Streamflow:*** Five of eight catchments showing significant decreasing trends	1950-2005	Ma *et al*., 2008
	China (Dongjiang River)	***Runoff:*** No significant change. Clear increasing trend at two of three stations in low-flow period	1956-2000	Liu *et al*., 2010
	China (Tarim River Basin)	***Streamflow:*** Three of four rivers with increasing streamflow except Akesu River	1960-2005	Zhang *et al*., 2010
		Mainstreams runoff: Decreased by 41.59% (1970s), 63.77% (1980s), 75.15% (1990s)	1957-2003	Hao *et al*., 2008
		Runoff: In 1990s runoff from headwaters of Aksu and Yarkand River increased by 10.9%	1955-2000	Chen *et al*., 2007
	China (Baimashi Basin)	***Runoff:*** Decreased by 1.88% per year, decreasing from 1960s	1950-2000	Wang *et al*., 2010
	China (Upper reaches of Tarim River Basin)	***Runoff:*** Aksu River showed a significant increasing trend by 10.9%. Three of four rivers showed an increasing trend with one showing a subtle reduction	1958-2004	Chen *et al*., 2009
	China (Laohahe Basin)	***Runoff:*** Runoff in 1980-2008 decreased by 36% compared with 1964-1979	1964-2008	Jiang *et al*., 2011
	China (Hun-Tai River Basin)	***Streamflow:*** Downward trends	1961-2006	Zhang *et al*., 2011
	China (Kaidu River Basin)	***Runoff:*** Increasing with rate of 8.4 mm/decade; 1994-2009 increased 26.4% compared to 1960-1993	1960-2009	Chen *et al*., 2013
	China (Haihe River Basin)	***Runoff:*** Significant downward trends	1957-2000	Wang *et al*., 2011
	China (Pearl River, Yangtze River, Yellow River, Liao River, Songhua River)	***Runoff:*** Increased by 10% (Pearl River), had little change (Yangtze River), decreased by 80% (Yellow River), decreased by 54% (Liao River), decreased by 14% (Songhua River)	1951-2000	Xu *et al*., 2010
	China (Qinghai-Tibetan Plateau)	***Active layer thickness along Qinghai-Tibetan Highway:*** Mean rate of +7.5 cm/year	1995- 2007	Wu and Zhang, 2010
		Position of lower altitudinal limit of permafrost in north: Moved up by 25 m	Last 30 years	Cheng and Wu, 2007; Li *et al*., 2008
		Position of lower altitudinal limit of permafrost in south: Moved up by 50-80 m	Last 20 years	
		Total area of glaciers of QTP and surrounding areas: Decreased by c. 9%, from 13363 ± 668 km^2 to 1213 ± 607 km^2	1970s-2000s	Yao *et al*., 2012
	China (Whole country)	***Start of plant growth in spring:*** Earlier start by c. 2 days per decade	Last 30 years	Table SM24-6
	China	***Rice yield*:** Positive correlation to temperature.	1981-2005	Zhang *et al*., 2010
	Taiwan (Mountains)	***Plant distributions:*** Upper limits shifted upwards by 3.6 m per year	1906-2006	Jump *et al*., 2012
North Asia	Mongolia (Kherlen River Basin)	***Underground water storage:*** No evidence for long-term storage change	1947-2006	Brutsaert *et al*., 2008
	Mongolia (Khentey Mountains)	***Growth of Siberian larch forest in forest-steppe ecotone:*** a. tree-ring analysis shows a decreasing annual increment. b. Regeneration of larch decreased	1940s -2010	Dulamsuren *et al*., 2010a; 2010b
	Mongolia (Hovsgol Mountain region)	***Mean annual permafrost temperature at 10 m depth:*** Increased on average by 0.02-0.03°C/year	Last 10-40 years	Sharkhuu *et al*., 2008; Zhao *et al*., 2010
	Mongolia (Hangai and Khentei Mountain regions)	***Mean annual permafrost temperature at 10 m depth:*** Increased on average by 0.01-0.02°C/year	Last 10-40 years	Sharkhuu *et al*., 2008; Zhao *et al*., 2010

	Russia, East of Urals (Siberia)	***Forest-tundra ecotone:*** a. larch stands crown closure, and larch invasion into tundra at a rate of 3-10 m/year. b. Shrub expansion in arctic tundra as result of an increase in shrub growth.	1970-2000	Kharuk *et al*., 2006; Myers-Smith *et al*., 2011; Blok *et al*., 2011
		Distribution of dark needle conifers (DNC), Siberian pine, spruce and fir: Invasion of DNC and birch into larch habitat	1980-2010	Kharuk *et al*., 2010a, b; Osawa *et al*., 2010; Lloyd *et al*., 2011
		Permafrost temperature at zero annual amplitude: Warming of permafrost in most permafrost observatories in Asian Russia by 0.5-2°C.	1970s-1990s	Romanovsky *et al*., 2008, with supplement; Romanovsky *et al*., 2010
		Permafrost temperature at zero annual amplitude: No significant warming.	2000-2007	
		Permafrost temperature at zero annual amplitude: Warming of permafrost resumed at many locations predominantly near Arctic coasts.	2007-2008	
	Russia, East of Urals (Asian Arctic)	***Average erosion rate of coastline:*** 0.27-0.87 m/year	-	Lantuit *et al*., 2012
	Russia, East of Urals (Ural Mountains)	***Area of glaciers:*** Decreased by 20-30% in total	1953-1981	Anisimov *et al*., 2008b
	Russia, East of Urals (Kodar Mountains)	***Area of glaciers:*** Exposed ice area (EIA) declined by c. 44%	ca. 1963-2010	Stokes *et al*., 2013
		Area of glaciers: EIA declined by c. 40%, from 11.72 ± 0.72 km^2 to 7.01 ± 0.23 km^2	1995-2010	
	Russia, East of Urals (Suntar Khayata Range)	***Area of glaciers:*** Decreased by19.3%	Mid. 20th C.-2003	Ananicheva *et al*., 2005, 2006
	Russia, East of Urals (Chersky Range)	***Area of glaciers:*** Decreased by 28 %	1970-2003	Anisimov *et al*., 2008b
	Russia, East of Urals (Kamchatka)	***Area of glaciers:*** Decreased for some glaciers, increased for others	Since Mid 19th C.	Anisimov *et al*., 2008b
South Asia	India (Upper Indus Basin)	***Water stress:*** No strong evidence for marked reduction in water resources	1961-2004	Archer *et al*., 2010
	India (Headwater of Kosi River)	***Water resources:*** Reduction in groundwater recharge, 36% of springs have dried, heads of perennial streams have dried and water discharge in springs and streams has decreased considerably	1990-2010	Tiwari and Joshi, 2012
	India (Andaman Islands)	***Coral health:*** Mass bleaching.	2010	Krishnan *et al*., 2011
	Nepal (Himalayan region)	***Water resources:*** Significantly moving snowline		Karki *et al*. 2009
	Nepal (Shorong, Khumbu, Langtang, Dhaulagiri, Kanchenjunga)	***River discharge:*** Decreasing trend in Karnali and Sapta Koshi; increasing trend in Narayani. No trend in southern rivers.	1970s-2000s	Shrestha and Aryal 2011
	Pakistan, India, Nepal, Bhutan (Himalayas)	***Start of plant growth in spring:*** Earlier start by 1.9 days per decade	1982-2006	Shrestha *et al*., 2012
		Livelihoods: Leave farming due to repeated droughts	-	Kulkarni and Rao, 2008
Southeast Asia	Republic Cambodia	***Poverty:*** Loss of crops, income and fallows	-	Kulkarni and Rao, 2008
	Indonesia (Province of Papua)	***Area of mountain glaciers Puncak Jaya, Central Cordillera, New Guinea Island:*** Reduced from 19.3 km^2 to 7.3 km^2 (Mid 19th C.-1972), reduced from 7.3 km^2 to 2.1 km^2 (1972-2002)	Mid 19th C. - 2002	Prentice and Glidden, 2010; Allison, 2011
	Malaysia (Mt Kinabalu, Sabah)	***Altitudinal distributions of moth species:*** Uphill shifts by average 83 m (upper) and 86 m (lower)	1965-2007	Chen *et al*., 2011
	Indonesia, Malaysia, Singapore	***Coral health:*** Mass bleaching and subsequent mortality	2010	Guest *et al*., 2012
West Asia	Jordan	***Wheat and barley yield*****:** In 1999, total production and average yield for wheat and barley were lowest among years due low rainfall which was 30% of average.	1996-2006	Al-Bakri *et al*., 2010
	Azerbaijan, Georgia (Southern flank of Greater Caucasus Range)	***Area of glaciers:*** Decreased by 31.2% in total	1895-2000	Anisimov *et al*., 2008b
	Iran, Iraq, Kuwait, Qatar, Saudi Arabia, UAE	***Coral health:*** Mass bleaching and subsequent mortality	1996-2012	Coles and Riegl, 2013
Kazakhstan, Kyrgyzstan, Tajikistan, China, Mongolia, Russia (East of Urals), Afghanistan (Altai-Sayan, Pamir, and Tien Shan Mountains)		***Area of glaciers:*** Decreased on average by 10%	1960-2009	Aizen, 2011; Aizen *et al*., 2006, 2007
		Ice volume of glaciers: Decreased on average by 15%		
East and South Asia		***Poverty:*** Disproportionately impacted by climate-related hazards	-	Kim, 2011
East and Southeast Asia (Mekong region)		***Livelihoods:*** Increased migration due to environmental (e.g. rapid-onset disasters), social and economic reasons	-	Warner, 2010; Black *et al*., 2011

Table SM24-5: Summary of key projected climate change impacts in Asia.

Sub-Region	Countries/Regions (Area)	***Parameters***: Projected impacts	Scenario/GCM (RCM)/Period (Base year)	Reference
Central Asia	N. & E. Kazakhstan	***Crop yield (cereal):*** Benefit from longer growing season, warmer winters and slight increase in winter precipitation		Lioubimtseva and Henebry, 2009
	W. Turkmenistan & Uzbekistan	***Crop yield (cotton):*** Negative impacts from frequent droughts		
East Asia	Japan (Tohoku and Hokuriku)	***River discharge:*** 200% higher in February, 50-60% lower in May.	A1B/AGCM/2080-2099 (1980-99)	Sato, Y. *et al*., 2012
	Japan	***Rice transplanting date:*** Northward shift of isochrones of safe transplanting dates for rice seedlings.	A2/MRI-CGCM2 (RCM20) /2081-2100 (1971–2000)	Ohta and Kimura, 2007
	China (Tarim River Basin)	***Flow:*** Positive change 1.3-12.8% in BYBLK and 17.7-29.7% in DSK	A2, A1B, B1/18GCMs/2046-65 (1979-98)	Liu *et al*., 2011
	China (Poyang Lake)	***Annual catchment inflow:*** Increased by 2.9% (A1B) and 6.5% (B1), decreased by 5.2% (A2).	A1B, B1, A2/ ECHAM5/ 2011-50 (1961-2000)	Ye *et al*., 2011
	China (Qinghai-Tibet Plateau)	***Permafrost area:*** Decrease by <19% (20-50 years since 1996), decrease by 58% (2099)	+1°C in air temp. in 30 years since 1996/HADCM2/20-50 years since 1996, 2099 (1996)	Results of Li & Cheng (1999) after Cheng & Wu (2007)
	China (Tibetan Plateau)	***Alpine vegetation:*** Most replaced by forest and shrubland	A1B/Pattern-scaled output of multiple models/2070-2099 (1931-1960)	Liang *et al*.., 2012; Wang *et al*., 2013
	Southeastern China	***Rice production:*** yield would change on average by 7.5% to 17.5% (–10.4% to 3.0%), 0.0% to 25.0% (–26.7% to 2.1%), and –10.0% to 25.0% (–39.2% to –6.4%) during the 2020s, 2050s, and 2080s, respectively, in response to climate change, with (without) consideration of CO2 fertilization effects	10 climate scenarios, relative to 1961–1990 levels	Tao and Zhang, 2013a
	China (Huang-Hai Plain in northeast China)	***Winter wheat yield:*** Increase by 0.2 Mg/ha (2015-45), increase by 0.8 Mg/ha (2070-99)	A2, B2/HadCM3/2015-45,2070-99 (1961-90)	Thomson *et al*., 2006
	China (Huang-Huai-Hai (3H) Plain)	***Wheat-maize relative yield change (RYC):*** a. +2ºC & +5ºC in temp., +15 & -30% in prec., 500 & 700 ppmv CO_2: Decreased on average by -10.33%. b. a. with CO_2 fertilization: +4.46±14.83% (2ºC), -5.78±25.82% (5ºC). Base year: 1996-2004.		Liu *et al*., 2010
	South Korea	***Paddy irrigation requirements:*** Decrease by 1-8%	A2, B2/HadCM3(RCMs)/ 2010-2039, 2040-2069, 2070-2099 (1961-90)	Chung *et al*., 2011
		Volumetric irrigation demand: Decrease by 4-10%		
	South Korea (Soyang, Chungju, Daecheong Basins)	***Annual mean streamflow:*** Reduced by 7.6%	2×CO_2/YONU GCM (WGEN)/ 2031-50 (1961-80)	Kim *et al*., 2007
	China, Taiwan province (Upstream catchment of Shihmen reservoir)	***Runoff:*** Future runoff may be higher during wet season and lower during dry season.	A2, B2/CCSR, CGCM2, CSIRO, ECHAM4, GFDL, HADCM3/2010-39; 2040-69; 2070-99 (1973-2000)	Yu and Wang, 2009
	China (Taiwan province)	***Annual renewable water resource:*** Drop by 12.3%	A1B/JAM/MRI TL 959L60/2080-99 (1949-2000)	Tsai and Huang 2012
		Water resource condition for five levels: good (L1), good (L2), fair(L3), poor (L4), very poor (L5): No change in northern and eastern parts with L2; visibly deteriorate in southern part with L3 to L4; central part will be L4	A1B/ JAM/MRI TL 959L60/2080-99 (1979-98)	Tsai and Huang, 2011
North Asia	Russia, East of Urals (Siberia)	***Tundra area:*** Decrease by 93% as result of boreal forest expansion	+1% GHG per year/HADCM3 (GGa1)/2090-2100 (1964)	Tchebakova *et al*., 2010
		Steppe area: Increase by 27%		
	Russia, East of Urals (Asian Russia)	***Tundra area:*** Decrease by 3% as result of boreal forest expansion	+1°C in annual mean global surface temp./ECHAM4/OPYC3, HadCM3a, IAP RAS CM/Late 2030s - early 2050s (1961-90)	Golubyatnikov & Denisenko, 2007
		Steppe area: Decrease by < 65%		
	Russia, East of Urals (Asian Arctic)	***Coast recession rate:*** Increase by 1.5- to 2.6-fold	+2°C in annual mean global surface temp. over 21st C., /2100 (c. 2000)	Pavlidis *et al*., 2007
	Russia, East of Urals (Arctic)	***Ice-dependent mammals***: Population declines in some species	Various/Various/21st C.	Post *et al*.., 2013; Kovacs *et al*., 2011
	Russia (East of Urals)	***Frequency of food production shortfalls:*** +3-4 years/decade in 2070s	A2, B2/ECHAM, HadCM3/2070s (1961-90)	Alcamo *et al*., 2007

South Asia	India(All)	***Forests:*** 34-39% of forests to change forest type	A2, B2/HadRM3/2085 (1931-60)	Chaturvedi *et al*., 2011
	India (Indo-Gangetic Plains, Indore, Hyderabad, Dhar-wad)	***Sorghum winter grain yield:*** Reduced by up to 7% by 2020, up to 11% by 2050, and up to 32% by 2080	A2a/HadCM3/2020, 2050, 2080 (1970-95)	Srivastava *et al*., 2010
	Pakistan(Swat & Chitral districts)	***Wheat yield:*** -7% & -24% (Swat district), +14% & -23% (Chitral district).	1.5 & 3°C in temp./ (1976-2000)	Hussain and Mudasser, 2007
Southeast Asia	Thailand (Chao Phraya River basin)	***River discharge:*** decreased 60% in January, no significant change in September	A1B/MRI-AGCM+TRIP/2075-2099(1979-2003)	Champathong *et al*., 2013
	Vietnam (Mekong River delta)	About 7% of Vietnam's agricultural land may be submerged by 1 m sea level rise	1 meter sea level rise scenario (no GCMs used)	Dasgupta et al., 2009
West Asia	Iran (all)	***Deep aquifer recharge:*** Decreases by 50-100% in groundwater recharge in eastern region	A1B; B1; A2/CGCM 3.1/2010-40, 2070-2100 (1980-2002)	Abbaspour *et al*., 2009
	Jordan (Upper Jordan; Wadi Faynan)	***Stream flows, flood flow and numbers:*** Decrease by 12%	A2/(HadRM3)/ 2071-2100 (1961–1990)	Wade *et al*., 2010
Eastern Mediterranean and Middle East region		***Internal water resource:*** Decreases from 464 to 419 and 412 km^3	A1B /HadCM3 (PRECIS)/2040-69, 2070-99 (1961-90)	Chenoweth *et al*., 2011
		Runoff: -9.5% & -10% (Tigris-Euphrates River), -22% & -30% (Jordan River)		
North Asia, East Asia, Central Asia	Asian Russia, China, Mongolia, Kazakhstan (Permafrost area in Asia)	***Permafrost degradation:*** Spread from southern and low-altitude margins, advancing northwards and upwards	Multiple scenarios/Multiple GCMs/21st C.	Multiple references, see section 24.4.2.3.
North, East Asia	Asian Russia, China (Siberia and Tibet)	***Permafrost distribution:*** Permafrost will remain only in Central and Eastern Siberia and in part of Tibet	A1B, A2/IAP RAS CM/Late 21st C.	Eliseev *et al*., 2009
West, South, Southeast Asia (all countries with tropical coasts)		***Coral health:*** Large declines in structure and diversity	Several/Several/2050	Hoegh-Guldberg, 2011; Burke *et al*., 2011
Asia		***Poverty:*** Negative impact on rice crop, increase in food price and cost of living, increased poverty, projections for 2030 by GTAP Model under three scenarios resulting low, medium and high productivity		Hertel *et al*., 2010
Central, East, South, Southeast Asia (Tibet/Himalayas)		***Livelihoods:*** Loss of livelihoods of indigenous people from declining alpine biodiversity		Salick and Ross, 2009; Xu *et al*., 2009

Table SM24-6: Summary of recent literature from East Asia (China and Japan) reporting phenological observations in relation to recent climate change. Studies differ in objectives, methods, locations, and study periods. The source publications should be consulted for details. Phenological responses are given in days per decade (d/dec), unless otherwise indicated, with negative values indicating an earlier occurrence of the event (i.e. an advance), and positive values a later occurrence (i.e. a delay). The 'major influence' column shows the environmental variable that the authors of the study considered most important.

Location	Latitude	Period	Type of data	Variable	Species	Response (timing)	Major influence	Source
China	All	1982-2006	observations + NDVI	spring green-up		-2.9 +/-2.3 d/dec	Temperature	Ma and Zhou, 2012
China	Most	1952-2007	observations	first leaf date	20 spp. broadleaved deciduous	-1.1 d/dec	Temperature	Ge *et al.,* 2013a
China	most	1960-2009	observations	first leaf date	4 tree spp.	-1.1 d/dec	Temperature	Dai *et al.,* 2013a
China	Most	1960-2009	observations	leaf coloring date	4 tree spp.	+0.9 d/dec	Temperature	Dai *et al.,* 2013a
China	>35ºN and <35ºN	1951-2007	meteorological data	thermal growing season length		+2.3 d/dec (N); +1.3 d/dec (S)	Temperature	Song *et al.*, 2010
China	>35ºN and <35ºN	1951-2007	meteorological data	start of thermal growing season		-1.7 d/dec (N); -0.6 d/dec (S)	Temperature	Song *et al.*, 2010
Eastern China	18-54ºN	1982-2006	GIMMS-NDVI	spring green-up	all	Advance in most areas except northeast China plain	Temperature	Yu *et al.*, 2013a
Xishuangbanna, China	21ºN	1973-1999	observations	leaf budburst	21 species	+14 d (7 spp.)	Temperature	Zhao *et al.*, 2013
Xishuangbanna, China	21ºN	1973-1999	observations	growing season length	21 species	+35 d (4 spp.)	Temperature	Zhao *et al.*, 2013
Xishuangbanna, China	21ºN	1973-1999	observations	first flowering	21 species	Varied	temperature, rainfall	Zhao *et al.*, 2013
China	23-46ºN	1952-2007	observations	first leafing	*Fraxinus chinensis*	NE -1.5, N 2.0, NW, -1.4, E -0.9, C -1.1, S-0.3, SW -0.6 d/decade	Temperature	Wang *et al.*, 2012
Yangtze River delta, China	28-32ºN	1834-2010	observations	flowering	14 ornamental species	Delayed 1843-1893, advanced 1893-1905, 1990-2010.	Temperature	Zheng *et al.*, 2013
temperate China	28-54ºN	1982-2006	GIMMS-NDVI	spring green-up	all biomes	Advanced to mid-late-1990s, then delayed to 2006	Temperature	Wu and Liu, 2013
temperate China (incl. Tibet)	c. 28-54ºN	1982-1998	GIMMS NDVI	start of growing season	all	-6.8 d/dec 1982-1998, +21.3 d/dec 1998-2005	temperature, snow depth	Yu *et al*.., 2013b
China	>30ºN	1986-2005	observations	leaf unfolding	*Ulmus pumila*	-4.0 d/dec	Temperature	Chen and Xu, 2012
China	>30ºN	1986-2005	observations	leaf fall	*Ulmus pumila*	+2.2 d/dec	Temperature	Chen and Xu, 2012
China	>30ºN	1982-2010	GIMMS-NDVI3g	spring green-up	all	-1.3+/-0.6 d/dec	Temperature	Cong *et al.*, 2013
N China	33-53ºN	1960-2009	observations + modeling	first leaf unfolding	4 deciduous tree spp.	-1.4 to -1.6 d/dec	Temperature	Xu and Chen, 2013
Xi'an, China	34ºN	1963-1996 vs. 2003-2011	observations	first leafing	42 woody species	-5.5 d between periods	Temperature	Dai *et al.*, 2013b
Xi'an, China	34ºN	1963-1996 vs. 2003-2011	observations	leaf coloring	42 woody species	+16.1 d between periods	Temperature	Dai *et al.*, 2013b
Xi'an, China	34ºN	1963-1996 vs. 2003-2011	observations	first flowering	42 woody species	-10.2 d between periods	Temperature	Dai *et al.*, 2013b

Beijing & Xi'an	34-40ºN	1963-2010	observations	leaf coloring	*Acer mono*	+4-5 d/dec	Temperature	Ge *et al.*, 2013b
temperate China	34-47ºN	1963-2009	observations	first flowering	210 species	NE -1.5 d/dec, N -2.2 d/dec	Temperature	Dai *et al.*, 2013c
Inner Mongolia, China	37-53ºN	1982-2006	observations	first flowers	*Populus tomentosa*	-2.9 (-6.5-+1.5) d/dec	temperature	Wu *et al.*, 2009
Inner Mongolia, China	37-53ºN	1982-2006	observations	leaf fall	*Populus tomentosa*	+3.1 (-5.8-+9.5) d/dec	temperature	Wu *et al.*, 2009
Beijing	40ºN	1963-2008	observations	growing season length	*Castanea mollissima*	+4.3 d/dec	temperature	Guo *et al.*, 2013
Beijing	40ºN	1963-2008	observations	leaf coloring	*Castanea mollissima*	not signif.	temperature	Guo *et al.*, 2013
Beijing, China	40ºN	1963-2008	observations	first flowers	*Castanea mollissima*	-1.6 d/dec	temperature	Guo *et al.*, 2013
Beijing, China	40ºN	1963-1989, 1990-2007	observations	First flowers	48 woody species	-5.4 d between periods	temperature	Bai *et al.*, 2011
NE China	40-52ºN	1980-2005	observations	Leafing	11 woody species	-2.3 d/dec	temperature	Li and Zhou, 2010
NE China	40-52ºN	1980-2005	observations	leaf yellowing	11 woody species	+1.9 d/dec	temperature	Li and Zhou, 2010
Inner Mongolia, China	42ºN	2006-2009	experimental warming (day and night)	flowering and fruiting	8 species in temperate steppe	-0.8 d (fl), -0.7 d (fr) with night warming	temperature	Xia and Wan, 2013
Northeast China	45-53ºN	2001-2009	MODIS EVI	start of season	broadleaved deciduous forest	Advance	temperature	Cai *et al..*, 2012
Tibet, China		1961-2000	herbarium collections	flowering	41 species	-5.0 d/dec	temperature	Li *et al.*, 2013
Tibet, China		1982-2006	GIMMS-NDVI	spring green-up	all	Advance to 1999 then delay	temperature	Piao *et al.*, 2011
Tibet, China		1982-2006	GIMMS-NDVI	spring green-up	grassland	advance to 1990s then delay	temperature	Yu *et al.*, 2012
Tibet, China		1982-2006	GIMMS-NDVI	senescence and end of growing season	grassland	mostly earlier	temperature	Yu *et al.*, 2012
Tibet, China		1999-2009	SPOT-VGT NDVI	start of growth season	grassland	-6 d/dec	-	Ding *et al.*, 2013
Tibet, China		1999-2009	SPOT-VGT NDVI	end of growing season	grassland	+2 d/dec	-	Ding *et al.*, 2013
Tibet, China		1982-2011	GIMMS & SPOT-VGT NDVI	spring green-up		-10.4 d/dec	temperature	Zhang *et al.*, 2013a
Tibet, China		1982-2006	GIMMS-NDVI	spring green-up	all	earlier in most areas	temperature	Panday and Ghimire, 2012
Tibet, China		1994-2005	observations	growing season	*Festuca rubra*, *Kobresia pygmaea*, *Poa pratensis*	Longer	precipitation	Zhang *et al.*, 2013b
Japan	31-44ºN	1969-1989, 1990-2005	observations	first flowers	*Prunus mume*	-7.0 (-22.8 to +8.0) d between periods	temperature	Doi 2007
Japan	31-44ºN	1953-2005	observations	leaf budburst	*Morus bombycis*	-1.3 d/dec	temperature	Doi 2012
Japan	31-44ºN	1953-2005	observations	leaf fall	*Morus bombycis*	+2.4 d/dec	temperature	Doi 2012
Japan	33-38ºN	1953-2005	observations	leaf budburst	*Gingkgo biloba, Morus bombycis, Salix babylonica, Camellia sinensis*	-2.7 d/dec	temperature	Doi and Katano, 2008
Kyoto, Japan	35ºN	812-2005	observations	peak flowering	*Prunus jamasakura*	general advance after 1820s	temperature	Aono and Kazui, 2008

Japan	36-41ºN	1977-2004	observations	budburst	*Malus pumila* var. *domestica*	-1.8 to -3.6 d/dec	temperature	Fujisawa and Kobayashi, 2010
Japan	36-41ºN	1977-2004	observations	flowering	*Malus pumila var. domestica*	-2.1 to -3.5 d/dec	temperature	Fujisawa and Kobayashi, 2010
Japan	42ºN	3 years	experimental soil warming	leaf phenology	7 understory species	variable between species	temperature	Ishioka *et al.*, 2013

Table SM24-7: Examples of adaptation options for agriculture in Asia.

Crop	Country/ Regions	Potential Adaptation strategies	Benefits/ Co-Benefits	References
Wheat	General	Conservation agriculture (reductions in tillage, surface retention of adequate crop residues, and diversified, economically viable crop rotations)	Improve rural incomes and livelihoods by reducing production costs, managing agroecosystem productivity and diversity more sustainably, and minimizing unfavorable environmental impacts	Ortiz *et al*., 2008
Wheat	Pakistan	Development of short duration and high yield varieties of wheat.	Can withstand climatic anomalies expected in future	Hussain and Mudasser 2007
Wheat	Indo-Gangetic Plains, India	Development of heat-tolerant wheat germplasm, as well as cultivars.	Better adapted to heat and conservation agriculture	Ortiz et al., 2008
Barley; wheat	Jordan	Soil water conservation. Selection of drought tolerant genotypes with shorter growing seasons.	Increase available water to crop	Al-Bakri *et al*., 2010
Sorghum	India	Changing variety and sowing date	Reduce impacts on monsoon sorghum to about 10%, 2% and 3% in 2020 scenario. Reduced impacts on winter crop to 1–2% in 2020, 3–8% in 2050 and 4–9% in 2080.	Srivastava *et al., 2010*
Rice	Sri Lanka	Traditional approaches for resolving water stress, such as increasing water use efficiency, water harvesting and/or reducing cropped areas. Earlier planting and shorter duration varieties to avoid impacts of less rainfall in January and February.		De Silva *et al*., 2007.
Rice	China	Shifts in planting dates and automatic application of irrigation and fertilization. Selection for more temperature-tolerant cultivars and later-maturing cultivars to take advantage of longer growing seasons		Tao *et al*., 2008
Corn	China	Using high-temperature sensitive varieties. Early planting, fixing variety growing duration, and late planting	Using high-temperature sensitive varieties, maize yield could increase on average by 1.0-6.0%, 9.9-15.2%, and 4.1-5.6%, by adopting adaptation options of early planting, fixing variety growing duration, and late planting, respectively	Tao and Zhang, 2010
General	India	Water harvesting		Kelkar *et al*., 2008
General	South Asia	Increasing livestock production relative to crops. Selection of crop varieties. Livelihood diversification		Morton, 2007
General	Central Asia	Replacement of existing network of open irrigation canals by more efficient drip irrigation systems. Development of early warning systems, such as drought forecast, pest and epidemic disease forecasts, and water quality monitoring systems.	Could significantly reduce evaporative water loss, while simultaneously improving crop productivity, reducing soil salinization, and decreasing risks of water contamination and transmission of vector-borne and waterborne diseases.	Lioubimtseva and Henebry, 2009
General	West Asia	Changing of cropping systems and patterns, switching from cereal-based systems to cereal–legumes and diversifying production systems into higher value and greater water use efficient options. Using supplementary irrigation systems, more efficient irrigation practices and adaptation and adoption of existing and new water harvesting technologies. Development of more drought and heat tolerant germplasm using traditional and participatory plant breeding methodologies and better predictions of extreme climatic events.		Thomas, 2008
General	Russia	Crop substitution Diversification of crops		Alcamo *et al*., ,2007,

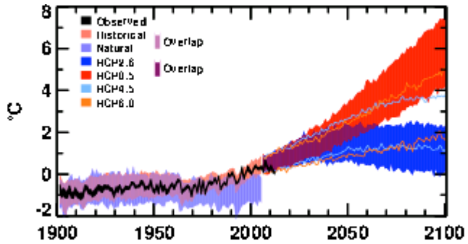
		Expanding irrigated agricultural areas Strategic food reserves, Improving management, Monitoring and early warning systems, Food imports from abroad.		
General	Philippines	Crop diversification; change of crop varieties, use of water conservation practices		Peras *et al.*, 2008; Lasco *et al.*, 2011
General	General	Cultivars with multiple resistance to insects and diseases		Sharma *et al.*, 2010

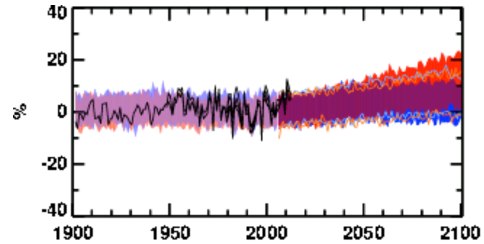
Table SM24-8: Examples of adaptation options for securing livelihoods in Asia.

Aspect/ Issues	Country/ Regions	Potential Adaptation strategies	Benefits/ Co-Benefits	References
Delay and shortfall in rainfall	Indonesia	Access to credit and public works project	Able to protect food expenditure in the face of weather shocks	Skoufias *et al*., 2011
General (droughts, floods etc.)	General	Weather index insurance, cattle insurance, seed banks, credit facilities, assisted migration, cash for work	Poverty-centered adaptation, creation of assets and access to resources	Barrett *et al*., 2007; Tanner and Mitchel, 2008; Jarvis *et al*., 2011
General	General	Assisted migration	Build financial, social and human capital	Barnett and Webber, 2010
General	Vietnam	Yield growth and improving agriculture labour productivity	Rural poverty reduction, livelihood diversification	Janvry and Sadoulet, 2010
Droughts and floods	Philippines	Bundling of improved varieties and agronomic practices and combination of production and market support	Economic benefits and social learning	Acosta-Michlik and Espaldon, 2008
General	Asia	Community based adaptation	Capture information at the grassroots, help integrating disaster risk reduction, development, and climate change adaptation, connect local communities and outsiders, and address the location-specific nature of adaptation.	van Aalst et al., 2008; Heltberg *et al*., 2010; Rosegrant, 2011
General	Asia	Forest management	Resilient livelihoods, buffer from shocks	Chhatre and Agrawal, 2009
General	Asia	Securing rights to resources, community forest tenure rights	Resilient livelihood benefits to the poor indigenous and traditional people	Macchi *et al*., 2008; Angelsen, 2009
Biodiversity loss	Tibet	Greater involvement of traditional and indigenous people in climate change adaptation decision making	Indigenous knowledge from the years of living in close harmony with nature	Byg and Salick, 2009; Salick and Ross, 2009

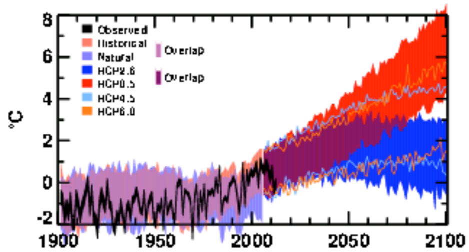
Table SM24-9: Recent publications on changes in Central Asian glaciers.

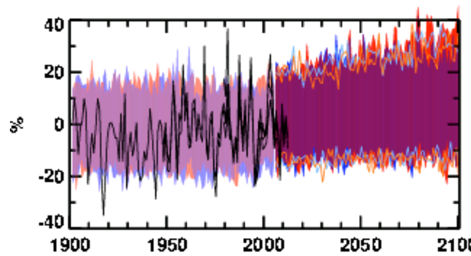
Region	**Period**	**Initial area (km^2)**	**Area change, km^2 (%)**	**References**
Akshiirak (Inner Tien Shan)	1977-2001	406.8	-93.6(-23)	Khromova *et al*., 2003
Akshiirak (Inner Tien Shan)	1977-2003	406.8	-35.15 (-8.6)	Aizen *et al*., 2007
ZailiyskiyAlatau (Northern Tien Shan)	1955-1990	287.3	-81.8 (-29)	Vilesov & Uvarov, 2001
ZailiyskiyAlatau (Northern Tien Shan)	1979-1999	198.37	-34.2 (-17.3)	Bolch, 2007
Sokoluk R. basin, Kirgizkiy range (Northern Tien Shan)	1963-1986 1986-2000	31.7 27.5	-4.2 (-13.3) -4.7 (-17.1)	Niederer *et al*., 2008
Gl.No. 1, Urumqi (Eastern Tien Shan)	1962-2003	1.94	-0.24 (-12.4)	Ye *et al*., 2005
Terskey-Alatoo (IssikKul Lake Basin, Northern Tien Shan)	1971-2002	245	-18 (-8)	Narama *et al*., 2006
Aksu R. basin (Kokshaaltau, Central Tien Shan)	1963-1999	1760	-58.6 (-3.3)	Li *et al*., 2006
Kaidu R. basin (Tarim R. Basin ,Central Tien Shan)	1963-2000	333	-38.5 (-11.6)	Liu *et al*., 2006
Central Tien Shan, Chinese territory	1960s- 1999	2093.8	-96.3 (-4.6)	Ding *et al*., 2006
Tien Shan (all mountain system) Altai (all mountain system)	1960s-2008 1960s-2008	17,679 2,169	-1,172 (6.6%) -127 (5.8%)	Aizen, 2011
Pamir (Amu Darýa R. Basin)	1960s-2008	14,095	-671 (4.8%)	Aizen, 2011



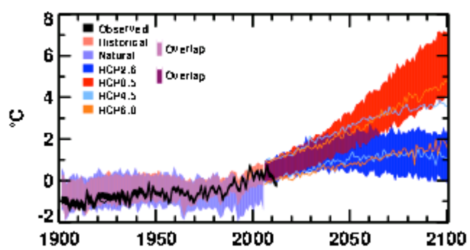


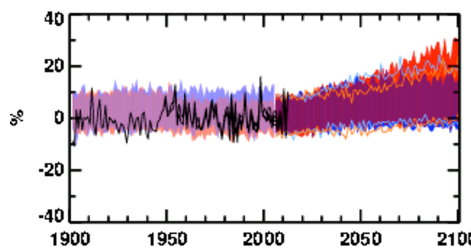
Asia **Asia**



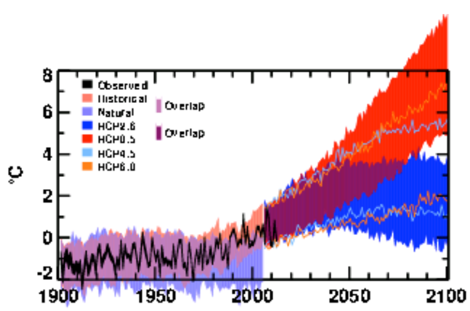


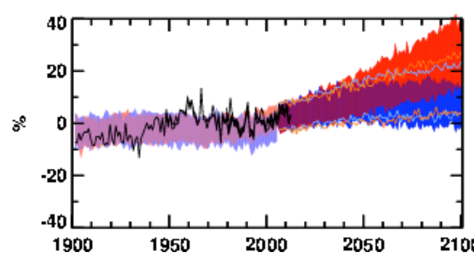
Central Asia **Central Asia**





East Asia **East Asia**





North Asia **North Asia**

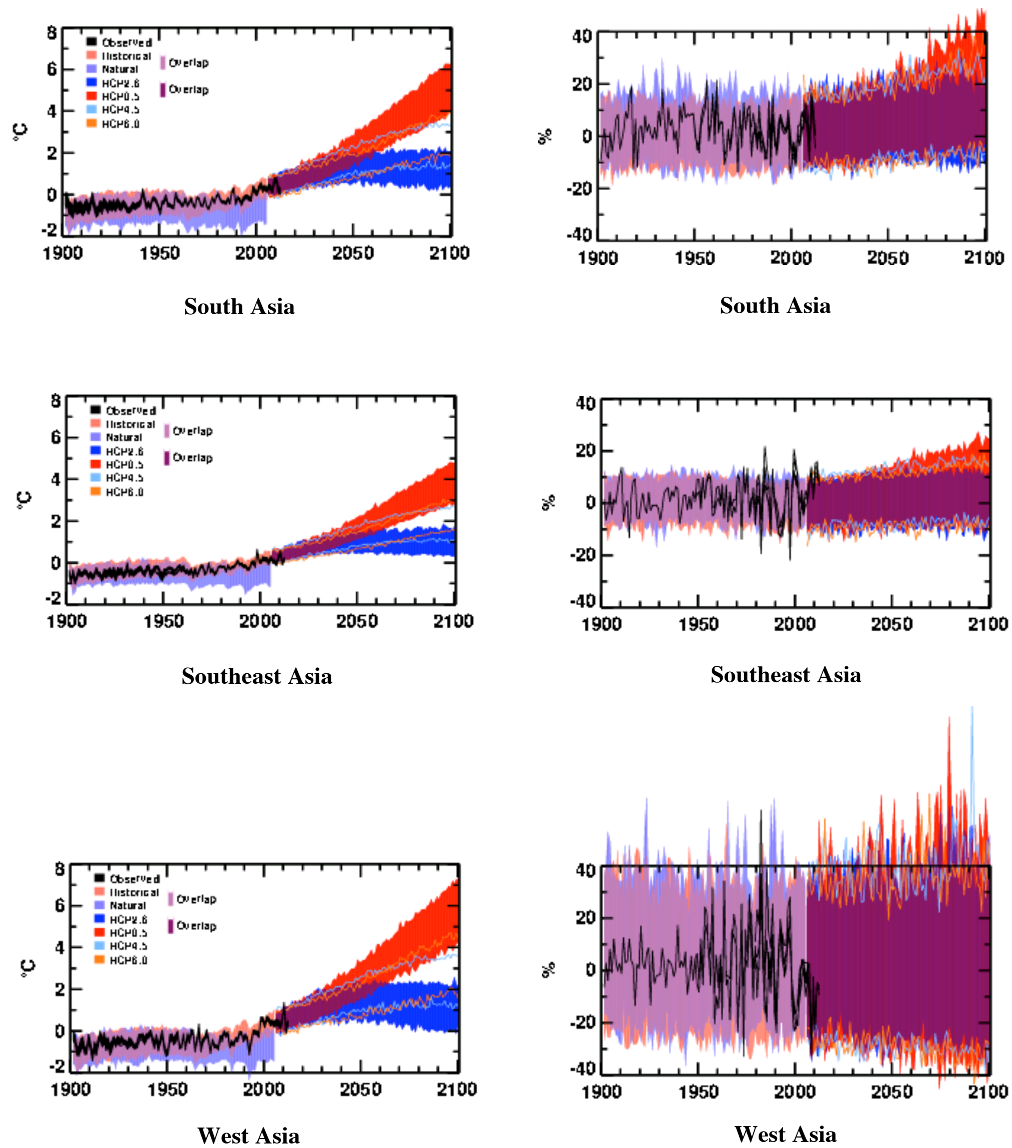


Figure SM24-1: Observed and simulated variations in past and projected future annual average temperature (left) and precipitation (right) over land areas of the regions shown in Figure 24-1. Black lines show various estimates from observational measurements. Shading denotes the 5-95 percentile range of climate model simulations driven with "historical" changes in anthropogenic and natural drivers (63 simulations), historical changes in "natural" drivers only (34), the "RCP2.6", "RCP4.5", and "RCP8.5" emissions scenarios (63 each), and the "RCP6.0" scenario (45). Data are anomalies from the 1986-2005 average of the individual observational data (for the observational time series) or of the corresponding historical all-forcing simulations. Further details are given in Box 21-3.
[Illustration to be redrawn to conform to IPCC publication specifications.]

Figure SM24-2: Geographical boundary and major cities of the LMB (MRC, 2009).
[Illustration to be redrawn to conform to IPCC publication specifications.]

Chapter 24 OLSM References

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