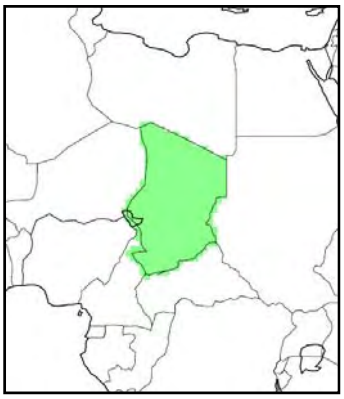
UNDP Climate Change Country Profiles

Chad

C. McSweeney[1], M. New[1,2] and G. Lizcano[1]

1. School of Geography and Environment, University of Oxford.
2. Tyndall Centre for Climate Change Research

http://country-profiles.geog.ox.ac.uk



General Climate

Chad is located in central northern Africa at 7-23˚ north of the equator, straddling the sub-tropical climate band called the Sahel. The north of Chad extends well into the arid Sahara desert, whilst the south has a much wetter, and typically tropical, climate.

The northern, desert regions of Chad receive very little rainfall all year round. The southern, tropical savannah regions of Chad experience a wet season between May and October (receiving 150-300mm per month), whilst the central sub-tropical regions have a shorter wet season between June and September (receiving 50-150 mm per month). In the dry months between November and March, almost no rain falls at all. These seasonal rainfalls are controlled by the movement of the tropical rain belt (also known as the Inter-Tropical Conversion Zone, ITCZ) which oscillates between the northern and southern tropics over the course of a year. Variations in the latitudinal movements of the ITCZ from one year to another cause large inter-annual and decadal variability in wet-season rainfall.

Annually, mean temperatures are similar across most of the country at 25-30˚C, and only differ substantially in the cooler mountainous regions of the north at 15-25˚C. However, seasonal variations are large, and differ in their patterns for different parts of the country. In the north and central regions, summer and winter temperatures are distinct at 27- 35˚C in summer and 20-27˚C in winter (these temperatures are 5-10˚C lower, year-round, in the northernmost mountainous regions). In the south, less seasonal variation is evident, but the summer months (JAS) are the coolest (22-25˚C) due to the cooling effects of rain at this time of year.

Recent Climate Trends

Temperature

- Mean annual temperature has increased by 0.7˚C since 1960, an average rate of 0.16˚C per decade.
- The rate of increase is most rapid in the wettest season, JAS, at 0.36˚C per decade, but there is no evidence of a warming trend in the driest season, JFM.

- There is insufficient daily observed data to identify trends in daily temperature extremes for all seasons, but the average number of 'hot' nights per year in Chad has increased by 50 (an additional 13.6% of days[1]) between 1960 and 2003.
- Cold nights are observed to decrease in all seasons where data are available (JFM, AMJ, and OND). The average number of 'cold' nights per month in these seasons has decreased by 3.6-4.6 (11.6-14.9% of days) between 1960 and 2003.

Precipitation

- Mean annual rainfall over Chad has not changed with any discernible trend since 1960. Some unusually high rainfalls have occurred in the dry season in the very recent years (2000-2006), but this has not been a consistent trend.
- There is not sufficient daily precipitation data available to determine trends in the daily variability of rainfall.

GCM Projections of Future Climate

Temperature

- The mean annual temperature is projected to increase by 1.0 to 3.4˚C by the 2060s, and 1.6 to 5.4˚C by the 2090s. The range of projections by the 2090s under any one emissions scenario is 1.5- 2˚C.
- The projected rate of warming is similar in all seasons and regions of Chad.

- All projections indicate substantial increases in the frequency of days and nights that are considered 'hot' in current climate.
    - Annually, projections indicate that 'hot' days will occur on 17-36% of days by the 2060s, and 21-54% of days by the 2090s. Days considered 'hot' by current climate standards for their season are projected to increase most rapidly in JAS, occurring on 35-84% of days of the season by the 2090s.
    - Nights that are considered 'hot' for the annual climate of 1970-99 are projected to occur on 26-49% of nights by the 2060s and 31-63% of nights by the 2090s. Nights that are considered hot for each season by 1970-99 standards are projected to

[1] The increase in frequency over the 43-year period between 1960 and 2003 is estimated based on the decadal trend quoted in the summary table.

increase most rapidly in JAS, occurring on 48-95% of nights in every season by the 2090s.

- Projected increases in hot days and nights are more rapid in the south of the country than the north.

- All projections indicate decreases in the frequency of days and nights that are considered 'cold' in current climate, and in much of the country, do not occur at all by the 2090s.

Precipitation

- Projections of mean annual rainfall averaged over the country from different models in the ensemble project a wide range of changes in precipitation for Chad. Projected change range from -15 to +9mm per month (-28 to +29%) by the 2090s, with ensemble means close to zero.
- Whilst the range of projections across the model ensemble is large, the regional changes in rainfall more consistently indicate increases in wet-season (JAS) rainfall in the south of the country.
- The relative (%) changes in rainfall in the dry regions and seasons are exaggerated because of the very small rainfall totals that changes are presented as a proportion thereof (i.e. a 400% increase in JFM rainfall is equivalent to only an additional 5mm).

- The proportion of total rainfall that falls in heavy[2] events is projected to increase in the south of the country, but to decrease in the north.
- Projections indicate that maximum 1- and 5-day rainfalls may increase in magnitude in the south of the country.

[2] A 'Heavy' event is defined as a daily rainfall total which exceeds the threshold that is exceeded on 5% of rainy days in current the climate of that region and season.

Other Regional Climate Change Information

- Model simulations of precipitation changes for the Sahelian regions of Africa are strongly divergent and most models fail to reproduce realistic inter-annual and inter-decadal rainfall variability in the Sahel in 20th century simulations. Our understanding of the processes causing tropical rainfall is insufficient to allow a prediction of the direction of change with any certainty. The IPCC identify this as an area requiring further research to understand the variety of model responses in this region (Christensen *et al*., 2007).

- For further information on climate projections for Africa, see Christensen *et al*. (2007) IPCC Working Group I Report: '*The Physical Science Basis'*, Chapter 11 *(Regional Climate projections*): Section 11.2 *(Africa*).

Data Summary

	Observed Mean 1970-99	Observed Trend 1960-2006		Projected changes by the 2030s			Projected changes by the 2060s			Projected changes by the 2090s		
				Min	Median	Max	Min	Median	Max	Min	Median	Max
Temperature												
	(˚C)	*(change in ˚C per decade)*		*Change in ˚C*			*Change in ˚C*			*Change in ˚C*		
			A2	1.0	**1.4**	1.9	2.1	**2.8**	3.4	3.6	**4.8**	5.4
Annual	26.4	0.16*	*A1B*	0.9	**1.5**	2.1	1.8	**2.8**	3.4	2.7	**3.6**	4.9
			B1	0.6	**1.2**	1.6	1.0	**1.9**	2.4	1.6	**2.4**	3.2
			A2	0.8	**1.4**	1.9	1.7	**2.7**	3.3	3.1	**4.4**	5.6
JFM	23.2	-0.01	*A1B*	0.9	**1.3**	2.2	1.7	**2.5**	3.3	2.7	**3.2**	4.7
			B1	0.4	**1.1**	1.8	0.7	**1.7**	2.3	1.2	**2.2**	3.0
			A2	0.9	**1.6**	1.9	2.0	**3.0**	3.5	3.4	**4.8**	5.8
AMJ	30.4	0.19*	*A1B*	1.0	**1.6**	1.9	2.1	**2.9**	3.6	2.4	**3.7**	5.4
			B1	0.7	**1.3**	1.8	1.3	**2.0**	2.9	1.7	**2.4**	3.5
			A2	1.1	**1.4**	2.0	2.0	**2.8**	3.6	3.3	**4.8**	6.0
JAS	28.4	0.36*	*A1B*	0.8	**1.5**	2.1	1.8	**2.8**	3.9	2.4	**3.8**	5.4
			B1	0.7	**1.1**	1.9	1.0	**2.0**	2.7	1.3	**2.4**	3.5
			A2	0.8	**1.4**	2.0	2.2	**2.9**	3.5	3.8	**4.8**	5.6
OND	23.7	0.12	*A1B*	0.8	**1.4**	2.3	1.5	**2.7**	3.6	2.2	**3.5**	4.7
			B1	0.5	**1.1**	1.8	0.7	**1.9**	2.7	1.6	**2.5**	3.2
Precipitation												
	(mm per month)	*(change in mm per decade)*		*Change in mm per month*			*Change in mm per month*			*Change in mm per month*		
			A2	-4	**0**	5	-12	**1**	10	-15	**0**	16
Annual	30.0	0.3	*A1B*	-4	**0**	3	-8	**0**	9	-11	**0**	9
			B1	-5	**0**	5	-4	**0**	6	-10	**1**	5
			A2	-2	**0**	0	-3	**0**	1	-4	**0**	5
JFM	1.2	0.3*	*A1B*	-1	**0**	2	-3	**0**	1	-2	**0**	2
			B1	-2	**0**	4	-2	**0**	3	-1	**0**	1
			A2	-10	**1**	4	-16	**0**	12	-24	**-1**	21
AMJ	24.4	0.0	*A1B*	-6	**0**	5	-20	**-1**	7	-16	**-1**	15
			B1	-12	**2**	15	-13	**0**	13	-12	**0**	4
			A2	-18	**1**	10	-32	**3**	19	-34	**6**	27
JAS	88.2	0.0	*A1B*	-10	**1**	7	-28	**0**	21	-32	**3**	19
			B1	-7	**1**	13	-20	**2**	15	-25	**5**	13
			A2	-4	**0**	6	-4	**2**	10	-2	**4**	11
OND	6.2	0.8*	*A1B*	-3	**0**	5	-7	**1**	7	-2	**3**	11
			B1	-4	**0**	5	-1	**0**	7	-5	**0**	9
Precipitation (%)												
	(mm per month)	*(change in % per decade)*		*% Change*			*% Change*			*% Change*		
			A2	-9	**-1**	9	-23	**6**	19	-28	**1**	29
Annual	30.0	0.9	*A1B*	-8	**0**	6	-17	**0**	16	-22	**1**	19
			B1	-11	**1**	8	-8	**1**	11	-20	**3**	9
			A2	-36	**-10**	29	-43	**-5**	30	-53	**-3**	86
JFM	1.2	26.6*	*A1B*	-44	**-10**	40	-35	**-6**	51	-43	**-7**	39
			B1	-54	**-8**	38	-34	**-3**	54	-38	**-11**	73
			A2	-12	**2**	7	-22	**0**	20	-28	**-4**	27
AMJ	24.4	-0.1	*A1B*	-8	**-1**	9	-26	**-1**	11	-21	**-3**	21
			B1	-16	**4**	27	-17	**2**	15	-15	**0**	7
			A2	-12	**2**	9	-33	**4**	19	-35	**8**	29
JAS	88.2	-0.1	*A1B*	-9	**2**	7	-23	**0**	20	-33	**2**	22
			B1	-8	**1**	8	-20	**3**	12	-26	**4**	12
			A2	-16	**3**	21	-20	**11**	34	-12	**18**	49
OND	6.2	13.6*	*A1B*	-18	**-1**	27	-31	**8**	30	-14	**17**	38
			B1	-21	**0**	18	-9	**3**	29	-25	**3**	23

	Observed Mean 1970-99	Observed Trend 1960-2006		Projected changes by the 2030s			Projected changes by the 2060s			Projected changes by the 2090s		
				Min	Median	Max	Min	Median	Max	Min	Median	Max
	% Frequency	Change in frequency per decade					Future % frequency			Future % frequency		
Frequency of Hot Days (TX90p)												
			A2	****	****	****	18	**27**	34	29	**40**	54
Annual	****	****	*A1B*	****	****	****	20	**26**	36	27	**32**	51
			B1	****	****	****	17	**23**	29	21	**26**	36
			A2	****	****	****	14	**25**	32	21	**37**	48
JFM	9.3	(-0.7)	*A1B*	****	****	****	17	**24**	27	24	**30**	47
(DJF)			*B1*	****	****	****	14	**20**	26	18	**24**	29
			A2	****	****	****	26	**35**	45	47	**54**	76
AMJ	****	****	*A1B*	****	****	****	26	**34**	51	39	**44**	74
(MAM)			*B1*	****	****	****	18	**29**	42	25	**33**	54
			A2	****	****	****	23	**41**	67	40	**65**	84
JAS	****	****	*A1B*	****	****	****	26	**41**	64	40	**55**	79
(JJA)			*B1*	****	****	****	18	**33**	52	35	**41**	64
			A2	****	****	****	18	**27**	34	34	**46**	51
OND	****	****	*A1B*	****	****	****	22	**29**	37	31	**38**	49
(SON)			*B1*	****	****	****	9	**22**	29	21	**30**	38
Frequency of Hot Nights (TN90p)												
			A2	****	****	****	31	**37**	46	50	**55**	63
Annual	12.4	(3.16*)	*A1B*	****	****	****	31	**36**	49	43	**47**	56
			B1	****	****	****	26	**29**	35	31	**38**	42
			A2	****	****	****	19	**25**	34	32	**39**	53
JFM	****	****	*A1B*	****	****	****	17	**24**	31	24	**34**	48
(DJF)			*B1*	****	****	****	14	**21**	26	17	**25**	28
			A2	****	****	****	40	**49**	56	62	**75**	80
AMJ	****	****	*A1B*	****	****	****	39	**47**	60	54	**64**	76
(MAM)			*B1*	****	****	****	29	**40**	46	37	**46**	58
			A2	****	****	****	51	**60**	80	81	**88**	95
JAS	****	****	*A1B*	****	****	****	54	**60**	79	71	**80**	92
(JJA)			*B1*	****	****	****	41	**46**	61	48	**64**	77
			A2	****	****	****	28	**31**	39	43	**52**	58
OND	****	****	*A1B*	****	****	****	26	**33**	45	33	**44**	52
(SON)			*B1*	****	****	****	21	**26**	30	24	**34**	40
Frequency of Cold Days (TX10p)												
			A2	****	****	****	2	**3**	6	0	**1**	4
Annual	****	****	*A1B*	****	****	****	1	**4**	5	1	**2**	3
			B1	****	****	****	3	**5**	7	2	**3**	5
			A2	****	****	****	0	**3**	8	0	**0**	8
JFM	****	****	*A1B*	****	****	****	1	**2**	5	0	**1**	3
(DJF)			*B1*	****	****	****	2	**5**	8	1	**4**	5
			A2	****	****	****	2	**3**	5	0	**1**	2
AMJ	****	****	*A1B*	****	****	****	2	**3**	4	0	**2**	4
(MAM)			*B1*	****	****	****	2	**5**	6	1	**3**	5
			A2	****	****	****	1	**2**	8	0	**0**	4
JAS	****	****	*A1B*	****	****	****	0	**2**	5	0	**1**	4
(JJA)			*B1*	****	****	****	1	**3**	8	1	**2**	4
			A2	****	****	****	1	**3**	5	0	**0**	5
OND	9	-0.75)	*A1B*	****	****	****	0	**3**	6	0	**1**	4
(SON)			*B1*	****	****	****	3	**4**	6	2	**2**	5
Frequency of Cold Nights (TN10p)												
			A2	****	****	****	0	**2**	4	0	**0**	1
Annual	****	****	*A1B*	****	****	****	0	**2**	4	0	**1**	2
			B1	****	****	****	2	**4**	5	0	**3**	4
			A2	****	****	****	0	**1**	2	0	**0**	1
JFM	8.6	(-2.69*)	*A1B*	****	****	****	0	**1**	3	0	**0**	1
(DJF)			*B1*	****	****	****	1	**3**	6	0	**2**	2
			A2	****	****	****	1	**2**	2	0	**0**	0
AMJ	7.8	(-3.46*)	*A1B*	****	****	****	1	**2**	3	0	**0**	1
(MAM)			*B1*	****	****	****	2	**3**	4	0	**2**	4
			A2	****	****	****	0	**0**	1	0	**0**	0
JAS	****	****	*A1B*	****	****	****	0	**0**	1	0	**0**	0
(JJA)			*B1*	****	****	****	0	**1**	2	0	**0**	1
			A2	****	****	****	0	**1**	3	0	**0**	0
OND	8.6	(3.06*)	*A1B*	****	****	****	0	**1**	4	0	**0**	2
(SON)			*B1*	****	****	****	2	**2**	5	0	**1**	3

	Observed Mean 1970-99	Observed Trend 1960-2006		Projected changes by the 2030s Min	Median	Max	Projected changes by the 2060s Min	Median	Max	Projected changes by the 2090s Min	Median	Max
% total rainfall falling in Heavy Events (R95pct)												
	%	*Change in % per decade*					*Change in %*			*Change in %*		
			A2	****	****	****	-12	**0**	5	-14	**0**	9
Annual	****	****	*A1B*	****	****	****	-9	**-1**	3	-15	**0**	8
			B1	****	****	****	-5	**0**	2	-8	**-2**	3
			A2	****	****	****	-22	**-5**	4	-27	**-4**	6
JFM	****	****	*A1B*	****	****	****	-18	**-4**	4	-27	**-9**	7
(DJF)			*B1*	****	****	****	-17	**-1**	12	-14	**-2**	13
			A2	****	****	****	-7	**-2**	9	-12	**-6**	11
AMJ	****	****	*A1B*	****	****	****	-12	**0**	6	-10	**0**	9
(MAM)			*B1*	****	****	****	-10	**1**	6	-6	**-2**	6
			A2	****	****	****	-8	**2**	6	-14	**0**	17
JAS	****	****	*A1B*	****	****	****	-7	**-1**	9	-11	**0**	14
(JJA)			*B1*	****	****	****	-10	**1**	11	-10	**0**	4
			A2	****	****	****	-8	**1**	8	-14	**0**	11
OND	****	****	*A1B*	****	****	****	-5	**2**	8	-12	**0**	11
(SON)			*B1*	****	****	****	-9	**1**	14	-9	**0**	11
Maximum 1-day rainfall (RX1day)												
	mm	*Change in mm per decade*					*Change in mm*			*Change in mm*		
			A2	****	****	****	-3	**1**	7	-3	**0**	18
Annual	****	****	*A1B*	****	****	****	-6	**0**	7	0	**0**	12
			B1	****	****	****	-1	**0**	5	-5	**0**	11
			A2	****	****	****	-2	**0**	0	-2	**0**	1
JFM	****	****	*A1B*	****	****	****	-1	**0**	1	-1	**0**	0
(DJF)			*B1*	****	****	****	-1	**0**	0	-1	**0**	1
			A2	****	****	****	-2	**0**	3	-3	**0**	5
AMJ	****	****	*A1B*	****	****	****	-3	**0**	3	-2	**0**	9
(MAM)			*B1*	****	****	****	-1	**0**	1	-2	**0**	1
			A2	****	****	****	-1	**0**	7	-1	**0**	12
JAS	****	****	*A1B*	****	****	****	-4	**0**	4	0	**0**	6
(JJA)			*B1*	****	****	****	-1	**0**	3	-6	**0**	9
			A2	****	****	****	-1	**0**	4	0	**0**	12
OND	****	****	*A1B*	****	****	****	-1	**0**	4	0	**0**	10
(SON)			*B1*	****	****	****	0	**0**	4	-2	**0**	8
Maximum 5-day Rainfall (RX5day)												
	mm	*Change in mm per decade*					*Change in mm*			*Change in mm*		
			A2	****	****	****	-5	**1**	9	-13	**1**	23
Annual	****	****	*A1B*	****	****	****	-14	**0**	7	-7	**0**	13
			B1	****	****	****	-4	**0**	5	-11	**0**	12
			A2	****	****	****	-4	**0**	1	-5	**0**	3
JFM	****	****	*A1B*	****	****	****	-4	**0**	5	-2	**0**	2
(DJF)			*B1*	****	****	****	-3	**0**	1	-1	**0**	2
			A2	****	****	****	-6	**0**	7	-10	**0**	10
AMJ	****	****	*A1B*	****	****	****	-12	**0**	5	-10	**0**	18
(MAM)			*B1*	****	****	****	-4	**0**	5	-9	**0**	3
			A2	****	****	****	-7	**1**	10	-11	**2**	15
JAS	****	****	*A1B*	****	****	****	-12	**0**	4	-10	**0**	12
(JJA)			*B1*	****	****	****	-6	**0**	5	-11	**1**	10
			A2	****	****	****	-3	**0**	8	-4	**1**	17
OND	****	****	*A1B*	****	****	****	-2	**1**	6	-5	**1**	12
(SON)			*B1*	****	****	****	-1	**0**	10	-6	**0**	11

* indicates trend is statistically significant at 95% confidence

**** indicates data are not available

Bracketed trend values for extremes indices indicate values for the closest seasons that data is available. See documentation.

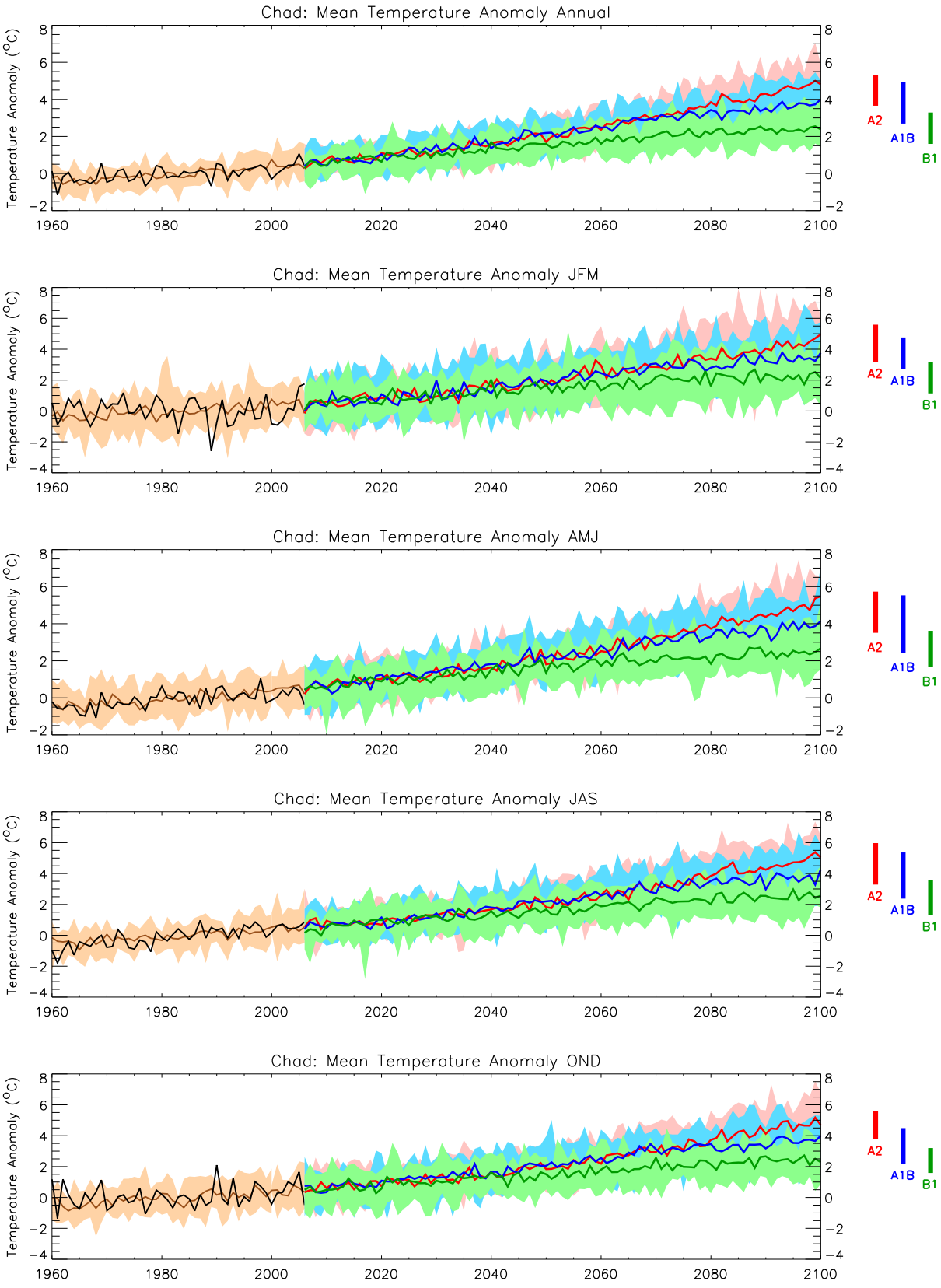


Figure 1: Trends in annual and seasonal mean temperature for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. Black curves show the mean of observed data from 1960 to 2006, Brown curves show the median (solid line) and range (shading) of model simulations of recent climate across an ensemble of 15 models. Coloured lines from 2006 onwards show the median (solid line) and range (shading) of the ensemble projections of climate under three emissions scenarios. Coloured bars on the right-hand side of the projections summarise the range of mean 2090-2100 climates simulated by the 15 models for each emissions scenario.

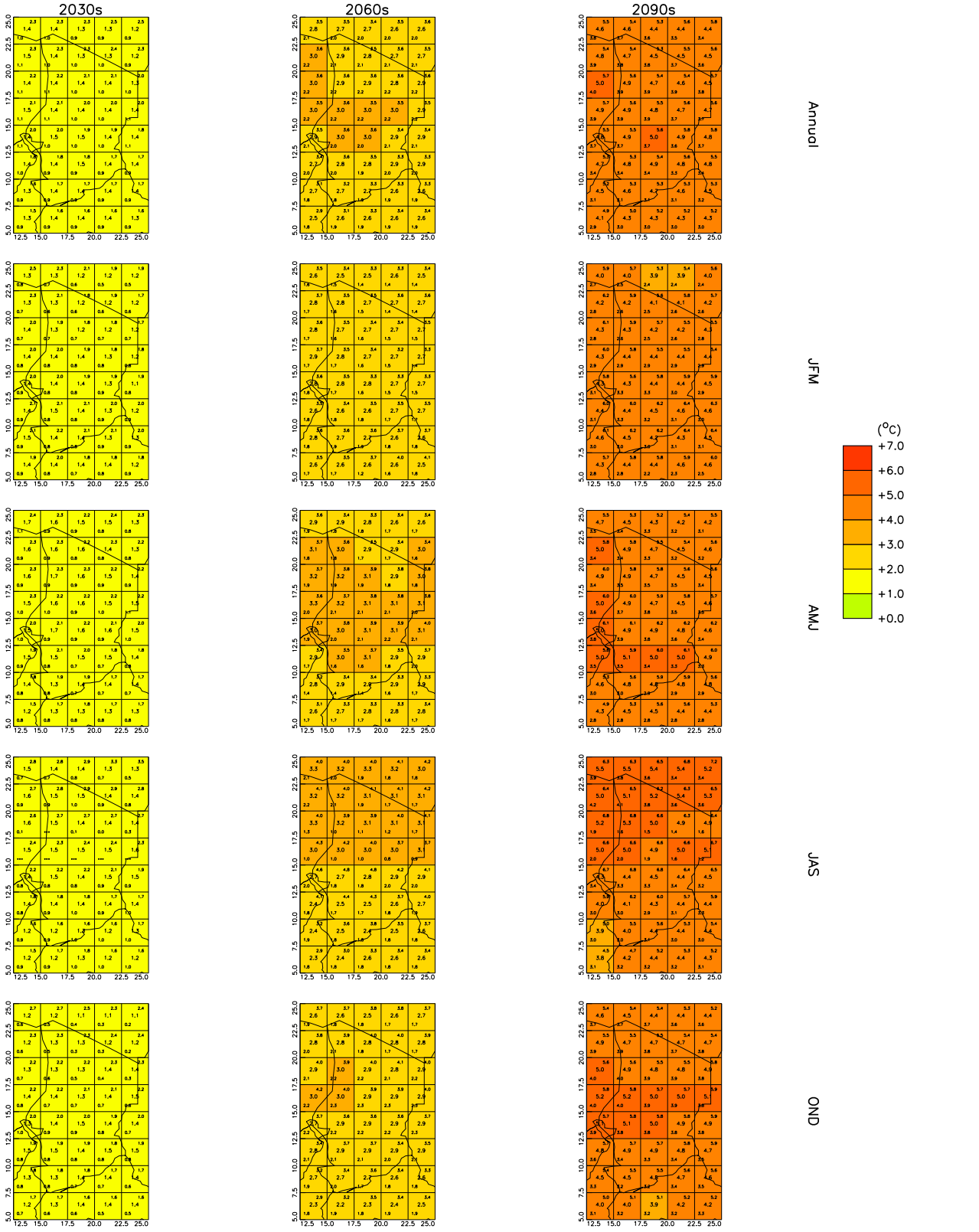


Figure 2: Spatial patterns of projected change in mean annual and seasonal temperature for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. In each grid box, the central value gives the ensemble median and the values in the upper and lower corners give the ensemble maximum and minimum.

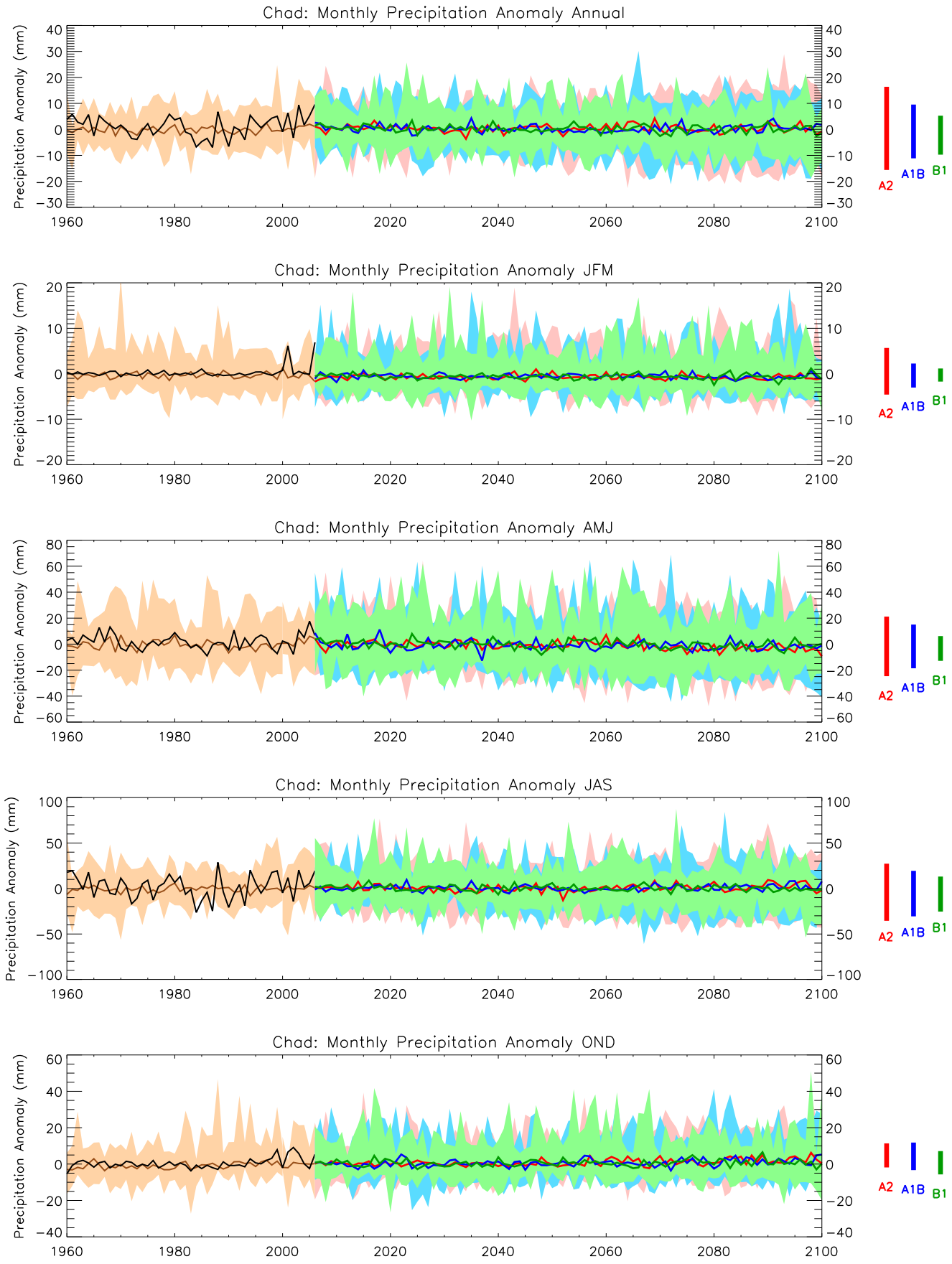


Figure 3: Trends in monthly precipitation for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

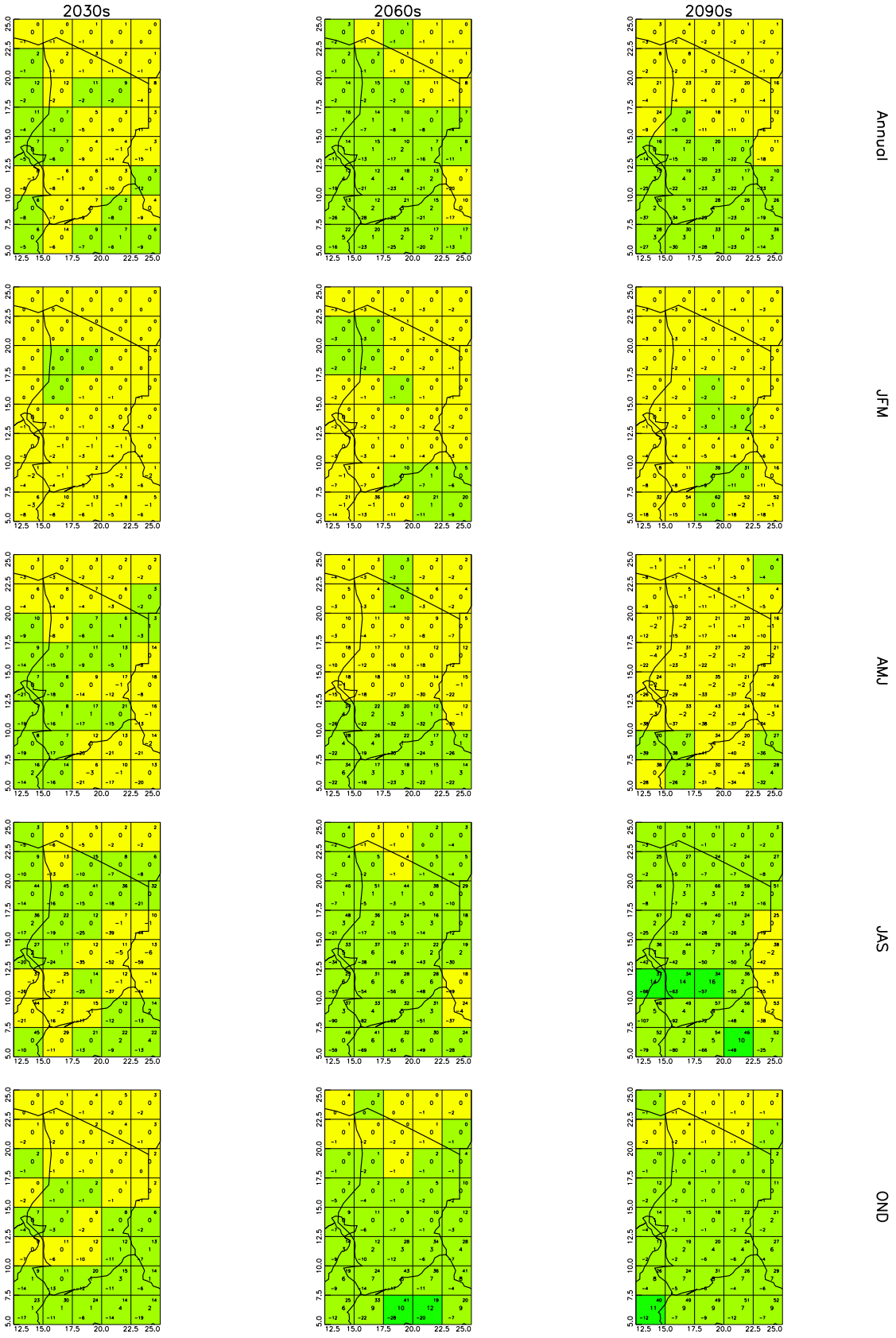


Figure 4: Spatial patterns of projected change in monthly precipitation for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999.See Figure 2 for details.

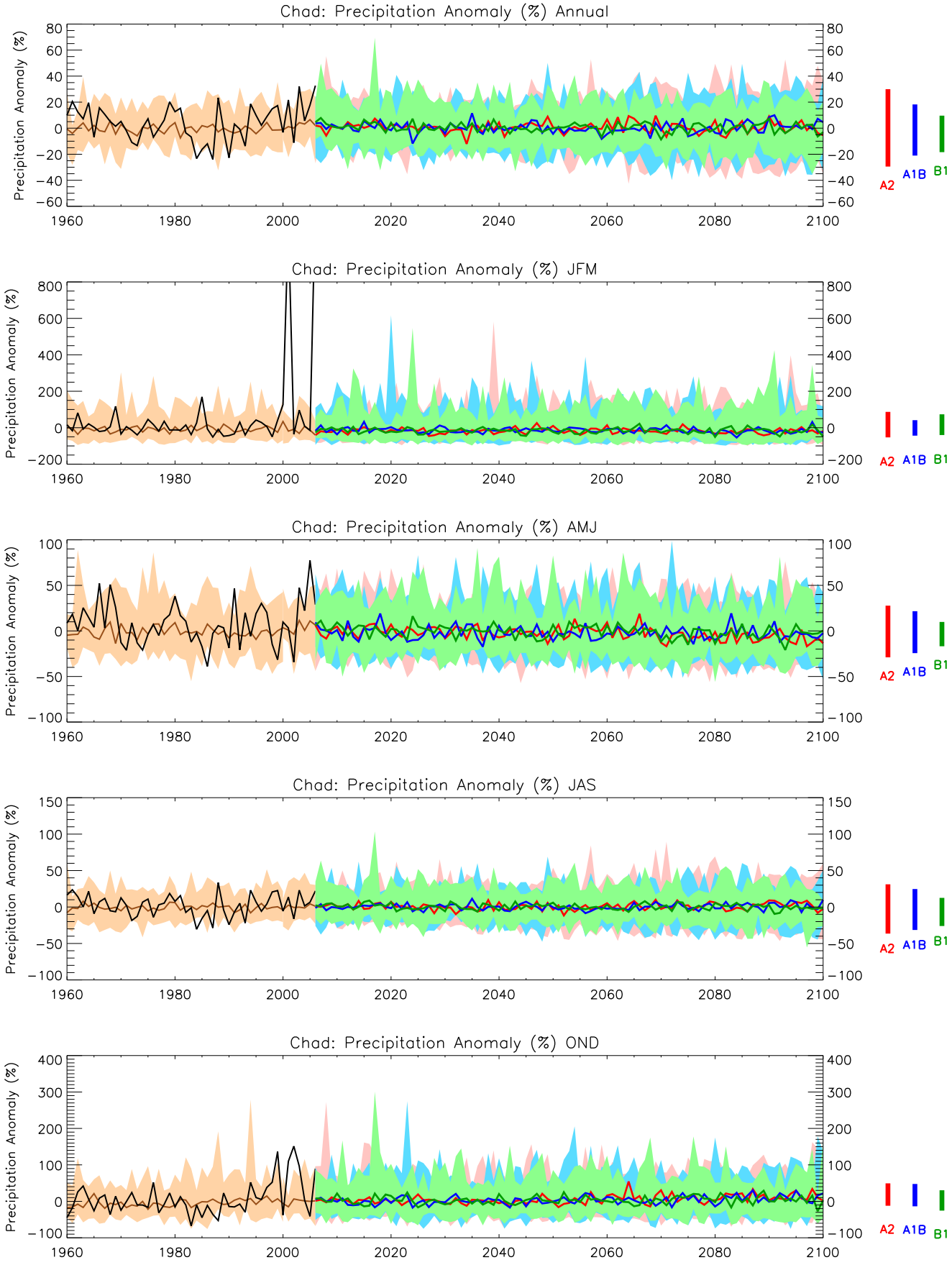


Figure 5: Trends in monthly precipitation for the recent past and projected future. All values shown are percentage anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

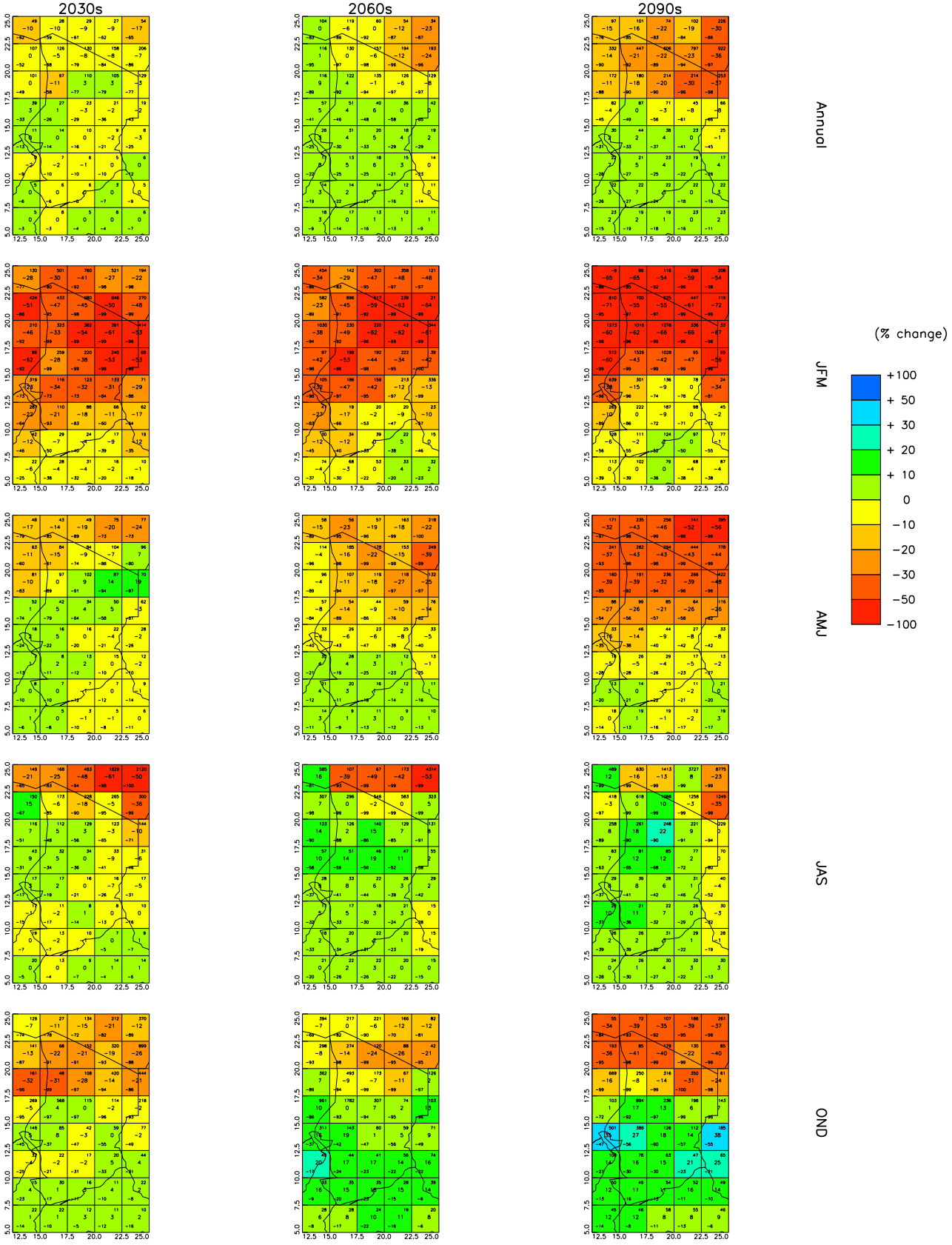


Figure 6: Spatial patterns of projected change in monthly precipitation for 10-year periods in the future under the SRES A2 scenario. All values are percentage anomalies relative to the mean climate of 1970-1999.See Figure 2 for details.

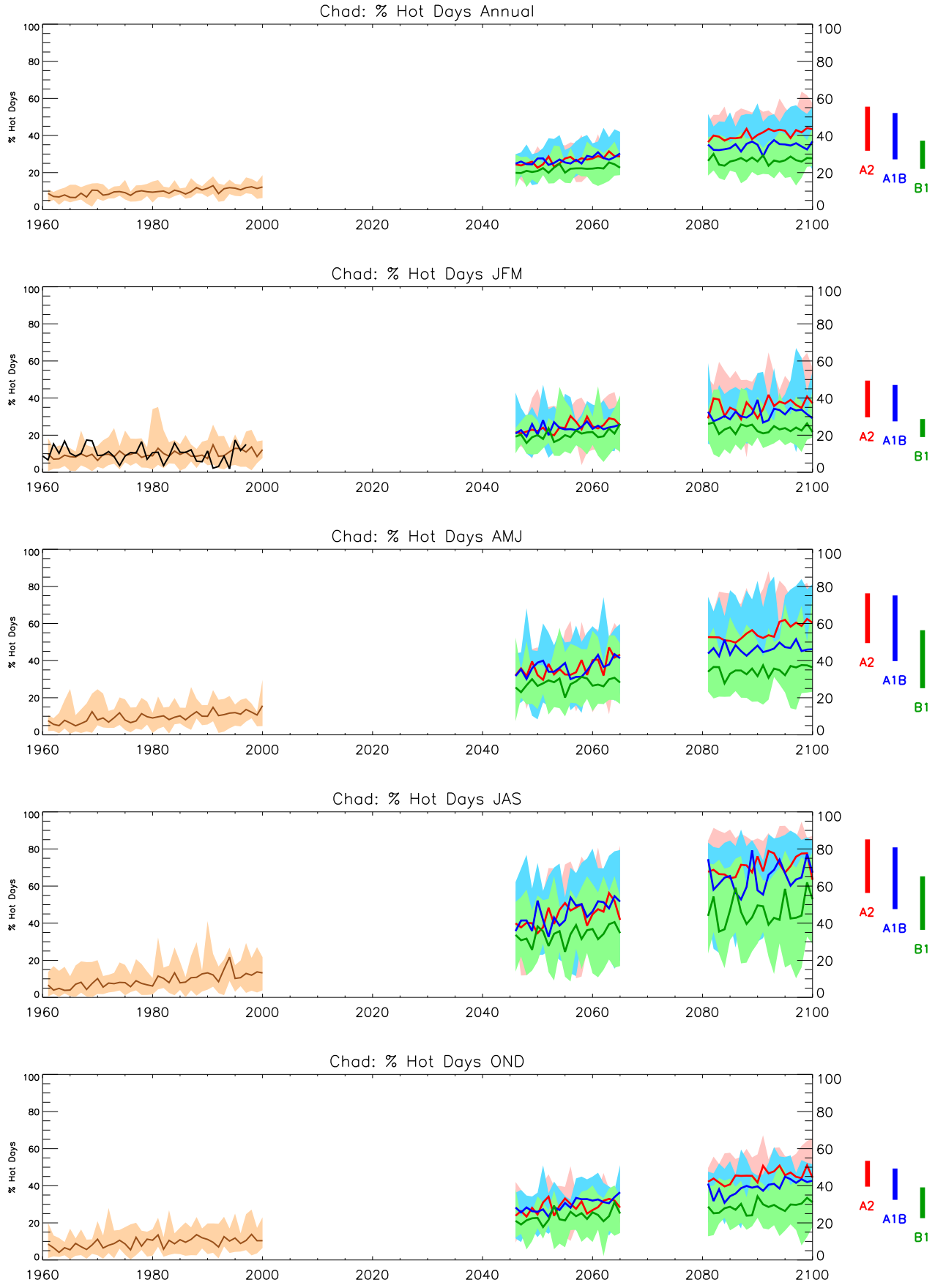


Figure 7: Trends in Hot-day frequency for the recent past and projected future. See Figure 1 for details.

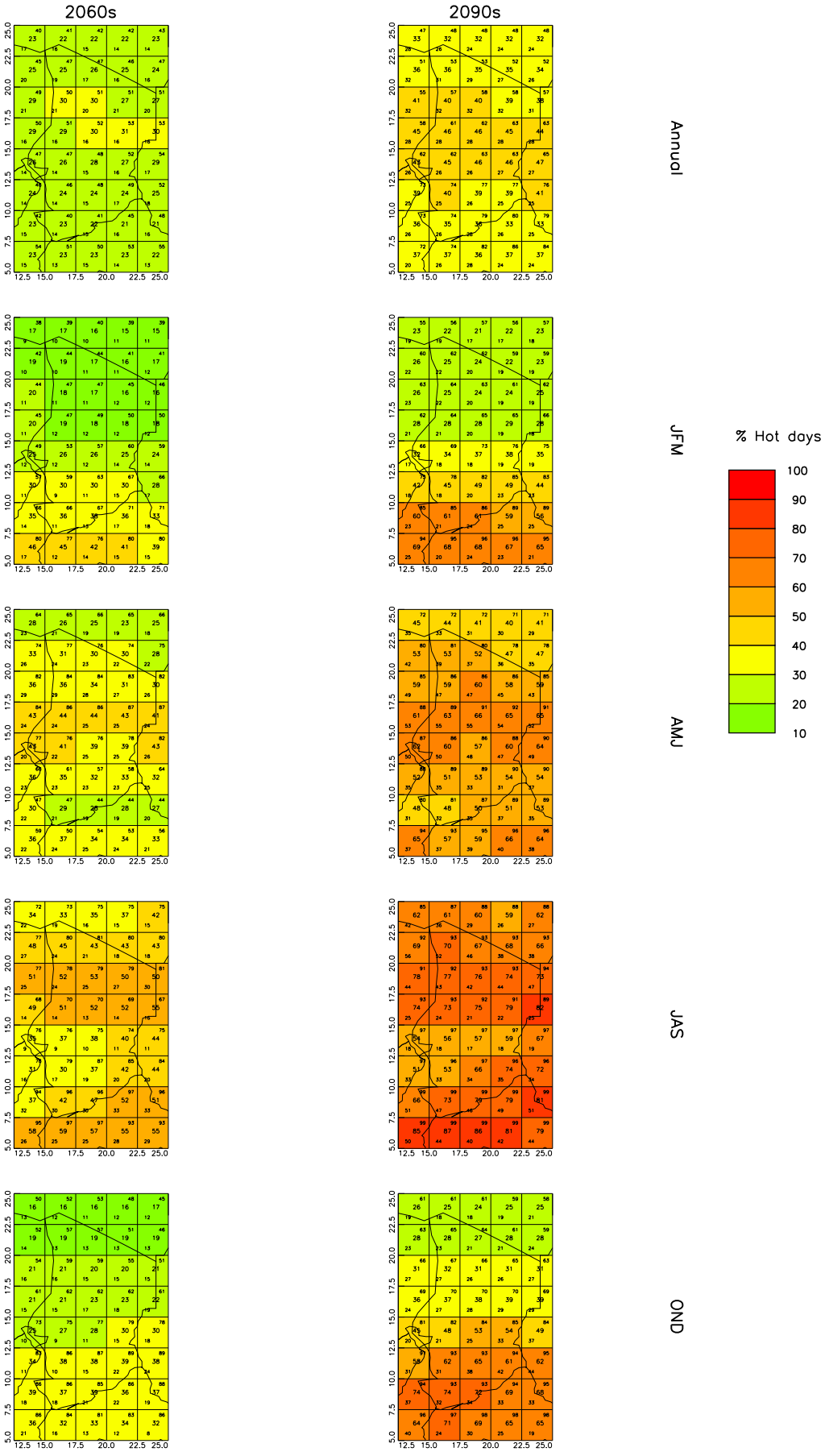


Figure 8: Spatial patterns of projected change in Hot-day frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

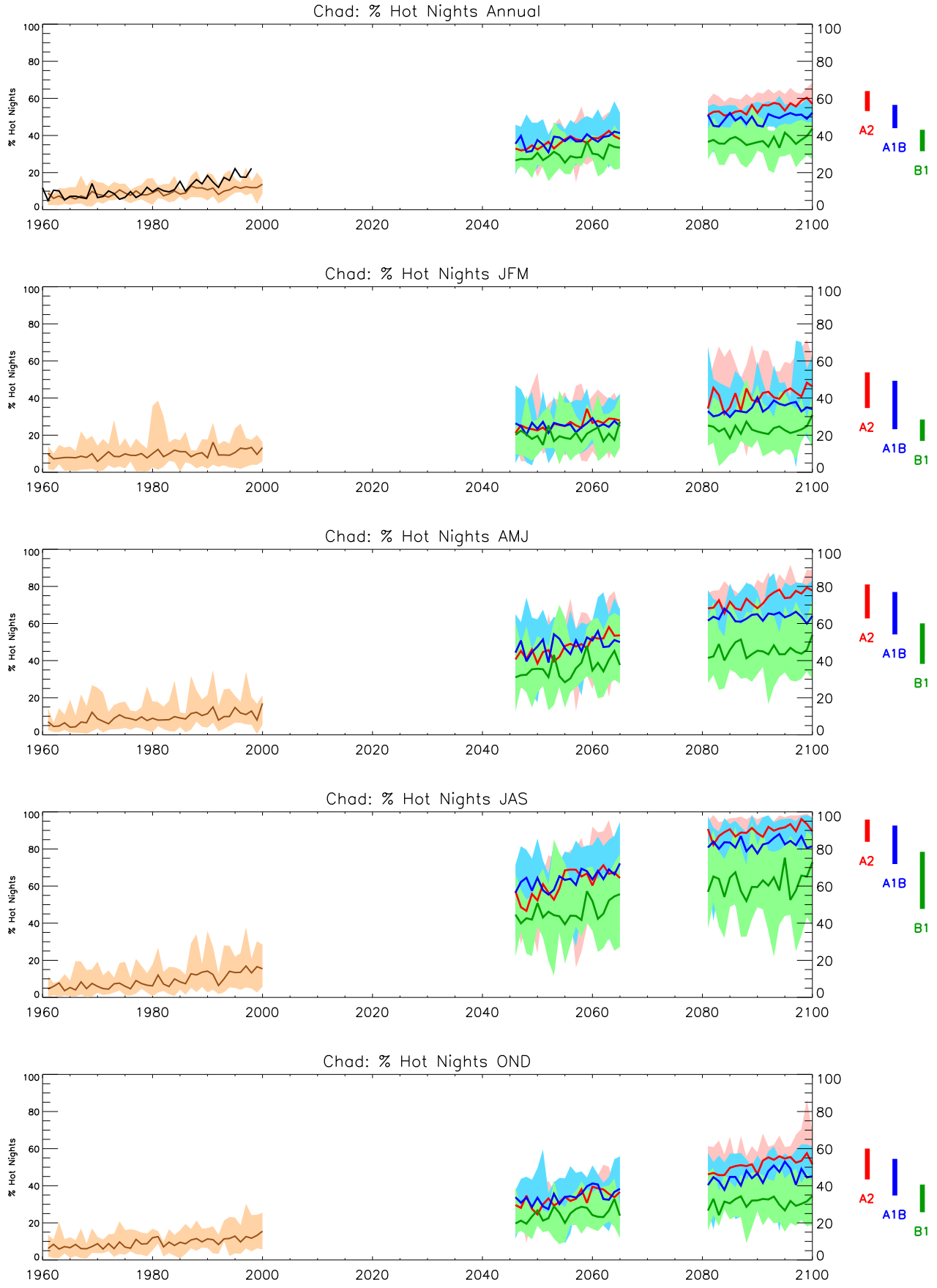


Figure 9: Trends in hot-night frequency for the recent past and projected future. See Figure 1 for details.

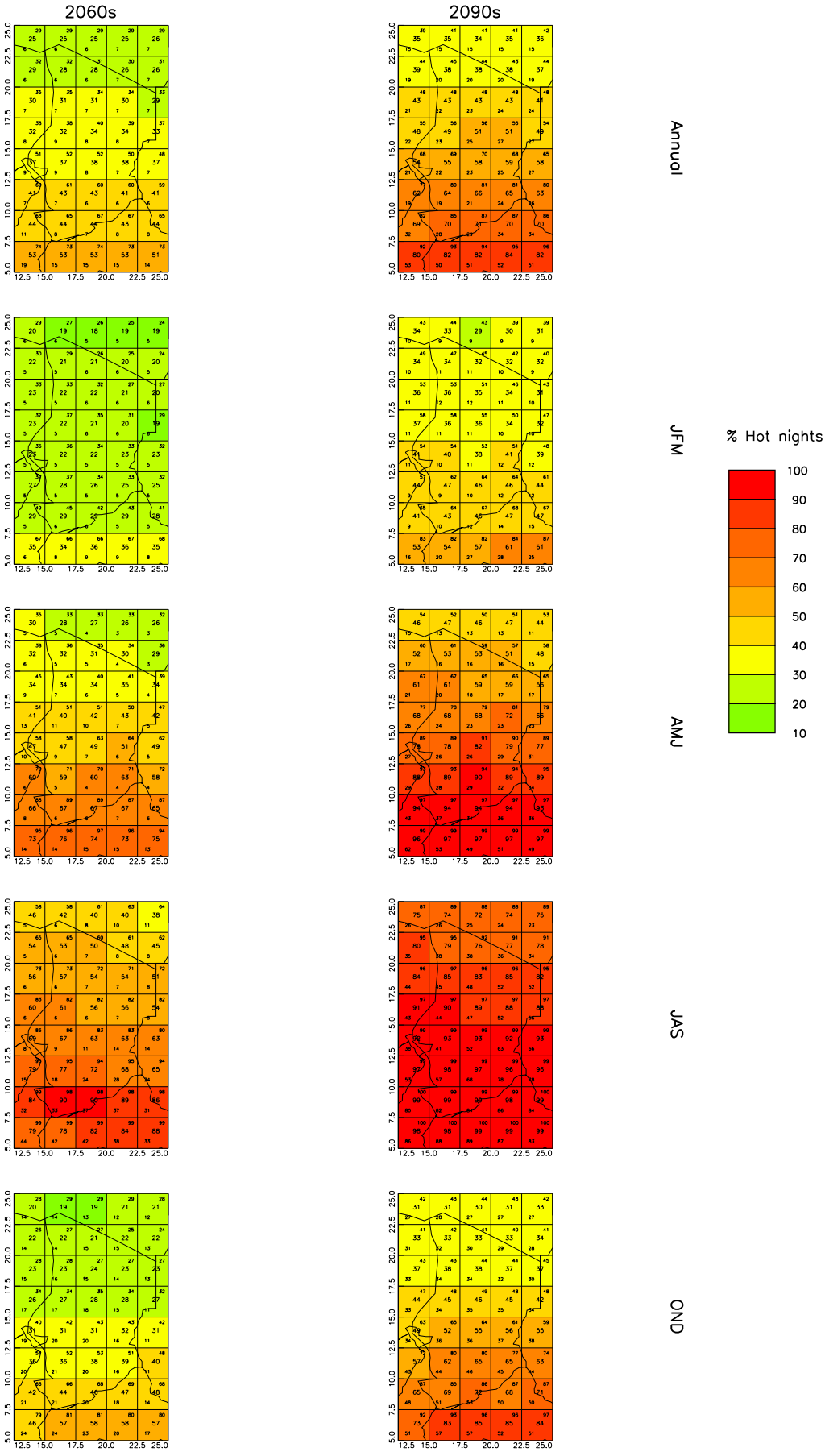


Figure 10: Spatial patterns of projected change in hot-night frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

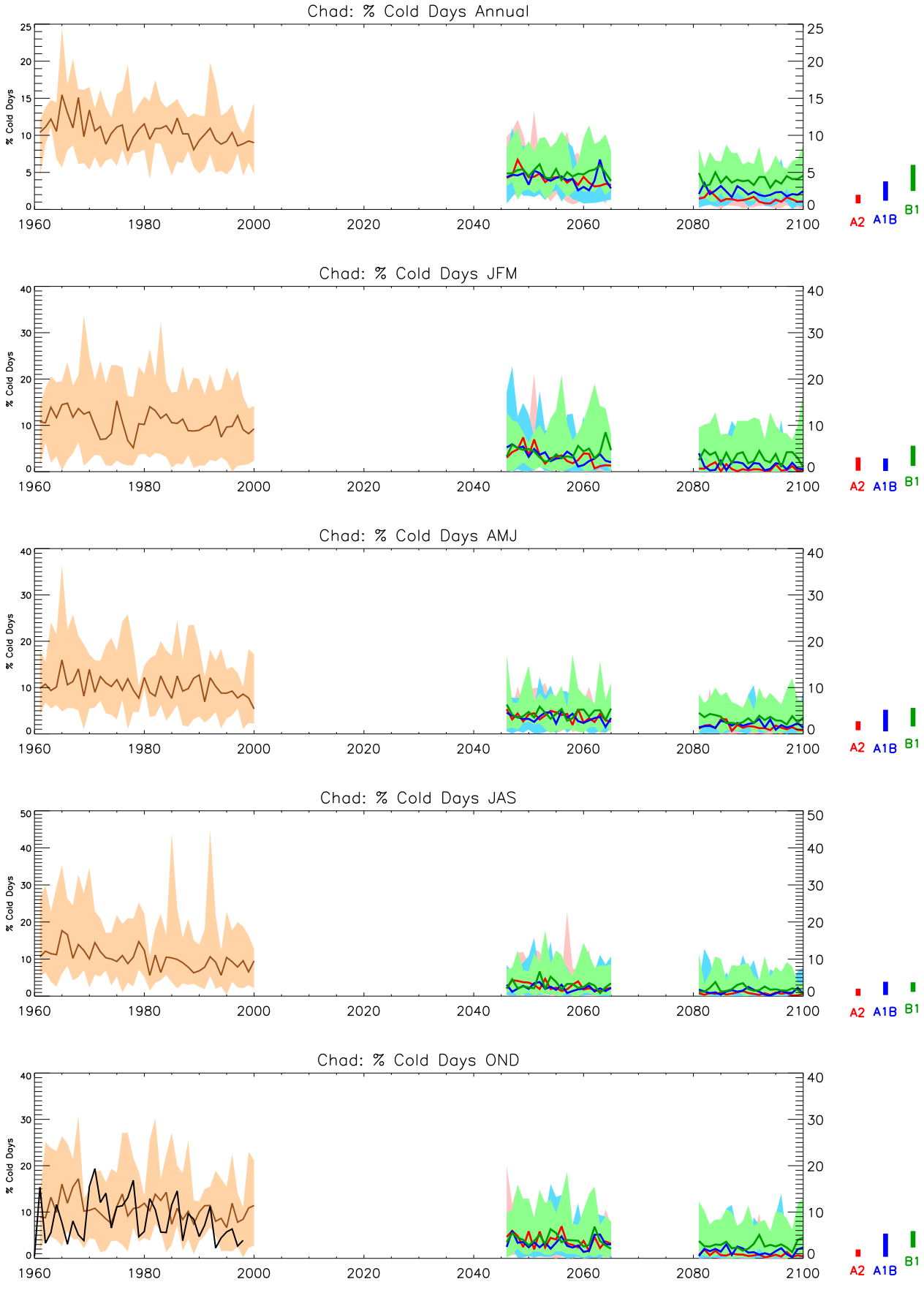


Figure 11: Trends in cold-day frequency for the recent past and projected future. See Figure 1 for details.

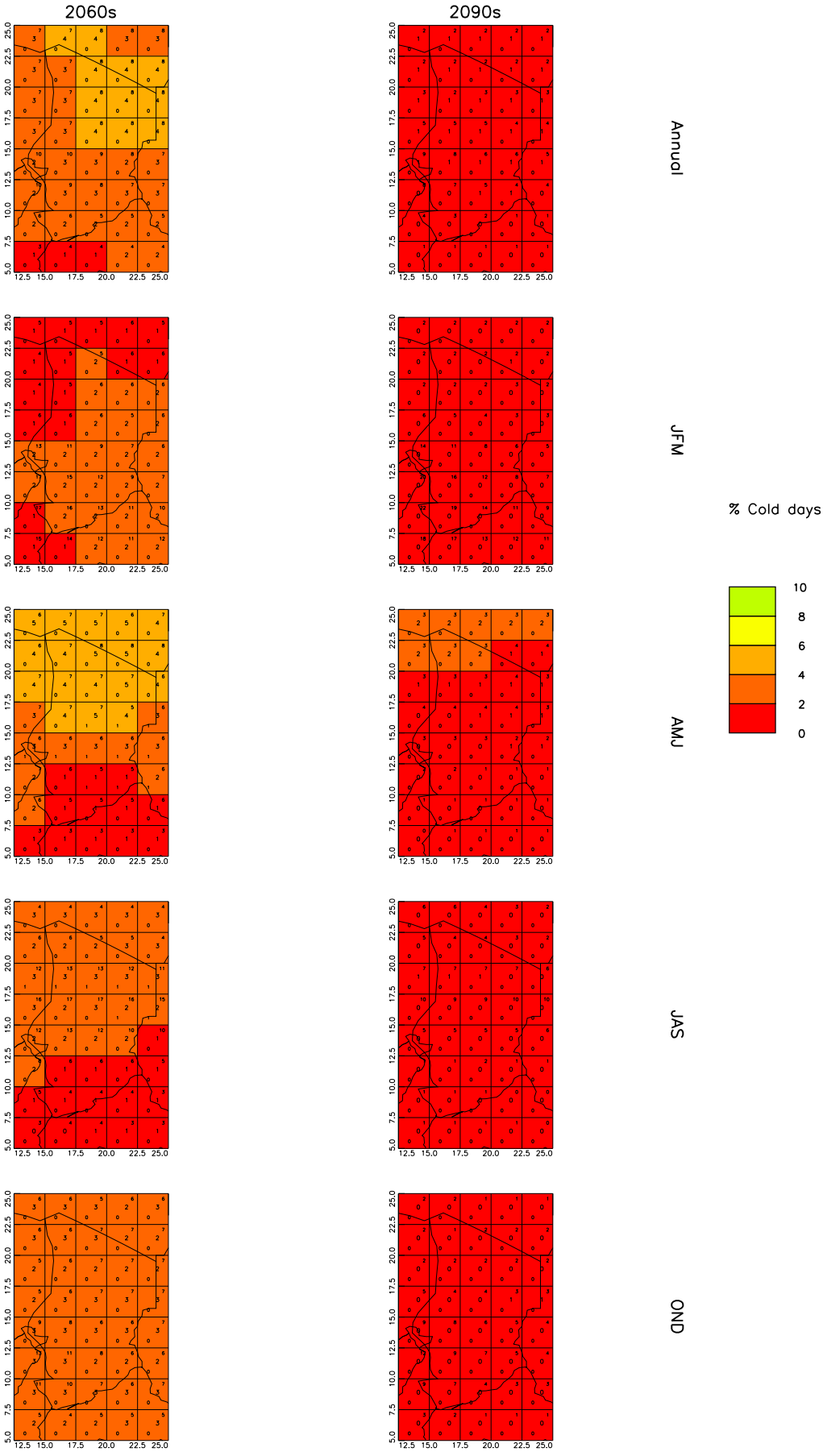


Figure 12: Spatial patterns of projected change in cold-day frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

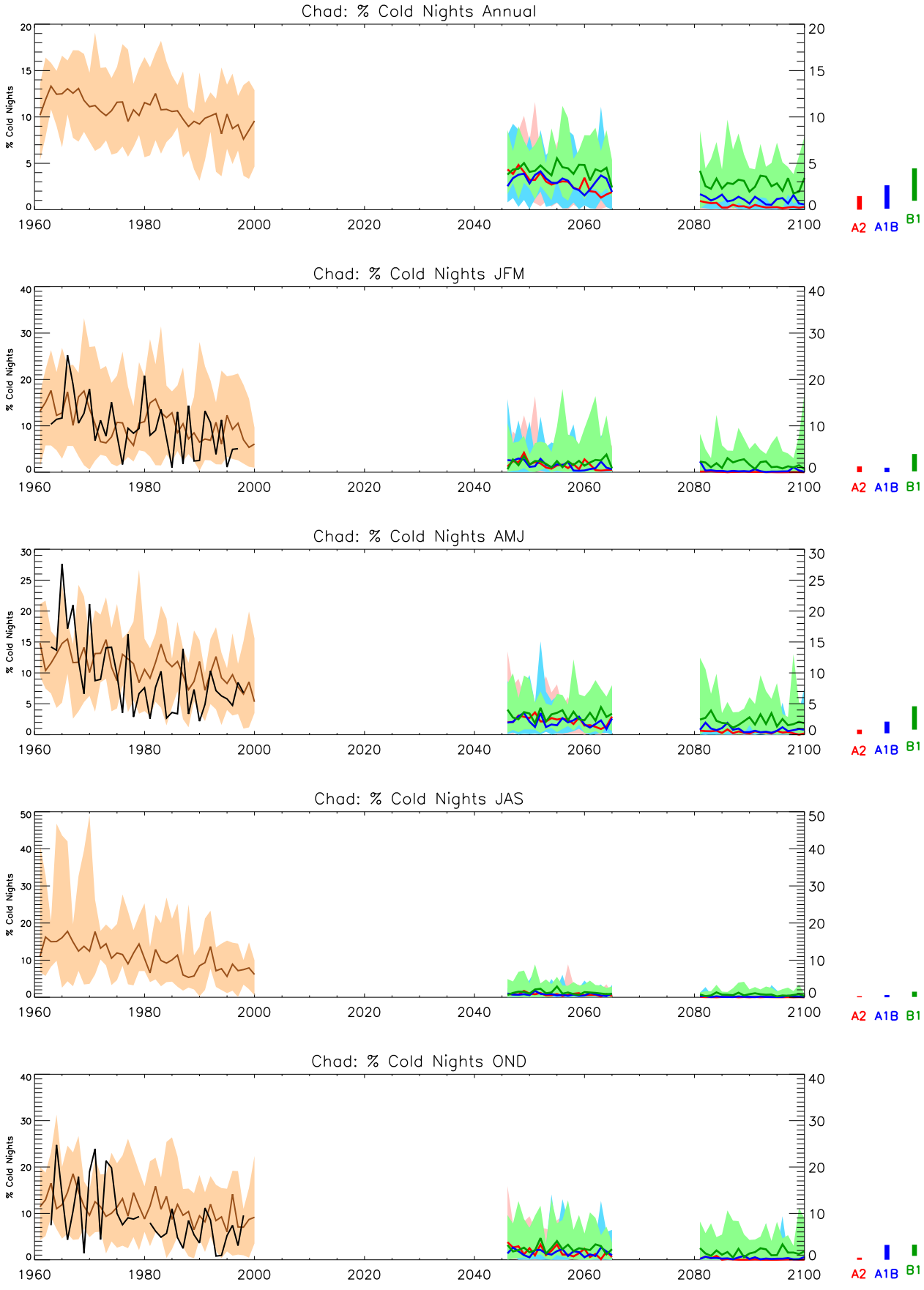


Figure 13: Trends in cold-night frequency for the recent past and projected future. See Figure 1 for details.

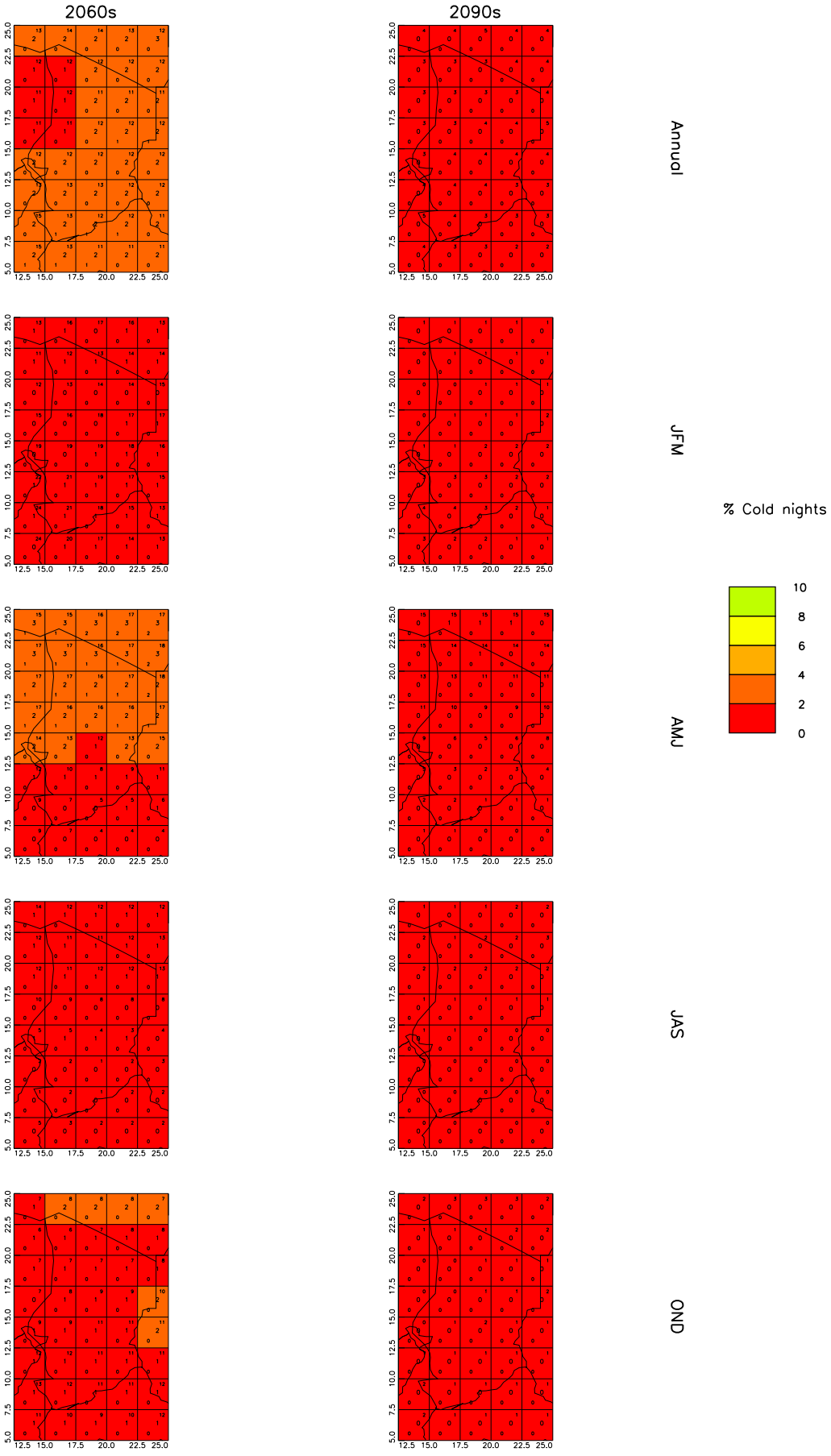


Figure 14: Spatial patterns of projected change in cold-night frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

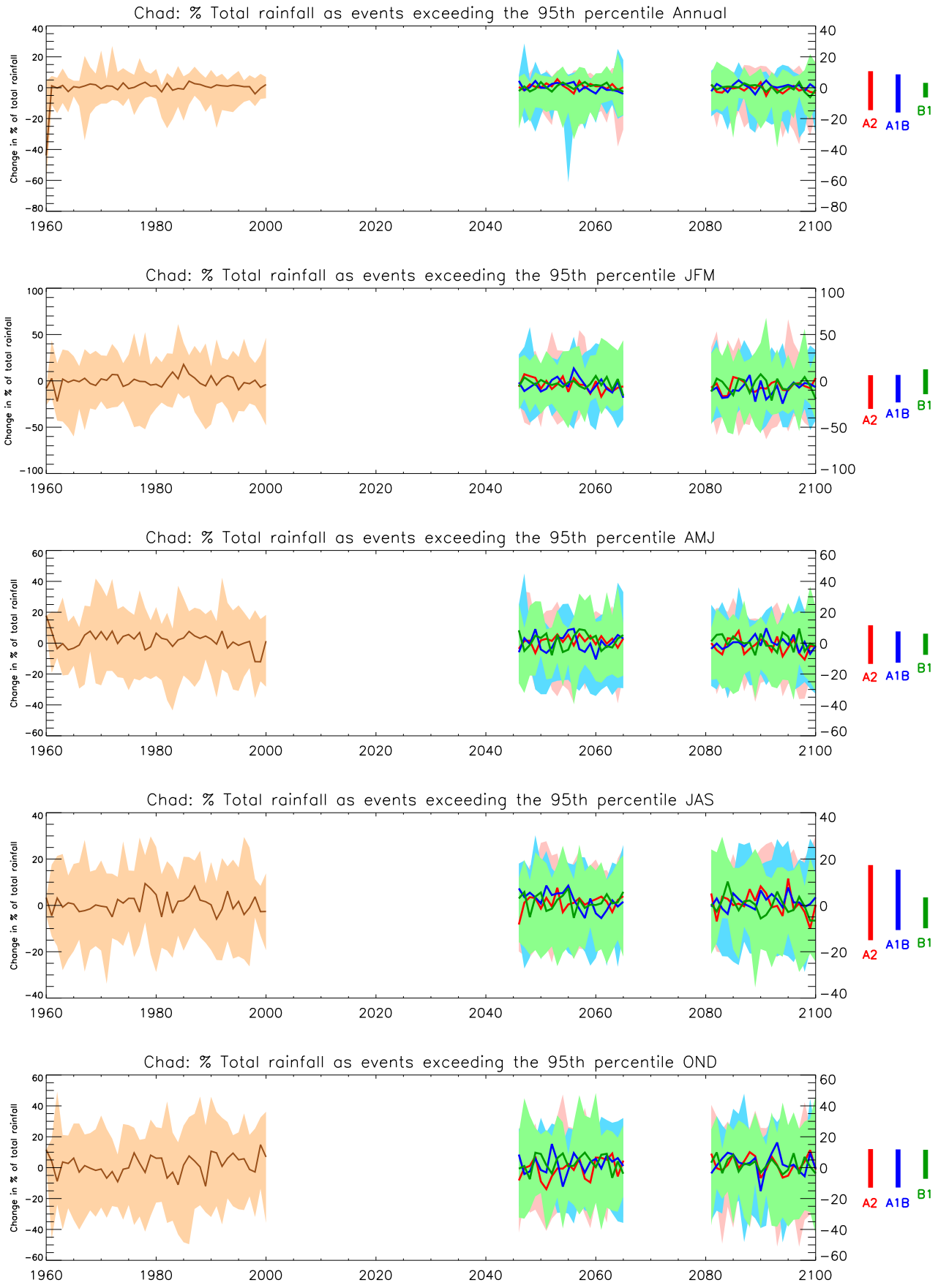


Figure 15: Trends in the proportion of precipitation falling in 'heavy' events for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

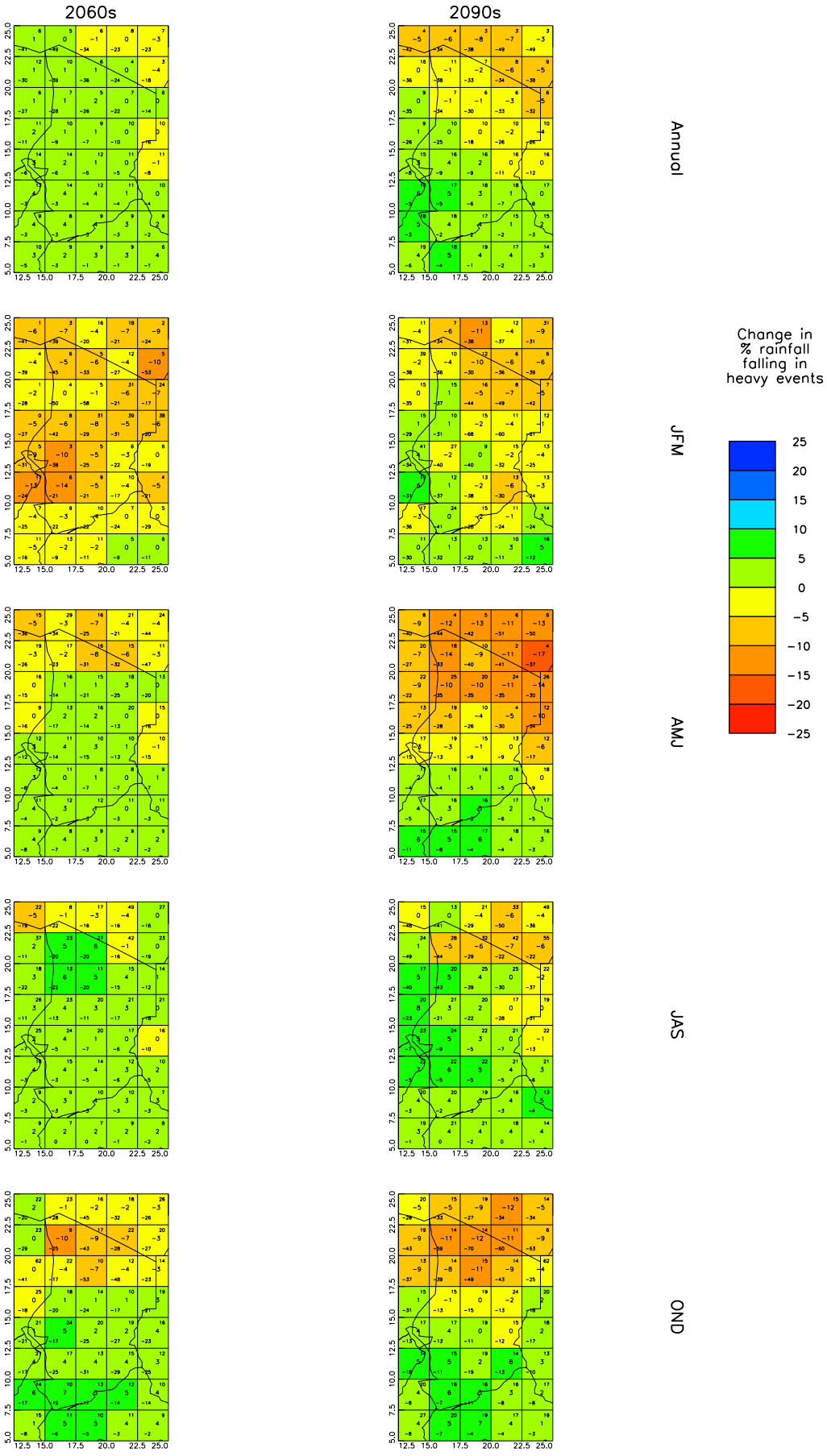


Figure 16: Spatial patterns of projected change in the proportion of precipitation falling in 'heavy' events for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. See Figure 2 for details.

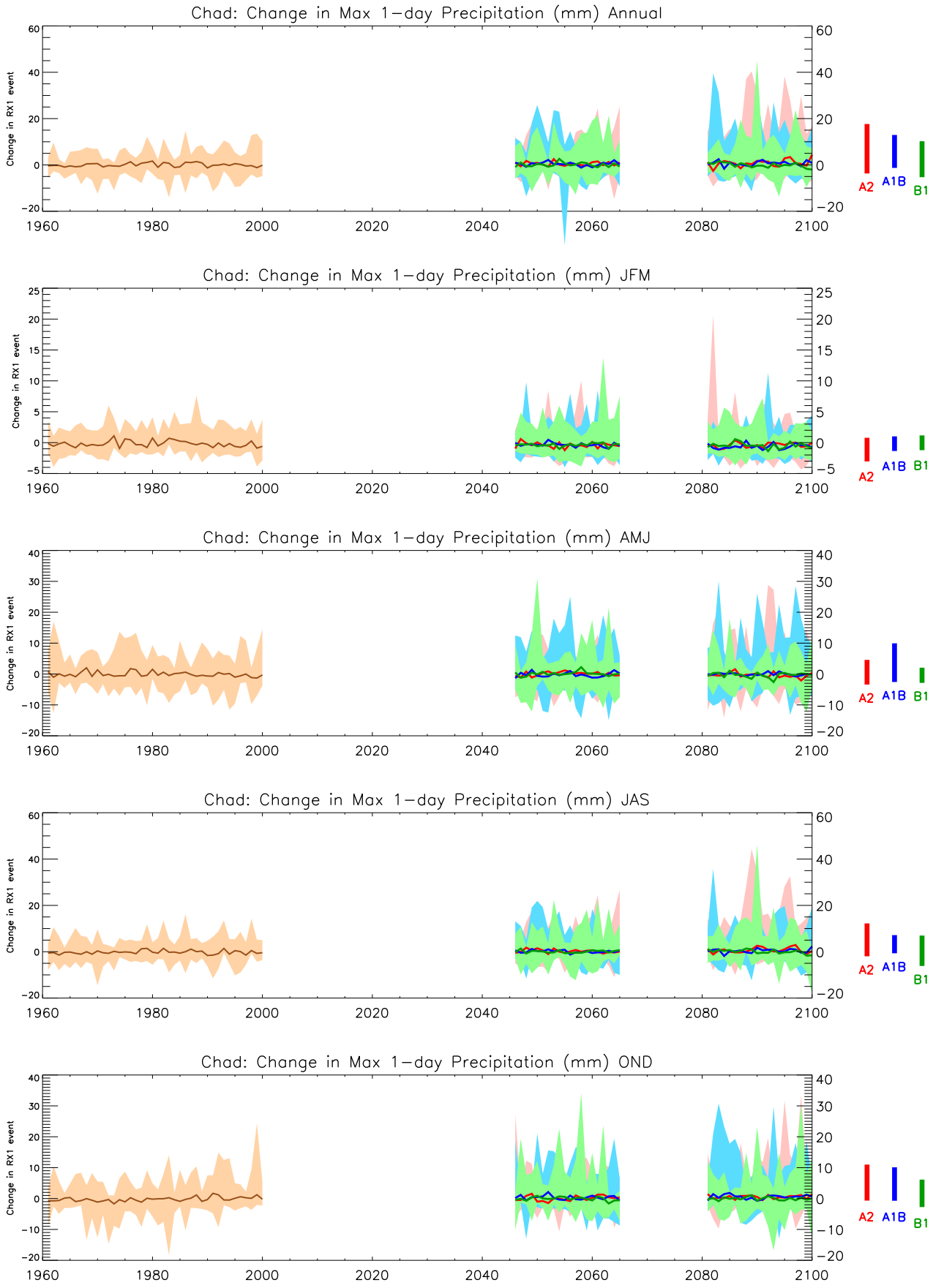


Figure 17: Trends in maximum 1-day rainfall for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

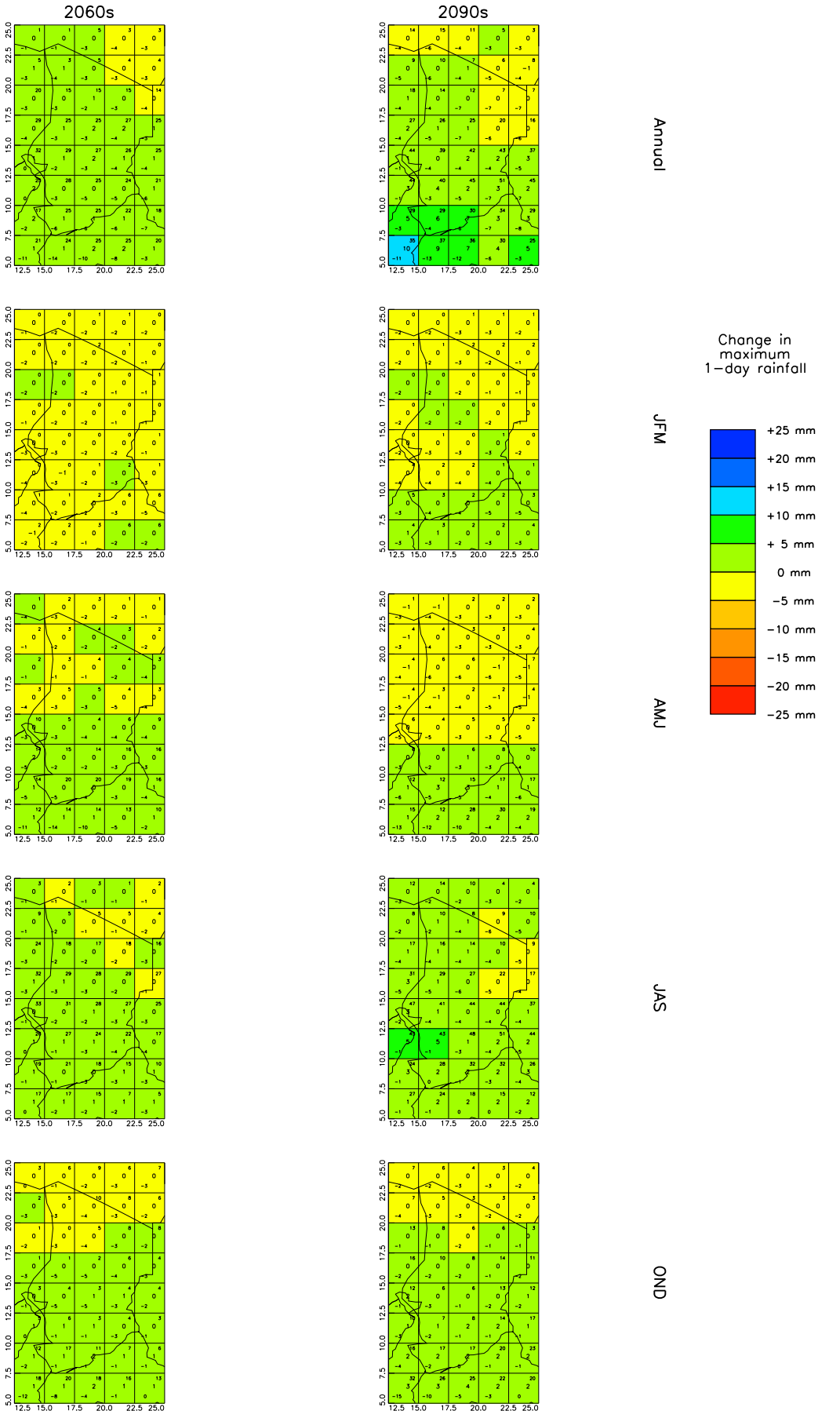


Figure 18: Spatial patterns of maximum 1-day rainfall for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. See Figure 2 for details.

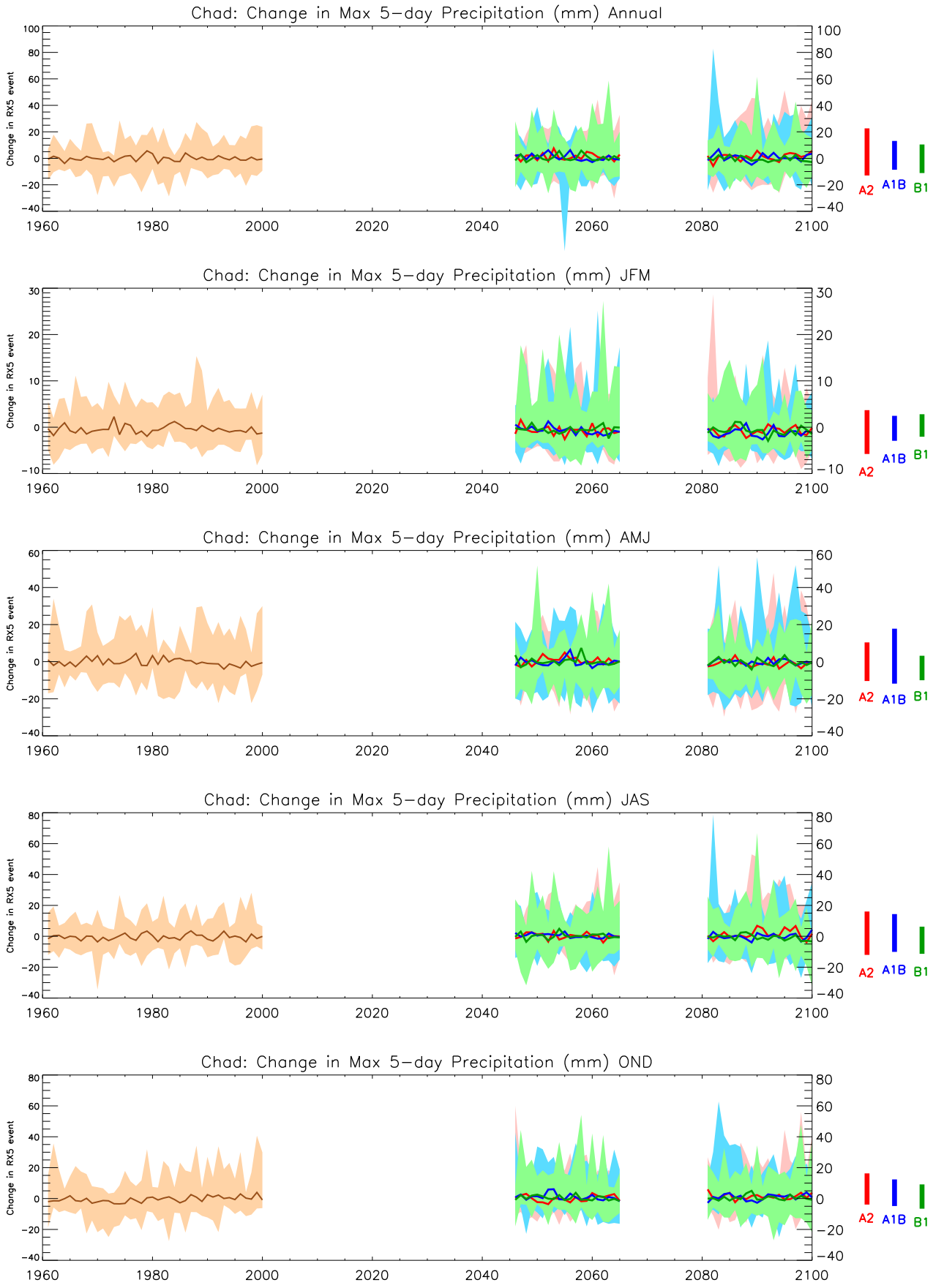


Figure 19: Trends in maximum 5-day rainfall for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

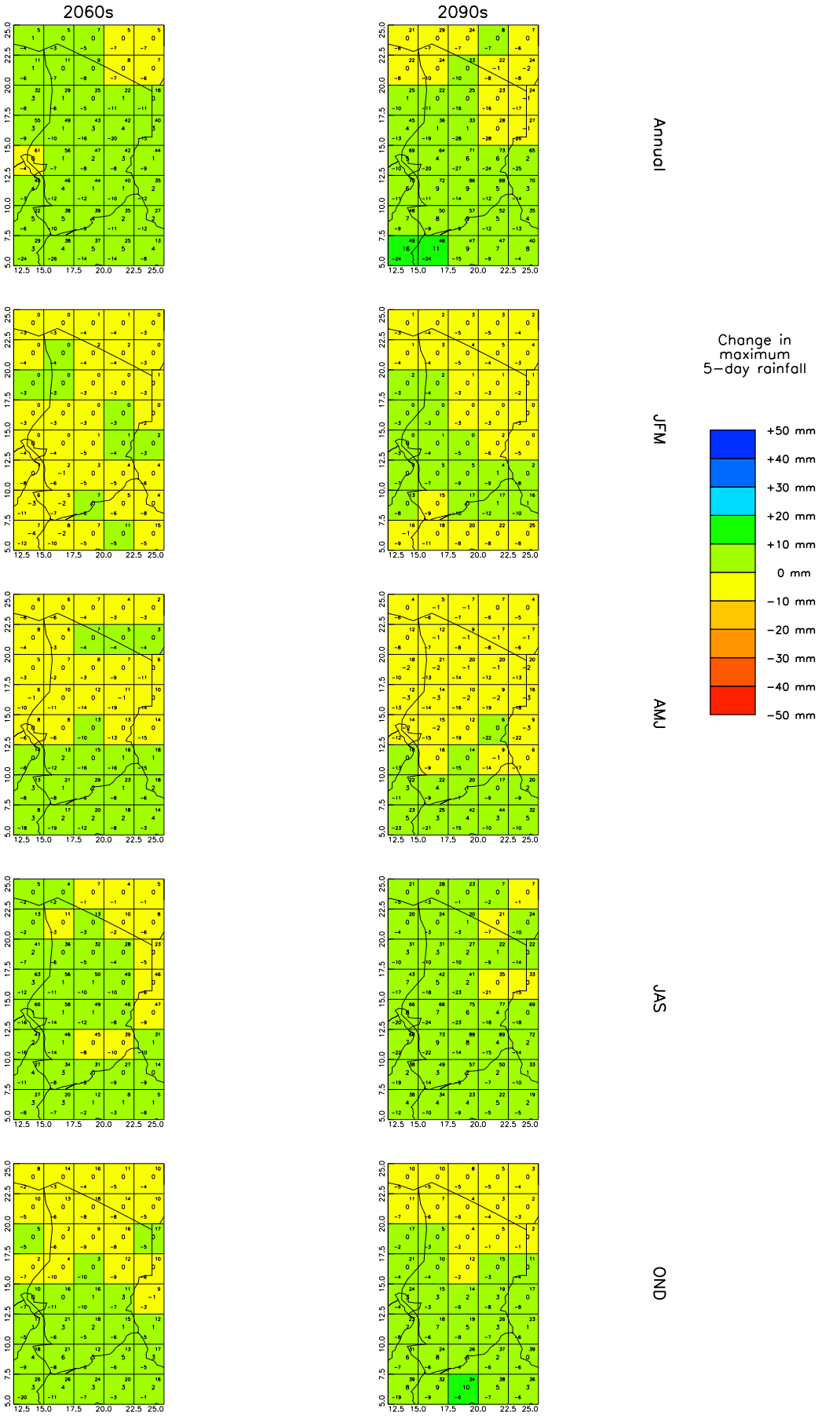


Figure 20: Spatial patterns of projected change in maximum 5-day rainfall for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. See Figure 2 for details.