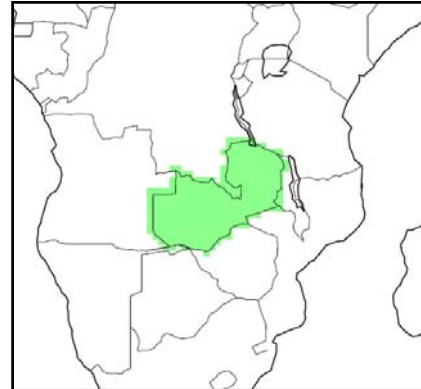


Zambia

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



General Climate

Zambia is located in central southern Africa at 8-17° south of the equator and although the country has a tropical climate, temperatures remain relatively cool throughout the year due to the high altitudes of the East African Plateau. The highest seasonal temperatures are reached in the hot, dry season SON (22-27°C), and coolest in the winter months JJA (15-20°C).

The hot summer months are very dry, receiving almost no rainfall between June and August. The wet season rainfalls are controlled by the passage of the tropical rain belt (also known as the Inter-Tropical Convergence Zone, ITCZ) which oscillates between the northern and southern tropics over the course of a year, bringing rain between October and April of 150-300mm per month. Variations in the movements of the ITCZ can cause large variations in the rainfall received from one year to the next. Rainfall in Zambia is also strongly influenced by the El Niño Southern Oscillation (ENSO), which causes further inter-annual variability. El Niño conditions (warm phase) bring drier than average conditions in the wet summer months (DJF) in the southern half of the country, whilst the north of the country simultaneously experiences significantly wetter-than average conditions. The reverse pattern occurs with La Niña (cold phase) episodes, with dry conditions in the north and wet conditions in the south. Zambia was one of the countries in Africa most severely affected by the 1997/1998 El Niño event, suffering flooding due to abnormally persistent and heavy rainfall in the north, as well as near-drought conditions in the south.

Recent Climate Trends

Temperature

- Mean annual temperature has increased by 1.3°C since 1960, an average rate of 0.29°C per decade. The rate of increase is most rapid in the winter, at 0.34°C per decade.

- Daily temperature observations show significantly increasing trends in the frequency hot days¹ and nights in all seasons.
 - The average number of 'hot' days per year in Zambia has increased by 43 (an additional 11.8% of days²) between 1960 and 2003. The rate of increase is seen most strongly in MAM when the average number of hot MAM days has increased by 5.2 days per month (an additional 16.8% of MAM days) over this period.
 - The average number of 'hot' nights per year increased by 43 (an additional 11.6% of nights) between 1960 and 2003. The rate of increase is seen most strongly in DJF when the average number of hot DJF nights has increased by 5.3 days per month (an additional 17.2% of DJF nights) over this period.
- The frequency of cold days³ and nights have decreased significantly since 1960 in all seasons.
 - The average number of 'cold' days per year has decreased by 22 (6% of days) between 1960 and 2003. The rate of decrease is similar in all seasons.
 - The average number of 'cold' nights per year has decreased by 35 (9.7% of days). This rate of decrease is most rapid in MAM when the average number of cold MAM nights has decreased by 3.5 nights per month (11.2% of MAM nights) over this period.

Precipitation

- Mean annual rainfall over Zambia has decreased by an average rate of 1.9mm per month (2.3%) per decade since 1960. This annual decrease is largely due to decreases in DJF rainfall, which has decreased by 7.1mm per month (3.5%) per decade.
- Daily precipitation observations show some indication of reductions in the contribution of heavy⁴ events to total rainfall, and the magnitude of maximum 1- and 5-day rainfalls, but none of these trends are statistically significant.

GCM Projections of Future Climate

Temperature

- The mean annual temperature is projected to increase by 1.2 to 3.4°C by the 2060s, and 1.6 to 5.5°C by the 2090s. The range of projections by the 2090s under any one emissions scenario is 1.5- 2.5°C.
- The projected rate of warming is a little more rapid in the southern and western regions of Zambia than the northern and eastern regions.
- All projections indicate substantial increases in the frequency of days and nights that are considered 'hot' in current climate.

¹ 'Hot' day or 'hot' night is defined by the temperature exceeded on 10% of days or nights in current climate of that region and season.

² 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.

³ 'Cold' days or 'cold' nights are defined as the temperature below which 10% of days or nights are recorded in current climate of that region or season.

⁴ 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.

- Annually, projections indicate that ‘hot’ days are projected to occur on 15-29% of days by the 2060s, and 16-49% of days by the 2090s. Days considered ‘hot’ by current climate standards for their season are projected to occur 22-80% of days by the 2090s.
- Nights that are considered ‘hot’ for the annual climate of 1970-99 are projected to increase more quickly than hot days, occurring on 26-54% of nights by the 2060s and 30-80% of nights by the 2090s. Nights that are considered hot for each season by 1970-99 standards are projected to increase most rapidly in DJF, occurring on 30-99% of nights in every season by the 2090s.
- All projections indicate decreases in the frequency of days and nights that are considered ‘cold’ in current climate. These events are expected to become exceedingly rare, occurring on maximum of 1-4% of days in the year, and potentially not at all by the 2090s in many of the projections. Cold nights decrease in frequency more rapidly than cold days.

Precipitation

- Projections of mean rainfall do not indicate large changes in annual rainfall. Seasonally, the range of projections from different models is large, but ensemble indicate decreases in SON rainfall (-39 to +14% by 2090) and increases in DJF rainfall (-11 to +15%), particularly in the north-east of the country.
- The proportion of total rainfall that falls in heavy events is projected to increase annually, but mainly in DJF and MAM.
- Projections indicate that maximum 1- and 5-day rainfalls may increase in magnitude in DJF and MAM.

Other Regional Climate Change Information

- Model simulations show wide disagreements in projected changes in the amplitude of future El Niño events. Zambia’s climate can be strongly influenced by ENSO, thus contributing to uncertainty in climate projections for this region.
- 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												
Annual	21.3	0.29*	A2	0.9	1.5	1.8	1.8	2.8	3.3	3.4	4.5	5.5
			A1B	0.9	1.5	1.8	1.9	2.6	3.4	2.7	3.7	5.2
			B1	0.6	1.1	1.5	1.2	2.0	2.8	1.6	2.4	3.1
DJF	22.2	0.28*	A2	0.8	1.2	1.6	1.4	2.5	3.1	2.8	4.1	5.2
			A1B	0.7	1.3	1.6	1.4	2.4	3.2	2.4	3.2	5.2
			B1	0.4	1.1	1.3	1.0	1.8	2.6	1.4	2.0	2.9
MAM	20.9	0.27*	A2	0.7	1.5	2.0	1.6	2.6	3.6	3.3	4.4	5.2
			A1B	0.8	1.6	2.1	2.0	2.6	3.3	2.4	3.3	4.8
			B1	0.6	1.1	1.7	1.1	2.0	3.1	1.5	2.4	3.7
JJA	18.0	0.34*	A2	0.9	1.4	2.1	2.0	2.6	3.4	3.4	4.6	5.8
			A1B	0.8	1.6	2.4	2.1	2.7	3.2	2.7	3.8	5.2
			B1	0.8	1.1	1.7	1.3	2.0	3.0	1.8	2.4	3.5
SON	24.2	0.26*	A2	1.3	1.5	2.0	2.2	3.3	3.5	4.0	5.0	6.3
			A1B	1.1	1.7	2.3	1.8	3.0	3.7	2.9	4.1	5.7
			B1	0.4	1.2	1.9	1.2	2.1	2.9	1.6	2.4	3.6
Precipitation												
	(mm per month)	(change in mm per decade)		Change in mm per month			Change in mm per month			Change in mm per month		
Annual	80.6	-1.9	A2	-6	-1	8	-7	-1	8	-8	0	13
			A1B	-8	0	5	-4	0	5	-6	-1	9
			B1	-8	-1	8	-9	0	4	-7	1	5
DJF	202.6	-7.1*	A2	-14	0	15	-16	0	24	-13	9	39
			A1B	-12	3	24	-9	2	18	-15	0	27
			B1	-14	0	25	-17	2	24	-19	1	17
MAM	69.4	-0.5	A2	-15	0	23	-6	4	23	-15	5	29
			A1B	-11	0	15	-9	1	15	-5	4	23
			B1	-14	2	15	-13	1	9	-17	4	20
JJA	1.0	0.1	A2	-1	0	0	-2	0	0	-3	0	2
			A1B	-2	0	0	-3	0	0	-3	0	0
			B1	-1	0	0	-2	0	0	-2	0	0
SON	48.7	-0.9	A2	-18	-3	5	-20	-6	10	-24	-15	11
			A1B	-10	-4	3	-20	-6	8	-23	-10	14
			B1	-19	-1	8	-21	-6	0	-20	-2	6
Precipitation (%)												
	(mm per month)	(change in % per decade)		% Change			% Change			% Change		
Annual	80.6	-2.3	A2	-6	-1	6	-8	-1	6	-7	1	13
			A1B	-9	0	6	-4	0	5	-7	-1	10
			B1	-8	-1	10	-10	0	5	-8	1	6
DJF	202.6	-3.5*	A2	-6	0	5	-9	0	11	-8	3	15
			A1B	-5	1	8	-6	1	7	-8	0	10
			B1	-8	0	11	-7	1	8	-11	0	7
MAM	69.4	-0.8	A2	-19	-1	29	-12	7	29	-19	9	55
			A1B	-21	-1	19	-11	2	17	-8	5	18
			B1	-26	3	17	-17	3	11	-21	5	20
JJA	1.0	11	A2	-60	-8	15	-45	-15	25	-72	-20	105
			A1B	-55	-10	28	-66	-21	9	-87	-18	-1
			B1	-46	-14	25	-60	-4	18	-67	-14	31
SON	48.7	-1.9	A2	-20	-4	12	-23	-11	12	-35	-19	14
			A1B	-18	-6	3	-23	-12	7	-39	-14	13
			B1	-21	-2	11	-32	-8	0	-22	-4	7

	Observed Mean	Observed Trend	Projected changes by the 2030s			Projected changes by the 2060s			Projected changes by the 2090s			
	1970-99	1960-2006	Min	Median	Max	Min	Median	Max	Min	Median	Max	
	% Frequency	Change in frequency per decade				Future % frequency			Future % frequency			
Frequency of Hot Days (TX90p)												
Annual	12.4	2.73*	A2	****	****	****	17	23	29	24	38	49
			A1B	****	****	****	15	22	29	21	31	45
			B1	****	****	****	15	20	24	16	23	28
DJF	12.6	3.23*	A2	****	****	****	23	36	51	39	62	79
			A1B	****	****	****	25	36	54	32	53	73
			B1	****	****	****	20	35	43	22	42	47
MAM	13.4	3.90*	A2	****	****	****	26	40	57	46	66	80
			A1B	****	****	****	28	38	58	42	50	79
			B1	****	****	****	24	31	46	26	39	58
JJA	11.7	2.95*	A2	****	****	****	18	30	35	38	59	66
			A1B	****	****	****	22	28	41	33	46	65
			B1	****	****	****	14	24	31	23	29	40
SON	12.9	3.55*	A2	****	****	****	30	42	50	53	63	76
			A1B	****	****	****	28	40	51	41	52	69
			B1	****	****	****	21	33	41	27	38	52
Frequency of Hot Nights (TN90p)												
Annual	11.7	2.70*	A2	****	****	****	35	41	53	56	66	80
			A1B	****	****	****	34	42	54	46	55	69
			B1	****	****	****	26	35	44	30	42	54
DJF	12.5	4.00*	A2	****	****	****	54	72	91	88	97	99
			A1B	****	****	****	56	72	90	73	95	98
			B1	****	****	****	37	58	71	48	78	87
MAM	11.3	3.02*	A2	****	****	****	36	52	69	57	77	91
			A1B	****	****	****	33	53	67	48	66	82
			B1	****	****	****	25	40	53	29	45	66
JJA	10.6	1.15*	A2	****	****	****	30	41	47	66	74	92
			A1B	****	****	****	34	40	53	51	58	80
			B1	****	****	****	23	30	37	29	39	50
SON	12.0	2.94*	A2	****	****	****	35	45	58	68	73	84
			A1B	****	****	****	38	44	60	52	63	77
			B1	****	****	****	25	36	47	28	44	59
Frequency of Cold Days (TX10p)												
Annual	8.7	-1.40*	A2	****	****	****	1	2	5	0	0	1
			A1B	****	****	****	1	2	4	0	1	1
			B1	****	****	****	2	4	5	1	2	4
DJF	8.9	-1.43*	A2	****	****	****	1	2	4	0	0	1
			A1B	****	****	****	1	2	3	0	1	2
			B1	****	****	****	1	3	5	0	3	4
MAM	8.2	-1.86*	A2	****	****	****	1	2	4	0	0	1
			A1B	****	****	****	0	2	4	0	0	2
			B1	****	****	****	1	3	4	0	2	4
JJA	8.7	-1.58*	A2	****	****	****	0	1	4	0	0	1
			A1B	****	****	****	0	2	3	0	0	1
			B1	****	****	****	1	3	4	0	2	2
SON	8.8	-1.33*	A2	****	****	****	1	3	5	0	0	3
			A1B	****	****	****	1	3	7	0	1	3
			B1	****	****	****	1	4	6	1	3	4
Frequency of Cold Nights (TN10p)												
Annual	7.8	-2.25*	A2	****	****	****	0	1	2	0	0	0
			A1B	****	****	****	0	1	2	0	0	0
			B1	****	****	****	1	2	4	0	1	3
DJF	7.9	-2.06*	A2	****	****	****	0	0	2	0	0	0
			A1B	****	****	****	0	0	1	0	0	0
			B1	****	****	****	0	1	2	0	1	1
MAM	7.8	-2.60*	A2	****	****	****	0	1	2	0	0	0
			A1B	****	****	****	0	1	3	0	0	1
			B1	****	****	****	0	2	4	0	1	2
JJA	7.5	-2.53*	A2	****	****	****	0	0	1	0	0	0
			A1B	****	****	****	0	0	1	0	0	0
			B1	****	****	****	0	1	2	0	0	2
SON	8.0	-1.82*	A2	****	****	****	0	0	2	0	0	1
			A1B	****	****	****	0	1	4	0	0	1
			B1	****	****	****	1	2	4	0	1	3

	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	
% total rainfall falling in Heavy Events (R95pct)												
	%	Change in % per decade				Change in %			Change in %			
Annual	23.2	-1.07	A2	****	****	****	-1	3	6	0	5	13
			A1B	****	****	****	-2	3	8	1	3	11
			B1	****	****	****	-3	2	5	-6	3	7
DJF	****	****	A2	****	****	****	-1	2	5	0	6	14
			A1B	****	****	****	-2	2	6	0	5	9
			B1	****	****	****	0	2	4	-4	4	5
MAM	****	****	A2	****	****	****	-3	4	11	-2	4	17
			A1B	****	****	****	-6	2	9	-5	5	12
			B1	****	****	****	-4	1	8	-7	5	10
JJA	****	****	A2	****	****	****	-20	-6	8	-23	-5	15
			A1B	****	****	****	-22	-3	8	-30	-8	3
			B1	****	****	****	-23	-5	9	-24	-6	4
SON	****	****	A2	****	****	****	-3	0	8	-14	-3	11
			A1B	****	****	****	-5	2	8	-18	-1	14
			B1	****	****	****	-5	1	6	-6	1	7
Maximum 1-day rainfall (RX1day)												
	mm	Change in mm per decade				Change in mm			Change in mm			
Annual	****	****	A2	****	****	****	-4	1	9	0	6	16
			A1B	****	****	****	0	1	10	0	4	13
			B1	****	****	****	0	0	7	-1	2	8
DJF	46.5	-0.29	A2	****	****	****	-4	1	5	0	5	16
			A1B	****	****	****	-2	0	7	-1	3	10
			B1	****	****	****	0	0	6	-1	2	8
MAM	36.3	-0.98	A2	****	****	****	-1	1	10	0	3	13
			A1B	****	****	****	0	1	7	0	1	11
			B1	****	****	****	-2	0	3	-1	2	6
JJA	1.3	-0.14	A2	****	****	****	-1	0	0	-1	0	1
			A1B	****	****	****	-1	0	0	-1	0	0
			B1	****	****	****	0	0	0	-1	0	0
SON	17.1	0.3	A2	****	****	****	-1	0	3	-5	0	5
			A1B	****	****	****	-2	0	3	-5	0	6
			B1	****	****	****	-2	0	2	-2	0	2
Maximum 5-day Rainfall (RX5day)												
	mm	Change in mm per decade				Change in mm			Change in mm			
Annual	132.1	-0.64	A2	****	****	****	-8	4	15	0	9	25
			A1B	****	****	****	-2	4	22	0	10	15
			B1	****	****	****	-4	3	15	-7	7	10
DJF	90.3	-1.74	A2	****	****	****	-6	4	13	-1	11	23
			A1B	****	****	****	-4	3	18	-1	9	12
			B1	****	****	****	-2	2	14	-9	6	12
MAM	69.1	-3.55	A2	****	****	****	-4	2	20	-1	7	27
			A1B	****	****	****	-3	1	12	-3	4	15
			B1	****	****	****	-5	1	5	-8	5	13
JJA	1.9	-0.01	A2	****	****	****	-2	0	0	-2	0	3
			A1B	****	****	****	-1	0	0	-2	0	0
			B1	****	****	****	-1	0	1	-2	0	0
SON	26.7	-0.54	A2	****	****	****	-7	0	6	-17	-4	10
			A1B	****	****	****	-9	1	7	-22	-2	11
			B1	****	****	****	-11	0	5	-8	0	6

* indicates trend is statistically significant at 95% confidence

**** indicates data are not available

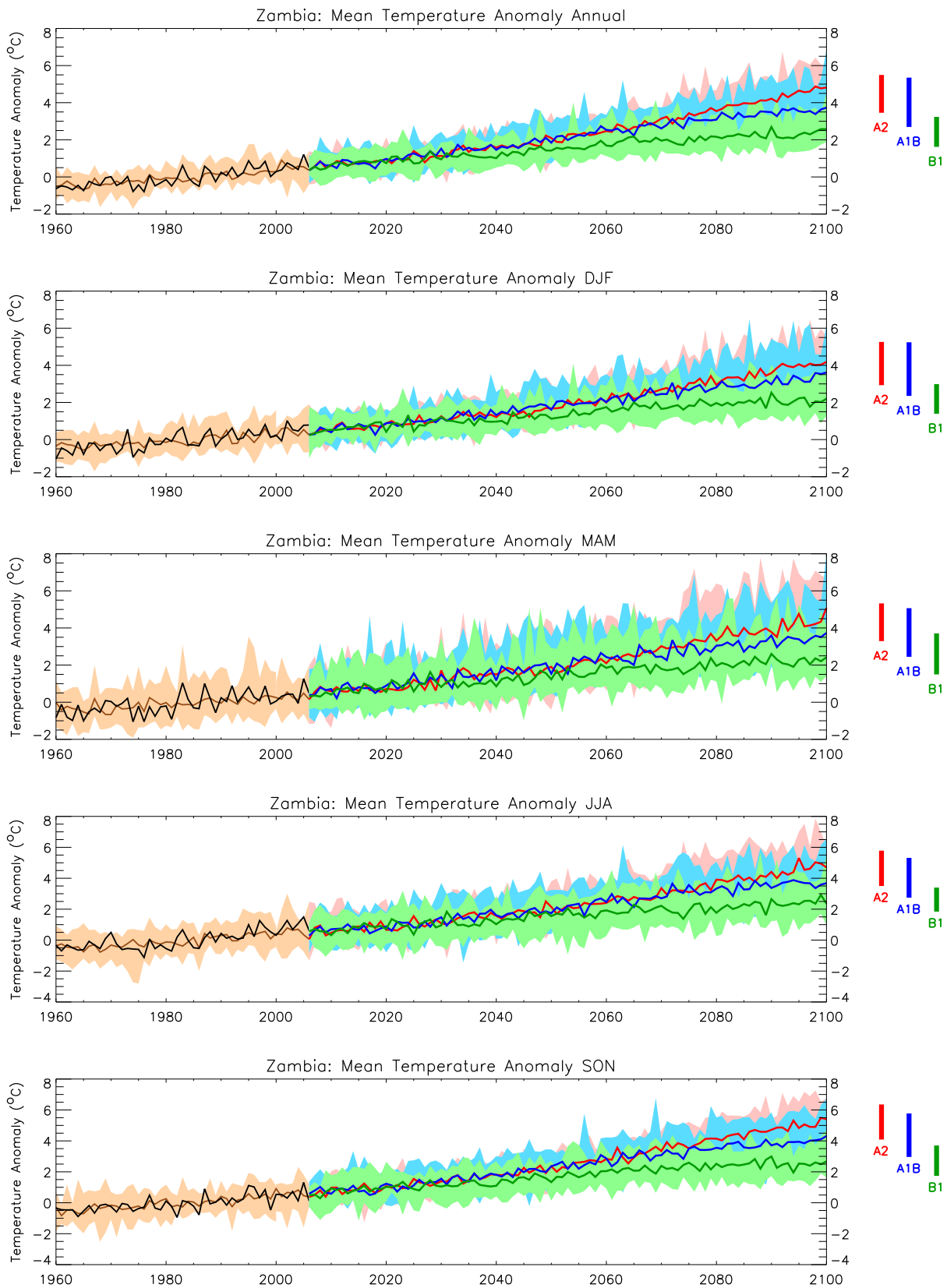


Figure 1: Trends in annual and seasonal mean temperature for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. Black curves show the mean of observed data from 1960 to 2006, Brown curves show the median (solid line) and range (shading) of model 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.

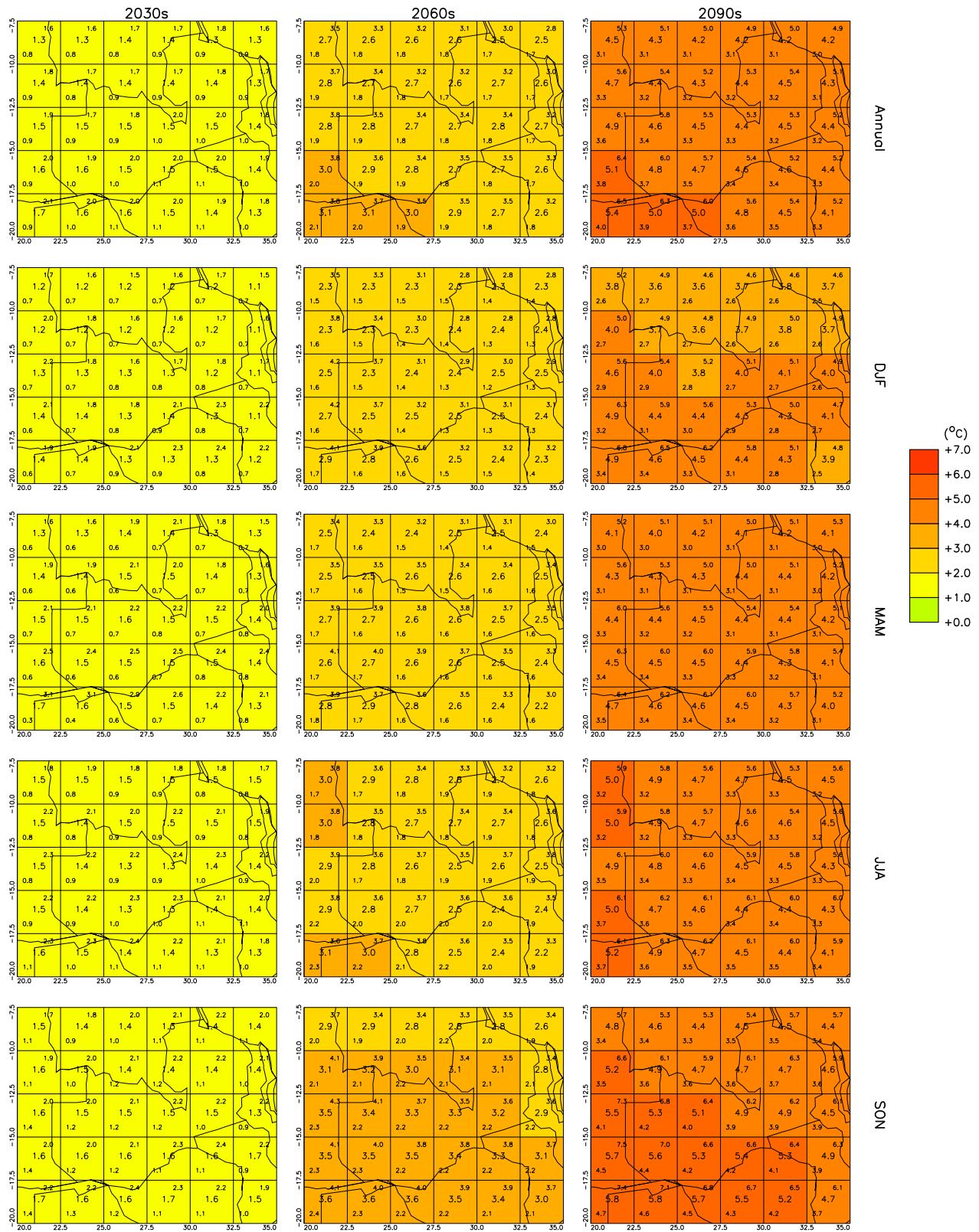


Figure 2: Spatial patterns of projected change in mean annual and seasonal temperature for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. In each grid box, the central value gives the ensemble median and the values in the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

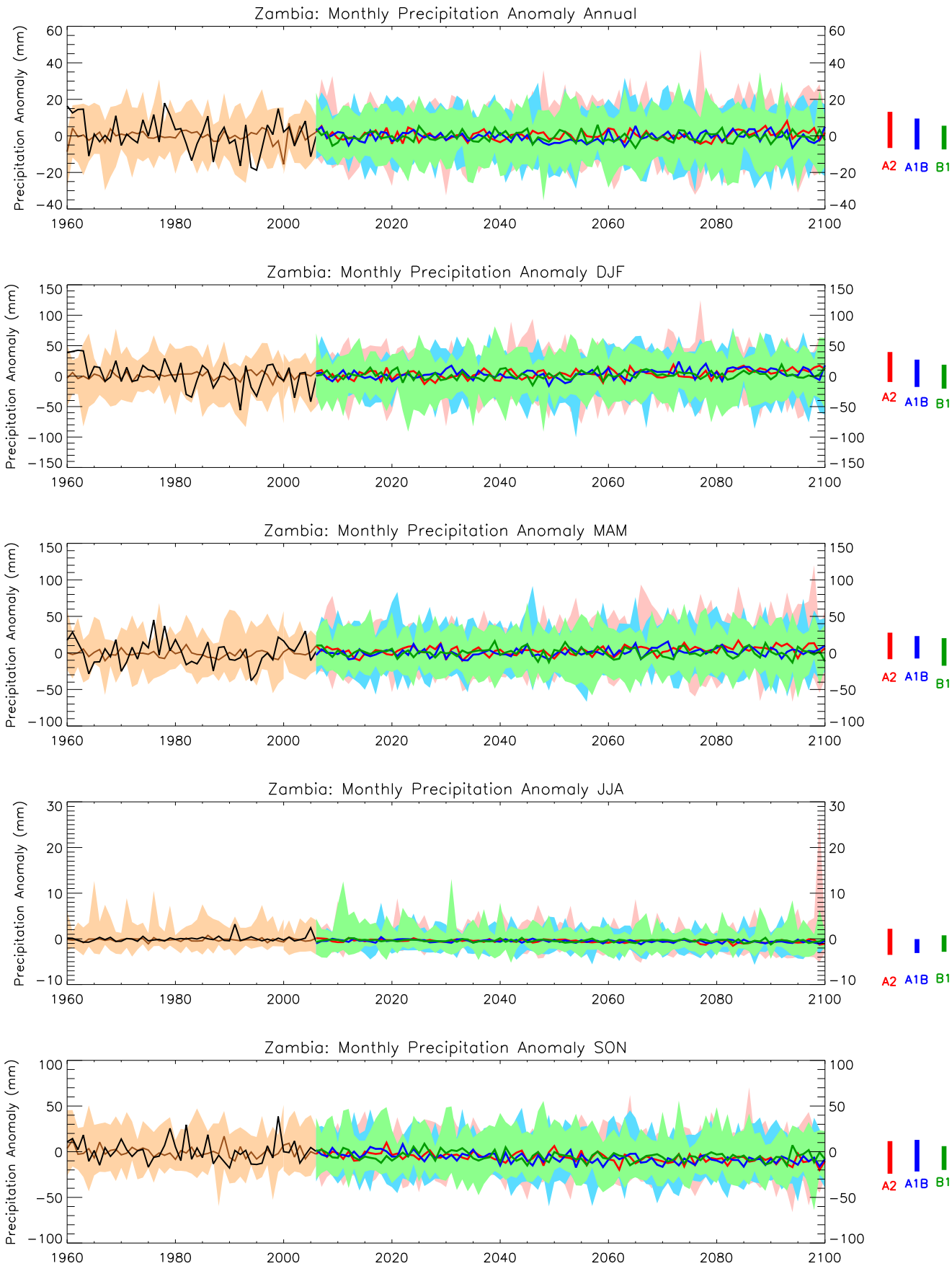


Figure 3: Trends in monthly precipitation for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

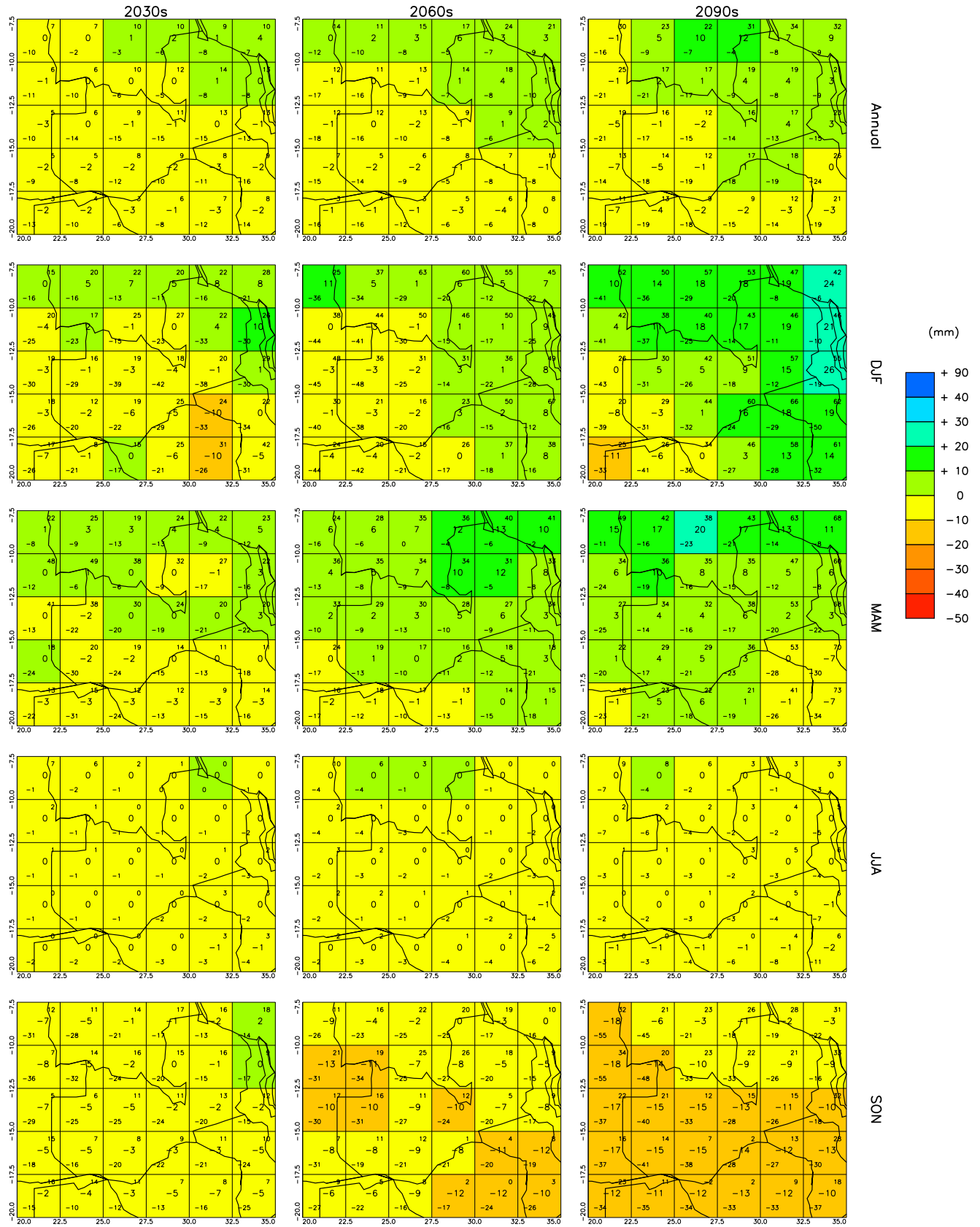


Figure 4: Spatial patterns of projected change in monthly precipitation for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. See Figure 2 for details.

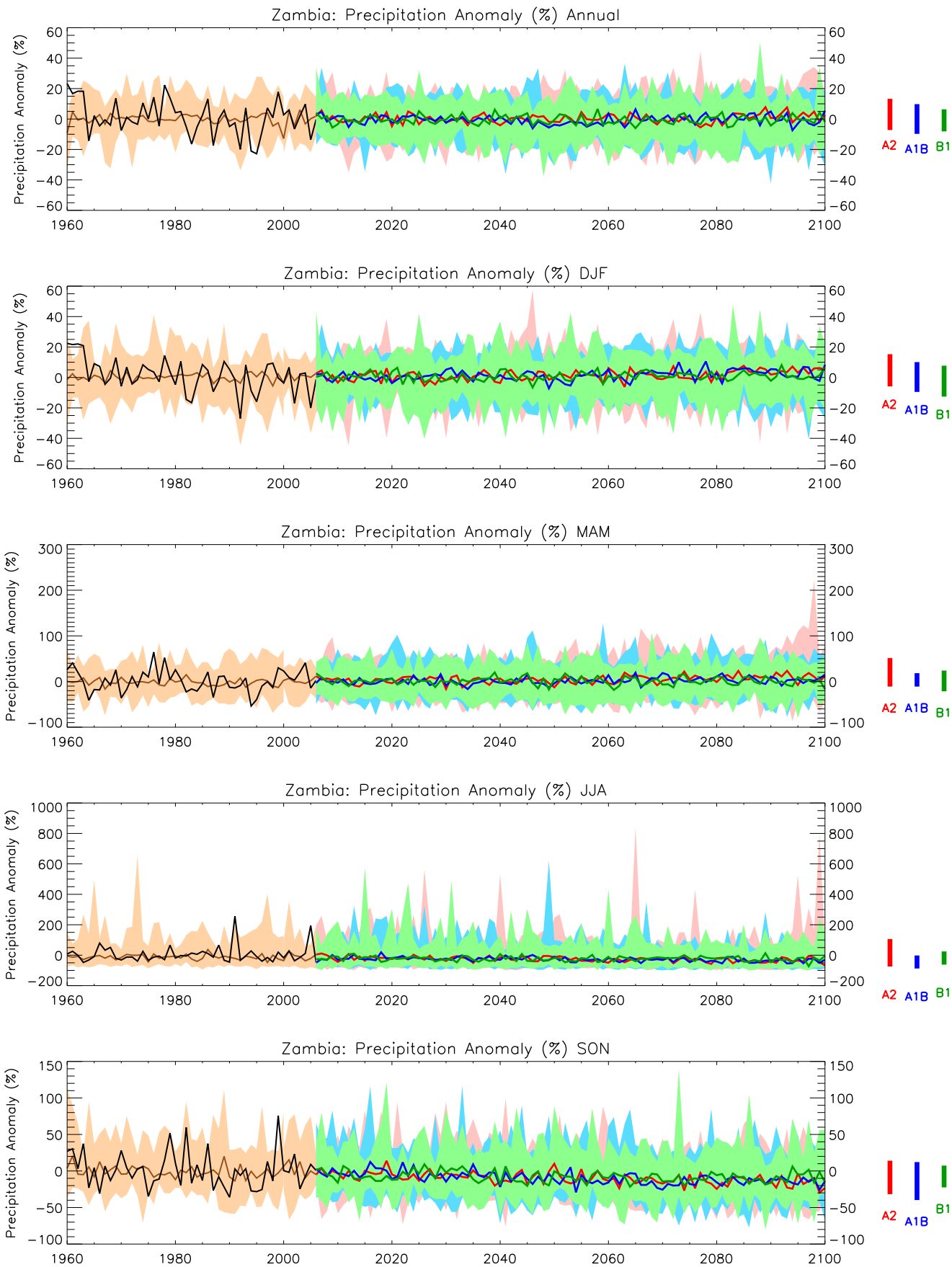


Figure 5: Trends in monthly precipitation for the recent past and projected future. All values shown are percentage anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

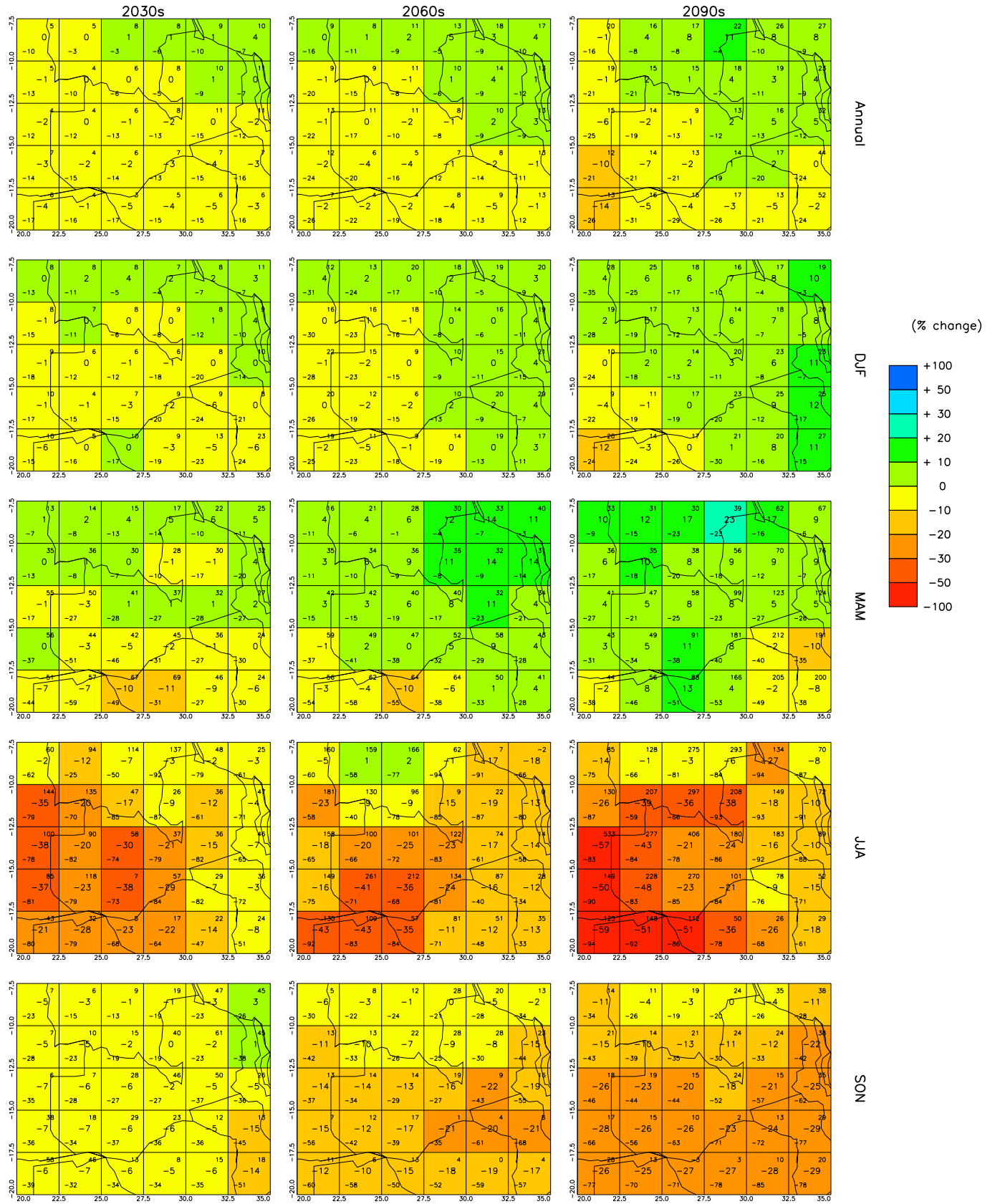


Figure 6: Spatial patterns of projected change in monthly precipitation for 10-year periods in the future under the SRES A2 scenario. All values are percentage anomalies relative to the mean climate of 1970-1999. See Figure 2 for details.

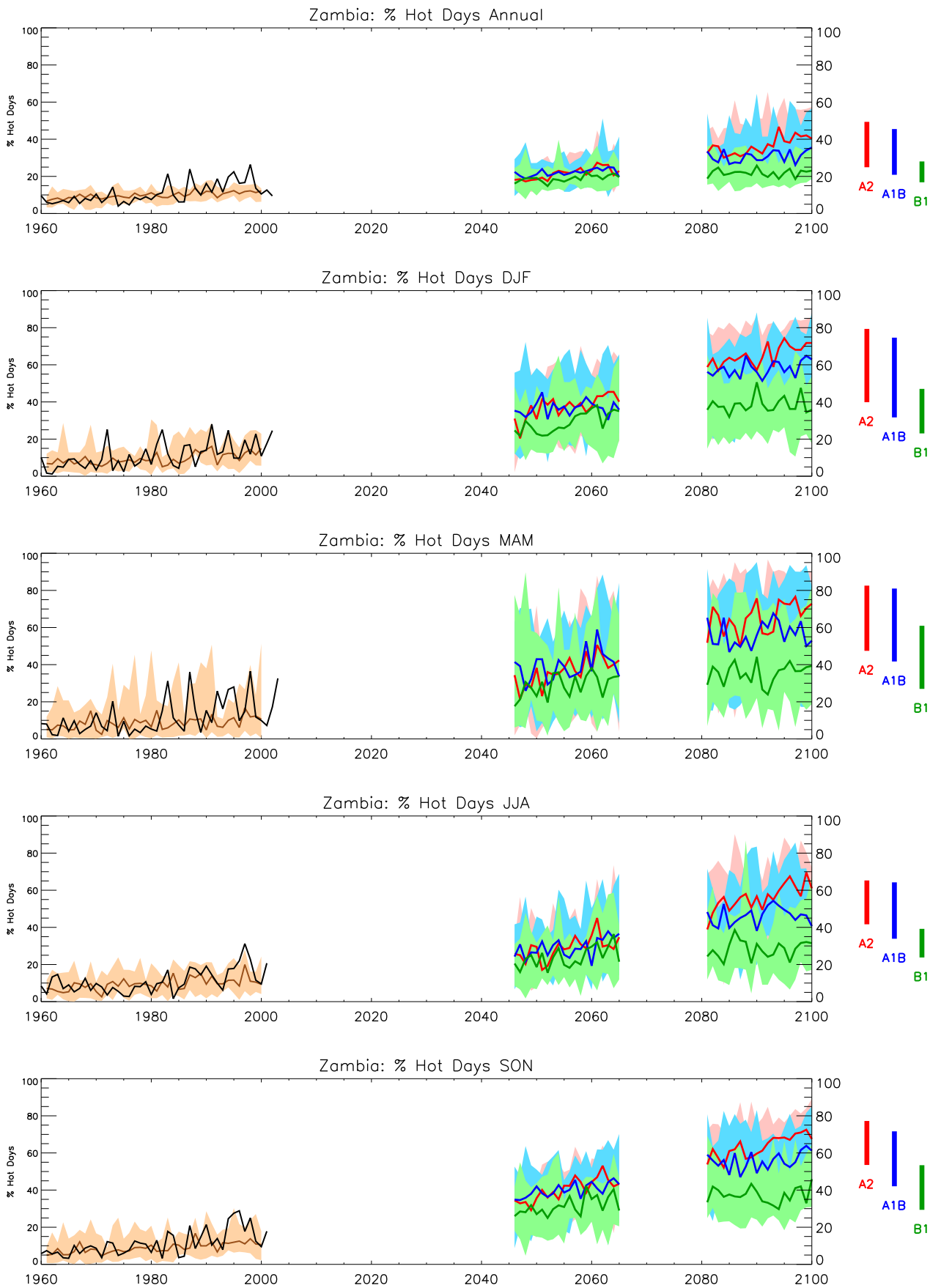


Figure 7: Trends in Hot-day frequency for the recent past and projected future. See Figure 1 for details.

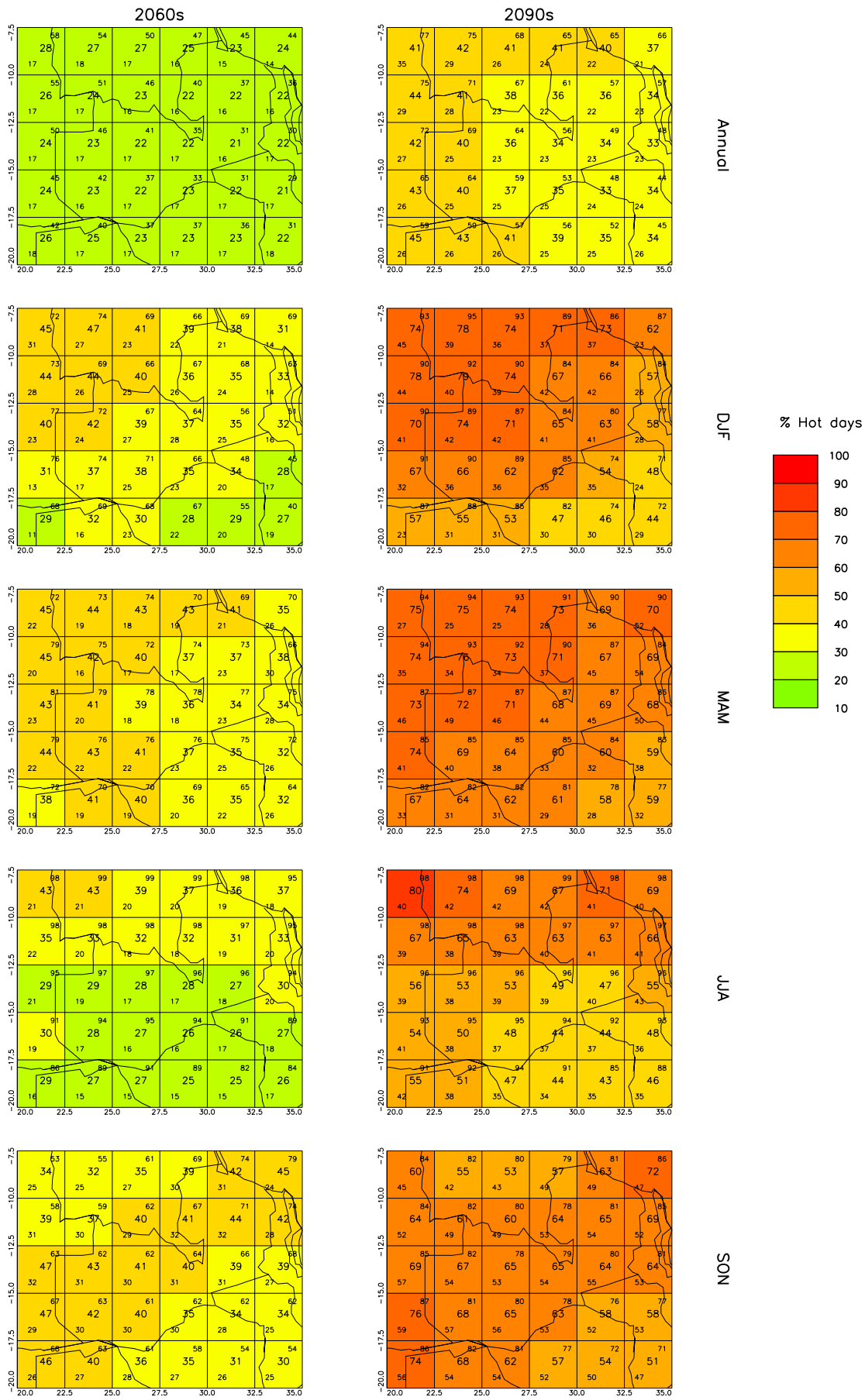


Figure 8: Spatial patterns of projected change in Hot-day frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

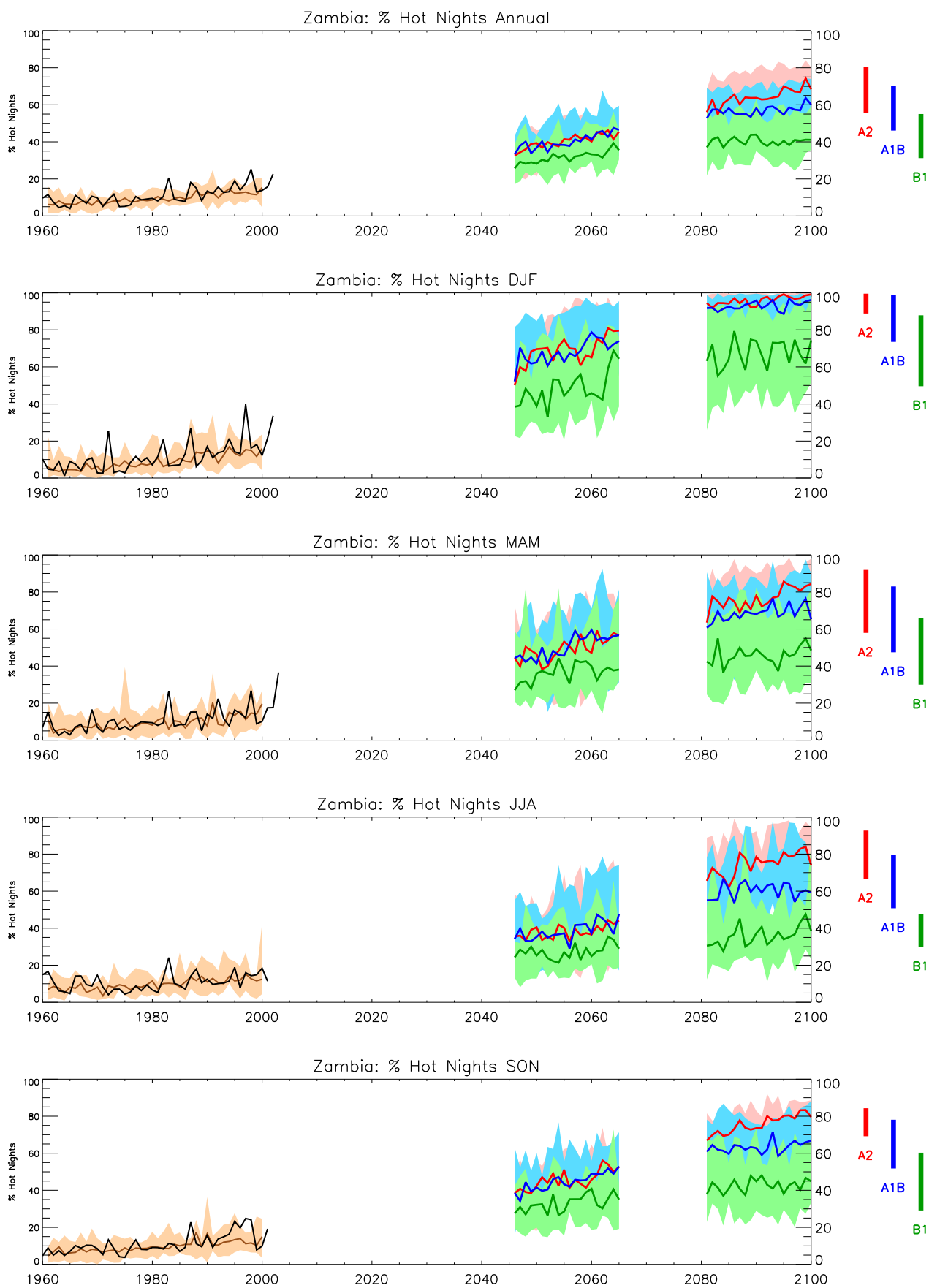


Figure 9: Trends in hot-night frequency for the recent past and projected future. See Figure 1 for details.

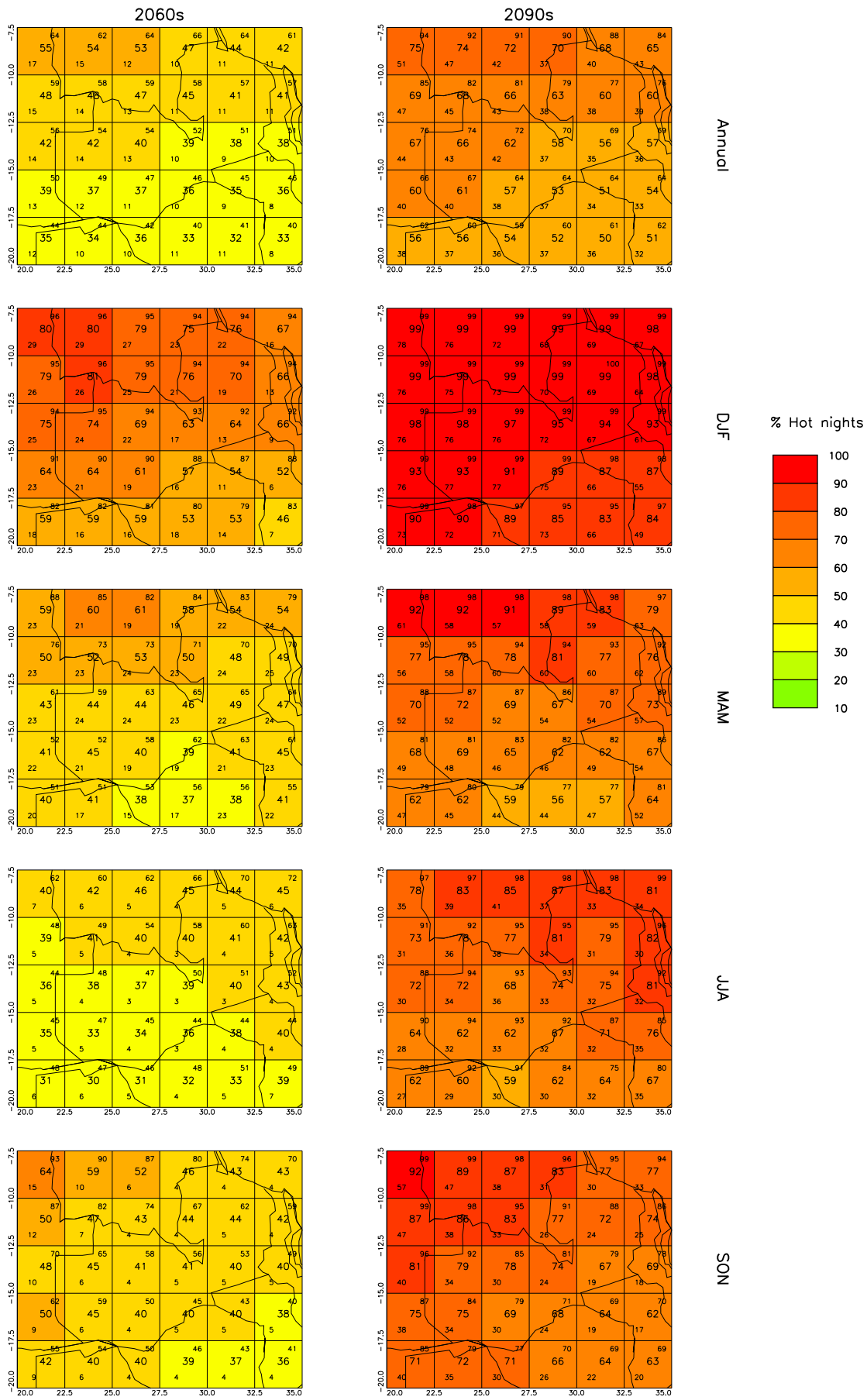


Figure 10: Spatial patterns of projected change in hot-night frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

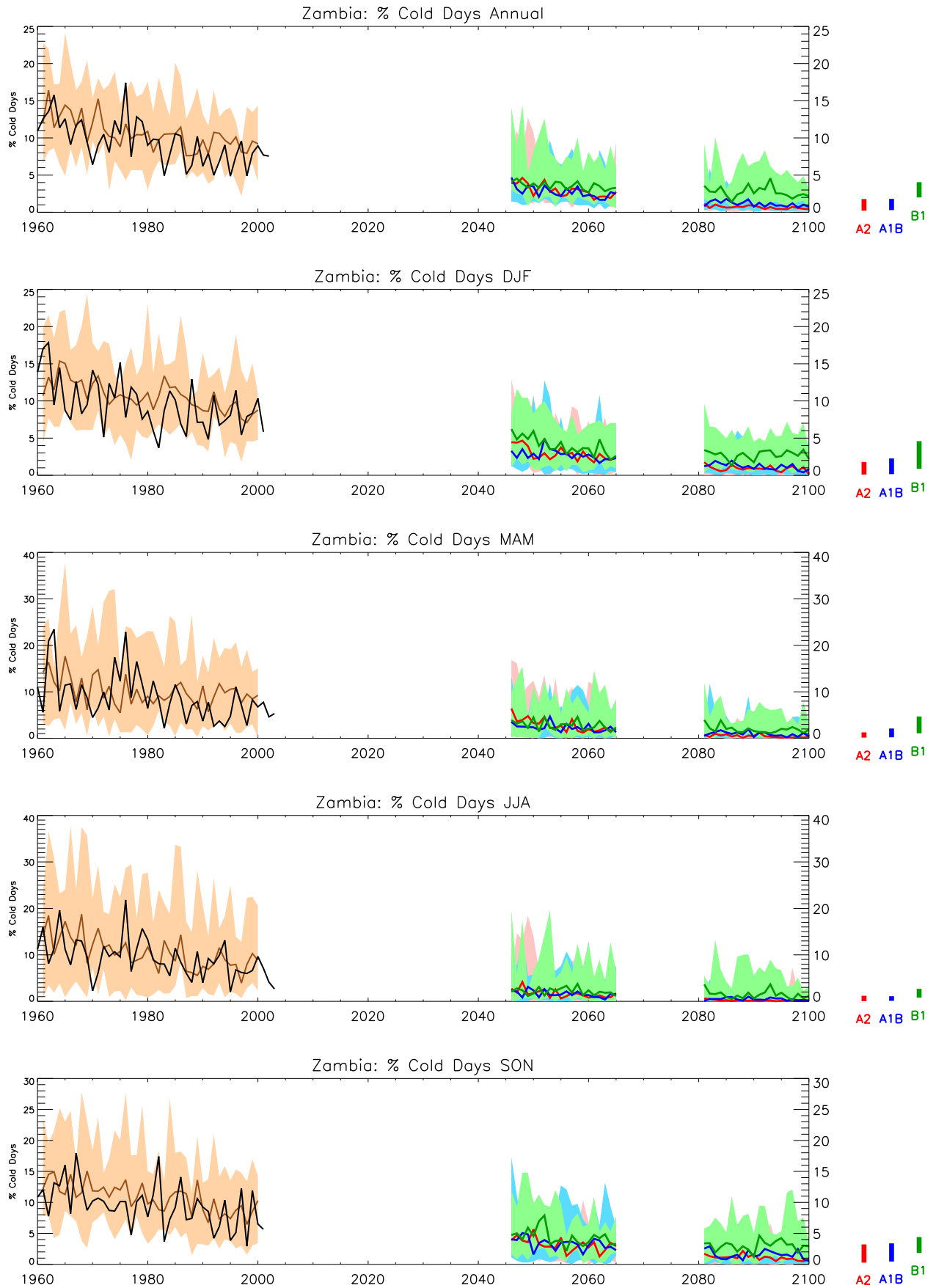


Figure 11: Trends in cold-day frequency for the recent past and projected future. See Figure 1 for details.

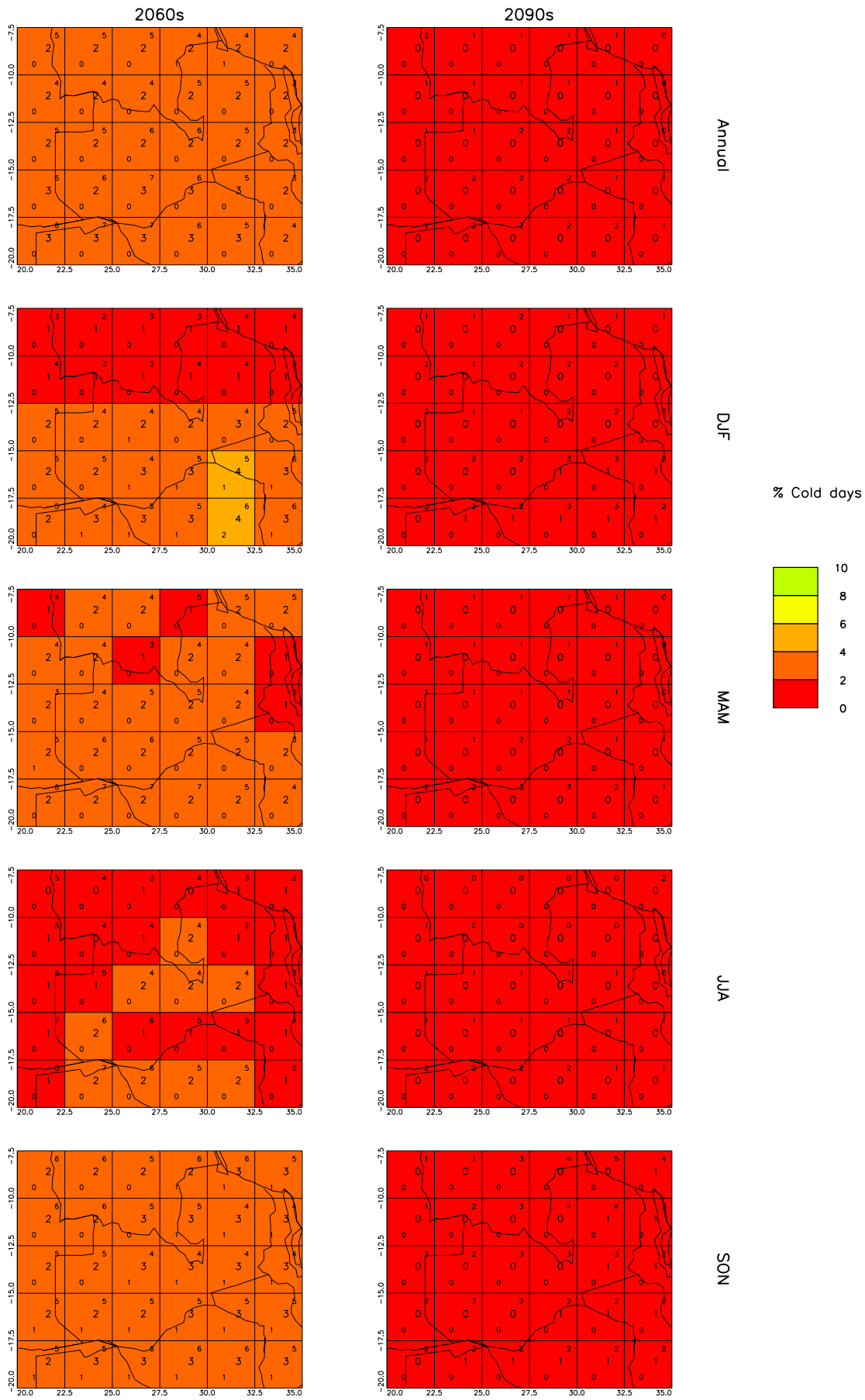


Figure 12: Spatial patterns of projected change in cold-day frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

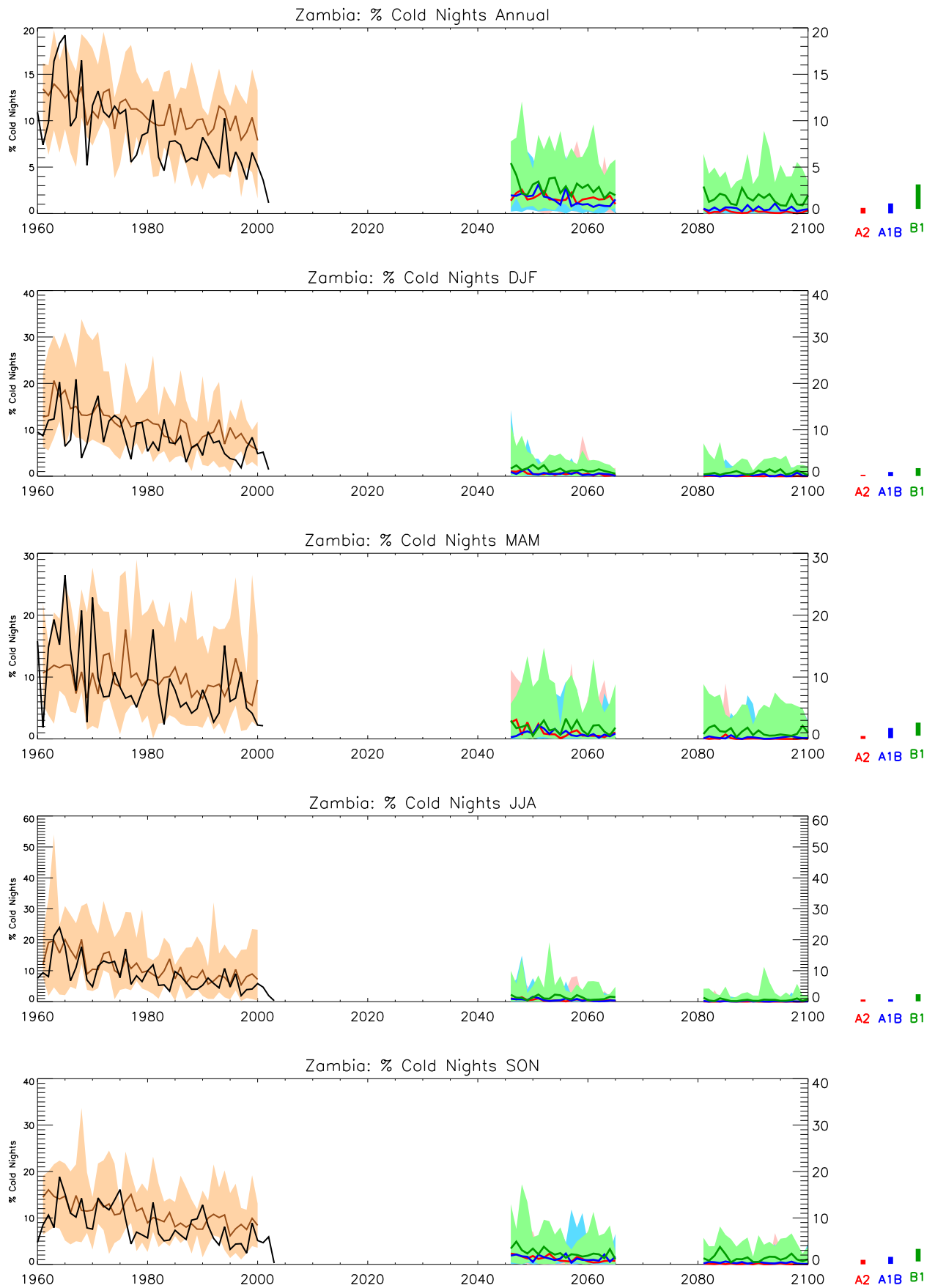


Figure 13: Trends in cold-night frequency for the recent past and projected future. See Figure 1 for details.

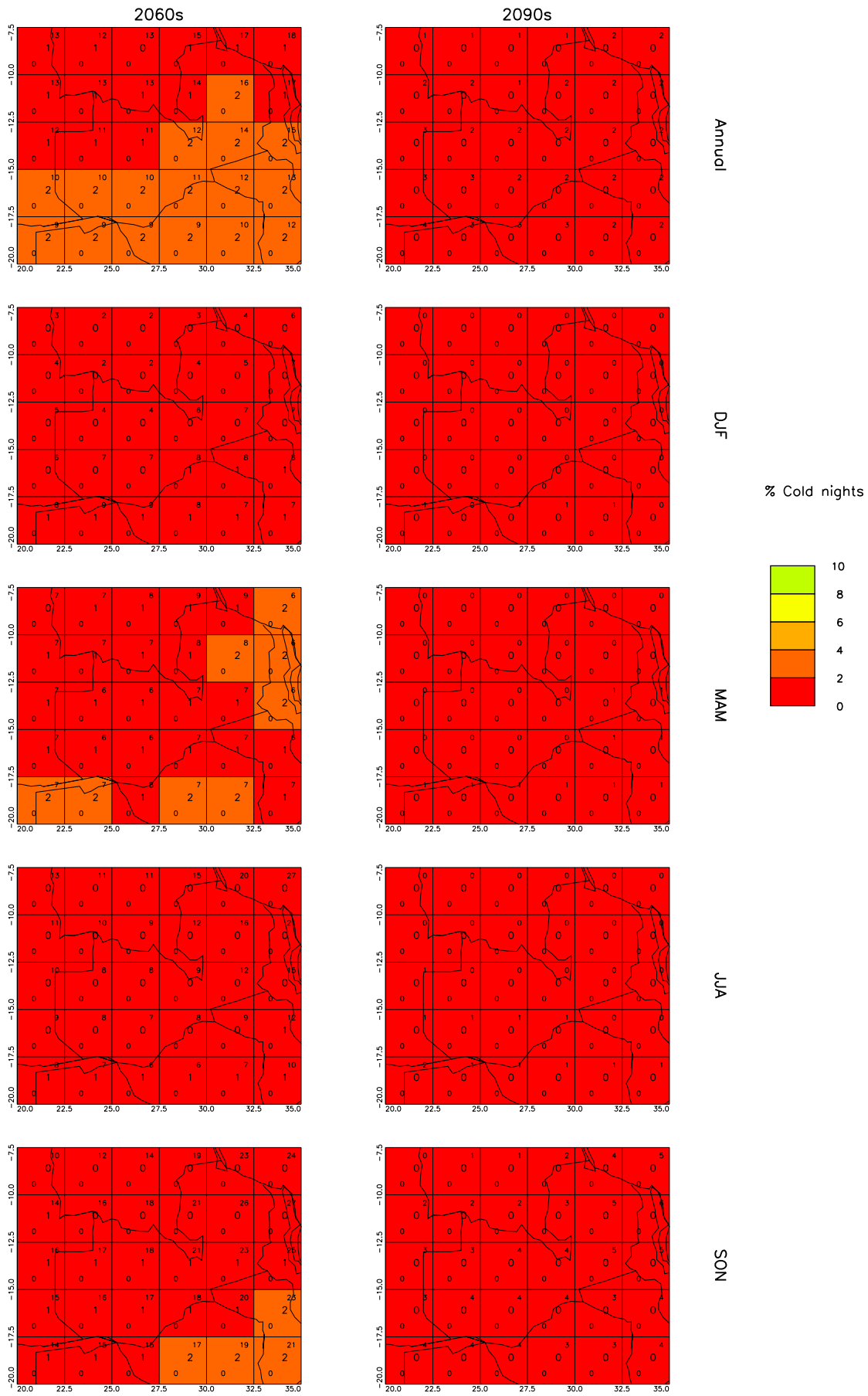


Figure 14: Spatial patterns of projected change in cold-night frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

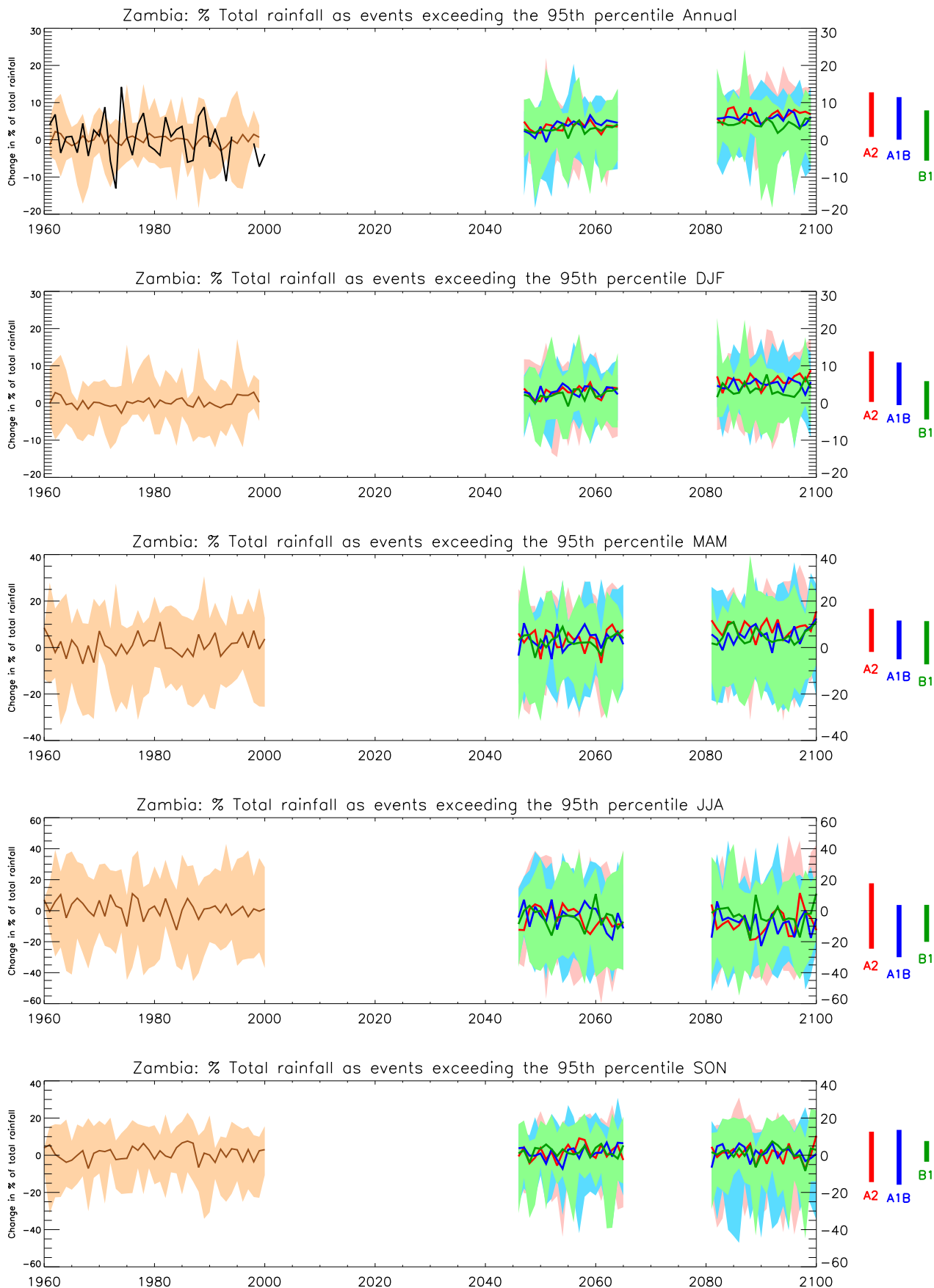


Figure 15: Trends in the proportion of precipitation falling in 'heavy' events for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

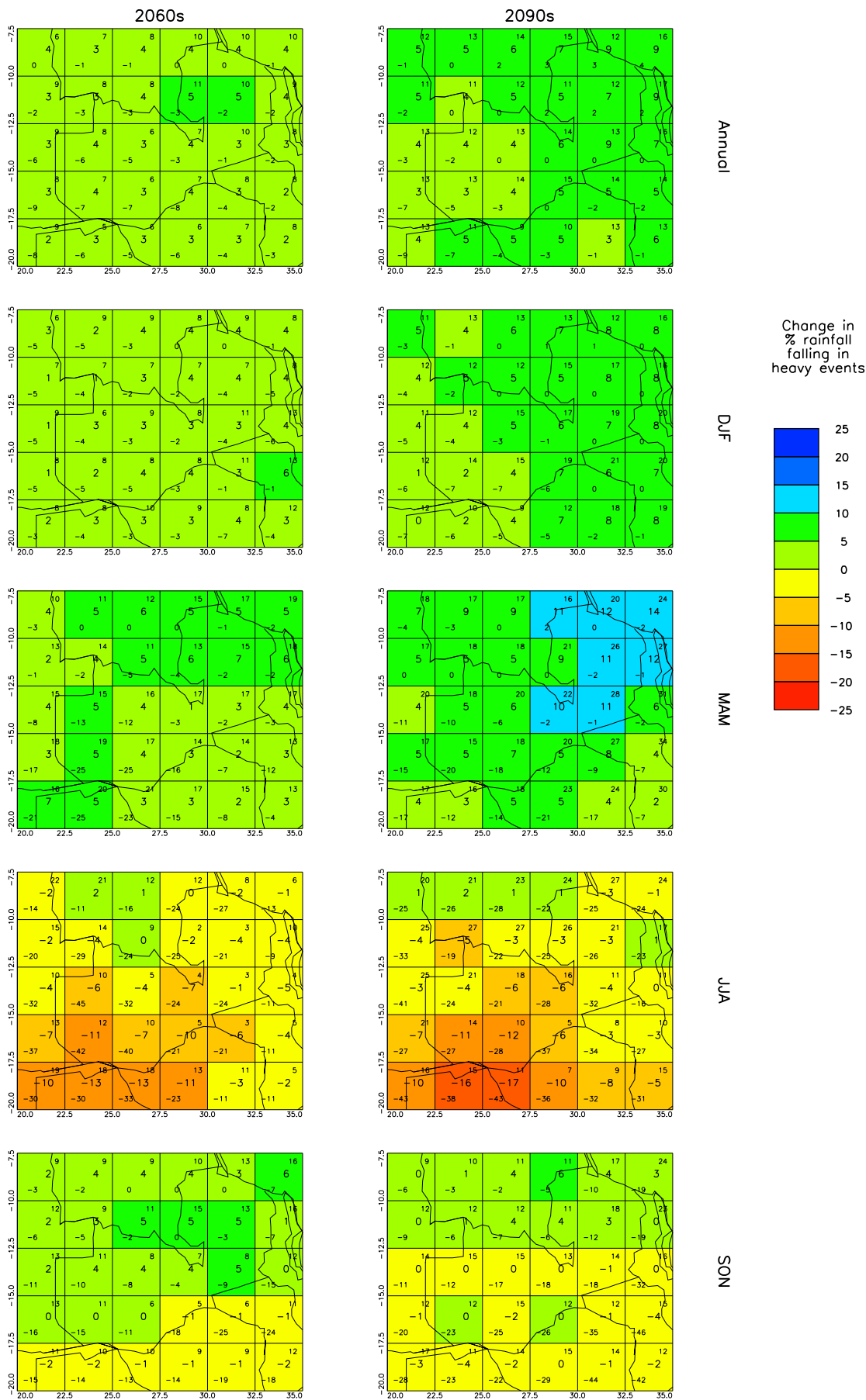


Figure 16: Spatial patterns of projected change in the proportion of precipitation falling in 'heavy' events for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. See Figure 2 for details.

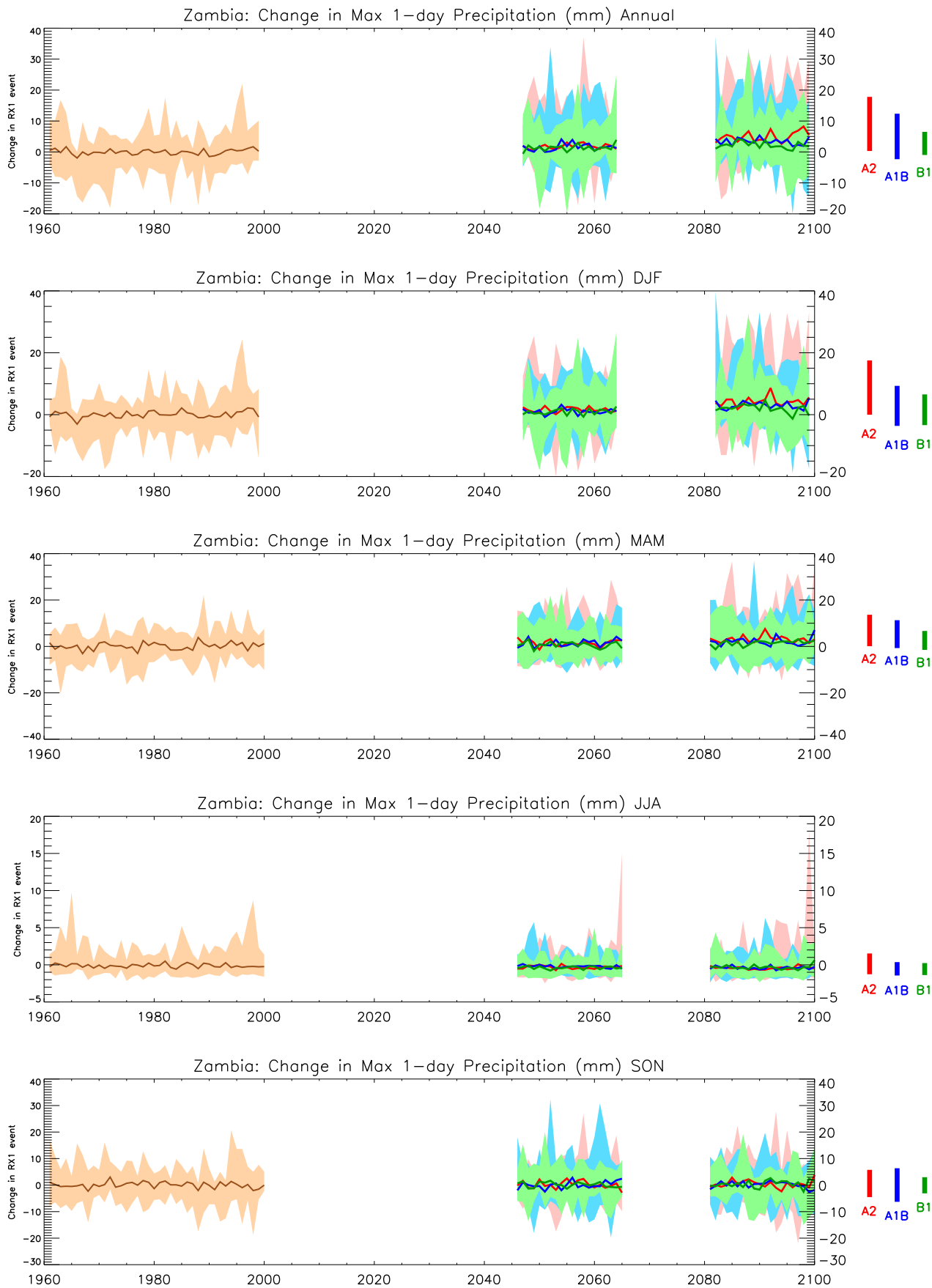


Figure 17: Trends in maximum 1-day rainfall for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

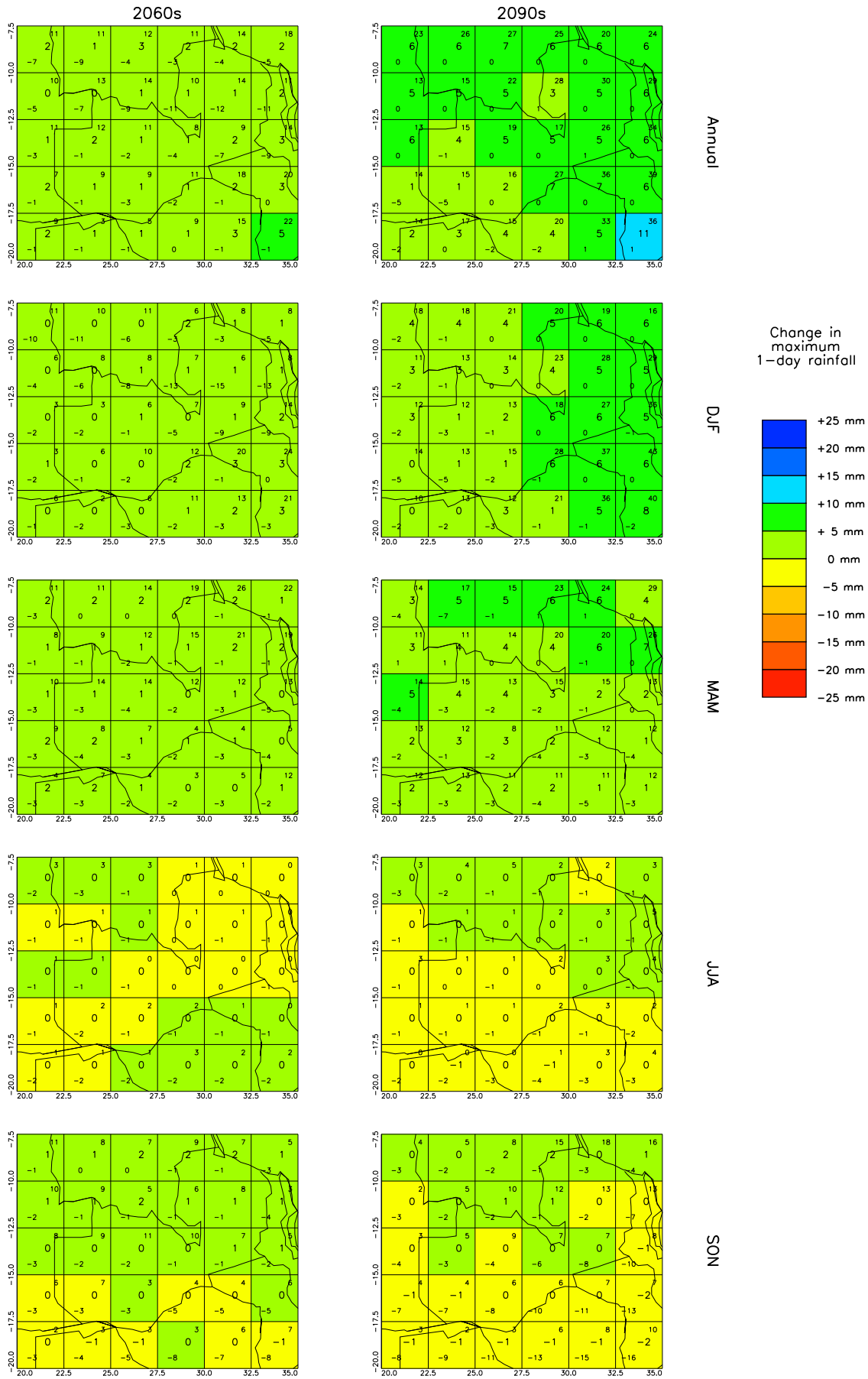


Figure 18: Spatial patterns of maximum 1-day rainfall for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. See Figure 2 for details.

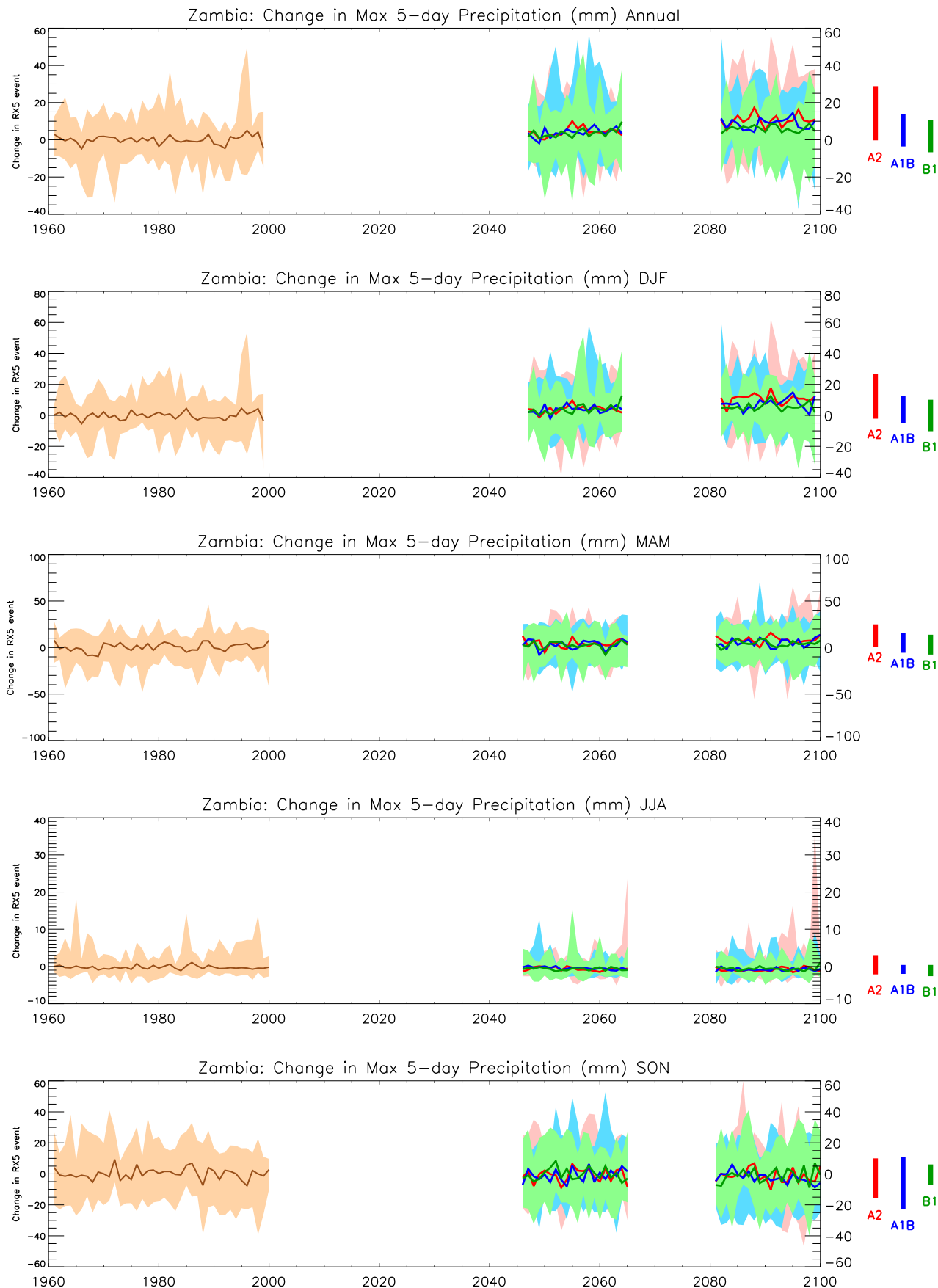


Figure 19: Trends in maximum 5-day rainfall for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

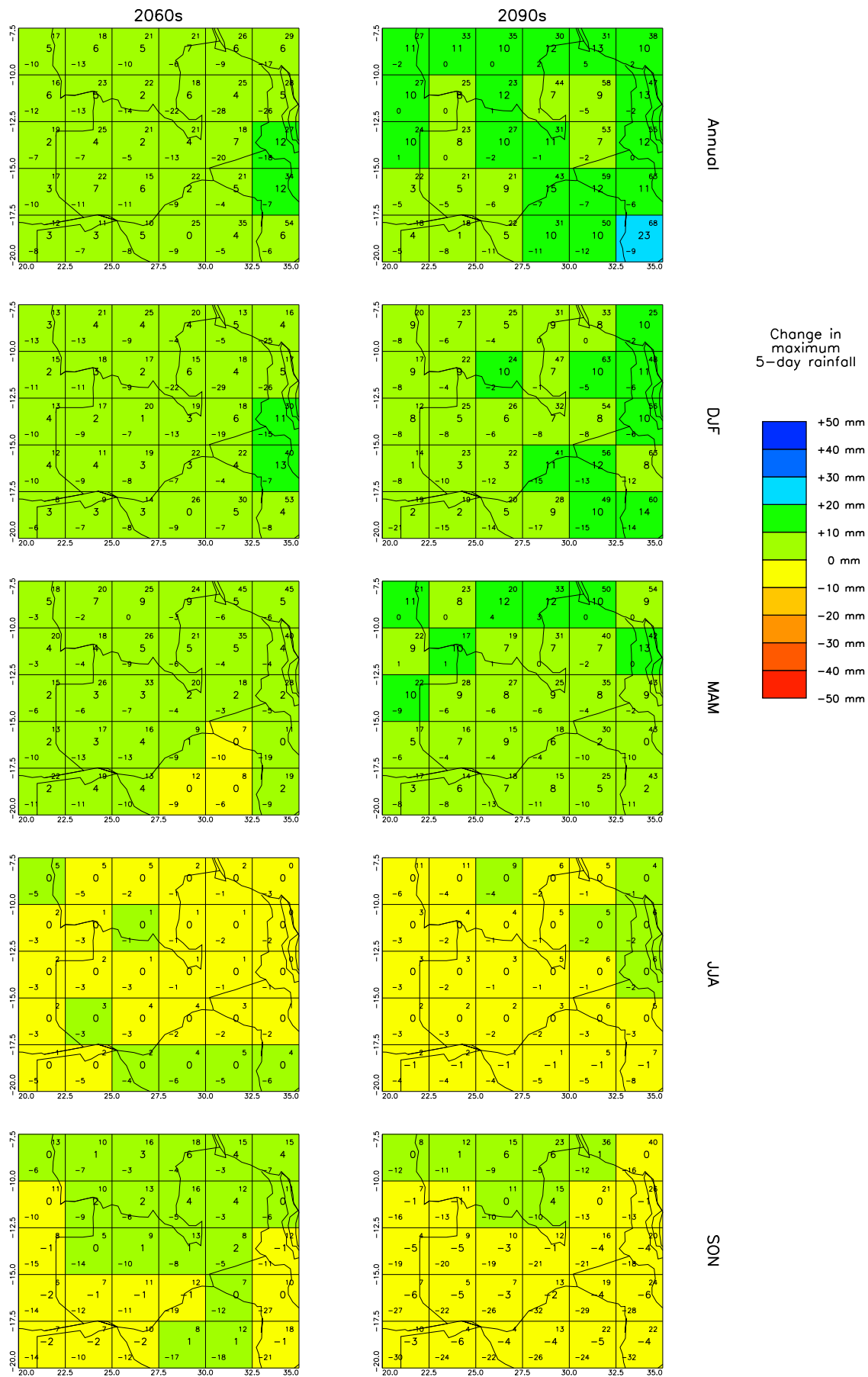


Figure 20: Spatial patterns of projected change in maximum 5-day rainfall for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. See Figure 2 for details.