

Uganda

C. McSweeney¹, M. New^{1,2} and G. Lizcano¹

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

Uganda is located in east Africa at latitudes of 2°S to 5°N, on the East African Plateau. Uganda's climate is tropical, but is moderated by its high altitude. Temperature vary little throughout the year, but the average temperatures increase in the south of the country as the elevation decreases towards the Sudanese plain. Average temperatures in the coolest regions of the south-west remain below 20°C, and reach 25°C in the warmest, northernmost parts.

Seasonal rainfall in Uganda is driven mainly by the migration of the Inter-Tropical Convergence Zone (ITCZ), relatively narrow belt of very low pressure and heavy precipitation that forms near the earth's equator. The exact position of the ITCZ changes over the course of the year, migrating southwards through Uganda in October to December, and returning northwards in March, April and May. This causes the Uganda to experience two distinct wet periods – the 'short' rains in October to December and the 'long' rains in March to May. The amount of rainfall received in these seasons is generally 50-200mm per month but varies greatly, exceeding 300mm per month in some localities.

The movements of the ITCZ are sensitive to variations in Indian Ocean sea-surface temperatures and vary from year to year, hence the onset and duration of these rainfalls vary considerably inter-annually. One of the most well documented ocean influences on rainfall in this region is the El Niño Southern Oscillation (ENSO). El Niño episodes usually cause greater than average rainfalls in the short rainfall season (OND), whilst cold phases (La Niña) bring a drier than average season.

Recent Climate Trends

Temperature

- Mean annual temperature has increased by 1.3°C since 1960, an average rate of 0.28°C per decade. This increase in temperature has been most rapid in JF at a rate of 0.37°C per decade.

- Daily temperature observations show significantly increasing trends in the frequency of hot days¹, and much large increasing trends in the frequency of hot nights.
 - The average number of 'hot' days per year in Uganda has increased by 74 (an additional 20.4% of days²) between 1960 and 2003. The rate of increase is seen most strongly in JJA when the average number of hot JJA days has increased by 8.6 days per month (an additional 27.8% of JJA days) over this period.
 - The average number of 'hot' nights per year increased by 136 (an additional 37.4% of nights) between 1960 and 2003. The rate of increase is seen most strongly in JJA when the average number of hot JJA nights has increased by 14 days per month (an additional 44.3% of JJA nights) over this period.
- The frequency of cold³ days has decreased significantly in all seasons except DJF. The frequency of cold nights has, however, decreased more rapidly and significantly in all seasons.
 - The average number of 'cold' days per year has decreased by 20 (5.5% of days) between 1960 and 2003. This rate of decrease is most rapid in SON when the average number of cold SON days has decreased by 2.2 days per month (7.1% of SON days) over this period.
 - The average number of 'cold' nights per year has decreased by 42 (11.3% of days). This rate of decrease is most rapid in DJF when the average number of cold DJF nights has decreased by 3.4 nights per month (11.1% of DJF nights) over this period.

Precipitation

- Observations of rainfall over Uganda show statistically significant decreasing trends in annual and MAM rainfall. Annual rainfall has decreased at an average rate of 3.4mm per month (3.5%) per decade, but this trend is strongly influenced by particularly high rainfall totals in 1960-61. MAM rainfalls have decreased by 6.0mm per month per decade (4.7%).
- Trends in the extreme indices based on daily rainfall data are mixed. There is no significant trend in the proportion of rainfall occurring in heavy⁴ events. 1- and 5-day rainfall maxima show small, non-statistically significant increasing trends in all seasons except JJA when the trend is decreasing.

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.

GCM Model Projections of Future Climate

Temperature

- The mean annual temperature is projected to increase by 1.0 to 3.1°C by the 2060s, and 1.4 to 4.9°C by the 2090s. The range of projections by the 2090s under any one emissions scenario is 1.0-2.0°C.
- Projected rates of warming are greatest in the coolest season, JJAS increasing by 1.5 to 5.4°C by the 2090s.
- All projections indicate increases in the frequency of days and nights that are considered ‘hot’ in current climate.
 - Annually, projections indicate that ‘hot’ days will occur on 15-43% of days by the 2060s, and 18-73% 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 31-84% of nights by the 2060s and 35-97% of nights 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, and do not occur at all by the 2090s in any projections under the highest emissions scenarios (A2 and A1B).

Precipitation

- Projections of mean rainfall are broadly consistent in indicating increases in annual rainfall. The ensemble range spans changes of -8 to +46% by the 2090s, with ensemble median changes of +7 to +11%.
- Projected increases in rainfall are largest in the short-rain season, OND (-8 to +35%).
- The models consistently project overall increases in the proportion of rainfall that falls in heavy events. The increases range from 0 to 15% in annual rainfall by the 2090s and affect the whole country throughout the year.
- The models consistently project increases in 1- and 5-day rainfall maxima by the 2090s of up to 27mm in 1-day events, and up to 37mm in 5-day events. The largest increases are seen in the rainy seasons, MAM and OND.

Other Regional Climate Change Information

- Model simulations show wide disagreements in projected changes in the amplitude of future El Niño events (Christensen *et al.*, 2007). East Africa's seasonal rainfall can be strongly influenced by ENSO, and this contributes to uncertainty in climate projections, particularly in the future inter-annual variability, 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													
(°C)													
Annual	22.0	0.28*	A2	0.9	1.2	1.7	1.9	2.5	3.1	3.0	3.8	4.9	
			A1B	0.8	1.4	1.6	1.6	2.3	2.8	2.4	3.3	4.4	
			B1	0.5	1.1	1.4	1.0	1.8	2.2	1.4	2.2	2.8	
			A2	0.7	1.2	1.5	1.5	2.3	3.3	2.6	3.6	4.9	
JF	23.1	0.37*	A1B	0.7	1.2	1.6	1.8	2.3	2.8	2.3	3.2	4.2	
			B1	0.4	1.0	1.3	1.0	1.5	2.1	1.2	2.0	2.6	
			A2	0.9	1.2	1.8	1.8	2.5	2.9	2.9	3.8	5.0	
			A1B	0.5	1.3	1.9	1.7	2.3	2.8	2.3	3.1	4.4	
MAM	22.6	0.31*	B1	0.6	1.0	1.6	1.1	1.7	2.2	1.4	2.2	3.0	
			A2	1.0	1.3	2.1	2.0	2.6	3.2	3.2	4.0	5.4	
			A1B	0.8	1.4	1.9	1.7	2.6	3.1	2.5	3.6	5.0	
			B1	0.6	1.1	1.5	0.9	1.9	2.4	1.5	2.2	3.1	
JJAS	21.1	0.24*	A2	0.5	1.1	1.5	1.8	2.2	3.1	2.9	3.5	4.4	
			A1B	0.8	1.3	1.5	1.3	2.3	2.6	2.0	3.2	3.8	
			B1	0.3	0.9	1.4	0.9	1.6	2.1	1.3	1.9	2.4	
			Precipitation										
Annual	96.3	-3.4*	(mm per month)	(change in mm per decade)			Change in mm per month			Change in mm per month			
			A2	-10	4	15	-2	7	29	-1	13	50	
			A1B	-4	2	18	-2	11	23	-2	14	32	
			B1	-2	1	11	-4	5	20	-8	9	22	
JF	42.4	-3.1	A2	-9	1	13	-10	3	33	-8	17	47	
			A1B	-11	8	20	-8	7	23	-9	2	38	
			B1	-15	2	11	-20	3	25	-11	9	19	
			A2	-10	4	17	-13	10	32	-24	16	40	
MAM	127.7	-6.0*	A2	-13	5	26	-13	14	37	-19	18	40	
			A1B	-13	5	26	-13	14	37	-19	18	40	
			B1	-23	2	32	-15	3	30	-21	7	42	
			A2	-13	0	23	-6	0	38	-11	6	64	
JJAS	101.0	-3.6	A2	-13	0	19	-6	2	32	-12	7	41	
			A1B	-15	0	19	-14	1	18	-8	3	24	
			B1	-4	-1	14	-14	1	18	-8	3	24	
			A2	-10	6	28	-7	14	41	3	30	54	
OND	94.6	-0.2	A2	-6	9	29	-3	22	32	2	22	48	
			A1B	-6	9	29	-3	22	32	-10	15	38	
Precipitation (%)													
Annual	96.3	-3.5*	(mm per month)	(change in % per decade)			% Change			% Change			
			A2	-7	3	11	-2	6	21	-1	10	46	
			A1B	-4	2	11	-2	8	25	-2	11	26	
			B1	-3	1	14	-5	4	13	-9	7	28	
JF	42.4	-7.2	A2	-5	0	18	-16	5	42	-9	16	61	
			A1B	-18	9	26	-13	10	29	-14	3	52	
			B1	-9	2	26	-12	4	34	-11	9	27	
			A2	-7	2	19	-10	7	19	-19	15	46	
MAM	127.7	-4.7*	A2	-8	4	15	-9	7	33	-13	9	26	
			A1B	-11	1	23	-9	3	21	-16	5	48	
			B1	-11	0	23	-8	0	43	-5	10	76	
			A2	-11	0	23	-8	0	43	-5	10	76	
JJAS	101.0	-3.5	A2	-12	1	18	-5	4	37	-5	6	32	
			A1B	-5	-1	15	-12	1	21	-7	5	19	
			B1	-5	3	13	-4	7	21	2	13	35	
			A2	-5	5	15	-2	9	18	2	11	31	
OND	94.6	-0.2	A2	-4	4	16	-8	5	11	-8	10	21	
			A1B	-4	4	16	-8	5	11	-8	10	21	

	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)												
Annual	14.8	4.74*	A2	****	****	****	19	29	43	30	50	74
			A1B	****	****	****	20	26	42	23	42	67
			B1	****	****	****	16	22	30	18	28	44
			A2	****	****	****	23	32	62	35	54	81
JF (DJF)	14.3	(3.97*)	A1B	****	****	****	20	36	55	30	54	78
			B1	****	****	****	17	29	42	23	34	56
			A2	****	****	****	19	35	50	31	54	75
MAM	16.5	5.82*	A1B	****	****	****	18	36	50	22	47	75
			B1	****	****	****	15	27	34	14	34	53
			A2	****	****	****	31	45	58	43	71	91
JJAS (JJA)	16.4	(6.46*)	A1B	****	****	****	28	41	59	35	63	88
			B1	****	****	****	20	33	43	29	43	59
			A2	****	****	****	17	29	52	28	55	80
OND	15.1	4.50*	A1B	****	****	****	20	28	52	24	48	73
			B1	****	****	****	16	23	38	17	36	54
Frequency of Hot Nights (TN90p)												
Annual	17.7	8.72*	A2	****	****	****	43	57	84	76	86	98
			A1B	****	****	****	44	55	85	62	72	98
			B1	****	****	****	31	38	73	35	49	85
			A2	****	****	****	44	57	84	77	91	98
JF (DJF)	17.6	(7.91*)	A1B	****	****	****	40	55	86	63	73	97
			B1	****	****	****	30	35	76	38	48	86
			A2	****	****	****	51	66	93	83	93	99
MAM	19.0	9.01*	A1B	****	****	****	46	58	94	70	85	99
			B1	****	****	****	34	45	79	40	60	94
			A2	****	****	****	44	69	90	77	94	99
JJAS (JJA)	19.2	(10.29*)	A1B	****	****	****	42	61	93	62	86	98
			B1	****	****	****	31	45	75	35	59	87
			A2	****	****	****	45	63	95	78	90	99
OND	18.8	9.65*	A1B	****	****	****	51	60	95	64	80	99
			B1	****	****	****	32	40	86	36	55	94
Frequency of Cold Days (TX10p)												
Annual	7.5	-1.28*	A2	****	****	****	0	2	4	0	0	1
			A1B	****	****	****	1	2	4	0	1	2
			B1	****	****	****	1	4	5	1	2	4
			A2	****	****	****	1	3	9	0	1	4
JF (DJF)	7.3	(-1.13)	A1B	****	****	****	1	3	6	0	1	6
			B1	****	****	****	2	4	6	1	3	7
			A2	****	****	****	0	2	5	0	0	2
MAM	7.9	-0.84*	A1B	****	****	****	0	2	5	0	0	4
			B1	****	****	****	1	2	6	0	1	5
			A2	****	****	****	0	2	3	0	1	1
JJAS (JJA)	7.7	(-1.06*)	A1B	****	****	****	0	2	4	0	1	2
			B1	****	****	****	1	4	5	1	2	4
			A2	****	****	****	1	2	4	0	0	1
OND	6.6	-1.66*	A1B	****	****	****	1	2	4	0	0	2
			B1	****	****	****	1	4	6	1	2	4
Frequency of Cold Nights (TN10p)												
Annual	6.6	-2.64*	A2	****	****	****	0	0	1	0	0	0
			A1B	****	****	****	0	0	2	0	0	0
			B1	****	****	****	0	1	3	0	0	2
			A2	****	****	****	0	0	1	0	0	0
JF (DJF)	6.3	(-2.58*)	A1B	****	****	****	0	0	2	0	0	0
			B1	****	****	****	0	2	3	0	0	3
			A2	****	****	****	0	0	1	0	0	0
MAM	6.4	-2.41*	A1B	****	****	****	0	0	2	0	0	0
			B1	****	****	****	0	0	2	0	0	2
			A2	****	****	****	0	0	0	0	0	0
JJAS (JJA)	5.8	(-2.43*)	A1B	****	****	****	0	0	1	0	0	0
			B1	****	****	****	0	0	1	0	0	0
			A2	****	****	****	0	0	2	0	0	0
OND	6.7	-2.39*	A1B	****	****	****	0	0	3	0	0	1
			B1	****	****	****	0	0	3	0	1	1

	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	26.4	0.49	A2	****	****	****	1	4	8	2	7	15
			A1B	****	****	****	1	4	9	2	6	13
			B1	****	****	****	0	3	5	0	3	10
			A2	****	****	****	-6	4	12	1	8	20
JF (DJF)	****	****	A1B	****	****	****	-2	5	11	-1	7	13
			B1	****	****	****	-1	2	9	1	3	13
			A2	****	****	****	0	3	8	1	7	12
MAM	****	****	A1B	****	****	****	0	3	8	-2	4	13
			B1	****	****	****	0	3	6	0	3	16
			A2	****	****	****	-1	2	14	-1	5	22
JJAS (JJA)	****	****	A1B	****	****	****	-2	2	14	0	5	17
			B1	****	****	****	-5	1	8	-4	3	10
			A2	****	****	****	0	5	9	1	9	16
OND	****	****	A1B	****	****	****	1	5	11	3	6	16
			B1	****	****	****	0	2	6	1	4	11
Maximum 1-day rainfall (RX1day)												
	mm	Change in mm per decade				Change in mm			Change in mm			
Annual	****	****	A2	****	****	****	0	4	14	0	9	27
			A1B	****	****	****	0	2	13	0	7	19
			B1	****	****	****	0	1	7	0	2	10
			A2	****	****	****	-2	1	8	-1	2	6
JF (DJF)	19.2	(0.28)	A1B	****	****	****	0	1	5	-4	2	4
			B1	****	****	****	-1	0	2	0	1	5
			A2	****	****	****	0	1	13	0	6	17
MAM	39.4	0.4	A1B	****	****	****	0	2	12	0	4	18
			B1	****	****	****	0	1	9	0	2	9
			A2	****	****	****	-1	1	6	0	4	12
JJAS (JJA)	30.8	(-0.73)	A1B	****	****	****	-2	0	3	0	3	7
			B1	****	****	****	-1	1	4	-2	1	3
			A2	****	****	****	0	2	13	0	7	21
OND	36.0	0.3	A1B	****	****	****	0	2	17	0	4	18
			B1	****	****	****	0	1	8	0	2	8
Maximum 5-day Rainfall (RX5day)												
	mm	Change in mm per decade				Change in mm			Change in mm			
Annual	126.1	0.23	A2	****	****	****	0	7	18	2	15	36
			A1B	****	****	****	2	7	15	2	12	23
			B1	****	****	****	1	3	9	1	6	17
			A2	****	****	****	-9	3	16	-3	3	18
JF (DJF)	28.8	(-1.23)	A1B	****	****	****	-2	4	8	-8	5	15
			B1	****	****	****	-2	1	6	-1	3	9
			A2	****	****	****	-2	3	16	1	11	19
MAM	69.7	0.17	A1B	****	****	****	1	4	16	-3	5	22
			B1	****	****	****	0	2	16	-1	4	19
			A2	****	****	****	-1	2	13	-1	6	18
JJAS (JJA)	52.7	(-1.15)	A1B	****	****	****	-4	1	10	-1	6	12
			B1	****	****	****	-4	1	6	-3	3	9
			A2	****	****	****	0	8	23	1	13	34
OND	61.7	1.68	A1B	****	****	****	2	8	23	1	8	22
			B1	****	****	****	0	4	9	1	5	14

* 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.

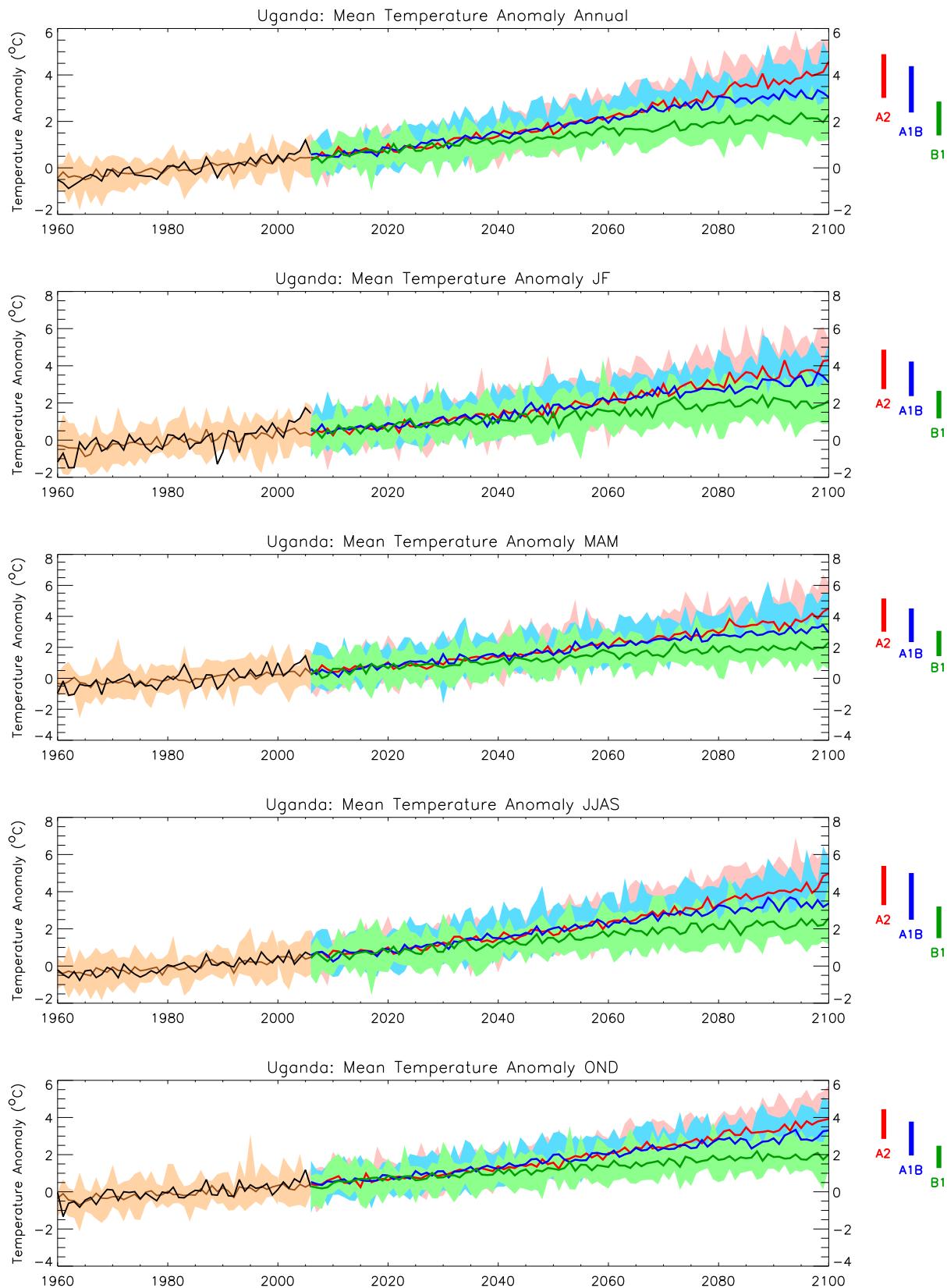


Figure 1: Trends in annual and seasonal mean temperature for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. Black curves show the mean of observed data from 1960 to 2006, Brown curves show the median (solid line) and range (shading) of model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

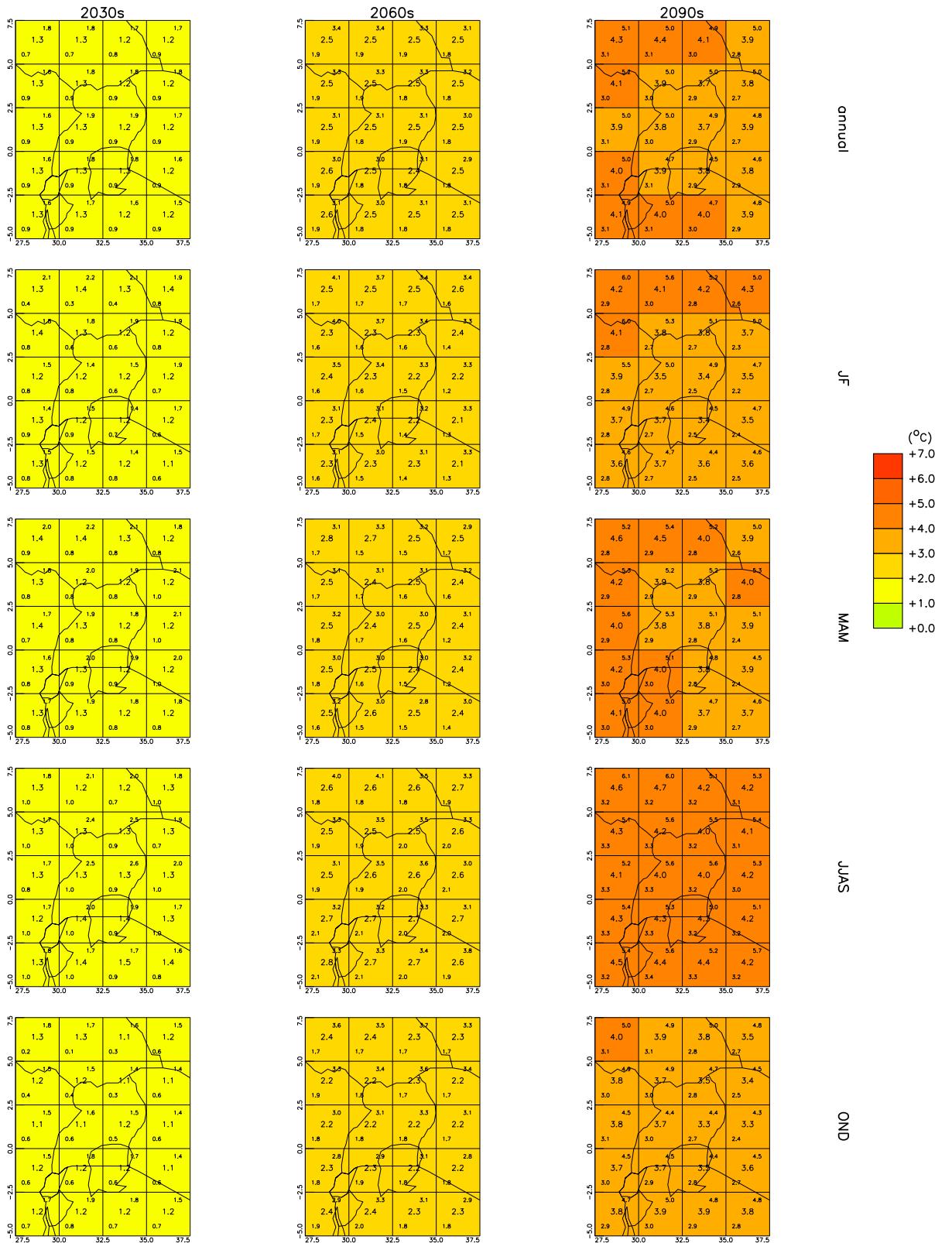


Figure 2: Spatial patterns of projected change in mean annual and seasonal temperature for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. In each grid box, the central value gives the ensemble median and the values in the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

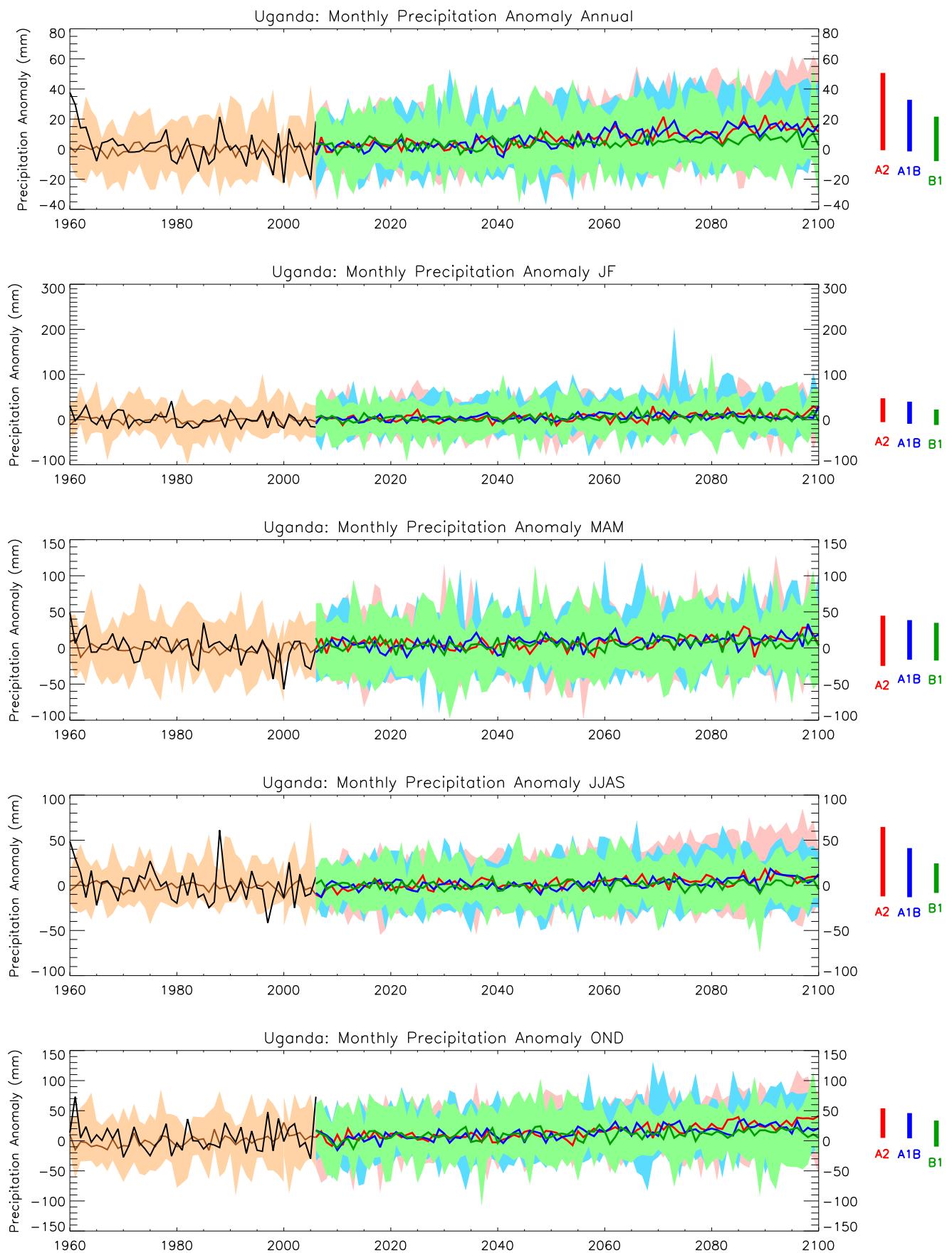
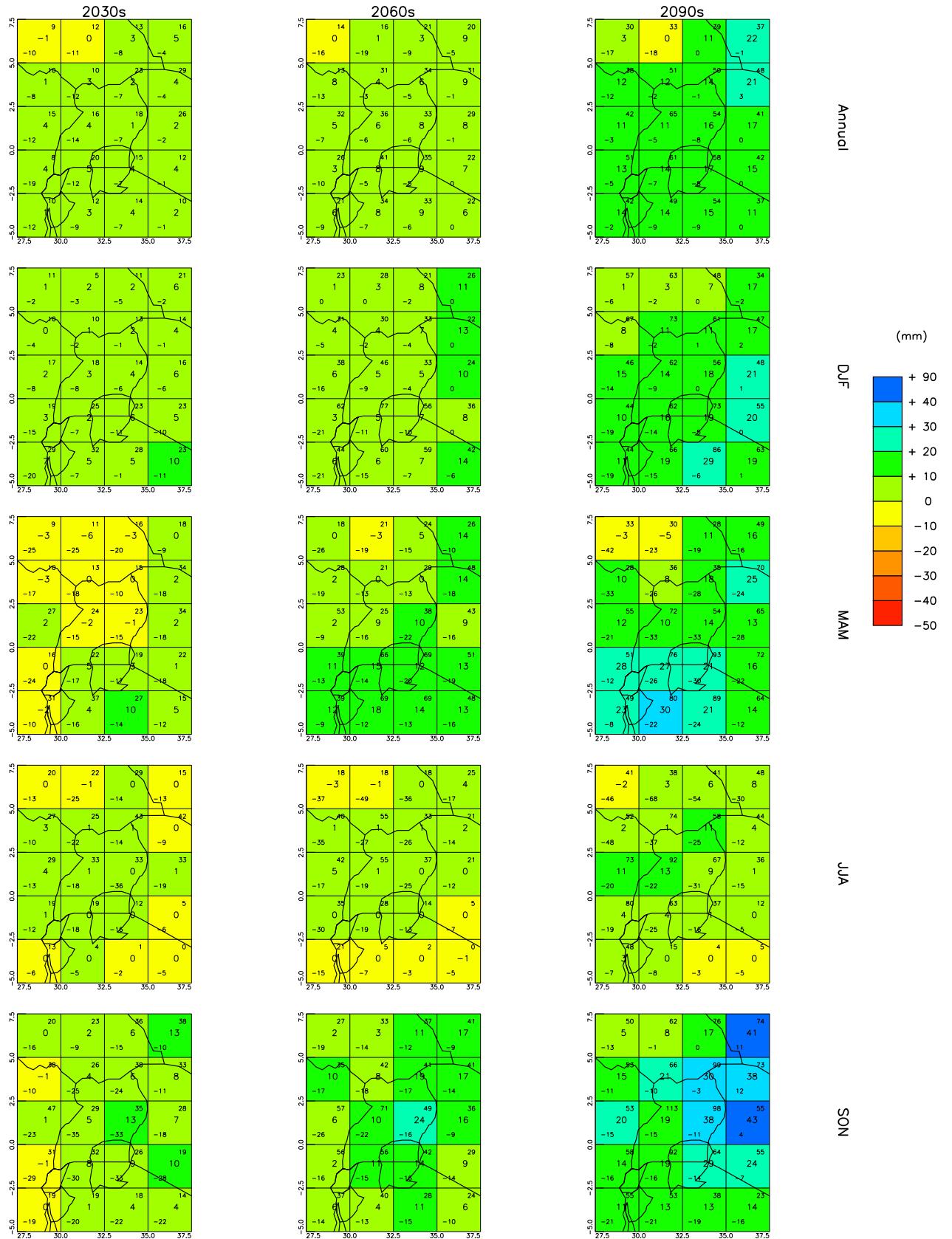


Figure 3: Trends in monthly precipitation for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.



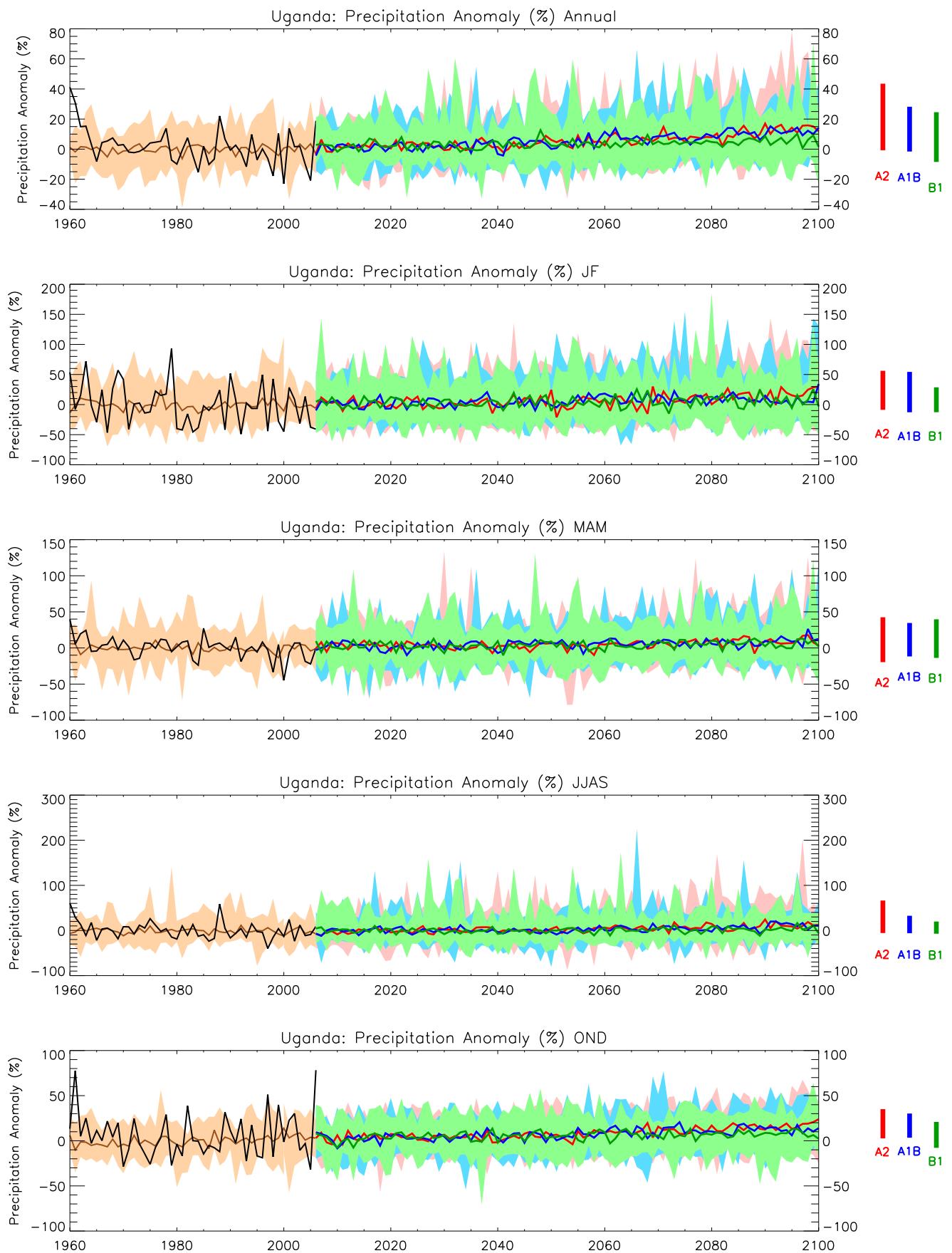


Figure 5: Trends in monthly precipitation for the recent past and projected future. All values shown are percentage anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

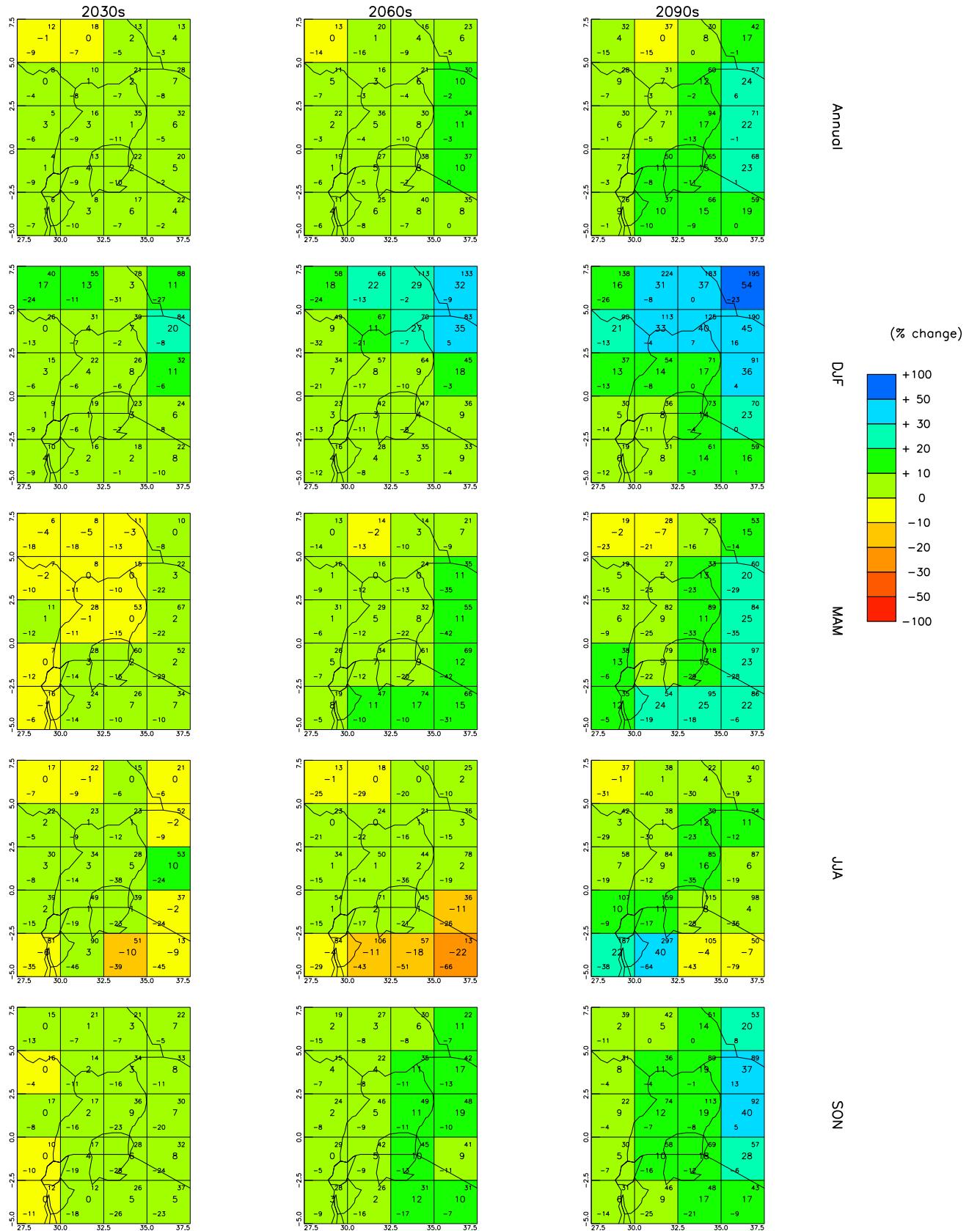


Figure 6: Spatial patterns of projected change in monthly precipitation for 10-year periods in the future under the SRES A2 scenario. All values are percentage anomalies relative to the mean climate of 1970-1999. See Figure 2 for details.

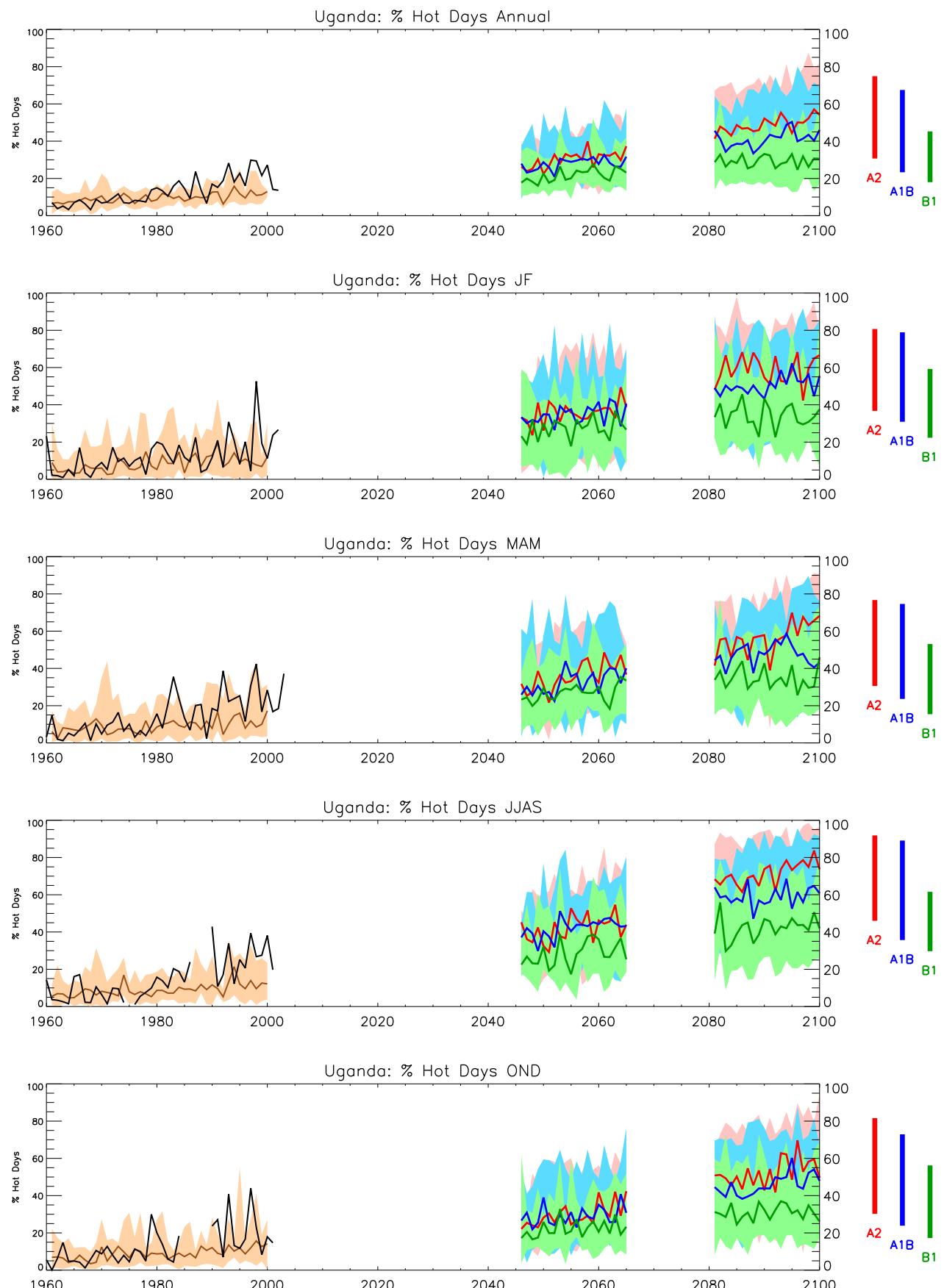


Figure 7: Trends in Hot-day frequency for the recent past and projected future. See Figure 1 for details.

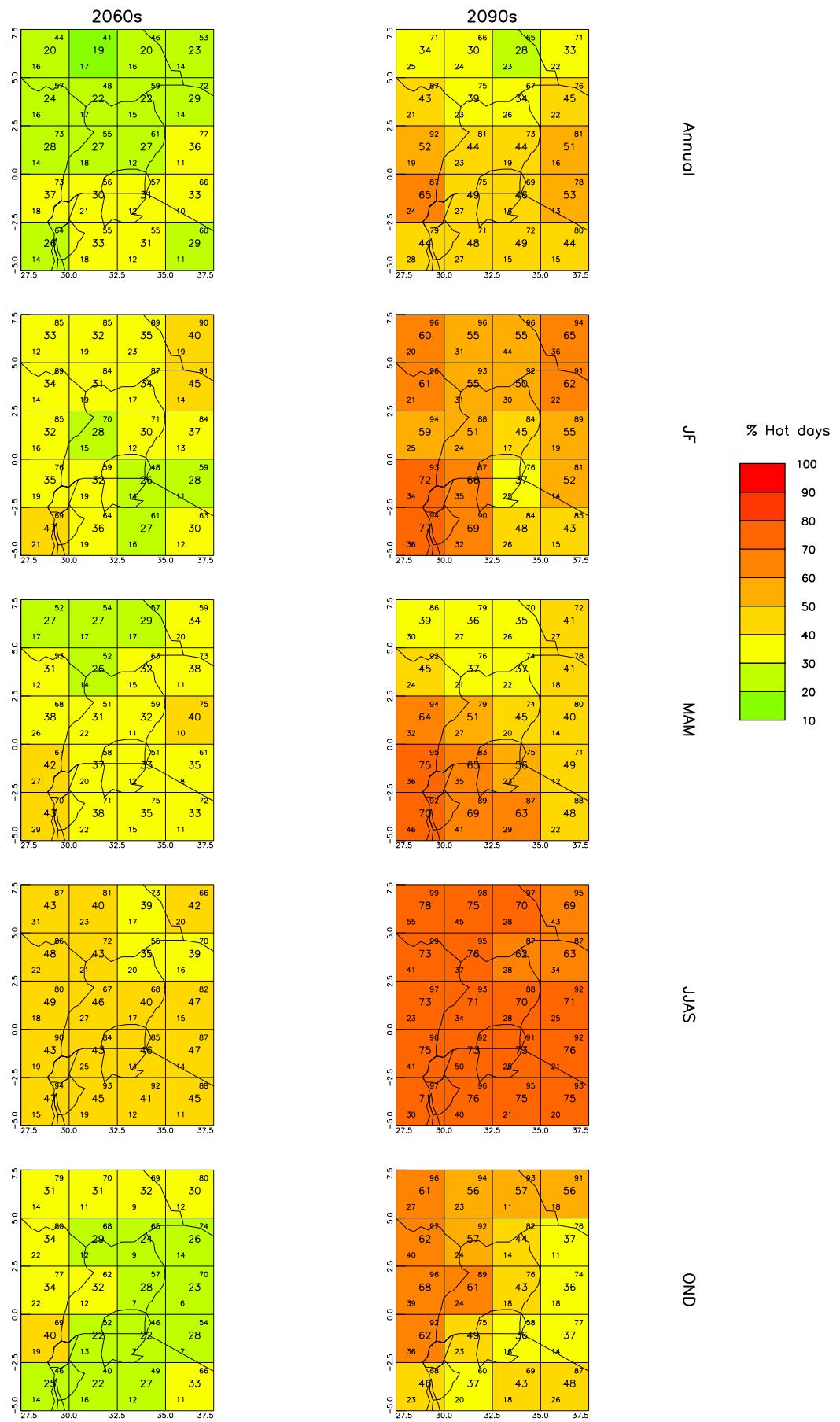


Figure 8: Spatial patterns of projected change in Hot-day frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

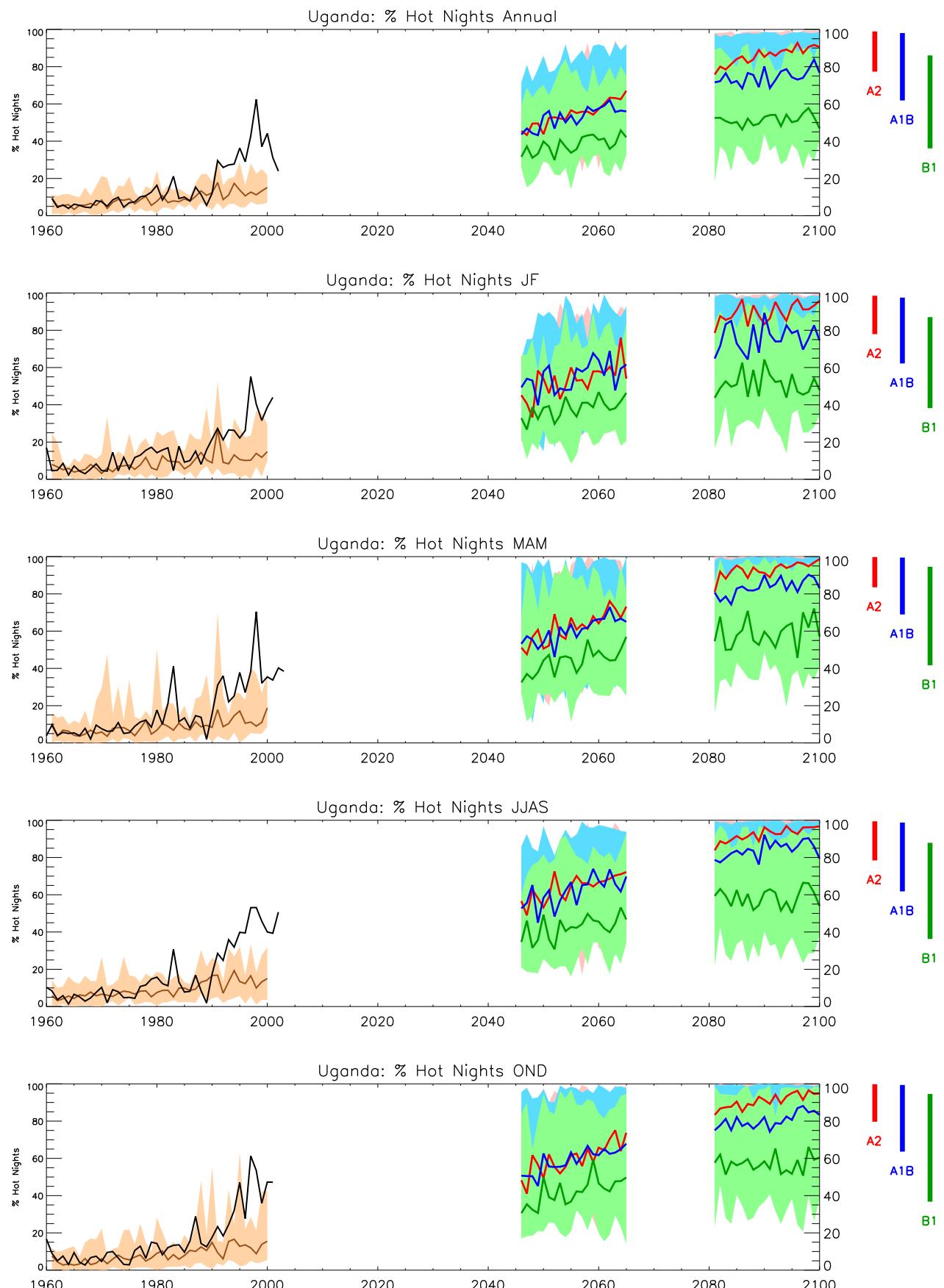


Figure 9: Trends in hot-night frequency for the recent past and projected future. See Figure 1 for details.

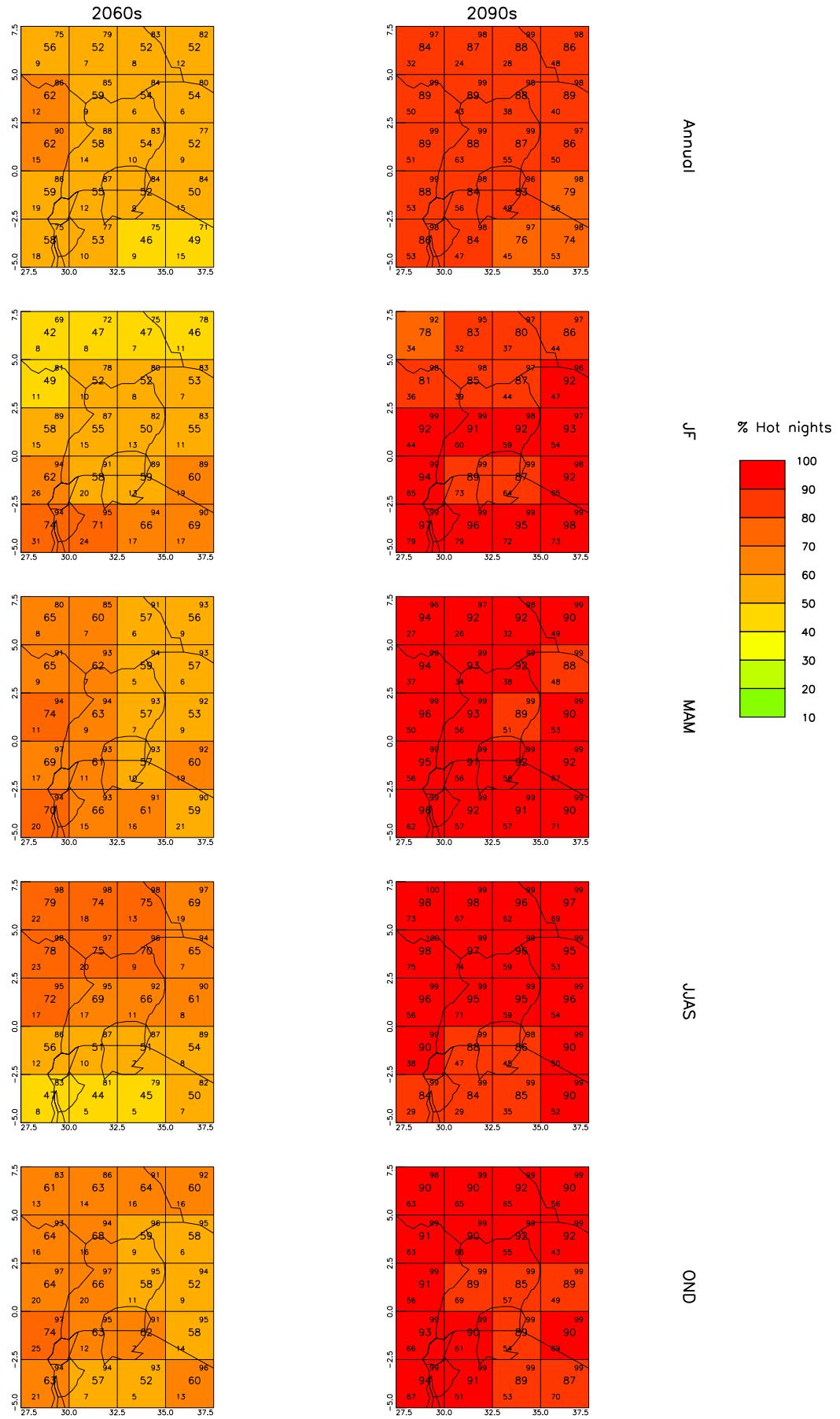


Figure 10: Spatial patterns of projected change in hot-night frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

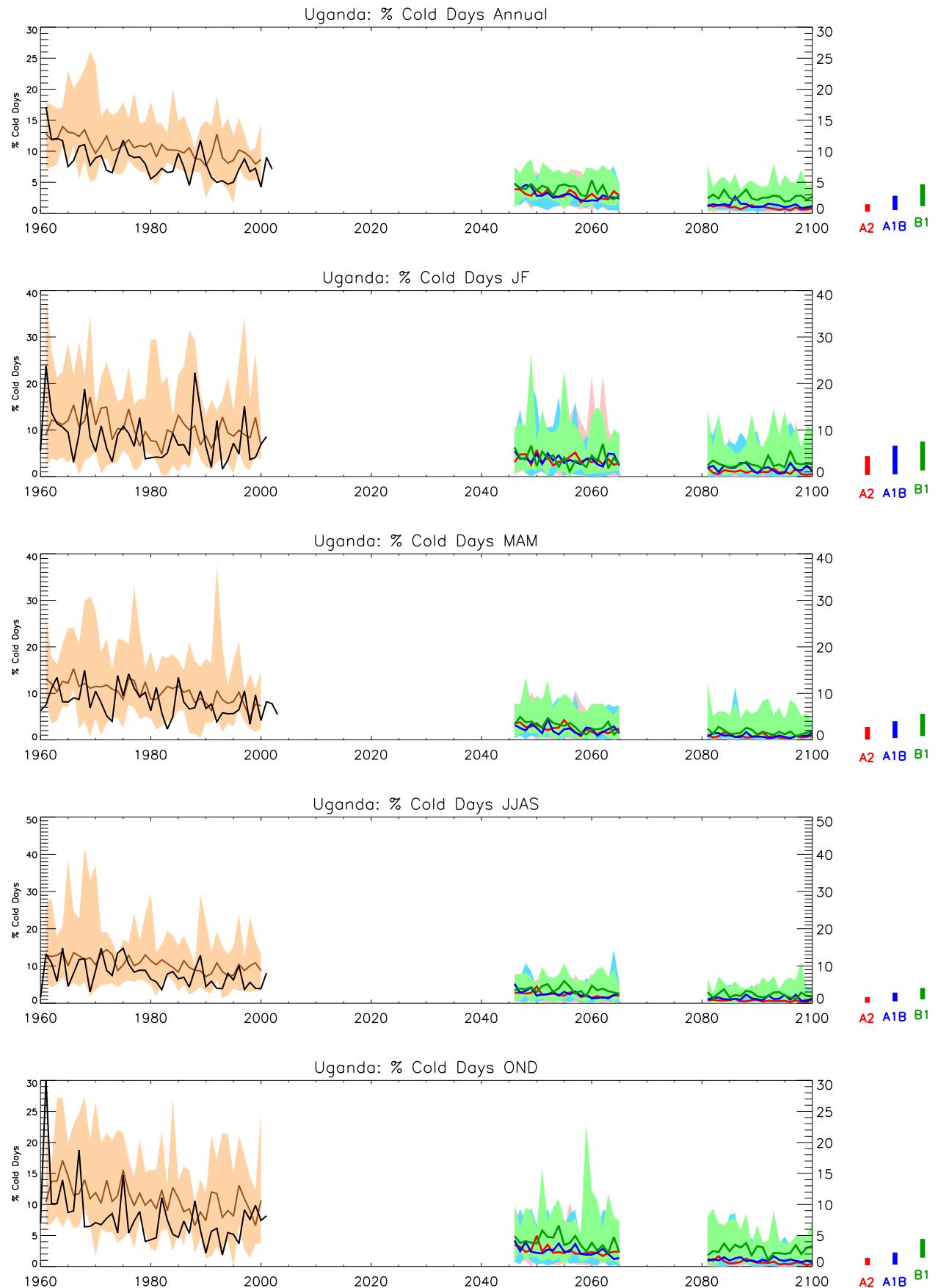


Figure 11: Trends in cold-day frequency for the recent past and projected future. See Figure 1 for details.

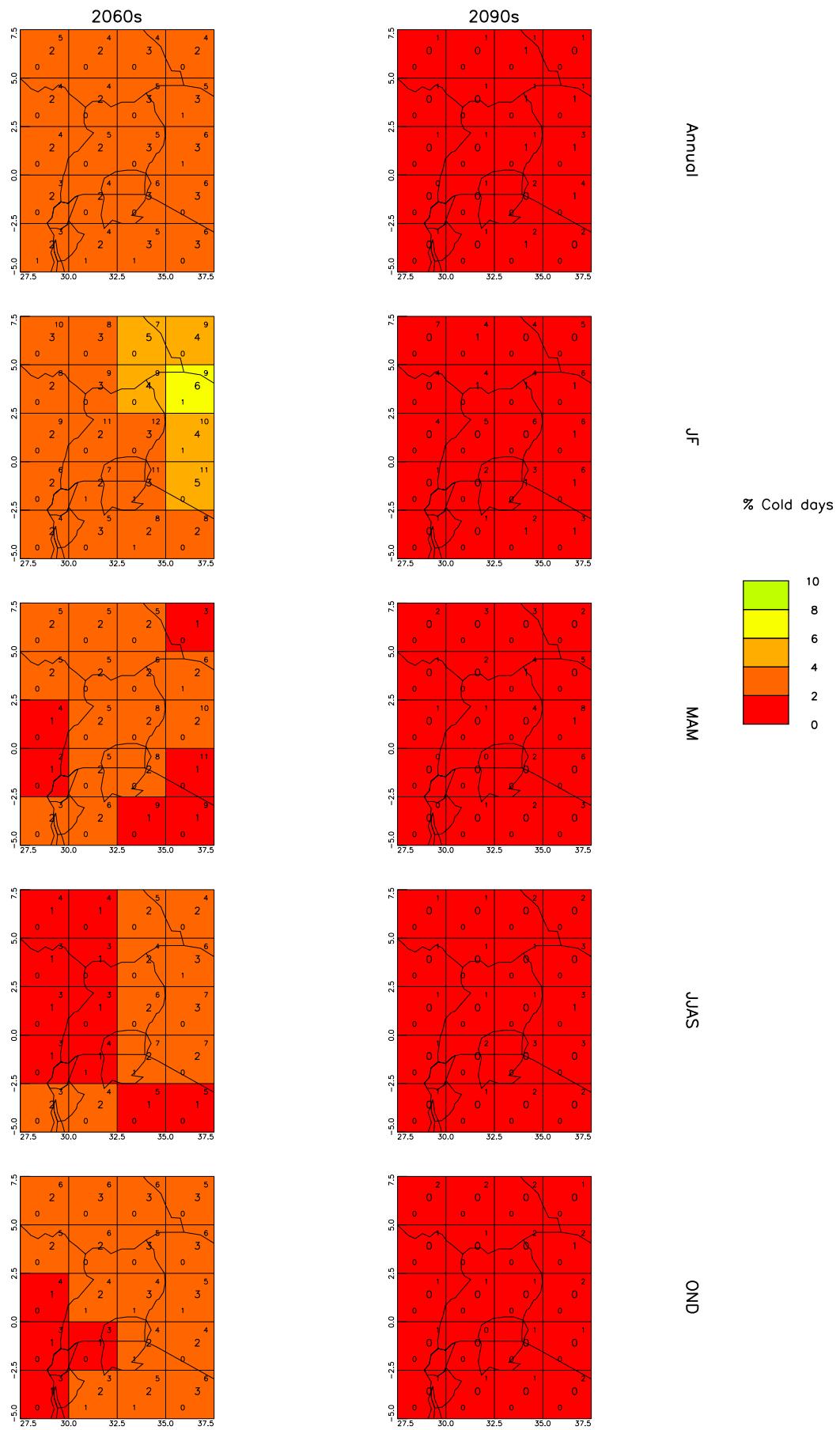


Figure 12: Spatial patterns of projected change in cold-day frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

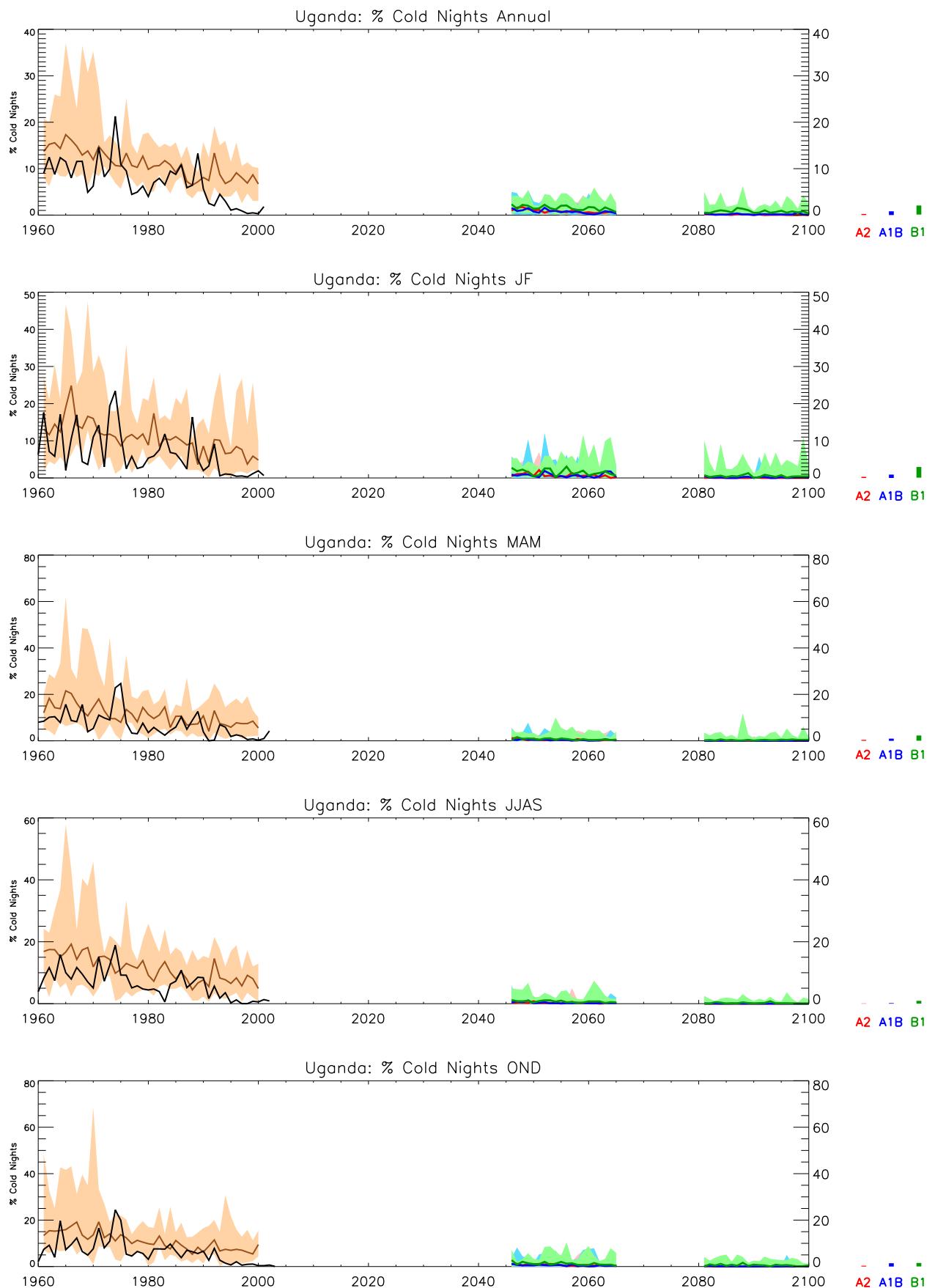


Figure 13: Trends in cold-night frequency for the recent past and projected future. See Figure 1 for details.

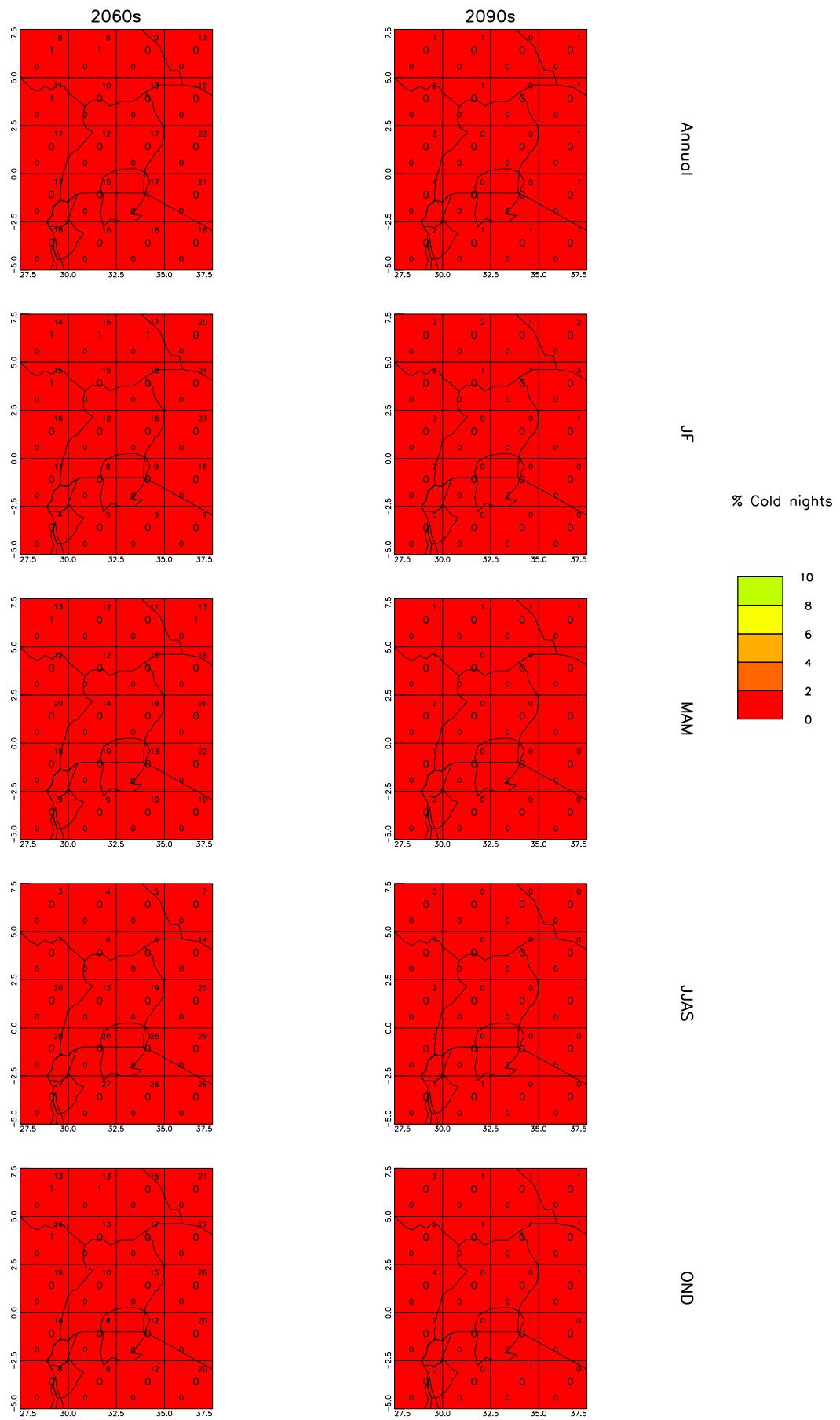


Figure 14: Spatial patterns of projected change in cold-night frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

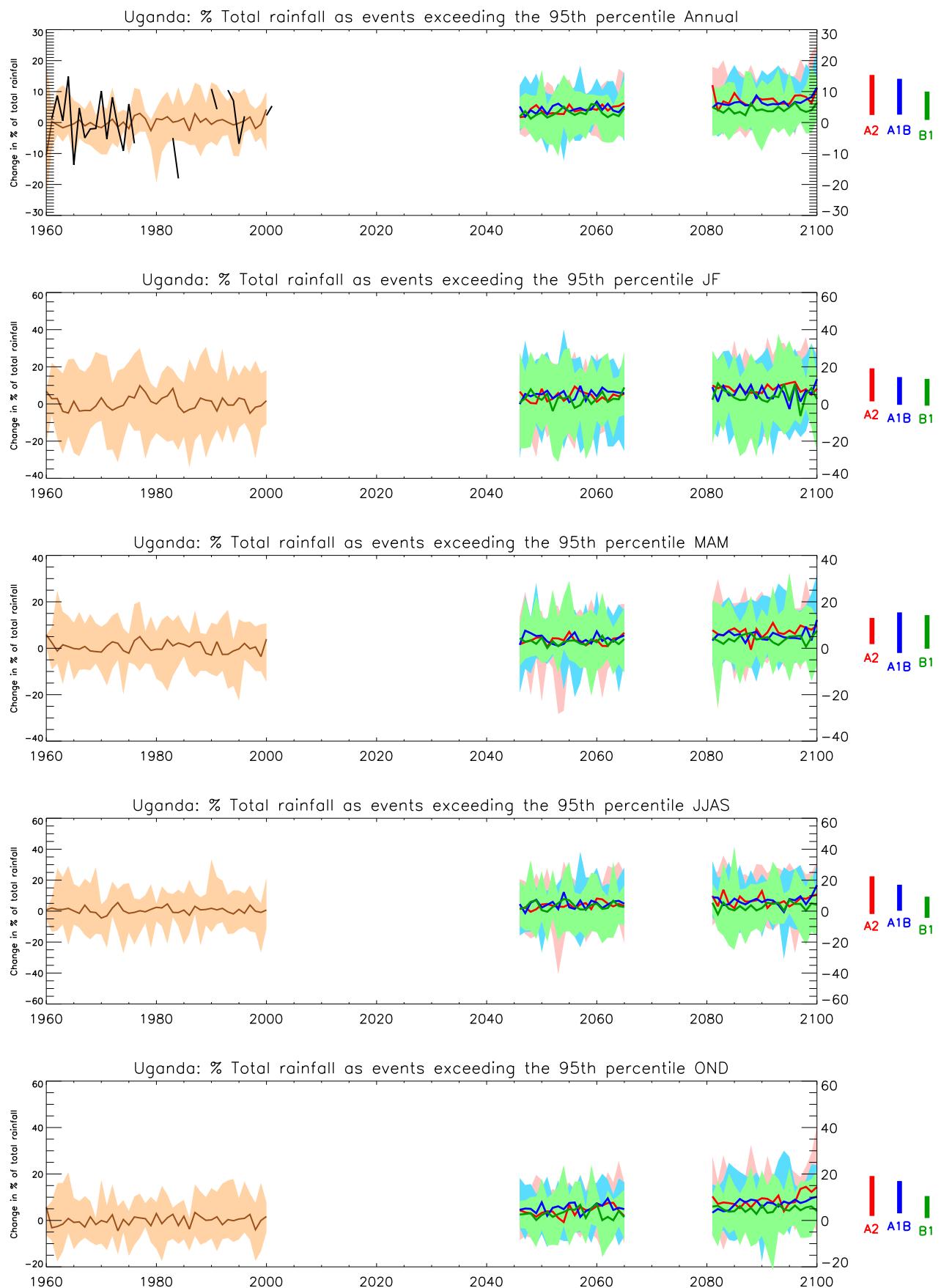


Figure 15: Trends in the proportion of precipitation falling in 'heavy' events for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

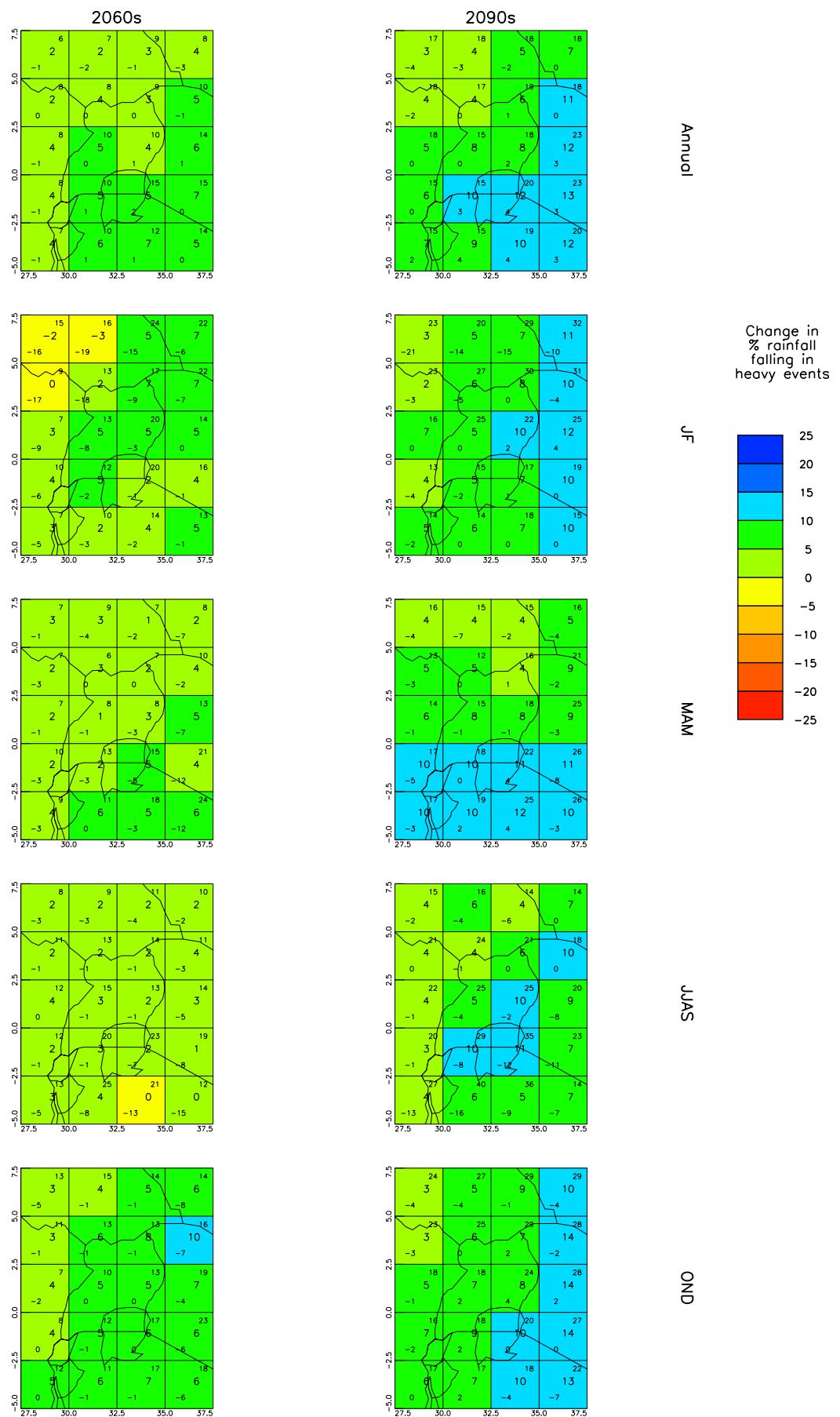


Figure 16: Spatial patterns of projected change in the proportion of precipitation falling in 'heavy' events for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970–1999. See Figure 2 for details.

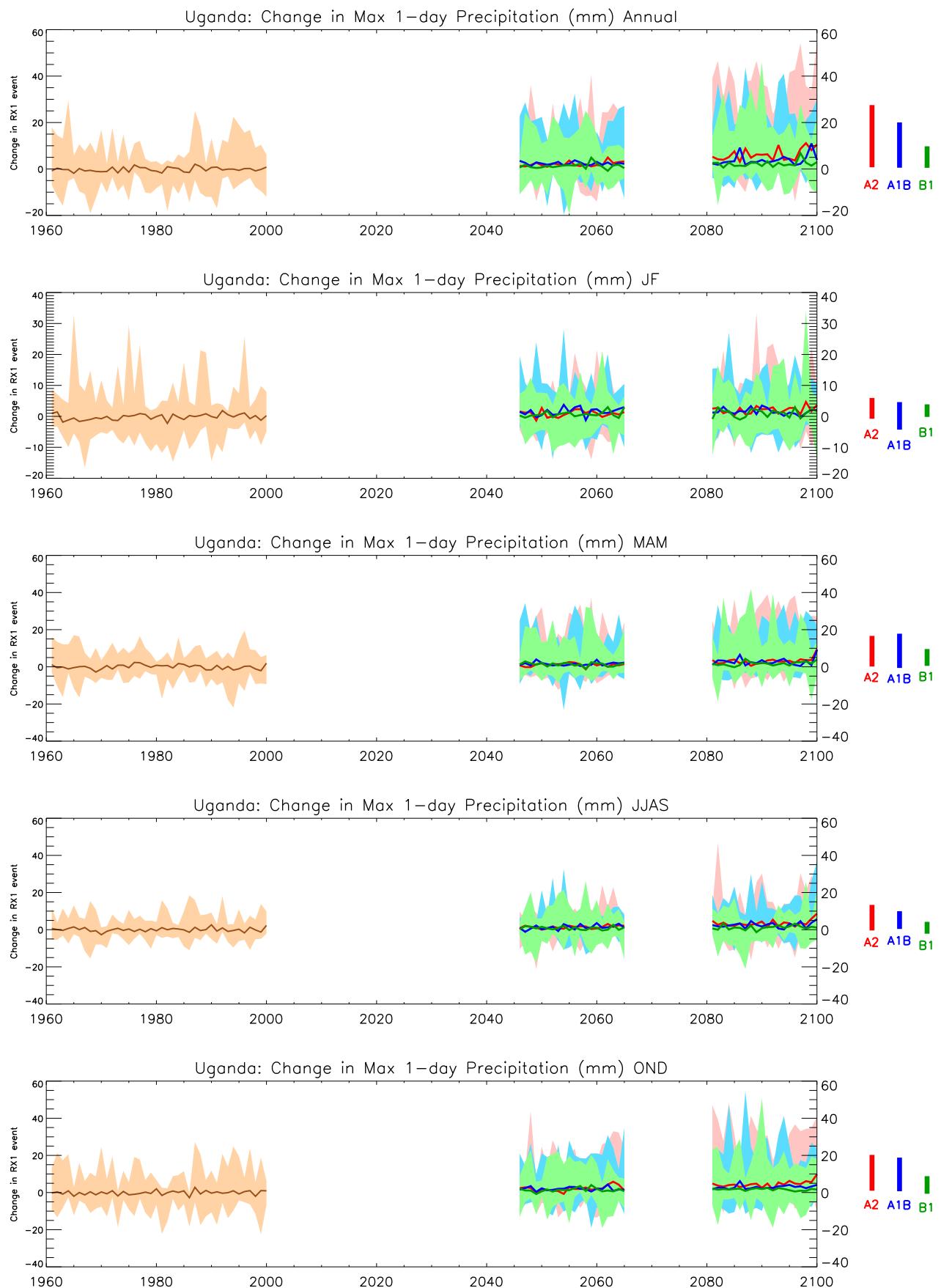


Figure 17: Trends in maximum 1-day rainfall for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

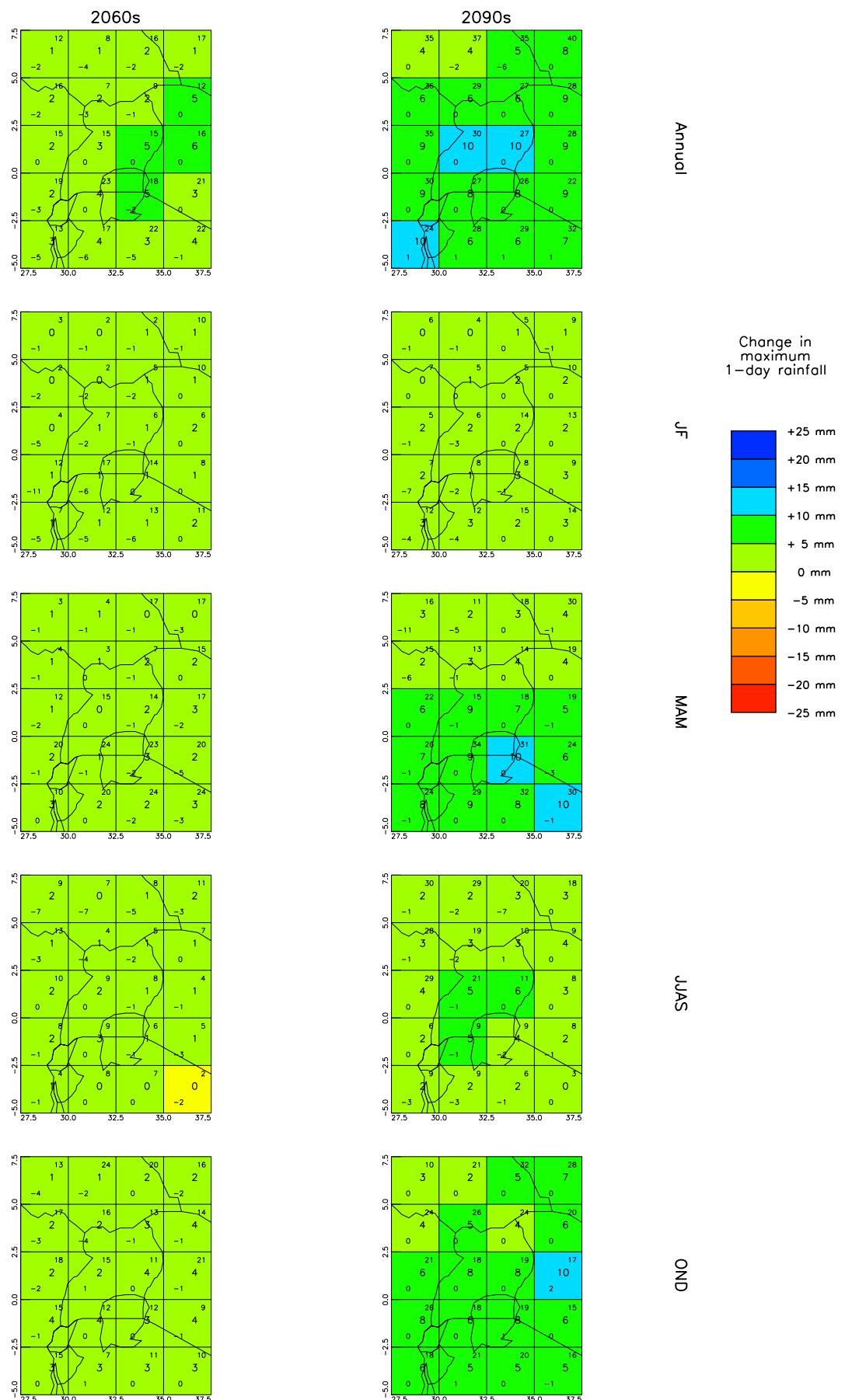


Figure 18: Spatial patterns of maximum 1-day rainfall for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. See Figure 2 for details.

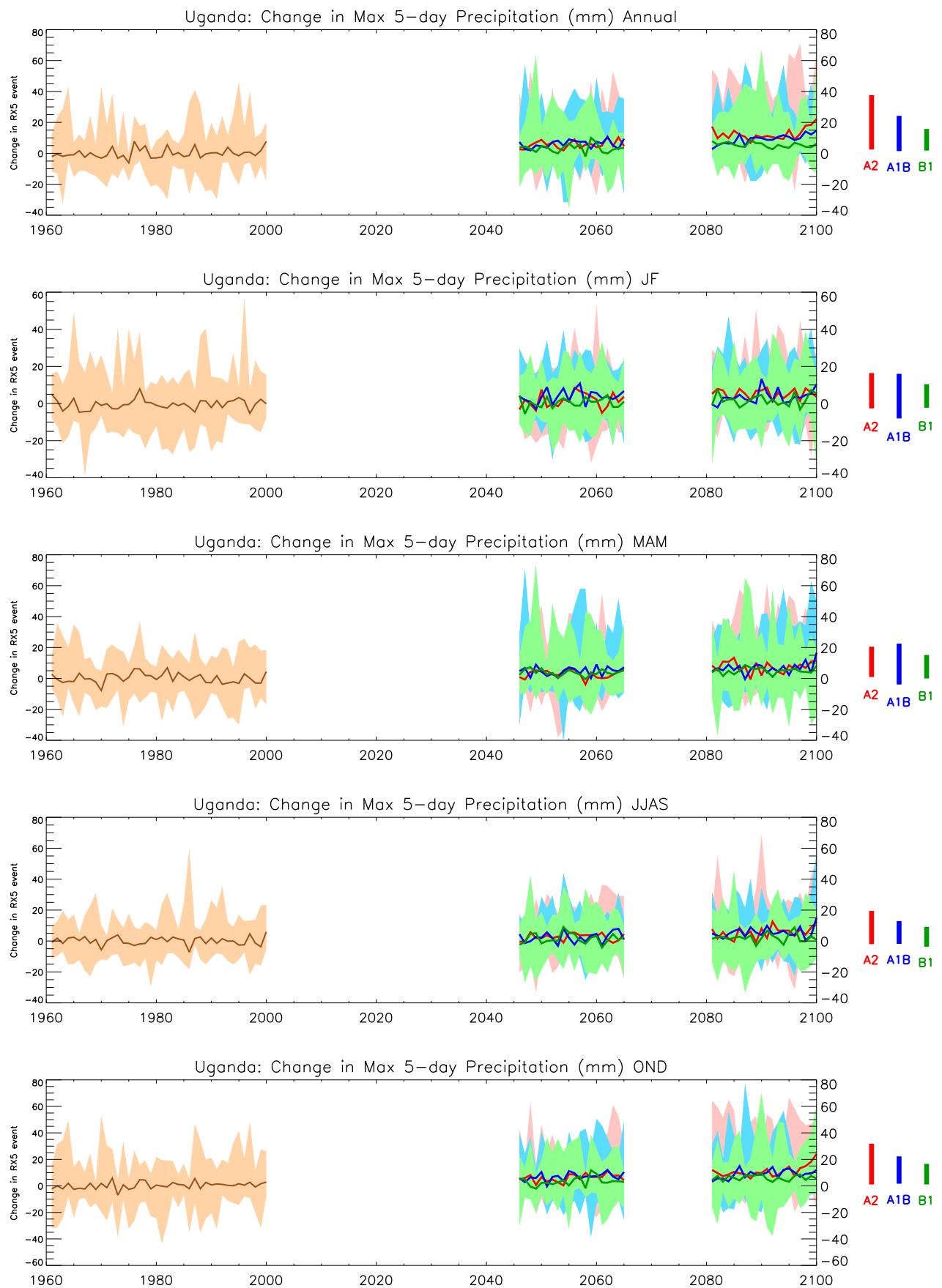


Figure 19: Trends in maximum 5-day rainfall for the recent past and projected future. All values shown are anomalies, relative to the 1970–1999 mean climate. See Figure 1 for details.

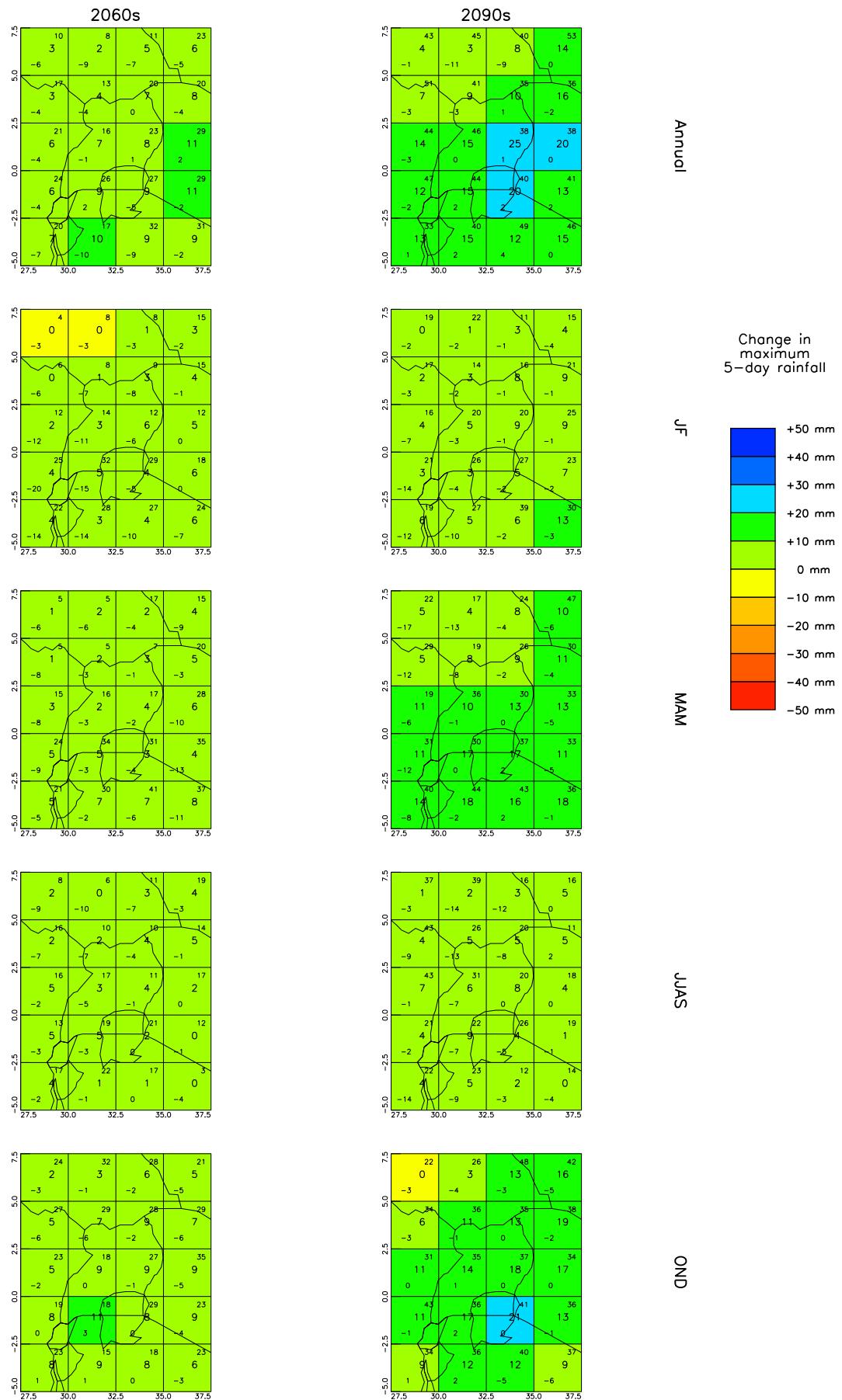


Figure 20: Spatial patterns of projected change in maximum 5-day rainfall for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970–1999. See Figure 2 for details.