

# Lebanon

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## General Climate

Lebanon is a country in Asia stretching along the east side of the Mediterranean Sea. Lebanon's north-south position, proximity to the sea, and mountainous terrain give rise to several climate zones. It has a Mediterranean-type climate characterized by hot and dry summers (Jun – Sep) and cool and rainy winters (Dec – mid-Mar). Spring and autumn are warm and pleasant.

Along the coast, summers are hot and humid with temperatures crossing 35°C in August. But due to the moderating effect of the sea, the daily temperature range is narrower than it is inland. January is the coldest month, with temperatures around 5 to 10°C. About 70% of the average rainfall in the country falls between November and March and is concentrated during only a few days of the rainy season, falling in heavy cloudbursts or violent storms. Rainfall in inland Lebanon is higher – with snow in the mountains – than that along the coast. The amount of rainfall varies greatly from year to year.

The climate of winter and spring are influenced by cold winds from Europe and hot winds blowing from the Egyptian desert called the *khamsin* respectively.

## Recent Climate Trends

### Temperature

- Mean temperature in Lebanon has increased in MAM and JJA at an average rate of 0.15°C per decade and 0.26°C per decade respectively (Table 1, Fig. 1). Increasing trend in mean annual temperature is not statistically significant.
- Daily temperature observations show statistically significant trends in the frequency of 'hot' and 'cold' nights. Trends in the frequency of 'hot' and 'cold' days are not statistically significant.

- The average number of 'hot'<sup>1</sup> nights per year in Lebanon has increased by 27 (an additional 7.3% of days) between 1960 and 2003 (Table 2). The rate of increase is seen most strongly in JJA.
- The average number of 'cold'<sup>2</sup> nights per year in Lebanon has decreased by 23 (an additional 6.4% of nights; Table 2). The rate of increase is seen most strongly in JJA.

## Precipitation

- Available observations do not show any statistically significant trend in rainfall in Lebanon since 1960 (Table 1).
- The magnitude of annual 1-day rainfall maxima shows statistically significant increases (2.71mm per decade) between 1960 and 2003 (Table 3). Other measures of extreme rainfall do not exhibit statistically significant trends.

## GCM Projections of Future Climate

### Temperature

- The mean annual temperature is projected to increase by 0.7 to 2.9°C by the 2060s, and 1.2 to 4.2°C by the 2090s (Table 1, Fig. 2). The range of projections by the 2090s under any one emissions scenario is around 1-2°C. The projected rate of warming is similar throughout the year.
- All projections indicate increases in the frequency of days and nights that are considered 'hot' in current climate.
  - Annually, projections indicate that the frequency of 'hot' days will increase from 14.5% during the period 1970-1999 to 15-24% of days by the 2060s, and 17-31% of days by the 2090s (Table 2, Fig. 7, 8).
  - Nights that are considered 'hot' for the annual climate of 1970-99 are projected to increase from 14% to 16-28% of nights by the 2060s and 18-34% of nights by the 2090s (Table 2, Fig. 9, 10).
- All projections indicate decreases in the frequency of days and nights that are considered 'cold' in current climate. The frequency of these events is reduced to 2 to 6% by the 2090s (Table 2, Figs. 11-14).

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<sup>1</sup> '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.

<sup>2</sup> 'Cold' day or 'cold' night is defined as the temperature below which 10% of days or nights are recorded in current climate of that region and season.

## Precipitation

- Projections of mean annual rainfall from different models in the ensemble are consistent in indicating decreases in rainfall for Lebanon. Ensemble median values for all seasons are negative (Table 1, Figs. 3-6). Annual projections vary between -53 to -10% by the 2090s with ensemble median changes of -27 to -15%.
- The proportion of total rainfall that falls in heavy<sup>3</sup> events decreases in most model projections, changing by -10% to +6% by the 2090s (Table 3, Figs. 15, 16).
- Projections for maximum 1-day rainfall indicate very small or no changes. Maximum 5-day rainfalls tend to decrease in model projections, changing by -9 to +2mm by the 2090s (Table 3, Figs. 17-20).

## Additional Regional Climate Change Information

- The size of Lebanon is much smaller than the typical horizontal resolution (roughly 200 km) of the climate models used for model projections (see Fig 2). Therefore, climate projections discussed here represent projections for a much bigger region surrounding Lebanon. Also, the coarse spatial resolution of the models hampers their ability to simulate local-scale climate features of the region.
- For further information see Christensen *et al.* (2007) IPCC Working Group I Report: '*The Physical Science Basis*', Chapter 11 (*Regional Climate projections*): Sections 11.4 (*Asia*).

## Methods and Documents

This report provides basic analyses of observations and climate model data in the form of narrative, data tables, and graphics as an “off the shelf” resource and can be consulted in investigations of climate impacts, risk assessments, or adaptation options and for use in further research. It is important to note that significant limitations and caveats are involved wherever climate model projections are applied. Please refer to the following documents for additional information.

Rationale and Methodology: McSweeney, C., G. Lizcano, M. New, X. Lu, 2010: The UNDP Climate Change Country Profiles. *Bull. Amer. Meteor. Soc.*, 91, 157–166. doi: 10.1175/2009BAMS2826.1  
<http://journals.ametsoc.org/doi/pdf/10.1175/2009BAMS2826.1>

Technical details: [http://country-profiles.geog.ox.ac.uk/UNDPCCCP\\_documentation.pdf](http://country-profiles.geog.ox.ac.uk/UNDPCCCP_documentation.pdf)

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<sup>3</sup> 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.

Data Summary

Table 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	
Temperature												
	(°C)	(change in °C per decade)		Change in °C			Change in °C			Change in °C		
Annual	16.6	0.11	A2	0.6	0.9	1.4	1	2.2	2.8	2.4	4	4.2
			A1B	0	0.9	1.6	0.7	2.2	2.9	1.7	3.2	3.7
			B1	0.2	1	1.5	0.7	1.6	2.2	1.2	2.3	2.7
DJF	8.6	0.01	A2	0.1	0.6	1	0.3	1.7	2.1	1.8	3	3.9
			A1B	-0.4	0.6	1.5	0.2	1.8	2.2	1	2.5	3.7
			B1	0.1	0.5	1.3	0.2	1.3	2	0.5	1.6	2.5
MAM	15.1	0.15*	A2	0.4	1.1	2	1.1	2.1	2.8	2.4	3.7	5.1
			A1B	-0.2	1.1	1.9	0.8	2.2	2.8	1.8	3	4.2
			B1	0.2	1	1.6	0.7	1.4	2.3	1	2.1	3
JJA	23.9	0.26*	A2	0.6	1.2	2.3	1.5	2.5	4.5	3.1	4.3	6
			A1B	0.3	1.1	2.4	1.3	2.8	4.3	2.3	3.9	4.6
			B1	0.5	1.2	2.8	0.9	1.8	2.7	1.8	2.5	3.6
SON	18.7	0.11	A2	0.1	1.1	1.7	1.1	2.2	3.5	2.4	4.2	5
			A1B	-0.1	1	2	0.6	2.4	3.6	1.6	3.3	4.2
			B1	-0.1	1.1	1.5	0.7	1.7	2.4	1.7	2.5	3.1
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	51.8	-0.6	A2	-3	-1	1	-6	-2	0	-11	-4	-2
			A1B	-4	-2	1	-7	-2	0	-9	-3	-1
			B1	-2	-1	1	-4	-1	0	-5	-2	0
DJF	120	-2.2	A2	-8	-1	4	-15	-4	0	-22	-10	-2
			A1B	-11	-2	2	-15	-6	4	-19	-6	0
			B1	-8	-1	1	-13	-5	1	-12	-5	1
MAM	48.5	-2.1	A2	-4	-1	3	-6	-2	0	-8	-3	-2
			A1B	-5	-2	4	-5	-2	2	-8	-3	-1
			B1	-3	0	2	-6	-1	2	-9	-1	1
JJA	1.7	0	A2	-3	0	0	-2	0	0	-3	0	0
			A1B	-5	0	2	-3	0	1	-1	0	1
			B1	-1	0	2	-3	0	2	-1	0	3
SON	36.3	1.3	A2	-6	0	5	-15	-3	0	-12	-3	4
			A1B	-7	0	1	-13	-2	2	-12	-4	3
			B1	-9	0	3	-7	0	1	-4	-2	2
Precipitation (%)												
	(mm per month)	(change in % per decade)		% Change			% Change			% Change		
Annual	51.8	-1.1	A2	-24	-7	10	-33	-15	-9	-53	-27	-10
			A1B	-24	-11	4	-32	-18	-2	-39	-19	-7
			B1	-16	-5	9	-28	-11	1	-31	-15	6
DJF	120	-1.8	A2	-30	-6	12	-35	-15	2	-51	-25	-12
			A1B	-33	-8	10	-41	-22	10	-43	-19	1
			B1	-22	-5	6	-29	-15	8	-30	-18	7
MAM	48.5	-4.3	A2	-26	-8	27	-44	-10	3	-61	-29	-12
			A1B	-37	-15	21	-35	-21	26	-36	-24	-16
			B1	-28	-6	15	-44	-8	14	-51	-6	21
JJA	1.7	-0.7	A2	-63	-8	30	-83	-18	14	-96	-39	37
			A1B	-73	-12	24	-66	-20	60	-85	-16	30
			B1	-75	-11	24	-74	-9	55	-93	-12	76
SON	36.3	3.5	A2	-41	-2	31	-62	-18	-1	-52	-28	28
			A1B	-46	-3	12	-55	-20	15	-51	-27	18
			B1	-37	-2	23	-35	-6	9	-28	-9	16



Table 2

	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	14.5	-0.29	A2	****	****	****	17	21	24	26	28	31
			A1B	****	****	****	18	22	24	21	26	28
			B1	****	****	****	15	17	20	17	20	23
DJF	12.1	-0.42	A2	****	****	****	16	26	37	27	45	68
			A1B	****	****	****	15	25	42	23	36	51
			B1	****	****	****	12	17	22	16	19	33
MAM	14.1	-0.04	A2	****	****	****	17	21	24	22	30	39
			A1B	****	****	****	15	20	25	22	25	32
			B1	****	****	****	13	18	21	17	18	24
JJA	14.8	0.36	A2	****	****	****	18	35	51	32	57	68
			A1B	****	****	****	26	36	49	24	47	67
			B1	****	****	****	17	24	43	18	34	44
SON	15.2	-0.74	A2	****	****	****	17	22	28	27	33	39
			A1B	****	****	****	16	24	29	22	30	39
			B1	****	****	****	14	19	23	18	23	28
Frequency of Hot Nights (TN90p)												
Annual	14.4	1.66*	A2	****	****	****	21	23	28	26	32	34
			A1B	****	****	****	19	24	27	24	29	32
			B1	****	****	****	16	19	23	18	22	26
DJF	12.4	-0.48	A2	****	****	****	15	25	30	22	39	55
			A1B	****	****	****	16	22	33	18	34	43
			B1	****	****	****	12	18	20	15	20	34
MAM	13.7	0.93	A2	****	****	****	19	21	28	28	34	43
			A1B	****	****	****	16	23	26	25	27	37
			B1	****	****	****	14	19	21	16	21	27
JJA	17.4	4.46*	A2	****	****	****	22	41	63	53	65	80
			A1B	****	****	****	27	38	63	34	54	77
			B1	****	****	****	15	27	56	21	36	61
SON	17.1	1.76*	A2	****	****	****	20	27	35	31	44	47
			A1B	****	****	****	19	31	35	26	36	44
			B1	****	****	****	15	23	31	21	29	36
Frequency of Cold Days (TX10p)												
Annual	10	-0.22	A2	****	****	****	2	4	8	0	2	5
			A1B	****	****	****	2	4	9	0	3	5
			B1	****	****	****	4	6	8	3	4	7
DJF	11.1	0.24	A2	****	****	****	1	3	9	0	2	5
			A1B	****	****	****	1	4	13	0	2	4
			B1	****	****	****	2	4	8	2	4	8
MAM	10.2	-0.01	A2	****	****	****	2	4	5	0	1	3
			A1B	****	****	****	2	4	5	1	3	5
			B1	****	****	****	2	6	6	2	4	8
JJA	9.7	-0.79	A2	****	****	****	1	2	3	0	0	1
			A1B	****	****	****	1	2	5	0	1	2
			B1	****	****	****	2	3	5	1	2	4
SON	10	0.01	A2	****	****	****	2	4	6	0	3	4
			A1B	****	****	****	1	4	8	0	3	6
			B1	****	****	****	5	7	8	3	4	7
Frequency of Cold Nights (TN10p)												
Annual	9.2	-1.46*	A2	****	****	****	3	5	6	0	3	5
			A1B	****	****	****	3	5	8	1	4	5
			B1	****	****	****	4	7	8	3	6	7
DJF	10.8	-0.54	A2	****	****	****	1	4	8	0	2	4
			A1B	****	****	****	2	4	12	0	3	4
			B1	****	****	****	3	6	9	2	5	7
MAM	9.3	-0.95	A2	****	****	****	1	3	5	0	2	3
			A1B	****	****	****	1	3	6	0	2	5
			B1	****	****	****	1	5	7	2	3	6
JJA	7.4	-3.38*	A2	****	****	****	1	1	2	0	0	0
			A1B	****	****	****	0	1	4	0	0	1
			B1	****	****	****	2	2	5	1	1	3
SON	9.1	-1.49*	A2	****	****	****	2	5	6	0	2	4
			A1B	****	****	****	1	4	7	1	4	6
			B1	****	****	****	4	6	7	2	5	7

Table 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	11	-0.59	A2	****	****	****	-6	0	1	-9	-2	6
			A1B	****	****	****	-4	-1	2	-10	-2	3
			B1	****	****	****	-6	-1	2	-5	0	4
DJF	****	****	A2	****	****	****	-10	-2	6	-8	-1	8
			A1B	****	****	****	-8	-2	4	-10	-1	3
			B1	****	****	****	-13	-2	4	-8	0	5
MAM	****	****	A2	****	****	****	-12	-2	5	-22	-6	5
			A1B	****	****	****	-11	-2	5	-22	-2	6
			B1	****	****	****	-8	1	6	-14	-2	8
JJA	****	****	A2	****	****	****	-22	-5	7	-40	-21	7
			A1B	****	****	****	-23	-7	13	-40	-9	12
			B1	****	****	****	-20	-3	5	-25	-9	1
SON	****	****	A2	****	****	****	-14	-4	1	-18	-5	11
			A1B	****	****	****	-16	0	7	-19	-1	10
			B1	****	****	****	-10	-1	7	-8	0	8
Maximum 1-day rainfall (RX1day)												
	mm	Change in mm per decade				Change in mm			Change in mm			
Annual	30.5	2.71*	A2	****	****	****	-2	0	0	-3	0	3
			A1B	****	****	****	-3	0	1	-2	0	1
			B1	****	****	****	-3	0	2	-4	0	1
DJF	15.9	0.14	A2	****	****	****	-1	0	0	-2	0	0
			A1B	****	****	****	-1	0	1	-2	-1	1
			B1	****	****	****	-2	0	0	-2	0	2
MAM	11.2	0.45	A2	****	****	****	-2	0	0	-3	0	0
			A1B	****	****	****	-1	-1	0	-3	-1	2
			B1	****	****	****	-1	0	3	-3	0	0
JJA	1	-0.11	A2	****	****	****	0	0	0	-3	0	1
			A1B	****	****	****	-3	0	1	-1	0	0
			B1	****	****	****	-2	0	1	-2	0	3
SON	9.7	-0.03	A2	****	****	****	-4	0	0	-2	0	1
			A1B	****	****	****	-3	0	1	-3	0	0
			B1	****	****	****	-1	0	1	-1	0	1
Maximum 5-day Rainfall (RX5day)												
	mm	Change in mm per decade				Change in mm			Change in mm			
Annual	54	-0.64	A2	****	****	****	-6	-2	1	-9	-3	0
			A1B	****	****	****	-5	-2	0	-9	-2	1
			B1	****	****	****	-5	-1	1	-5	-1	2
DJF	33.8	-1.67	A2	****	****	****	-6	-3	1	-10	-2	0
			A1B	****	****	****	-7	-1	0	-9	-3	0
			B1	****	****	****	-6	-2	0	-5	-2	2
MAM	19.3	-0.88	A2	****	****	****	-3	-1	0	-5	-2	1
			A1B	****	****	****	-4	-2	0	-5	-2	1
			B1	****	****	****	-3	0	3	-5	-1	2
JJA	1.8	-0.14	A2	****	****	****	-1	0	0	-6	-1	2
			A1B	****	****	****	-5	0	1	-3	0	2
			B1	****	****	****	-3	0	2	-5	0	5
SON	16.5	0.02	A2	****	****	****	-8	-2	0	-6	-2	2
			A1B	****	****	****	-8	-2	2	-7	-2	1
			B1	****	****	****	-4	-1	1	-4	0	5

\* indicates trend is statistically significant at 95% confidence

\*\*\*\* indicates data are not available

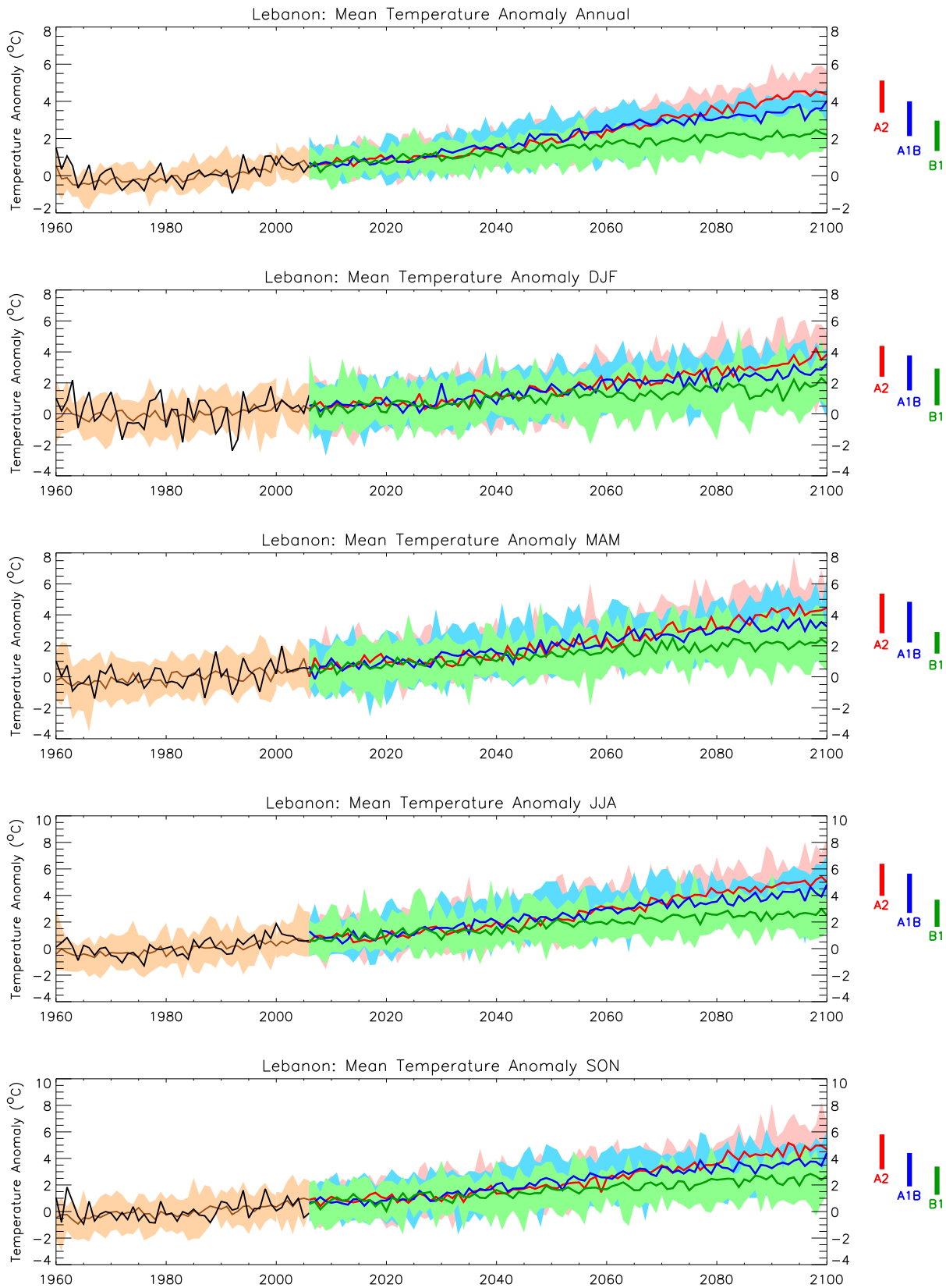


Figure 1: Trends in annual and seasonal mean temperature for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. Black curves show the mean of observed data from 1960 to 2006, Brown curves show the median (solid line) and range (shading) of model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

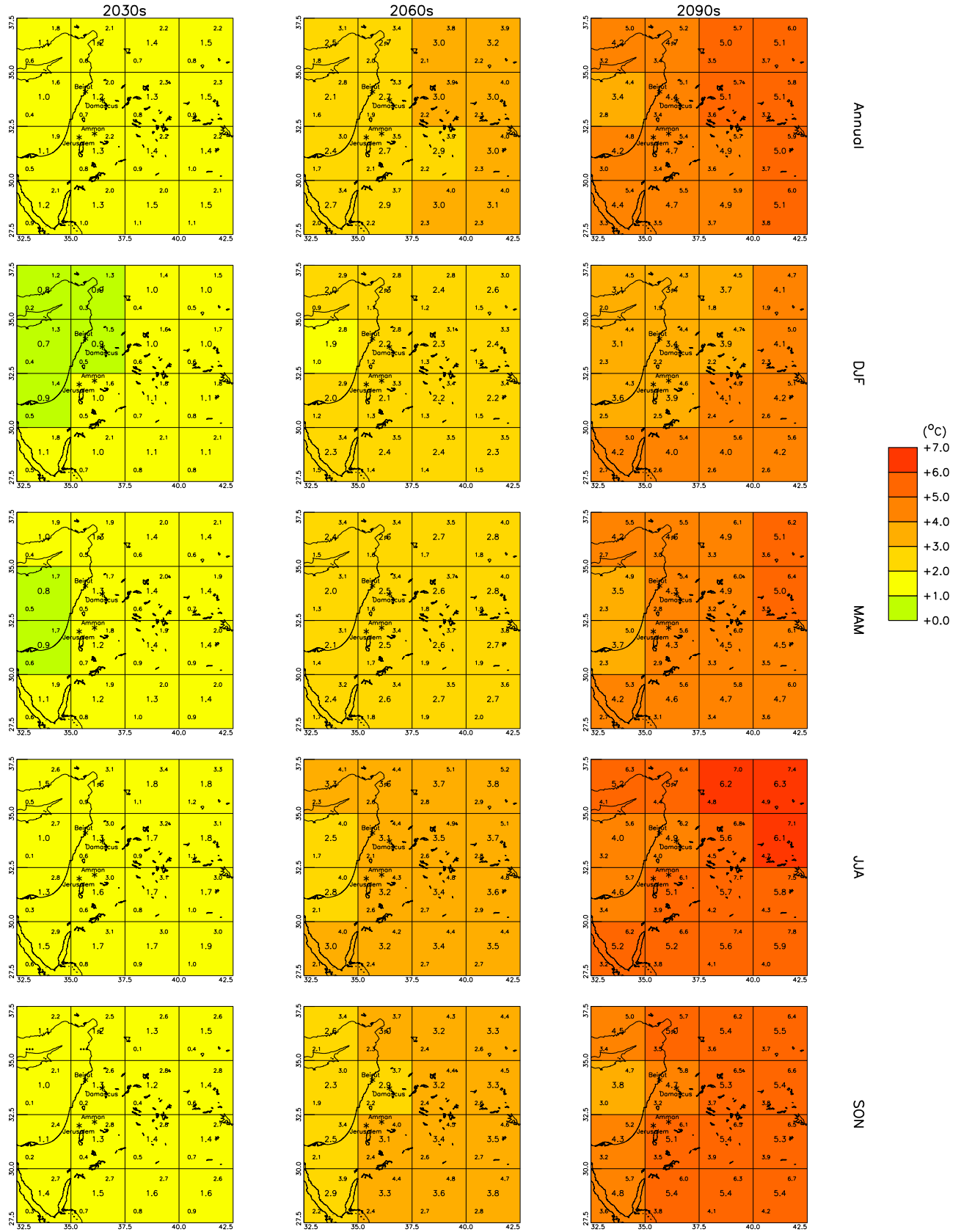


Figure 2: Spatial patterns of projected change in mean annual and seasonal temperature for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. In each grid box, the central value gives the ensemble median and the values in the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



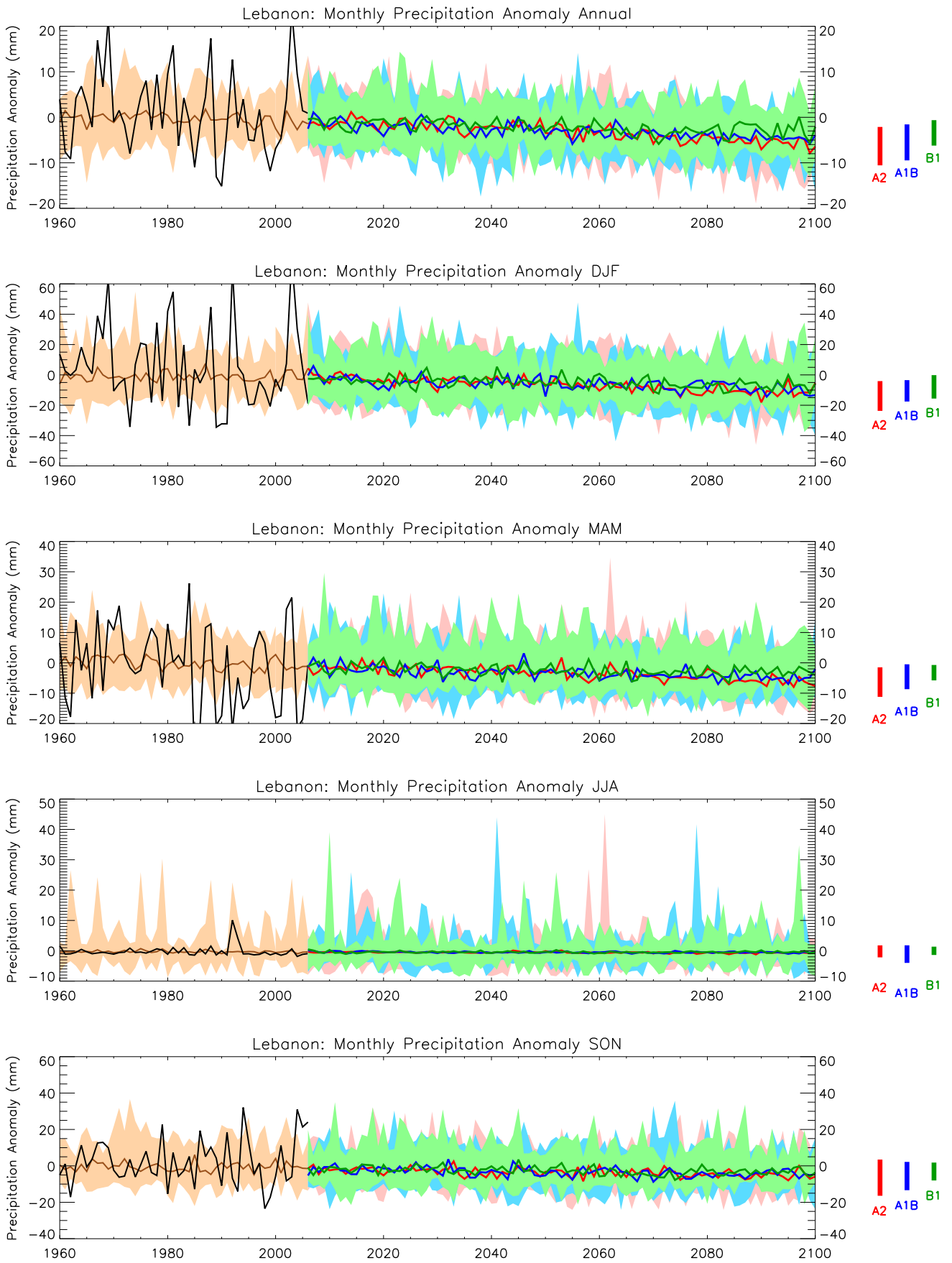


Figure 3: Trends in monthly precipitation for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

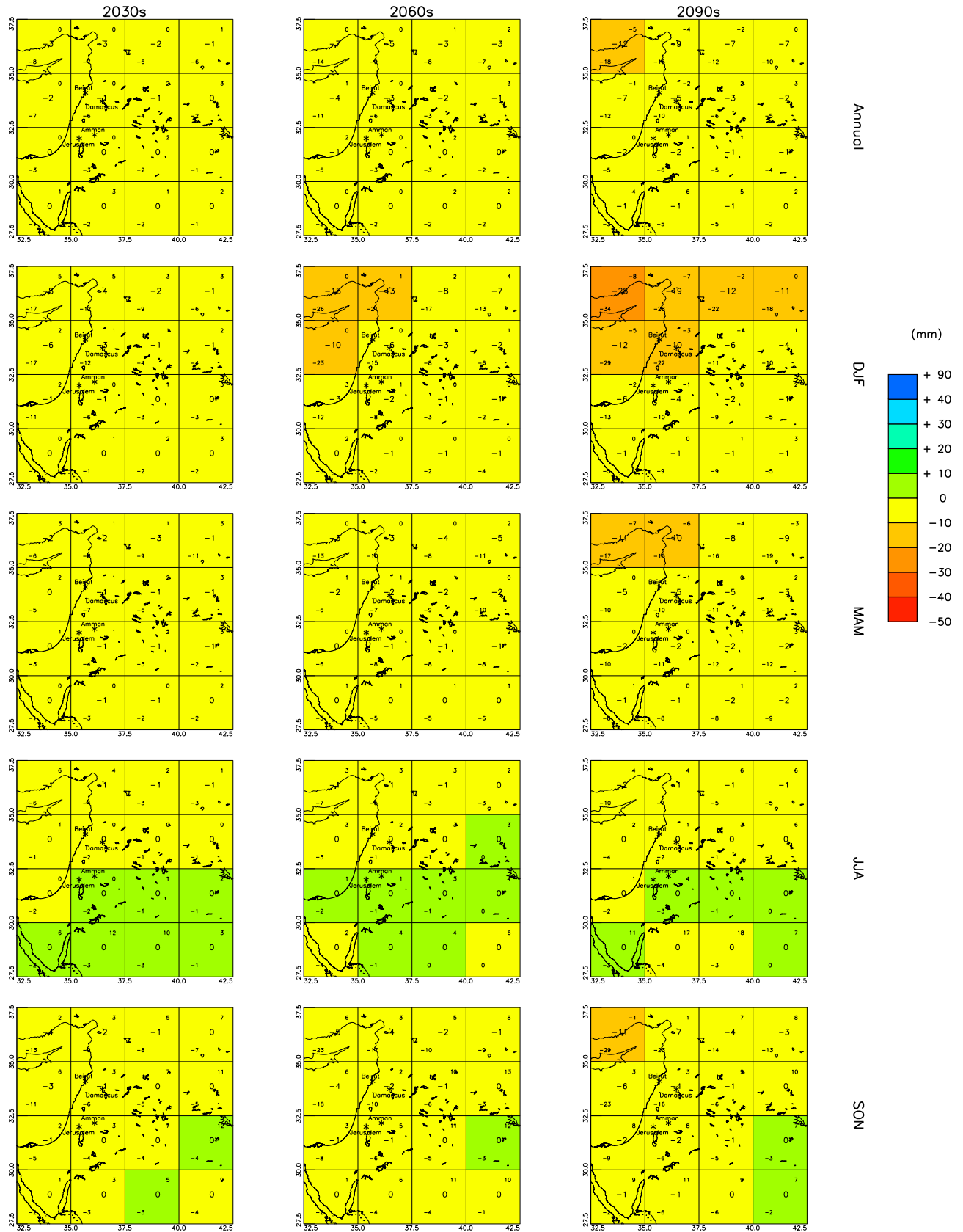


Figure 4: Spatial patterns of projected change in monthly precipitation for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. See Figure 2 for details.

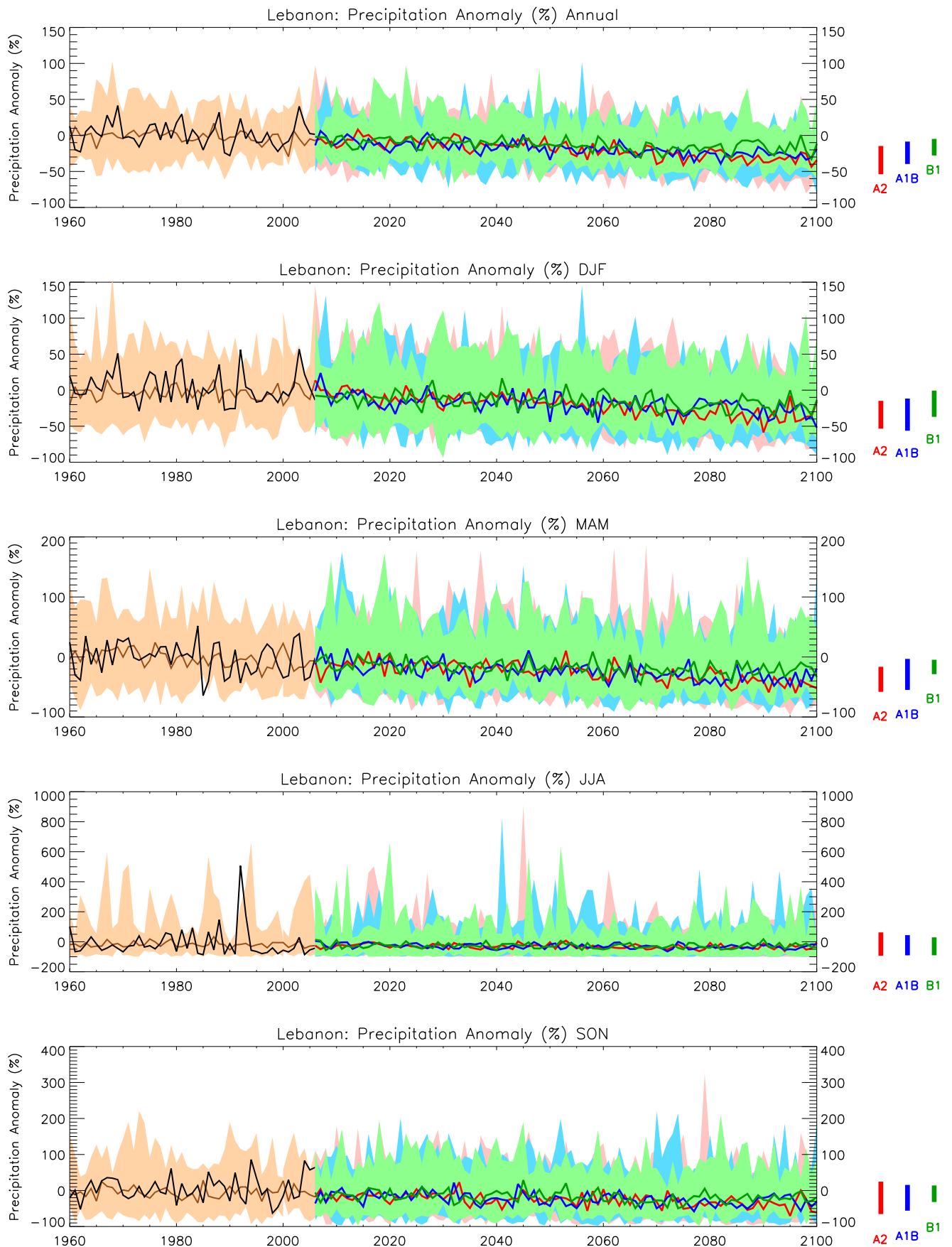


Figure 5: Trends in monthly precipitation for the recent past and projected future. All values shown are percentage anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.



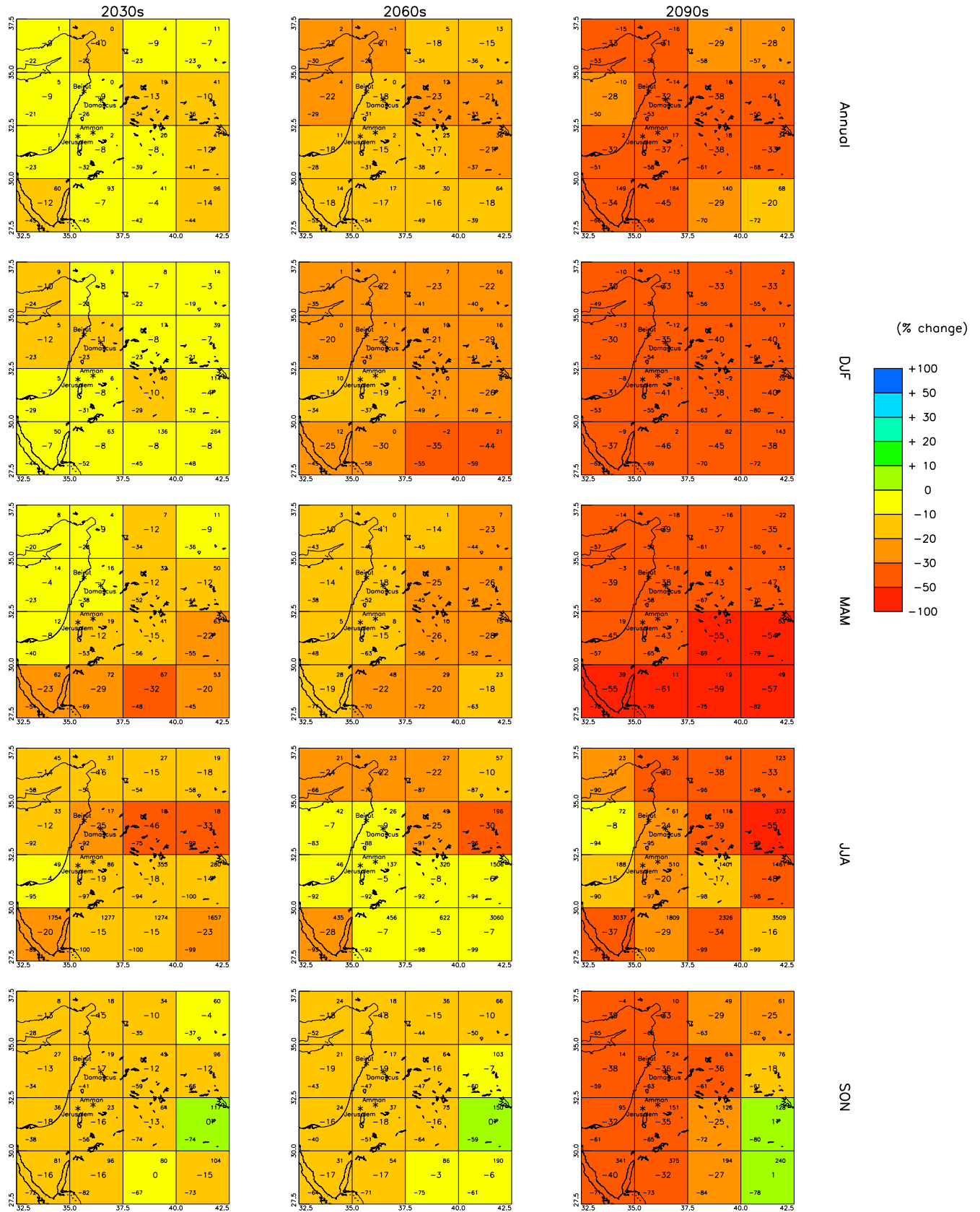


Figure 6: Spatial patterns of projected change in monthly precipitation for 10-year periods in the future under the SRES A2 scenario. All values are percentage anomalies relative to the mean climate of 1970-1999. See Figure 2 for details.

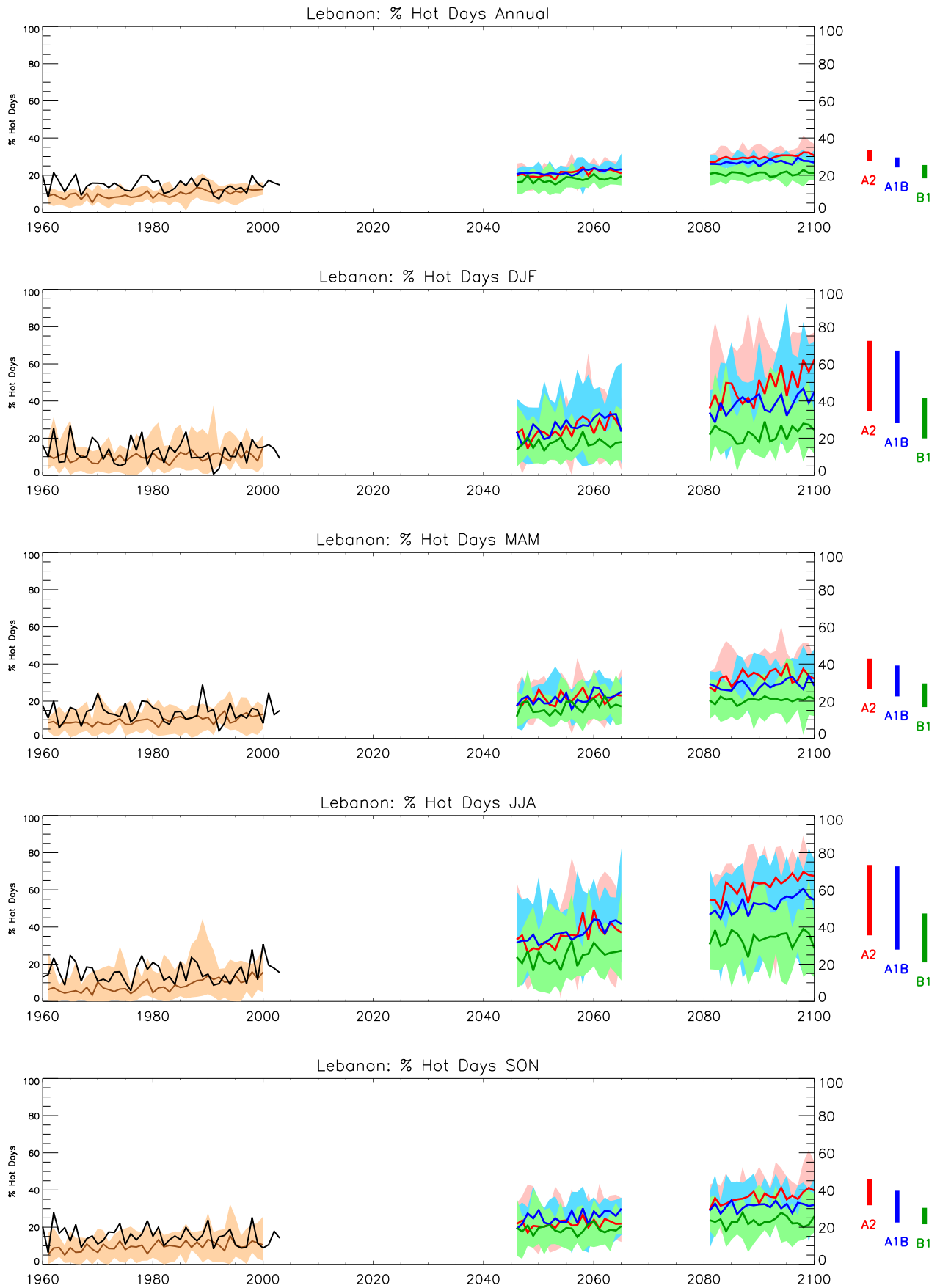


Figure 7: Trends in hot-day frequency for the recent past and projected future. See Figure 1 for details.

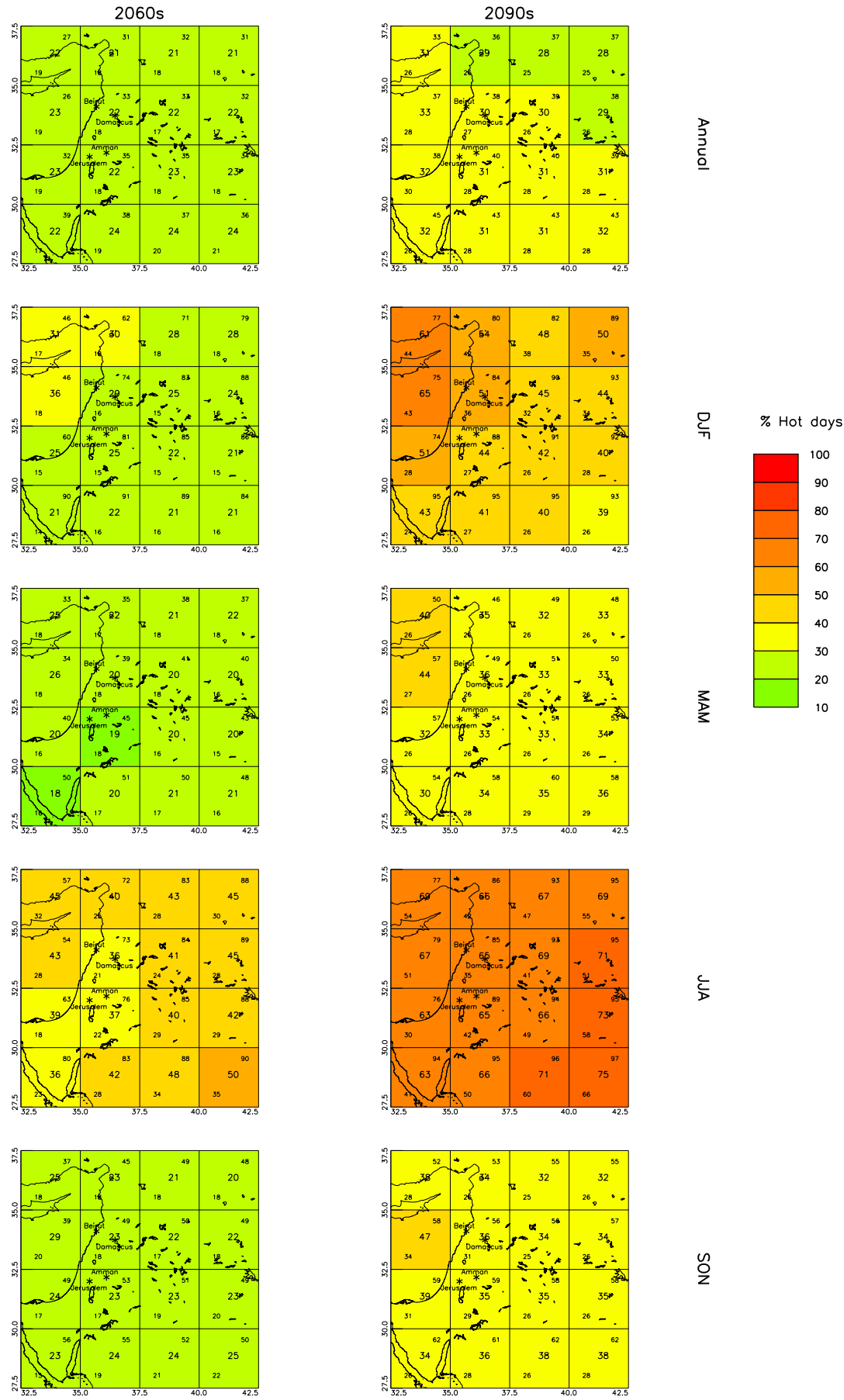


Figure 8: Spatial patterns of hot-day frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

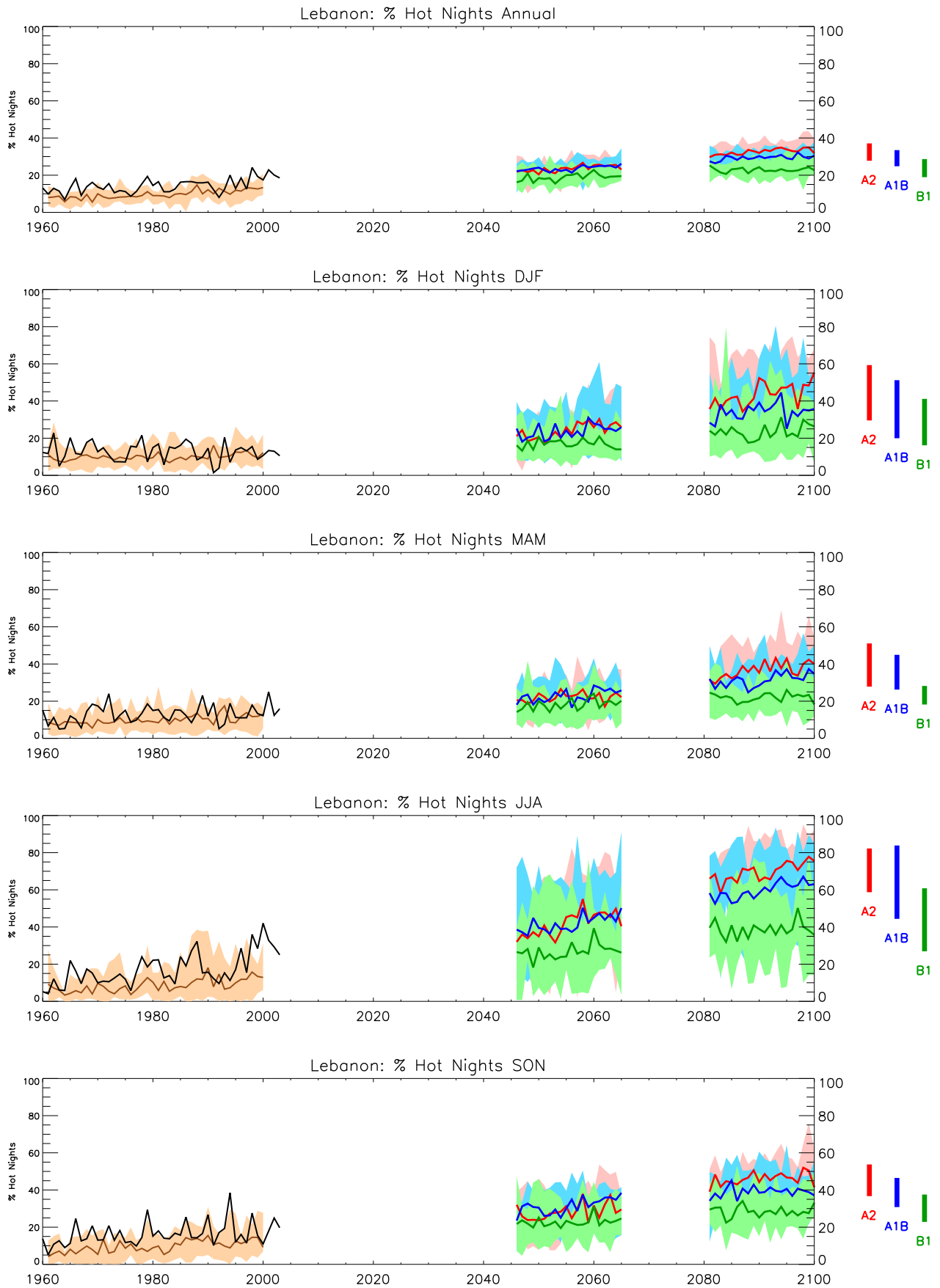


Figure 9: Trends in hot-night frequency for the recent past and projected future. See Figure 1 for details.

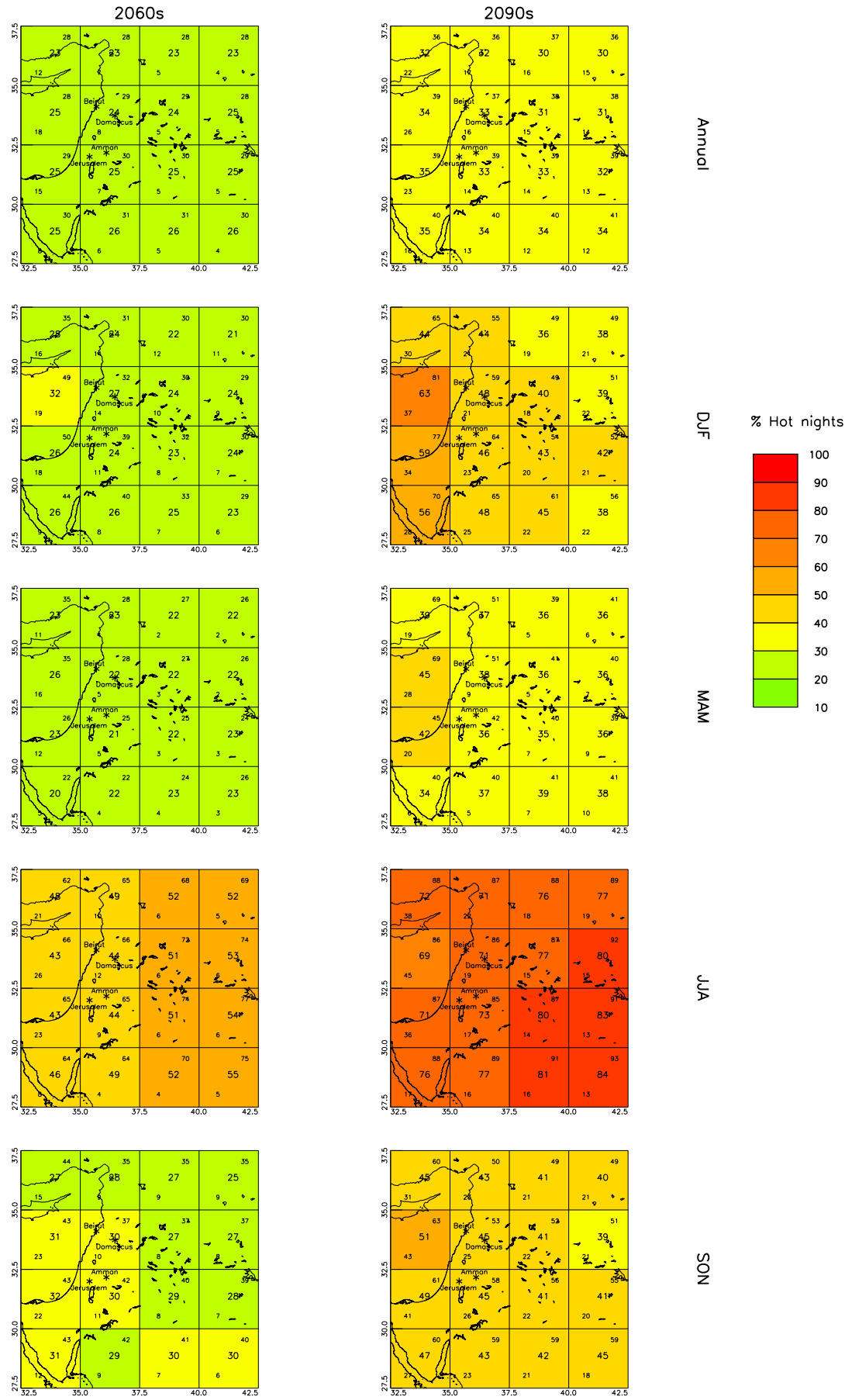


Figure 10: Spatial patterns of hot-night frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

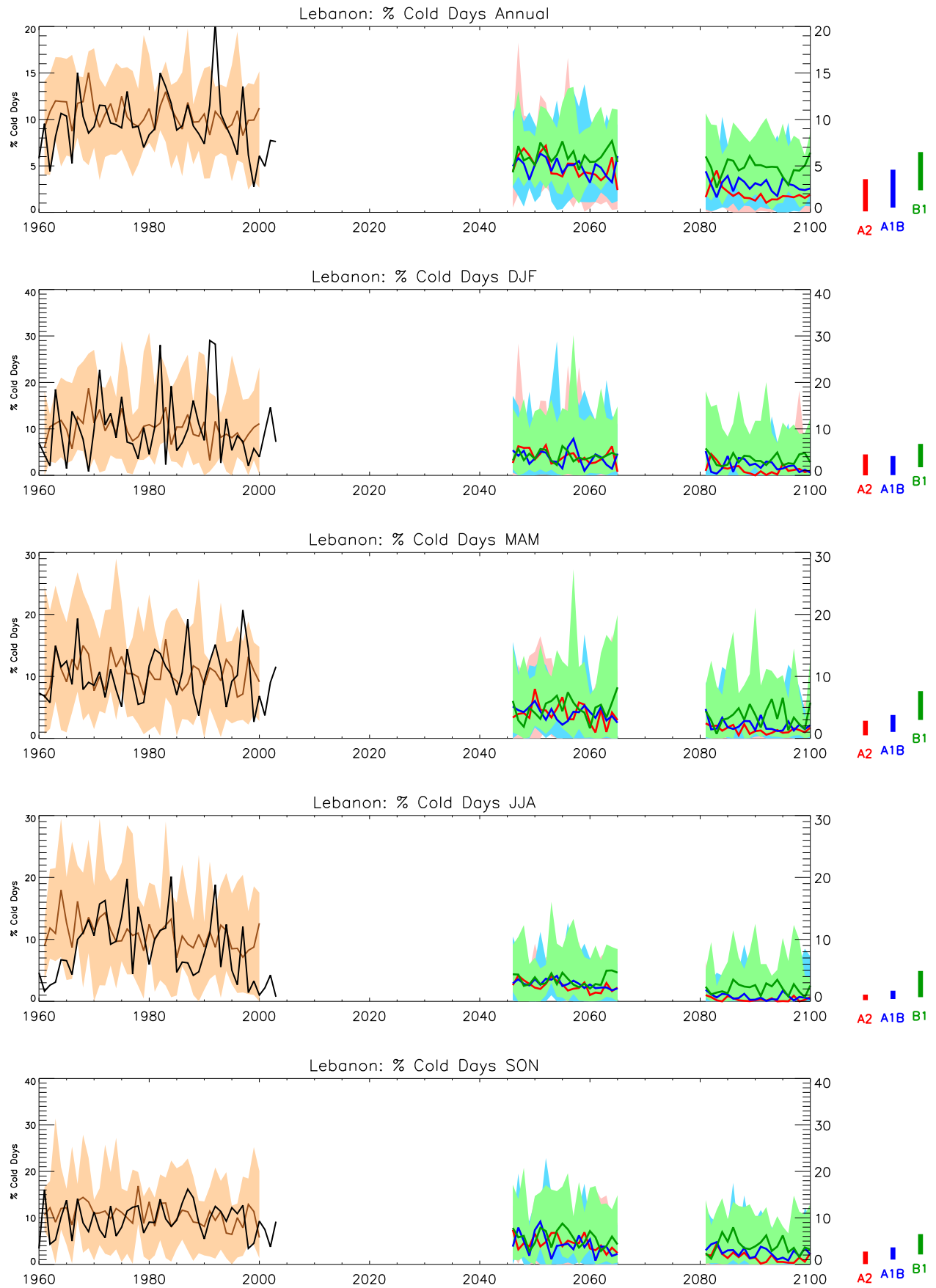


Figure 11: Trends in cold-day frequency for the recent past and projected future. See Figure 1 for details.

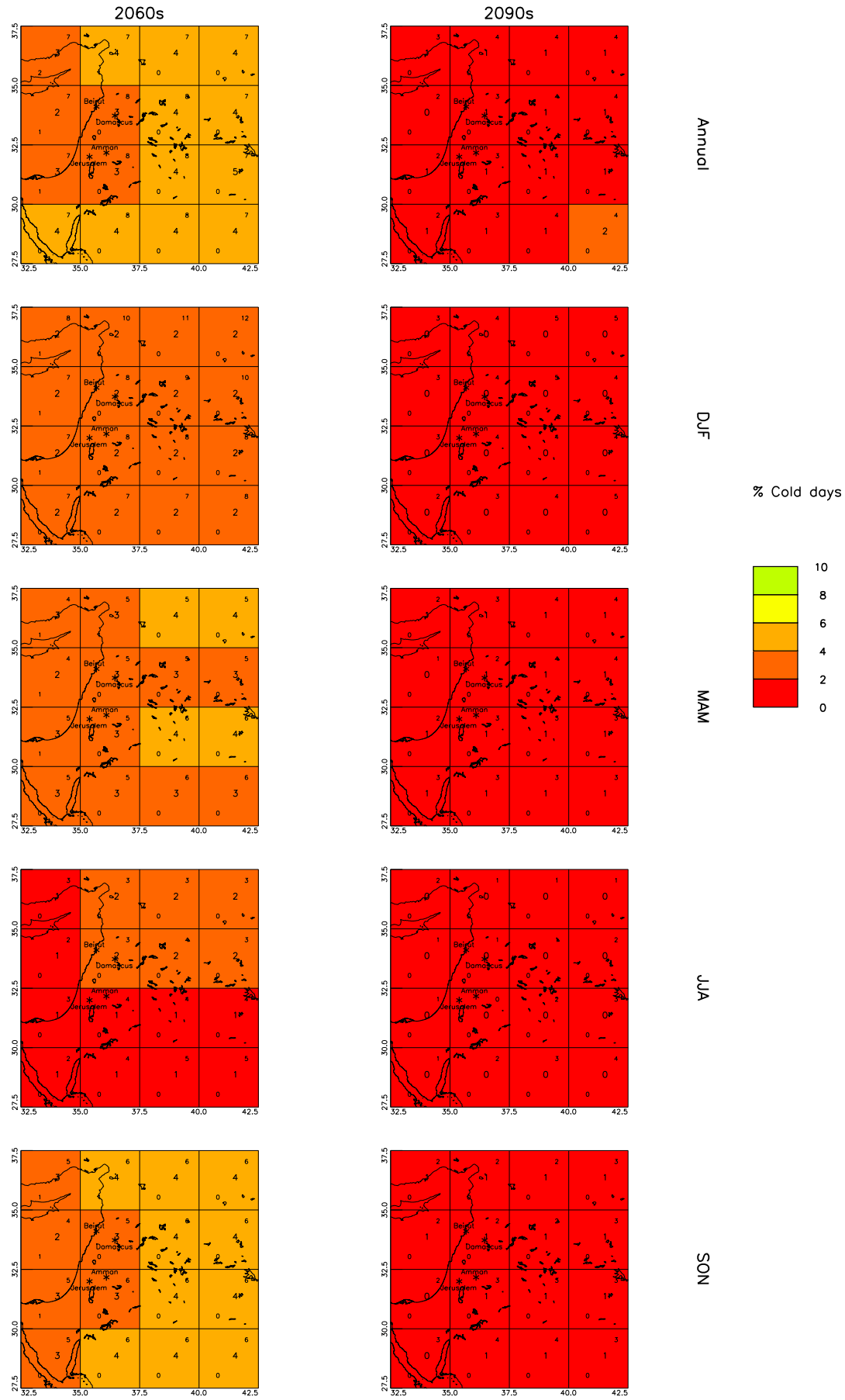


Figure 12: Spatial patterns of cold-day frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

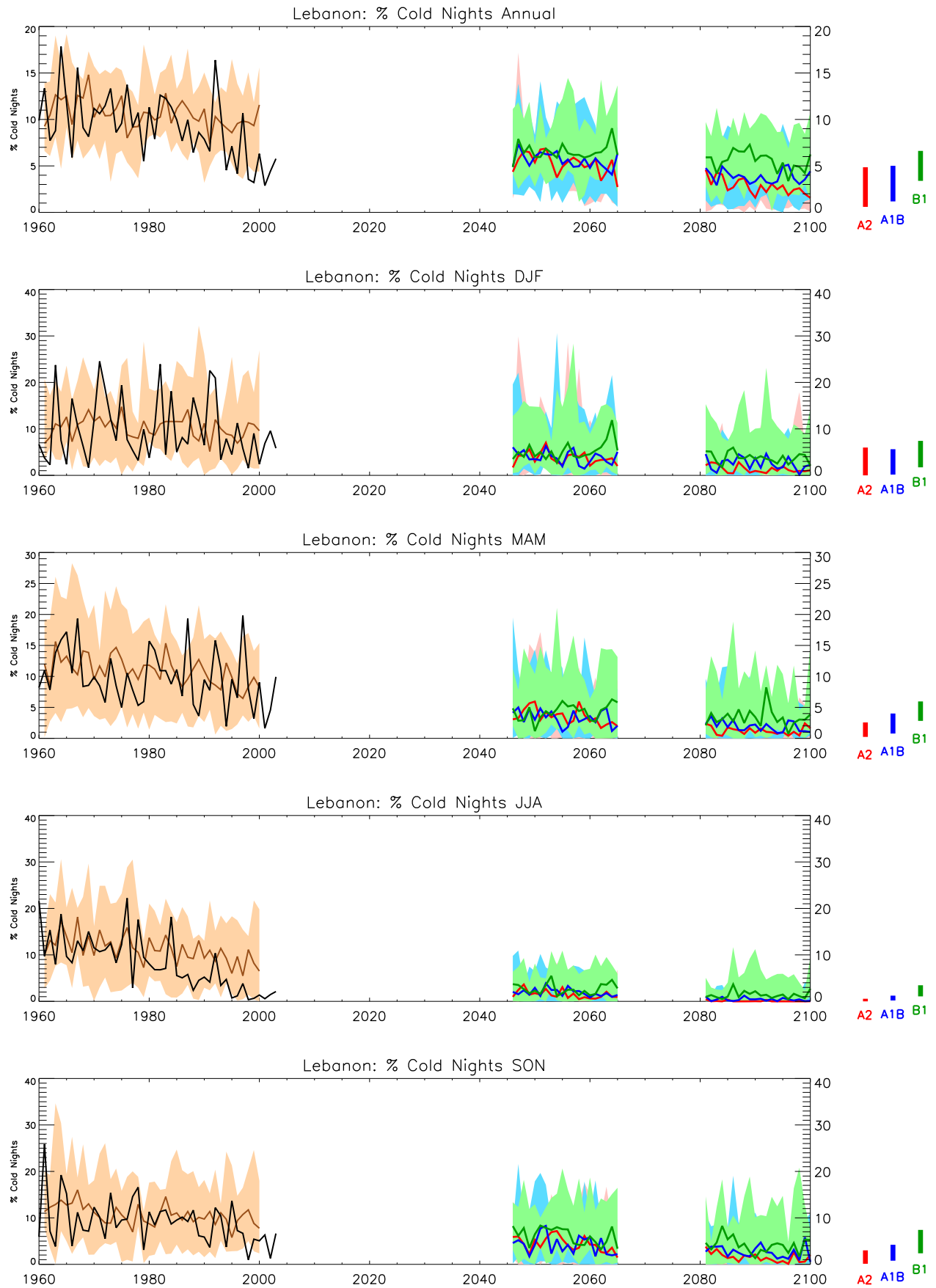


Figure 13: Trends in cold-night frequency for the recent past and projected future. See Figure 1 for details.



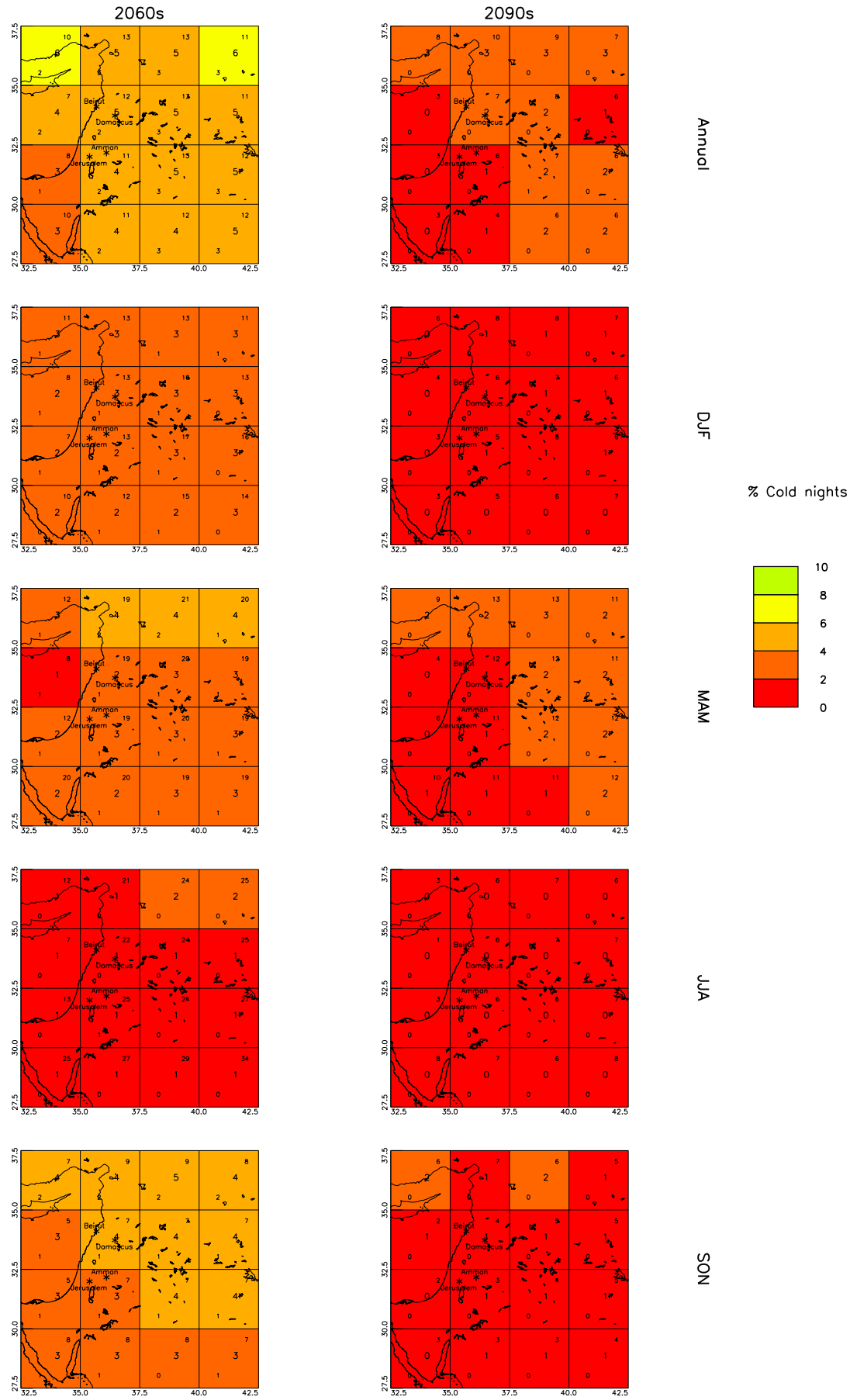


Figure 14: Spatial patterns of cold-night frequency for 10-year periods in the future under the SRES A2 scenario. See Figure 2 for details.

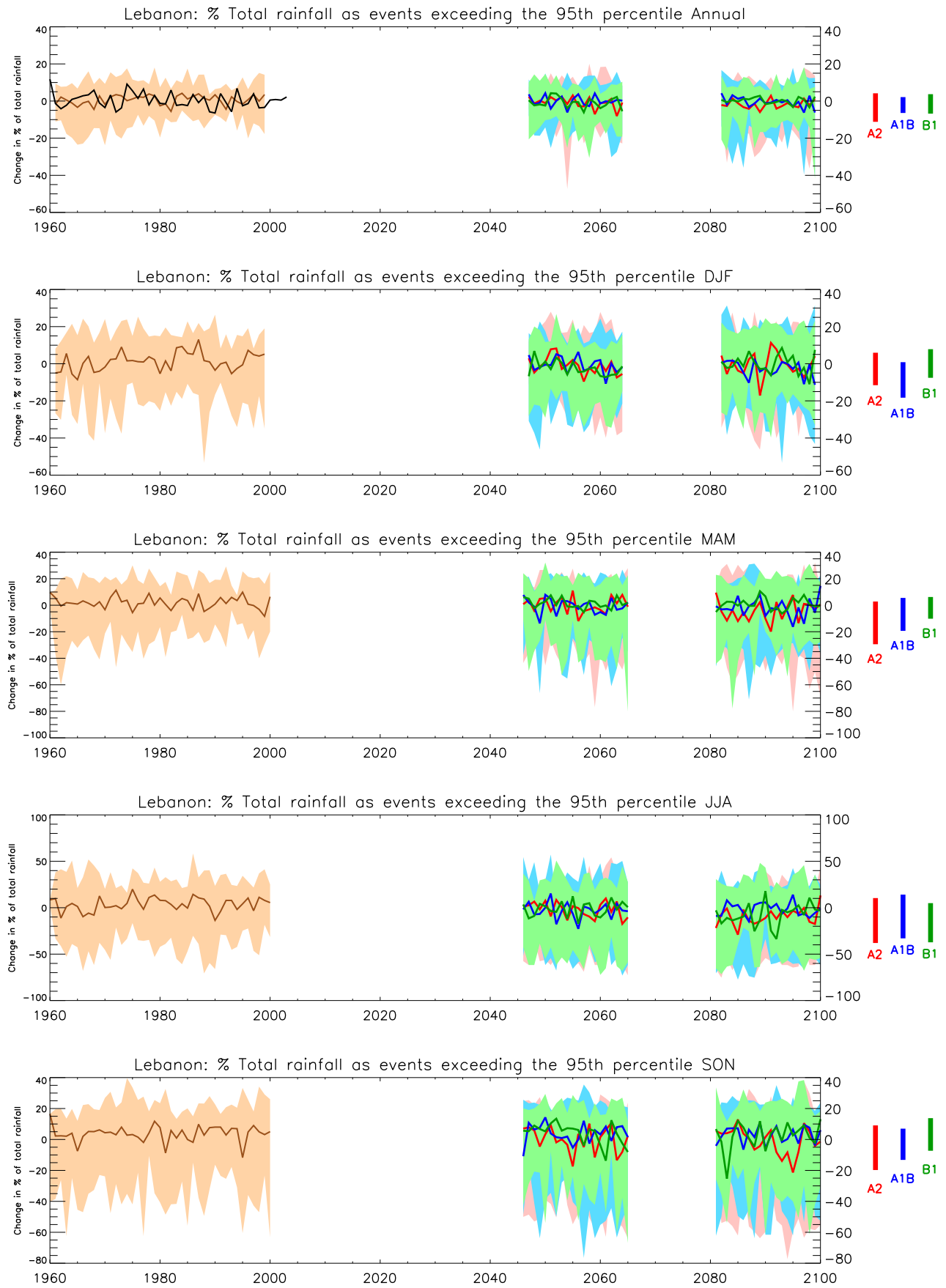


Figure 15: Trends in the proportion of precipitation falling in 'heavy' events for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

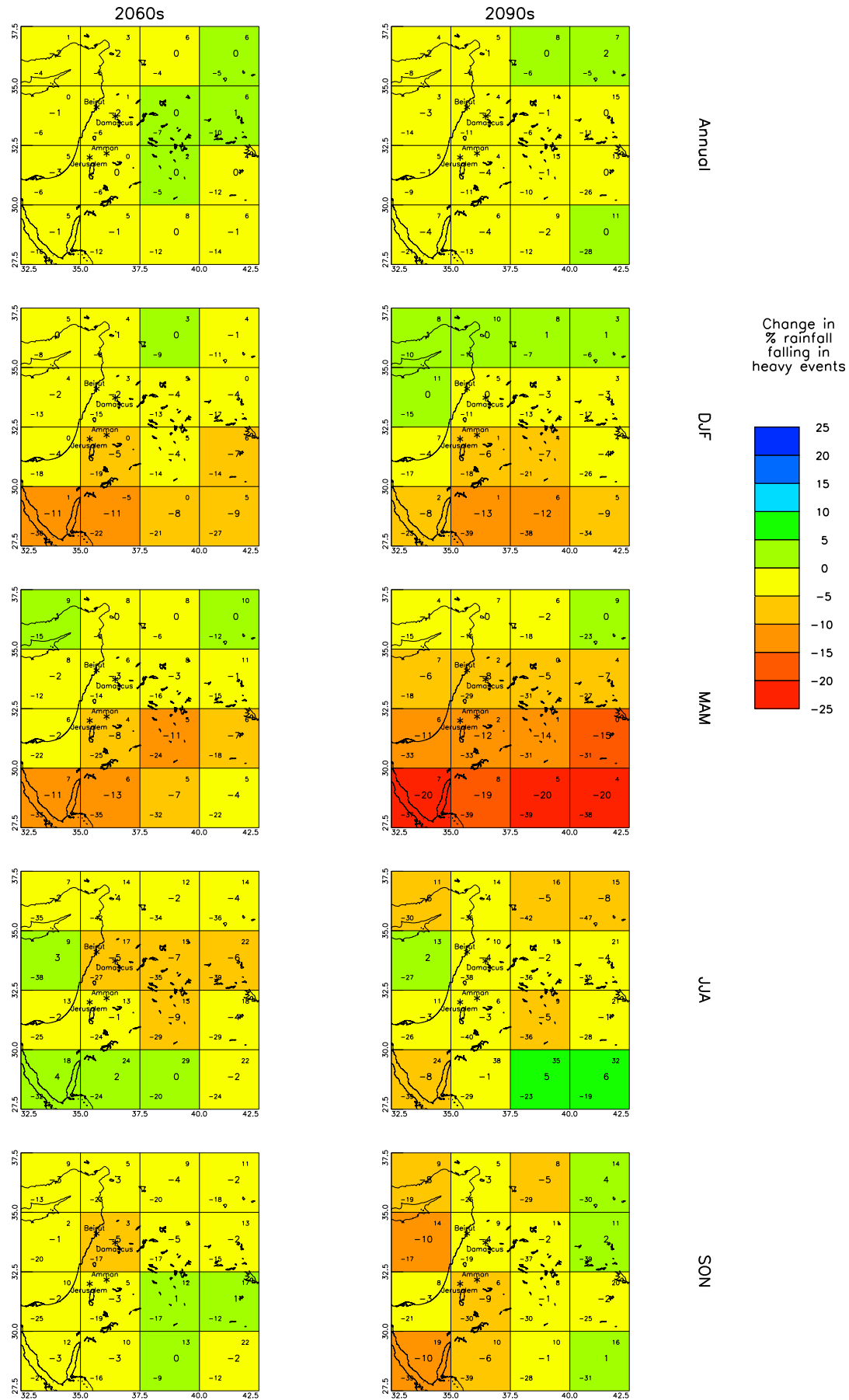


Figure 16: Spatial patterns of projected change in the proportion of precipitation falling in 'heavy' events for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. See Figure 2 for details.

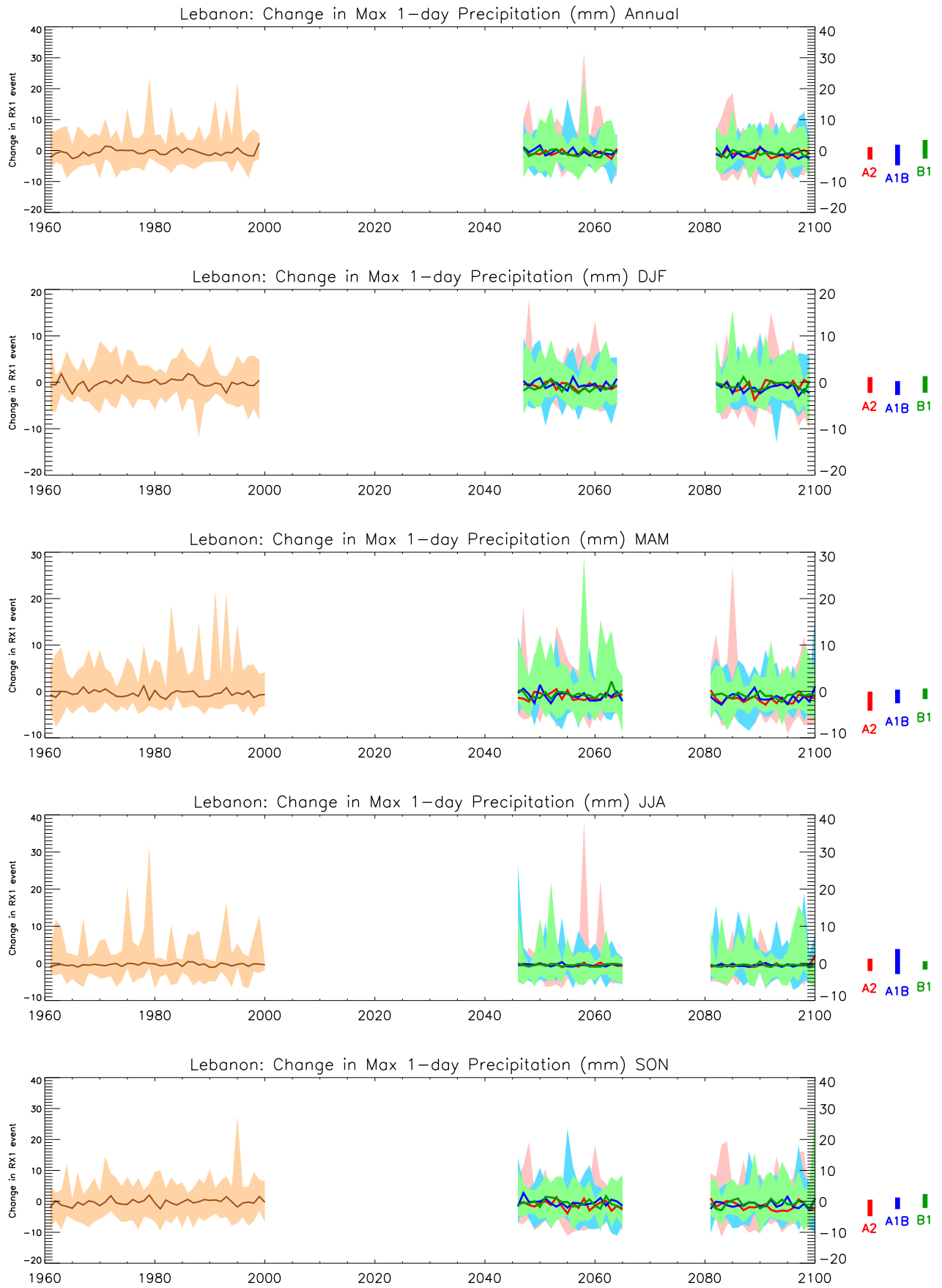


Figure 17: Trends in maximum 1-day rainfall for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

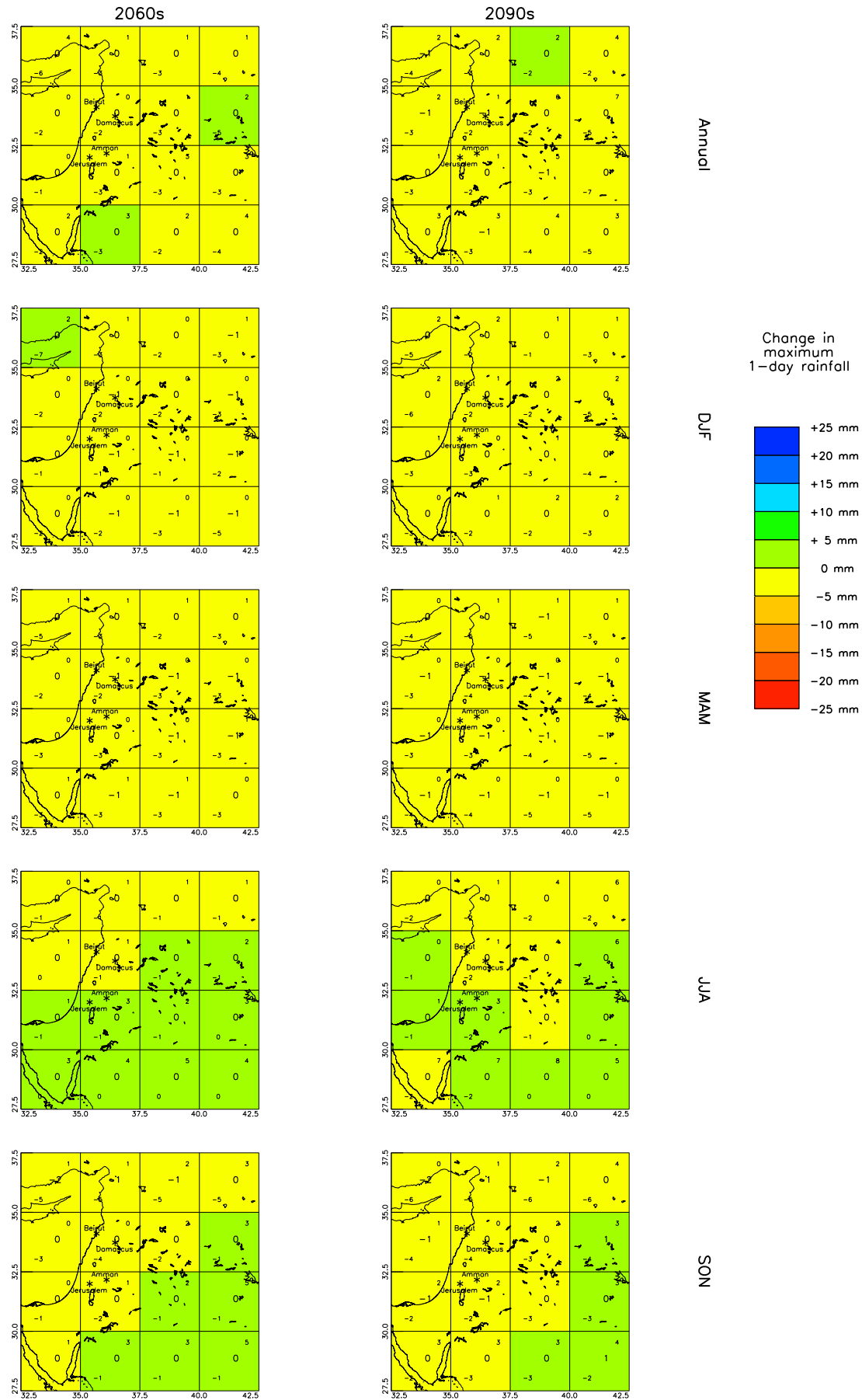


Figure 18: Spatial patterns of maximum 1-day rainfall for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. See Figure 2 for details.

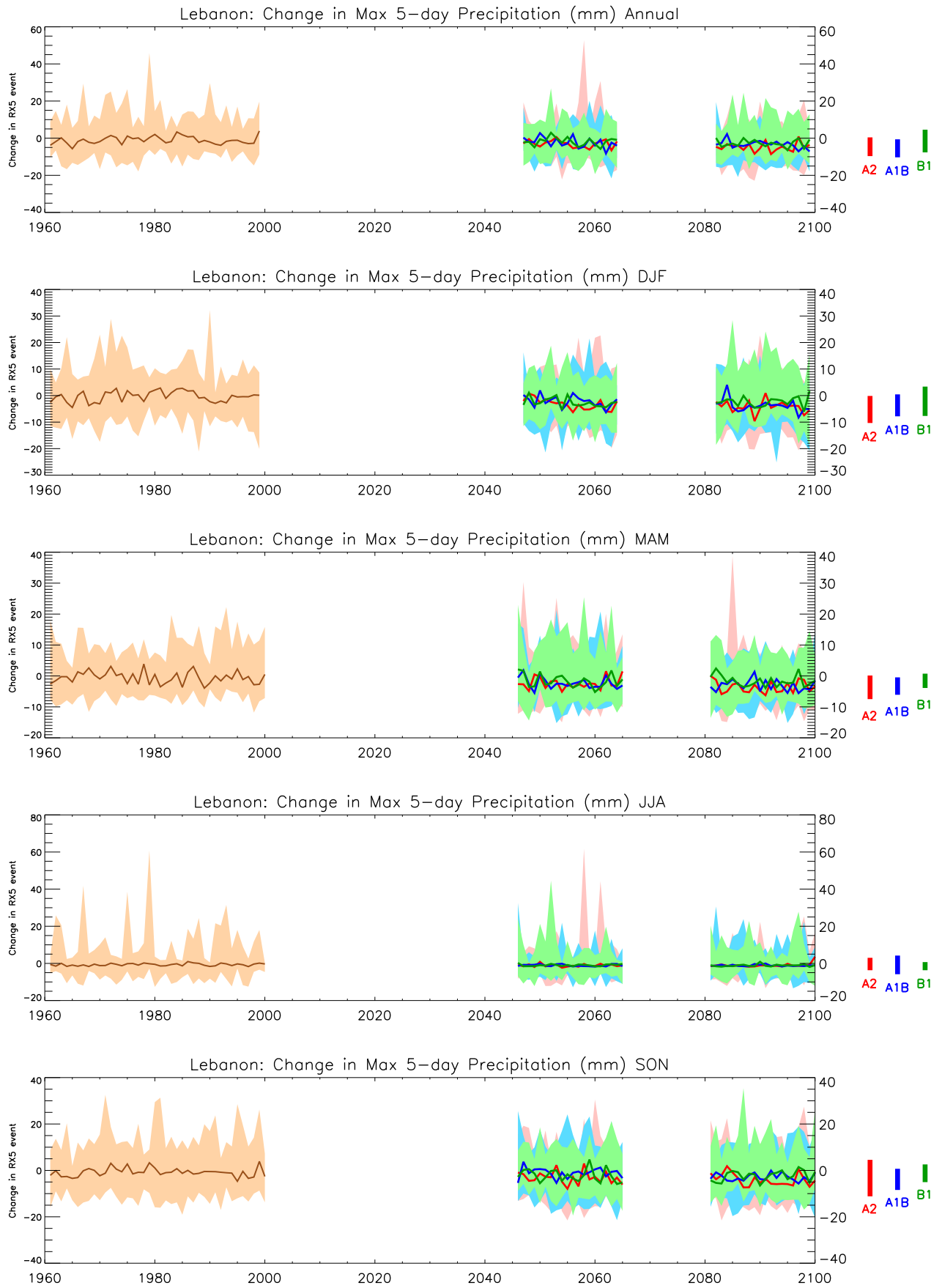


Figure 19: Trends in maximum 5-day rainfall for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. See Figure 1 for details.

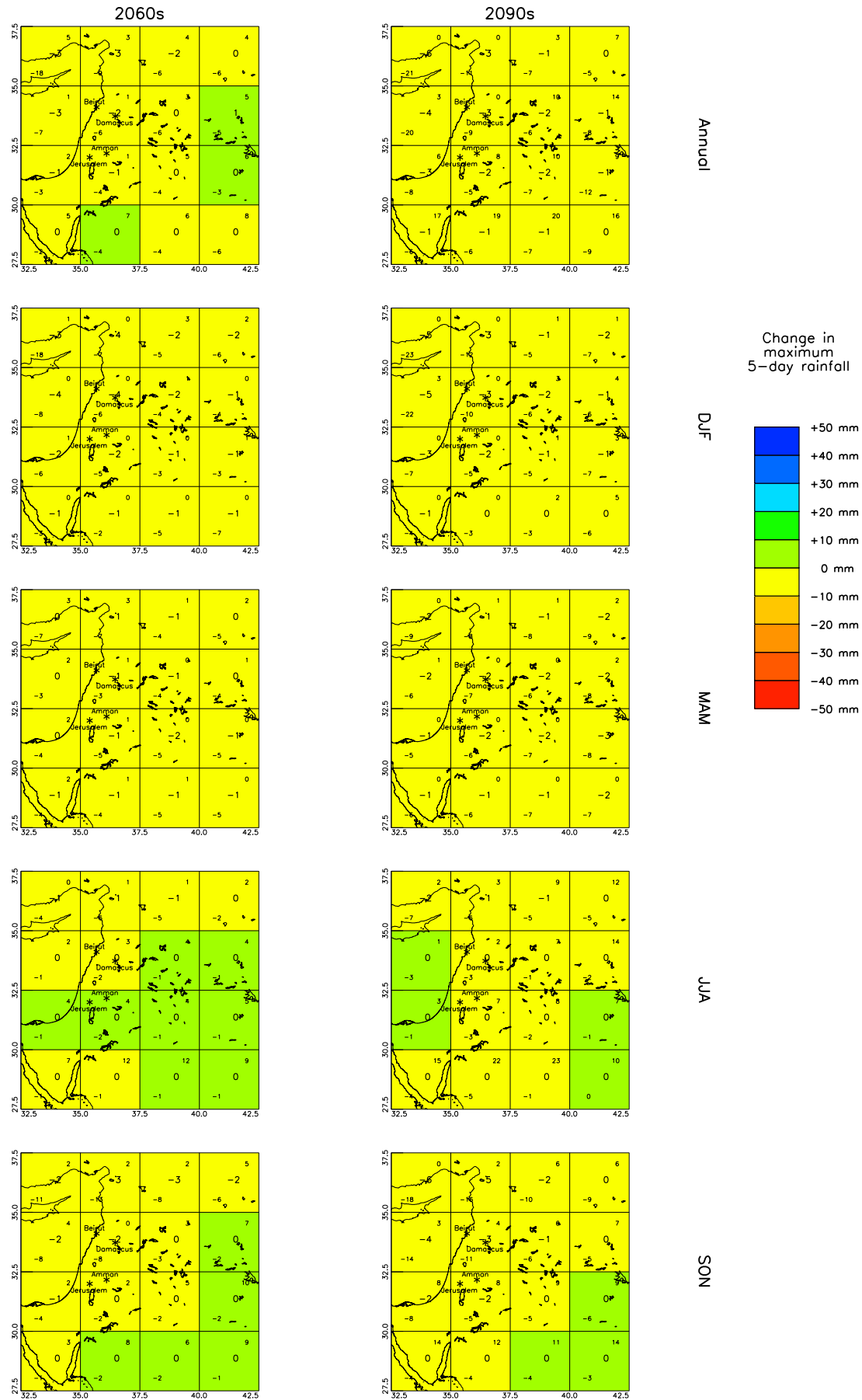


Figure 20: Spatial patterns of projected change in maximum 5-day rainfall for 10-year periods in the future under the SRES A2 scenario. All values are anomalies relative to the mean climate of 1970-1999. See Figure 2 for details.