ACRP

Final Report – Appendix – containing all figures and maps

Program control:
Climate and Energy Fund

Program management:
Kommunalkredit Public Consulting GmbH (KPC)

1 Project Data

Short title	*reclip:century 2*	
Full title	*reclip:century 2 - transiente regionale Klimamodellergebnisse für Österreich und die Alpen bis 2100* *(transient regional climate simulations for Austria and the entire Alps till 2100)*	
Project number	*A963768*	
Program/Program line	*ACRP 2nd Call*	
Applicant	*AIT – Austrian Institute of Technology GmbH* *Donau-City Str. 1* *1220 Wien* *Dr. Wolfgang Loibl*	
Project partners	*Universität für Bodenkultur, Institut für Meteorologie (BOKUMet)* *Peter-Jordan-Str. 82, 1190 Wien* *Karl-Franzens-Universität Graz, Wegener Zentrum für Klima und globalen Wandel (WEGC)* *Brandhofgasse 5, 8010 Graz* *Zentralanstalt für Meteorologie und Geodynamik (ZAMG)* *Hohe Warte 38,1190 Wien*	
Project start and duration	Project start: 01.10.2010	Duration: 24 months
Reporting period	from 01.10.2010 to 30.09.2012	

Figures and Tables

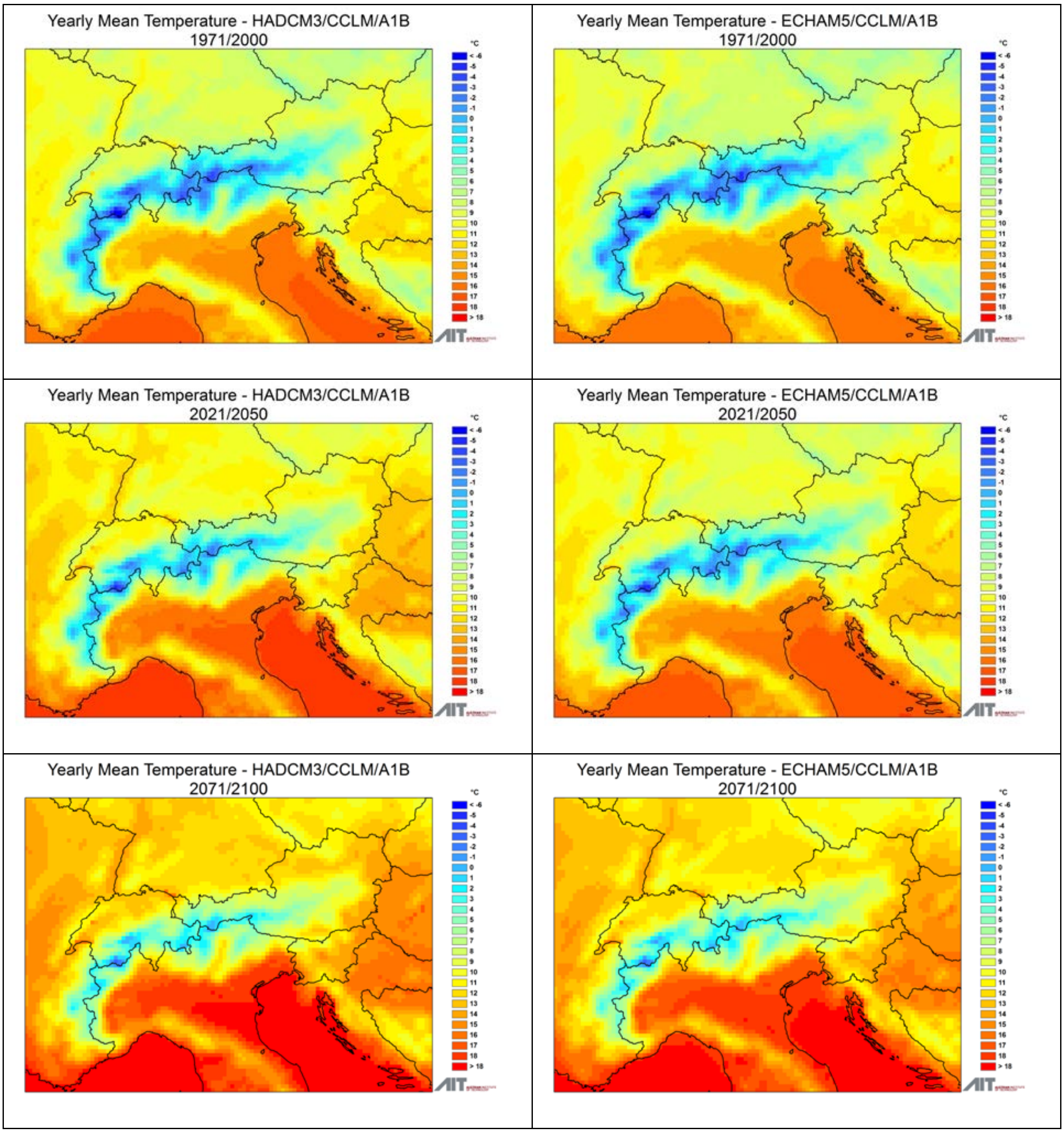


Fig. 1: Annual mean temperature for episodes 1971/2100 (top), 2021/2050 (middle) and 2071/2100 (bottom), scenario HadCM3/A1B (left), ECHAM5/A1B (right).

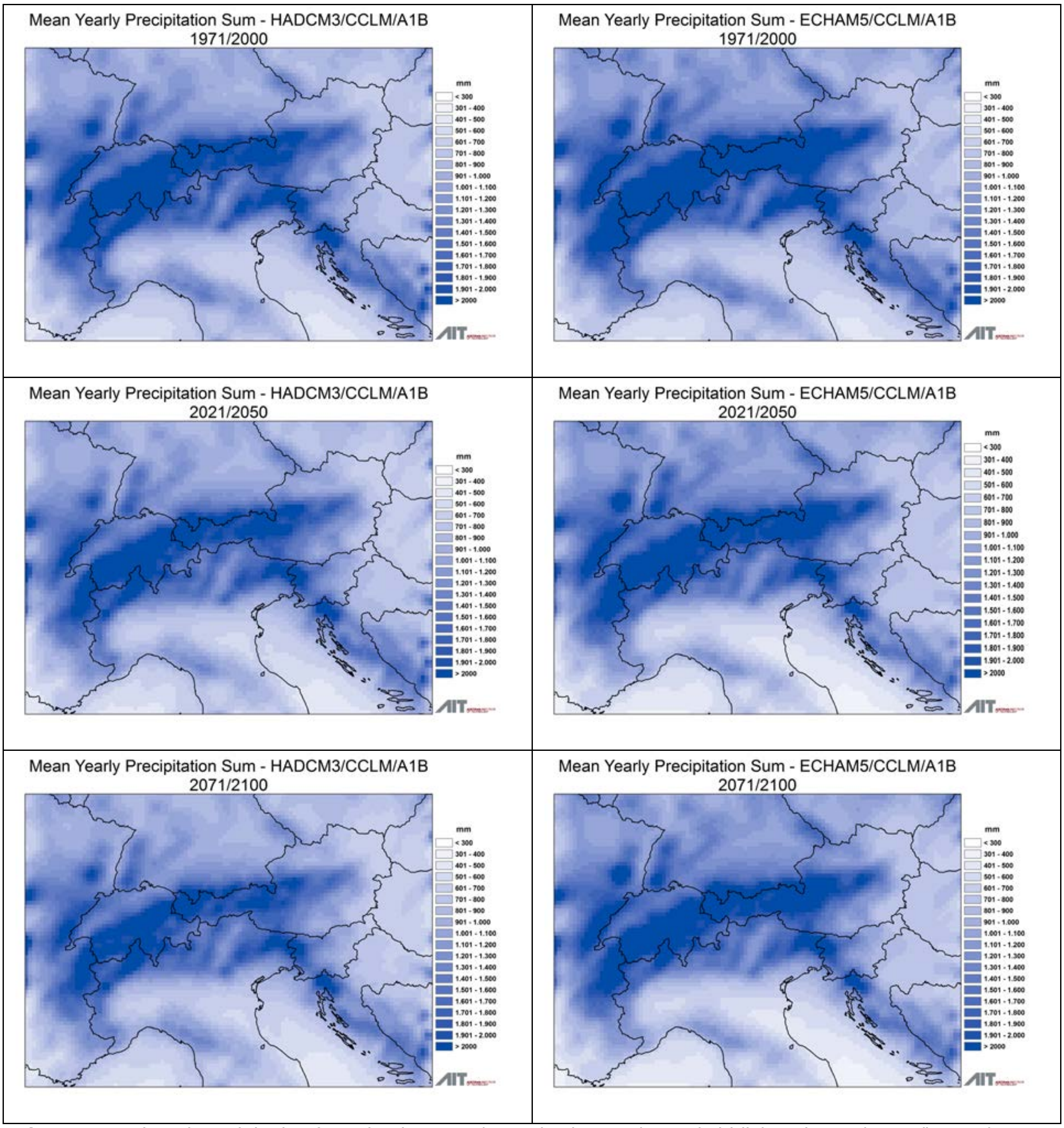


Fig. 2: Annual total precipitation for episodes 1971/2100 (top), 2021/2050 (middle) and 2071/2100 (bottom), scenario HadCM3/A1B (left), ECHAM5/A1B (right).

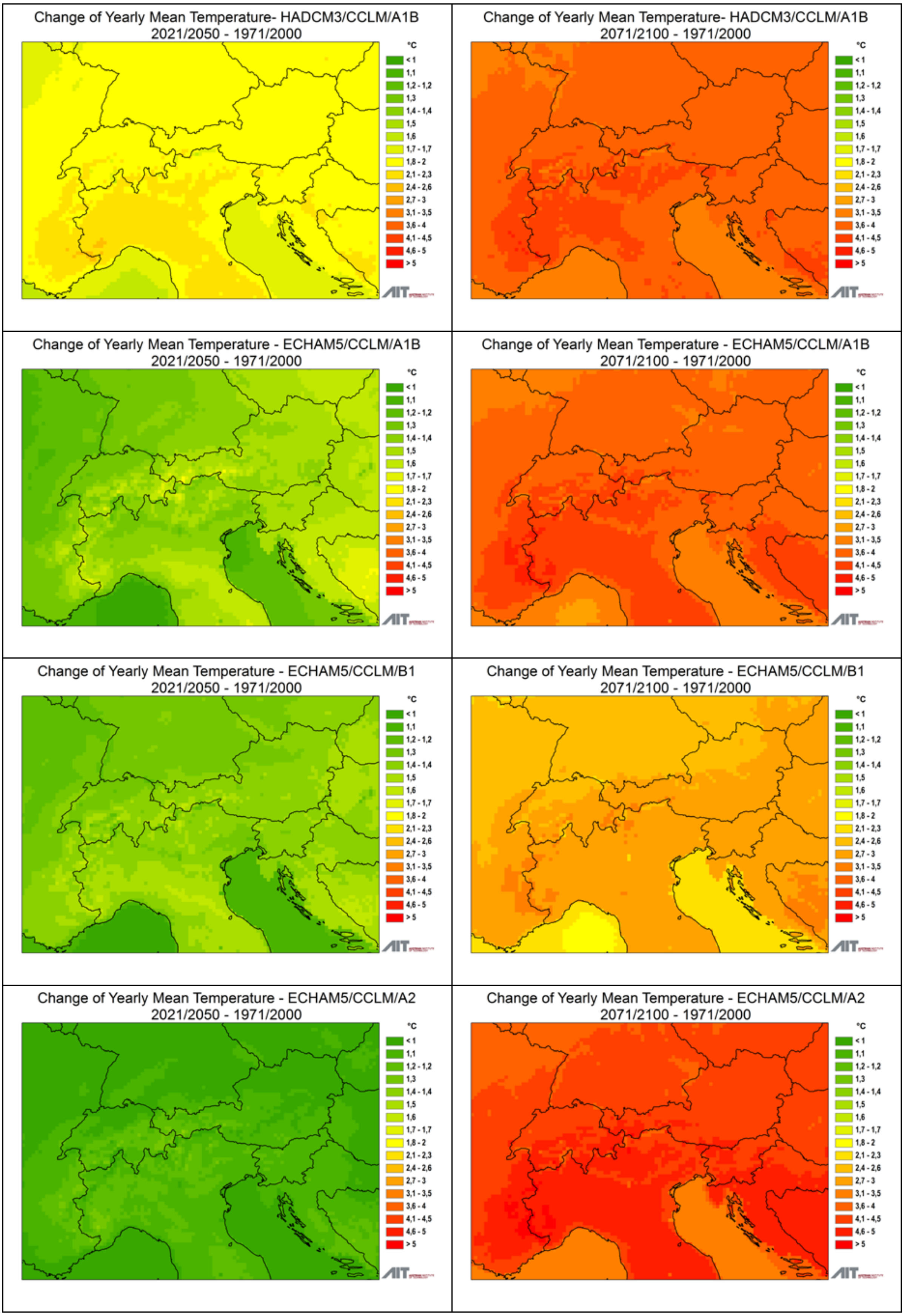


Fig. 3: Change of annual mean temperature between episode 1971/2100 and 2021/2050 (left) and 2071/2100 (right), scenario (HadCM3/A1B (top row), ECHAM5/A1B (2nd row), ECHAM5/B1 (3rd row) and ECHAM5/A2 (bottom row).

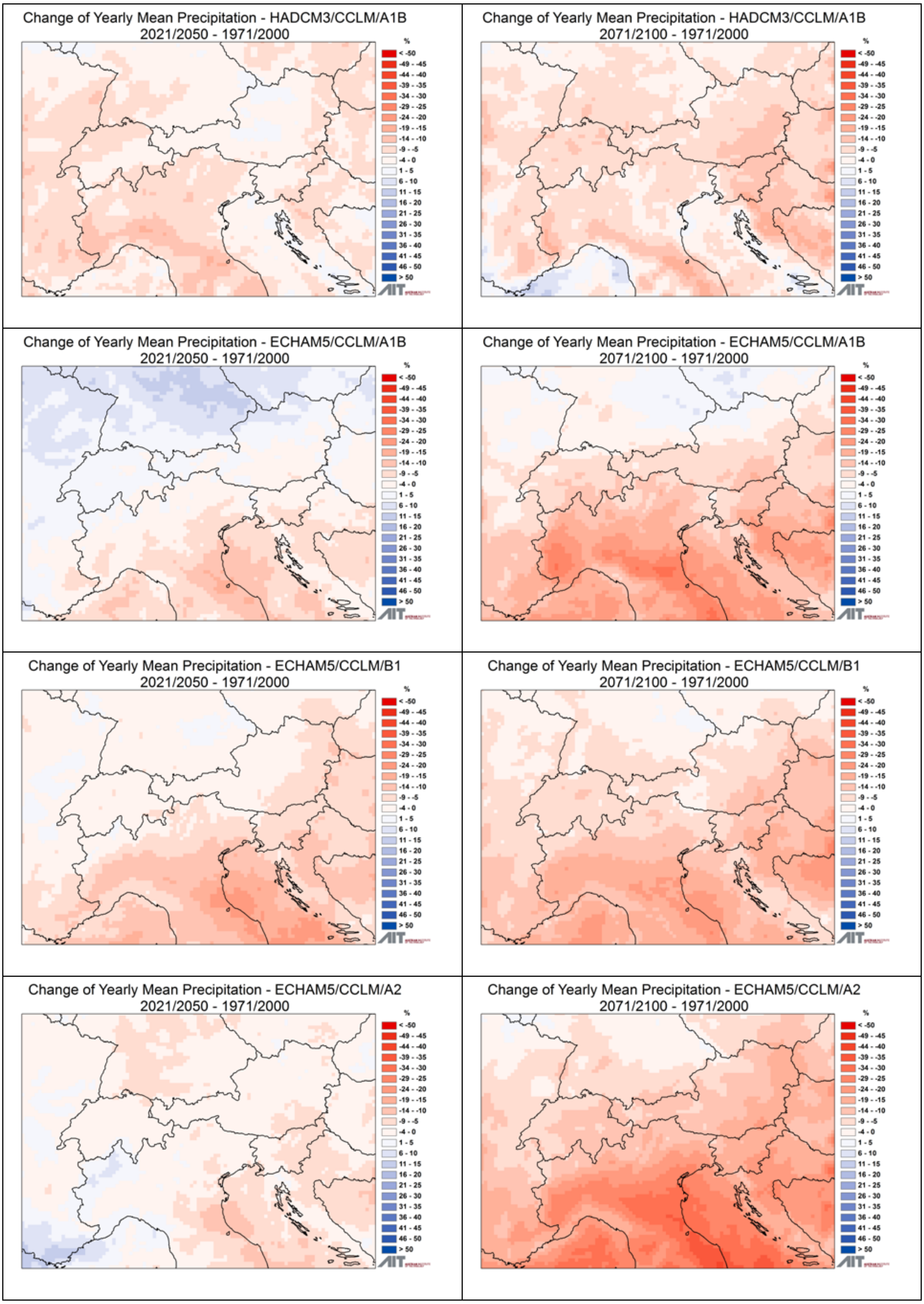


Fig. 4: Relative change of annual total precipitation between episode 1971/2100 and 2021/2050 (left) and 2071/2100 (right), scenario (HadCM3/A1B (top row), ECHAM5/A1B (2nd row), ECHAM5/B1 (3rd row) and ECHAM5/A2 (bottom row).

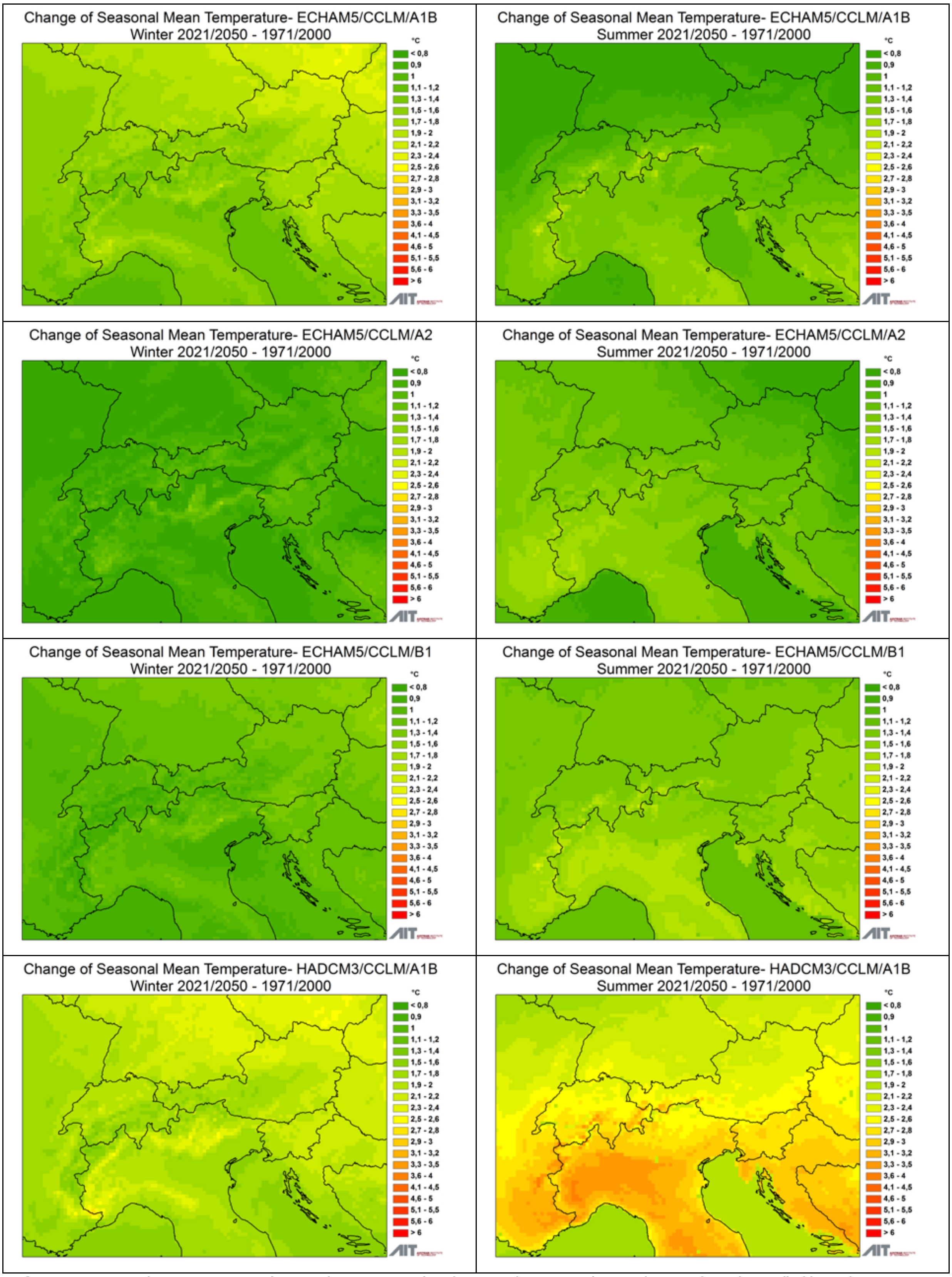


Fig. 5: Seasonal temperature change between episode 1971/2000 and 2021/2050, for winter (left) and summer (right) and scenario ECHAM5/A1B (top row), ECHAM5/A2 (2nd row), ECHAM5/B1 (3rd row) and HadCM3/A1B (bottom row)

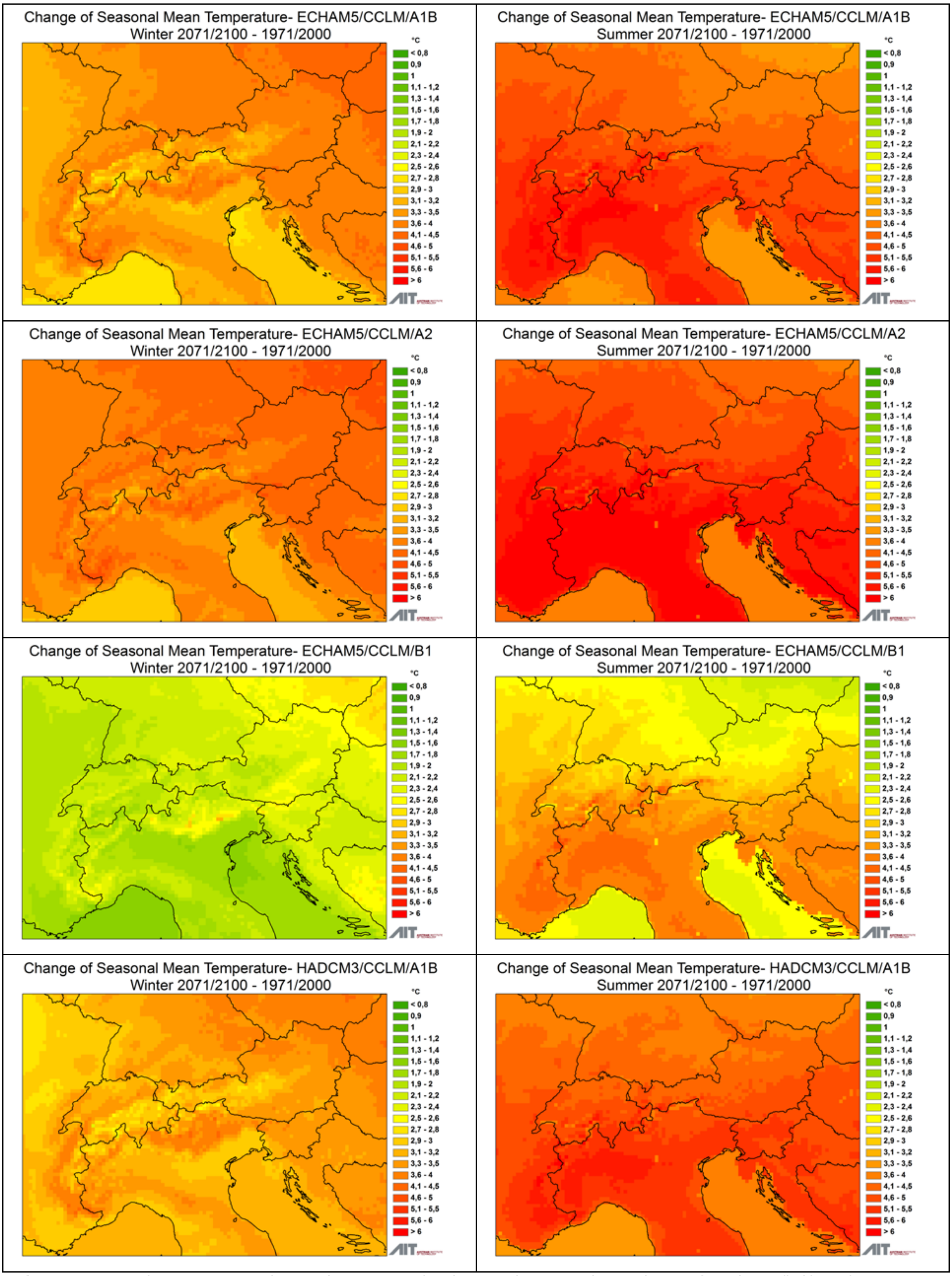


Fig. 6: Seasonal temperature change between episode 1971/2000 and 2071/2100, for winter (left) and summer (right) and scenario ECHAM5/A1B (top row), ECHAM5/A2 (2nd row), ECHAM5/B1 (3rd row) and HadCM3/A1B (bottom row)

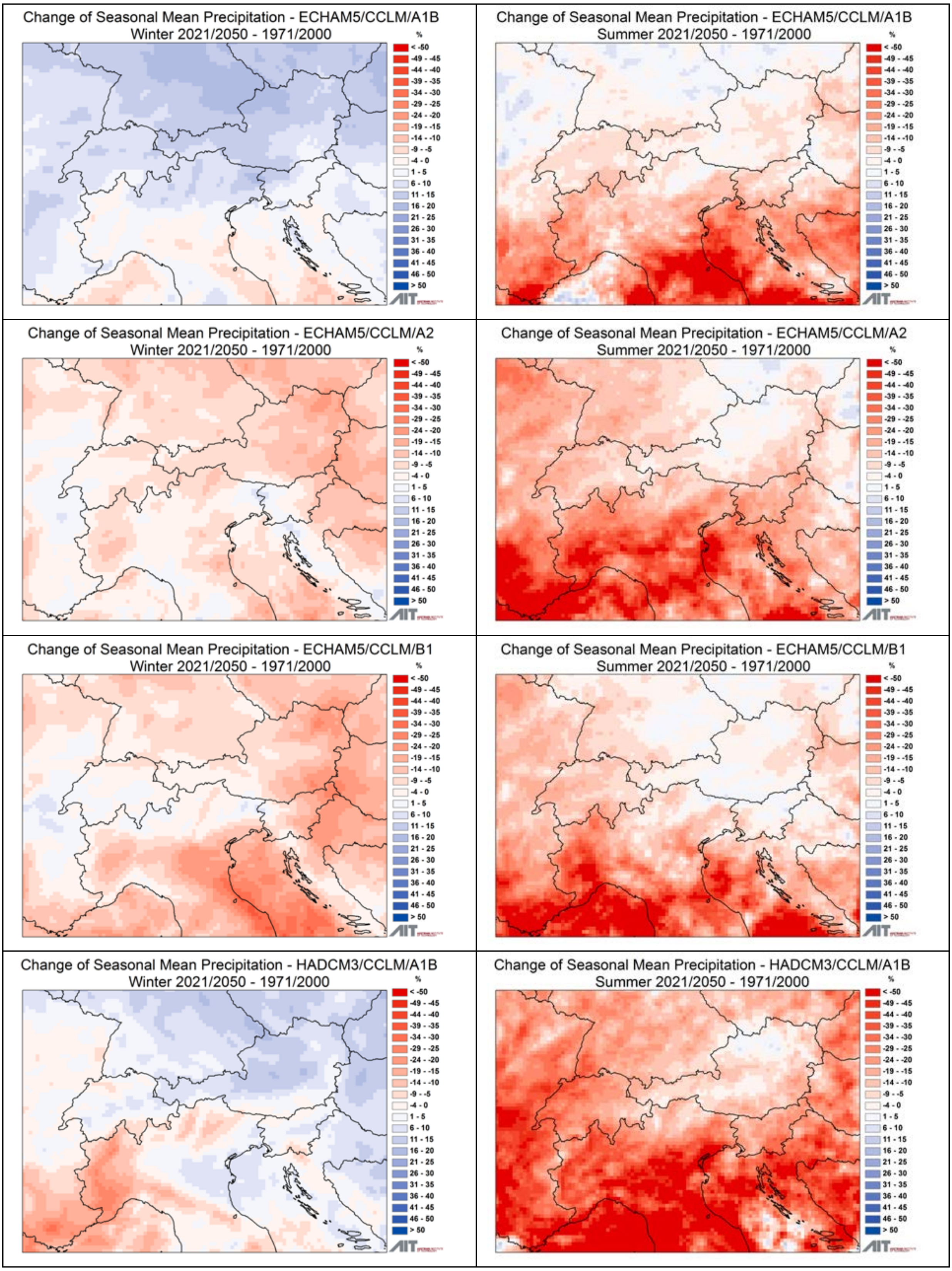


Fig. 7: Seasonal change of total precipitation between episode 1971/2000 and 2021/2050, for winter (left) and summer (right) and scenario ECHAM5/A1B (top row), ECHAM5/A2 (2nd row), ECHAM5/B1 (3rd row) and HadCM3/A1B (bottom row)

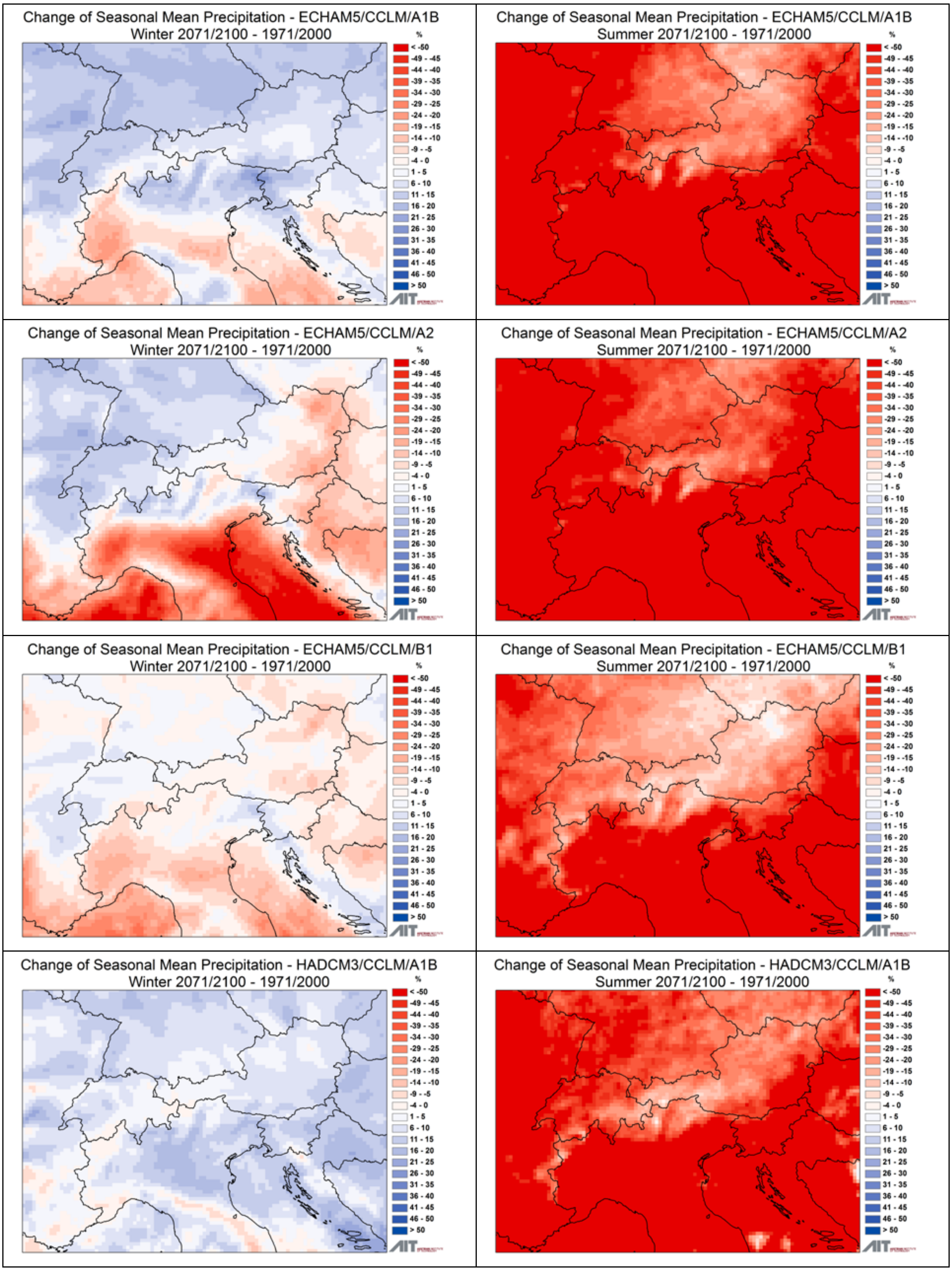


Fig. 8: Seasonal change of total precipitation between episode 1971/2000 and 2071/2100, for winter (left) and summer (right) and scenario ECHAM5/A1B (top row), ECHAM5/A2 (2nd row), ECHAM5/B1 (3rd row) and HadCM3/A1B (bottom row)

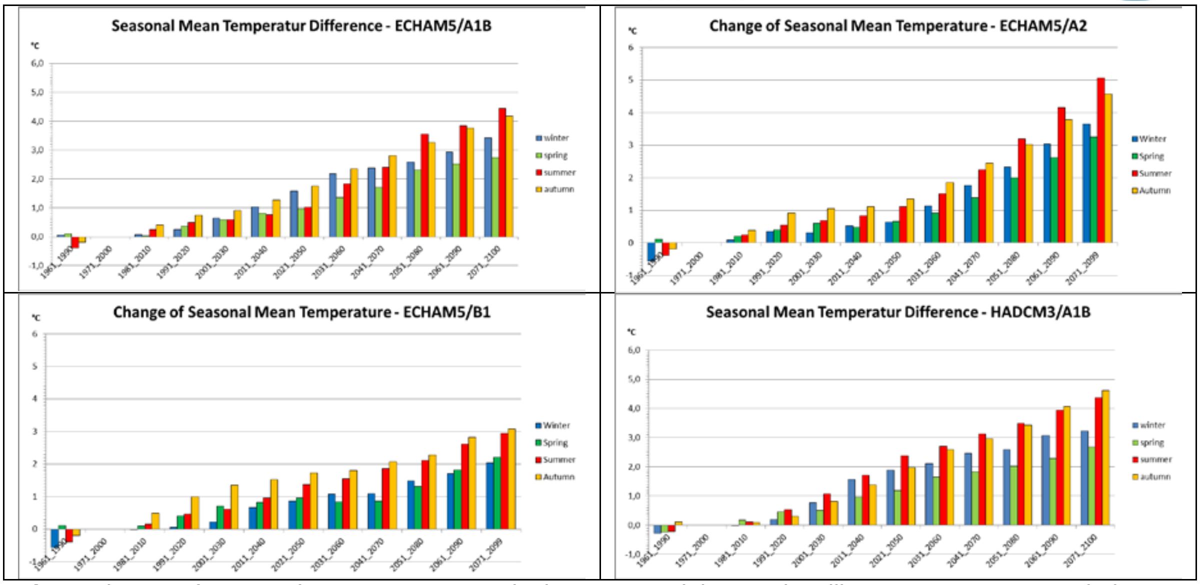


Fig.9: Change of seasonal mean temperature in the Greater Alpine Region till 2100 over 30 year periods compared to 1971/2000 – ECHAM5/A1B (top left), ECHAM5/A2 (top right), ECHAM5/B1 (bottom left) and HadCM3/A1B (bottom right)

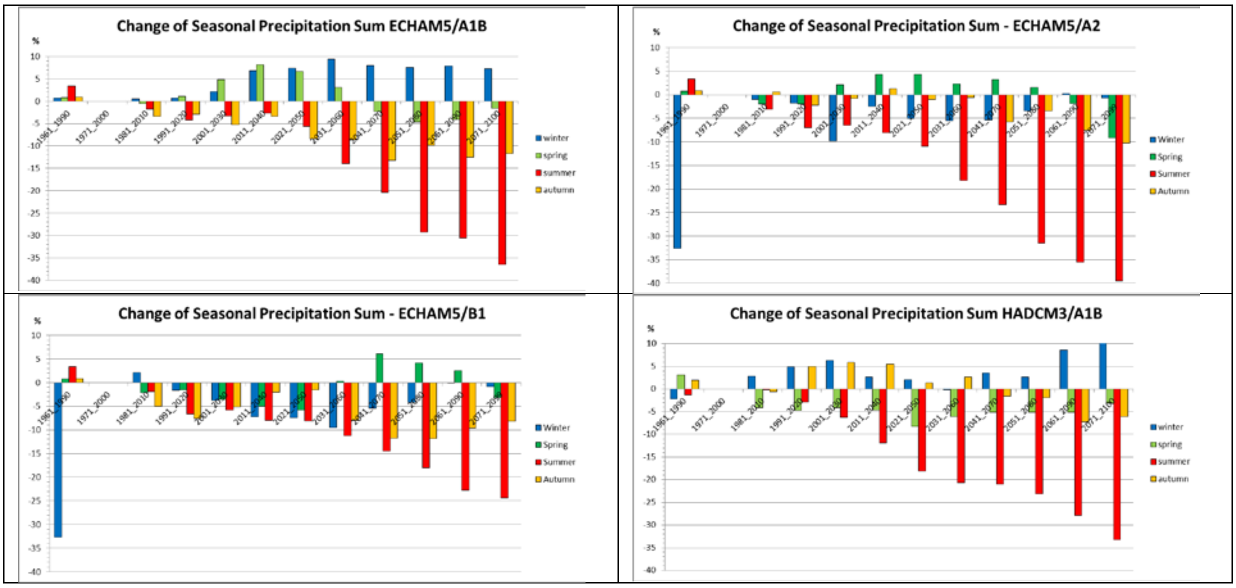


Fig.10: Relative change of seasonal precipitation totals in the Greater Alpine Region till 2100 over 30 year periods compared to 1971/2000 – ECHAM5/A1B (top left), ECHAM5/A2 (top right), ECHAM5/B1 (bottom left) and HadCM3/A1B (bottom right)

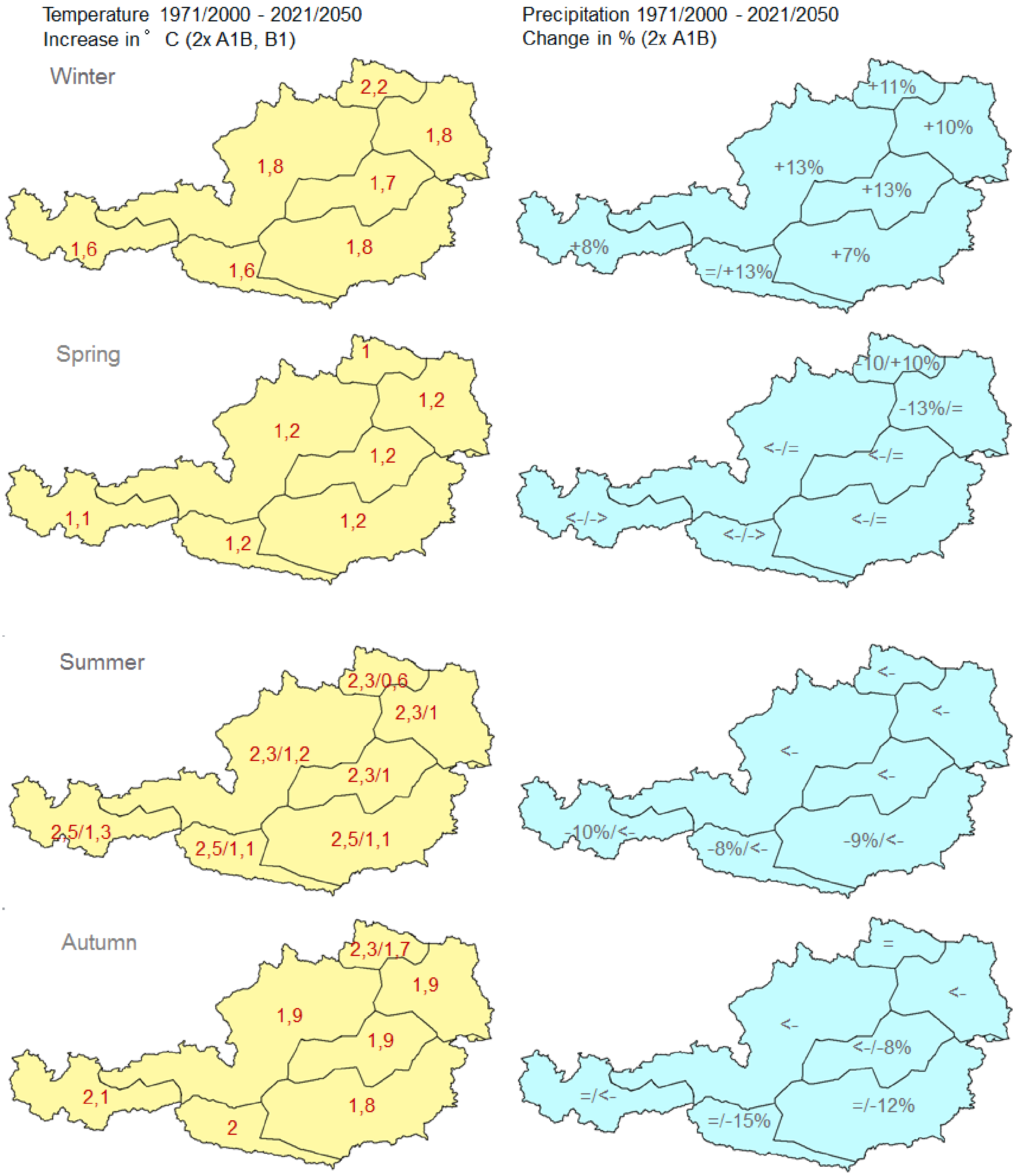


Fig. 11: Regional climate change signals – scenarios 2021-2050 against 1971/2000: difference ranges of seasonal temperature means in °C (HadCM3/CCLM/A1B; ECHAM5/CCLM/A1B, ECHAM5/CCLM/B1), difference ranges of precipitation in % (HadCM3/CCLM/A1B; ECHAM5/CCLM/A1B, ECHAM5/CCLM/B1, ECHAM5/CCLM/A2), (if changes are small only <-/+> trend is shown)

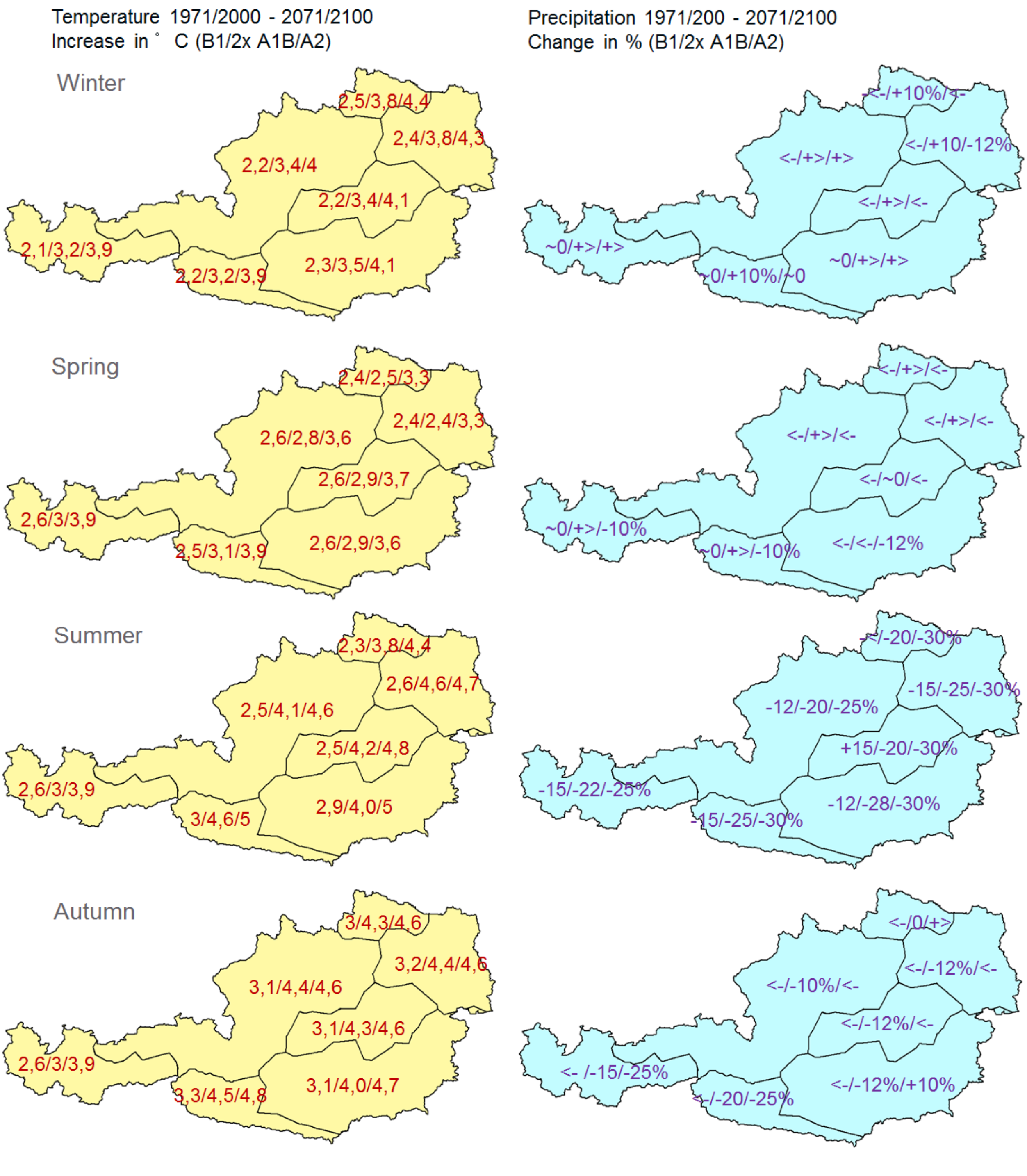


Fig. 12: Regional climate change signals – scenarios 2071-2100 against 1971/2000: difference ranges of seasonal temperature means in °C (HadCM3/CCLM/A1B; ECHAM5/CCLM/A1B, ECHAM5/CCLM/B1, ECHAM5/CCLM/A2), difference ranges of seasonal precipitation sums in % (HadCM3/CCLM/A1B; ECHAM5/CCLM/A1B, ECHAM5/CCLM/B1, ECHAM5/CCLM/A2 (if changes are little - only <-/+> trend is shown)

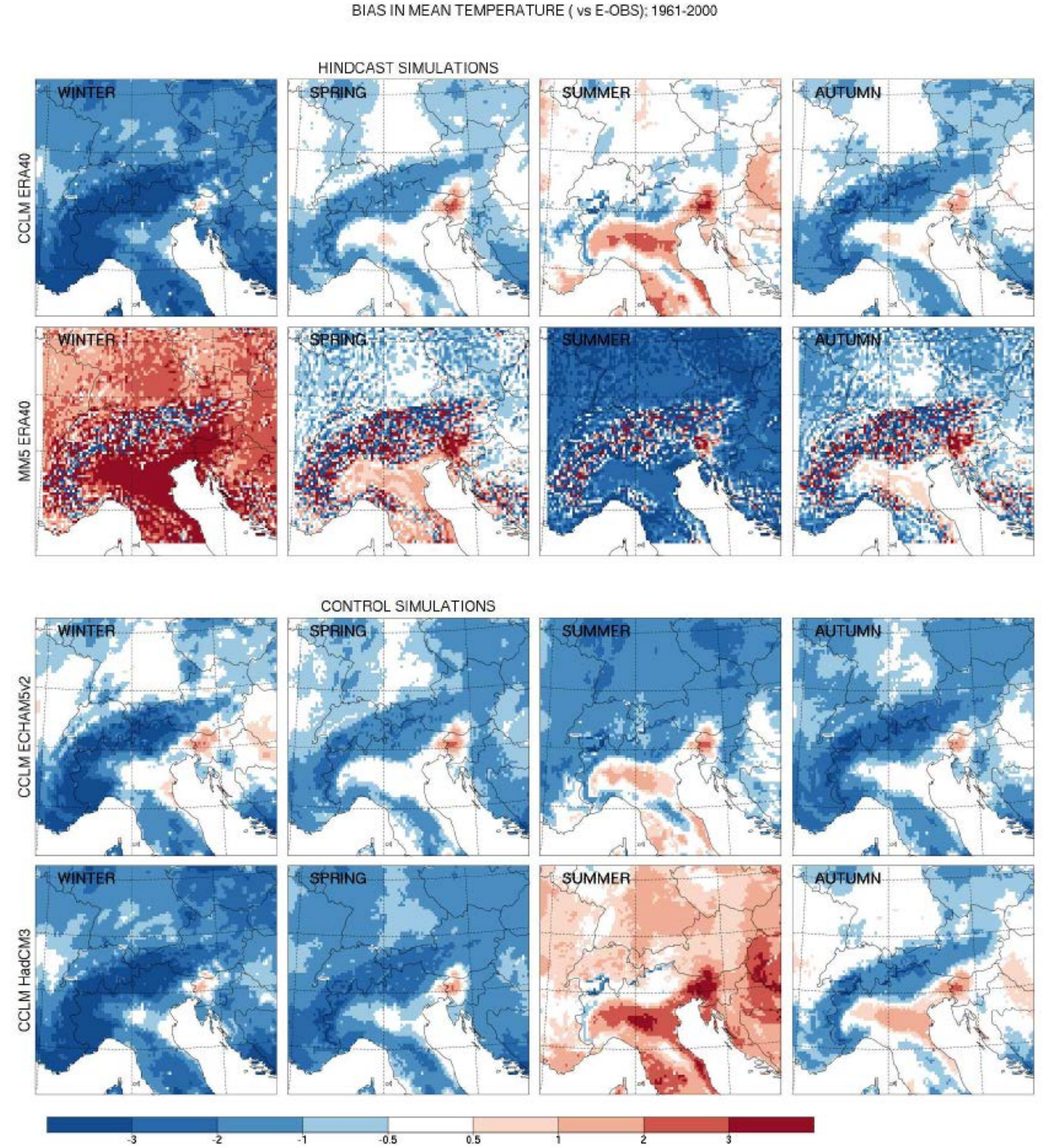


Fig. 13: Bias in simulated seasonal mean temperature, compared to gridded observations by E-OBS for period 1961-2000

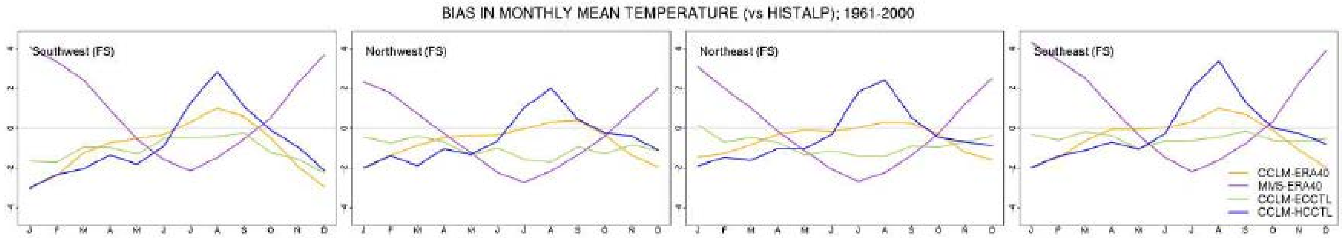


Fig. 14: Annual cycle of the mean temperature bias (RCMs vs. HISTALP for 1961-2000

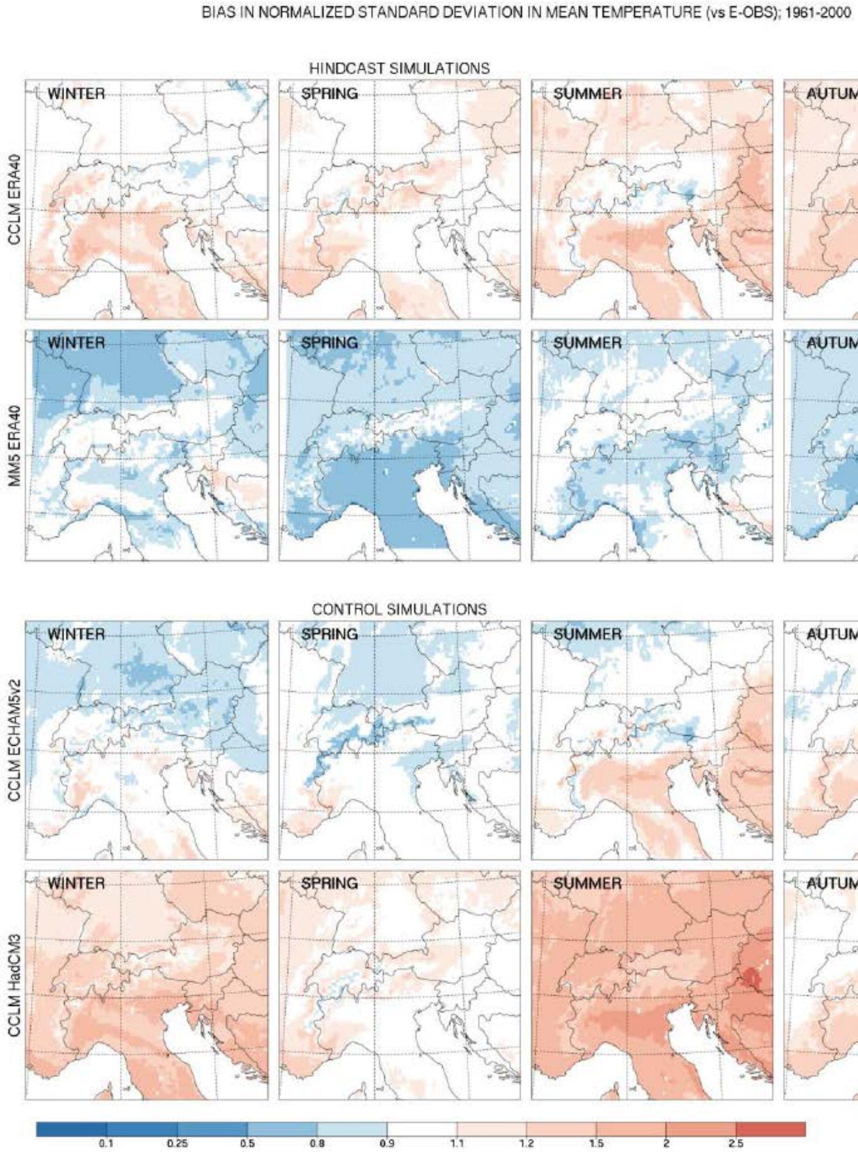


Fig. 15: Bias in simulated standard deviations per season normalized to gridded data observed by E-OBS for the same time period

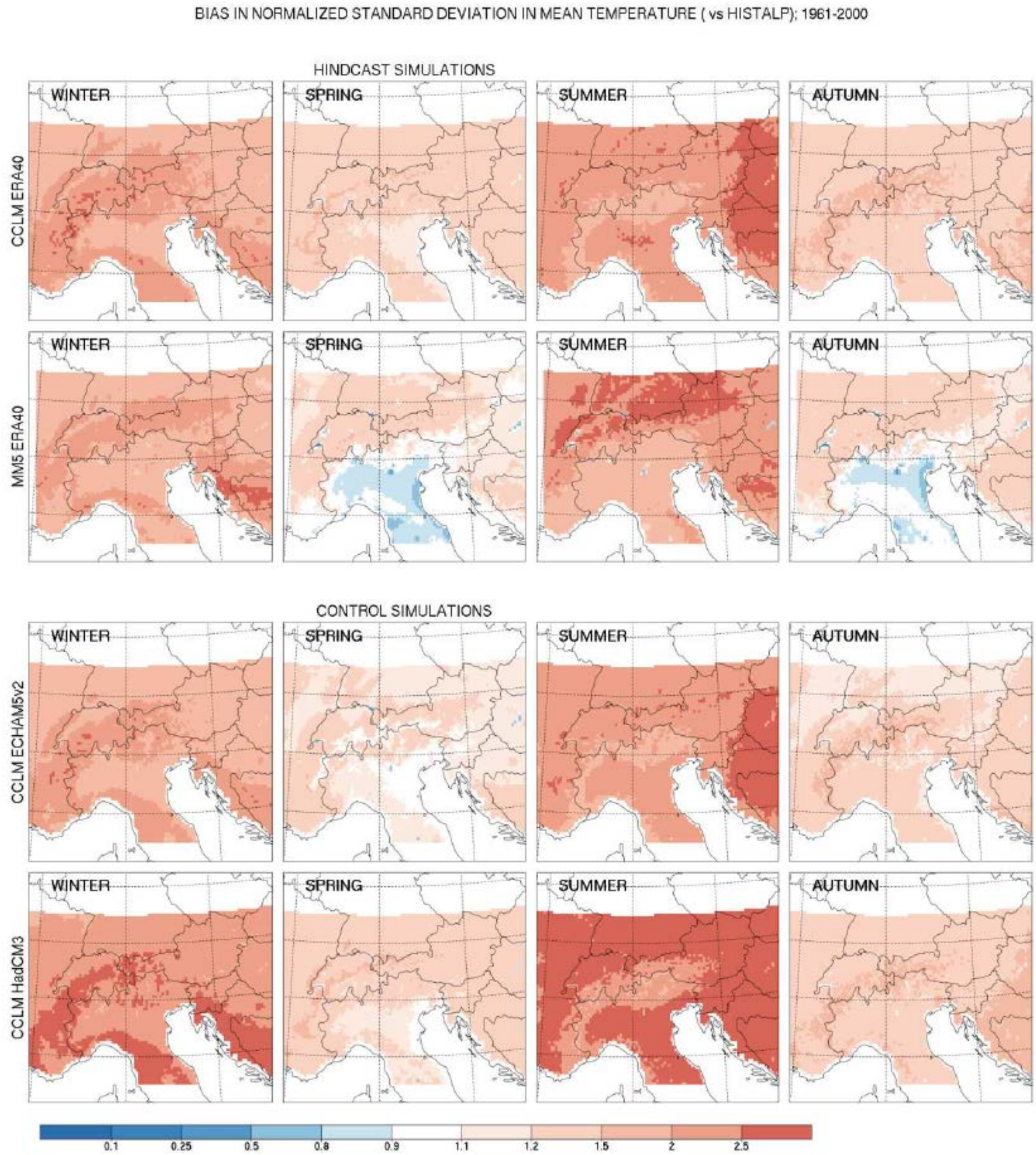


Fig. 16. Bias in simulated standard deviation per season normalized to gridded observed data by HISTALP for the period 1961-2000.

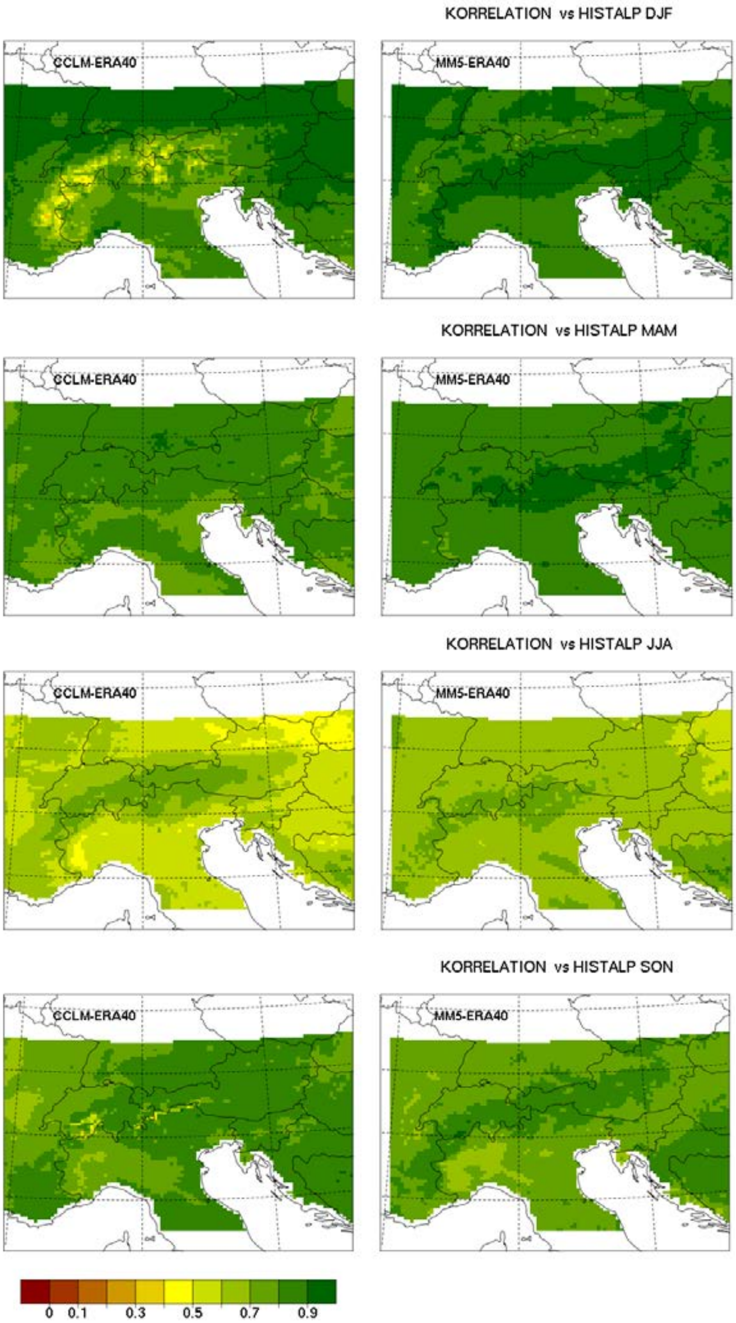


Figure 17: Correlation in seasonal mean temperature simulated by CCLM (left column) and MM5 (right column) compared to HISTALP gridded observations for the time period 1961-2000. (DJF – December to February, MAM . March to May, JJA – June to August, SON – September to November)

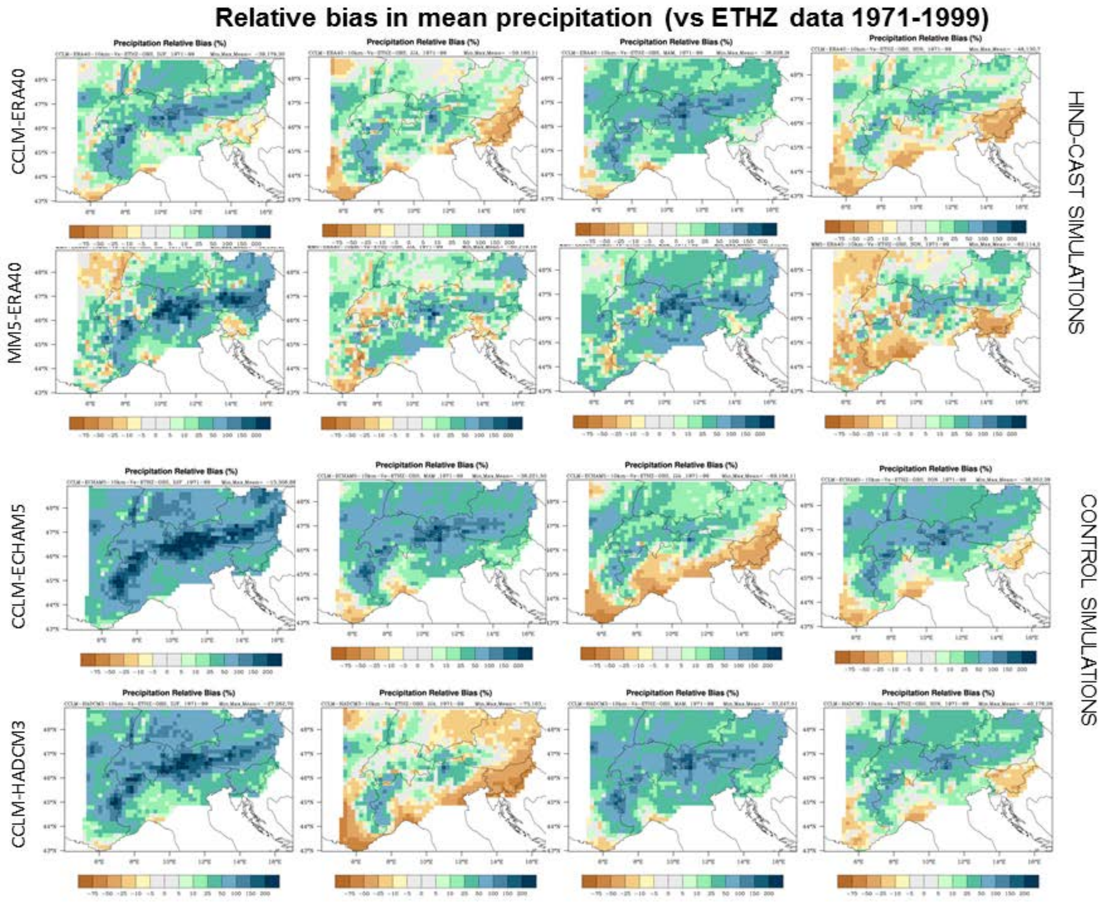


Figure 18: Relative bias of mean seasonal precipitation compared to the gridded observational dataset of ETHZ for the period 1971-1999

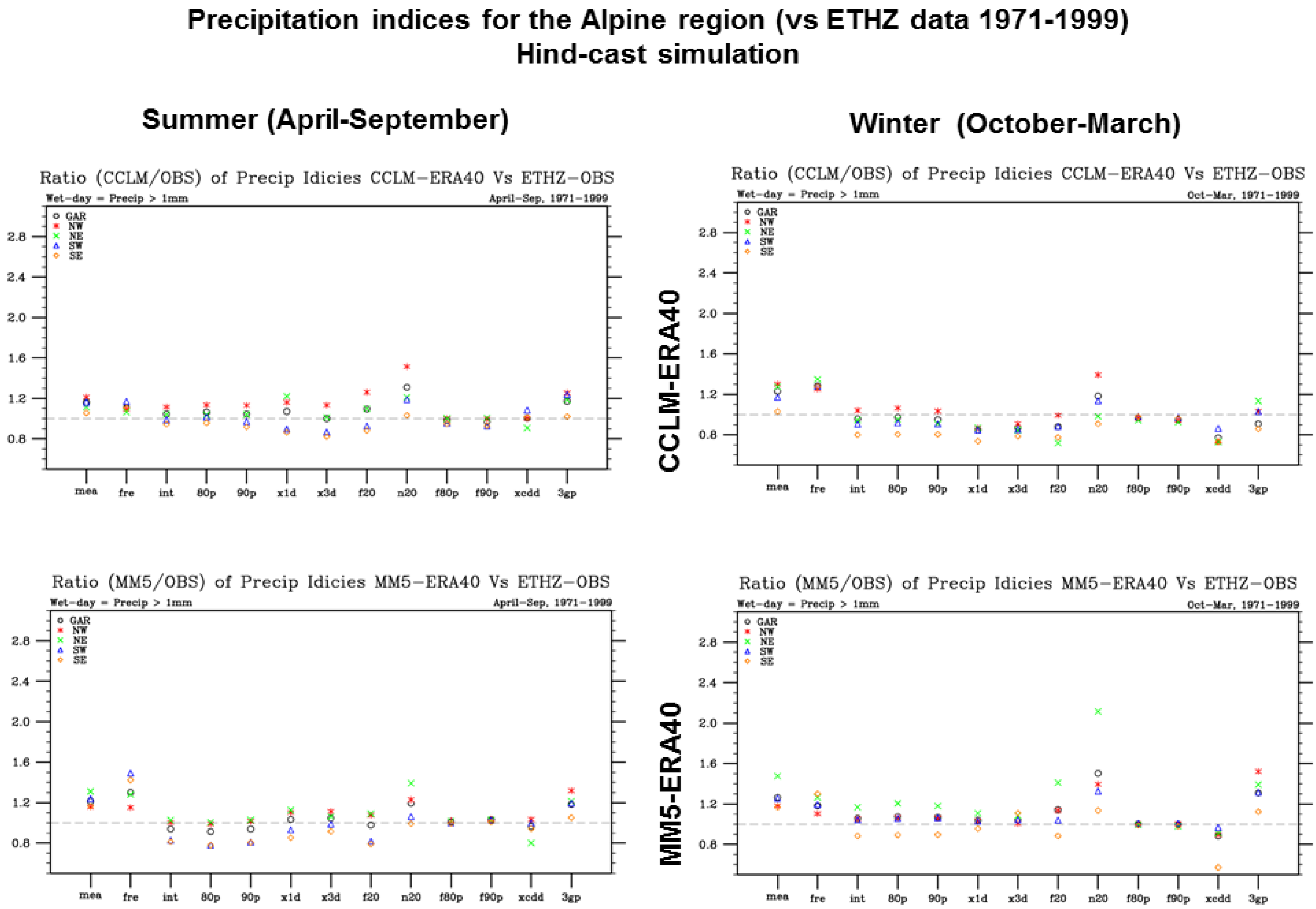


Figure 19: Precipitation indices of daily precipitation in the Alpine region (hind-cast simulations) compared to the gridded observational dataset of ETHZ for the period 1971-1999. An explanation of the used acronyms can be found in Table 1. left side: summer half year (April to September), right side: winter half year (October to March). The upper panel gives the results for CCLM and the lower that of MM5 simulations.

Table 2 Description of acronyms used in Fig. 18. and 19.

1	Mean Precipitation	(mea)
2	Frequency of wet days (precip. >= 0.5/1.0 mm/day)	(fre)
3	Precipitation Intensity (precip. per precip.day)	(int)
4	20 Percentile of wet day amounts	(20p)
5	90 Percentile of wet day amounts	(90p)
6	Maximum 1-day total precipitation	(x1d)
7	Maximum 3-day total precipitation	(x3d)
8	Ratio of precip. above 10mm to total precip.	(f10)
9	Number of events (days) with precip. >= 10mm	(n10)
10	Ratio of precip. above 80 pct. to total precip.	(f80p)
11	Ratio of precip. above 90 pct. to total preci.p	(f90p)
12	Maximum no. of consecutive dry days (longest dry period)	(xcdd)

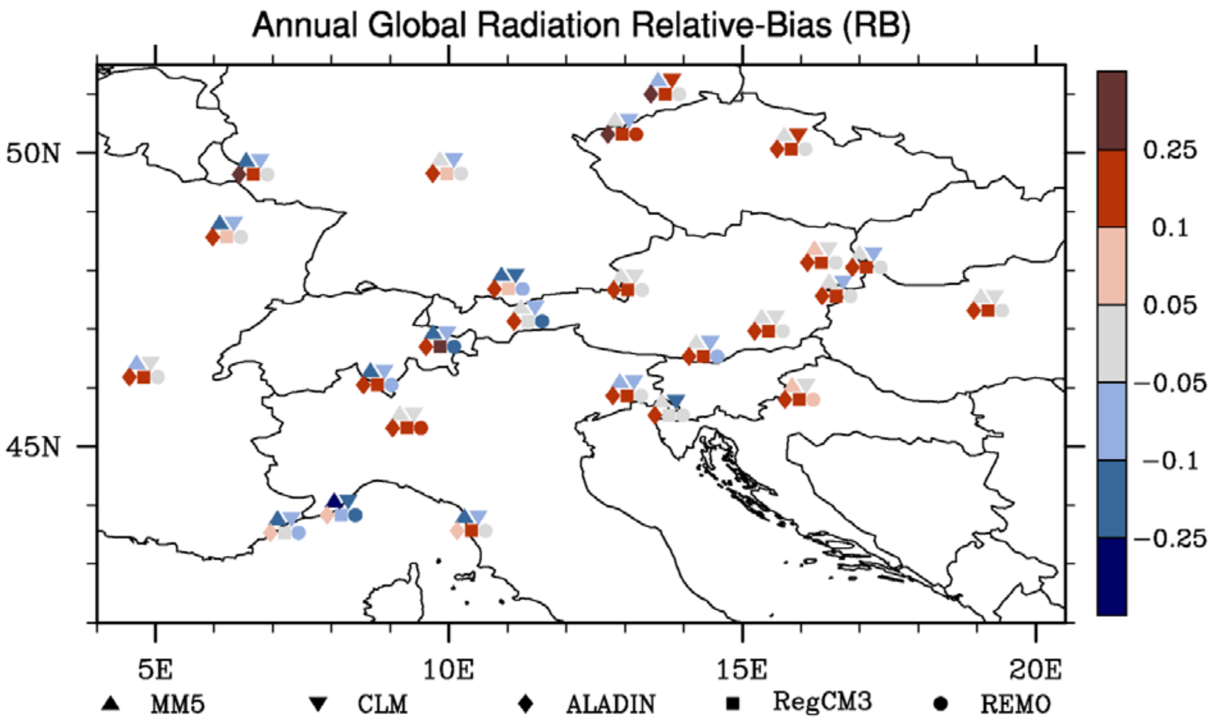


Figure 20: Relative bias of the annual global radiation of the hind-cast simulations of CLM and MM5 (triangles) and three members of the ENSEMBLES project (ALADIN, RegCM3 and REMO) compared with station observations within the Alpine region (source

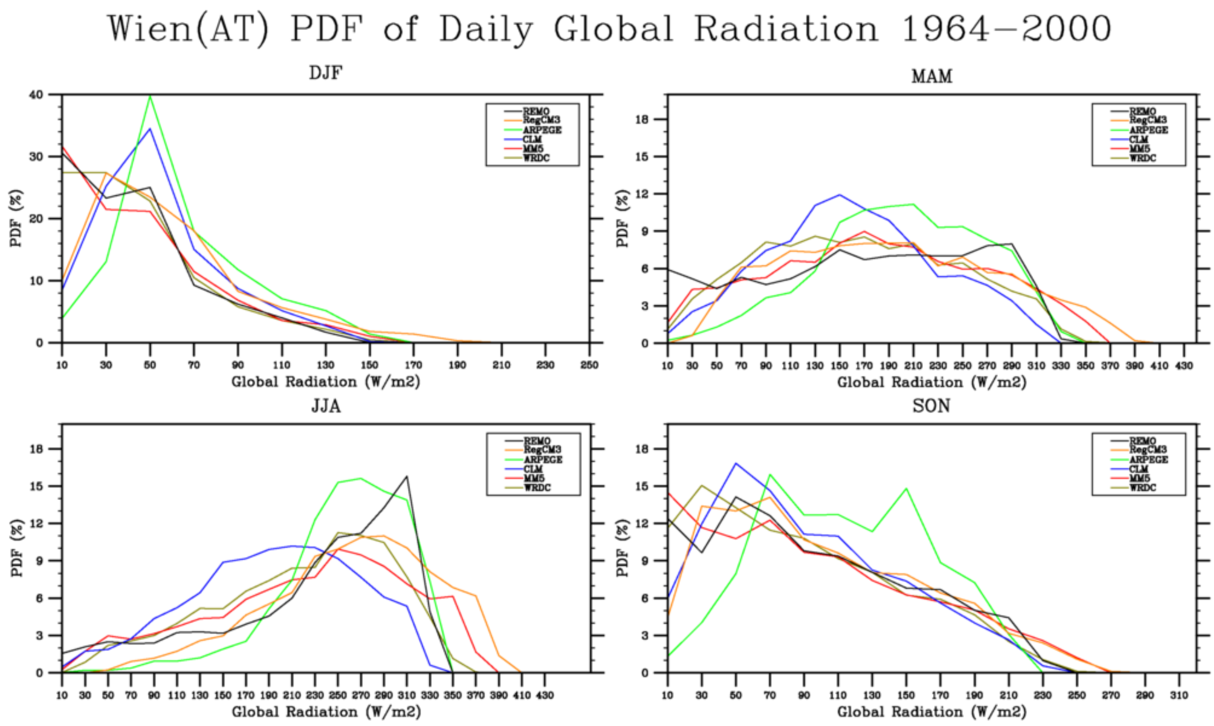


Figure 21: Frequency distribution of daily global radiation sums of the hind-cast simulations of CLM (blue) and MM5 (red) and three members of the ENSEMBLES project (ALADIN, RegCM3 and REMO) compared with station observation of Wien Hohe Warte.

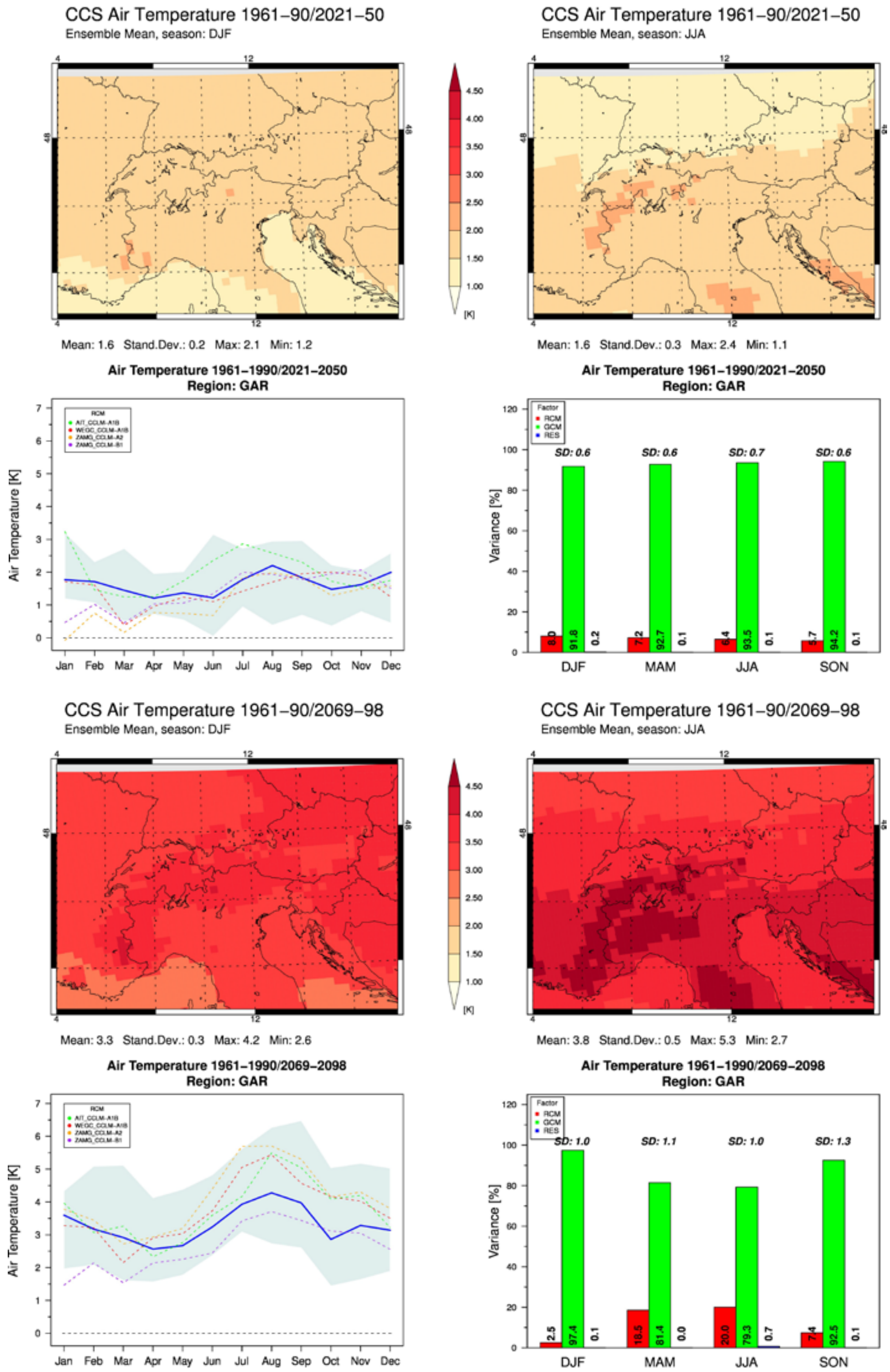


Fig. 22 Projected changes of air temperature in the GAR until the mid (upper four panels) and the end (lower four panels) of the 21st century for the 15 ENSEMBLES simulations. In each block, the upper left and right panels display the changes in DJF and JJA, respectively. The lower left panel shows the annual cycle of the expected changes as thick blue line (50th percentile of the reconstructed CCSs) and the according uncertainties as blue shaded area (range between 10th and 90th percentile of the reconstructed CCSs). The lower right panel shows the results of the ANOVA based on the reconstructed CCSs. From Heinrich et al. (2012b)

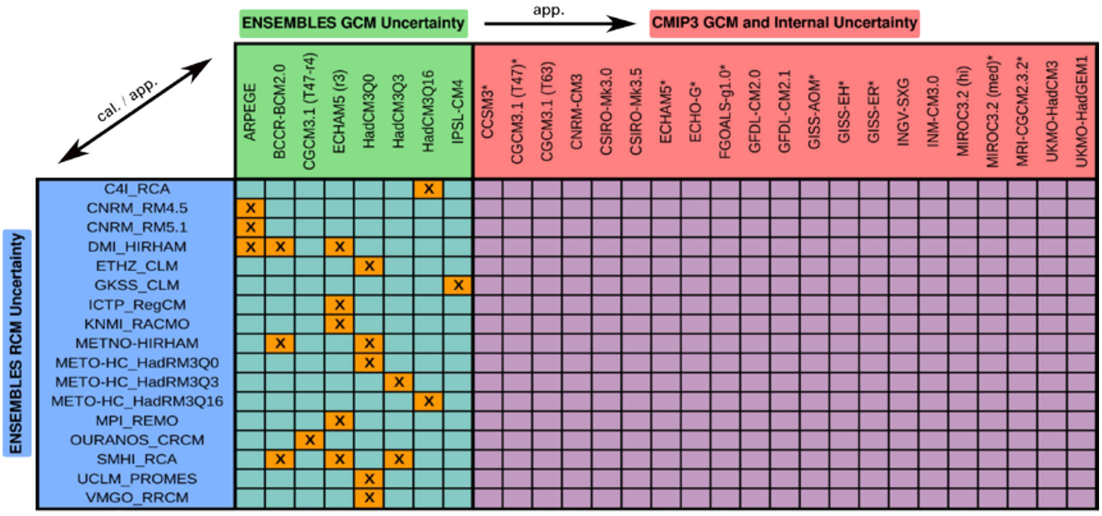


Fig. 23 The ENSEMBLES simulation matrix of the 25 km runs until 2050. The orange coloured cells marked with X's indicate the available simulations and empty cells represent the missing realisations. The models spanning the GCM and RCM uncertainty of ENSEMBLES are highlighted in green and blue, respectively. Additional uncertainty due to the CMIP3 GCMs is displayed in red and GCMs which are driven by multiple initial conditions are marked with an asterisk. The GCMs and RCMs of ENSEMBLES are used for calibrating the statistical reconstruction methods which are then applied to the GCMs of both ENSEMBLES and CMIP3 in order to fill the according missing values. From Heinrich et al. (2012).

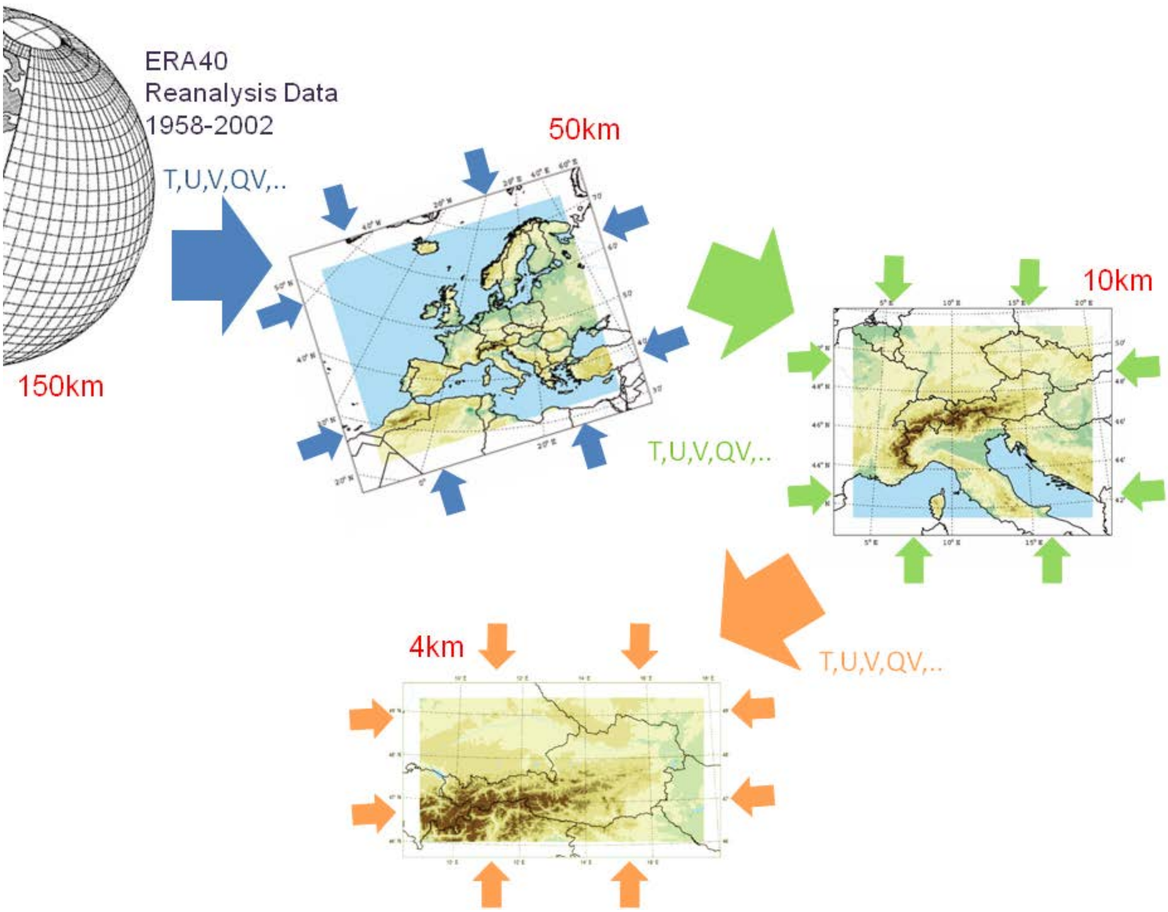
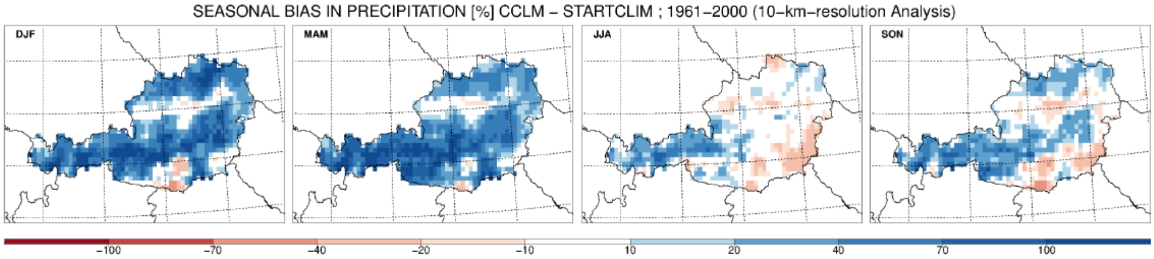
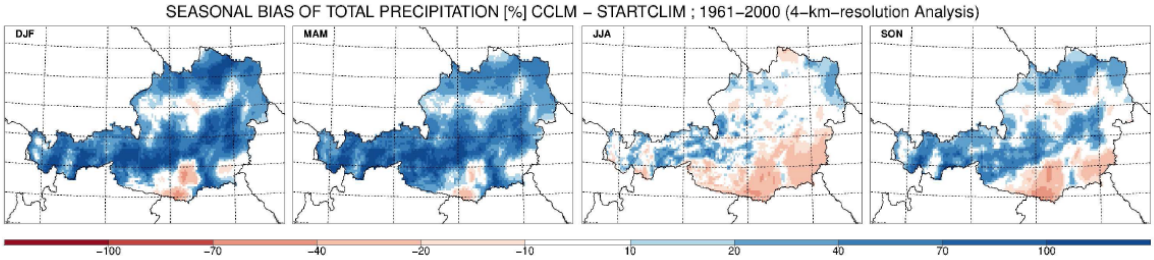


Fig. 24: All nesting steps from the GCM down to the 4x4km resolved simulation for the Austrian territory.



(a) 10-km-resolution



(b) 4-km-resolution

Fig. 25: Mean bias of total precipitation of CCLM vs. STARTCLIM. 10x10km (a) compared to 4x4km spatial resolution (b).

Table 3: Monthly mean seasonal bias of 2m-temperature for each Austrian climate sub-region of CCLM vs STARTCLIM for 10x10-km and 4x4-km analysis.

Regions	Year		DJF		MAM		JJA		SON	
Scale	10km	4km	10km	4km	10km	4km	10km	4km	10km	4km
West	−2.2	−2.3	−3.1	−2.3	−2.1	−2.6	−1.4	−2.0	−2.3	−2.2
North	−0.6	−0.4	−1.6	−1.0	−0.3	−0.4	0.0	0.0	−0.6	−0.4
Southeast	−0.8	−0.4	−1.7	−1.0	−0.7	−0.6	−0.1	0.3	−0.8	−0.3
Central Alpine	−2.0	−1.8	−2.8	−2.1	−1.8	−1.9	−1.2	−1.3	−2.0	−1.7
High Altitude (> 1500m)	−3.1	−2.4	−4.3	−3.1	−3.1	−2.4	−1.8	−1.5	−3.3	−2.5
Austria	−1.5	−1.2	−2.4	−1.7	−1.3	−1.3	−0.7	−0.6	−1.5	−1.2

Table 4: Absolute mean values for monthly precipitation [mm] for each Austrian climate sub-regions of CCLM vs. STARTCLIM for 10x10-km and 4x4-km analysis.

Regions	Year		DJF		MAM		JJA		SON	
Scale	10km	4km	10km	4km	10km	4km	10km	4km	10km	4km
West	125	118	92	88	114	110	181	174	102	100
North	92	75	63	55	74	74	107	109	70	64
Southeast	98	81	51	44	72	74	122	125	94	82
Central Alpine	115	104	76	71	96	95	157	156	97	96
High Altitude (> 1500m)	114	113	73	79	93	102	162	173	98	98
Austria	107	92	71	63	84	86	135	137	87	82

Table 5: Mean relative bias of monthly precipitation [%] for each Austrian climate subregion of CCLM vs STARTCLIM for 10-km and 4-km analysis.

Regions	Year		DJF		MAM		JJA		SON	
Scale	10km	4km	10km	4km	10km	4km	10km	4km	10km	4km
West	35.2	33.0	42.9	46.0	60.4	58.3	27.2	14.9	25.0	24.7
North	9.3	16.0	22.3	30.6	21.5	27.5	−0.8	4.3	5.7	10.6
Southeast	−10.4	−6.5	2.7	18.2	28.3	21.3	−15.3	−24.2	−19.5	−17.4
Central Alpine	21.2	21.2,	0.9	46.3	53.1	52.1	4.8	−2.8	13.6	11.6
High Altitude (> 1500m)	34.1	34.1	66.1	63.7	79.5	69.8	16.1	2.1	25.5	29.8
Austria	22.1	19.9	39.4	42.0	45.6	44.3	5.2	−0.8	14.8	12.1

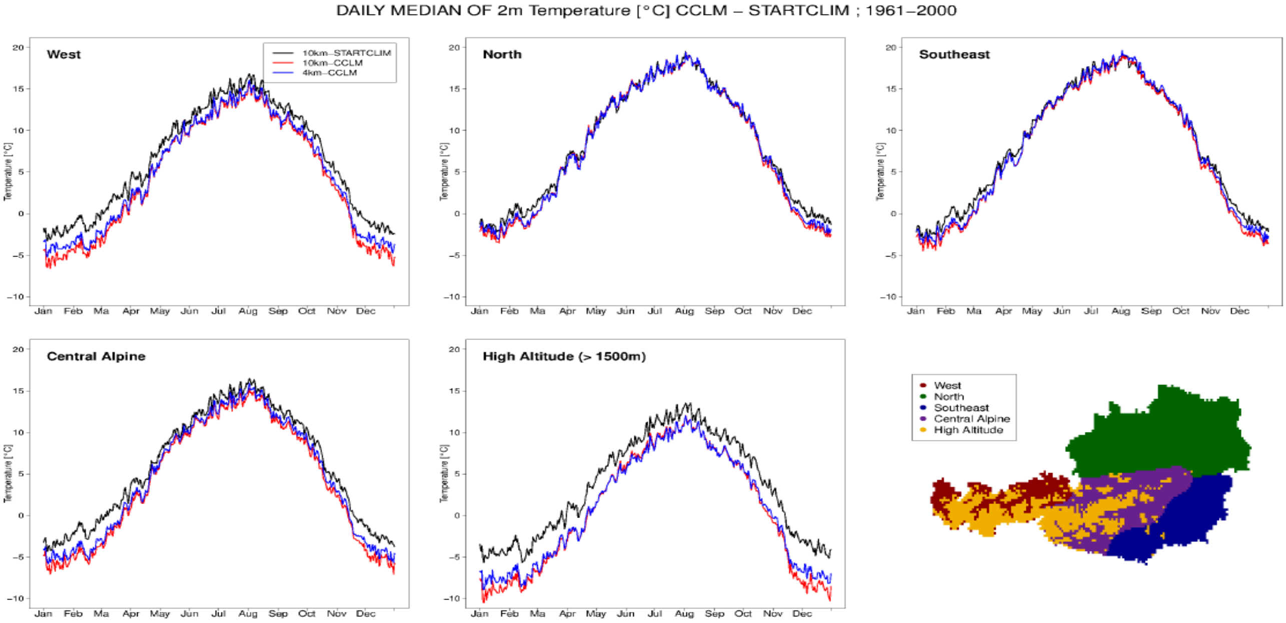


Fig. 26: Mean bias of total precipitation of CCLM vs. STARTCLIM. 10x10km (a) compared to 4x4km spatial resolution.

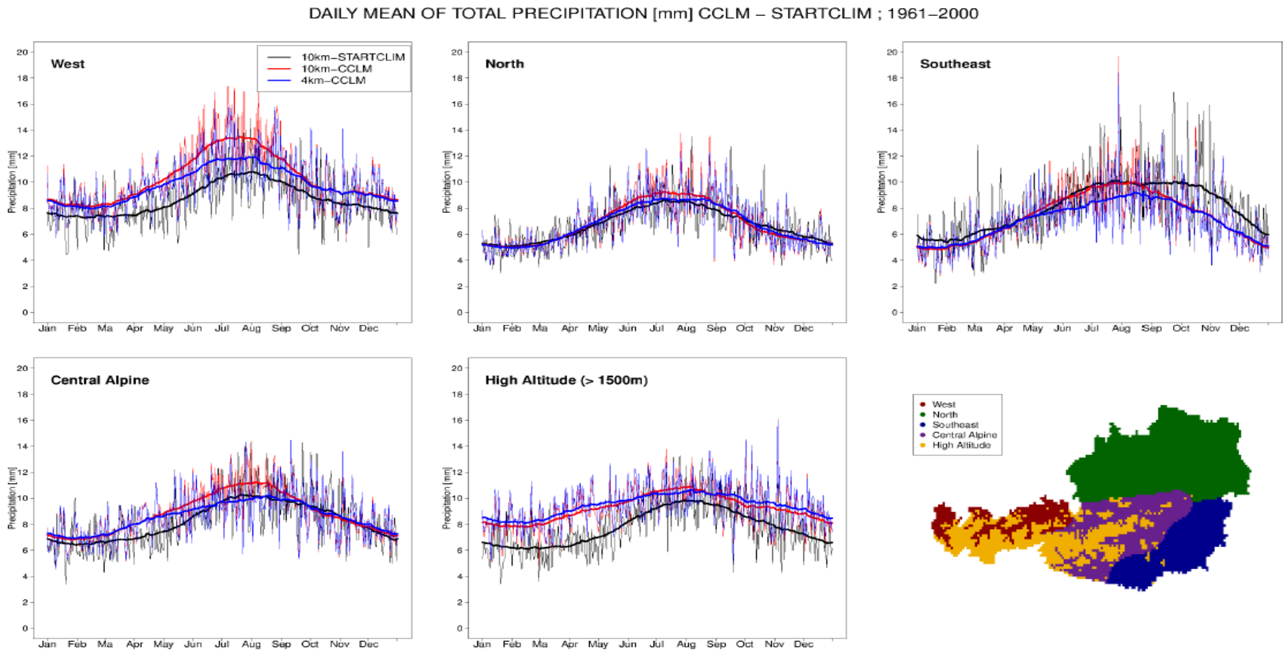


Fig. 27: Daily mean of total precipitation STARTCLIM interpolated 10x10km (a) compared to 4x4km spatial resolution.

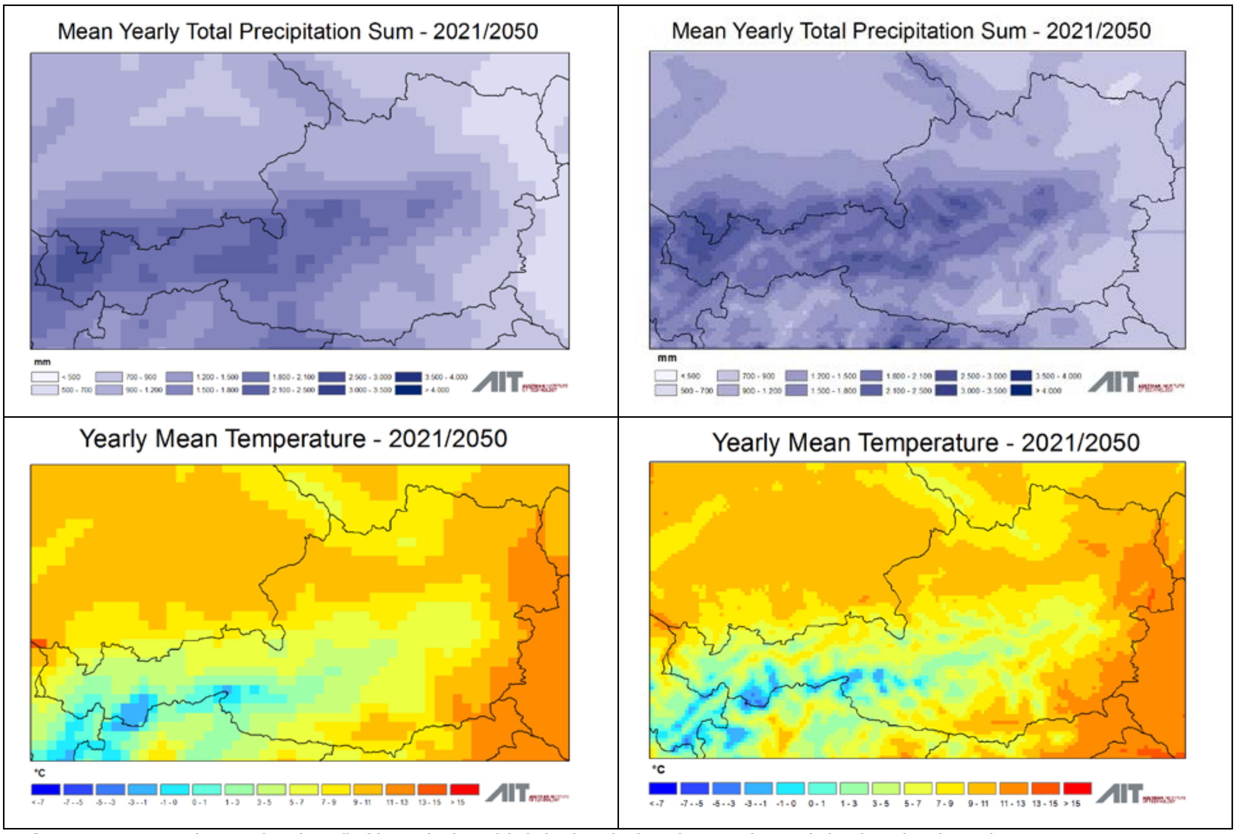


Fig. 28: Comparison of 10km (left) and 4km (right) simulation for total precipitation (top) and 2m-temperature (bottom) for the period 2021/2050.

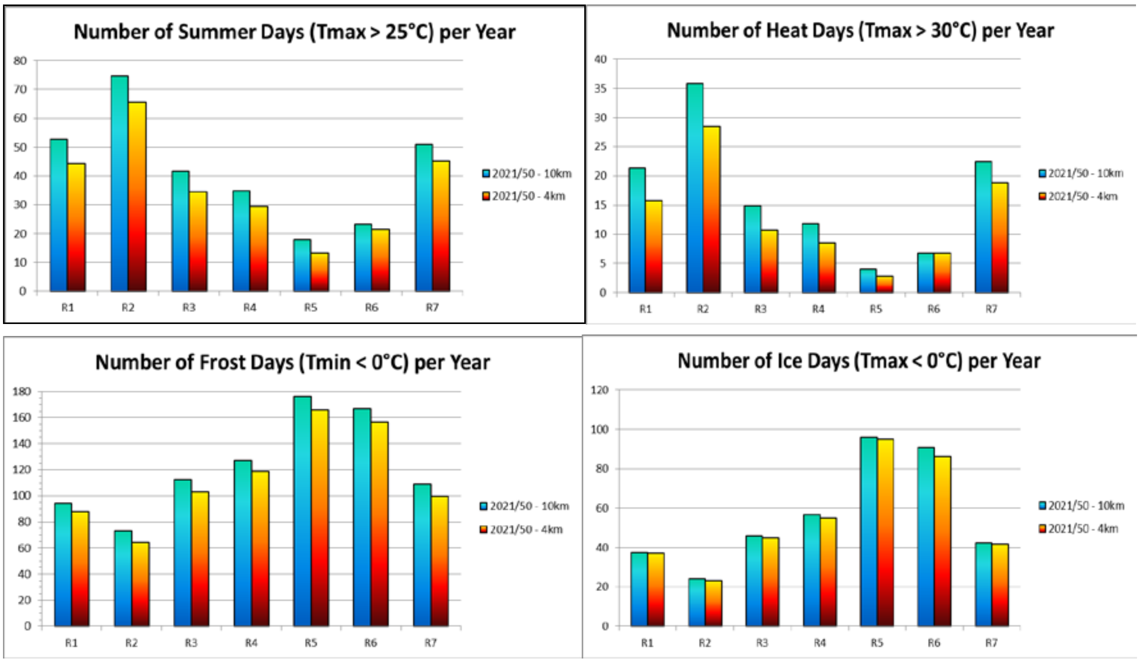


Fig. 29: Comparison of tempeature related extreme event days per region for 10x10 (blue) and 4x4 (orange-yellow) resolution (regions to be seen in figure 30)

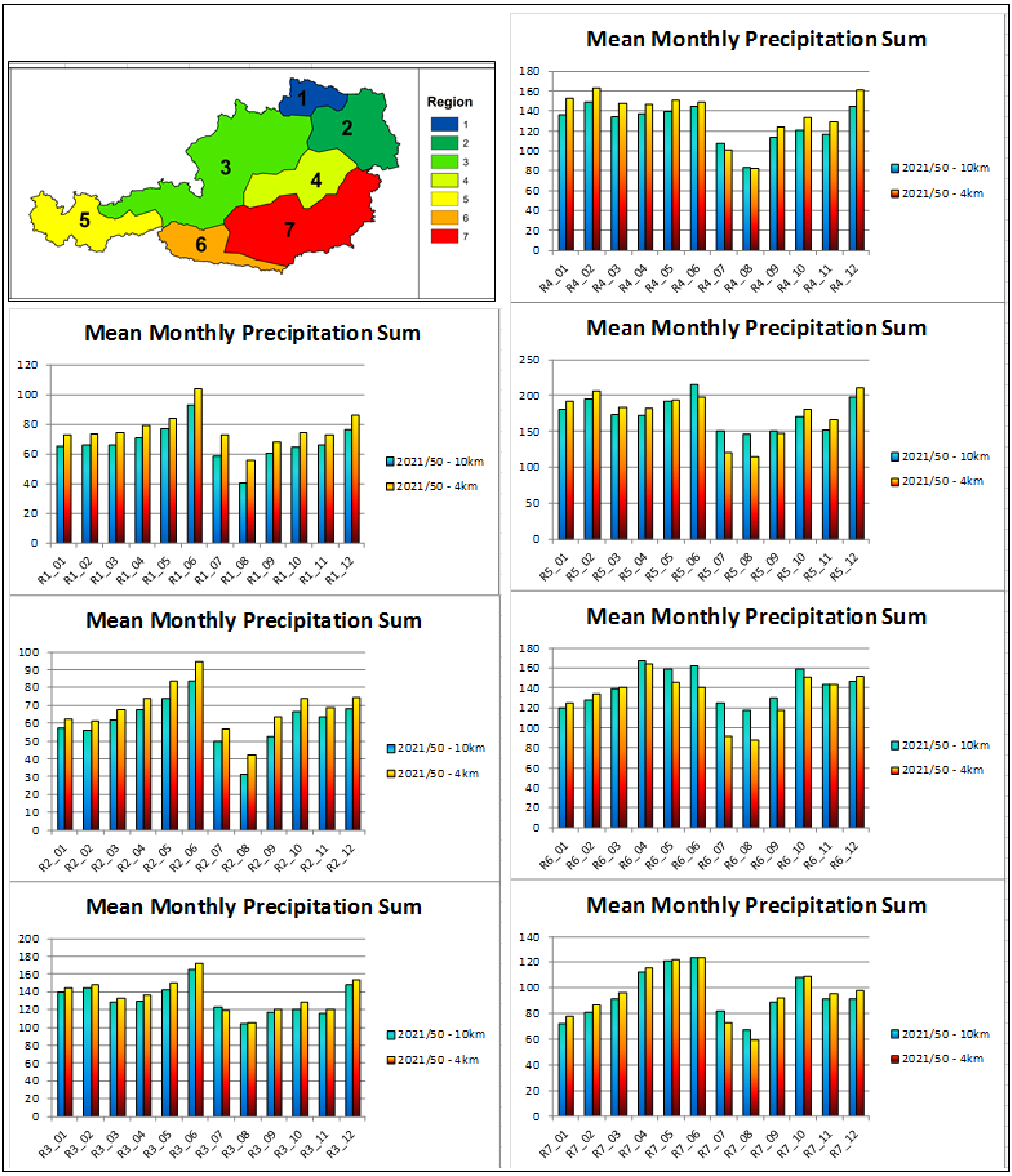


Fig. 30: Regional averages of precipitation sums per month for 10x10 (blue) and 4x4 (orange-yellow) resolution (Regions 1-3 left column, regions 4-7 right column)

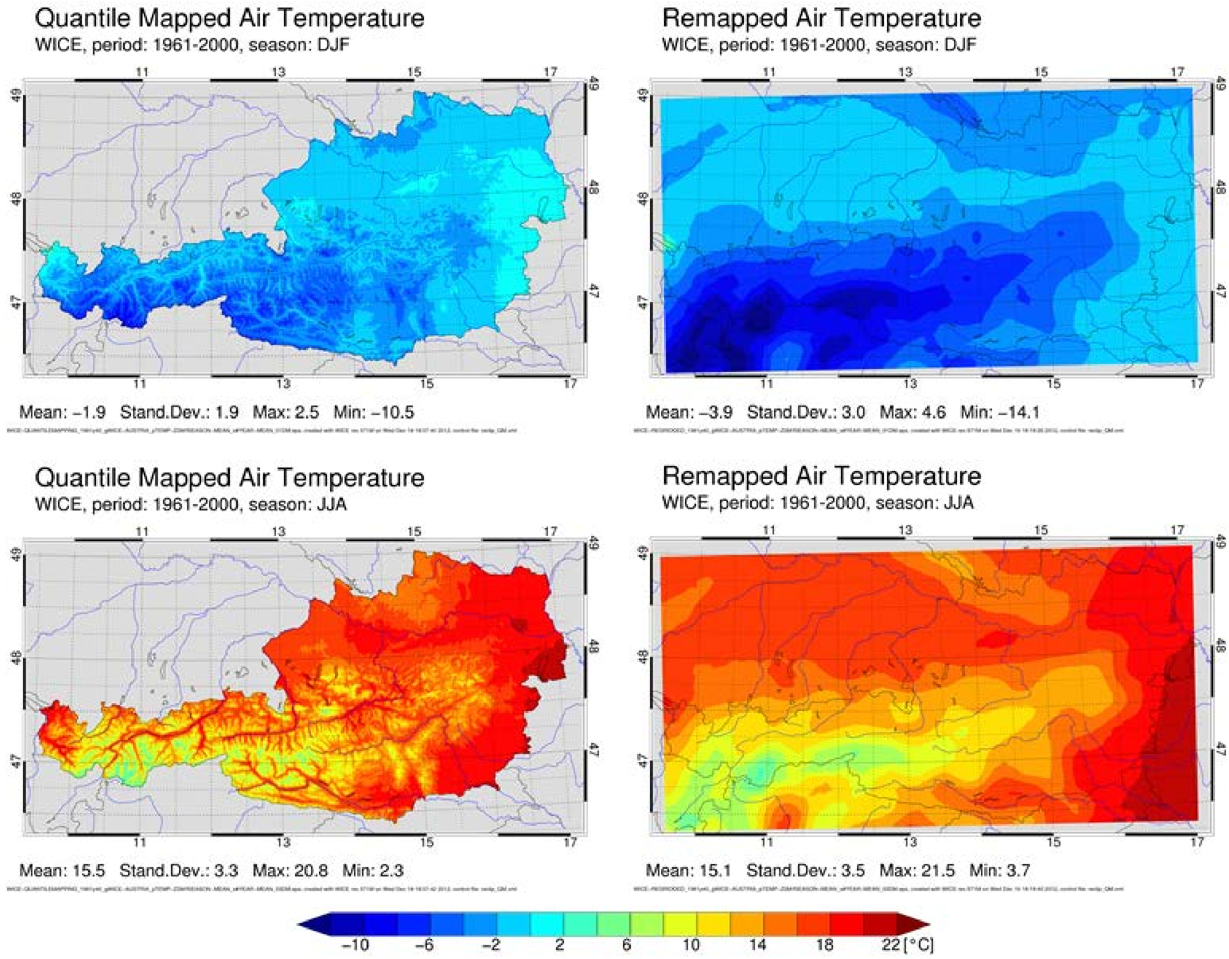


Fig. 31: Seasonal (top row: winter; bottom row: summer) mean temperature in Austria with 1 km grid spacing derived from differently downscaled ERA-40 driven CCLM hindcast (period 1961 to 2000; 10 km grid spacing; generated in reclip:century 1): quantile mapping (left column), simple remapping (right column).

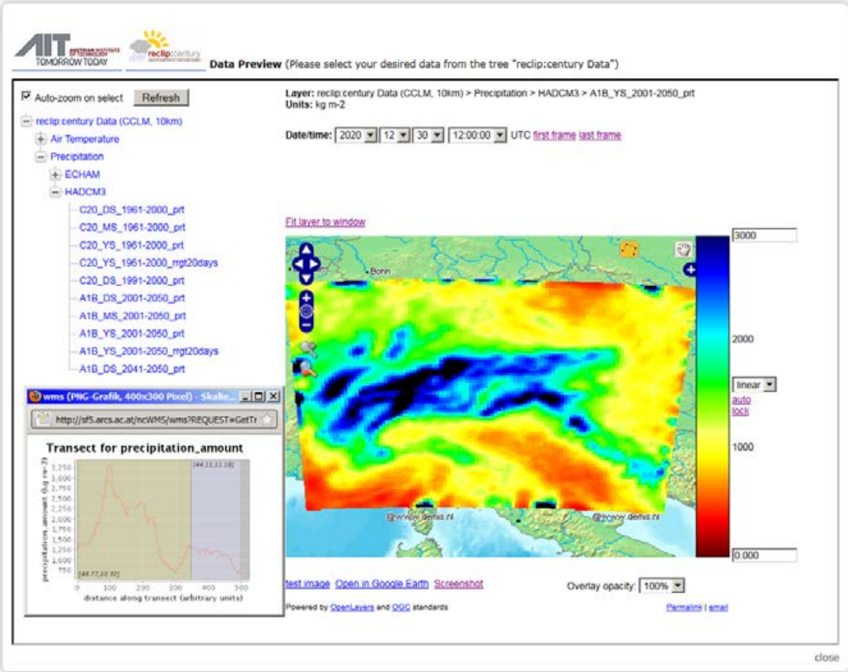


Figure 32: Data retrieval and exploration tool provided in the project's web site http://reclip.ait.ac.at/reclip_century/ (exemplary screen shot)