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Region	Region-ID	Model version	Institution	Vertical levels Model top	Time step (s)	Aerosol	Tuning parameters	Comments	Reference
Europe (EUR)	EUR-11	CCLM4-8-17	BTU, DWD, ETH	40/22.7km	100	Tanre	Default	Evaluation run 1989-2008	Kotlarski et al. (2014); Keuler et al. (2016); Dalelane et al. (2018); Bülow et al. (2019).
		COSMO-crCLIM-v1-1	ETH	40/22.7km	90	Aerocom	Default, except a some changed due to past experience and sensistivity runs (tkhmin, tkmmin,		Leutwyler et al. (2017) Vautard et al. (2020)
	EUR-44	CCLM4-8-17	BTU	40/22.7km	300	Tanre	Default		
		CCLM5-0-6	ETH	40/22.7km	300	Tanre	Objective Calibration	The recommended version from the CLM-Community (from year 2015)	Sørland et al. (2018)
Africa (AFR)	AFR-22	CCLM4-8-17	KIT	35/30km	120	Tanre	Default	Used to investigate the added value of increasing the horizontal resolution. Thus, only one evaluation run (1989-2000).	Panitz et al. (2014)
		CCLM-5-0-15	KIT	57/30km	150	Tegen	Default, except q_crit, rlam_heat, uc1, following Bucchignani et al. (2016)	CORDEX-CORE framework	
	AFR-44	CCLM4-8-17	KIT	35/30km	240	Tanre	Default	Tropical setup, and lower height of damping changed to 18 km. Evaluation run 1989-2008	Panitz et al. (2014) Dosio and Panitz (2016) Dosio et al. (2015)
East Asia (EAS)	EAS-22	CCLM5-0-9	POSTECH	40/22.7km	150	Tanre	Default except tkhmin, rlam_heat, entr_sc, uc1, fac_rootdp2, soilhyd	Spectral nudging on. CORDEX-CORE framework	
	EAS-44	CCLM-5-0-2	HZG	45/30km	300	Tegen	Default	Tropical setup, and lower height of damping changed to 18 km.	Li et al. (2018, 2019)
Australasia (AUS)	AUS-22	CCLM-5-0-15	HZG	57/30km	150	Tanre	Default (except rat_sea which is decreased)	Tropical setup, and lower height of damping changed to 18 km. Bechthold et al. (2008) convection scheme. CORDEX-CORE framework.	
	AUS-44	CCLM4-8-17-CLM3-5	HZG	35/30km	360	Tanre	Default	Tropical setup, and lower height of damping changed to 18 km Bechthold et al. (2008) convection scheme. Coupled to the Community Land Model	Di Virgilio et al. (2019) Hirsch et al. (2019)
South Asia (WAS)	WAS-22	COSMO-crCLIM-v1-1	ETH/GUF	57/30km	150	Aerocom	Default, except a couple changed due to sensitivity runs: rlam_heat, radfac, l_g	Tropical setup, and lower height of damping changed to 18 km. CORDEX-CORE framework.	Leutwyler et al. (2017) Pothapakula et al. (2020)
	WAS-44	CCLM4-8-17	GUF	35/30km	240	Tanre		Kessler (1969) microphysics scheme. No ERA-Interim simulation is performed, but the MPI-ESM-LR has been downscaled for the historical period and RCP4.5 scenario.	Asharaf and Ahrens (2015)

Table S1. Overview of the different model versions and the associated configurations and horizontal resolution, for the five different domains investigated; Europe at 0.44 ° (EUR-44) and 0.11° (EUR-11), Africa at 0.44 ° (AFR-44) and 0.22° (AFR-22), East-Asia at 0.44 ° (EAS-44) and 0.22° (EAS-22), Australasia at 0.44 ° (AUS-44) and 0.22° (AUS-22), and South Asia at 0.44 ° (WAS-44) and 0.22° (WAS-22). The institute acronyms are Brandenburg University of Technology Cottbus - Senftenberg, Germany (BTU); Deutscher Wetterdienst, Germany (DWD); ETH Zurich, Switzerland (ETH); Goethe University Frankfurt, Germany (GUF); Helmholtz-Zentrum Geesthacht, Germany (HZG); Karlsruhe Institute of Technology, Germany (KIT); POSTECH, South-Korea (POSTECH). For each model configuration, an evaluation run has been performed, where the boundary conditions are taken from the ERA-Interim reanalysis. If nothing else is stated, the evaluation period is covering the years 1979-2010. The log-files from the respective simulations with a full overview over the different configurations is provided as a supplementary file.

Variable, symbol (unit)	Dataset and version	Temporal resolution	Spatial resolution	References
Near-surface temperature, T2M (K)	GHCN v2 +CAMS	monthly	0.5 °	Fan and van den Dool (2008)
	UDEL v401	monthly	0.5 °	Willmott and Matsuura (2001)
	TS CRU v3.24	monthly	0.5 °	Jones (2008)
Precipitation, P (mm)	UDEL v401	monthly	0.5 °	Willmott and Matsuura (2001)
	CRU v401	monthly	0.5 °	Jones (2008)
	GPCC v2018	monthly	0.25 °	Schneider et al. (2018)
	MSWEP v2	3H	0.1 °	Beck et al. (2019)
	GPCP v2.3	monthly	2.5°	Adler et al. (2003)
	CPC v1.0	daily	0.5 °	Chen et al. (2008)

Table S2. Overview over the observational datasets with their temporal and spatial resolution and references. All datasets provide data for the full evaluation period 1979 - 2010.

		EUR		AFR		EAS		AUS		WAS	
		0.11	0.44	0.22	0.44	0.22	0.44	0.22	0.44	0.22	0.44
MPI-ESM-r1	CCLM4-8-17	✓	✓		✓						(✓)
	CCLM4-8-17-CLM3-5								✓		
	CCLM5-0-2						✓				
	CCLM5-0-6		✓								
	CCLM-5-0-9					✓					
	CCLM-5-0-15			✓				✓			
	CcrCLIM-v1-1	✓								✓	
MPI-ESM-r2	CcrCLIM-v1-1	✓									
MPI-ESM-r3	CcrCLIM-v1-1	✓									
HadGEM2-ES-r1	CCLM4-8-17	✓			✓						
	CCLM5-0-2						✓				
	CCLM5-0-6		✓								
	CCLM5-0-15			✓				✓			
HadGEM2-AO-r1	CCLM-5-0-9					✓					
CNRM-CM5-r1	CCLM4-8-17	✓			✓						
	CCLM5-0-2						✓				
	CCLM5-0-6		✓								
EC-EARTH-r12	CCLM4-8-17	✓			✓						
	CCLM4-8-17-CLM3-5								✓		
	CCLM5-0-2						✓				
	CCLM5-0-6		✓								
	CcrCLIM-v1-1	✓								✓	
CanESM2-r1	CCLM4-8-17	✓									
NorESM-r1	CCLM5-0-15			✓				✓			
	CcrCLIM-v1-1	✓								✓	
MIROC5-r1	CCLM4-8-17	✓									
	CCLM5-0-6		✓								
Sum RCP8.5	38	11	6	3	4	2	4	3	2	3	0
Sum RCP4.5	16	4	1	0	4	0	4	0	2	0	1
Sum RCP2.6	14	4	0	3	0	2	0	3	0	2	0
Sum all RCPs	68 (80 incl ERA-I)										

Table S3. Overview over the GCMs that have been downscaled for the RCP8.5 scenario with various COSMO-CLM model versions and the horizontal grid spacings 0.44°, 0.22° and 0.11°. The number of simulations for each domain is given at the bottom, where RCP4.5 and RCP2.6 is included for reference. The tick with a parenthesis means that there is no evaluation simulation performed.

tas land abs bias (K)	DJF	MAM	JJA	SON
EUR-44-CCLM4.8.17	**1,30**	**0,81**	**1,44**	**0,61**
EUR-44-CCLM5.0.6	**0,94**	**1,47**	**1,56**	**0,91**
EUR-11-CCLM4.8.17	**1,17**	**0,85**	**1,22**	**0,68**
EUR-11-crCLIM	**1,25**	**0,88**	**1,31**	**0,80**
AFR-44-CCLM4.8.17	**1,61**	**1,27**	**1,84**	**1,38**
AFR-22-CCLM4.8.17	**1,51**	**1,48**	**1,82**	**1,34**
AFR-22-CCLM5.0.15	**1,68**	**1,02**	**1,45**	**1,18**
WAS-22-crCLIM	**1,58**	**1,34**	**1,44**	**1,36**
AUS-44-CCLM4.8.17	**0,83**	**0,91**	**0,79**	**0,97**
AUS-22-CCLM5.0.15	**0,88**	**0,80**	**1,00**	**0,79**
EAS-44-CCLM5.0.2	**2,14**	**1,47**	**1,65**	**1,29**
EAS-22-CCLM5.0.9	**2,01**	**1,40**	**1,57**	**1,12**

pr land abs bias (%)	DJF	MAM	JJA	SON
EUR-44-CCLM4.8.17	**30,86**	**40,17**	**48,59**	**33,08**
EUR-44-CCLM5.0.6	**33,77**	**41,28**	**38,29**	**29,32**
EUR-11-CCLM4.8.17	**32,84**	**46,43**	**47,37**	**30,33**
EUR-11-crCLIM	**32,16**	**41,28**	**45,13**	**33,34**
AFR-44-CCLM4.8.17	**62,35**	**85,38**	**75,28**	**65,34**
AFR-22-CCLM4.8.17	**65,63**	**63,89**	**70,72**	**56,66**
AFR-22-CCLM5.0.15	**52,33**	**68,42**	**68,78**	**47,13**
WAS-22-crCLIM	**109,98**	**80,12**	**64,88**	**62,43**
AUS-44-CCLM4.8.17	**29,76**	**38,42**	**29,64**	**28,81**
AUS-22-CCLM5.0.15	**33,87**	**30,95**	**25,16**	**23,21**
EAS-44-CCLM5.0.2	**115,42**	**83,19**	**52,4**	**59,72**
EAS-22-CCLM5.0.9	**107,8**	**89,79**	**41,25**	**44,89**

Table S4. Mean absolute bias (only land points, and also including the masked out values shown in Figure 2, 3, S11 and S12) for the seasons DJF, MAM, JJA and SON for each ERA-Interim driven simulation for the five domains for 2m temperature (K) and precipitation (%). The background color is to distinguish simulations with large temperature (precipitation) bias, where white has a mean absolute bias of less than 1 K (40 %), yellow between 1 and 1.5 K (40 and 80 %) and read is larger than 1.5 K (80 %).

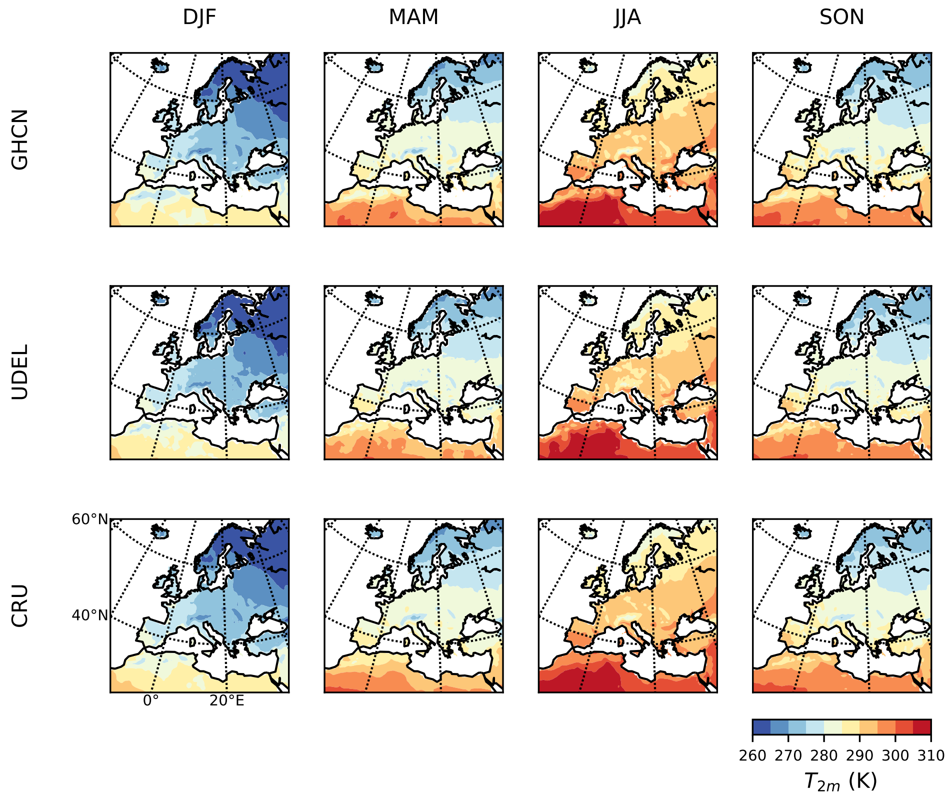

Figure S1. Temperature seasonal Climatology (1981-2010) for Europe given by the three different observational datasets GHCN, UDEL and CRU. See Table S2 for details about the observatios.

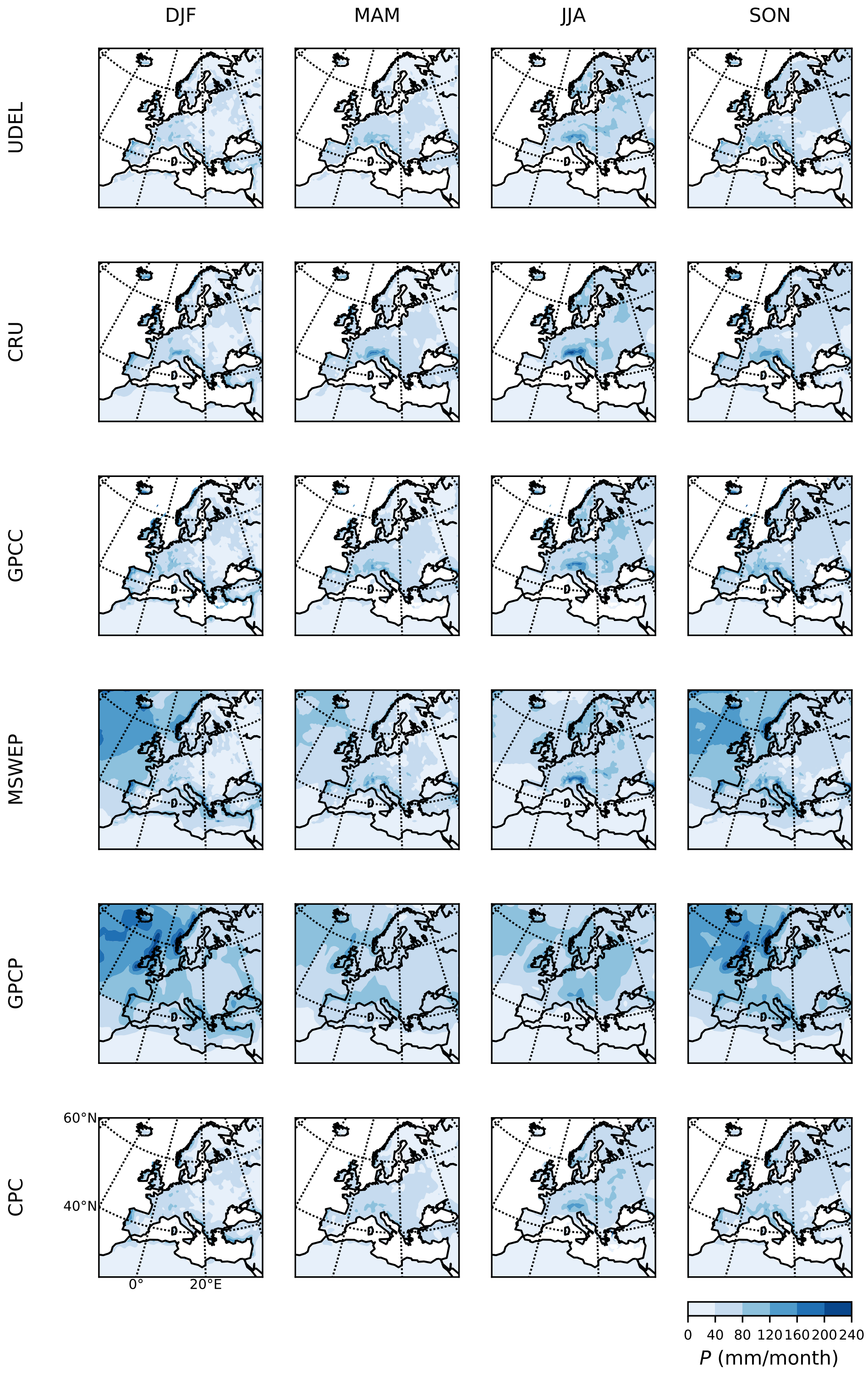

Figure S2. Precipitation seasonal climatology (1981-2010) for Europe given by the three different observational datasets UDEL, CRU, CPCC, MSWEP, GPCP and CPC. See Table S2 for details about the observatios.

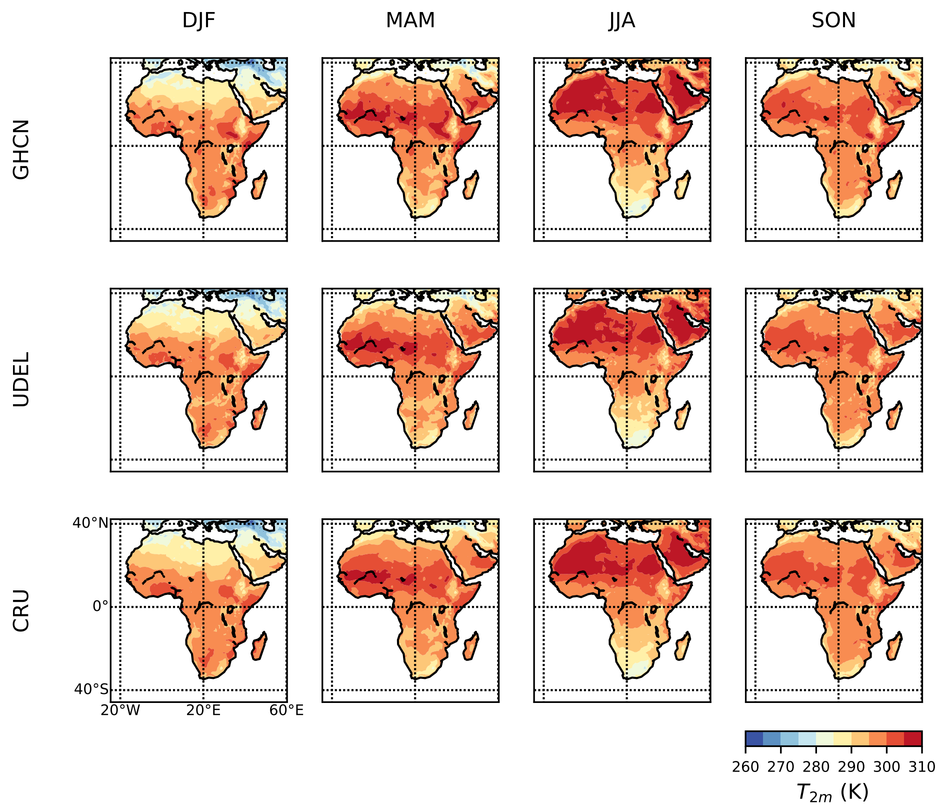

Figure S3. Same as Figure S1, but for Africa.

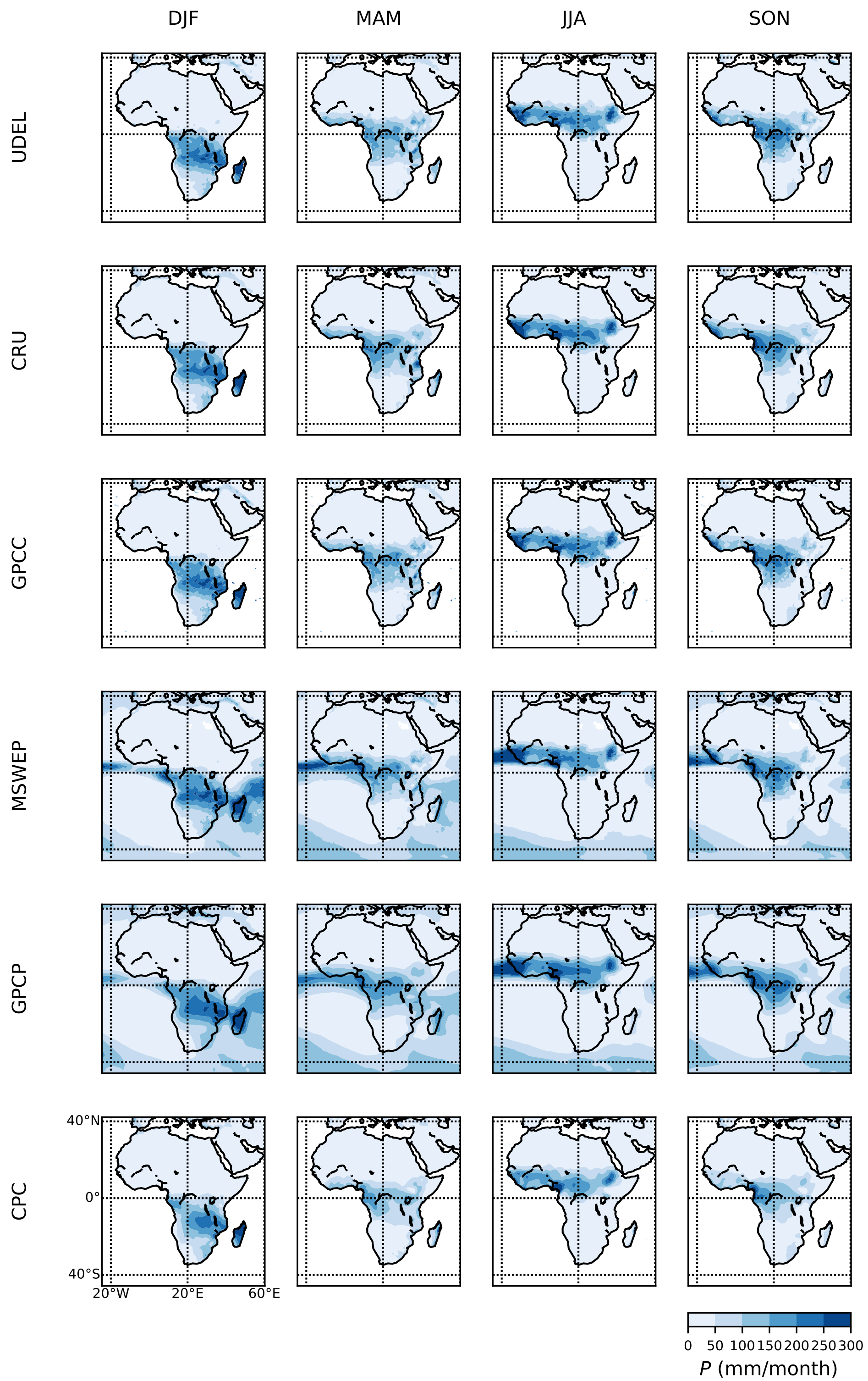

Figure S4. Same as Figure S2, but for Africa.

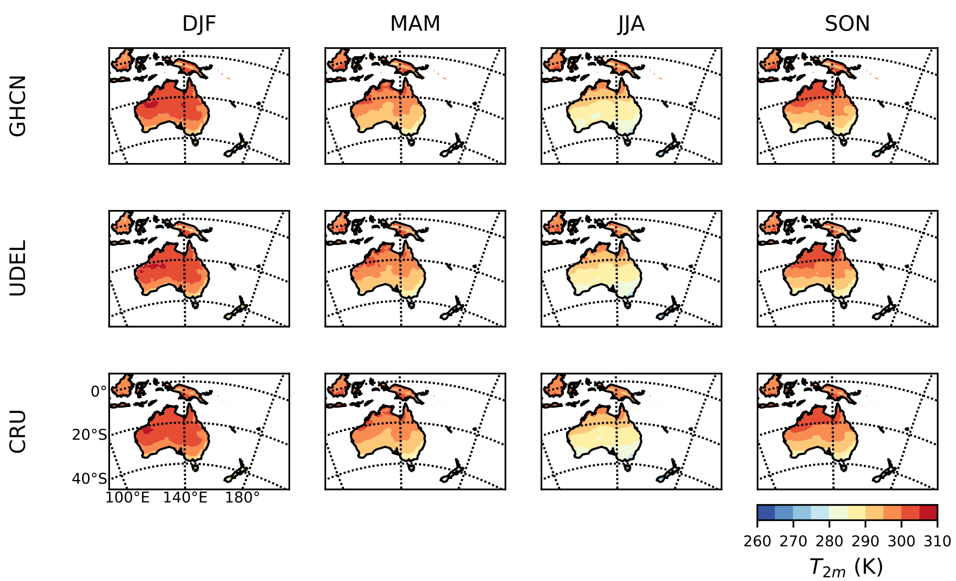

Figure S5. Same as Figure S1, but for Australasia.

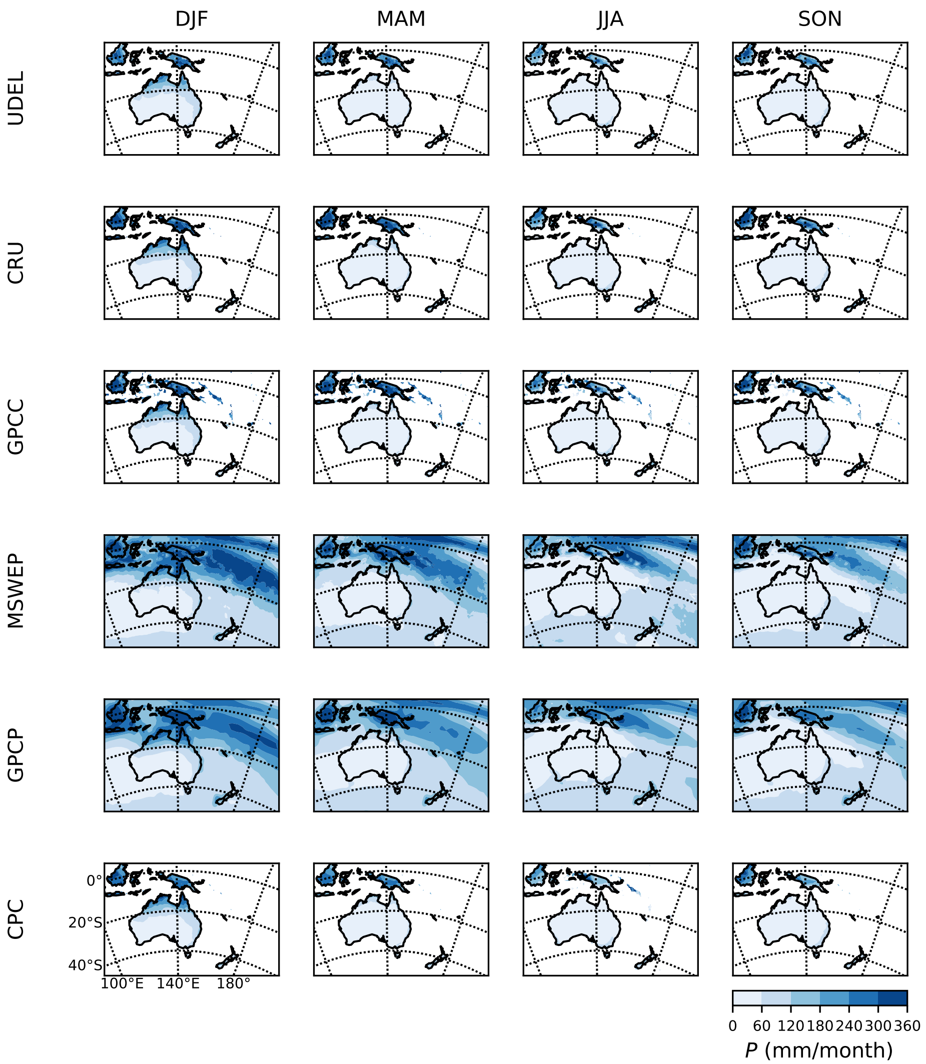

Figure S6. Same as Figure S2, but for Australasia.

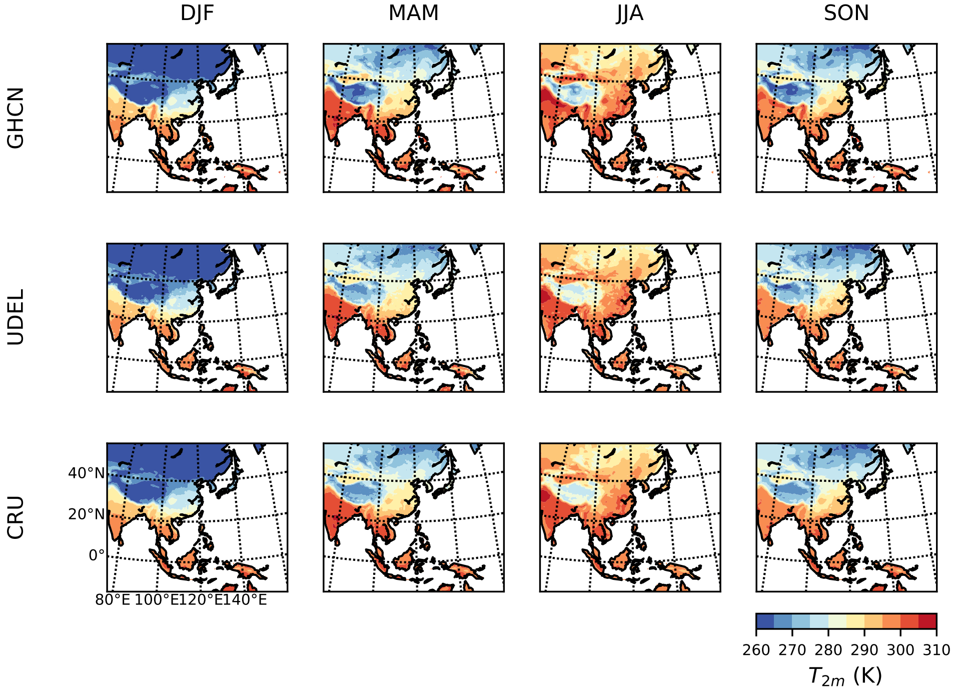

Figure S7. Same as Figure S1, but for East-Asia.

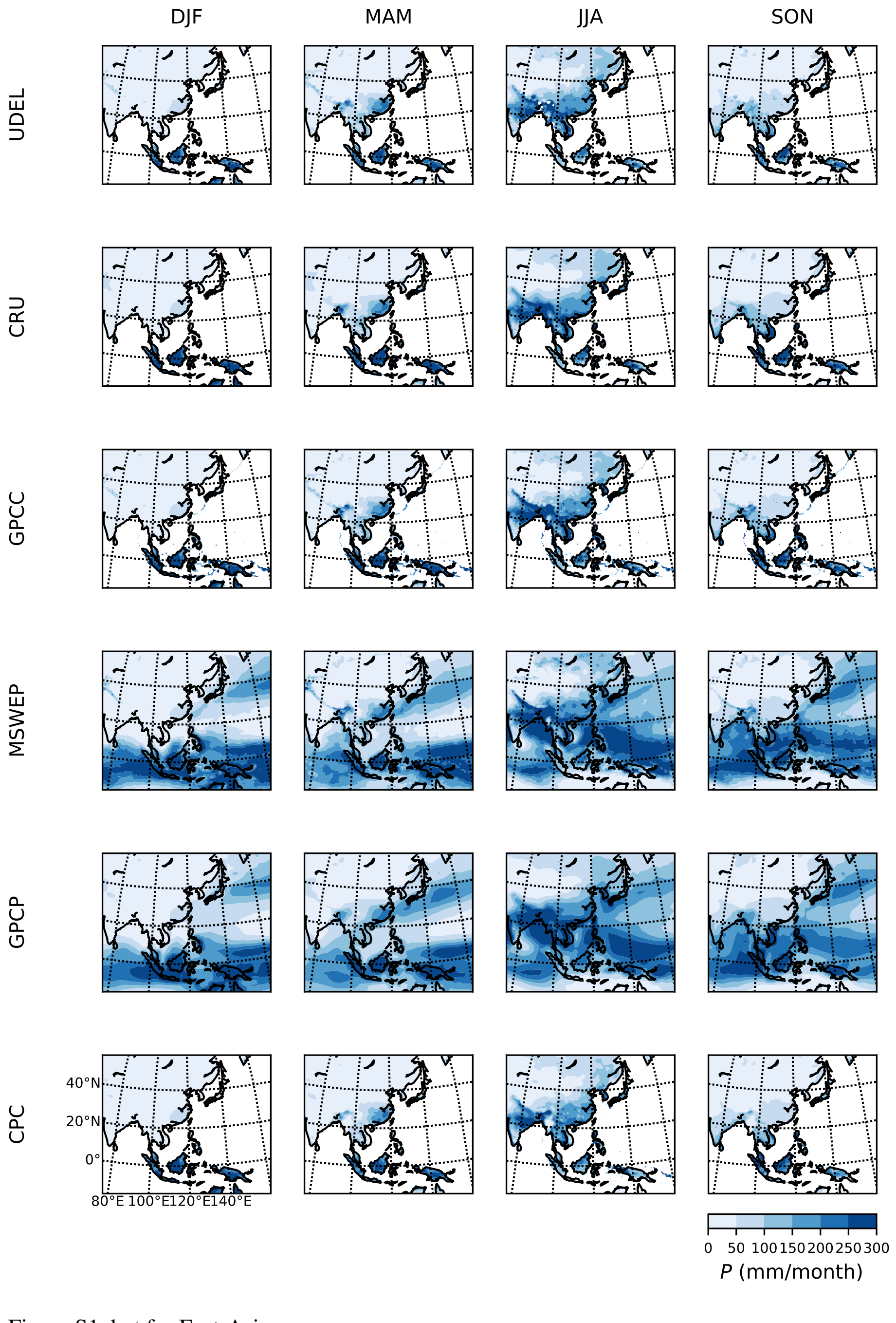

Figure S8. Same as Figure S1, but for East-Asia.

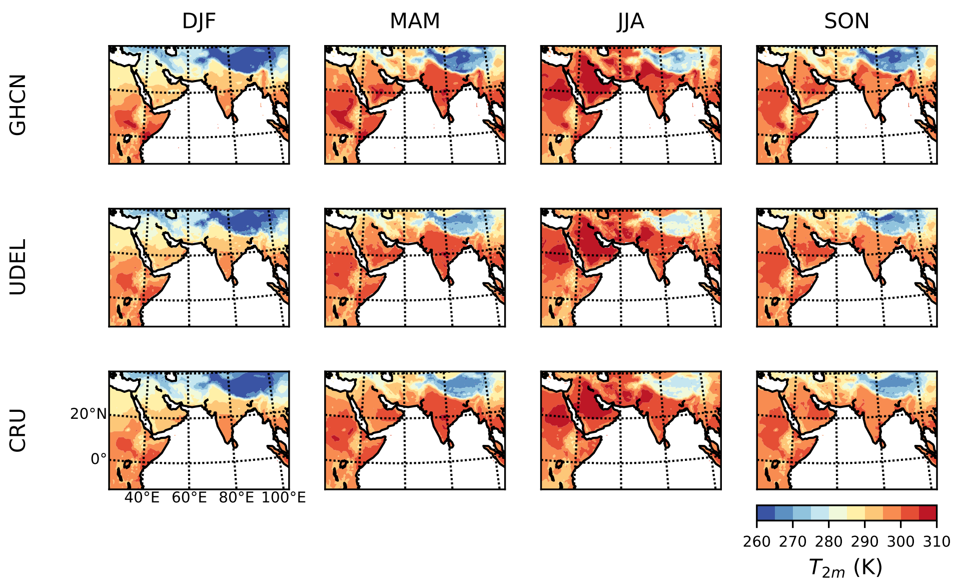

Figure S9. Same as Figure S1, but for South-West Asia

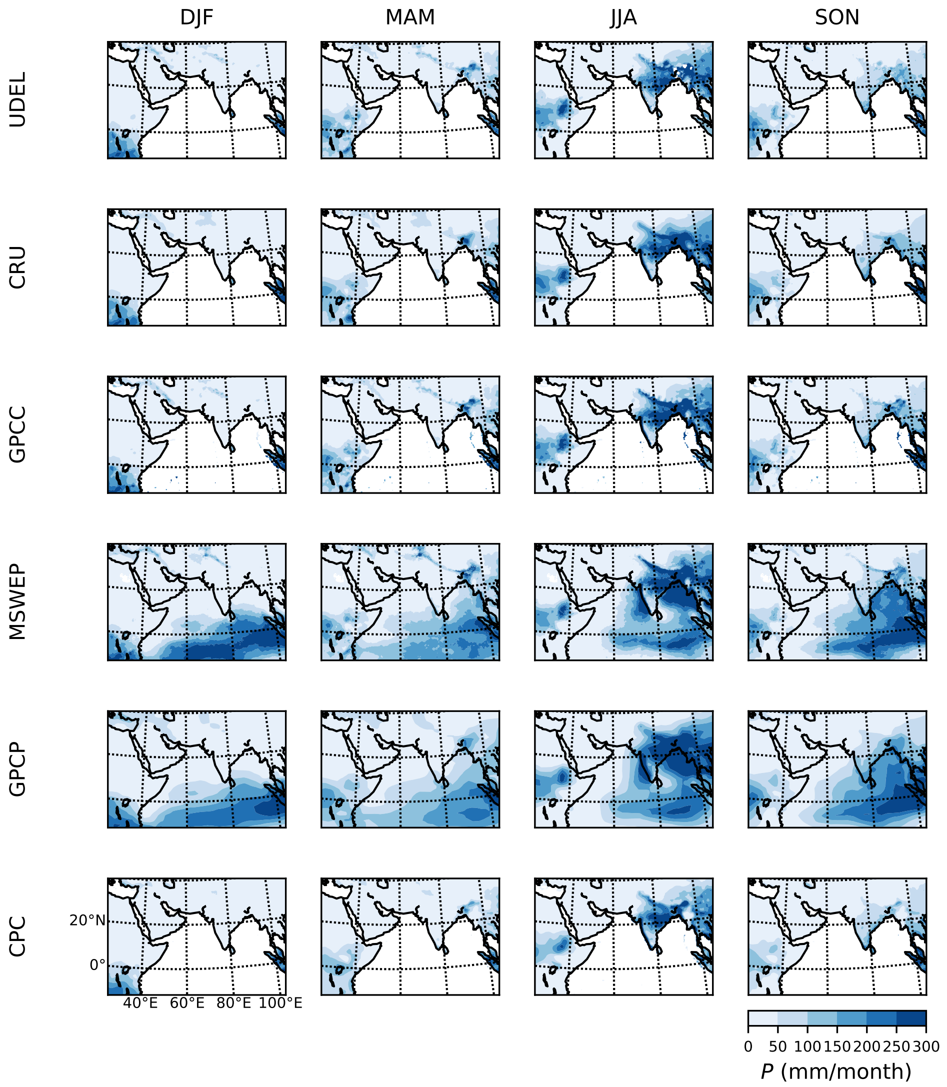

Figure S10. Same as Figure S2, but for South-West Asia

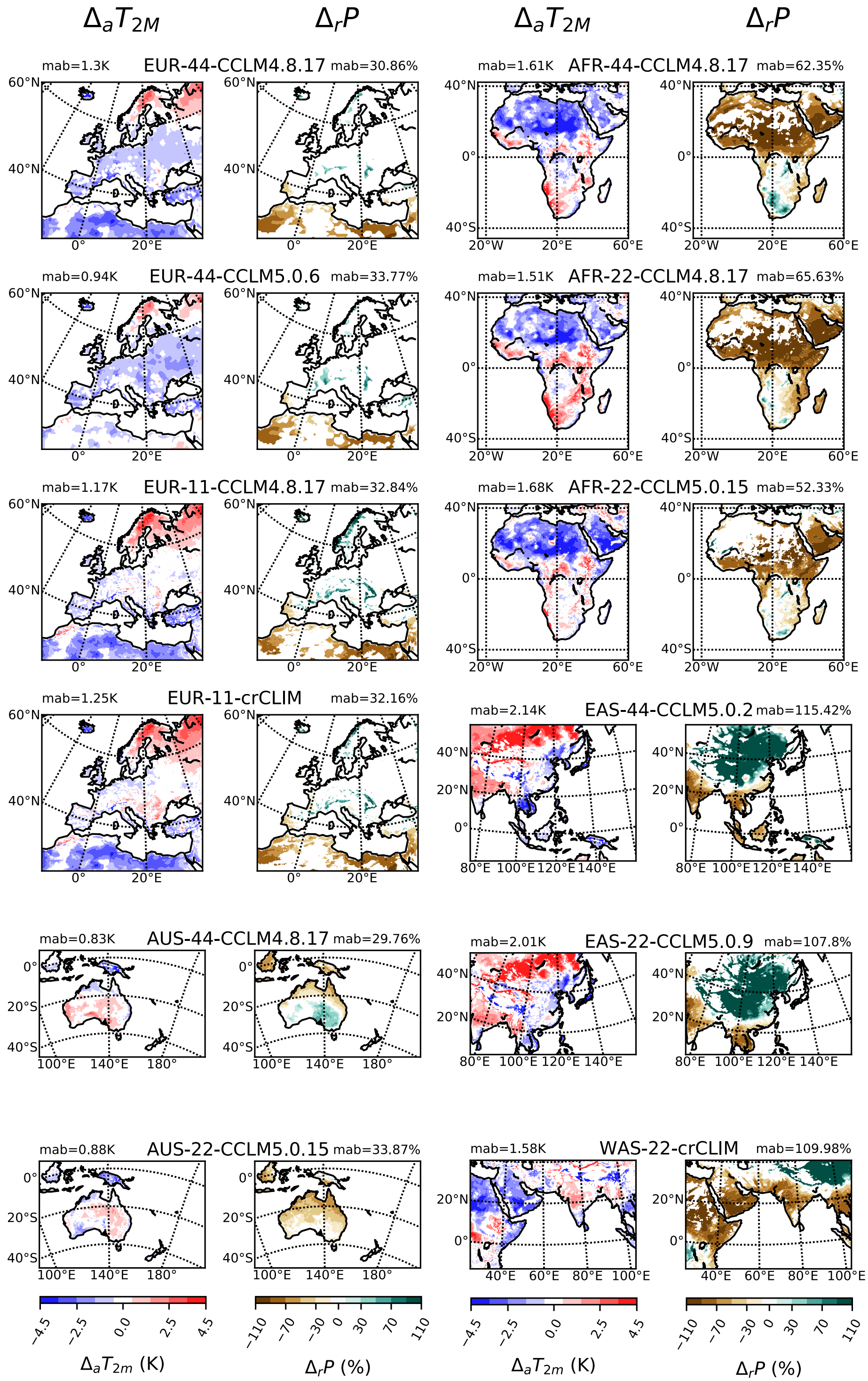

Figure S11. Same as Figure 2, but for MAM.

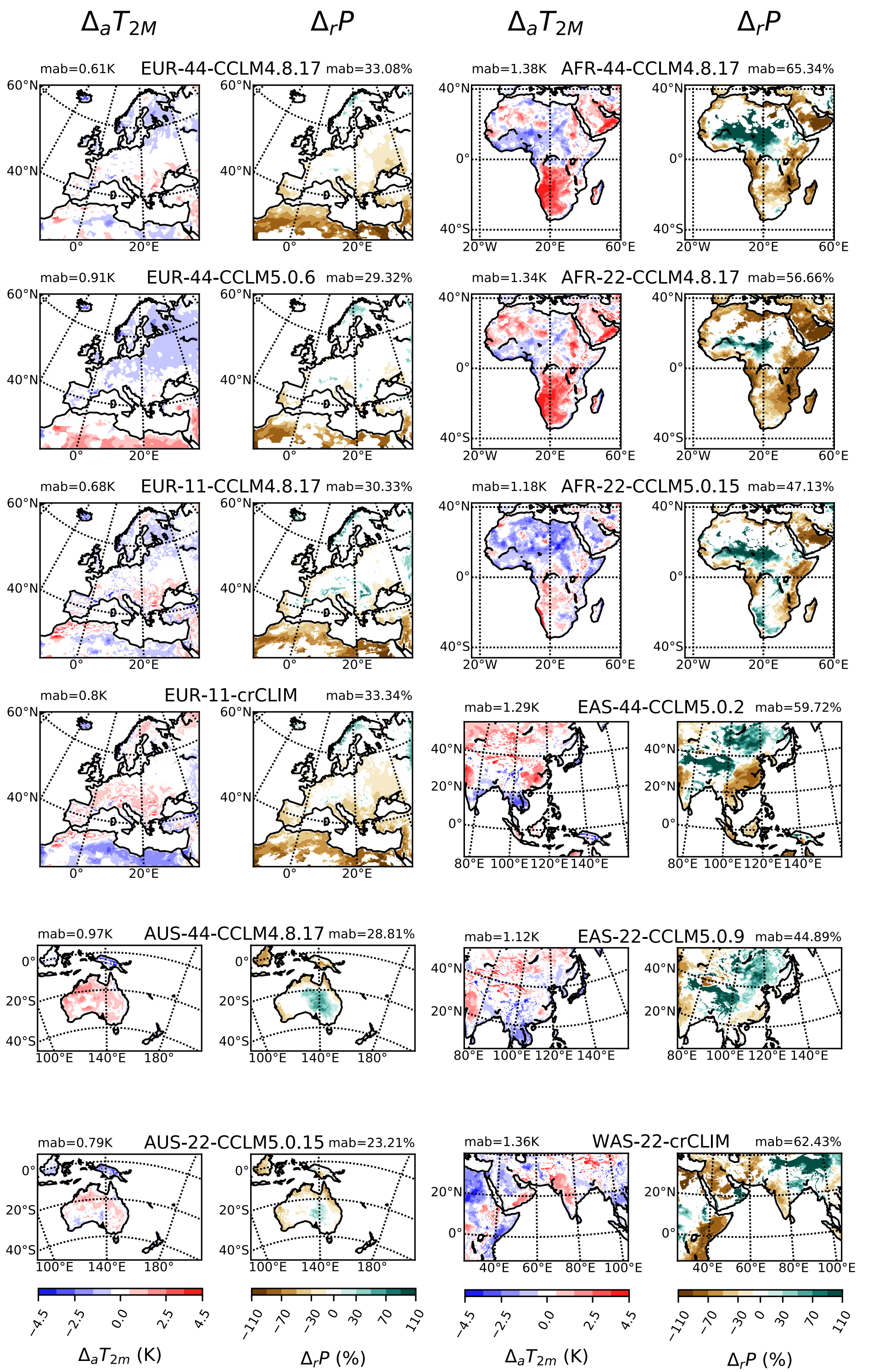

Figure S12. Same as Figure 2, but for SON.

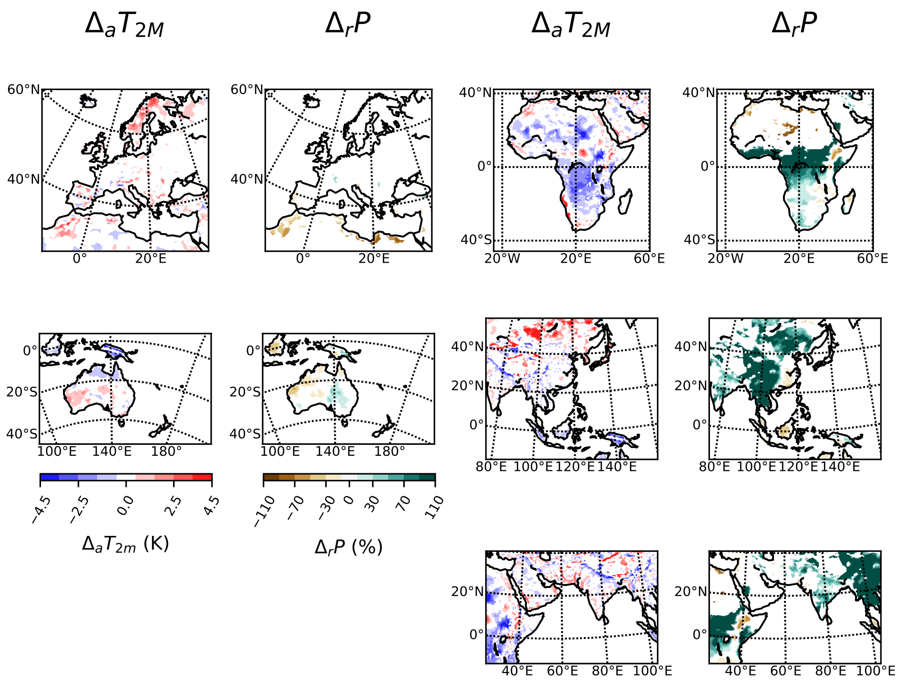

Figure S13. 2-meter air temperature absolute bias ($\Delta_a T_{2m}$; column 1 and 3) and total seasonal precipitation relative bias ($\Delta_r P$; column 2 and 4) of the ERA-Interim reanalysis for DJF for the different domains. The bias is masked white when the model value falls within the observational range.

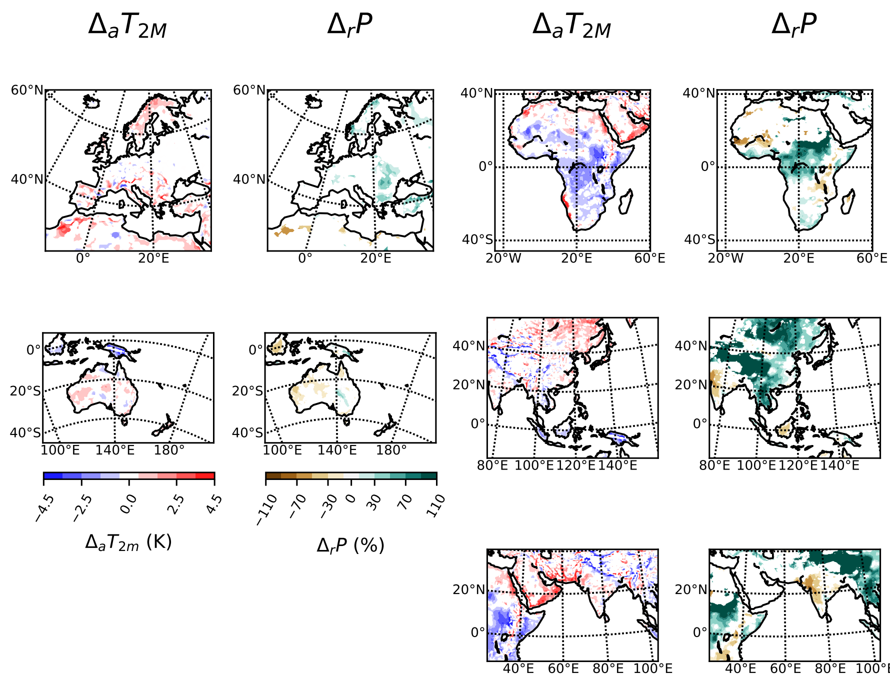

Figure S14. Same as Figure S13 but for MAM.

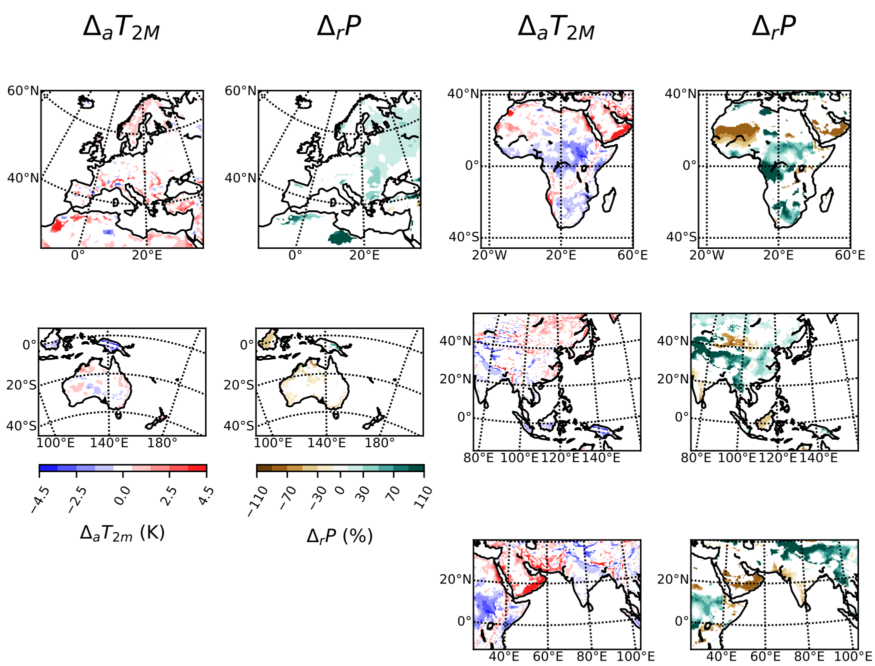

Figure S15. Same as Figure S13 but for JJA.

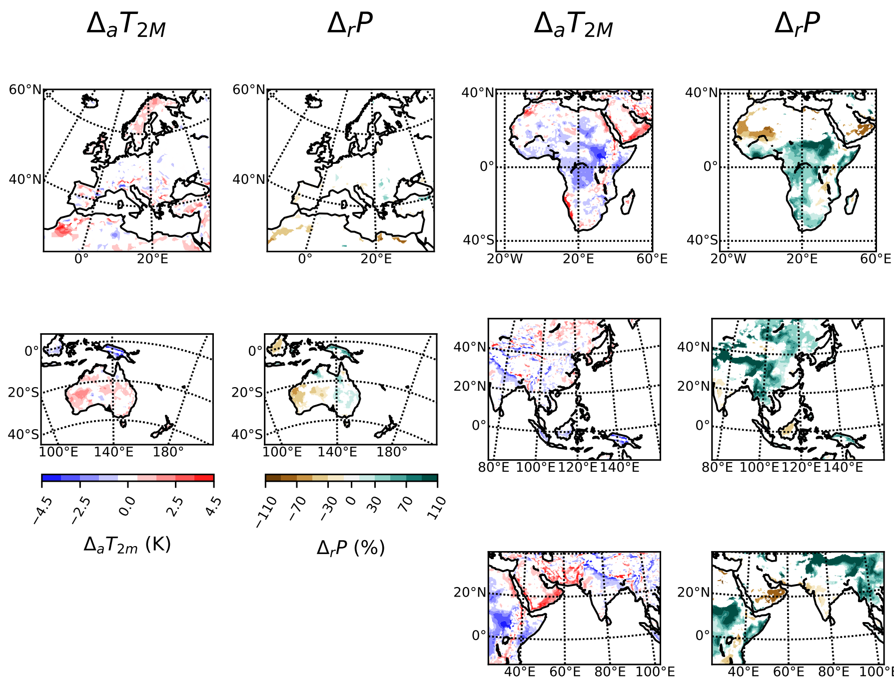

Figure S16. Same as Figure S13 but for SON.