

Supplementary information for

Business-as-usual will lead to super and ultra-extreme heatwaves in the Middle East and North Africa

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Supplementary Table 1: Description and temporal extent of MENA-CORDEX experiments considered in the present study. (Experiment IDs denoted with * indicate availability of pathway RCP4.5.)

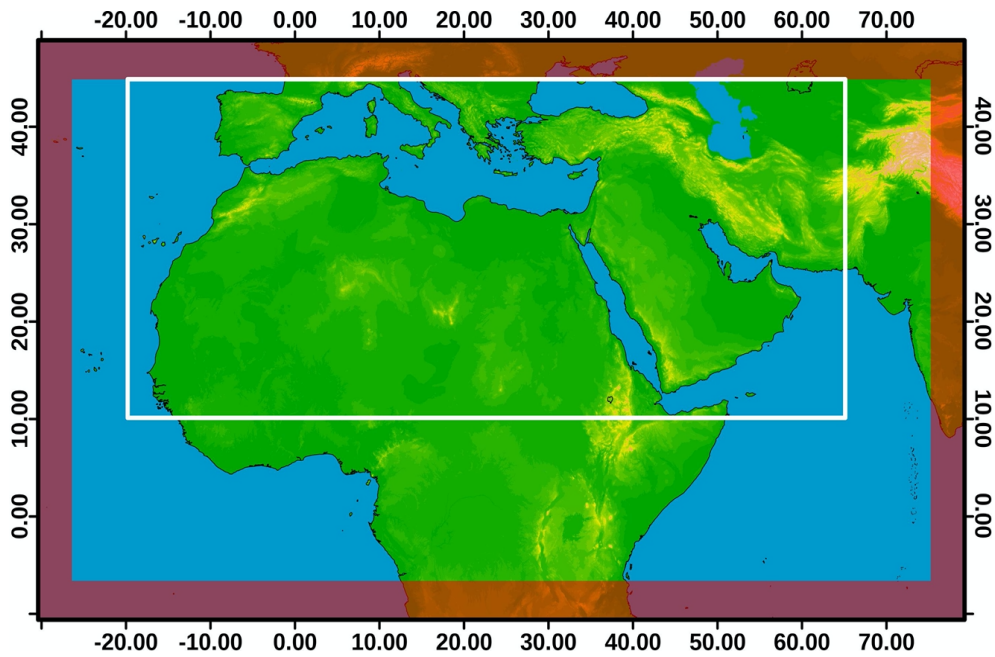
ID	Global Model	Regional Model	Institute	Simulation length
R1*	CNRM-CM5	RCA4	SMHI	1951-2100
R2*	GFDL-ESM2M	RCA4	SMHI	1951-2100
R3*	ICHEC-EC-EARTH	RCA4	SMHI	1951-2100
R4*	NCAR-CESM1	WRF-1-CYI	CYI	1951-2100
R5*	NCAR-CESM1	WRF-2-ICBA	ICBA	1951-2005 / 2021-2100
R6	CNRM-CM5	ALADIN	DGM-MOR	1970-2100
R7*	HadGEM2-ES	RegCM4	BOUN	1970-2099
R8*	MPI-ESM-LR	RegCM4	BOUN	1970-2100
R9	HadGEM2-ES	RegCM4	KAU	1960-2099
R10	MPI-ESM-LR	RegCM4	KAU	1970-2099

Supplementary Table 2: Land area percentiles of biases/differences (in °C) of MENA-CORDEX ensemble mean from observations/reanalysis datasets for warm season mean and maximum values of maximum temperature averaged for the period 1981-2010.

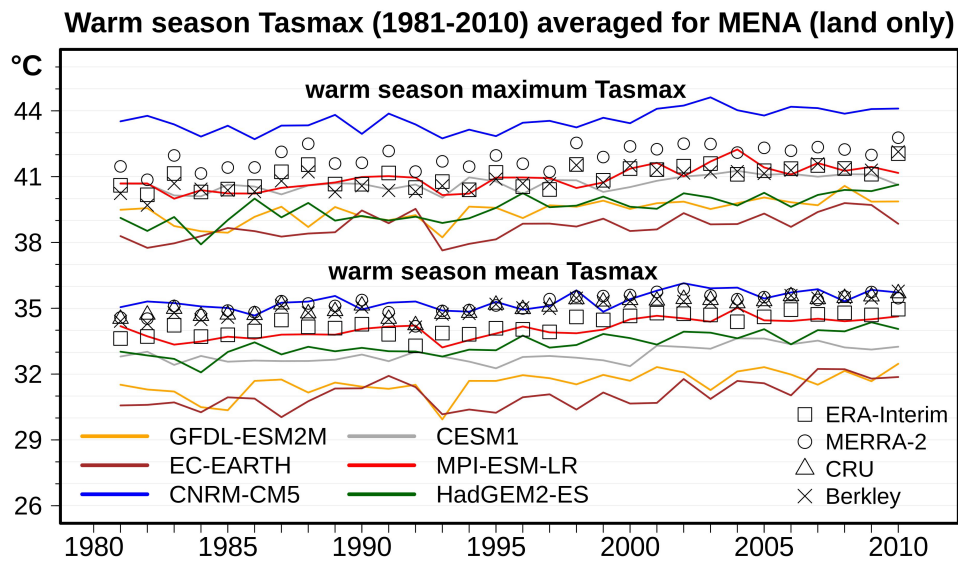
Percentile (of land grid cells):		5 th	25 th	median	75 th	95 th
Summer season mean	CORDEX-CRU	-3.9	-2.5	-1.7	-0.3	2.7
	CORDEX-Berkeley	-4.5	-2.5	-1.6	-0.5	1.4
	CORDEX-ERA1	-3.3	-2.0	-0.9	0.4	2.3
	CORDEX-MERRA2	-3.9	-2.6	-1.7	-0.8	0.4
Summer season max.	CORDEX-Berkeley	-3.8	-2.0	-0.8	1.1	3.9
	CORDEX-ERA1	-2.7	-1.7	-0.9	0.3	2.9
	CORDEX-MERRA2	-3.3	-2.3	-1.6	-0.7	0.8

Supplementary Table 3: Land area percentiles of biases/differences (in °C) of the CMIP5 driving models ensemble mean from observations/reanalysis datasets for warm season mean and maximum values of maximum temperature averaged for the period 1981-2010.

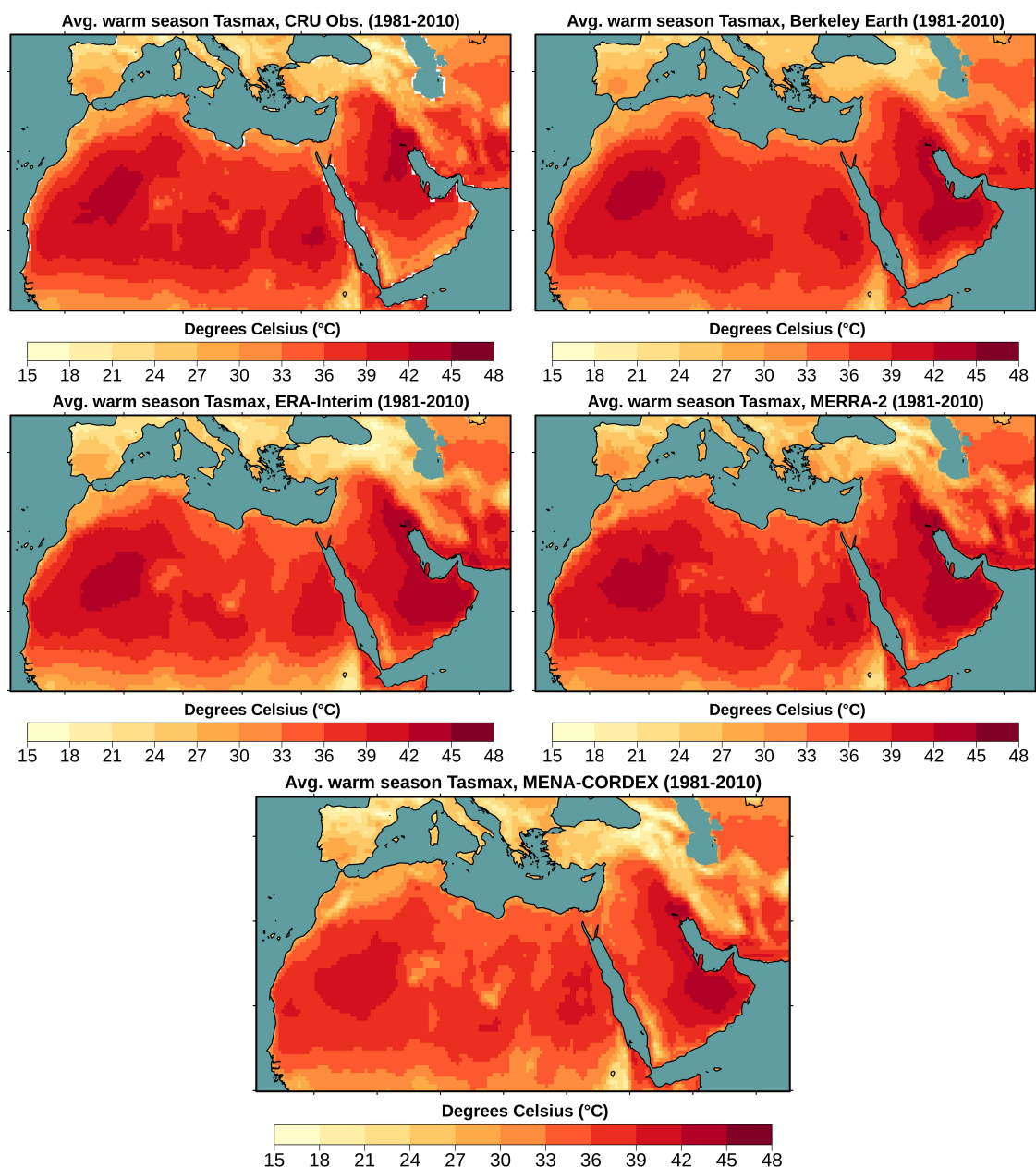
Percentile (of land grid cells):		5 th	25 th	median	75 th	95 th
Summer season mean	CMIP5-CRU	-4.3	-3.2	-2.2	-0.7	2.4
	CMIP5-Berkeley	-4.3	-2.9	-2.1	-1.2	0.7
	CMIP5-ERA1	-3.5	-2.4	-1.5	0.0	1.8
	CMIP5-MERRA2	-4.3	-3.2	-2.3	-1.3	0.6
Summer season max.	CMIP5-Berkeley	-4.3	-1.7	-0.4	1.1	3.6
	CMIP5-ERA1	-3	-1.6	-0.8	0.4	2.8
	CMIP5-MERRA2	-4.8	-2.5	-1.4	-0.3	1.7



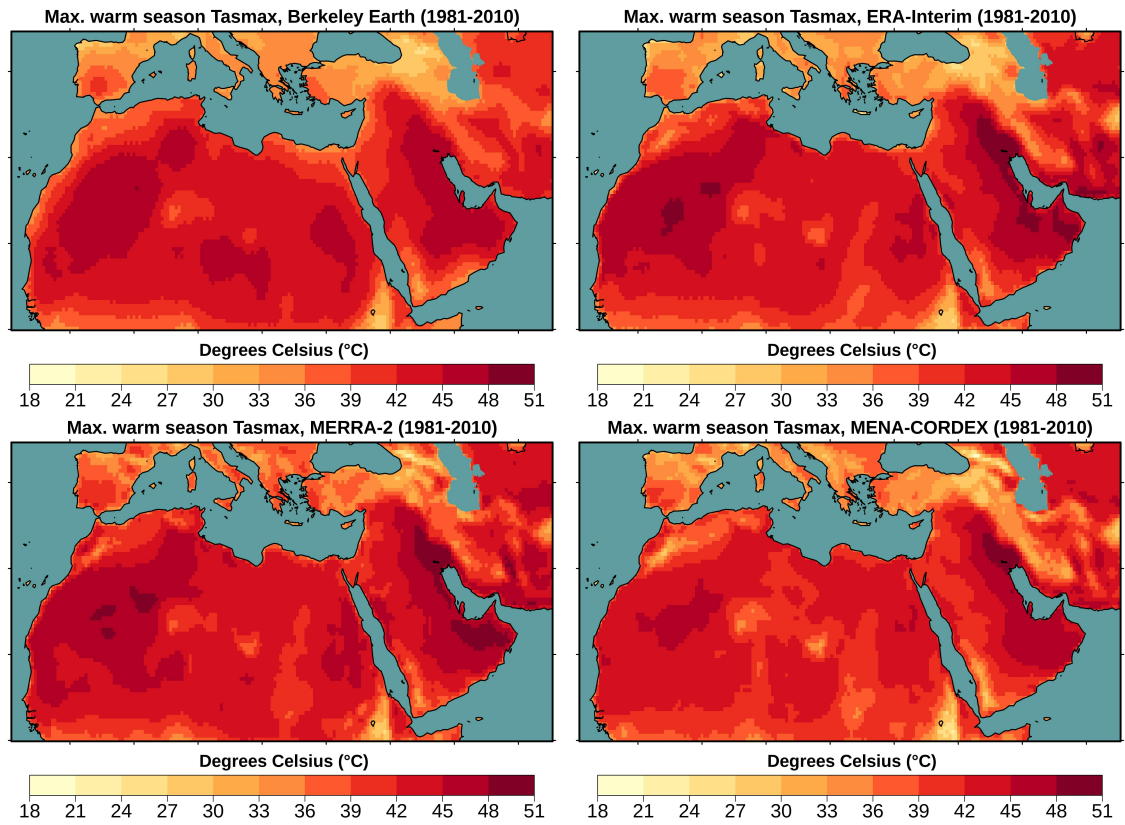
Supplementary Figure 1: Full extend of the MENA-CORDEX domain. The red-shaded area designates the discarded relaxation buffer zone. The white rectangle shows the area considered in the present study.



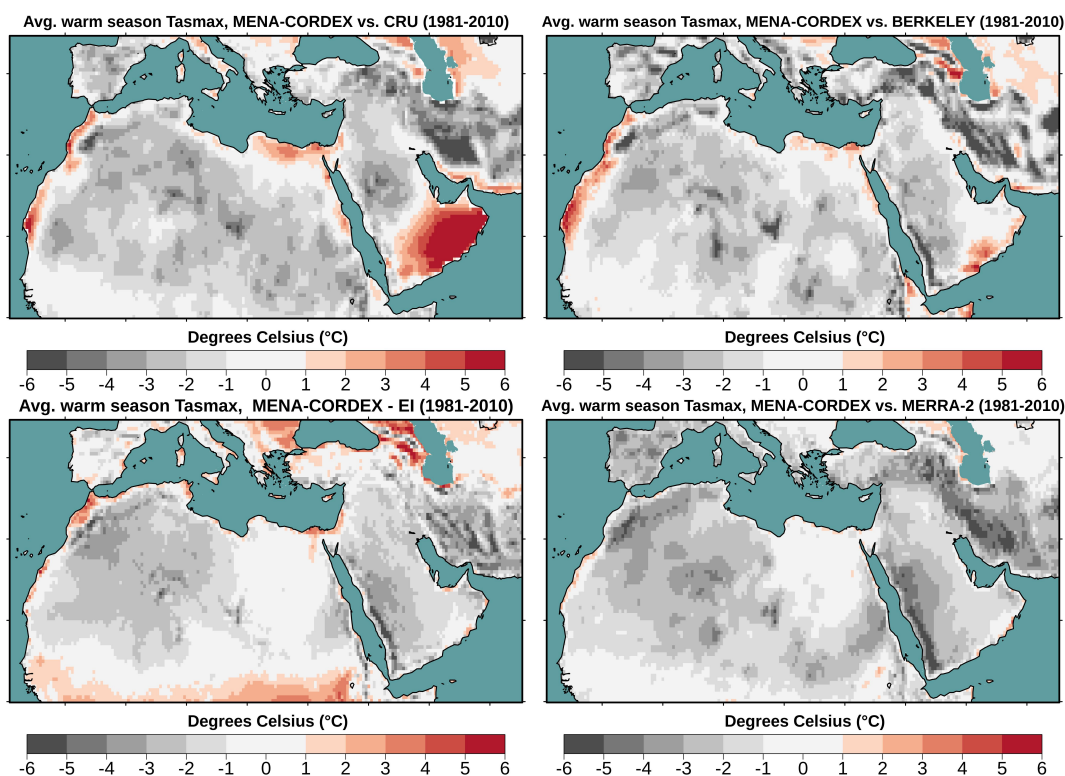
Supplementary Figure 2: Time-series of warm season (May-September) mean and maximum values of maximum daily temperature (tasmax), averaged for the MENA region for the individual driving global models and four reference datasets for the historical reference period 1981-2010.



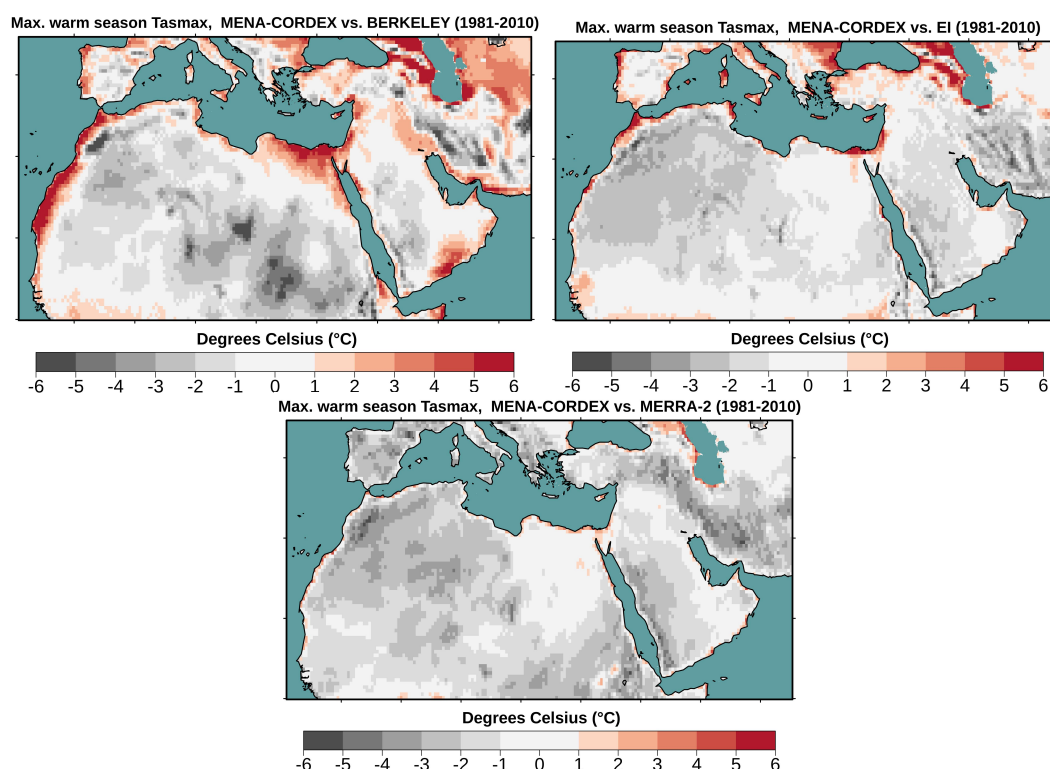
Supplementary Figure 3: Observed and simulated maximum daily temperature as mean values of the extended warm season (May – September) averaged for the period 1981-2010 based on the CRU observations (top-left), Berkeley Earth (top-right), MERRA-2 (middle-left), ERA-Interim (middle-right) and MENA-CORDEX ensemble mean (bottom).



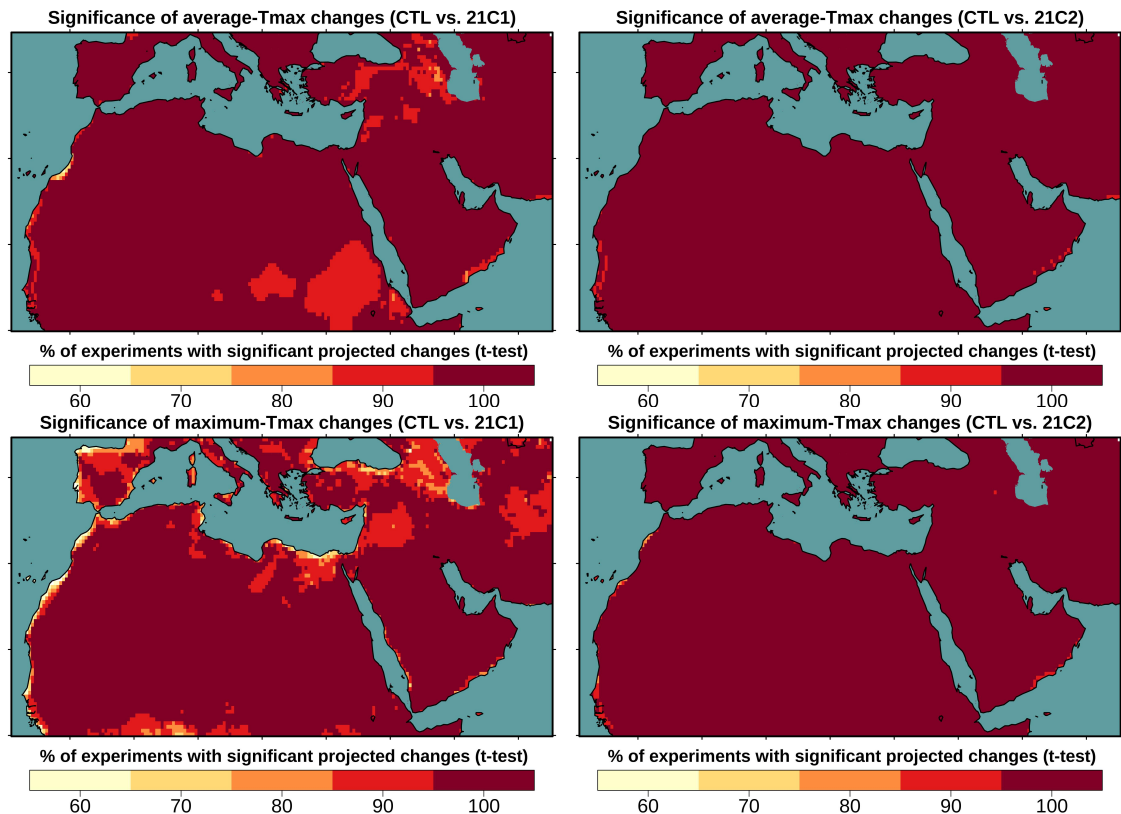
Supplementary Figure 4: Observed and simulated maximum daily temperature as absolute maximum of the extended warm season (May – September) averaged for the period 1981-2010 based on the Berkeley Earth observations (top-left), ERA-Interim (top-right), MERRA-2 (bottom-left), and MENA-CORDEX ensemble mean (bottom-right).



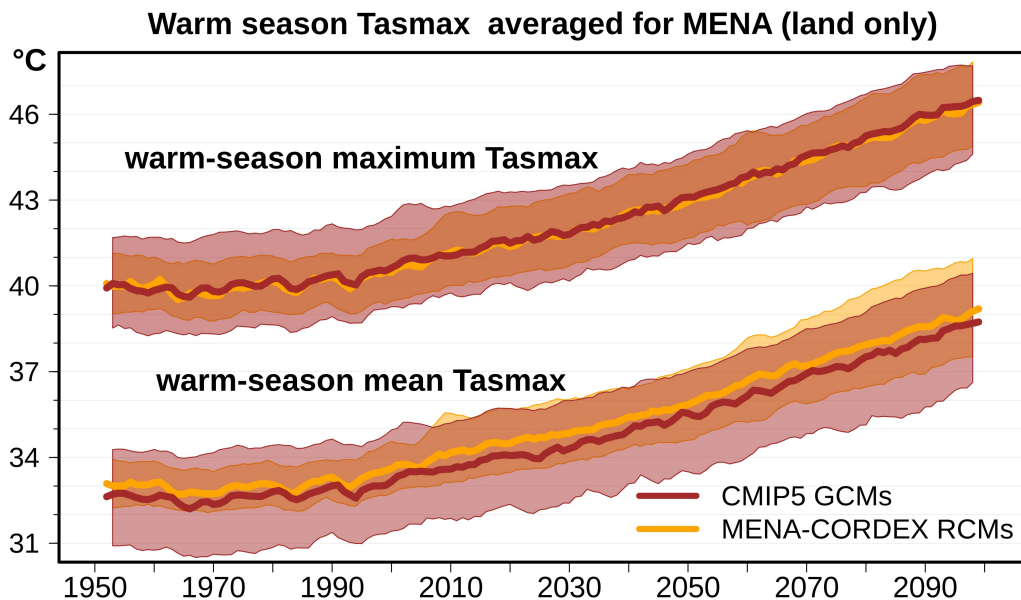
Supplementary Figure 5: Biases/differences of MENA-CORDEX ensemble mean from observations/reanalysis datasets for warm season mean values of daily maximum temperature averaged for the period 1981-2010. Modelled values minus CRU observations (top-left), Berkeley Earth (top-right), ERA-Interim (bottom-left) and MERRA-2 (bottom-right).



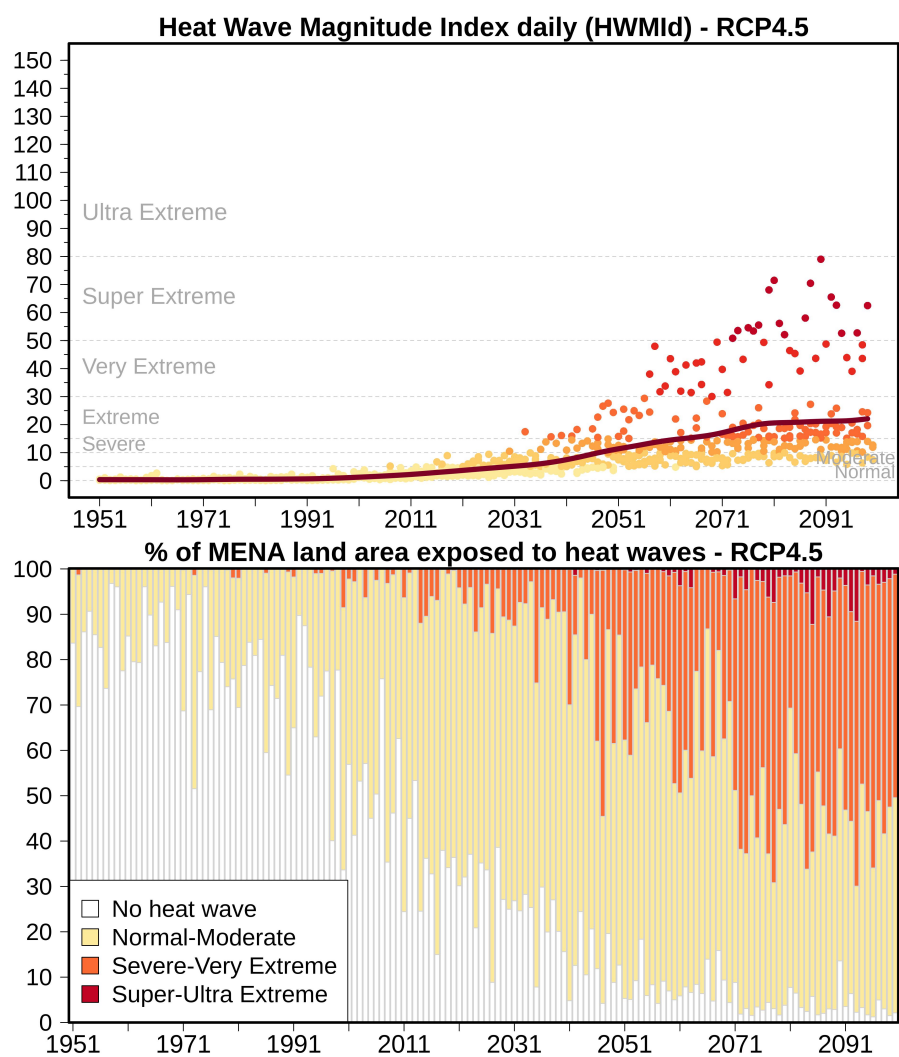
Supplementary Figure 6: Biases of MENA-CORDEX ensemble mean from observations/reanalysis datasets for warm-season absolute maximum values of daily maximum temperature averaged for 1981-2010. Modelled values minus Berkeley Earth (top-left), ERA-Interim (top-right), MERRA-2 (bottom).



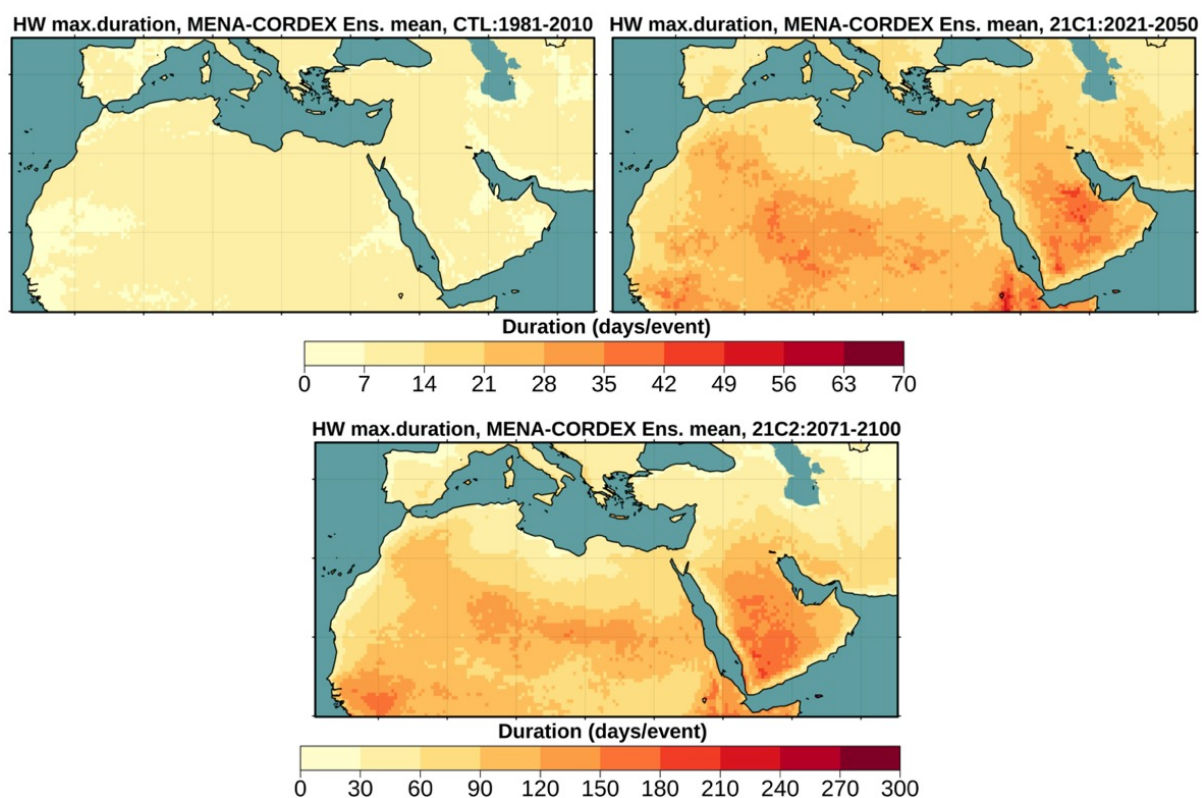
Supplementary Figure 7: Percentage of model simulations with statistically significant differences between the historical reference period (CTL: 1981-2010) and the near future (21C1: 2021-2050) (left panels) and the end of the 21st century (21C2: 2071-2100) (right panels), for average (top panels) and maximum (bottom panels) warm-season Tasmax.



Supplementary Figure 8: Time-series of MENA-average mean and absolute maximum warm-season maximum temperature (tasmax) based on the MENA-CORDEX (yellow curve) and CMIP5 (brown curve) ensembles.



Supplementary Figure 9: Annual values of the daily Heat Wave Magnitude (HWMId) for individual models (dots) and ensemble mean (curve) (top panel) and percentages of MENA land area annually exposed to several heatwave categories (bottom panel) for the period 1951-2100. Projections are based on pathway RCP4.5.



Supplementary Figure 10: Ensemble mean of maximum heatwave duration for the historical reference period (CTL: 1981-2010), the near future (21C1: 2021-2050) and the end of the 21st century (21C2: 2071-2100) based on pathway RCP8.5.