modextreme
agriculture facing extreme climatic events

Scenarios for future changes in extremes for agricultural modelling

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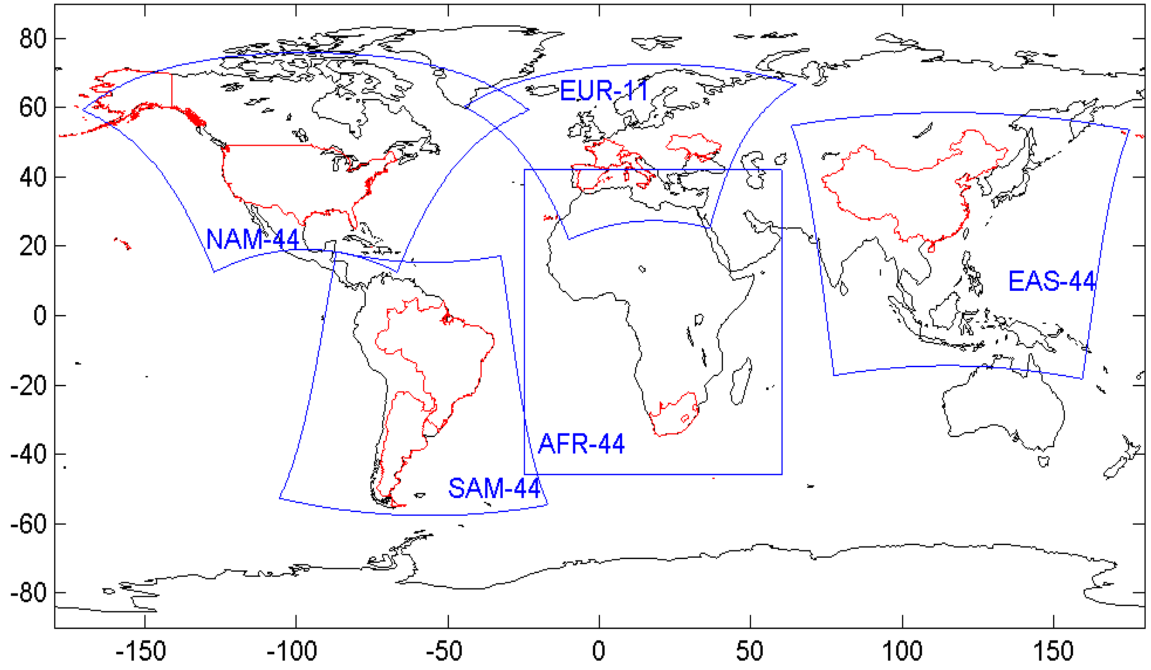
Sources of climate change data

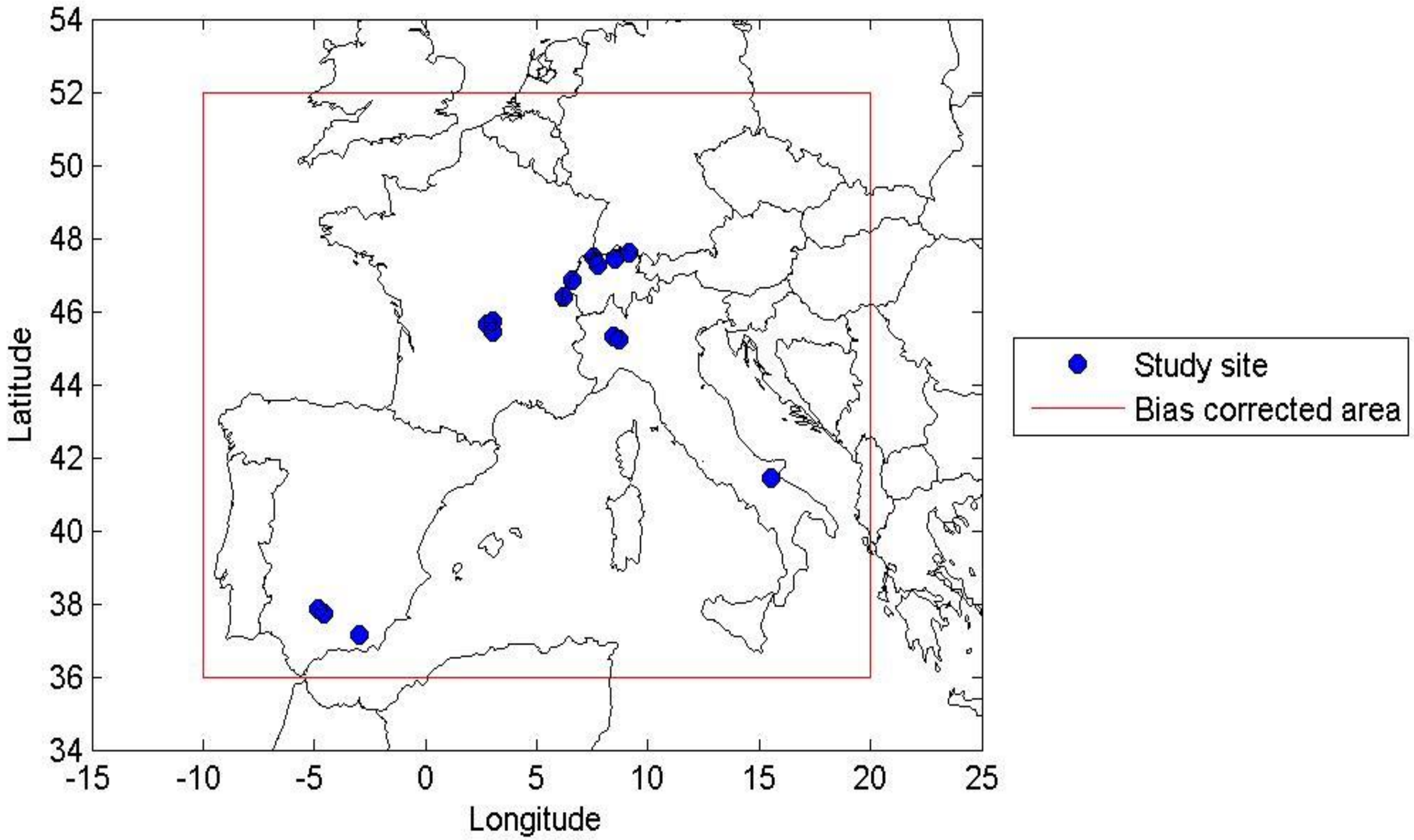
- CORDEX (http://www.cordex.org)
- Regional models covering land areas of the World



Regional Model Output

- For all simulations, there are gridded daily data for daily maximum and minimum temperature plus precipitation on a common grid, both non-corrected and bias corrected.
- Other fields, e.g. incoming solar radiation, actual and potential evaporation etc. are available, but cannot be bias corrected

Study sites in SW Europe



Available CORDEX simulations

- Europe: 11 simulations (present-day, RCP4.5, RCP8.5)

GCM	RCM	Acronym	Calendar
CNRM-CERFACS-CNRM-CM5_r1i1p1	CLMcom-CCLM4-8-17	CERFACS-CCLM	Standard
CNRM-CERFACS-CNRM-CM5_r1i1p1	SMHI-RCA4	CERFACS-RCA	Standard
ICHEC-EC-EARTH_r1i1p1	KNMI-RACMO22E	ECEARTH-RACMO	Standard
ICHEC-EC-EARTH_r3i1p1	DMI-HIRHAM5	ECEARTH-HIRHAM	Standard
ICHEC-EC-EARTH_r12i1p1	CLMcom-CCLM4-8-17	ECEARTH-CCLM	Standard
ICHEC-EC-EARTH_r12i1p1	SMHI-RCA4	ECEARTH-RCA	Standard
IPSL-IPSL-CM5A-MR_r1i1p1	IPSL-INERIS-WRF331F	IPSLCM-WRF	365-day calendar
IPSL-IPSL-CM5A-MR_r1i1p1	SMHI-RCA4	IPSLCM-RCA	365-day calendar
MOHC-HadGEM2-ES_r1i1p1	SMHI-RCA4	HadGEM-RCA	360-day calendar
MPI-M-MPI-ESM-LR_r1i1p1	CLMcom-CCLM4-8-17	MPIESM-CCLM	Standard
MPI-M-MPI-ESM-LR_r1i1p1	SMHI-RCA4	MPIESM-RCA	Standard

Bias correction

- Bias correction needs observations!
- Available observations:

MODEXTREME STUDY AREA	CORDEX DOMAIN	OBSERVATIONS	Simulations available	Simulations selected
France Spain Italy Switzerland Ukraine	Euro-CORDEX 0.11	E-OBS (tasmax, tasmin, pr) Entire grid	11	4
South Africa	CORDEX Africa 0.44	One station	18	4
China	CORDEX East Asia 0.44	GHCN (tasmax, tasmin, pr) 10 stations close to 7 study sites	3	3
Argentina Brazil	CORDEX South America 0.44	Station data Argentina: 11 stations for 6 sites Brazil: 1 station for 2 sites	2	2

Bias correction

- Method is quantile-based for temperature and precipitation
- Basically, we sort model values and observed values according to size and correct modelled present-day values to the corresponding observed value. Do ”the same” for scenario.
- Corrections depend on time of year, based on 20 years of overlapping observation/simulation, 30-day running calendar window, i.e., 600 values
- Some problems for large extremes
- Possibility to make T-based corrections for specific humidity and dew point T

Model selection

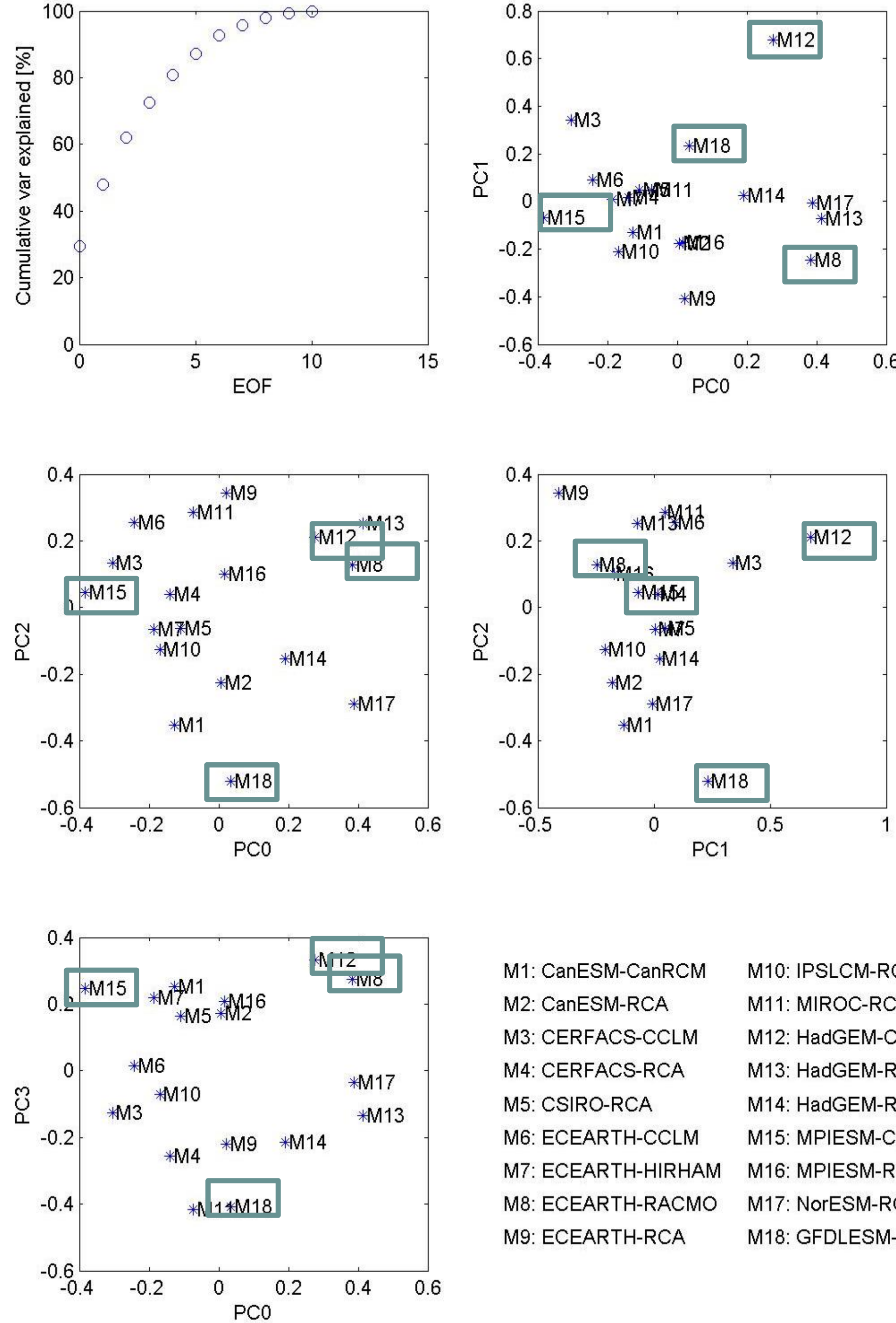
- We choose to select up to 4 models per area, one central and 3 to span the variation within a set of 8 indices based on precipitation: Average precipitation plus

RX1day	Highest precipitation amount in one-day period.	-	•
RX5day	Highest precipitation amount in five-day period.	-	•
SDII	Simple daily intensity index	Mean of precipitation (RR) on days when rain occurred (days when RR ≥ 1mm).	•
R10mm	Heavy precipitation days	Count of days where RR (daily precipitation amount) ≥ 10 mm.	•
R20mm	Very heavy precipitation days	Count of days where RR (daily precipitation amount) ≥ 20 mm.	•
CDD	Consecutive dry days	Maximum length of dry spell (RR < 1 mm).	•
CWD	Consecutive wet days	Maximum length of wet spell (RR ≥ 1 mm)	•

Model selection

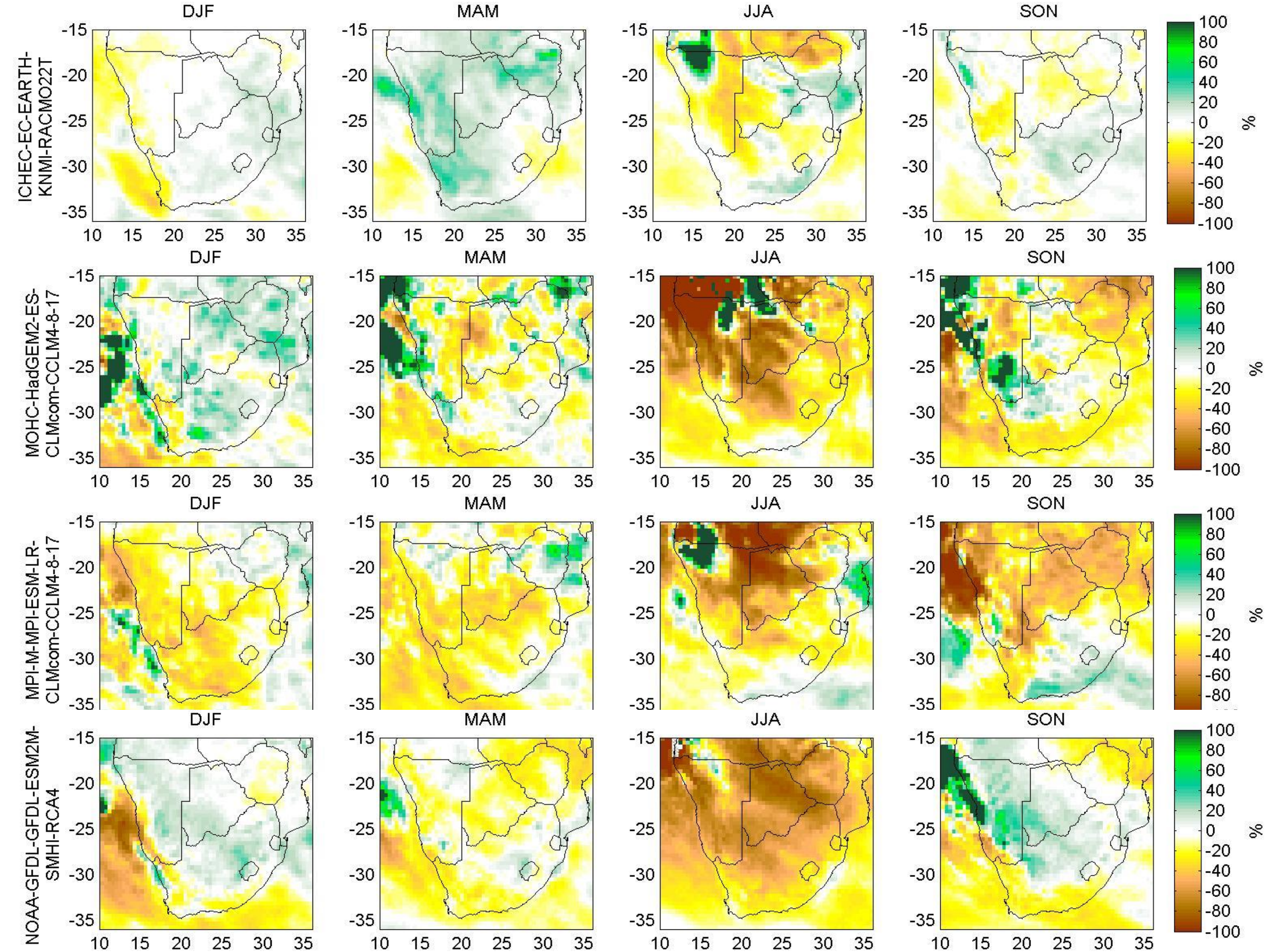
- Principal Component Analysis in index/model space: Identify which models and which indices follow each others, and which are independent.
- Select one central and 3 others spanning the independent directions subjectively
- Selected simulations for SW Europe: ECEARTH-HIRHAM (central), CERFACS-RCA, ECEARTH-RACMO, MPIESM-CCLM
- For Ukraine: CERFACS-RCA, ECEARTH-RACMO, HadGEM-RCA, MPIESM-CCLM

Choice of models for South Africa



M1: CanESM-CanRCM
M2: CanESM-RCA
M3: CERFACS-CCLM
M4: CERFACS-RCA
M5: CSIRO-RCA
M6: ECEARTH-CCLM
M7: ECEARTH-HIRHAM
M8: ECEARTH-RACMO
M9: ECEARTH-RCA
M10: IPSLCM-RCA
M11: MIROC-RCA
M12: HadGEM-CCLM
M13: HadGEM-RACMO
M14: HadGEM-RCA
M15: MPIESM-CCLM
M16: MPIESM-RCA
M17: NorESM-RCA
M18: GFDLESM-RCA

Differences in climate change



Extremes Indices: full list

Standard Indices: Temperature			Standard Indices: Precipitation		
1	**FD**	**Frost days (Tmin < 0°C)**	8	RX1day	Highest precipitation amount in one-day period.
2	**SU**	**Summer days (Tmax > 25°C)**	9	RX5day	Highest precipitation amount in five-day period.
3	TR	Tropical nights (Tmin > 20°C)	**10**	**SDII**	**Simple daily intensity index**
4	**GSL**	**Growing season length**	12	R10mm	Heavy precipitation days (RR > 10mm)
5	WSDI	Warm Spell Duration Index	12	R20mm	Very heavy precipitation days (RR > 20mm)
6	WSDImax	Length of longest Warm Spell	**13**	**CDD**	**Consecutive dry days**
7	CSDI	Cold spell duration index	**14**	**CWD**	**Consecutive wet days**

Phenological Indices: Cold Temperatures			Phenological Indices: Extreme Heat		
15	S.EM.CRIT.8	Sowing-emergence critical days (< -8°C)	22	TMAX.40	Ceiling temperature for development (Tmax > 40°C)
16	S.EM.CRIT.3	Sowing-emergence critical days (< -3°C)	23	TMAX.45	Ceiling temperature for development (Tmax > 45°C)
17	EM.AN.CRIT.2	Emergence-flowering critical days (< -2°C)			**Phenological Indices: Grasslands**
18	LASTFROST.0	Final frost day (0°C)	24	GSL.GRASS	Growing Season length for Grasses/Clover mix
19	LASTFROST.8	Final frost day (-8°C)	25	VHOT.DAYS	Very Hot Days (Tmax > 35°C)
20	LASTFROST.3	Final frost day (-3°C)			
21	LASTFROST.2	Final frost day (-2°C)			* **Bold** Indicates the six “core” indices

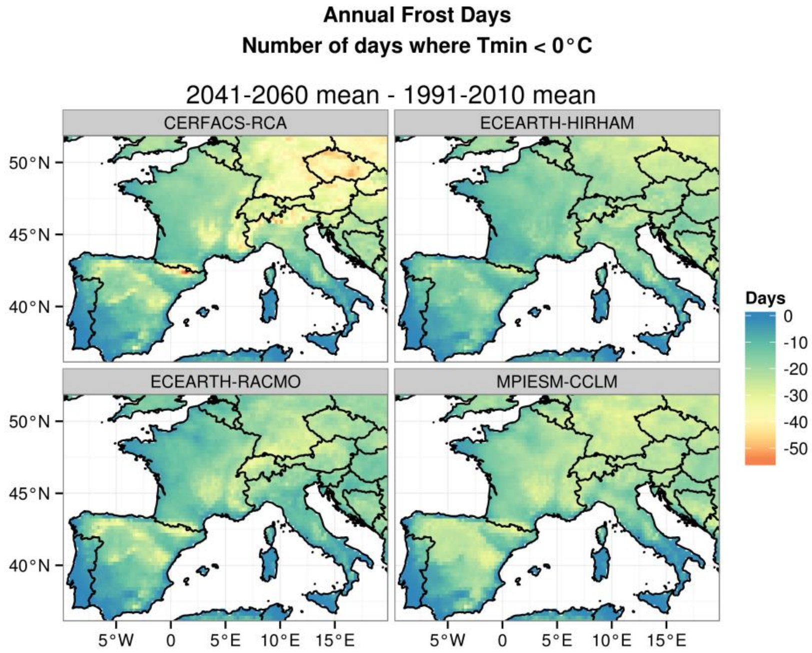
Good and bad things for bias correction

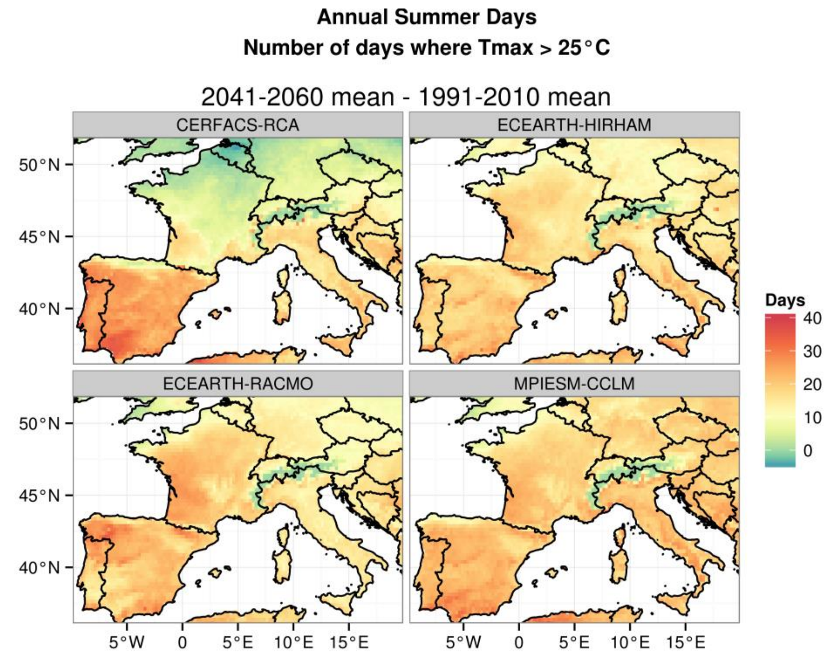
- We are guaranteed the statistics of temperature and precipitation, including extremes, which correspond to observations

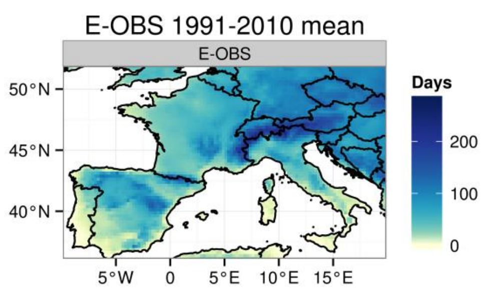
Good and bad things for bias correction

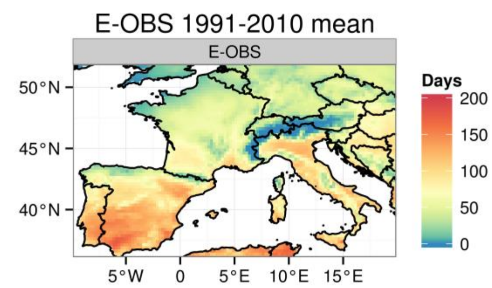
- The corrected values may not be consistent with weather type.
- Other variables cannot be corrected; therefore P+E may have erroneous values.
- It is difficult to treat future extremes larger than anything seen in the calibration period; the current technique has present-day period the same as calibration period, which leads to correction-induced biases in climate change

Indices from corrected model data









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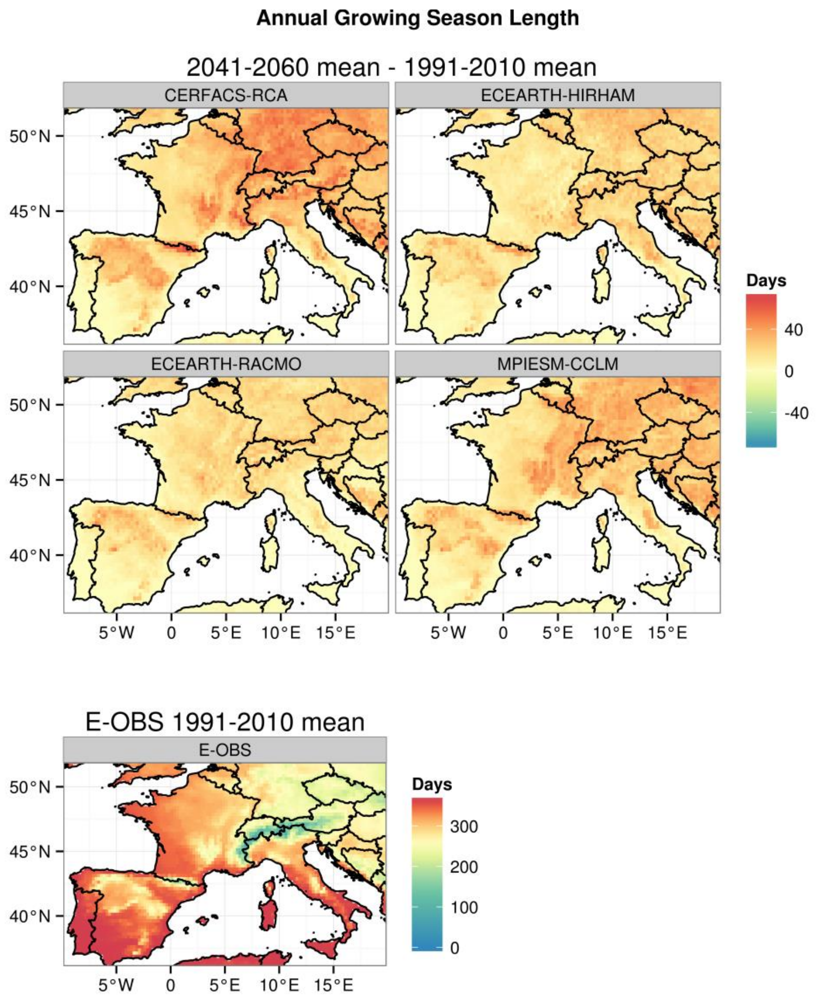

Conclusions

- We have varying amounts of simulations and of observation data for the different MODEXTREME areas
- For all areas we will be able to something, but uncertainty estimates may not be possible
- With bias correction we can improve temperature and precipitation. It remains to be seen how well the corrected and non-corrected fields can be used together

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