

Meteorological Dry and Wet Spells in Europe: observed and simulated by climate models

Bodo Ahrens

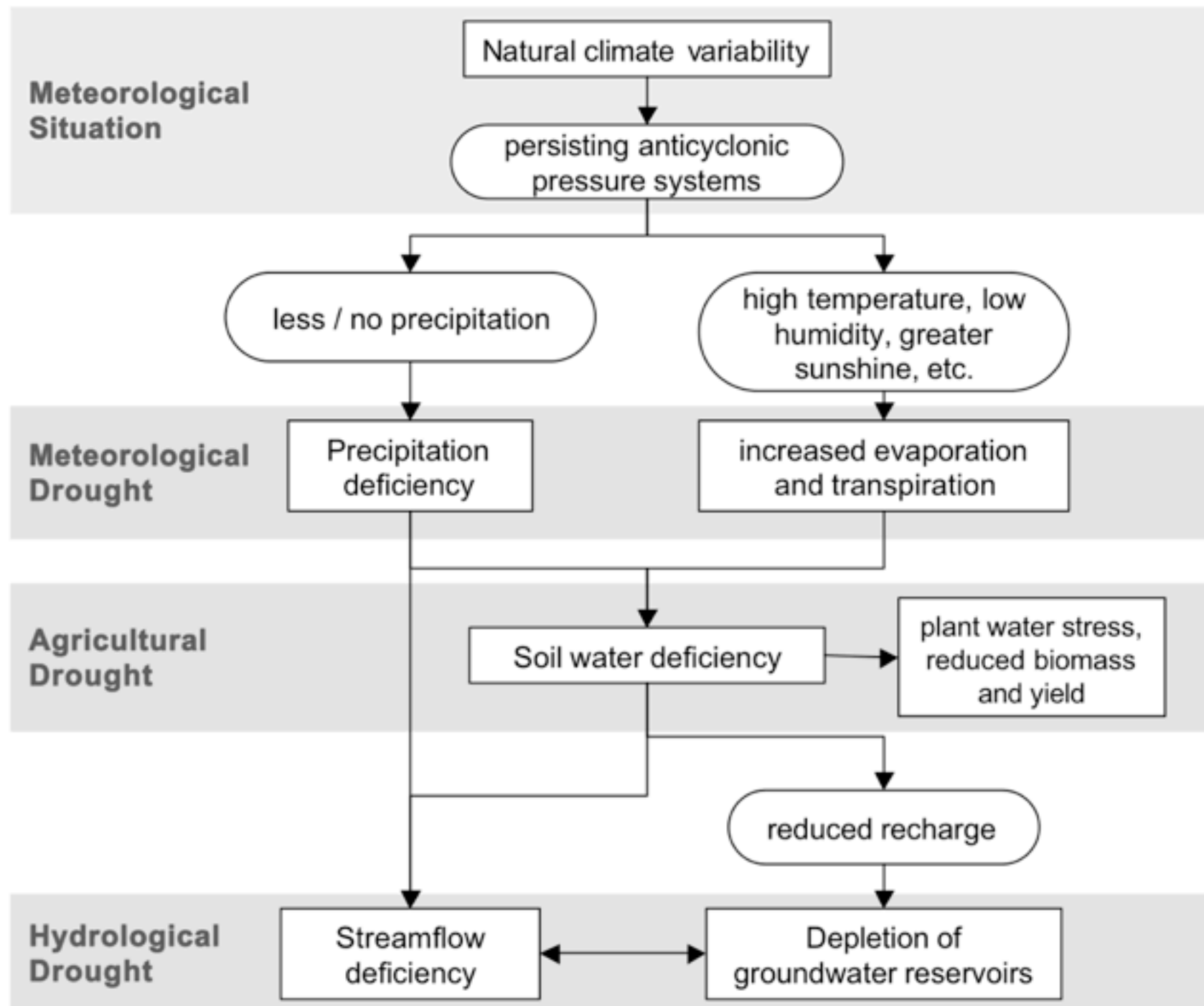
Institute for Atmospheric and Environmental Sciences

Goethe-University Frankfurt

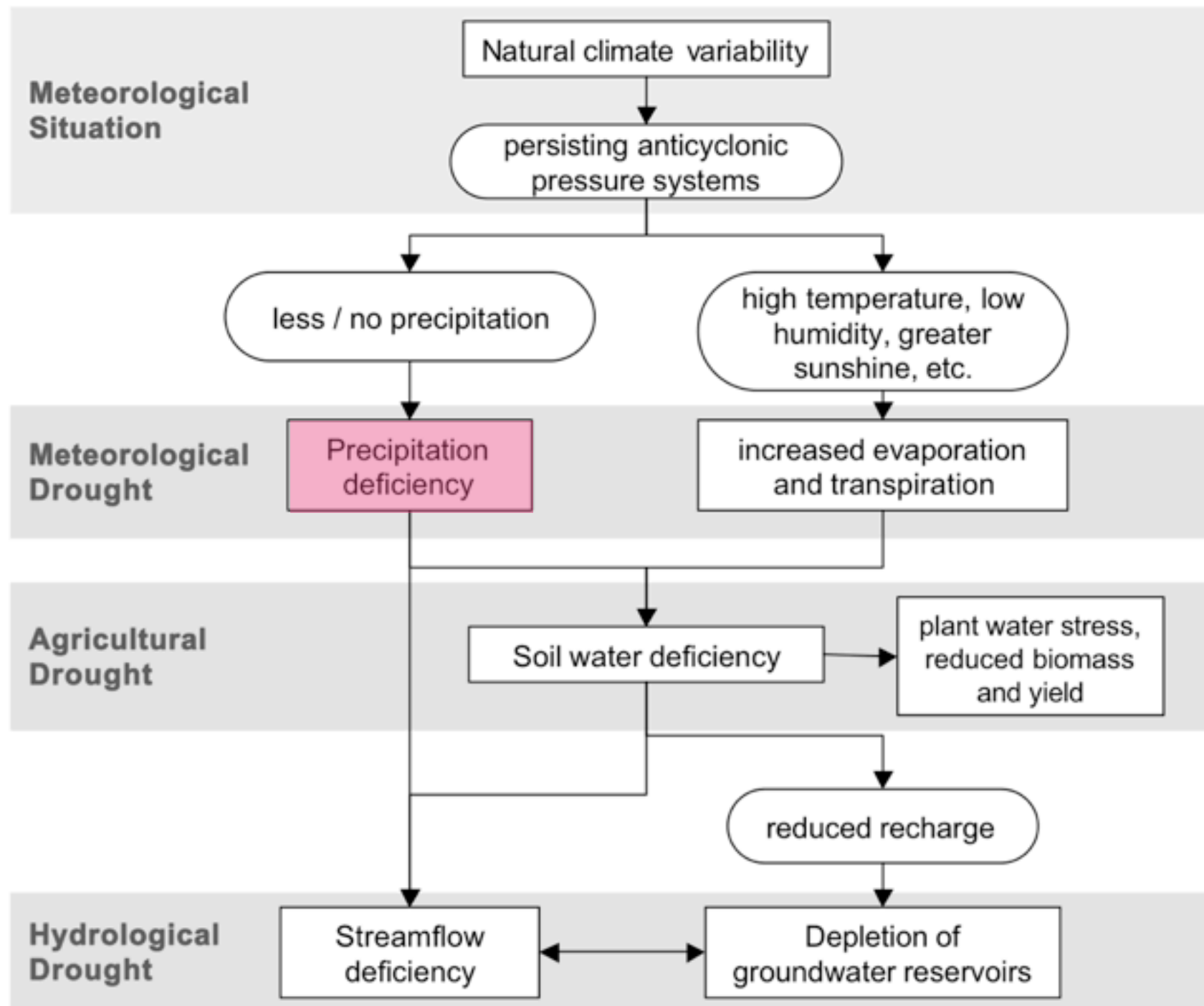


Biodiversität und Klima
Forschungszentrum

Drought propagation through the hydrological cycle



Drought propagation through the hydrological cycle



Examples

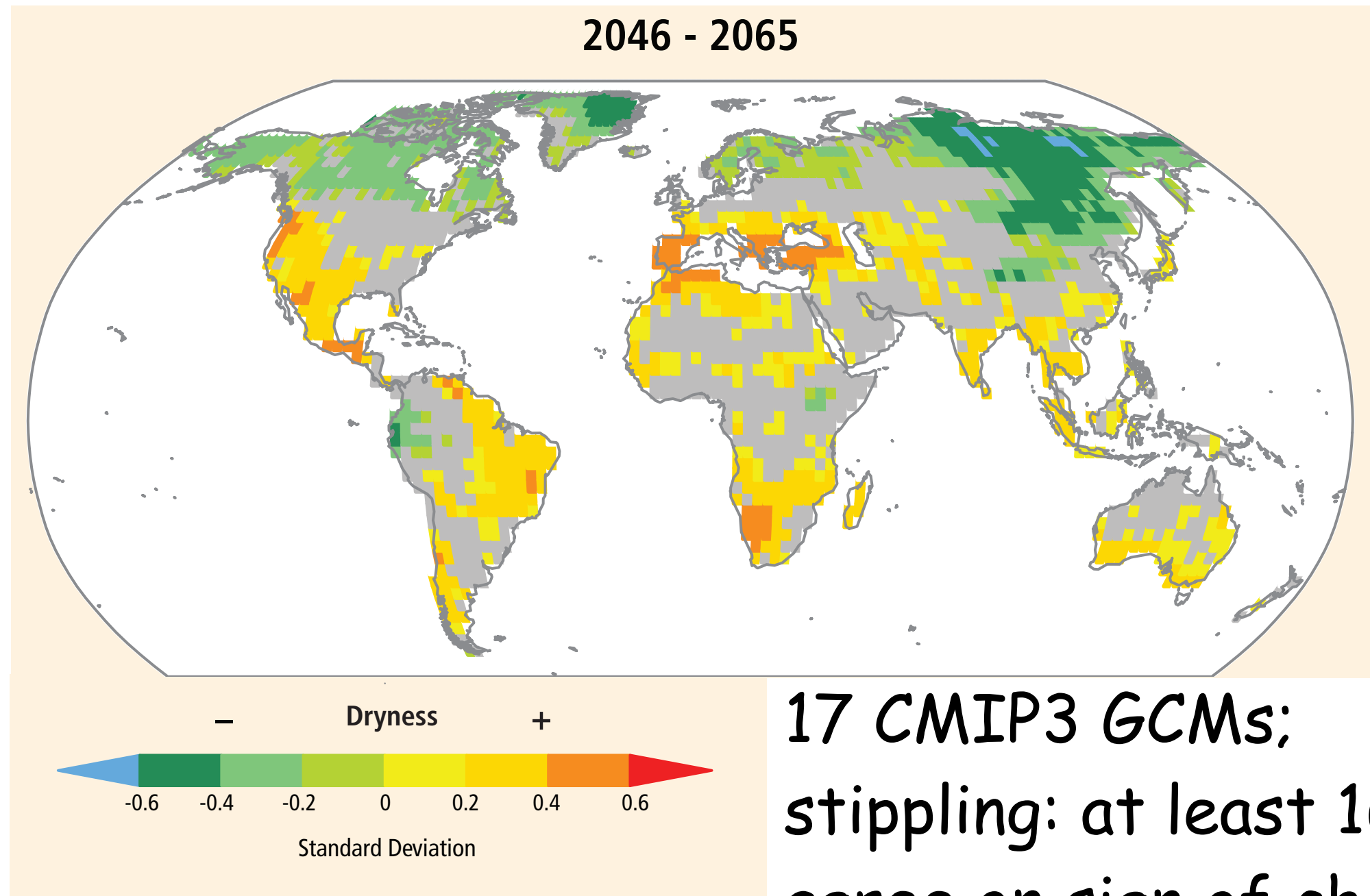


Dry spell



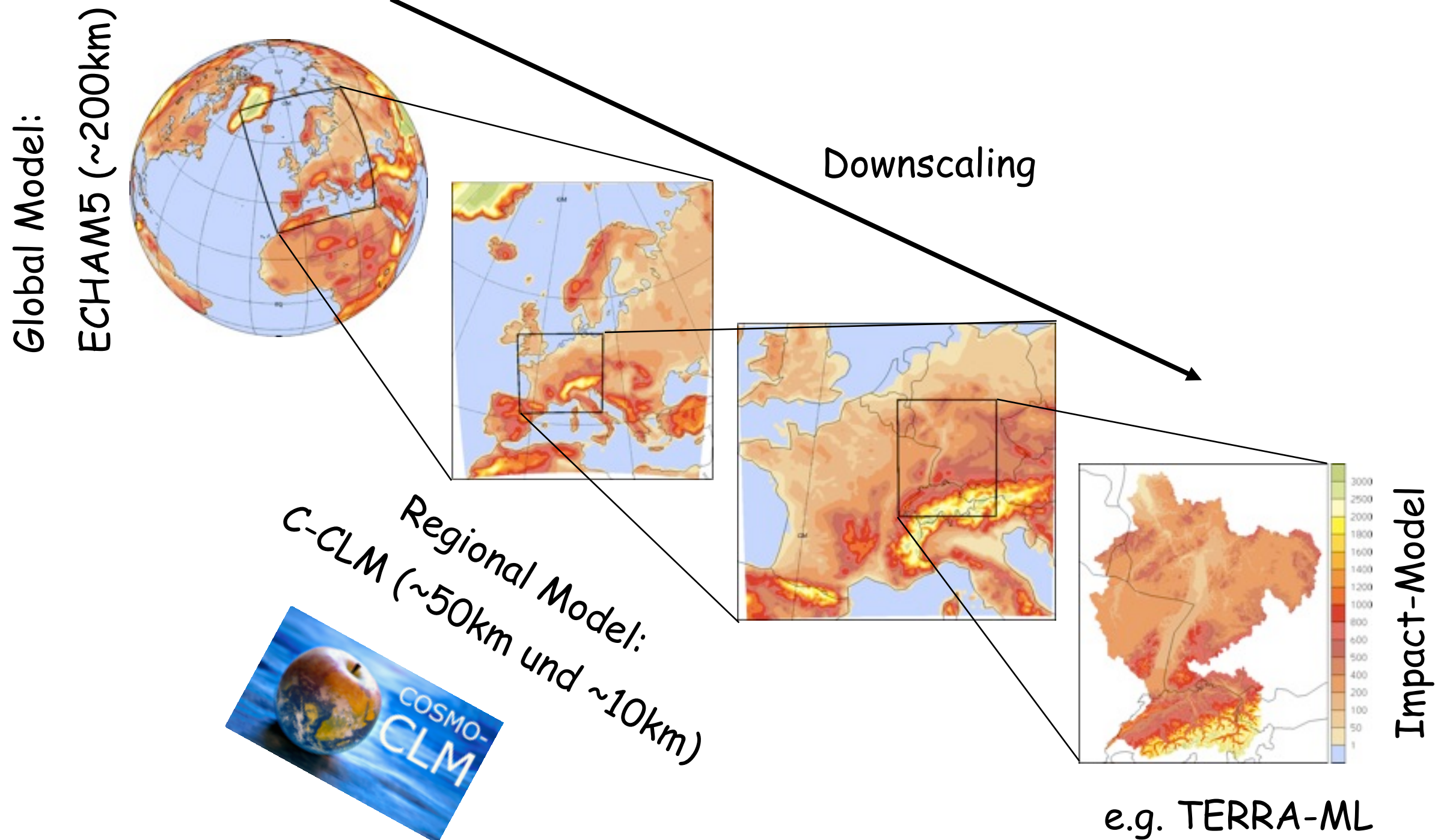
Wet spell

Change in annual maximum number of consecutive dry days



17 CMIP3 GCMs;
stippling: at least 16 models
agree on sign of change

Regional Climate Models

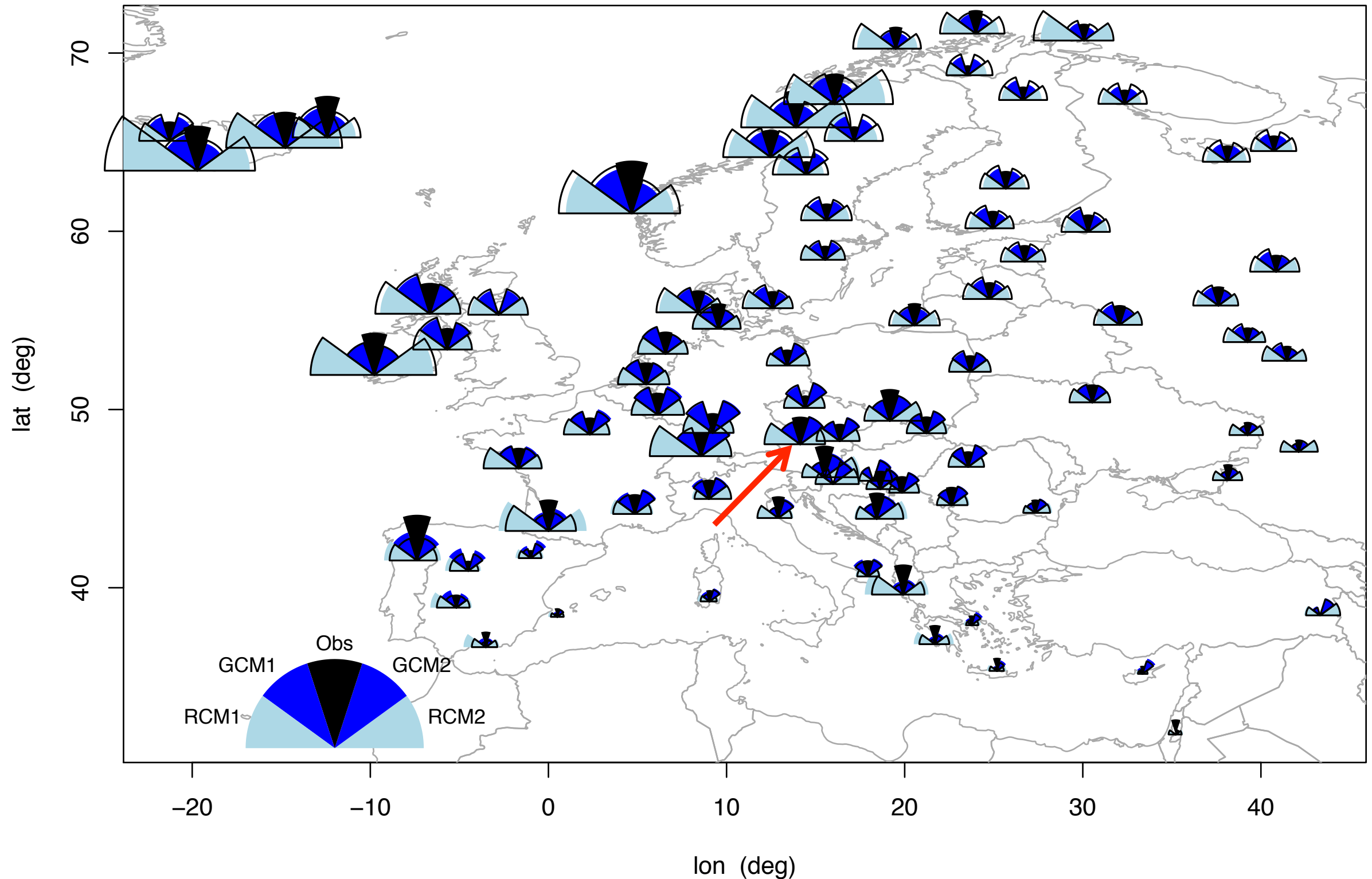


<http://www.clm-community.eu>

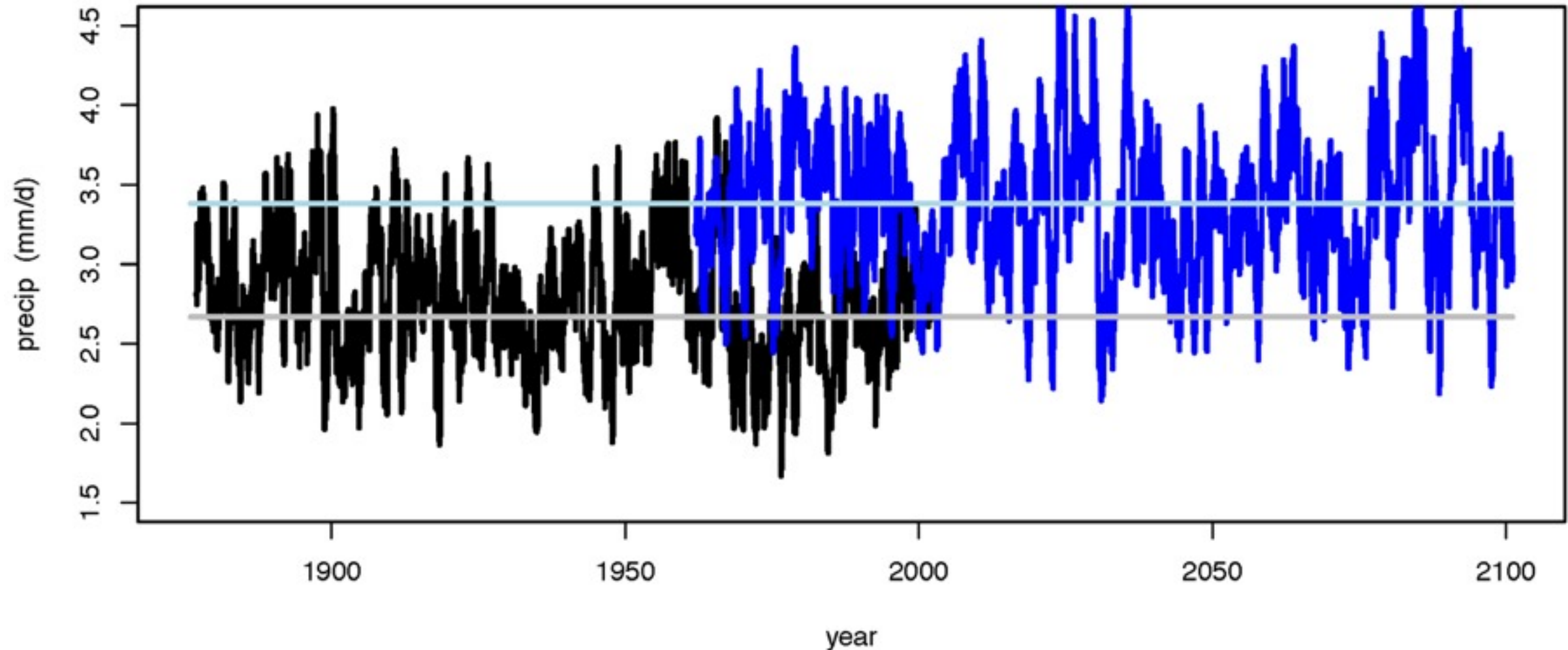
Can RCMs add value on the GCMs?

Precip. in 1961-00 and

2061-00



Precipitation



More

Longer

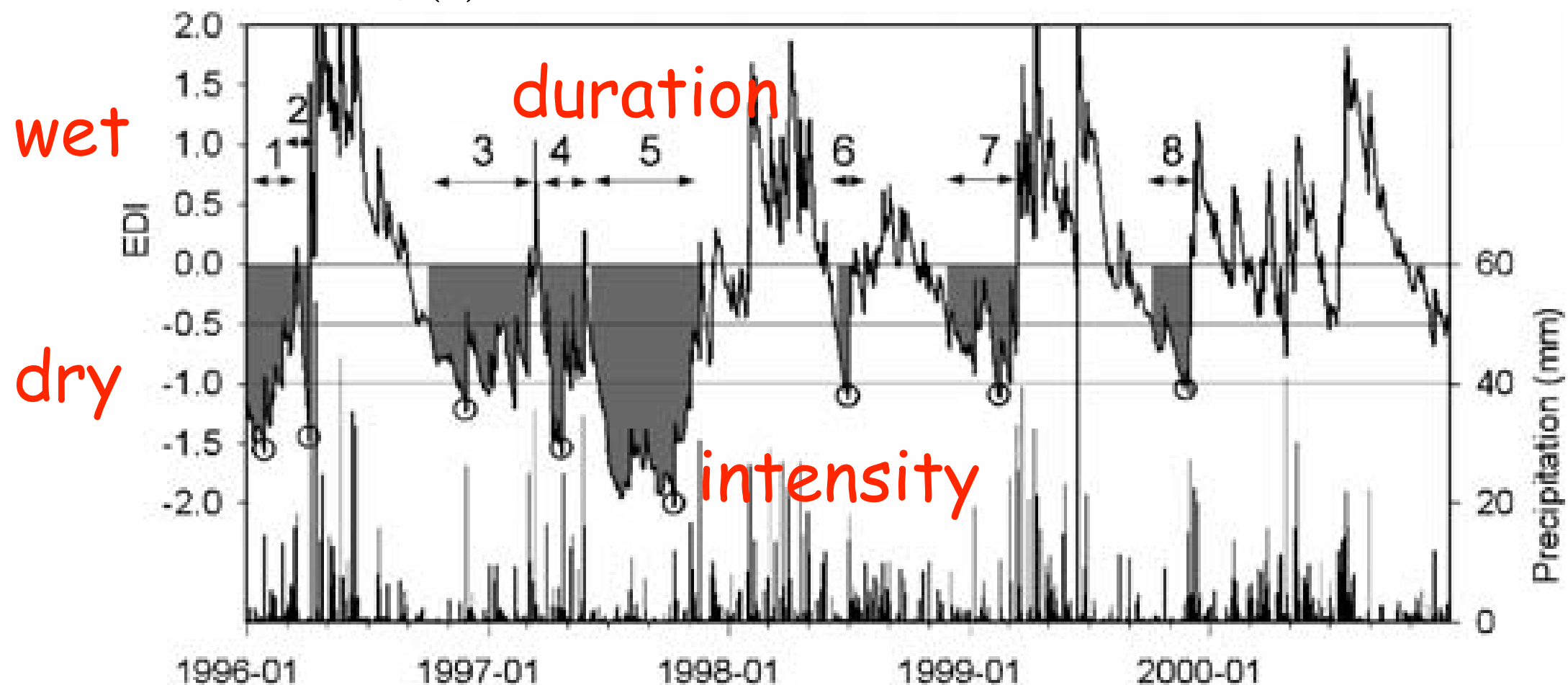
More intense

dry/wet spells in a future climate?

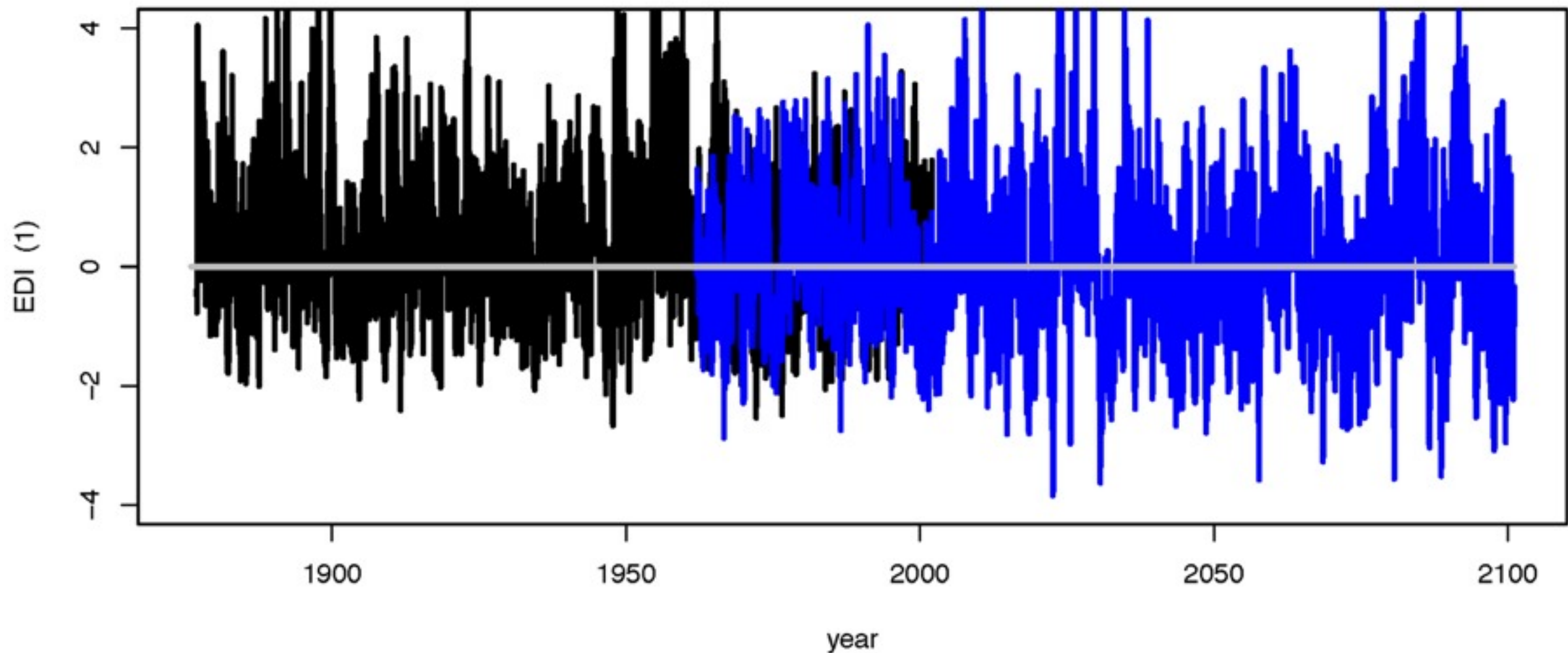
What is a dry/wet spell?

$$EP_t = \sum_{n=1}^L \left[\left\{ \sum_{m=1}^n P_{t-m} \right\} / n \right] \quad \text{with the averaging period } L = 365 \text{ days}$$

$$EDI_t = \frac{EP_t - \mu_j(t)}{\sigma_j(t)} \quad \text{standardization with mean climate}$$



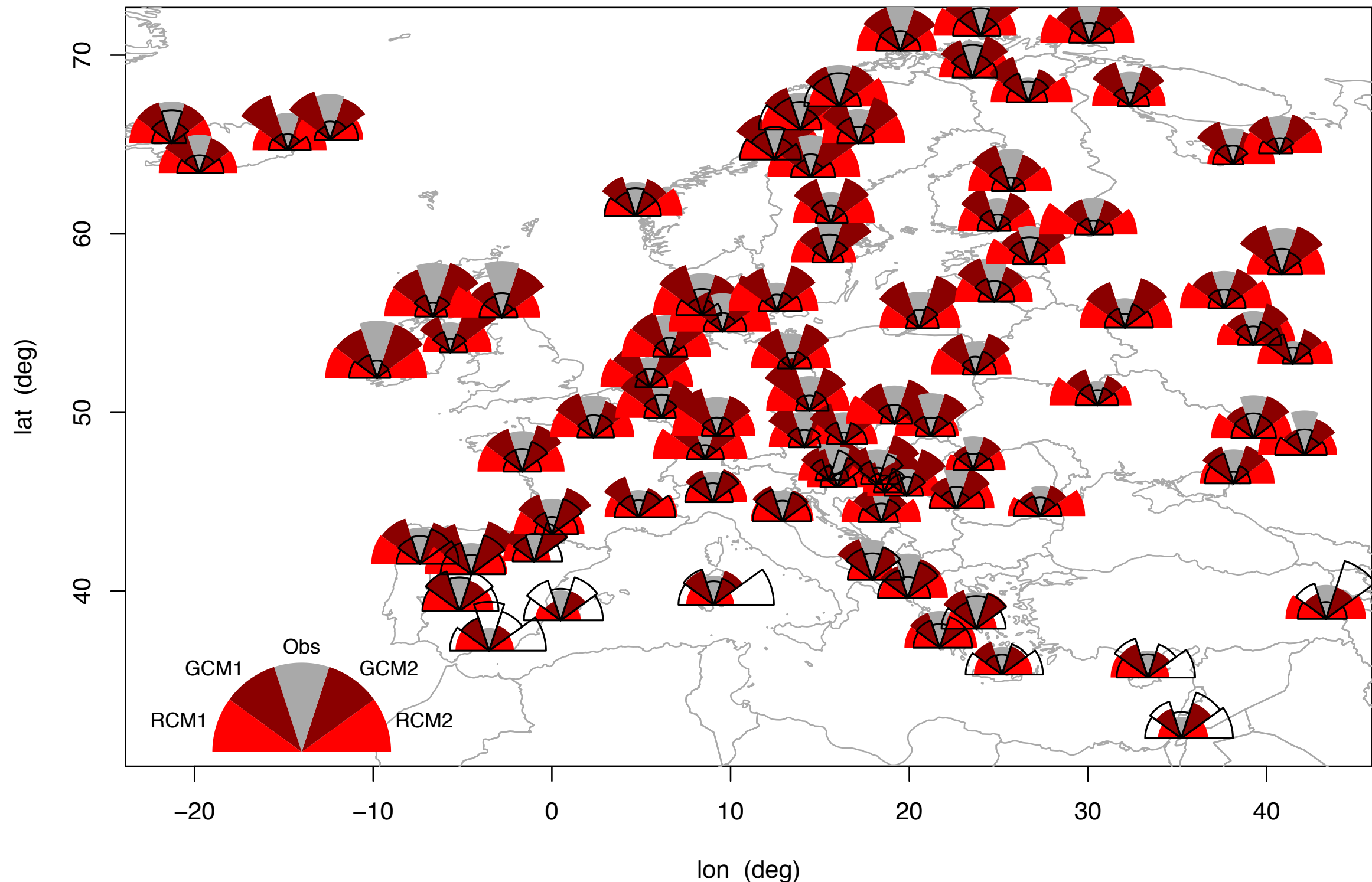
Effective Drought Index



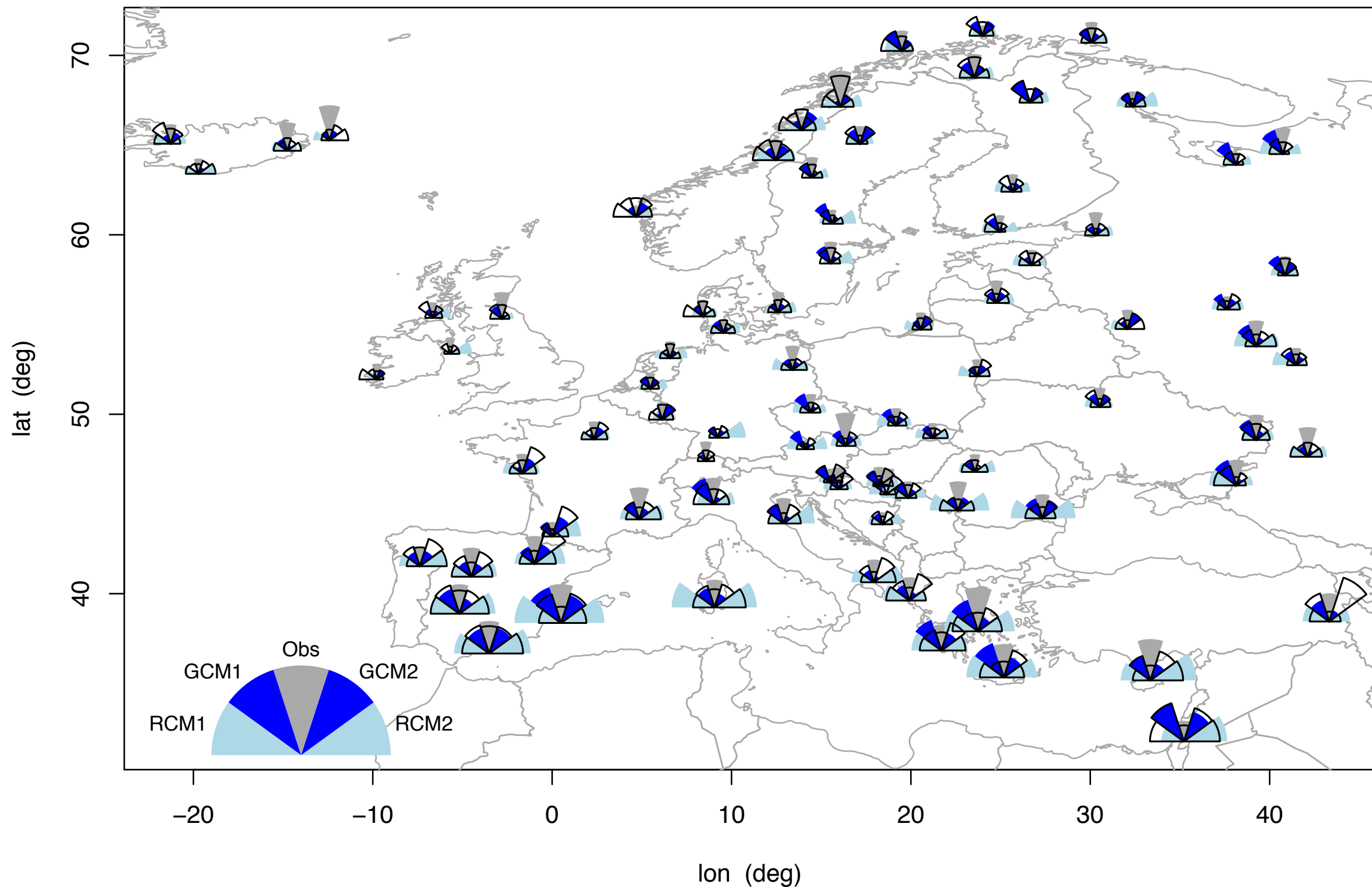
105 dry spells
118 wet spells

observed in 1961-2000

Mean Dry Spell **Lenghts** and Intensities 1961-2000



Mean Wet Spell **Lenghts** and Intensities 1961-2000



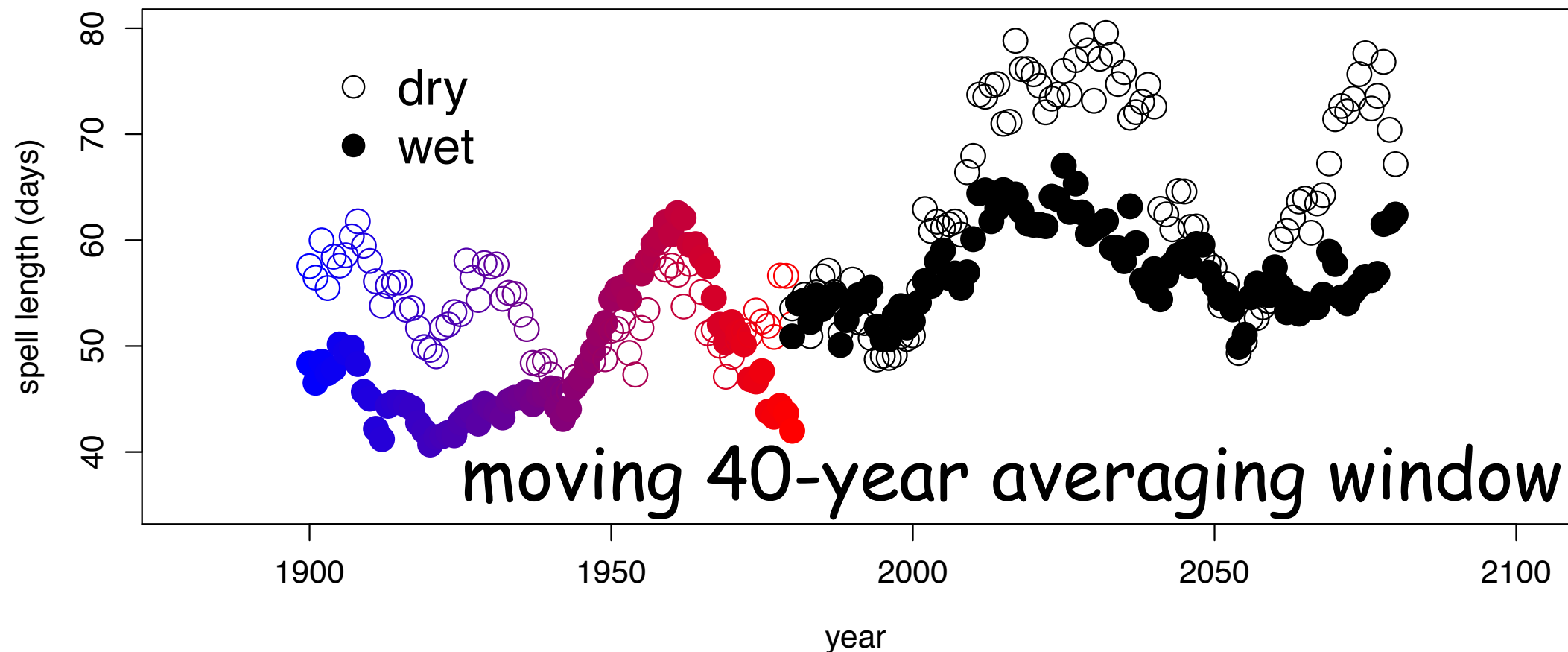
	Obs	ERA	GCM1	GCM2	RCM1	RCM2	mean	
μ_{DI}	-1.06	-1.10	-1.09	-1.10	-1.07	-1.07	dry	spell intensity
μ_{WI}	1.39	1.35	1.34	1.27	1.36	1.40	wet	
μ_{DL}	62	68	65	69	64	69	dry	spell length
μ_{WL}	59	65	65	68	62	63	wet	
r_{DI}	1	.27	.22	.45	.28	.25		
r_{WI}	1	.21	.37	.26	.56	.43		
r_{DL}	1	.54	.46	.32	.57	.42		
r_{WL}	1	.61	.43	.21	.57	.43		

=> RCMs add value on GCMs

But:

- > Significance? (Yes, they are even better than ERA40, which is in-phase with our climate system)
- > Why? (Better orography => better spatial pattern, but why better temporal pattern?)

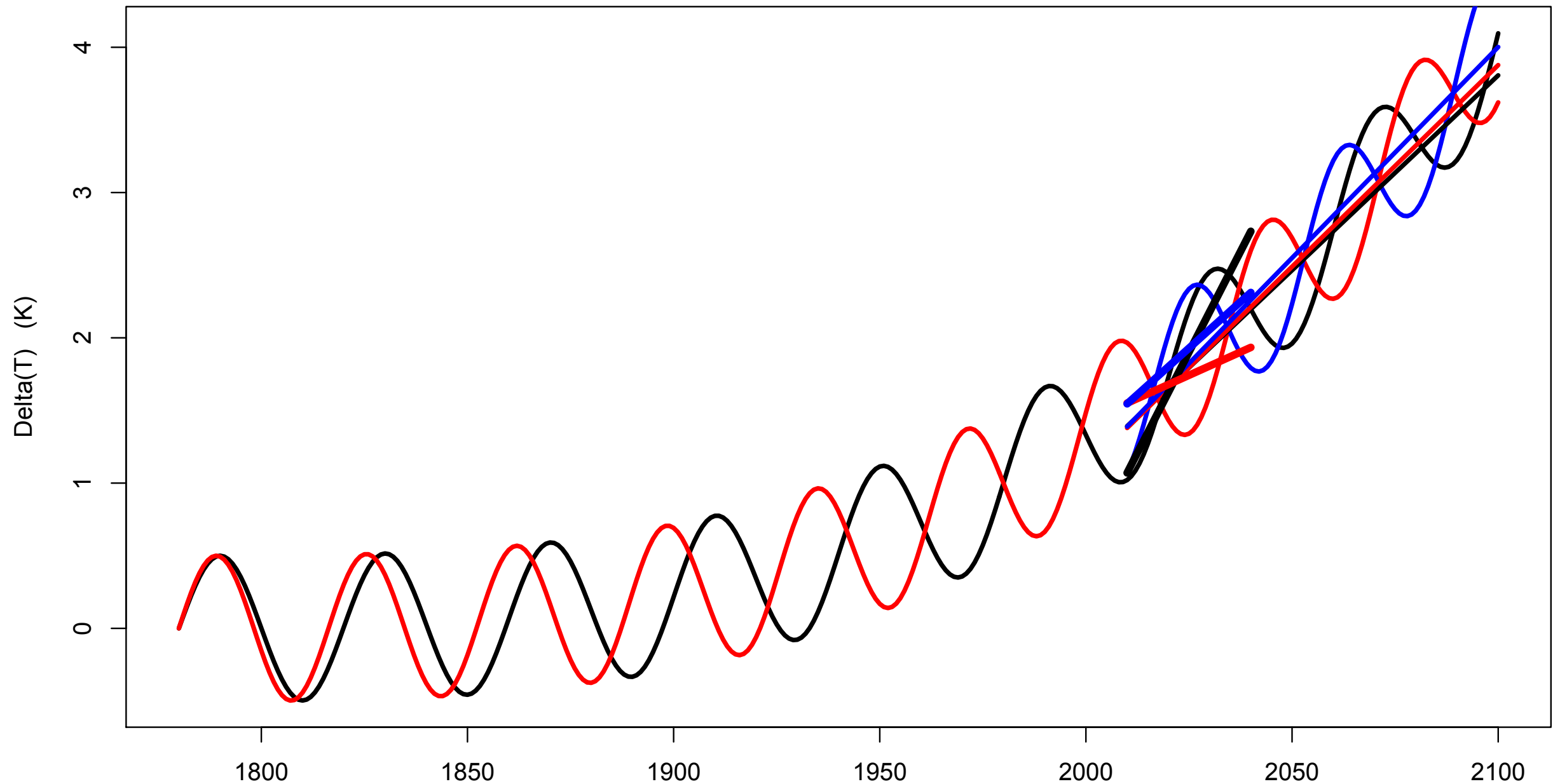
Significance?



Out-of phase by $O(10y) \leadsto O(10 \text{ days})$

=> Initialization challenge: A prediction needs to know the initial state of the ocean and land surface (e.g. soil moisture) globally and perfectly

Significance?



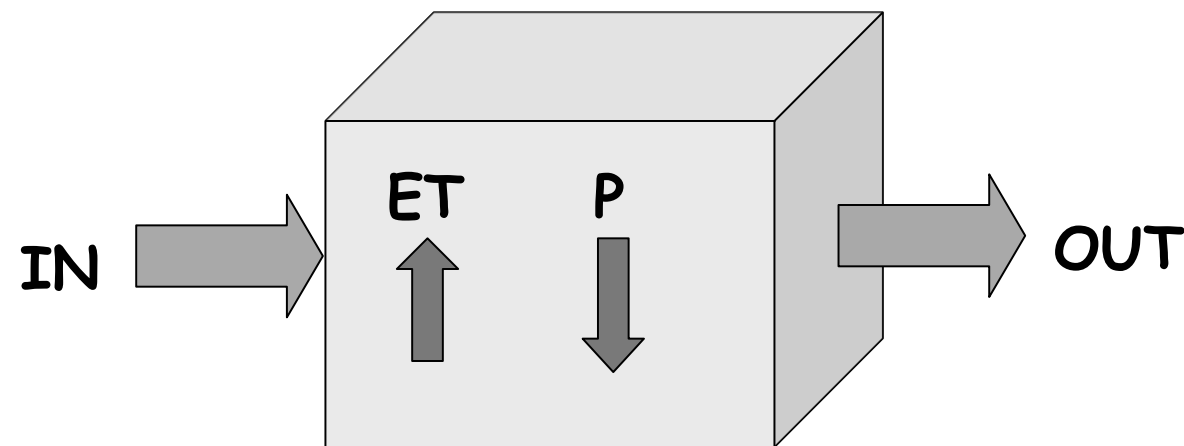
Why RCMs better than GCMs?

Ok, better spatial patterns (-> orography), but
systematic differences in precip. not relevant
for EDI

and timing of precipitation events driven by
GCMs ...

but: systematic precipitations differences feedback

Why RCMs better than GCMs?



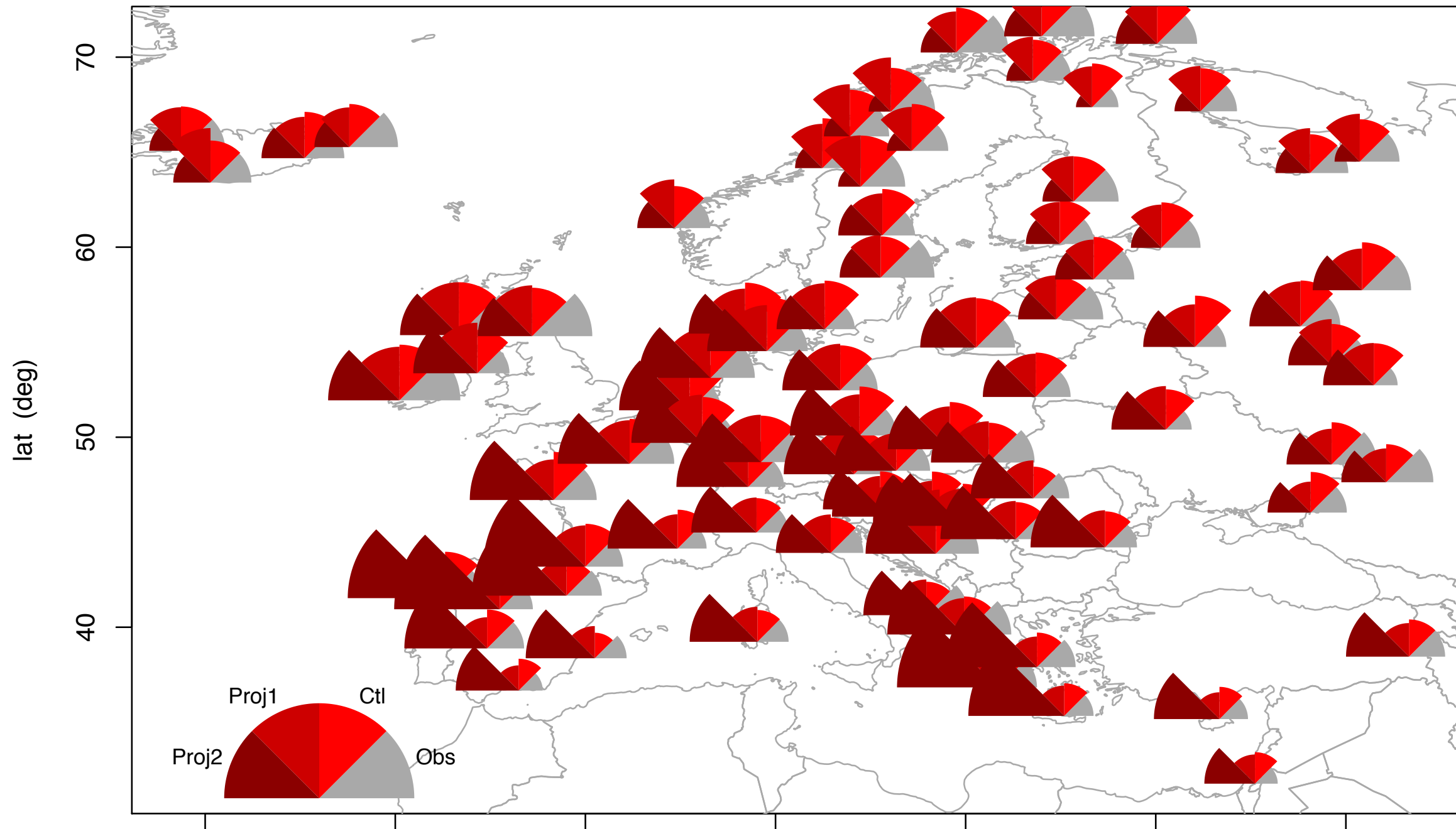
$$\Delta P = \underbrace{\Delta\chi(ET + IN)}_{\text{Efficiency effect}} + \underbrace{\chi\Delta ET}_{\text{Surface effect}} + \underbrace{\chi\Delta IN}_{\text{Remote effect}}$$

with efficiency $\chi = \frac{P}{ET + IN}$

ET moisture limited: Soil-moisture - Precipitation feedback
& modification of persistence!

Projections

Mean Spell Intens. 2061-2100 @



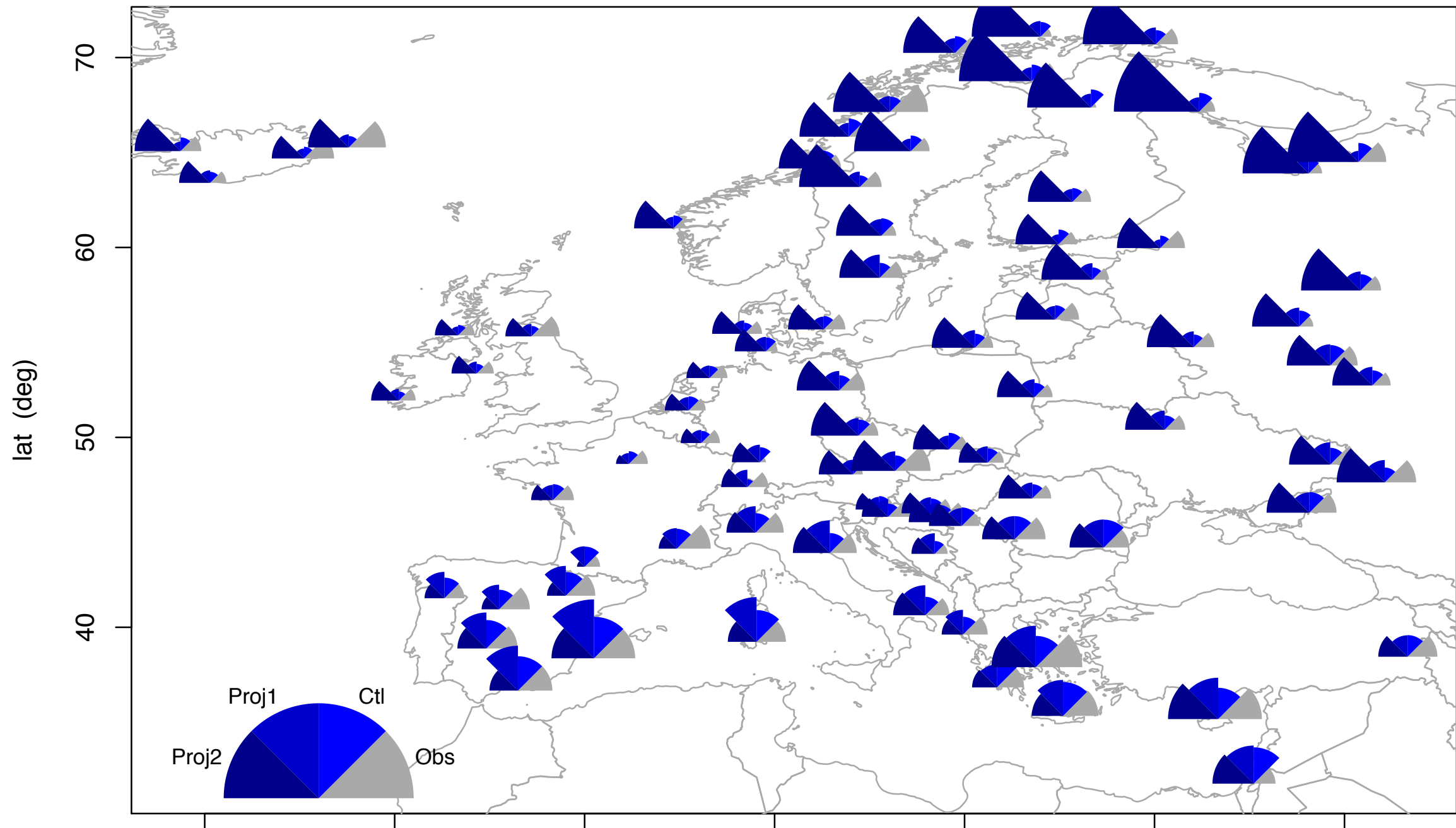
$$EDI_t = \frac{EP_t - \mu_j(t)}{\sigma_j(t)}$$

Proj1: std. with future

Proj2: std. with control

climate

Mean Spell Intens. 2061-2100 @



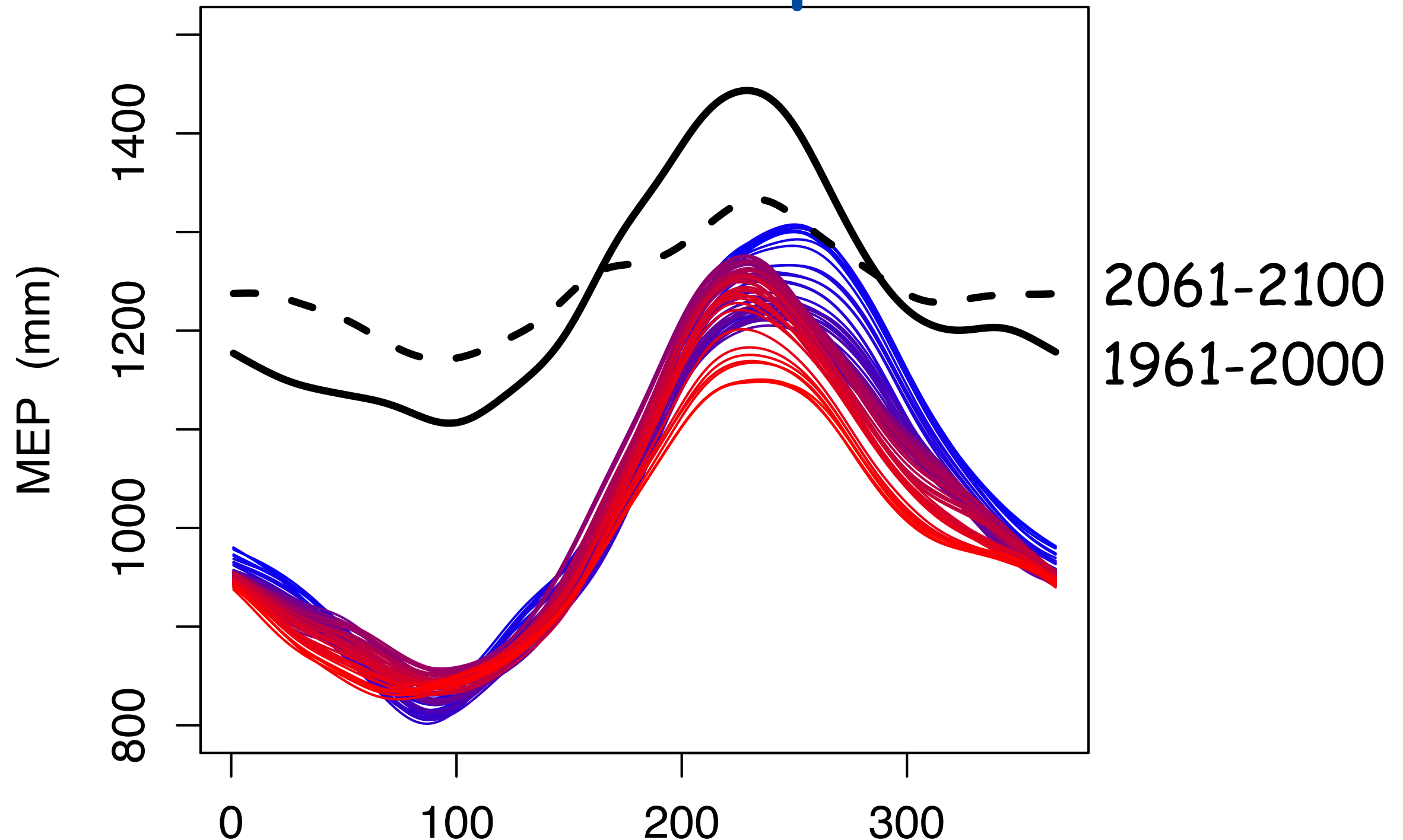
$$EDI_t = \frac{EP_t - \mu_j(t)}{\sigma_j(t)}$$

Proj1: std. with future

Proj2: std. with control

climate

Mean Effective Precipitation



standardization with control climate => it looks like more extremes ... but it is change of the mean climate

Summary & Questions

- Climate models useful in describing characteristics/
patterns of wet/dry spell climate

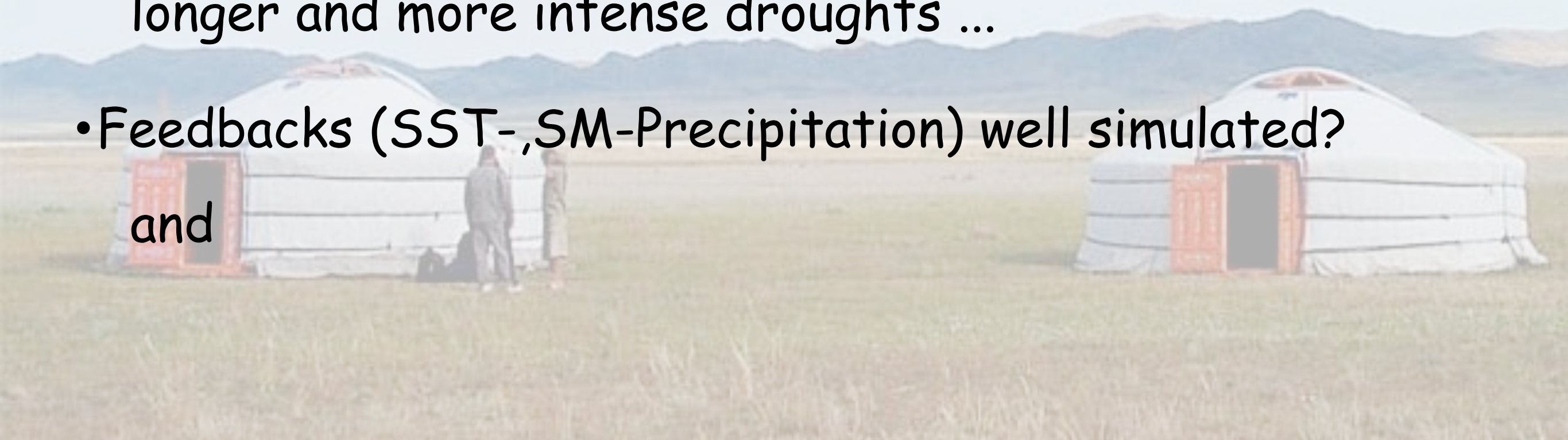
- RCMs add value on GCMs

- What is the reference of future extremes?

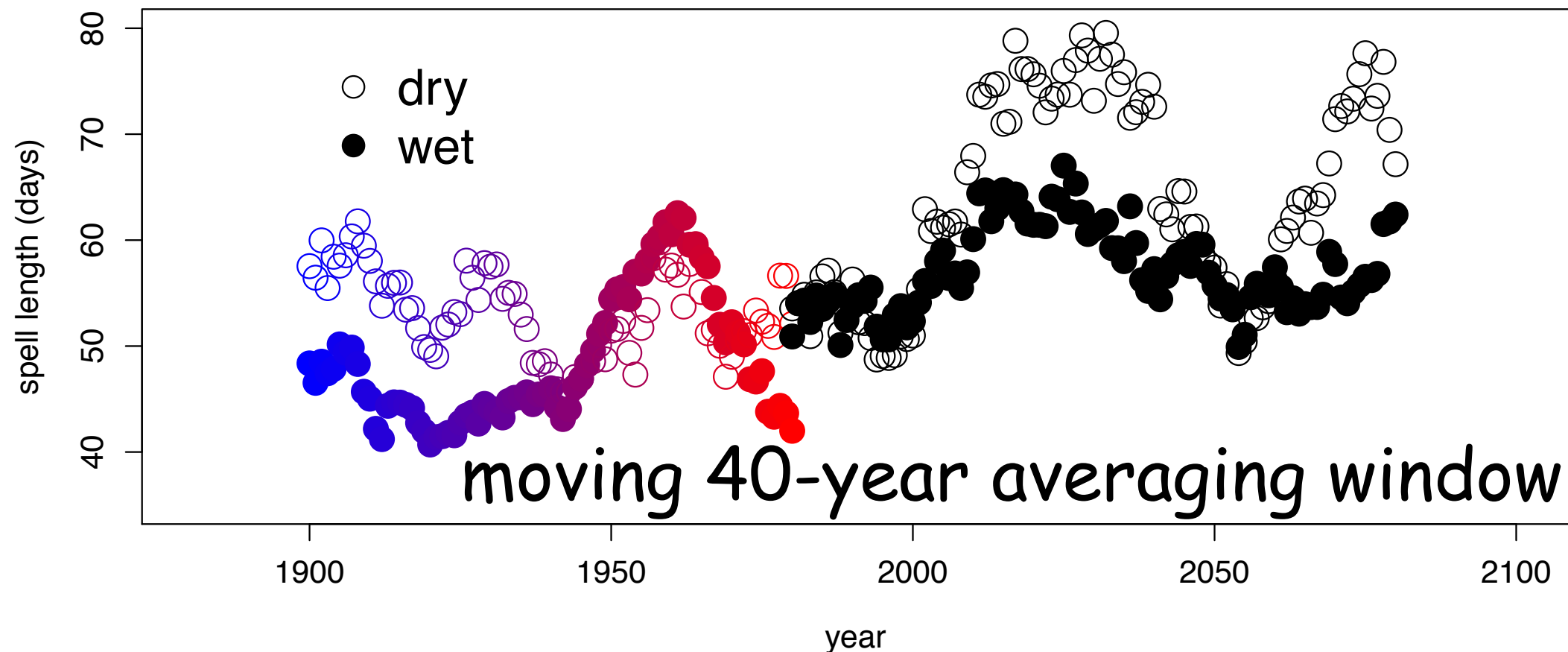
Compared to the control climate the Med. expects
longer and more intense droughts ...

- Feedbacks (SST-, SM-Precipitation) well simulated?

and



Variability



What size is the natural variability?

How to get in-phase with the natural system? I.e. How to initialize? Do we need the soil moisture content in 3m depth etc. for decadal predictions?