Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Seasonal prediction of extreme events

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MedCOF training, 29 October 2015, Madrid

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Barcelona Supercomputing Center
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Outline:

- Why focusing on extreme events?
- “Extremeness” metric
- Soil influence on extreme temperature
- Heatwave prediction

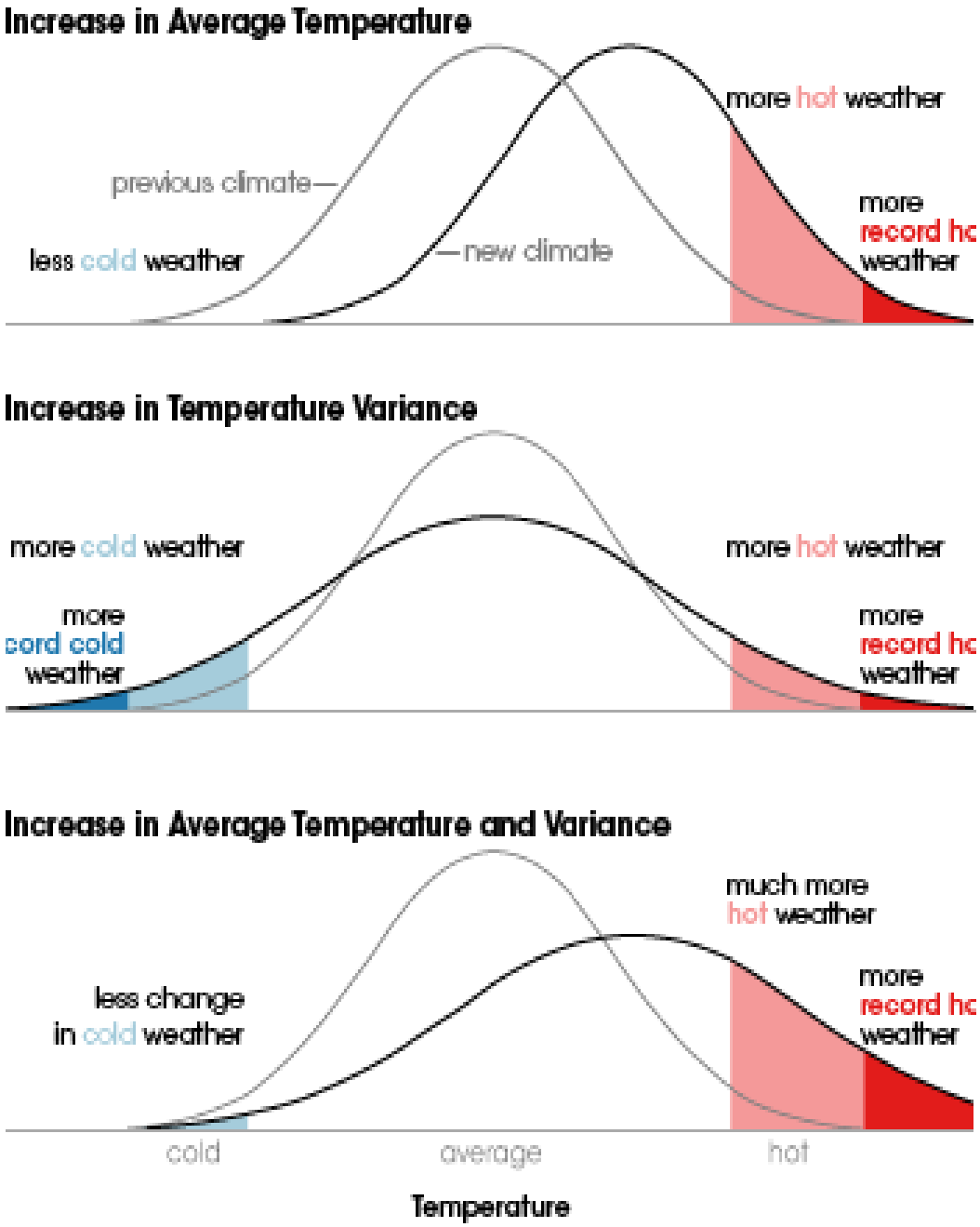
What are extreme events?

"There are a number of ways extreme climate events can be defined, such as extreme daily temperatures, extreme daily rainfall amounts, large areas experiencing unusually warm monthly temperatures, or even storm events such as hurricanes. Extreme events can also be defined by the impact an event has on society. That may involve excessive loss of life, excessive economic or monetary losses or both." (Easterling et al. 2000)

What are extreme events?

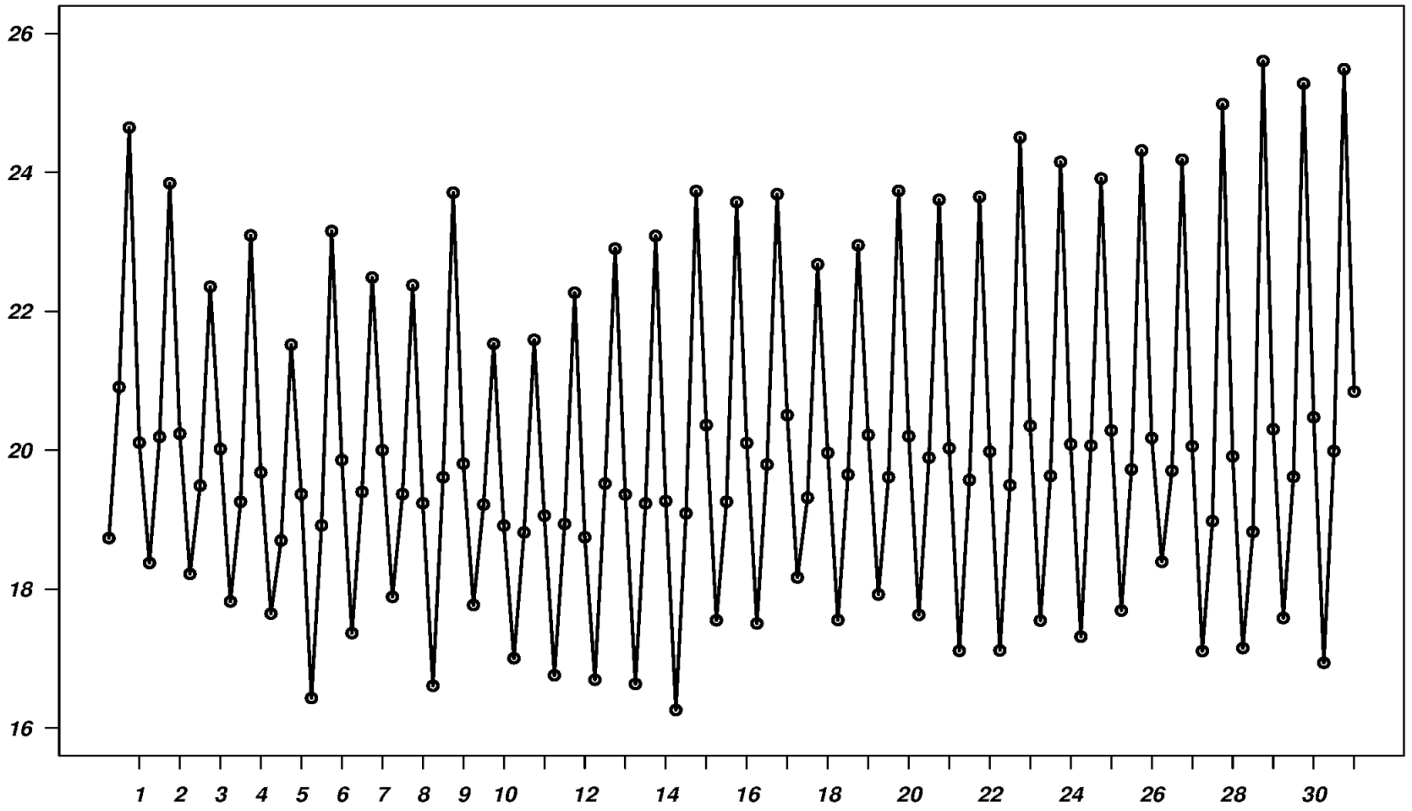
→ Global warming will shift and modify the distribution of temperature implying that more extremes will occur.

→ Seasonal prediction of extremes is thus indispensable for adaptation.



“Extremeness” metric

Six-hourly 2m-temperature (ºC) in May 1985 from ERAint in one grid point in Europe



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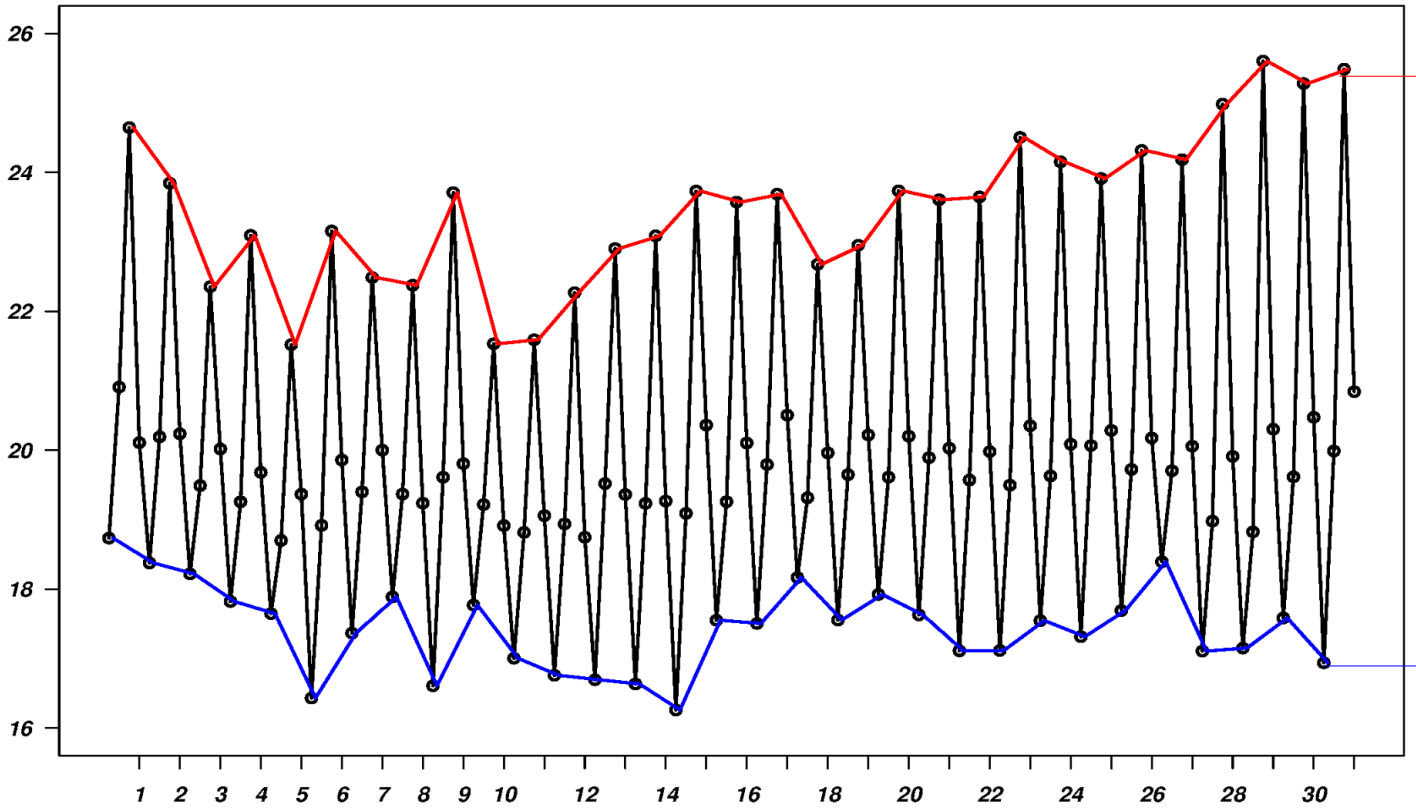

Daily maximum Temperature (Tx) ~ Day temperature

Daily minimum Temperature (Tn) ~ Night temperature

“Extremeness” metric

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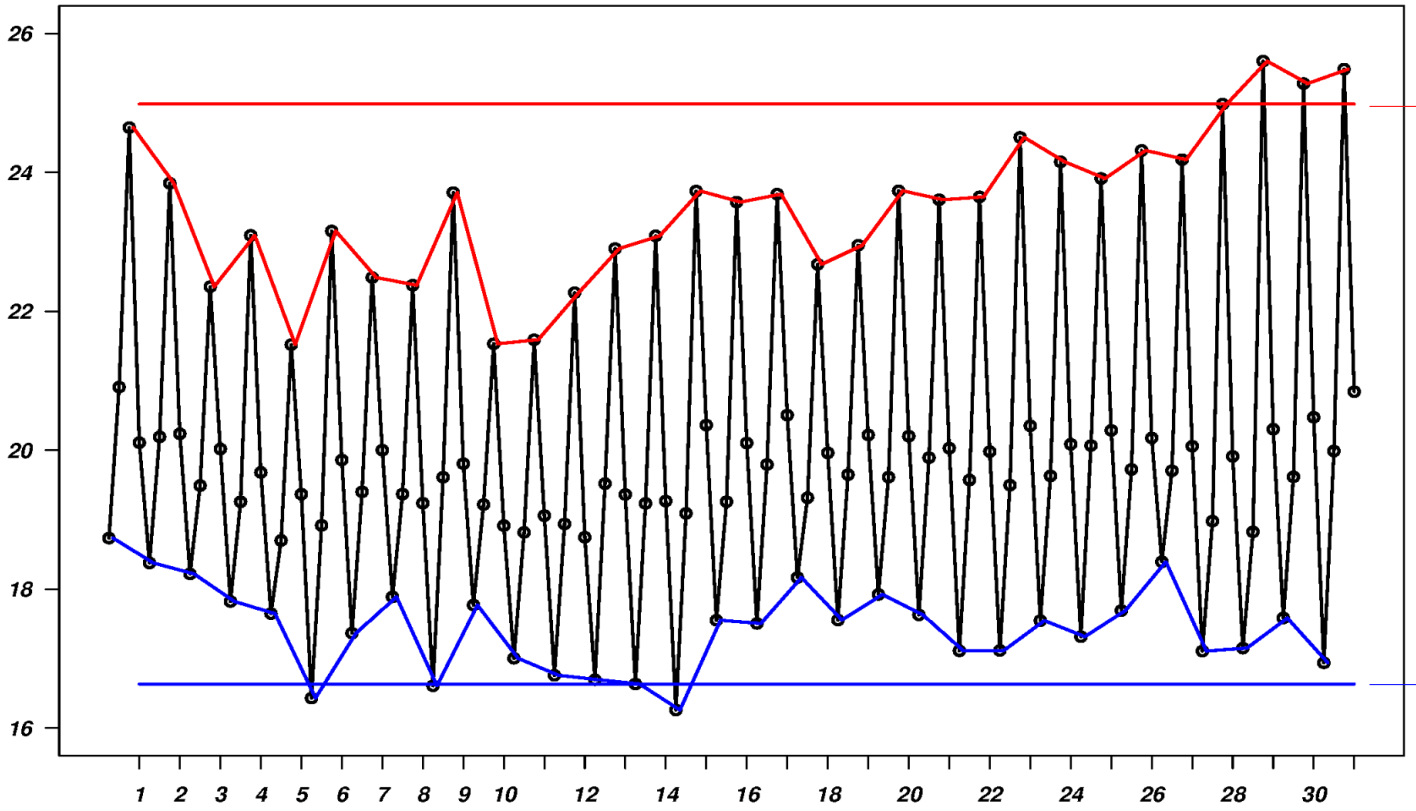


Monthly 90th percentile of Tx

~

Temperature during the warmest days

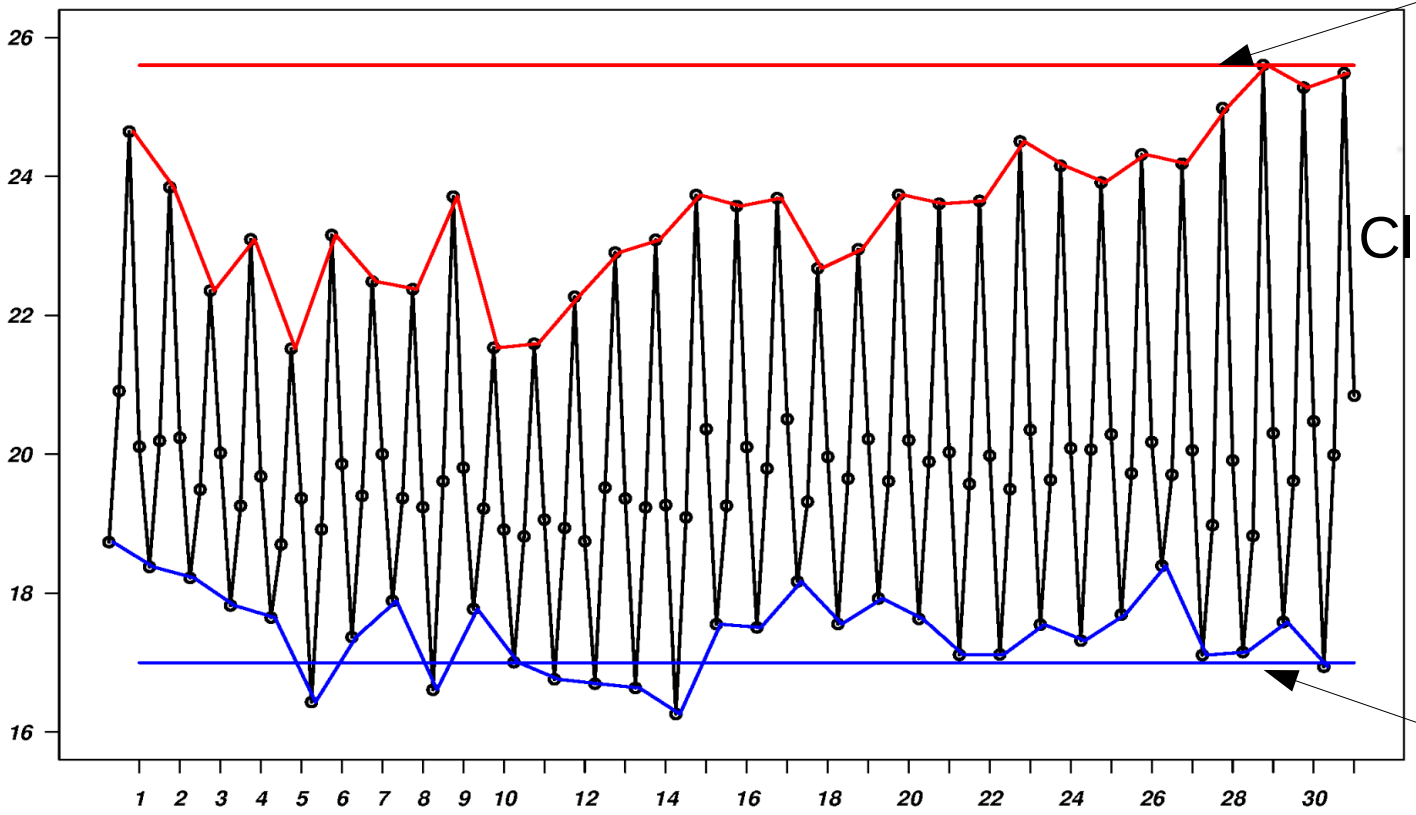
Monthly 10th percentile of Tn

~

Temperature during the coldest nights

“Extremeness” metric

Six-hourly 2m-temperature (ºC) in May 1985 from ERAint in one grid point in Europe



Climatological 90th Percentile of Tx over a given period (1981-2010)

~

Climatological temperature of the warmest days

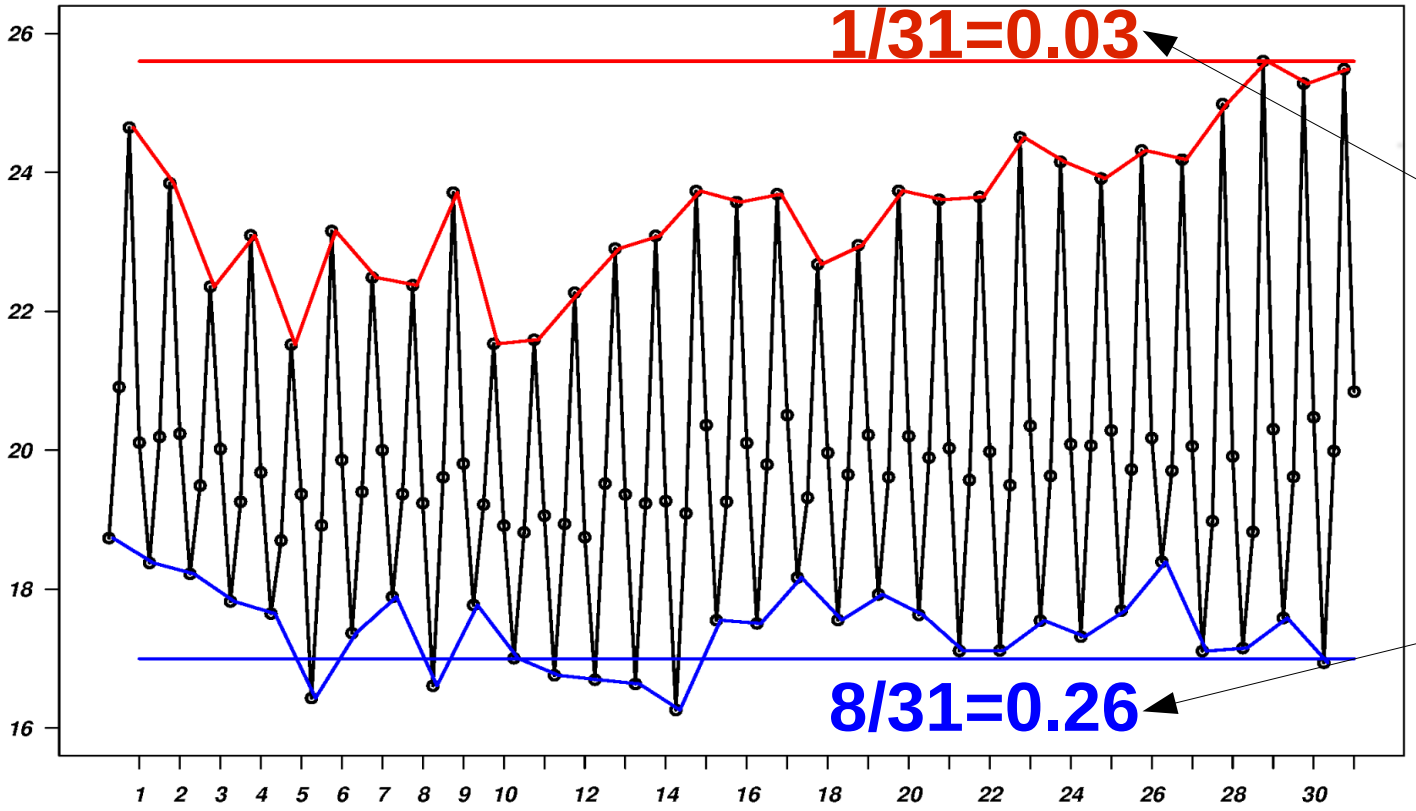
Climatological 10th Percentile of Tn over a given period (1981-2010)

~

Climatological temperature of the coldest nights

“Extremeness” metric

Six-hourly 2m-temperature (ºC) in May 1985 from ERAint in one grid point in Europe



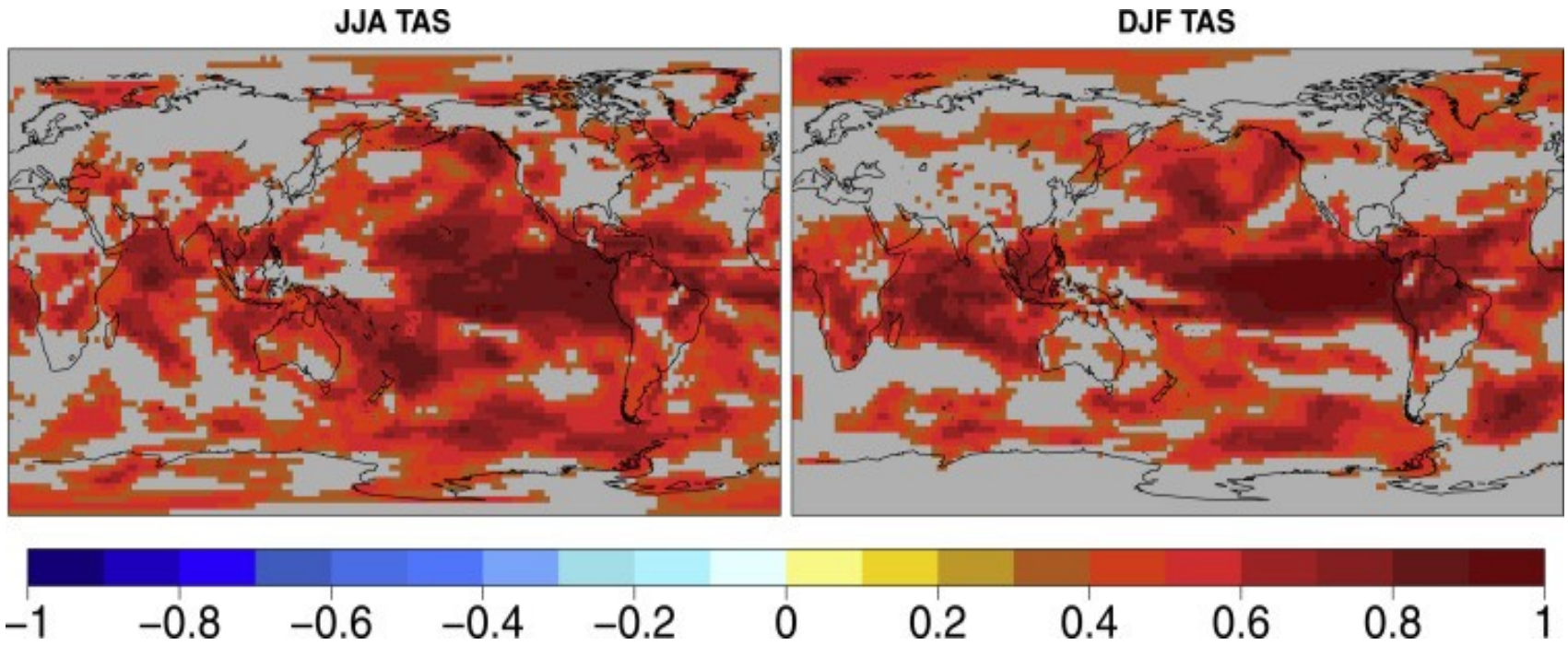
Percentage of days
Over the
Climatological 90th
Percentile of Tx
over the whole period
(1981-2010)
~
Number of warm days

Percentage of days
Under the
Climatological 10th
Percentile of Tn
over the whole period
(1981-2010)
~
Number of cold nights

More computationally expensive!
This method “bias-corrects” the hindcasts temperature distribution.

“Extremeness” verification

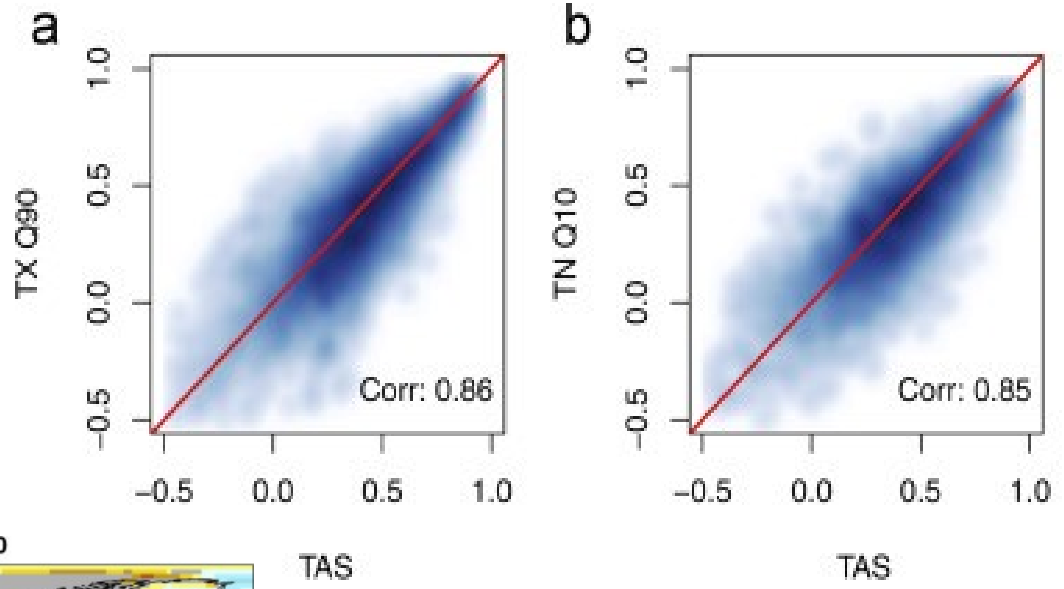
The ENSEMBLES multi-model seasonal forecasts (Weisheimer et al., 2009):
- UK Met Office (UKMO)
- Météo-France (MF)
- European Centre for Medium-Range Weather Forecasts (ECMWF)
- Leibniz Institute of Marine Sciences at Kiel University (IFM-GEOMAR)
- Euro-Mediterranean Centre for Climate Change (CMCC-INGV) in Bologna. .



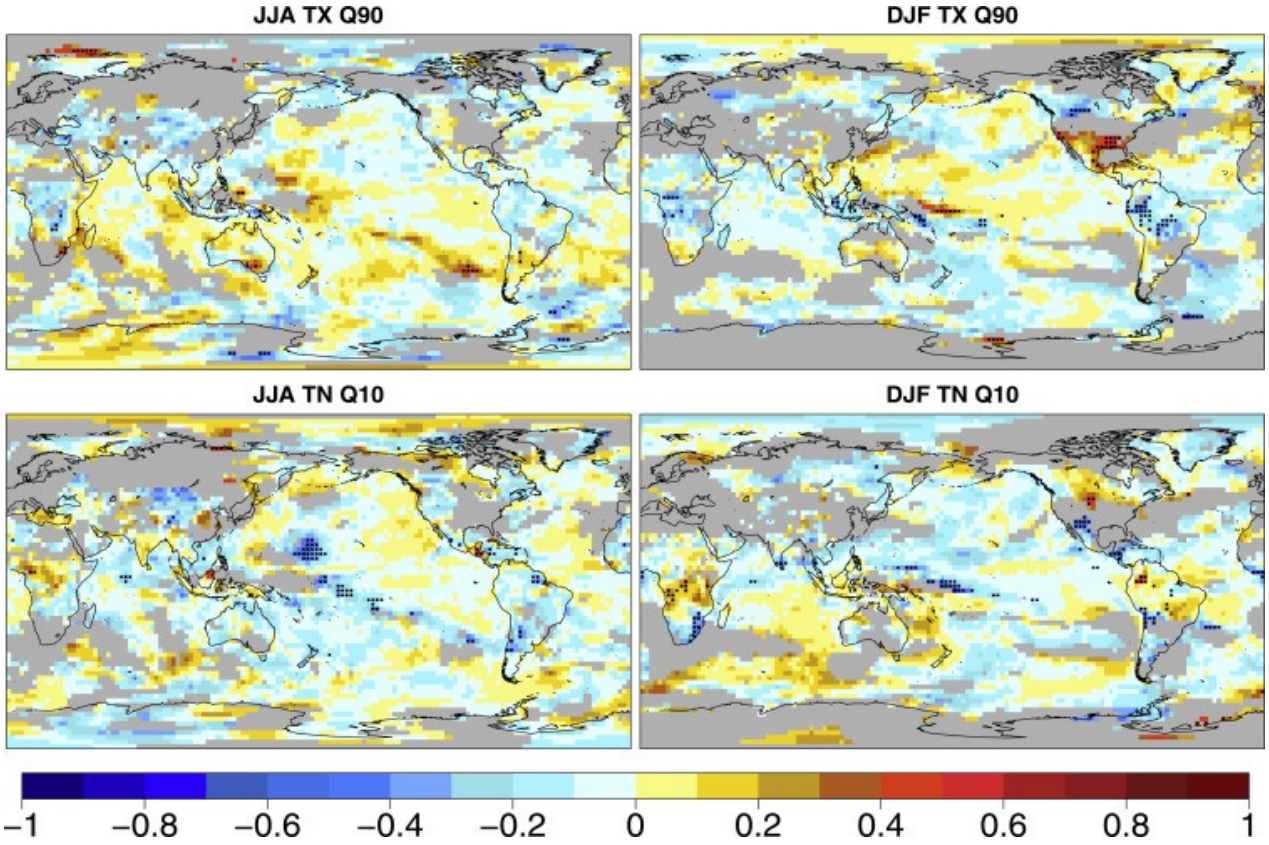
Anomaly correlations between the ENSEMBLES ensemble mean temperature forecast and ERA-Interim reanalysis. May (left) and November (right) start date.

“Extremeness” verification

The difference between the anomaly correlation between the ERAI observations and the ENSEMBLES multi-model forecast mean as obtained for indices of seasonal extremes, and the same correlation for the seasonal mean temperature.



Scatter plot of anomaly correlation for the mean daily temperature and the 90th and 10th percentiles over the entire globe in JJA



Skill for mean and extreme is similar.

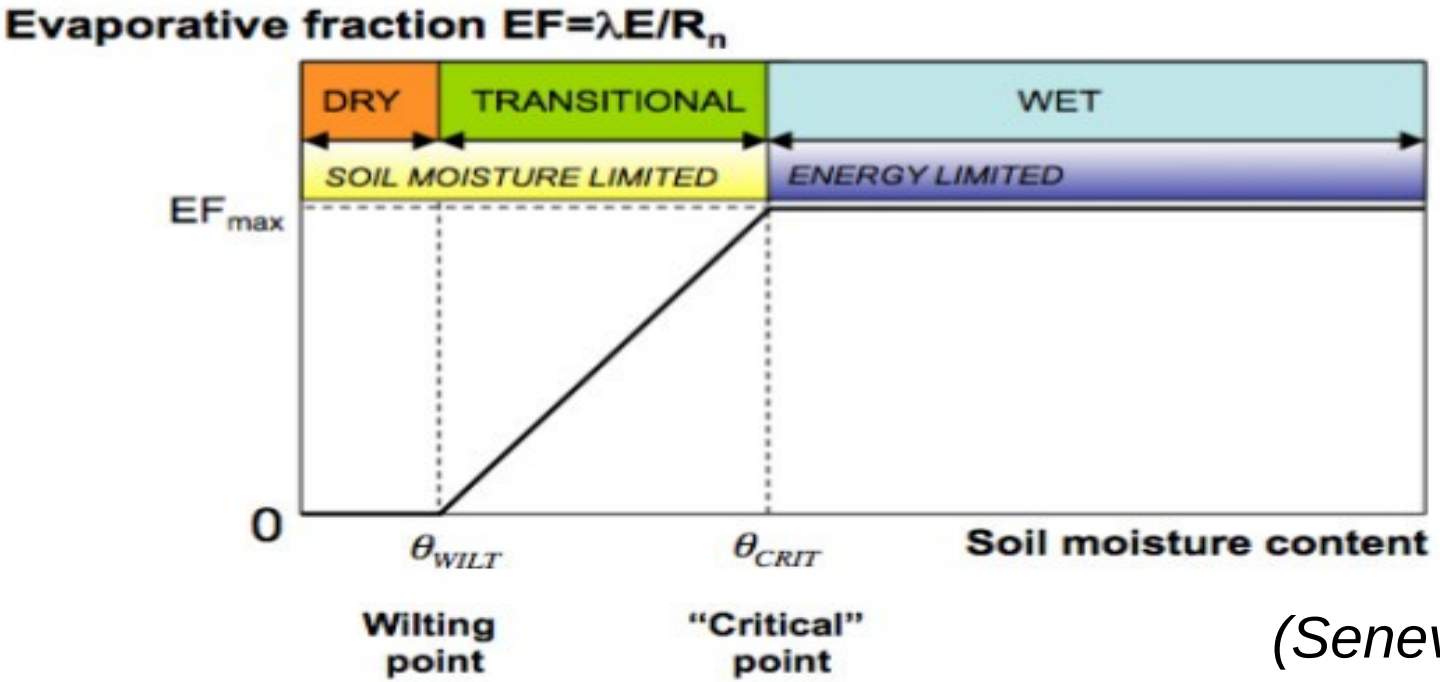
Pepler et al. (2015)

More variables….

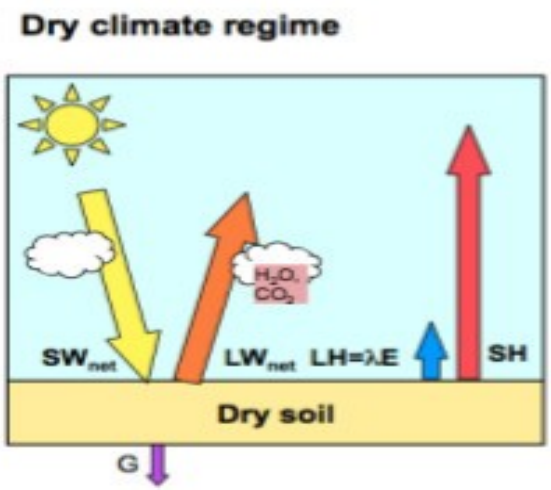
According to the **user needs**, many other extreme variables can be defined:

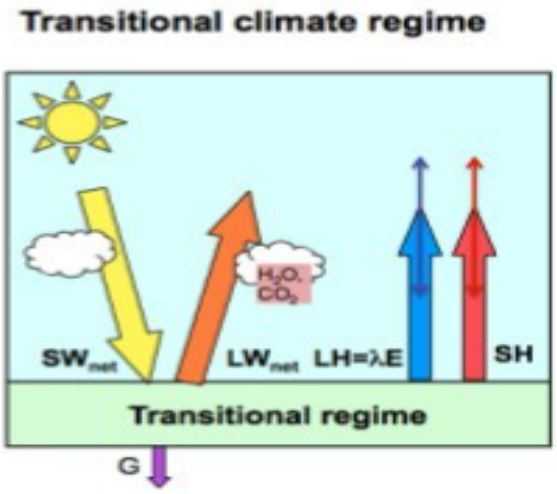
- Temperature and number of warm nights (Impact on human and animals health)
- Number of nights over a temperature threshold (cattle loss)
- Number of nights under 0ºC (crop damage, road...)
- Extreme precipitation (floods)
- Number of consecutive dry/warm days (drought)
- Wind module exceeding a threshold (wind energy)
-.....

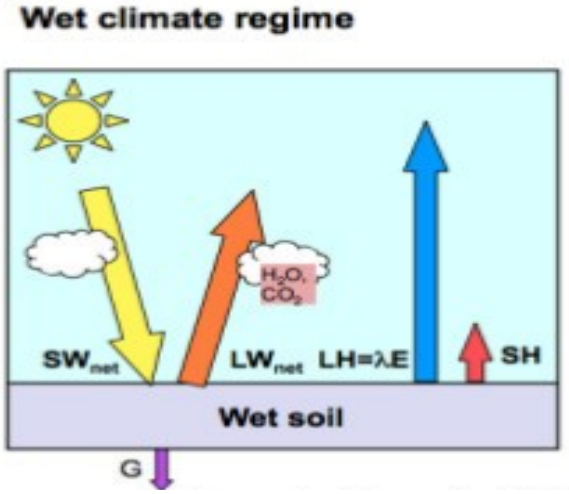
Land-atmosphere coupling



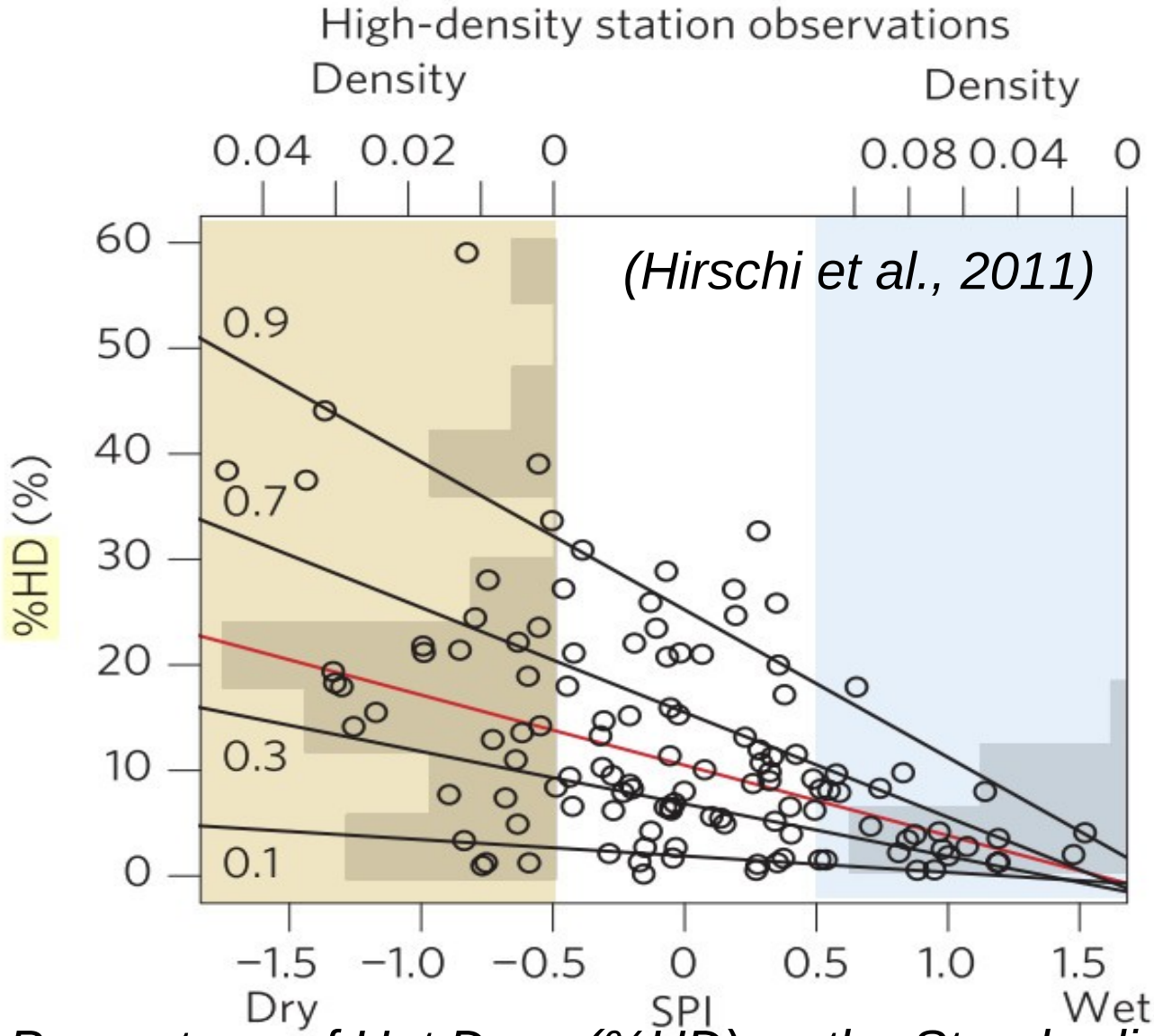
(Seneviratne et al., 2010)







Land-atmosphere coupling



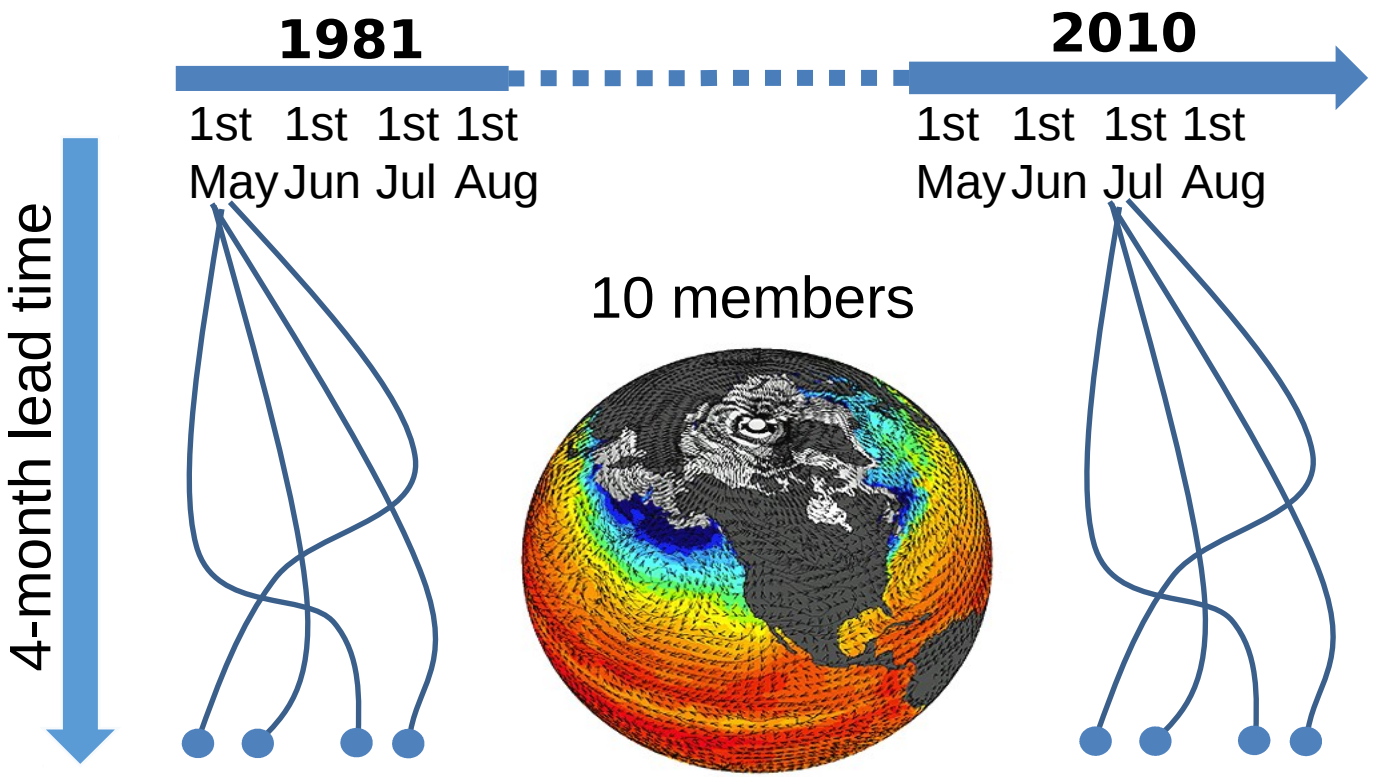
(Hirschi et al., 2011)

Warm extremes only occur when the soil is dry.

Percentage of Hot Days (%HD) vs the Standardized Precipitation Index (SPI) in the southeast European domain (1961-2000 period).

Experiment description

	Model	Start dates	Land IC	Atm IC	Oce/Ice IC
INIT	EC-Earth 2.3	May	**ERA-Land**	ERAInt	ORA-S4
CLIM	EC-Earth 2.3	May	**ERA-Land Climatology**	ERAInt	ORA-S4



Impact of soil IC on temperature skill

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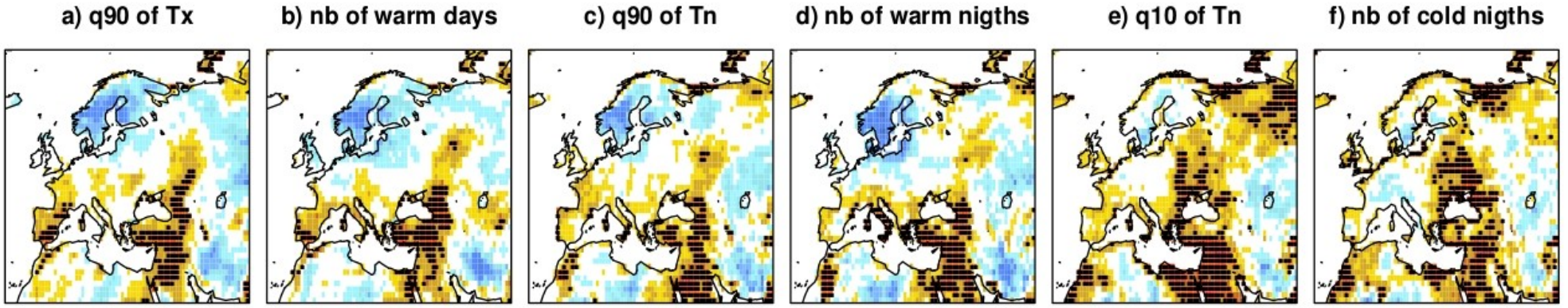
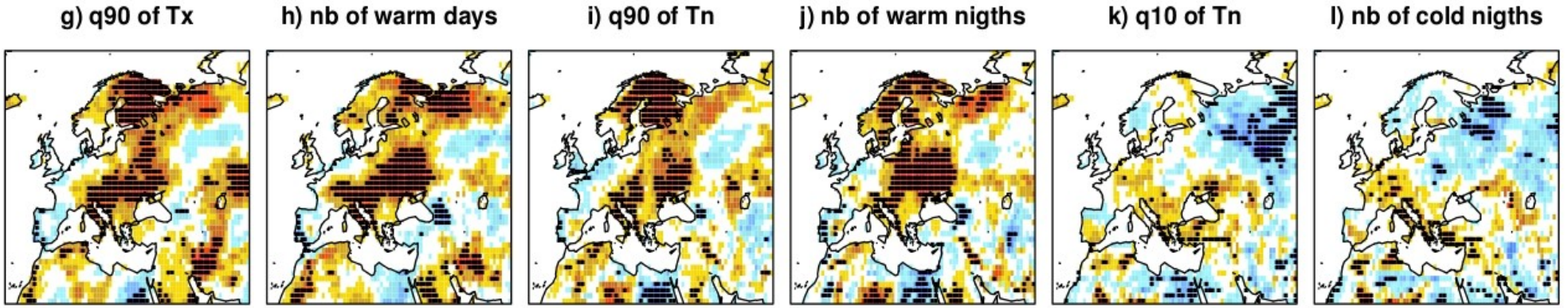
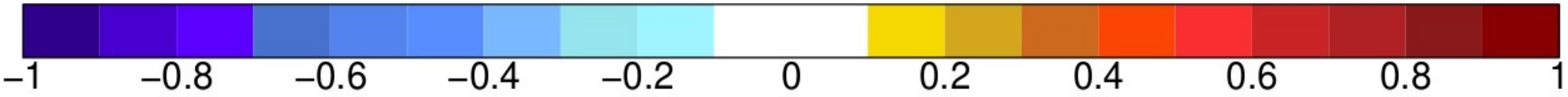
Correlation between CLIM and ERA-interim



Difference of correlation: INIT-CLIM





With realistic soil initialization skill of warm extremes significantly increases

2003 and 2010 heat waves

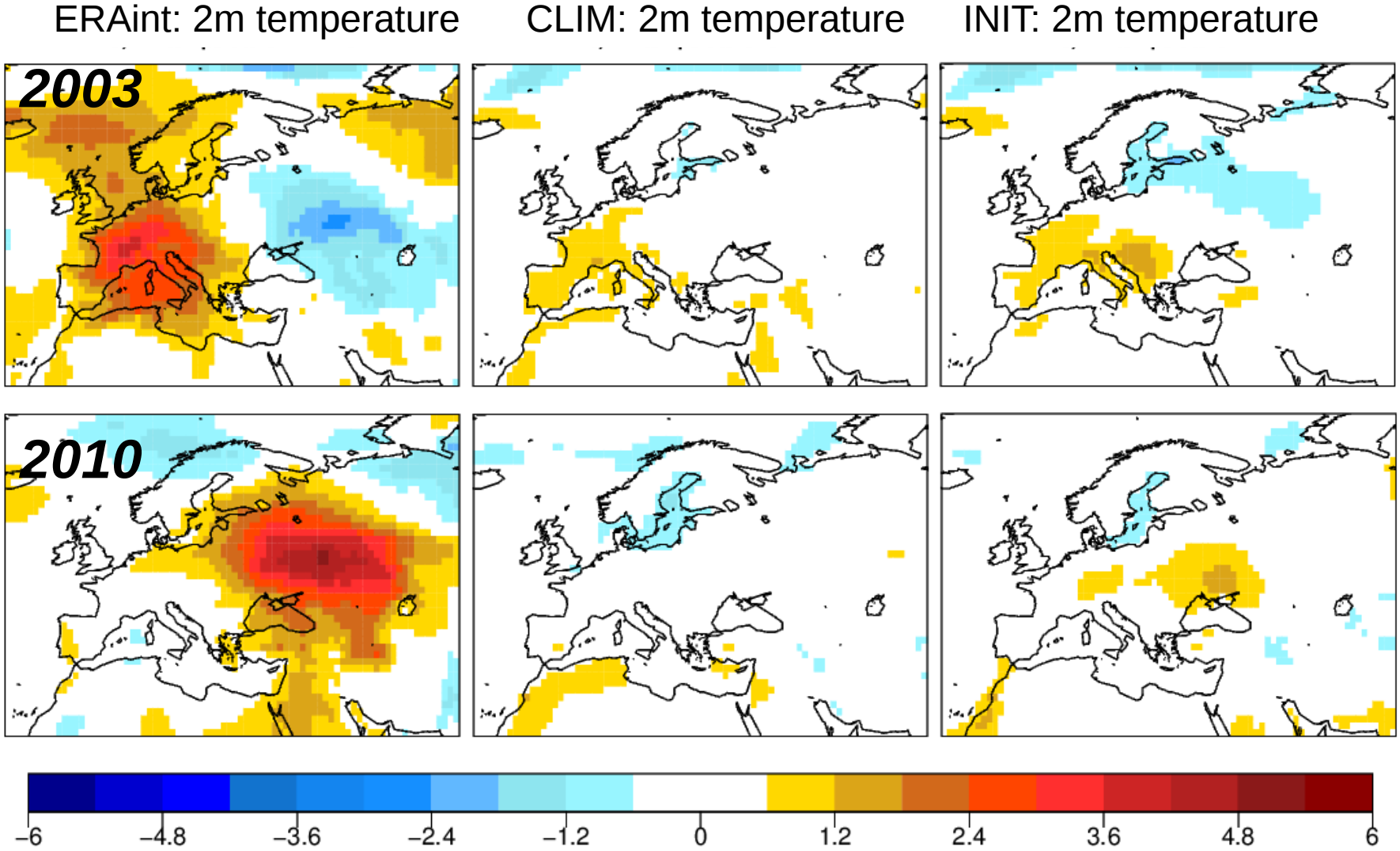
2m-Temperature anomalies (JJA)

2003

The European heat-wave of 2003 caused the death of 35,000 people and damages of $15 billion.

2010

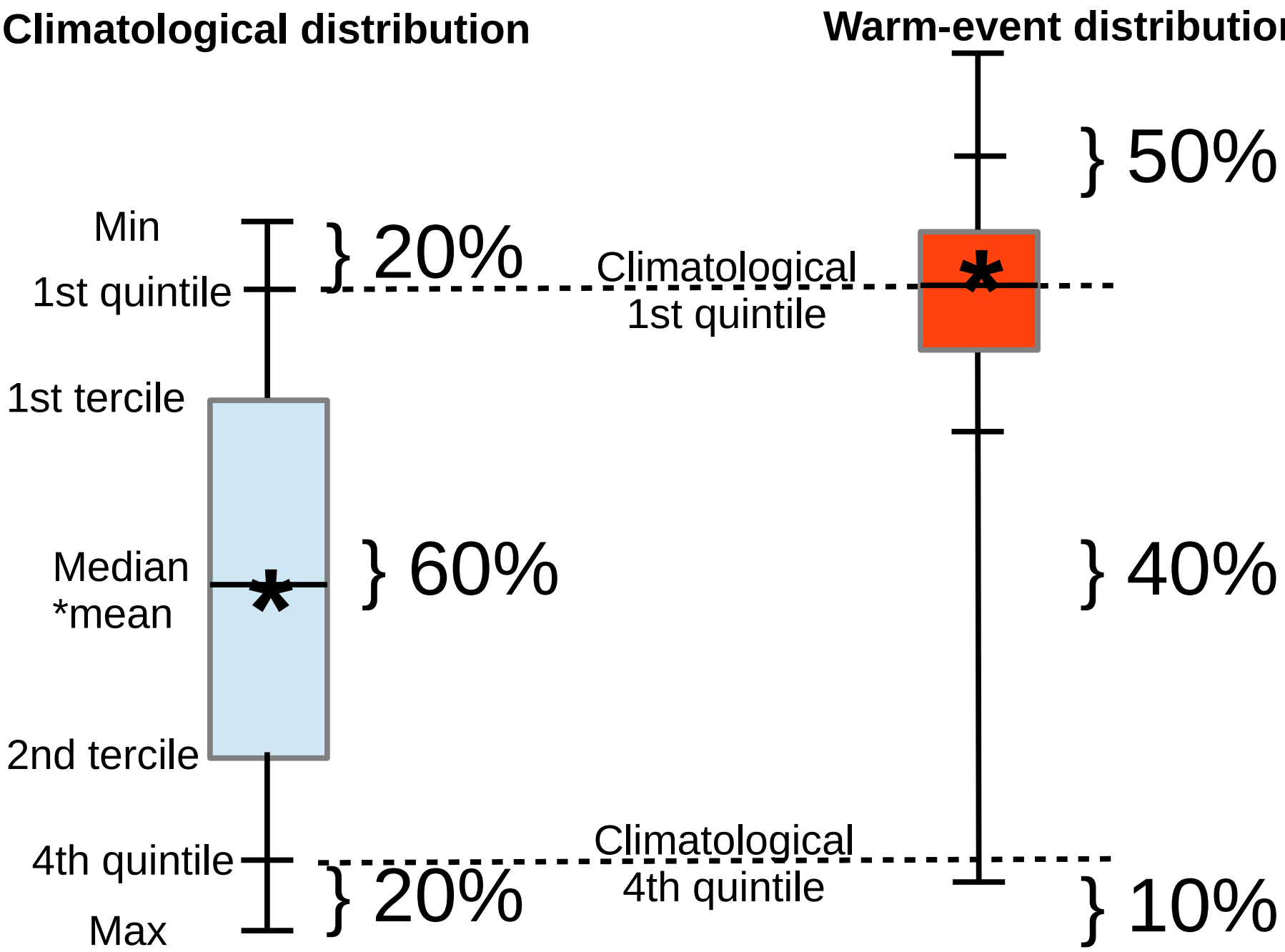
Are they predictable?



- 2003 and 2010 seems to be predictable, soil initial conditions seem to be important only for 2010.

- Using ensemble mean anomaly smooths out the signal and is not adequate to assess the ensemble predictions.

Odds ratio: Metric for heat waves



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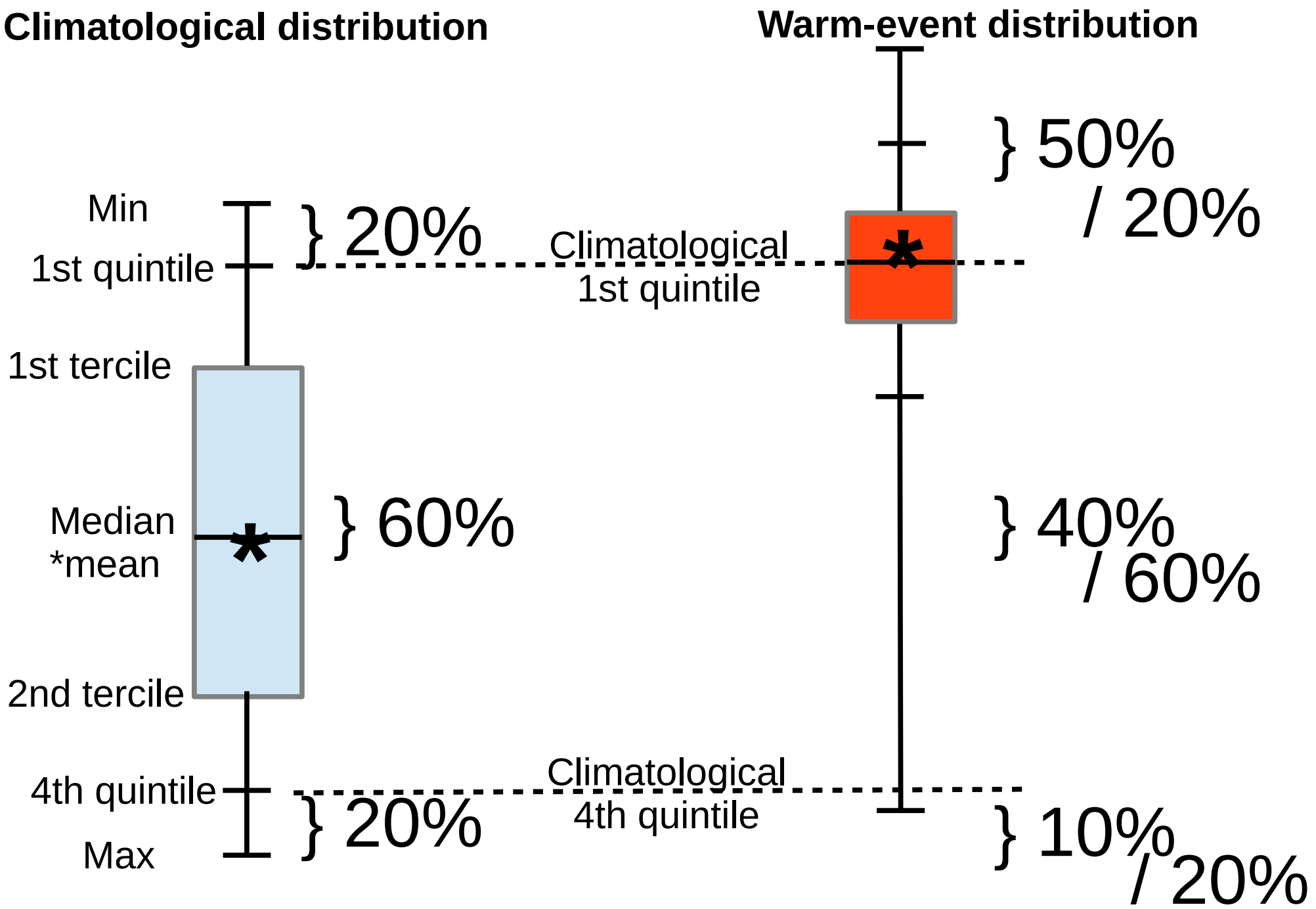

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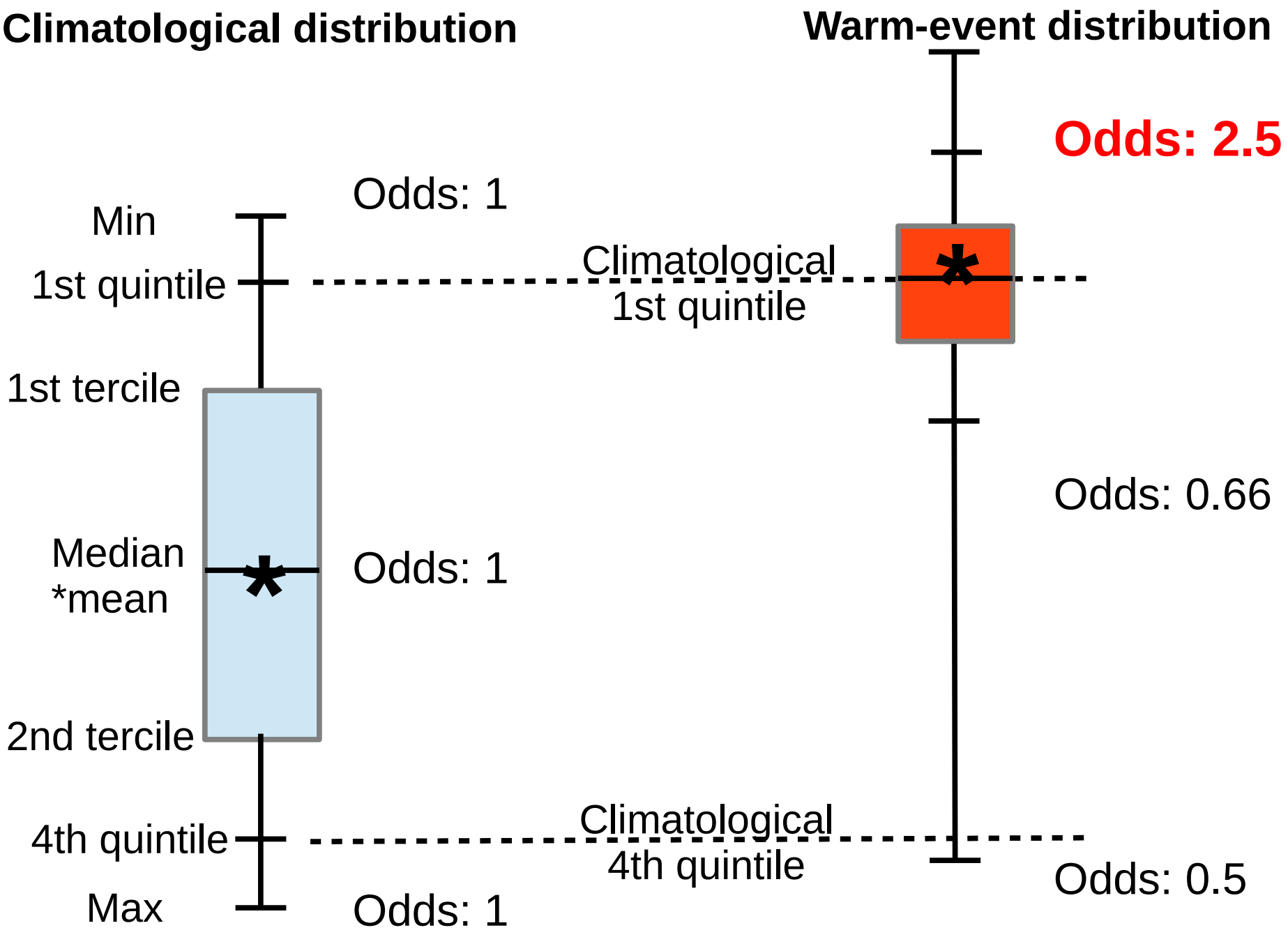
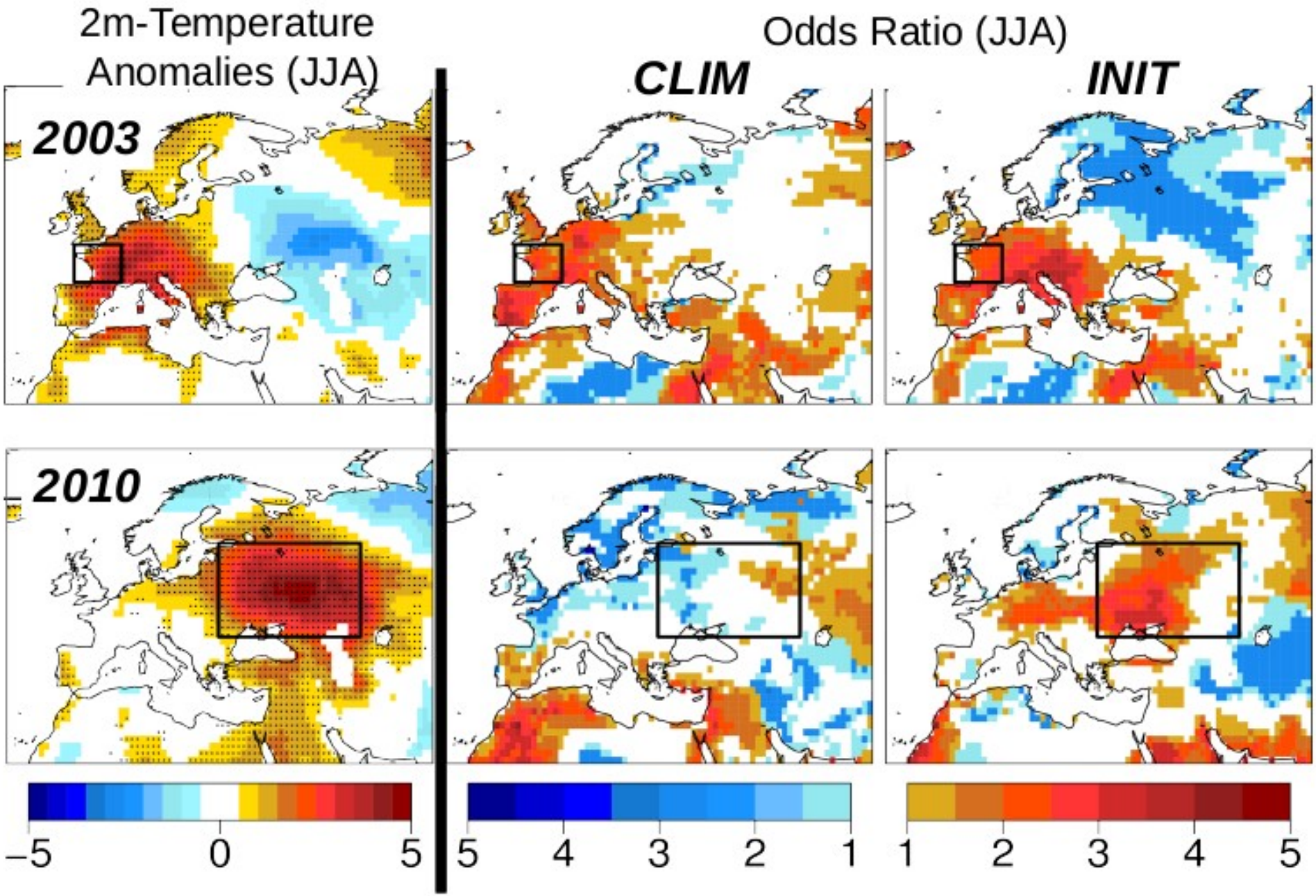


Odds ratio: Metric for heat waves



Conclusions

- Extreme temperature variables can be predicted with skill equivalent to the skill of the mean.
- Land-atmosphere coupling is extremely important for extreme temperature and realistic soil initial conditions are important for the skill of extreme temperature.
- Heatwaves can be predicted and soil initial conditions can be important for predicting the heatwave development.
- The ensemble-mean anomaly is not suitable for expressing the extremes; metrics based on the forecast distribution such as the odds ratio are more adequate.
- Extreme variables should also be defined from the users needs.