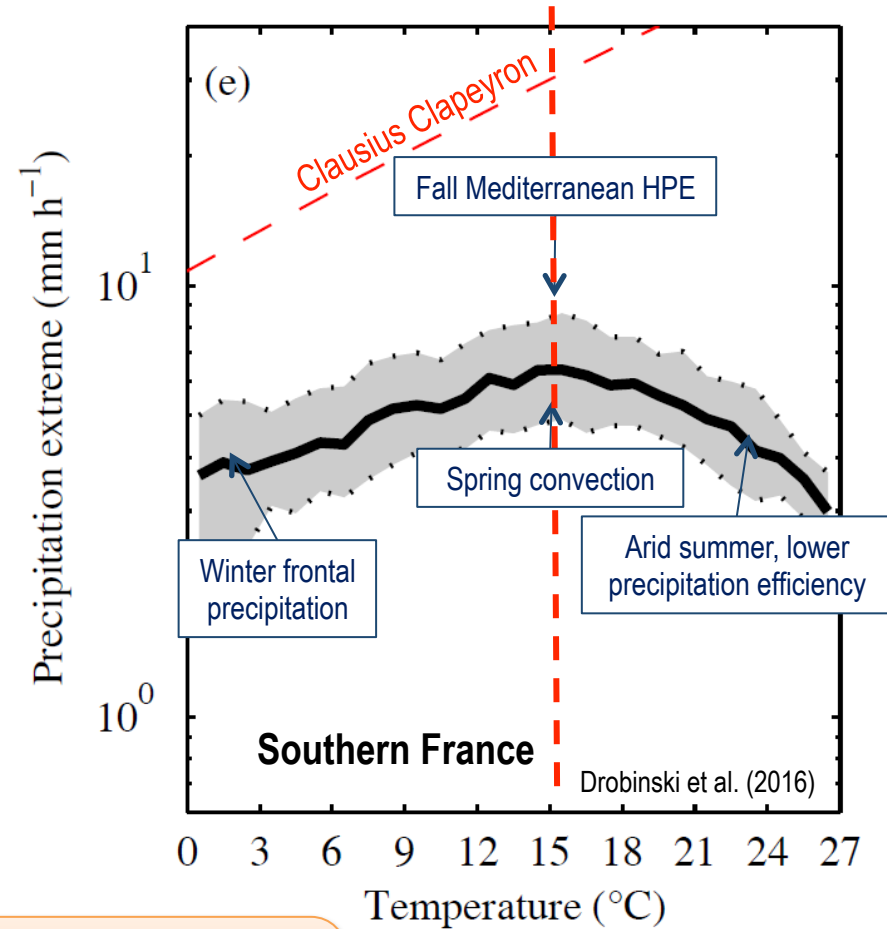
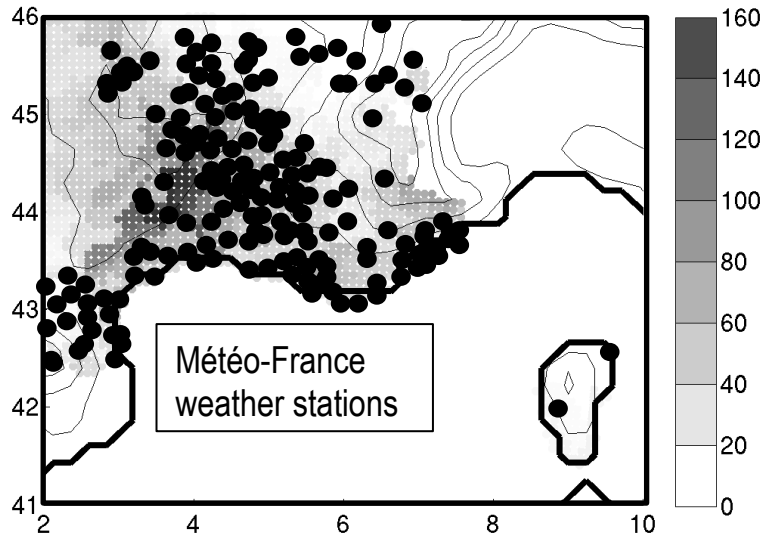


# Scaling precipitation extremes with temperature in the Mediterranean: past climate assessment and projection in anthropogenic scenarios

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# Issues



1. Is there a relationship between maximum water vapor content and precipitation extremes ?
2. Why do precipitation extremes change differ from CC-scaling?
3. Is the scaling of precipitation extremes predictive for future climate?
4. Is the scaling spatially variable over the Mediterranean region?

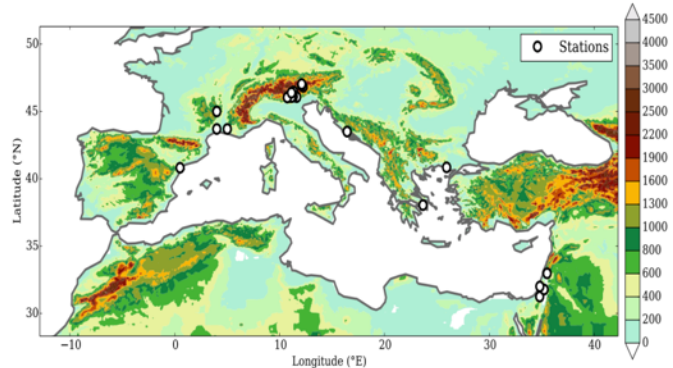
Temperature break

# Data and method

## Data

RCM validation

Type	Data (time series)	Location
In-situ HyMeX	Temperatures, precipitation 10 min-12h	6 countries: Spain, France, Italy, Croatia, Greece, Israel
E-OBS	Temperatures, precipitation, 24h	Whole Mediterranean
14 RCMs ERA-I, CMIP5 (HIST, RCP8.5)	Temperatures, precipitation, specific humidity 3h	Whole Mediterranean



Geographical patterns

## Method

selection of rainy events (daily)  
sorted in increasing order of temperature (daily averaged)  
bins of 100 samples

99<sup>ème</sup> qu. Pr.  
50<sup>ème</sup> qu. T°C

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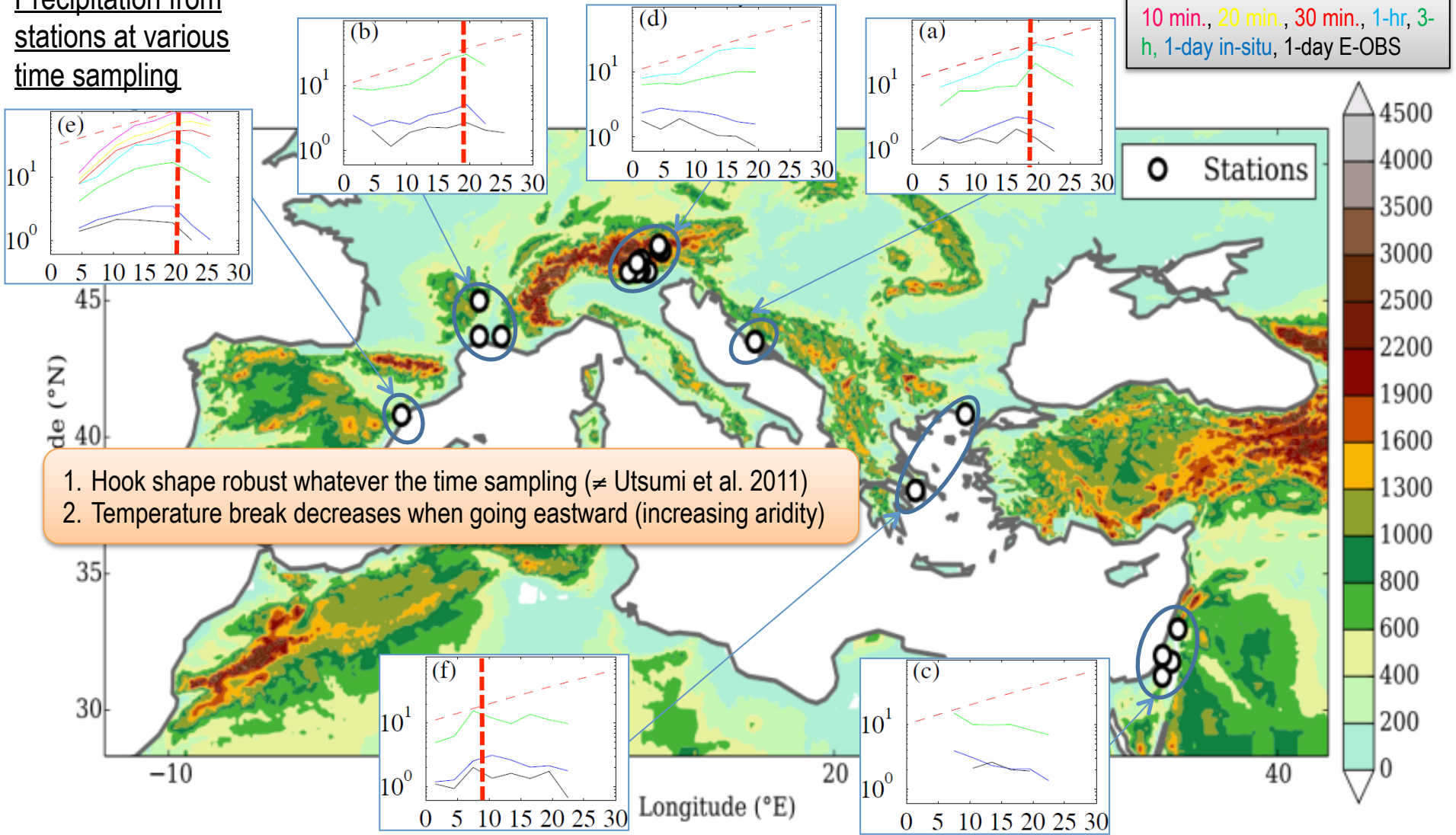
99<sup>ème</sup> qu. Pr.  
50<sup>ème</sup> qu. T°C



# Scaling of precipitation extremes in present climate

Precipitation from stations at various time sampling

10 min., 20 min., 30 min., 1-hr, 3-h, 1-day in-situ, 1-day E-OBS

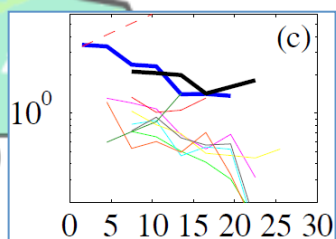
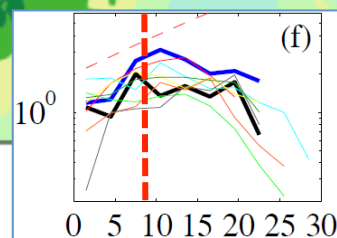
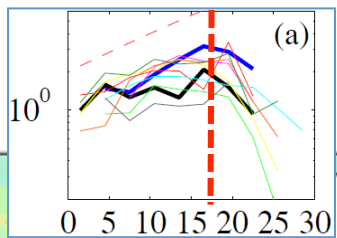
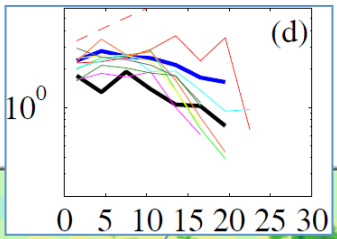
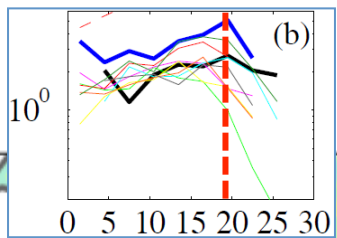
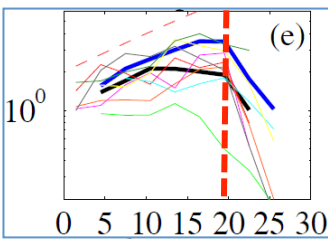


1. Hook shape robust whatever the time sampling ( $\neq$  Utsumi et al. 2011)
2. Temperature break decreases when going eastward (increasing aridity)

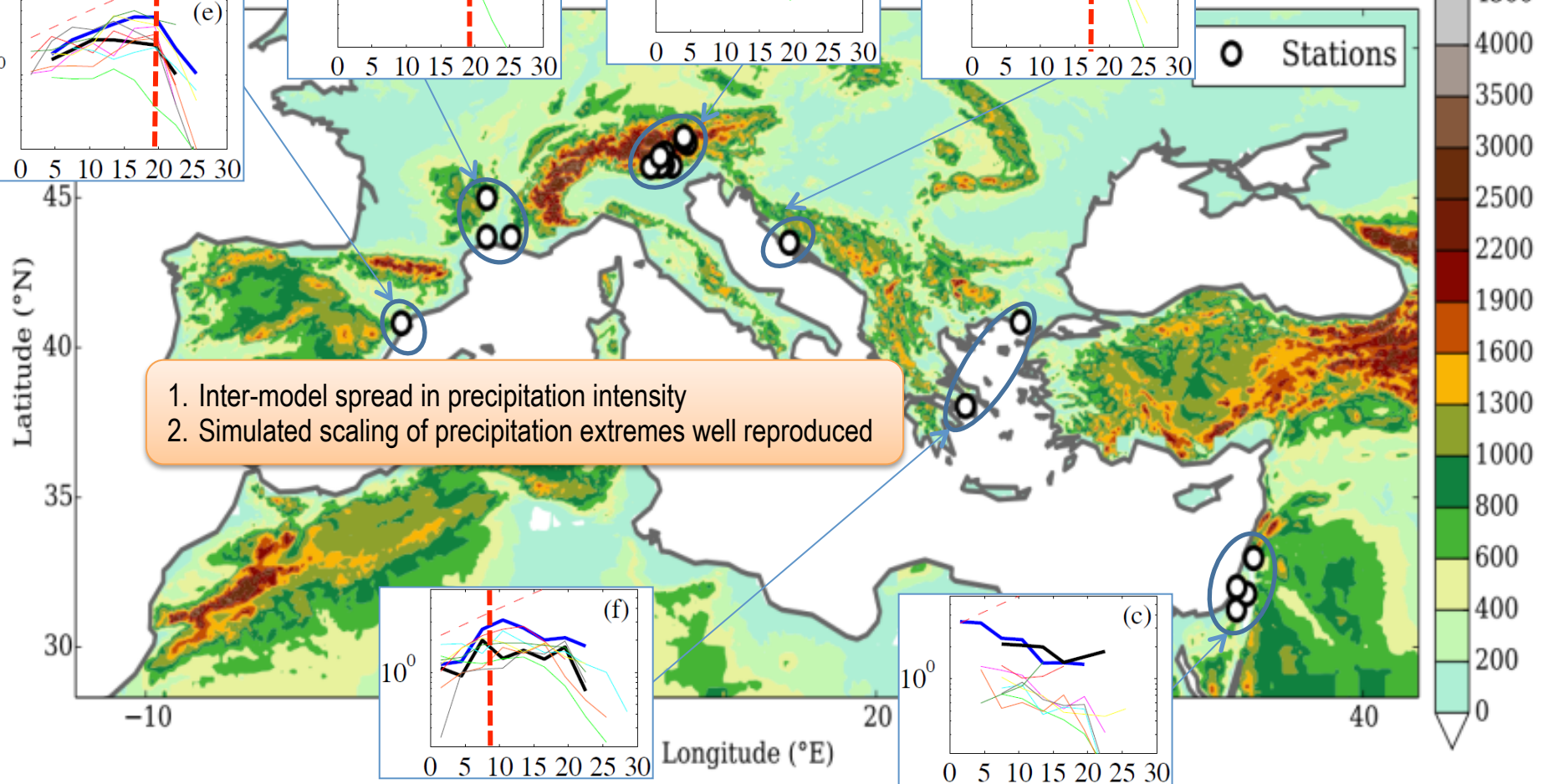
# Scaling of precipitation extremes in present climate

Daily precipitation from observations and RCM

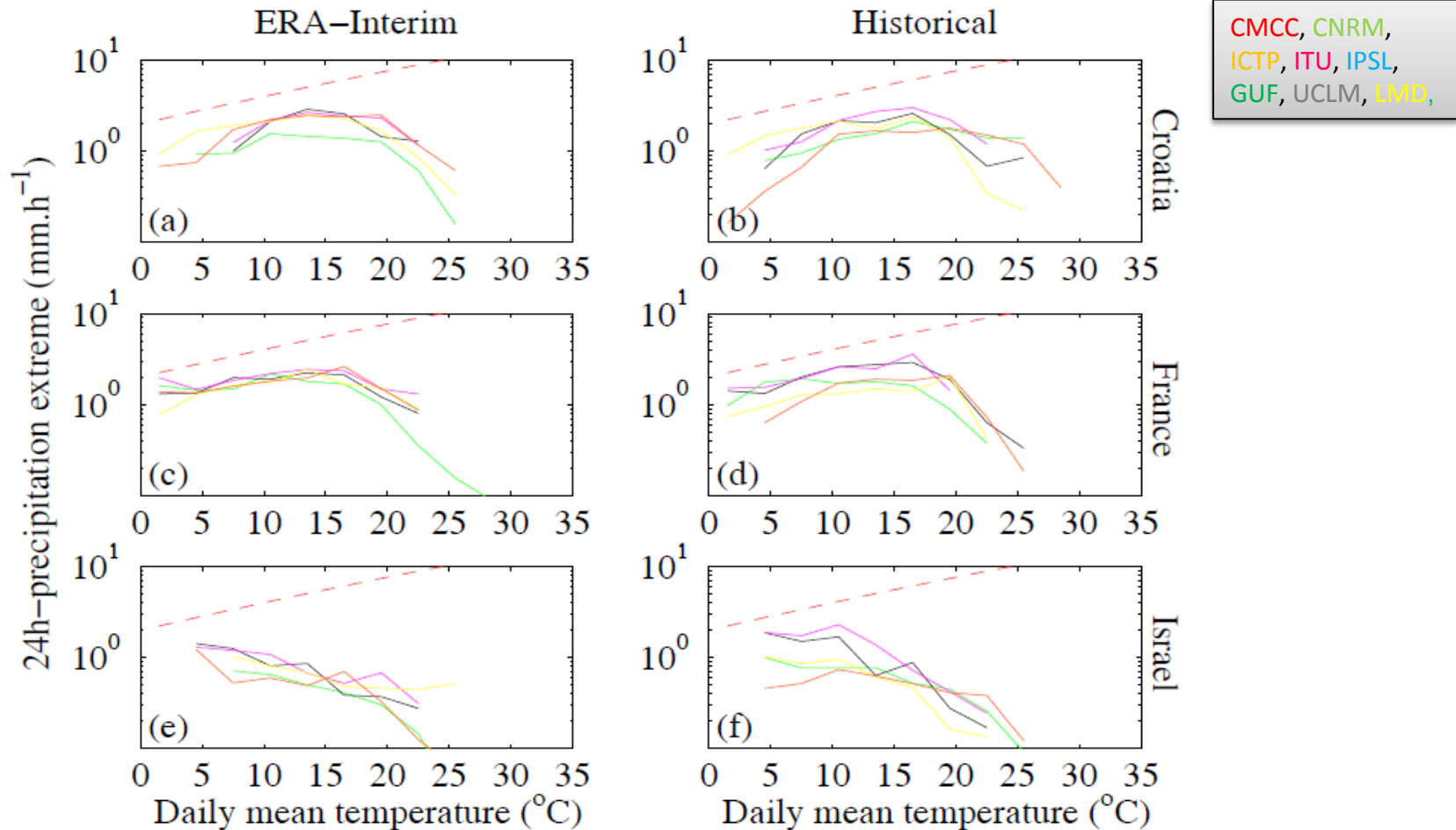
CMCC, CNRM, ICTP, ITU, IPSL, GUF, UCLM, LMD, 1-day in-situ, 1-day E-OBS



1. Inter-model spread in precipitation intensity
2. Simulated scaling of precipitation extremes well reproduced

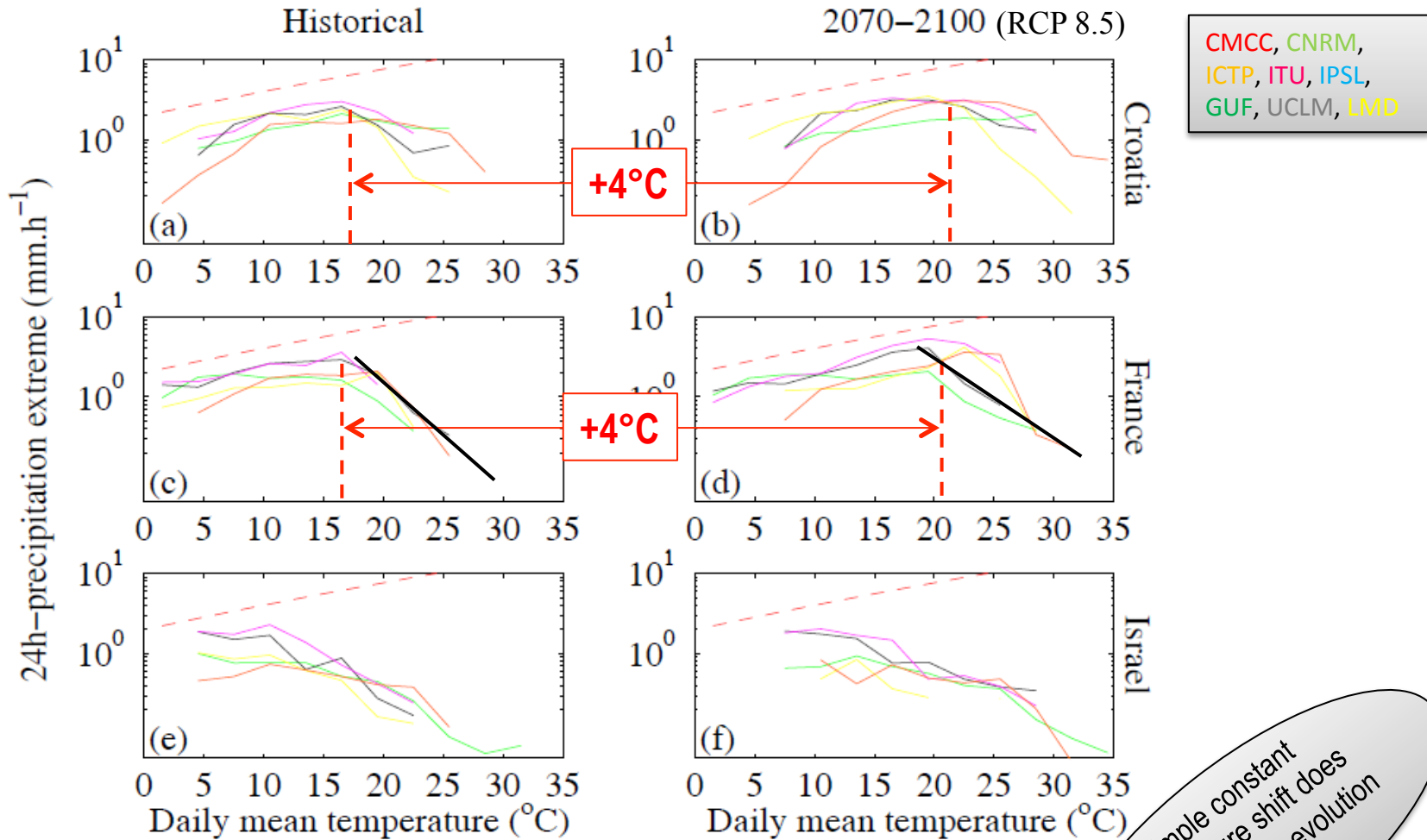


## Scaling of precipitation extremes in future climate



1. Inter-model spread in precipitation extremes intensity similar scaling between ERA-Interim and CMIP5 historical runs
2. Good agreement for precipitation extremes scaling between ERA-Interim and CMIP5 historical runs

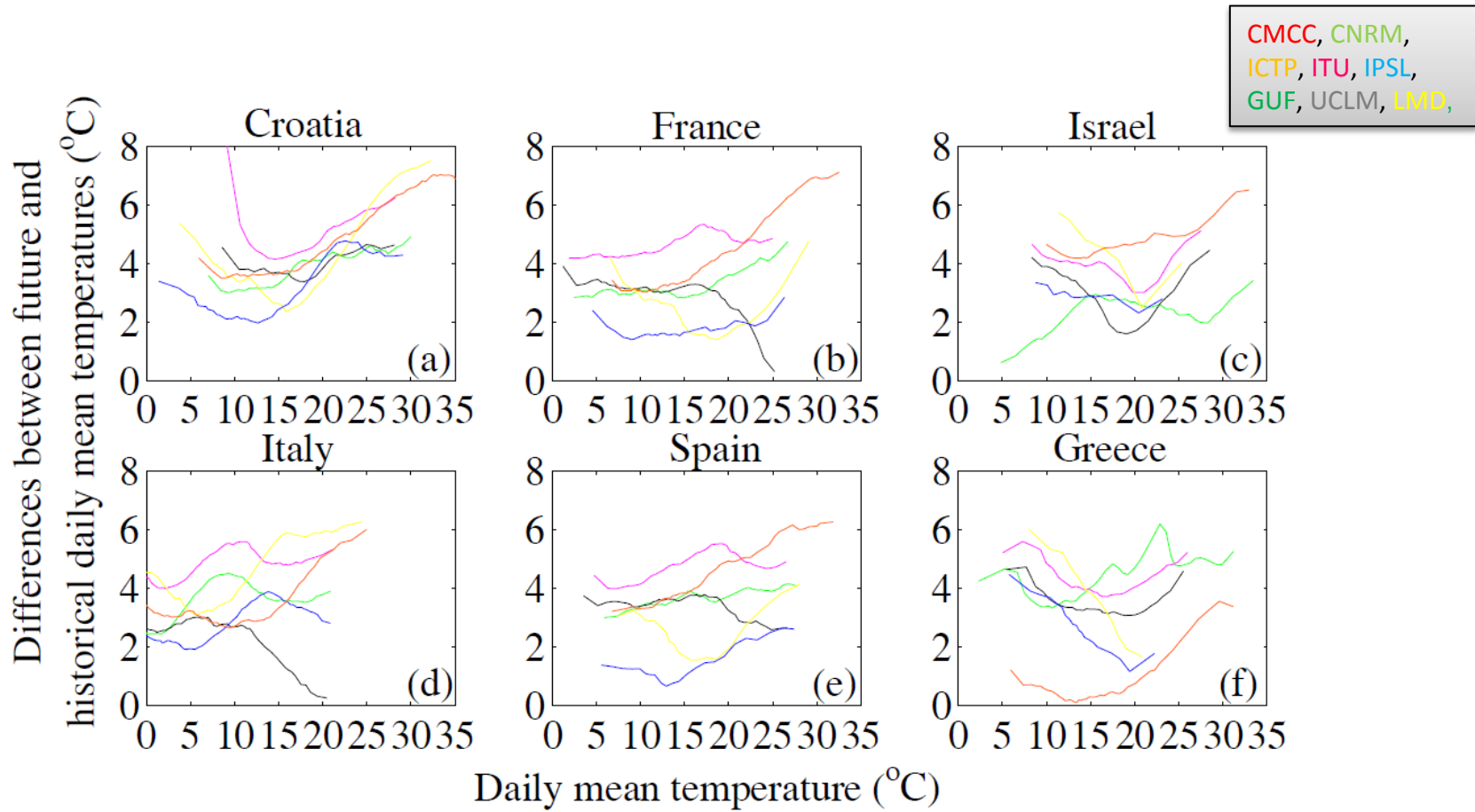
# Scaling of precipitation extremes in future climate



1. Temperature break increases by about 4-5°C (i.e. the average regional warming)
2. Temperature range with CC-scaling increases in future climate
3. Hook less steep, i.e. increased precipitation extremes intensity

Simple constant temperature shift does not explain the evolution of the scaling

# Scaling of precipitation extremes in future climate

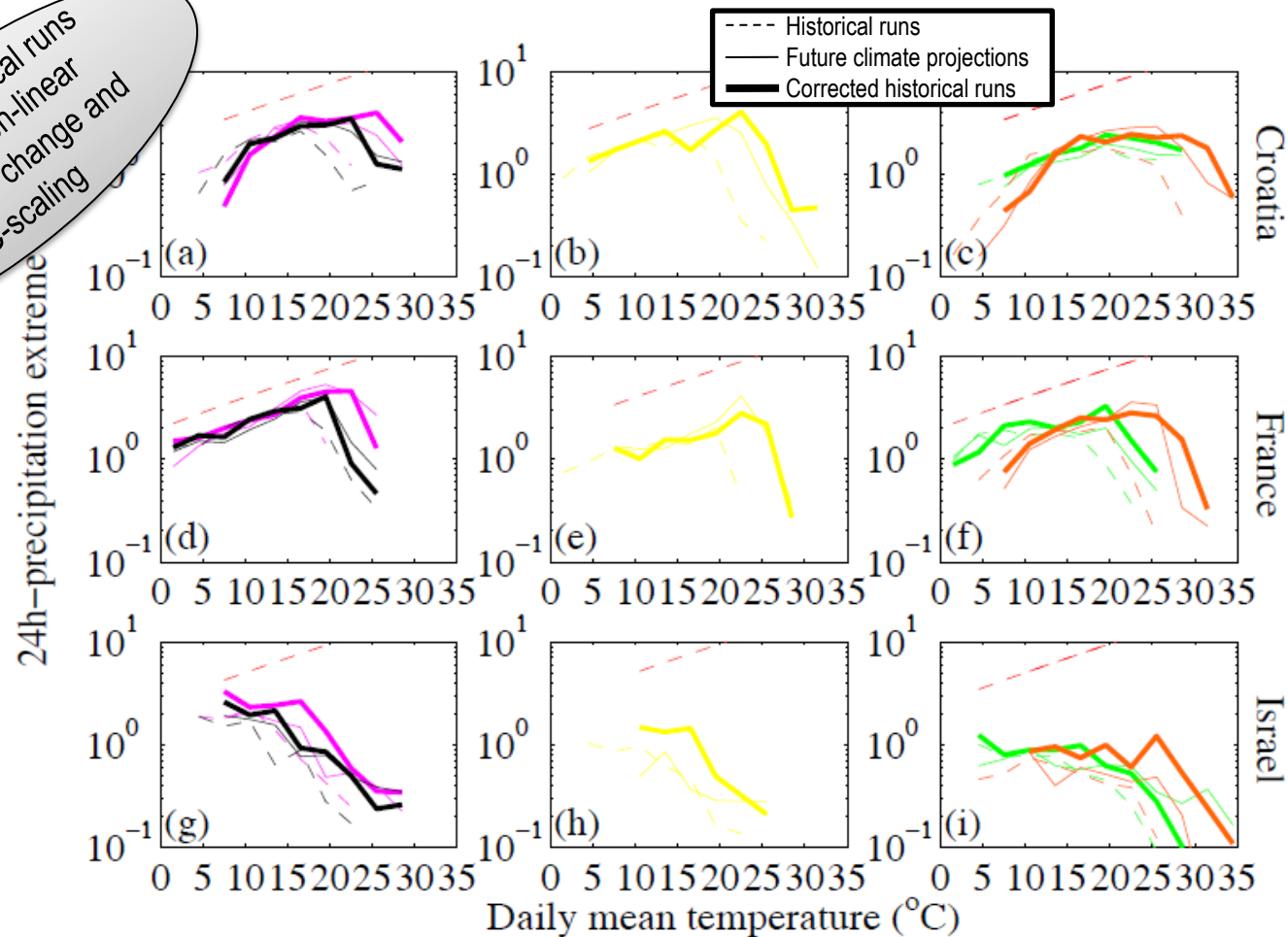


1. Temperature-temperature change relationships characterized by a large spread across models
2. Non-linear scaling between temperature and temperature change
3. Non linear distortion of the temperature scale not enough to explain change in change of precipitation extremes scaling



# Scaling of precipitation extremes in future climate

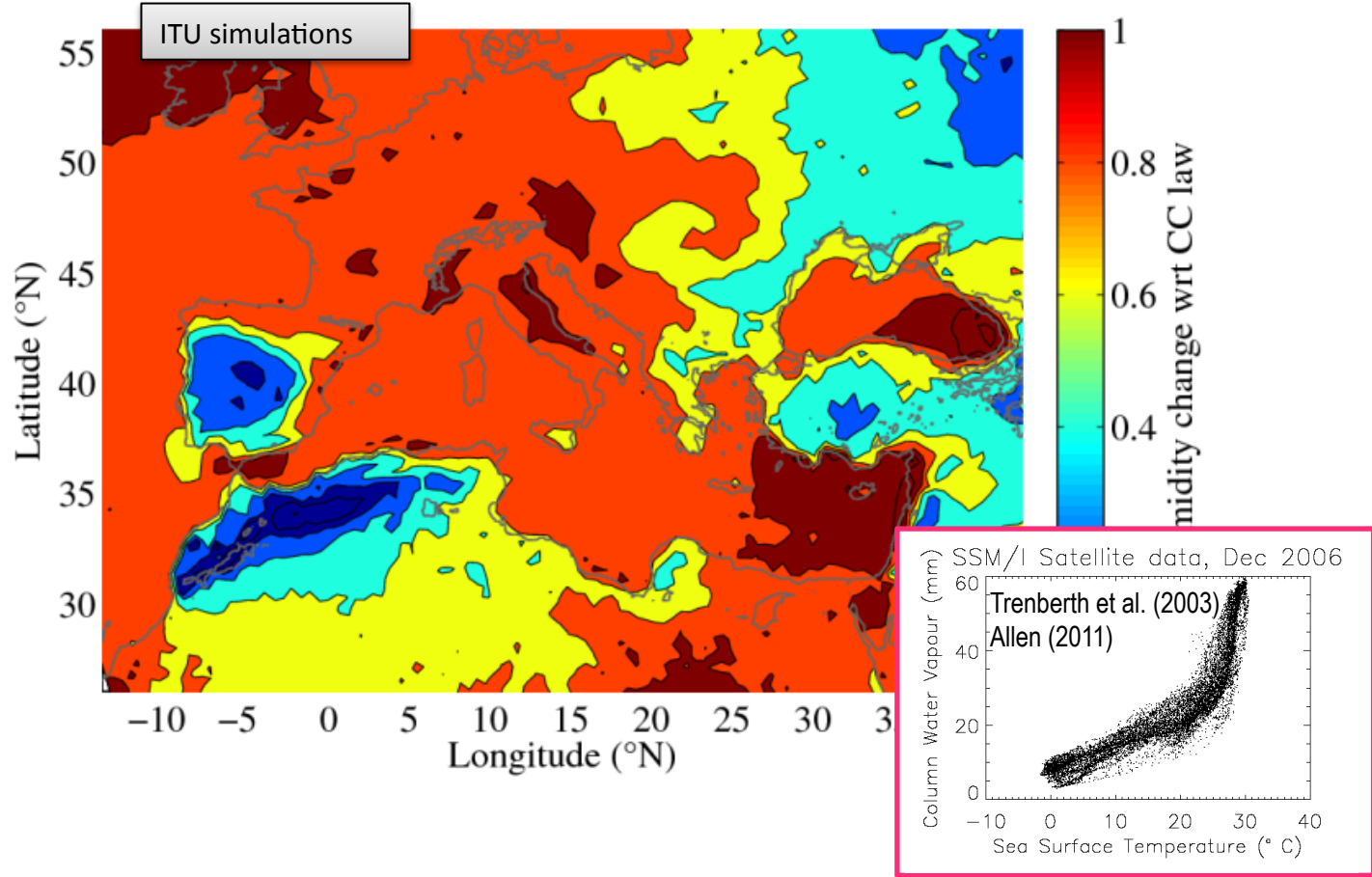
Corrected historical runs assuming non-linear temperature change and CC-scaling



CMCC, CNRM, ICTP, ITU, IPSL, GUF, UCLM, LMD

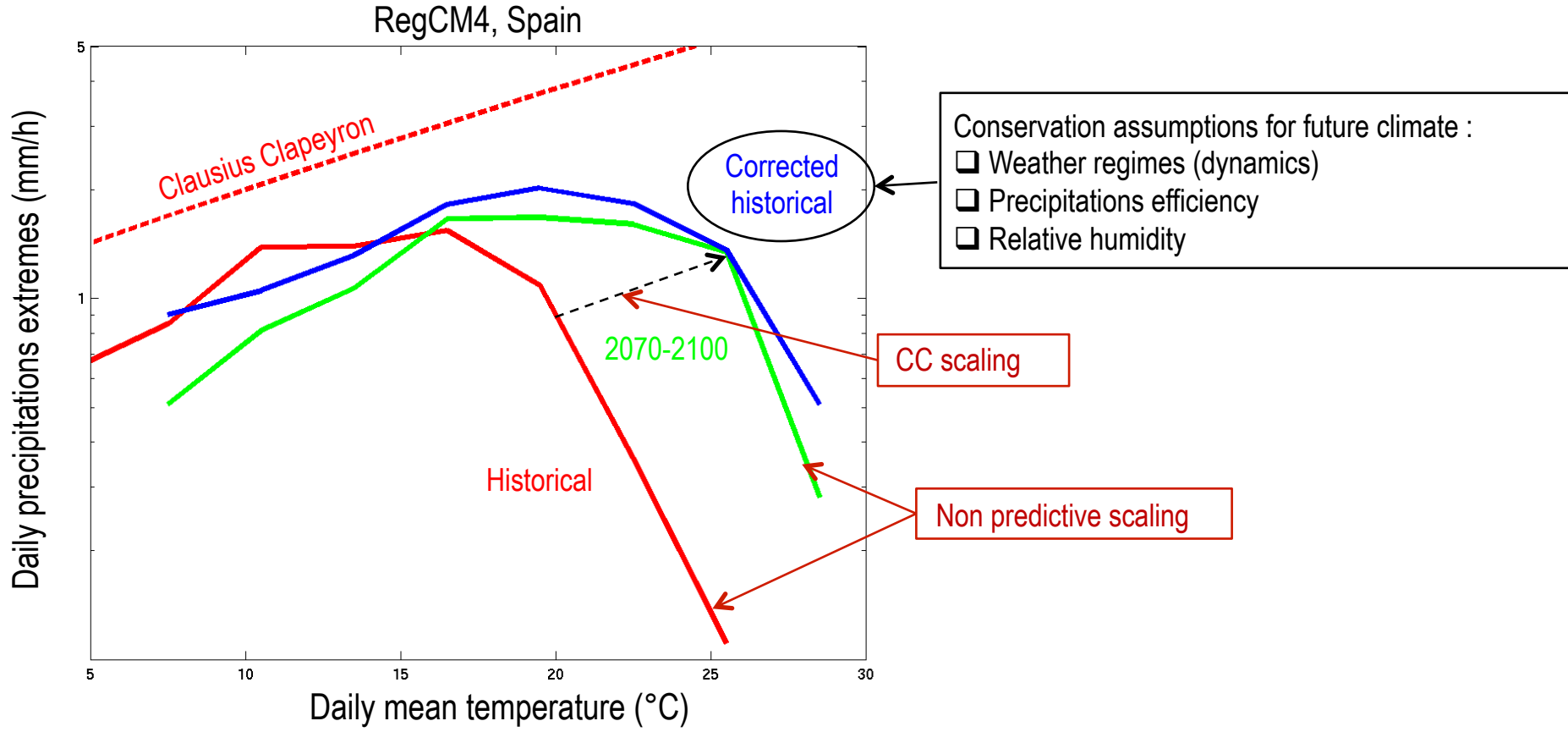
1. Corrected historical runs agree with scaling of precipitation extremes in future climate projections
2. Applying CC-scaling correction using the simulated temperature range assumes conservation of relative humidity
3. Unexpected absence of trend of relative humidity at all Mediterranean sites (warming and drying)

# Scaling of precipitation extremes in future climate



1. Relative humidity decreases in arid regions (continental Europe, north Africa, Arabic Peninsula)
2. Relative humidity remains constant in the regions affected by marine source of humidity from the European Seas
3. Mediterranean Sea, source of moisture which compensates expected relative humidity decrease

# Conclusion



1. The scaling of precipitation extremes in the Mediterranean displays a robust hook shape
2. In a drying and warming region, the « Mediterranean » relative humidity remains constant in a changing climate
3. Increase of Mediterranean precipitation extremes expected to follow CC-scaling, i.e.  $\sim 7\%/^{\circ}\text{C}$
4. Mediterranean Sea, most probably the origin of the increase of precipitation extremes intensity



*With this pessimistic conclusion...*

*... I thank you for your attention... Questions?*

