



# Regional patterns of precipitation extremes on various timescales

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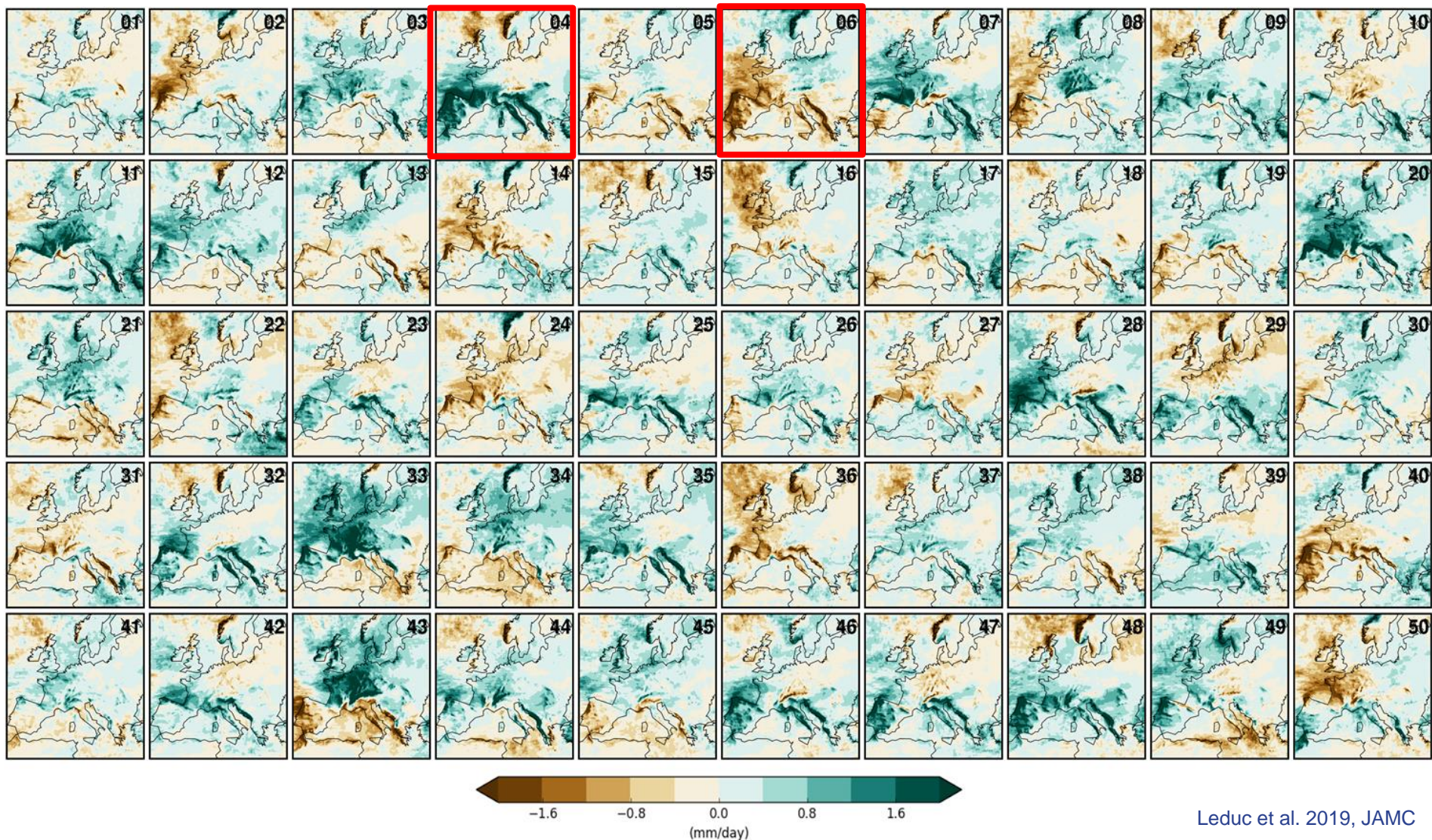
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« **Extreme precipitation events** over most of the mid-latitude land masses and over wet tropical regions will *very likely* become **more intense** and **more frequent**. »  
- IPCC AR5 report

ClimEx results confirm this!

# Internal Variability in a SMILE

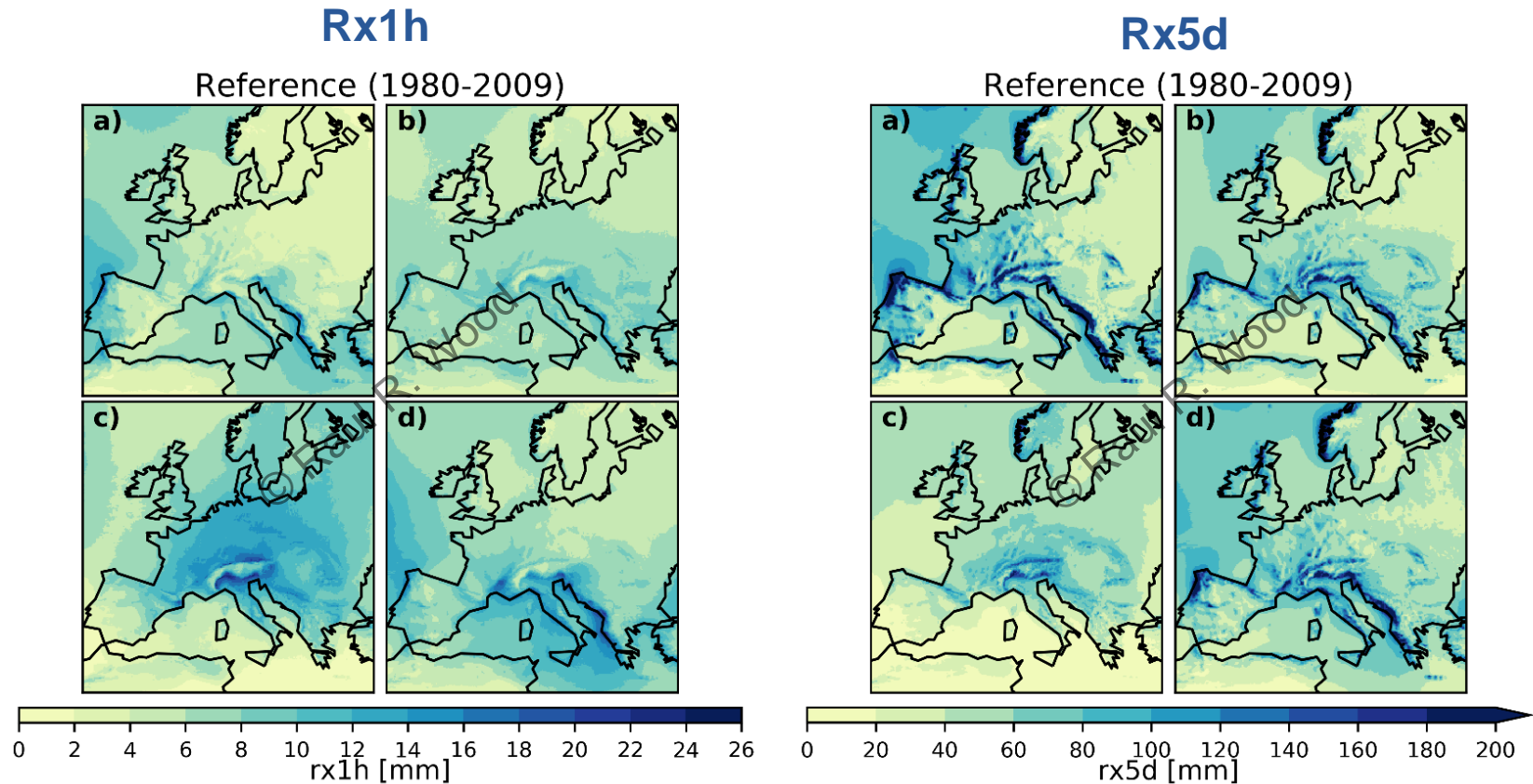


Leduc et al. 2019, JAMC

50 possible future changes for PRC (in %) between 2020-2039 and 2000-2019 over Europe from CanESM2-CRCM5 at a 12-km resolution

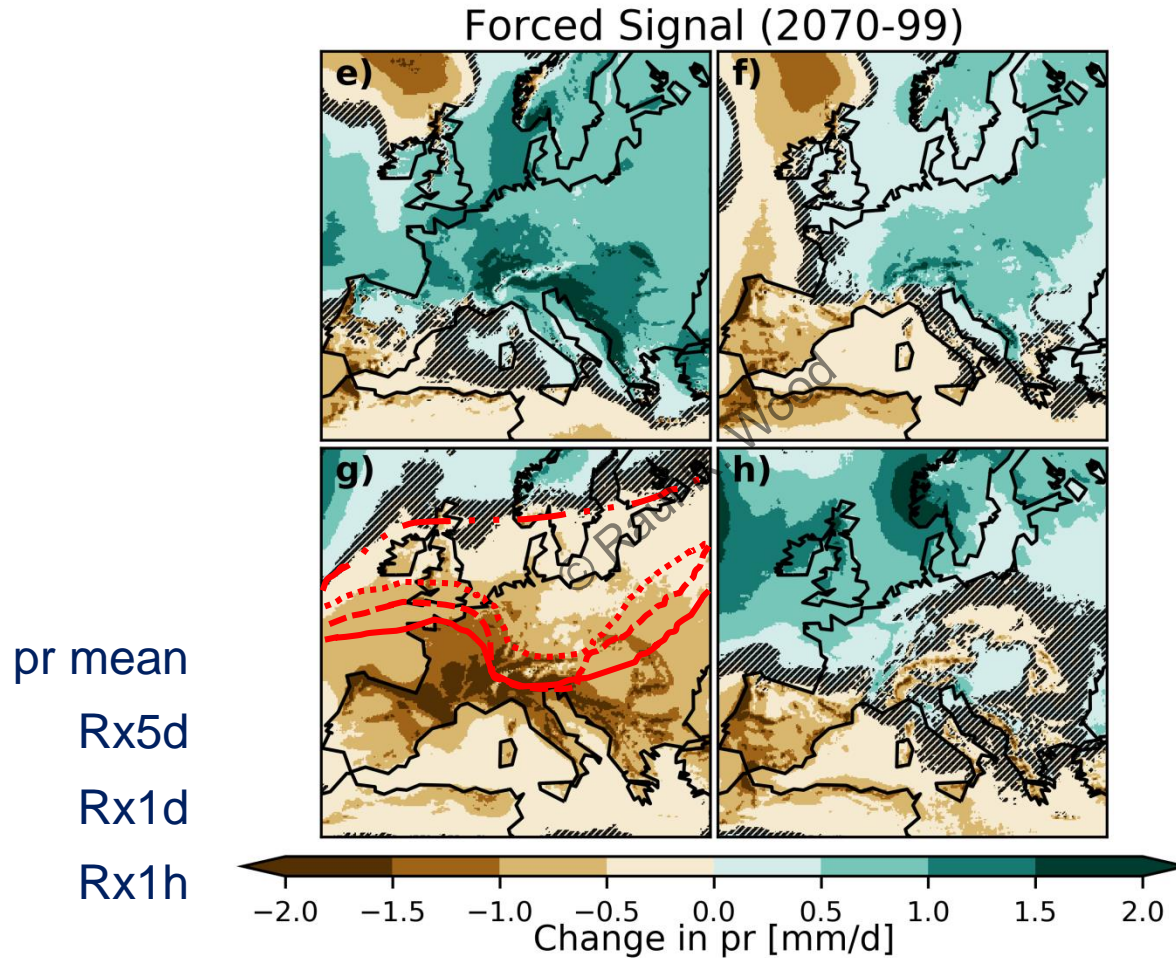
## What precipitation indices are we looking at and on what timescales?

Rx1h (maximum hourly precipitation), Rx1d (maximum daily precipitation), Rx5d (maximum 5 day precipitation) for seasons DJF, MAM, JJA and SON



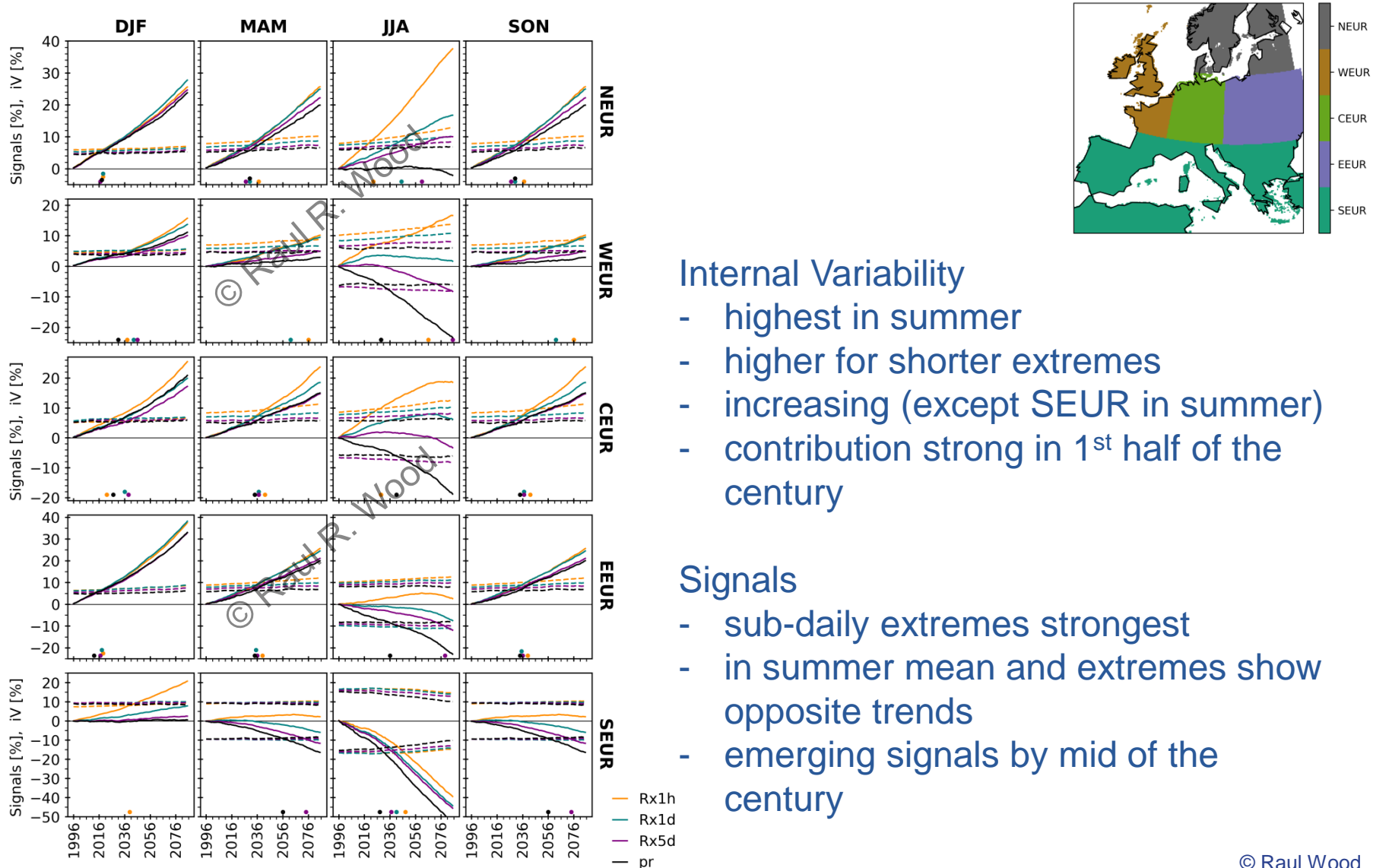
50-Member mean climatology of Rx1h (left) and Rx5d (right) for DJF (a), MAM (b), JJA (c) and SON (d)

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50-Member forced signal of extreme precipitation by 2070-2099 for DJF (e), MMA (f), JJA (g) and SON (h). Hatched areas do not show significant trends following a two-sided t-test with unequal variances and a p-value of 0.01.

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## Internal Variability

- highest in summer
- higher for shorter extremes
- increasing (except SEUR in summer)
- contribution strong in 1<sup>st</sup> half of the century

## Signals

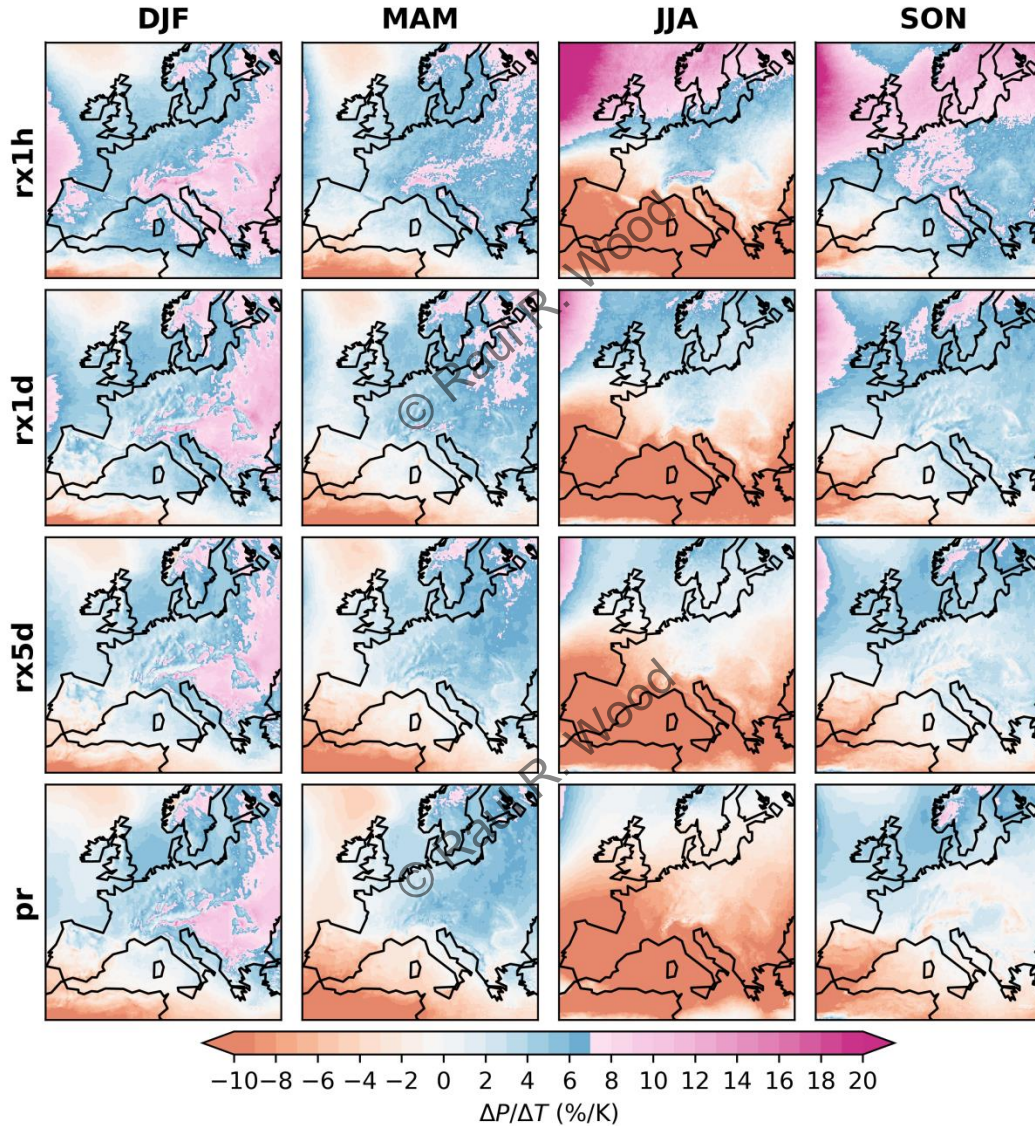
- sub-daily extremes strongest
- in summer mean and extremes show opposite trends
- emerging signals by mid of the century

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# Scaling with global mean temperature

Can changes in  
The Clausius-Clap

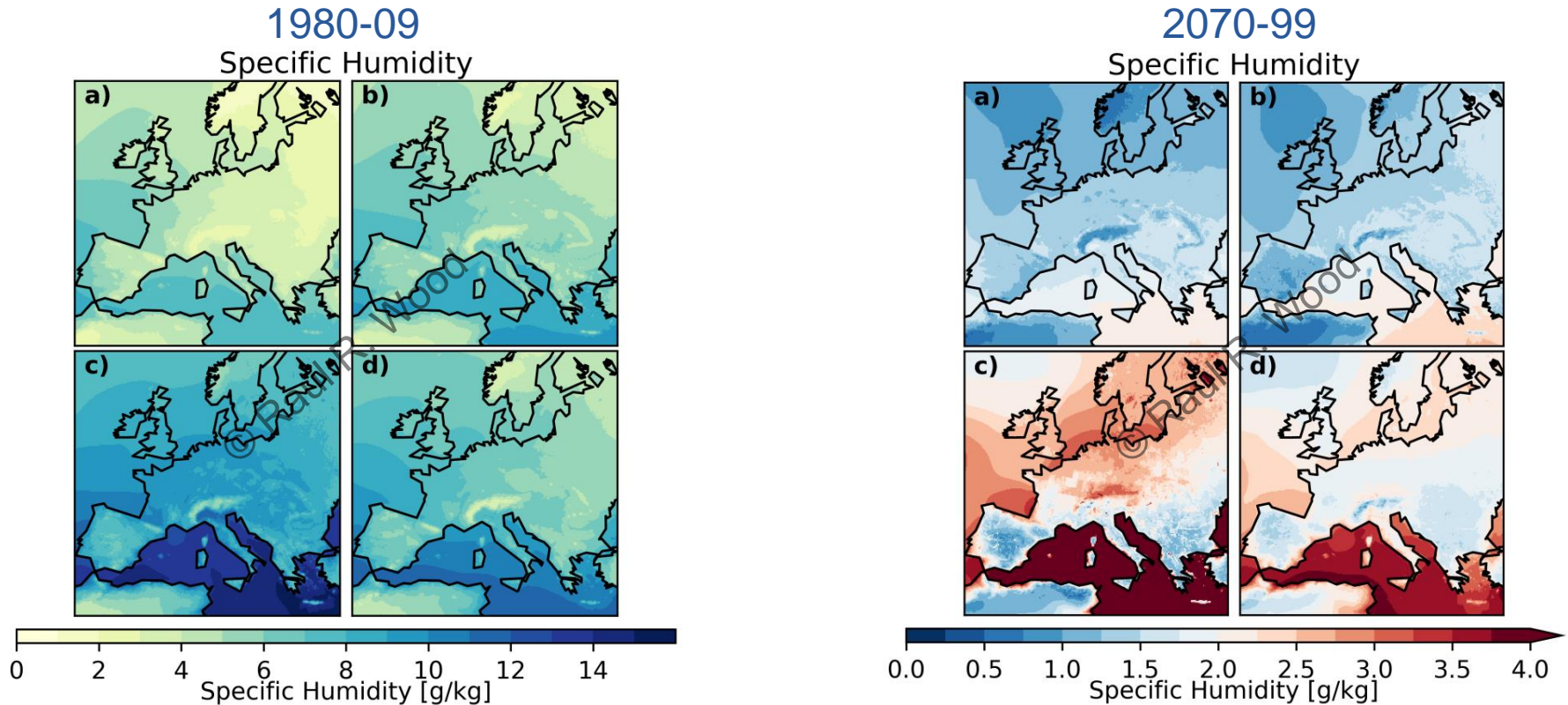
namics?



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# Changes in specific humidity (huss)

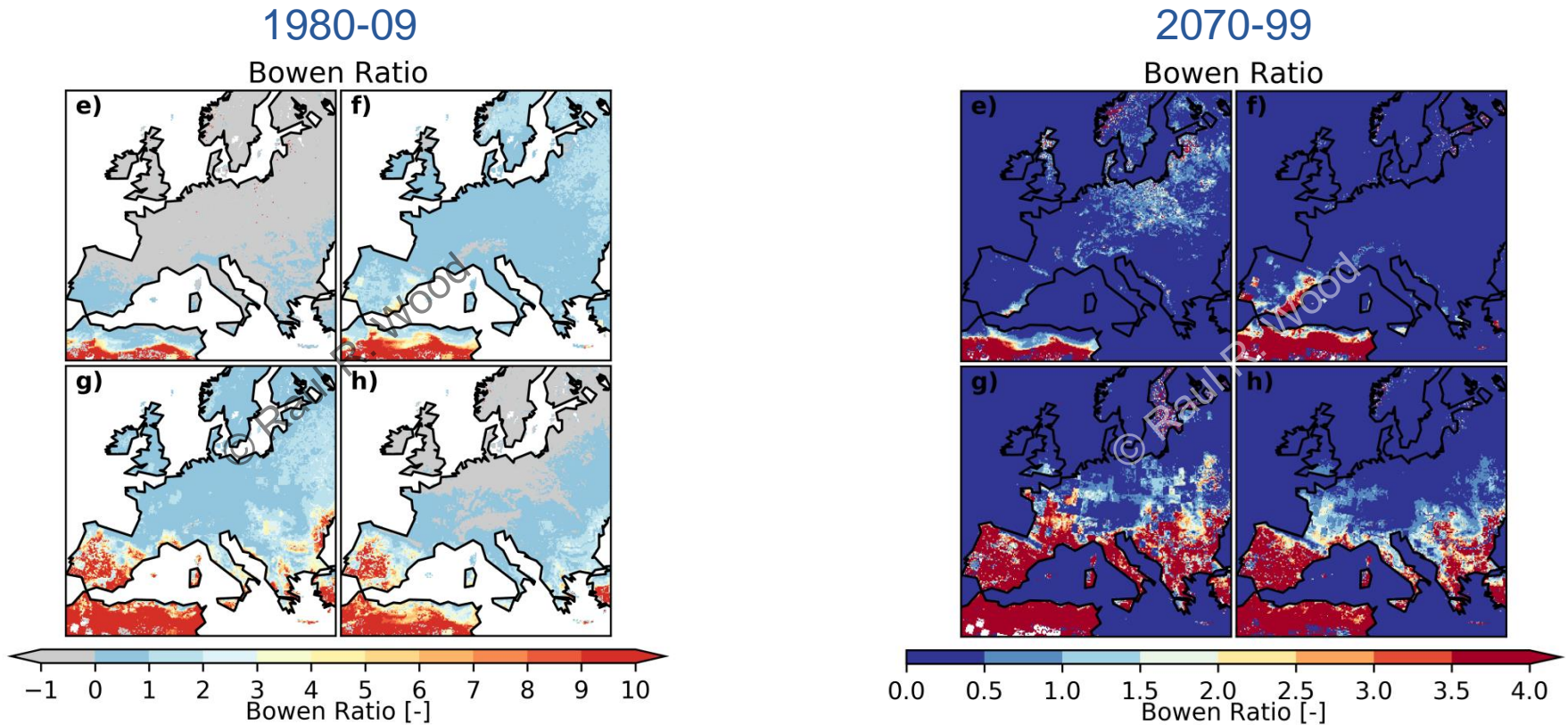
Global warming is intensifying the global water cycle resulting in air columns holding more water.



50-Member mean climatology of specific humidity near surface (left) and forced signal (right) for DJF (a), MMA (b), JJA (c) and SON (d). All areas show significant trends following a two-sided t-test with unequal variances and a p-value of 0.01.

# Changes in the Bowen ratio (bo)

From warming temperatures and declining summerly rainfall we can expect and increased sensible heat flux resulting in increased aridity and reduced evaporation.

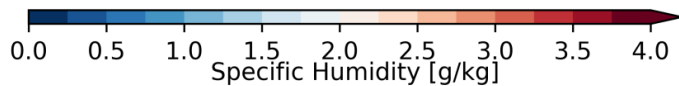
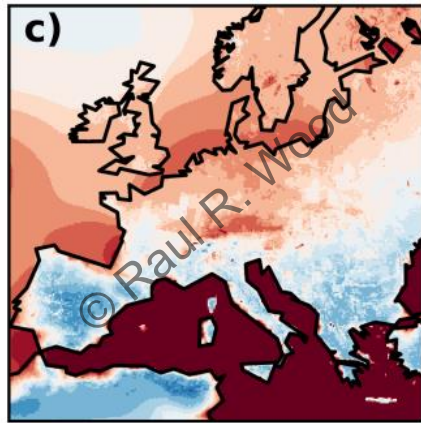


50-Member mean Bowen ratio for 1980-09 (left) and forced signal (right) for DJF (e), MMA (f), JJA (g) and SON (h). The Bowen ratio is calculated as the ratio of sensible heat flux ( $hf_{ss}$ ) and latent heat flux ( $hf_{ls}$ ). The Bowen ratio is less than one over surfaces with abundant water supplies. Negative Bowen ratio means a downward direction indicating advection.

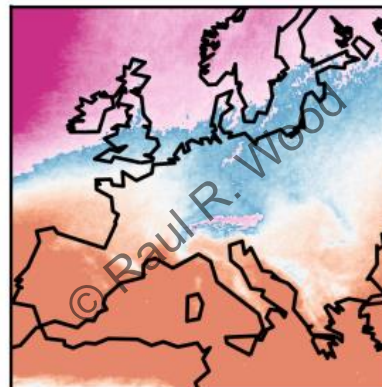
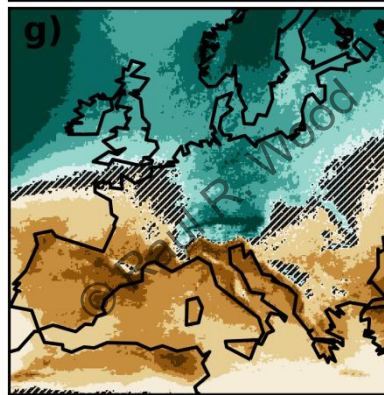
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## Can changes in maximum precipitation be explained by thermodynamics?

$\Delta$  specific humidity

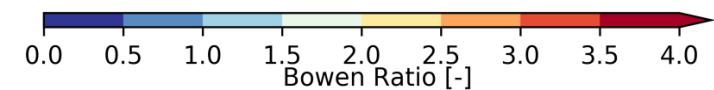
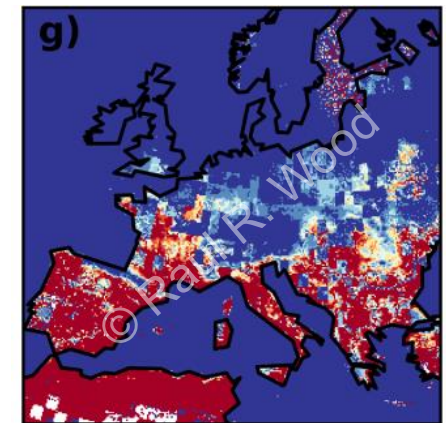


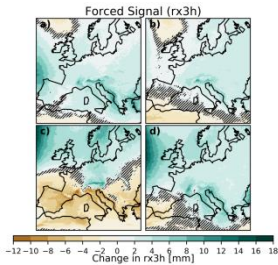
$\Delta$  rx1h



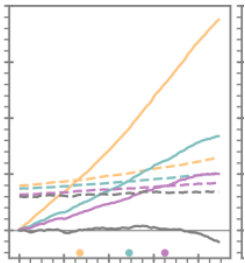
rx1h scaling

$\Delta$  Bowen Ratio

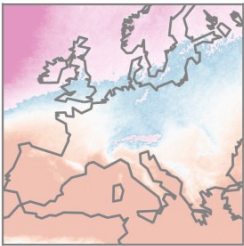




- SMILE simulations are needed to determine the ‘true’ forced response
- Northward shifting negative trends in summerly extremes



- Internal variability is important in 1<sup>st</sup> half of the century
- Increasing internal variability
- Emerging trends of extremes by mid of the century



- Hourly maximum precipitation shows stronger scaling with global temperature
- In higher latitudes thermodynamics contribute to changes in maximum precipitation
- Other regions are stronger influenced by dynamic changes