Regional patterns of precipitation extremes on various timescales

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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

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

Leduc et al. 2019, JAMC
Maximum Precipitation in the CRCM5-LE

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

Rx1h

Reference (1980-2009)

Rx5d

Reference (1980-2009)

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

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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Evolution of RxN and internal variability

Internal Variability
- highest in summer
- higher for shorter extremes
- increasing (except SEUR in summer)
- contribution strong in 1st half of the century

Signals
- sub-daily extremes strongest
- in summer mean and extremes show opposite trends
- emerging signals by mid of the century
Can changes in maximum precipitation be explained by thermodynamics?

The Clausius-Clapeyron relation states an increase of precipitation by 6-7%/K.
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.

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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 ($h_{fss}$) and latent heat flux ($h_{fls}$). The Bowen ratio is less than one over surfaces with abundant water supplies. Negative Bowen ratio means a downward direction indicating advection.
Synthesis

Can changes in maximum precipitation be explained by thermodynamics?

Δ specific humidity

Δ Bowden Ratio

Δ rx1h

rx1h scaling
Take-Home

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

- Internal variability is important in 1st 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