Storm-type specific scaling of sub-daily precipitation with temperature over the North Atlantic and Europe

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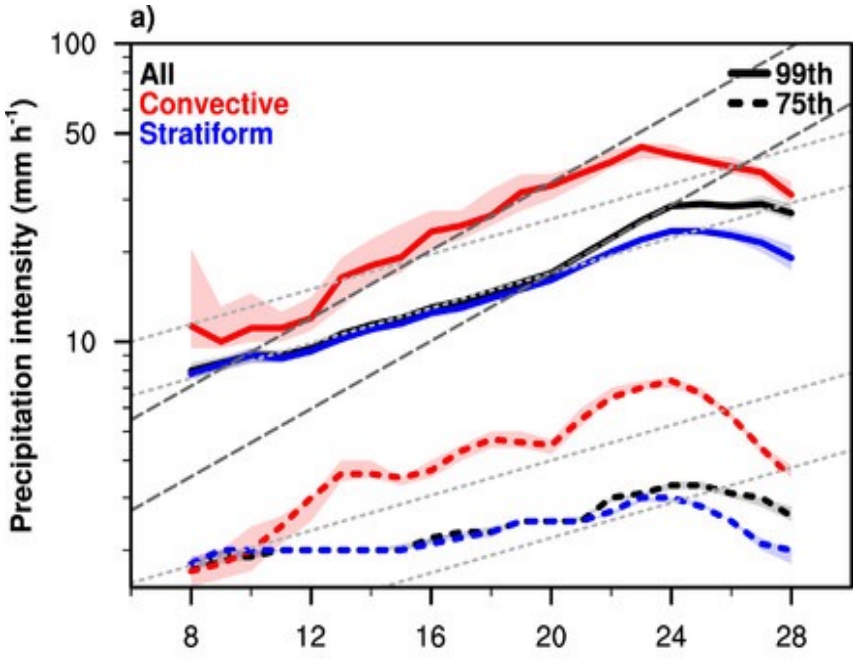
NERC STORMY-WEATHER project

Extreme precipitation scaling with temperature depends on precipitation type

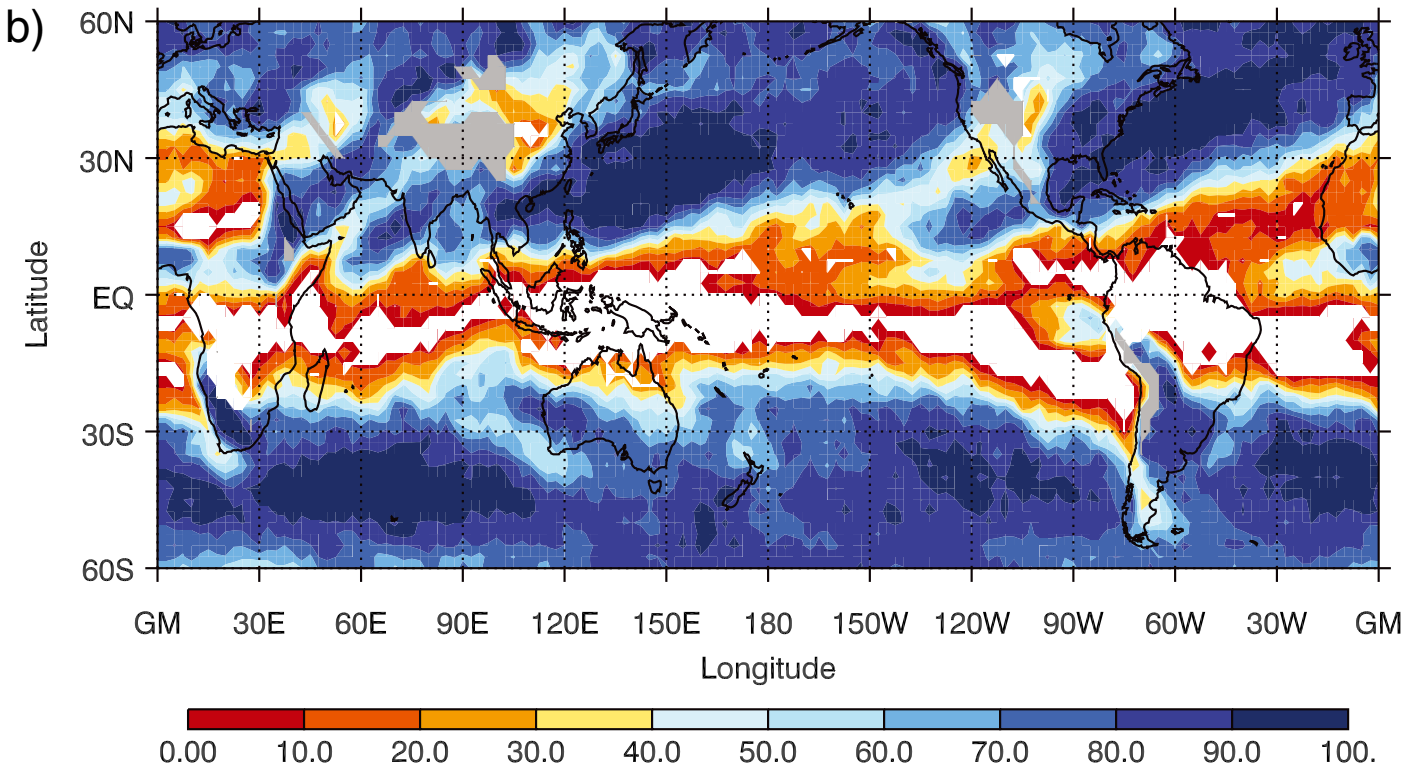


From Park and Min 2017

- Clausius Clapeyron (CC) relation shows how the saturation vapour pressure increases with temperature at a rate of ~7%/K.
- 99th percentile precipitation scales at ~ CC rate when the precipitation is stratiform
- Scaling is much higher when precipitation is convective.

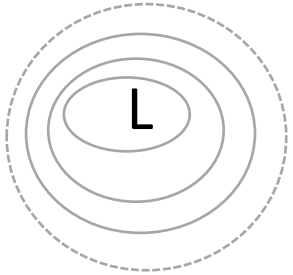
Frequency of weather systems and their importance to extreme precipitation vary regionally

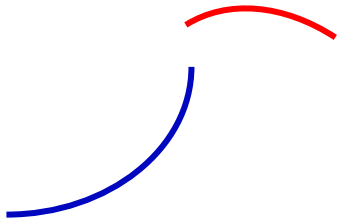
The proportion of 99th percentile extreme precipitation events associated with fronts.

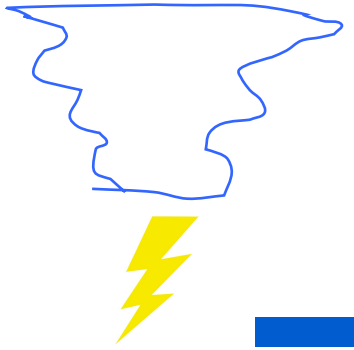


From Catto and Pfahl (2013).

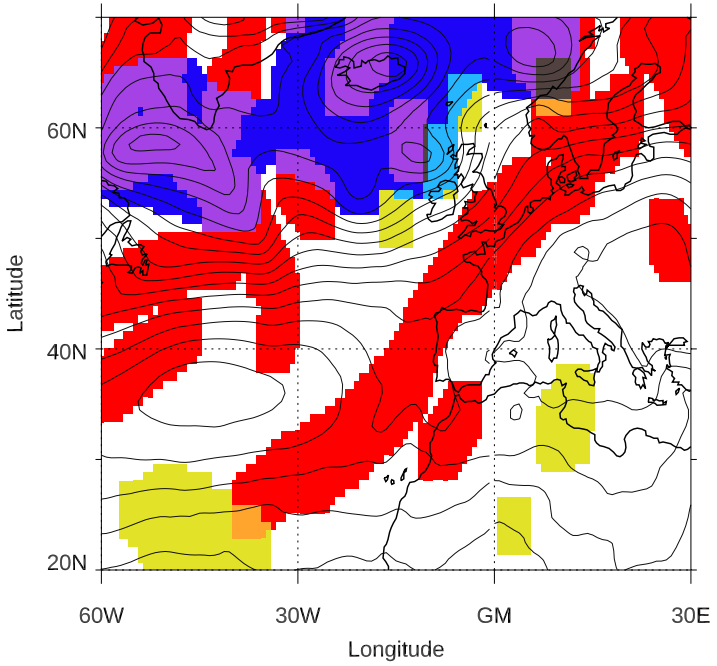
Does the extreme precipitation scaling with temperature depend on the storm type?

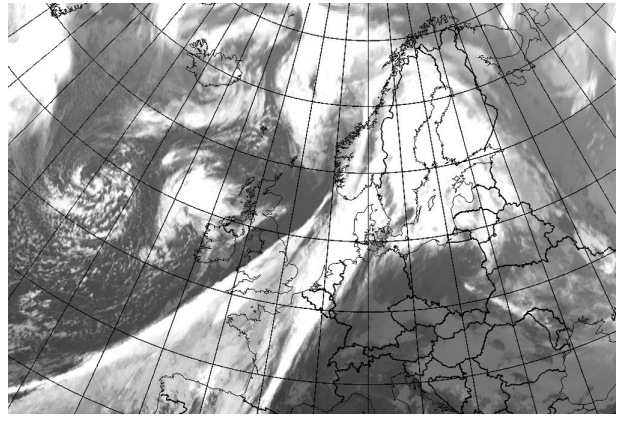






- Cyclones
  - Identified using closed contours of MSLP (following Schwierz and Wernli)
- Fronts
  - Based on Berry et al 2011/Hewson 1998 Thermal front parameter method.
  - Now can be used on higher resolution datasets.
  - Built in R and soon available to share.
- Thunderstorm proxy:
  - Combine convective available potential energy (CAPE) and bulk wind shear from 0–6 km (S06) - Dowdy 2020. Trained on the WWLLN dataset.
- These three systems combined to give 7 weather system types from ERA5.

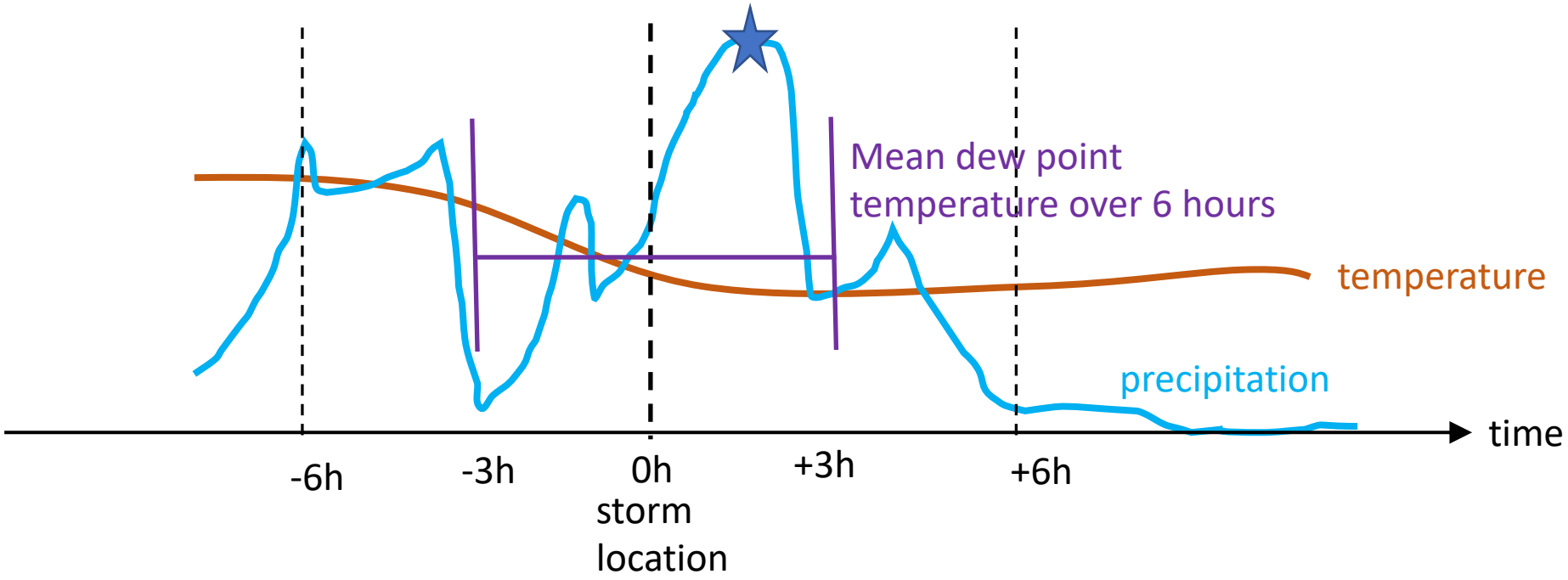




Storm combinations

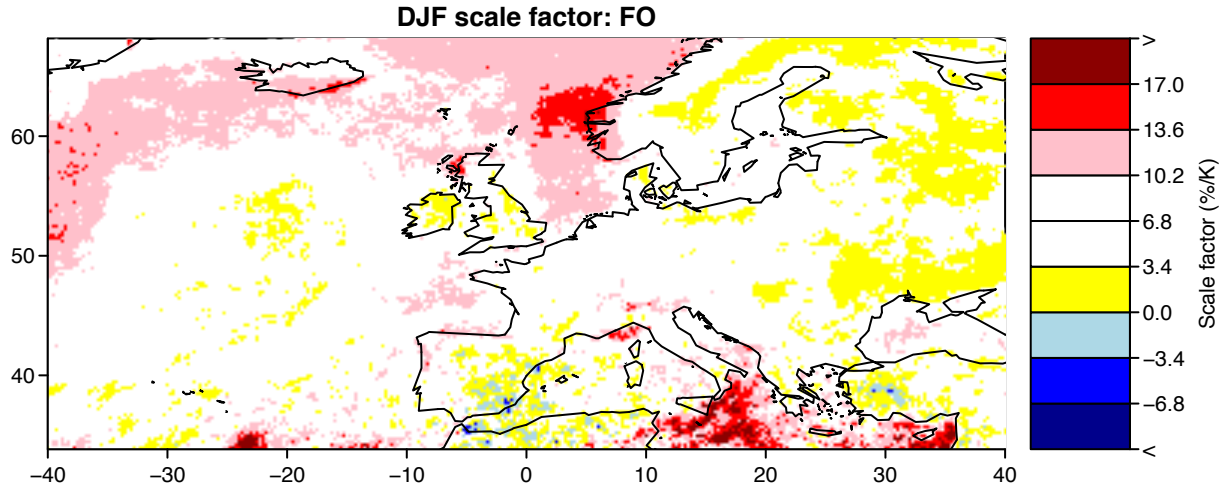
Cyclone Only (CO)	Front Only (FO)	Thunderstorm Only (TO)	Cyclone & Front (CF)	Cyclone & Thunderstorm (CT)	Front & Thunderstorm (FT)	Cyclone, Front & Thunderstorm (CFT)

A quantile regression model is used to estimate scaling of 99th percentile precipitation with dew point temperature



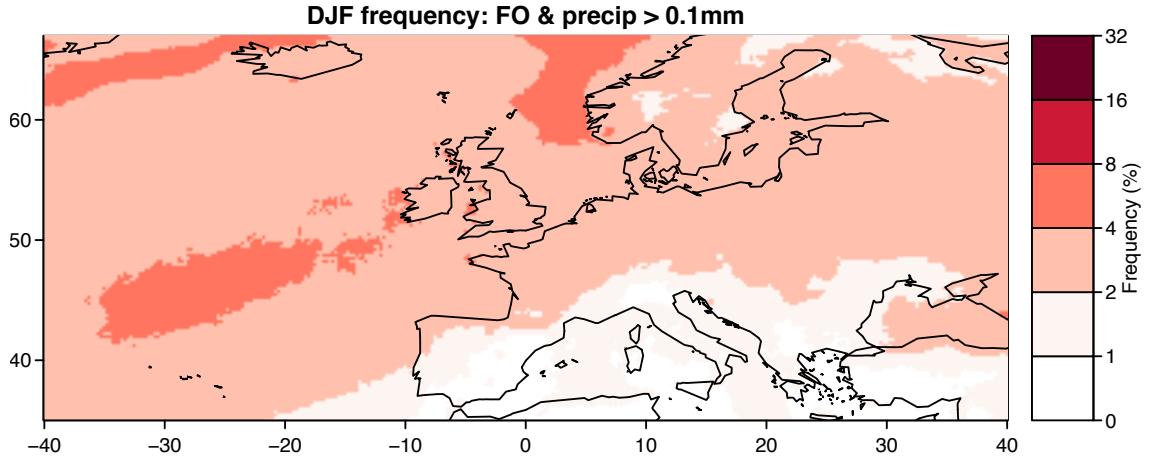
- Estimate scaling of 99th percentile of maximum 1-h precipitation within 6 hours from ERA5 with dew point temperature
- Perform quantile regression for each storm type simultaneously.
- Using DJF 1979-2020.

Scaling of precipitation extremes varies regionally and reveals land/sea contrasts



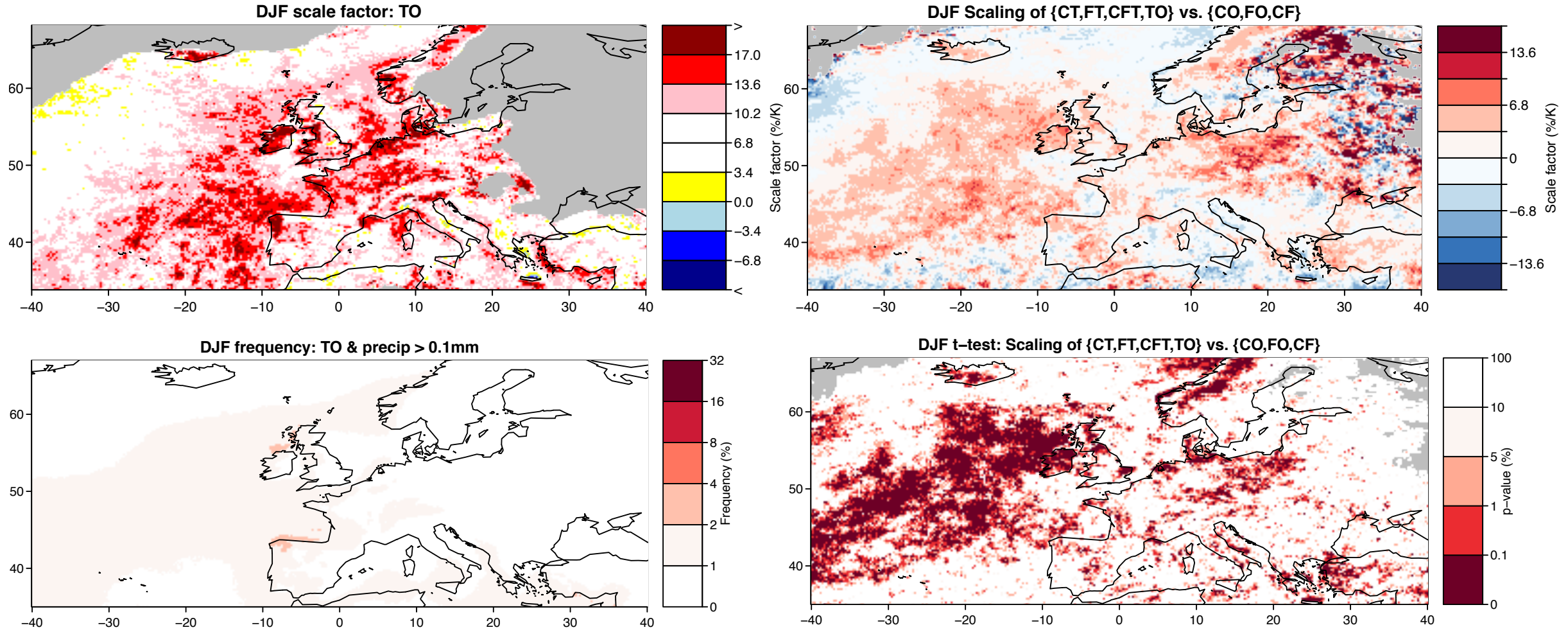
Pink and red show where the scaling is above 10.2%/K.

Yellow where it is below 3.4%/K.



Relatively high frequency of the front-only weather type over the North Atlantic and northwest Europe.

Thunderstorm extreme precipitation events scale at higher rate than others



Storm type is an important consideration in extreme precipitation scaling and impacts

- By using objective identification of a number of storm types we have shown that the scaling with dew point temperature of extreme precipitation depends on the storm type associated with the precipitation events.
- Need to further understand some of the patterns and differences.
- Next steps:
  - Compare with the IMERG data
  - Consider footprints of precipitation and the total volume associated with different storm types
  - Consider future changes in the storms versus the precipitation scaling for the changes in precipitation extremes in future climates

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