STORMY-WEATHER: past and future hazards from a weather system perspective

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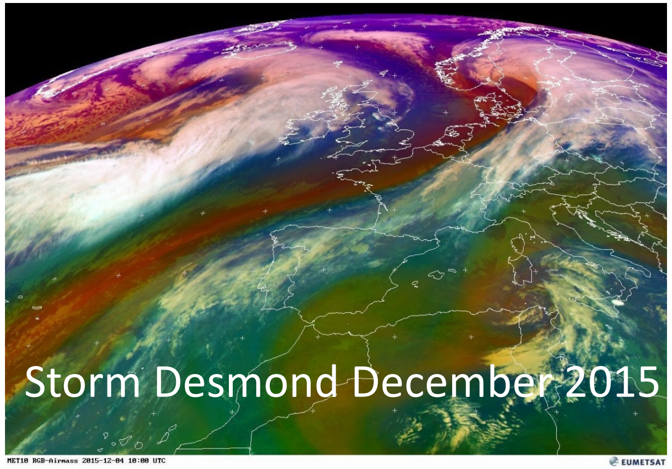
STORMY-WEATHER Objectives

1. To characterise the precipitation and wind associated with different storm types over the UK (i.e. cyclones, fronts, embedded deep convection).
2. To develop event-based metrics based on their precipitation and wind footprints and understand their combined hazard.
3. To investigate the relationship between regional and global temperature change and these event-based footprints for different storm types, identifying plausible future storm hazards from ensembles of state-of-the-art climate simulations.
4. To produce storylines of plausible footprints of storm hazards for use by stakeholders in impacts models.



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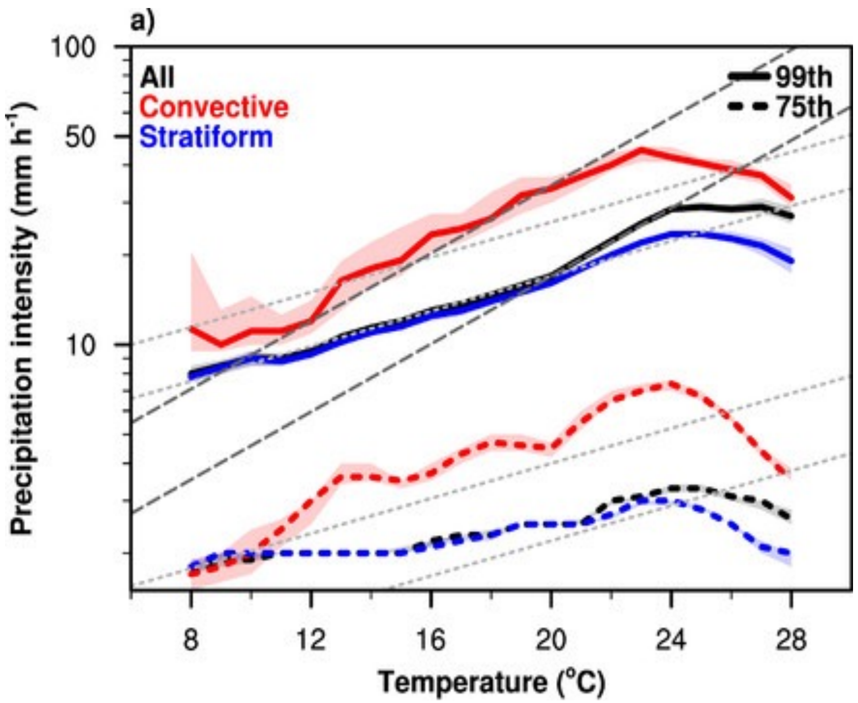
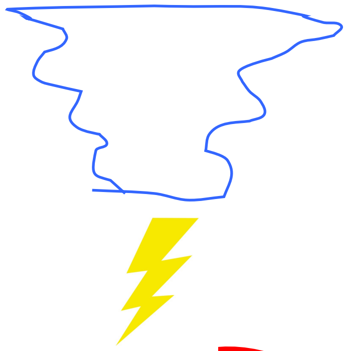
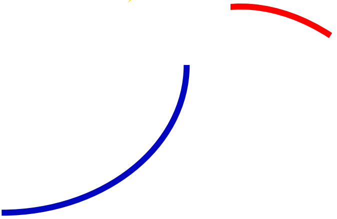


From Park and Min 2017

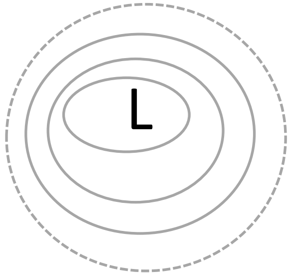
Identification of weather systems



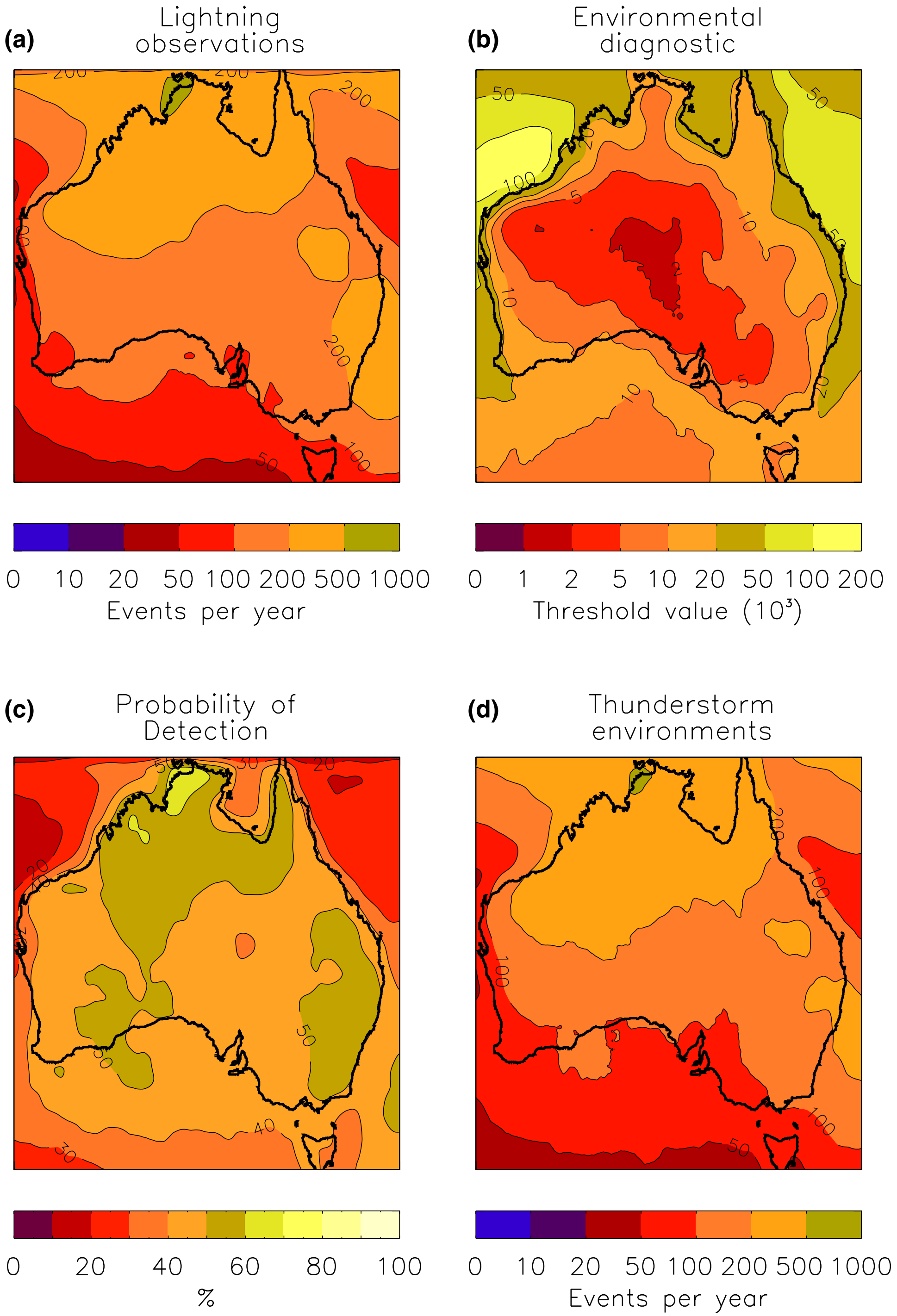
- Thunderstorm proxy:
  - combination of convective available potential energy (CAPE) and bulk wind shear from 0–6 km (S06) - Dowdy 2020. Trained on the World Wide Lightning Location Network dataset.



- New and improved front identification
  - 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.

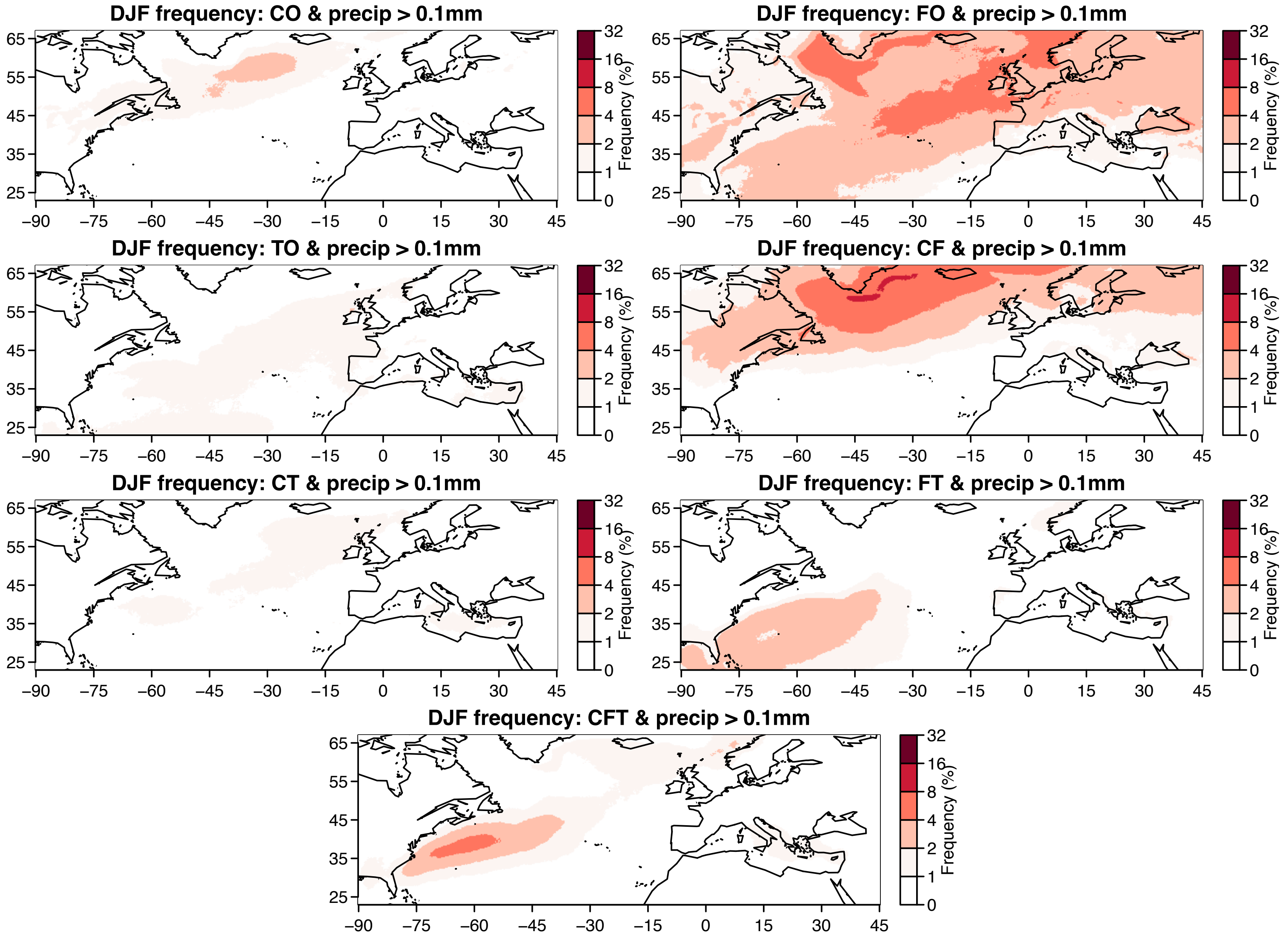


- Updates to cyclone identification to make it more portable.



Dowdy, A. J., Climatology of thunderstorms, convective rainfall and dry lightning environments in Australia, Climate Dynamics, 54 (5-6), 3041-3052, doi:11910.1007/s00382-020-05167-9, 2020.

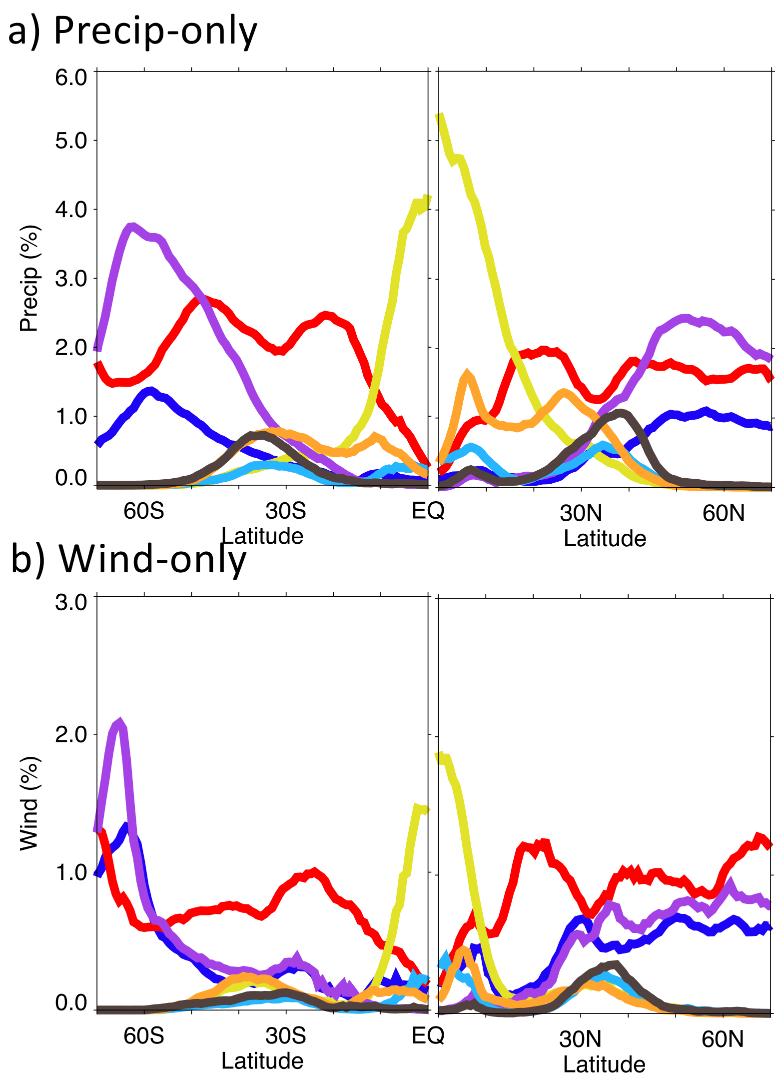
Frequency of the storm types

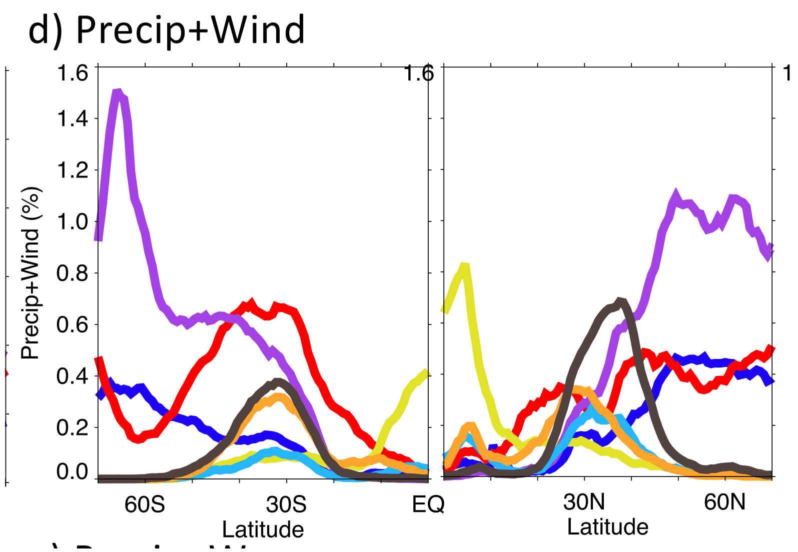


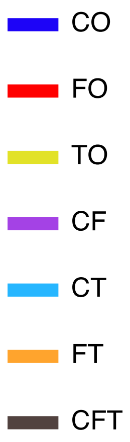
CO = cyclone only
FO = front only
TO = thunderstorm only
CF = cyclone + front
CT = cyclone + thunderstorm
FT = front + thunderstorm
CFT = cyclone + front + thunderstorm

Frequency of storm types from ERA5 data.

Importance of weather systems for hazards - winter



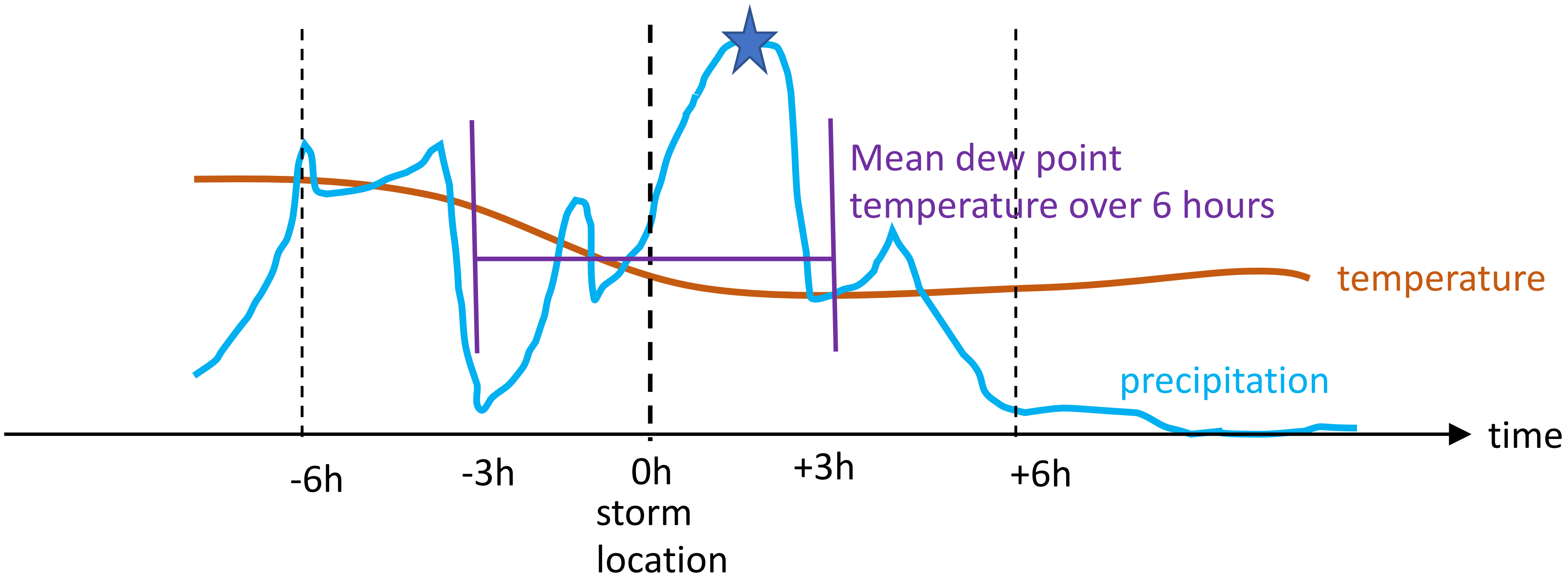




- Using previous versions of the weather system identification:
- Different regions show different weather systems are more important for extremes of precipitation, wind, and combined precipitation and wind.

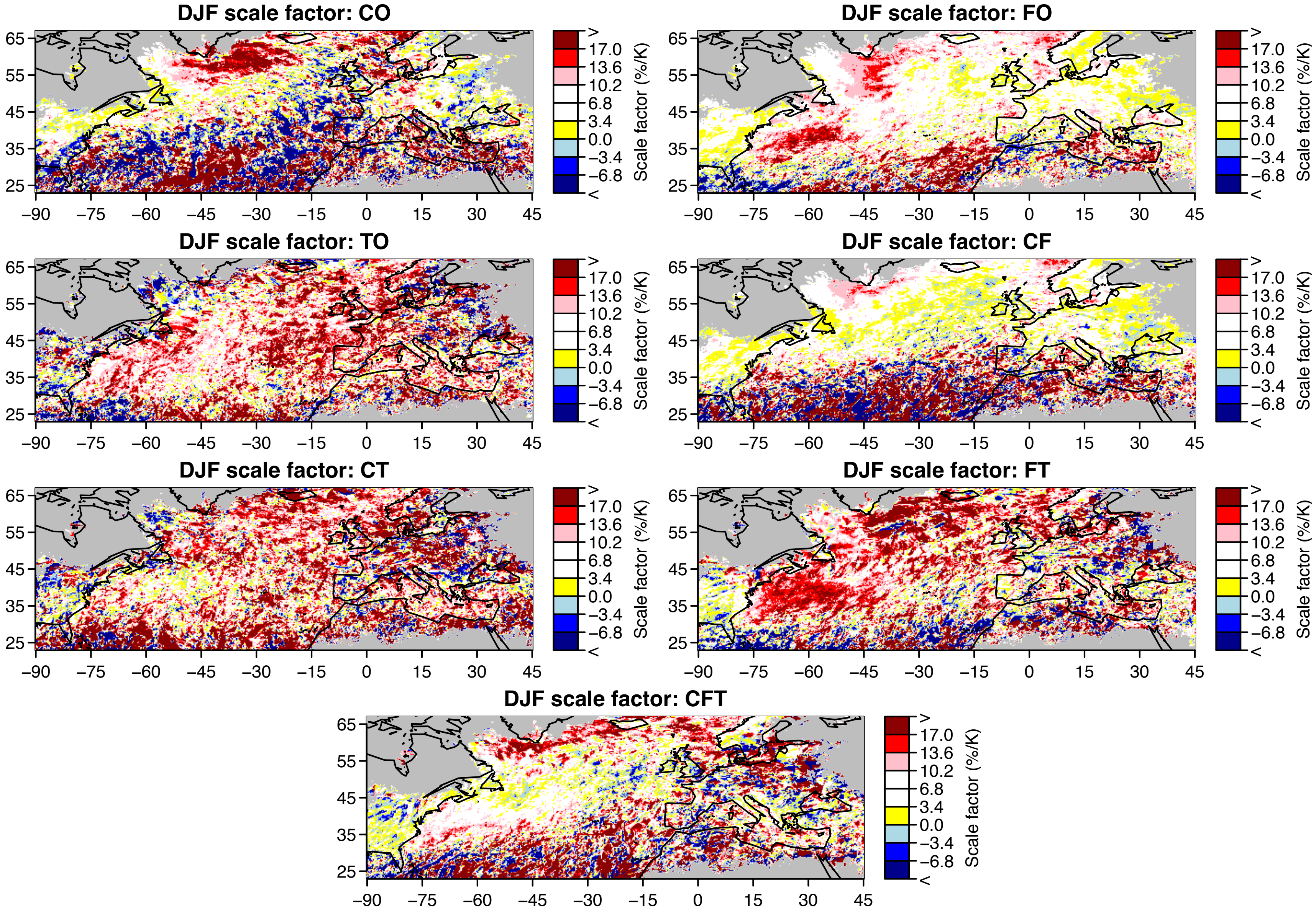
Catto and Dowdy (2021), Understanding compound hazards from a weather system perspective, Weather and Climate Extremes, https://doi.org/10.1016/j.wace.2021.100313

Temperature scaling of precipitation extremes with different storm types



- Estimate scaling of 99th percentile of precipitation from ERA5 with temperature for each storm type simultaneously using quantile regression.
- (plans to use IMERG data for verification/comparison)

Scale factors for different storm types



- FO and CF mostly show scaling below CC over Northern North Atlantic and Europe.
- Apparently larger scaling for TO, CT and FT over large parts of region.

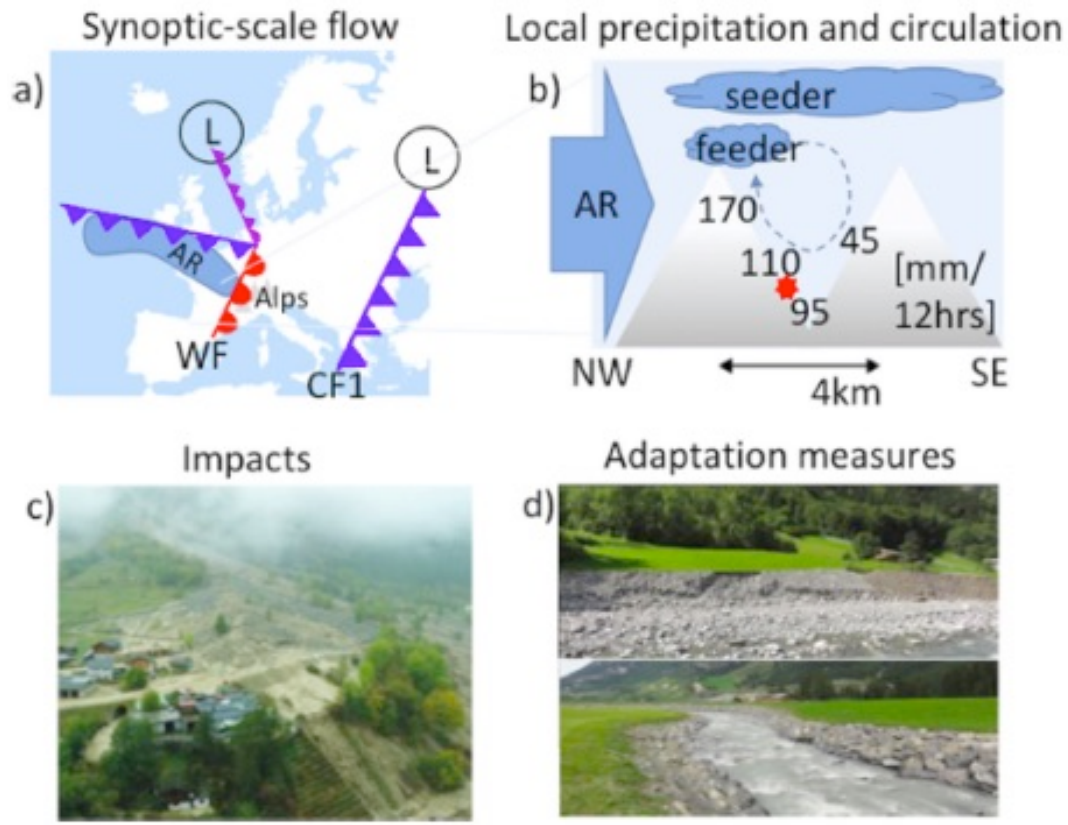
Summary of work achieved so far

- New shareable front identification code.
- Portable cyclone identification method that gives predefined cyclone areas.
- New storm-type dataset based on ERA5.

- Preliminary results show evidence of different extreme precipitation scaling with temperature for different weather systems.
- We also need to understand how different characteristics of the storms scale with temperature, e.g. winds, compound extreme occurrence.
- These algorithms are now being applied to model simulations of present and future climate.

STORMY-WEATHER

Using process understanding and expert judgement to produce storylines of plausible extreme events for risk assessment



Storyline of a past event, but storylines can also be produced for plausible extremes in current and future climates

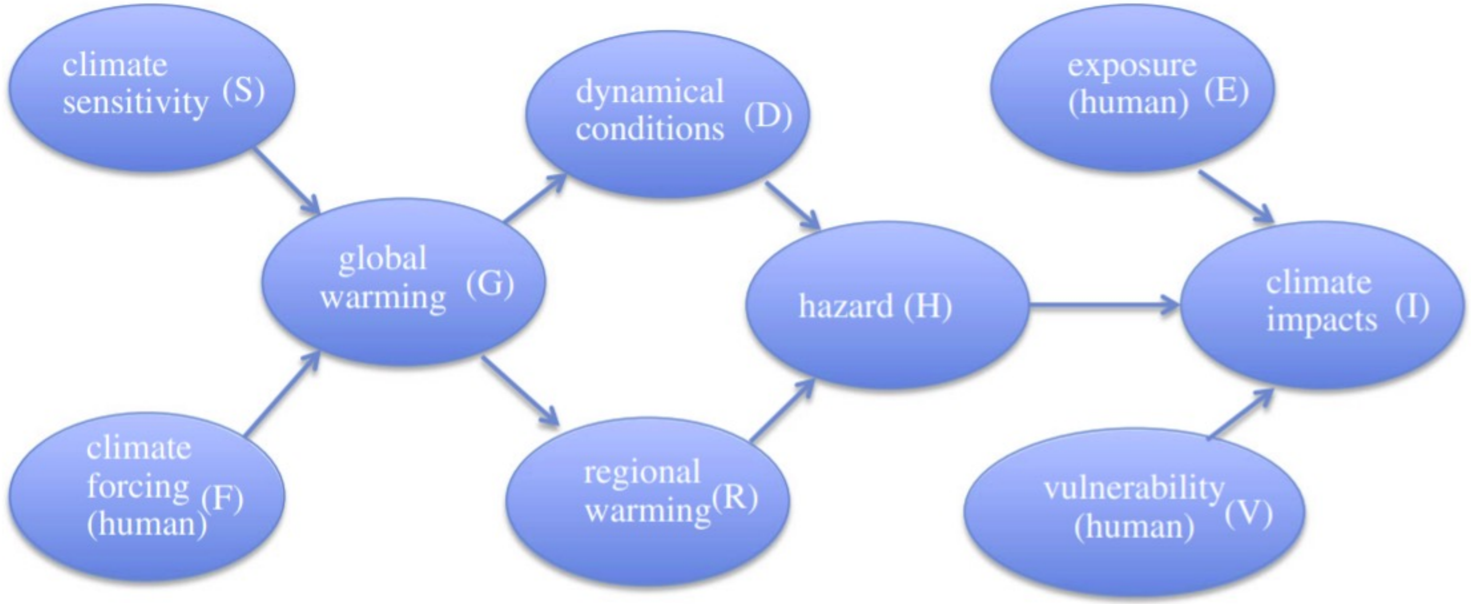
Shepherd et al., 2018, Climatic Change

Time	Water + national authorities	CI	Local authorities	Inhabitants unprotected areas	Inhabitants protected areas
-2 days	Forecast: storm Dordrecht+ high river discharge				
-31 h	pre-warning WL>1.8m		Prepare unprotected areas: close off sewer systems, warn inhabitants, distribute sand bags		
-24 h	Warning WL > 2.3m			Inhabitants remove cars, protect properties	
-21h	Barrier closes, warning: WL will rise to design level		Emergency centre is installed. Dike patrols started		
-17h	Flooding unprotected areas	Roads in harbour areas flooded		Stay indoors	
-10h	Warning: embankments in danger		Communicate to inhabitants: stay indoors, shift on TV/radio		People stay in, 10% leaves the island
0	Dike failure, water flows through	Power switched off on the whole island, gas, communication out of function, flooded roads out of use	Communication possibilities limited (only radio), responders try to rescue and warn people.	Stay in, or act carefully outside	People flee, become rescued, or die
1h	Fast inflow in industrial areas				
2h	First residential areas flooded				
4h	More residential areas flooded, river level reduces fast				
5h	River level below alarm level, unprotected areas dry	CI restored in non-flooded areas, out of function in flooded areas	Water managers realize flooding will be limited to western part.	Start cleaning, and help fellow citizens	
36h	Max flood extent reached water flows in and out with tides		Communication restored in non-flooded areas, rescue, breach repair continues		
7d	Protected areas is emptying		Pumping, repairs		
1 month	Protected area is dry again	CI repair starts	Repairs	Recovered	Repairs start in areas with CI
2 year		CI fully repaired	Repairs finalized		people returned home

Storylines allow planning and management strategies to be tested during crisis situations

de Bruijn et al., 2016, Nat. Haz.

How can we provide more robust information for climate adaptation?



"Causal networks can provide the diagnostic framework within which to extract the relevant climate information from simulations, and combine it with other sources of information in a format that is suitable for decision-making."
Shepherd (2019)

Causal Network describing regional climate risk from Shepherd (2019): causal networks allow us to combine expert knowledge with probability

STORMY-WEATHER: Storylines

Future changes in storm-related precipitation and wind events will come from a combination of changes in the frequency of the storm types, and changes of the within-storm characteristics.

1. Develop reliable statistical methods to quantify how extreme precipitation and wind speed marginal and conditional distributions are related to temperature changes for different storm types.
2. Produce storylines of the ‘reasonable worst case’ for each storm type for a 2°C and 4°C world, and different future time-slices, for use in planning purposes. For each storm type we will produce summary hazard metrics, including joint hazards.

STORMY-WEATHER: Questions

- What metrics should we use to define the ‘reasonable/plausible worst case’?
- What matters – peak intensity/spatial extent, volume, other metrics? Should we somehow define overall storm severity?
- What information is needed in each storyline? Footprints of storm at each timestep – just wind and rain or other variables?
- What is important to include in a narrative describing the storyline?
- Any other comments?