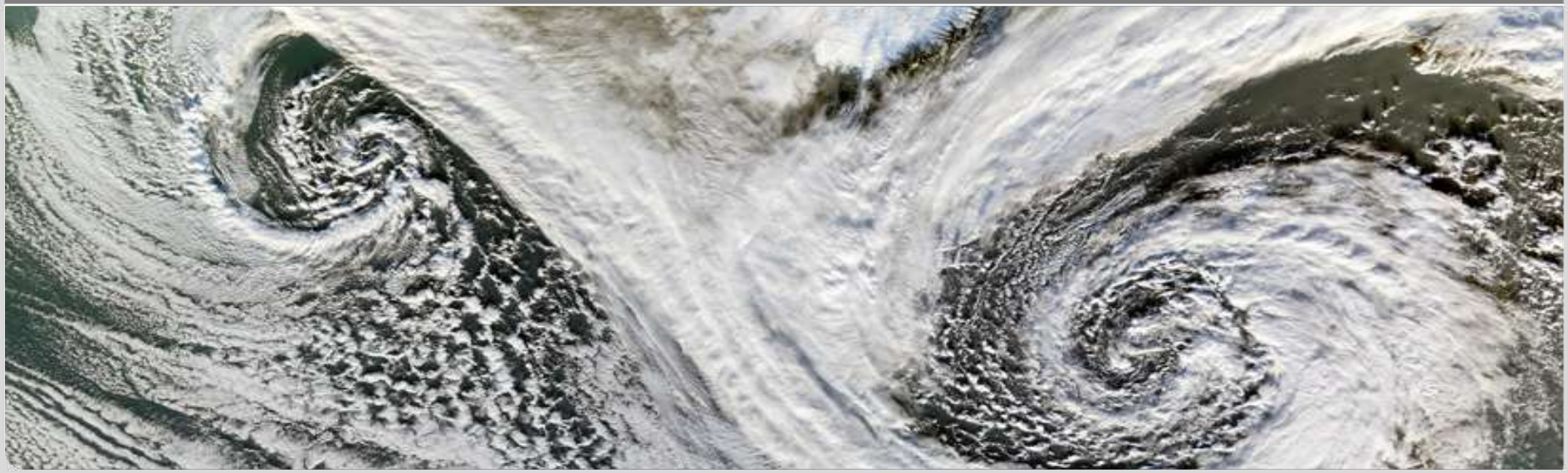
The Linkage of Serial Cyclone Clustering in Western Europe and Weather Regimes in the North Atlantic-European Region in Boreal Winter

Seraphine Hauser, Xiaoyang Chen, Sebastian Mueller, Joaquim G. Pinto, Christian M. Grams

Institut für Meteorologie und Klimaforschung – Department Troposphärenforschung

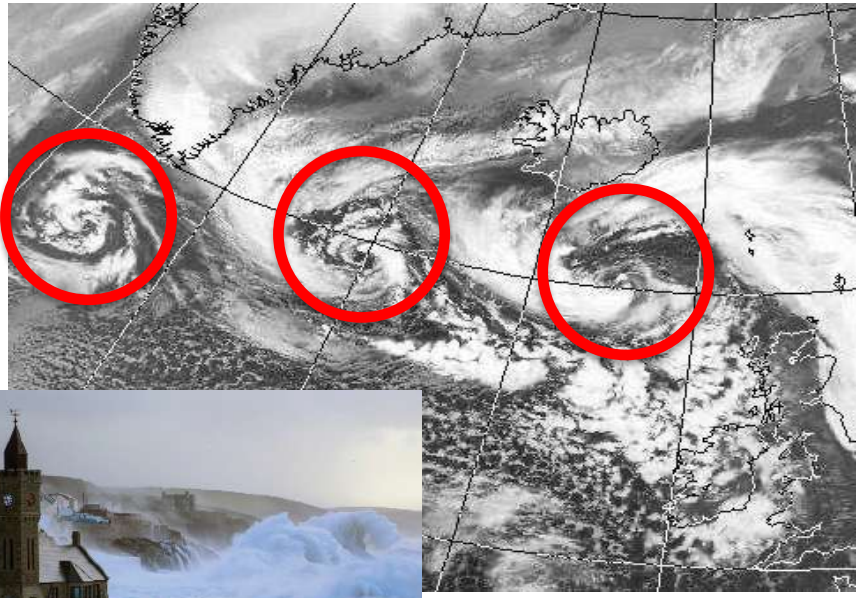


Winter 2013/2014 – Storms and UK floods

This winter was the stormiest on record for the UK (Matthew et al., 2014, *Nat.Clim.Ch.)*

Recurrent occurence of storms over the British Isles (37 in DJF) combined with stalling.

What was the role of the large-scale circulation?



Tewkesbury 2014

Source: Priestley et al (2017) Weather, Tim Prestridge, NASA, DPA

Clustering: key questions and link to WR

?

Weather regimes (WR): influence on cyclonic behaviour / weather on multi-day timescales

⇒ **Can we predict the onset and duration of cyclone families from the characteristics of the large-scale atmospheric flow and/or 1st cyclone?**

⇒ **Better understanding and prediction of clustering periods, e.g. potential predictability through stratospheric conditions (2-4 weeks)**

⇒ **We investigate the relationship between serial cyclone clustering (SCC) at different latitudes over Western Europe and large-scale weather regimes (WRs) in the North Atlantic-European sector for boreal winter.**

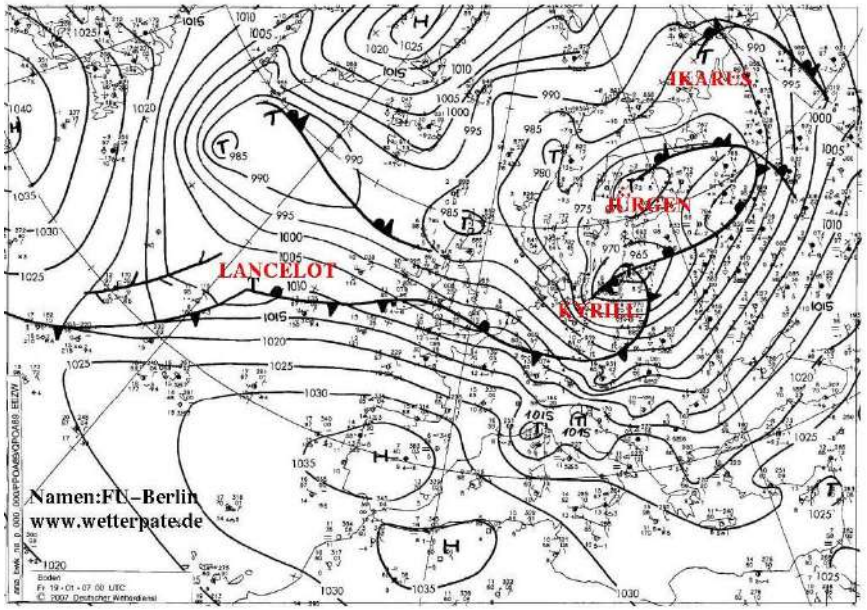
Source: Dacre and Pinto (2020) NPJ Clim Atmos Sci

Clustering: Statistics, Synoptics, Quantification

Ψ =0: „random“

Ψ >0: „clustering“

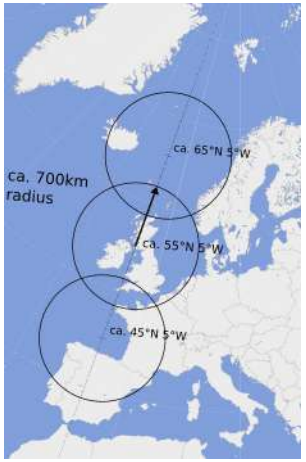
Multiple extreme storms within a week (11.-18.01.2007)



Latitude: 65/55/45 °N
Intensity: 95/98%

7-days running mean
4 or more cyclones =>
clustering (3 for 45°N)

Average SCC: ~ 14 days



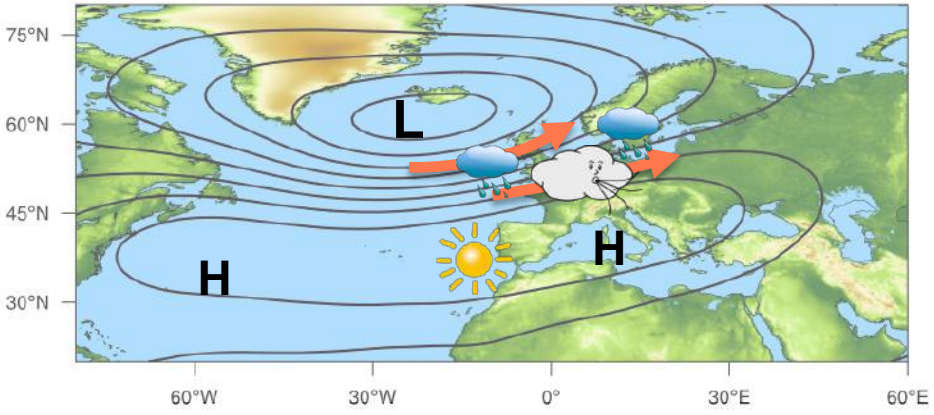
Source: Pinto et al. (2013) JGR-A; FU-Berlin; Wetter3.de

Weather regimes

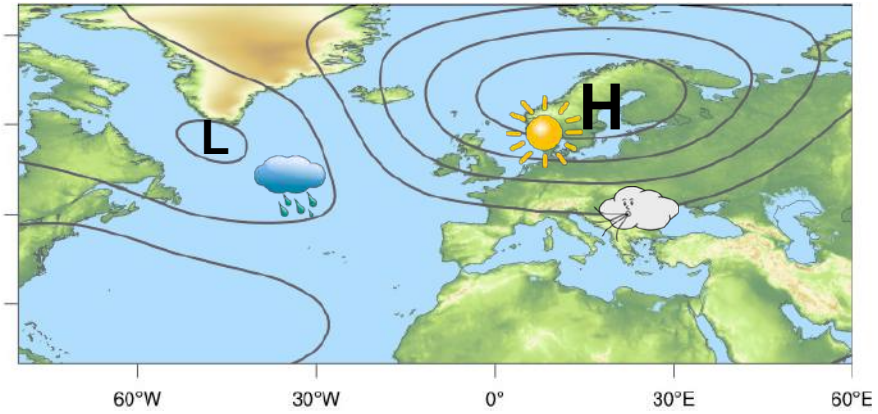
- WR are *quasi-stationary, persistent, and recurrent* large-scale flow patterns
- WR describe *multi-day variability* of *large-scale flow* over a specific region

(e.g Michelangeli and Vautard, 1995; Ferranti et al. 2015)

Cyclonic regimes



Blocked regimes



- Here: Year-round definition of Atlantic-European regimes (Grams et al., 2017)
  - 10d low-pass filtered Z500 anomalies from ERA-Interim (1979-2016)
  - EOF analysis & k-means clustering of 7 leading EOFs (76% of variability)
  - Objective definition of individual regime life cycles (onset, decay, transitions)

Source: Grams et al., 2017, Nat. Geo.

Weather regimes

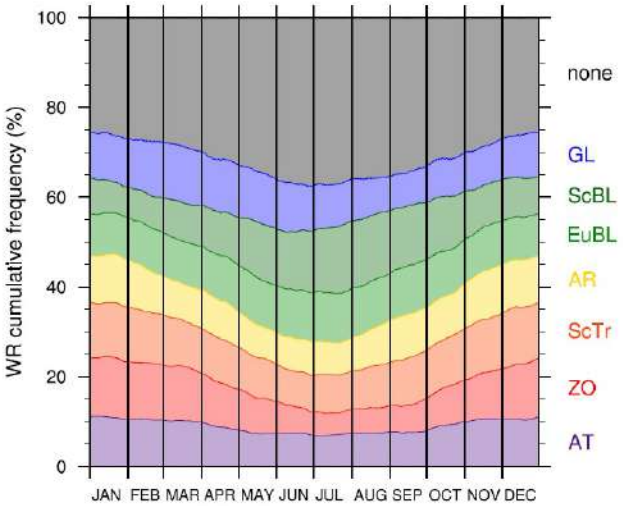
- Year-round 7 WRs:

Cyclonic regimes:
- Atlantic trough
- Zonal Regime
- Scandinavian trough

Blocked regimes:
- Atlantic ridge
- European blocking
- Scandinavian blocking
- Greenland blocking

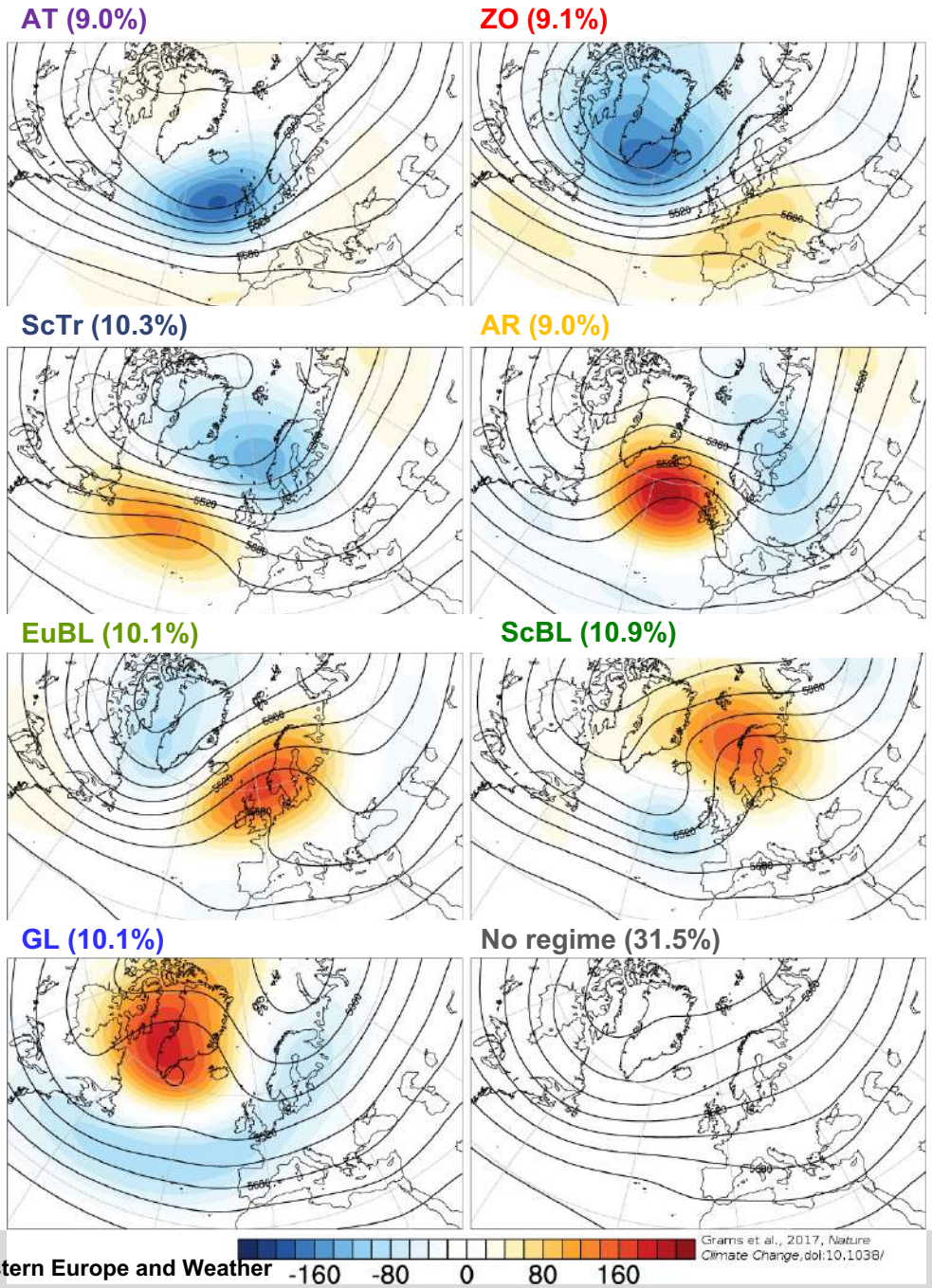
Objective definition of **onset, maximum, decay** for individual WR life cycles

regime frequency



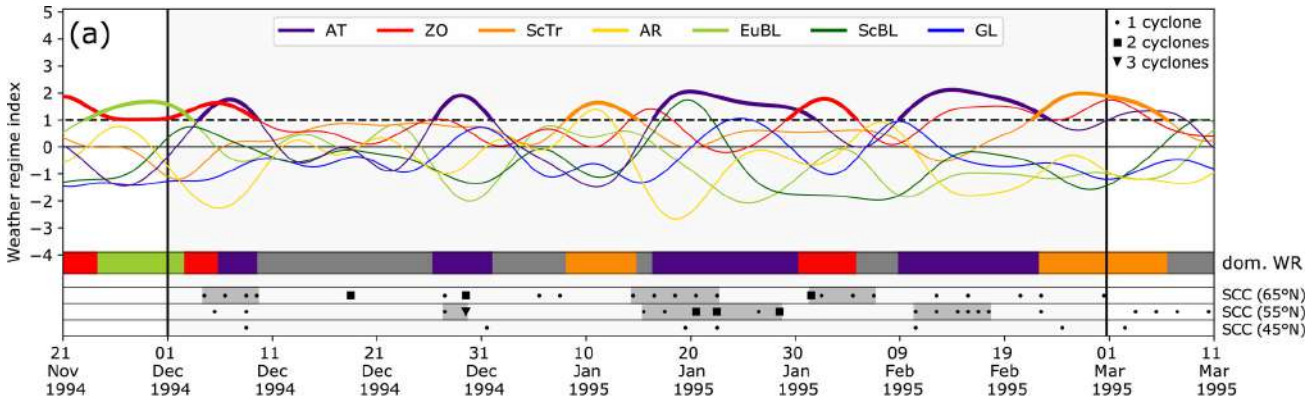
Source: Grams et al., 2017, Nat. Geo.

Shading: cluster mean Z500 anomaly, black contours: cluster mean Z500

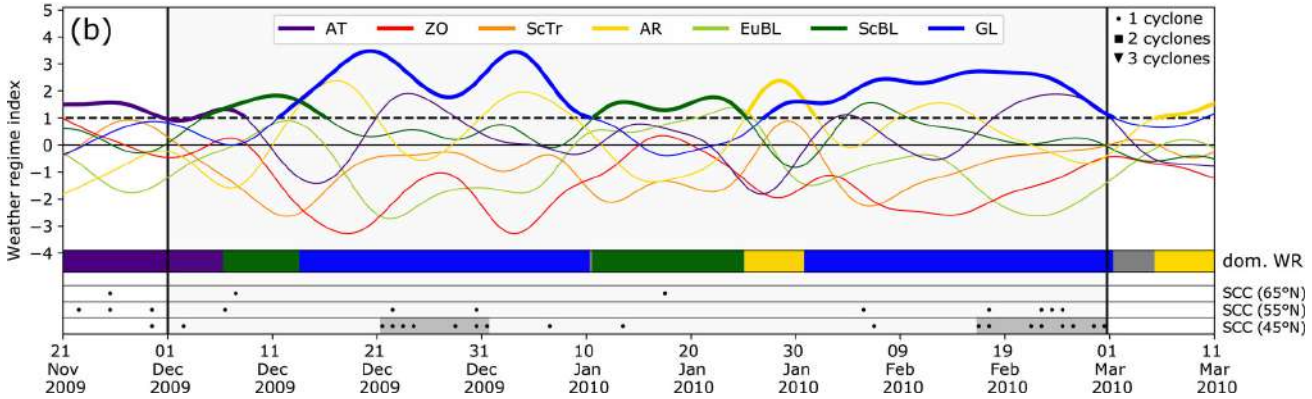


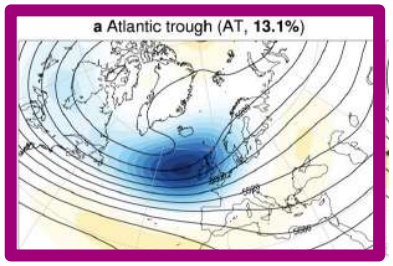
Clustering vs Weather regimes

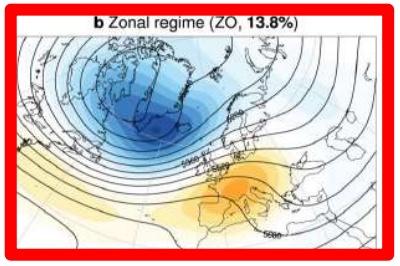
1994-1995

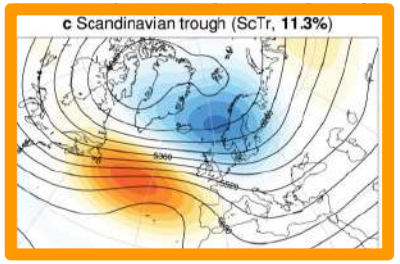


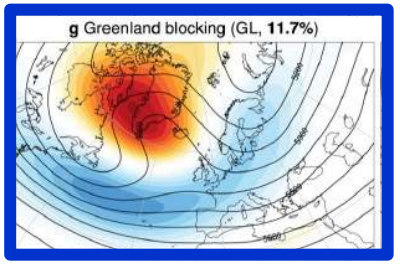
2009-2010





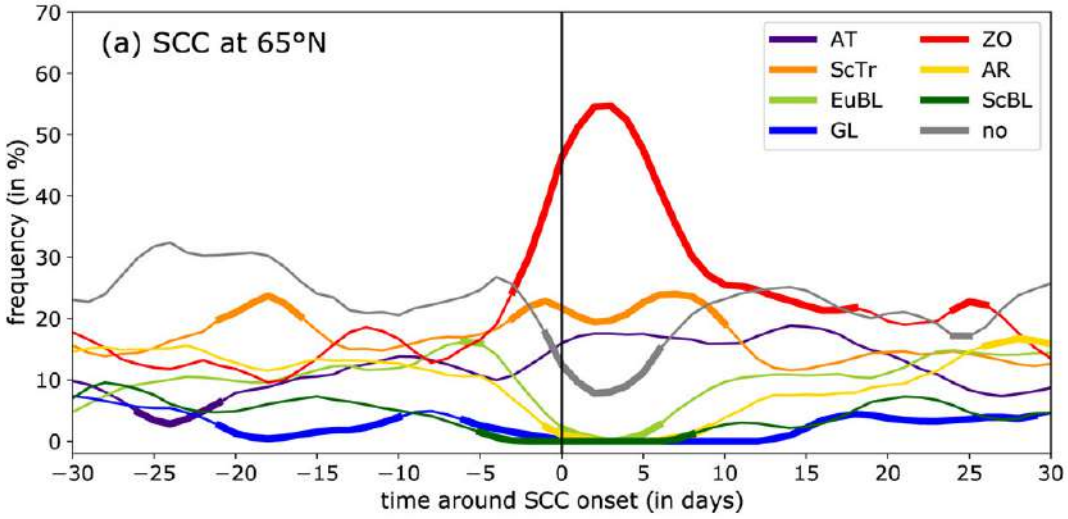




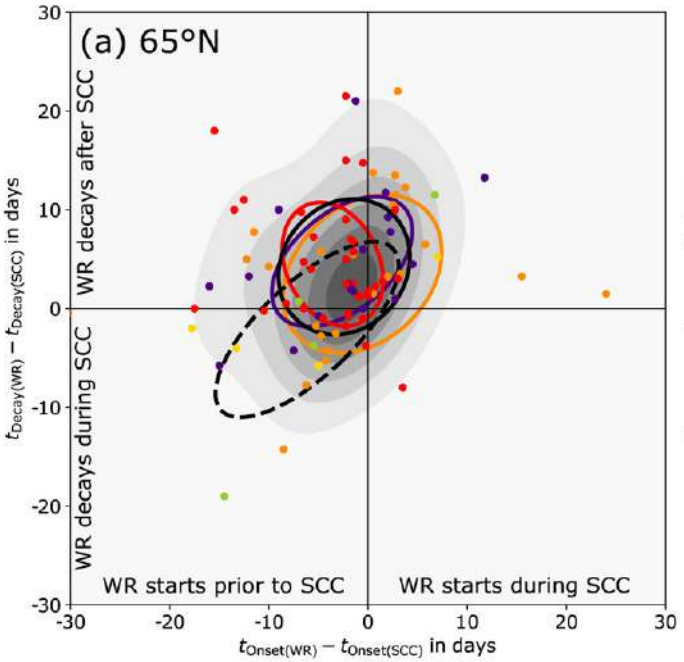


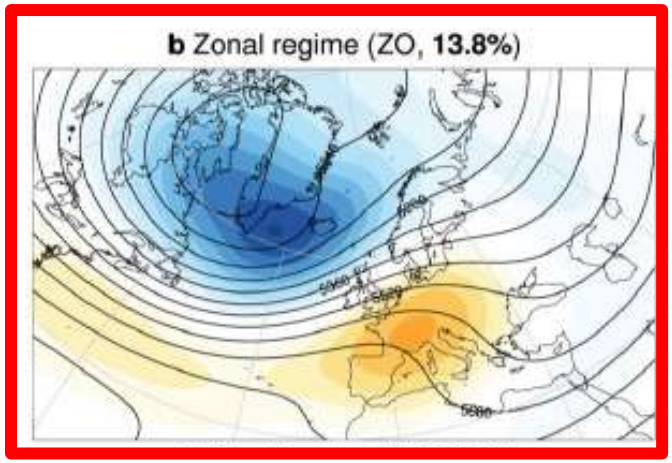
Source: Hauser et al., 2023, GRL

Clustering vs Weather regimes – 65°N



Period: 1979-2019, DJF only

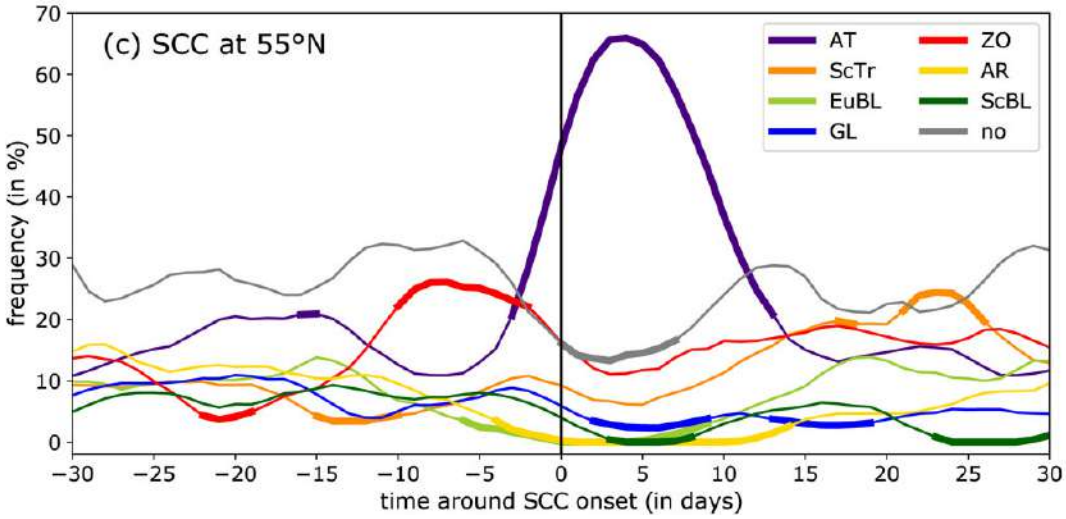




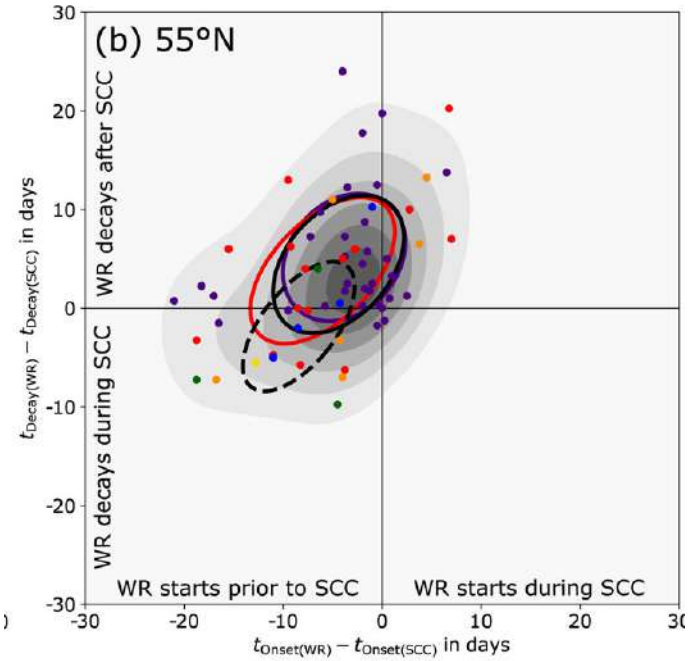
Clustering at 65°N is associated with an enhanced frequency of cyclonic WRs, particularly **Zonal** and **Scandinavian Trough**, which **builts up before** and often **outlasts cyclone clustering**

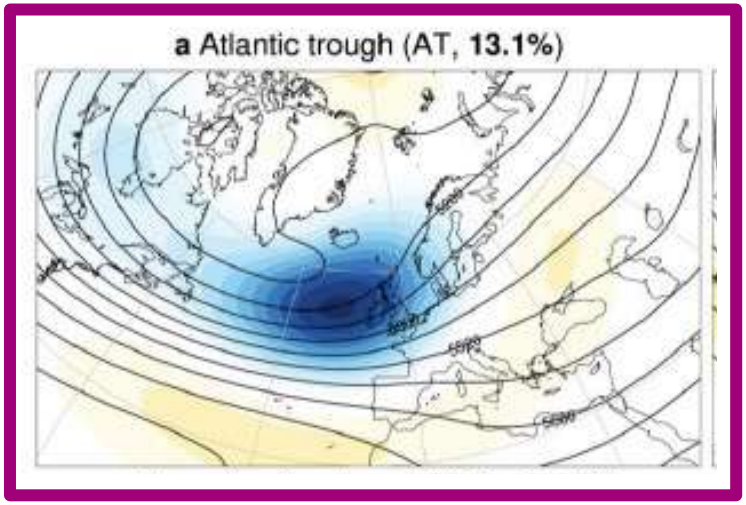
Source: Hauser et al., 2023, GRL

Clustering vs Weather regimes – 55°N



Period: 1979-2019, DJF only

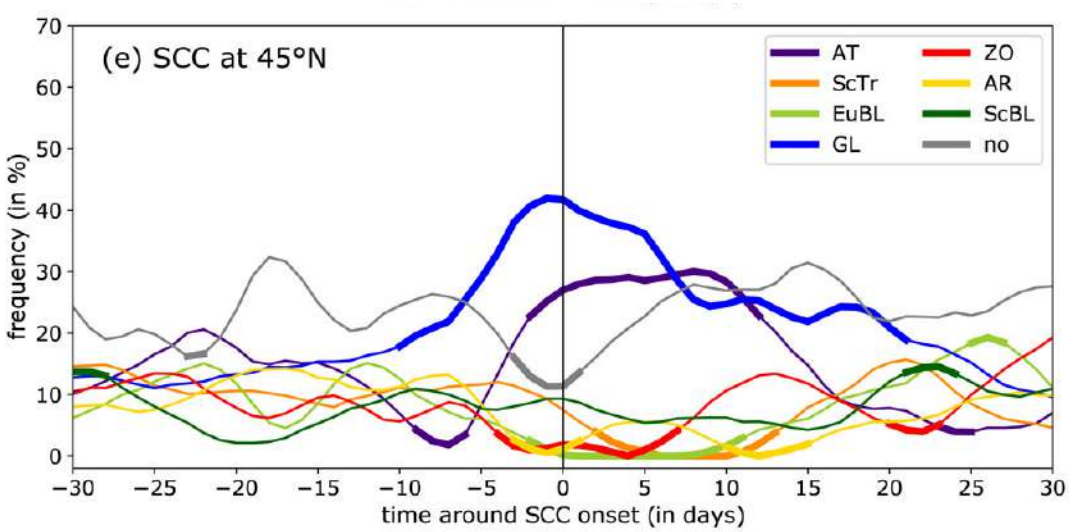




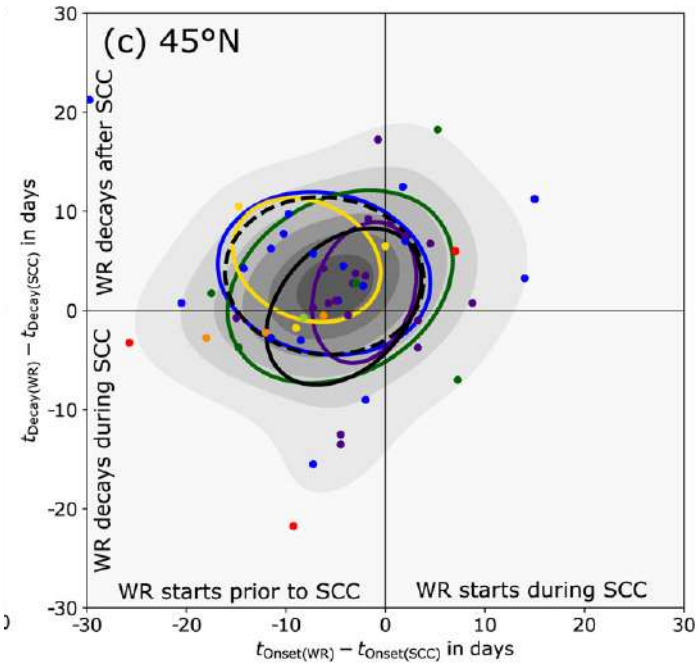
Clustering at 55°N is associated with an enhanced frequency of cyclonic WRs, particularly **Atlantic Trough**, which **builts up before** and often **outlasts cyclone clustering**

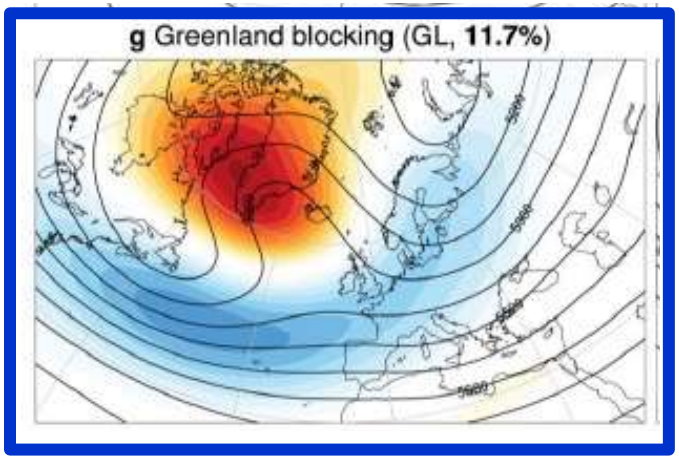
Source: Hauser et al., 2023, GRL

Clustering vs Weather regimes – 45°N



Period: 1979-2019, DJF only





Clustering at 45°N is associated with an enhanced frequency of **Greenland Blocking** and **Atlantic Trough**, which **typically start earlier than cyclone clustering onset** and often **decay after clustering period**

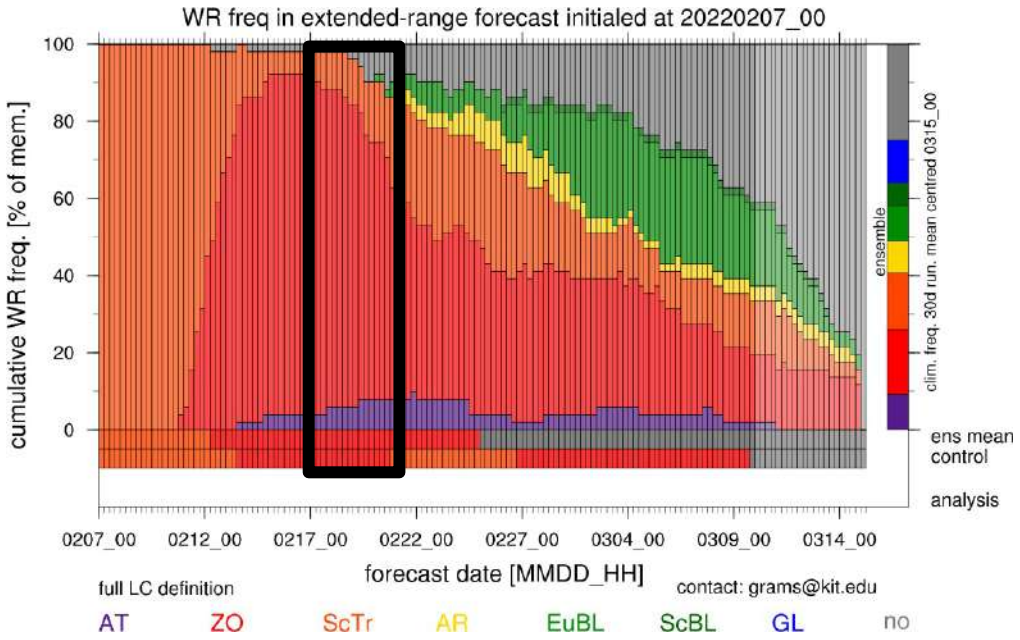
Source: Hauser et al., 2023, GRL

Operational Ensemble Forecasts of WR

- **Cyclone clustering occurs mostly during an active regime life cycle and is manifested in a well-established Weather Regime**
- **Test value of this relationship for the prediction of cyclone clusterig (and associated impacts) on sub-seasonal times scales (2-4 weeks)**

Winter storm series: Ylenia, Zeynep, Antonia
(int: Dudley, Eunice, Franklin)
16.-21. February 2022 (NW & Central Europe)

e.g. CEDIM Forensic Disaster Analysis
doi10.5445/IR/1000143470



https://www.ecmwf.int/en/newsletter/165/meteorology/how-make-use-weather-regimes-extended-range-predictions-europe.

Take Away Messages

- **Cyclone Clustering is a natural phenomena,** which affects e.g. Western Europe, and may lead to large cumulative impacts.
- **A clear relationship is found** between serial cyclone clustering (SCC) and weather regimes (WRs) in the North Atlantic-European region
- **SCC at high latitudes** (55 °N, 65 °N) **is mostly associated with cyclonic WRs** that built up before and often outlast the SCC period
- **SCC at lower latitudes** (45 °N) is often **linked to Greenland BL** or **Atlantic Trough WR** which precede the onset and decay after the SCC period
- **Next Steps: Test value of this relationship for the prediction of SCC (and associated compound events / impacts) on sub-seasonal times scales (2-4 weeks)**

Hauser et al. (2023) Geophys Res Lett, 50, e2022GL101900. doi:10.1029/2022GL101900

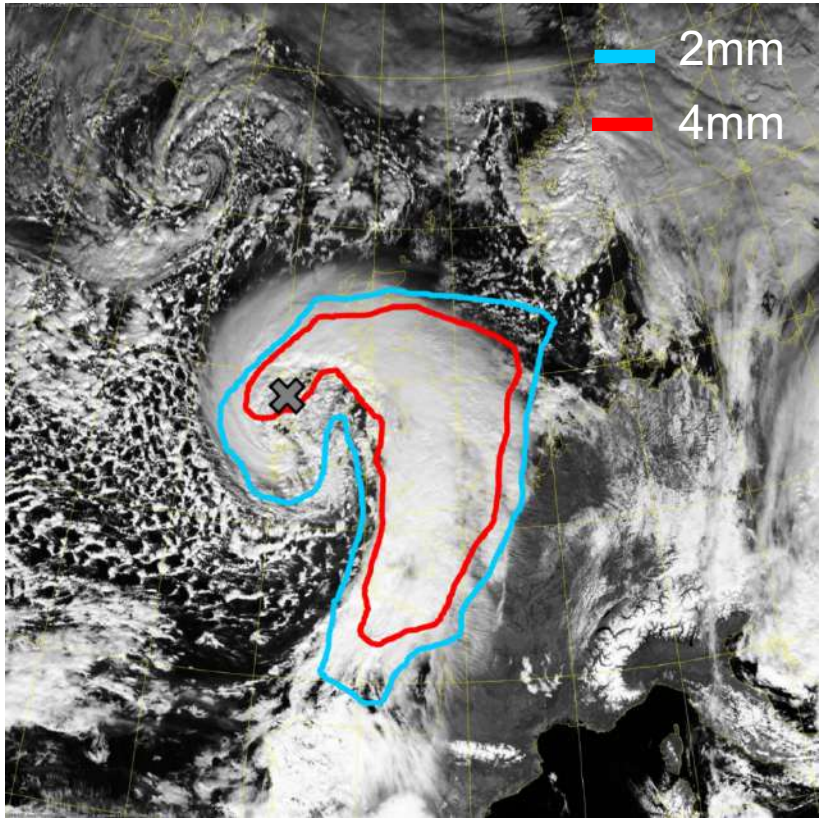
Extras

Source: Priestley et al (2017) Weather, Tim Prestridge, NASA, DPA

Winter 2013/2014 – Storms and UK floods

This winter was the stormiest on record for the UK (Matthew et al., 2014, *Nat.Clim.Ch.)*

Recurrent occurence of storms over the British Isles (37 in DJF) combined with stalling.



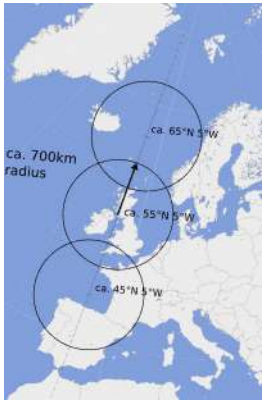
Visible image of Windstorm Tini 12.02.2014, 12 UTC, with ERA-I rainfall estimates (mm)

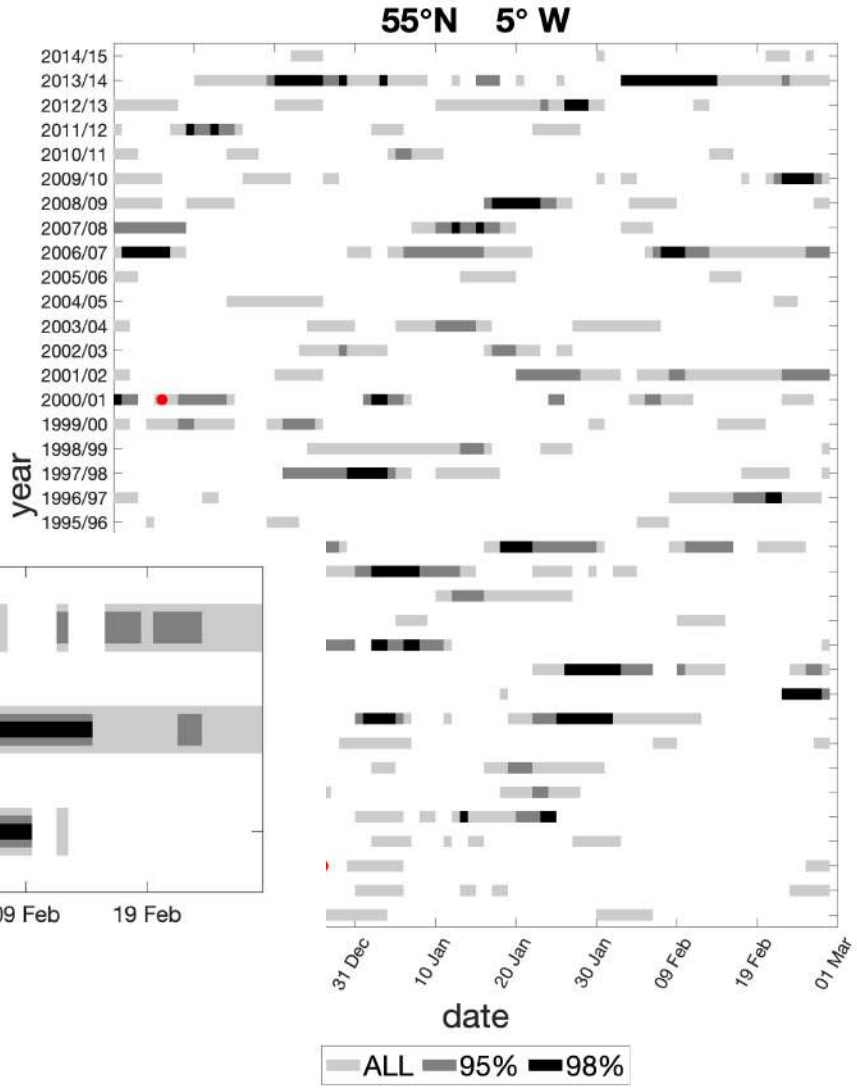
Source: Priestley et al (2017) Weather; Tim Prestridge

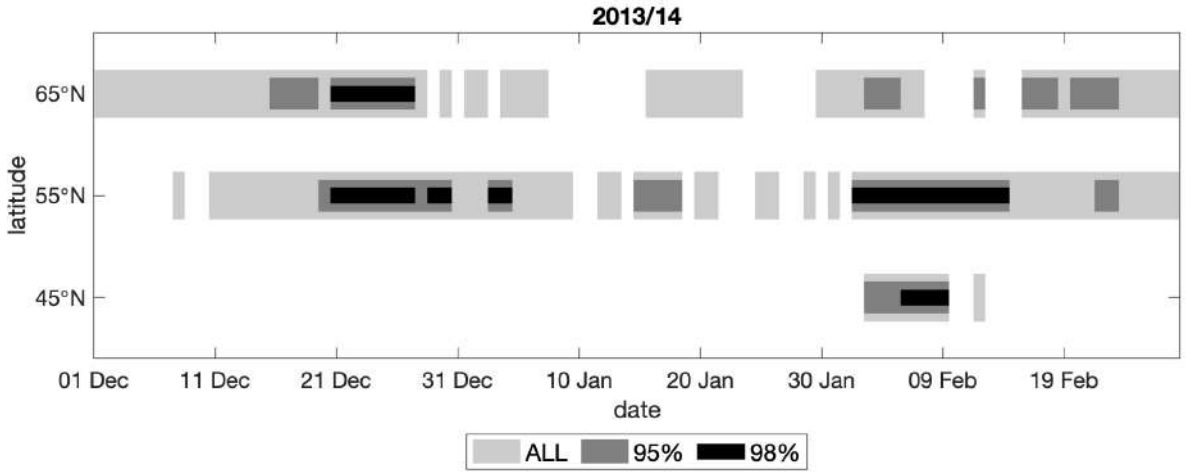
Clustering quantification

Cyclone clustering
Latitude: 45/55/65 °N
Intensity: 95/98%

7-days running mean

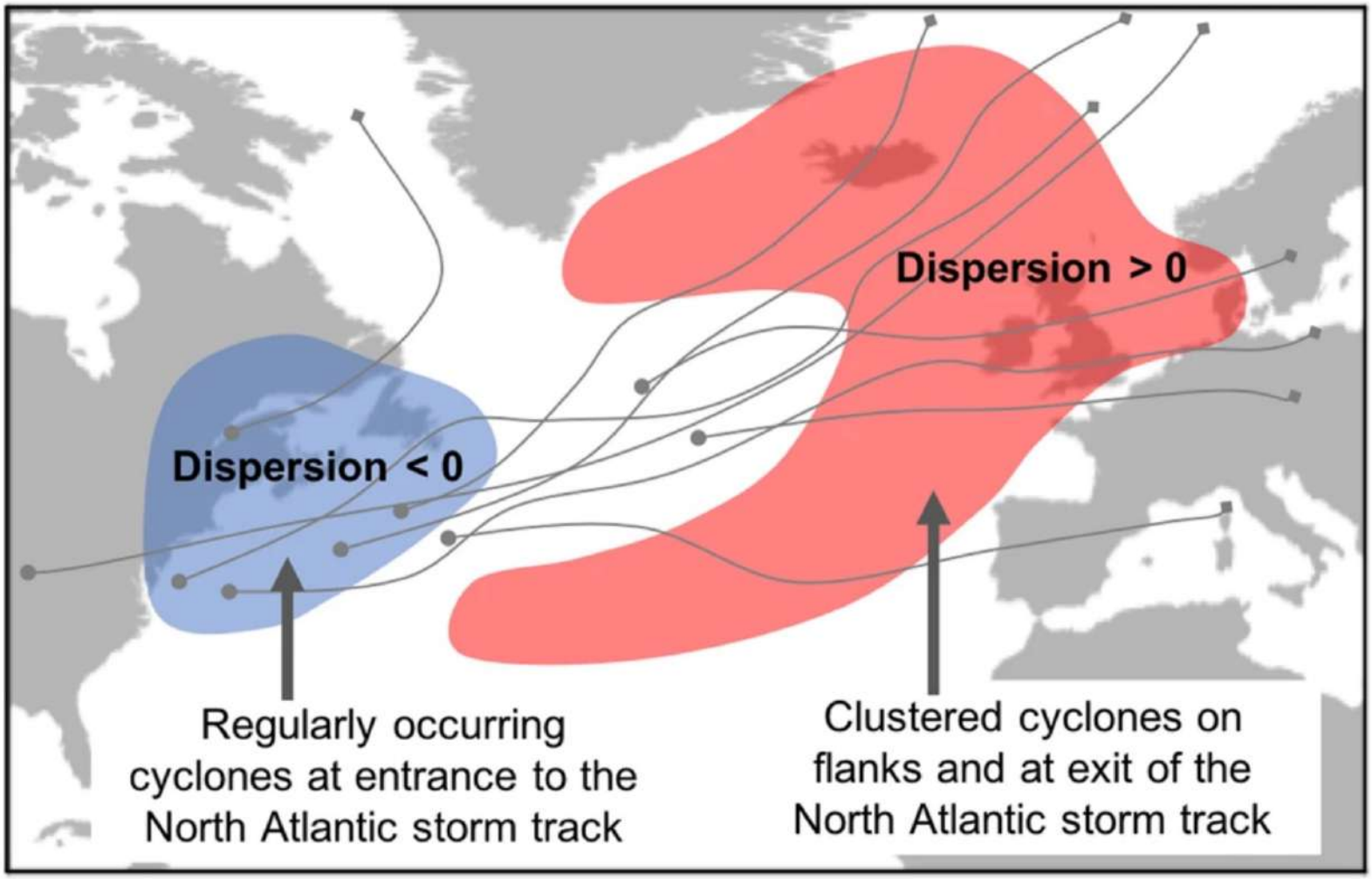






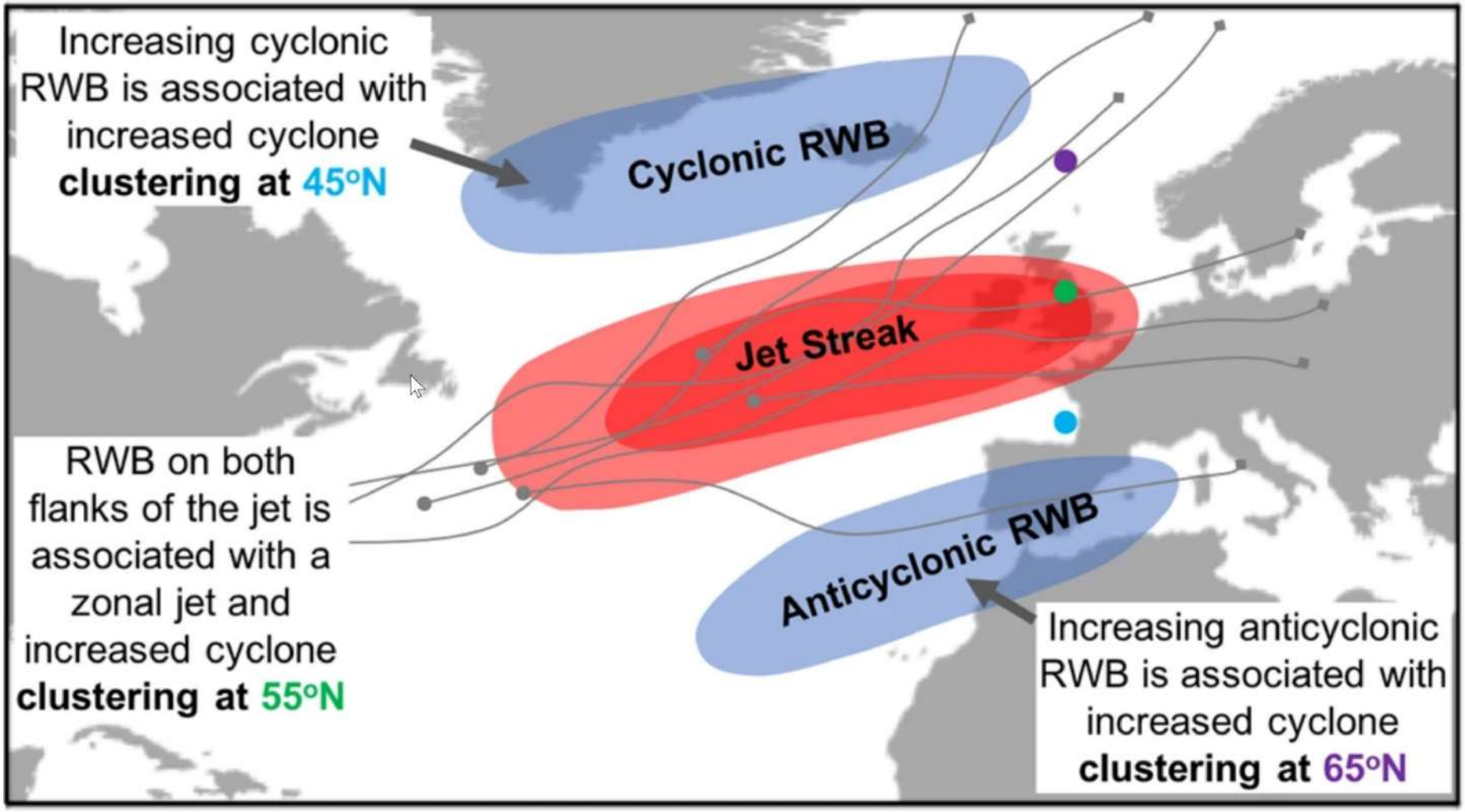
Source: Xiaoyang Chen, Sebastian Müller

Clustering: dispersion statistics



Source: Dacre and Pinto (2020) npj Clim Atmos Sci

Dynamics of cyclone clustering



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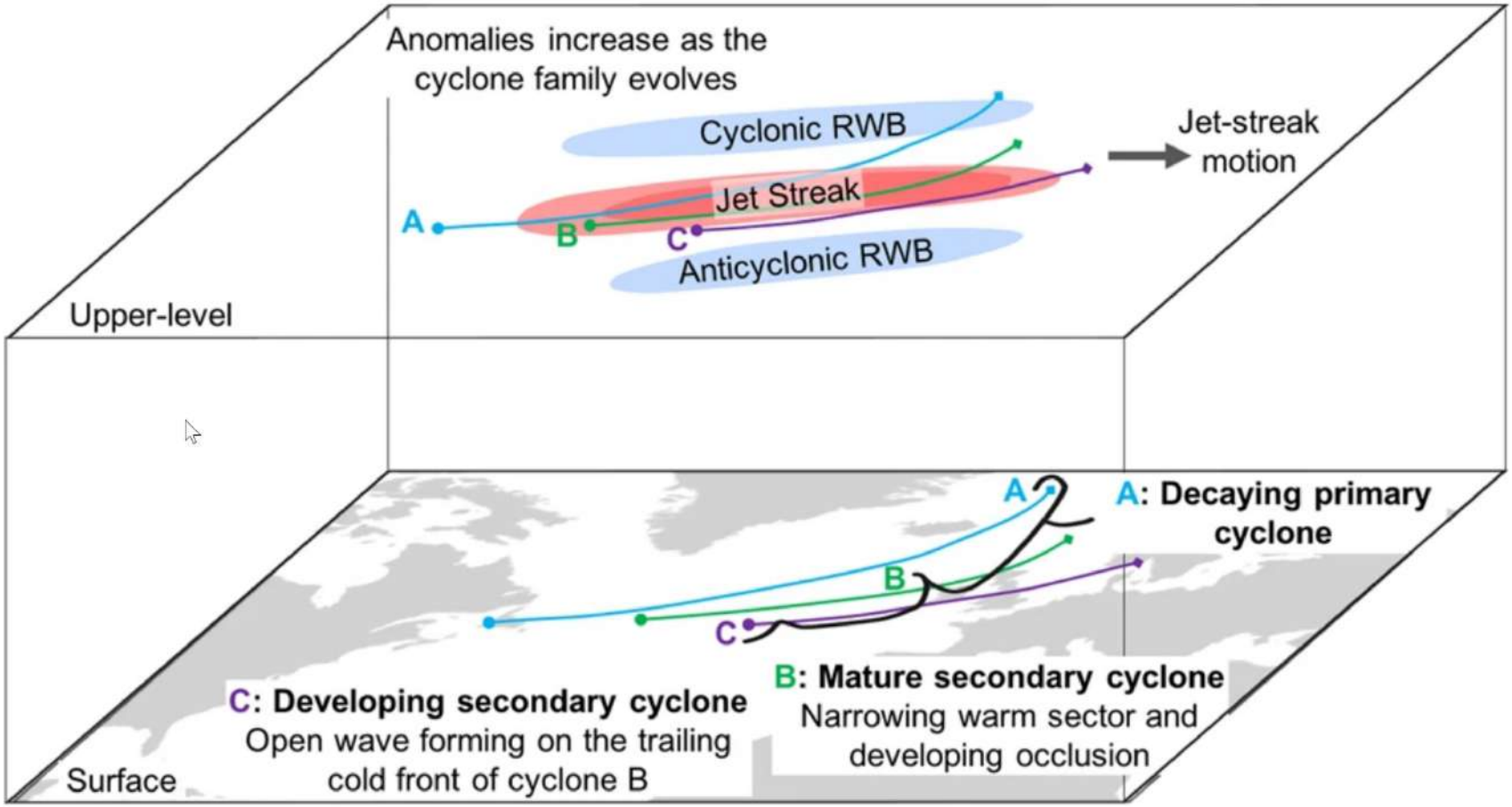

Typical cyclone family and their associated surface tracks. At upper-levels, the cyclone family is associated with evolving jet and RWB anomalies, moving eastward with cyclone family.

Source: Dacre and Pinto (2020) npj Clim Atmos Sci