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The dynamics of cyclone clustering in re-analysis and a high-resolution climate model

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1. Introduction

The clustering of cyclones has significant impacts on western Europe. An initial study by *Pinto et al. (2014)* looked at several highly clustered months and concluded how they were all associated with anomalous Rossby wave breaking (RWB) on both sides of the jet. We explore the dynamical setup of clustering across the entire ERA-Interim period for a number of geographical areas. Clustering is also examined in the HiGEM climate model in an attempt to gain confidence for future climate projections.

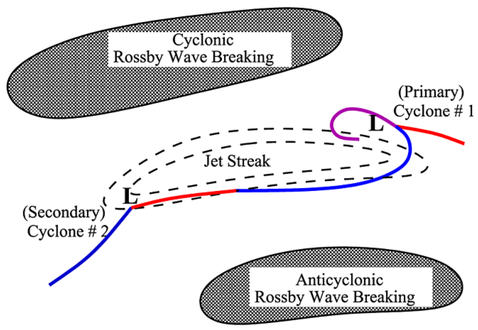

Figure 1. A schematic of the dynamics associated with cyclone clustering based on the initial analysis of *Pinto et al. (2014)*. Figure 7f in their paper.

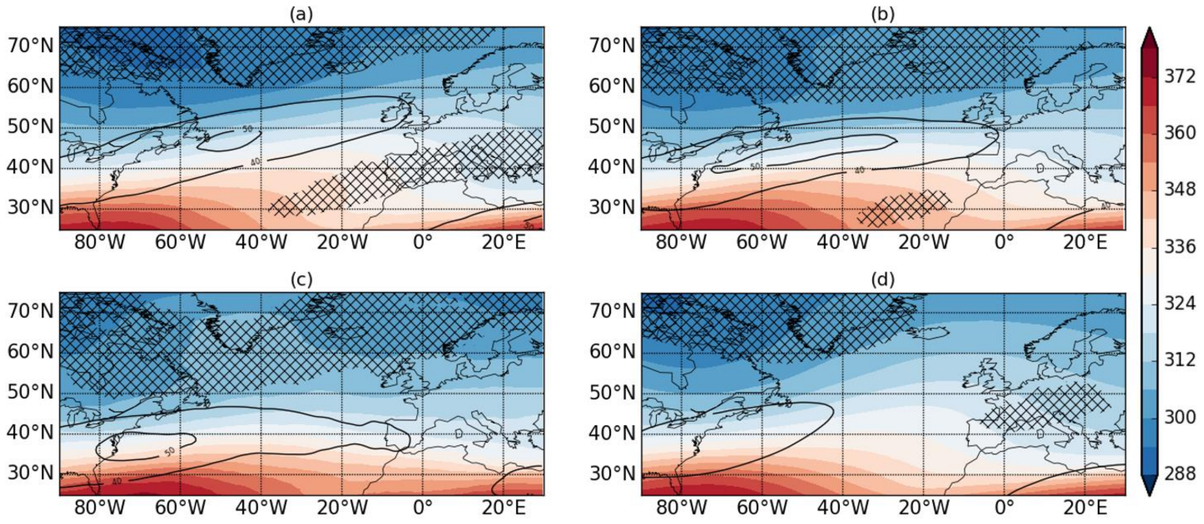

Figure 2. Composites of clustered days at (a) 65°N, (b) 55°N, and (c) 45°N. (d) Climatology. For all panels the coloured contours are θ on the 2 PVU surface (K). Black contours are the 250 hPa wind speed from 40 m s^{-1} and every 10 m s^{-1} above. The crossed hatchings are where RWB was occurring on at least 30% of days *(Priestley et al., 2017)*.

2. Clustering in ERA-Interim

Composites of clustered days have been created for three 700km radius latitude areas of western Europe, centred along 5°W. All three regions exhibit marked departures from the climatological state (Figure 2d).

- At 65°N (Figure 2a) there is an increased presence of anticyclonic RWB on the southern flank of the jet. This generates a greater jet tilt
- At 55°N RWB activity dominates both the northern and southern sides of the jet (Figure 2b). This acts to keep the jet in a more zonal state and accelerated across the North Atlantic.
- RWB to the north of the jet dominates when cyclones are clustering at 45°N (Figure 2c). The jet is kept in a very zonal state and cyclones are deflected toward Iberia.

Both the jet and the RWB exhibit a statistically significant positive relationship with the intensity of clustering (Figure 3). RWB tend to precede the jet anomalies by approx. 2 days, with the RWB driving the jet acceleration.

3. Comparison with HiGEM

HiGEM has an atmosphere resolution of N144 and 1/3° x 1/3° in the oceans. We are using 30 years of DJF data from the control run.

There is a good representation of the storm track and upper level jet when compared to ERA-Interim. Jet biases are generally much less than those seen in the CMIP5 multi-model mean (Figure 4a).

The model is able to reproduce the right amount of clustering for the right reasons at each of our 3 latitudes. The anomalous behaviour of the jet and RWB and consistent with ERA-Interim (Figure 2b/4b), however there are some slight differences compared to ERA-Interim:

- The jet is often slightly too zonal by a few degrees
- There is an under-representation of RWB on the equatorward flank of the upper level jet

The under-representation of RWB is clearly apparent in the DJF climatology (Figure 4c), with this also being noticeable at 55°N (Figure 4b) and 65°N (not shown).

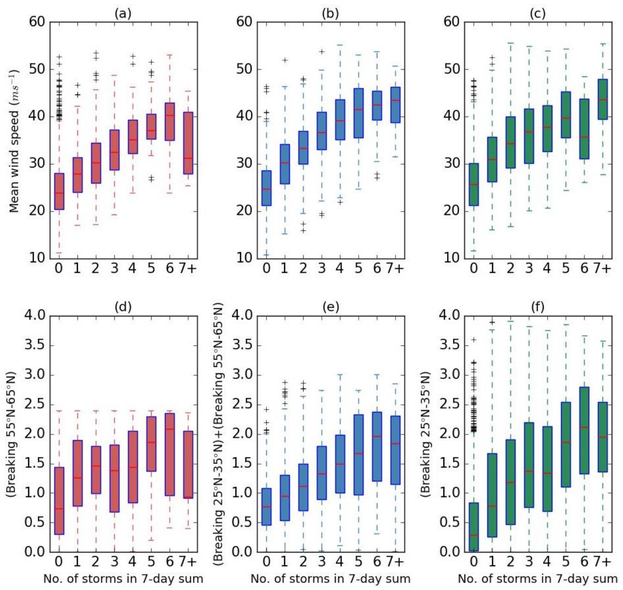

Figure 3. (a–c) Average 250 hPa wind speeds from 40-50°N, 30°W-10°E (for 55°N) ± 10° latitude (for 45°N/65°N) against the number of cyclones in each days 7 day sum. (d–f) The amount of RWB that takes place in a combination of boxes. Figures 3a and 3d are for 45°N. Figures 3b and 3e are for 55°N. Figures 3c and 3f are for 65°N *(Priestley et al., 2017)*.

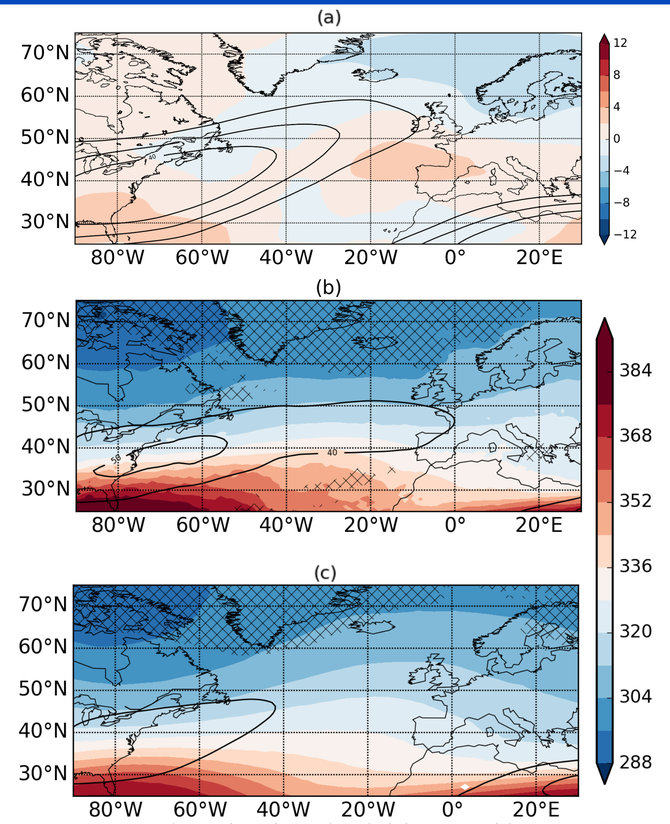

Figure 4. (a) 250 hPa wind speed anomalies (shaded contours) of the 30-year HiGEM control run compared to ERA-Interim (black contours). (b) Representation of clustering in HIGEM at 55°N and (c) climatology. Contours and hatchings in (b) and (c) the same as in Figure 1.

4. Conclusions

- **Cyclone clustering is associated with anomalous RWB activity on one or both flanks of an eastward extended and strengthened upper level jet.**
- **When the RWB and jet anomalies are larger the intensity of clustering is increased.**
- **HiGEM has a good representation of the North Atlantic storm track and also the 250 hPa jet.**
- **Clustering in HiGEM is consistent with ERA-Interim, however there is an under-representation of anticyclonic RWB.**

References

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Acknowledgements

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