Review of 'Identification of high-wind features within extratropical cyclones using a probabilistic random forest - Part 2: Climatology' by Eisenstein et al. submitted to Weather and Climate Dynamics

General comments:

This is an interesting study describing the results of applying a methodology previously published by the authors to develop a 19-extended-winters climatology of mesoscale wind features in cyclones over Western and Central Europe. The topic is very suitable for this journal. The research is novel in the generation of this type of climatology over this region, and in the method used to obtain the climatology. I have a few questions about the details of the methods (some of the description is confusing, at least to me) and about the robustness of the results. The work would also benefit from a more detailed comparison with previous literature to draw out the novelties of the findings. The paper is well presented apart from some small language glitches (not all of which I've likely commented on in my review).

Major specific comments:

L105 Here it is stated that the focus of this study is on cyclones occurring in Western and Central Europe. This geographical focus of the study should be included in the paper title.

Introduction Given the focus of this paper on the different sources of strong low-level winds, it might be helpful to include a diagram showing where these are located within a classic cyclone as a first figure. The different features are explained in the text but it may be difficult for less knowledgeable readers to visualise these. Related to this comment, some more detail on how the features are defined in probabilistic characterisation would be helpful. I realise that these details are described in the part 1 of this paper but it should be possible for readers to follow part 2 without having first read part 1.

L73 Here you refer to the Earl et al. study. One interesting result from that study is the different of the prevelence of the features changes depending on whether those generating the top 1% or 0.1% of daily maximum wind gusts are considered. Did you consider changing your windspeed threshold to look at how the relative importance of the features changes?

L203 "the proportion of NF is considerably lower in COSMO-REA6 data" – this statement is true but "no feature" strong winds still account for about 30% of the strong winds. Please can you say more about what these strong winds are likely to be caused by and whether they are likely to be linked to cyclones? How often are these NF strong wind regions close to the tracked cyclones (all strong wind regions are within 15 degrees of a cyclone (L167), but are the NF regions relatively more likely to be further away (e.g. beyond 7.5 degrees)?

Section 3.1 Here the pie charts showing the relative frequency of the different strong wind features are discussed with the pie charts showing percentage occurrence values to 1 decimal place. It would be useful to have some sense of how robust these relative percentages are to small changes in the datasets used and hence how meaningful the interpretations are. For example, what happens if some of the years are omitted from the datasets used, the definition of strong winds is changed slightly, or the domain of interest (the blue box in Fig. 2) is shifted slightly?

L228 For calculation of the seasonal and inter-annual evolution of the wind features, the strong winds need to be present at at least 100 grid points over the domain. The model grid is a latitude-longitude grid with a spacing of 0.0625 degrees. Hence, the size of the grid boxes (in km^2) changes with latitude. Is this change taken into account?

Existing literature While I don't know of other papers that have produced long term climatologies of mesoscale wind features, there are some other papers that the authors should consider referencing. Rivière et al. (2014, https://rmets.onlinelibrary.wiley.com/doi/10.1002/qj.2412) shows the evolution from a dominant warm to dominant cold conveyor belt jet (see fig. 10 particularly) and Dacre et al. (2012, https://journals.ametsoc.org/view/journals/bams/93/10/bams-d-11-00164.1.xml) describes the generation of a cyclone "atlas" which includes analysis of the warm and cold conveyor belts. I also suggest attempting a more quantitative comparison with the existing literature that is cited. The term "mostly consistent" is used in the conclusions – can you provide a deeper comparison? How do the cyclones over the Western and Central Europe region analysed here compare with those over the North Atlantic or UK? It would also be helpful to contrast the descriptions of the cold and warm jets here with some much older literature. For example, for me the classic paper on cyclone structure is Browning and Roberts (1994, https://rmets.onlinelibrary.wiley.com/doi/epdf/10.1002/qj.49712052006). See also Browning (2005, https://rmets.onlinelibrary.wiley.com/doi/10.1256/qj.03.201). This deeper analysis would help the reader understand what new knowledge is generated by this research. Currently this seems rather modest as it is detailed in just two sentences in the conclusions as follows: "The large number of storms investigated helped revealing the large variability in the location of CFC in a system-relative framework. Other differences to the literature include the time of occurrence of the CJ already several hours before the time of maximum depth in contrast to Hewson and Neu (2015)."

Minor specific comments:

L2 I suggest replacing "high winds" with "strong winds" as used on the previous line as "high" could refer to the altitude of the winds rather than their strength. Please also consider other places where "high" or "highest" is used.

L3 "strong cold-sector winds" are not a "dynamical feature" (unlike the other mesoscale features considered).

L35 Here it is stated that cold frontal convection is more common in cyclones following the Norwegian cyclone model. Can you point to evidence supporting this statement? Although cyclones following the Shapiro-Keyser conceptual model undergo frontal fracture, the cold front can be stronger than the warm front in idealised lifecycle simulations of these cyclones with the converse true for Norwegian-type cyclones (e.g., see Fig. 3 of Shapiro et al. 1999: https://link.springer.com/chapter/10.1007/978-1-935704-09-6_14).

L55 Regarding tracking cyclones over the Mediterranean, you might be interested in this recent paper: https://wcd.copernicus.org/preprints/wcd-2022-63/

L59 Probably worth pointing out that the calculation of Laurila et al. considers the wind extremes using monthly values (i.e., the extreme wind factor is the monthly 98th percentile/monthly mean)

L66 In this paragraph you should point out that the studies referred to consider different regions e.g., the Parton et al. and Earl et al. studies only consider the UK and so may not be representative of cyclones in general.

L107 Here it states that "January 2001 to December 2019" data is used whereas at the start of this section the observational dataset is described as extending to mid-2020.

L114 "we concentrate here on October 2000 to March 2019, i.e., a minor shift of three months". The model data starts 3 months earlier than the observational data but ends 9 months earlier. The reason this doesn't make any difference is because only extended winter data is considered - this could be made clearer.

L114 Can you please state the number of data points used to calculate the 98th percentile at each location and date. I think it's 210 (21 days of data for each of 10 years) but it would be good to know if I'm correct. The 98th percentile winds at any grid point will be strongly dependent on whether a localised strong wind region happens to cross that grid point on one of these 210 days. How does the value of this 98th percentile (or the lower "windy" threshold) vary spatially for a sample time snapshot? Also, is it correct that the wind speed threshold at a given time and place will be different in absolute terms for the model and observational data because the normalisation is calculated separately for the model and observational data?

L129 Here it states "Here, we apply RAMEFI to station observations and COSMO-REA6 data under windy conditions during the extended winter months, regardless of whether a storm occurred or not. However, we later filter the output for cyclone occurrence as discussed in Sect. 2.4." Please can you clarify if any of the results shown are not filtered for cyclone occurrence? I wondered if the filtering for cyclones might only be applied in Sections 3.2 and 3.3 or even just in Section 3.3.

Fig. 2 Can you provide more details on how the track density is calculated? This field is very smooth in the plot so I suspect that there is some averaging occurring (typically track densities are plotted as the number of tracks within a certain area, such as a 5 degree spherical cap, of each grid point). I don't think it's possible that there are up to about 3 storms with their MSLP centre located at a single grid point each winter. Also, it would be more helpful to readers for the track density per year to be plotted rather than the number over the 19 years.

Fig. 3 The domain used for analysis of the observational data is, I think, smaller than that used for the model data (see L105 and L118) with the latter extending further east and north. However, a further domain is specified in L169. If these domains are different then how does this difference affect the comparison between the results from the observations and model output shown in this figure? What would the figure look like if the same domains were used?

Fig. 4 Does this plot consider a feature as occurring if it has at least 100 grid points with any percentage of likelihood at each grid point or only if it is the most probable feature at a given grid point? What is the definition of a stormy time step (is it that any feature is present at at least 100 grid points?).

L242 "However, the recent two decades w[h]ere characterised by an unusual number of storms in October," - please provide evidence for this statement.

L243 I'm confused by the statement "given the lower threshold of $\tilde{v}$ - leads to a larger number of stormy time steps in the 19 years". $\tilde{v}$ is the wind speed normalised by it's 98th percentile value on the day of the year (and time of day and location) over the period 2005-2015 and stormy timesteps are those in which the windspeed exceeds 80% of $\tilde{v}$. Given this normalisation I'd expect the number of stormy days not to vary too much between months (as that is what the normalisation is trying to achieve). I suspect I've misunderstood something here - is it that the location specific nature of the windspeed threshold simply means that it picks out all stormy events? Please can you explain?

L247 Here the frequency of the cold jet is linked to that of cold air outbreaks. Please can you explain why these two phenomena could be expected to be linked?

L271 The definition of "windy" is different here to that in L167. L167 defines it as strong winds "in the vicinity of 15 degrees of the cyclone centre," which implies a circular region around the cyclone whereas here a box with ±15 degrees in the zonal direction and -15 to 5 degrees in meridional direction is stated. Which is correct? Also, how is the reducing zonal extent (in km) with latitude accounted for (e.g., 30 degrees in the zonal direction varies from 2330 to 1390 km between 45 and 65 degrees North)?

299 Here it is stated ”As orography can induce convection, CFC might be detected without the occurrence of a cold front or even cyclone”. I thought only windy features were identified close to a cyclone were considered though (see above comment and also the comment relating to line 129).

Fig. 6 I think a constant latitude has been assumed here (of 50 degrees) in the calculation of the distance circles as they appear circular. If the variation of zonal distance with latitude had been considered the distance circles would not be circular. This assumption should be stated in the caption. Please also add to the caption that the grey shading in (a) is for the NF winds.

Fig. 6a How is the location of the NF winds close to the cyclone centre consistent with Fig. 5b which shows NF winds are typically found to the south and north of the main storm track?

L373 ”RR values over $1\,\mathrm{m\,s^{-1}}$”. ”RR” isn’t defined in this paper but based on the earlier paper by the authors I guessed that it stood for precipitation amount. However, the units are then incorrect. Please define RR.

Fig. 8 What heights are all the fields considered at?

L383 Here it is stated that it is not surprising that the highest gust ratio is found for the CFC features because convection is associated with high instability and turbulence. The grid spacing of the model is about 6 km. Does it use a convection scheme or is convection represented explicitly? How are the gusts diagnosed in the model? Related to this point, it would be interesting to know how the climatology of model gusts shown in Section 4 compares to a similar climatology generated from the observations given the likely parametrization dependence of the model-derived gusts. Have you considered this?

L425 What is the evidence from your analysis that the CFC feature requires a convective trigger? The term ”trigger” is also vague: do you include both forced ascent and ascent due to the release of convective instability?

Technical errors:

L34 ”causing” → ”it causes”.

L44 ”As CJ” → ”As the CJ”

L51 ”perception on” → ”perception of”

L74 ”convection-induces” → ”convection-induced”

L85 ”northeastern” → ”northeast”

L106, L170, L190 ”less than” → ”fewer than” (n.b. you should use ”fewer than” if you can count the objects e.g., fewer bottles of lemonade but less lemonade). Please also check elsewhere in the paper.

L110 ”Ger- man” → ”German”

L156 Remove full stop before start of 1st sentence.

L168 ”in altitudes above 800m consistent to Part 1” → ”at altitudes above 800m consistent with Part 1”

L197 ”perscpective” - spelling.

L232 ”any” → ”every”

L239 ”amount” → ”number” (because the number of stormy timesteps can be counted).

L241 ”consistent to Feser et al.” → ”consistent with Feser et al.”

L242 ”where” → ”were”

L244 ”corresponds” → ”correspond”

L301 ”of CJ” → ”of the”

L306 add ”this” before ”suggests”

L326 ”(Gentile and Gray, 2023)” → ”Gentile and Gray (2023)”.

L330 ”particular” → ”particularly”

L446 ”helped revealing” → ”helped to reveal”

L450 ”larger” → ”longer”