'Review of “Identification of high-wind features within extratropical cyclones using a probabilistic random forest – Part 2: Climatology” by Lea Eisenstein et al.'
10.5194/wcd-2023-10

This paper provides a valuable 19-year, extended-winter climatology of strong winds related to cyclones in northwestern Europe. The novel aspect is the use of the RF-based approach recently published by the authors to label the near-surface winds according to distinct mesoscale features that produce the strong winds: the warm jet, cold jet, cold-front convection and cold-sector winds, along with a ‘no feature’ category. This distinction indeed shows different Earth-relative and cyclone-relative characteristics, and it opens the door to understanding the predictability of cyclone-induced winds which would likely depend on the feature.
The scope fits WCD well, the text is very well written and the figures compelling. I enjoyed reading the manuscript and I overall support its progress towards publication. There are, however, some aspects needing attention and clarification before its acceptance.

Thank you for the thorough review of our manuscript and many valuable comments that help to improve our paper. We have been carefully considering each comment, which are addressed in blue below. Text changes and more details will be provided in the Author’s response.

**Major comments**

1. Some key aspects related to the RAMEFI method need to be enhanced in the manuscript, so that Part 2 can stand alone: please explain how can station data from only 12 cyclones construct a sufficient training dataset for its applicability to (i) all cyclones in the climatology, to (ii) other, gridded data, and to (iii) location-specific features, such as land/sea differences or orographic effects.
   We will expand the description of RAMEFI regarding the following aspects:
   (i) While 12 case studies seem to be quite few, they represent a healthy diversity of cyclone developments and features including very intense and more moderate cyclones with differing storm tracks. Overall, almost 280 time steps leading to almost 80,000 data points are included in training the RF. The promising evaluation using a cross-validation approach in Part 1 suggests a reliable detection of the features in long-term data for most cyclones
   (ii) The statistical evaluation of the application on COSMO-REA6 data in Part 1 demonstrates that RAMEFI generates reliable identification of the features for gridded data despite being trained solely on surface observations.
   (iii) While the normalisation of $v$ and $\theta$ brings some independence of location-specific effects and we remove grid points/stations over 800m, some areas are still affected by nearby orography (e.g., Norway and the Balkans) and results should be treated with some caution here. As written in the manuscript, we did not statistically evaluate RAMEFI over the ocean and smaller differences are to be expected, but looking at several case studies did not show any obvious issues.

2. It is not entirely clear how the distinction is made among the WJ/CJ/CS/CFC during the initial subjective labelling in the vicinity of the front. Since the front is a narrow and slanted surface, the location of the front line changes with height, and accordingly the attribution of the windy grid points on both its sides. It is unclear how the station-based identification of convection relates to the commonly-used front detection by the 850-hPa temperature/wind/humidity gradients and why these features are mostly absent from oceanic locations. In this context I find the comment in lines 299-300 somewhat disturbing. How should one distinguish between winds caused by frontal convection from any other isolated convective downdrafts? It would be beneficial to clarify these points, so that the high uncertainty of the CFC winds can be reduced or better understood.
   Please note that we do not identify the front itself, but the convection induced in association with a front. While the most important predictor is *RR*, further predictors ensure the location in the frontal region, such that post-CFC is identified as CS rather than CFC. These include for example $\Delta p$ and $\theta$. However, in orographic regions such as the Norwegian mountains, CFC can be falsely detected.

3. The description of the application of the RAMEFI method to both station and model data should be enhanced. It was not clear to me from the text whether the method is carried out independently for each data set, and therefore providing independent probabilities for each, and why is it designed so? Therefore I wasn't sure if the differences among the datasets seen in Fig. 3 stem from the fact that there are stations only over land, and they are not evenly distributed, or whether there are additional biases from the application of the method to each dataset separately?
   RAMEFI makes decision based on only the single station or grid point at a certain time. Hence, it is not only applied to the data sets individually, but the output is also not dependent on neighbouring stations or grid points.
   Small biases are to be expected as the evaluation of COSMO-REA6 is slightly worse than for the observation data set, it was trained on. This is the reason why we compare the two data sets in this section. More substantial differences are rather due to data point distribution and overall differences in the development of a cyclone in the data sets.

4. The fact that NF is not randomly distributed in Figs. 6 and 7 suggests that some wind is currently associated to NF even though it should be coherently linked to the cyclone and is therefore mislabeled. Please quantify the sensitivity of the results to the labelling procedure, and estimate how much of the NF signal in Figs. 3 or 5 is found in the vicinity of cyclones.
   Fig. 6 and 7 show the absolute occurrence, i.e., independently of the other features or number of windy data points. The south-western area of a cyclone is characterised by higher wind speeds, while the north-eastern quadrant shows windy conditions less often. The relative occurrence shows the NF feature mostly in the north-eastern region as shown in Fig. FR1, which will be added to the Appendix.
   This climatology showed us that for example the CCBa, i.e., the CJ before it wraps around the cyclone centre, is more common than we expected when developing the method as a distinct peak of NF occurrence is visible there. Although, the CCBa could be considered as an additional feature in future work, the focus here is on WJ, CJ, CS and CFC, which are the most common causes of high-winds, and their detection is not hindered by CCBa being included in NF.
   The absolute occurrence of NF in the south-western quadrant is mostly caused by uncertainty, e.g., due to double fronts or untypical structures (see Sections 7.1 and 7.3 in Part 1).

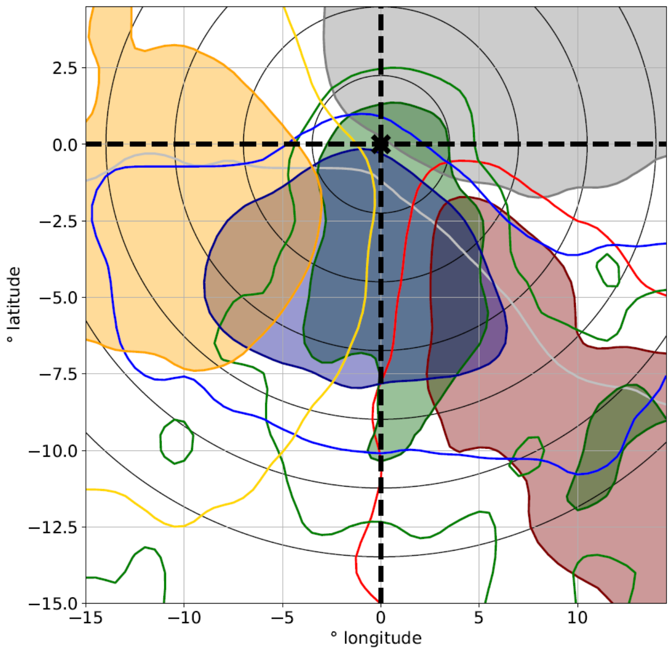


*Figure FR1: As Fig. 6 but divided by the number of windy conditions.*

**Specific comments**

Line 107: what is the timestep interval?

The timestep interval is hourly as mentioned in line 98 ("*The observational data set includes hourly surface observations*").

Subsection 2.2: Please provide more information on the model run: what is the domain? Boundary conditions? How are wind gusts and cloud cover parameterized in the model? Have they been verified against stations where these data are available?

Boundary conditions: ERA-Interim.

The cloud cover scheme is based on the contributions from grid-scale clouds, sub-grid convective clouds and sub-grid stratiform clouds. The cloud cover scheme is currently based on cloud water and cloud ice only, the contribution from the precipitation categories snow and rain are neglected. (COSMO Documentation Part II, https://www.cosmo-model.org/content/model/cosmo/coreDocumentation/cosmo_physics_6.00.pdf)

Cloud cover is verified with ceilometer measurements (Bollmeyer et al. 2015)

Convection scheme: Tiedtke (1989)

Gusts are estimated following Schulz & Heine (2003; https://www.cosmo-model.org/content/model/documentation/newsLetters/newsLetter03/cnl3-chp3.pdf) and Schulz (2008; www.cosmo-model.org/content/model/documentation/newsLetters/newsLetter08/cnl8_schulz.pdf) with a turbulent and convective gust component.

Line 164: what is the gridding radius of the tracks to produce the "track density"? also in this line it is mentioned "of all cyclones" - it is unclear if the track density is therefore normalized, and if so, what are the units in Fig. 2?

The radius is 750km. The track density is divided by the time period, so Fig. 2 shows the average number per year. We clarified this in the text and the caption.

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Fig. 2: add lat/lon labels, as these are referred to in the text

Lat/lon labels have been added here and in Fig. A1.

Line 260-261: A bit unclear if 0-10% refer only to NF and CS? And if so, CS in line 261 should be CJ? Is the correlation computed using monthly/seasonal means?

The 0-10% refer to every single feature to the number of stormy time steps. The correlation is computed for both monthly and seasonal means. We clarify this statement.

Fig. 5 and accompanying text: why are the areas east of the Alps masked as white?

We found that this area is affected by the westerly flow, hence, the Alps. The area commonly showed unreasonably high feature probabilities (especially for WJ). As this area is not often affected by extratropical cyclones or rather the associated mesoscale wind features, we decided to mask it. A short explanation will be added.

Line 356: mention how many individual cyclones are composited

We consider 1910 cyclones over around 20,000 timesteps. This will be added to Section 2.4.

Line 355-356: I cannot see the shorter duration of CFC in Figs. 6 and 7. Please clarify.

Fig. 6 and 7 only show when CFC – or any other feature – is common to occur relative to the cyclone lifecycle but do not consider the duration of CFC. As the chosen area does not always include the full development of a cyclone and, hence, does not allow for a meaningful analysis of duration of each feature, we decided not to show a corresponding figure. We added "not shown" to clarify this.

Fig. 8: are the gust data available from observations as well? Have they been verified against observations?

Unfortunately, gust data are not available in the used observational data set, such that a comparison is not possible.

Line 410: Mention also the other excluded regions east of the Alps
This will be done accordingly.

Lines 410-412: it is unclear if the cyclone-relative windy time steps use this relative domain or a 15-degree radius as inferred from line 167. Please clarify
We apologise for the confusion. We always consider the domain +-15° in zonal and -15 to +5° in meridional direction for a consistent analysis.

**Technical corrections**
Thank you for making us aware of these errors. If not noted otherwise, they have been changed accordingly.

Line 157: missing “are” before “targeted”

Line 168, 241: change “consistent to” to “consistent with”

Lines 192, 201, 209, 218: change “percentage points” to “percent” or simply “%”
We would like to clearly separate between ‘%’ and percentage points and keep the section as is.

Line 221: add “of” after “number”

Line 228: replace first “at” with “in”

Line 242: delete “h” from “where”

Line 273: remove “.” from “i..e”

Line 343: add “.” before “24h”

Line 391: add “relatively cooler” before “land”

Line 425: change “occurrence” to “occurs”

Line 450: replace “larger” with “longer”