

## **REFeree COMMENT**

Title: A global climatology of polar lows investigated for local differences and wind-shear environments

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### **1. GENERAL COMMENTS**

Most of the climatologies of polar lows (PLs) focus on a particular region, mainly in the Northern Hemisphere. A previous work of the same author provided the first much-needed global climatology of PLs using the predecessor of ERA5 and a regional reanalysis. This new study makes a significant contribution to the study of PLs by providing a global climatology of PLs based on the recently released ERA5 reanalysis.

The methodology used is adequate, and the selection of parameters to detect PLs is reasonable and well explained. The analysis of the climatology focuses on the main points of interest for the research community. In particular, the focus on the differences between PLs from different ocean basins is a subject that has received little attention in the past; thus, this is also an important contribution of this work. Finally, the section “Validation: Misses and False Positives” highlights one of the main problems of developing the climatology of PLs, which is selecting the adequate PL criteria that will minimize false positives and misses.

In general, the text is well-structured and easy to follow. The language is clear and concise, although there are several technical corrections that need to be done. Some minor corrections are also needed.

### **2. SPECIFIC COMMENTS**

#### *1. Introduction*

- p. 1, line 25, & p.3, line 81: The author uses Hersbach and Dee (2016) as reference, but that is a short text that was part of ECMWF’s newsletter that was written before the release of ERA5. Therefore, I recommend using Hersbach et al. (2020) since it describes the ERA5 reanalysis in detail:

Hersbach, H., Bell, B., Berrisford, P., Hirahara, S., Horányi, A. and co-authors. 2020. The ERA5 global reanalysis. Q. J. Roy. Meteorol. Soc. 146, 1999-2049. doi: 10.1002/qj.3803

- p. 2, lines 49 – 51: There should be a reference for those two sentences. For the sentence “Criteria for these characteristics are to some degree arbitrary due to a smooth transition between PLs and other cyclones”, Yanase et al. (2016) would be a good reference.

## *2. Data and methods*

- p.6, lines 154-155: The Verezhenskaya et al. (2017) study did analyze whether a system was intense enough to be considered as PL. Verezhenskaya et al. (2017) found 1735 mesocyclones and classified three quarters of those to be PLs. Although the criteria they used to classify mesocyclones as PLs was not very strict (mesocyclones developing over the ocean with maximum wind speeds > 15 m/s at least once during their lifetime), this reduced list would be more appropriate for this study than the whole list of polar mesocyclones, and it could potentially contribute to the parameter derivation of this study.  
If the Verezhenskaya list does not contribute to the parameter derivation of this study, it does not seem necessary to include it (and it is a little bit confusing for the reader to see that list in the study). It would be more appropriate to show the results obtained using the Verezhenskaya list in the supplementary material.
- p.7, line 195: Since there is no universal agreement on the PV threshold to define the dynamical tropopause, it would be relevant to add a reference here for the choice of 2 PVU.

## *3. Polar-low criteria*

- p. 8, lines 217 – 221: I suggest moving the summary of the PL criteria to the end of this section (before section 3.1), after the author has explained how the thresholds for the parameters have been selected. Otherwise, the reader gets the impression that the PL criteria have been obtained from another study.
- p.8, line 236-237: This sentence is not clear. The legend of Table 3 explains this a little bit better (it says: ““The last column displays the additionally excluded cyclones by the threshold after application of the polar-low criteria of different type.”). Since the other types of polar low criteria include different thresholds, it is not clear which thresholds are being considered here for each of those three criteria.
- p.15, lines 370-373: The statement that PLs with a longer lifetime are better simulated by ERA5 needs a reference to support it.
- p.16, line 420: Rather than “high quality”, it seems more appropriate to say that the derived climatology is “reasonable” given the disagreement in manually detected PLs. This section shows how difficult is to obtain a climatology of high quality, and the choice of the author seems reasonable given those challenges. This choice ensures that the climatology corresponds almost only to PLs (given that the false positive rate is 10 - 20%), but may not be complete since all PLs may not be captured (given that the miss rate is 48%).

## *4. Global polar-low climatology*

- p.17, lines 451-452: It would be relevant to shortly explain why the medicanes are “the Mediterranean sibling of PLs” and add a reference to support that statement. Some suggested references:

Businger, S. and Reed, R. J. 1989. Cyclogenesis in cold air masses. *Wea. Forecasting* 4, 133–156. doi:10.1175/1520-0434(1989)004<0133:CICAM>2.0.CO;2

Romero, R. and Emanuel, K. 2017. Climate change and hurricane-like extratropical cyclones: projections for North Atlantic polar lows and medicanes based on CMIP5 models. *J. Clim.* 30, 279–299. doi:10.1175/JCLI-D-16-0255.1

Moreno-Ibáñez, M., Laprise, R., and Gachon, P.: Recent advances in polar low research: current knowledge, challenges and future perspectives, *Tellus A: Dynamic Meteorology and Oceanography*, 73, 1–31, 2021.

- p.18, lines 481-482: It is more appropriate to say that this demonstrates that the PL climatology is “not strongly dependent on” the exact threshold in one of the criteria.
- p.19, line 495: According to Figure 4, the main PL season is between April and October, both included.
- p.19, lines 512-513: A reference is needed for this sentence “January and February (...) this is the time when cold-air advection from the Eurasian continent has the lowest temperatures”.

## 5. *Differences between polar lows*

- Section 5.1 (p.20-21): For each parameter, it would be pertinent to write the reference to the figure (e.g., “The typical vortex diameter of PLs (Fig. 3b)”).
- p.20, lines 546-547: This does not necessarily mean that “the fetch of the air masses in which PLs develop is often of only a few 100 km” because PLs can develop near a certain landmass (e.g., Svalbard), and travel many km before reaching another landmass (e.g., norther Norway), so the distance to the closest landmass will be of a few 100 km, but the air mass could have actually travelled more km.
- p.21, lines 566-567: A reference is needed for “due to generally lower sea-level pressure in the Southern Ocean at winter times, than anywhere else”.

## *Figures*

- Figure 5: It is hard to compare the results of the different regions because the y axis is different for each region.

### 3. TECHNICAL CORRECTIONS

#### *Text*

- p.4 lines 99-101: This sentence is hard to understand, so I recommend dividing it into two sentences.
- p. 2, line 43: “intentionally” instead of “intensionally”.
- p. 3, line 62: “affected” instead of “effected”.
- p. 4, line 103-104: I think this sentence is not needed and does not provide additional information: “they are expected neither over sub-tropical nor over ice-covered areas nor over landmasses.”
- p.5, line 124: Add “Hemisphere” after “Northern”.
- p.5, line 130: Define the acronym STARS since it is the first time that it is mentioned here: “Sea Surface Temperature and Altimeter Synergy for Improved Forecasting of Polar Lows (STARS)”
- p.7, line 174: “explained by the fact that the list consists of” instead of “explained by the list consist of”.
- p. 7, line 175: This sentence is needed because the previous and next sentences are sufficient to explain the results: “The high rate of weak systems in the Verezemskaya list is also expressed by a large number of cases in a short time period of four months as compared to the other PL lists that span multiple years.”
- p.8, line 222: “fourth” instead of “forth”.
- p.8, line 227: Add “The” before “following”.
- p.8, line 229: The fraction of PLs retained is 69-89% according to Table 2. I suppose the author excludes here the results related to the Verezemskaya list.
- p.12, line 286: Add “,” after “(SST–T<sub>500hPa</sub>”
- p.13, line 312: “Col. 6” instead of “Col.5”.
- p.13, line 313: “Col. 6” instead of “Col.5”.
- p.13, line 314: Consider using other word instead of “punishing”.
- p.15, line 371: “explained by the fact that PLs from the lists are biased towards longer lifetimes since” instead of “explained that PLs from the lists being biased towards longer lifetimes, since”
- p.15, line 387: “ground truth” instead of “ground-true”.
- p.16, lines 407-408: Add “according to the PL lists” after “whether they are considered PLs”.
- p.17, line 454: “edge” instead of “cover”.
- p.17, line 456-457: Remove “however” and “only”.
- p.19, line 519: Remove ‘,’ after “Note”
- p.20, line 555: “Bering Sea, whereas they” instead of “Bering Sea. Whereas, they”
- p.21, line 564: Add “d” after “measure”.
- p.21, line 586-587: A southerly wind is a wind that blows from the south, so I suppose the author means “northerly wind, warm-ward flow”.
- p.22, line 601-602: This sentence is not correctly written and does not add additional information, so it could be deleted: “Both these aspects point toward that PLs in a weak shear being mainly in the decaying stage in accordance to”.

- p.22, line 611: Write “the classification of a specific phenomenon as PL can be subjective” instead of “the choice whether a specific phenomenon is labeled as PL can be subjective”.
- p.22, line 620: “known” instead of “know”.

### *Tables*

- Table 1, line 2 (legend): Add “list” after “Yanase”.
- Table 1, line 6 (legend): There is information missing in this line. I suggest modifying what is written after “the PL from the list,” as follows: “and column 7 shows the number of tracks that are excluded since the ERA-5 track matches two PLs from the list”.
- Table 2, lines 1-2 (legend): Add “Hemisphere” after “Northern”.
- Table 3, lines 3-4 (legend): Delete “in addition also”, and add “also” before “presented.”
- Table 3, lines 3-4 (legend): Mention which of the rows corresponds to the threshold obtained excluding the Smirnova list.

### *Figures*

- Figure 1 (legend): Modify the first sentence because it is not well written, and it is not clear.
- Figure 2, line 5 (legend): Add “(f)” before “the sea-level”.
- Figure 2 (legend): The figure *e* needs to be explained in the legend.
- Figure 7 (legend): “Parameter distributions of polar lows for the different regions” instead of “Parameter distributions polar lows from the different regions”.
- Figure 7 (legend): The figure *d* needs to be explained in the legend.
- Figure 9 (legend): The quality of the figure needs to be improved.
- Figure 10, line 4 (legend): “are” instead of “is”.