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Interactive comment on "Polar Lows – Moist Baroclinic Cyclones Developing in Four Different Vertical Wind Shear Environments" *by* Patrick Johannes Stoll et al.

Anonymous Referee #3

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In the first part of this study, a new classification of the environment of polar lows. It is based on a SOM analysis applied to a polar low dataset detected from the ERA-5 analysis. The SOM analysis reveals that the polar low environments are characterized by the vertical wind shear vector relative to the propagation direction. In the second part of this study, the development of the polar lows is discussed using composite analyses. The authors concluded that most polar lows in strong shear environment develops through moist baroclinic instability, while weak shear environment are related to mature or lysis stage of polar lows. They also concluded that spirali-form polar lows are associated with warm seclusion process, not a hurricane-like process. There is a great interest on the question the authors tried to address, and the topic of the paper

fits the scope of WCD. The SOM analysis provides an objective support for a previously identified categorization i.e. forward and reverse shear. This paper clearly shows the moist-baroclinic development of polar lows and the absence of the hurricane-like development. The results are presented clearly, and the conclusions are logically supported by the results. However, there are several points that should be clarified before the paper will be accepted. Some of them are associated with the detection methods and the rest with development mechanism of polar lows.

1. The detection method -The detection rate of the polar low depends on the thresholds used in the algorithm. Usually, weaker thresholds result in the higher detection rate, but they also cause more false detection. The false detection does not affect the polar low list in this study, because it is compiled by comparing the detected polar lows with "observed" polar lows in Rojo list. However, to evaluate the capability of ERA-5, the sensitivity to the threshold should be examined. -The authors use all timestep of detected polar lows. I think this means that polar lows with longer lifetime have larger effect on SOM analysis. Is that affects the result?

2. Development mechanism of polar lows -The authors concluded that the orientation of the vertical-shear vector for the strong shear categories determines the dynamics of the systems. However, the fundamental development mechanism is moist baroclinic processes for all strong shear categories, while there are slight differences in their environments. Please clarify what is the different dynamics between these categories. -The authors mentioned the production of the potential vorticity associated with latent heat release. If this mechanism works, polar lows tend to move the direction of the maximum precipitation, which occurs in the warm sector. This is related to the diabatic Rossby vortex mechanism indicated by Terpstra et al. (2015). However, in Fig. 8, the distribution of the precipitation is not related to the propagation of the polar lows. Do the authors conclude the DRV mechanism does not account for the development of the polar low? Please clarify.

Specific comments L. 95: Why the authors used 850 hPa vorticity? L. 116: 13221

hourly time steps for 374 PL tracks means an average lifetime of 35.4 hour. This is almost upper end of the typical lifetime of the polar low (6-36h). Is this related to the higher capability of the ERA-5, i.e. the initial stage of the polar low can be detected? L. 192: Is this mean that each PL has one time step for the mature stage and the timesteps before (after) the mature stage are categorized into genesis and lysis stage? L. 216 I think low-level trough is located slightly “down-shear” of the upper-level trough. Fig. 2: Do the amount of the transition include all timestep? If a polar low experience several transitions, are all transitions counted? Fig. 4: I recommend the same arrangement of the number in the legend as the Fig. 2. L. 345: Fig 7c -> Fig. 7d L. 347: Fig 7d -> Fig. 7b. L. 370-373: From this paragraph, I could not understand the updraft is associated with baroclinic (i.e. adiabatic) or diabatic process. Please clarify. L. 434: Could you add the information about the number of transitions between shear category like Fig. 2.

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