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Prognostic criteria for Polar Lows

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Polar lows (PLs) are important mesoscale (horizontal diameter up to 1000 km) maritime weather systems at high latitudes, forming pole ward from the polar front. We consider the possible prognostic criteria of PLs, in particular, the kinematic helicity as a quadratic characteristic related to the integral vortex formations and the kinematic vorticity number (KVN). To calculate such characteristics we use reanalysis data and the results of numerical simulation with the WRF-ARW model (Version 4.1.) for the PLs over the Nordic (Norwegian and Barents) seas. For comparison, experimental data are used.

Our estimate of helicity is based on the connection of an integral helicity (IH) in the Ekman layer with the geostrophic wind velocity, due to the good correlation between IH and half the sum of the wind velocity squared. We have chosen IH averaged over preselected area covering the locality of PLs genesis. This area was moving along with the centre of PL during the numerical simulation.

The genesis of PLs can be divided into three stages: (i) an initial development stage, in which a number of small vortices appear in a shear zone; (ii) a late development stage, characterized by the merger of vortices; (iii) a mature stage, in which only a single PL is present. Approximately one day before PL formation, a significant increase in helicity was observed. The average helicity bulk density of large-scale motions has values of 0.3 – 0.4 ms^{-2}. The local changes in helicity are adjacent to the front side of the PLs. The IH criterion described facilitates the identification of the PLs genesis area. For a more detailed analysis of the PL genesis, it is recommended to apply KVN, which is the additional indicator of PL size and intensity. At the moment of maximum intensity of PLs KVN can reach values of 12 – 14 units. The advantage of using KVN is also in its clear change directly in the centre of the emerging PLs, which allows to precisely indicates the limits of the most intense part of PLs.

The main challenge is to make the operational forecast of PLs possible through the selection of the prognostic integral characteristics of PLs, sufficient for PLs identification and for analysis of their size and intensity in a convenient, usable and understandable way. The criteria associated with vorticity and helicity are reflected in the PLs genesis and development quite clearly. At this time, such a claim is only a hypothesis, which must be tested using a larger set of cases. Future work will need to extend these analyses to other active PL basins. Also, it would be interesting to compare the representation of PLs by using any other criteria. It is intended to use our combined criteria as

a precursor to machine learning-based PLs identification procedure where satellite image analysis and capture of particular cloud patterns are currently applied in most of the cases. It would eliminate the time consuming first stage of collecting data sets.

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