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Detection, monitoring and study of polar lows in the Arctic from satellites: advanced approach

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Polar lows are small-scale, short-living severe mesoscale storms which develop over the open ocean water areas in the polar regions. They are observed in both hemispheres, but the Arctic polar lows are significantly more intensive than Antarctic ones. Extreme winds, around and above the gale force of 15 m/s, are among the general features of all polar lows. Polar lows create a danger to oil and gas exploitation, fisheries, shipping and other activities in the Arctic. Their characteristics, intensity and areas of occurrence are changing with the global warming. Knowledge about polar lows is limited, mostly due to the lack of meteorological in-situ observational data in the polar regions. The detection, monitoring, study and forecasting of polar lows is extremely complicated due to their small size and short lifetime, as well as sparse synoptic observations and insufficient resolution of the most of the existing numerical weather models. In most cases satellite observations remain the only source of information about the polar lows. Therefore interpretation of satellite data becomes the most important factor in the study of the polar lows. Satellite passive microwave data represent an invaluable source of regularly available remotely sensed information for monitoring and study of polar lows. In this connection, a new approach for detection and tracking of polar lows is suggested which utilizes these data and consists of two stages. At the first stage the atmospheric columnar water vapor (Q) fields are retrieved from satellite passive microwave measurements. At the second stage the vortex structures are detected in these fields and polar lows are identified. The first stage is based on the developed special Neural Network Arctic regional polar algorithms for Q retrievals from SSM/I and AMSR-E data. These algorithms have high retrieval accuracies under wide range of environmental conditions. This technology ensures detection and tracking of all polar lows which is not achievable by any other means. Another, a multi-sensor approach, is used for polar low studies. This approach is based on combined use of data from various satellite sensors taking advantage of each of them. A number of polar lows, manifesting themselves in the water vapor vortex fields, retrieved from SSM/I and AMSR-E data, are detected, monitored and studied. All available satellite and in-situ data are used for this: Terra and Aqua MODIS visible and infrared images, Envisat ASAR images, QuickScat scatterometer and Metop ASCAT wind fields, surface analysis maps and re-analysis data. Based on the availability of satellite passive microwave data since 1979, polar low statistics for the Arctic, including trajectories of these mesoscale cyclones, is generated. By means of the analysis of two consecutive years of observations, 2006 and 2007, it is shown that the new areas appeared in the Arctic where these dangerous events can occur.