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Polar low monitoring

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Polar lows are intense mesoscale atmospheric low pressure weather systems, developing poleward of the main baroclinic zone and associated with high surface wind speeds. Small size and short lifetime, sparse in-situ observations in the regions of their development complicate polar low study.

Our knowledge of polar lows and mesocyclones has come almost entirely during the period of satellite remote sensing since, by virtue of their small horizontal scale, it was rarely possible to analyse these lows on conventional weather charts using only the data from the synoptic observing network. However, the effects of intense polar lows have been felt by coastal communities and seafarers since the earliest times. These weather systems are thought to be responsible for the loss of many small vessels over the centuries, although the nature of the storms was not understood and their arrival could not be predicted.

The actuality of the polar low research is stipulated by their high destructive power: they are a threat to such businesses as oil and gas exploration, fisheries and shipping. They could worsen because of global warming: a shrinking of sea ice around the North Pole, which thawed to its record minimum in the summer of 2007, is likely to give rise to more powerful storms that form only over open water and can cause hurricane-strength winds. Therefore, study of polar lows, their timely detection, tracking and forecasting represents a challenge for today meteorology.

Satellite passive microwave data, starting from Special Sensor Microwave Imager (SSM/I) onboard Defense Meteorological Satellite Program (DMSP) satellite, remain invaluable source of regularly available remotely sensed data to study polar lows. The sounding in this spectral range has several advantages in comparison with observations in visible and infrared ranges and Synthetic Aperture Radar (SAR) data: independence on day time and clouds, regularity and high temporal resolution in Polar Regions. Satellite passive microwave data make it possible to retrieve several important atmospheric and oceanic parameters inside the polar lows, such as sea surface wind speed, water vapour content in the atmosphere, total liquid water content in the clouds and others, providing not only qualitative image of a vortex, but also quantitative information about these severe events, constituting a promising tool for their study and monitoring.

An approach for detection and tracking of polar lows is developed utilizing the data from two sensors: SSM/I onboard DMSP and Advanced Microwave Scanning Radiometer – Earth Observing System (AMSR-E) onboard Aqua satellite. This approach consists of two stages. At the first stage total atmospheric water vapor fields are retrieved from SSM/I and AMSRE-E measurement data using precise Arctic polar algorithms, developed at NIERSC. These algorithms are applicable over open water. They have high retrieval accuracies under a wide range of environmental conditions. Algorithms are based on numerical simulation of brightness temperatures and their inversion by means of Neural Networks. At the second stage the vortex structures are detected in these fields, polar lows are identified and tracked and some of their parameters are calculated.

A few case studies are comprehensively conducted based on SSM/I and AMSRE-E measurements and using other satellite data including visible, infrared and SAR images, QuickScat Scatterometer wind fields, surface analysis maps and re-analysis data, which demonstrated the advantages of satellite passive microwave data usage in the polar low studies.