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Detecting polar lows using total water vapour retrieved from the space-bourne microwave radiometer AMSU-B

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In the Arctic, mesoscale cyclones, such as polar lows, are common particularly over the open ocean and the marginal ice zone. The strong winds associated with the cyclones have a major influence on sea ice dynamics, and present a serious risk for navigation. In addition, mesoscale cyclones are supposed to make a large, but insufficiently known, contribution to the lateral transport of heat and moisture into the Arctic atmosphere. As even the present-day observational network is incapable of detecting all mesoscale cyclones, there is a need for new and/or improved methods to detect polar lows.

Here we present a study on the detectability of polar lows in maps of the total water vapour (TWV, also called column water vapour or precipitable water) derived from data of the space-bourne microwave radiometers AMSU-B (Advanced Microwave Sounding Unit B) on the polar-orbiting satellites of NOAA since NOAA-15 (1999). The method to derive the TWV [1, 2] uses the radiances at five frequencies between 89 and 183 GHz. It is independent of the surface emissivity, of daylight and of most clouds. The method can retrieve TWV values up to about 7 kg/m^2 (20 kg/m^2 over ice) which makes it suitable for the polar regions. There are about 14 satellite passes (swath width is about 2000 km) per day, so typically, a location in the Arctic is covered twice per day by one satellite. As there are generally two NOAA satellites operational at most times, each location in the Arctic is covered up four times daily. The spatial resolution of the AMSU-Bdata (and hence of the TWV data) is 15 km in the middle of the swath (nadir pixels) and 50 km near the edges.

Starting point was a list of polar lows in the years 2001 to 2005, mostly based on cases detected by the Norwegian Meteorological Institute weather service in Tromsø, but with added information of the mean sea level pressure and TWV from the ECMWF (European Centre for Medium-Range Weather Forecasts) operational analyses. We have compared the 15 most prominent cases with TWV data retrieved from AMSU-B, selecting the satellite pass which was closest in time to the reported polar low; typically, the time difference is less than 6 hours.

In almost all of the 15 cases, there was an area of *low* TWV at the location of the polar low. This seems somewhat surprising as polar lows are expected to be associated with high humidity. However, it is known that the TWV algorithm yields erroneously low TWV when there are strong ice clouds. Polar lows typically show strong convective activity which in turn is known to be associated with high cloud ice values. For the polar low cases investigated here, ECMWF-based cloud ice content at the locations of the Polar lows was indeed high, so it is likely that cloud ice causes the TWV algorithm to yield very low TWV values. This, in turn, makes polar lows detectable in the TWV data.

Better detection and tracking of polar lows can improve monitoring, modelling and forecasting of the Arctic ocean and atmosphere.

References

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[2] Melsheimer, C., and G. Heygster. Improved Retrieval of Total Water Vapour over Polar Regions from AMSU-B Microwave Radiometer Data. Submitted to *IEEE Trans. Geosci. Remote Sens.*, 2007.