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The mesoscale structure of a mature polar low: Airborne measurements and numerical simulations

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A unique data set of airborne light detection and ranging (LIDAR) and dropsonde observations was obtained during the field campaign IPY-THORPEX (IPY-THORPEX was an international field campaign funded by the Norwegian Research Council, DLR and EUFAR. The DLR Falcon was employed in about 60 flight hours to observe Arctic fronts, polar lows and terrain-induced flow disturbances, see e.g. http://www.pa.op.dlr.de/ipy_thorpex) over the Norwegian and Barents Seas in February and March 2008. The presentation overviews selected research flights focussing on the concomitant LIDAR observations of water vapour and wind.

The mesoscale structure of a mature polar low was studied in detail on the basis of high resolution airborne measurements and numerical modelling. Numerical simulations were performed with the Integrated Forecast System (IFS) of the European Centre for Medium-Range Weather Forecasts (ECMWF) and a high resolved, polar version of the Weather Research & Forecasting Model (WRF) driven by the ECMWF data. The LIDAR observations provided cross sections of water vapour mixing ratio, backscatter ratio and horizontal wind speed around the polar low and through its centre. Mesoscale structures, such as shallow convection in a cold air outbreak, deep convection in the eye wall and a dry intrusion in the centre of the cyclone could be identified. WRF simulations reproduced these structures and showed that the polar low had a warm, upper level core with descending motions.

Several WRF sensitivity tests showed the influence of the initialisation time and sensible and latent heat fluxes from the surface on the simulated polar low development. The polar low was better simulated the more closely the simulation started at the mature stage. Heat fluxes from the surface supported the polar low energetics especially at final stages. When surface fluxes were switched off, the polar low weakened too much and sea level pressure in the core was significantly too high. Quantitative comparisons between simulations and LIDAR observations showed that cloud top heights and vertical water vapour profiles were simulated properly both in shallow and deep convection.

Special investigations focussed on the eye of the polar low. The centre was characterised by rather stable stratification, horizontally constant potential temperatures and calm winds. Wind speeds increased rapidly in the eye wall. The size of the eye was about 100-150 km in diameter. Similar eye structures were already found in idealised simulations.