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The full life cycle of a polar low over the Norwegian Sea observed by three research aircraft flights

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During 3-4 March 2008, the Norwegian IPY-THORPEX field campaign successfully carried out three flight missions that probed the full life cycle of a polar low over the Norwegian Sea. The three dimensional structure and underlying physics of the polar low have been investigated using dropsonde data from the three flights and a series of fine mesh (3 km) experiments with the Weather Research and Forecast (WRF) model. The polar low developed in a cold air outbreak, with temperature differences between the sea surface and 500 hPa of about 45-50ºC. Cross sections show that the horizontal gradients of potential temperature weakened as the polar low matured, suggesting that baroclinic energy conversion took place. Dropsonde data of potential temperature and relative humidity show evidence of a tropopause fold, which is possibly a manifestation of upper level forcing. This is corroborated by potential vorticity inversion, which shows a dominant role of upper level forcing throughout the polar low lifetime. During the cyclogenesis stage the polar low circulation was confined below 700 hPa, with a northerly low level jet of 26 ms-1. In the mature stage, its circulation reached up to the tropopause (∼450 hPa), with maximum wind speed between 700-900 hPa of about 28-30 ms-1. At this stage the polar low warm core was about 3 K warmer than surrounding air masses. The deep moist towers at the eye-like structure of the polar low extended up to the tropopause with relative humidity values above 70%, indicating a possibly important role of condensational heating for the development. This suggestion is supported by sensitivity experiments with condensational heating switched off, which produced a much weaker polar low. Estimates of surface fluxes of sensible and latent heat using temperature and moisture from the dropsonde data show latent heat fluxes west of the polar low increasing from 175 to 300 Wm-2 as the low matured, while the sensible heat flux rose from 200 to 280 Wm-2, suggesting a gradually increasing contribution of surface fluxes to the energetics of the polar low with time. In an experiment with both surface energy fluxes turned off, the polar low failed to deepen, revealing the crucial role of surface fluxes for the polar low evolution. Omitting sensible and latent heat fluxes separately showed that the polar low was dominated by sensible heat fluxes, with latent heat fluxes playing a minor role.