Evaluation of two NWP model experiments for very stable conditions over an Antarctic ice shelf

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Abstract

Numerical weather prediction (NWP) and climate models continue to have large errors for stable boundary layers (SBL). Many models commonly have too much turbulent mixing in SBL, which may be compensated by errors in other flux variables. Observations from the British Antarctic Survey station Halley on the Brunt Ice Shelf, Antarctica, represent one of the best data sets available from flat polar areas. We present preliminary results of NWP model evaluation against observations of very stable conditions at Halley.

From the observations of Halley, a case with development of very stable boundary layer was identified between 17 and 21 May 2003 and this period was selected for a numerical model validation study. Observations included temperature, humidity and wind measurements from a 32-m mast, turbulent and radiative fluxes, snow temperatures, daily rawinsonde soundings, and visual cloud observations. During the development of the very stable stratification, the 1-m wind speed calmed down from 6 m s-1 to less than 1 m s-1, the 1-m air temperature dropped from -17 C to -35 C, and a 15 C inversion was generated in the 31-m layer observed by the mast instruments.

The selected case was simulated applying two NWP models: The Polar WRF and HIRLAM. The models took the initial and boundary conditions from ECMWF analyses; however, HIRLAM was initialized every 6 h. In the Polar WRF simulations, three nested domains (36, 12 and 4 km) were applied, whereas the domain of HIRLAM had a 7-km grid mesh. The physical parameterization schemes varied between the models, and the combination of schemes used in the Polar WRF simulations was selected to follow the scheme combination of the Antarctic Mesoscale Prediction System (AMPS).

Results of the simulations indicated that both Polar WRF and HIRLAM had systematic cold bias at 32 m, but mostly warm bias at snow surface. The turbulent surface flux of sensible heat was far too large in both models in the very stable conditions, which inhibited the realistic simulation of near-surface air temperatures. Initialization of snow temperature profiles also required special attention in order to get realistic near-surface air temperatures. On the other hand, temporal evolution of wind speed was well captured, especially by Polar WRF. Generally, Polar WRF and HIRLAM gave fairly similar results for the near-surface variables, which suggests same type of weaknesses in these models. Their most apparent difference was that Polar WRF succeeded much better for the surface friction velocity, which was strongly overestimated in HIRLAM.