Prediction of Antarctic weather by JMA-NHM to support JARE

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1. Introduction

The 6-year phase IX of the Japanese Antarctic Research Project began in the 2016–17 austral summer with the main scientific theme of "Investigation of changes in the Earth system from Antarctica". This project uses the Japan Meteorological Agency's Non-Hydrostatic Model (JMA-NHM; Saito *et al.*, 2006) for weather prediction over the entire Antarctic continent to support the activities of the Japanese Antarctic Research Expedition (JARE). This article describes the numerical prediction system and preliminary results.

2. Numerical prediction system

The numerical prediction system is established based on the JMA-NHM with several modifications, as described in Hashimoto et al. (2016, 2017), to better represent the meteorological processes over the ice sheet, since the original model was fitted to mid-latitude environments.

The computational domain is 6096 km × 5664 km wide and its horizontal resolution is 6 km (1016 x 944 grid cells). The standard latitude and longitude are at 80.00 °S and the prime meridian, respectively, in the polar stereographic projection. The lower left point of the domain is located at 54.63 °S, 132.47 °W (Fig. 1). The top height of the domain is 22 km. There are 50 layers in the vertical direction, increasing from 40 m thick at the surface to 886 m at the top in a terrain-following coordinate system. The integration time is 42 h, with a timestep of 15 s. The radiative process are computed every 15 min at a horizontal grid spacing of 12 km. The initial and boundary conditions are obtained from the JMA's global forecast. The model topography is based on the 5-km-mesh surface elevation data from the digital elevation model of Antarctica provided by Le Brocq et al. (2010).

The simulation is performed twice a day starting at 0900 or 2100 SYOT (UTC+3), corresponding to the forecast time FT = 6 h in the JMA's global forecast starting at 0300 or 1500 SYOT, respectively. Boundary conditions are given every 6 h. Figure 2 shows the schedule and data flow for the prediction starting at 0900 SYOT.

Computations are run on the HITACHI SR24000 Model XP1 supercomputer at the National Institute of Polar Research (NIPR).

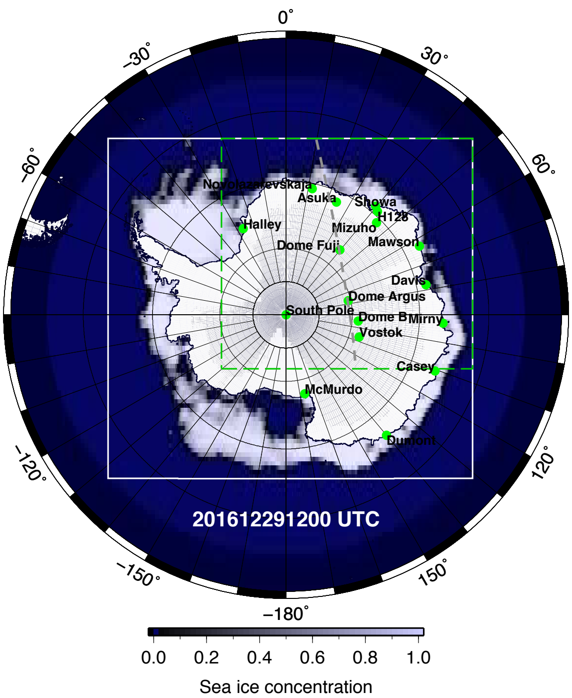

Fig. 1. Computational domains of the weather model (white line) and the test-bed system (green broken line). The gray broken line shows the CloudSat orbit corresponding to Fig. 5.

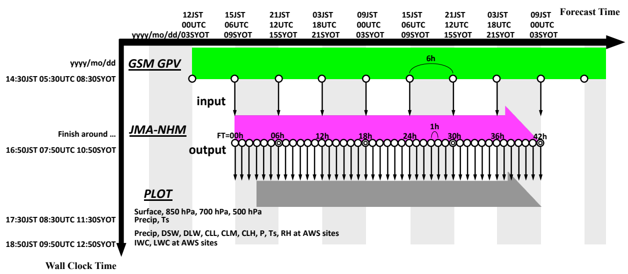

Fig. 2. Schedule of weather prediction starting at 0900 SYOT. Fine black arrows indicate data flow.

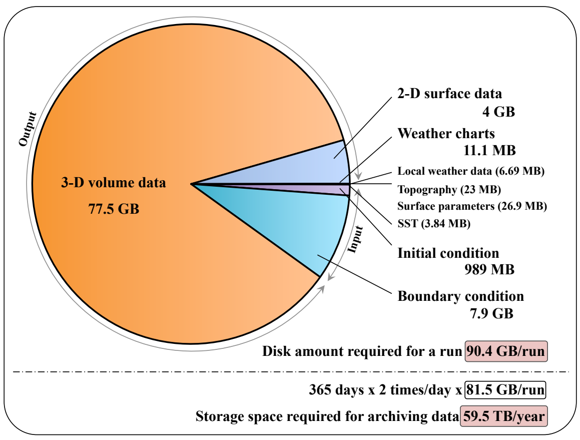

Fig. 3 Data storage required for one run of the weather prediction model and for archiving data for a year.

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Each job runs with 320 Multi Processor Interface (MPI, 20 MPI x 16 nodes) and finishes in about 2 h. This costs 23,360 node-hours/year (16 nodes x 2 h x 2 runs x 365 days). Each run needs 90.4 GB of free disk space for input/output operation (Fig. 3). For archiving the data, including vertical profiles above observation sites and plotted graphs for each simulation, the data size is 81.5 GB/run, which equals to 59.5 TB/year. Excluding the three-dimensional from the archive reduces this to 4.0 TB/year. A test-bed system is also operated once a day with a smaller domain (Fig. 1) at the Meteorological Research Institute in parallel with the main system as a backup and for testing for improvement of the system in future. In the next section, we present preliminary results from the test-bed system.

3. Preliminary results from test-bed system

Figure 4 shows the observed and predicted results for surface wind speed and surface air temperature from 22 December 2016 to 15 February 2017. Wind speeds of >10 m s^{-1} were observed in several storm events accompanied by synoptic-scale perturbations (Fig. 4a). The model predicted these winds well. On the other hand, in the absence of considerable synoptic scale forcing, during the first couple of weeks, the model over-predicted the wind speed, which was mostly < 2 m s^{-1}. The model tended to underestimate surface air temperature throughout most of the period (Fig. 4b). Local air circulation near Syowa station is likely to be influenced by coastal topography. These results indicate that it is difficult for a model with a horizontal resolution of several kilometers to precisely predict the transport of heat and momentum by local circulation. Figure 5 shows reflectivity at 1400 on 29 December 2016 observed by CloudSat Cloud Profiling Radar (CPR) and simulated by the Joint-Simulator (Hashino et al. 2013) from the output from the JMA-NHM. Both observations and the model consistently detected cloud systems over the Antarctic Ocean and over the slope of the Antarctic ice sheet.

4. Summary

A numerical weather prediction system was established based on the JMA-NHM to support the activities of JARE in Antarctica and for performance evaluation. Comparisons between observations and model predictions of local weather at Syowa station and vertical cross-sections of cloud systems agreed well. Further validation and improvement of the model will be the basis of future work.

Acknowledgement

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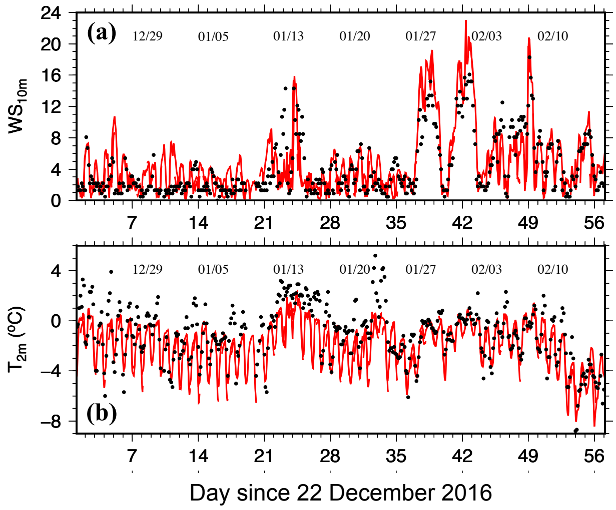

Fig. 4 Observed and predicted (a) surface wind speed and (b) surface air temperature.

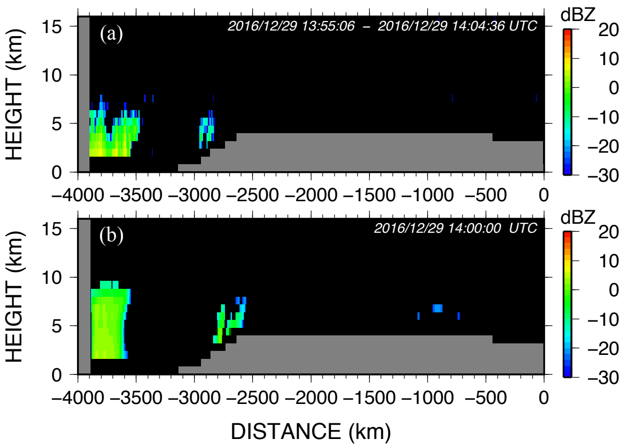

Fig. 5 Cloud reflectivity (a) observed by CloudSat Cloud Profiling Radar on 29 December 2016 along the orbit shown in Fig. 1 and (b) simulated by Joint Simulator from output from the JMA-NHM.

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