Impacts of Surface Pressure Observations in the Antarctica on JMA's Global Data Assimilation and Forecasting

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Background

Part of JMA's work involves assimilating surface pressure observations in the global data assimilation system. Direct measurement of meteorological parameters, such as surface pressure through conventional observation instruments provides an important source of data for maintaining operational analysis and forecast accuracy. Antarctica is a data-sparse region whose land surface is characterized by extremely steep topography and is covered with snow and/or ice for most of the year. This land surface situation makes it difficult to use surface-sensitive satellite data in NWP because of the insufficient accuracy of the surface emissivity modeling in radiative transfer calculation. Accordingly, surface observations in Antarctica are considered more important than those in other areas, and JMA's system has accepted these observations as much as possible.

However, recent improvements to the horizontal resolution of JMA's global forecast model (to about 20 km) and analysis accuracy have revealed the improper use of surface pressure measurements in Antarctica within the current JMA system. As a result, this is an appropriate time to review quality control performance for surface observations in JMA's global data assimilation system.

In this study, we identified unacceptable surface pressure measurements in Antarctica for the global data assimilation system. As data rejection is difficult in the current normal quality control scheme, data which have systematic biases were blacklisted in the system. As a result, improvements in analysis and forecast were confirmed.

Surface pressure observation in Antarctica

Figure 1 shows the reported locations of surface pressure observations in Antarctica from 20 July to 9 October 2009. The data were assimilated after quality control in the operational system. Figure 2 shows time sequences of surface pressure innovations (O-B) for data at two locations. We found that surface observations at several points in Antarctica had large negative or positive biases against the background field for the period, and a large bias was also found for another period. A scheme to correct differences between the model topography and the reported topography was utilized in quality control. The remaining bias could be caused by a number of factors (e.g., disagreement between the reported altitude of observation location in the WMO station table and the actual instrument altitude, erroneous instrument characteristics, JMA global model biases). It should be noted that about 17% of surface observations in Antarctica were blacklisted. Other data at many locations showed good agreement with the background field for the same period.

Impact of data removal on JMA's operational data assimilation and forecasting

Figure 3 shows a comparison of the root mean square (RMS) for analysis increments of 500-hPa geopotential height with and without biased data. After the removal of biased surface pressure data at several locations in Antarctica, the erroneous analysis increment for 500 hPa disappeared. RMS errors for 24-hours forecasts against the analysis were also improved around Antarctica (Fig. 4). The biased data were blacklisted on December 10, 2009 in the operational system. Figure 5 shows a time sequence of monthly averaged RMSEs of 24-hour forecasts for 500-hPa geopotential height in the Southern Hemisphere. An improvement in operational JMA forecast accuracy was confirmed in comparison with other NWP center forecast scores in Dec. 2009.

Summary

In JMA's global data assimilation system, quality control for surface pressure data in Antarctica was revised on December 10, 2009. Although satellite data have a dominant impact on analysis and forecast accuracy, the removal of biased conventional data produced improvements in the operational forecast score. This outcome suggests that quality control for conventional data is more important than expected in the JMA system, especially for data-sparse areas.

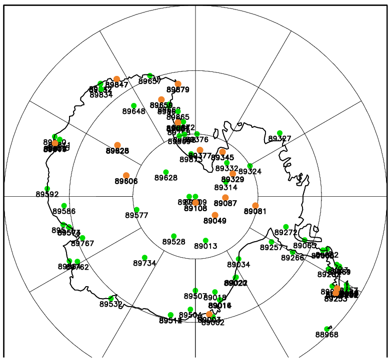

Fig. 1 Reported locations of surface pressure data in Antarctica. The orange points indicate blacklisted observation locations.

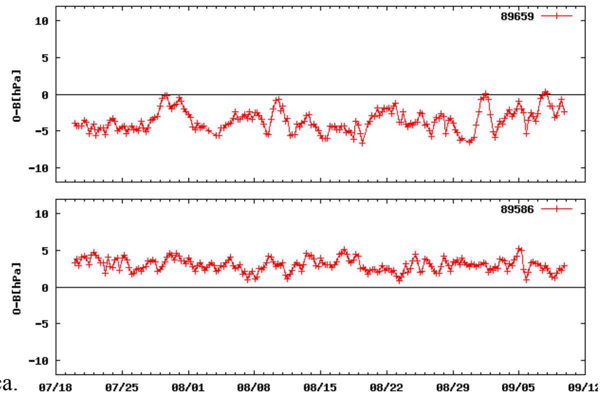

Fig. 2 Time sequences of surface pressure innovations (observed – background) for biased data against JMA background field in Antarctica.

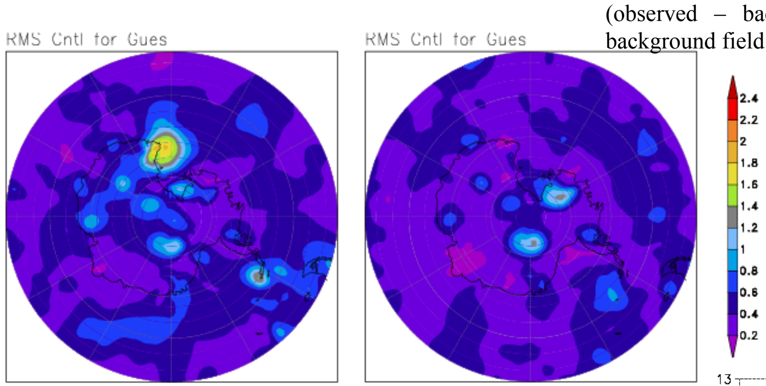

Fig. 3 Comparison of three-day averaged root mean squares for analysis increments of 500-hPa geopotential height. On the left are the RMSs before data removal (i.e., with biased surface pressure data), and on the right are those after data removal (without biased data).

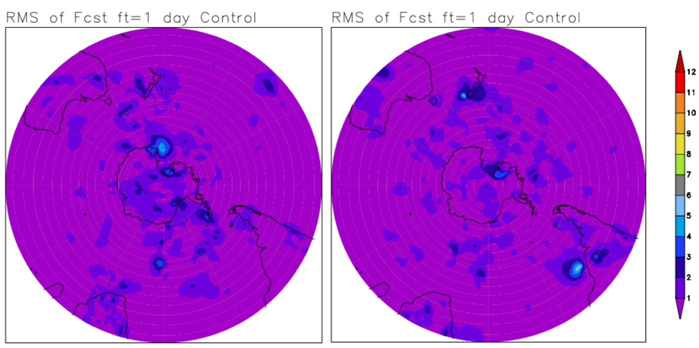

Fig. 4 Three-day averaged RMSEs of 24-hour forecasts for 500-hPa geopotential height. On the left are the RMSEs before data removal, and on the right are those after the data removal.

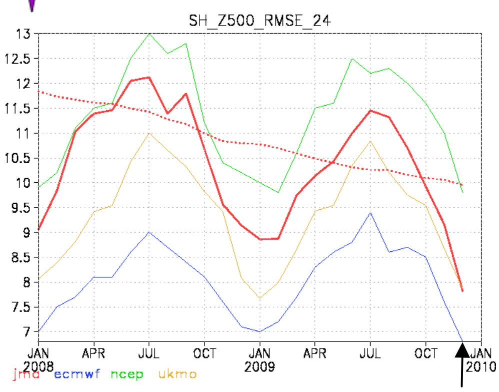

Fig. 5 Time sequence of monthly averaged RMSEs of 24-hour forecasts for 500-hPa geopotential height in the Southern Hemisphere for several NWP centers. The dotted line is the 12-month moving average. The black arrow indicates data for Dec. 2009