Modifications to INTERPF for Antarctic Forecasts

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The Antarctic Mesoscale Prediction System produces real-time high-resolution numerical forecast products in support of operations in Antarctica (AMPS; Powers et al., 2001a; 2001b). A problem that has been noticed is a large imbalance in the initial conditions pressure field. This paper outlines the problem and suggests a solution which has been implemented in AMPS.

Antarctica has large areas of elevated terrain, in excess of 3 and 4 km. The vertical temperature structure of the atmosphere over the Antarctic continent is characterized by a persistent and strong inversion. These two characteristics together confound the algorithm used in program INTERPF to compute surface pressure. For example, the surface perturbation pressure from the output of INTERPF shows a discontinuity around the region of elevated terrain (Fig. 1). A pressure trace (Fig. 2) from the South Pole in the MM5 forecast initialized

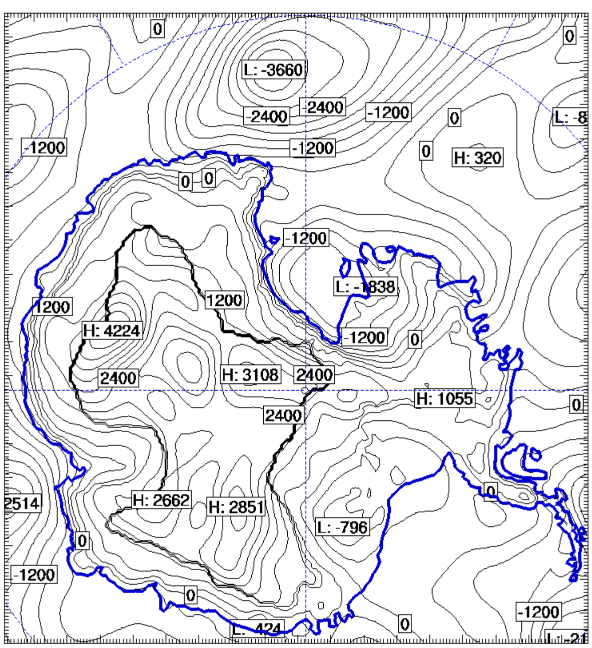

Fig. 1: Initial conditions surface perturbation pressure (Pa) from the original INTERPF program.

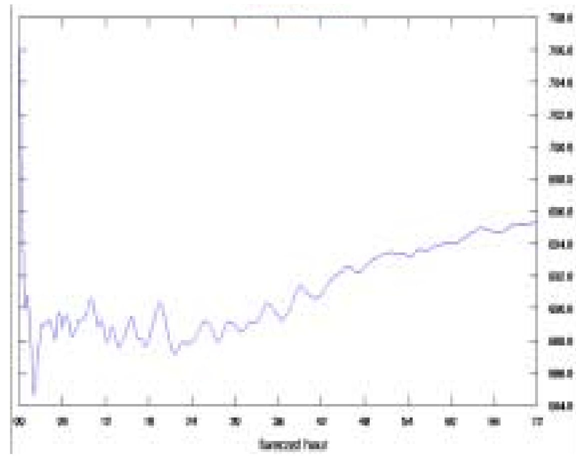

Fig. 2: Pressure trace (hPa) from MM5 forecast initialized with the original INTERPF program. Time series from the model point situated at the South Pole.

with those conditions shows a large adjustment to significantly lower pressures in the first few time steps. The initial imbalance and rapid model adjustment excite acoustic and gravity waves which can be seen in the results for many hours.

The algorithm in INTERPF to compute surface pressure varies depending on the elevation of the terrain, but in any case it depends on deriving an artificial surface temperature from upper-level temperatures. For estimated surface pressures below (i.e., higher in the atmosphere than) 700 mb, the artificial surface temperature is derived essentially by hydrostatically reducing the 500 mb temperature to the surface, applying the standard lapse rate of 6.5 K km^{-1}. The surface pressure is then computed hydrostatically from the sea-level pressure and the artificial surface temperature, again assuming a standard lapse rate from surface to sea-level.

For estimated surface pressures above 700 mb, the artificial surface temperature is derived, again making the hydrostatic assumption with the standard lapse rate, from a temperature interpolated from surrounding mandatory levels to a level approximately 100 mb above the surface.

A large area of Antarctica has terrain above the 700 mb level; in those areas, the artificial surface temperature used in computing surface pressure is computed hydrostatically from the 500 mb temperature. However, the strong inversion over the continent and the elevated terrain means that the 500 mb level may often be nearly the warmest level in the troposphere. The algorithm for surface pressure then completely ignores the cold air near the surface, mischaracterizing the thermal structure of the atmosphere, and producing a surface pressure that is too high. Additionally, the change in the algorithm between estimated surface pressures below and above 700 mb results in the discontinuity seen in Figure 1.

Since the failure of the algorithm comes in the estimation of an artificial surface temperature, we have adapted the methods slightly for use over Antarctica. Instead of deriving this artificial temperature from upper-level temperatures which may not represent the atmosphere well, we simply take a temporal average of surface air temperatures as our artificial sur-

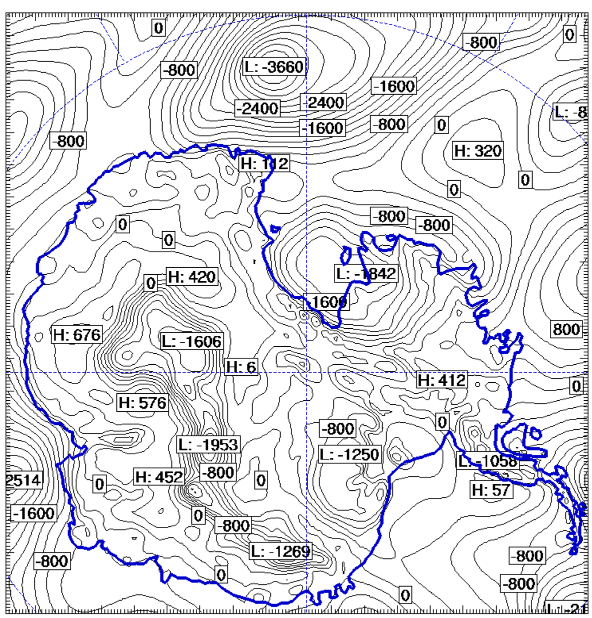

Fig. 3: Initial conditions surface perturbation pressure (Pa) from modified INTERPF program

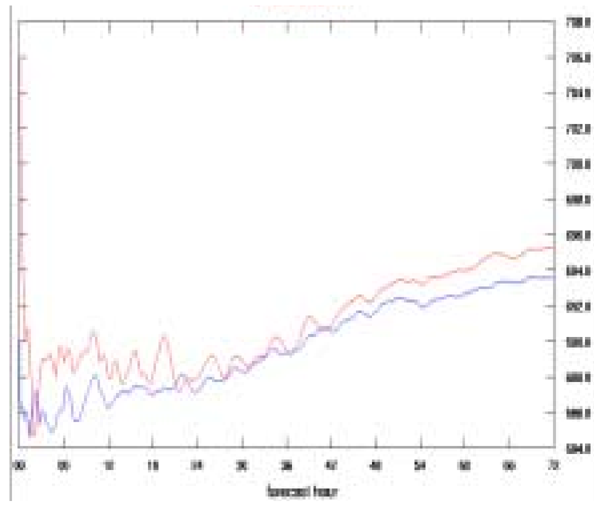

Fig. 2: Dark line: pressure trace (hPa) from MM5 forecast initialized with the modified INTERPF program. Light line indicates results with the original INTERPF program.

face temperature. This gives us a field which better represents the lower-atmospheric temperature, and avoids the discontinuities of moving from level to level. Results are presented in Figures 3 and 4, which show considerable improvement over Figures 1 and 2.

The perturbation pressure field (Fig. 3) shows no discontinuity, and is lower than the original perturbation pressure field by 30 to 40 mb in places. There is still evident some correlation with terrain. The pressure trace (Fig. 4) shows a much smaller adjustment than before, and less oscillation of pressure throughout the forecast.

In general, we do not expect this modification to find much application outside of the unique circumstances of Antarctica. Tests of midlatitude cases have shown minimal improvement or even slight degradation of the initial conditions.

References

Powers, J.G., Y.-H. Kuo, J.F. Bresch, J.J. Cassano, D.H. Bromwich, and A. Cayette, 2001: The Antarctic Mesoscale Prediction System. 6th Conf. on Polar Meteorology and Oceanography. San Diego, CA, 14-18 May 2001, 339-342.

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