The Impact of High Resolution Satellite Data on MM5 Forecasts

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1 INTRODUCTION

In the 2008-2010 time frame, a new meteorological satellite system will become operational. This new system, called the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) [2], is the result of the convergence of the U.S. civilian (POES) and the Department of Defense (DMSP) polar-orbiting satellite systems. NPOESS will be comprised of at least three spacecraft in sun-synchronous orbit, each carrying a suite of instruments representing the next generation of meteorological remote sensors. The design specifications for the sensors and data-processing algorithms include spatial resolutions and accuracies for each physical quantity reported. These specifications represent an improvement in quality and quantity over the data currently available for operational weather forecasting.

The impact of a proposed observing system on weather forecasting can be evaluated by an observing-system simulation experiment (OSSE) [1]. In such an experiment the observing system data is simulated by appropriate quantities derived from the results of a numerical weather prediction model, chosen to serve as a nature run. Then an independent forecast model is used to make weather predictions both with and without the simulated observations. The results are compared to assess the overall impact of the new observing system.

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2 METHODOLOGY

In the present study the simulated observations are based on the Mesoscale Atmospheric Simulation System (MASS) model [3], [4] created and run for an Air Force Combat and Climatology Center project. Model results pertaining to a 30-day period in 1982 over the Korean peninsula are sampled to simulate NPOESS data and soundings at World Meteorological Organization (WMO) locations. The simulated NPOESS data has a horizontal resolution of approximately 18.5km for temperature and dew point temperature and a horizontal resolution of 50km for winds. The vertical resolutions are finer than the MM5 grid used.

The MM5 version 3 is used to generate forecasts using NCEP analyses with and without the enhancement of NPOESS simulated data. The MM5 is implemented in a way that is consistent with its use by the Air Force Weather Agency so as to focus on potential benefits of NPOESS to current Air Force weather prediction operations. The MM5 calculations are on two, nested grids, covering a 1500 by 1500km region centered on the Korean peninsula. The inner grid has a 10km horizontal resolution and 21 vertical levels.

Two assimilation runs are made with the MM5 for the 30-day experiment period to produce fields enhanced only by WMO data and those enhanced by both NPOESS and WMO data. In both cases the simulated observations influence the calcula-

tions through little_r and four-dimensional data assimilation (observational analysis). For simplicity, observational data is used at a single, fixed time each day, even though NPOESS will likely provide data three times a day. These results are used to initialize 6, 12, and 24-hour forecasts, which are then compared to the nature run.

3 RESULTS AND DISCUSSION

A comparison of the assimilation runs and the nature run shows that the addition of simulated NPOESS data brings the fields closer to the nature run, as expected. However, the differences between the two assimilation runs are small in comparison to the differences between the nature run and either assimilation run. This is attributed to several factors, including the use of only one observation time each day. In addition, some of the MASS model data is suspect, such as small-scale temperature fluctuations (that are not maintained by the MM5). Also, the time and location chosen for the experiment coincided with an El Nino year and a Monsoonal transition period, making mesoscale modeling especially challenging. It is noted that certain quantities, such as mid-level temperatures, are nudged more successfully than others, such as dew point temperature.

The MM5 forecasts initialized by the assimilation runs diverge further from the MASS model (the nature run). Certain forecast quantities show that errors (relative to nature run) are significantly reduced when NPOESS simulated data is used. For example, 500mb temperature accuracies are significantly improved for three and six-hour forecasts, and only marginally improved for longer forecasts. On the other hand 850mb temperature and 300mb temperature are not improved by the use of NPOESS simulated data. Cloud water predictions, which are particularly important in military applications, are marginally improved at 850mb for short forecasts and are not improved at other levels.

Overall, NPOESS simulated data provides little improvement in forecasting. This is due, in part, to the relatively small impact of observations seen in the assimilation runs, suggesting that an alternative to four-dimensional data assimilation (perhaps 4DVAR) will be needed to exploit the high resolution data that will be produced by NPOESS. Problems in the data produced by the MASS model are acknowledged. Some of these may be overcome by pre-processing the data to remove biases and smooth unrealistic fluctuations.

REFERENCES

[1] Arnold, C. P., Jr. and C. H. Dey, Observing-systems simulation experiments: past, present, and future, *Bull. Amer. Meteor. Soc.*, **67** , 1986, pp. 687 - 695.

[2] NPOESS web site: www.ipo.noaa.gov

[3] Zack, J. W., G. E. Van Knowe, P. E. Price, M. D. Bousquet, S. Young, and C. E. Graves, Development of methods to generate high resolution climatological databases to support DoD modeling and simulation programs, *Air Force Research Laboratory Scientific Report*, **AFRL-VS-HA-TR-98-0047**, Scientific Report No. 1, 1998.

[4] Zack, J. W., G. E. Van Knowe, P. E. Price, M. D. Bousquet, K. T. Waight III, and C. E. Graves, Development of methods to generate high resolution climatological databases to support DoD modeling and simulation programs, *Air Force Research Laboratory Scientific Report*, **AFRL-VS-TR-2000-1520**, Scientific Report No. 2, 2000.