Impact Studies of Satellite Observations in the Antarctic Mesoscale Prediction System: AMSU-A Radiance Measurements

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1. Introduction

The Antarctic Mesoscale Prediction System (AMPS) is a real-time WRF forecast and data assimilation system to provide numerical forecasts over Antarctica in support of the United States Antarctic Program (USAP). In addition to other difficulties present in polar area weather forecasting, the lack of conventional observations in Antarctic areas presents a challenge in the effort to produce more accurate AMPS forecasts. Therefore, the advent of satellite data measurements is a major motivation for establishing the AMPS Testbed at the NCAR Data Assimilation Testbed Center (DATC) with the goal to evaluate, and eventually ingest, new satellite observations into AMPS.

The DATC has conducted various extended tests of the end-to-end system to assess the impact of the Advanced Microwave Sounding Unit–A (AMSU-A) satellite radiance observations on short-term forecasts in the Antarctic domain. This paper will present the latest results from these impact studies and a preview of future plans.

2. Model and Data

The AMPS Testbed mimics the operational AMPS as closely as possible. It uses the end-to-end system to perform tests. The system includes the WRF Preprocessing System (WPS), WRF-ARW, the WRF Three-Dimensional Variational Data Assimilation System (3D-Var) and the WRF 3D-Var verification package. The testing was conducted in the AMPS 60km domain (AMPS Domain 1) with 57 vertical levels and the model top at 10mb. The assimilation time window was 4 hours. The testing period was October, 2006.

The AMSU-A instrument employs a cross-track scanning strategy. As such, the resolution of each of the 30 Fields Of View (FOV), or scenes, used by the instrument decreases with increasing scan angle. A horizontal representation looks like the scan swath in Figure 1.

There are 15 discrete frequency channels onboard the AMSU-A instrument. Individual channels (i.e., frequencies) are carefully chosen based on principles of radiative transfer theory. Each channel (frequency) is radiatively selective in the sense that it detects microwave radiation from discrete layers within the earth's atmosphere. Satellite meteorologists typically relate the radiation sensed in individual AMSU-A channels/frequencies to specific atmospheric layers by use of a term called a weighting function as shown in Figure 2.

3. Results

In order to use AMSU-A radiances, biases between the observed radiances and those simulated from the model first guess must be corrected. Figure 3 shows the bias and standard deviation (STD) profiles of the observed brightness temperature (derived from radiances) compared with the WRF forecasts for October, 2006. Compared with the other channels, Channels 4-9 showed reasonably small STDs and were selected in this study. As the first effort to assimilate radiance data into AMPS, only oceanic data were used to avoid any possible contamination within data sets due to the complexity of the Antarctica related to the cloud/ice cover issues, complicated topography among others. Figure 4 shows the impact of the bias correction on the observed data. Clearly, the systematic bias of the AMSU-A observed brightness temperature from Channel 6 on the NOAA-16 satellite was removed.

Figure 5 shows the impact of the direct AMSU-A radiance data assimilation on the 36-hour forecasts of U, V, T and Q. The RMSEs of the forecasts from the radiance data assimilation experiment (blue) are smaller than those from the experiment without radiance data assimilation (red). Such a RMSE reduction is more obvious for the wind field.

4. Summary and Conclusions

The AMPS testing of WRF 3D-Var has been focusing on impacts of satellite data. The majority of AMPS DA efforts are in observation QC/bias-correction, testing and tuning. The DATC conducted a number of cycling runs of the forecast and DA system and compared the results from the experiments with or without radiance data assimilation. It shows that direct assimilation of radiance data has significant potential to improve the forecasts in the Antarctic areas, especially of the wind field.

In the future, the DATC will keep working on tuning the radiance data assimilation, including data thinning and bias correction. The inland data from AMSU-A will also be included into the testing. The AMPS Testbed forecast model will be updated to the polar version of WRF to catch up with the latest NWP developments in polar areas.

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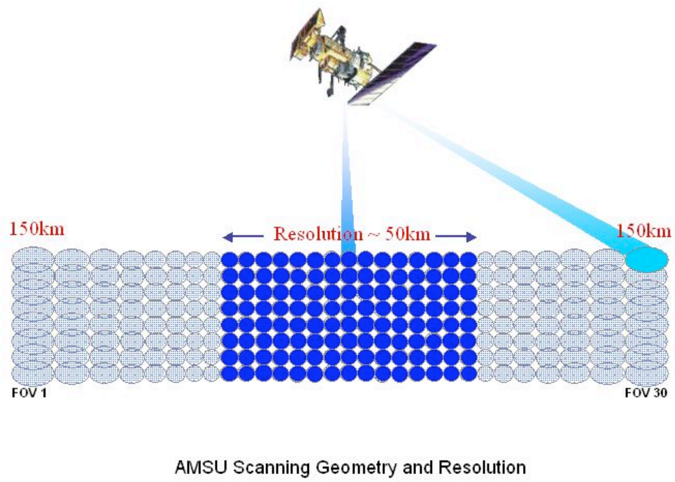

Fig. 1 AMSU Scanning Geometry and Resolution (from http://amsu.ssec.wisc.edu/explanation.html).

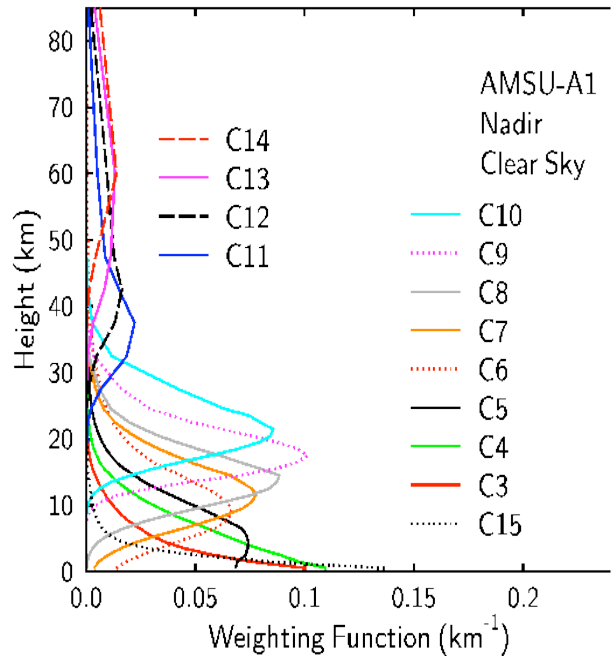

Fig. 2 The weighting functions for 15 channels of the AMSU-A instrument (from http://amsu.ssec.wisc.edu/explanation.html).

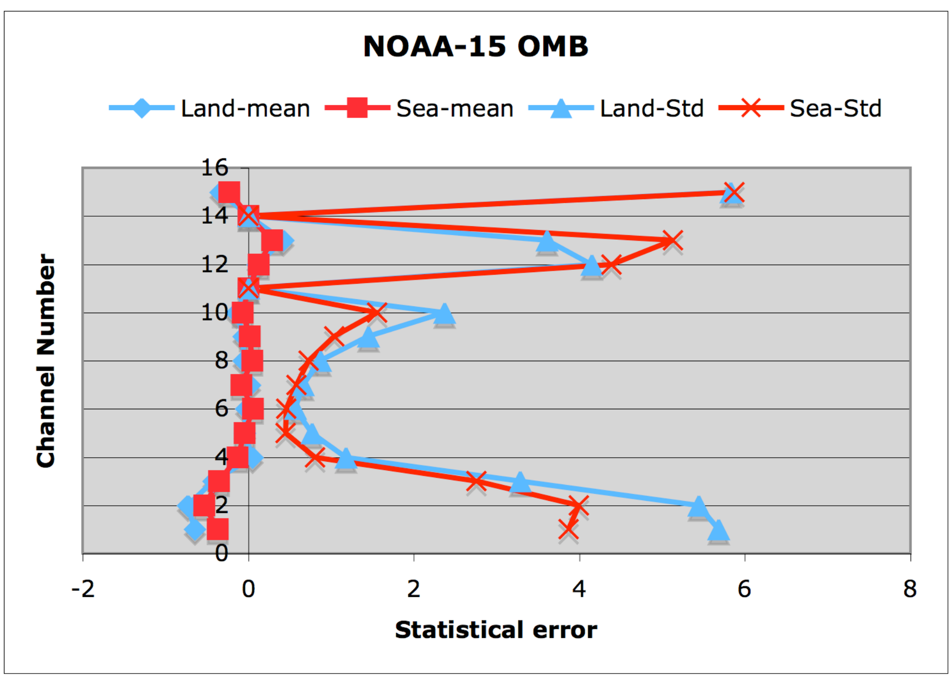

Fig. 3 Statistical Errors for the NOAA-15 AMSU-A instrument.

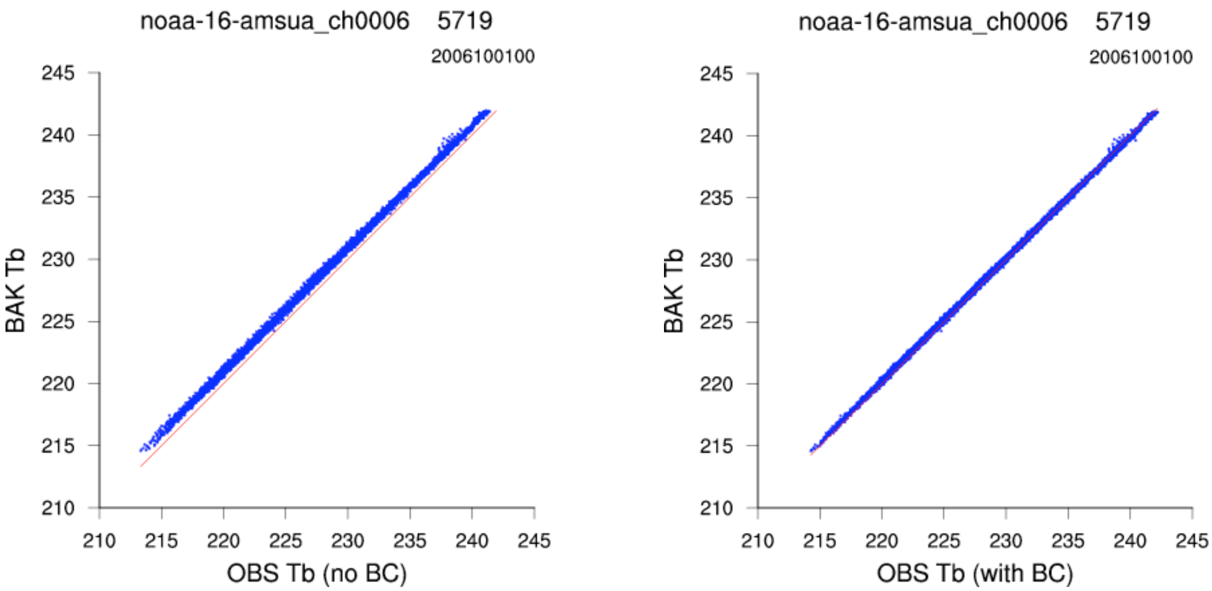

Fig. 4 The AMSU-A observations against the WRF forecasts before and after bias correction.

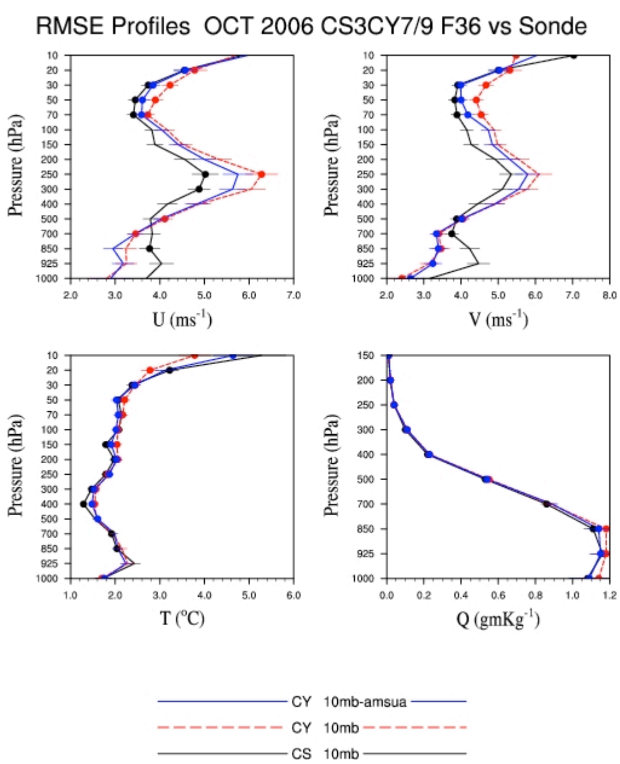

Fig. 5 The vertical profiles of the RMSEs of the 36-hour forecasts of U, V, T and q verified against the radiosonde observations within the AMPS domain.