Improving Forecast Skill by Assimilation of AIRS Temperature Soundings

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1. INTRODUCTION

AIRS was launched on EOS Aqua on May 4, 2002, together with AMSU-A and HSB, to form a next generation polar orbiting infrared and microwave atmospheric sounding system. The primary products of AIRS/AMSU-A are twice daily global fields of atmospheric temperature-humidity profiles, ozone profiles, sea/land surface skin temperature, and cloud related parameters including OLR. Also included are the clear column radiances $\hat{R}_i$ used to derive these products which are representative of the radiances AIRS would have seen if there were no clouds in the field of view. All products also have error estimates. The sounding goals of AIRS are to produce 1 km tropospheric layer mean temperatures with an rms error of 1K, and layer precipitable water with an rms error of 20 percent, in cases with up to 90 percent effective cloud cover. The products are designed for data assimilation purposes for the improvement of numerical weather prediction, as well as for the study of climate and meteorological processes. With regard to data assimilation, one can use either the products themselves or the clear column radiances from which the products were derived.

The AIRS Version 5 retrieval algorithm (Susskind et al 2010), is now being used operationally at the Goddard DISC in the routine generation of geophysical parameters derived from AIRS/AMSU data. A major innovation in Version 5 is the ability to generate case-by-case level-by-level error estimates $\delta T(p)$ for retrieved quantities and the use of these error estimates for Quality Control. These error estimates are used to determine a case-by-case characteristic pressure p_{best}, down to which the profile is considered acceptable for data assimilation purposes. The characteristic pressure p_{best} is determined by comparing the case dependent error estimate $\delta T(p)$ to the threshold values $\Delta T(p)$. The AIRS Version 5 data set provides error estimates of $T(p)$ at all levels, and also profile dependent values of p_{best} based on use of a “Standard” profile dependent threshold $\Delta T(p)$. These “Standard” thresholds were designed as a compromise between optimal use for data assimilation purposes, which requires highest accuracy (tighter Quality Control), and climate purposes, which requires more spatial coverage (looser Quality Control). Subsequent research using Version 5 sounding and error estimates showed that tighter Quality Control performs better for data assimilation proposes, while looser Quality Control (better spatial coverage) performs better for climate purposes.

We conducted a number of data assimilation experiments using the NASA GEOS-5 Data Assimilation System as a step toward finding an optimum balance of spatial coverage and sounding accuracy with regard to improving forecast skill. The model was run at a horizontal resolution of 0.5° latitude x 0.67° longitude with 72 vertical levels. These experiments were run during four different seasons, each using a different year. The AIRS temperature profiles were presented to the GEOS-5 analysis as rawinsonde profiles, and the profile error estimates $\delta T(p)$ were used as the uncertainty for each measurement in the data assimilation process.

We compared forecasts analyses generated from the analyses done by assimilation of AIRS temperature profiles with three different sets of thresholds; Standard, Medium, and Tight. More details concerning these thresholds are given in Susskind et al, 2010. We compared the results of these forecasts to those generated from a "Control" analysis, in which all the data used operationally by NCEP in 2003 was assimilated, but no AIRS data was assimilated. Radiances from the Aqua AMSU-A instrument were assimilated operationally by NCEP and are included in the "Control". It should be noted that the Aqua orbit (1:30 ascending) is almost identical to that of NOAA 16 carrying HIRS3, AMSU-A and AMSU-B, so AIRS/AMSU temperature soundings are providing additional information to that contained in the AMSU-A/AMSU-B radiances on NOAA 16 in the same orbit, as well as those of the Aqua AMSU-A radiances. No AIRS data was assimilated operationally at that time. An additional set of data assimilation experiments was also performed in which all data used in the Control, as well as observed AIRS radiances, were assimilated as is now done operationally by NCEP and ECMWF. These experiments are referred to as Radiance Assimilation. Global correlation coefficients of forecasted 500 mb heights are shown in figure 1 for all of the experiments described above, with the exception of the assimilation of AIRS temperature profiles using Medium Quality Control, which lies between the results using Tight Quality Control and Standard Quality Control.

Assimilation of Quality Controlled AIRS temperature profiles significantly improve 5-7 day forecast skill compared to that obtained without the benefit of AIRS data in all of the cases studied. In addition, assimilation of Quality Controlled AIRS temperature soundings performs better than assimilation of AIRS observed radiances. Based on the experiments shown, Tight Quality Control of AIRS temperature profile performs best on the average from the perspective of improving Global 7 day forecast skill.

One of the time periods studied contains Tropical Cyclone Nargis which devastated parts of Myanmar in May 2008. The Control analyses in the days prior to the landfall of Tropical Cyclone Nargis contained substantial misrepresentations, or even lack of representation, of the location a cyclone in the Bay of Bengal. Consequently, the storm track of this devastating storm was very poorly predicted ahead of time at NCEP (as occurred in reality). Reale et al (2009) showed that the prior analyses and subsequent forecasts of the Nargis storm track were significantly better when AIRS Standard Quality Controlled temperature soundings were assimilated, and in fact an excellent prediction of when and where Nargis would hit land was produced from the AIRS Standard analysis 108 hours (4.5 days) ahead of forecast time. An intermediate ability to predict landfall of Nargis was produced using forecasts from the AIRS Radiance analysis. Reale et al did not examine the assimilation of Tight Quality Controlled AIRS temperature profiles in their study. Subsequent research has shown that as with 7 day Global forecast skill, assimilation of Tight Quality Controlled AIRS temperature soundings further improved the ability to forecast the characteristics of Tropical Storm Nargis.

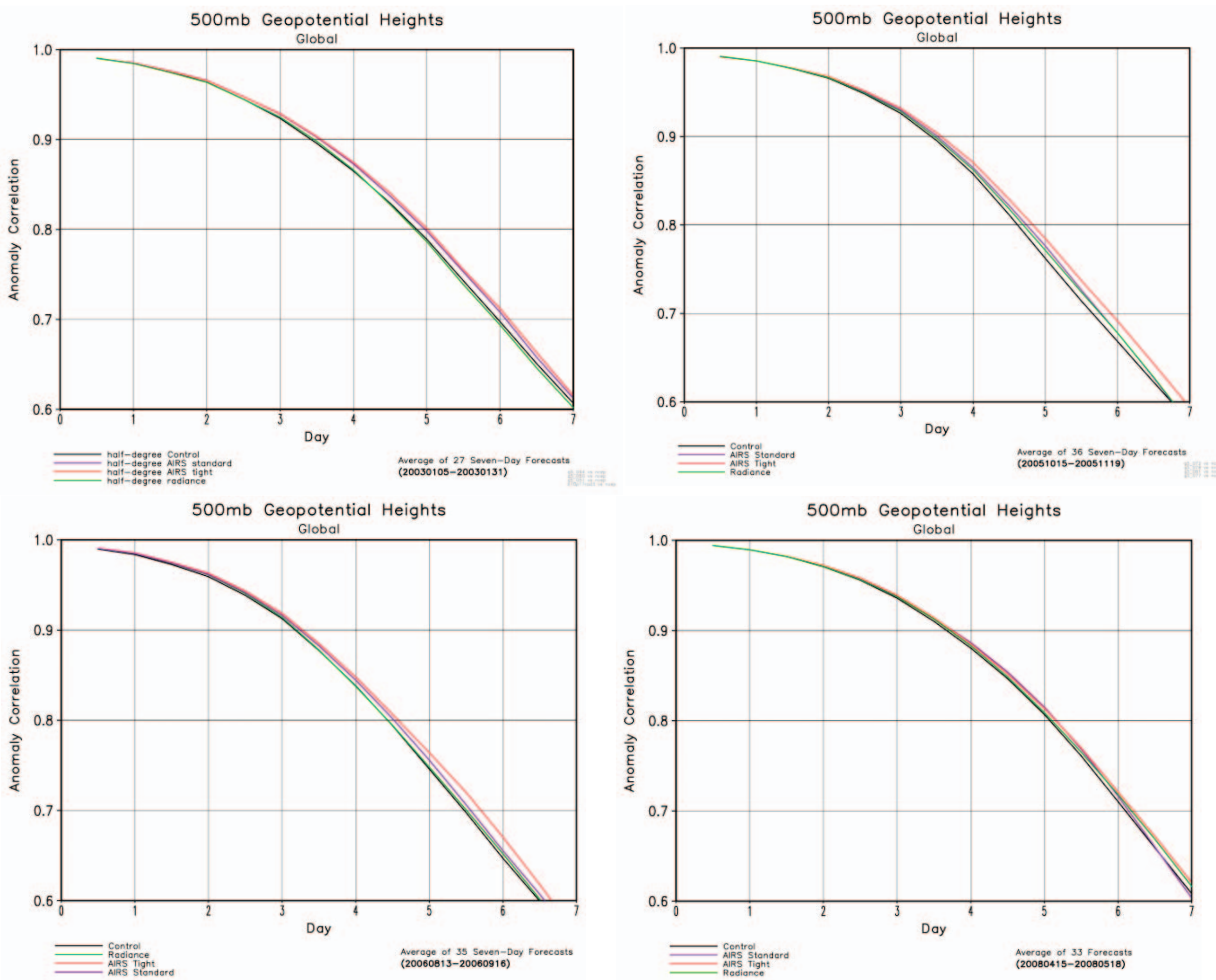

Figure 1

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