Improving 7-Day Forecast Skill by Assimilation of Retrieved AIRS Temperature Profiles

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Last year I gave a presentation entitled “Improving Forecast Skill by Assimilation of AIRS Cloud Cleared Radiances $R_{i}^{CC}$”

The objective of that research was to assess the degree of improvement in seven day forecast skill achieved by assimilating values of AIRS $R_{i}^{CC}$ in place of AIRS observed radiances $R_{i}$, as done by GMAO, everything else being done the same.

7-day forecast results were shown covering the period Sept. 10, 2014 – Oct. 31, 2014 based on Data Assimilation studies using GEOS-5.

Assimilations were done and presented using the GMAO operational procedure as a control run, as well as using five other assimilations performed differently all assimilating either AIRS $R_{i}$ or Quality Controlled (QC’d) AIRS $R_{i}^{CC}$.

We also performed one additional study using GEOS-5 in which we assimilated AIRS QC’d retrieved values of $T(p)$. $T(p)$ retrievals are presented to the analysis as if they were radiosonde reports.

The following 5 charts were shown at last year’s presentation.
First Set of Forecast Impact Tests

All experiments use MERRA2 with the GEOS DAS. We ran forecasts with a resolution of 0.25° x 0.25° and analyses with 0.5° x 0.5°. Data period covers September 1, 2014 – October 31, 2014.

Five data assimilation experiments were run:
1) “AIRS radiance” assimilates all data GMAO used operationally at that time, including $R_i$ of AIRS/AMSU, CrIS/ATMS, and IASI/AMSU.
2) “AIRS $R_i^{CC}$ ” uses the same data but with AIRS $R_i^{CC}$ in place of AIRS $R_i$.
3) “No AIRS” uses otherwise the same data but uses no AIRS data at all.
4) “AIRS radiance, no CrIS/ATMS” is like “AIRS radiance” but uses no CrIS/ATMS data.
5) “AIRS $R_i^{CC}$, no CrIS/ATMS” is like “AIRS $R_i^{CC}$”, but uses no CrIS/ATMS.

52 independent 7-day forecasts were run from each 0Z analysis starting September 10. Forecasts are verified against the concurrent NCEP analysis.
Assimilation of CrIS/ATMS (solid lines) degrades global forecast skill when used with AIRS. The best global 7-day forecast skill is obtained assimilating AIRS $R_{ij}^{CC}$ with no CrIS/ATMS.
Considerable improvement in Northern Hemisphere 7-day forecast skill as compared to the control is obtained by assimilating AIRS $R_{i}^{CC}$ with no CrIS/ATMS.
Global Mean 500 mb height anomaly correlation coefficients assimilating QC’d $T(p)$ are better than those of all other experiments at all time scales. Global mean 7-day forecast skill is improved by 6 hours as compared to the control.
More Recent Data Assimilation Research

Our most recent data assimilation research has concentrated on further improvements in 7-day forecast skill by assimilation of AIRS Version-6 retrieval values of $T(p)$ passing Data Assimilation QC. Retrieved values of $T(p)$ are presented to the GEOS DAS as if they were radiosonde reports.

Data Assimilation experiments were conducted over the time period December 15, 2015 through February 29, 2016. Sixty 7-day forecasts from each experiment were made each day at 0Z over the period January 1, 2016 through February 29, 2016, and verified every 12 hours against the current NCEP analysis.

Our experience in these experiments indicates that the GEOS DAS analysis does not perform as well, from the 7-day forecast skill perspective, when a large number of values of $T(p)$ are assimilated, especially when they come from different sources, in neighboring locations, that may (will) have different error characteristics.
Experiments Involving Assimilation of $T(p)$ from Different Sources

We have conducted the following tests in conjunction with AIRS $T(p)$

1) Assimilate AIRS $T(p)$ but do not assimilate radiosonde $T(p)$, while still assimilating radiosonde $q(p)$ and radiosonde winds. This significantly improves 7-day forecast skill.

2) Assimilate AIRS $T(p)$ but do not assimilate radiosonde $T(p)$, $q(p)$, or winds. This significantly degrades 7-day forecast skill.

WE STILL NEED RADIOSONDES

3) Assimilate AIRS $T(p)$ but do not assimilate radiosonde $T(p)$ or aircraft temperatures. This produces the best results at this time.

The next charts show 7-day forecast skill for four experiments:

1) Control; 2) AIRS $R_i^{CC}$ with no CrIS/ATMS; 3) AIRS $T(p)$, no CrIS/ATMS, no radiosonde $T(p)$; and 4) AIRS $T(p)$, no CrIS/ATMS, no radiosonde $T(p)$, and no aircraft temperatures.
Global mean 7-day forecast skill is improved over the Control by four hours by assimilation of AIRS QC'd values of $T(p)$ without radiosonde or aircraft temperatures.
All experiments improve the Southern Hemisphere Extra-tropics forecast skill significantly compared to the Control. The largest improvement in 7-day forecast skill (10) hours is obtained when AIRS $T(p)$ is assimilated without radiosonde or aircraft temperatures.
Assimilation of AIRS $T(p)$ without radiosonde or aircraft temperatures is the only experiment that does not degrade the Control in the Northern Hemisphere Extra-tropics.
Summary

We conducted a new set of Data Assimilation Experiments covering the period January 1 to February 29, 2016 using the GEOS-5 DAS.

Our experiments assimilate all data used operationally by GMAO (Control) with some modifications.

Significant improvement in Global and Southern Hemisphere Extra-tropical 7-day forecast skill was obtained when:

We assimilated AIRS Quality Controlled temperature profiles in place of observed AIRS radiances, and also did not assimilate CrIS/ATMS radiances, nor did we assimilate radiosonde temperature profiles or aircraft temperatures.

This new methodology did not improve or degrade 7-day Northern Hemispheric Extra-tropical forecast skill. We are conducting experiments aimed at further improving of Northern Hemisphere Extra-tropical forecast skill.