Bias Correction for Assimilation of Retrieved AIRS Profiles of Temperature and Humidity

Clay Blankenship1, Bradley Zavadsky2, and William Blackwell3

1Universities Space Research Association, Huntsville, AL 2NASA Marshall Space Flight Center, Huntsville, AL 3Massachusetts Institute of Technology, Cambridge, MA 4clay.blankenship@nasa.gov

Abstract

The Atmospheric Infrared Sounder (AIRS) is a hyperspectral radiometer aboard NASA’s Aqua satellite designed to measure atmospheric profiles of temperature and humidity. AIRS retrievals are assimilated into the Weather Research and Forecasting (WRF) model over the North Pacific for an “atmospheric river” case. These events bring large flux of water vapor to the west coast of North America and often lead to extreme precipitation in the coastal mountain ranges. An advantage of assimilating retrievals rather than radiances is that information in partly cloudy fields of view can be used.

Motivated by previous work which found inconsistencies in the range of humidity in the AIRS profiles and the WRF model for a given layer, we developed a bias correction for the AIRS profiles. Corrections are significant at the upper troposphere and very small below 500 mb. Above about 200 mb, there is very little correlation between AIRS retrievals and the WRF model fields.

The bias-adjusted AIRS profiles are assimilated into WRF. Results are compared to a control run with no assimilation and a run with raw AIRS profiles. Validation is ongoing but it is hoped that the bias-adjusted profiles will lead to better forecasts.

Atmospheric Rivers

Atmospheric rivers are narrow, linear regions in the atmosphere responsible for the transport of large amounts of water vapor. These phenomena can have a large impact on precipitation. In particular, they are often responsible for intense rain events on the west coast of the United States during the winter season. (Ralph et al. 2011) These plots show total precipitable water from the AIRS instrument for one such case in March 2011.

Bias Correction Methodology

• These plots show the mean profiles of temperature and moisture by layer for our WRF model run and for the AIRS profiles. Also plotted is bias (upper scale) and the correlation.

• We are also evaluating an AIRS profile product (Blankenship et al. 2011) based on a neural net retrieval. Their new humidity profile is shown in the bottom right panel.

• Temperature bias is low at all layers.

• Humidity bias is low at low levels.

• For upper levels (300 mb and higher), there is very low correlation between modeled and observed humidity profiles. We do not assimilate AIRS profiles above about 200 mb.

• For intermediate levels (250 mb to 400 mb), there is a significant bias but high correlation between model and observations, suggesting that bias correction has a large potential benefit for these layers.

WRF Experiment Setup

Atmospheric River in March 2011

• WRF domain in eastern North Pacific and western North America at 13 km resolution.

• NCEP reanalysis initial and lateral boundary conditions

• Initial and boundary conditions come from GFS, which incorporates assimilations of various observation types including AIRS radiances (but not in cloudy regions).

• Data assimilation using Gridpoint Statistical Interpolation (GSI) (Developmental Trend Model Center 2011)

Model runs:

• No bias (control)

• AIRS profile assimilation

• Bias-corrected AIRS profile assimilation

Model Forecast Results

The following figures illustrate the effect of the correction on the assimilated observations. The background fields are the same in both cases, showing the model specific humidity at 500 mb. The small crosses indicate the locations of the AIRS profiles and are colored according to their 250 mb humidity. The air parcel has the raw observations and the light gray panel has the bias corrected observations, which agree more closely with a range of nearby values in the atmosphere.

Validation against ECMWF Re-Analyses (ERA)

The Taylor diagram shows standard deviation (normalized by layer mean humidity, distance from origin), correlation (on raw axis), and normalized mean error (dashed lines) for model specific humidity at four layers (250, 500, 750, and 900 mb), validated against ECMWF Re-Analyses (ERA). Differences between uncorrected and bias-corrected AIRS runs are marginal.

Selected statistics are given below, with bias and error standard deviation normalized by the layer mean values.

Ongoing Work

• Test robustness of correction from day to day and season to season, investigate proper timescale to update correction.

• Do a cycling model run for a period of weeks to the impact of continued assimilation.

• Further validation, including against satellite analysis on the west coast.

• Perhaps validation of forecast cloud cover vs. satellite observations.

References


