Assimilation and Impact Studies of AIRS Radiance Data

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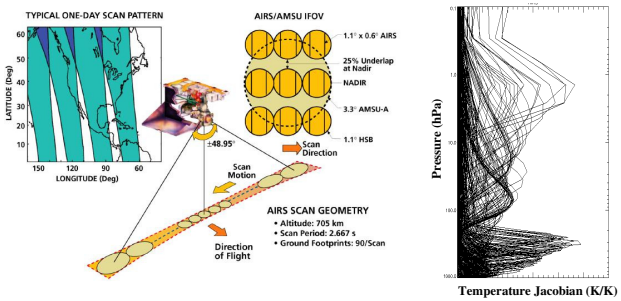
1. Objective

- Test Atmospheric Infrared Sounder (AIRS) radiance data assimilation capability developed recently as part of the NCAR Weather Research and Forecasting Model's Three-Dimensional Variational Data Assimilation System (WRF-Var).
- Understand the possible roles of the AIRS data in improving weather analysis and forecasting.

2. AIRS Instrument

- High spectral resolution spectrometer with 2378 bands in the thermal infrared (IR) (3.7 - 15.4 μm) and 4 bands in the visible (0.4 - 1.0 μm).
- Swath of ±49.5 degree centered on the nadir in the cross-track direction.
- Ninety IR footprints for each scan line with a resolution of 13.5 km at nadir.
- Determination of atmospheric temperature with an accuracy of 1°C in layers 1 km thick, and humidity with an accuracy of 20% in layers 2 km thick in the troposphere.



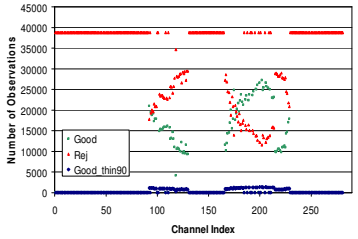
Scan geometry of AIRS (left) and vertical profiles of temperature Jabobians for each of AIRS channels (right). (Courtesy of AIRS Science Team, NASA/JPL)

3. AIRS Data Processing

- **Thinning** - 90km resolution, warmest FOV (Only NCEP pre-selected 281 channels of data are processed).

Number of accepted (green) and rejected (red) AIRS data by WRF-Var QC.

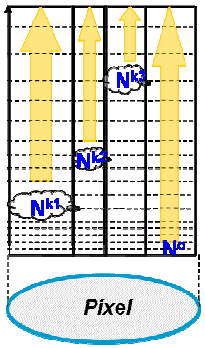
Number of accepted (blue) AIRS data after thinning.



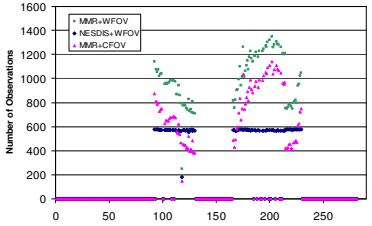
- **Quality control (QC)**
  - Pixel-level QC: Reject limb observations
  - Channel-level QC: Gross check: innovations <15 K; First-guess check: innovations < $3\sigma_o$
  - Multivariate Minimum Residual (MMR) cloud detection:

$$R_v^{cld} = N^o R_v^o + \sum_{k=1}^{n} N^k R_v^k$$

Where R_v^o and R_v^k are radiances calculated in clear sky and overcast black cloud at level k.

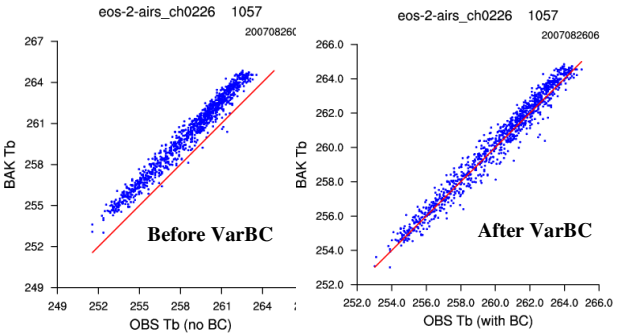


MMR Cloud detection

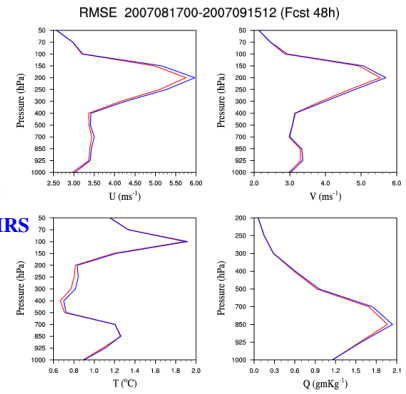


MMR and Warmest FOV schemes increased assimilated observation number at 2007082606 compared with the default cloud detection and thinning schemes (Center FOV) in WRF-Var.

- **Variational Bias Correction (VarBC)**
  - VarBC cycle period for the AIRS assimilation experiment: 24 hours (to avoid potential diurnal variation of bias correction coefficients).
  - Four bias predictors: offset, satellite scan position, square of the satellite scan position and cube of the satellite scan position.



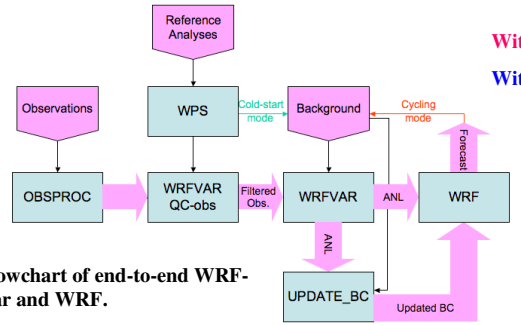
4. Forecast Impacts



With AIRS

Without AIRS

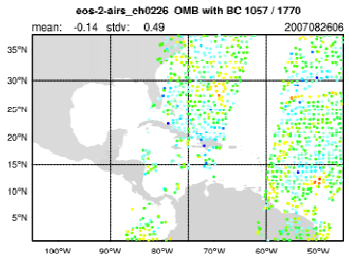
Vertical profiles of the RMSE of 48 hour forecasts at 00Z and 12Z verified against ECMWF analyses.



Flowchart of end-to-end WRF-Var and WRF.

Experimental design:

Two sets of month-long WRF-Var and WRF runs:
15km, 6hr cycling runs, 2007081500-2007091512
10mb model top, 4(6) hr time window for AIRS (conventional) data.
AIRS data were only available at 06Z and 18Z.



Conclusions:

The assimilation of AIRS radiance data was implemented and tested and its impacts were evaluated through a series of experiments conducted for the testing period of 15 August – 15 September, 2007. The system proved to be robust and the configuration for AIRS radiance data assimilation is suitable. The monthly runs show assimilation of AIRS radiance data reduced the biases of moisture forecasts and imposed positive impacts to reduce the RMSEs of the forecasts of wind, temperature and moisture fields throughout the entire forecast range.

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