JP6.11 DATA ASSIMILATION AND REGIONAL FORECASTS USING ATMOSPHERIC INFRARED SOUNDER (AIRS) PROFILES

Shih-hung Chou*, Brad Zavodsky†, Gary J. Jedlovec*

*SPoRT, NASA/MSFC, Huntsville, AL

†SPoRT, UAH, Huntsville, AL

1. MOTIVATION

- To improve weather forecasts using AIRS temperature and moisture profiles

2. AIRS PROFILES

2.1. AIRS Profile Description

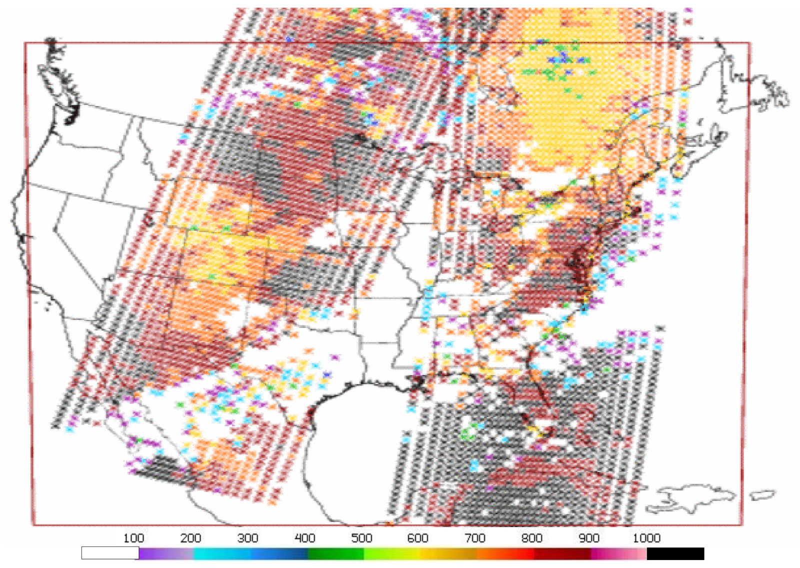

Fig. 1. Three-dimensional distribution of AIRS profile data assimilated at 0800 UTC on 17 January 2007. The red rectangle denotes the bounds of the WRF domain.

- Version 5 L2 ***temperature*** and ***moisture*** profiles over ***land*** and ***water***
- ~50 km spatial resolution at nadir; 14 levels between 1000 and 50 hPa
- Level-dependent quality indicators (QIs) determine maximum pressure level above which quality data should be assimilated (colored points in Fig. 1)
- AIRS soundings assimilated as separate land and water data types with separate errors

2.2. Observation Error Matrix

- Separate observation errors are used for the land and water soundings
  - Land: From Tobin et al. (2006)
    - Emissivity issues make land soundings less accurate than water
    - Validation for SGP which has similar environment to SPoRT domain
  - Water: From AIRS instrument specs
    - Better soundings than land
    - Verified against TWP which has different environment than SPoRT domain

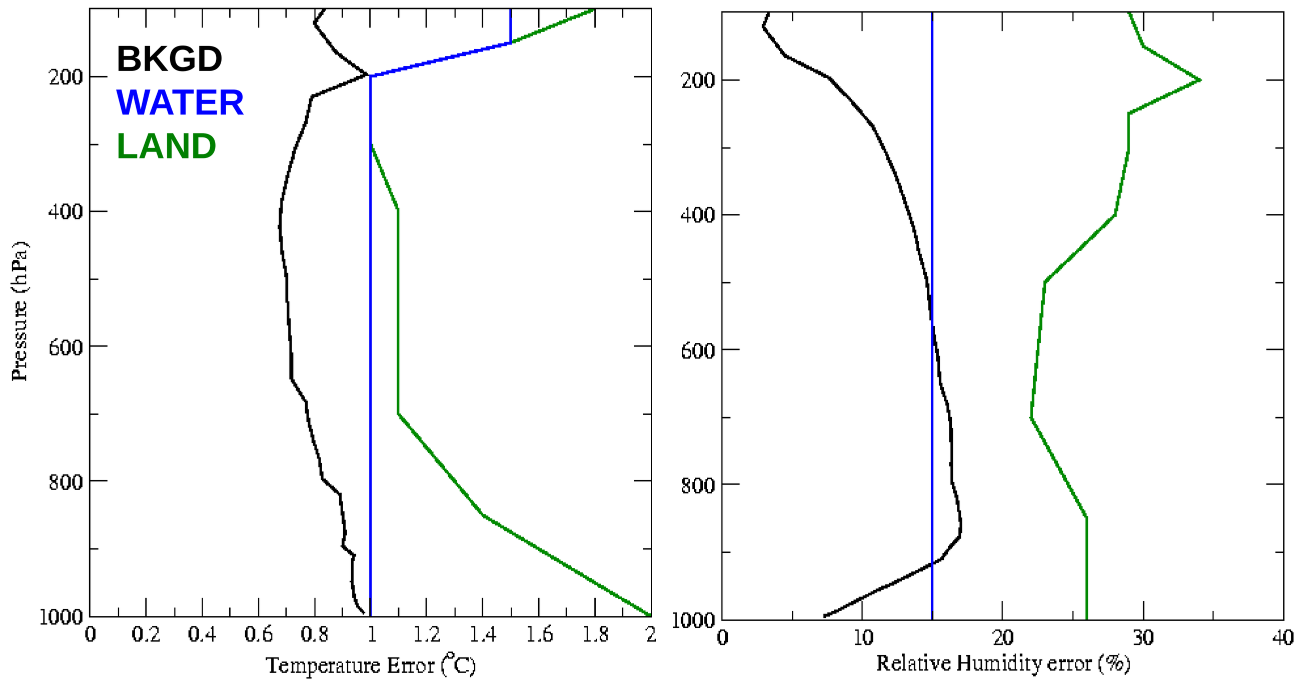

Fig. 2. Background (black line) and observation (blue: AIRS water, green: AIRS land) errors for WRF-Var analysis. It is the ratio of the background errors that controls the magnitude of the analysis increment during the assimilation process.

3. ANALYSIS/FORECAST MODEL

3.1 Model Configuration

- WRF-Var v2.2.1 on CONUS domain (Fig. 1)
- 12-km resolution, 450 x 360 horizontal grid, 37 vertical levels, top at 50 hPa
- ARW initialized at 0000 UTC each day using 40-km NAM
- 6-8h ARW forecast used as first-guess for WRF-Var; AIRS profiles assimilated at observation time

3.2. Background Error (*B*) Matrix

- A SPoRT ***B*** matrix was generated using gen_be with 37 days of WRF forecasts initialized at 00 and 12 UTC (NMC Method)
- The horizontal transform is performed using recursive filter, and vertical transform is applied via EOF
- For more information see JP6.11 in this session

4. ANALYSIS IMPACT: 17 January 2007

700 hPa WRF-Var Temperature and Moisture Analyses

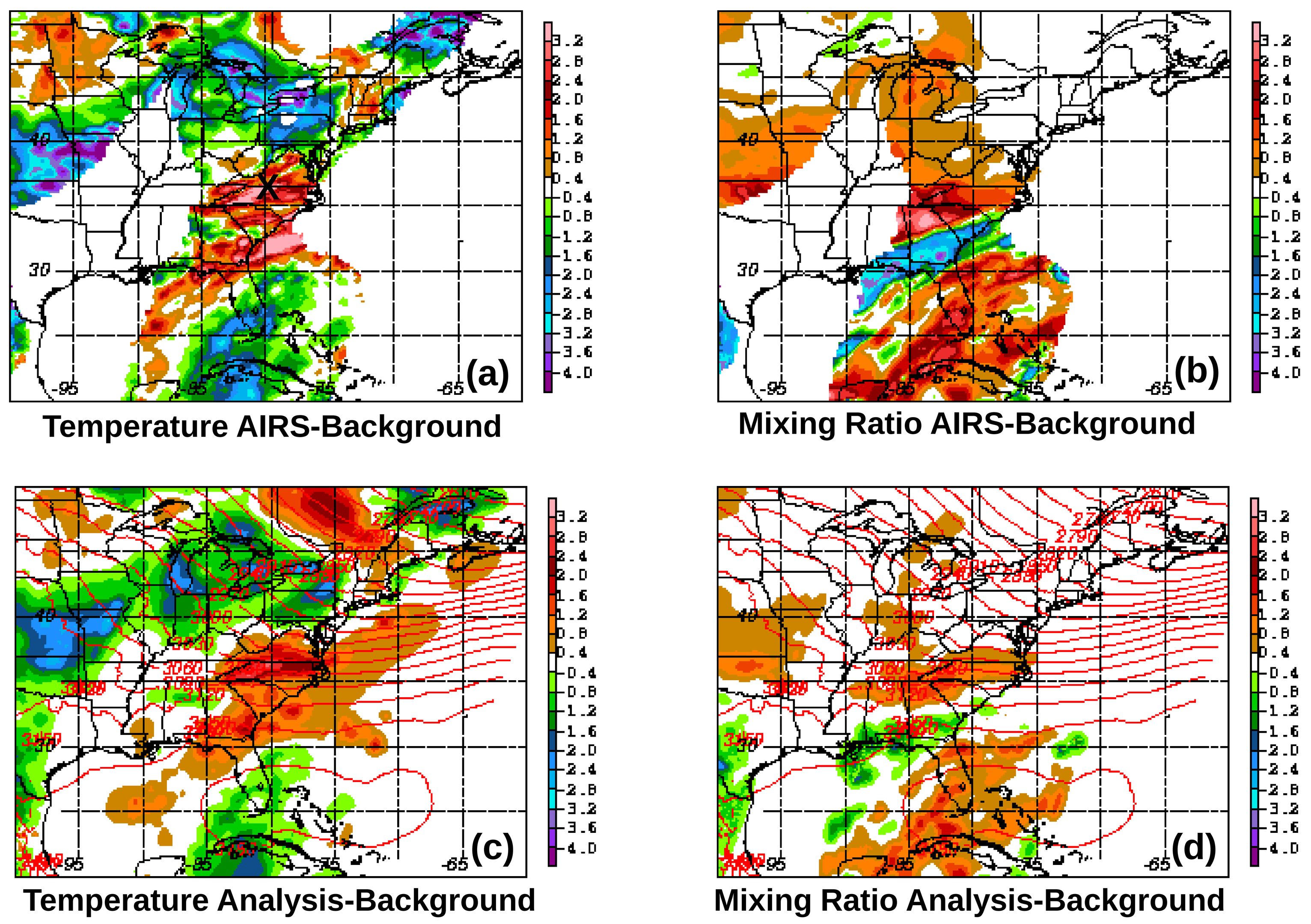

Fig. 3. Analysis impact of AIRS at 700 hPa. The top row shows innovation fields (AIRS minus background) for a) temperature and b) mixing ratio. The corresponding analysis increments (WRF-Var minus background) are shown in c) and d). The "x" in a) denotes the location of the Greensboro, NC sounding described in Figure 4.

- AIRS profiles cooler than background over FL and Great Lakes; warmer over SE US (Fig. 3a); they are generally moister except in upper midwest and eastern Gulf of Mexico (Fig. 3b)
- *Absolute* magnitude (4ºC for temperature, 2 g/kg for mixing ratio) and spatial distribution of the differences are representative of other levels
- Analysis increments shows similar temperature (Fig. 3c) and moisture (Fig. 3d) pattern compared to innovations

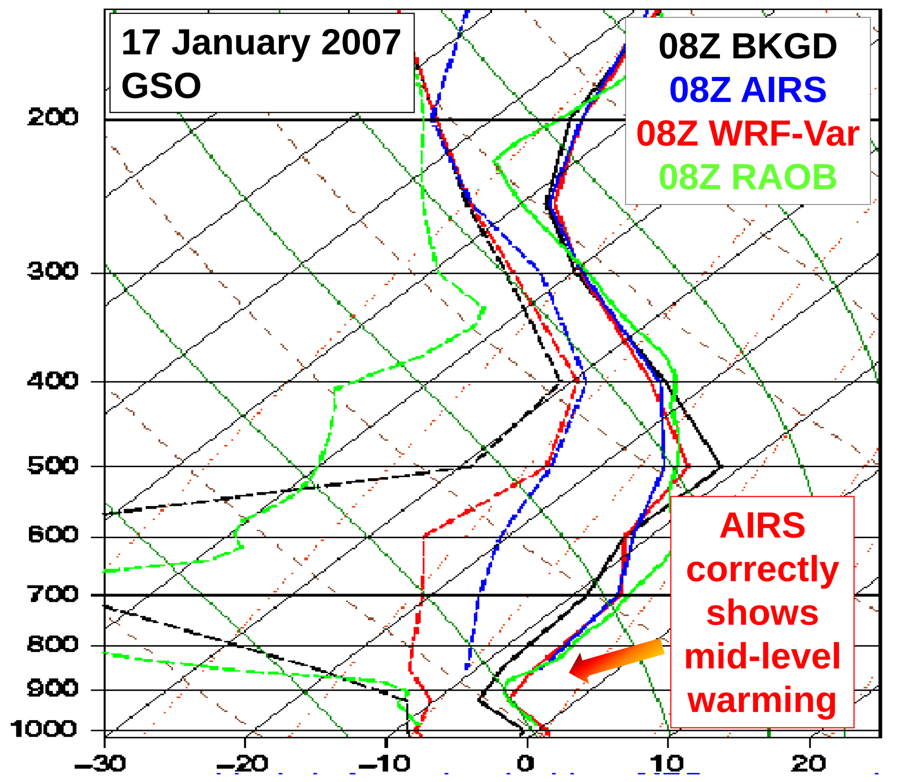

Fig. 4. Profiles of temperature (solid) and dew point (dashed) near Greensboro, NC (GSO) for 0800 UTC 17 January 2007. The background (black) and WRF-Var (red) profiles are for the nearest grid point. The AIRS profile (blue) is for the highest-quality retrieval closest to the grid point. The radiosonde (green) is a linear interpolation of the 0000 and 1200 UTC soundings to 0800 UTC.

- Temperature and moisture soundings of AIRS-enhanced analysis lie between those of background and AIRS profiles below 300 hPa
- AIRS correctly shows mid-level warming
- Addition of AIRS produces analysis more comparable to radiosondes than background at mid- and lower troposphere (Fig. 4)

5. 48-H FORECAST IMPACT

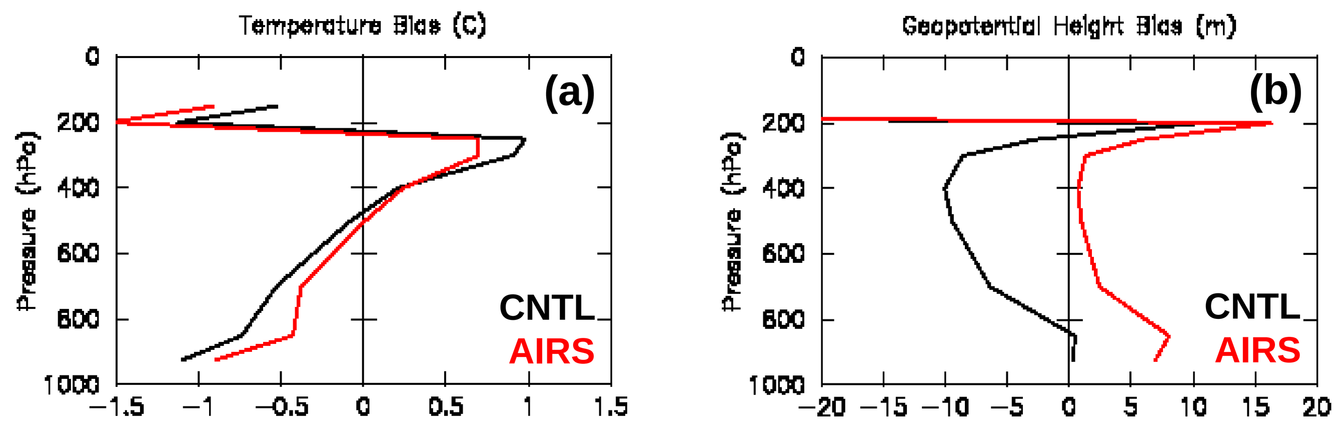

Fig. 5. Bias verification statistics (forecast-obs) of 48-h forecasts compared to 50 radiosonde east of 105ºW for (a) temperature (ºC) and b) geopotential height (m) for 37 days between 17 January and 22 February 2007.

Temperature Results:

- CNTL too cool in lower troposphere; too warm in upper troposphere
- AIRS warms lower levels and cools upper levels reducing bias (Fig. 5a)
- Daily bias statistics confirm temperature improvement in AIRS runs (Fig. 6a)

Geopotential Height Results:

- CNTL heights too low in mid- and upper troposphere; good near surface
- AIRS raises heights at all levels degrading bias near surface but improving aloft (Fig. 5b)
- Daily bias statistics show that AIRS forecasts are biased towards higher geopotential heights (Fig. 6b)

6-h Cumulative Precipitation Bias Score Results:

- Bias score > 1 means over forecasting; bias score < 1 means under forcasting
- Overall AIRS bias score is slightly larger than CNTL (AIRS=1.51; CNTL=1.48)
- Daily statistics show mixed results

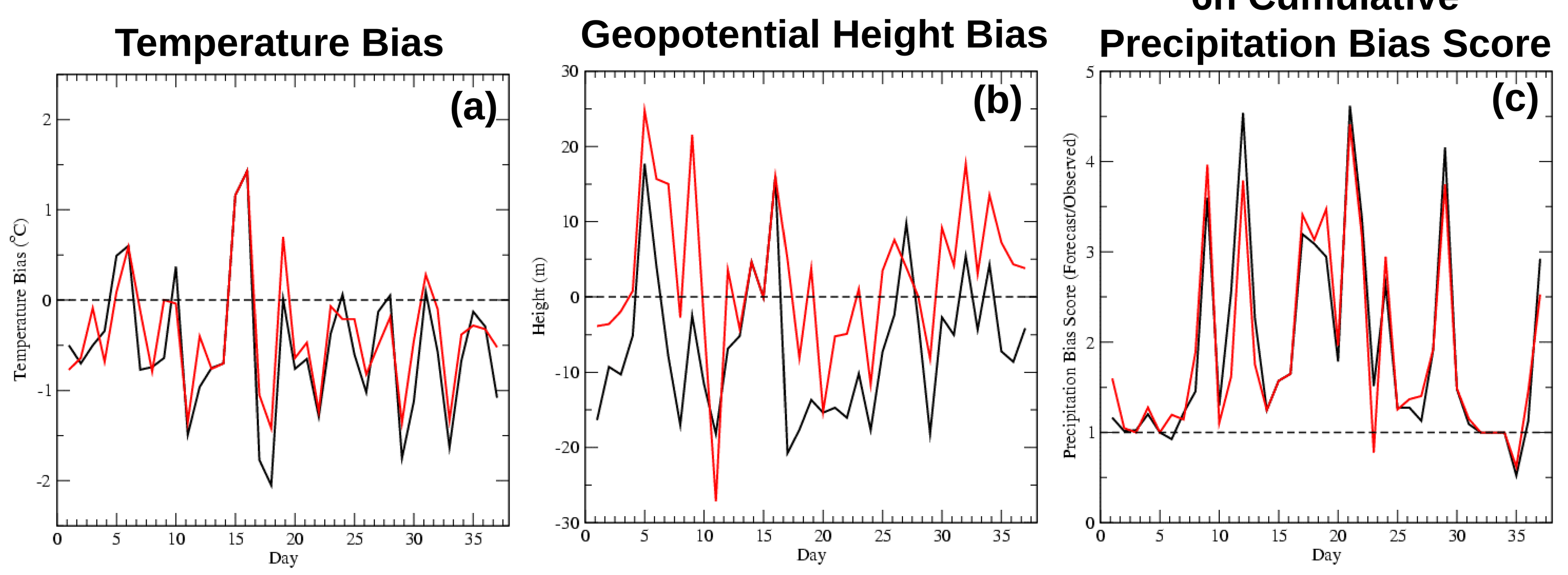

Fig. 6. Time series of each day in the 37-day case study period for 48-hr forecasts of a) temperature bias, b) geopotential height bias, and c) 6-h cumulative precipitation bias score. Precipitation bias is validated against NCEP Stage IV precipitation data.

6. CONCLUSIONS/FUTURE WORK

- Prudent assimilation of AIRS thermodynamic profiles and quality indicators can improve initial conditions for regional weather models
- In general, AIRS-enhanced analysis more closely resembles radiosondes; forecasts yield mixed results
- Future work will involve closer investigation of select dates

ACKNOWLEDGEMENTS

This work is supported by Dr. Tsengdar Lee of NASA Headquarters. The authors would like to thank Will McCarty, Jonathan Case, and Tim Miller for their assistance and input on this project.