ASSIMILATION OF ATMOSPHERIC INFRARED SOUNDER (AIRS) PROFILES USING WRF-VAR

Shih-Hung Chou*, Brad Zavodsky†, Gary J. Jedlovec*, William M. Lapenta*

****SPoRT, NASA/MSFC, Huntsville, AL***

†SPoRT, UAH, Huntsville, AL

1. MOTIVATION

- To improve initial states for short-term weather forecast using AIRS data
- To demonstrate a robust procedure to create a background error covariance for regional assimilation of AIRS thermodynamic profiles in WRF-Var
- To show a positive impact of AIRS profiles on analyses when compared to collocated radiosondes

2. ANALYSIS CONFIGURATION

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

2.1. *AIRS Profile Configuration*

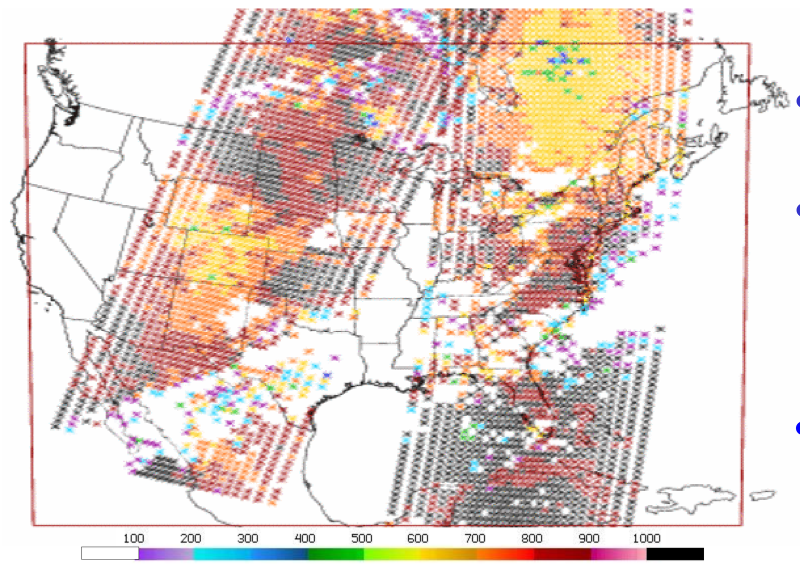

Fig. 1. Three-dimensional distribution of AIRS profile data assimilated at 0700 UTC on 17 January 2007. Each colored point denotes the maximum pressure level from the AIRS QIs. The red rectangle denotes the bounds of the WRF-Var domain.

- Version 5 L2 temperature and moisture profiles over land and water
- ~50 km spatial resolution at nadir; 54 levels between 1013 and 100 hPa
- Level-dependent quality indicators (QIs) determine maximum pressure level above which quality data should be assimilated (Fig. 1)
- AIRS soundings assimilated as separate land and water data types by altering WRF-Var source code
- Observation errors from AIRS Science Team profile validation (Fig. 2; red: water, green: land)

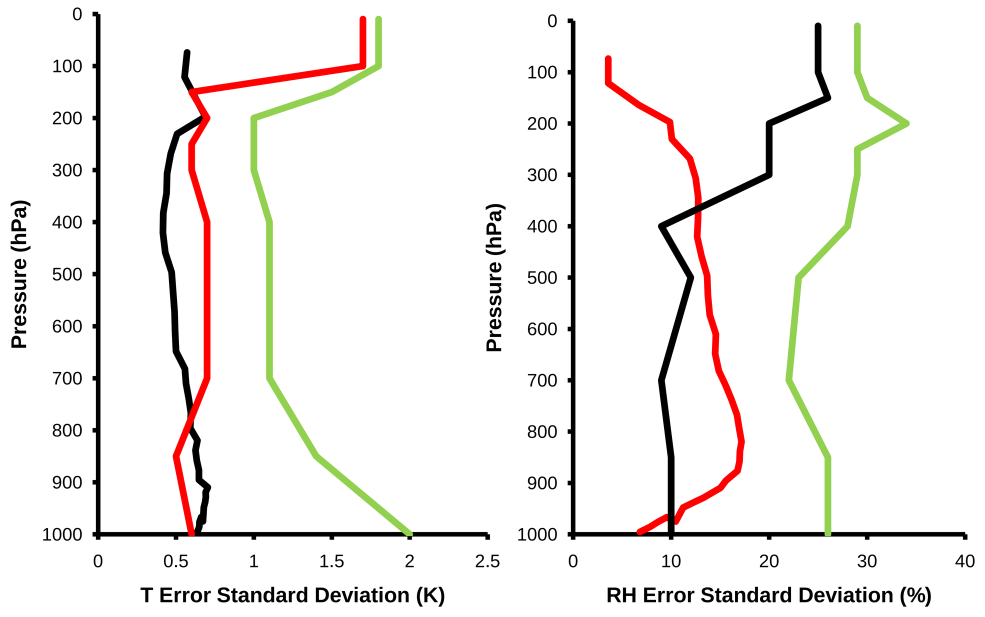

Fig. 2. Background (black line) and observation (red: AIRS water, green: AIRS land) errors for WRF-Var analysis. It is the ratio of the background errors that controls the magnitude of the analysis increment during the assimilation process.

2.2. *Background Error Covariances*

- Background error covariances were generated using gen_be with 2 weeks of WRF forecasts initialized at 00 and 12 UTC
- Information in the observations is spread horizontally through the length scale (Fig. 3) and vertically through the eigenvectors (Fig. 4)
- Length scales generated from gen_be lead to bull's eyes and stripping features in the analysis (Fig. 5c and 6c)—tuned to increase the length scale factor to 1.5 and 2 for temperature and moisture, respectively
- Background error comparable to AIRS observation error (Fig. 2; black line)

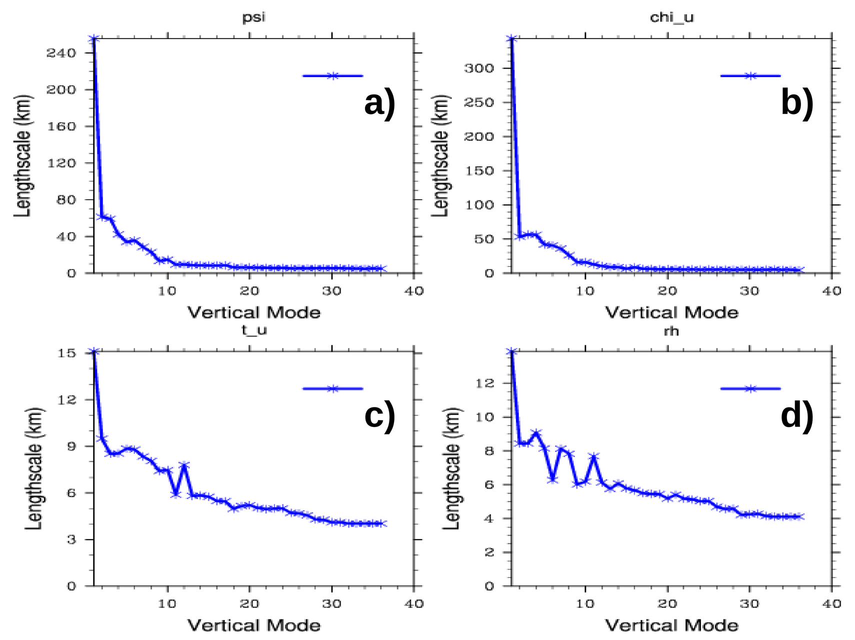

Fig. 3. Length scale for each control variable—a) streamfunction, b) velocity potential, c) temperature, and d) relative humidity—for WRF-Var analysis. The length scale controls the horizontal spread of the observations during the assimilation process.

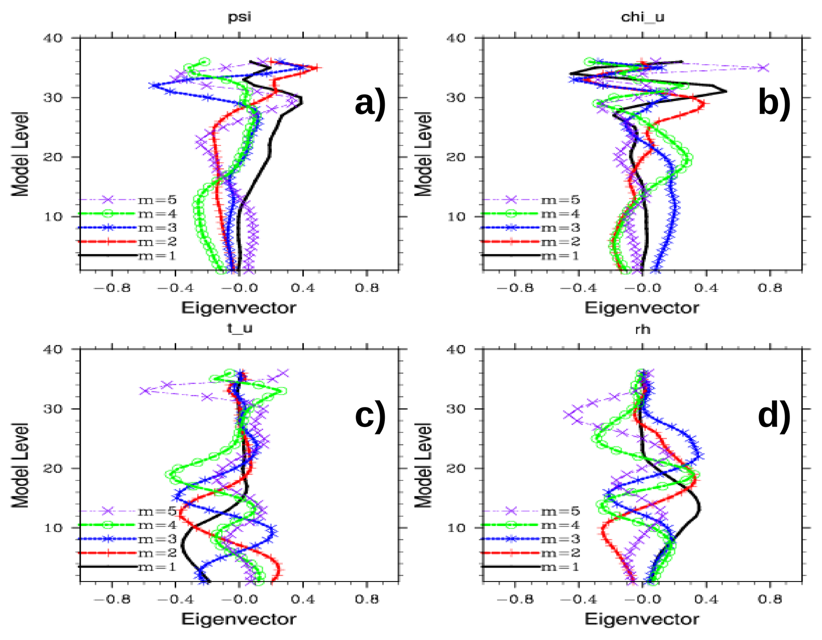

Fig. 4. Eigenvector for each control variable—a) streamfunction, b) velocity potential, c) temperature, and d) relative humidity—for WRF-Var analysis. The eigenvector controls the vertical spread of the observations during the assimilation process.

3. IMPACT OF AIRS PROFILES ON WRF-VAR ANALYSIS: 17 JANUARY 2007

- AIRS profiles at 700 hPa cooler than background over FL and Great Lakes; warmer over SE US (Fig. 5b); generally moister except in upper Midwest and eastern Gulf of Mexico (Fig. 6b)
- The absolute magnitude (4°C for temperature, 2 g/kg for mixing ratio) and spatial distribution of the differences shown at 700 hPa are representative of other levels
- The analysis increment shows similar temperature and moisture pattern compared to the observation innovation.
- Increasing temperature length scale by 50% and doubling the moisture length scale smooth out the bull eyes and stripping features (Fig. 5d and 6d)

700 hPa Temperature Analysis

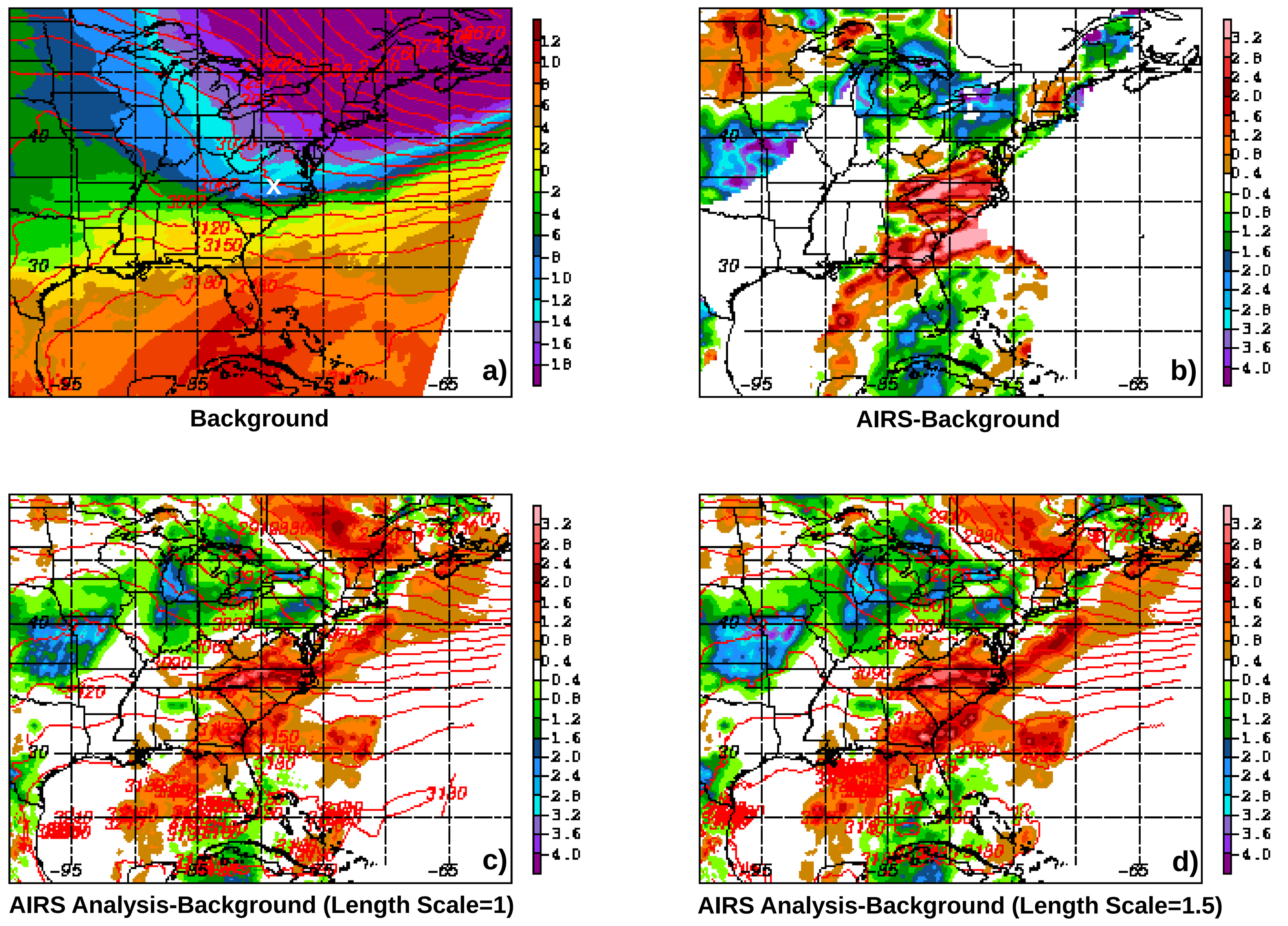

Fig. 5. Analysis impact of AIRS on 700 hPa temperature. The difference between the AIRS and the background field is shown in b) resulting in the analyses in c) and d). Figure 5c shows the analysis with the original length scale that has obvious bull's eyes and streaking (especially evident over KS and MO) while d) shows the impact of tuning the length scale to remove some of those smaller scale features. The "x" in a) denotes the location of the Greensboro, NC sounding described in Figure 7.

700 hPa Mixing Ratio Analysis

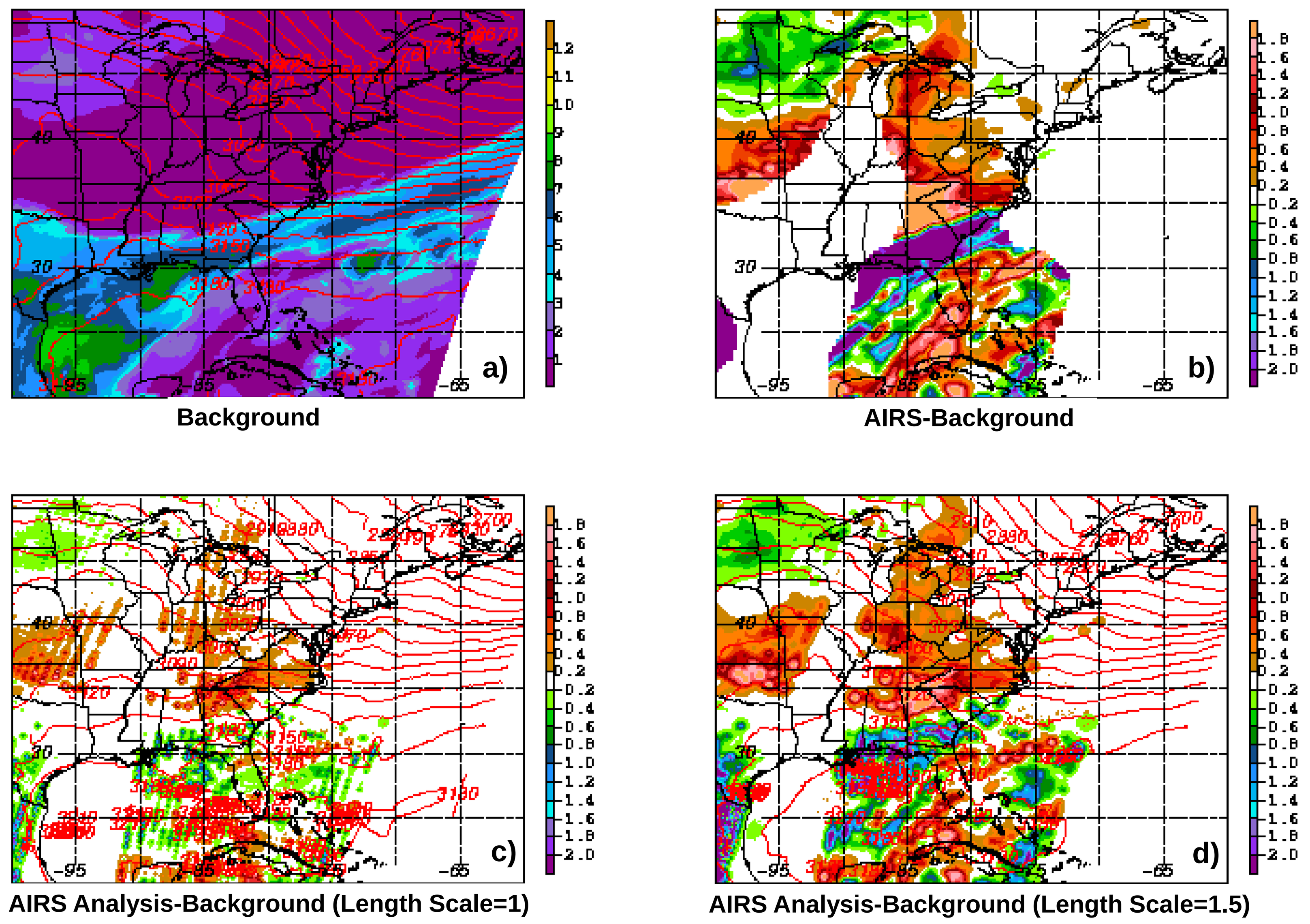

Fig. 6. Same as Fig. 5, except for mixing ratio. Figure 6d shows the impact of doubling the moisture length scale to smooth out some of the small-scale features.

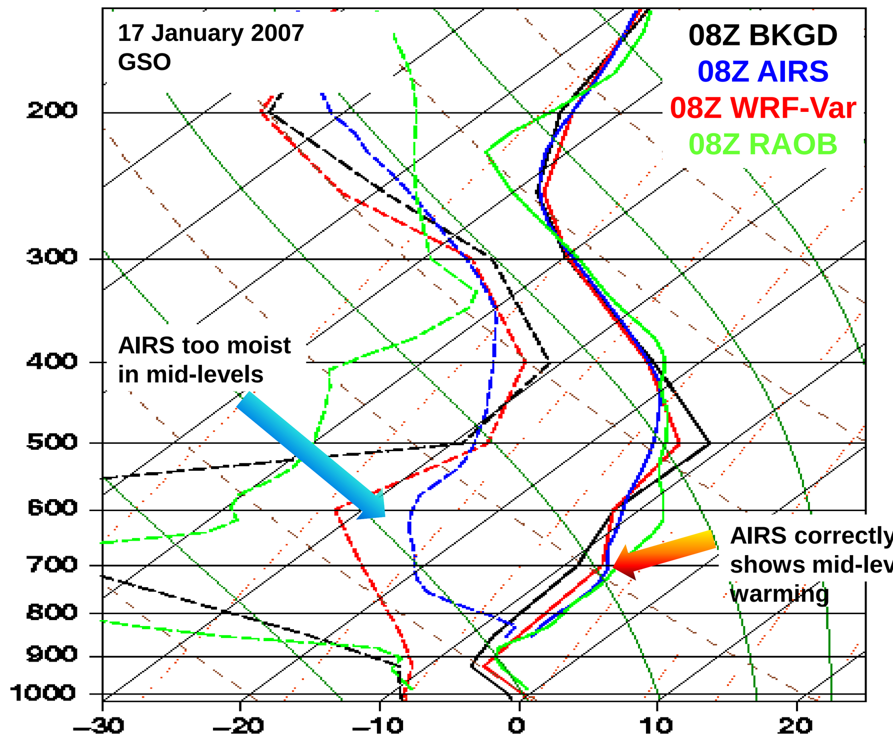

Fig. 7. Profiles of temperature (solid) and dew point (dashed) near Greensboro, NC (GSO) radiosonde location for 0800 UTC 17 January 2007. The background (black) and WRF-Var (red) profiles are for the nearest grid point. The AIRS profile (blue) is for the highest-quality retrieval closest to the grid point. The radiosonde plotted here is a linear interpolation of the 0000 and 1200 UTC soundings to 0800 UTC.

- Temperature and moisture soundings of AIRS analysis lie between those of background and AIRS profiles below 300 hPa
- AIRS analysis more comparable to radiosondes than background at mid- and lower troposphere (Fig. 7)

4. CONCLUSIONS/FUTURE WORK

- Prudent assimilation of AIRS thermodynamic profiles and quality indicators can improve initial conditions for regional weather forecast models
- For this particular analysis, the AIRS analysis more closely resembles radiosondes
- Future work: ARW model simulations to determine if the AIRS initial conditions lead to better short-term regional forecasts
- If forecast improvement is shown, AIRS initial conditions will be transitioned to selected NWS offices for local WRF runs

5. 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.