THE IMPACT OF ATMOSPHERIC INFRARED SOUNDER (AIRS) DATA ON SHORT-TERM WEATHER FORECASTS

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1. MOTIVATION

- LeMarshall et al. (2006) has shown that global assimilation of AIRS radiances has yielded forecast improvements (in terms of 500 hPa height anomaly correlations) out to 5 days
- AIRS profiles may benefit regional centers that are influenced by data sparse areas—such as the Atlantic Ocean, Gulf of Mexico, or Northern Mexico—but are not equipped to handle radiance assimilation (e.g. FL and TX NWS WFOs)
- This paper describes a procedure for regional assimilation of AIRS thermodynamic profiles into the Weather Research and Forecasting (WRF) model using the ARPS Data Assimilation System (ADAS)
- Results follow previous case study work presented in Chou et al. (2007) but provide a more robust set of results obtained from cumulative statistics of forecast impact

2. AIRS DATA

- L2 Version 5 temperature and moisture profiles assimilated over land and water
  - Version 5 profiles contain:
    - improved radiative transfer algorithm for better moisture and over land soundings
    - level-dependent quality indicators (QIs) based on retrieval error statistics
  - QIs based only on temperature but are used for moisture quality control
  - ≈54 levels below 100 hPa, ≈50 km spatial resolution
- Eastern and Central CONUS swathes combined into one swath; time of overpass is average of the two overpasses (e.g. Figs. 1 and 2)
- Only data from night time overpasses are used

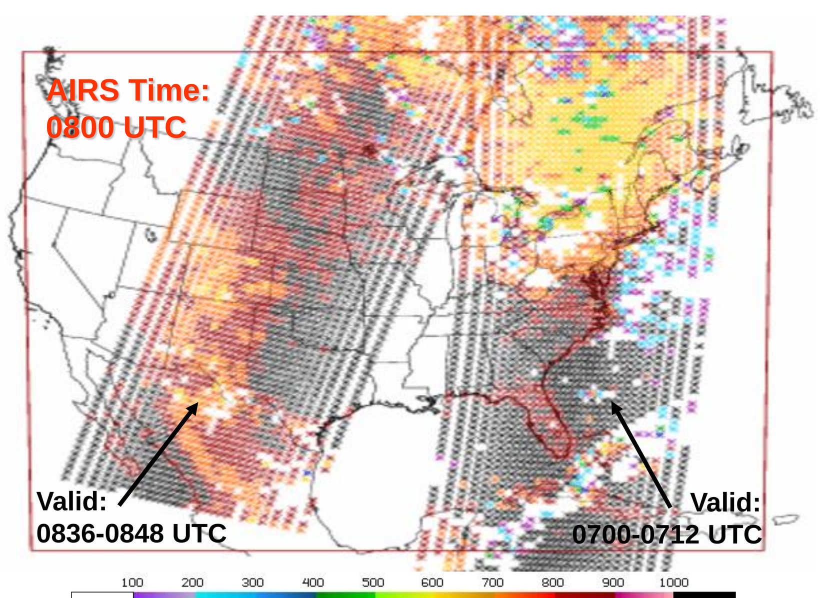

Fig. 1. Example of three-dimensional distribution of AIRS profile data assimilated on 0800 UTC on 26 January 2007. Each colored point denotes the maximum pressure level above which quality data is found according to the AIRS QIs. The red rectangle denotes the bounds of the ADAS/WRF domain.

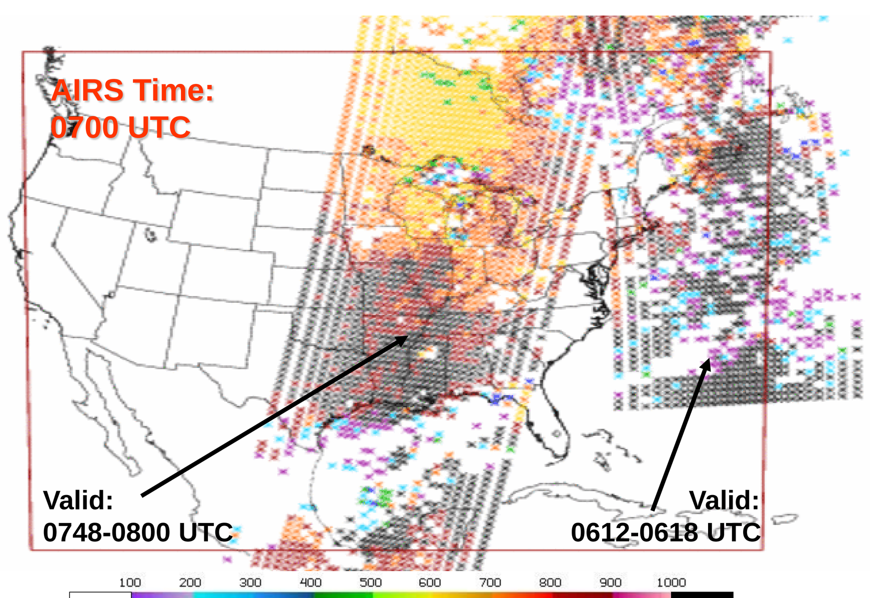

Fig. 2. Same as Fig. 1 but for 0700 UTC on 3 February 2007.

3. EXPERIMENT DESIGN

- Bulk statistics to investigate if inclusion of AIRS profiles adds value to operational forecasts
- 33 days of model runs from 17 January to 22 February 2007 (missing initial conditions for Feb. 3-5, 11)
- 12-km WRF domain (see Fig. 1) initialized at 0000 UTC on each forecast date using 40-km ETA/NAM tiles (with LBCs updated from ETA/NAM every 3h); run for 48 hours
- WRF forecast used as background for ADAS assimilations
- Larger observation error assigned to over land soundings
- Two sets of ADAS analyses provide updated initial conditions for two sets of WRF forecasts (no other external data used):
  - CNTL: no AIRS data assimilated
  - AIRS: all high quality AIRS observations as defined by QIs

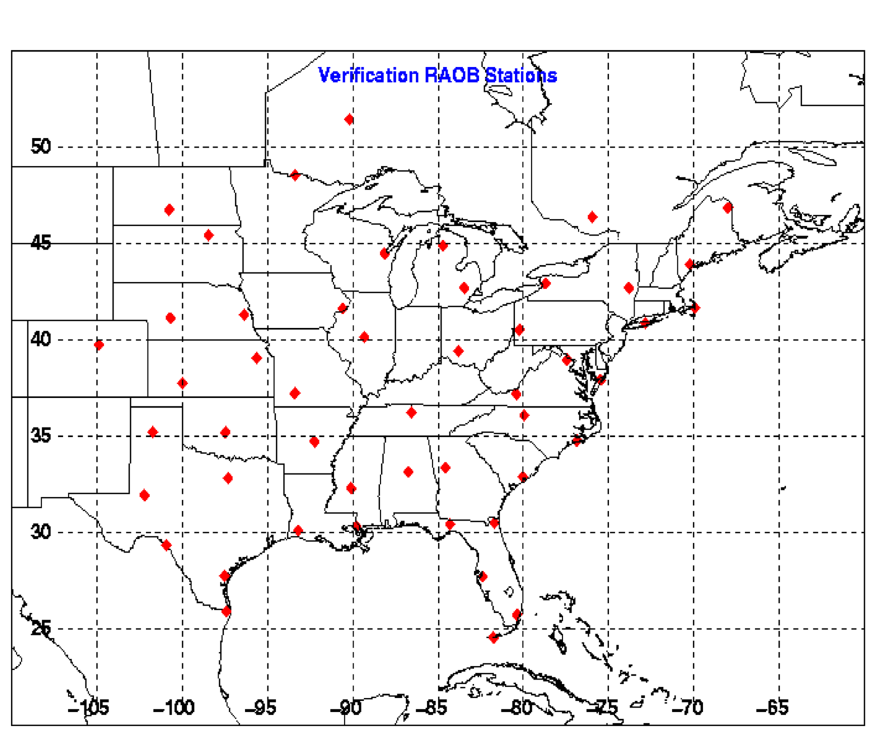

Fig. 3. Location of the 50 rawinsondes east of 105ºW that were used for verification of temperature and mixing ratio. Stage IV precipitation was verified over all valid grid points east of 105ºW.

4. RESULTS

- Temperature and mixing ratio are verified against 50 rawinsondes east of 105ºW (Fig. 3) using closest model grid point
- 6-h cumulative precipitation is verified against all NCEP Stage IV data east of 105ºW
- Stage IV data composite of rain gauge and radar data; no data outside of radar range (e.g. over open ocean
- Stage IV data is mapped to WRF model grid

4.1 Temperature and Moisture Forecast Verification (Fig. 4)

- CNTL too cool in the lower troposphere and too warm in the upper troposphere
- CNTL too dry in lower and upper troposphere and too moist in middle
- AIRS reduces temperature bias at most levels by ≈0.3ºC in lower and upper levels
- AIRS changes low and mid-level moisture by as much as 5% at some levels
- Temperature and moisture adjustments made without increasing RMS error

4.2 6-hr Cumulative Precipitation Verification (Fig. 5)

- Threat scores show overall improvement at 36 hours with AIRS
  - Larger ETS (bars) for the AIRS case at all thresholds indicates improvement in predicted precipitation location and amount
  - Bias scores (lines) suggest that AIRS improves the coverage of the precipitation features

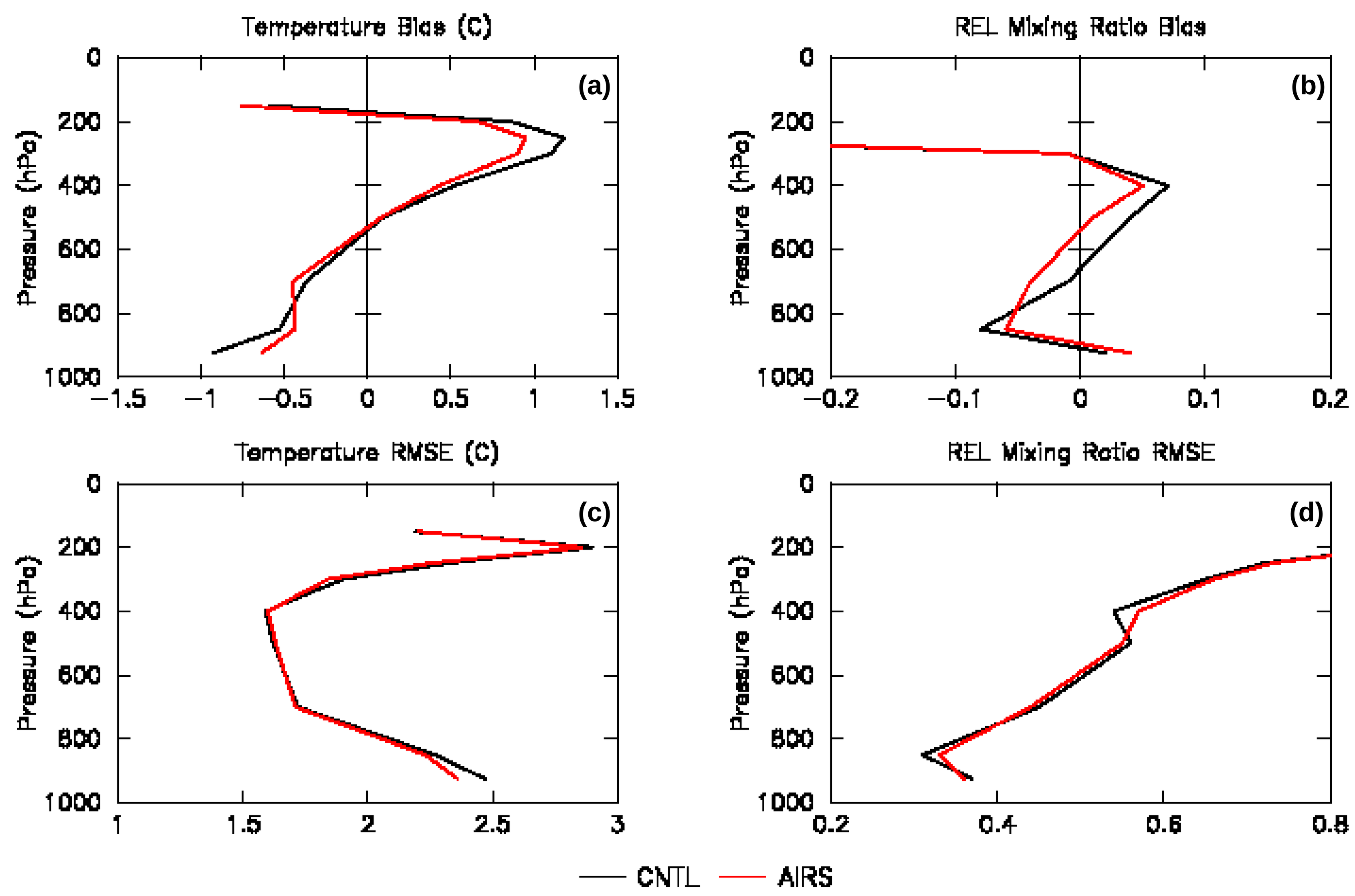

Fig. 4. Cumulative statistics for 36-h forecasts from 33 days from mid-January to mid-February of temperature bias (ºC) (FCST – OBS) (a), and RMS error (ºC) (c) and mixing ratio bias (FCST – OBS) (b) and RMS error (d). The units for mixing ratio are the normalized moisture compared to the overall moisture at a given level.

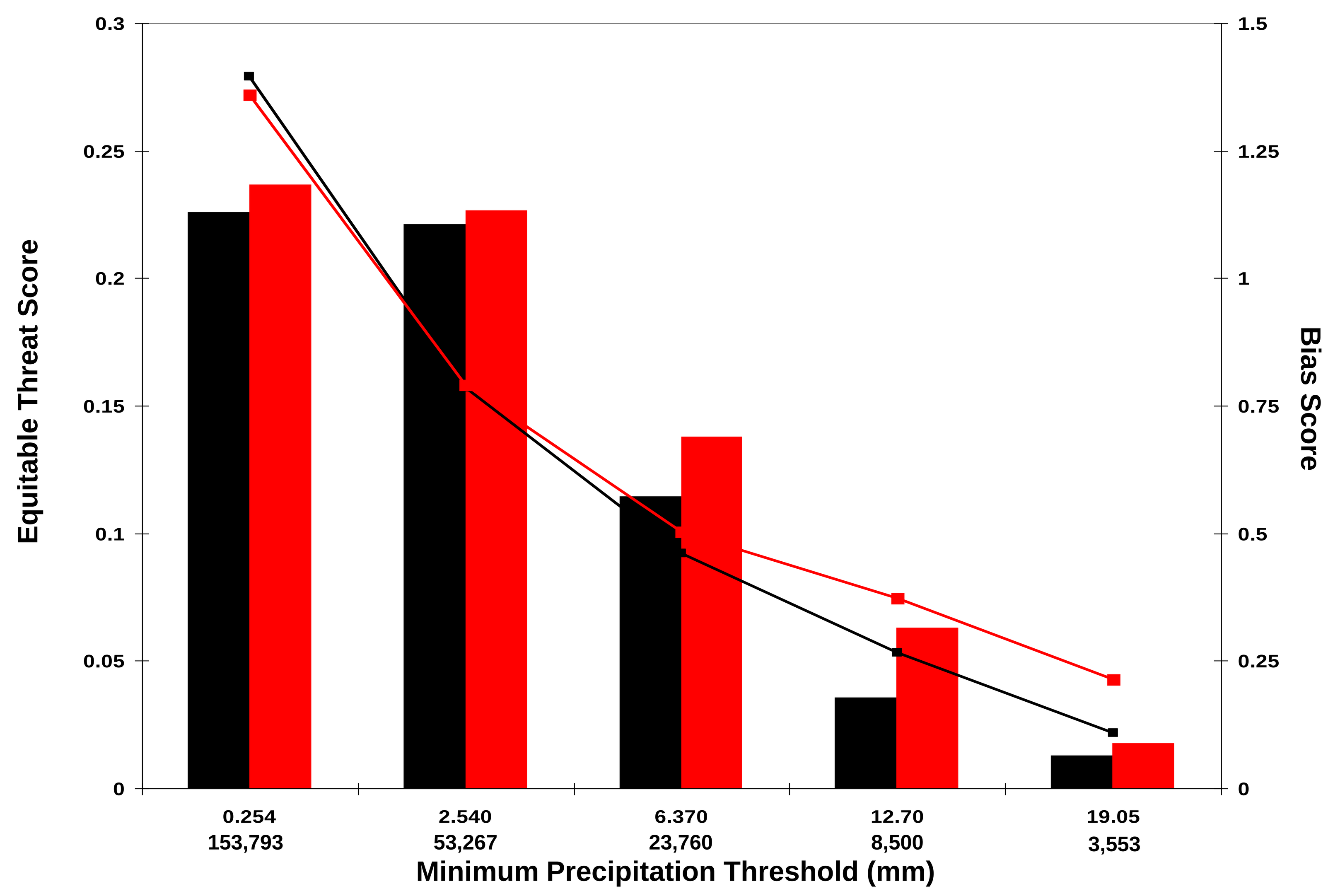

Fig. 5. Equitable threat scores (ETS; bars) and bias scores (lines) for 6-h cumulative precipitation ending at the 36-h forecast, which is representative of the overall trends in the statistics. The numbers below each threshold represent the number of observed grid points used in the statistics calculations.

5. NEAR REAL TIME (NRT)/OPERATIONAL AIRS ASSIMILATION (Fig. 6)

- Operational users of AIRS data require quick availability for nowcasting (e.g. in AM for forecasting PM thunderstorms)—current configuration completes model run at approximately 9:15 AM local time
- University of Wisconsin Direct Broadcast is quickest NRT data source—awaiting implementation of V5 algorithm on this system

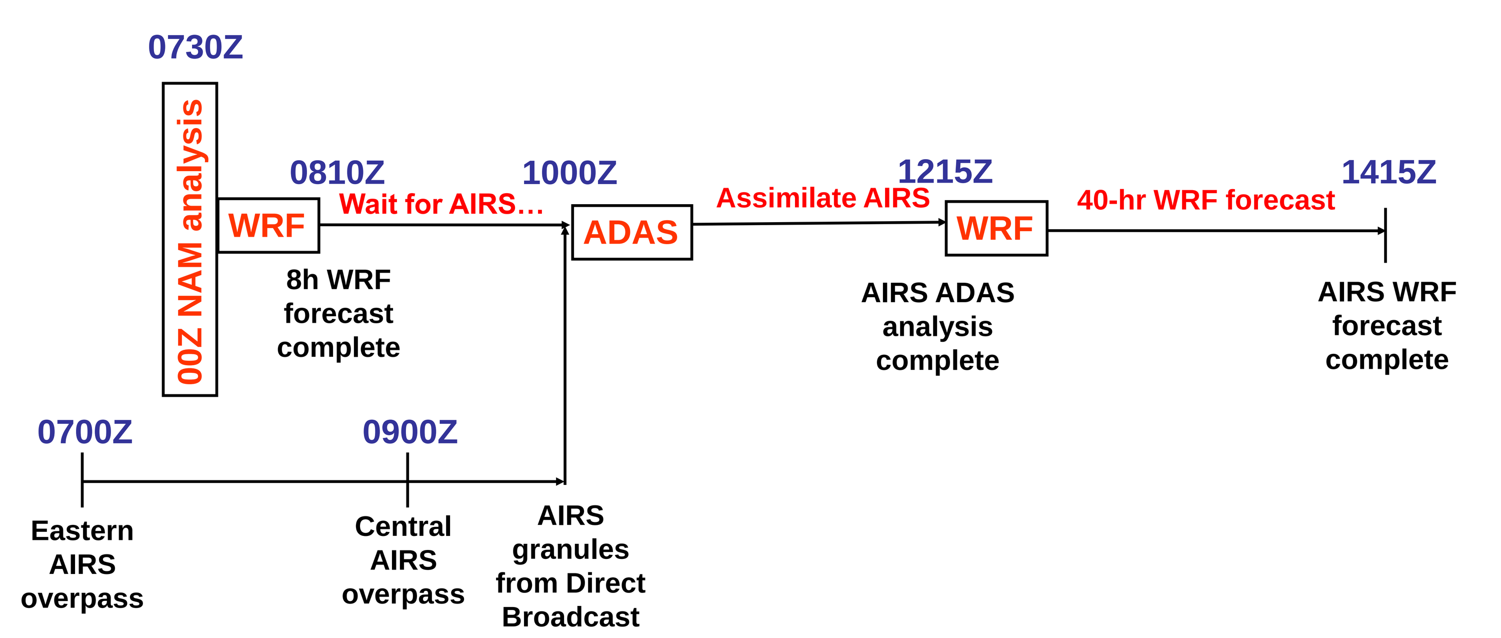

Fig. 6: Schematic of NRT assimilation system using 26 January 2007 (see Fig. 1) as an example. The blue numbers represent wall time that a certain segment of the process are completed in the current configuration.

6. CONCLUSIONS/FUTURE WORK

- Prudent assimilation of AIRS thermodynamic profiles and quality indicators can improve initial conditions for regional weather forecast models
- For 33 days of model runs, improvements are seen at most forecast times for temperature, mixing ratio, and cumulative precipitation
- Further investigation is necessary to understand under what types of weather patterns and what layout of AIRS data produces the largest improvements
- Future work will involve possible implementation of variational assimilation system and transition of AIRS-enhanced initial conditions to WFOs

7. ACKNOWLEDGEMENTS

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8. REFERENCES

See preprint for references