



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



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1. MOTIVATION

- The Joint Center for Satellite Data Assimilation (JCSDA) has shown that the global assimilation of AIRS radiances has yielded forecast improvements (in terms of 500 hPa height anomaly correlations) out to 5 days
- AIRS profile assimilation is a logical first step to using AIRS data in regional forecast models
- 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 show impact of AIRS profiles on initial analyses and subsequent numerical forecasts

2. AIRS DATA

- L2 prototype Version 5 thermodynamic profiles are assimilated over water only (Fig. 1)
 - Improved radiative transfer algorithm and level-dependent quality indicators (QIs) based on error statistics
 - Temperature and moisture at ~54 levels below 100 hPa, ~50 km spatial resolution

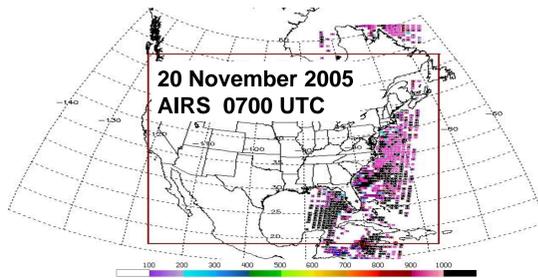


Fig. 1. Three-dimensional distribution of AIRS profile data assimilated at 0700 UTC on 20 November 2005. Each colored point denotes the maximum pressure level above which quality data is found according to the AIRS quality indicators. The red rectangle denotes the bounds of the ADAS/WRF domain.

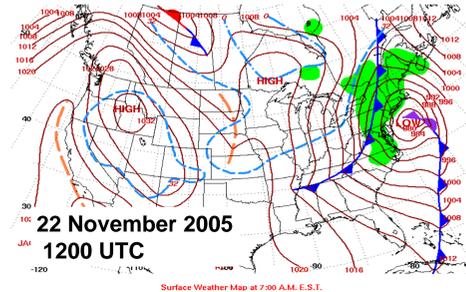


Fig. 2. Surface map valid at 0000 UTC 22 November 2005 showing location of surface low that is the focus of this case study.

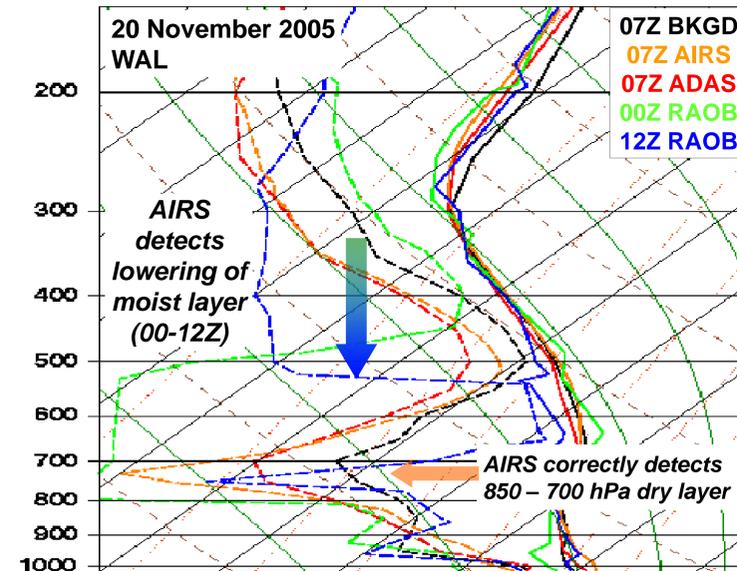


Fig. 4. Profiles of temperature (solid) and dew point (dashed) near Wallops Island, VA (WAL) RAOB location on 20 November 2005. The background (black) and ADAS (red) profiles are for the nearest grid point. The AIRS profile (orange) is for the highest-quality retrieval closest to the grid point.

- Detailed structure exhibited in the AIRS moisture profiles show thin dry layer at 850-700 hPa (as seen in Fig. 3) and moistening at 500 hPa ahead of the storm system, which is consistent with RAOBs (Fig. 4)

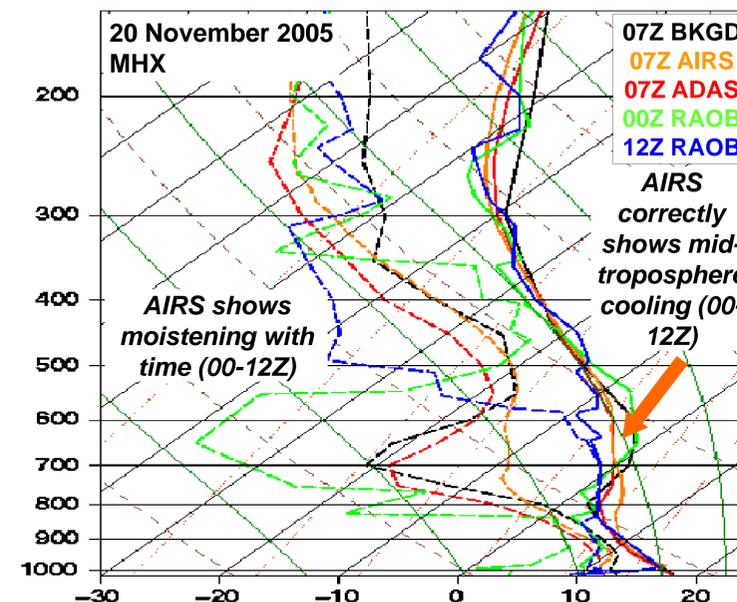


Fig. 5. Same as Fig. 4 but for Morehead City, NC (MHX) RAOB location. The background (black) and ADAS (red) profiles are for the nearest grid point. AIRS profile (orange) is for the highest-quality retrieval closest to the grid point.

- AIRS profiles correctly detect destabilization of the mid-troposphere (700 – 500 hPa) in advance of the developing storm system (Fig. 5)
- These features are not well defined in the background field profiles
- Assimilation of AIRS profiles improves initial conditions for WRF

4.2 Temperature and Moisture Forecast Verification

- WRF forecasts made for 60h from 0600 UTC 20 November 2005
- Verify temperature and mixing ratio against 17 east coast RAOBs (Fig. 6)

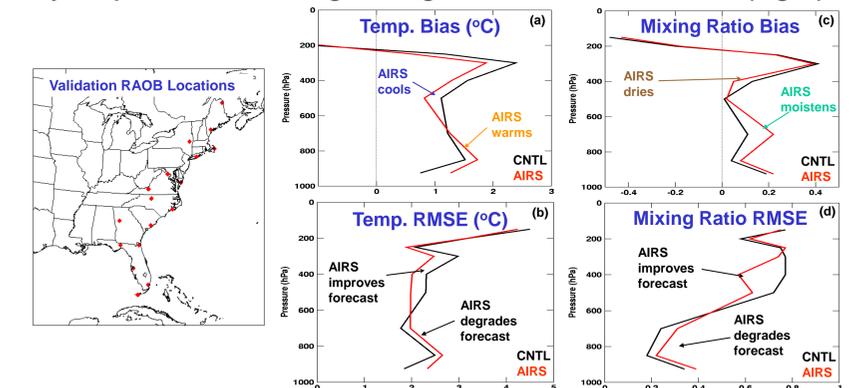


Fig. 6. Verification statistics for the 42h forecast valid at 0000 UTC 22 November 2005 showing (a) temperature bias (FCST - OBS), (b) temperature RMSE, (c) mixing ratio relative bias (FCST - OBS), and (d) mixing ratio relative RMSE. Map (left) shows the location of the 17 RAOB sites used for the verification.

- CNTL forecast is too warm and moist at all levels below 200 hPa
- Adding AIRS profiles produces the following forecast trends compared to CNTL:
 - Warming and moistening of the forecast (raising RMSE) below 600 hPa
 - Cooling and drying of the forecast (lowering RMSE) above 600 hPa

4.3 Precipitation Forecast Verification

- Verify against NCEP Stage IV data for 6-h cumulative precipitation ending at the 42-h forecast valid at 0000 UTC on 22 November 2005

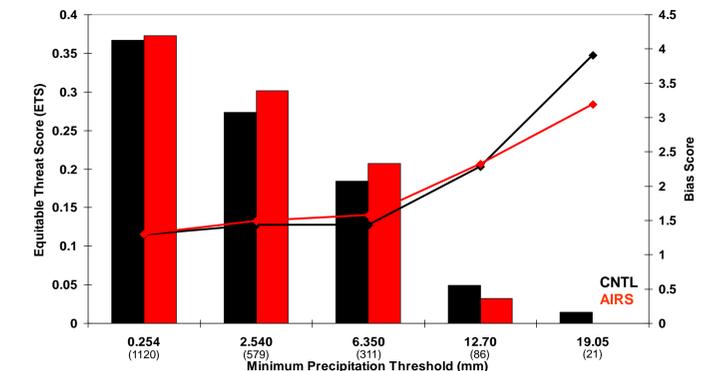


Fig. 7. Equitable Threat Score (ETS; bars) and Bias Score (lines) for 6-h cumulative precipitation ending at 0000 UTC 22 November 2005 (42-h forecast), which is representative of the overall trends in the statistics. The number in parentheses below each threshold represents the number of grid points used in the statistics calculations.

- Threat scores show overall improvement with AIRS (Fig. 7)
 - Larger ETS (bars) for the AIRS case at most thresholds indicates improvement in predicted precipitation location and intensity below 12.70 mm threshold
 - Bias score (lines) suggests slight degrading in accuracy of precipitation coverage with AIRS data below 12.70 mm threshold

5. CONCLUSIONS/FUTURE WORK

- Prudent assimilation of AIRS thermodynamic profiles and quality indicators can improve initial conditions for regional weather forecast models
- For this case study, AIRS data improved temperature and moisture forecasts above 600 hPa and 6h cumulative precipitation ETS out to 42h
- Future work will extend evaluation datasets using near-real-time forecasts with Version 5 AIRS data (available in early '07) to obtain bulk statistics of forecast impact and to aid selection of new cases

6. ACKNOWLEDGEMENTS

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3. EXPERIMENT DESIGN

- 20-22 November 2005 case study following development of surface low that originates in the Gulf of Mexico, strengthens and moves up the US east coast (Fig. 2)
- WRF initialized at 0600 UTC on 20 November 2005 and run for 60h--ETA/NAM tiles are used to initialize the 36-km domain WRF and update LBCs every 3h
- A 1h WRF forecast is used as background for ADAS and assimilation of 0700 UTC profile data
- Two ADAS analyses are produced to provide updated initial conditions for WRF:
 - CNTL: no AIRS data assimilated, AIRS: use all AIRS profiles deemed high quality by QIs

4. PRELIMINARY RESULTS

4.1 Impact of AIRS Data on ADAS Analyses

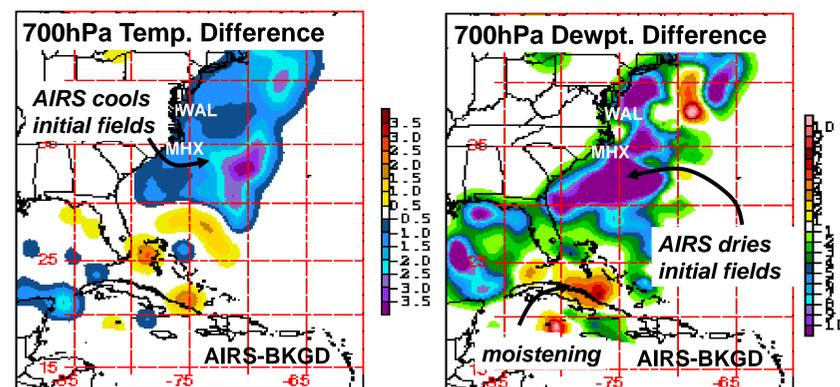


Fig. 3. 700 hPa ADAS analysis differences (AIRS - BKGD) of temperature (°C; left) and dew point temperature (°C; right) showing large-scale cooling and drying effect of AIRS on the analysis.

- AIRS profiles at 700hPa have an overall cool and dry impact over a large region (Fig. 3)
- The absolute magnitude (4°C for temperature, 10°C for dew point) and spatial distribution of the differences shown at 700 hPa are comparable to other levels
- AIRS analysis is consistent with trends in the RAOB data (Figs. 4 and 5)