Impact of AIRS Thermodynamic Profile on Regional Weather Forecast

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Outline

• AIRS and assimilation technique
• WRF forecast/assimilation system
• Overall forecast impact on 6-h precipitation
• Case study of severe weather outbreak
  • Impact of AIRS on WRF-Var analysis
  • Improvements in precipitation forecast
• Summary
Atmospheric InfraRed Sounder (AIRS)

- High quality and global coverage
- L2 Version 5 temperature and moisture profiles
- Land and water soundings with separate errors
- Quality control using $P_{best}$ value in each profile
- Sensitivity study assimilating only AIRS profiles

AIRS QI’s for 17 Jan 2007
WRF Forecast/Assimilation System

- 12-km, 450x360 horizontal grid
- 50 vertical levels topped at 50 hPa
- WRF ARW initialized at 0000 UTC using NAM analysis
- AIRS profiles assimilated at observation time
- 7-9 h forecast used as background
- B matrix generated using 37 control forecasts
- Two 48-h forecast runs: Control and AIRS

Current Analysis Error Characteristics
Overall Impact on 6-h Precipitation

Combined forecast results for 12-48 h forecasts of precipitation for 37-days from winter 2007: verified against Stage IV precipitation

- Bias score shows F/O
  - Control runs over-forecast light rain and under-forecast moderate to heavy rain
  - Improved (closer to 1) for all thresholds with AIRS

- Equitable Threat Score shows forecasted and observed precipitation matches
  - Improvement at all thresholds except lightest
  - Best results for moderate thresholds (12.7 - 25.40 mm/6h)
Case Study: 12-13 February, 2007

2/12/07 1200Z Surface Analysis

Developing front draped across Texas

2/12/07 0742-0900Z AIRS

High-quality AIRS profiles in clear skies ahead of front

2/12/07 0900Z GOES IR Image
Case Study: 12-13 February, 2007

Impact of AIRS profile on WRF-Var Analysis

- Clear sky over the Gulf of Mexico allow for high-quality AIRS data to be assimilated
- AIRS profile is warmer near-surface and cooler in upper levels
- Entire column is moistened
- Result in a more unstable sounding
Case Study: 12-13 February, 2007

Impact of AIRS on analysis

• AIRS is warmer and moister than background
• Produces a warmer and moister analysis
• Results in a higher CAPE
Case Study: 12-13 February, 2007
24-h Forecast valid 00 UTC 2/13/2007

- Convective precipitation in Eastern Texas
  - Control produces some rain but does not capture significant precipitation
  - AIRS reproduces convective precipitation line
- Better representation of lower level moisture
- CAPE values above 1800 J kg\(^{-1}\) in NAM analysis
  - AIRS nicely represents CAPE
  - Control run gives no hint of higher CAPE values
Control + AIRS transitioning unique NASA data and research technologies to operations

AIRS impact on WRF forecasts

- stronger updraft and higher low-level moisture
- more unstable $\Theta_e$ profile and near saturation in convective core
- more conducive for convective activity than the control forecast

Case Study: 12-13 February, 2007

X-Section at 32 N 00 UTC 2/13/07

Shaded: $\omega$ (hPa s$^{-1}$) $r$ (g kg$^{-1}$) $\Theta_e$($^0$K) 85% RH
Summary

- Prudent assimilation of AIRS thermodynamic profiles and quality indicators can improve initial conditions for regional weather models.
- AIRS-enhanced analysis has warmer and moister PBL
- Forecasts with AIRS profiles are generally closer to NAM analyses than CNTL.
- Assimilation of AIRS leads to an overall QPF improvement in 6-h accumulated precipitation forecasts.
- Including AIRS profiles in assimilation process enhances the moist instability and produces stronger updrafts and a better precipitation forecast than the CNTL run