

Impact of AIRS Thermodynamic Profile on Regional Weather Forecast

Shih-Hung Chou, Brad Zavodsky, Gary Jedlovec
NASA/MSFC, Huntsville, AL

17th Conference on Satellite Meteorology and Oceanography
Annapolis, Maryland, 28 September, 2010



transitioning unique NASA data and research technologies to operations



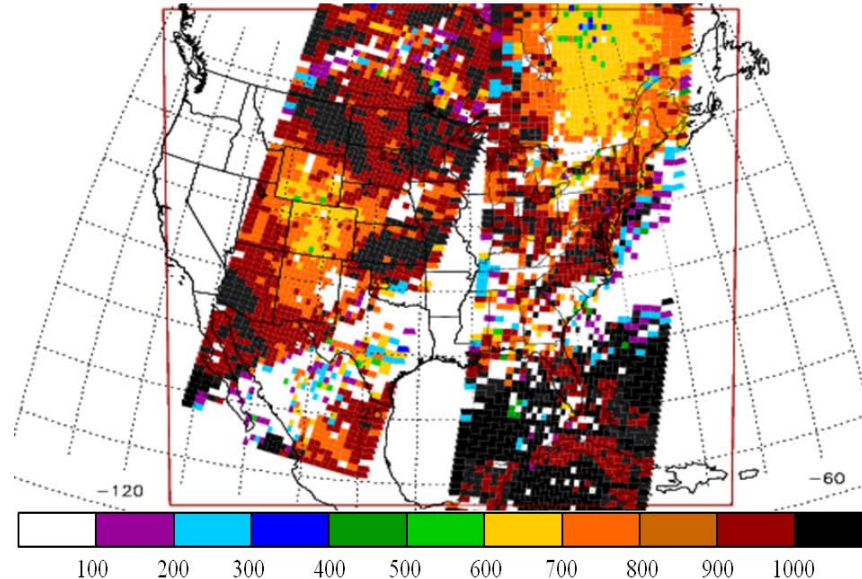
Outline

- **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 w/ separate errors
- Quality control using P_{best} value in each profile
- Sensitivity study assimilating only AIRS profiles

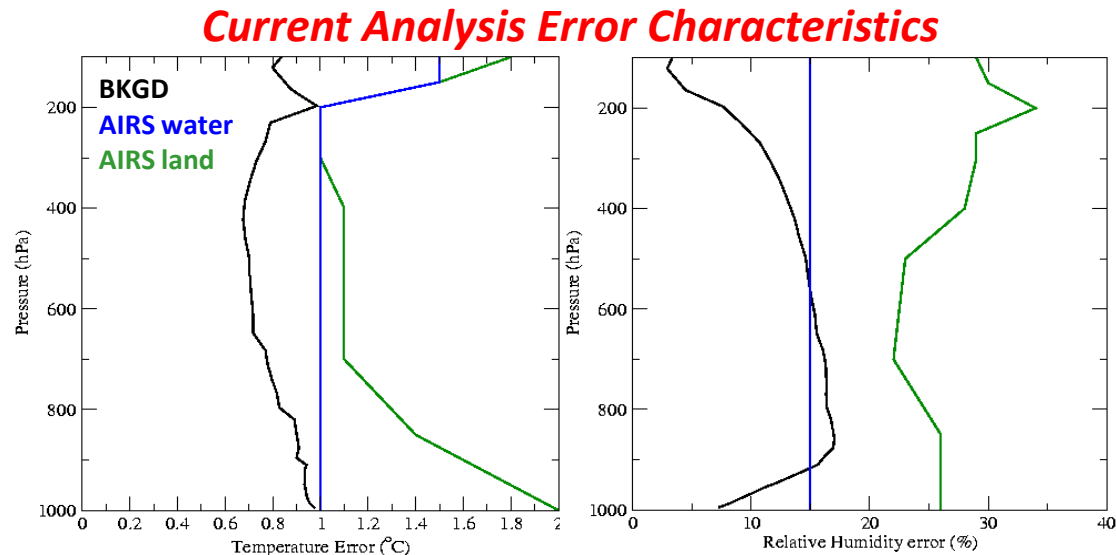
AIRS QI's for 17 Jan 2007



transitioning unique NASA data and research technologies to operations

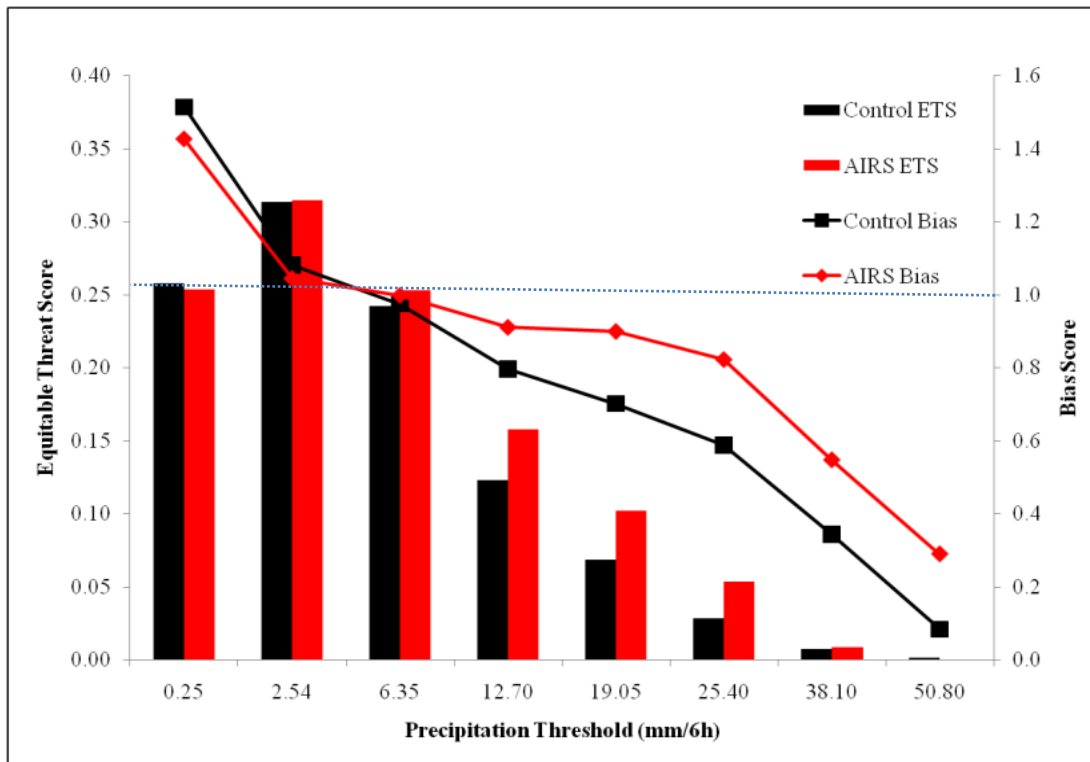
WRF Forecast/Assimilation System

- 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



Overall Impact on 6-h Precipitation

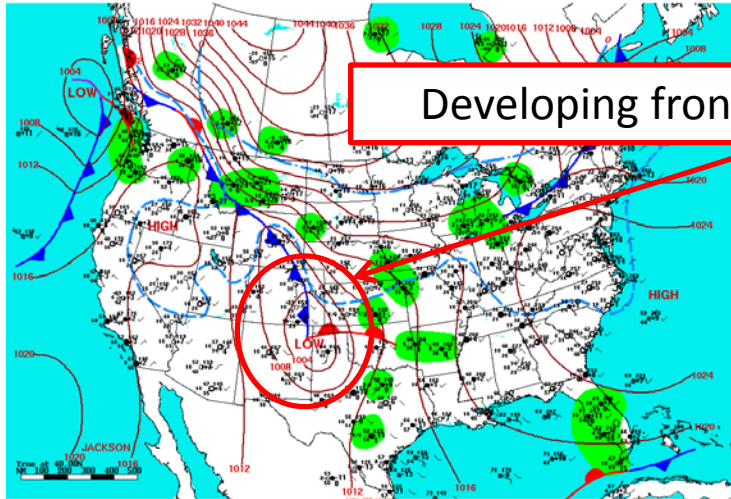
Combined forecast results for 12-48 h forecasts of precipitation for 37-days from winter 2007: verified against Stage IV precipitation



- 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)

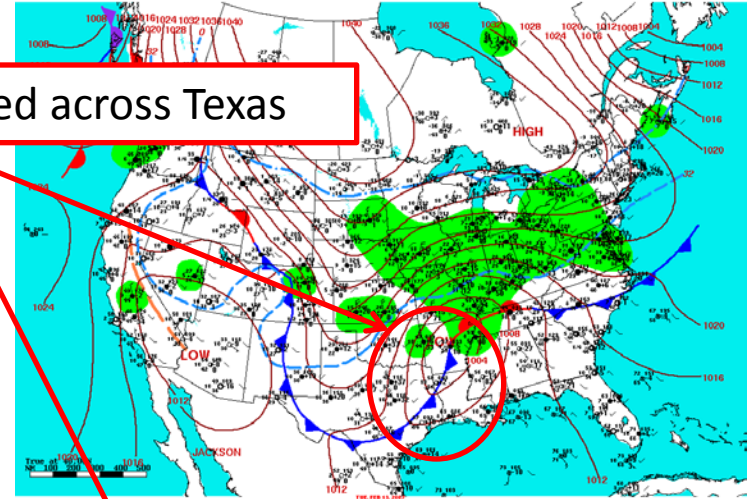
Case Study: 12-13 February, 2007

2/12/07 1200Z Surface Analysis



Surface Weather Map and Station Weather at 7:00 A.M. E.S.T.

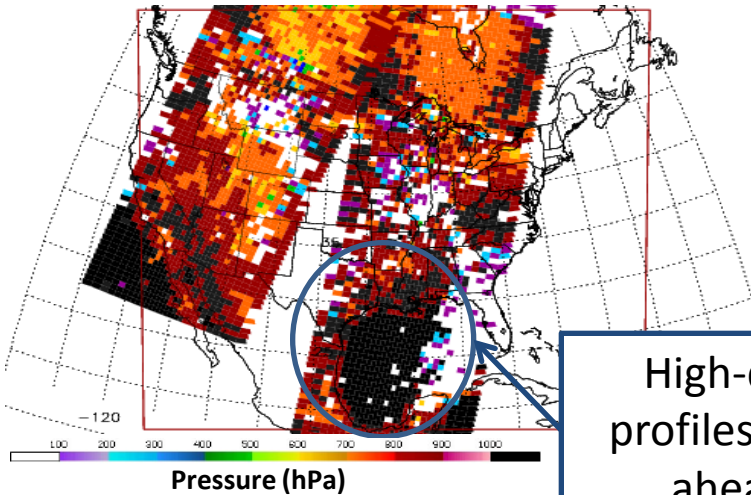
2/13/07 1200Z Surface Analysis



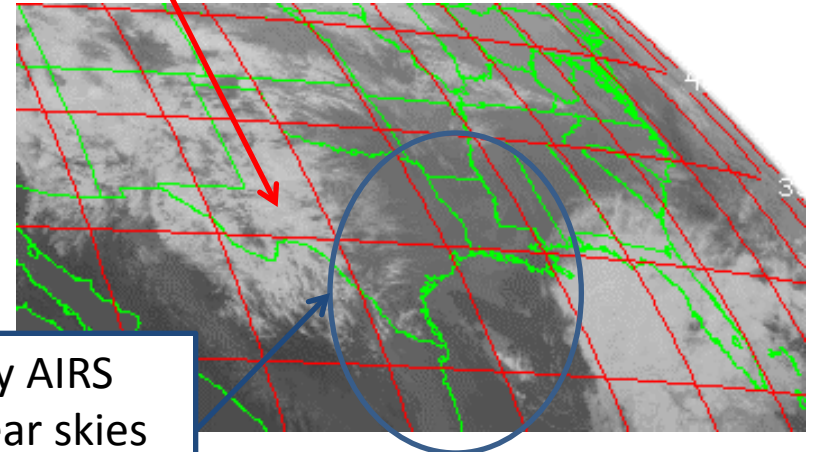
Surface Weather Map and Station Weather at 7:00 A.M. E.S.T.

Developing front draped across Texas

2/12/07 0742-0900Z AIRS



2/12/07 0900Z GOES IR Image



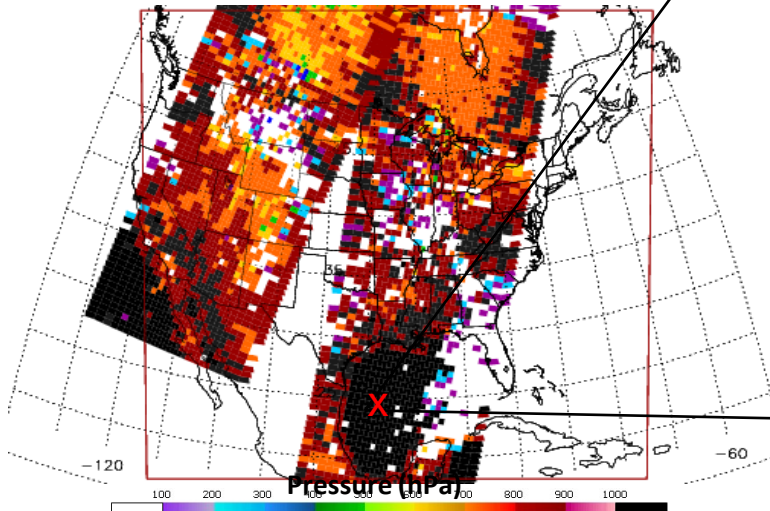
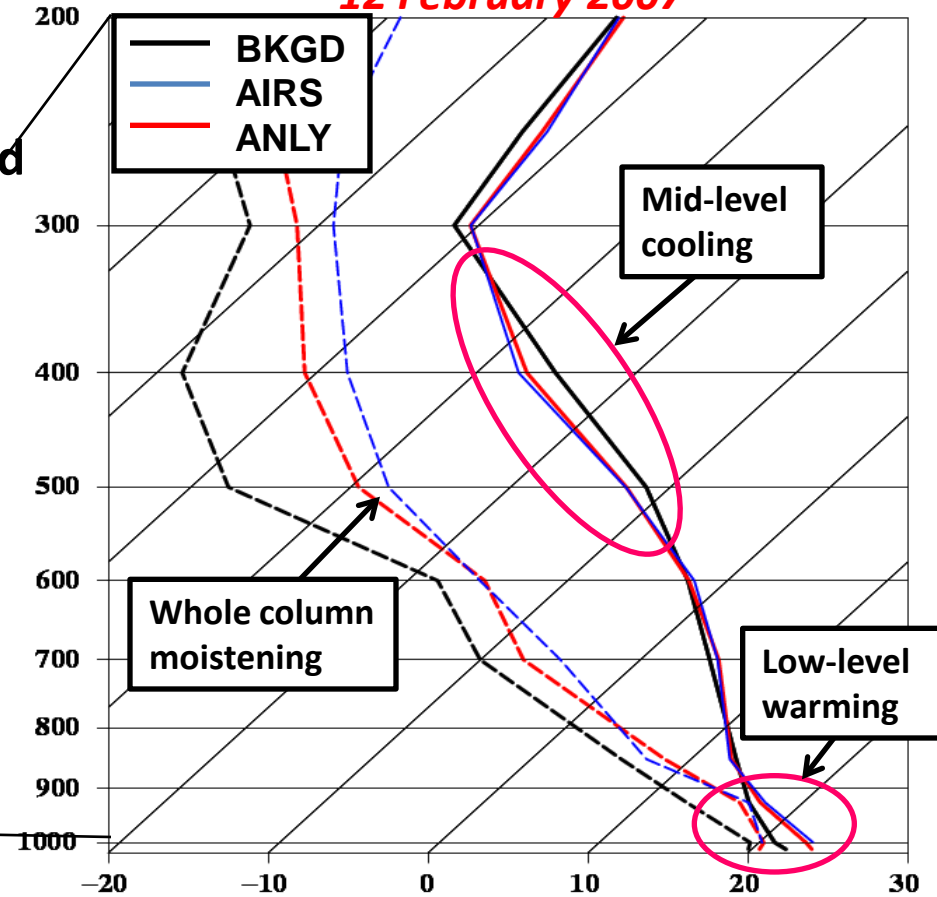
High-quality AIRS profiles in clear skies ahead of front

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

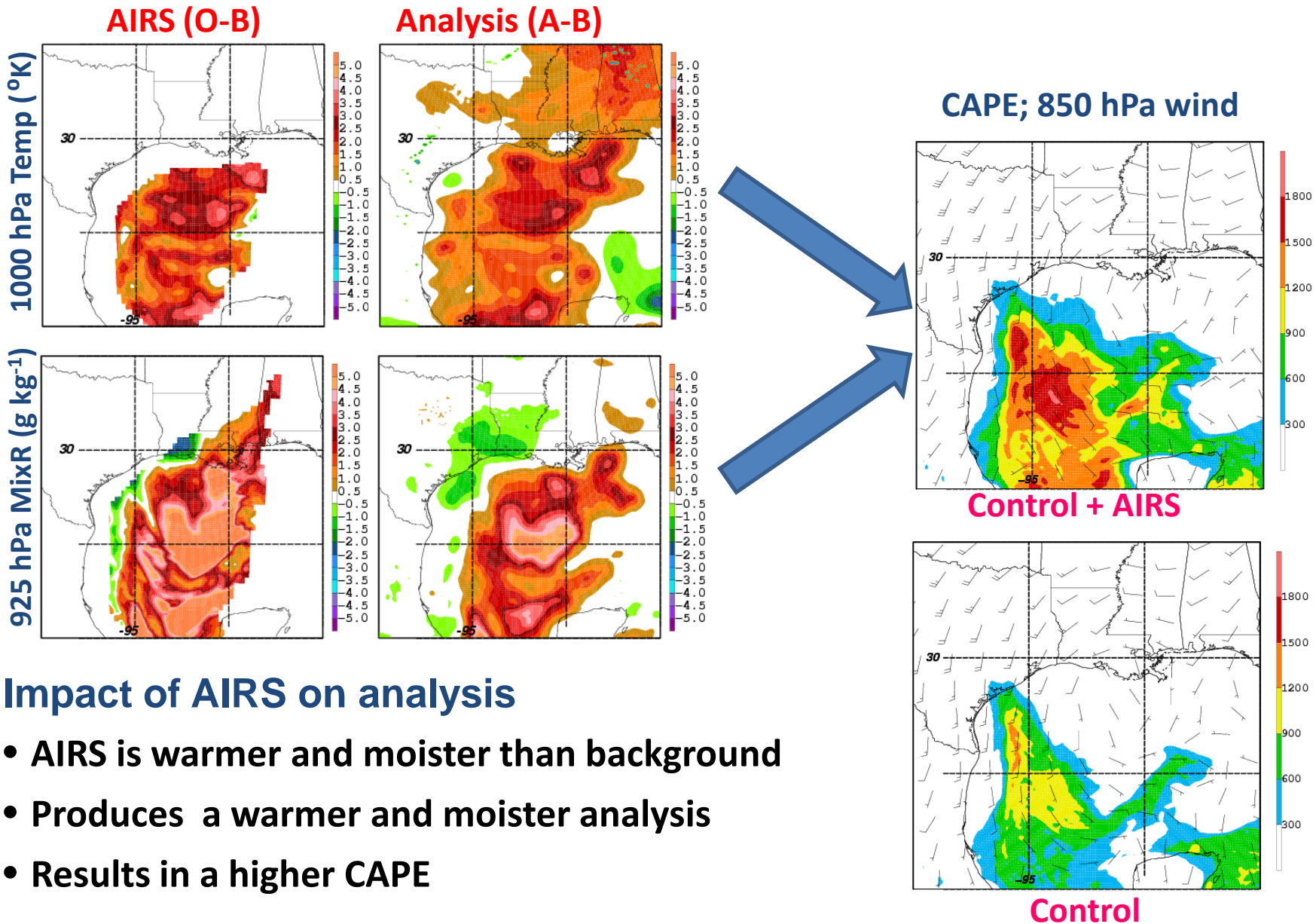
*Gulf of Mexico soundings at 09 UTC
12 February 2007*



transitioning unique NASA data and research technologies to operations



Case Study: 12-13 February, 2007

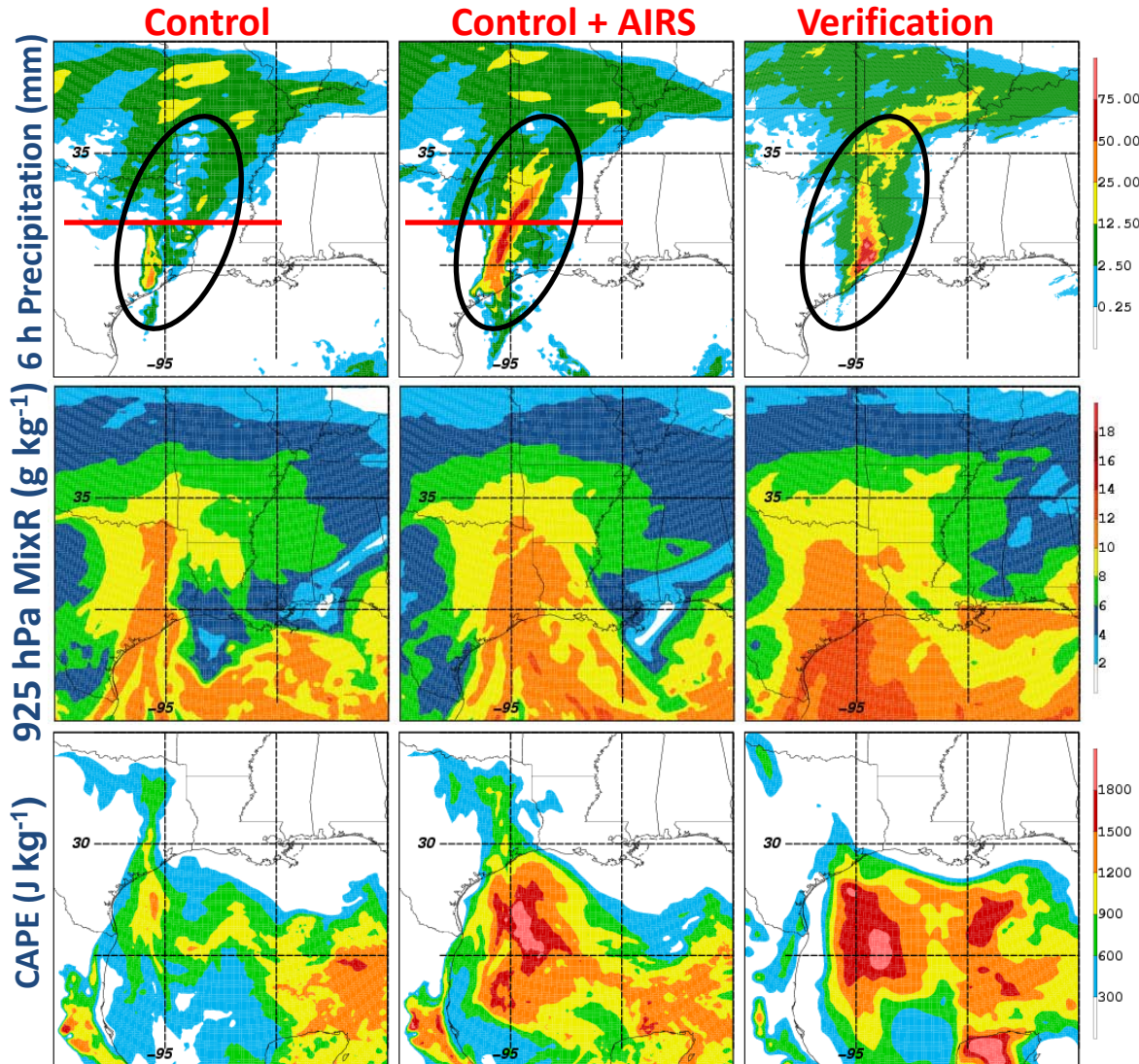


Impact of AIRS on analysis

- AIRS is warmer and moister than background
- Produces a warmer and moister analysis
- Results in a higher CAPE

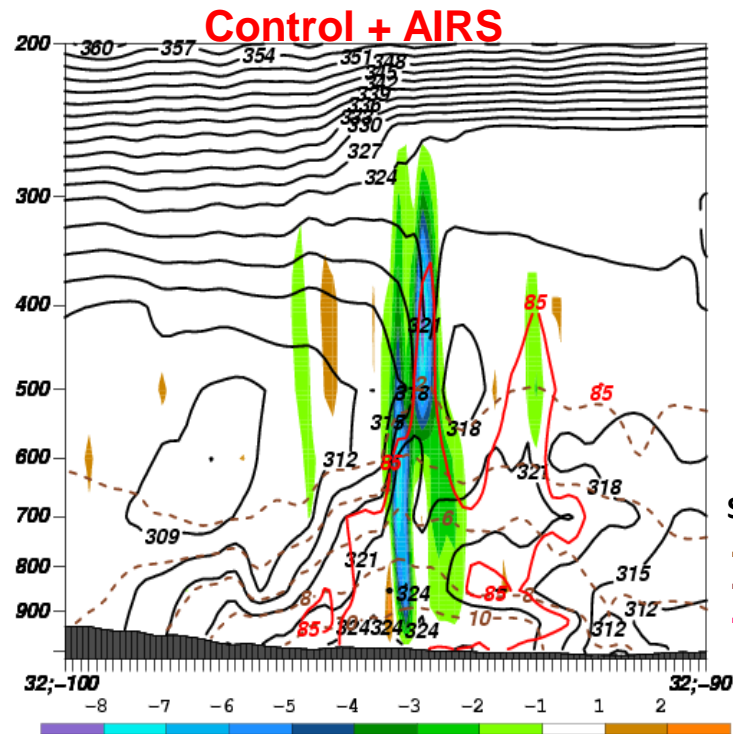
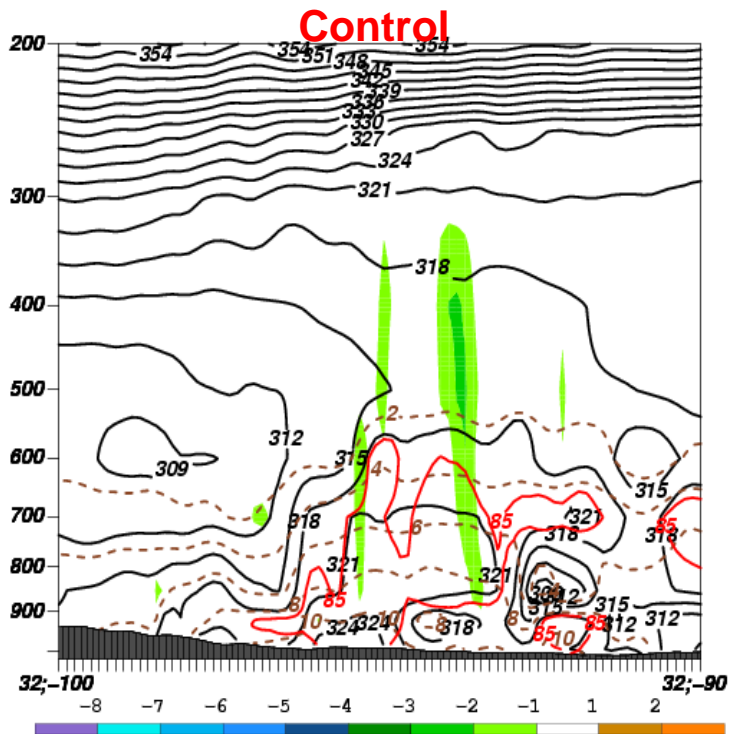
Case Study: 12-13 February, 2007

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

Case Study: 12-13 February, 2007



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

Shaded: ω (hPa s^{-1})
- - - r (g kg^{-1})
— Θ_e ($^{\circ}\text{K}$)
— 85% RH

AIRS impact on WRF forecasts

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

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