



AIRS Profile Data Assimilation in WRF

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SPoRT: NASA/MSFC

NASA Sounder Science Team Meeting

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NASA's Short Term Prediction Research and Transition (SPoRT) Center

Mission: Apply NASA measurement systems and unique Earth science research to improve the accuracy of short-term (0-24 hr) weather prediction at the regional and local scale
(<http://weather.msfc.nasa.gov/sport/>)

- ◆ Test-bed for rapid prototyping of new products
- ◆ Development of new products is end-user driven
- ◆ Transition research capabilities/products to operations
 - real-time MODIS and GOES data and products to NWS weather forecast offices and private companies (e.g. Worldwinds, Inc., The Weather Channel)
- ◆ Development of new products and capabilities for transition
 - MODIS SST composites, AMSR-E rain rates, ocean color products
- ◆ AIRS Data Uses/Plans
 - Regional assimilation of L2 temperature and moisture profiles into regional model (Chou, Zavodsky)
 - Regional assimilation of L1B radiances into regional model (McCarty; JGR)
- ◆ All work with AIRS has application to other current (IASI) and future (CrIS) instruments





Past Work/Results with WRF-Var

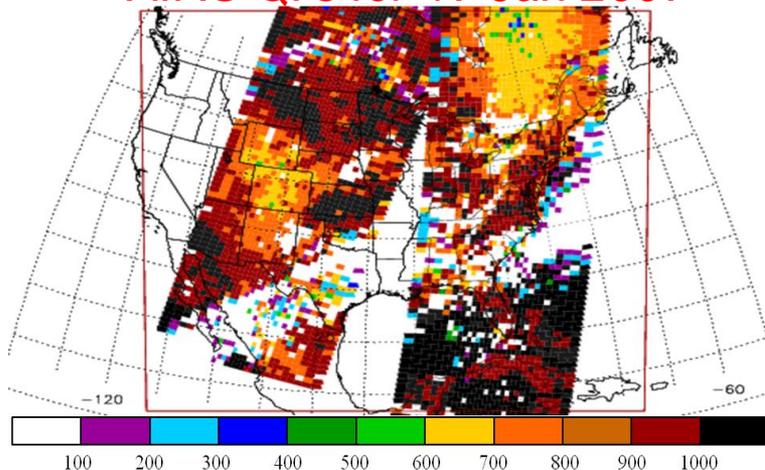
- ◆ Developed and tuned WRF-Var system to assimilate AIRS L2 temperature and moisture profiles for regional analyses and forecasts
 - generated background error covariance matrix using control WRF forecasts and internal “gen_be” software (NMC method)
 - altered source code to add AIRS profile data sets as separate land and water sounding data types with separate error characteristics
 - locally generated B-matrix is critical to success
- ◆ Examined over a month of analyses and forecasts (17 January – 22 February 2007)
- ◆ Found that proper assimilation of AIRS profiles yields improved precipitation forecasts and produces improved temperature and moisture forecasts at most forecast times and most pressure levels
- ◆ Revealed some limitations to current methodology and use of AIRS profiles
- ◆ What follows is an overview of the some lessons learned for regional assimilation of AIRS thermodynamic profiles



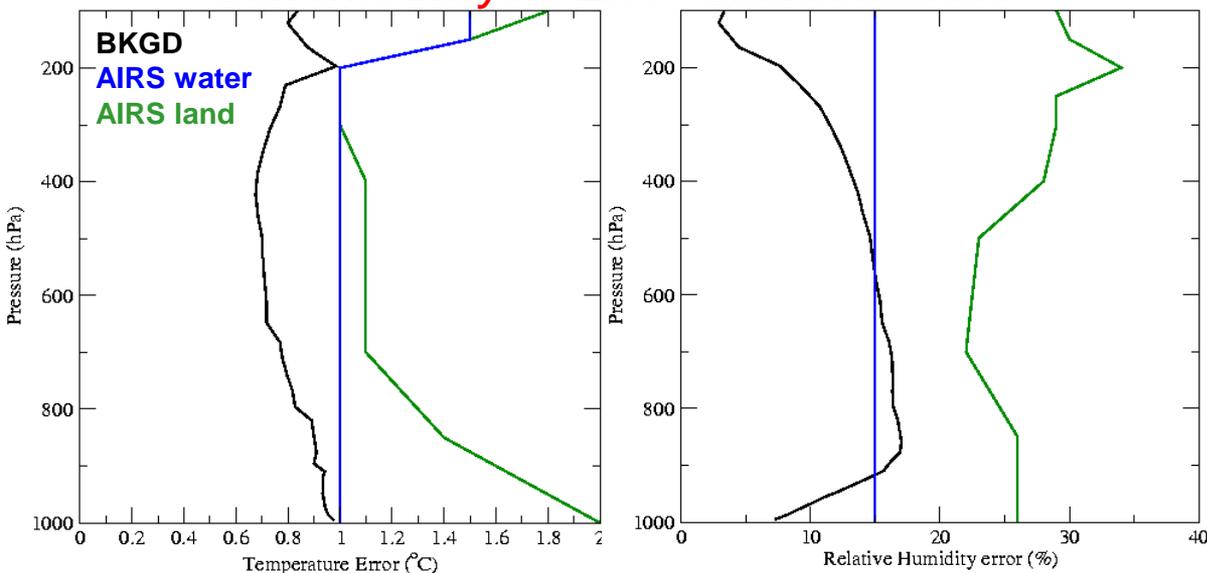
WRF-Var Setup Overview

- ◆ L2 Version 5 temperature and moisture profiles
- ◆ 28-level standard product
- ◆ Land and water soundings w/ separate errors
- ◆ Quality control using P_{best} value in each profile

AIRS QI's for 17 Jan 2007



Current Analysis Error Characteristics



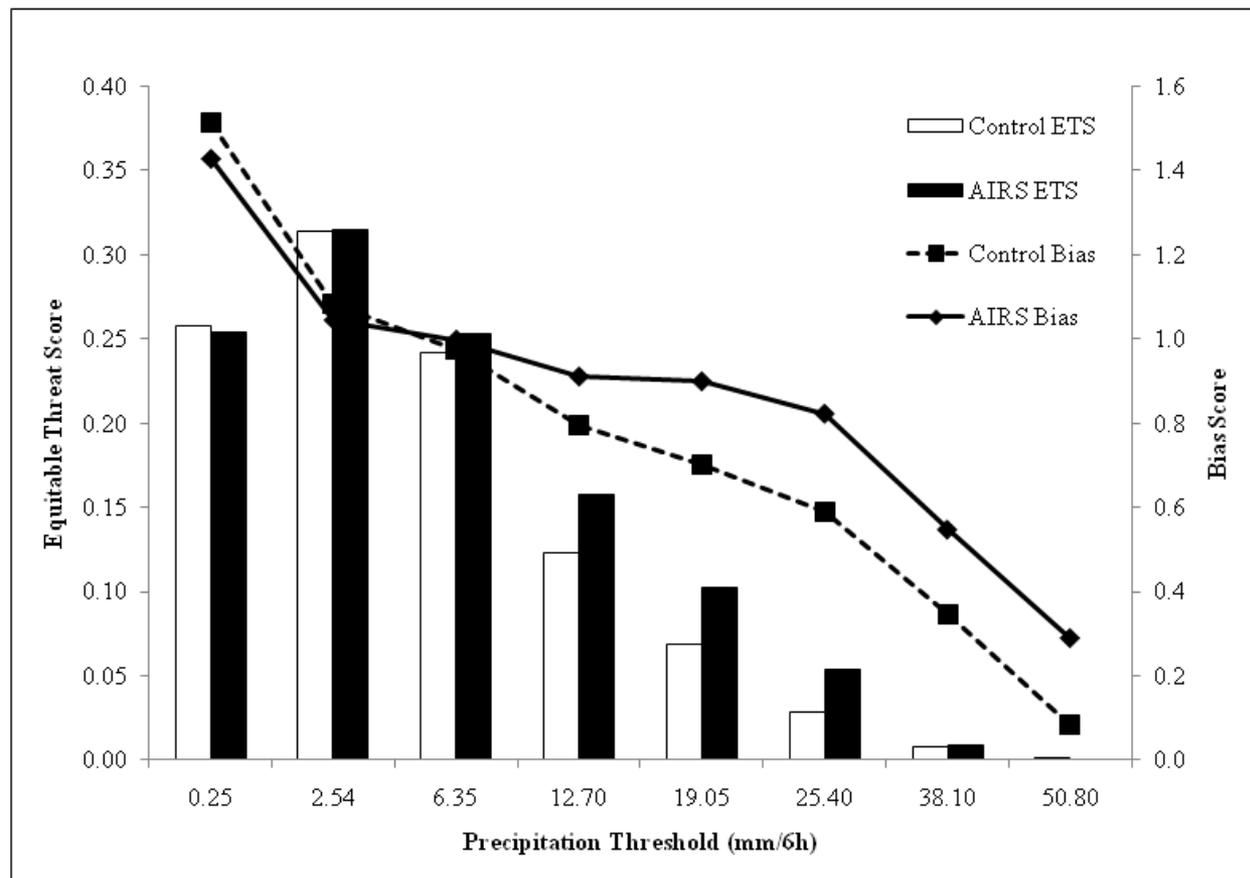
- ◆ WRF initialized with 40-km NAM at 0000 UTC
- ◆ 12-km analysis and model grid
- ◆ Short WRF forecast used as background for analysis





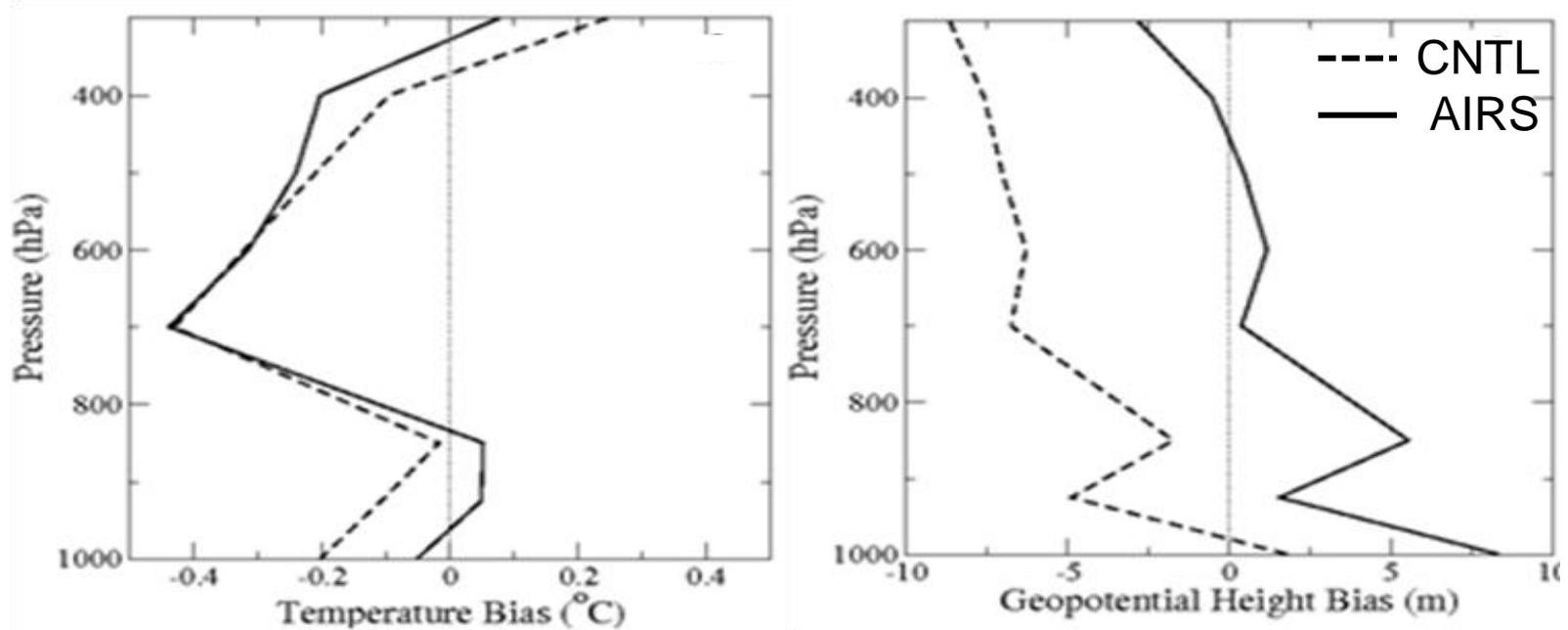
Overview of Results

- ◆ Combined forecast results for 12-48 hr forecasts of precipitation
- ◆ ETS shows how close forecasted precipitation matches observed precipitation (1.0 is best)
- ◆ Bias score shows ratio of forecasted to observed precipitation (1.0 is best)
- ◆ Improved bias score and ETS at most precipitation thresholds with assimilation of AIRS profiles





Overview of Results (cont'd)

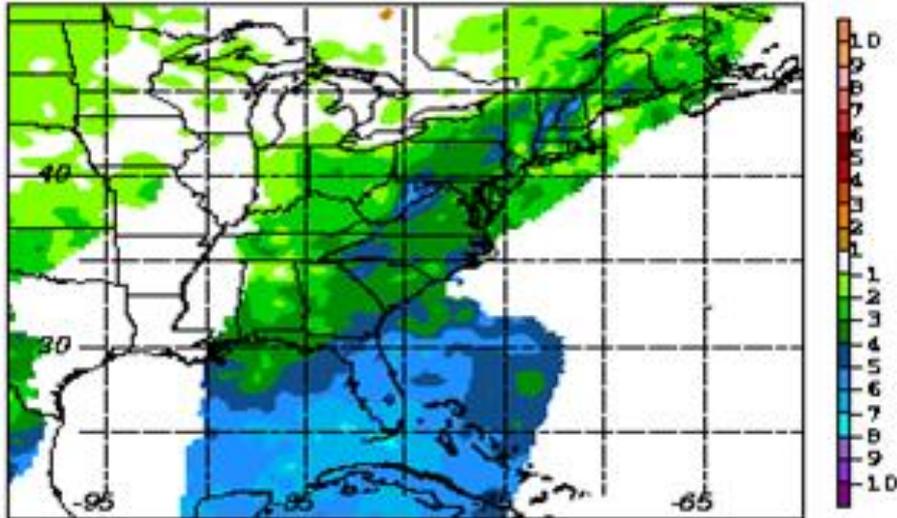


- ◆ Temperature and height forecasts for combined 12-48 h forecasts compared to NAM analyses are compared above
- ◆ Lower level warming resulting in improved forecasts; upper level cooling
- ◆ Shift in geopotential height to higher heights throughout the entire troposphere, which improves height forecasts in mid- and upper-levels
- ◆ Improve lower level heights/surface pressure to improve entire column bias

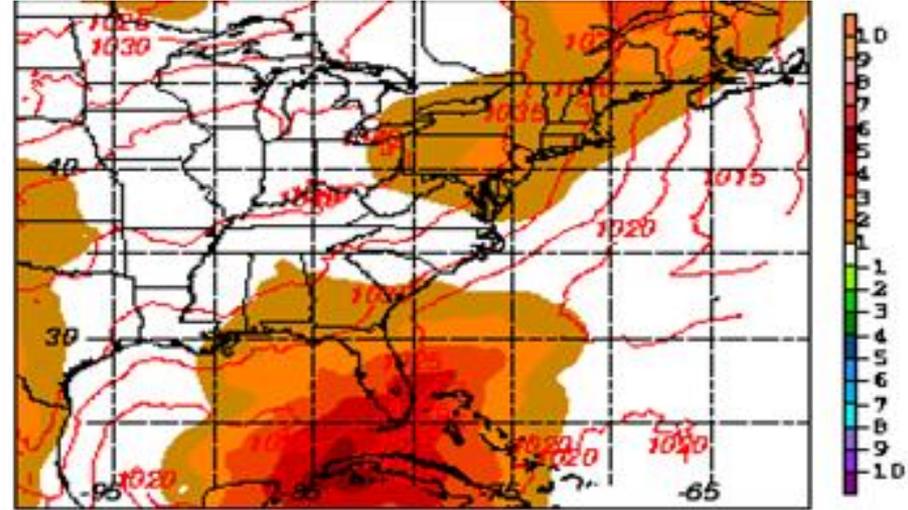


Overview of Results (cont'd)

100 hPa Innovations (AIRS-BKGD)



MSLP Analysis Increment (ALYS-BKGD)



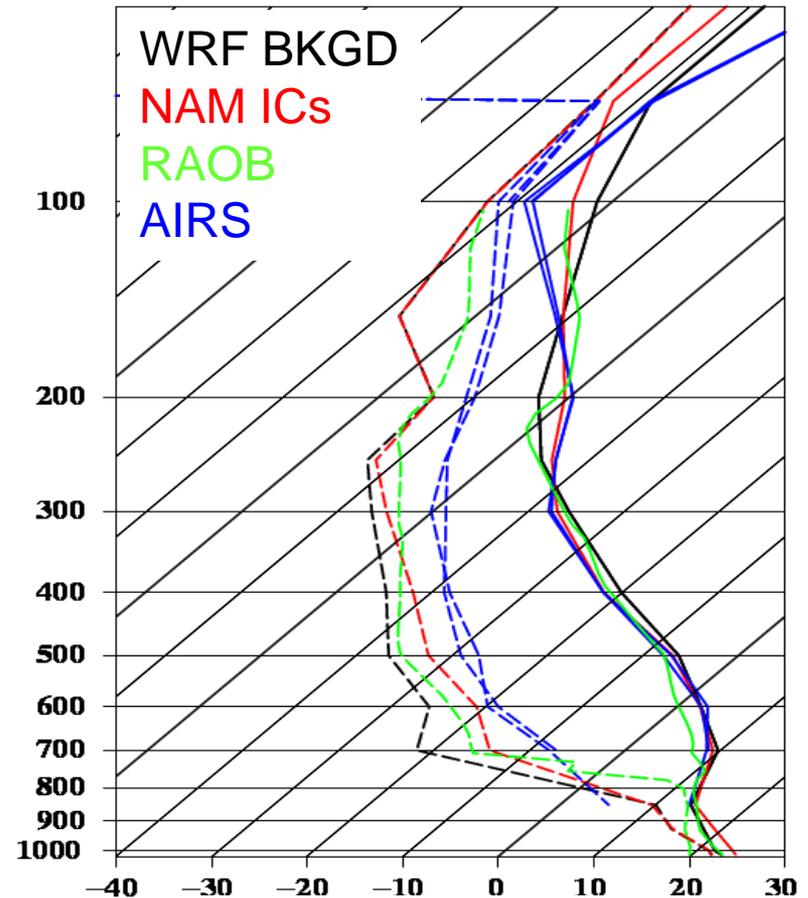
- ◆ 100 hPa AIRS is cooler than the background (especially south of 30°N)
- ◆ Analysis lower levels warm to compensate of upper-level warming
- ◆ This increase in temperature results in atmospheric expansion leading to higher surface pressure and larger heights
- ◆ Addition of surface pressure observations to mitigate effects
- ◆ Sensitivity study impacted because other observations not used to constrain changes



AIRS Profiles Too Cold Near Tropopause Over Gulf of Mexico

- ◆ Consistent pattern for much of January-February 2007 timeframe
- ◆ AIRS is approximately 3-7°C cooler than background over Gulf of Mexico at 100 hPa
- ◆ Effect of the inversions on the sounding at this level at this time of year and location
- ◆ Impact from best part of profile (mid-troposphere) is reduced
- ◆ Better handling of observations (and their errors) at upper levels is necessary
- ◆ Others have not used profile data above 400 hPa (Auligne, personal communication), but there is valuable information at these levels

Key West Soundings at 08 UTC on 17 January 2007





Vertical Resolution of Analysis Grid

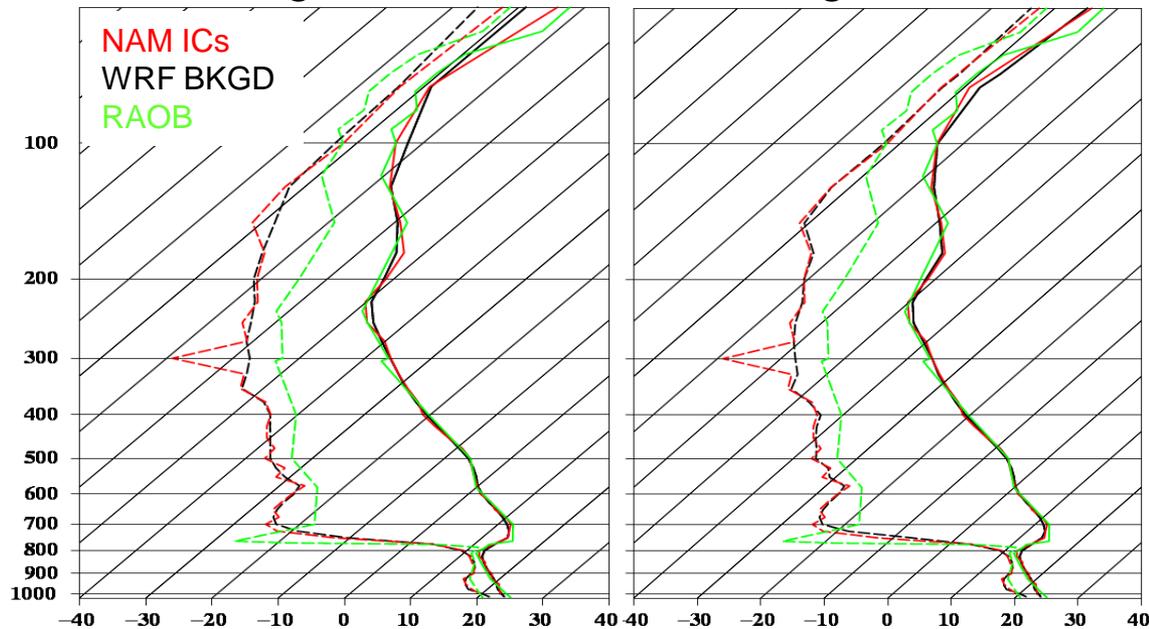
- ◆ Originally grid had 37 levels with high resolution near surface and lower resolution aloft
- ◆ Interpolation of NAM initial conditions to WRF led to the background field being 2-3°C too warm
- ◆ Interpolation error leads to exaggerated innovations at 100 mb that cause either:

- large changes to the surface pressure field due to correlations in the B matrix or
- large changes to the surface pressure field due to analysis balance that leads to warming in the other levels to compensate for the large cold change aloft

◆ Important to match (as best we can) model levels between initial conditions, background field, and observations to cut down on interpolation errors

Model/Ob Soundings near Key West 1/17/07

37 Sigma Levels 50 Sigma Levels

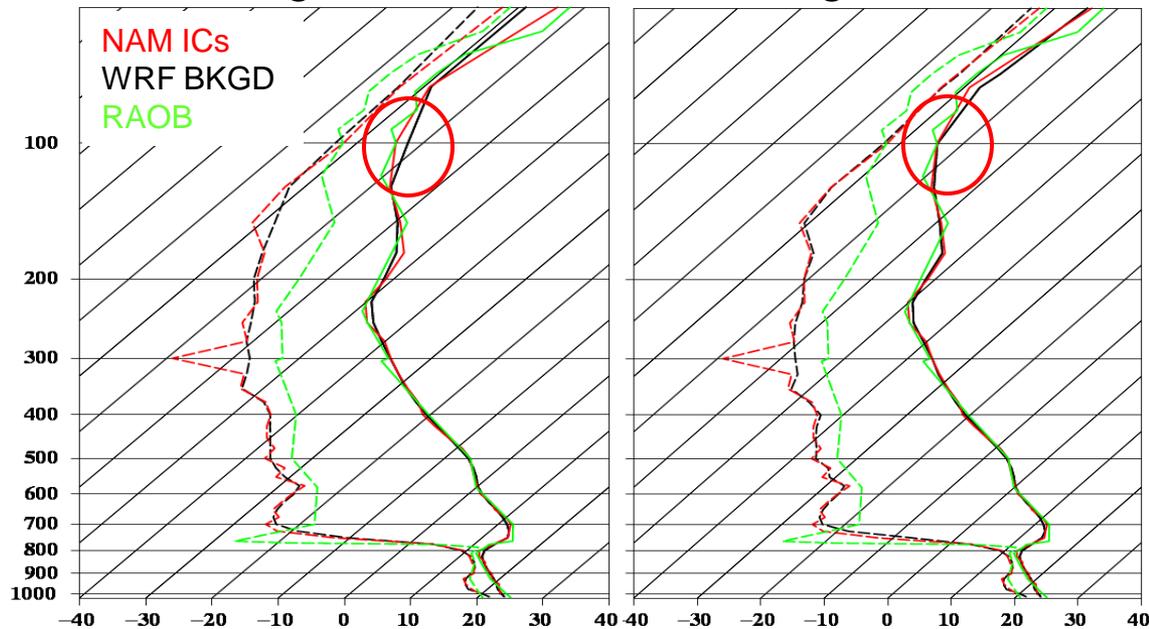




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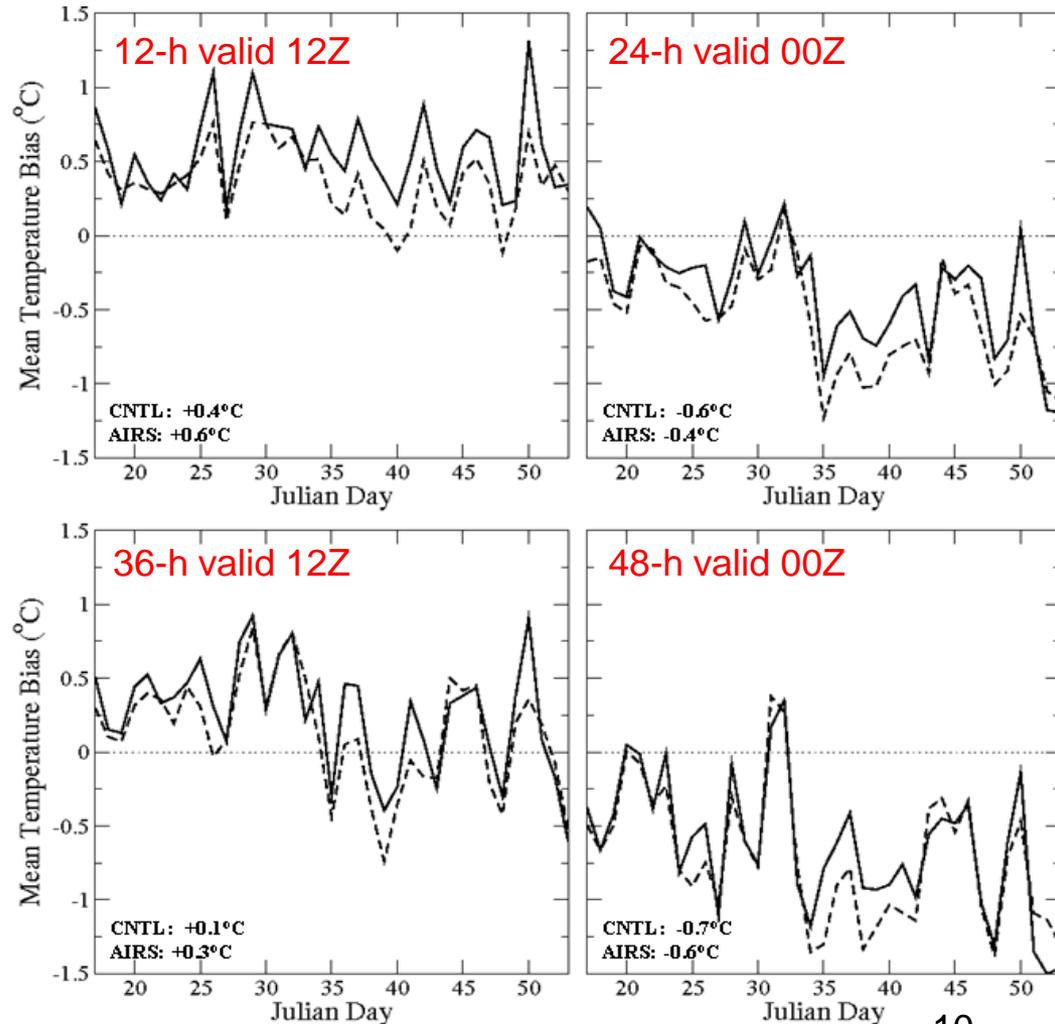
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Cold Bias in WRF Forecasts with Dudhia Scheme

- ◆ AIRS-NAM (solid) seems warm biased at most days in lowest levels compared to CNTL-NAM (dashed) throughout forecast cycle
- ◆ Dudhia SW Radiation Scheme in WRF model used for this experiment
 - Case et al. (2007) showed Dudhia scheme exhibits a slight daytime cold bias
 - Negative forecast in day; positive forecast at night
- ◆ Changes in lower-level temperature result in changes to geopotential height field in model
- ◆ Model physics scheme can have large impact on regional forecasts

1000 hPa Temperature Difference Time Series





Conclusions/Future Work

- ◆ Found that proper assimilation of AIRS profiles yields improved precipitation forecasts and produces improved temperature and moisture forecasts at most forecast times and most pressure levels
- ◆ Key points when working with regional assimilation and assimilation of profiles
 - Use partial soundings based on QC to assimilate most quality data with specific errors for land and water soundings; proper assigning of observation errors is important
 - Generate local BEs for specific assimilation domain
 - Assimilation and modeling system can not be used as a “black box”
 - Appropriate assignment of model levels is necessary to reduce model errors
 - Model physics options must be monitored as they can bias forecast results
- ◆ Apply lessons learned to producing an optimal configuration of the GSI to test assimilation of IASI profiles (and eventually CrIS) and develop methodology for IASI radiances
- ◆ Real-time 3D moisture analysis using AIRS profiles over data void regions to help NWS track moisture trends in Pacific and Gulf of Mexico



Questions?

Suggestions?

Comments?

Website: <http://weather.msfc.nasa.gov/sport>

Wide World of SPoRT Blog: <http://www.nsstc.uah.edu/sportblog/>

