Assimilation of AIRS radiance and SFOV retrieval profiles in the Rapid Refresh model system

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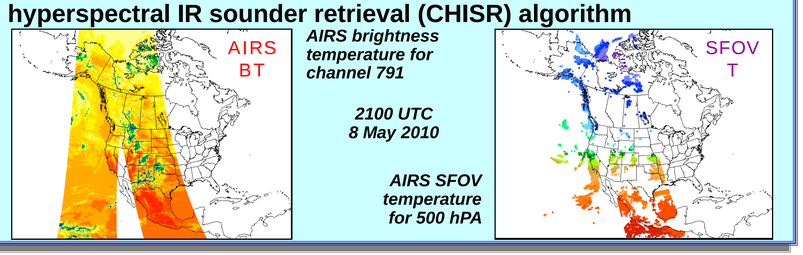
BACKGROUND

Evaluate the impact of AIRS data on the Rapid Refresh (RAP) and High Resolution Rapid Refresh (HRRR) mesoscale prediction systems, examine ways to maximize forecast improvement

Atmospheric Infrared Sounder (AIRS) data provide high-resolution temperature and water vapor information

Single Field of View (SFOV) profiles (temperature, moisture for clear sky conditions) obtained from application of CIMSS hyperspectral IR sounder retrieval (CHISR) algorithm



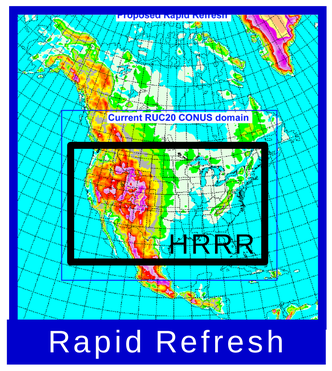
AIRS brightness temperature for channel 791

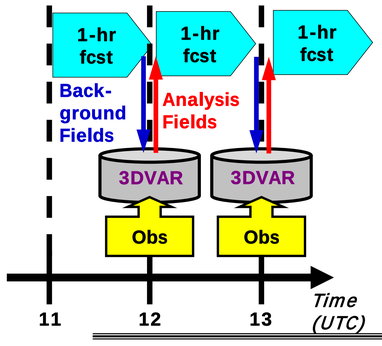
2100 UTC 8 May 2010

AIRS SFOV temperature for 500 hPa

RAP and HRRR

- Hourly updated assimilation / model system replacing RUC
- RAP uses GSI analysis and WRF ARW model
- Implement at NCEP May 2012
- 13km domain covers all of North America, large oceanic region (few conventional obs.)
- HRRR 3km domain covers CONUS, initialized from RAP
- Evaluate impact of AIRS SFOV and radiance data within full mix of observations





Data types – counts / hr

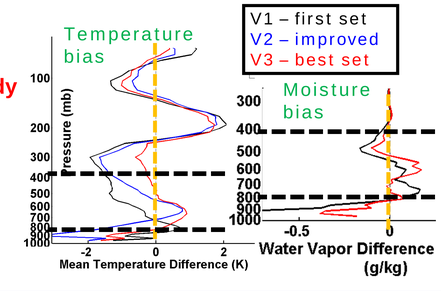
Rawinsonde (12h)	150
NOAA profilers	35
VAD winds	~130
PBL profilers / RASS	~25
Aircraft (V,T)	3500–10,000
TAMDAR	200 – 3000
METAR surface	2000 -2500
Mesonet (T,Td)	~8000
Mesonet (V)	~4000
Buoy / ship	200-400
GOES cloud winds	4000-8000
METAR cloud/vis/wx	~1800
GOES cloud-top P,T	10 km res.
satellite radiance	AMSUA/MHS/HIRS
Radar reflectivity	1 km res.

Experiment Design

- 9-day retrospective period (May 8-16, 2010)
- 3-h fully-cycled runs (real-time RAP uses 1-h with partial cycle)
- Raob denial experiment yields results that closely match those in previous RUC raob denial study
- Evaluate impact of AIRS data relative to control experiment with only standard observations
- Evaluate different SFOV DA strategies (data thinning, quality control, bias correction)

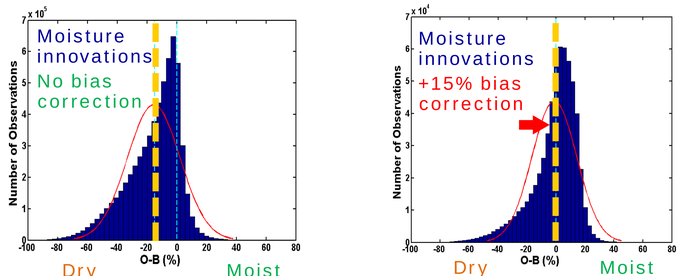
SFOV – raob comparison

- 53 matched profiles (clear sky, 15-km horizontal distance, 3-h time window)
- Three SFOV observation sets provided by U. Wisc. CIMSS, improvement shown

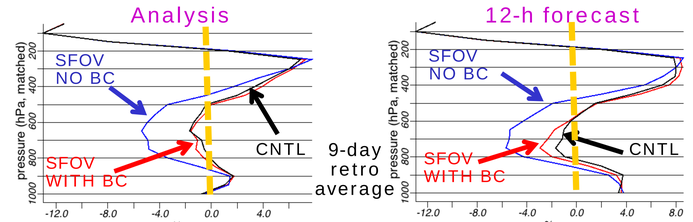


SFOV Moisture Bias Correction (BC)

SFOV moisture innovation before and after BC



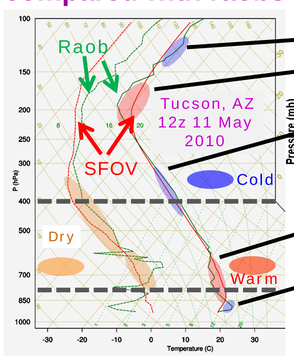
Histogram of moisture innovations [specific humidity (O-B) normalized by background saturation specific humidity] for the data in 400-800 hPa before and after BC from 9-day control run with SFOV in monitoring mode



0-h analysis and 12-h forecast relative humidity bias for control run (no SFOV, black), SFOV with NO bias correction (blue) and SFOV with bias correction (red)

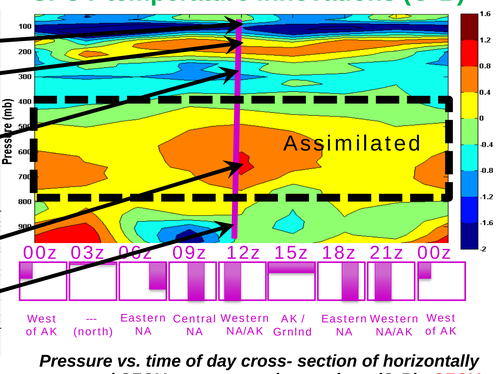
SFOV Temperature Bias Correction

Sample SFOV profiles compared with raobs

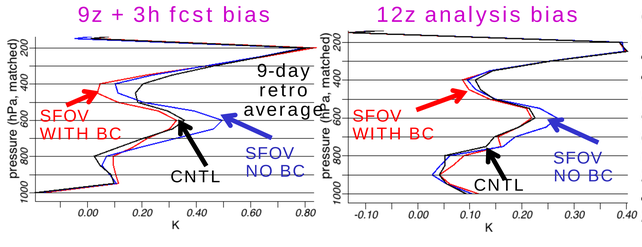


Compare sample SFOV vs. raob temperature and moisture profiles

Diurnal variation of horizontal avg. SFOV temperature innovations (O-B)

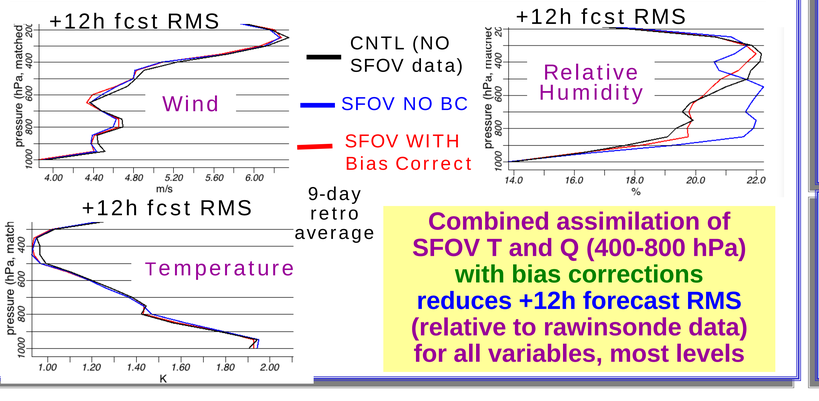


Pressure vs. time of day cross- section of horizontally averaged SFOV temperature innovations (O-B). SFOV observations between 400 and 800 hPa are assimilated



(left) 3-h forecast temperature bias and (right) 0-h analysis bias valid at 12Z for control run (black), SFOV temperature with NO BC (blue) and SFOV with BC (red)

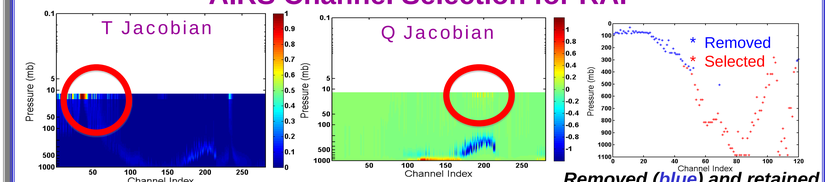
Forecast Impact from SFOV Assimilation



Combined assimilation of SFOV T and Q (400-800 hPa) with bias corrections reduces +12h forecast RMS (relative to rawinsonde data) for all variables, most levels

Radiance Assimilation Results

AIRS Channel Selection for RAP

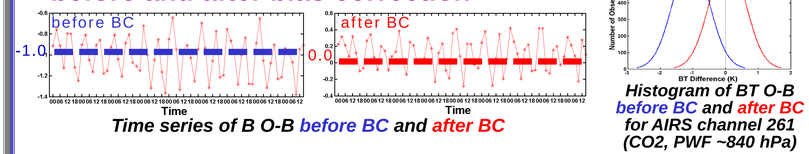


Temperature Jacobian *Moisture Jacobian*

(from CRTM applied to a standard profile interpolated to RAP pressure levels with 10 hPa model top)

Removed (blue) and retained (red) channels vertically arranged by Peak Weighting Function (PWF) height

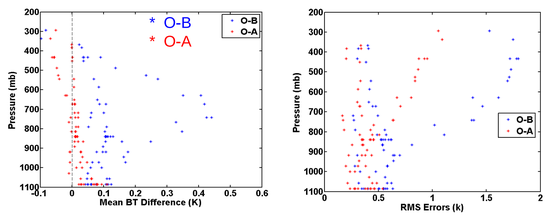
Brightness Temperature (BT) O-B before and after bias correction



Time series of B O-B before BC and after BC

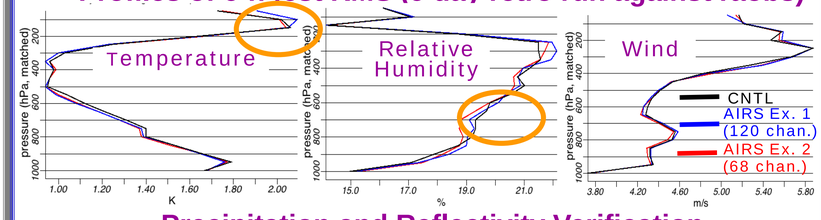
Histogram of BT O-B before BC and after BC for AIRS channel 261 (CO2, PWF ~840 hPa)

BT Diff. & RMS Errors before and after Assimilation

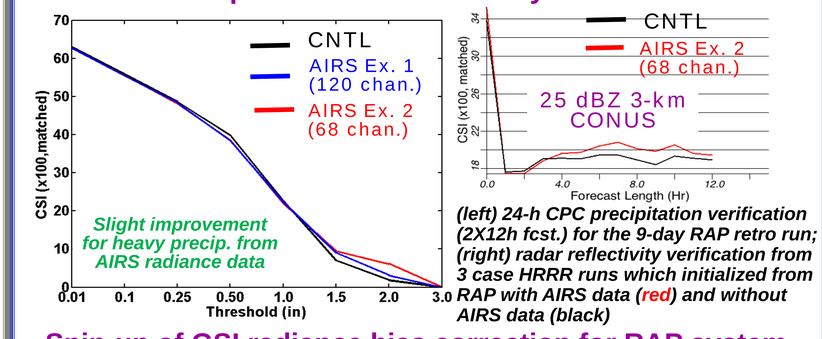


(left) BT difference and (right) RMS errors before (blue) and after (red) assimilation vertically arranged by channel's peak weighting function height

Profiles of 6-h fcst RMS (9 day retro run against raobs)

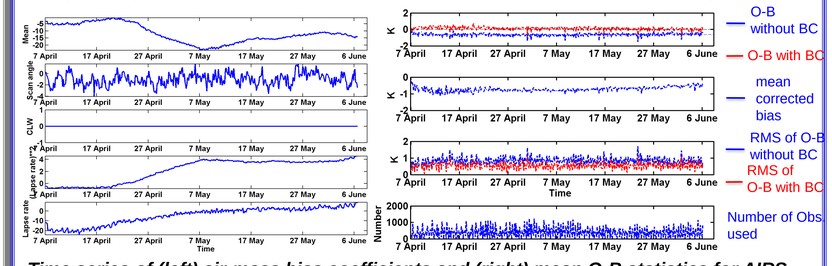


Precipitation and Reflectivity Verification



(left) 24-h CPC precipitation verification (2X12h fcst.) for the 9-day RAP retro run; (right) radar reflectivity verification from 3 case HRRR runs which initialized from RAP with AIRS data (red) and without AIRS data (black)

Spin-up of GSI radiance bias correction for RAP system



Time series of (left) air-mass bias coefficients and (right) mean O-B statistics for AIRS channel 1382 (water vapor channel) from a 2-month RAP retro run (April - June 2010)

SUMMARY AND FUTURE WORK

Results: AIRS SFOV and radiance data with bias correction produce small positive impact for short-term predictions in the Rapid Refresh assimilating the full mix of observations. Dry bias in SFOV moisture, diurnal bias pattern in Temperature indentified and corrected. Challenges in radiance BC for regional models due to limited coverage and low model top.

Plans: Examine AIRS impact for hurricane and other cases; cloud contamination investigation for radiance data; work toward use of AIRS data in operational RAP