Status of the Hyperspectral IR OSSE effort in NOAA/JCSDA

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with contributions from:

Zhenglong Li[4] (AIRS_G13 simulation)

Michiko Masutani[1, 2, 5] (control radiance simulation)

Jack Woollen[2, 5] (conv obs, GPSRO simulation)

Tong Zhu[2, 3] (random-error addition)

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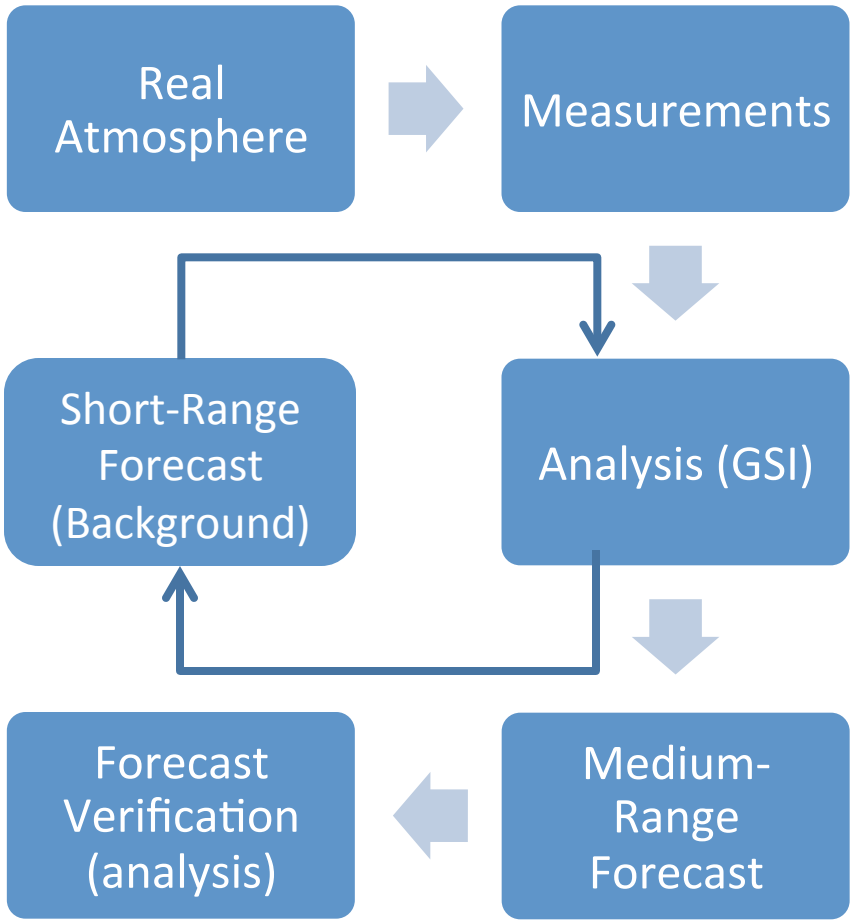
Motivation

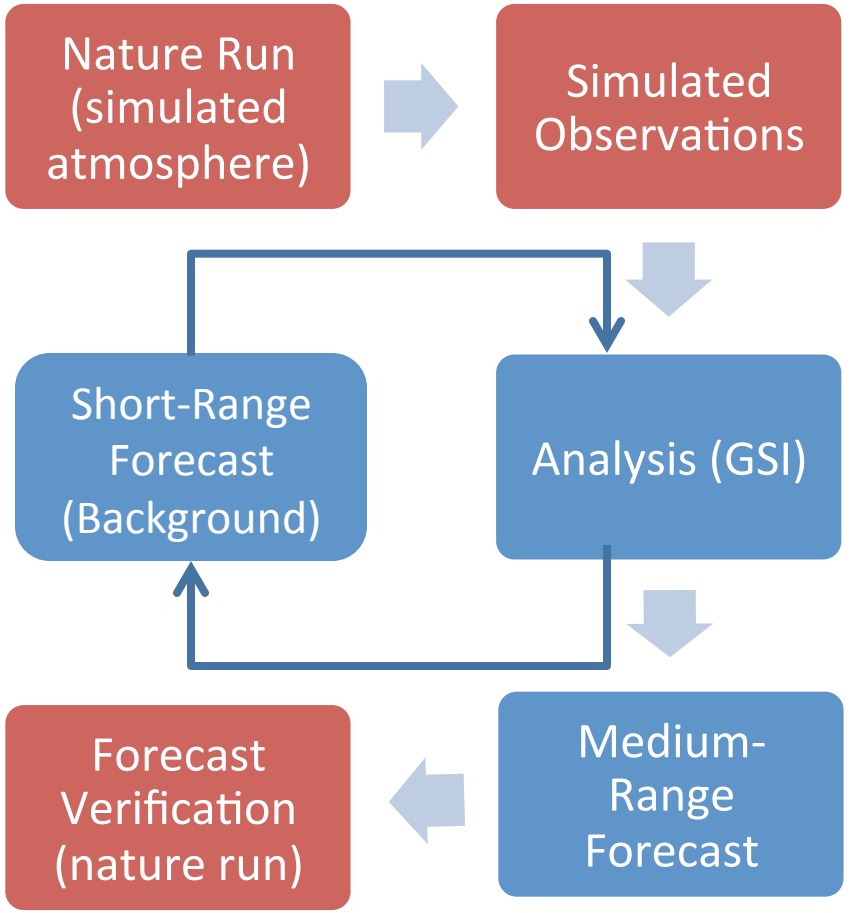
- Disaster Relief Appropriations Act of 2013 (H.R. 152), Title X, Chapter 2, Section 4 included funding "to improve weather forecasting and hurricane intensity forecasting capabilities, to include data assimilation from ocean observing platforms and satellites"
- NOAA OAR awarded a portion of these funds to Robert Atlas (AOML) for a larger Observing System Simulation Experiment (OSSE) investigating prospective new observations, including geostationary hyperspectral IR sounders
- As part of this larger project, the Joint Center for Satellite Data Assimilation (JCSDA) will be working with the Global Forecast System (GFS) developed by NOAA/NCEP to investigate global impacts of new sensors, as well as providing boundary conditions for regional studies by other project partners

What is an OSSE?

Real World



Observing System Simulation Experiment



2014 Study Experiments (in preparation for main 2015 study)

- Prs382hna
  - "Parallel-Run, Sean Casey, T382-3D-Hybrid, No AIRS_G13"
  - Control run
    - Simulated observations for July-August 2005 (T511 ECMWF NR) assuming 2012 observation system
    - All instruments (conv, GPS, radiance) operational in July-August 2012, with addition of SSMIS-F16,F17,F18
    - Random-errors added to all radiance observations using modified version of R. Errico's (GMAO) error-addition code
    - Two week spin-up, 47-day experiment period (20050716-20050831)
- Prs382hwa
  - As prs382hna, only "With AIRS_G13" (AIRS instrument in the location of GOES-13, 75°W)
  - Simulated from T511 NR by Z. Li, U. Wisconsin, using SARTA (compared to CRTM for JCSDA-simulated radiances)
  - Random-errors added using expected error distribution for AIRS_AQUA

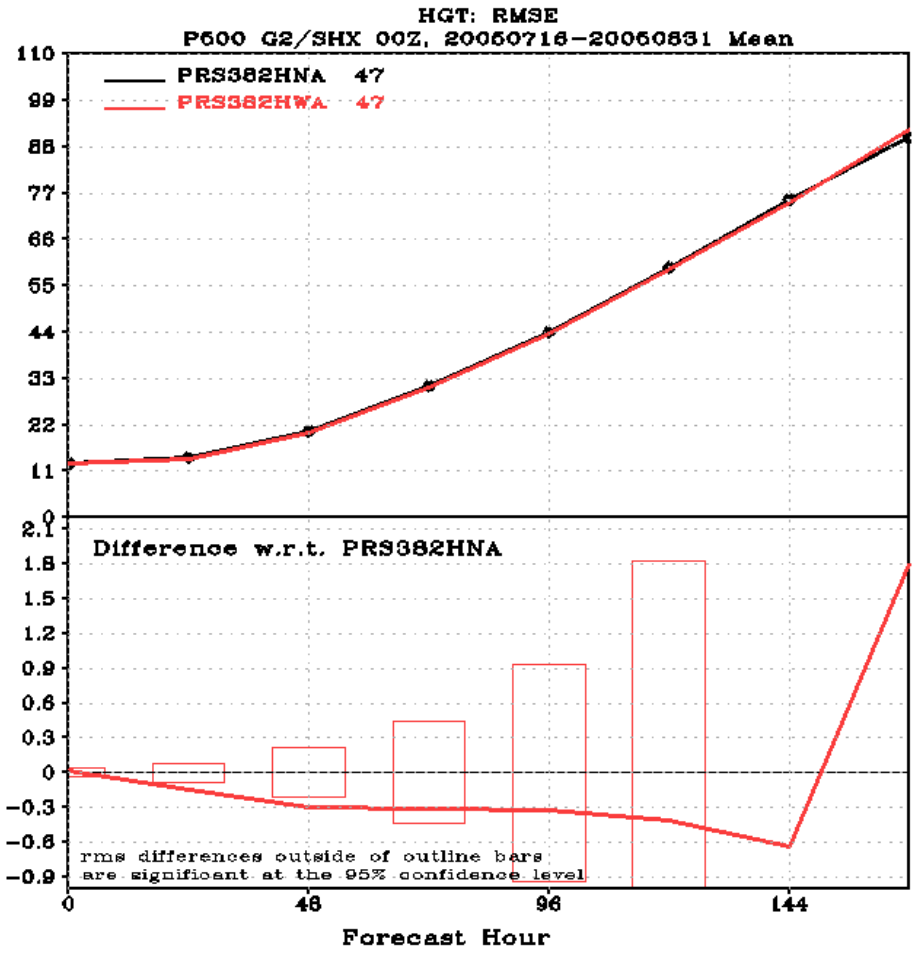
Geo-Hyper Experiments, 2014 vs. (planned) 2015

- Ten areas of concern for 2014 study with plans to remedy these by the start of 2015 study (May)
- Cover each aspect of OSSE process:
  - Nature Run (1)
  - Simulation (6)
  - Analysis (2)
  - Forecast (1)
  - Verification (1)
- Because of these issues, the following results should be considered <u>preliminary</u> (i.e., not suitable for programmatic conclusions)

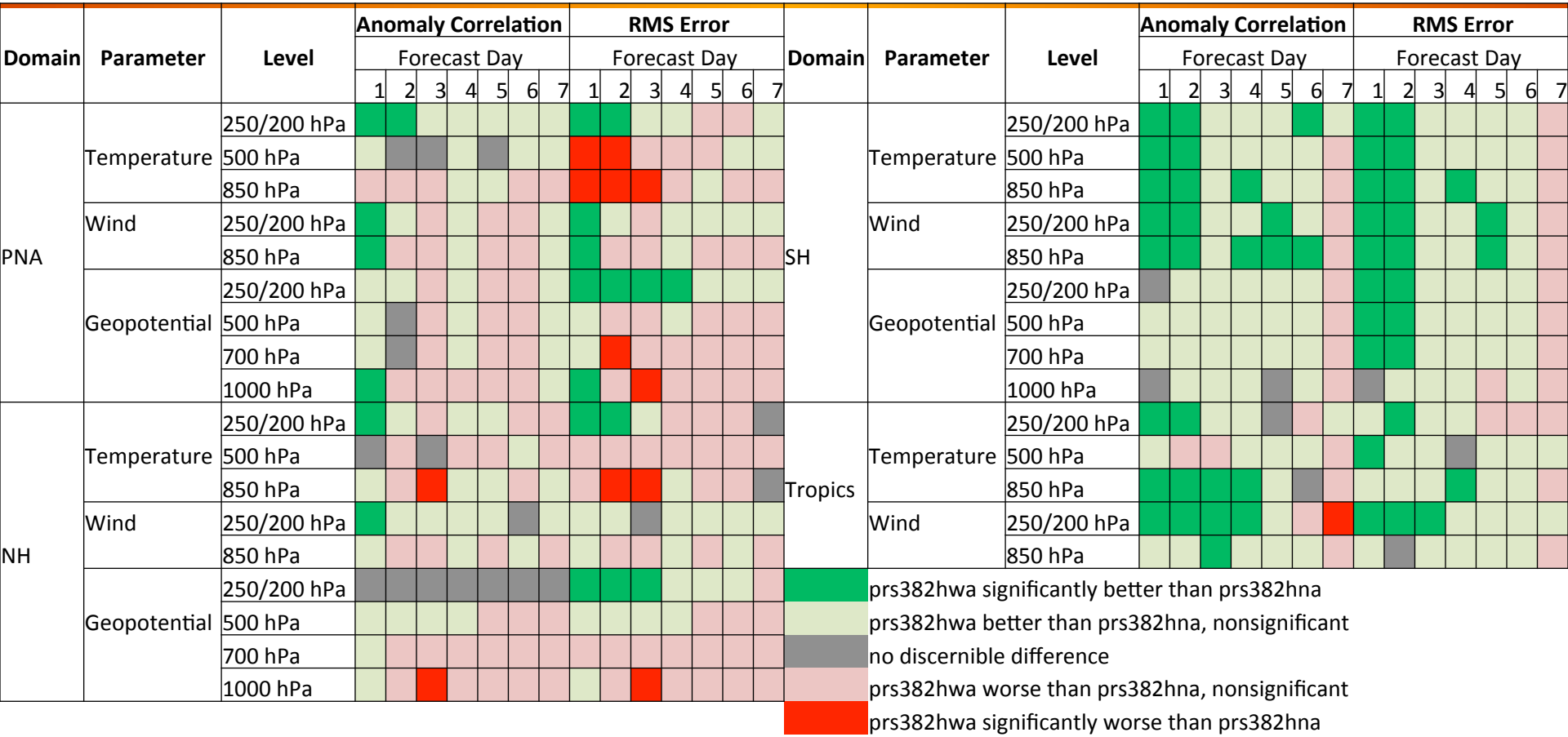
System Tool	2014 study	Planned 2015 study
Nature Run (NR)	ECMWF T511	GMAO 7-km or ECMWF T1279
Conventional obs errors	None	Assigned bias/random errors as appropriate
GPSRO obs type	Refractivity	Bending-angle
GPSRO obs errors	None	Assigned bias/random errors as appropriate
CRTM version	2.0.5 (control obs only)	2.1.3
Radiance obs errors	Added random errors	Assigned bias/random errors as appropriate
Test obs simulation	SARTA (U. Wisconsin)	CRTM (JCSDA)
GDAS/GFS resolution	T382 analysis, forecast; T190 3D-hybrid ensemble	T1534 forecast; T574 analysis, 3D-hybrid ensemble
Radiance bias correction	Two-factor (one internal to GSI assimilation, one external)	One-factor (internal in GSI assimilation)
VSDB	Version 16	Version 17

Preliminary VSDB Results

- Right: RMSE for SH 500 hPa geopotential height (forecast hour on horizontal axis)
- Lower figure: difference between mean RMSE, prs382hwa-prs382hna
- Red boxes: 95% confidence interval; counts outside these bounds are considered statistically significant
- Comparisons done with respect to T511 NR
- Here, the experiment with AIRS_G13 shows significant reduction in RMSE for days 1, 2
- Full results can be viewed on JCSDA website: http://www.jcsda.noaa.gov/vsdb/users/scasey/prs382hwa/vsdb.php
- VSDB Version 17 (planned for 2015) includes a "scorecard" summary plot which includes multiple metrics/regions in one easy-to-read image
- I created a "rough scorecard" based on the Version 16 results (next slide)

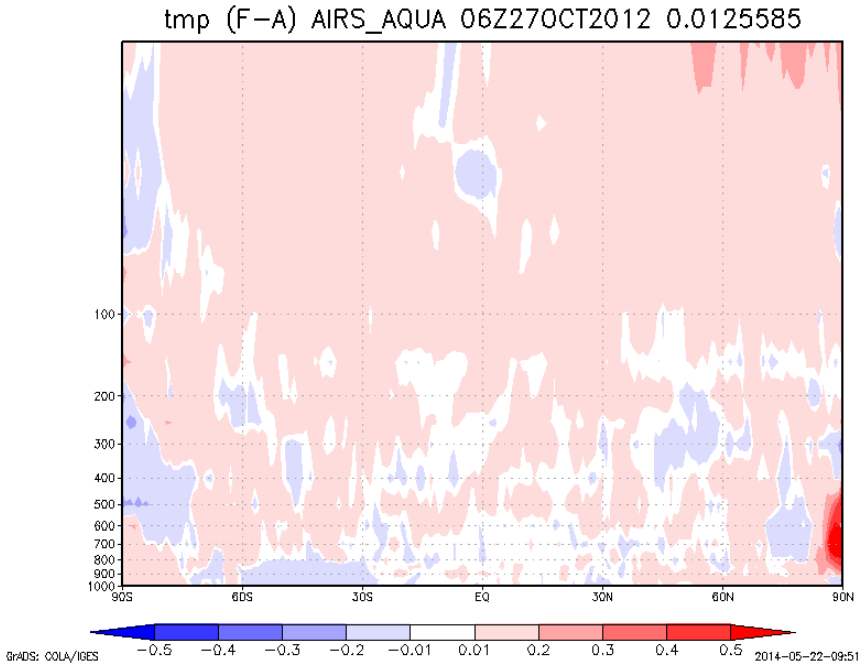


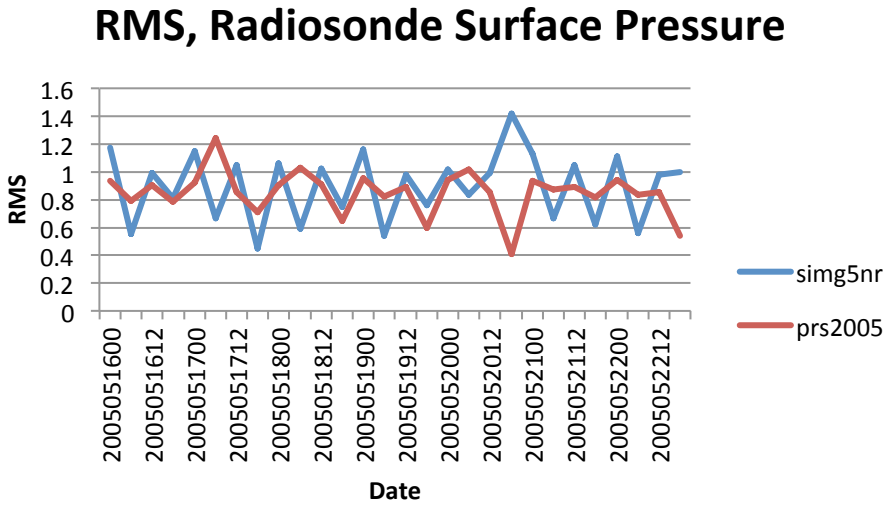
Preliminary AIRS_G13 impacts (00Z runs)



- Bright Green, Red = statistically significant
- Visual interpretation, erred on side of caution (i.e., calling results “significant” only if clear without a doubt)
- Separation will be quantitative in Version 17 scorecard

Improvements for 2015: simulations from new NRs





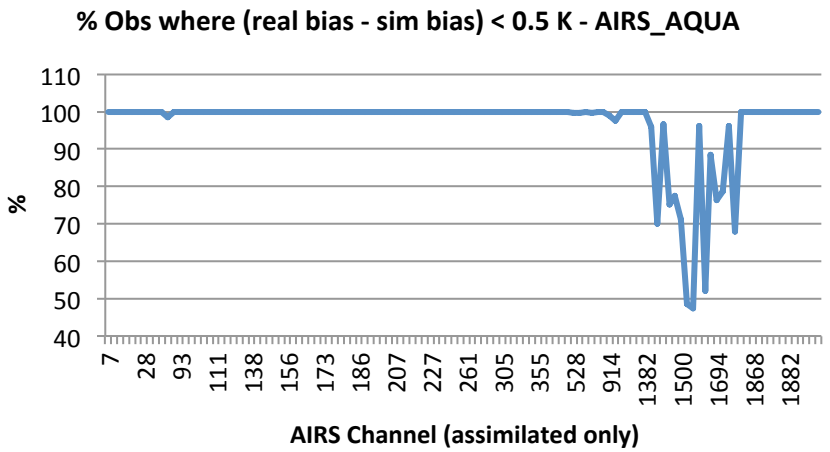
- Left: Impact of assimilating simulated AIRS_AQUA data from ECMWF T1279 sample period (2012102706); red=analysis closer to sample data
- Right: model-identified O-A RMS error for radiosonde surface pressure, 2005051600-2005052218, assimilating only conv obs
  - Red: real observations
  - Blue: simulated observations from GMAO G5NR (7-km resolution)

Observation Error

type	id	bias	rms	var	type	id	bias	rms	var
ps	120				uv	252			
ps	180				uv	253			
ps	181				uv	257			
ps	182				uv	258			
ps	187				uv	259			
uv	220				uv	280			
uv	221				uv	282			
uv	223				t	120			
uv	224				t	130			
uv	229				t	131			
uv	230				t	132			
uv	231				t	133			
uv	232				t	180			
uv	233				t	182			
uv	242				q	120			
uv	243				q	132			
uv	245				q	180			
uv	246				q	182			

simg5nr >3-sigma higher
simg5nr between 2- and 3-sigma higher
simg5nr not significantly different
simg5nr between 2- and 3-sigma lower
simg5nr >3-sigma lower

- Investigating methods of adding bias, variance to conventional observations until statistics match real data for first week of GMAO G5NR (when real, simulated obs differ minimally)
  - Should also account for adding bias, variance for new observations
  - Will be applicable for radiance, GPSRO assessment as well
- Left: Summary table for comparison between real, simulated conventional obs (pressure, wind, temperature, moisture) model-identified O-B bias/rms/ variance
  - No errors added to simulated data
  - Dark blue = model-identified biases/variances more than 3σ lower than expected for real observations



- Previous investigations looked at a "brute-force" method of adding biases (adding model-identified bias magnitudes from real observations directly to simulated observations for a similar time period)
  - Left: AIRS_AQUA (assimilated) channels where real, "simulated" bias identified by the model was less than 0.5 K
  - Temperature sounding channels (for all radiance instruments) showed good agreement
  - Poor agreement for surface, water vapor channels

Summary

- Preliminary testing for a geo-Hyper IR showed promise, highlighted areas for improvement
- Current work focusing on system improvements
  - Simulations from higher-resolution NRs
  - Bias/variance for conventional obs
  - Uncertainty for radiance obs
  - Upgrade to higher-resolution GDAS/GFS
- Hope to have these, and additional updates, ready by projected start date of main Geo-Hyper IR experiment (May 1, 2015)