New Software Architecture for Enterprise SDR Processing

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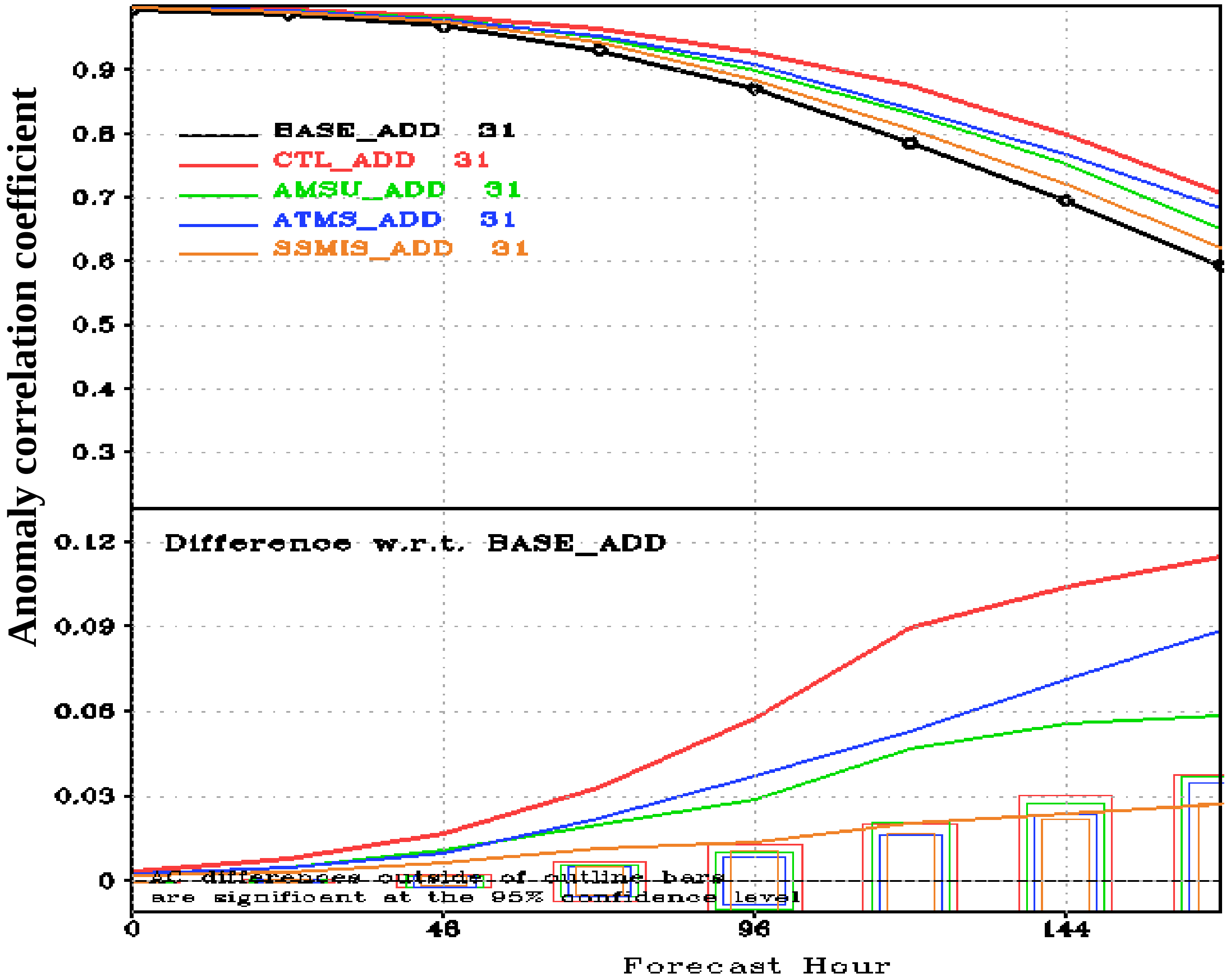
Outline

- Lessons learned from NWP observing system experiments
- Motivations for the enterprise SDR processing
- Proposed future SDR software architecture
- Summary and conclusions

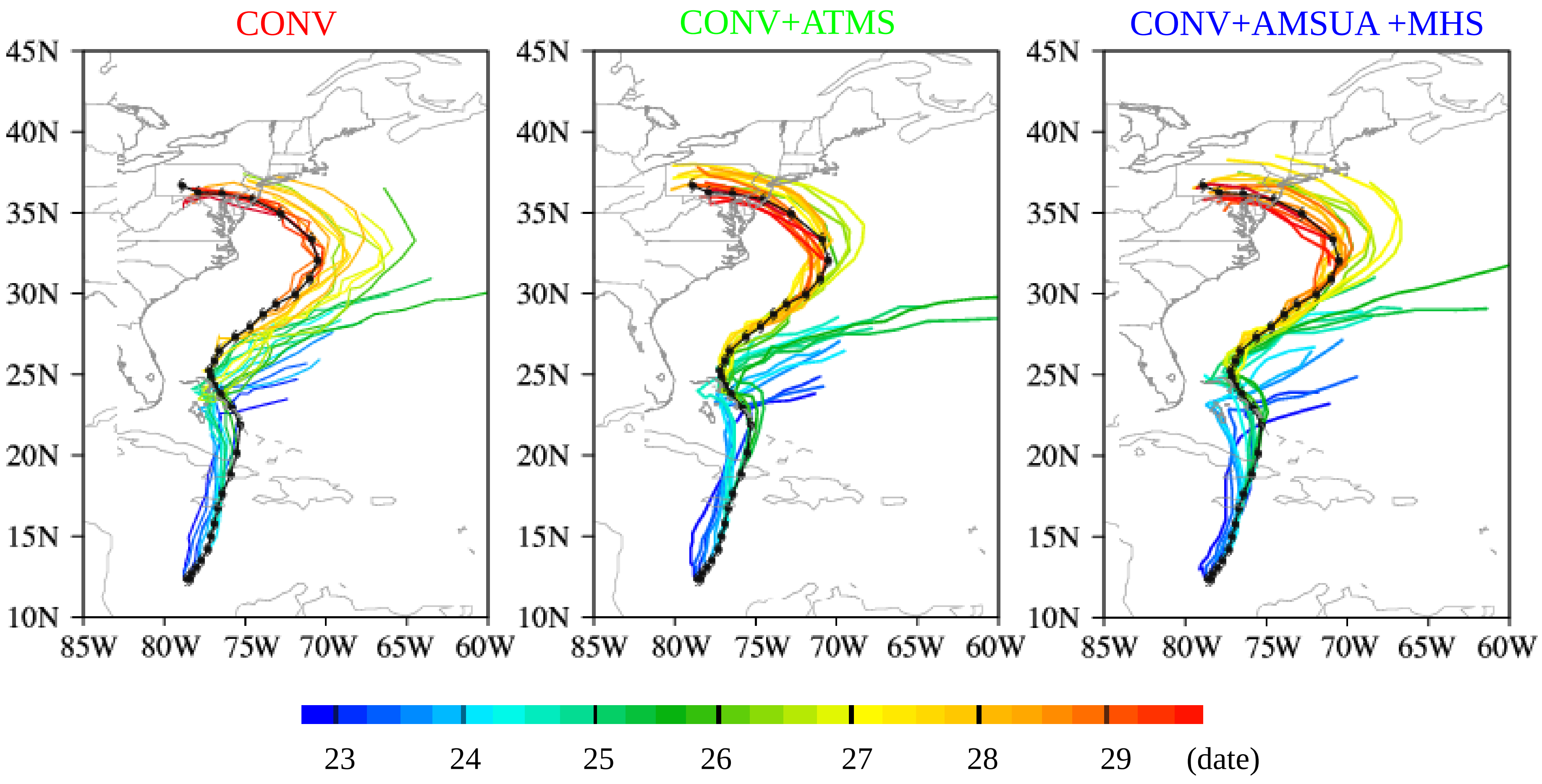
Impacts of Microwave Sounders in NCEP GFS

500 hPa Southern Hemisphere AC scores for 20140101 – 20140131 00Z



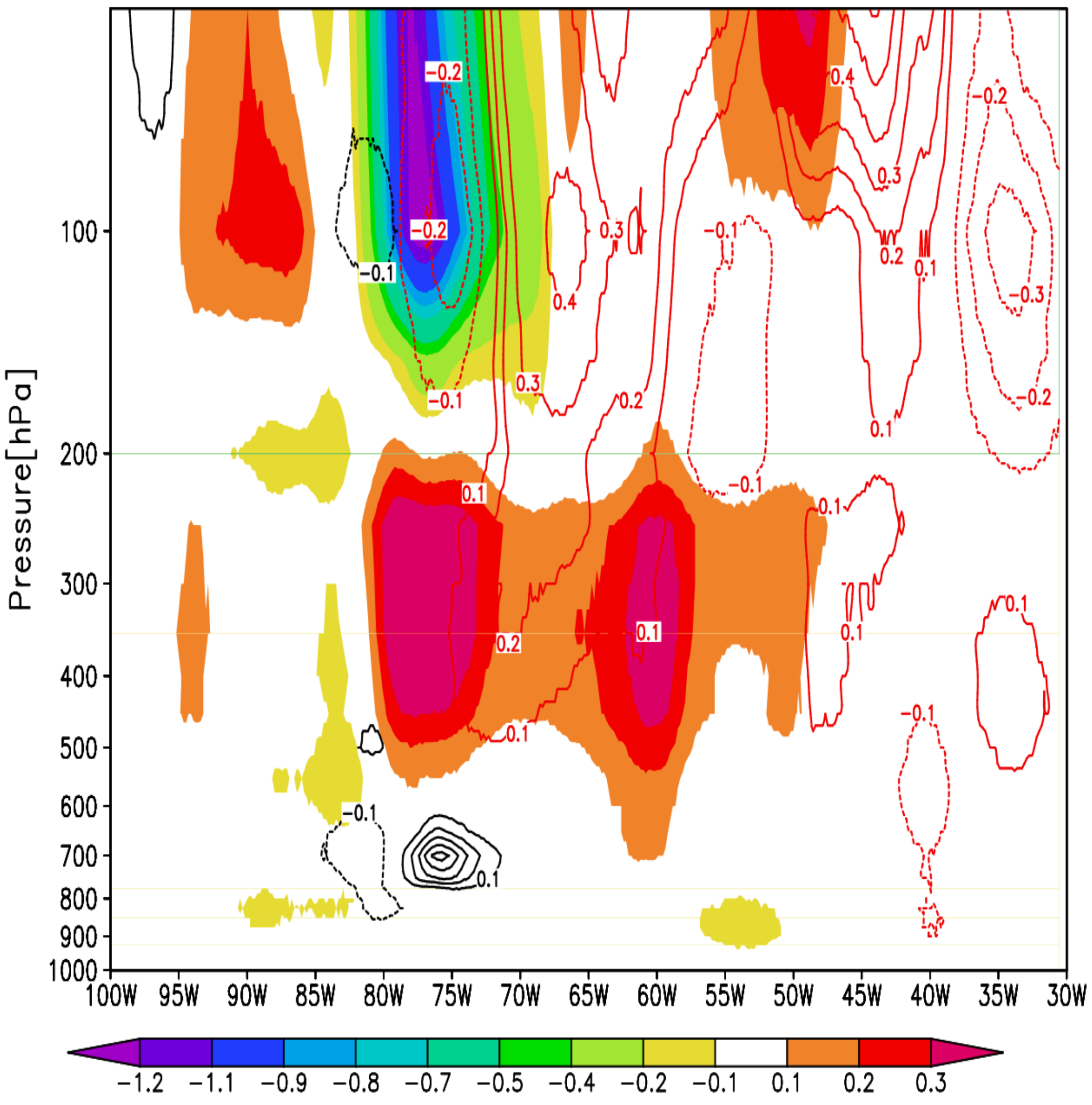
Assimilation of ATMS radiances in NCEP GFS produces a largest impact on global medium-range forecast, especially in southern hemisphere. The baseline experiment includes the conventional and GPSRO data and the control experiment includes all the satellite instruments and conversional data.

Forecasting the Track of Hurricane Sandy using HWRF



Operational HWRF model was updated with higher model top (0.5 mb) and more vertical levels (61). The model was started with its own 6 hour forecasting field (warm start) and GSI is used for assimilation of satellite data in all the domains. Conventional data include radiosonders and aircraft reports, ship/buoy,surf obs, pival winds/wind profilers, VAD wind, dropsondes. ***ATMS has higher positive impacts on Sandy's track forecasts after October 26.***

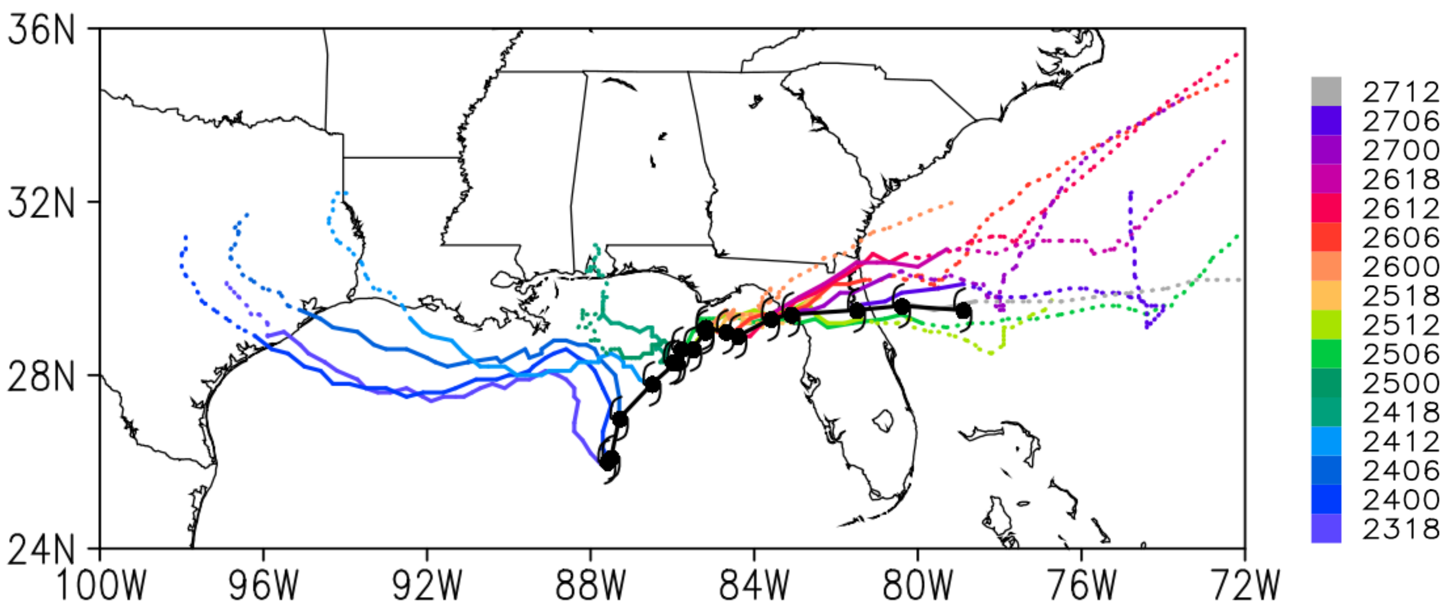
Temperature Innovation from ATMS and AMSU-A



Shaded: ATMS
Red contour: AMSU-A
Black contour: Conventional

ATMS and AMSU-A (NOAA-19) both have temperature innovation near 100 mb at 80W but the magnitude from ATMS is much larger in the overlapping regions of ATMS and AMSU

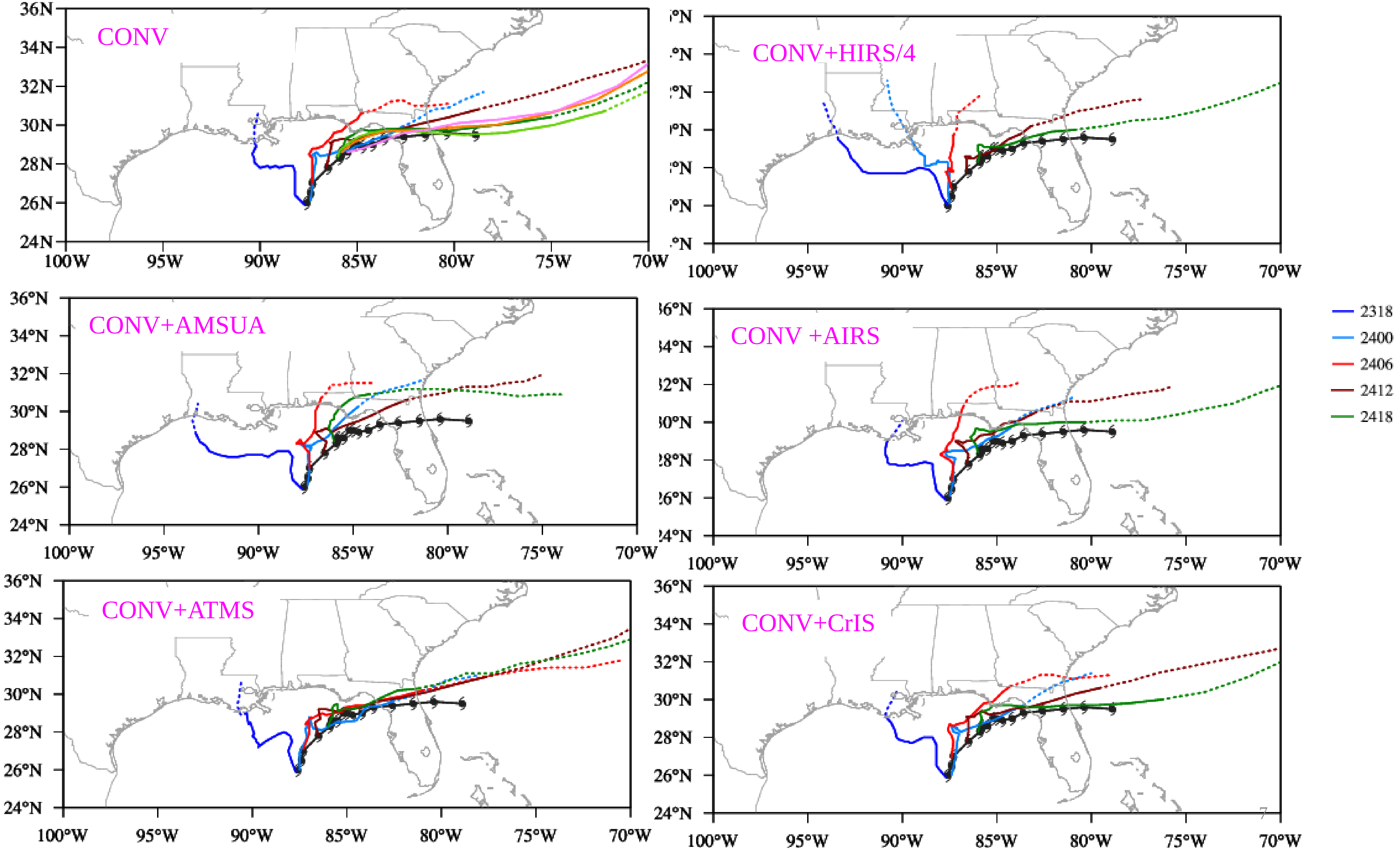
Forecasting the Track of Hurricane Debby



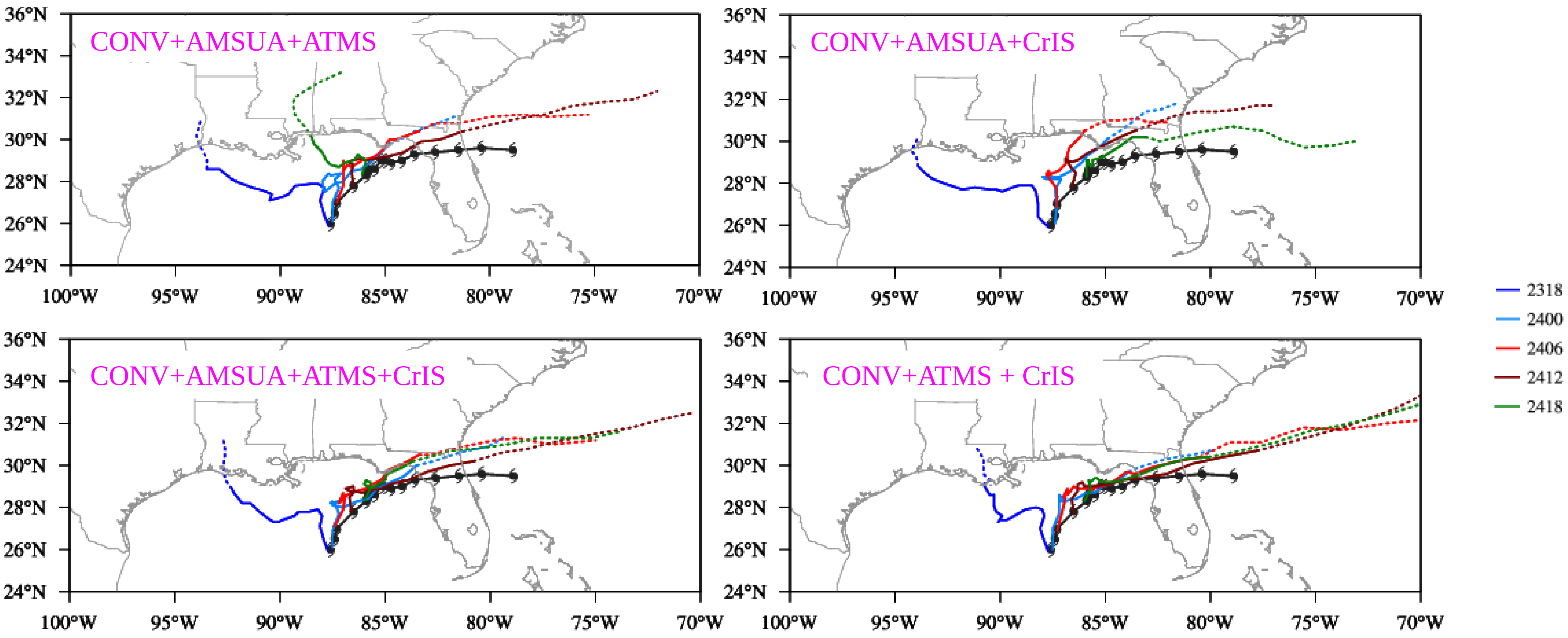
- Before June 25, 2012, the operational HWRF model produces westward propagating tracks while the actual track was northeastward
- The operational HWRF model produces reasonably good track forecasts after June 25 and afterward.

The track prediction of Debby before June 25, 2012 was a major challenge.

Track Prediction for Tropical Storm Debby



Observing System Experiment for A Combination of Instruments



It appears that assimilating the AMSU-A and ATMS data at the same time causes negative impact on the track forecast initialized at 1800 UTC 24 June, 2012.

Quantitative Precipitation Forecast-
A Negative Impact from MHS Data Assimilation

Advanced Research WRF (ARW)
Model/ GSI 3D-Var

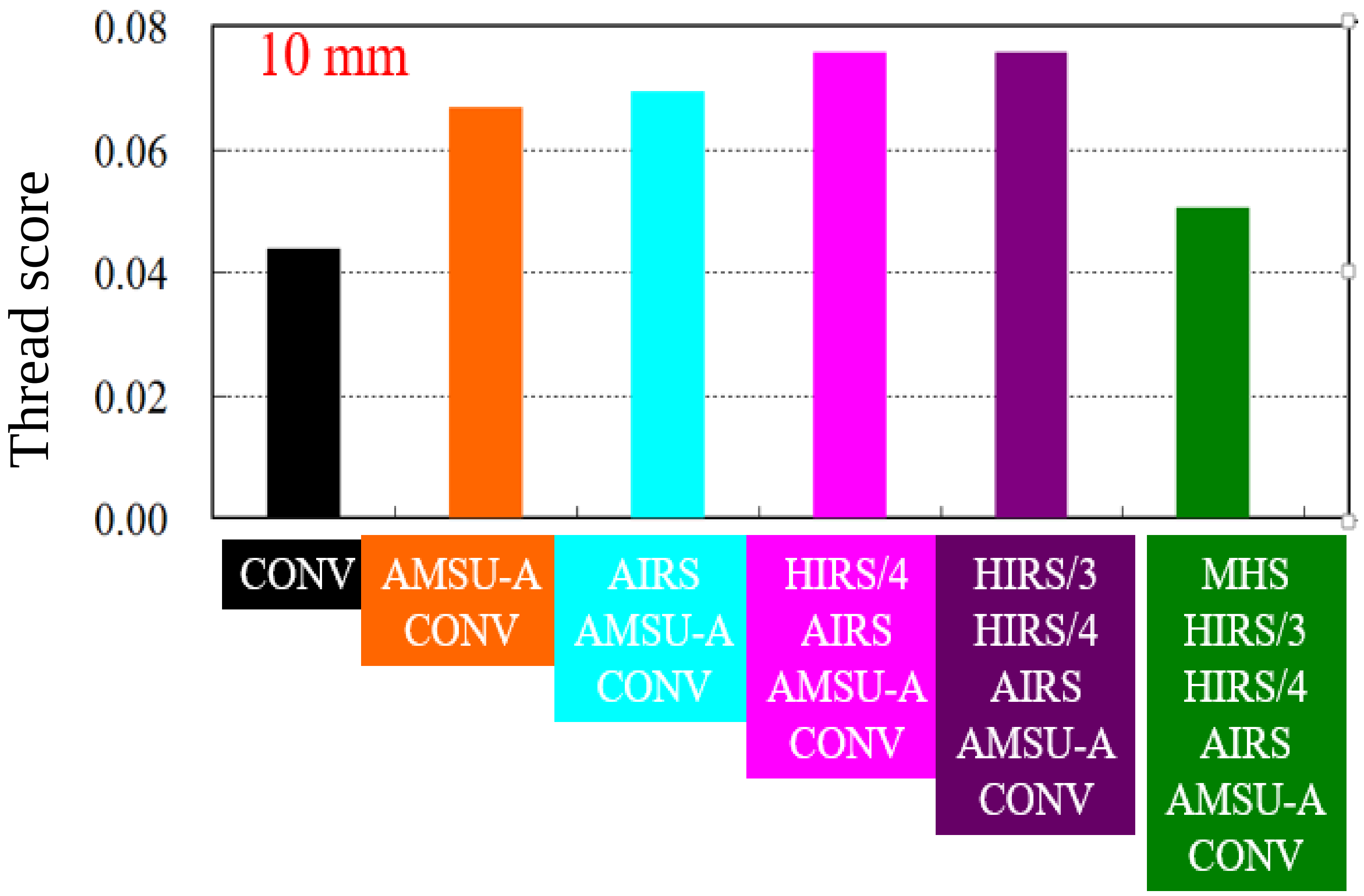
Resolution: 10 km, 27 layers

Domain size: 250x200x27

Observations: Conventional data
+ satellite data

Cycling interval: 6 hours

DA period: 1200-2400 UTC, May 22, 2008
Forecast Period:0000-24000 UTC May 23, 2008



Three Steps for MHS Data Rejection in GSI

Step I:

$$TPW_{index} > 1$$

Step II:

$$\left|O - B\right| > 3\left(e_i \times \left(1 - TPW_{index}^2\right) \times f_H \times \tau_i^{top}\right)$$

or: $\left|O - B\right| > 6\mathrm{K}$

e_i is accuracy of obs.

f_H=2000/H, H is terrain height>2km

τ_i^{top} is ransmittance at model top

Step III:

All five channels if data of any other channel was removed by the first two QC steps

MHS QC in GSI

- An LWP index is calculated as follows:

$$LWP_{index}^{ocean} = \begin{cases} 0.13 \times \left\{ \left(T_{b,1}^{o} - T_{b,1}^{m} \right) - 33.58 \times \dfrac{\left(T_{b,2}^{o} - T_{b,2}^{m} \right)}{300 - T_{b,2}^{o}} \right\}, & \text{if } \; T_{b,2}^{o} \le 300 \\ 9, & \text{otherwise} \end{cases}$$

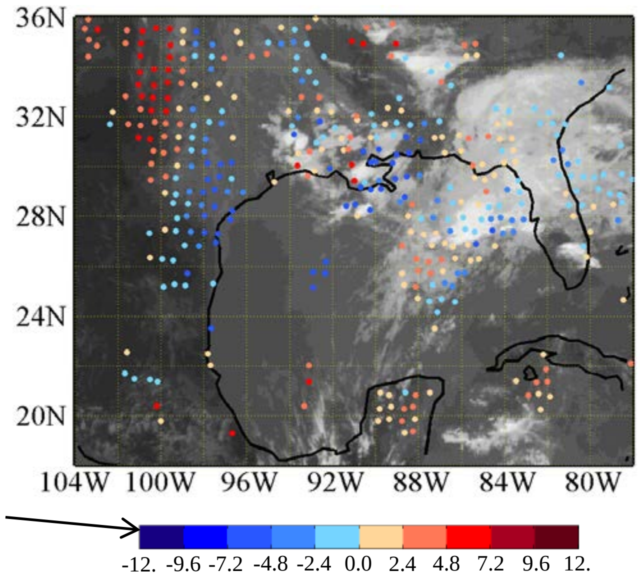
$$LWP_{index}^{land} = 0.85 \times \left(T_{b,1}^{o} - T_{b,1}^{m} \right) - \left(T_{b,2}^{o} - T_{b,2}^{m} \right)$$

- An TPW index is calculated as follows:

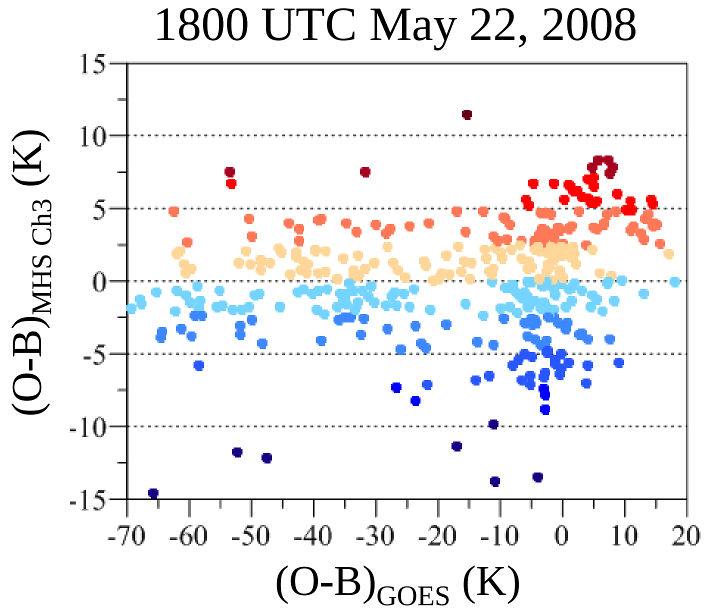
$$TPW_{index} = \left\{ \left[\left(T_{b,1}^{o} - T_{b,1}^{m} \right) - 7.5 \times LWP_{index} \right] \Big/ 10.0 \right\}^{2} + LWP_{index}^{2}$$

Diagnosis of MHS GSI QC

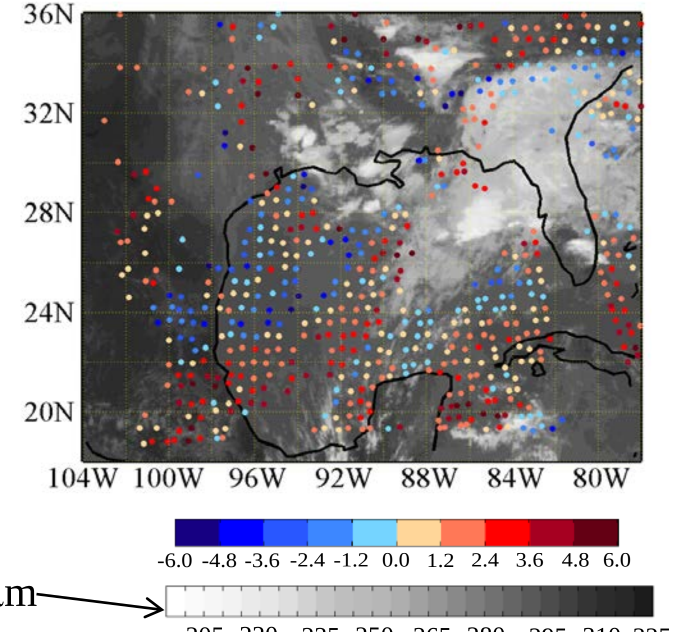
Data removed by GSI QC



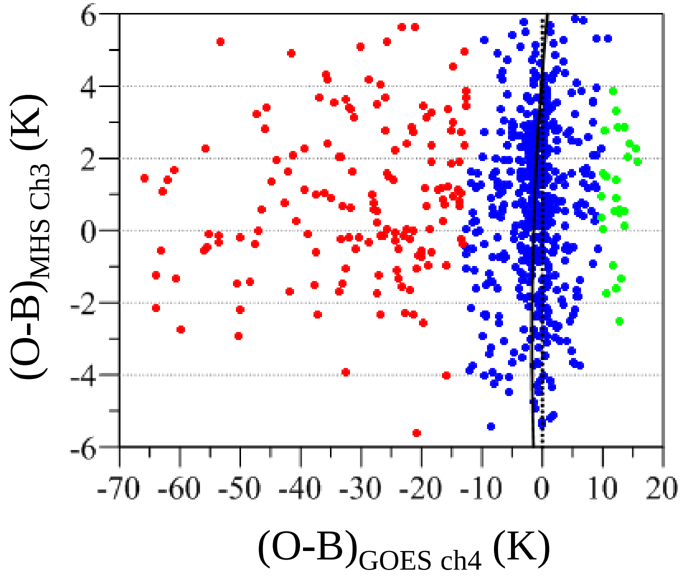
MHS O-B



Data that pass GSI QC

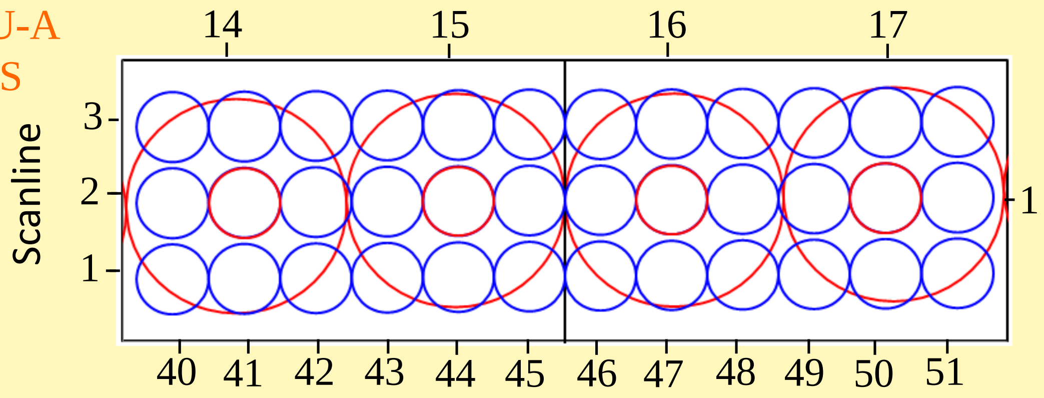


GOES 10.7μm



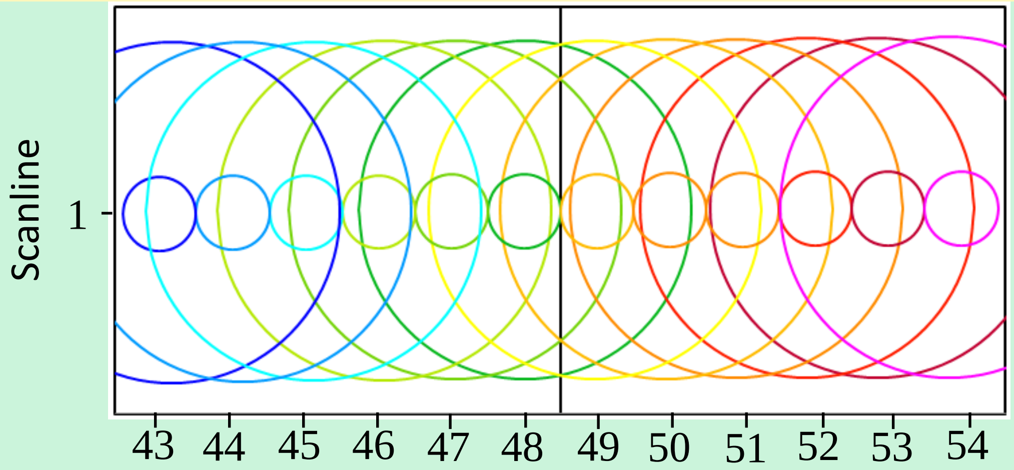
FOV Comparison between ATMS and AMSU-A/MHS

AMSU-A
MHS

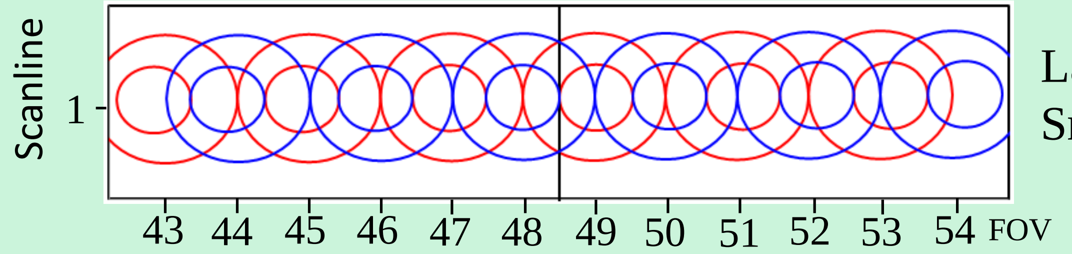


Larger FOVs: AMSU-A (LWP)
Smaller FOVs: MHS (IWP)

ATMS



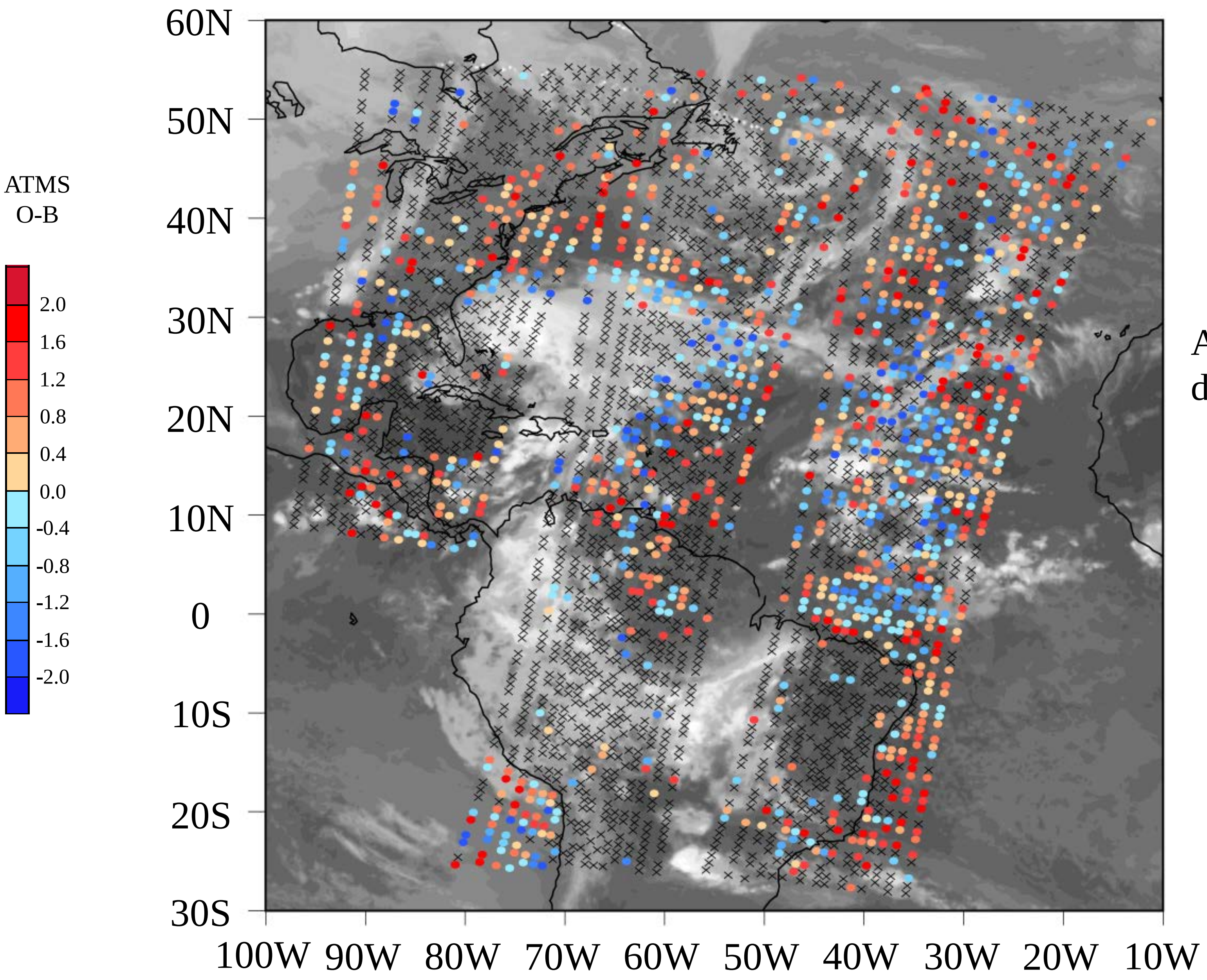
Larger FOVs: ATMS Ch1-2 (LWP)
Smaller FOVs: ATMS Ch17-22 (IWP)



Larger FOVs: ATMS Ch3-16
Smaller FOVs: ATMS Ch17-22

An automatic collocation between temperature and humidity channels from ATMS makes it possible to detect both liquid and ice clouds simultaneously!

Diagnosis of GSI QC for ATMS



0600 UTC October 26, 2012

ATMS water vapor channel data that passing GSI QC

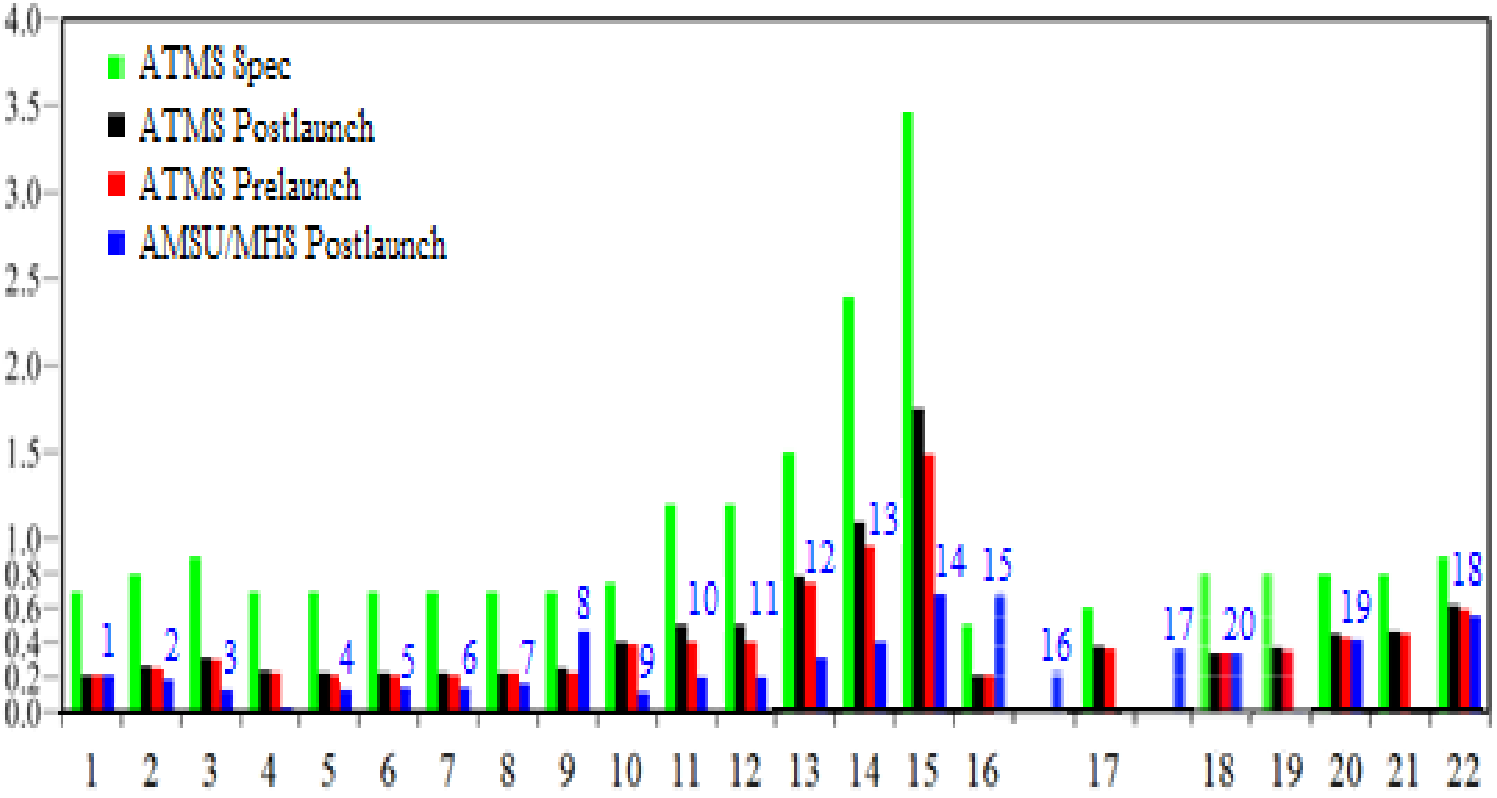
σ_o
σ_o^m

Observation and Forward Model Error Specified in GSI

Channel	σ_o (unit: K)		σ_m (unit: K)
	NOAA-15	NOAA-18	NOAA-15, -18
1	3.00	2.50	4.50
2	2.00	2.00	4.50
3	2.00	2.00	4.50
4	0.60	0.55	2.50
5	0.30	0.30	2.00
6	0.23	0.23	2.00
7	0.25	0.23	2.00
8	0.275	0.25	2.00
9	0.34	0.25	2.00
10	0.40	0.35	2.00
11	0.60	0.40	2.50
12	1.00	0.55	3.50
13	1.50	0.80	4.50
14	2.00	3.00	4.50
15	3.00	2.50	4.50

Prescribed observation error, σ_o (K) and the maximum observation error σ_m (K) for AMSU-A onboard NOAA-15 and NOAA-18/METOP-A

ATMS Noise Equivalent Temperature (NEDT)



Channel Number

On-orbit ATMS noise from the standard deviation is lower than specification but is higher than AMSU/MHS. ATMS resample algorithm can further reduce the noise comparable to AMSU/MHS

Lessons Learned from NWP Assimilation of MW Sounding Data

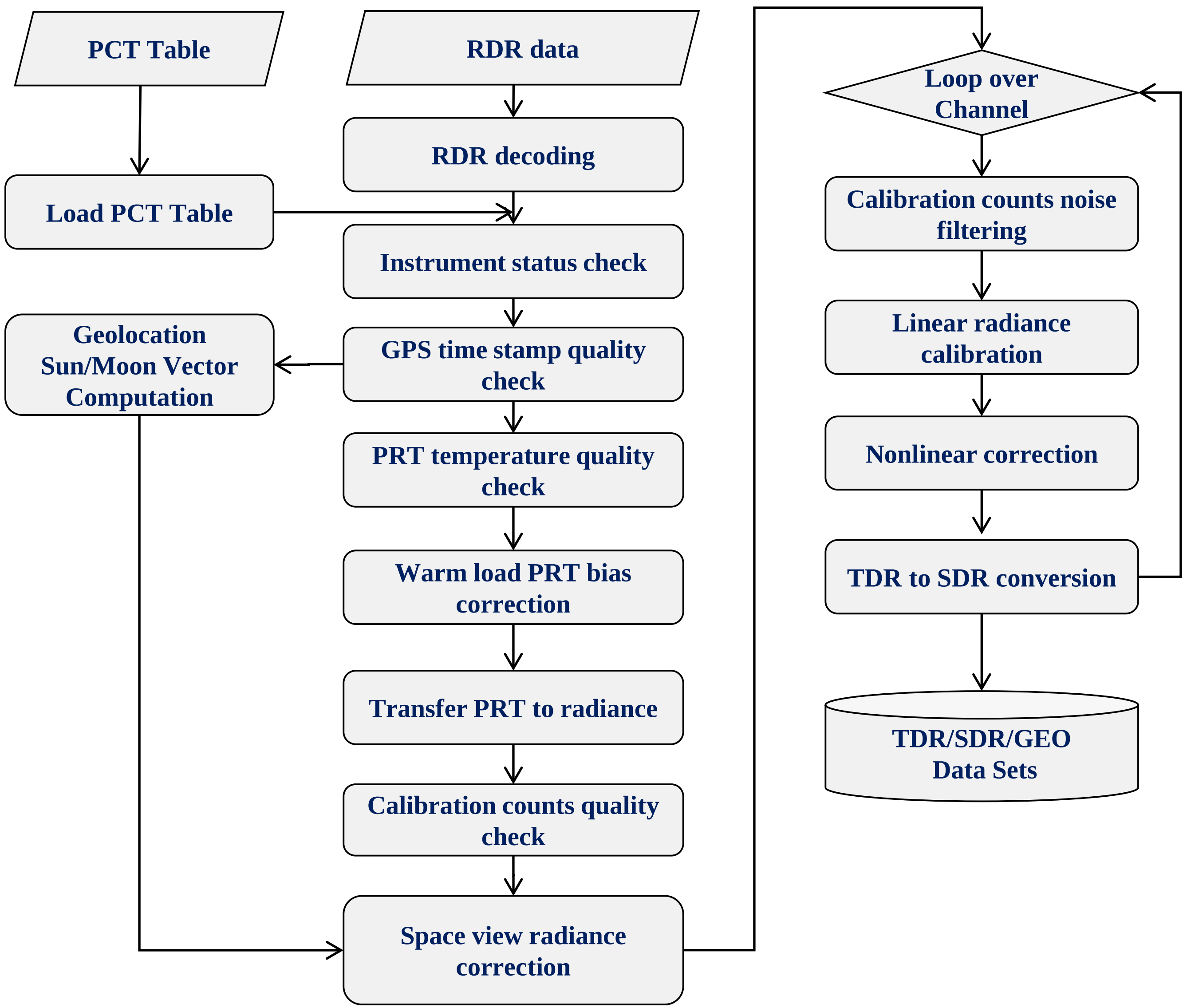
- The SDR products from all operational NOAA (including JPSS) and METOP satellites are well calibrated and are also cross-calibrated. Calibration uncertainties (e.g. accuracy and precision) are characterized but are not as part of SDR data streams

- When satellite SDR data are assimilated, users typically worked out bias corrections and characterized the error covariance among all the channels. Using NWP O-B for diagnosing the instrument is insightful but some cautions must be taken for those channels more affecting by NWP model bias

- Historically. NOAA/METOP microwave sounding data (AMSU-A1/A2/MHS) are packed into separate data streams. Assimilation of MHS without AMSU-A information is generally problematic in quality control, especially near the outflow boundary of convective storms and in warm precipitation regime where ice scattering is insignificant

- ATMS data are packed into one data stream and are resampled to AMSU-A resolution and assimilated into NWP. The quality control of ATMS water vapor channels can be much more comprehensive due to the availability of lower frequency channels at k/ka bands.

Future Microwave Sounder SDR Processing Diagram

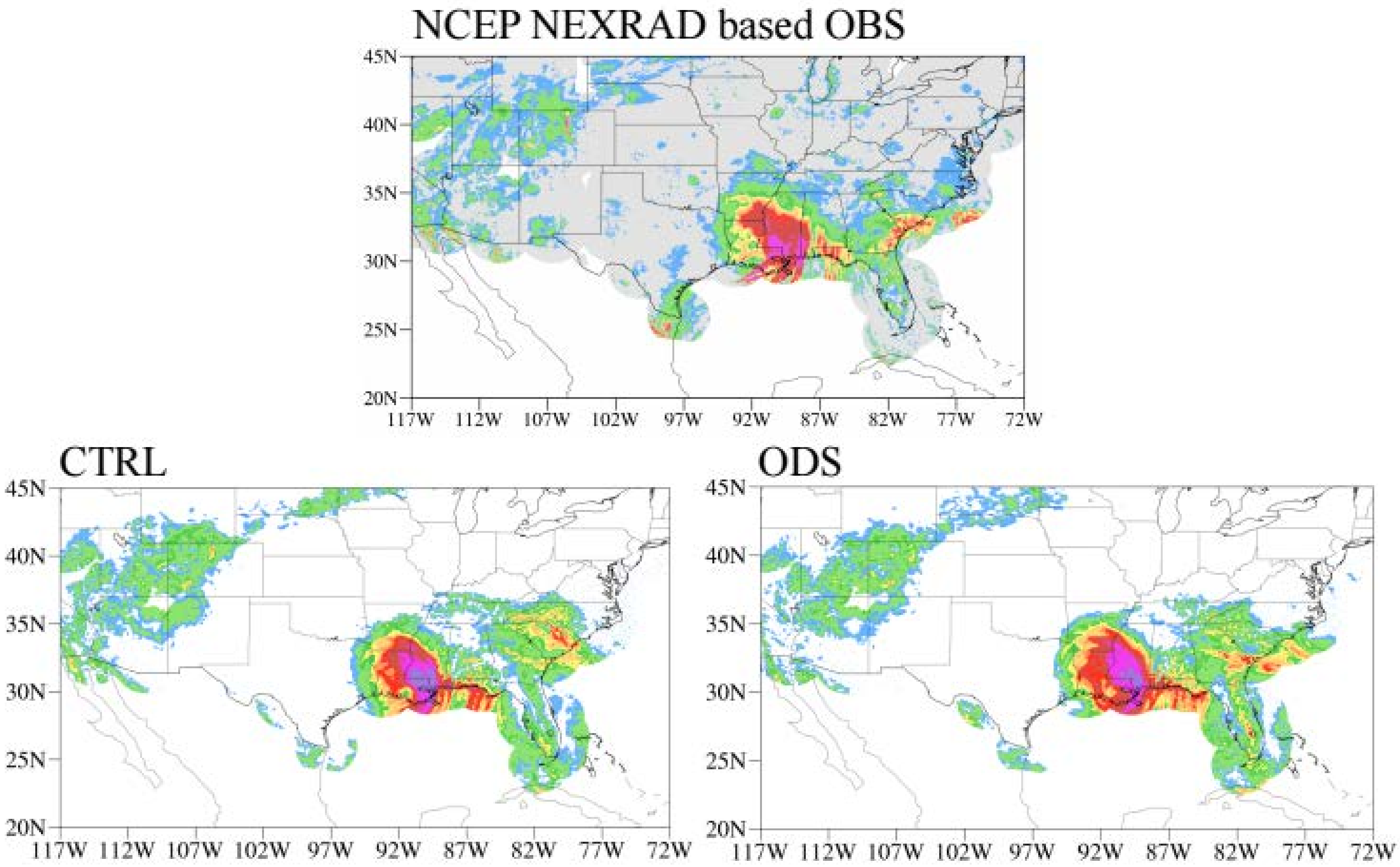


Outcomes from Enterprise SDR Processing System

- Temperature and water vapor sounding channels are grouped into a single data stream, following ATMS.
- Radiation from calibration targets are calculated as radiance instead of brightness temperature
- Lunar contamination correction is included in space view radiance correction
- Nonlinearity correction is based on “μ” parameter derived from TVAC
- Brightness temperature is computed from Planck’s function
- Error budgets in calibration are traceable and will be part of SDR data
- SDR outputs are generated at various fov size through resampling or foot-print matching

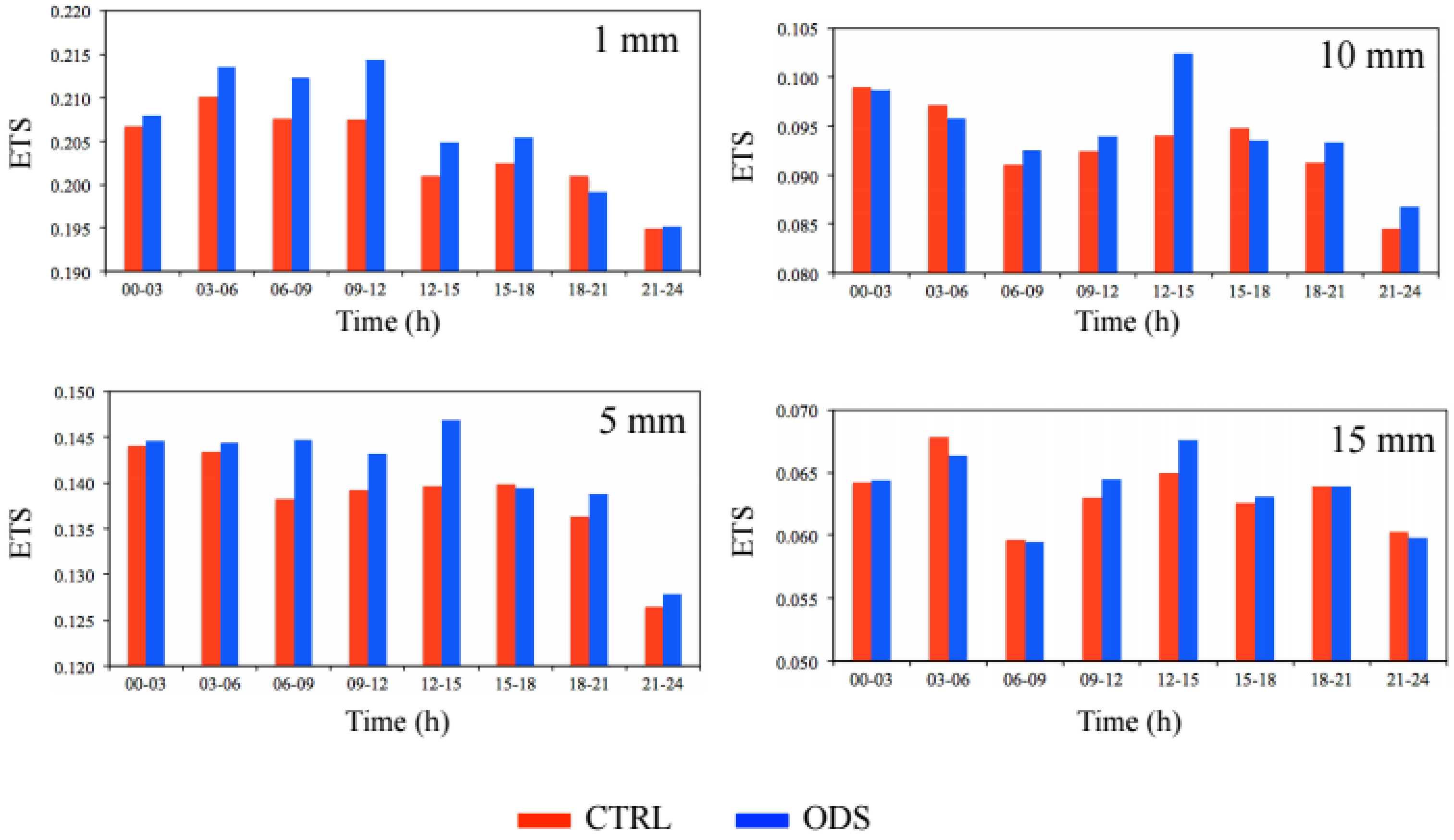
Impacts of One Data Stream (AMSU-A+MHS) on Coastal QPF

24-h Accumulative Rainfall on August 2012



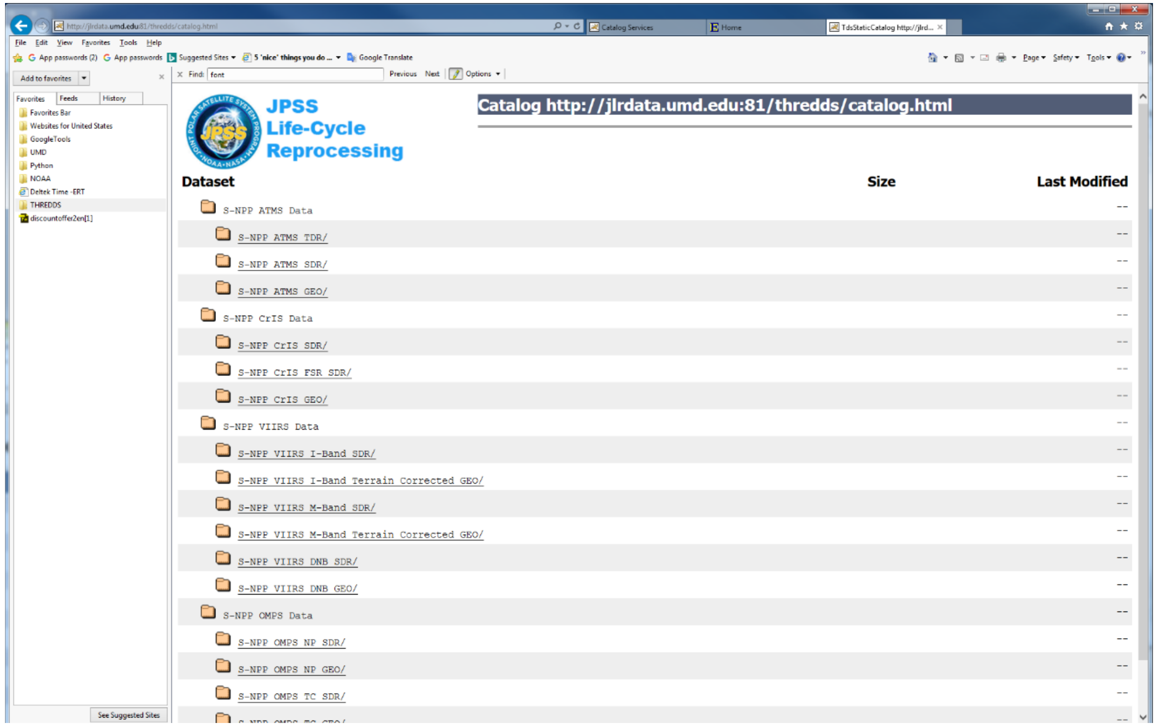
Impacts of One Data Stream (AMSU-A+MHS) on Coastal QPF

Statistical Performance of QPFs Averaged over 40 Forecasts



Enterprise Microwave Sounder Algorithm for Suomi NPP ATMS SDR Reprocessing

- Server: jlr.essic.umd.edu
- ~1000 cores
- 1.4 PB storage
- InfiniBand(56GB) internal connections
- 10GB internet access



http://jlrdata.umd.edu:81/thredds

JPSS Life-Cycle Reprocessing

JPSS Life_Cycle Reprocessed Data

THREDDS Data Server

Catalog http://jlrdata.umd.edu:81/thredds/catalog/snppatmssdr2012/2012-01-06/catalog.html

Dataset: 2012-01-06/SATMS_npp_d20120106_t0002419_e0003135_b00988_c20160331155032257128_star_sdr.h5

- *Data format:* HDF5
- *Data size:* 167.5 Kbytes
- *Naming Authority:* gov.noaa.nesdis.star
- *ID:* snppatmssdr2012/2012-01-06/SATMS_npp_d20120106_t0002419_e0003135_b00988_c20160331155032257128_star_sdr.h5

Documentation:

- **summary:** NOAA NESDIS STAR: JPSS Life-Recycle Reprocessing for S-NPP ATMS SDR
- **rights:** Freely available
- STAR JPSS Science Documents

Access:

1. **OPENDAP:** /thredds/dodsC/snppatmssdr2012/2012-01-06/SATMS_npp_d20120106_t0002419_e0003135_b00988_c20160331155032257128_star_sdr.h5
2. **HTTPServer:** /thredds/fileServer/snppatmssdr2012/2012-01-06/SATMS_npp_d20120106_t0002419_e0003135_b00988_c20160331155032257128_star_sdr.h5

Dates:

- 2016-03-31T15:50:32Z **(modified)**

Viewers:

- NetCDF-Java ToolsUI (webstart)

Summary and Conclusions

- In global data assimilation systems, ATMS forecast impacts are much larger than AMSU-A/MHS
- Assimilation of MHS can degrade forecasting of precipitation. The root-cause could be due to poor quality control
- A combined data stream of AMSU-A and MHS and shows a better performance than two separate data streams for AMSU-A and MHS.
- An enterprise SDR processing system is being developed for AMSU-A/MHS and ATMS SDR data and will be tested for METOP-C AMSU-A/MHS and JPSS-1 ATMS.