Testing and Evaluation of the GSI Data Assimilation System

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What is GSI?

- **G**ridpoint **S**tatistical **I**nterpolation
- Developed at NCEP/EMC, NOAA/GSD, NASA/GMAO, and NCAR/MMM
  - Community code supported through the DTC
- Primarily a three dimensional variational (3D-Var) data assimilation system
- Run for both regional and global operations
  - GFS, NAM, RR, HWRF

DTC Testing and Evaluation Objectives

- Perform GSI + WRF-ARW configuration runs
  - Determine the capability and robustness of the GSI+ARW in regional applications
  - Evaluate impact from a variety of existing and proposed new operational data types
- Provide rational basis for operational centers and the research community for advancements of NWP systems

Ming Hu
Introduction to Community GSI and its User Support
Thursday 4:30 pm J18.2

http://www.dtcenter.org/com-GSI/users

GSI updates

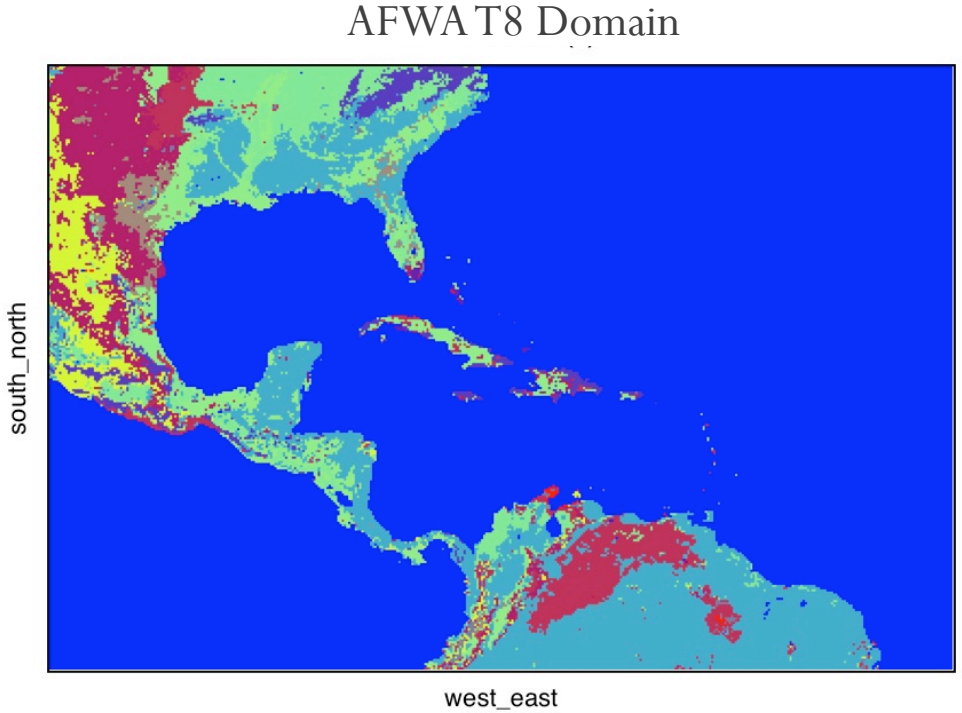
- GSI Q1FY11 candidate code used for all extended tests
- See release notes for full list of v2.0 updates
  - http://www.dtcenter.org/com-GSI/users/support/release_notes/index_GSIv2.0.php

- GSI GPS Quality Control (QC) Changes (Cucurull 2010)
  - Improve QC statistics
    - Seasonal statistics to account for model skill score changes, smoothed QC altitude transitions
    - Fixed code errors
  - Reduce approximations in refractivity forward operator and improved assumptions
  - Improved observation errors
    - New ob errors are nearly always smaller than previous in tropics
    - Not much change in extratropics
  - These changes increase data usage in tropics

Extended Tests

- GSI Q1FY11 candidate coupled with WRF-ARW v3.2
- 15 August 2007 (12 UTC) – 15 September 2007 (12 UTC)
- 15 km horizontal resolution
- 57 vertical levels, 10 mb model top
- AFWA T8 domain
- GDAS prepBUFR data
- Global BE used in all runs

- Verification using Model Evaluation Tools (MET) v2.0



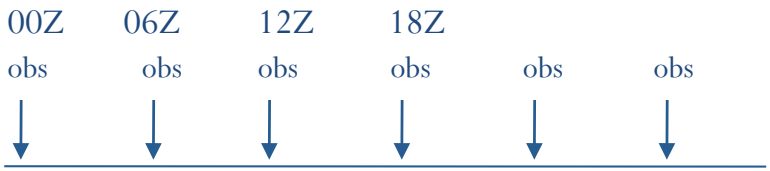
Experimental Design

- GFSWRF: ARW runs started from GFS analysis every 6 hours
- GSI+ARW full cycling (6hrs) runs *(following NAM configurations)*:

Surface

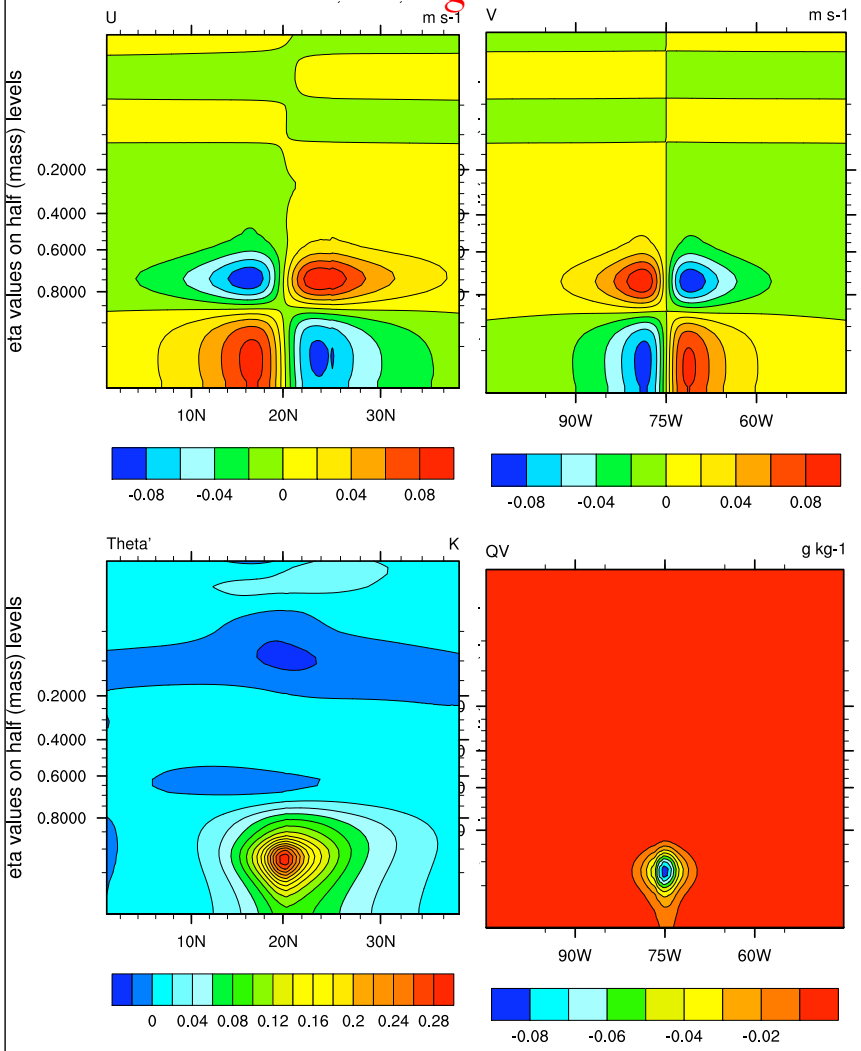
  - CYC_CONV_default: PrepBUFR data were assimilated
  - CYC_CONV_allobs: PrepBUFR data with increased surface observations were assimilated
  - CYC_CONV_nosfc: No surface PrepBUFR data assimilated

  - CYC_GPS: PrepBUFR (CYC_CONV_default) + GPS RO data were assimilated
  - CYC_AMSU-A: PrepBUFR (CYC_CONV_default) + AMUS-A radiance data were assimilated

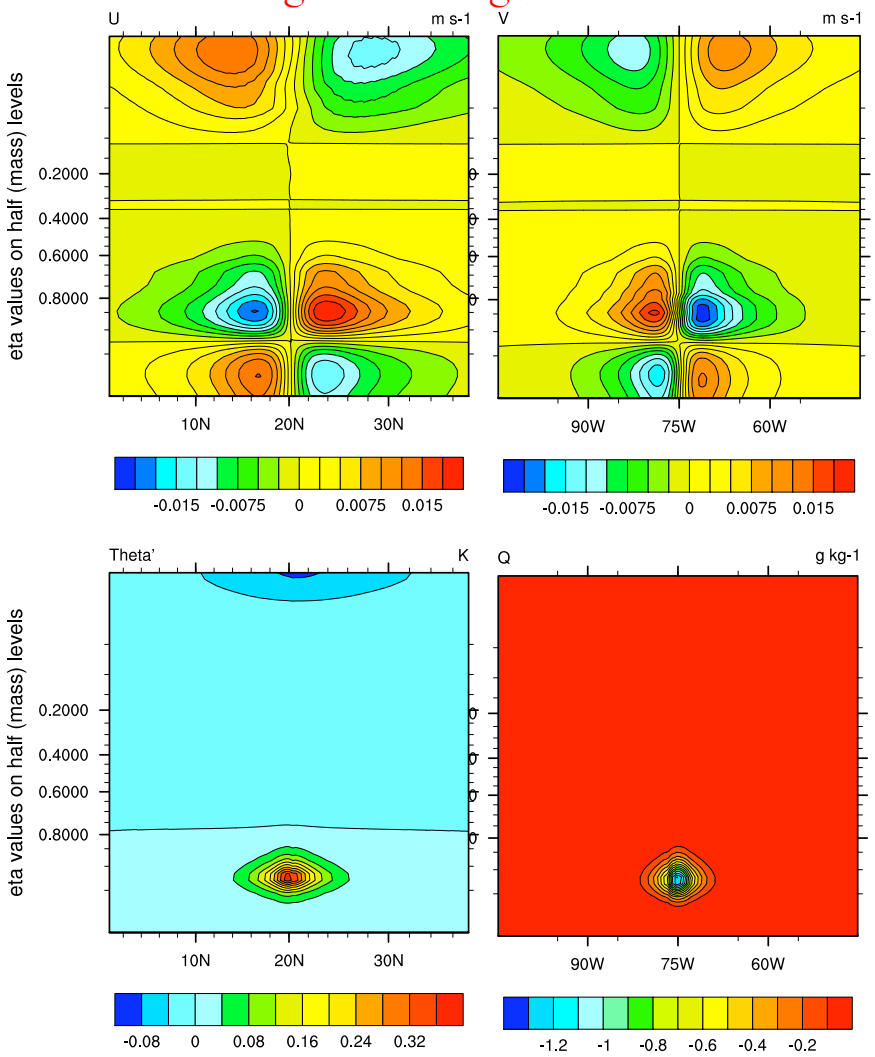


Pseudo Single Observation Test

Global Background Errors

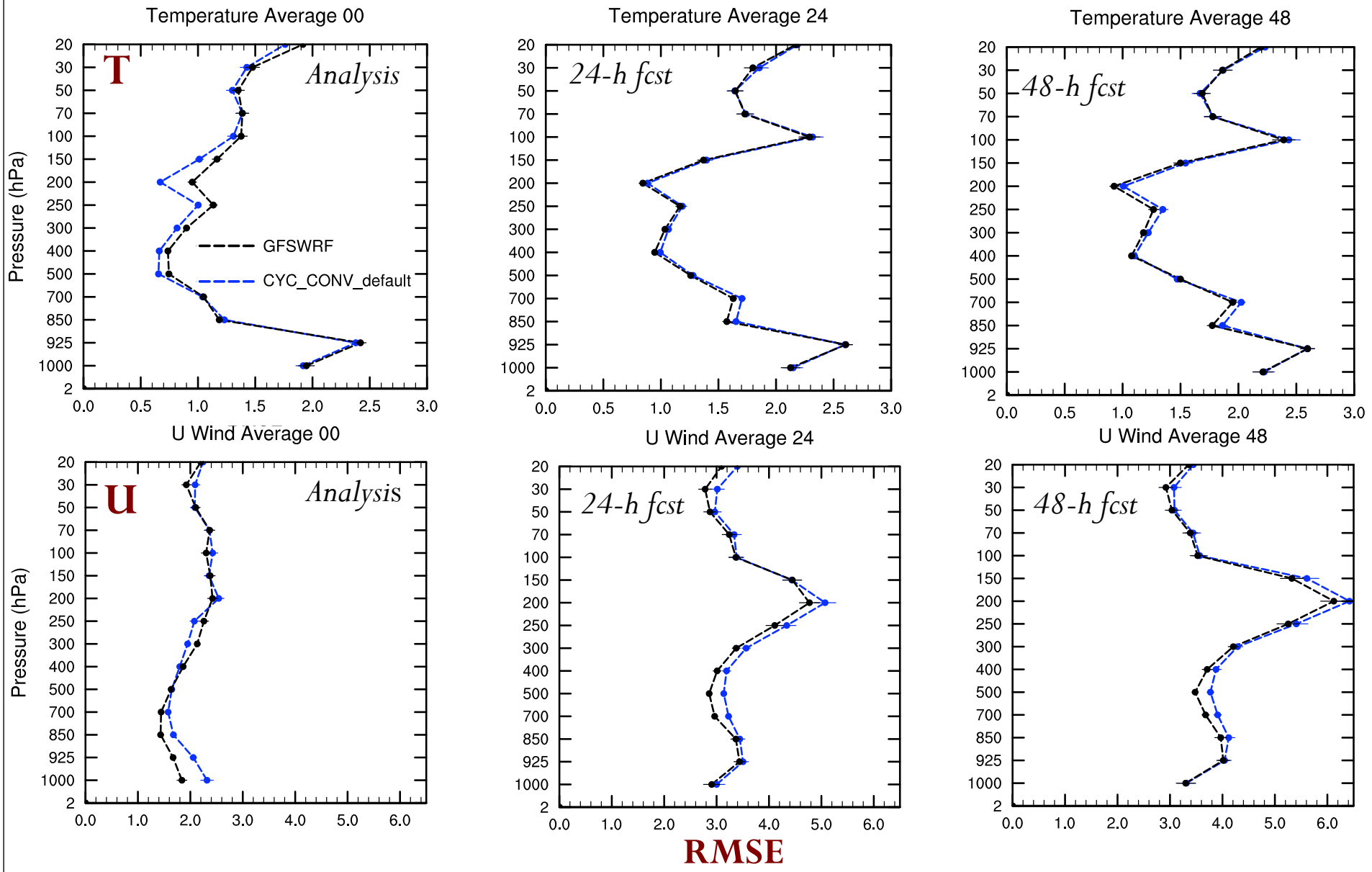


Regional Background Errors



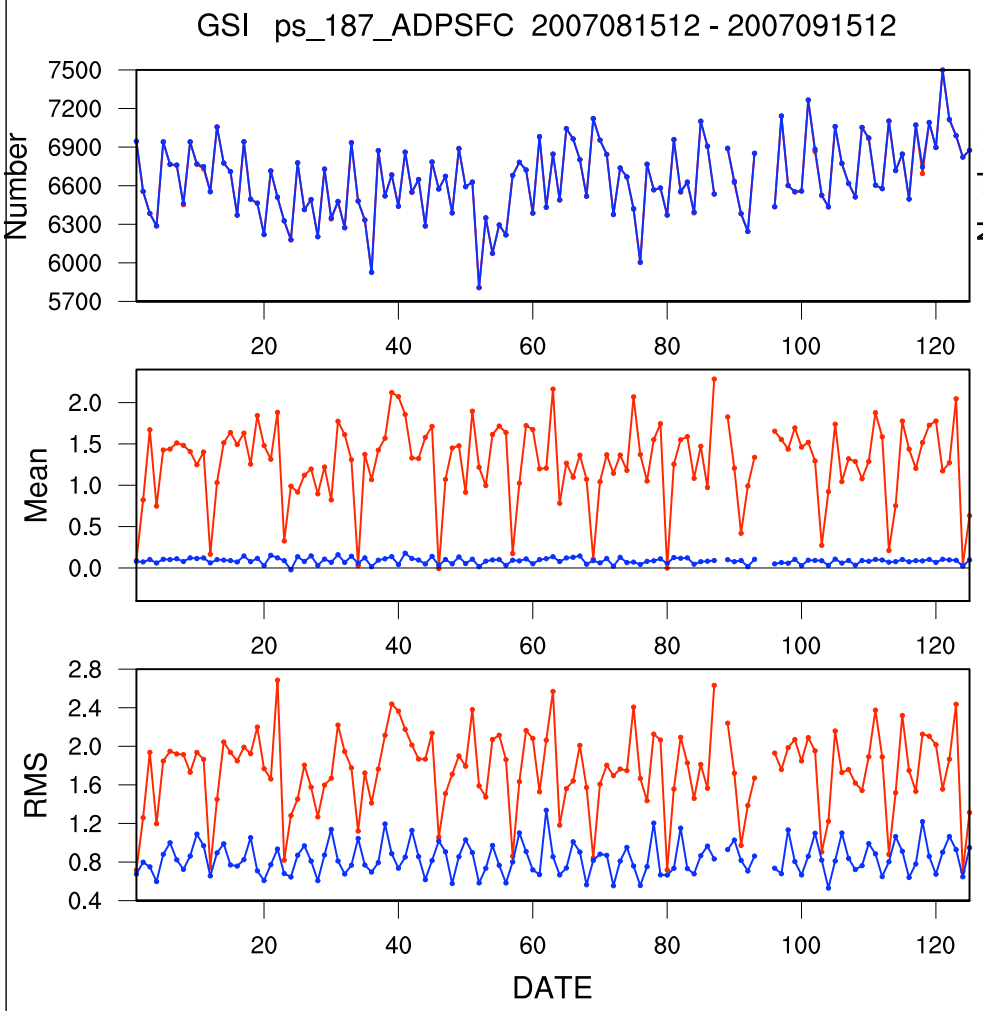
- 1 K temperature increment with 1 K observation error
- Analysis increment for same data is larger for regional BE than global BE
- Increment in stratosphere (regional BE) known issue
- ✓ Global BE used in extended runs

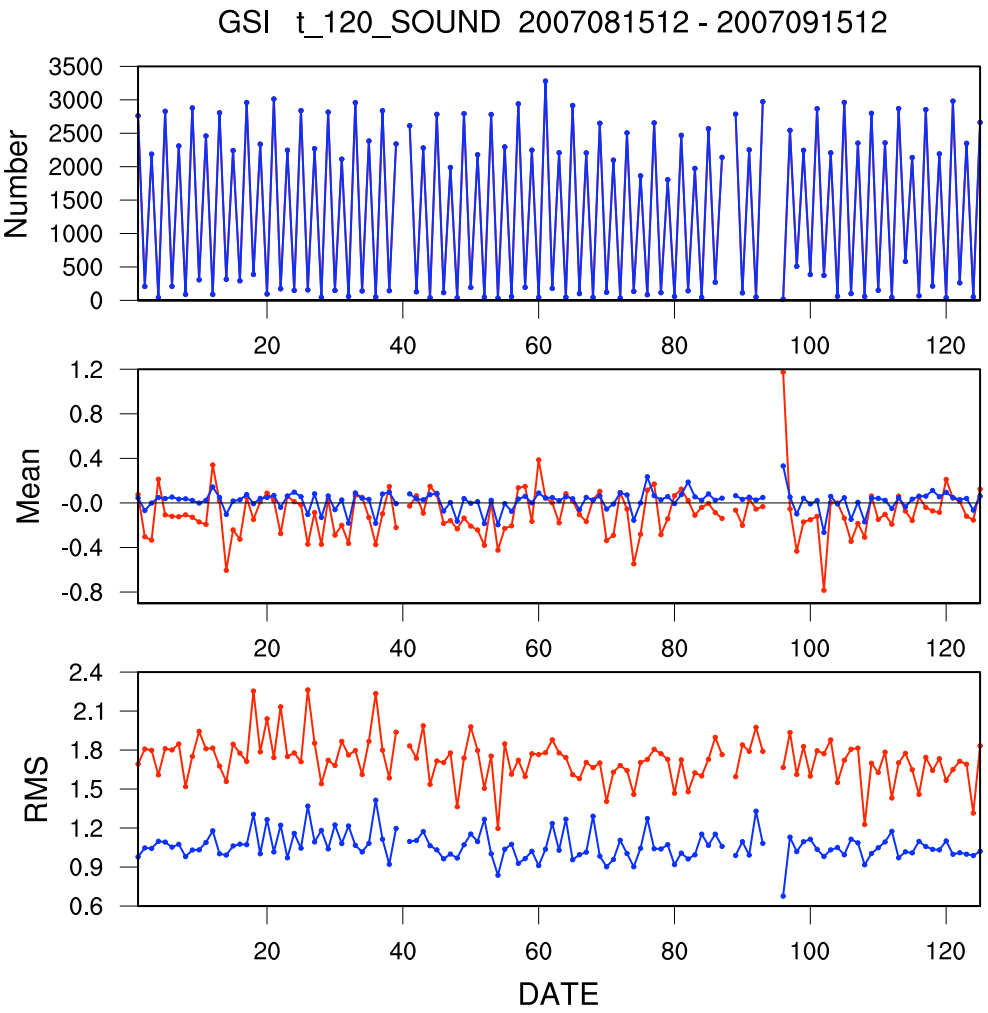
GFSWRF benchmark run



- 6 hr full cycling assimilating conventional observations still difficult to find SS improvement over GFSWRF

Analysis fit to PrepBUFR observations

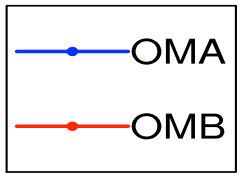




Surface synoptic stations (ps)

RAWINSONDE soundings (t)

✓ GSI properly assimilating conventional observations



Surface Assimilation Impact

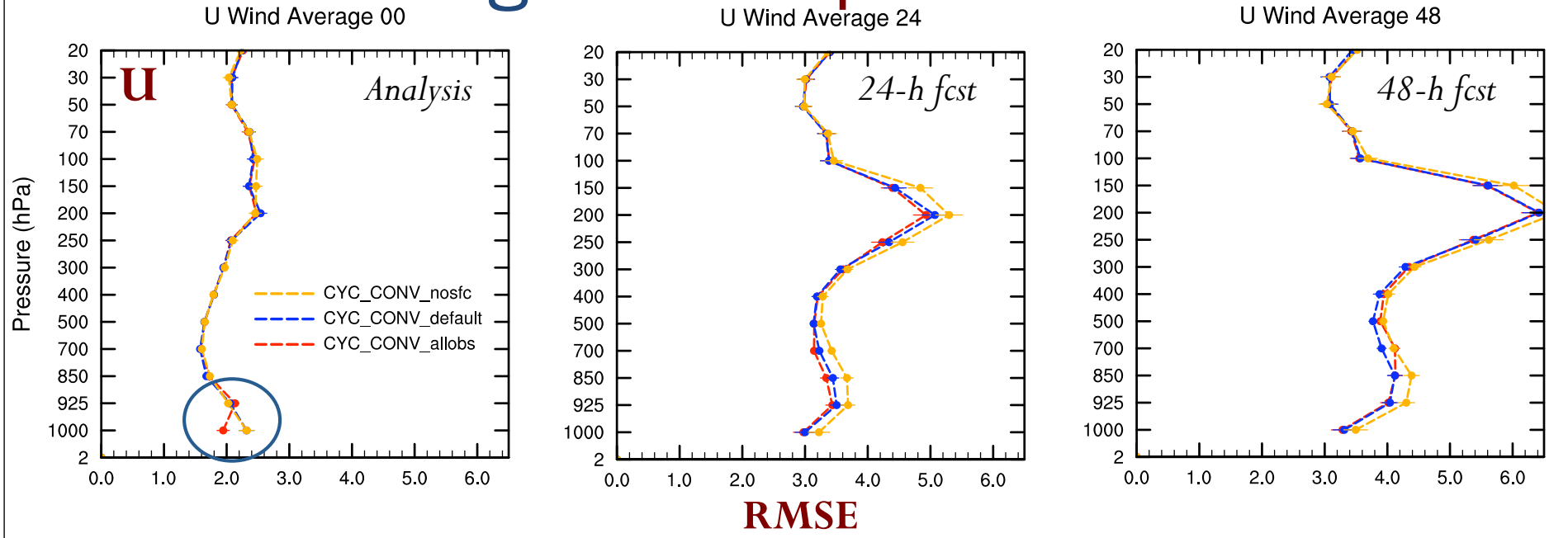
- CYC_CONV_default: QC marks result in most surface data rejected during GSI minimization (*due to GFS quality marks*).
- CYC_CONV_allobs: Surface data set to match data allowed for NAM
  - This process may introduce some bad observations to the analysis
- CYC_CONV_nosfc: no surface prepBUFR report types assimilated

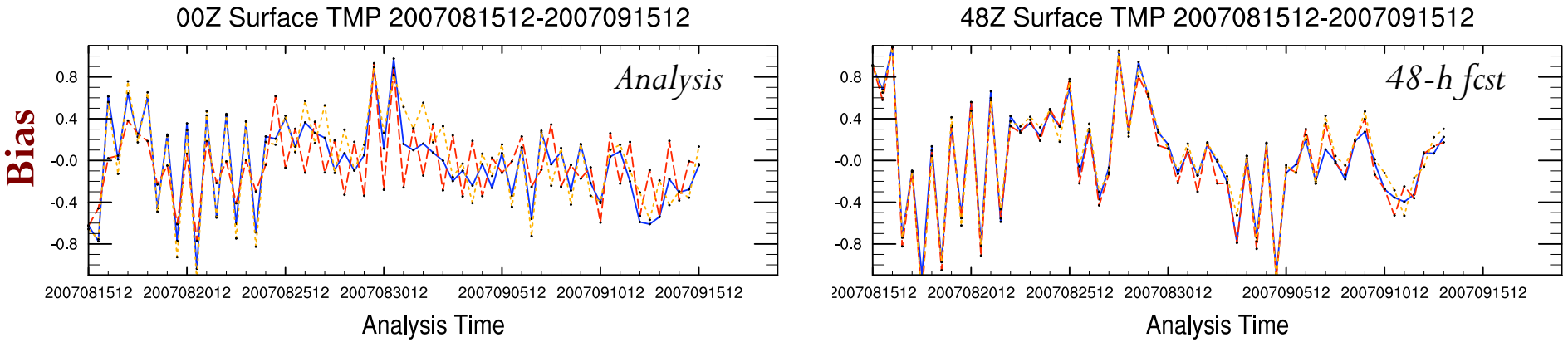
	ADPSFC 181	ADPSFC/ SFCSHP 183	ADPSFC 187		ADPSFC 281	SPSSMI 283	ADPSFC/ SFCSHP 284	QKSWND 285	ADPSFC 287
Ps Q T	2.00 9.00 8.00	9.00 9.00 8.00	6.00 9.00 8.00	UV	9.00	2.00	9.00	2.00	9.00

Table 1: QC mark value for corresponding prepbufr report type

- All runs following NAM configurations
  - amount of surface data assimilated was altered
- Adjustment made to 'qcmark' to allow more surface observations to be assimilated

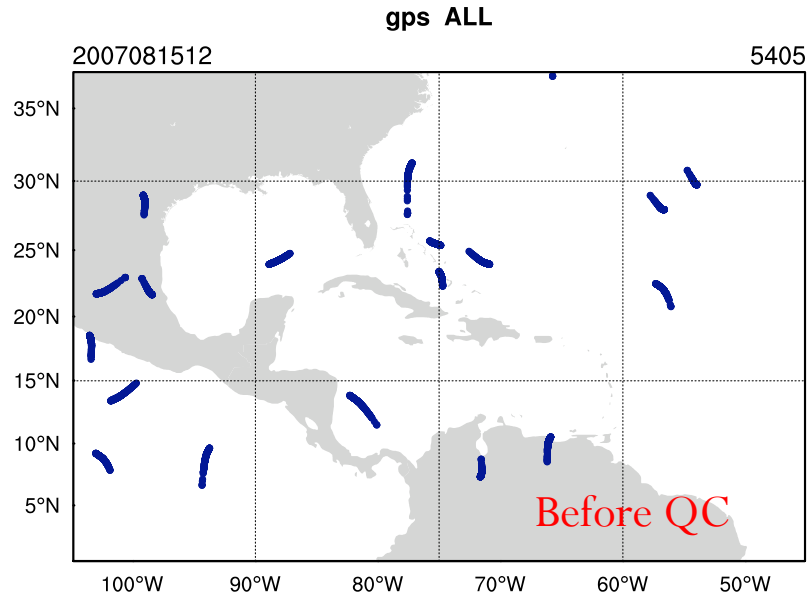
Verification against PrepBUFR observations

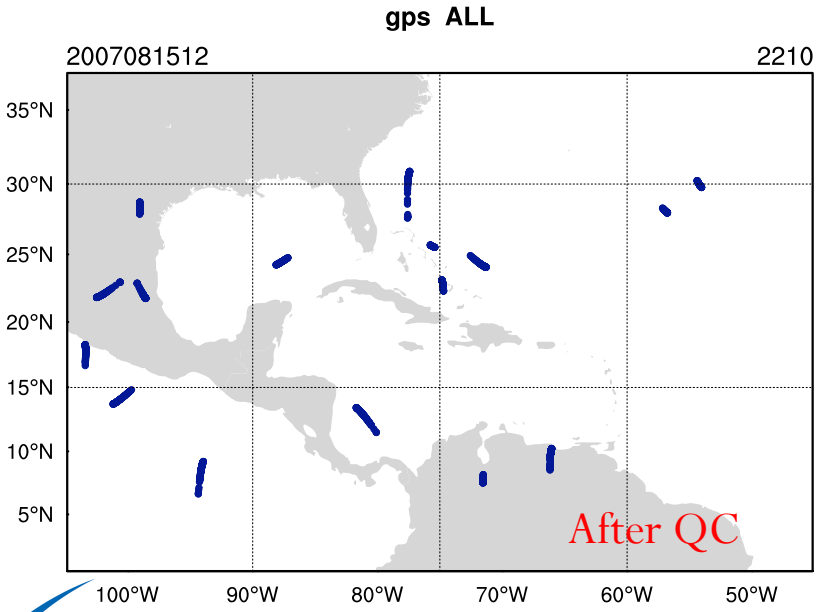


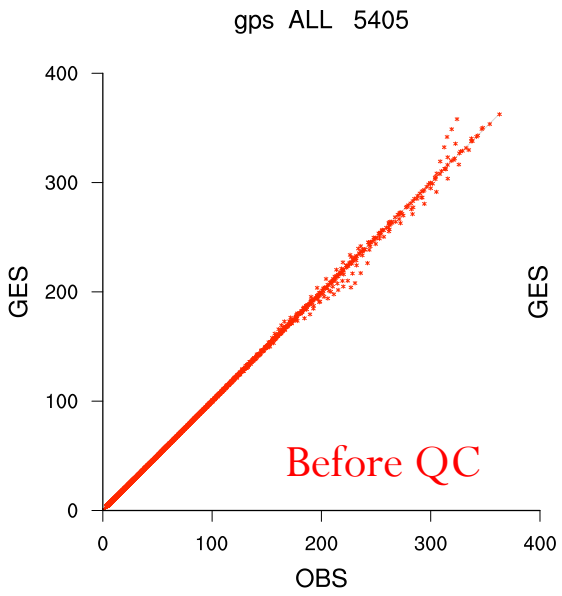


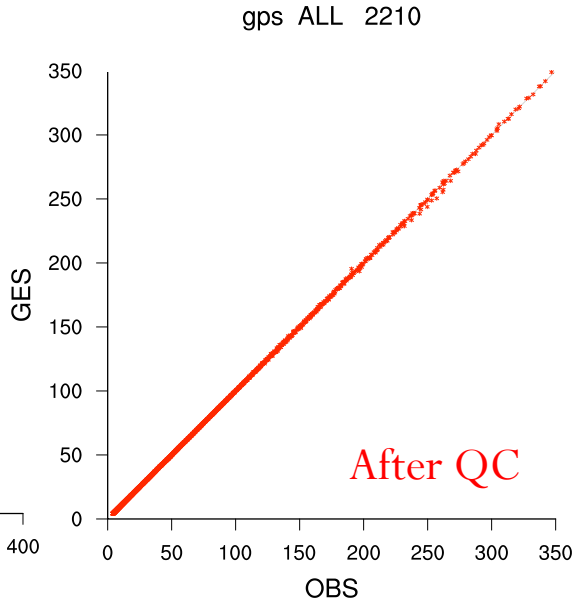
- Verification against ADPUPA (sonde only, top), ADPSFC (bottom)
- Impact of additional sfc obs apparent at analysis time, little/no SS impact for fcst
- Negative impact from no sfc obs at fcst times relative to default surface obs

GPS RO Assimilation





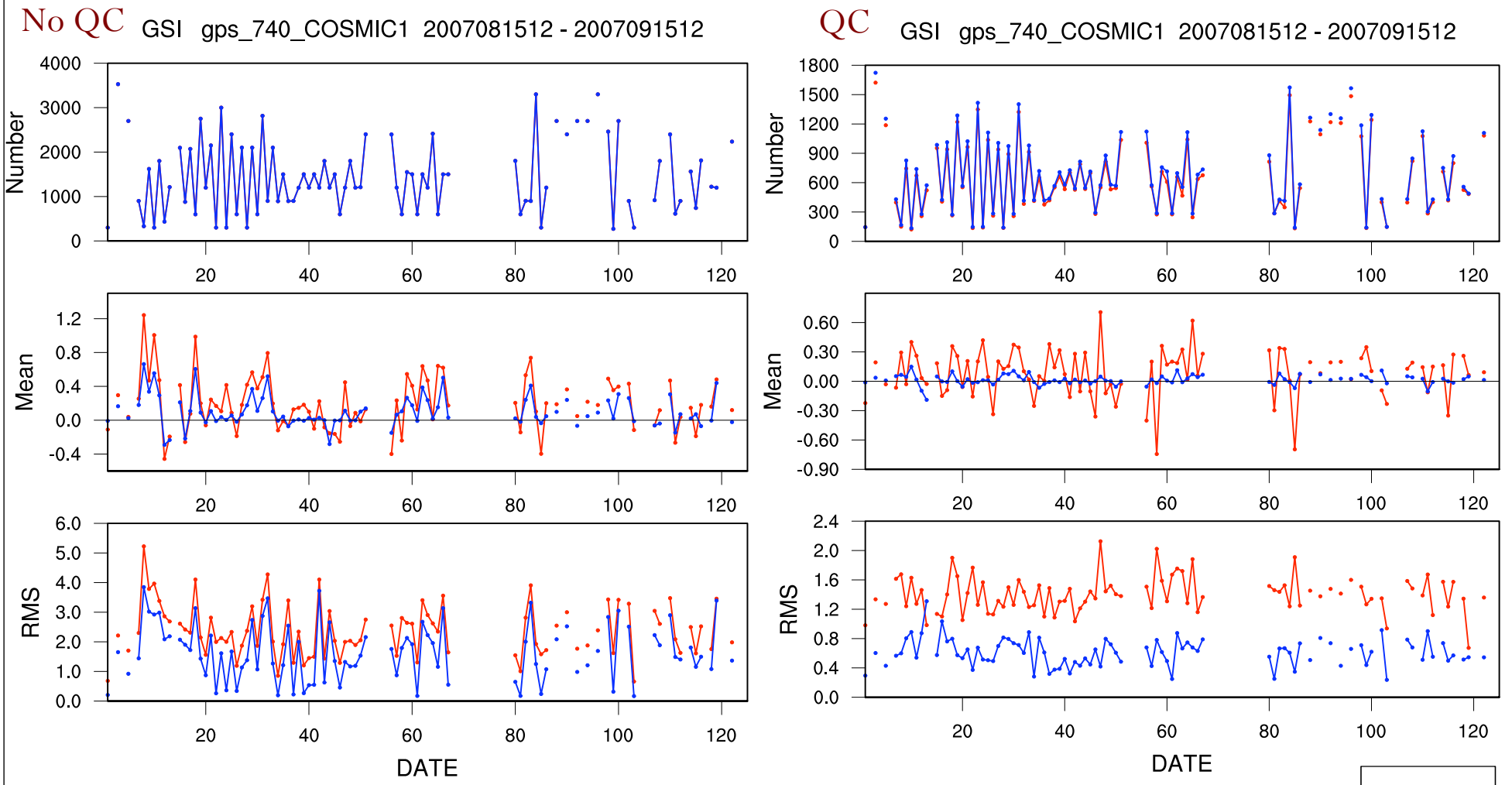




	Ob Rejection	RMS
GSI v1.0	~100%	-
GSI v1.0 w/ '2.0' QC	61.2%	1.16
GSI v2.0	59.1%	0.97

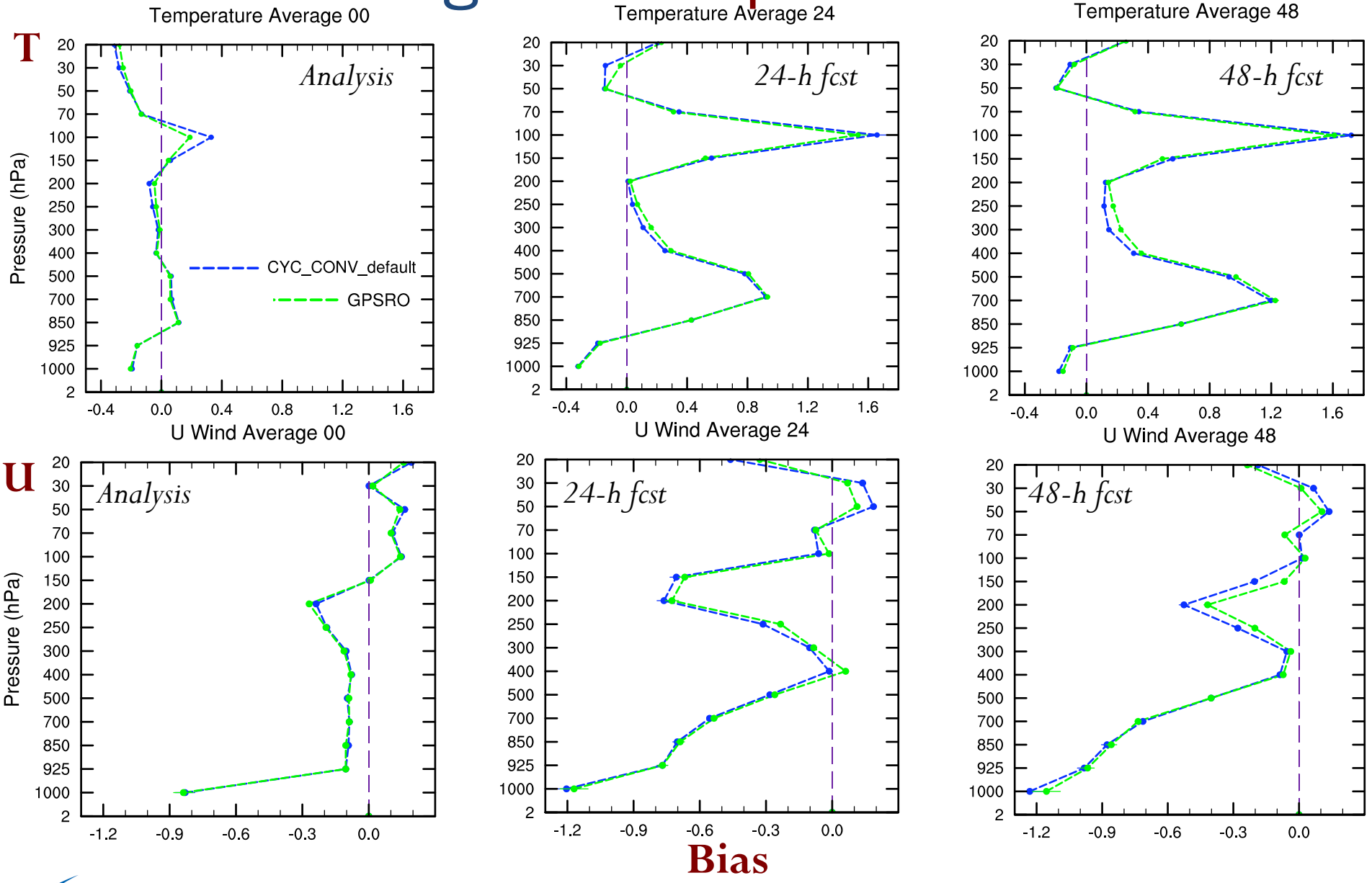
** Results for 2007081512*

GPS RO Assimilation



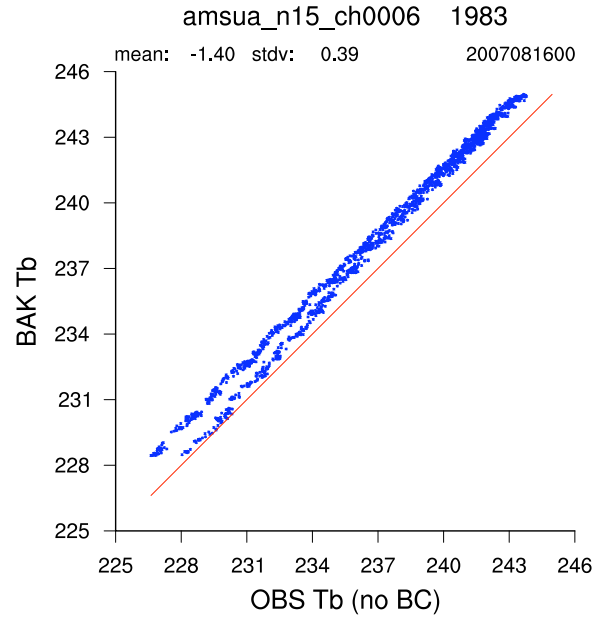
- ✓ GPS RO data assimilated from COSMIC 1
- ✓ GSI properly assimilating GPS observations
- ✓ Improvement in analysis from the QC
- ✓ Analysis increment has lower RMS value than background innovation

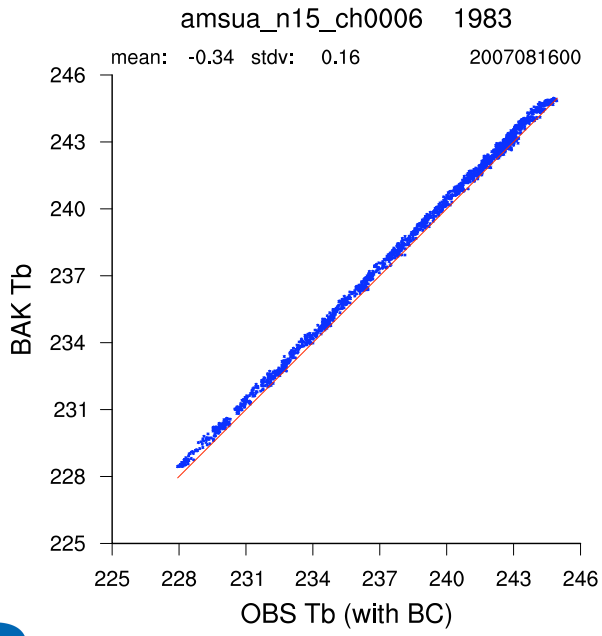
Verification against PrepBUFR observations

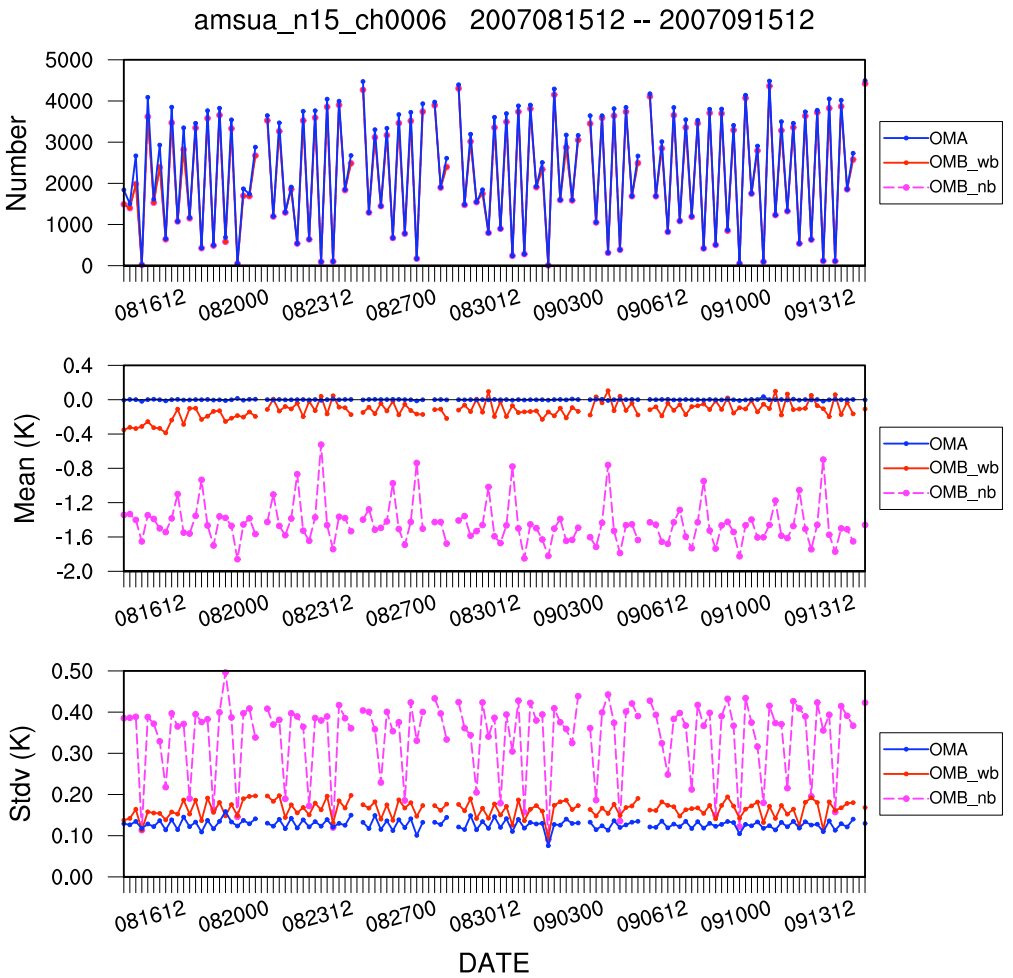


- Slight positive SS impacts in GPS RO over conventional assimilation
- Most noticeable impacts in upper troposphere/ lower stratosphere

AMSU-A Bias Correction



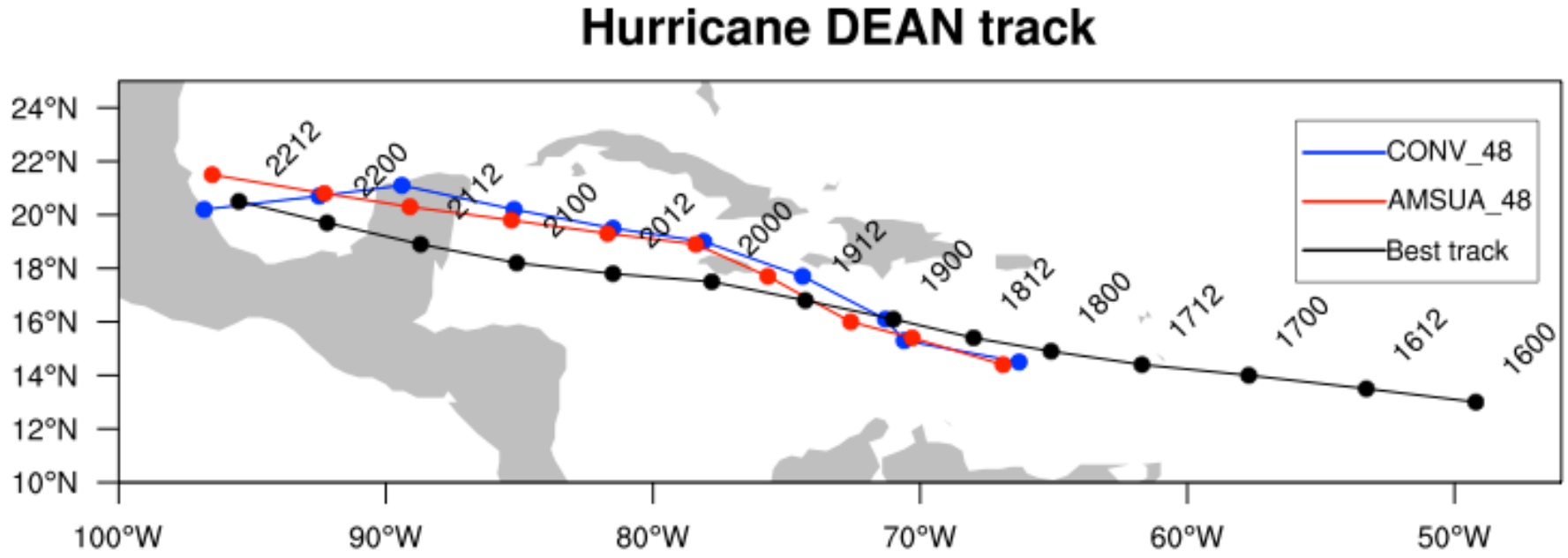




- Variational Bias correction (within GSI)
- Bias correction working with AMSU-A radiance assimilation
- Improvement in Bias and much smaller Stdv after bias correction

✓Fcst verif showed neutral to slightly negative impact from AMSUA against default CONV

AMSU-A Radiance - Hurricane Dean



	Track error (km) - CONV	Track error (km) – AMSU-A
T + 00h	48.15	48.69
T + 12h	53.95	47.75
T + 24h	77.65	86.13
T + 36h	116.45	138.65
T + 48h	166.41	178.26

- CONV+AMSUA track error higher than CONV alone
- Track position generally closer to best track with AMSU-A run, however timing of track negatively affecting track error
  - 1800-1912 UTC AMSU-A run moves storm too quickly

Summary and Conclusions

- A series of monthly experiments were run using GSI+ARW to investigate the capability and performance of the system
  - Included observations impact of surface, GPS RO, and radiance assimilation
- Surface
  - Increased surface observations showed impact at the analysis time, but no impact on forecast
    - Simply adding more surface obs will not increase fcst skill. Default configuration has most impact.
- GPS
  - GSI v2.0 assimilated GPS RO data properly, increased data usage in tropics
  - Forecast verification showed slight positive impact over conventional obs alone – particularly in upper troposhpere/lower stratosphere
- Radiance
  - Forecast verification showed neutral to slightly negative impact over conventional alone
  - Bias correction, domain, data coverage, etc are major issues with regional radiance data assimilation.
    - Although current bias correction seems to work, it doesn't positively impact fcst

- Contact:
  - knewman@ucar.edu
- DTC community GSI:
  - http://www.dtcenter.org/com-GSI/users/
- Presentation on DTC GSI community code:
  - M. Hu: Introduction to Community GSI and its User Support
    - Thursday 4:30 pm J18.2