



Observing System Experiments Using the NCEP Global Data Assimilation System

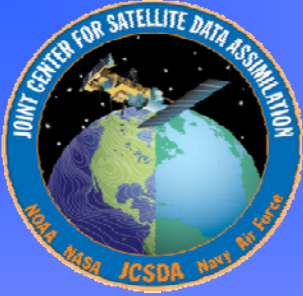
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University of Maryland, Baltimore County





Overview

- Background / Experiments
- Anomaly Correlations
- Tropical Wind Vector RMSE
- Time Series / Poor Forecast Performance
- Forecast Impact
- Hurricane Statistics
- Summary



Background

- NCEP Operational GDAS/GFS May 2011 version
- T574L64 operational resolution
- Two Seasons
 - Aug-Sept 2010
 - Dec 2010-Jan 2011
- Cycled experiments
- 7 Day forecast at 00Z
- Control late analysis (GDAS) used for verification
- Not NCEP operations computer





Experiments

No Satellite Data

- AMSU-A
- MHS
- AMVs
- GPS-RO
- Hyperspectral
- GOES Sounder
- HIRS
- WindSat

No Conventional Data

- Rawinsondes
- Aircraft
- Ship / Buoy
- Profilers
- VAD winds



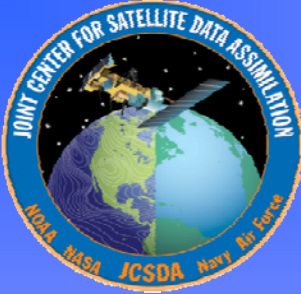
Experiments

- No AMSU-A
 - N-15, N-18, N-19, MetOp-A, Aqua
- No MHS
 - N-18, N-19, MetOp-A
- No Atmospheric Motion Vectors (AMV)
 - MTSAT, Meteosat-7, Meteosat-9, GOES-E, GOES-W, MODIS
- No GPS-RO (11)
 - CNOFS, COSMIC, GRACE, MetOp-A, SACC, TerraSAR-X

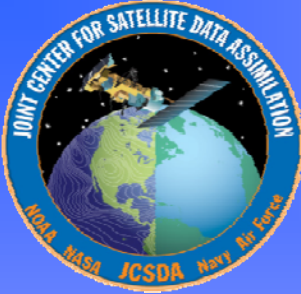


Experiments

- No Rawinsondes (T, Q, UV)
 - Rawinsondes, Dropsondes, PIBALs
- No Aircraft data
 - AIREP, ASDAR, AIRCAR
- No Hyperspectral IR data
 - AIRS, IASI

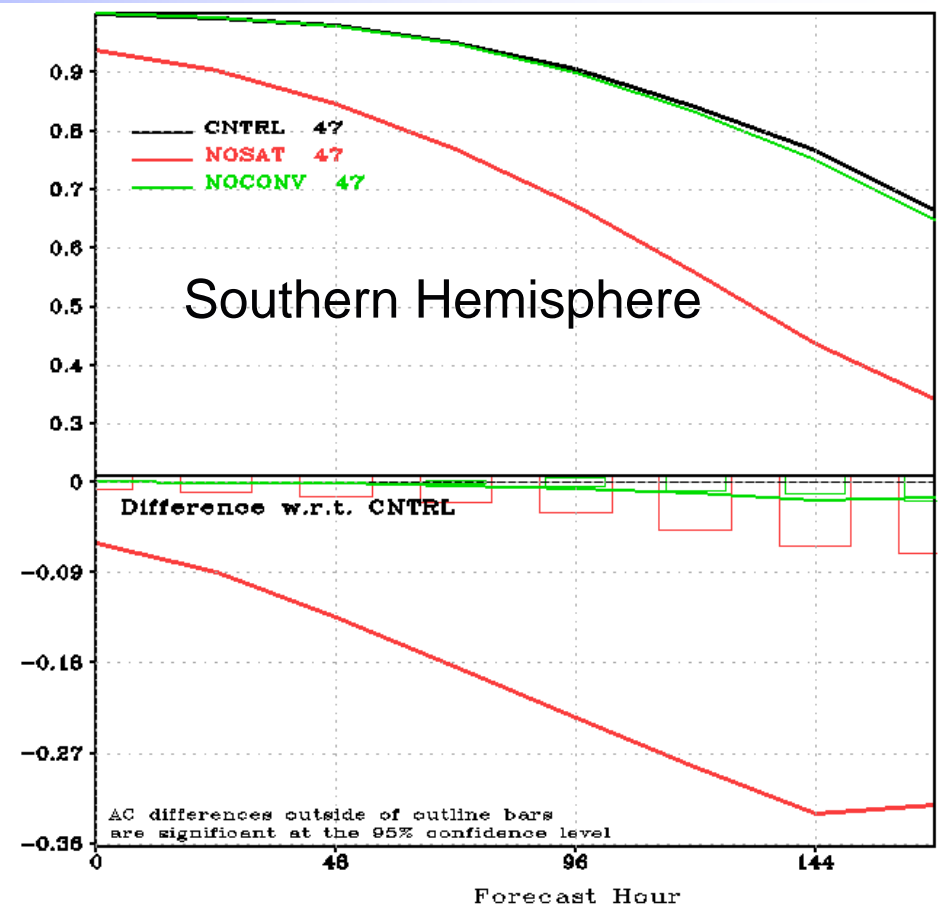
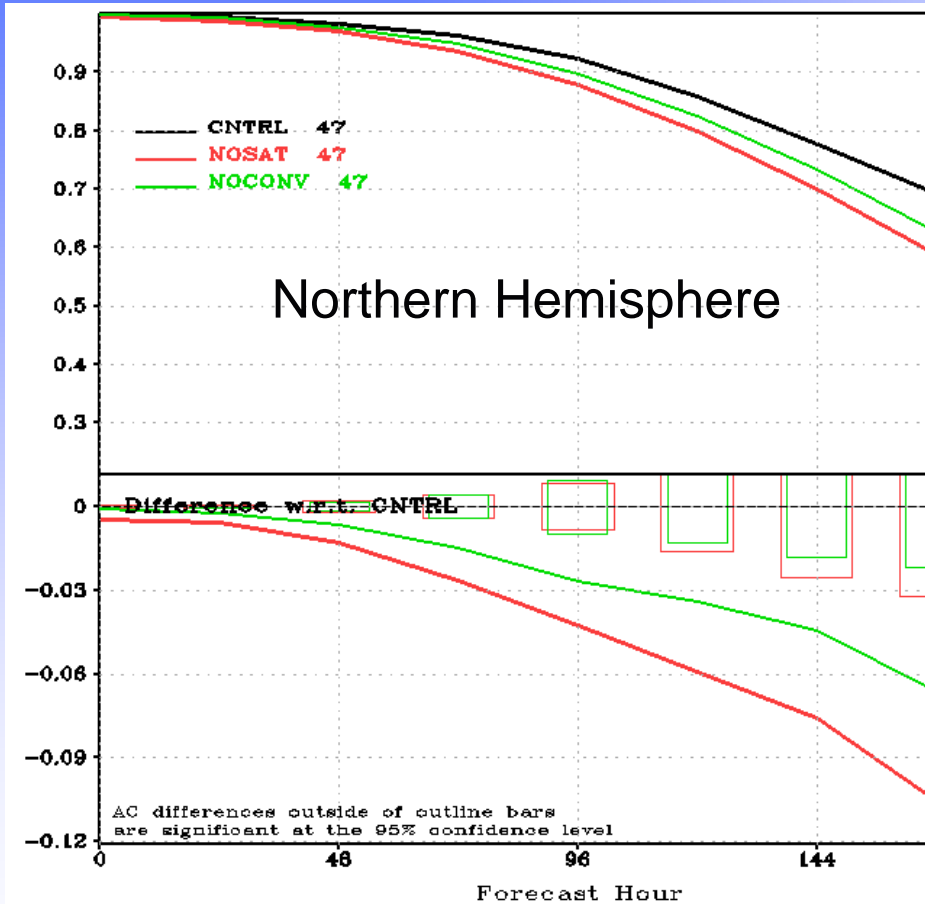


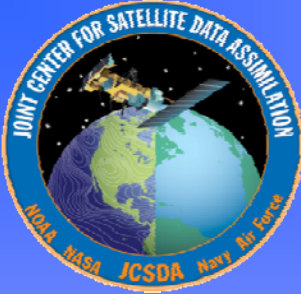
Anomaly Correlations



500 hPa Anomaly Correlations 15 Aug – 30 Sep 2010

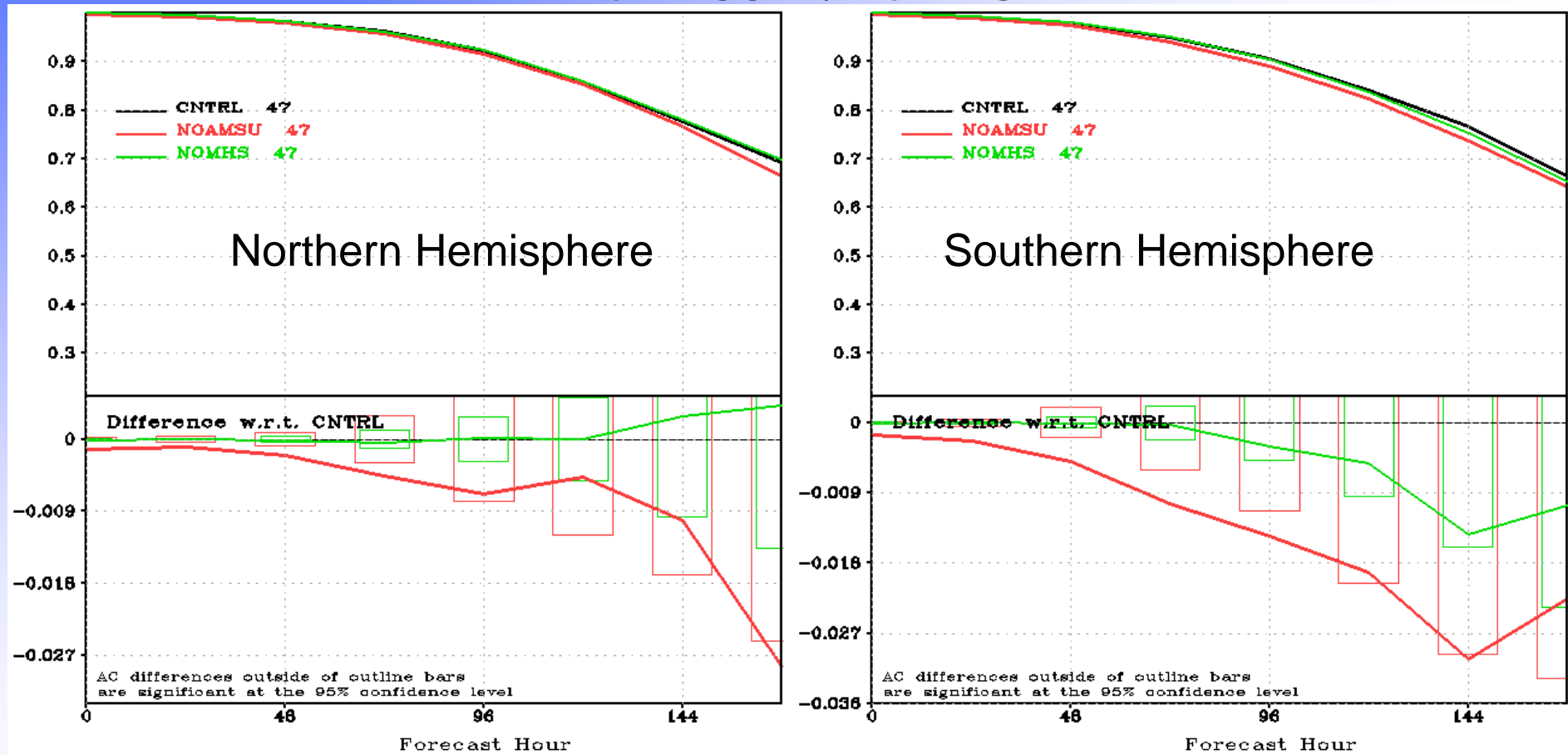
No Satellite / No Conventional Data

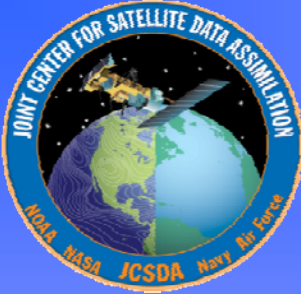




500 hPa Anomaly Correlations 15 Aug – 30 Sep 2010

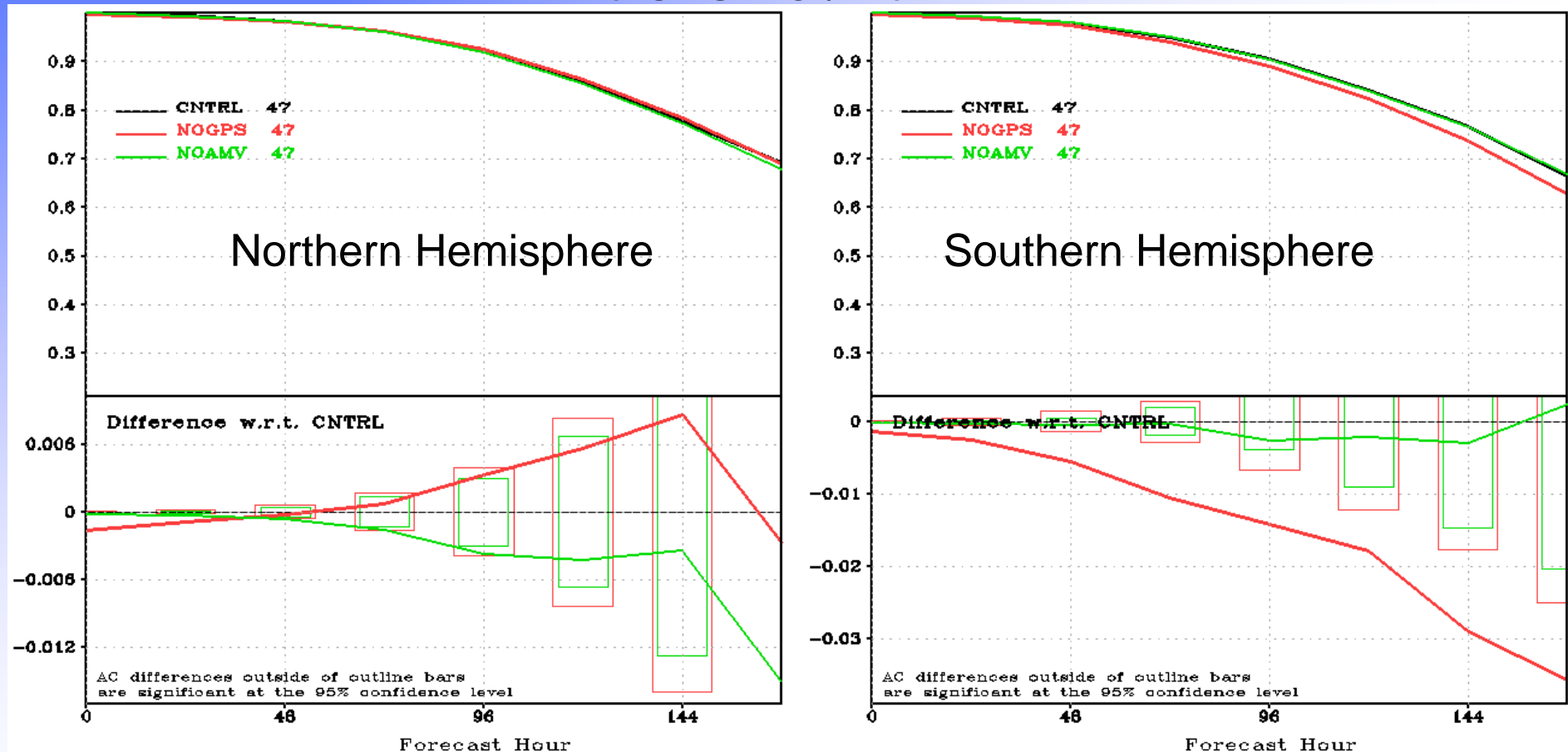
No AMSU-A / No MHS

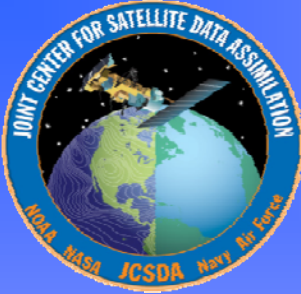




500 hPa Anomaly Correlations 15 Aug – 30 Sep 2010

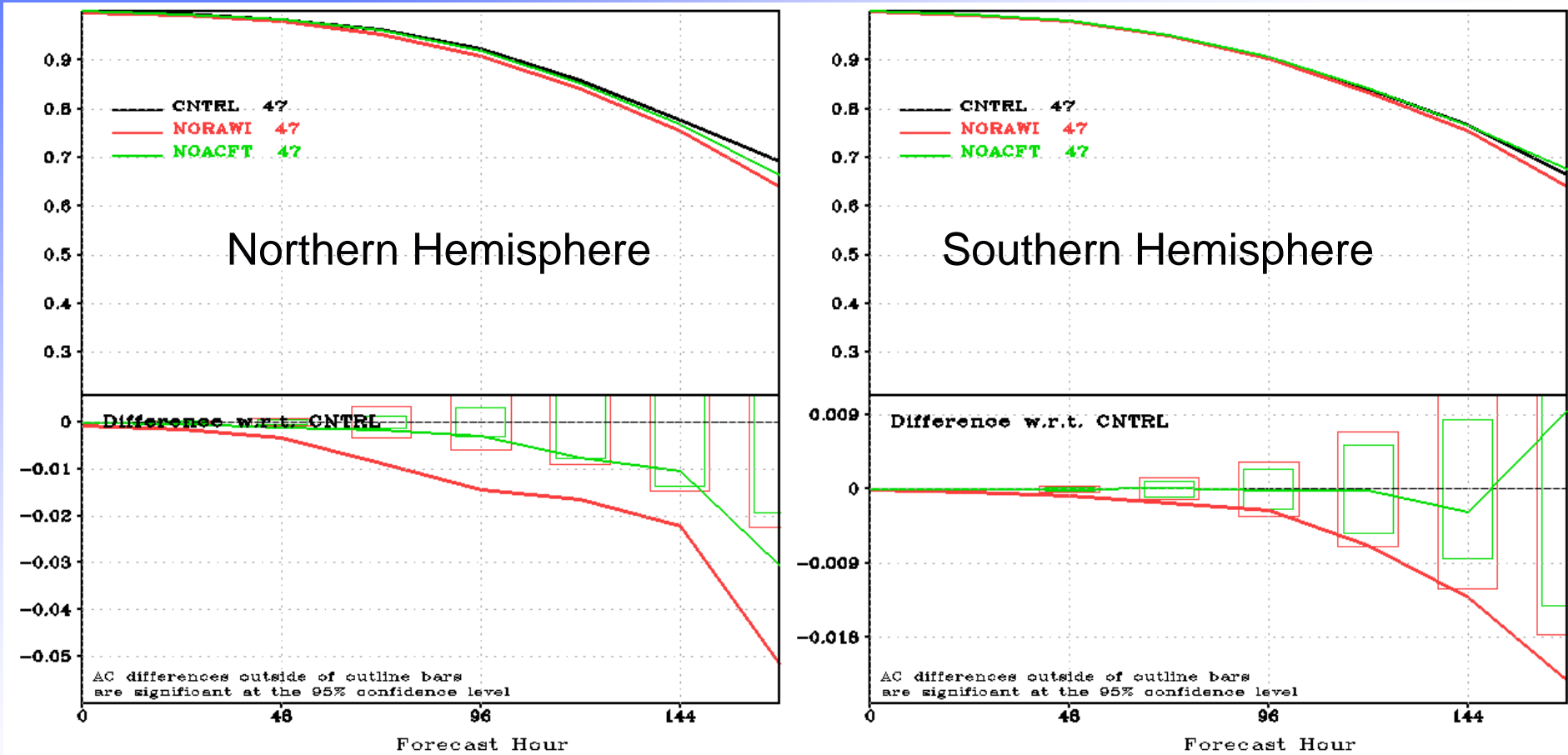
No GPS-RO / No AMV

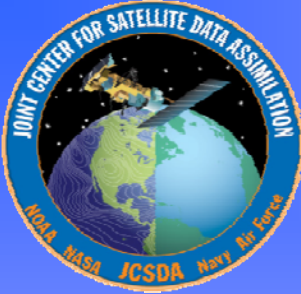




500 hPa Anomaly Correlations 15 Aug – 30 Sep 2010

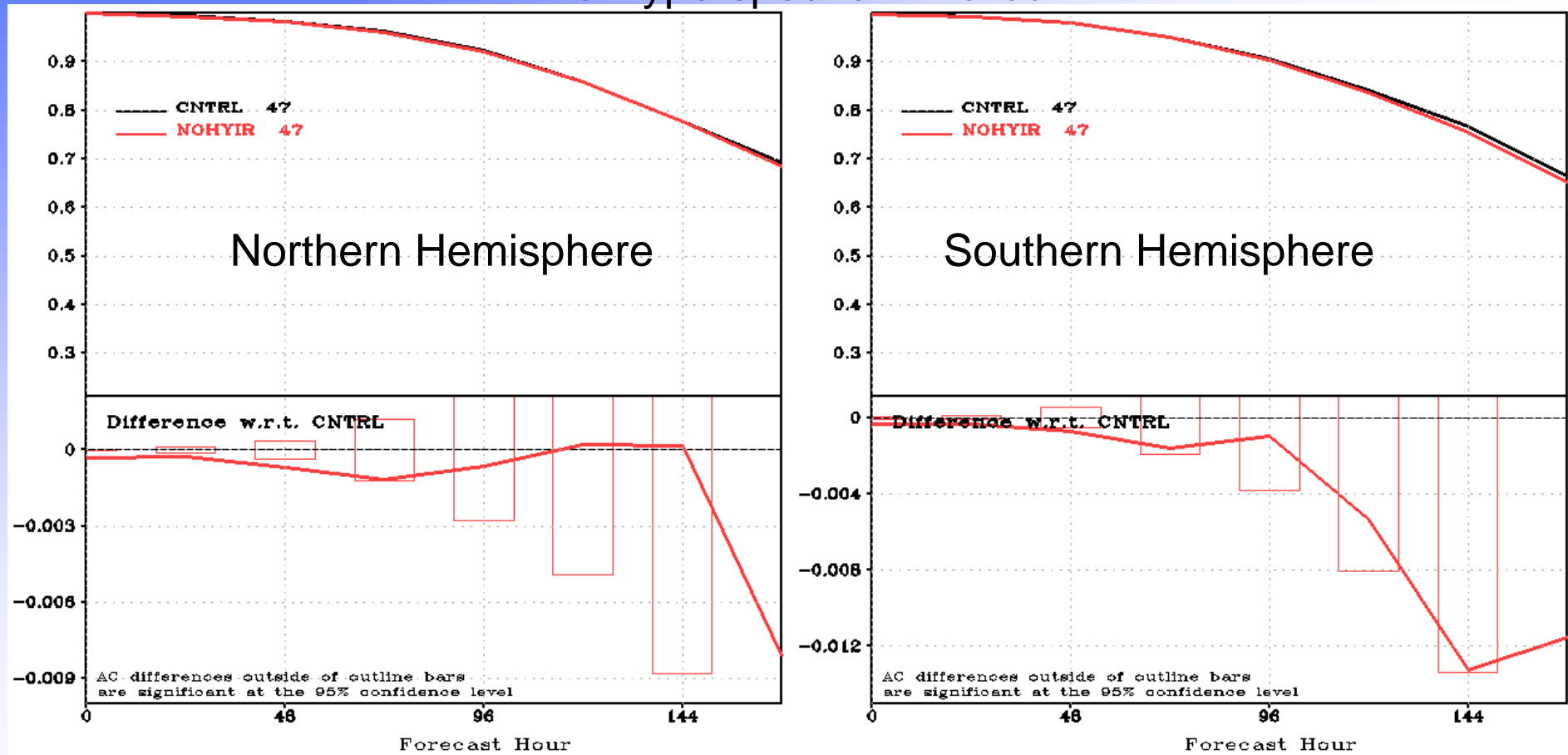
No Rawinsondes / No Aircraft





500 hPa Anomaly Correlations 15 Aug – 30 Sep 2010

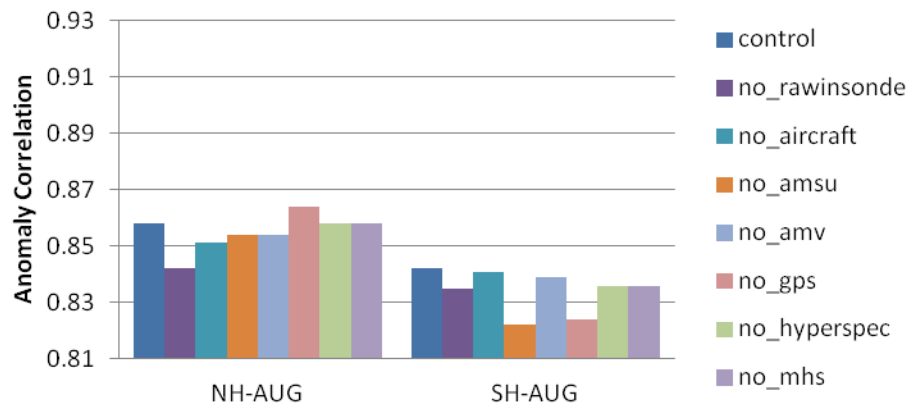
No Hyperspectral Infrared



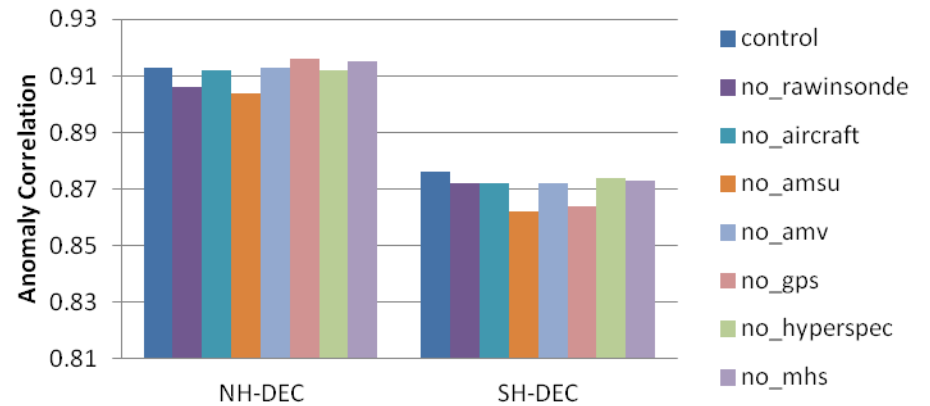


500 hPa, Day 5, Instrument Average AC scores

**500 hPa Day 5 AC Scores
15 Aug - 30 Sep 2010**



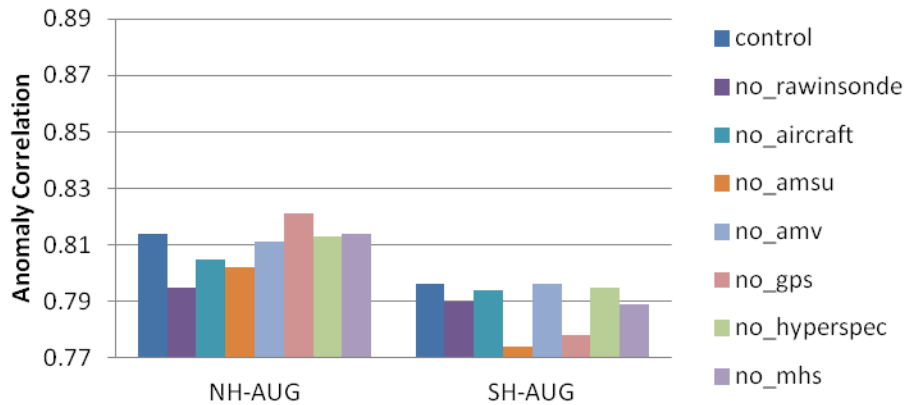
**500 hPa Day 5 AC Scores
15 Dec 2010- 31 Jan 2011**



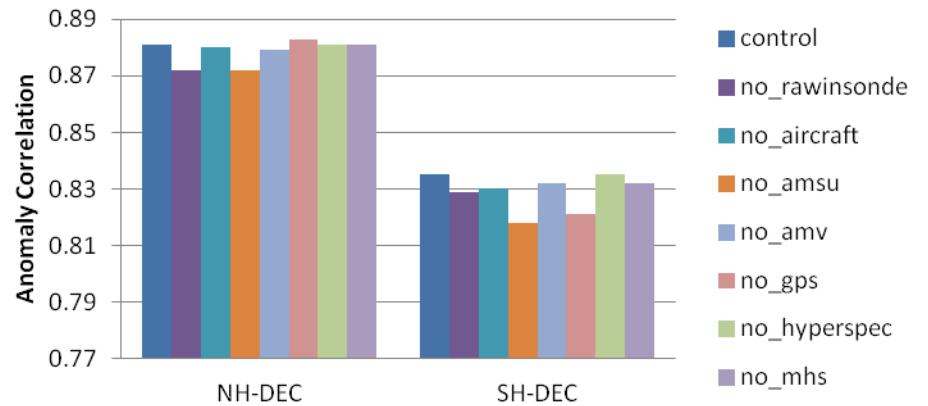


1000 hPa, Day 5, Instrument Average AC scores

**1000 hPa Day 5 AC Scores
15 Aug - 30 Sep 2010**



**1000 hPa Day 5 AC Scores
15 Dec 2010 - 31 Jan 2011**





Anomaly Correlation Conclusions

500 hPa Summary

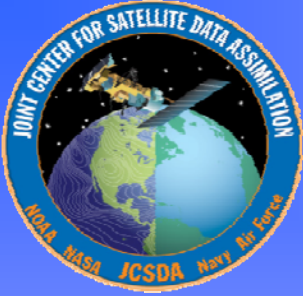
- No satellite and no conventional data experiments are similar to previous studies.
 - No Satellite has greatest impact, especially in Southern Hemisphere.
- Single instrument scores are much smaller than entire suite denial.
- Few instruments have statistically significant impact at day 5.
 - Satellite, Conventional, Rawinsonde, Aircraft (Aug-NH)
 - Satellite, Conventional, Rawinsonde, GPS-RO (Aug-SH)
 - Satellite, Conventional, Rawinsonde, AMSU-A (Dec-NH)
 - Satellite, Conventional, AMSU-A, GPS-RO (Dec-SH)



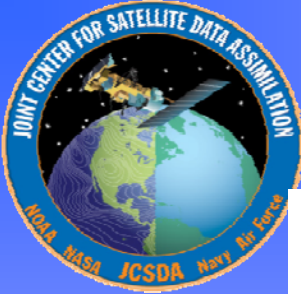
Anomaly Correlation Conclusions

1000 hPa Summary

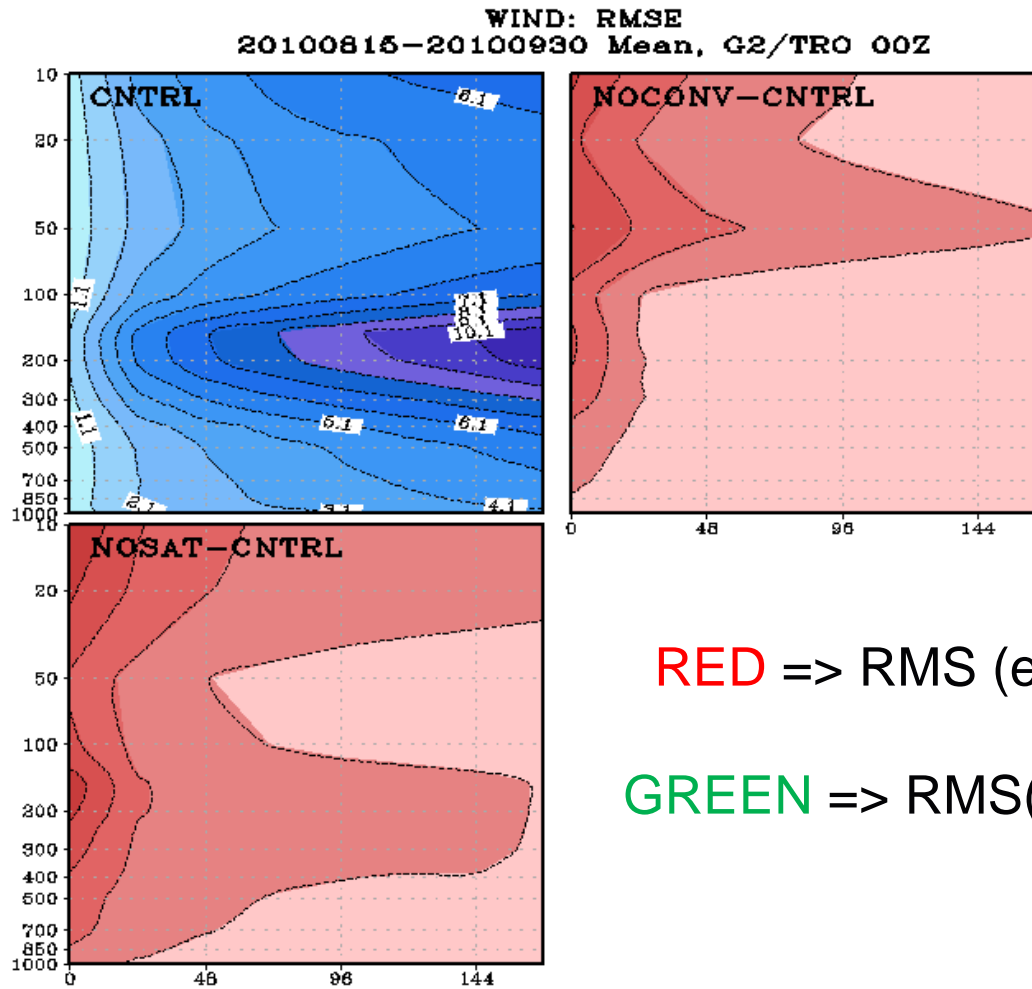
- In general, similar (but less) impact as at 500 hPa
- Single instrument scores are much smaller than entire suite denial.
- Less sensors have statistically significant impact at day 5.
 - Satellite, Conventional, Rawinsonde (Aug-NH)
 - Satellite, Conventional (Aug-SH)
 - Satellite, Conventional, Rawinsonde (Dec-NH)
 - Satellite, Conventional, Rawinsonde, AMSU-A (Dec-SH)



Tropical Vector Wind RMSE

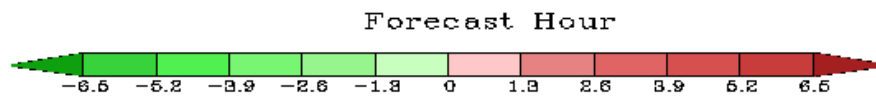


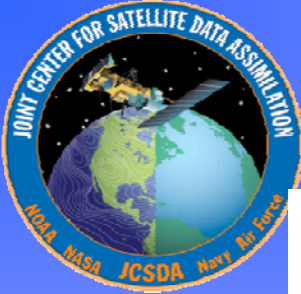
No Satellite / No Conventional Data 15 Aug – 30 Sep 2010



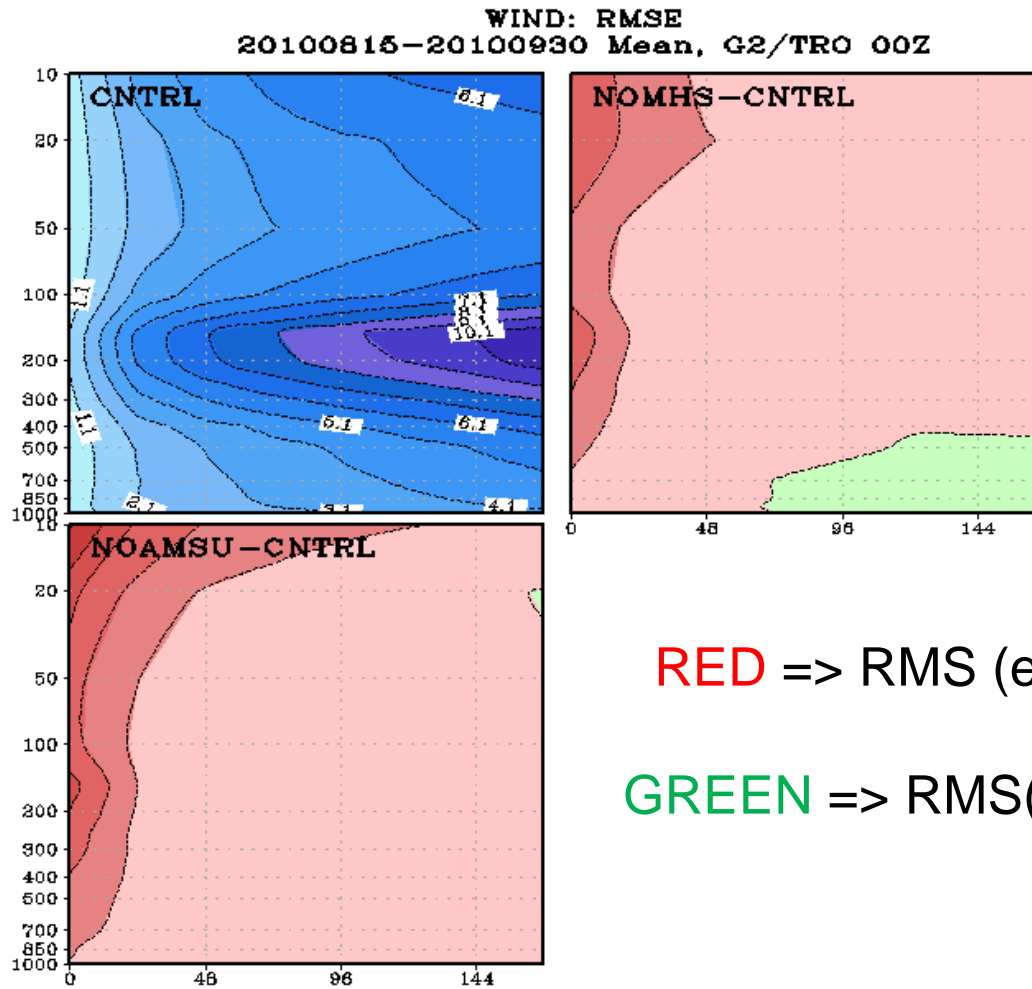
RED => $RMS(\text{exp}) > RMS(\text{control})$

GREEN => $RMS(\text{exp}) < RMS(\text{control})$



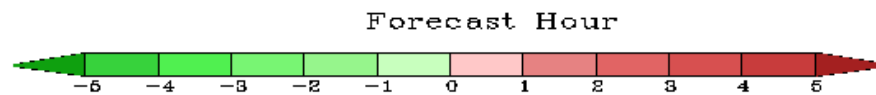


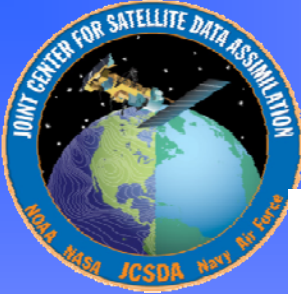
No AMSU-A / No MHS 15 Aug -30 Sep 2010



RED => $\text{RMS}(\text{exp}) > \text{RMS}(\text{control})$

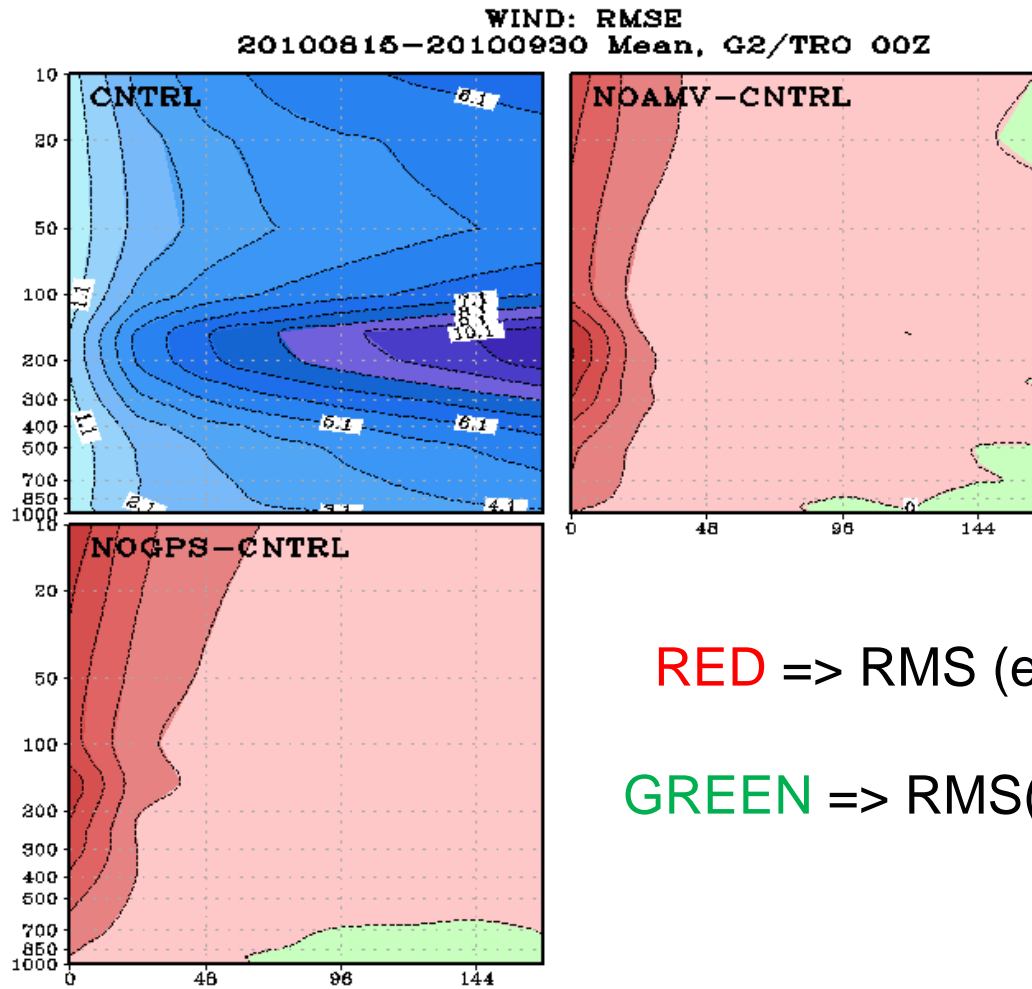
GREEN => $\text{RMS}(\text{exp}) < \text{RMS}(\text{control})$





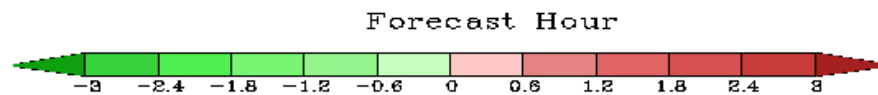
No GPS-RO / No AMV

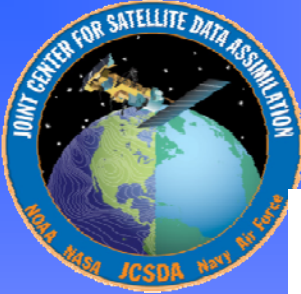
15 Aug -30 Sep 2010



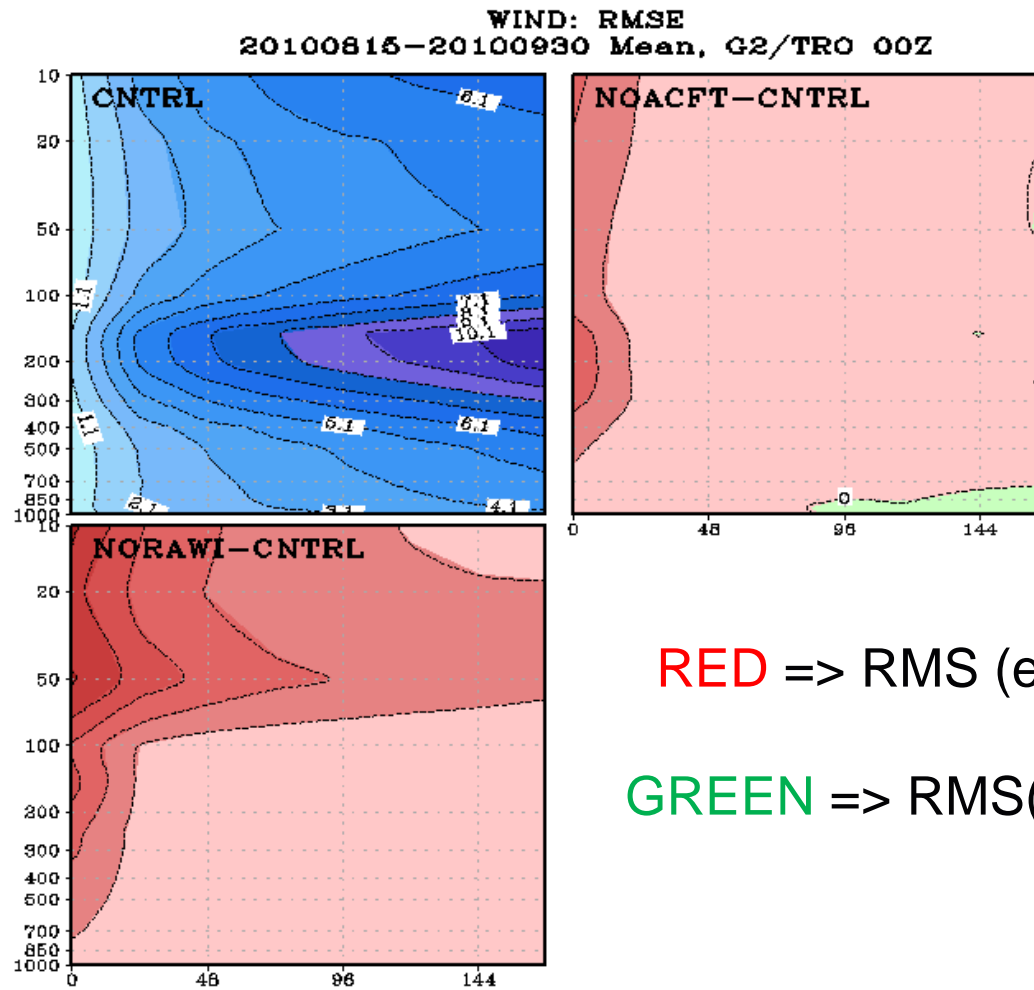
RED => $RMS(exp) > RMS(control)$

GREEN => $RMS(exp) < RMS(control)$



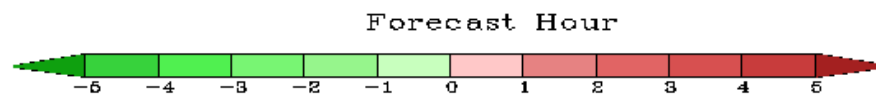


No Rawinsondes / No Aircraft 15 Aug -30 Sep 2010



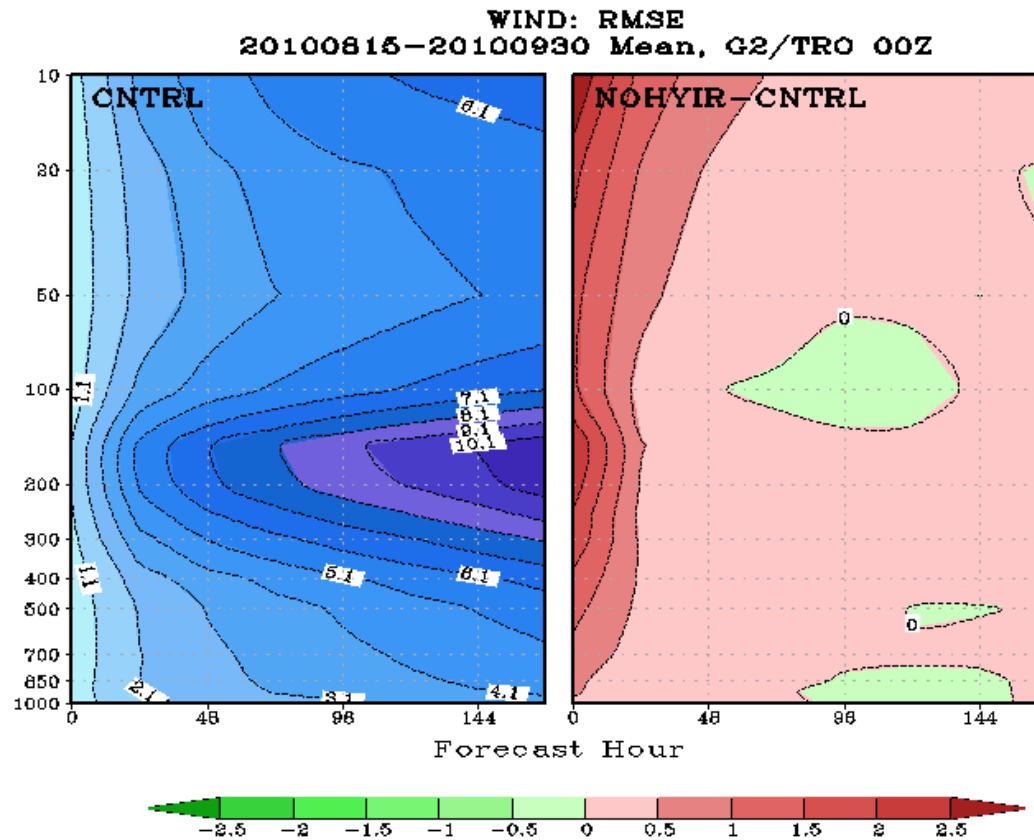
RED => RMS (exp) > RMS(control)

GREEN => RMS(exp) < RMS(control)





No Hyperspectral Infrared 15 Aug -30 Sep 2010



RED => $\text{RMS}(\text{exp}) > \text{RMS}(\text{control})$

GREEN => $\text{RMS}(\text{exp}) < \text{RMS}(\text{control})$



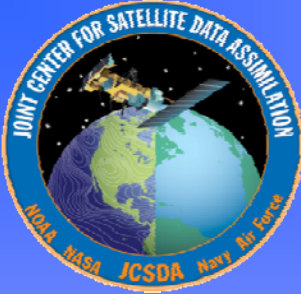
Tropical Wind Statistics Conclusions

- RED implies data has positive effect on tropical winds
- All data types have a positive impact on Vector Wind Statistics in the Tropics

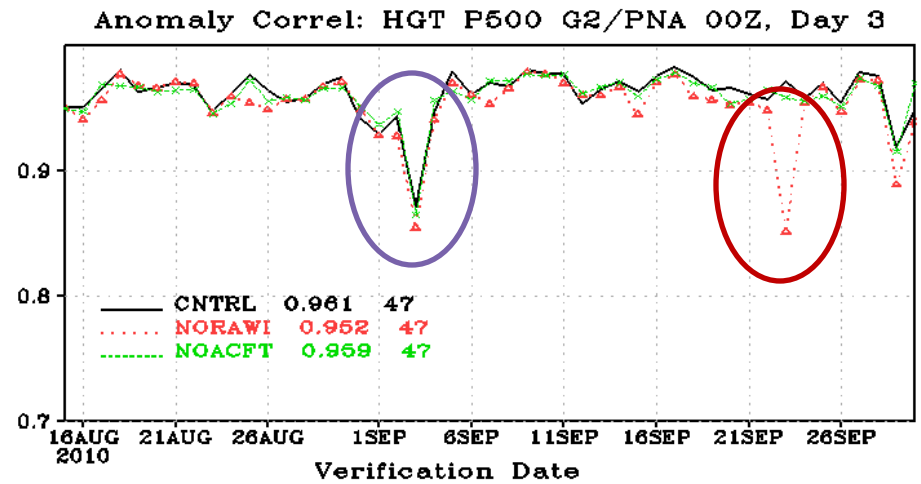
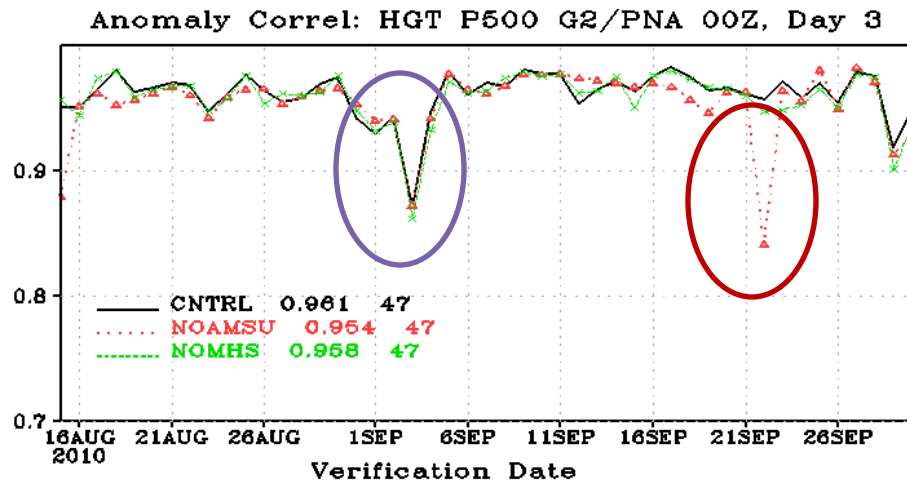
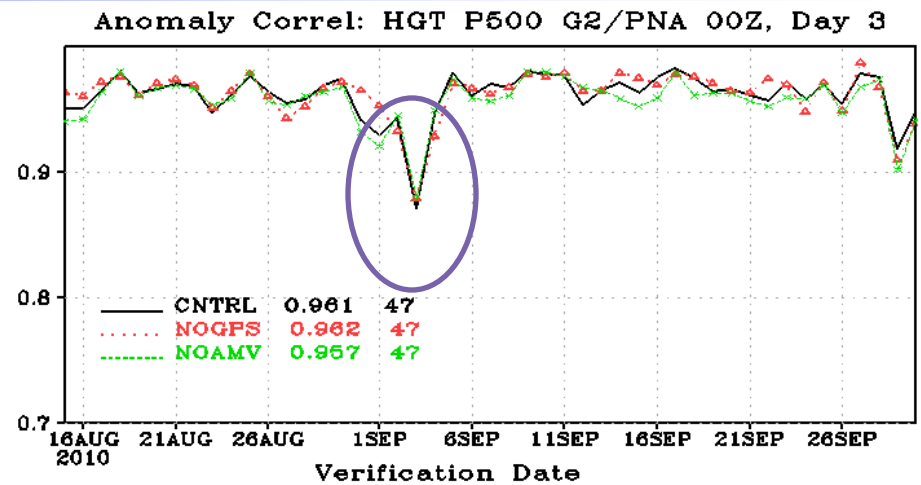
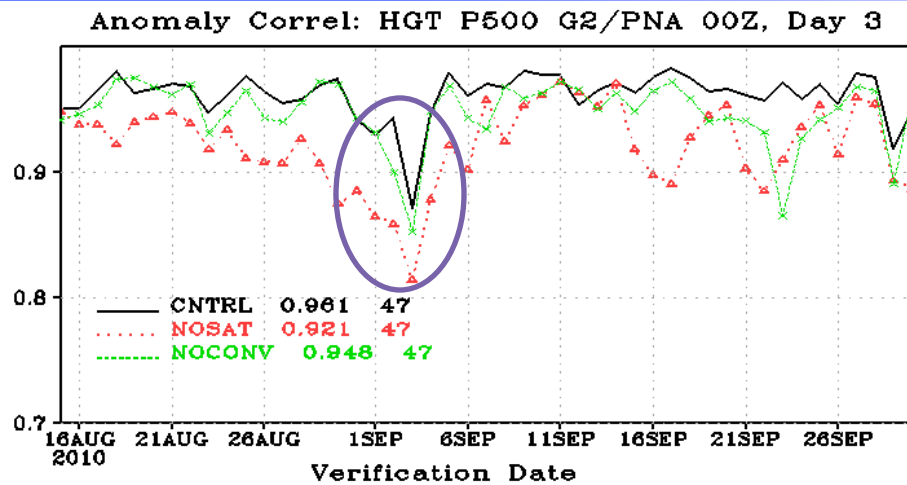


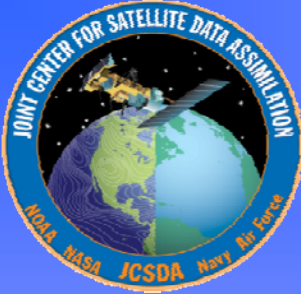
Time Series

Poor Forecast Performance



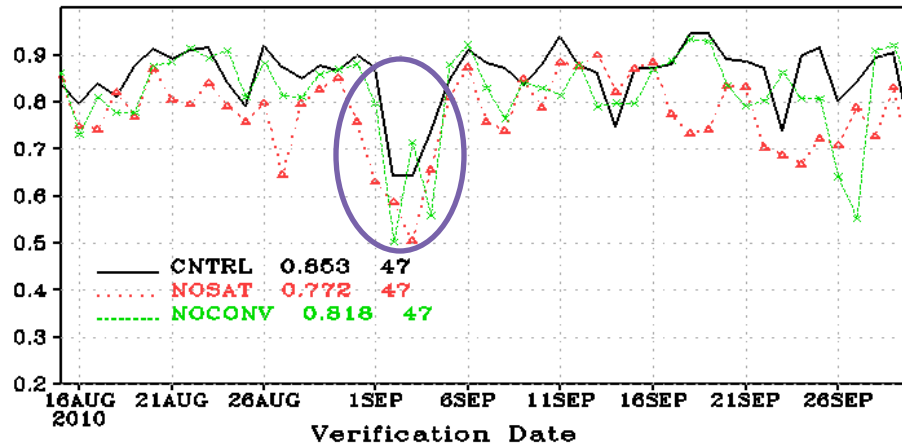
500 hPa Day 3 North America Time Series



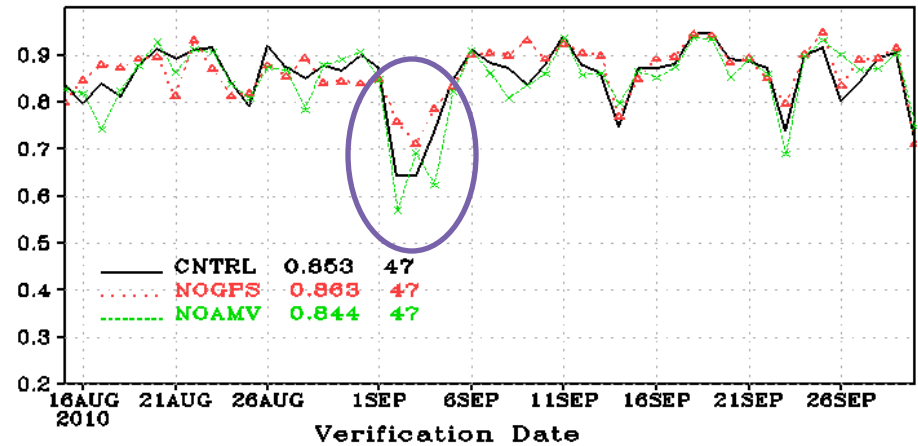


500 hPa Day 5 North America Time Series

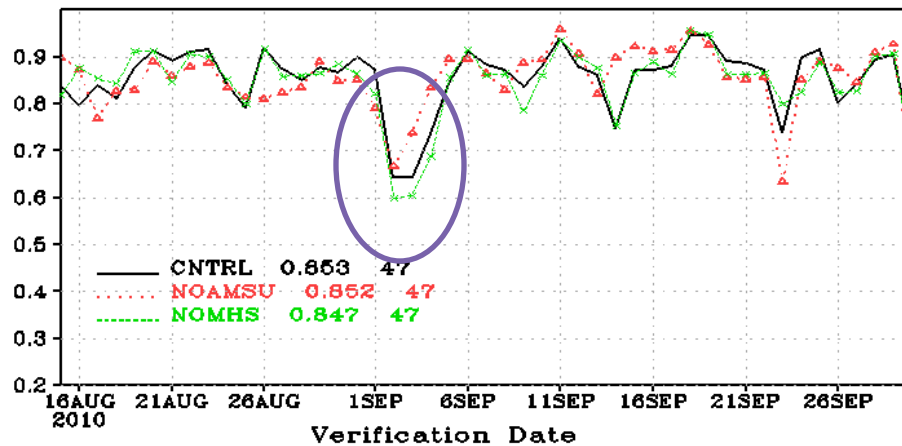
Anomaly Correl: HGT P500 G2/PNA 00Z, Day 5



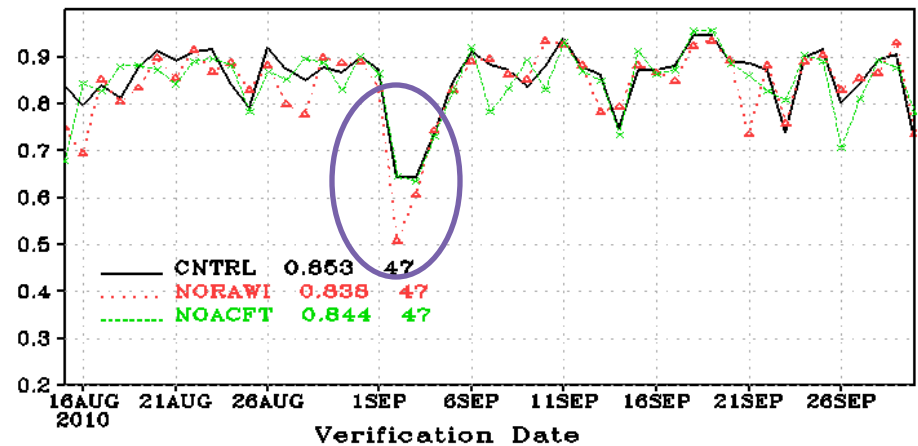
Anomaly Correl: HGT P500 G2/PNA 00Z, Day 5



Anomaly Correl: HGT P500 G2/PNA 00Z, Day 5



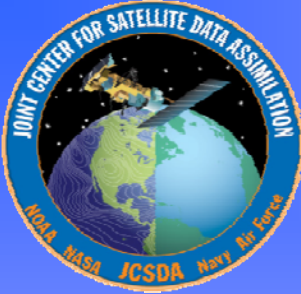
Anomaly Correl: HGT P500 G2/PNA 00Z, Day 5





Conclusions

- Poor forecast performance observed on 3 September 2010 for both day 3 and day 5 forecast over North America.
- No clear data type is responsible for this case.
- A missing data type can lead to poor forecast performance.



Forecast Impact Time Series



Forecast Impact Time Series

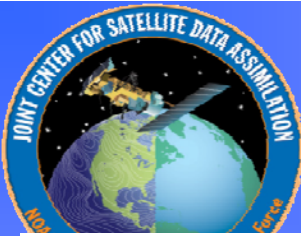
- Measures the difference of the RMSE growth in short term forecasts
- Uses late analysis with all data (best estimate of atmosphere)
- Area weighted
- Normalized by control
- August – September 2010



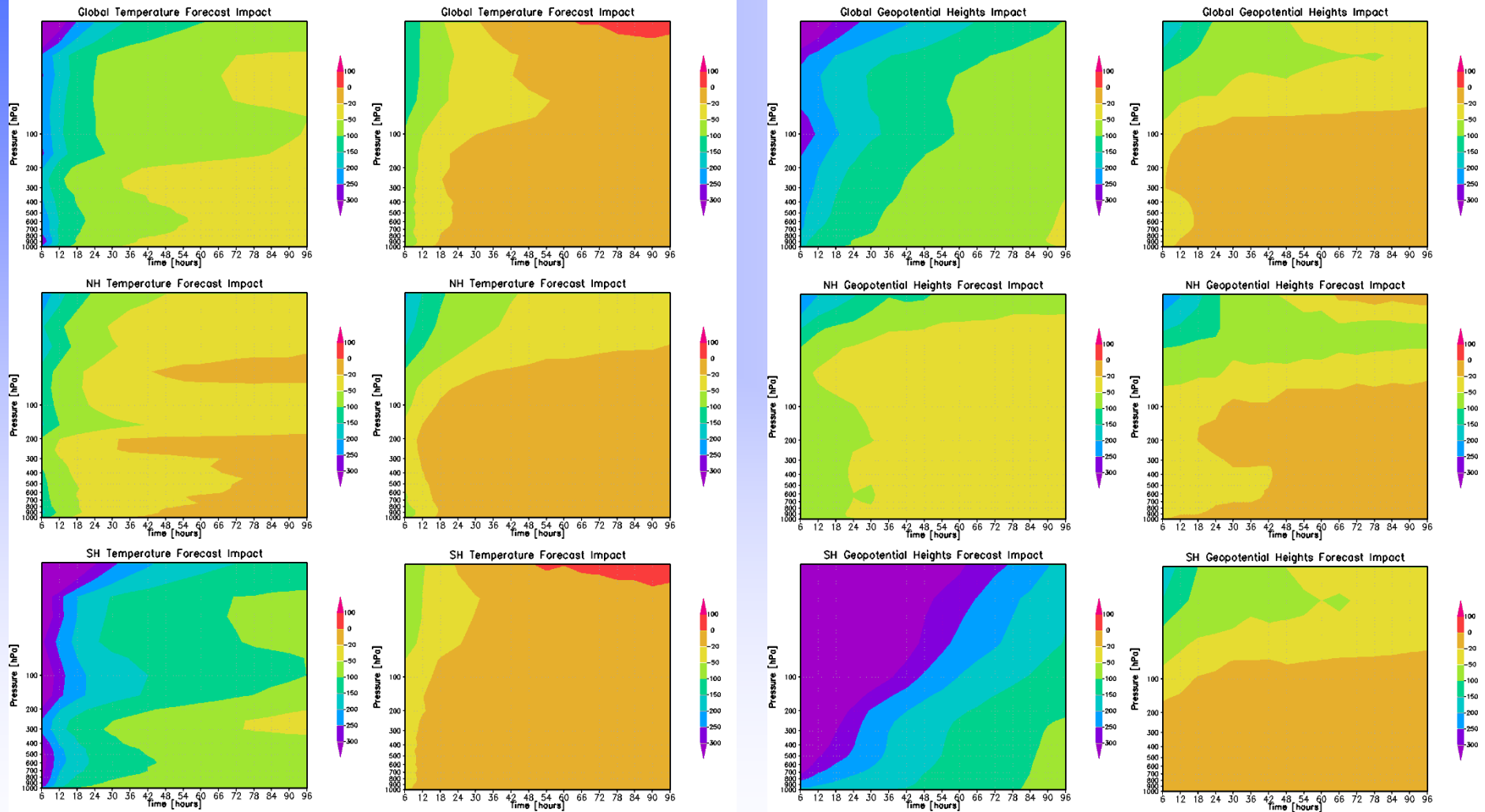
Forecast Impact

$$FI(x, y) = 100 \times \left\{ \left[\sqrt{\frac{\sum_{i=1}^N (C_i - A_i)^2}{N}} - \sqrt{\frac{\sum_{i=1}^N (E_i - A_i)^2}{N}} \right] / \sqrt{\frac{\sum_{i=1}^N (C_i - A_i)^2}{N}} \right\}$$

- Control “C” uses all data
- Experiment “E” denied specific data
- Control Analysis “A” the late analysis (GDAS) with all the data



Forecast Impact Time Series Temperature / Geopotential Heights



No Satellite

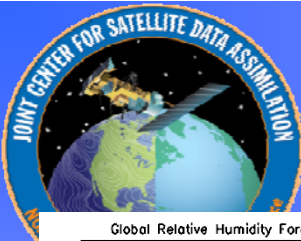
No Conventional

No Satellite

No Conventional

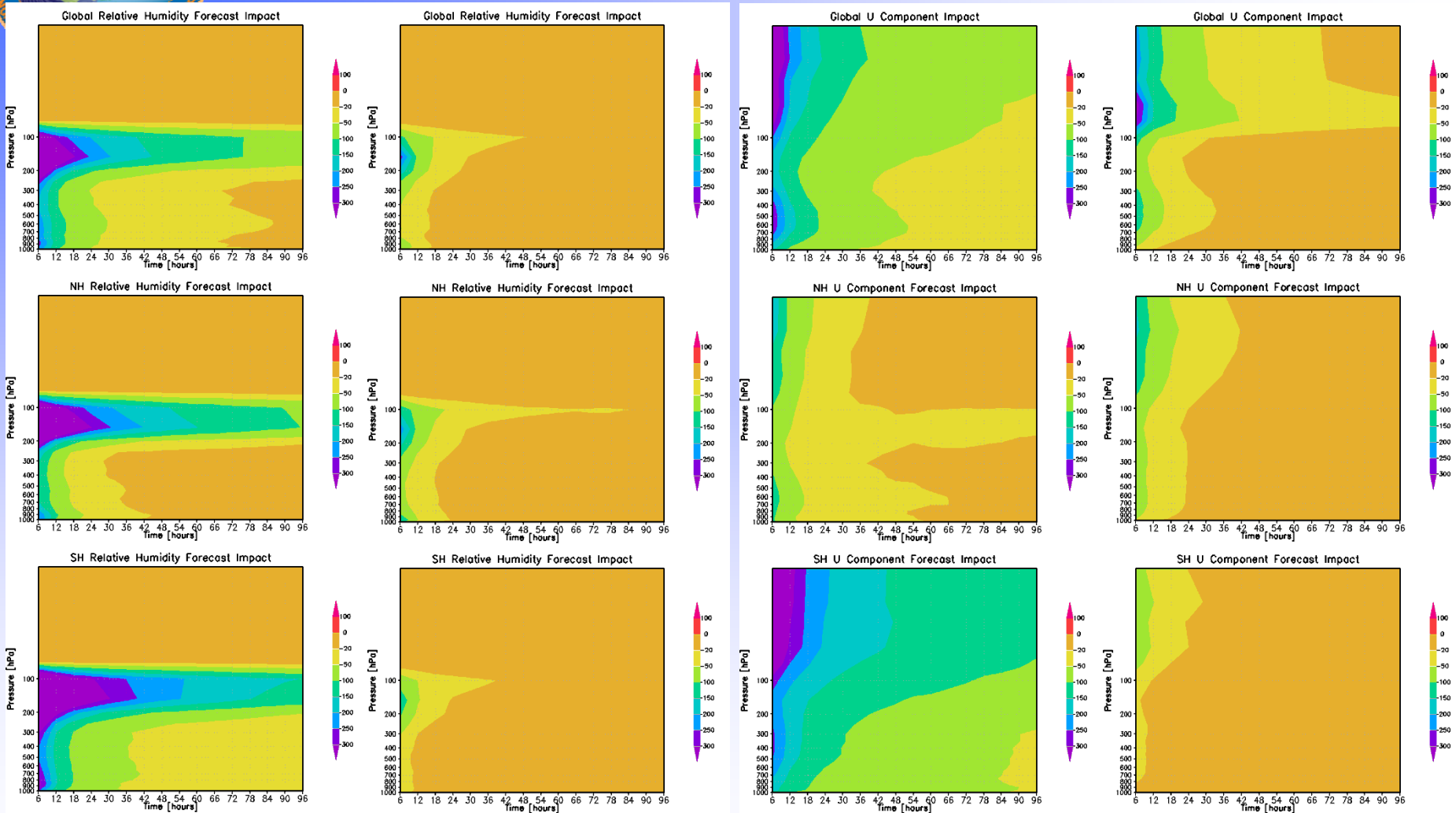
5th WMO Observing Systems Impact
Workshop





Forecast Impact Time Series

Relative Humidity / U Component



No Satellite

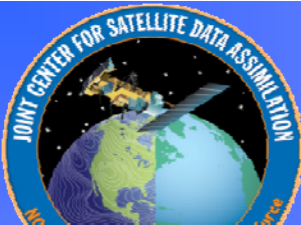
No Conventional

No Satellite

No Conventional

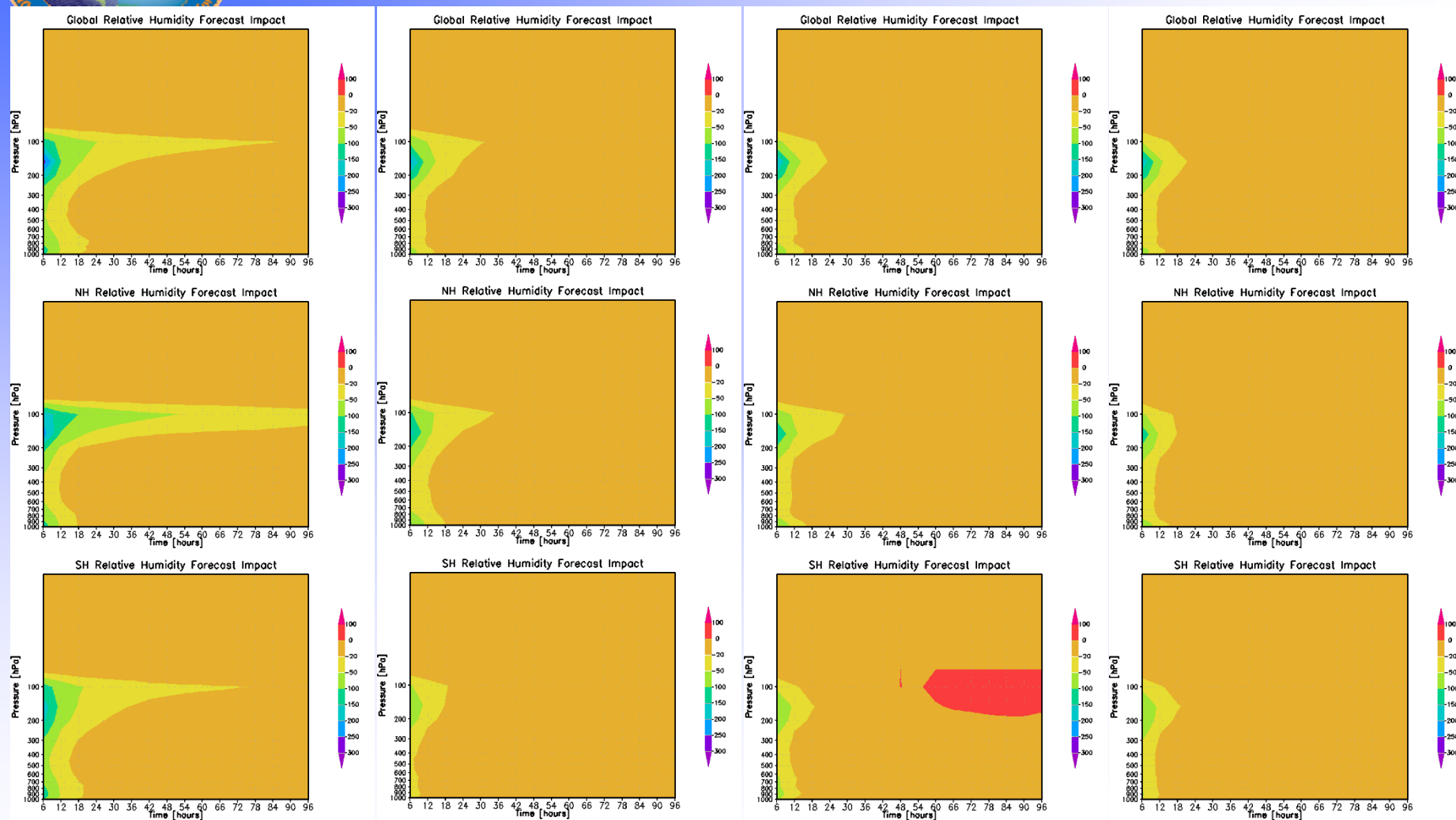
5th WMO Observing Systems Impact
Workshop





Component Forecast Impact Time Series

Relative Humidity



No AMSU

No Rawinsonde

No MHS

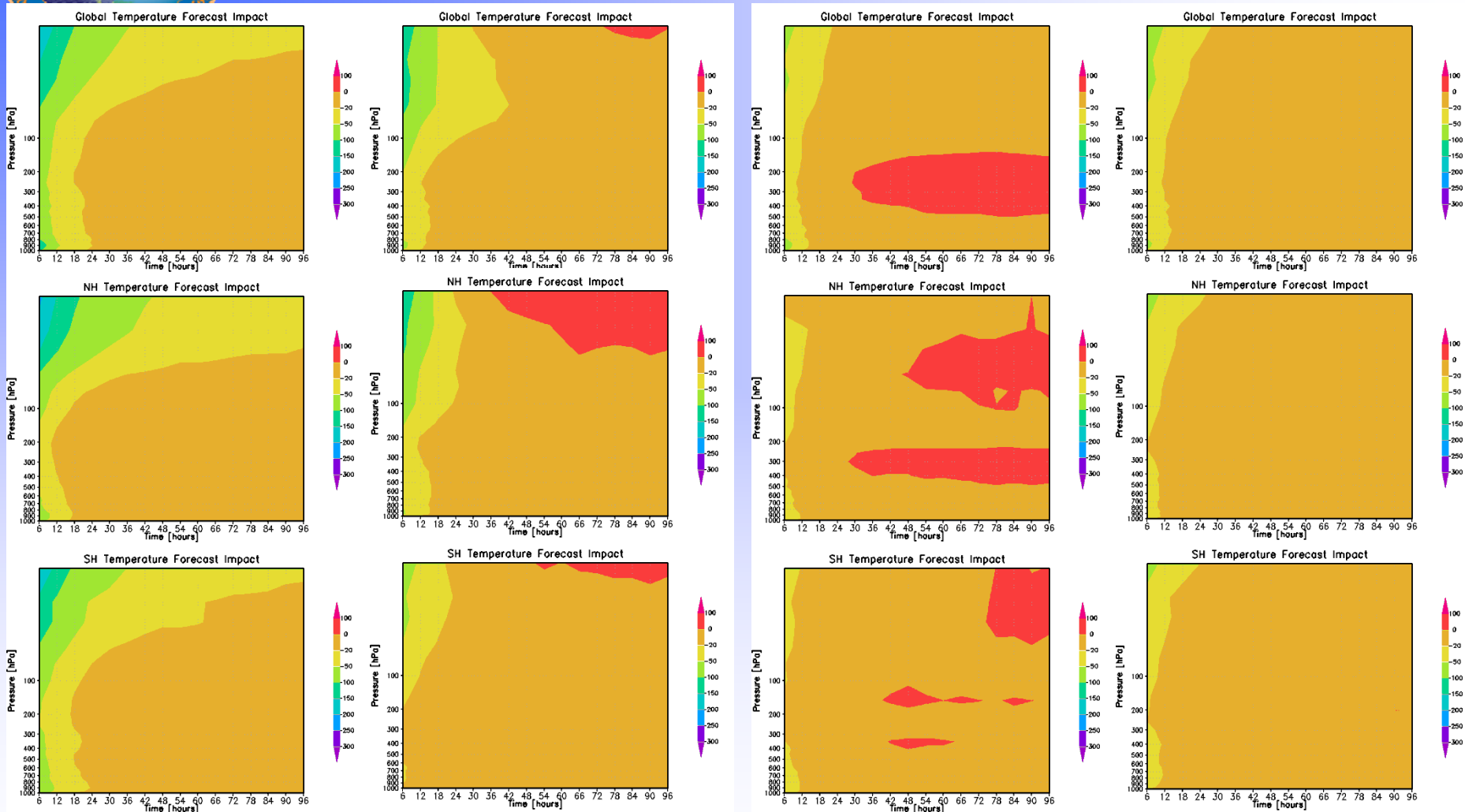
No Hyperspectral

5th WMO Observing Systems Impact
Workshop





Component Forecast Impact Time Series Temperature



No AMSU

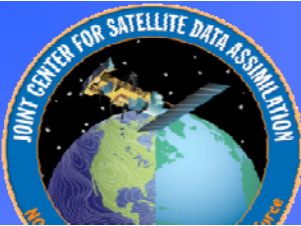
No Rawinsonde

No MHS

No Hyperspectral

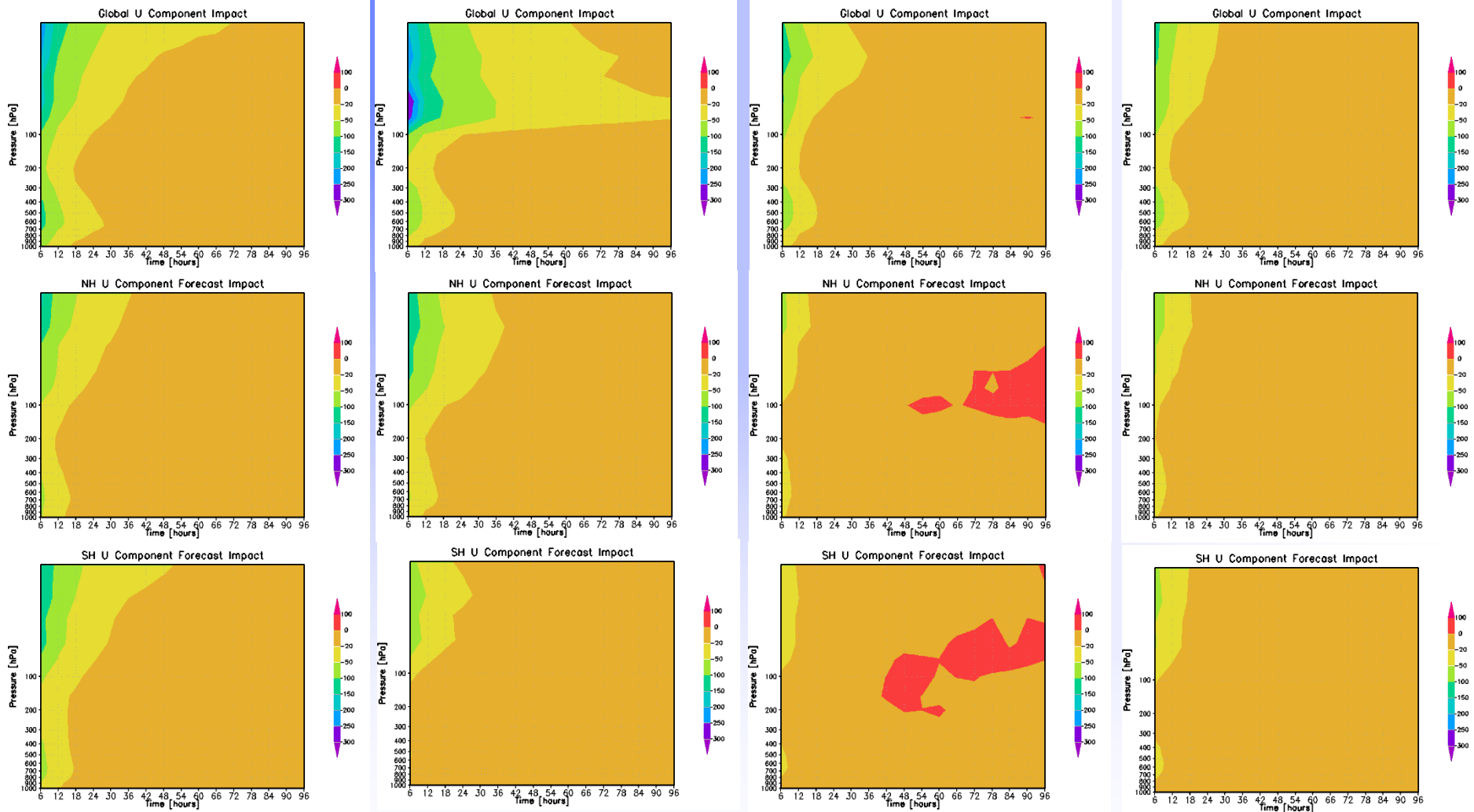
5th WMO Observing Systems Impact
Workshop





Component Forecast Impact Time Series

U Component



No AMSU

No Rawinsonde

No MHS

No Hyperspectral

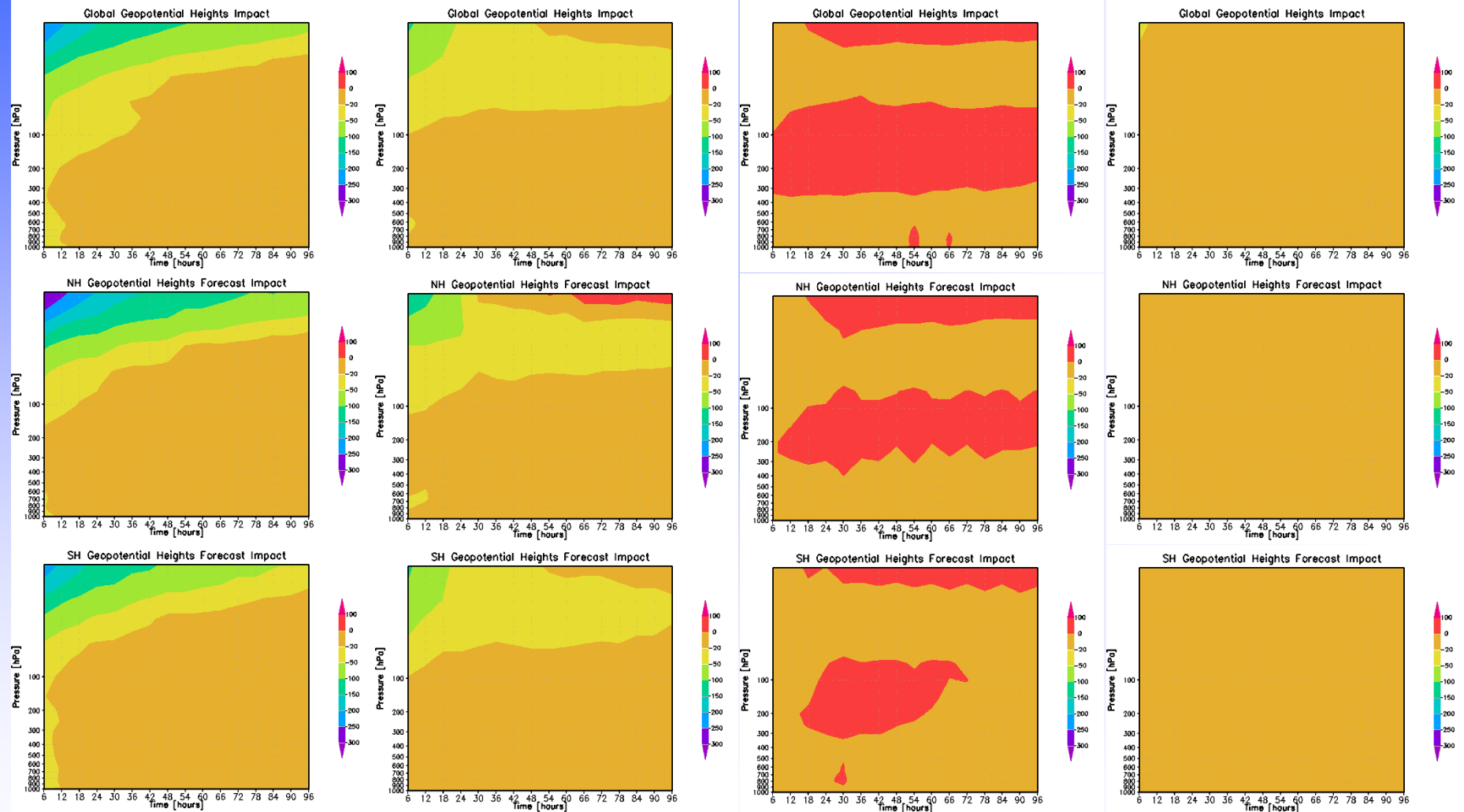
5th WMO Observing Systems Impact
Workshop





Component Forecast Impact Time Series

Geopotential Heights



No AMSU

No Rawinsonde

No MHS

No Hyperspectral

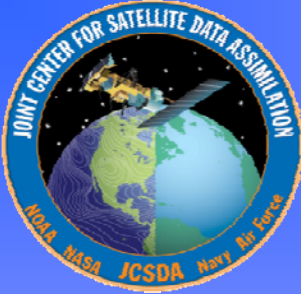
5th WMO Observing Systems Impact
Workshop





Conclusions

- Satellite data dominates short term RMS statistics.
- Again, single instruments are not equal to entire suite.
- Upper tropospheric relative humidity signal is not from a specific humidity instrument.
 - Probably from AMSU via improved temperature

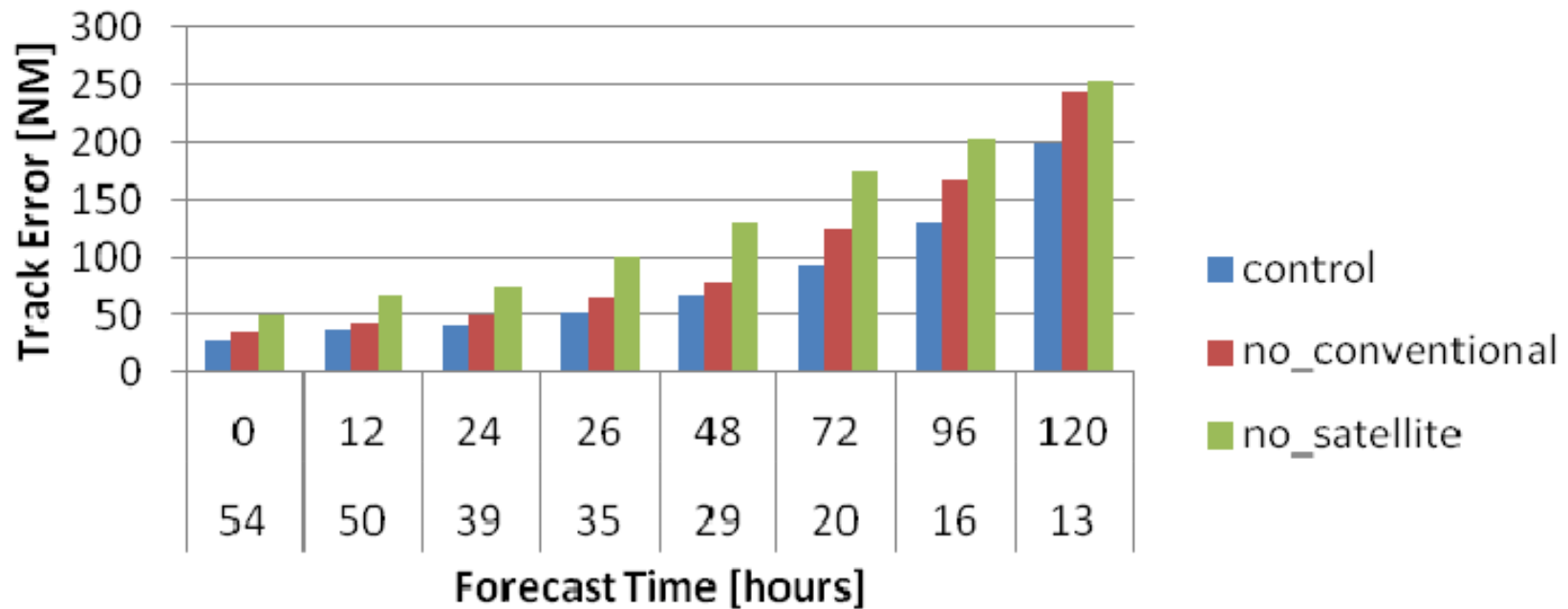


Hurricane Statistics



Hurricane Statistics

Atlantic Basin Hurricane Track Mean Errors



* NOT SIGNIFICANT

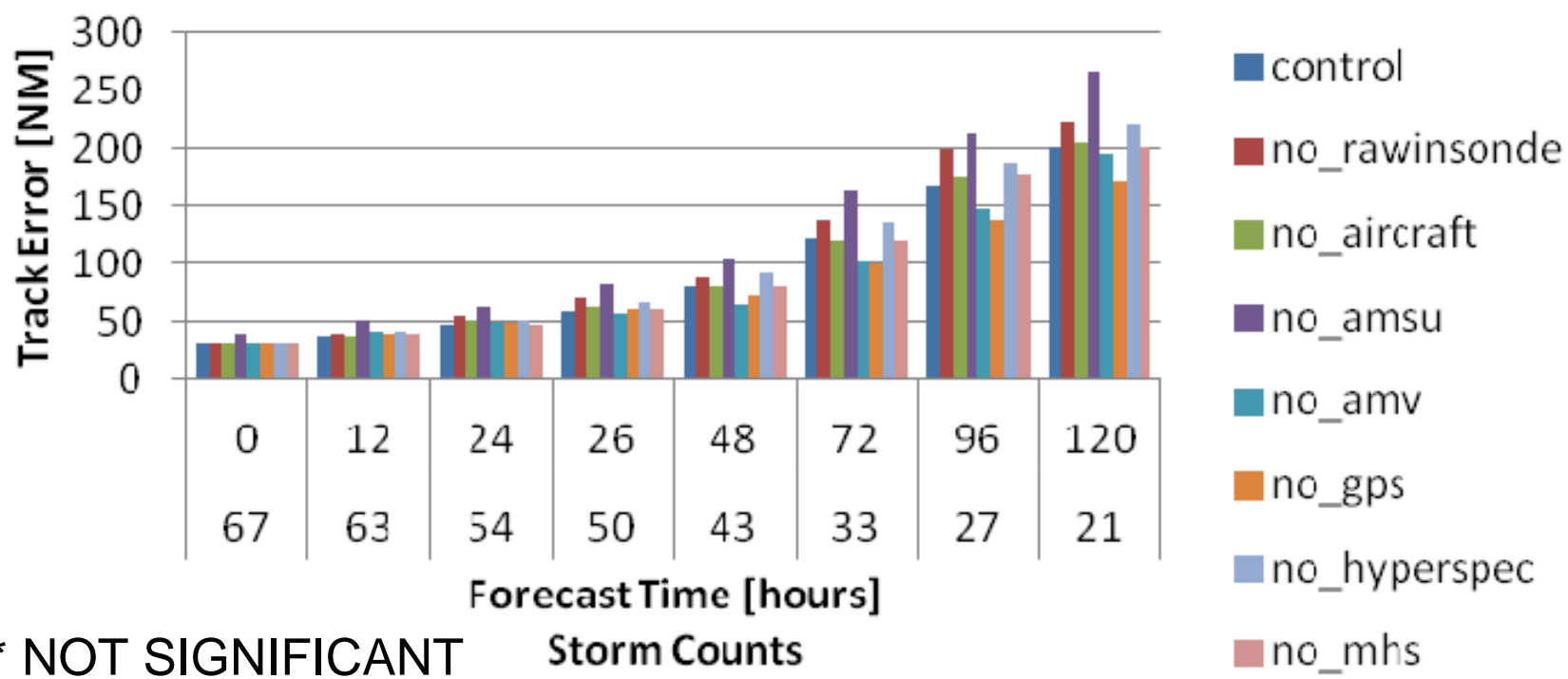
Storm Counts





Hurricane Statistics

Atlantic Basin Hurricane Track Mean Errors





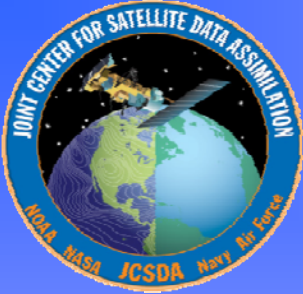
Conclusions

- Only one hurricane season.
 - Atlantic Basin
- Statistics do not pass significance tests.
- Both satellite and conventional data increase track errors.
- Rawinsondes (dropsondes) and AMSU-A seem to have the greatest individual impact on track forecasts.



Summary

- NCEP operations version of the GDAS (May 2011) at the operational resolution (T574L64) was used
- Experiments conducted on a different computing system
- No Satellite / No Conventional data statistics similar to previous studies.
- Impact from individual sensors is less than expected
 - less sensors make significant changes to the anomaly correlation scores.
- Most instrument types have a positive impact on tropical winds
 - Conventional data, AMSU, AMV, GPS-RO, Aircraft, Rawinsondes



Summary

- No clear data type is responsible for the poor forecast performance on 3 Sept 2010.
- A missing data type can lead to poor forecast performance.
- Forecast Impact also shows individual instruments have less impact than expected.
- Upper tropospheric relative humidity forecast impact seems to be from more than just moisture sensors.
- Rawinsondes and AMSU-A have the greatest individual impact on Atlantic Basin Hurricane statistics (qualitative).

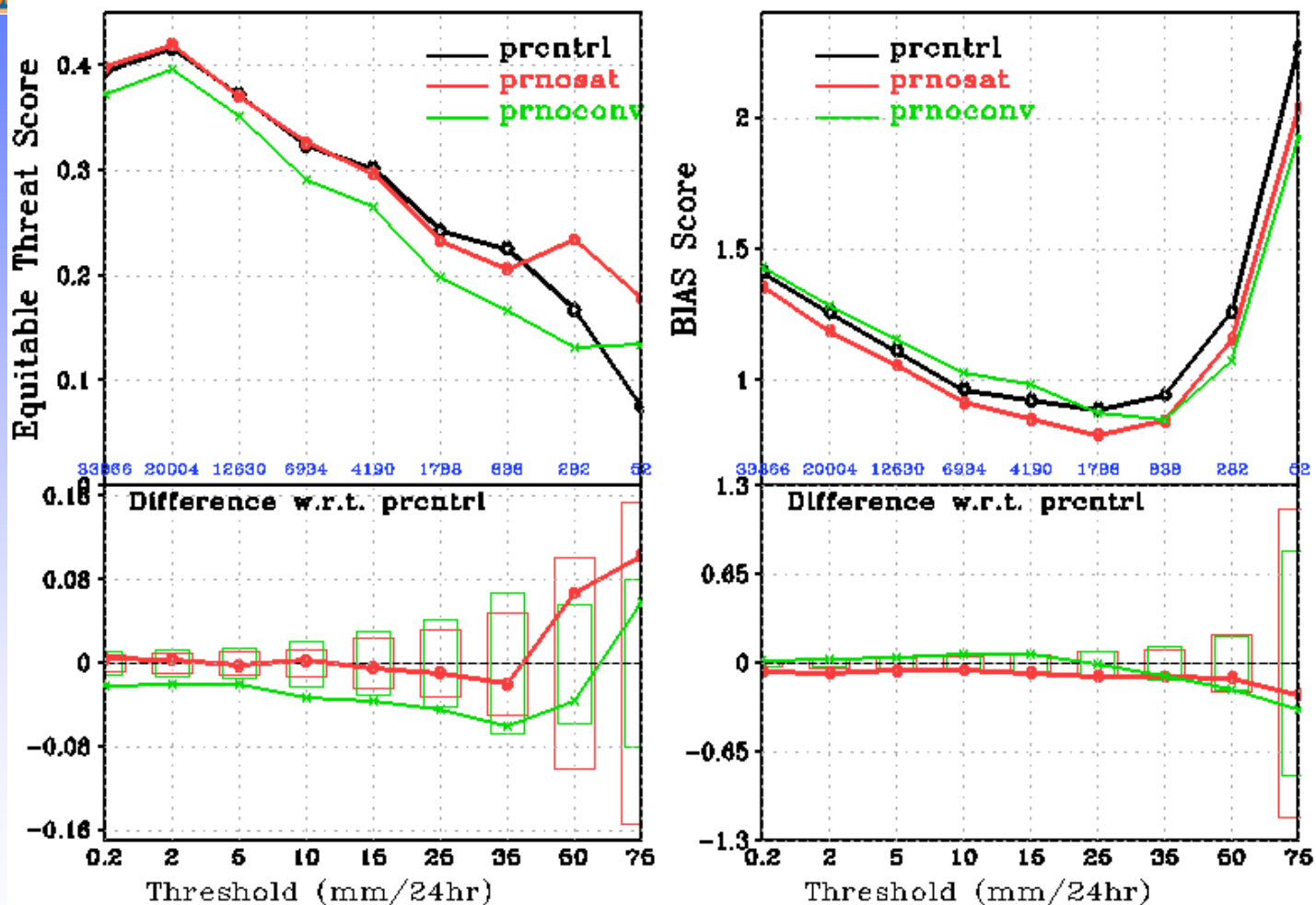


Precipitation Statistics



Precipitation Statistics

CONUS Precip Skill Scores, f12-f36, 15aug2010-30sep2010



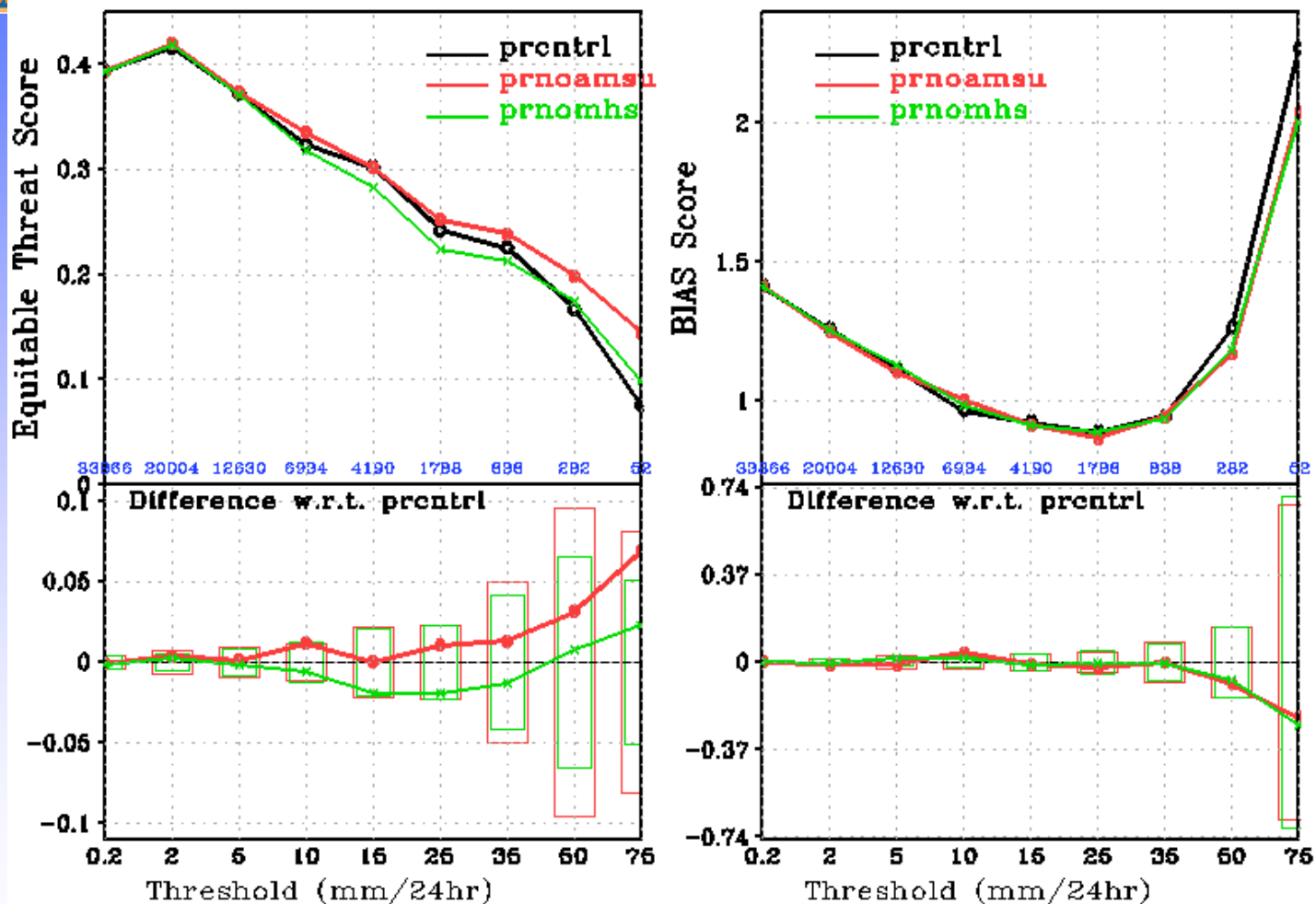
Differences outside of the hollow bars are 95% significant based on 10000 Monte Carlo Tests





Precipitation Statistics

CONUS Precip Skill Scores, f12-f36, 15aug2010-30sep2010



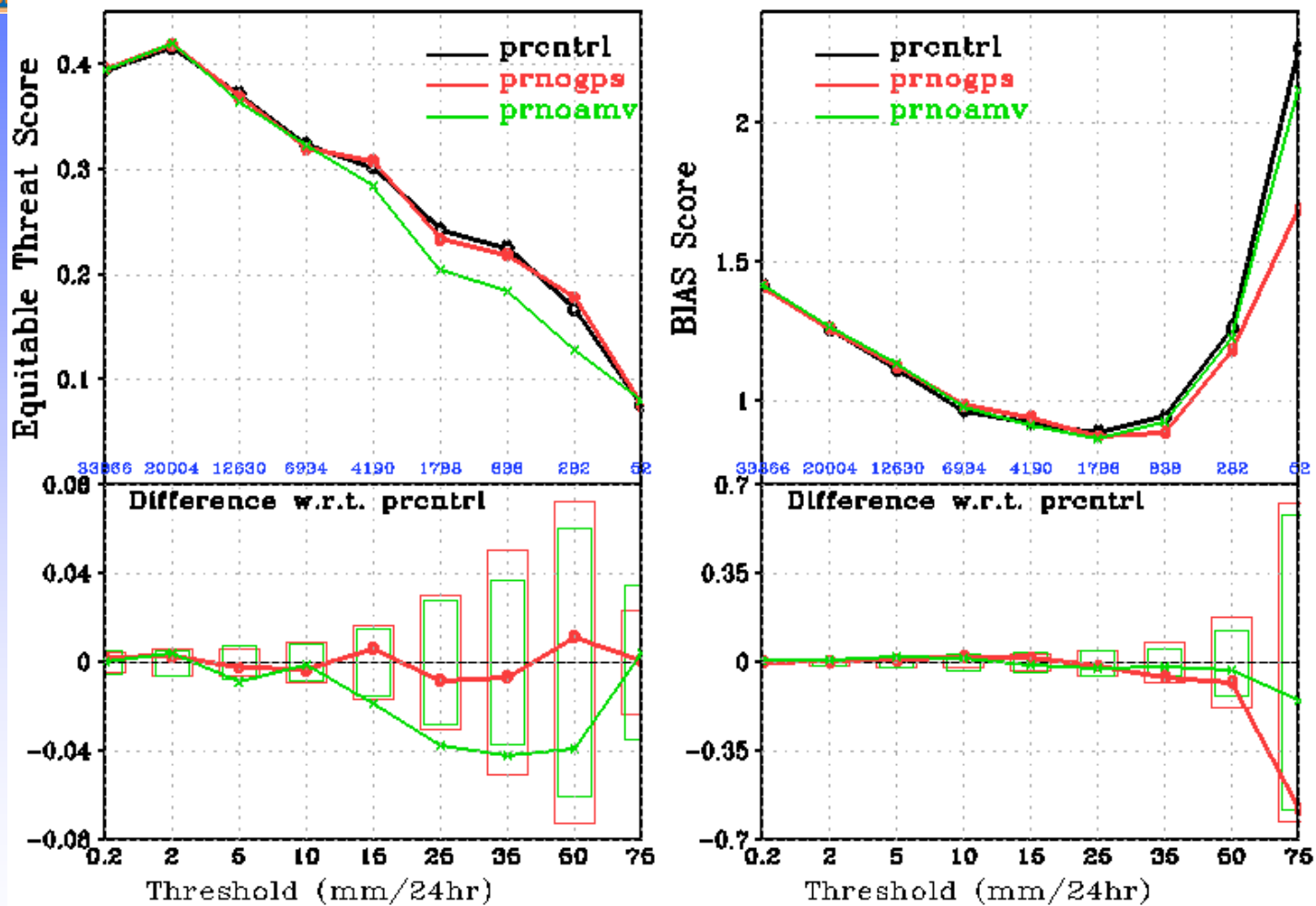
Differences outside of the hollow bars are 95% significant based on 10000 Monte Carlo Tests





Precipitation Statistics

CONUS Precip Skill Scores, f12-f36, 15aug2010-30sep2010



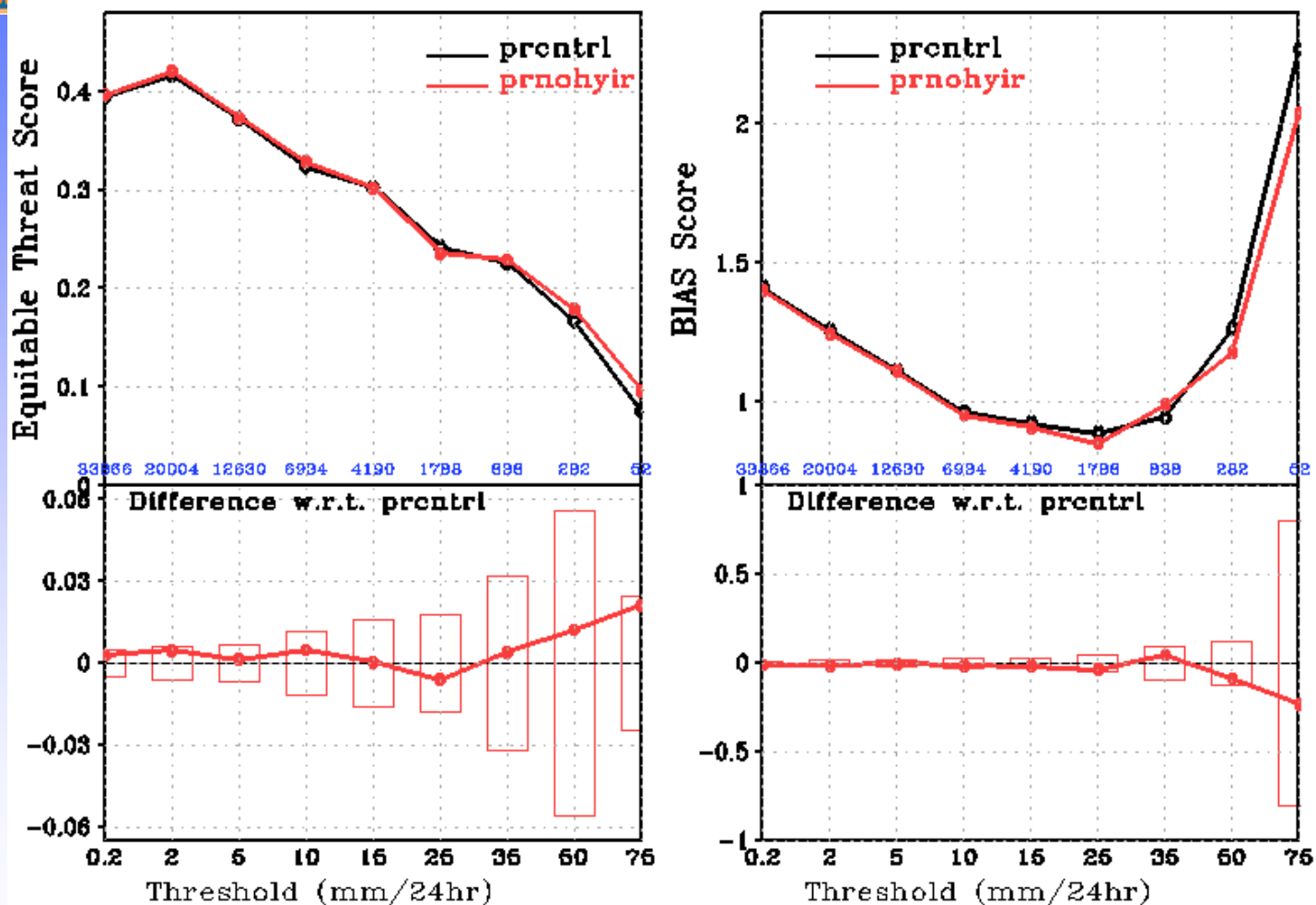
Differences outside of the hollow bars are 95% significant based on 10000 Monte Carlo Tests





Precipitation Statistics

CONUS Precip Skill Scores, f12-f36, 15aug2010-30sep2010



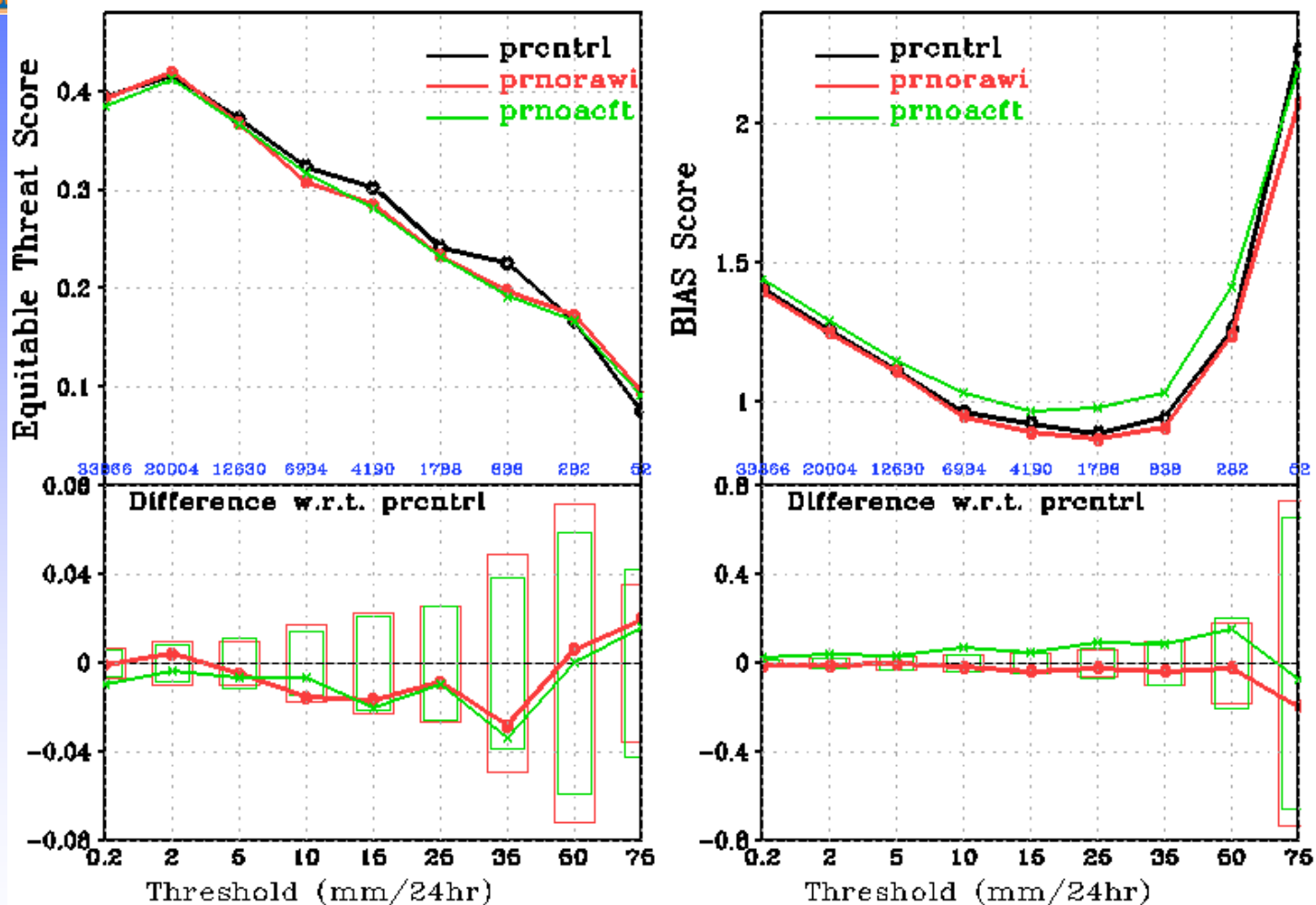
Differences outside of the hollow bars are 95% significant based on 10000 Monte Carlo Tests





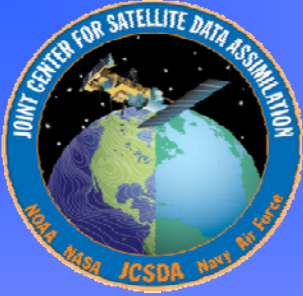
Precipitation Statistics

CONUS Precip Skill Scores, f12-f36, 15aug2010-30sep2010



Differences outside of the hollow bars are 95% significant based on 10000 Monte Carlo Tests





Summary

- Precipitation threat scores are for CONUS only.
- Conventional data has greatest impact on short term precipitation threat scores.
 - Rawinsondes & Aircraft
- AMVs and MHS also show short term impacts
- No consistent signal in longer term scores or the Dec-Jan season.