Observing System Experiments Using the NCEP Global Data Assimilation System

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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

Northern Hemisphere

Southern Hemisphere

AC differences outside of outline bars are significant at the 95% confidence level.
500 hPa Anomaly Correlations
15 Aug – 30 Sep 2010
No AMSU-A / No MHS

Northern Hemisphere

Southern Hemisphere

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500 hPa Anomaly Correlations
15 Aug – 30 Sep 2010

No GPS-RO / No AMV

Northern Hemisphere

Southern Hemisphere

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500 hPa Anomaly Correlations
15 Aug – 30 Sep 2010

No Rawinsondes / No Aircraft

Northern Hemisphere

Southern Hemisphere

AC differences outside of outline bars are significant at the 95% confidence level

Forecast Hour

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500 hPa Anomaly Correlations
15 Aug – 30 Sep 2010

No Hyperspectral Infrared

Northern Hemisphere

Southern Hemisphere

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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

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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

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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 (exp) > RMS(control)
GREEN => RMS(exp) < RMS(control)
No AMSU-A / No MHS
15 Aug - 30 Sep 2010

RED => RMS (exp) > RMS(control)
GREEN => RMS(exp) < RMS(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 $\Rightarrow$ RMS (exp) $>$ RMS (control)
GREEN $\Rightarrow$ RMS (exp) $<$ RMS (control)
No Hyperspectral Infrared
15 Aug - 30 Sep 2010

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

GREEN => RMS (exp) < RMS (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 5 North America Time Series

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

Verification Date

16 AUG 21 AUG 26 AUG 1 SEP 6 SEP 11 SEP 16 SEP 21 SEP 26 SEP 2010

CNTRL 0.663 47
NOGAPS 0.883 47
NOCONV 0.516 47

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

Verification Date

16 AUG 21 AUG 26 AUG 1 SEP 6 SEP 11 SEP 16 SEP 21 SEP 26 SEP 2010

CNTRL 0.553 47
NOGAPS 0.883 47
NOAMV 0.544 47

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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

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

- 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
Forecast Impact Time Series
Relative Humidity / U Component

No Satellite  No Conventional  No Satellite  No Conventional

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Component Forecast Impact Time Series Temperature

- No AMSU
- No Rawinsonde
- No MHS
- No Hyperspectral

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Component Forecast Impact Time Series
U Component

No AMSU
No Rawinsonde
No MHS
No Hyperspectral

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Component Forecast Impact Time Series
Geopotential Heights

No AMSU  No Rawinsonde  No MHS  No Hyperspectral

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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

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Hurricane Statistics

Atlantic Basin Hurricane Track Mean Errors

* NOT SIGNIFICANT

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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

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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

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Precipitation Statistics

CONUS Precip Skill Scores, 15aug2010–30sep2010

Equitable Threat Score

BLAS Score

Difference w.r.t. prontrol

Threshold (mm/24hr)

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

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Precipitation Statistics

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

Equitable Threat Score

proctrl

prnhyr

Difference w.r.t. proctrl

Threshold (mm/24hr)

0.00

0.01

0.02

0.03

0.04

0.05

0.06

0.2

2

4

6

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76

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

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Precipitation Statistics

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

Equitable Threat Score

BLAS Score

Threshold (mm/24hr)

Difference w.r.t. prontrl

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

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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.