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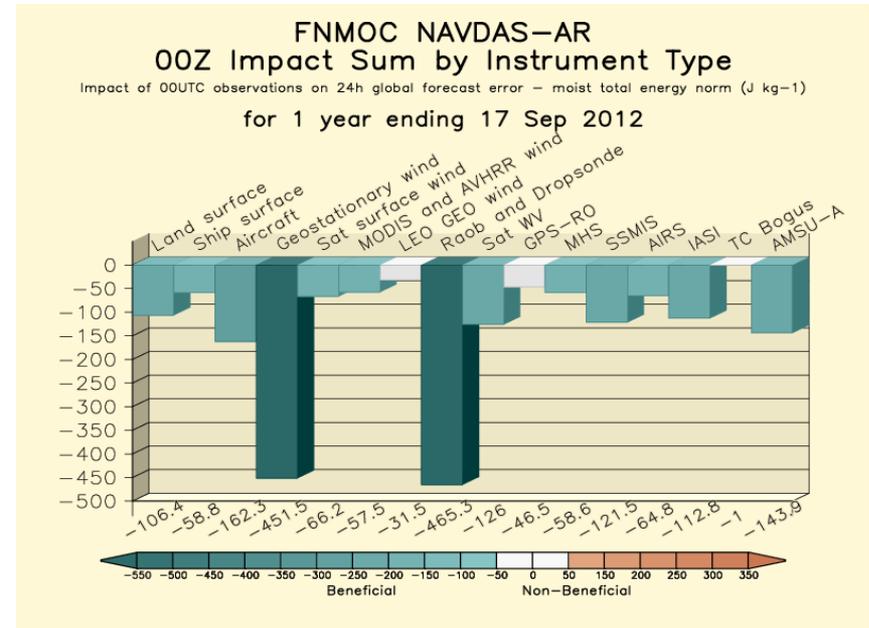
# **Optimization of the usage of AMV data within the GSI - Interaction with NRL**

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# Optimize the exploitation of AMVs and forecast impact from AMVs in the NOAA global forecast/analysis system

- Leverage past experiments performed by NRL and GMAO exploring the differential impact of these data.
- Compare difference between NCEP and NAVY (NRL) impact of AMVs on data assimilation systems.
  - Data volume differences
  - Observation error
  - Filtering (thinning versus superobbing/averaging)
  - Blacklisting/QC of data types assimilated
- Sensors
  - Polar : MODIS, AVHRR, VIIRS, etc.
  - GEO : EUMETSAT METEOSAT-7,10, JMA MTSAT-2, GOES 13, 15
- Improved AMV assimilation is essential for JPSS Data Gap Mitigation due to potential decrease in assimilated afternoon radiances.



**NRL assimilates 4x as many winds**

Observation Counts per 6h (K)

	Satwind	MSU-A	Hyps IR	AllObs	
GMAO	90	520	1220	2500	GMAO: 1.5x Radiances
FNMOC	350	350	800	2200	FNMOC: 4x Winds

Approximate average values for the year ending 15 May 2012

Figures courtesy of JCSDA data assimilation workshop (R. Gelaro)

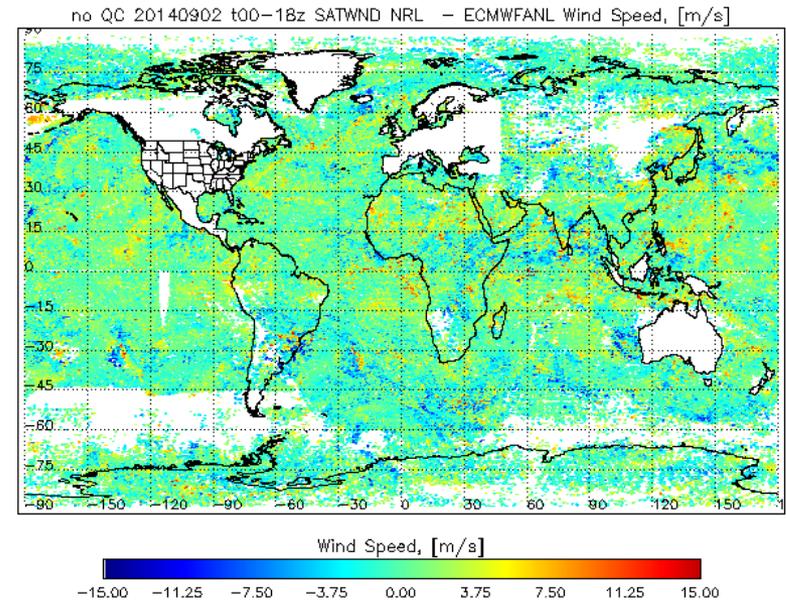
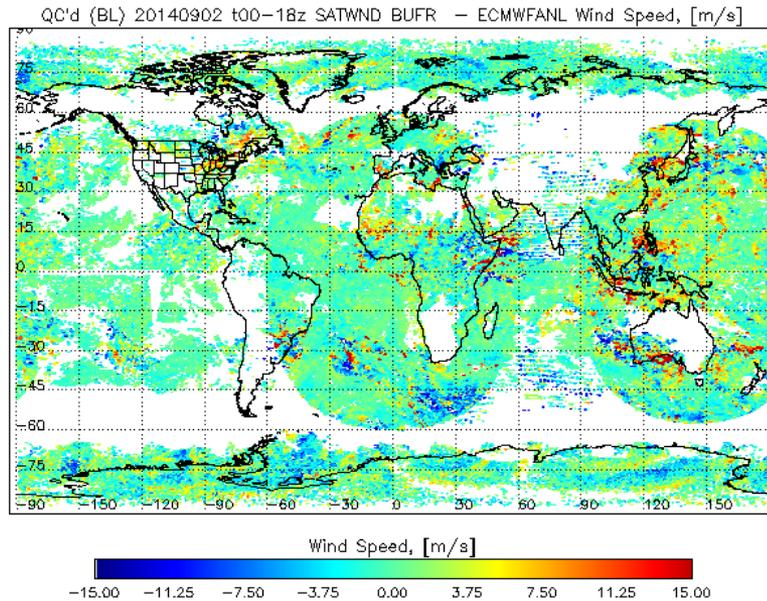
JCSDA satellite winds working group established between partnering agencies (NESDIS/JCSDA, NCEP/EMC, NAVY/NRL, NASA/GMAO, U.Wisc/CIMMS) to leverage earlier work and to improve AMV assimilation across the board.

# Overview

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- Comparison of current operational GDAS SATWND BUFR data to NRL super-obs for 1 day of data (other days are similar)
- Catalog of NRL AMV “flavors” – more than Baskin Robbins.
- Comparison of O-B/O-A statistics of GDAS SATWND BUFR and NRL super-obs
- Preliminary assessment of forecast/analysis impacts in an operations parallel environment with NCEP’s GDAS and GFS.
  - FY15 3D EnsVar GSI (T670/T254).

# GDAS SATWND BUFR and NRL super-obs (20140902) wind speed versus collocated ECMWF analysis



- QC is applied to SATWND BUFR (no thinning or gross check), QC on NRL is based on NRL system QC.
- Generally speaking, NRL observations :
  - have much better spatial coverage – redundancy?
  - smaller outliers – smoother wind speed difference
    1. Super-ob average should reduce random noise
    2. NRL has also applied a gross check to super-ob innovations in their system.

# NRL AMV “flavors”

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- Cataloging of NRL AMVs are based on character string tags in their assimilation “innovation” files.
- Sources of data and satellites include
  - JMA – MTSAT-2
  - EUMETSAT – METEOSAT 7, 10, 8
  - NESDIS – GOES 13, 15
  - UW – all of the above, Polar MODIS Aqua/Terra, NOAA-series and MetOp AVHRR, MODISx, LeoGeo
  - AFWA – backup for UW but sometimes data shows up due to hiccups in super-ob preprocessing codes. Mostly METEOSAT obs.
- Algorithms include
  - IR, SW, WV (IR and DL), and VIS
- For a somewhat random selection of files for dates between 09/2014-11/2014, there are 36 unique flavors of NRL AMVs
  - I do not distinguish between super-obbed AMVs and observations which are not super-obbed (raw data).

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# **NRL AMVs in the GSI (work in progress)**

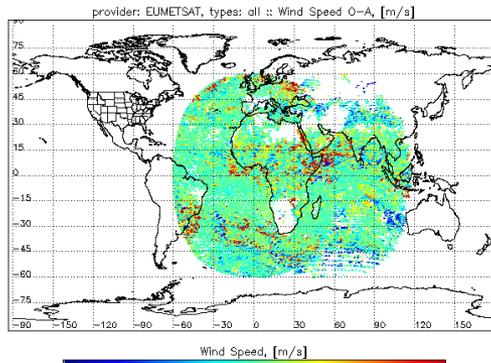
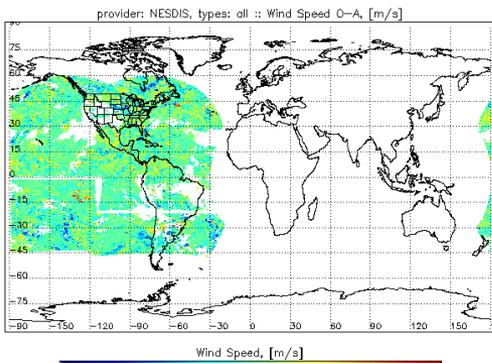
**quick look at locations assimilated and O-B/O-A statistics for 1 day of data**

**preliminary forecast/analysis verifications with FY15 operational parallel version at T670/T254.**

# Experiments with NRL Super Observations within the GSI

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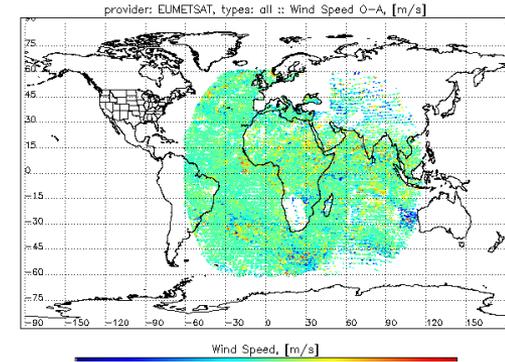
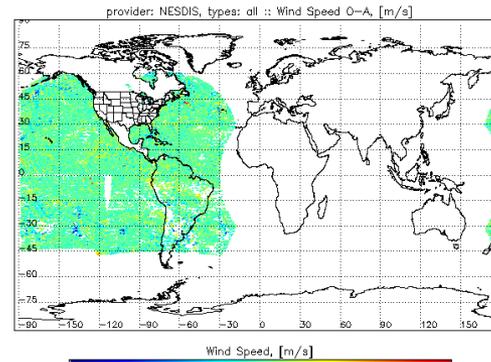
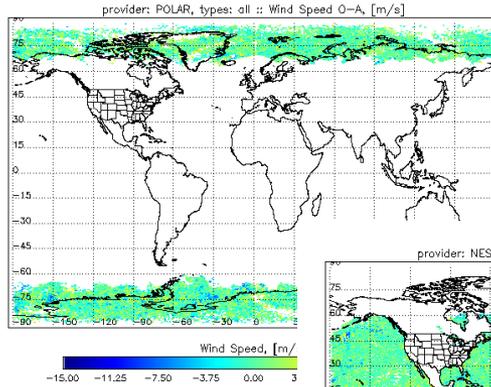
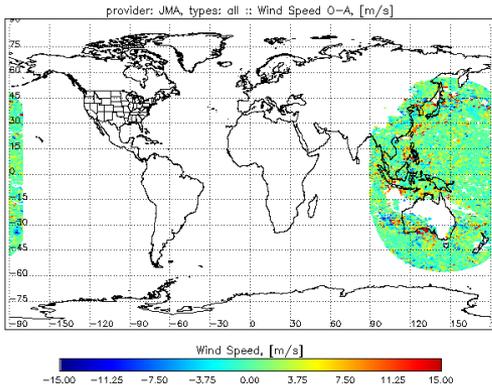
- Replace ingest of operational SATWND BUFR data with NRL super-obs.
- Control run with operational SATWND BUFR
- Experiments with NRL super-observations
  - All 36 flavors used
  - No thinning (data has already been super-obbed in pressure, time, lat/lon).
  - Observation errors are set to nominal GSI SATWND BUFR observations or something smaller by a factor of  $\frac{3}{4}$ .
- Runs currently cycling and have completed 3 weeks (09/01/2014 – 09/20/2014)
  - assessment of O-B/O-A in terms of coverage and uncertainty
  - Preliminary assessment of forecast/analysis skill using NCEP's verification package (VSDBv17).



**GSI O-A, O :: SATWIND BUFRR  
sources (prepbufr data use flag –  
nogross check = no test on  
anluse))**

Clockwise from left:

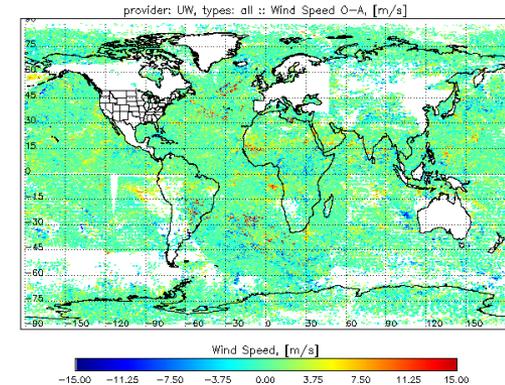
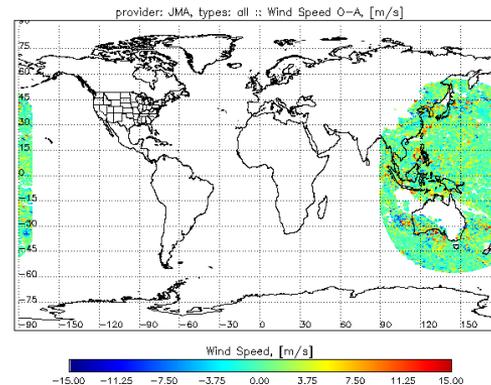
- NESDIS
- EUMETSAT
- Polar (MODIS, AVHRR)
- JMA



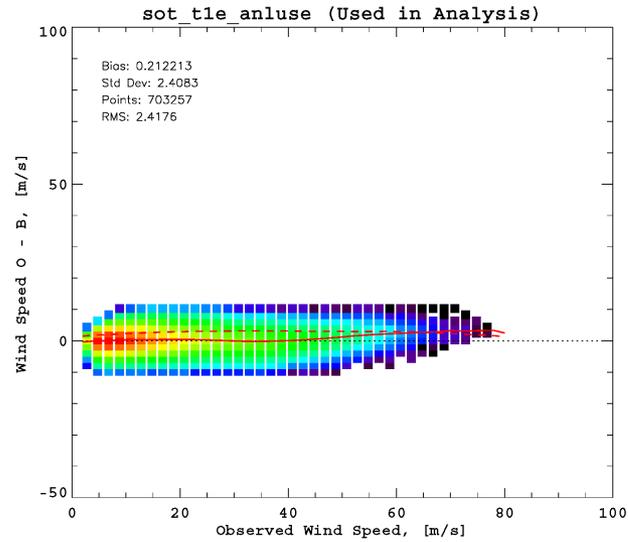
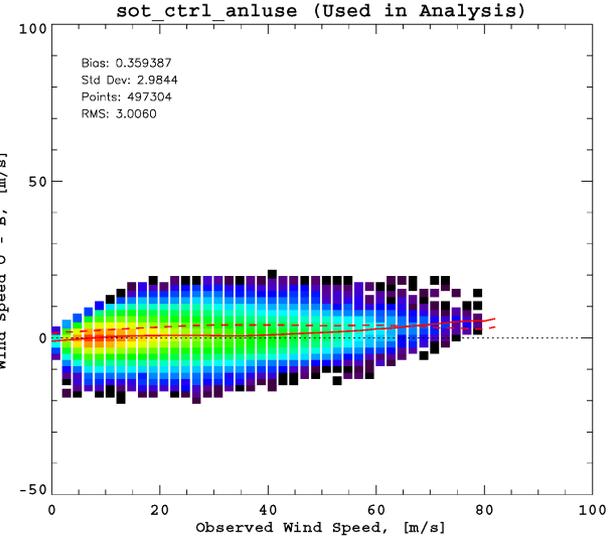
**GSI O-A, O :: NRL super-ob  
sources (prepbufr data use flag –  
no test on anluse)**

Clockwise from left:

- NESDIS
- EUMETSAT
- UWisc (All the above + MODIS, AVHRR, LeoGeo, MODISx)
- JMA
- AFWA (not shown)



# O-B versus O wind speed/direction for all used winds 20140902 00z-18z (left: SATWND BUFR, right: NRL Super-obs)

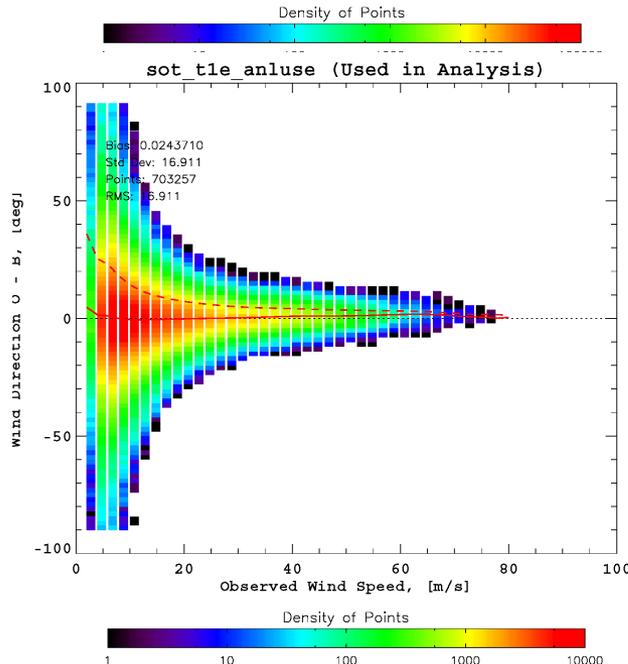
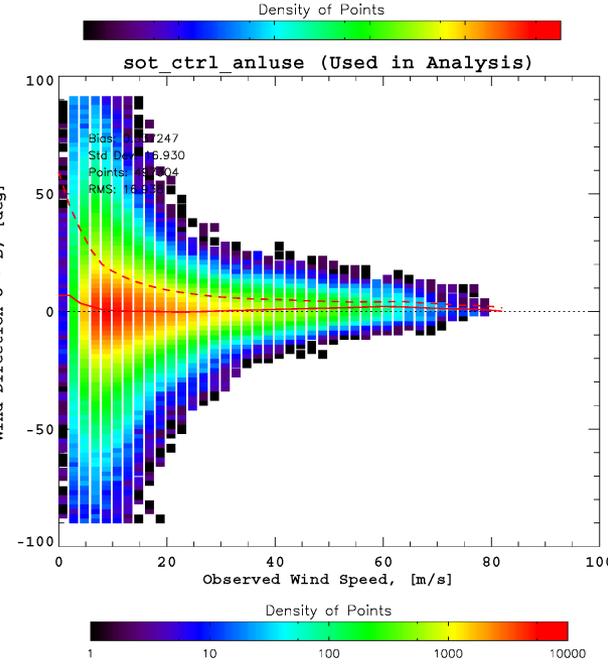


**SATWND BUFR:**  
Total number of obs: 1877896  
Number accepted : 497304

Progression of NRL testing

**NRL Sobs**  
Total number of obs: 727172  
Number accepted : 703257

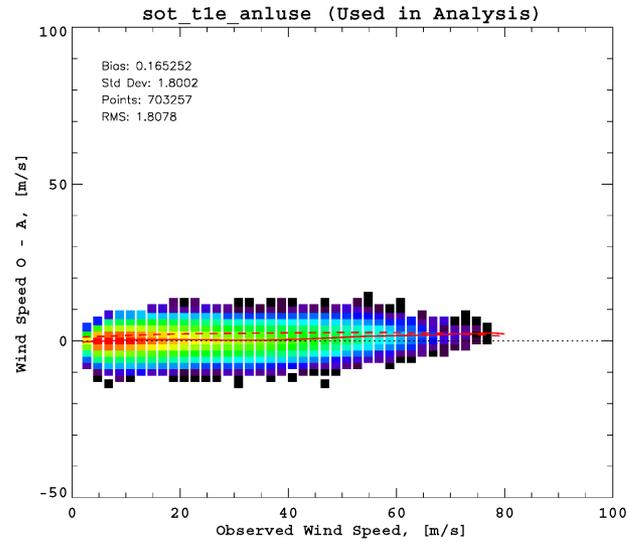
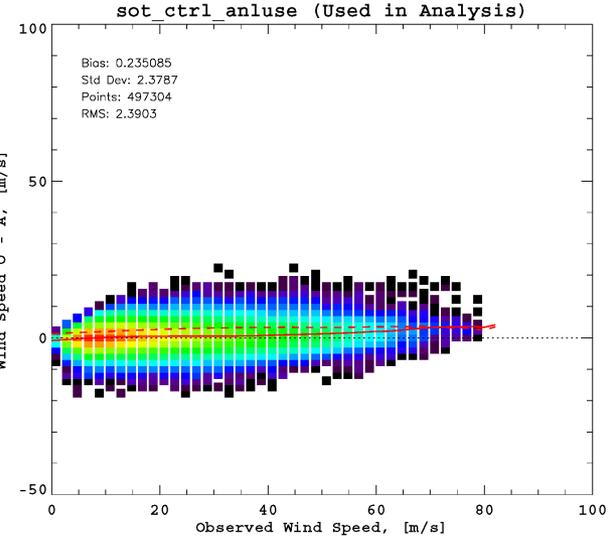
- Total number of SATWND BUFR observations is greater than total number of NRL Sobs – super observations are produced on regular grid (time, pressure, lat/lon).



- 2x the number of accepted superobs compared to accepted NCEP SATWND BUFR. Partly due to redundancy in AMVs produced by UW

- Statistics are improved wrt. NCEP BUFR AMV observations.

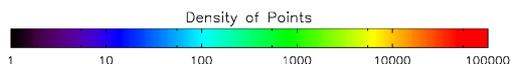
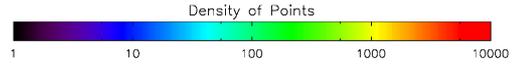
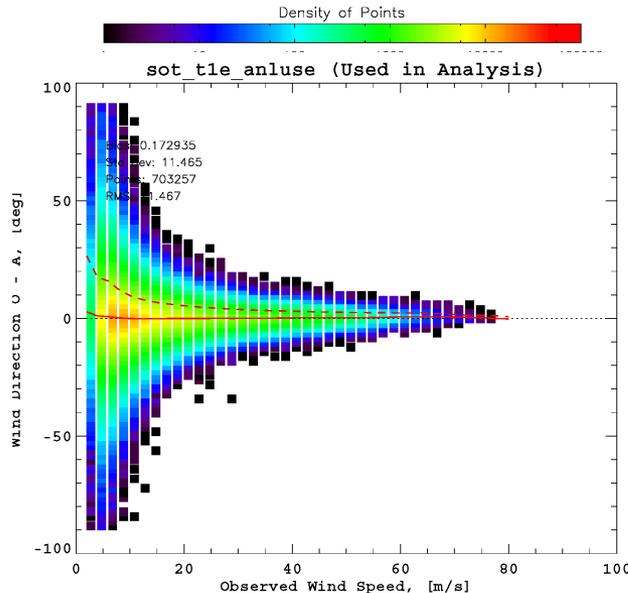
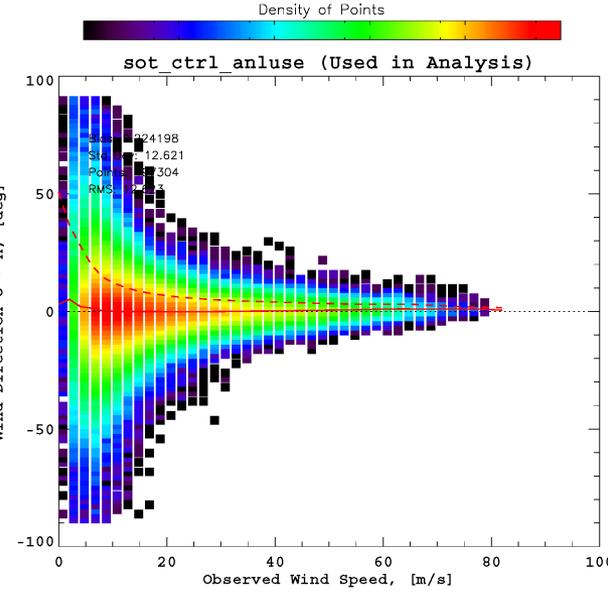
# O-A versus O wind speed/direction for all used winds 20140902 00z-18z (left: SATWND BUFR, right: NRL Super-obs)



**SATWND BUFR:**  
Total number of obs: 1877896  
Number accepted : 497304

**NRL Sobs:**  
Total number of obs: 727172  
Number accepted : 703257

- Super-obs have smaller random errors in both wind-speed and wind-direction. ~ 0.5 m/s random and systematic.
- Super-obs have better coverage spatially and vertically.



# Summary on assessment of NRL Super-observations

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- NRL super-obs O-A and O-B statistics are cleaner than GDAS BUFR. This is not surprising because:
  - Super-obs should have some noise reduction over raw AMV data (2 deg. × 2 deg. × 50hPa × 60min. average for each observation provider and algorithm).
  - Data provided by NRL have had an internal gross check limit on innovations (O-B) in addition to the gross check on O-B applied within the GSI.
- Verification of 3 week run of T670/T254 system with NRL super-obs or GDAS BUFR satellite wind observations is in progress ... preliminary results follow and suggest a longer time period of verification is needed for spin-up.

# Scorecard: (140904-140920) nominal errors (3 week run : with 3 day spinup)

- **Red:** Superobs worse than SATWND BUFR
- **Green:** Superobs better than SATWND BUFR
- Lots of significant negative verification stats at day 1 which become non-significant after day 3.
- Some positive verification stats in S.H. and tropical wind speed biases and heights. Also N.H mid-level wind speed biases.

Use of larger observation errors show fewer significant negative impacts and more consistent positive impact.

		N. American						N. Hemisphere						S. Hemisphere						Tropics					
		Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10
Anomaly Correlation	Heights	250hPa																							
		500hPa	▼	▼					▼																
		700hPa	▼	▼					▼																
		1000hPa	▼	▼					▼																
	Vector Wind	250hPa							▲																
		500hPa	▼	▼					▼																
		850hPa	▼	▼					▼		■														
	Temp	250hPa							■																
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RMSE	Heights	10hPa	▼	▲				▼	▲												▲	▲			
		20hPa	▼	▲		■			▼	▲											▲	▲	■		
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		100hPa	▼	▲					▼	▲											▲	▲	■		
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Temp	10hPa																			▼	▼	▼	▼		
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Bias	Heights	10hPa	▼	▲				▼	▲												▲	▲			
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	Wind Speed	10hPa	■	■					■	■		▲									▲	▲	■		
		20hPa	■	■					■	■		▲									▲	▲	■		
Temp	10hPa																			▼	▼	▼	▼		
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	850hPa																			▼	▼	▼	▼		

# Summary and Discussion of Caveats to experiments with/without NRL superobs

- Positive, negative and non-significant forecast skill impacts are observed when NRL super-obs are used in place of SATWND BUFR.
- Runs have progressed only 3 weeks at this point; however, there is evidence of day 1-3 degradation in forecast skill when NRL super-obs are used in place of SATWND BUFR.
  - Possibly due to the effect of abrupt change in AMV wind coverage (both in spatial and vertical coordinates and number of obs in general)/observation errors on model dynamics – mass/wind balance.
  - Probably need a longer spin-up period to accurately assess impact of super-obs on both short term and longer term forecast skill.
- Superobs are produced in hourly intervals.
  - 3-D hybrid system and current ingest of super-obs is not explicitly taking advantage of time information in super-obs – issue in the conversion of information from NRL files and also an issue in the NRL super-obbing routines.
  - Su's 4D thinning and the upcoming 4D hybrid system should be better at handling temporal information from hourly observations.
- Observation errors for all types are set equal across the board for all NRL wind flavors.
  - Some observation types will have too large a penalty while others will have too small a penalty. –
  - We will investigate several options with guidance from offline data quality assessments of super-obs versus ECMWF/GDAS 6hr forecast, etc.
    - use of NRL wind errors provided by their analysis
    - parallel current GSI Rx for height error assignment vs. wind type/subtype
    - ...