Impact of METOP ASCAT Ocean Surface Winds in the NCEP GDAS/GFS and NRL NAVDAS COAMPS@

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Part I: Assimilating ASCAT surface wind retrievals in the NCEP GDAS/GFS

Part I: Outline

- ASCAT experiment design and work plan
- Results from ASCAT analysis
- Results from forecast verification
  - Traditional stats diagnosis and anomaly correlation results
  - Geographic anomaly correlation results
  - Forecast impact investigations
- Conclusions

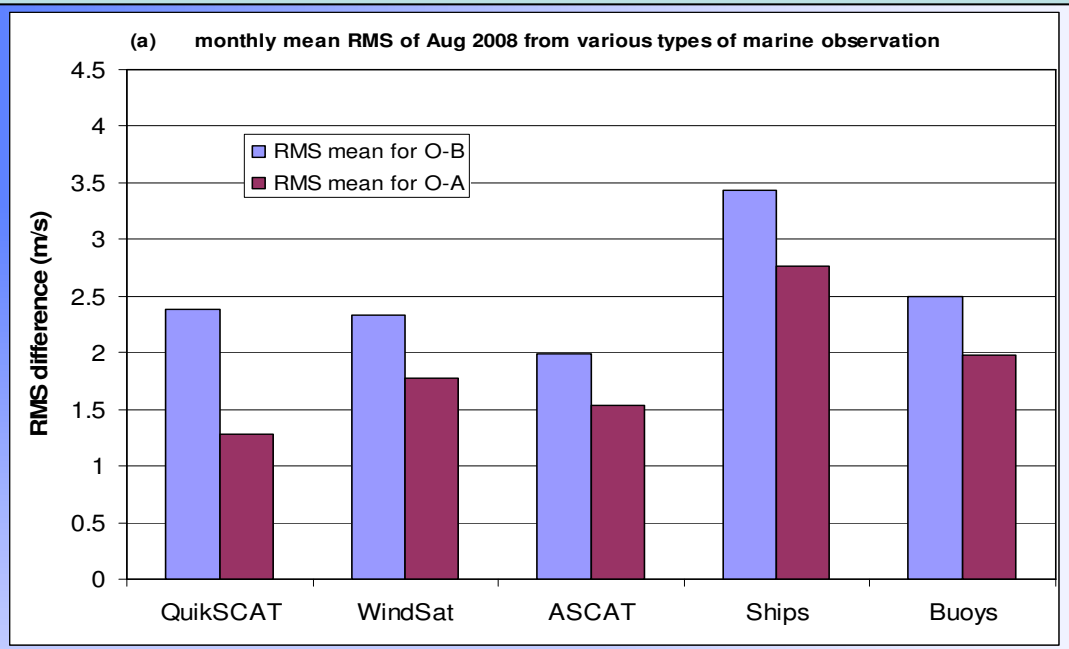
Work Plan

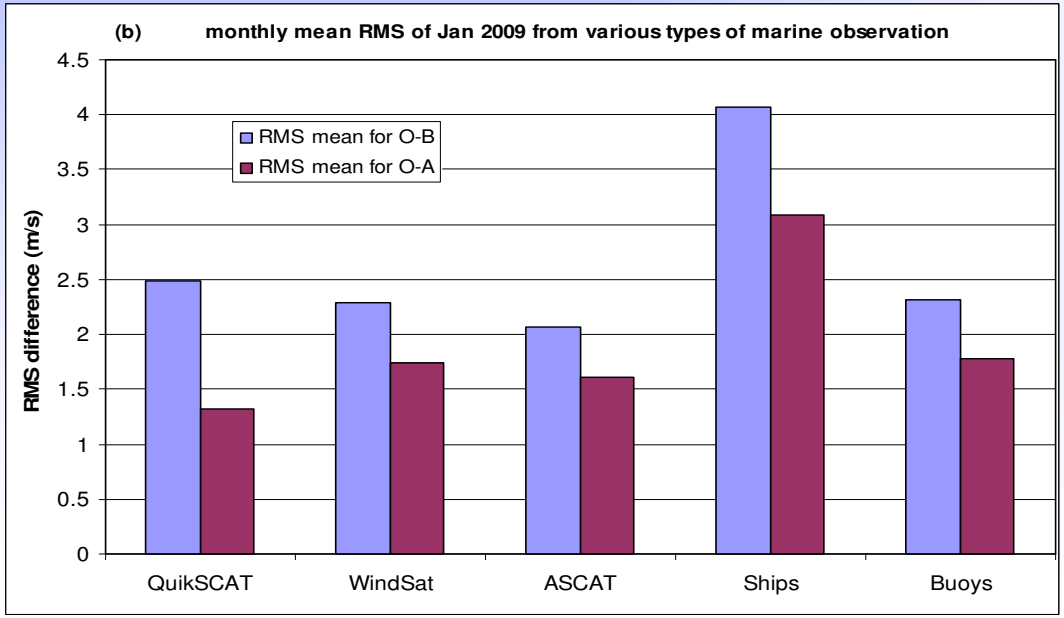
- Worked with the JCSDA (Joint Center for Satellite Data Assimilation) to evaluate the forecast impact of assimilating ASCAT data in the NCEP GDAS/GFS
- Conducted experiments during two seasons
- December 2007 version of GDAS/GFS with modifications for:
  - Thinning routine for winds (Kistler, Su)
- Used the low resolution ASCAT data
- Determined quality control procedures
- Investigated analysis and forecast impacts of assimilating ASCAT
  - Anomaly Correlations
  - Geographic Anomaly Correlations results
  - Forecast Impact

ASCAT Assimilation Experimental Design

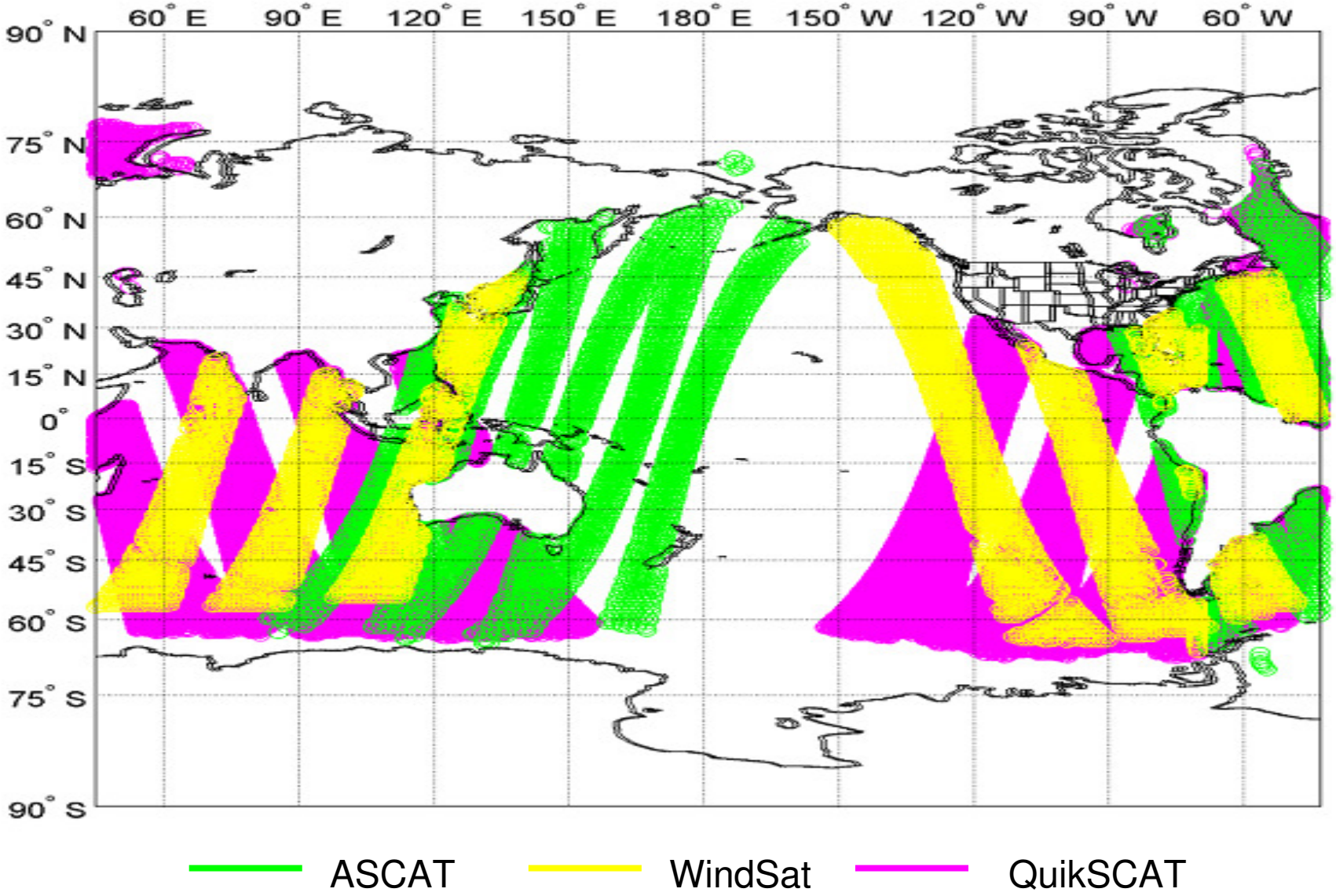
- Used GDAS/GFS operational resolution of T382L64
- Used July-August 2008 and December 2008 – January 2009 data
- All operational data types were used
- Data used at 6 hour synoptic time with +/- 3 hour window
- Thinned instead of superobed ASCAT data
  - Thinned to 100 km
- ASCAT quality control:
  - Non-ocean observations rejected (GFS land, sea, ice flag)
  - Observations that differ by more than 5 m/s from the background are rejected (U, V).
  - Sea surface temperature of 273K was used as a criteria to remove sea ice contamination.
  - Directional QC, ambiguity removal.

Monthly mean RMS for various types of marine observation

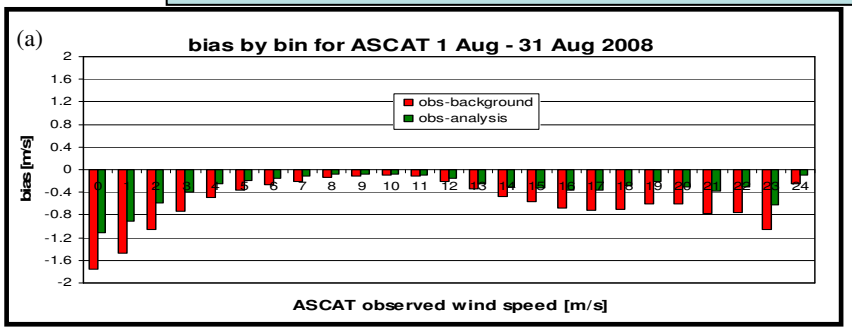


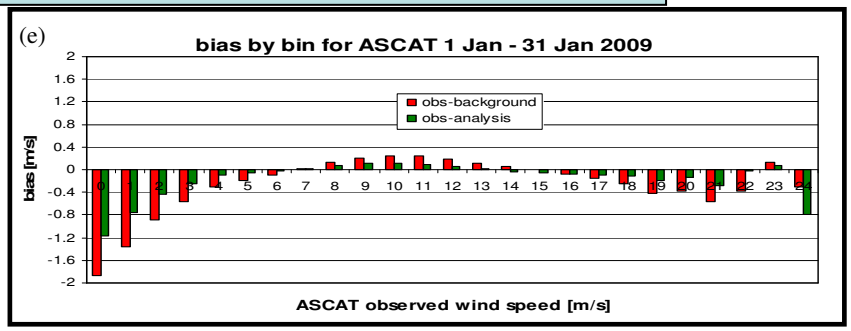


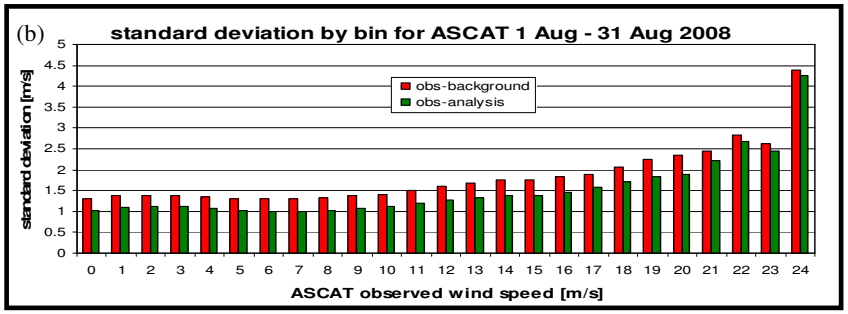
ASCAT, WindSat, QuikSCAT orbit 20081205 00Z

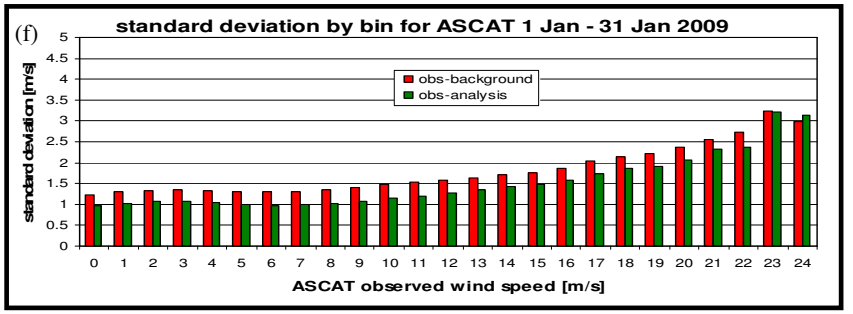


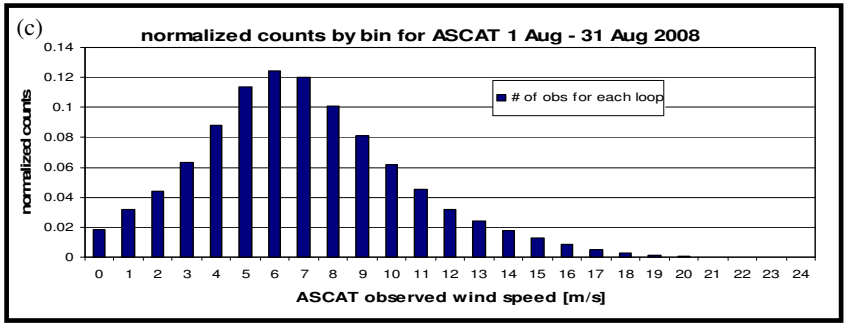
ASCAT statistics results of Aug 2008 and Jan 2009 – by observation wind speed bins

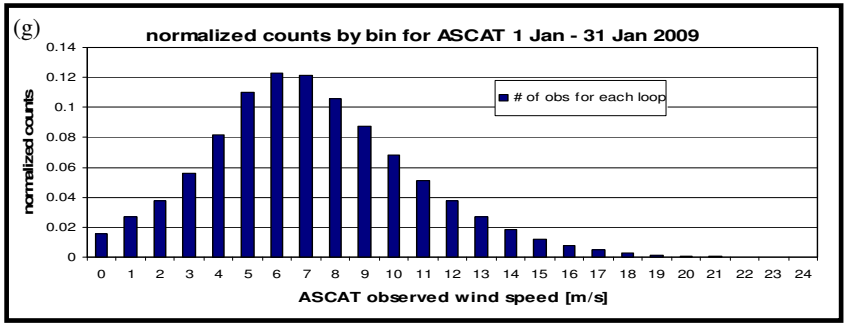


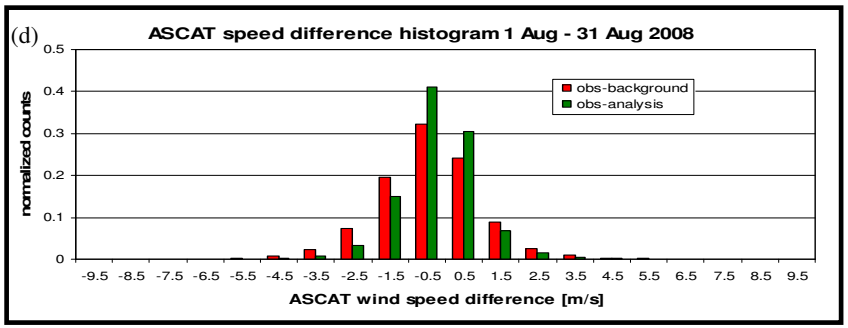


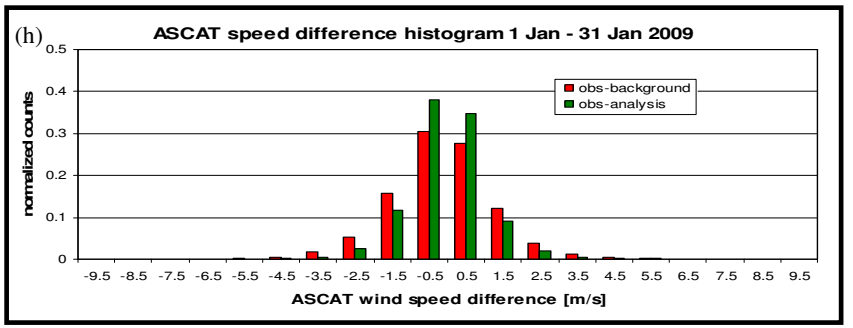




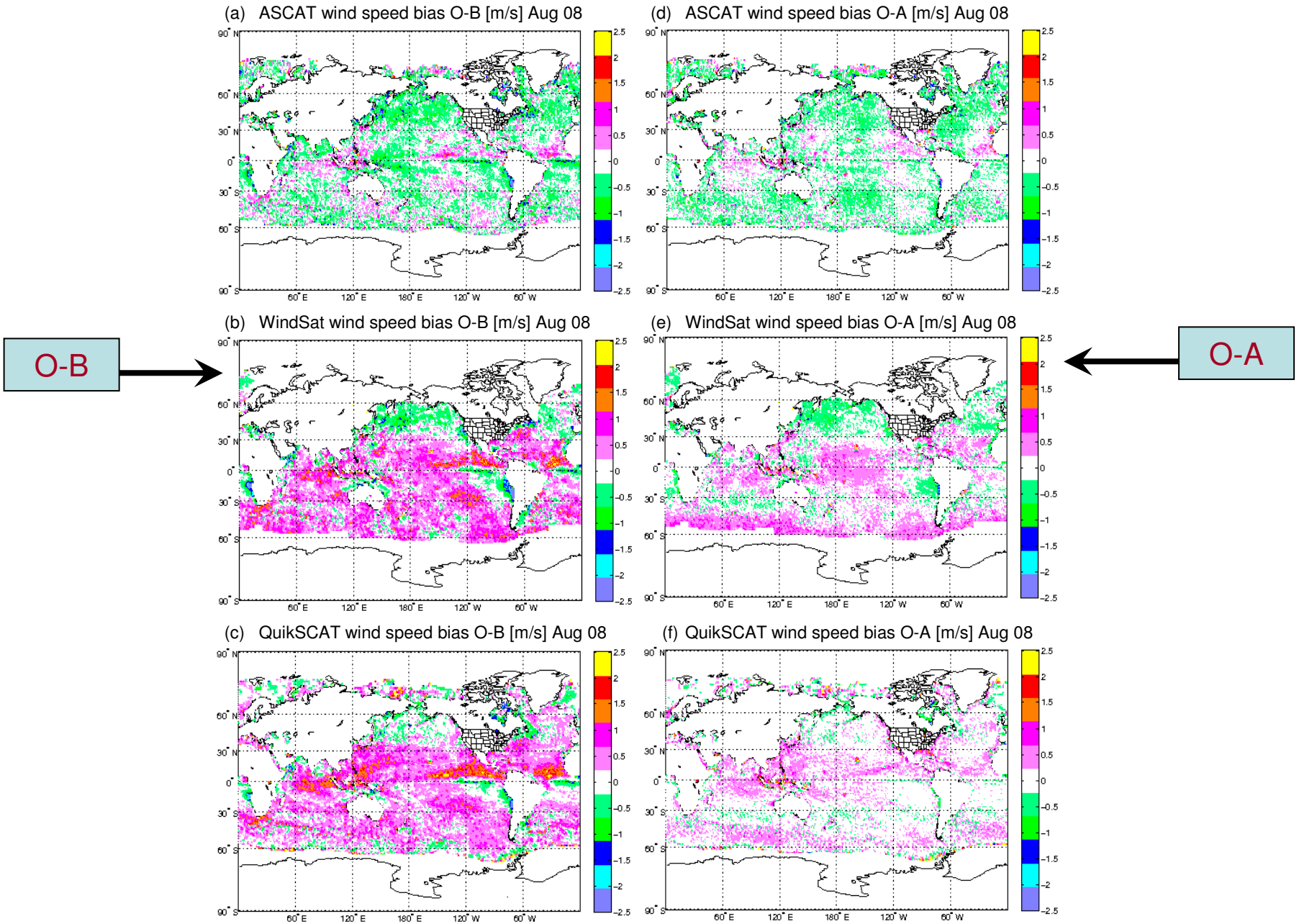






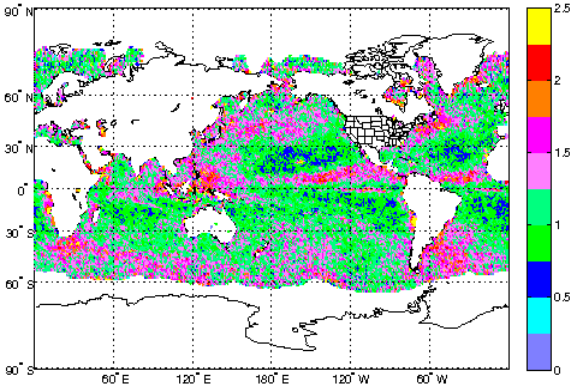


Geographic statistics results – by lon/lat bins wind speed bias

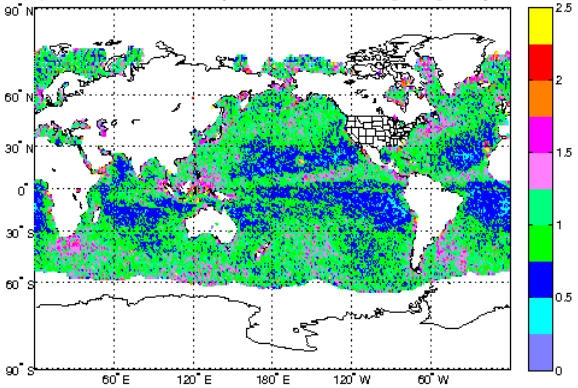


Geographic statistics results – by lon/lat bins wind speed RMS

(a) ASCAT wind speed RMS O-B [m/s] Aug 08

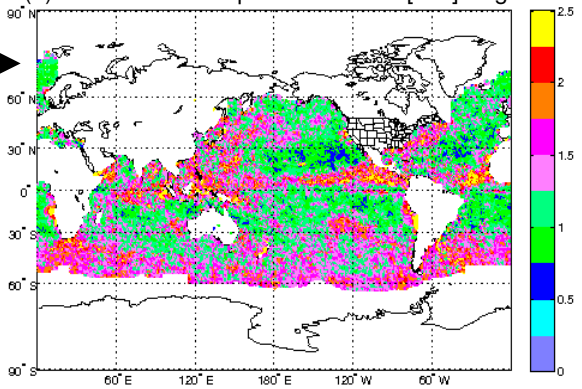


(d) ASCAT wind speed RMS O-A [m/s] Aug 08

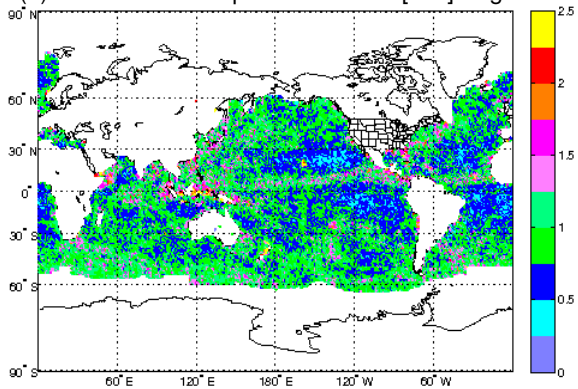


O-B

(b) WindSat wind speed RMS O-B [m/s] Aug 08

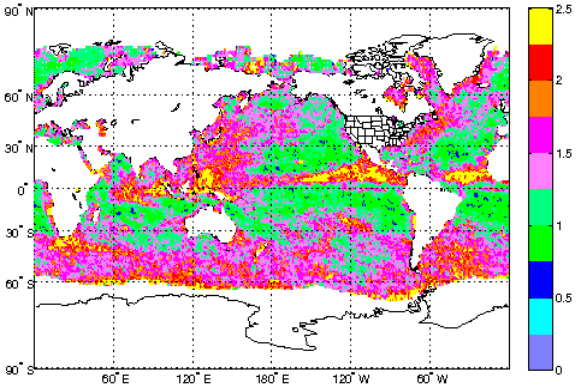


(e) WindSat wind speed RMS O-A [m/s] Aug 08

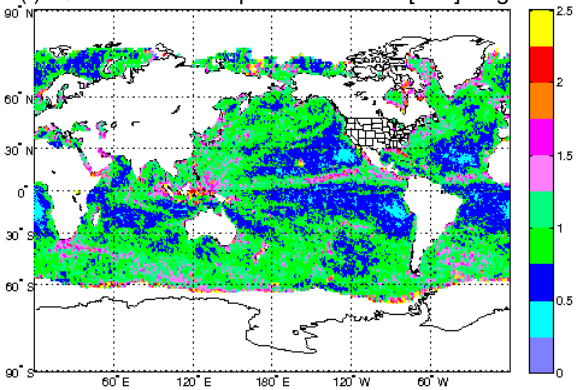


O-A

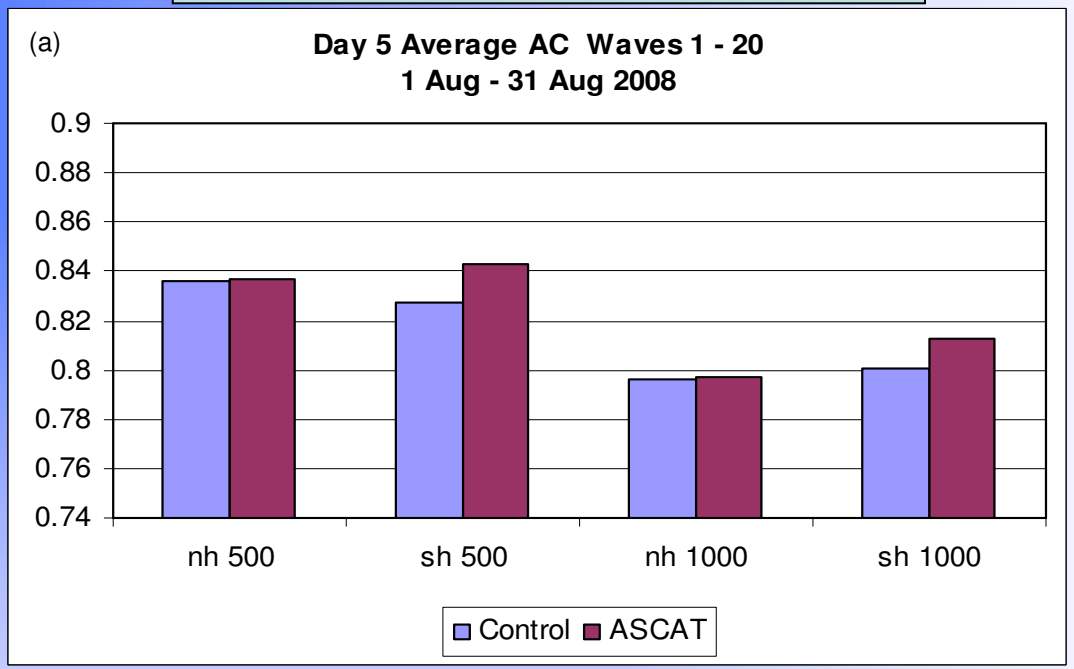
(c) QuikSCAT wind speed RMS O-B [m/s] Aug 08

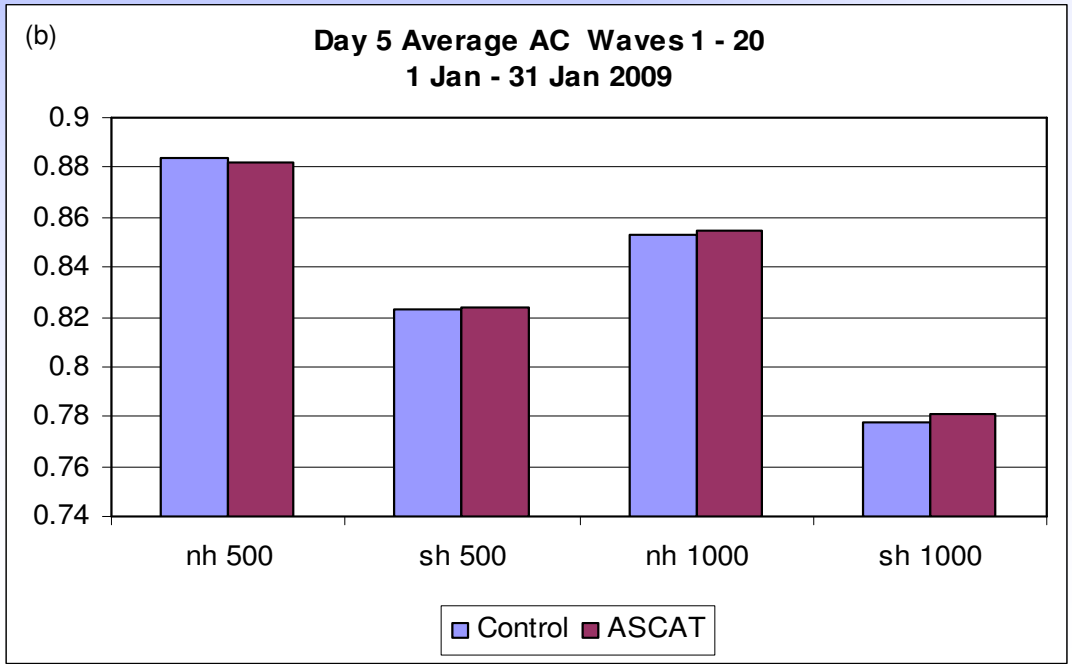


(f) QuikSCAT wind speed RMS O-A [m/s] Aug 08

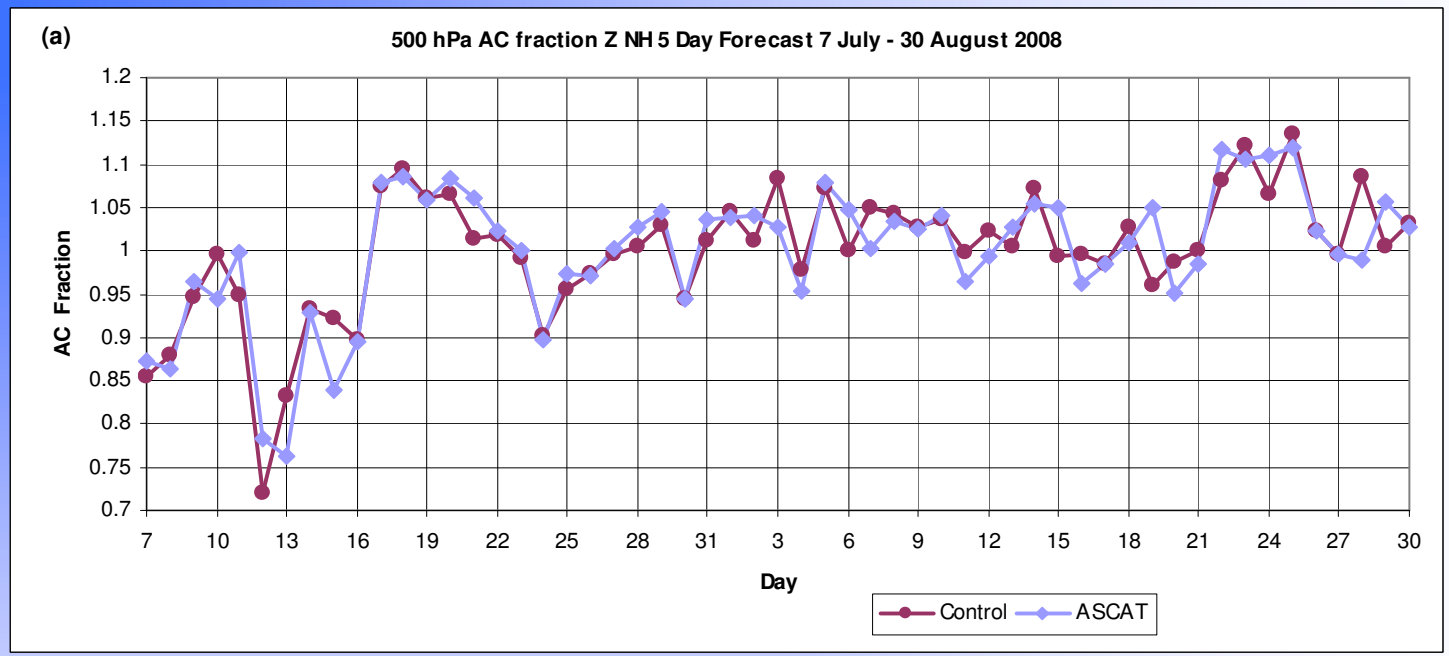


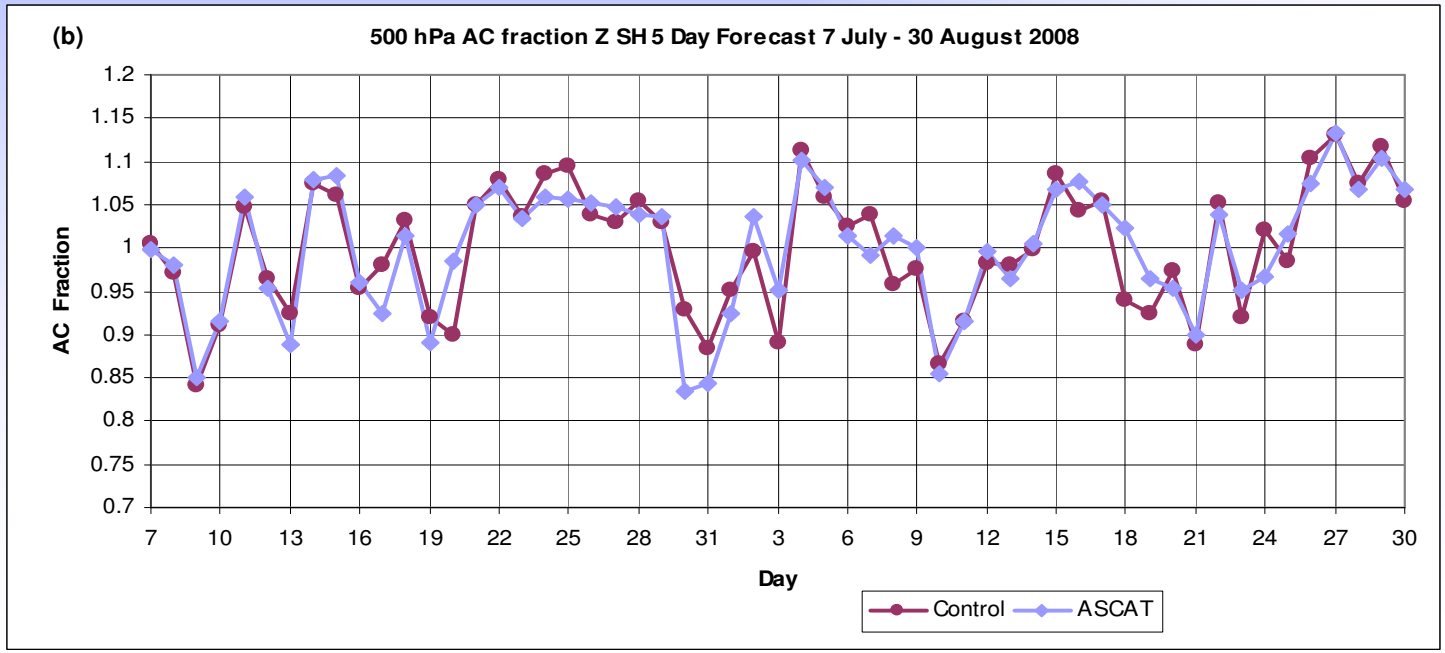
Anomaly Correlation (AC) results





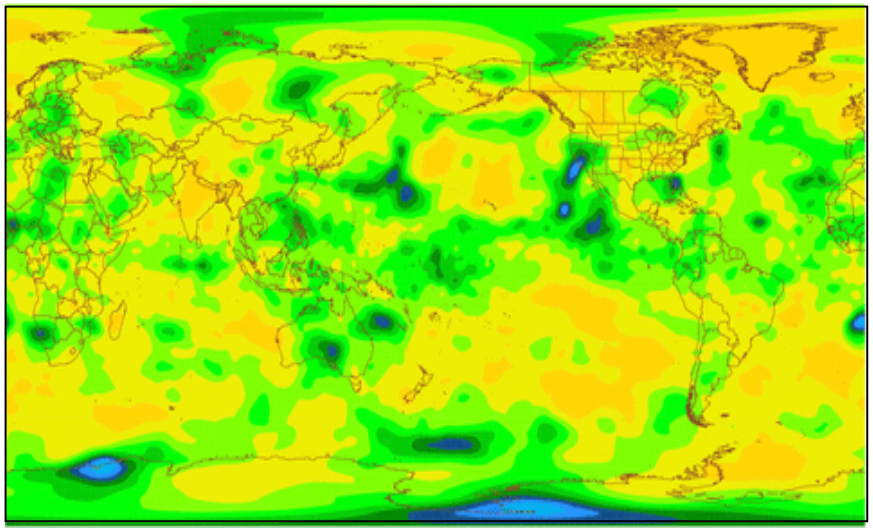
Fraction of daily AC time series



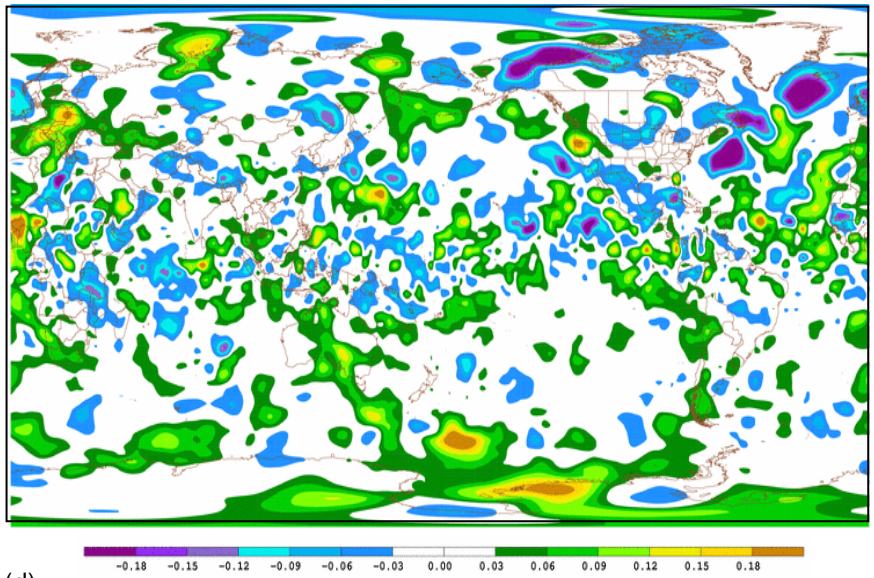


Geographic AC results for 500hPa geopotential heights

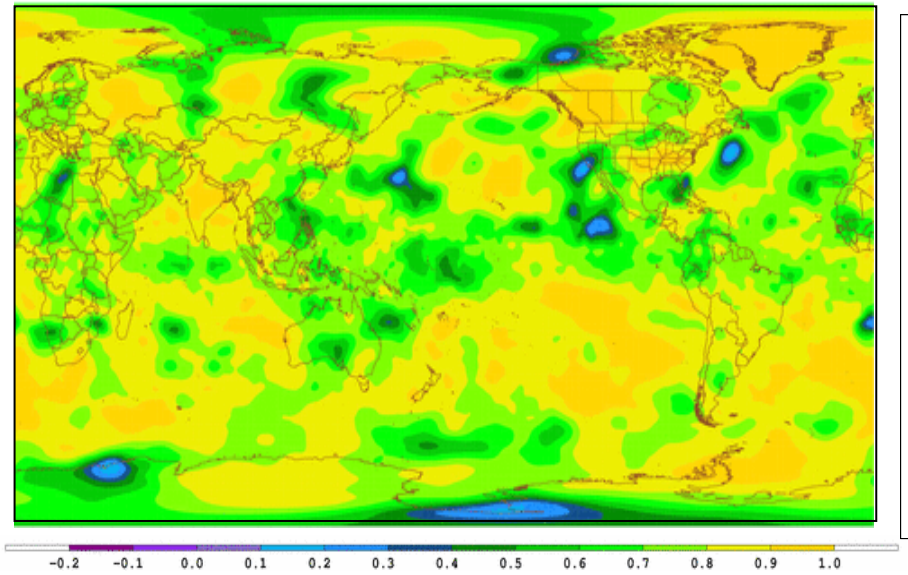
(a) 500hPa AC Z day 5 control 1 Aug – 31 Aug 2008



(c) 500hPa AC Z day 5 ASCAT – control 1 Aug – 31 Aug 2008



(b) 500hPa AC Z day 5 ASCAT experiment 1 Aug – 31 Aug 2008



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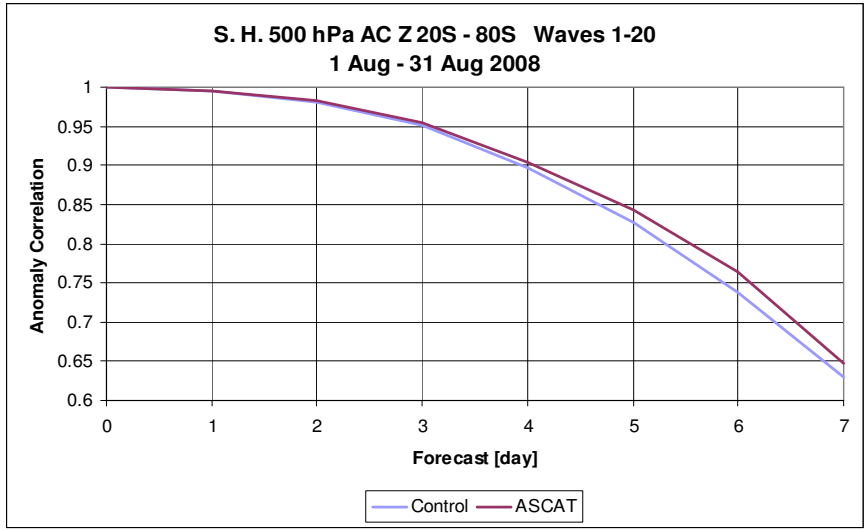
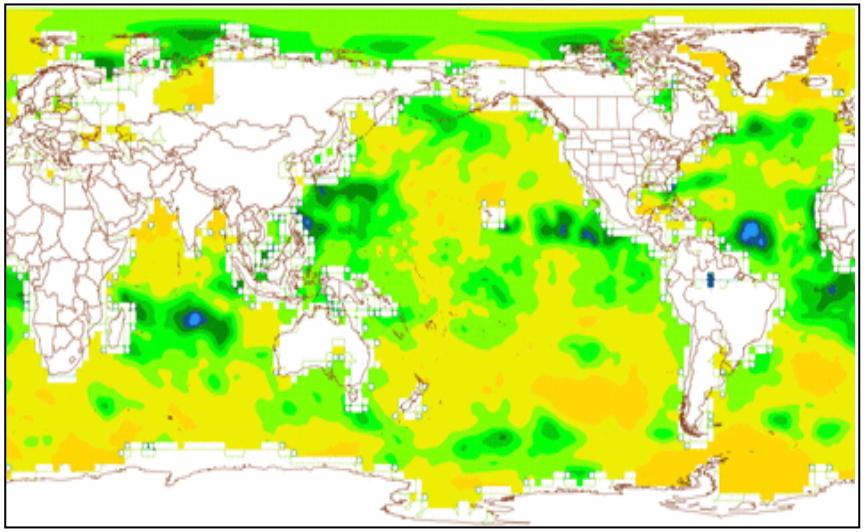
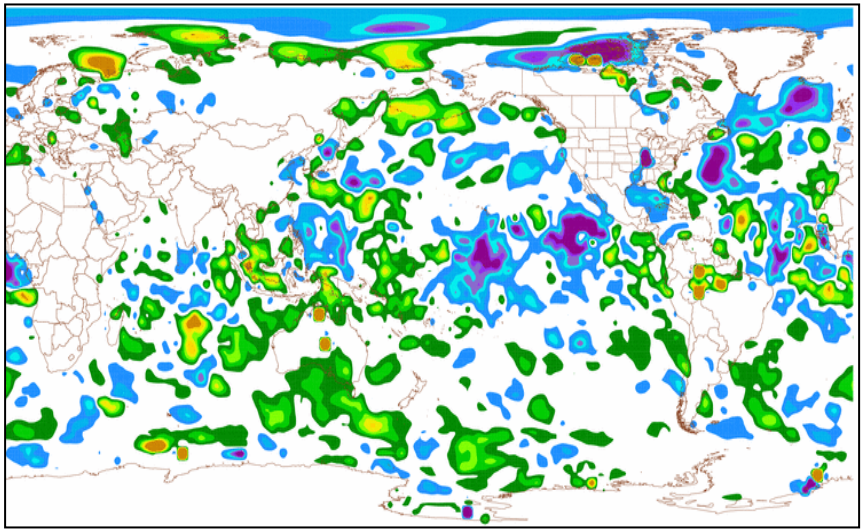


Geographic AC results for 1000hPa geopotential heights

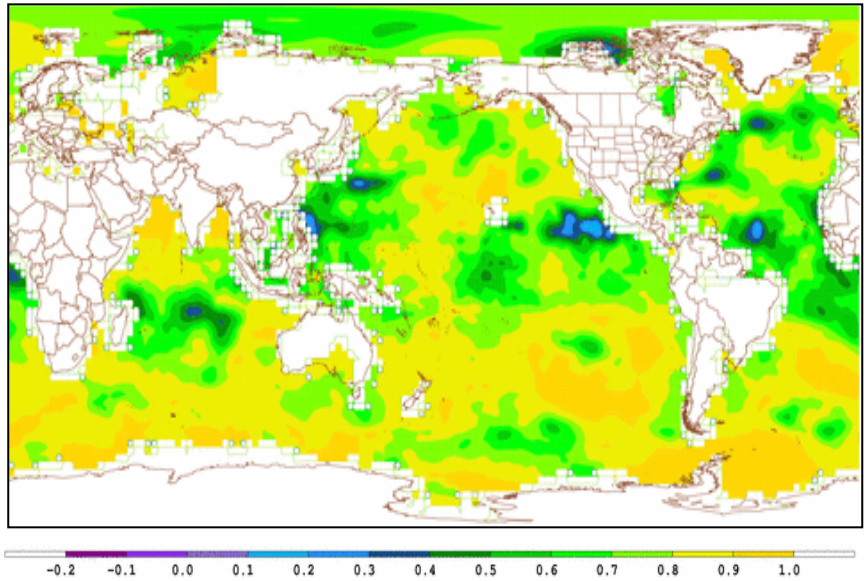
(a) 1000hPa AC Z day 5 control 1 Aug – 31 Aug 2008



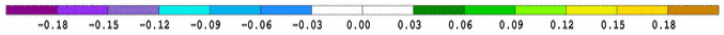
(c) 1000hPa AC Z day 5 ASCAT – control 1 Aug – 31 Aug 2008

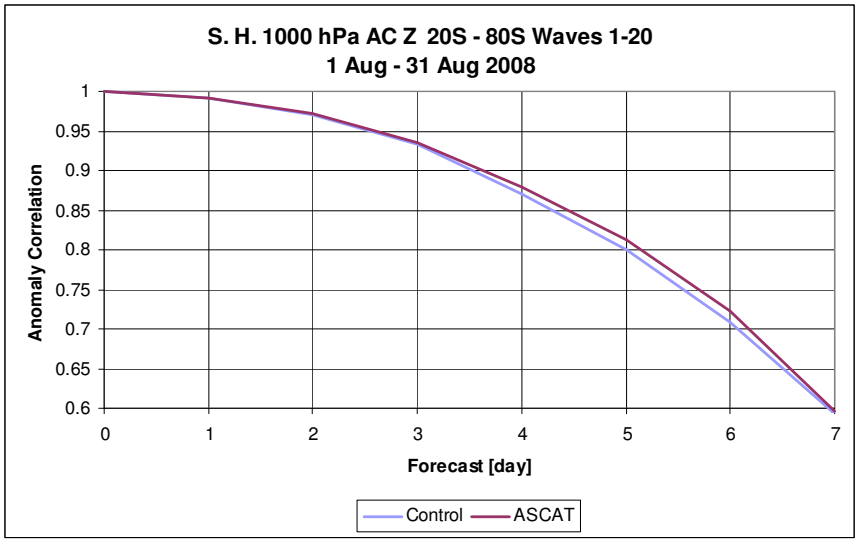


(b) 1000hPa AC Z day 5 ASCAT experiment 1 Aug – 31 Aug 2008



(d)





Conclusions of ASCAT experiment

- Improvements of O-A standard deviations are noted in the ASCAT analysis.
- Anomaly correlations show neutral to modest improvements.
- Improvements are realized as small improvements each day rather than large discrete improvements associated with particular weather events.
- Positive Forecast Impacts occurred for the wind and temperature fields and these impacts decay over time.
- Greatest Forecast Impacts occurred for the wind and temperature fields in the first 6 hour of the forecast.

Part II: Satellite Surface Wind Assimilations in the NRL Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS@)

Motivation

- Evaluate the impact of different horizontal resolutions for different types of satellite surface observations on the NAVDAS/COAMPS@ TC track.
- Determine best horizontal resolutions for satellite surface wind observations assimilation.

What is new to COAMPS®-Beta?

- *Operation*
  - *~~QuikSCAT~~*
    - *1.5 degree superob*
  - *SSM/I wind speed*
    - *2.0 degree superob*
  - *Scat winds*
    - *1.5 degree superob*

- *Operation*
  - *~~QuikSCAT~~*
    - *1.5 degree superob*
  - *SSM/I wind speed*
    - *2.0 degree superob*
  - *Scat winds*
    - *1.5 degree superob*
- *Test*
  - *ASCAT*
    - *? degree superob/thinning*
  - *WindSat*
    - *? degree superob/thinning*

Experiment setup

- *Control*
  - *Reject QuikSCAT, WindSat, ASCAT ocean surface winds*
  - *Reject SSM/I wind speed*
  - *Reject Scat winds*

- *Experiment 1*
  - *Assimilate QuikSCAT, WindSat, ASCAT ocean surface winds, SSM/I wind speed, Scat winds*
  - ***0.5 degree thinning box***

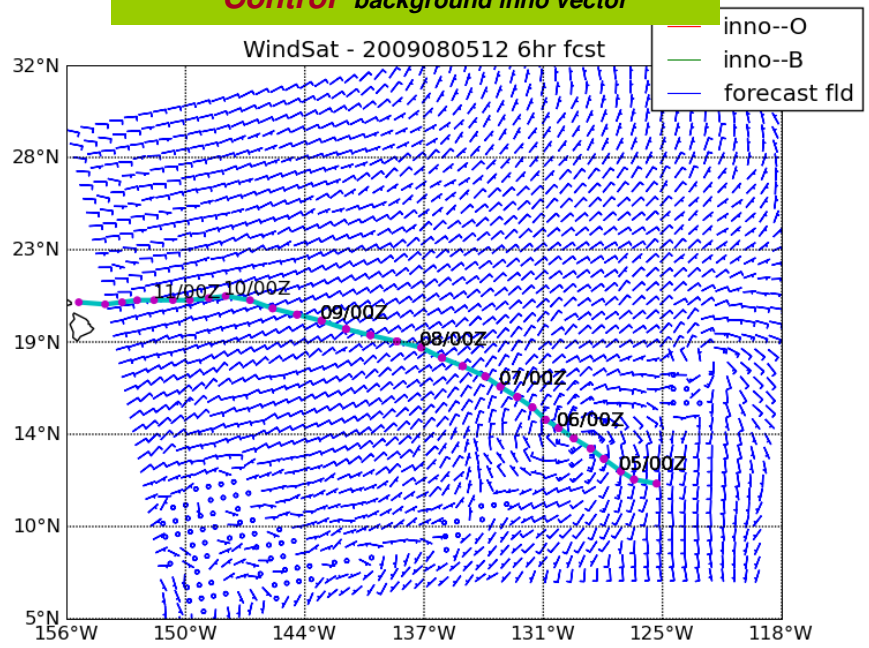
- *Experiment 2*
  - *Assimilate QuikSCAT, WindSat, ASCAT ocean surface winds, SSM/I wind speed, Scat winds*
  - ***1.0 degree super-ob***

- *Experiment 3*
  - *Assimilate QuikSCAT, WindSat, ASCAT ocean surface winds, SSM/I wind speed, Scat winds*
  - ***1.0 degree thinning box***

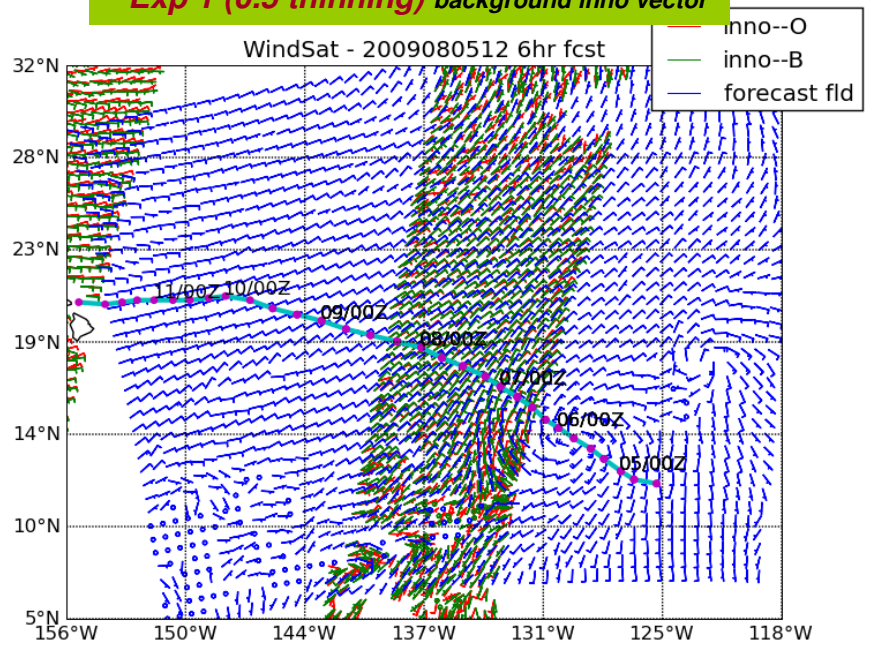
Case study

- 1 August – 30 August, 2009.
- Results from east pacific hurricane Felicia

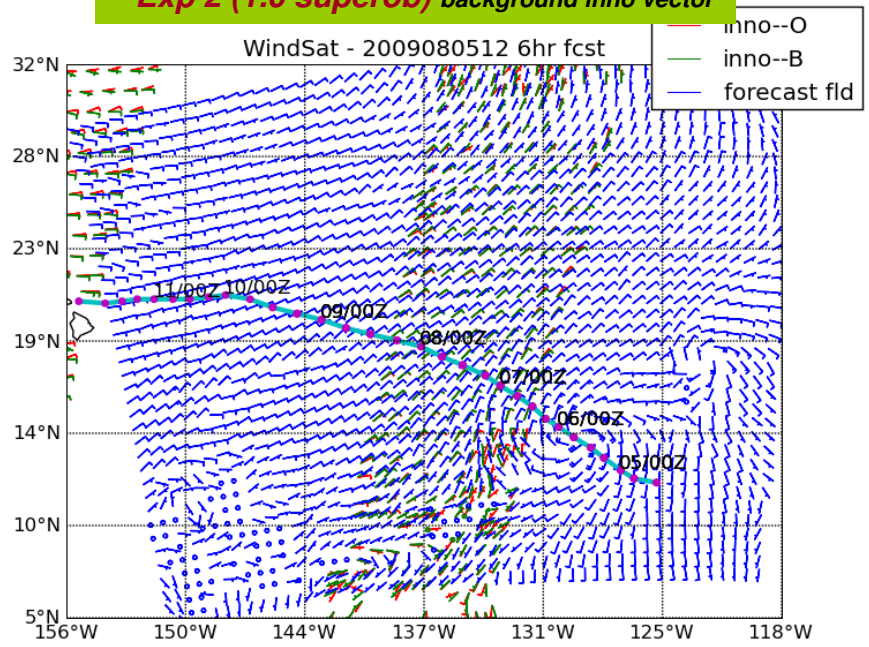
Control background inno vector



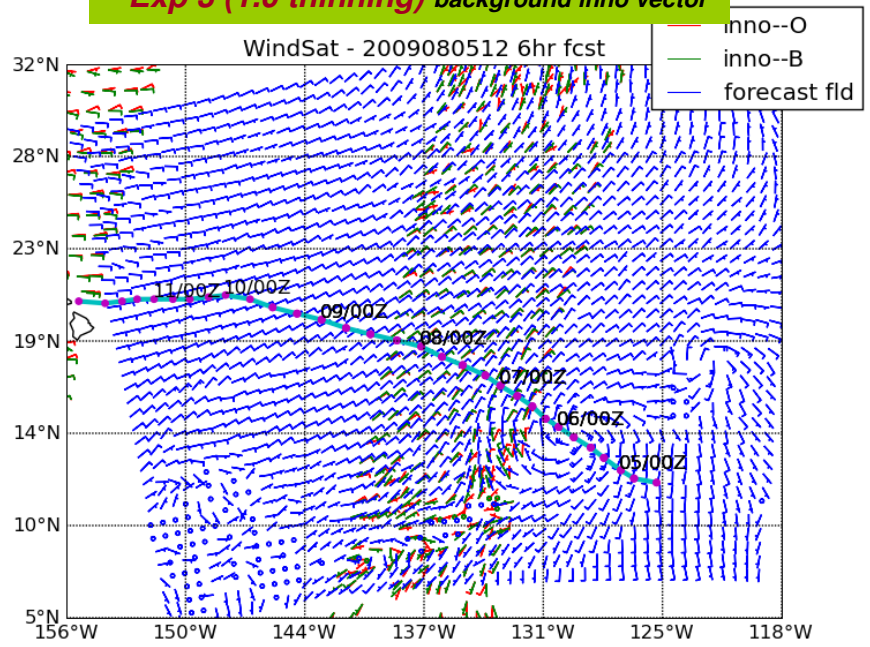
Exp 1 (0.5 thinning) background inno vector



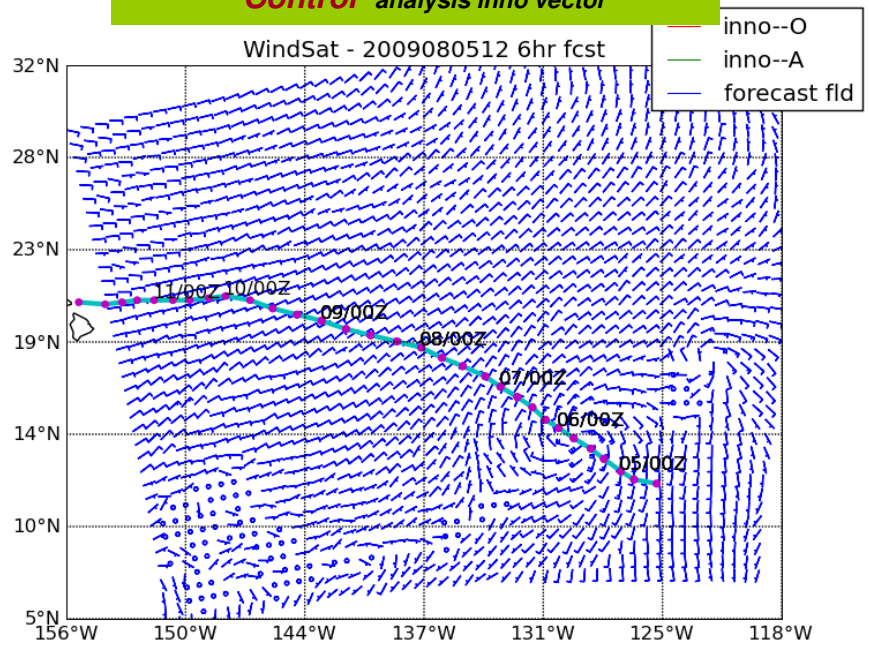
Exp 2 (1.0 superob) background inno vector



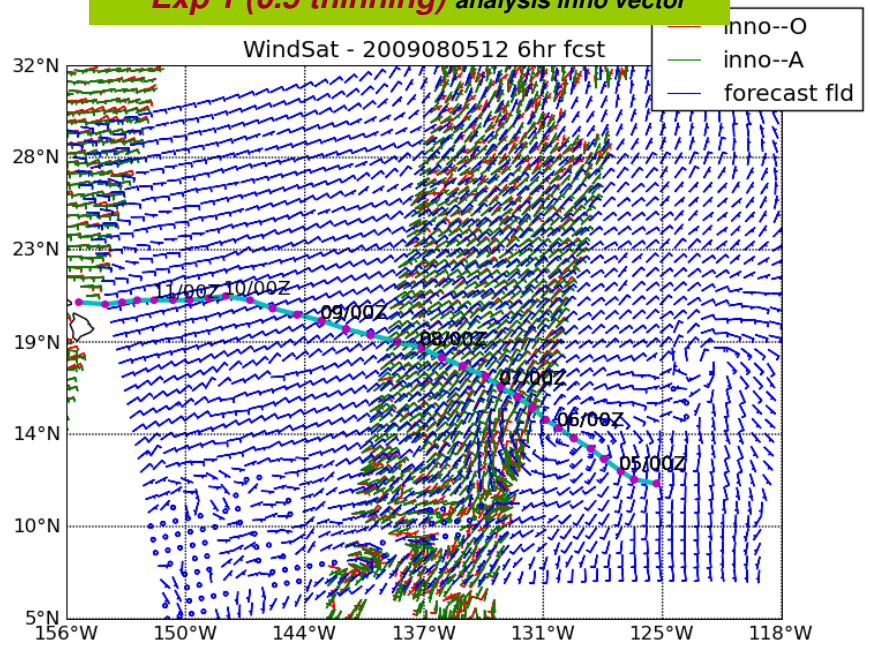
Exp 3 (1.0 thinning) background inno vector



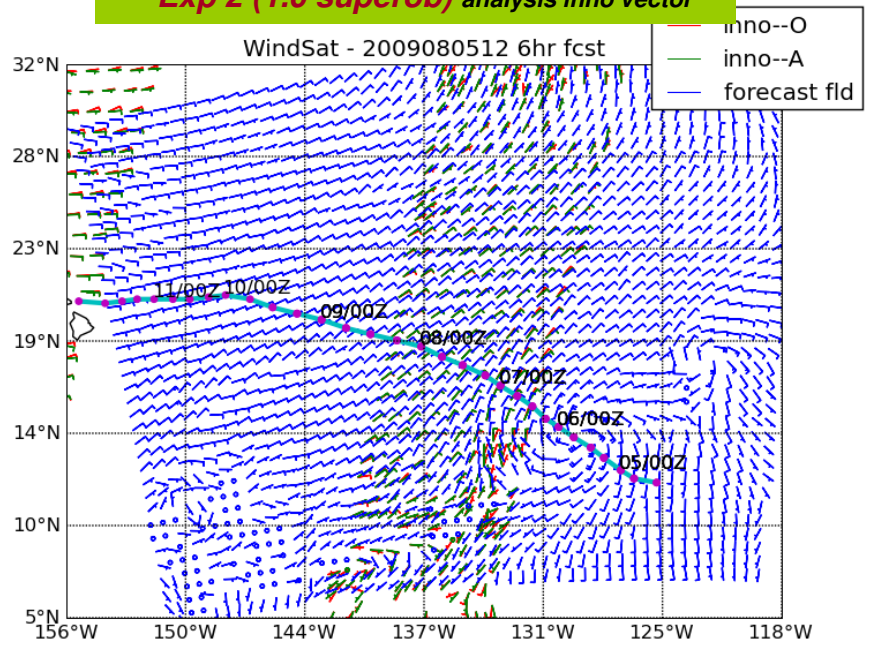
Control *analysis inno vector*



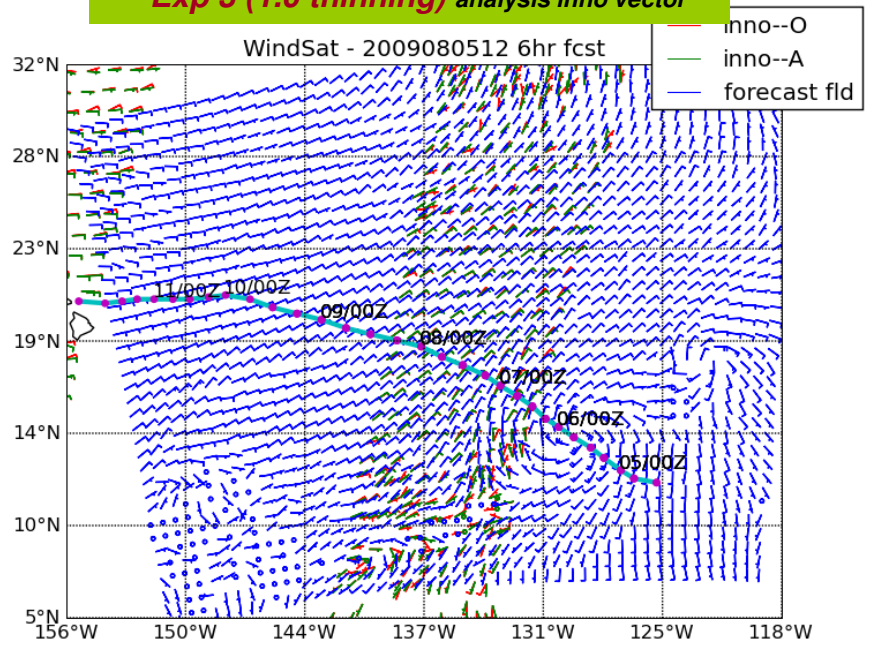
Exp 1 (0.5 thinning) *analysis inno vector*



Exp 2 (1.0 superob) *analysis inno vector*

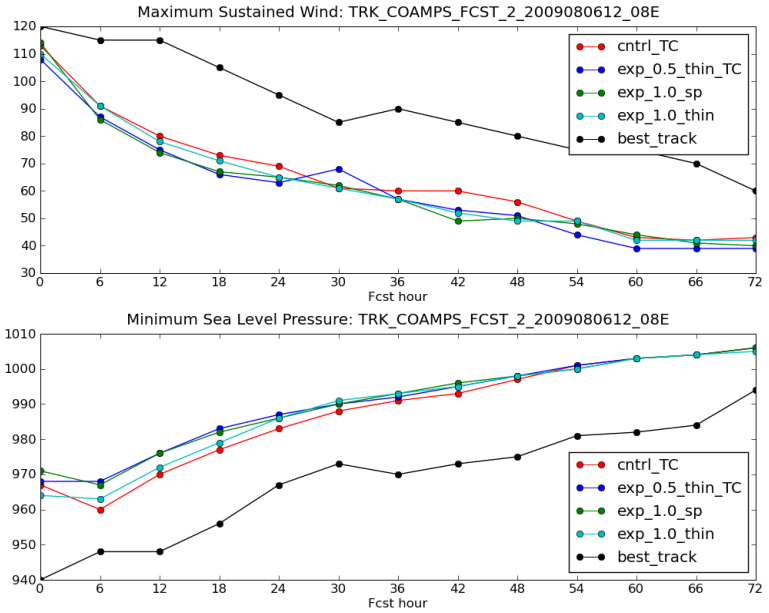


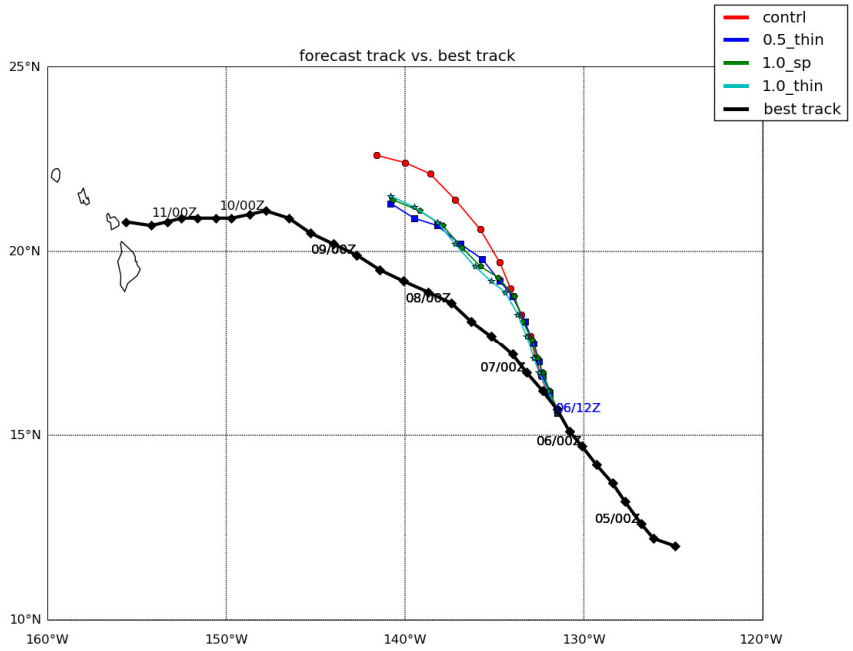
Exp 3 (1.0 thinning) *analysis inno vector*



Comparison of intensity track and position track

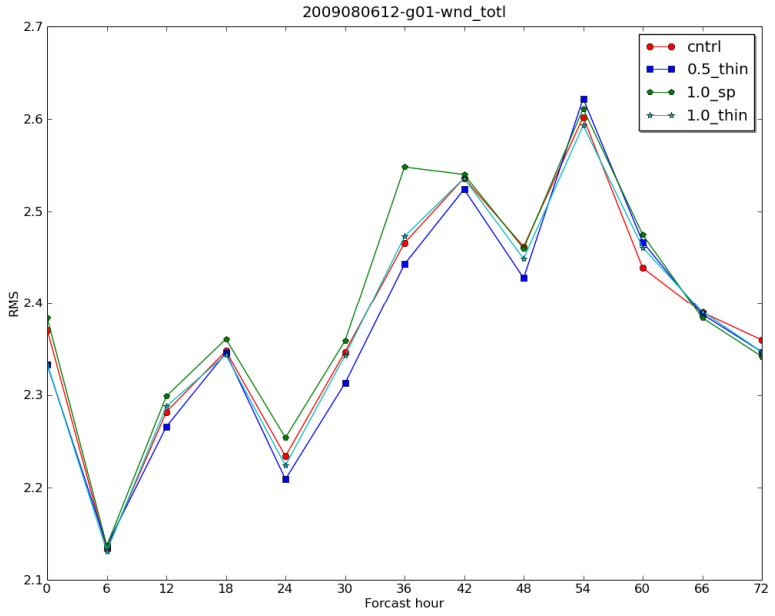
2009080612 72hr forecast



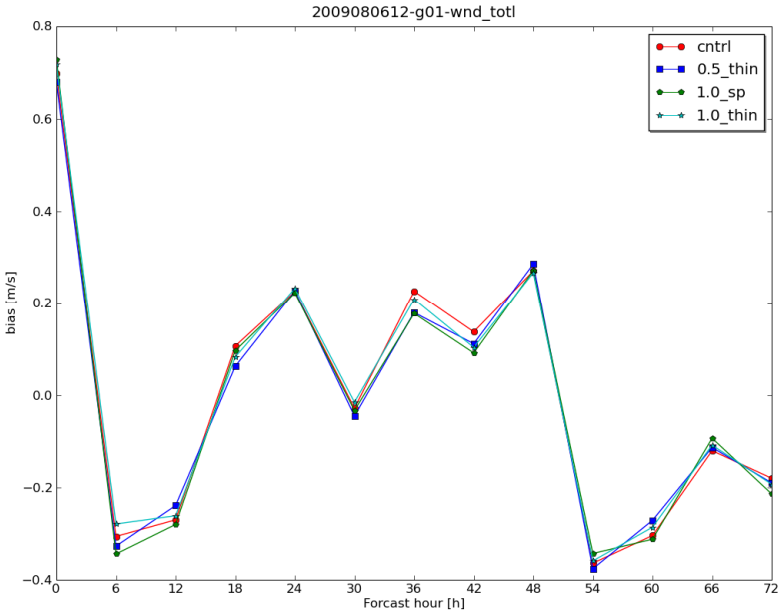


Verification again surface observations

2009080612 72hr forecast

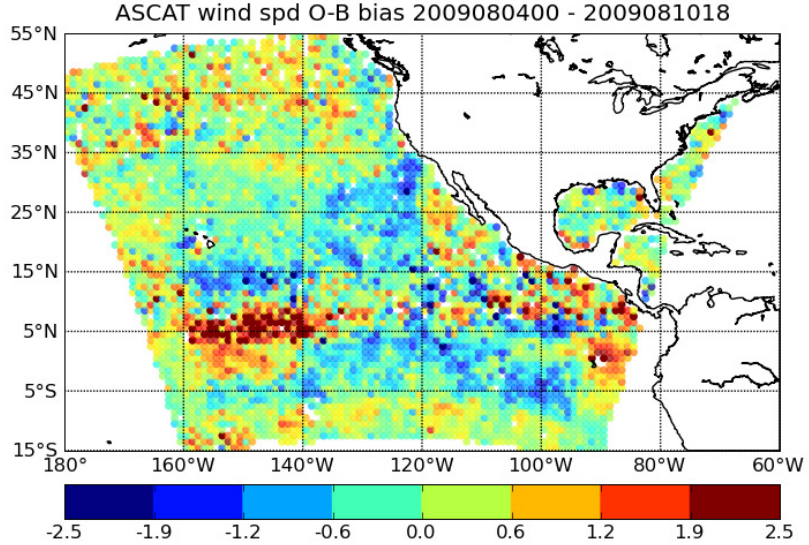


10m wind speed RMS

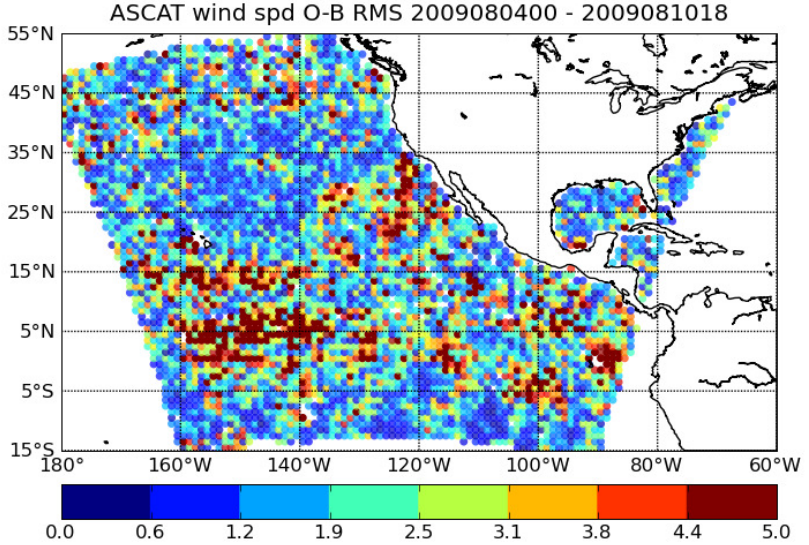


10m wind speed bias

O-B bias

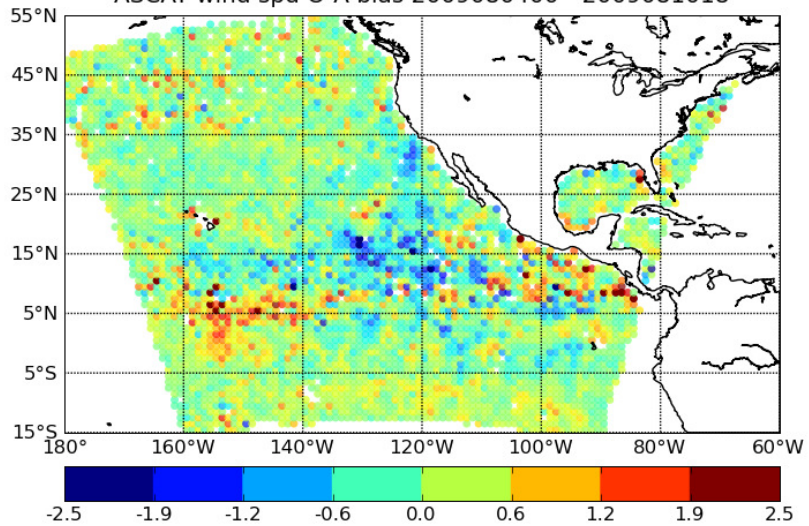


O-B RMS

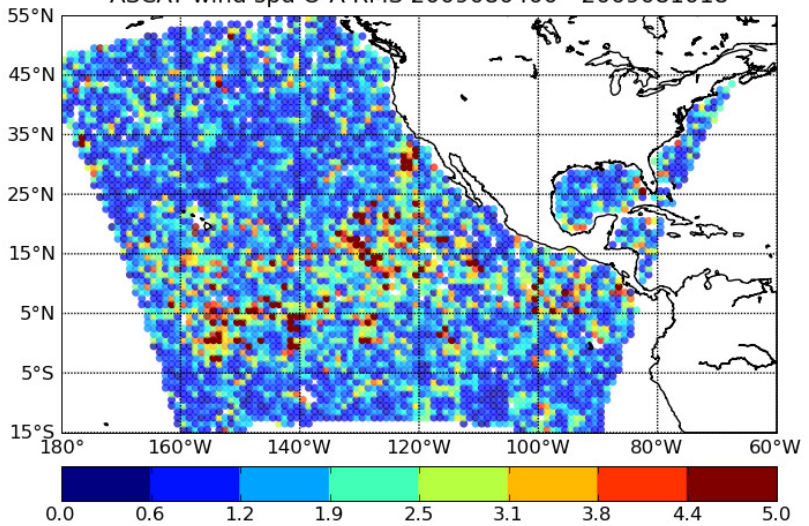


exp_1.0_superob

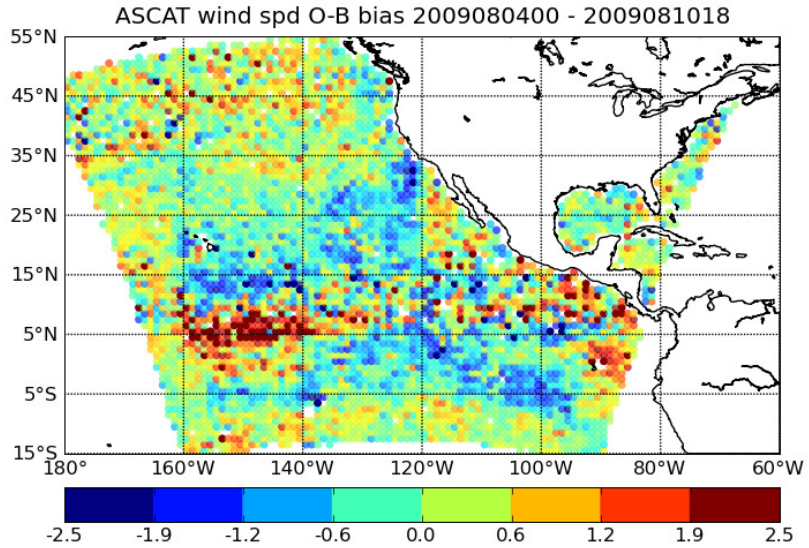
O-A bias



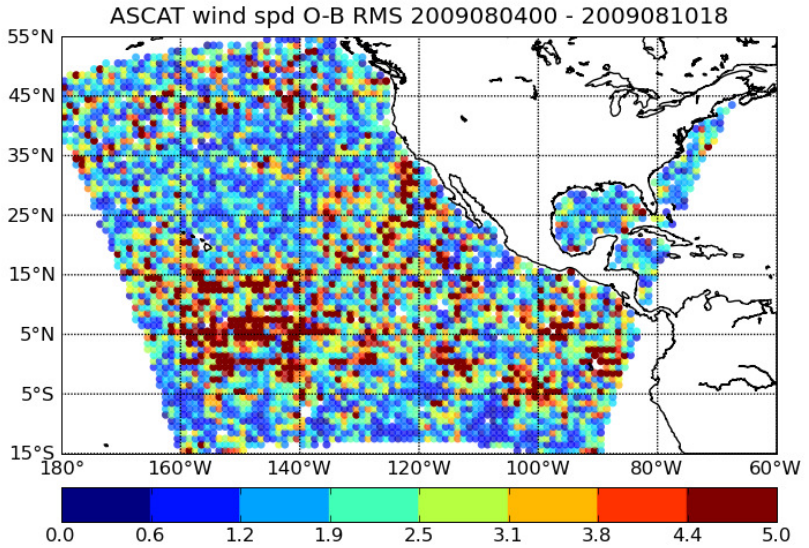
O-A RMS



O-B bias

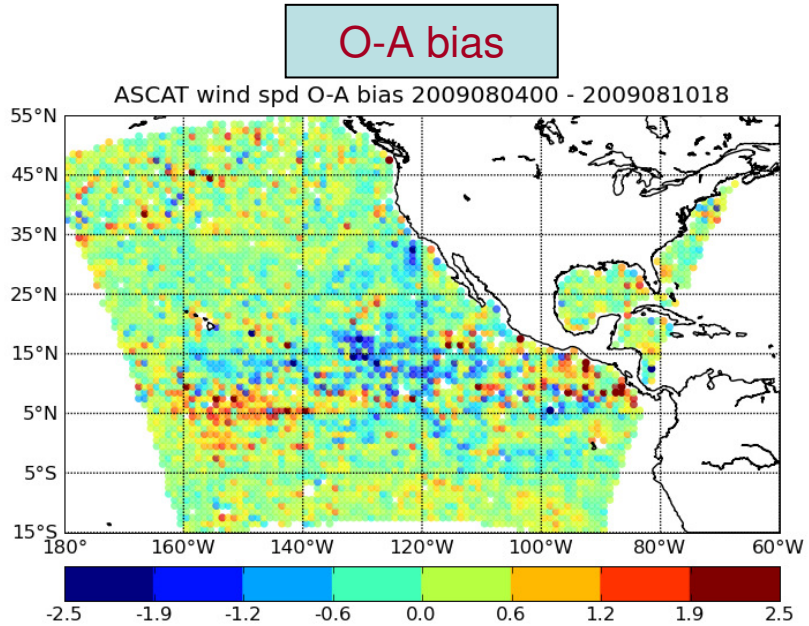


O-B RMS

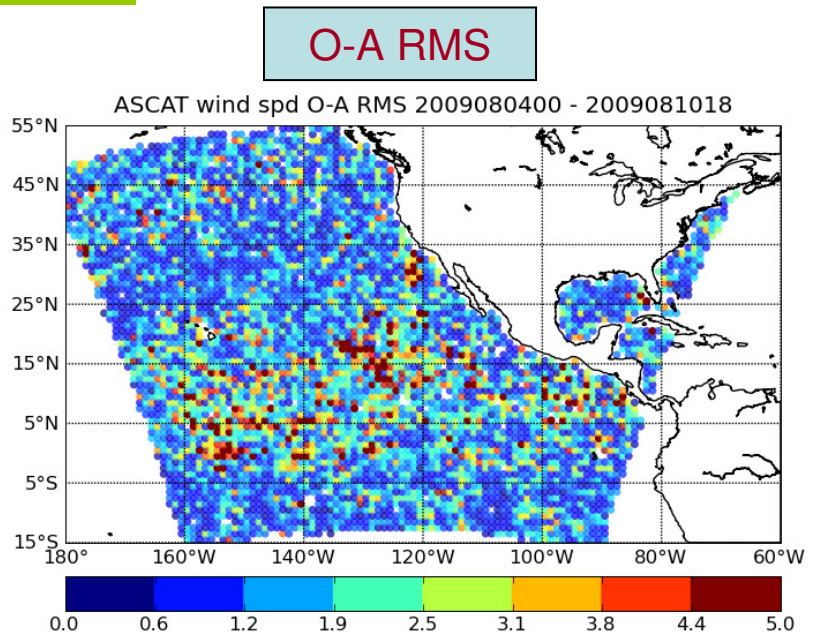


exp_1.0_thinning

O-A bias



O-A RMS



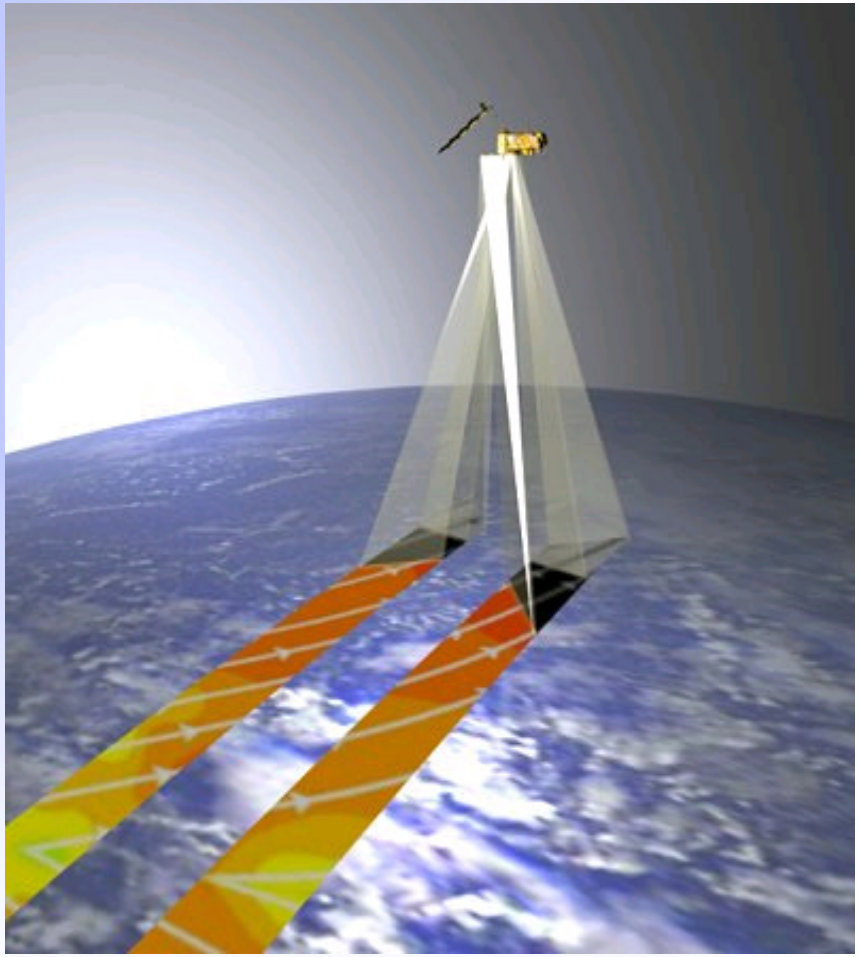
Summary

- Scatterometer winds on the TC position track were slightly positive through forecast length 72 hr.
- There were no significant improvement/degradations on the TC intensity track.
- Too early to draw conclusion on horizontal resolution.

Back Up Slides

ASCAT Overview

- The Advanced Scatterometer (ASCAT) is one of the new-generation European instruments carried on Meteorological Operational Polar Satellite (MetOp)
- Measures ocean surface wind speed and direction
- Launched aboard MetOp in October 2006



ASCAT scanning principle

http://www.esa.int/esaLP/SEMBWEG23IE_LPmetop_0.html

ASCAT Overview

- ASCAT uses radar to measure the electromagnetic backscatter from the wind-roughened ocean surface.
- The ASCAT mission employs two sets of three antennas to make observations in two 550 km wide swaths
- ASCAT products will provide two swaths of wind vectors at a resolution of 50 and 25 km.
- Two wind vector solutions instead of four (QuikSCAT and WindSat).

http://www.esa.int/esaLP/SEMBWEG23IE_LPmetop_0.html

Results from forecast verification Cont.

- Geographic forecast impact (FI) investigations (Bi et al. 2010) for ASCAT retrieval data:

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

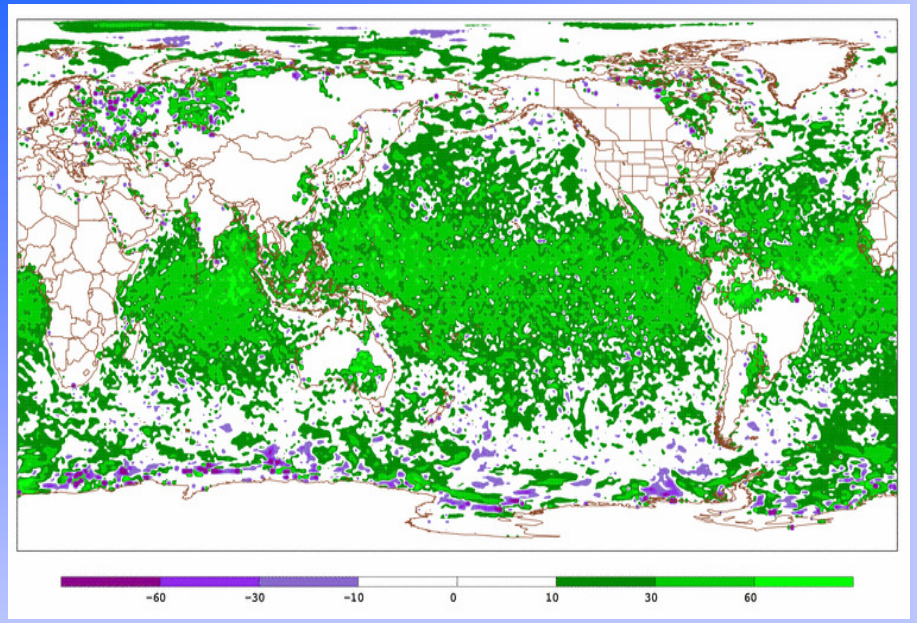
Error in control ***Error in experiment*** ***Error in experiment***

❖ *A positive FI means the forecast is better with the data type included than the control*

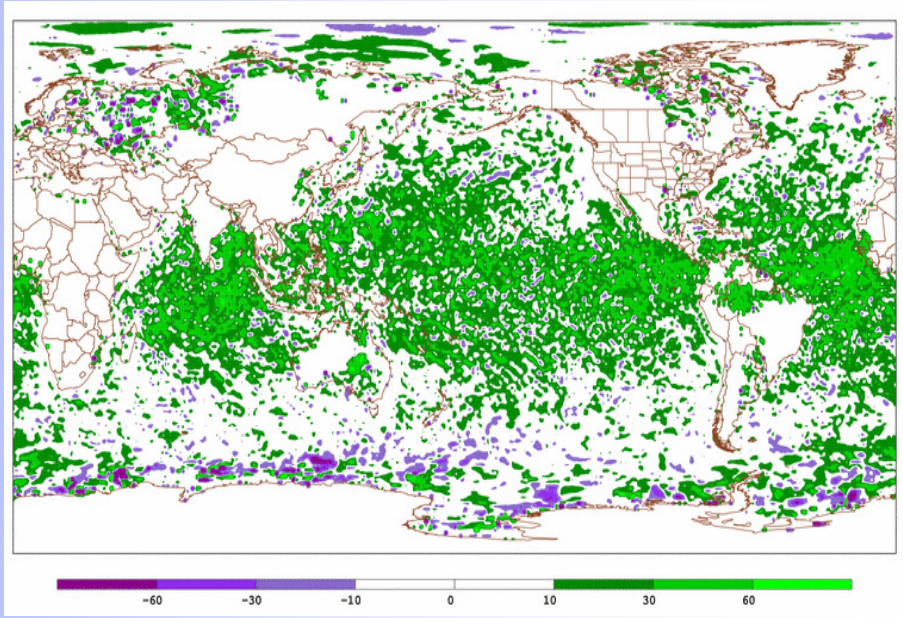
❖ *A useful tool to evaluate short term forecast skill*

❖ *Assumption is that analyses with more data are closer to the truth*

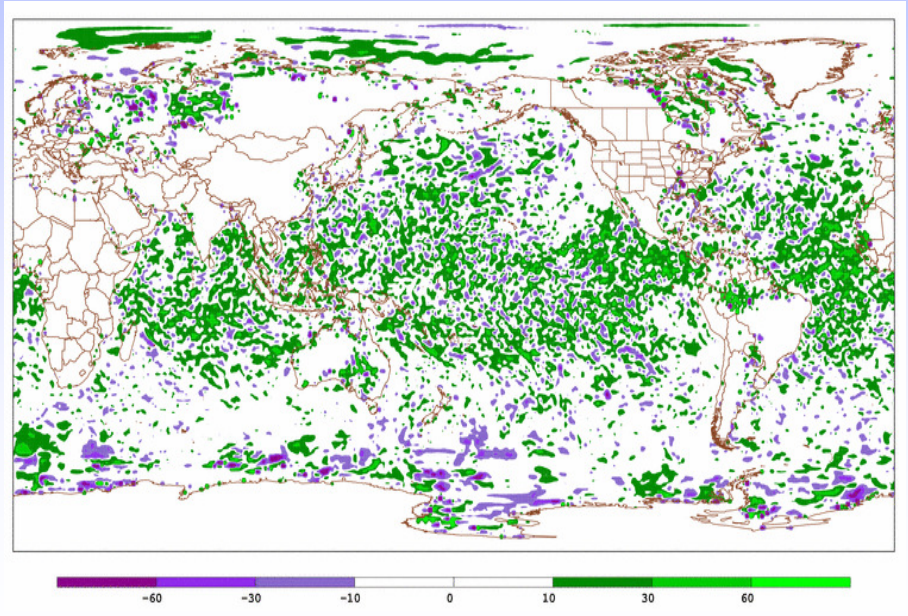
(a) 6 hour Forecast Impact on 1000hPa Temperature Aug 2008



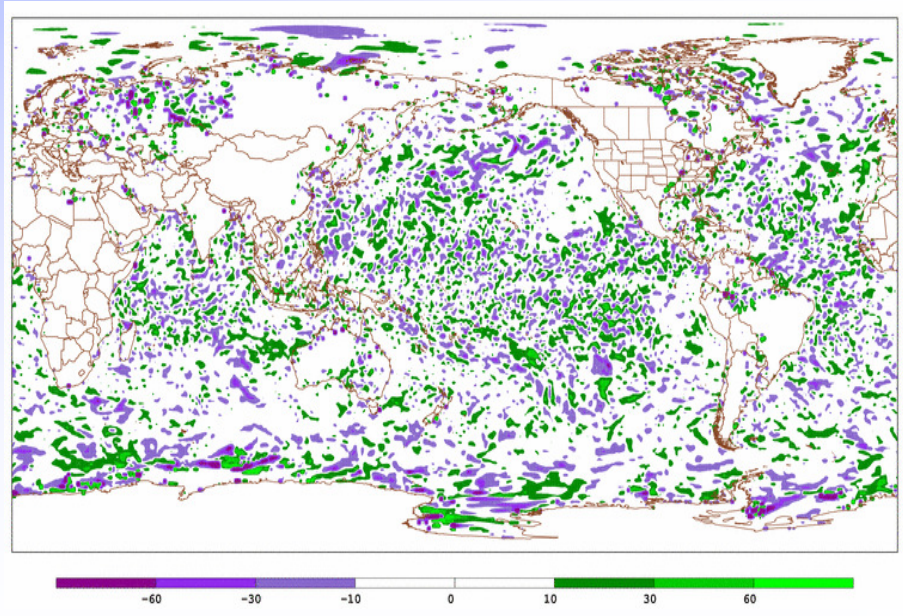
(b) 12 hour Forecast Impact on 1000hPa Temperature Aug 2008



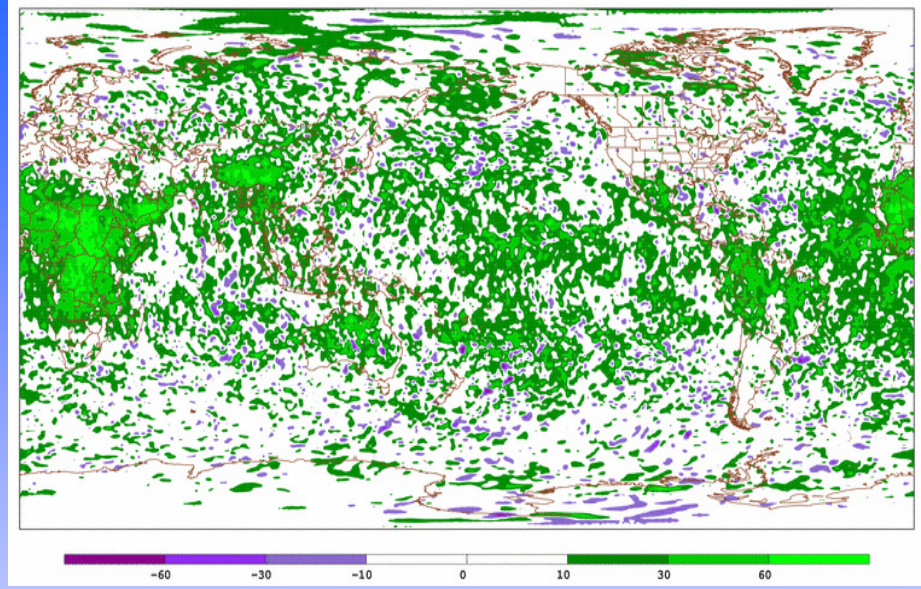
(c) 24 hour Forecast Impact on 1000hPa Temperature Aug 2008



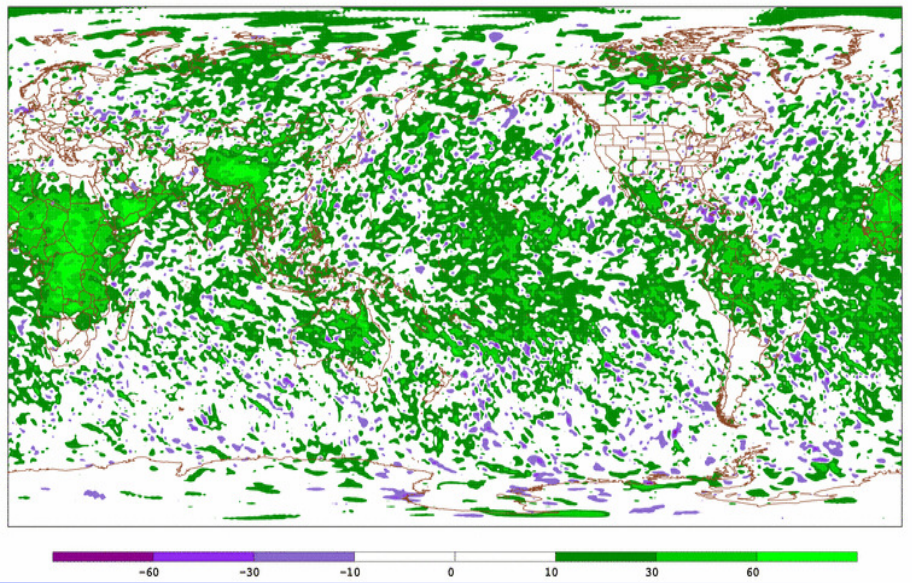
(d) 48 hour Forecast Impact on 1000hPa Temperature Aug 2008



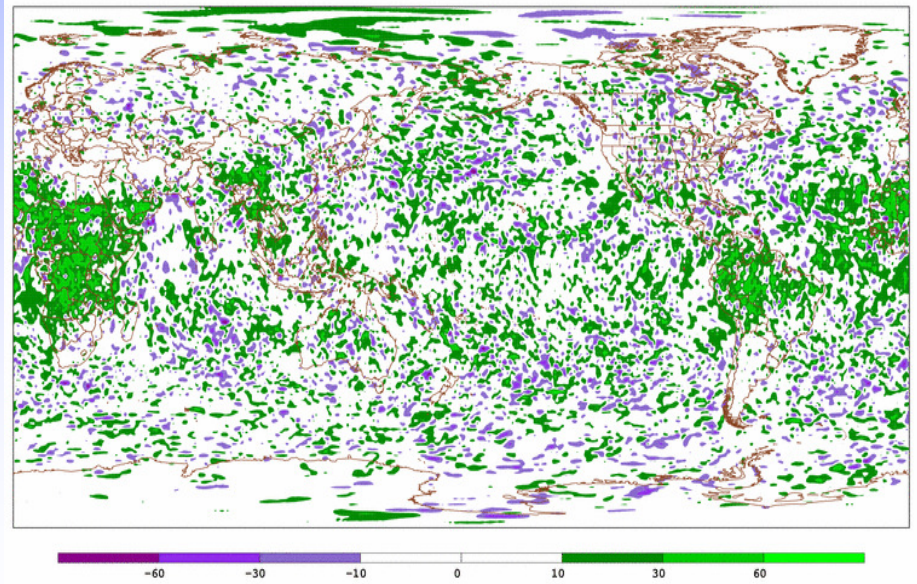
(a) 12 hour Forecast Impact on 10 m u component of winds Aug 2008



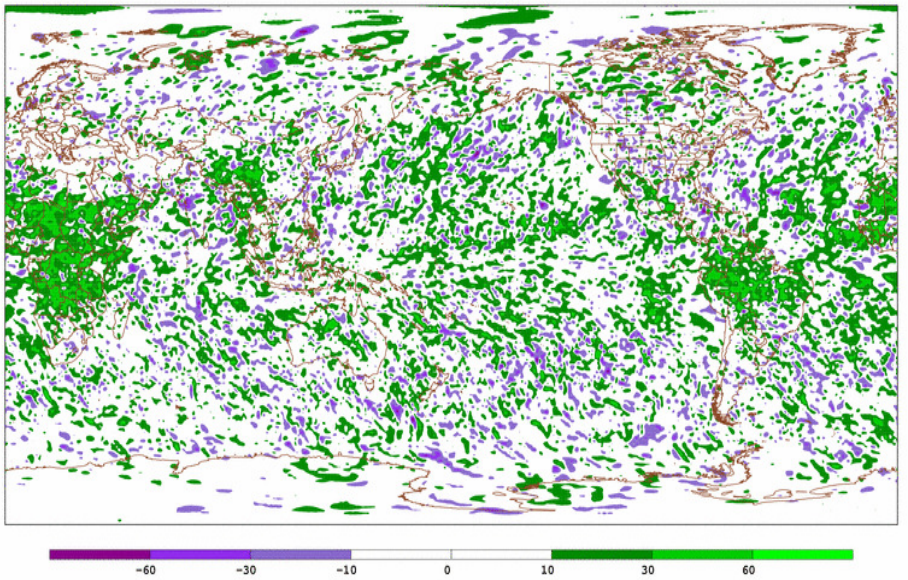
(b) 12 hour Forecast Impact on 10 m v component of winds Aug 2008



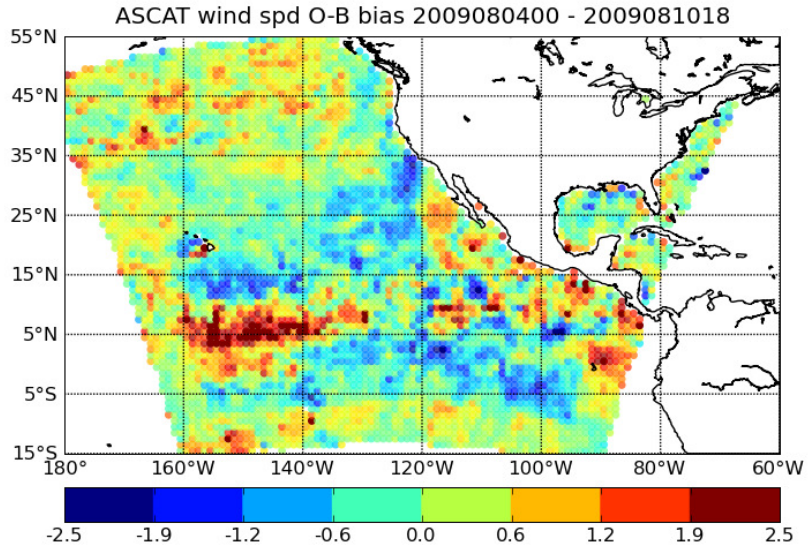
(c) 24 hour Forecast Impact on 10 m u component of winds Aug 2008



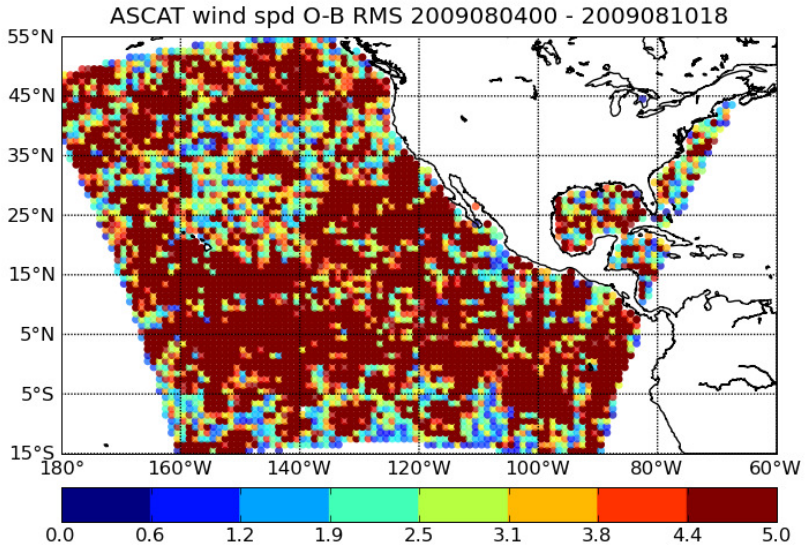
(d) 24 hour Forecast Impact on 10 m v component of winds Aug 2008



O-B bias

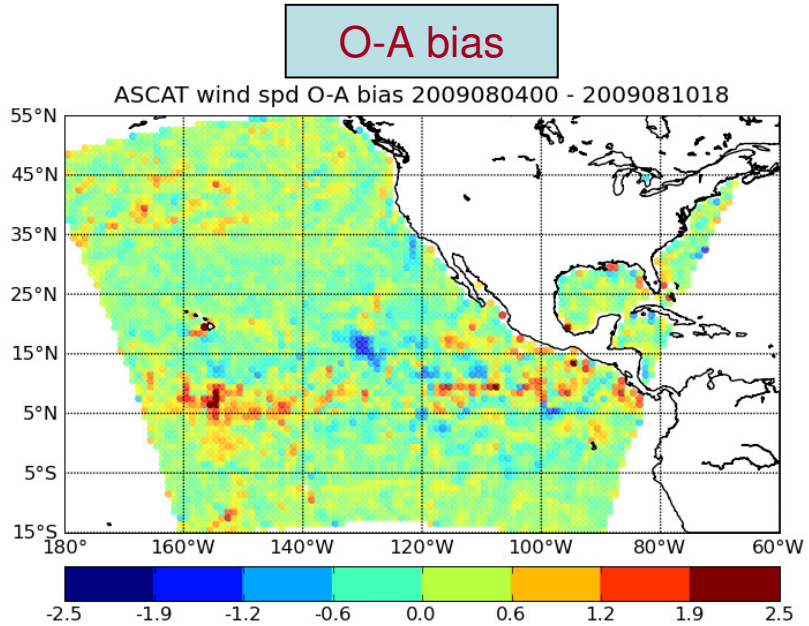


O-B RMS

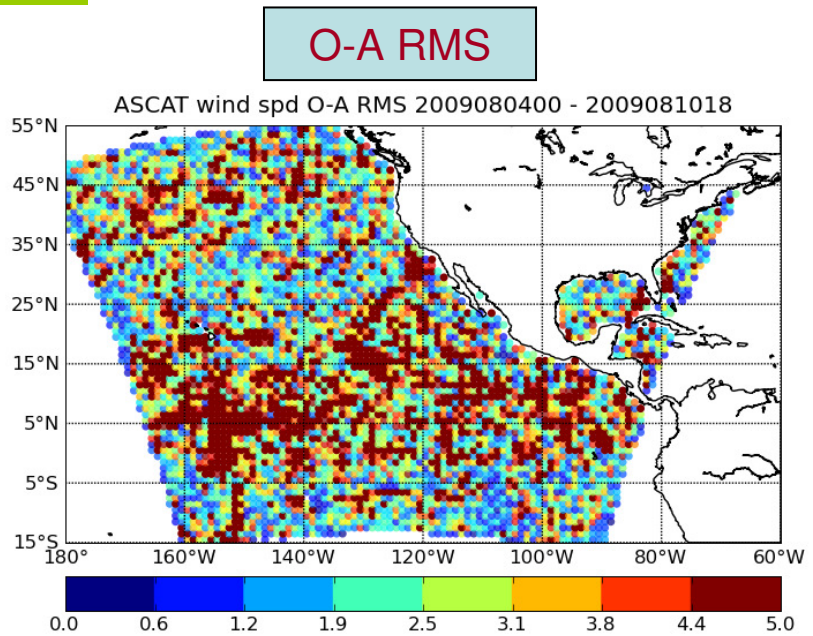


exp_0.5_thin

O-A bias



O-A RMS

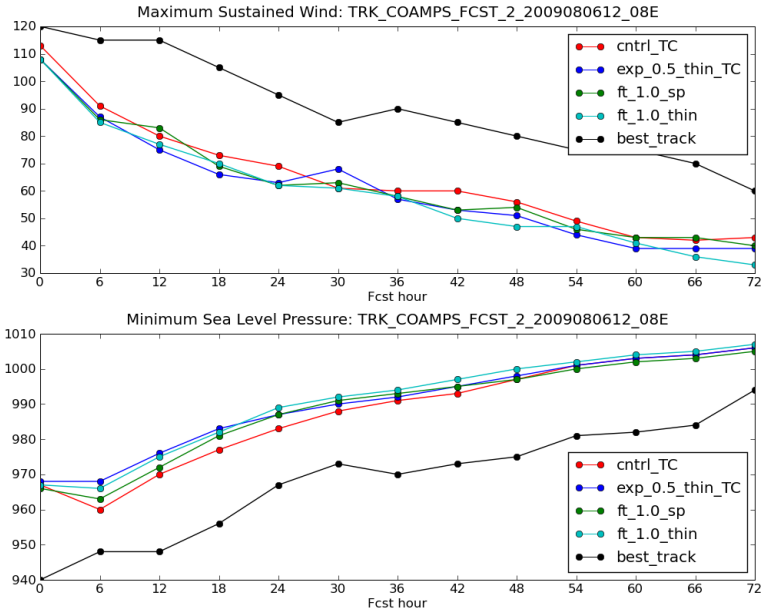


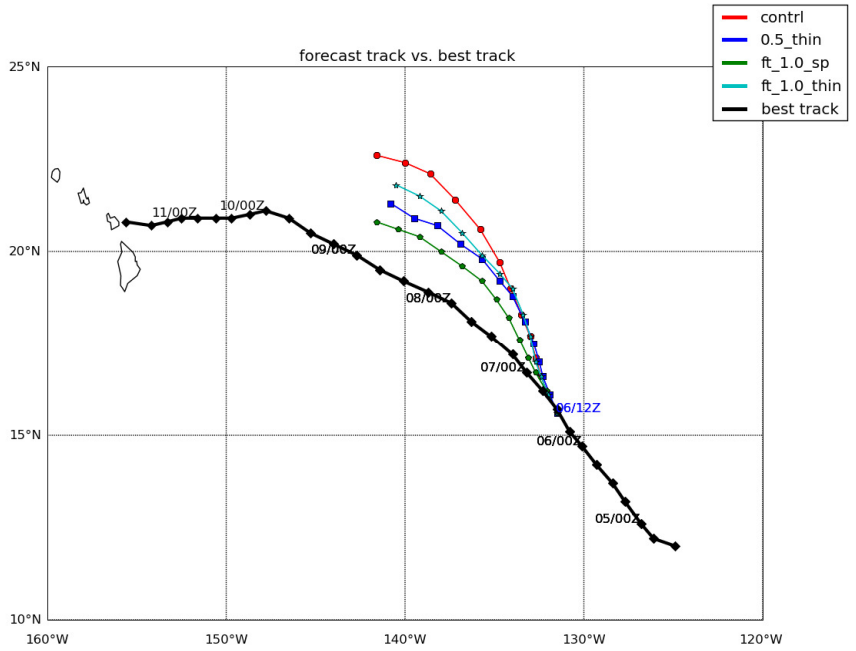
Work plan

- Test assimilation with NRL's latest algorithm.
- Continue to work on the 'optimal' horizontal resolution for satellite surface winds assimilation.
- Evaluate impact of different horizontal resolutions for feature track winds on TC track forecasts.
- Impact of SSMI TPPW and WindSat TPPW on TC track forecasts.

Comparison of intensity track and position track

2009080612 72hr forecast





Initial results on impact of different horizontal resolutions for feature track winds on TC track forecasts

Future work

- Continue working on the quality control procedures:
  - Investigate, in greater detail, regions of high bias and standard deviations for possible improvements.

- Conduct a series of denial experiment
  - Turn off all the other surface wind vectors (Windsat)