



Active Sensor Data Assimilation using GSI

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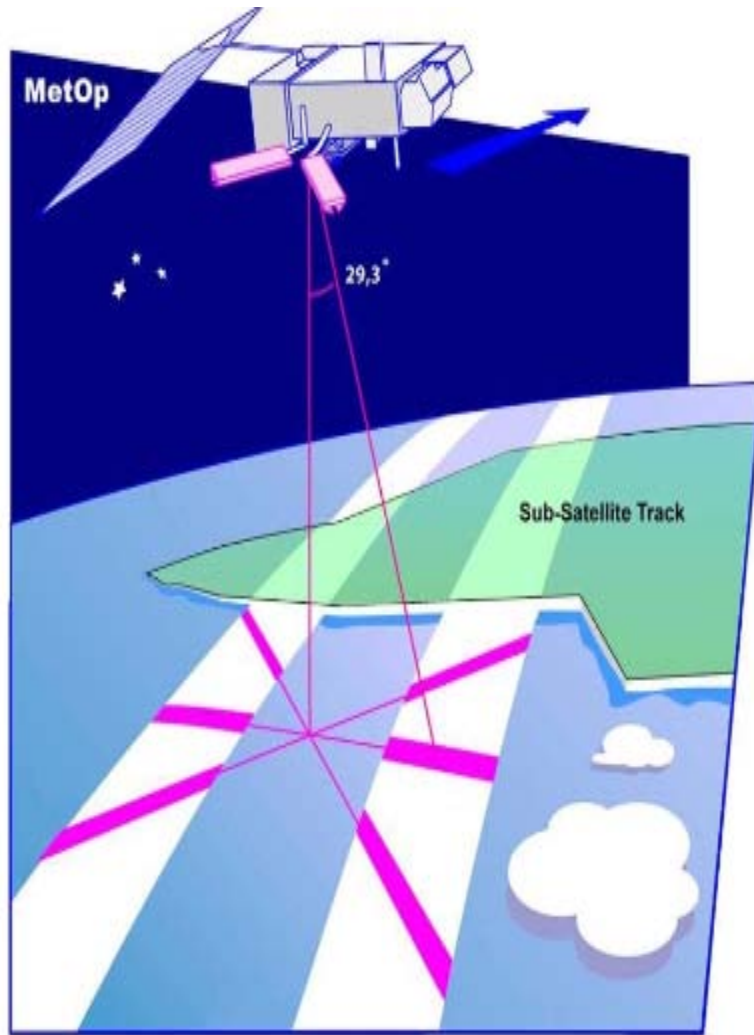


***GSI Tutorial and Workshop, Aug 5-8, College Park
08/07/13***

Outline

- Characteristics of the active sensor – scatterometers background
- Scatterometer products validation
- Choices of data assimilation (DA) related techniques
- Assimilation of scatterometers within GSI
- Forecast impact results

Advanced Scatterometer (ASCAT)



C-band (5.255 GHz)

Cross track

VV pol

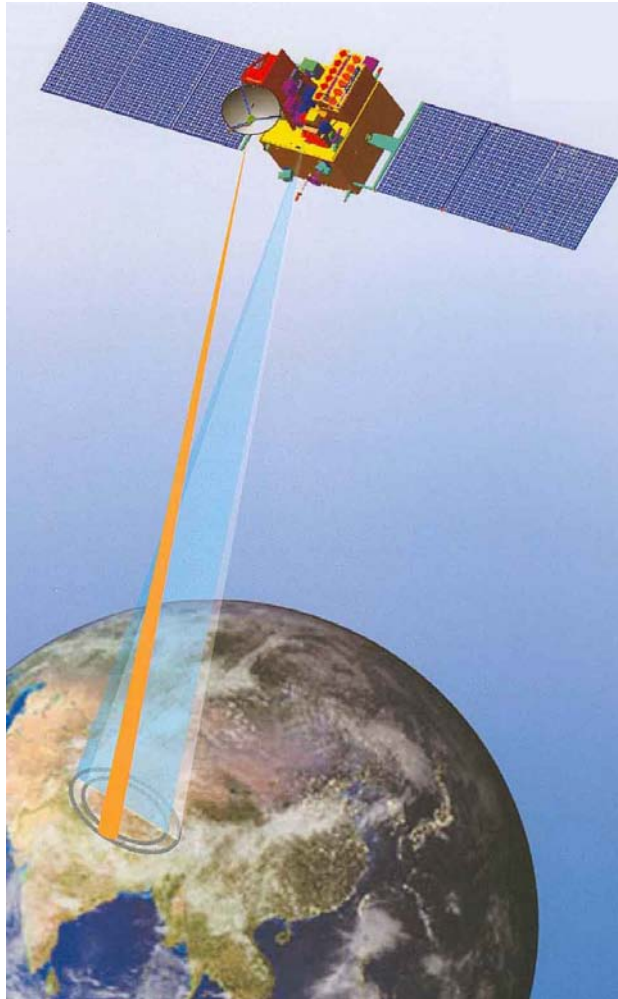
09:30(dsc)

50/25km resolution

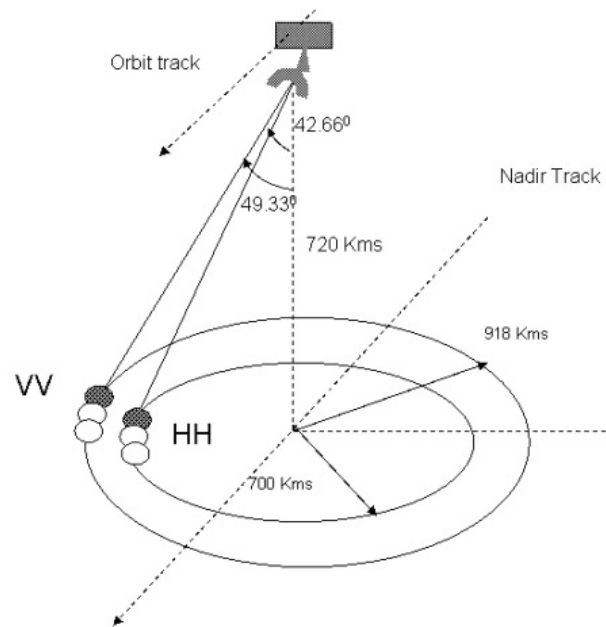
2X550 km swath



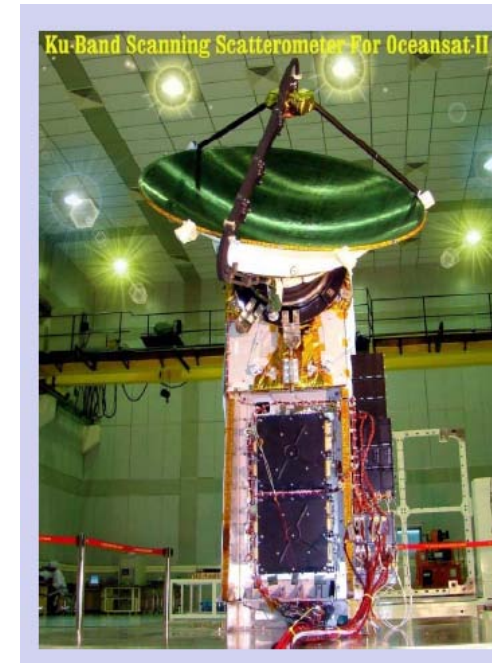
Oceansat-2 Scatterometer (OSCAT)



Ku-band (13.51 GHz)
noon (dsc)
VV and HH pol
50/25km resolution
1800 km swath



Oceansat-II Scatterometer Viewing Geometry

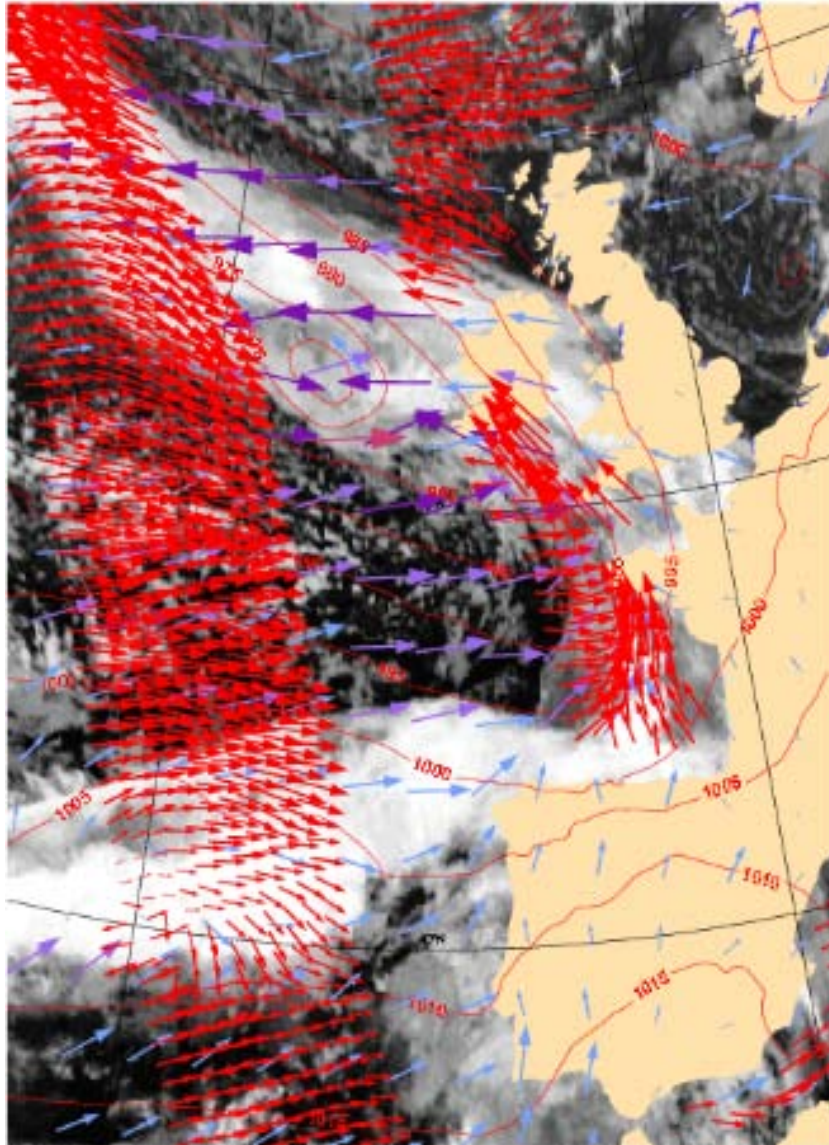


OceanSat-2 Scatterometer- OSCAT Introduction

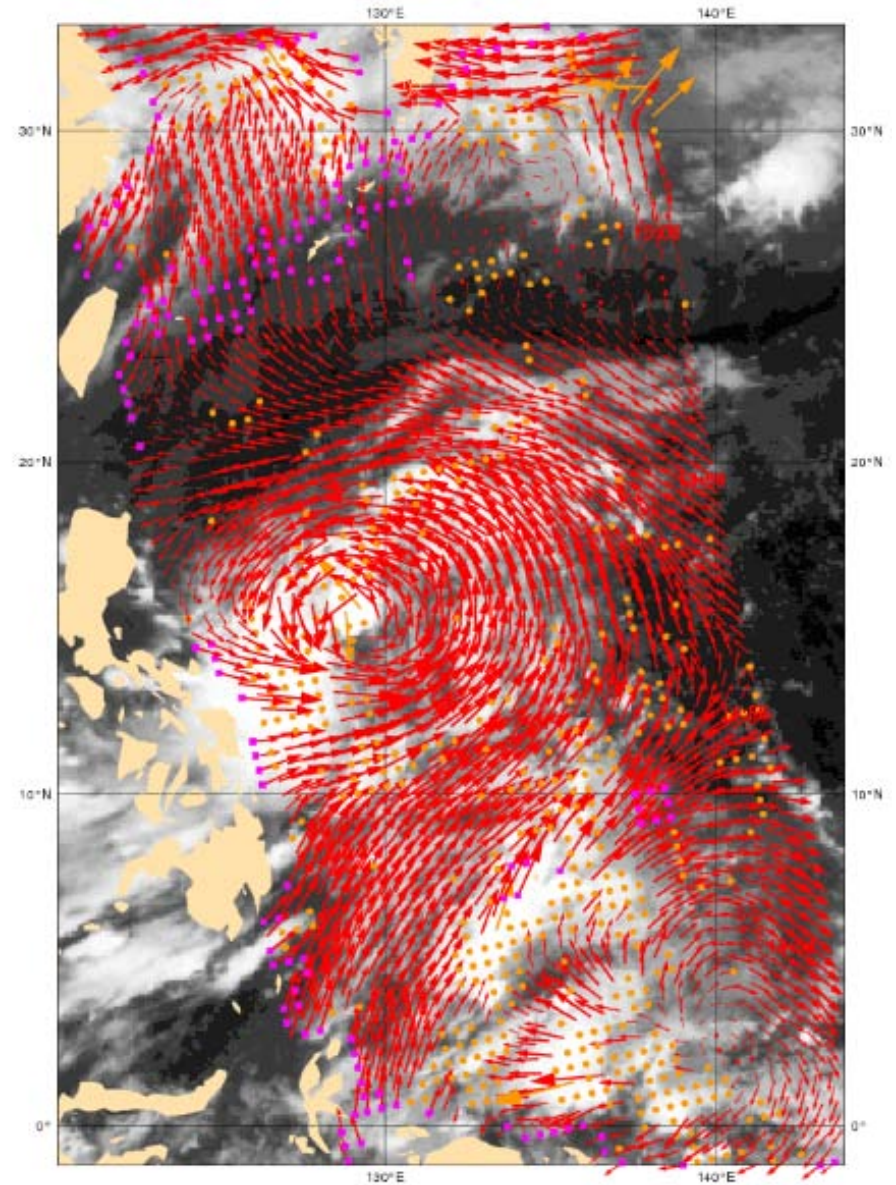
- OSCAT is a Ku-band scatterometer with similarities to QuikSCAT
 - Launched Oct 2009 on board of OceanSat-2 satellite by ISRO.
 - Provide ocean surface wind speed and direction measurements.

Parameter	OSCAT
Operational Frequency	13.515 GHz
Polarization (Inner/Outer)	HH/VV
Altitude at Equator	720 km
Orbit Near Repeat Cycle	2 days
Local time at asc/desc node	noon at desc node
HH 3dB footprint (Az x El)	26.8 x 45.1 km
Incidence Angle (Inner)	49 deg
Incidence Angle (Outer)	57 deg
Swath Diameter (Inner)	1400 km
Swath Diameter (Outer)	1836 km

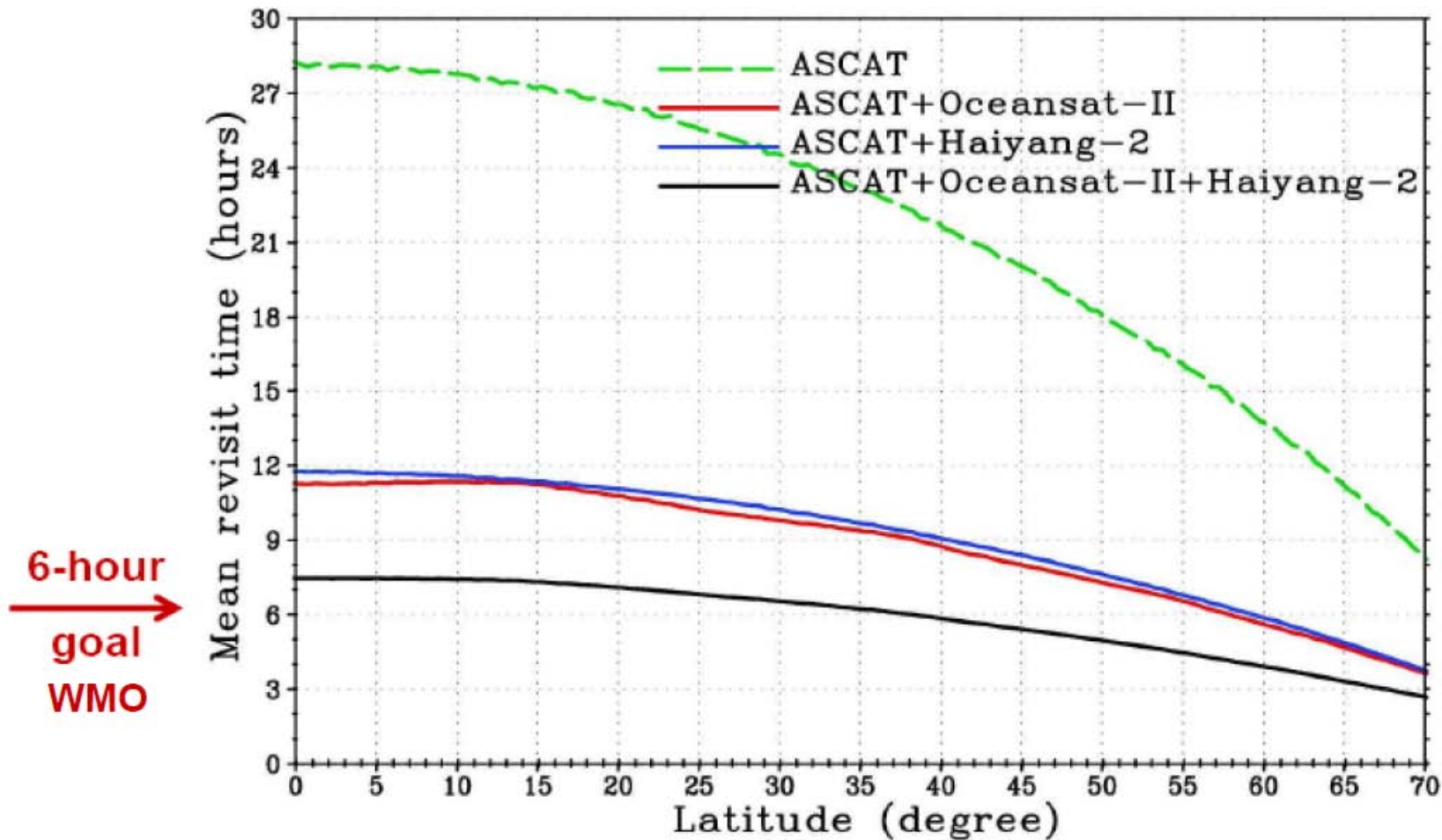
ASCAT Winds



OSCAT Winds



Timely sharing of data enables a significant reduction in revisit time

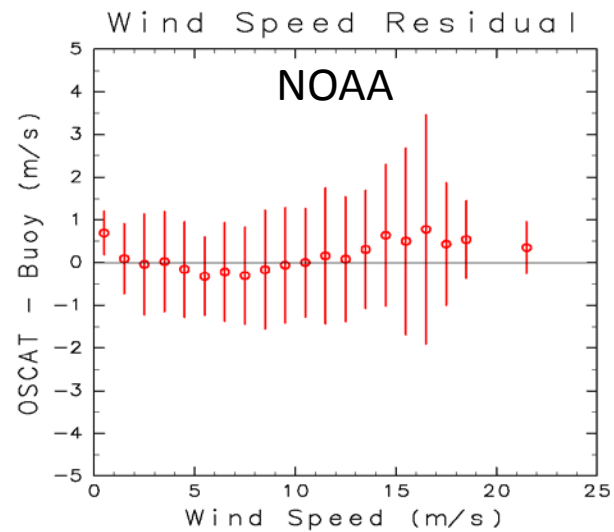
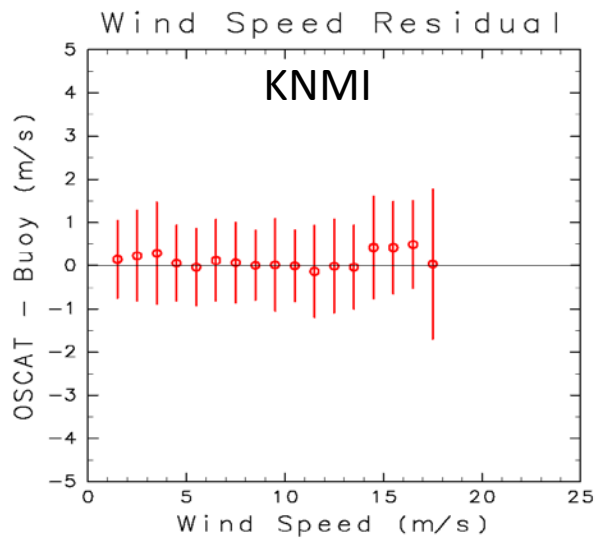
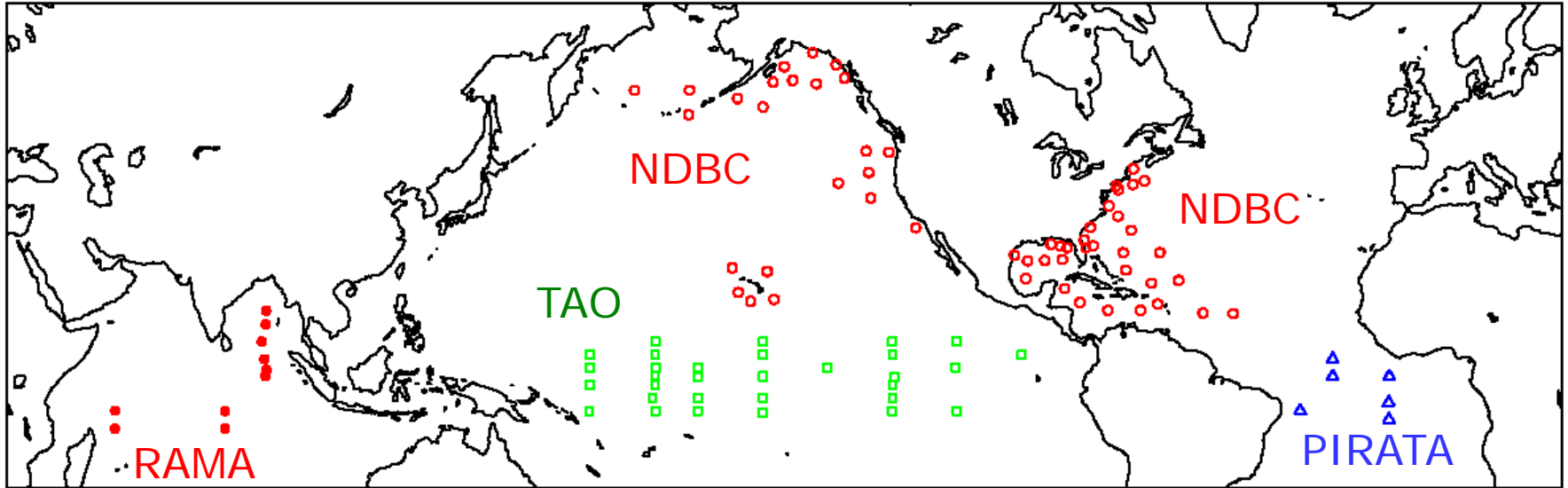


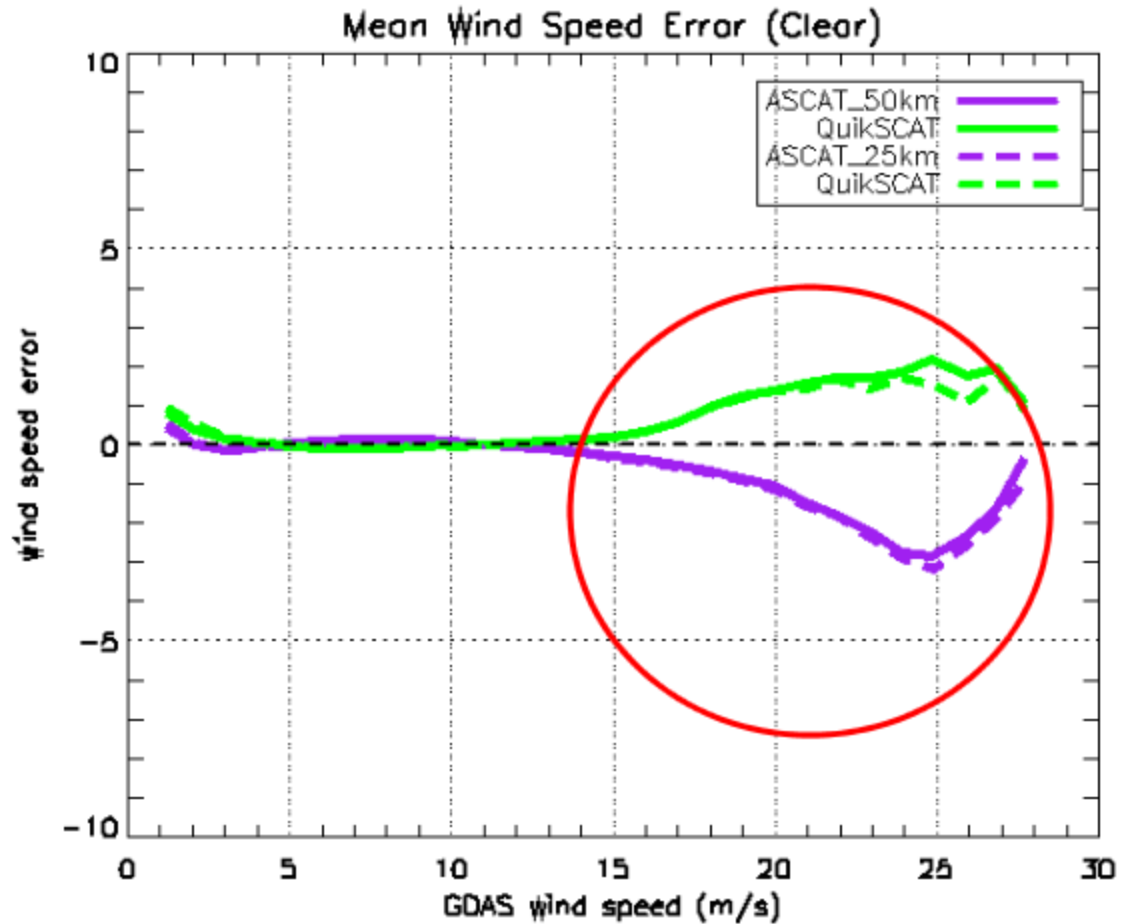
Liu et al. 2007, Int. J. of Remote Sensing

Scatterometer Products Validation

- Collocation with buoy, ship data.
- Validation against GDAS, ECMWF 10 meter winds.
 - Speed
 - Direction

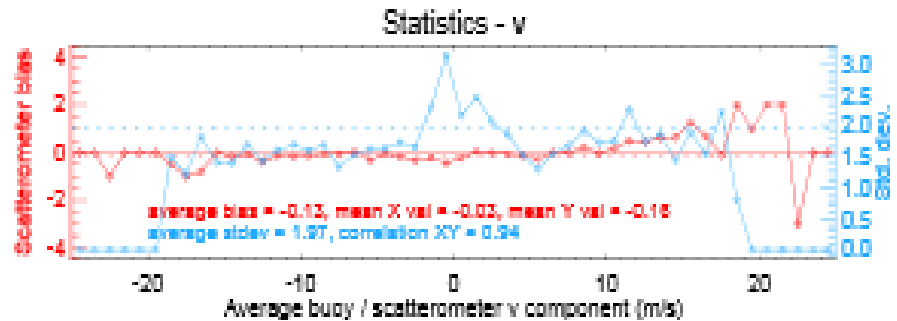
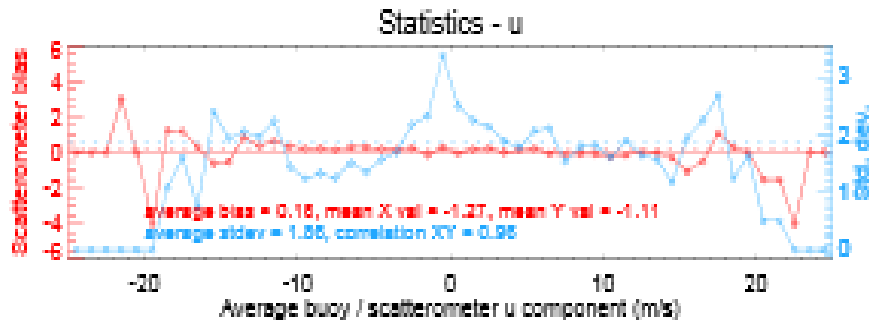
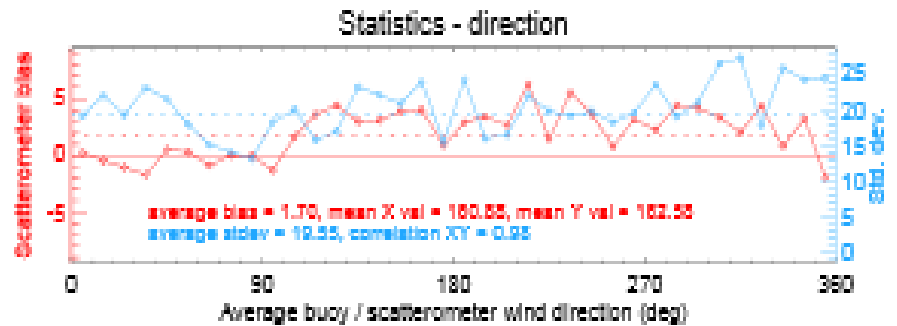
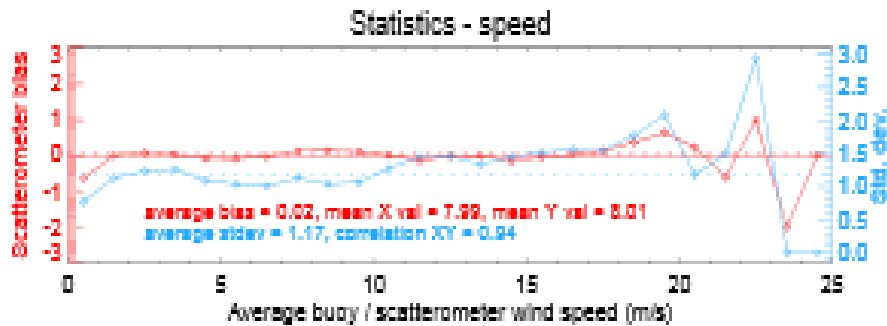
Buoy Data for Comparison with OSCAT





<http://coaps.fsu.edu/scatterometry/meeting/docs/2008/new/jelenak.pdf>

OSCAT Validation with Buoy data



— stdev — bias

Winds Assimilation in GSI

$$J = \mathbf{x}^T \mathbf{B}^{-1} \mathbf{x} + (\mathbf{H} \mathbf{x} - \mathbf{y})^T \mathbf{R}^{-1} (\mathbf{H} \mathbf{x} - \mathbf{y})$$

\mathbf{x} : Vector of analysis increments.

\mathbf{R} : observation error + representativeness error, since the (spatial) context of observation is generally different from state variables.

\mathbf{B} : random background error, contains, e.g., spatial correlations between errors of neighbouring state variable.

\mathbf{H} : transformation operator from the analysis variable to the form of the observations.

Winds Assimilation in GSI (cont'd)

- State Vector: U, V
 - Needed for many routines
 - setupw.f90, read_sfcwnd.f90
 - u,v updated by calculating derivations of streamfunction and velocity potential
- Control Vector: Stream function, Velocity potential
- H: transformation operator from the analysis variable to the form of the observations.
 - Interpolation to ob location/time
 - 3-D sigma interpolation reduction below bottom level using model factor

Steps towards assimilating OSCAT in GSI

Steps	Action
I	Receive and archive OSCAT WMO BUFR data (50KM) from KMNI daily.
II	Convert OSCAT BUFR data to EMC tanks
III	Generate 6 hour NCEP OSCAT dumps (OSCAT is not part of PREPBUFR).
III	Read OSCAT bufr dump directly from GSI. (new subroutine read_sfcwnd.f90 added)
V	Modify setupw.f90 and add QC for OSCAT. (291 has been assigned to OSCAT for global error table)
VI	Two Season OSCAT assimilation run on Zeus for impact study.

Scripts modifications for submitting OSCAT job

- **Set paths to BUFR data:**
 - `COMDMP='$DSDUMP/$CDATE/${CDUMP},$GFSDUMP/$CDATE/${CDUMP},/scratch1/portfolios/NCEPDEV/jcsda/noscrub/Li.Bi/oscat'`
- **Adding new data entry to convinfo file:**
 - `lotype type sub iuse twindow numgrp ngroup nmitter gross ermax ermin var_b var_pg ithin rmesh pmesh npred`
 - `uv 291 0 1 3.0 0 0 0 5.0 6.1 1.4 5.0 0.000500 1 100. 1200. 0`
- **Adding new data entry to obs error table:**
 - `291 OBSERVATION TYPE`
 - `0.11000E+04 0.10000E+10 0.10000E+10 0.35000E+01 0.10000E+10 0.10000E+10`
 - `0.10500E+04 0.10000E+10 0.10000E+10 0.35000E+01 0.10000E+10 0.10000E+10`
 - `0.10000E+04 0.10000E+10 0.10000E+10 0.35000E+01 0.10000E+10 0.10000E+10`
 - `0.95000E+03 0.10000E+10 0.10000E+10 0.35000E+01 0.10000E+10 0.10000E+10`
 - `0.90000E+03 0.10000E+10 0.10000E+10 0.35000E+01 0.10000E+10 0.10000E+10`
 - `0.85000E+03 0.10000E+10 0.10000E+10 0.35000E+01 0.10000E+10 0.10000E+10`
 - `....`
- **Namelist update:**
 - `&OBS_INPUT`
 - `dfile(05)='prepbuf', dtype(05)='uv', dplat(05)=' ', dsis(05)='uv', dval(05)=0.0, dthin(05)=0, dsfcalc(05)=0,---`
 - `---`
 - `dfile(76)='oscatbuf', dtype(76)='uv', dplat(76)=' ', dsis(76)='uv', dval(76)=0.0, dthin(76)=0, dsfcalc(76)=0 ...`

Scripts modifications for submitting OSCAT job (cont'd)

- **Namelist update (exglobal_analysis.sh) :**
 - &OBS_INPUT
 - dfile(05)='prepbuf', dtype(05)='uv', dplat(05)=' ', dsis(05)='uv', dval(05)=0.0, dthin(05)=0, dsfcalc(05)=0,---
 - ---
 - dfile(76)='oscatbuf', dtype(76)='uv', dplat(76)=' ', dsis(76)='uv', dval(76)=0.0, dthin(76)=0, dsfcalc(76)=0 ...
- **Rlist modifications:**
 - Adding new data to anal step:
 - */*/anal/DMPI = oscatw.\$CDUMP.\$CDATE
 - Adding new data to eobs step:
 - */gdas/eobs/DMPI = oscatw.\$CDUMP.\$CDATE
- **Append_enkf.rlist update:**
 - */gdas/eobs/DMPI = oscatw.\$CDUMP.\$CDATE
- **Anal.sh update:**
 - export OSCATBF=\${OSCATBF:-oscatw.\$CDUMP.\$CDATE}

Scripts modifications for submitting OSCAT job (cont'd)

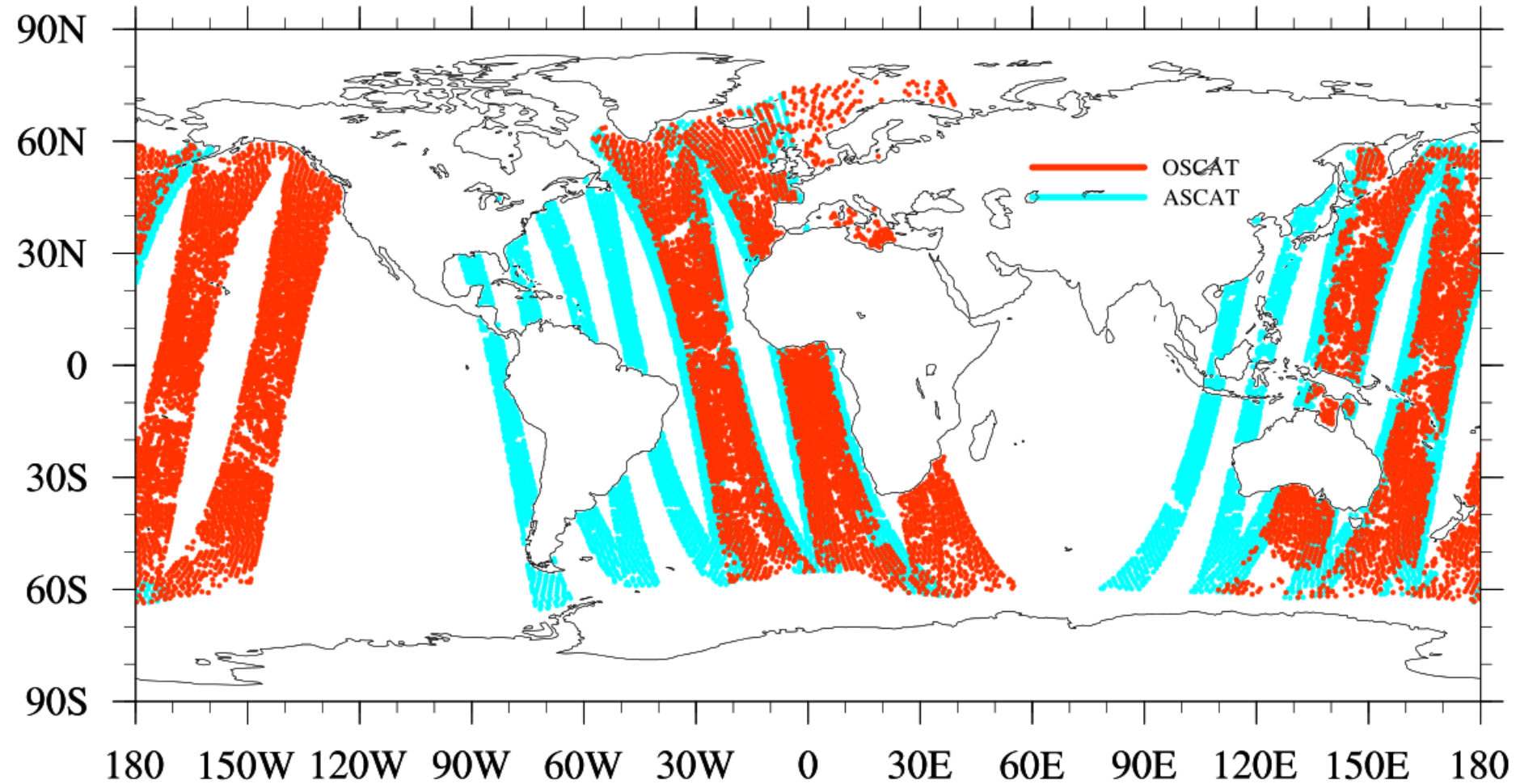
- **GSI src code change:**

- Read_sfcwnd.f90
- Setupw.f90

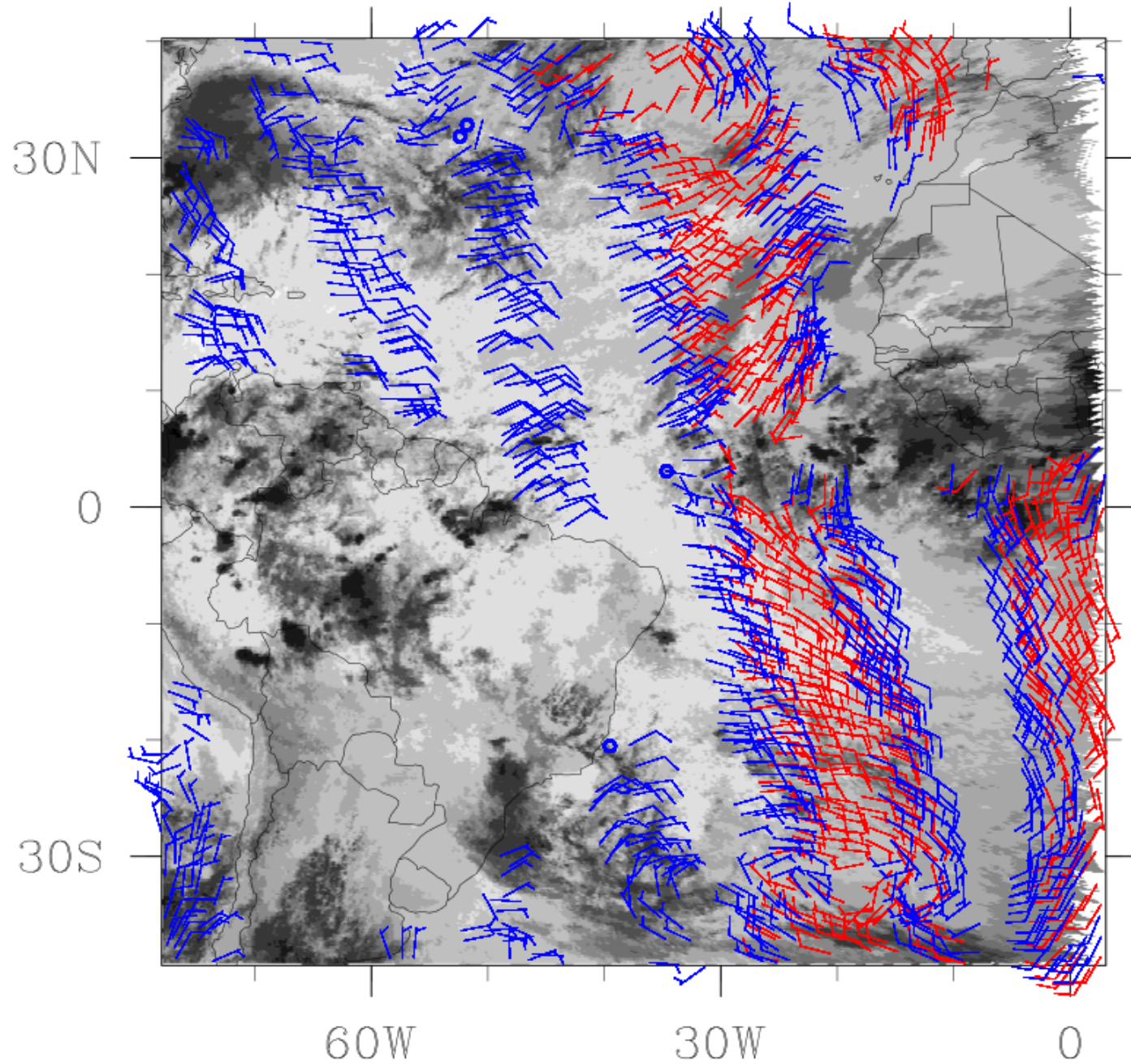
- **Checking GSI stats files:**

```
– o-g 01 uv 291 0000 count 6489 1658 0 0 0 0 0 0 0 0 0 0 8147
– o-g 01 uv 291 0000 bias 0.27 -0.41 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.14
– o-g 01 uv 291 0000 rms 1.92 2.13 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 1.96
– ....
– o-g 01 uv rej 291 0000 count 1013 313 0 0 0 0 0 0 0 0 0 0 0 1326
– o-g 01 uv rej 291 0000 bias 0.34 -0.27 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.20
– o-g 01 uv rej 291 0000 rms 11.86 19.02 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 13.89
– ...
```

ASCAT/OSCAT Orbit +/- 3h 2012052500



ASCAT/OSCAT Wind Vectors



Quality Control

- Current QC used for OSCAT assimilation
 - Data within +/-3 hours synoptic window.
 - High wind speed cut off:
 - 20m/s
 - u and v component check:
 - 6m/s
 - Vector Check $\sqrt{\frac{(\delta u)^2 + (\delta v)^2}{(speed)^2}}$:
 - 1.0

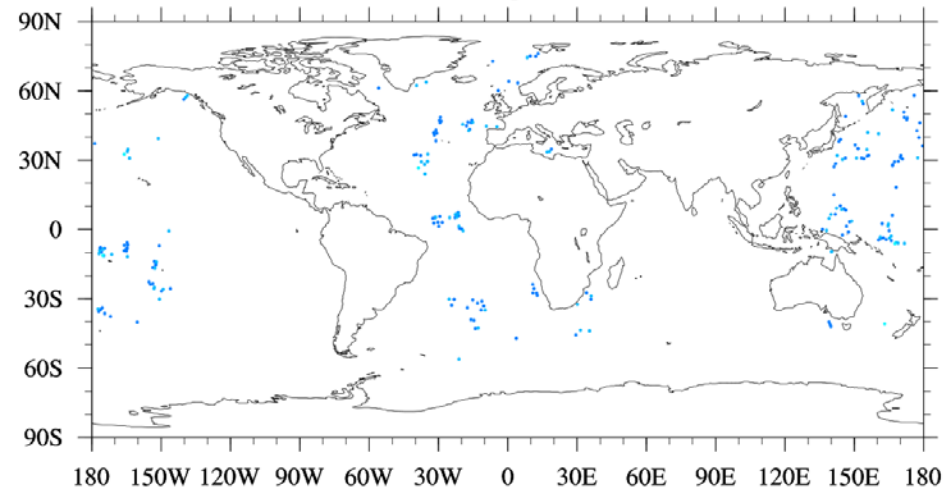
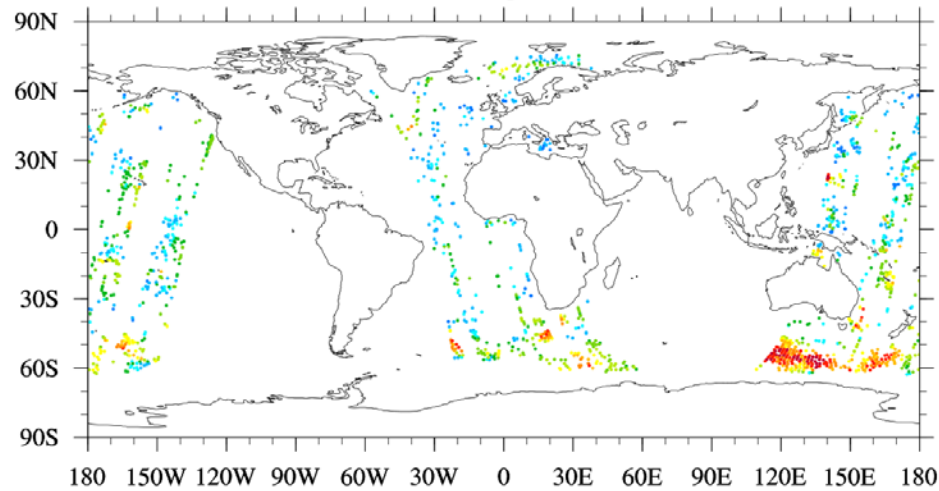
9332 obs assimilated, 1628 obs rejected, 17.4% rejected rate

2012052500 rejected speed loop2
From 20m/s and 6m/s u/v qc check

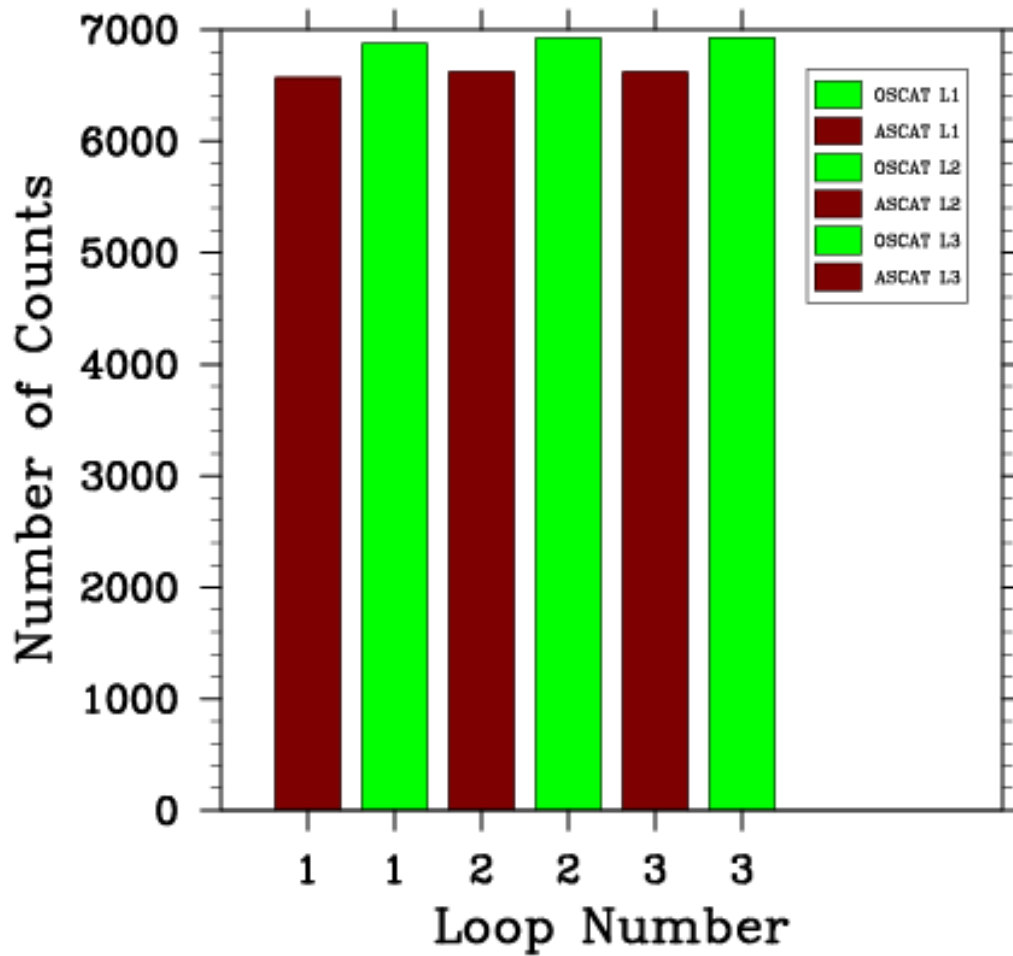
2012052500 rejected speed loop2
From 1.0 Vector qc check 727 total obs
rejected due to this check

OSCAT Wind Spd 2012052500

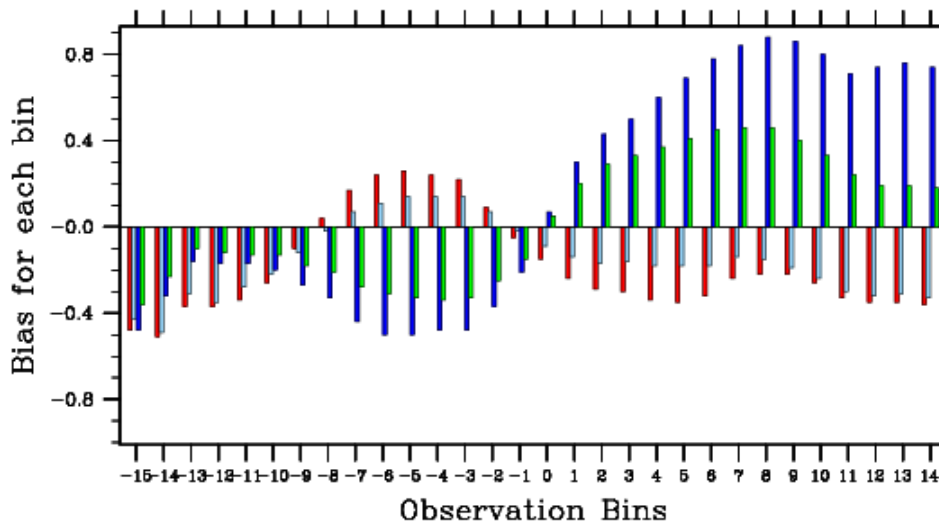
OSCAT Wind Spd 2012052500



ASCAT/OSCAT Data Counts For Each Loop

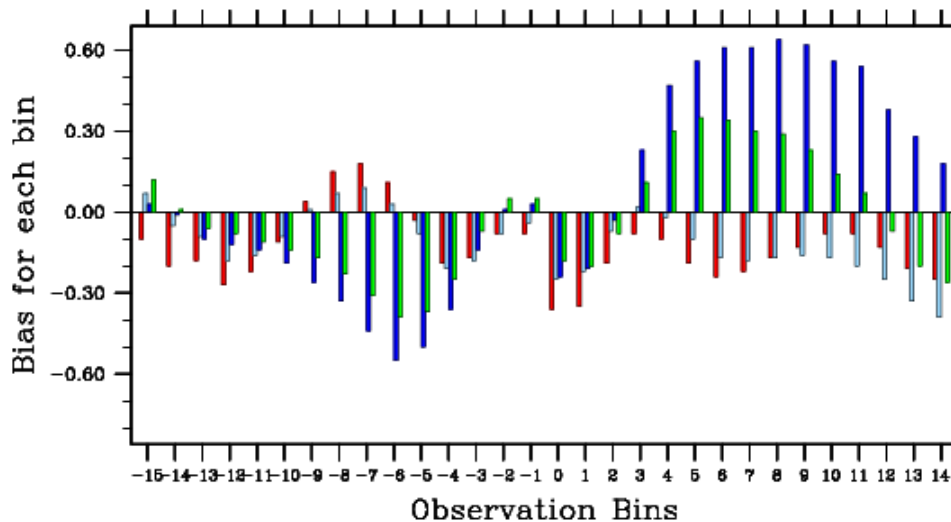


OSCAT U/V Bias Stats 1-30 June 2012



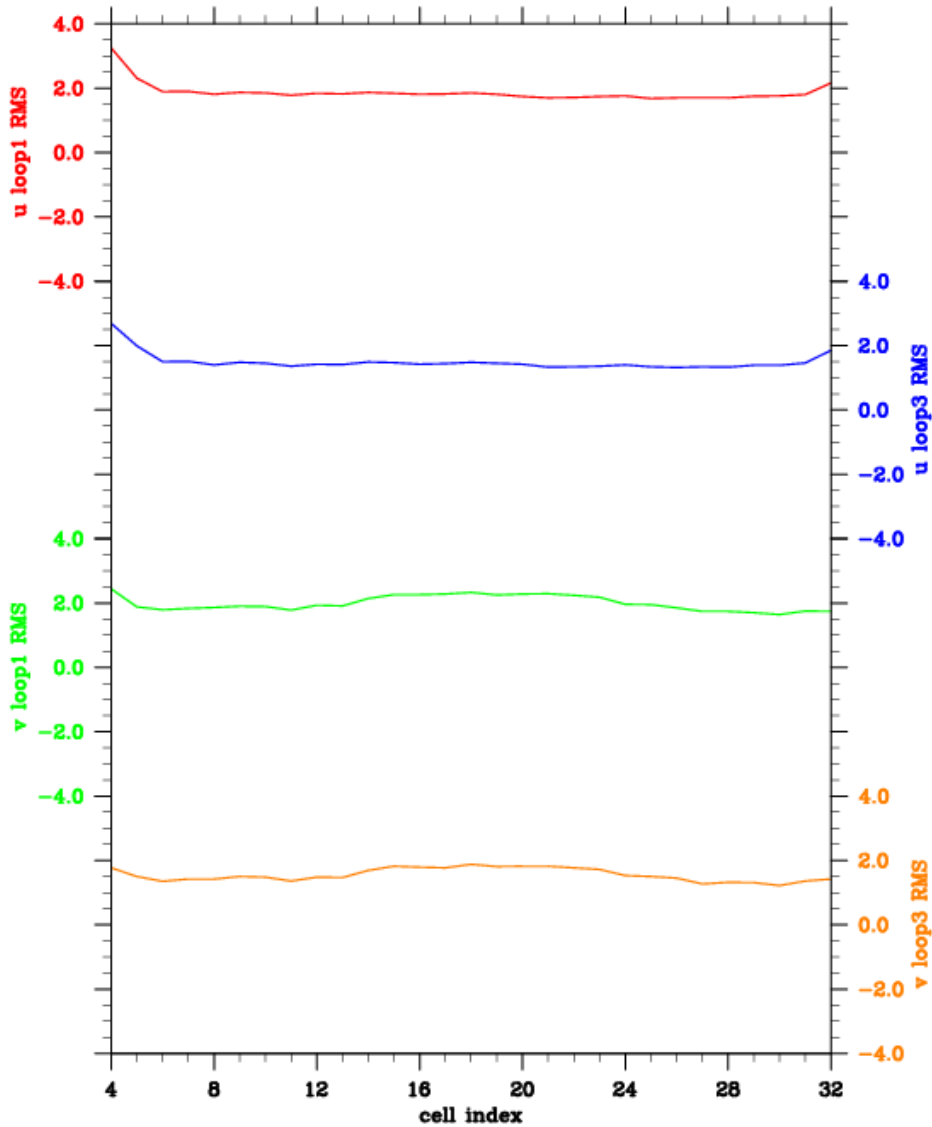
U/V bias histogram with winds assimilated

ASCAT U/V Bias Stats 1-30 June 2012

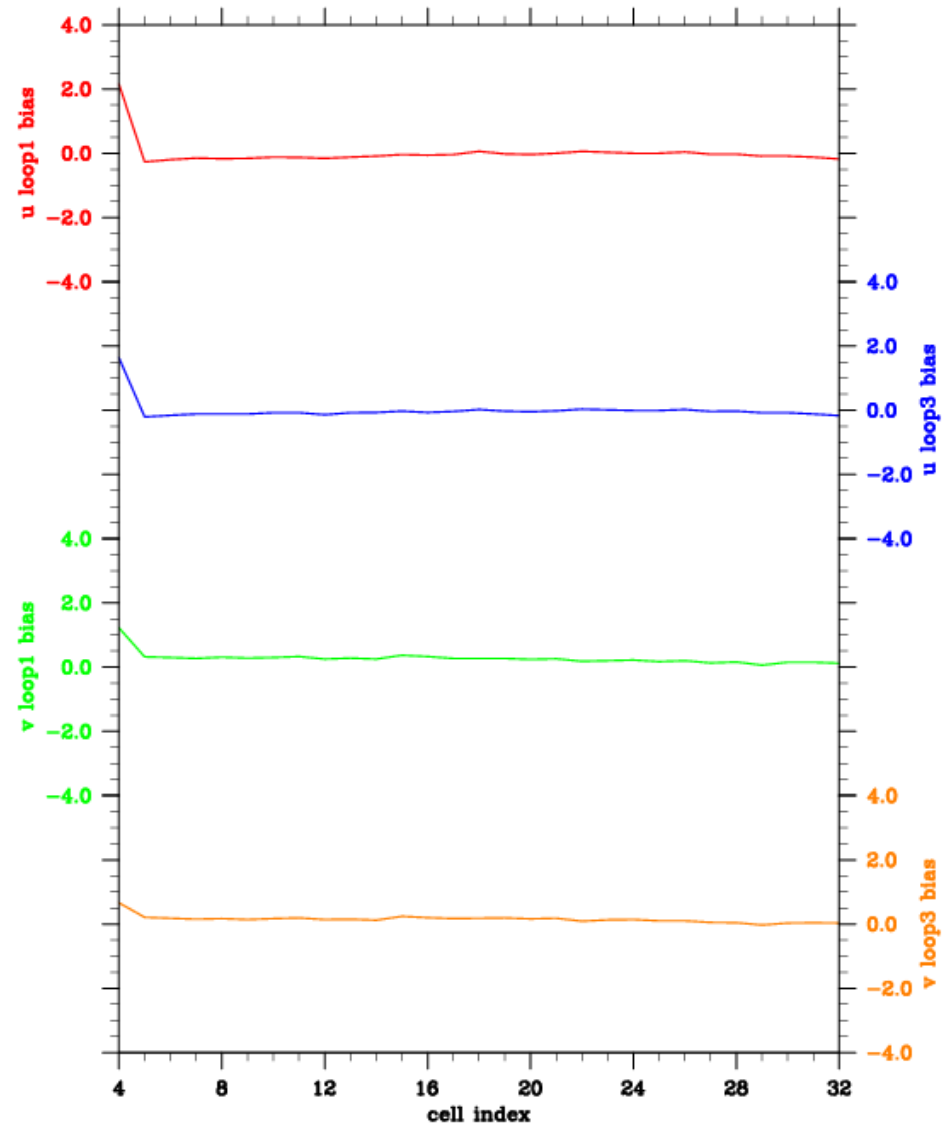


Assimilated OSCAT U/V vs. Model Analysis - by Cell Number

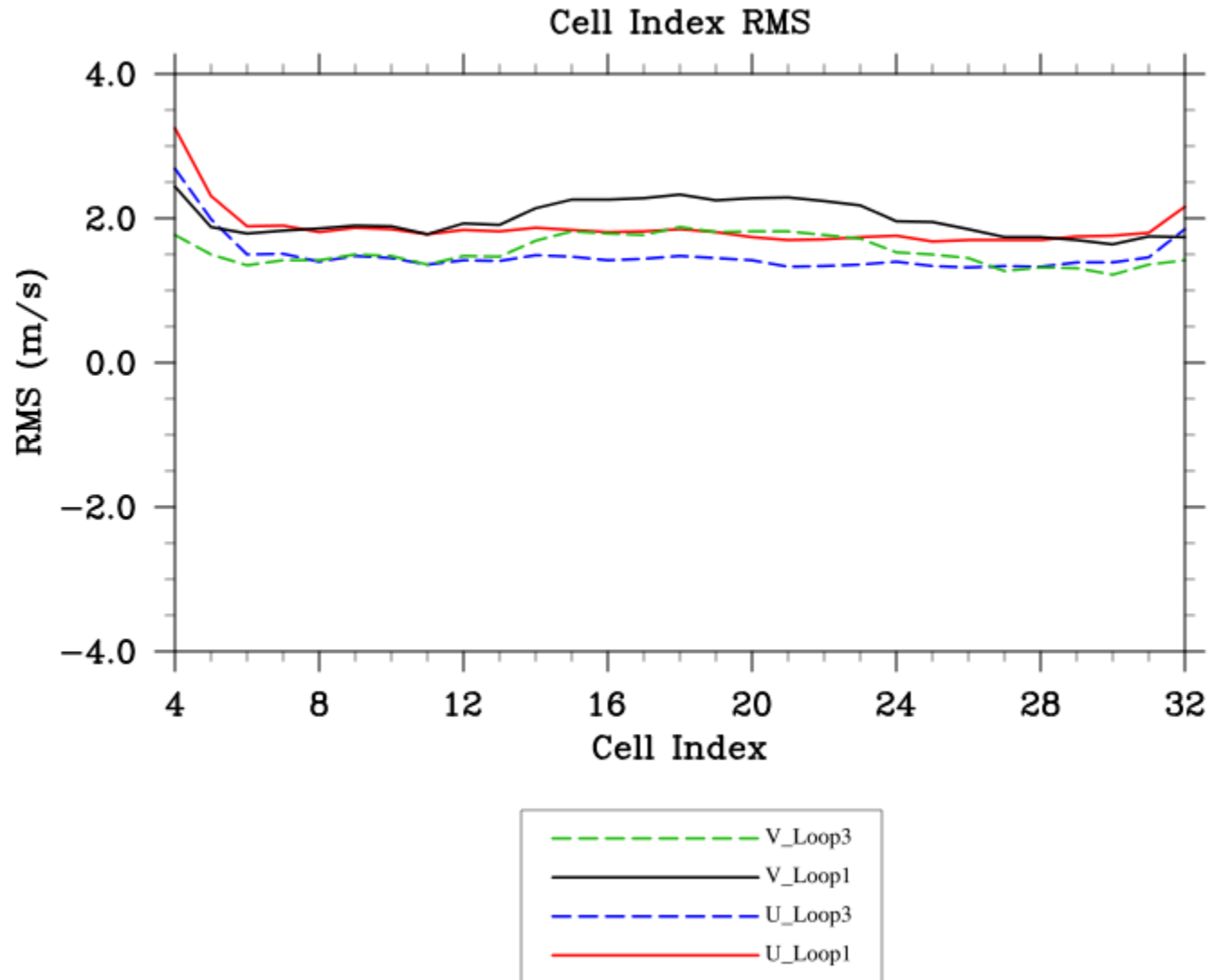
Cell Index RMS



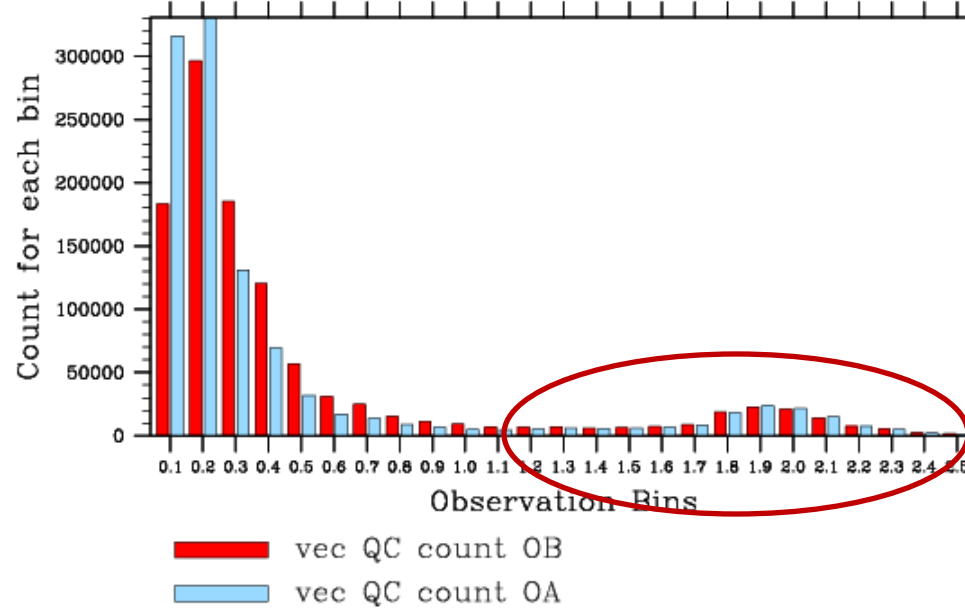
Cell Index Bias



Assimilated OSCAT U/V vs. Model Analysis - by Cell Number



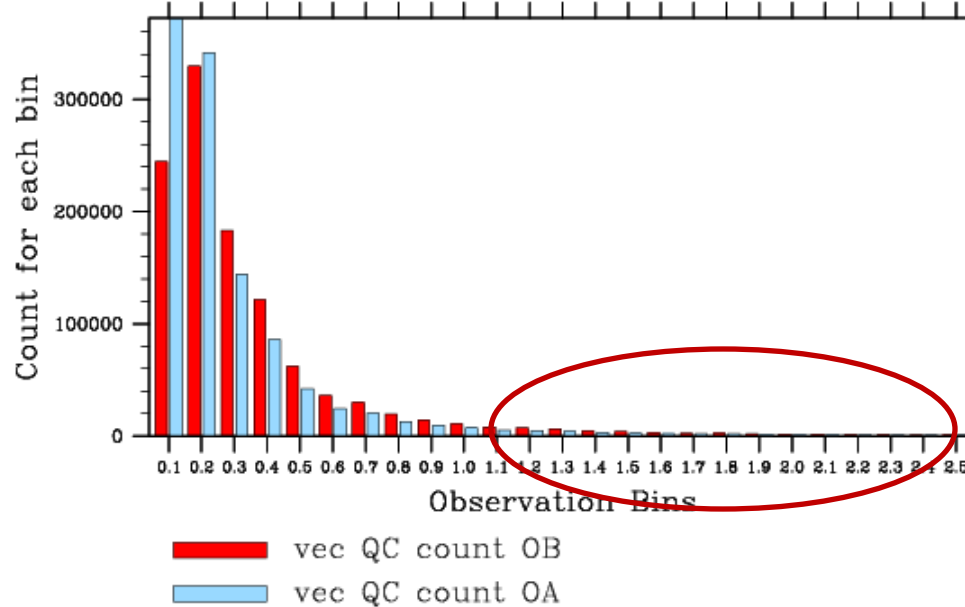
OSCAT Vector QC Total Counts Stats 1-30 June 2012



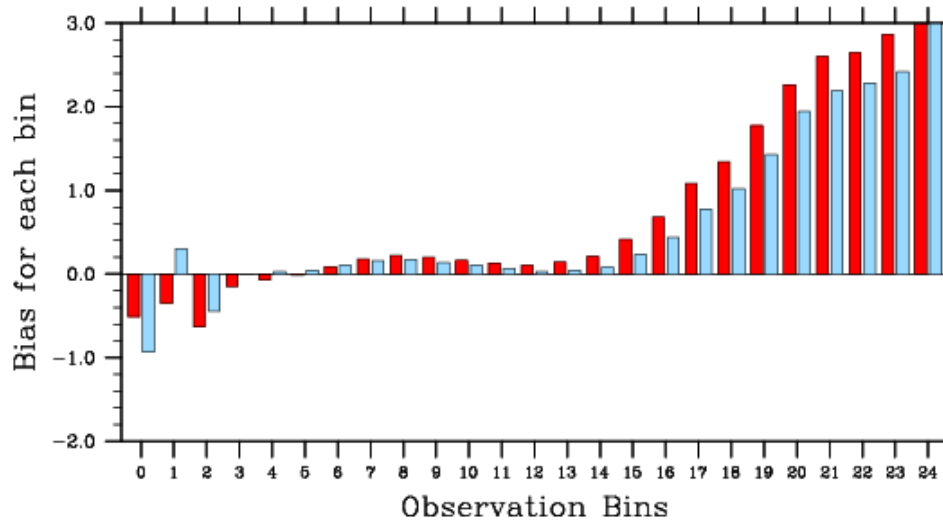
Vector Check QC

Before
Assimilation

ASCAT Vector QC Total Counts Stats 1-30 June 2012



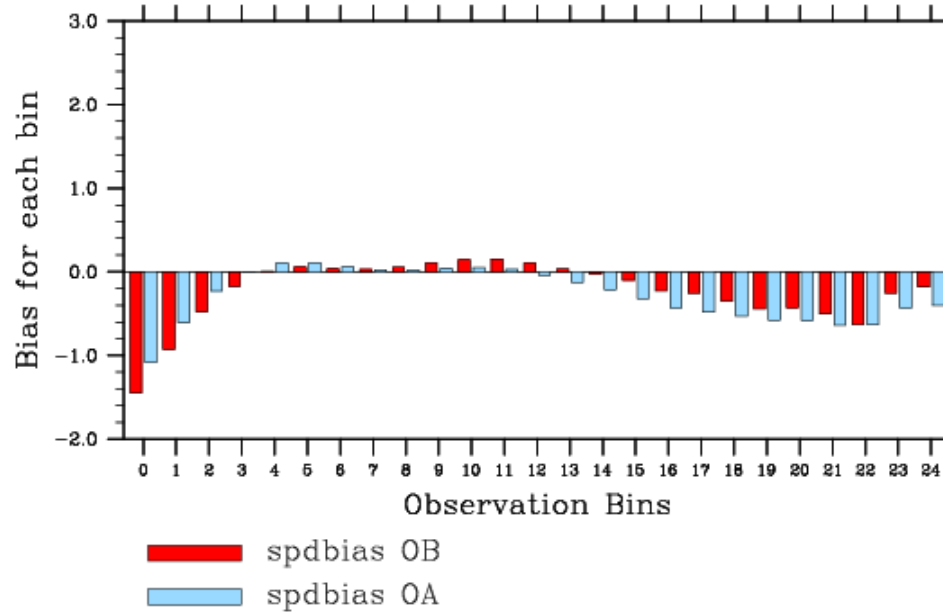
OSCAT Spd Bias Stats 1-30 June 2012



Before QC:

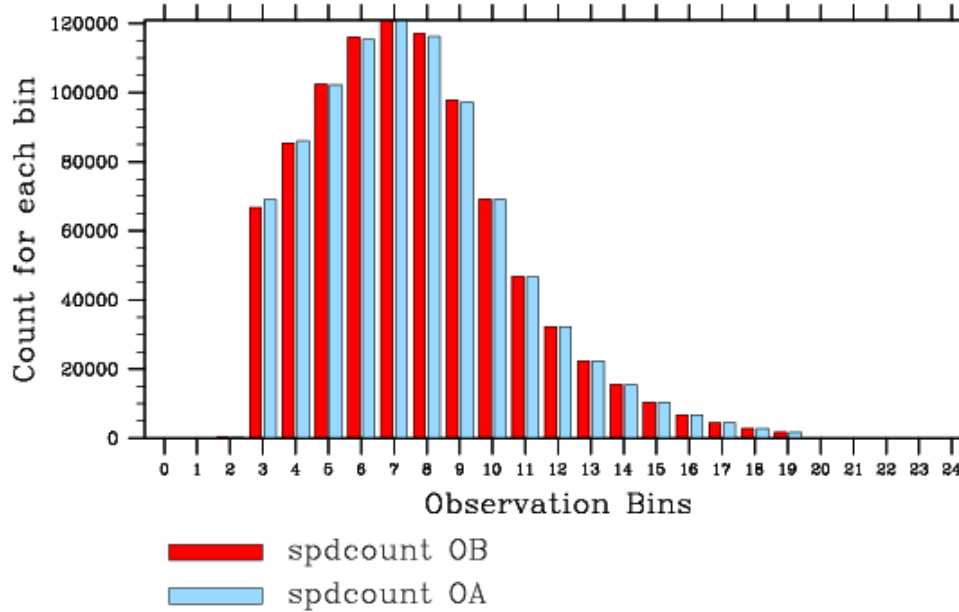
spdbias OB
spdbias OA

ASCAT Spd Bias Stats 1-30 June 2012



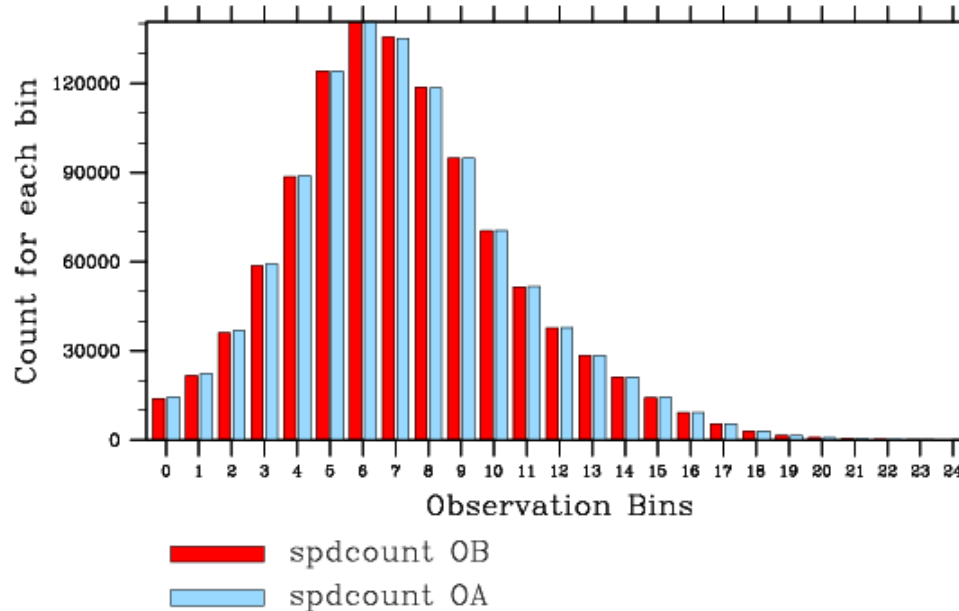
Before
Assimilation

OSCAT Spd Total Counts Stats 1-30 June 2012

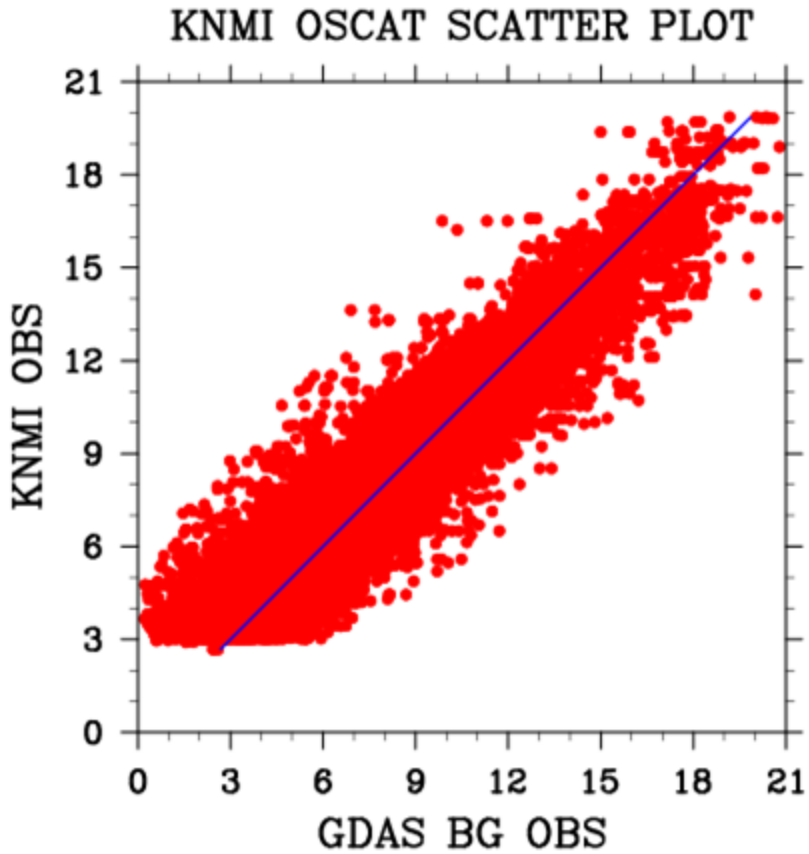


Before
Assimilation

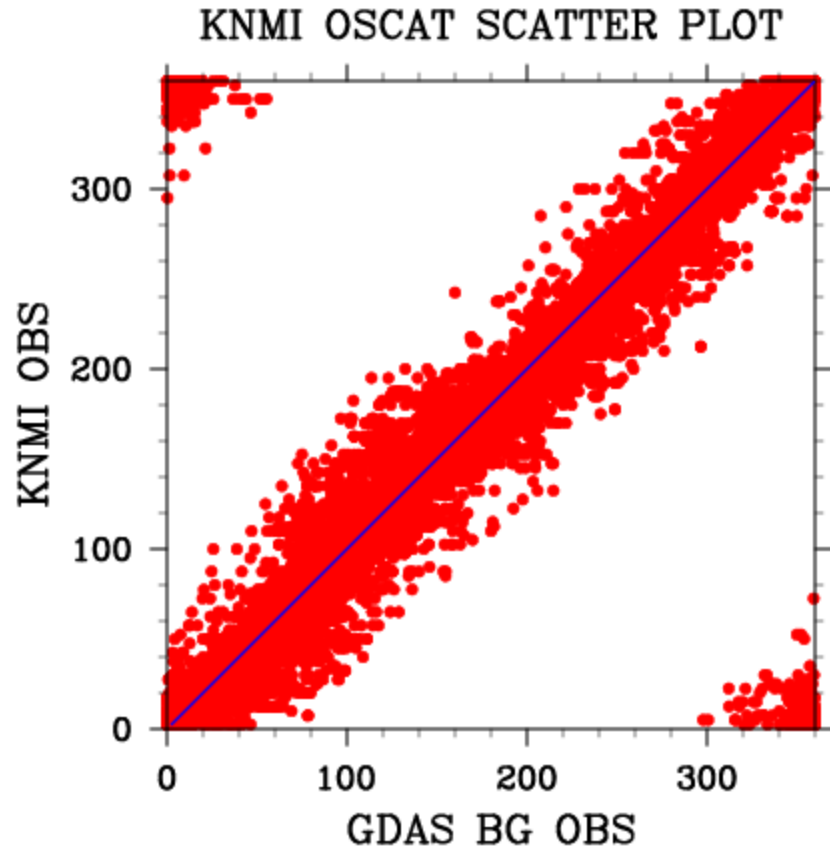
ASCAT Spd Total Counts Stats 1-30 June 2012



Assimilated obs from 2012061800 GSI cycle



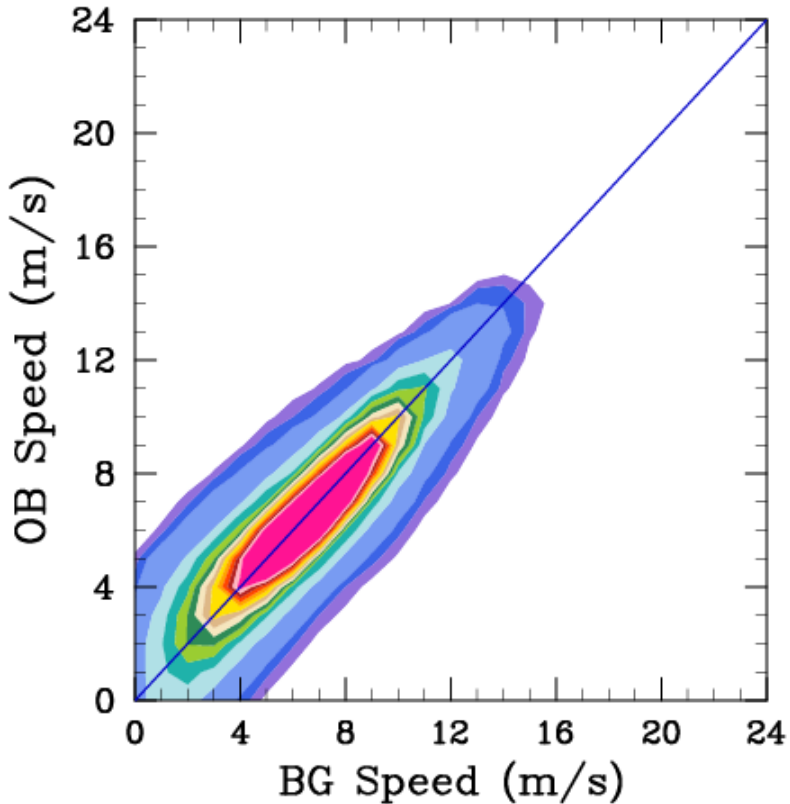
OSCAT Wind Speed



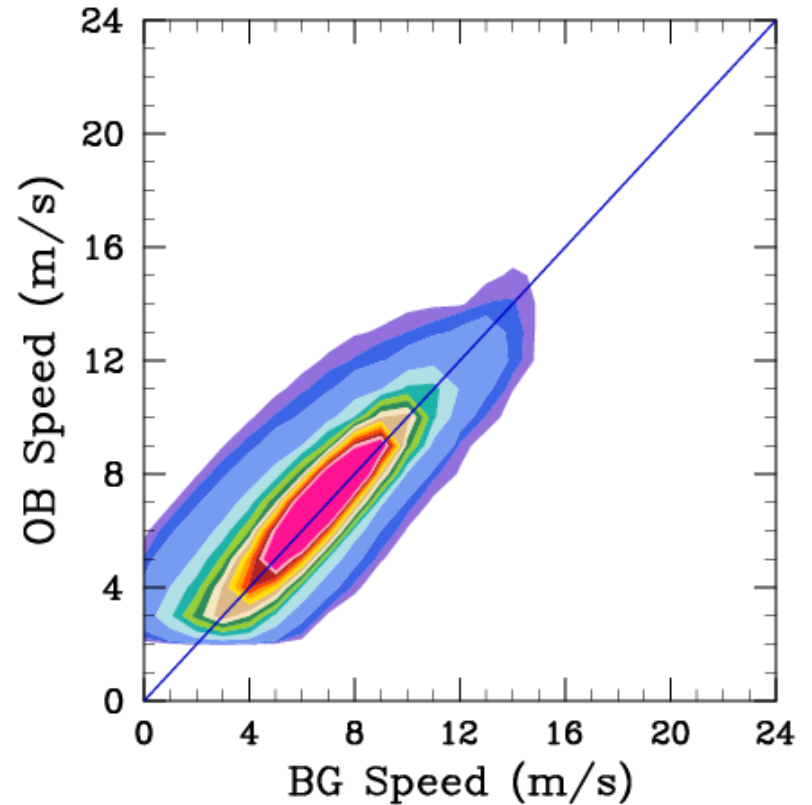
OSCAT Wind Direction

2012060100-2012063018 Tropics

Density plot of ASCAT (20S,20N)



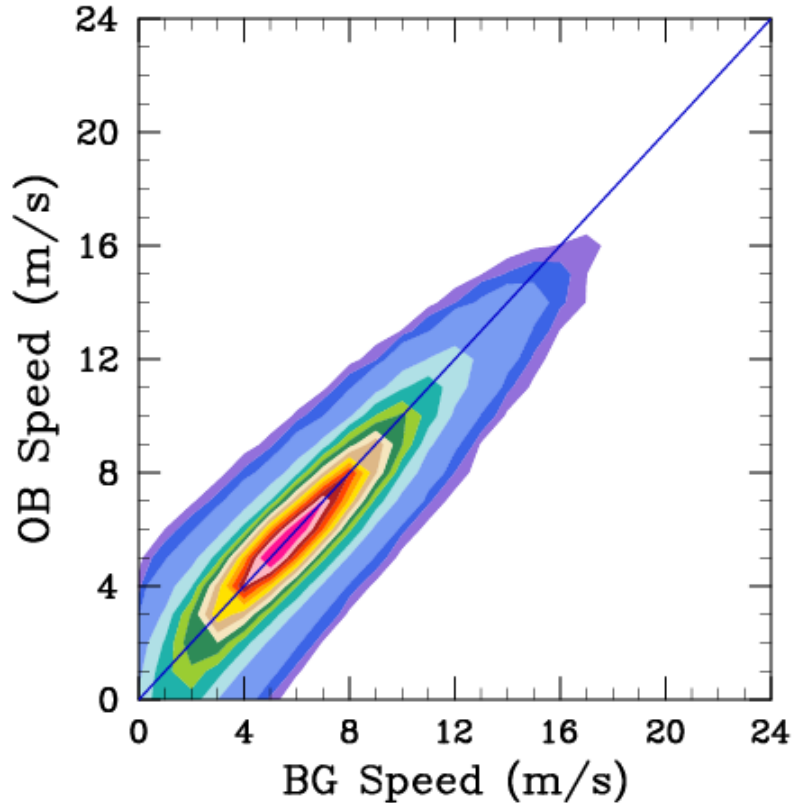
Density plot of OSCAT (20S,20N)



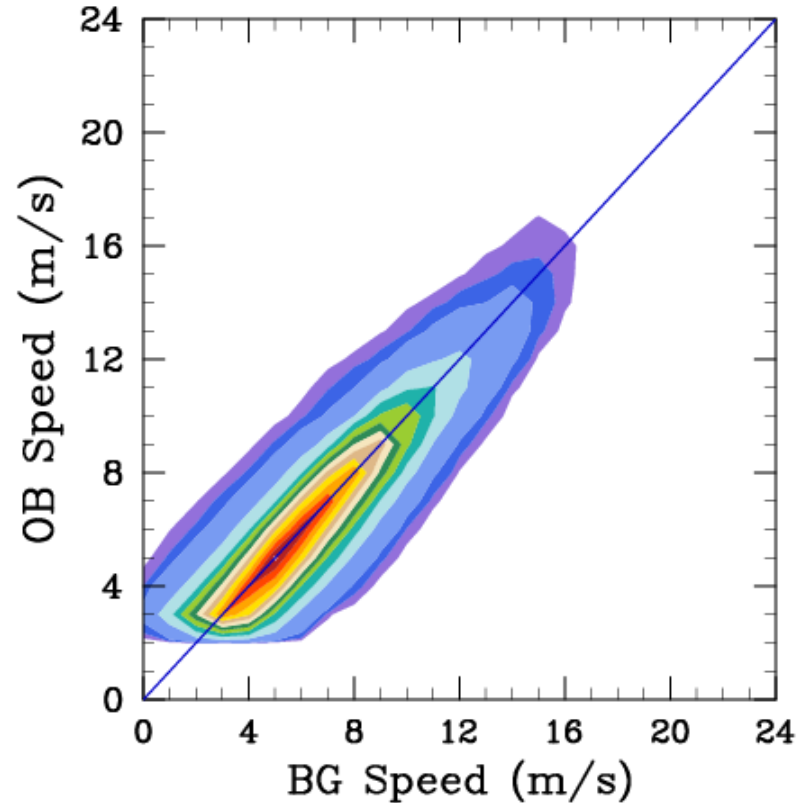
Density plots of assimilated obs from loop 1

2012060100-2012063018 Northern Hemisphere

Density plot of ASCAT (20N,90N)



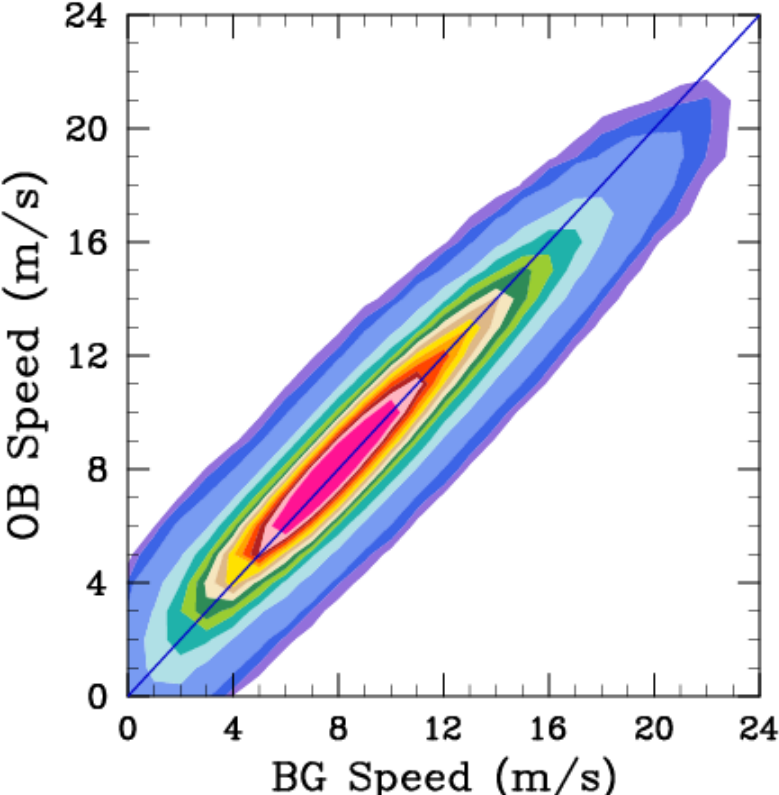
Density plot of OSCAT (20N,90N)



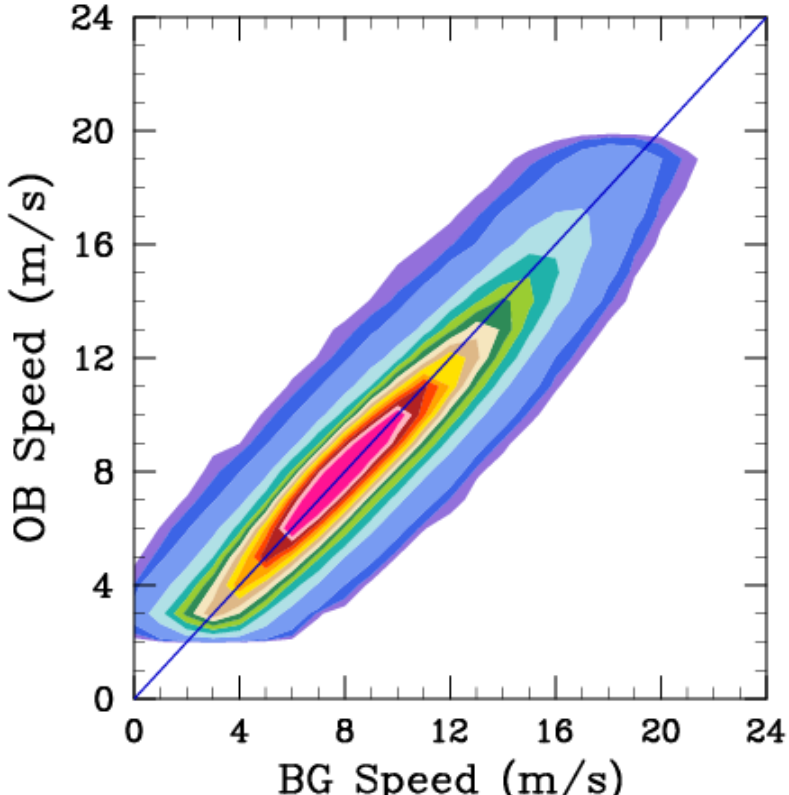
Density plots of assimilated obs from loop 1

2012060100-2012063018 Southern Hemisphere

Density plot of ASCAT (90S,20S)



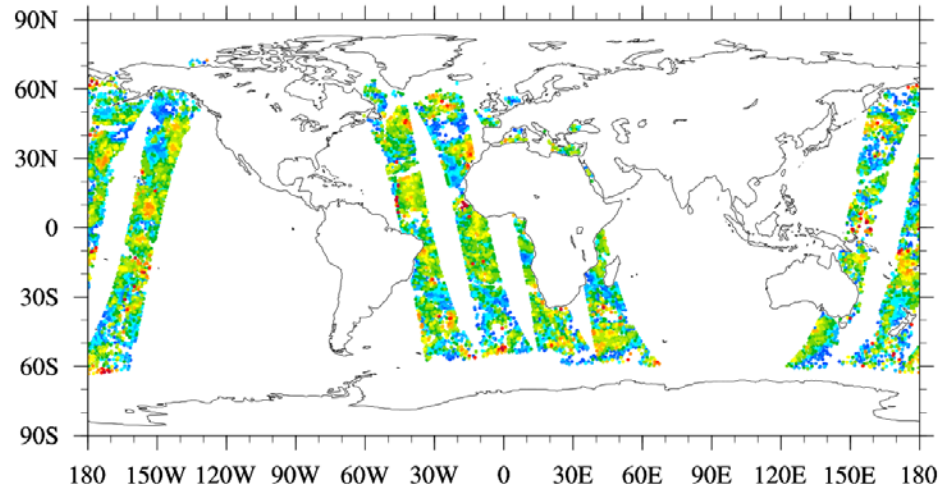
Density plot of OSCAT (90S,20S)



Density plots of assimilated obs from *loop 1*

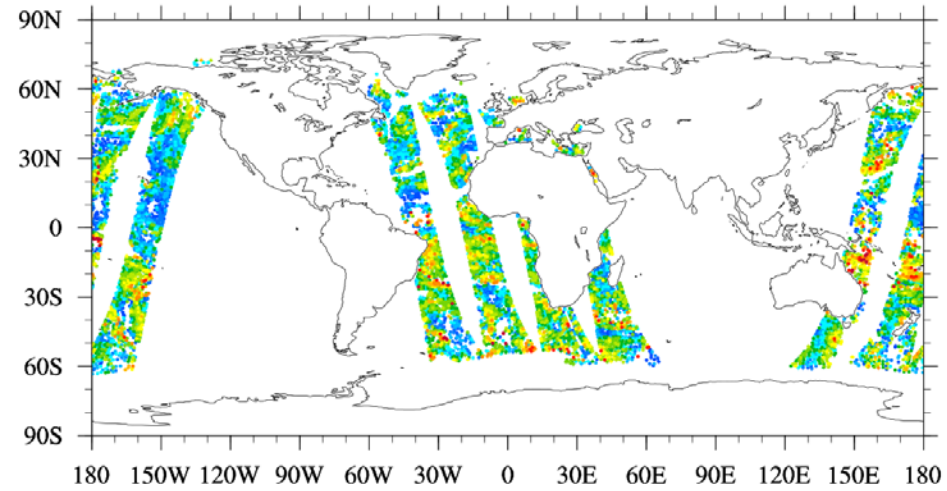
O-B U departure

OSCAT Wind U/V bias 2012062500



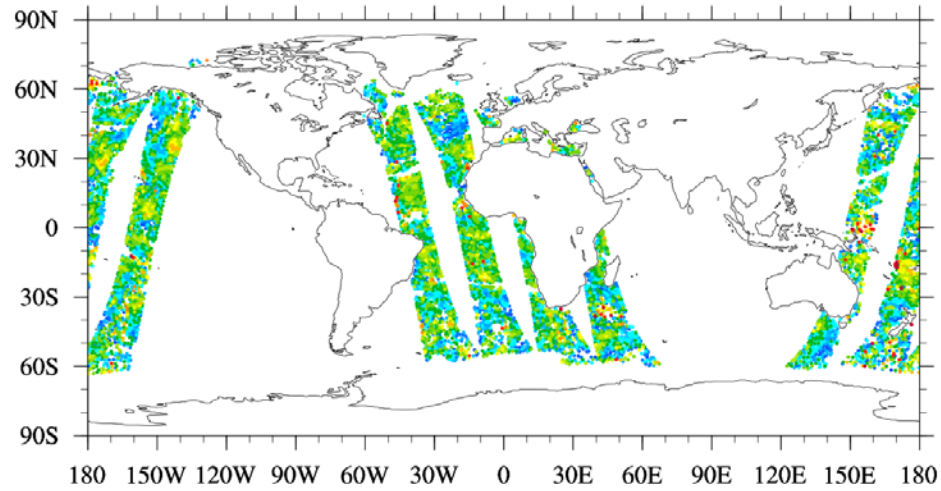
O-B V departure

OSCAT Wind U/V bias 2012062500



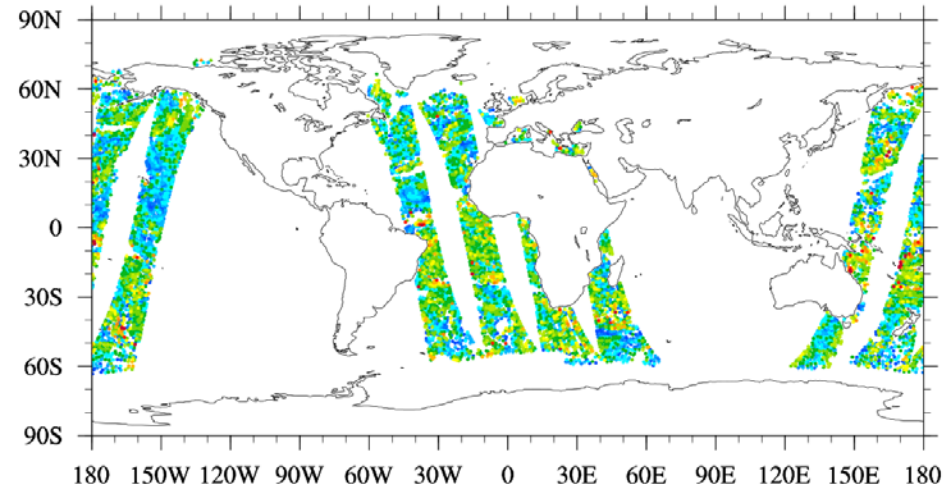
O-A U departure

OSCAT Wind U/V bias 2012062500



O-A V departure

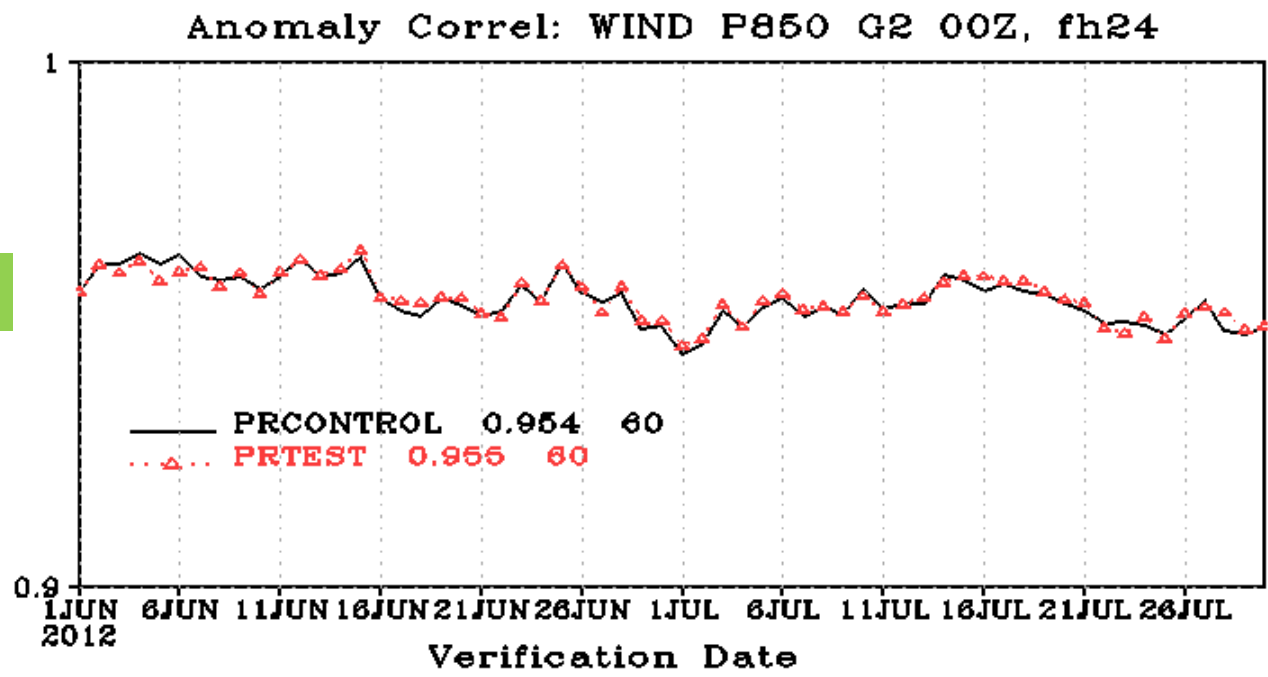
OSCAT Wind U/V bias 2012062500



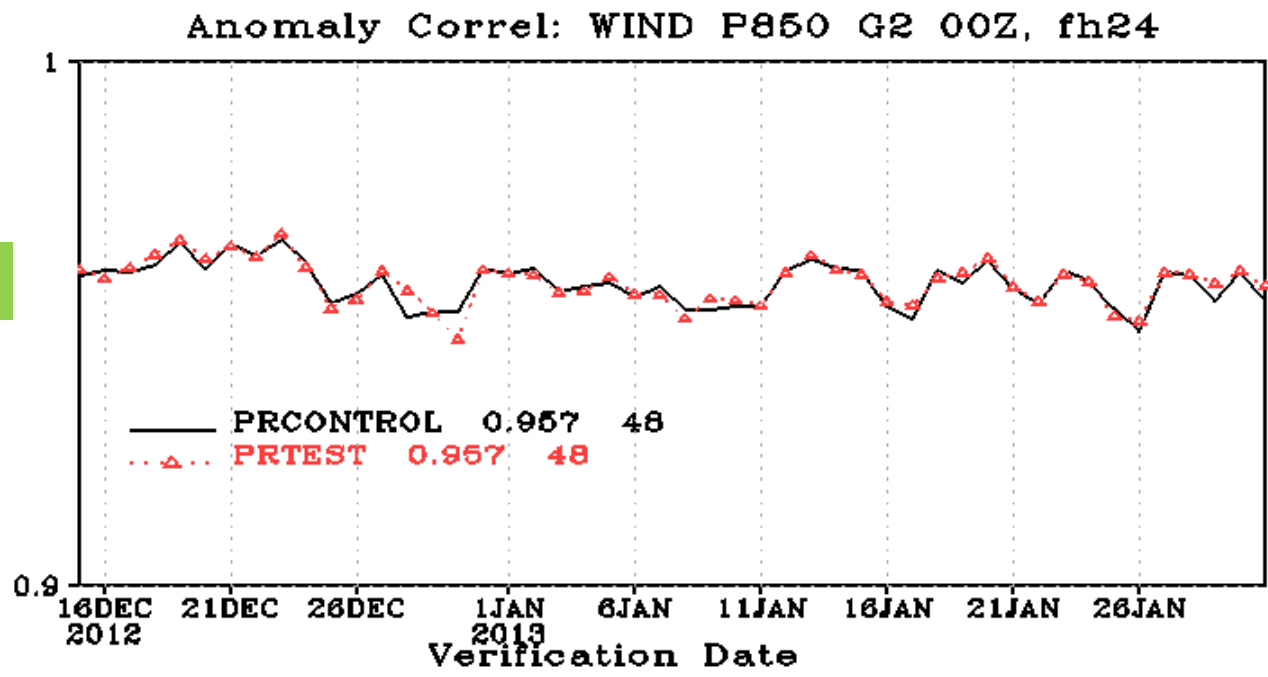
Verification Stats

- AC daily score and die off curve for both seasons.
- RMSE mean for both seasons.
- Forecast differences between control and experiment.
- RMS differences for surface fields.

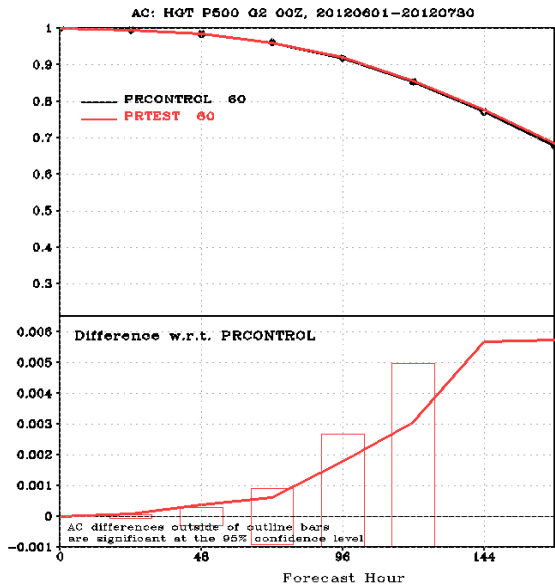
Season I



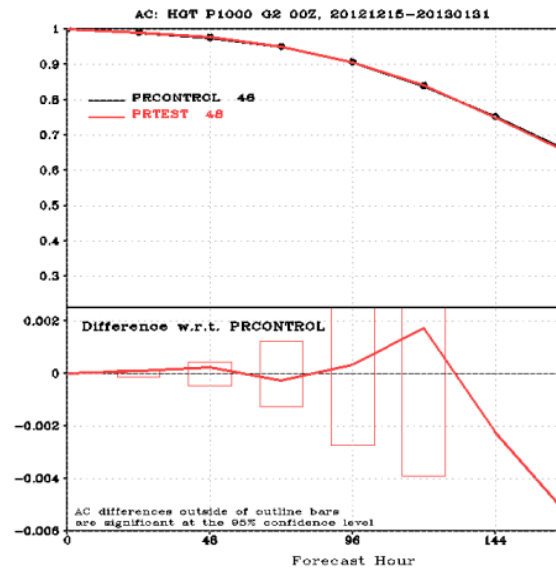
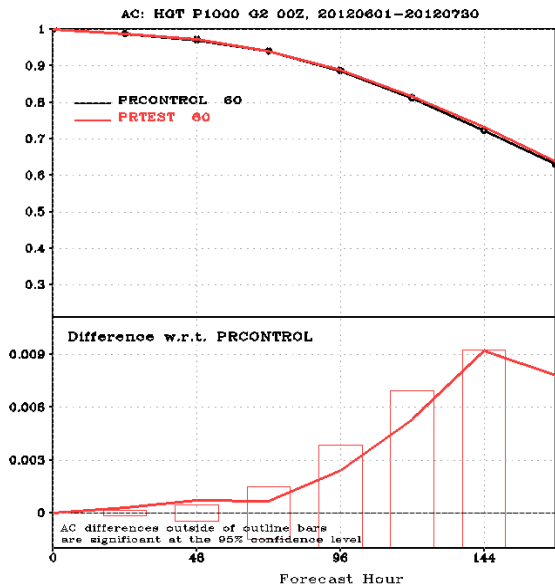
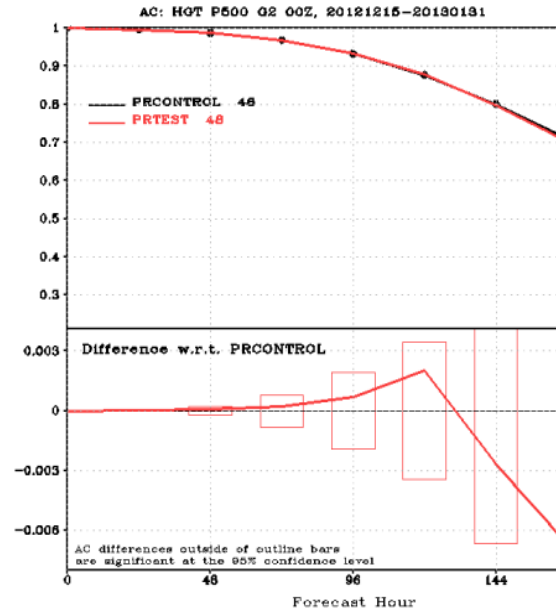
Season II



Season I



Season II

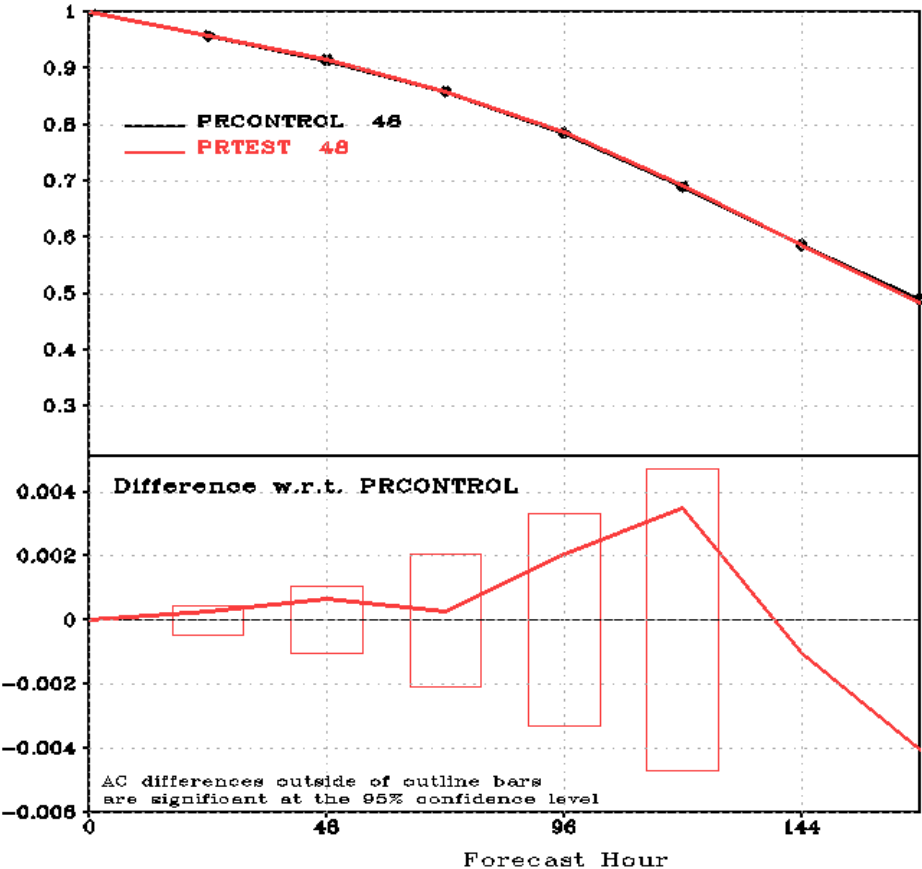
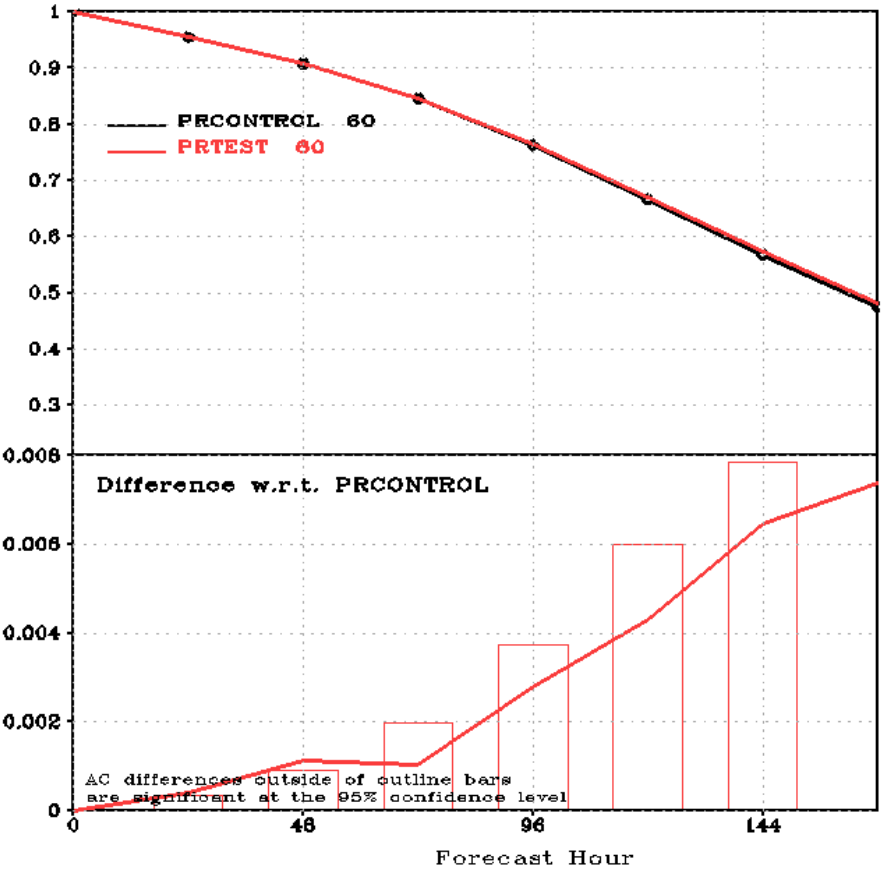


Season I

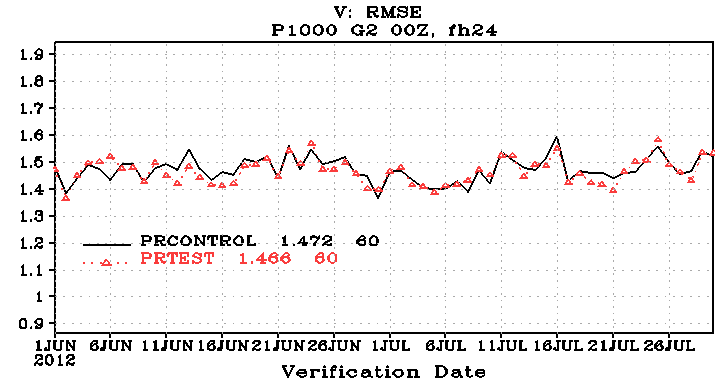
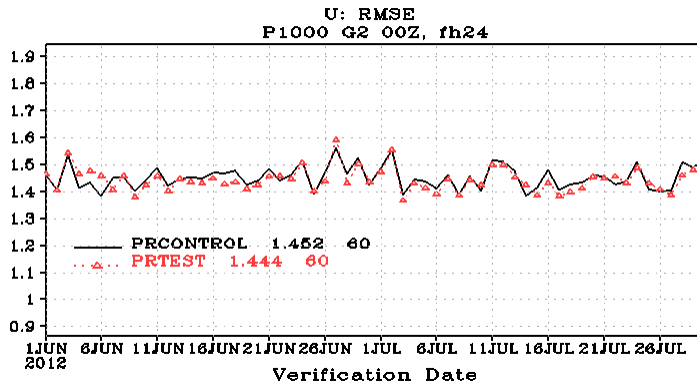
Season II

AC: WIND P850 G2 00Z, 20120601-20120730

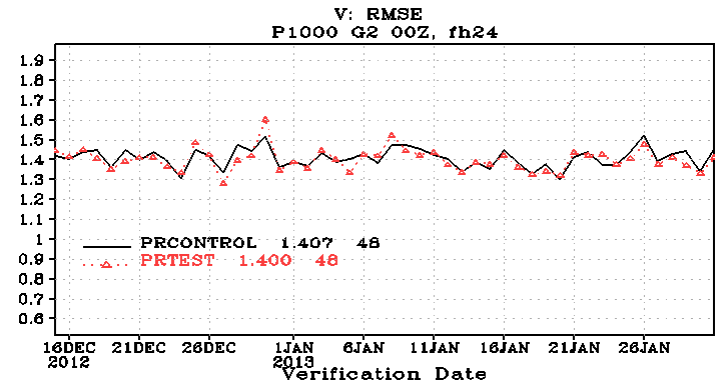
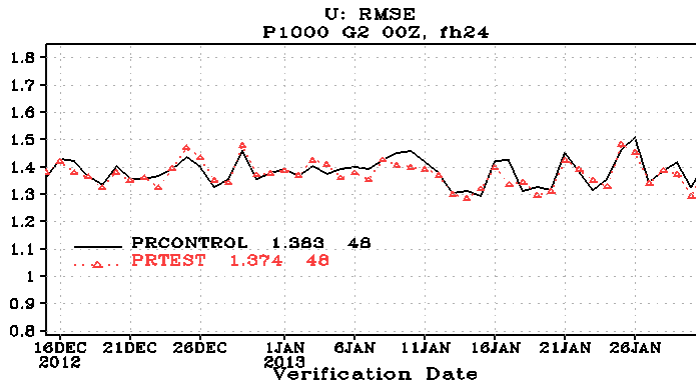
AC: WIND P850 G2 00Z, 20121215-20130131



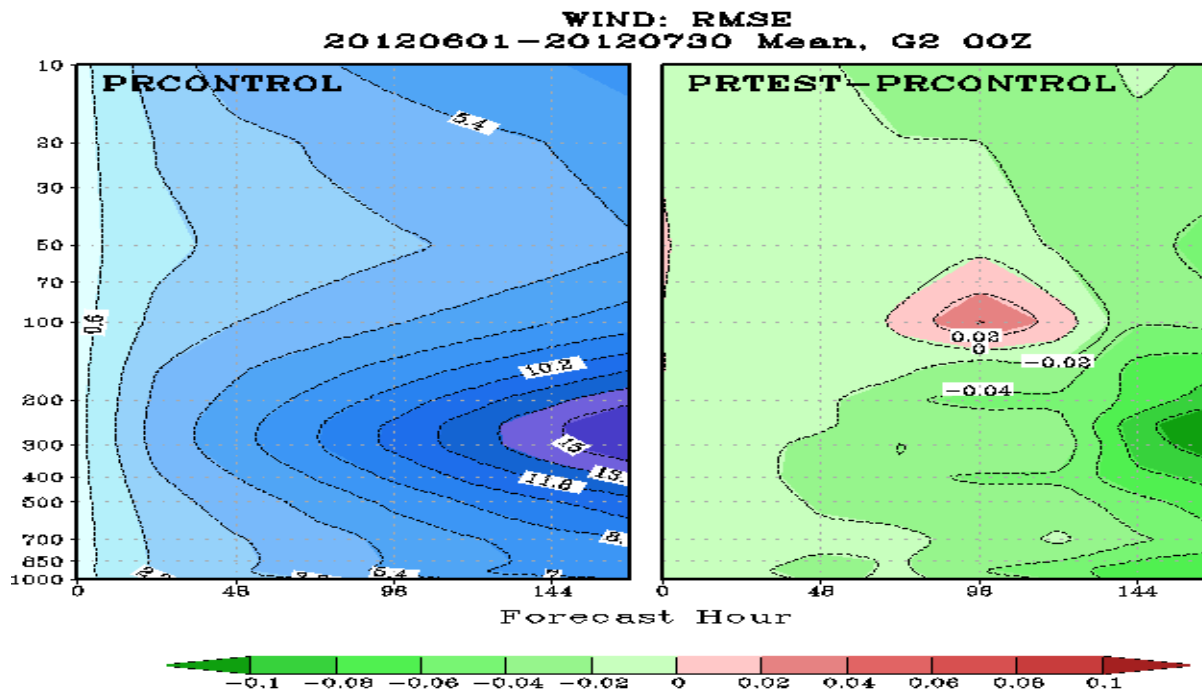
Season I



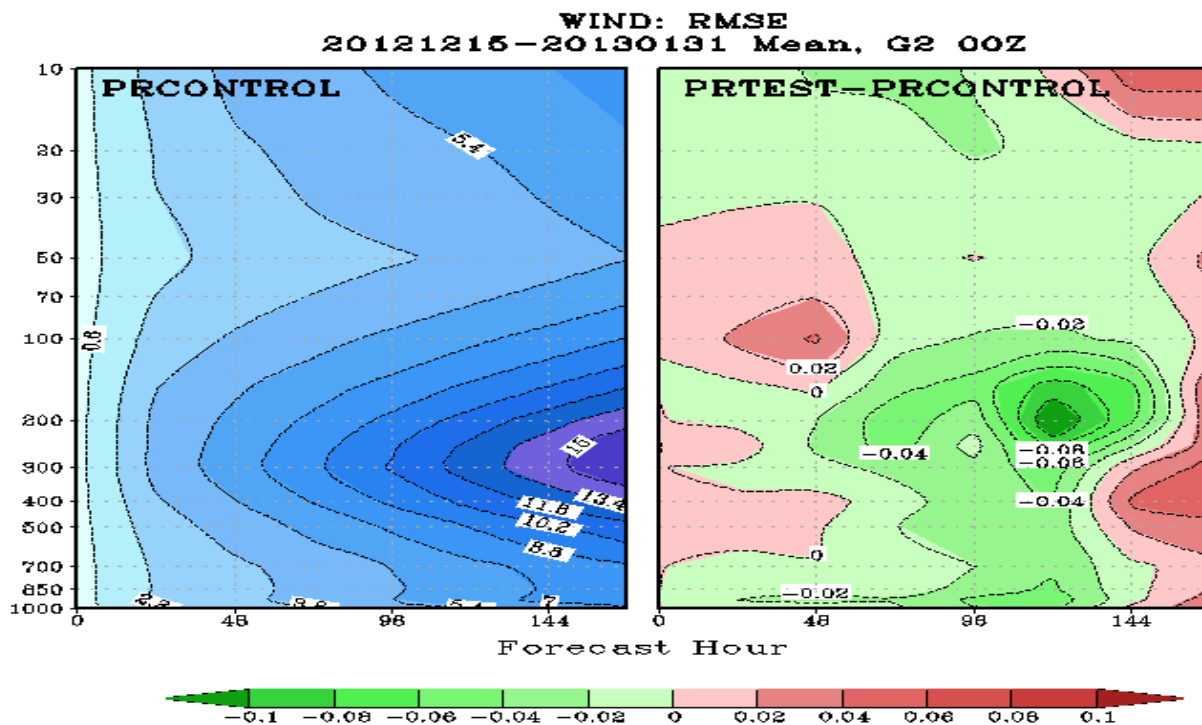
Season II



Season I



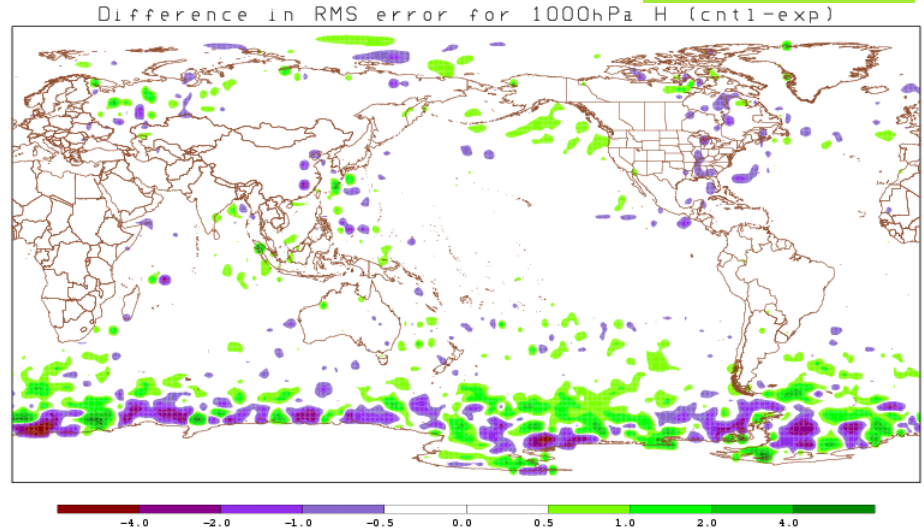
Season II



RMS Difference (control – OSCAT exp) for 1000hPa H

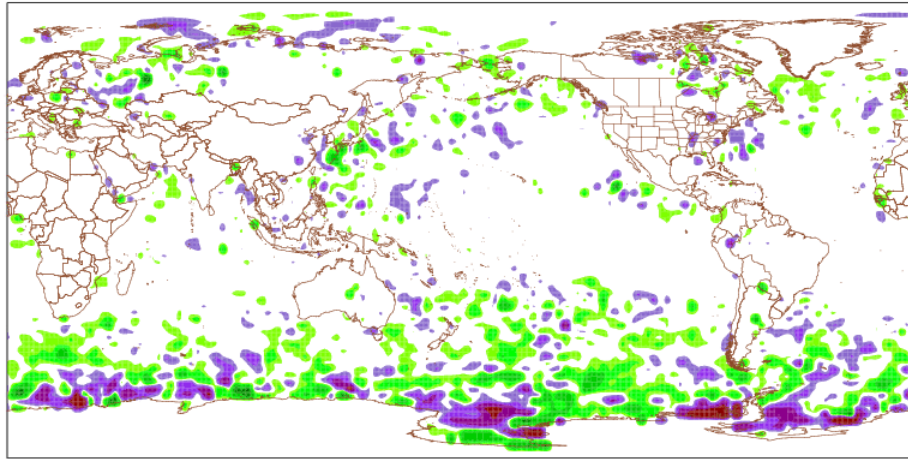
12hr fcst

- **Model Resolution:** T574 (~35km); 64 levels
- **DA system:** Hybrid-Ensemble and an analysis resolution of T574 (~35km)
- **Period:** 15 May – 30 July 2012 f48 forecast - Analysis
- **Experiments:** Cntl (operation full observing system) vs. Exp (Cntl + OSCAT)



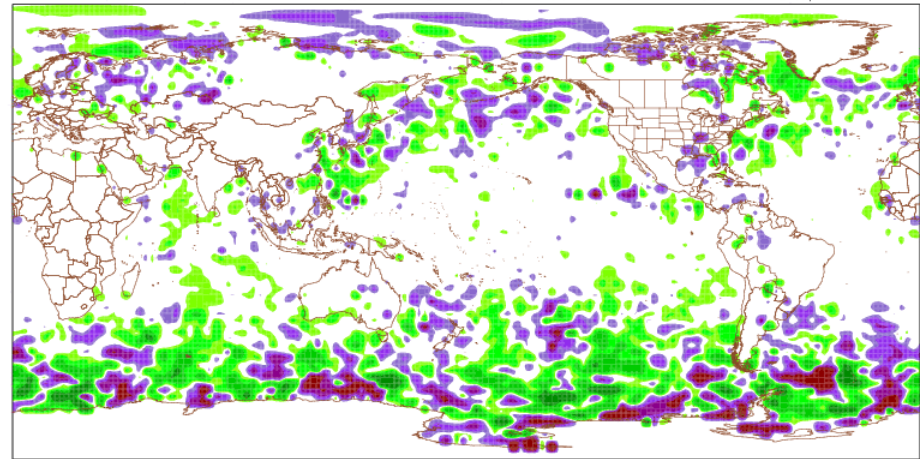
24hr fcst

Difference in RMS error for 1000hPa H (cntl-exp)



48hr fcst

Difference in RMS error for 1000hPa H (cntl-exp)

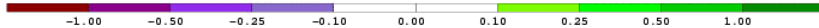
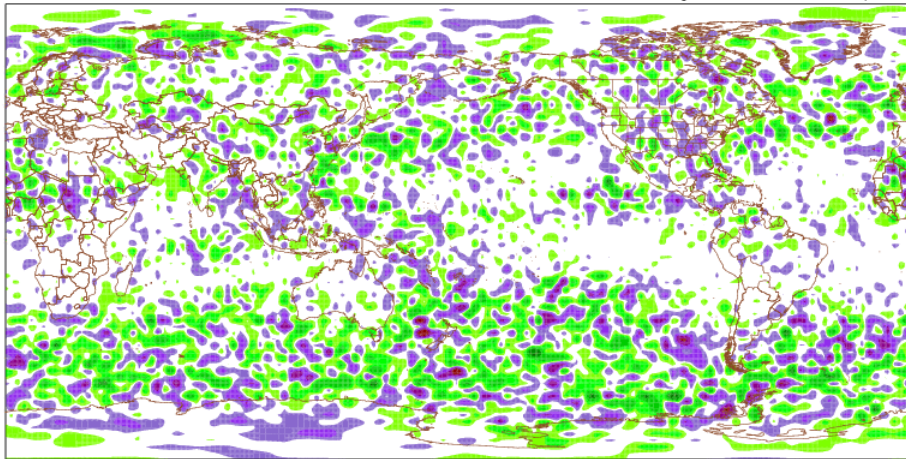


← Scat bad → Scat good →

RMS Difference (control – OSCAT exp) for U and V

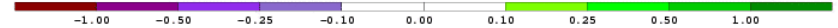
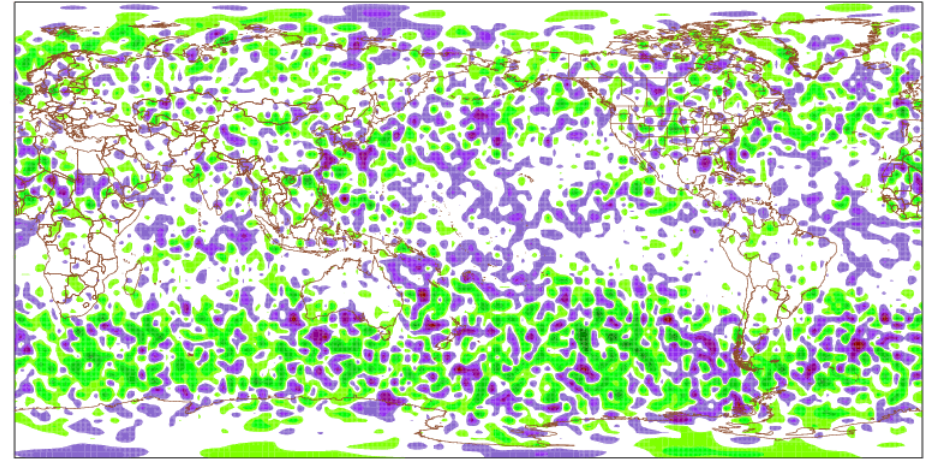
48hr fcst - analysis

Difference in RMS error for UGRD 0.9950 sigma (cnt1-exp)



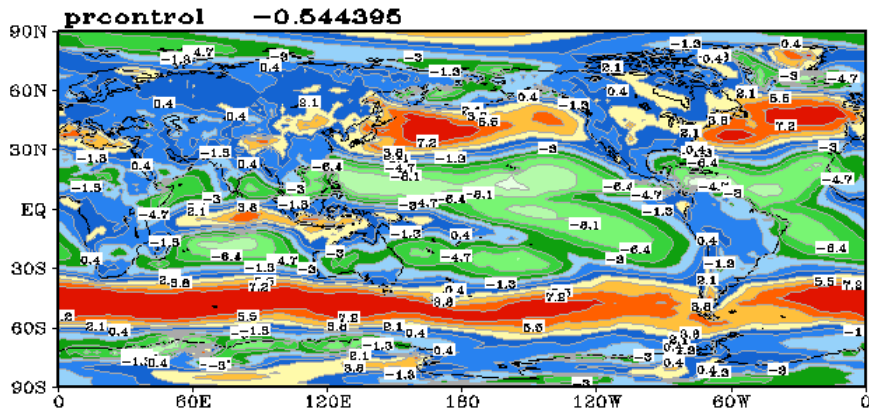
0.9950 sigma UGRD

Difference in RMS error for VGRD 0.9950 sigma (cnt1-exp)

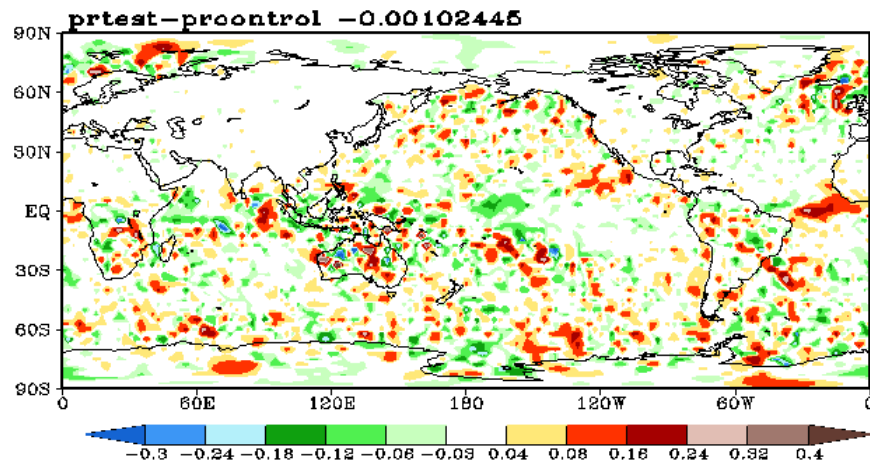
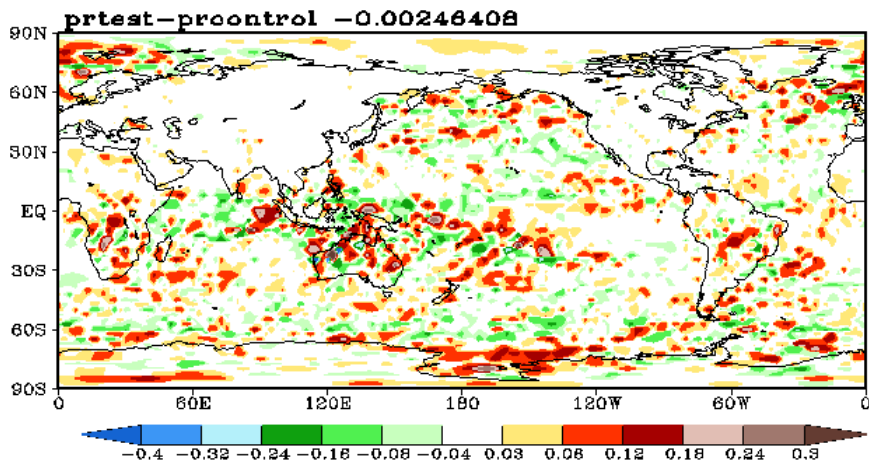
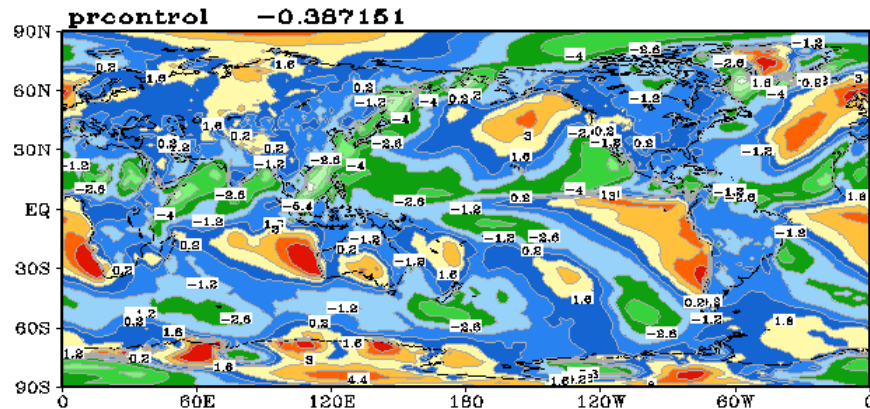


0.9950 sigma VGRD

$s=.995$ U Wind [m/s], 00Z-Cyc 15Dec2012-28Jan2013 Mean
(f06 f12 f18 f24) Post-Hour Average



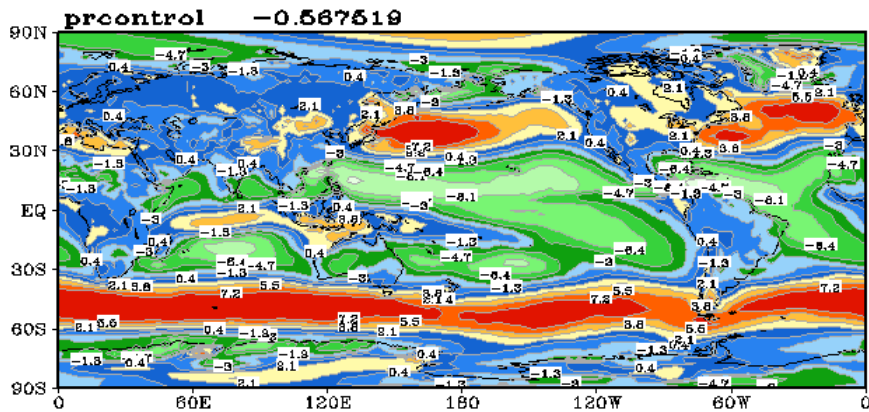
$s=.995$ V Wind [m/s], 00Z-Cyc 15Dec2012-28Jan2013 Mean
(f06 f12 f18 f24) Post-Hour Average



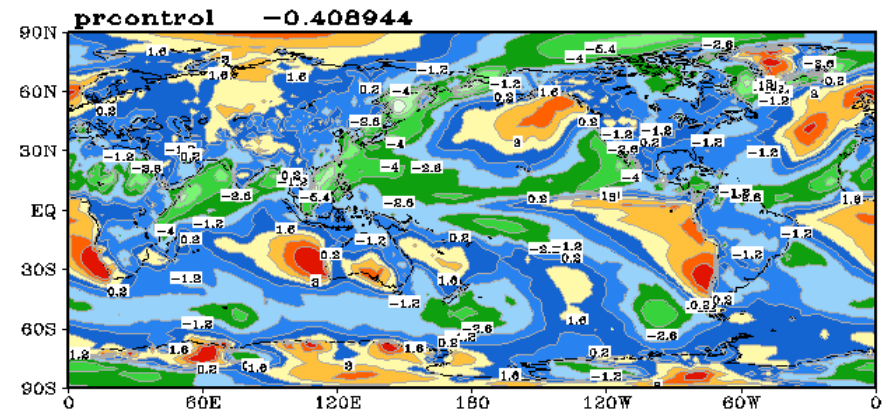
f24 fcst difference for 0.9950 u

f24 fcst difference for 0.9950 v

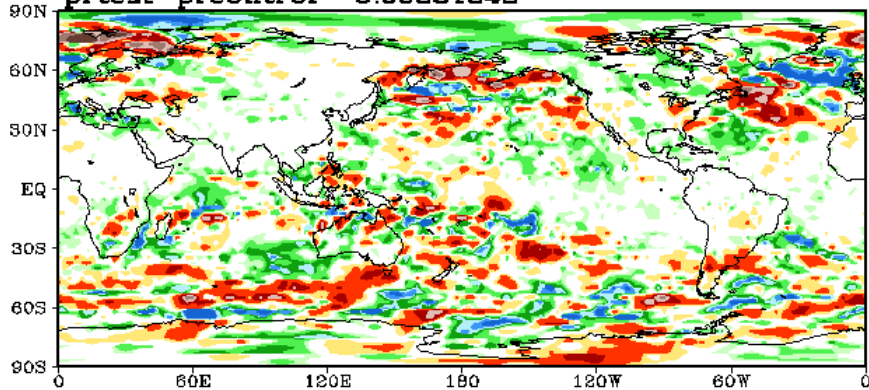
$s=0.996$ U Wind [m/s], 00Z-Cyc 15Dec2012-28Jan2013 Mean
(f102 f108 f114 f120) Post-Hour Average



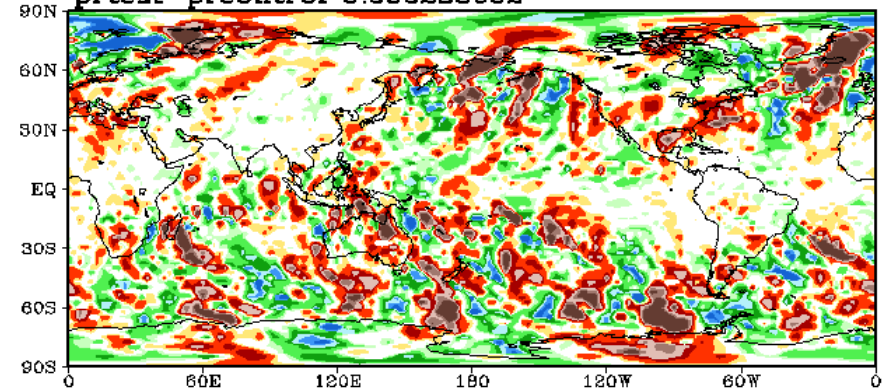
$s=0.996$ V Wind [m/s], 00Z-Cyc 15Dec2012-28Jan2013 Mean
(f102 f108 f114 f120) Post-Hour Average



prtest-precontrol -0.00831848



prtest-precontrol 0.00285902



f120 fcst difference for 0.9950 u

f120 fcst difference for 0.9950 v