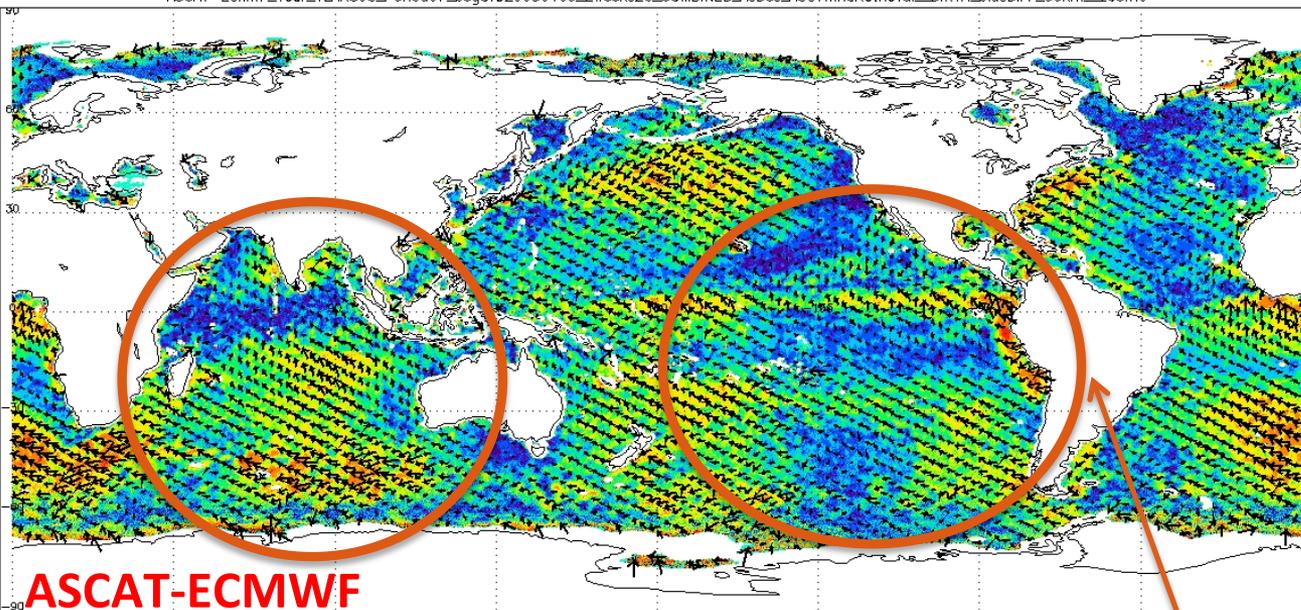


The impact of resolution on SST-Induced Surface Wind Response: Is that the answer for observed differences in QuikSCAT and ASCAT retrievals?

Svetla Hristova-Veleva and Ernesto Rodriguez

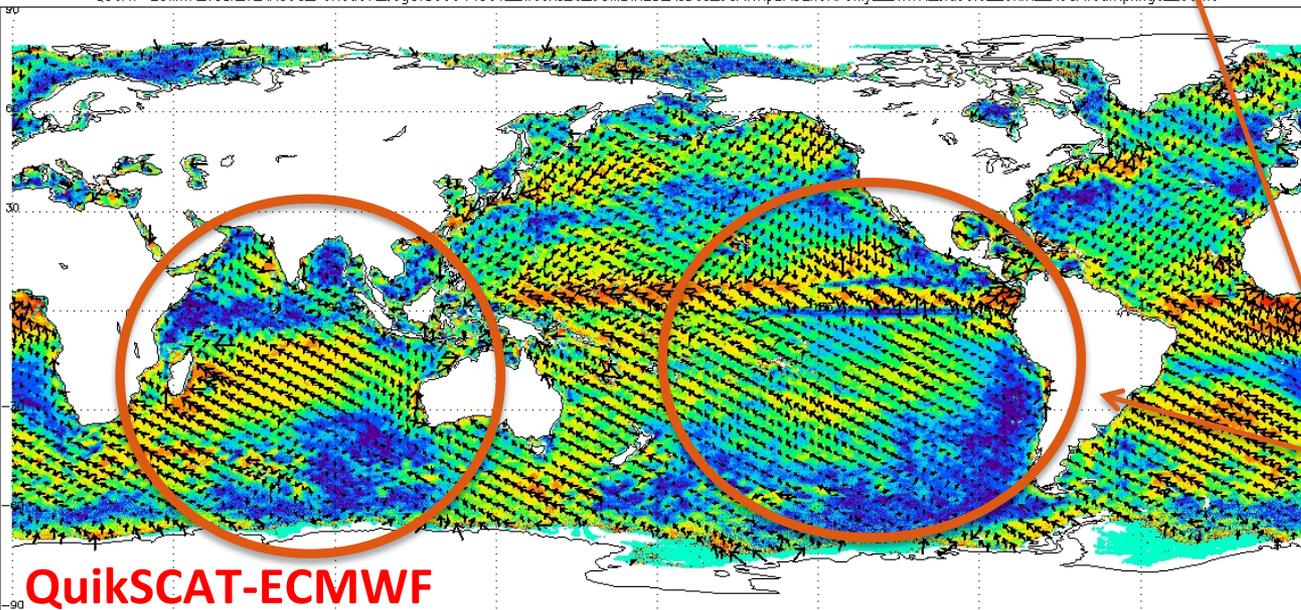
**Jet Propulsion Laboratory,
California Institute of Technology**

IOVWST 2012, Utrecht, NL



Merging the wind estimates from ASCAT and QuikSCAT will allow extending the climate data record.

Before merging them, we have to evaluate their consistency.

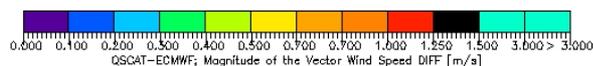


Climatologies based on 1-year average:

2008

Wind calculated from L2 wind products

The overall pattern is similar, but differences exist



Dynamical Significance of the differences

- Coupling between SST gradients and near-surface wind response - investigating the correlation between the high-frequency wind curl and divergence fields, and the cross-wind and down-wind SST gradients.

From O'NEILL, CHELTON, AND ESBENSEN, 2003

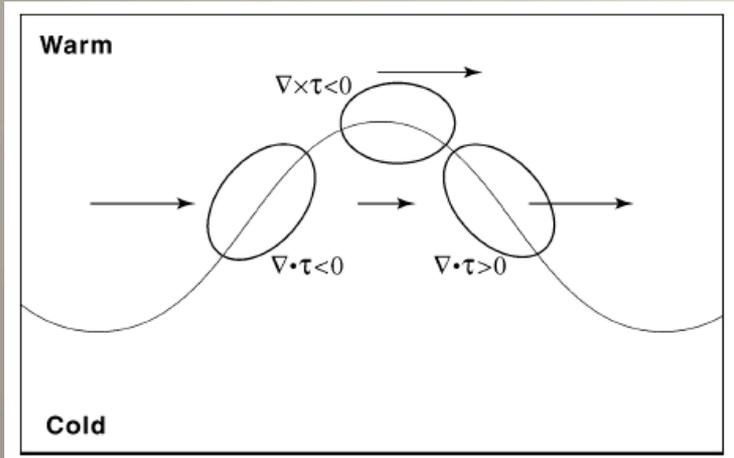


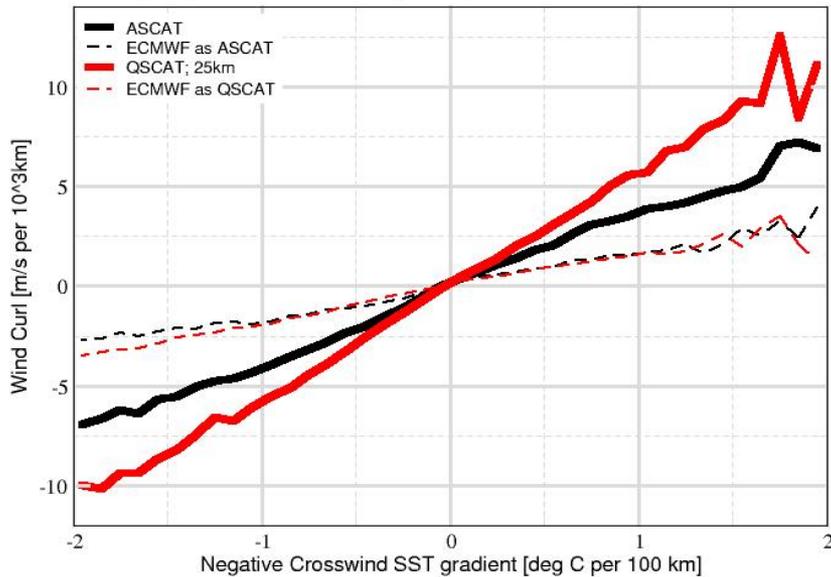
FIG. 3. Schematic of the hypothesized interaction between wind stress and SST for wind blowing obliquely across a meandering SST front. The SST front is delineated as the black sinusoidal curve, separating warm and cold water. The lengths of the arrows schematically represent the hypothesized relative magnitudes of the surface wind stress. Regions of nonzero wind stress curl and divergence are indicated.

- ASCAT/QuikSCAT comparison
 - High-resolution daily SST product (OSTIA)
 - Using ASCAT KNMI
 - bias-corrected data before March 2009 (+0.2m/s)
 - Computing **WIND curl/divergence**
 - from orbital instead of gridded (averaged) wind components (Chelton et al, 2007) to preserve the signals of each meteorological event and to avoid introducing artifacts from computing gradients of averaged quantities over a number of different events.

Wind; From swath; 2-week averages

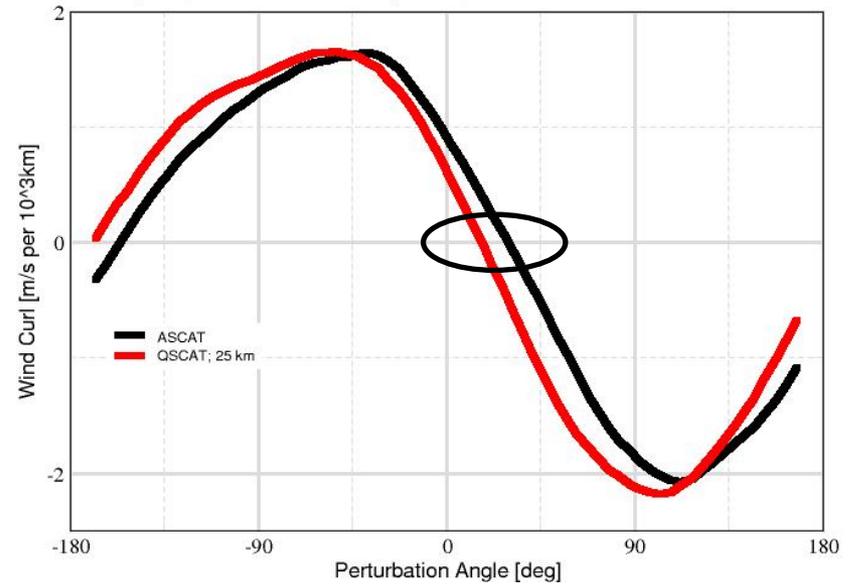
Southern Ocean

Full year (March 2008 - February 2009); $-55 < \text{LAT} < -32$; $0 < \text{LON} < 359$



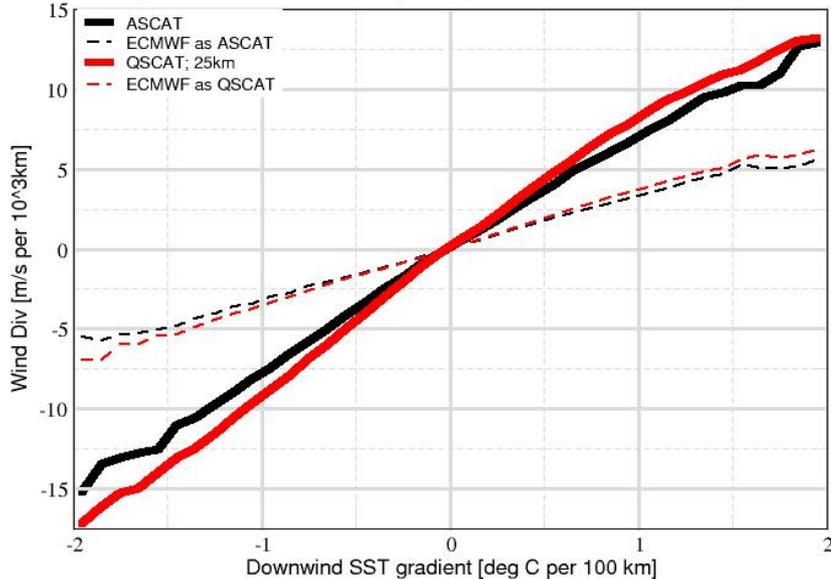
Southern Ocean; 5-point averages

Full year (March 2008 - February 2009); $-55 < \text{LAT} < -32$; $0 < \text{LON} < 359$



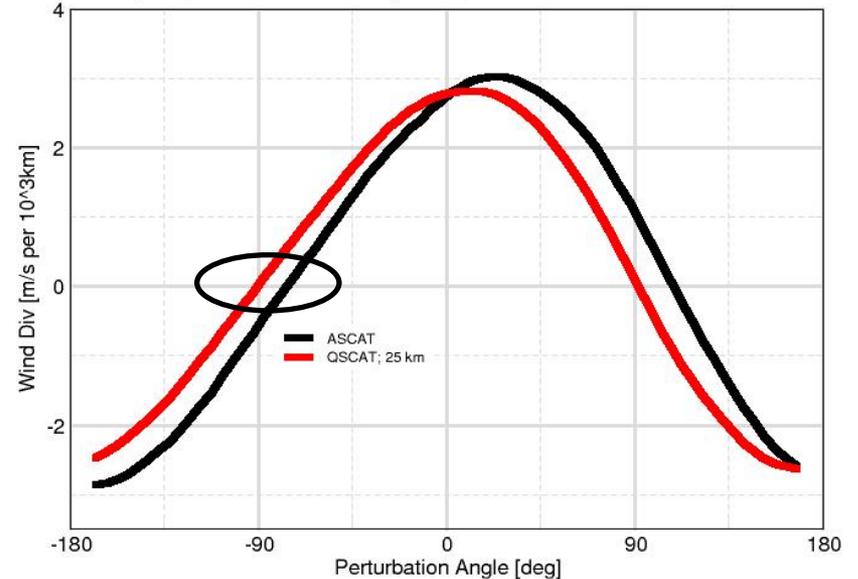
Southern Ocean

Full year (March 2008 - February 2009); $-55 < \text{LAT} < -32$; $0 < \text{LON} < 359$



Southern Ocean; 5-point averages

Full year (March 2008 - February 2009); $-55 < \text{LAT} < -32$; $0 < \text{LON} < 359$





Following O'Neill et al, 2010

In curvilinear natural coordinates
(e.g., Haltiner and Martin, 1957)

Perturbation vorticity	Local crosswind speed gradient	Local downwind direction gradient
------------------------	--------------------------------	-----------------------------------

→ related to the **radius of curvature** of surface streamlines.

$$\nabla \times \mathbf{U}' = - \left(\frac{\partial V}{\partial n} \right)' + \left(V \frac{\partial \psi}{\partial s} \right)'$$

Perturbation divergence	Local downwind speed gradient	Local crosswind direction gradient
-------------------------	-------------------------------	------------------------------------

→ related to the **spreading or contracting** of surface streamlines in the crosswind direction.

$$\nabla \cdot \mathbf{U}' = + \left(\frac{\partial V}{\partial s} \right)' + \left(V \frac{\partial \psi}{\partial n} \right)'$$

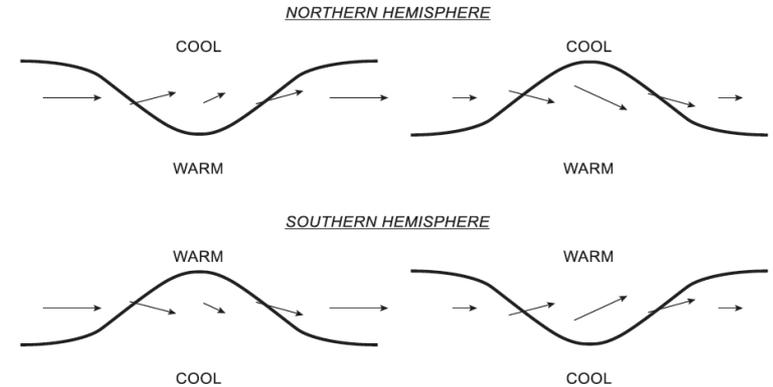
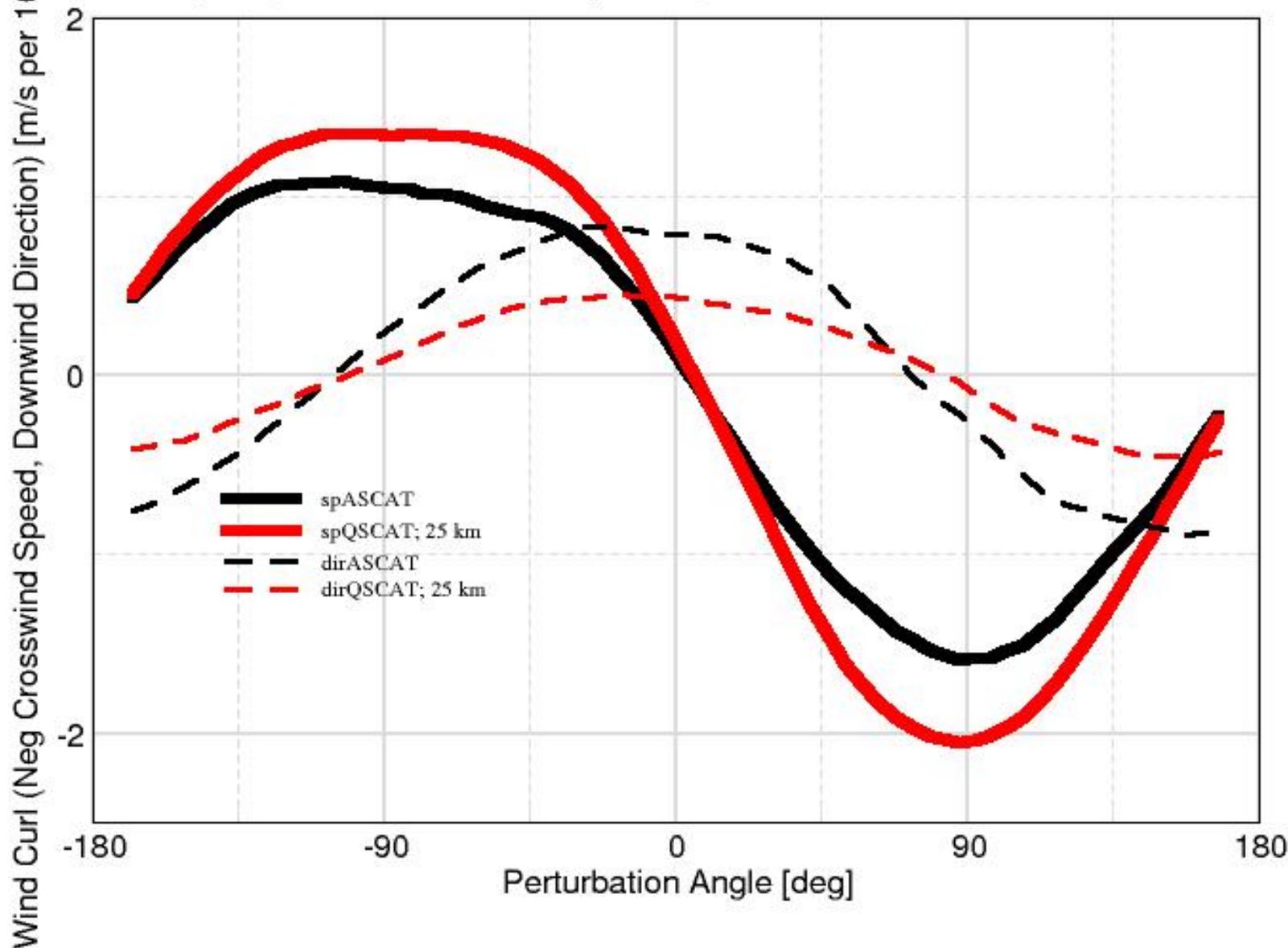


FIG. 7. Summary schematic of the vector wind response to meanders along an extratropical SST front, represented here by the solid curves, as deduced from the wind speed and direction dependencies on SST. Whereas the wind speed response to SST (as represented by the relative length of the vectors) is the same for both hemispheres, the wind direction response to SST (as represented by the relative turning of the vectors) differs in sign between the Northern and Southern Hemispheres.

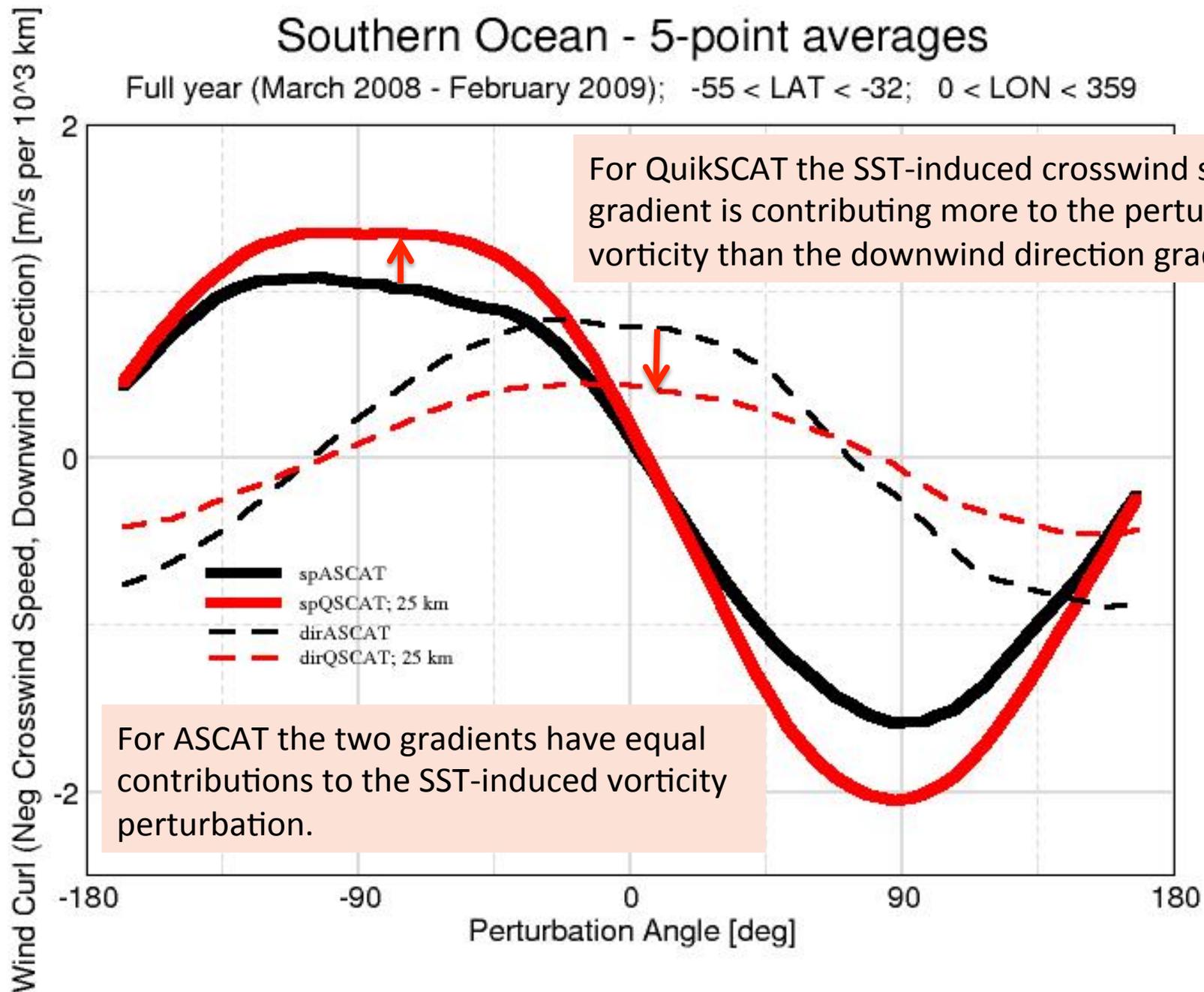
Southern Ocean - 5-point averages

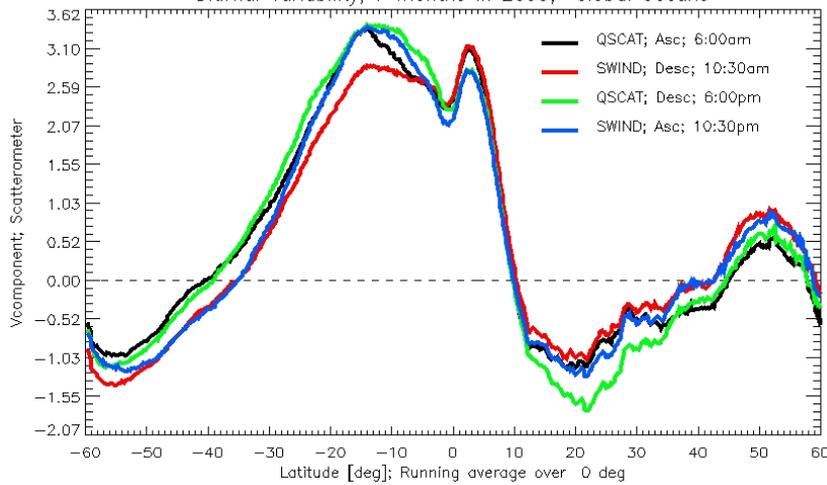
Full year (March 2008 - February 2009); $-55 < \text{LAT} < -32$; $0 < \text{LON} < 359$



Southern Ocean - 5-point averages

Full year (March 2008 - February 2009); $-55 < \text{LAT} < -32$; $0 < \text{LON} < 359$





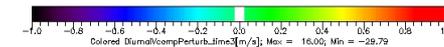
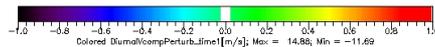
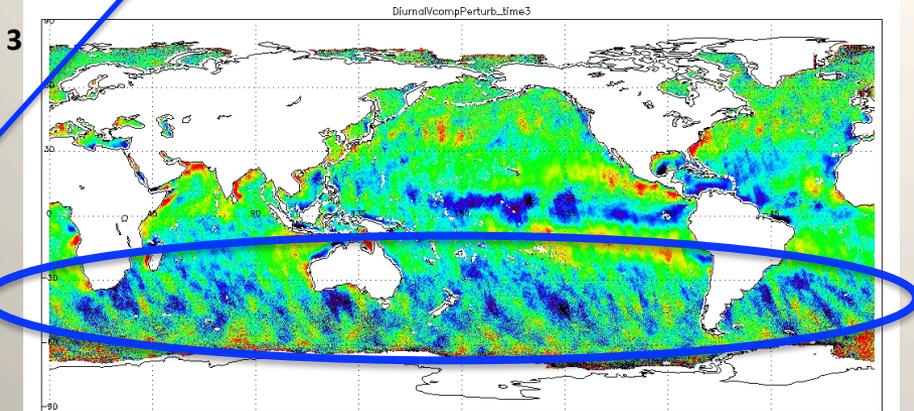
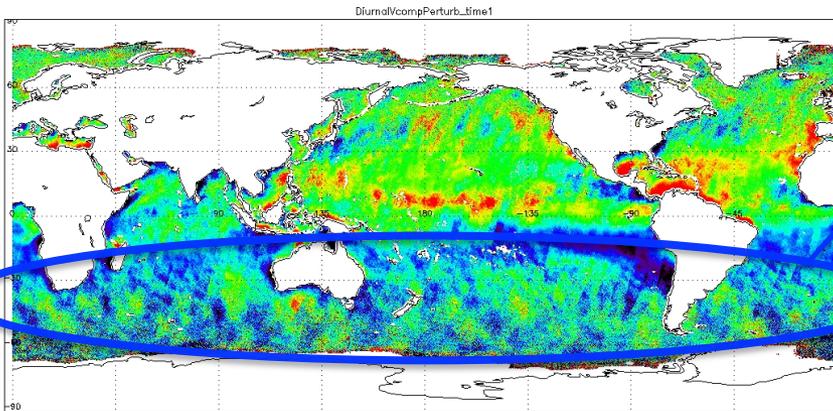
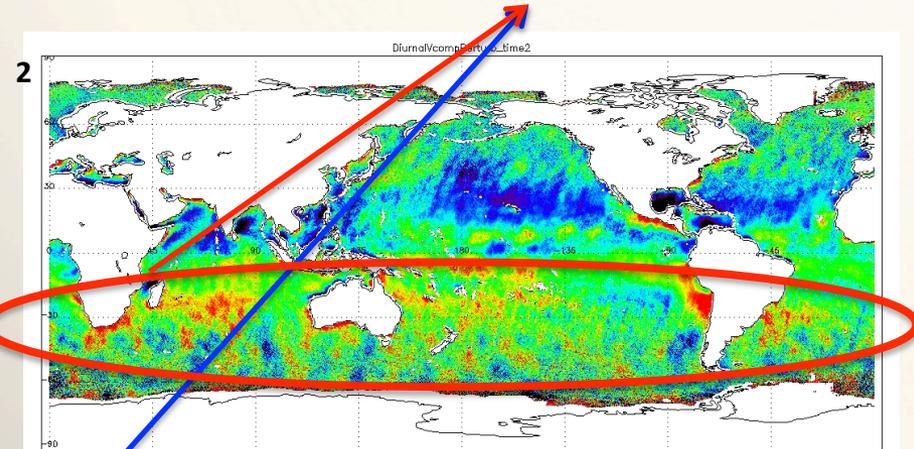
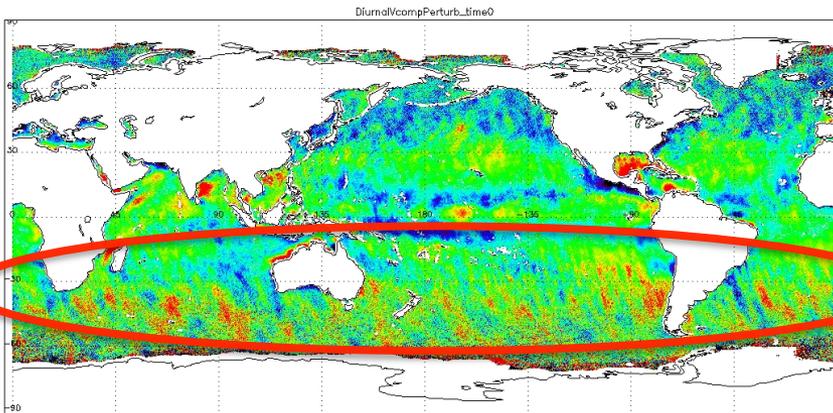
• 7 months of data; 2003;

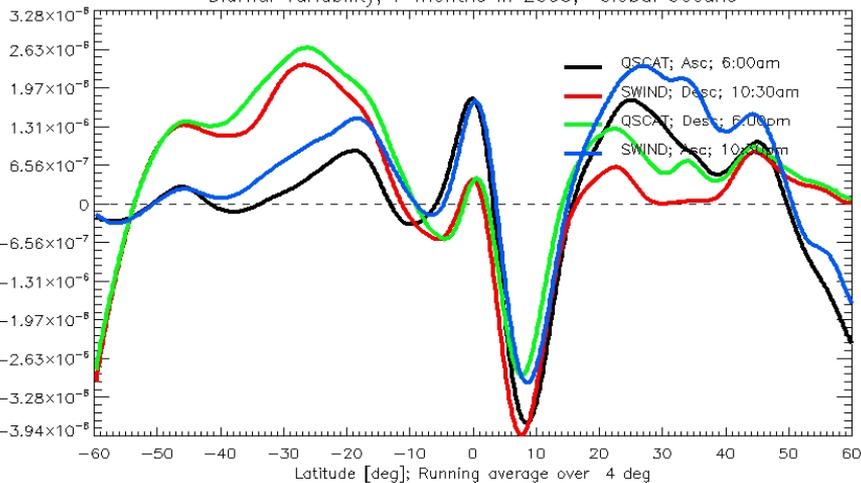
Diurnal Variability in V component



- 0 – 6:00 am; $QS_{\text{ascending}}$ - mean
- 1 - 10:30 am; $SW_{\text{descending}}$ - mean
- 2 – 6:00 pm; $QS_{\text{descending}}$ - mean
- 3 – 10:30 pm; $SW_{\text{ascending}}$ - mean

Strong Diurnal Variability in Meridional wind



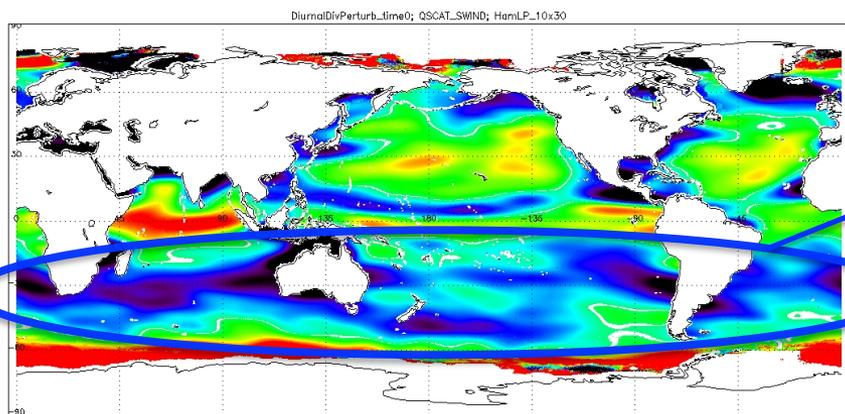


• 7 months of data; 2003;

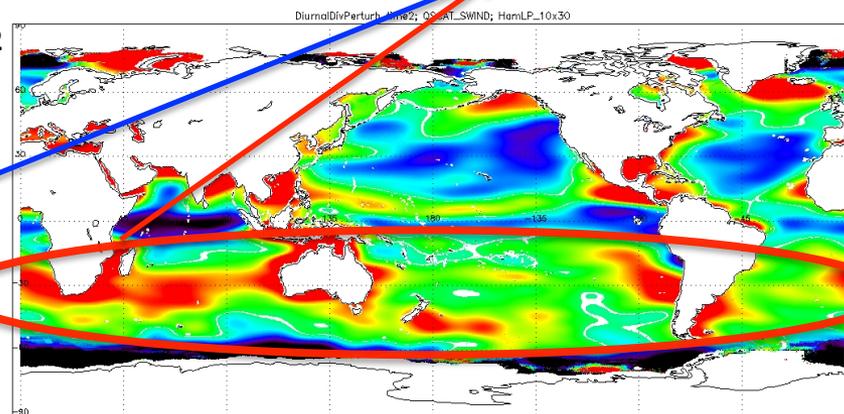
Diurnal Variability in Divergence

- 0 – 6:00 am; $QS_{\text{ascending}}$ - mean
- 1 - 10:30 am; $SW_{\text{descending}}$ - mean
- 2 – 6:00 pm; $QS_{\text{descending}}$ - mean
- 3 – 10:30 pm; $SW_{\text{ascending}}$ - mean

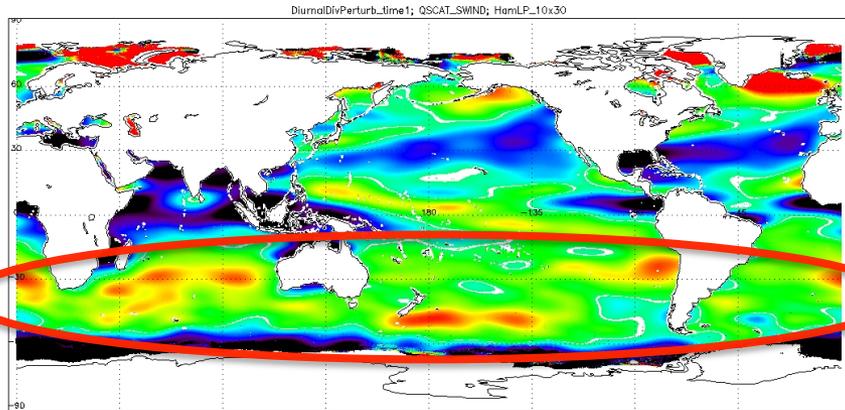
Strong Diurnal Variability in Divergence



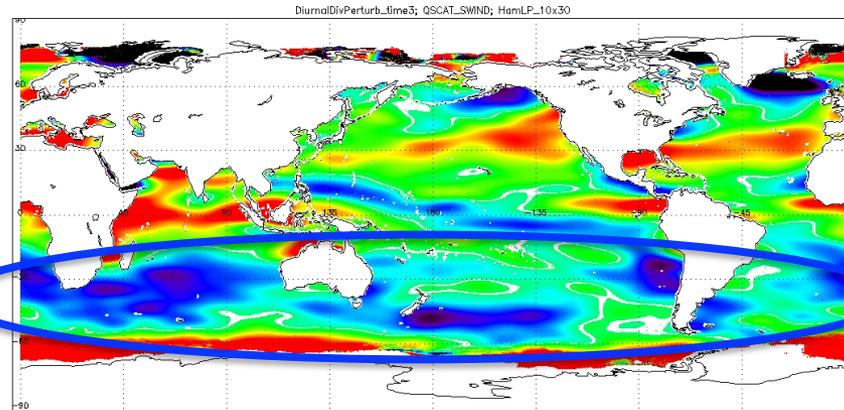
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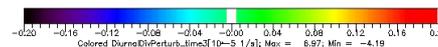
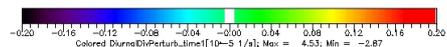
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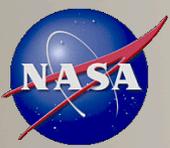


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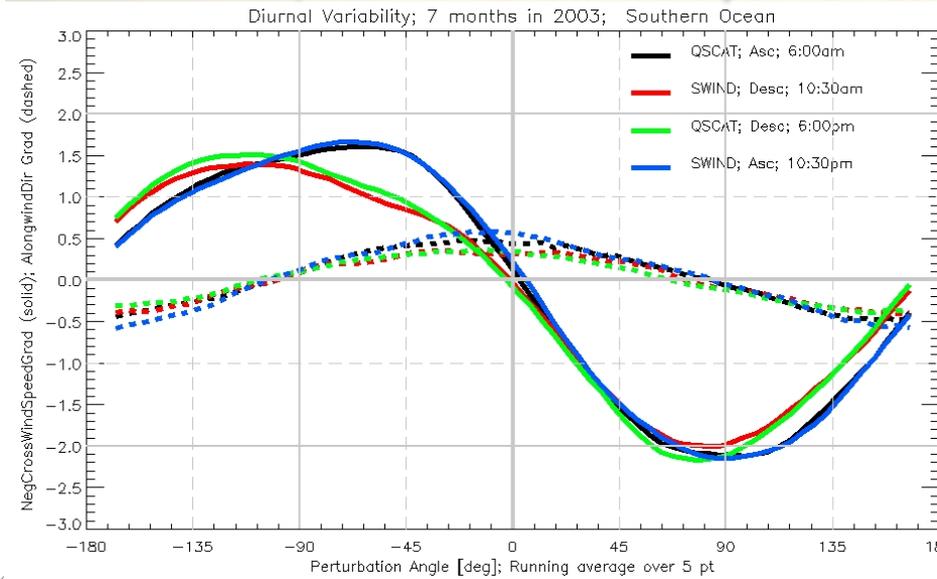
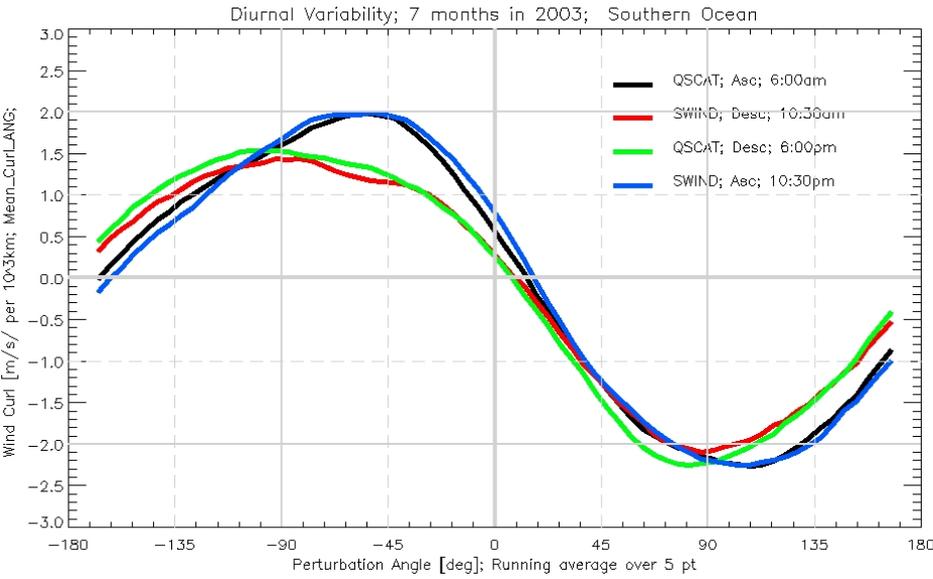
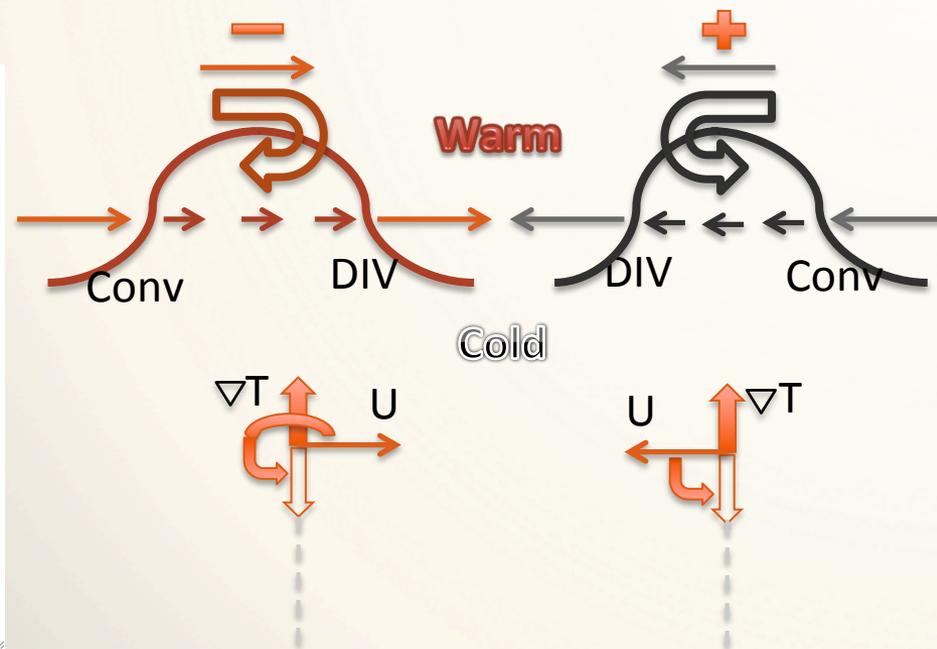
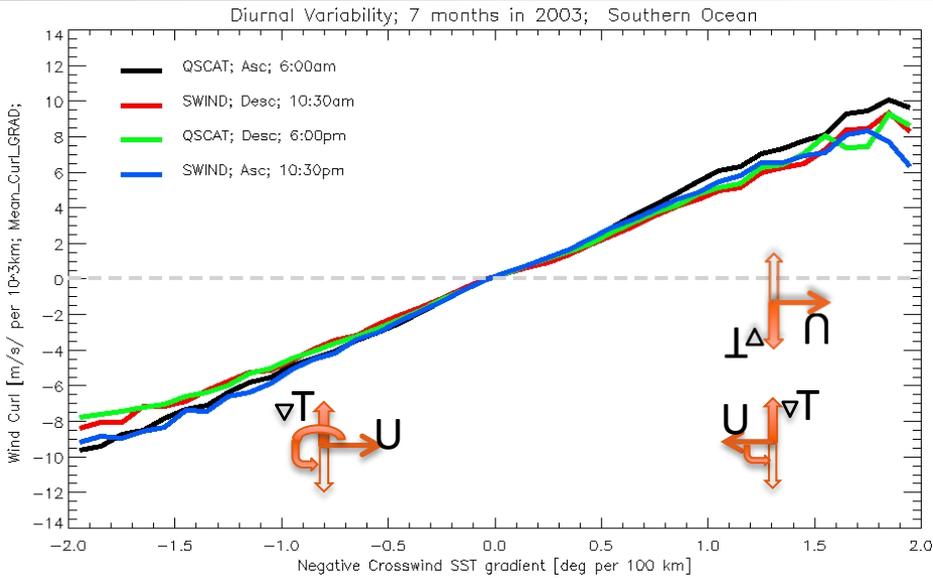
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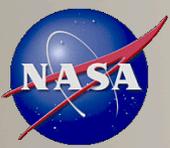




QuikSCAT and SeaWINDS

- CURL

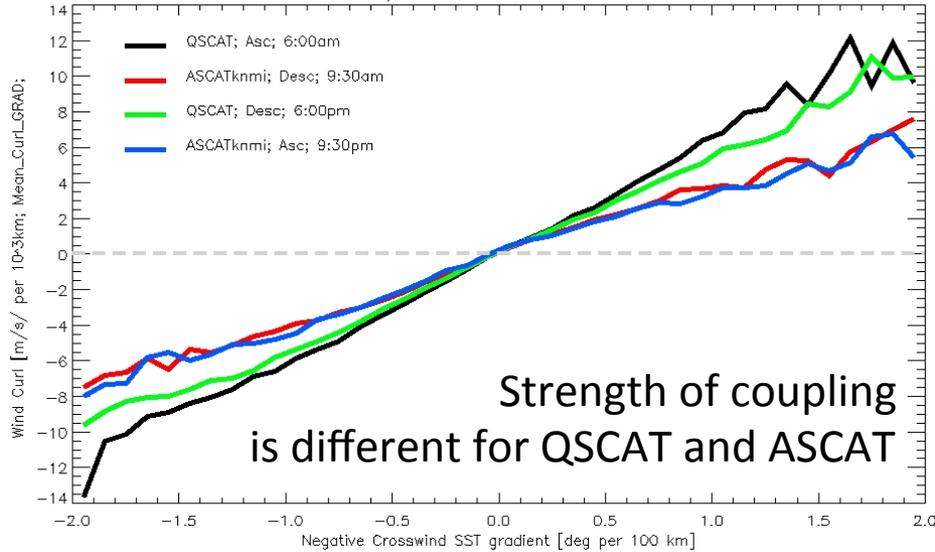




• QSCAT and ASCAT (KNMI) - CURL



Diurnal Variability; 7 months in 2008; Southern Ocean

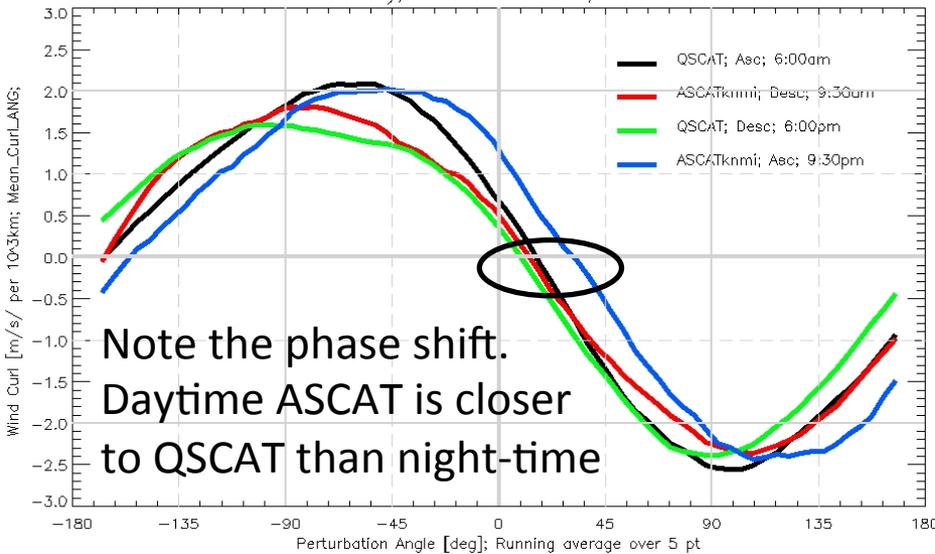


Diurnal variability as depicted by the QSCAT/ASCAT tandem missions is similar to that depicted by the QSCAT/SWIND tandem missions.

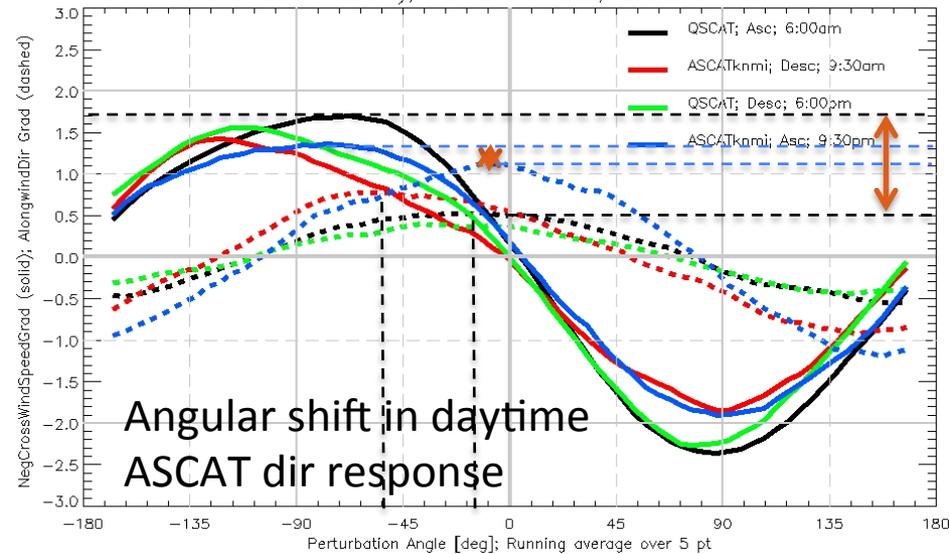
Differences:

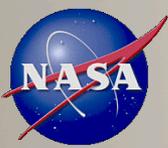
- strength of coupling
- speed and dir responses are similar in magnitude for ASCAT but not for QuikSCAT

Diurnal Variability; 7 months in 2008; Southern Ocean

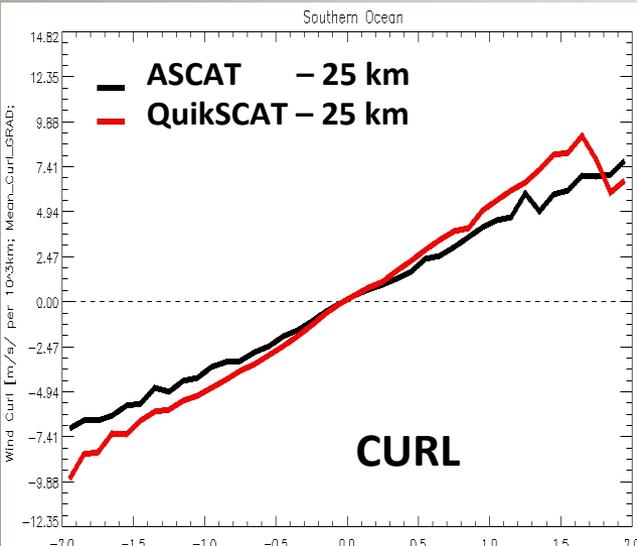


Diurnal Variability; 7 months in 2008; Southern Ocean

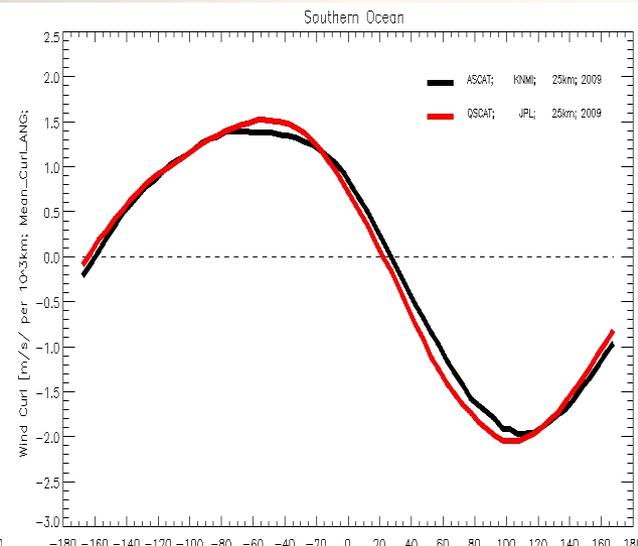




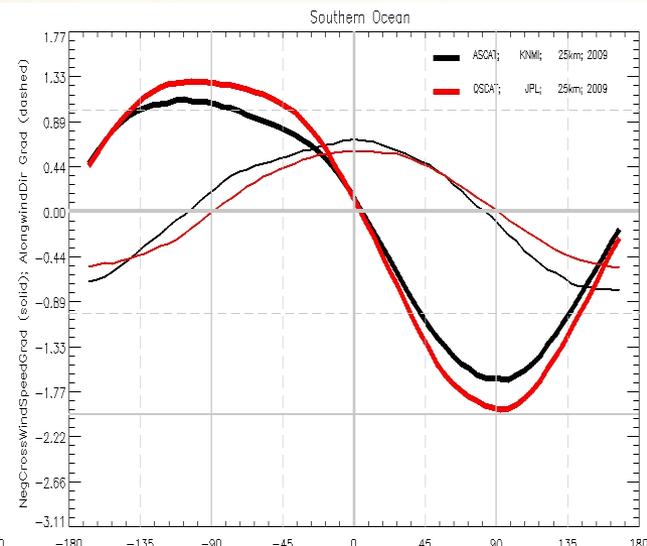
Impact of resolution – 2009 – 25km



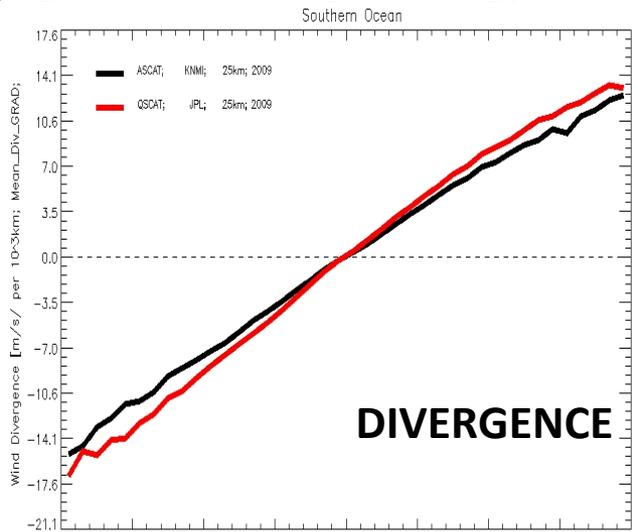
Negative crosswind SST gradient [deg per 100 km]



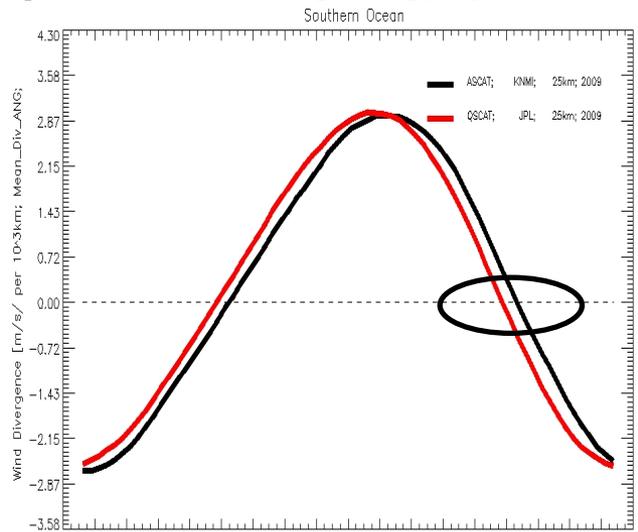
Perturbation angle [deg]; 5 point ave.



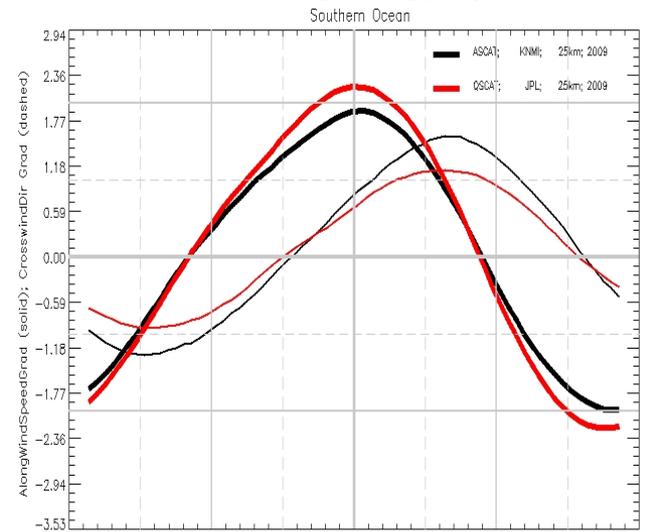
Perturbation angle [deg]; 5 point ave.



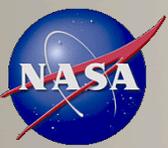
Alongwind SST gradient [deg per 100 km]



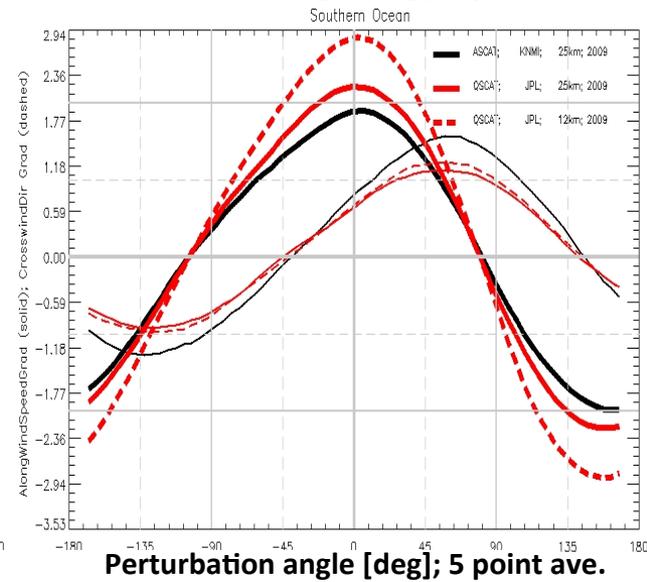
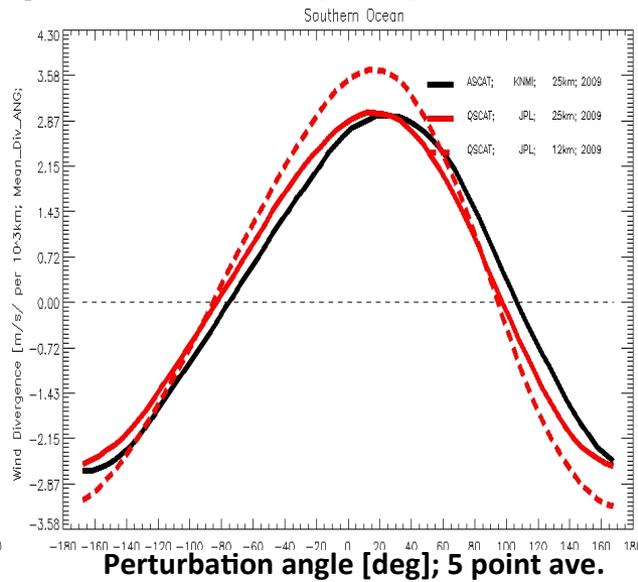
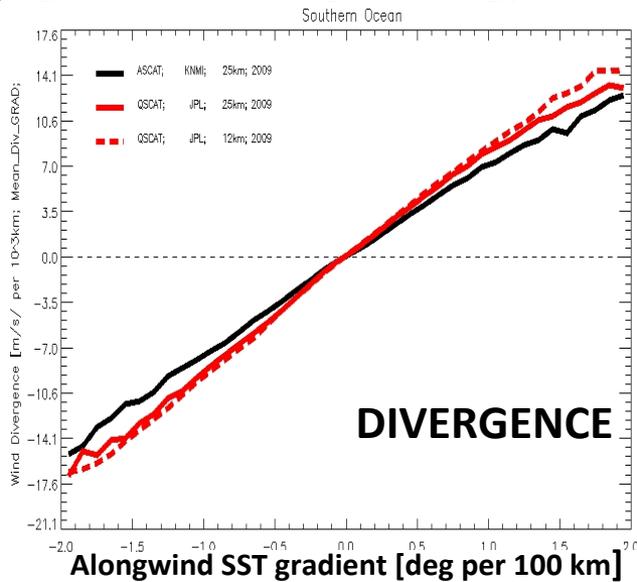
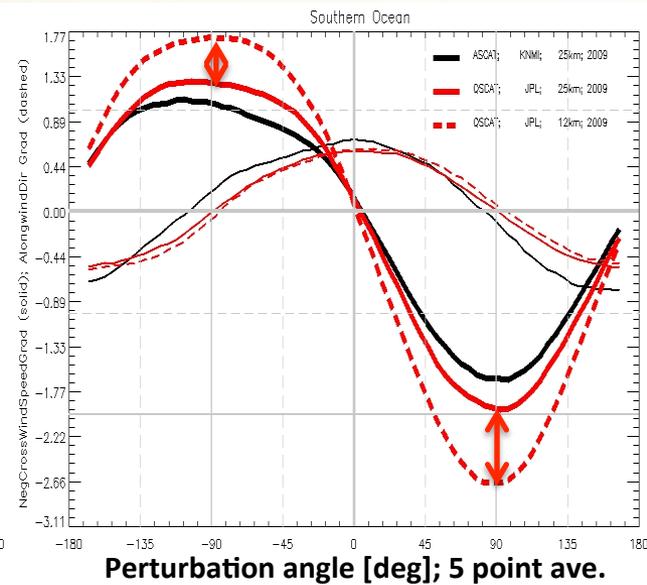
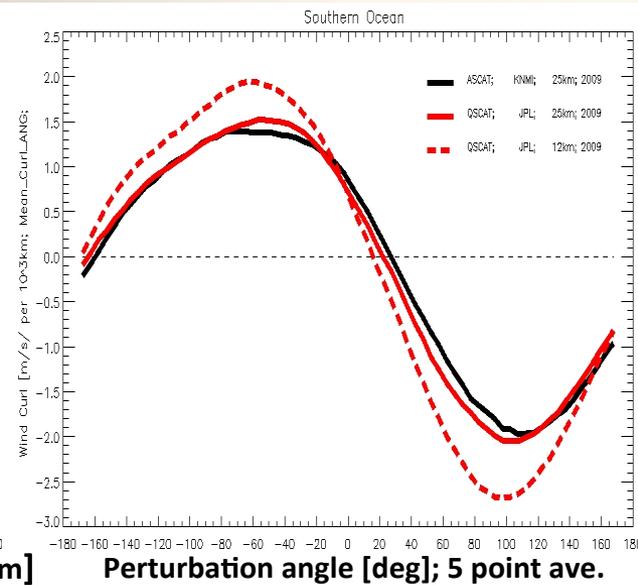
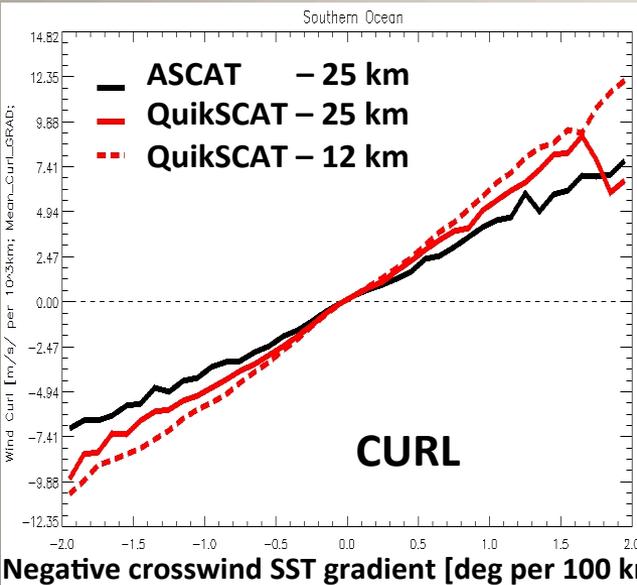
Perturbation angle [deg]; 5 point ave.

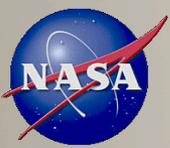


Perturbation angle [deg]; 5 point ave.

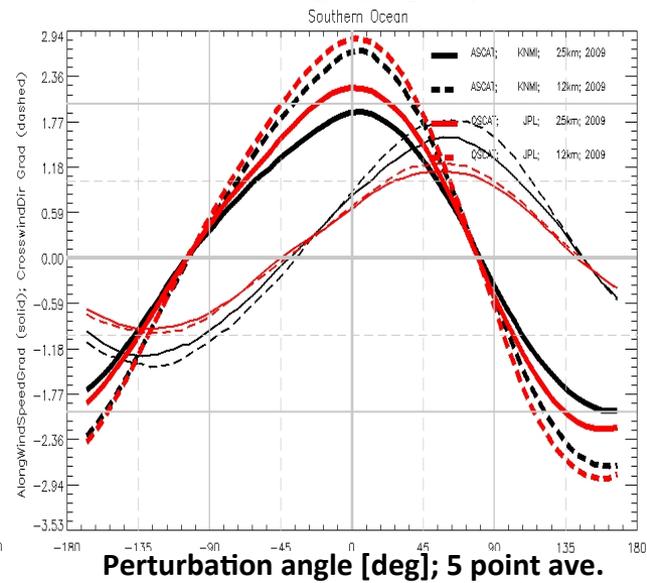
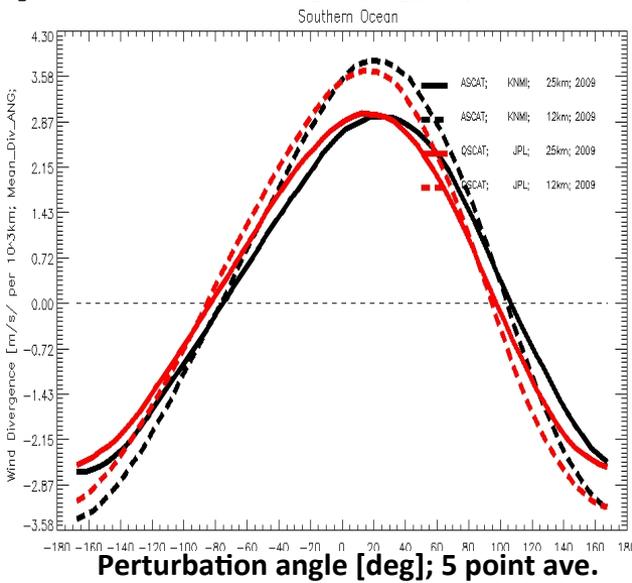
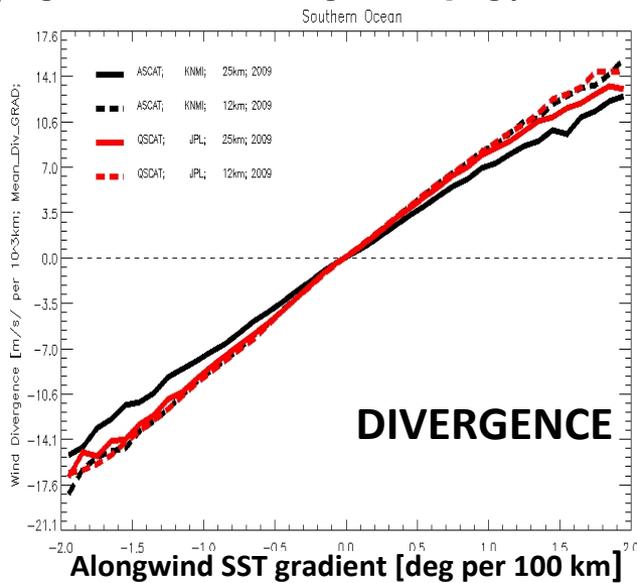
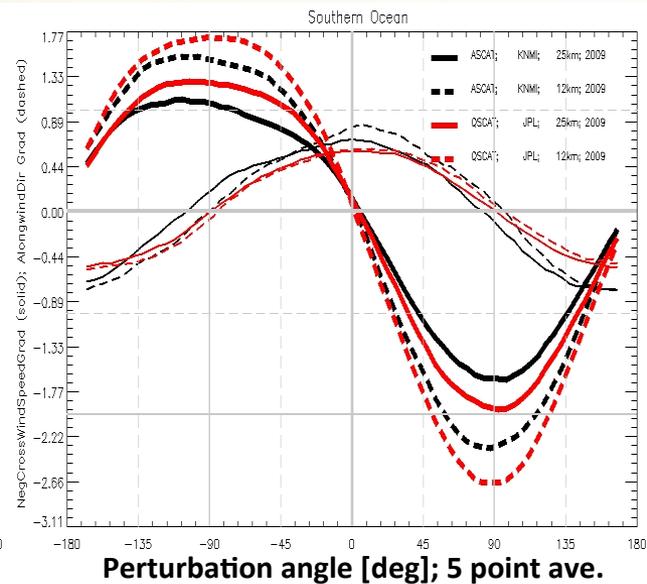
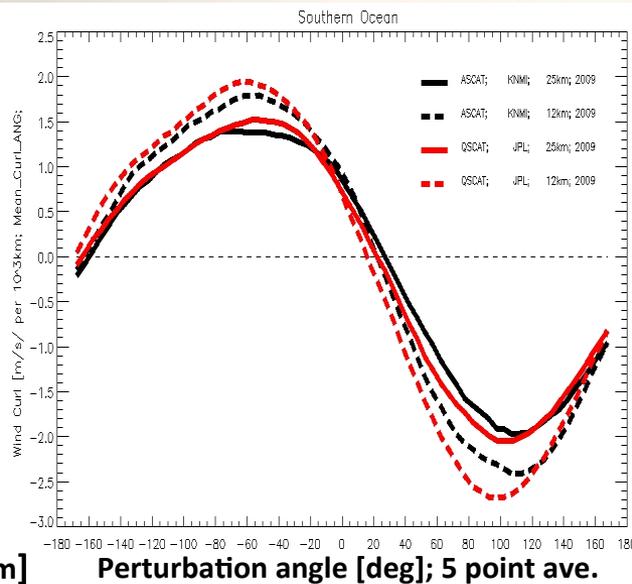
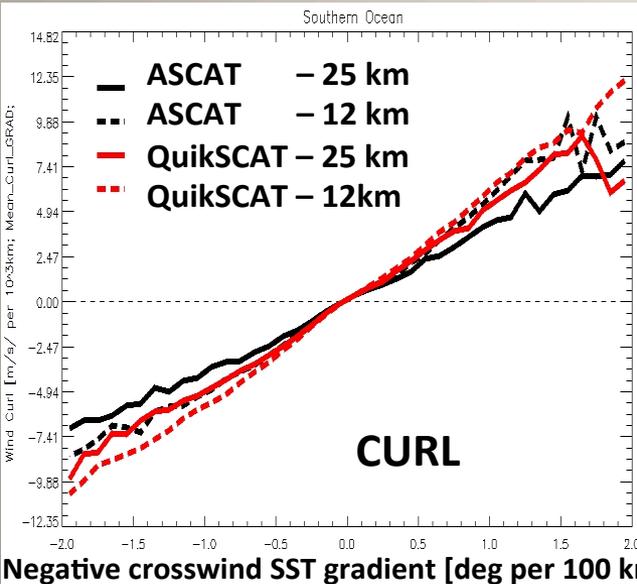


Impact of resolution – 2009



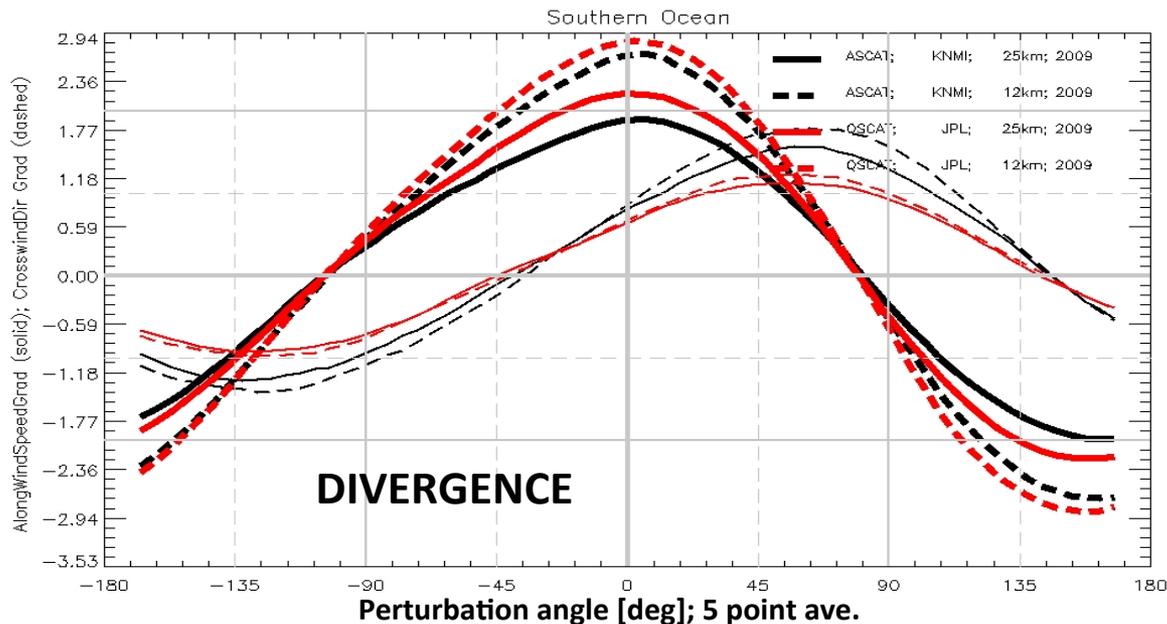
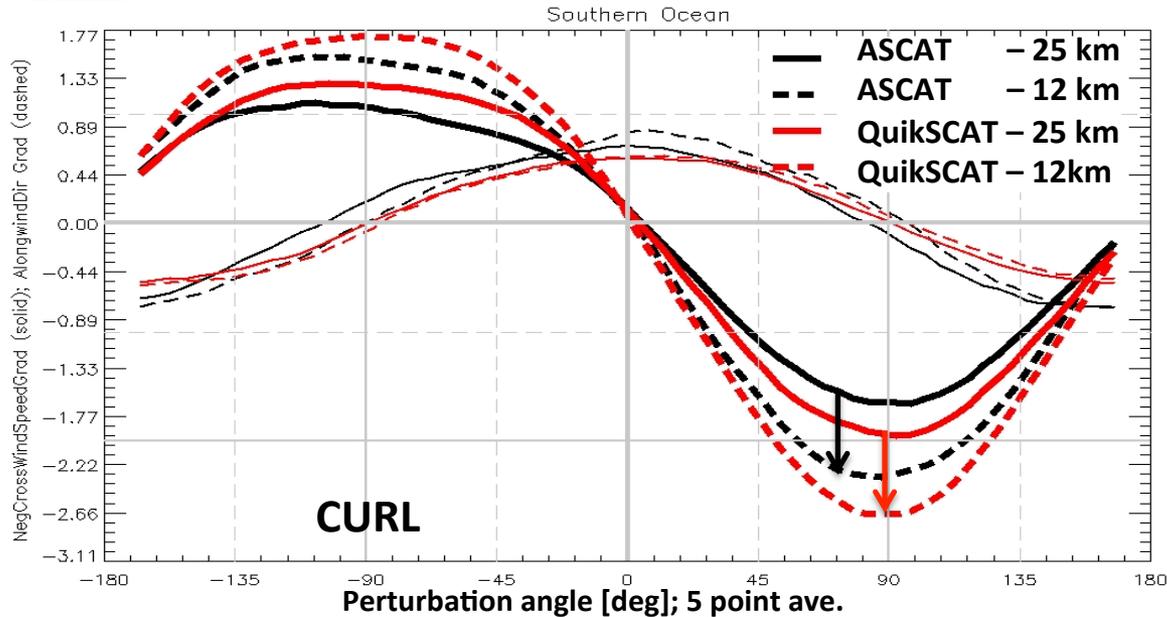


Impact of resolution – 2009





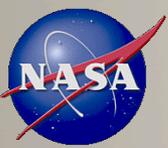
Impact of resolution – 2009



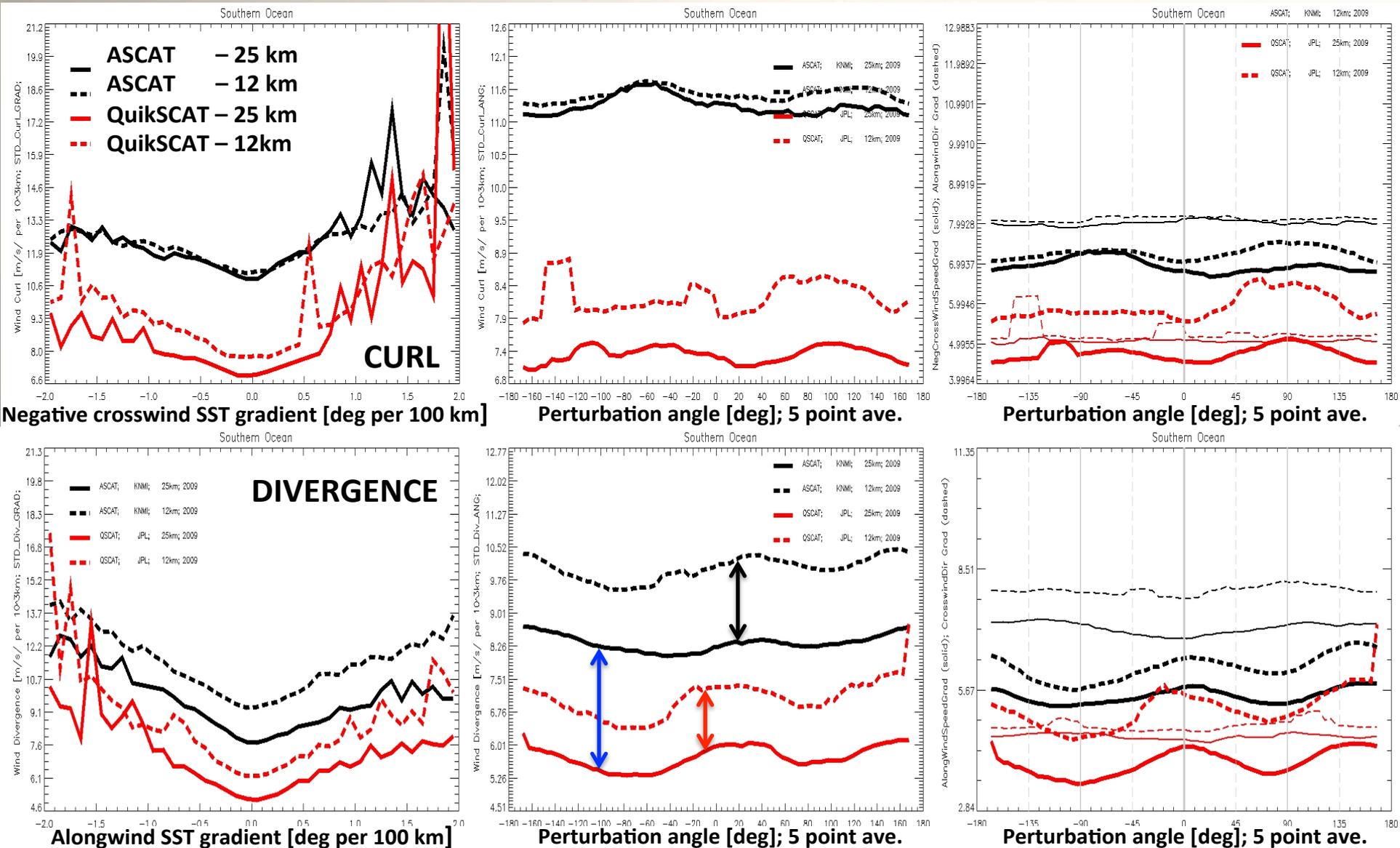
Increase in the resolution of the scatterometer winds (from 25km to 12km) results in increase in the speed response while the directional response remains almost unchanged. This is true for both QuikSCAT and ASCAT.

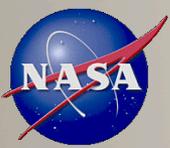
The enhancement of the speed coupling might be reflective of the increased contribution of the vertical turbulent mixing!

As O’Niell et al., 2010 pointed out, idealized large-eddy simulations (Skylingstad et al. 2007) showed that on spatial scales of 1–20 km near-surface wind speed variations are influenced predominantly by SST-induced cross-frontal variations in the vertical turbulent mixing of momentum.

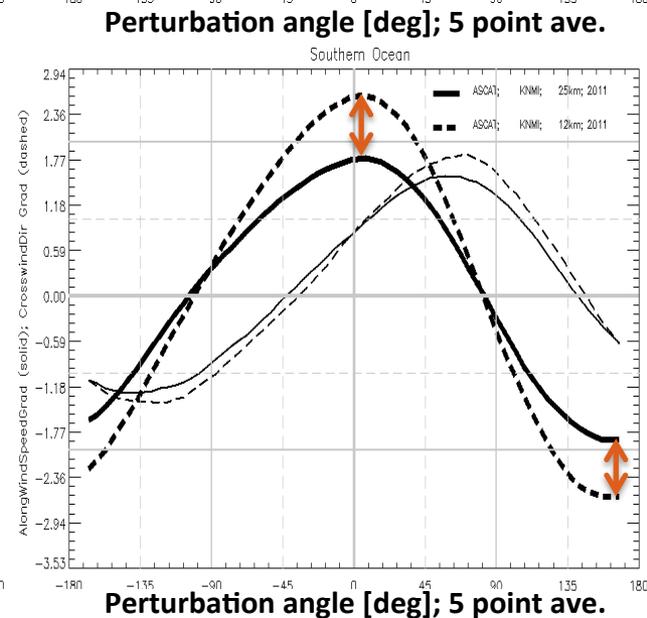
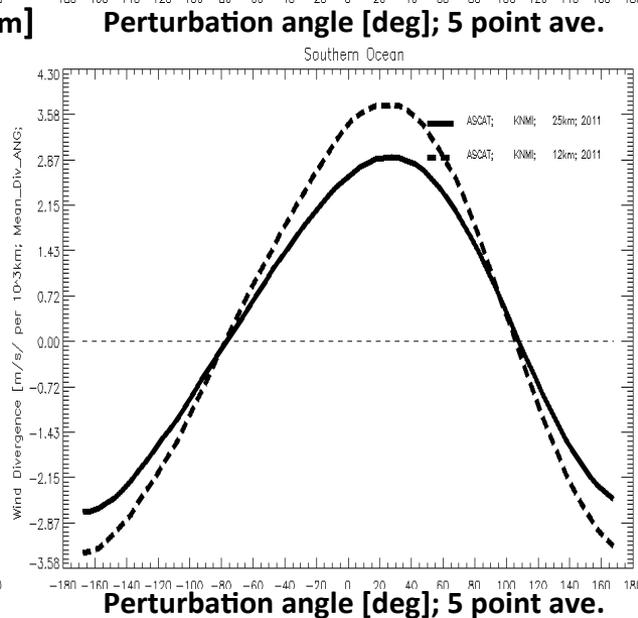
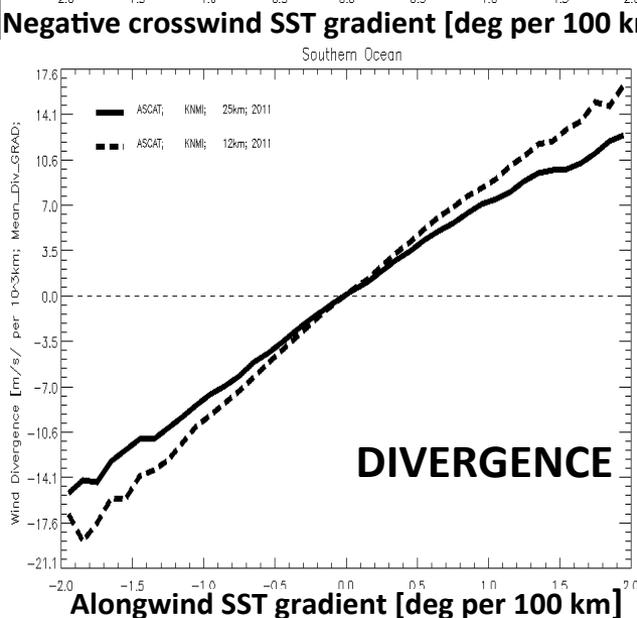
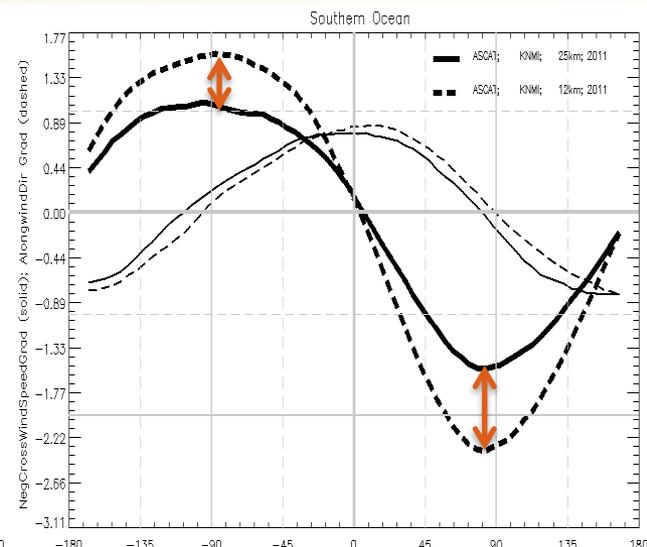
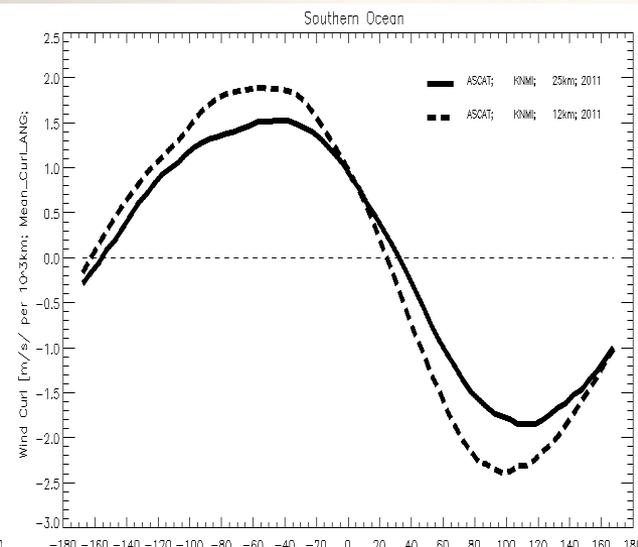
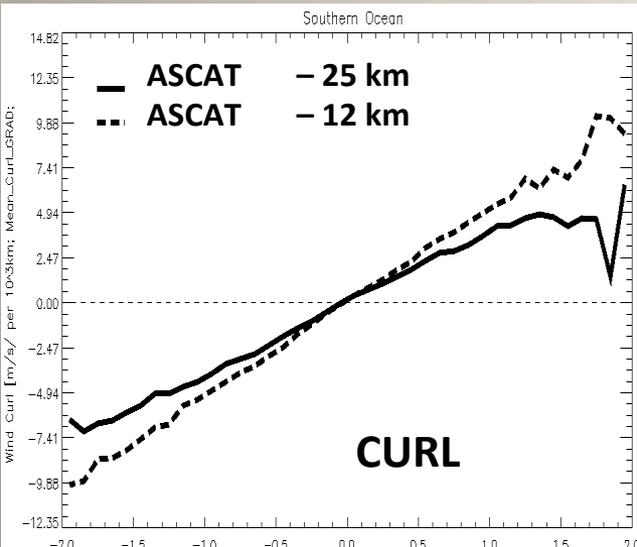


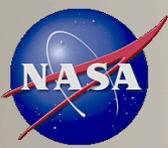
Impact of resolution – 2009 - STD



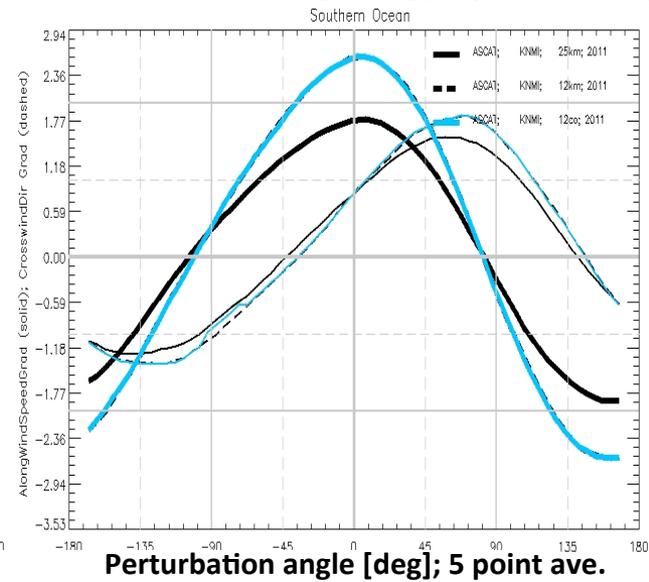
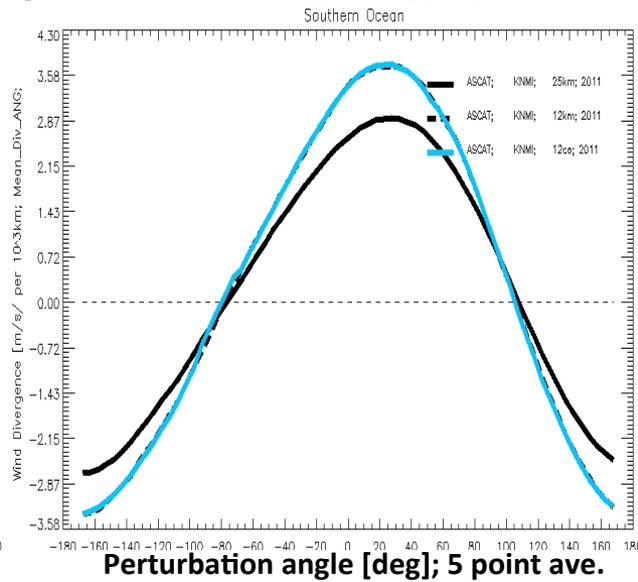
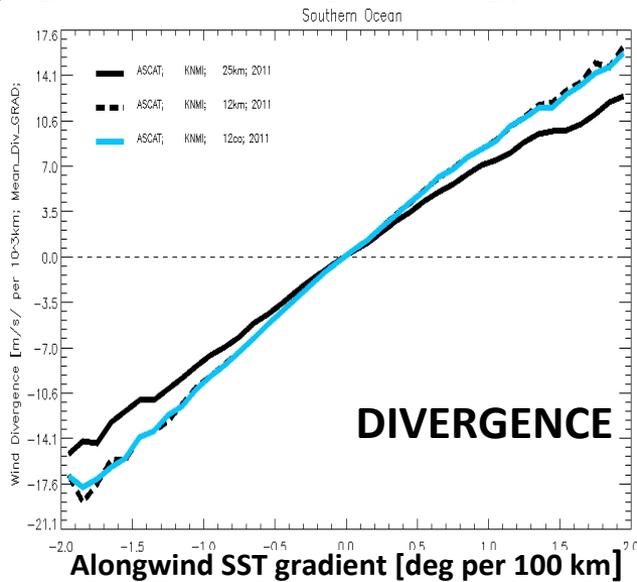
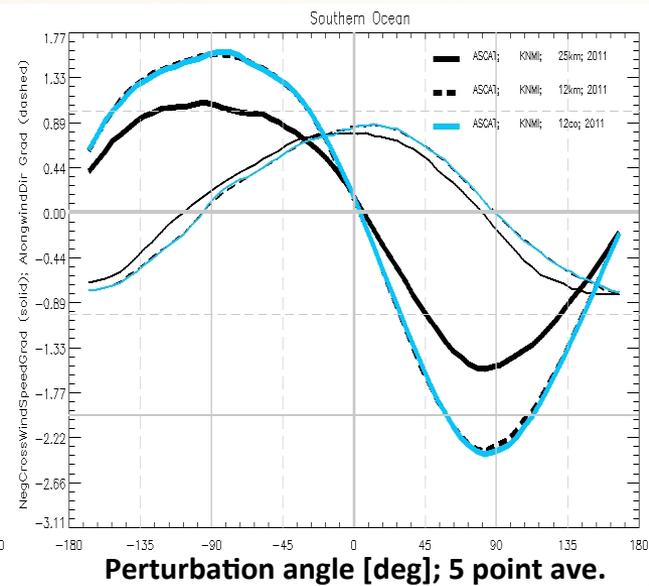
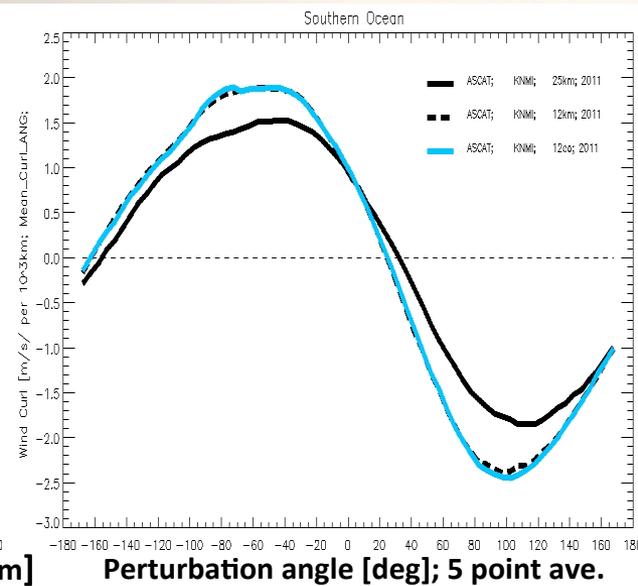
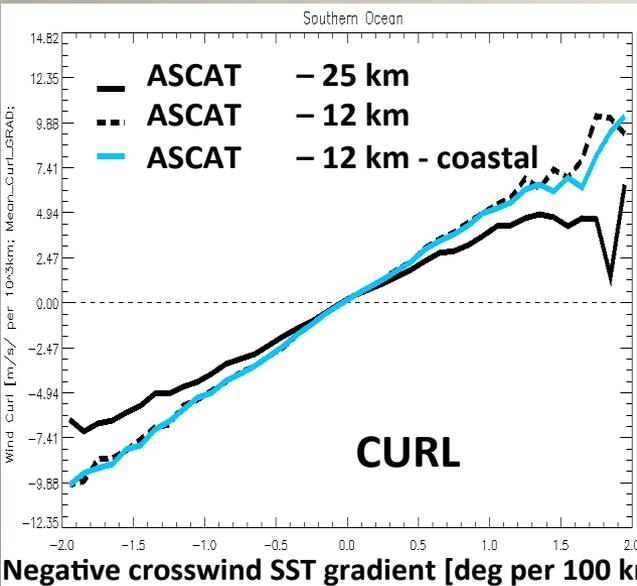


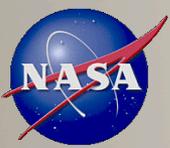
Impact of resolution – 2011 - coastal



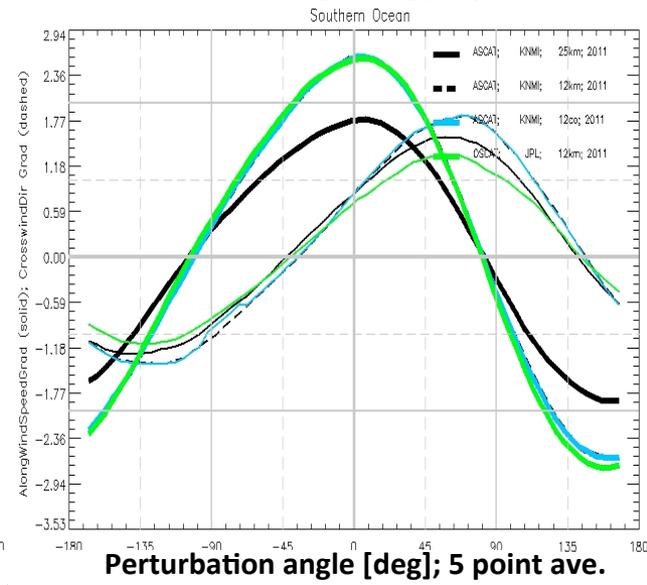
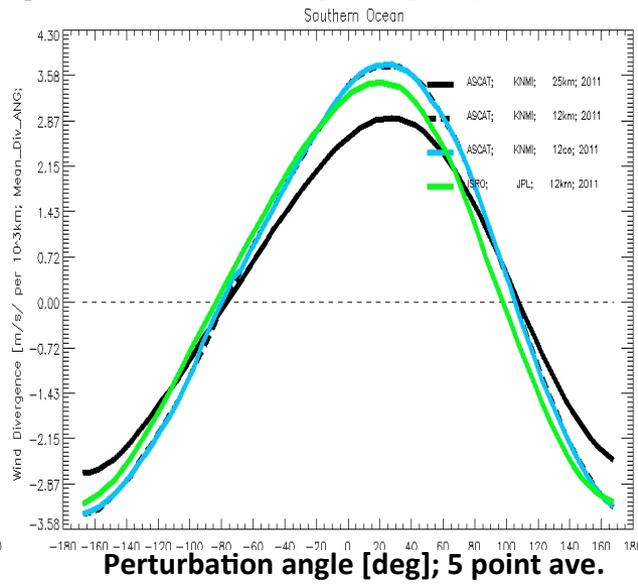
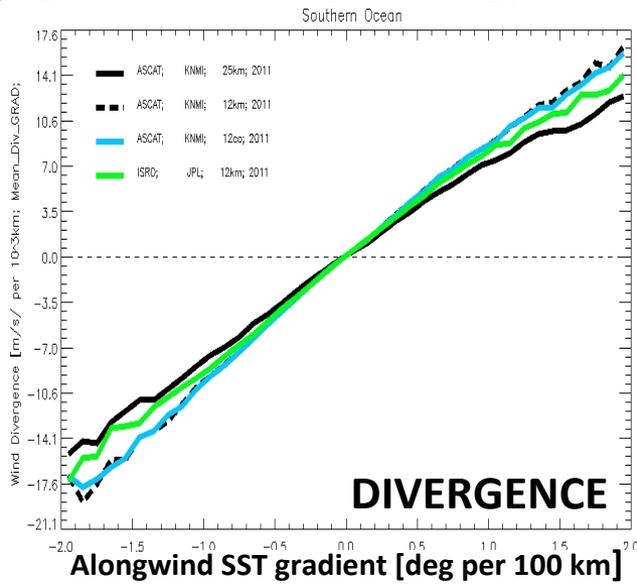
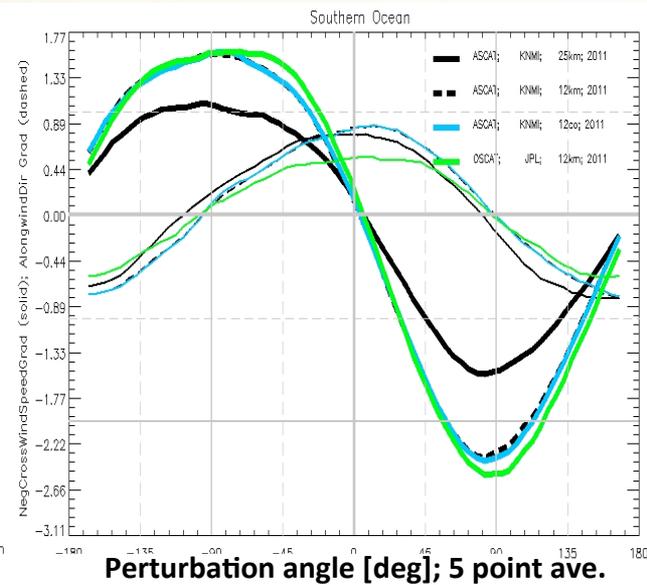
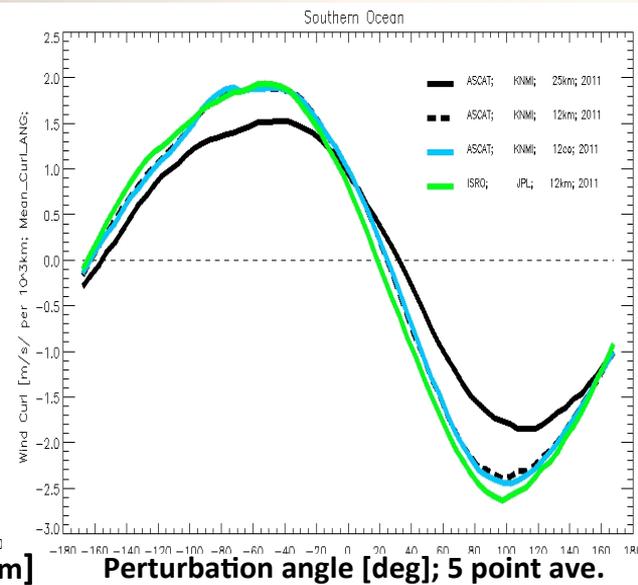
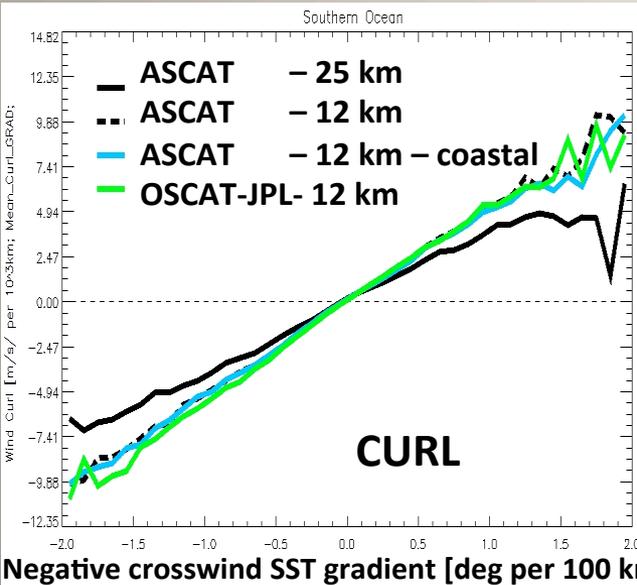


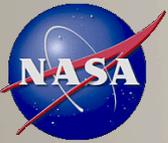
Impact of resolution – 2011 - coastal



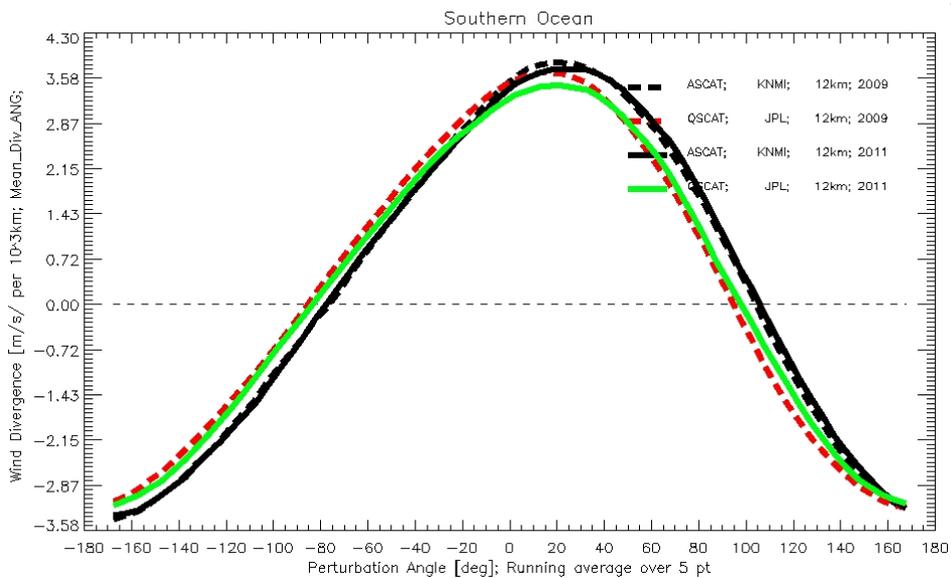
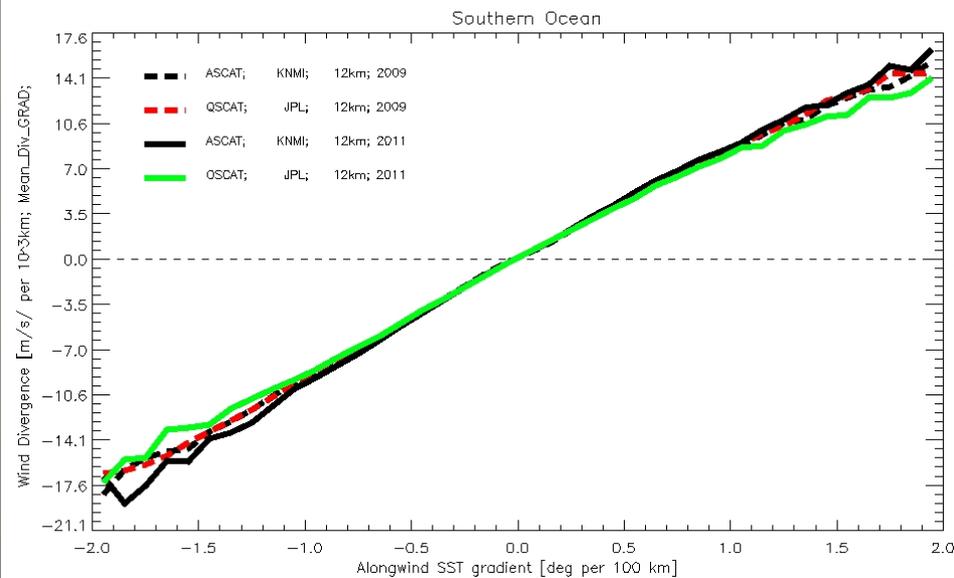
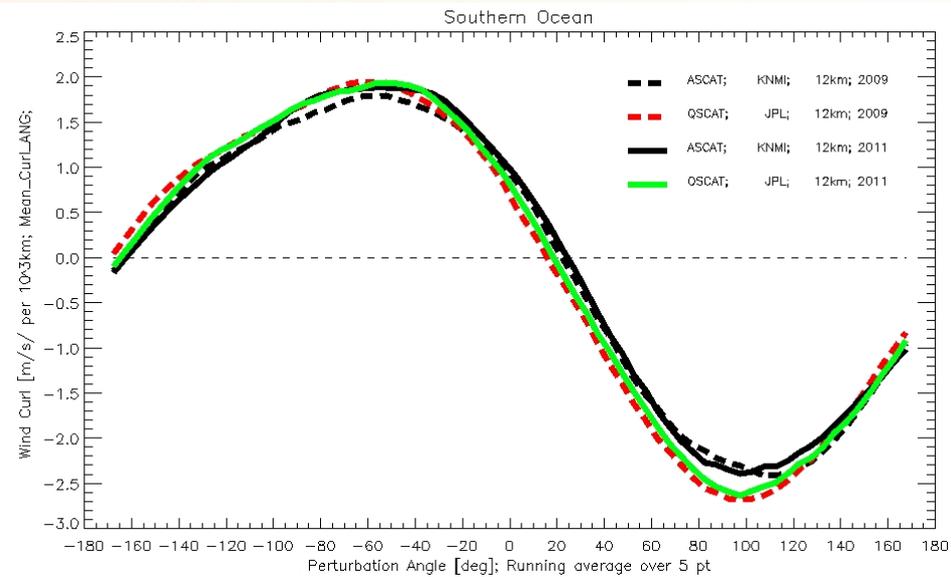
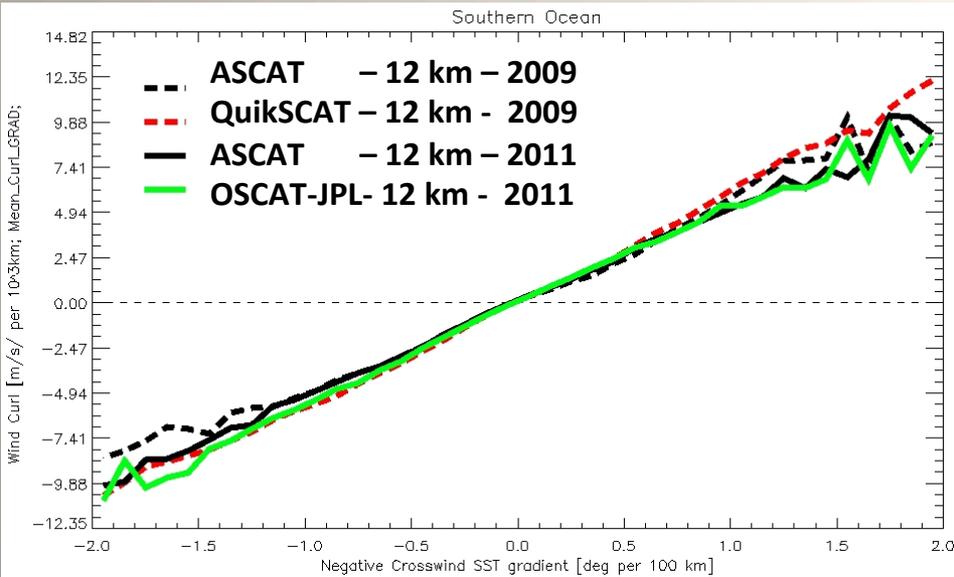


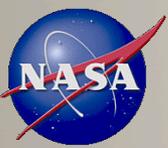
ASCAT versus OSCAT - 2011



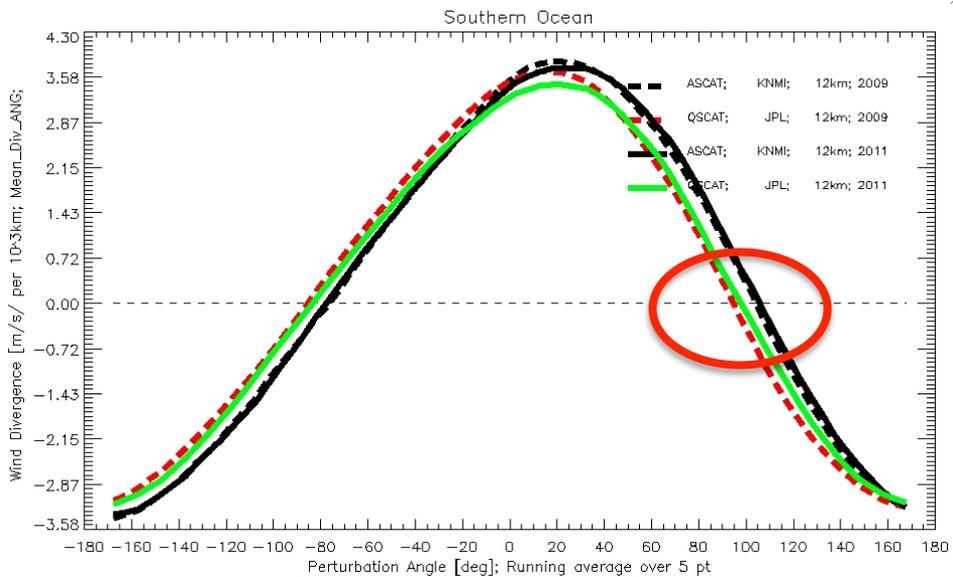
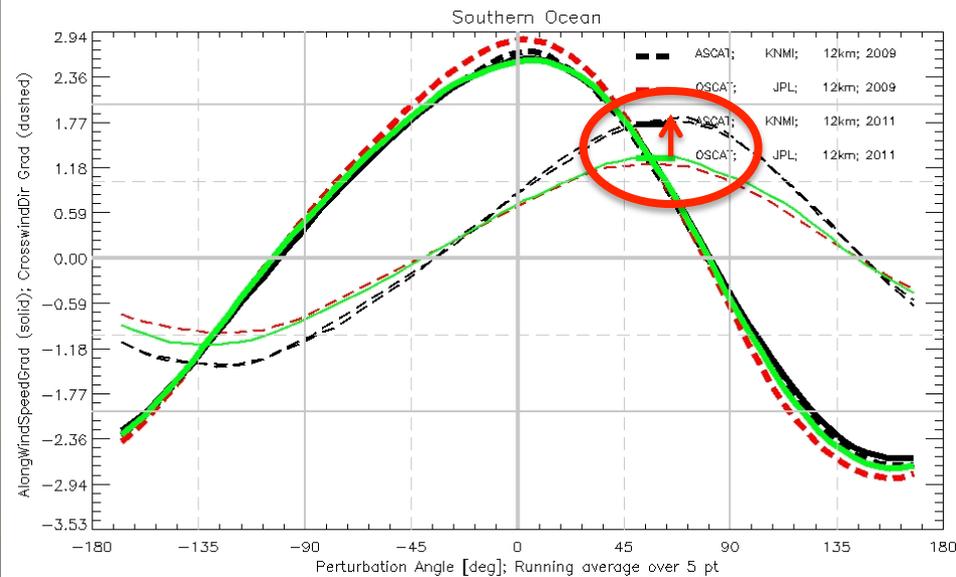
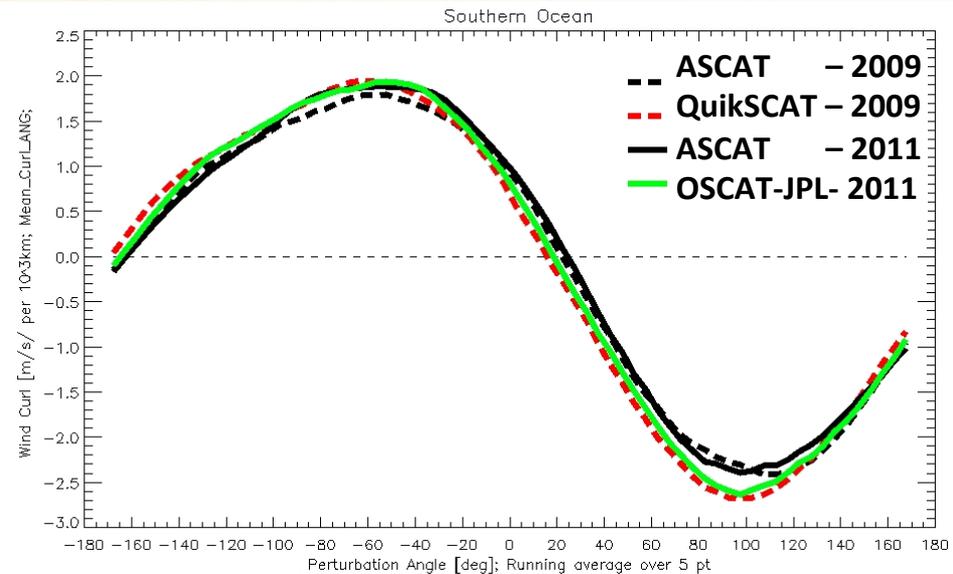
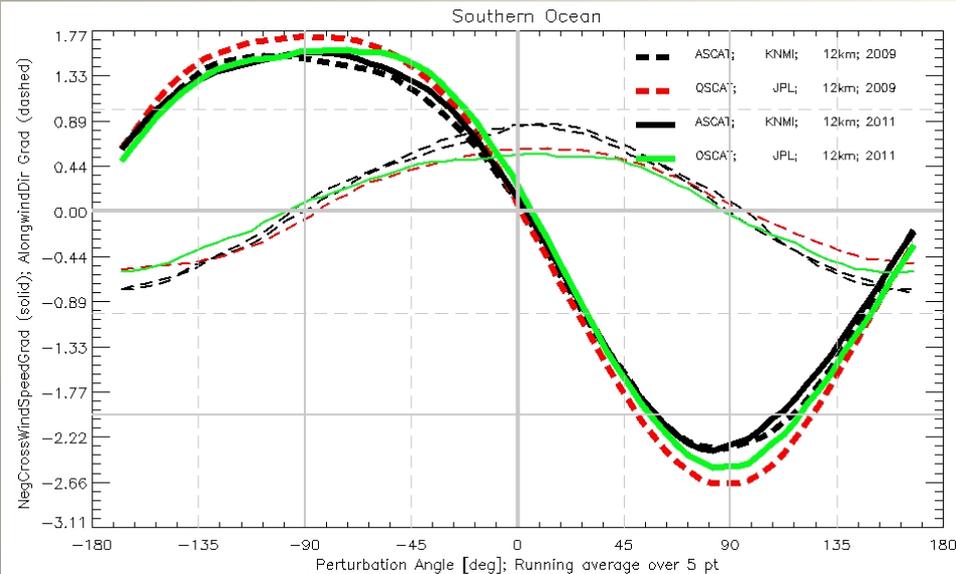


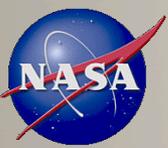
ASCAT vs QuikSCAT(2009) and ASCAT vs OSCAT (2011)



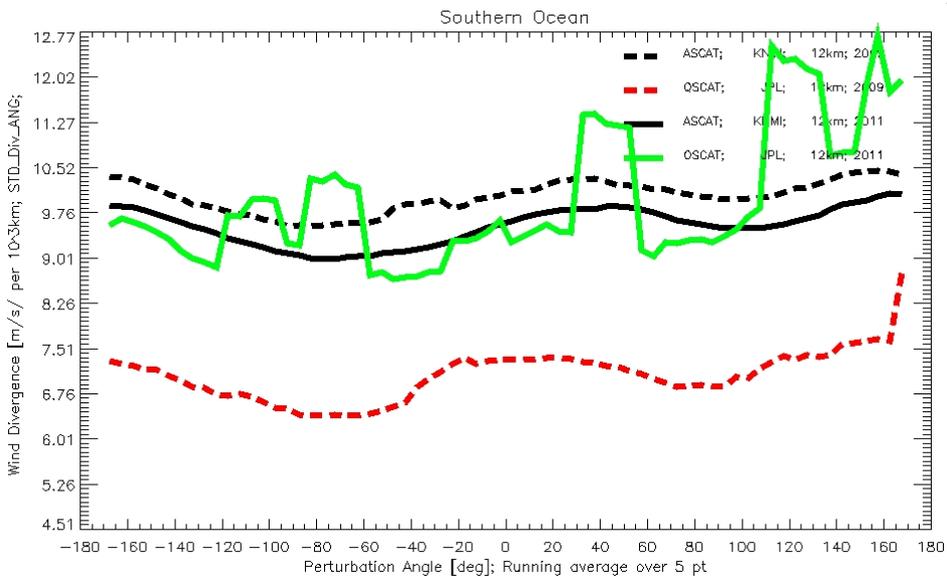
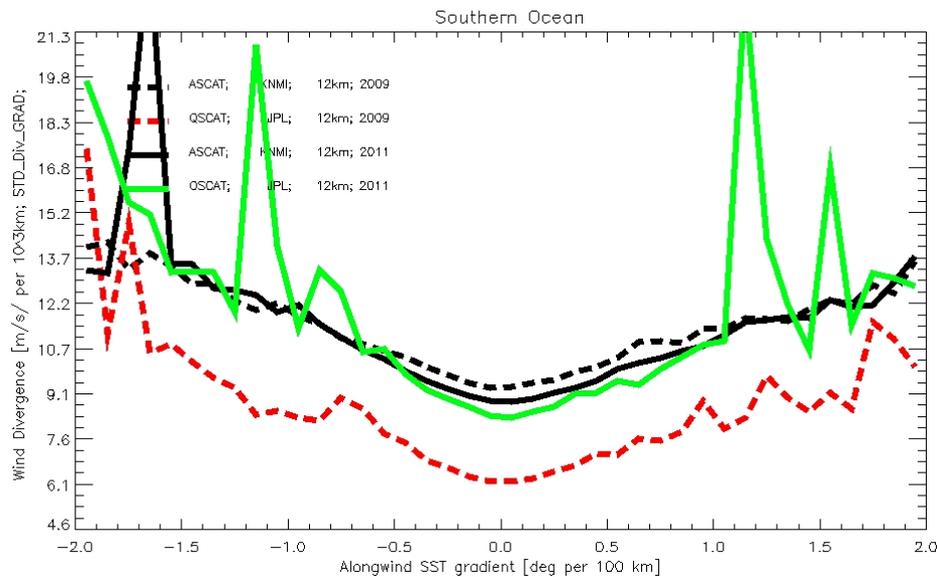
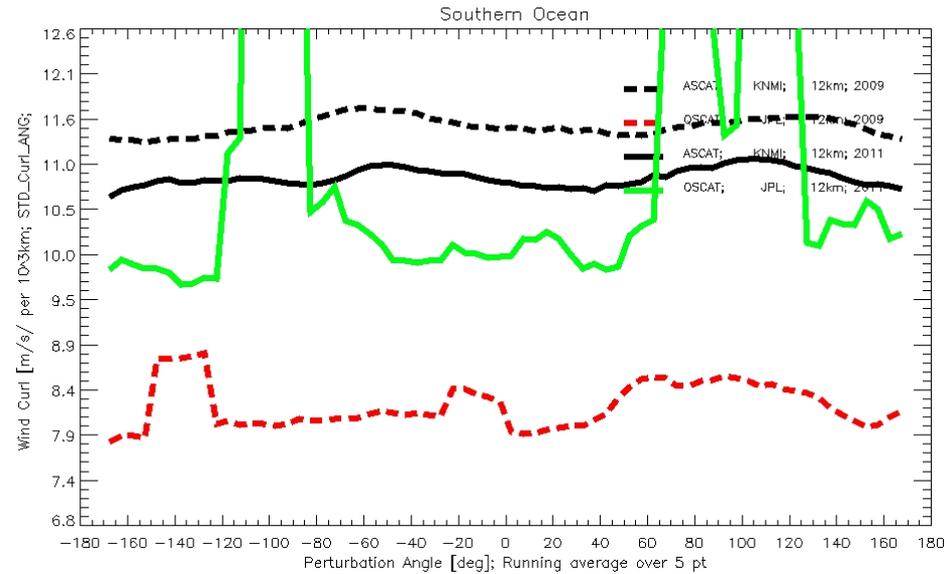
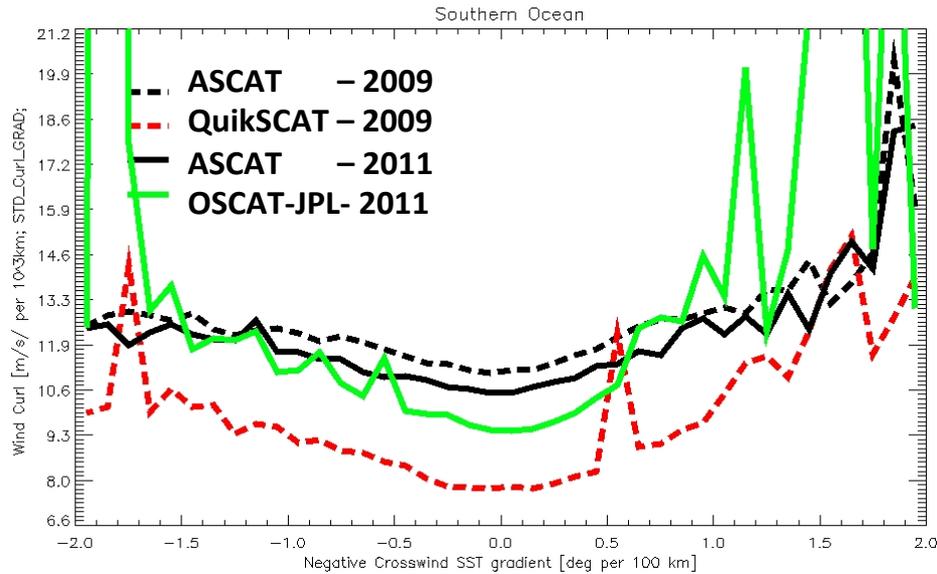


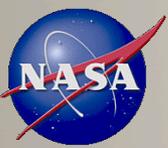
ASCAT vs QuikSCAT(2009) and ASCAT vs OSCAT (2011)





ASCAT vs QuikSCAT(2009) and ASCAT vs OSCAT (2011)





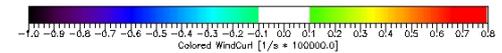
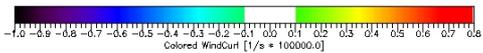
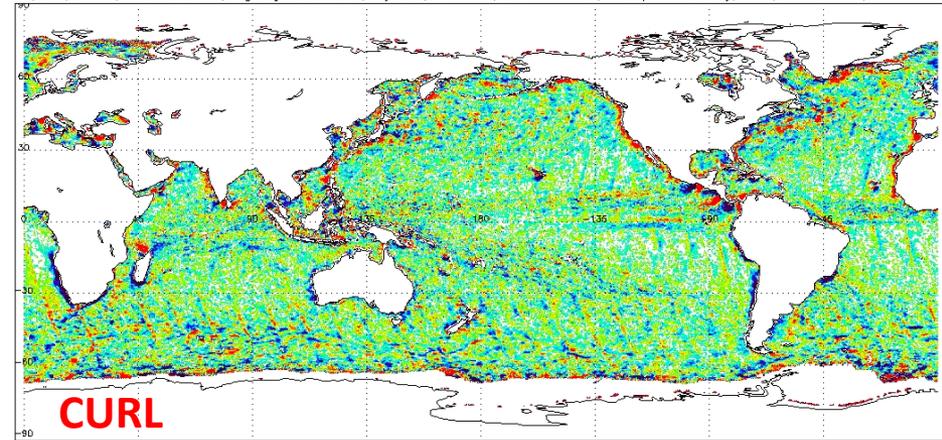
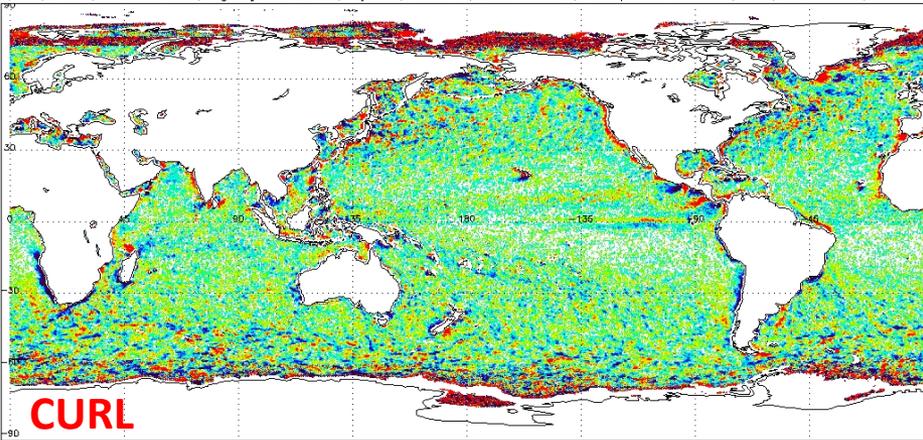
ASCAT

OSCAT



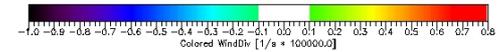
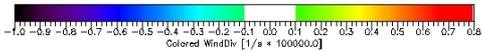
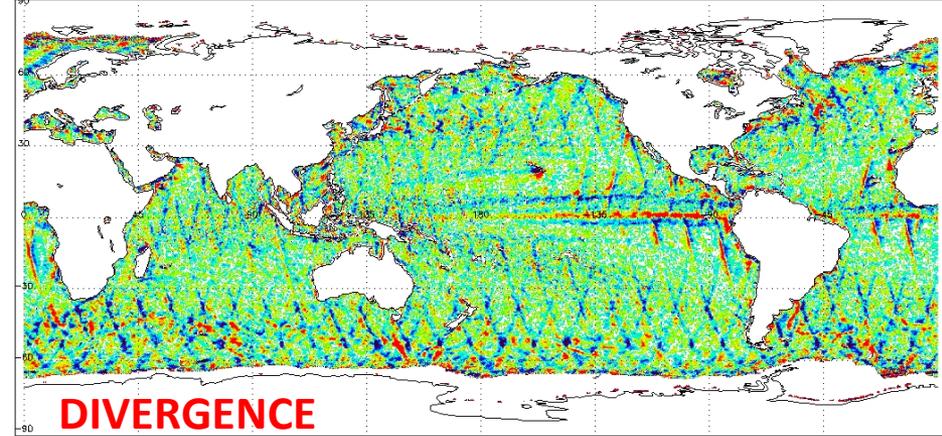
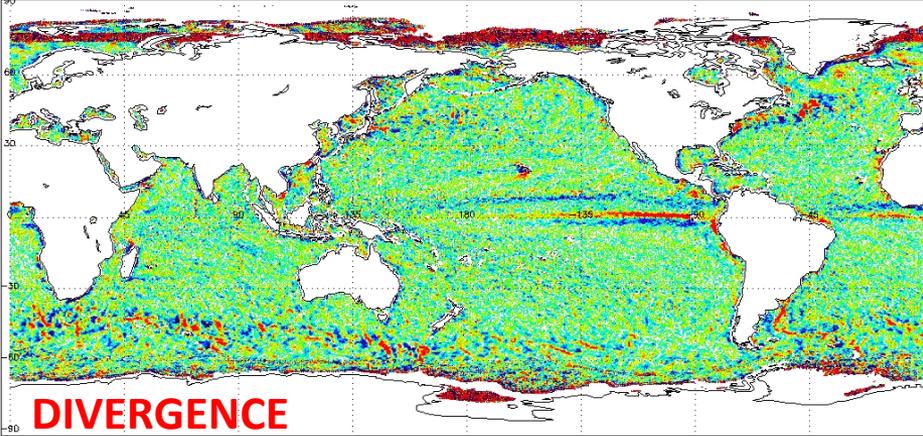
ASCAT; Year; YEAR11; Resolution=12km; BeginDay 2011-07-09; Days 306; _2weeks22; COMBINED_AsDes; ASCTmpBASE WindRetrieval; DIRTH; HamHP_10x30; bias0.0_2weeks

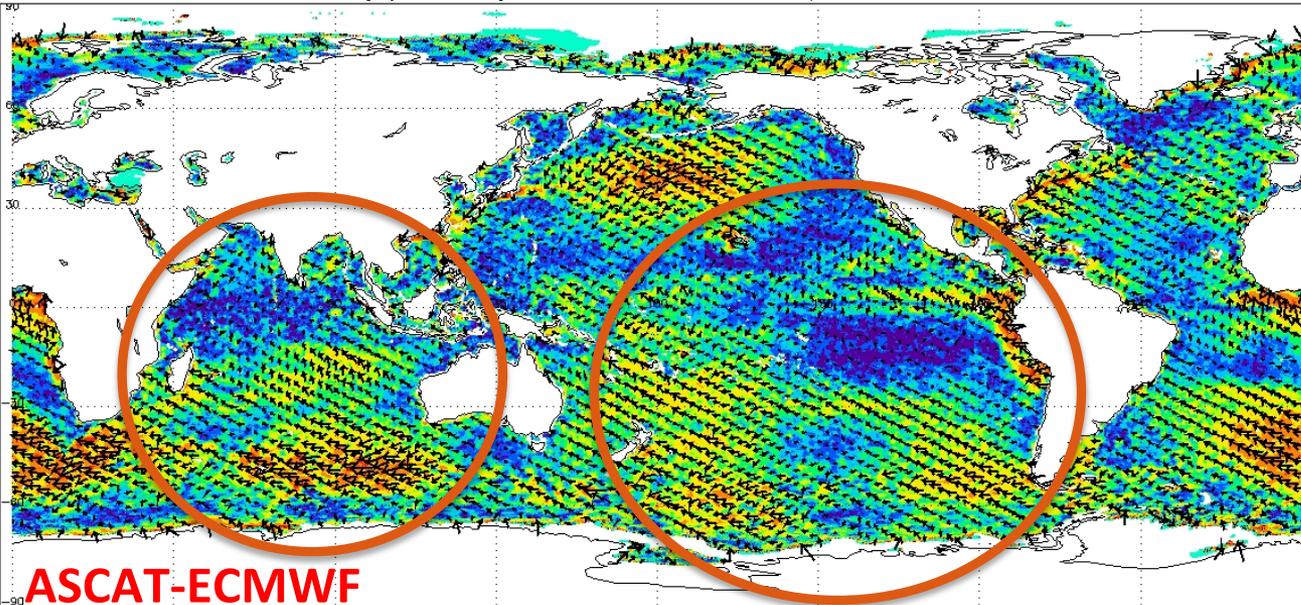
OSCAT; Year; YEAR11; Resolution=12km; BeginDay 2011-07-09; Days 306; _2weeks22; COMBINED_AsDes; ISRCmpBASE noRfOnly; DIRTH; HamHP_10x30; bias0.0_2weeks



ASCAT; Year; YEAR11; Resolution=12km; BeginDay 2011-07-09; Days 306; _2weeks22; COMBINED_AsDes; ASCTmpBASE WindRetrieval; DIRTH; HamHP_10x30; bias0.0_2weeks

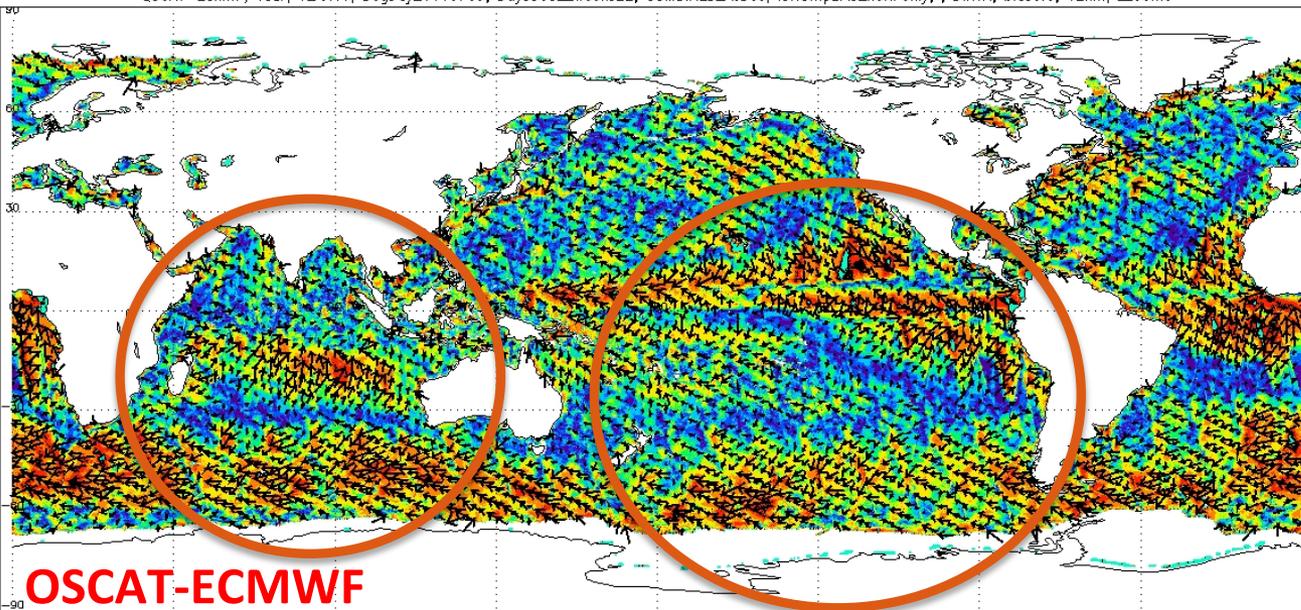
OSCAT; Year; YEAR11; Resolution=12km; BeginDay 2011-07-09; Days 306; _2weeks22; COMBINED_AsDes; ISRCmpBASE noRfOnly; DIRTH; HamHP_10x30; bias0.0_2weeks





Merging the wind estimates from ASCAT and OSCAT will allow extending the climate data record and increasing the time sampling.

Before merging them, we have to evaluate their consistency.

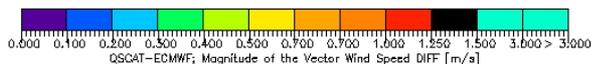


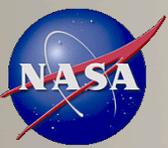
Climatologies based on 1-year average:

2011

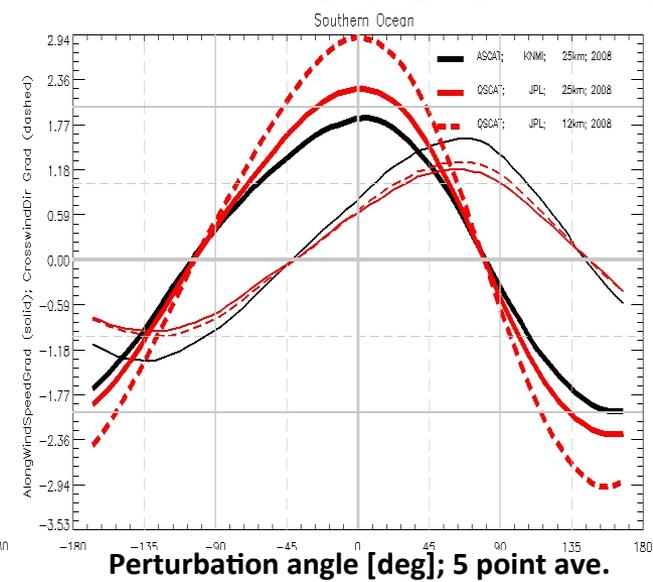
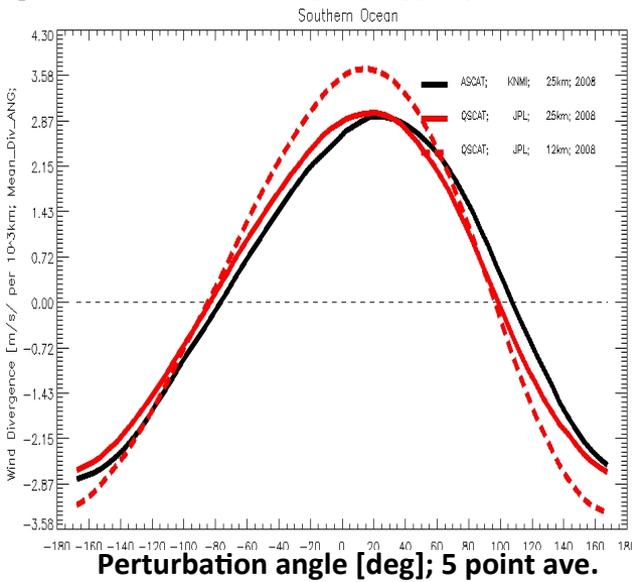
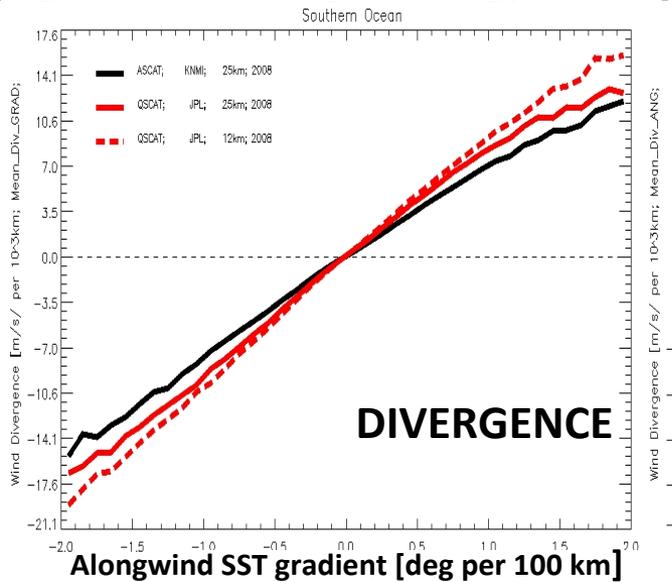
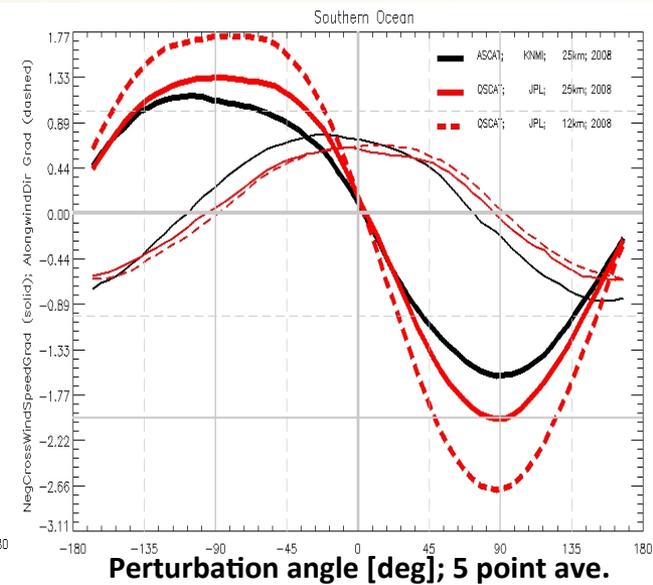
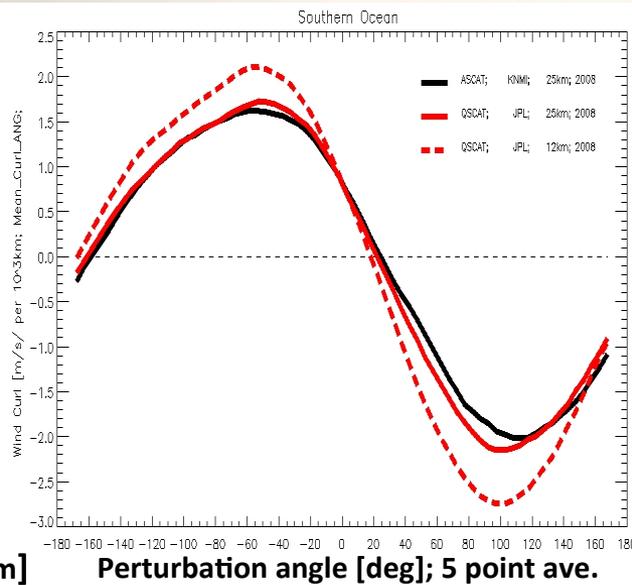
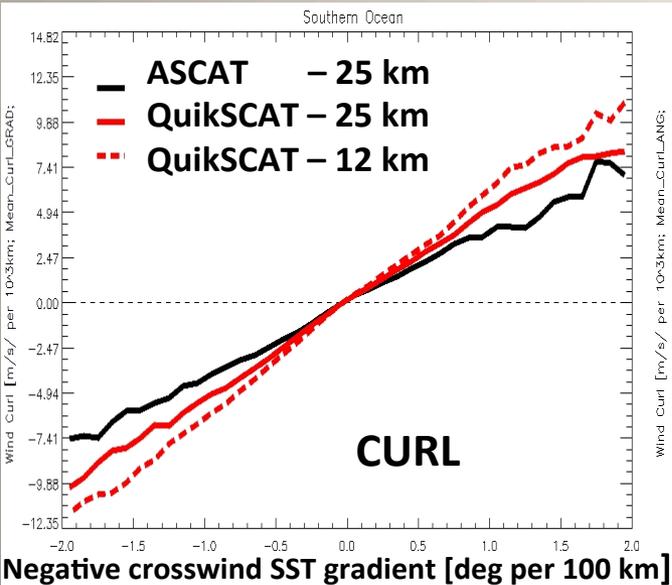
Wind calculated from L2 wind products

Differences are larger than between QuikSCAT and ASCAT



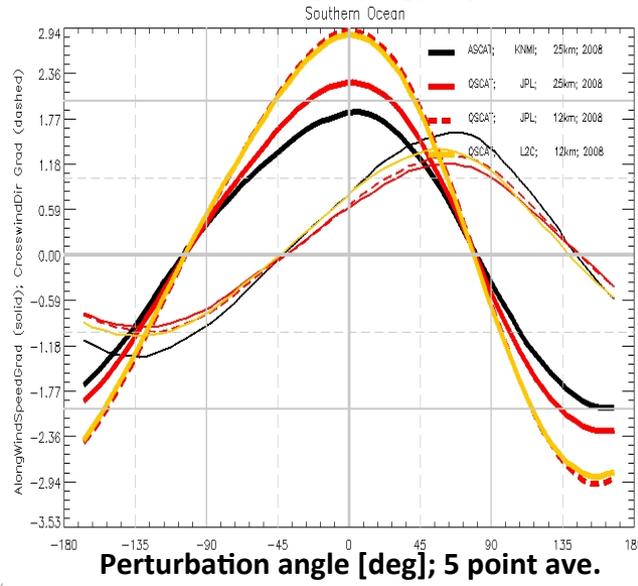
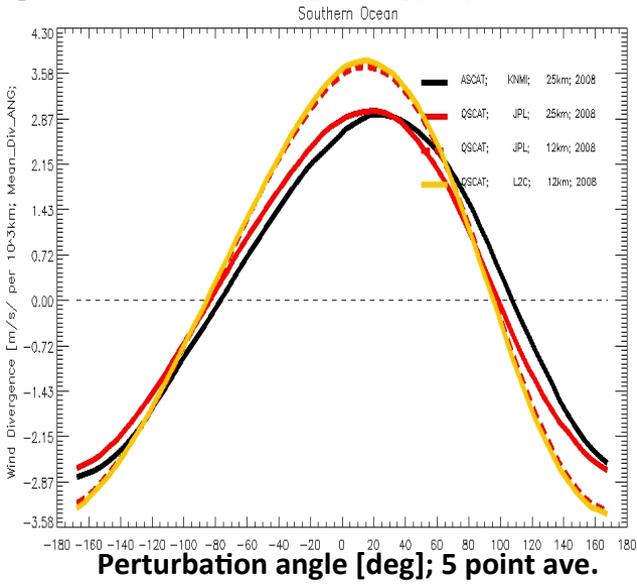
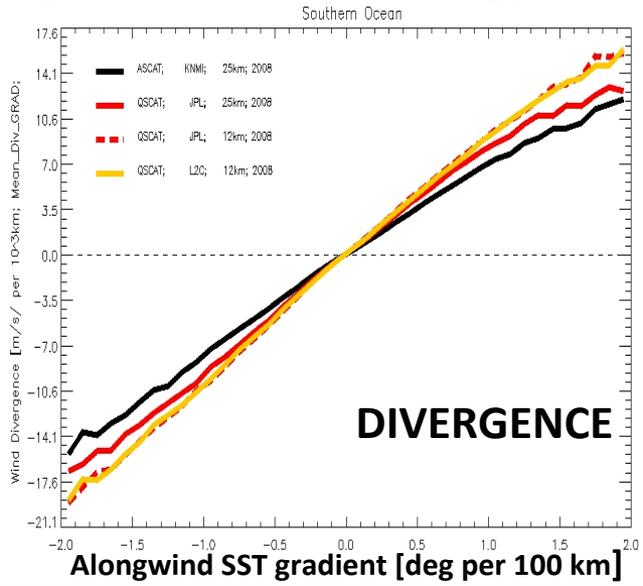
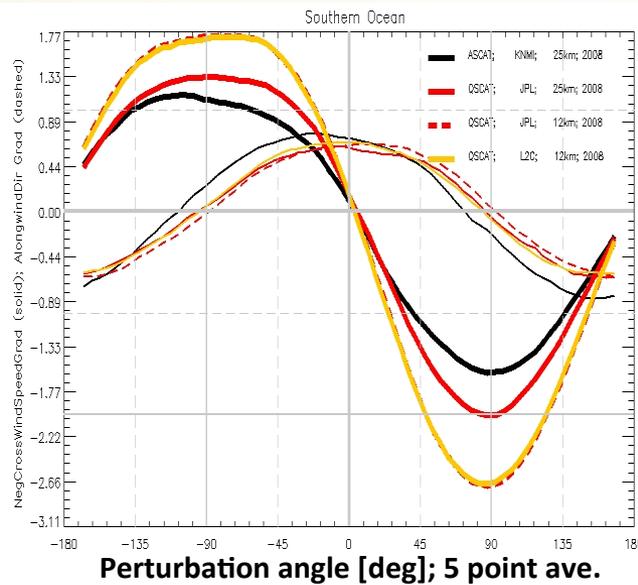
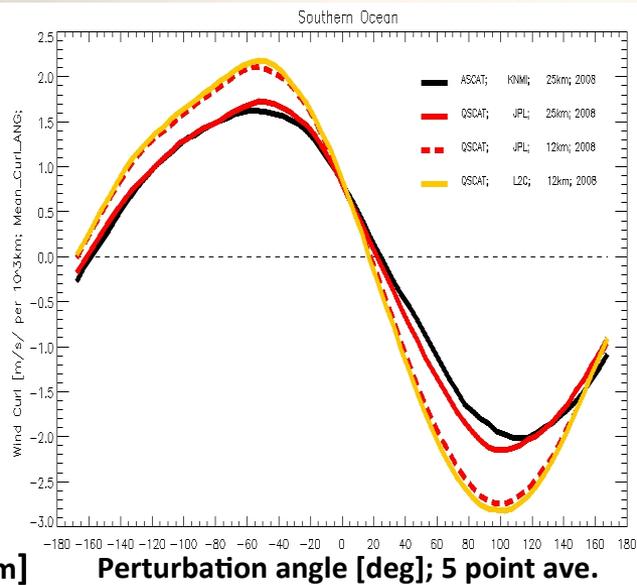
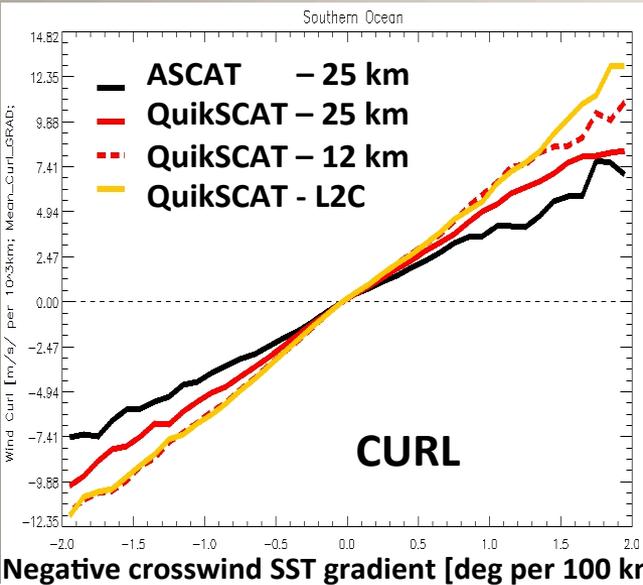


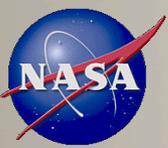
L2C – Southern Ocean - 2008



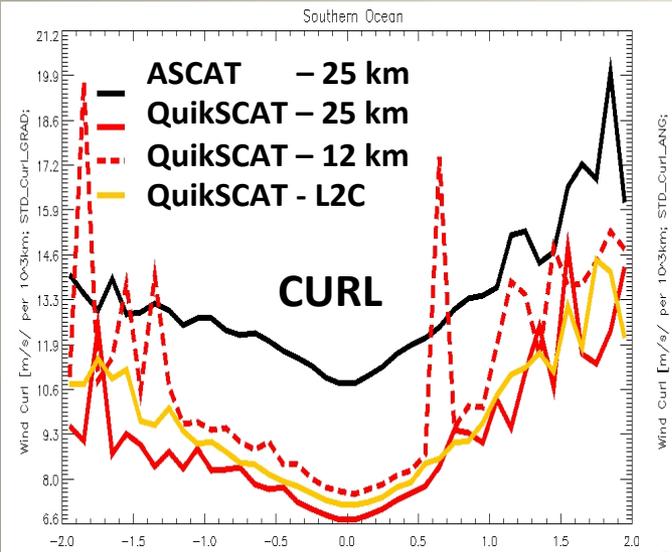


L2C

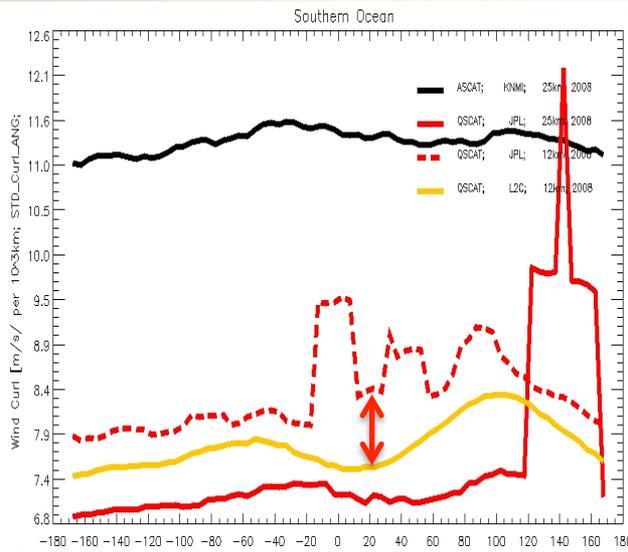




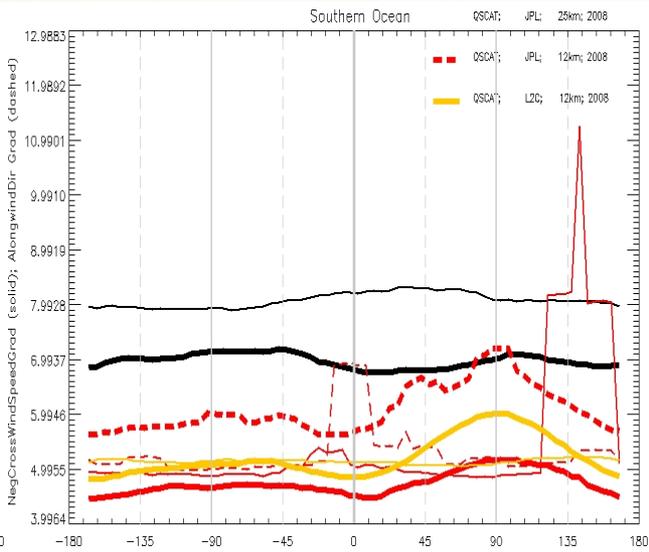
L2C - STD



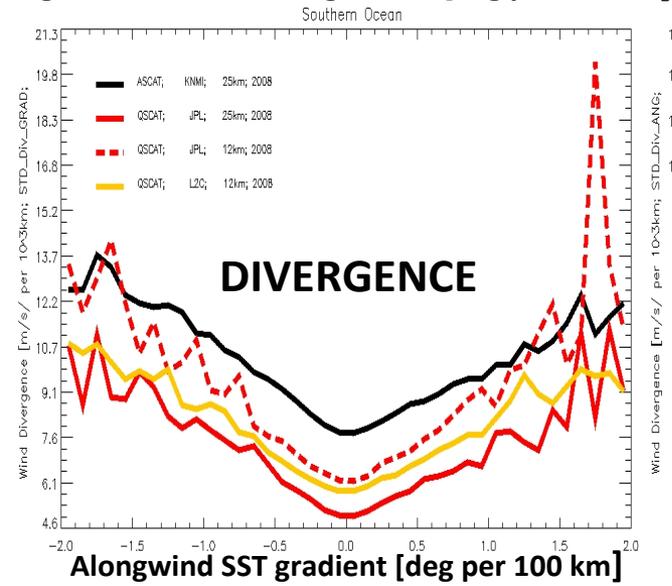
Negative crosswind SST gradient [deg per 100 km]



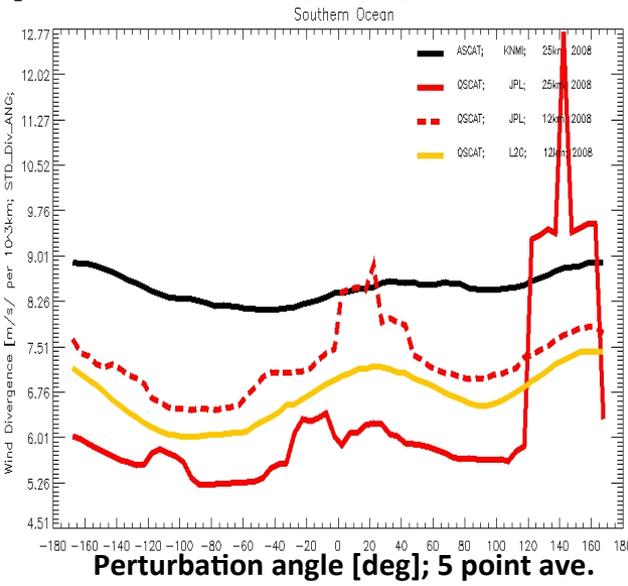
Perturbation angle [deg]; 5 point ave.



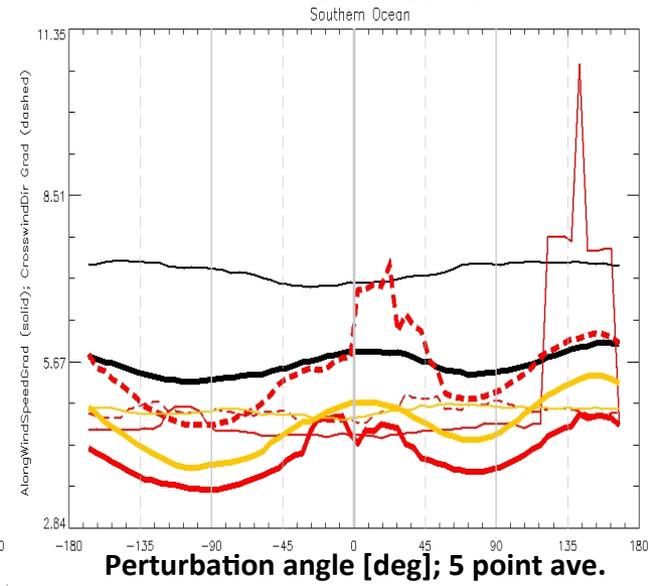
Perturbation angle [deg]; 5 point ave.



Alongwind SST gradient [deg per 100 km]



Perturbation angle [deg]; 5 point ave.



Perturbation angle [deg]; 5 point ave.



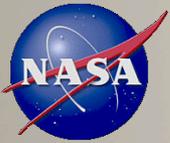
Summary – the resolution impact

- Increase in the resolution of the scatterometer retrievals results in enhanced wind/SST coupling.
- This is consistent with several studies that highlight the important role of the vertical turbulent mixing of momentum in determining the near-surface wind speed variations near SST fronts. As O’Niell et al. (2010) pointed out:
 - “Idealized **large-eddy simulations** of the flow across sharp SST fronts by Skillingstad et al. (2007) showed that on spatial scales of 1–20 km, **near-surface wind speed variations are influenced predominantly by SST-induced cross-frontal variations in the vertical turbulent mixing of momentum**, consistent with the Wallace et al. (1989) and Hayes et al. (1989) hypotheses.
 - Finally, **weak coupling of surface winds to SST in the European Centre for Medium-Range Weather Forecasts (ECMWF) model over the Agulhas Return Current (Maloney and Chelton 2006) was shown** by Song et al. (2009) **to be attributable primarily to a weak response of the parameterized vertical turbulent stress divergence to SST-induced surface heating perturbations.**”



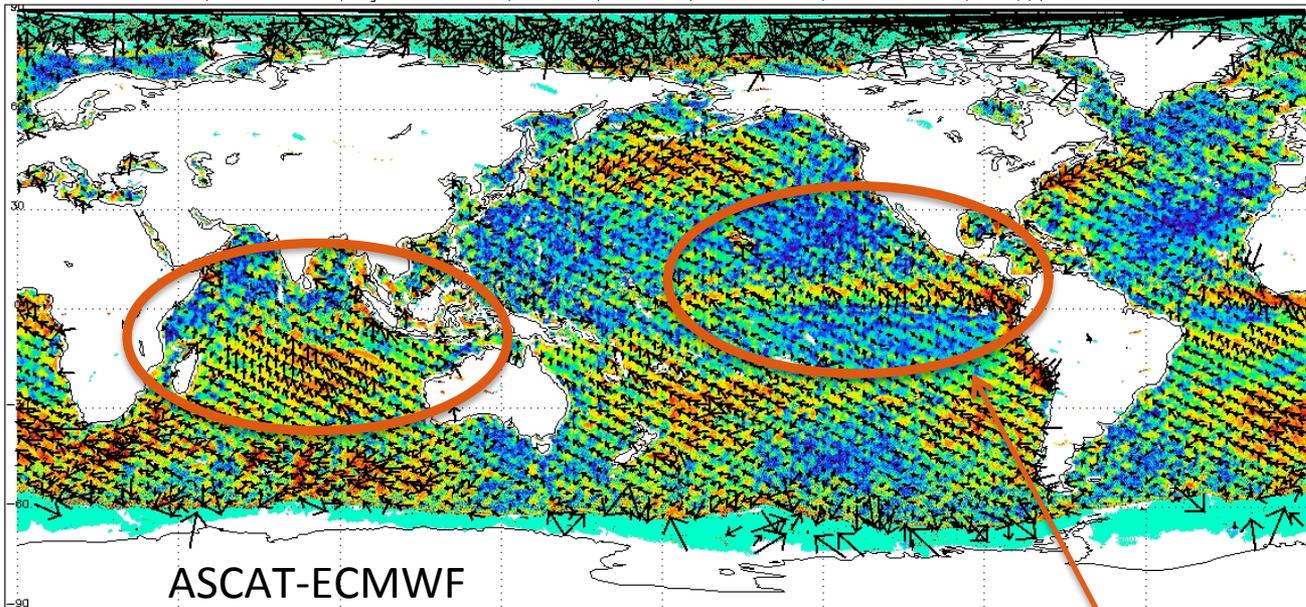
Summary – cont.

- The new QuikSCAT L2C product is very consistent with the L2B product with the benefit of lower standard deviation in the SST-wind coupling.
- The ASCAT 12km coastal product is almost indistinguishable from the regular 12km product with respect to the SST-wind coupling.
- The JPL OSCAT retrievals (at 12km resolution) show:
 - SST-wind coupling that is very similar in strength to that depicted by QuikSCAT and ASCAT
 - The coupling is noisier
 - The coupling shows speed vs direction contributions that are more similar to that of QuikSCAT than that of ASCAT.
 - There are still some residual cross-track biases in the OSCAT retrievals
 - At high latitudes the retrieved winds are quite different (stronger) than ECMWF
 - Model function issues??
 - Calibration issues?



BACKUP

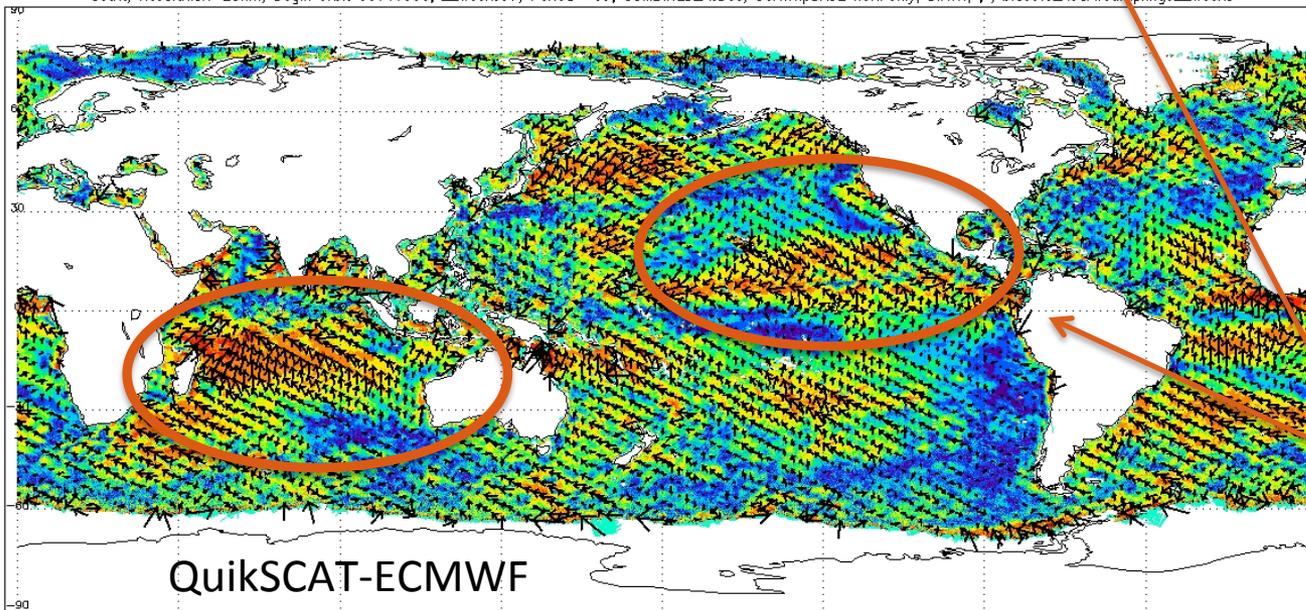
ASCAT; Resolution=50km; Begin orbit 20080628; _2weeks07; Period =09; COMBINED_AsDes; ASCT WindRetrieval; DIRTH; ; ; bias0.3_2weeks



Merging the wind estimates from ASCAT QuikSCAT and OSCAT will allow extending the climate data record.

Before merging them, we have to evaluate their consistency.

Scatt; Resolution=25km; Begin orbit 00046996; _2weeks07; Period =09; COMBINED_AsDes; SCATmpBASE noRFonly; DIRTH; ; ; bias0.0_ASCATsampling0_2weeks

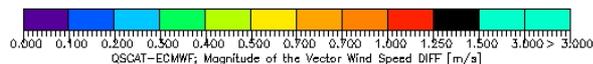


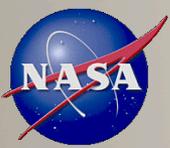
Climatologies based on 3 month average:

JAS 2008

Wind calculated from L2 wind products

The overall pattern is similar, but differences exist



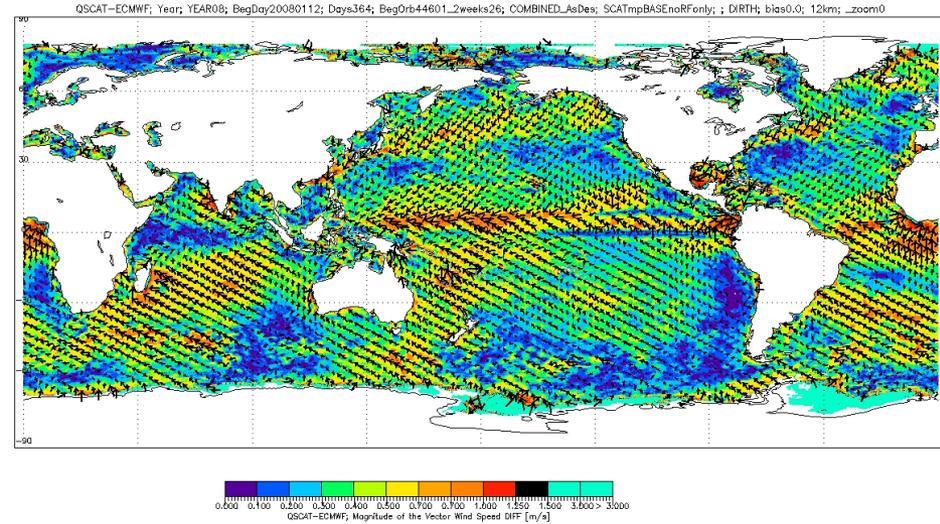
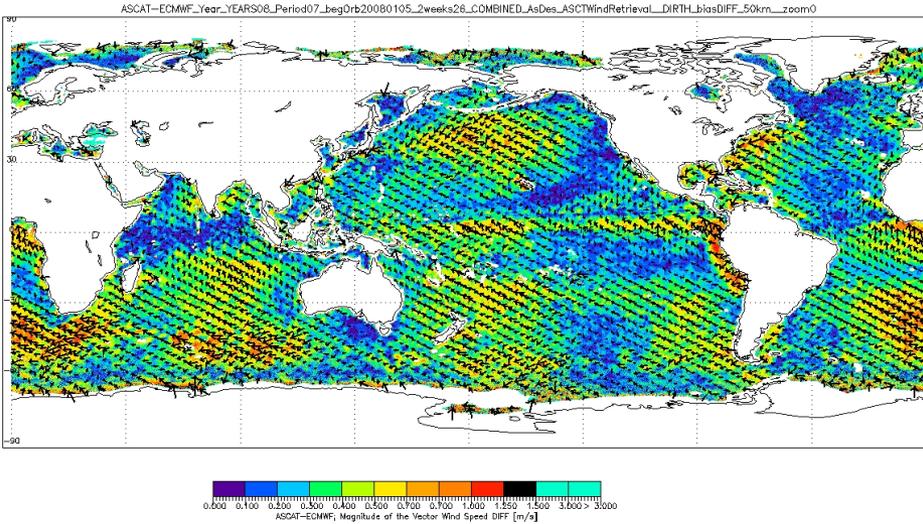


2008 ASCAT and QuikSCAT



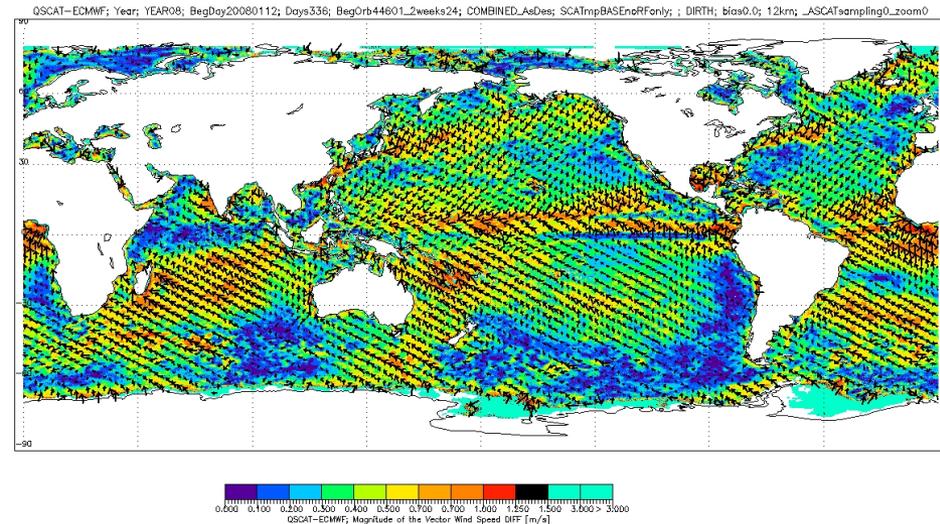
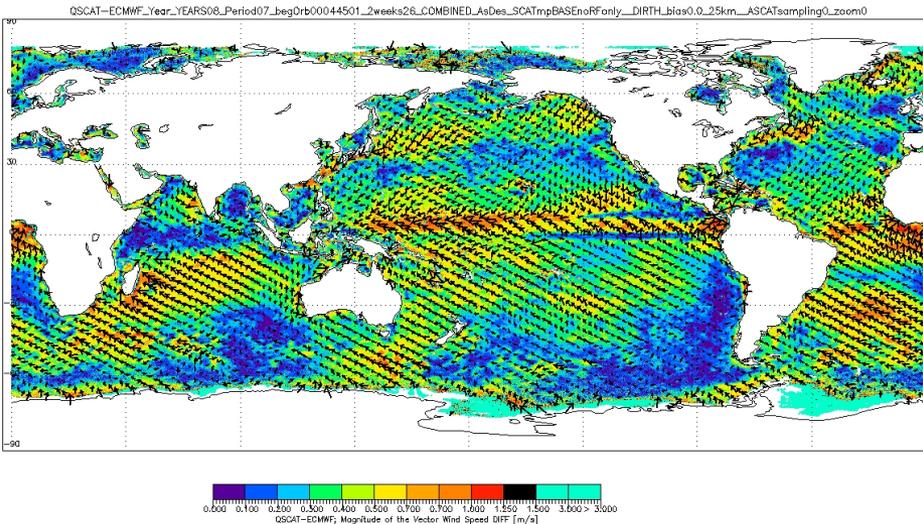
ASCAT – KNMI - 25 km

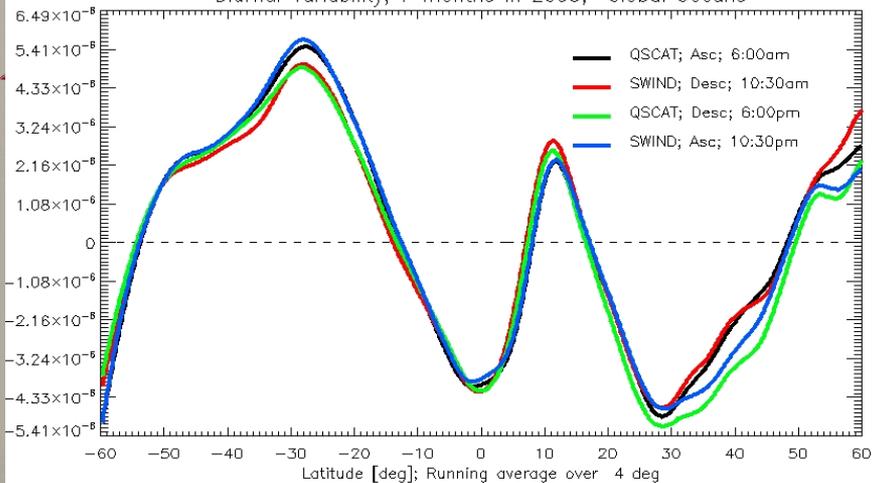
QuikSCAT – L2B - 12 km



QuikSCAT – L2B - 25 km

QuikSCAT – L2C - 12 km



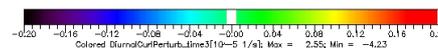
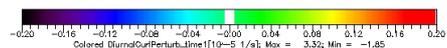
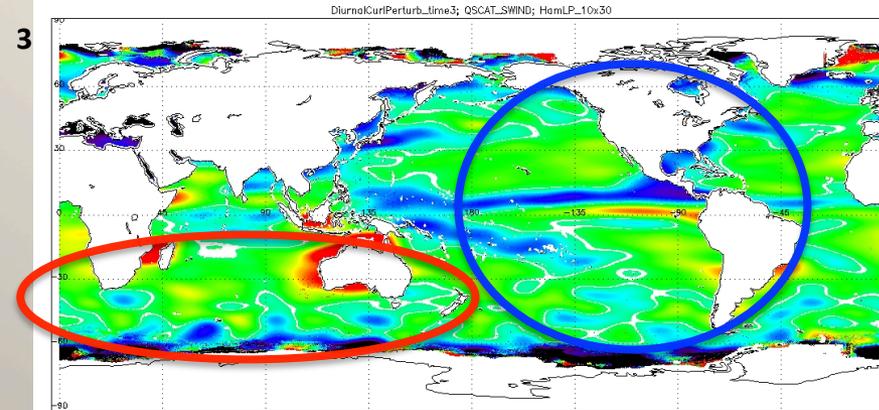
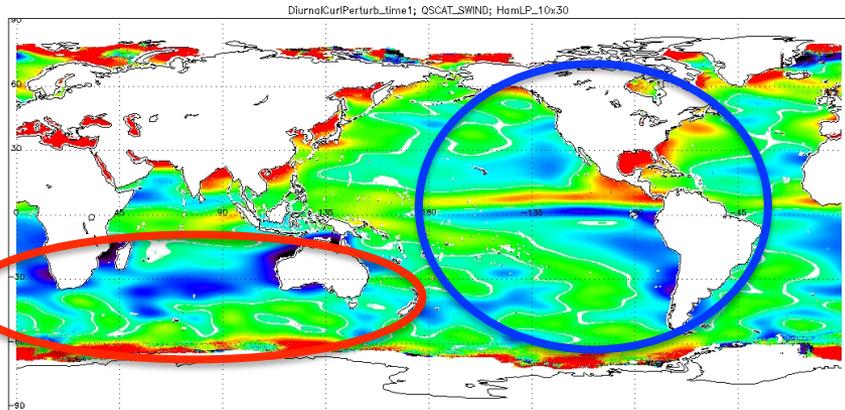
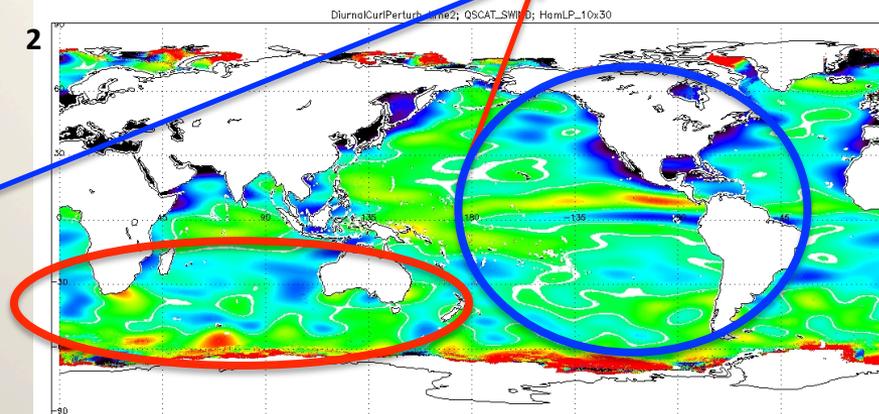
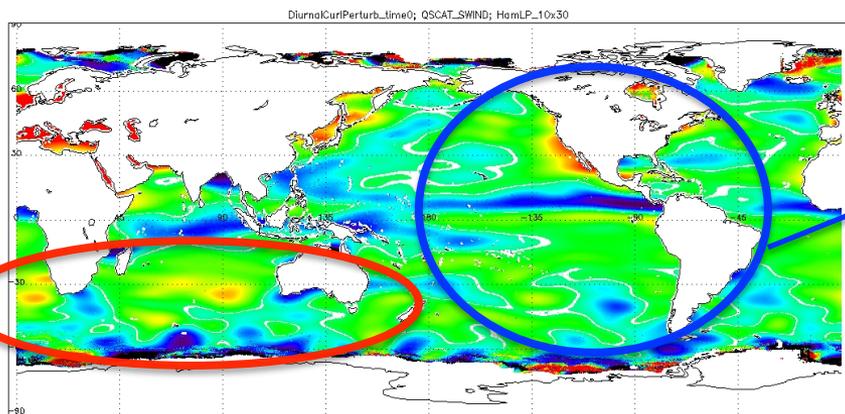


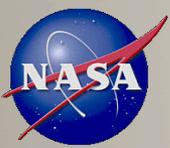
• 7 months of data; 2003;

Diurnal Variability in Curl

- 0 – 6:00 am; $QS_{\text{ascending}}$ - mean
- 1 - 10:30 am; $SW_{\text{descending}}$ - mean
- 2 – 6:00 pm; $QS_{\text{descending}}$ - mean
- 3 – 10:30 pm; $SW_{\text{ascending}}$ - mean

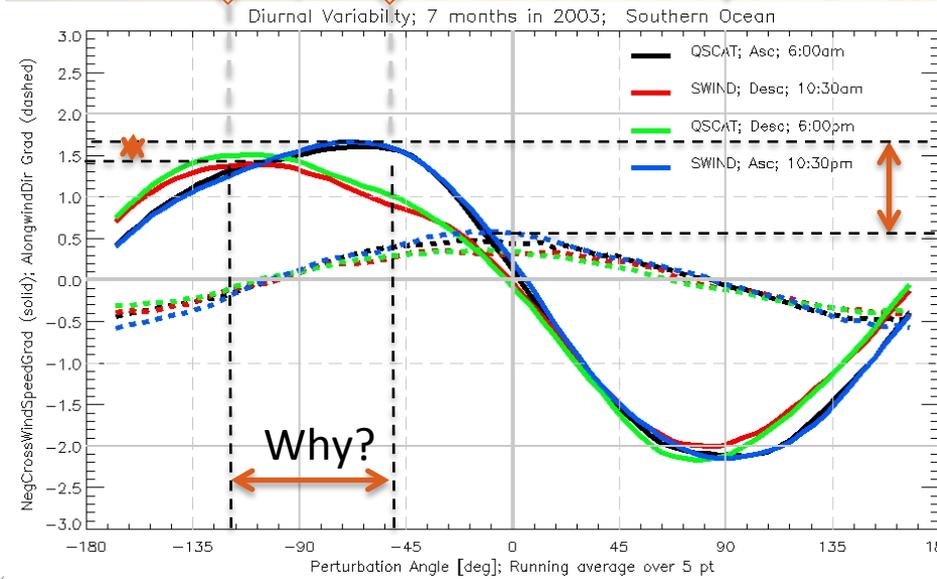
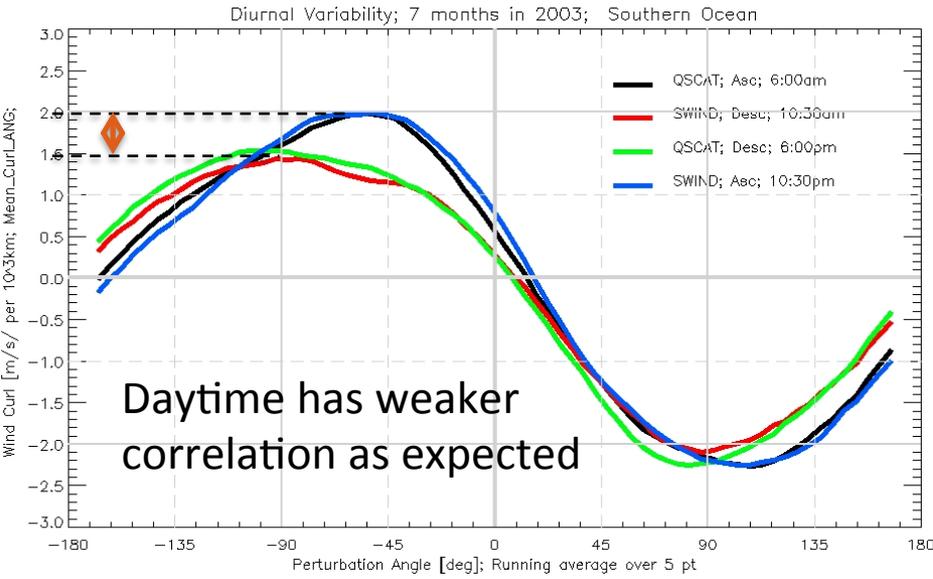
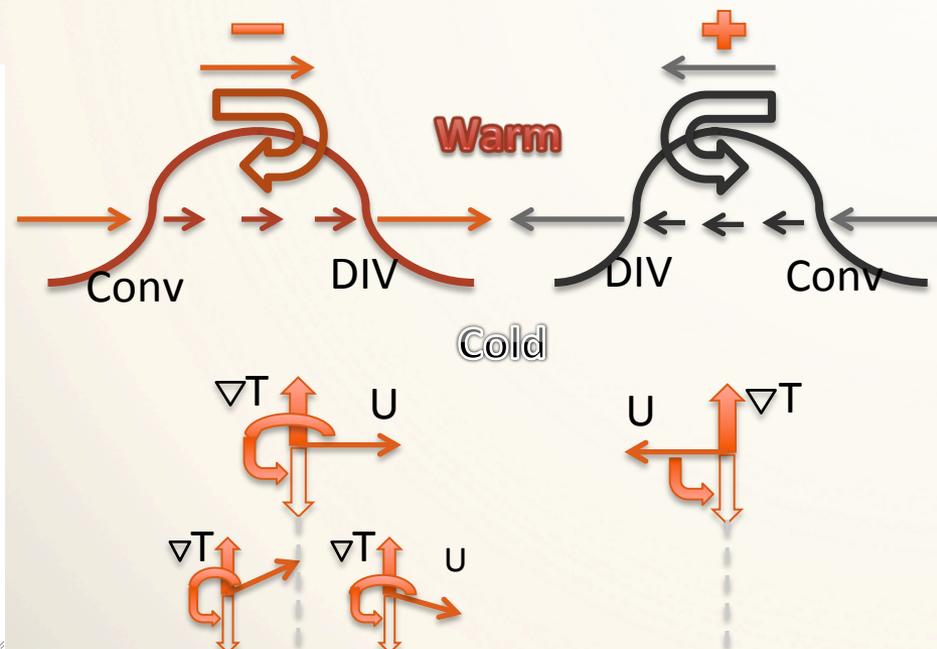
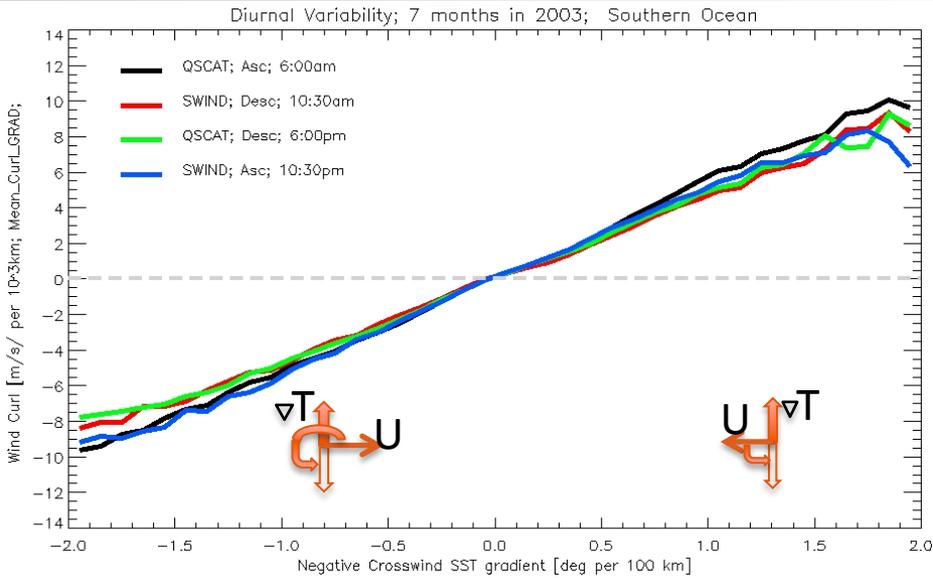
Diurnal Variability
in Curl

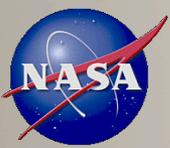




QuikSCAT and SeaWINDS

- CURL





- QSCATasASCAT and ASCAT (KNMI) - CURL

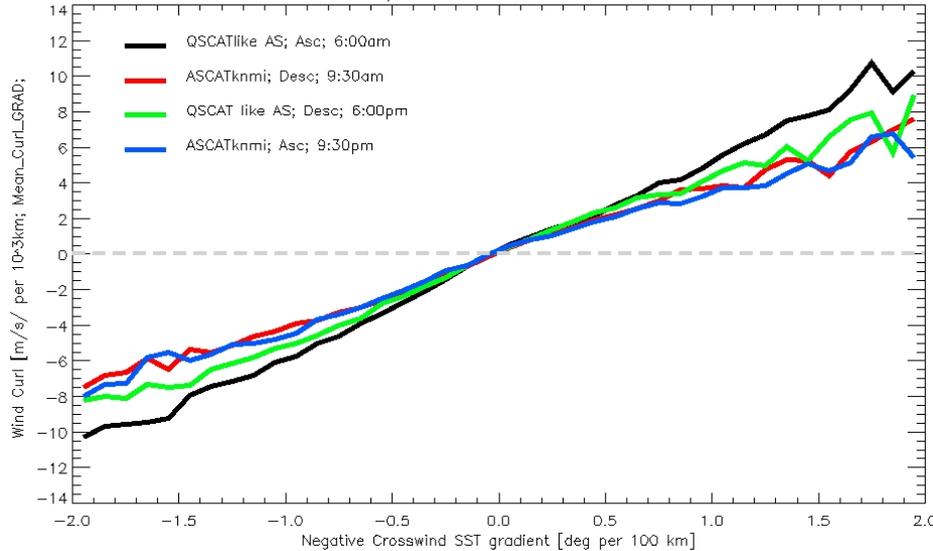


QuikSCAT has been averaged down and the mid section was cut off to resemble the ASCAT sampling and resolution.

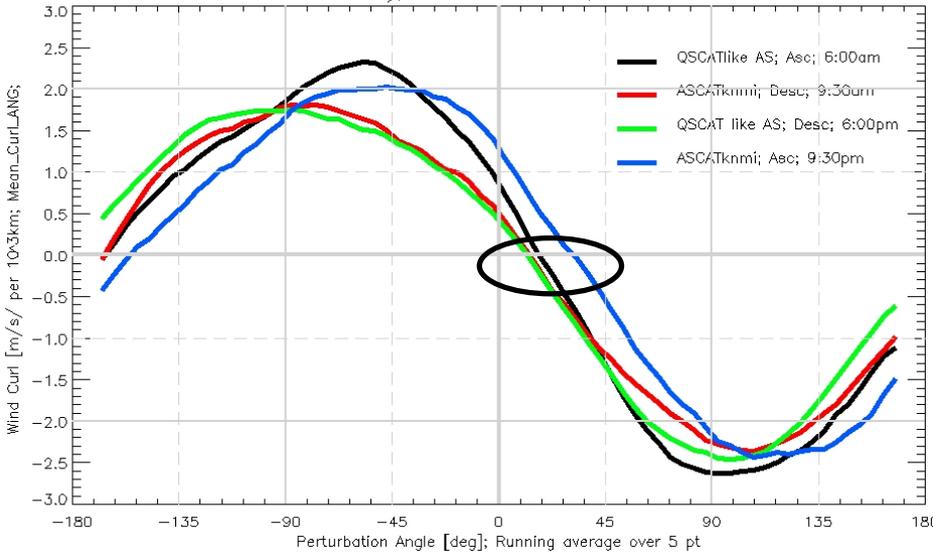
This results in bringing the two scatterometers in a closer agreement. This is especially true for the daytime orbits.

Still - remaining differences in strength of coupling and angular dependence

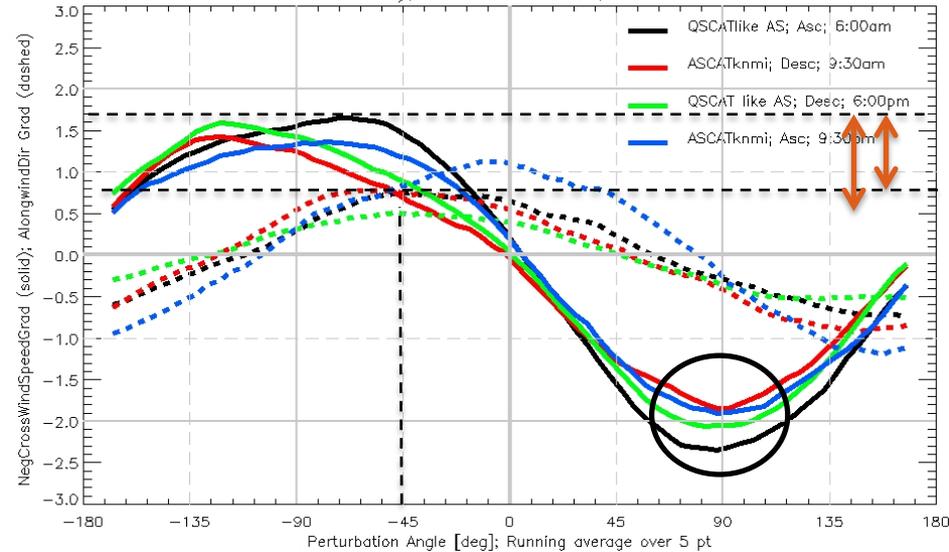
Diurnal Variability; 7 months in 2008; Southern Ocean

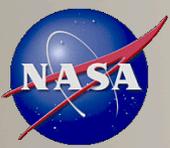


Diurnal Variability; 7 months in 2008; Southern Ocean

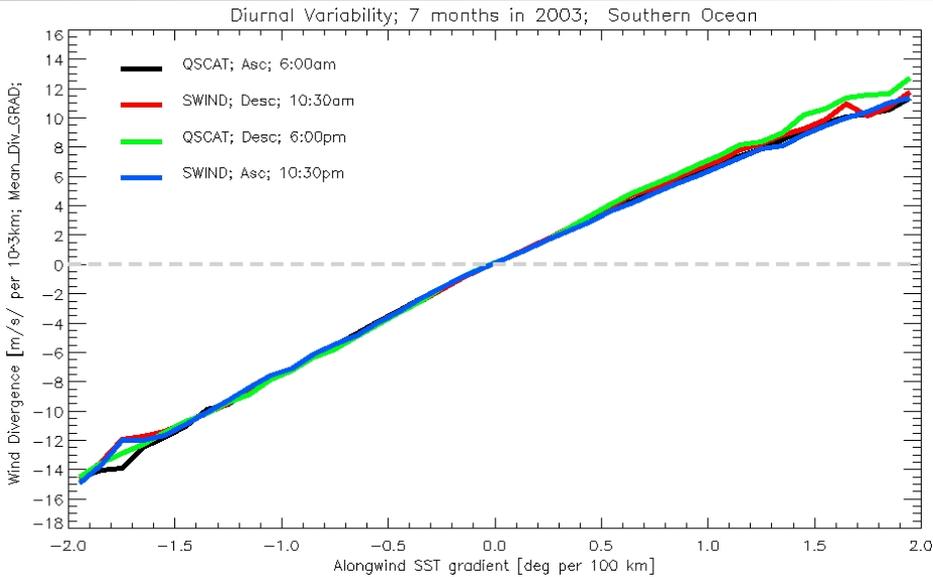


Diurnal Variability; 7 months in 2008; Southern Ocean



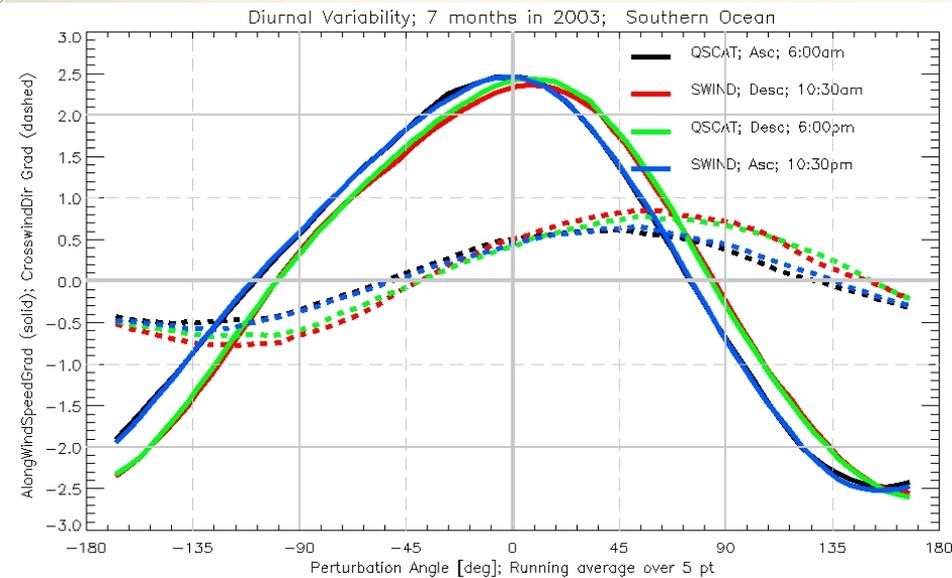
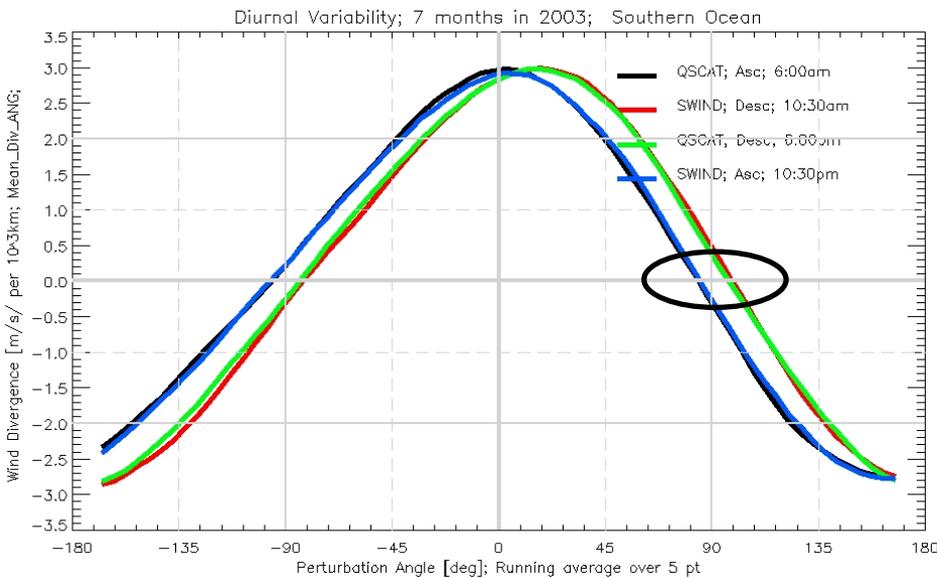


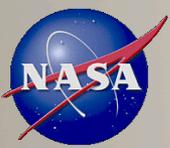
- QuikSCAT and SeaWINDS (KNMI) - DIV



Strength of coupling has no diurnal variability.

Angular dependence has a very well defined diurnal dependence

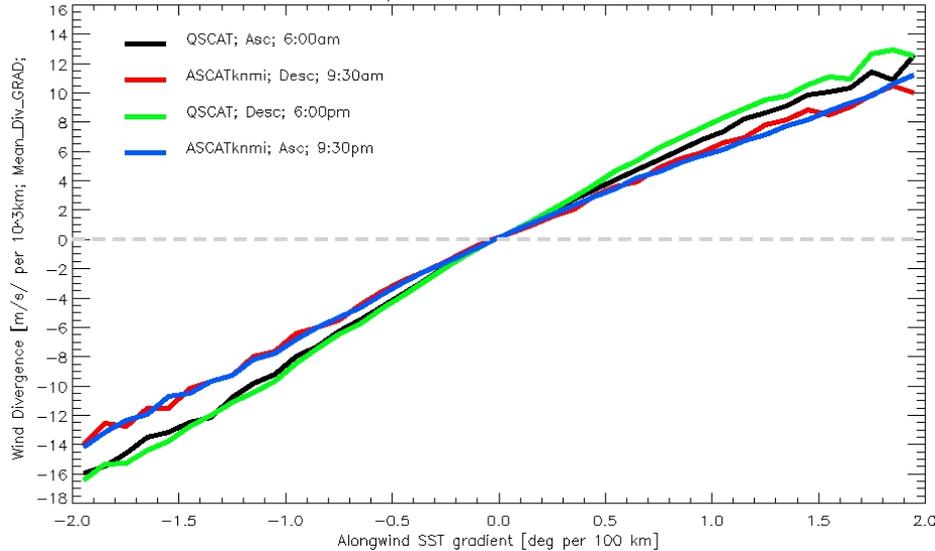




QuikSCAT and ASCAT (KNMI) -DIV



Diurnal Variability; 7 months in 2008; Southern Ocean

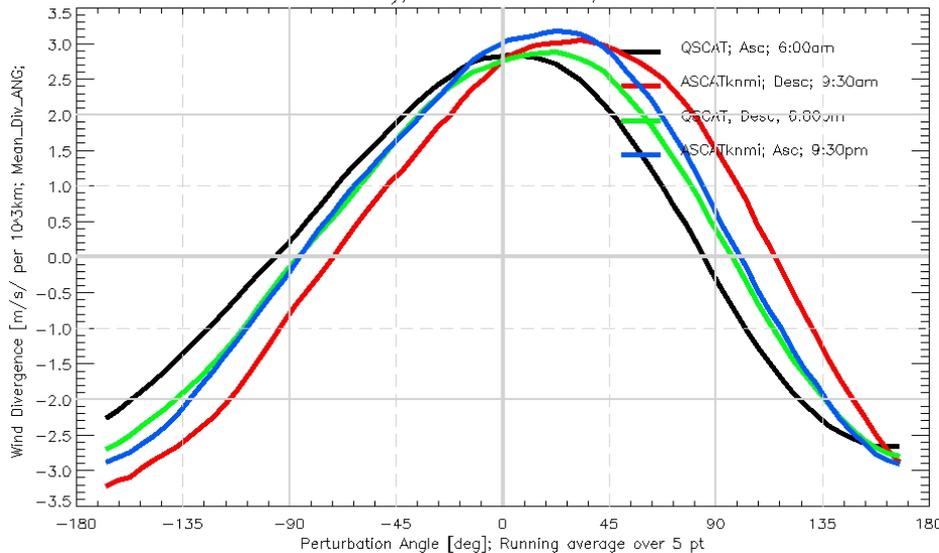


QSCAT and ASCAT show different strength of the coupling.

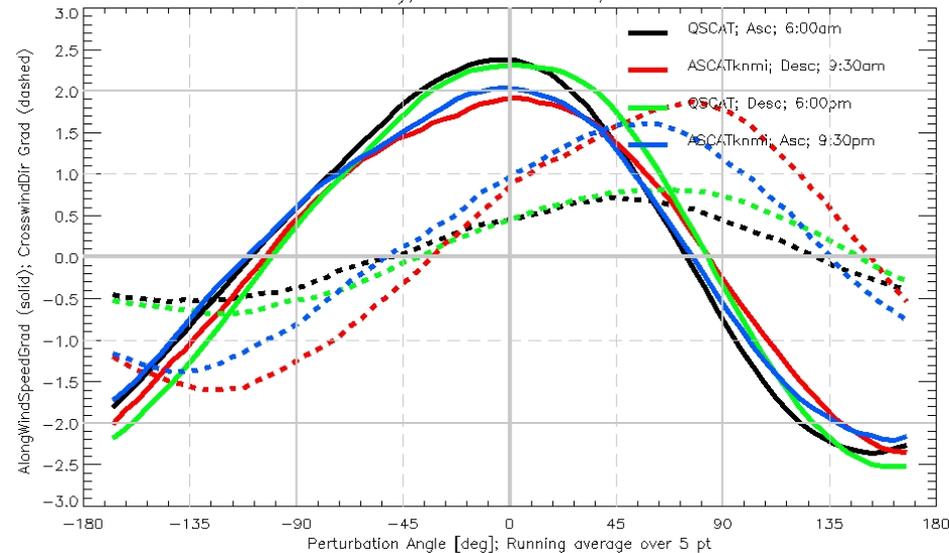
ASCAT

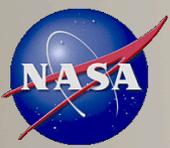
- even bigger angular shift
- speed and dir responses have similar magnitude; not for QSCAT
- ASCAT's daytime angular dependence is most different

Diurnal Variability; 7 months in 2008; Southern Ocean



Diurnal Variability; 7 months in 2008; Southern Ocean





- QSCATasASCAT and ASCAT (KNMI) - DIV



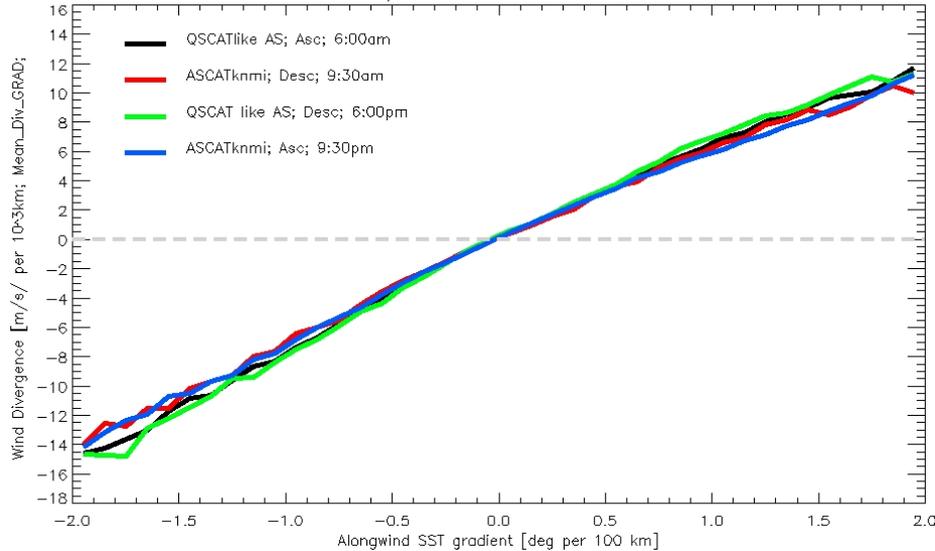
QuikSCAT has been averaged down and the mid section was cut off to resemble the ASCAT sampling and resolution.

This results in bringing the two scatterometers in a much closer agreement. This is especially true for the strength of the coupling.

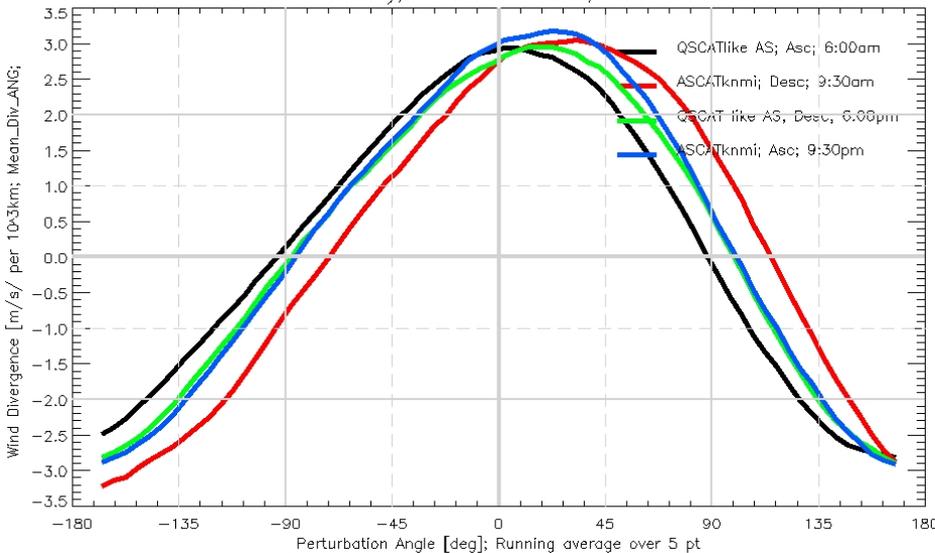
Remaining differences

- ASCAT has much stronger directional response; Especially in daytime

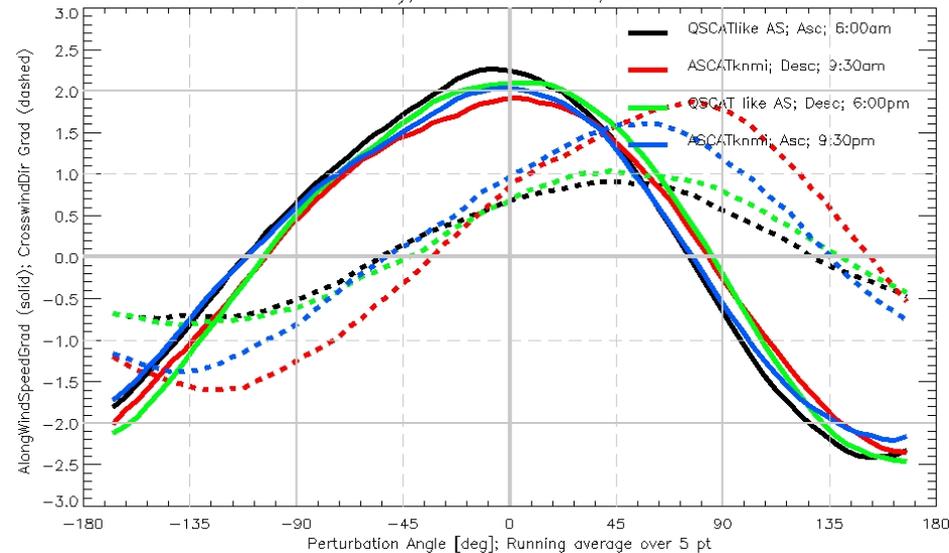
Diurnal Variability; 7 months in 2008; Southern Ocean

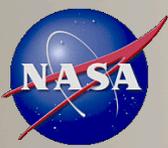


Diurnal Variability; 7 months in 2008; Southern Ocean

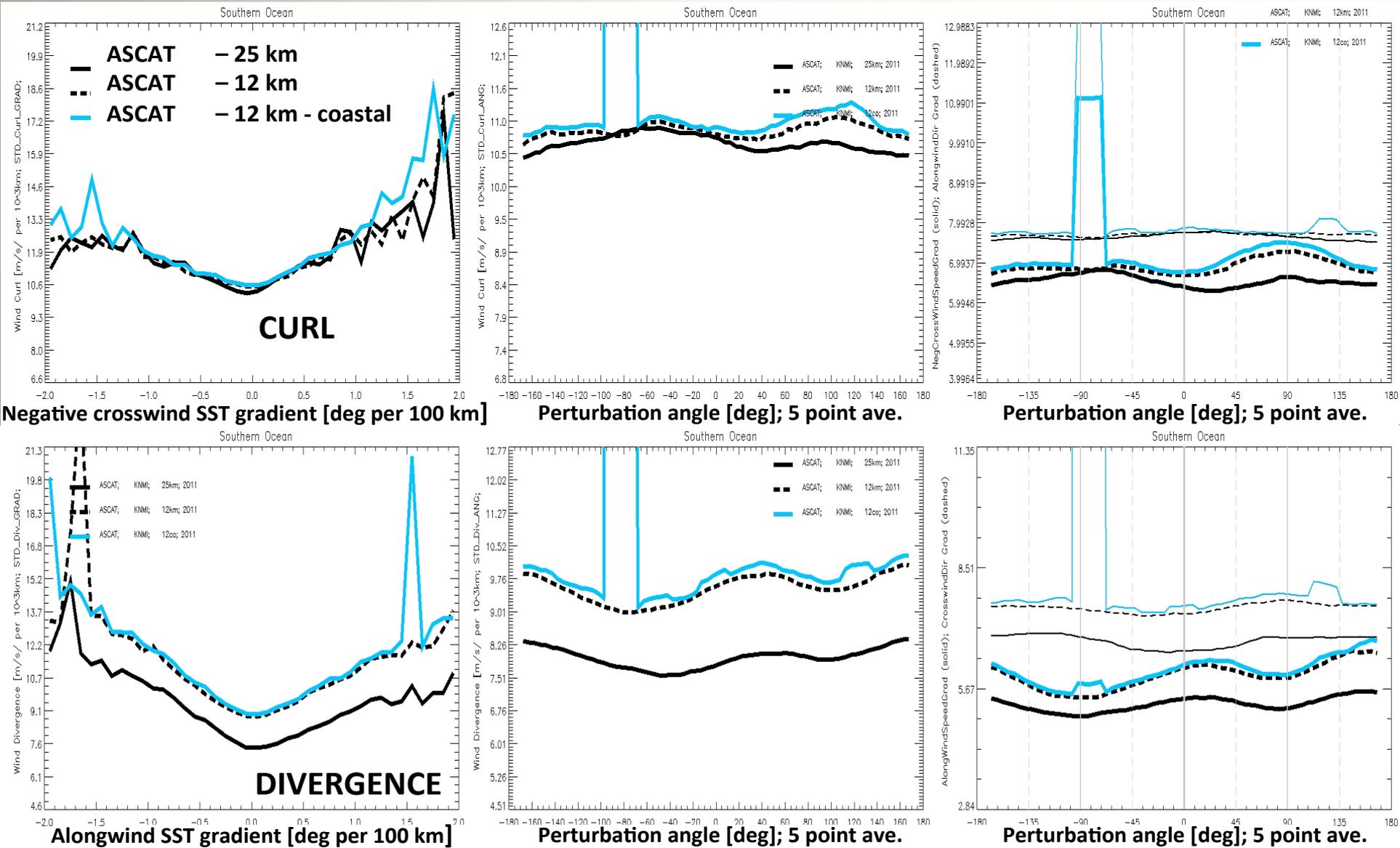


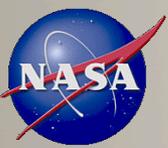
Diurnal Variability; 7 months in 2008; Southern Ocean



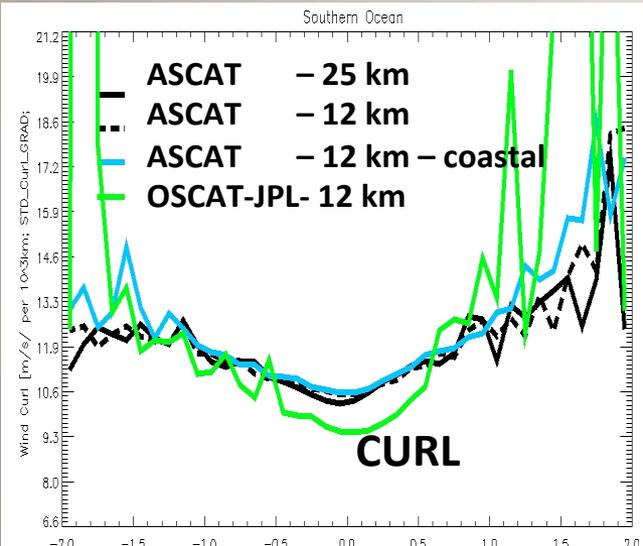


Impact of resolution – 2011 - coastal

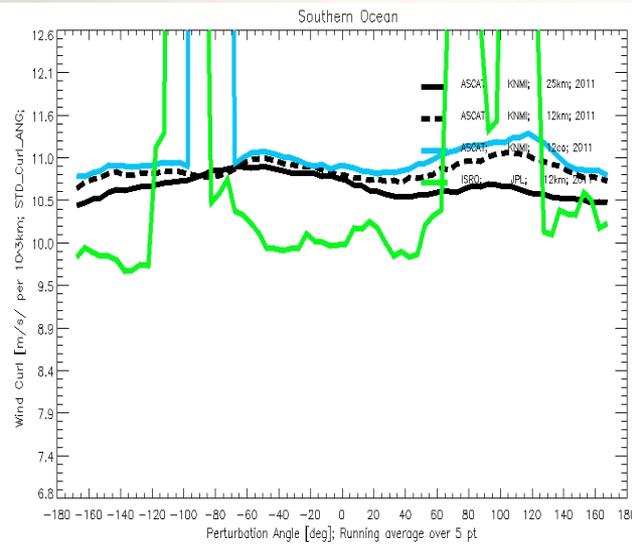




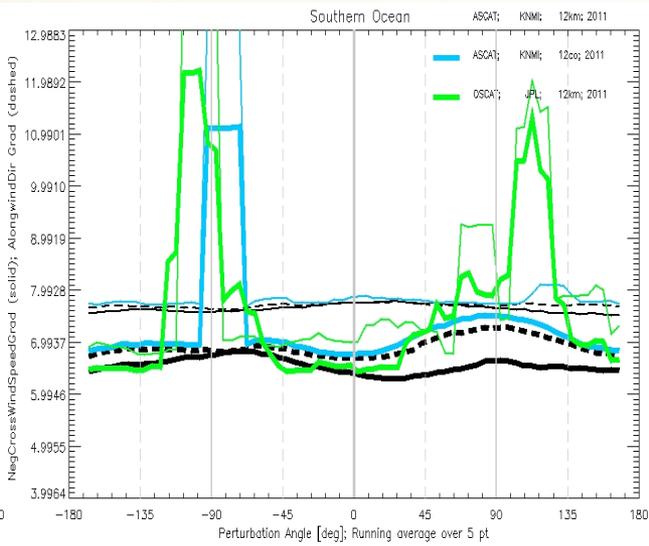
ASCAT versus OSCAT – 2011 - STD



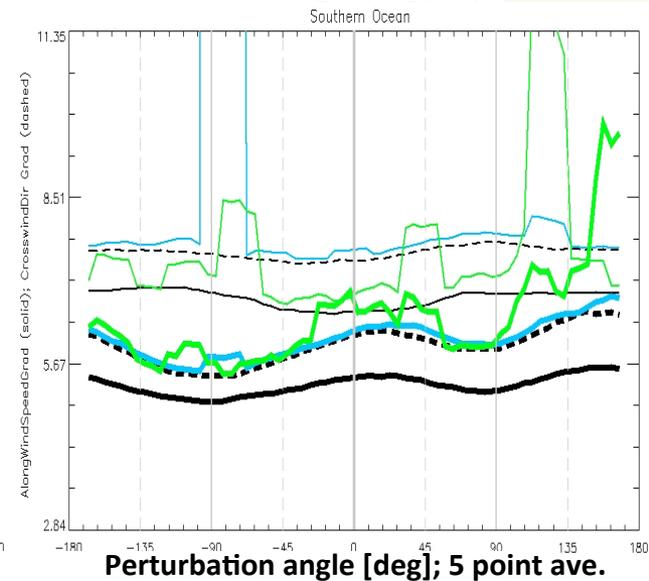
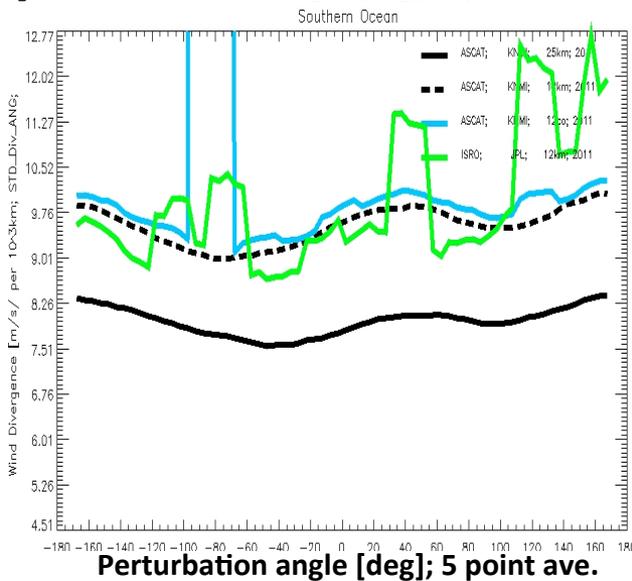
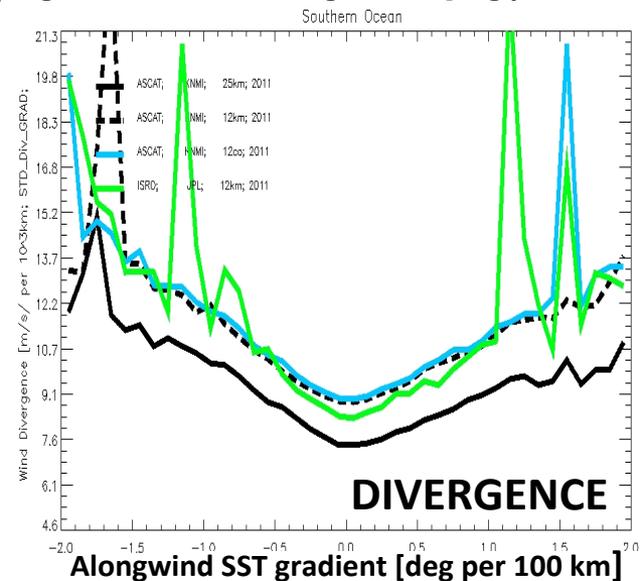
Negative crosswind SST gradient [deg per 100 km]

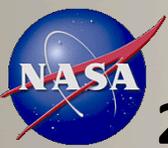


Perturbation angle [deg]; 5 point ave.



Perturbation angle [deg]; 5 point ave.





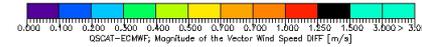
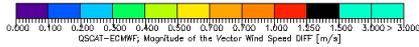
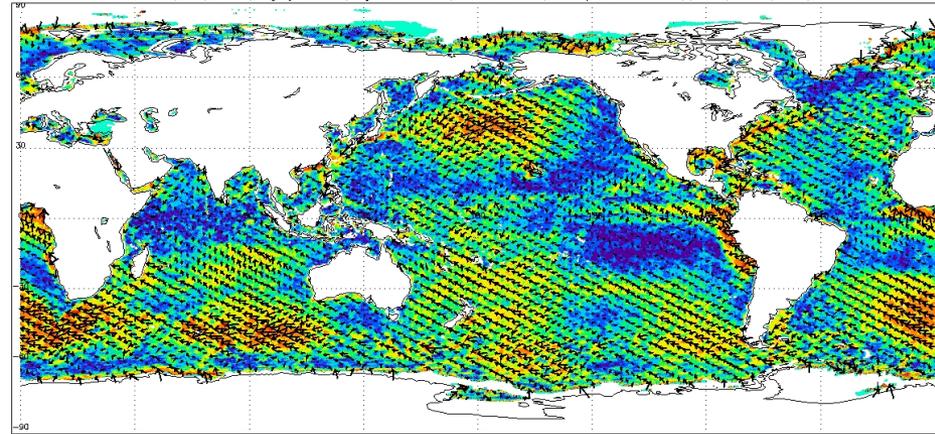
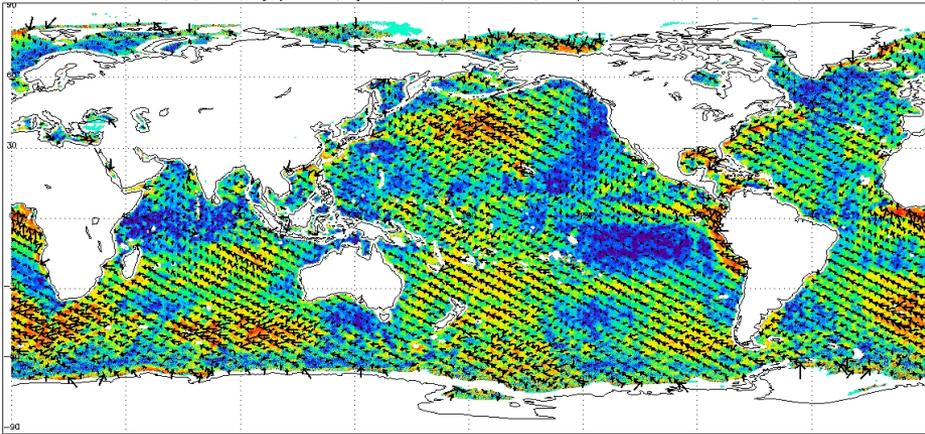
2011 ASCAT and OSCAT – vector difference from ECMWF

ASCAT - 25 km

ASCAT - 12 km

OSCAT-ECMWF; Year; YEAR11; BegDay20110709; Days308_2weeks22; COMBINED_AsDes; ASCTmpBASEWindRetrieval; ; DIRTH; bias0.0; 25km; _zoom0

OSCAT-ECMWF; Year; YEAR11; BegDay20110709; Days308_2weeks22; COMBINED_AsDes; ASCTmpBASEWindRetrieval; ; DIRTH; bias0.0; 12km; _zoom0

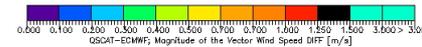
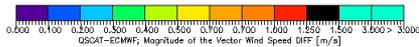
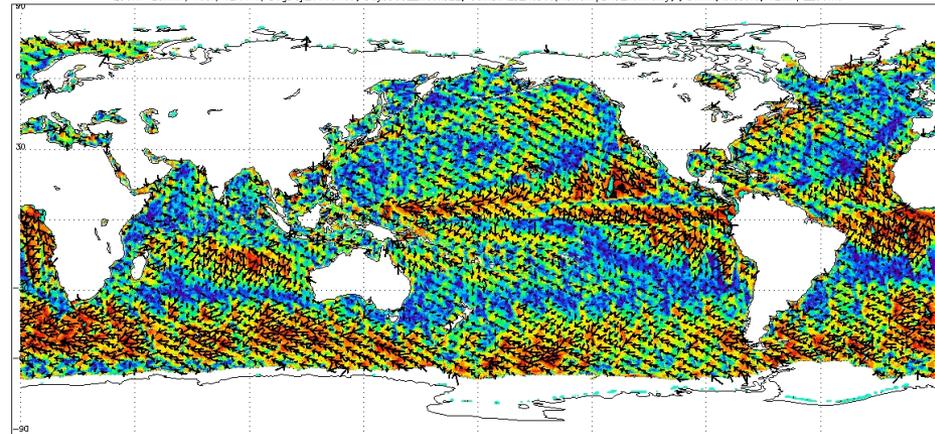
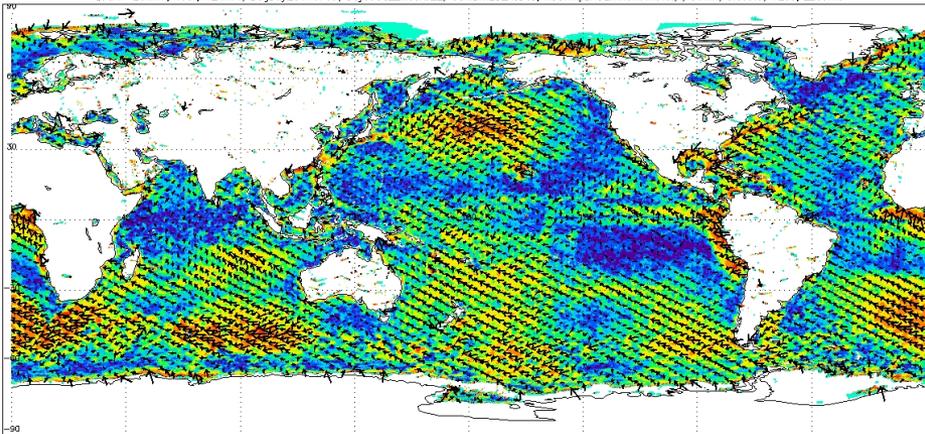


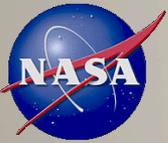
ASCAT - 12 co

OSCAT - 12 km

OSCAT-ECMWF; Year; YEAR11; BegDay20110709; Days308_2weeks22; COMBINED_AsDes; ASCTmpBASEWindRetrieval; ; DIRTH; bias0.0; 12co; _zoom0

OSCAT-ECMWF; Year; YEAR11; BegDay20110709; Days308_2weeks22; COMBINED_AsDes; ISROmpBASENoRFonly; ; DIRTH; bias0.0; 12km; _zoom0



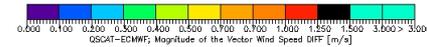
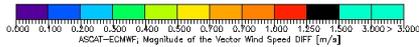
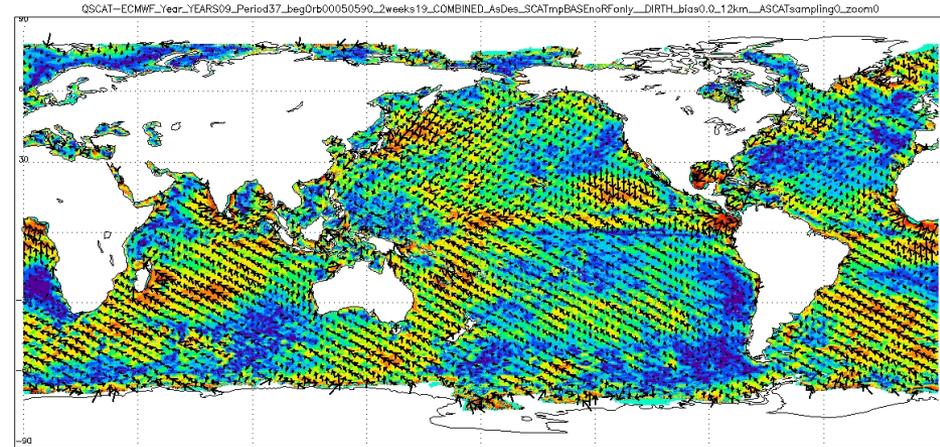
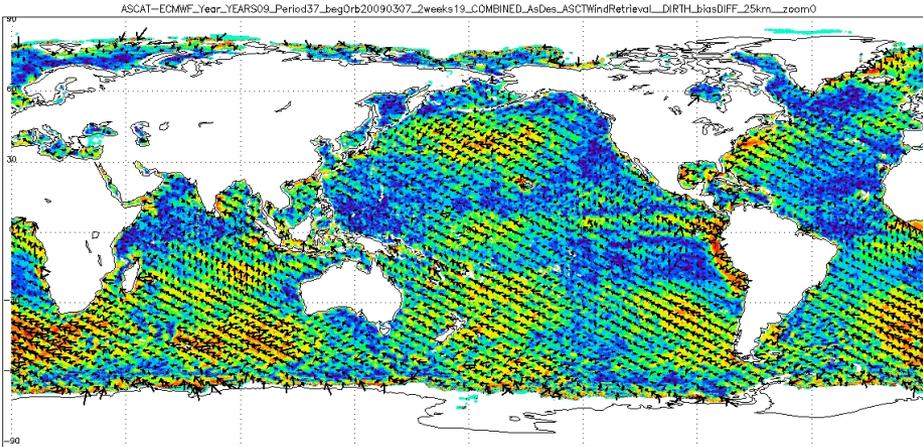


All four – vector difference from ECMWF



ASCAT - 12 km – 2009

QuikSCAT - 12 km - 2009



ASCAT – 12 km 2011

OSCAT - 12 km - 2011

