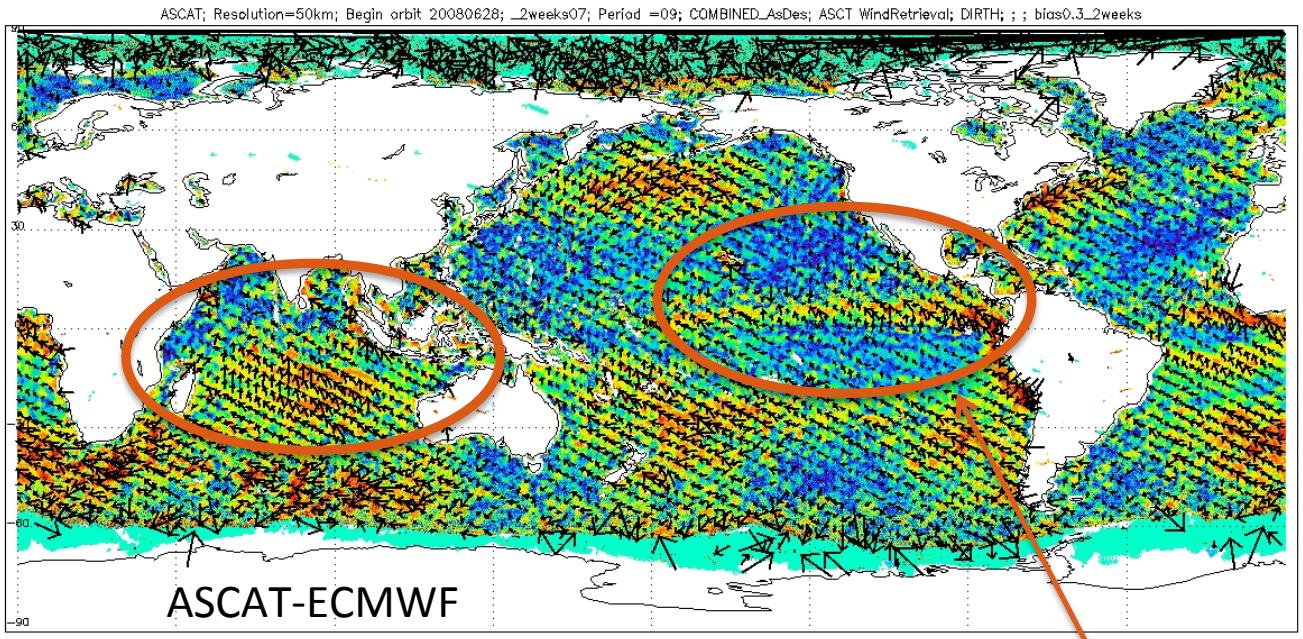
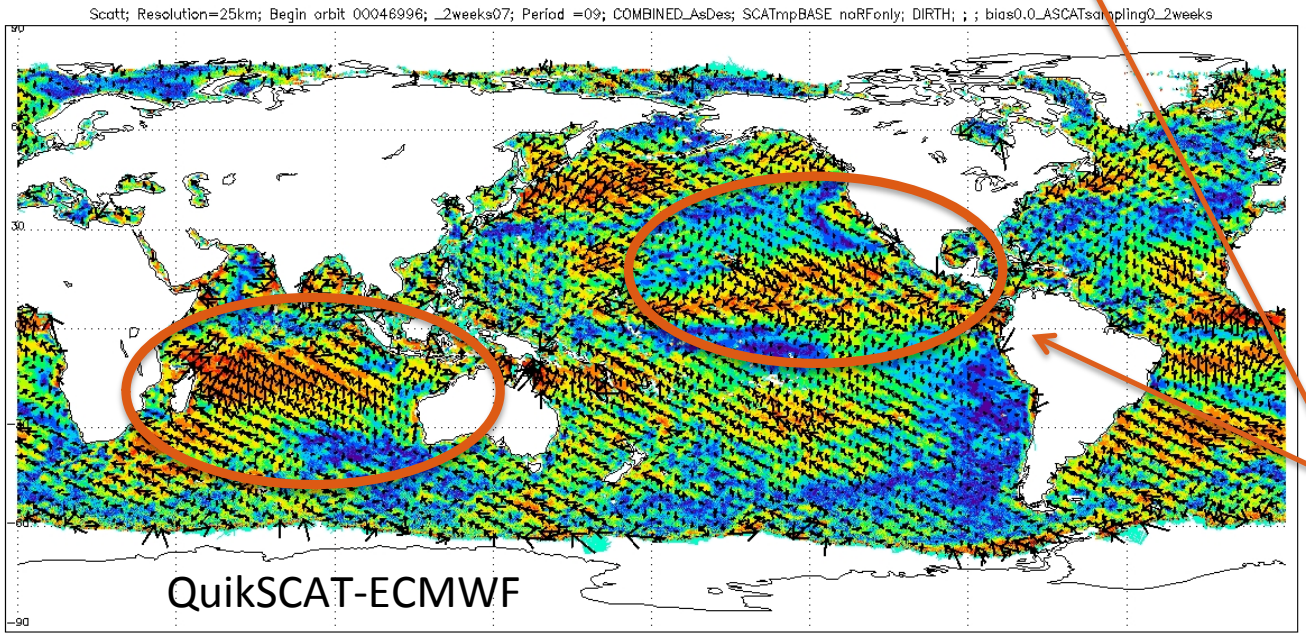
# Diurnal variability in the wind curl/divergence coupling with SST gradients as depicted by SeaWinds, QuikSCAT and ASCAT tandem missions.

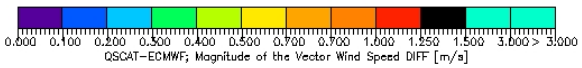
**Svetla Hristova-Veleva, Ernesto Rodriguez and Joe Turk**

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

IOVWST 2011




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 3 month average:

## JAS 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**

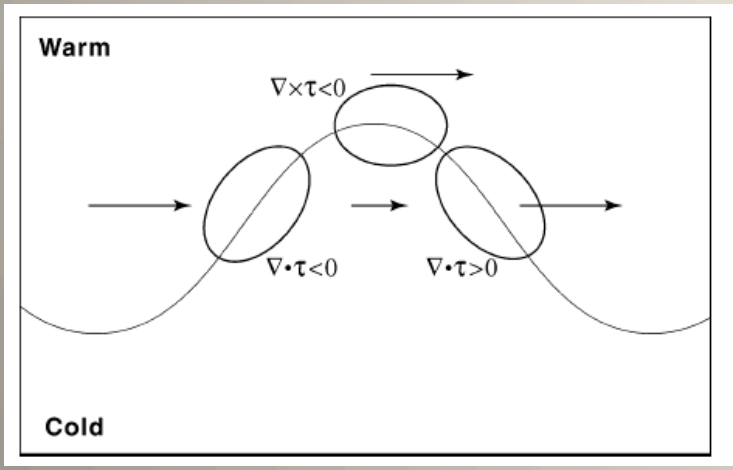



FIG. 3. Schematic of the hypothesized interaction between wind stress and SST for wind blowing obliquely across a meandering SST front. The SST front is delineated as the black sinusoidal curve, separating warm and cold water. The lengths of the arrows schematicallyrepresent the hypothesized relative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

•ASCAT/QuikSCAT comparison

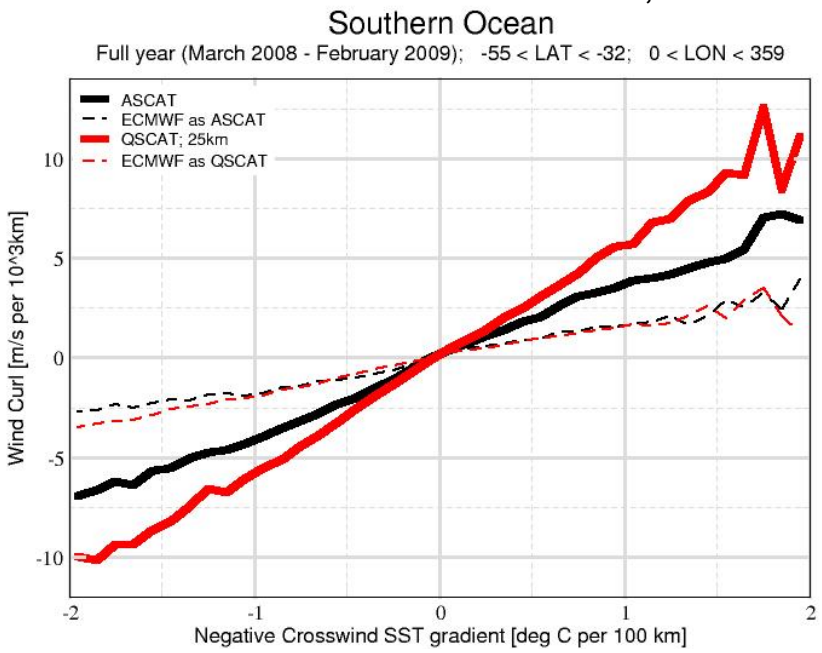
– High-resolution daily SST product (OSTIA)

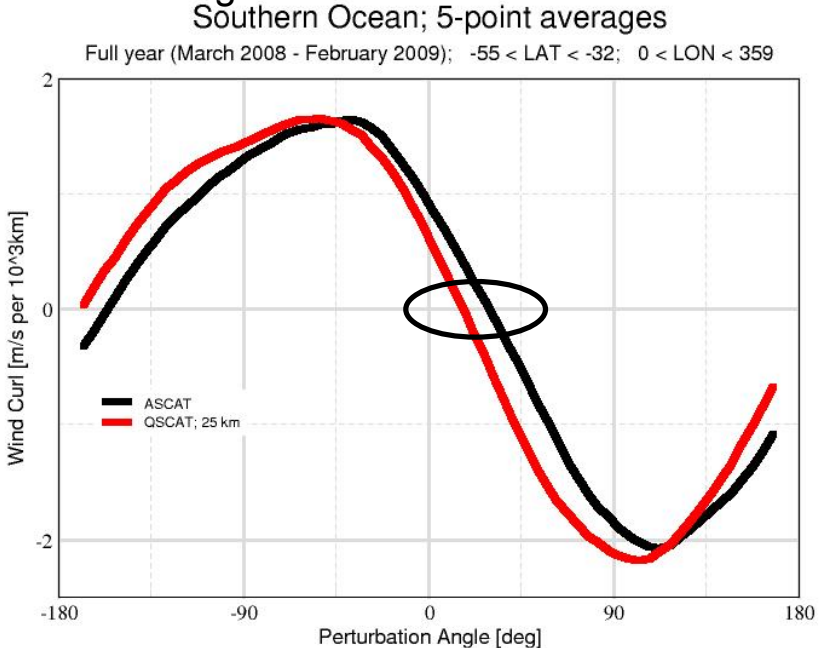
– Using ASCAT KNMI bias-corrected data (+0.2m/s)

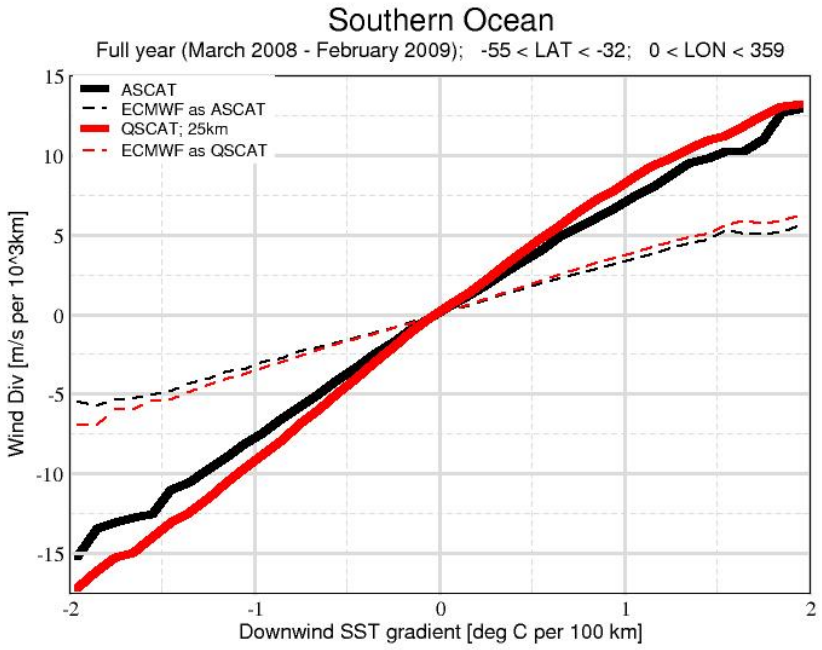
– Computing **WIND curl/divergence**

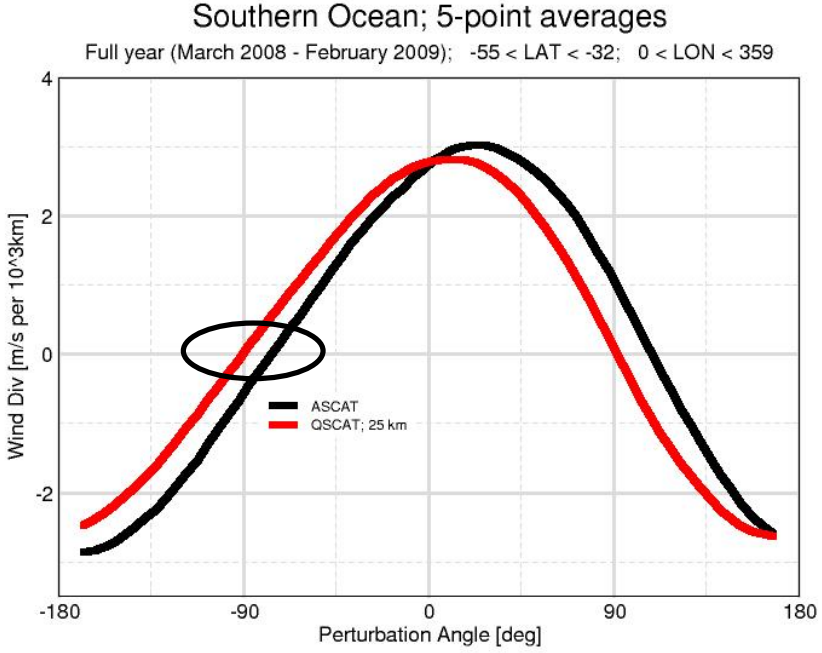
– from orbital instead of gridded (averaged) wind components (Chelton et al, 2007) to preserve the signals of each meteorological event and to avoid introducing artifacts from computing gradients of averaged quantities over a number of different events.

# Wind; From swath; 2-week averages



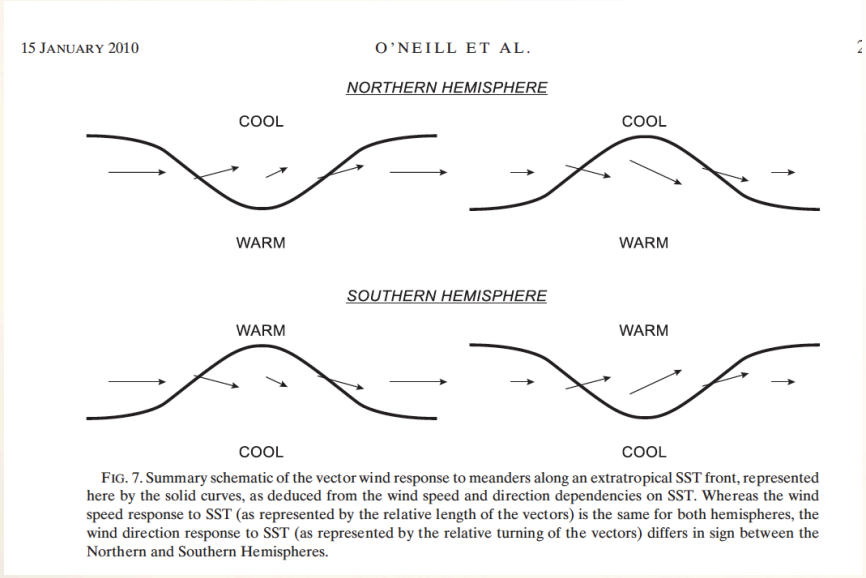



FIG. 7. Summary schematic of the vector wind response to meanders along an extratropical SST front, represented here by the solid curves, as deduced from the wind speed and direction dependencies on SST. Whereas the wind speed response to SST (as represented by the relative length of the vectors) is 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.

# In curvilinear natural coordinates

**(e.g., Haltiner andMartin, 1957)**

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

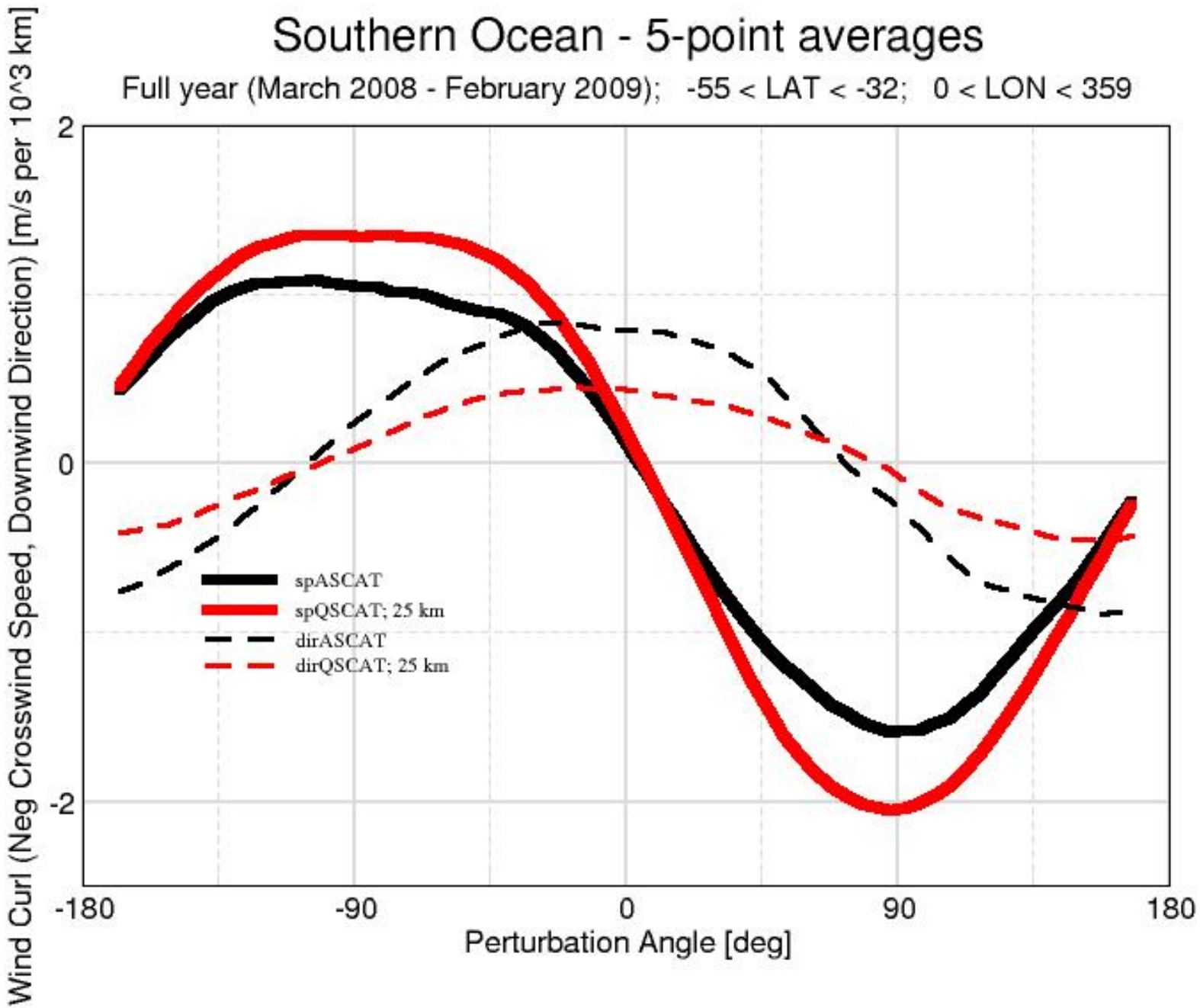
$$\nabla \times U' = -\left(\frac{\partial V}{\partial n}\right)' + \left(V\frac{\partial \psi}{\partial s}\right)'$$

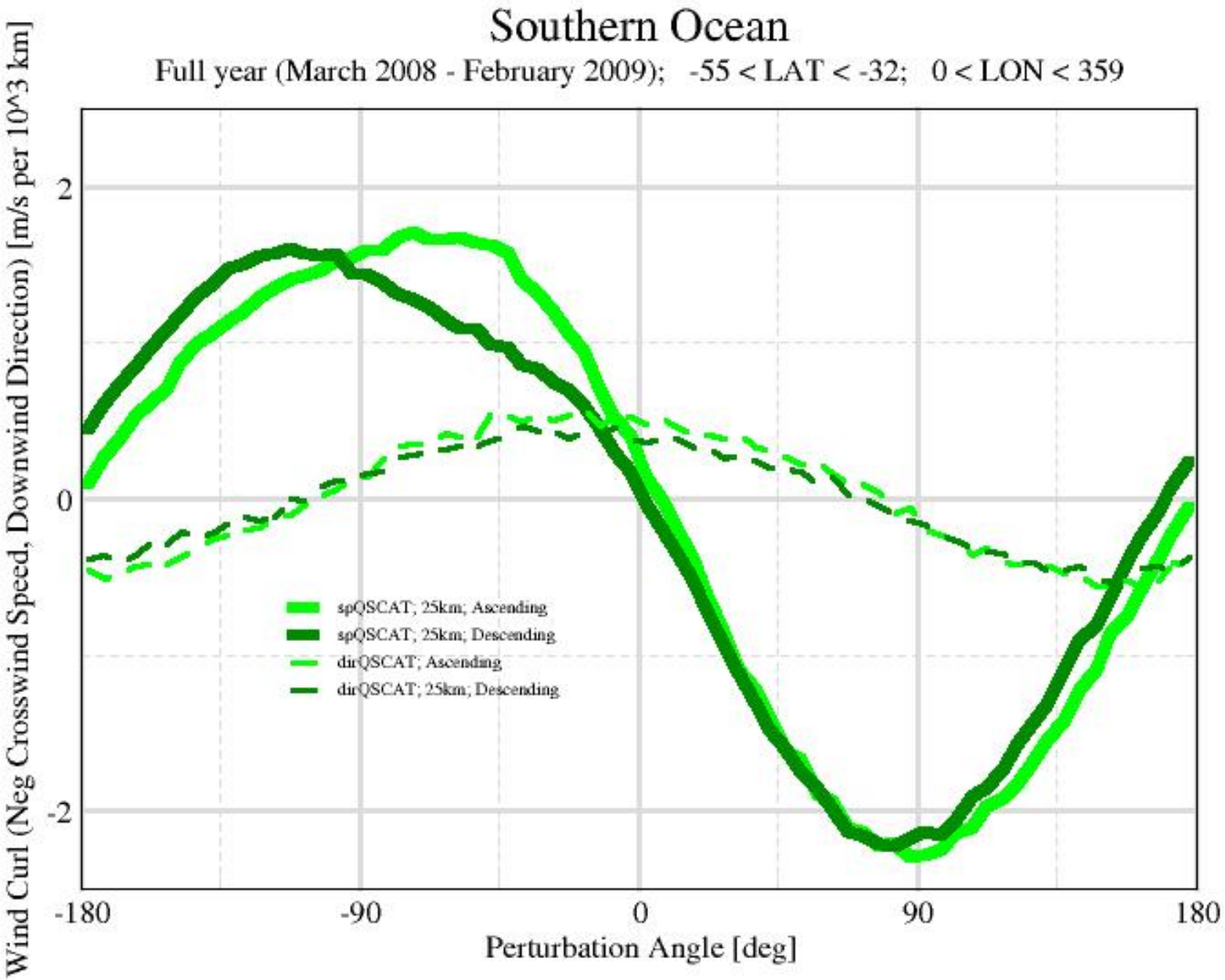
→ related to the **radius of curvature** of surface streamlines.

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

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

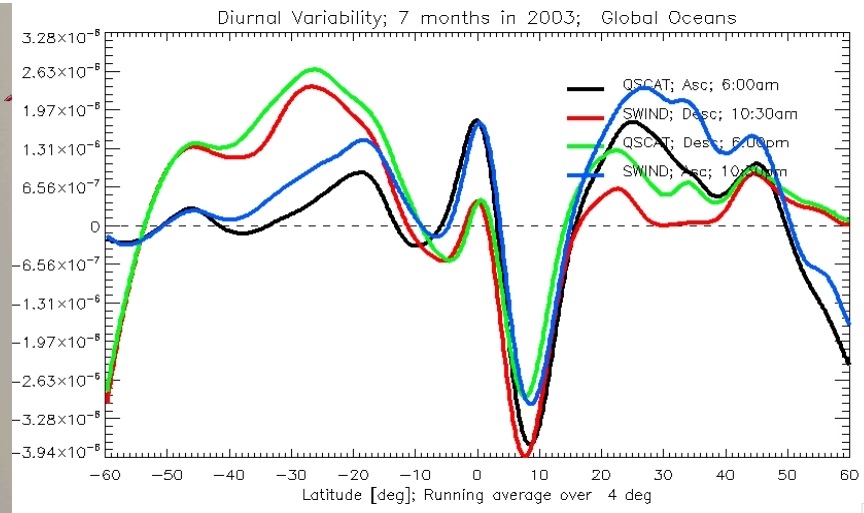
→ related to the **spreading or contracting of surface streamlines in the crosswind direction**.


Southern Ocean - 5-point averages
Full year (March 2008 - February 2009); -55 < LAT < -32; 0 < LON < 359
Wind Curl (Neg Crosswind Speed, Downwind Direction) [m/s per 10^3 km]
2
0
-2
-180
-90
0
90
180
Perturbation Angle [deg]
spASCAT
spQSCAT; 25 km
dirASCAT
dirQSCAT; 25 km


Southern Ocean
Full year (March 2008 - February 2009); -55 < LAT < -32; 0 < LON < 359
Wind Curl (Neg Crosswind Speed, Downwind Direction) [m/s per 10^3 km]
2
0
-2
-180
-90
0
90
180
Perturbation Angle [deg]
spQSCAT; 25km; Ascending
spQSCAT; 25km; Descending
dirQSCAT; Ascending
dirQSCAT; 25km; Descending

# What do we look at

- Diurnal variability as depicted by the tandem missions of :
  - QuikSCAT and SeaWinds - 7 months in 2003
  - QuikSCAT and ASCAT - 7 months in 2008
- Culprits for the remaining differences:
  - Sampling and Resolution
  - GMF
  - Retrieval Approach

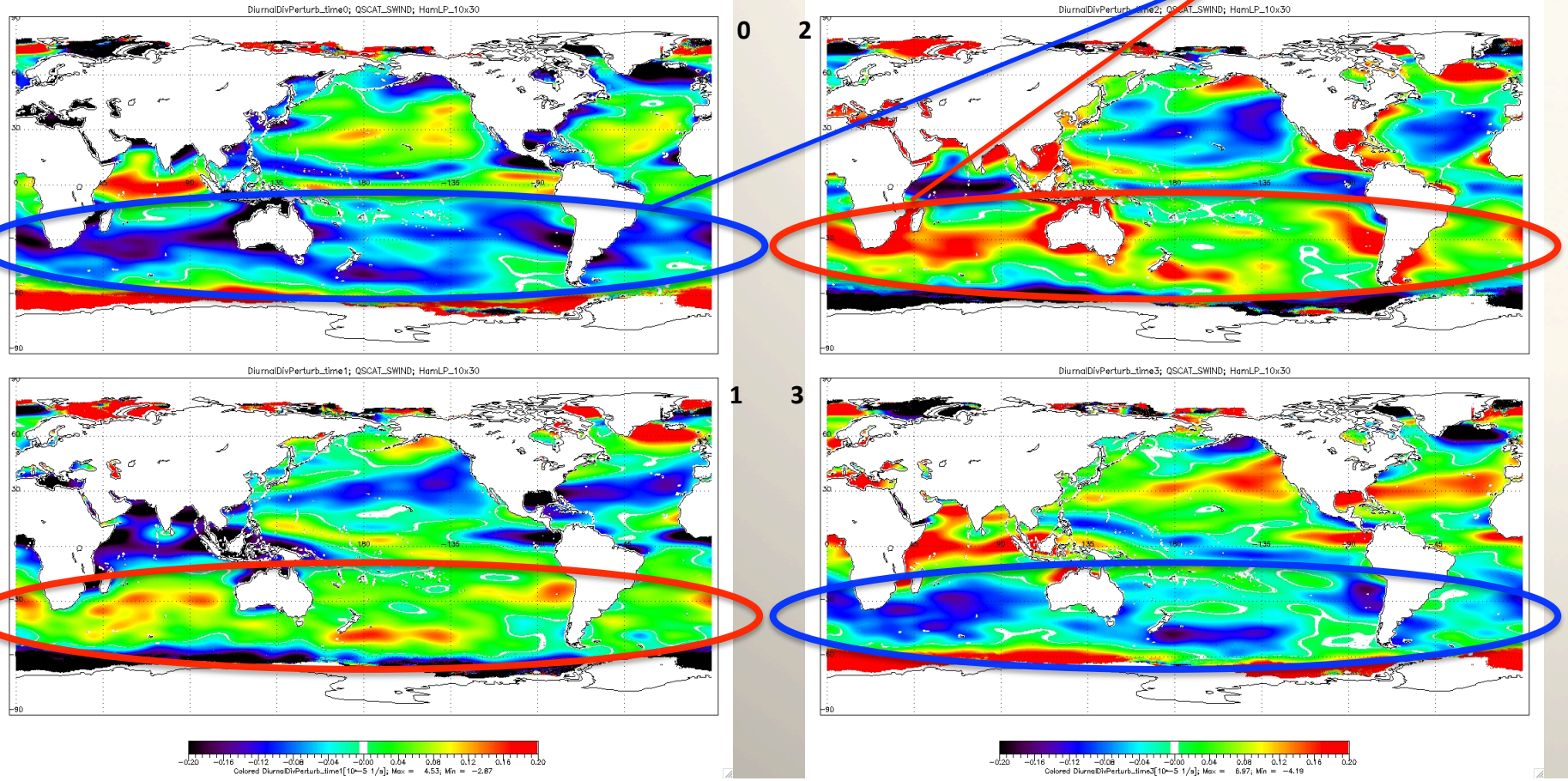


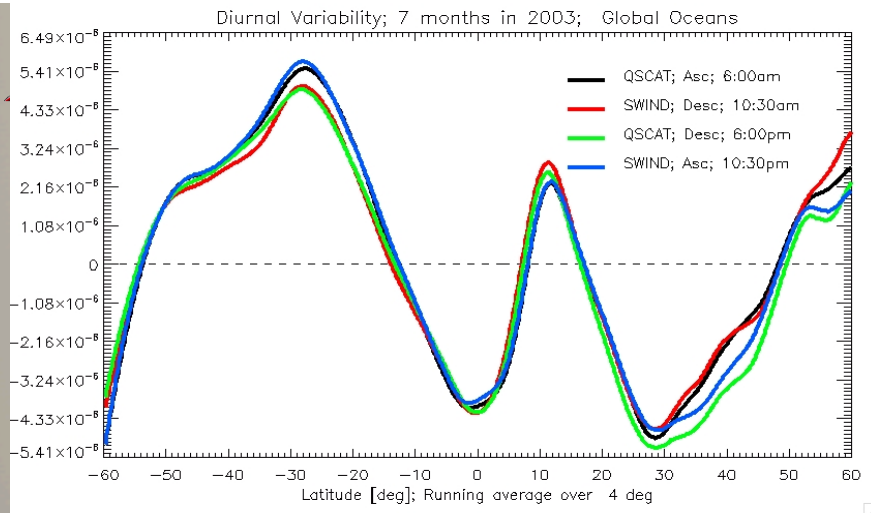

- 7 months of data; 2003;

## Diurnal Variability in Divergence

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

**Strong Diurnal Variability in Divergence**



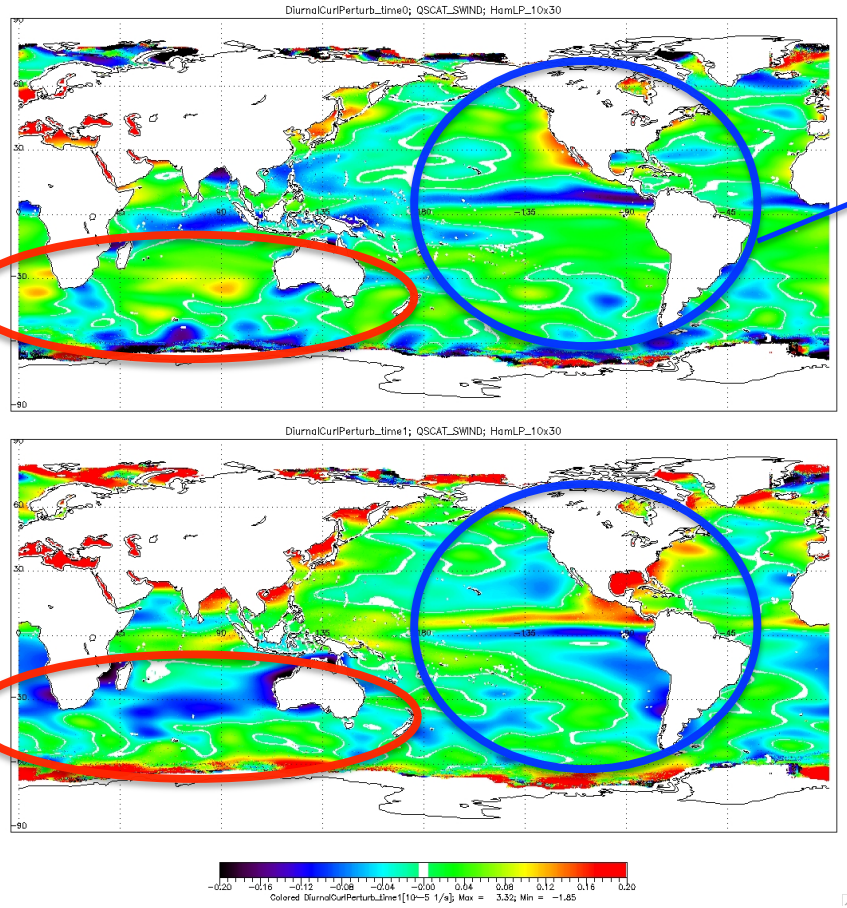



- 7 months of data; 2003;

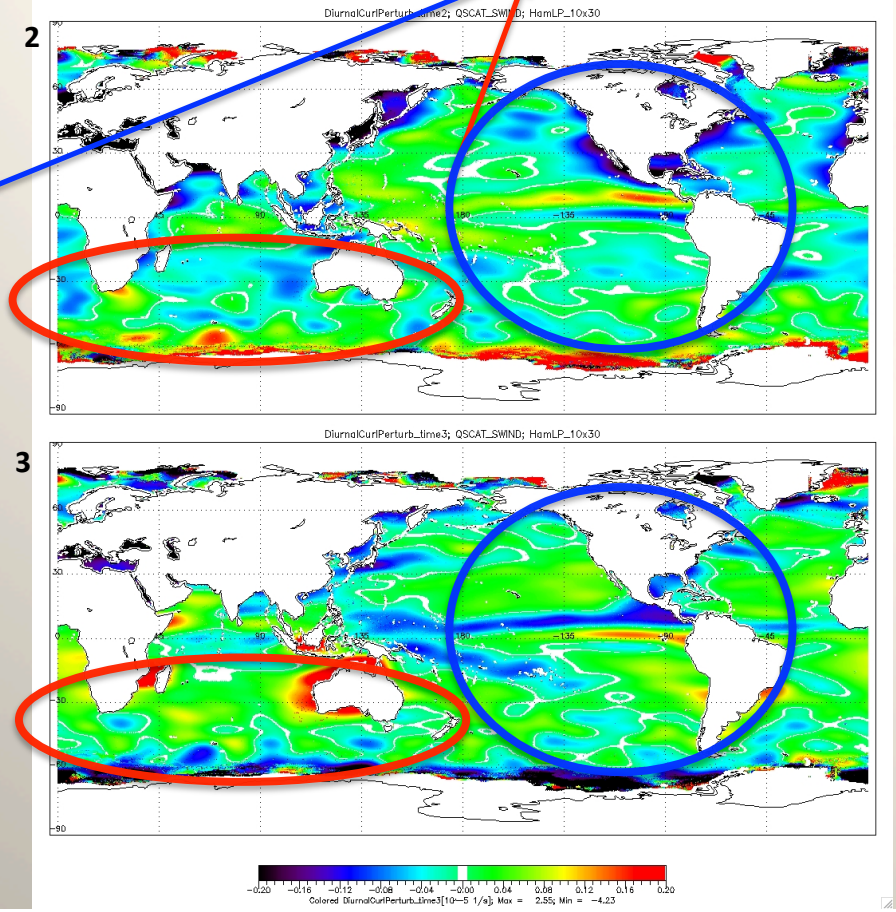
## Diurnal Variability in Curl

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

Diurnal Variability in Curl

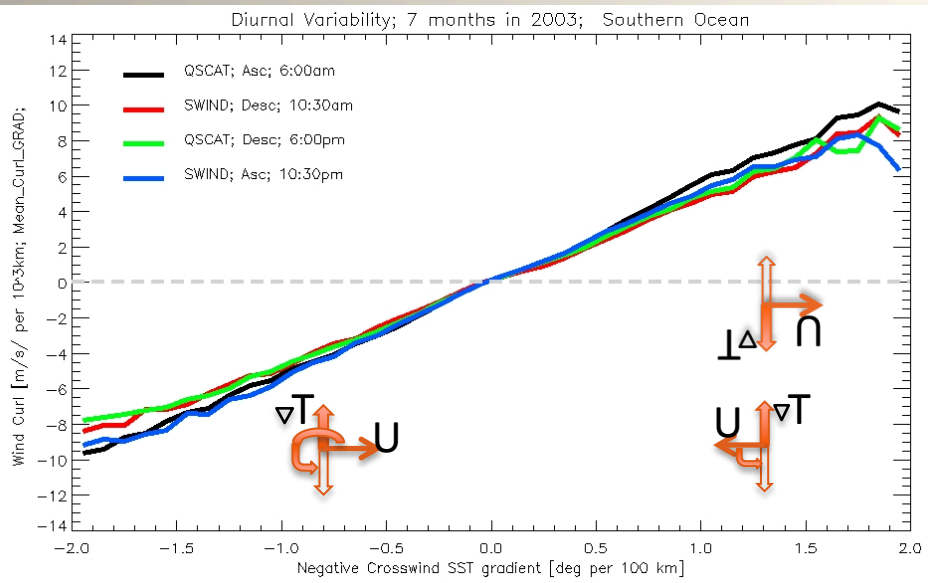


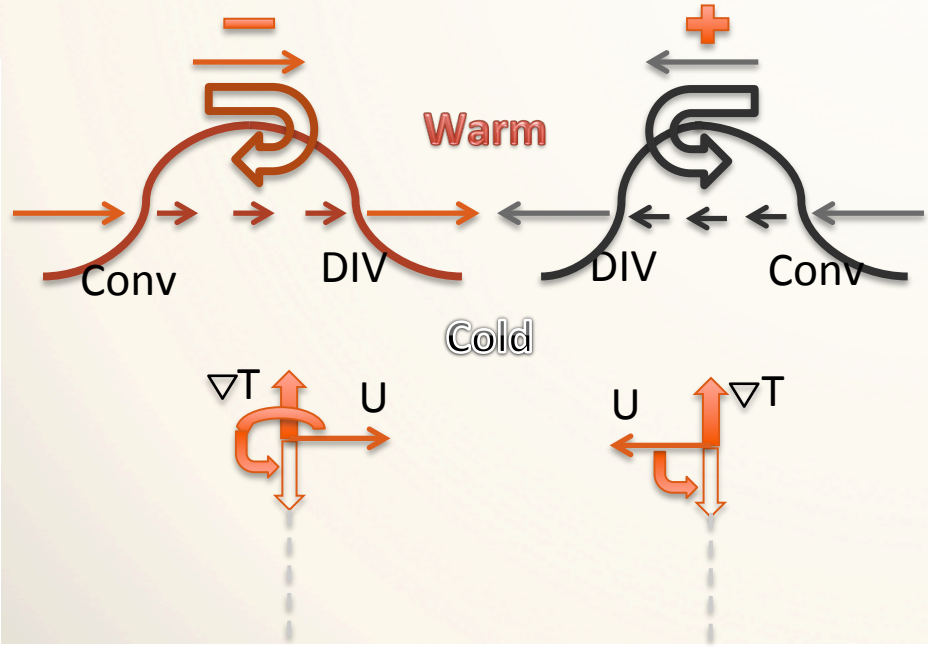

0 2

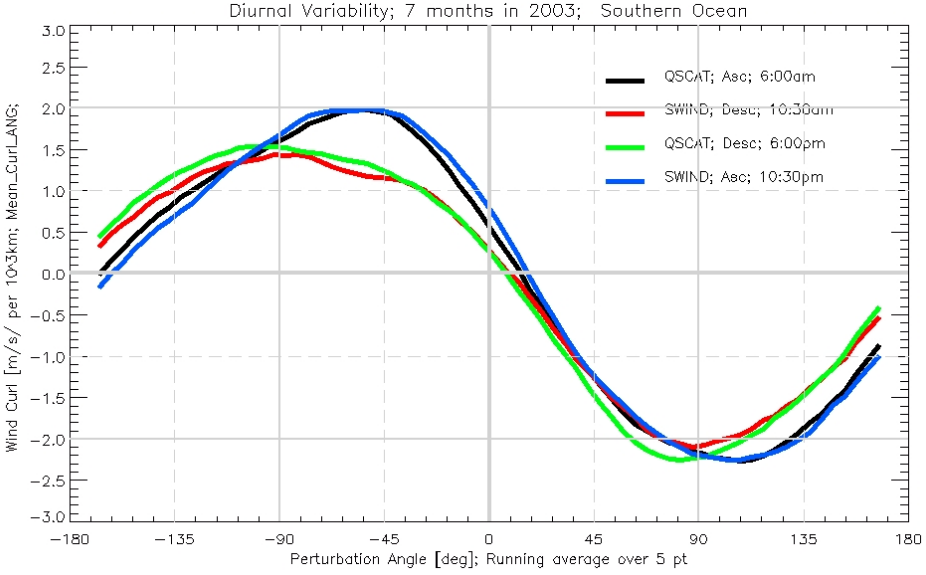


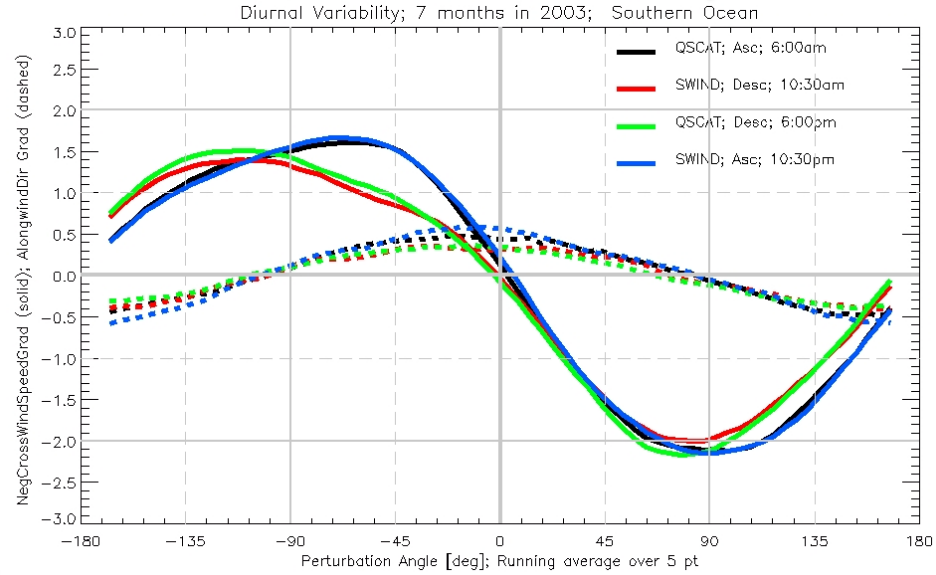

1 3

- **QuikSCAT and SeaWINDS - CURL**

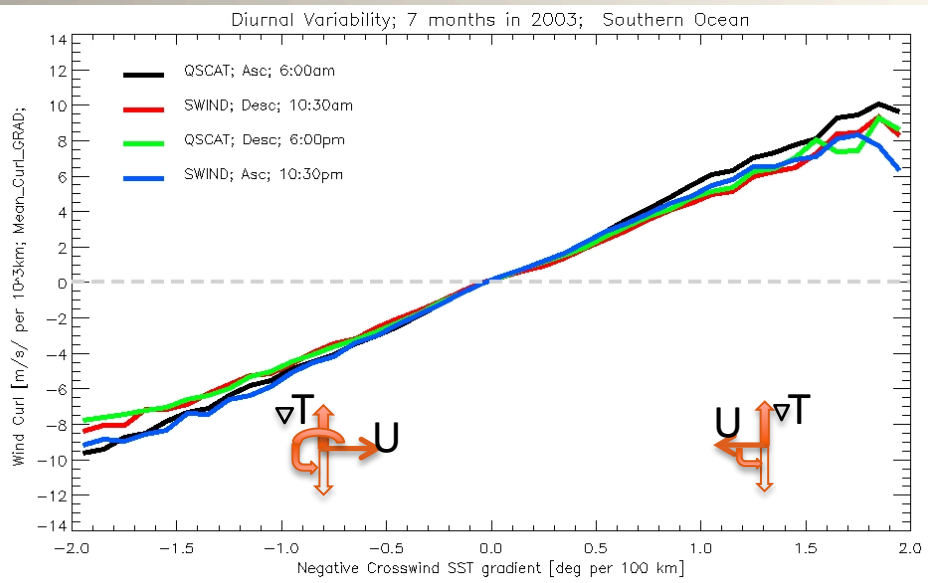


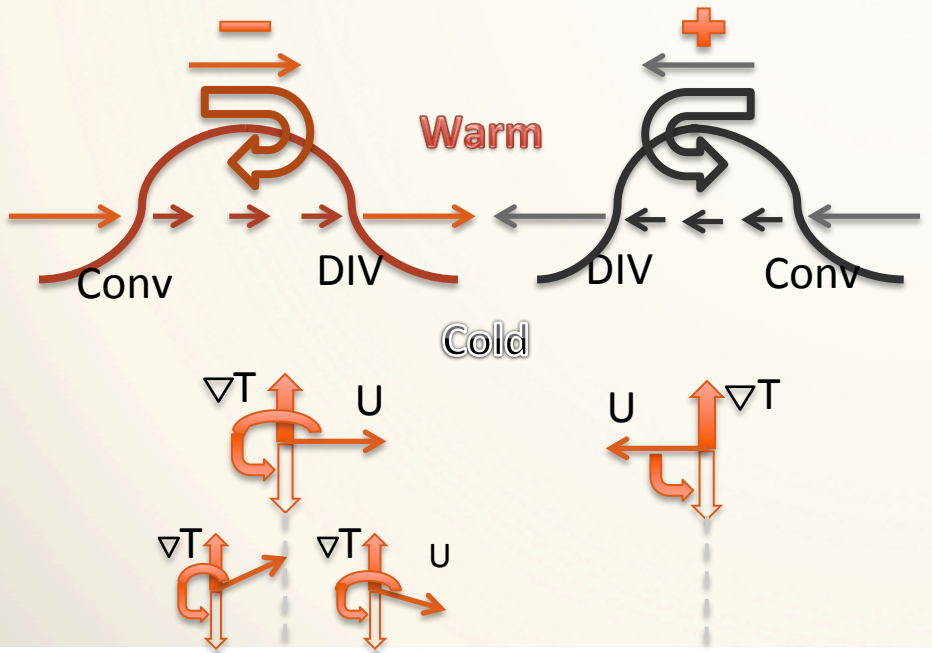



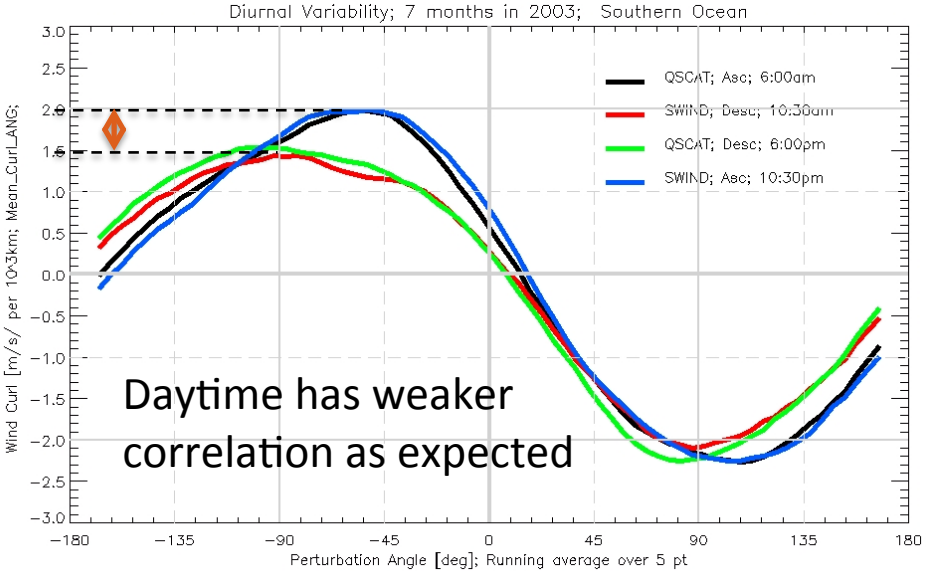



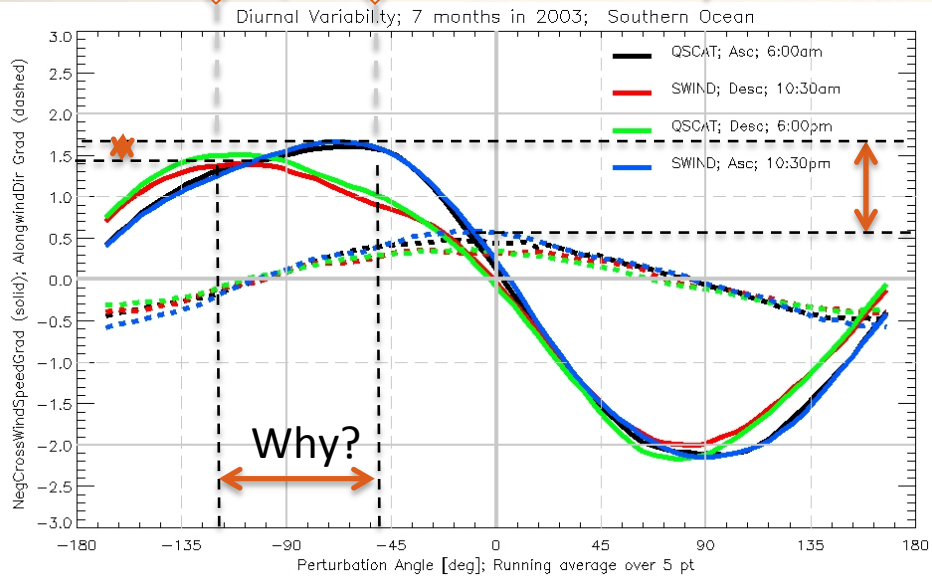



- **QuikSCAT and SeaWINDS - CURL**

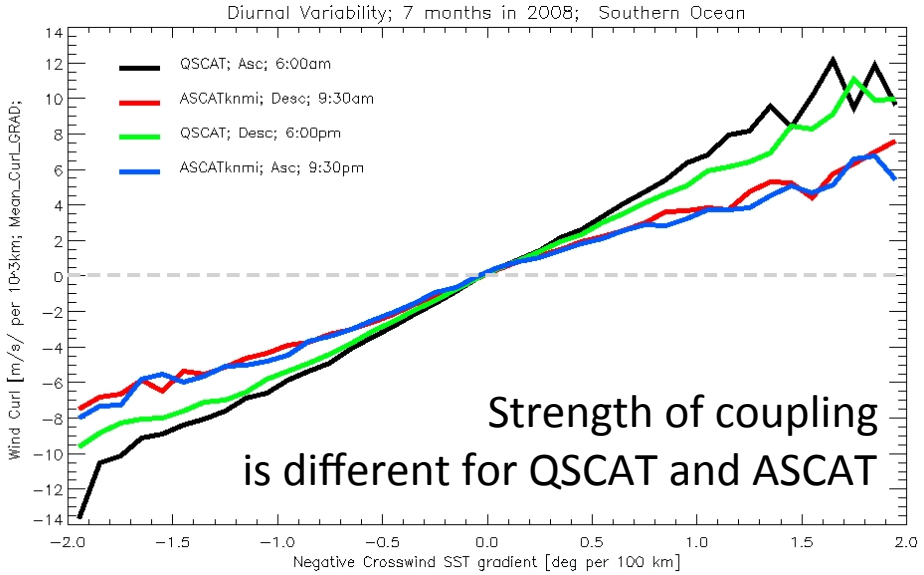


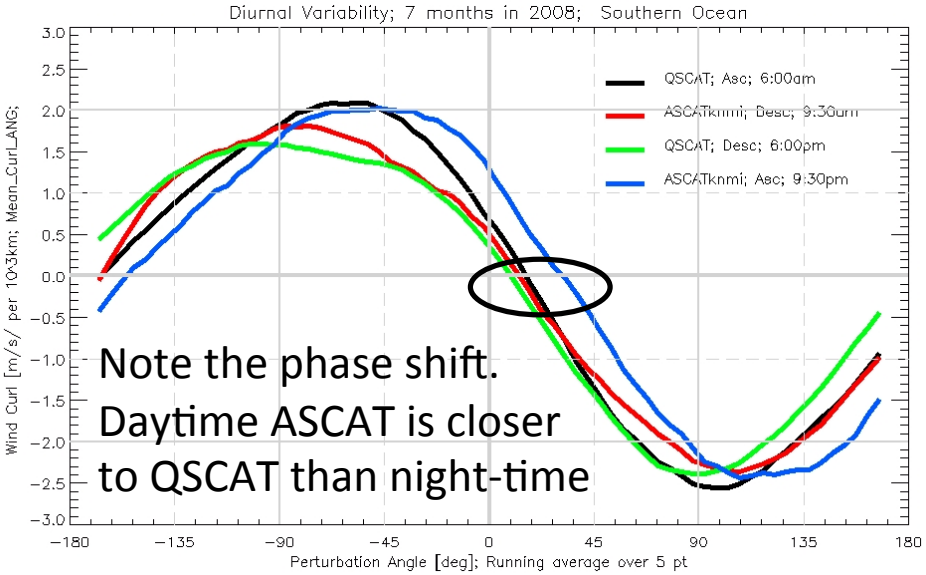
# • QSCAT and ASCAT (KNMI) - CURL

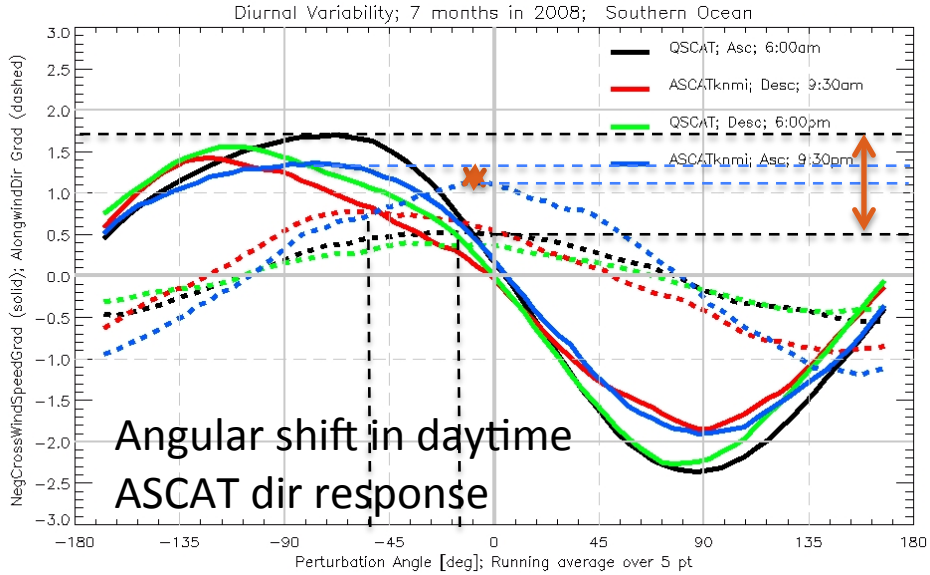



Diurnal variability as depicted by the in the QSCAT/ASCAT tandem missions is similar to that depicted by the QSCAT/SWIND tandem missions.

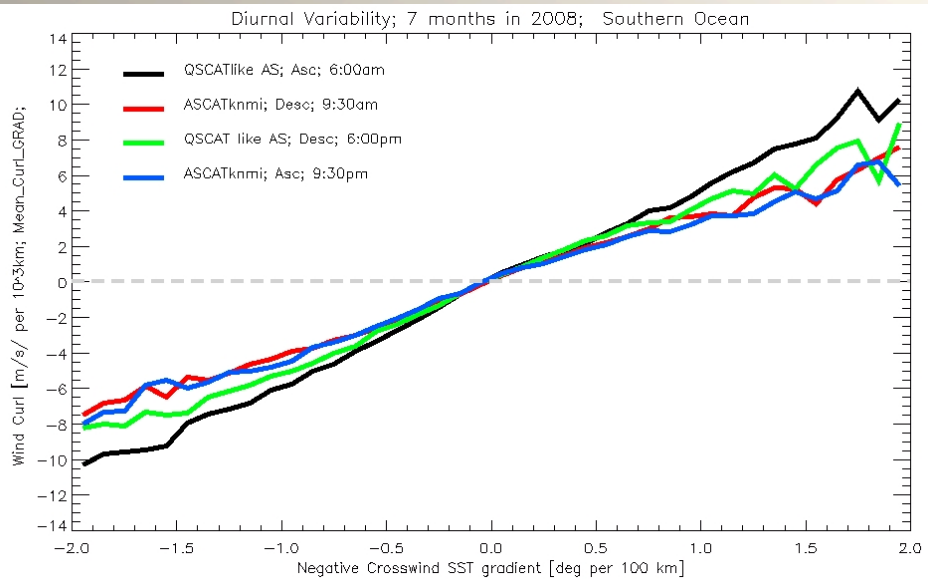
Differences:

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



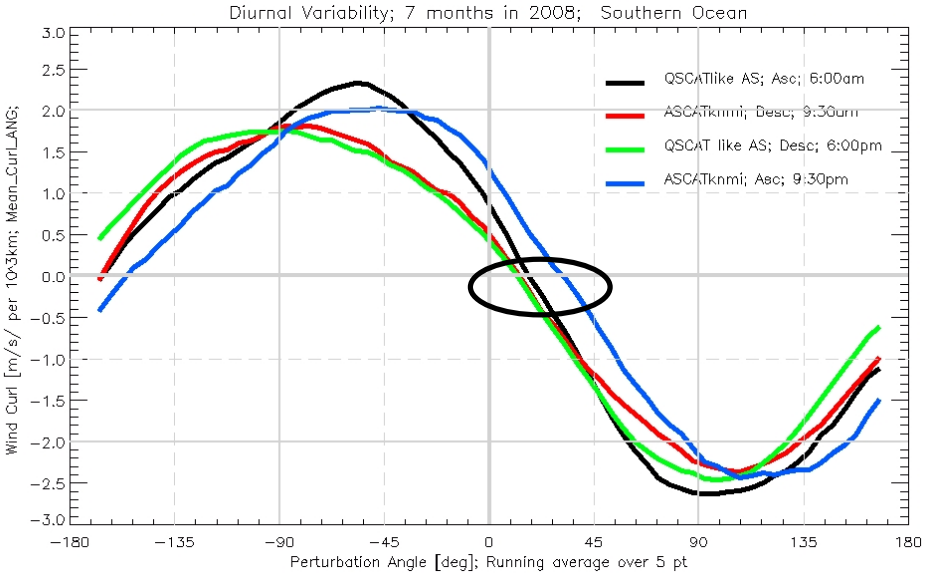
# • QSCATasASCAT and ASCAT (KNMI) - CURL

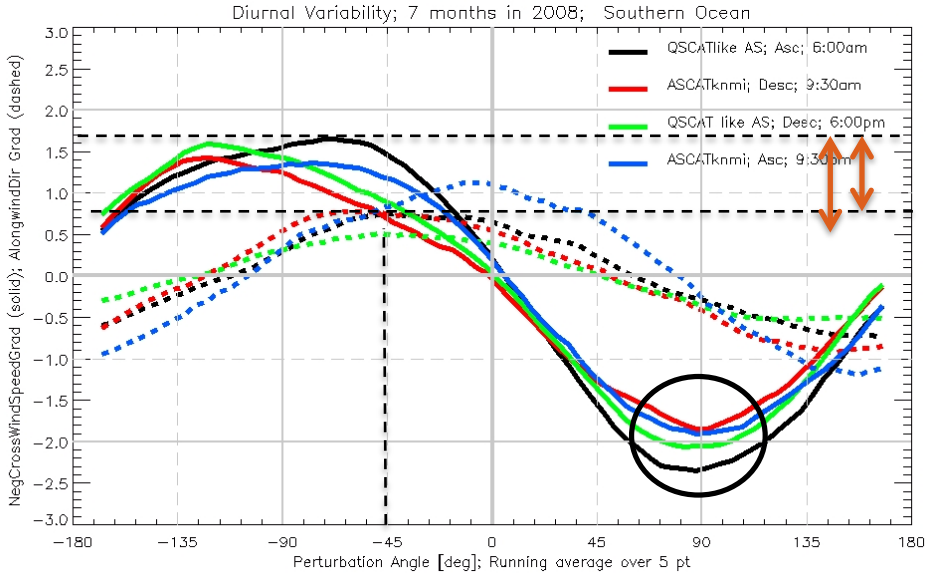



QuikSCAT has been averaged down and the mid section was cut off to resemble the ASCAT sampling and resolution.

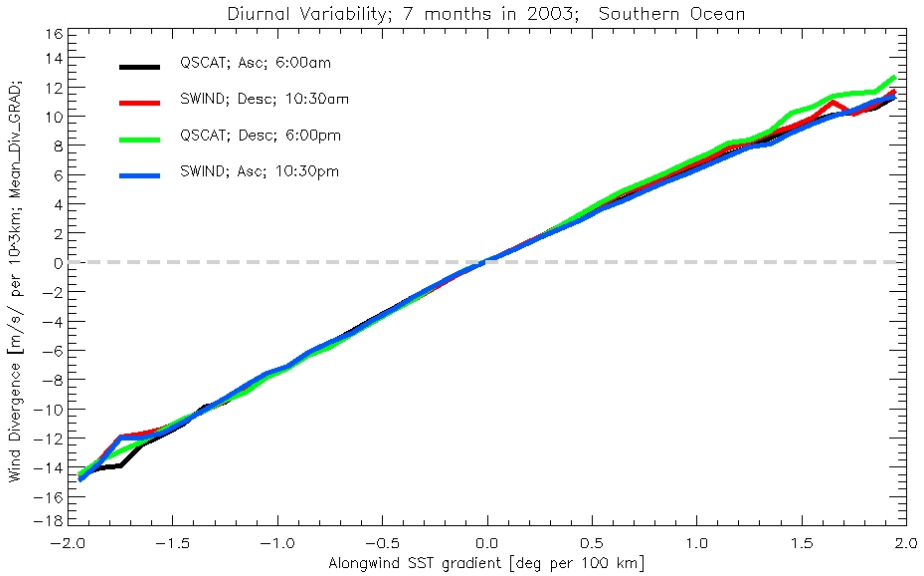
This results in bringing the two scatterometers in a closer agreement. This is especially true for the daytime orbits.

Still - remaining differences in strength of coupling and angular dependence



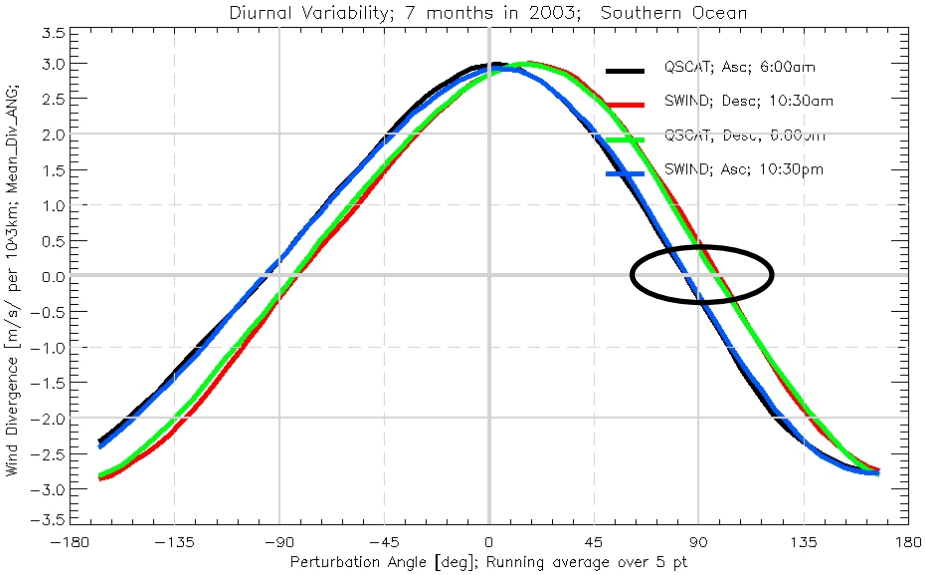



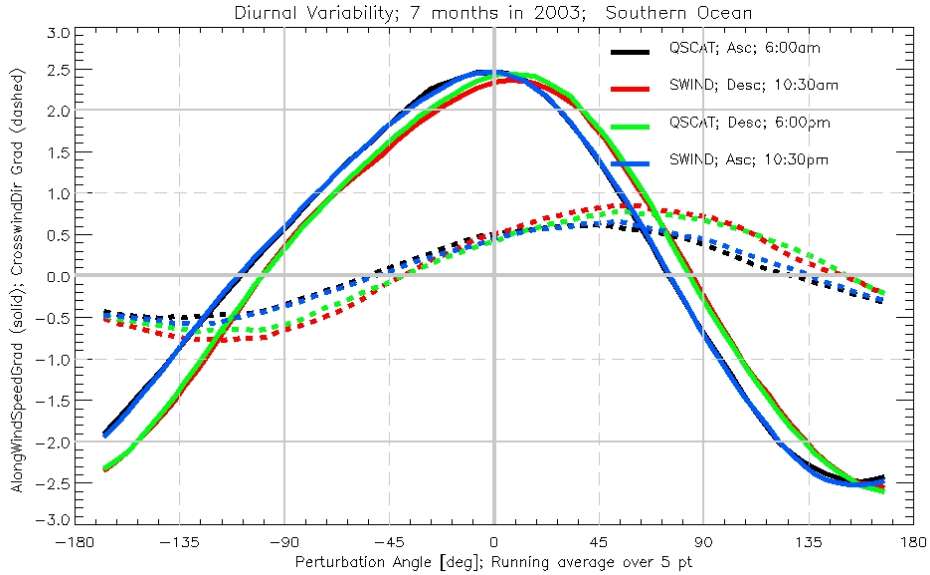
# • QuikSCAT and SeaWINDS (KNMI) - DIV



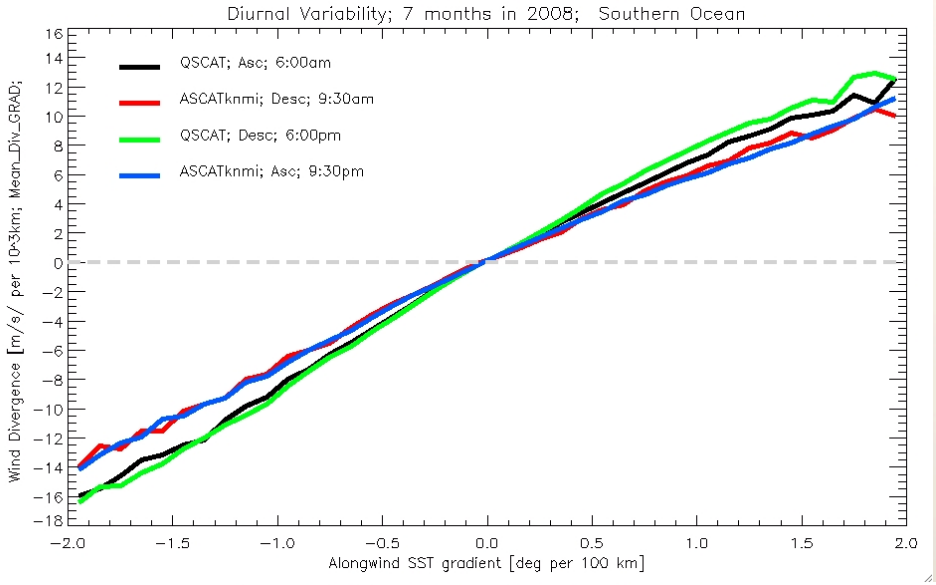

Strength of coupling has no diurnal variability.

Angular dependence has a very well defined diurnal dependence



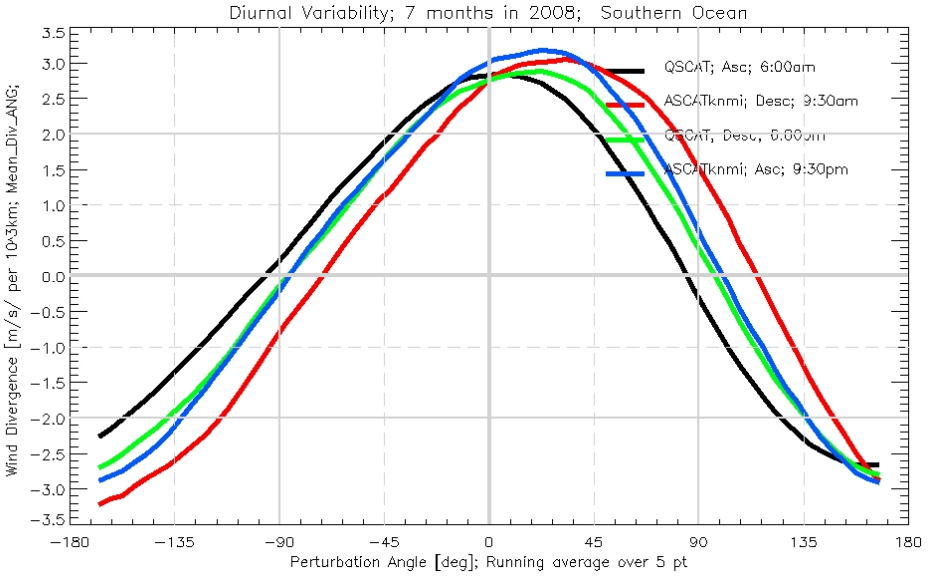
# • QuikSCAT and ASCAT (KNMI) -DIV

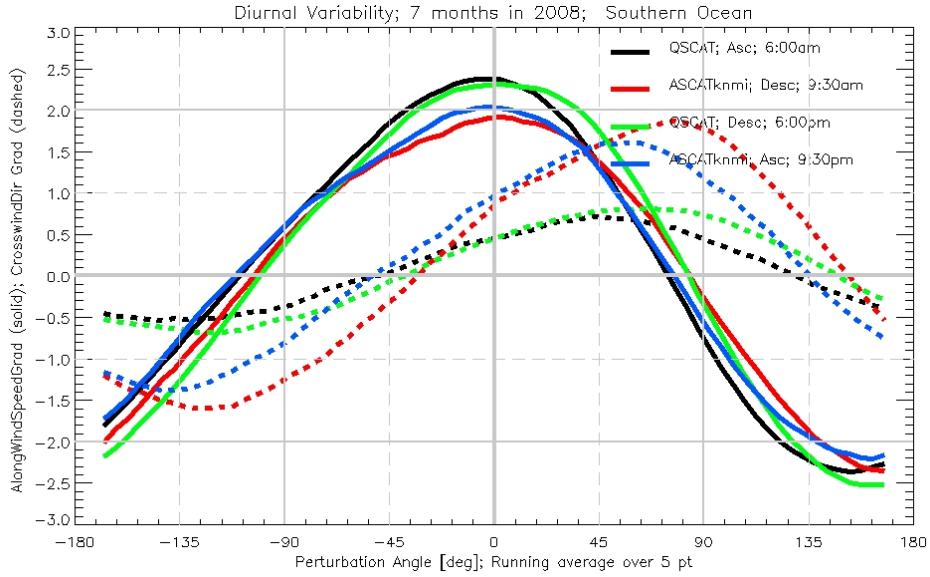



QSCAT and ASCAT show different strength of the coupling.

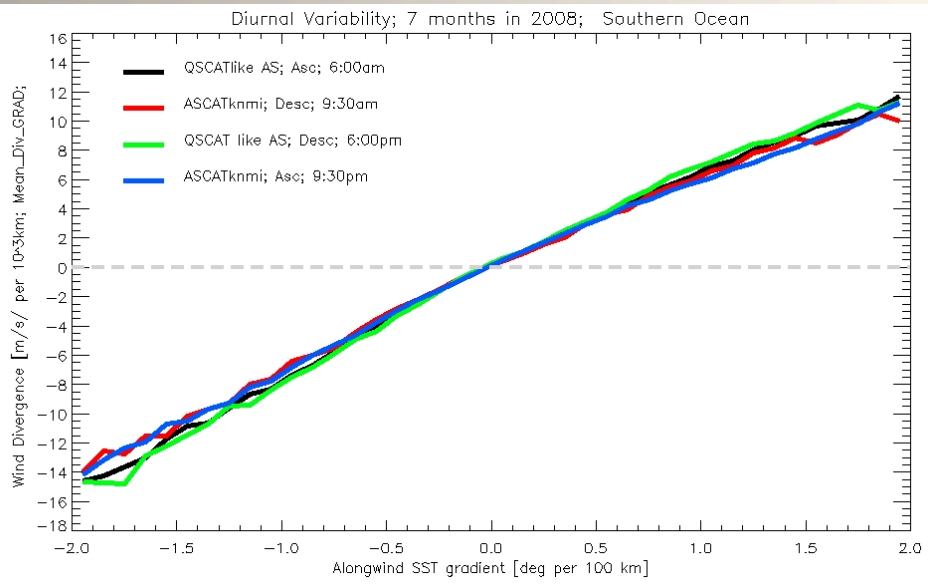
ASCAT

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



# • QSCATasASCAT and ASCAT (KNMI) - DIV

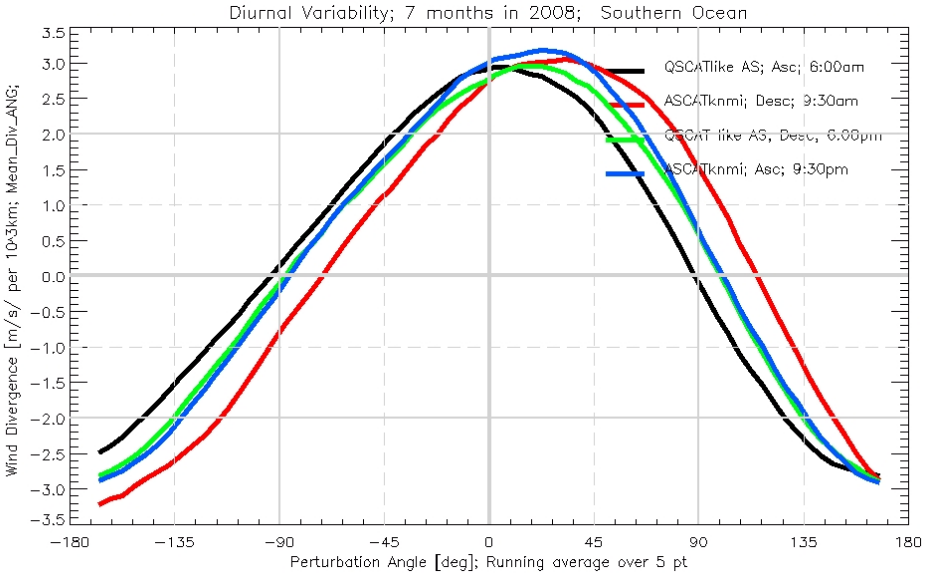


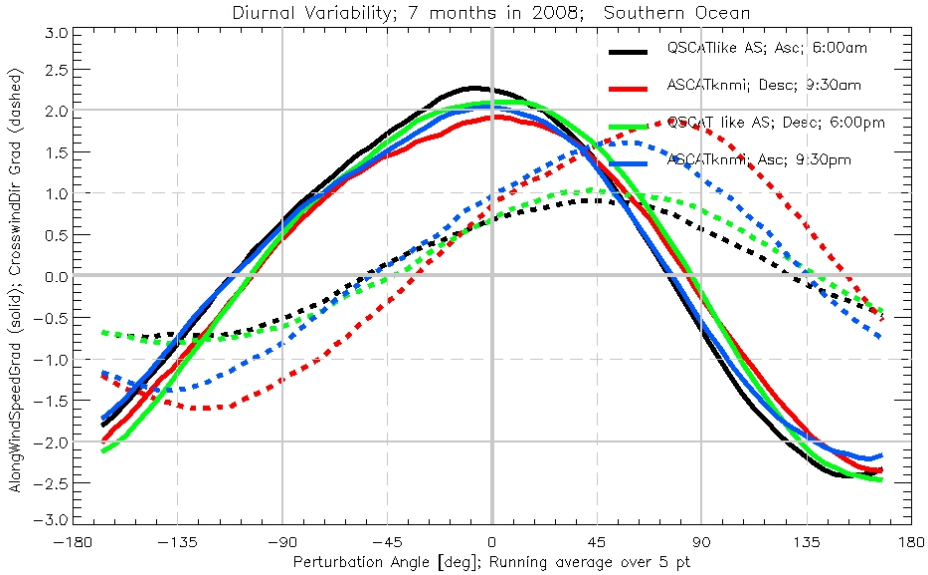

QuikSCAT has been averaged down and the mid section was cut off to resemble the ASCAT sampling and resolution.

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

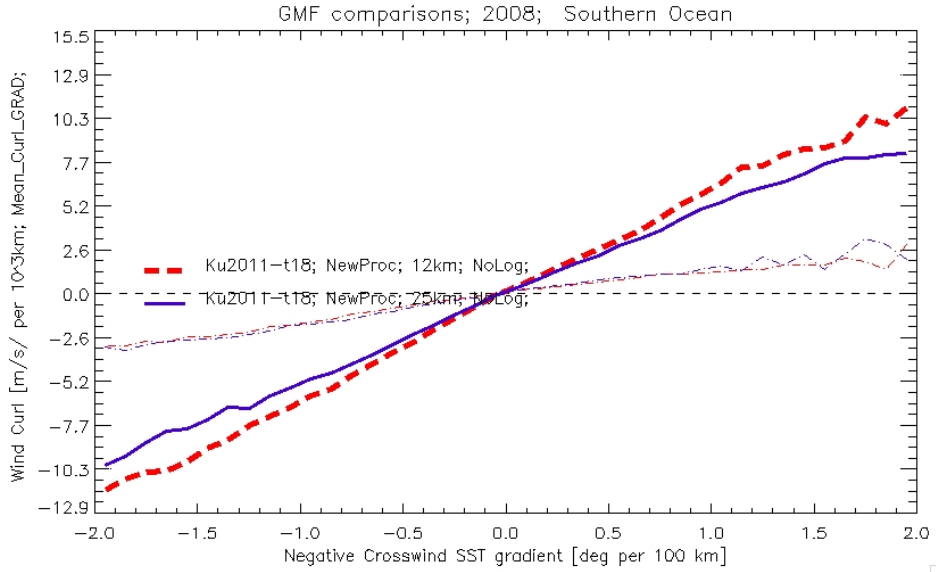


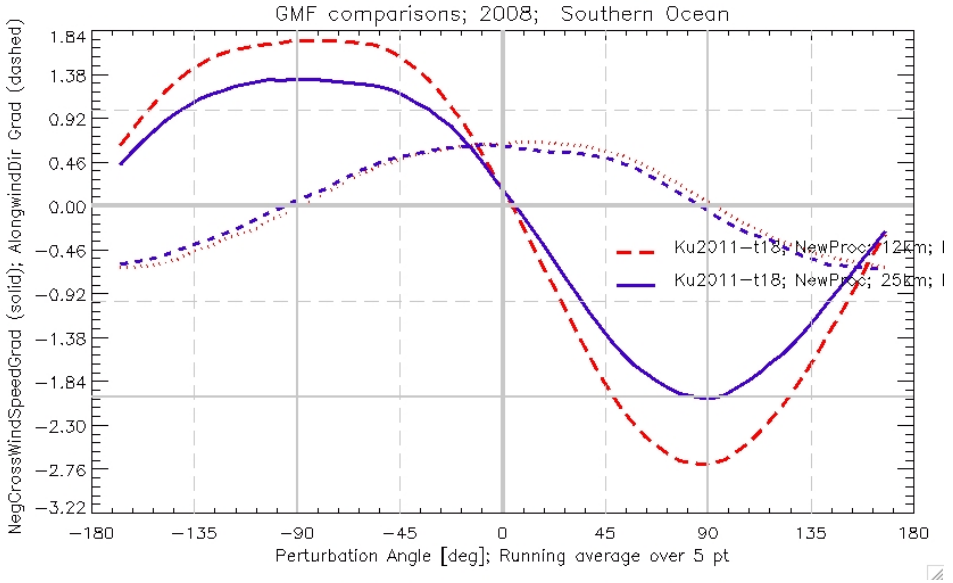



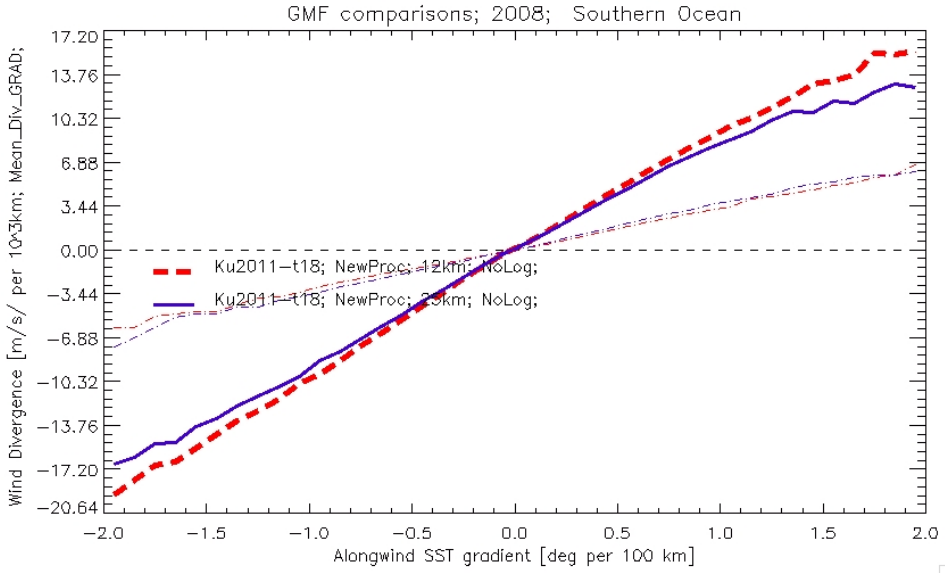
# Summary

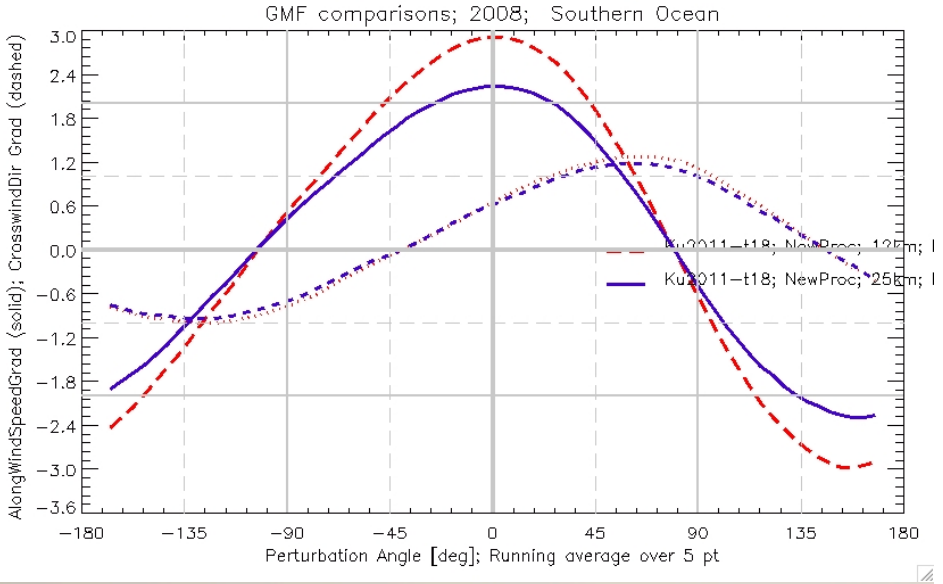
- QSCAT/SWIND tandem mission reveals:
  - strong diurnal cycle in the large-scale divergence
  - NO diurnal cycle in the strength of the coupling
  - well defined diurnal cycle in the angular dependence of the SST/wind coupling
  - STD
    - night-time curl STD is higher (as compared to daytime)
    - Day-time div STD is higher (as compared to night-time)
- QSCAT/ASCAT tandem mission shows:
  - similar diurnal variability exhibited by similar shifts in the angular response
    - curl - QSCAT and ASCAT are more similar during the daytime
    - divergence - QSCAT and ASCAT are more similar during the night time
  - different strength in the coupling
  - different relation between the magnitude of the speed and directional responses
    - stronger dir response and weaker speed response in ASCAT as compared to QSCAT
    - this results in a shift in the angular depiction of the couplin
- Modifying the QuikSCAT winds to resemble the resolution and the sampling of the ASCAT winds brings the two scatterometers in closer agreement in their depiction of the SST/wind coupling.
- Still, there are remaining differences

# • QSCAT – Impact of Resolution;

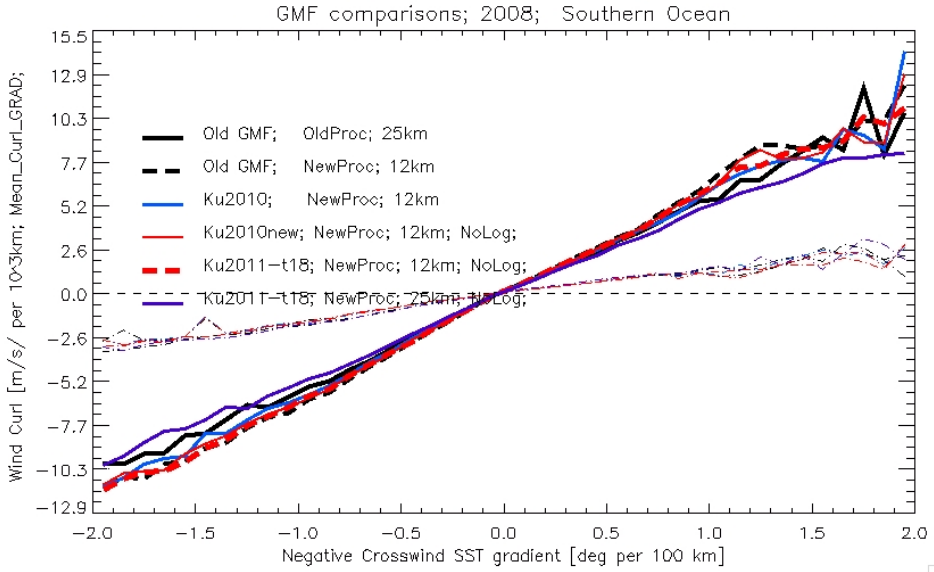


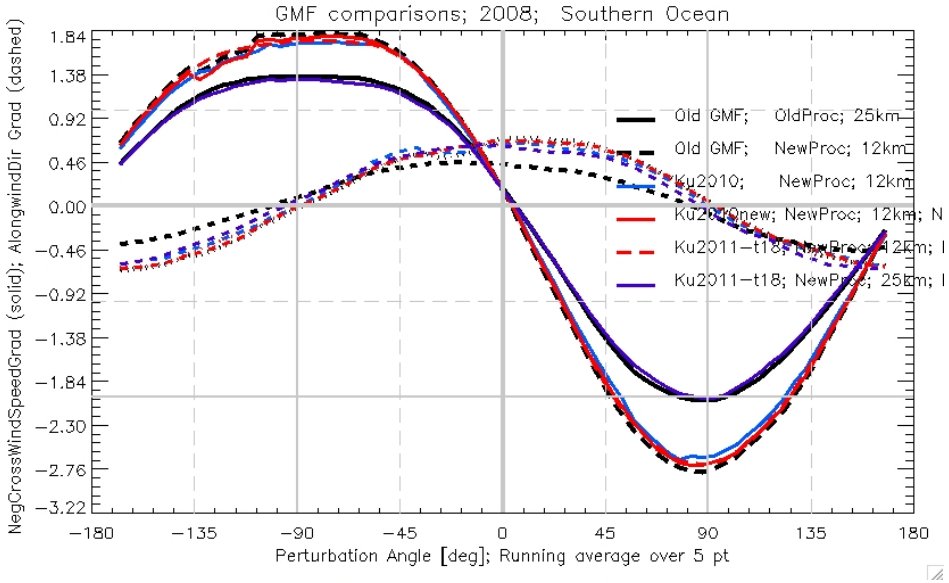



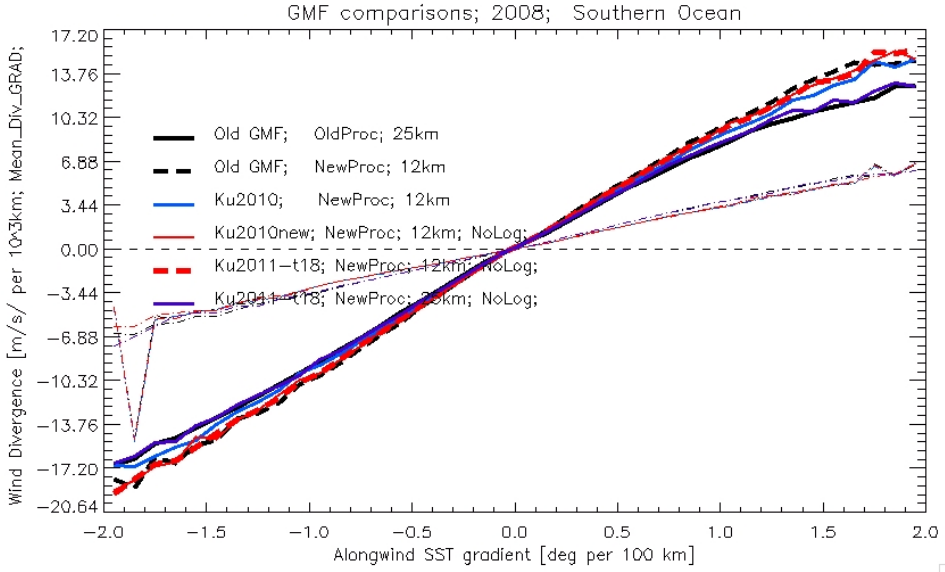



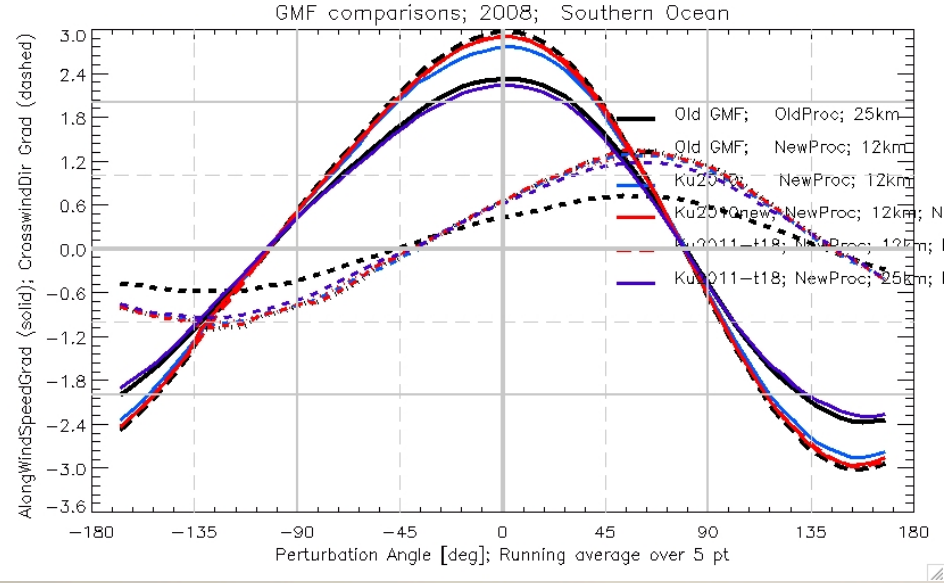



# • QSCAT – GMF and Processing

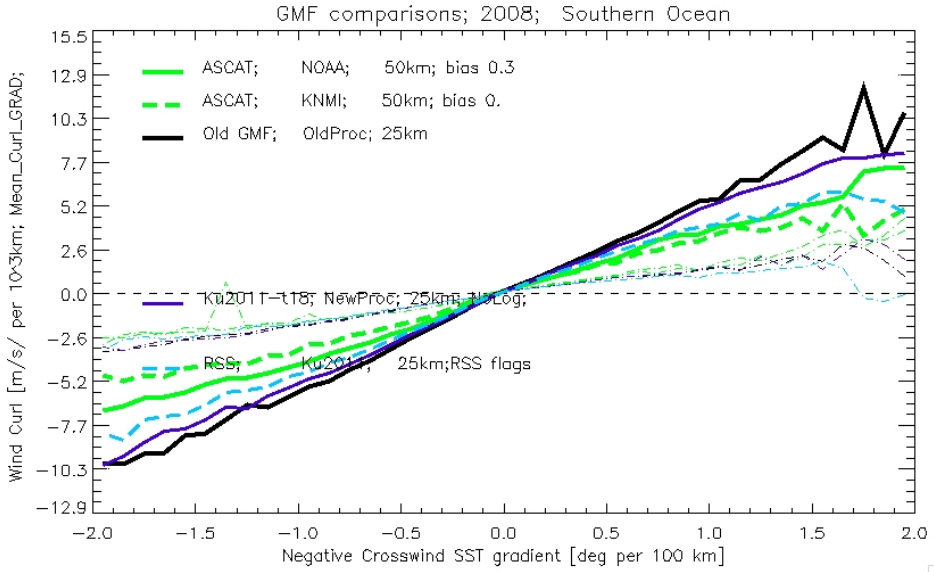


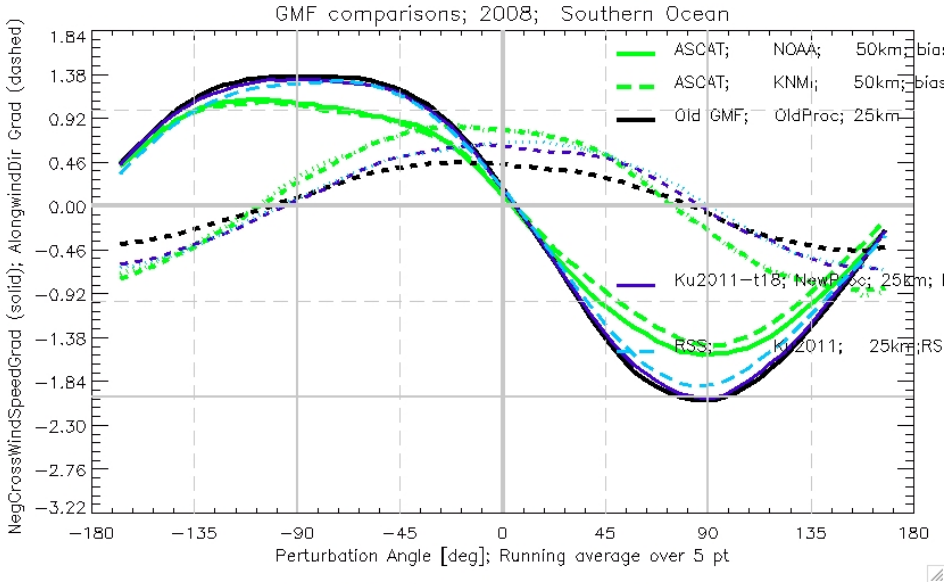



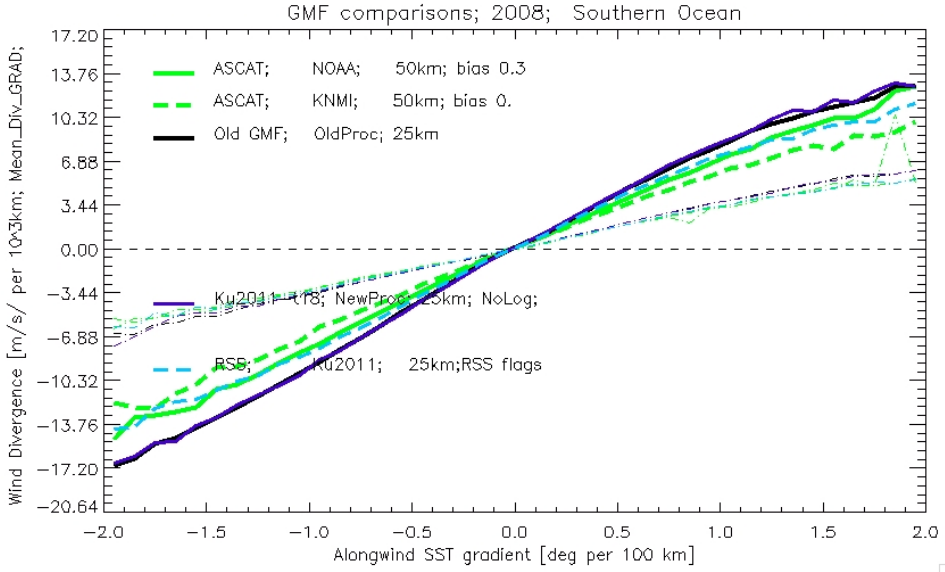



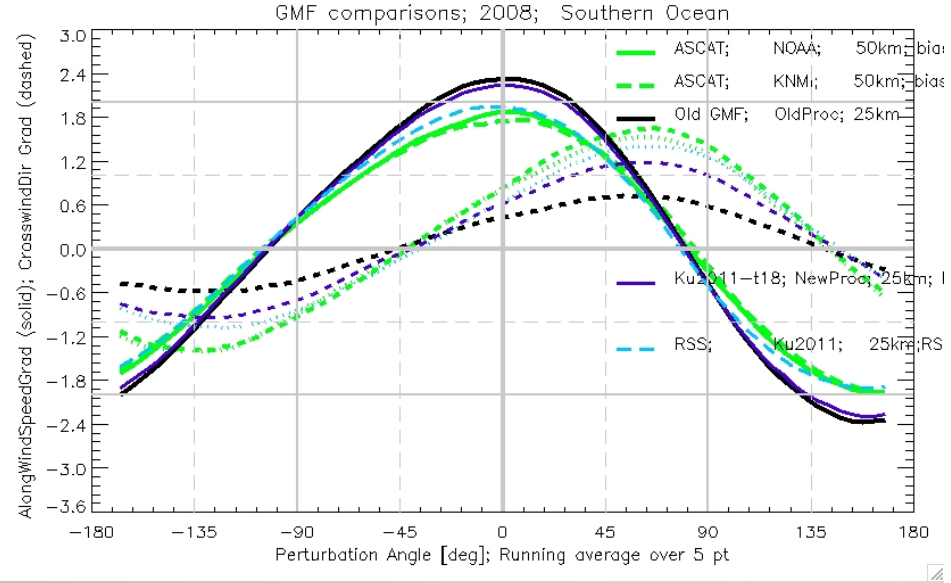



# Impact of algorithms



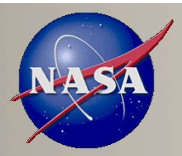



# SUMMARY

- The differences between the QSCAT and ASCAT depiction of the SST coupling
  - do not seem to be related to the GMF
  - can be explained (to a degree) by their different:
    - resolution
    - sampling
    - retrieval algorithms

- To evaluate the impact of retrieval algorithms, we are now looking at a detailed comparison between QSCAT retrievals performed at JPL, RSS and KNMI.

- Thanks to RSS and KNMI for the collaboration in addressing uncertainty introduced by retrieval approaches!!



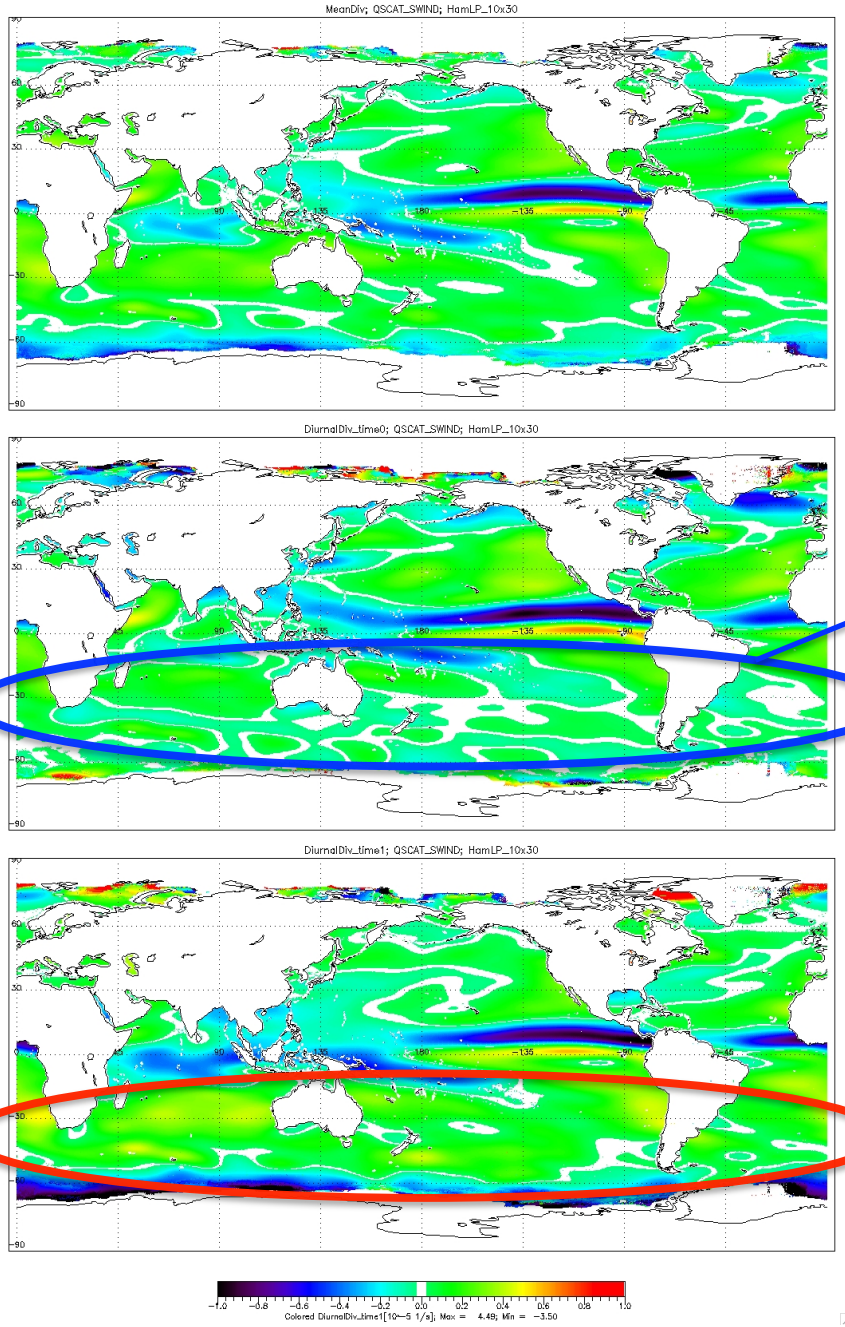
# Backup

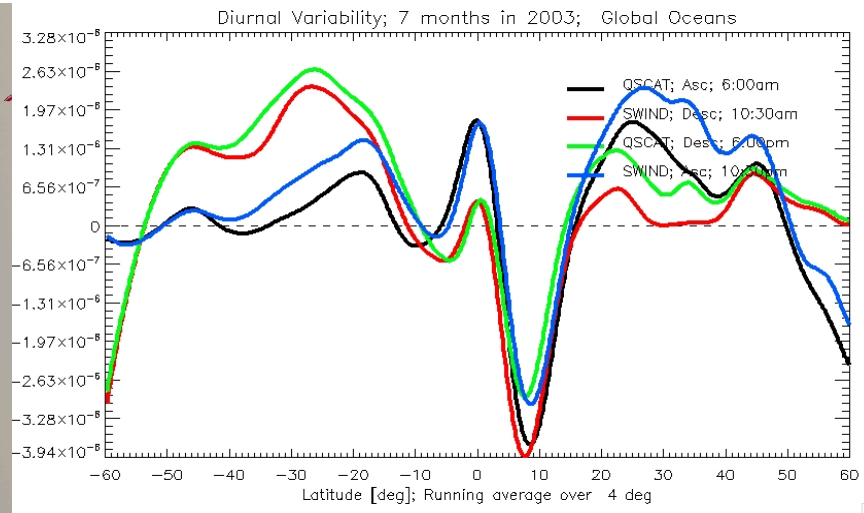
- 7 months of data; 2003;

## Diurnal Variability in Divergence

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

**Strong Diurnal Variability in Divergence**



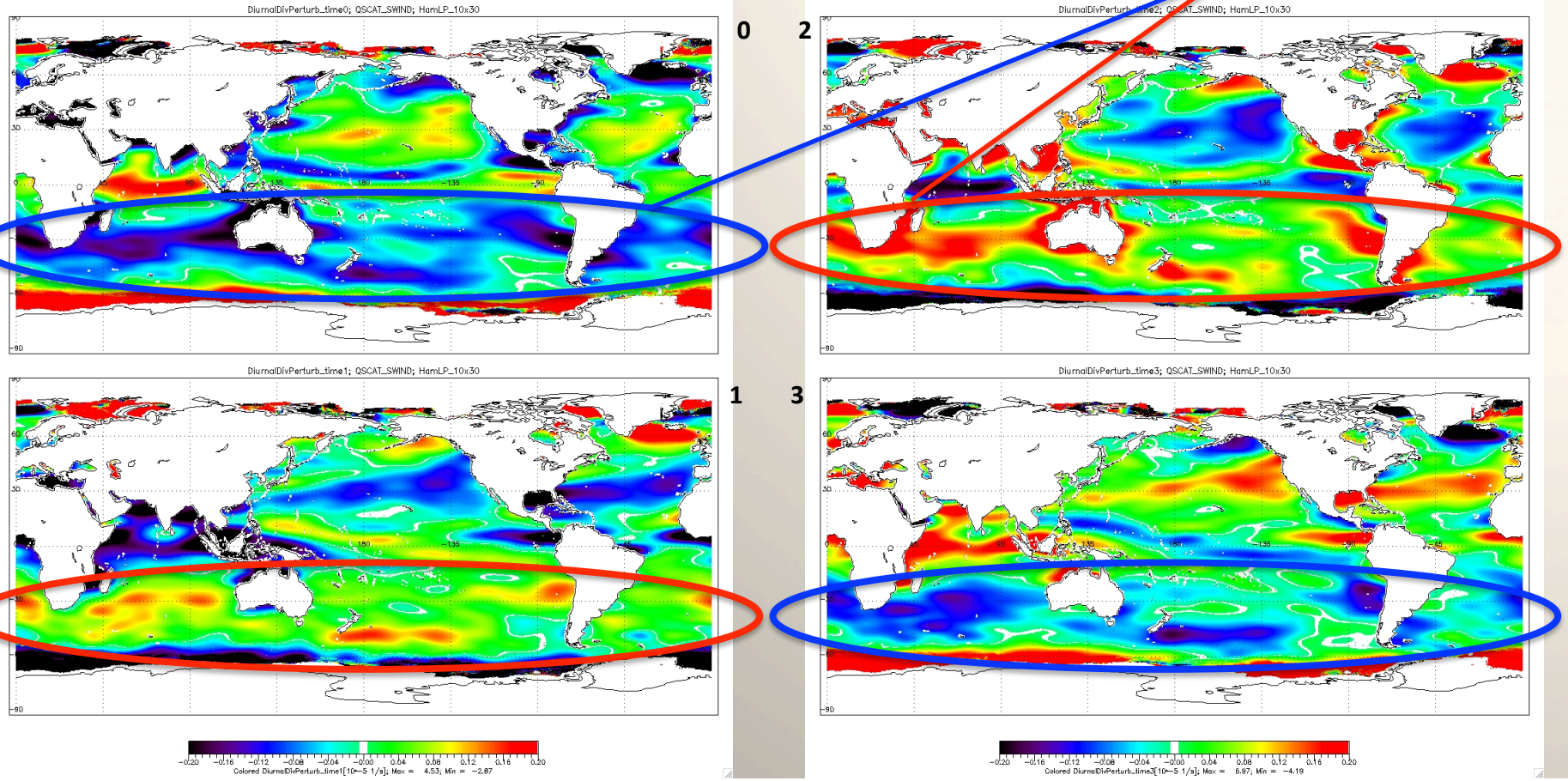


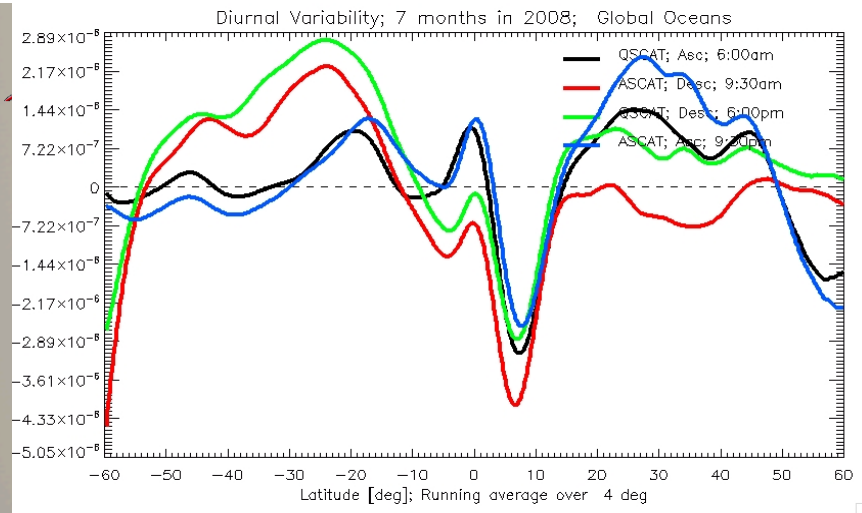

- 7 months of data; 2003;

## Diurnal Variability in Divergence

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

**Strong Diurnal Variability in Divergence**

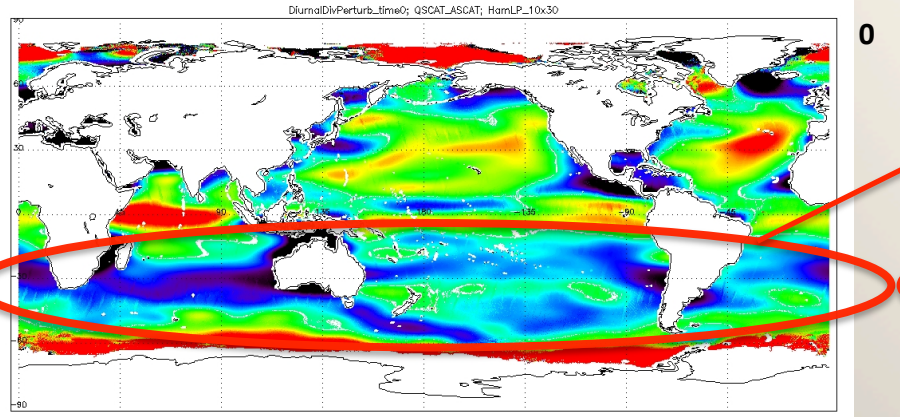




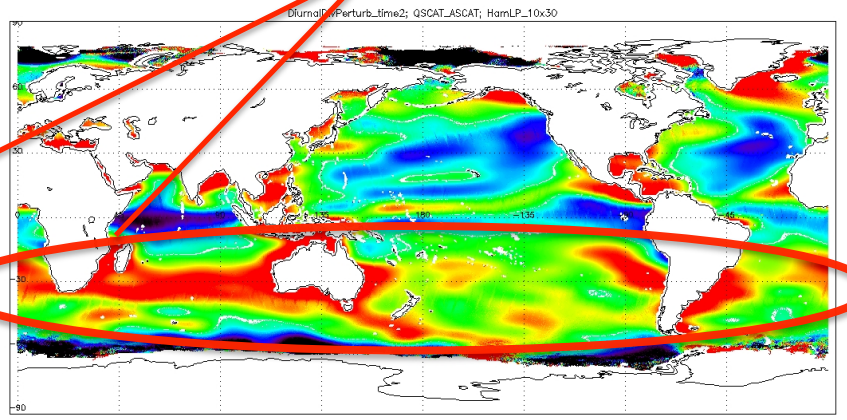

- **7 months of data; 2008;**
  - **Diurnal Variability – DIV**
- **0 – 6:00 am; $QSCAT_{asc}$ - mean**
- **1 - 9:30 am; $ASCAT_{desc}$ - mean**
- **2 – 6:00 pm; ; $QSCAT_{asc}$ - mean**
- **3 – 9:30 pm; $ASCAT_{asc}$ - mean**

Mean

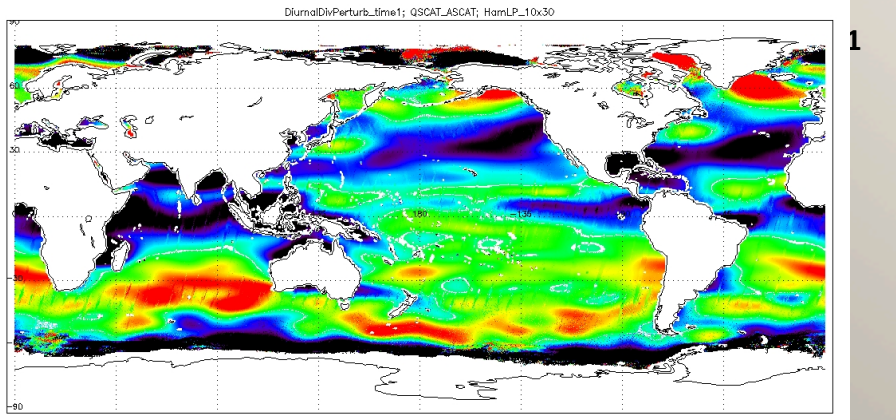
**Strong Diurnal variability in Convergence**



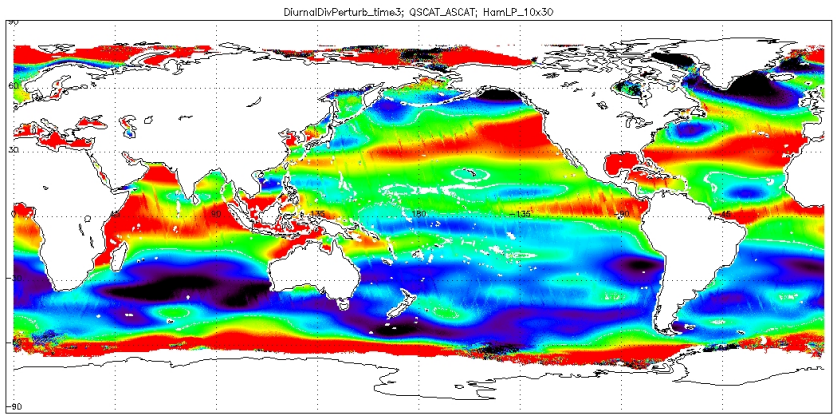

**0**



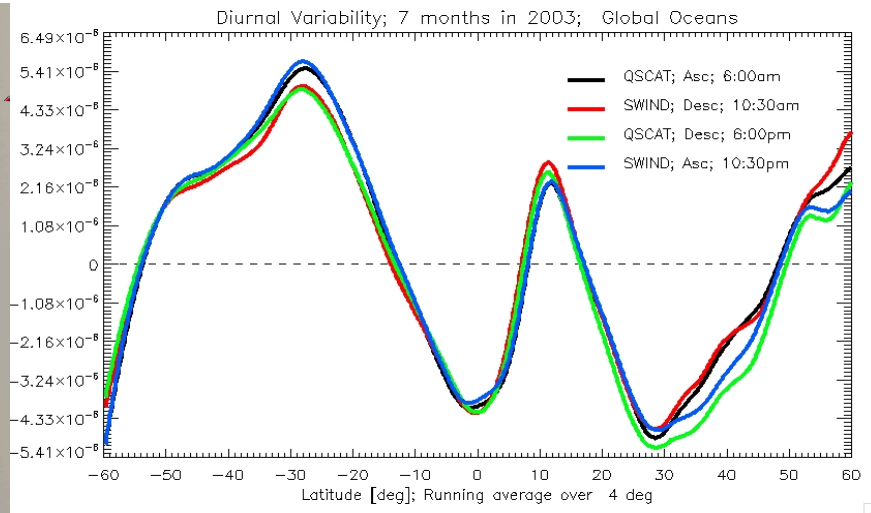

**2**




**1**




**3**

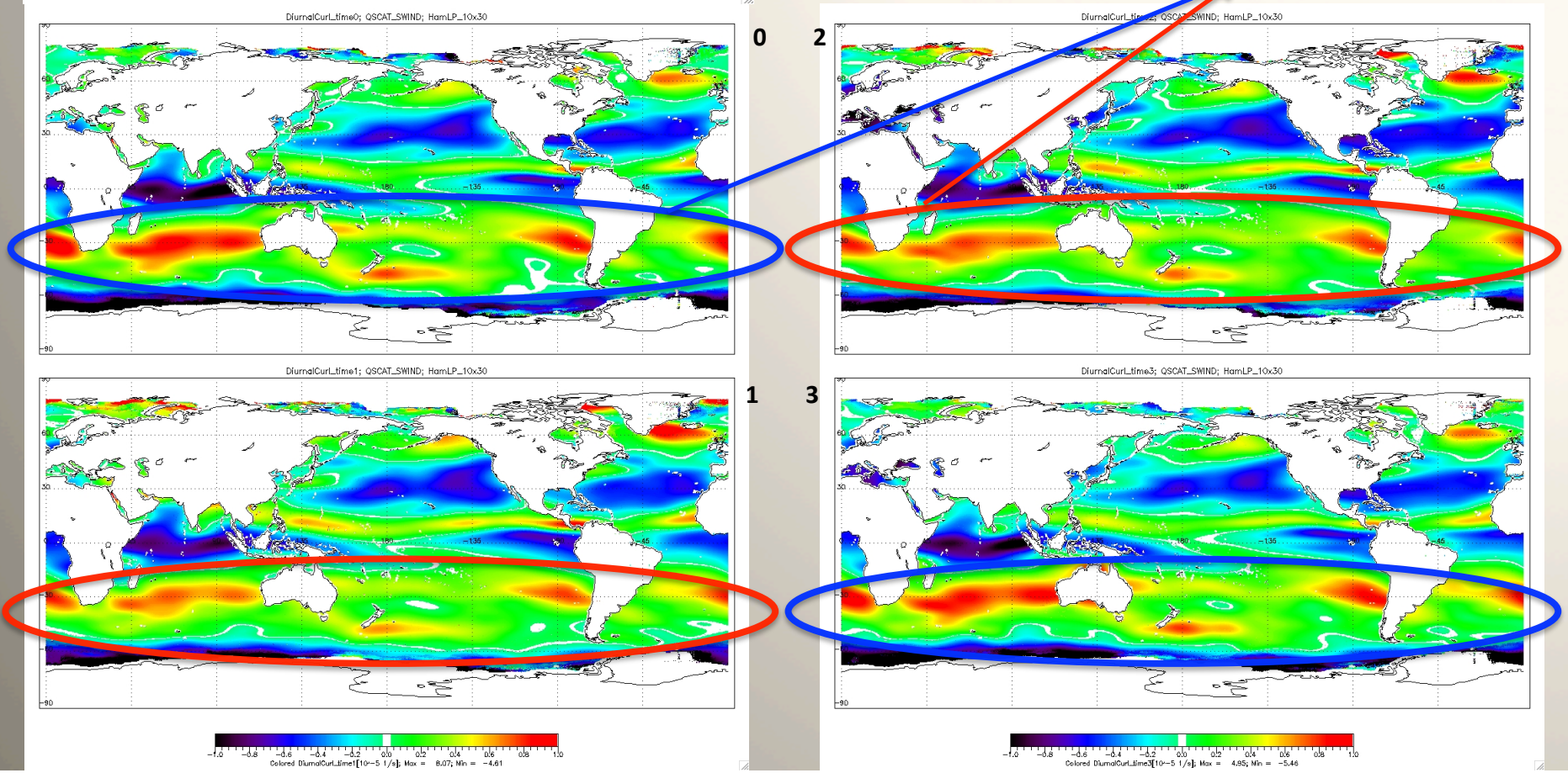



- 7 months of data; 2003;

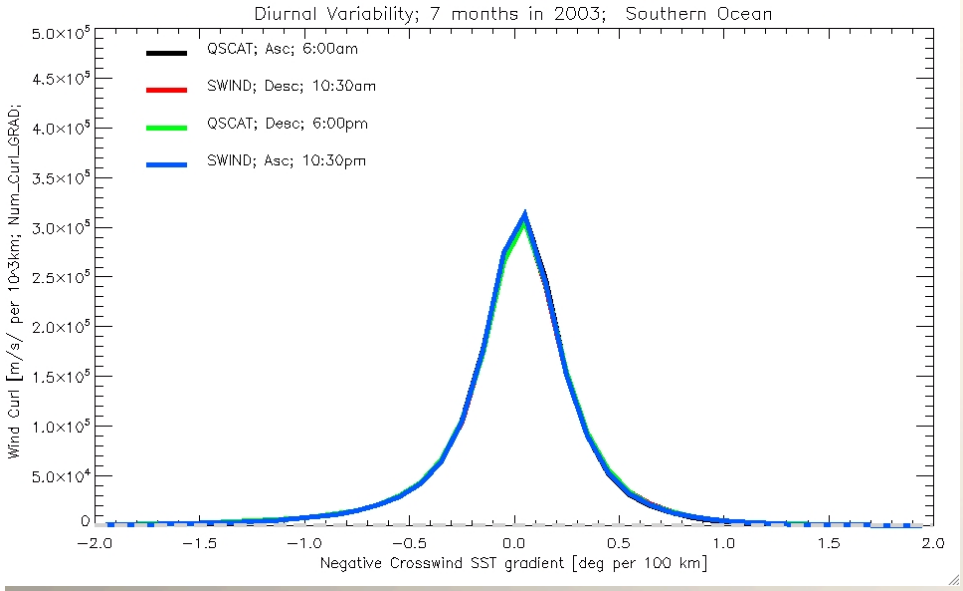
## Diurnal Variability in Curl

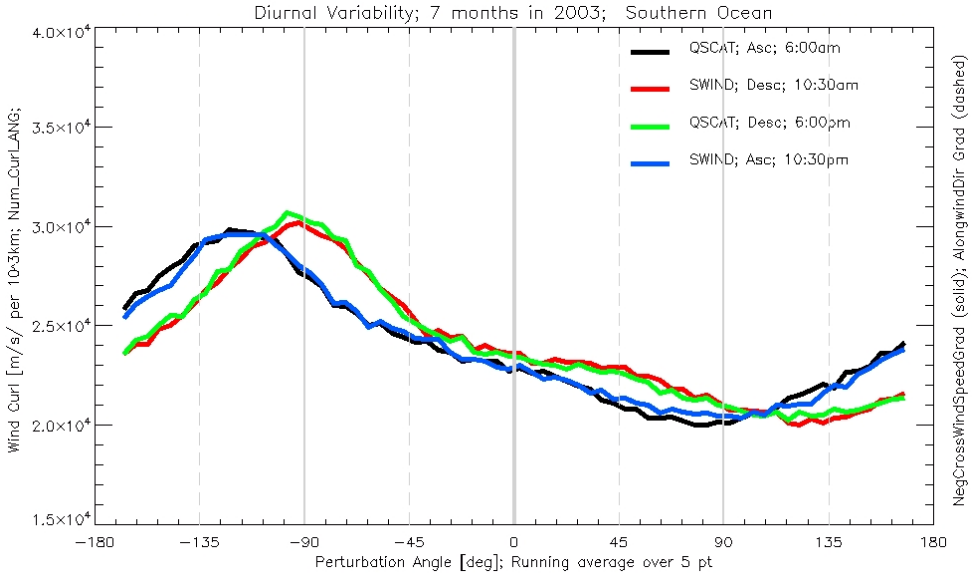
- 0 – 6:00 am; $QS_{ascending}$
- 1 - 10:30 am; $SW_{descending}$
- 2 – 6:00 pm; $Qs_{descending}$
- 3 – 10:30 pm; $Sw_{ascending}$

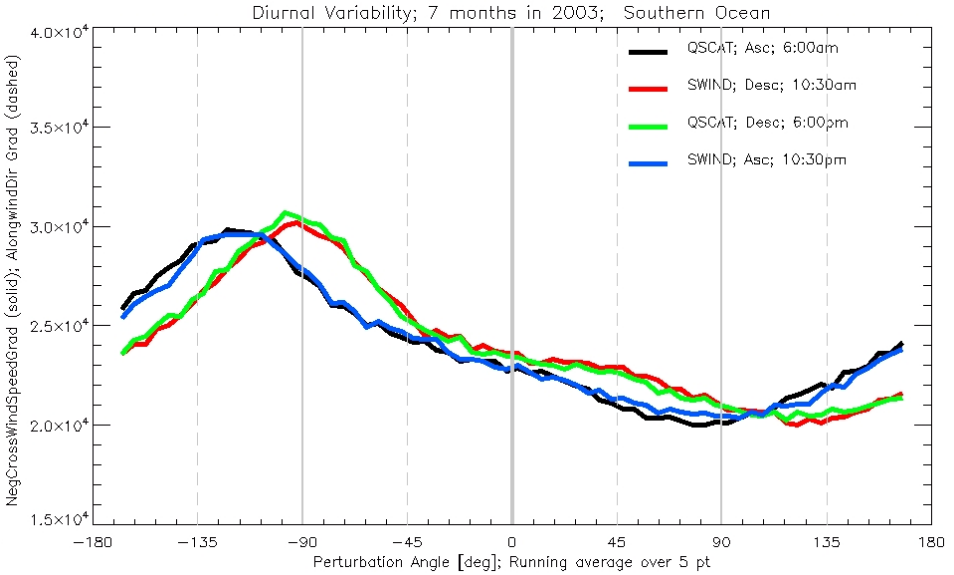
Diurnal Variability in Curl



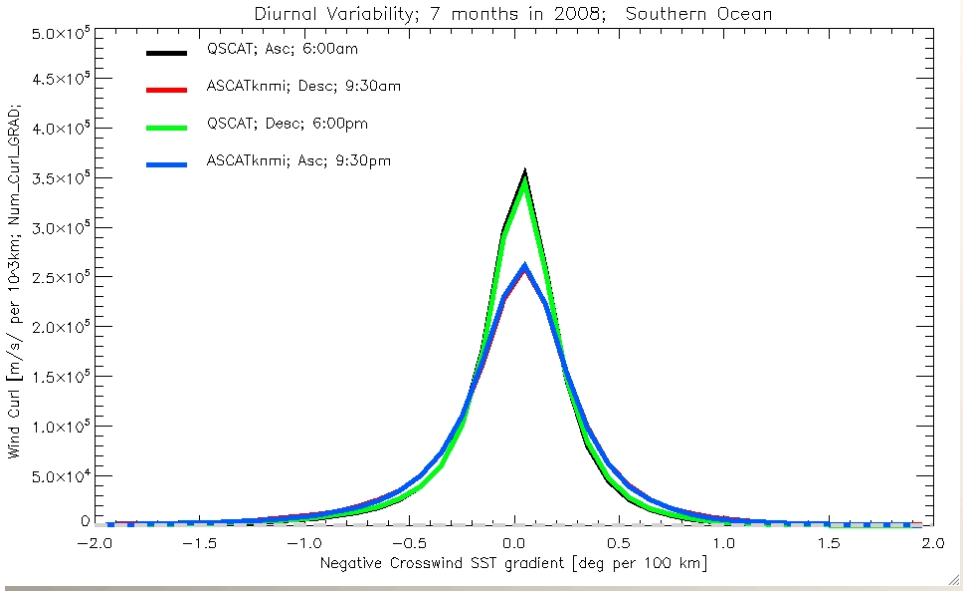
- **QSCAT and SWIND; - CURL**

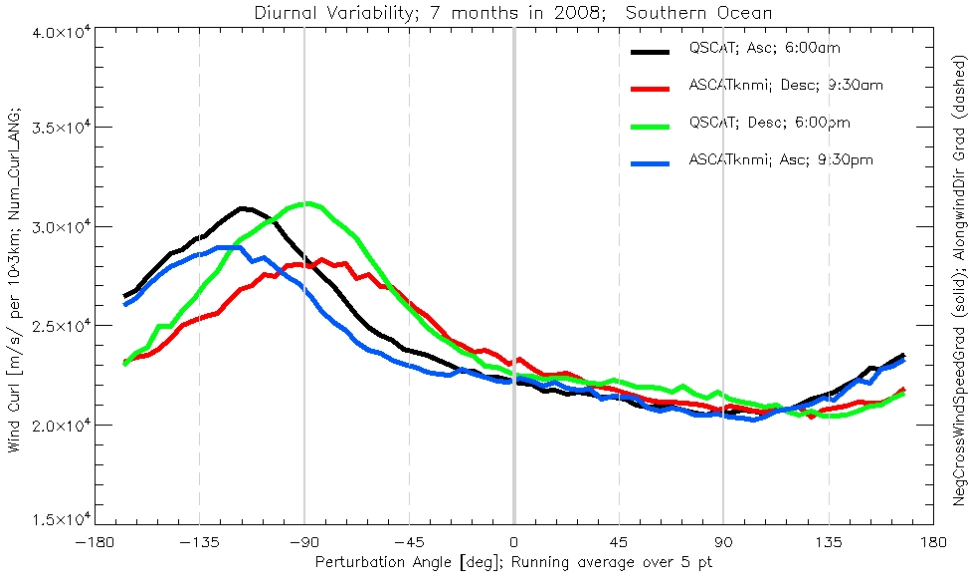


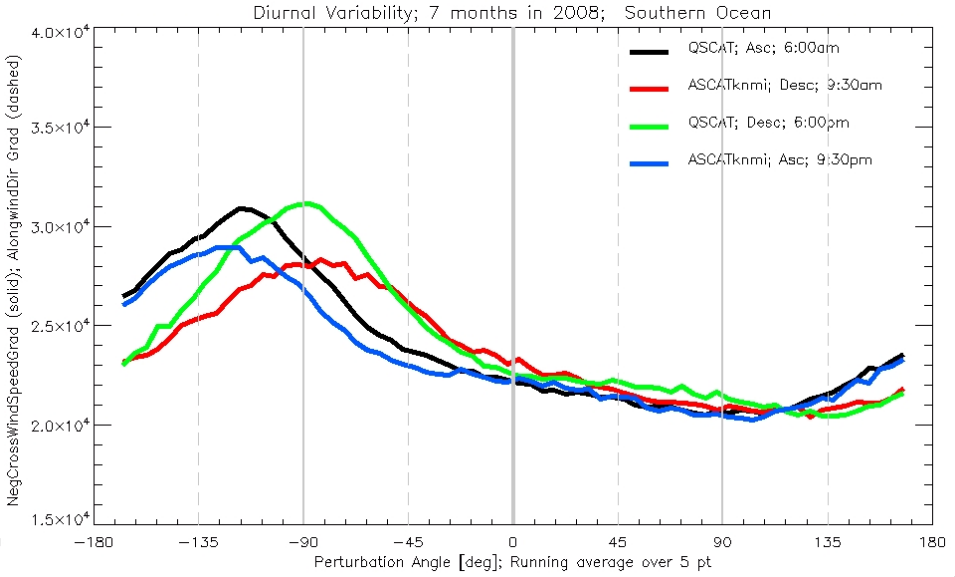



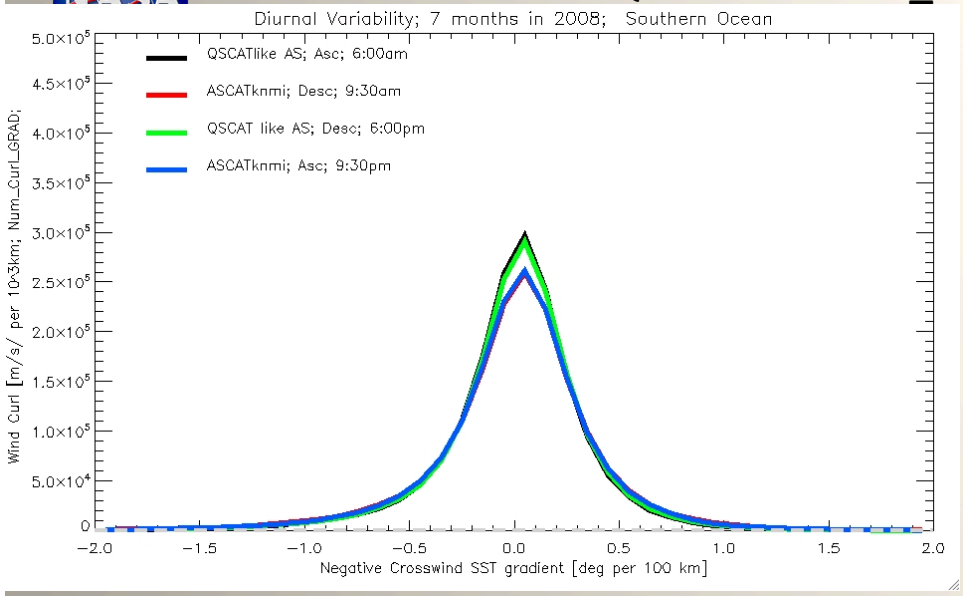
- **QSCAT and ASCAT; KNMI; - CURL**

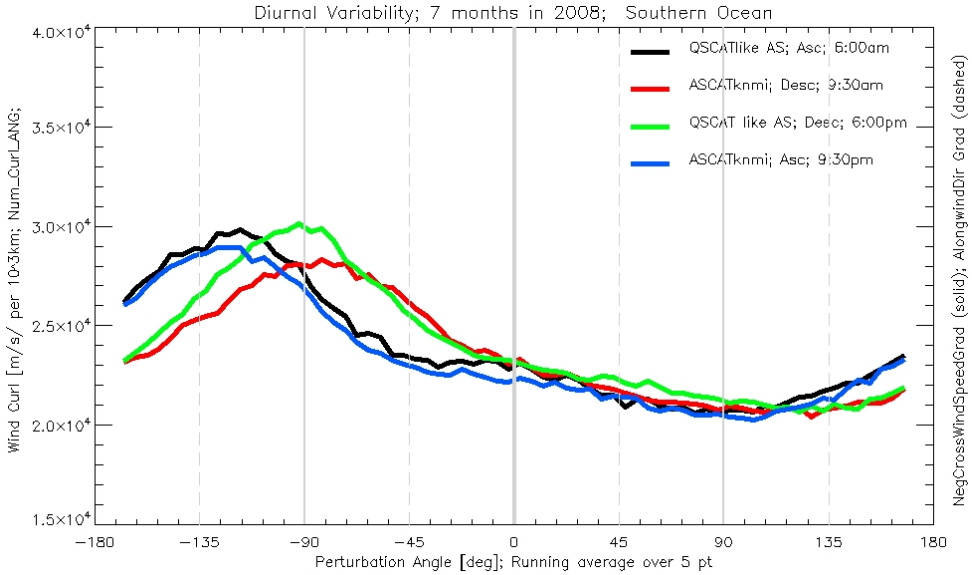


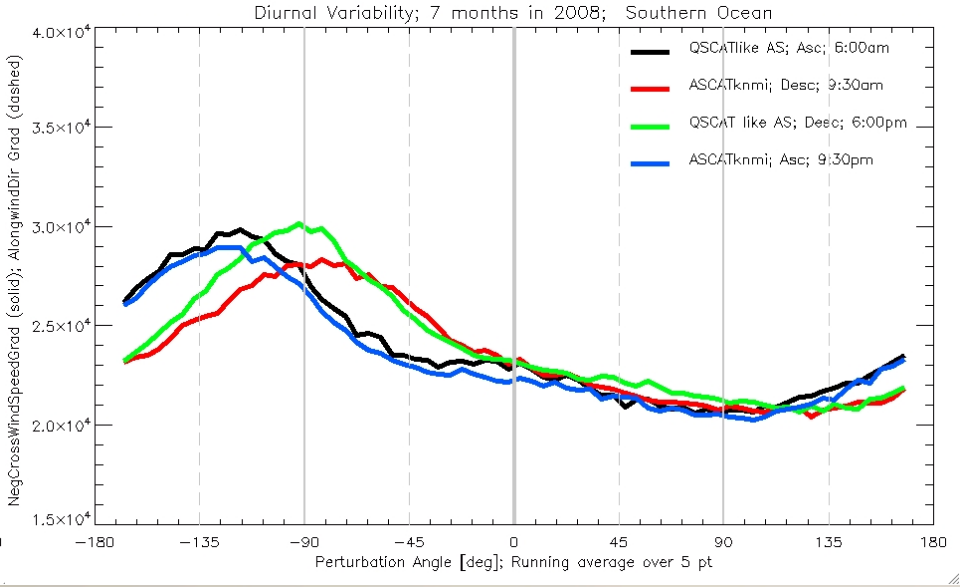



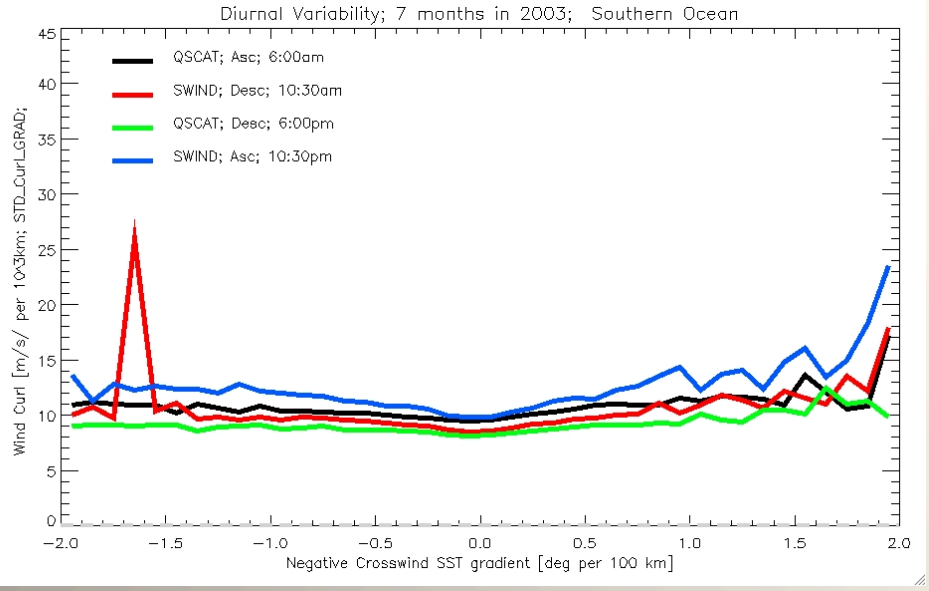
- **QSCATasASCAT_ASCAT; KNMI; - CURL**

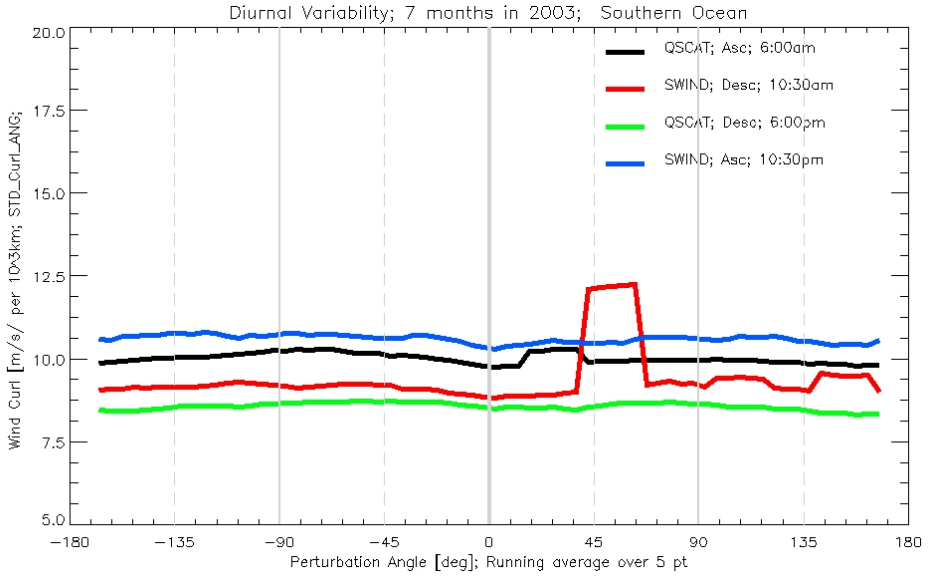


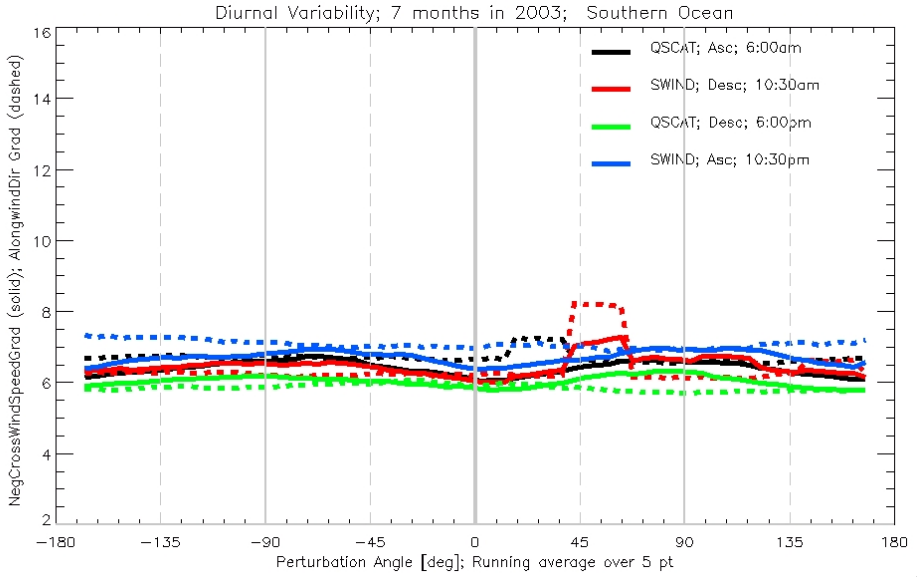



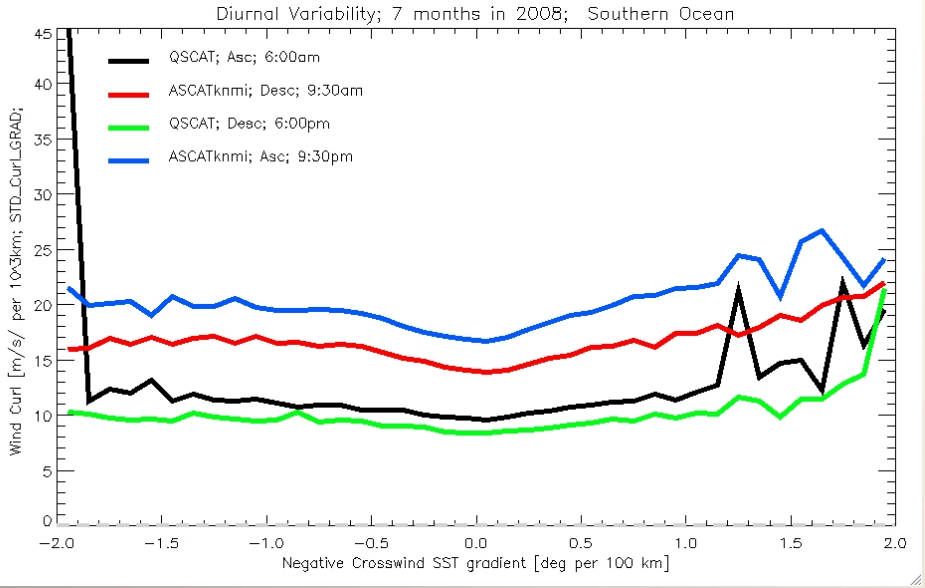
- **QSCAT and SWIND; - CURL**

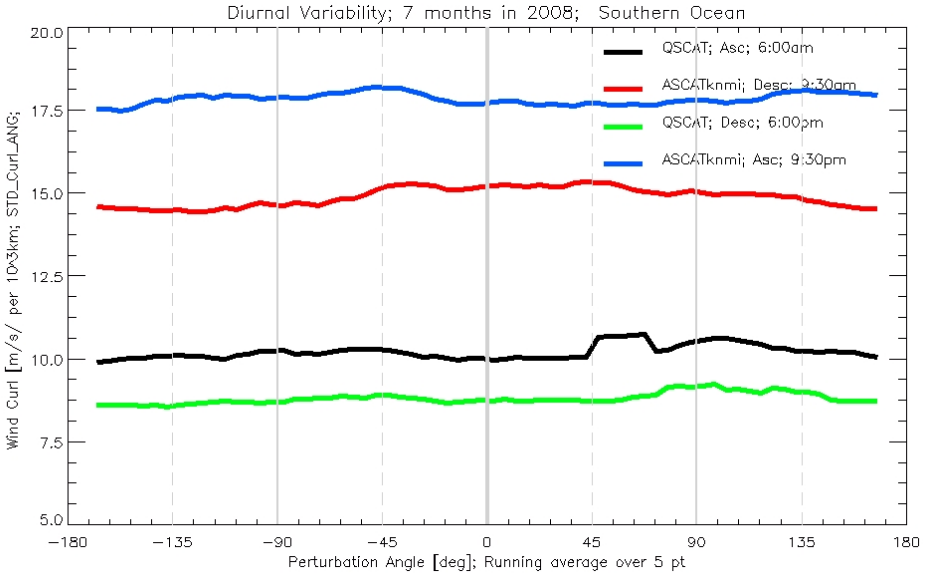


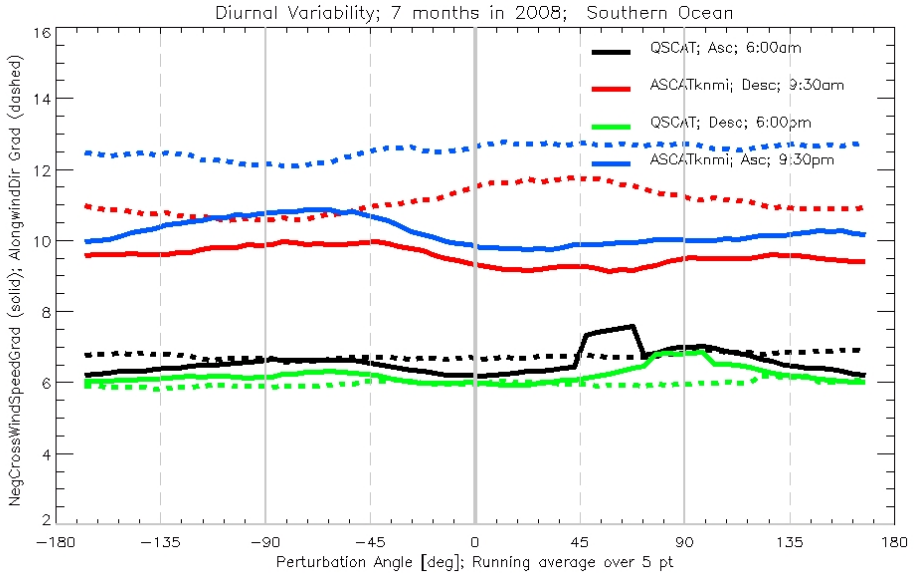



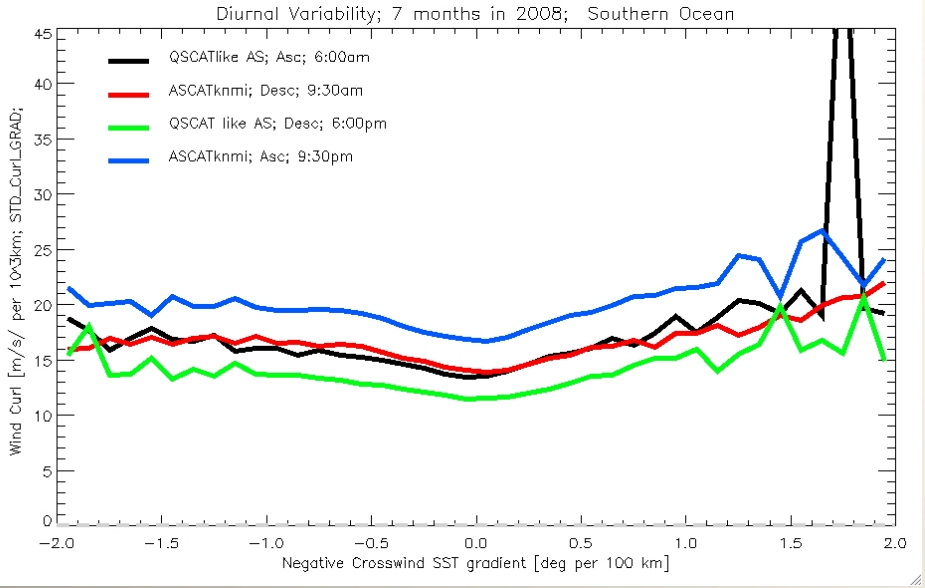
- **QSCAT and ASCAT; KNMI; - CURL**

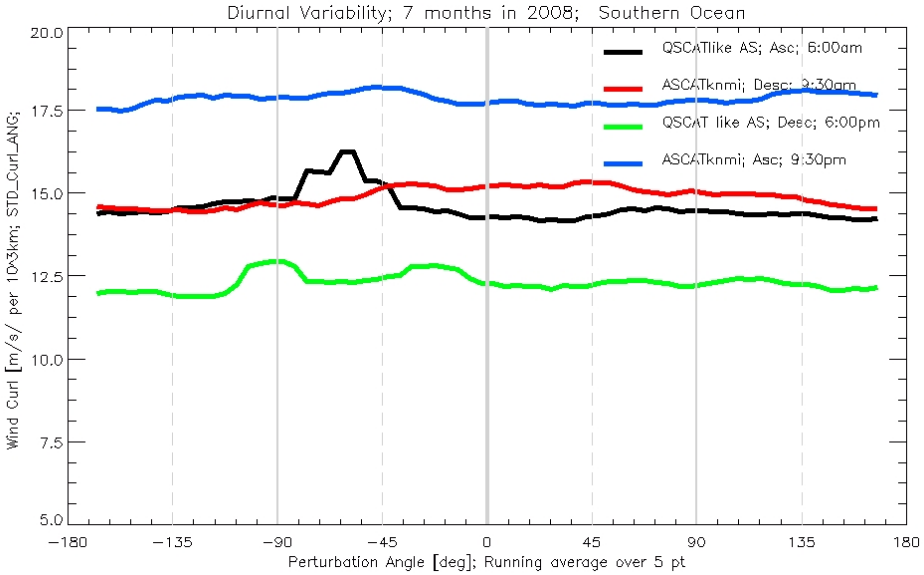


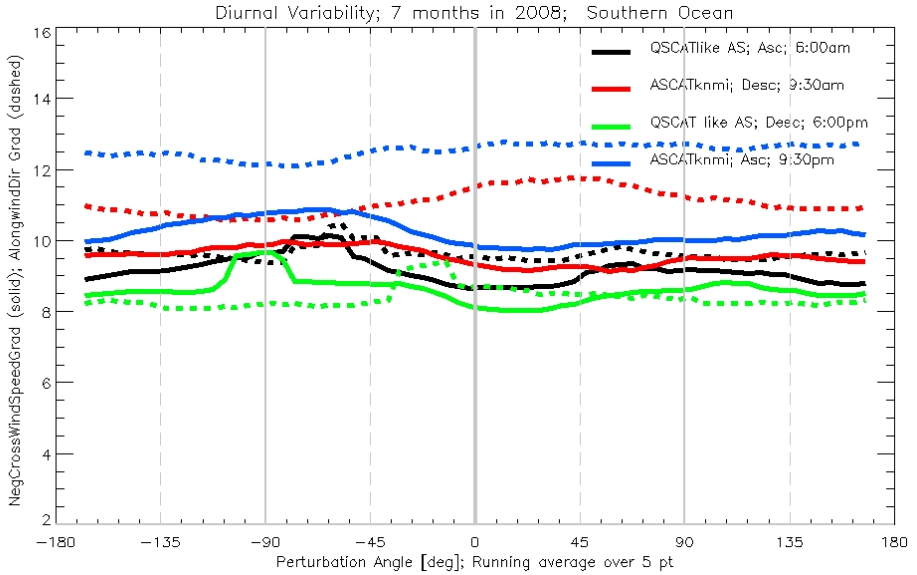



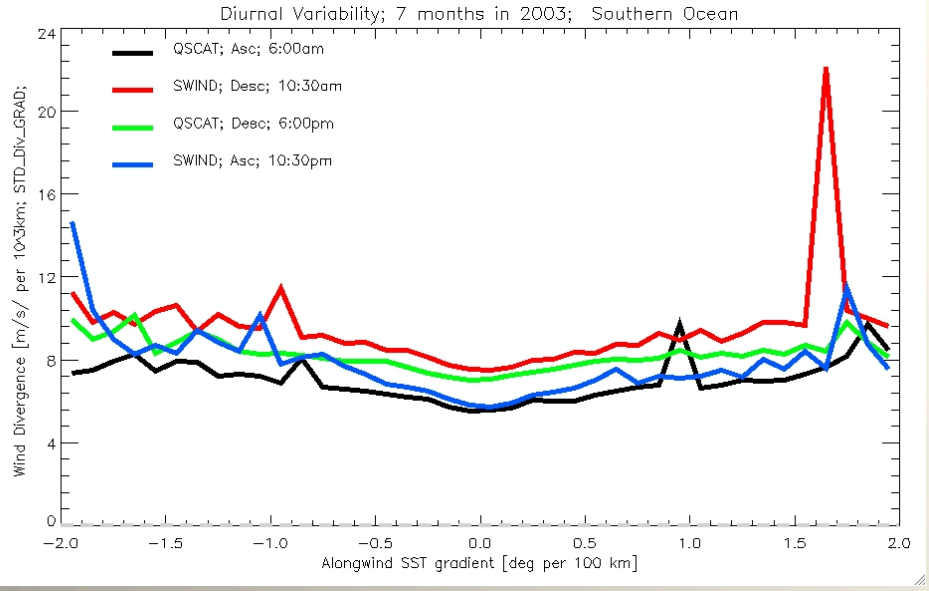
- **QSCATasASCAT_ASCAT; KNMI; - CURL**

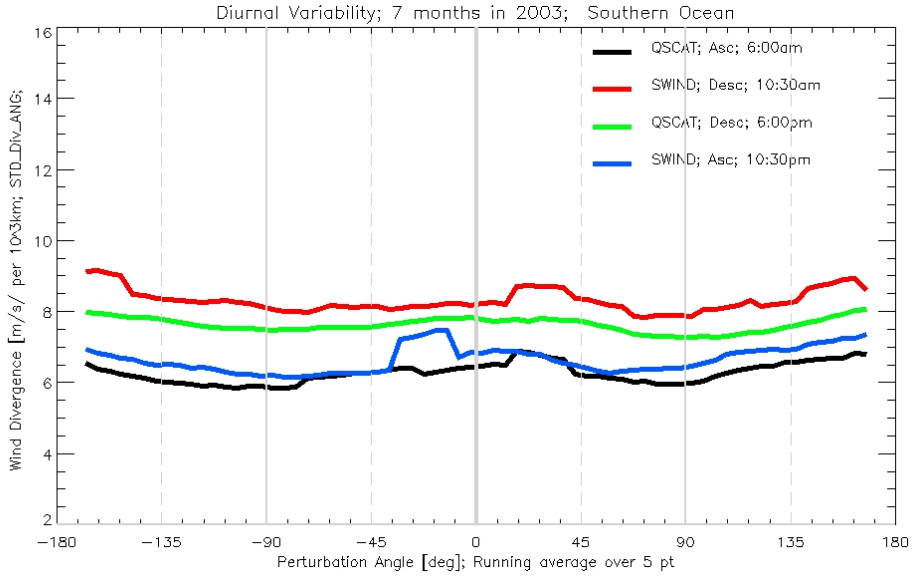


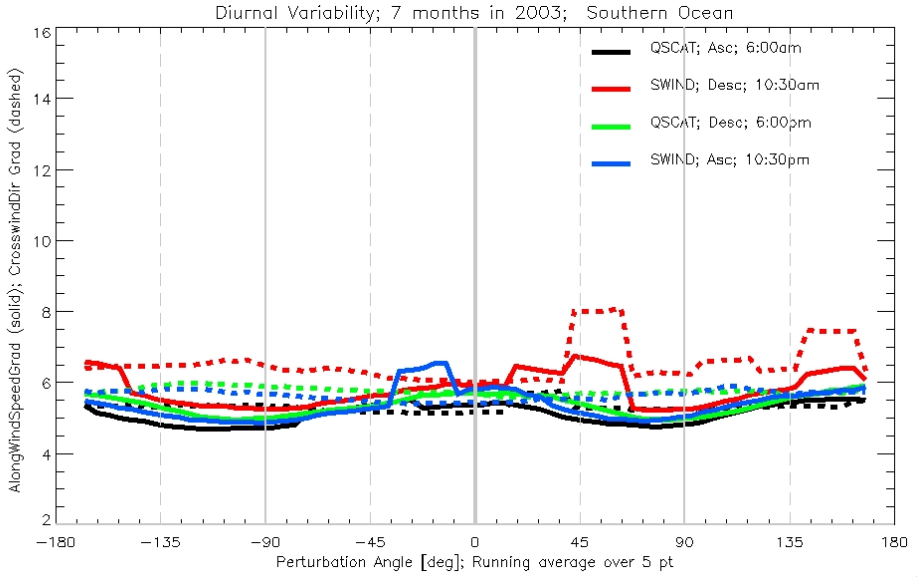



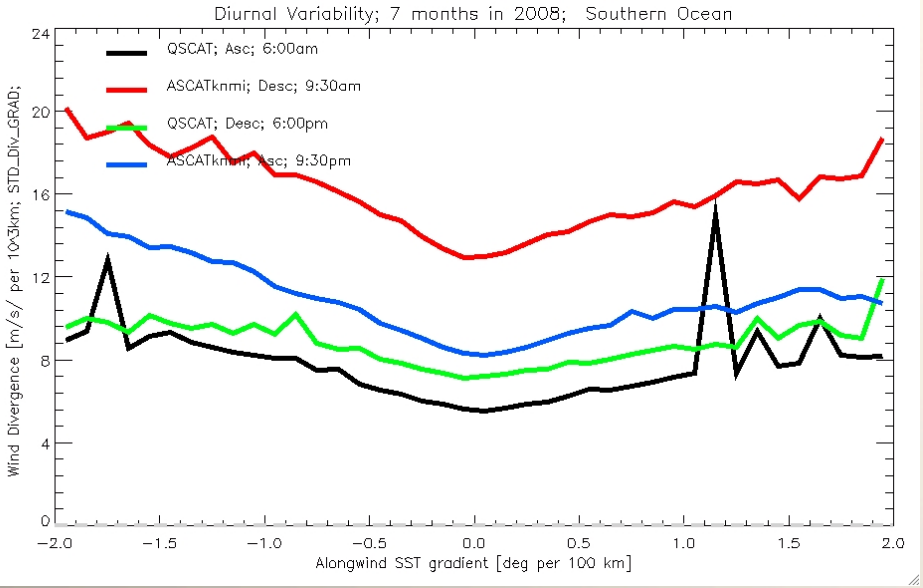
- **QSCAT and SWIND; - DIV**

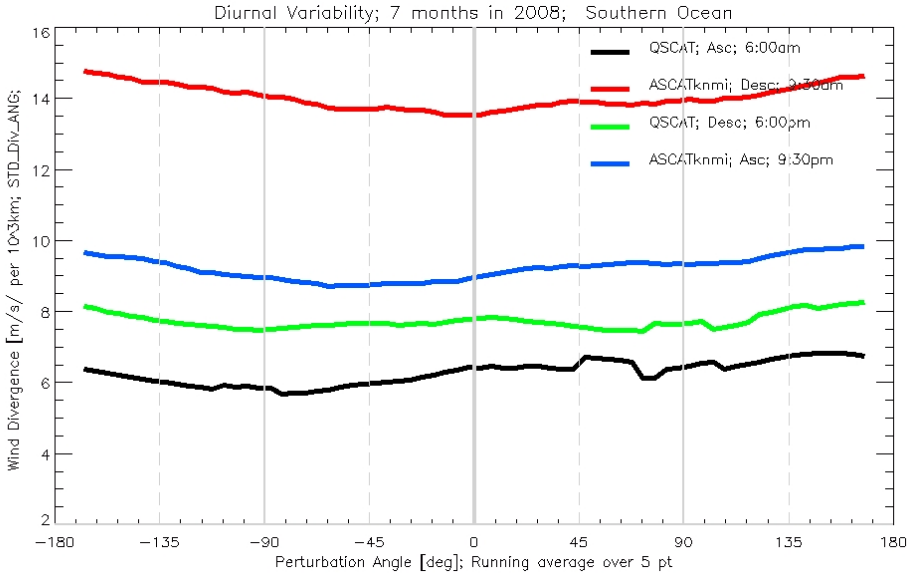


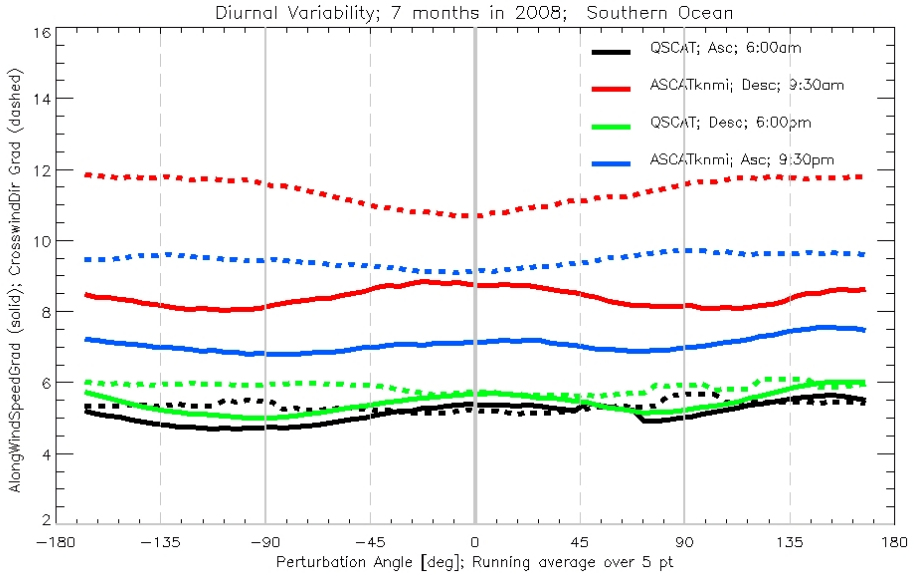



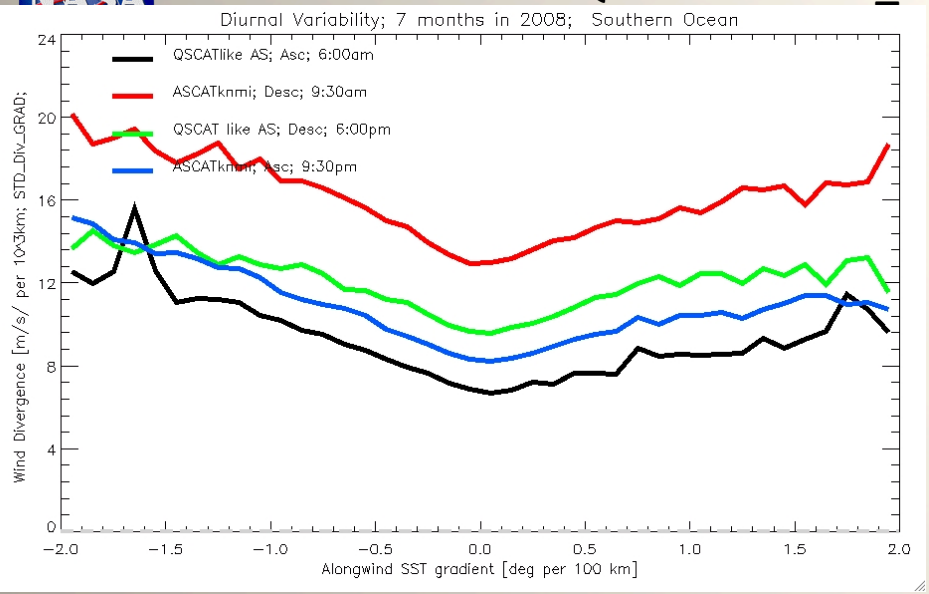
- **QSCAT and ASCAT; KNMI; - DIV**

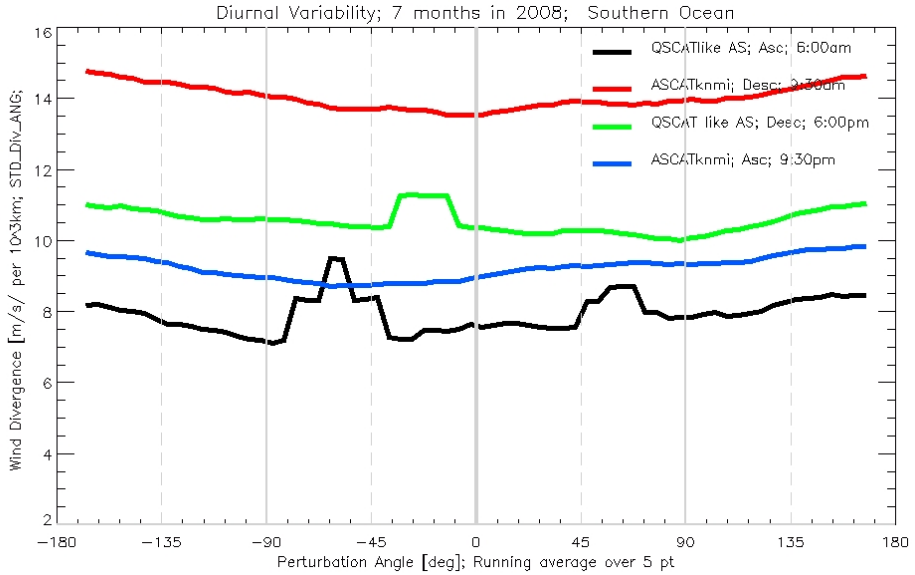


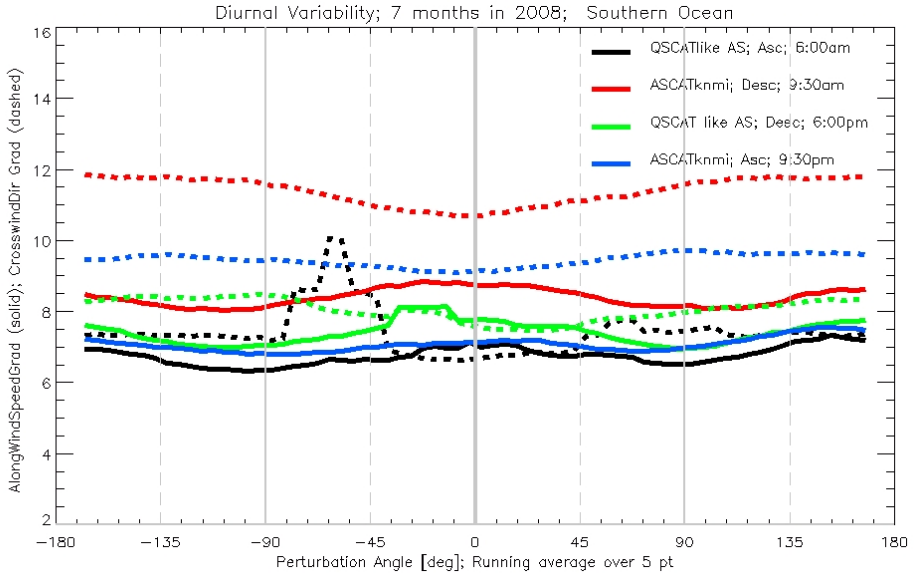



- **QSCATasASCAT_ASCAT; KNMI; - DIV**

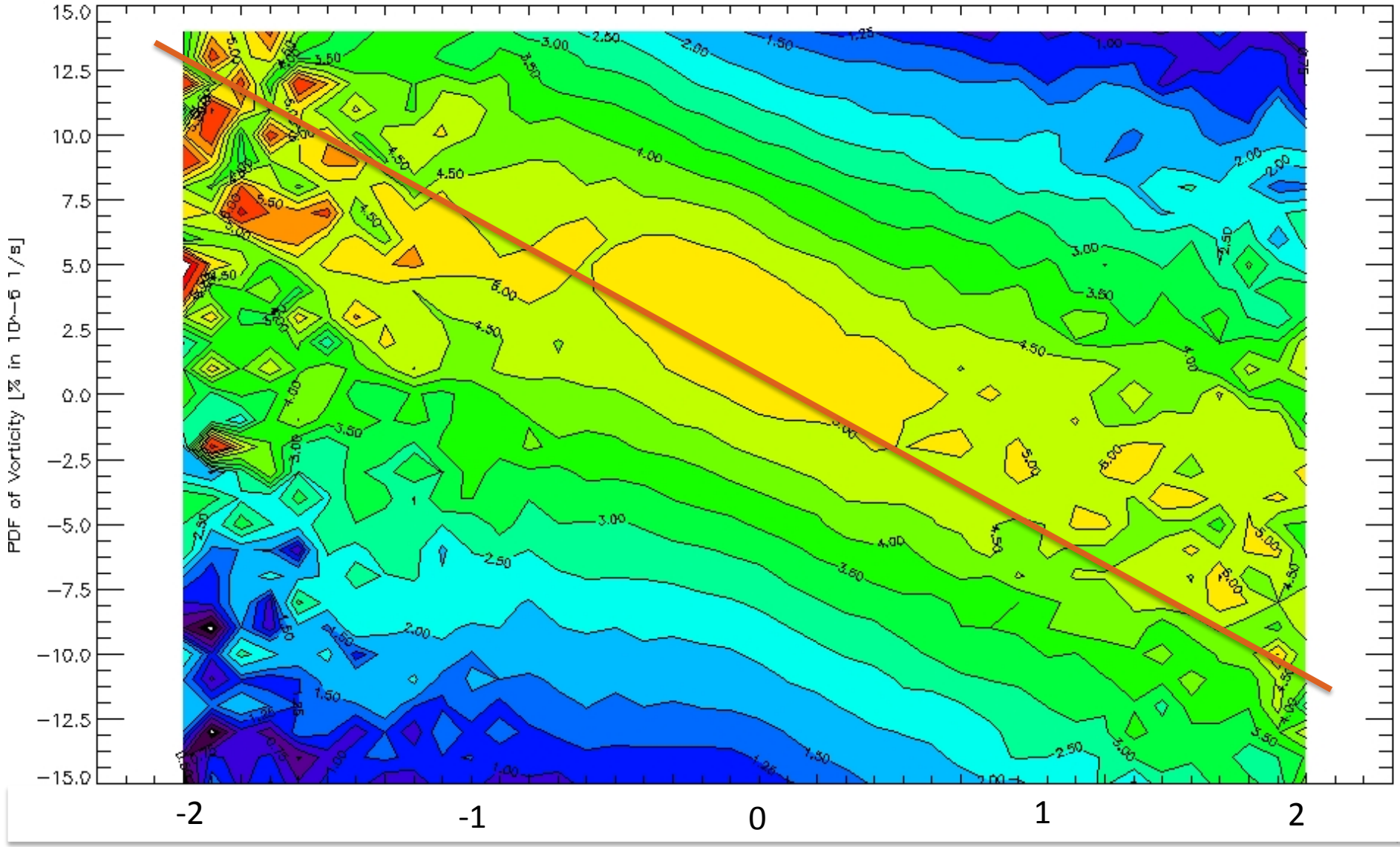


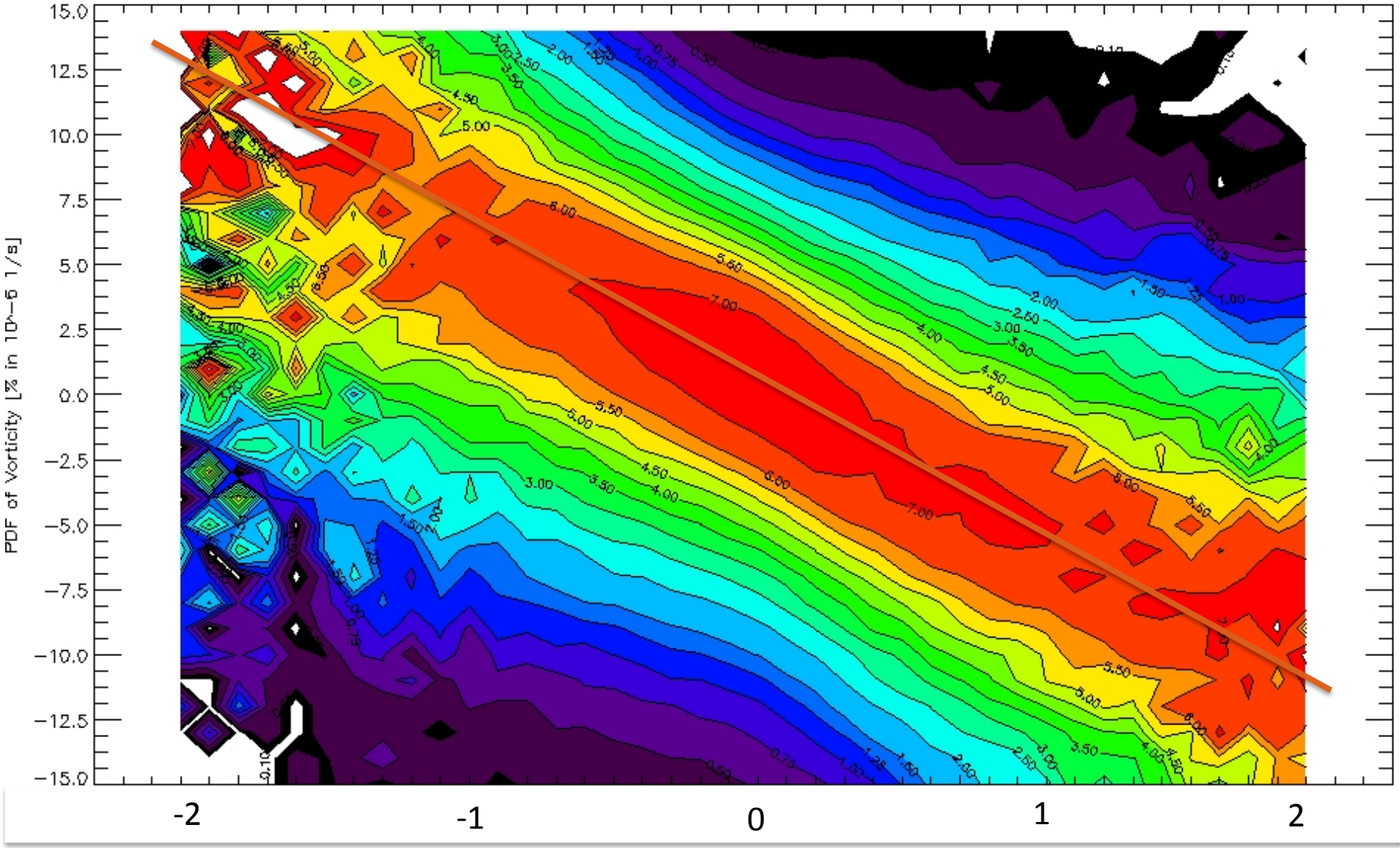
# ASCAT

PDF of the vorticity perturbation as a function of the crosswind SST gradients



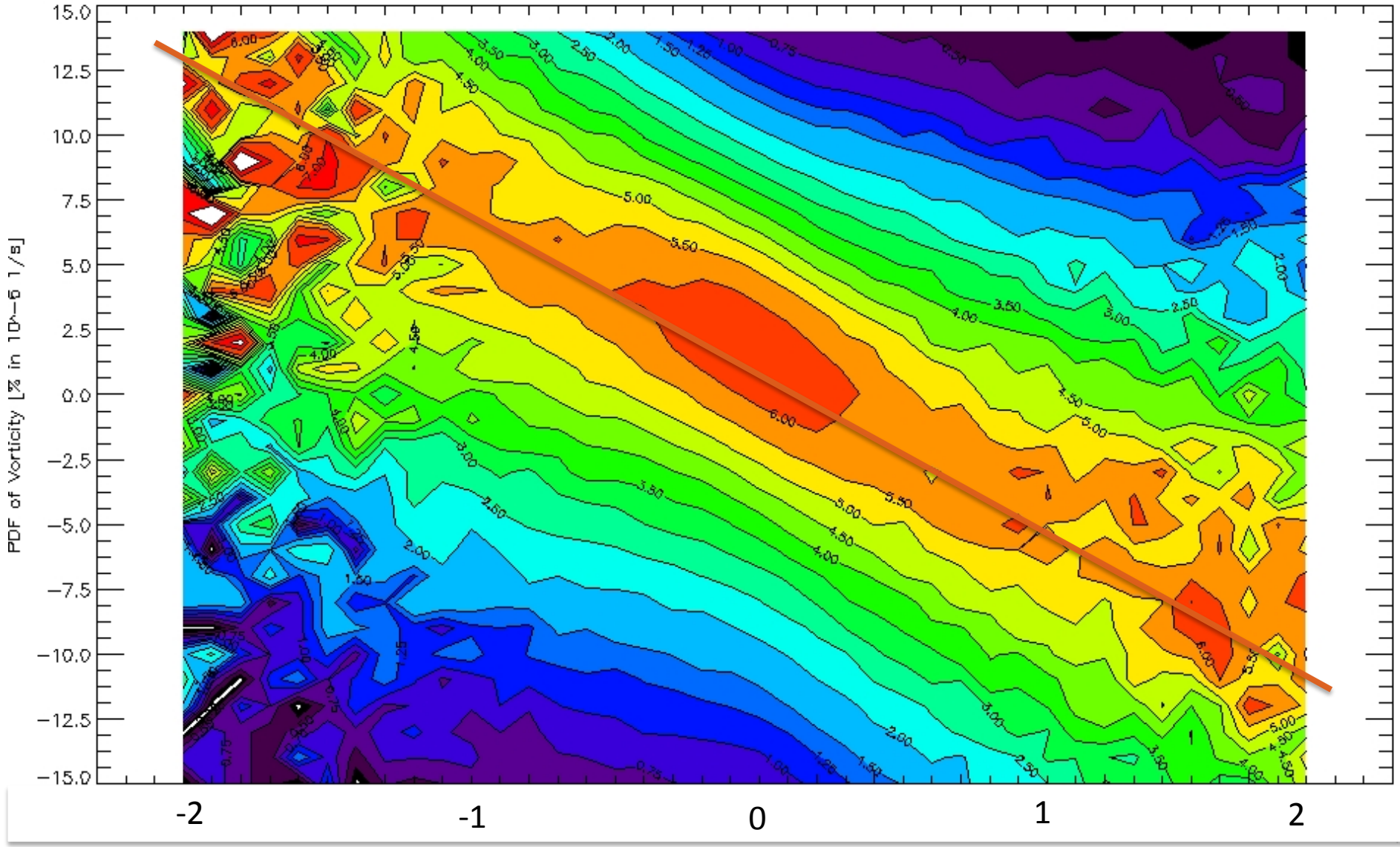
# QuikSCAT; 25 km resolution

PDF of the vorticity perturbation as a function of the crosswind SST gradients



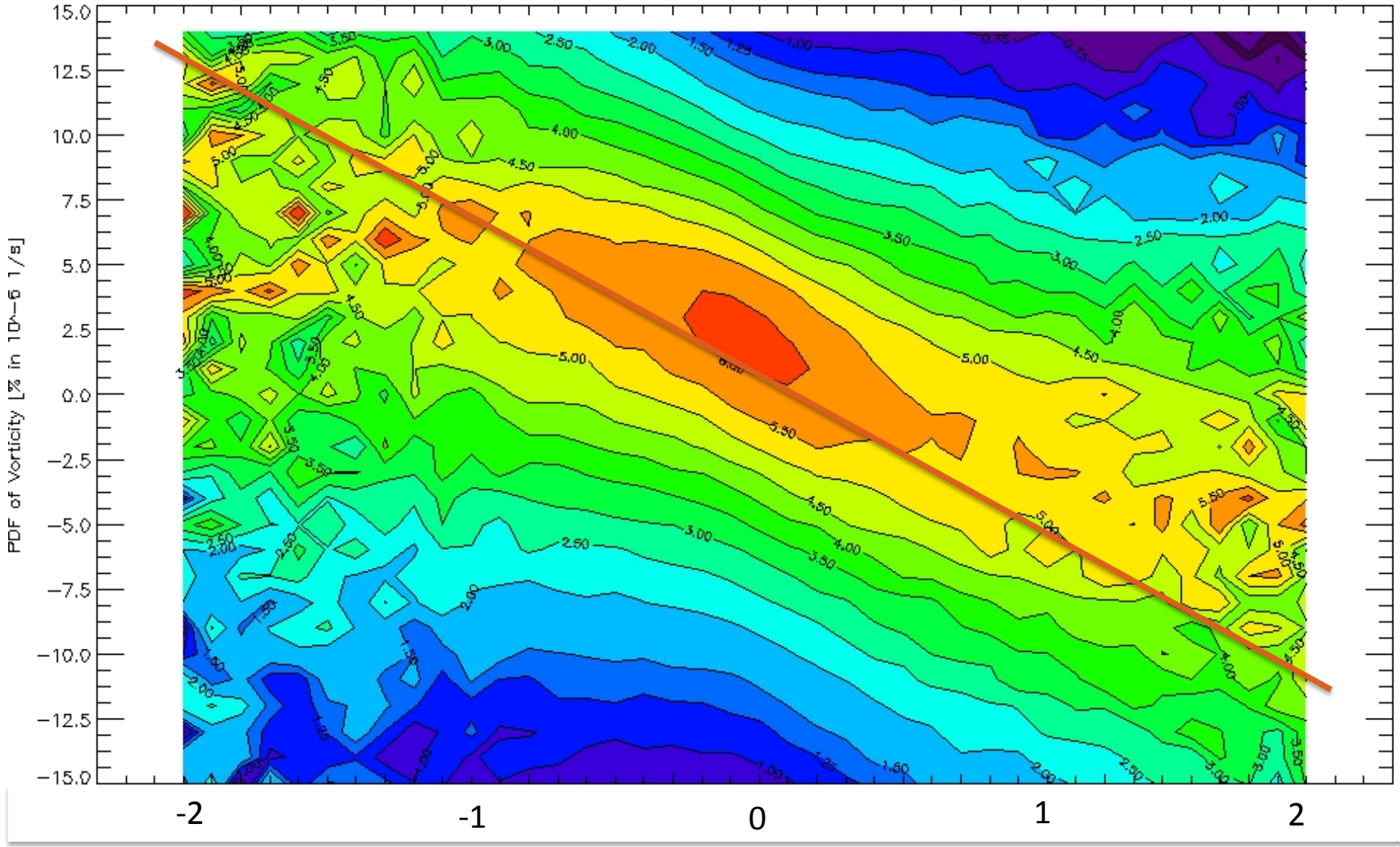
# QuikSCAT; 50km; ASCAT sampling

PDF of the vorticity perturbation as a function of the crosswind SST gradients



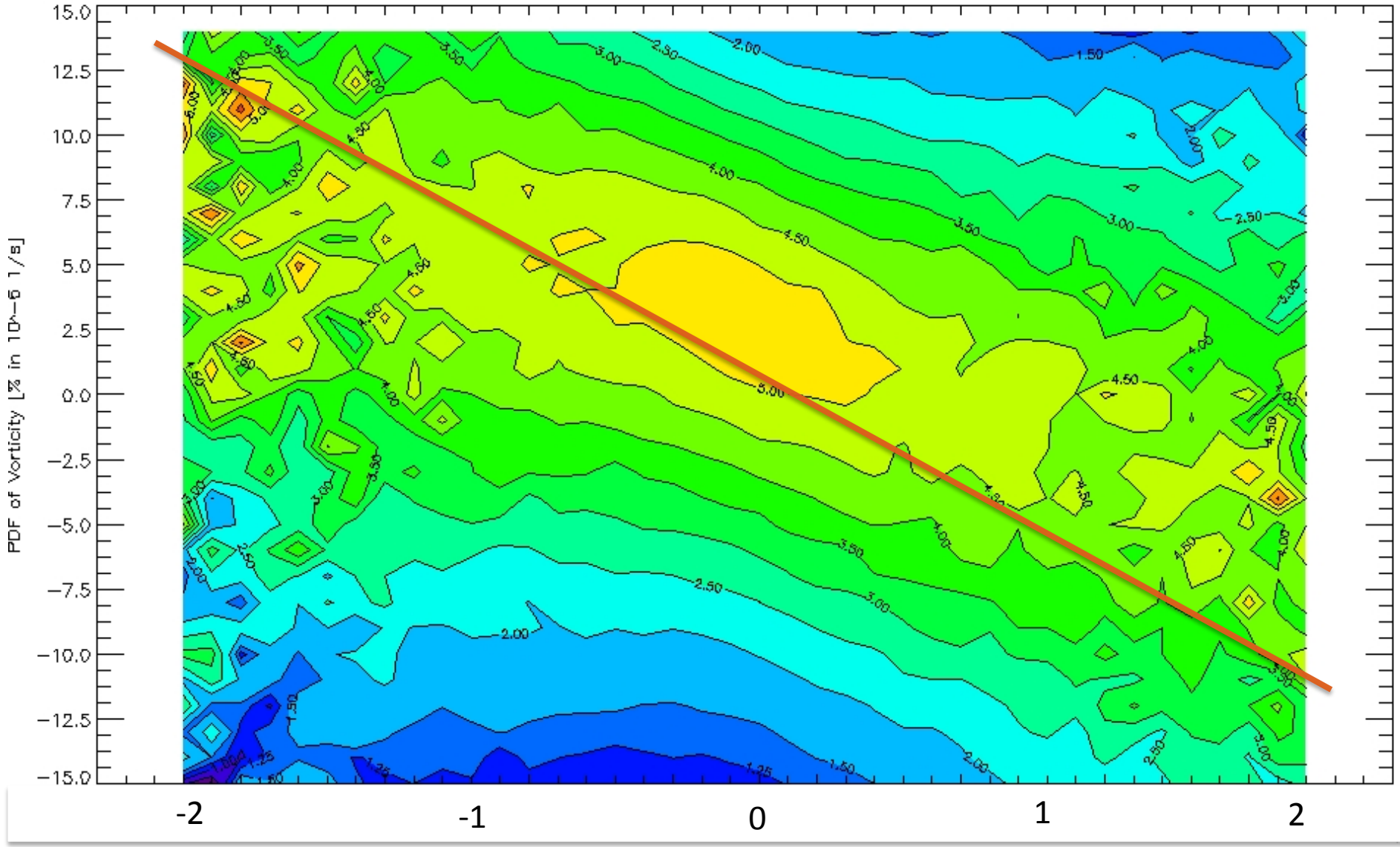
# QuikSCAT; 50km; ASCAT sampling; speed 5-15 m/s

PDF of the vorticity perturbation as a function of the crosswind SST gradients



# ASCAT; speed 5-15 m/s

PDF of the vorticity perturbation as a function of the crosswind SST gradients



# ASCAT

PDF of the vorticity perturbation as a function of the crosswind SST gradients