Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment

CENTRO DE GEOFÍSICA DA UNIVERSIDADE DE LISBOA
Instituto D. Luiz

Using structure functions to compare ASCAT and QuikSCAT winds

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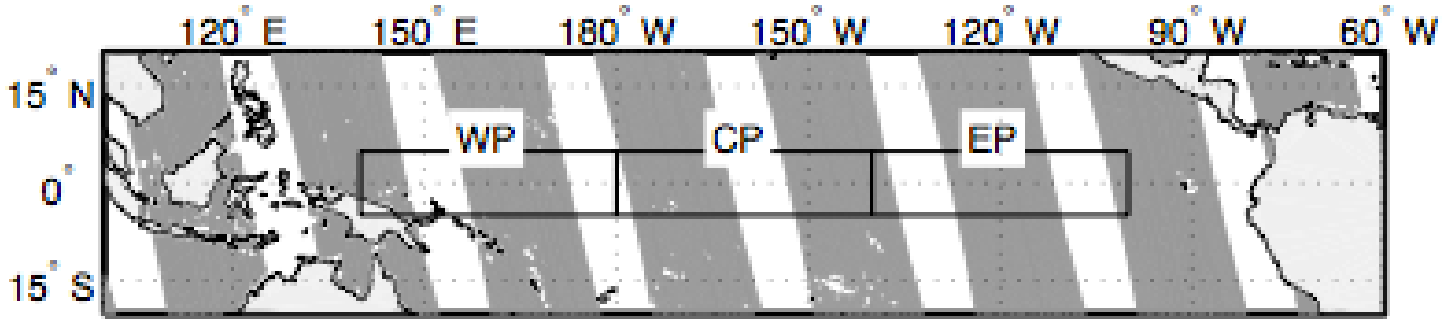
- Objectives / Motivation

Is mesoscale turbulence more like 2D or 3D turbulence?
Do ASCAT and QSCAT yield the same answer?

- Data (Nov 2008 - Oct 2009)
  - A-25, A-12.5
  - Q-25 (V2-2006), Q-12.5 (V3)
- Methods…
  - Structure functions…

    correlation functions of velocity differences (Kolmogorov 1941)
  - Samples… Along-Track
  - Discard rain-flagged data
  - Ensembles averaged over a lat-lon box, over a month, and asc + dsc
- Results...
  - Second-order Structure Functions
    - Longitudinal (meridonal) and Transverse (Zonal)
    - Shapes
    - Ratios (transverse-to-longitudinal)
    - Slopes (50 - 250 km)
  - Third-order Structure Functions (12.5 km winds)
- Summary



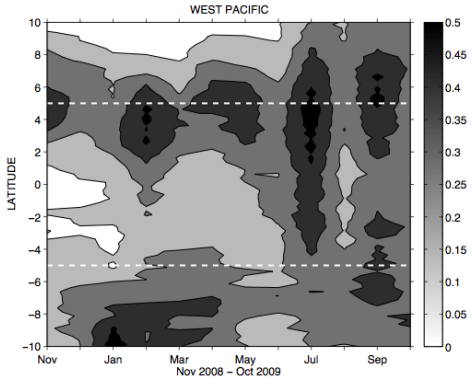
Characterize local environment…

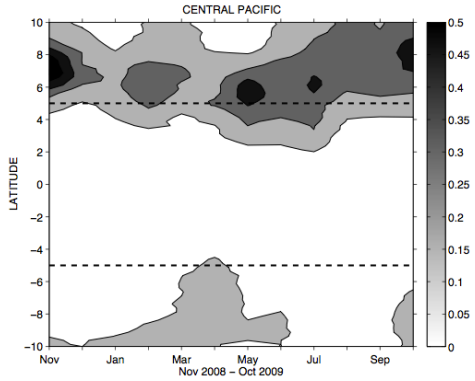
Rain Rate: Nov 2008 - Oct 2009

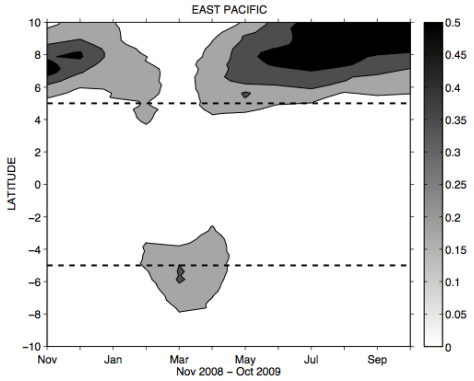
TMI

5

-5



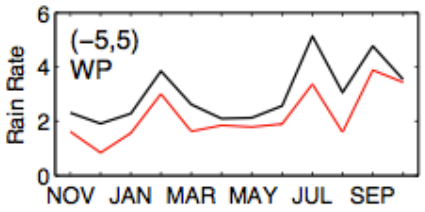


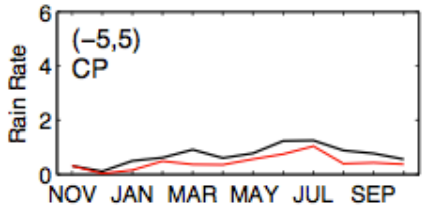


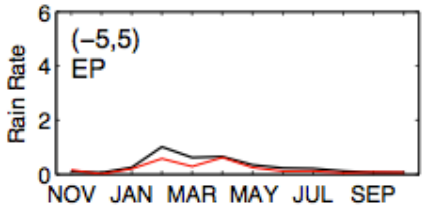
(-5,5) =>

QSCAT asc

SRAD dsc







Structure Functions

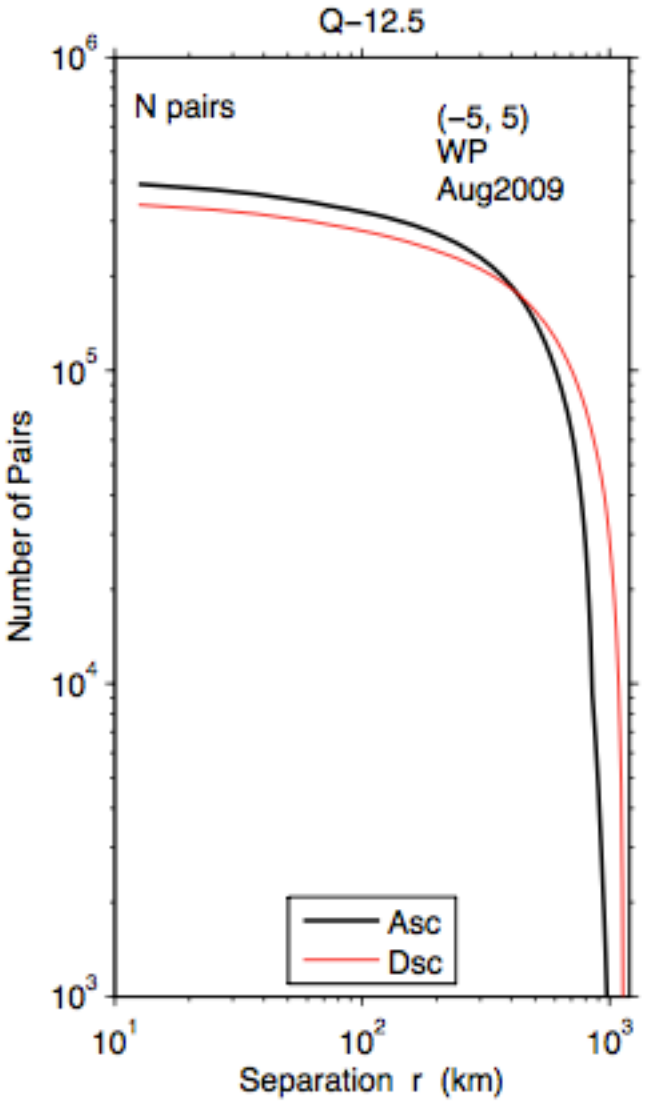
In Fourier duality with energy spectra

Advantages

- Tolerant of missing data
- Sample length requirement not strict
  - Smaller regions
- Implicit detrending and mean removal (but only approximate)

Disadvantages

- Cumulative Energy Variance more difficult to identify



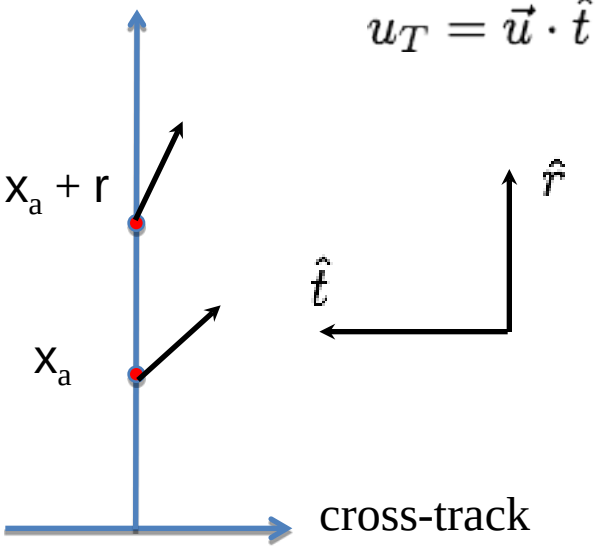
Second-order Structure Functions

Velocity components

along-track

$$u_L = \vec{u} \cdot \hat{r}$$

$$u_T = \vec{u} \cdot \hat{t}$$



Velocity differences

$$\delta u_L(x_a, r) = u_L(x_a + r) - u_L(x_a)$$

$$\delta u_T(x_a, r) = u_T(x_a + r) - u_T(x_a)$$

1D Structure Functions

$$D_{LLa}(r) = \langle \delta u_L \delta u_L \rangle$$

$$D_{TTa}(r) = \langle \delta u_T \delta u_T \rangle$$

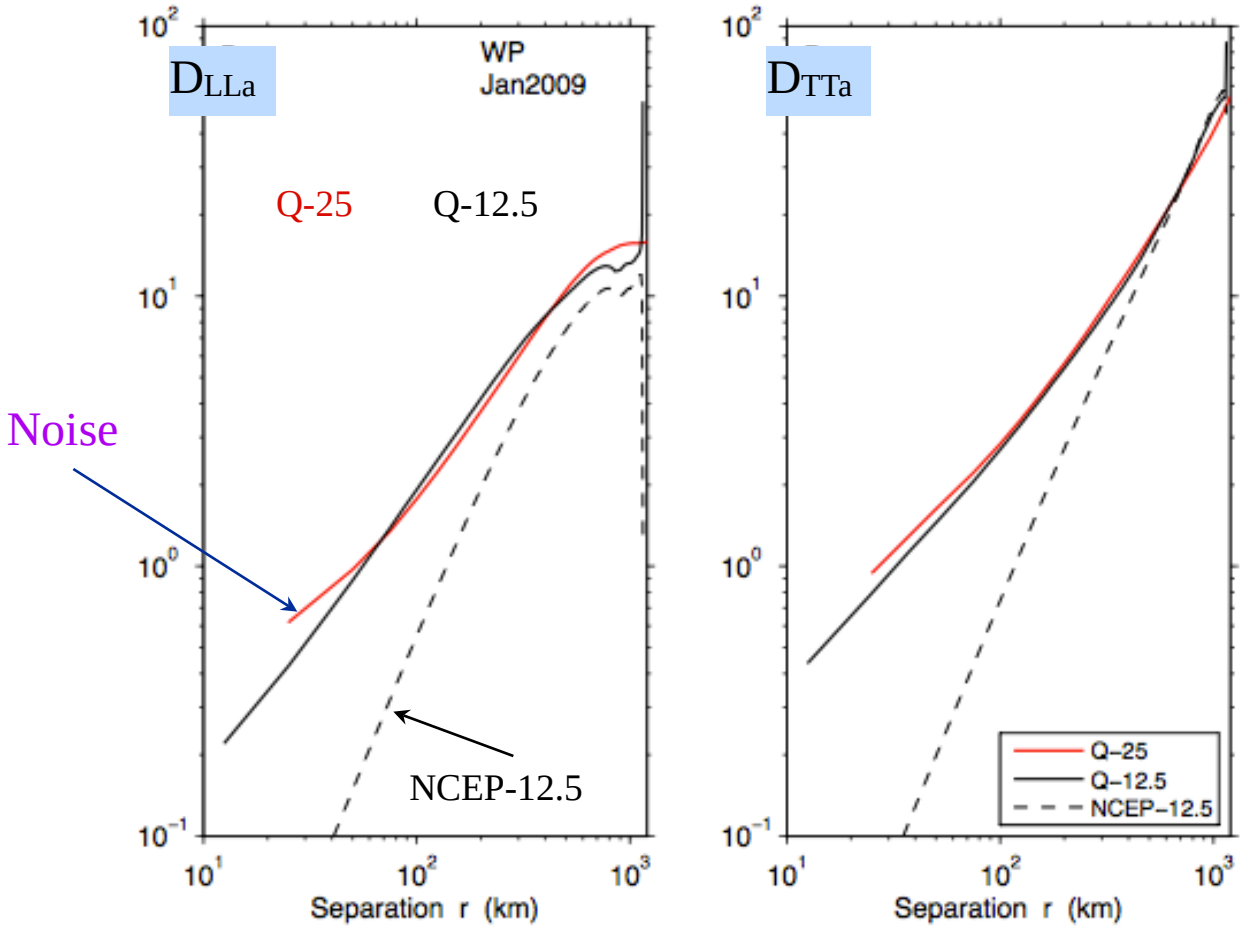
$$E(k) \sim k^{-\alpha} \qquad D_2(r) \sim r^{\beta}$$

where $\alpha = \beta + 1$

$$k^{-5/3} \longrightarrow r^{2/3}$$

$$k^{-2} \longrightarrow r$$

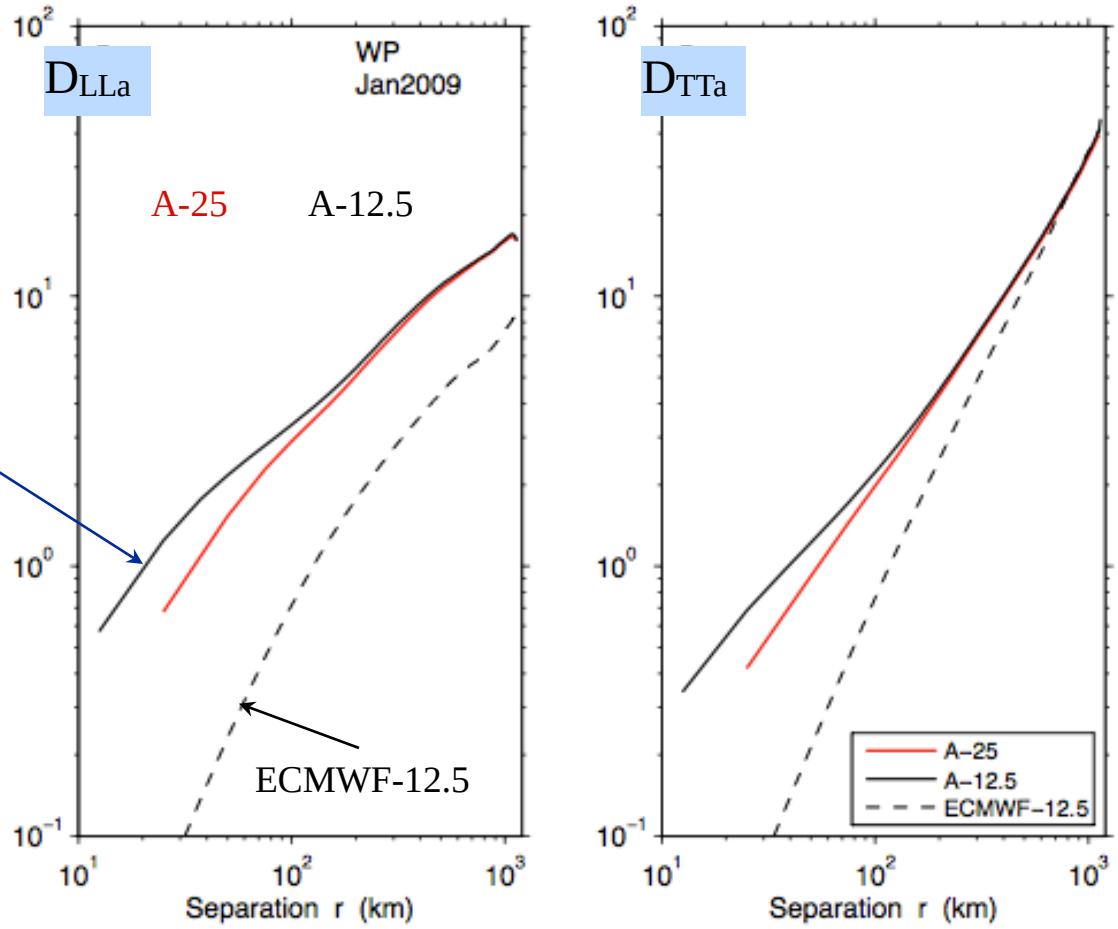
Q-25 and Q-12.5



Separation r (km)

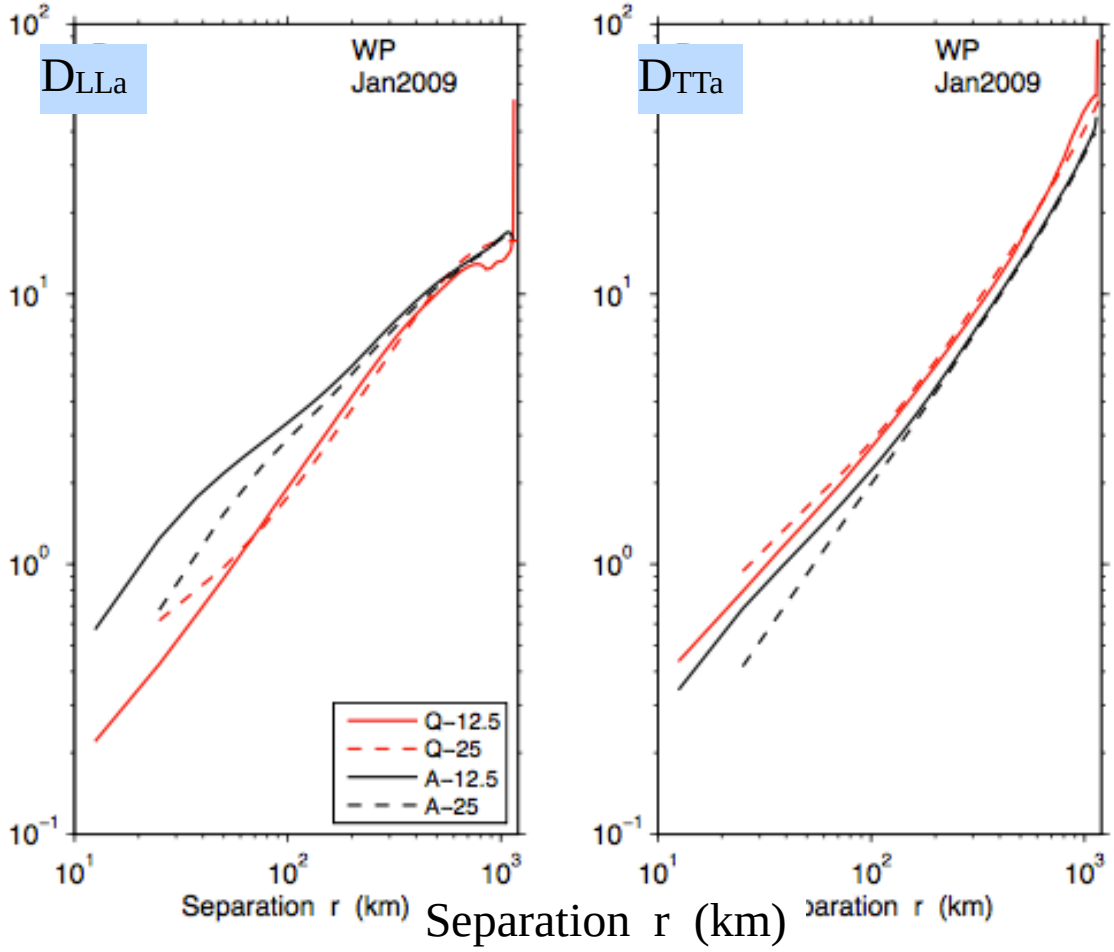
A-25 and A-12.5

Steeper slope
due to Filtering



Separation r (km)

QSCAT and ASCAT



Separation r (km)

Clear differences in
- shape
- slope
- amplitude

Quantify slope and relative amplitudes

$\delta u_L^2 \sim$ ll divergence ll

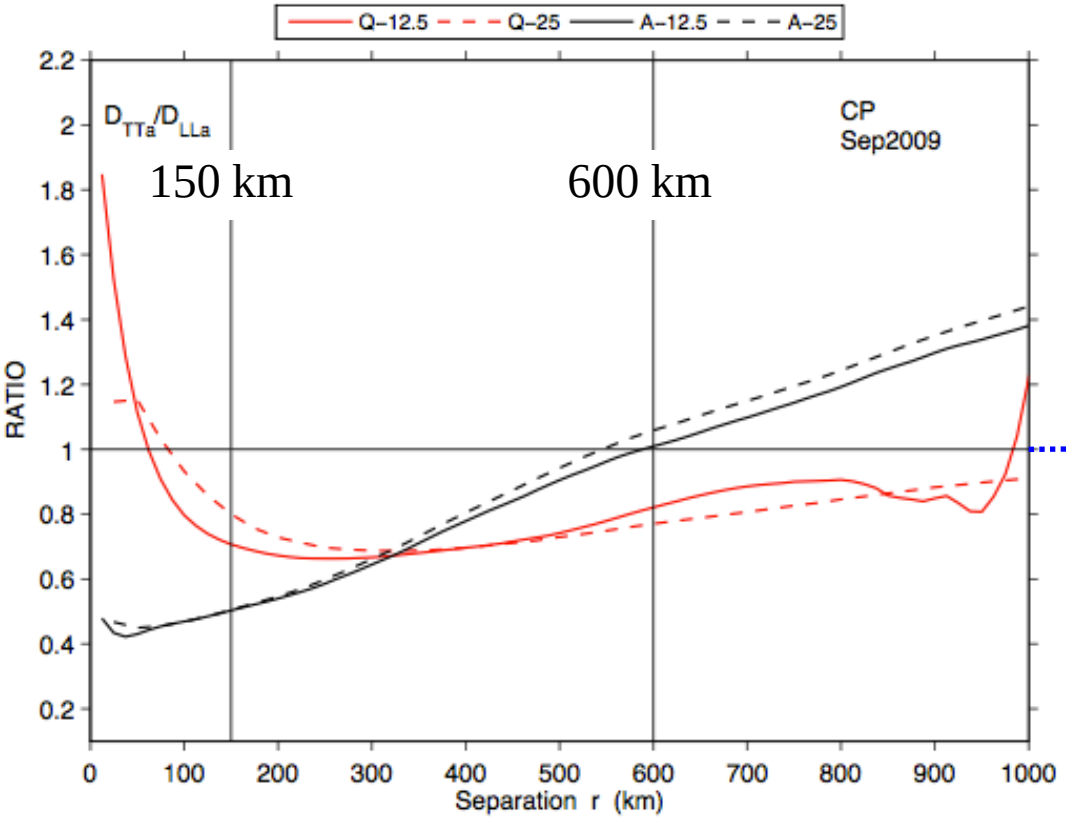
$\delta u_T^2 \sim$ ll vorticity ll

$$\frac{D_{TTa}}{D_{LLa}} > 1 \qquad \text{(vortical modes dominate)}$$

$$\frac{D_{TTa}}{D_{LLa}} < 1 \qquad \text{(gravity modes dominate)}$$

RATIOS

D_{TT}/D_{LL}



Vortical modes dominate

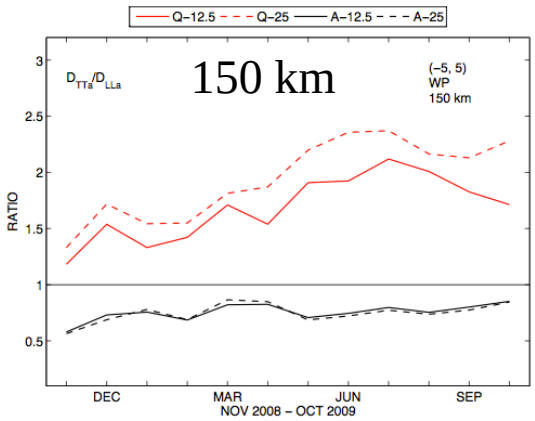
gravity modes dominate

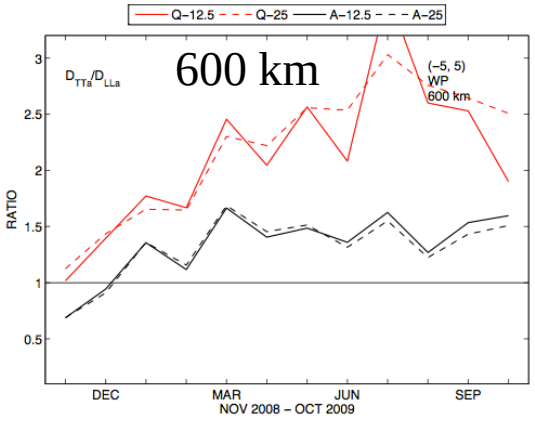
Monitor Ratios at
150 km
600 km

RATIOS

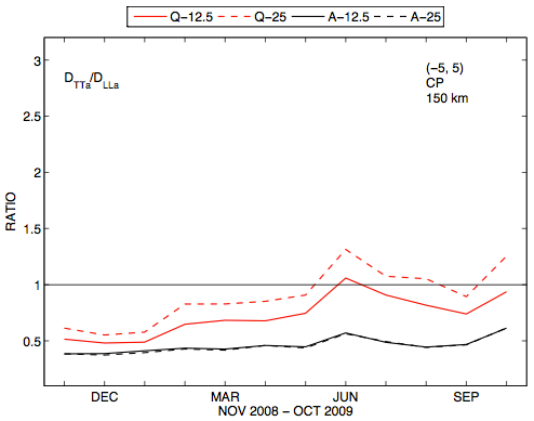
D_{TT}/D_{LL}

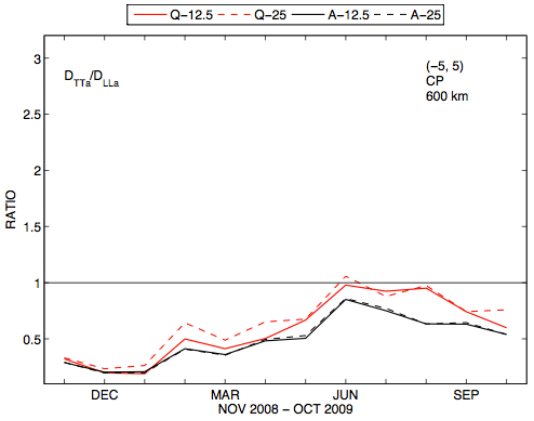
WP



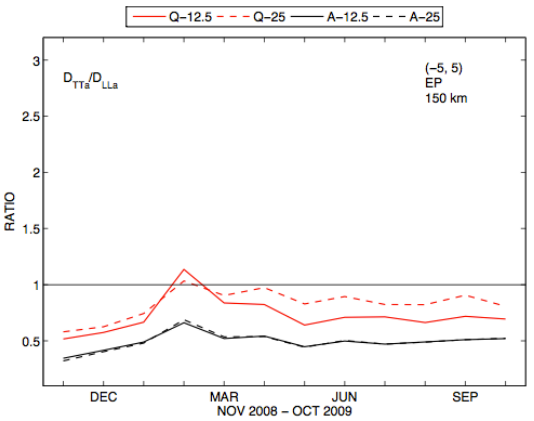


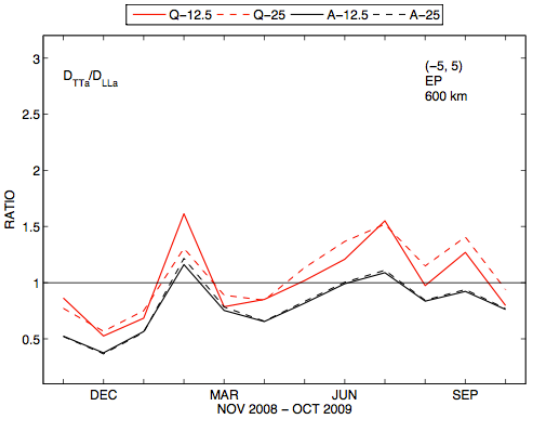
CP





EP



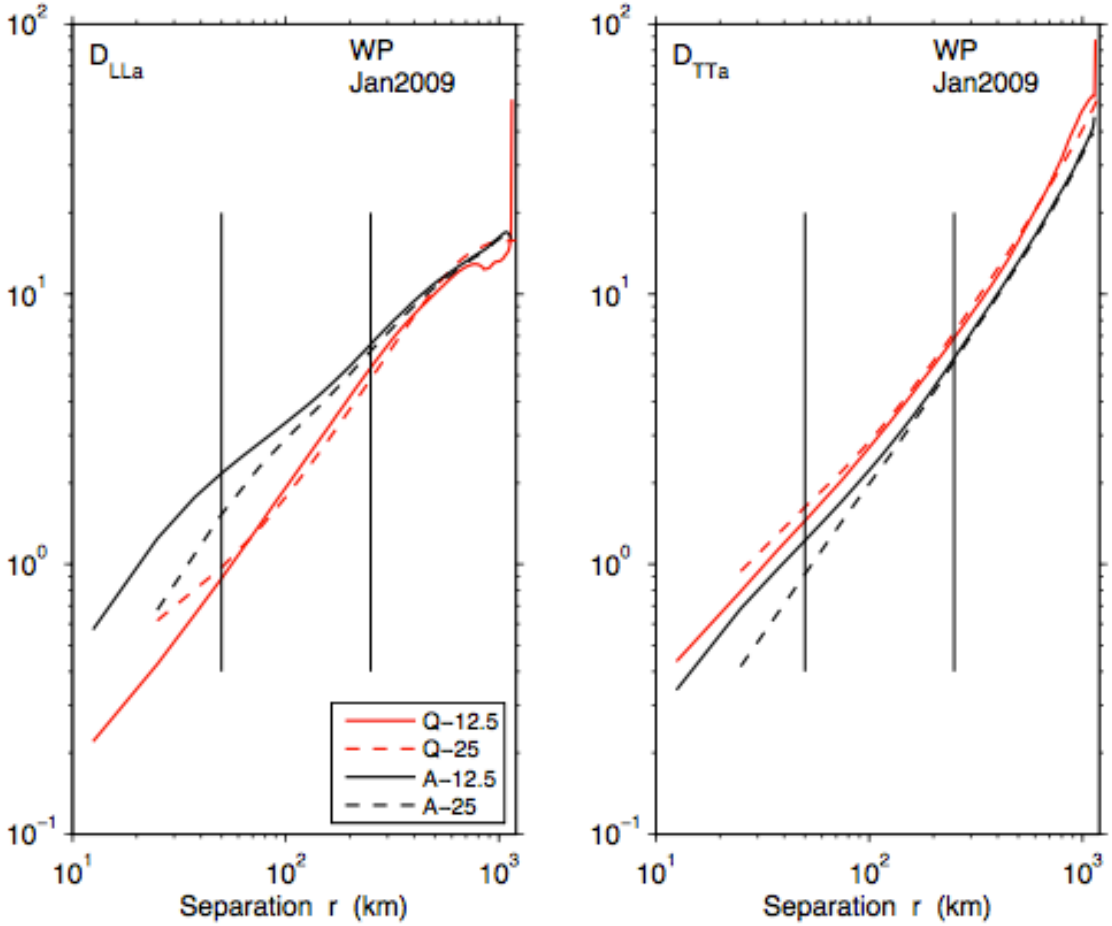


Nov 2008 - Oct 2009

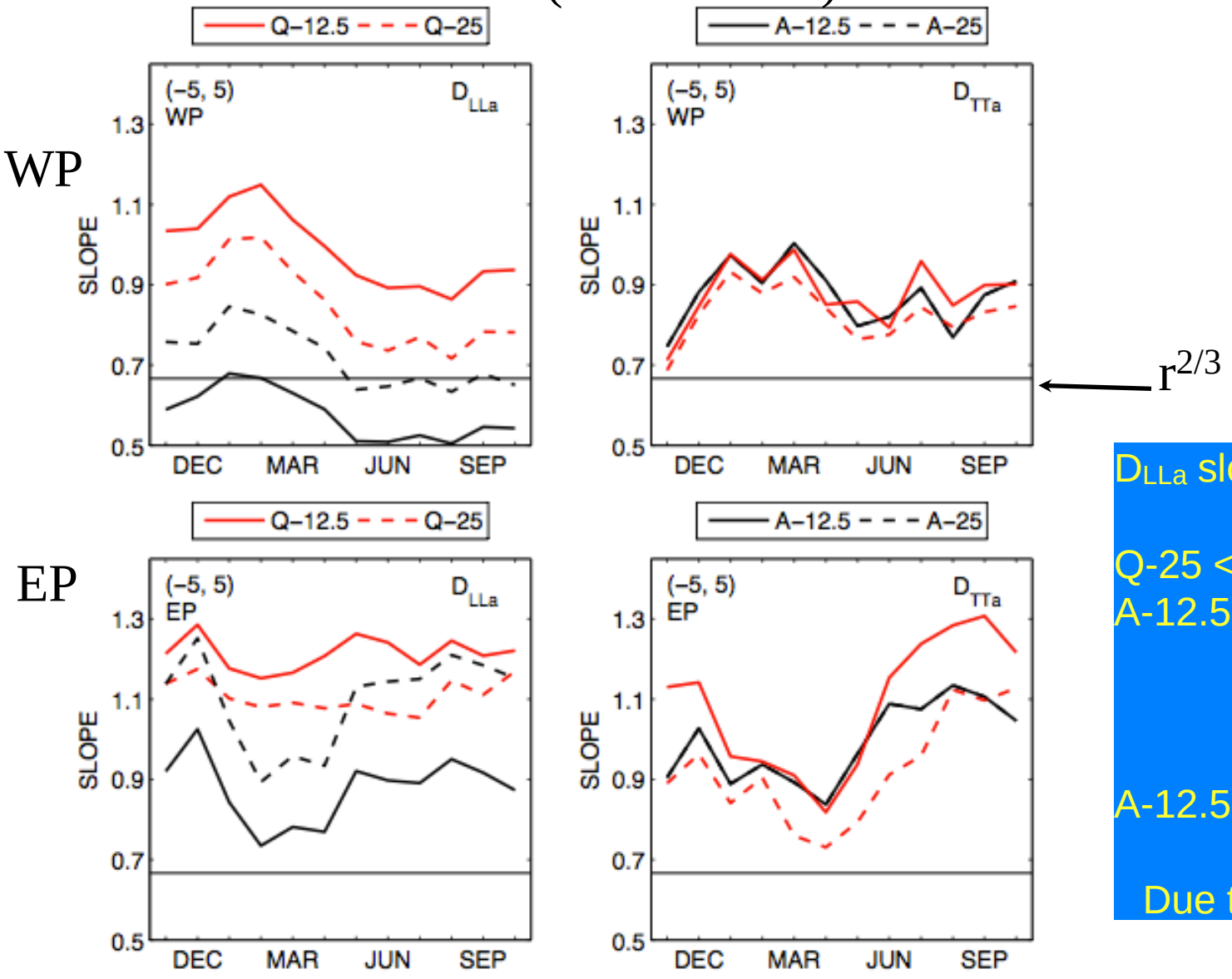
Large differences in WP

Figures suggest that QSCAT produces larger vorticity than ASCAT

SLOPES
(50 - 250 km)



Slopes
(50 - 250 km)



$r^{2/3}$

D_{LLa} slopes…

Q-25 < Q-12.5
A-12.5 < A-25

and

A-12.5 < Q-12.5

Due to noise ??

Third-order Structure Functions
(Kolmogorov 1941)

$$D_{LLLa}(r) = \langle \delta u_L \delta u_L \delta u_L \rangle$$
$$D_{LTTa}(r) = \langle \delta u_L \delta u_T \delta u_T \rangle$$

$$D_{3a} = \langle \delta u_L (\delta u_L \delta u_L + \delta u_T \delta u_T) \rangle$$

$D_3 < 0$ => Downscale energy transfer

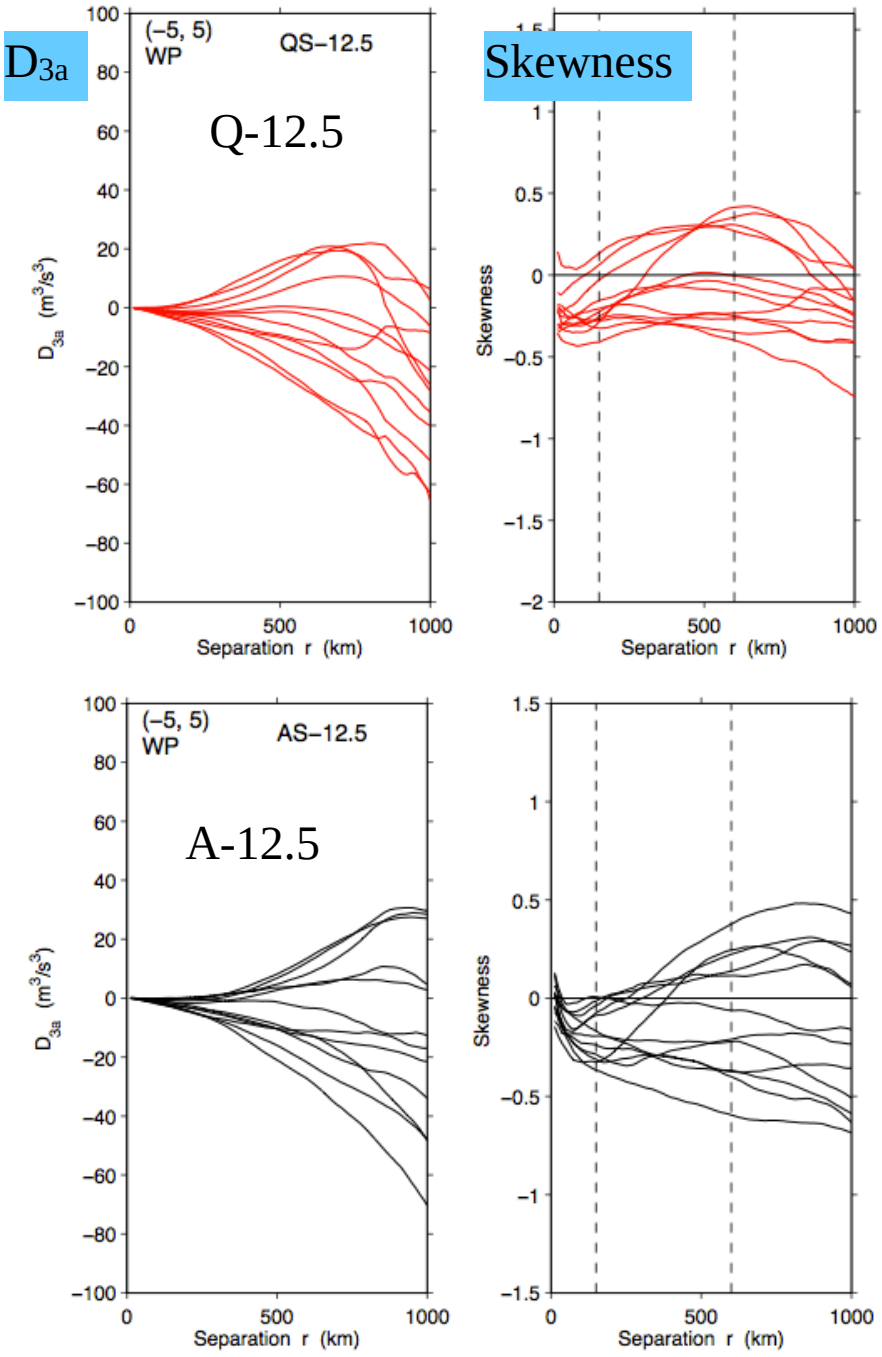
$D_3 > 0$ => Upscale energy transfer

$\delta u_L < 0$ (Convergence or deceleration)

$\delta u_L > 0$ (divergence or acceleration)

Skewness

$$S_a(r) = \frac{D_{3a}}{(D_{LLa} + D_{TTa})^{3/2}}$$

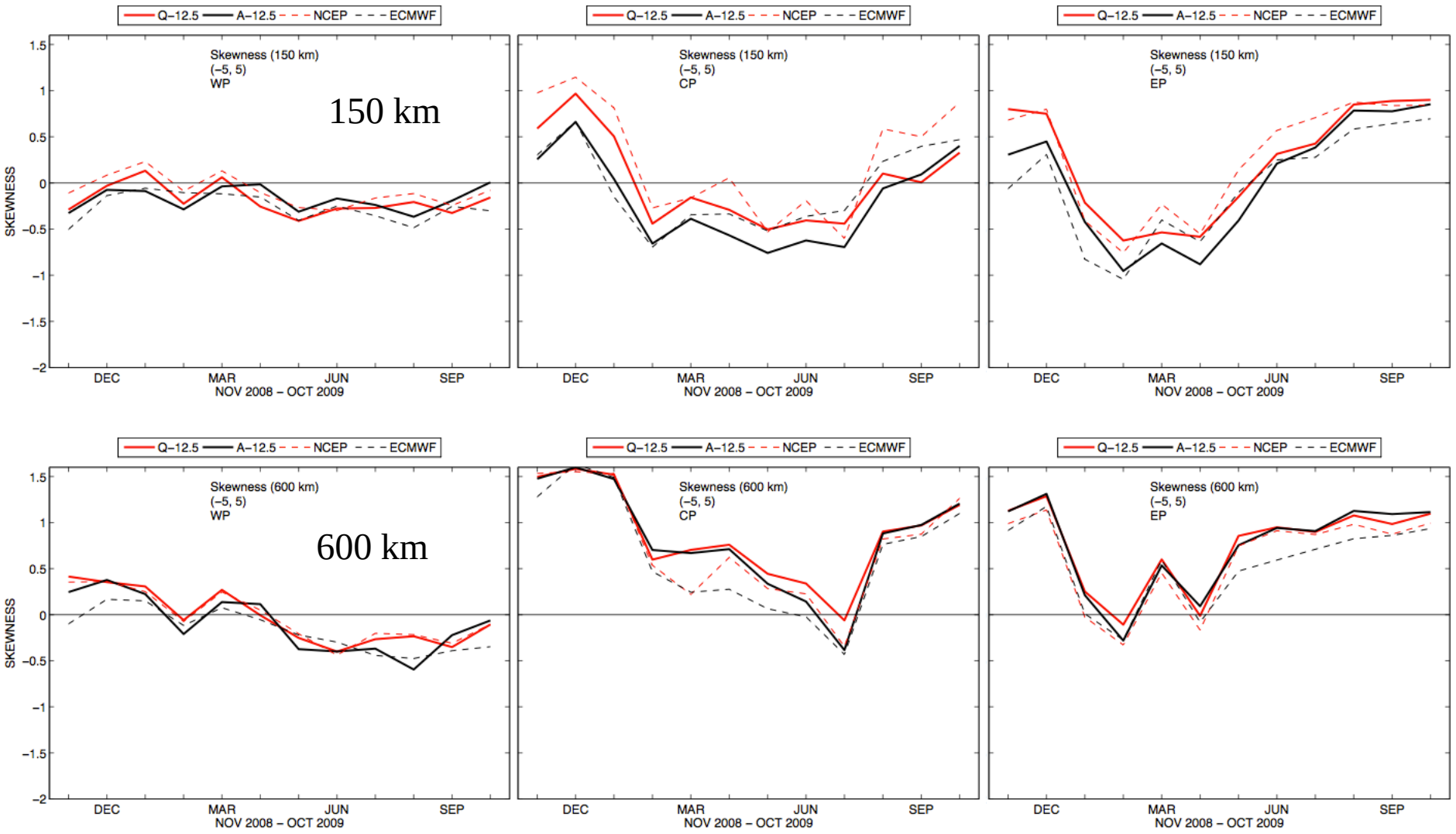


Monitor Skewness at

150 km
600 km

Skewness at 150 and 600 km

WP CP EP



Nov 2008 - Oct 2009

Summary

Second-order Structure Functions...

- Ratios suggest
  - QSCAT has more vorticity than ASCAT
  - Vorticity in WP
    (large difference between QSCAT and ASCAT)

- Slopes…
  - Q-25 < Q-12.5
  - A-12.5 < A-25
  - A-12.5 < Q-12.5

Due to noise?
Filtering?

Third-order Structure Functions...

In good agreement with each other and with NWP

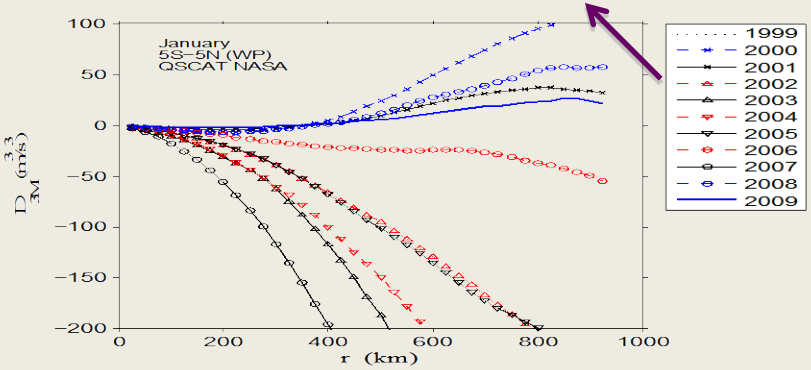
Can we do the same kind of analysis with Buoy Winds??

Backup Slides

$D_{3a}(r)$

All Januaries WP

$$D_{3a} = \frac{1}{2}\langle \delta u_l (\delta u_l \delta u_l + \delta u_t \delta u_t) \rangle$$

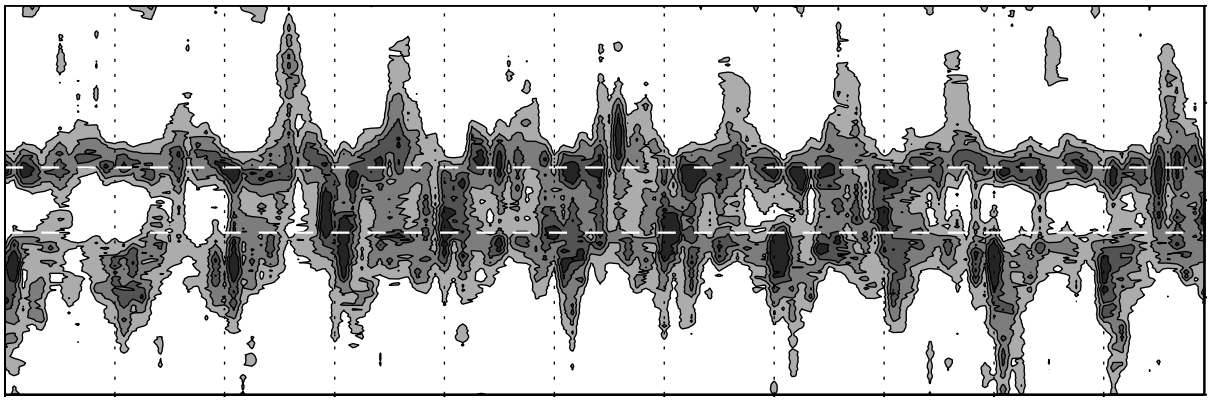


La Nina Januarys

WP

latitude-time
(zonal average)

Rain rate



$$D_{3a} = \frac{1}{2}\langle \delta u_L (\delta u_L \delta u_L + \delta u_T \delta u_T) \rangle$$