

# Meso-Scale Eddy Tracking via Model- and Satellite-SSH Data

Update

NK

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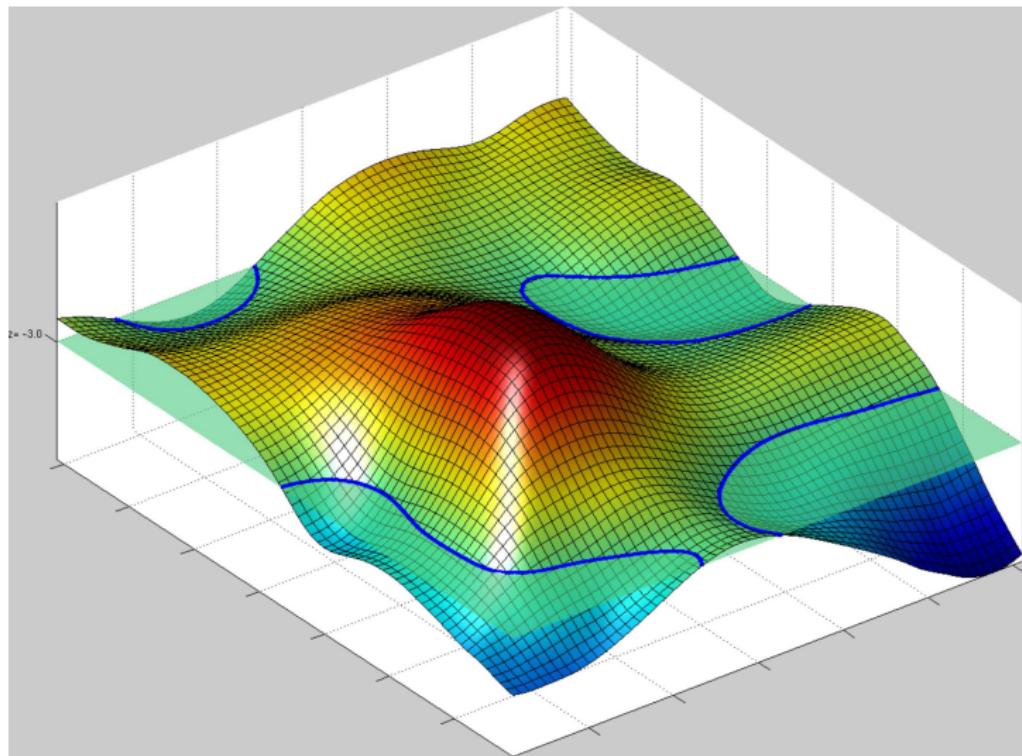
  Detection

  Tracking

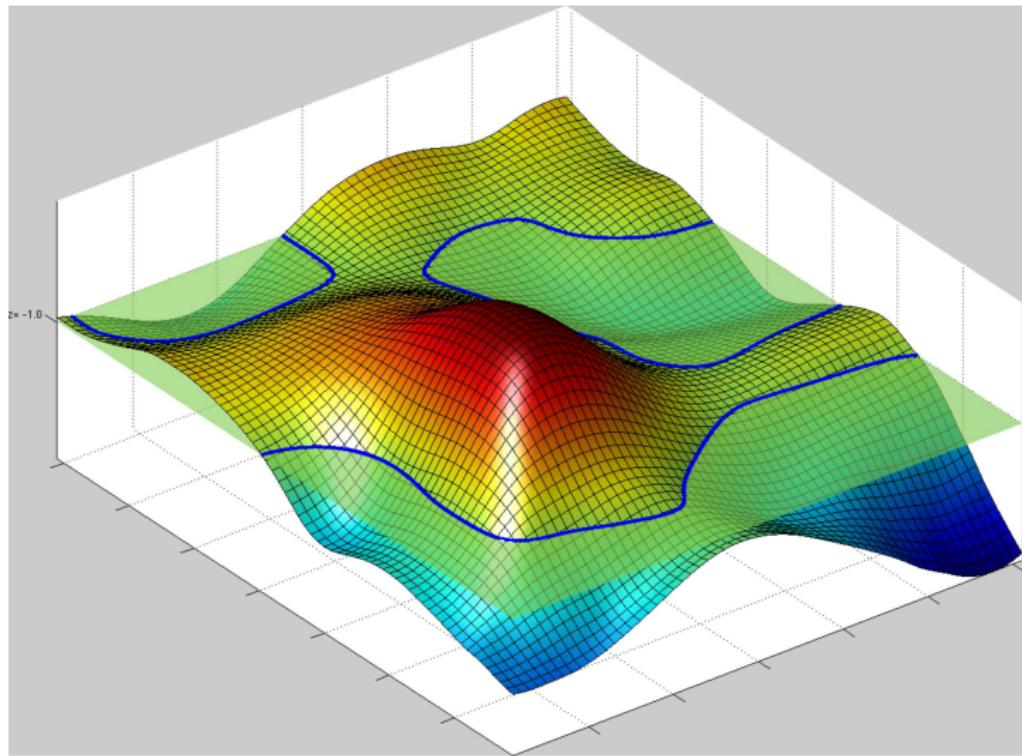
New Results

next..

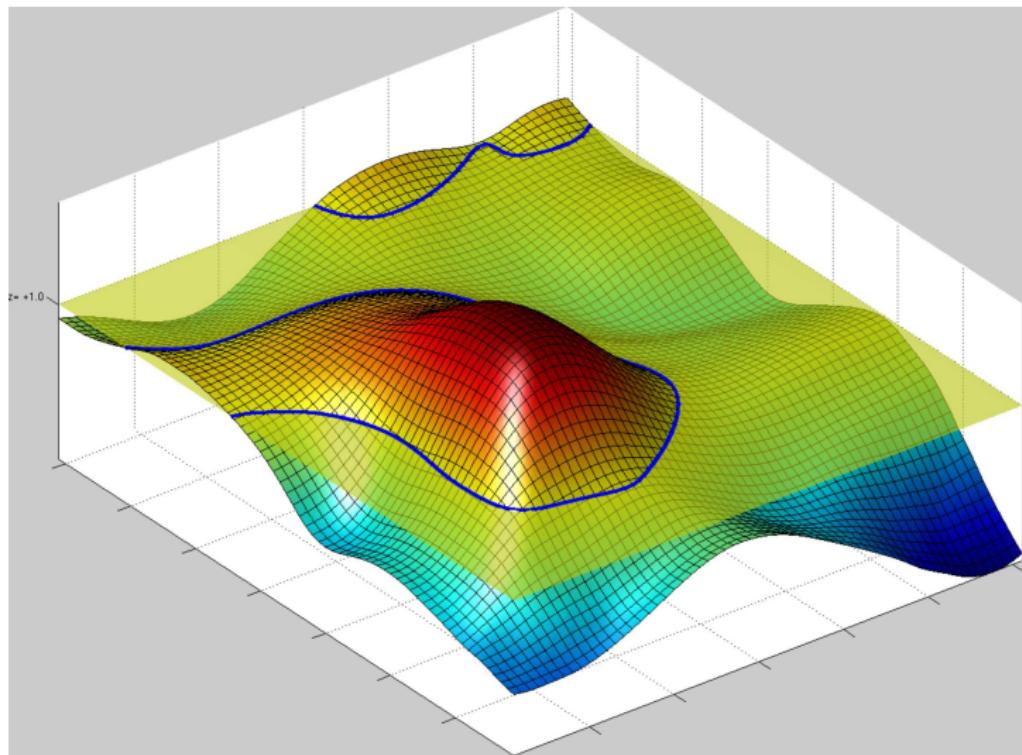
## SSH-based detection



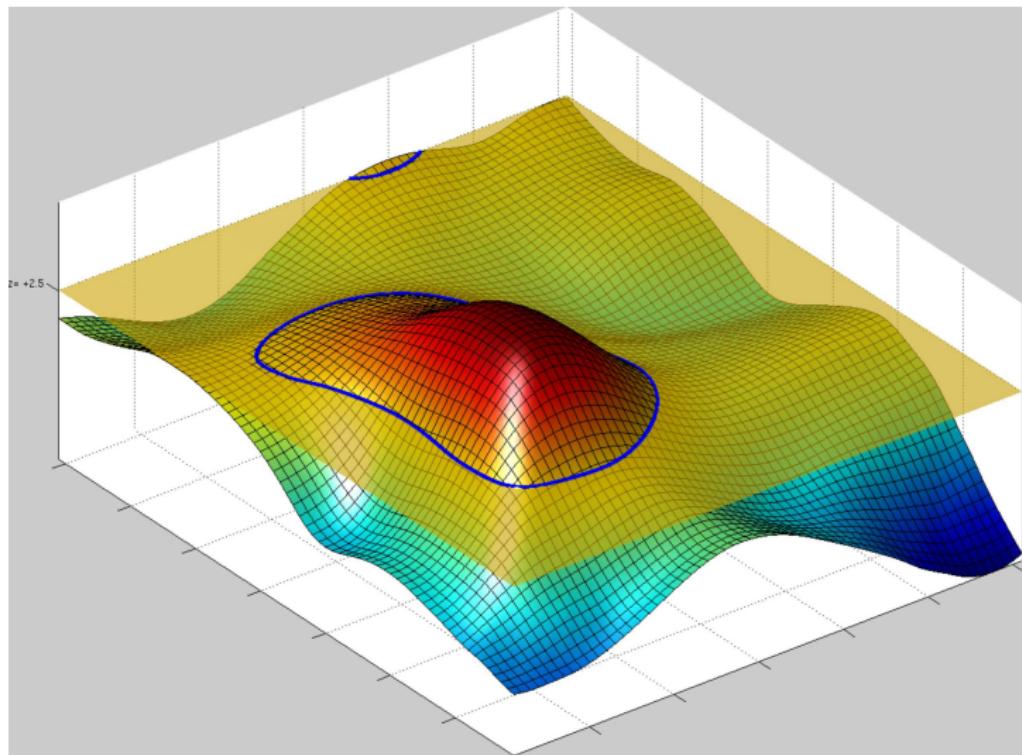
## SSH-based detection



## SSH-based detection

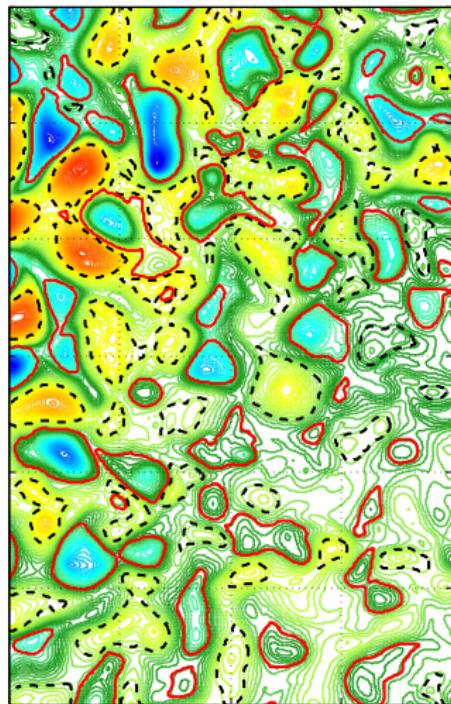


## SSH-based detection



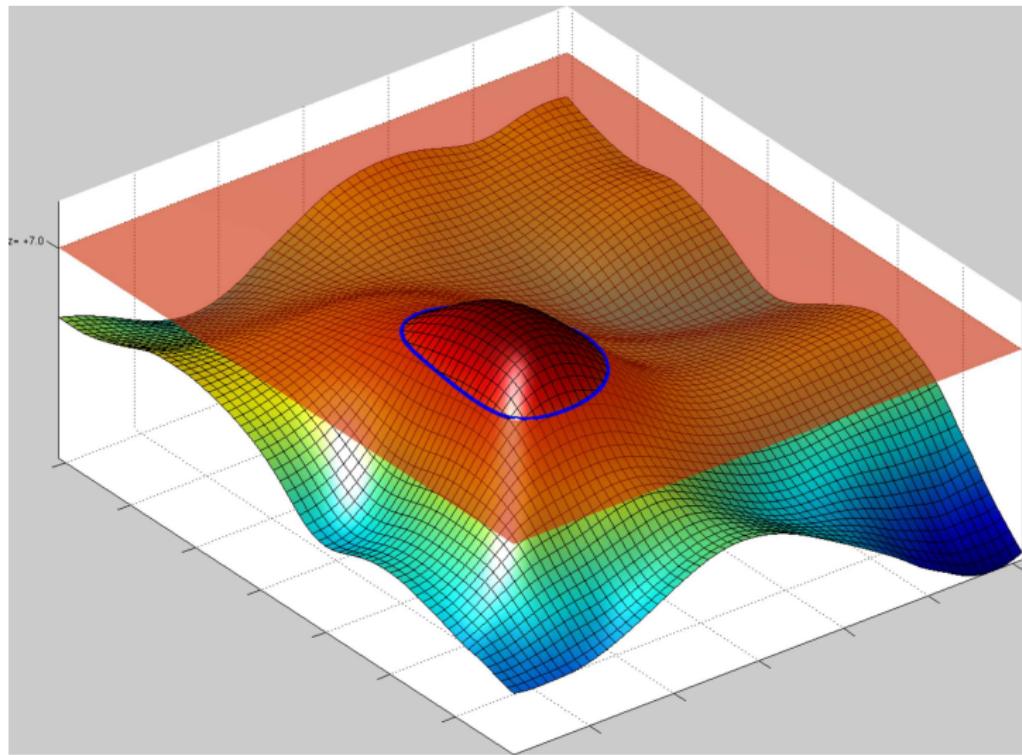
# does found contour qualify?

chelton's method



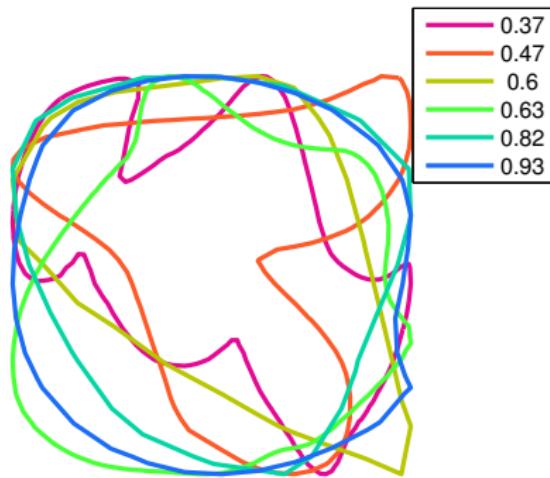
- (1) The SSH values of all of the pixels are above (below) a given SSH threshold for anticyclonic (cyclonic) eddies.
- (2) There are at least 8 pixels and fewer than 1000 pixels comprising the connected region.
- (3) There is at least one local maximum (minimum) of SSH for anticyclonic (cyclonic) eddies.
- (4) The amplitude of the eddy is at least 1 cm (see below).
- (5) The distance between any pair of points within the connected region must be less than a specified maximum.

new approach: demand circular shapes



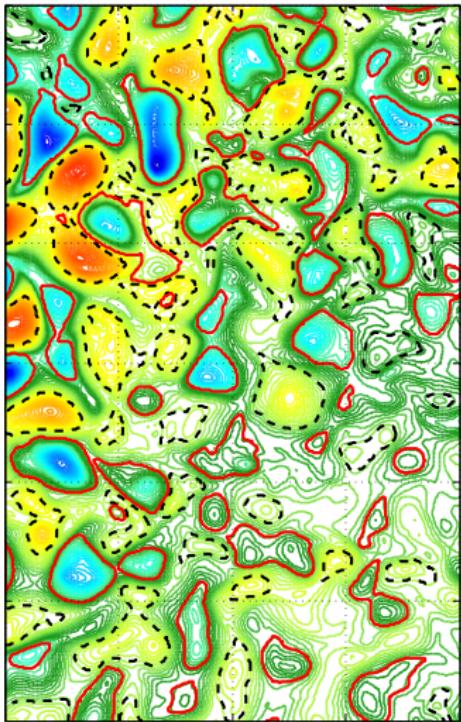
# Isoperimetric Quotient

$$IQ = A/A_c = \frac{4\pi A}{c}$$

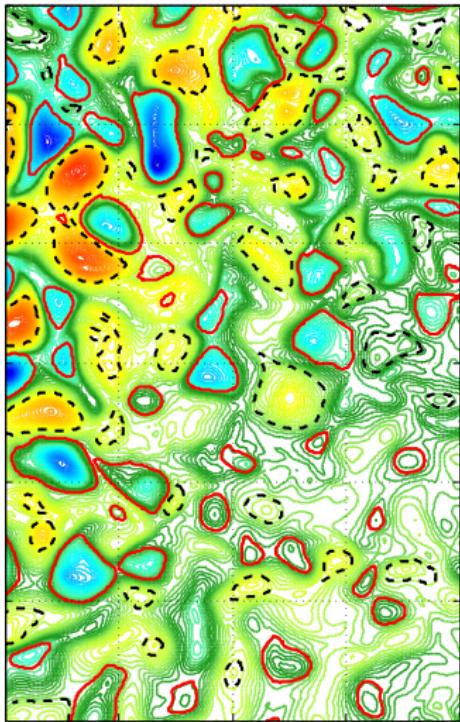


## new problem: deformed eddies get rejected

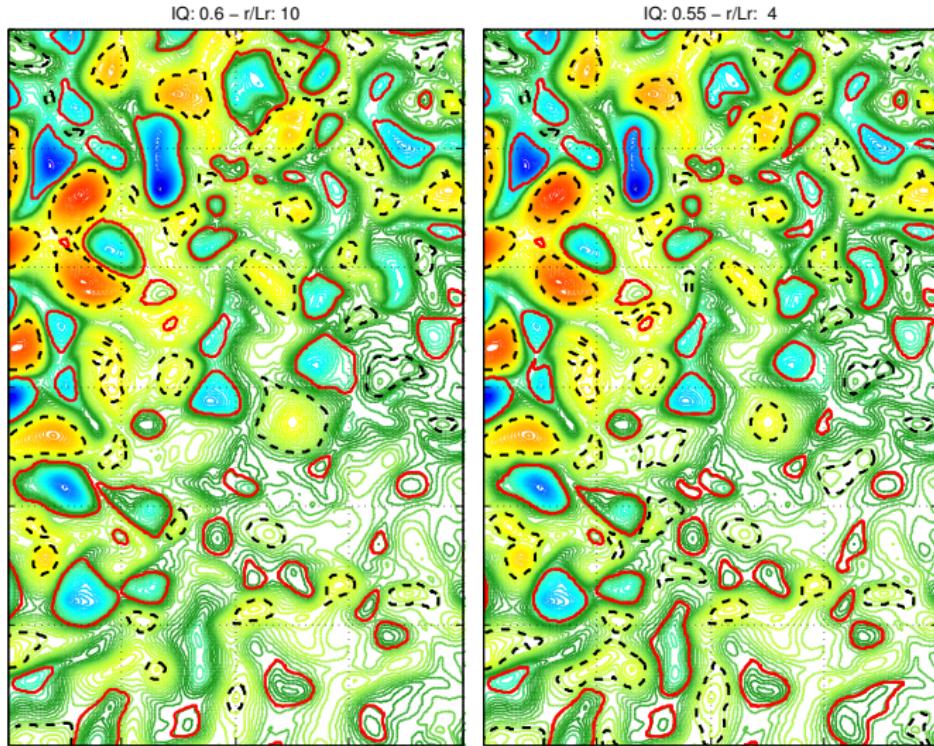
chelton's method



IQ: 0.6 –  $r/L_r$ : 10



solution: allow more deformation but limit hor. scale



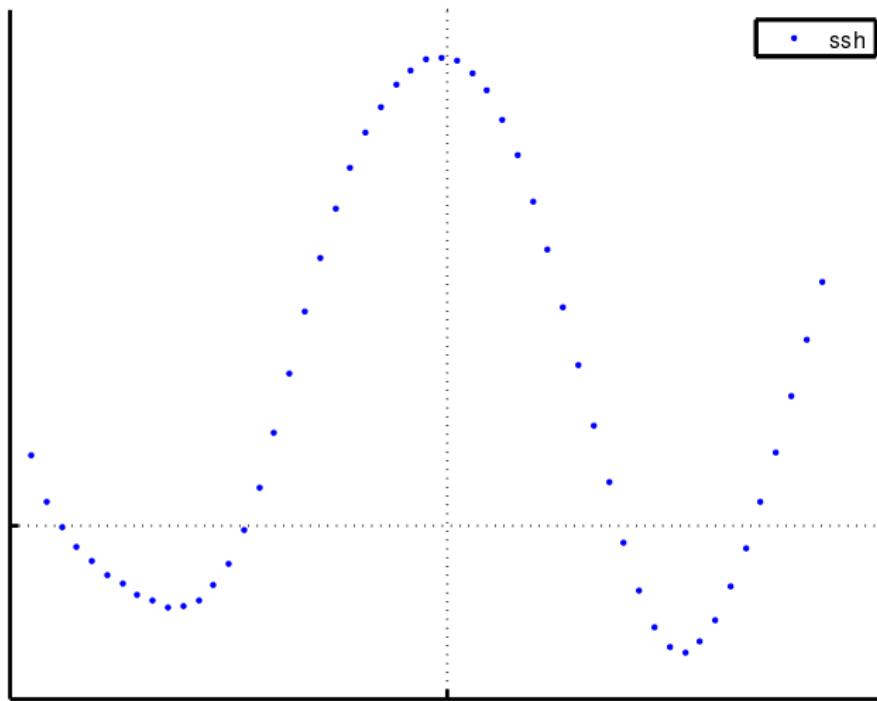
# Tracking

1. Build distance matrix  $\mathbf{D}(\text{old}, \text{new})$  between all eddies( $t = \text{now} - dt$ ) to all eddies( $t = \text{now}$ ).
2. Flag all  $\mathbf{D}(\text{old}, \text{new}) > \text{threshld}$ .
3. Flag all not meeting a *similarity criterion* (function of scale and amplitude).
4.  $\min(\mathbf{D})$  in both directions.
  - ▶ agreement: eddy is tracked!
    - append to respective track in running archive.
  - ▶ no new eddy agrees with old eddy: eddy just died..
    - if age  $\geq$  threshold, write track to archive, else delete!
  - ▶ no old eddy agrees with new eddy: a new eddy was born
    - initiate new track in running archive.

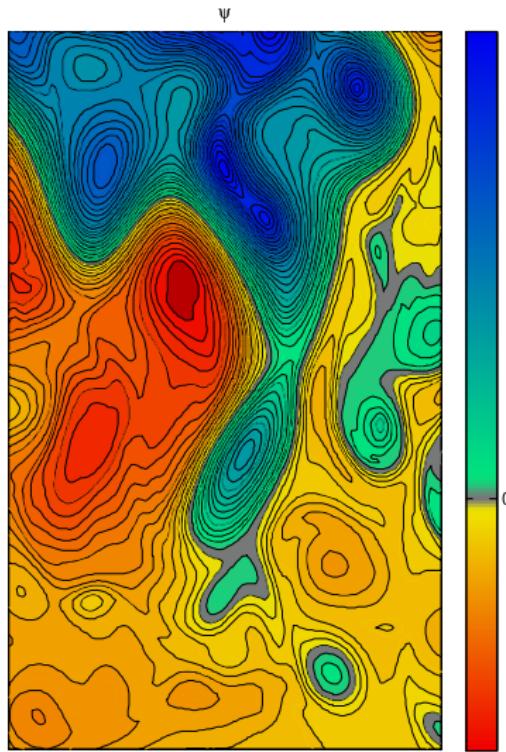
# Tracking

1. Build distance matrix  $\mathbf{D}(\text{old}, \text{new})$  between all eddies( $t = \text{now} - dt$ ) to all eddies( $t = \text{now}$ ).
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  - ▶ no old eddy agrees with new eddy: a new eddy was born
    - initiate new track in running archive.

# What is the scale and amplitude of an eddy ???

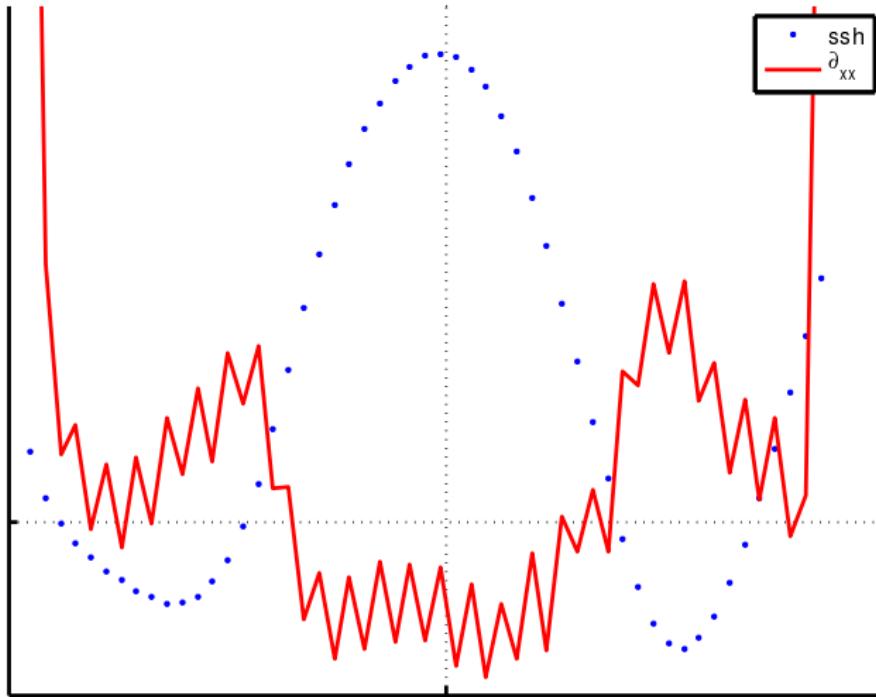


example: meander

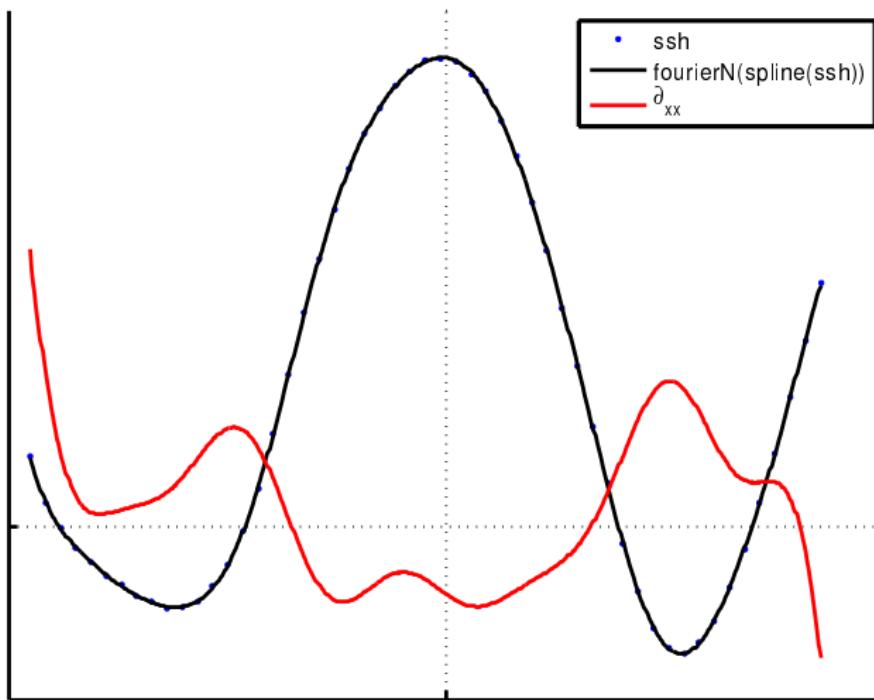


## Problem: coarse resolution

$$\partial_x \sim \mathbf{U}, \partial_{xx} \sim \omega$$

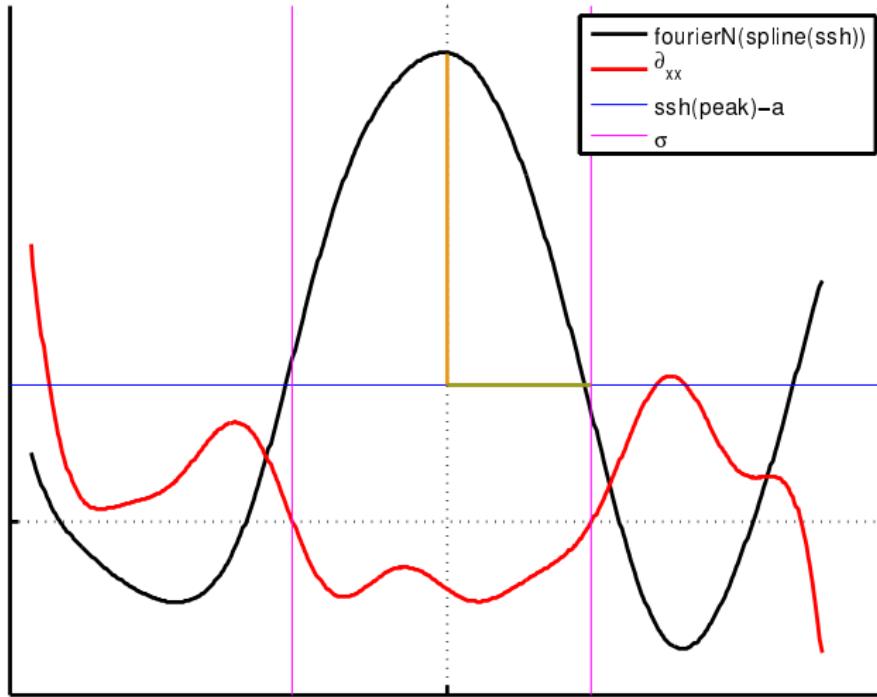


## Solution: Interpolate and use Fourier Series for differentials

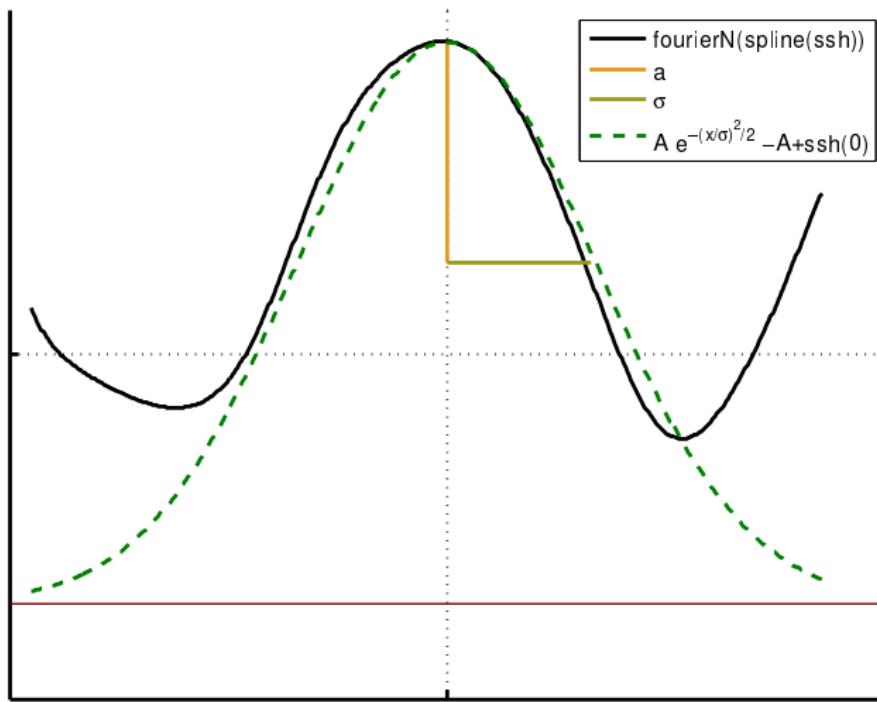


Assuming gauss shape:  $Ae^{(-x^2/2\sigma^2)}$ ;  $a = A(1 - e^{-1/2})$

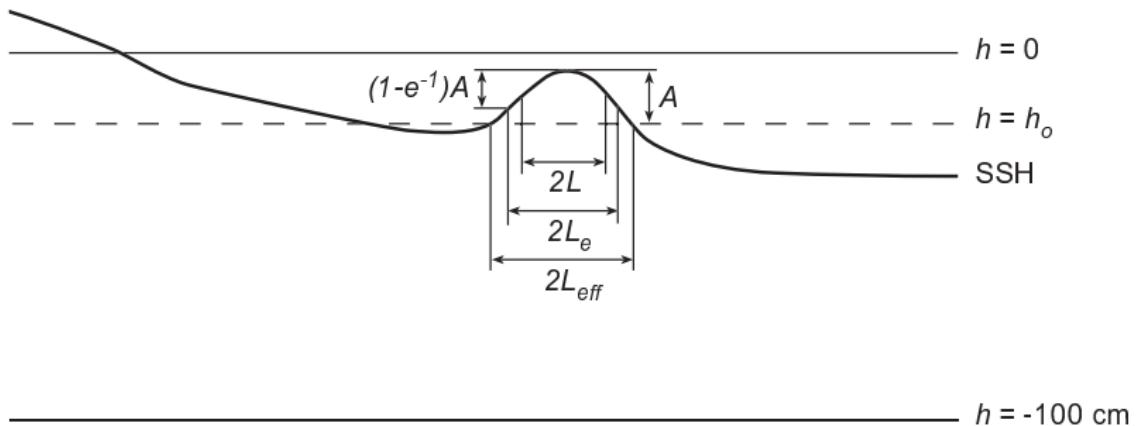
All shape-defining parameters for the *similarity criterion* are determined!



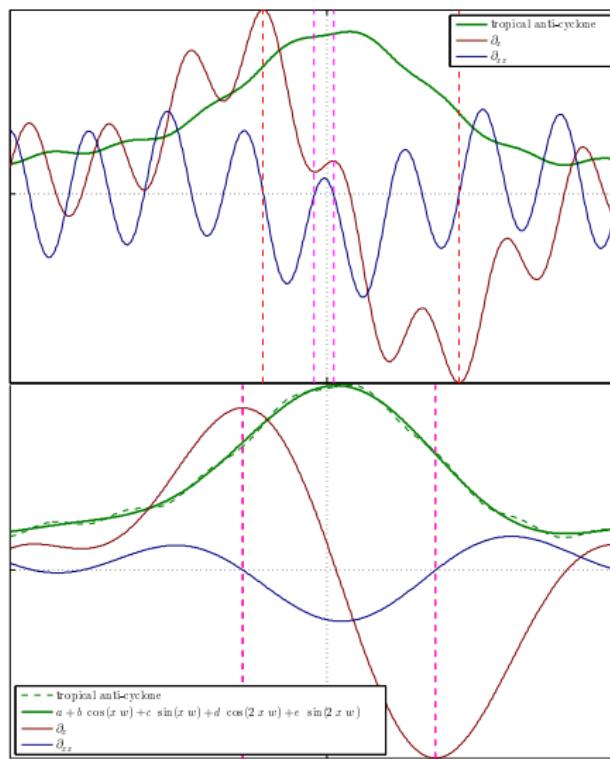
Note: Gauss shape assumption not necessary for this method.



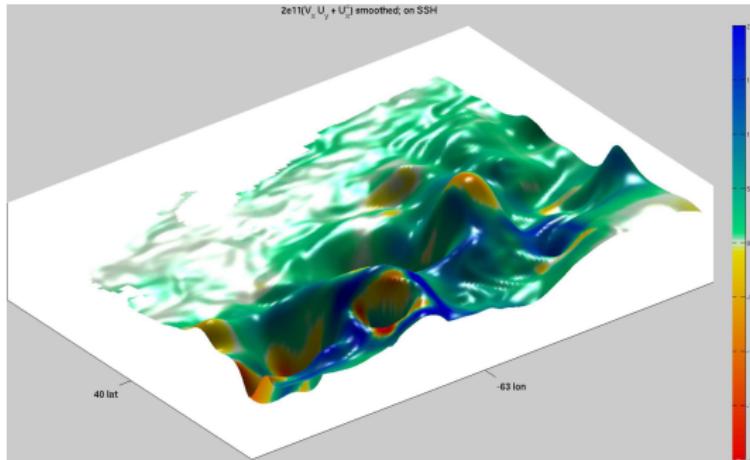
Chelton et al. define 4 different eddy scales.



# problematic: broad flat *wobbly* eddies



# Okubo-Weiss

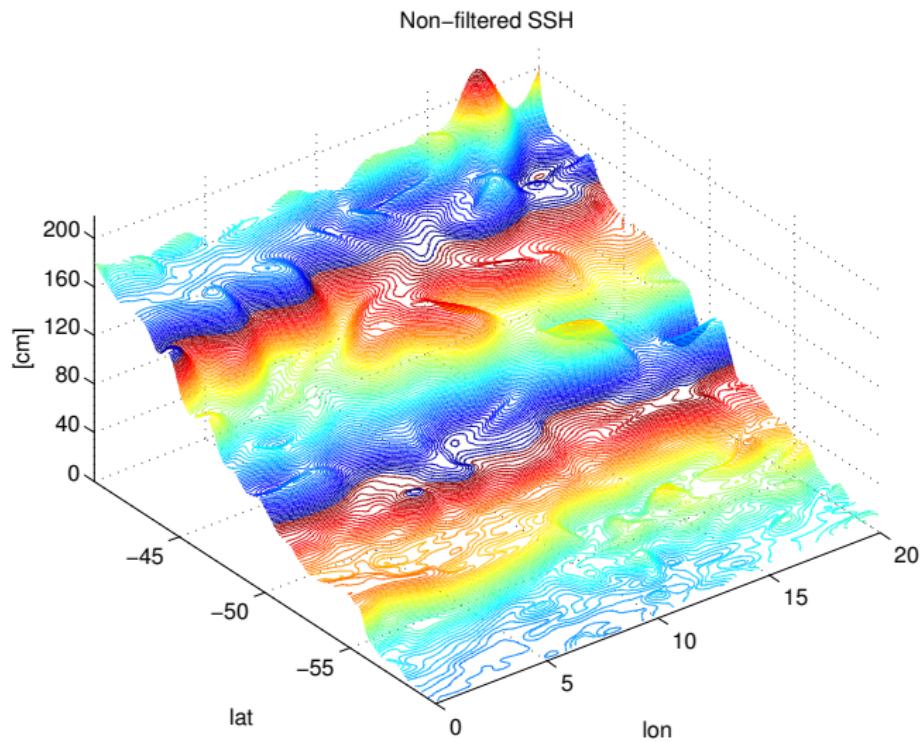


use eigenvalues of 2d deformation tensor to detect vortex:

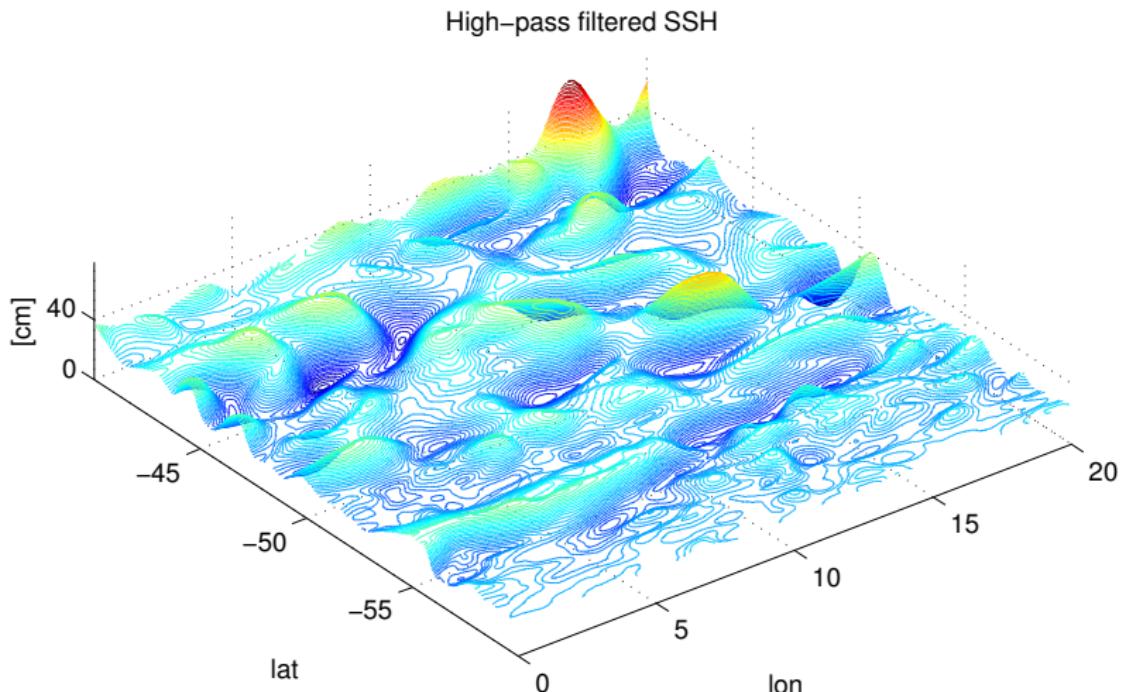
$$\det(\lambda \mathbf{I} - \nabla \mathbf{u}) = 0$$

$$\lambda^2 = OW/2 = 2u_x^2 + v_x u_y$$

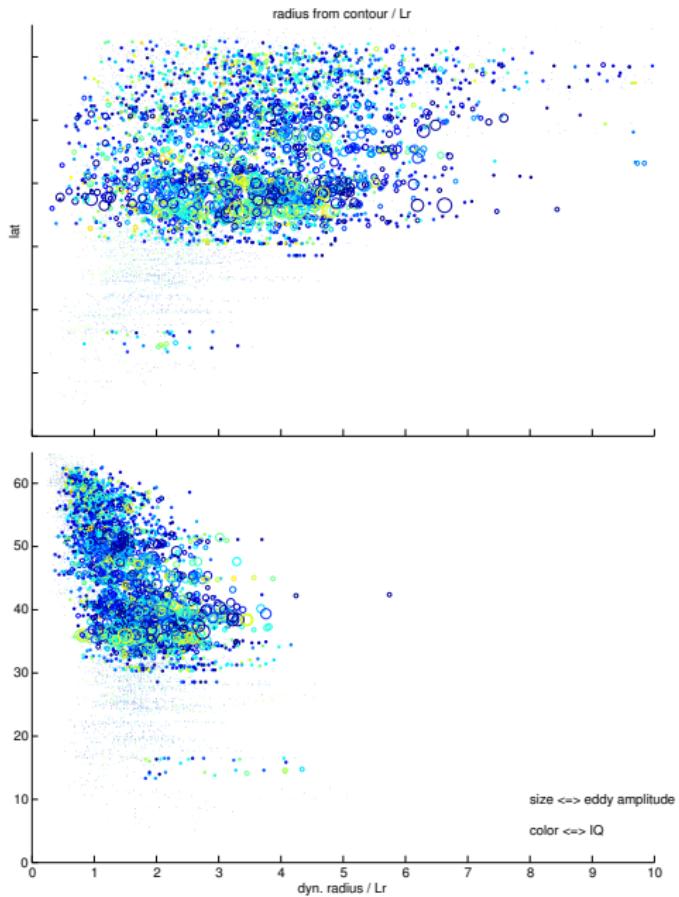
Removing larger scale signals important for Chelton's method.

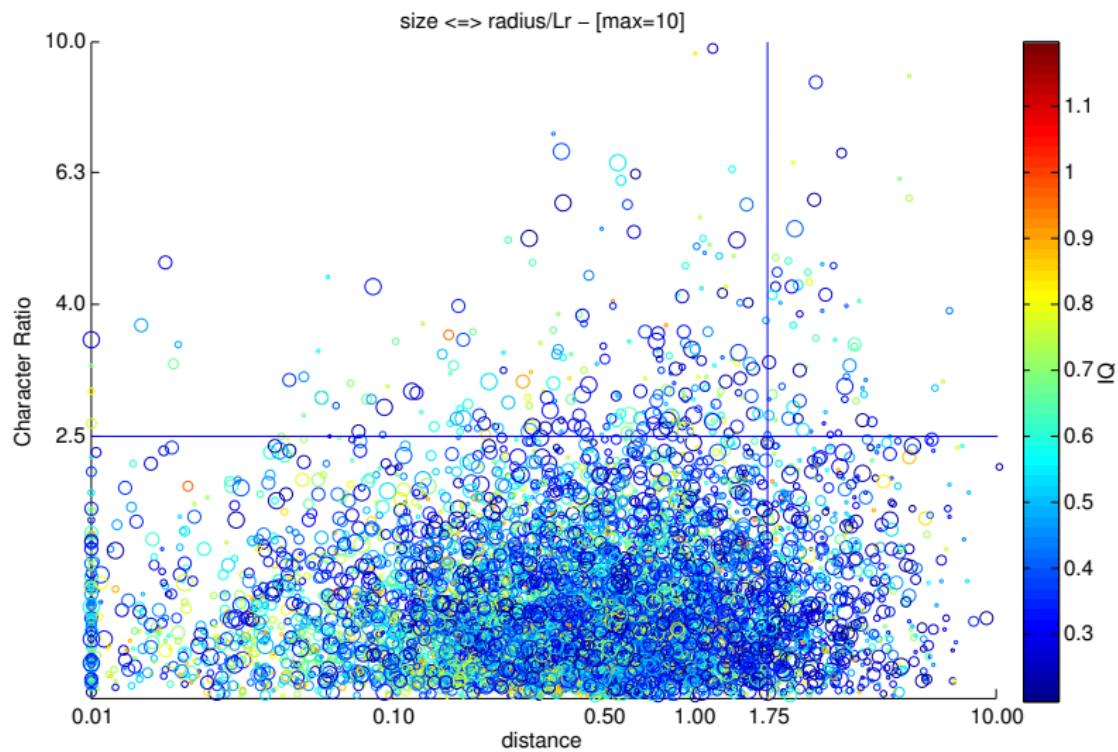


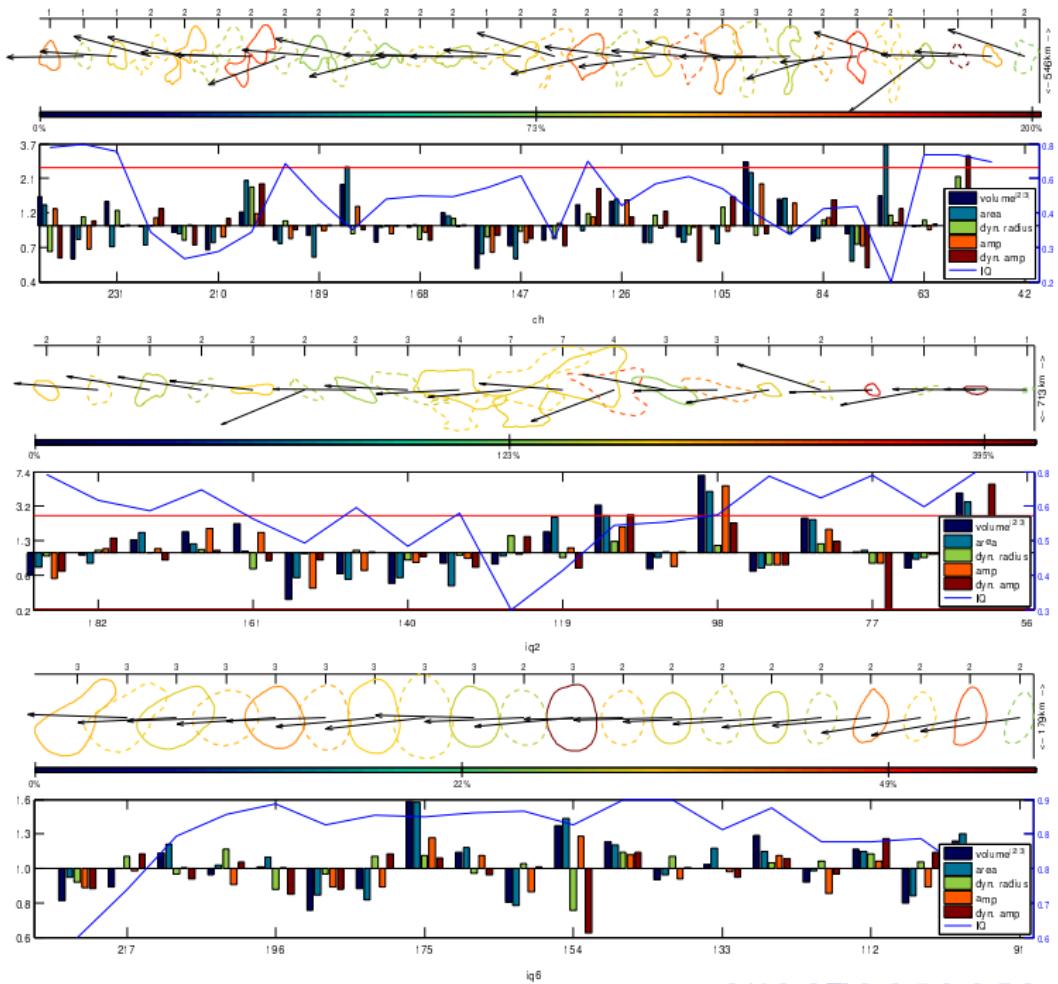
easiest: subtract annual mean

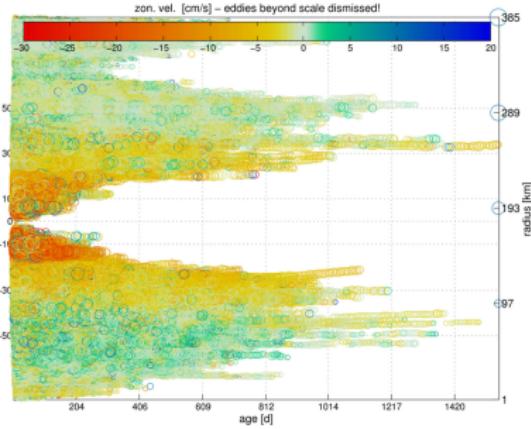
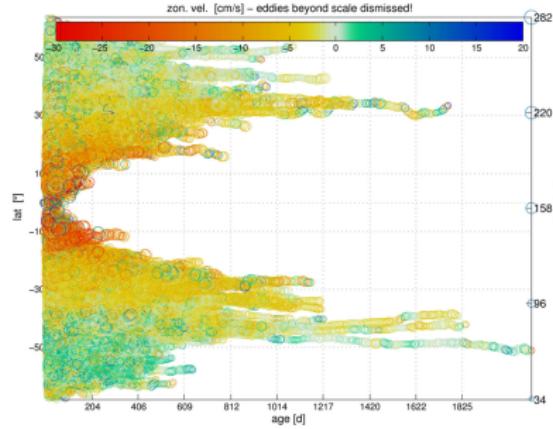
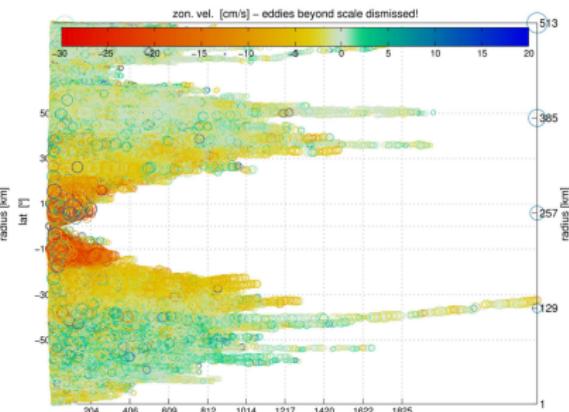
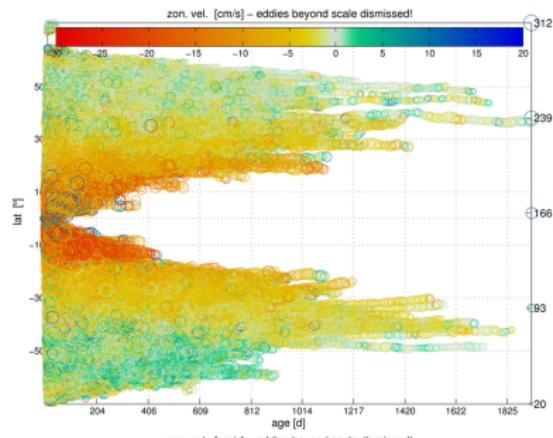


# finding a suitable scale threshold

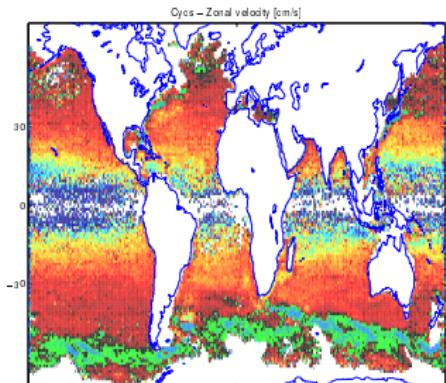




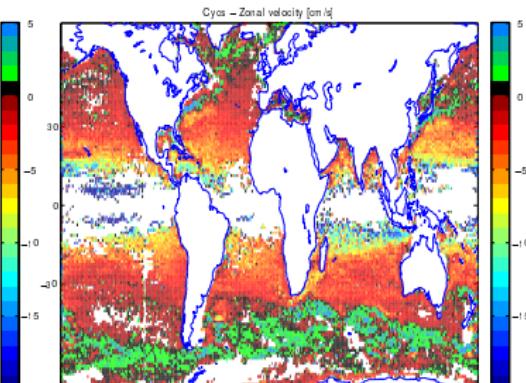




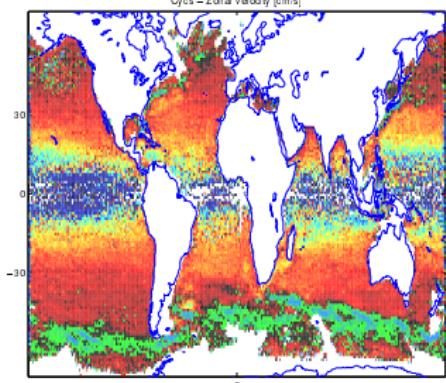
	aviso	pop
me	U	U
chelton	U	U



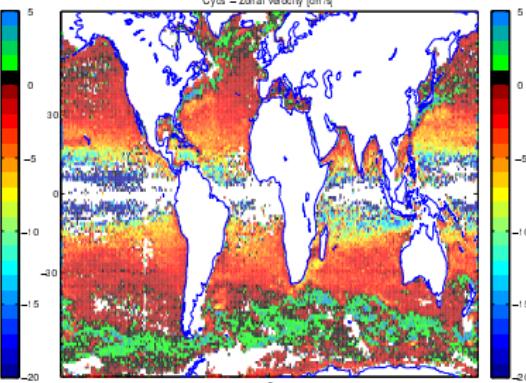
Eddies that died within 56 days are excluded



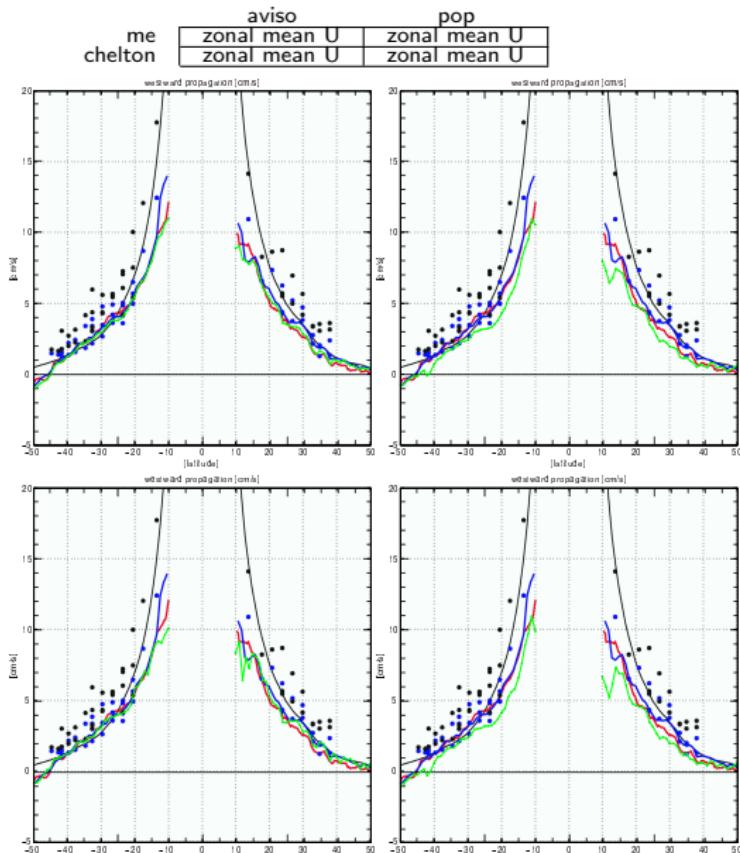
Eddies that died young or 56 days are excluded



Eddies that died younger 28 days are excluded

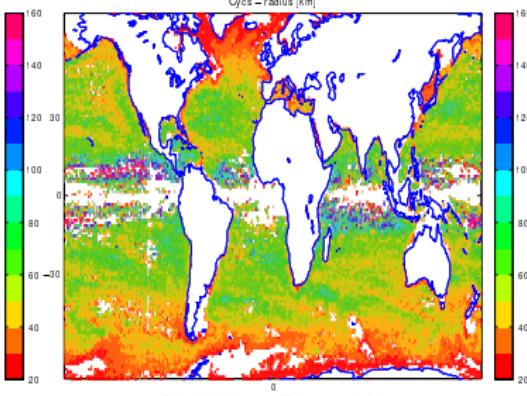
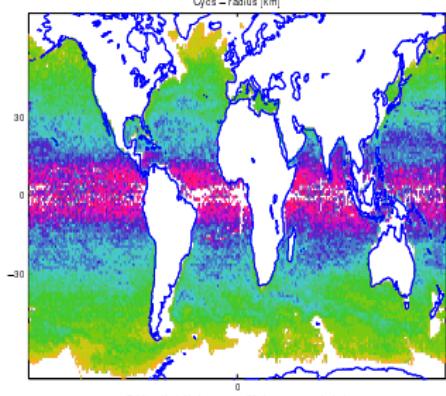
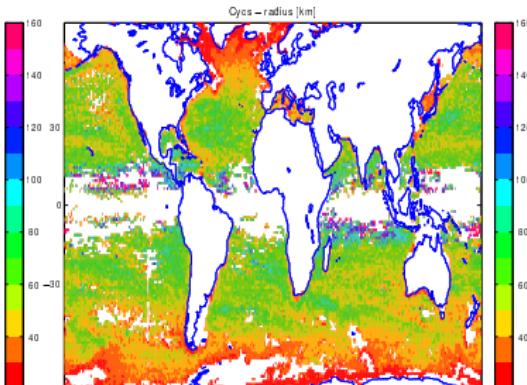
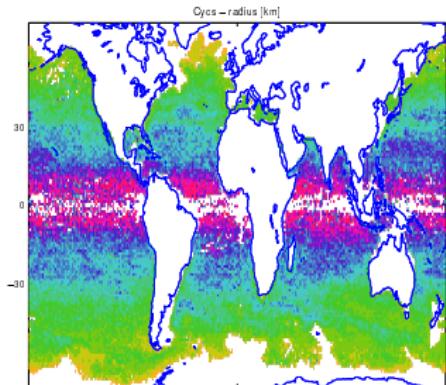


Eddies that died younger than 28 days are excluded

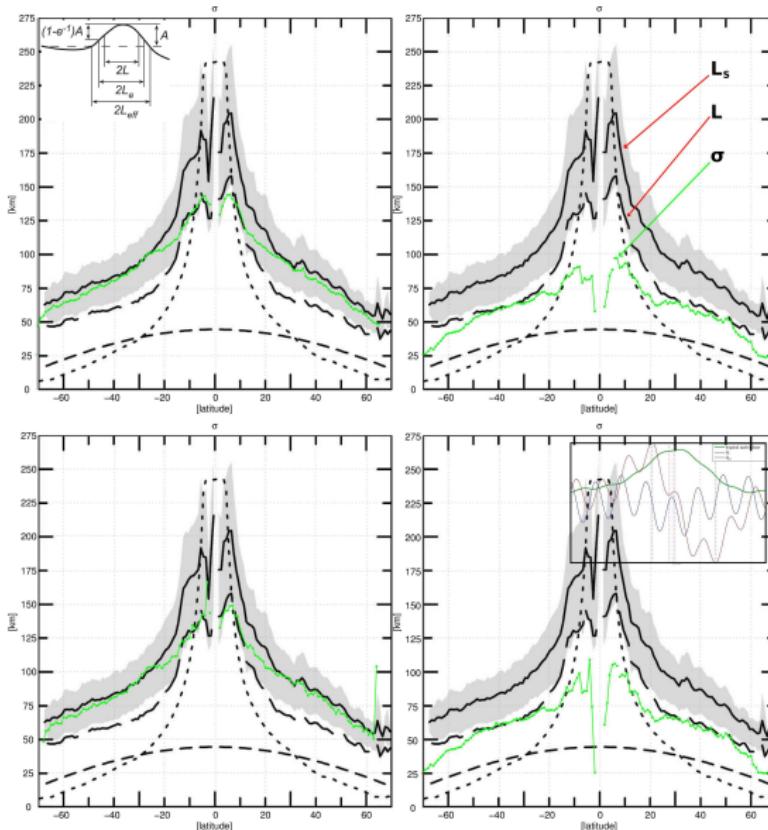


**Figure:** black dots: Radon transforms of 20x10 high-pass filtered SSHelds along the 45 zonal sections. Red dots: means of  $U$  along those sections (age  $\geq 16$  weeks). red line: zonalmean( $U$ ). blue line: space-time-lagged cross-correlation (Fu 2009).

me	aviso	pop
chelton	$\sigma$	$\sigma$



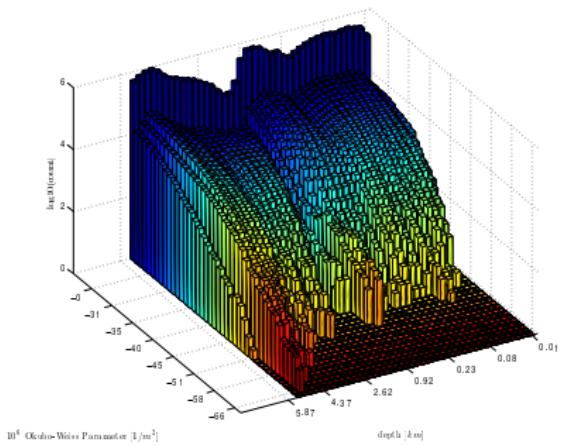
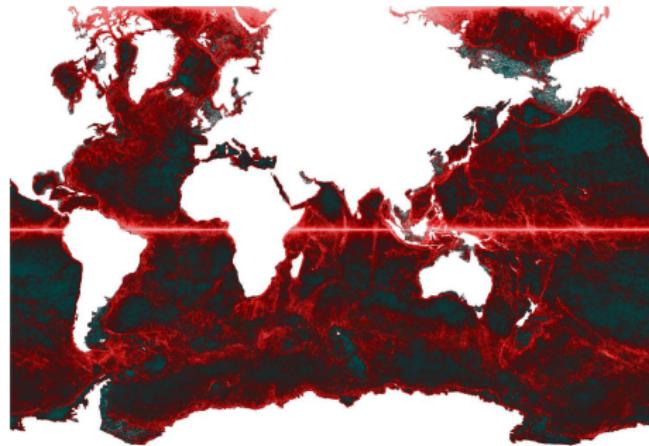
	aviso	pop
me	zonal mean $\sigma$	zonal mean $\sigma$
chelton	zonal mean $\sigma$	zonal mean $\sigma$



# to-do-matrix

	pop	aviso	comparison
U	[? ]	[? ? ]	[? ]
scale	[? ]	[? ? ]	[? ]
method Chelton	N	[? ],N	N
method $R^2$	[? ]	n/a	n/a
method OW	[? ]	[? ]	[? ]
method IQ	N	N	N
net U	N	N	N
steering level	N	n/a	n/a
$p(z)$	N	n/a	n/a
$f/H$	N		
remap pop2avi			
drop buoys into eddies			
go 3d			

# Which depth to take mean current from?



14-Oct-1913

