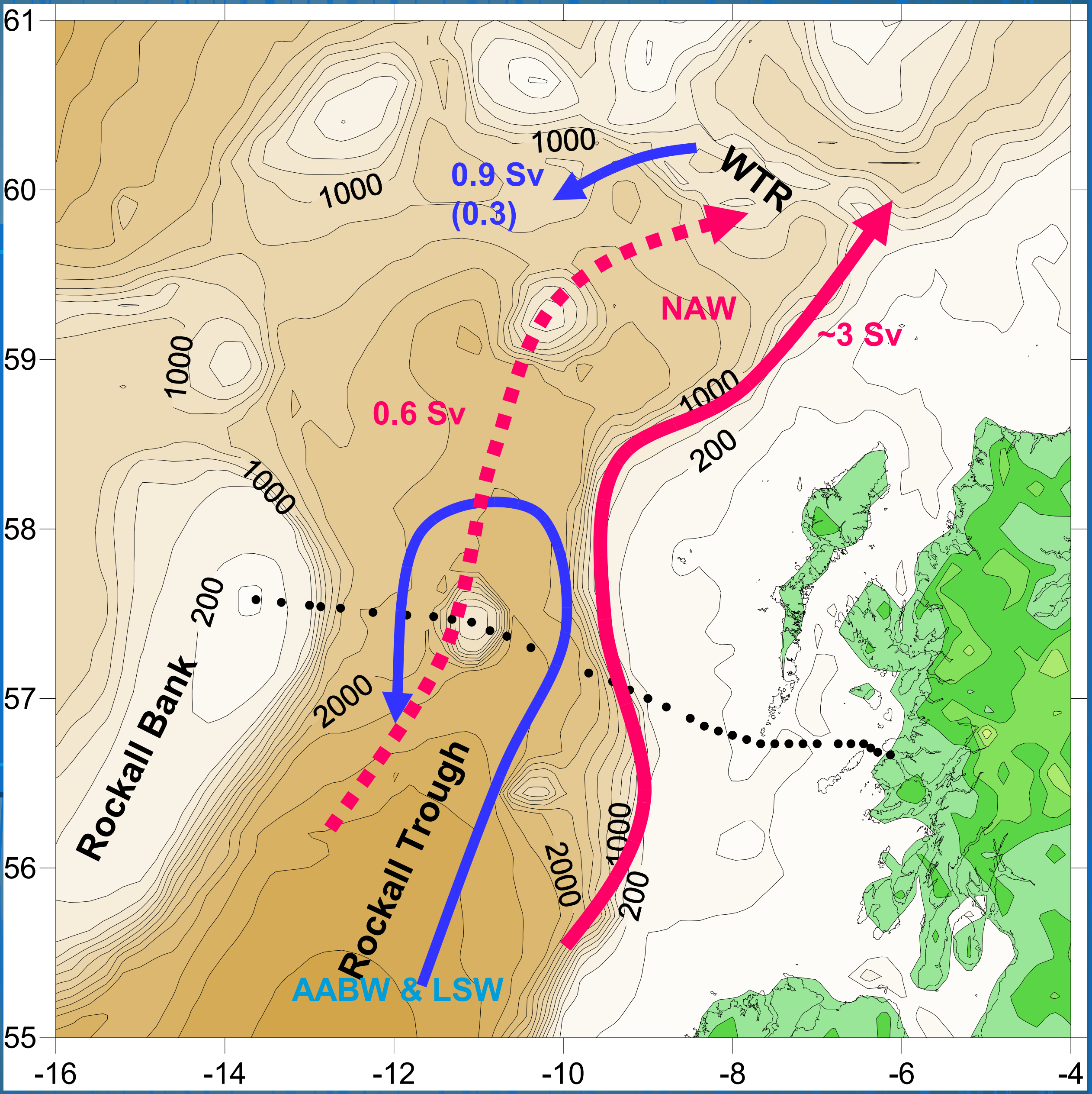
How good is a (Sea)glider at measuring mean currents?

Toby Sherwin, Estelle Dumont and SAMS glider team

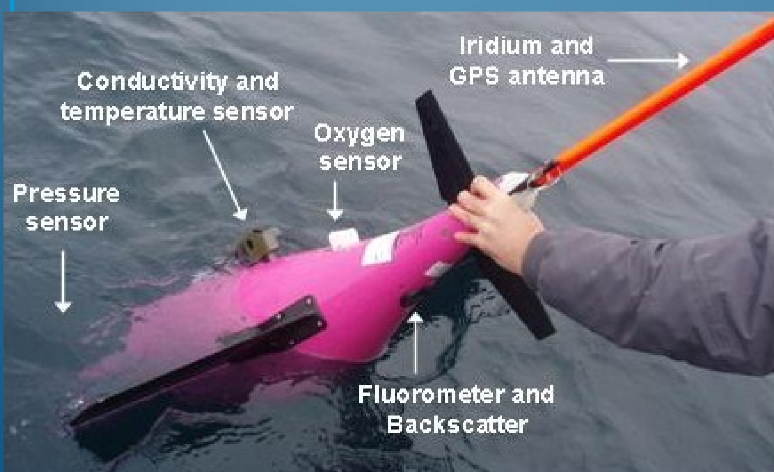
Scottish Association for Marine Science, Scottish Marine Institute, Oban, Scotland

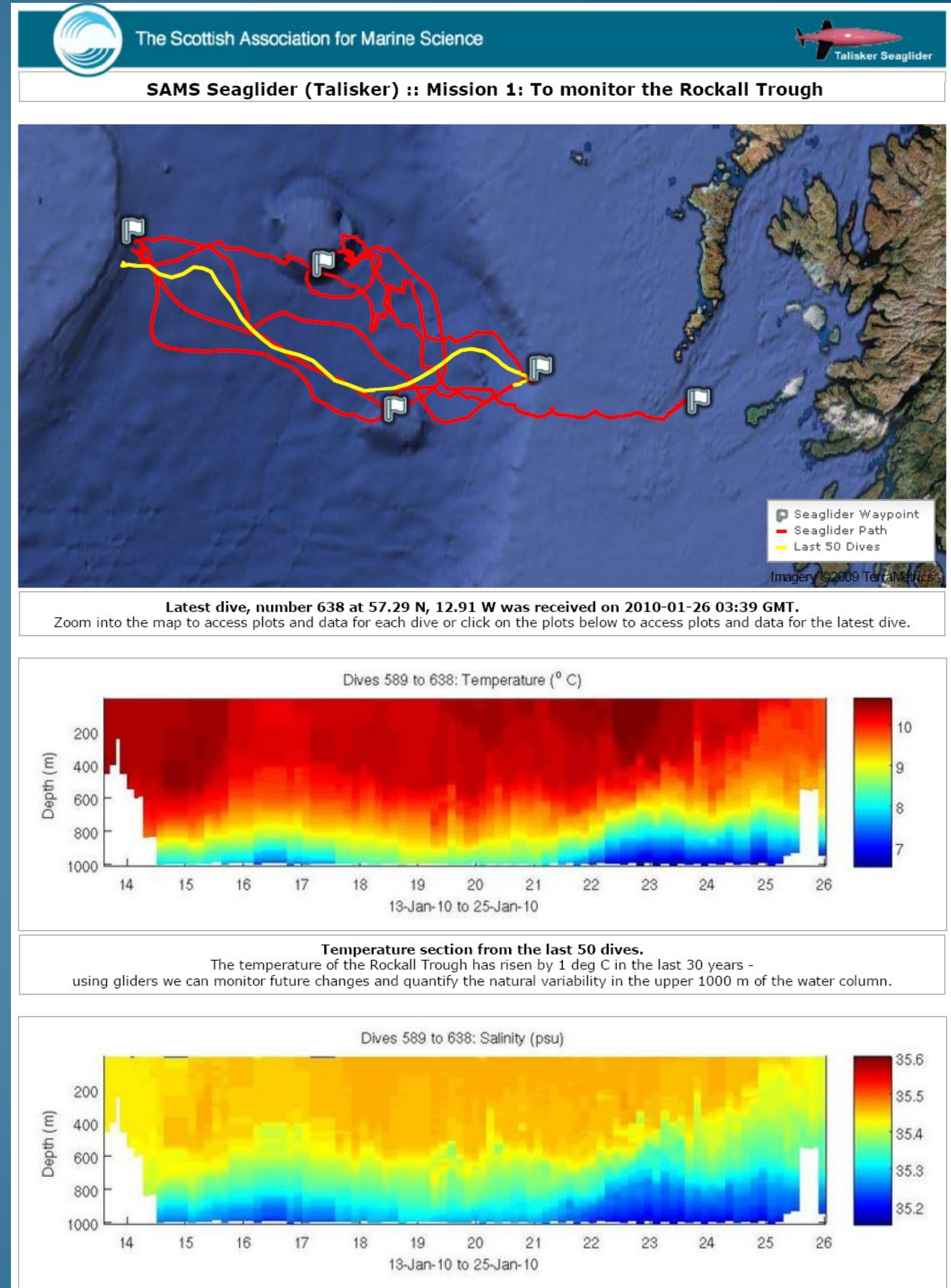
Circulation in the Rockall Trough



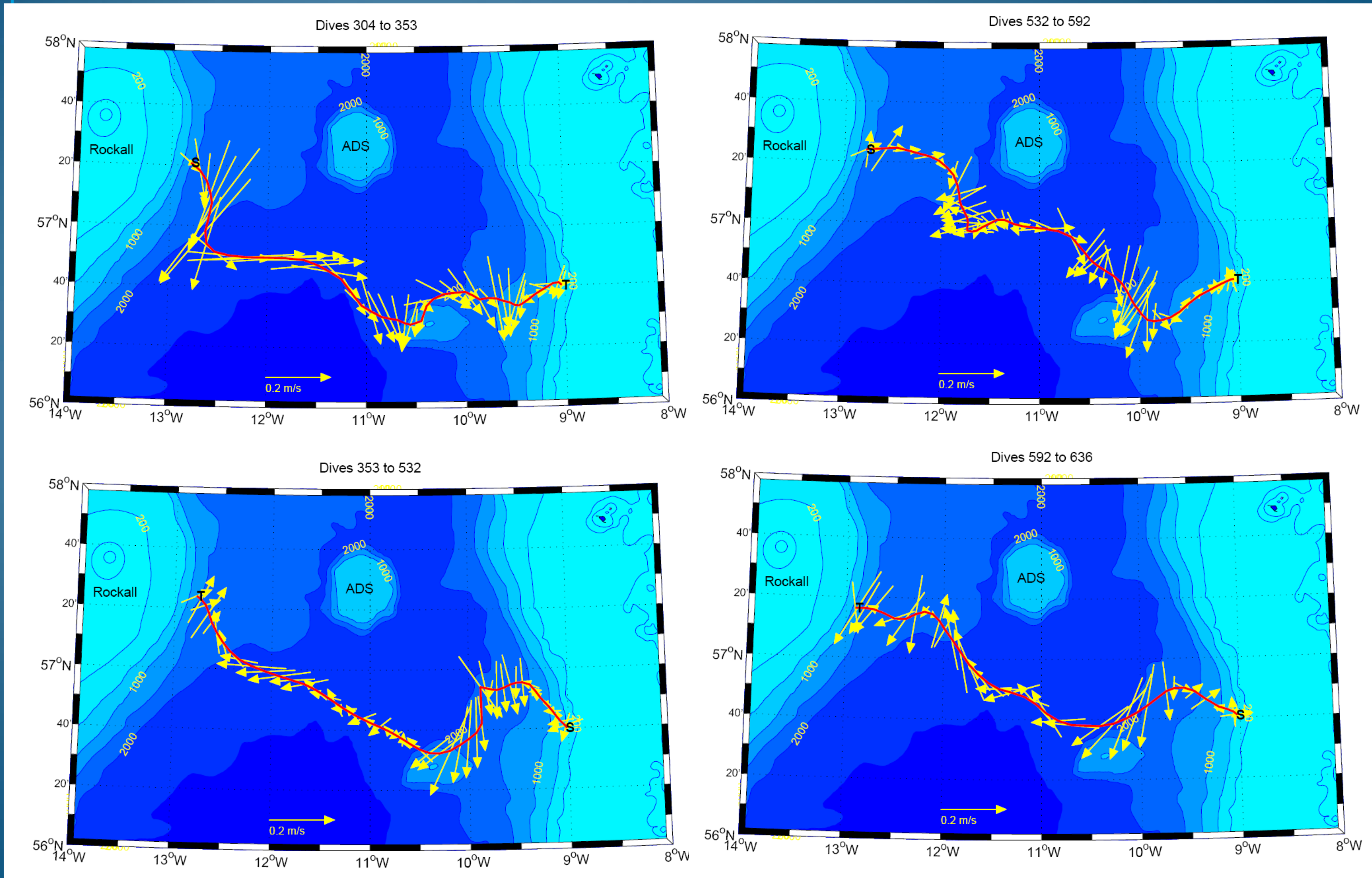
Talisker Mission 1

October 2009 to March 2010





Dive average currents (DACs) from selected transects



Dive Average Currents (to ~1000 m) in cm s^{-1} computed from binned averages

Dive range	North (W to E)	North (E to W)	East (W to E)	East (E to W)	No of dives
304:353	-10.7		-0.035		49
353:532		-1.19		-0.053	78*
532:592	-4.37		0.079		60
592:636		-1.62		0.626	42
636:708	-8.78		-0.003		46*
708:742		-1.17		0.083	34
742:789	-6.42		0.084		47
mean	-7.6	-1.3	0.03	0.25	
std dev	±2.8	±0.25	±0.06	±0.32	

* some dive sequences ignored

Approx width of Rockall Trough = 250 km;

Implied surface transport from { } = 11 Sv to the south

This talk will address the question:

What is the explanation of the observed 4.5 cm s^{-1} southward drift ?

1. Is it real? X

2. Is it due to compass error (or problems with the hydrodynamic model)?

3. Is it due to eddy aliasing (or background diffusion)?

Epilogue – Strange gliders attracters

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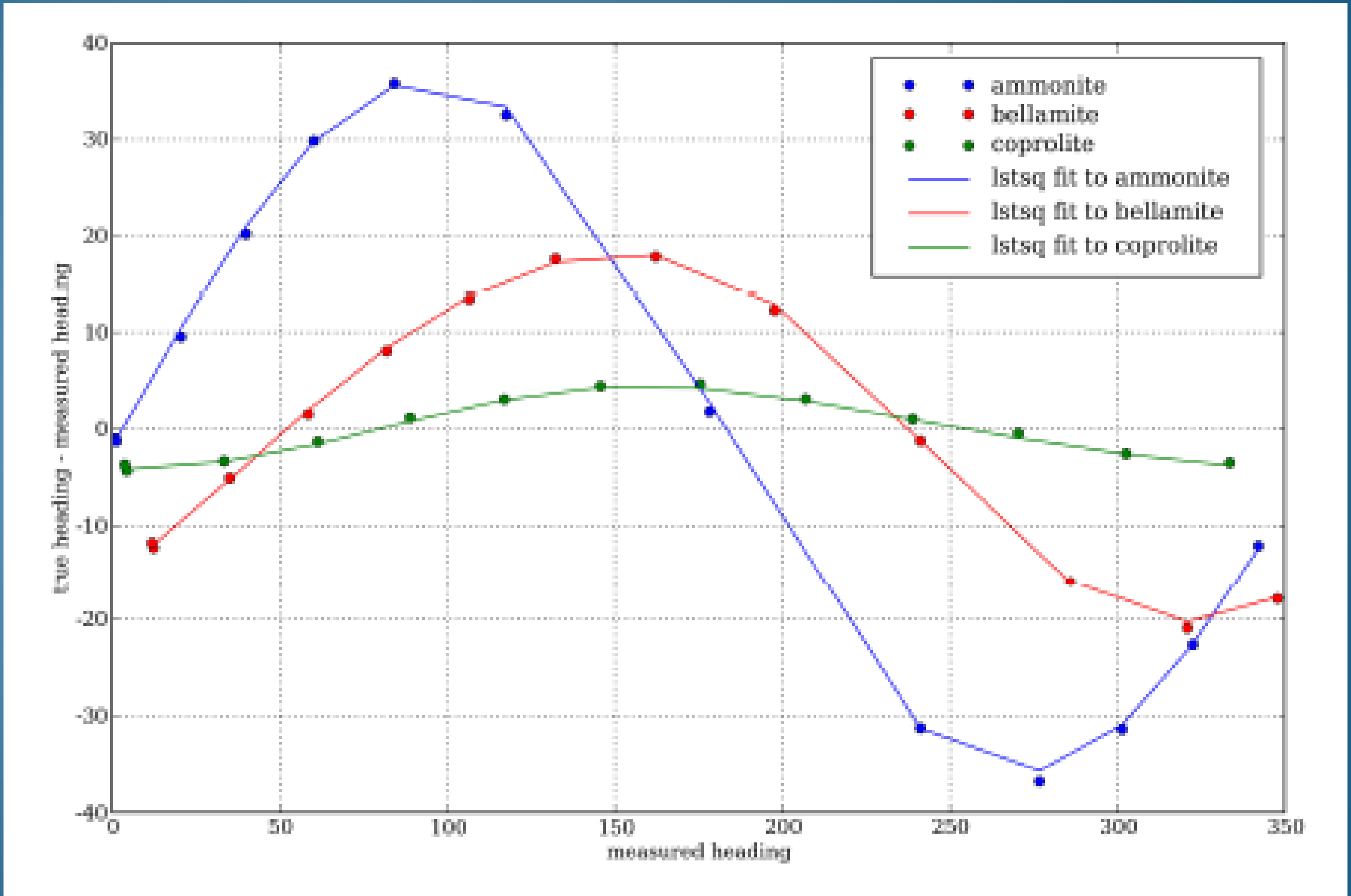
Epilogue – Strange gliders attracters

Compass errors reported for Slocum gliders



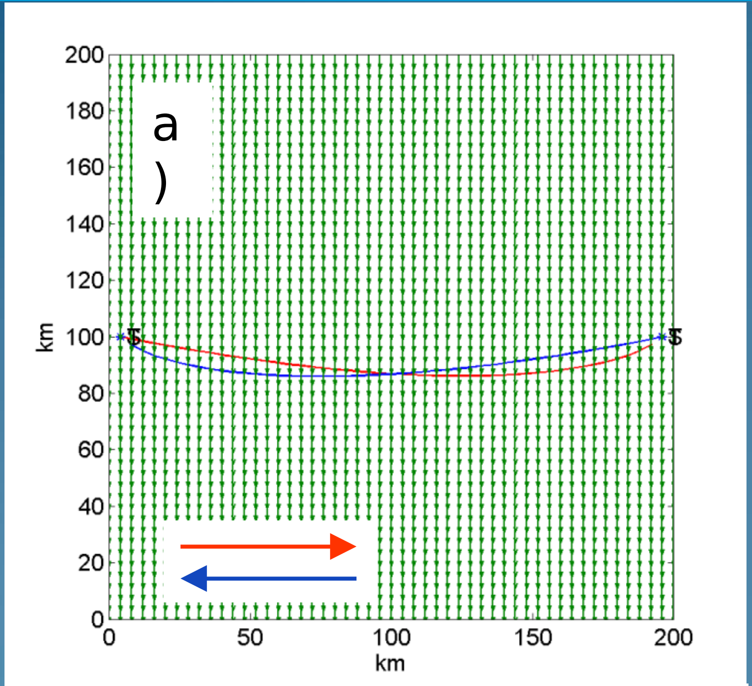
Merckelbach, L.M., Briggs, R.D., Smeed, D.A., Griffiths, G., 2008. Current measurements from autonomous underwater gliders. IEEE/OES 9th Working Conference on Current Measurement Technology. IEEE Xplore, Charleston, pp. 61 - 67.

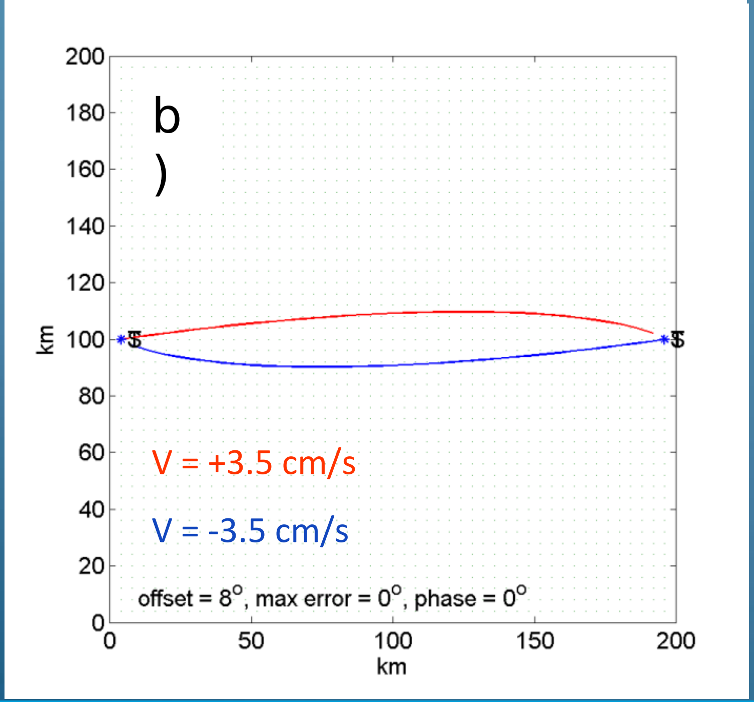
Pseudo glider tracks

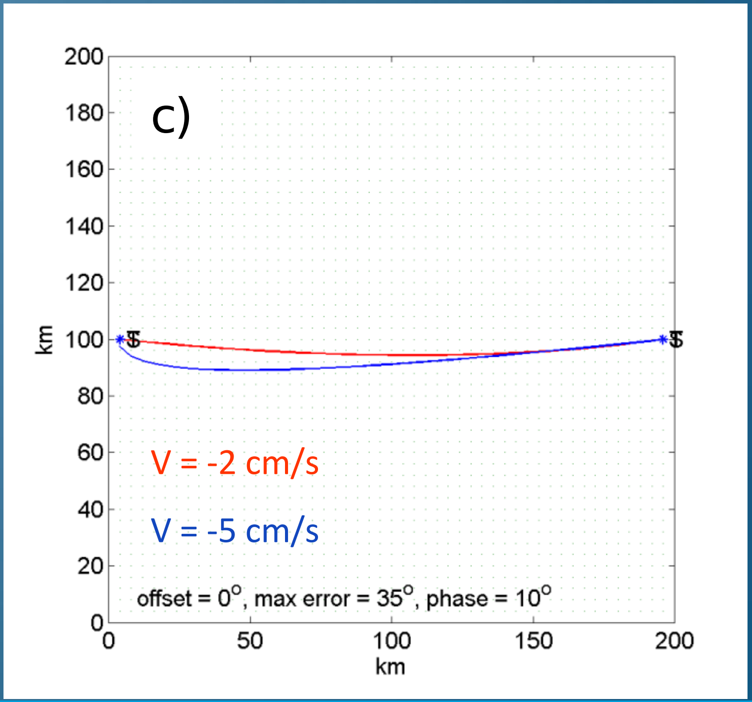
a) No compass error; the mean current (-5 cm/s) is correctly measured

b) Simple compass offset; errors in the measured current cancel

c) Variable compass offset; errors in mean current do not cancel







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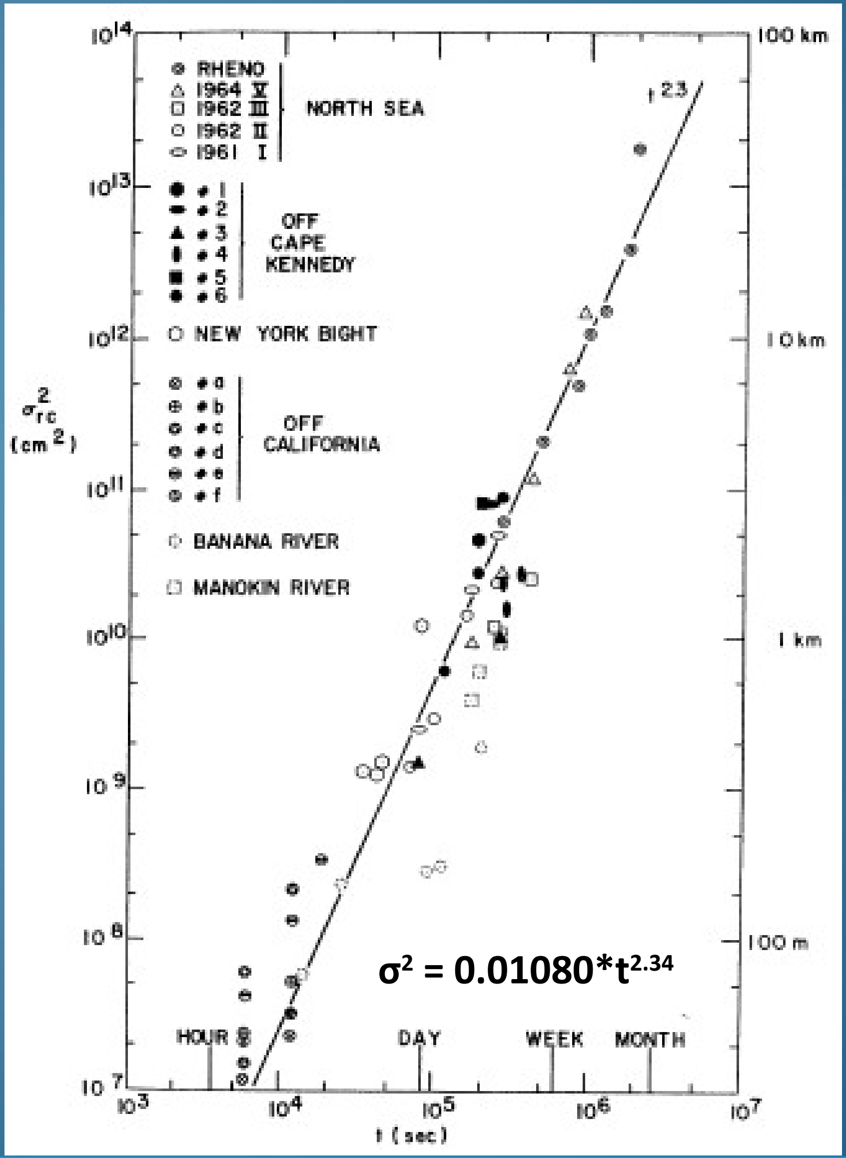
Epilogue – Strange gliders attracters

The Lagrangian view of natural variability:

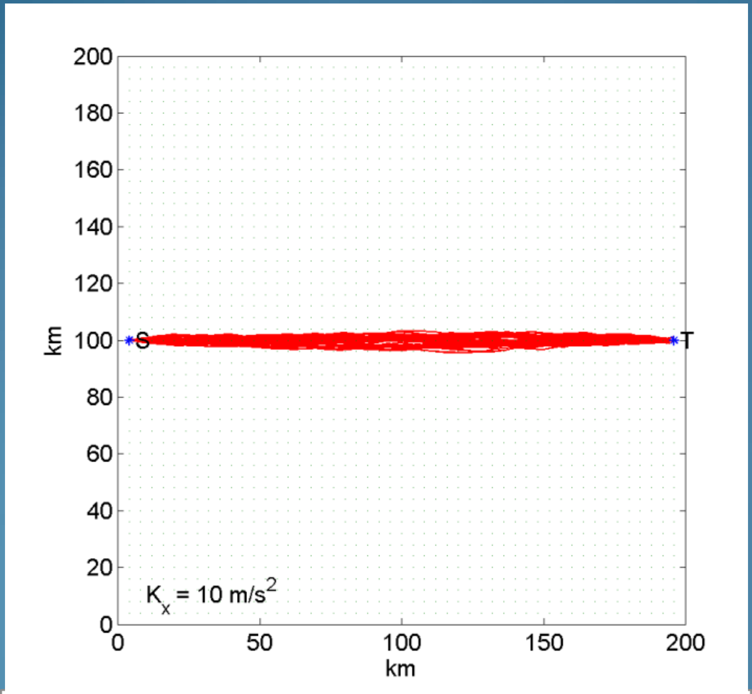
Turbulent diffusion exists at all scales in the ocean

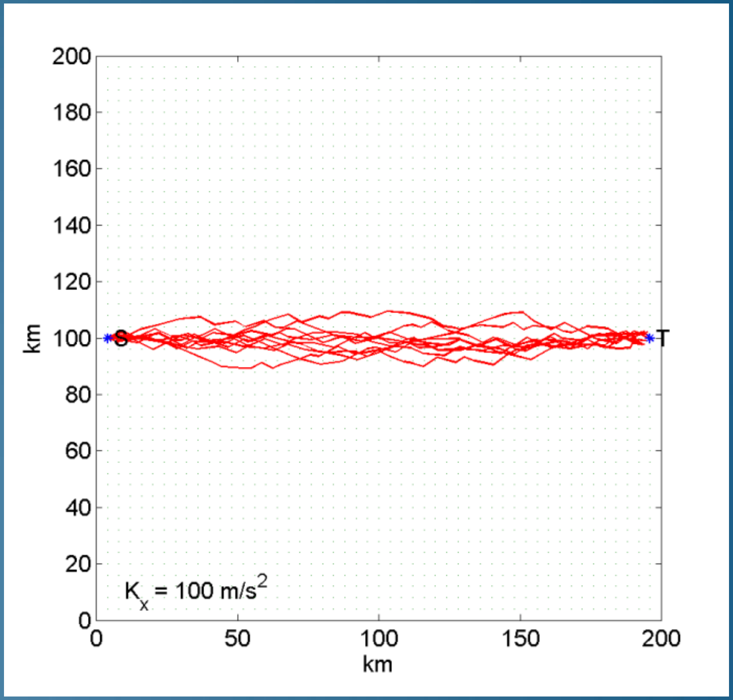


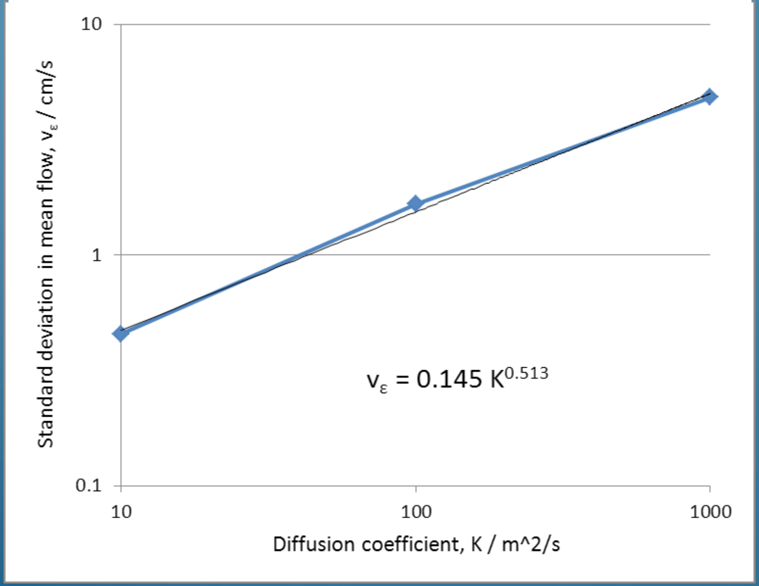
$\sigma^2 = 0.01080 * t^{2.34}$

Okubo, A (1969)
Johns Hopkins University, Technical Report 55

Does turbulence affect mean transport estimates?







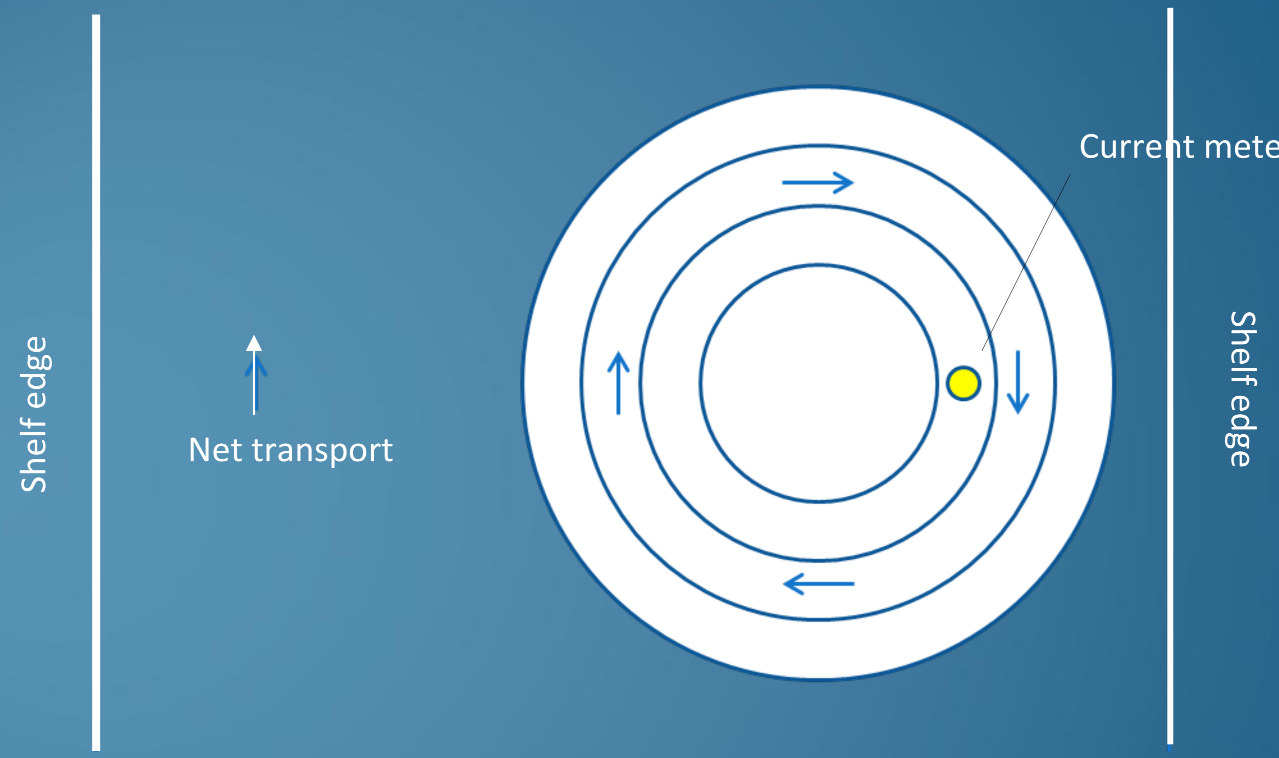
v_ε, the standard deviation in the apparent mean flow, scales with diffusivity as:

$$v_\varepsilon = 0.145\ K^{0.51}\ \mathrm{cm\ s^{-1}}$$

(assuming variance, $\sigma^2 = 2Kt$)

The Eulerian view of natural variability:

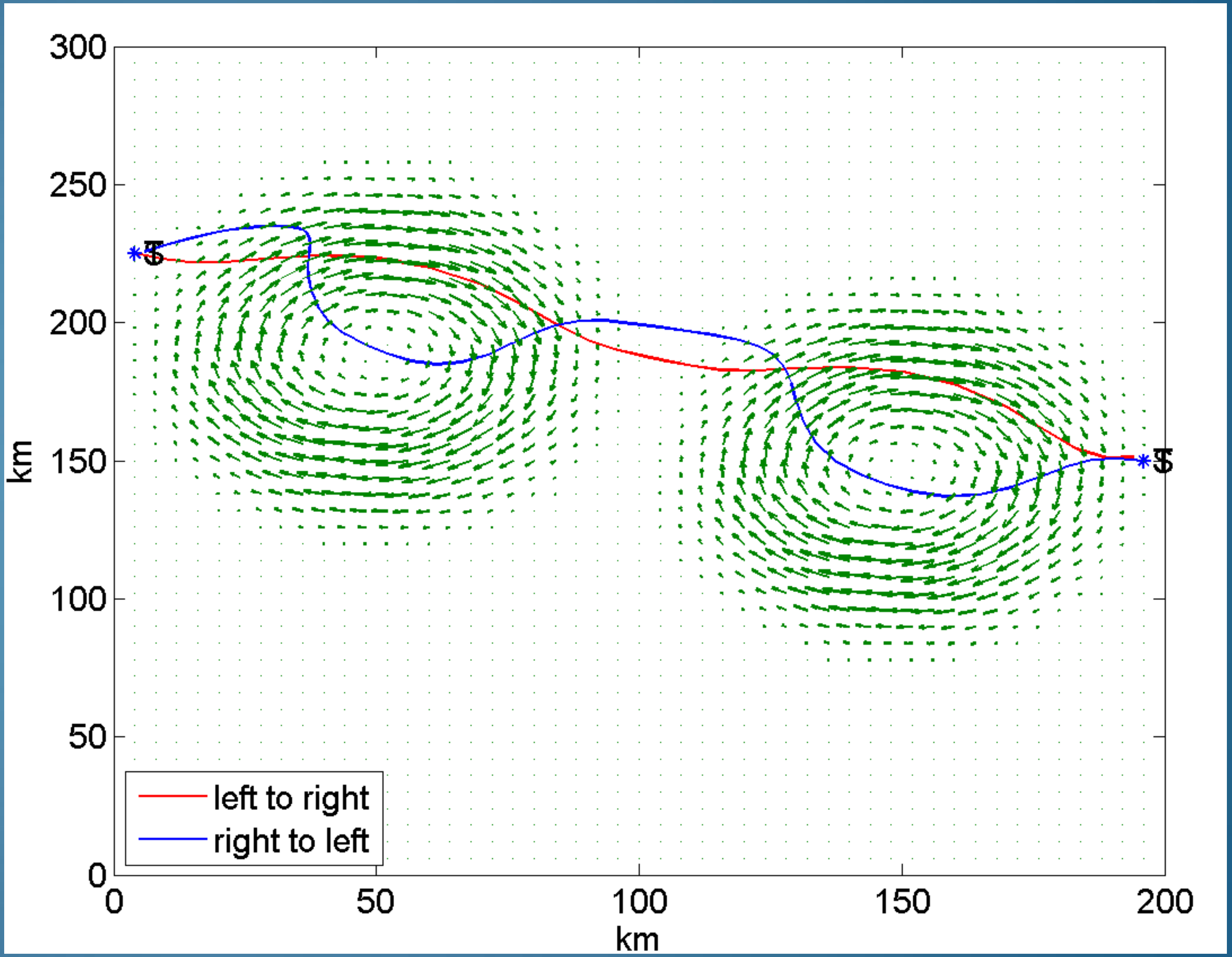
Eddy aliasing



Eulerian measurements of transport can be contaminated by a stationary eddy

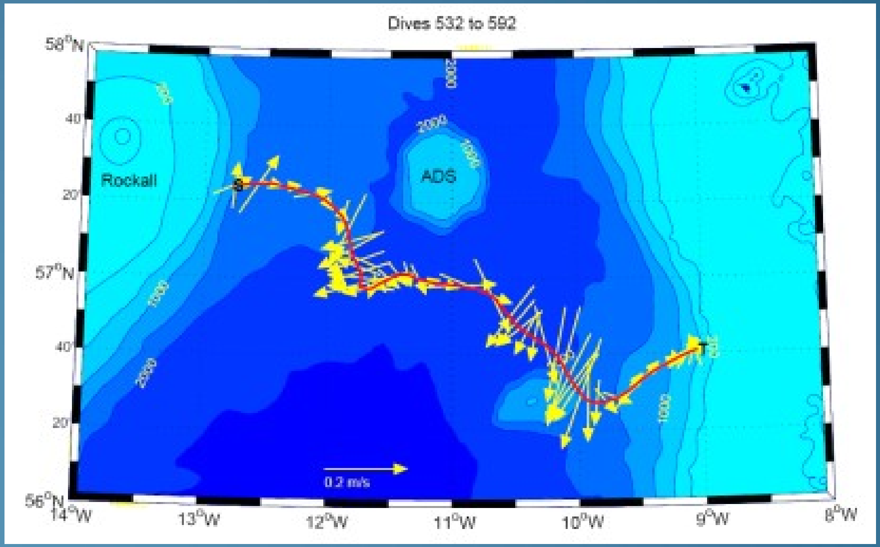
So do gliders make Eulerian or Lagrangian measurements?

Impact of eddy motion on mean transport estimates



Max eddy speed = 0.30 m s^{-1}, mean DAC = +3.7 cm s^{-1} or ~ 7.4 Sv
(no difference between traverses)

What do the Mission 1 observations tell us?



The standard deviations, σ, for all DACs are:

σ_u = 12.3 cm s^{-1} (E-W), σ_v = 13.8 cm s^{-1} (N-S)

Say 45 DAC estimates are independent, the error in the mean N-S <u>velocity</u> is:

$v_\varepsilon = 13.8/\sqrt{45} = 2.0$ cm s^{-1}

i.e the error in the section <u>transport</u> is:

$T_\varepsilon = \pm 4$ Sv

(assuming the Rockall Trough is 200 km wide)

Conclusions

1. Compass calibration errors can lead to false estimates of the mean transport, but …

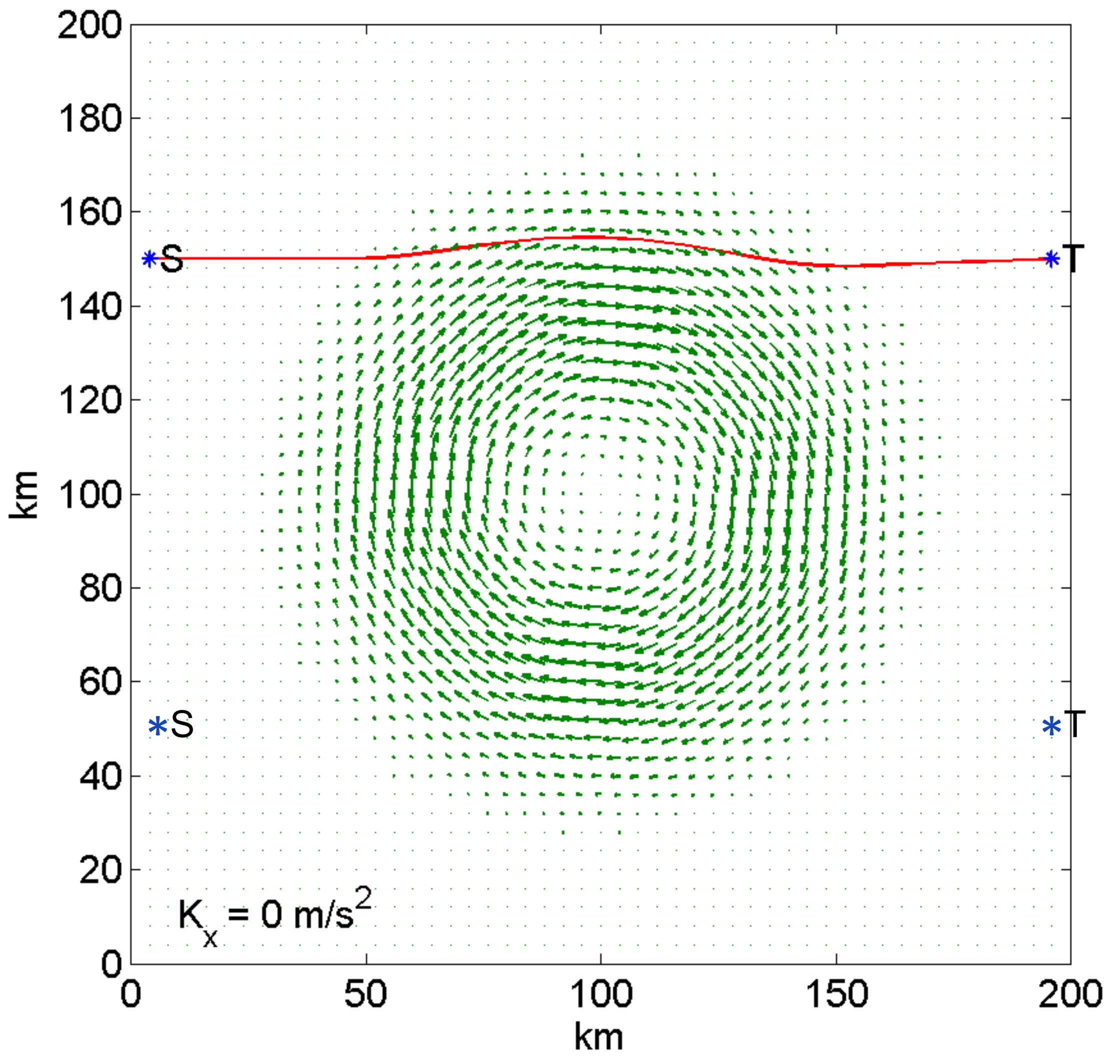
2. Mesoscale variability can lead to errors of similar magnitude

Thus:

- Estimates of transport from gliders are prone to error due to natural variability, and …

- Must be disregarded if the signal : noise ratio is too small

Now for the Epilogue (the fun bit) ...



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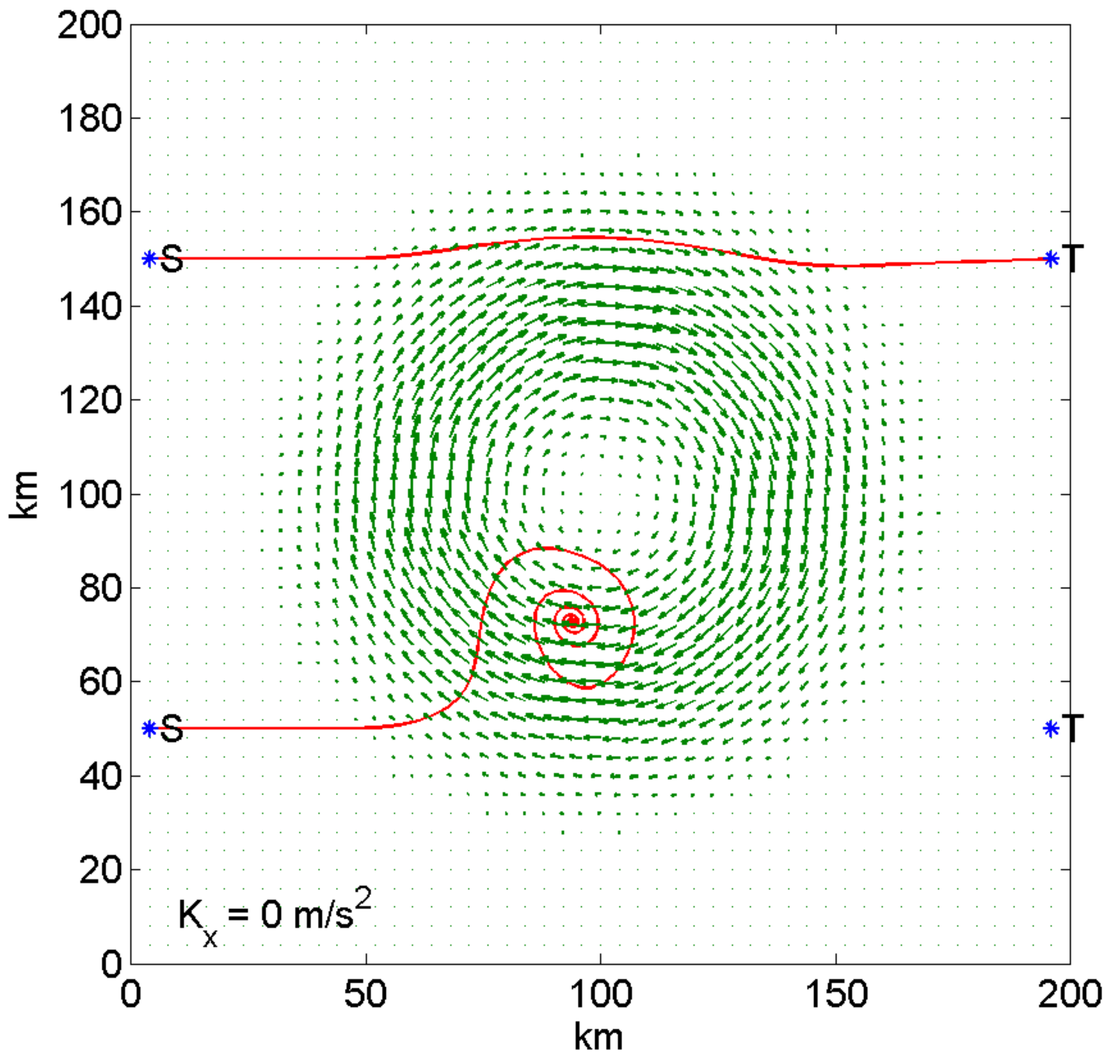

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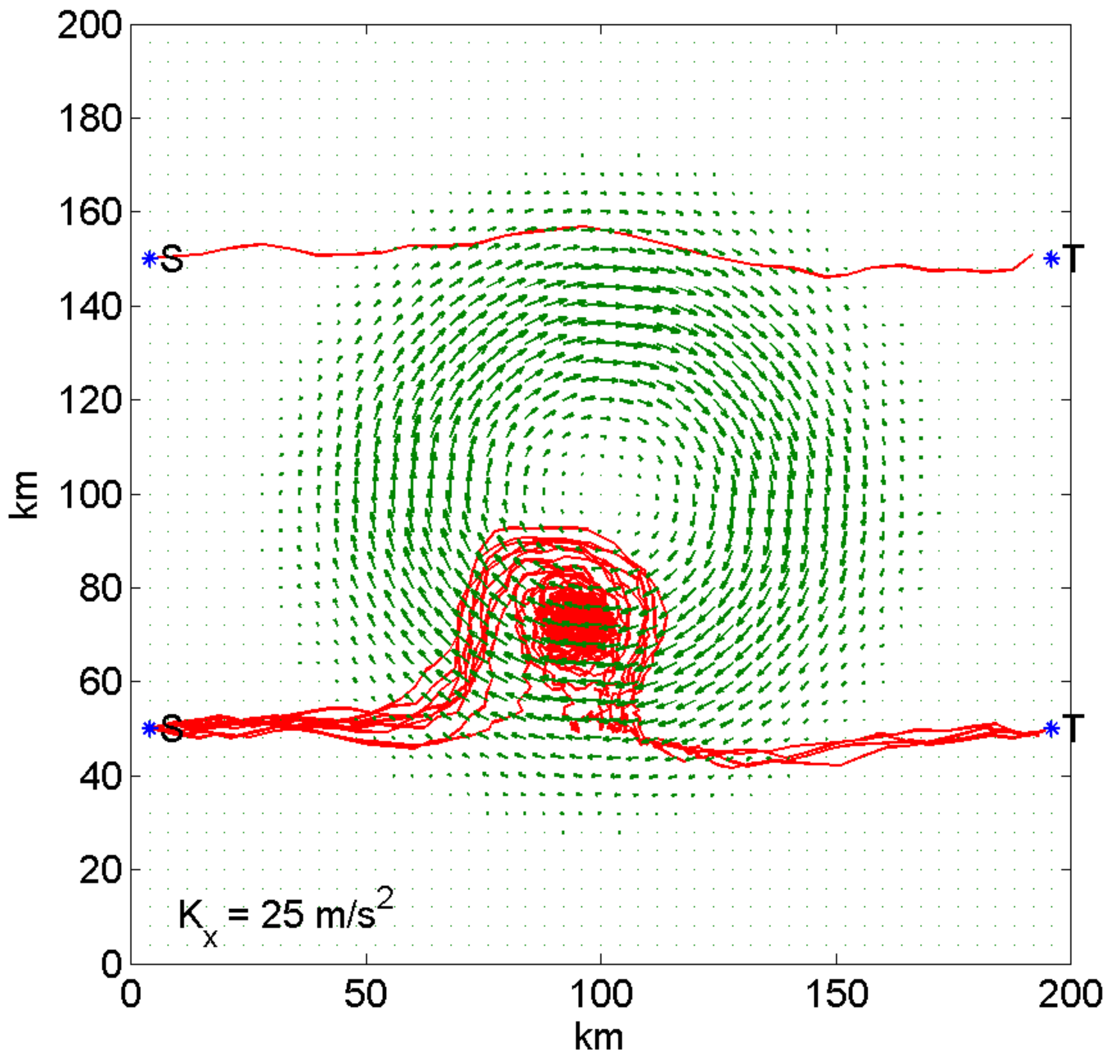

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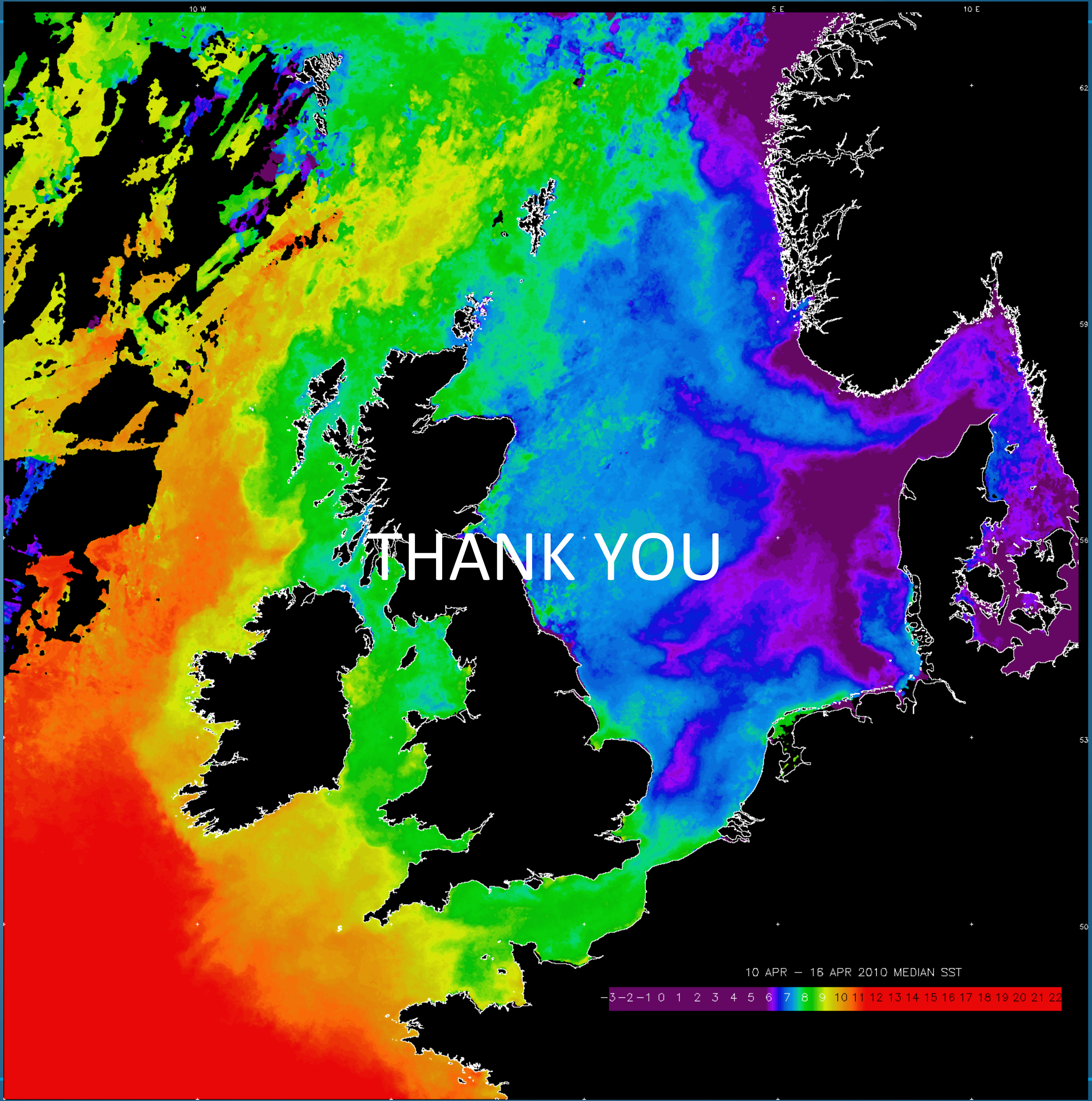
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THANK YOU

Pseudo glider tracks simulated with matlab routines

Pseudo glider speed through water: 0.25 m/s ; Dive duration: 6 h
Hence Δx = 5.4 km. This is broken down into 6 x 0.9 km segments which allow the ambient current to be modified every pseudo hour or 0.9 km

Step 1

Intended track is along Δx from S towards T

After deflection by the ambient current the achieved position is 1

Step 2

Repeats step 1 starting at position 1 and achieving position 2

T

Every 6 hours this algorithm is repeated until the pseudo glider is close to T

- An arbitrary ambient current field is specified, which can include eddies and mean flows
- Diffusion can be added using a random walk (randomly rotating vector method)
- Compass errors deflect the intended track