ENSO and short-term variability of the South Equatorial Current

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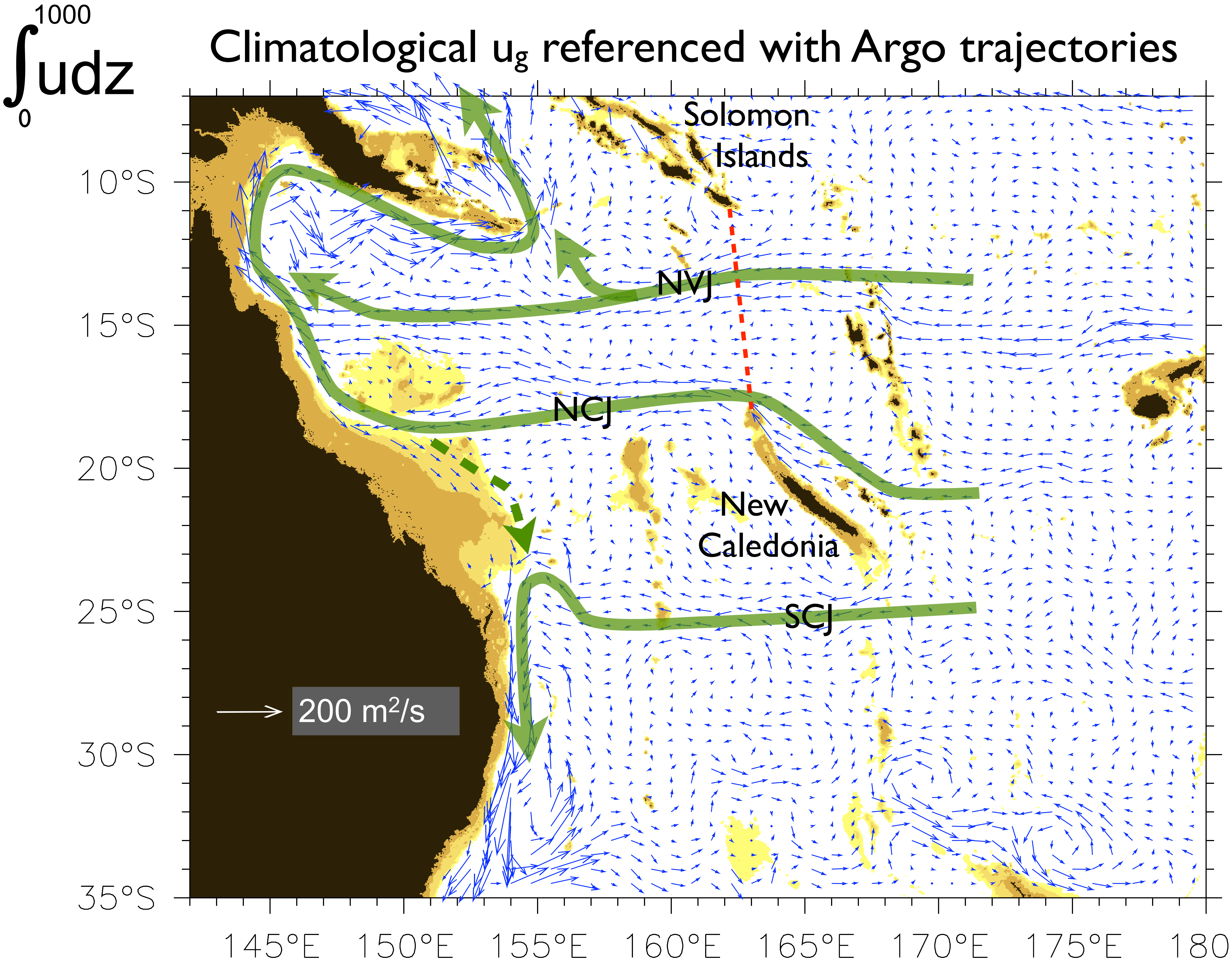
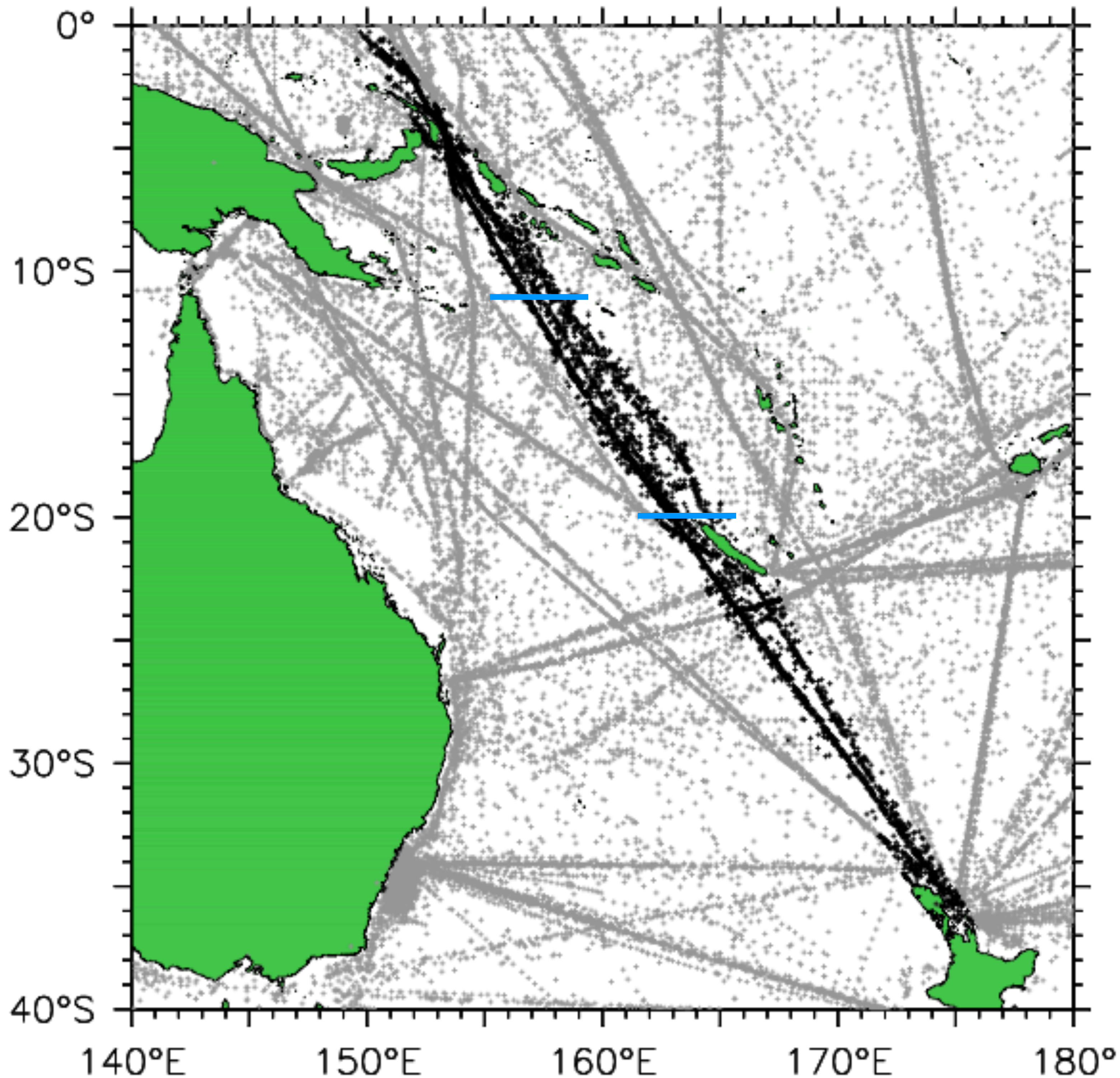
NOAA / PMEL (USA) IRD (France)

- Extend transport estimates back to 1985 using XBT data
- ENSO signal: (*y*,*z*) structure and a simple Rossby model
- Compare with transport entering the Solomon Sea from glider data
- Strong mesoscale eddy aliasing .... consequences

Mean circulation splits around N. Caledonia: SEC (mostly) flows to Solomon Sea



XBT data along the Auckland-Solomon St track



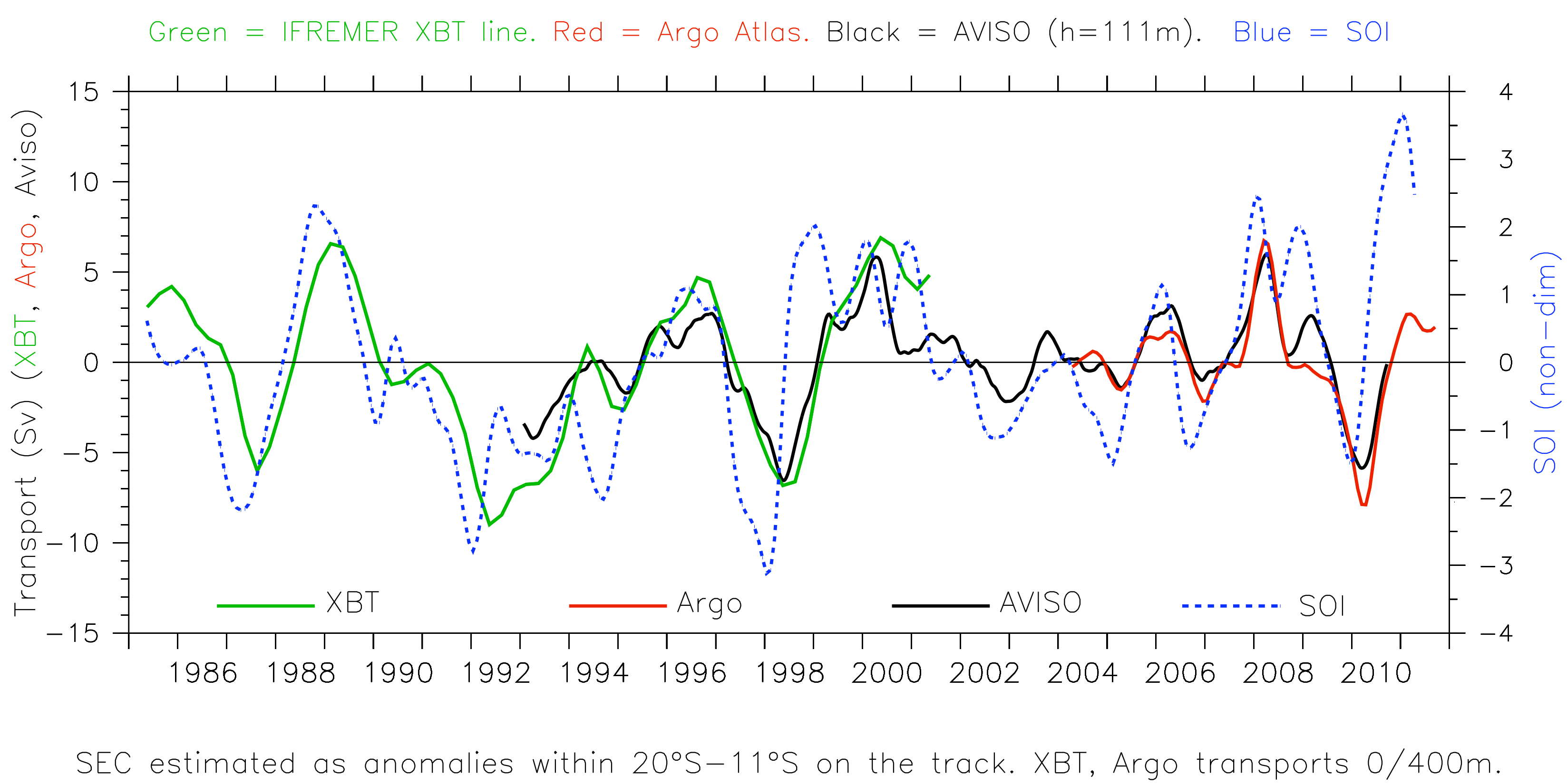
3917 profiles 1985-2000
1346 between 20°S-11°S
(~1 profile / 1.3°lat / month)

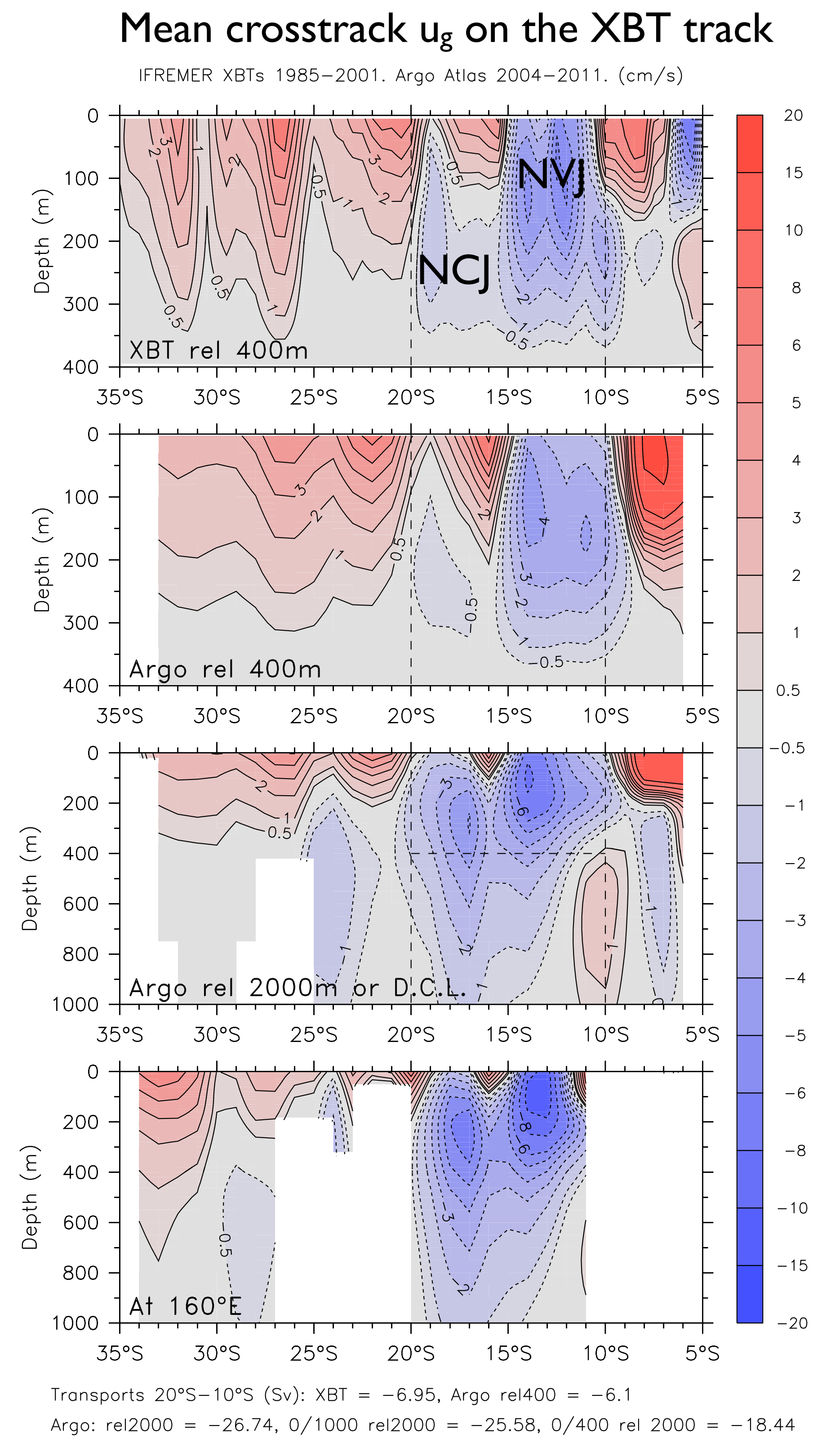
To 400m: not deep enough for the mean, but gets most of the interannual variabilty (test with Argo since 2004).

Transport on the XBT track

0-400m XBT transport is insufficient for the mean, but represents most of the interannual variance (test with Argo Atlas data during 2004-2010).

SEC velocity/transport anomalies on the XBT track: highly correlated with ENSO (2-4 month lag)

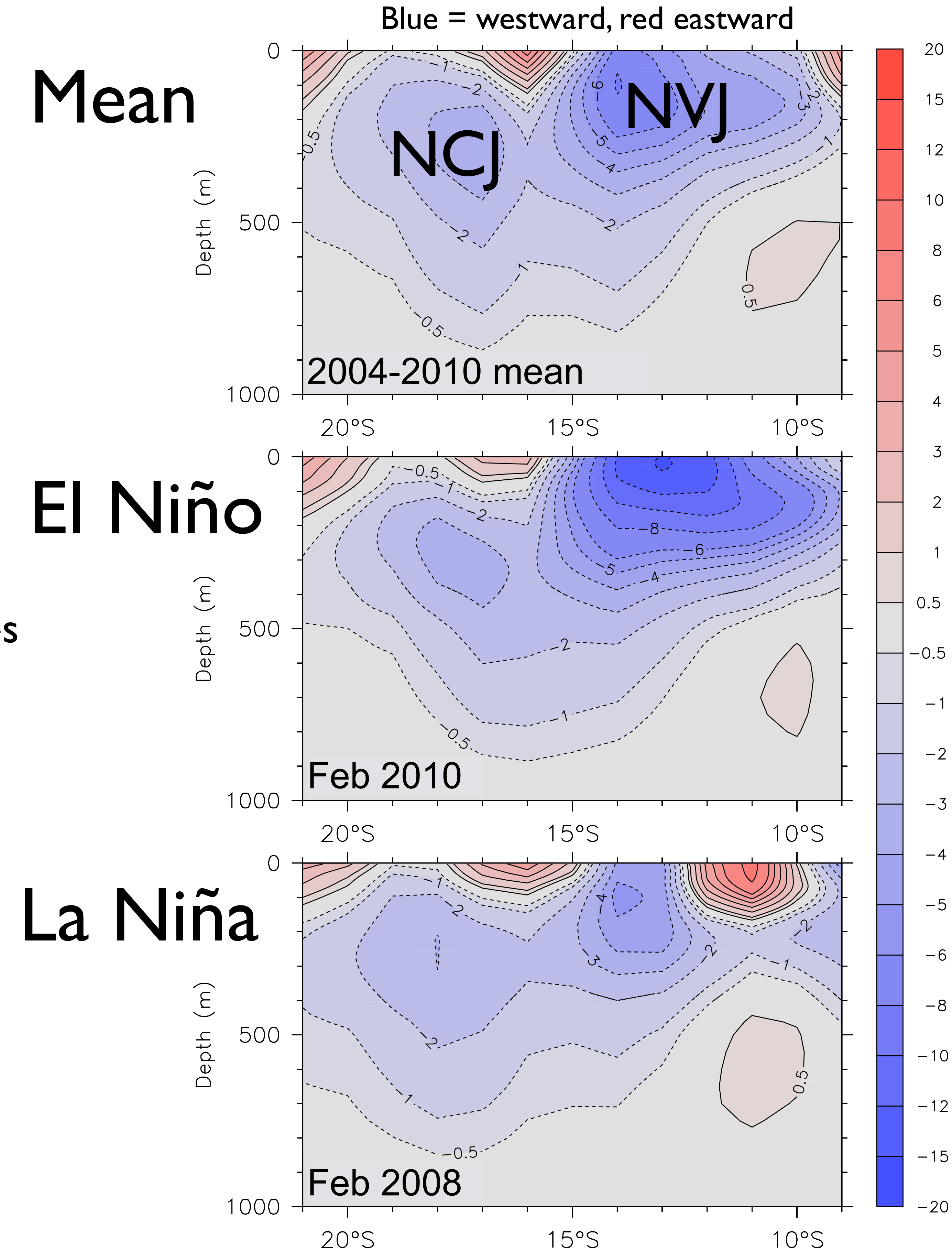




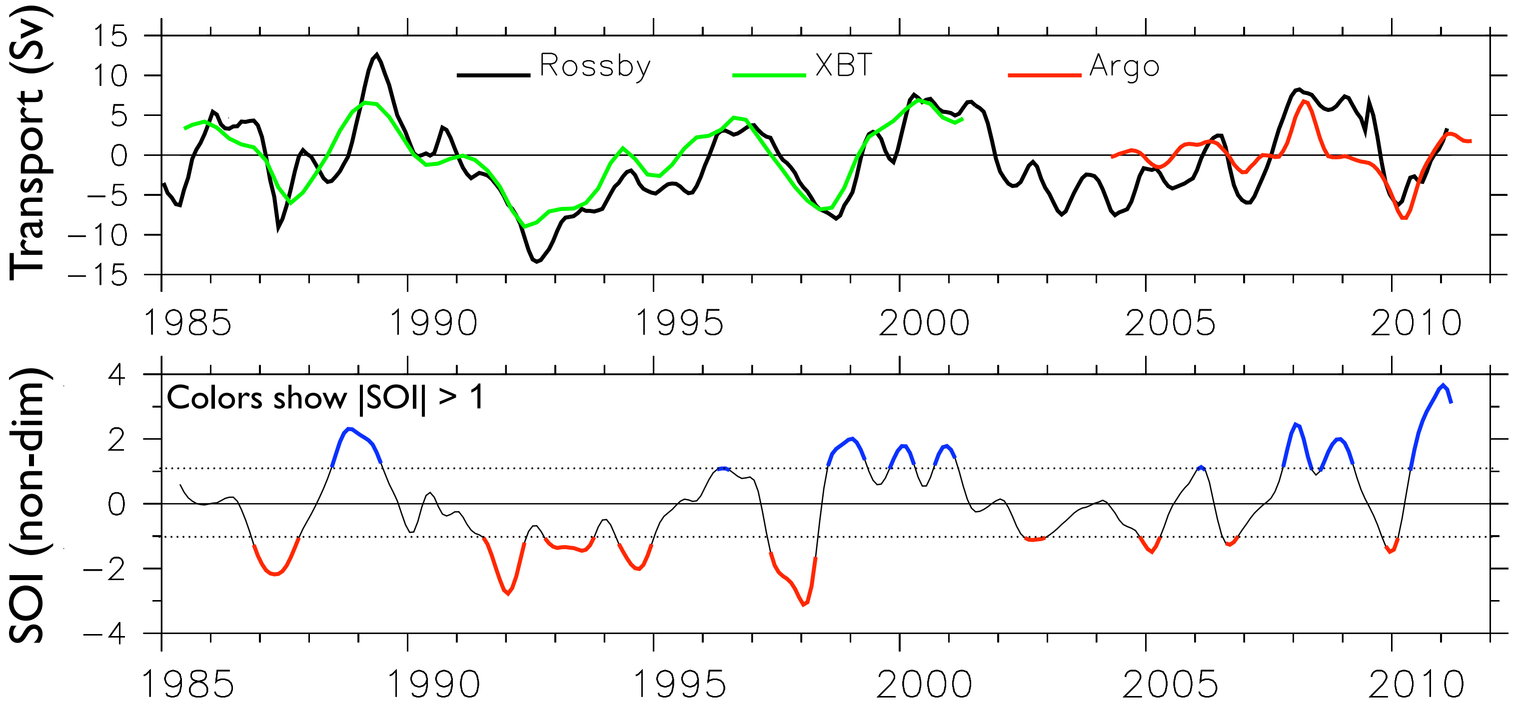
While the XBT and Argo data do not overlap, Aviso spans both.

ENSO anomalies are focused shallow and close to the equator

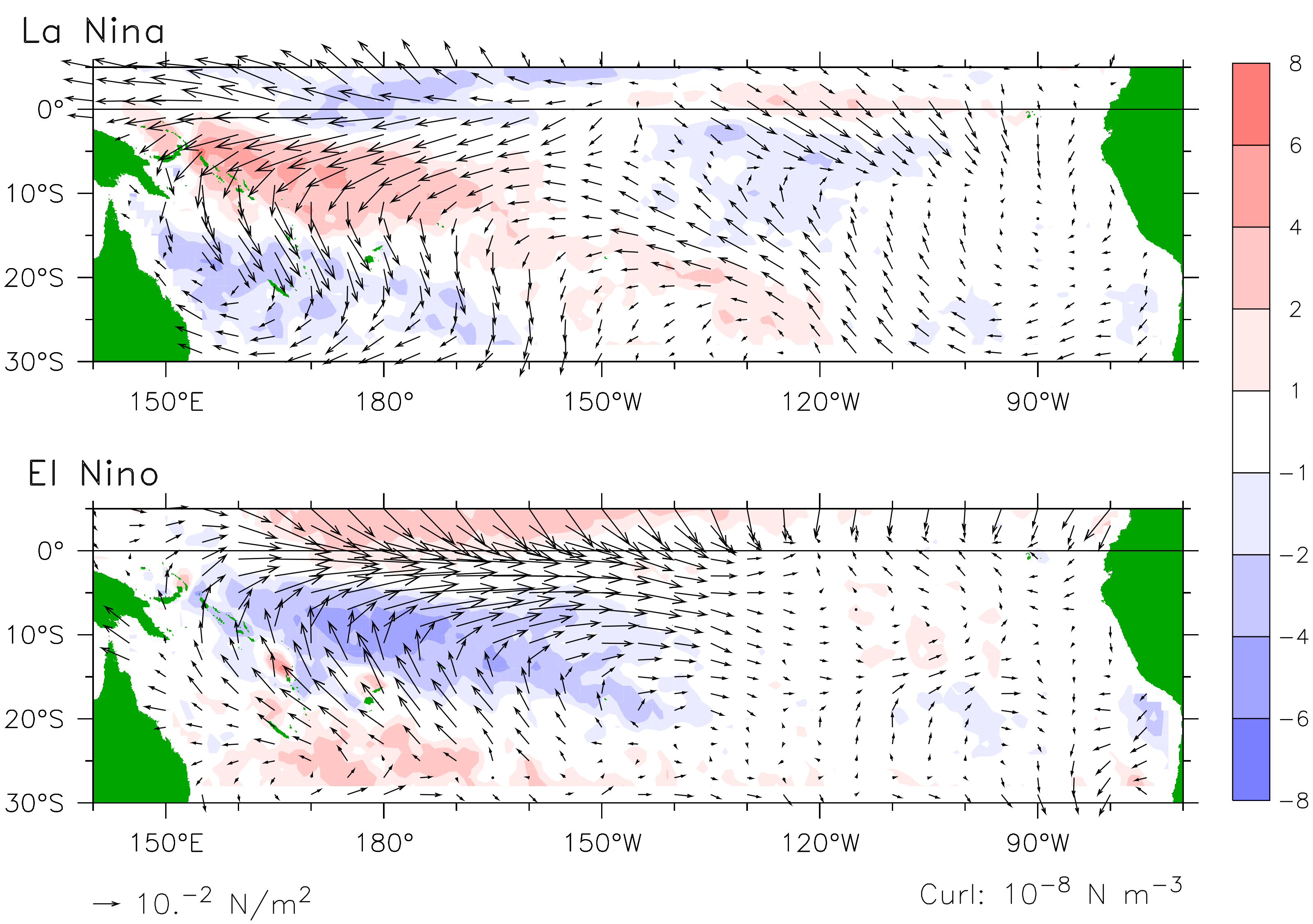
- Much larger anomalies in the NVJ (<15°S), Very little change in the NCJ.
- Surface intensification ⇒ Aviso is a good index of transport anomalies.
- Best-fitting implies a scale depth of 111m for 0-400m interannual transport anomalies (183m for 0-2000m)



Interannual SEC transport anomalies are well represented by a simple Rossby model



$$\frac{\partial h}{\partial t} + c_r \frac{\partial h}{\partial x} + Rh = -Curl\left(\frac{\tau}{f\rho}\right), \qquad c_r = -\beta \frac{c^2}{f^2}$$



Curl averaged over ENSO phases:

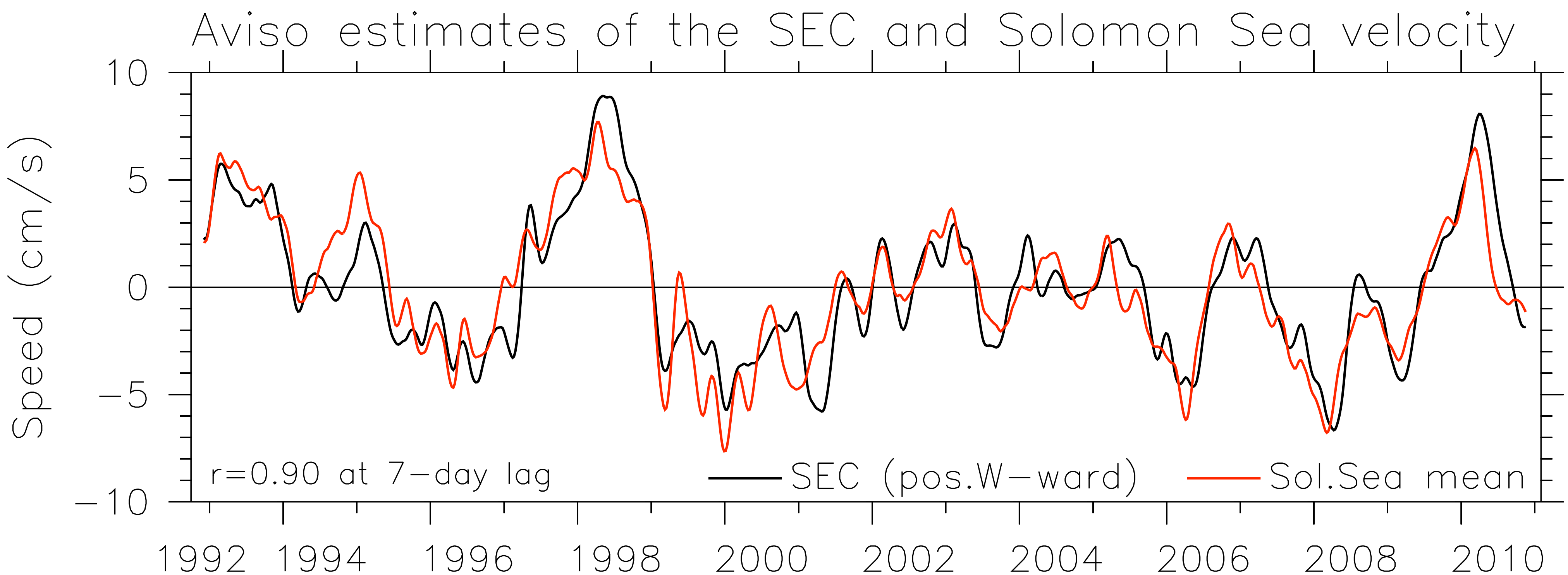
Red = downwelling

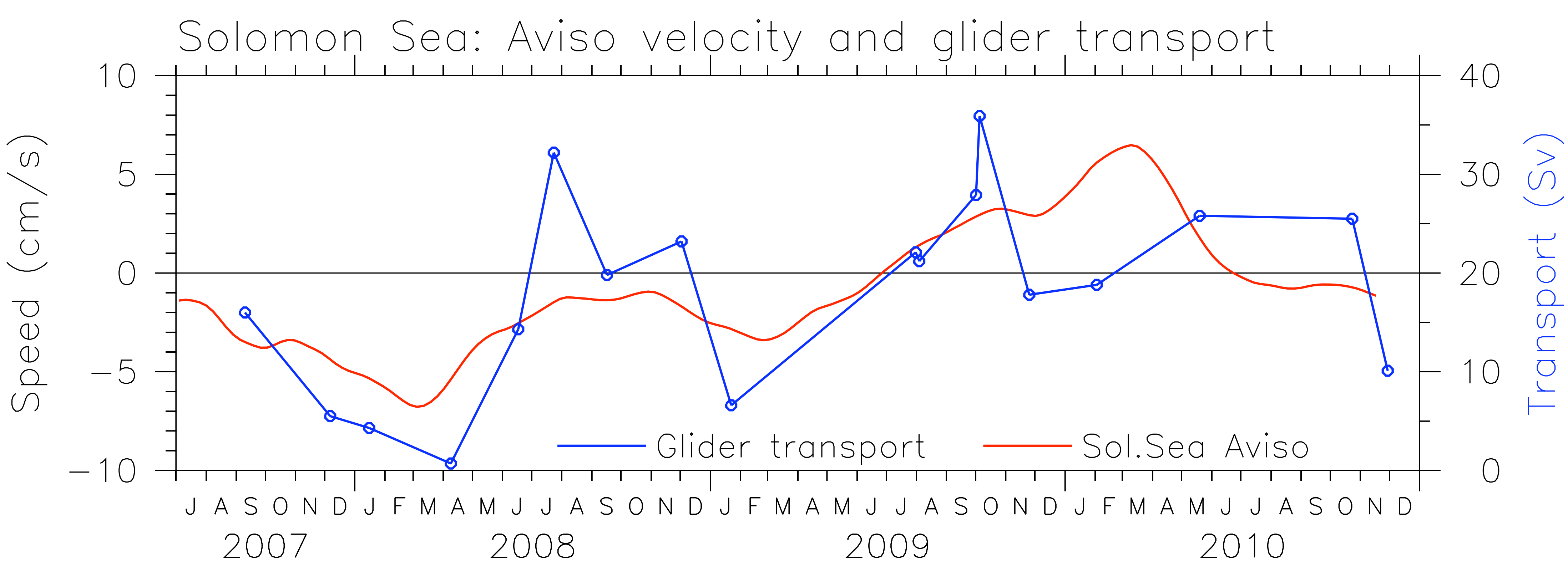
Blue = upwelling

La Niña: Curl pattern reduces the thermocline slope across the SEC and weakens its transport.

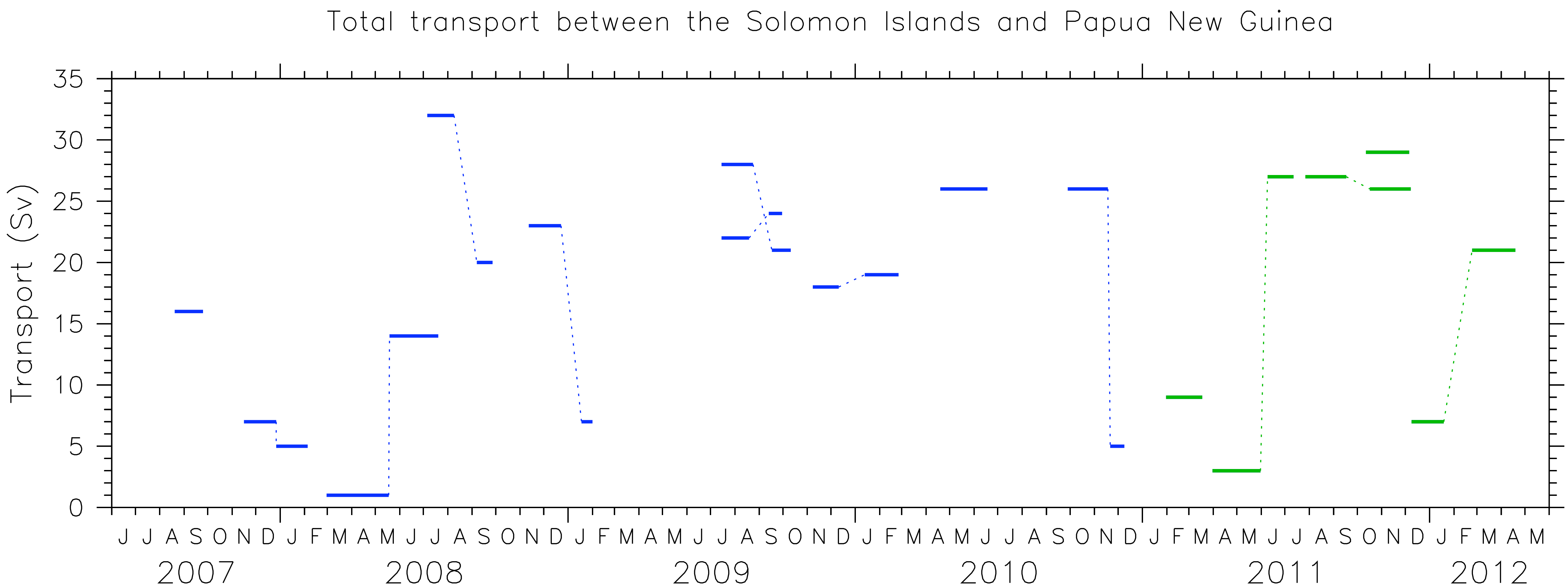
El Niño curl does the opposite.

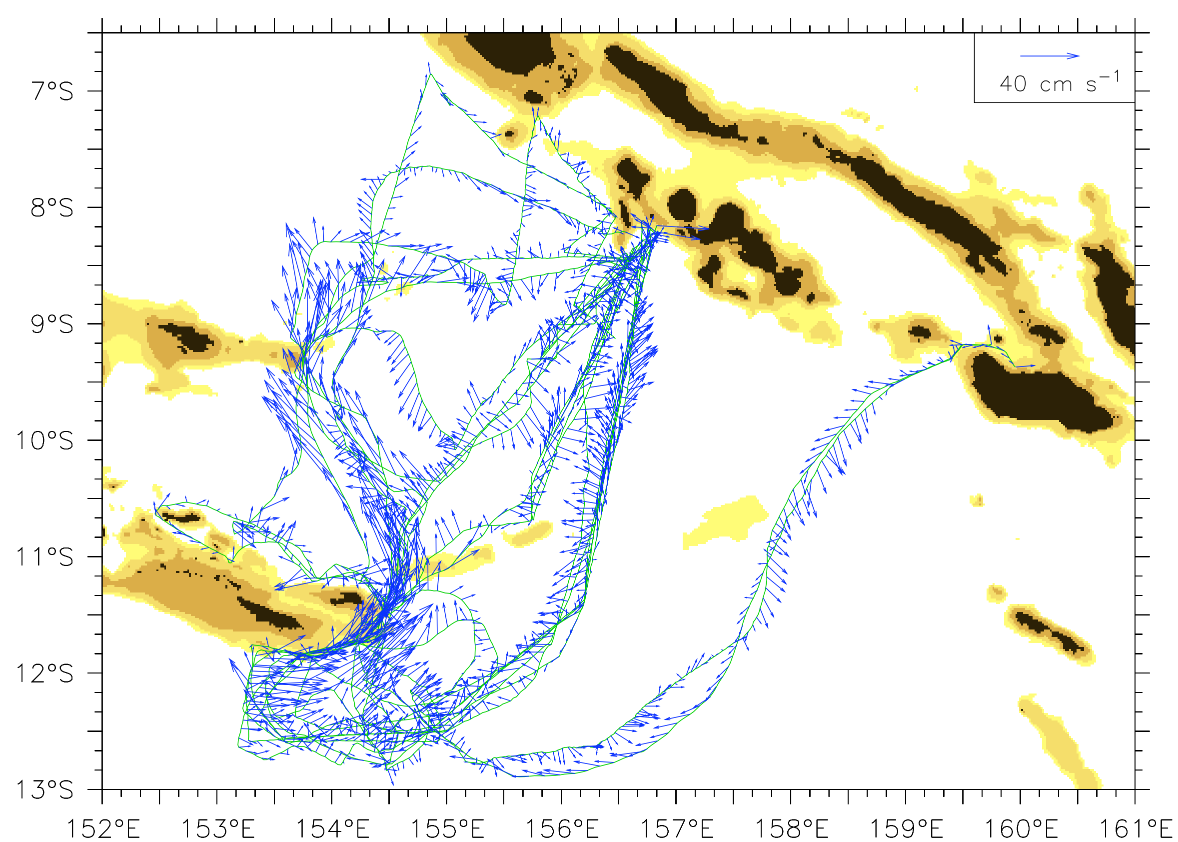
Solomon Sea Aviso surface v_g is very similar to the SEC





Solomon Sea transport measured by the Spray glider





(Blue = corrected, green = raw)

(Lots of short-term variability!
Even with more than 5 sections/yr,
we are barely resolving the ENSO cycle)

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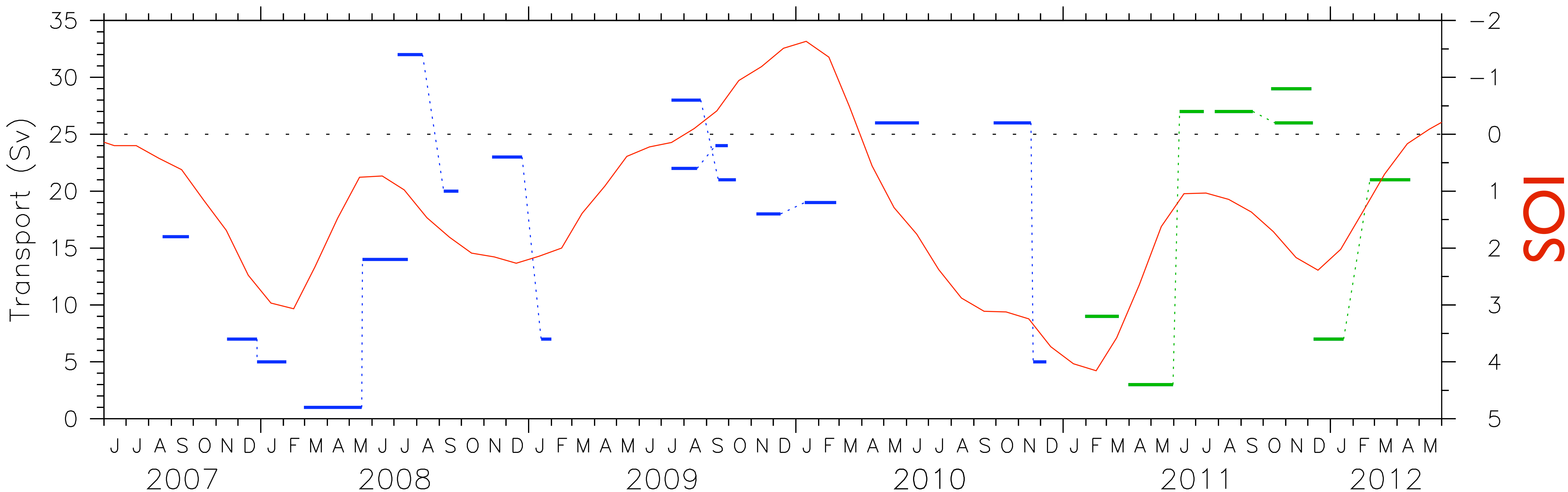

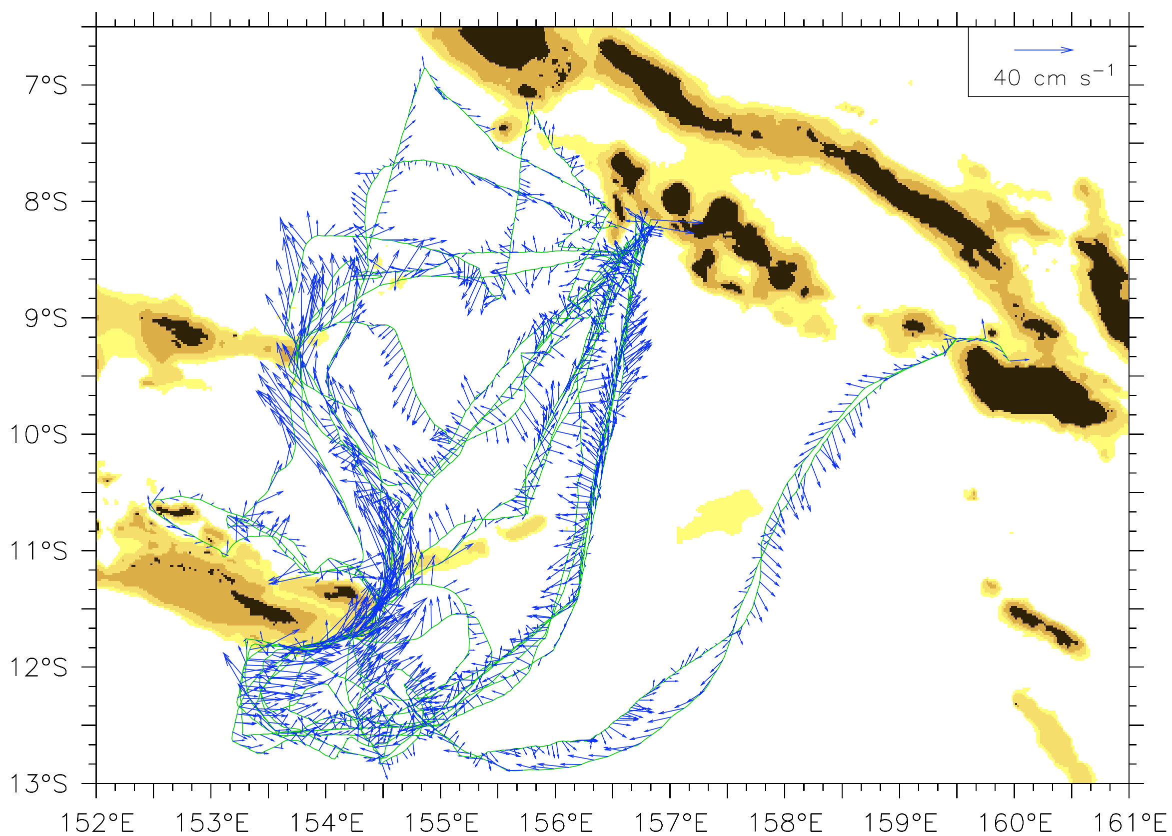

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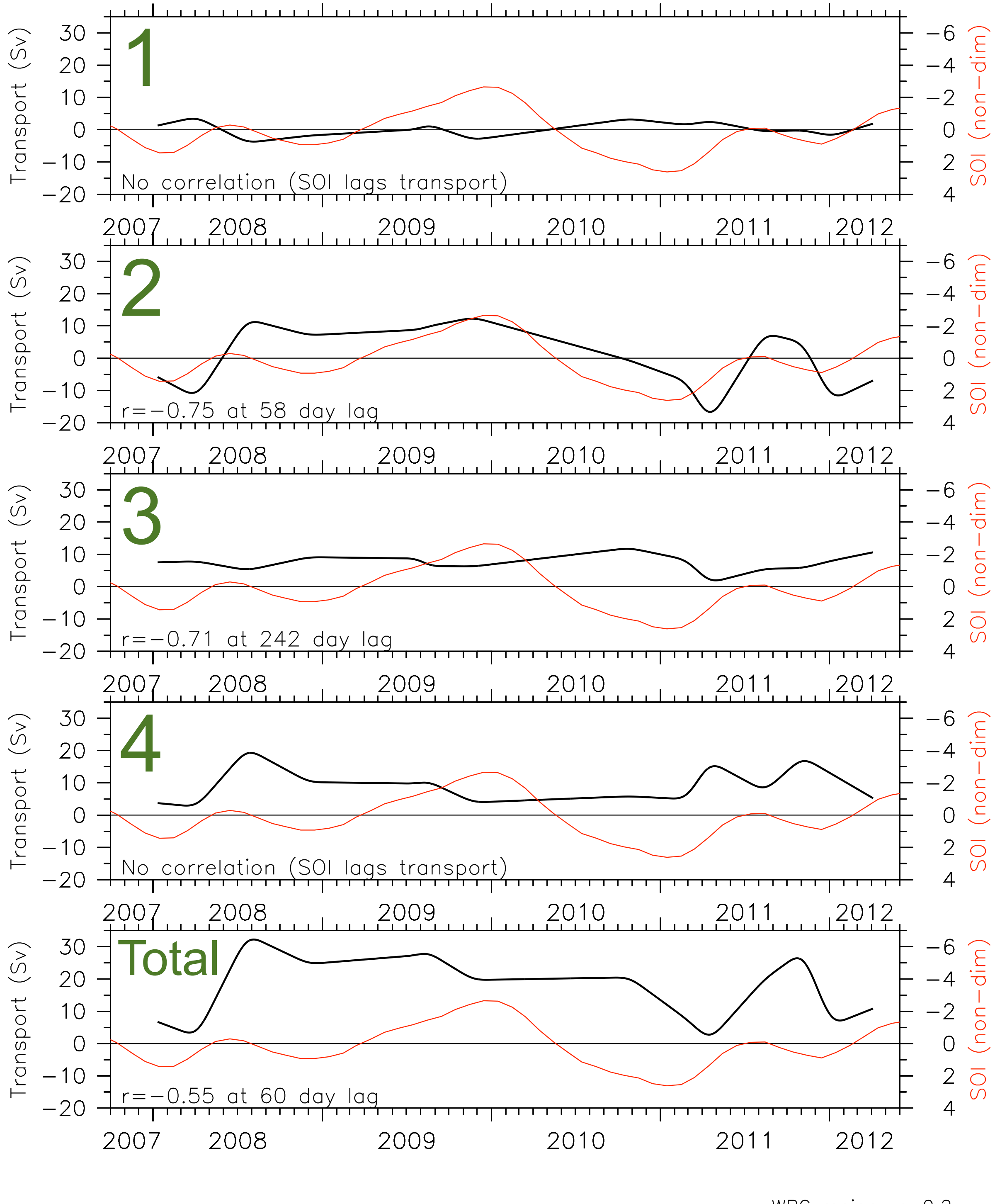
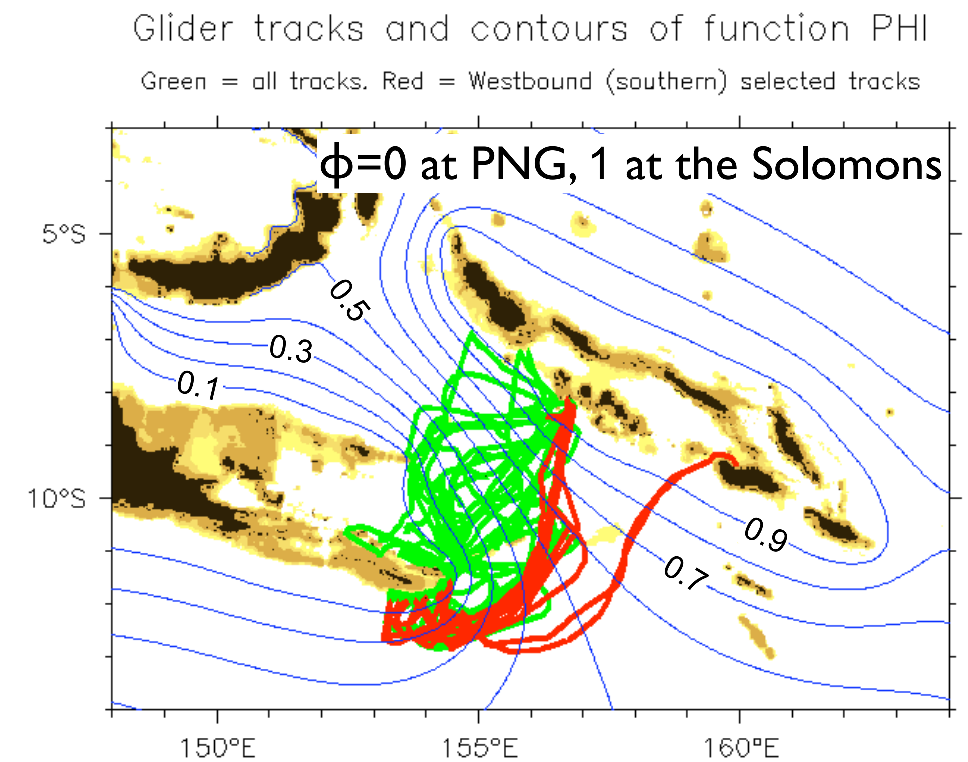
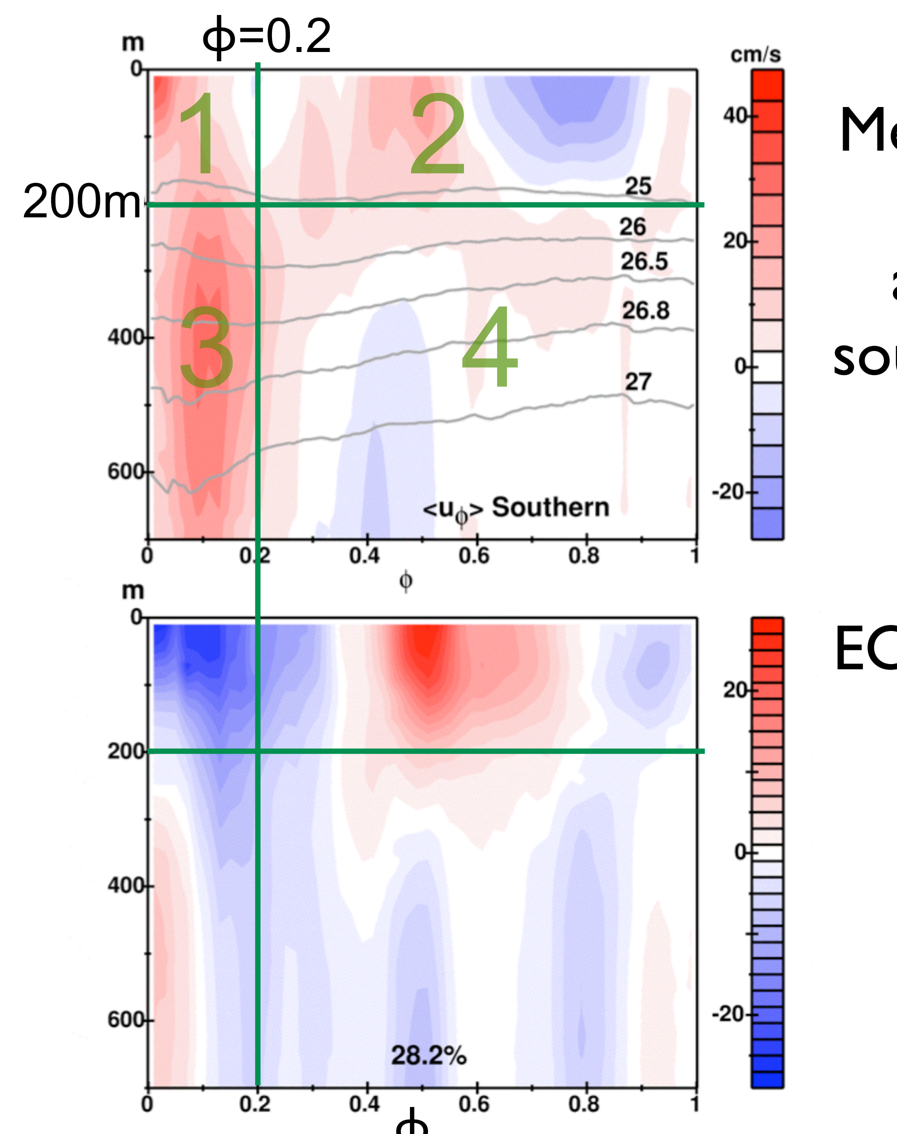
ENSO transport variability entering the Solomon Sea is focused in the upper center of the Sea: Glider data

Glider transport time series by region and SOI







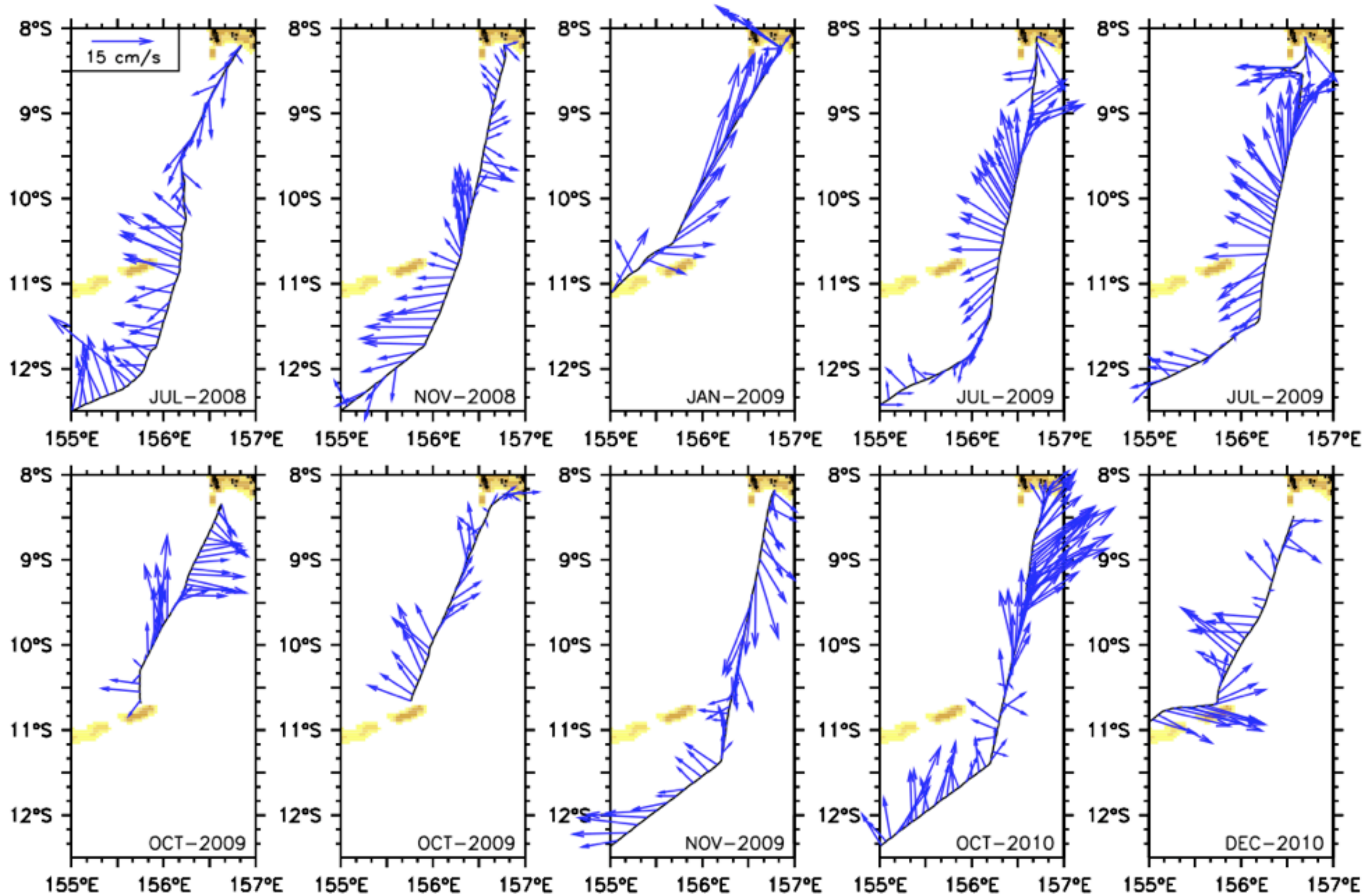
Mean eq-ward velocity across the southern track

EOF 1

(Davis et al. 2012)

Can we measure transport from sparse (ship, glider) sampling?

Examples of absolute 0-700m velocity measured by the Spray glider in the eastern Sol. Sea.
Substantially different patterns even a few weeks apart.
Eddy scales are 50-200km



3 repeat tracks in less than 6 weeks

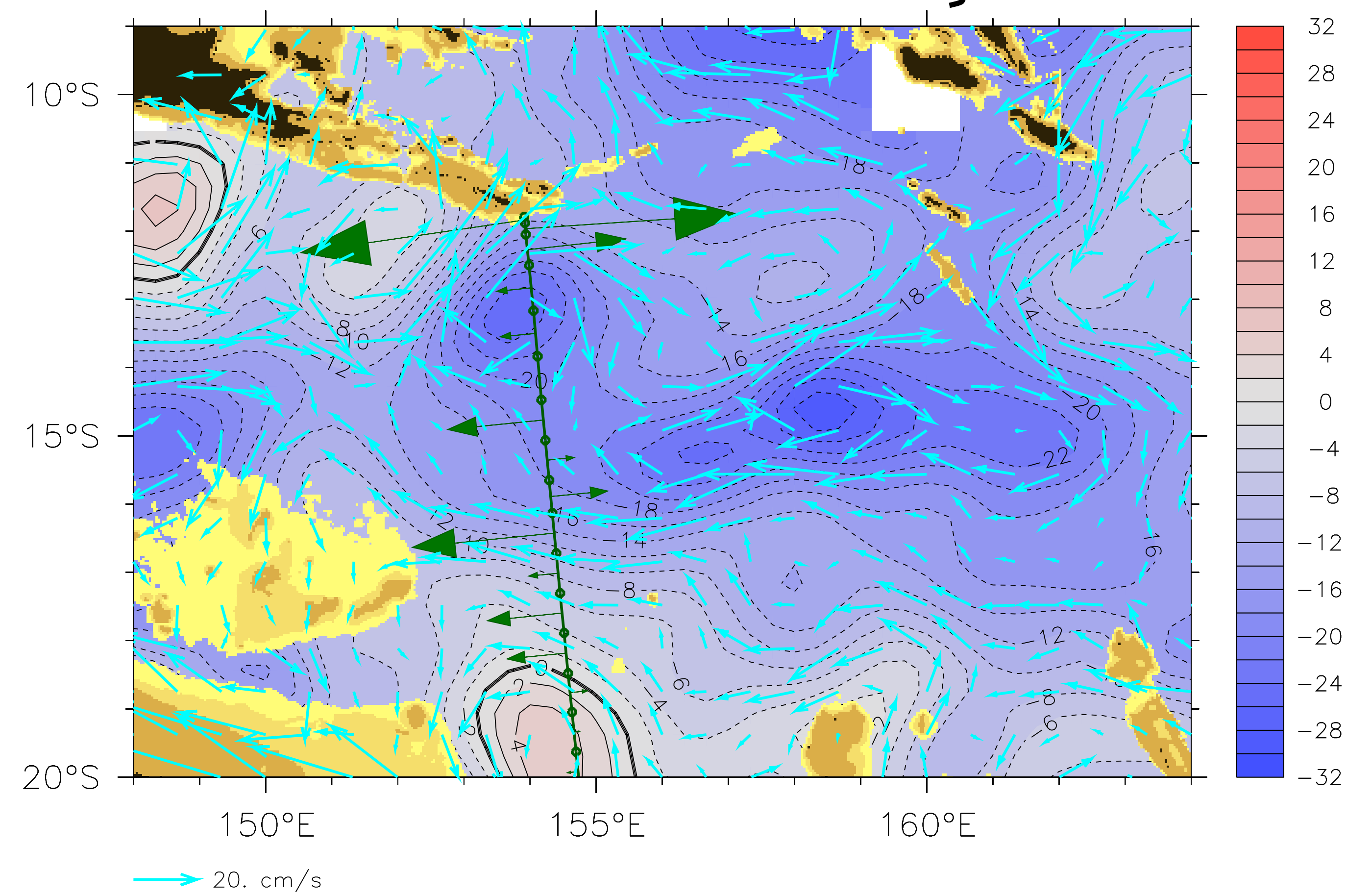
Can we measure transport from sparse (ship, glider) sampling?

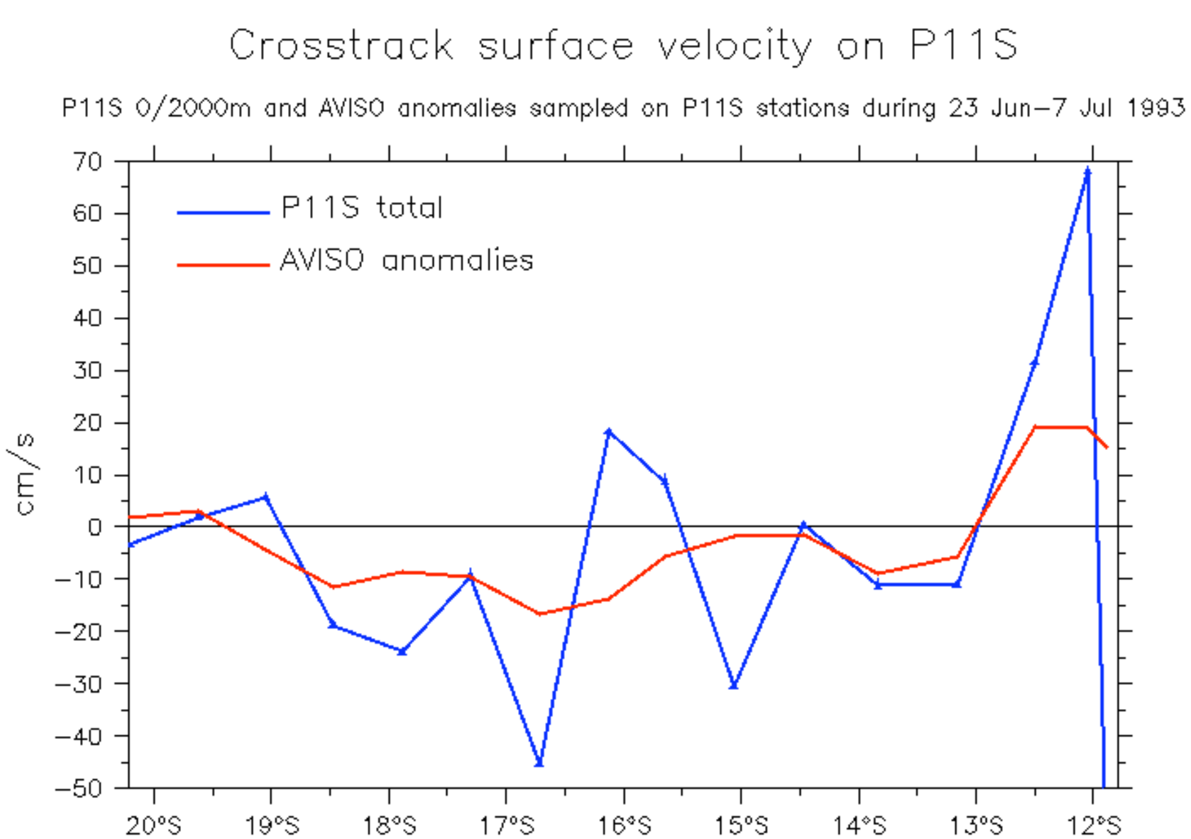
The ubiquitous eddies revealed by altimetry produce aliasing in snapshot samples of u_g, or absolute u from the glider.

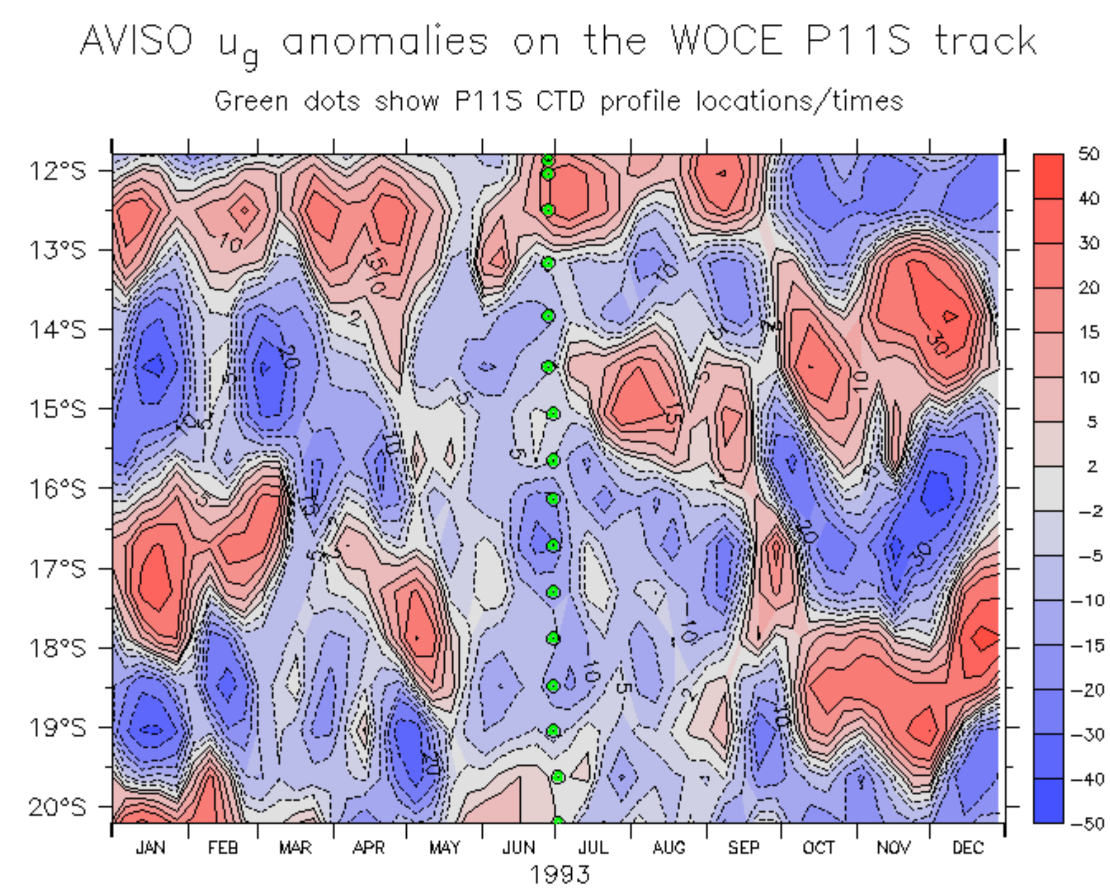
The WOCE P11S cruise (Sokolov & Rintoul 2000), probably the most authoritative sampling across the Coral Sea, estimated SEC transport about twice as large as other estimates.

Unfortunately, the P11S data was strongly aliased (westward) by mesoscale eddies, amounting to perhaps 1/3 the estimated transport.

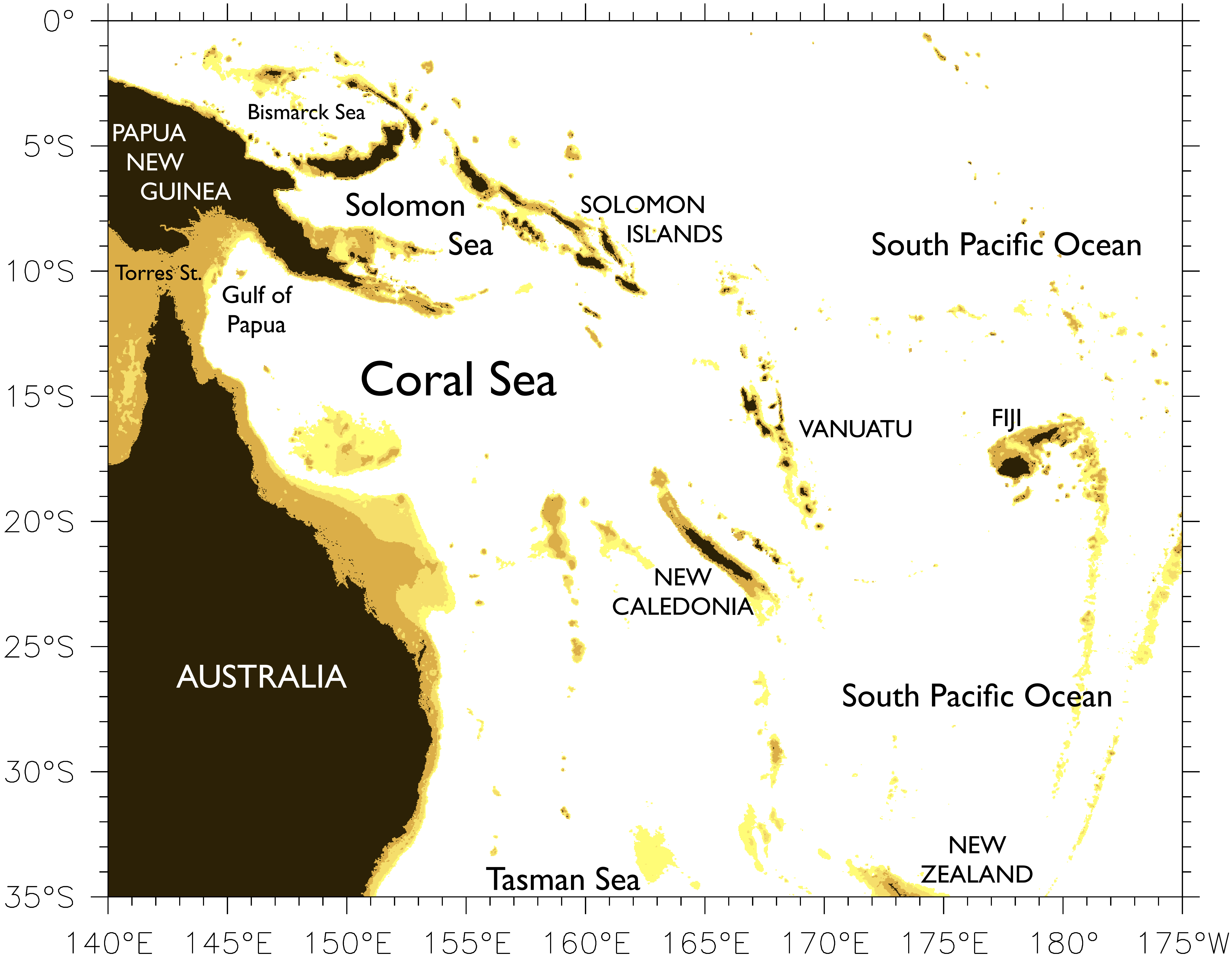
Aviso SLA and u_g (blue vectors)
P11S track and surface u_g (green)
} 23 Jun-7 Jul 1993







Extra Figures


0°
5°S
10°S
15°S
20°S
25°S
30°S
35°S
140°E
145°E
150°E
155°E
160°E
165°E
170°E
175°E
180°
175°W
Bismarck Sea
PAPUA NEW GUINEA
Solomon Sea
SOLOMON ISLANDS
South Pacific Ocean
Torres St.
Gulf of Papua
Coral Sea
VANUATU
FIJI
NEW CALEDONIA
AUSTRALIA
South Pacific Ocean
NEW ZEALAND
Tasman Sea

Deducing western boundary current anomalies from the interior Rossby solution

- By its neglect of velocity acceleration terms, friction and nonlinearity, the long Rossby model explicitly excludes western boundary dynamics.
- But, the WBC can be deduced as an equatorward accumulation of the incoming zonal transport due to Rossby waves (Godfrey 1975, Appendix B.2).

In the reduced gravity system, the WBC transport anomaly is:

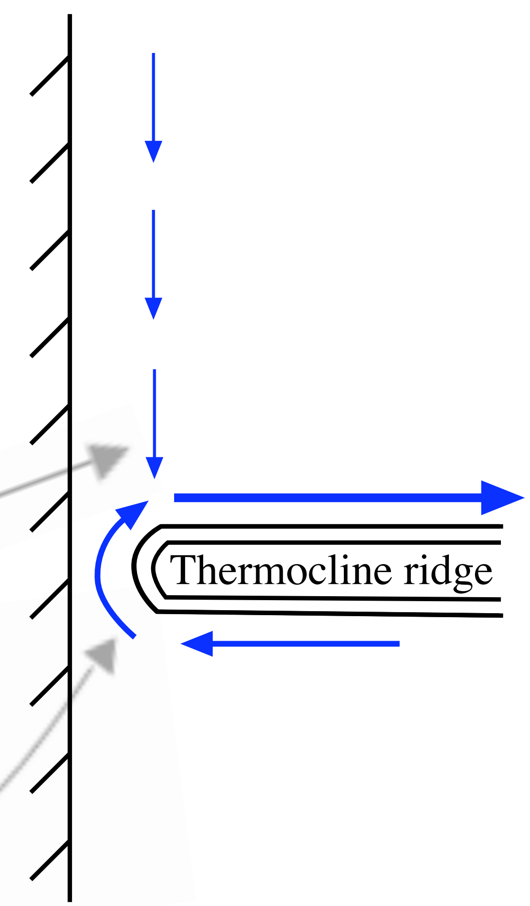
$$V(y) = V_S - \int_{y_S}^{y} u_{RW}\, dy' = V_S + \int_{y_S}^{y} \frac{c^2}{f}\frac{\partial h_{RW}}{\partial y'} dy'$$

$$= V_S + c^2 \left(\frac{h_{RW}(y)}{f} - \frac{h_{RW}(y_s)}{f_S} + \int_{y_S}^{y} \frac{\beta}{f^2} h_{RW}\, dy' \right)$$

Direct effect of Rossby h-field

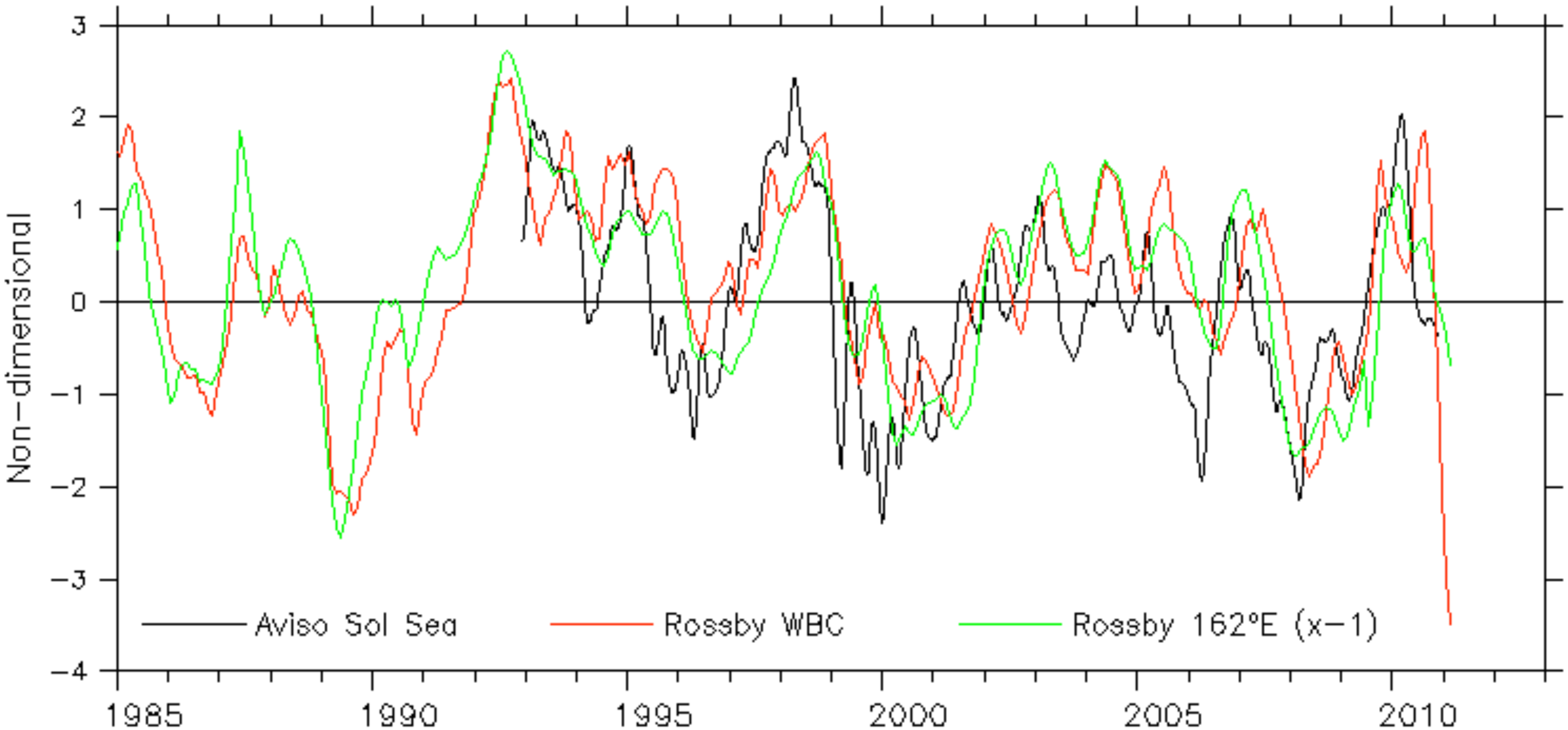
Constant term. Cancels at y_S

β-term. Mismatch of u_{RW}



Estimates of transport entering the Solomon Sea

Aviso surface mean v_g, Rossby model WBC and SEC. All non-dimensional.



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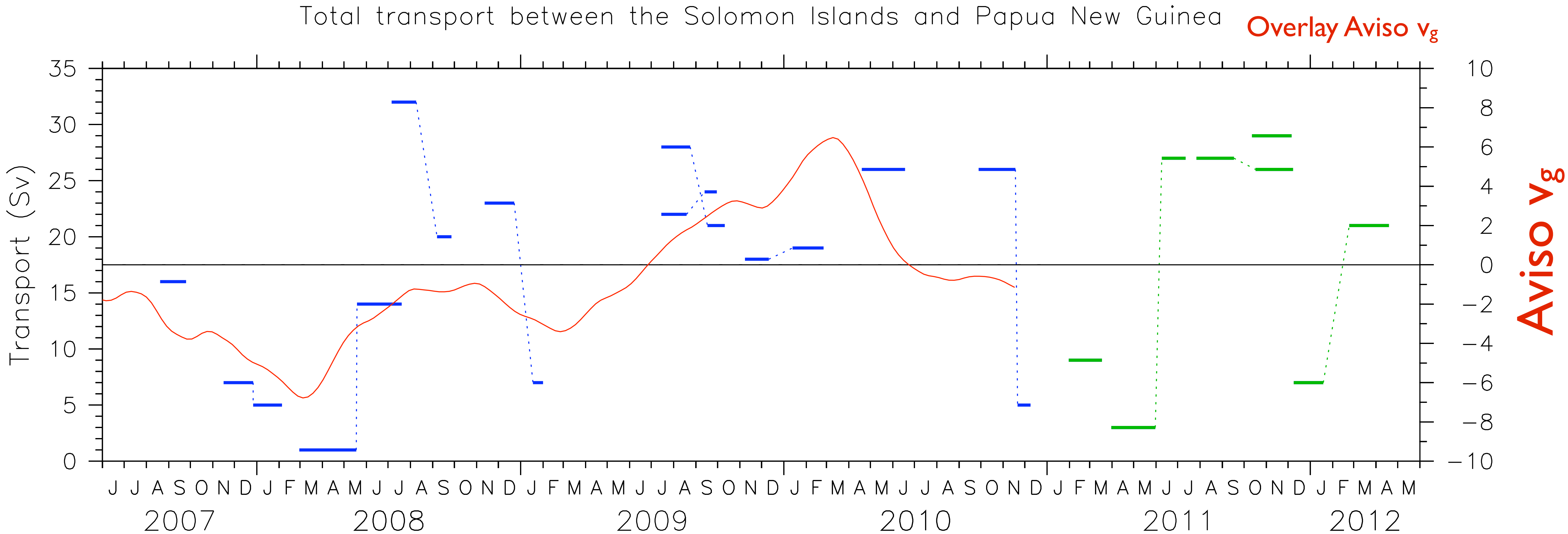

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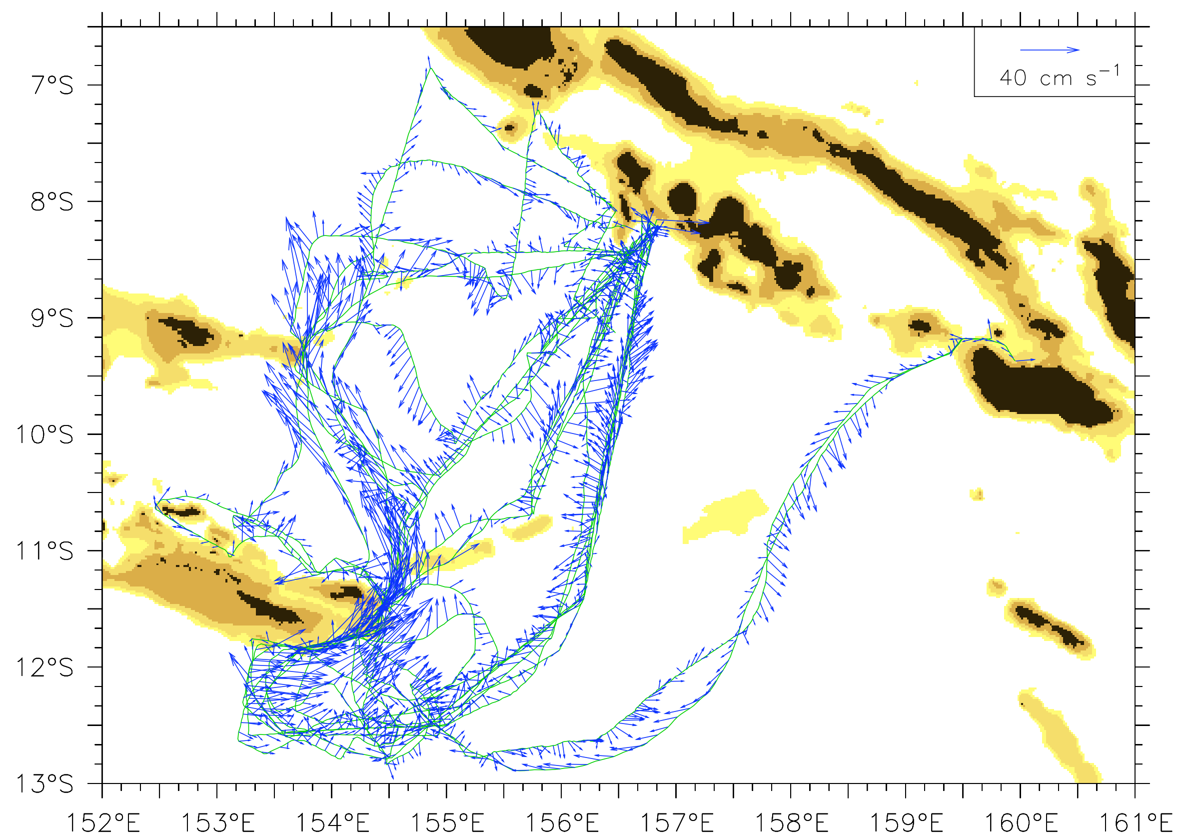

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