Glider measurements of the Solomon Sea: A piece of the El Niño puzzle

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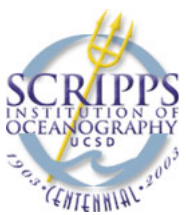
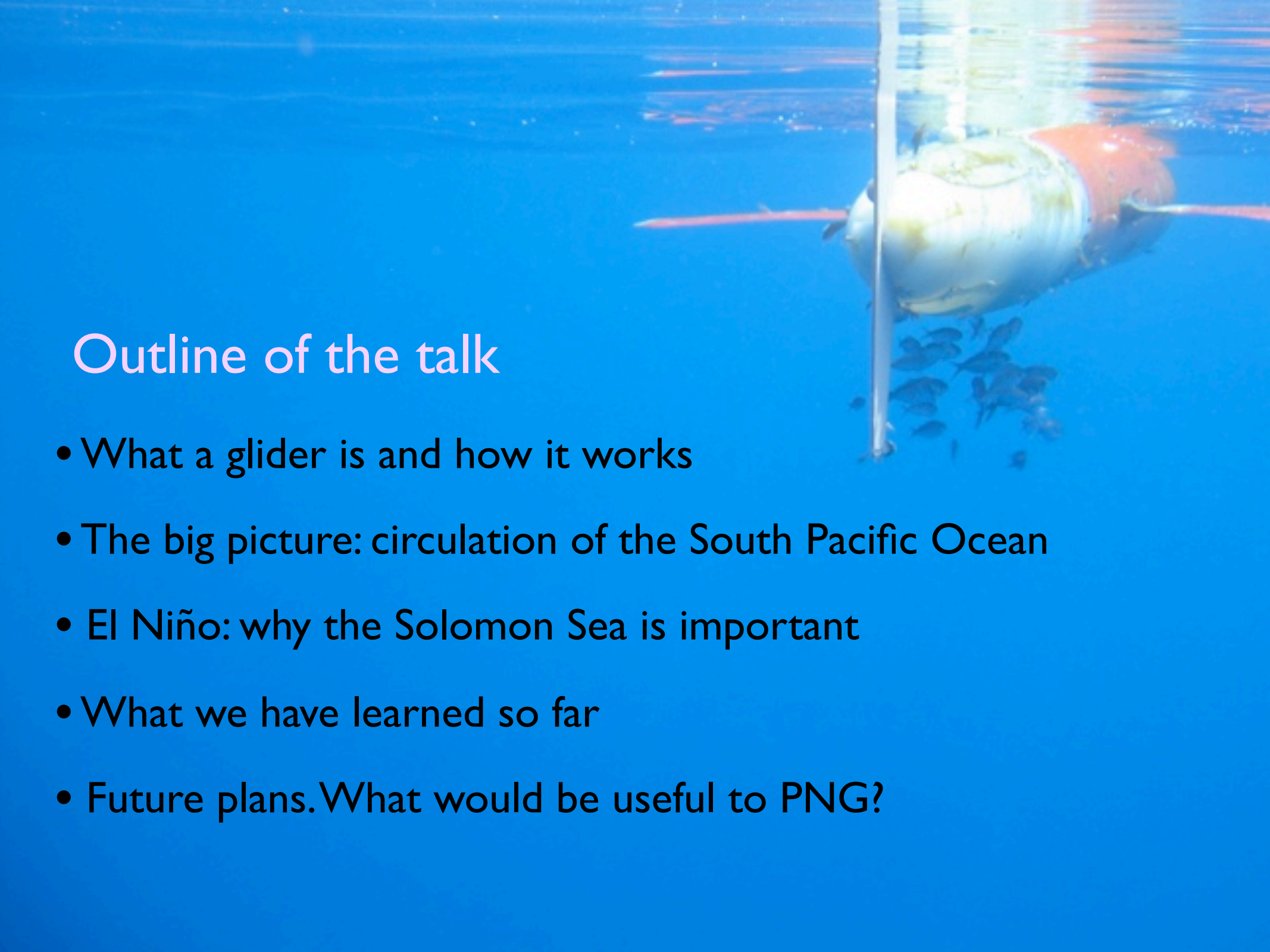
(Scripps Institution of Oceanography, La Jolla USA)

(With inspiration from Patricia Pepena and Masio Nidung
and help from the PNG MSR Committee)



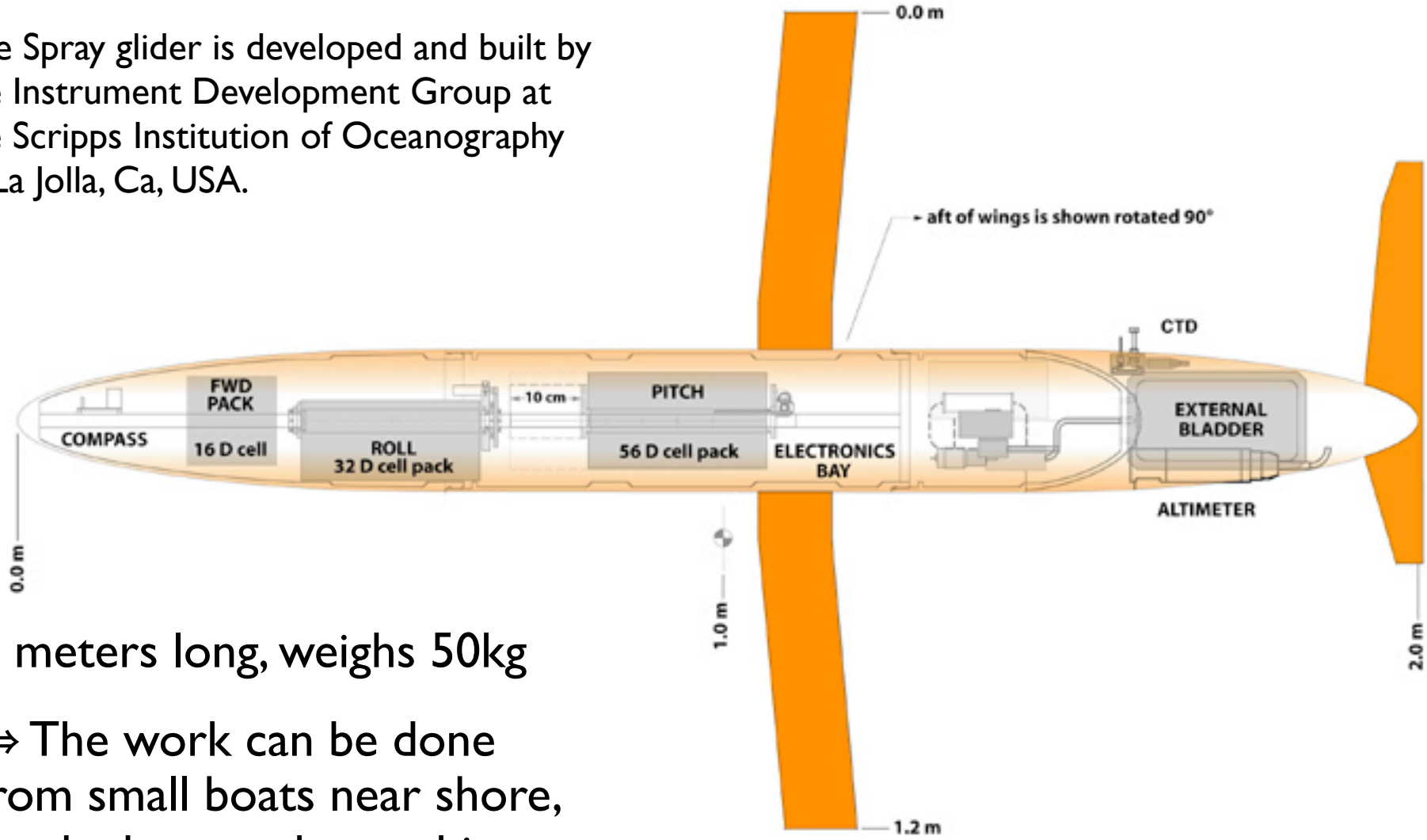


Outline of the talk

- What a glider is and how it works
- The big picture: circulation of the South Pacific Ocean
- El Niño: why the Solomon Sea is important
- What we have learned so far
- Future plans. What would be useful to PNG?

The ocean glider "Spray": Schematic diagram

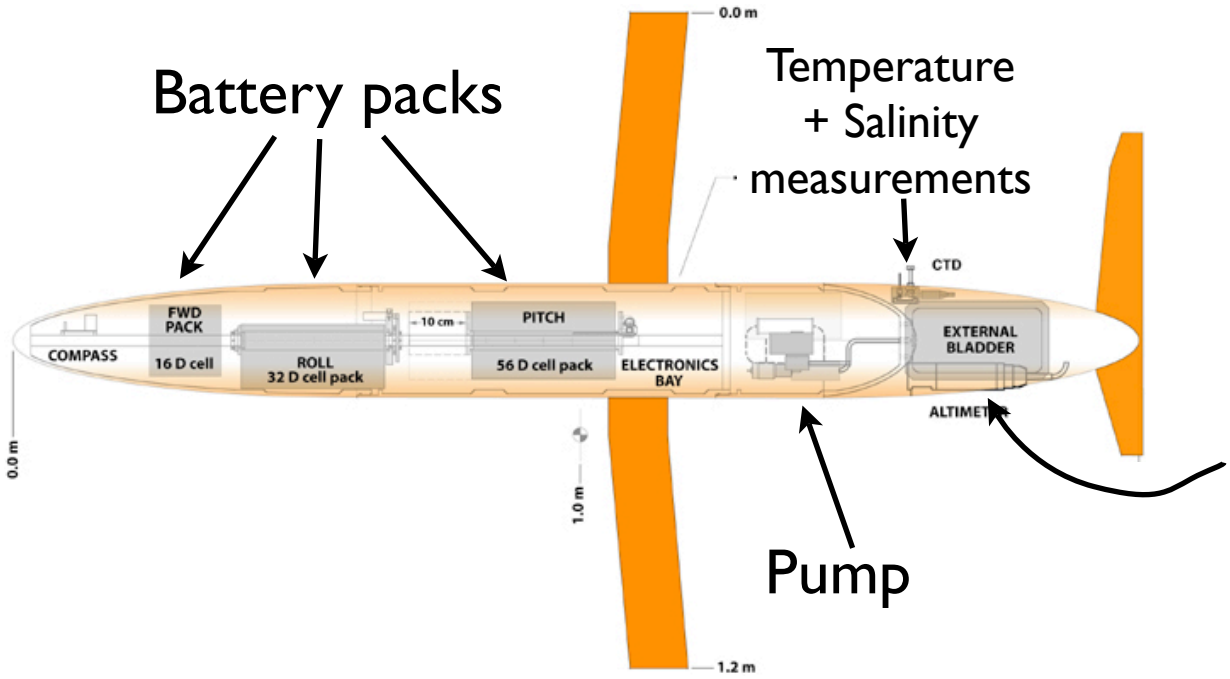
The Spray glider is developed and built by the Instrument Development Group at the Scripps Institution of Oceanography in La Jolla, Ca, USA.



2 meters long, weighs 50kg

⇒ The work can be done from small boats near shore, much cheaper than a ship.
Cost to build: about USD50K

How the glider propels itself



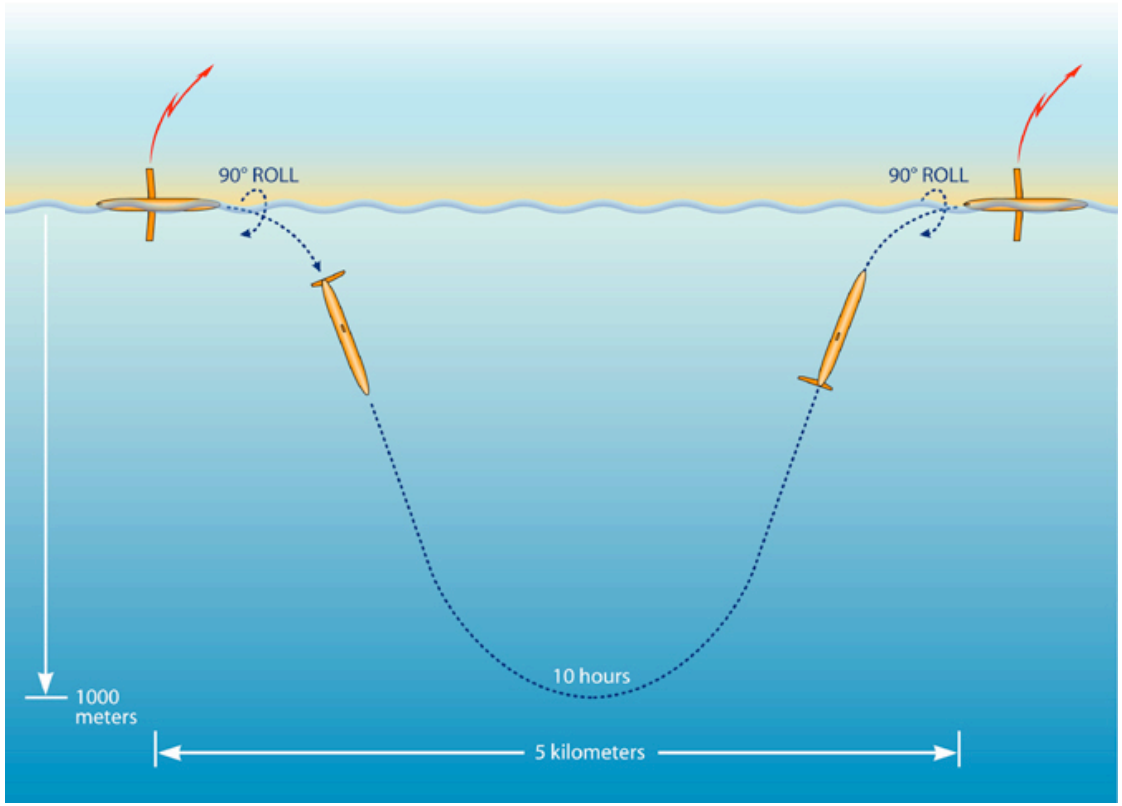
The glider is precisely balanced to be just barely buoyant.

Its only propulsion is a pump and external oil bladder. The pump inflates and deflates the bladder like a balloon.

When the bladder is inflated, the glider becomes a little lighter, and floats up. When it is deflated, it sinks.

The battery packs move forward and back to control the orientation in the water. To rise, it points up as it floats up, and glides forward, and vice versa.
It moves very slowly (20 km/day).

A dive of the Spray glider



500-1000 m

← 3 km →

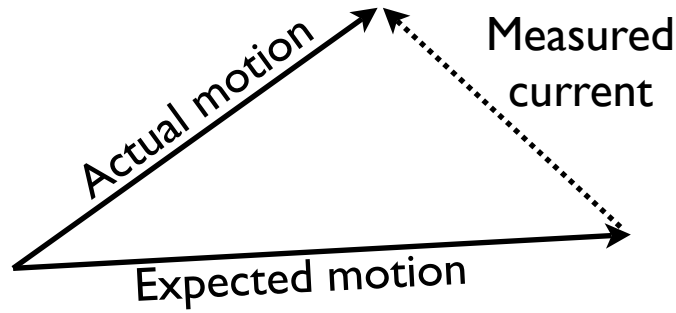
20 cm/s (3-5 hr)

A glider dives to 500-1000m, taking 3-5 hours, and moves forward about 2-4 km.

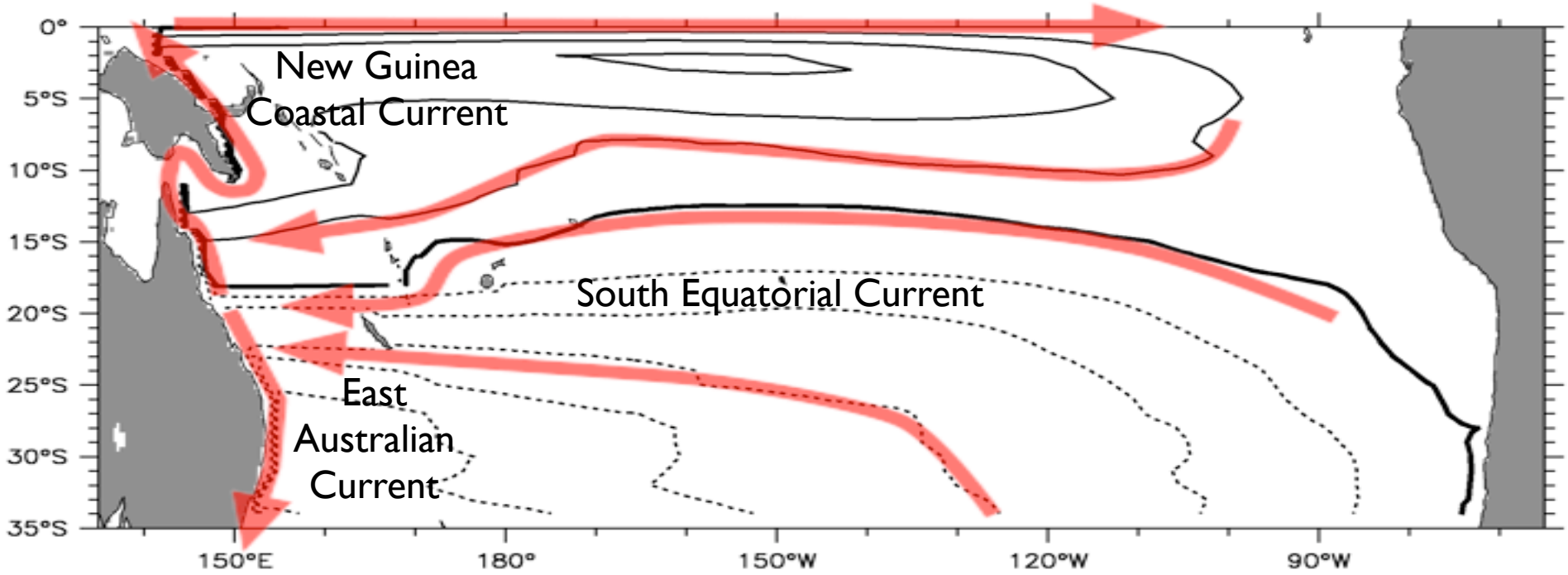
During a dive, it measures the temperature and salinity.

It reports the data by satellite each time it surfaces.

Estimate the currents by the glider's drift:



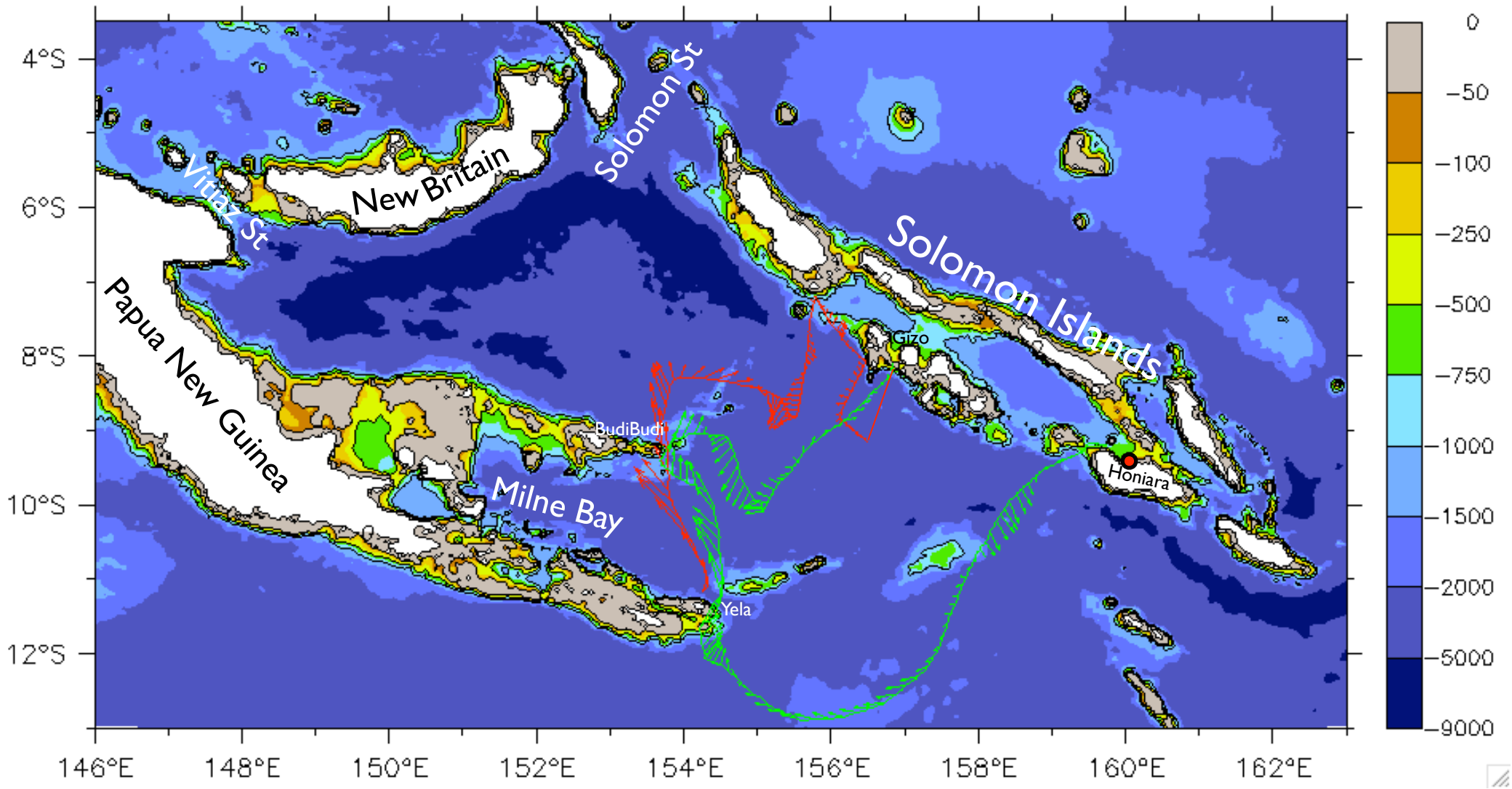
The South Pacific circulation



About half the SEC transport goes north through the Solomon Sea to the equator.

The currents are huge:
about 20 million cubic meters per second flows north through the Solomon Sea
(roughly 2000 times as large as the Sepik River maximum flood).

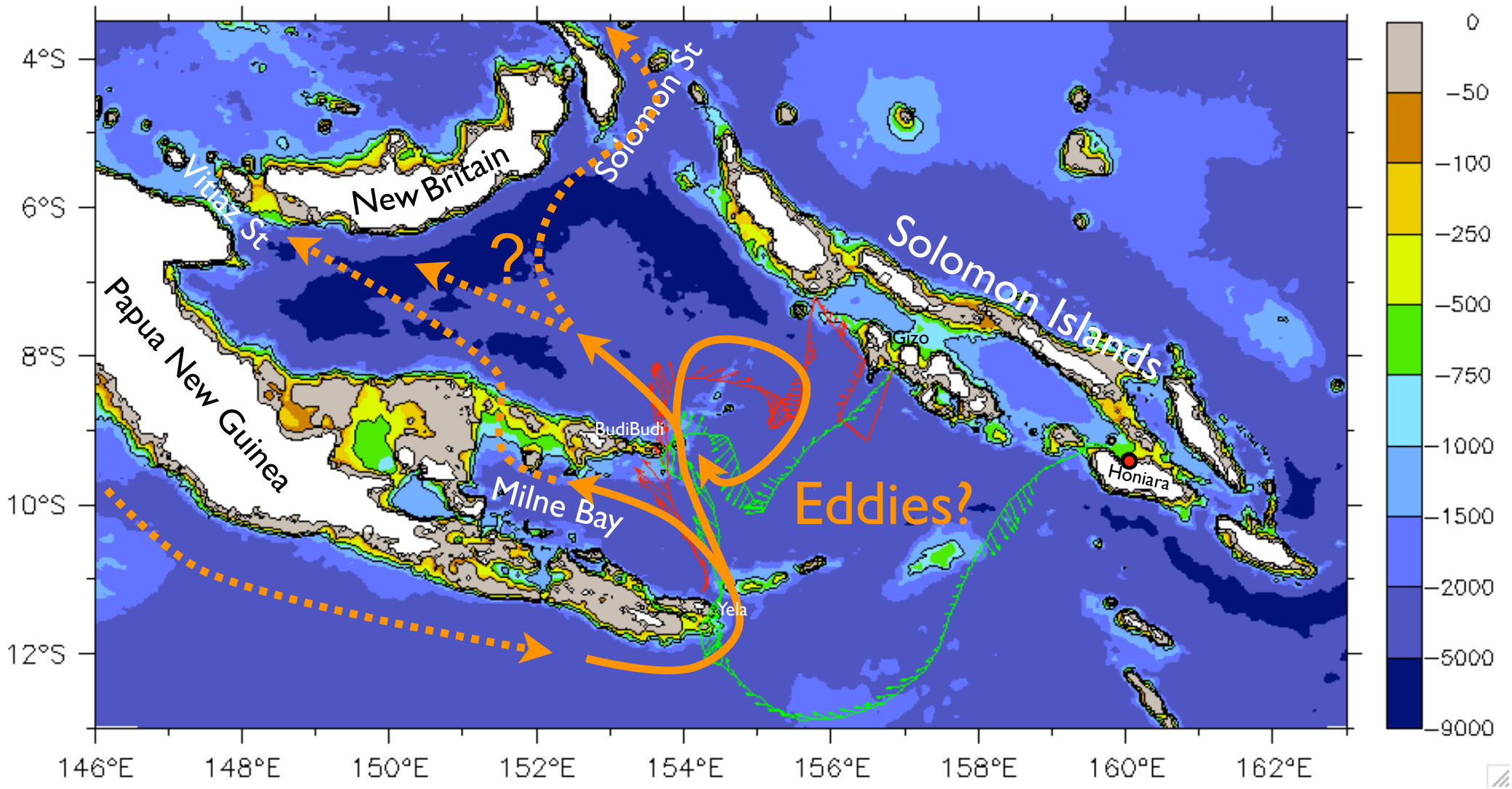
The 2 glider surveys done so far



Red = Aug-Nov 07 (Yela, PNG to Gizo, Solomon Islands)

Green = Nov 07-Feb 08 (Honiara to Gizo via Yela)

A first guess at the currents, based on the 2 surveys to date



Red = Aug-Nov 07 (Yela, PNG to Gizo, Solomon Islands)

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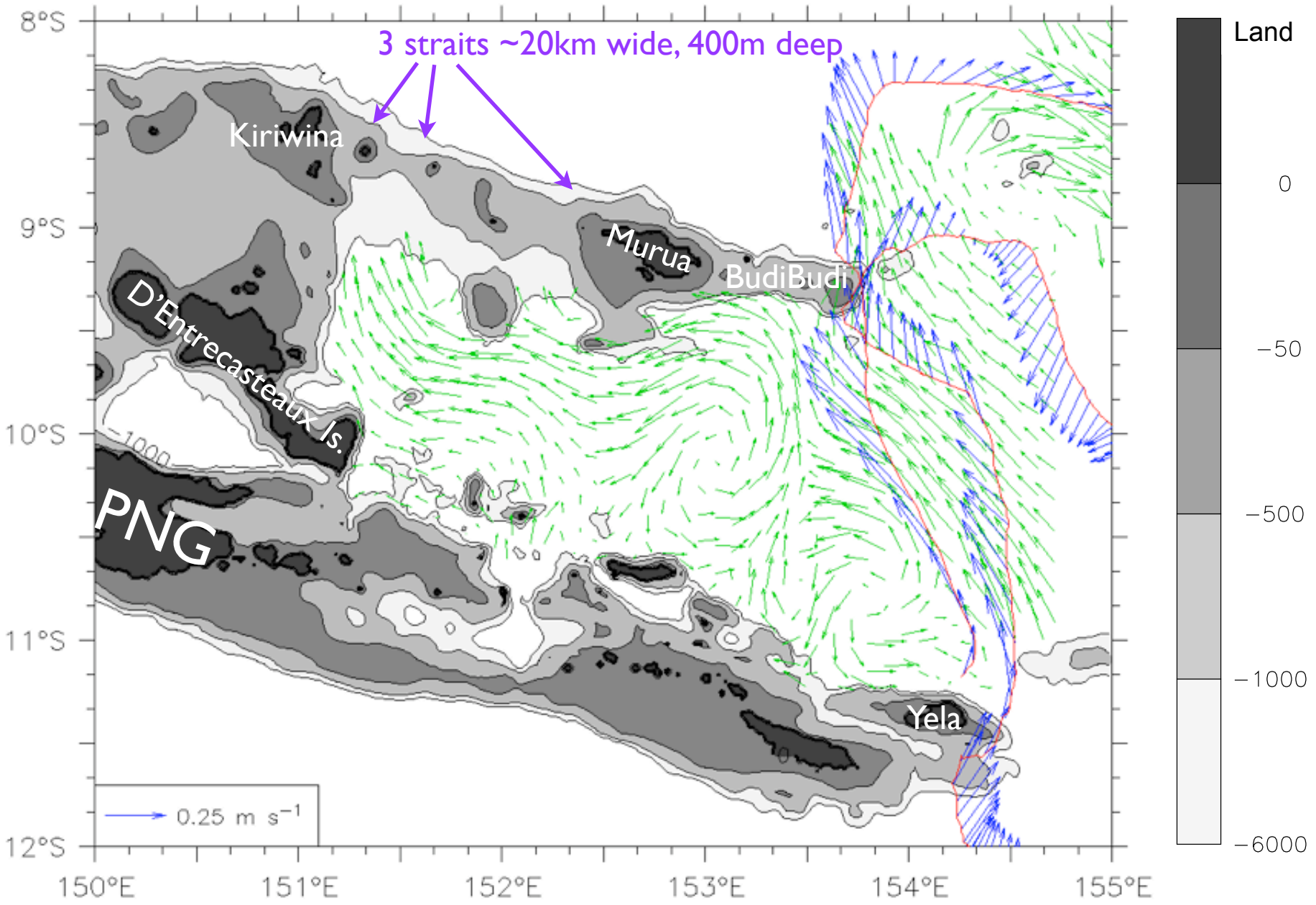
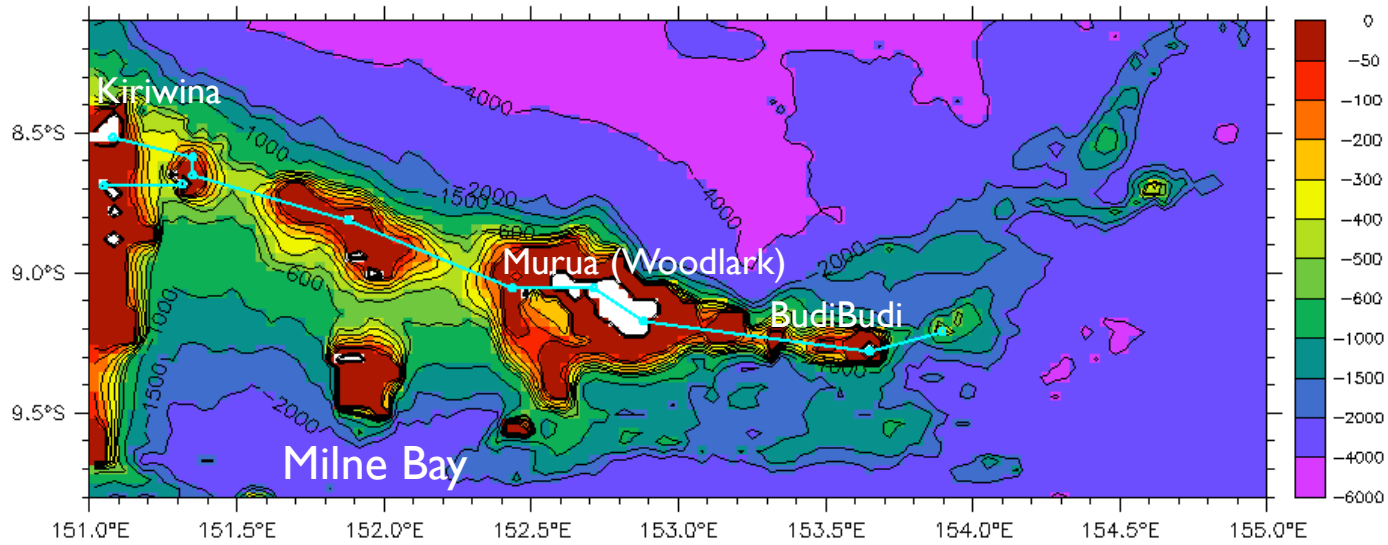
Ship and glider currents in Milne Bay, PNG



(Green vectors are from a 1993 ship survey, Blue from the glider)

Bathymetry of the Trobriand Archipelago, PNG

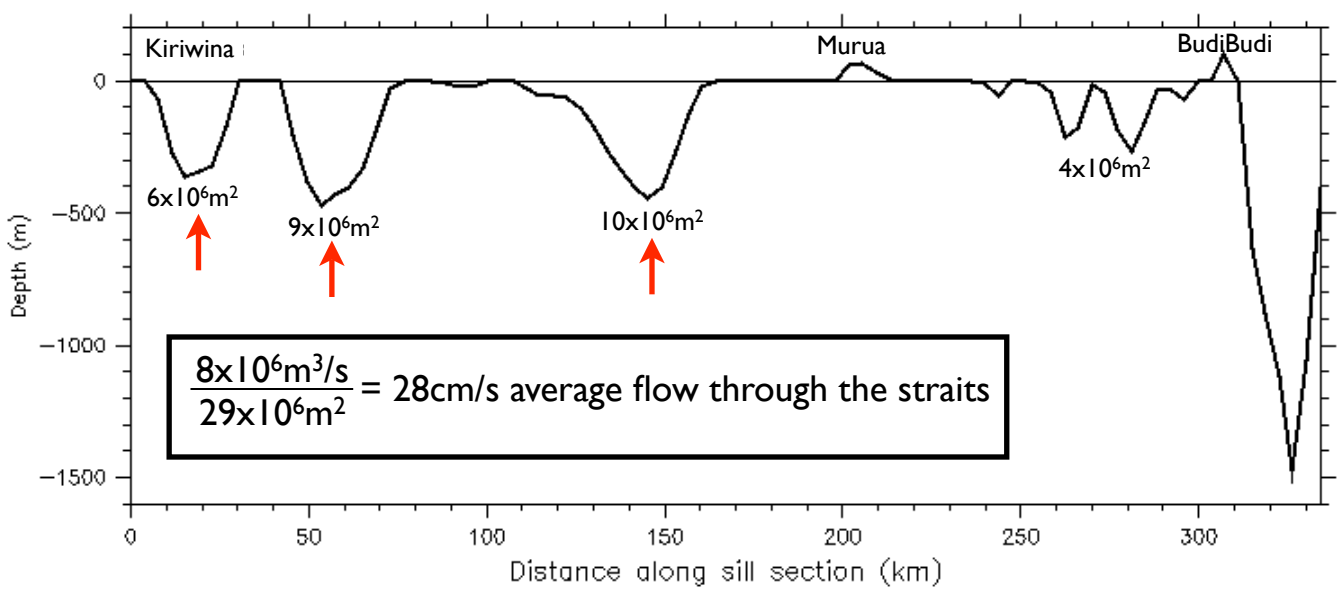
Smith/Sandwell 2–minute bathymetry



Sill line overlaid

Sill depths along the Trobriand Archipelago

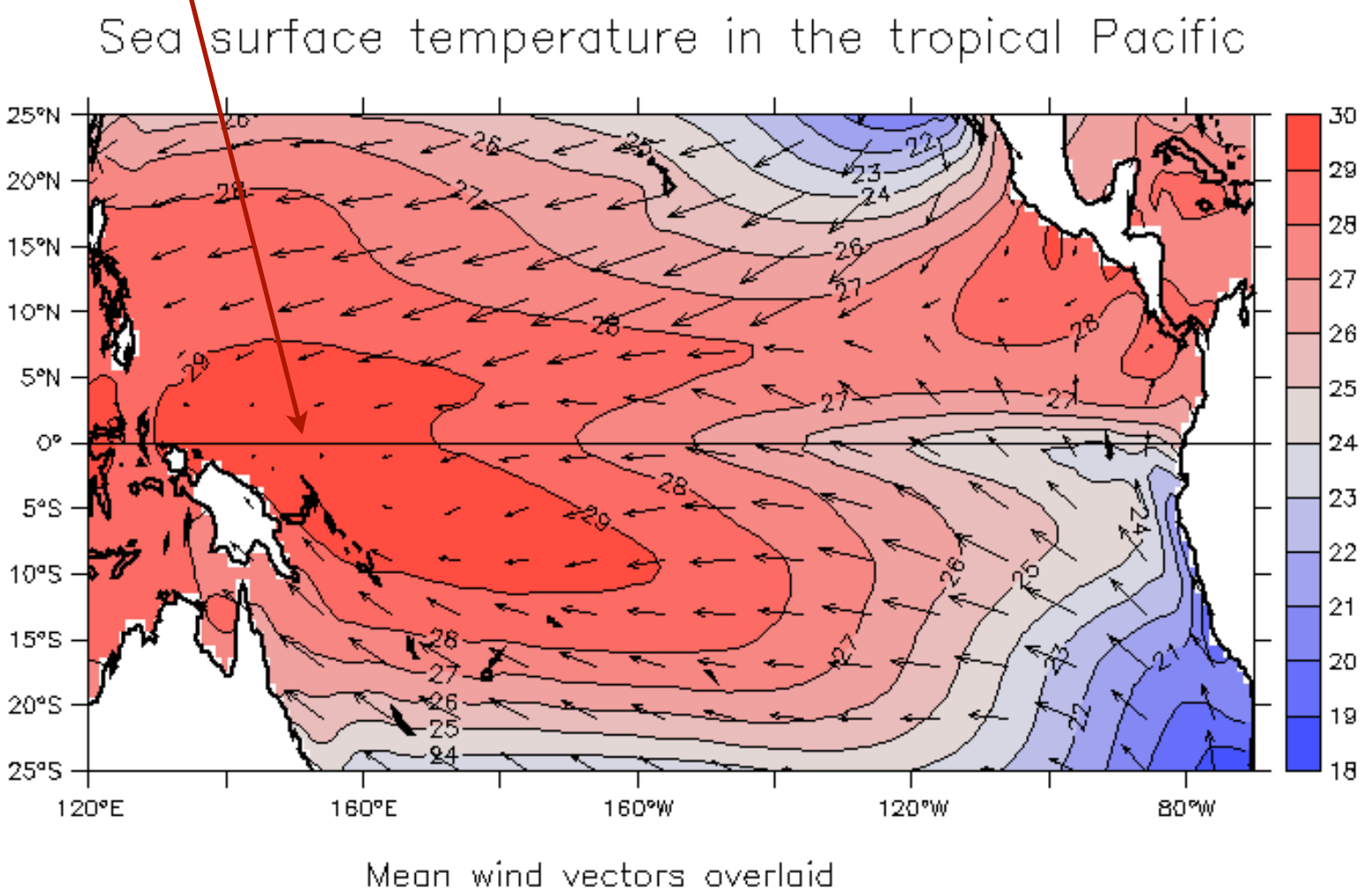
Smith/Sandwell 2–minute bathymetry (sill section found by hand)



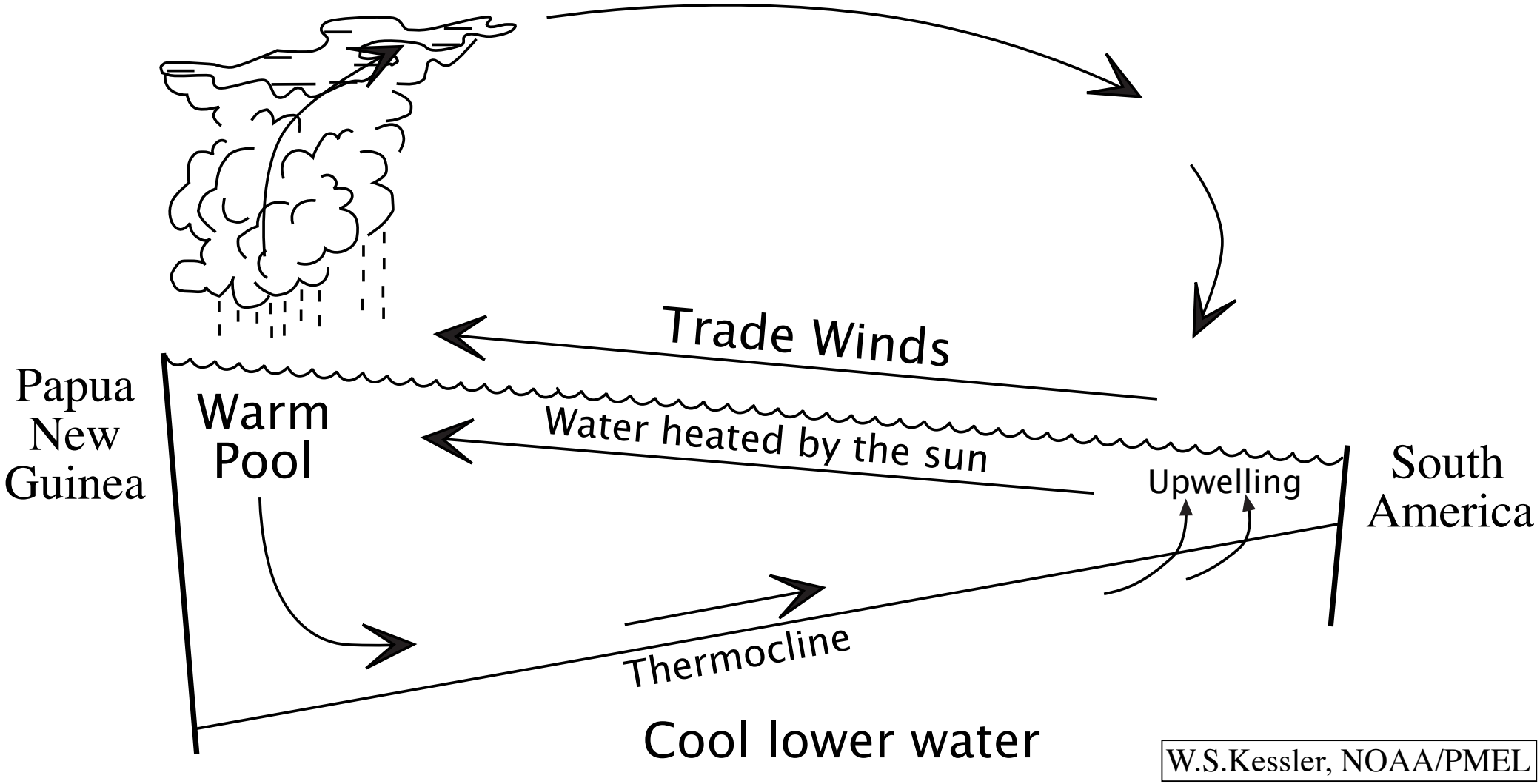
$$\frac{8\times10^{6}\,m^{3}/s}{29\times10^{6}\,m^{2}} = 28\,cm/s$$ average flow through the straits

The climate importance of Solomon Sea currents: El Niño

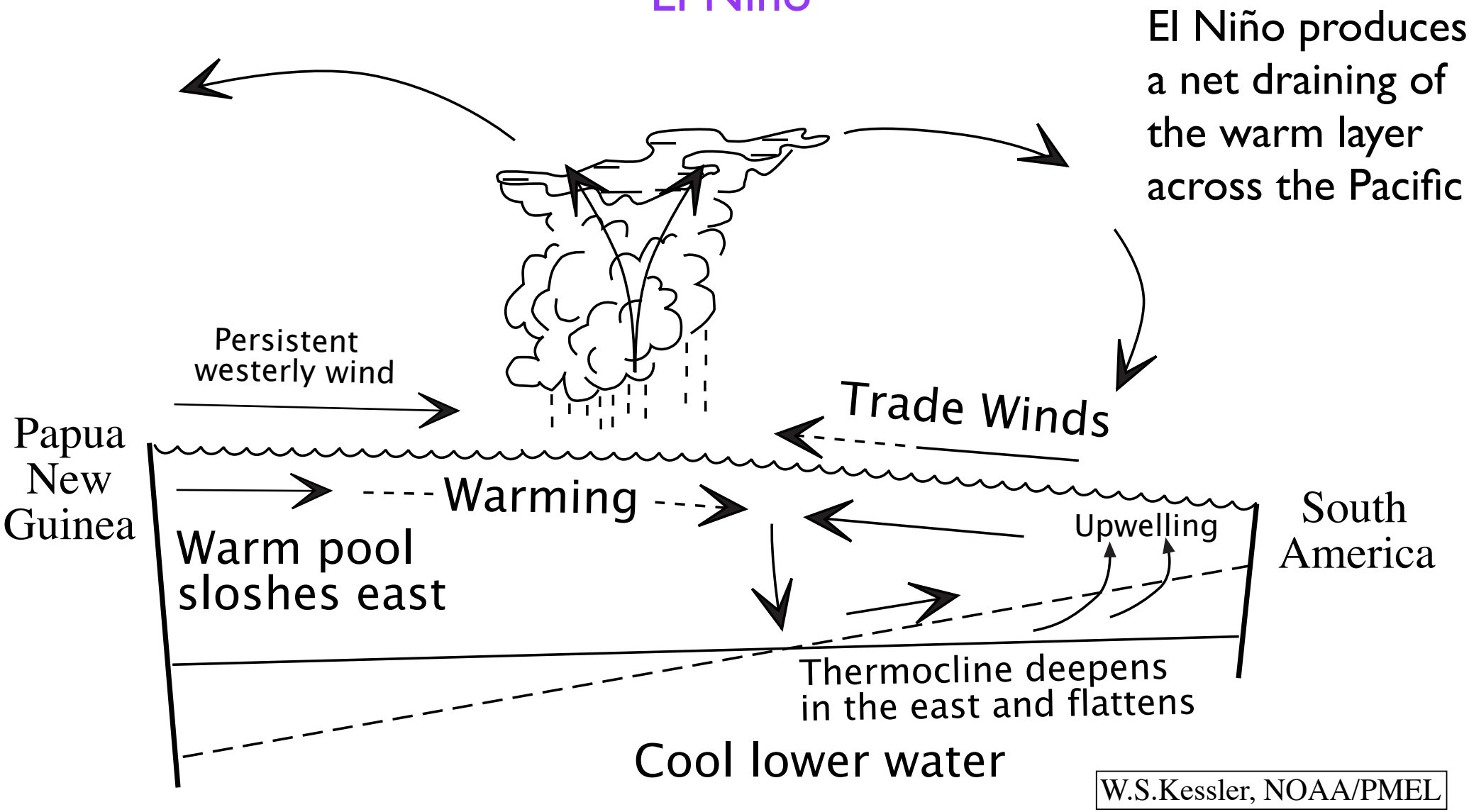
- The warmest water is not necessarily at the equator!
- There is a roughly 5°C temperature contrast from west to east.
- Winds blow from the cooler to the warmer water, and converge on the West Pacific Warm Pool.



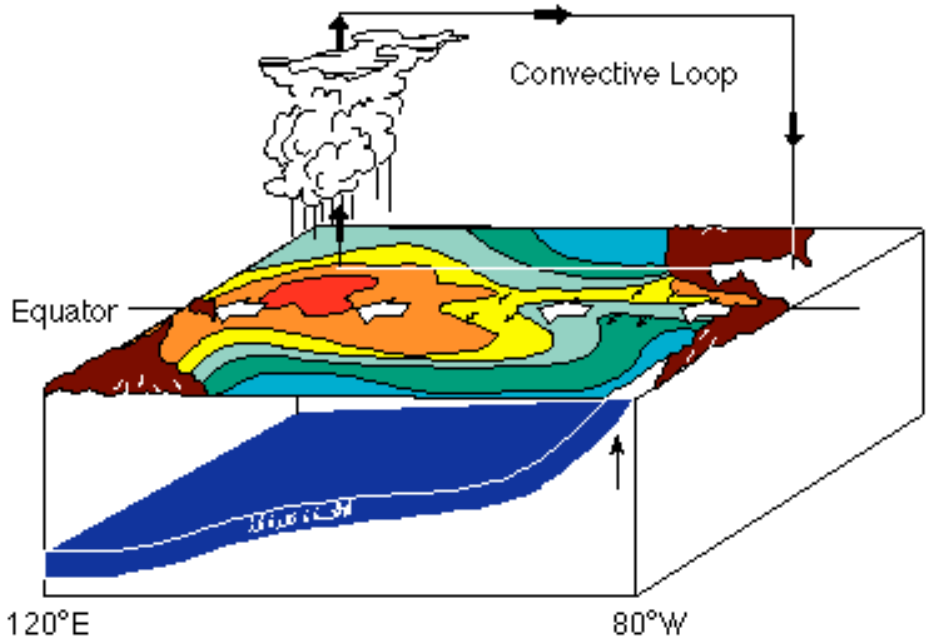
Schematic diagram of the coupled interaction along the equator: The normal situation



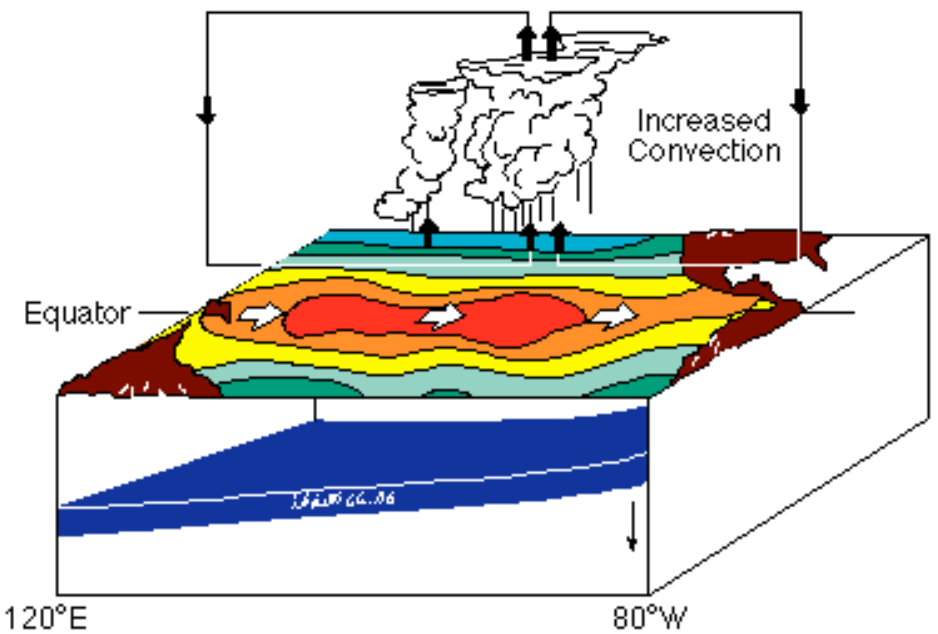
Schematic diagram of the coupled interaction along the equator: El Niño



Normal Conditions

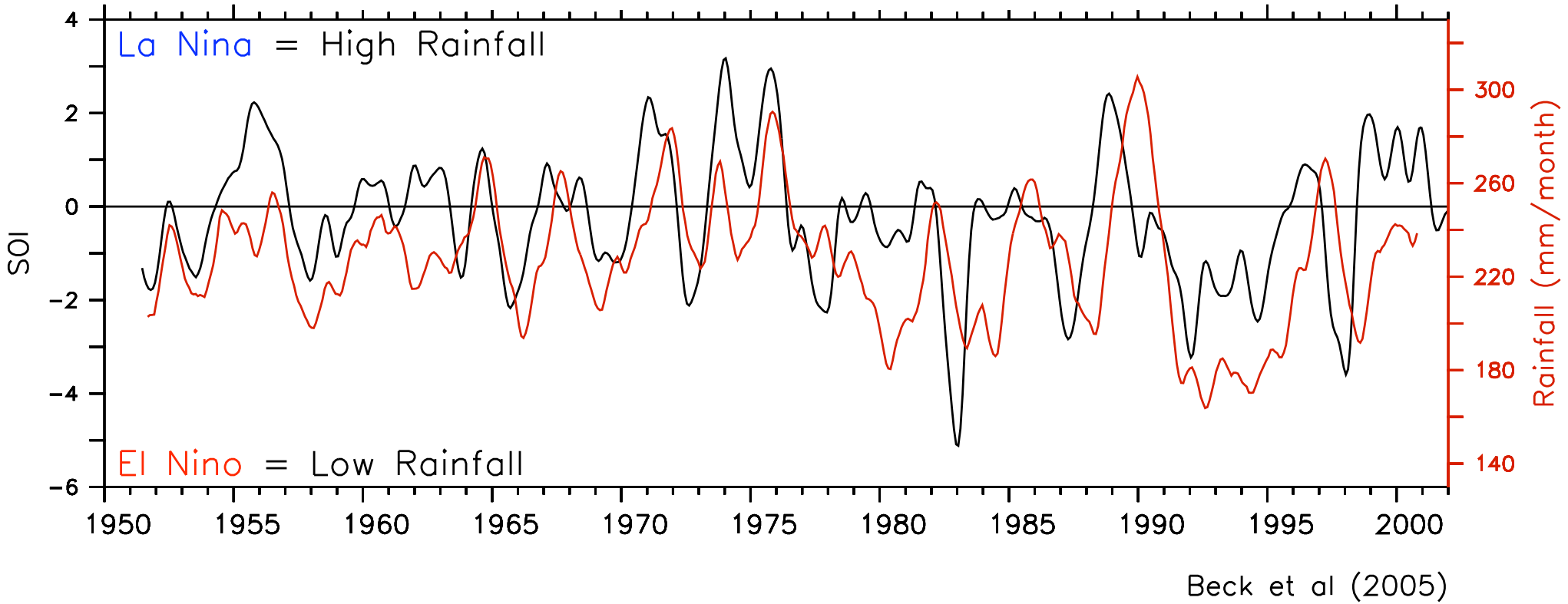


El Niño Conditions



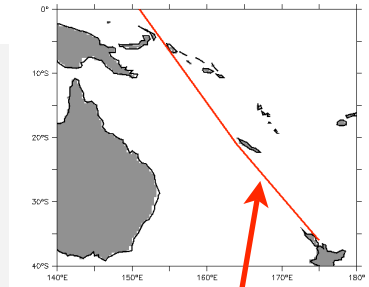
New Britain rainfall and El Niño

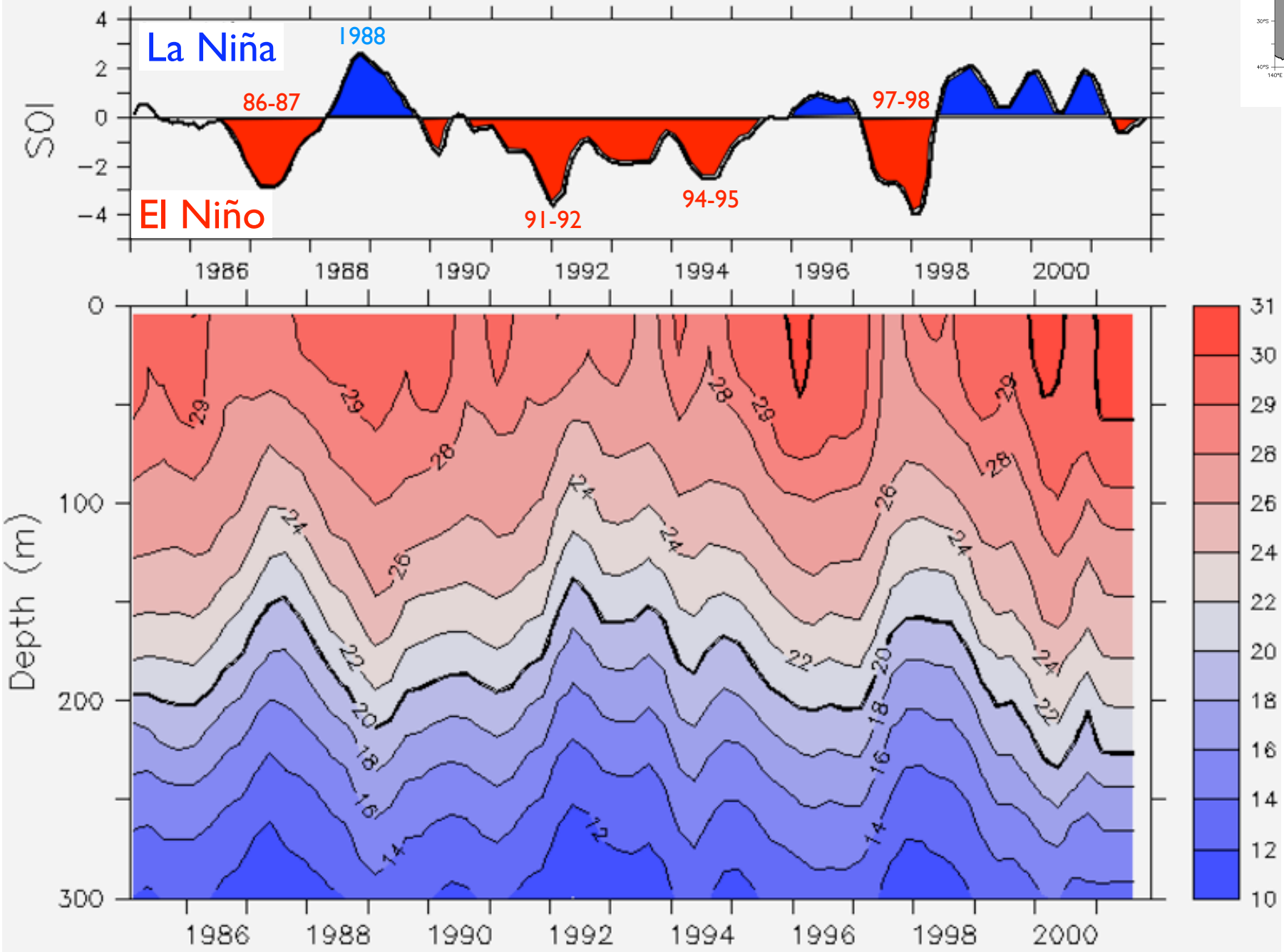
New Britain rainfall is about 5-10 cm/month lower during and after an El Niño

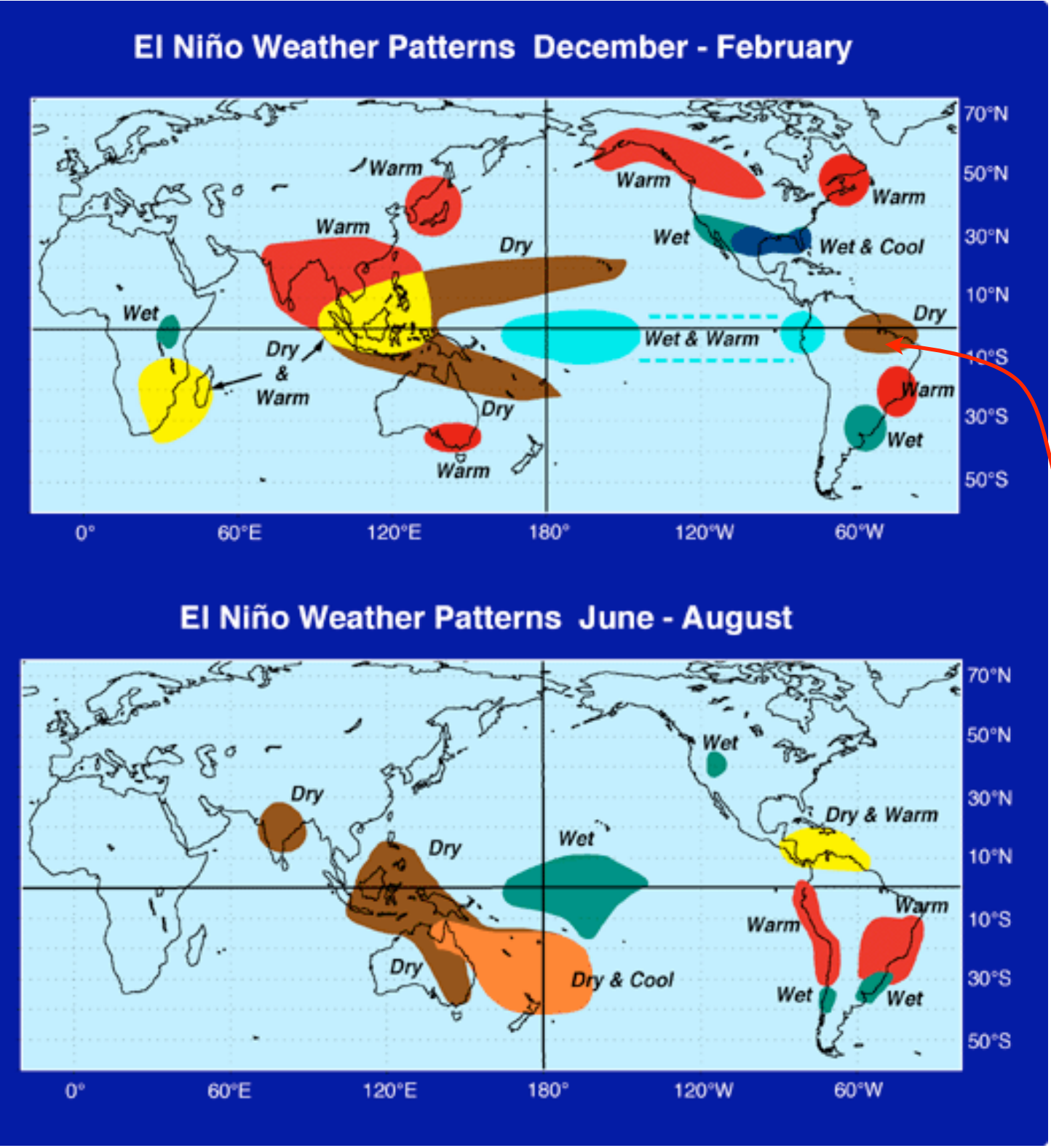


This is due to the eastward shifting of the region of warmest water and rainfall.

Solomon Sea temperatures and El Niño







Great benefit around the world if these events (and their subsequent effects) could be accurately predicted.

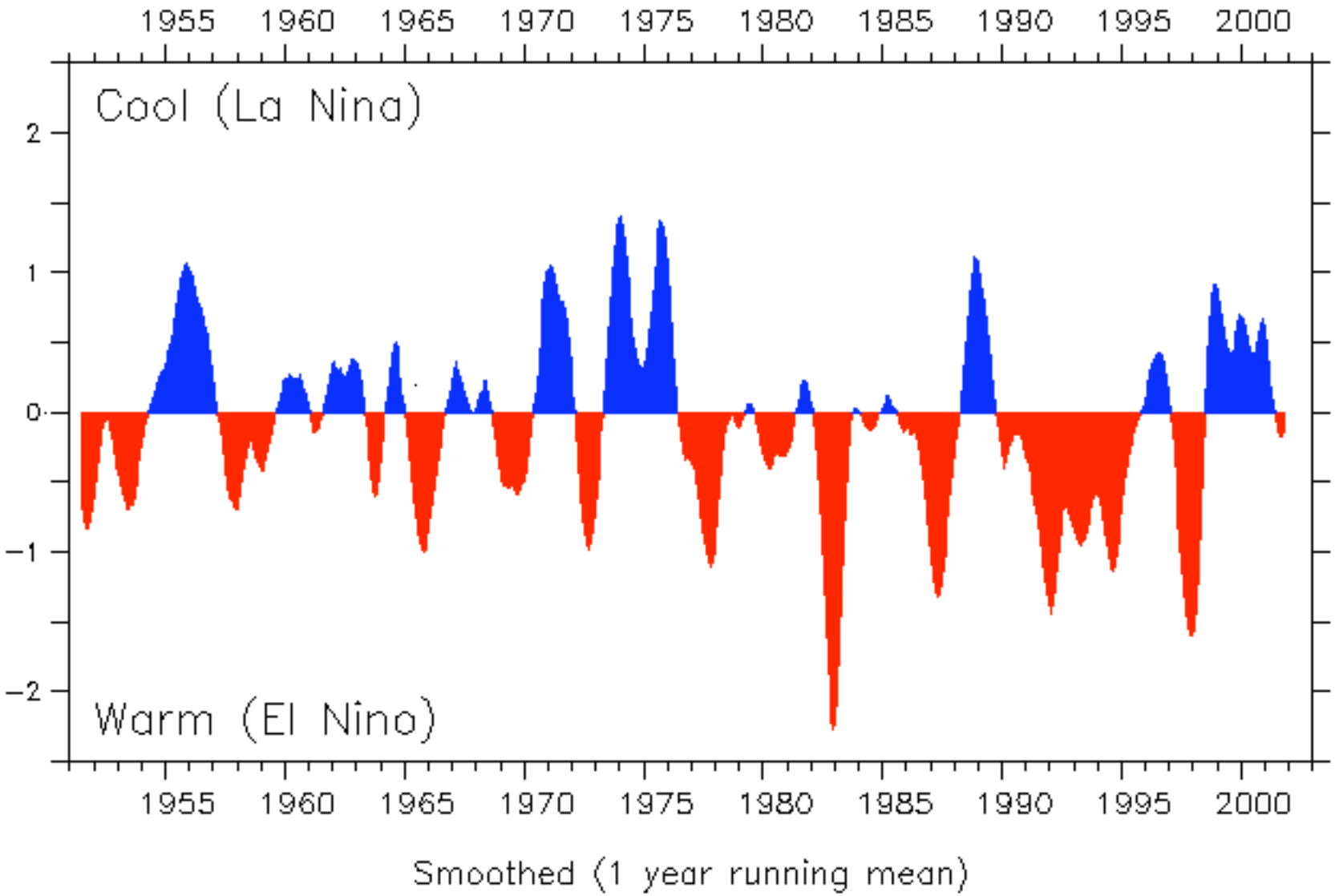
NE Brazil

El Niño droughts used to reduce crop yields by 75%. With predictions, famers plant drought-tolerant beans and crop losses are much less.

On the other hand, predictions are not always correct (Australia 1997).

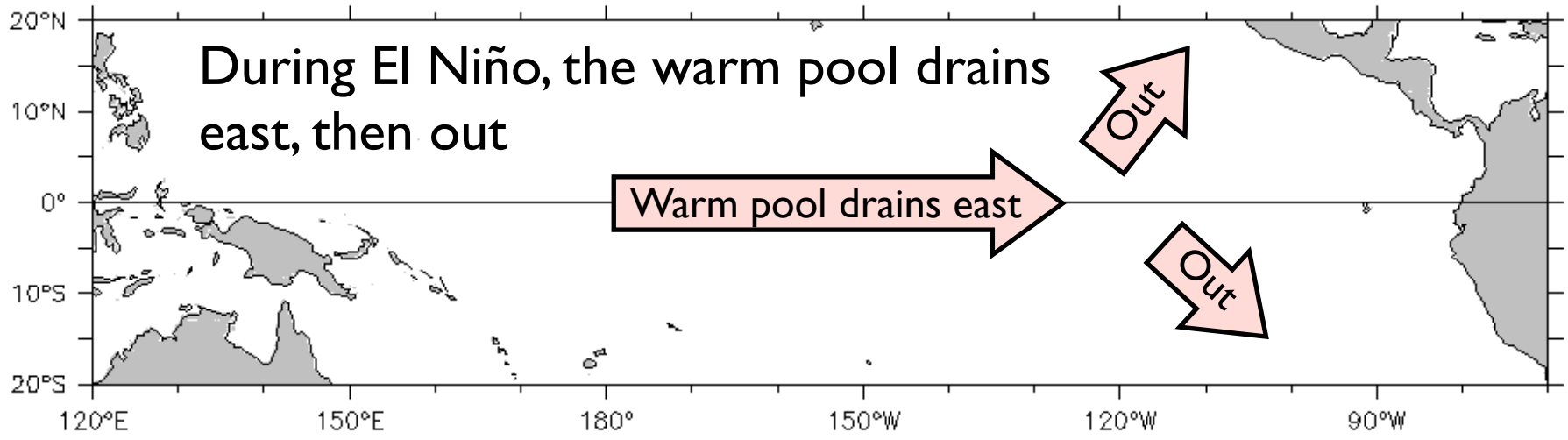
The Southern Oscillation Index gives a time history of El Niño

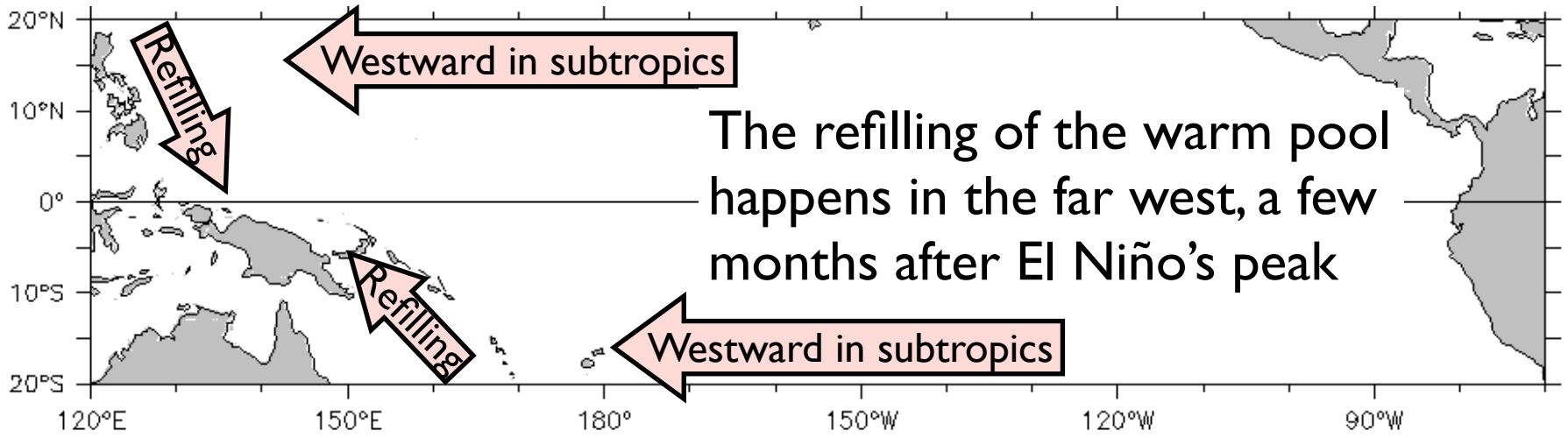
It is highly irregular and hard to predict!



(The SOI is based on the atmospheric pressure at Tahiti and Darwin, Australia)

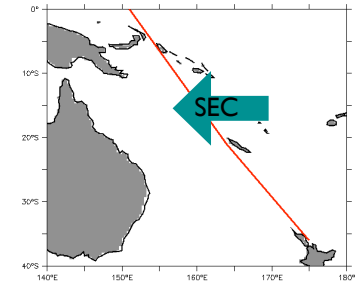
What does this have to do with the Solomon Sea?



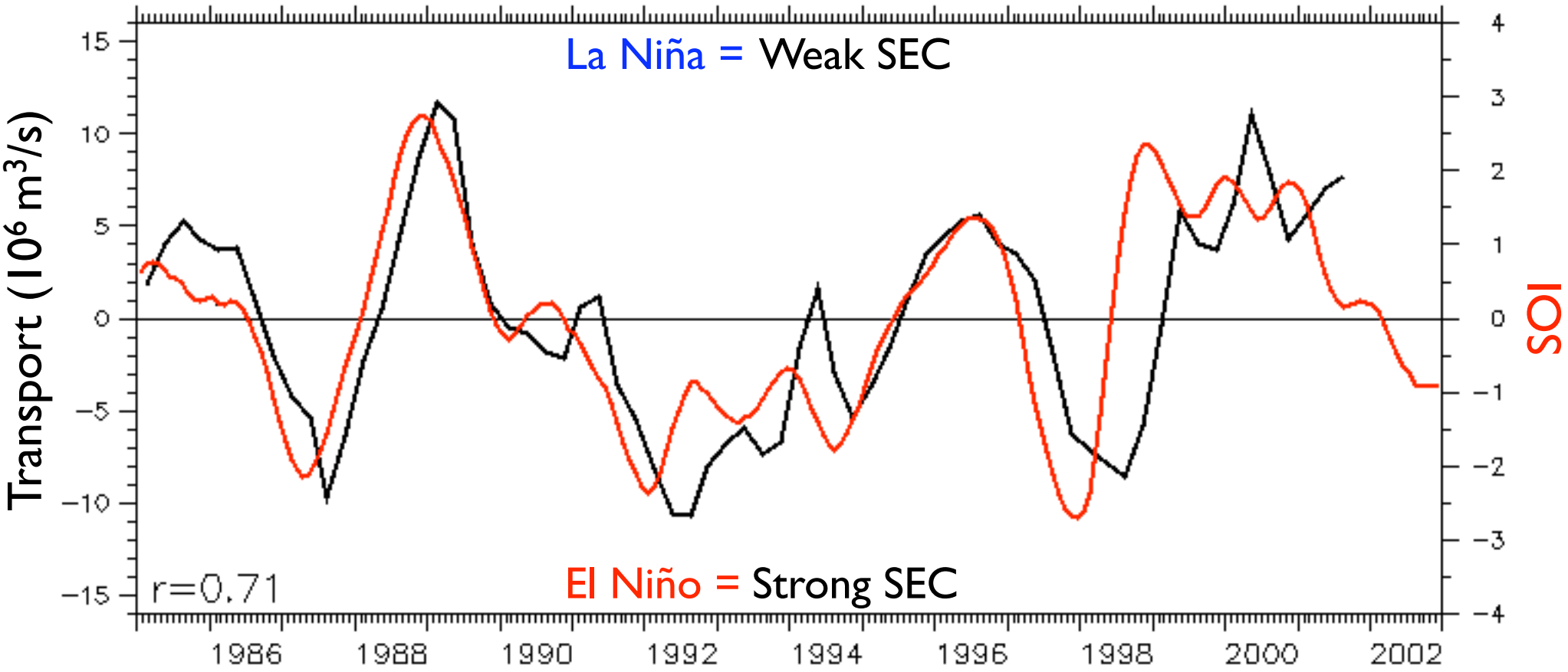


Cannot have another El Niño until the warm pool is refilled

South Equatorial Current transport has a strong El Niño signal



SEC on the Auckland-Japan XBT track, over 10°S-20°S. Demeaned.

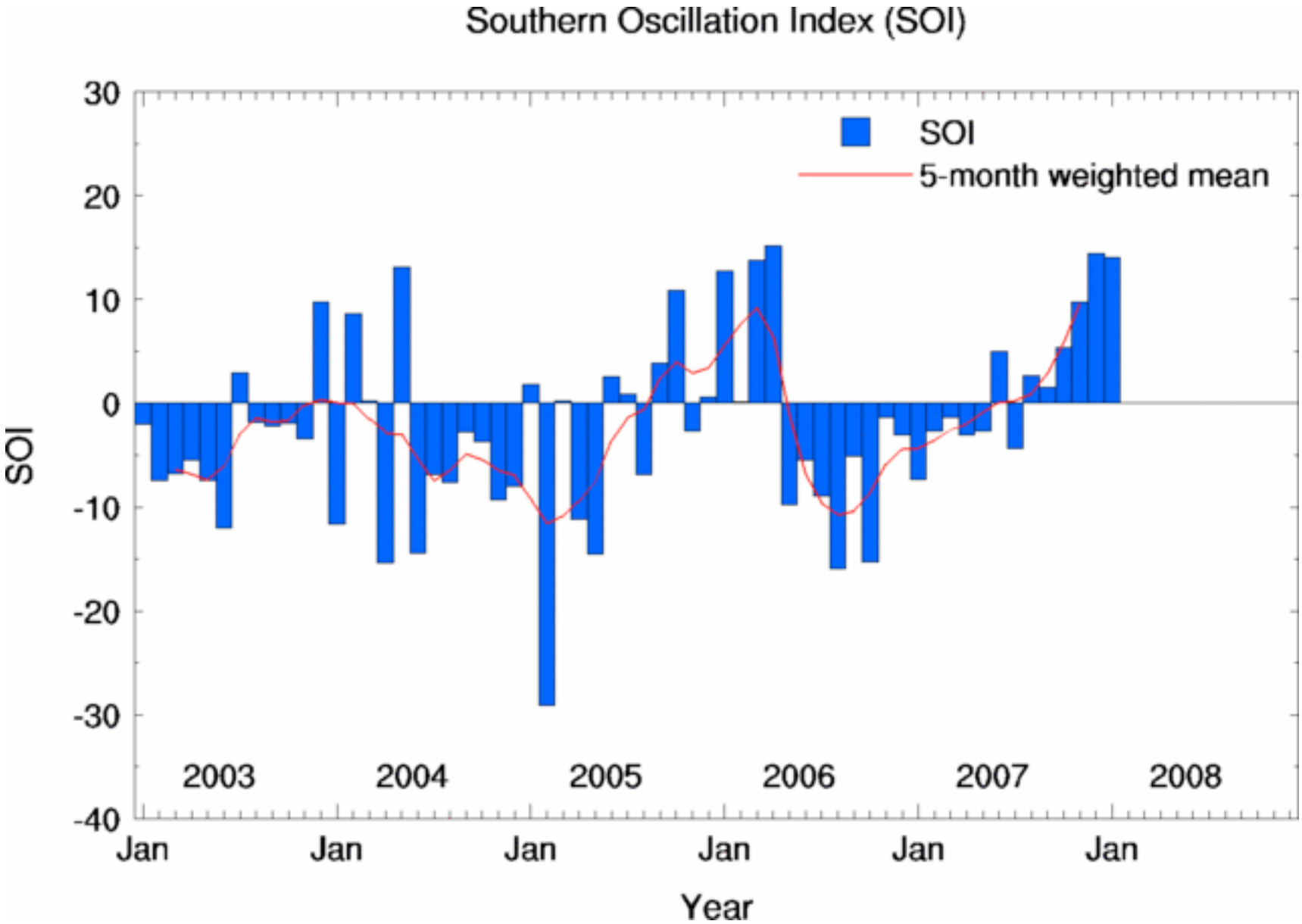


South Equatorial Current flow

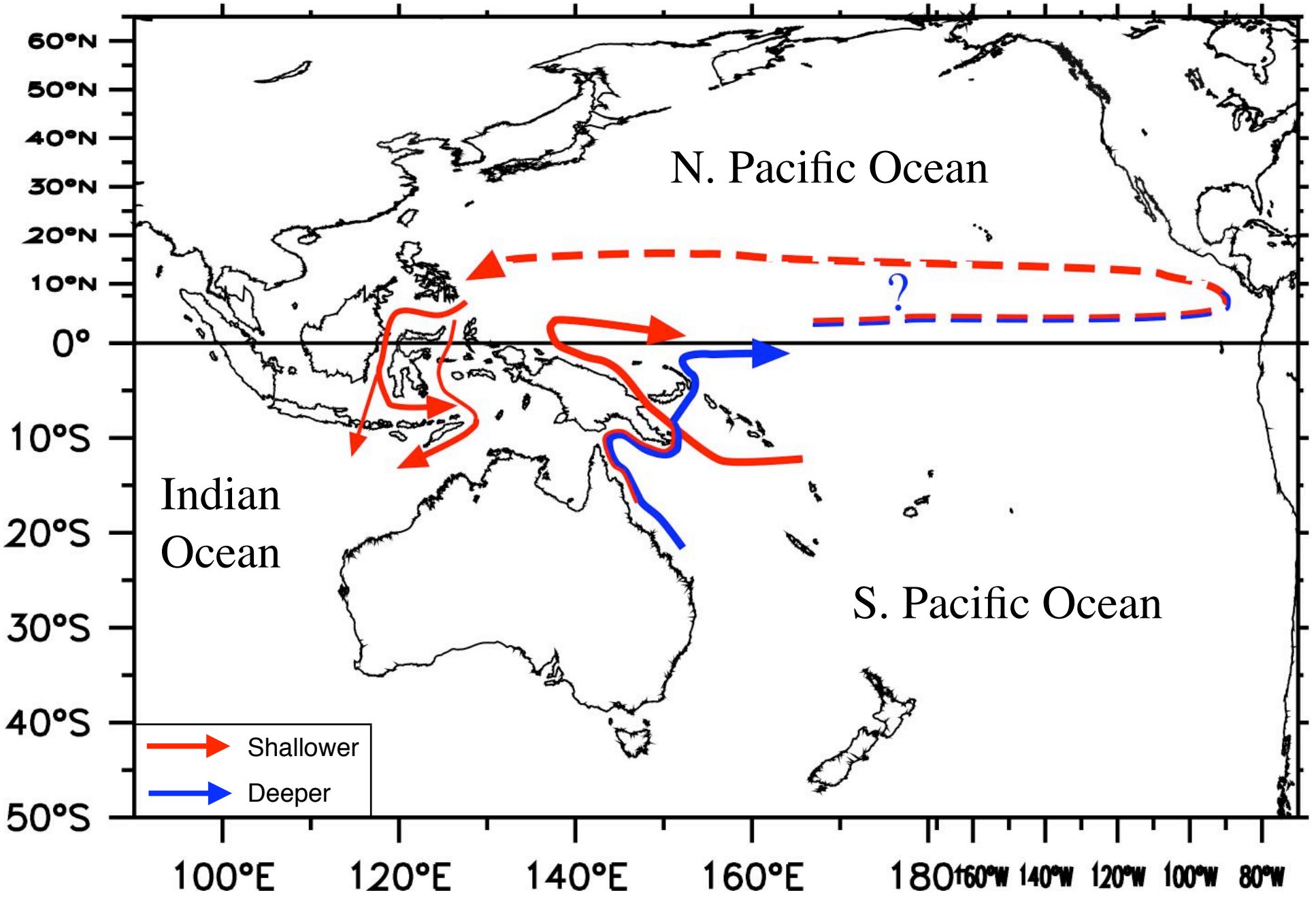
The Southern Oscillation Index (time history of El Niños)

Where are we now?

A La Niña began in late 2007. We would expect a weak NGCC.



The biggest picture is the flow around Australia-PNG

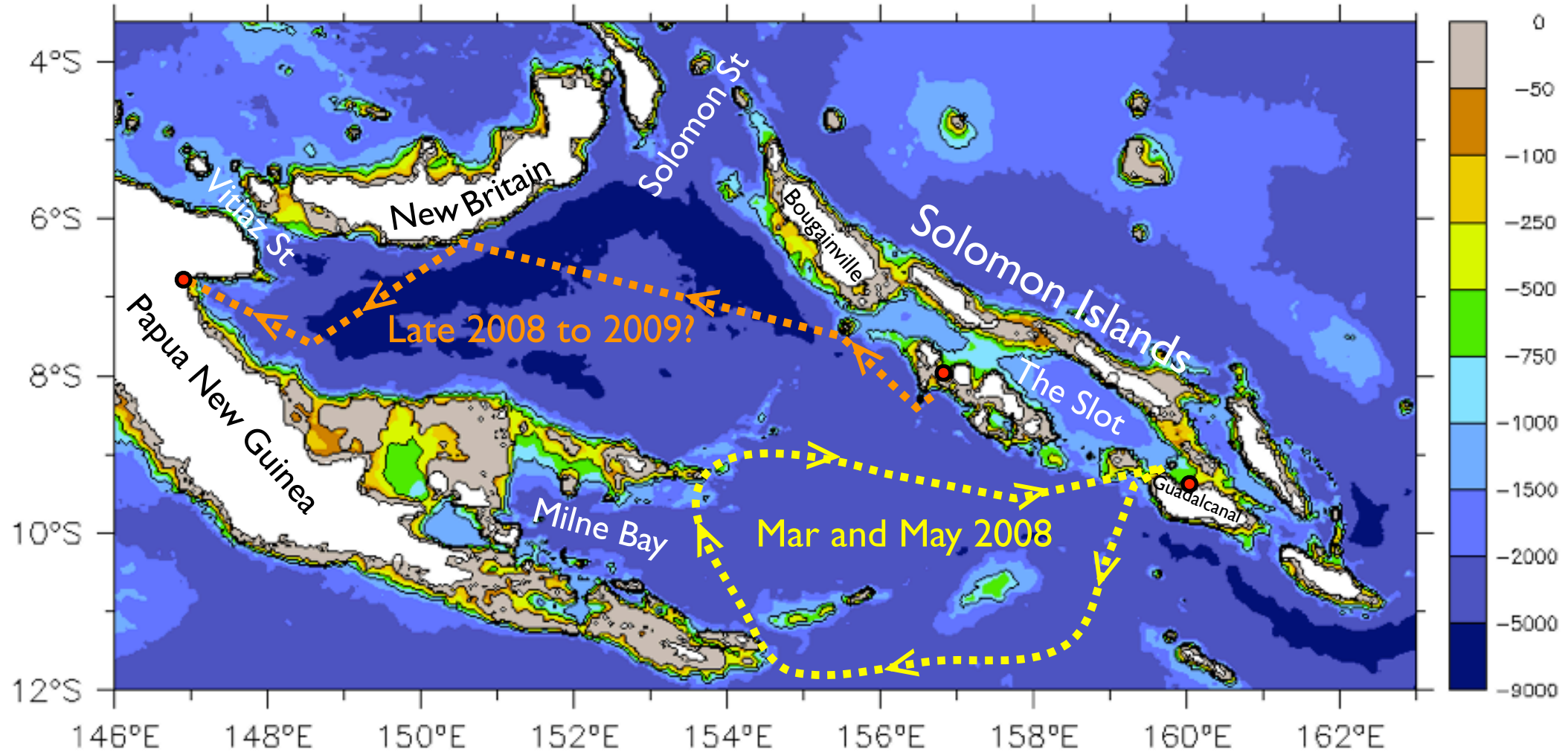


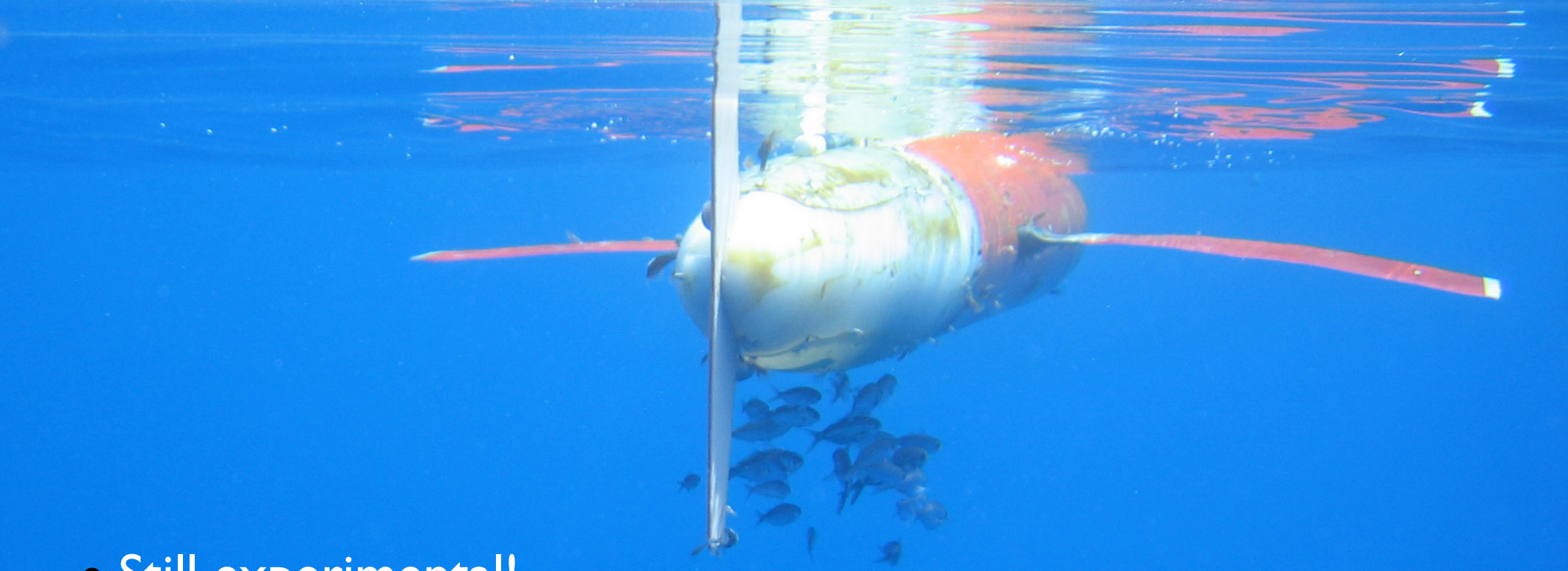
Future plans

Funded (NOAA/Scripps/IRD) for 2 more deployments this year

→ Redeploy in Mar 08, then May 08. Recover in Aug 08 after sampling a complete annual cycle.

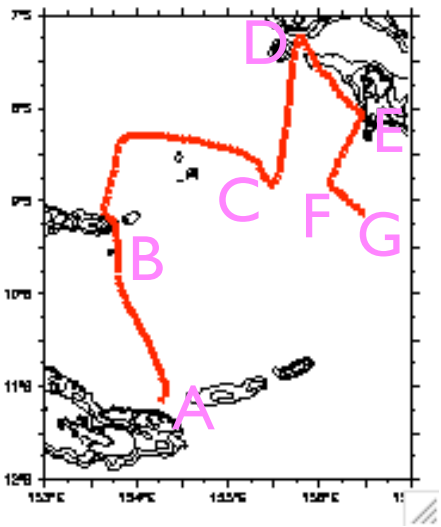
..... Digest results, then propose ongoing monitoring. Explore further north?
What would be useful to PNG? Looking for guidance and collaborators.



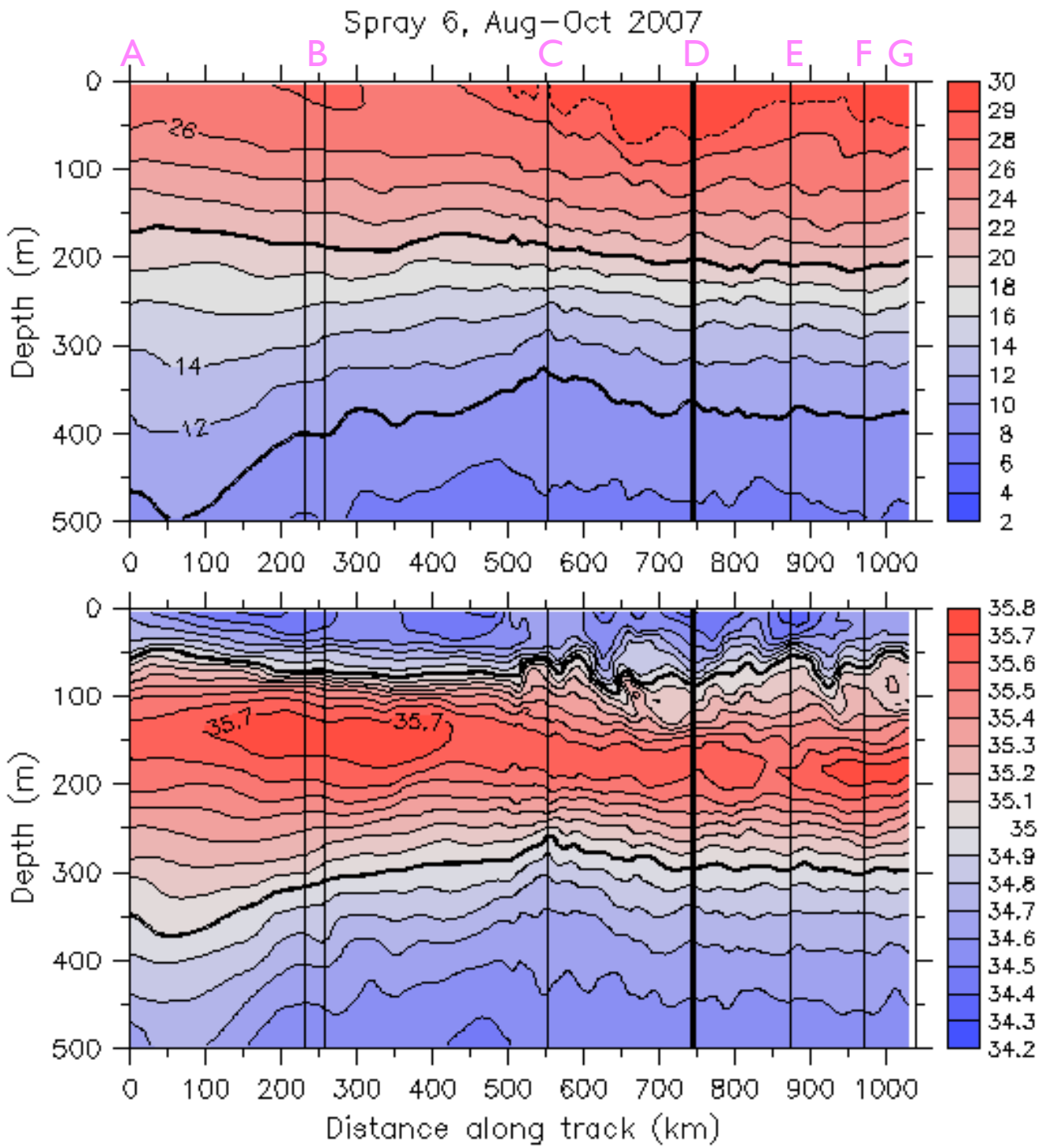


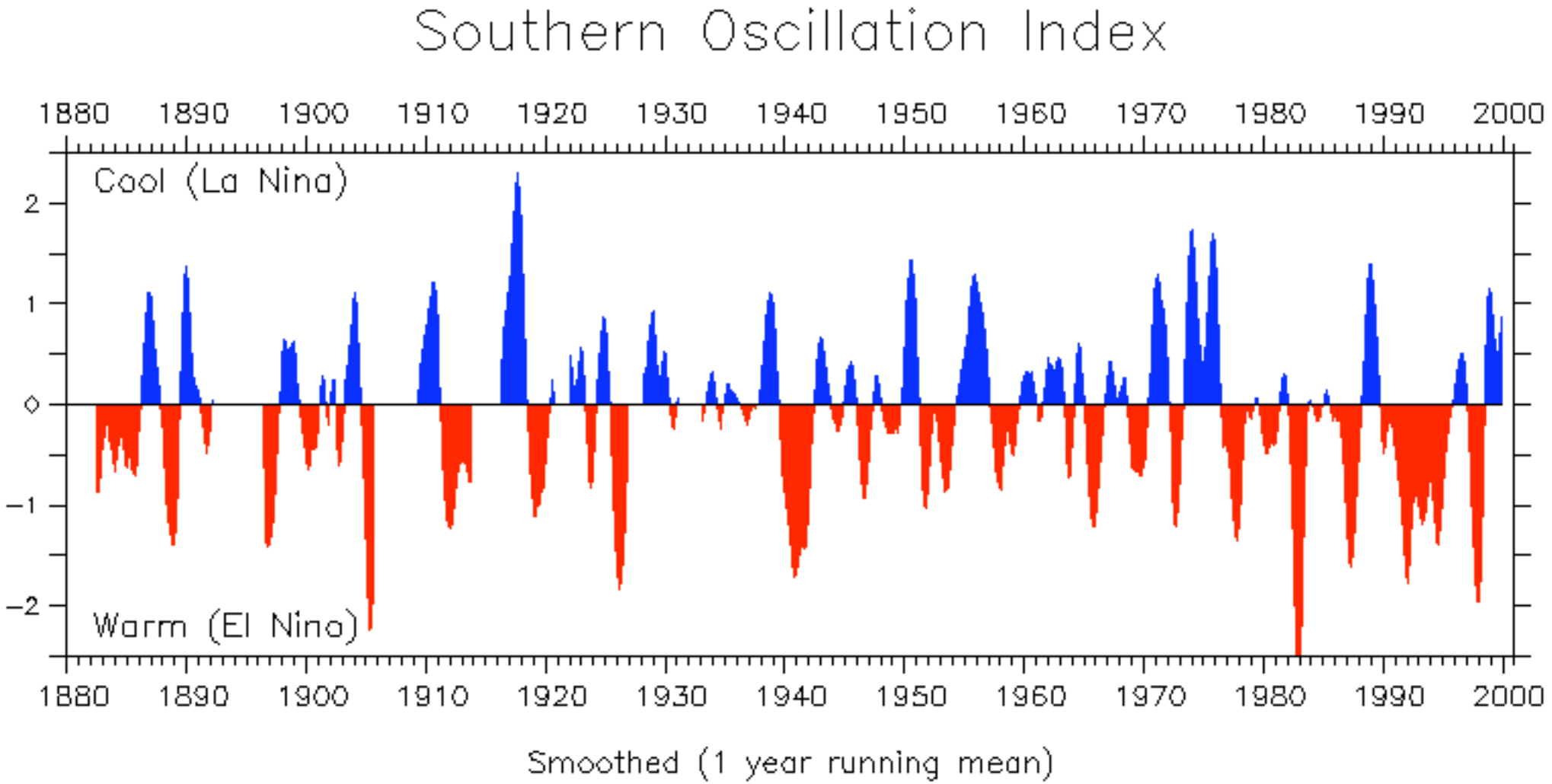
- Still experimental!
  But proof of concept that the glider can measure the NGCC.
- The Solomon Sea is a crucial area whose currents may give important predictability for the turns of the El Niño cycle and other climate signals.
  These currents will be difficult to monitor except by instruments that can control their position.

Extra Figures Follow ...

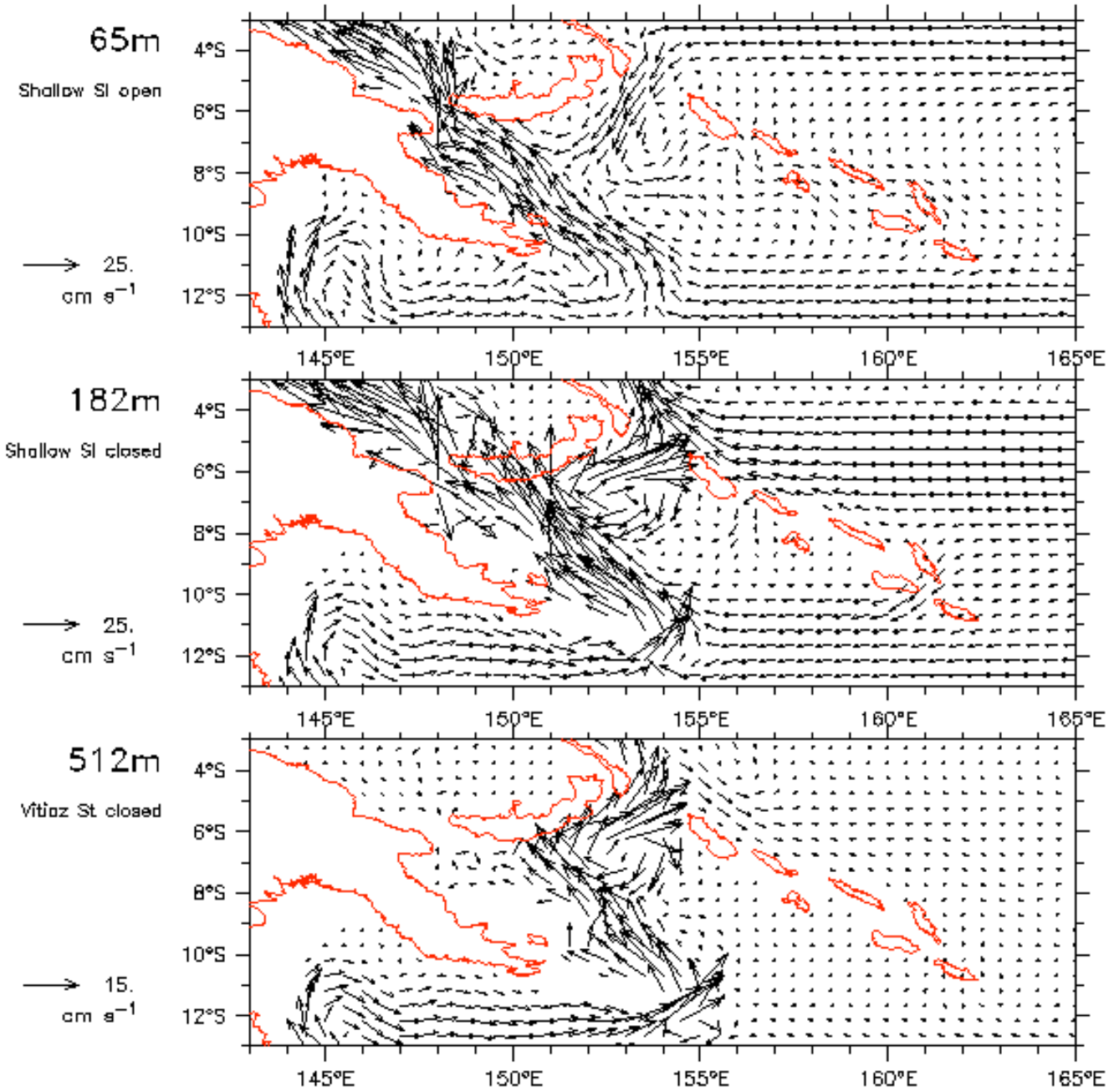


Temperature and salinity along the glider track




Southern Oscillation Index
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Cool (La Nina)
Warm (El Nino)
2
1
0
−1
−2
Smoothed (1 year running mean)

ORCA model circulation at surface, thermocline and below



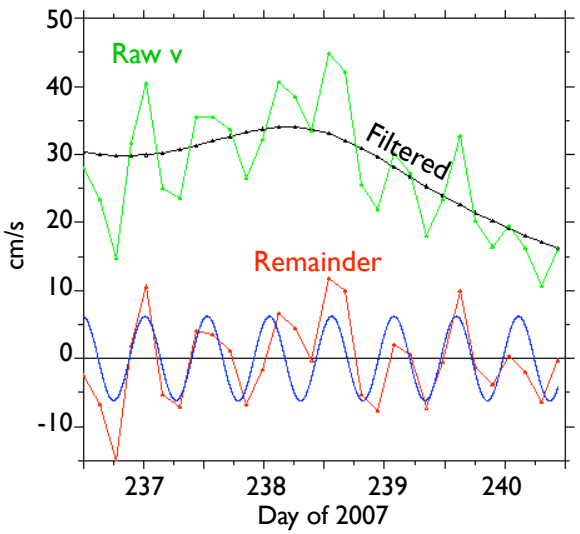
Above 100m:
Flow through Sol. St. is *southward*.
(Consistent w/ obs).

Thermocline level:
Sol. St. flow is northward
(Pacific inflow ~1/2 total).

Below Vitiaz St:
Entire WBC exits Solomon Sea via Sol. St.
(No Pacific inflow).

Vector absolute current above 500m

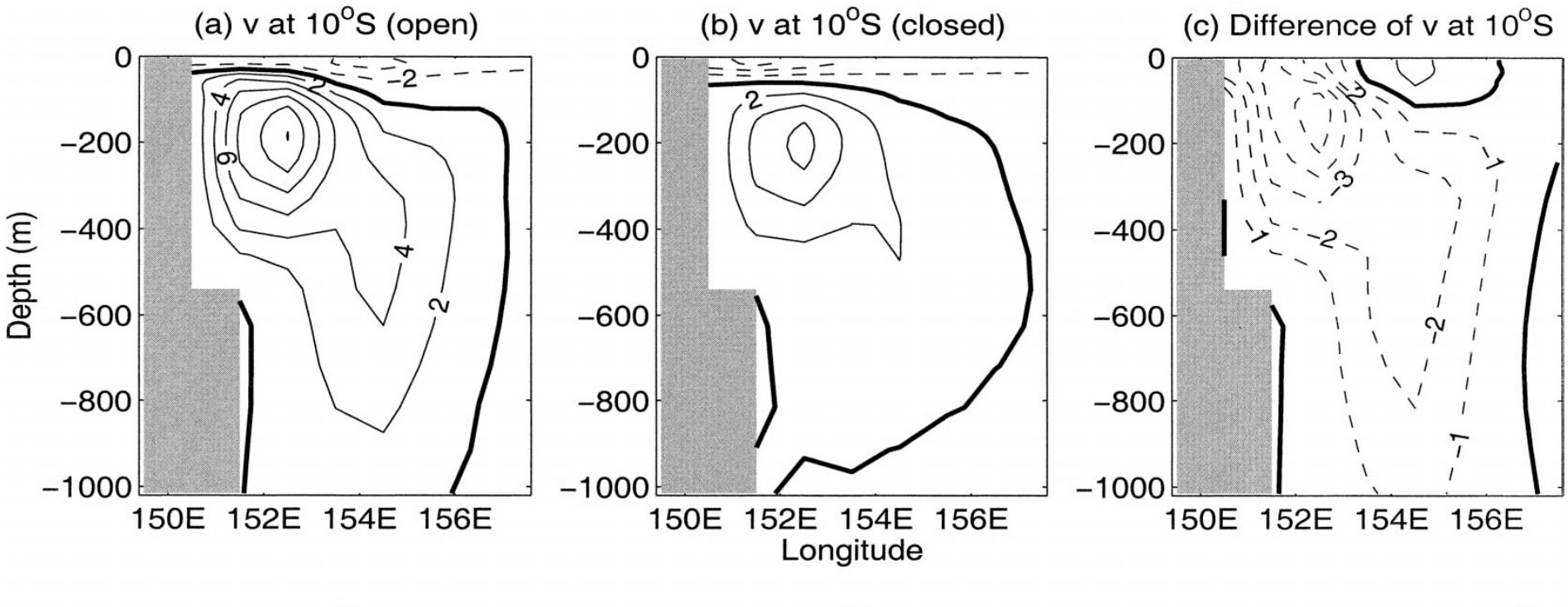
(Tide-filtered)



Tide-filtering by a Gaussian objective mapping on time with a time-scale of 1.5 days.

(Every other vector plotted)

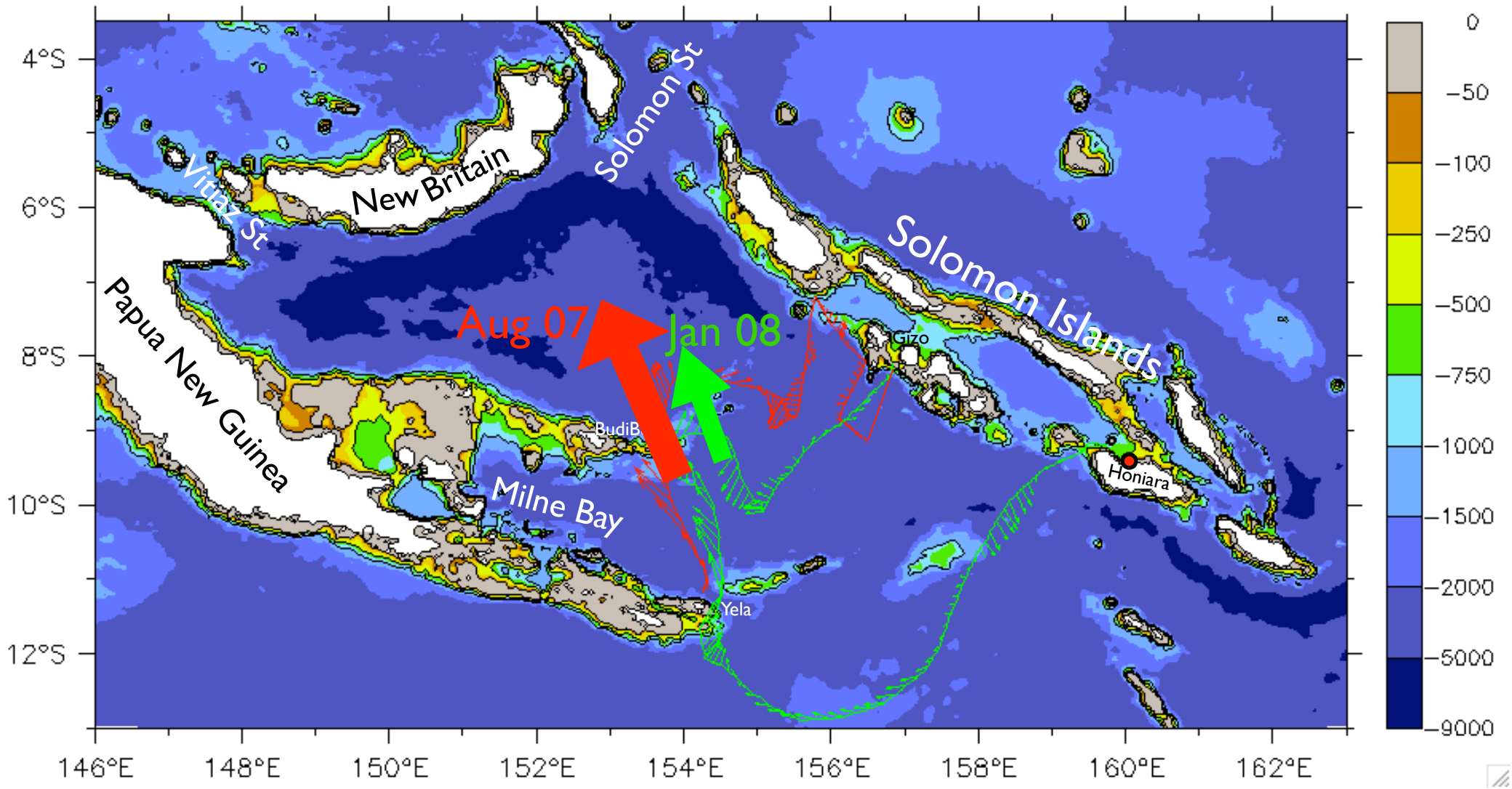
OGCM meridional current at 10°S with and without an ITF:



(Difference = effect of closing ITF)

Lee et al (2002)
MIT OGCM

The glider observations show that the NGCC is weakening



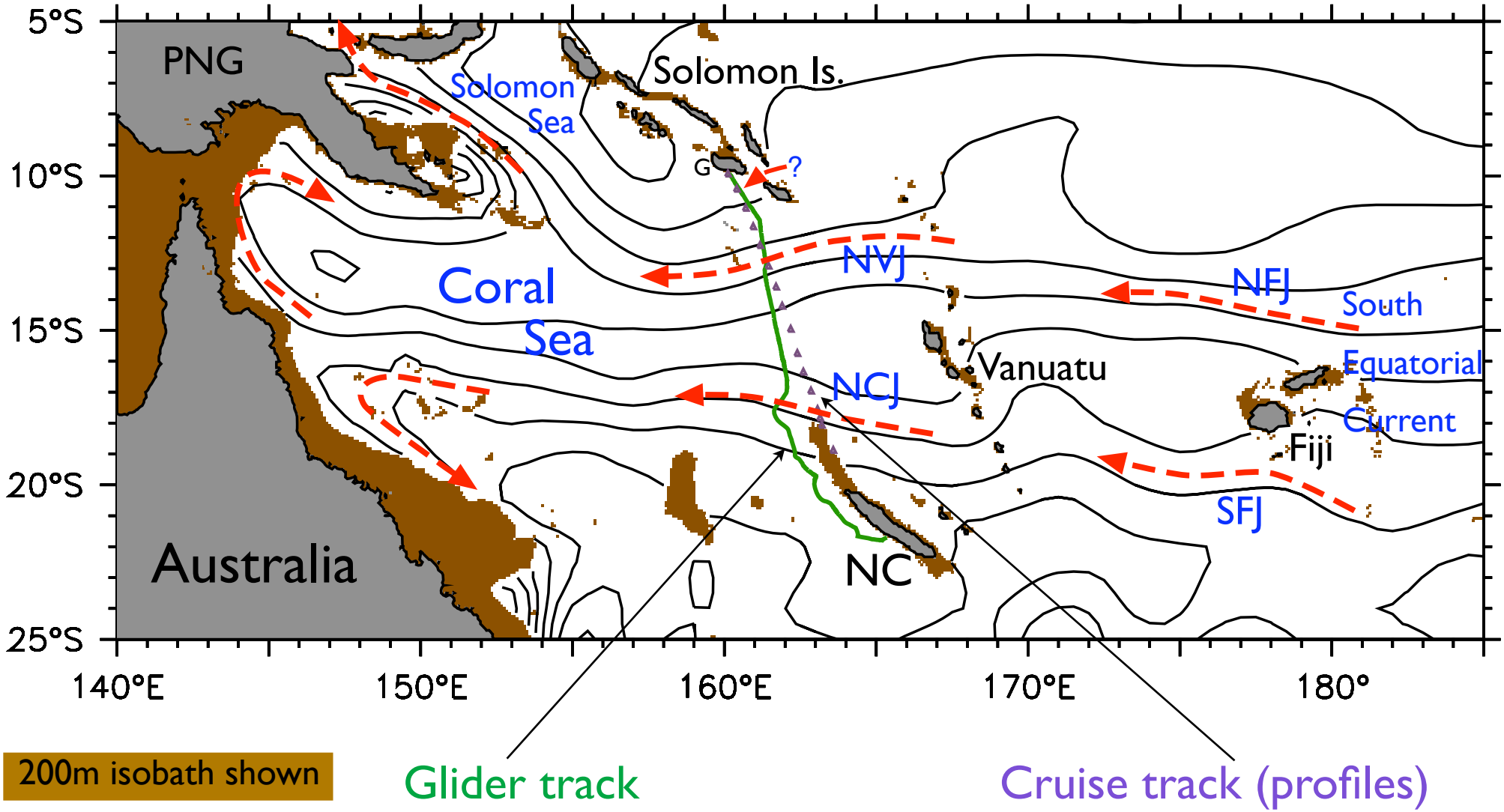
The transport of the NGCC declined by about 60% between August 2007 and January 2008 as the La Niña grew

Shipboard and glider section between Guadalcanal and New Caledonia

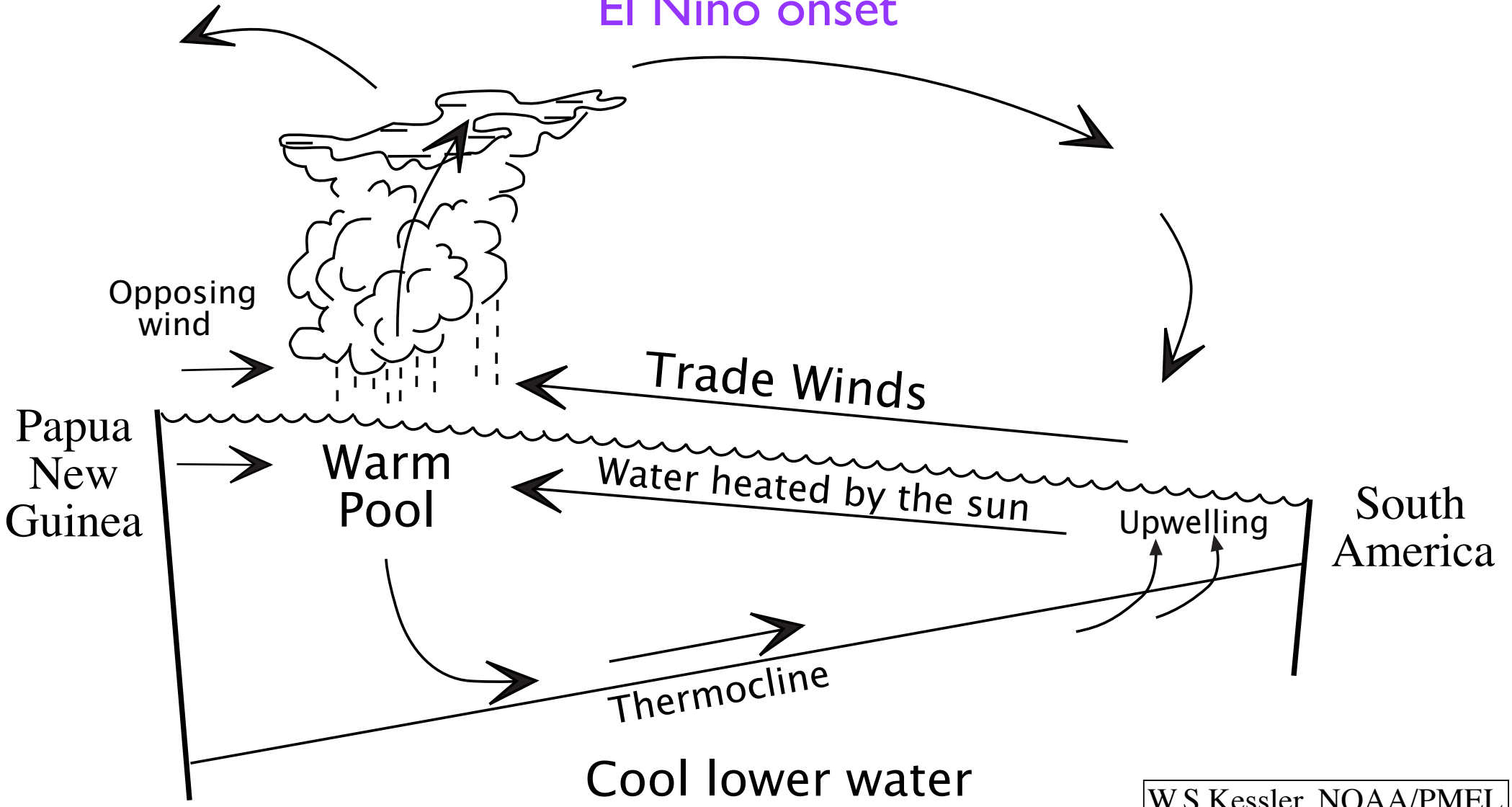
A coordinated experiment

July-October 2005, glider repeated Nov 06-Mar 07

(Gourdeau et al, in press, JPO)



Schematic diagram of the coupled interaction along the equator: El Niño onset

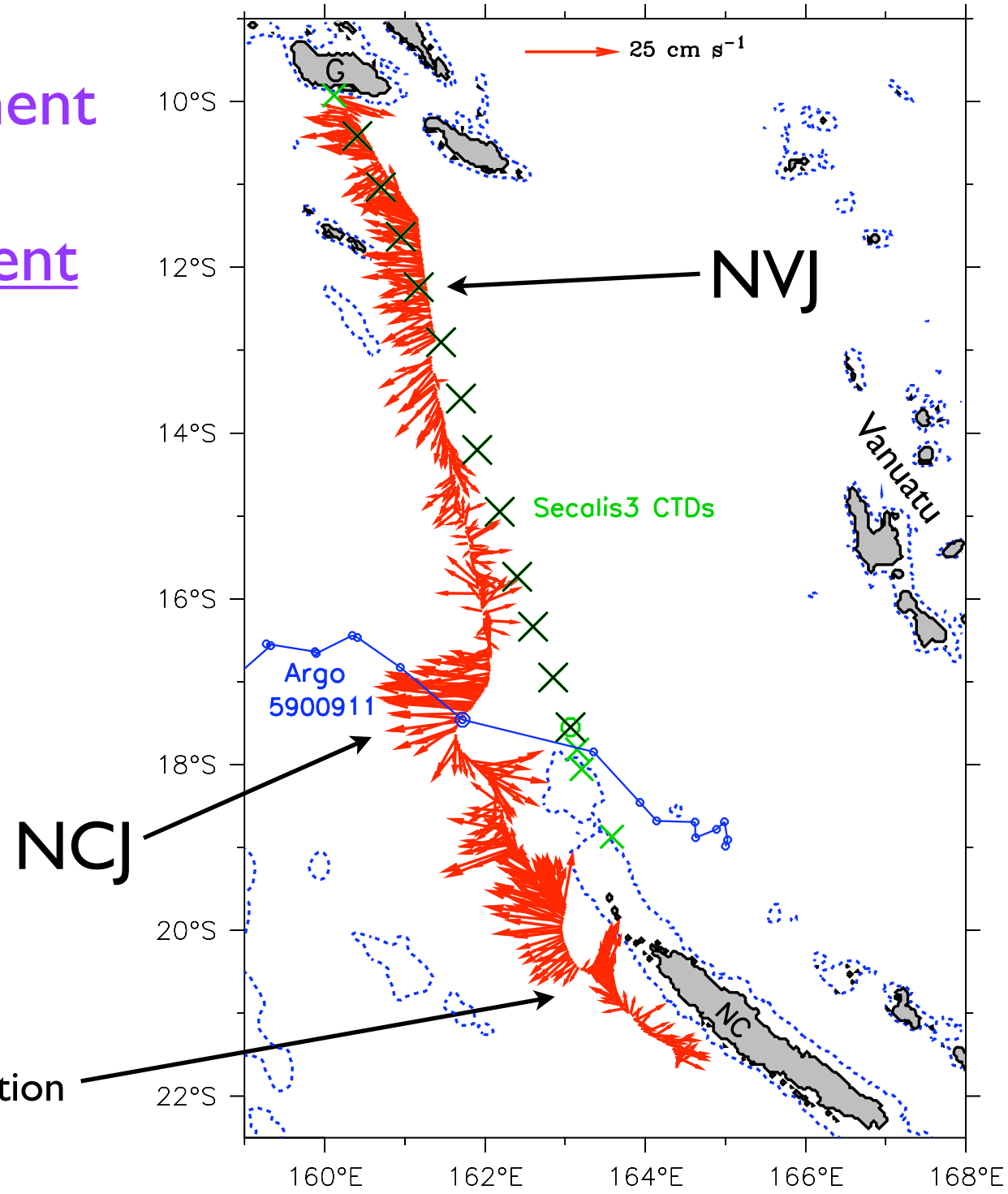


First mission:
A coordinated experiment to study the South Equatorial Current

Jul-Oct 2005

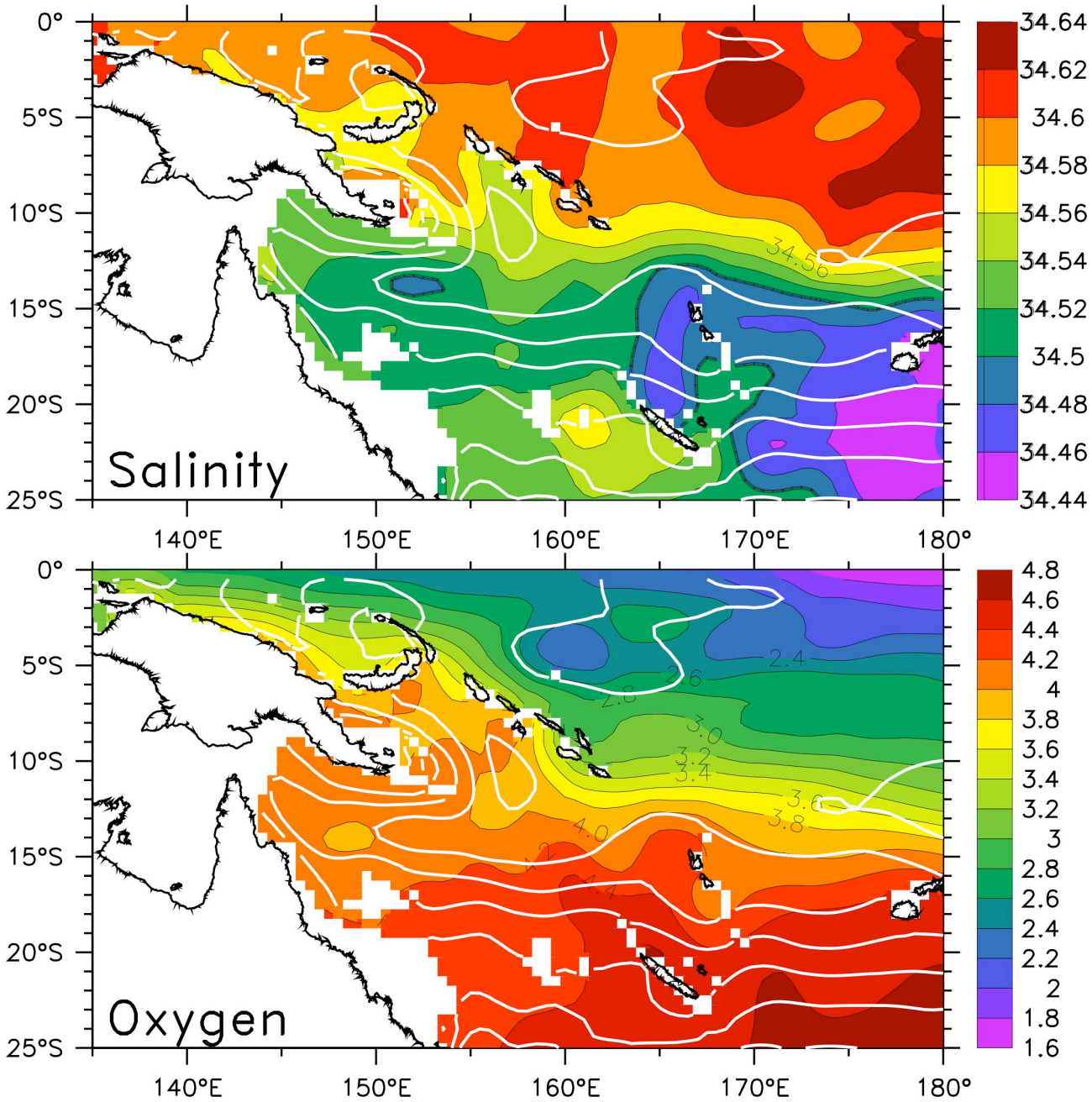
- A shipboard section made 14 profiles to 2000m.
- A glider section made dense profiles to 600m.
- An Argo float drifted through the NCJ.

Strong near-coastal circulation



Salinity and Oxygen on Sigma-theta = 27

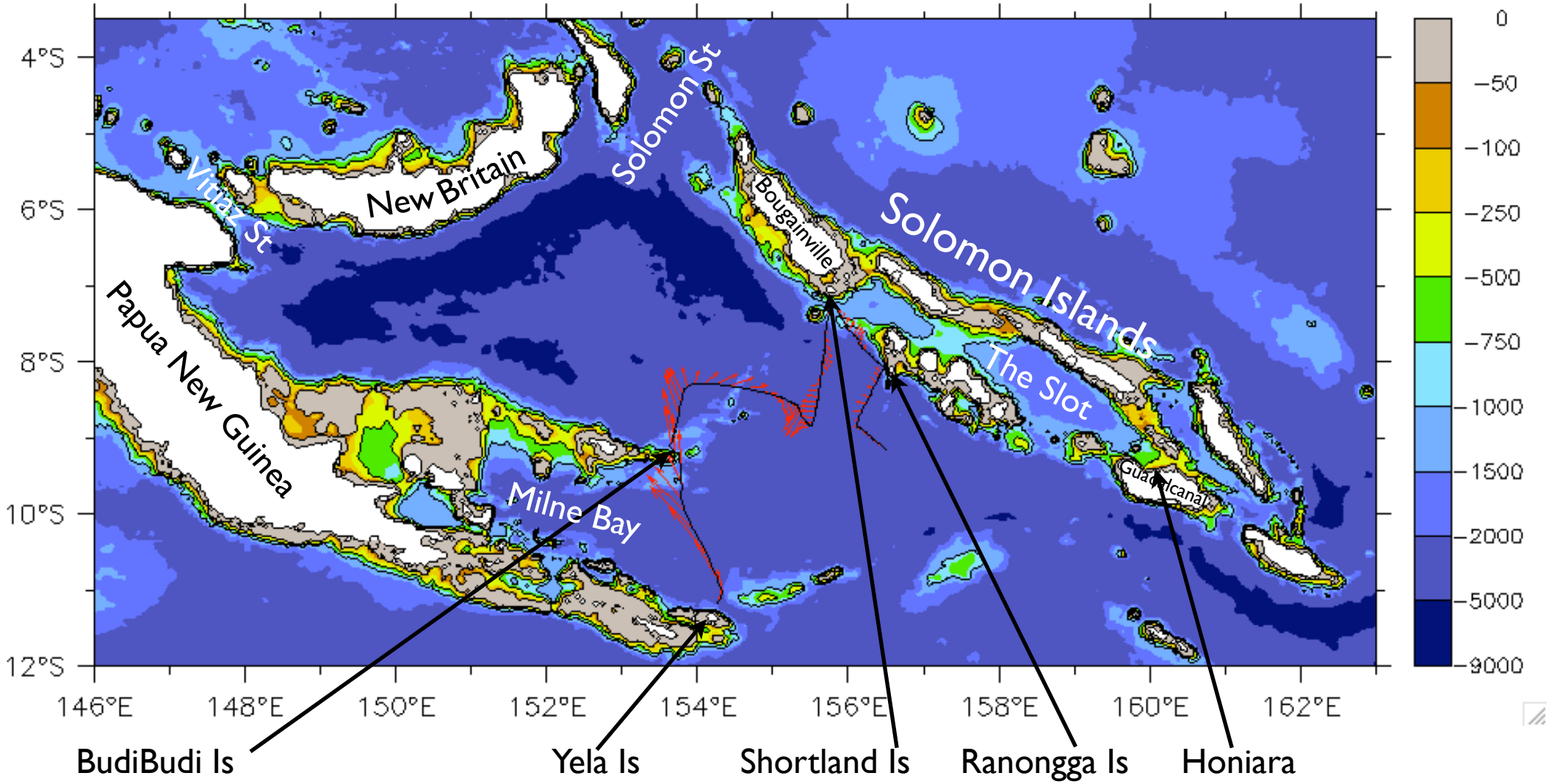
CARS data. Overlay streamlines on isopycnal



At sigma 27 (~6-800m), the sparse available data suggests that a low-S, high-O_2 tongue penetrates out of the Solomon Sea into the equatorial Pacific via the Australian WBCs.

Glider monitoring of the Solomon Sea

Funded for 4 deployments starting Aug 07



Crosstrack transport accumulated from Rossel Is.