# Rossby Waves — *A movement with three signatures*


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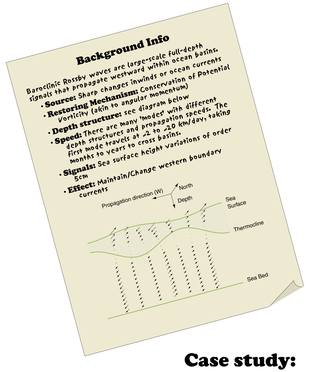
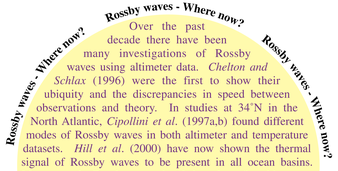


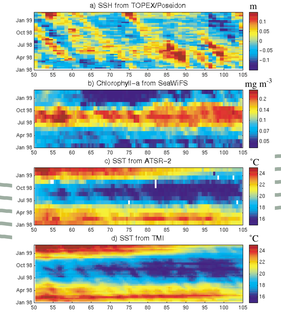

## Case study: 32°S in the Indian Ocean

SSH — TOPEX / Poseidon (T/P)

Ocean Colour — SeaWiFS on OrbView-2

SST Infra-red — ATSR-2 on ERS-2

SST Passive m/wave — TMI on TRMM

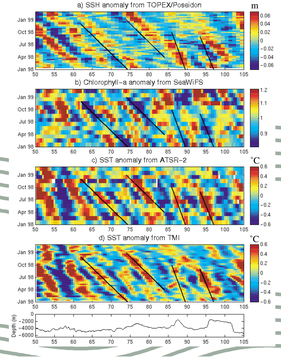



We take data from 4 different sensors on 4 different platforms, and apply standard corrections and interpolate to a regular grid.

Each parameter shows a strong seasonal variation: SST peaks in January-February, the SSH (affected by the seasonal warming) a few months later, and there is a "*spring bloom*" leading to maximum in a chlorophyll-a content in August-September.

[ Note the SeaWiFS and ATSR data are binned by month; T/P and TMI in 10-day intervals. There is a logaritmic scale for b). ]

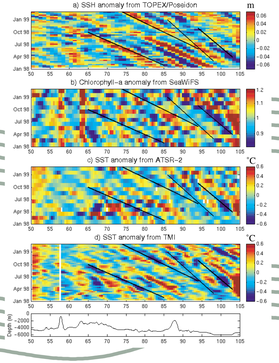
SPATIAL FILTERING (only in longitudinal direction) ⇒ anomalies relative to local mean




Although each time interval was processed independently, there are clearly westward-propagating signals in all 4 parameters.

There is very good agreement between the passive microwave-derived SSTs and the infra-red values.

As filtering was on *log(chlorophyll)*, plot b) shows proportional changes. Black lines highlight 4 decreases in chlorophyll.




Results for similar processing at 20°S. The middle pair of lines (i.e. around 85°-95°E) are placed along decreases in SST and show a divergence / crossing of two different baroclinic modes.

**Note**

- Similar features seen in SST and ocean colour, being in phase at 20°S and exactly out of phase at 32°S.
- Western basin has fast (1st mode) Rossby waves; eastern half has slower ones — bathymetry may be the key to the change.
- Slower modes less clear in SSH.
- SST usually leads SSH by 90° of phase.

## Mechanisms?

In studies of the "waveguide" at 34°N in the N. Atlantic, *Cipollini et al.* (1997a,b) found the signals in SSH and SST to be in phase with one another. This tallied with the idea that the SST signal reflected a change in density of the upper waters, and that height and density effects balanced one another out.

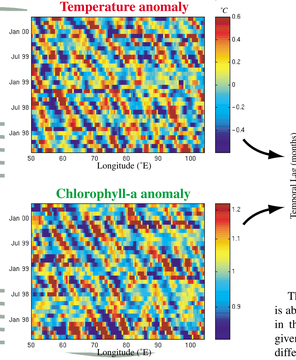
However the signal in ocean colour was a little surprising. *Cipollini et al.* (2000) advance 2 possible explanations:

- A physical lifting of more phytoplankton into the top of the water column that is sensed by satellite,
- A mixing of phytoplankton with nutrient rich waters, leading to biological growth.

To distinguish between these ideas we look at the phase relationships between the Rossby wave signatures in the various parameters.

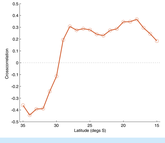
## Cross-Correlation

To investigate the observed correlation between SST and ocean colour we perform a cross-correlation between the anomalies for the 33-month overlap of the ATSR-2 and SeaWiFS datasets.




The value at the centre (zero spatio-temporal lag) is about -0.4. This indicates a strong anticorrelation in the phasing of the thermal and visible signals, given the amplitude of each varies seasonally in different ways.

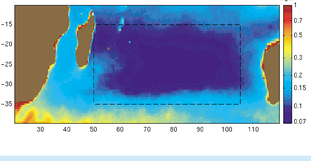
**Variation of correlation with latitude**




## Results and Conclusion

An extension to all latitudes between 35°S and 15°S shows a clear change from anti-correlation to positive correlation at ~30°S. This corresponds to a change from the meridional gradients in SST and chlorophyll from being in opposition to being in phase, and suggests that meridional advection may be the key mechanism behind the thermal and visible signatures of Rossby waves in this region, in agreement with the observations of *White et al.* (1998) for SSH, SST and wind speed in the Pacific.

**Annual mean chlorophyll-a content**




Synergy — Can you handle it?


**References**

Chelton, D.B. and M.G. Schlax, 1996, "Global observations of oceanic Rossby waves", *Science*, **272**, 234-238.

Cipollini, P., D. Cromwell, M.S. Jones, G.D. Quartly and P.G. Challenor, 1997a, "Concurrent altimeter and infrared observations of Rossby wave propagation near 34°N in the northeast Atlantic", *Geophys. Res. Lett.*, **24**, 889-892.

Cipollini, P., D. Cromwell, M.S. Jones, G.D. Quartly and P.G. Challenor, 1997b, "The potential of ERS for the detection of Rossby waves in the northeast Atlantic", *3rd ERS Symposium - Space at the service of our environment*, Florence, Italy, ESA, 1473-1478.

Cipollini, D. Cromwell, P.G. Challenor and S. Raffaglio, 2000, "Rossby waves detected in global ocean color data", *Geophys. Res. Lett.*, in press.

Hill, K.L., I.S. Robinson and P. Cipollini, 2000, "Propagation characteristics of extratropical planetary waves observed in the global ATSR sea surface temperature record", *J. Geophys. Res.*, **105**, 21927-21946.

White, Y. Chao and C.-K. Tai, 1998, "Coupling of biennial oceanic Rossby waves with the overlying atmosphere in the Pacific basin", *J. Phys. Oceanogr.*, **28**, 1236-1251.



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