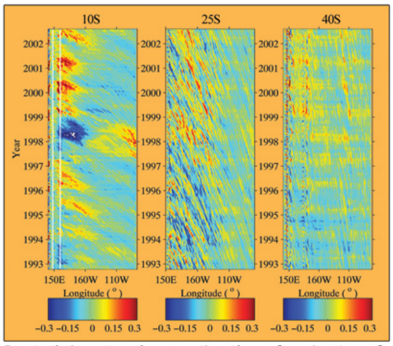
An evaluation of the classical and extended Rossby wave theories in the South Pacific Ocean.

Angela M. Maharaj[1], Paolo Cipollini[2], Neil J. Holbrook[1] Peter D. Killworth[2] and Jeffrey R. Blundell[2]

1.Department of Physical Geography, Macquarie University, Sydney, Australia, 2.National Oceanography Centre, Southampton, European Way, Southampton, UK.

email: amaharaj@els.mq.edu.au



Due to their westward propagation, the surface signature of Rossby waves is clearly visible in longitude-time plots of SLA as diagonally aligned peaks and troughs.

Introduction

As the main oceanic response to changes in atmospheric forcing, baroclinic Rossby waves play a critical role in ocean dynamics. The aims of this study are:

1.To determine the spectral signature and energy contributions of the first four baroclinic Rossby wave modes in the South Pacific SLA using two Rossby wave theories: the classical linear wave theory and the Killworth and Blundell (2005) extended theory.
2.To evaluate the appropriateness of the two theories for the region from the amount of variance that can be explained by the first four modes of each theory.
3.To ascertain the relative roles of bathymetry and mean flow in the extended theory.

This poster is based on the results of Maharaj et al. (2007) Ocean Dynamics.

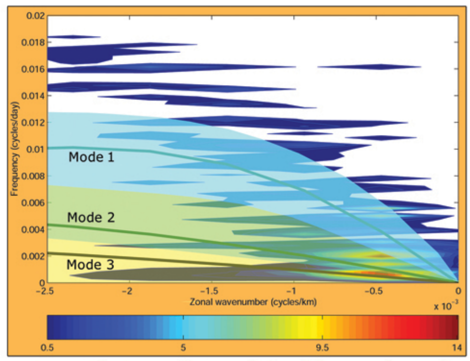
Data

Merged T/P + ERS 1 and 2 altimeter dataset (DUACS/CLS) of observed sea level anomalies (SLA) for the South Pacific Ocean (10°S-50°S) from 14 October 1992 to 7 August 2002.

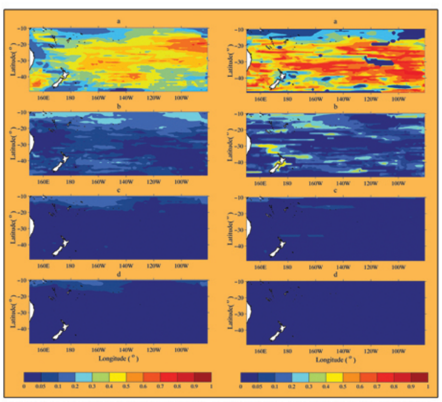
Method

- Extract 1° latitude, 20º longitude running window of longitude-time plots.
- 2D-FT to find power spectrum of longitude-time plots
- Determine dispersion curves for 1st to 4th baroclinic modes for:
  1. Classic linear wave theory-Zero background flow and flat bottom ocean.
  2. Extended theory (Killworth and Blundell 2005) - Includes the effects of the baroclinic background mean flow and 1° resolution topography.

  and project onto the power spectrum
- Quantify the contribution of each mode. For every 20° window:
  1. Partition the energy in the spectra. Define the boundary of each mode as the bisector between the median dispersion curve of each mode.
  2. Impose a 95% confidence interval to take into account variability in and the number of actual solutions available to compute the median dispersion curve.
  3. Integrate the variance within the boundary and divide by the total variance to yield an energy ratio for each mode.



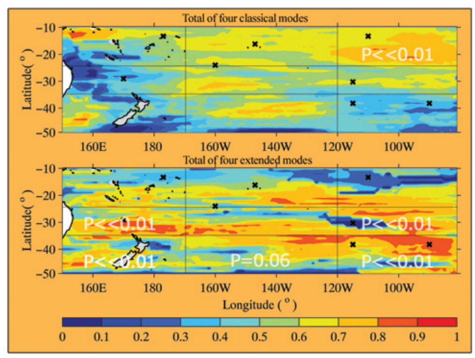
The energy ratio for each mode is a simple measure of the variance in the power spectrum that can be explained by each mode.



Energy ratio quantifying proportion of variance explained by modes 1(a) through to 4(d) for classical (left) and extended (right) theories.

1.Energy contributions of the first four baroclinic Rossby wave modes for the two theories

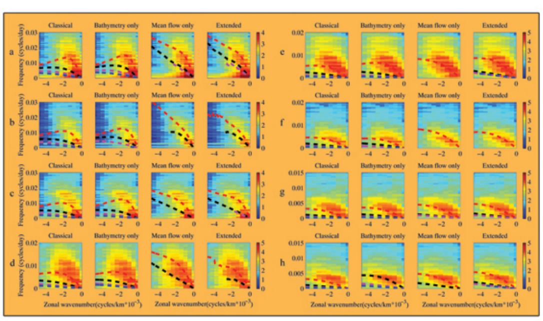
- First mode contributions dominate
- Second mode contributions are important across most of the basin
- Third mode contributions are small and localised
- Fourth mode contributions are negligible



2.Evaluation of classical and extended theories

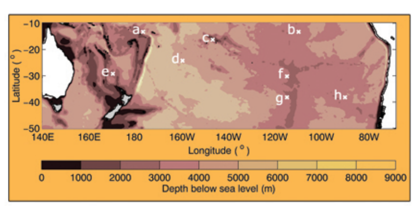
A statistical comparison of the energy ratios over these regions indicates that:

- The classical theory explains a significantly larger proportion of the energy in the Eastern Tropics than the extended theory
- The extended theory performs significantly better in the Western and Eastern Subtropics, Mid-latitudes and the Mid-latitude Central Pacific
- Statistically, there is little difference between the two theories in the remaining regions.



3.Ascertain the relative roles of bathymetry and mean flow in the extended theory

- Extended theory first mode predicts the main SLA signal very well at low wave-numbers and fairly well at larger wavenumbers
- Bathymetric effects may dominate at long wavelengths and yield higher order mode solutions
- Mean flow influence dominates the extended theory. Generally, it reduces higher order mode solutions and improves predictions at larger wavenumbers
- There is regional variability in the dispersion curve characteristics across the basin



Conclusion

The large proportion of spectral energy explained by the second baroclinic mode suggests that it plays an important role in South Pacific ocean dynamics. The dispersion characteristics and regional variability of the first few baroclinic modes is complex and may potentially translate to varying Rossby wave dynamics.

References

Killworth, P. D., and J. R. Blundell (2005) The dispersion relation for planetary waves in the presence of mean flow and topography. Part II: Two-dimensional examples and global results, J. Phys. Oceanogr., 35, 2110–2133.

Maharaj, A. M., P. Cipollini, N. J. Holbrook, P. D. Killworth and J. R. Blundell (2007) An evaluation of the classical and extended Rossby wave theories in explaining spectral estimates of the first few baroclinic modes in the South Pacific Ocean, Ocean Dynamics, DOI: 10.1007/s10236-006-0099-5

MACQUARIE UNIVERSITY~SYDNEY

National Oceanography Centre, Southampton
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL