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

Angela M. Maharaj¹, Paolo Cipollini², Neil J. Holbrook¹, Peter D. Killworth² and Jeffrey R. Blundell²

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

email: amaharaj@eol.mq.edu.au

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 (10⁰S-50⁰S) from 14 October 1992 to 7 August 2002.

Method

- Extract 1⁰ latitude, 2⁰ 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:
  2. Extended theory (Killworth and Blundell 2005): Includes the effects of the baroclinic background mean flow and 1st 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.

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 localized
   - 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 Middle-Longitude 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 wave-numbers.
   - 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 wave-numbers.
   - 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
