Interactions of the eastern and western boundary systems off South America and South Africa with the large-scale circulation in the Southern Ocean

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The goal of this project is to investigate linkages between basin-scale circulation and the eastern and western boundary currents next to South America and South Africa. We are attempting to identify the primary causes of variability in those boundary currents. The specific regions of interest are the two eastern boundary currents (the Peru-Chile Current System and the Benguela Current System) and the two extremely energetic confluence regions for the western boundary currents (the Brazil-Malvinas Confluence and the Agulhas Retroflection Region).

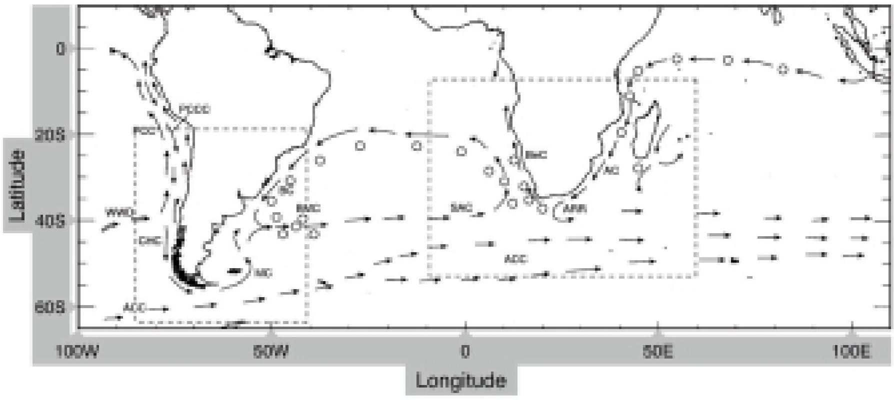

Figure 1: The domains of interest and the relevant currents.

Objectives

Our overall scientific goal is to quantify the contribution of upstream and downstream features to the variability of the regional boundary current systems.

Our specific objectives include: Analyzing model output, and altimeter and other satellite data in the Southern Ocean eastern boundary currents (EBC), and exploring their connections to basin scale currents. These basin-scale currents are affected by the equatorial currents on their northern boundaries and the eastward flowing west wind drift currents and Antarctic Circumpolar Current (ACC) to their south.

We will also extend our analyses to the western boundary currents (WBCs) off the eastern coasts of South America and South Africa, and to the Cape Horn Current off the southwest coast of South America. Off South America, the strongest interactions are presently thought to be between the ACC, Malvinas and Brazil Currents.
Off South Africa, the Agulhas and Benguela Currents interact with the South Atlantic Current and the ACC, providing a connection between the boundary currents from both sides of the continent. Our recent analyses of both altimeter and model data suggests that the upstream region of the Agulhas Current is affected by eddies that originate north of Madagascar. Similarly, the Brazil Current is thought to be impacted by upstream eddies that originate in the Agulhas Retroflection Area, after crossing the South Atlantic.

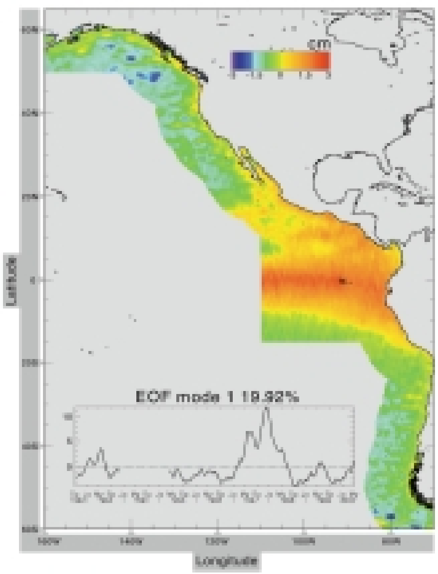

Figure 2: First EOF of Eastern Pacific residual SSH, showing the El Niño Signal.

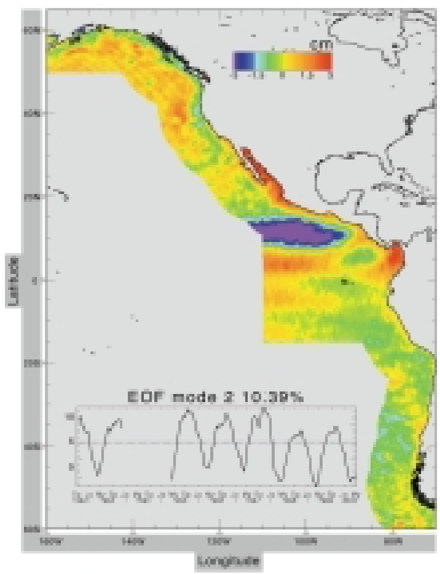

Figure 3: Second EOF of Eastern Pacific residual SSH, showing the annual cycle.

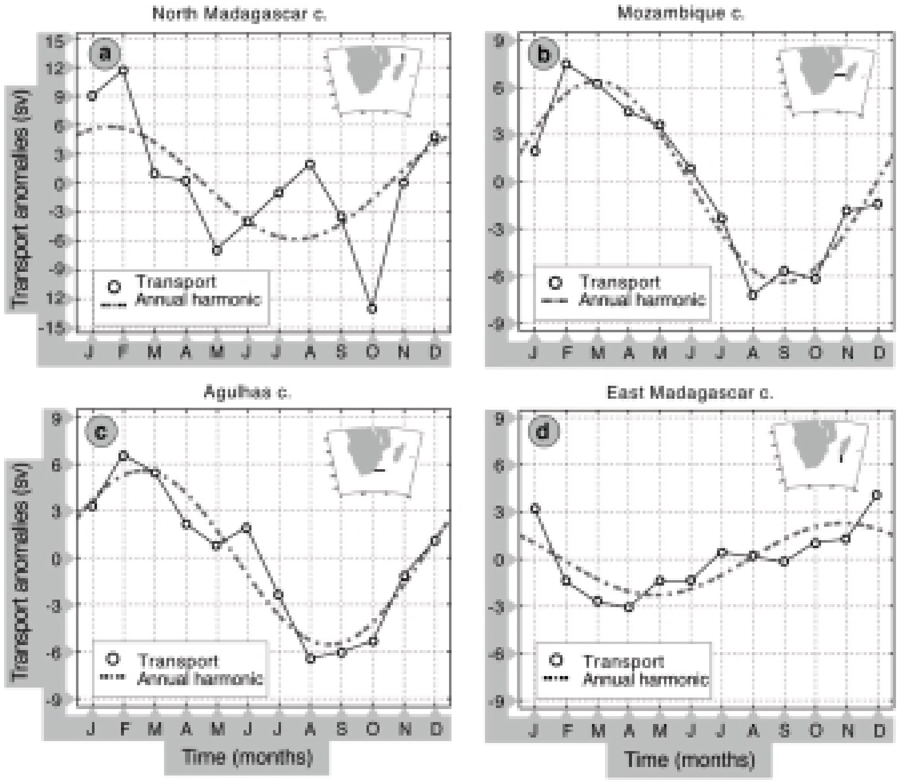

Figure 4: Harmonic analysis of the transports across four sections (inset maps) of the global model (12 years of POCM), showing the upstream contribution to the Agulhas annual cycle.

Our final objective is to conduct regional model studies around the southern "cones" of both continents, in order to further examine the dynamics of the currents and their interactions with upstream and downstream influences.

Progress

Figure 1 shows our large-scale regions of interest. Our present efforts are primarily directed toward understanding the causes of annual and interannual variability in the Peru-Chile Current and in examining the sources of annual variability in the Agulhas Current, in both cases extending work started under the TOPEX/POSEIDON Extended Mission (TPEM). On interannual scales, the work in the Peru-Chile Current has traced the Equatorial El Niño signal into both hemispheres. This work is continuing, primarily with funding from the U.S. GLOBEC Northeast Pacific project. The first EOF of SSH in the eastern Pacific (figure 2) is the clear El Niño signal, which explains 20% of the variance and shows the strong connection between the equator and coastal regions to approximately 20°N and 20°S. Weaker connections continue to mid-and high-latitudes. Figure 3 shows the second EOF of SSH in the eastern Pacific, which explains 10% of the variance and picks out the seasonal cycle, including the strong connection between the North Equatorial Counter Current (NECC), the Costa Rica Current along Central America and the California Current along North America (out of phase with the signal off Central America).
The striking feature in figure 3 is the relative weakness in the seasonal cycle off South America in comparison to Central/North America. We hypothesize that this is due to the lack of a strong ITCZ and NECC in the southeast Pacific [Strub and James, 2001a, 2001b, 2001c].

Off South Africa, analysis of regional models and altimeter data have documented the annual cycle of transport in the Agulhas Current and determined that this variability is not propagating into the Agulhas region from the mid-latitude South Indian Ocean to its east [Matano et al., 1998; Matano et al., 1999]. Further analysis using global numerical model output has traced this variability to the Mozambique and North Madagascar Currents (figure 4) where the variability appears to be driven by the large-scale winds in the western part of the South Indian Ocean north of Madagascar [Matano et al., 2001]. The same analysis determined that this variability does not originate farther east. Both altimeter data and the global model output suggest that the eastern and central Indian Ocean regions are decoupled from the circulation in the western region by the topographic control of the Mid-Indian Ridge. A similar analysis of the Brazil-Malvinas Confluence is in its early stages.

References

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