SOUTH ATLANTIC SEASONAL AND INTERANNUAL VARIABILITY AND ITS RELATION TO INTERBASIN EXCHANGE

A.L. Gordon, D.L. Witter
(Lamont-Doherty Earth Observatory of Columbia University, USA)

The objectives of this project are to quantify the seasonal to interannual variability of South Atlantic circulation, its relation to interbasin exchange, and its relation to the large-scale wind field. As demonstrated by recent observational and modeling studies [Gordon et al. 1992; Schmitz 1995; Thompson et al. 1997], interbasin exchange may contribute to the heat, salt, and vorticity balances of the South Atlantic. Time-dependent variations of interbasin exchange may also play a role in variability of the thermohaline circulation.

Project description

In many ways, the large-scale circulation of the South Atlantic subtropical gyre is similar to that of other ocean gyres. However, the unique position of the South Atlantic allows this basin to play a particularly important role in the cycle of global ocean circulation. The geometry of the South Atlantic basin, in particular the fact that South Africa doesn't extend to the latitude of maximum westerlies, allows for the possibility of heat, salt, and vorticity communication between the South Atlantic thermocline and its counterpart in the South Indian Ocean. In addition, exchanges between the Pacific and Atlantic basins at Drake Passage may also play a significant role in the global thermohaline circulation. These processes at the eastern and western boundaries of South Atlantic are linked by the large-scale gyre circulation and by the transport of mesoscale eddies across the basin. Variations of South Atlantic circulation must therefore be considered for the basin as a whole, in conjunction with analysis of circulation in adjacent ocean regions. The sampling provided by satellite altimetry is ideally suited for this task. In this project, we investigate variations of South Atlantic ocean circulation using TOPEX/POSEIDON altimetry, in situ observations, atmospheric reanalyses, and a numerical ocean model.

Activities and progress during 1997

During the first phase of this project, we are quantifying South Atlantic ocean variability and its link to atmospheric forcing from TOPEX/POSEIDON altimetry, in situ measurements, and NCEP/NCAR atmospheric reanalyses fields [Kalnay et al. 1996]. Using singular value decomposition (SVD), we have isolated gyre-scale and regional modes of South Atlantic zonal wind and sea level covariability. The lowest order modes include patterns marked by variations of the Brazil-Malvinas Confluence, basin-scale patterns, and patterns which suggest

a relationship between time-dependent variations of zonal wind and time-dependent variations of interbasin exchange via Agulhas eddies (Figure 1).

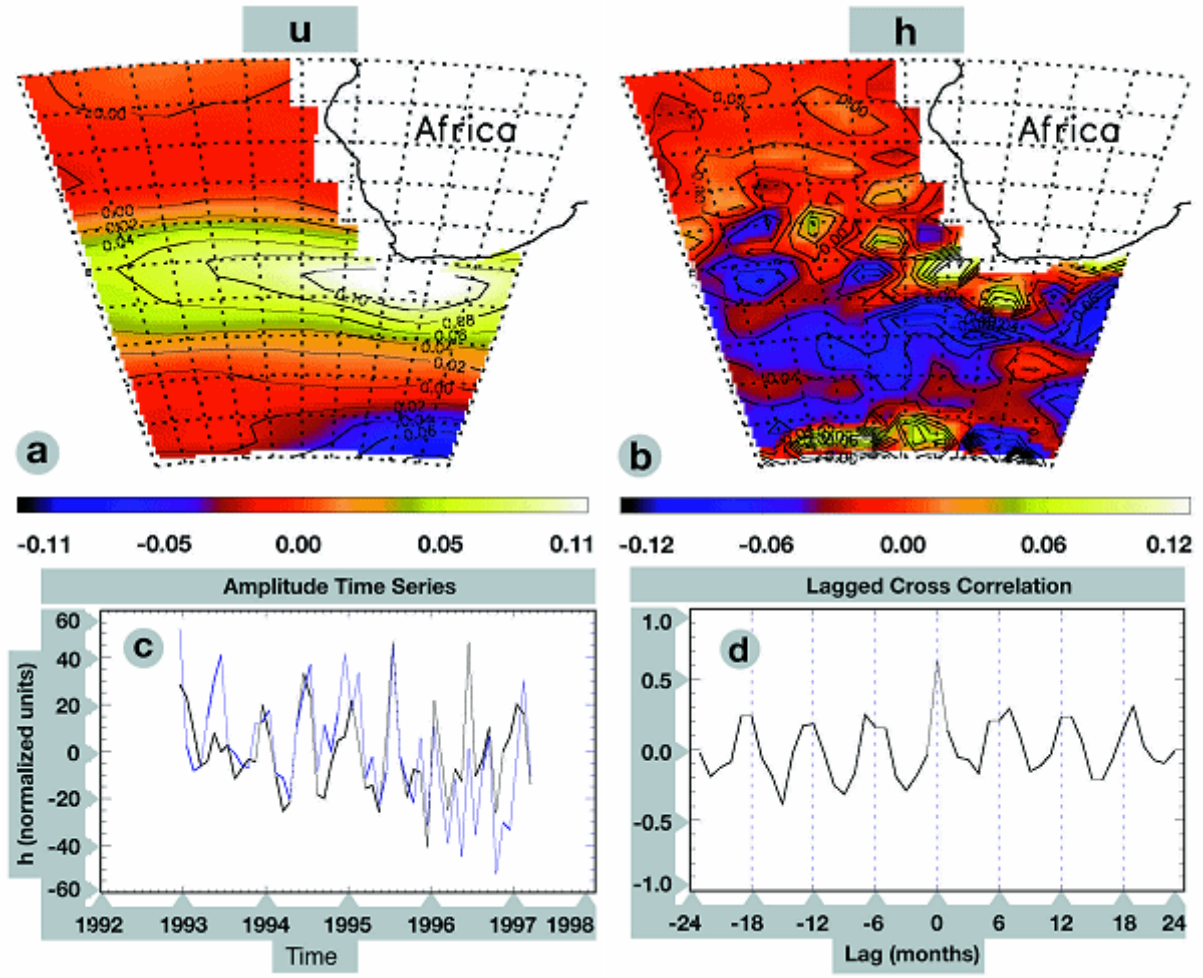

Figure 1

A mode of South Atlantic zonal wind (u) and sea level (h) covariability isolated from SVD analysis of NCEP/NCAR reanalysis fields and TOPEX/POSEIDON observations. The spatial patterns of u (a) and h (b) suggest a link between zonal wind variations south of South Africa and sea level variability associated with Agulhas eddy propagation. The amplitude time series (c), and the lagged cross correlation between these two time series (d) indicate that this mode includes both semiannual and year-to-year fluctuations. This mode represents 44.8% of the mean-squared temporal covariability between u and h in the domain shown.

During 1997, we have also focused on quantifying the seasonal and year-to-year variability of South Atlantic sea level from the TOPEX/POSEIDON observations alone. Our analysis of seasonal variability demonstrates that both annual and semiannual Rossby waves propagate through the South Atlantic subtropical gyre. The propagations of these waves differs, however, for the two seasonal components. Annual Rossby waves generally propagate across the entire basin; semiannual propagation is more spatially inhomogeneous, with a particularly striking dependence on bathymetry. Our analysis of interannual variability demonstrates that year-to-year variations of sea level are larger in the gyre interior than at the gyre boundaries. Preliminary results from analysis of the high-resolution, along-track data suggest that some of

this interannual variability is linked to year-to-year changes in the migration of Agulhas eddies from the Cape Basin to the interior of the gyre. A smaller component of the interannual variability appears to be related to low frequency variations of local atmospheric forcing.

Future work

Our immediate plans are to continue the statistical analysis of the TOPEX/POSEIDON observations and other South Atlantic data sets. During year 2, we intend to focus primarily on:

1. the relationship between year-to-year variations of sea level at the interior of the gyre and variations of the large-scale wind field, and
2. the link between variations of sea level at the interior of the gyre and the migration of Agulhas eddies westward from the Cape Basin to the interior of the gyre.

We also plan to expand the scope of the analysis to investigate relations between sea level and sea surface temperature variability.

During phase two of this study, we will perform simulations with a wind-forced numerical ocean model to further investigate the dynamics of the signals isolated in the first phase of the project. As part of this numerical study, we plan to investigate effects of regional and basin-scale wind forcing on South Atlantic ocean circulation and interbasin water mass exchange. We anticipate that analysis of TOPEX/POSEIDON observations, in conjunction with numerical experiments, will improve understanding of the role of the South Atlantic in the global ocean circulation.

References :

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