BCLME Project EV/LS/02/06/

South Atlantic Climate Modes and their linkages with the Benguela Current Large Marine Ecosystem

Preliminary Report 1

Prof Chris Reason

February 2004

Centre for Marine Studies **University of Cape Town**	**Oceanography** **University of Cape Town**

Introduction

Variability of the South Atlantic Ocean plays an important role in affecting both global and regional climate. The former results from its unique geographical location connecting the Indian Ocean to the North Atlantic Ocean, thus, this basin acts as an important part of the thermohaline circulation. The latter arises since sea surface temperature (SST) patterns in the South Atlantic interact with the atmosphere, leading to rainfall variability over neighbouring countries (Reason, 2001; Rouault *et al*., 2003 and Robertson *et al*., 2003). Reason *et al*. (2002) present evidence of rainfall variability over the South Western Cape region of South Africa in the context of an enhanced meridional SST gradient in the South Atlantic. A later study (Reason *et al.*, 2003) examined the winter variability of the South East Atlantic and neighbouring South Africa and Namibia in an AGCM to show that there were significant changes in low level winds and moisture fluxes which not only affect SW Cape Winter rainfall but also upwelling off Namibia. Robertson *et al.* (2003) found evidence of an atmospheric response to oceanic SST anomalies in the tropics and subtropics of the South Atlantic in an AGCM. The existence of warm events in the in the eastern South Atlantic (Benguela -and Angola current region) and the impact on fish stocks along the western African coast has been examined by Binet *et al*. (2001) and Gammelsrod *et al*. (1998).

The South Atlantic Ocean experiences significant variability on interannual to multidecadal timescales (e.g. Venegas *et al*., 1996, 1997 and 1998; Wainer *et al*., 2001; Palastanga *et al*., 2002; Reason, 2000; Reason *et al*., 2002). Some SST variability occurs during El Niño and La Niña events implying a relationship with ENSO as a possible forcing. This assumption gains support from Venegas *et al*. (1996) where the third singular value decomposition (SVD) mode between SST anomalies and pressure anomalies of the South Atlantic is highly correlated with ENSO. The associated spatial pattern suggests a north-south displacement of the subtropical anticyclone implying gyre modifications due to ENSO. Analyses of SST anomalies on the Western South Atlantic

(Lentini *et al*., 2000) show that warm (cold) phases of the ENSO are connected to north (southward) extensions of cold (warm) water a year later in that region. Other studies such as Melice *et al*. (2002) find correlations between the tropical Atlantic meridional SST gradient (TAMG) and the SOI again suggesting connections between ENSO and the South Atlantic region. Other South Atlantic modes may however occur due to atmospheric forcings, coupled ocean-atmosphere modes and internal basin modes.

A recent study from Palastanga *et al*. (2002) shows that various modes of variability in the South Atlantic may be dependent on the degree of data coverage in certain areas as well as on the statistical tools used. These results show that there is still much investigation needed in order to understand South Atlantic variability. Both analysis of available observations and output from ocean and coupled models are necessary in order to better understand the variability of the region. In fact, not many attempts have been made to investigate South Atlantic Ocean variability using model output. Wainer and Venegas (2002) detected South Atlantic multidecadal variability in the NCAR Climate System model in a 300 year integration model run and found significant oscillations of a 25-30 year period. Observational data show a similar signal indicating that models are indeed a useful tool in order to detect climate variability. Furthermore, models offer a more complete picture of what is happening in the oceans since they supply not only information about the surface but also allow investigation of sub-surface features such as Kelvin waves, which are thought to be important for SE Atlantic variability (e.g., Benguela warm and cool events) (Florenchie *et al*., 2003).

Goals and strategy of the project

The aim of this study are to investigate linkages between South Atlantic climate modes and the Benguela Current System and also their possible socio-economic implications. In order to achieve this, model output from a global ocean general

circulation model (OGCM) (the ORCA model) will be used. The model is forced with the NCEP reanalyses (Kalnay *et al*., 1996) from 1948 to 1999 which enables assessment of the interannual to interdecadal variability of the South Atlantic over the last 50 or so years. The initial work will be divided in two parts:

1. the first part deals with ENSO induced variability in the South Atlantic. Here, composite pattern of El Niño and La Niña years are derived and their characteristics for the Benguela Current region in the context of the greater South Atlantic domain are discussed. This also means investigating possible large-scale influences on South Atlantic variability, since ENSO is a large-scale phenomenon.
2. in the second part, ocean variability at longer timescales will be examined. This also requires investigating the internal basin-dependent variability of the South Atlantic. Understanding these modes is necessary in order to be able to detect trends in the climate system and thus, it addresses the question of a possible improvement of predictions (for example SSTA) for the South Atlantic and Benguela current system.

This project is part of a PhD thesis at UCT that deals with South Atlantic climate variability.

References:

Binet, D., B. Gobert, and L. Maloucki, 2001: El Niño-like warm events in the Eastern Atlantic (6 N, 20 S) and fish availability from Congo to Angola (1964-1999). *Aquat. Living Resource.*, **14**, 99-113

Blanke, B., and P. Delecluse, 2002: Variability of the tropical Atlantic ocean simulated by a general circulation model with two different mixed layer physics. *Journal of Physical Oceanography*, **23**, 1363-1388

Florenchie, P., J.R.E. Lutjeharms, C.J.C. Reason, S. Maason and M. Rouault, 2003: The source of Benguela Ninos in the South Atlantic. Ocean *Geophysical Reasearch Letters*, **30**, 10, 10.1029/2003GLO17172

Gammelsrod, T., C.H. Bartholomae, D.C. Boyer, V.L.L Philipe, and M.J. O' Toole, 1998: Intrusion of warm surface layer along the Angolan- Namibian coast on February-March: the 1995 Benguela Nino, *S. Afr. J. Mar. Sci.*, **19**, 41-56

Kalnay, E., et al.,1996: The NCEP/NCAR, 40-Year Reanalysis Project, *Bull. Amer. Meteor. Soc*., **77**, 437-471

Lentini, C.A.D., G.G. Podesta, E.J.D Campos and D.B. Olson, 2000: Sea surface temperature anomalies on the Western South Atlantic from 1982 to 1994. *Continental Shelf Research*, **21** (2001), 89-112

Melice, J.-L. and L. Servain, 2002: The tropical Atlantic meridional SST gradient index and its relationships with the SOI, NAO and Southern Ocean. *Climate Dynamics*, Submitted

Palastanga, V., S.C.S. Vera and A.R. Picola, 2002: On the leading modes of sea surface temperature variability on the South Atlantic Ocean. *Exchanges*, **25**

Reason, C.J.C., 2000: Multidecadal climate variability in the subtropics/ mid-latitudes of the Southern Hemisphere oceans. *Tellus,* **52A**, 203-223

Reason, C.J.C., 2001: The wet winter of 2001 over the southwestern Cape, South Africa: potential large scale influences. *South African Journal of Science*, **98**, 307-310

Reason, C.J.C., M. Rouault, J.-L. Melice and D. Jagadeesha, 2002: Winter rainfall variability in SW South Africa and large scale ocean-atmosphere interactions. *Met. Atmos. Phys*., Special Issue on Atmosphere-surface interactions, **80** (1-4), 19-29

Reason, C.J.C., D. Jagadheesha and M. Tadross, 2003: A model investigation of interannual winter rainfall

variability over southwestern South Africa and associated ocean-atmosphere interaction. *S. Afr. J. Sci.,*

99, 75-80.

Robertson, A.W., J.D. Farrara and C.R. Mechoso, 2003: Simulations of the Atmospheric Response to South Atlantic Sea Surface Temperature Anomalies. *Journal of Climate*, **16**, 2540-2551

Rouault, M., P. Florenchie, N. Fauchereau, and C.J.C. Reason, 2003: South East tropical Atlantic warm events and southern African rainfall. *Geophysical Research Letters*, **30**, 5, 8009

Venegas, S.A., A. Lawrence, M. and N. Straub, 1996: Evidence for interannual and interdecadal climate variability in the South Atlantic. *Geophysical Research Letters*, **23**, 19, 2673-2676

Venegas, S.A., L.A. Mysak and D.N. Straub, 1997: Atmosphere-ocean coupled variability in the South Atlantic. *Journal of Climate*, **10**, 2904-2920

Venegas, S.A., L.A. Mysak and D.N. Straub, 1998: An interdecadal cycle in the South Atlantic and its links to other ocean basins. *Journal of Geophysical Research*, **103**, C11, 24, 723-24, 736

Wainer, I., and S.A. Venegas, 2001: South Atlantic Multidecadal Varibility in the Climate System Model. *Journal of Climate*, **15**, 1408-1420