Modelling the variability of the South Indian Ocean and its influence on southern African weather & climate

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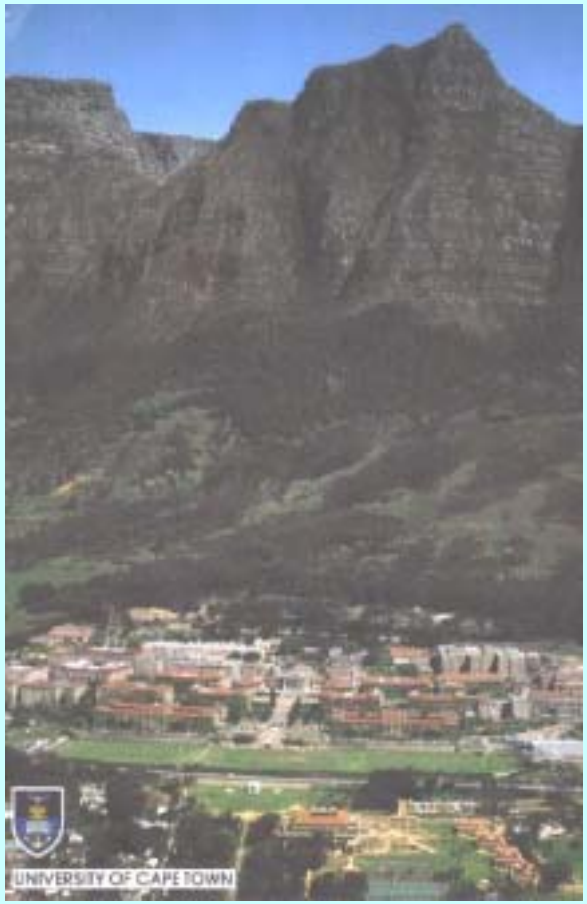


- **Links between African rainfall variability and Indian Ocean SST**
- **Modulation of Benguela Niño impacts by the midlatitude South Indian Ocean ?**
- **Tropical storm relationships with the South Indian Ocean**
- **Rossby wave influences**
- **Modelling variability in the South Indian Ocean**

Indian Ocean & African climate

- **Many studies have shown robust relationships between South Indian Ocean variability and southeastern African climate and between tropical Indian Ocean variability and East African climate.**

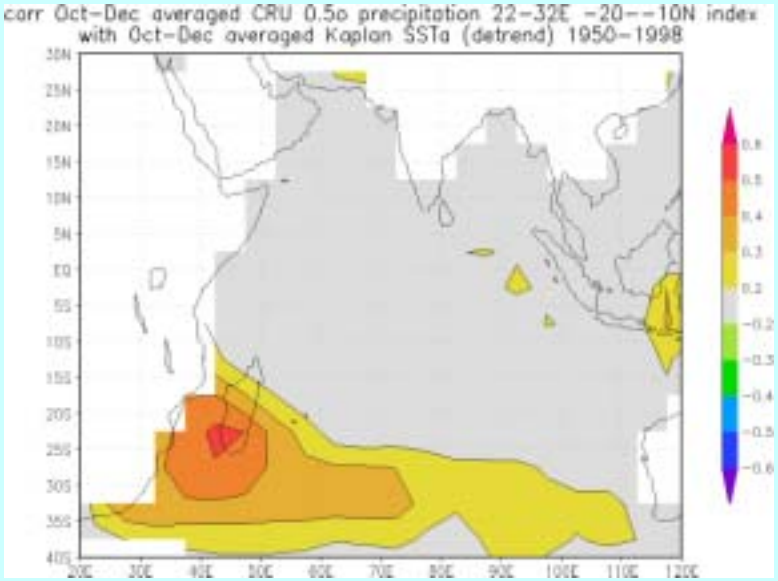
- **Less well known is that the Indian Ocean may influence weather and climate patterns over Atlantic rim countries of Africa**

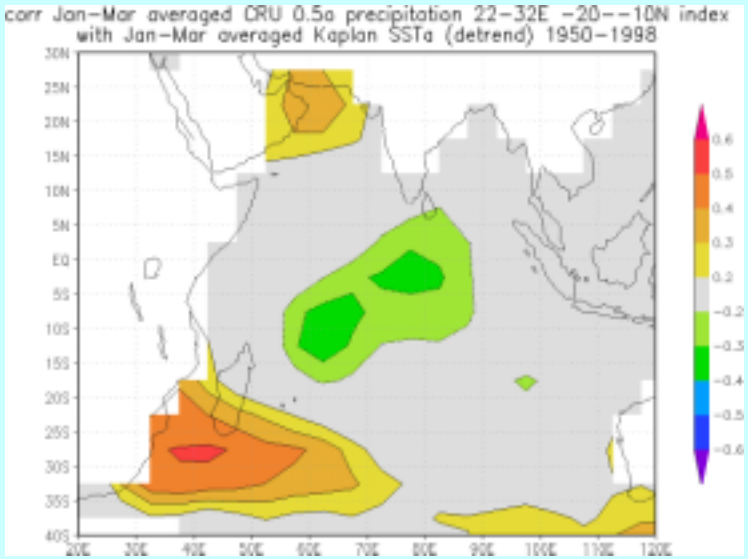
- **Trzaska *et al* (2004) show evidence of a link between Indian Ocean variability and the West African monsoon**

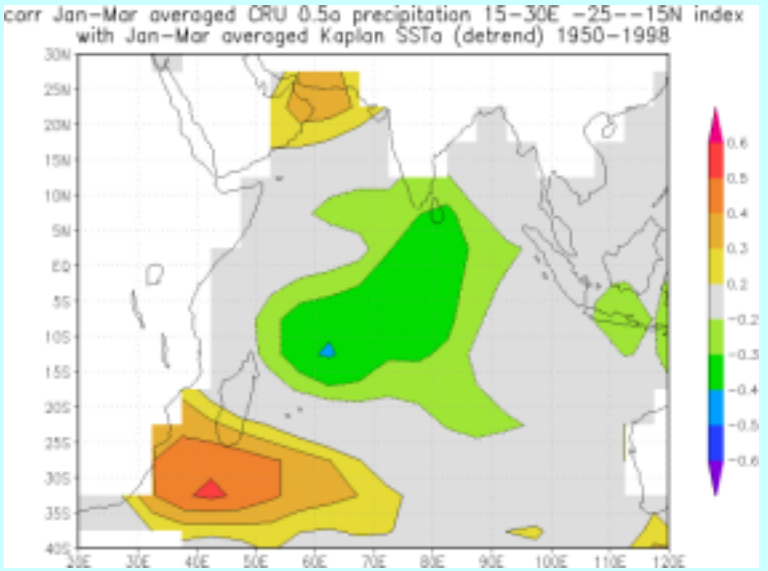
- **Landman and Mason (1999), Rouault et al (2003) and Reason and Keibel (2004) showed links between South Indian Ocean variability and rainfall over Angola and Namibia in SW Africa.**

Indian Ocean & Southern African rainfall

Zambia / Zimbabwe rainfall correlated with SST – Oct-Dec (right), Jan-Mar (below)







Namibia / Botswana Jan-Mar rainfall correlated with SST– pattern is similar to JFM SST anomalies during ENSO (right)

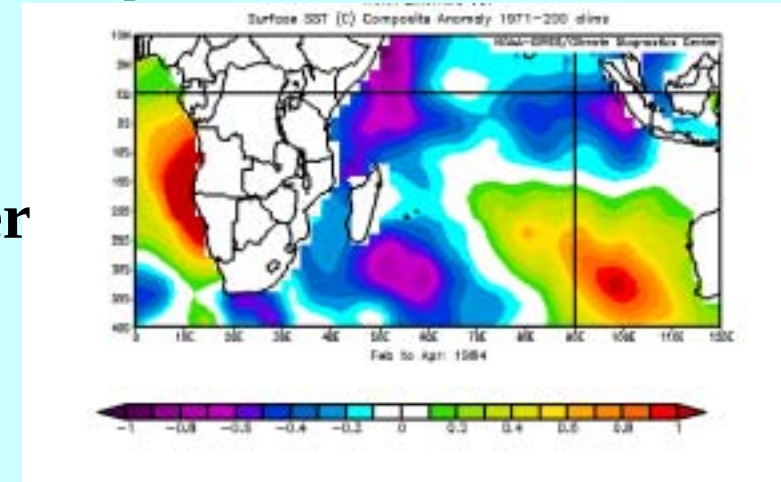
Example 1: Does the South Indian Ocean modulate the impacts of the Benguela Niño on southwestern Africa ?

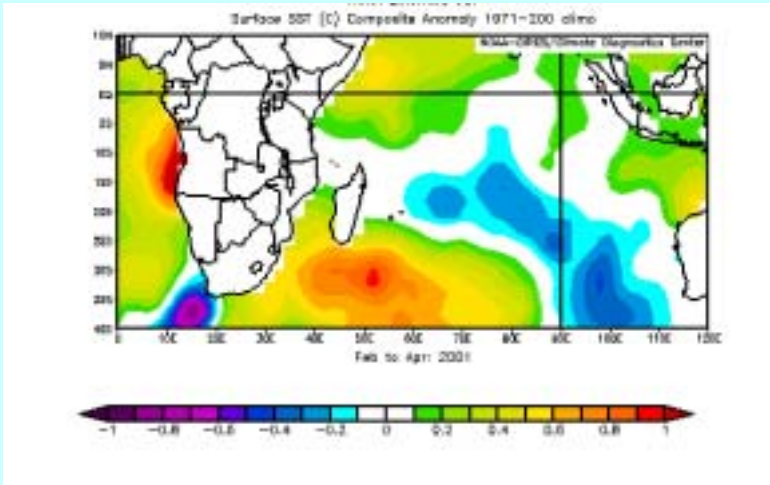
The Benguela Niño is one of the leading South Atlantic modes and has strong impacts on regional fisheries and rainfall. Rouault et al. (2003) showed that the rainfall impacts of the 1984 and 1995 Benguela Niños was smaller than 2001 despite the SE Atlantic SST anomalies being much larger

The SST anomaly plots below suggest that a warmer SW Indian Ocean may have increased the 2001 rainfall impacts – note that mean moisture flux over southern Africa is easterly

1984

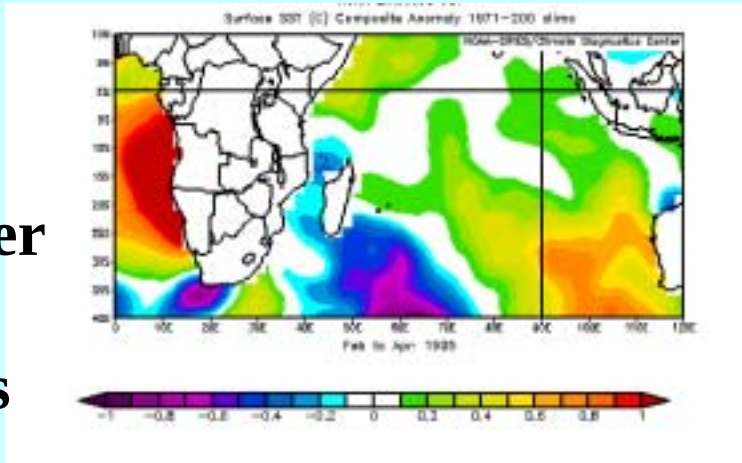
Smaller wet anoms





1995

Smaller wet anoms



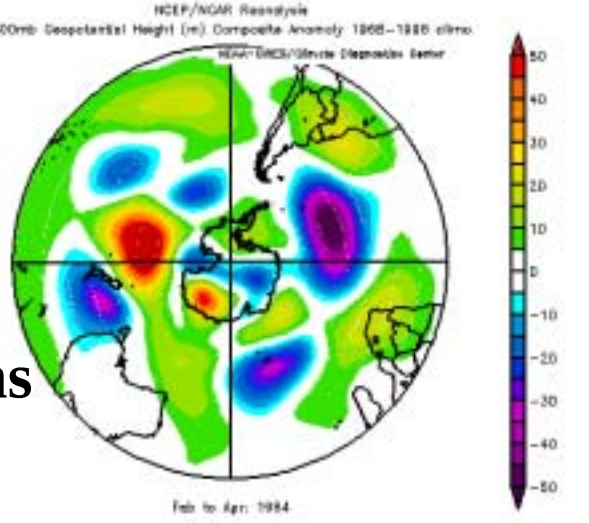
2001

Larger wet anoms

The preceding SST anomaly plots are reminisicent of dipole-like patterns in the South Indian Ocean (Behera and Yamagata, 2001). MSLP (not shown) and 500 hPa gph anomalies (below) suggest that shifts in the wave 3-4 pattern (Hermes and Reason, 2004) are important for forcing the South Indian Ocean SST anomaly – in 2001, high pressure anomalies were evident over the South West Indian Ocean leading to warm SSTA there

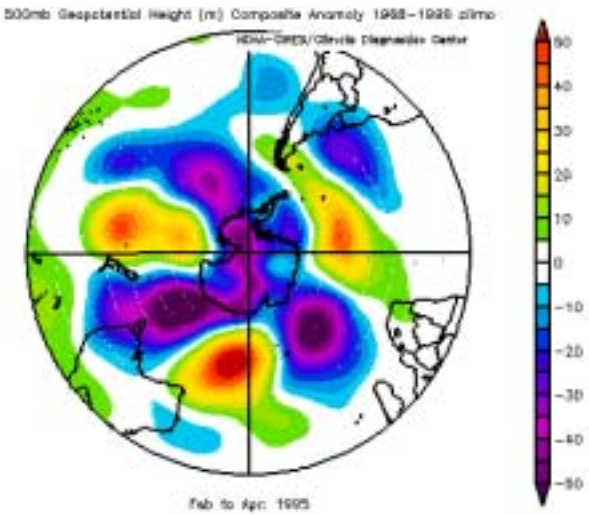
1984

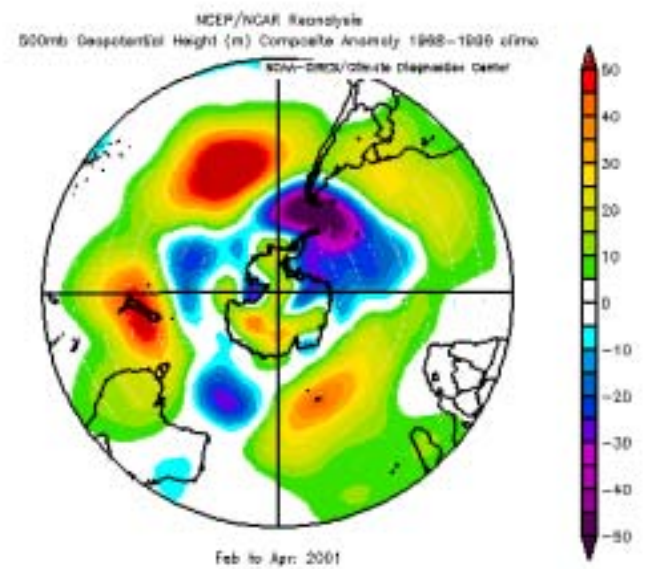
Smaller wet anoms



1995

Smaller wet anoms

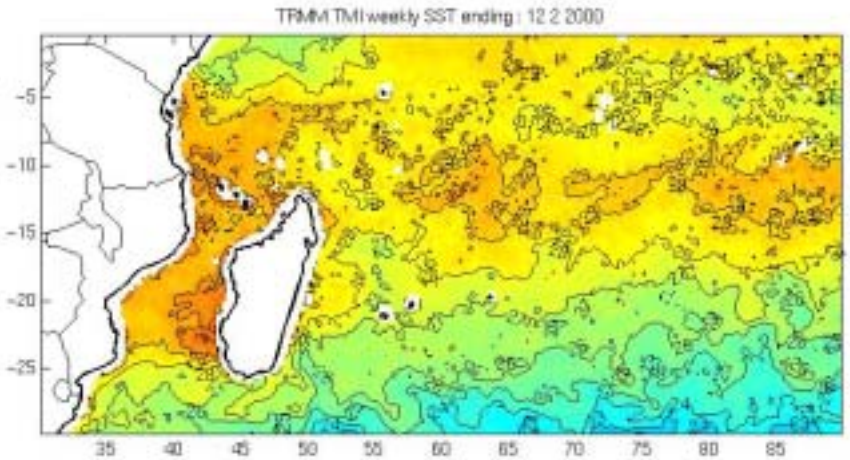




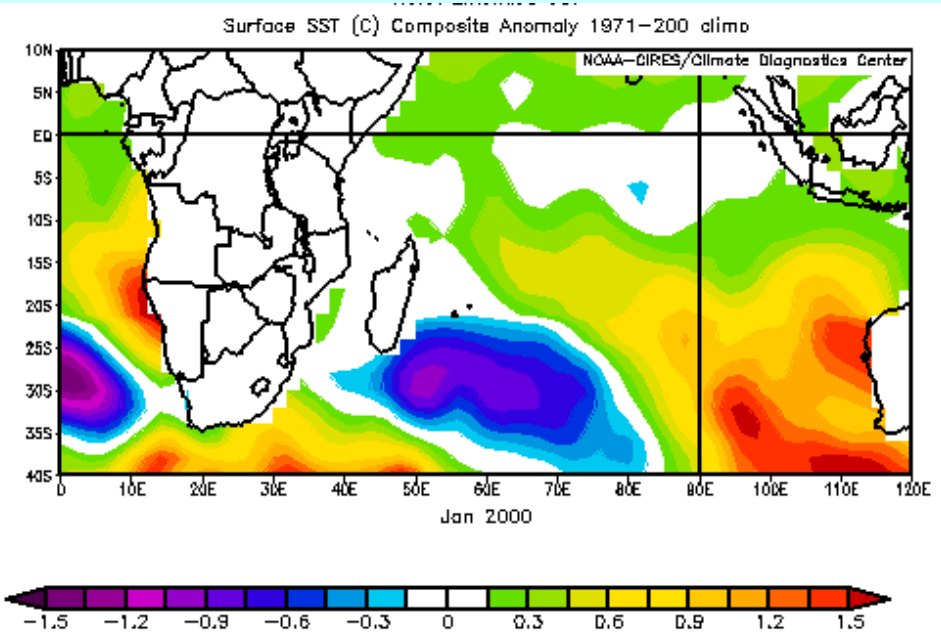
2001 Larger wet anoms

Example 2: Increased penetration of tropical storms into southern Africa from the SW Indian Ocean

Summer 2000 was the 3rd wettest summer in Namibia since 1950, many other areas of southern Africa showed well above average rainfall. Mozambique suffered devastating floods which displaced ½ million people. This excess rainfall resulted from a few intense tropical storms making landfall and penetrating well into the mainland (ex TC Eline tracked over 2000 km overland to Namibia) (Reason and Keibel, 2004).

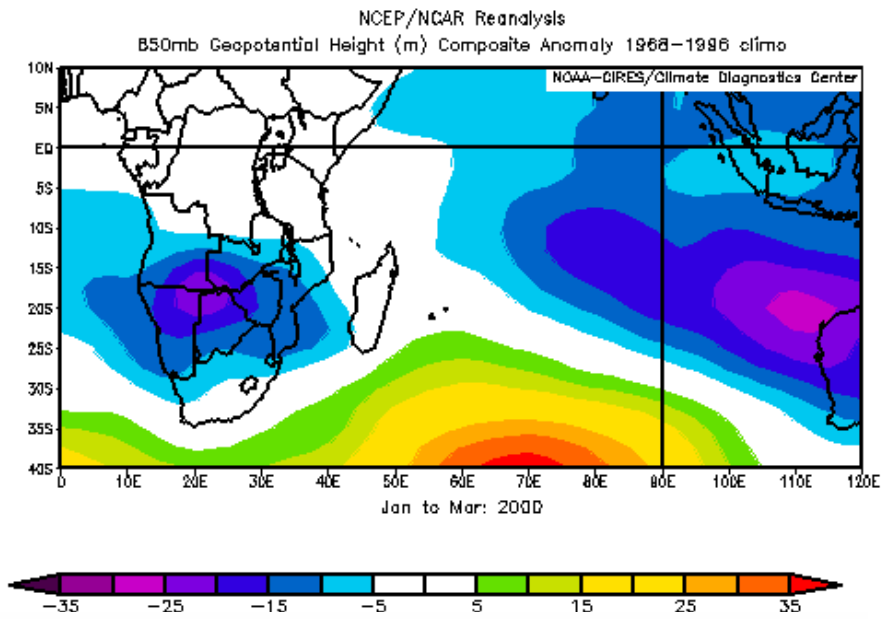


SST > 30 C in Mozambique Channel during Jan / Feb 2000 – TRMM

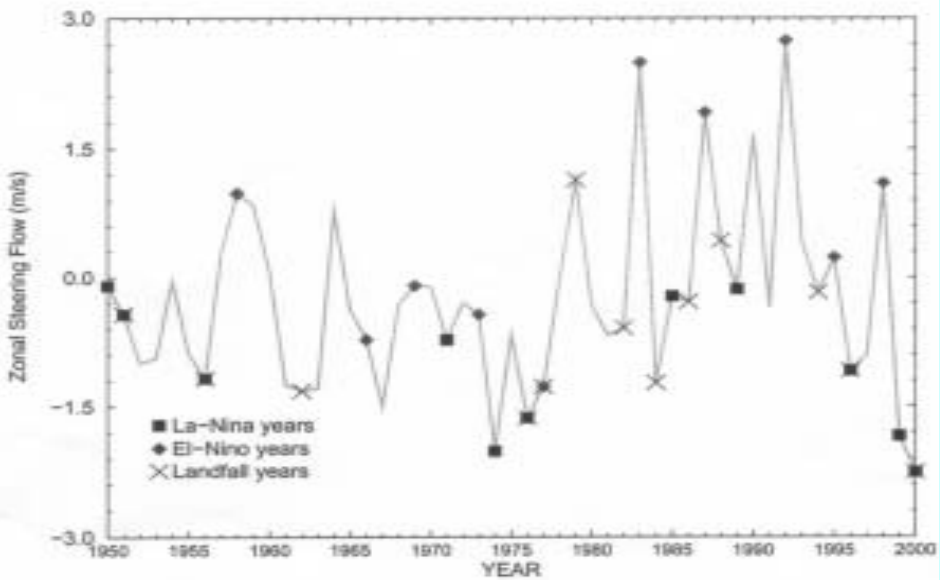


Warm SSTA in cyclogenesis areas in central and eastern tropical S Indian Ocean in Jan 2000

Enhanced westward steering current – South Indian Ocean anticyclone shifted south and stronger in JFM 2000

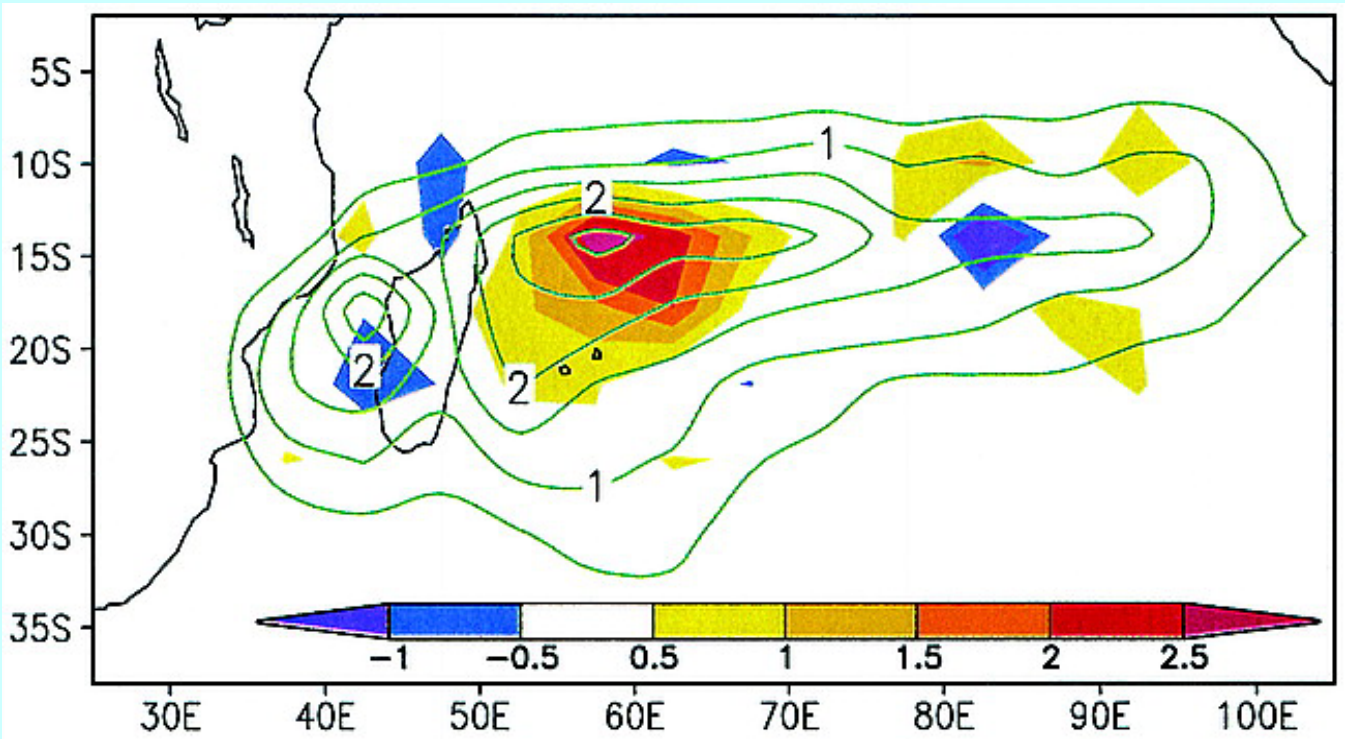


Vitart *et al.* (2003) show that conditions of enhanced westward steering current, and hence landfall in Mozambique of TCs is more likely during La Niña

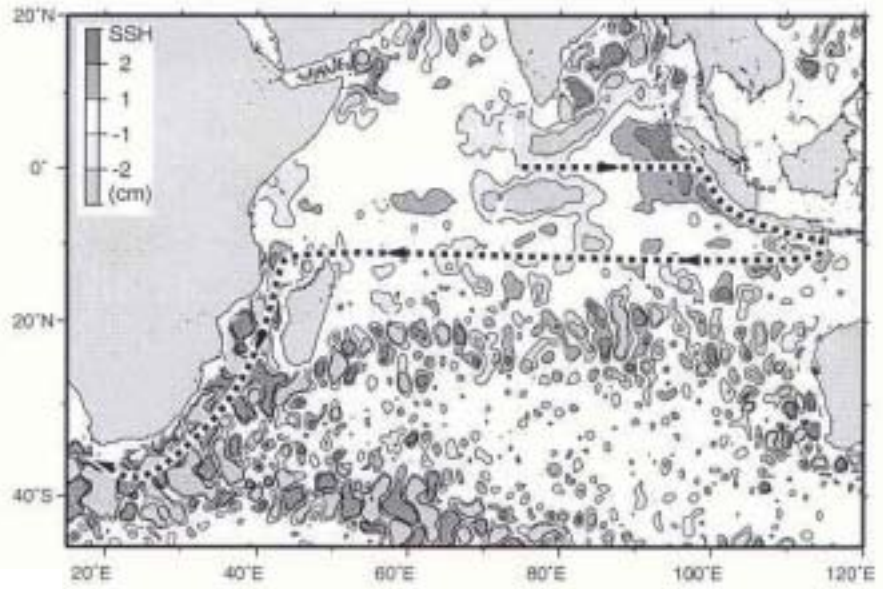


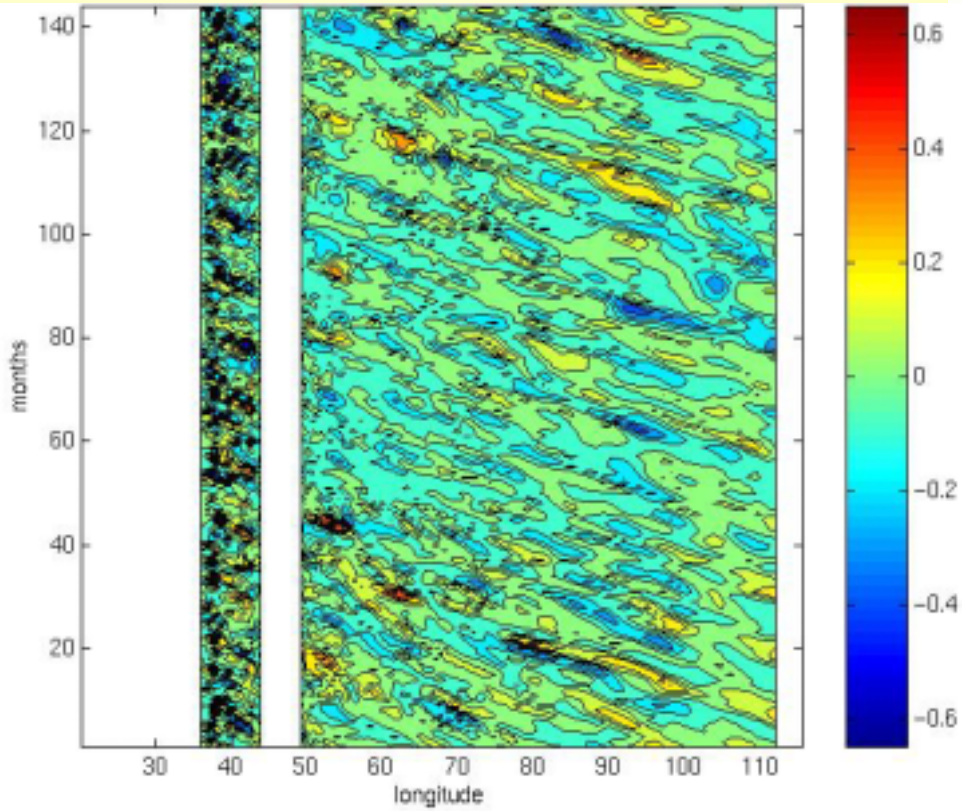
TC days in the SW Indian Ocean (contours) are related TC days in Dec-Apr and difference (colour) between years of deep and shallow thermocline in 8-12S, 50-70E Xie et al. (2002). Years with anomalously deep thermocline show 4 TC days per year as compared to only 1 when thermocline is anomalously shallow.

2000 was a year of anomalously large TC activity (including Eline) and penetration of these storms into southern Africa. ECCO ocean model analyses (Stammer *et al.*, 2003) suggest that the thermocline was anomalously deep during 2000 (Reason and Keibel, 2004)



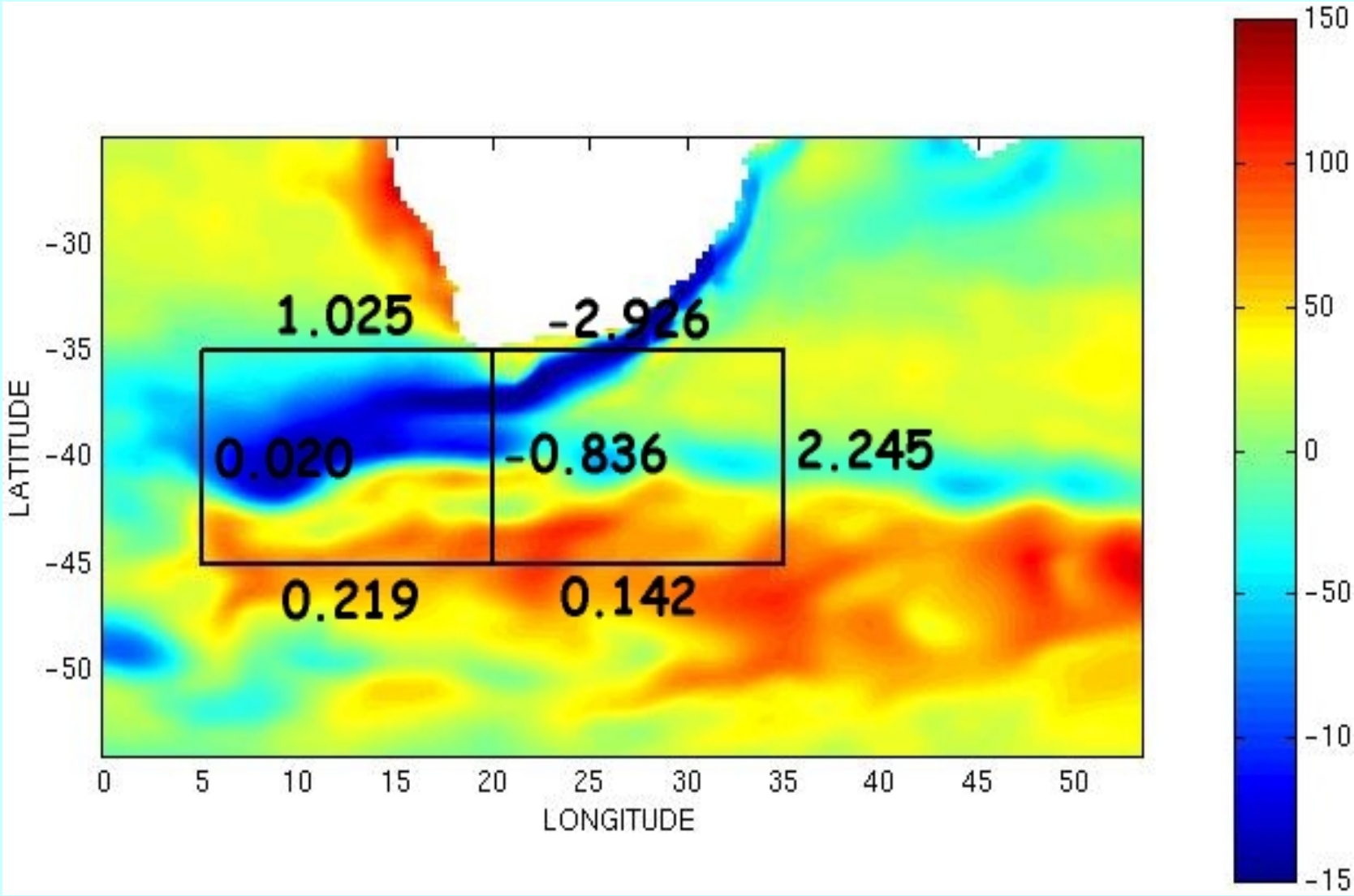
Xie *et al.* (2002) showed the importance of Rossby wave propagation for South Indian Ocean SST variability. Schouten *et al*, (2002) suggested a link between these waves and equatorial waves (see their altimeter data - right) showing high variability along Rossby wave tracks near 12 and 23 S.





Rossby wave propagation along 20S in 12 years of AGAPE (Biastoch and Krauss, 1999) eddy permitting model run (Hermes and Reason, 2004)

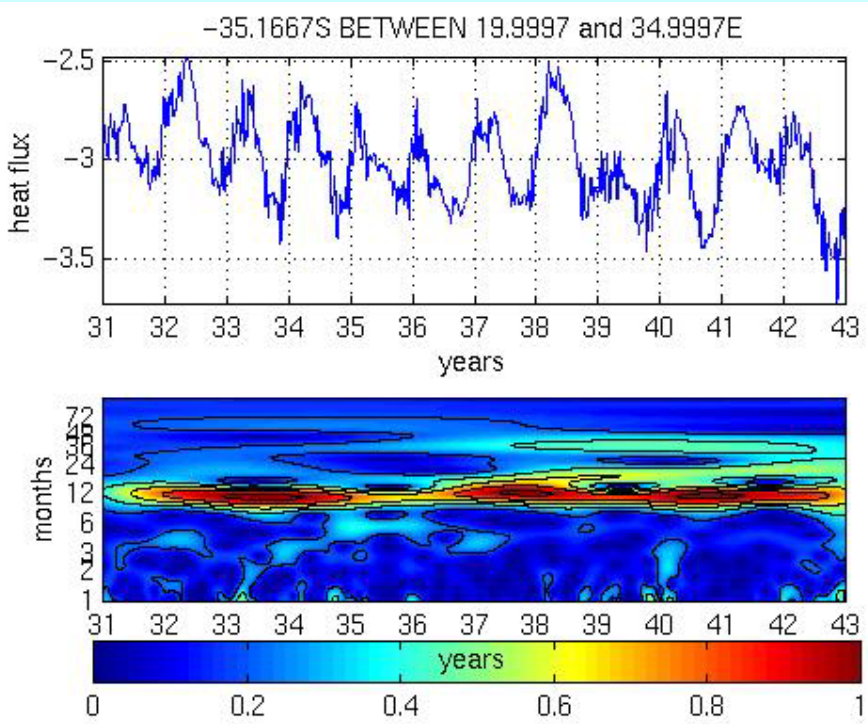
AGAPE Annual mean surface heat flux in Agulhas region (colours – Wm^{-2} and ocean heat transport (PW).

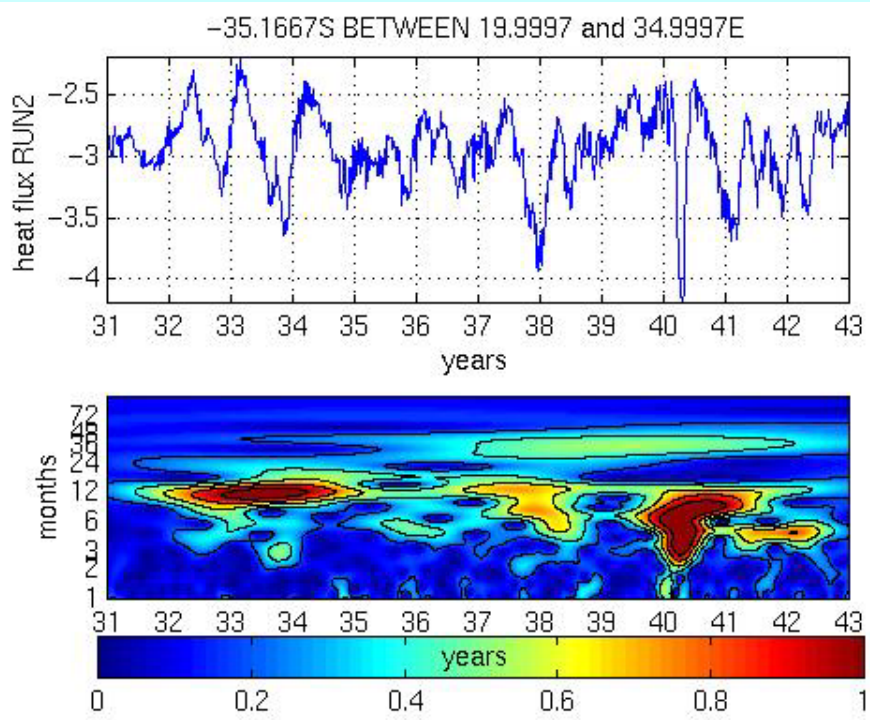


SW Indian Ocean SST variability has strong influence on summer rainfall over southern Africa. Local atmospheric forcing may generate some of this SST variability. The sensitivity of the AGAPE model heat transport in the SW Indian Ocean to a southward shift in the mean anticyclonic winds is shown

Time series of heat transport under climatological wind forcing

Southward shifted winds – annual cycle is weakened but variability on mesoscale and interannual scales is strengthened





Summary

- **Southern African climate is strongly linked to variability in both the tropics and midlatitudes of the South Indian Ocean**

- **Midlatitude South Indian Ocean variability may modulate the African impacts of South Atlantic modes such as the Benguela Niño**

- **Designing an observing system that monitors both tropical and midlatitude South Indian Ocean areas is needed to improve African climate prediction**