Trends in oceanographic regimes at the northern extremity of the Benguela system, 1968-2011

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Introduction

• The Angola coastal zone is characterized by particular oceanographic dynamics inducing some variability, such as anomalous warm and cold events, that may have significant impact on dynamic of living resources;

• Despite of the scientific interest, the Angolan coastal zone still a poorly researched area;
OBJECTIVE

• To combine data set of satellite and hydrographic observations, to identify the signatures of warm and cold events along the Angolan coast;

• Describe the variability / trends of sea surface temperature, mean sea level anomalies and north component of wind during these events;

• To research the response of Angola Ocean Coast through the Nansen data set, collected along the three decades;
DATA

• **Sea surface temperature:** AVHRR PATHFINDER. January 1982 to December 2009. Temporal resolution_ monthly and Spatial resolution_ 0.25° x 0.25°;

• **Mean Sea level Anomalies:** Satellite altimeter Topex/Poseidon (T/P). October 1992 to August 2011. Temporal resolution_ weekly and Spatial resolution_ 0.25° x 0.25°;

• **North wind component:** Quickscat. August 1999 to November 2009. Temporal resolution_ weekly and Spatial resolution_ 0.25° x 0.25°;

• **Hydro graphic Data:** R/V Fridtjof Nansen. Regularly cruises from 1984 to 2011. Temporal resolution_ twice per year and Spatial resolution_ along the coast;
Geographical Area

- Areas over which the data has been averaged: **Ambriz** - north of Angola; **Quicombo_Lobito** - central Angola; **Baia dos Tigres** - south of Angola.
## Coordinates of chosen area

<table>
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<th>NO</th>
<th>Areas</th>
<th>Name</th>
<th>Latitude</th>
<th>Longitude</th>
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<td><strong>Ambriz</strong></td>
<td>07.49° S</td>
<td>12.0° E</td>
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<td></td>
<td></td>
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<td>08.00° S</td>
<td>14.0° E</td>
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<td></td>
<td></td>
<td></td>
<td>12.40° S</td>
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</tr>
<tr>
<td>3</td>
<td>South</td>
<td><strong>Baia dos Tigres</strong></td>
<td>16.30° S</td>
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<td></td>
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Methods

• The original data files (satellite) were in bin format. Using qscat program, data files were read and transformed into a Surfer and ODV formats.

• Statistical methods were used to discuss the variability of weekly and monthly anomalies and the relationship between variables.

• All analyses were performed using appropriate statistical and graphical functions based on the Surfer, ODV and Excel software package.
Results - SST Variability


• The summer of 1995, the sea level shows a highest values more than 20 cm referenced as the warmest and the 1997 referenced as the coldest, shows the lowest values less than -7 cm.

• Since 2004 the mean sea level in winter does not keep the same pattern, became smaller and a mixed between low and high waters.
North wind component variability

- The fluctuations are observed whole years, and is difficult to associate relaxation and increase of wind to warm or cold events;
- Strong winds are expected more during the autumn and spring;
- No signal of strong wind during the cold season.
Climatology of SST

- Sea surface temperature ranging from 16°C to 30°C and the seasonal variability is characterized by a single warm period with a maximum in February/March (23-30°C) and a cold period centred in August (16 - 22°C) and a rise trend during the tropical spring.
- The period 2006 – 2010 shown high variability (warmest) from the climatology during the summer season in 2 °C, in south area.
Climatology of MSLA

- The seasonal variability clearly shows two peaks of high MSLA, in warm (March/April) and tropical spring (October/November) season.
- The 1993 – 1998 periods the MSLA present low variability and the period 2006 – 2010 show higher variability.
- The warm season is associated with high MSLA and cold season with low MSLA.
Climatology of North Component of Wind

- The wind component gets more intense during the tropical autumn and tropical spring, whereas show low in warm and cold season.
- The positive signal of the wind kept for the whole period of the year, may indicates that the direction is on average towards the equator throughout the year.
- The wind shows low variability the period 2006 – 2010 from the climatology.
- As years with warm events were selected 1995, 1996, 2001, 2007, 2011;
Time Series of Sea Salinity

- Presence of fresh water in north and centre
- The salinity during the warm events of 2001, 2007 and 2011 presented high values (more than 35.90) in south.
• Stability in SACW water mass properties between 1995 – 2007 during the warm and cold season.
• Major variability is on the surface layers where the amplitude of temperature may reach 4 – 6 °C.
• The south region does not under influence of fresh or brackish waters during the warm and cold events.
• The lowest values of salinity (34.07) where observed during the warm event of 1995.
• A peak of maximum salinity is observed during warm events, when the temperature at surface more than 25 °C.
Transect - Salinity
• The following years, 1995, 1996, 1997, 2001, 2004, 2007 and 2011 were selected;
• The warm events linking with temperature above 25 °C at surfaces layers in south region, but the values of salinity also above the minimum of ocean salinity 35.00;
• The thermocline became deepest from offshore toward to the coast;
• During the most intensive warm event (1995), the signal of low salinity was capture between Ponta Albina and Baia dos Tigres, < 35.00;
• Intrusion of water with high values of salinity > 35.90 in surface layers are observed in sections of 1997, 2001 and 2011;
• Below 200 m depth for both warm and cold events, the sections show a stability of parameters;
Horizontal Distribution

- The retention of warm waters with depth, are more consistent in central area then north area;
- At 35 m clear location of these warm waters in Quicombo_Lobito areas;
- During the warms events, the salinity along the coast is higher than off shore, suggesting that intrusion of this waters come from offshore and not across the coast;
- No signal of low salinity (< 35 ) below 16ºS
CONCLUSION/CONSIDERATION

• It was possible to view the signal of warm and cold from satellite data.

• The significant warm events in 1995 and 2001 and cold event in 1997 during the summer where associated with variability in MSLA. High MSLA for warm events and low MSLA for cold event.

• Although it is known that winds are a major driving force of currents, upwelling and Benguela Niños, the obtained results, is not so clear and is difficult to associate variability of north wind component to the warm or cold events. This argument is enforced by low values observed during the winter (upwelling season) time.
• Amazing feature is that the figure of Sea Surface Temperature and Mean Sea Level show that the time of cold season became smaller, start late and finish early.
• Since 2004 during the winter period is observed frequency of high MSLA. An increasing trend of sea surface temperature is also observed.
• Times series, sections and T-S diagram from hydrographic data set, collected on board Research Vessel Fridjof Nansen, despite many gaps and geographical position, shows clear of warm and cold events observed and described in many papers.
• Major variability and trend occurs in summer period at surface layers while below the 200 m keep the stability of the parameters.
Thanks