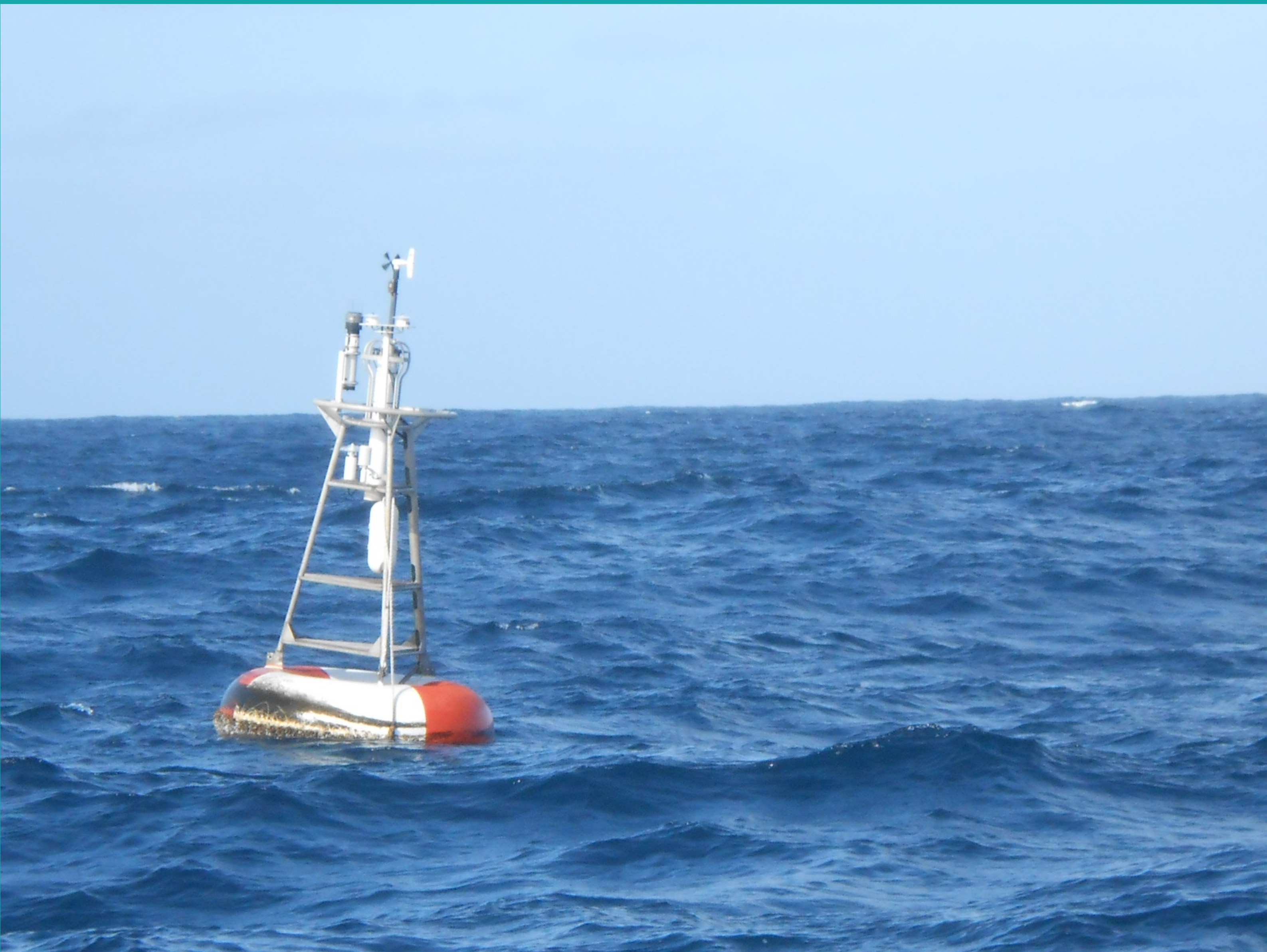
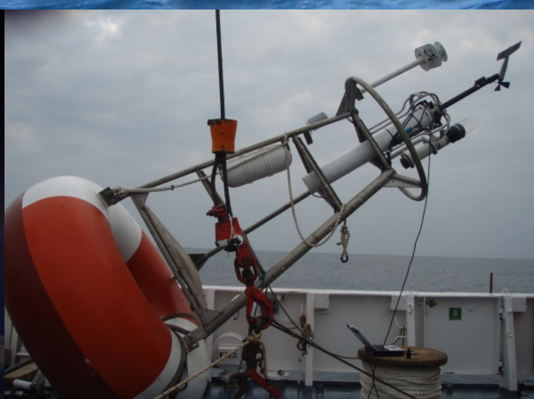
ANNUAL REPORT 2014





NANSEN-TUTU CENTRE FOR MARINE ENVIRONMENTAL RESEARCH

affiliated with the University of Cape Town, South Africa

2014 – Report from The Board

Vision

The vision of the Nansen-Tutu Centre for Marine Environmental Research is to serve Africa through advancing knowledge of the marine environment and climate system in the spirit of Nobel Peace Laureates Fridtjof Nansen and Desmond Tutu.

The priority research activities at the Centre are:

- Ocean modeling and prediction
- Ocean-atmosphere, climate and regional impact
- High resolution satellite remote sensing of the regional shelf seas
- Regional sea level variability and global change
- Capacity building and education

Acknowledgement

The Nansen-Tutu Centre's activities are enabled through financial contributions from its Norwegian partners. In 2014 the Nansen Environmental and Remote Sensing Center and the Nansen Scientific Society contributed funding to the Centre. In kind contributions are received from the other partners.

Organisation

The Nansen-Tutu Centre (NTC) is a non-profit research centre hosted at the Marine Research Institute and the Department of Oceanography at the University of Cape Town (UCT). The administrative and legal responsibilities reside with the University of Cape Town. It is a joint venture agreement between the signatory partners from South Africa, Norway and the United States. From South Africa including the Marine Research Institute (Ma-Re)/Department of Oceanography, University of Cape Town, the Applied Centre for Climate and Earth System Studies (ACCESS), the Council for Scientific and Industrial Research (CSIR) – Earth Observation research group, the South African Environmental Observation Network (SAEON), and the International Centre for Education, Marine and Atmospheric Sciences over Africa (ICEMASA). From Norway including the Nansen Environmental and Remote Sensing Center (NERSC) and the Nansen Scientific Society of Bergen and from the USA the Geosciences Department, at the Princeton University. The extension of the joint venture for 3 years (Phase II) was initiated in July 2013, with seed funding commitments from NERSC and the Nansen Scientific Society. Additional funding for projects is applied for externally notably South African and Norwegian funding bodies, bilateral funding agreements, the European Union's Framework Programmes, space agencies, industry and private sponsors.

Cover image: *Redeployent deployment of the ATLAS mooring off Angola. The mooring is the PIRATA extension in the South East Tropical Atlantic and was deployed as part of the preface project.*
Images courtesy of Bernard Boulres from the IRD.

Staff

Nansen-Tutu Centre staff consists of partially funded and seconded associate researchers and administrators from the partner institutes, as well as fully or co-funded MSc, PhD students and Post-doctoral research fellows. During 2014, the Nansen-Tutu Centre comprised 20 persons, including 3 MSc students, 4 PhD students, 2 Post-doctoral research fellows, and 10 associate researchers and 1 adminstrator from some of its founding partners, including the Marine Research Institute and the Department of Oceanography at the University of Cape Town, the Council for Scientific and Industrial Research, South African Environmental Observation Network, and the Nansen Environmental and Remote Sensing Center.

Scientific production, capacity building and teaching

A total of 19 publications emanated from the Centre, which included: 14 papers in peer-reviewed journals published or in press;; 2 chapters in books;; and 3 articles in peer-reviewed conference proceedings.

In 2014, the Nansen-Tutu Centre supported the students and Post-docs listed below. They either received a full bursary, top-up funding towards their bursaries or travel support for research exchanges or conference attendance

- Kyle Cooper (travel support) - MSc (graduated December 2014), South Africa
- Isabelle Giddy (top-up funding) - MSc (graduated December 2014), South Africa
- Daniel Schilperoort (full bursary) - MSc, South Africa
- Rodrigue Anicet (full bursary) - PhD, Cameroon
- Neil Malan (travel support) - PhD, South Africa
- Georges-Noel Longandjo (full bursary) - PhD, Democratic Republic of Congo
- Patrick Vianello (full bursary) - PhD, South Africa
- Dr Charine Collins (top-up funding) - Post-doc, South Africa
- Dr Issufo Halo (full bursary), Post-doc, Mozambique

Additionally, NTC staff and associates were involved in the co-supervision of Honours, MSc and PhD students registered at the University of Cape Town and the University of Bergen, as well as teaching in the Department of Oceanography's undergraduate and post-graduate programmes, the Applied Marine Science MSc programme and the African Climate and Development Initiative MSc programme.

During 2014, the Centre facilitated four international research exchanges, three to the Nansen Environmental and Remote Sensing Center in Bergen, Norway, and one semester exchange to the University of Sao Paulo.

Workshops and summer schools

The Centre helped coordinate 2 workshops and 2 summer schools in 2014.

The International workshop on HF Radar was held from 17-19 February. Two potential sites near Port Elizabeth were identified by a team from South Africa and CODAR Europe.

A strategic workshop on *Global change and southern African Marine Ecosystem Research* was jointly hosted by the Centre with ICEMASA and Ma-Re. The workshop was held at the University of Cape Town from 8-10 April. The aims of the workshop were to view the marine research horizon in a different dimension, discussing four themes that might form the basis of future research collaboration and co-ordination, given the historic strengths of the existing and new partners. The discussions held during the workshop have been synthesized into a research strategy document for marine science to facilitate planning for future research proposals, and key research groups will be identified that will address marine research issues at an international level.

The Centre co-organised the *Intergovernmental Oceanographic Commission of UNESCO, Summer School on Application of Ocean and Coastal Data and Modelling products* which was held at the University of Ghana in Accra from 9 – 13 June, 2014. The main goal of this initiative is to build African capacity to access and utilize ocean and coastal data from in situ and satellite observations, as well as those generated from ocean models to generate useful services for local use, for a wide variety of human and economic benefit purposes.

The Centre organised and hosted the *Nansen Tutu Summer School on Ocean, Climate and Marine Ecosystem* focused on Agulhas Current, the Benguela upwelling system and the Tropical Atlantic and it dealt with field observations, remote sensing and modelling. It was held at University of Cape Town from Monday 1 to Monday 8 of December 2014. 34 students from Europe and Africa attended lectures given by African and European scientists. Sponsors include CLIVAR, the FP7 PREFACE project, the Norwegian RESCLIM project, the German SACUS/SPACES project and the Nansen Scientific Society.

National cooperation

The Centre actively participates in national research and development activities, including the projects funded through the National Research Foundation, Water Research Commission (WRC) and ACCESS. In addition to this, the Centre provides expert consultation for Anchor Environmental on some of their Environmental Impact Assessments projects.

International activities

The Centre facilitated 6 research exchanges between South African and Norwegian researchers during 2014, and supported one MSc student's attendance at a summer school in Brest, France. In addition to this the Centre contributed to a number of international projects. These include 2 European Seventh Framework Programmes, the Marie Curie Actions, People International Research Staff Exchange Scheme for the project "The role of the Southern Ocean carbon cycle under climate change" (SOCCLI), and the project "Enhancing prediction of Tropical Atlantic climate and its impacts" (PREFACE). The centre is a partner in a project funded under South Africa - Norway Research Co-operation on Climate Change, the Environment and Clean Energy, entitled "Seasonal to decadal Changes Affecting Marine Productivity: an Interdisciplinary investigation" (SCAMPI).

Financial situation

A total of 887 000 ZAR seed funding for the Centre was made available from Norwegian partners: 482 000 ZAR from NERSC and 385 000 ZAR from the Nansen Scientific Society. In addition to this, almost 2,500,000 ZAR was raised through project proposals in 2014. These include project proposals submitted to the South African National Research Foundation, the Department of Science and Technology, the Water Research Commission, the South Africa-Norway Research Co-operation and the European Framework 7 Programme.

Prospects for 2015

The Centre will continue to support its existing PhD and MSc students as well as the Post-doctoral research fellows Drs Charine Collins and Issufo Halo.

Given the potential for a deficit budget by the end of 2015, new MSc and PhD students will only be appointed from successful project funding applications.

The Centre will host and organise the CLIVAR Atlantic/Preface/Pirata meeting, which is scheduled to held in Cape Town during the last week of August 2015.

Approved by The Board
Cape Town, July 2015

Science report for 2014

The Lofoten Vortex of the Nordic Seas

Roshin P. Raj, Léon Chafik, Jan Even Ø. Nilsen, Tor Eldevik and Issufo Halo

The Lofoten Basin is the largest reservoir of ocean heat in the Nordic Seas (Figure 1). A particular feature of the basin is 'the Lofoten Vortex', a most anomalous mesoscale structure in the Nordic Seas. The vortex resides in one of the major winter convection sites in the Norwegian Sea, and is likely to influence the dense water formation of the region.

High-resolution sea level anomalies (SLA) during the past 16 years (1995–2010) are used to study the vortex. The SLA fields, corrected for the inverse barometer effect, tides, and tropospheric effects, are based on merged Envisat and ERS-I and II altimetric data. The SLA fields obtained from AVISO are provided as weekly means on a 1/3° Mercator projection grid. This corresponds to a resolution (twice the grid spacing) of 22–29 km in the Lofoten Basin study region and 24–27 km in the tracking areas (68.1°N to 72.1°N and 41°W to 201°E). Sea surface geostrophic velocity anomaly components, u and v, are computed from the SLA gradients using the conventional geostrophic relation.

In addition to SLA fields, we also use gridded weekly absolute dynamic topography (ADT) data (1995–2010) in this study. The ADT fields are used to quantify the relation between the seasonality of the slope current, and the strength of the Lofoten Vortex, using an along-isobath approach. The ADT dataset is the sum of the time invariant CNES-CLS09 mean dynamic topography (MDT) and the time variant weekly SLA data. The errors associated with the estimation of CNES-CLS09 MDT are provided together with the MDT dataset, and in the Lofoten Basin, from the continental plateau and out, the errors are less than 1 cm (not shown). The errors associated with ADT are the quadratic sum of the errors in SLA (3 cm) and MDT (1 cm), i.e., 3 cm.

The detection of Lofoten Basin ed-

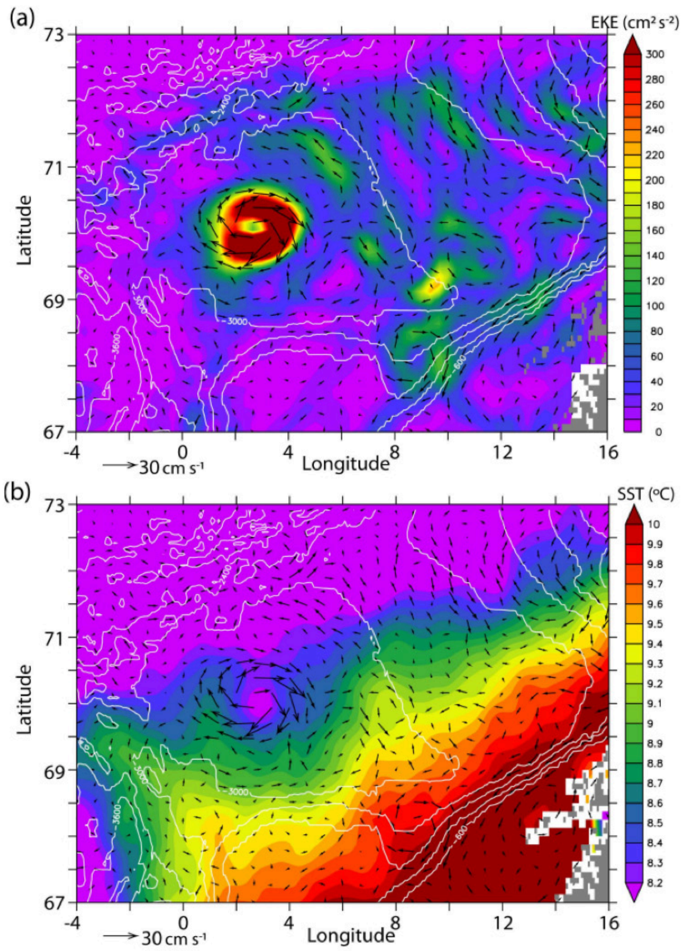


Figure 1. Monthly (July 2000) mean satellite altimeter derived surface geostrophic velocity anomalies (arrows) superimposed on (a) eddy kinetic energy and (b) MODAS sea surface temperature. Isobaths are drawn for every 600m.

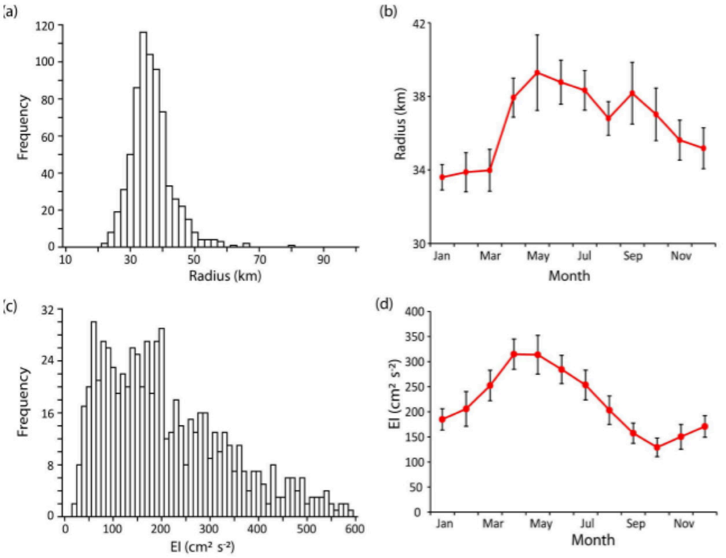


Figure 2. *(a) Frequency distributions of the (a) radius and (c) eddy intensity of the Lofoten Vortex. Annual climatologies of (b) radius and (d) eddy intensity of the Lofoten Vortex together with error estimates.*

dies was done using the automated hybrid algorithm described by. It combines the two most used criteria to identify an eddy, namely, closed contours of streamlines of sea surface height and a negative Okubo–Weiss parameter, i.e., where the vorticity of the flow field dominates its deformation. Long term climatology (1949–2008) of temperature and salinity in the Nordic seas, largely focusing along 70.1°N are prepared from the hydrographic NISE dataset (Norwegian Iceland Seas experiment). The NISE dataset consists of decimated CTD data and bottle data. Winter mixed layer depth (MLD) climatology of the Norwegian Sea is calculated using a finite difference method.

Validating Hycom-EnOI in the Agulhas using Argo profiling floats.

Charine Collins, Björn Backeberg, François Counillon and Johnny Johannessen

The greater Agulhas Current system, one of the most energetic systems in the world, plays a key role in the global ocean circulation, regional weather, and the marine environment. A prediction system of the marine environment around southern Africa would not only be beneficial to regional commercial, industrial, and leisure activities, but it would also aid search and rescue activities, and the monitoring of accidental pollutants and harmful algal blooms.

Despite the emergence of various global prediction (operational data assimilation) systems (e.g. MyOcean, BlueLink), there is hitherto no system for the southern African regional ocean. As a first attempt towards an ocean prediction system for southern Africa, A regional data assimilation system of the greater Agulhas system was developed recently. This system, while not operational yet, assimilates satellite altimeter along-track sea level anomaly (SLA) data into a HYbrid Coordinate Ocean Model (HYCOM) simulation of the Agulhas Current System using the Ensemble Optimal Interpolation (EnOI) data assimilation scheme (hereafter referred to as HYCOM-EnOI). While HYCOM-EnOI improved the meso-scale dynamics in the Agulhas Current system, as well as the water mass characteristics and velocities at ~1000m, there was a slight degradation of the SST distribution.

In this study, we assess the limitations of HYCOM-EnOI in reproducing the water mass properties of the Agulhas Current region through a detailed comparison with Argo profiling floats. A comparison between HYCOM-EnOI and the Argo profiling floats is made in terms of temperature and salinity differences at various depths, differences in water mass characteristics, and mixed layer depth.

The temperature values in the upper 100m simulated in HYCOM-EnOI are, for most of the region, in close agreement (±1°C)

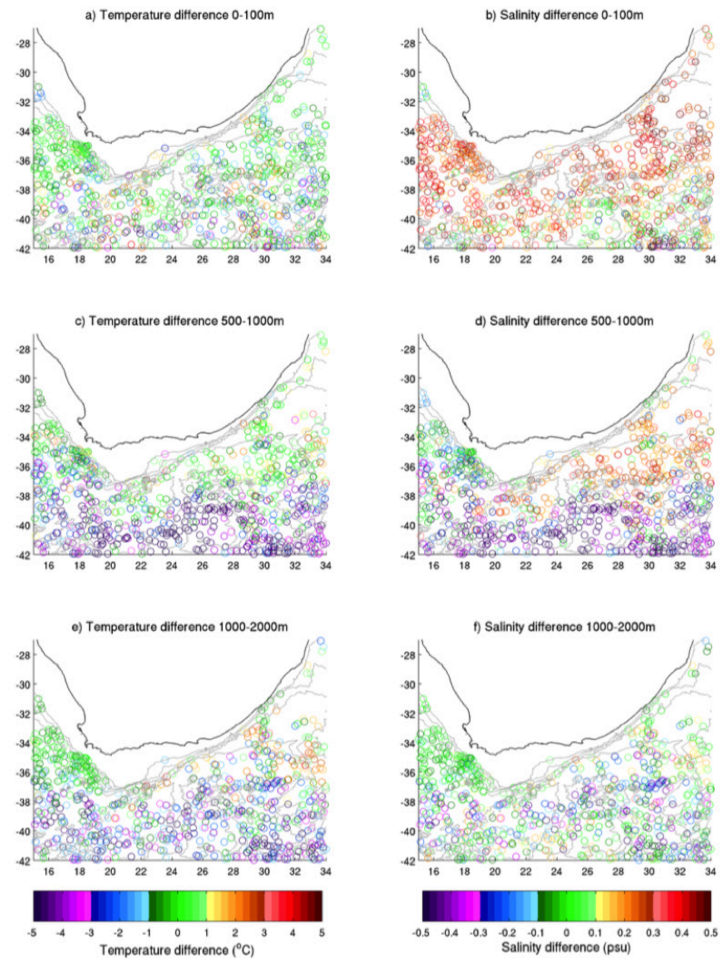


Figure 3. *Difference between Argo and HYCOM-EnOI temperature (left panel) and salinity (right panel) for the upper 100m (a and b), 500-1000m (c and d) and 1000-2000m (e and f).*

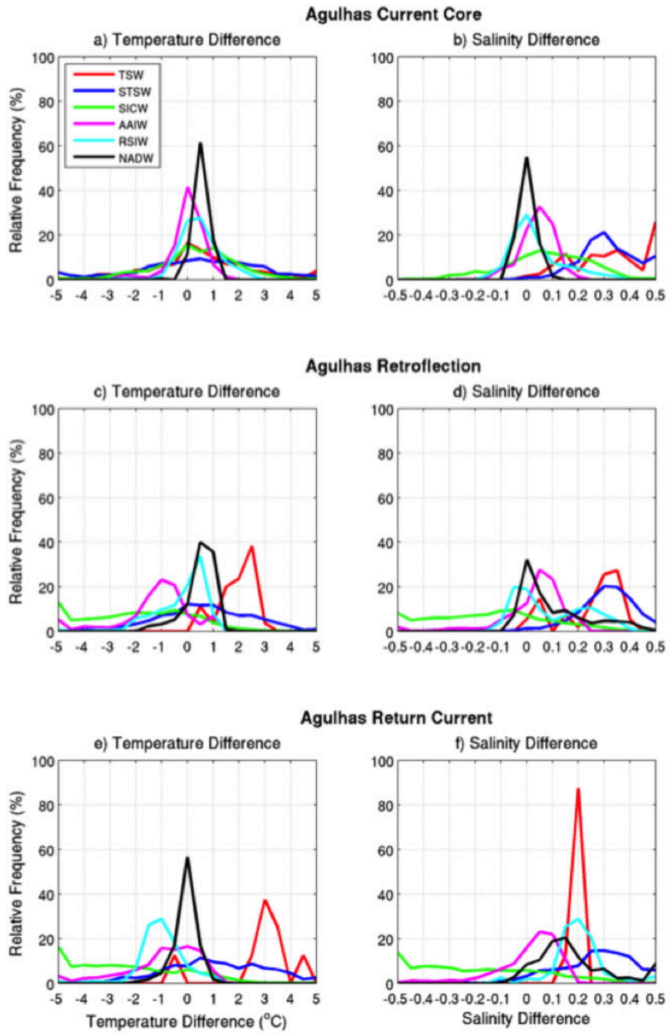


Figure 4. *Temperature and salinity differences between Argo and HYCOM-EnOI for the main water masses of the Agulhas Current Core (a and b), Agulhas Retroflection (c and d) and the Agulhas Return Current (e and f).*

with the observations (Figure 3a). On the contrary there is an overestimation of the salinity values in the upper 100m simulated in HYCOM-EnOI by about 0.1psu (Figure3b). In the 500-1000m depth range, HYCOM-EnOI tends to underestimate temperature (Figure 3c) and salinity (Figure 3d) values south of the Agulhas bank, in the vicinity of the Agulhas Retroflection region and the Agulhas Return Current. West of the Agulhas bank, the temperature of HYCOM-EnOI is in good agreement with the observations (±1°C), however, there is again an overestimation of the salinity values by more than 0.1psu. In the deeper layers (1000-2000m, HYCOM-EnOI tends to underestimate the temperature and salinity throughout the region, except east of the Agulhas Bank where there is a good agreement with the observations.

To put the above results into context in terms of water masses, the differences in temperature and salinity of the major water masses in the region (TSW, STSW, SICW, AAIW, RSIW, NADW) were calculated for three sub-regions (Agulhas Current core, Agulhas Retroflection, Agulhas Return Current). For the Agulhas Current core and Agulhas Retroflection regions, all the water masses tend to be more saline in HYCOM-EnOI compared to the observations (Figure 4). In contrast, the temperature values of the water masses within the Agulhas Current core are in close agreement with the observations. However, in the Agulhas Retroflection region TSW (AAIW) is warmer (cooler) in HYCOM-EnOI compared to the observations. In HYCOM-EnOI, TSW in the Agulhas Return Current is warmer and saltier while RSIW are cooler and saltier (Figure 4).

The disparity in HYCOM-EnOI in terms of temperature and salinity suggests that the vertical density structure of the Agulhas Current region is not well resolved. The density structure as well as the overall performance of HYCOM-EnOI may therefore be improved by including the Argo profile data into the data assimilation scheme.

Analysis of SAR winds and reanalysis products over the Agulhas Current

Daniel Schilperoort, Marjolaine Krug, Mathieu Rouault, Johnny Johannessen and Morten Hansen

Since it's implementation, Spaceborne Synthetic Aperture Radar (SAR) has become a particularly effective remote sensing system for measuring fine resolution wind speed patterns over the ocean. However, due to the empirical nature of derivation models utilised in the determination of wind speeds and dynamics

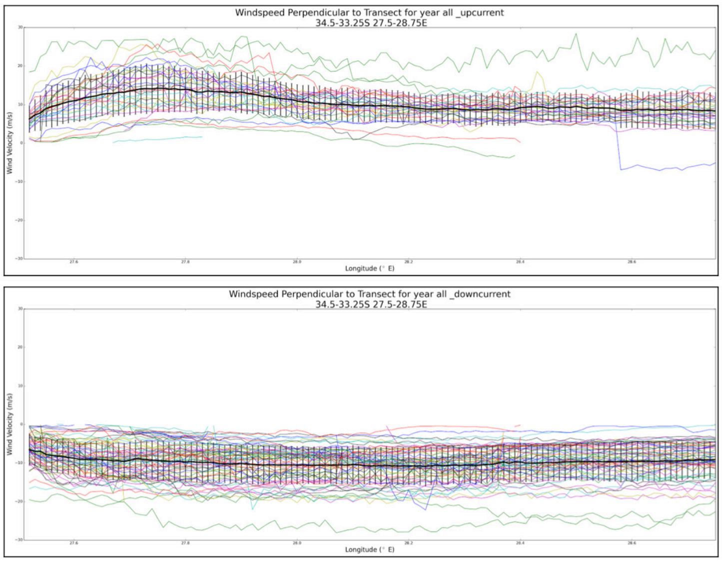


Figure 5. *Line plot of Transect from 33.25S : 27.5E to 34.5S : 28.75E showing the perpendicular component of the up-current (A) and down-current (B) SAR derived, winds over the Agulhas current for the period 2007 to 2012*

as well as physical limitations of measuring surface backscatter, there are still many errors and caveats in the data interpretation which need to be addressed. Principally, the effect of relative motion from a non-static ocean on wind-wave interactions means that many mesoscale and sub-mesoscale ocean dynamical processes, such as: ocean fronts, barrier waves, convection and barrier effects, are evident in SAR derived wind measurements and can cause over- or underestimations in wind speed. In particular, the fast flowing ocean currents such as the Agulhas Current can have a substantial influence on wind speed measurements over their locations.

The focus of this investigation is to investigate the effect that the Agulhas Current may have on SAR derived wind estimations, particularly in the upcurrent and down-current components of wind velocities. Secondly, further investigation will be made into the in-shore, high resolution wind regimes and patterns and the effects of coastal orography on near shore winds.

In order to illustrate the apparent influence of the Agulhas Current on SAR derived wind speeds, cross sections will be taken over specific regions above the Agulhas Current. The wind regimes will be split into predominantly upcurrent and down-current regimes, from which the current-parallel component can be extracted and investigated. Geolocation of the current against the SAR extracted wind using MODIS SST data will enable assessment of increasing wind speeds directly over the current.

Preliminary, encouraging, results from the tester transect (Figure 5) seem to show an increase in wind speed over the current during upcurrent wind regimes and a decrease in wind speed during down-current regimes. This is as expected and prompts the expansion of the study to the rest of the transects along the current.

Understanding the South African east coast shelf environment - a modelling approach

Neil Malan, Björn Backeberg, Juliet Hermes, Chris Reason, Mike Roberts and Annette Samuelsen

Upwelling cells on the inshore edge of the Agulhas Current, along South Africa's east coast, play an important role in maintaining marine ecosystems. These highly dynamic shelf regions are strongly influenced by the powerful Agulhas Current and provide a spawning environment for several commercially harvested species.

Recent numerical modeling and satellite remote sensing studies have suggested that the Agulhas Current core and its variability are changing in response to basin-scale wind changes that drive it. Resulting impacts on ocean circulation over the continental shelf as a result of these changes could have effects on the functioning of marine ecosystems along the east coast. In order to understand the functioning of these coastal shelf regions, their interaction with the Agulhas Current, and their sensitivity to climate change, it is first necessary to develop model configurations that can accurately simulate the dynamics responsible for driving the upwelling of nutrient rich waters onto the continental shelf.

This study looks at the performance over the shelf regions of two existing ocean model simulations for the Greater Agulhas System, Agulhas HYCOM and INALT01, comparing the results of these models against in-situ and satellite remote sensing data sets. Encouragingly, results of these analyses show that both models represent the mean state of shelf circulation well and show inter-annual variability consistent with observations. However, INALT exhibits a cool bias when compared to satellite observations, but a warm bias at depth. HYCOM shows better agreement of mean state, but does not sufficiently capture the high frequency variability at depth. Both models successfully simulate the large solitary meanders, which are the main mode of variability in the Agulhas Current, and provide new insights into their role in the shelf circulation.

A 1/20th degree resolution configuration of Aguhas HYCOM has now been set up and will be analysed in early 2015, with the increase in grid resolution enabling finer-scale and coastal processes to be better resolved.

Figure 6 shows an example of a tracer experiment run in HYCOM in order to examine the spatial extent of upwelling forced by a large meander in the Agulhas Current. In addition to upwelling concentrated at 27 ° in the cyclonic

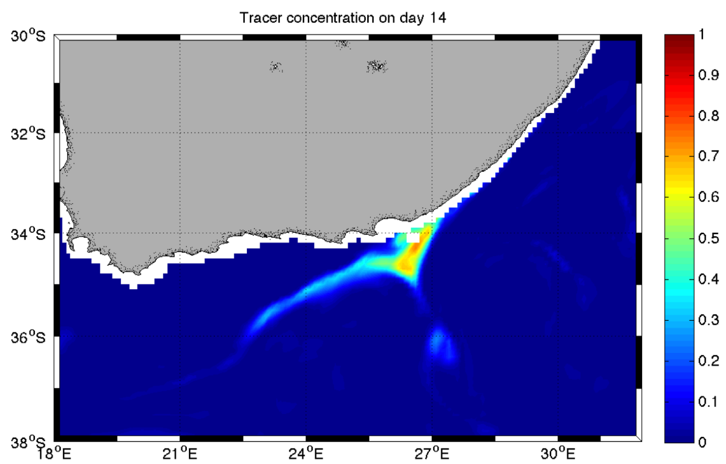


Figure 6. *Concentration of upwelled tracer at 100m depth during a large meander in the Agulhas Current in HYCOM. Tracers are initialised at 1 below 200m and 0 above 200m and the simulation is run for 14 days.*

core of the meander, there is also vertical motion extending south westwards along the shelf break, possibly driven by Ekman veering in the bottom layers. These large meander events appear to be the dominant driver of upwelling of water onto the shelf inshore of the Agulhas Current, however the interplay between this eddy driven upwelling and the more continuous nature of wind and current driven upwelling still requires detailed exploration in order to understand the feedbacks of the current itself on the shelf circulation.

Central Africa rainfall and its relationships with the surrounding tropical Oceans: Do ENSO or IOD play any important role?

Georges-Noel T. Longandjo and Mathieu Rouault

Rainfall over Central Africa (7°-32°E, 10°N-15°S) and its relationship with surrounding tropical Oceans sea surface temperature (SST) is evaluated using GPCP v2 Rain rate, NOAA OI v2 SST and wind of ERA-Interim reanalysis data. We show that Central Africa rainfall anomalies are asymmetricly influenced by the SST gradient between the tropical Atlantic Ocean (10°W-12°E, 5°N-15°S) and the Indian Ocean (40°W-65°E, 5°N-15°S) Oceans, with far stronger influence from negative SST gradient. During positive years of SST gradient, Central Africa is associated with above normal rainfall for March-April-May (MAM) and September-October-November (SON) while the opposite lead to drought in SON and December-January-February (DJF). However the Atlantic Ocean is influenced by El Nino Southern Oscillation (ENSO) and the Indian Ocean is influenced by El Nino Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). In austral spring (SON), the asymmetry impact of SST gradient on Central Africa seems to be distorted: tropical rainfall anomalies occur over the southern part of Central Africa during negative years of SST gradient$_{|ENSO}$. This finding suggests that the IOD might play an important role than ENSO on Central Africa rainfall.

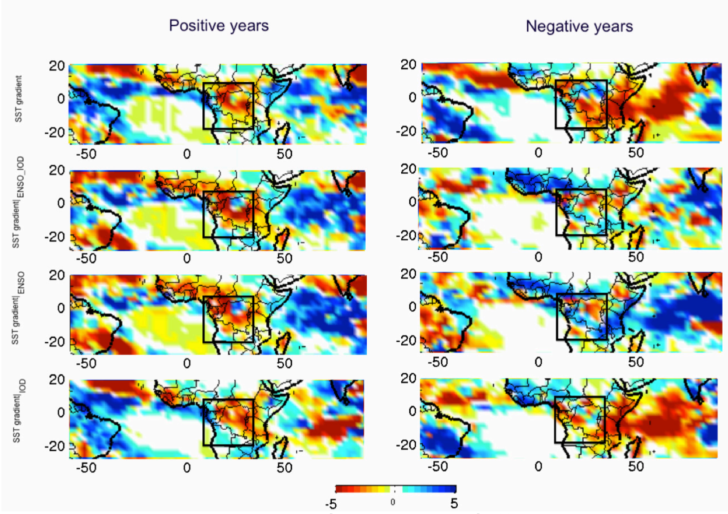


Figure 8. *Regression of SON rainfall anomalies onto respectively SON SST gradient, SON SST gradient$_{|ENSO_IOD}$ (residual SSTgradient where ENSO and IOD have been removed), SON SST gradient$_{|ENSO}$ (residual SST gradient where ENSO has been removed) and SON SST gradient$_{|IOD}$ (residual SST gradient where IOD has been removed) for positive and negative years of SST gradient. Unit: mm d^{-1} °C^{-1}.*

The relationship between SSTs over Atlantic and Indian Oceans and rainfall over some regions in Central Africa (7°-32°E) has been found to be statistically significant, but remains complex and seasonally dependent. Furthermore, the Atlantic Ocean is influenced by ENSO variability whereas the Indian Ocean is influenced by both ENSO and IOD climate modes.

The aims of this study is not only to contribute to an improved definition of the relation between SST gradient and the inter-annual variability of rainfall over Central Africa, evidencing in particular, spatial patterns and their annual (or seasonal) cycle by focusing on the response of rainfall to inter-basin SST, but also to investigate the inter-annual changes in rainfall over Central Africa caused by ENSO- or IOD-induced changes through the inter-basin SST gradient between tropical Atlantic (10°W-12°E, 5°N-15°S) and Indian Oceans (40°W-65°E, 5°N-15°S). The SST gradient index is defined as the difference of detrended SST anomalies averaged over the eastern tropical Atlantic Ocean (ETAO, 30°-12°E) and over western tropical Indian Ocean (WTIO, 40°-82°E) over similar latitudes (15°S-5°N).

The annual cycle of rainfall over Central Africa has a bimodal characteristic with the maximum oc-

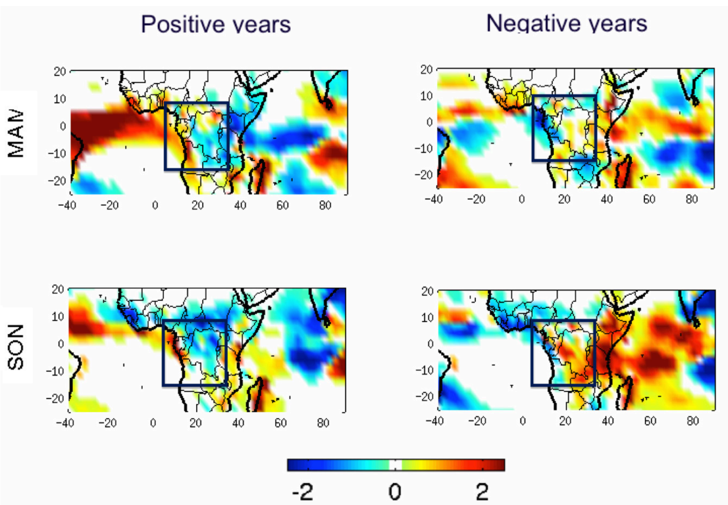


Figure 7. *Composite of MAM and SON rainfall anomalies from GPCP for positive and negative years of SST gradient between tropical Atlantic and Indian Oceans. The black box delineates Central Africa.*

curing respectively in MAM and SON and the minimum during JJA and DJF as shown in Figure 7. So, during negative years of SST gradient, Central Africa is associated with above normal rainfall for MAM and SON, except over its Atlantic coasts. Meanwhile during positive gradient years, Central Africa experiences below normal conditions for MAM and SON, except over its Atlantic coasts and its north part (about 0°-10°N) for MAM.

Considering austral spring (September-November, SON) when IOD matures and became strongly correlated to ENSO, we compute the regressions patterns of rainfall anomalies with SST gradient, SST gradient$_{|ENSO_IOD}$ (residual SST gradient where ENSO and IOD have been removed), SST gradient$_{|ENSO}$ (residual SST gradient where ENSO has been removed) and SST gradient$_{|IOD}$ (residual SST gradient where IOD has been removed) for positive and negative years of SST gradient to better understand the asymmetry relationship. The results are shown in Figure 8.

We can note above normal rainfall occurs over central Africa more during negative years than during positive years of SST gradient. And the asymmetry impact of SST gradient on Central Africa seems to be distorted: we have a deep tropical convection anomalies (above normal conditions) over south part of Central Africa during negative years of SST gradient$_{|ENSO}$. This finding suggests that the IOD might play an important role than ENSO on Central Africa rainfall.

In conclusion, SST gradient has an impact on Central Africa rainfall and their relationship is asymmetric. During negative years of SST gradient, the Central Africa is associated to above normal (flood) conditions while the opposite leads to below normal conditions. This finding suggests that Indian Ocean could play as important a role as the Atlantic Ocean over Central Africa. Central Africa is not only a transitional region between Southern and Northern part of Africa, but also between west and east regions of Africa. So its rainfall presents non-homogeneous signal with respect to West Africa or East Africa where rainfall seems more coherent. The IOD seems to play a more important role than ENSO on Central Africa rainfall.

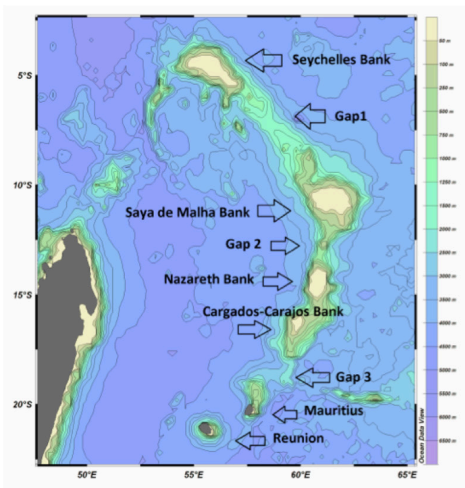
Mascarene Ridge circulation

Patrick Vianello, Mathieu Rouault and Isabelle Ansorge

The Mascarene Plateau is a submerged volcanic plateau to the east of Madagascar which extends over 2200 km between the Seychelles and Mauritius. It is a complex feature, which is composed of 4 banks separated by 3 channels – namely the Seychelles, Saya de Malha, Nazareth and Cargados-Carajos Banks.

The main objective of the research is to analyze cruise data obtained during the October/November 2008 ASCLME (Agulhas Somali Current Large Marine Ecosystem) cruise on board the Dr Fridtjof Nansen which surveyed the region around the Mascarene Plateau. Due to the paucity of data in the region, the cruise was a routine cruise with no specific scientific questions to be answered. A comparison is also made between sea surface temperature (SST) and Acoustic Doppler Current Profiler (ADCP) derived currents on board to satellite estimate to possibly extend cruise results in space and time. Although the resolution of satellite estimate is low compared to cruise measurements, satellite estimate of geostrophic velocities and sea surface temperatures compare well with cruise data and can therefore be used in the region with confidence. This is invaluable since the Mascarene Plateau is relatively poorly understood and it allows us to link cruise data with Rossby waves and currents impacting the region.

The water masses in the region can be divided into 3 regions. The northern region (north of 8°S) is characterized by Red Sea Water in the intermediate layers and Arabian Sea High Salinity Water in the surface waters. Mixing of surface waters (Arabian Sea High Salinity



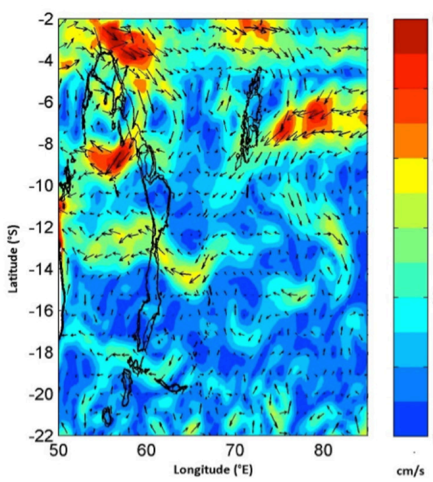


__Figure 9a.__ The Mascarene Plateau with its associated Banks and gaps. The Plateau is crescent shaped and is composed of 4 shallow banks and 3 gaps separating these banks. It lies mainly in a meridional direction from the Seychelles to Mauritius. Some of the banks have regions where it breaches the surface to form small islands. The deepest gap is between the Saya de Malha and Nazareth Banks where depths exceed 1000m. Isobath interval: 500m. __Figure 9b.__ Altimetry derived Geostrophic Velocities during October/November 2008 (period during the Nansen cruise across the Mascarene Plateau).

Water and Indonesian Throughflow Water) was observed. The central region between 8°-13°S exhibits mixing between Red Sea Water And Antarctic Intermediate Water in the intermediate waters while surface waters are predominantly Indonesian Throughflow Water, Tropical Surface Water and Sub-Tropical Surface Water. The South Equatorial Current acts as a barrier to Sub-Tropical Surface Water. To the south of 13°S, only water masses of Southern Indian Ocean origin exist (Antarctic Intermediate Water and Sub-Tropical Surface Water) with the exception of Indonesian Throughflow Water (where the South Equatorial Current flows). Many areas in this region exhibit mixing between Sub-tropical Surface Water and Indonesian Throughflow Water. North Indian Deep Water exists throughout the region of the Mascarene Plateau except in regions where the bathymetry is too shallow. South Indian Central Water exists south of 8°S. Corroborating these findings, nutrient rich water associated with Arabian Sea High Salinity Water and nutrient poor water associated with Sub-Tropical Surface Water, the area is broadly divided into 2 regions of nutrient rich waters to the north of approximately 13° S and nutrient poor waters to the south.

The cruise results from the October/November 2008 Dr Fridtjof Nansen cruise show that the SEC splits into 3 cores to the east of the Mascarene Plateau and is channeled through the 3 major gaps in the plateau. The total transport for the upper 450 m was 36.53 Sv with 14.93 Sv, 14.41 Sv and 6.19 Sv flowing through the Seychelles – Saya de Malha, Saya de Malha – Nazareth and Cargados – Carajos gaps respectively. The only bank to experience flow is the Seychelles Bank due to the South Equatorial Counter Current. The South Equatorial Current does not act as a constant current in the region but rather oscillates in strength. The Saya de Malha, Nazareth and Cargados-Carajos Banks retain similar high Chl-a values throughout the year suggesting that a distinct ecosystem could exist across these banks.

During both cruises conducted in the region (2002 and 2008) there were no major Rossby wave propagations in the area and hence sampling was undertaken during normal conditions with regards to Rossby wave propagations induced by Indian Ocean Dipole (IOD) and/or El Niño. During the period 1994-2011, the majority of the major Rossby waves crossed every part of the Mascarene Plateau whilst the Rossby waves which passed through the gaps in the Mascarene Plateau significantly increased the geostrophic velocity in the gaps (Figure 9).

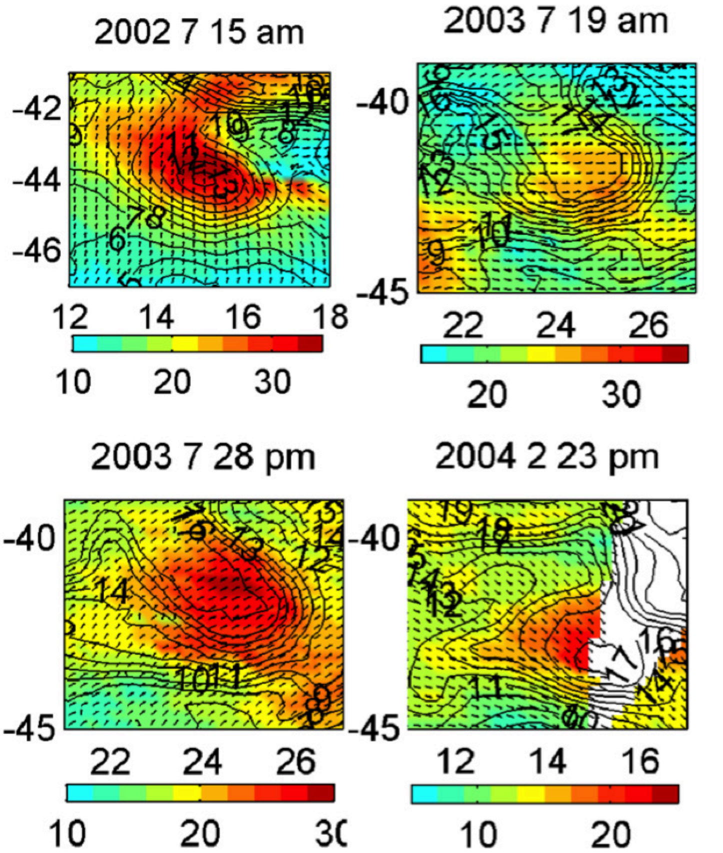


Figure 10. Clockwise from top left, Instantaneous estimate of QuikScat wind speed in m.s-1(color) and directions (arrows) and AMSR microwave sea surface temperature (contours) south of the Agulhas Current system in the "Roaring forties" on the 15 07 2002 (morning path) 19 07 2003 (morning path), 23 02 2004 (evening path) and 28 07 2003 (evening path) showing strong and homogeneous increase and decrease in wind speed collocated with increases and decrease of sea surface temperature.

Wind increase above warm Agulhas Current eddies

Mathieu Rouault, Philippe Verley and Bjorn Backeberg

The objective of our study is to explore the interaction between the atmosphere and ocean eddies warmer than their surroundings. The goal is to quantify the effect of the sea surface (SST) perturbation on surface wind speed increase without filtering the data. Eddies are identified with a combination of AMSR-E SST and altimetry. Twice daily instantaneous gridded wind speed field estimates from QuikScat are examined south of the Agulhas current. For the two year period from 2 July 2002 to 2 June 2004, we select 6 warm eddies south of Africa that presents strong surface thermal contrasts with the surrounding ocean (SST perturbation > 1°C) for a variety of wind directions and SST perturbation. Such eddies were found in an area between 35°S to 45°S latitude and 15°E to 25°E longitude. The record represents a total of 22 months of clear-cut, identifiable

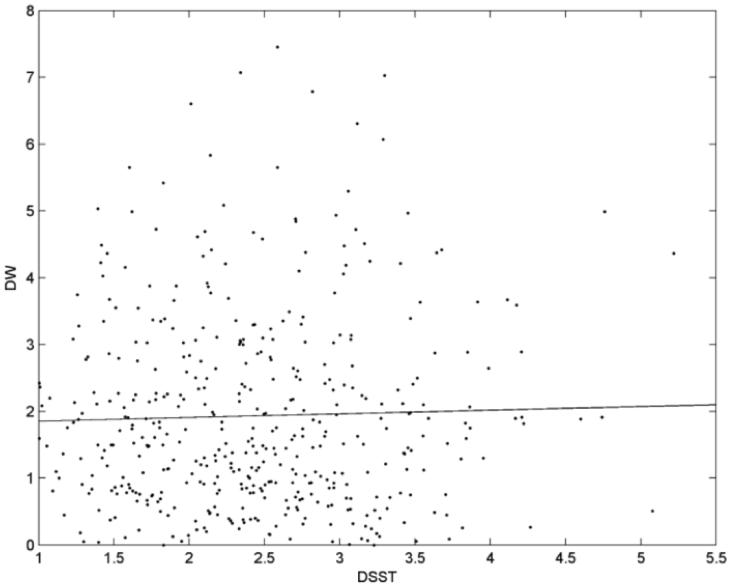


Figure 11. *Scatter plot of SST perturbation versus wind speed increase for cases when the wind increased homogeneously above eddies and for SST perturbation from the surrounding ocean superior to 1°C*

eddies. We have cases for all seasons with a variety of SST (19°C to 12°C) and SST perturbations (1° to 5.5°C). Figure 10 shows 4 examples of scenes showing high acceleration above a warm eddy.

The analysis of 2500 instantaneous charts of equivalent stability neutral wind speed estimates from the SeaWinds scatterometer onboard the QuikScat satellite collocated with sea surface temperature and sea level anomaly shows stronger wind speed above warm eddies than surrounding water at all wind directions in about 800 of the 2500 cases. To quantify the relationship between SST perturbation, wind speed increase, season and eddy duration we looked at the statistics of the merged dataset of those 800 cases that present a clear homogeneous increase and a SST perturbation > 1°C. For each scene, we extract SST, SLA, absolute geostrophic current and wind speed at three positions along the wind flow: a) before the border of the eddy in undisturbed condition b) in the middle of the eddy c) downwind of the eddy border. SST and wind speed gradient and perturbation are calculated across the eddy border at the entrance of the flow. Figure 11 presents a scatter plot of the instantaneous wind speed increase versus the SST perturbation. Wind speed increase of up to 7 $m.s^{-1}$ are evident in our dataset with a great number of case showing increase superior to 2 $m.s^{-1}$. For those 800 scenes, the mean increase was about 2 $m.s^{-1}$ for a mean wind speed of 11 $m.s^{-1}$ at the entrance, slightly higher than other studies of wind speed modification across Gulf Stream eddies who found an increase of about 10 to 15%. Most of selected wind speed background ranged between 5 $m.s^{-1}$ and 20 $m.s^{-1}$. The eddy SST centers range from 19°C to 12°C with SST perturbation of up to 5.5°C for a mean gradient of 2.5°C per 100 km. Sizes of eddies range from 100 to 250 km diameter This is substantially higher than values of wind speed increase and SST perturbation given in previous studies for the region using filtered data. Previously an average increase of 1.2 $m.s^{-1}$ for an average SST perturbation of 0.8°C was found.

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Longandjo, G.N.T and **M. Rouault** (2014). The annual cycle of Central Africa rainfall and its relationship with the surrounding tropical oceans. *Proceedings of 30th Annual Conference of South African Society for Atmospheric Science,* 01-02 October 2014, Potchefstroom, South Africa. ISBN 978-0-620-62777-1

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Dr. Bjorn Backeberg (Co-director, 30% salary) – Oceanography, modeling and data assimilation

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