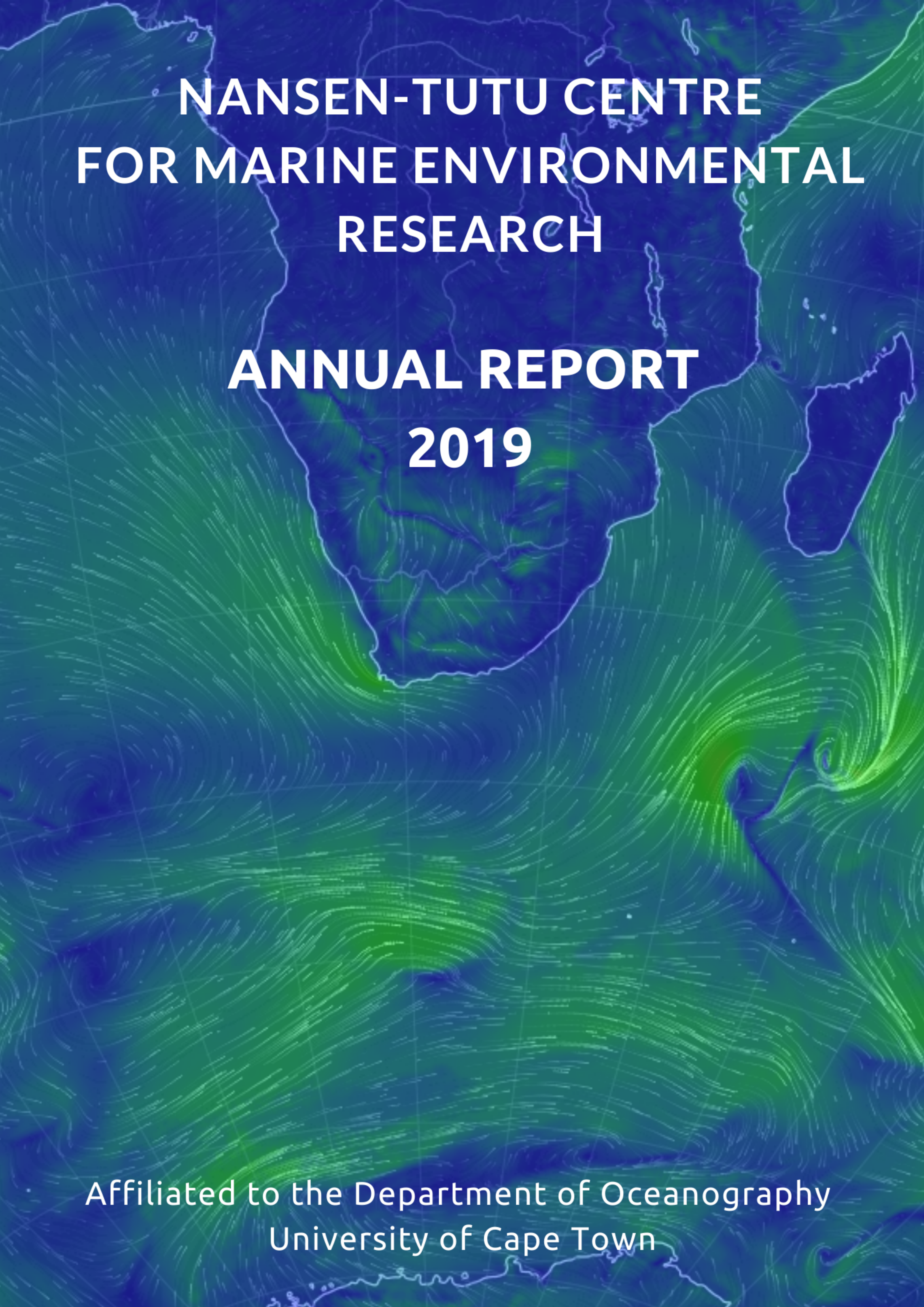
NANSEN-TUTU CENTRE FOR MARINE ENVIRONMENTAL RESEARCH

ANNUAL REPORT 2019



Affiliated to the Department of Oceanography
University of Cape Town

BOARD REPORT 2019

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:

- Capacity building and education with a focus on African students
- Ocean modelling and prediction
- Ocean-atmosphere interaction, climatology and regional impact
- High-resolution satellite remote sensing of the regional seas
- Regional sea level variability and global change

Organisation

The Nansen-Tutu Centre (NTC) is a University of Cape Town (UCT) accredited non-profit research centre hosted at the Department of Oceanography at UCT. The administrative and legal responsibilities reside with UCT. It is a joint venture agreement between the signatory partners from South Africa, Norway, France and the United States.

In 2019, the signatory partners from South Africa included Department of Oceanography, UCT; the Alliance for Collaboration on Climate and Earth System Studies (ACCESS), National Research Foundation (NRF); the Council for Scientific and Industrial Research (CSIR); the South African Environmental Observation Network (SAEON), the Department of Environment Forestry and Fisheries (DEFF), Oceans and Coasts Branch; the South African Weather Service (SAWS); the Cape Peninsula University of Technology (CPUT); and Institute for Coastal and Marine Research of the Nelson Mandela University (NMU). From Norway, the signatory partners included the Nansen Environmental & Remote Sensing Centre (NERSC); the University of Bergen (UiB); and the Institute of Marine Research (IMR). From France, the Institut de Recherche pour le Développement (IRD) and the Université de Bretagne Occidentale (UBO), are signatories and from the USA the Geosciences Department at Princeton University.

Staff

The 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 Honours, MSc, PhD students and post-doctoral research fellows. During 2019, the Nansen-Tutu Centre comprised 28 persons, including two honours students, five MSc students, five PhD students, four postdoctoral researcher fellows, 11 associate researchers and one part-time administrator.

Acknowledgements

The Nansen-Tutu Centre's activities are enabled through contributions from its signatory partners and project funding.

In 2019, the Centre received direct funding from the Nansen Environmental and Remote Sensing Centre, University of Bergen and the Institute for Marine Research. In addition, project funding, travels and bursaries were obtained from South Africa, Norway and France. Moreover, in-kind contributions were received from partners of the Joint Venture.

Scientific production

A total of 25 publications emanated from the Centre in 2019, which included: 16 papers published in peer-reviewed journals, three articles in peer-reviewed conference proceedings, a book chapter and six other publications. 43 oral presentations or posters were presented at national or international conferences and workshops.

Graduation

Congratulations to our **2019 graduates**:

- Arielle Stella Nkwinkwa Njouado (PhD)
- Bernardino Nhantumbo (PhD)
- Tumelo Maja (MSc)
- Sian Seymour (MSc)
- Michael Hart-Davis (MSc)
- Tesha Tolsee (BSc Honours)
- Sonia Heye (BSc Honours)

Cover: surface wind speed from GFS Earthnull during very strong upwelling, 11/12/2017. Courtesy Kirstin Peter

Student support and supervision

In 2019, the Nansen-Tutu Centre supported the students and postdoctoral fellows listed below, who either received a full bursary, top-up funding towards their bursaries or travel support for research exchange visits and conference attendance.

Marie-Lou Bachelery (co-funded: NTC and NRF SARChI) – postdoctoral research fellow, France. Supervisors: Mathieu Rouault, Annette Samulelsen and Serena Illig

Juliano Dani Ramanantsoa (NTC and NRF SARChI) – postdoctoral research fellow, Madagascar. Supervisors: Mathieu Rouault and Marek Ostrowski

Georges-Noel Tiersmondo Longandjo (NTC and ACCESS) – PhD then postdoctoral research fellow, Democratic Republic of Congo. Supervisors: Mathieu Rouault and Noel Keenlyside

Founi Mesmin Awo - postdoctoral research fellow, Benin. Supervisors: Mathieu Rouault and Marek Ostrowski

Serge Tomety (NTC and NRF SARChI) – PhD, Togo. Coastal change and Variability in the Benguela Upwelling System: Decadal Variability and Trend. Supervisors: Mathieu Rouault, Serna Illig, Noel Keenlyside and Annette Samuelsen

Hermann Luyt (NTC and ACCESS) – PhD, South Africa. Assimilating regionally tailored satellite SSTs in an assimilative model of the Agulhas and Benguela currents. Supervisors: Björn Backeberg, Francois Counillon and Jennifer Veitch

Bellinda Monyella (UCT and NRF SARChI) – PhD, South Africa. Impact of ENSO on Southern African rainfall. Supervisor: Mathieu Rouault

Bafana Gweba (NTC and NRF SARChI) - PhD, South Africa. Modelling current wave interaction in the Agulhas Current. Supervisor: Marjolaine Krug, Pierrick Penven, Fabrice Collard and Johnny A. Johannessen

Tumelo Maja (NTC and NRF SARChI) – MSc, South Africa. Validation of GlobCurrent data in the Agulhas Current. Supervisors: Marjolaine Krug and Johnny A. Johannessen

Bellinda Nhesvure (NTC and ACCESS) - MSc, Zimbabwe. Impact of ENSO on South African coastal sea surface temperature. Supervisor: Mathieu Rouault

Michael Hart-Davis (NTC and SAEON) - MSc, South Africa. Particle trajectory modelling in the South African shelf sea region. Supervisors: Björn Backeberg, Juliet Hermes, Johnny A. Johannessen and Mostafa Bakhoday-Paskyabi

Jason O'Connor (NTC and NRF SARChI) - MSc, South Africa. Impact of Agulhas Current on storm development. Supervisor: Mathieu Rouault

Anathi Manyakanyaka (NTC and NRF SARChI) - MSc, South Africa. The variability of retention in St Helena Bay. Supervisor: Jenny Veitch

Tesha Tolsee (NTC and NRF SARChI) - BSc Honours, Mauritius. Seasonal variation of surface hydrographic conditions around the Prince Edward Islands. Supervisors: Tarron Lamont and Isabelle Ansorge

Sonia Heye (NTC and NRF SARChI) - BSc Honours, South Africa. Impact of the Agulhas Current mesoscale variability on the surface dispersion in the KwaZulu-Natal Bight. Supervisors: Marjolaine Krug and Jenny Veitch

Exchange with Norway

During 2019, the Centre facilitated **8 international research exchange visits** to Bergen, Norway, including one MSc student, Michael Hart-Davis; two PhD students, Serge Tomety and Herman Luyt; two postdoctoral fellows, Marie-Lou Bachelery and Juliano Dani Ramanantsoa; and three senior scientists - Mathieu Rouault, Björn Backeberg and Issufo Halo.

The students worked on their thesis dissertations under the supervision of Norwegian scientists. In addition, three Norwegian scientists - Johnny A. Johannessen, Annette Samuelsen and Marek Ostrowski - visited Cape Town.

Two Norwegian students participated in the SEAmester Cruise organised by Isabelle Ansorge, board member and head of UCT's Department of Oceanography.

Capacity building

- **George Noel Longandjo** gave 10 hours of lectures in tropical climatology in the Department of Environment and Geography at UCT.
- **Mathieu Rouault** gave 10 hours of lectures in air-sea interaction for the honours class of UCT's Department of Oceanography in April 2019.
- **Johnny A. Johannessen,** together with Mathieu Rouault and Marjolaine Krug, convened and gave lectures in operational oceanography for the Applied Ocean Sciences taught masters course at UCT in May 2019.
- **Jenny Veitch** lectured the mid-latitude ocean circulation module to the third-year ocean dynamics students at UCT in April 2019.
- **Harry Luyt** participated in the Data Assimilation Summer School in Timisoara, Romania and to the University of Bergen class in Numerical Modelling.
- **Bafana Gweba** went to the advanced CROCO ocean modelling training course and the WAVEWATCHIII training workshop in Brest, France.
- **Serge Tomety** attended the ICTP-CLIVAR summer school on Oceanic Eastern Boundary Upwelling Systems in Trieste, Italy.

Conference, workshop and summer school attendance

Michael Hart-Davis presented his work at two international conferences - the EGI 2019 Conference in Amsterdam and the EPOS-N research group workshop at the University of Bergen. Michael also visited the Technical University of Munich. **Bjorn Backeberg** presented his work at conferences in Belgium, Vienna, Milan and Chiba, Japan. **Juliano Dani Ramanantsoa** presented his work at 10th WIOMSA Scientific Symposium in Mauritius and in LEGOS, Toulouse and Ifremer, Brest in France, where he spent six months. **Marie-Lou Bachèlery** gave a presentation and co-convened a session at the EGU General Assembly 2019 in Vienna. **Issufo Halo** attended the UNEP & Nairobi Convention meeting WIO Regional Science to Policy Workshop and co-convened a special session on the 11th WIOMSA Scientific Symposium.

Altogether **43 presentations** and posters were delivered overseas or in South Africa.

National and international activities

The Centre actively participated in national research and development activities, including projects funded through the NRF, the Department of Science and Innovation (DSI), and the Alliance for Collaboration on Climate and Earth System Studies (ACCESS). ACCESS is an NRF research program for integrated and end-to-end research and education, services and training outputs and outcomes related to the opportunities and challenges emanating from a varying and changing environment, collectively referred to as Earth Systems Science.

Marjolaine Krug was the PI of the GINA 2019 gliders deployments, a contribution to the ACEP CAPTOR project (African Coelacanth Ecosystem Programme - connectivity and dispersal between protected areas), led by ORI and which investigates the connectivity between Marine Protected Areas.

Mathieu Rouault and **Jenny Veitch** are members of the CLIVAR research focus group on Eastern Boundary Upwelling and Jenny Veitch attended the first meeting in the USA.

The Centre's researchers serve on several international panels, including the GODAE OceanView Coastal Ocean and Shelf Sea Task Team, the GCSO/GOOS/WCRP Ocean Observations Panel for Climate (OOPC), the Oceangliders Boundary Ocean Observing Network (BOON). The Nansen-Tutu Centre is co-pi in the Horizon 2020 TRIATLAS project.

Highlights

George Noel Longandjo organised the International Conference on Central Africa Climate and Hydrology at Université Nouveaux Horizons in Lubumbashi, Democratic Republic of Congo. **Herman Luyt** took part in the South African National Antarctic Expedition Voyage and the Weddell Sea Expedition from 7 December 2018 to 15 March 2019. **Michael Hart-Davis** and **Sian Seymour** were awarded their MSc with distinction. In addition, Michael Hart-Davis published and submitted many papers. **Marjolaine Krug** organised successfully the Captor glider experiment. **Founi Mesmin Awo** was invited to the FAO Nansen workshop in Abidjan, Côte d'Ivoire, from the 15 to 17 October 2019. **Issufo Halo** and **Marie-Lou Bachelery** convened sessions in international conferences. **Mathieu Rouault** and **Anicet Imbol Koungue** won the Stanley Jackson Award for best peer-reviewed publication.

Financial situation

A total of 750 000 ZAR (500 000 NOK) seed funding for the Centre was made available from Norwegian partners in 2019: notably 450 000 ZAR (300 000 NOK) from NERSC; 150 000 ZAR (100 000 NOK) from UiB; and 150 000 ZAR (100 000 NOK) from IMR.

In addition, almost 3 000 000 ZAR was raised through project funding in 2019.

These include projects funded by the South African National Research Foundation, the Alliance for Collaboration on Climate and Earth System Science, the NRF's South African Research Chairs Initiative and the EU 2020 TRIATLAS project.

Members of the Board

- Prof. J.A. Johannessen, NERSC (Co-chair)
- A/Prof. I. Ansorge, UCT (Co-chair)
- Mr A. Naidoo / Mr A. Johnson, DEA
- Mr J. Stander / Mr M. Majodina, SAWS
- Dr N. Sweijd, ACCESS
- Dr S. Bernard, CSIR
- Dr J. Hermes, SAEON
- Dr Conrad Sparks, CPUT
- Prof. Andrew Leitch, CMR, NMU
- Prof. N.G. Kvamstø, GFI, UiB
- Prof. G. Philander, Princeton University
- Prof. Peter Haugan
- Dr. F. Marsac, for IRD and UBO

Administrative and technical staff

Sharon Bosma, associate staff, secretariat and finances

Useful links

Nansen-Tutu Centre: www.nansen-tutu.org
Department of Oceanography: www.sea.uct.ac.za
NERSC: www.nersc.no

Approved by The Board
Cape Town, November 2019

Scientists

- Dr Annette Samuelsen, NERSC, Norwegian co-director, ocean modelling and prediction
- Prof. Mathieu Rouault, South African co-director, ocean-atmosphere interaction, climate and regional impact
- Dr Issufo Halo, Associate researcher, CPUT, South Africa, ocean modelling and prediction
- Prof. Johnny A. Johannessen, Associate researcher, NERSC, Norway, satellite remote sensing of regional shelf seas
- Prof. Noel Keenlyside, Associate researcher, UiB, Norway, ocean-atmosphere, climate and regional impact
- Dr Marjolaine Krug, Associate researcher, CSIR, South Africa, satellite remote sensing of regional shelf seas
- Dr Marek Ostrowski, Associate researcher, IMR, Norway, ocean-atmosphere, climate and regional impact
- Dr Jenny Veitch, Associate researcher, SAEON, South Africa, ocean modelling and prediction
- Dr Taron Lamont, Associate researcher, DEFF. South Africa
- Dr Mostafa Bakhoday-Paskyabi, Associate researcher, UiB, Norway, ocean modelling and prediction
- Dr Bjorn Backeberg, Associate researcher, ERSC and NTC, Norway and South Africa, ocean modelling and prediction
- Dr Francois Counillon, Associate researcher, NERSC, Norway, ocean modelling and prediction

Prospects for 2020

- Continue to support existing PhD students.
- Appoint new MSc and PhD students depending on available funding.
- Improve science outreach through popular articles, social media and newsletters.
- Organize the TRIATLAS summer school and the 10th Anniversary NTC Symposium in Cape Town.
- Participate in summer schools, national and international conferences and working groups.
- Raise funding for student exchange visits to Norway and France and attendance to international summer schools and conferences.
- Sign the NTC phase 4 agreement.
- Secure funding for assignment of a permanent NTC research assistant.

PUBLICATIONS 2019

Peer-reviewed papers

Bourles B, Araujo M, Rouault M et al. (2019). PIRATA: A Sustained Observing System for Tropical Atlantic Climate Research and Forecasting. Earth and Space Science, 6(4):577-616.

Cronin MF, Gentemann CL, Krug M et al. (2019). Air-Sea fluxes with a focus on heat and momentum. Frontiers in Marine Science, 6:430.

D'Hotman J, Malan N, Collins C, de Vos M, Lumpkin R, Morris T and Hermes J. (2019). Using a jet reference frame to target drifter deployments in the Agulhas Current. Journal of Geophys. Res. Oceans, 124:4238–4247.

Dieppois B, Pohl B, Crétat J, Eden J, Sidibe M, New M, Rouault M, Lawler D. (2019). Southern African summer-rainfall variability, and its teleconnections, on interannual to interdecadal timescales in CMIP5 models. Climate Dynamics, 53:3505-3527.

Illig S, Bachèlery M-L. (2019). Propagation of Subseasonal Equatorially Forced Coastal Trapped Waves down to the Benguela Upwelling System, Scientific Reports, 9: Article 5306.

Imbol Koungue RA, Rouault M, Illig S, Brandt P, Jouanno, J. (2019). Benguela Niños and Benguela Niñas in forced ocean simulation from 1958 to 2015. Journal of Geophysical Research: Oceans, 124, 8: 5923-5951.

Malan N, Durgadoo J, Biastoch A, Reason CJC and Hermes J. (2019). Multidecadal wind variability drives tempeature shifts on the Agulhas Bank. Journal of Geophysical Research: Oceans, 124(5):3021–3035.

Nkwinkwa Njouado AS, Rouault M and Johannessen J. (2019). Turbulent Latent heat flux in the Agulhas Current. Remote Sensing, 11 (13),1576.

Pfaff MC, Logston RC, Raemaekers SJ, Hermes JC, Rouault M, Krug M et al. (2019) A synthesis of three decades of socio-ecological change in False Bay, South Africa: setting the scene for multidisciplinary research and management. Elementa Science of the Anthropocene, 7(1): Article 32.

Ragoasha, N, Herbette, S, Cambon, G, Veitch, J, Reason, C and Roy, C. 2019. Lagrangian pathways in the southern Benguela upwelling system. Journal of Marine Systems, 195, pp.50-66.

Singh, SP, JC Groeneveld, M Hart-Davis, BC Backeberg, S Willows Munro (2019). Seascape genetics of the spiny lobster Panulirus homarus in the Western Indian Ocean: understanding how oceanographic features shape the genetic structure of species with high larval dispersal. Ecology and Evolution, 8, 23.

Sloyan, B, Wilkin, J, Hill, K, Chidichimo, M, Cronin, M, Johannessen, J, Krug M, Palmer, M. (2019). Evolving the physical global ocean observing system for research and application services through international coordination. Frontiers in Marine Science. 6,449.

Tedesco P, Gula J, Ménesguen C, Penven P and Krug M. (2019). Generation of submesoscale frontal eddies in the Agulhas Current. Journal of Geophysical Research: Oceans, 124.

Testor P, DeYoung B, Haugan PM, Krug M et al. (2019). OceanGliders: a component of the integrated GOOS, Front. Mar. Sci., 6:422.

Todd, RE, Chavez, FP, Krug M et al. (2019). Global perspectives on observing ocean boundary current systems. Frontiers in Marine Science, 6, p.423.

Veitch J, Rautenbach C, Hermes J and Reason CJC. (2019). The Cape Point wave record, extreme events and the role of large-scale modes of climate variability. Journal of Marine Systems, 199:103185.

Vermeulen, E, Backeberg B, Hermes J, Elipot S. (2019) Investigating the relationship between volume transport and sea surface height in a numerical ocean model. Ocean Sciences, 15, 513-526

Peer-reviewed conference proceedings

Krug, M, Rouault M, Willmott P (2019), Spatial variability in coastal winds over the Cape Peninsula region from Synthetic Aperture Radar observations, Proceedings of the 31 SASAS Conference, ISBN: 978-0-6398442-0-6, 8-9 October 2019, Vanderbijlpark, (South Africa), Pg. 20-23, Editor Christien Engelbrecht.

Seymour SAM, Krug M, Smith M, Rouault M (2019), Temperature and chlorophyll response to spatial variability in upwelling favourable winds in False Bay, Proceedings of the 31 SASAS Conference, ISBN: 978-0-6398442-0-6, 8-9 October 2019, Vanderbijlpark, (South Africa), Pg. 99-103, Editor Christien Engelbrecht.

Rouault M, Nkwinkwa Njouado NS and Johannessen J. The annual cycle of moisture exchange above the Agulhas Current, Proceedings of the 31 SASAS Conference ISBN: 978-0-6398442-0-6, 8-9 October 2019, Vanderbijlpark, (South Africa), Editor Christien Engelbrecht.

Other publications

Backeberg, B: The EMSO Data Management Platform: from prototype to full production, EGI Inspire, 34

Hart-Davis, MG ESASTAP workshop – inspiring greater collaboration between oceanographers. SAEON Newsletter, December 2019.

Hart-Davis, MG and Butt, T: Board almost obliterated after horror wipe-out. ends up intact 425kms away. Magic Seaweed.

Hart-Davis, MG and Butt, T: How a surfboard washing up 1,600kms away raises serious concerns over ocean plastics. Magic Seaweed.

Hart-Davis, MG and Paterson, D: An Odd Odyssey. Wavescape.

Krug M two articles in the Zululand Observer based on our ocean glider activities off the Natal Bight.

Nansen-Tutu TRIATLAS summer school on Ocean, Climate and Marine Ecosystem participants - University of Cape Town, Jan 2020

Seasonal and interannual variabilities of sea surface salinity in the Angolan upwelling system

F.M. Awo, M. Rouault, M. Ostrowski

Warm oceanic events that appear some years in the southeast tropical Atlantic in the Angola-Benguela region are called Benguela Niños. These events are caused mainly by suppression of local upwelling and are remotely forced by Kelvin waves. They have severe consequences for local fisheries. Increased mortality in sardine and horse mackerel and their poleward shifts are observed during this event.

Recent studies have shown that in the 2016 warm event, surface freshening water, detected in satellite observations of Sea Surface Salinity (SSS), caused a very shallow mixed layer and enhanced upper ocean stratification that reduced the upwelling of the cool subsurface water into the mixed layer.

These findings have highlighted the strong role of ocean salinity in the development of Benguela Nino. Our goal is to understand the SSS variability in Angola and Northern Namibia (Figure 1) using observations, satellite estimates and ocean general circulation model. Fig 2 shows the evolution of the SSS annual cycle along south Angola. Low salinity appears during the austral autumn which then bottoms in March-April, then increases. reaching the maximum value in austral winter, with the peak in August (Fig 1 & 2) .

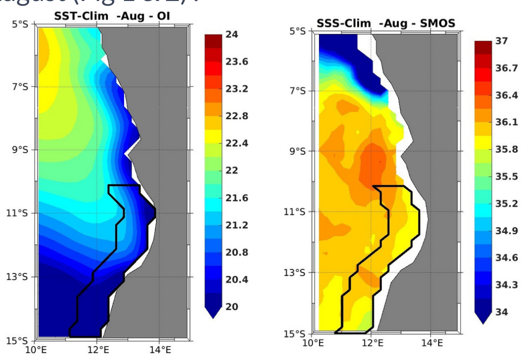


Fig 1: Seasonal climatology of sea surface temperature (SST) ***left*** *and salinity (SSS)* ***right*** *in August, with Optimum Interpolation (OI) of SST and Soil Moisture–Ocean Salinity (SMOS) satellite mission. Black lines represent the Southern Angola region (15°S–10°S and 1° offshore).*

The model follows relatively well the observations except in February to April, where it is saltier than observed (Fig 2, full red line). Despite this difference, the model reproduces well the seasonal variability (Fig 2, dashed red line).

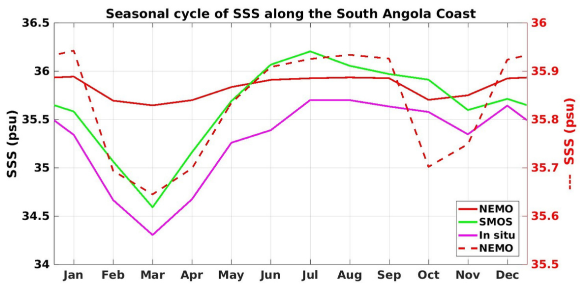


Fig 2: Seasonal cycle of SSS along the south Angola coast (black line in Fig 1) using SMOS satellite (green line), in situ products (magenta line) and model NEMO (Nucleus for European Modeling of the ocean, red lines).

The model is then used to diagnose the dominant physical mechanisms responsible for this variability.

The change in horizontal advection, related to surface currents, is the main process that drives the seasonal SSS cycle, whereas the atmospheric forcing (precipitation, evaporation and river discharge) contribution is weak and relatively constant all year.

The subsurface forcing maintains the balance with small contribution especially during austral autumn until early summer.

To understand this better we have deepened our investigation by decomposing the horizontal advection term into their zonal and meridional components. The results reveal that only meridional advection by Angola current is the main driver. This current carry low salinity from the Congo River plume; located at 6°S; southward until the south Angola Coast in March-April (Fig 2) and reverses with salted water in austral summer during the Angola upwelling (Fig 1 & 2).

The next step of this study is to investigate the interannual timescale of this SSS variability and identify the potential oceanic and/or atmospheric drivers.

The variability of retention in St Helena Bay

A. Manyakanyaka, J. Veitch, M. Rouault

St Helena Bay, located on the west coast of South Africa, is an important nursery area for juvenile anchovy and sardine. These two species are the dominant species that are exploited by South Africa's profitable fishing industry.

The success of the fish recruitment is dependant on the retentive nature of St Helena Bay created by very specific ocean dynamics.

The circulation in St Helena Bay and the variability of the retention of the Bay are investigated using seasonal climatology forced in the Region Ocean Modelling System (ROMS).

While retention has been studied from a biological point of view, the seasonality of the hydrodynamics contributing to the retention has received less attention.

In this study, we explore how the wind stress, wind stress curl, sea temperature and currents contribute to the seasonal recirculation dynamics in St Helena Bay.

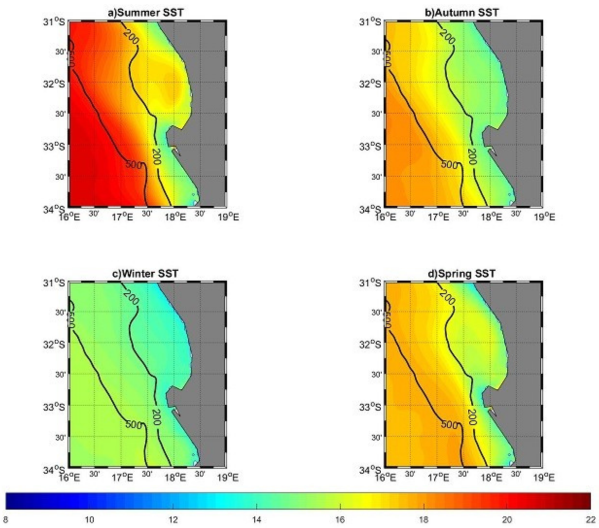


Fig 1: Surface seasonal SST (°C) climatology. Isobaths of bathymetry are displayed at 200 m and 500 m in black. (a) is summer SST, (b) autumn SST, (c) winter SST and (d) spring SST.

Ichthyop, a Lagrangian particle tracking method is used to study the spatial variations of local retention rates, with the particles released from the Bay.

The circulation on the west coast shelf is dominated by the equatorward boundary current, the Benguela Current. St Helena Bay is sheltered from the direct influence of the Benguela current by the coastal geographical features.

A cyclonic circulation pattern is observed in the bay especially in the autumn and winter seasons.

The results suggest that the recirculation patterns are prominent in autumn and winter and a southward current flow along the coast. Similar cyclonic features are observed at a depth of 100 m in the water column.

An analysis of the particle tracking reveals that more drifters are retained in winter than in summer, confirming what is observed in the circulation patterns.

More drifters are retained in the deep waters than the surface waters.

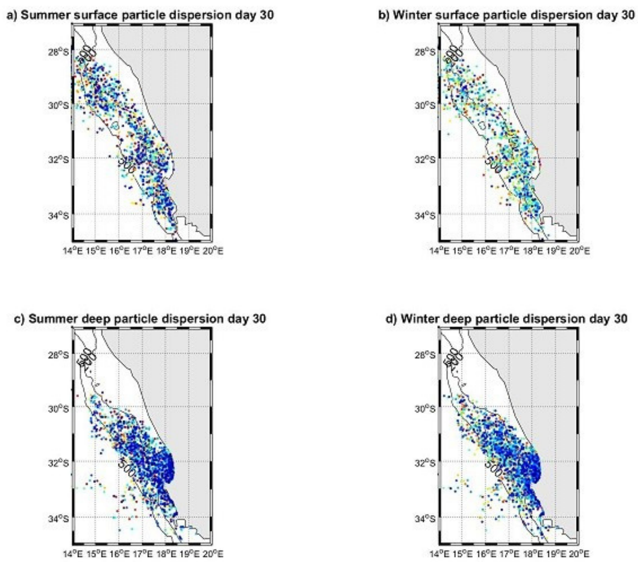


Fig 2: Surface seasonal SST (°C) climatology. Isobaths of bathymetry are displayed at 200 m and 500 m in black. (a) is summer SST, (b) autumn SST, (c) winter SST and (d) spring SST.

On the Control of the Central Africa Rainfall Annual Cycle

G.N. Longandjo, W. Moufouma-Okia, M. Rouault

The intertropical convergence zone (ITCZ) is not only the region in which the trade winds from the Northern and Southern Hemispheres converge (Miller 1996; van Heerden and Taljaard 1998), but also is defined as a narrow belt of clouds located on average around six degrees on either side of the equator and associated with high rainfall (Donohoe et al. 2013; Schneider et al. 2014). The north-south progression of the ITCZ, with its twice-annual passage corresponding to the two equatorial rainy seasons, is considered as the primary driver of the annual cycle of rainfall (Nicholson, 2009; Nicholson, 2011; Suzuki, 2011). However, this seasonal march is insensitive to differences in climate model physics and resolution (Suzuki, 2011).

Recently, Nicholson (2018) showed that the ITCZ controls neither the north-south seasonal migration of rainfall over central Africa, nor does the ITCZ explain the rainfall seasonality over central Africa. She also argued that the use of the ITCZ terminology over central Africa landmass is misleading. This suggests that drivers of the annual cycle of rainfall over central Africa have not been carefully examined. Using observed rainfall, reanalyses and an atmospheric climate model (ECHAM5.3), we try to propose a new and simple paradigm that explains the climatological seasonal cycle of rainfall over central Africa, an important question for climate and hydrological sciences focusing on this region.

To destabilize the stable lower troposphere over central Africa, both Congo basin cell and shallow meridional overturning cell are key features by which the low-level circulation is coupled to the mid-upper circulation, associated with deep convection, and hence control the seasonal rainfall migration and distribution.

Critical in these mechanisms are the ventilation mechanism and the local evaporative cooling–circulation feedback. Indeed, the convection depends on the strength of the upward air mass, which in turn, is controlled by the characteristic of both atmospheric energy transport related to the low-level westerly jet and the shallow meridional overturning circulation driven by the Sahel thermal low.

The low-level cross-equatorial southerly advects poleward water vapour from relative cold, vegetated central Africa to warm the Sahel to invigorate the convection, while the midlevel southward transport of warm and moist air mass determines the position of maximum rainfall (Fig. 1).

Overall, the seasonality over central Africa is controlled by changes in the atmospheric low-pressure system rather than by changes in local temperature and water vapour.

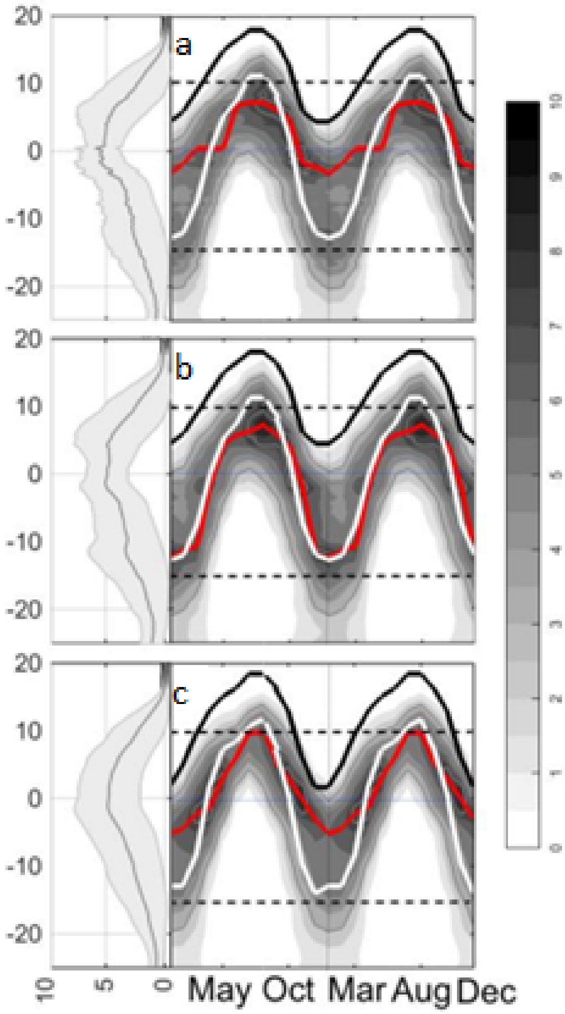


Fig 1: Hovmöller (latitude-time) of the climatological seasonal rainfall and the annual cycle of the latitudinal variation of rainfall (at the left of each panel) (mm/day) averaged between 7° -33°E. (a) ERA5; (b) CHIRPS; (c) ECHAM5.3. The annual cycle is shown twice. Bold black, white and red lines on each panel represent the latitudinal position of (a) low-level (1000-850- hPa) and (b) midlevel (700 and 600- hPa) ascending branch of Hadley cells and maximum rainfall. Horizontal dashed black lines delineate the boundaries of central Africa (10°N-15°S).

Developing ocean particle tracking tools for cross-disciplinary oceanic research with applications in the Agulhas Current region

M.G. Hart-Davis, B. Backeberg, M. Bakhoday-Paskyabi, J. Hermes, J. Johannessen

Lagrangian ocean analysis is a powerful way to study ocean processes from in-situ observations and numerical model simulations.

As numerical modelling capabilities develop and physical mechanisms of the ocean are better understood, the importance of particle trajectory modelling continues to increase. Therefore, developing cross-disciplinary particle trajectory model applications for the Greater Agulhas System is highly relevant due to its potential contribution to scientific studies and operational applications.

This research presents the results of developing particle trajectory model applications in the Greater Agulhas System towards better understanding the physical mechanisms that drive ocean processes in the region.

The model is used in three applications that demonstrate their cross-disciplinary potential. These applications include a search and rescue scenario, the study of ocean dynamics and the study of the fate of juvenile turtles.

By comparing a pair of real surface drifters with the particle trajectory model and analysing high-resolution sea surface temperature (SST) fields it was shown that the formation of an eddy on the Agulhas Plateau combined with the weakening of the core current velocity resulted in enhanced eddy-current interactions facilitating the separation of the real surface drifter-pair as they passed through this region.

Lastly, the particle trajectory model was used to study the importance of including active swimming characteristic when studying the fate of juvenile turtles.

It was found that including active swimming resulted in a change in the distribution of juvenile turtles and, therefore, needs to be included to provide a proper understanding of the fate of juvenile turtles in the ocean.

With further development and refinement of the particle trajectory model, Lagrangian ocean analysis has the potential to provide valuable information towards improving our understanding of physical and biological ocean processes at a range of spatial and temporal scales with potential operational oceanography applications.

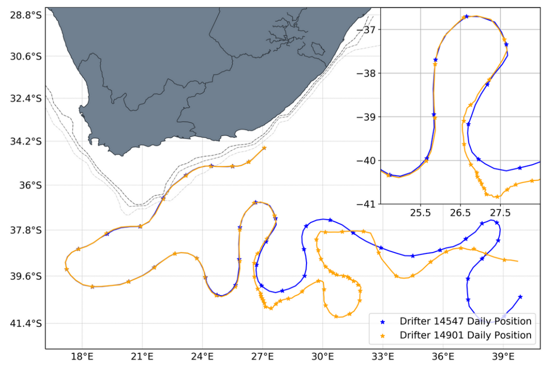


Fig 1: The pathway of a drifter pair deployed in the Agulhas Current on the 11th of April 2015. The subplot shows a zoom into the trajectories of the two drifters around the Agulhas Plateau.

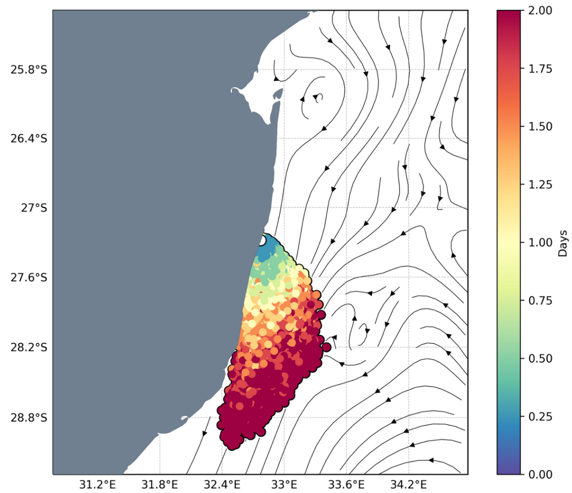


Fig 2: The initial swimming of virtual juvenile turtles as deployed by the particle trajectory model in the Copernicus surface current model.

Does the East Madagascar Current retroflect?

J.D. Ramanantsoa, P. Penven, R.P. Raj, L. Renault, L. Ponsoni, M. Ostrowski, A. F. Dilmahamod, M. Rouault

The Indian Ocean is the fastest-warming ocean in the world for the last two decades.

Western boundary currents in this ocean, such as the East Madagascar Current (EMC), play a key role in transporting heat from the tropics toward the poles. There is a crucial need to assess the functioning of the EMC. The study aims to understand the sudden eastward drift of the EMC southern extension.

In-situ and remote sensing data are used to identify three states of the EMC southern extension: Early Retroflection, Canonical Retroflection and No Retroflection.

Retroflections occur 47% of the time. This study found that the EMC transports back through a retroflection half of water mass eastwards toward the Indian Ocean instead of flowing mainly toward the pole.

EMC strength regulates the retroflection state, although impinged mesoscale eddies also contribute to the retroflection formation.

The Early Retroflection is linked with the EMC volume transport. Anticyclonic eddies drifting from the central Indian Ocean to the coast favour Early Retroflection formation, anticyclonic eddies near the southern tip of Madagascar promotes the generation of Canonical Retroflection, and No Retroflection appears to be associated with a lower Eddy Kinetic Energy (EKE).

Knowledge of the EMC retroflection state could help of predicting the coastal upwelling south of Madagascar, the South-East Madagascar phytoplankton bloom, the formation of South Indian Ocean Counter Current.

The EMC retroflection status appears to have a slightly noticeable impact on the Agulhas Current system.

Based on a possible climate change scenario of intensification of the EMC and eddies, this could lead to more EMC Early Retroflection which may induce an imbalance in the Indian Ocean subtropical gyre.

Therefore, to answer the controversial question: "does the EMC retroflect"? It does indeed!

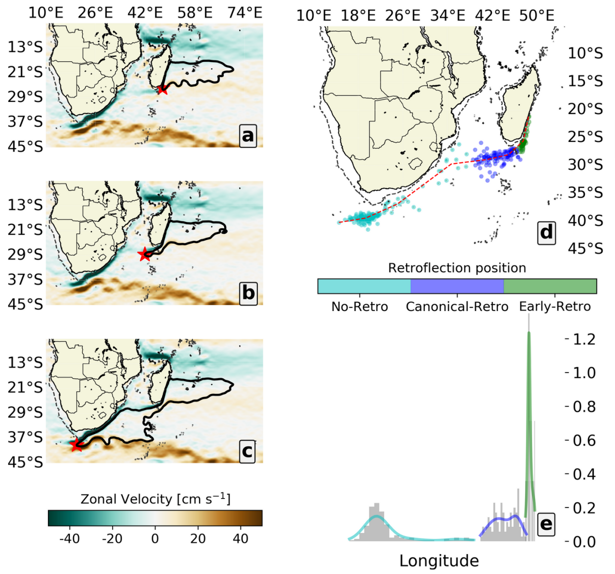


Fig 1: EMC retroflection spatial extent based on satellite altimeter. Panels (a), (b) and (c) display composites of detected EMC retroflection positions using the SSH from satellite altimetry.

The black contour represents the EMC and its retroflection. Red stars highlight the westernmost point of the selected SSH contour, considered as the EMC retroflection position.

The maps in the background represent composites of zonal velocity corresponding to each retroflection cases. (d) presents the spatial classification of the EMC retroflection position from the unsupervised k-mean clustering.

The dotted red line delineates the most probable location of EMC retroflection positions.

Each classified EMC retroflection case is used to build the composites of panels (a), (b) and (c). (e) displays the longitudinal distributions of the three EMC retroflection cases. (f) displays the latitudinal distribution for the Early-Retroflection case.

Scaling observation error for optimal assimilation of CCI SST data into a regional HYCOM EnOI system

H. Luyt, F. Counillon, B.C. Backeberg, S. Akella, J. Veitch & M. Rouault

South Africa boasts a range of oceanographic decision support tools. An operational regional wave forecasting system and a bay-scale forecast product for Algoa Bay is currently under development.

There is, however, no operational regional ocean forecasting system in place tailored to the unique South African environment comprising both the Agulhas and Benguela oceanic currents. Forecasts from such a system are invaluable to marine industries including those involved in search and rescue, fishing and offshore mining. To get the most accurate forecast possible, accurate and up-to-date observations of the true state of the ocean must be synthesised into the forecasting system through data assimilation.

Initial efforts towards this goal have resulted in a system using a regionally optimised Hybrid Coordinate Ocean Model (HYCOM) along with the Ensemble Optimal Interpolation (EnOI) assimilation scheme. Adding Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA) to the assimilation did not seem to improve the forecast skill.

Aiming to address this issue and improve the forecast skill, a more recent data set, namely the Climate Change Initiative (CCI) sea surface temperature (SST), is assimilated into the system. Both the SST data and the associated estimated errors in these observations are used in this system. The observation errors are used to determine whether more confidence should be placed in the ocean model or observations in producing the analysis, and thereby the forecast, from the system. Overconfidence in observations can therefore artificially 'shock' the model and result in the model crashing. To circumvent this issue, a scaling factor is applied to the observation errors which artificially inflates the errors synoptically, leading to less confidence in the observations.

For the CCI SST product, a scaling factor of 25 was found to produce a favourable result with lowest mean root mean square error (RMSE) of 1.098°C between the model and SST data over time (Figure 1). Postulating the observation error to be overconfident (especially when compared to the aforementioned assimilation of OSTIA SST), a 'floor' value, or minimum threshold, is introduced to set a minimum value for the observation errors thereby reducing confidence in the SST data. However, these experiments fared less favourably with a floor value of 0.5°C and a scaling factor of 14 producing the best mean RMSE (1.118°C, Figure 2).

A scaling factor of 25 will be used in upcoming work where assimilation of the CCI product will be compared to the assimilation of along-track SST variants I order to create an improved forecasting system.

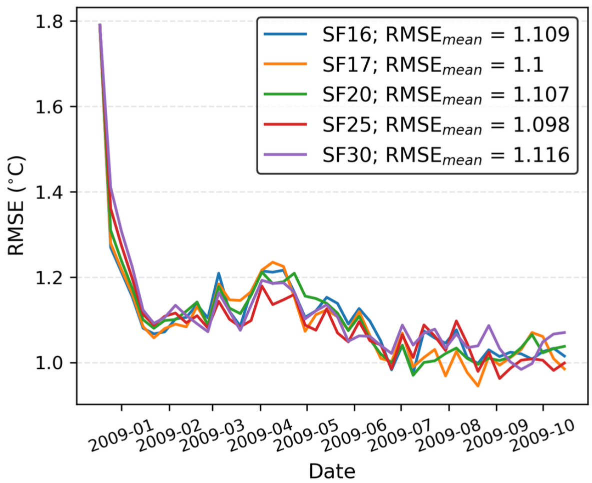


Fig 1: Time-evolution RMSE of the SST for scaling factors 16 (blue), 17 (orange), 20 (green), 25 (red) and 30 (purple)..

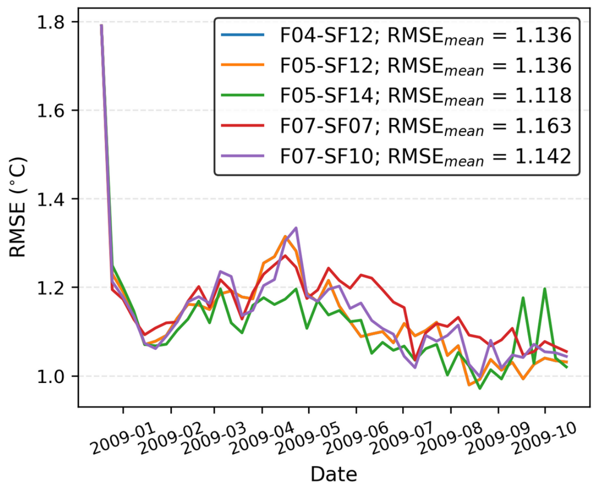


Fig 2: Time-evolution RMSE of the SST for scaling factors 7, 10, 12 and 14 with varying floor values of 0.4°C, 0.5°C and 0.7°C.

Dynamical connection between the equatorially-forced Coastal Trapped Waves and the Benguela Niño-Niña events

ML. Bachelery, S. Illig, M. Rouault

In the south-eastern tropical Atlantic, the equatorial dynamics characterized by the propagation of Equatorial Kelvin Waves and subsequent remotely-forced Coastal Trapped Waves (CTW), explains a large amount of the interannual Angolan and Namibian coastal variability. In particular, it controls 70% of the 0–200m integrated temperature fluctuations in the Coastal Angola Benguela Area (CABA – 10°S-20°S/1°-width band).

The objective of this study is to evaluate and discuss the dynamical connection between energetics CTW and the phenology of the extreme warm (cold) Benguela Niño (Niña) events that occurs in the CABA. To do so, our approach relies on numerical experimentation with the Regional Ocean Modeling System. The simulation is run from 1958 to 2008 using interannual surface atmospheric forcings and boundary conditions.

Also, a new methodology was used to extract the three gravest CTW modes amplitude from the model outputs. CTW are expressed in terms of their contribution to coastal interannual sea level anomalies averaged within the 0.5°-width coastal band.

As pointed out by previous studies, there is no consensus in the scientific community on a criterion that identifies a Benguela Niño or Niña events. Several criteria can be found based on the amplitude or/and the duration of the interannual Sea Surface Temperature anomalies (iSST).

Overall these criteria have in common that they examine the temperature variations in the surface layer. Yet, it has been shown that the maximum temperature variability is located under the mixed-layer, approximately at the mean depth of the thermocline. In line with the previous studies, we define and compare here two criteria for classifying Benguela Niño/Niña events and investigate their relationship with extreme CTW events.

Both our criteria are defined when coastal interannual temperature anomalies averaged within CABA remain higher than ± 1 standard deviation (STD) for at least 3 months in a row.

The first criteria (CRIT-SURF) considers the temperature averaged in the surface layer (0-20m), while the second one (CRIT-SUBS) uses the temperature fluctuations below the mixed layer averaged within 50-60 m depth. Figure 1a displays the iSST time series along with the identified Benguela Niño/Niña episodes (yellow and turquoise stars, respectively) based on CRIT-SURF methodology. 31 events (17 warm and 14 cold events) are selected over the 1958–2008 periods. Most of these events have been documented in the literature. Periods of strong downwelling and upwelling CTW events (vertical yellow and turquoise bars) are overlaid on Fig. 1a.

Results show that there is a good correspondence between indexes: of the 31 Benguela Niño/Niña events, 18 events (10 warm (yellow-filled stars; Fig. 1a) and 8 cold (turquoise-filled stars; Fig. 1a) are in phase with peaks in the CTW index, i.e. 59% of the events. Among the 13 events that do not strictly coincide, 4 are, nevertheless, in phase with moderate CTW activity (defined as CTW exceeding ± 1 STD for 2 months – not shown). As a result, 22 (18 + 4) events can be related to CTW propagation, which increases the detection performances to 71% of the iSST events.

The same analysis but using the subsurface temperature criterion (CRIT-SUBS), is presented in Fig. 1b. Interestingly, the agreement between both signals becomes stronger when considering the index in sub-surface: only 5 events (3 cold (1963, 1983, and 2001–2002) and 2 warm (1965 and 1977)) out of a total of 29 extreme events selected here are not associated with intense CTW episodes.

This represents a total of 83% of coherence between signals. However, as alluded to earlier, these specific 5 events are in phase with moderate CTW activity (not shown).

Hence, 100% of the extreme temperature conditions below the mixed layer can be related to energetic CTW propagations. This remarkable correspondence (71% in surface and 100% in the subsurface) confirmed the high dynamical connection between CTW and extreme temperature conditions along the continental shelf.

Benguela Niños-Niñas are associated with fluctuations in the oxygen content of the shelf water and significantly affect the marine ecosystem and fish resources. Therefore, it is likely that extreme low-oxygen episodes along the continental shelf and their ecological consequences are connected to CTW propagations.

The advent of satellites made it possible to document Benguela Niños-Niñas events as it provides surface observations on a wide spatial and temporal coverage.

However, our results suggest that the understanding of the hypoxic and Benguela Niños-Niñas events can be significantly improved if also documenting and analysing the sub-surface variability.

This will, for instance, require the implementation of mooring monitoring on the shelf where the CTW signature is substantial, similar to the PIRATA observational network in the tropical Atlantic.

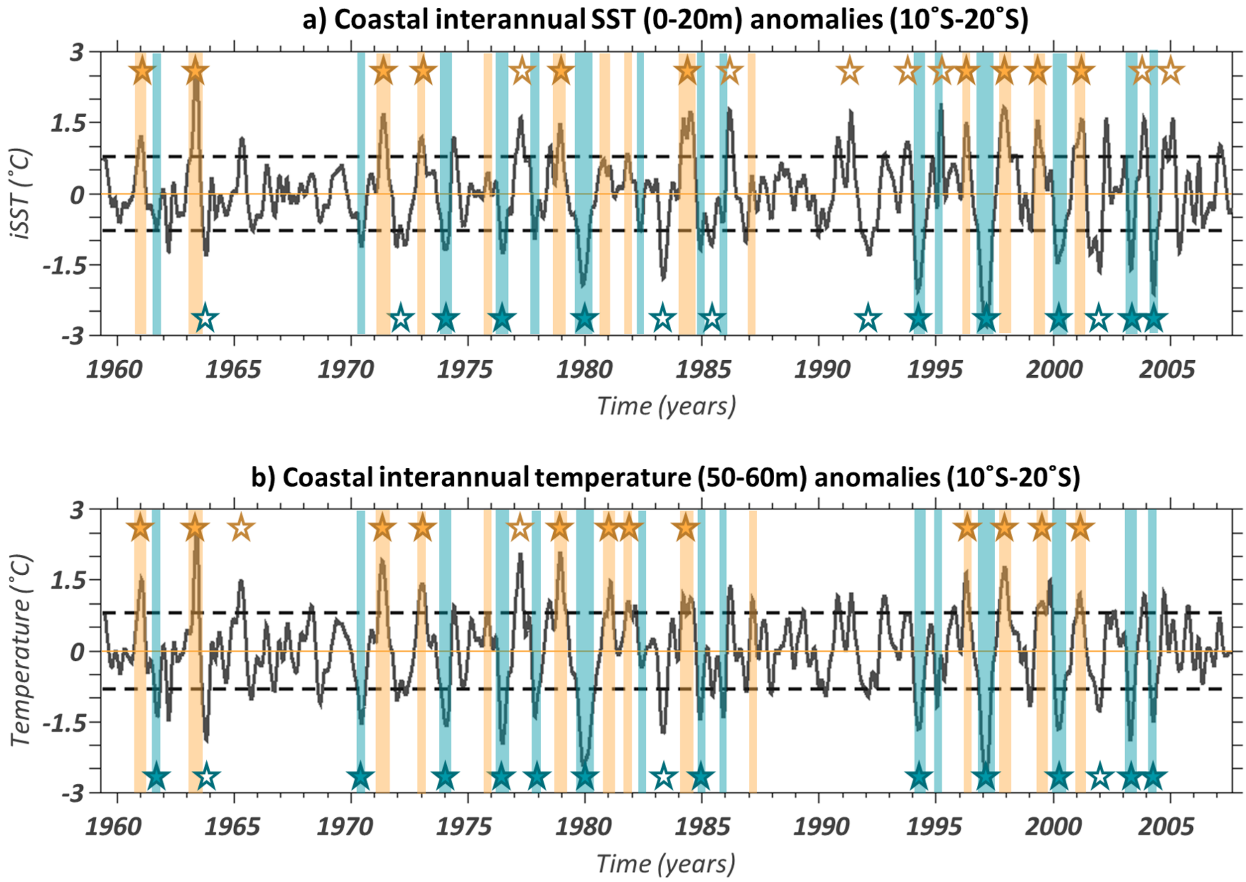


Figure 1:

a) ROMS-CR 0–20 m depth interannual Sea Surface Temperature (iSST; °C) anomalies averaged from 10°S to 20°S in a 1°-width coastal fringe. Extreme downwelling and upwelling CTW propagating episodes in ROMS-CR are emphasized with the yellow and turquoise vertical bars, respectively. Yellow (turquoise) stars denote the extreme Benguela Niño (Niña) episodes defined as iSST larger than ± 1 STD (grey dashed lines) for at least 3 months. Extreme Benguela Niño (Niña) events that do not coincide with extreme downwelling (upwelling) CTW episodes are depicted by empty yellow (turquoise) stars.

b) Same as Fig. 1a for interannual temperature anomalies averaged under the mixed layer between 50 and 60 m depth.

Impact of the Agulhas Current on storm development

J. O'Connor & M. Rouault

Few studies have been dedicated to the investigation of specific storm events occurring over the Agulhas Current.

As the strongest Western Boundary Current (WBC) in the Southern Hemisphere, the Agulhas Current plays a pivotal role in the climate system of Southern Africa. Sharp sea surface temperature (SST) gradients found between the Current and surrounding waters result in high latent and sensible heat fluxes above the Current.

Latent heat losses from such WBCs have been observed to be much larger during extreme weather events. The development of such weather events over the Agulhas Current is the primary focus of this study as these storms could potentially have devastating socio-economic impacts through coastal flooding.

This study makes use of the Advanced Research version of the Weather Research and Forecast (WRF) model to run two simulations: Control (CTL) and Smooth (SMTH).

The evolution of storms over the Current in these two simulations are analysed. The impact of the Agulhas Current on atmospheric variables is quantified by taking the difference (CTL – SMTH) between the two model configurations. Using a spatial filter, SST boundary conditions in the SMTH configuration are smoothed out thereby lowering the SST of the Agulhas core by roughly 1.0 – 1.5°C and the surrounding region by 0.25 – 1.0°C (Figure 1).

Reducing SSTs in the SMTH simulation results in higher (100 – 150 $W.m^{-2}$) latent heat fluxes at the proper Agulhas region (24 - 37° S & 21 - 38° E) in the CTL run.

All rain-producing, synoptic-scale, low-pressure systems passing over the Agulhas Current between 2001 and 2005 were identified and consequently analysed using the WRF model output.

Five atmospheric variables were used as proxies for the study of each storm's intensity.

The evolution of the 850mb geopotential height (m), surface rain rate ($mm.hr^{-1}$), surface wind speed ($m.s^{-1}$), eddy kinetic energy (EKE) up to the 850mb level ($m^2.s^{-2}$) and turbulent moisture flux at the surface ($g.m^{-2}.s^{-1}$) of each storm was analysed.

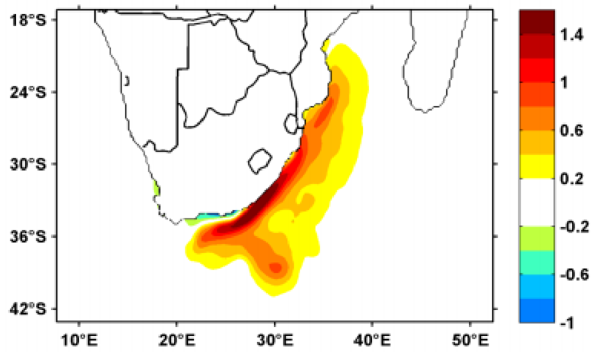


Fig 1: Absolute difference between Control (CTL) and Smooth (SMTH) sea surface temperature WRF model simulations. Measured in °C. Warm (cold) colours indicate warmer (colder) SSTs in the CTL simulation.

Two hundred (200) synoptic-scale storms were identified passing over the Agulhas Current from 2001 to 2005. Seventy (70) were found to produce significant rainfall.

After analysing the model output of these 70 synoptic-scale, rain-producing storms, it was found that 10 showed intensifying development over the Current whereas 28 storms showed cases of sustained storm intensity over the Agulhas Current and 32 showed instances of dissipation over the Current region.

Most storms where sustained storm intensity was modelled turned out to be mid-latitude cyclones whereas the majority of the dissipating storms were smaller low-pressure systems, namely coastal and interior lows.

Of the ten storms that showed intensification patterns, in the CTL run, all ten had lower geopotential heights, seven had higher rain rates, nine had faster surface wind speeds, eight had higher EKE values and nine had greater turbulent moisture fluxes at the surface once each storm had developed over the Agulhas Current.

Impact of the Agulhas Current mesoscale variability on surface dispersion in the KwaZulu-Natal Bight

S. Heye, M. Krug, J. Veitch, M. Hart-Davis

The KwaZulu-Natal (KZN) Bight has a widened shelf and a slightly bay-shaped coastline. This traps water in the KZN Bight, which is higher in nutrients than the surrounding water due to upwelling cells and nutrient inputs within this region. It is therefore a biologically important area.

In this study, a Lagrangian approach is used to investigate the impact of the Agulhas Current's mesoscale variability on surface dispersion in the KZN Bight.

Virtual particles are released in a high-resolution ocean model, in a region encompassing the iSimangaliso MPA, north of the KZN Bight. They are left to drift within the model for 32 days, in a steady and a meandering Agulhas Current. Drifters are used as a comparable observational dataset.

The results show that the residence times of the virtual particles are the longest over the shelf (inshore of the 200m isobath) with typical residence times of 4 to 8 days. The residence times over the shelf are very variable, reflecting the ocean variability. Residence times over the shelf break (between the 200m and 1000m isobaths) are short with the virtual particles either moving inshore or being advected offshore into the Agulhas Current. A steady Agulhas Current favours the retention in the KZN Bight, as a greater percentage (49.83%) of virtual particles move onto the shelf compared to when the Agulhas Current is meandering (9.52%).

These differences are due to the presence of an anticyclonic eddy when the Agulhas Current is meandering as well as the different alignment of the Agulhas Current relative to the isobaths. The anticyclonic eddy pulls particles offshore and the meandering Agulhas Current has an isobath-following trajectory near the KZN Bight, which does not favour the inshore movement of the virtual particles.

A steady Agulhas Current has a cross-isobath flow, allowing virtual particles to move inshore of the KZN Bight. It also has a northward circulation in the northern KZN Bight, which favours the connectivity between the iSimangaliso MPA and the KZN Bight's shelf.

Overall, the steady Agulhas Current forms more favourable conditions for recruitment.

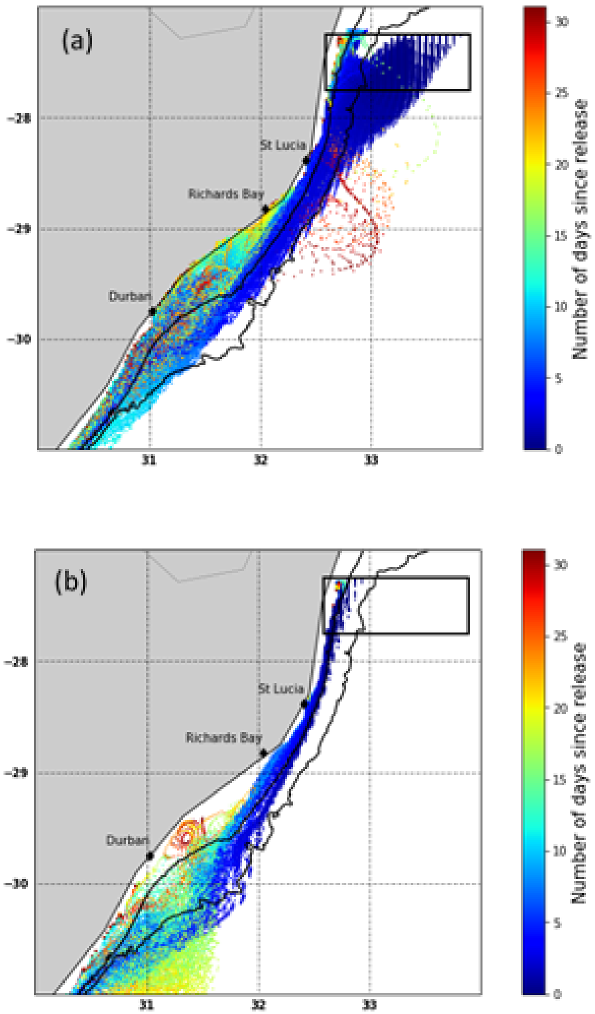


Figure 1: Virtual particles that move inshore of the 200m isobath.

a), the virtual particles are released in a stable Agulhas Current

b) the particles are released in a meandering current. The trajectories are colour coded by the time in days that the particles spend in the water after being released. The particles are blue on the day on which they were released and on the last day of the month, the particles are red. The black box is the box in which the investigated virtual particles were released.

Seasonal variation of surface hydrographic conditions around the Prince Edward Islands

T. Toolsee, T. Lamont, I. Ansorge

The Prince Edward Islands (PEIs), situated in the Southern Ocean, are known through previous studies to be a key location for the identification and understanding of disturbances associated with climate change. The understanding of the seasonal cycle in the oceanographic conditions around the PEIs is critical in developing a comprehensive overview of the interaction between the oceanography and the biology at the islands.

The current study characterised the seasonal cycle of surface hydrographic conditions and examined whether there were differences in those conditions upstream and downstream of the PEIs. Different satellite products were used to calculate monthly climatologies, from 1993 to 2018, of Absolute Dynamic Topography (ADT), Geostrophic Velocity and Sea Surface Temperature (SST) from which the seasonal cycle associated with each variable was examined. Hovmöller diagrams of those monthly climatologies were then plotted to investigate the differences between the upstream and downstream regions of the PEIs.

No clear seasonal pattern, with the same meridional gradient of lower values (< -0.2 m) south and higher values (>-0.1 m) north of the study area were observed in the ADT throughout the year around the PEIs. The seasonal pattern associated with the geostrophic current showed the highest speed in the resultant (0.3 m s-1) and zonal flow (0.2 m s-1) during winter which appeared to be closely related to the seasonal cycle of the westerly winds blowing at the latitudes of the PEIs (Fig 1). SST values were highest in summer (8°C) and lowest in winter (2°C) (Fig 2). This seasonal cycle of SST showed high coherence to the intensity of solar radiation incident on the surface of the ocean in the vicinity of the PEIs.

The southern branch of the sub-Antarctic Front showed a deflection slightly south of the PEIs during winter and was positioned north of the islands during the rest of the year while the northern branch of the Antarctic Polar Front showed no variation in its position within our study area (Fig 1).

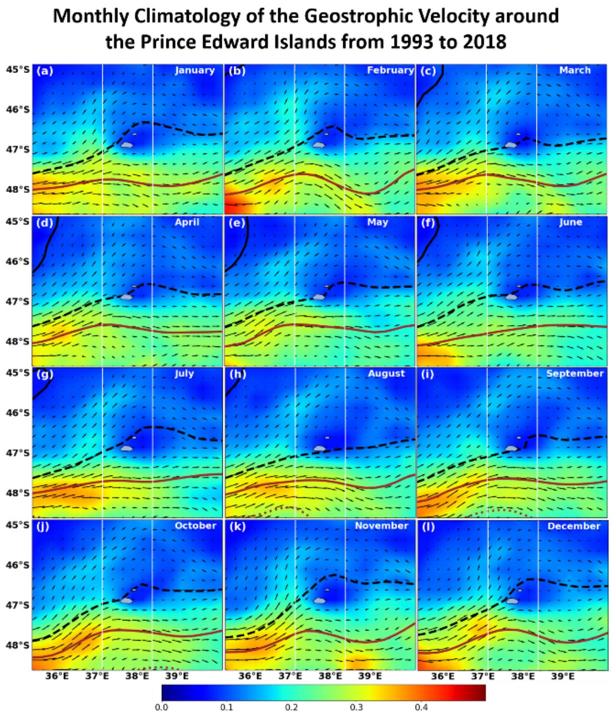


Fig 1: The monthly climatology of the mean of Geostrophic Velocity (m s-1) around the PEIs from January to December (a-l). The black solid line represents the position of the Middle sub-Antarctic Front (M-SAF), the dashed black line represents the position of the Southern sub-Antarctic Front (S-SAF), the brown solid line represents the position of the Northern Antarctic Polar Front (N-APF), and the dotted brown line represent the position of the Middle Antarctic Polar Front (M-APF). The two solid white lines represent the longitude upstream (37.125°E) and downstream (38.375°E) of the PEIs.

The region of high variability associated with the interaction of the Antarctic Circumpolar Current with the Andrew Bain Fracture Zone in the south-west region of the PEIs mentioned by several previous studies was also perceived over a long time-scale using the standard deviation of the monthly climatological means (> ± 0.12 m in ADT, > ± 0.10 m s-1 in geostrophic velocity and > ± 0.65 °C in SST) in the current study.

Due to the close interaction between the oceanography and the biology at the PEIs, the results of the current study can be used by the scientific community and governmental departments to better implement conservation regulations regarding the marine protected area in the region.

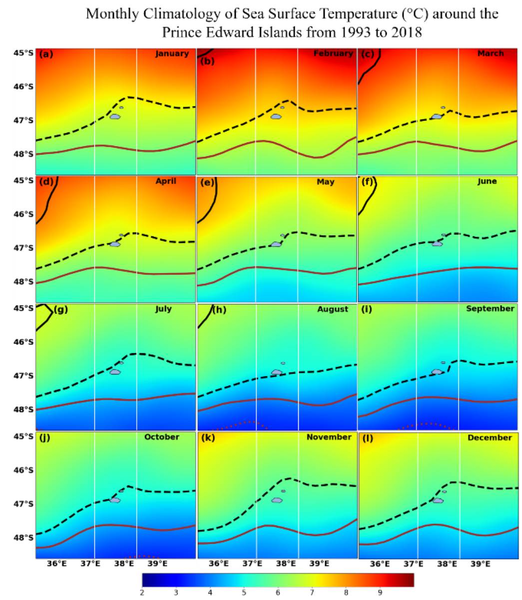


Figure 2: The monthly climatology of the mean of Sea Surface Temperature (°C) around the PEIs from January to December (a-l). The black solid line represents the position of the Middle sub-Antarctic Front (M-SAF), the dashed black line represents the position of the Southern sub-Antarctic Front (S-SAF). The brown solid line represents the position of the Northern Antarctic Polar Front (N-APF). The dotted brown line represents the position of the Middle Antarctic Polar Front (M-APF). The two solid white lines represent the longitude upstream (37.125°E) and downstream (38.375°E) of the PEIs.

Decadal variability of the Benguela Upwelling System using MICOM model

F.S. Tomety, Y.C. He, F. Counillon, M.L. Bachelery, A. Samuelsen, M. Rouault

The dynamics of the Benguela Upwelling System is maintained by the coastal trade winds controlled by the South Atlantic high-pressure system. In a context of climate change, the amplitude of the upwelling is expected to intensify due to the intensification of equatorward coastal wind leading to cooler coastal SST.

Here, we investigate the decadal variability and trends of the SST in the Angola Benguela Upwelling System using observations, model and reanalysis datasets. We investigate the decadal variability using a 100 year-long (1900-2009) simulation of the global ocean-ice component of the Norwegian Earth System Model (NorESM).

With 1° X 1° resolution, the model is forced by an adjusted version of the twentieth Century Reanalysis version 2 dataset (20CRv2 dataset) and the second version of atmospheric forcing dataset for the Coordinated Ocean Ice Reference Experiment Phase-II (CORE-II).

The results suggest a strong decadal signal of periods of 10 to 20 years in the Benguela Upwelling System, in agreement with the decadal variability of the coastal trade wind (Figure 1).

Data is average between 30°S and 34°S and 4° off the coast. The correlation is -0.71 and p-value 0.0014. Most of the variability is observed in austral summer, so we investigate the link between SST in SB with the world ocean in summer (Figure 2). There is a statistically significant negative correlation between the North Atlantic and SB. There is also correlation about 0.4 between the ENSO region and SB. Finally, we highlight a statistical good correlation between Atlantic Multidecadal Variability (AMV) with meridional wind stress in the Benguela Upwelling System.

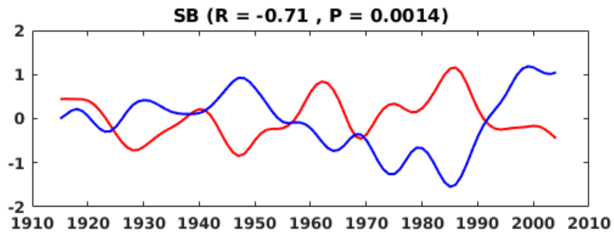


Fig 1: relation between the 11-year running mean of annual mean SST (red line) and meridional wind stress in the South of Benguela region.

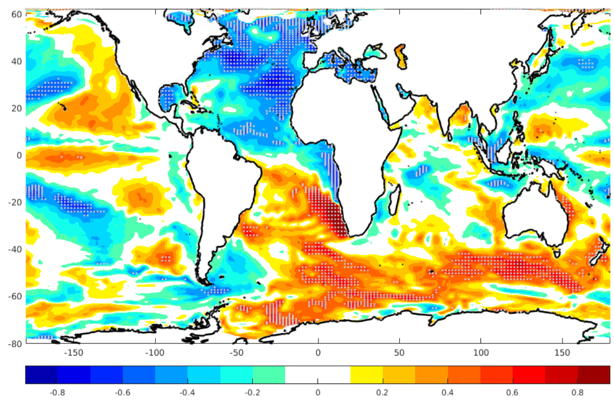


Fig 2: Correlation at low frequency between SST in South Benguela and world ocean. The grey dote denote where the correlation is statistically significant at 95%.

Numerical modelling of wave-current interaction in the Agulhas Current towards better sea-state information

B. Gweba, M. Krug, P. Penven, F. Collard

Ocean waves which are generally referred to as wind-generated waves are regarded as an important factor of the sea state. They have an impact on a wide range of activities such as shipping, fisheries and offshore operations. Numerical modelling provides a better way of understanding the variability of ocean surface properties. These include surface winds, waves, currents and other essential variables. Ocean currents such as Gulfstream, Kuroshio and the great Agulhas Current system, which flows along the South African eastern shores, have a direct influence on the wavefield propagation. The south-westerly swells which approach the south-west Indian Ocean in a direction opposite to the Agulhas Current, alter the wavefield and result in wave steepness and crossing seas which can lead to extreme wave conditions (e.g. rogue waves). Few wave models account the influence of the ocean's currents on the wavefield. To date, no operational wave model that takes currents into account. This limitation of existing wave models undermines the quality of wave predictions along the South Africa coasts. Thus, in this study, the aim is to investigate the effect of the Agulhas Current and the Agulhas Return Current in the characteristics of the wavefield. Numerical wave model Wave-Watch III (WWIII) was used to quantify these effects were cases with and without surface currents where considered.

Figure 1 shows the spatial variability of the significant wave height with and without surface currents. The influence of currents is quite eminent, especially along the Agulhas Current, the Agulhas Return Current and retroflection. To see the net effect of the current field on the wave height spatial variability, the map of the height difference in both large and small-scale features is presented in Figure 2. There is a reduction in wave height between East London and Durban stations. This is due to the wave refraction induced by bottom topography on that region.

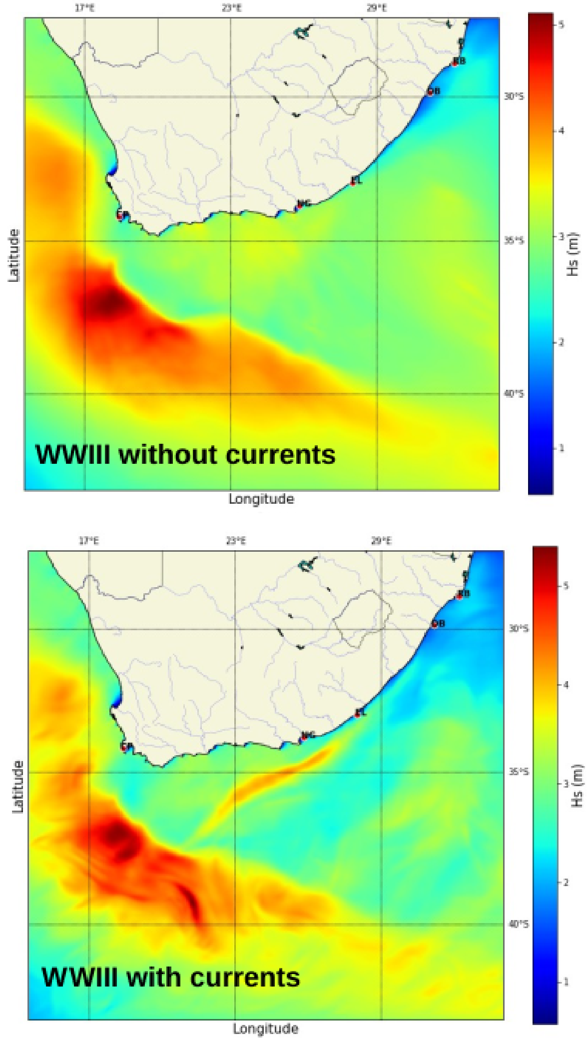


Fig 1: The spatial distribution of the significant wave height with and without surface urrents along the South African coast for 2017 - 01 – 24 at 18:00 UTC. There is a reduction in ave height between East London and Durban stations. This is due to the wave refraction nduced by bottom topography on that region.

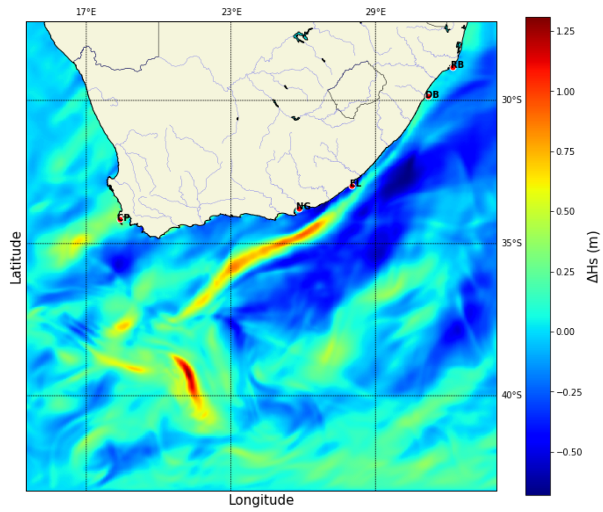


Fig 2: The spatial distribution of the significant wave height differences along the South African coast for 2017 - 01 – 24 at 18:00 UTC.

Nansen-Tutu TRIATLAS summer school on Ocean, Climate and Marine Ecosystem participants - University of Cape Town, Jan 2020

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