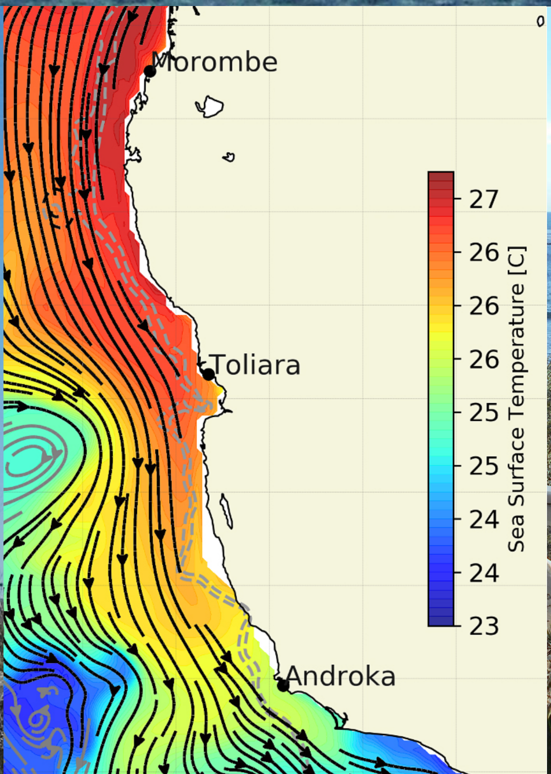
ANNUAL REPORT

2018

NANSEN-TUTU CENTRE FOR MARINE ENVIRONMENTAL RESEARCH AFFILIATED TO THE DEPARTMENT OF OCEANOGRAPHY, UNIVERSITY OF CAPE TOWN



2018 – 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:
• Capacity building and education with a focus on African students.
• Ocean modelling 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.

ACKNOWLEDGEMENTS

The Nansen-Tutu Centre's activities are enabled through contributions from its signatory partners and through project funding. In 2018, the Center received direct funding from the Nansen Environmental and Remote Sensing Center, University of Bergen and the Institute for Marine Research. In addition, project funding and bursaries was obtained from South Africa, Norway and France. Moreover, in kind contributions were received from all partners of the Joint Venture.

ORGANISATION

The Nansen-Tutu Centre (NTC) is a University of Cape Town accredited 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, France and the United States. In 2018, the signatory partners from South Africa included the Marine Research Institute (Ma-Re)/Department of Oceanography, University of Cape Town; the Alliance for Collaboration on Climate and Earth System Studies (ACCESS), National Research Foundation; the Council for Scientific and Industrial Research (CSIR); the South African Environmental Observation Network (SAEON), the Department of Environmental Affairs (DEA), 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 the Princeton University.

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 Honours, MSc, PhD students and Post-doctoral research fellows. During 2018, the Nansen-Tutu Centre comprised 27 persons, including two Honours students, five MSc students, eight PhD students, three Postdoctoral researcher fellows, two full time, eight associate researchers and one administrator.

SCIENTIFIC PRODUCTION

A total of 20 publications emanated from the Centre in 2018, which included 14 papers published in peer-reviewed journals and five articles in peer-reviewed conference proceedings. In addition, five papers have been submitted to peer-reviewed journals.

STUDENT SUPPORT AND SUPERVISION

In 2018, the Nansen-Tutu Centre supported the students and postdoctoral fellows listed below. They either received a full bursary, top-up funding towards their bursaries or travel support for research exchange visits and conference attendance.

1. **Marie-Lou Bachelery** (co-funded: NTC and NRF SARChI) – Postdoctoral research fellow, France. Supervisors: **Mathieu Rouault** and **Serena Illig**.
2. **Juliano Dani Ramanantsoa** (NTC and NRF SARChI) – PhD then Postdoctoral research fellow, Madagascar. Supervisors: **Marjolaine Krug**, **Mathieu Rouault** and **Pierrick Penven**.
3. **Rodrigue Anicet Imbol Koungue** (NTC, ACCESS and NRF SARChI) – PhD, Cameroon. Supervisors: **Mathieu Rouault**, **Serena Illig** and **Marek Ostrowski**.
4. **Neil Malan** (NTC and SAEON) – Postdoctoral research fellow, South Africa. Supervisors: **Chris Reason**, **Björn Backeberg**, **Juliet Hermes** and **Annette Samuelsen**.
5. **Bernardino Nhantumbo** (NTC and ACCESS) – PhD, Mozambique. Supervisors: **Björn Backeberg** and **Jan-Even Nilsen**.
6. **Arielle Stella Nkwinkwa Njouado** (NTC, ACCESS and NRF SARChI) – PhD, Cameroon. Supervisors: **Mathieu Rouault** and **Noel Keenlyside**.
7. **Georges-Noel Tiersmondo Longandjo** (PREFACE and ACCESS) – PhD then Postdoctoral research fellow, Democratic Republic of Congo. Supervisor: **Mathieu Rouault**.
8. **Serge Tomety** (NTC and NRF SARChI) – PhD, Togo. Supervisors: **Mathieu Rouault** and **Thomas Toniazzo**.
9. **Hermann Luyt** (NTC and NRF) – MSc, South Africa. Supervisors: **Björn Backeberg** and **Jennifer Veitch**.
10. **Bellinda Monyella** (project co-funded: WRC and ACCESS) – MSc, South Africa. Supervisor: **Mathieu Rouault.**
11. **Tumelo Maja** (NTC and NRF SARChI) – MSc Hons, South Africa. Validation of GlobCurrent data in the

Main cover image: The picturesque village of Lavanono in Madagascar, at the heart of the upwelling cell unravelled byJuliano Dani Ramanantsoa for his PhD thesis. Juliano is also shown with his catch from a day at sea with local fisherman. While investigating the origins of water feeding the upwelling, Juliano revealed a current never yet documented, which he named the South Madagascar Counter Current (shown in the bottom middle panel). Also shown is Gigi (left), our local contact and data collector installing our weather station at Lavanono. (Photos by Mathieu Rouault).

Agulhas Current. Supervisors: **Marjolaine Krug** and **Johnny A. Johannessen**.
12. **Bellinda Nhesvure** (NTC and NRF SARChI) – MSc, Zimbabwe, Forecasting Seas Surface Temperature in the Western Cape. Supervisor: **Mathieu Rouault**.
13. **Sian Seymour** (NTC and NRF SARChI), MSc, South Africa, SAR high resolution wind speed in False Bay. Supervisors: **Marjolaine Krug** and **Marie Smith**.
14. **Michael Hart-Davis** (NTC and SAEON), MSc, South Africa, Particle trajectory modelling in the South African shelf sea region. Supervisors: **Björn Backeberg**, **Johnny A. Johannessen** and **Mostafa Bakhoday-Paskyabi**.
15. **Jason O'Connor** (NTC and NRF SARChI) BSc Honours, South Africa, Impact of Agulhas Current on storm development. Supervisor: **Mathieu Rouault**.
16. **Lisa Shangeta** (NTC and NRF SARChI), BSc Honours, Namibia, Modelling Benguela Current with different wind speed. Supervisors: Marielou Bachelery, **Serena Illig** and **Jennifer Veitch**.

GRADUATION

Congratulations to Juliano Dani Ramanantsoa (PhD), Rodrigue Anicet Imbol Koungue (PhD), Georges-Noel Tiersmondo Longandjo (PhD), Neil Malan (PhD), Hermann Luyt (MSc), Belinda Monyella (MSc), Jason O'Connor (BSc Hons), Lisa Shangeta (BSc Hons), who completed their studies in 2018.

CAPACITY BUILDING

Mathieu Rouault and Arielle Stela Nkwinkwa Njouado gave 10 hours of lectures in air-sea interaction for the Honours class of the Oceanography Department at University of Cape Town in April 2018. Johnny A. Johannessen together with Bjorn Backeberg and Marjolaine Krug convened and gave lectures in Operational Oceanography for the Applied Ocean Sciences taught Masters course at University of Cape Town in May 2018. Jenny Veitch lectured the mid-latitude ocean circulation module to the third-year ocean dynamics students at UCT in April 2018.

EXCHANGE WITH NORWAY

During 2018, the Centre facilitated 10 international research exchange visits to Bergen, Norway, including two MSc students, Tumelo Maja and Michael Hart-Davis, six PhD students, Bernardino Nhantumbo, Juliano Dani, Serge Tomety, Bellinda Monyella, Rodrigue Anicet Imbol Koungue, one postdoctoral fellow, Marielou Bachelery, and two senior scientists; Björn Backeberg and Issufo Halo. The students worked on their thesis dissertations under the supervision of Norwegian scientists and three attended the Bergen Summer School. In addition, Johnny A. Johannessen and Marek Ostrowski visited Cape Town.

CONFERENCE WORKSHOP AND SUMMER SCHOOL ATTENDANCE

Serge Tomety, Bellinda Monyella, Rodrigue Anicet Imbol Koungue attended the Bergen Summer School. Arielle Stela Nkwinkwa Njouado and Rodrigue Anicet Imbol Koungue went to Ocean Sciences 2018 in USA to present their work. Rodrigue Anicet Imbol Koungue, Marielou Bachelery and Mathieu Rouault participated and gave presentations at the final PREFACE FP7 project conference on "Prediction of the Tropical Atlantic" in Lanzarote, Canaries Islands. Marjolaine Krug attended the 21st Session of the GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC-21) in Argentina as part of her duties on the OOPC panel and the 2nd IndOOS Review Workshop in Indonesia. Marjolaine Krug was one of the review board members. She also gave a presentation at the SEASAR 2018 workshop held at ESA-ESRIN in Italy). Serge Tomety and Anicet Imbol Koungue presented at the Symposium of the Effects of Climate Change on World's Oceans in USA. Bernardino Nhantumbo attended the Sea Level Futures Conference in the UK and participated to the 6th European Climate Research Alliance Sea Level Change and Coastal Impacts also in the UK. George Noel Tiersmondo Longandjo attended the AGU Chapman Conference on Hydrological Research on Congo Basin, in the USA and the 8th Gewex Conference in Canada. He was also invited at Florida State University from September to November 2018. Mathieu Rouault was the keynote speaker the 34th annual conference of the South African Society for Atmospheric Science in Ballito, KwaZulu-Natal while Arielle Stela Nkwinkwa Njouado got the prize of the best student oral presentation. Marie-Lou Bachèlery, Folly Serge Tomety, George Noel Tiersmondo Longandjo and Bellinda Monyella presentations were well received. Mathieu Rouault participated to the 21st PIRATA CLIVAR meeting and to the Tropical Atlantic CLIVAR Review panel in France.

NATIONAL AND INTERNATIONAL ACTIVITIES

The Centre actively participated in national research and development activities, including projects funded through the National Research Foundation, the Department of Science and Technology, 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. The NTC Centre contributed financially to the GINA 2018 gliders deployments and Marjolaine Krug is the PI. It is 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 Protectedive Areas. Two workshops were organized by the Nansen Tutu Center on Benguela upwelling and on Climate variability in Cape Town. The Nansen-Tutu Centre participated actively in the EAF-Nansen Programme workshop in Cape Town. Mathieu Rouault and Jenny Veitch were appointed 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

CLIVAR focus group on Eastern Boundary Upwelling system and the committee for the extension of PIRATA in the Tropical Atlantic which funded an Atlas mooring deployed at 8ºE, 6ºS off the Congo River.

HIGHLIGHTS

• The discovery of the Southwest Madagascar Coastal Current (SMACC) (Ramanantsoa et al., 2018) was covered extensively by the media, including EOS highlights.
• The paper by Hart-Davis et al. (2018) published in RSE was from his BTech project, this is the first time a BTech level research project in physical oceanography has been published at CPUT.
• "Atmospheric signature of the Agulhas Current" paper published this year in Geophysical Research Letters by Arielle Stela Nkwinkwa Njouado and co-authors Mathieu Rouault and Shunya Koseki and Noel Keenlyside from University of Bergen was awarded the Stanley Jackson award for best peer reviewed paper.
• Two profiling gliders were deployed off the Natal Bight in September 2018 as part of the Glider in the Agulhas (GINA) project led and coordinated by Marjolaine Krug.

FINANCIAL SITUATION

A total of 750 000 ZAR (500 000 NOK) seed funding for the Centre was made available from Norwegian partners in 2018: 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 to this, almost 3 000 000 ZAR was raised through project funding in 2018. 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 CSIR's Strategic Research Programme.

PROSPECTS FOR 2019

• 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.
• Participate in summer schools, international conferences and working groups.
• Raise funding for student exchange visits and attendance at international summer schools and conferences.
• Preparation of the 2020 10 anniversary NTC symposium.
• Preparation for the NTC phase 4 agreements.

MEMBERS OF THE BOARD

Approved by The Board, Cape Town, November 2018.
1. Prof. J. A. Johannessen, NERSC (Co-chair)
2. A/Prof. I. Ansorge, UCT (Co-chair)
3. A/Prof. M. Vichi, Ma-Re, UCT
4. Mr. A. Naidoo / Mr. A. Johnson, DEA
5. Mr. J. Stander / Mr. M. Majodina, SAWS
6. Dr. N. Sweijd, ACCESS
7. Dr. S. Bernard, CSIR
8. Dr. J. Hermes, SAEON
9. Dr. Conrad Sparks, CPUT
10. Prof. Andrew Leitch, CMR, NMU
11. Prof. N.G. Kvamstø, GFI, UiB
12. Prof. G. Philander, Princeton University
13. Prof. Å. Bjordal, IMR
14. Dr. F. Marsac, for IRD and UBO

PUBLICATIONS IN 2018

Peer-reviewed papers:

Hart-Davis, M.G., Backeberg, B.C., Halo, I., van Sebille, E. and Johannessen, J.A., 20108 Assessing the accuracy of satellite derived ocean currents by comparing observed and virtual buoys in the Greater Agulhas Region. *Remote Sensing of Environment. 216:735-746.*

Illig S., Cadier E., Bachèlery M.L., Kersalé M. (2018). Subseasonal Coastal Trapped Wave Propagations in the Southeastern Pacific and Atlantic Oceans: A New Approach to Estimate Wave Amplitude. *Journal of Geophysical Research: Oceans, 123(6):3915-3941.*

Illig S., Bachèlery M.L., Cadier E. (2018). Subseasonal Coastal Trapped Wave Propagations in the Southeastern Pacific and Atlantic Oceans: 2. Wave Characteristics and Connection with Equatorial Variability. *Journal of Geophysical Research: Oceans, 123(6):3942-3961. DOI: 10.1002/2017JC013540.*

Koseki, S., Pohl, B., Bhatt, B.C., Keenlyside, N. and Nkwinkwa Njouado, A.S., 2018. Insights into the summer diurnal cycle over eastern South Africa. *Monthly Weather Review, 146:4339-4356. DOI:10.1175/MWR-D-18-0184.1.*

Krug M., Schilperoort D., Collard F., Hansen M. W., and Rouault M. Signature of the Agulhas Current in ASAR derived wind fields. *Remote Sensing of the Environment, 217:340-51.*

Malan N., Backeberg B., Biastoch A., Durgadoo J.V., Samuelsen A., Reason C.J.C. and Hermes J. Agulhas Current meanders facilitate shelf-slope exchange on the Eastern Agulhas Bank. *Journal of Geophysical Research: Ocean, 123(7):4762-4778.*

Nkwinkwa Njouado, A.S., Koseki, S., Keenlyside, N. and Rouault, M. Atmospheric signature of the Agulhas Current. *Geophysical Research Letters. 45(10): 5185-5193.*

Pohl B., Dieppois B., Crétat J., Lawler D., Rouault M. From synoptic to interdecadal variability in southern African rainfall: towards a unified view across timescales. *Journal of Climate, 31, 5845-5872.*

Ramanantsoa, J.D., Penven, P., Krug, M., Gula, J. and Rouault, M. Uncovering a New Current: The Southwest Madagascar Coastal Current. *Geophysical Research Letters, 45(4), pp.1930-1938.*

Ramanantsoa, J.D., Krug, M., Penven, P., Rouault, M. and Gula, J. Coastal upwelling south of Madagascar: temporal and spatial variability. *Journal of Marine Systems, 178, pp.29-37.*

Rouault, M., Illig, S., Lübbecke, J. and Koungue, R.A.I. Origin, development and demise of the 2010–2011 Benguela Niño. *Journal of Marine Systems. 188:39–48. DOI: 10.1016/j.jmarsys.2017.07.007?*

Singh, S.P., Groeneveld, J.C., Hart-Davis, M.G., Backeberg, B.C. and Willows-Munro, S. 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 potential. *Ecology and Evolution. 8:12221-12237.*

Shalin, S., Samuelsen, A., Korosov, A., Menon, N., Backeberg, B. C., and Pettersson, L. H.: Delineation of marine ecosystem zones in the northern Arabian Sea during winter. *Biogeosciences, 15, 1395-1414.*

de Vos M, Backeberg B, Counillon F. Using an eddy-tracking algorithm to understand the impact of assimilating altimetry data on the eddy characteristics of the Agulhas system. *Ocean Dynamics. Ocean Dyn., 68(9):1071-1091.*

Peer reviewed Conference Proceedings:

Bachèlery, M-L., Illig, S., Rouault, M. How low-frequency Equatorial Kelvin Wave activity and local coastal winds modulate the south-eastern interannual Atlantic variability? *Proceedings of 34th Annual conference of the South African Society for Atmospheric Science, Durban, South-Africa, 20- 21 September 2018.*

Longandjo, G-N. T. and M. Rouault. Central Africa Low: Identification, seasonal evolution, variability and its influence on regional climate. *Proceedings of 34th Annual conference of the South African Society for Atmospheric Science, Durban, South Africa, 20-21 September 2018.*

Hart-Davis, M. G., B. C. Backeberg and M. Bakhoday-Paskyabi: An assessment of the importance of combining wind, ocean currents and stochastic motions in a particle trajectory model for search and rescue applications. *Proceedings of 34th Annual conference of the South African Society for Atmospheric Science, Durban, South Africa, 20-21 September 2018.*

Tomety F. S., M. Rouault, S. Illig. Coastal variability and change in the Benguela Upwelling System: Decadal trend Analysis, *Proceedings of 34th Annual conference of the South African Society for Atmospheric Science, Durban, South Africa, 20-21 September 2018.*

Nkwinkwa Njouado A. S., Koseki S., Keenlyside N., and Rouault M. Impact of the Agulhas Current on coastal South African precipitation, *Proceedings of 34th Annual conference of the South African Society for Atmospheric Science, Durban, South Africa, 20-21 September 2018.*

Other publications:

Krug, M., S. Swart, and J. Hermes Ocean gliders ride the research wave in the Agulhas Current Eos, 99.

STAFF IN 2018

Scientists

Dr. Björn Backeberg, Norwegian co-director, Ocean modeling and prediction.
Prof. Mathieu Rouault, South African co-director, Ocean-atmosphere, climate and regional impact.
Dr. Issufo Halo, Associate researcher, Ocean modelling and prediction.
Prof. Johnny A. Johannessen, Associate researcher, Satellite remote sensing of regional shelf seas.
Prof. Noel Keenlyside, Associate researcher, Ocean-atmosphere, climate and regional impact
Dr. Marjolaine Krug, Associate researcher, Satellite remote sensing of regional shelf seas.
Dr. Jan-Even Nilsen, Associate researcher, Regional sea level variability and global change.
Dr. Marek Ostrowski, Associate researcher, Ocean-atmosphere, climate and regional impact.
Dr. Annette Samuelsen, Associate researcher, Ocean modelling and prediction.
Dr. Jenny Veitch, Associate researcher, Ocean modelling and prediction.
Dr. Mostafa Bakhoday-Paskyabi, Ocean modelling and prediction.

Administrative and technical staff

Sharon Bosma, associate staff, finances.

USEFUL LINKS

Nansen-Tutu Centre: http://www.nansen-tutu.org
Marine Research Institute: http://ma-re.uct.ac.za/
Department of Oceanography: http://www.sea.uct.ac.za/

SCIENCE REPORT 2018

IMPACT OF THE AGULHAS CURRENT ON SOUTHERN AFRICAN RAINFALL

A.S. Nkwinkwa Njouado, M. Rouault, N. Keenlyside, S. Koseki.

Results from the Weather Research and Forecasting (WRF) model show that the Agulhas Current anchors a band of precipitation along the east coast of South Africa on the annual scale. This is due to the pressure adjustment mechanism, in which the sea surface temperature (SST) of the Agulhas modifies the marine atmospheric boundary layer, and the resultant pressure anomalies induce surface wind convergence over warm SST and wind divergence over cool SST. This mechanism explains the precipitation along the eastern coast of South Africa in austral summer (December to February), autumn (March to May), winter (June to August) and spring (September to November). South African precipitation is maximum in summer, and ranges between 0 to 10 mm.d-1 for WRF control experiment. Figure 1a shows summer precipitation for WRF control (Fig. 1a) and the precipitation anomalies (difference between the control and the smoothed SST experiments)

(Fig. 1b). Maximum precipitation is southeast of the country around the Drakensberg region, between 25-32°S and 27-31°E. Meanwhile, the southwest of the country is arid. Over the ocean, precipitation follows the convergence zone. Maximum oceanic rainfall difference occurs off Durban (30-32°S, 31-33°E) and above the core of the Agulhas Current, where the Current is adjacent to the coast. This result is consistent with the SST and the latent heat flux difference between control and smoothed in the Agulhas Current. The rain band anchored by the Agulhas Current is mostly due to cumulus convective rainfall (not shown). Moreover, we investigate the relationship between the geopotential heights and the moisture flux. We find that the control experiment creates a 2°C warm SST anomaly, leading to a low-pressure system anomaly. This weakens the high-pressure system and creates a cyclonic motion anomaly, transporting moisture anomalies from the ocean to the interior. The moisture flux penetrates the land through the South and eastern coast of South Africa, especially where the Agulhas Current hugs the coast. The vertically integrated moisture flux convergence (VIMFC) anomalies and the precipitation minus evaporation (P-E) anomalies are balanced, and this relationship shows the VIMFC anomalies are due to wind anomalies, leading to more precipitation anomalies in southern Africa. This result indicates that the Agulhas Current also influences southern Africa precipitation inland. More precipitation above the continent will result in more geopotential anomaly up to 500 hPa leading to more cyclonic moisture flux anomalies.

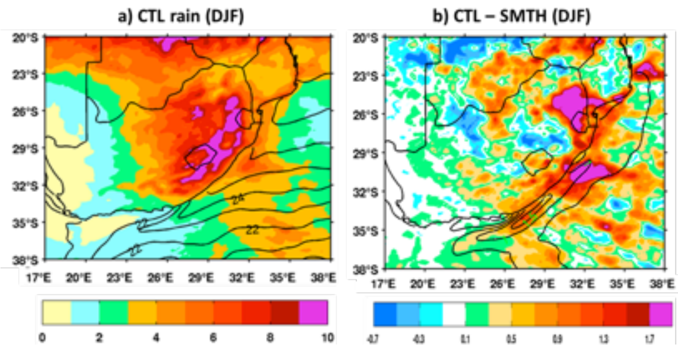


Figure 1: Summer (DJF) rainfall (mm.d-1) of WRF model: a) Control experiment with control SST overlaid, b) difference between control and smoothed SST experiments, with the SST difference overlaid.

ATMOSPHERIC DRIVERS OF TIDE GAUGE SEA LEVEL VARIABILITY ALONG THE EAST AND SOUTH COAST OF SOUTH AFRICA

B. Nhantumbo, J.E. Nilsen and B. Backeberg.

The physical mechanism by which sea level pressure (SLP) gradient anomalies and the corresponding wind variations influence monthly mean coastal sea level variability of southern Africa, although mentioned in previous studies, has neither been shown nor explained to our knowledge, for several reasons, including the limitations of data. In fact, it is even emphasized that given for instance, the poor data quality, conclusions were based solely on visual correlations and the consistency of the results with the studies conducted out elsewhere around the globe. As a result, all available monthly mean tide gauge records from the mid-1900s (depending on location) until December 2015, at seven individual tide gauge locations on the south and east coast of South Africa were used to study the timescales of variability and their relationships to atmospheric drivers. The atmospheric data were the monthly mean gridded reanalysis SLP and 10 m winds from the National Centre for Environmental Prediction/National Centre for Atmospheric Research (NCEP/NCAR). Additionally, the same monthly gridded SLP data sets were extracted at the nearest tide gauge location grid point to correct for the inverse barometer (IB) effect of the sea level records. The sea level records were optimized by filling in the gaps as best as possible, and then the oscillatory timescales of variability separated using the Empirical Mode Decomposition (EMD) method. However, it was found challenging to find which driver is embedded in the data when interpreting each mode. Thus, the oscillatory modes identified by the EMD were summed to obtain a physically more meaningful timescale.

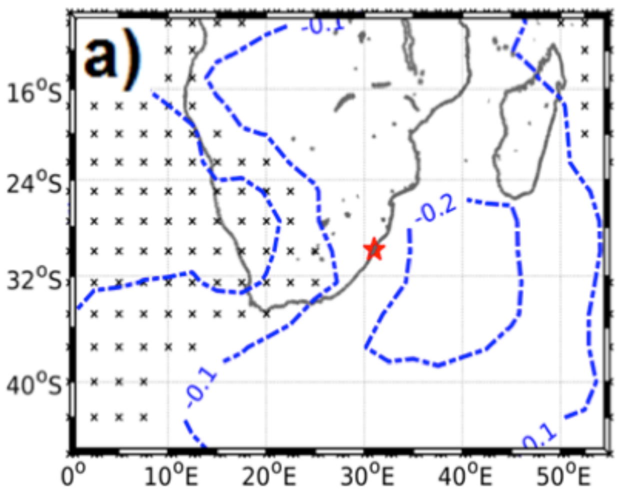


Figure 1: Correlation, at the sub-annual timescale, between monthly mean SL records at Durban and regional gridded monthly mean SLP Red star indicates the tide gauge location. Black crosses indicate area statistically non-significant at 95% confidence level.

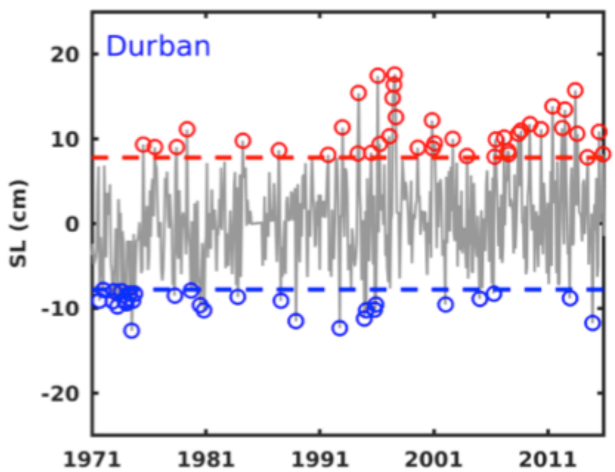


Figure 2: Monthly mean sea level, with high events (>1.5 standard deviations, red circles) and low events (<1.5 standard deviations, blue circles) at Durban.

Therefore, the sub-annual timescale was the ensemble of the modes with a periodicity lower than approximately 18 months. Then, the time series at each studied tide gauge site were correlated with the data sets at each grid point of the regional atmospheric data and the statistical significance of the resultant correlation was estimated through a two-sided t-test (Figure 1). In summary, the results indicated that SLP gradient anomalies cause enhanced longshore winds leading to an increased or decreased coastal sea level through Ekman transport dynamics, at the sub-annual timescale (Figure 2), suggesting that sea level responds to the mesoscale and synoptic weather systems in the annual cycle.

AN ASSESSMENT OF THE IMPORTANCE OF COMBINING WIND, OCEAN CURRENTS AND STOCHASTIC MOTIONS IN A PARTICLE TRAJECTORY MODEL FOR SEARCH AND RESCUE APPLICATIONS

M.G. Hart-Davis, B. C. Backeberg and M. Bakhoday-Paskyab.

Lagrangian analyses of oceanic fluid by virtual particles, advected with the background flow information of ocean models, have been increasingly used to study physical and biogeochemical oceanographic processes. In Hart-Davis et al (2018) particle trajectory modelling was used in a search and rescue application using a satellite-derived ocean product. This case study identified the shortcomings of using only passive particles and surface current velocities in predicting the path of a capsized vessel. On the 18th of January 2016, the upturned hull of a catamaran was spotted approximately 113 Nautical Miles off Cape Recife, near Port Elizabeth (South Africa), which was first reported missing a year earlier, in January of 2015. Five days after being spotted off Cape Recife, on the 22nd of January 2016, the National Sea Rescue Institute (NSRI) found the capsized catamaran south of Cape Agulhas. The approximate locations, the last known position (25° 41' 59.46"E and 34° 24' 11.08"S) and the recovery site (20° 07' 32.58"E and 35° 01' 31.94"S), of the capsized vessel provided valuable information that can be used to assess the ability of the particle trajectory model in applications. Here, a Lagrangian numerical model for at sea search and rescue applications is presented. The model incorporates the effects from wind, surface currents, as well as stochastic diffusivity to determine the horizontal trajectory of each virtual particle released. The importance of including each of these two parameters as well as stochastic motions when predicting the path of an object lost at sea were determined through several model simulations. The preliminary results suggest that the drift of an object depends on the variability of the wind field, surface currents and characteristics of sub-grid scale effects of unresolved motions. It is shown that, by incorporating wind and surface current data into the particle trajectory model, the model more accurately predicts the drift of the capsized vessel over a five-day period. Furthermore, by incorporating the impacts of stochastic motion into the model, the model provides a better probabilistic forecast of the outcome of the capsized vessel. It is anticipated that with some refinement (such as using spatially varying horizontal eddy diffusivity and different boundary conditions) and the incorporation of other parameters (e.g. interactions between wind, current, wave and turbulence), that the accuracy of the particle trajectory model will continue to improve and result in the increased use of this model in scientific and operational applications.

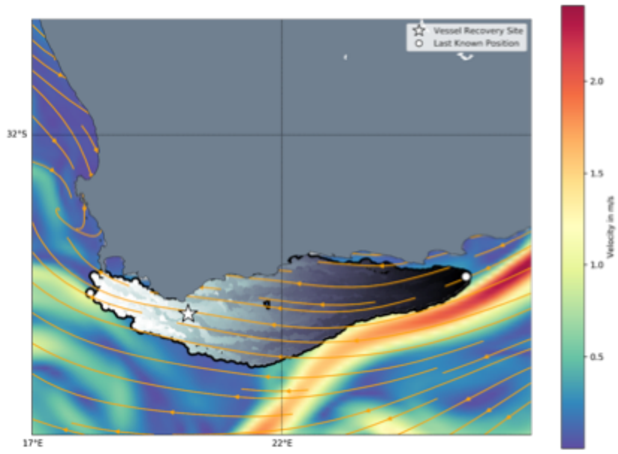


Figure 1: A simulation of 1000 virtual particles deployed at the location where the capsized vessel was last seen (white circle). The white star represents the final location where the capsized vessel was recovered by the NSRI. The colourbar represents the mean 5-day surface current velocities, with the streamlines representing the mean 5-day wind velocities and direction.

HOW LOW-FREQUENCY EQUATORIAL KELVIN WAVE ACTIVITY AND LOCAL COASTAL WINDS MODULATE THE SOUTH-EASTERN INTERANNUAL ATLANTIC VARIABILITY

M-L. Bachèlery, S. Illig and M. Rouault.

Figure 1a shows the modulation of the amplitude of the interannual variability at low-frequency of the coastal temperature and Sea Level Anomalies (SLA) off the Angolan coast. Two main mechanisms have been identified to be responsible for the interannual variability. 1) At a regional scale, wind events trigger significant variations of the upwelling intensity and force poleward propagating Coastal Trapped Wave (CTW). 2) The south-eastern African coastal ocean variability is connected to the equatorial dynamics. Part of the energy of eastward propagating Equatorial Kelvin Waves (EKW) is transmitted poleward and propagate along the South African coasts as CTW. The objective of this study is to describe the low-frequency modulation of the EKW activity in the tropical Atlantic as well as the local coastal winds along the coast of south-western Africa. We based our methodology on the development of a long interannual oceanic simulation using the Regional Ocean Modeling System. Contributions of the first three gravest EKW modes in the Atlantic Oceans are computed following a modal decomposition. Results show a significant modulation of EKW amplitude (Fig. 1b). Low-frequency modulations of the EKW energy are observed over the 1958-2008 period. The interannual EKW activity peaks in 1965, 1982 and 2000, almost in phase with the peaks of energy of coastal interannual temperature and SLA (Fig. 1a). Also, results show an increase in the interannual EKW activity in the early 1990s. This is consistent with the increase of the temperature and the upwelling variability off the coast of Angola and support the possible control of the equatorial forcing on the oceanic south-eastern coastal properties. However, the modulation of the coastal ocean properties might also be linked to changes in the amplitude of the coastal winds. The evaluation of the variance in function of latitude of the interannual alongshore winds shows that the interannual wind activity is much more energetic south of 15°S. Off the Angolan coast, one peak of energy is observed between 1976 and 1988 while the variance over the other period remains low and constant. Further south, in the BUS, the evolution over time of alongshore winds amplitude is similar than in figure 1a, with peaks of variance in 1970, 1985 and 1992 and a slight increase of the variability starting in the early 90s. Finally, the role of the low-frequency modulation of the EKW activity and coastal local winds on the coastal ocean interannual variability in the south-eastern Atlantic sector is investigated. Results emphasizes the contrast between the coastal ocean dynamics north and south of the Angola-Benguela front (~20°S) which are controlled and modulated by different forcing. From the equator to the northern Benguela the interannual variability is mainly driven and modulated by the equatorial Kelvin waves activity, while in the southern Benguela the strong coherence with the alongshore winds suggest a more important contribution of the local forcing. Indeed, along the Angolan coast, statistically significant correlation coefficient between the EKW activity and the coastal dynamic are found for the whole period (Fig. 2a). Interestingly, we observe a slight increase of the coherence with the equatorial variability in mirror with

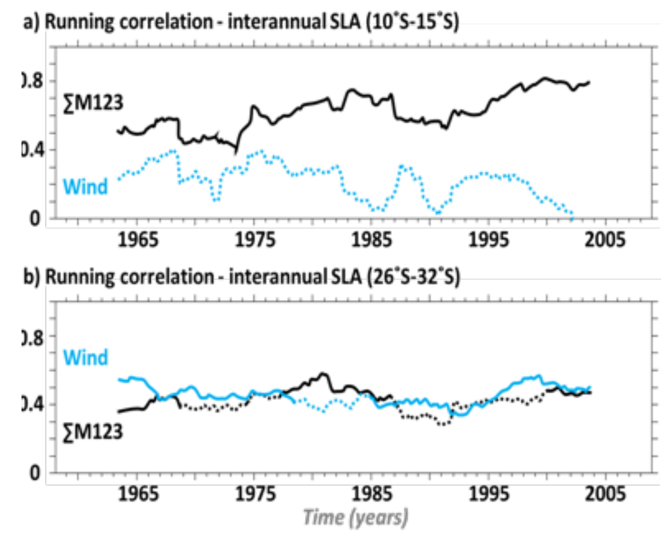


Figure 1: a) 10-year running variance of interannual ROMS SLA (m) and temperature (°C; over the first 150m) averaged off the coast of Angola (between 10°S-15°S / 0.5°-width band). b) 10-year running variance of EKW modes (summed-up contribution of the three first baroclinic modes) amplitude (m) averaged in the Guinea Gulf (within 5°W-5°E/1°S-1°N).

the progressive reduction over time of the correlation with the coastal alongshore wind stress (Fig. 2a). Quasi-similar results are found down to 20°S in the northern BUS. Further south, in the southern BUS, the coherence between the EKW activity and the coastal dynamic decreases. Off the Namibian coast statistically significant correlations appear only during three periods: before 1970, between 1977 and 1986 and after 2000 (Fig 2.b) which corresponds to the periods where the remote equatorial forcing is more energetic. Furthermore, the interannual alongshore wind stress significantly contributes to the coastal interannual SLA during the full period except during the 1979-1985 period (Fig. 2.b).

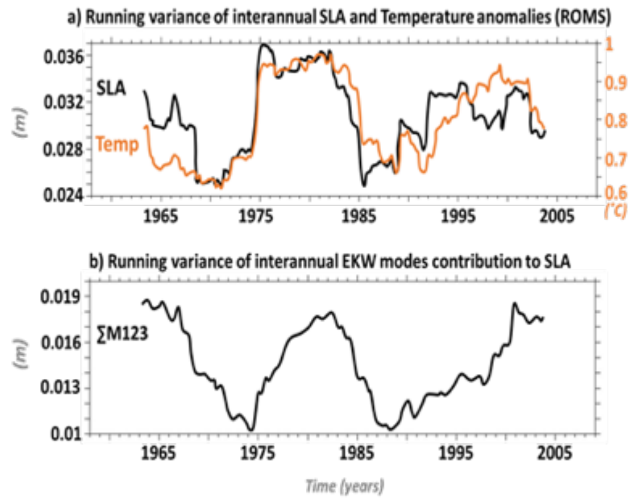


Figure 2: 10-year running correlation between interannual coastal ROMS SLA and EKW mode amplitude (summed-up contribution of the three first baroclinic modes; black line) or ROMS alongshore wind (blue line). EKW have been averaged in the Guinea Gulf (5°W-5°E/1°S-1°N) while SLA and alongshore wind stress have been averaged between 10°S-15°S (Fig. 2a) and 26°S-32°S (Fig. 2b). Dashed lines indicate correlation with a level of significance lower than 95%.

MULTIPLE FORCING MECHANISMS DRIVING THE VARIABILITY OF COASTAL UPWELLING SOUTH OF MADAGASCAR

J.D. Ramanantsoa, M. Krug, M. Rouault, P. Penven, J. Gula.

Number of different data sets, such as, satellite remote sensing, in-situ observations, and a numerical model were used to characterize the structure, variability and drivers of the coastal upwelling at the south of Madagascar. The study provides new insights on the seasonal cycle of the coastal upwelling and the drivers dominating this seasonality. Results reveal the presence of two well defined upwelling cells: Core 1, Core 2 (Figure 1). The cores are characterized by different seasonal variability, different intensities, different upwelled water mass origins, and distinct forcing mechanisms. Core 1 is associated with a dynamical upwelling forced by the detachment of the East Madagascar Current (EMC), which is reinforced by upwelling favorable winds. Core 2 appears to be primarily forced by upwelling favorable winds but is also influenced by a poleward eastern boundary flow coming from the Mozambique Channel. This intrusion of Mozambique Channel warm waters was identified as a coastal surface poleward flow in the south-west of Madagascar: The South-west Madagascar Coastal Current (Figure 1). The SMACC is a relatively shallow (<300 m) and narrow (<100 km wide) warm and salty coastal surface current, which flows along the south western coast of Madagascar toward the south, opposite to the dominant winds. The SMACC exhibits a seasonal variability: more intense in summer and reduced in winter. It is forced by a strong cyclonic wind stress curl associated with the bending of the trade winds along the southern tip of Madagascar. The SMACC directly influences the coastal upwelling regions south of Madagascar. The intrusion of SMACC's warm waters could result in an asynchronicity in seasonality between upwelling surface signature and upwelling favorable winds. The inter-annual variability of the upwelling is also highly associated with the multiple forcing mechanisms influencing the seasonal cycle. Results reveal that Core 1 and Core 2 have a different inter-annual variability. Core 1 inter-annual variability is associated with East Madagascar Current (Figure 1) while Core 2 is influenced by the South-west Madagascar Coastal Current. The inter-annual variability of EMC is significantly linked with the South Equatorial Current bifurcation latitude off Madagascar, while the inter-annual incidence of SMACC is influenced by the inter-annual variation of the cyclonic wind stress curl. The upwelling in Core 1 is elucidated as driven by the bottom Ekman transport, associated with the alongshore bottom stress in vicinity of 24.5°S, which has a strong linear relationship with the inter-annual variation EMC volume transport and the upwelling indices in inter-annual time scale.

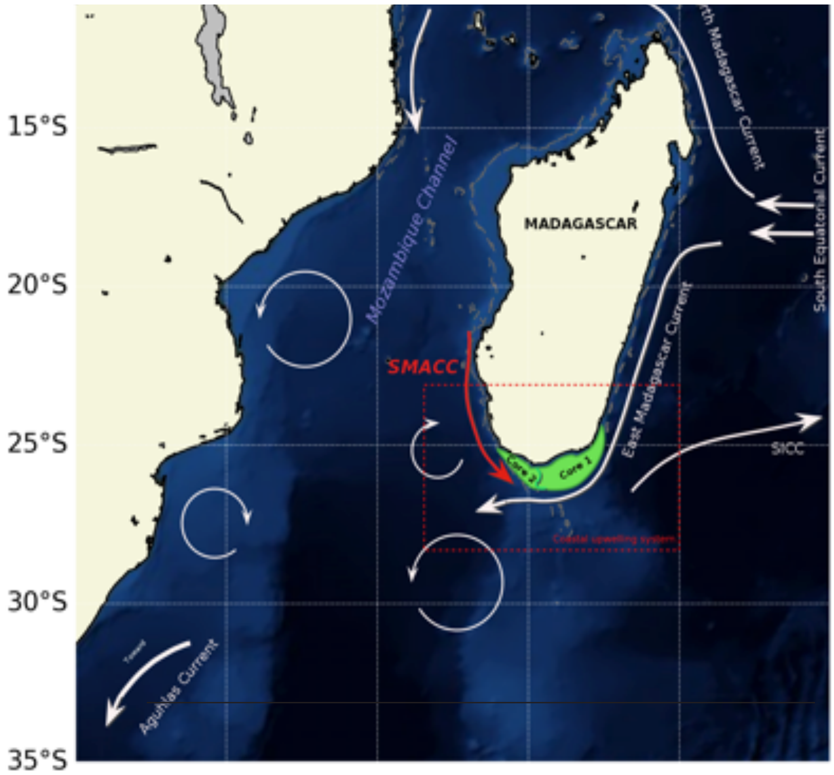


Figure 1: Schematic illustration of the oceanography of the region. Green polygons illustrate Core 1 and Core 2 upwelling cells extent. The red arrow is the SMACC.

MECHANISMS RESPONSIBLE FOR THE ANNUAL CYCLE OF RAINFALL OVER CENTRAL AFRICA

G-N T. Longandjo, M Rouault and Noel Keenlyside.

Using ERA-Interim data and ECHAM5.3 datasets, we investigate the drivers of the annual cycle of rainfall over central Africa. Many studies used moist static to examine the role of both energy and water budgets to understand precipitation over regions of deep convection. The vertical profile of moist static energy is a good indicator of atmospheric instability derived from vertical distribution of moisture and temperature. The moist static stability (MSS) is defined as difference between moist static energy at near surface (1000- hPa) and saturated moist static energy (MSE*) at 700- hPa (Neelin and Held, 1987). The atmosphere is unstable whether the moist static stability is positive. The annual cycle of the zonal-mean of moist static stability, near surface moist static energy and saturated moist static energy at 700-hPa averaged over Central Africa (07°-33°E) is shown in Fig. 4. The seasonal migration of the atmospheric instability over central Africa is like the so-called ITCZ over Central Africa. The atmospheric instability lasts year-round, indicative of unstable atmosphere (positive value of moist static stability) dominating the Central Africa (Fig. 1, top right panel). At near surface, warm and moist air (h > 330 K) – associated with northerly circulation of the Hadley cell at low-levels – is surrounded by regions of warm and dry air associated with stable atmosphere (negative value of moist static stability) over Sahel and southern Africa respectively (Fig. 1 top left panel). This indicates that the presence of water vapour over Central Africa is likely to destabilize the low-level troposphere, particularly during SOND and JFMA seasons, while the lack of water vapour leads to more stability over Sahel and Southern Africa. In MJJAS, the neutral atmospheric conditions (h < 330K) over Central Africa is associated with the equatorward transport of the dry static energy related to the dry air that prevails in Sahel and Southern Africa (Fig. 1, top left panel). At 700- hPa, high saturated moist static energy value is associated with northerly wind component in JFMA and OND, while in MJJAS, the low saturated moist static energy value is associated with southerly wind (Fig. 1 top middle panel). Overall at 700-hPa, the saturated moist static energy (h*) features a similar pattern than at near surface for the moist static energy, but with relatively high magnitudes (Fig. 1, top middle panel). Comparing dry (MJJAS) and rainy (SOND and JFMA) seasons, we notice that the north-south atmospheric instability contrast is consistent with the interhemispheric moist static energy and saturated moist static energy at near surface and 700-hPa respectively. This instability contrast is also associated with the meridional wind shear dipole (Fig. 1, top right panel). This indicates that changes in the seasonal variation of the atmospheric instability is strongly related to low-level branches of Hadley cells that dominate the Central African troposphere. The annual cycle of Central Africa rainfall is primarily dominated by the change in atmospheric pressure system (and its associated Hadley and Walker circulations) rather than the local temperature and water vapour. The seasonal migration of rainfall over central Africa is mostly controlled by the atmospheric instability driven by the presence of high water vapour rather than by the insolation through the vertical moist instability as suggested by Suzuki (2011) and Biasutti et al. (2004).

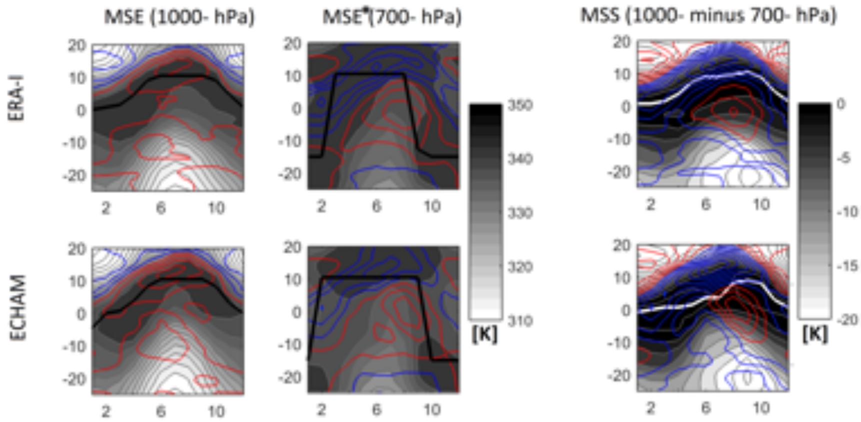


Fig. 1. Hovmoller (longitude-time) of ERA-Interim (top panel) and ECHAM (middle panel) and bias (bottom panel) of moist static energy (K) and zonal wind component (m/s) at 1000- hPa (left panel), saturated moist static energy (K) and zonal wind component (m/s) at 700-hPa (middle panel) and moist static stability (K) and vertical zonal wind shear (m/s) (right panel) averaged over central Africa (7°-33°E). The bold black line on all panels represents the zonal propagation of the rainfall maximum over central Africa, while the bold white line indicates the moist static stability maximum over central Africa and bold green dashed line indicate the limit of central Africa. Blue and red line represent the easterly and westerly respectively, with contour interval of 1m/s and zero line omitted.

DROUGHTS OVER SOUTHERN AFRICA DURING NON-ENSO SUMMER EVENTS FROM 1950/1951 TO 2012/2013

B Monyella and M Rouault.

Southern Africa, a semi-arid region situated south of 15° of the Equator, is prone to the occurrence of extreme rainfall anomalies during austral summer such as droughts and floods. Majority of the population, both commercial and subsistence farmers relies on rain-fed agriculture, therefore negative departures in rainfall (droughts) have significant regional and national socio-economic impacts. Drought in this region during summer are mostly linked to the warm phase of the El Niño Southern Oscillation (ENSO), called El Niño. This event is mostly characterized by mid tropospheric high-pressure anomalies, low–level and mid-tropospheric divergence across the subcontinent which tends to export moisture off the continent and suppress rainfall (Dieppois et al., 2015). More work over this region has focused on investigating the influence of ENSO on drought than on neutral year (non-ENSO) related droughts. A better understanding of the mechanisms that lead to non -

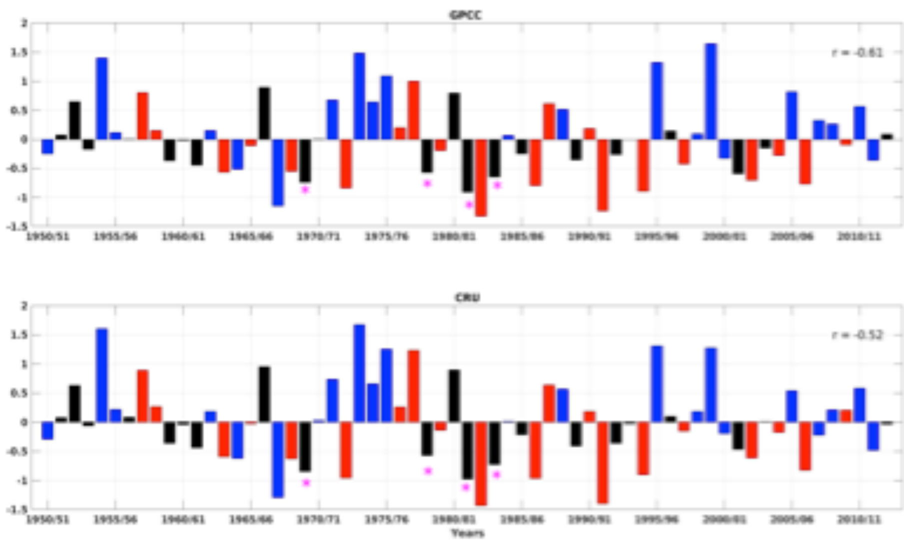


Figure 1: Standardized rainfall anomalies (bars, right) for summer season (Dec - Feb) over SRI (left) region from 1950/51 to 2012/13. Positive (negative) anomalies indicate wetter (drier) than normal rainfall. Red, blue and black colors represent El Niño, La Niña and normal years respectively.

ENSO droughts will be essential for seasonal forecasting in the subcontinent. Therefore, the objective of the study is to explore the droughts that occurred over the Southern African Rainfall Index (SRI) region during neutral ENSO summers using standardized anomalies from 1950/51 to 2012/2013. The standardized anomalies were calculated by dividing summer anomalies (deviation from climatological mean) by climatological summer standard deviation. The rainfall datasets used to identify the non-ENSO droughts were obtained from Global Precipitation Climatology Centre (GPCC) and Climate Research Unit (CRU) v4.01 rainfall available monthly at 0.5° x 0.5° resolution. The Extended Reconstructed Sea Surface Temperature (ERSST v4) dataset was used to categorize El Niño, La Niña and neutral years. The preliminary results from summer rainfall anomalies (Figure 1) suggest that the driest rainfall anomalies during a non - ENSO summer greater than -0.5 for both datasets occurred during the following summers: 1969/70, 1978/79, 1981/82 and 1983/84. The results further show that a third of non–ENSO droughts succeeded an El Niño event while a quarter of these non–ENSO droughts preceded an El Niño event. Circulation anomalies (geopotential height) were further assessed using the National Centre for Environmental Prediction (NCEP) Reanalysis data available monthly at 2° x 2° resolution. The mid-tropospheric atmospheric circulation (not shown) shows anomalous high pressure over the subcontinent, a common pattern observed during an El Niño summer drought. These positive high-pressure anomalies over the subcontinent, especially over Namibian-Angolan border for all three summers except 1978/79, might have weakened the continental (Angola) low, reduced moisture into the subcontinent and thus suppressed rainfall.

AGULHAS CURRENT MEANDERS FACILITATE SHELF-SLOPE EXCHANGE ON THE EASTERN AGULHAS BANK

N. Malan, B. Backeberg, J. Durgadoo, A. Samuelsen and J. Hermes

Large solitary meanders are arguably the dominant mode of variability in the Agulhas Current. Observational studies have shown these large meanders are associated with strong upwelling velocities and affect the shelf circulation for over 100 days per year. Here, 10-year time series from two Ocean General Circulation Models are used to create a composite picture of the Agulhas Current and its interactions with the shelf circulation in meandering and non-meandering modes. Both models show good agreement with the size, propagation speed and frequency of observed meanders. These composite meanders are then used to examine the response of shelf waters to the onset of large meanders, with the use of model output enabling the dynamics at depth to be explored. Results show a composite mean warming of up to 3°C of depth-averaged temperature along the shelf edge associated with an intrusion of the current jet onto the shelf driven by an intensification of the flow along the leading edge of large meanders. However, this intensification of flow results in cooling of bottom waters, driving cold events at the shelf break of <10°C at 100m. Thus, the intensification of the current jet associated with large meander events appears to drive strong up and downwelling events across the inshore front of the Agulhas Current, facilitating shelf-slope exchange.

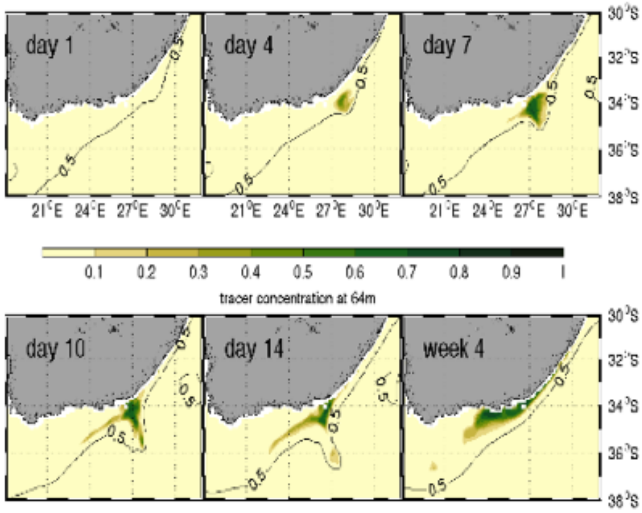


Figure 1: Tracer concentration at 64m in AGUHYCOM, Tracers were initialized below 400m over a 6-week period during a meander event in 2001 and used as a proxy for upwelling. The 0.5m sea level contour is highlighted to show the inshore edge of the current as the meander propagates along the coast.

IMPACT OF WIND DRIVEN VARIABILITY ON SEA SURFACE TEMPERATURE AND OCEAN COLOUR IN FALSE BAY

S. Seymour, M Krug, M Smith, M Rouault, A Mouche

False Bay is the largest true bay in South Africa and is an important area for conservation, the local fishing industry and marine based recreational activities. A large amount of studies, both recent and historical, have been carried out on the biology of the bay, but studies on the physics of the bay are very few in comparison. In this study high resolution satellite imagery is used to investigate the impact of the wind on sea surface temperature (SST) and ocean colour variability within False Bay. High resolution (1 km) coastal winds derived from the Sentinel-1 satellite Synthetic Aperture Radar (SAR) show that winds are strongly influenced by topography under the predominant South-easterly wind regime. The Hottentots-Holland mountain range and Cape Peninsula mountain range creates wind shadows as well as areas of increased wind speed with False Bay and west of the Cape Peninsula (fig. 1). Our observations also show that global atmospheric models, such as ECMWF, are not able to capture the spatial variability in the wind fields driven by the orography. Analyses of the SST and ocean colour imagery show that wind shadows are generally associated with warmer surface waters and higher chlorophyll concentrations. In contrast, regions of enhanced wind speeds show colder surface waters and decreased chlorophyll concentration. Our results suggest that spatial variation in the horizontal wind fields have direct and significant impact on the water properties within False Bay. This study highlights the need for high resolution wind observations and simulations to force regional oceanic models of False Bay.

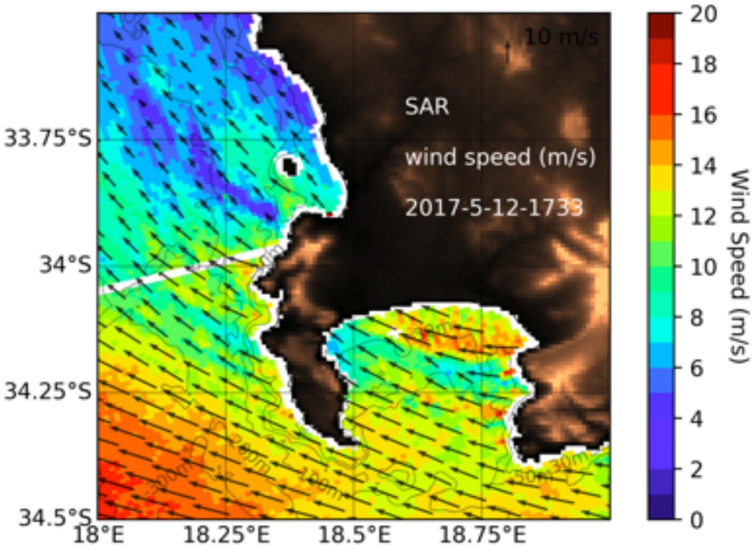


Figure 1: SAR derived wind speed (m/s) over False Bay and off Cape Point. Arrows show ECMWF wind direction and difference in elevation of the surrounding land is depicted in colour, with lighter areas being of higher altitude and darker areas being of lower altitude.

COASTAL VARIABILITY AND CHANGE IN THE BENGUELA UPWELLING SYSTEM: DECADAL TREND ANALYSIS

F. S. Tomety, M Rouault and S. Illig.

Sea Surface Temperature is a good indicator of upwelling strength in Eastern Boundary Currents, such as the Benguela Current. South-easterly winds lead to upwelling of cold water along the west coast of Southern Africa. The upwelling in the Benguela system is controlled by the anticyclonic wind of the South Atlantic Anticyclone. Satellite remote sensing provides estimation of sea surface temperature for most of the ocean since the 1980s and allows to quantify the decadal and interannual variabilities. An apparent paradox associated with global warming is that it might lead to intensified upwelling favorable wind leading to cooling of coastal upwelling such as the Benguela Upwelling System (BUS). A rigorous analysis of sea surface temperature and surface wind of various datasets over 36 years (1982-2017) is used to examine sea surface temperature and wind speed linear trends and decadal variability in the Angola, Benguela and Agulhas currents. The trends observed both in SST and wind speed show a strong spatial and seasonal variability. Statistically significant warming trends in SST are found off the Angolan coast (> 0.35°C per decade) and in the Agulhas retroflection region (~ 0.5°C per decade) (Figure 1). In Angola, the warming trend is concurrent with a negative trend in local wind speed (Figure 1 and Figure 2). Cooling trends in SST are found in the Southern Benguela in most of the SST dataset and is more pronounced mainly in the late austral autumn and winter. Discrepancies among the datasets mainly occur in the South African region. By constructing a time series of annual means of SSTs for the oceanic datasets used in this study, at different location in the BUS, we find that in the St. Helena Bay (~32°S, 18°E), the HadISST1 and OISST 1° x 1° start with a warmer state than the other which could explain the difference in cooling trend observed in BUS between datasets (Figure 1). Figure 2 illustrates the wind speed trends over the period 1982-2017 of NCEP2. Positive trends, up to 0.7 m/s per decade, are observed in the open ocean and along the Namibian and South African west coast. These positive trends along the coasts are more pronounced in austral summer (November–January). The trend is weak and not significant in winter (May-July) while the trend in SST shows a pronounced cooling in that area, which is an inconsistency according to Ekman dynamics in the St. Helena Bay (~32°S, 18°E), the HadISST1 and

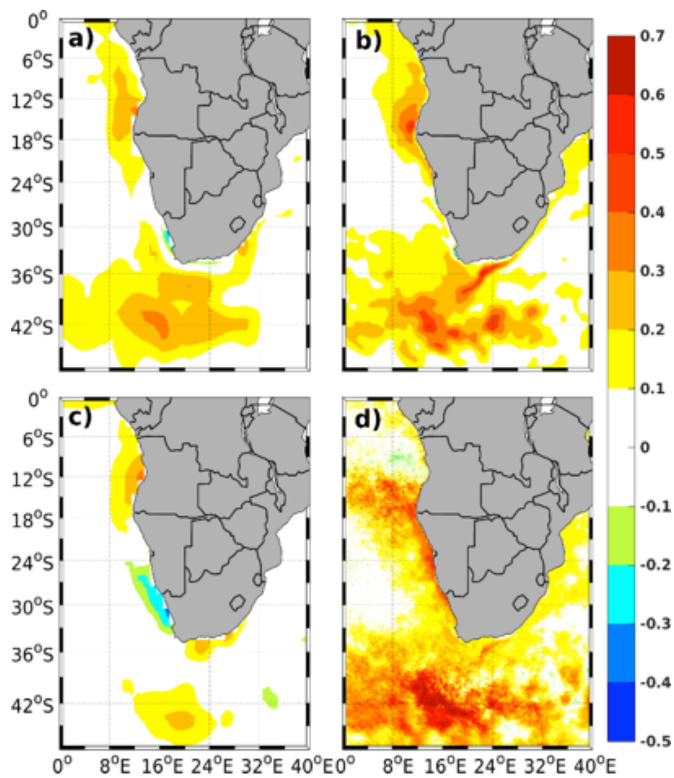


Figure 1: Linear trend in annual mean SST (°C per decade) for the a) OISST 1°x1°, b) OISST 1/4°x1/4°, c) HadISST and d) AVHRR Pathfinder during the period 1982-2017.

OISST 1° x 1° start with a warmer state than the other which could explain the difference in cooling trend observed in BUS between datasets (Figure 1). The figure 2 illustrates the wind speed trends over the period 1982-2017 of NCEP2. Positive trends, up to 0.7 m/s per decade, are observed in the open ocean and along the Namibian and South African west coast. These positive trends along the coasts are more pronounced in austral summer (November–January). The trend is weak and not significant in winter (May-July) while the trend in SST shows a pronounced cooling in that area, which is an inconsistency according to Ekman dynamics.

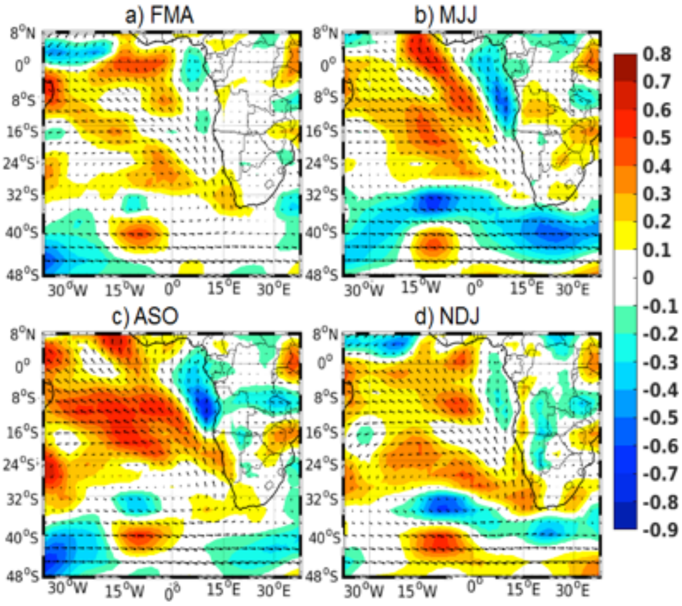


Figure 2: Seasonal linear trend of NCEP2 at 1000hpa wind speed (m/s per decade) over the period 1982-2017 superimposed with the climatological mean direction.

CROSS SHELF DYNAMICS IN THE AGULHAS CURRENT REGION FROM GLOBCURRENT AND GLIDER OBSERVATIONS

T Maja, M Krug, J Johannessen

The Agulhas Current plays a significant role in the circulation of shelf and coastal waters. Large scale variability in this region is dominated by mesoscale meanders and intrusion of the main flow onto the wide shelf of the Agulhas Bank (Krug et al., 2014). Various processes at mesoscale and sub-mesoscale spatial and temporal scales modify the local oceanography of the shelf region (Krug et al., 2014). These structures are an important channel for the dissipation and diapycnal mixing transfer of energy from the major reservoirs of ocean kinetic energy. Change in the Agulhas Current's flow strength or the position of the core flow can modify the hydrographic condition of shelf water and occasionally leads to a cross-shelf exchange of waters. The in-situ data for our study was obtained from Shelf in the Agulhas Glider Experiment (SAGE: April-May 2015) and the Glider in the Agulhas (GINA: June-August 2017) sea gliders. The satellite SST product used in our study was obtained from ODYSSEA SST. The SST fields are a level 4 product produced by merging of observations from infrared and microwave satellites. Ocean currents data were obtained from GlobCurrent. GlobCurrent has geostrophic, Ekman and the combination of both components at 25 km resolution. We present on the time series comparisons of currents from GlobCurrent and seagliders. High resolution SST satellite maps are used to describe meso and submesoscale structures. We define sub-domain with our main domain of study: upper (< 31 ° S), mid (31 – 34 ° S), and lower (>34 ° S). The interim results from the glider vs GlobCurrent comparison (Figure 1) show good correspondence in current measurements. Although difference between the glider data and GlobCurrent are statistically significant, a correlation coefficient of about 0.79 supports the generally coherent patterns exhibited in Figure 1. The mean difference between glider data and GlobCurrent variable across all the subdomains. Maximum differences of 0.7451 m/s (-1), 0.6911 m/s (-1) and 0.9870 m/s (-1) were observed in the upper, mid and lower domains respectively. GlobCurrent overestimates the current flows by 41% in the upper subdomain and underestimate flows by up to 80% in the lower domain. The discrepancies between the in-situ and satellite current observations may be due to coarse resolution of GlobCurrent. The GlobCurrent is unable to resolve finite oceanic structures less than 25 km resolution and shorter time scales. However, the product can represent the general circulation including some small-scale structures although there are no valid observations within 100 km off the coast. The SST map in Figure 2 shows the surface temperature field over the Agulhas Current region. The distinction of the evolutionary process may be important to understanding the role of submesoscale features in the cross-shelf exchange of waters.

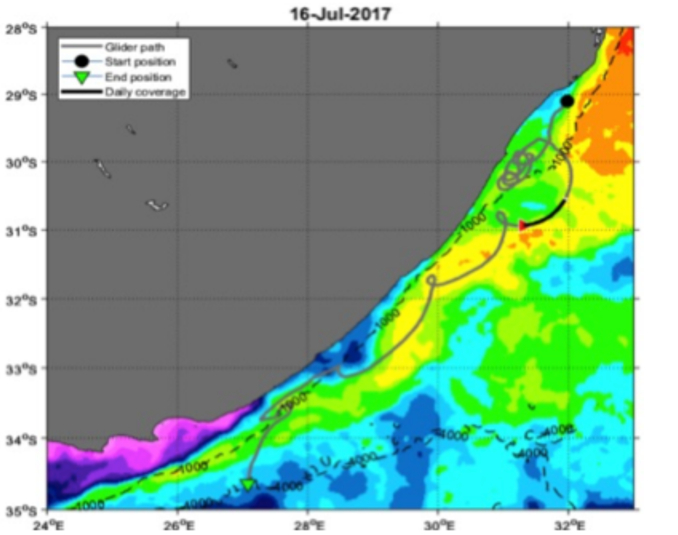


Figure 1: Time series of current speed from 25 km GlobCurrent and GINA seaglider in 2017. Glider data are averaged into daily means.

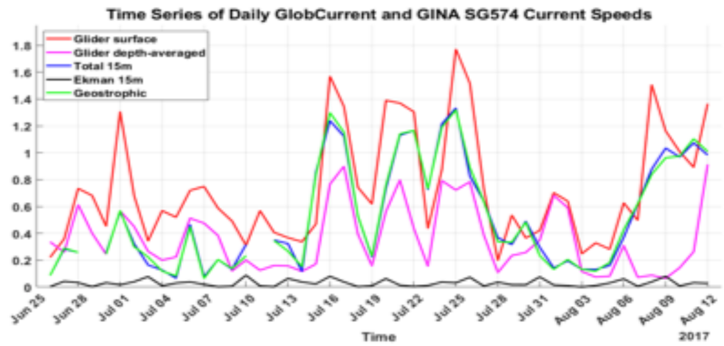


Figure 2: Daily ODYSSEA Sea Surface Temperature maps and GINA seaglider trajectory (grey line). The black circle and green triangle marks the start and end of the glider trajectory respectively. Dashed lined indicate the bathymetric contours at 1000m and 4000m. The black line indicates the spatial distance covered by the glider over a 1-day period.

IMPACT OF ENSO ON COASTAL SOUTH AFRICAN SEA SURFACE TEMPERATURES

Nhesvure B and M Rouault.

The aim of this study is to assess the impact of ENSO on sea surface temperatures (SST) around the coast of South Africa and update Rouault et al. (2010) as far as ENSO and SST is concerned. For this study, SSTs in six coastal regions across South Africa namely; West Coast, South Coast, Port Elizabeth/Port Alfred, Transkei, KwaZulu-Natal and the Agulhas Current System are averaged monthly from 1982 to 2017. The sampling method used for this study is like Rouault et al. 2010 and update it although we use here three different SST products. Each domain along the coast is approximately the same size: 3° along the coast and 1° offshore except for the Agulhas Current system which is averaged from 36° to 42° South and 15° to 30° East. The three SST products evaluated in this study include the 1x1 degree optimum interpolation Reynolds OI SST (Reynolds et al. 2002), the 0.25x0.25 degree OI SST and the 4x4 km Advanced Very High-Resolution Radiometer (AVHRR) Pathfinder dataset. Average annual SST ranges between 15°C and 25°C. We illustrate here some of the variations in SST anomalies and their association with ENSO across the regions. The monthly or seasonal average is detrended and normalized by the respective standard deviations. We present in Figure 1 a time series of averaged December, January, February (DJF) normalized and detrended SST anomalies from 1982–2017 with the corresponding ENSO phase each summer for all regions. Figure 1 is color-coded with El Nino summer in red, neutral summer in black, and La Nina summer in blue. Year in abscissa correspond the January of the summer considered. The interannual variability in (December, January, February) SST in most of these regions is closely related to ENSO. According to the Ocean Nino index, 12 El Nino years occurred in summer 1983, 1987, 1988, 1992, 1995, 1998, 2003, 2005, 2007, 2010, 2015 and 2016 and 14 La Nina years occurred in summer 1984, 1985, 1989, 1996, 1999, 2000, 2001, 2006, 2008, 2009, 2011, 2012, 2017 and 2018 and 11 ENSO neutral years occurred in 1982, 1986, 1990, 1991, 1993, 1994, 1997, 2002, 2004, 2013 and 2014. For this study, anomaly of greater or equal 0.5 are defined as warm events and anomaly of less than or equal 0.5 is defined as a cold event. The time series indicates that in general but not all the time warm events occur during El Niño and cold events during to La Nina for West Coast, South Coast and PE/PA. Nine warm events occurred during El Nino and six cold events occurred during La Nina in the West Coast region, three warm events and six cold events occurred during the neutral phase and two warm events occurred during La Nina. Figure 1. also shows that the intensity of SST anomalies associated with El Nino and La Nina, respectively, are not proportional to the intensity of the ENSO events. For the Agulhas Current it seems that the association ENSO warm and cold events is opposite to the West Coast.

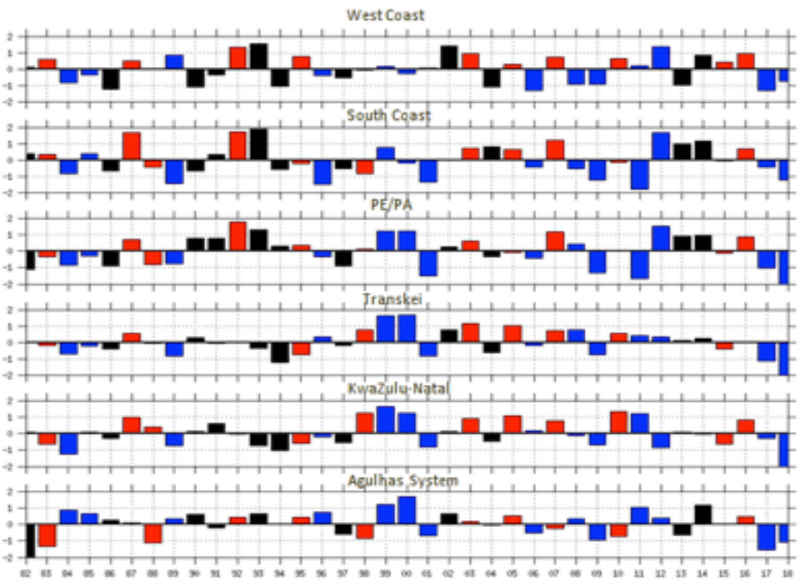


Figure 1. Detrended normalised anomalies from the mean of December, January, February from 1982 to 2018 March for the six domains, indicating the association between cold and warm events and La Niña and El Niño years (in standard deviation) using OISST. Red represents El Nino, blue La Nina and black represents a normal year.

Nansen-Tutu Science Day on November 2, 2018 at the University of Cape Town during the 2018 Board Meeting.

Nansen-Tutu Centre for Marine Environmental Research, Department of Oceanography, Marine Research, University of Cape Town, Rondebosch, Cape Town, 7700, South Africa

University of Cape Town • iDyunivesithi yaseKapa • Universiteit van Kaapstad

NANSEN-TUTU CENTRE
MARINE ENVIRONMENTAL RESEARCH

A PARTNER IN THE NANSEN GROUP OF INTERNATIONAL RESEARCH INSTITUTES

Nansen-Zhu International Research Center, Beijing, China
http://nzc.iap.ac.cn

Nansen Environmental and Remote Sensing Center, Bergen, Norway
www.nersc.no

The University of Bergen, Bergen, Norway
https://www.uib.no/

Institute of Marine Research, Bergen, Norway
http://www.imr.no/

Nansen Environmental Research Center, Cochin, India
www.nerci.in

Nansen International Centre for Coastal, Ocean and Climate Studies, Dhaka, Bangladesh

Nansen International Environmental and Remote Sensing Center, St. Petersburg, Russia
www.niersc.spb.ru

Nansen Scientific Society
Bergen, Norway