Marine Climate Change and the Impact on Coastal Regions

SUMMARY

Title

Coastal Risk Information Service (C-RISe)

Key Points

- Mozambique, Madagascar, Mauritius and South Africa have significant coastal populations whose lives and economic security are highly vulnerable to the consequences of climate variability and change. Mozambique, Madagascar, and Mauritius are highly exposed to surges associated with cyclones, and all have economically important coastal ecosystems sensitive to climate change.

- Access to enhanced regional information on coastal risk factors (sea level, wave and wind extremes) improves capability to develop plans to protect coastal communities and safeguard economic activity.

- C-RISe is delivering access to information on sea level rise, storm surge, wind speed, and wave heights derived from satellite altimetry and validated with local in-situ measurements. Local stakeholders are applying these products in a series of focused Use Cases.

Service

Coastal management, Fisheries, Marine ecosystems, Mitigation

End users

- Local communities, Policymakers, Reef managers, Researchers

Intermediate user(s)

- NGOs, Scientific Researchers, Operational Agencies
- Universidado Eduardo Mondlane, Mozambique
- Instituto Nacional de Hidrografia e Navegação (INAHINA), Mozambique
- Conservation International (CI), Madagascar
- Centre de Fusion des Information Maritimes (CFIM), Madagascar
- Direction Générale de la Météorologie, Madagascar
- WWF, Madagascar
- Centre National De Récherches Océanographiques (CNRO), Madagascar
- Institut Halieutique et des Sciences Marines (IHSM), Madagascar
- University of Mauritius

DESCRIPTION

It is well established that global sea level is increasing, and that large-scale weather patterns are changing. However, even within the Indian Ocean, these changes are not geographically uniform or steady in time, with short-term variability on a range of time scales (seasonal and inter-annual). Mozambique, Madagascar, Mauritius, and South Africa have significant coastal populations whose lives and economic security are highly vulnerable to the consequences of climate variability and change. They are highly exposed to the surges associated with cyclones and have economically important coastal ecosystems, sensitive to climate change. Access to enhanced regional information on coastal risk factors (sea level, wave and wind extremes) improves local capability to plan to protect coastal communities and safeguard economic activity.

C-RISe is a four-year project funded by the UK Space Agency through the International Partnership Programme (IPP), working with local partners (including NGOs, local government agencies, universities, and research organizations) to deliver a Coastal Risk Information Service for the South West Indian Ocean. C-RISe is providing satellite-derived information about sea level, currents, wind, and waves (Table 1) to support coastal vulnerability assessment and management. The goal is to enable local stakeholders to use this information to reduce the social and economic impact of coastal inundation and increasingly variable weather patterns.

Table 1 – Satellite-derived data products provided

	Parameters	Source	Time Coverage	Satellites
1	Total water level envelope Significant wave height Surface radar backscatter	Along-track data from the National Oceanography Centre's coastal processor	2002–2019	Jason-1, Jason-2, Jason-3
2	Significant wave height climatologies	Monthly, 1° x 1° gridded climatologies sourced from ESA Globwave project	1992–2019	ERS-1, ERS-2, Envisat, Topex, Jason-1, Jason-2, Jason-3
3	Ocean wind speed and direction climatologies	Monthly, 0.25° x 0.25° gridded climatologies sourced from CMEMS	2007–2019	Metop-A, Metop-B
4	Total Surface Current (geostrophic + Ekman)	Daily, 0.25° x 0.25° gridded climatologies sourced from ESA Globcurrent project	1993–2019	Envisat, Jason-1, Jason-2, Jason-3
5	Near-real time along-track data	Significant wave height and wind speed	Daily updated	Jason-2, Jason-3, AltiKa, Sentinel-3A, Sentinel-3B

The three main objectives of the C-RISe project are to:

- Deliver a Coastal Risk Information Service, providing satellite-derived information about coastal vulnerability to environmental threats such as sea level rise and extreme wind and wave events.
- Apply and evaluate the C-RISe service through a set of Use Cases, applying the C-RISe products to end-use applications meeting local priorities.
- Build local capacity to use satellite data to provide scientific decision support for strategy development, governance, and management of coastal areas to increase resilience to coastal hazards.

The C-RISe team has applied an innovative satellite altimeter data-processing technique, developed in the UK by the National Oceanography Centre, to data for the Mozambique, Madagascar, Mauritius, and South Africa coastal regions (see Figure 1). These data are integrated in a web-based portal developed with CSIR (Council for Scientific and Industrial Research, South Africa, https://ocims.csir. co.za/crise/) and local partners are supported in using the data, through capacity building and software provision. Using the C-RISe portal, specifically developed Python scripts, and the BILKO satellite data tool (http://www.learn-eo.org/software.php, first developed for UNESCO), local users have been trained in the validation and use of marine satellite data to quantify coastal hazards and incorporate this into ongoing development and disaster prevention initiatives.
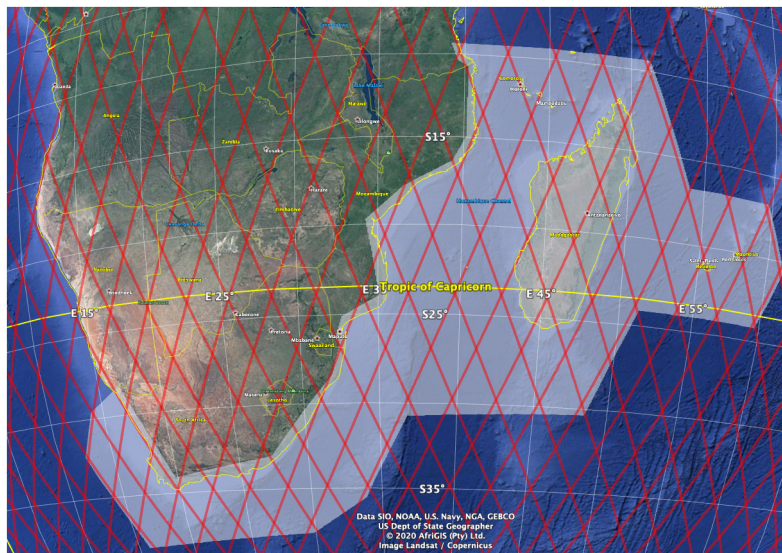

Figure 1. Coverage of C-RISe data products. The shaded area gives the overall coverage of the project. The red lines are the ground tracks for the Jason-series satellites, for which data from the National Oceanography Centre's coastal processor has been generated

Sea level data were validated against local tide gauge data, where available (see Figure 2), and regional sea level trends have been generated (Figure 3). Software enables the interrogation of climatology trends, such as the mean significant wave height, mean currents, or wind speed and direction for a given month (Figure 4).
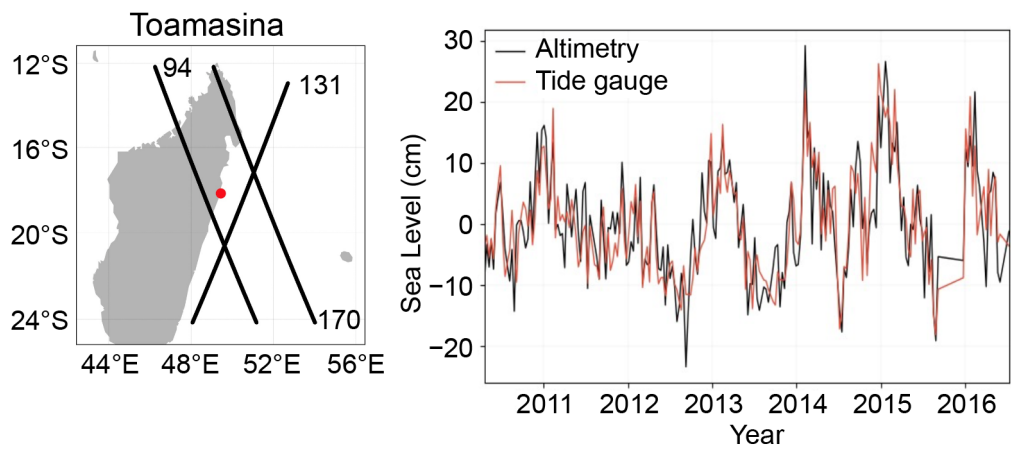

Figure 2. Jason altimeter tracks close to Toamasina, Madagascar (left); Comparison of tide gauge and altimeter sea level data at Toamasina, Madagascar (right). The point of best agreement between tide gauge data and satellite data was on pass 94, 32.5 km from the coast, and 166.69 km from the tide gauge. Here the correlation was 0.83, and the RMS difference was 4.44 cm.
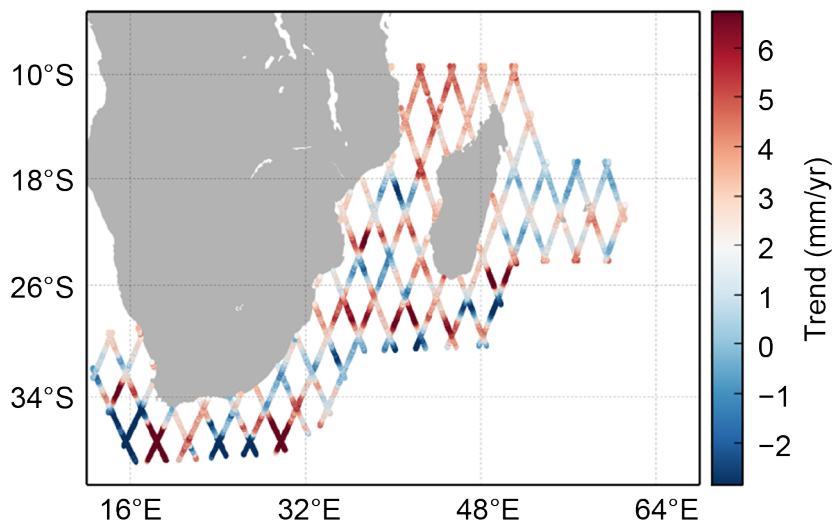

Figure 3. Sea level trend generated from the 2002 to 2016 along track time series sea level data.
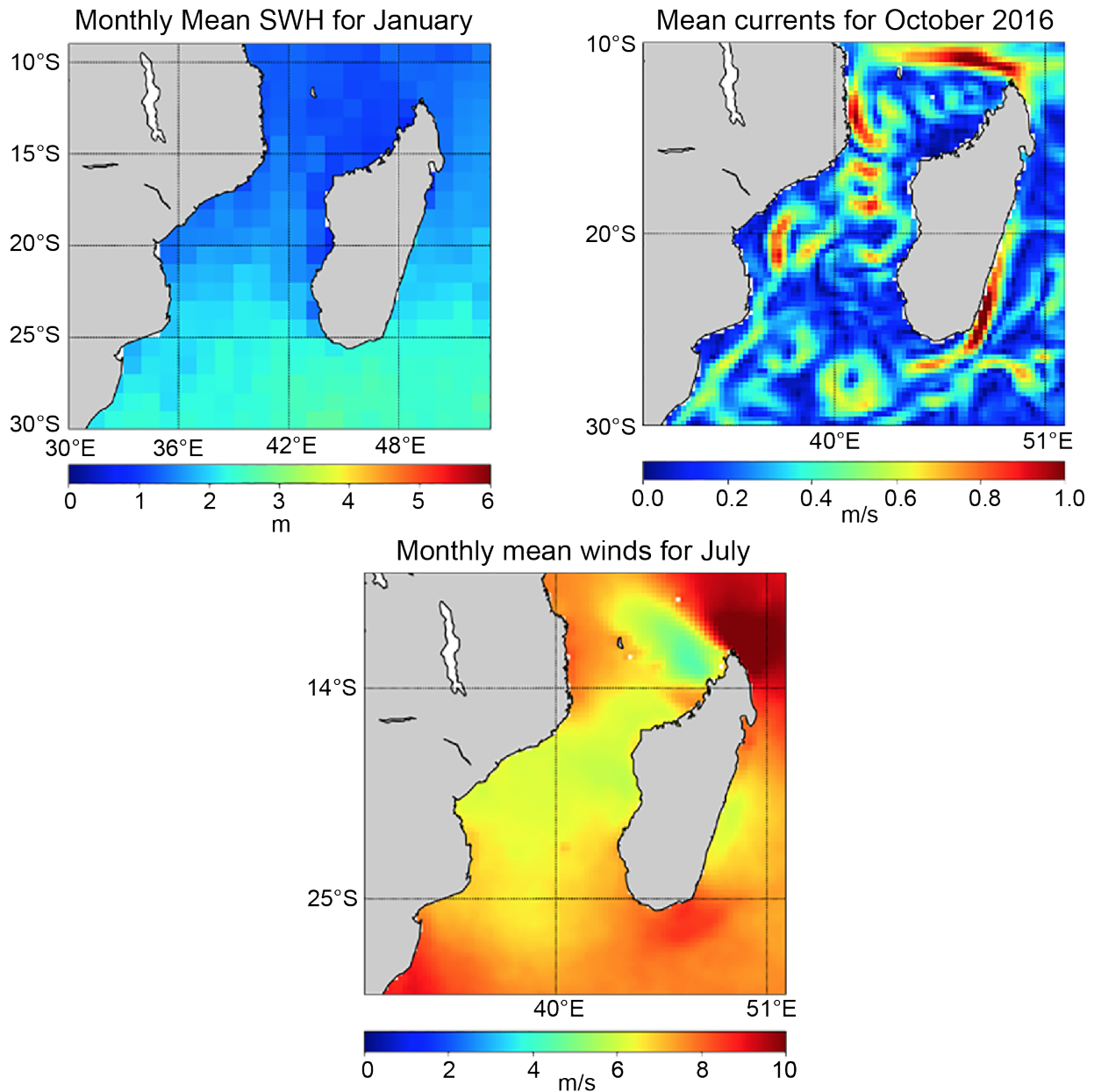
Figure 4. Climatologies: Mean significant wave height for January, Madagascar and Mozambique Channel (top left); mean currents for October 2016, Madagascar and Mozambique Channel (top right); and mean wind speed for July, Madagascar and Mozambique Channel (bottom).

In-country partners have worked to develop a range of Use Cases (27 in total) to demonstrate how the data may be used in various areas of application. These Use Cases range across five themes: Marine Protected Area (MPA) management; sea state and surface current Information, sea level analyses; wind and wave climate variability; and climate change impact on marine ecosystems. Use Cases have delivered a range of impacts so far, including:

- Enabling law enforcement in cases of drug trafficking and illegal migration
- Improved management of mangroves and reefs
- Improved management of Marine Protected Areas, leading to their expansion

Application(s)

- Ocean climate data for coastal zone management; infrastructure protection and development; and operational planning
- Sea level and tidal analyses for climate change mitigation and adaptation; coastal management; and infrastructure planning
- Near-real time marine environmental conditions support for community and operational safety; and law enforcement
- Marine Protected Area (MPA) management; marine ecosystem monitoring; and marine fisheries support

Essential Climate Variables

—Atmospere

- Wind Speed and direction

—Ocean

- Sea level
- Sea state
- Sea surface currents

Models

- Tide models
- Storm surge models
- Ocean circulation hind cast models Wavewatch III model

Climate data records used

- Sea Level trends and variability, calculated from Coastal Geophysical Data Records produced by the National Oceanography Centre (UK) coastal processor: DOI not available. Reference: Passaro M., Cipollini P., Vignudelli S., Quartly G., Snaith H. (2014). "ALES: a multi-mission adaptive sub-waveform retracker for coastal and open ocean altimetry," Remote Sensing of Environment, Vol. 145, pp. 173-189.
- Ocean Surface wind Velocity from Copernicus Marine Environment Monitoring Service: Global ocean wind L4 reprocessed monthly mean observations. https://catalogue.marine.copernicus.eu/documents/PUM/CMEMS-WIND-PUM-012-003.pdf.
- Significant wave height from ESA CCI+ Project
Level 4 Product – Global remote sensing merged multi-mission monthly gridded significant wave height, L4 product, version 1.1. https://dx.doi.org/10.5285/47140d618dcc40309e1ed bca7e773478
- Ocean Surface Current Velocity from Copernicus Marine Environment Monitoring Service: Global total surface and 15m current (copernicus-globcurrent) from altimetric geostrophic current and modeled Ekman current reprocessing. http://marine.copernicus.eu/documents/PUM/CMEMS-MOB-PUM-015-004.pdf. Reference: Rio, M.-H., S. Mulet, and N. Picot, 2014: Beyond GOCE for the ocean circulation estimate: Synergetic use of altimetry, gravimetry, and in situ data provides new insight into geostrophic and Ekman currents, Geophys. Res. Lett., 41, doi:10.1002/2014GL061773.

Agencies that produce records

- Regional Sea Level: National Oceanography Centre UK (https://c-rise.info/data-products)
- Monthly Mean global ocean Surface wind from Copernicus Marine Environment Monitoring Service – (https://catalogue.marine.copernicus.eu/documents/PUM/CMEMS-WIND-PUM-012-003.pdf)
- Surface waves from ESA CCI+ Sea State Project (http://cci.esa.int/seastate)
- Surface Currents from Copernicus Marine Environment Monitoring Service – ESA GlobCurrent Project (http://www.globcurrent.org)

Satellite observation used

- Satellite Altimeter: ERS-1, ERS-2, Envisat, TOPEX, Jason-1, Jason-2, Jason-3, Altika/SARAL, Cryosat-2.
- Scatterometer (ASCAT) Metop-A, Metop-B.

Sustainability of service (demonstration or ongoing)

C-RISe is funded for four years by the UK Space Agency 2017-2021. The project team is currently looking into funding options to continue delivering the service.

The spatial resolution of data is too coarse for some applications at the coast. Applications would benefit from higher resolution EO data and the use of models.

INFORMATION FLOW

sensing
- Satellite altimetry:
- Tide gauges
- Wind and wave measurement buoys
- Drifter velocities
- Satellite Scatterometry

climate data records
- Coastal Sea-level record
- Ocean wind speed and directions
- Ocean significant wave Height
- Ocean surface currents and drifter velocities
- Ocean circulation model re-analyses

application
- Regional sea level
- Rate of sea level change and related uncertainty
- Maps of spatial trend patterns in sea level
- Gridded global wave climatology
- Gridded global surface wind climatology
- Gridded global surface current climatology

decision making
- Coastal zone management
- Infrastructure protection and development
- Marine protected area management
- Marine ecosystem management

- Ocean tide models
- Sea surface temperature
- Sentinel-2 imagery
- Local in situ marine ecosystem monitoring data

use additional data

climatemonitoring.info/use−cases/