Coastal Risk Information Service (C-RISe) Training Course and Workshop

Wind, Wave and Sea Level Information from Satellites

Maputo, 16-20 October 2017.

Workshop Report and Recommendations

Content

Introduction

The C-RISe training course on wind, waves and sea level information from satellites was organised by the C-RISe project in collaboration with the School of Marine and Coastal Sciences at University of Eduardo Mondlane (UEM) and the Mozambique National Hydrographic Office (INAHINA). The course was hosted by the UEM Centre for Informatics (CIUEM), and supported by the UK Space Agency's International Partnership Programme.

Twenty-one participants from UEM, INAHINA, the National Institute of Meteorology (INAM), the National Maritime Authority (INAMAR), Corredor de Desenvolvimento de Norte (CDN), and the Natural History Museum participated in the training sessions and workshop discussions. A list of participants is given in Appendix 1.

The training course looked at the strengths and limitations of technologies used to measure wind, waves and sea level from satellites, as well as the main applications of this data. Participants also gained hands-on experience in using the C-RISe data product, which brings these measurements closer to the coast. The training course schedule is provided in Appendix 2.

One of the aims of the training course was to act as a starting point for local validation of the C-RISe data, and encourage participants with access to *in situ* data to participate in this activity. A total of five participants signed up to validation of the sea level product using local tide gauge data. A further two participants volunteered to participate in validation of the wind/wave data products. Details are provided in Appendix 3.

The week also included discussions of how access to improved information on sea level, wave and wind extremes could be used to inform efforts to improve safety at sea, protect coastal communities, and safeguard economic activity along the Mozambique coast. Participants identified a number of 'use cases' – priority studies that will demonstrate how C-RISe data can contribute to economic development and increased resilience to marine and coastal hazards in Mozambique. If adopted, the use cases will be developed and delivered by local partners with support from the UK C-RISe team over the 12-18 months. The selected use cases are described in more detail below.

Selected Use Cases

1. Satellite-derived current climatologies for the Mozambique Channel

Participating organisations: INAHINA, UEM, SatOC, NOC, CDN.

Accurate current information is important for navigation, port operations and port development.

Existing information on currents is out of date. INAHINA is therefore planning to update its current charts, and will be deploying two current meters in Beira in March and September 2018. Combining these measurements with satellite-derived information on ocean currents could deliver improved information to support the planning of three large ports in the north of the country, helping engineers to identify suitable sites and specifications for new installations. The coal terminal in Macuzi will also benefit from improved current information.

The proposed study will be carried out as an MSc research project at UEM, co-supervised by staff from INAHINA and the UK National Oceanography Centre (NOC). Potential students for this are Hulda Cau or Ilário Timba.

In addition to the current meter measurements from INAHINA, data used for the project will include mean offshore currents from the European GlobCurrent project (www.globcurrent.org), and may also include coastal currents from the tidal dynamics model developed by NOC Liverpool.

2. Sea level trends, climatology and extremes for the Mozambique coast

Participating organisations: INAHINA, UEM, NOC, CDN.

Good sea level climatologies are important for planning of new infrastructure developments due to start in the next 2-3 years. This may be obtained from a comparison of archive satellite and tide gauge (TG) data for the region, and statistical analysis of these data sets. The C-RISe data provides information closer to the coast than conventional altimetry, and is therefore particularly suitable for comparison with TG data.

The analysis will be carried out by an INAHINA trainee (Hulda Cau or Ilário Timba) as an MSc research project at UEM, with co-supervision from INAHINA and NOC. In addition to the existing C-RISe archive data and tide gauge data from sites in the Permanent Service for Mean Sea Level (PSMSL), the project will build on records from other Mozambican tide gauges held by INAHINA, the Global Extreme Sea Level Analysis (GESLA) data set (www.gesla.org) and information on Mozambican surge events from the e-Surge project (www.storm-surge.info) where this is available. Statistical analysis of the satellite and TG data will provide information on long-term trends, as well as seasonal variability in mean sea level. Analysis will also include removal of tidal harmonics to obtain a sea level residual for comparison with archive wind data to obtain a climatology for surge events.

3. Wave climatology for the Mozambique Channel

Participating organisations: INAM, UEM, SatOC, NOC, CDN.

Wave information is important for planning navigation and port developments. Climatologies that include monthly averages and extremes as well as information on inter-annual variability can be developed from archive data on significant wave height, derived from satellite altimetry.

The research will be carried out by an INAM trainee, as an MSc project at UEM, co-supervised by UEM, INAM and NOC and/or SatOC. The study will build archive data from the NOAA WaveWatch-III model (http://polar.ncep.noaa.gov/waves/index2.shtml). The model uses wind input to model wave heights, and also assimilates wave data from satellite altimetry. Archive WW3 data will be extracted for the Mozambique coast for comparison with in situ measurements form wave sensors on current meters deployed by INAHINA in Beira, and UEM in Quelimane, Short periods of archive wave data will be supplemented with new measurements in 2018. After validation, means, variability and extremes will be obtained through statistical analysis of the WW3 archive.

4. Seastate information for maritime operations

Participating organisations: INAM, SatOC, INAMAR, UEM

Daily information about wind and waves are needed for planning port operations, maritime traffic and offshore activities. Ideally this includes real-time information about current conditions as well as forecasts for up to three days ahead – the time required to plan shipping operations between the North and South of Mozambique.

Wind velocities from satellite scatterometry and significant wave heights from satellite altimetry are available in near-real-time (NRT). These may be compared with wind and wave forecasts from global meteorological and wave models. At present INAM delivers wind forecasts for Mozambican waters. SatOC produces model output for current conditions combined with satellite wind velocities and wave heights for the C-RISe region (Mozambique, Madagascar, South Africa), updated every three hours. This use case will set up a similar, but extended service for Mozambican waters, delivered by INAM, with support from SatOC during the implementation phase.

The proposed service will cover three overlapping regions of Mozambican water, from South to North, visualised using Google maps. It will consist of:

- maps of current wind and wave conditions from models and NRT satellite data
- wind and wave forecasts for the next three days
- short archive of past model output with overlaid satellite data, to allow users to assess the accuracy of recent forecasts.
- Text forecasts for smaller areas around individual ports, including the confidence level derived from past comparisons with satellite data.

The maps will be available online from INAM; the text forecasts will be transmitted to smaller ships and fishers by INAMAR via broadcasts and SMS.

A potential UEM student project will look at the best way to present the forecast and satellite data to end users.

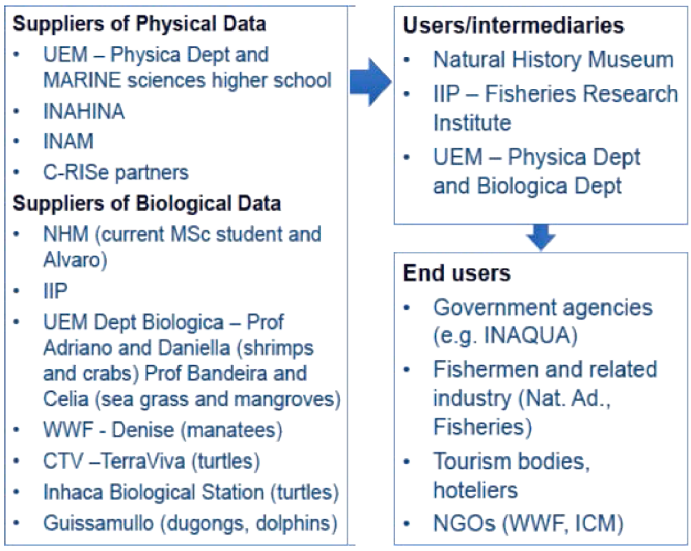
5. Changes in physical processes and their impact upon coastal and marine ecosystems

Participating organisations: Natural History Museum, UEM, NOC, SatOC, INAHINA, CSIR

Physical processes include, winds, wave conditions, sea surface temperature (SST), sea level and tides. Changes occur on many timescales: daily, seasonally, inter-annually and in the longer term, for instance due to climate change. Information about trends and variability in these parameters may be derived from satellite data, which are therefore an important tool in understanding coastal and marine ecology. Environmental parameters observed from satellites allow us to infer the spatial distributions of marine species. This includes fish and other species of commercial importance, including large species such as sharks, which can have an impact on the tourism industry. This also applies to the zonation of plants, and important ecosystems such as corals, sea grass and mangroves. Better information about variability and change in the physical environment will lead to improved understanding of recruitment patterns and movement of marine species, especially those that have a larval stage and can be transported by physical processes.

This use case will demonstrate how satellite data can contribute to sustainable management of marine living resources by providing a scientific basis for decision-making, for example by Government departments, leading to more informed fisheries management and environmental protection measures. In the longer term the fishery stability brought on by improved management will benefit Mozambican fishers and those engaged in associated industries. Better understanding of the links between environmental parameters and behaviour of shark populations, can potentially benefit local communities and the tourism industry, through reduction in shark attacks.

In addition to the C-RISe parameters (SSH/sea level, wind, waves and tides) the use case will require the use of chlorophyll, sea surface temperature (SST) and sea surface salinity (SSS) from



satellites, as well as data from Argo floats and tidal models, These will be acquired with support from the UK C-RISe team and INAHINA.

Physical and biological data such as historical fish catches and habitat maps will be collated and distributed through a data portal to facilitate comparisons between environmental and biological records. This will require one or more Mozambique-based biological data co-ordinators and in the first instance will be Alvaro Albino Vetina and/or Veronica Rose. An MSc student of Alvaro's is currently employed in similar work and may be able to undertake this task.

Participating organisations in this use case are numerous, as summarised in the figure above, left. Stakeholder recruitment will be facilitated by the use of social media, establishing a Facebook or WhatsApp Instagram page to encourage participation and publicise products to potential users. The initial page will be set up by Alvaro Albino Vetina in Portuguese.

Recommendations

The workshop participants make the following recommendations to support the development and implementation of the use cases outlined above. It is important that these recommendations are adopted as soon as possible to ensure that the use case research can be completed within the time frame of the current C-RISe project, which finishes at the end of November 2019.

1. UEM should include the use case studies outlined above among the MSc research projects scheduled to start in January 2018, and identify suitable supervisors for each use case.

2. Mozambican organisations likely to benefit from the proposed research activities should identify junior staff who could take on the MSc research, support their studentship and identify a senior member of staff to act as co-supervisor for the research.

3. The UK C-RISe partners (SatOC and NOC) should identify suitable co-supervisors for the MSc research and facilitate access to satellite data and model output identified at necessary for the research.

4. C-RISe partners in UK and South Africa should facilitate collection of additional satellite date (SST, SST, Chlorophyll) and Argo float data making this available to support Use Case 5.

5. Mozambican partners in Use Case 5 (Natural History Museum, UEM) should collate existing biological data from the region and make this available through a data portal. A Facebook or WhatsApp Instagram page should be set up to encourage participation in Use Case 4, and to publicise products to potential users.

Appendix 1: Participants

Trainers

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Local organisers

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Other participants

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Cau, Hulda Felisberto, UEM, huldacau@gmail.com

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Vetina, Alvaro Albino, Natural History Museum, aavetina@gmail.com

Zandamela, Dércio João Zandamela, INAHINA, derciozandamela@gmail.com

Appendix 2: Schedule

Trainers: Ellis Ash (SatOC), Angela Hibbert, Val Byfield (NOC)

Local organisers:

Fialho Nehama, UEM, E-mail: fialho.nehama@gmail.com

Clousa Maueua, INAHINA, E-mail: clousam@yahoo.com.br

Monday 16 October

10:30-11:00	Arrival and registration	
11:00-11:10	Welcome and Introductions	Val
11:10-11:30	Introduction to C-RISe	Ellis
11:30-12:30	Mozambican plans for using C-RISe data Participants will give a brief overview of their work and how they hope C-RISe data may contribute to their activities. Participants from the same organisation may deliver joint presentations if they so wish.	Course Participants
12:30-14:00	Lunch break	
14:00-14:20	Demonstration of on-line data portals for C-RISe data access	Ellis
14:20-15:20	Bilko exercise: opening and viewing C-RISe data	Val
15:20-15:40	Break	
15:40-16:20	Introduction to satellite ocean measurements	Ellis
16:20-17:00	C-RISe use cases: what makes a good use case? Discussion: How can C-RISe support on-going and planned activities presented by the course participants? Formation of groups for further planning of C-RISe use cases during afternoon sessions.	Val All

Tuesday 17 October: Altimetry applications; wind and waves

08:30-09:15	Introduction to satellite altimetry	Val
09:15-10:00	Altimetry applications and synergy with other sensors	Val
10:00-10:30	Break	
10:30-11:15	Introduction to wind and wave data processing and data product levels.	Ellis
11:15-12:00	Introduction to wind and wave statistics and interpretation.	Ellis
12:00-13:30	Lunch break	
13:30-14:15	The C-RISe wind and wave data archive, other data sources, how to access public sources.	Ellis
14:15-17:00	Parallel sessions* **Group A:** Hands-on exercise with monthly gridded sea state data (with Ellis). 1) Reading the wind and wave archive data, plotting basic quantities for a single sea area. 2) Generating maps of simple quantities for the national sea area. 3) Calculating and plotting statistics for single sea areas, comparing with data from a wave buoy. **Group B:** Use case planning (with Val & Angela)	Participants, Ellis, Val, Angela

Wednesday 18 October: Wind and waves. Sea Level

08:30-09:15	Introduction to sea level variability; typical features of a sea level record: tides, seiches, storm surges, long term change.	Angela
09:15-12:00	Parallel sessions* Group A: Use case planning Group B: Exercises with monthly gridded sea state data	Participants Val, Angela Ellis
12:00-13:30	Lunch break	
08:30-09:15	Introduction to GLOSS data portals providing sea level records from tide gauges. How to access data from IOC SLMF, UHSLC and PSMSL archives.	Angela
13:50-14:30	The theory of tides and tidal analysis	Angela
14:30-17:00	Parallel sessions* **Group A:** Tidal analysis exercise (with Angela): Reformatting, sub-sampling, quality control and tidal analysis of the sample time series using TASK Tidal Analysis Software **Group B:** Use case planning (with Val and Ellis).	Participants, Angela Val & Ellis

Thursday 19 October: Sea Level from Tide Gauge data. Altimetry data validation

08:30-09:15	Introduction to the analysis of sea level variability with along-track satellite altimetry data	Angela
09:15-12:00	Parallel sessions* Group A: Use case planning Group B: Exercises TASK tidal analysis software	Participants Val, Ellis Angela
12:00-13:30	Lunch break	
13:30-14:15	Introduction to methods and statistics for altimetry validation	Ellis
14:15-16:30	Parallel sessions **Group B**: Hands on exercise with altimetry & TG data 1. Reading the altimetry sea level data, extracting total water levels and sea level anomalies. 2. Validation of altimetry data against single tide gauge records as a function of distance from the coast. 3. Generating easy-to-understand sea level maps of the annual cycle, inter-annual variability, and trends **Group A:** Use case planning	Participants Ellis Val, Angela

Friday 19 October: Quality Control and C-RISe Data Validation

08:30-09:00	Plans for local validation of C-RISe data. Who will take part?	All
09:00-11:00	Parallel sessions* **Group A**: Exercise with altimetry and TG data **Group B:** Use case planning	All Ellis Val, Angela
11:00-12:00	Group presentations of use case plans. Discussion.	Participants All
12:00-12:30	Summary and final questions	
12:30	Workshop close	

*During the parallel sessions groups will take a short break at a time that is convenient for the exercises and use case discussions.

Appendix 3: Local data validation

Validation of wind and wave data products

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Validation of sea level data products

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Appendix 4: Acronyms and abbreviations

C---RISe	Coastal Risk Information Services
CDN	Corredor de Desenvolvimento de Norte (the Northern Development Corridor)
CIUEM	Centro de Informática da Universidade Eduardo Mondlane (Eduardo Mondlane University, Centre for Informatics)
GESLA	Global Extreme Sea Level Analysis
INAHINA	Instituto Nacional de Hidrografia e Navegação (Mozambique National Hydrographic Office)
INAM	Instituto Nacional de Meteorologia (Mozambique National Meteorology Institute)
INAMAR	Instituto Nacional da Marinha (Mozambique National Maritime Authority)
IPP	International Partnership Programme (UK Space Agency)
MTC	Ministério dos Transportes e Comunicações (Mozambique Ministry of Transport and Communcation)
NOAA	National Oceanographic and Atmospheric Administration (U.S.)
NOC	National Oceanography Centre (U.K.)
NRT	Near Real Time
PSMSL	Permanent Service for Mean Sea Level
SatOC	Satellite Oceanographic Constultants
SSH	Sea Surface Height
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
TG	Tide Gauge
UEM	Universidade Eduardo Mondlane (Eduardo Mondlane University)
WW3	Wave Watch 3 (wave model)