Application of satellite altimetry as a tool for managing coastal risk in Mozambique and Madagascar

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C-RISe
COASTAL RISK INFORMATION SERVICE

Coastal Risk Information Service

- C-RISe is providing satellite-derived information about sea level, wind and waves to support coastal vulnerability assessment and hazard management efforts in Mozambique and Madagascar.
- C-RISe products are being applied through a set of Use Cases, end use applications to address local priorities.
- A priority is to develop local capacity to access and apply satellite data, there is a strong training element to the project.

METEO Madagascar

CNDO

INSTITUT HALIEUTIQUE ET DES SCIENCES MARINES – IH.SM – UNIVERSITE DE TOLIARA

INAHINA – REPÚBLICA DE MOÇAMBIQUE

CONSERVATION INTERNATIONAL

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Project aims

Improve resilience in vulnerable coastal areas by ensuring that C-RISe data are used:

- in decision making processes
- in climate adaptation strategy documents or management plans
- to mitigate and prevent impacts from coastal inundation
- to reduce risks to marine traffic and offshore activities

The problem

Very sparse long term in-situ sea level measurements in the region.

Country	Length of coastline (km)	Area (km^2)	Number of tide gauges
UK	12,429	243,610	44 (NTSLF)
Madagascar	4,828	587,041	1
Mozambique	2,470	801,590	4
Australia	25,760	7,692,000	16 (14 SEAFRAME)

Satellite altimeter data can provide “virtual” tide gauges, and offer basis for measuring long term variability.

Data provision

Satellite data:

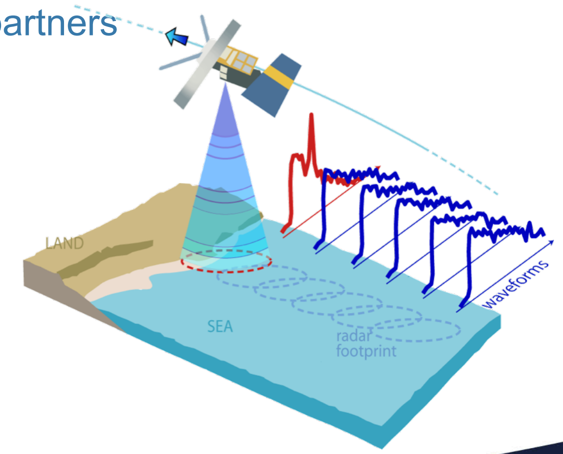
- **Along-track satellite data reprocessed with the NOC Coastal Processor. 2002-2016. Parameters include total water sea level, sea level anomaly and significant wave height**
- Sea state (significant wave height) and wind speed climatologies, 1992-2016.
- Near Real Time satellite wind and wave data, overlaid on model forecasts.
- Surface current climatologies.

In-situ data will include:

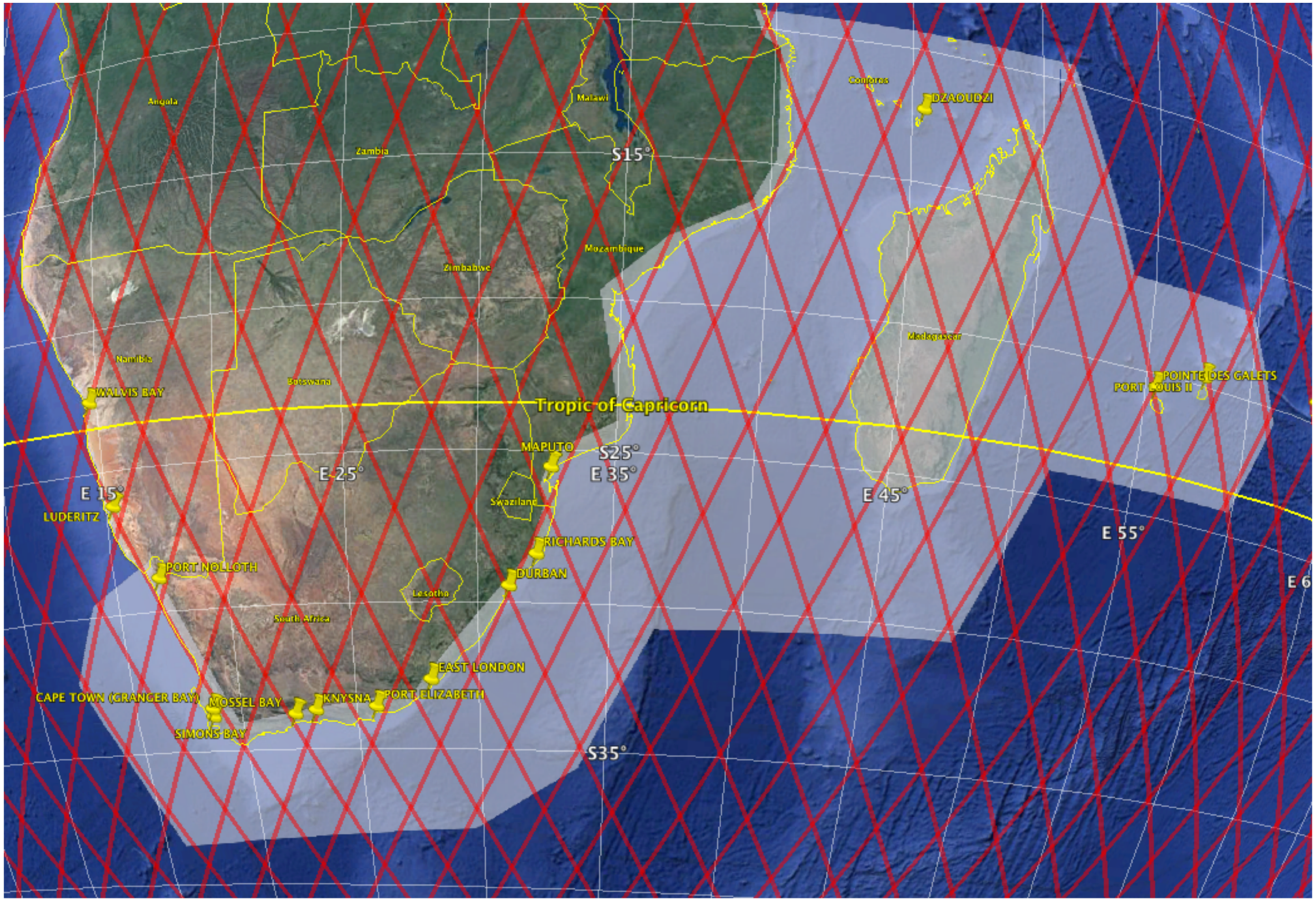
- **Tide gauge data as available from the region: including data from South Africa, Mozambique, Madagscar, La Réunion and Mauritius.**
- Weather station data from Madagascar
- Relevant in-situ marine observations data as available from regional partners

Analyses will include:

- **Sea level analyses from tide gauge and satellite altimeter data:**
  - **Long-term trend**
  - **Annual cycle**
  - **Regional variability characteristics**
- Wind/ wave data
  - Validation of wind/wave data against available in-situ data.
  - Statistical analyses of wind and wave climatologies.

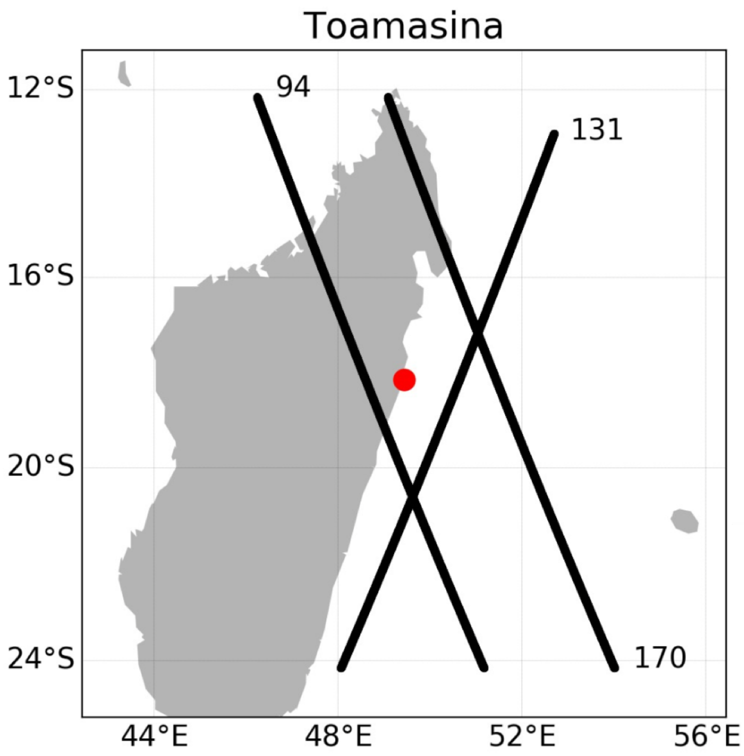


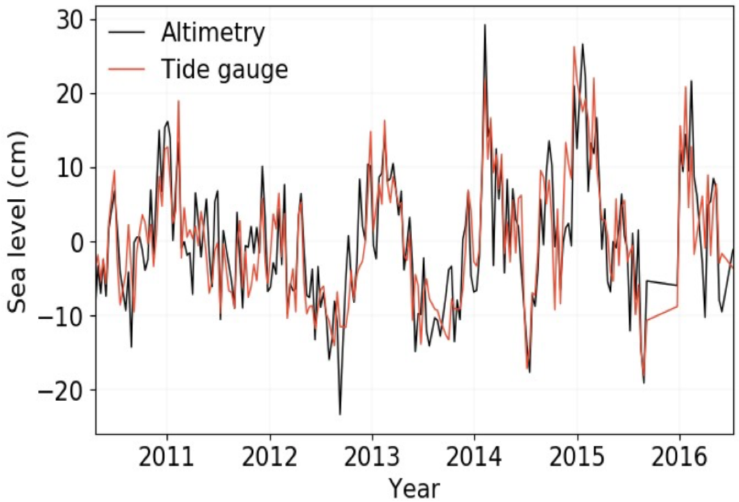
Location



Angola
Zambia
Malawi
S15°
Comoros
DZAOUDZI
Mozambique
Zimbabwe
Namibia
Botswana
Madagascar
WALVIS BAY
Tropic of Capricorn
MAPUTO
S25°
E 35°
E 25°
E 15°
E 45°
LUDERITZ
Swaziland
POINTE DES GALETS
PORT LOUIS II
E 55°
RICHARDS BAY
PORT NOLLOTH
DURBAN
Lesotho
South Africa
EAST LONDON
CAPE TOWN (GRANGER BAY)
MOSSEL BAY
KNYSNA
PORT ELIZABETH
SIMONS BAY
S35°

Validation of altimeter sea level against tide gauge - Toamasina



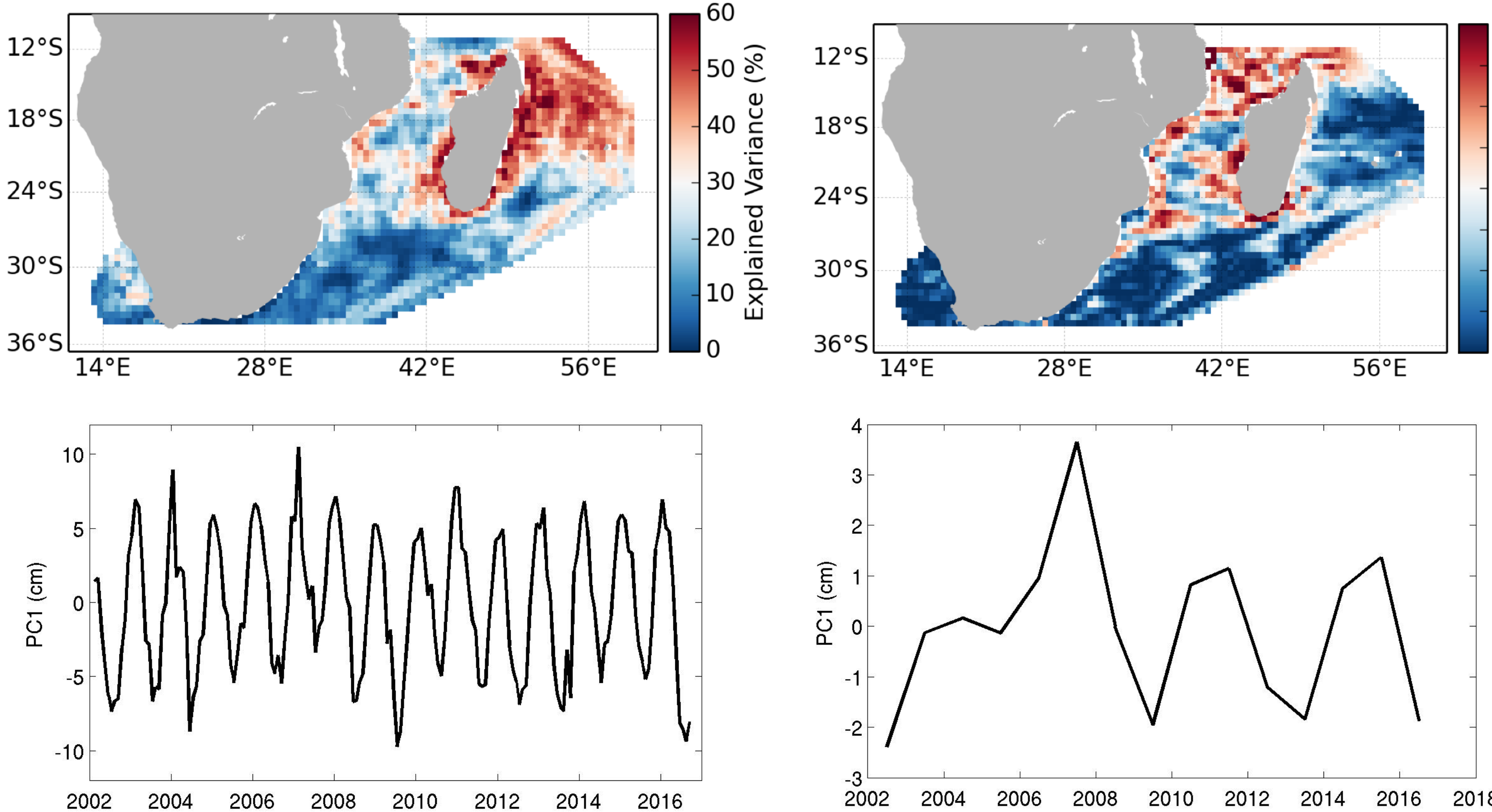


Correlation: 0.83
RMS diff: 5.02 cm
Distance from coast: 6.6 km

	Altimetry	Tide gauge
Annual amplitude (cm)	6.8 ± 1.0	7.0 ± 1.0
Annual phase (days)	32 ± 9	37 ± 8
Semi-annual amplitude (cm)	1.4 ± 0.7	1.8 ± 0.8
Semi-annual phase (days)	22 ± 37	25 ± 21
Max anomaly (cm)	14.4	NaN
Min anomaly (cm)	-12.0	NaN

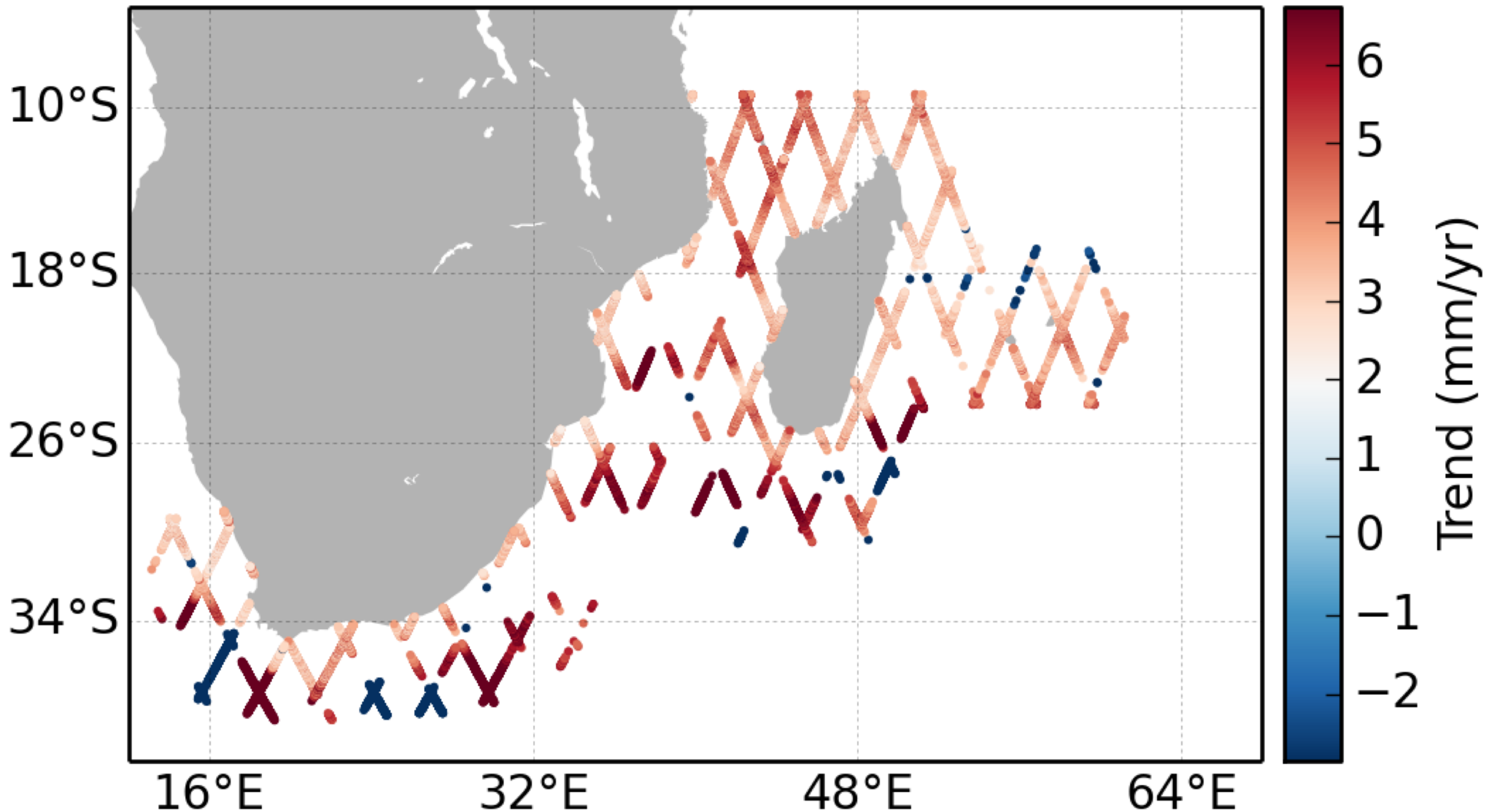
Analysis by R. Rajaonarivony (DGM) using C-RISe analysis software

Variability in Sea Surface Height from C-RISe data



EOF (Empirical Orthogonal Function) analysis of C-RISe sea level, map and time series of detrended (left) monthly means, and right (annual means). The seasonal (annual) cycle dominates the monthly data, the annual data show different behavior in 2005-2008 from the rest of the time series

Sea level trend from C-RISe data 2002-16 (95% sig.)

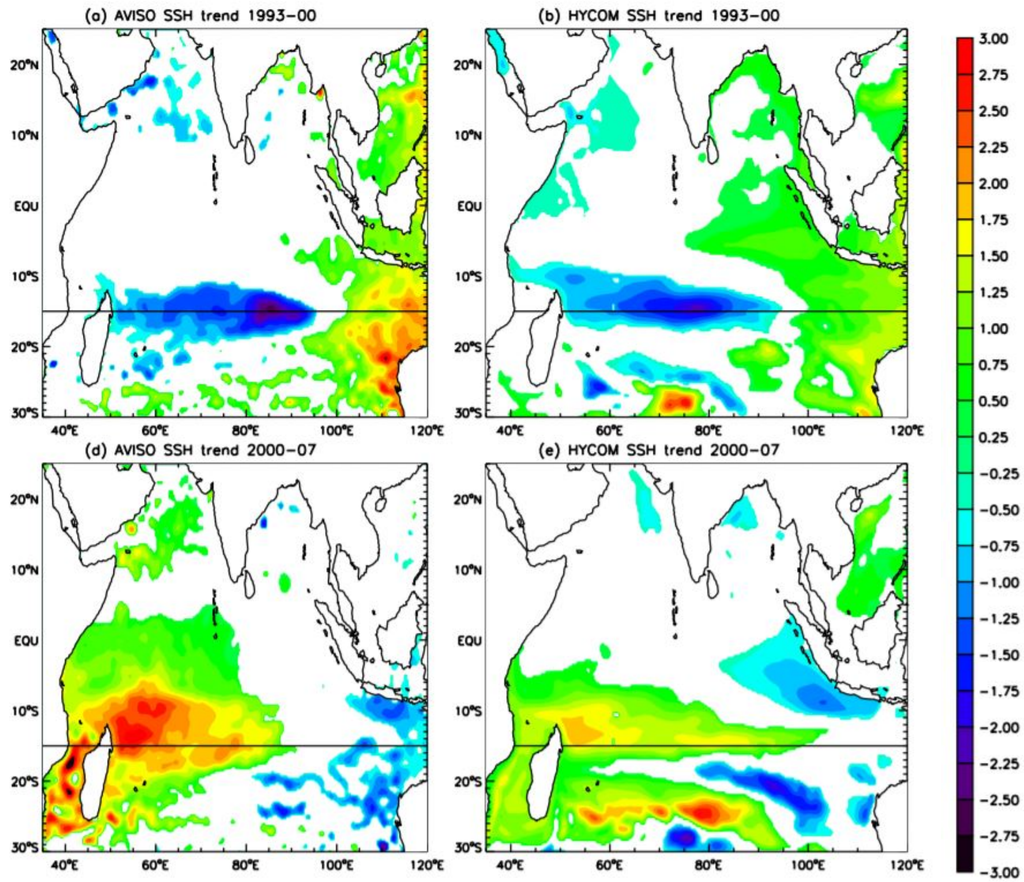


Decadal Variability in Sea Surface Height

Satellite Altimeter — Ocean Model (HYCOM)

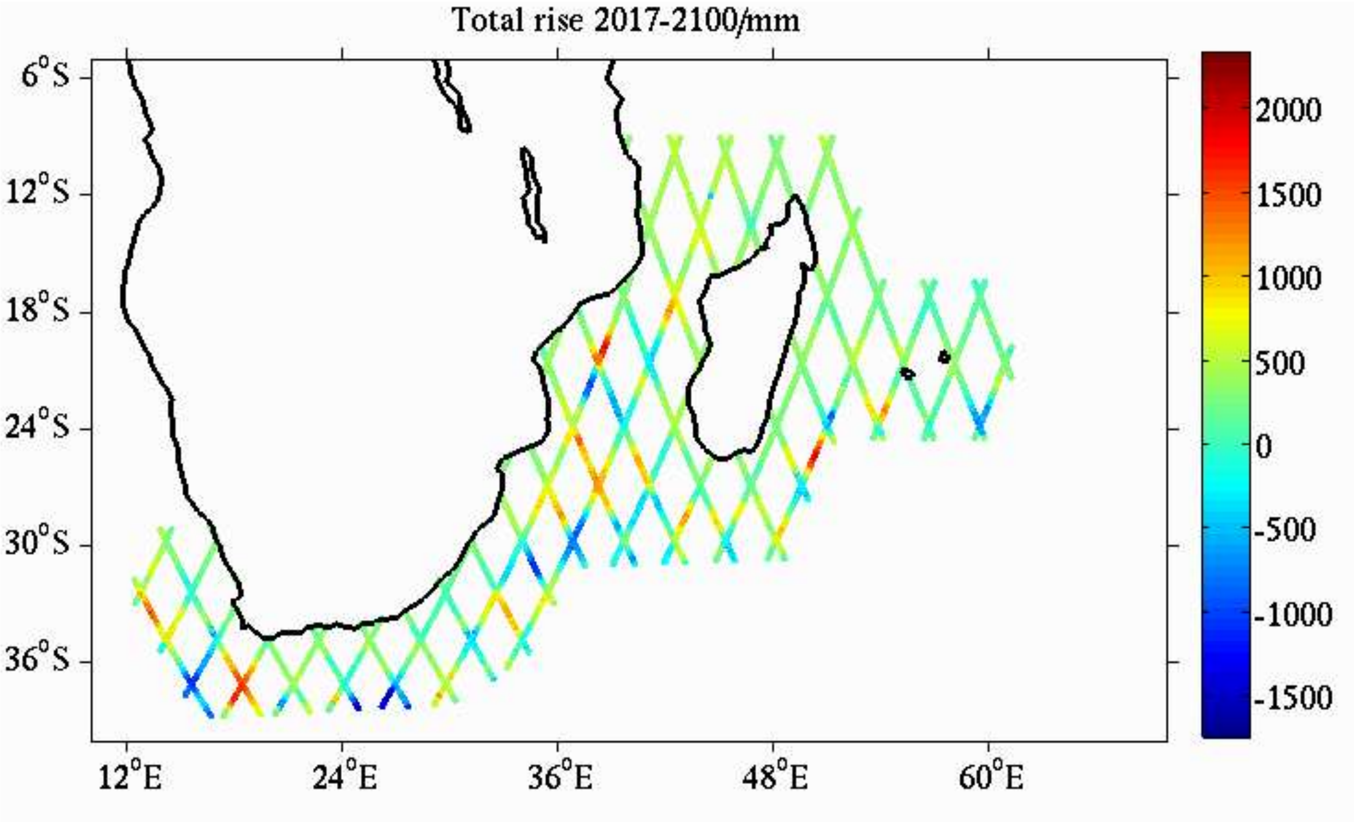
1993-2000

2000-2007



Trenary, L.L. and Han, W., 2013, Local and remote forcing of decadal sea level and thermocline depth variability in the South Indian Ocean, Journal of Geophysical Research: Oceans, 118, 1, 381-398

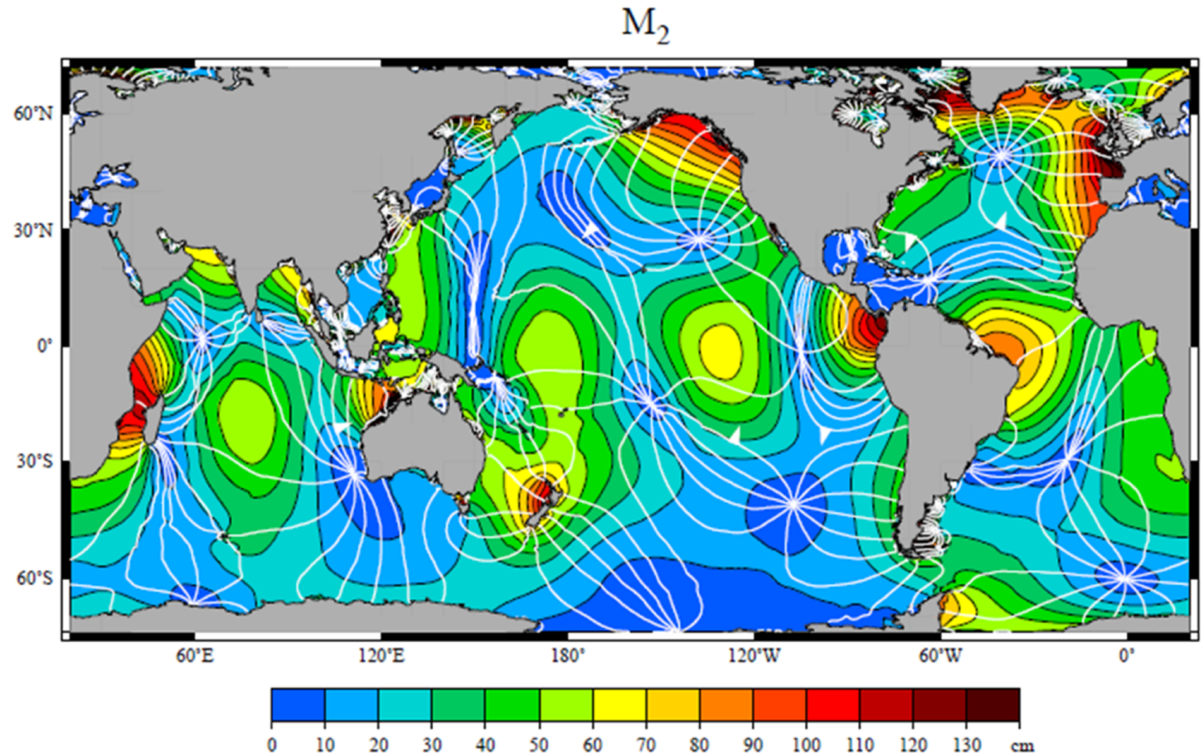
Total projected SLR by 2100



Work in progress to relate the total projected sea level rise by 2100, derived from C-RISe altimetry, to changes in MHW based upon Pickering et al. (2012)

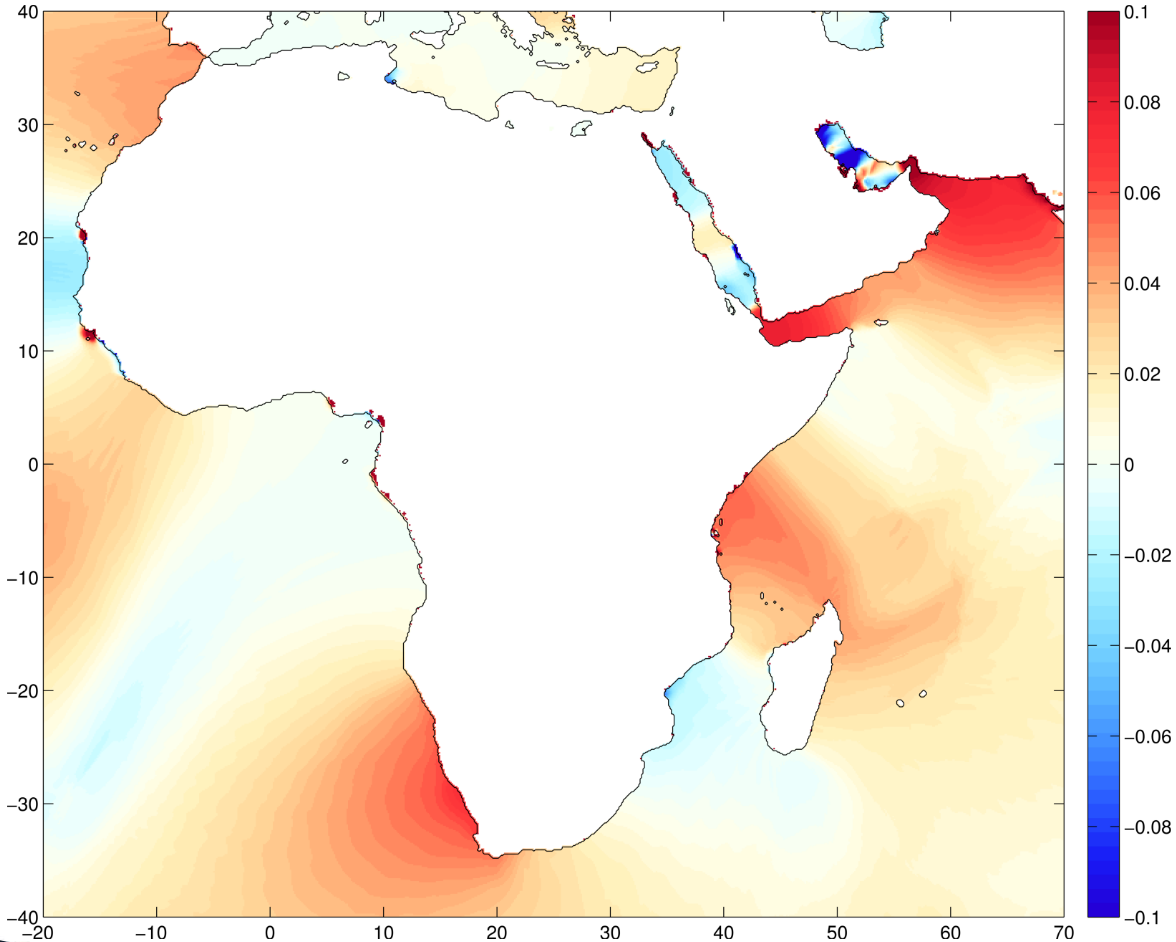
Tides

- Pickering et al. (2012) Semidiurnal tidal regime dominates on European Shelf, so study evaluated impact of various SLR scenarios on M2 tide. Found that in near-resonant regions, amplitude of M2 is significantly increased.
- Mozambique/Madagascar tidal regime is also predominantly semidiurnal, so we can use C-RISe projected SLR to make similar inferences



(Pugh and Woodworth, 2014)

Projected Change in Mean High Water (2 m SLR)



Projected change in MHW (m) around the coast of Africa, under 2 m of uniform SLR (Courtesy of M. Pickering)

Summary

- Altimetry data provides long-term data on sea surface height to locations which do not have reliable data sets from tide gauges
- Annual variability and inter-annual variation are much larger than observed sea level change
- We need to be aware of longer term (decadal) variations
- Using C-RISe data, projected sea level rise to 2100 is ~0.5 m
- The Mozambique Channel is dominated by semidiurnal tides, we will therefore be able to use the method of Pickering et al. 2012 to estimate the effect of rising sea level on Mean High Water

Thanks for your attention