C-RISe – Coastal Risk Information Service
UKSA International Partnership Programme

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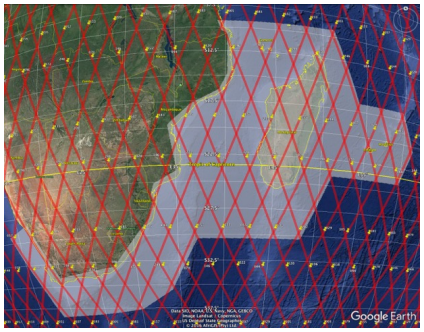

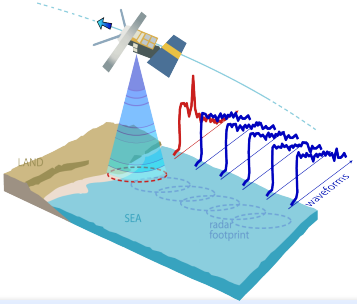

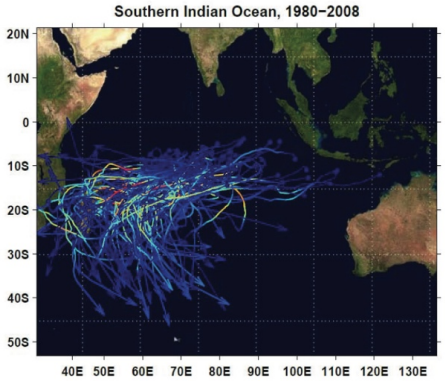

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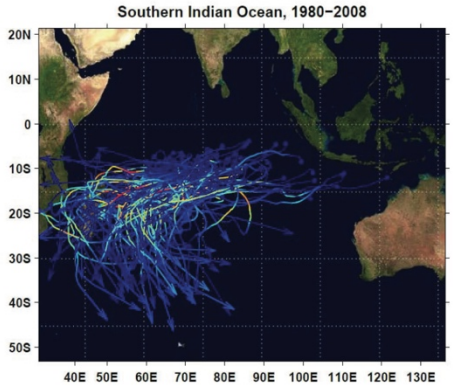
C-RISe Overview: Objectives

- **C-RISe:** A 3 year project to develop, deliver and evaluate a Coastal Risk Information service to South Africa, Mozambique and Madagascar
- Supported by UK Space Agency'International Partnership Programme
- Objectives:
  - Deliver a **Coastal Risk Information service**, providing satellite-derived information about sea level, wind and waves to support coastal vulnerability assessment and hazard management efforts.
  - Apply and evaluate the C-RISe service through a set of **Use Cases**, applying the C-RISe products to end use applications that address local priorities.
  - Build **local capacity** to use satellite data to provide **scientific decision support** for strategy development and management of coastal areas to increase resilience to coastal hazards

C-RISe Overview: Why is it needed?

- Global sea level is increasing, and large scale weather patterns are changing.
- Mozambique, Madagascar and South Africa have significant coastal populations and ecosystems vulnerable to changes in met-ocean climate.
- Mozambique and Madagascar are highly exposed to the cyclone surges, and have economically important coastal ecosystems sensitive to climate change.
- Access to improved regional information on coastal threat factors will allow plans to protect coastal communities and safeguard economic activity.



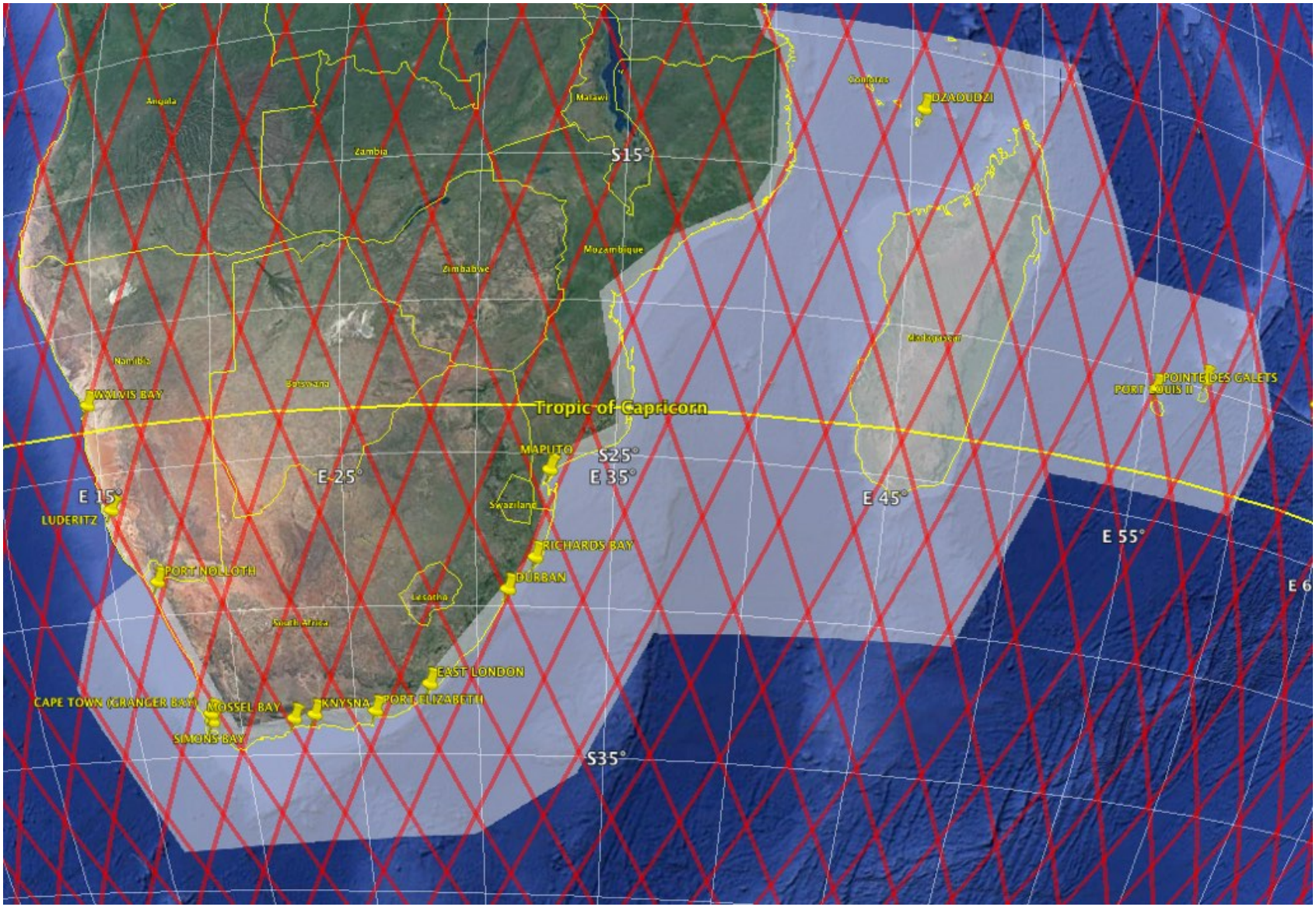
C-RISe Service: Products

- **What Products / Information is CRISe delivering?**

- Reprocessed Satellite altimeter data (using the NOC ALES processor) to provide accurate sea-level information along the coast of Madagascar and SE Africa.
- Satellite wind and wave data (climatologies and near real time), and derived statistics.
- Validation against local data sources and analyses of regional, seasonal & inter-annual variability.
- Delivered through a regional geo-spatial information tool, developed by CSIR.

Parameter	Description	Time Coverage	Satellites
Total Water Level Envelope, Sea Surface Height Anomaly, Significant Wave Height, Surface Radar Backscatter (σ^0)	Along track data from the NOC coastal processor	2002-2016	Jason-1, Jason-2, Jason-3
Significant Wave Height and Wind Speed Climatologies	Monthly, 1° x 1° gridded climatologies, from Globwave	1992-2014	ERS-1, ERS-2, Envisat, Topex, Jason-1, 2,3
Significant Wave Height, wind speed	Near Real Time along track data	Daily updated	Jason-2,
Wind speed and wind direction	Near Real Time data across scatterometer swath (25km resolution)	Daily updated	Metop/ ASCAT-A

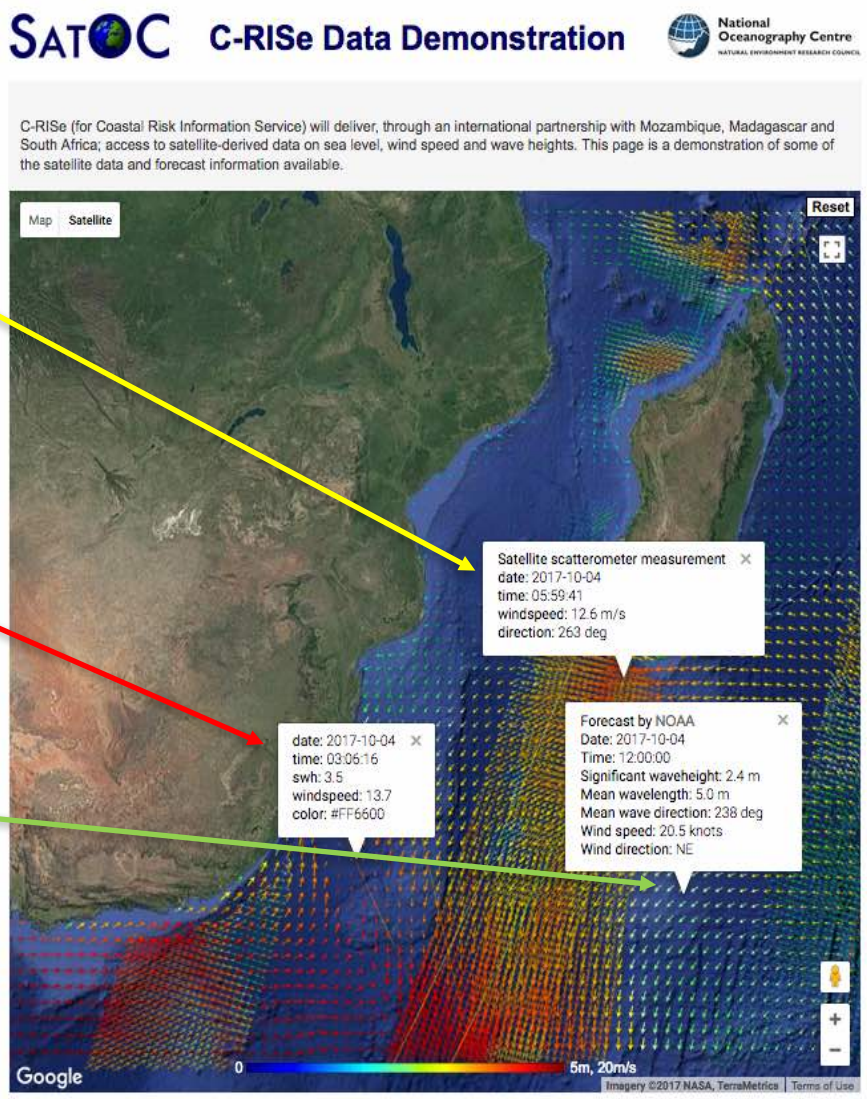
C-RISe Service: Coverage



C-RISe Service: Near Real Time

- Wind speed and direction from satellite scatterometer (ASCAT)
- Along track wind speed and wave height data from satellite altimeter, most recent passes (Jason-2, Jason-3, AltiKa, Sentinel-3)
- Forecast winds and waves from US NOAA model

http://www.satoc.eu/projects/c-rise/demo.html

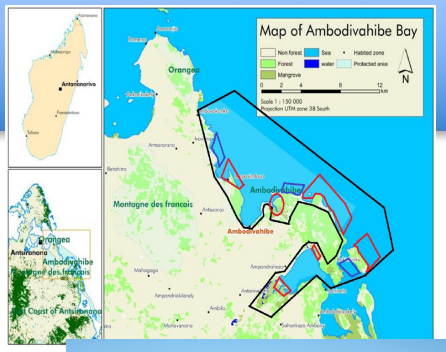


C-RISe Applications: Use Cases

- Use Cases provide the basis for practical implementation and the Monitoring and Evaluation of the CRISe service in each partner country – testing the usefulness and benefits of the service in real life applications.
- In the region, there are internationally important marine ecosystems, but fairly basic infrastructure, with limited resources to maintain or improve.
- Very high level of interest: 9 Use Cases in Mozambique; 16 Use Cases in Madagascar, when we were only planning for 4 in total.
- Focus on developing national capability in accessing and applying EO data.
- Strong capacity building / training element:
  - Series of workshops
  - Python software for sea level validation/ analysis; and for wind/wave climatology statistical analyses
  - Development of Bilko tool to read NOC coastal altimeter product

C-RISe Applications: Use Cases

- Marine Protected Area Management - Information Services



- Near Real Time Sea State Information
  - Maritime safety, search and rescue support
  - Operational Planning: illegal logging, smuggling, pollution
  - Improved tropical storm information

- Sea Level Analyses:
  - Tidal Analyses, extreme events, inter-annual variability
  - Understanding changing coastal risk
  - Port development, coastal defences

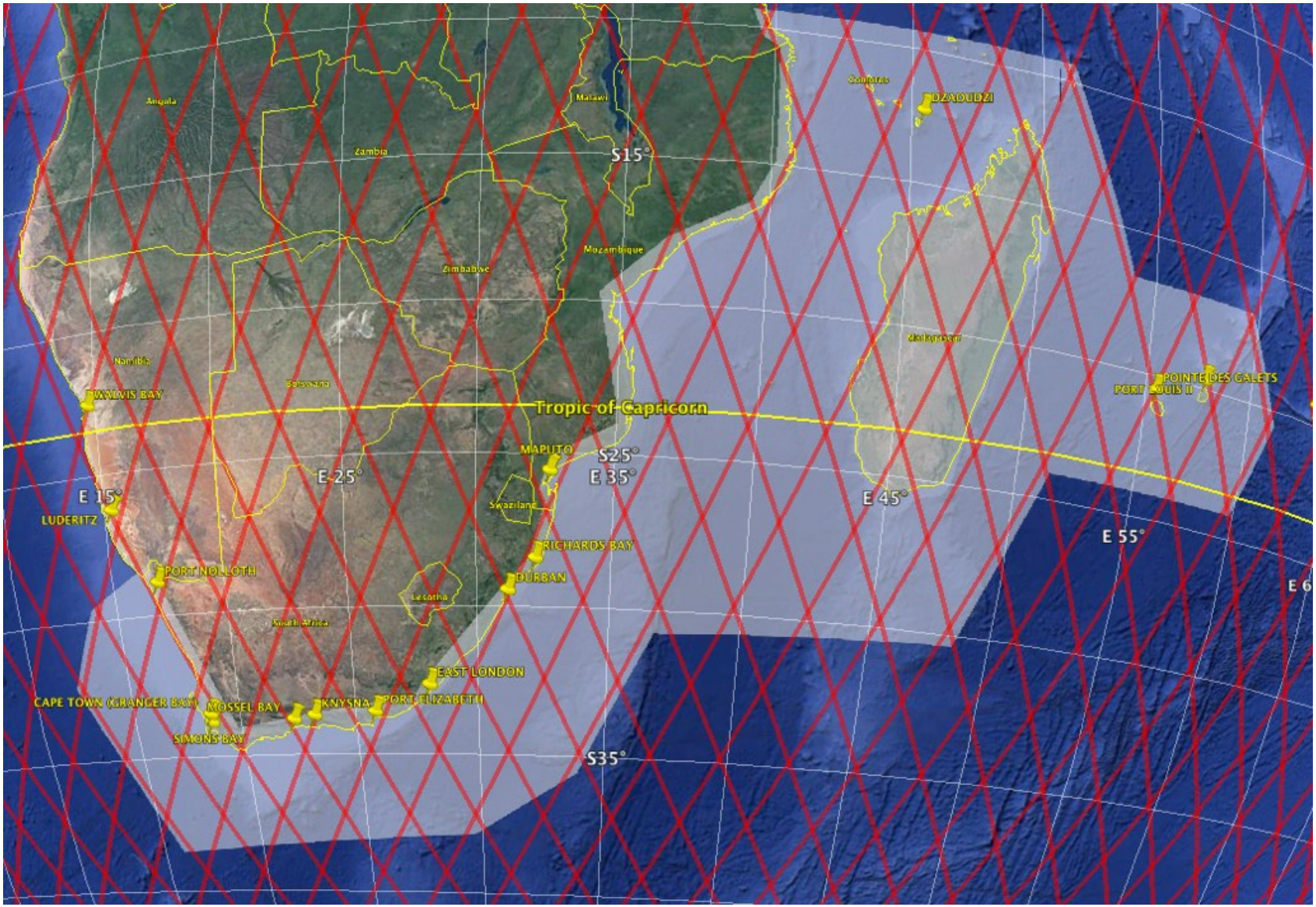
- Wave and Wind (and current) climatologies
  - Operational planning
  - Coastal and Marine Atlas
  - Wind and wave energy resource
  - Infrastructure planning and developments

- Climate change impact on marine ecosystems
  - Mangroves, coral reefs, turtles, shrimp fisheries,
  - Algal blooms, sea water quality, pollution, acidification

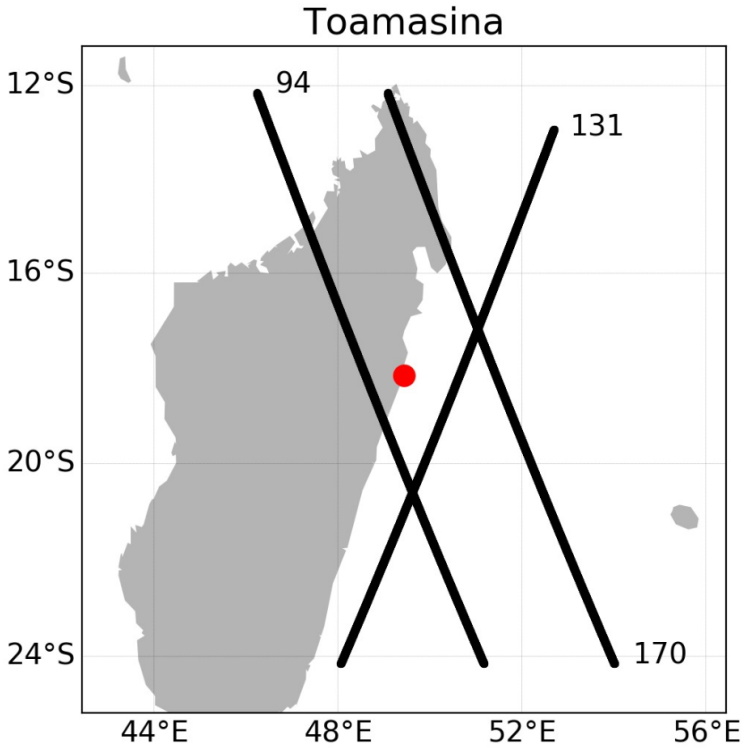
C-RISe Service: Coastal Processing

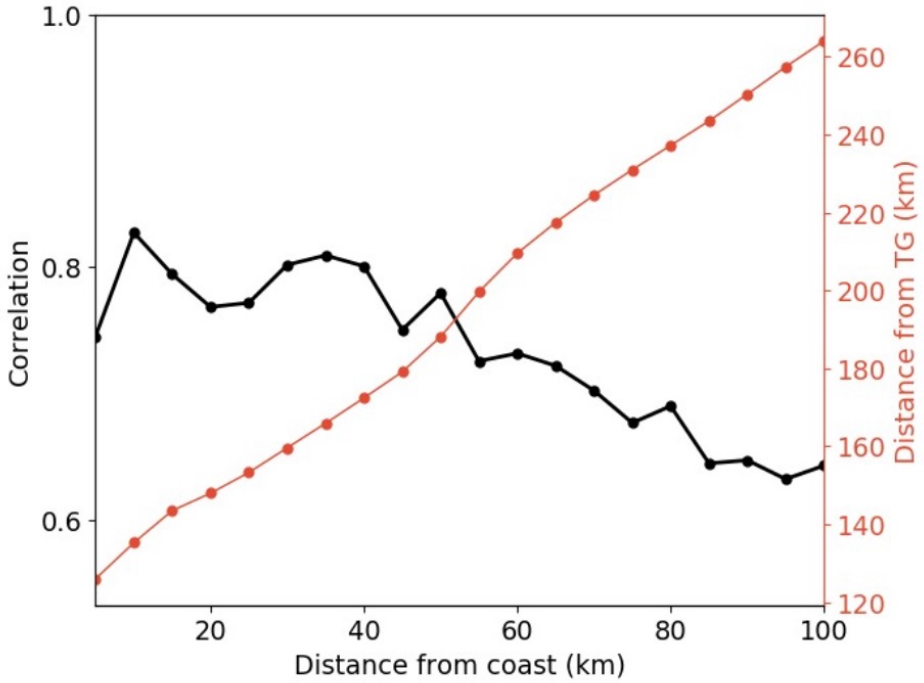
- NOC ALES processor *(Passaro et al, 2014)*
  - Jason-1, Jason-2 data (Jan 2002 – Sept 2016)
  - Coastal Geophysical Data Records
    - Time, location (lat, lon), TWLE, SSHA, SWH, σ^0, geophys corrns (inv bar, tides,…)
- Along-Track Co-located Time Series on Reference Tracks
    - TWLE, SSHA, SWH , σ^0
- Trends and Variability
    - Long-term sea level trend in mm/yr (2002-2016).
    - Annual sea level cycle (amplitude and time of maximum).
    - Inter-annual variability (characterised by the standard deviation and maxima of the annual sea level values).

C-RISe Service: Coverage



Validation of altimeter sea level vs Tide Gauge - Toamisina





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

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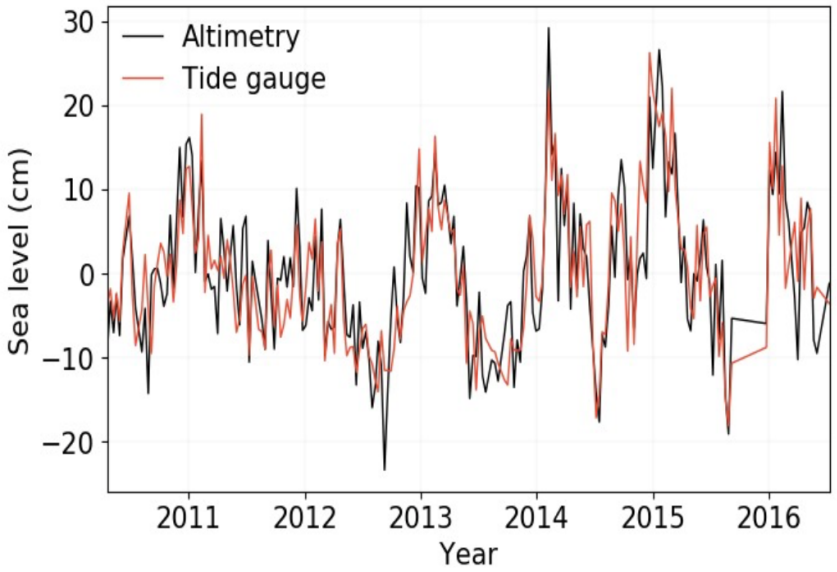


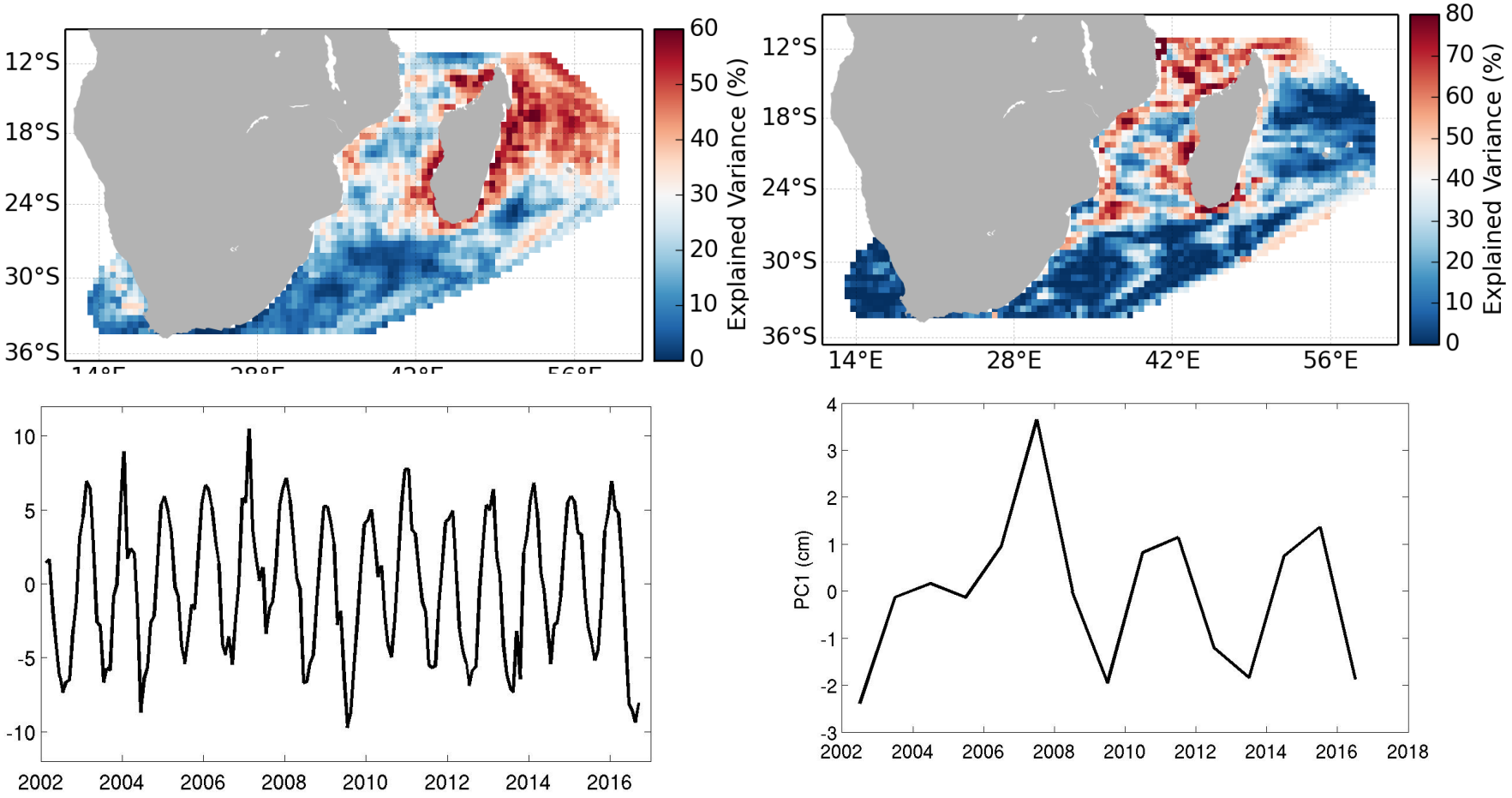
Corr 0.83
Rms diff 5.02 cm
Dist fm coast 6.6 km

	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

C-RISe Analyses

Variability in SSH from C-RISe data

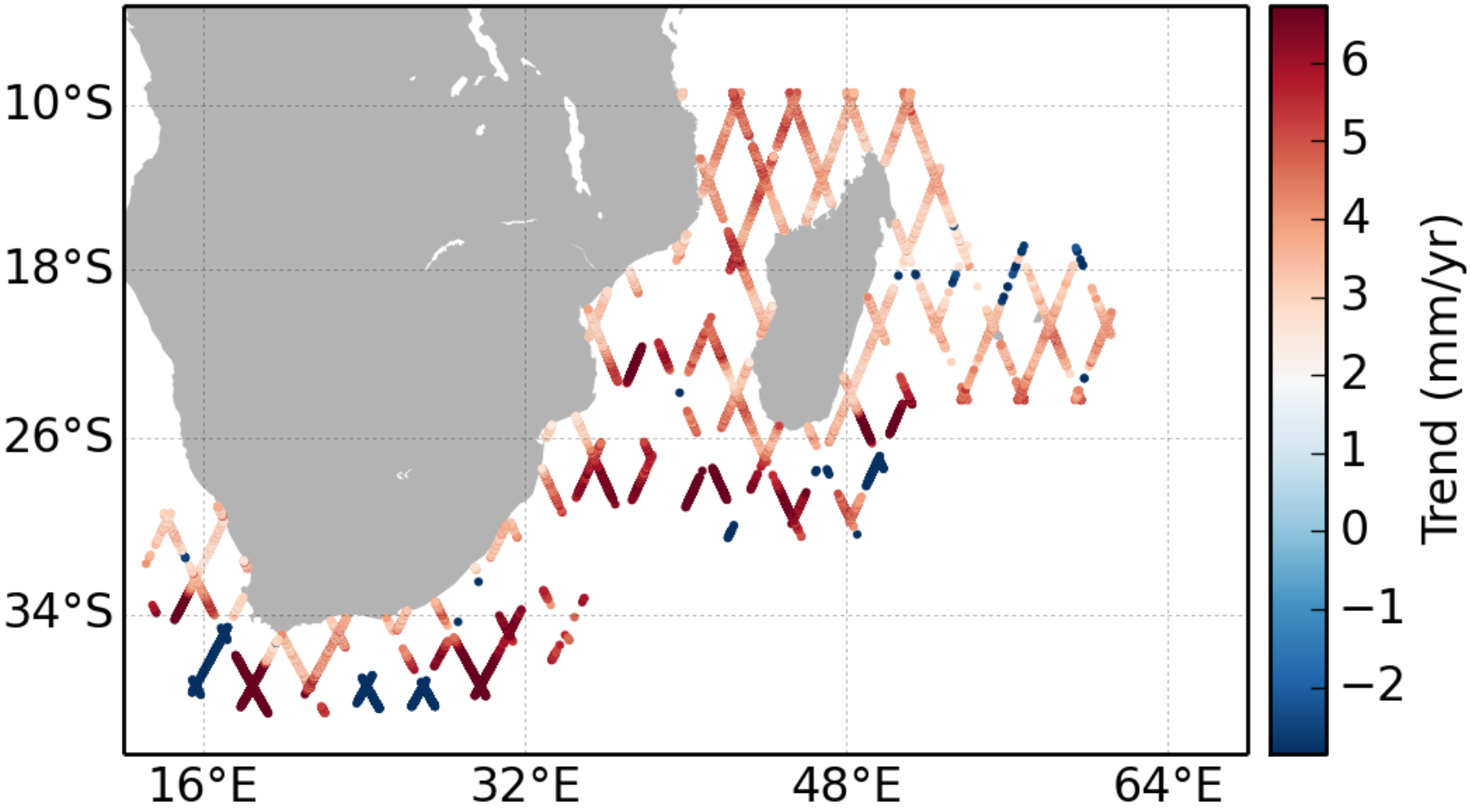


EOF (Empirical Orthogonal Function) analysis of C-RISe sea level, map and time series of detrended (left) monthly means, and right (annual means). The seasonal (annual) cycle dominates the monthly data, the annual data show different behaviour in 2005-2008 from the rest of the time series

Analysis by F Calafat (NOC)

C-RISe Analyses

Sea Level Trend from CRISe Data 2002-16 (95% sig)



Trends significant at the 95% confidence level

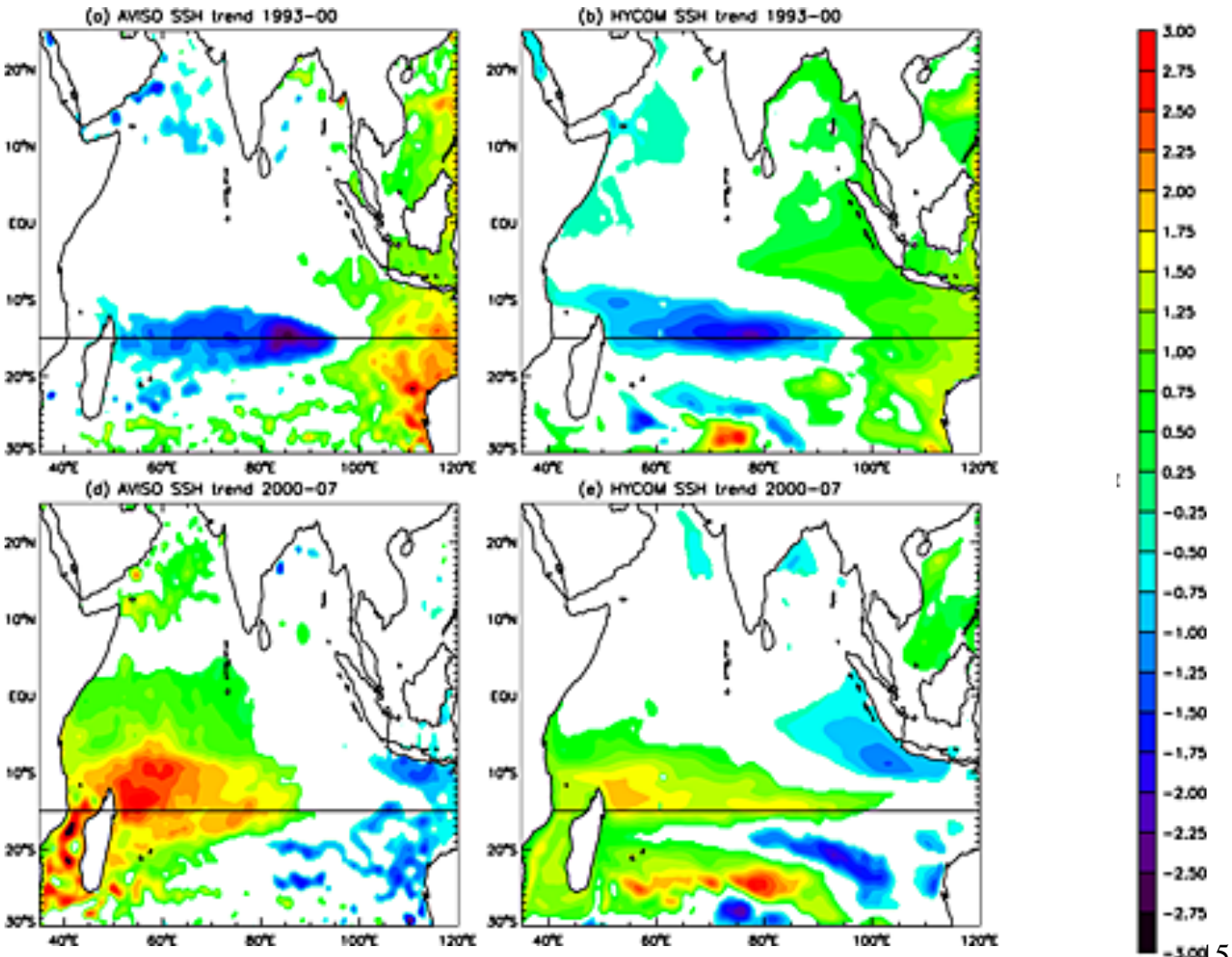
Regional Variability in SSH

Satellite Altimeter | **Ocean Model (HYCOM)**

SSH Trend

1993-2000

2000-2007



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http://onlinelibrary.wiley.com/doi/10.1029/2012JC008317/full#jgrc20035-fig-0005

C-RISe Application to Storm Surges?

- Mozambique is particularly vulnerable:
  - Low lying coastal plains
  - High population concentrations at the coast
  - Low capacity to defend infrastructure / inadequate and ageing coastal defences
  - Risk expected to increase as a result of climate change
- Tropical Storms / cyclones making landfall on Mozambique Coast during 2002-2016 listed below

Year	Name	Landfall	Date	Strength	Wind speed
2003	Japhet	South	2 March	Cat 2	167 km/h
2002	Atang	North	13 Nov	TD	46 km/h
2004	Delfina	Central	1 Jan	TS	93 km/h
2007	Favio	South	22 Feb	Cat 3	185 km/h
2008	Jokwe	North	8 Mar	Cat 3	180 km/h
2012	Dando	South	17 Jan	TD	85 km/h
2012	Funso	North	22,23 Jan	Cat 4	205 km/h

- Next steps:
  - Are there CGDR products at the time / location of these events?
  - Access e-Surge data base

Summary and Conclusions

- 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.
- Very sparse long term in situ sea level measurements in the region, satellite altimeter data can provide “virtual” tide gauges, and offer basis for measuring long term variability.
- 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.

Thank you!

http://www.satoc.eu/projects/c-rise/