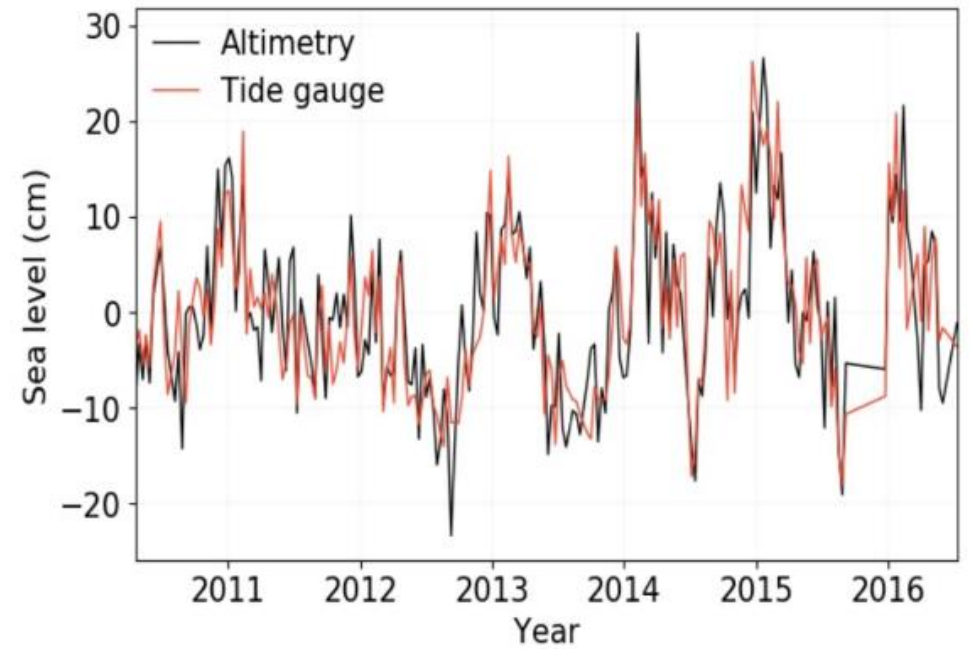
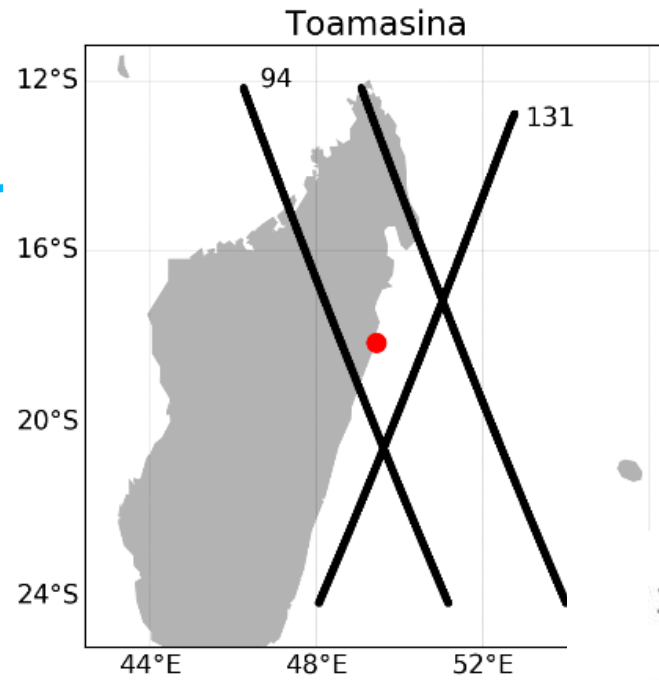
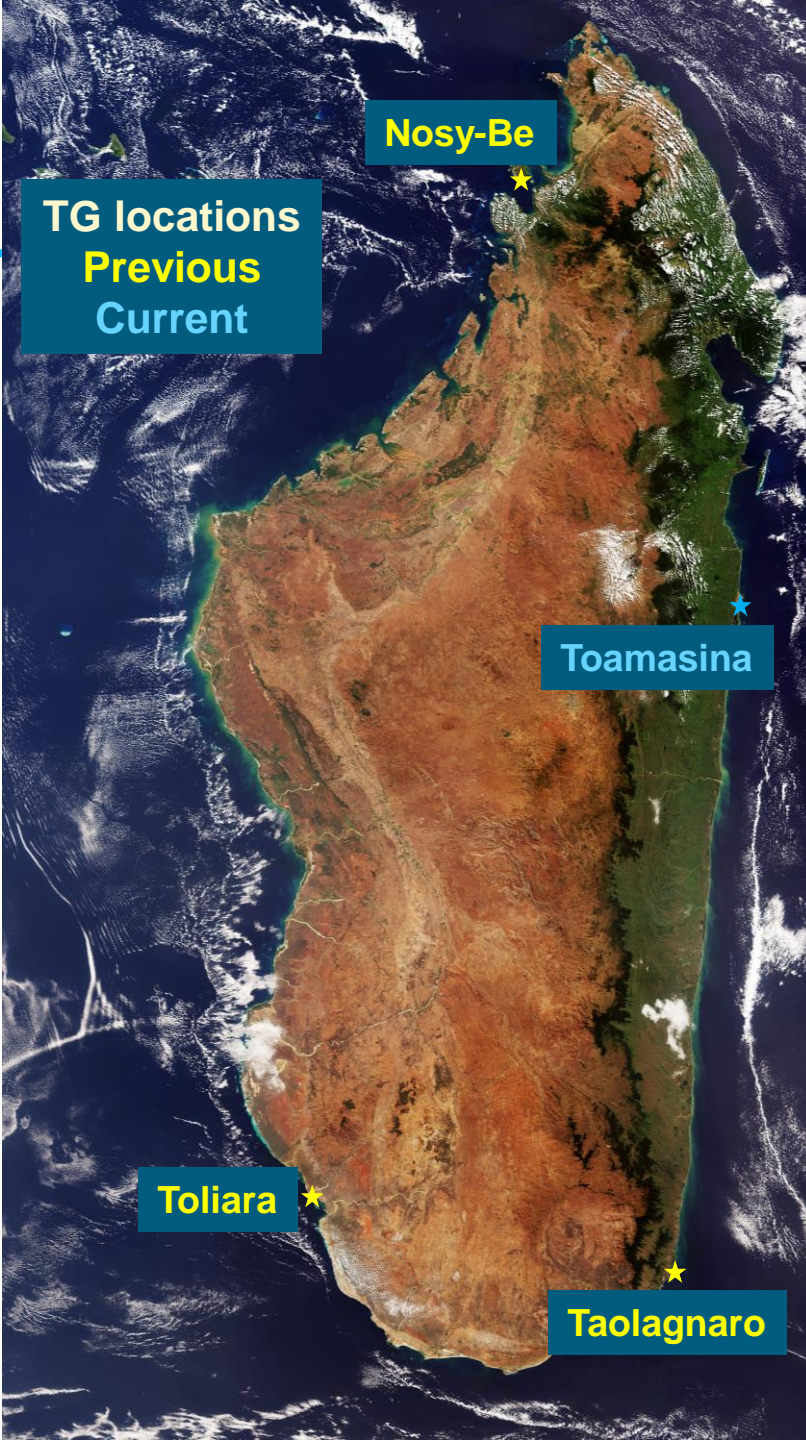


National
Oceanography
Centre

**PASS-SWIO
PORTAGAUGE AND SATELLITE SEA
LEVEL MONITORING SYSTEM FOR
THE SOUTHWEST INDIAN OCEAN**



Sea level data are vital for



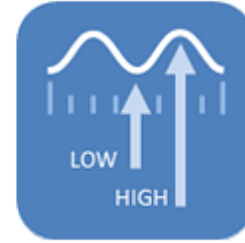
Research into sea level change and ocean circulation



Coastal protection during events such as storm surges



Providing flood warning and monitoring tsunamis



Tide tables for port operations, fishermen, and recreation



Defining datums for national or state boundaries

Sea level is one of the most useful oceanographic variables, used for a wide variety of scientific, economic and social purposes.

SEA LEVELS VARY ON DIFFERENT TIMESCALES

- Tsunamis (minutes to an hour)
- Seiches (minutes to hours)
- Tides (daily, 2 x daily)
- Storm surges (few days)
- Seasonal cycle (annual, semiannual)
- Mean sea level changes (months – millennia)



Captured by tide gauges



Captured by satellite altimetry

Tide gauges can measure all of these features provided they offer high frequency sampling and long (>30yr) duration. Satellite altimetry can capture the longer-term variations.

PORTAGAUGE

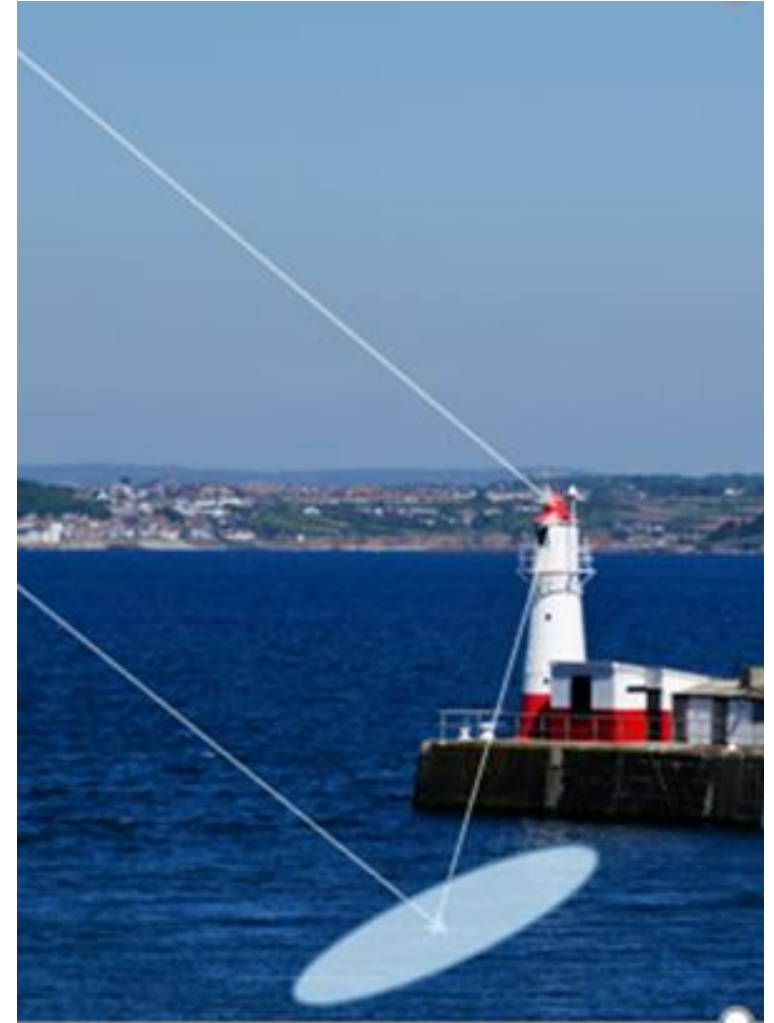
The project aims to establish a sea level monitoring system for Madagascar based on the installation and deployment of a low-cost relocatable tide gauge – Portagauge.

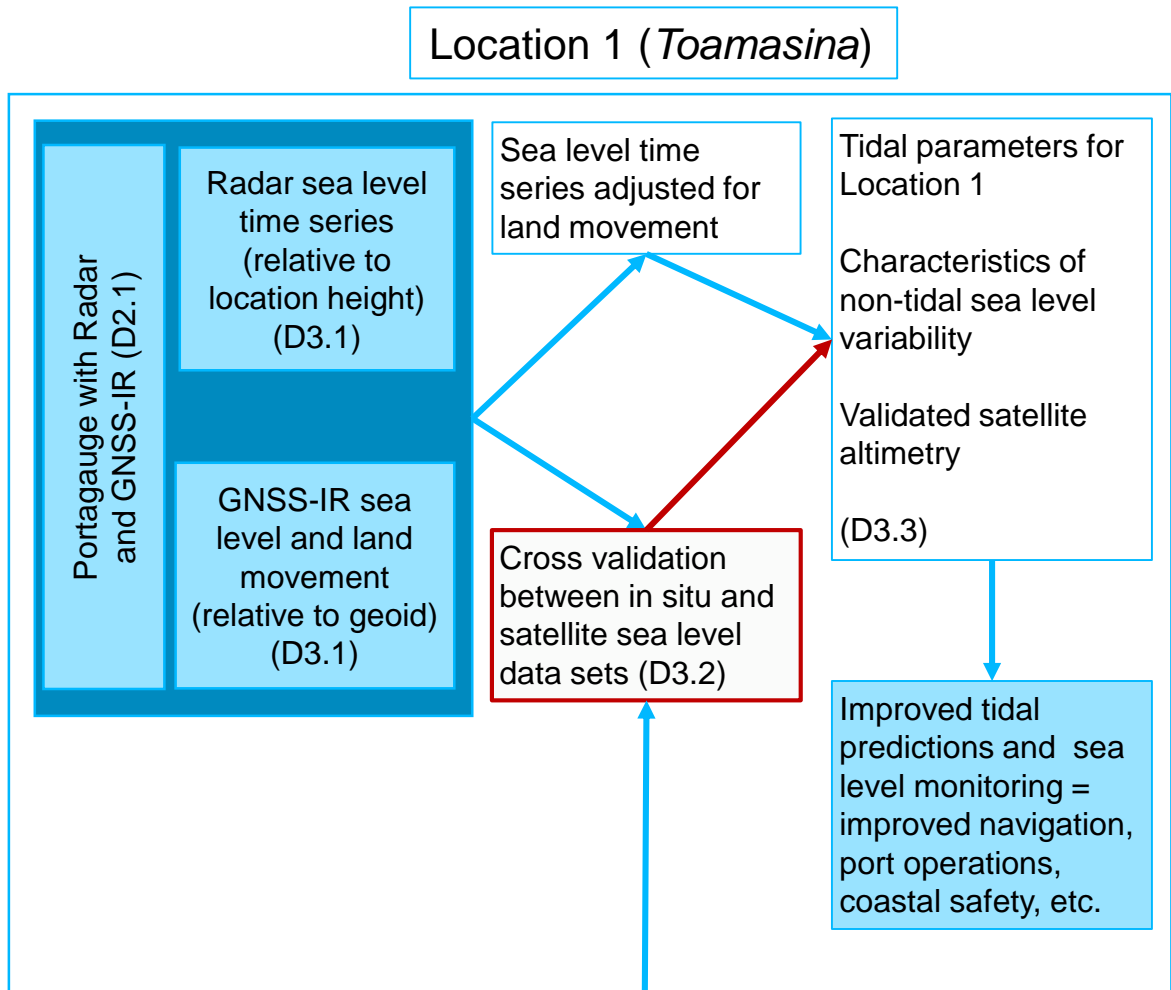
- Conventional radar tide gauge (measuring sea level to local fixed datum on land)
- GNSS measuring sea level and land motion relative to geoid
- Relocatable platform for campaign measurements where tide gauges are few
- Level instruments to local benchmarks
- Post-process GNSS-IR data, vertical land motion and radar data to establish relationship between local benchmarks, geoid, absolute sea level and relative sea level



GNSS - INTERFEROMETRIC REFLECTOMETRY

- GNSS-IR exploits a periodic variation in the signal-to-noise ratio between a direct GNSS signal and one that is reflected from a relatively flat surface (such as the sea)
- Allows the elevation of the flat surface (i.e. sea level height) to be inferred in a geocentric reference frame (the same as satellite altimetry)

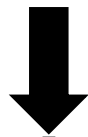




Satellite Altimeter Sea Level (along-track)
Validation reference, 20 year time series and spatial variability (D3.1)

National sea level monitoring system
Road Map (D4.1)

Move Portagauges to Location 2



Move Portagauges to Location 3



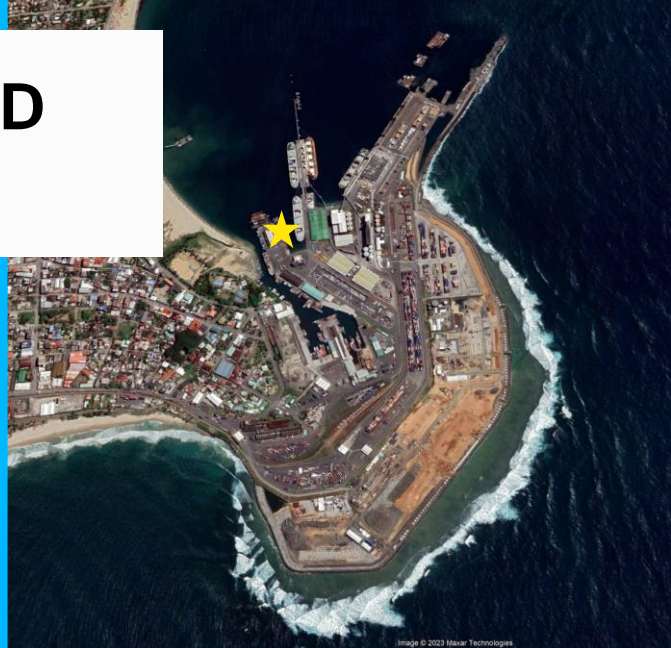
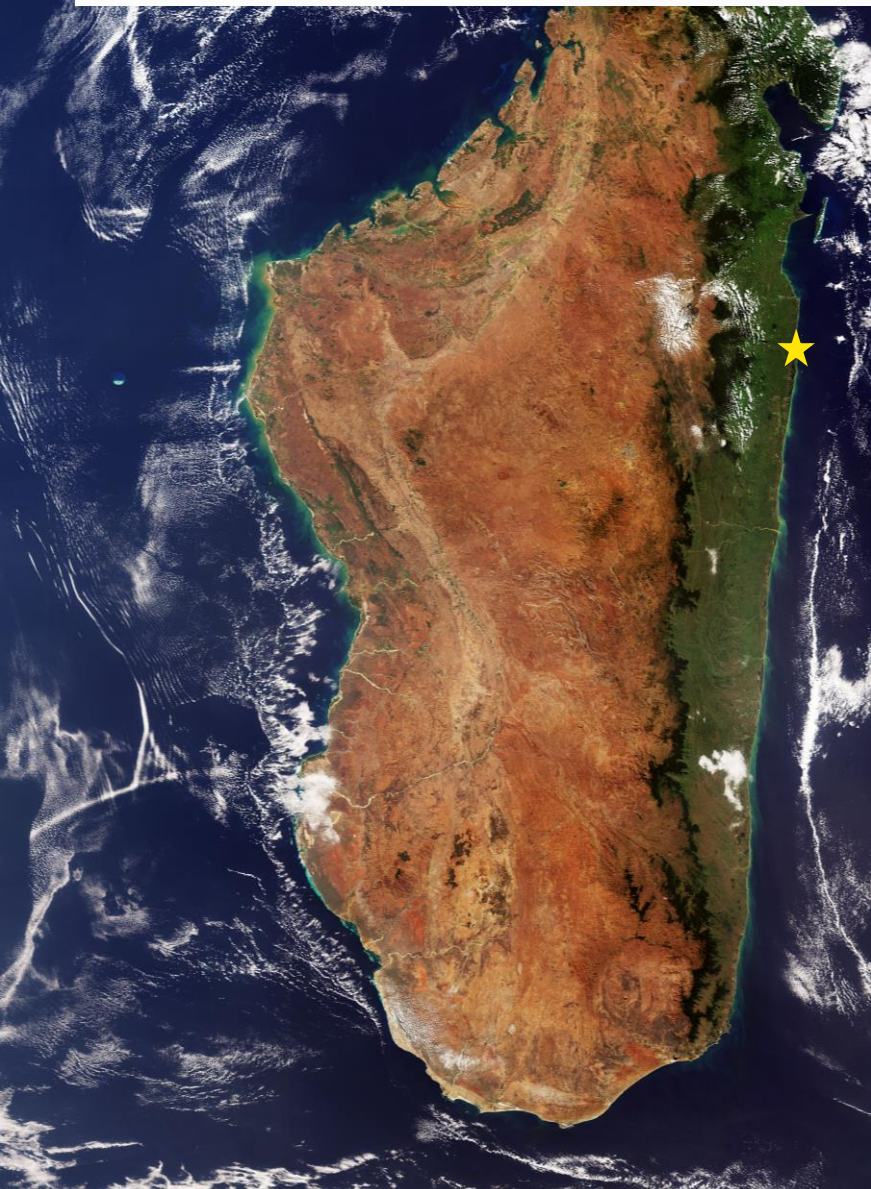
Relocate Portagauges and repeat data collection and analysis

Improved tidal predictions and sea level monitoring = improved navigation, port operations, coastal safety, etc.

End of ESA-funded project

PORTGAUGE INSTALLED

13TH JUNE 2023

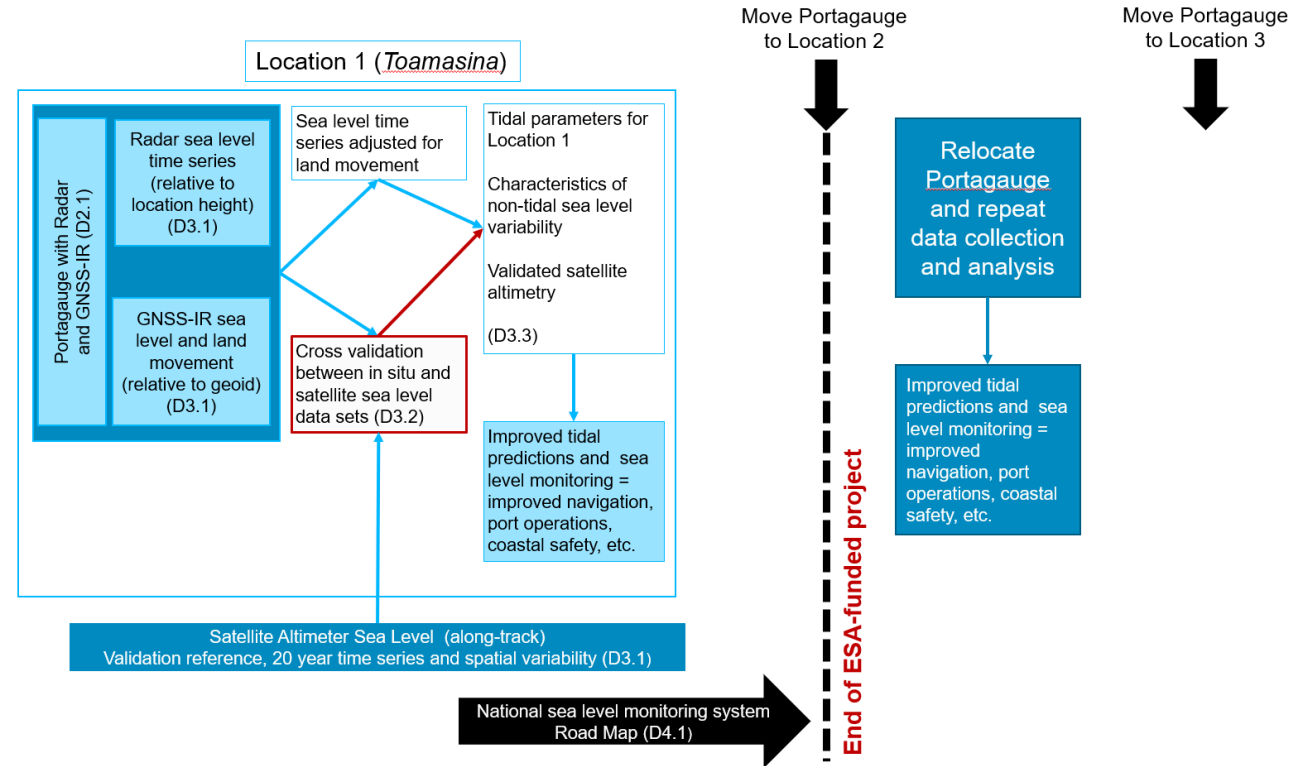


NEXT STEPS

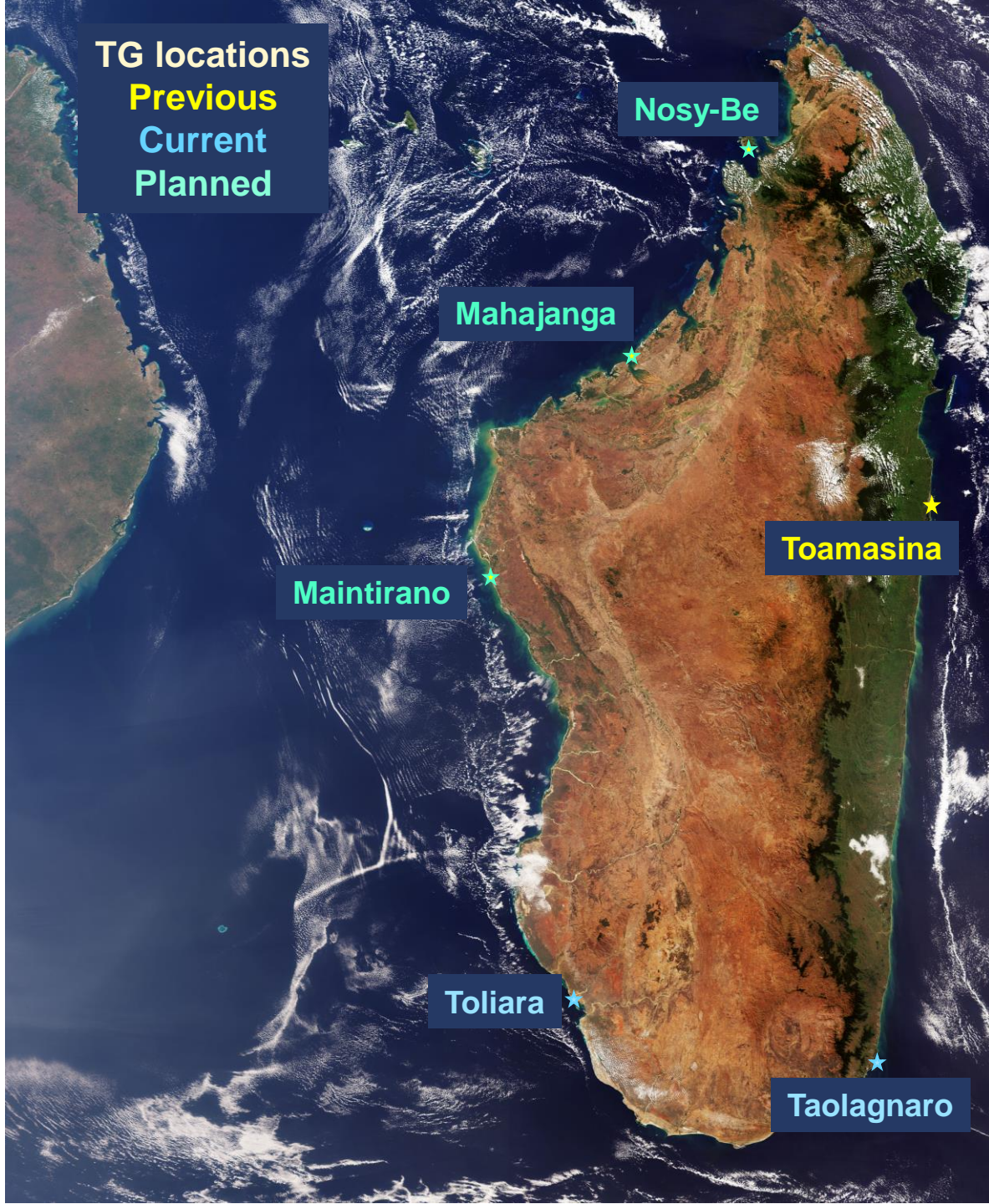
Reporting to European Space Agency (ESA)

- Data sets
- Validation report
- Sea level variability report
- Road map

Identify funding opportunities



INITIAL ANALYSIS OF POSSIBLE FUTURE PORTAGAUGE LOCATIONS



CONSIDERATIONS FOR FUTURE LOCATIONS

To understand sea level

- Tidal and non-tidal variability

Important considerations

- Changes in sea level
- Locations prone to flooding and erosion
- Most vulnerable populations
- Vulnerable infrastructure
- Port operations

Practicalities

- Cross validation of tide gauge and portogauge
- Security
- Suitable site available
- People available to operate
- Site access

SITE SUITABILITY FOR TIDE GAUGES

An ideal location for a tide gauge:

- Away from risks of shipping and construction
- On flat, solid, stable ground
- Does not dry out at low water
- Exposed to the open ocean (i.e. not up-river, in an estuary or behind sand banks or lagoons).
- Harbours are suitable as they are exposed to the ocean, but also provide some protection from extreme conditions

Avoid these!

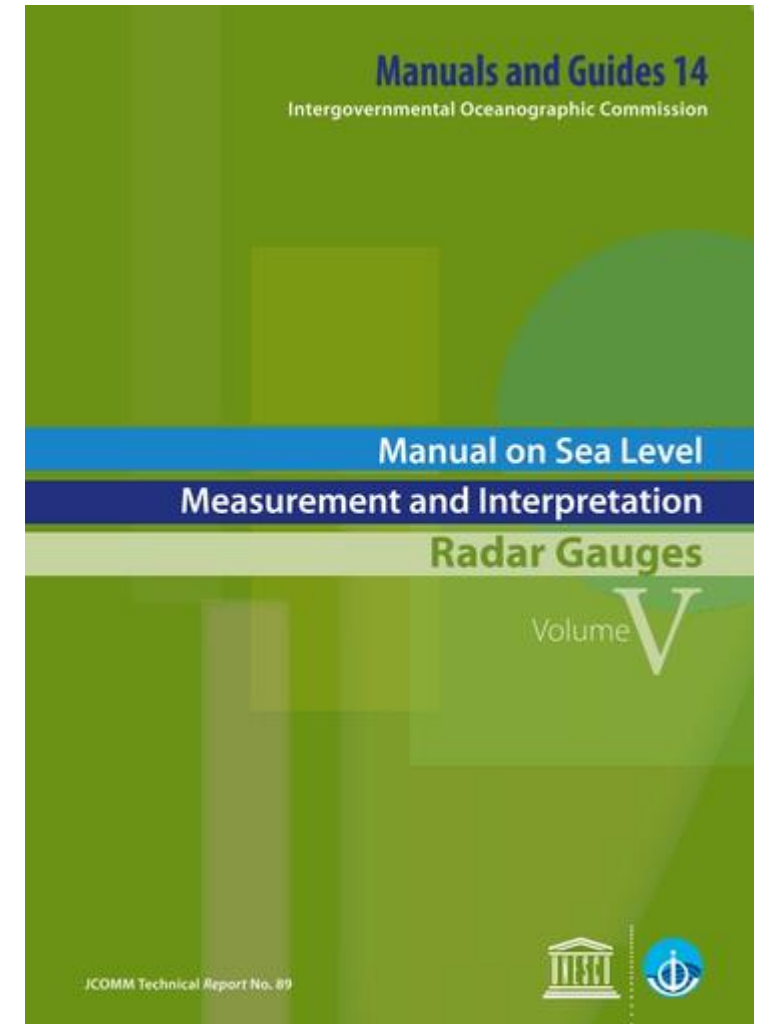
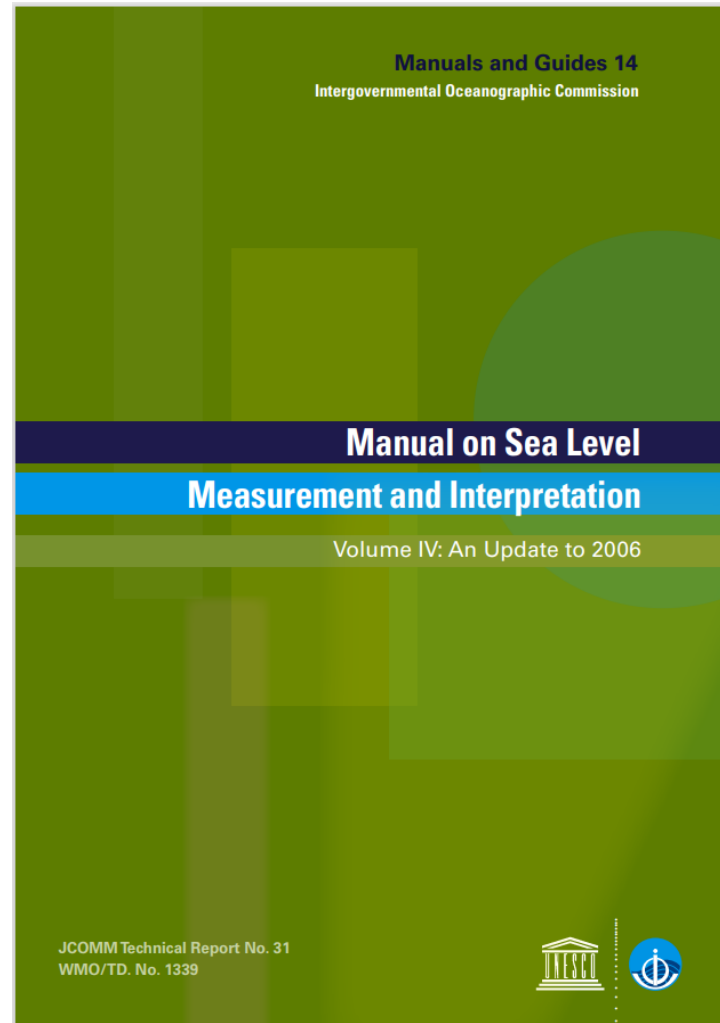


IOC MANUALS ON SEA LEVEL MEASUREMENT AND INTERPRETATION

Volume IV – general guidance on different technology types, suitability of locations etc

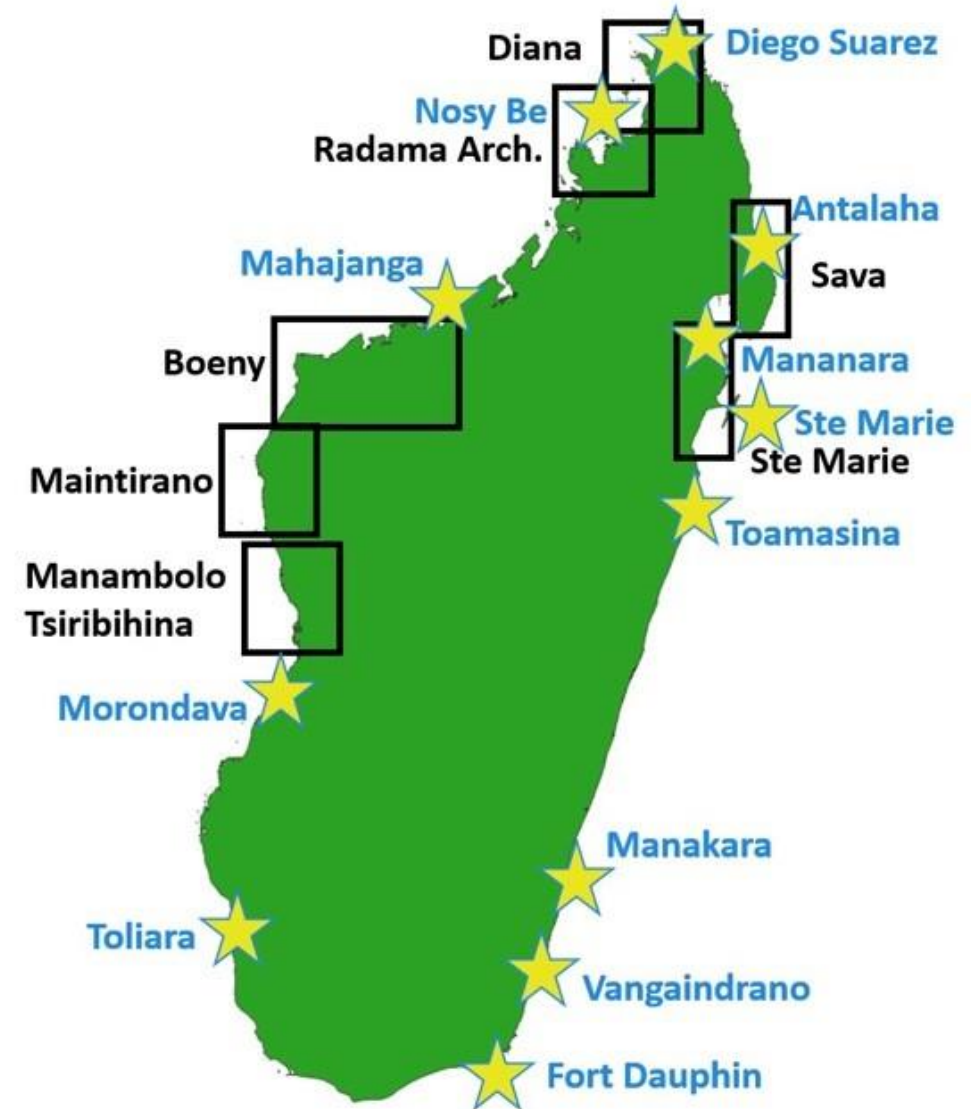
Volume V – specific to radar gauges (newer technology) also available in French

Available from www.unesco.org



FROM PASS-SWIO QUESTIONNAIRE

The locations of the regional areas (black boxes) and specific sites (stars) for which sea level data was required by respondents

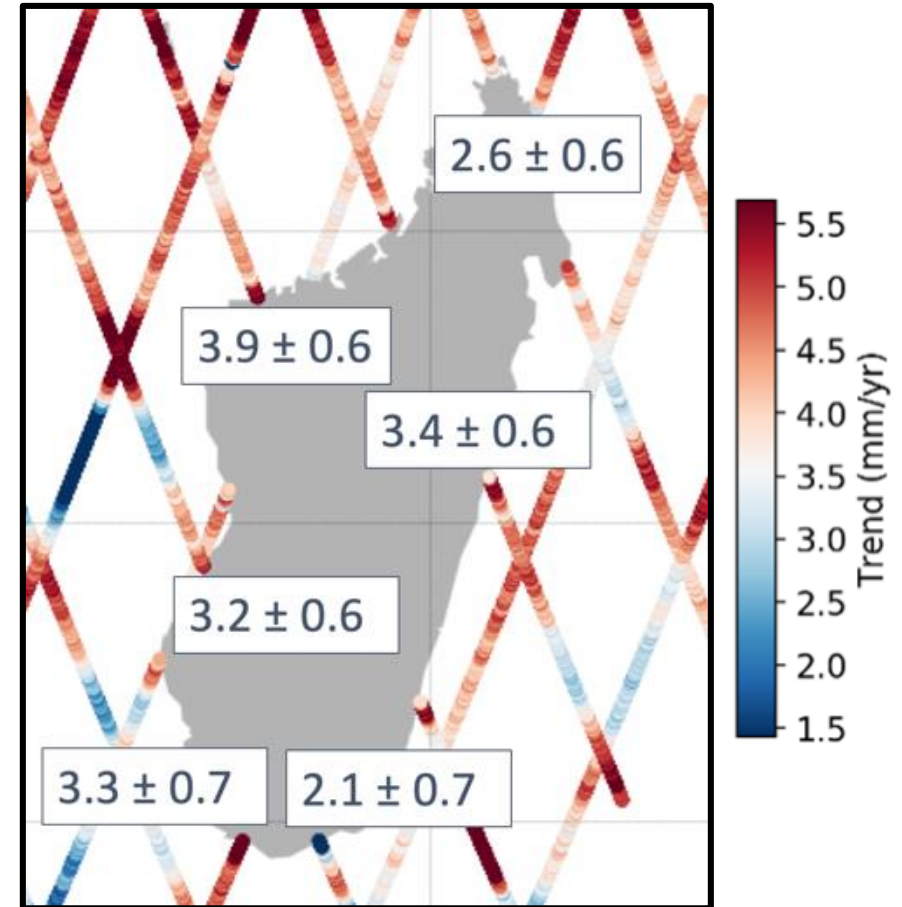


SEA LEVEL VARIABILITY

Tidal variability

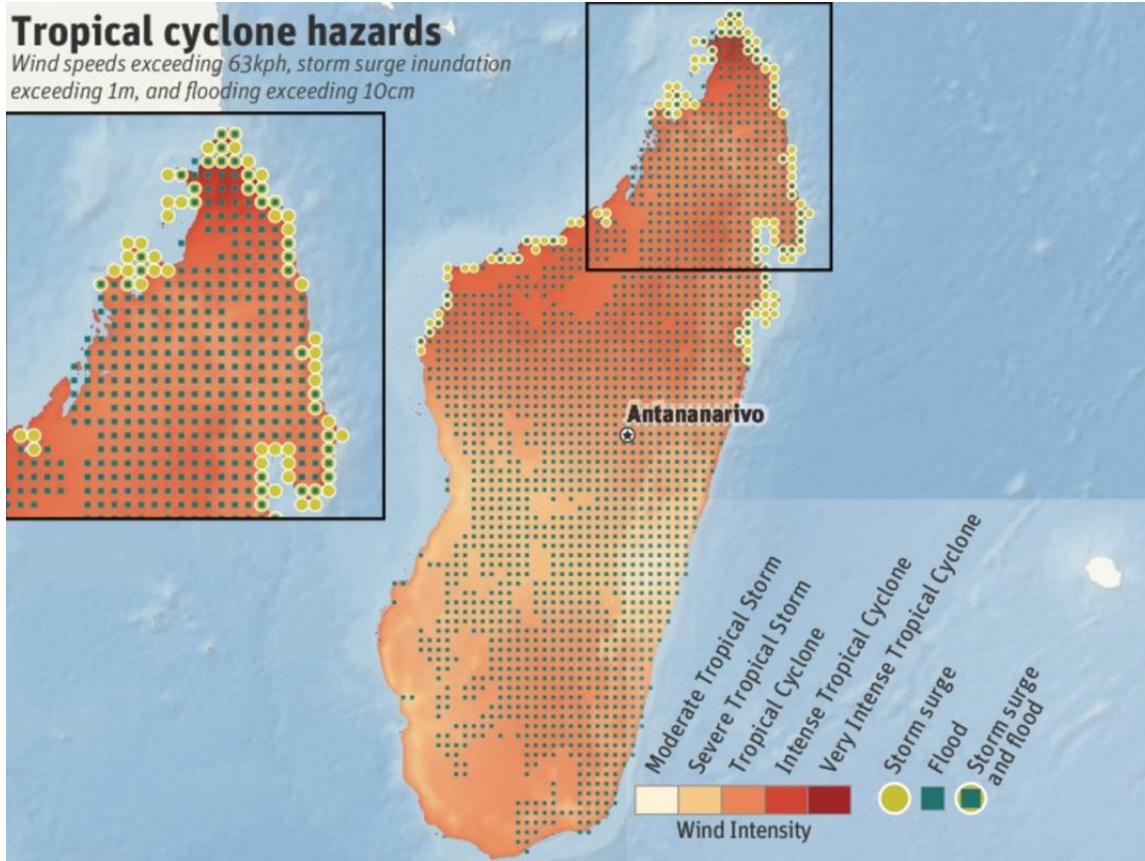
Location	Mahajanga	Morondava	Toliara	Toamasina	Mananjary
Highest Astronomical Tide	2.07m	1.96m	1.49m	0.36m	0.27m
Lowest Astronomical Tide	-1.98m	-1.95m	-1.47m	-0.37m	-0.29m
Maximum Range	4.03m	3.91m	2.96m	0.72m	0.55m

Long term sea level trend



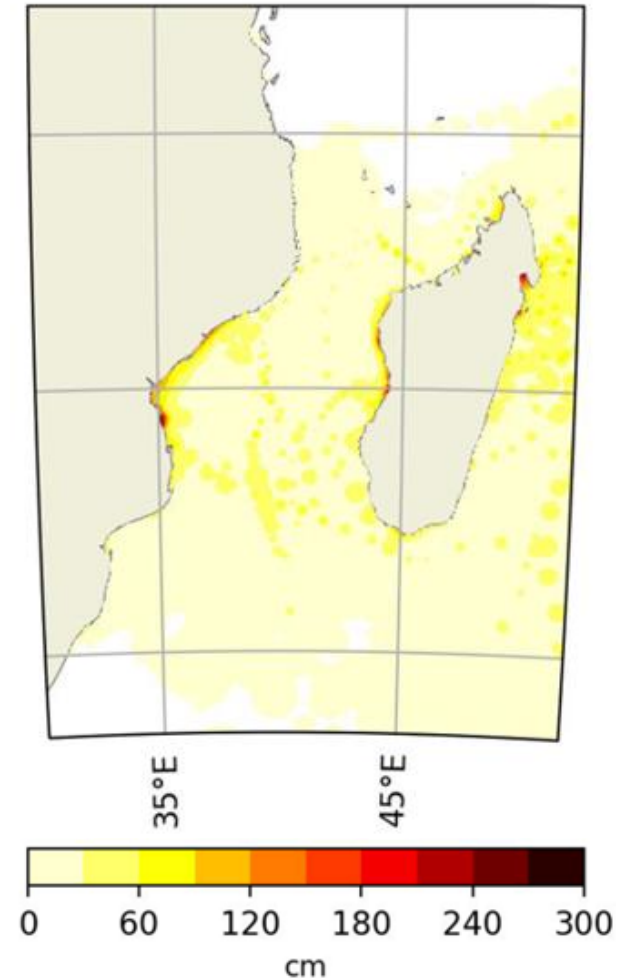
For the coast of Madagascar – trend is 2.1 to 3.9 mm/yr (2000-2020)

STORM SURGE



GFDRR (Global Facility for Disaster Reduction and Recovery) 2016

Combined Max SSH for 66 storms



NOC modelled surge from 66 storms, 1990-2015

VULNERABILITY

Esteves, L.S. and Ballesteros, C. 2019. Building an index of exposure to coastal change in Eastern Africa with applications to conservation of cultural heritage. *Coastal Sediments* 1063-1077.

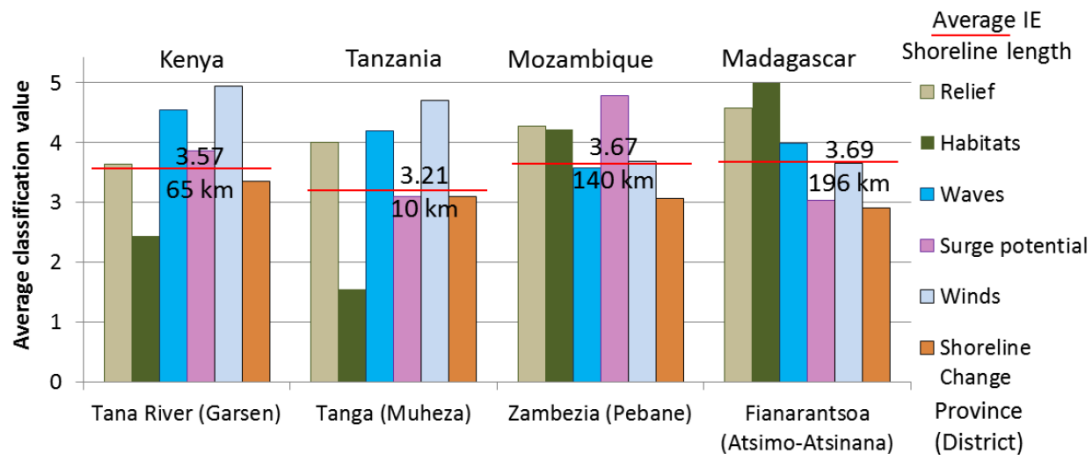
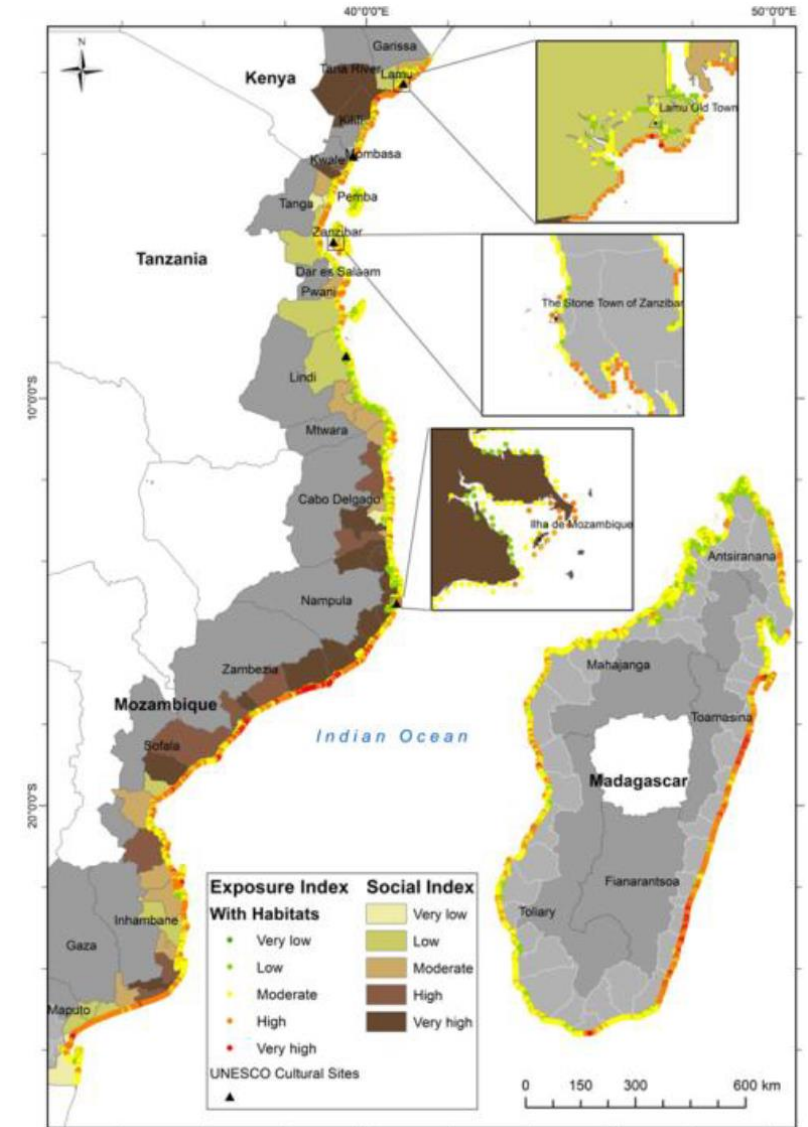
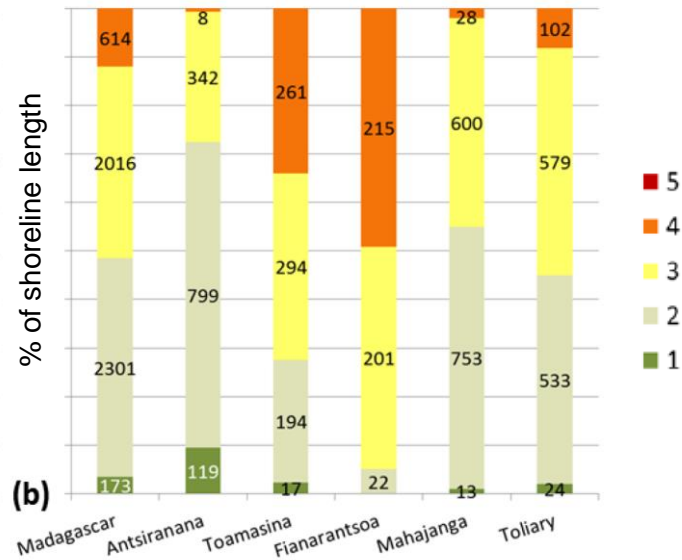


Fig. 2. Average classification value of each indicator for the four districts showing the highest average exposure index in each country.

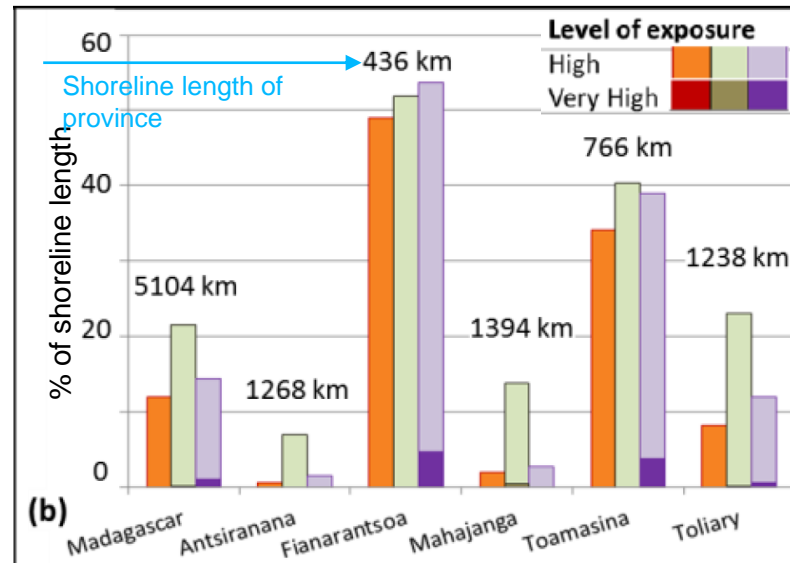


VULNERABILITY

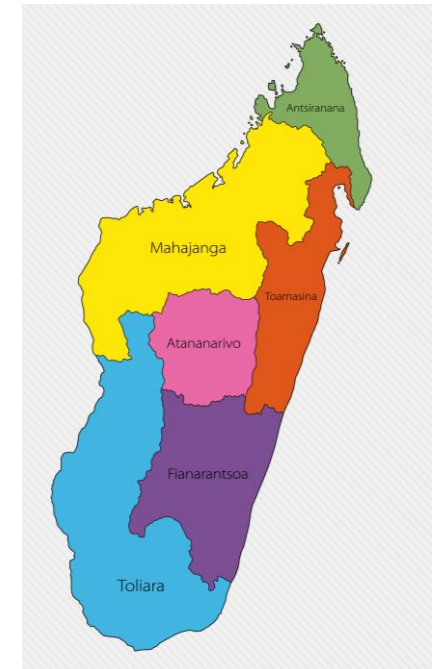
Index of Exposure is calculated based on seven variables: geomorphology, relief, wave exposure, wind exposure, surge potential, presence of natural habitats with an important coastal protection role and relative sea-level change rate. However, sea-level change and geomorphology were not considered here due to the scarcity of comparable data that can meaningfully reflect variations across the study area.



Distribution of the five classes of the index of exposure to coastal hazards (5 = very high exposure, 1 = very low exposure) in percentage of shoreline length



Percentage of shoreline length showing high or very high exposure to coastal hazards based on calculations of the index, and excluding data on habitats and shoreline change rates



PORTS

Ports of National Interest: Toamasina, Toliara, Antsiranana (Diego Suarez), Mahajanga

Ports of Regional Interest: Taolagnaro (Ehoala – Port Dauphin), Mananjary, Manakara, Morondava, Morombe, Maintirano, Antsohihy, Nosy Be, St Louis, Iharana, Antalaha, Maroantsetra, Ste Marie



HUMAN RESOURCE

Installation

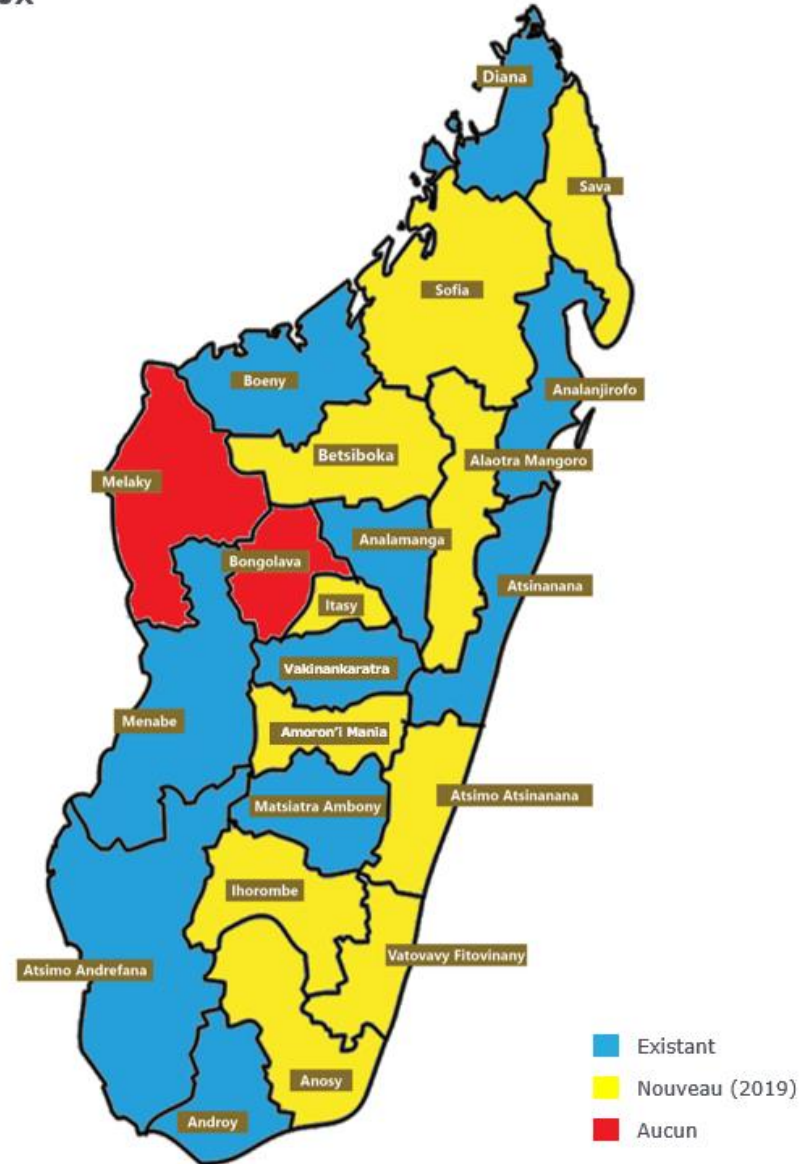
Operation – trouble shooting problems, downloading data

Data processing



REGIONAL OFFICES

Carte de Madagascar montrant les services régionaux



SITE ACCESS



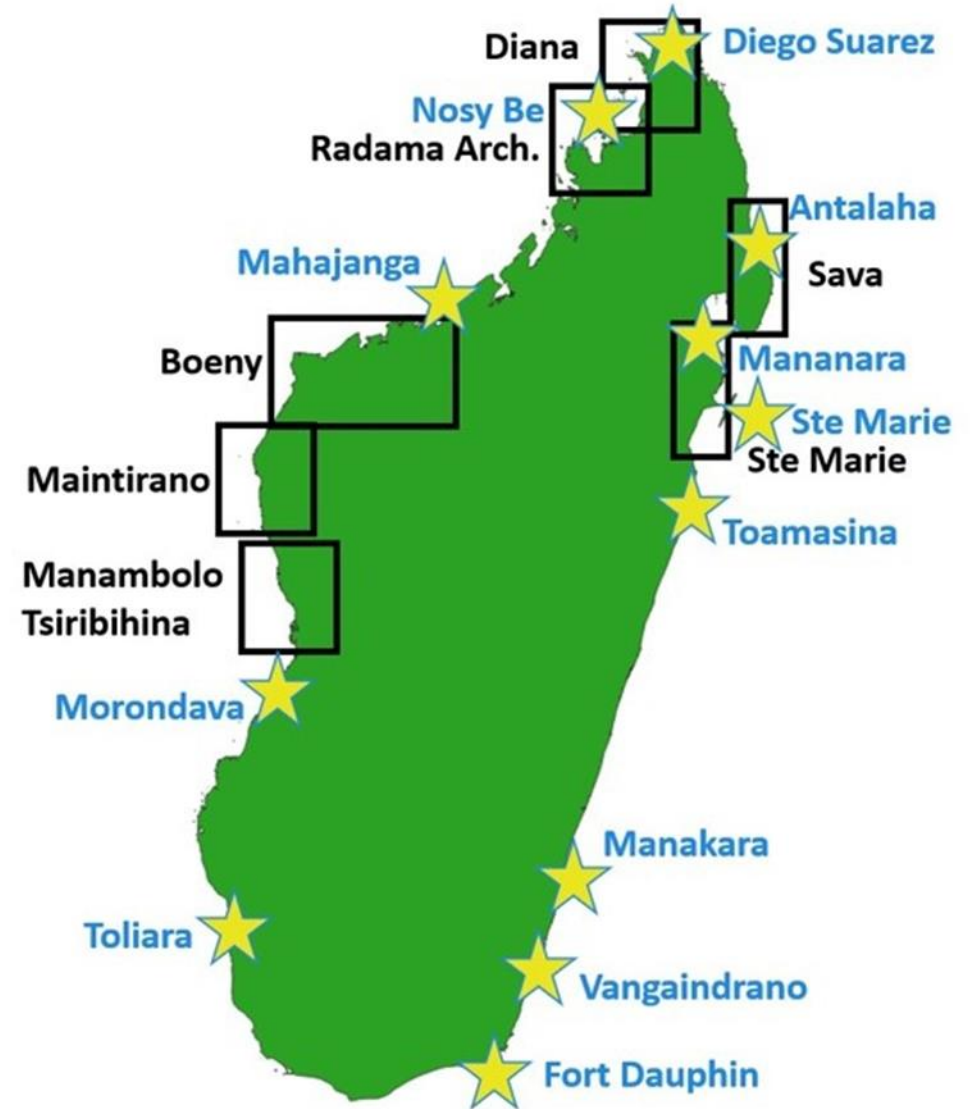
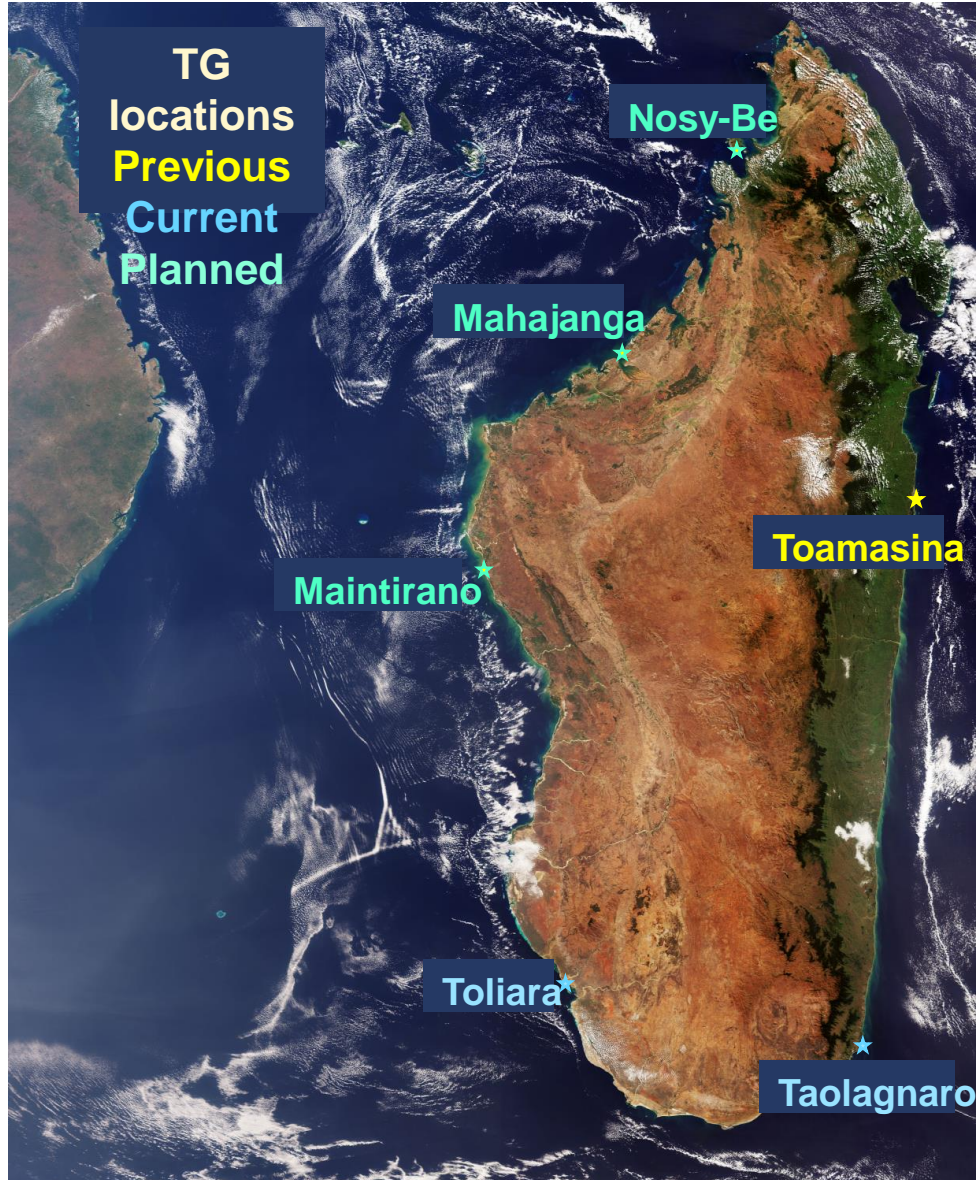
Transporting the Portagaugue across Madagascar

- Is it easier to transport by ship?

Local access



WHERE NEXT?



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