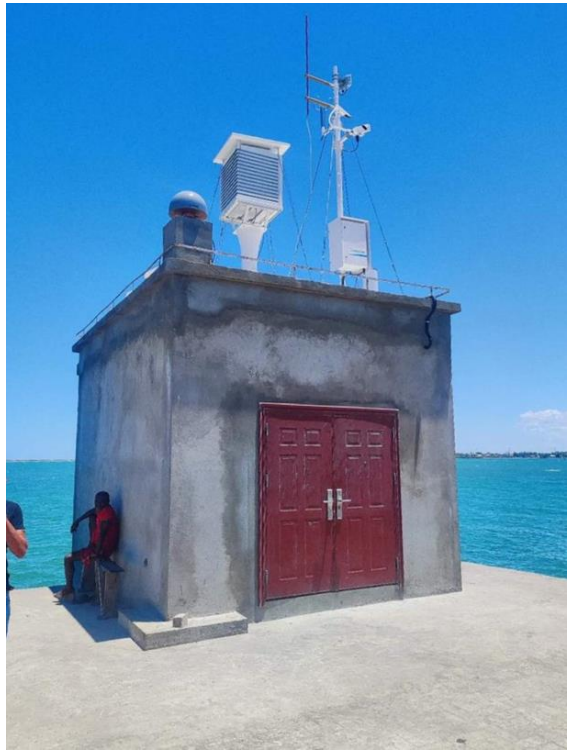
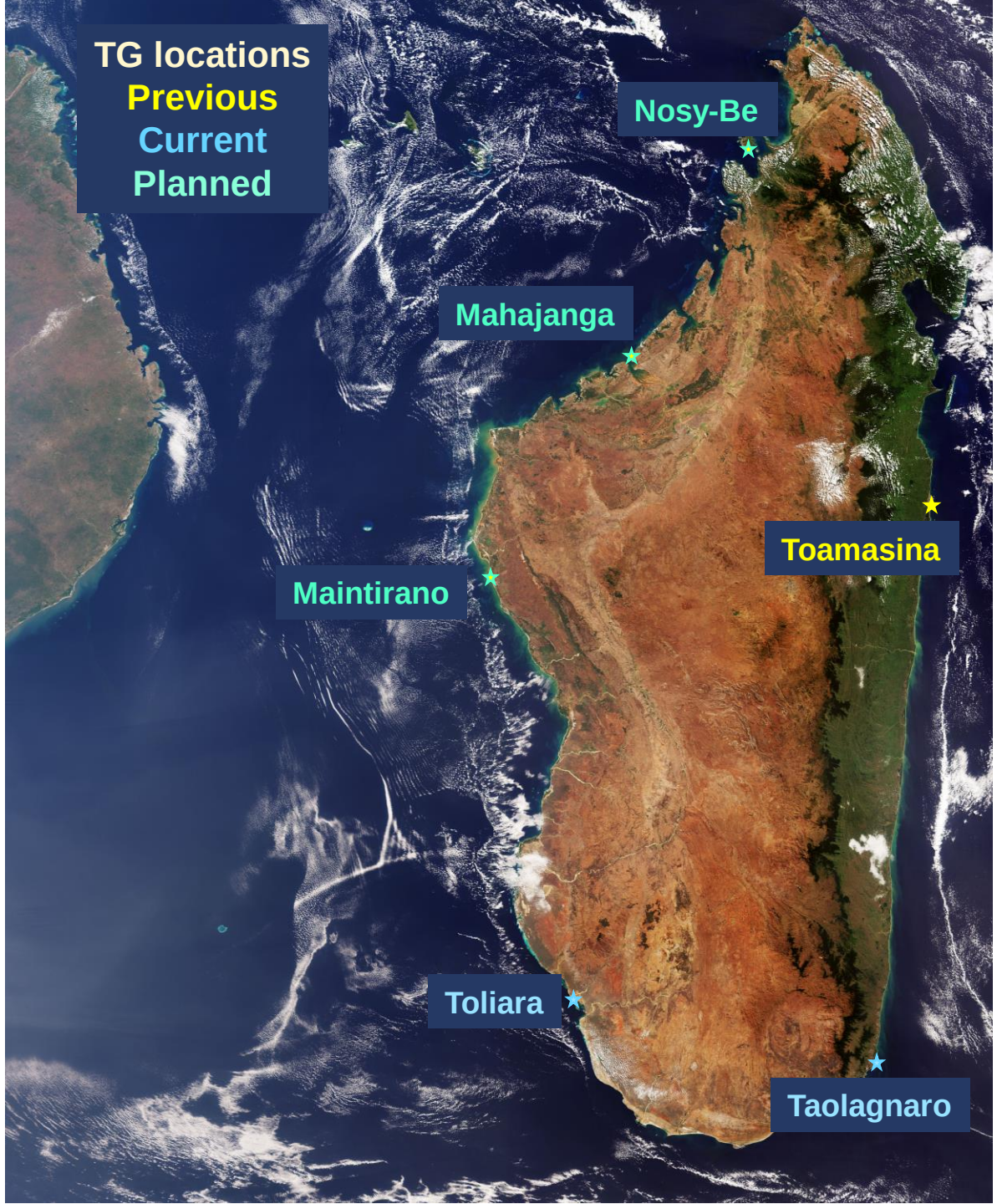
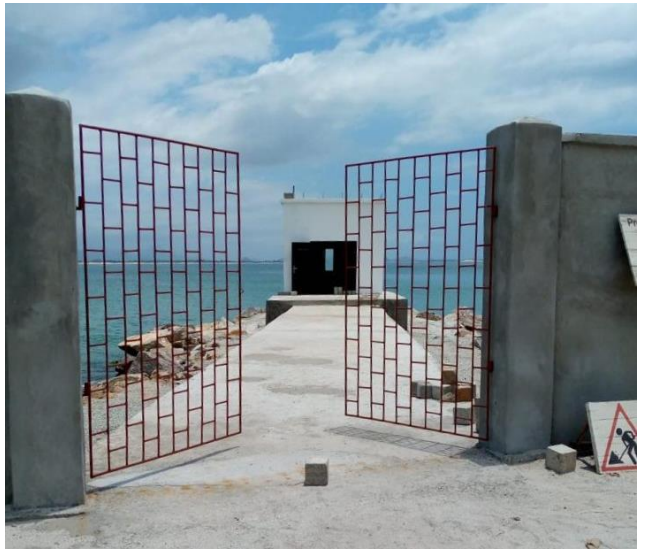
PASS-SWIO

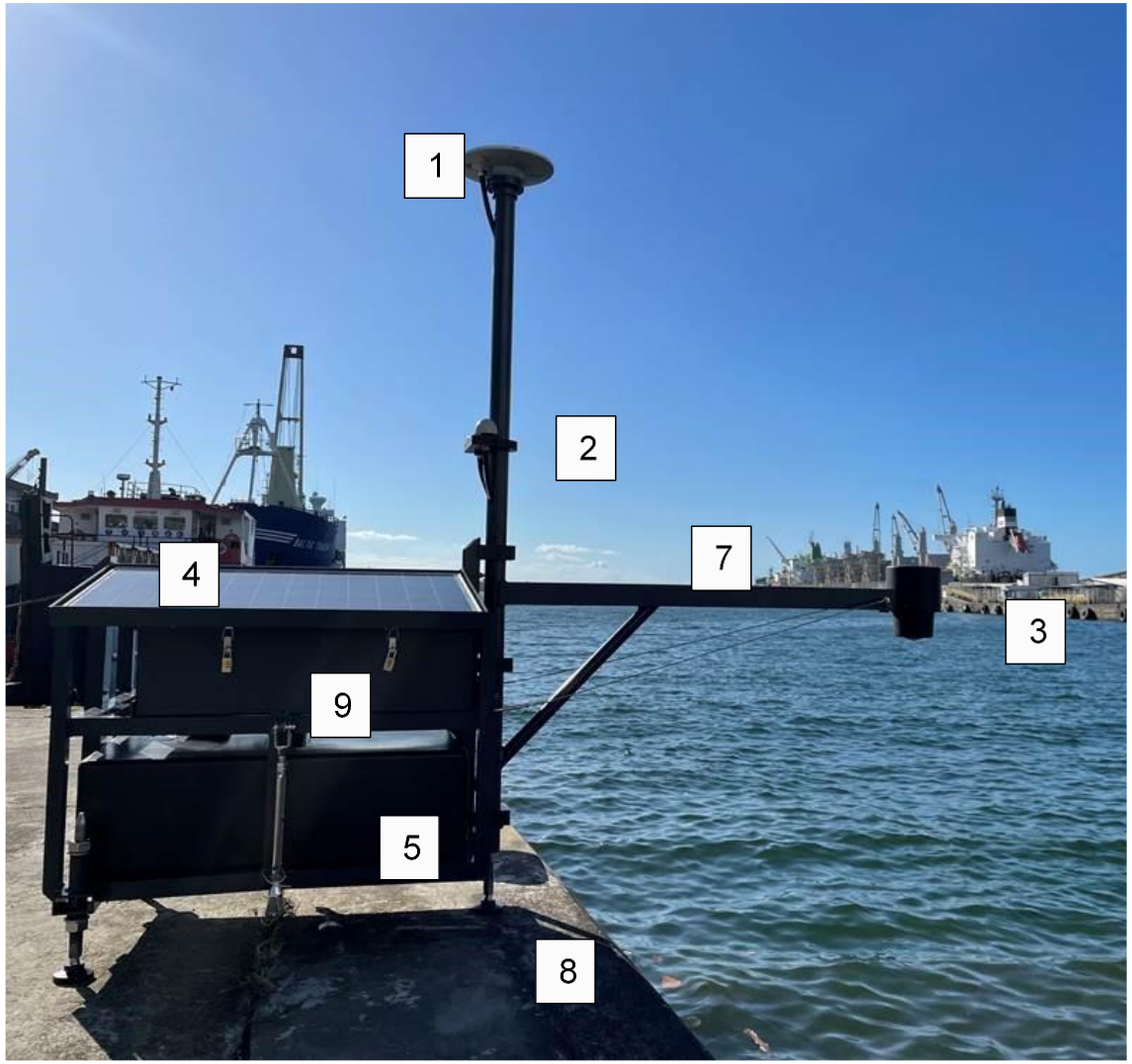
WP4000 – SUSTAINABLE IMPLEMENTATION ROAD MAP




TG locations
Previous
Current
Planned
Nosy-Be
Mahajanga
Toamasina
Maintirano
Toliara
Taolagnaro

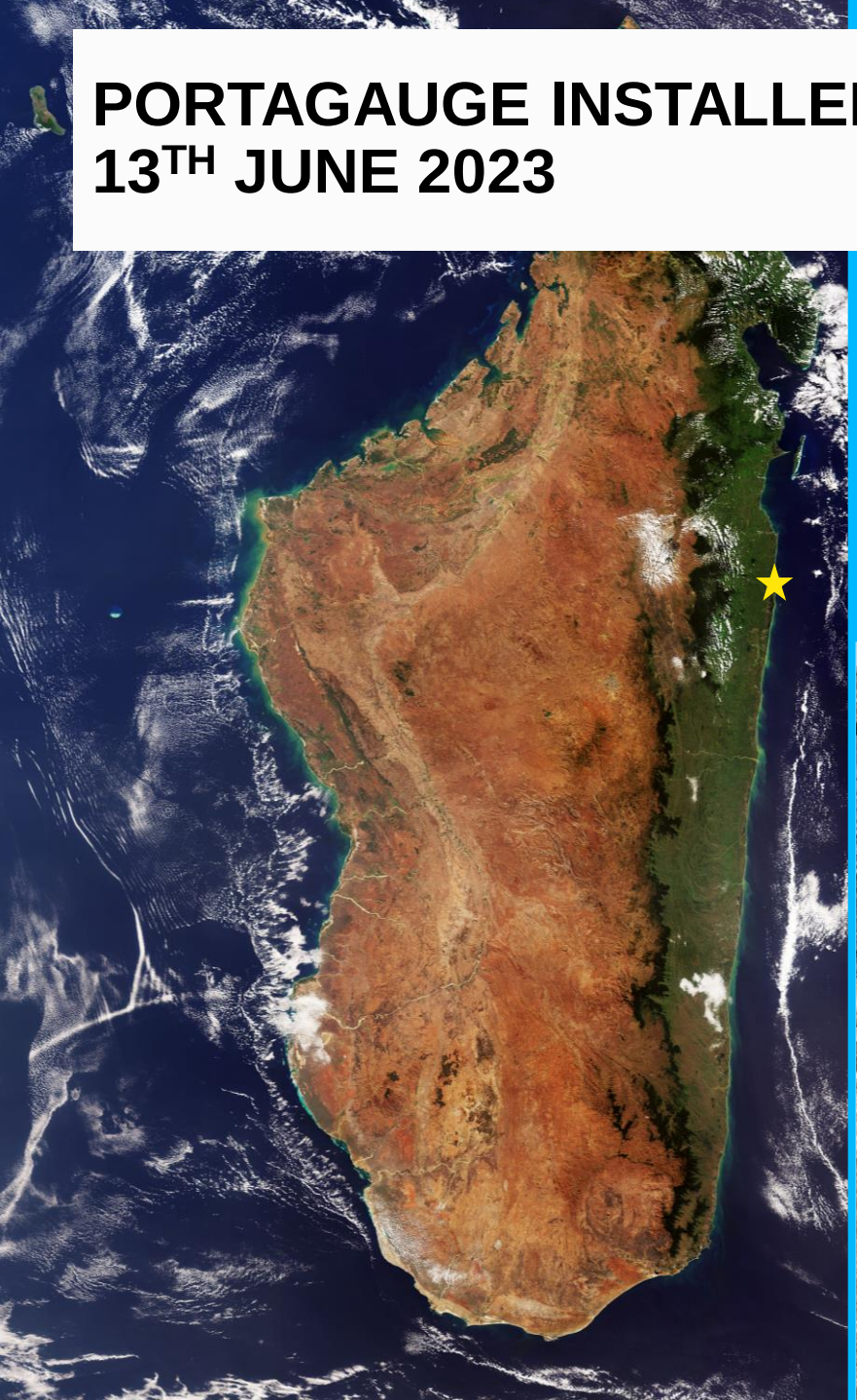


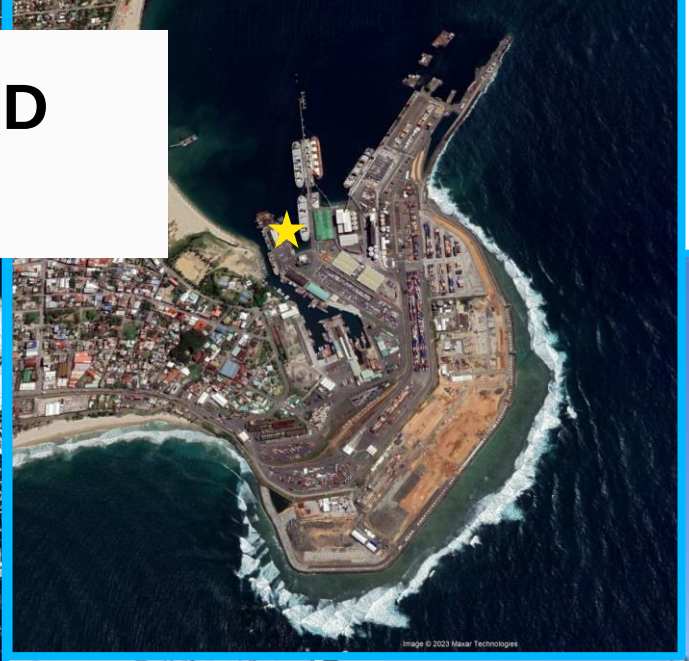
THE PORTAGAUGE



1. Trimble Zephyr GNSS antenna
2. GPS and 4G antennas for data logger time and communications
3. Vegapuls 6X radar sensor shown with protective cover
4. Solar panels
5. Water ballast tank
6. Turnbuckle anchoring point
7. GNSS mast / radar arm
8. Levelling feet
9. Instrument box

PORTAGAUGE INSTALLED 13TH JUNE 2023





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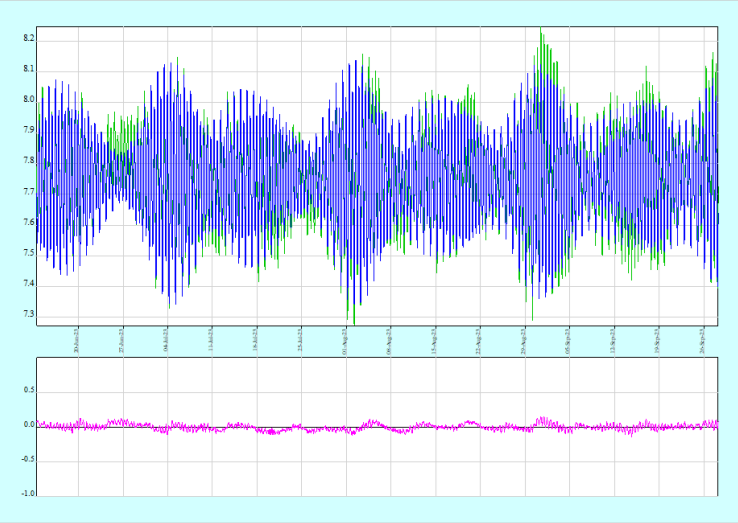
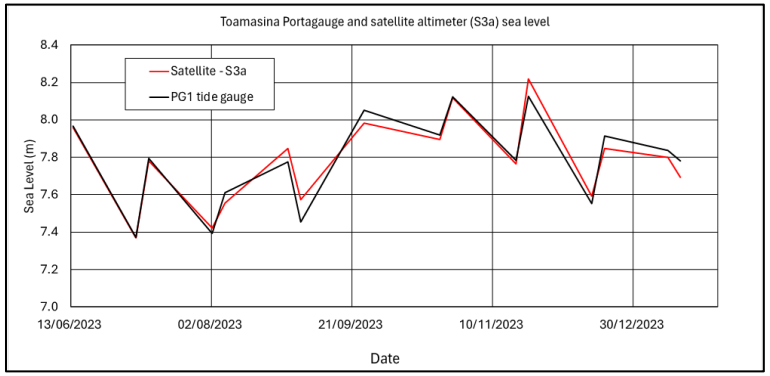
PORTAGAUGE AT TOAMASINA

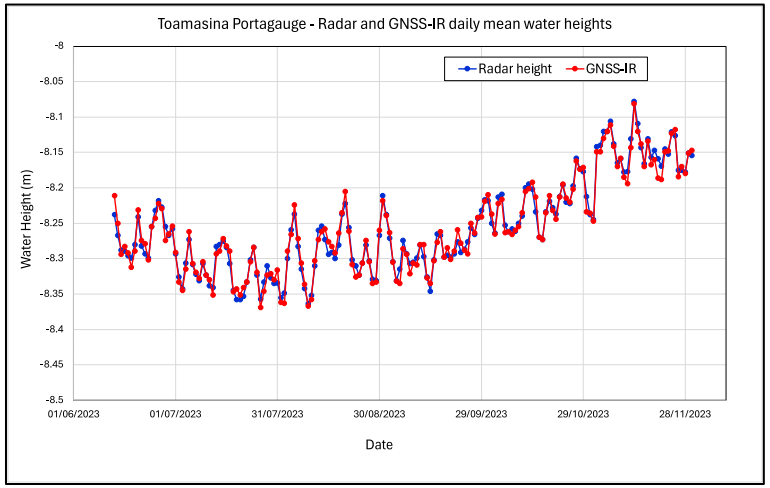


Portagauge radar gauge data (blue) overlaid on model tidal predictions (green) and residuals (magenta) for eight months from 13/06/2023 to 31/01/2024

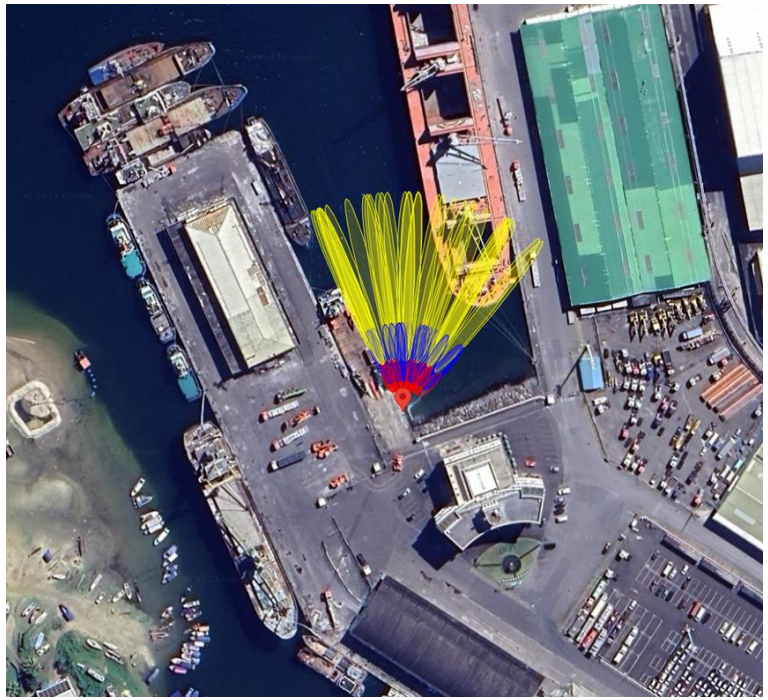
A relatively short-term deployment of the NOC Portagauge can provide sufficient data for a reliable cross-validation against satellite altimeter data.



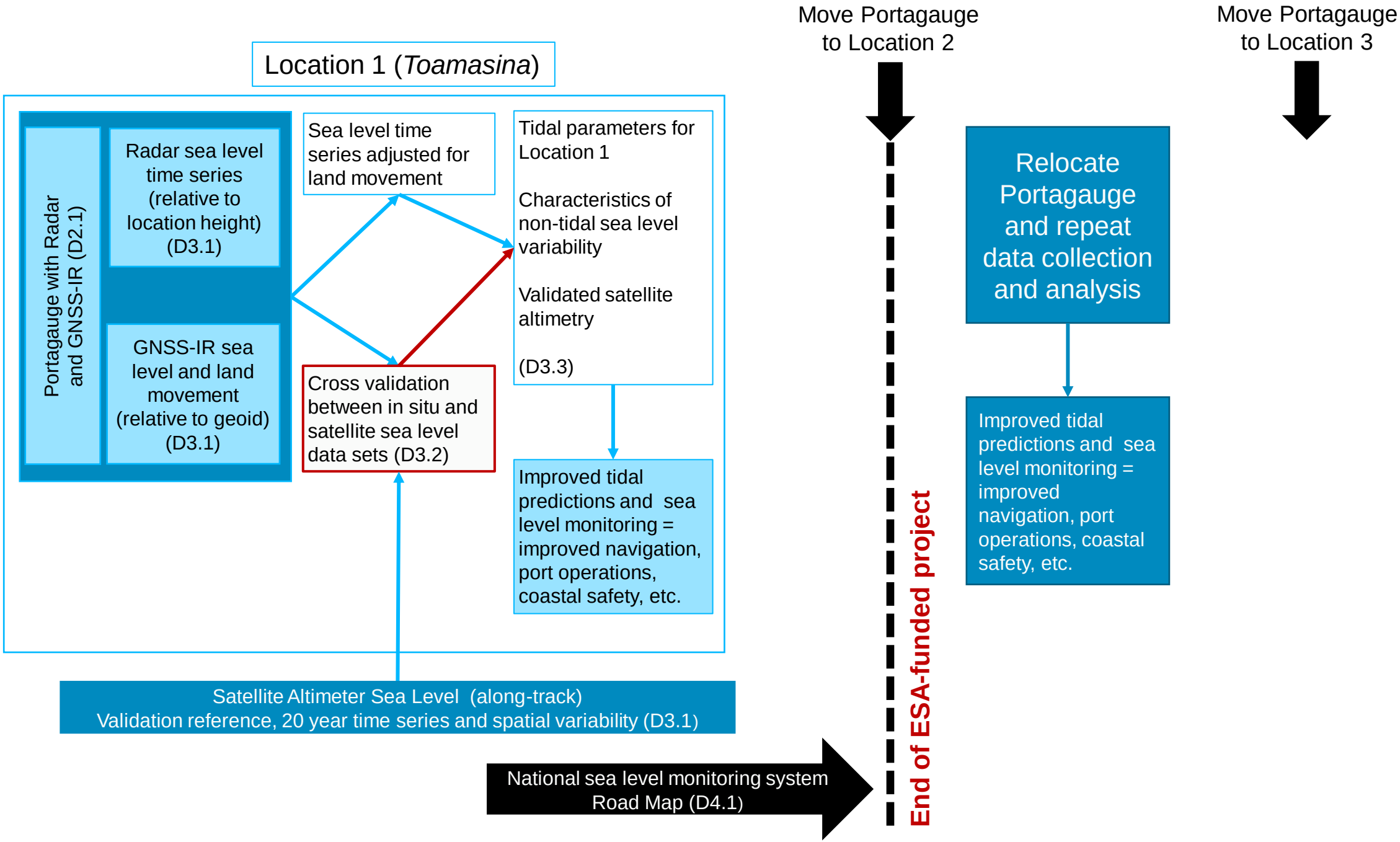
Cross-validation between Toamasina Portagauge and satellite altimeter (S3a) sea level



Daily mean water height measurements from the Toamasina Portagauge radar sensor and GNSS-IR



Field of view for GNSS-IR measurements in Toamasina Port


Location 1 (*Toamasina*)
Portagauge with Radar and GNSS-IR (D2.1)
Radar sea level time series (relative to location height) (D3.1)
GNSS-IR sea level and land movement (relative to geoid) (D3.1)
Sea level time series adjusted for land movement
Cross validation between in situ and satellite sea level data sets (D3.2)
Tidal parameters for Location 1
Characteristics of non-tidal sea level variability
Validated satellite altimetry
(D3.3)
Improved tidal predictions and sea level monitoring = improved navigation, port operations, coastal safety, etc.
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 Portagauge to Location 2
Move Portagauge to Location 3
Relocate Portagauge 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

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REQUIREMENTS FOR SEA LEVEL MONITORING

REQUIREMENTS FOR SEA LEVEL MONITORING

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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.

Source: GLOSS

ISSUES IN MEASURING COASTAL SEA LEVEL FOR DEVELOPING STATES

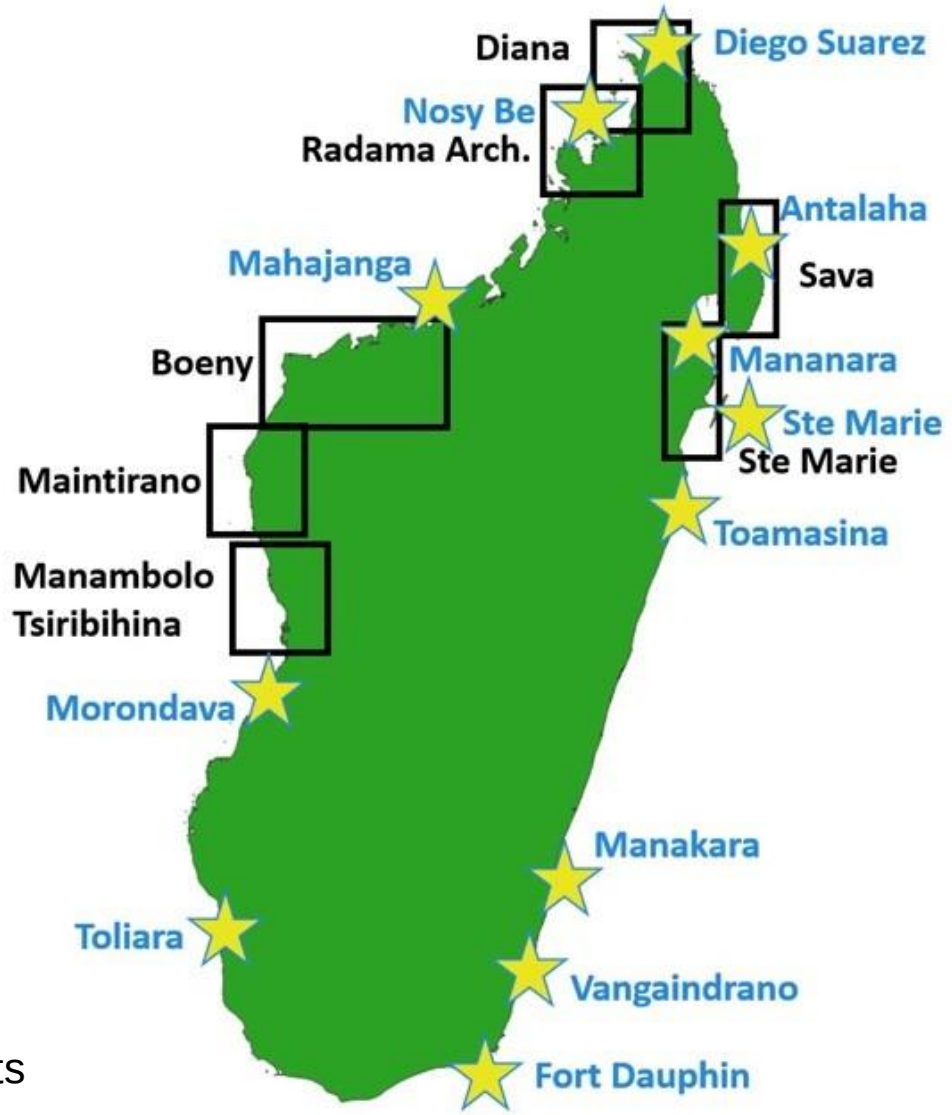
The main four reasons that tide gauges are non-operational in developing states, identified by Hoguane (1999), are:

- Lack of equipment (and difficulty acquiring replacement parts (Mundlovo et al., 2007));
- Lack of qualified maintenance personnel;
- Lack of funds to maintain tide gauges;
- Difficulty in accessing remote tide gauges due to poor transport infrastructure, poor roads and insurgency.

“To achieve a fully operational national tide gauge network and make data available to end users, some national capacity development is required” (Razakafoniaina, 2001)

USER REQUIREMENTS

Applications	Derived Products	Characteristics
Risks	Sea level rise	Interoperable
Disasters	Tidal predictions	Daily data
Coastal retreat	Cyclone surges	Regularity
Marine erosion	Tide gauge data	Timely and high resolution
Coastal protection work	Satellite data	Easy to handle formats
Livestock and marine culture	Sea level at specific times and places	
Hotels		
Urban planning		



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

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REVIEW OF LOCATIONS

REVIEW OF POTENTIAL PORTAGAUGE LOCATIONS

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Important considerations

- Sea level variability
- Locations prone to flooding and erosion
- Most vulnerable populations
- Vulnerable infrastructure
- Port locations

Practicalities

- Security
- Suitable site available (next slide)
- 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

SEA LEVEL VARIABILITY

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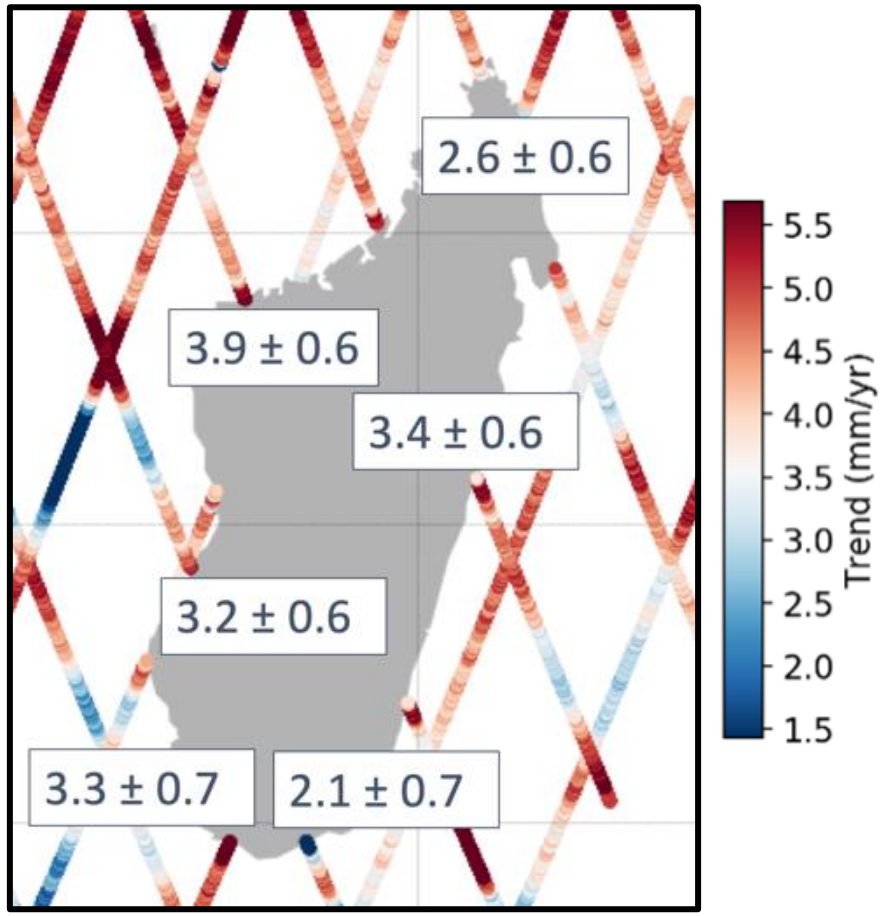
Tidal variability

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

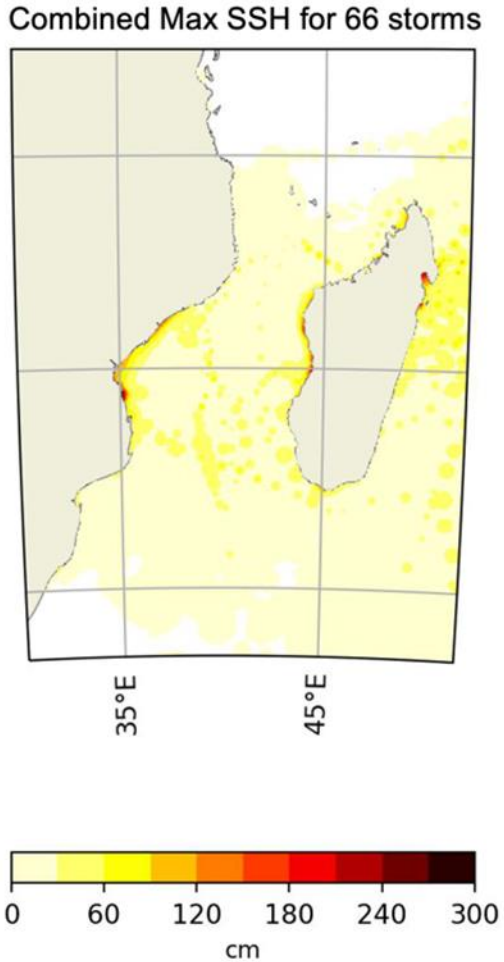
Long term sea level trend



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

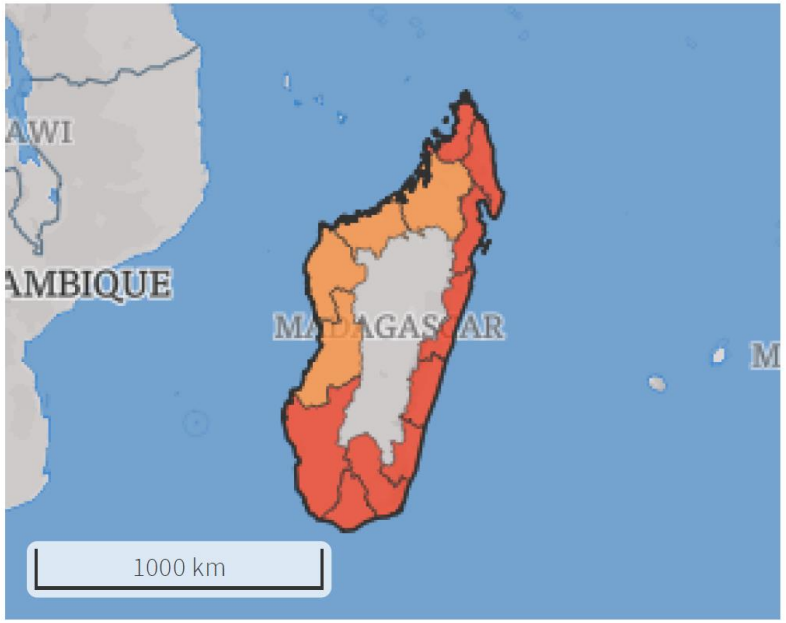
EXTREME EVENTS

Storm surge



NOC C-RISC project

Tsunami



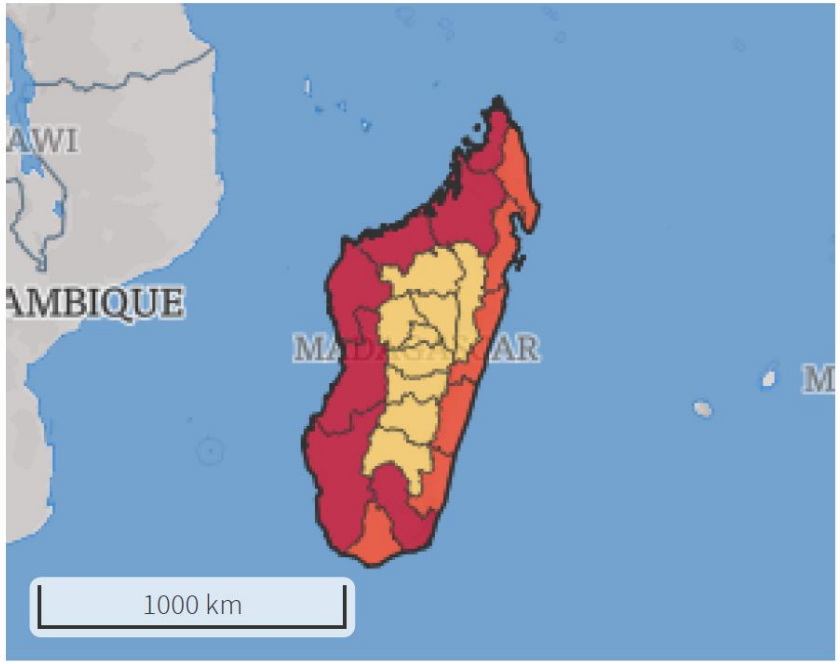
© Mapbox © OpenStreetMap

High Medium Low Very low

GFDRR (2020) https://thinkhazard.org/en/report/150-madagascar/TS

FLOODING AND EROSION

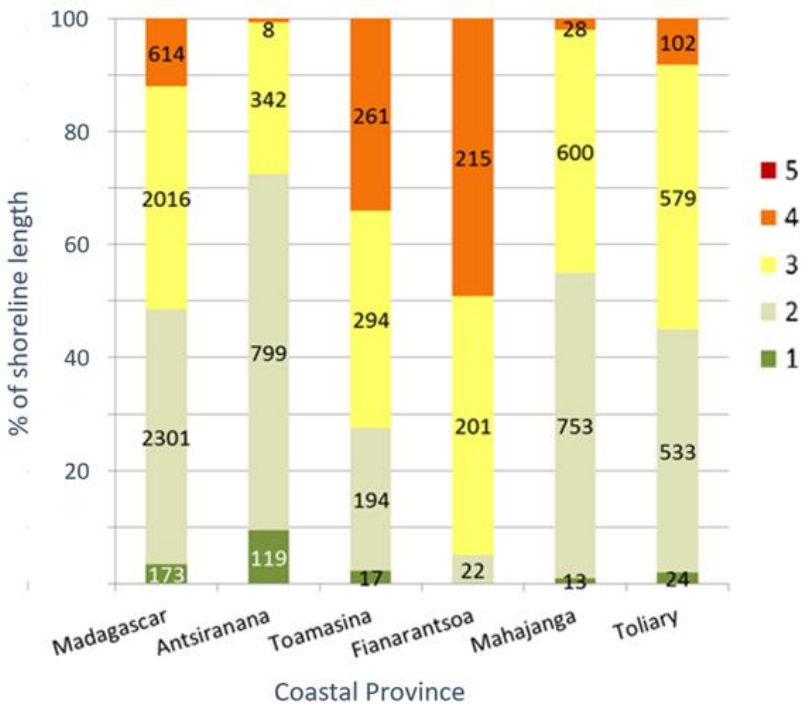
Coastal flood risk



GFDRR (2020) https://thinkhazard.org/en/report/150-madagascar/CF

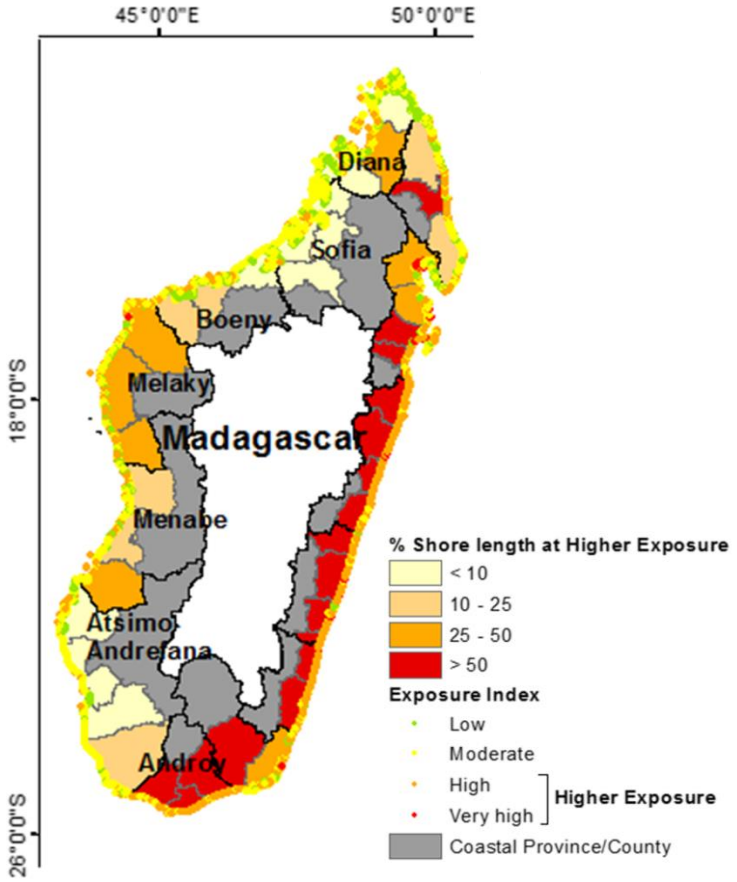
Erosion

VULNERABILITY



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 (Esteves and Ballesteros 2019). The map shows the locations of the Provinces, these were abolished as administrative areas in 2007, with the creation of smaller regions

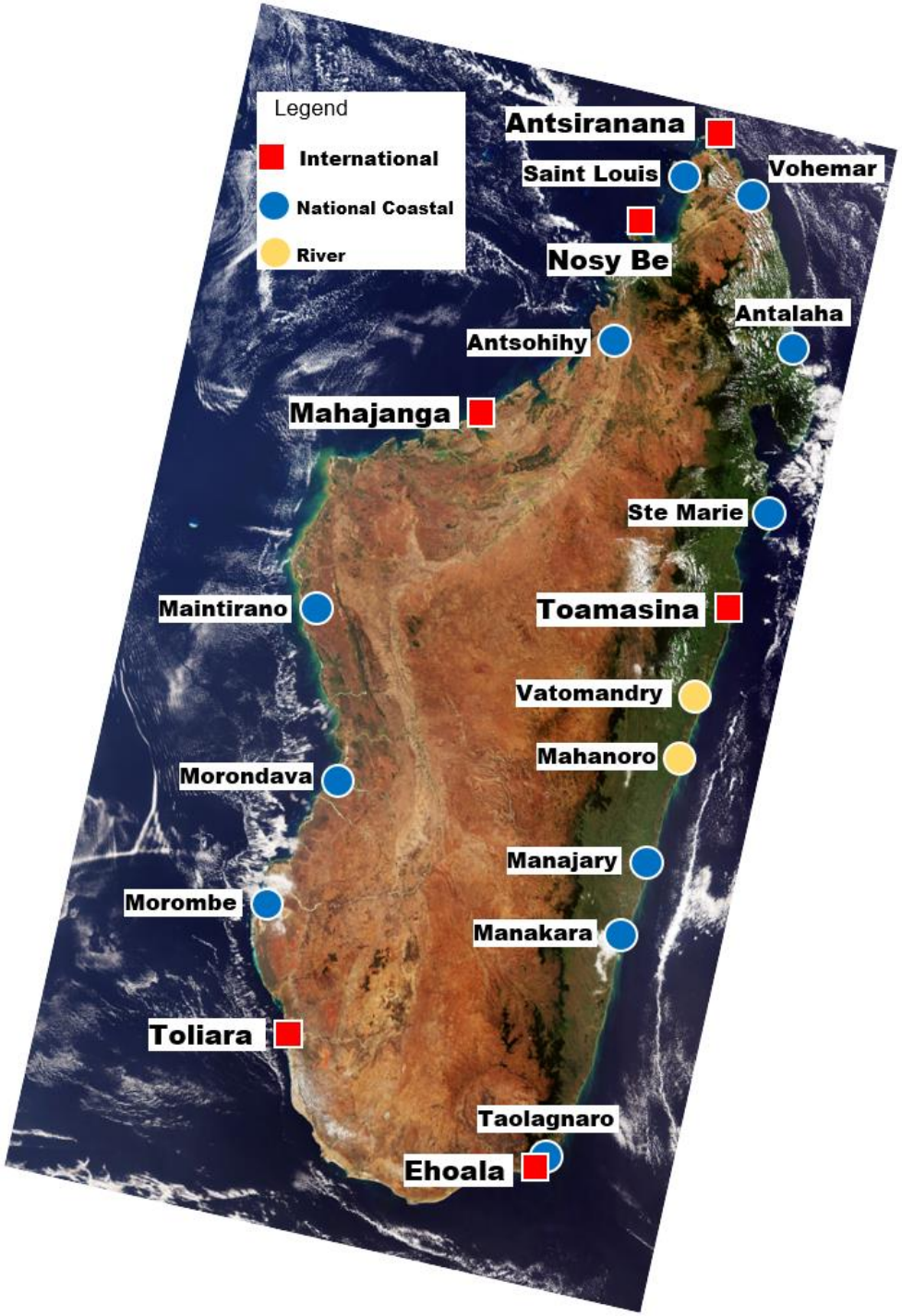
IoE is calculated based on 7 variables: geomorphology, relief, wave exposure, wind exposure, surge potential, presence of natural habitats with an important coastal protection role and relative sea-level change rate.



1,156,800 people in Madagascar are at higher exposure to coastal hazard (within 5km of coast) (Esteves and Ballesteros, 2021)

PORTS

Ports of National Interest: Toamasina, Toliara, Antsiranana (Diego Suarez), Mahajanga, Ehoala (Fort Dauphin) and Nosy Be



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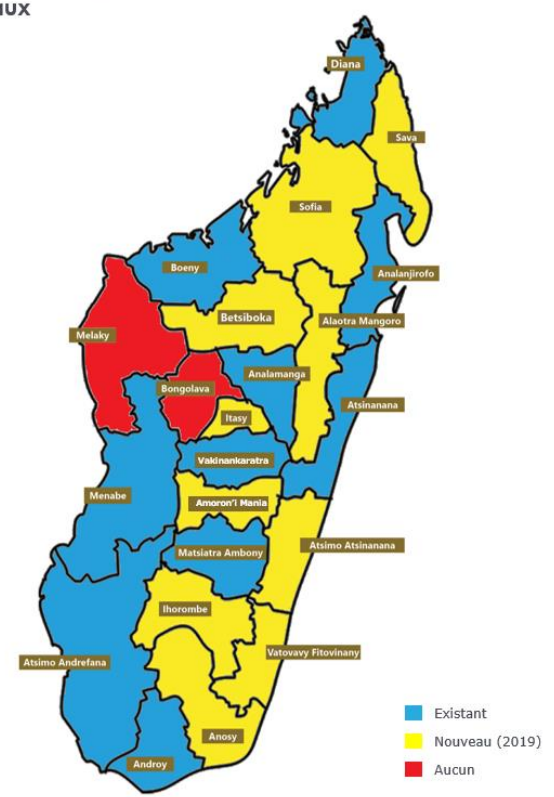
HUMAN RESOURCE

Installation

Operation – trouble shooting problems, downloading data

Data processing



SITE ACCESS

Transporting the Portagauge across Madagascar

Is it easier to transport by ship?

Local access

DISCUSSIONS WITH STAKEHOLDERS, FEBRUARY 2024

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COSTS AND FUNDING SOURCES

COSTS

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Item	Details	Estimated cost (Euro)
Installation of Portagauge at new port location	Local DGM staff to liaise with port authorities to identify a suitable location for Portagauge installation Two DGM staff to install Portagauge FTM staff (with assistance from local DGM staff) to level Portagauge to local benchmark Hire of forklift and possible storage costs prior to installation	10,500 (per installation x5)
De-installation of Portagauge	Two DGM staff to de-install and pack Portagauge. Hire of forklift and cost of packing case repairs or packing materials	7,500 (per de-installation x5)
Transportation of the portagauge between locations	It is expected that this will be by ship	2,000 (per move x5)
Operational cost	Local DGM staff to check on Portagauge Cost of SIM card/data transfer Data checking and processing by DGM Project management from NOC and SatOC	57,000 (per deployment x5)
	Total repeat costs	**75,000 (15,000 per deployment)**
Data Management	Computer hardware Computer Software (TASK and POLTIPS licences) BODC Data Management	9,000
Survey at Toamasina	One off cost at Toamasina to carry out levelling to local benchmark. FTM staff, with assistance from local DGM staff	500 (one off cost)
Portagauge Maintenance	Visit to Portagauge for maintenance/repair by NOC staff Assistance from in-country staff Portagauge parts	30,500 (two visits)
Stakeholder engagement	Visit of NOC and SatOC staff to Madagascar for meetings with stakeholders, knowledge exchange and data sharing	25,000 (one visit)
	Full implementation plan for five further deployments	**140,000**
Capacity building in data management with DGM, IH.SM and FTM	Creation of training material Visit of NOC and SatOC staff to Madagascar to host capacity building workshop Hire of venue Expenses of Malagasy attendees	31,000 (one off cost)
	Total estimated cost for 4-years	**171,000**

POSSIBLE FUNDING SOURCES

- **UNESCO Intergovernmental Oceanographic Commission (IOC)**

UN Ocean Decade Capacity Development Call (closes 31/8/24)

- **International Hydrographic Organization (IHO) Capacity Building Work Programme**

Capacity Building support, but not for instrumentation

- **WIOMSA**

Regional funding focussed on marine conservation, fisheries, ecosystems and climate change

- **Indian Ocean Commission**

- **UK FCDO Blue Planet Fund**

Will provide targeted technical assistance to the Government of Madagascar

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS AND RECOMMENDATIONS

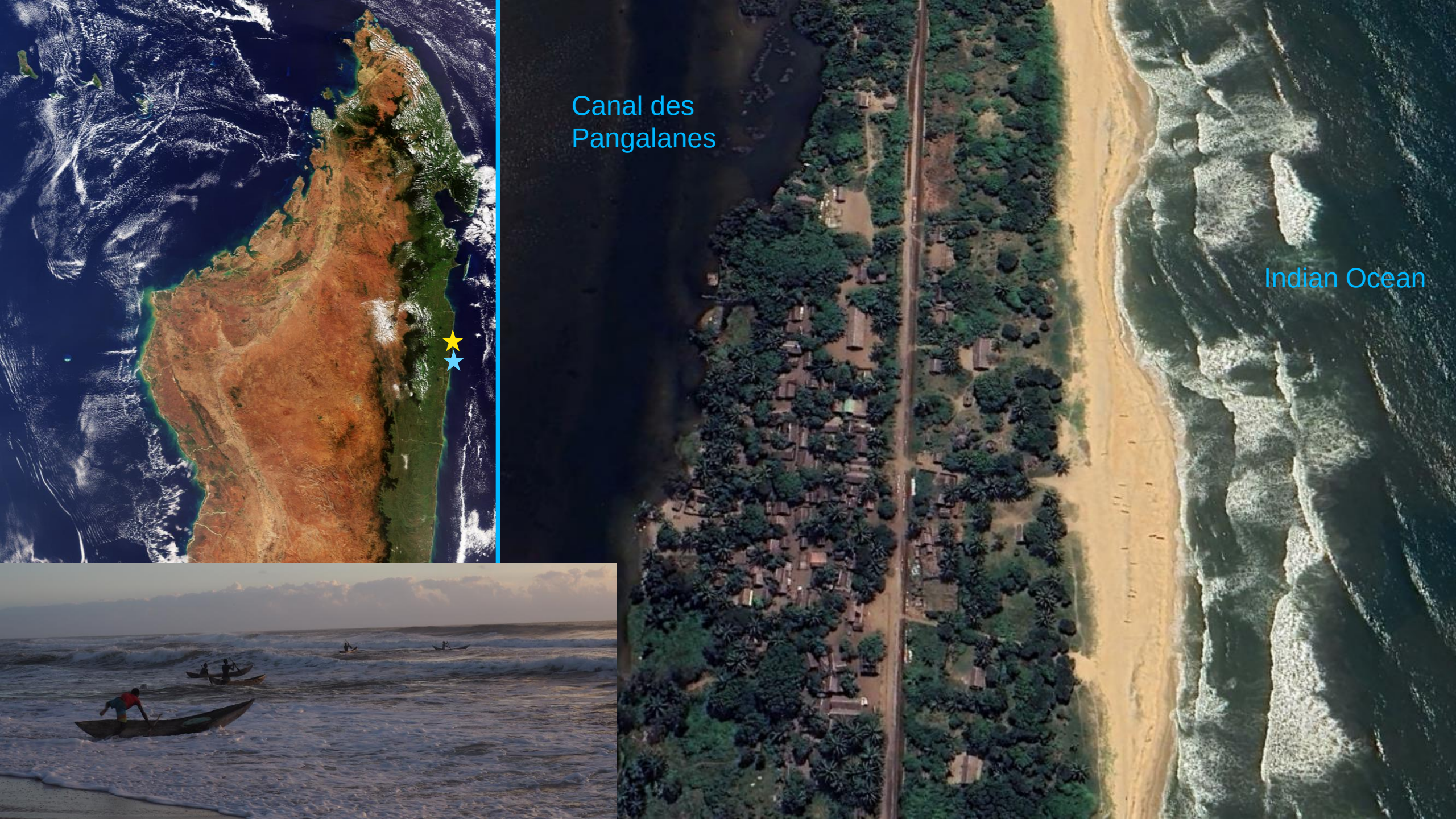
PASS-SWIO has:

- Provided of the portagauge concept
- Trained DGM staff
- Highlighted a high level of interest from Malagasy stakeholders

We recommend implementation of the system at all major ports in Madagascar over 4 years starting with either Mahajanga or Nosy Be and capacity building to address the need to co-ordinated national data management infrastructure.

Other recommendations:

- Provide Road Map to stakeholder agencies, IHO, the Indian Ocean Commission and WIOMSA
- Make GNSS data available to FTM and further discuss issue of low precision local geoid model
- NOC to discuss Tsunami warning systems with BNGRC
- Improve data on sea level change and geomorphology of Madagascar to better understand exposure to coastal change
- FFSAR processing of Sentinel 3 data along Pangalanes Canal to understand water levels


Canal des
Pangalanes
Indian Ocean

SATOC
SATELLITE OCEANOGRAPHIC CONSULTANTS

METEO Madagascar

esa

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NOC.AC.UK