Portagauge and Satellite Sea level monitoring system for the Southwest Indian Ocean – PASS-SWIO

D Cotton[1], A Becker[2], A Hibbert[2], F Calafat[2], S Williams[2],
H Razafindraibe[1], M Restano[3], J Benveniste[4]
(1) SatOC (UK), (2) National Oceanography Centre (UK), (3) SERCO/ESA (Italy), (4) ESA-ESRIN (Italy)

PASS-SWIO Project

PASS-SWIO, funded by the ESA Science for Society Programme EO Open Call, is a capacity building project which aims to establish a sea level monitoring system for Madagascar based on the installation and deployment of a low-cost relocatable tide gauge (Portagauge), which uses Global Navigation Satellite System interferometric reflectometry (GNSS-IR) technology, combined with the analysis of satellite altimeter sea level data to provide validation and wider scale knowledge on sea-level variability.

The project is working closely with the national Madagascar Meteorological Agency (DGM, Direction Générale de la Météorologie) who will take responsibility for the local maintenance and operation of the Portagauge, and who are being trained to carry out the data processing and analysis.

Discussions are being held with key stakeholders to review the project and agree a Road Map for the sustainable long-term implementation of a national sea-level monitoring system for Madagascar, which can serve as model for other island states and coastal countries in the South West Indian Ocean (SWIO) region and beyond.

Importance of Sea Level Measurements

Madagascar has very limited tidal prediction (primarily based on model data) and currently has no national sea level monitoring capability, with only one functioning tide gauge (Fig. 1). An earlier tide gauge, in the cyclone prone north of the island, was swept away several years ago. Tidal information is vital for the safety of communities, infrastructure and commerce, and as short-term hazards are exacerbated by long-term increases in sea level, knowledge of longer-term change is also essential.

Improved information on sea-level and sea-level variability will result in enhanced safety in navigation and coastal activities (through better knowledge of tides), accurate modelling of extreme events (such as storm surges associated with tropical cyclones) and will support better planning and management of the coastal zone through improved knowledge of long-term sea-level change.

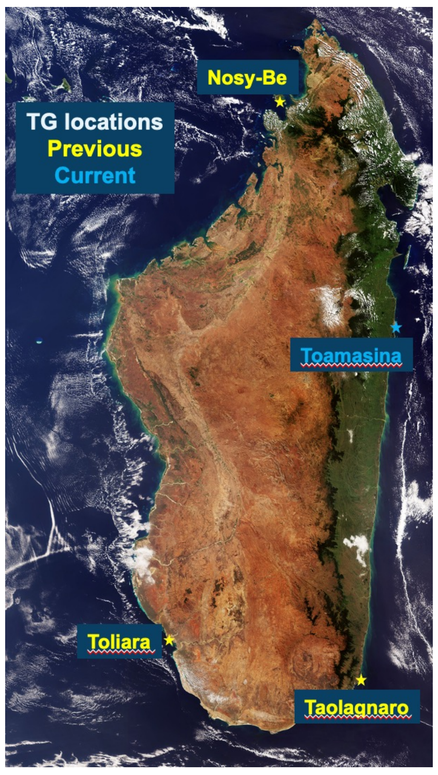

Figure 1. Locations of Tide Gauges in Madagascar

The NOC Portagauge

The Portagauge (Fig. 2), developed and built at the NOC, includes a conventional radar gauge and a GNSS receiver, which enables monitoring of relative sea level, absolute sea level and land motion relative to the geoid and to local datums. It is a stand alone system powered by batteries recharged by solar panels with a robust aluminium frame construction and a water tank for ballast and stability.

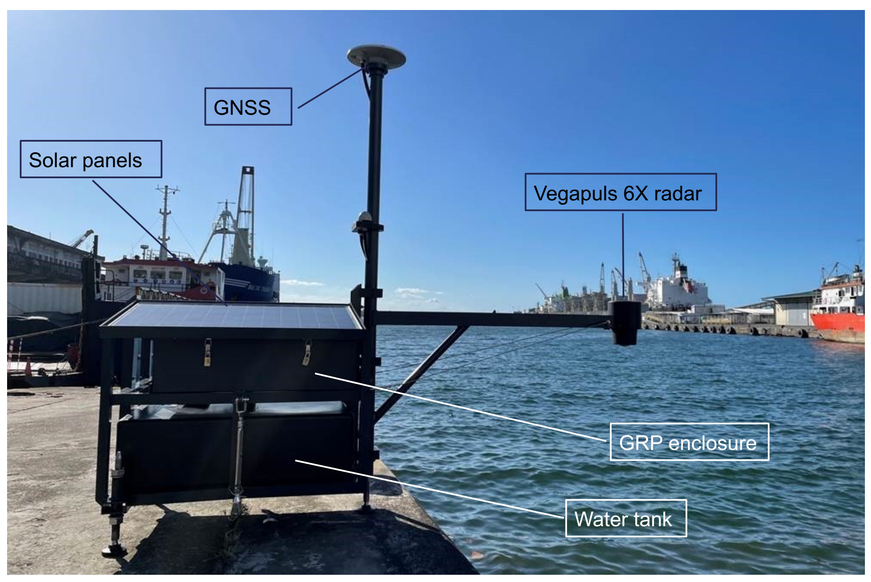

Figure 2. Portagauge deployed at Toamasina, Madagascar

Satellite sea level data for Madagascar

The use of satellite data to produce time series along-track "Total Water Level Envelope" (TWLE) is a well-established procedure, employed by NOC in previous projects (e.g. the UKSA-funded C-RISe, www.c-rise.info). The PASS-SWIO project is using the CMEMS sea surface height anomaly multi-mission data set to cross- validate against in-situ data and to provide information on spatial characteristics of variability – including annual and semi-annual cycles, long-term trends and inter-annual variability (Fig. 3 and 4).

Thanks to ESA Network of Resources (NoR) sponsorship, Earth Console has reprocessed Sentinel 3A and 3B data through the Altimeter Virtual Laboratory (https://earthconsole.eu/groups/altimetry/) using the specialised SAMOSA+ coastal re-tracker, with a posting rate of 80Hz. Initial along-track analysis has compared noise levels and percentage of valid data points retrieved on these re-processed data with respect to the "'standard" EUMETSAT product (Fig. 5) and has demonstrated improved performance within 5km of the coast. The project will carry out further validation and assessment of variability using these coastal processed data.

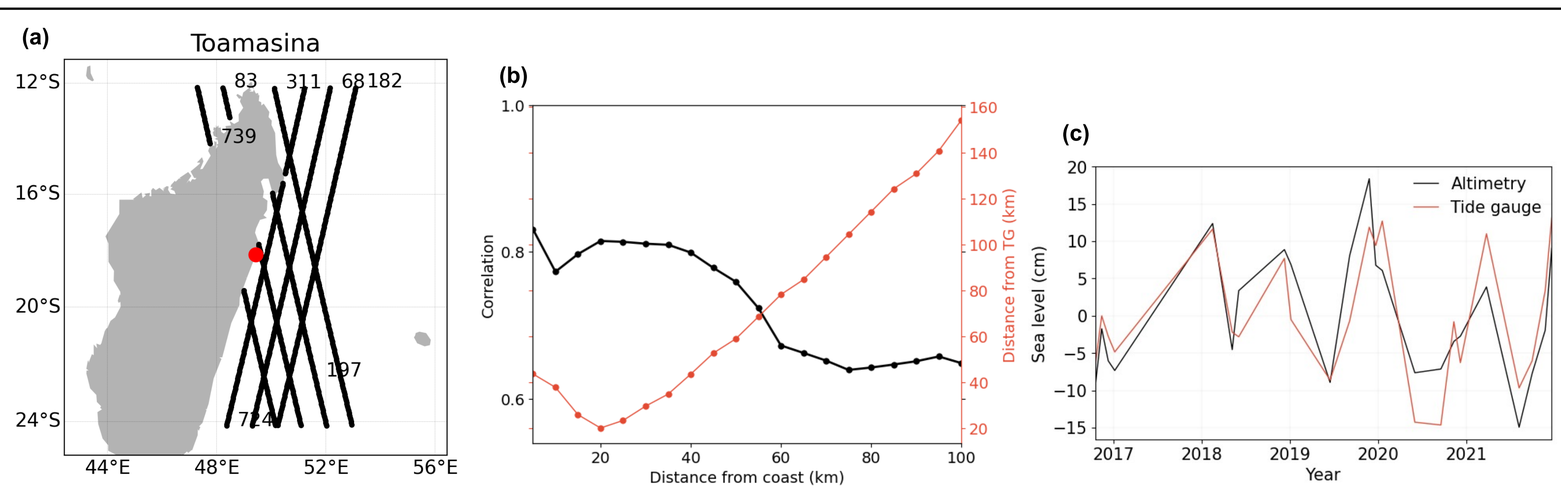

Figure 3. Validating CMEMS Sentinel 3a data against the Toamasina Tide Gauge (a) S3a tracks; (b) Correlation against distance from coast; (c) S3a and Tide gauge TWLE time series

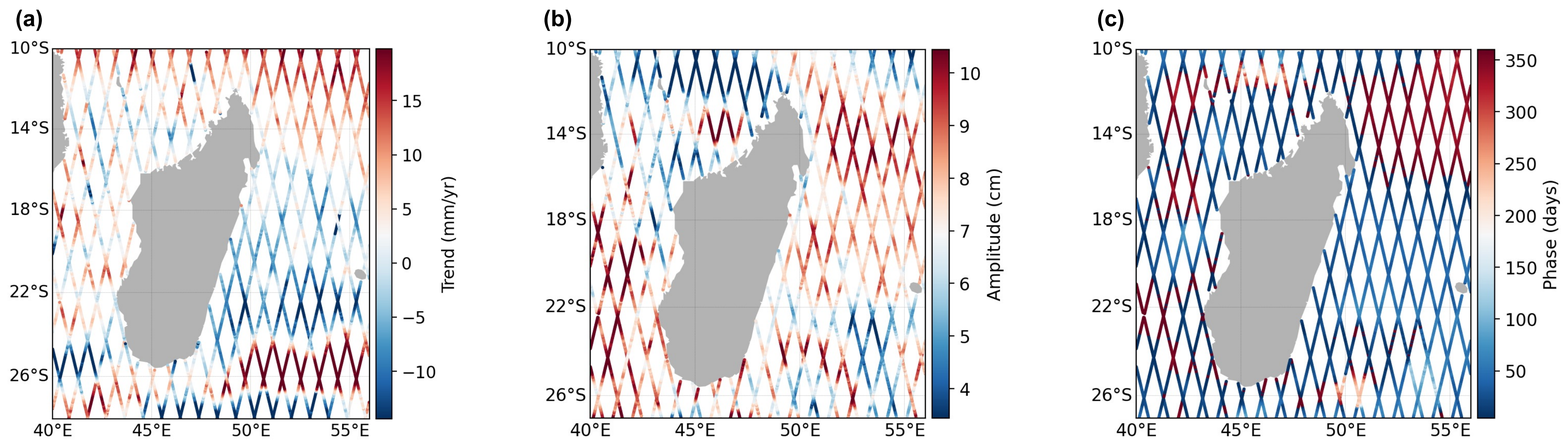

Figure 4. Sea level variability from CMEMS Sentinel 3a data (2016-2022): (a) Sea level trend (mm/yr); (b) Amplitude of annual cycle (cm); (c) Peak of annual cycle (day of year)

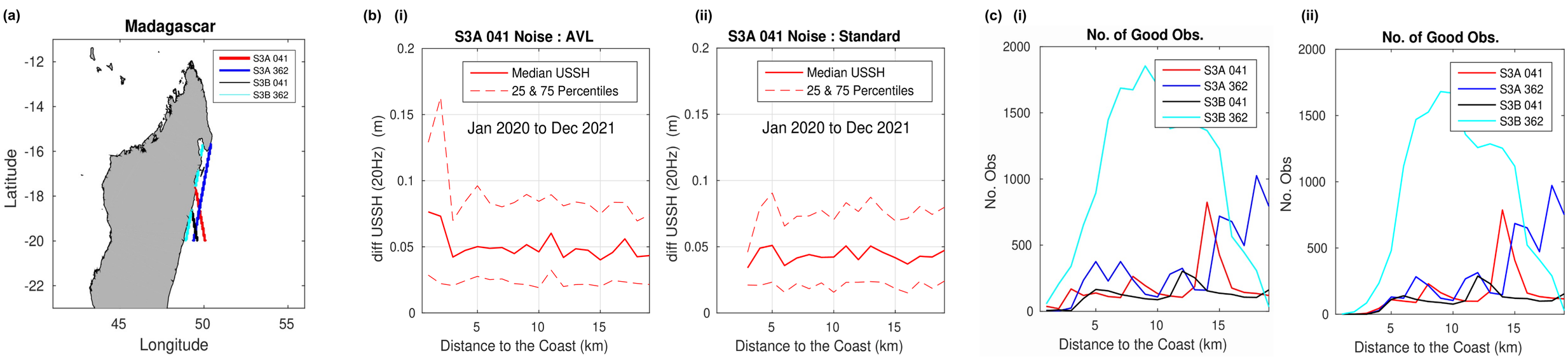

Figure 5. Comparison of EUMETSAT Sentinel 3 product ("Standard") against data reprocessed with SAMOSA+ re-tracker ("AVL"): (a) Map of S3A passes; (b) Along-track noise for Sentinel 3A track 41, (i) SAMOSA+ and (ii) standard ESA product; (c) no of good data points, (i) SAMOSA+ and (ii) standard ESA product. All data from the 20Hz product.

www.satoc.eu/projects/pass-swio