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LONGTERM SEA LEVEL CHANGE IN NIGERIAN COASTAL WATERS FROM MULTI-MISSION ALTIMETRY DATA

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ABSTRACT. The long-term sea level change from 2000 to 2015 was investigated within the Nigerian coasts of the Gulf of Guinea and the Atlantic Ocean from satellite altimetry data of the TOPEX, JASON-1, JASON-2, ERS-2, ENVISAT and SARAL missions. Sea level data retrieval and reduction were carried out using the radar altimeter database system (RADS). In RADS data processing, the 2008 updated environmental and geophysical corrections were applied. Three tidal stations were chosen for the altimetry data comparison in order to ascertain the correlation that exists between the ocean tide models selected for the study. Similarity in the patterns of sea level variations indicates good agreement between altimetry data independently obtained with GOT4.10 ocean tide model (OTM)and FES2004 OTM. From the 16 years' altimetry data, results from both ocean tide model show positive sea level trend within the region. The altimeter sea level time series revealed that since 2000, the mean sea level in Nigerian coasts has been rising at a geographically-dependent rate of 2.4mm/year and 3.6mm/year with the GOT4.10 and FES2004 OTMs respectively. Also, both ocean tide models vary in the estimated sea level trends by 1.2mm/year and have a root-mean-square difference of 1.3cm. This kind of information is important for better understanding of the marine ecosystem; studying environmental issues related to flood investigations and global warming especially for an area that until now is yet to be adequately explored by the altimeter science community.

Keywords. Sea Level Anomaly, Satellite Altimeter, Ocean Tides; Radar Altimeter Database System (RADS)

INTRODUCTION

Unlike the sparse network of coastal and mid-ocean island tide gauges, measurements of sea level from space by satellite radar altimetry provide near global and common origin coverage of the world's oceans, thereby allowing more accurate determination of regional sea level change.

Satellite altimeters also measure sea level with respect to the centre of the earth. Satellite altimetry avoids vertical land movements (tectonic motions, subsidence) that affect local determinations of sea level trends measured by tide gauges [1]. Furthermore, Nigeria with a coastline of overt 800km presents one of the longest coastlines in the Gulf of Guinea, unfortunately, the dynamics of Nigeria coastal waters and its impact on the large coastal population is not well studied due to paucity in data infrastructure.

In this study, the crossovers were performed between ERS2-Envisat-Cryosat2-Saral and Topex-Jason satellites. The timeframe covered by individual crossovers is limited to 18 days to reduce the risk of eliminating real oceanic signal and, with that, the sea level trend [2]. Altimetry data was extracted ranging between 1°N ≤ Latitude ≤ 8°N and 0°E ≤ Longitude ≤ 12°E, covering the Nigerian seas (Gulf of Guinea and the Atlantic Ocean). All satellite altimeter missions were merged and then gridded to sea level anomaly grids on a daily basis. The best range and geophysical corrections for Nigerian seas have been applied in RADS processing. A regression model was performed to develop the sea level trend using altimetry data. Before developing the regression model, annual signal / relative offsets have been removed from the altimetry data and the dataset has also been filtered by one-month running means.

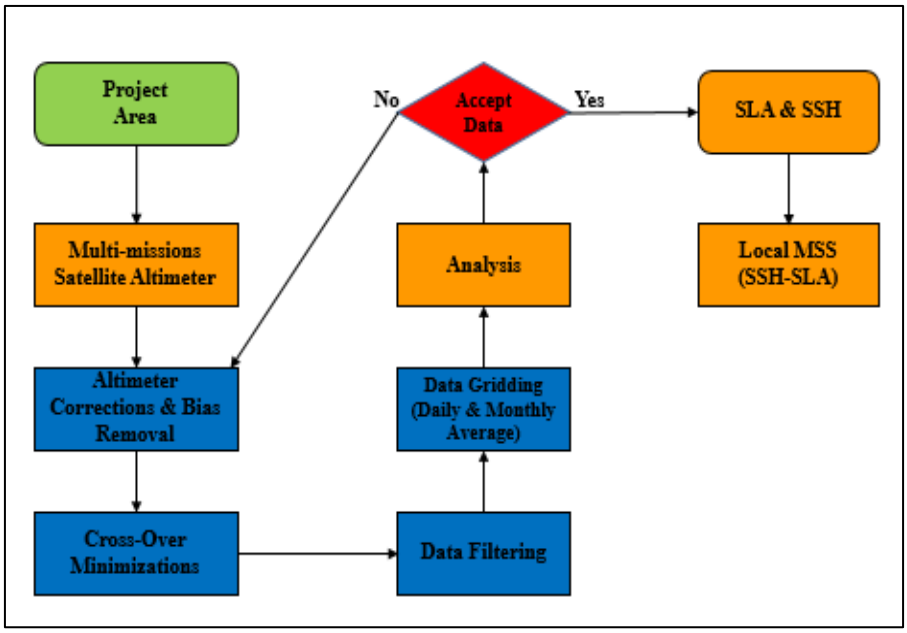

Figure 1. Altimeter Data Processing Flows in RADS

RESULTS AND DISCUSSION

2.1 Sea Level Trend Using Multi-Mission Altimetry

This study was conducted using 7 satellite altimeter missions from 2000–2015 (16 years) and processed using two (2) different ocean tide models –GOT4.10 and FES2004. Three tidal stations at Forcados, Lagos and Tema were also chosen. In Figures 2 and 3, the rise of mean sea level is clearly visible in the altimetry data for both models. There were estimated sea level trends of 2.4mm/year and 3.6mm/year with the GOT4.10 and FES2004 OTMs respectively. This is an indication that the overall sea level for the Nigerian seas is rising. Also, it could be seen that both OTMs vary in the estimated sea level trends by 1.2mm/year and have a root-mean-square

difference of 1.3cm. Tables 2 & 3 show the variation in the estimated Sea Level Anomaly & Mean Sea Surface respectively by the models at each tidal station. Finally, Figures 4 and 5 give the modelled spatial trend patterns in altimetry-based sea level anomaly for 2000–2015 using FES2004 and GOT4.10 OTMs respectively.

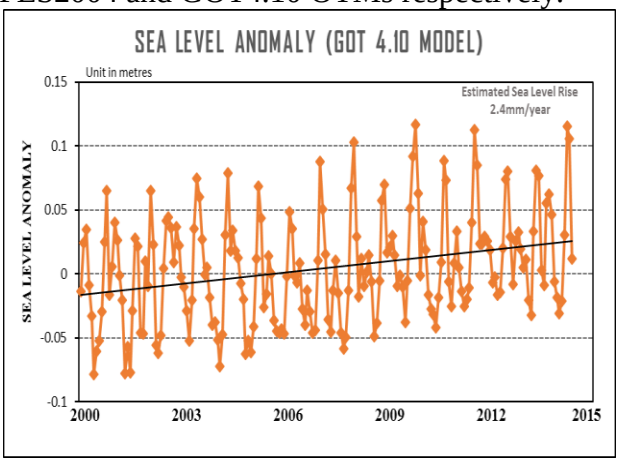

Figure 2. Sea Level Anomaly with GOT4.10 OTM

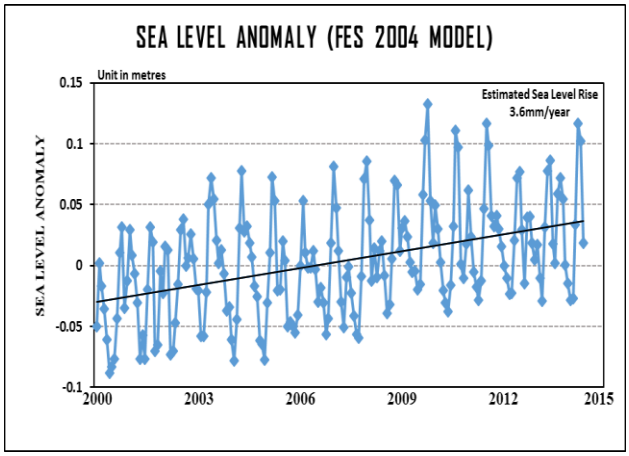

Figure 3. Sea Level Anomaly with FES2004 OTM

Table 1: Sea Level Anomaly for each OTM at Tidal Stations

Tidal Stations	Sea Level Anomaly (m)		Difference (mm)
	GOT4.10	FES2004	
Forcados	0.006687	0.009810	3.123
Lagos	0.016146	0.019045	2.899
Tema	0.016417	0.013516	2.901

Table 2: Mean Sea Surface for each OTM at Tidal Stations

Tidal Stations	Mean Sea Surface (m)		Difference (cm)
	GOT4.10	FES2004	
Forcados	19.638560	19.600240	3.832
Lagos	16.106945	15.990723	11.622
Tema	18.146111	18.336169	19.006

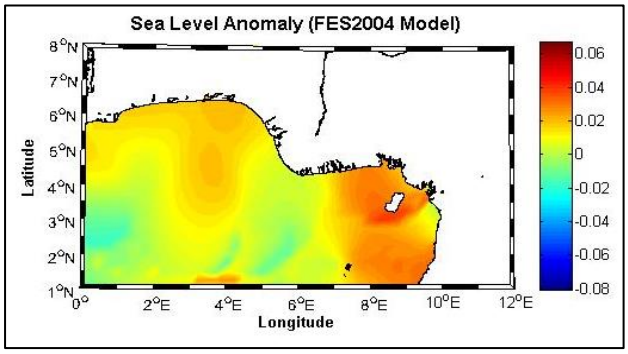

Figure 4. Model of Sea Level Anomaly using FES2004 OTM (Unit in metres).

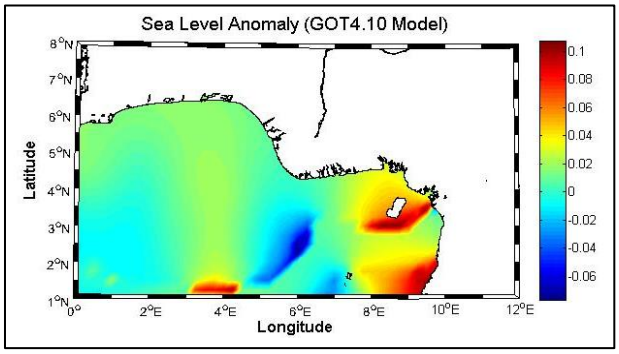

Figure 5. Model of Sea Level Anomaly using GOT4.10 OTM (Unit in metres).

CONCLUSION

This study has been able to show using altimetry, for the first time, the rate of sea level rise within the Nigerian seas. With both OTMs showing positive trends over a period of 16 years,

which indicate regional sea level variations. Furthermore, the study has shown that the sea level trends using both OTMs vary geographically at the selected tidal stations.

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