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Validation of satellite-derived sea level data against tide gauge data from the Mozambique coast

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Background

Satellite-derived data comes as solution for the lack of observed in-situ data, essential for comprehending various marine processes worldwide. These remotely-sensed data have better spatial coverage, and provide a quasi-synoptic view of the global ocean. However, the data comprise only the surface measurements of a limited number of variables, and are subjected to contamination by many factors, such as the reference level in the case of sea surface heights. Until recently, satellites could not resolve satisfactorily the oceanic features near the coasts due to interference of atmospheric factors. Today the coastal data can be used with the same level of confidence as that of non-coastal data, thanks to improvements made in the algorithms used to acquire and process satellite raw data. The ALES (Adaptive Leading-Edge Subwaveform) is one of these modified algorithms that uses only a portion of the returned echo to estimate sea level and sea state, adapting the width of the estimation window according to the significant wave height.

The ALES algorithm was designed in order to maintain the same degree of precision both in open ocean, and along the coasts, and in the present study we seek to validate sea level data retrieved by this algorithm against tide gauge observations from four ground stations along the Mozambique coast. The rationale here is that once validated for the selected three stations, sea users and decision makers in the surrounding areas will be able to use satellite-derived and ALES-reprocessed data for any nearby location of interest.

Methods

This study is part of the Coastal Risk Information Service (C-RISe) project of the National Oceanographic Centre that hosts a repository of sea level data processed under ALES, along with analysis software. Our approach consisted in extracting selected portions of data, processing and interpretation. The data used in this study comprised (i) altimetry data from the Jason-1 and Jason-2 missions, spanning the years 2002 and 2016, resampled for the

Western Indian Ocean, and (ii) hourly tide gauge data collected at Maputo (32.57°E, 25.97° S), Inhambane (35.75°E, 23.87°S), Beira (34.83°E, 19.82°S), and Pemba (40.48°E, 12.97°S) stations, gently provided by the Mozambican National Institute of Hydrography and Navigation. The tide gauge data were collected using a floating buoy during 2002-2004 at the Maputo station, a radar gauge during 2011 at the Inhambane station, a floating buoy during 2002 at the Beira station, and a radar gauge during 2007-2013 at the Pemba station.

The processing involved harmonic analyses performed using the TASK software, and comparisons using Python software.

Results

A good agreement was found between the altimeter and tide gauge data, as indicated by the correlation coefficient that was above 0.5 in most of the stations. The correlation for the Maputo station was the least (r=0.29) for a point in the satellite pass located 67 km from the coast and nearly 257 km from the tide gauge. The correlation at the Pemba station was the best (r=0.71) among the four stations, taken for a point in the satellite pass located 17 km from the coast and 139 km from the tide gauge. There seems to have some relation between the distance to tide gauge and the best correlation found, given that in all stations the closer the distance to tide gauge, the greater was the correlation.

By analysing the difference between the amplitude and phase of the satellite-derived and tide gauge data, for the annual cycle we found differences varying between -2.3, -37, -43.8, and +1.3 centimetres of amplitude and +18, -12, -17, and -9 days of phase lag for Maputo, Inhambane, Beira and Pemba, respectively. Similarly, for the seasonal cycle we found -2.7, -23.2, -22.3, and -1.3 centimetres on amplitude, and +8, -6, -173, and -40 days of phase lag, for the Maputo Inhambane, Beira and Pemba stations, respectively. These differences a indicates an even better agreement in cycles retrieved for dataset from Pemba station, suggesting that length of tide gauge data might be a positive influence for the great results from Pemba.

Conclusion

With these results we conclude that in the absence of long-term observed data from Pemba, or the locations nearby, the satellite-derived data from Jason-1 and Jason-2 missions can be used with more confidence than in other 3 stations, and urges for the maintenance of a continuous record of sea level data in locations of particular interest.