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Shallow Water Wave Characteristics During Laila Cyclone Using Satellite And In-Situ Wave Measurements

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Abstract:

Extreme weather events like cyclones cause severe damage to coasts by inducing very high waves. Studies of such waves are important for several coastal processes. Satellite altimetry data used to study one of such extreme events LAILA cyclone during the year 2010 over Bay of Bengal. This cyclone caused severe erosion along the coast and of course first ever severe cyclone crossed Andhra coast since may-1990. The satellite altimetry data showed that prolonged high waves during and after the cyclone. The in-situ observations show wave heights up to 3m under the influence of cyclone. The satellite altimetry gridded data performs well with In-situ data.

Keywords: Coastal processes, Erosion, Extreme events, Satellite altimetry, Wave heights

1.Introduction

Wave information is essential for navigation, design of coastal/offshore structures and other marine activities especially in extreme events such as cyclones, storm surges etc., because giant and high energetic waves will develop and cause intense damage to coastal/offshore structures and to the ships. Sometimes, during cyclones characterized by high waves and strong winds will cause severe erosion to the coastal regions. Satellite Altimeters play an important role in measuring these high waves and strong winds during the cyclone, if satellite passes close to the cyclone track. It also helps to improve the model predictions in generating warnings and alerts by assimilating altimeter data and to investigate the possible causes of intensification of the cyclone. In the North Indian Ocean, Arabian Sea (AS) and Bay of Bengal (BoB) were frequently affected by the tropical cyclones during the transition months. The frequency of storm surges is less in the Arabian Sea than in the Bay of Bengal. Most of the countries located along the periphery of the North Indian Ocean, particularly Bay of Bengal, are threatened by storm surges associated with severe tropical cyclones. In the Present study, we used the merged altimeter data obtained from AVISO website and in-situ data were collected from the wave rider buoy with in the vicinity of Visakhapatnam region for the study and comparison purpose.

2. Data And Methodology

The cyclone Laila was initially begins as a low pressure over the south east Bay of Bengal on 15 May 2010 and developed into a depression on 17 May 2010 at 0600 UTC and moved north westerly and further intensified and crossed Bapatla coast in Andhra Pradesh on 20 May 2010 and finally dissipated on 21 May 2010 and the cyclone track is shown in fig.1

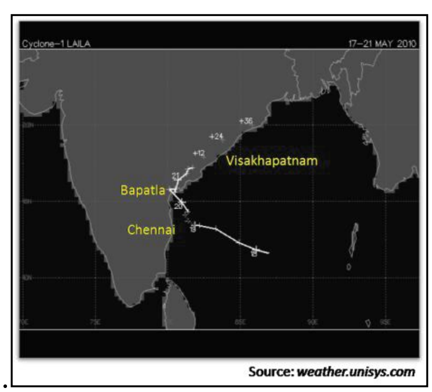

Figure 1: Laila cyclone track during 17-21May 2010

Satellite altimetry works on the principle of sending an electromagnetic pulse and receives back called range and also measures the shape and intensity of the reflected pulse. The significant wave height was computed from the slope of the return pulse of the radar known as leading edge slope returned from the ground and the wind speed was computed from the backscattering coefficient (sigma-naught) and sigma-naught was measured from power of the return pulse.

Satellite altimetry data gridded were obtained from the AVISO (Archiving, Validating and Interpretation of satellite oceanographic data) website through geographical extraction services. The gridded data obtained were of merged multi-satellite altimeter data. The gridding technique for combining multiple altimeters was described by Le Traon et al. [2003]. AVISO gridded data has been widely used by all over the world for different applications.

The wave data was obtained from the *in-situ* buoy measurement near Gangavaram region during and after the land fall of cyclone. The data was averaged and interpolated for every day in order to make comparison with merged altimeter data.

3.Results And Discussion

3.1.Wind Speed

During cyclone period wind speeds greater than 12m/s was observed. These high wind speeds are responsible for the development of higher wave heights. The wind speed obtained from Ascat scatterometer were plotted in fig.2.

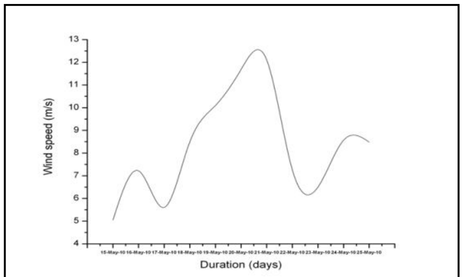

Fig 3: Wind speed near Visakhapatnam as obtained from Ascat scatterometer

Figure 2

3.2.Wave Heights

The wave height development was dependent on the wind speeds. During the observation period, the Maximum wave heights reached up to 3 meters were recorded in the wave rider buoy placed in the vicinity of Visakhapatnam are plotted in the fig.3. The wave height parameters are presented in Table.1.

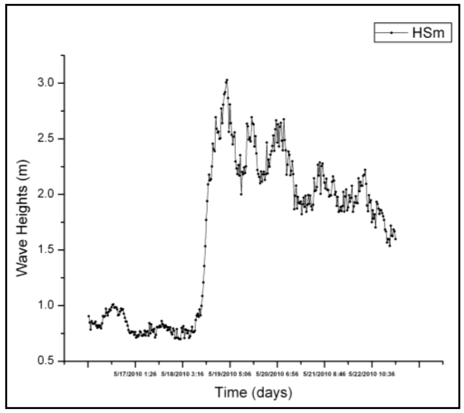

Figure 2: Insitu buoy observations from Visakhapatnam region

	Hs	**Hswell**	**Hsea**
Average	1.787	0.826	1.528
Maximum	3.029	1.882	2.688
Minimum	0.699	0.239	0.564

Table 1: Wave height parameters during the cyclone Laila near Visakhapatnam coast

3.3.Altimeter

The merged altimeter data during the cyclone was interpolated and extracted for the *In-situ* buoy location. It was found that range of altimeter wave heights were half meter more than the *In-situ* buoy data during the cyclone. This type of study was previously carried by Krogstad.et. al. in satellite wave measurements. All calibration relations for the Topex altimeter give more or less the same correction for the most frequent sea states. There is a 1/2m difference in the range of calibration functions at Hs=10m. This highlights the necessity of validating altimeter data against as large a set of buoy data as possible before using the data for extreme wave analysis (cotton, loc.cit). The comparison of merged altimeter data after removing the half meter difference with buoy was plotted in fig.4.

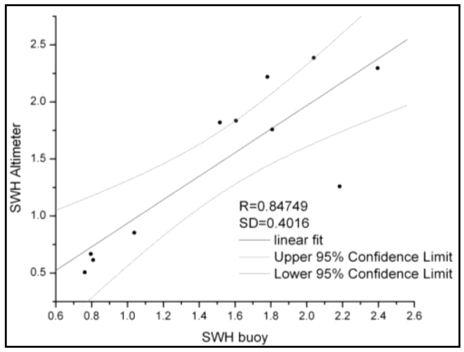

Figure 4: Comparison between Altimeter and in-situ wave heights for Laila cyclone.

The comparison between the swell and significant wave height was plotted in the fig. 5. The comparison shows the dominance of swell contribution. About 80 percent of the waves in the data are the corresponding to these swell.

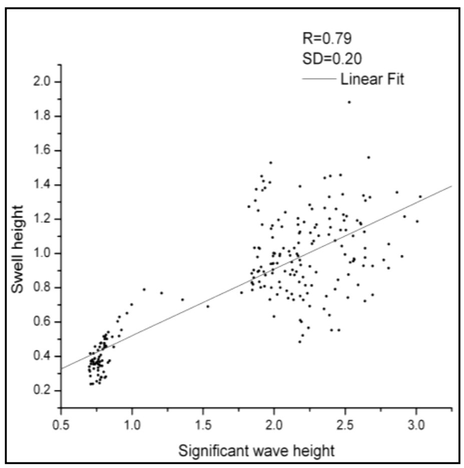

Figure 5: Comparison between Significant and swell wave heights during the Laila cyclone.

3.4.Wave period

The wave period observed from the buoy during the cyclone from 16-22 May 2010 was presented in the fig.6. As the wave height increases range of wave period decreases during the cyclone. The wave period during the normal period was high compared to the cyclone conditions. The wave period of range 7-11 sec were observed with an average of around 9sec were observed.

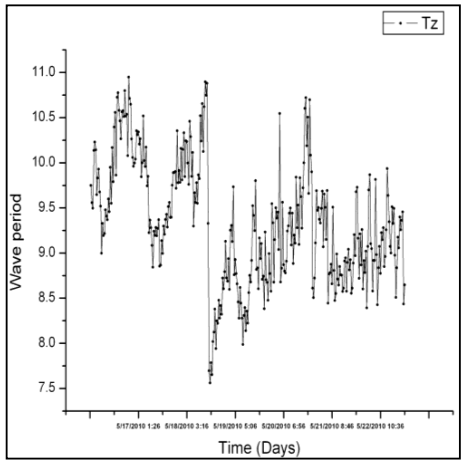

Figure 6: Observed wave period from buoy during the cyclone period

3.5.Mean Wave Direction

The mean wave direction during the cyclone was plotted in the fig.7.The average mean wave direction was around 127 degrees North when they are approaching the coast during the cyclone the direction of waves are around 52 – 181degrees North along Visakhapatnam coast.

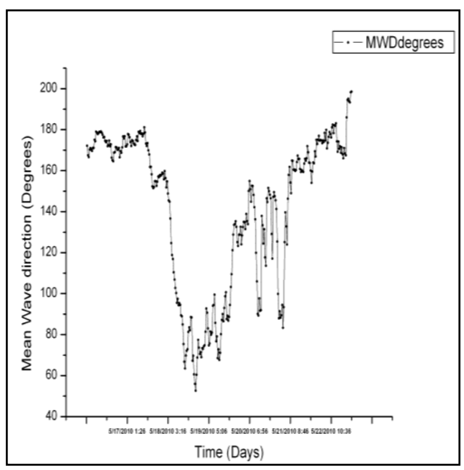

Figure 7: Observed Wave Direction From Buoy During The Cyclone Period

4.Conclusions:

- The Laila cyclone has caused severe erosion along the Visakhapatnam coast because of the high wave activity during and after the cyclone.
- The wave energy is proportional to the square of the wave heights. During the cyclone the maximum significant wave height reached up to 3m and the average height of about 1.7 meters were observed.

- It is observed that swell waves were dominant and their heights are increased by the influence of cyclone.
- The direction of wave approach along the coast was 52 to 181 with an average direction of 127 degrees to the North.
- The altimeter data shows good correlation of 84 percent with the in-situ buoy data near the Visakhapatnam coast.

5.Acknowledgement

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