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Storm surge associated with the Paradip cyclone of 1982

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सार — ज्वार भाटा मापियों तथा भारत मौसम विज्ञान विभाग और उड़ीसा सरकार द्वारा तूफान के बाद किए गए सर्वेक्षणों से उपलब्ध सभी आंकड़ों के आधार पर 1982 में पाराद्वीप चक्रवात द्वारा उत्पन्न तूफान महोर्मि का सही परिमाण प्राप्त किया गया।

ABSTRACT. Based on all available data from tide gauges and post storm surveys by India Meteorological Department and Government of Orissa, the correct magnitude of storm surge generated by the Paradip cyclone of 1982 has been obtained.

1. Introduction

In recent issues of *Mausam* two papers have appeared dealing with the storm surge associated with the Paradip cyclone of 1982. In the first paper Das *et al.* (1983) have described a numerical model for prediction of storm surges and have compared the observed tide levels near Paradip and Dhamra with storm surge heights predicted by the model. In the other paper Ramasastry *et al.* (1984) have given detailed description of the storm and its associated features throughout its life span based on all available data.

According to the authors of the first paper water surface elevation to the extent of 6.7 m was observed at Dhamra port which is about 15 km from the coast. Subtracting the astronomical tide value of 2.8 m they obtained a value of 3.9 m for the storm surge at Dhamra. In the second paper a storm surge of 7 ft (2.13 m) was reported near the landfall point Baranipaniya and a surge of 2 m was reported at the port at Chandbali. The computed value of the surge at the landfall point as given in by Das *et al.* (1983, Fig. 6) of the first paper was 1.5 m.

In view of the discrepancy in observations as presented in the above papers, all the available data collected by the India Met. Dep., the Government of the State of Orissa and Port authorities at different ports in Orissa about the storm surge and associated inundation by saline water are re-examined in the present paper and an attempt is made to deduce the correct magnitude of the peak surge generated by the cyclone.

2. Discussion

A close scrutiny of all the available reports reveals the following important points.

2.1. Inundation by saline water was confined to the shaded area in Fig. 1. This area is approximately 1000 sq. km or 1.0 lakh hectare and it extends from 12 km to the south to 60 km to the north of the landfall point. This is in sharp disagreement with the computations (Das *et al.* 1983) according to which maximum surge of height 4.8 m is predicted at distance of 90 km to the right of landfall.

2.2. The storm surge heights and accompanied saline inundation were assymetric in nature — areas to the right of the landfall point were more affected than those to the left of landfall point. This fact agrees very well with the envelope of maximum surge heights presented in Das *et al.* (1983, Fig. 6).

According to reports considerable area was submerged by fresh water due to heavy rain associated with the storm. This indicates that care should be taken to

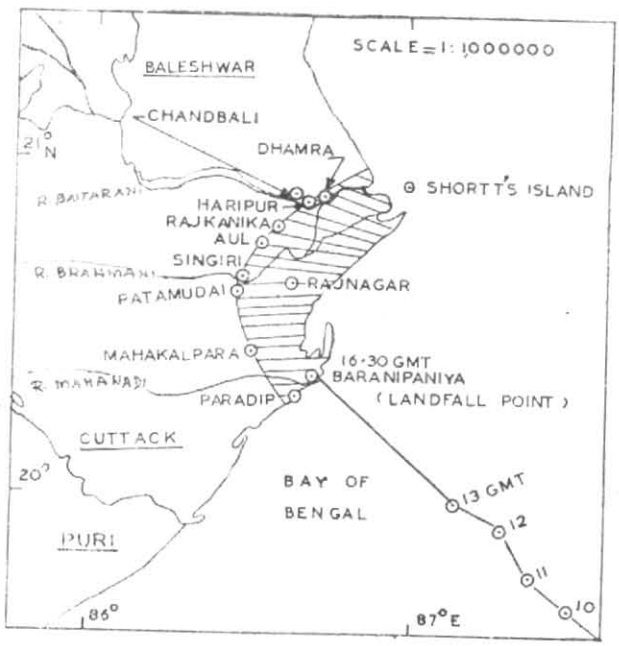

Fig.1. Area (shaded) inundated by sea water due to the Paradip cyclone of June 1982

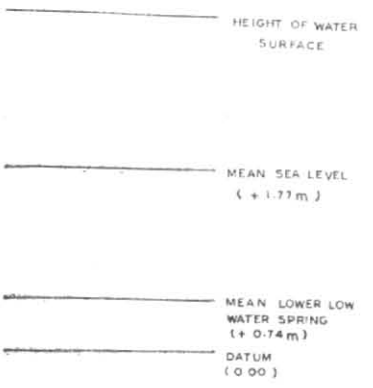

Fig. 2. Relative position of different levels of river *Dhamra* at the port of Chandbali

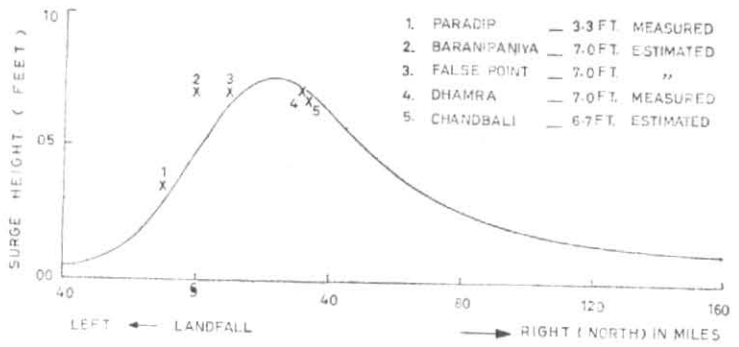

Fig. 3. Peak surge envelope computed from the model of Ghosh *et al.* (1983). Observed surge values are earmarked by 'X'.

separate out the fresh water component while computing the area inundated by saline water due to storm surge. Further, it is indicated that enhanced discharge might have already raised the water surface height in rivers at the time the storm surge peak arrived.

2.3. On examination of actual records at Dhamra it is seen that observations were discontinued after 1400 IST on 3 June 1982 due to high winds. However, the maximum water surface elevation was estimated to be 4.9 m above datum level at 2200 IST. The figure of 6.7 m as reported by Das *et al.* (1983) has been probably arrived at by adding to the estimated river level elevation of 4.9 m another 1.80 m, which is the height of the mean sea level (m.s.l.) with respect to the datum level. The reason for adding up the two numbers given above and declaring the resultant as the peak elevation is not clear. It is obvious from Fig. 2 of this paper that to obtain the elevation of river surface with respect to m.s.l. one should subtract, and not add, 1.8 m from the estimated river level elevation with respect to the datum. Thus, the maximum total water level elevation with respect to m.s.l. at Dhamra on the night of 3 June 1982 was 3.1 m. That the datum level is below m.s.l. is clearly indicated by the fact that all heights are with respect to the datum level and the height of m.s.l. at Chandbali is given as 1.77 m (p. 230, *Indian Tide Tables*-Part I 1982) published by the Surveyor General of India—even the mean low water spring is 0.74 m above the datum level.

The predicted tide value at 2143 IST on 3 June 1982 at Dhamra was 2.8 m above datum or 1 m above m.s.l. Subtracting this value from the total water surface elevation (after reducing both to the same reference level) one obtains a value of 2.1 m. This should be the height of storm surge at Dhamra if one neglects the surge-tide interaction.

2.4. From observations of pressure as recorded by the ship M.V. *Renusagar* anchored at the Paradip port it is seen that minimum pressure recorded was 952 mb at 2035 IST of 3 June 1982. Since the landfall point was about 10 km to the NE of Paradip and the value of the outermost cyclonically curved isobar was 1000 mb, a pressure defect of 50 mb at the centre appears reasonable. The average speed of movement of the cyclone during last 100 km before landfall was 16 kmph as determined from radar fixes of the cyclone centre. The latitude of the place of landfall was 20.7°N and the angle of approach of the cyclone with respect to the tangent at the point of landfall was measured to be 96°. Using the above parameters and assuming the radius of maximum wind to be 40 km [same as that used by Das *et al.* (1983)] the model of Ghosh *et al.* (1983 simulates a peak surge of height 7.6 ft (2.28 m) at a point about 24 miles (38.2 km) to the right of the landfall point. The surge profile computed from the model of Ghosh *et al.* and observed surge heights are presented in Fig. 3 of this paper.

2.5. The observations of pressure and wind as reported by M.V. *Renusagar* are used to verify the relationship between maximum wind and pressure defect at the centre of the storm as given by Mishra and Gupta (1976). It is found that close to the time of occurrence of minimum pressure the computed wind values agree well with the observed wind speeds. This indicates that during this period the belt of maximum wind was near the Paradip port area.

2.6. During the cyclone of 1982 the number of human casualties in Orissa was 245 dead. This is much less than those caused by the 1971 cyclone during which human casualties were 10,000 dead (India Met. Dep. 1972). Evidently, storm surge which accounts for the major part of such losses could not have been comparable in 1982 to the 4 to 5 m surge reported in 1971 (India Met. Dep. 1972).

2.7. The port at Dhamra is about 15 km away from the sea-shore and is situated on the river *Baitarani*. The total water level elevation at this port is due the combined effect of storm surge, astronomical tide, increase in river level due to heavy rainfall in the catchment area and also wind waves. Even when the last two components are neglected and the first two components are assumed to superpose linearly, the surge height estimated inland over a river surface may not be true representative of the surge height on open coast. The modifications undergone by the surge as it moves along a river will depend on the topography of the river bed and it may not be correct to compare elevation of river surface inland with the computed values at the coast.

3. Conclusions

In view of the foregoing discussion one is led to conclude that the peak storm surge generated by the Paradip cyclone of 1982 was about 2 metres.

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