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Analysis of Average Rainfall Super Cyclone by using Double Integration Technique

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***Abstract*—** Cyclones are highly calamitous weather phenomena initiating harm to the life and physical organization in tropical seafaring countries. Cyclones form over whole-hearted tropical oceans and change to the land under the act of routing forces. India's eastern coastline is one of the most violent wind inclined regions on the planet. Despite the fact that the coastline of Orisha has been just about 17% of the Indian eastern coastline, yet Orisha has been influenced by about 35% of all cyclonic and serious cyclonic tempests that have crossed the eastern coastline and related tempest floods that have been regularly immersing huge areas along the coasts. A Cyclone is an enormous scale air mass that turns around a solid focal point of low climatic weight caused due to low atmospheric pressure over oceans resulting in rainfall in the coastal regions. The results of this study indicate that the double integration technique has good potential for calculating the average rainfall during the super cyclone.

***Keywords*—**Tempests, Tropical Cyclone, Super Cyclone, Rainfall, Double IntegrationTechinque

I. INTRODUCTION

Tropical cyclone (TC) explosions are one of the most dangerous and deadly meteorological events in coastal areas globally. Destruction is largely caused by strong currents of wind, heavy rainfall, and associated temperature surges. Apart from human reason, tropical cyclones cause massive destruction of property. The loss of life and property due to these land-falling cyclones can be significantly reduced by giving more accurate forecasts of the track, touchdown (location and time), and speed of movement. The Bay of Bengal is a potentially active region for the growth of cyclonic temperatures and around 7% of tropical temperatures are formed in the region with two cyclone seasons annually.

Prediction rainfall related to tropical cyclones is a major operative challenge. Floods have become a threat to human life in India in the last few decades due to landslides in tropical cyclones. Even though the track-forecasting quantitative rain forecast (QPF) for tropical cyclones continues to improve. One of the issues in the QPF is the lack of data on rainfall over the open oceans to assess and confirm numerical weather prediction (NWP) model results. Methods of predicting tropical cyclone rainfall lag far behind track forecasting. Nevertheless, significant developments have taken place over the years due to developments in remote sensing observations and the growth of mesoscale models and data simulation techniques.

Until recently, tropical cyclone precipitation was largely predicted by empirical methods and subjective experience from the forecaster. Nevertheless, the latest techniques for Quantitative Rain Estimate (QPE) are currently employed in the effective application in some major forecasting centres, which until now have greatly enhanced the forecast of tropical cyclone-associated precipitation.

Explored the hydro metrological characteristics of the tropical cyclone ‘Gonu’ through atmospheric, ocean, and land surface modelling coupled to the atmospheric component based on the MM5 model [1]. Current studies have shown that some high-resolution dynamic model simulations are efficient in capturing the rainfall patterns of tropical cyclones. The horrific rainfall investigated by associated with thunderstorms in South Korea in 2002 using numerical simulations using the Weather Research Forecast (WRF) model [2].

There are other tasks related to the performance of weather forecasting models ([3]-[7]). Some cyclonic events such as SIDR (November 2009), Aila (May 2009), and Laila (May 2010) as well as the effects of rainfall in North East India [7]. The correlation of forecasting systems for forecasting rainfall is discussed [8]. The contribution of tropical cyclones to the landslide process [4] and Predicts landslide forecasts in tropical cyclones and calculates landslide times and terrain forecasts [10].

The intensity and the environmental relationship of tropical cyclones that hit the Bay of Bengal (BoB) during 2000–11. For this purpose, the author considers the pre-and postmonsoon seasons to study the position and intensity of cyclones on the BoB and explore the relationship between parameters of different environments with varying intensity of tropical cyclones. The influence of low-level airplanes in the Bay of Bengal in the region of the northern Indian Ocean and the planetary boundary layer on the strength of the cyclone [11]. The track of the steamy cyclone 'Phailin' and also calculated the tracking error using the innovative mesoscale (WRF) model [12]. The annual frequency of the TC 'Genesis' in the western north pacific by the Poisson regression model [13].

The present study has its limitations because heavy rainfall mostly occurs nearby the landfall position of the tropical cyclone. Section II describes the study area and rainfall data. Section III describes the methodology of the present work. Section IV discusses the results and discussion and Section V describes the conclusion of the present study. The authors have investigated the track of the super cyclone over Odisha [14] and in this study an attempt has been made to find the average rainfall over Odisha state by double integration technique.

II. STUDY AREA AND DATA

In the present study, the eastern part of the Orisha coastal area has been taken (Fig. 1) for estimating the average rainfall during the super cyclone. The observational data for analysis during this study has been taken from the Indian Meteorological Department (IMD) weblink and the total 21 stations data have been used (Table 1) for the study.

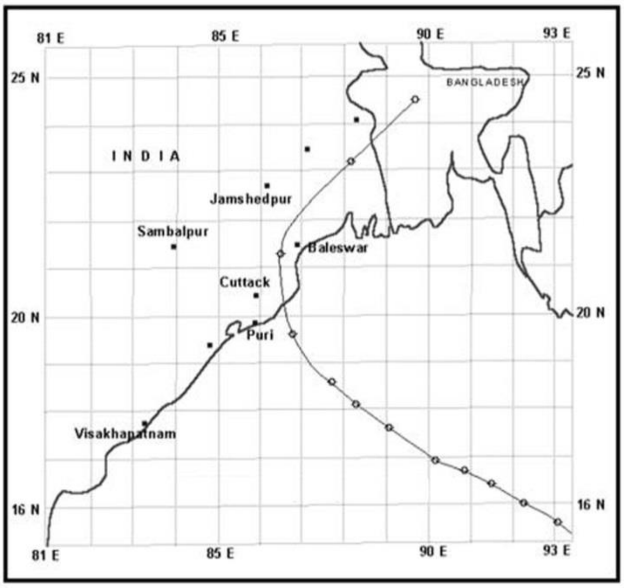

Fig. 1: Track of Super Cyclone 1999

Table 1: Rainfall during super cyclone according to IMD

S.N.	Stations	Total Rainfall (in Inches)	S.N.	Stations	Total Rainfall (in Inches)
1	Oupada	37.6	12	Cuttack	12.1
2	Bhadrak	34.1	13	Rajghat	14.8
3	Anandpur	28.5	14	Nilgiri	16.9
4	Paradip	37	15	Suneidam	30.9
5	Chandbali	27.2	16	Akhuapada	24.4
6	Bhubaneswar	22.1	17	Astarang	23.6
7	Udala	18.7	18	Kakatpur	21.5
8	Puri	13.9	19	Kujang	18.7
9	Kamakhyanagar	11.7	20	Jenapur	17.5
10	Daitary	10.6	21	Hadgarh	27.2
11	Dhenkanal	10.4			

Notations have been used in the present studies

The present study has the following notations:

i. $f(x, y)$: The rainfall in inches at a point x miles to east of origin (placed at Satapada, Orissa in this work) and y miles north of origin.
ii. R : Entire Area under Integration.
iii. (x_{ij}^*, y_{ij}^*) : Approximately the midpoint of sub-rectangle R_{ij}

III. METHODOLOGY

The Satapada district of Orissa was the most affected area during this cyclone. For the same, in this study considered, the entire affected area of Satapada lies under the first Quadrant, so all values are positive & dividing the map in sub rectangles as shown in Fig. 1. The method of double integration has been used to investigate the average rainfall during Super Cyclone which hit Orissa in 2009. The locations of Orissa which used for study purpose seen in Fig. 2.

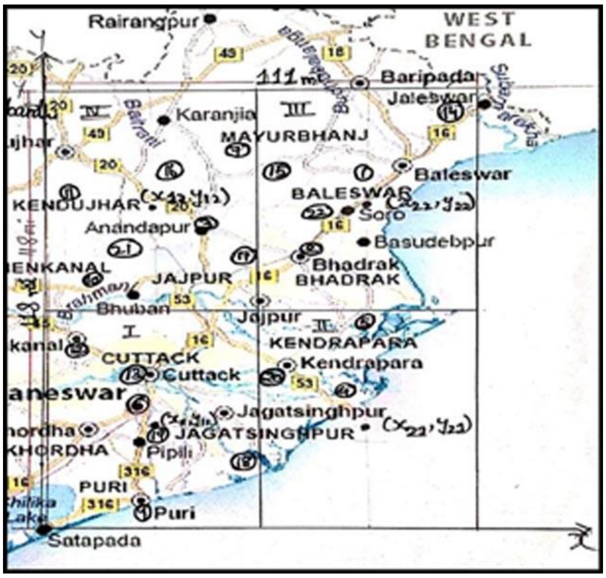

Fig. 2: Study area and numbers are showing the monitoring location in Orisha

IV. Results and Discussion

In this study, the total area 13098 miles^2 has been taking for the calculating purpose and the rainfall estimated at midpoints of each grid. The Satapada district has been used for the initial value of the data in the present study.

R = 111 * 118 = 13098 miles^2

Now, ΔA = ¼ [13098] = 3274.5 miles^2

The rainfall at each midpoints (x_{ij}^*, y_{ij}^*) can be estimated as

At (x_{11}, y_{11}) = 17.2 inches, At (x_{12}, y_{12}) = 20.4 inches, At (x_{21}, y_{21})= 27.6 inches and At(x_{22}, y_{22})= 26.1 inches

Now, average rainfall in the area was as follows

$$f_{average} = \frac{1}{R}\left[\iint R.f(x.y)dx.dy\right]$$

$$= \frac{1}{13098}\left[\iint Rf(x,y)dxdy\right]$$

$$\approx \frac{1}{13098}\left[\sum x_{ij}^*, y_{ij}^*\right]\Delta A$$

$$= \frac{1}{13098}\left[f(x_{11}, y_{11})\Delta A + f(x_{12}, y_{12})\Delta A + f(x_{21}, y_{21})\Delta A + f(x_{22}, y_{22})\Delta A\right]$$

$$= \frac{1}{13098}[17.2 + 20.4 + 27.6 + 26.1]\Delta A$$

$$= \frac{1}{13098}[91.3][3274.5]$$

$$= \frac{91.3}{4}$$

= 22.825 inches

According to above calculation the average rainfall estimated 22.825 inches. The average rainfall 22 inches estimated by the India Meteorological Department. After the statistical analysis this study has only 3.25% error, it may be reasonable quite value.

V. Conclusion and Future Scope

The Odisha state was hit by the severe super cyclonic storm in 29-30th October 1999 that covered all the coastal districts. The most affected areas are Jagatsingpur, Kendrapara, Cuttack, Khurda, and Purifrom this cyclone. The cyclone hit landfall near Paradip coast on 29th October 1999 the wind velocity during cyclone was estimated to be 270 to 300 Km/hr. After hitting the Paradip coast, the cyclonic storm with a tidal wave of 5 to 7 meters height ravaged the coastal districts of Jagatsingpur, Kendrapara, Khurda, and Cuttack. We applied the method of double Integration to find the area under the specified region for calculating the average rainfall during Super cyclone. We also presented a graphical representation of track of super cyclone. After careful examination the present study advocates that the double integration technique may be used for estimating the average rainfall during such type of cyclone.

In the present study, author used double integration technique to find the average rainfall. Researcher may also extend this study by applying the numerical method to find the approximate average rainfall.

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