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Changes in Sea Surface TemperatureDuring the passage of Cyclone *Phailine*

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Abstract

In Indian Ocean Bay of Bengal is the area experiencing largest number of cyclones compared to other parts, impacting property damage and human loss. *Phailine* is the cyclone that blew over Bay of Bengal and that happened on 2013 October. Sea Surface temperature has an important role in formation and intensification of cyclone. Cyclone develops only in warm water body and for which SST should be more than 26 ^{0}C. Warm water gives energy for the development of Cyclone; when the water is warm it evaporates and releases latent heat and gives energy to the atmosphere. We analysed the changes in SST during the passage of Cyclone *Phailine* and we found a cooling effect after the passage and strength of Cyclone is going to decrease due to cooling effect.

Introduction

The Bay of Bengal is having highest number of cyclone, it is surrounded by ample population; due to heavy damage created by cyclone on these areas, prediction and analysis of cyclone turns out to be very important. By definition cyclones are low-pressure systems of wind revolving clockwise and anticlockwise in southern and northern hemispheres respectively accompanied by strong weather changes. It is understood that ocean gives energy for the formation and development of cyclone (Palmen, 1948; Riechi, 1979; and Miller, 1958). Tropical cyclones (TC) are powerful extreme events that release latent heat and develop in warm water body and latent heat gives energy for cyclone up on condensation of water vapor in atmospheric boundary layer (Ooyama,1969). During cyclone there will be strong oceanic surface cooling (e.g., Leipper, 1967; Withee and Johnson, 1976; Pudov et al. 1979; Mc Phaden et al. 2008) that will reduce the effect of cyclone gradually. In this article, it is attempted to assess the changes, if any, during the passage of a cyclone, particularly *Phailine*, as a case study.

Data and methods

Data sets, for the present study, are drawn from NASA's MERRA* (Modern - ERA Retrospective analysis for Research and Application), and are on

hourly scale. It is having resolution of 0.5 ^{0} and clearly depicting all characteristics of Cyclone. For the analysis we have taken averages over Bay of Bengal Using Matlab and plotted time series around 15 days including cyclone, Pre cyclone and Post cyclone periods. The Modern-Era Retrospective analysis for Research and Applications version 2 (MERRA-2) is a NASA atmospheric reanalysis for the satellite era using the Goddard Earth Observing System Model, Version 5 (GEOS-5) with its Atmospheric Data Assimilation System (ADAS), version 5.12.4. The MERRA project focuses on historical climate analyses for a broad range of weather and climate time scales and places the NASA EOS suite of observations in a climate context. Using Matlab we made time series plot for SST, latent heat and wind stress. SST gives indication about cooling of water; latent heat gives about heat release after evaporation and wind stress give reason for subsurface water movement. Bathymetry data taken from ETOPO1, it is a 1 arc-minute global relief model of Earth's surface that integrates land topography and ocean bathymetry.

Cyclone Track

Description of cyclone track is given below as the study pertains to the changes in the SST along the path of the cyclone *Phailine*. Table 1 provides the necessary detail as to the cyclone track. Fig. 1 illustrates the *Phailine's* northwesterly path across BOB and ocean depth. Originating at Myanmar (Lat. 13.20°N-Long. 93.40°E) as a tropical storm it travelled along an arc of easterly orientation. At a location Lat. 14.90°N-Long. 91.0°E it took another arcuate path slightly of westerly orientation with cyclone levels. Finally, the cyclone crossed land mass at Lat. 19.60°N-Long. 84.90°E somewhere near Odissa, India.

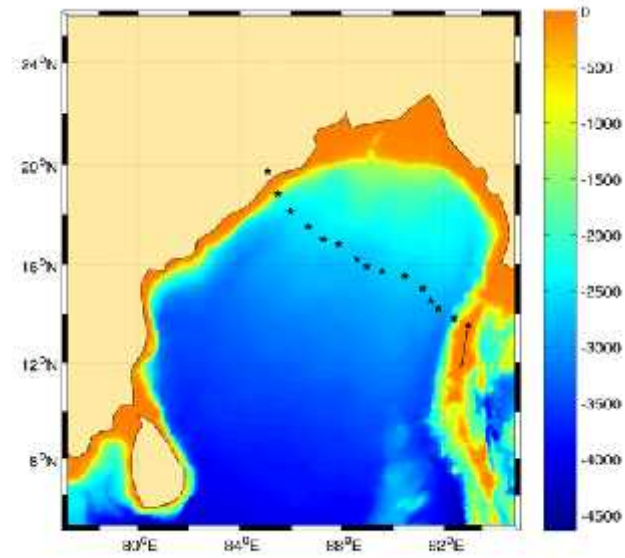

Fig. 1 Track of cyclone *Phailine* from 10/09.00z to 10/12/18z

Table 1 Path of cyclone *Phailine* and its speed and status

S. No.	Latitude N	Longitude	Time	Wind speed in m/sec	Status	Depth(m)
1	13.20	93.40	10/09/00Z	35	Tropical Storm	-1445
2	13.40	92.80	10/09/06Z	40	Tropical Storm	-10
3	13.70	92.20	10/09/12Z	40	Tropical Storm	-2897
4	14.10	91.6	10/09/18Z	50	Tropical Storm	-2887
5	14.40	91.3	10/10/00Z	55	Tropical Storm	-2817
6	14.90	91.0	10/10/06Z	65	Cyclone-1	-2731
7	15.60	89.40	10/10/18Z	125	Cyclone-4	-2711
8	15.80	88.80	10/11/00Z	135	Cyclone-4	-2750
9	16.10	88.40	10/11/06Z	135	Cyclone-4	-2707
10	16.70	87.70	10/11/12Z	140	Cyclone-5	-2576
11	16.90	87.10	10/11/18Z	140	Cyclone-5	-2554
12	17.40	86.50	10/12/00Z	140	Cyclone-5	-2534
13	18.00	85.80	10/12/06Z	130	Cyclone-4	-2529
14	18.70	85.30	10/12/12Z	120	Cyclone-4	-1291
15	19.60	84.90	10/12/18Z	100	Cyclone-3	120
Location and track of cyclone as obtained from Unisys weather						

Result and discussion

On October 4th 2013, it was detected a low pressure system in Gulf of Thailand and on Oct 10th it started towards Bay Of Bengal, the speed of the wind was 35 m/s, once reached Bay it became full-fledged cyclone. Before it hit land, India Government evacuated people and emergency was declared. SST the main factor that control the path of cyclone. It develops on warm water body raising the

SST from 29 to 29.2°C. Passage of *Phailin*e across Bay of Bengal decreased SST due to cooling effect, and once pass-through Bay of Bengal Temperature decreases due to cooling effect, the cooling effect is due to movement of subsurface water in to surface due to wind stress.

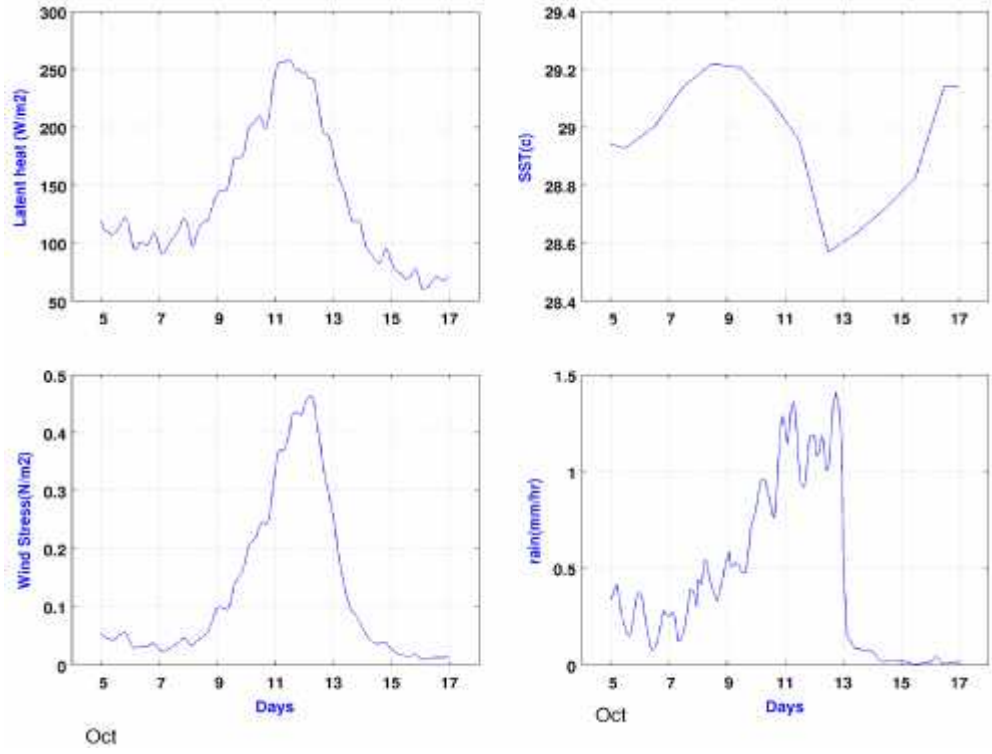

Fig. 2 Changes in SST, latent heat, wind stress and rainfall during October 2013

As illustrated in Fig. 2, latent heat increased sharply and reached to peak then decreased during passage of cyclone. When cyclone reached its maximum power, SST began to decrease (Fig. 2). It is due to the presence of cold subsurface water, cyclone influenced SST seasonal cycle and ocean heat transport (Emmanuel, 2012). It contributes to the meridional oceanic heat transport by injecting heat into the subsurface through mixing. This leads to a ~10% reduction of the SST seasonal cycle within TC basins, which may impact climate system, when SST is high creating evaporation, and resulting in moisture flux, it converges due to wind convergence. It leads to heavy rain (Fig. 2) and controls water budget (WU Wei 2012). This documents that SST has significant impact on cyclone.

Conclusion

Ocean gives energy for seeding movement and intensification of cyclone. From this study, it is also verified prevalence of a noticeably higher SST before the onset of cyclone *Phailine*. It was also attenuated by rising subsurface water to surface region of sea, towards lowering of SST. Wind stress provides energy for the water movement and this impacts negatively with cyclone intensity.

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