Study of critical factors on cyclone genesis in the Bay of Bengal during 2010 – 2015

U.P.G. Pathirana[1*], S.U.P. Jinadasa[2] and P.N. Ranasinghe[1]

[1]*Department of Oceanography and Marine Geology, University of Ruhuna, Sri Lanka*

[2]*National Institute of Oceanography Marine Sciences, National Aquatic Resources Research and Development Agency (NARA), Sri Lanka*

Abstract

Bay of Bengal (BoB) is semi-enclosed basin renown for the seasonal formation of tropical cyclones and depressions (TCs and TDs). Unpredictable severe cyclones with massive destructive powers could cause for the loss of human life and property, unless we prepared with prior notice. When favorable conditions such as Warm Ocean water layer (50-60m), high humidity (> 60 %), low wind shear, Coriolis force, lower and upper air level disturbances combines to form cyclones over the bay, situation becomes more complex. Events like Indian Ocean Dipole (IOD) and El-Nino effect on the cyclone genesis over BoB by altering the normal conditions. During the study period, we have observed highest (8) TCs and TDs in 2013 and lowest (2) in 2015 under normal and El-Nino conditions respectively. In normal conditions the factors contribute for the TCs and TDs genesis shows higher positive correlations and conclude the role of air temperature is the strongest. During the El-Nino conditions higher negative correlations could be observed and conclude the role of sea level pressure is the strongest factor.Cyclone genesis over BoBis not constant due to one or more limiting factors, though the others are favorable. Hence it emphasizes the importance of studying the role of upper water layer (50 – 60 m) on cyclone genesis which will enhance the predictions on TCs and TDs.

Keywords: cyclones, depressions, Bay Of Bengal, El-Nino, upper water layer

---

**Corresponding author: upgpathirana@gmail.com*

Introduction

International Workshop on Tropical Cyclones (IWTC) Statement Report defines Tropical Cyclone (TC) as the generic name for a non-frontal synoptic scale low pressure system over tropical or sub-tropical waters with organized convection and a definite cyclonic surface wind circulation (Holland, 1993, as cited in WMO, 2016). When a cyclone develops over warm sea it prevails longer than a cyclone which develops on land. Genesis of TCs becomes more convenient when they met favorable conditions such as warm sea surface temperatures, low vertical wind shear (McBride, 1995) high humidity (> 60%) integrated with warm (> 26°C) water layer up to a depth of 50 - 60 m, upper air disturbances and Coriolis force.

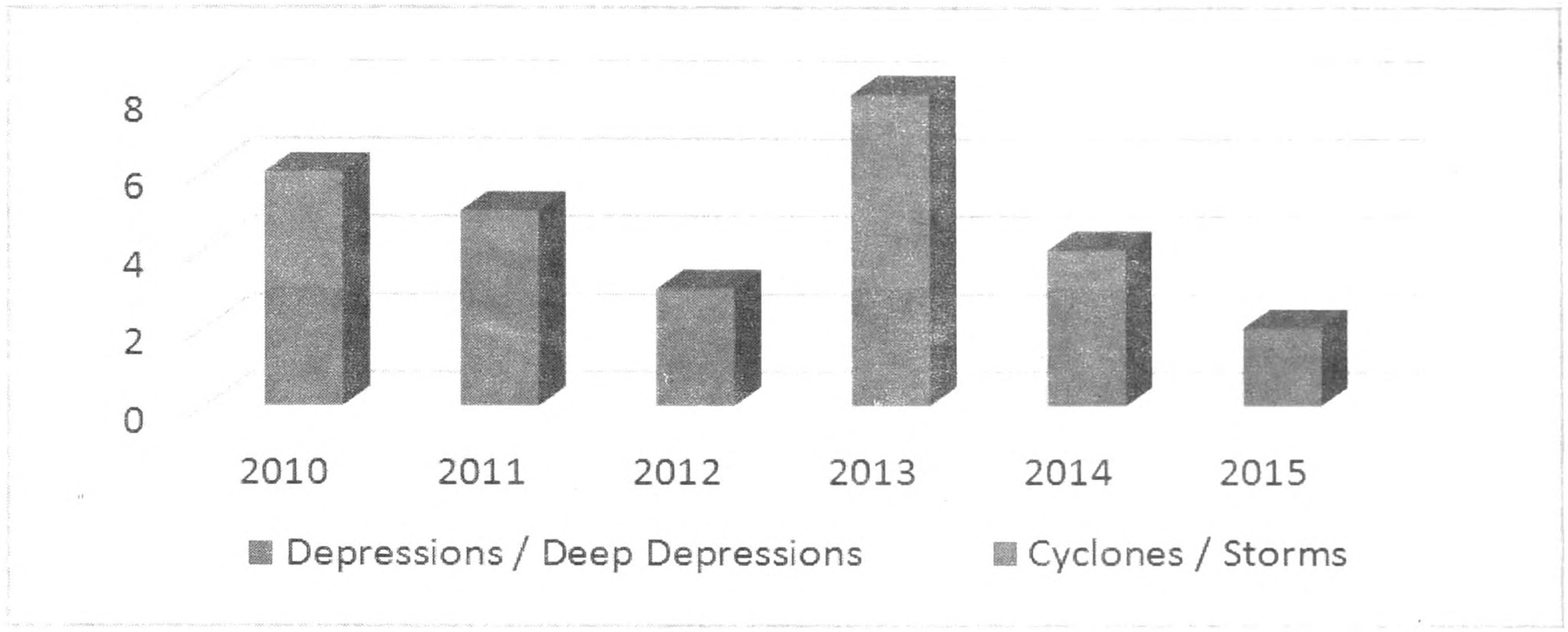

Fig.1: Frequency of Cyclones/Depressions in BoB 2010-2015

BoB which represents the northeast section of the Indian Ocean, is a semi-enclosed basin occupying an area of 2.172×10^6 km^2 between 0 - 22° N 80 - 100° E latitudes and longitudes respectively. According to Gray's publication in 1975 based in historical data, about seven percent of global tropical cyclones are formed in the NIO, while the ratio between Arabian Sea and BoB is around 1:4, emphasizing majority lies in BoB. TCs over BoB occur mainly during April-May (pre-monsoon) and October-November (post-monsoon), less during southwest monsoon where wind is stronger though the other conditions are ideal for cyclone genesis.

Materials and Methods

Ocean data from RAMA (The Research Moored Array for African, Asian, Australian Monsoon Analysis and Prediction) buoys from 2010 - 2015 were used for the analysis of conditions favorable for cyclone genesis over BoB and cyclone data were collected from Indian Meteorological Department (IMD) to study the frequency of cyclones and their conditions. Statements on tropical cyclones and climate change by WMO (World Meteorological Organization) were referred to study the previous studies on TCs. Correlation analysis was done for the selected parameters to study their interactions under normal and the El-Nino conditions.

Results and Discussion

During the study period we have observed 11 cyclones and 17 depressions over BoB (Fig. 1), highest numbers (8) in 2013 and the lowest (2) in 2015 (IMD 2016). Comparison of surface conditions (sea level pressure (SLP), wind speed (WSPD), relative humidity (RH), surface temperature (SST), sub-surface temperature (T_{ss}) and air-temperature (T_a)) over BoB during 2013 is shown in Fig. 2. Negative SLP and positive RH anomalies were observed from May – October (Fig. 2) during the study period while the T_a and SST anomalies follows a bimodal pattern where maximum temperature observed during May and November.

Early studies suggest during normal conditions the TCs and TDs formation is higher than El-Nino years and during La-Nino period intensifies the cyclone formation (Wang and Chan, 2002).

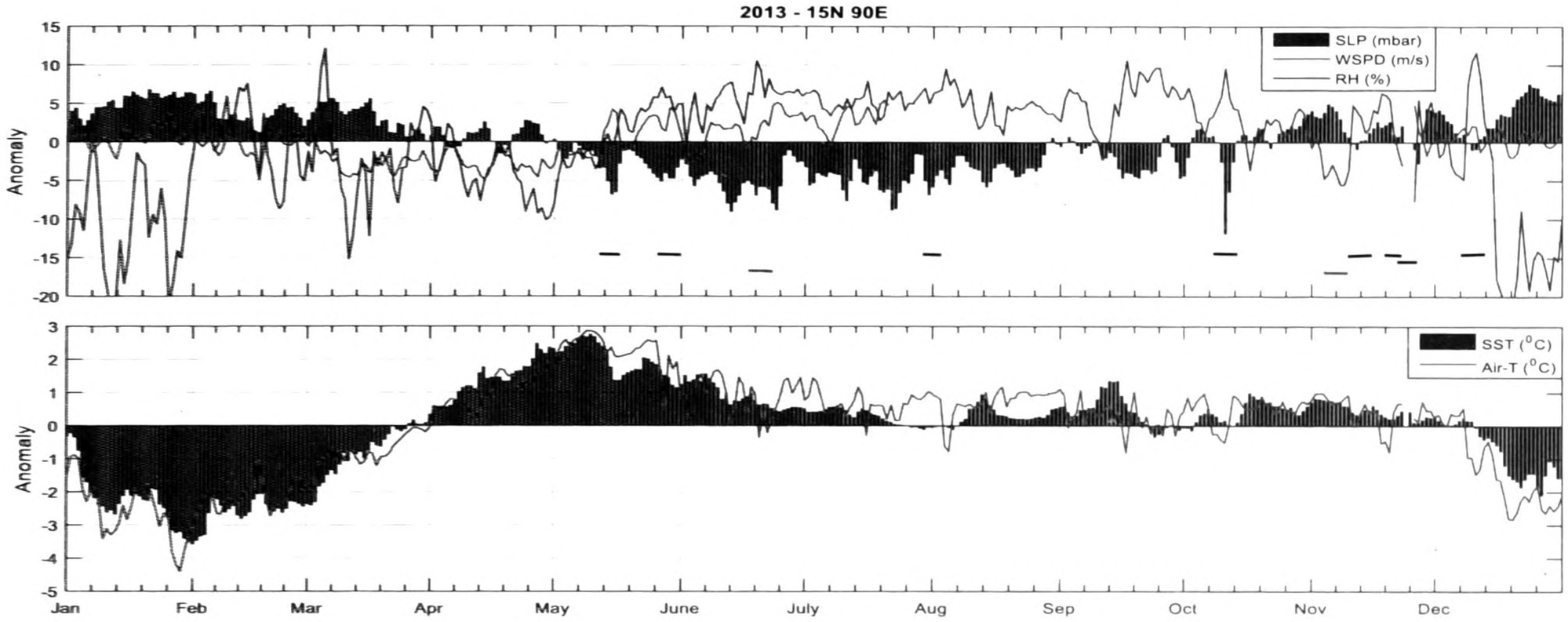

Fig.2: Frequency of TCs and Ds and the surface conditions in BoB under normal condition during 2013 (Black stripe denotes depressions/cyclones in 2013 and Red stripes 2015).

According to statistics, there is no significant variation of the averages of selected parameters throughout the study period except SLP, but there is a difference between TCs and TDs formation over BoB (Fig. 1). Reduction of low pressure zones over BoB during El-Nino condition may be the reason to observe fewer TCs and TDs during 2015 compared to other years. We have selected the temperature values at 60 m depth (T_{ss}), to study the effect of warm water layer (> 26.5 °C) with the surface conditions. During 2013, we have detected higher positive correlations (Table 1) between the parameters and it indicates, under normal conditions T_a and T_{ss} are the most significant to provide favorable conditions to TCs and TDs genesis in BoB following a warm water layer (T_{ss}). In the El-Nino years (2015) (*NOAA, 2016*) SLP becomes the most significant factor to reduce TCs and TDs genesis in BoB, which shows higher negative correlations (table 2) with the other parameters.

Table 1. Correlations among selected parameters in BoB (15N 90E) during 2013.

	SLP	WSPD	RH	SST	T_a	T_{ss}
SLP	1.0					
WSPD	0.081	1.0				
RH	0.609**	-0.069	1.0			
SST	0.484**	-0.084	0.505**	1.0		
T_a	0.788**	-0.035	0.732**	0.782**	1.0	
T_{ss}	0.575**	0.065	0.417**	0.725**	0.543**	1.0

Table 2. Correlations among selected parameters in BoB (15N 90E) during 2015 .

	SLP	WSPD	RH	SST	T_a
SLP	1.0				
WSPD	-0.527**	1.0			
RH	-0.679**	0.485**	1.0		
SST	-0.472**	-0.075	0.287**	1.0	
T_a	-0.616**	0.147**	0.473**	0.890**	1.0

(For table 1 and 2; N=365; **. Correlation is significant at the 0.01 level; *. Correlation is significant at the 0.05 level).

Conclusion

SLP, WSPD, RH, SST, T_a and T_{ss} shows a combine effect on the cyclone genesis over BoB and the relationship among these parameters indicates variations responding to prevailing conditions such as El-Nino. Under normal conditions RH, $T_a$and the warm water layer up to 60 m depth become more significant showing strong positive correlations while SLP become more significant showing strong negative correlations under El-Nino conditions. Warmer conditions in BoB may be the reason to intensify the TCs and TDs genesis frequency during normal years while higher SLP may be the reason to decrease the TCs and TDs genesis frequency during El-Nino years.

Acknowledgement

Authors would like to thank TAO Project Office of NOAA/PMEL for providing RAMA data. Also Indian Meteorological Department for providing cyclone data.

References

Gray, W.M., 1975: Tropical cyclone genesis. Dept. of Atmospheric Science Paper No. 234, Colorado State University, Fort Collins, CO, 121 pp.

Indian Meteorological Department, 2016. *Regional Specialized Meteorological Centre for Tropical Cyclones over North Indian Ocean.* [Online] Available at: <http://www.rsmcnewdelhi.imd.gov.in/index.php?lang=en> [Accessed 20th January 2016].

McBride, J.L., 1995. Tropical Cyclone Formation. Global perspectives on tropical cyclones, WMO/TD-No. 693, 289p.

NOAA 2016. *National Weather Service Climate Prediction Service.* [Online] Available at: <http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml> [Accessed 29th January 2016].

Wang, B., Chan, J. C. L. 2002. How Strong ENSO Events Affect Tropical Storm Activity over the Western North Pacific. *Journal of Climate,* **15:** 1643–1658.

WMO 2016. *World Meteorological Organization.* [Online] Available at: <https://www.wmo.int/pages/prog/arep/tmrp/documents/iwtc_statement.pdf > [Accessed 20th January 2016].