International Journal of Academic Research
ISSN: 2348-7666; Vol.5, Issue-9, September, 2018
Impact Factor: 6.023; Email: drtvramana@yahoo.co.in

Tropical cyclones over north Indian Ocean during Unseasonal IOD years

K.G. Sumesh, Dept. of Agricultural Meteorology, University of AgriculturalSciences, Dharwad, Karnataka-580005

Abstract *The IOD activity over the Northern Indian Ocean (NIO) generally strengthens during the post-monsoon (October-December) season. Recent studies show that there exists another type of IOD event which develops during March-May and matures during July-August. This situation helps the formation and intensification of tropical cyclones over NIO during the summer monsoon seasons, this phenomenon is called the Unseasonal IOD. The influence of various air-sea interaction parameters have been studied on the the formation and intensification of tropical cyclones formed over NIO during the recent unseasonal IOD years. Results show that the frequencies of severe cyclonic storms are more compared to the frequencies of cyclonic storms over both Arabian Sea (AS) and Bay of Bengal (BB). This study further results that the higher magnitudes of Middle Tropospheric Instability and Low Level Relative Vorticity and the lower magnitudes of Vertical Wind Shear play a major role for the formation and intensification of tropical cyclones over this basin.*

Key words:- *Indian Ocean, Indian Ocean Dipole, air-sea interaction parameters*

Introduction

Indian Ocean Dipole (IOD) is an air sea interaction process that occur over the tropical Indian Ocean (Saji et al. 1999; Webster et al. 1999). This event is characterized by the anomalous warming and cooling of Sea Surface Temperature (SST) over the western and eastern equatorial Indian Ocean. A positive IOD event is characterized as warmer than normal SSTs over the western tropical Indian Ocean and cooler than normal SSTs over eastern tropical Indian Ocean. And a negative IOD event is characterized as cooler than normal SSTs over the western tropical Indian Ocean and warmer than normal SSTs over eastern tropical Indian Ocean. Yan Du. et.al (2013) showed that there exists three different phases of positive IOD namely, the Unseasonal IOD (UNIOD), the Prolonged IOD (PRIOD) and the Normal IOD (NRIOD). This study further states that unlike the canonical IOD events, there will not be any ENSO activity in the Pacific Ocean immediately after the unseasonal IOD events, because of the IOD-favorable wind conditions. Unseasonal IOD can also exist in the negative phase of IOD, but it is very rare and short lived, and it is also observed that the unseasonal IOD event is about two-thirds of the canonical IOD events. There have been less studies towards the unseasonal IOD events and its influence on the tropical cyclones over NIO. The Cyclonic storms and Severe cyclonic storms formed over NIO during the period of 1979 to 2010have been studied. There have been five unseasonal IOD years during the study period (Table 1). Francis et.al (2009) shows that a Positive IOD event can be triggered by the occurrence of severe cyclones over Bay of Bengal. Sumesh and Ramesh (2013) states that the concurrent occurrence of El-Niño Modoki and positive IOD can produce more cyclones over NIO.

Table.1: Frequencies of tropical cyclones over over NIO during Unseasonal IOD years

	Arabian Sea		Bay of Bengal	
	Cyclonic storms	Severe cyclonic storms	Cyclonic storms	Severe cyclonic storms
1983	0	0	1	2
1991	0	0	2	1
2003	0	1	0	2
2007	1	1	1	1
2008	0	0	2	1
Total	**1 (0.2)**	**2 (0.4)**	**6 (1.2)**	**7 (1.4)**

Material and Methods

The process of initiation of a cyclone is called cyclogenesis. Many authors have tried to quantify this cyclogenesis over various basins (Gray 1975, Zehr 1992 and Kotal 2009). Zehr proposed a parameter known as Genesis Parameter (GP), which is the product of three dynamical parameters such as low level relative vorticity at 850 hPa, negative of low level divergence at 850 hPa (for low level convergence) and vertical wind shear co-efficient. GP is expressed in units of $10^{-12}s^{-2}$. This study also provides threshold values for these parameters which are favorable for the formation of a cyclone, such as low level relative vorticity at 850 hPa is (1.05x10-5S^{-1}), low level convergence at 850 hPa is (0.33x10-5S^{-1}) and vertical wind shear co-efficient is (10.3xmS^{-1}). In this present paper we are using these threshold values of dynamic parameters for the cyclones over north Indian Ocean.

Roy Bhowmic (2003) used this genesis parameter to study the developing and non-developing systems over NIO, and observed GP values around 20 x10^{-12} sec^{-2} against T-No:1.5 has the potential to develop into a severe cyclonic storm. Kotal et al. (2009) introduced a genesis parameter and termed it as the Genesis Potential Parameter (GPP) for the Indian Seas. The threshold for Mid Tropospheric Instability is 23^{o}C and the threshold for Mid Tropospheric Relative Humidity is 40% or 0. The cyclogenesis parameters used in this present study are *i) Low Level Relative Vorticity at 850 hPa LLRV = (∂v/∂x - ∂u/∂y)*

ii) Low Level Convergence at 850 hPa LLC = - (∂u/∂x - ∂v/∂y) (negative of low level divergence at 850hPa)

iii) S = Shear Coefficient = [25.0 mS⁻¹ - (200 – 850 SHEAR)] / 20 ms⁻¹

iv) Middle Tropospheric Relative Humidity variable (M), M= [RH-40] / 30

(where RH is the mean Relative Humidity between 700 and 500 hPa)

v) Middle Tropospheric Instability (I), I= T850 – T500.

(The temperature difference between 850 and 500 hPa)

The composite anomalies of all these variables have been prepared, using NCEP/NCAR Re-Analysis -II daily data. All the parameters are averaged with the cyclone days, and studied the variations of these parameters for the cyclones during the different types of IOD events. The genesis locations of all the cyclones during 1979 to 2010 are obtained from the cyclone e-Atlas prepared by India Meteorological Department (IMD). The study area includes Arabian Sea [50°E-78°E, 0°N – 30°N] and Bay of Bengal [78°E-100°E, 0°N – 30°N].

Tropical cyclones over NIO during unseasonal IOD years

From figure (1a) it is observed that all the cyclones have crossed the threshold for MTI, hence MTI is a favorable parameter for the cyclones over AS during UNIOD years. From (1b) it is observed that no cyclones has crossed the threshold for MTRH. The 2 severe cyclones formed at the MTRH between (-0.4 to 0.0) and the other cyclone formed MTRH at (-0.6), the magnitude of MTRH is very less for the further intensification. From figure (1c) it is observed that 2 cyclones out of 3 have formed at LLRV between (0.5 to 1.0) $x10^{-5}S^{-1}$, these cyclones have intensified into severe cyclones. The other cyclone has formed at LLRV around (-0.5) $x10^{-5}S^{-1}$, this cyclone did not intensify as severe cyclone. This shows that LLRV is a conducive parameter for the cyclones over this basin during UNIOD years. From figure (1d) it is observed that the severe cyclones have formed at low magnitudes of LLC (-0.6 to 0.2) $x10^{-5}S^{-1}$.Only one cyclone crossed the threshold for LLC but it did not intensify as a severe cyclone, because it is influenced by the low magnitudes of LLRV. From figure (1e) it is observed that, all the cyclones formed at low magnitudes of VWS, it is a favorable condition for the cyclones over AS during the UNIOD years.

From figure (2a) shows the variations of MTI over BB during the UNIOD years. It is observed that only 6 cyclones have crossed the threshold for MTI. This means MTI is not a favorable parameter for the cyclones over BB during this period. From figure (2b): it is observed that except 3 all the cyclones have crossed the threshold for MTRH, and they have intensified into severe cyclones. So MTRH is a conducive parameter for the cyclones over BB during this period. From figure (2c): it is observed that except 5 all the cyclones have crossed the threshold for LLRV, and they intensified into severe cyclones. But the 5 cyclonic storms formed at LLRV between (0.5 to 1.0) $x10^{-5}S^{-1}$. This is also a large magnitude LLRV, so LLRV is a conducive parameters for the cyclones over BB during this period. From figure (2d) it is observed that the magnitude of LLC is

International Journal of Academic Research
ISSN: 2348-7666; Vol.5, Issue-9, September, 2018
Impact Factor: 6.023; Email: drtvramana@yahoo.co.in

very less over BB. All cyclones have formed at LLC between (-0.4 to 0.2) x10^{-5}S^{-1}. LLC does not have any influence on the intensification of cyclones over BB during this period. From figure (2e) it is observed that the magnitude of VWS is very less over BB during this period and it is found to be a favorable parameter for the formation and intensification of cyclones over BB during the UNIOD years.

Figure 1. Variations of cyclogenesis parameters over AS during Unseasonal IOD years

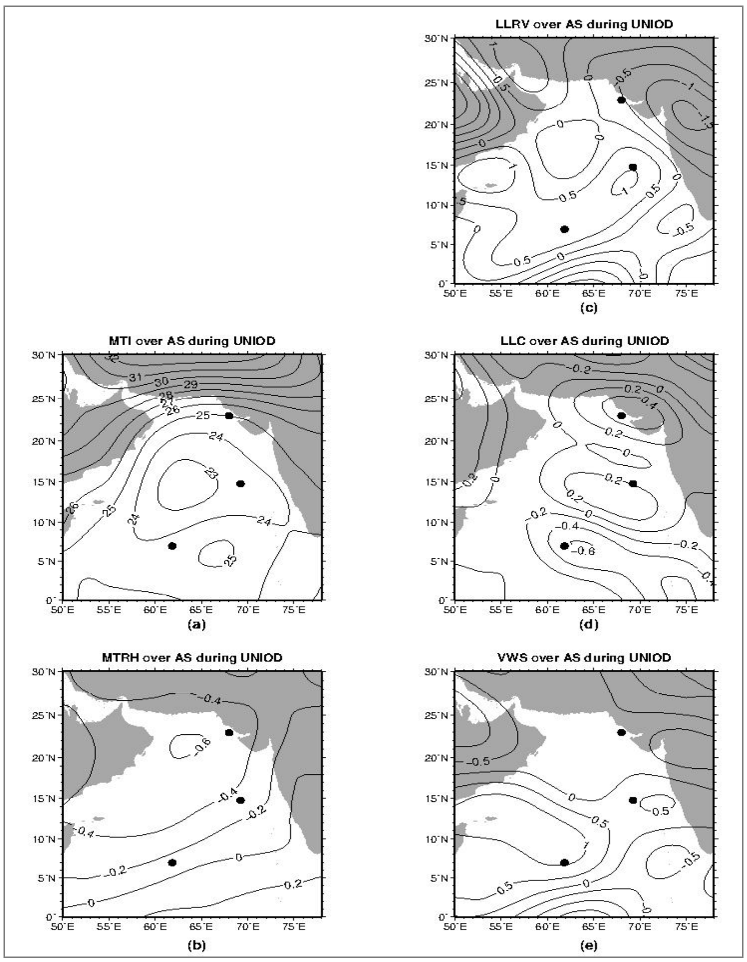
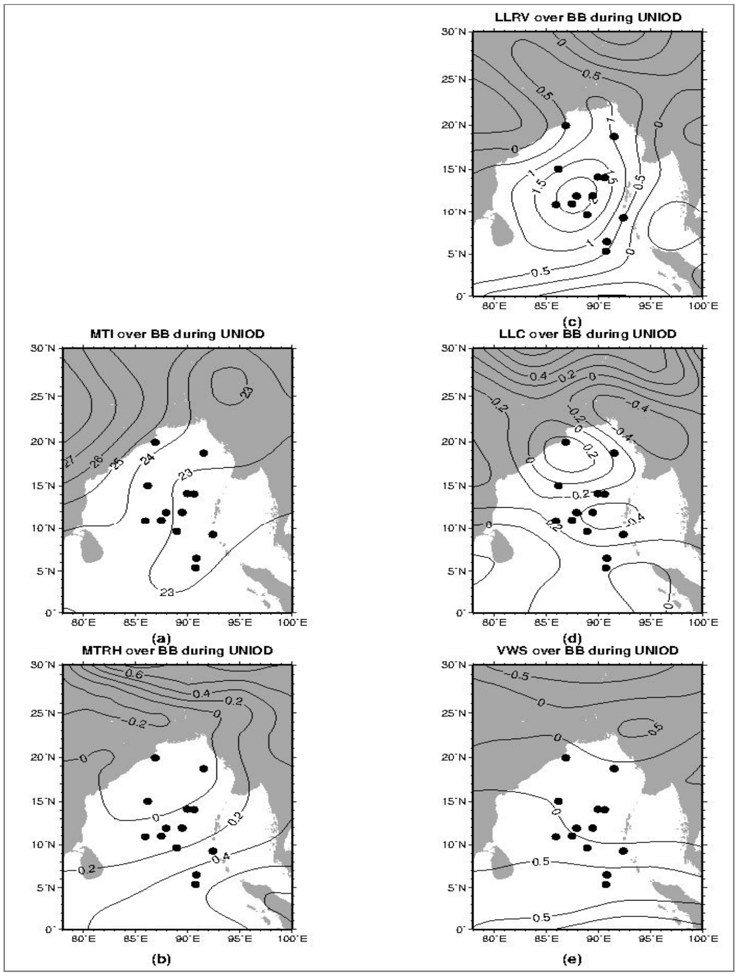


Figure 2. Variations of cyclogenesis parameters over BB during Unseasonal IOD years



Summary

It is observed that the frequencies of tropical cyclones are highly variable during the UNIOD events. Even though these IOD events are in the positive phase a good number of tropical cyclones are formed over BB. A low magnitude of LLC is observed over BB, during all these periods and other cyclogenesis parameters like LLRV, MTI MTRH and VWS played significant role in the formation and the intensification of the cyclones over BB. This study results that the frequency of UNIOD year is more than the other types of IOD years, and also the frequencies of tropical cyclones are more over this basin during this period.

Acknowledgements

The author is grateful to the University of Agricultural Sciences, Dharwad and NIO Goa for providing necessary facilities to conduct this research. The author is thankful to India Meteorological Department, New Delhi for providing the cyclone e-Atlas and Unisys Weather. The author acknowledge the use of NCEP Re-Analysis -II daily data and free wares such as FERRET and GMT used in this research work.

References

Gray WM (1975) Tropical cyclone genesis. Dept of Atmos Sc Paper No. 232 Colorado State University Port Collins Co USA, p 121

Francis PA, Sulochana Gadgil, Vinayachandran PN (2007) Triggering of the positive Indian Ocean Dipole events by severe cyclones over the Bay of Bengal. Tellus 59A:461- 475

Kotal SD, Kundu PK, and Roy Bhowmik SK (2009) Analysis of cyclogenesis parameter for developing and non-developing low pressure systems over the Indian Sea. Nat Hazards (2009) 50:389–402. DOI 10.1007/s11069-009-9348-5

Roy Bhowmik SK (2003) An evaluation of cyclone genesis parameter over the Bay of Bengal using model analysis. Mausam (New Delhi) 54:351–358.

Saji NH, Goswami BN, Vinayachandran PN, Yamagata T (1999) A dipole mode in the tropical Indian Ocean. Nature 401:360-363

Sumesh KG and Ramesh Kumar MR (2013) Tropical cyclones over north Indian Ocean during El-Nino Modoki years, Nat Hazards, doi:10.1007/s11069-013-0679-x.

Webster PJ, Moore AM, Loschnigg JP, Leben RR (1999) Coupled Oceanic-Atmospheric dynamics in the Indian Ocean during 1997-98. Nature 401: 356-360

Yan Du, Wenju Cai, Yanling Wu (2013) A new type of the Indian Ocean Dipole since the mid-1970s. Journal of Climate, DOI: 10.1175/JCLI-D-12-00047.1, pp. 959-972

Zehr RM (1992) Tropical cyclogenesis in the western north Pacific. NOAA Tech. Rep. NESDIS 61, 181pp