International Journal
of
Integrated Sciences & Technology (IJIST)
http://www.cuet.ac.bd/IJIST/index.html

International Journal of Integrated Sciences & Technology 3 (2018) 30-36

# Study the Relation Between Environmental Convective Available Potential Energy and Convective Inhibition with Tropical Cyclones Intensity Change Over the Bay of Bengal

S. Saha*and N. Akter

*Department of Physics, University of Engineering and Technology, Dhaka - 1000, Bangladesh.*

## Abstract

Tropical cyclones (TCs) are the intense atmospheric vortices that develop over the warm tropical oceans. Due to the position in the tropical region, the Bay of Bengal (BoB) is a suitable for tropical cyclones and several cyclonic stormshit its coastal area every year. A total of 44 active TCs were formed in BoB, during the study period (2000-2011), which were bimodal in distribution during pre-and post-monsoon seasons. Within these cyclones, 6 pre-monsoon cyclones and 4 post-monsoon cyclones were considered for this study becausethese have sustainable maximum wind speed of >64 knot(>33ms-1). Thermodynamic environmental parameters including, Convective available potential energy (CAPE) and Convective inhibition (CIN) were analyzed and correlated with the change in intensity of each TC. Environmental data has been extracted from 6-hourly National Centers for Environmental Prediction (NCEP)-Climate Forecast System Reanalysis (CFSR) data, averagedand compared for all cyclones during each level of intensity.The values of CAPE were found to be decreased with the increased of cyclone intensity and the average decreasing values per intensity level of TC were 10% and 5%, respectively for all pre-and post-monsoon cyclones and 4.5% higher inpre-monsoon than post-monsoon. CIN were showed increasing trend with increasing of intensity and averaged increasing value per intensity level were approximately 44.4% and 42.2% for pre-monsoon and post-monsoon cyclone.

***Keywords:*** *Tropical cyclone, Cyclone intensity, Environmental parameters, Pre-monsoon and post-monsoon.*

## 1. Introduction

The genesis of a TC, is characterized by a cyclonic vortex and a surface wind speed of at least 17.5 ms-1 (34 knot). The distribution of sea surface temperature (SST) exceeding 26 °C and the location of the monsoon trough (monsoontype intertropical convergence zone) are primary factors explaining the seasonal distribution and frequency of tropical cyclones over the oceans except North Atlantic [1]. North Indian Ocean (NIO) has two wings, the Arabian Sea and the Bay of Bengal (BoB). In the NIO basin, a distinctly bimodal cyclone season is observed: March–May (pre-monsoon) and October–December (post-monsoon); the primary peak in cyclone frequency is in November while the secondary peak is in May [2,3]. According to global cyclone statistics, only 7% of TC occurin the North Indian Ocean, but five to six times as many occur in the BoB as in the Arabian Sea [4]. Cyclone formation and intensification is also correlated with the seasonally averaged values of six parameters: three dynamic variables (low-level relative vorticity, inverse of the tropospheric vertical wind shear, and the Coriolis parameter) and three thermodynamic variables (ocean thermal energy extending to a sufficient depth, moist static instability, and mid-tropospheric relative humidity) [5,6].

CAPE is an indicator of the environmental potential for the formation of a tropical deep convection ormesoscale convective system [7-10]. In the BoB during the pre-monsoon season, the potential for convection was highest, with surface-based CAPE values more than 2,500 J/kgin the northern and northwestern parts of the BoB. In contrast, CAPE was relativelyuniform and moderate (mostly less than 1,500 J/kg) over the entire BoB during the post-monsoon season [11]. CAPE was

**Corresponding author: ssccu86@gmail.com*

high in the initial stages of development but as the cyclone intensified, CAPE decreased in the innercore region.Convective inhibition(CIN)is definedas the negative buoyant energy exerted on anair parcel by the environment and it can limit convection even when CAPE is very large. During the pre-monsoon, BoB was capped bya CIN of greater than 50 J/kg, up to a maximum of 180 J/kg. On the other hand during the post-monsoonthe entire BoB maintained the constant geopotential thickness and CIN is < 30 J/kg.The frequency of cyclone formation is inversely related to the environmental CIN [11]. In this paper try to correlate environmental CAPE and CIN with TCs intensity change which may help to forecast sever cyclone more accurately and minimize losses of costal life.

**2. Data used and Method**

The date is obtained over a 12 year period ranging from 2000 to 2011. Best-track data provided by the Joint Typhoon Warning Center (JTWC) were used to determine the positions and intensities of TCs in the BoB. For analysis of large-scale seasonal environmental conditions related to cyclone formation over the BoB, the National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR) data product was used. The 6-hourly NCEP−CFSR data were obtained with a coupled atmosphere-ocean-sea ice-land model system. The data product has a horizontal resolution of 0.5° X 0.5° and it uses a hybrid sigma-pressure vertical coordinate system with 64 levels, with a top pressure of ~ 0.266 hPa. For the seasonal-scale analysis, monthly averaged NCEP−CFSR reanalysis data were used and 6-hourly NCEP−CFSR data of specific parameters were used [12]. BoB is a part of NIO with geographical area 5° -25° N and 75°-105° E is the study area which is indicated in Fig 1. JTWC records show that in the 12 years from 2000 to 2011, 44 cyclones formed over the BoB, 36.36 % during the pre-monsoon and 63.64 % during the post-monsoon season. The cyclones were widely distributed across the BoB.

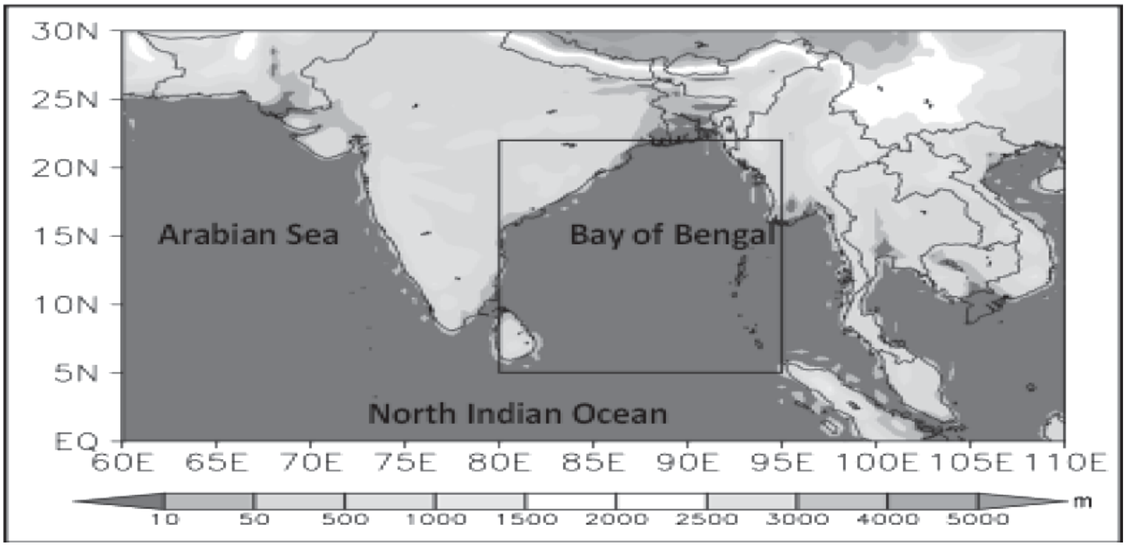


**Fig 1**. Topography of BoB (The box indicates the study area).

Total 44 cyclones has occurred during study period, among them only 10 cyclones have higher intensity (≥64 knot) according to India Meteorological Department (IMD) TCs intensity scale are considered for the study purpose shown in Fig 2 [13].

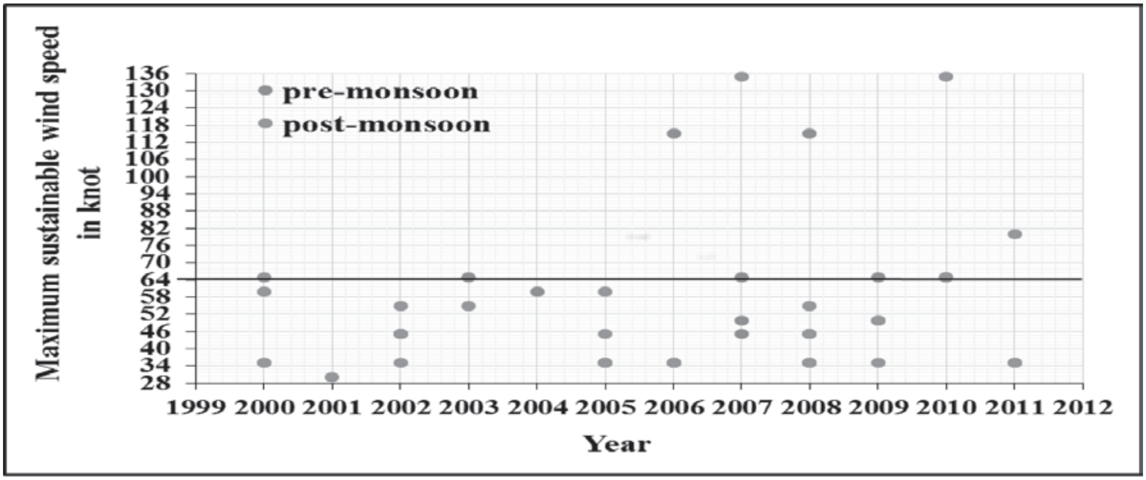


**Fig 2**. Total number of TCs over BoB during 2000-2011.

Within 10 higher intensity cyclones, the 6 pre-monsoon cyclones named Cylone-2004, Mala-2006, Akash-2007, Nargis-2008, Aila-2009 and Laila-2010 and the 4 post-monsoon cyclones named Cyclone-2000, Sidr-2007, Giri-2010 and Thane-2011 have the intensity ≥ 64 knot. Fig 3 shows the Position and intensity of 10 cyclones are extracted from JTWC Best track Data. According to IMD cyclones has six intensity levels, Depression (Dep) (≤27 K not), Deep Depression (DDep) (28-33 knot), Cyclonic Storm (CS) (34-47 knot), Severe Cyclonic Storm (SCS) (48-63 knot), Very Severe Cyclonic Storm (VSCS) (64-119 knot), and Super Cyclonic Storm (SuperCS) (>120 knot) [13]. For every (3-6) hourly cyclone position the different environment data are extracted for the area 5° X 5° centered the location of eye and from the center of eye it covers 2.5° area all around. After that, the extracted values are averaged for each intensity levels i.e. environment between Depressions to DDep is the environment for DDep intensity level and so on. By this process environmental data values are collected and compared for all cyclones during each level of intensity.

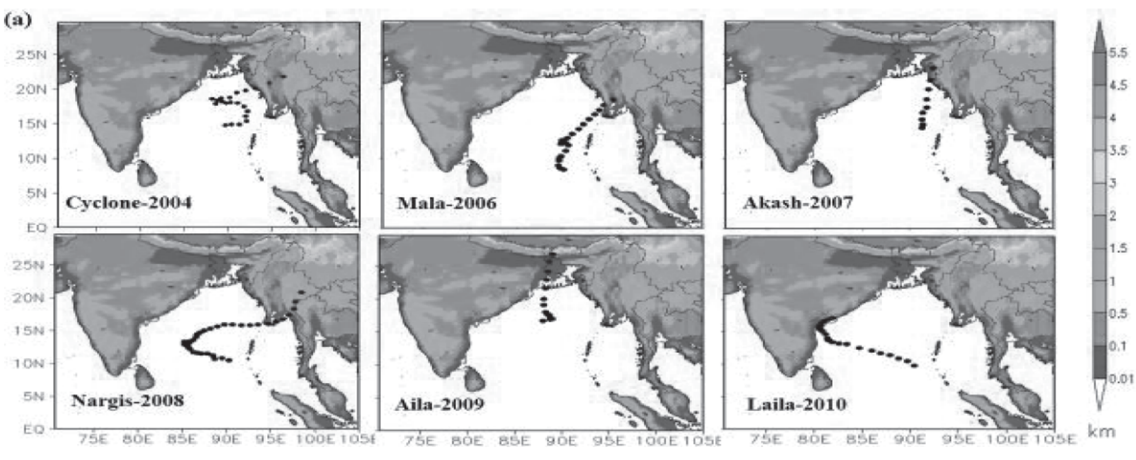


**Fig. 3 (a):** Track of pre-monsoon cyclones.

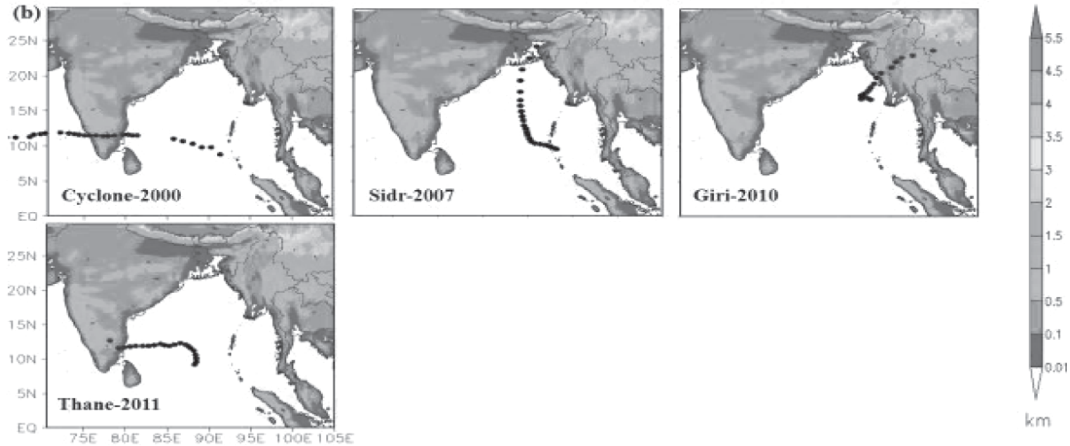


**Fig. 3 (b):** Track of post-monsoon cyclones.

## 3. Results and Discussion

The environmental parameters CAPE and CIN are analyzed for 10 cyclones (6 pre-monsoon, 4 post-monsoon). It is to be mentioned that all pre-monsoon cyclones i.e. Cyclone-20004, Akash-2007, Nargis -2008, Aila-2009 and Laila-2010 has the maximum intensity up to VSCS except Mala--2006 which has more intense (SuperSC) than other, whereas in post-monsoon, two cyclones i.e. cyclone-2000, Thane-2011 have the intensity of VSCS and other two cyclones have higher intensity of SuperSC.

***3.1. Convective available potential energy*** CAPE value varies from minimum 300 j/kg to maximum 2500 j/kg with cyclone intensity change shown in Fig 4. CAPE shows decreasing trend with increasing of cyclonein-tensity in case of pre-and post-monsoon cyclone except Nargis-2008 and Sidr-2007. Average CAPE for pre-monsoon cyclones (1325 j/kg) is greater than post-monsoon cyclones (962 j/kg) where Cyclone-2004has maximumvalueand Thane-2011 hasminimum value shown in Fig 5a. Average CAPE increment(%) per intensity level shown in Fig 5b, found that CAPE valuedecreased 5 to10 % with intensity level change except Nargis-2008 and Sidr-2007.

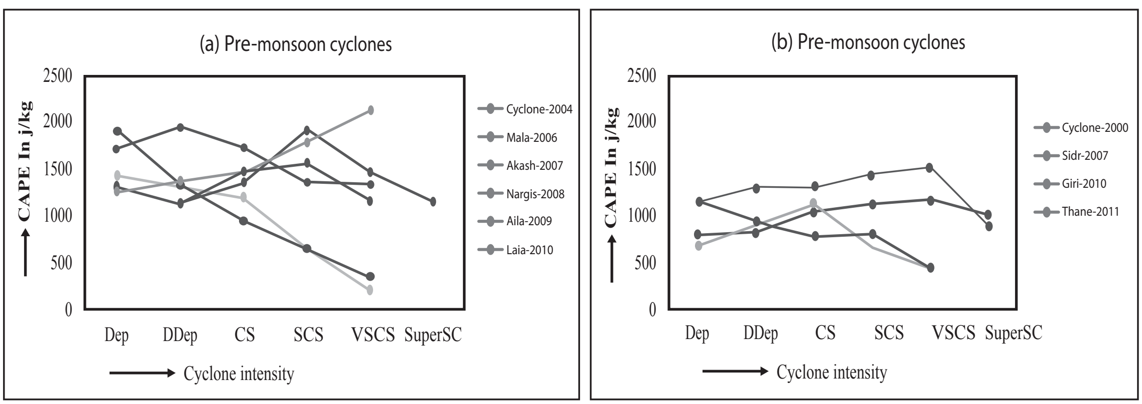


**Fig. 4:** Variation of CAPE for all (a) pre-monsoon cyclones (b) post-monsoon cyclones

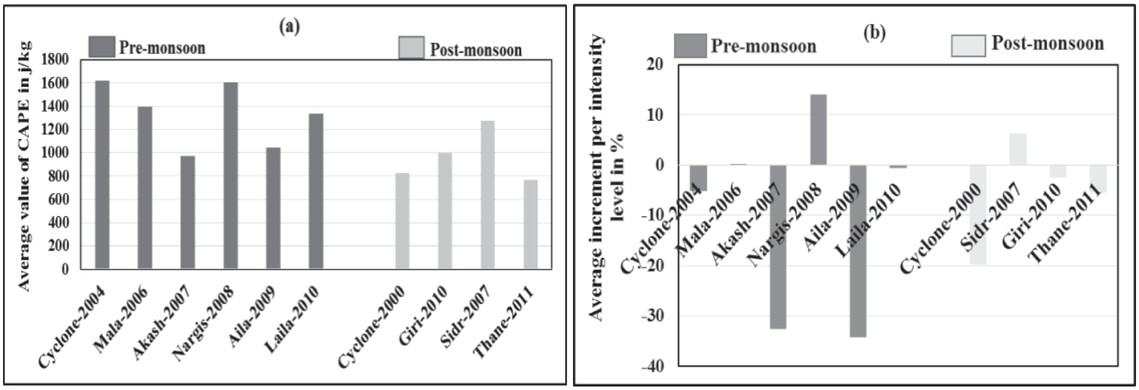


**Fig. 5:** (a). Average value of CAPE during cyclones period (b) Average increment per intensity level of CAPE (%).

### *3.2. Convective inhibition*

Variation of CIN values with intensity change are less than 50 j/kg for all cases shown in Fig 6. CIN shows increasing trend with intensity increment, however, in case of pre-monsoon at the highest intensity level values are relatively lower (~ 5 j/kg) from the previous intensity level shown in Fig 6a.

CIN values are fluctuate from minimum 2 j/kg to maximum 11 j/kg with an average 6 j/kg where Cyclone-2004 shows maximum value and Mala-2006 minimum value shown in Fig 7a. Average CIN value in case of post-monsoon (6.18 j/kg) is greater than pre-monsoon (5.65 j/kg), however average increment of CIN per intensity level for pre-monsoon (44.4 %) is greater than post-monsoon (42.42 %) shown in Fig 7b.

Some cyclone shows fluctuation which can be described by the individual cyclone analysis i.e. their recurvative nature, during progression long time stay in a particular position etc.

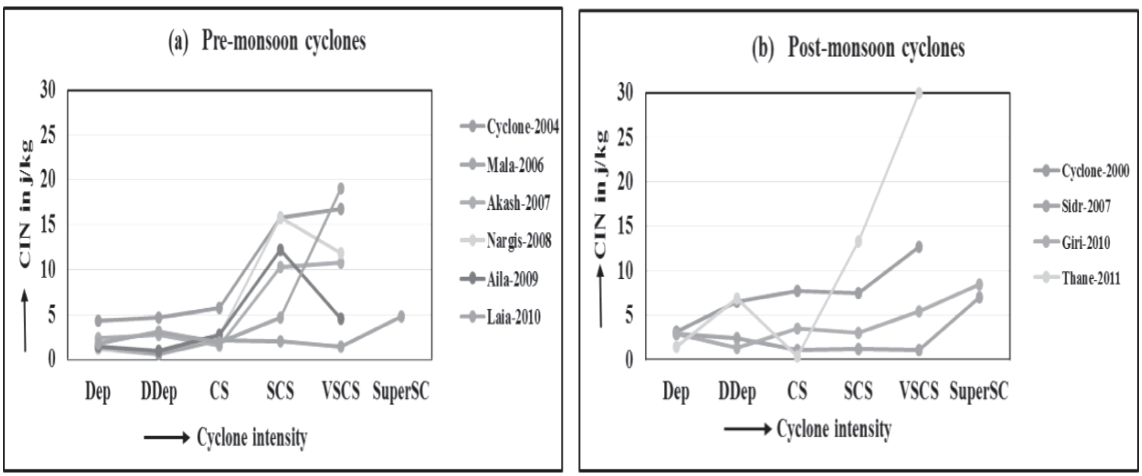


**Fig. 6:** Variation of CIN for (a) all pre-monsoon cyclones (b) all post-monsoon cyclones

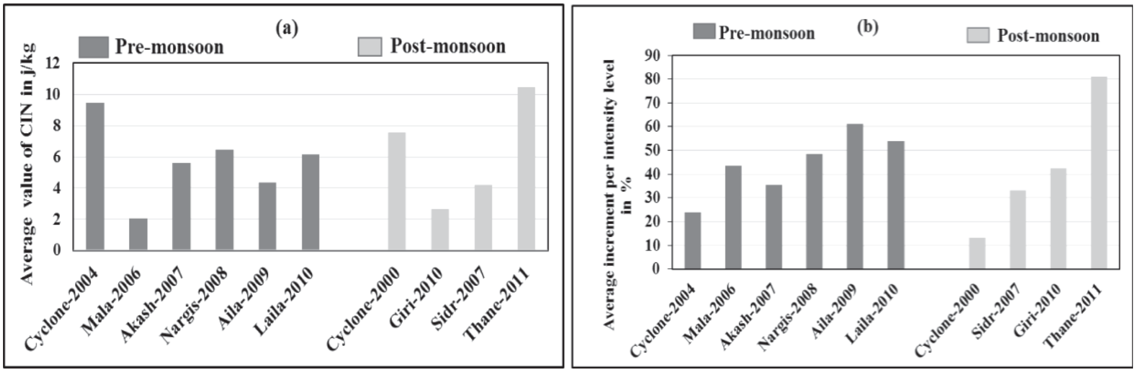


**Fig. 7:** (a). Average value of CIN during cyclones period (b). Average increment per intensity level of CIN (%).

## 4. Conclusions

Cyclones formed over the 5° N to 22° N and 80° E to 95° E during the years from 2000-2011 are considered in this studyand found bimodal in distribution for the pre-and post-monsoon seasons.It is found that CAPE is high in the initial stages of development but as the cyclone intensified CAPEdecreased. CAPE shows decreasing trend with increasin-gof cyclone intensity for both season cyclones. Average CAPE value for the pre-monsoon cyclones (1325 j/kg) is higher than the post-monsoon cyclones (962 j/kg). This is because, during pre-monsoon, the BoB maintains higher SSTs,which in turn influences the vertical gradient of potential temperature and results an increased CAPE compared with that in the post-monsoon season[14, 15]. However, CAPE is not steady for the progression of the cyclone it varies from cyclone to cyclone.In all cases CIN values are found less than 50 j/kg which coincide with the cyclone formation and intensification condition. CIN shows increasing trend with increasing of cyclone intensity except few points for all cyclones. Average CIN value with intensity increment is higher in case of the post-monsoon than the pre-monsoon cyclones but average increment per intensity level for the pre-monsoon is 2 % higher than that in the post-monsoon. During pre-monsoon, the average CIN value increased gradually from northwestern India toward the BoB and almost half of the BoB capped by the CIN. In contrast, during the post-monsoon, the entire BoB maintained the constant temperature aloft and CIN is less. Overall study reveal that environmental CAPE and CIN have significant correlation with cyclone intensity.

## References

[1] J. L. McBride, World Meteorological Organization, Geneva, 63 (1995).

[2] S. J. Camargo, K. A. Emanuel and A. H. Sobel, J Clim. 20, 4819 (2007).

[3] K. Kikuchi and B. Wang, J Meteorol Soc. Japan, 88, 475 (2010).

[4] C. J. Neumann, World Meteorological Organization, Geneva, Switzerland, 11(1993).

[5] W. M. Gray, Dept of Atmos Scipaper no. 234 Colo State Univ. Ft. Collins co, 121 (1975).

[6] W. M. Gray, RMS, James Glaisher House, Grenville Place, Bracknell, Berkshire, 155 (1979).

[7] T. S. Glickman, Glossary of meteorology, 2nd edn. Am Meteorol Soc, Boston (2000).

[8] B. E. Mapes and R. A. Houze, Quart. J. R. Meteorol Soc., 118, 927 (1992).

[9] E. R. Williams and N. O.Renno, Mon. Wea. Rev., 121, 21 (1993).

[10] P. T. May and D. K. Rajopadhyaya, Australia Mon. Wea. Rev., 127, 1056 (1999).

[11] N. Akter and K. Tsuboki, Clim. Dynam. 43, 2651 (2014).

[12] S. Saha, S. Moorthi, Wu. X. Pan H-L, J. Wang and S. Nadiga, Bull. Am. Meteorol. Soc., 9, 1015 (2010).

[13] K. A. Emanuel, J. Atmos. Sci. 45, 1143 (2003).

[14] S. K. Sasamal, Int. J. Remote Sens. 28, 4403 (2007).

[15] D. P. Alappattu and P. K. Kunhikrishnan, J. Geophys (2009).

ISSN: 2411-9997