Average Annual Global Temperature and Cyclonic Disturbance over the North Indian Ocean

R. Samuel Selvaraj and [1]R.Uma

Department of Physics, Presidency College, Chennai, India.
[1]Department of Physics, D. G. Vaishnav College, Chennai, India.
Corresponding author: umajeel@gmail.com

Abstract:

Tropical Cyclone activities over the North Indian Ocean (comprising Bay of Bengal and Arabian Sea) constitute one of the major natural disasters of our country. To understand the Tropical Cyclonic activities, estimations of their frequencies are necessary. In this study, the Average Annual Global Temperature and Cyclonic disturbance that includes Depression, Cyclonic Storm and Severe Cyclonic Storm over the North Indian Ocean has been analysed using Spearman Rank Correlation technique. Tropical Cyclone over the North Indian Ocean has decreased to some extent due to the increase in global temperature.

Keywords: Cyclonic disturbance, global temperature, spearman rank correlation

1.0 Introduction:

A Tropical Cyclone (TC) is the generic term for a non-frontal synoptic scale low-pressure system originating over tropical or sub-tropical waters with organised convection and definite cyclonic surface wind circulation. Tropical cyclones with maximum sustained surface winds of less than 18 ms^{-1} are called "tropical depressions". Once a tropical cyclone achieves surface wind strengths of at least $18ms^{-1}$ it is typically called a "tropical storm" and assigned a name. If the surface winds reach $33ms^{-1}$, the storm is called a "typhoon" in the Northwest Pacific Ocean, a "hurricane" in the North Atlantic Ocean and the Northeast Pacific Ocean, or it is named as a "severe tropical cyclone" in the Southwest Pacific Ocean and Southeast Indian Ocean (Neumann 1993).

Tropical cyclones are seasonal phenomena: most tropical ocean basins have a maximum frequency of cyclone formation during the late summer to early autumn period. This is associated with the period of maximum Sea Surface Temperature (SST), although other factors, such as the seasonal variation of the monsoon trough location, are also important (Frank 1987; McBride 1995). The storm season in the North Atlantic becomes highly active during August-September-October, with a maximum frequency of occurrence in September (Neumann *et al*. 1985). The Western North Pacific region receives an average tropical cyclone occurrence of about 26 per year, with a maximum cyclonic disturbance in August and a highly seasonal variation. This is the highest recorded value when compared with any other region (Xue and Neumann 1984) and this is also the only

region where tropical cyclogenesis has been observed in all months of the year (Camargo, Suzana J., Adam H. Sobel, 2005).

Prediction of the tracks of tropical cyclones is one of the most difficult and challenging problems of current international tropical cyclone research. Availability of a large number of subjective and objective techniques reflects the level of importance and concern of the cyclonic forecasters. In recent years, attempts to associate tropical cyclone trends with climate change resulting from greenhouse warming has led to additional attention being paid to tropical cyclone prediction (e.g., Emanuel 1987; Evans 1992; Lighthill *et al*. 1994). Exploring possible changes in tropical cyclone activity due to global warming is not only of theoretical but also of practical importance.

Records show that about 80 tropical cyclones form over the globe every year (McBride, 1995). The number of cyclonic storms that form over north Indian Ocean is five to six per year on average which is about 6.5% of the total number over the globe (Neumann, 1993). More cyclones occur over Bay of Bengal than over Arabian Sea roughly in the ratio 4:1. On an average 2-3 cyclones affect the coastal belt of India every year. The globally-averaged annual variation of cyclone occurrence is only about 10%. But variations in percentage do occur often around 30%, and no obvious correlations exist in variations between different regions (Wigley and Raper 1993). For instance, the average number of tropical cyclones observed

during 1950-1986 was 14.8, with an annual variation of 40% in the Australian/Southwest Pacific region, (Evans 1990). The quality of the tropical cyclone databases can be highly variable (Holland 1981).

Gray (1968) produced a global map of genesis points for all tropical cyclones over the 20-year period 1952-1971. Over the past decade, compositing techniques have been developed to study the large scale characteristics associated with tropical cyclones over different regions. The techniques and observational approaches may produce errors and biases in these datasets which could have implications for the study of the natural variation of tropical cyclone activities and the detection of possible historical trends (Nicholls *et al*. 1998). In this paper an attempt is made to understand the effect of average annual global temperature with cyclonic disturbances over the North Indian Ocean.

2.0 Materials and Methods:

For this study, Spearman's rank correlation technique is used to find out the statistical relationship between Average Annual Global Temperature and frequency of Cyclonic disturbance includes Depression, Cyclonic Storm and Severe Cyclonic Storm over the North Indian Ocean. Cyclonic Storm data are obtained from IMD Cyclone E- Atlas. The Global temperature data is collected from Indian Meteorological Department. The Spearman Rank Correlation (ρ) is a non-parametric measure of statistical dependence between two variables. It is a test for correlation using ranked data. As we use the rank order than the actual values for determining the association between the two set of values it is called a "rank correlation." The actual data are ranked, usually in ascending order i.e., a rank order 1 is allotted to the smallest values of each variable in x and y. The rank order n is given to the largest variable. If two or more values of the variable x and y are tied, they are each assigned the average of the rank positions otherwise they would have been assigned individually if ties had not occurred. For each of the n values of the variables, a set of rank difference is obtained, $d = R_x - R_y$ as the sum of the difference in rank of paired values is zero i.e., $\sum d=0$, we use $\sum d^2$. Finally Spearman Rank Correlation (ρ) is

$$P = 1- (6 \sum d^2/n^2-n)$$

Where n is the number of data considered and d is the difference between the ranks of each observation on the two variables. The rank correlation coefficient is a relative measure which varies from -1 through 0 to +1.

3.0 Results and Discussion:

In this present work, we have analysed 110 years of data (1891-2000) of Average Annual Global Temperature and frequency of Cyclonic disturbance includes Depression, Cyclonic Storm and Severe Cyclonic Storm over the North Indian Ocean and introduced them to Spearman's Rank Correlation technique. Correlation value was found to be -0.03. The corresponding correlated value for the Average Annual Global Temperature and frequency of Southwest Monsoon Cyclonic disturbance was found to be -0.221. The correlated values are least negative. Thorough analysis shows the decreasing trend in the Tropical Cyclone disturbance over the North Indian Ocean due to the increase in the Annual Average Global Temperature.

The annual frequency of the cyclonic disturbances data over North Indian Ocean is obtained from IMD Cyclone E- Atlas plotted against the average annual global temperature data from IMD. The criteria followed by the Indian Meteorological Department to classify the tropical disturbance are on the basis of maximum sustained winds (usually expressed in knots/kmph). The tropical disturbance o less than 17 are called low pressure area. About 17-27 knots are called depressions, 28-33 knots are deep depressions, 34-47 are cyclonic storm, 48-63 knots are severe cyclonic storm, and 64-119 are very severe cyclonic storm and 120 and above are termed as super cyclone. Fig. 1 shows the number of cyclones that includes depressions, cyclonic storm and severe cyclonic storm over north Indian Ocean has reduced for the past two decades with an increase in the annual average global temperature. It may be noted that for the first time in the last 115 years of data available with (IMD), not a single depression or cyclonic storm formed over the Indian region, including the Bay of Bengal, and Arabian sea during the monsoon season of 2002 (Nirupa sen, 2003). Fig. 2 gives a vivid picture of the decreasing trend of tropical cyclones over the North Indian Ocean. As we see from Fig. 3 that the number of Southwest Monsoon Cyclones over the North Indian Ocean have decreased considerably for the past two decades. Fig. 4 shows the number of Southwest Monsoon Cyclones over North Indian Ocean also very much decreased for the period 1891-2000 due to the increase in the global temperature.
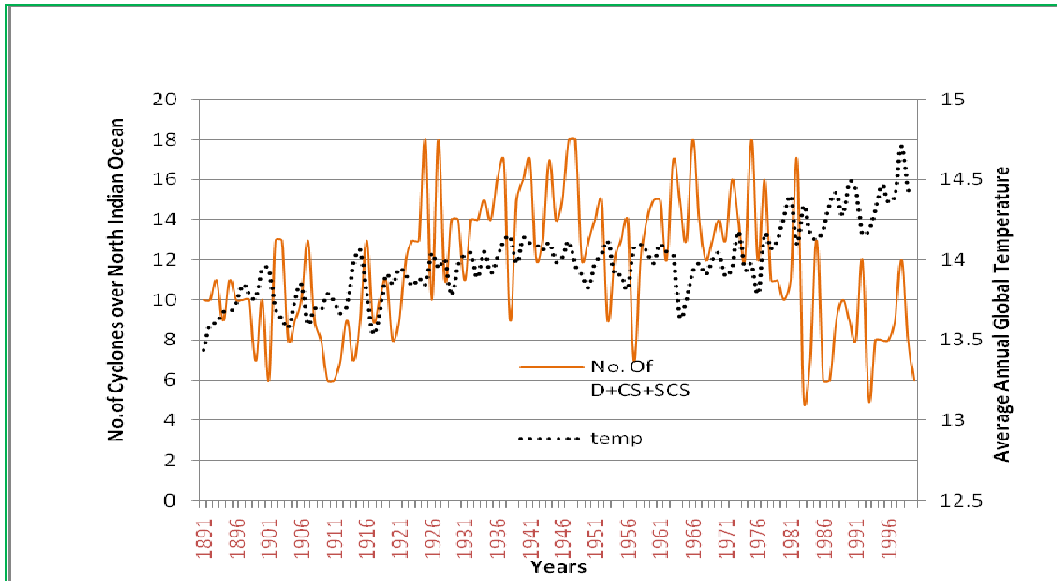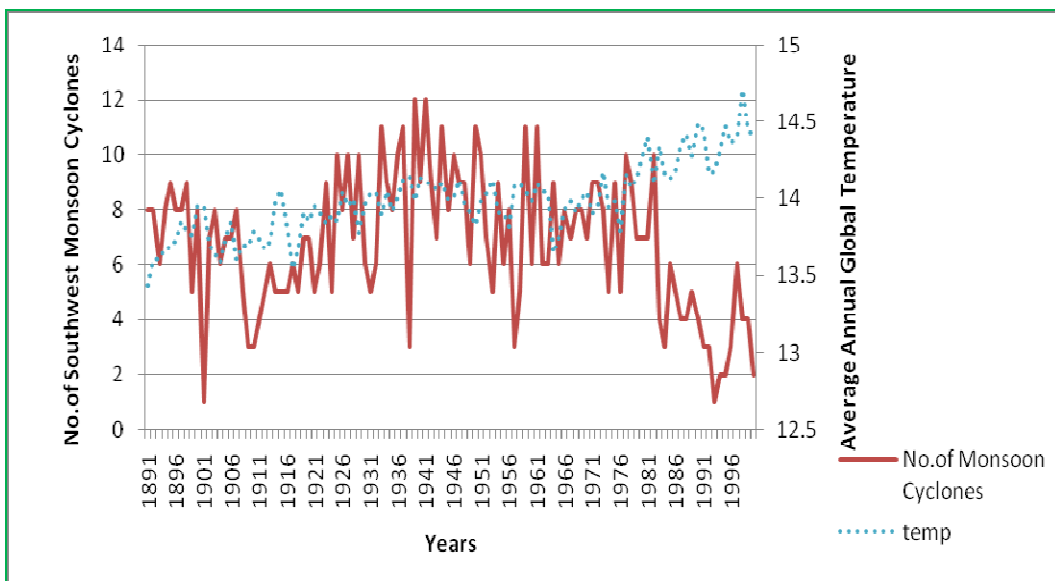
Fig. 1: Average Annual Global Temperature vs Number of Cyclones (including Depressions (D), Cyclonic Storms (CS) and Severe Cyclonic Storms (SCS)) over North Indian Ocean for the period 1891-2000.
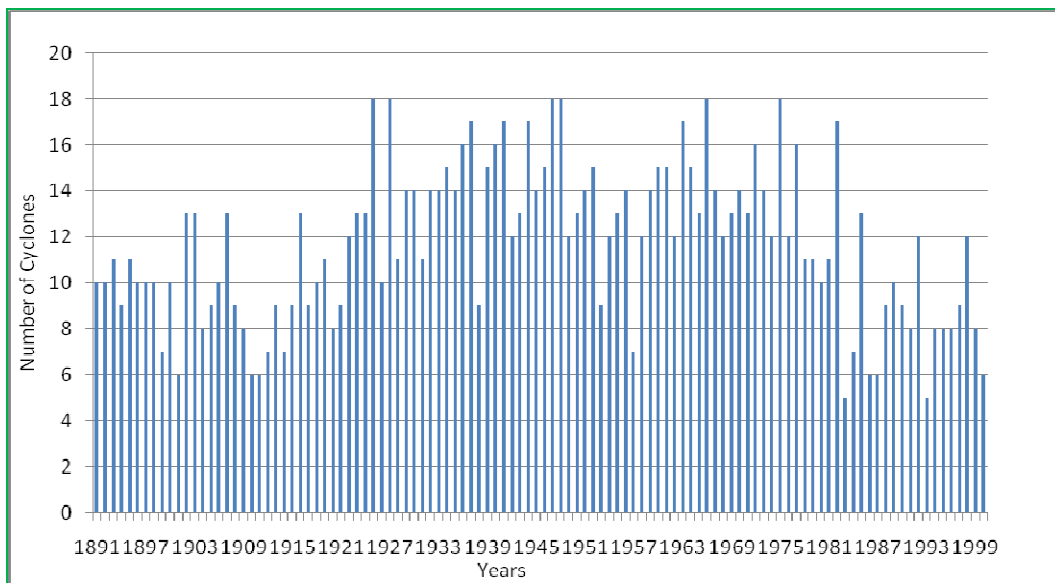
Fig. 2: Number of Cyclones (including Depressions, Cyclonic Storms and Severe Cyclonic Storms) over North Indian Ocean for the period 1891-2000.

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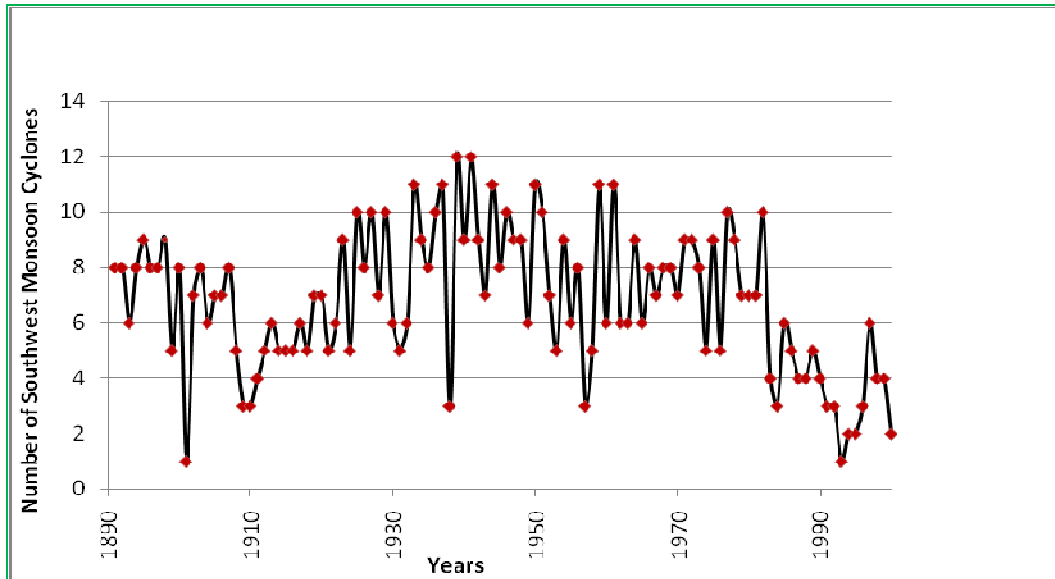
Fig. 3: Number of Southwest Monsoon Cyclones (including Depressions, Cyclonic Storms and Severe Cyclonic Storms) over North Indian Ocean for the period 1891-2000.

Fig. 4: Average Annual Global Temperature vs Number of monsoon Cyclone over North Indian Ocean for the period 1891-2000.

The term 'cyclone' is a generic term covering all the four atmospheric disturbances, namely, low pressure areas, depressions, deep depressions and cyclonic storms. Fig. 1 and Fig. 4 illustrate the effect of increase in global temperature on the cyclonic disturbances over the north Indian Ocean. From this we infer a decreasing trend of cyclonic disturbance happens to be followed with an increase in the global temperature.

4.0 Conclusion:
From this paper we infer that with an increase in the Average Annual Global Temperature, the number of Cyclones as well as the number of Southwest Monsoon Cyclones has very much decreased over the North Indian Ocean for the past two decades. The negative correlated values for these also coincide with the graphical illustrations.

5.0 Acknowledgement:

References:

1. Camargo, Suzana J., Adam H. Sobel. (2005): Western North Pacific Tropical Cyclone Intensity and ENSO, J. Climate, 18, 2996-3006.
2. Emanuel, K.A. (1987): The dependence of hurricane intensity on climate. Nature, 326, 483-485.
3. Evans, J.L. (1990): Envisaged impacts of enhanced greenhouse warming on tropical cyclones in the Australian region, Published by Common wealth Scientific and Industrial Research Organization (CSIRO, Australia), Division of Atmospheric research technical paper, 20.
4. Evans, J. L. (1992): Comment on "Can existing climate models be used to study anthropogenic changes in tropical cyclone climate?" Geophys. Res. Lett., 19, 1523-1524.
5. Frank, W. M. (1987): Tropical cyclone formation. A global view of Tropical Cyclones, Elsberry, R.L., Frank, W.M., Holland, G.J., Jarell, J.D. and Southern, R.L., Eds., Naval postgraduate school, 53-90.
6. Gray, W.M. (1968): A global view of the origin of tropical disturbances and storms, Mon. Wea. Rev., 96, 669-700
7. Holland, G.J. (1981): On the quality of the Australian tropical cyclone data base. Aust.Met.Mag., 29.
8. Lighthill, J., Holland, G.J., Gray, W.M., Landsea, C., Emanuel, K. Craig, G., Evans, J., Kurihara, Y. and Guard, C.P. (1994): Global climate change and tropical cyclones, Bull. Amer. Met. Soc., 75, 2147-2157.
9. McBride, J. L. (1995): Tropical cyclones in a warmer world, Report, WMO/TD-No. 693, No. TCP-38, WMO, Geneva, 63–105.
10. Neumann, C.J., Cry, G.W., Caso, F.L. and Jarvinen, B.R. (1985): Tropical cyclones of the North Atlantic Ocean, 1871-1980, NOAA Special Publication, National Hurricane Centre, 174 pp.
11. Neumann, C. J. (1993): Global Overview - Chapter 1, Global Guide to Tropical Cyclone Forecasting, WMO / TC-No. 560, Report No. TCP-31, World Meteorological Organization; Geneva, Switzerland.
12. Nicholls, N., Landsea, C.W. and Gill, J. (1998): Recent trends in Australian tropical cyclone activity, Met. Atmos. Phys., 65, 197-205.
13. Nirupa sen, (2003): New forecast models for Indian south-west monsoon season rainfall, Current Science, vol 84 No, 10, 25 May 2003 pp1290.
14. Wigley, T. M. L., and Raper, S. C. B. (1993): Future changes in global mean temperature and sea level. Climate and Sea Level Change: Observations, Projections and Implications, Warrick, R. A. *et al.*, Eds., Cambridge University Press, 111–133.
15. Xue, Z., and Neumann, C.J. (1984): Frequency and motion of western North Pacific tropical cyclones, Tech. Memo. NWS NHC 23, NOAA, Washington DC.80.