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Modulation of Cyclonic Disturbance by Natural Climate Variability over the North Indian Ocean

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Abstract:

Tropical cyclones are one of the nature's most violent manifestations and potentially the deadliest of all meteorological phenomena. In this paper, an attempt is being made to study the Tropical Cyclonic disturbance over the North Indian Ocean (comprising Bay of Bengal and Arabian Sea) by natural climate variability. In order to understand how the tropical cyclones will cause change in future climate, we need first to understand their respond to natural climate variability. The predictor chosen is the intraseasonal - interannual time scale namely Quasi – Biennial Oscillation (QBO). Correlation coefficients are found for westerly and easterly phase of the QBO. The correlated values are least negative. The correlation is less significant for the Tropical Cyclone and QBO data.

Keywords: correlation coefficient, cyclonic disturbance, quasi- biennial oscillation

1.0 Introduction:

Tropical cyclones are magnificent storms that form over warm tropical oceans and usually die over cold water or land. Cyclones consist of relatively small but very intense low pressure areas in which the wind circulates. A full blown cyclone is 150 to 1000 km across, with winds of 120 km/hr or more, spiraling around a centre of very low pressure. Cyclones are most frequently observed in the Bay of Bengal during the northeast monsoon season (October-December). Some of the cyclones, which originate in the Bay of Bengal travel across the peninsular, weaken and emerge into the Arabian Sea as low pressure areas. This may again intensify into cyclonic storms. The Arabian Sea cyclones are weak compared to the Bay of Bengal cyclones and its impact is considerably less severe (Dube et.al 1997).

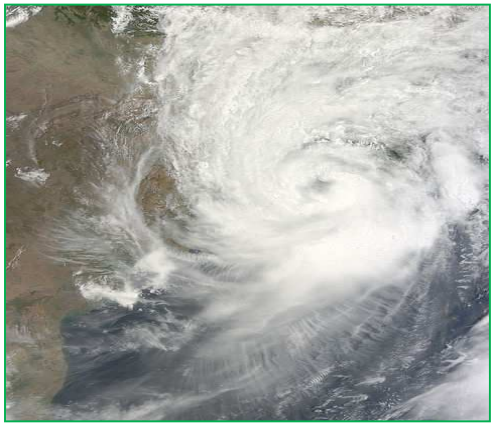


Fig. 1: Satellite image of cyclone formed in North Indian basin from ncdc.noaa.gov

Tropical cyclone activity is influenced by various natural modes of climate variability. A global map of genesis points for all tropical cyclones over the 20-year period 1952-1971 was produced by Gray (1968). On intraseasonal - interannual time scales, the main factor that influences the tropical cyclone activity in most basins is the El Nino-Southern Oscillation (ENSO) phenomenon (Gray 1984a; Camargo et al. 2007a). An apparent influence of the QBO on Atlantic TC activity was pointed out by Gray (1984a, b). Gray (1984a) found that when the QBO was in its westerly phase or becoming westerly, cyclonic disturbance in the Atlantic was greater than when the QBO was in the easterly phase, with more intense Atlantic hurricanes occurring in the westerly QBO years. The quasi-biennial oscillation of the tropical lower stratosphere is one of the best examples of wave, mean-flow interaction in the Earth's atmosphere. Holton and Lindzen (1972) suggested that Kelvin and Rossby – gravity waves drive the QBO.

The quasi-biennial oscillation (QBO) is a quasi-periodic oscillation of the equatorial zonal wind between easterlies and westerlies in the tropical stratosphere. With the alternating periods of easterly E and westerly W zonal winds that descend with time, the QBO dominates the interannual variability of the equatorial stratosphere and then repeat with a very well-defined period whose mean is about 28 months. Downward motion of the easterlies is more irregular than that of the westerlies. The amplitude of the easterly (negative) phase is about twice as strong as

that of the westerly (positive) phase. The QBO affects stratospheric dynamics globally and also has impacts on the troposphere, such as on winter temperature in North America (Barnston and Livezey 1989). A recent review on QBO was found in Baldwin et al. (2001). Balachandran and Guhathakurta (1999) discussed about the modulation of storm and depression tracks over North Indian Ocean by the QBO of zonal winds in the equatorial stratosphere. In this paper an attempt is being made to understand the effect of the quasi-biennial oscillation (QBO) with cyclonic disturbances over the North Indian Ocean (Camargo and Sobel 2010).

2.0 Methods:

For this study, correlation coefficients are calculated to analyze the statistical relationship between Quasi-Biennial Oscillation (QBO) 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 Quasi-Biennial Oscillation (QBO) data is obtained from the official website NOAA. The QBO affects stratospheric dynamics globally and also has impacts on the troposphere. Easterlies propagate from upper stratosphere to lower stratosphere during one half and they are replaced by westerly winds during the other half. They start at 10 hPa and descend to 100 hPa and maximum amplitude of 20hPa. Westerlies move down faster than easterlies.

3.0 Results and Discussion:

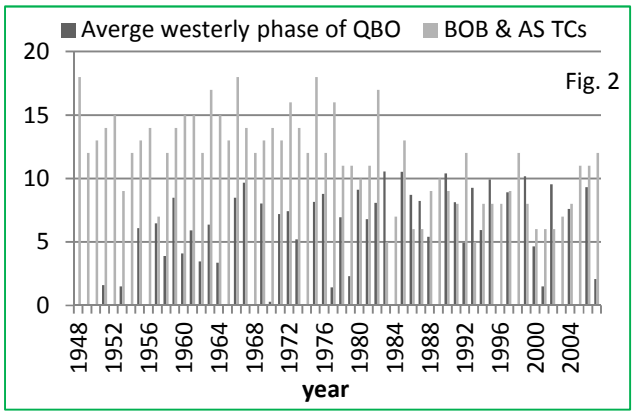
In this present work, a long term (1948 to 2007) analysis of the Quasi-Biennial Oscillation (QBO) and the frequency of Cyclonic disturbance that includes Depression, Cyclonic Storm and Severe Cyclonic Storm over the North Indian Ocean has been done. Correlation coefficients for Westerly and Easterly phase of the Quasi-Biennial Oscillation (QBO) were found separately. Table 1 illustrates the comparison of the correlation coefficients of QBO with the annual frequency of Cyclonic Storms and Southwest Monsoon season. The correlated values are least negative. The correlation is less significant for the Tropical Cyclone and QBO data.

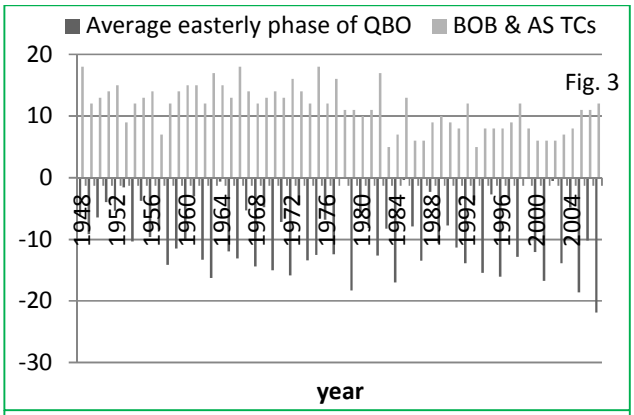
The annual frequency of the cyclonic disturbances data over North Indian Ocean is obtained from IMD Cyclone E- Atlas plotted against the Quasi-Biennial Oscillation (QBO) data from official website of NOAA. According to the Indian Meteorological Department the tropical disturbance are classified on the basis of maximum sustained winds (usually expressed in knots/kmph). The tropical disturbance of less than 17 is 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. 2 & 3 shows the plot of the number of tropical cyclones that includes depressions, cyclonic storm and severe cyclonic storm over North Indian Ocean and the Quasi-Biennial Oscillation (QBO) data during the westerly and easterly phase respectively. Fig. 5 & 6 illustrates the plot of southwest monsoon tropical cyclones over the North Indian Ocean with the Quasi-Biennial Oscillation (QBO) data during the westerly and easterly phase. Whereas fig. 4 & 7 gives a vivid picture of the number of annual and southwest monsoon tropical cyclones over the north Indian Ocean with the yearly average Quasi-Biennial Oscillation (QBO) data.

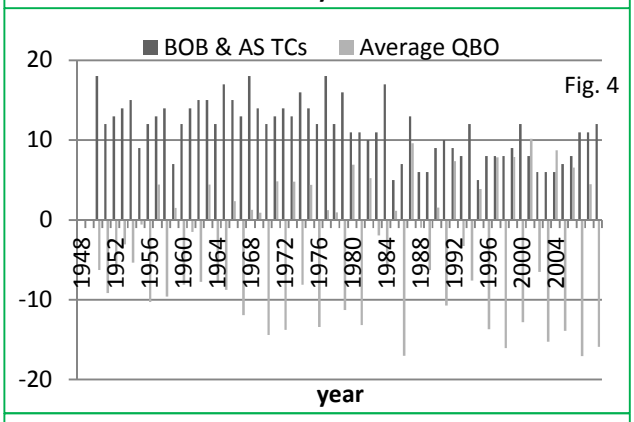
Table 1: Correlation coefficients for the Quasi-Biennial Oscillation (QBO) with the annual frequency of Cyclonic Storms and the number of Southwest Monsoon Cyclonic Storms.

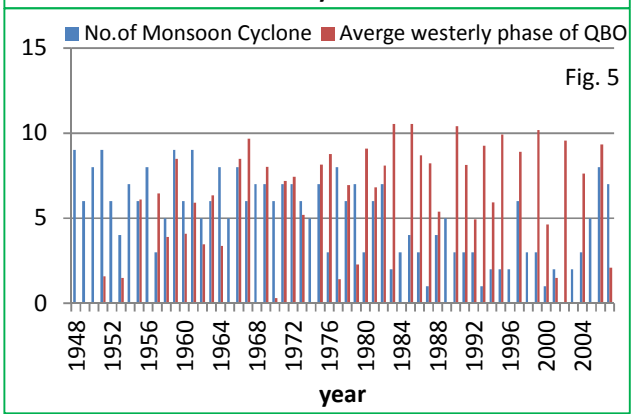
QBO	Correlation (1948 to 2007) No. of Cyclonic Storms	
	Annual frequency	Southwest Monsoon
Overall Average	-0.073	-0.05
Westerly phase	-0.176	-0.237
Easterly phase	-0.068	-0.011

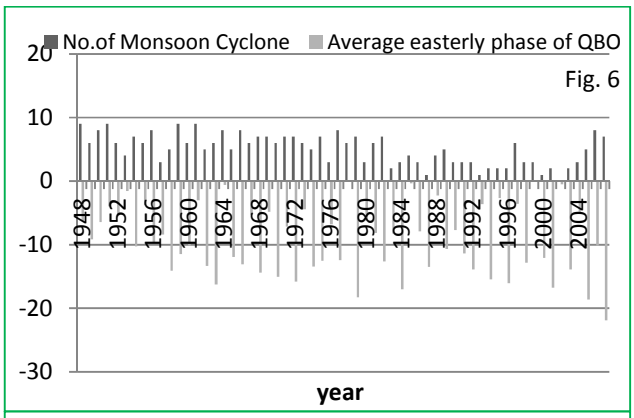
A statistically significant relationship between the QBO and Tropical cyclones on the North Atlantic from 1950 – 1980 was found by Camargo and Sobel (2010) and they also found that the relationship is no longer present in later years. In the other basins, the relationship is weaker than in the Atlantic, even in the early record. The number of Tropical cyclone over the Western North Pacific (WNP) appeared to be unrelated to the QBO phases (Chang-Hoi Ho et.al 2009). With the comparison of the above plots with the calculated correlation coefficients, it has been noted that there exist no significant relationship between them. It is very difficult to draw a firm conclusion from these plots and correlated values about the influence of the QBO on the tropical cyclonic disturbance in the North Indian Ocean.











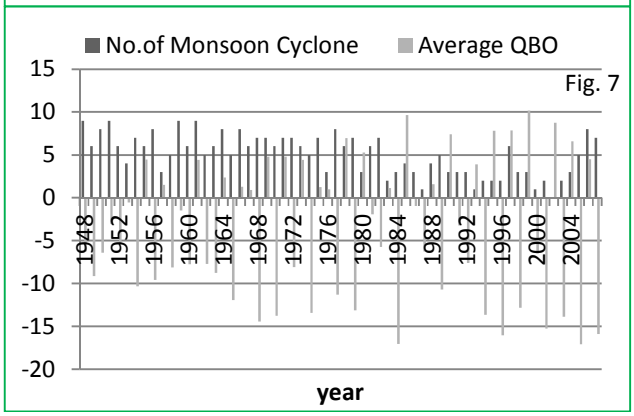


Fig. 2: The number of tropical cyclones over the North Indian Ocean per year to the average Quasi-Biennial Oscillation (QBO) data during the westerly phase.

Fig. 3: The number of tropical cyclones over the North Indian Ocean per year to the average Quasi-Biennial Oscillation (QBO) data during the easterly phase.

Fig. 4: The number of tropical cyclones over the North Indian Ocean per year to the average Quasi-Biennial Oscillation (QBO) data.

Fig. 5: The number of southwest monsoon tropical cyclones over the North Indian Ocean per year to the average Quasi-Biennial Oscillation (QBO) data during the westerly phase.

Fig. 6: The number of southwest monsoon tropical cyclones over the North Indian Ocean per year to the average Quasi-Biennial Oscillation (QBO) data during the easterly phase.

Fig. 7: The number of southwest monsoon tropical cyclones over the North Indian Ocean per year to the average Quasi-Biennial Oscillation (QBO) data.

4.0 Conclusion:

Many papers have been documented to materialize a relationship between QBO and the tropical cyclones. The QBO shear is restricted to very high levels.

(i) The temperature perturbations are of the wrong sign for a stability argument (lower stratosphere is warm in westerly QBO phase). Time-height plot of

equatorial stratospheric zonal wind showing Quasi-Biennial Oscillation (QBO) here, we revisit the statistical relationship, using the longer data record now available.

(ii) It is difficult to draw a firm conclusion from these results about whether the QBO exerts a true physical influence on tropical cyclonic disturbance in the North Indian Ocean.

(iii) The lack of a statistically significant relationship for the long term data shows relatively speculative nature of the physical arguments to explain the QBO and tropical cyclone correlation.

5.0 Acknowledgement:

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References:

1) Balachandran, S., and P. Guhathakurta. (1999): On the influence of QBO over north Indian Ocean and depression tracks. *Meteor. Atmos. Phys*., 70, 111–118.
2) Baldwin, M. P., and Dunkerton, T. J. (2001): Stratospheric harbingers of anomalous weather regimes. *Science*, 294, 581–584.
3) Barnston, A. G., and Livezey, R. E. (1989): A closer look at the effect of the 11-year solar cycle and the Quasi-Biennial Oscillation on the Northern Hemisphere 700 mb height and extratropical North American surface temperature. *J. Climate*, 2, 1295–1313.
4) Camargo, S. J., Sobel, A. H., Emanuel, K. A. and Sobel, A. H. (2007a): Use of a genesis potential index to diagnose ENSO effects on tropical cyclone genesis. *J. Climate*, 20, 4819–4834.
5) Camargo, S. J and Sobel, A. H. (2010): Revisiting the Influence of the Quasi-Biennial Oscillation on Tropical Cyclone Activity. *J. Climate*, 23, 5810–5825.
6) Chan, J. C. L. (1995): Tropical cyclone activity in the western North Pacific in relation to the stratospheric Quasi-Biennial oscillation. *Mon. Wea. Rev*., 123, 2567–2571.
7) Chang-Hoi Ho, Hyeong-Seog Kim, Jee-Hoon Jeong and Seok-Woo Son. (2009): Influence of stratospheric quasi-biennial oscillation on tropical cyclone tracks in the western North Pacific. *Geophys. Res. Lett*., 36, L06702, doi: 10.1029/2009GL037163.
8) Dube, S. K., Rao, A. D., Sinha, P. C., Murty, T. S. and Bahulayan, N. (1997): Storm surge in the Bay of Bengal and Arabian Sea: The problem and its prediction, *Mausam*, 48, 2, 283-304.
9) Gray, W. M. (1968): A global view of the origin of tropical disturbances and storms. *Mon.Wea. Rev*., 96, 669-700.
10) Gray, W. M. (1984a): Atlantic seasonal hurricane frequency. Part I: El Nino and 30-mb Quasi-Biennial Oscillation influences. *Mon. Wea. Rev*., 112, 1649–1688.
11) Gray, W. M. (1984b): Atlantic seasonal hurricane frequency. Part II: Forecasting its variability. *Mon. Wea. Rev*., 112, 1669–1683.
12) Holton, J. R. and Lindzen, R. S. (1972): An updated theory for the Quasi Biennial cycle of the Tropical Stratosphere. *J. Atmospheric Sciences*, 29, 1076-1080.
13) Ihara, C., Kushnir, Y. and Cane, M. A. (2007): Indian summer monsoon rainfall and its link with ENSO and Indian Ocean climate indices. *Int. J. Climatol*., 27, 179–187.