C1. Climatological Study of Borneo Vortex during Northern Hemisphere Winter Monsoon

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Introduction

- Borneo vortex, renowned as monsoon disturbance, is a synoptic-scale low-level quasi-stationary cyclonic circulation embedded within the monsoon trough that is persistently formed off coast of the Borneo Island during Northern Hemisphere winter monsoon.
- The presence of the vortex in this region has long been associated with the active period of the winter monsoon that leads to heavy rainfall activity and flood disaster. It has also been connected to the formation of two tropical cyclones, namely TS Greg (1996) and Typhoon Vamei (2001), which are considered as unusual phenomena over this region.

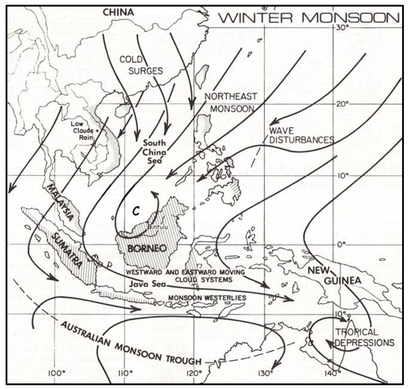

Figure 1. Primary synoptic-scale circulation features over Southeast Asia during winter monsoon (Johnson and Houze, 1987)

Goal:

- To determine the climatology of the Borneo vortex and sense its interannual and interdecadal variability with tropical climate systems during 1970/71 to 2010/11 winter monsoon seasons between November and February.

Data:

- Using the ERA-Interim and ERA-40 reanalysis data retrieved online from the European Center for Medium-range Weather Forecasting (ECMWF) website at http://data.ecmwf.int/data.
- Applying the work of Chang (2005) by analyzing 00Z wind field at 925 hPa level within the domain set in *Figure 2* using the Integrated Data Viewer (IDV) application.
- The vortex, such as in *Figure 2*, was determined based on closed cyclonic circulation with wind speed should be at least 2 ms^{-1} in the four corner points of the 2.5° X 2.5° grid square within which the center circulation was located.

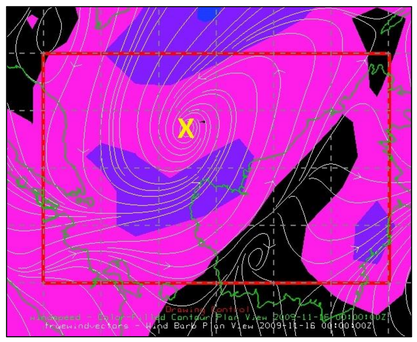

Figure 2. One of the Borneo vortices observed within the study domain bounded by red box (2.5°S-7.5°N latitudes and 102.5°E-117.5°E longitudes). The vortex center is marked as yellow "X" and the color-shaded area indicates wind speed of at least 2 ms^{-1}

Results:

- 2,278 Borneo vortices were identified throughout 41 winter monsoon seasons, which occupied 46% of the time span of the study period.
- The seasonal mean was 55.6 vortices. December had the most vortices with an average of 18.6, followed by January, November and February with 13.9, 13.4 and 9.7, respectively.
- The Borneo vortex mean center was calculated at 2.4°N and 110.6°E and its seasonal mean positions shifted slightly westward throughout the study period based on the long-term trend.
- The periodograms from *Figure 4* and *Figure 6* suggest that the variability of the vortex frequencies and center positions are coincided with PDO, ENSO, TBO and QBO phases

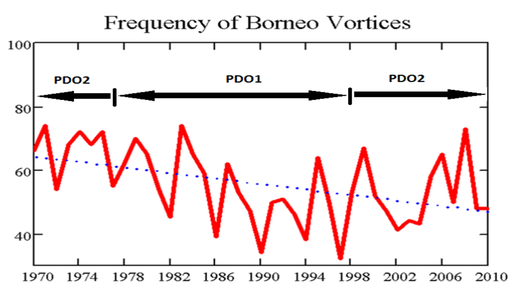

Figure 3. Amount of Borneo vortices per winter monsoon between 1970/71 and 2010/11 seasons. The blue-dotted line indicates the long-term trend.

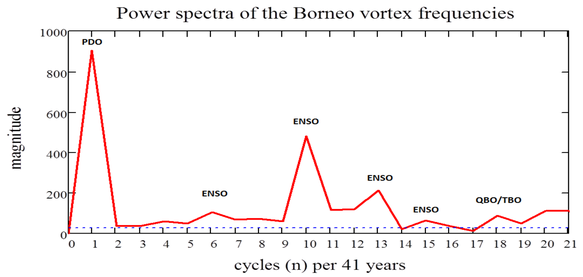

Figure 4. The seasonal frequencies of Borneo vortex plotted as Fourier power spectra. The blue-dashed line indicates the 99% confidence level.

(a)	All	PDO1 (1977–1998)	PDO2 (1970-1976) & (1999-2010)
Seasons	41	22	19
Vortex frequency	2,278	1,168	1,110
Vortices per season	55.6	53.1	58.4

(b)	All	El Nino	La Nina	Neutral
Seasons	41	10	10	21
Vortex frequency	2,278	508	619	1151
Vortices per season	55.6	50.8	61.9	54.8

(c)	All	PDO1			PDO2		
		EN	LN	NEU	EN	LN	NEU
Seasons	41	5	2	15	5	8	6
Vortex frequency	2,278	228	106	834	280	513	317
Vortices per season	55.6	45.6	53.0	55.6	56.0	64.1	52.8

(d)	All	Westerly QBO	Easterly QBO
Seasons	41	21	20
Vortex frequency	2,278	1,193	1,086
Vortices per season	55.6	56.8	54.3

Table 1. The average amounts of the Borneo vortices with respect to the PDO periods (a), ENSO years (b), combination of the PDO and ENSO (c) and QBO phases (d).

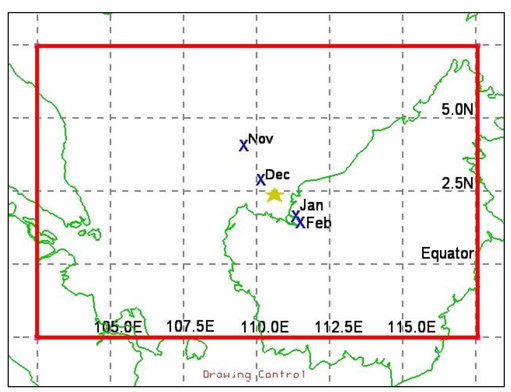

Figure 5. Monthly mean positions of the Borneo vortex centers. The yellow star is the long-term average position.

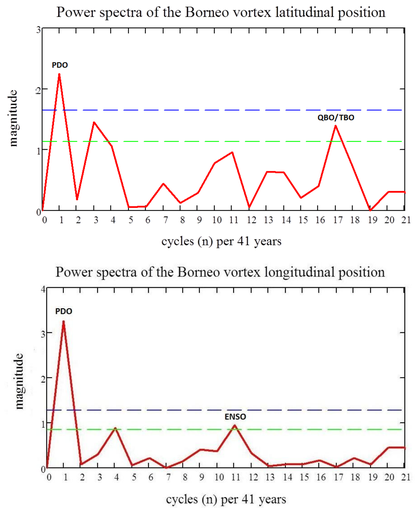

Figure 6. The latitudinal and longitudinal positions of the Borneo vortex plotted as Fourier power spectra. The blue-dashed line is the 95% confidence level and the green-dashed line is at 80% level.

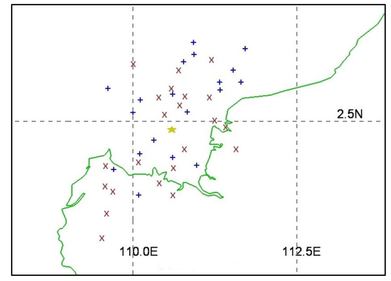

Figure 7. The Borneo vortex centers associated with PDO periods. The brown "X" indicates the vortex center during the PDO1 period while the blue "+" during PDO2.

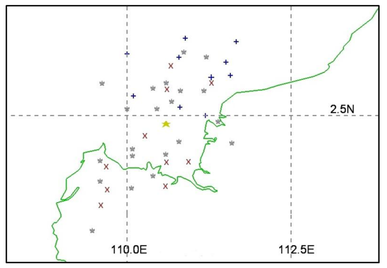

Figure 8. The Borneo vortex centers associated with ENSO years. The brown "X" indicates the vortex center during the El Nino years, blue "+" for La Nina and grey "*" for neutral.

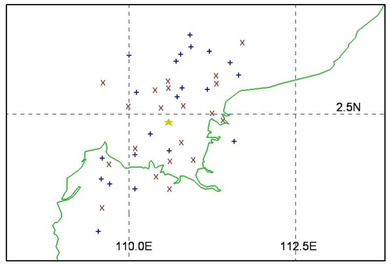

Figure 9. The Borneo vortex centers associated with QBO phases. The brown "X" indicates the vortex center during the QBO easterly phase while the blue "+" during QBO westerly.

Summary and Key Conclusions

- On average, the Borneo vortex was observed on every alternate day within the study domain during winter monsoon period between November and February. Its mean center was located off coast of west Borneo Island.
- The long-term trend of the seasonal frequencies was downward and its seasonal mean positions was shifted westward. The monthly mean vortex centers moved southeastward as the winter monsoon progressed following the ITCZ.
- Interannual variability was found in the 3-7 year range and is likely linked to ENSO. More vortices was observed during La Nina years and less during El Nino. The vortices tend to form northeastward of their long-term mean position during La Nina year and southwestward in El Nino years.
- The 2.5-year interannual variability is likely linked to TBO or QBO. The association with QBO doesn't show any prominent outcome while the relation with TBO can't be quantified since its phase has not been established.
- The 40-year interdecadal variability is most likely associated with PDO. PDO2 together with La Nina enhanced the vortex frequencies and vice versa for the case of PDO1 and El Nino combined.