The QBO/ENSO relationship and Cold Point Tropopause Temperatures

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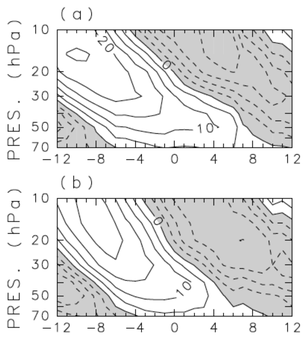


Figure 9 from Taguchi(2010), time-height section of U composited under (a) LA and (b) EL conditions.

Motivation

Figure on the left, Taguchi(2010) found out that QBO has longer period and larger period during (a)La Niña months than during (b)EL niño months. But in this study the author only took three stations' zonal wind data into account. We want to check whether this QBO/ENSO relationship is symmetric around the tropical Equator.

So we are trying to look into separating the QBO from ENSO using radiosonde data. HRES data set has higher vertical resolution, but it is not long enough, and there are less tropical stations than IGRA. IGRA data have longer record (over 50 years of data), can we use IGRA in our research?

First we check the temperature and zonal wind composite during two ENSO phases and two QBO phases, using the same time period (1998-2007) from HRES and IGRA. Results showed in figure 1 and 2.

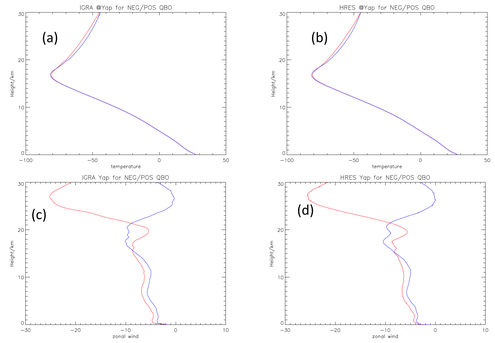


Figure 1: Temperature composite according to QBO positive/negative phases using IGRA data(a) and HRES data(b); (c) and (d) are like (a) and (b) but they are the zonal wind composites. Red line represents the QBO positive phase, while blue line represents the QBO negative phase.

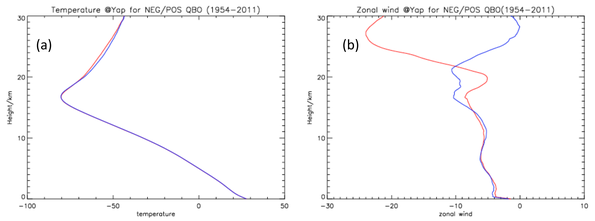


Figure 2: Temperature(a) and zonal wind(b) composite according to QBO positive/negative phases using IGRA at YAP station, time range is from 1954 to 2011. Red line represents the QBO positive phase, while blue line represents the QBO negative phase.

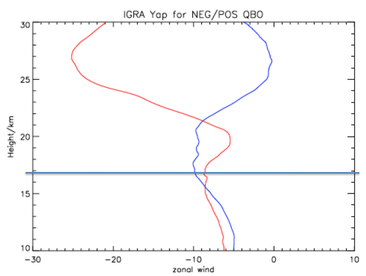


Figure 3: Zoom in view of figure 1(a), the horizontal line shows the position of Tropopause. The stratosphere QBO signal can penetrate down into the upper troposphere. This feature can be seen in the longer time composite too.

Brief summary of the comparison

For 10 years composite(1997-2008), temperature composite results are almost identical between HRES and IGRA. The zonal wind profile composite are very similar between the two data sets too.

In the zonal wind composite according to QBO phases, there is difference between the two profiles in the lower troposphere, which means ten years' data is not long enough to exclude the influence of ENSO. The difference becomes much smaller when using 58 years data to calculate the composite, shown in figure 2.

QBO information can penetrate down for several kilometers into the upper troposphere, see in figure 3.

Results with IGRA data set

From all the IGRA stations, we choose 11 tropical stations between [10S 10N]. On these stations, the radiosonde data are around or longer than 50 years and there is a good record of the stratosphere zonal wind.

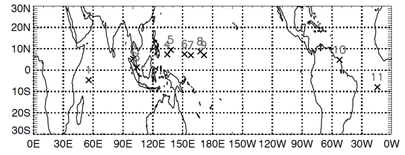


Figure 4: 11 stations along the Equator from IGRA data

Apply the method used in Taguchi(2010) to these stations, We get the QBO amplitudes and periods during EL and LA for each station, as shown in Table 1

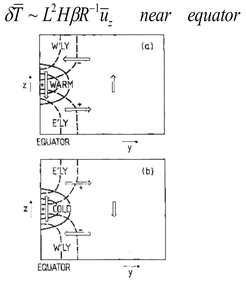
Station	EL_PS(/month)	LA_PS(/month)	EL_AMP	LA_AMP
Seychelles	11.7	9.61	0.92	1.12
Penang	14.58	11.14	1.04	1.11
Singapore	15.23	10.96	1.04	1.21
Koror	14.25	11.09	1.17	1.20
Yap	14.18	11.14	1.13	1.18
Chuuk	14.39	10.69	1.17	1.24
Ponape	14.32	10.83	1.16	1.22
Kwajalein	10.06	8.32	1.23	1.39
Majuro	16.38	10.48	1.18	1.25
Howard	12.46	10.45	0.79	0.74
Cayenne	14.29	10.25	1.01	1.15
Wideawake	13.48	9.14	1.22	1.32
Mean	*13.78*	*10.34*	*1.09*	*1.18*
	26.5±3.7 months	35.1±3.4 months	1	1.08±0.07

Table 1: QBO period and amplitude during EL and LA for the 11 IGRA stations. The last row shows the mean QBO period during EL/LA along the Equator and the ratio between mean LA amplitude and mean EL amplitude.

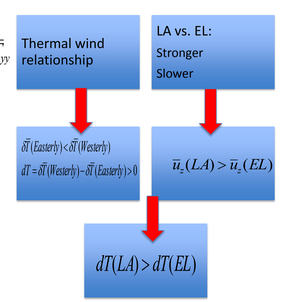
$$\bar{u}_z = -R(H\beta y)^{-1}\bar{T}_y$$

$$\bar{T}_y = 0 @ equator \Rightarrow \bar{u}_z = -R(H\beta)^{-1}\bar{T}_{yy}$$

$$\delta\bar{T} \sim L^2 H\beta R^{-1}\bar{u}_z \quad near \quad equator$$



From Plumb and Bell(1982)



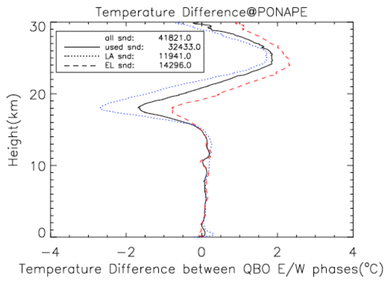


Figure 5: Temperature difference between QBO E/W phases during LA/EL months and all time mean. Blue line is during LA months, red line is during EL months and black solid line is all time mean result.

Brief summary of this part, the QBO/ENSO relationship found in Taguchi(2010) is symmetric along the Equator, QBO has longer period and greater amplitude for all 11 stations. The CPT temperature difference between QBO E/W phases is larger during La Nina months than EL Nino months, which agree with the QBO amplitude relationship.

Some ongoing research

Garfinkel and Hartmann(2007) found that the correlation between ENSO and QBO index varies from different time periods, the correlation during 1957~1982 is -0.25, while it's during 1990~2007 is 0.26. This may imply that the QBO/ENSO period/amplitude relationship may change during different time periods too.

So we split the 50 years into two parts(before or after 1984), and check the QBO period/amplitude during EL/LA separately. The results are shown in table 2. It shows that QBO always has longer period during LA than during EL. QBO amplitude is larger during LA than EL after 1984, which is the same as the 50 year calculation, but this amplitude relationship doesn't hold before 1984. We are trying to understand this change and the mechanism of the ENSO influence of QBO.

Period of Analysis	QBO period EL	QBO period LA	QBO Amplitude LA/EL
1953-2008	24.7 months	31.9 months	1.1
1950S~200S	26.5 months	35.1 months	1.1
1950S~1984	25.3 months	31.4 months	0.97
1985~200S	24.5 months	33.8 months	1.13

Table 2: QBO period and amplitude during EL/LA. The first row is from Taguchi(2010), second row is the result from Table 1, the last two rows are the results before and after 1984.