Chapter 1 Introduction

1.1 Quasi-Biennial Oscillation

Besides the externally forced diurnal and annual cycles, the most observed phenomenon that exhibits periodic behaviour in the tropics is the QBO in the mean zonal winds of the equatorial lower stratosphere. The QBO involves the regular oscillation of the zonally symmetric easterly and westerly winds found at a height ranging roughly from 18 to 30 km (~100 to 10 hPa), with periods slightly more than two years.

Reed et al. (1961) and Veryard and Ebdon (1961) discovered the QBO in the equatorial stratospheric winds almost simultaneous. Later, Angell and Korshover (1962) included temperature in their studies of the tropical stratospheric QBO and extended their studies to include higher latitudes. There were a lot more updated documentations regarding QBO in the later years (Tucker, 1964; Tucker and Hopwood, 1968; Coy, 1979 and 1980; Angell, 1986; Naujokat, 1986; Wang et al., 1995; Kinnersley and Pawson, 1996; Maruyama, 1997 etc.). Others have simulated the existence of the QBO by using different models (Reed, 1964; Lindzen and Holton, 1968; Holton and Lindzen, 1972; Plumb and Bell; 1982; Saravanan, 1990; Takahashi and Boville, 1992; Geller et al., 1997; Horinouchi and Yoden, 1998; Hamilton, 1998; Kinnersley, 1999 etc.). Reed (1964) has presented a consistent model of the three-dimensional wind and temperature fields in the

QBO based partly on empirical results and partly on theoretical findings. Lindzen and Holton (1968) presented a theoretical model that successfully showed how vertically propagating equatorial gravity waves could drive the QBO by depositing vertical flux of momentum in the mean flow at critical levels. Holton and Lindzen (1972) updated the model while Plumb and Bell (1982), Saravanan (1990) and Takahashi and Boville (1992) extended it to a two-dimensional beta-plane model, a multi-wave model and a three-dimensional mechanistic model respectively. Others, such as Geller et al. (1997), Horinouchi and Yoden (1998) and Hamilton (1998) further updated the model by introducing a time-varying equatorial wave forcing, convectively excited waves and an imposed zonal momentum forcing into the model respectively.

1.2 Tropospheric Biennial Oscillation

For the past 10-15 years, many observational studies have provided evidence of a remarkable biennial, or quasi-biennial, oscillation in the interannual variability in the tropical Indian and Pacific Ocean regions (Meehl, 1987, 1993) and of the Asian and Australian monsoons (Meehl, 1994; Yasunari, 1991; Shen and Lau, 1995 etc.). This biennial oscillation, referred to as the TBO by Meehl (1997) in order to differentiate it from the stratospheric QBO, is associated with variations in the tropical atmospheric circulation and the SST over the tropical oceans. This TBO feature of the Asian-Australian monsoon may involve strong coupling and interactions between atmosphere, ocean and land surface.

The Asian monsoon consists of three subregions, the Indian monsoon, the East Asian monsoon and the Australian monsoon. Many studies regarding the relationship between TBO and monsoon had been carried out. Meehl (1997) had studied the relationship between TBO and the Indian monsoon. By using an idealized TBO cycle, the evolution of seasonal cycle beginning with strong Indian monsoon was used to explain how and why it could lead to a weaker Indian monsoon the following season. Similarly, while Shen and Lau (1995) and Chang et al. (2000) related TBO to the East Asian monsoon, Chang and Li (2000) had created a conceptual model on the relationship between TBO and the Indian and Australian monsoon.

1.3 The Link between QBO and TBO

Many studies have reviewed that other atmospheric parameters such as temperature and tropopause height in the tropics as well as in the middle and higher latitudes also exhibit QBO-like variations (Angell and Korshover, 1964, 1968; Trenberth, 1975 etc.). Others have related different types of atmospheric phenomena to the stratospheric QBO (Ebdon, 1975; Trenberth, 1980; Maruyama and Tsuneoka, 1988; Xu, 1992 etc.). However, most of these studies inter-relate tropospheric phenomena in the middle and higher latitudes to the equatorial stratospheric QBO. For example, Trenberth (1980) has found that the QBO in the regional meridional index of the sea level atmospheric circulation in the Southern Hemisphere and the QBO in the zonal winds of the equatorial lower stratosphere are unrelated.

Yasunari (1989) is the first to study the relationship between QBO and TBO in the tropics and suggests that the QBO mode of the tropospheric zonal wind and SST in the tropical Pacific is linked with the QBO in the stratosphere through the coupled atmosphere-ocean system.

The main objective of this study is to perform a systematic analysis of the possible relationship between QBO and TBO by focusing on the near-two-year period window of the stratospheric and tropospheric wind and height fields and that of the SST. Mainly based on the lag correlation between the various fields, a conceptual model to interpret the relationship as a forcing of QBO from a SST-coupled TBO is presented. Due to the limited data domain size, this model is only applicable to the Malaysian region, but may reasonably be extended to represent situation over the Southeast Asian region.