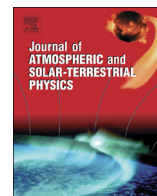




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## Review article

## Downward propagating Equatorial Annual Oscillation and QBO generated multi-year oscillations in stratospheric NCEP reanalysis data

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## ABSTRACT

In this brief review we discuss and summarize the results of an analysis of zonal wind and temperature variations from the National Center for Environmental Prediction (NCEP) reanalysis, which provide observational evidence for the 12-month Equatorial Annual Oscillation (EAO), in addition to the classical equatorial oscillations, the 6-month Semi-annual Oscillation (SAO) and Quasi-biannual Oscillation (QBO). The EAO is observed slowly propagating down with a velocity of about 3 km/month in agreement with the results from a numerical model, and characteristic of wave mean flow interactions at low latitudes that generate the QBO at 1.3 km/month. For data samples that cover as much as 40 years, the NCEP zonal winds reveal a rich spectrum of oscillations with periods between 3 and 10 years. Such multi-year oscillations can be generated by the QBO interacting with the seasonal variations through wave filtering. As shown with model simulations, the 30-month QBO can interact with the 12-month Annual Oscillation (AO) to generate a 5-year oscillation, which is prominent in the NCEP data. And the 27-month QBO can generate a 9-year quasi-decadal oscillation, which is also observed along with the related modulation signatures close to 3 years.

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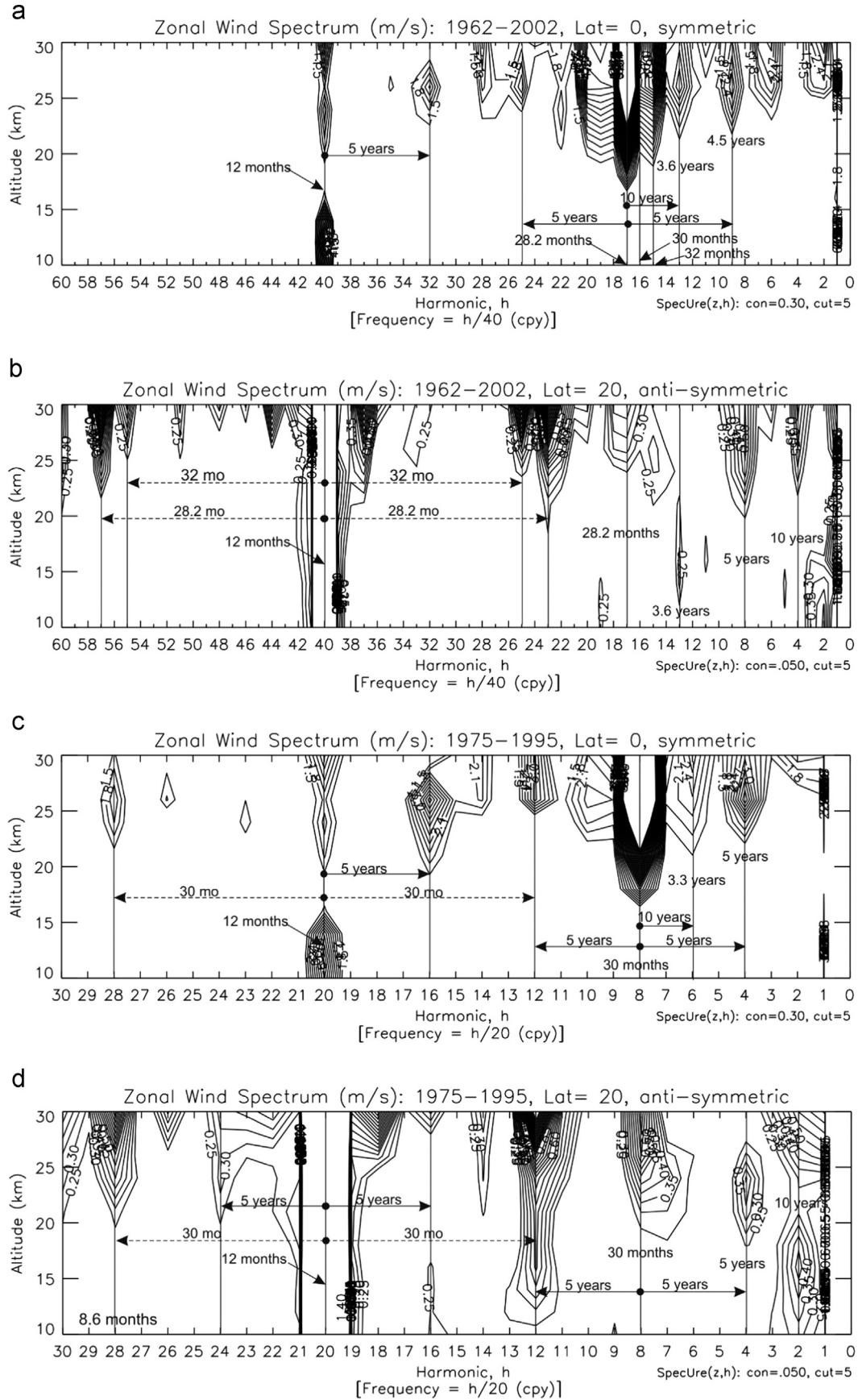
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## 1. Introduction

The solar cycle (SC) effect in the stratosphere has been linked observationally to the Quasi-biennial Oscillation (QBO) of the zonal circulation. In several papers (Labitzke, 1982, 1987; Labitzke and Van Loon, 1988, 1992; Dunkerton and Baldwin, 1992; Baldwin and Dunkerton, 1998) it is shown that the temperatures at

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**Fig. 1.** Zonal wind amplitude spectra for the NCEP/NCAR R-1 data from 1962 to 2002 and 1975 to 1995, plotted versus Fourier harmonics,  $h$ , and altitude. The corresponding frequencies, respectively, are  $h/40$  and  $h/20$  cycles per year (cpy) and the periods are  $40/h$  and  $20/h$  (years). Shown are the symmetric and anti-symmetric components at the equator (a, c) and at  $20^\circ$  latitude (b, d), respectively, with contour intervals of 0.3 and 0.05 m/s (lowest 4 suppressed). The most prominent features in the spectra represent the 12-month AO and the dominant QBO with periods of 28.2 (a) and 30 (c) months. Horizontal arrows identify the modulation signatures in the spectra, mainly the 5-year semi-decadal (SD) oscillation. (Figure taken from Mayr et al. (2007b)).

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