Mem. S.A.It. Vol. 76, 880

Memorie della

Tropical versus extratropical changes related to solar flux variations

K. Coughlin, Ka-Kit Tung and D. Camp

University of Reading, Meteorology Department, Earley Gate, PO Box 243, Reading, RG6 6BB, UK
e-mail: katie@met.rdg.ac.ukUK

Abstract. Changes in the Solar Flux are very small compared to the total Solar Flux and the influence that these changes have on our atmosphere is also relatively small compared to many other climate changes that happen on much faster time scales. This makes it difficult to ascertain exactly what influence the solar flux variation has on our atmosphere. In both the tropics and in the extratropics, the atmosphere is warmer on average when the solar flux is larger (Coughlin and Tung 2004). However, this picture does not include the solar modulation of physical processes with faster time scales. These added information may be important in our understanding of the total solar-climate connection. In the stratosphere, it has been shown that there is a possible interplay between the solar irradiance changes and the direction of the Quasi-Biennial Oscillation (QBO) winds (among others, Labitzke and van Loon 1982,2002).

1. Introduction

We take a closer look at the extratropical (north of 45N) pressure and temperature (NCEP/NCAR reanalysis, Kalnay et al. 1996) where we find evidence of a solar modulation (see figure 1) using EMD analysis (Huang et al. 1998). Figure 1 shows a latitude/time diagram of the second mode of geopotential height. The amplitudes of this oscillating mode are plotted as the colored contours (positive amplitudes are in green to red colors and negative amplitudes are blue). Most noticeable are the changes in amplitude over the north pole. The solar cycle time series is plotted on the right of the figure and the amplitudes seem to be out of phase with the solar cycle. That is, large amplitude changes in geopotential height in the northernmost latitudes correspond with lower solar flux.

This second mode contains signals of the extratropical QBO. It is important to note that the extratropical QBO in geopotential height is of the opposite sign as the QBO winds in the tropics (this is due to the Holton-Tan effect, Holton and Tan, 1980). A quantitative examination of the envelope of the second mode, shows that it is anticorrelated with the changes in solar flux. However, this is only part of the total signal over the extratropics. As previously mentioned, it has already been shown that there is a small general warming with increased solar irradiance. This is a solar offset to the amplitude modulation. When taken all together, we find that during the Westerly phase of the QBO, the northern extratopics are warmer when there is a larger solar irradiance. However, during the Easterly phase of the QBO, changes in solar flux have little affect on the extratropics. Thus, this modulation is one-sided. During Easterly

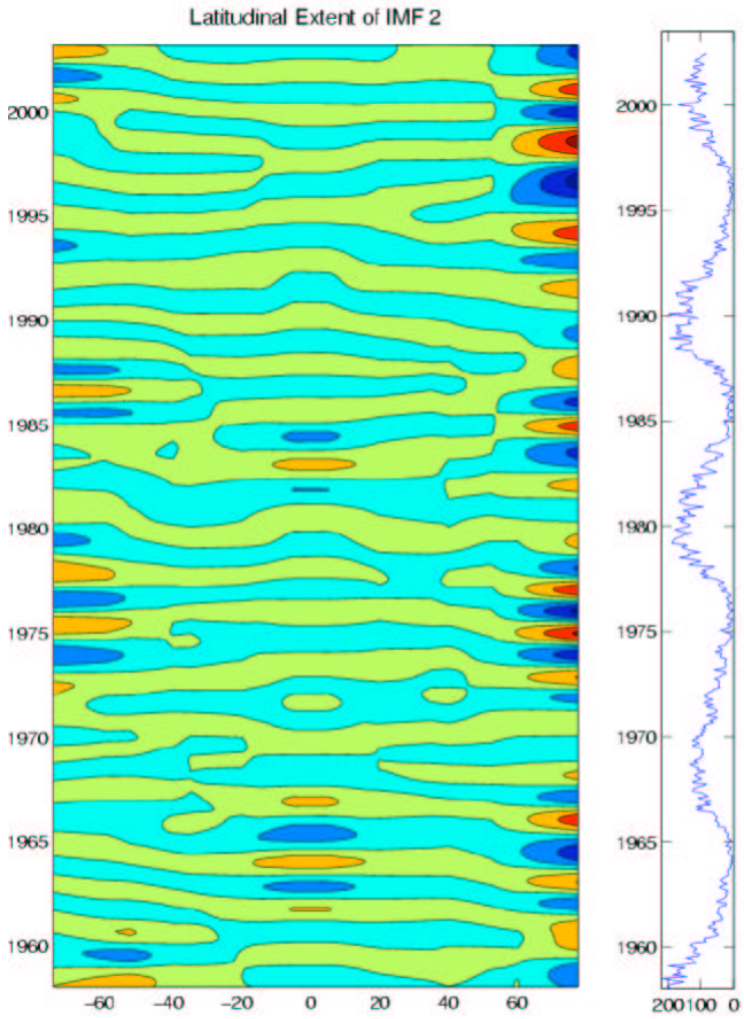

Fig. 1. Latitude-time diagram of the second mode of geopotential height.

QBOs, the east-west zero wind line moves into the winter hemisphere and a narrowing of the planetary wave guide leads to increased wave breaking and a warming of the extratropics – this is the Holton-Tan effect. However, during Westerly QBOs, the plantary waves are not focused towards the pole by the QBO winds. During this time, the thermodynamic effect of increased ozone heating in the subtropics, due to increased solar irradiance, may also produce a dynamical response near the pole. This would explain the one-sided solar modulation in the northern stratosphere.

References

Coughlin, K. T., & Tung, K. K. 2004, Advances in Space Research, 34, 323

Holton, J. R., & Tan, H.C. 1980, J. Atmos. Sci., 37, 2200

Huang, N. E., et al. 1998, Proc. R. Soc. Lond. A, 454, 903

Kalnay, E., et al. 1996, Bull. Amer. Meteor. Soc., 77, 437

Labitzke, K., 1982, J. Met. Soc. Japan, 60, 124

Labitzke K., et al., 2002, J. Atmos. Sol-Terr. Phys., 64, 203