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Article

The global signal of the 11-year sunspot cycle in the atmosphere: When do we need the QBO?

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Abstract

The global structure and the size of the signal of the 11-year sunspot cycle in the stratosphere and troposphere was examined in earlier studies. The correlations between the solar cycle and heights and temperatures of and at different pressure levels were mainly carried out with the whole data set and only during northern winters the years were separated according to the phase of the Quasi-Biennial Oscillation. Here, this work is expanded and it is shown that the Quasi-Biennial Oscillation must be introduced during northern summers, because the solar signal is very different in the respective phases of the Quasi-Biennial Oscillation, particularly over the tropics and subtropics. The structure of the solar signal in (northern) summer appears to indicate that the mean meridional circulations (Hadley and Brewer-Dobson Circulations) are influenced by the 11-year sunspot cycle, especially during the east phase of the Quasi-Biennial Oscillation. This result may help to find the mechanism through which the solar cycle (and the connected variation of the ultraviolet radiation) can influence the atmosphere.

Zusammenfassung

Die globale Struktur und die Größe des Signals des 11-jährigen Sonnenfleckenzyklus in der Strato- und Troposphäre wurde von uns in verschiedenen Arbeiten untersucht. Meist standen etwa vier Zyklen zur Verfügung. Bisher haben wir nur im Nordwinter die Quasi-Biennial Oscillation eingeführt, um das solare Signal zu finden, außerhalb dieser Saison benutzten wir fast immer den gesamten Datensatz, um die Anzahl der Fälle groß zu lassen. In dieser Arbeit soll aber gezeigt werden, dass man die Quasi-Biennial Oscillation auch im Nordsommer einsetzen muss, weil das solare Signal auch außerhalb des Nordwinters in den verschiedenen Phasen der Quasi-Biennial Oscillation über den Tropen und Subtropen sehr unterschiedlich ist. Die Struktur des solaren Signals im Sommer deutet darauf hin, dass die mittleren Meridionalzirkulationen (Hadley und Brewer-Dobson Zirkulation) besonders während der Ostphase der Quasi-Biennial Oscillation beeinflusst werden. Dieses Ergebnis soll helfen, den Mechanismus zu finden, durch den der 11-jährige Sonnenfleckenzyklus und insbesondere die damit verbundenen Schwankungen der UV-Strahlung auf die Atmosphäre wirken können.

1 Introduction

It is well known that the 11-year sunspot cycle is connected with a large variability of the solar radiation in the ultraviolet (UV) part of the spectrum. Near 200 nm, the range which is important for the formation of ozone, the difference between the extremes in the 11-year sunspot cycle (SSC) amounts to 6%–8% (LEAN et al., 1997). That is enough to cause in the upper stratosphere changes in the temperatures, winds and ozone that will result in circulation changes here and it is possible that such changes have an indirect feedback on the lower stratosphere and on the troposphere. Haigh (1996) carried out a model experiment which suggested such a feedback and today several research groups are engaged in simulations of the middle atmosphere, using General Circulation Models (GCMs) and an observed solar energy spectrum and connected ozone changes (e.g., HAIGH, 1999; LARKIN et al., 2000; MATTHES et al., 2003; SHINDELL et al., 1999).

Based in the beginning on our own data (The Berlin Stratospheric Data Series, LABITZKE et al., 2002) and later using the re-analyses from NCEP/NCAR (US National Center for Environmental Prediction/National Center for Atmospheric Research), we have shown in several publications (e.g., LABITZKE, 1987, 2001; LABITZKE and VAN LOON, 1988, 2000; VAN LOON and LABITZKE, 1994, 2000) that during northern winters the signal of the SSC can be established only if the data are grouped according to the different phases of the Quasi-Biennial Oscillation (QBO). This result was confirmed by SALBY and CALLAGHAN (personal communication) who defined for their study the northern winter period from September till February.

We showed further that during January/February, i.e. during southern summers the influence of the QBO is also large over the southern hemisphere (LABITZKE, 2002). A summary of current ideas explaining the observed solar signal in the stratosphere is given in

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