Atmospheric Chemistry and Physics
An Interactive Open Access Journal of the European Geosciences Union

Atmos. Chem. Phys., 8, 6505-6525, 2008
www.atmos-chem-phys.net/8/6505/2008/

Net effect of the QBO in a chemistry climate model

H. J. Punge[1,2] and M. A. Giorgetta[1]
[1]Max Planck Institute for Meteorology, Bundesstr. 53, 20146 Hamburg, Germany
[2]IMPRS on Earth System Modelling, Bundesstr. 53, 20146 Hamburg, Germany

Abstract. The quasi-biennial oscillation (QBO) of zonal wind is a prominent mode of variability in the tropical stratosphere. It affects not only the meridional circulation and temperature over a wide latitude range but also the transport and chemistry of trace gases such as ozone. Compared to a QBO less circulation, the long-term climatological means of these quantities are also different. These climatological net effects of the QBO can be studied in general circulation models that extend into the middle atmosphere and have a chemistry and transport component, so-called Chemistry Climate Models (CCMs). In this work we show that the CCM MAECHAM4-CHEM can reproduce the observed QBO variations in temperature and ozone mole fractions when nudged towards observed winds. In particular, it is shown that the QBO signal in transport of nitrogen oxides NO_x plays an important role in reproducing the observed ozone QBO, which features a phase reversal slightly below the level of maximum of the ozone mole fraction in the tropics. We then compare two 20-year experiments with the MAECHAM4-CHEM model that differ by including or not including the QBO. The mean wind fields differ between the two model runs, especially during summer and fall seasons in both hemispheres. The differences in the wind field lead to differences in the meridional circulation, by the same mechanism that causes the QBO's secondary meridional circulation, and thereby affect mean temperatures and the mean transport of tracers. In the tropics, the net effect on ozone is mostly due to net differences in upwelling and, higher up, the associated temperature change. We show that a net surplus of up to 15% in NO_x in the tropics above 10 hPa in the experiment that includes the QBO does not lead to significantly different volume mixing ratios of ozone. We also note a slight increase in the southern vortex strength as well as earlier vortex formation in northern winter. Polar temperatures differ accordingly. Differences in the strength of the Brewer-Dobson circulation and in further trace gas concentrations are analysed. Our findings underline the importance of a representation of the QBO in CCMs.

Final Revised Paper (PDF, 4128 KB)   Discussion Paper (ACPD)

Citation: Punge, H. J. and Giorgetta, M. A.: Net effect of the QBO in a chemistry climate model, Atmos. Chem. Phys., 8, 6505-6525, 2008.   Bibtex   EndNote   Reference Manager