Geophysical Research Abstracts
Vol. 13, EGU2011-2721, 2011
EGU General Assembly 2011

The influences of planetary waves induced by longitude dependent ozone on the variability of the circulation in the boreal stratosphere - model study

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A series of sensitivity studies highlighted the important role of longitude dependent ozone for the general circulation. In previous studies it was shown that the boreal zonal mean stratosphere may be warmed up during wintertime due to higher planetary wave activity and – probably – stronger coupling with the troposphere in relation to an enhanced NAO pattern. The role of longitude dependent ozone on the seasonal evolution of the atmospheric circulation from autumn to winter has not been studied so far but may be important in modifying the planetary wave activity, especially during the transition period of planetary wave amplitude increase from autumn to winter.

In this study the mechanisms of the effect of the longitude dependent ozone on the wintertime general circulation is investigated based on a sensitivity experiment using the GCM MAECHAM5. The control run with the decadal mean of zonally symmetric stratospheric ozone was performed for September to February of the 1990 decade. For the same time period a model experiment was carried out with a prescribed mean longitude dependent ozone distribution but with identical boundary conditions otherwise.

The harmonic decomposition shows that the interplay of the planetary wave one and two mirrors the main part of the westward shift of the polar vortex in the stratosphere induced by the longitude dependent ozone, and that the interaction of the waves up to zonal wave number four defines the tropospheric change pattern. Based on a linear model approach it is shown that the heating rates in the stratopause region related to the longitude dependent ozone force a planetary wave one in the middle atmosphere, where the change in amplitude is in the order of 10% of the mean amplitude. Moreover, the analyses of the zonal asymmetric fields show an increase of the amplitude of planetary waves from October to December in the middle atmosphere. In January a nonlinear tropospheric feedback was identified causing the up- and eastward directed wave train. The analyses of the seasonal evolution of the zonal mean fields makes clear that the longitude dependent ozone increases the amplitude of the stratospheric vacillation cycle, which is characterized by a period of about 60 days, and in agreement with that an oscillation of the divergence of planetary wave fluxes was identified.