Atmos. Chem. Phys. Discuss., 10, C9637–C9639, 2010
www.atmos-chem-phys-discuss.net/10/C9637/2010/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "The role of the QBO in the inter-hemispheric coupling of summer mesospheric temperatures" *by* P. J. Espy et al.

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Received and published: 12 November 2010

GENERAL COMMENT

This paper presents an observed time series of the July-mean temperature in the northern summer mesopause region in correlation with southern winter stratospheric temperatures and equatorial lower stratospheric zonal winds from analyses. The applied statistical methods are sound. The results are conclusive and important for our understanding of the long-term internal variability of the atmosphere. In particular, the authors show 1) the first long-term observational evidence of the interhemispheric coupling in the mesosphere with regard to temperatures and 2) a strong control of the southern winter stratosphere out of the polar vortex during July by the QBO. These results should be published in ACP.

The paper is well organized and in most parts well written. Nevertheless, the authors should improve their recapitulation of the interhemispheric coupling mechanism, which is used to explain the correlation between the summer mesopause and the winter stratosphere. Also application of the Holton mechanism to explain the correlation between the southern winter stratosphere and the QBO should be motivated more rigorously if possible.

SPECIFIC COMMENTS

1) The introduction reviews some knowledge about the interhemispheric coupling. The authors should state explicitly how the coupling shows up: A warmer summer mesopause is linked to a winter stratosphere (weaker zonal wind) and vice versa.

The introduction is confusing concerning some basic arguments of middle atmosphere dynamics that are necessary to explain interhemispheric coupling:

Page 1, 1st paragraph: The generally accepted causality of the global circulation in the extratropics is as follows (see text of Andrews et al., 1986): Momentum deposition (EPF divergence) due to wave breaking drives a residual circulation; then the upwelling and downwelling associated with the residual circulation causes deviations from the radiatively determined state and thus determines the temperature; the zonal wind follows from the temperature via gradient wind balance. In the quasi-stationary TEM picture, waves do not accelerate or decelerate the zonal wind since du/dt=0. Furthermore, only kinetic energy can be dissipated, but not momentum. Momentum is deposited. It is general wisdom among modelers that the GW-induced downwelling in the winter mesosphere strongly contributes to the dynamically induced polar winter stratopause, but not to a warm winter mesopause.

Page 1, 2nd paragraph: The GW momentum deposition is not necessarily directed against the mean flow. Consider for instance the region above the wind reversal in the summer mesopause region. It is correct that the momentum flux passing the upper stratosphere and lower mesosphere is usually against the mean zonal wind. Therefore, according to the dispersion relation of GWs and simple arguments for wave stability and/or filtering, a weaker mean wind in this region - not a stronger wind as written in the paper - will reduce the GW momentum flux that penetates to higher altitudes and vice versa.

The introduction could also mention that explanations for interhemispheric coupling (as proposed by Becker and Fritts (2006, AG) and Karlsson et al. (2009, JASTP)) were confirmed in a simplistic model by K"ornich and Becker (2010, ASR).

2) Planetary waves in southern winter are usually quite weak. Therefore, the Holton-Tan mechanism does hardly work with regard to planetary waves in the southern hemisphere (if we neglect the exceptional year 2002). In late winter, however, synoptic waves can propagate into the radiatively weakened polar vortex and the Holton-Tan mechanism applies. This is the picture drawn by Baldwin and Dunkerton (1998, GRL) and their paper is quoted in the present manuscript. However, the authors claim that the year-to-year variability of the July-mean southern stratospheric is due to the Holton-Tan mechanism acting on planetary waves. How can this view be reconciled with the analysis of Baldwin and Dunkerton?

A possible explanation consistent with Fig. 16 of Baldwin and Dunkerton (1998) is that in July the Holton-Tan mechanism modulates the propagation of synoptic waves - NOT planetary waves as suggested by the authors - into the lower winter stratosphere at middle latitudes. The resulting wind reduction in the stratosphere will then cause the (negative) GW drag to get weaker and shift to lower altitudes, which is the starting point for interhemispheric coupling to occur. Can this explanation be checked by correlating the southern stratosphere July-mean temperatures and zonal winds at different latitudes with the equatorial wind?

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 23403, 2010.