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The relationship between tropospheric wave forcing and tropical lower stratospheric water vapor

S. Dhomse, M. Weber, and J. Burrows
Institute of Environmental Physics, University of Bremen, Bremen, Germany

Abstract. Using water vapor data from HALOE and SAGE II, an anti-correlation between planetary wave driving (here expressed by the mid-latitude eddy heat flux at 50 hPa added from both hemispheres) and tropical lower stratospheric (TLS) water vapor has been obtained. This appears to be a manifestation of the inter-annual variability of the Brewer-Dobson (BD) circulation strength (the driving of which is generally measured in terms of the mid-latitude eddy heat flux), and hence amount of water vapor entering the stratosphere. Some years such as 1991 and 1997 show, however, a clear departure from the anti-correlation which suggests that the water vapor changes in TLS can not be attributed solely to changes in extratropical planetary wave activity (and its effect on the BD circulation). After 2000 a sudden decrease in lower stratospheric water vapor has been reported in earlier studies based upon satellite data from HALOE, SAGE II and POAM III indicating that the lower stratosphere has become drier since then. This is consistent with a sudden rise in the combined mid-latitude eddy heat flux with nearly equal contribution from both hemispheres as shown here and with the increase in tropical upwelling and decrease in cold point temperatures found by Randel et al. (2006). The low water vapor and enhanced planetary wave activity (in turn strength of the BD circulation) has persisted until the end of the satellite data records. From a multi-variate regression analysis applied to 27 years of NCEP and HadAT2 (radiosonde) temperatures (up to 2005) with contributions from solar cycle, stratospheric aerosols and QBO removed, the enhancement wave driving after 2000 is estimated to contribute up to 0.7 K cooling to the overall TLS temperature change during the period 2001–2005 when compared to the period 1996–2000. NCEP cold point temperature show an average decrease of nearly 0.4 K from changes in the wave driving, which is consistent with observed mean TLS water vapor changes of about −0.2 ppm after 2000.

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