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

Atmos. Chem. Phys., 9, 2157-2170, 2009
www.atmos-chem-phys.net/9/2157/2009/

Atmospheric tracers during the 2003–2004 stratospheric warming event and impact of ozone intrusions in the troposphere

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Abstract. We use the stratospheric/tropospheric chemical transport model MOZART-3 to study the distribution and transport of stratospheric O_3 during the remarkable stratospheric sudden warming event observed in January 2004 in the northern polar region. A comparison between observations by the MIPAS instrument on board the ENVISAT spacecraft and model simulations shows that the evolution of the polar vortex and of planetary waves during the warming event plays an important role in controlling the spatial distribution of stratospheric ozone and the downward ozone flux in the lower stratosphere and upper troposphere (UTLS) region. Compared to the situation during the winter of 2002–2003, lower ozone concentrations were transported from the polar region to mid-latitudes, leading to exceptional large areas of low ozone concentrations outside the polar vortex and "low-ozone pockets" in the middle stratosphere. The unusually long-lasting stratospheric westward winds (easterlies) during the 2003–2004 event greatly restricted the upward propagation of planetary waves, causing the weak transport of ozone-rich air originated from low latitudes to the middle polar stratosphere (30 km). The restricted wave activities led to a reduced extratropical downward ozone flux from the lower stratosphere to the lowermost stratosphere (or from the "overworld" into the "middleworld"), especially over East Asia. Consequently, during wintertime (15 December~15 February), the total downward ozone transport on 100 hPa surface by the descending branches of Brewer-Dobson circulation over this region was about 10% lower during the 2003–2004 event. Meanwhile, the extratropical total cross-tropopause ozone flux (CTOF) was also reduced by ~25%. Compared to the cold 1999–2000 winter, the vertical CTOF in high latitudes (60°~90° N) increased more than 10 times during the two warming winters, while the vertical CTOF in mid-latitudes (30°~60° N) decreased by 20~40%. Moreover, during the two warming winters, the meridional CTOF caused by the isentropic transport associating with the enhanced wave activity also increased and played an important role in the total extratropical CTOF budget.

Final Revised Paper (PDF, 1935 KB) Discussion Paper (ACPD)

Citation: Liu, Y., Liu, C. X., Wang, H. P., Tie, X. X., Gao, S. T., Kinnison, D., and Brasseur, G.: Atmospheric tracers during the 2003–2004 stratospheric warming event and impact of ozone intrusions in the troposphere, Atmos. Chem. Phys., 9, 2157-2170, 2009. Bibtex EndNote Reference Manager