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# Behavior of Atmospheric Tracers during the 2003-04 SSW and Change of Ozone Flux in the UT/LS

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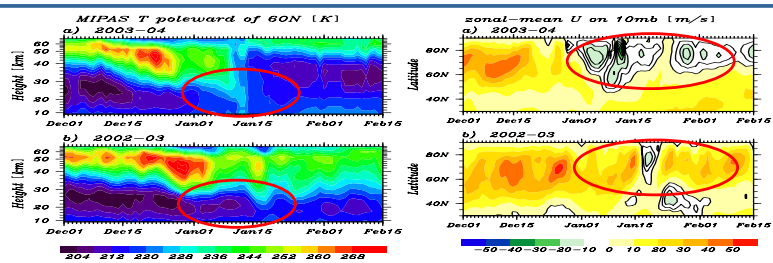
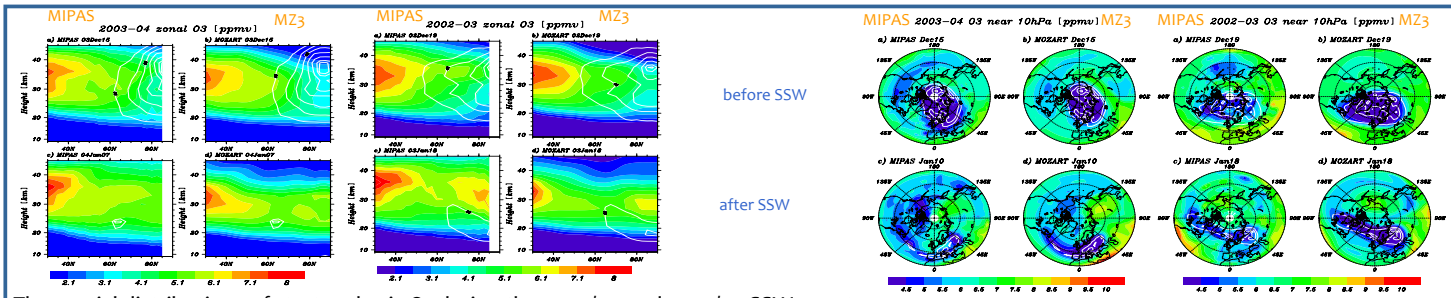
## Abstract
We use the stratospheric/tropospheric chemical transport model MOZART-3 to study the distribution and transport of stratospheric O3 during an exceptionally intense SSW event in 2003-04 boreal winter and another major SSW event in January 2003. Comparisons between MIPAS observations and simulations show that both SSW events caused the weakening and distortion of the polar vortex, and that the evolutions of the polar vortex and of planetary waves during the warming events played important roles in controlling the spatial distribution of stratospheric ozone and the downward ozone flux in the UTLS regions. Compared to the 2002-03 SSW event, 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 during the 2003-04 event greatly restricted the upward propagation of planetary waves, which might be responsible for the rapid recovery of high-level polar vortex and the weak poleward transport of ozone-rich air to the polar stratosphere (10 hPa). The restricted wave activities also led to a reduced downward ozone flux from lower stratosphere (LS) to upper troposphere (UT), especially in East Asia. Consequently, in this region during wintertime, the column ozone between 100 and 300 hPa was about 10% lower during the 2003-2004 event compared to the situation in 2002-2003.
**available from :** http://www.atmos-chem-phys-discuss.net/8/13633/2008/acpd-8-13633-2008.html

**MOZART-3** Model for Ozone And Related chemical Tracers ,version 3 [*Kinnison* et al., 2007] accounts for physical and chemical processes from the Earth's surface to the lower thermosphere, including vertical mixing associated with gravity wave breaking in the upper stratosphere and mesosphere, molecular diffusion of constituents above 80 km, photochemical reactions, stratospheric heterogeneous processes and auroral contribution to the chemical budget. In this study, the MOZART-3 is driven with operational ECMWF analysis.

**MIPAS** Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) on board the ENVISAT provides a global coverage with nearly 14 orbits per day at a horizontal resolution of ~ 500 km . In this study, the MIPAS Level 2 consolidated O3, N2O and temperature profiles in 2003/04 and 2002/03 boreal winter are used and re-gridded onto 73x72 (about 2.5 x 5 degree) horizontal grid meshes.

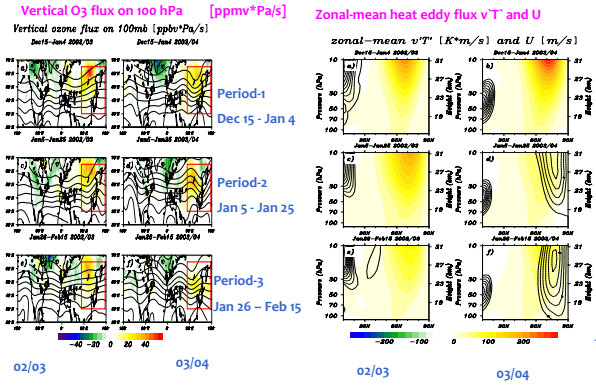



The boreal winter has witnessed a remarkable major stratospheric warming in January, 2004 [*Manney* et al., 2005]. This event was characterized by an extraordinarily long vortex disruption in the lower and middle stratosphere, with a strong and rapid recovery of the vortex in the upper stratosphere. The evolution of temperature and zonal-mean wind in polar region is compared with 2002-03 case.




The spatial distributions of stratospheric $O_3$ during the 2003/04 and 2002/03 SSW events, with the white solid lines corresponding to polar vortex edge. Influenced by the SSW event, the polar vortex and low O3 concentrations inside it are greatly disturbed by the planetary waves. After the polar vortex is shifted off the north pole, tongues with high O3 concentration extend into the polar regions.
Compared to 2002-03 case, the polar vortex is much more disturbed d by the enhanced planetary waves. However, the poleward transport of tropical O3 is more prominent in 2002-03 case.

## Impacts of SSW on the UT/LS ozone flux over East Asia




East-Asia area-averaged (30°-65°N,80°-180°E) 100 hPa eddy heat flux [K*m/s] and UT/LS (100 – 300 hPa) column $O_3$ increment [DU] for different periods.

| | $[\overline{vT}]_{former}$ | $[\overline{vT}]_{latter}$ |
|---|---|---|
| 2002-03 | 16 | 24 |
| 2003-04 | 27 | 22 |

1st column for Period-1
2nd column for Period-2,3

| | $\Delta[O_3]_{former}$ | $\Delta[O_3]_{latter}$ |
|---|---|---|
| 2002-03 | 5 | 3 |
| 2003-04 | 15 | 3 |

1st column: increase from Period-1 to Period-0
2nd column: increase form Period-1 to Period-2,3

The vertical ozone flux on 100 hPa during 3 periods are derived from MOZART-3. In both cases, the major downward $O_3$ flux are located over East Asia. The downward $O_3$ flux in 2003/04 event is weaker and more southward, the latter of which may be associated with the southward shift of the East Asia trough. The zonal mean eddy heat flux v'T' is used as a proxy to represent the intensity of B-D circulation. The BDC in 2003/04 winter undergoes an abrupt decline during Period-2 and 3, which is dynamically related to the emergence and persistence of easterly winds at high latitudes.

**References**
*Kinnison* et al. (2007), Sensitivity of chemical tracers to meteorological parameters in the MOZART-3 chemical transport model, *J. Geophys. Res.*, 112, D20302, doi:10.1029/2006JD007879
*Manney* et al. (2005), The remarkable 2003–2004 winter and other recent warm winters in the Arctic stratosphere since the late 1990s, *J. Geophys. Res.*, 110, D04107,doi:10.1029/2004JD005367

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