Transport and Chemistry in the 2002 Antarctic Ozone Hole

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Motivation

Observations show that the 2002 Antarctic ozone hole was not only smaller than usual but also split into two on September 26 - an unprecedented event in the Southern Hemisphere in recent decades (**Fig 1**). This is a unique situation under which to study the chemistry and transport of the SH lower stratosphere. Here we investigate how the SLIMCAT 3D chemical transport model (*Chipperfield*, 1999) performs in capturing this event and diagnose the model O_3 budget**.** We also compare 2002 with the more typical 1999 hole.

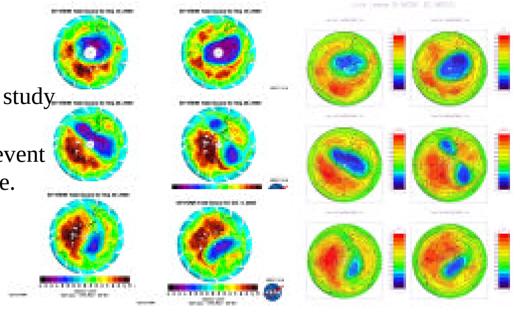

Fig 1. Comparison of total column O_3 (DU) between TOMS observations (left) and SLIMCAT model (right).

2. Description of 3D CTM runs

- Forced by ECMWF analyses (T42L60);
- Detailed Stratospheric photochemical scheme.

Result 1: Total Column Ozone

SLIMCAT successfully reproduces the observed overall O_3 evolution and some detailed features, i.e. elongated vortex on 22/09 and two separate holes on 26/09 (**Fig1**) - due to the abnormal vortex meteorology compared with 1999 (**Fig 2**). The SH ECMWF analyses seem to capture the 2002 vortex evolution well.

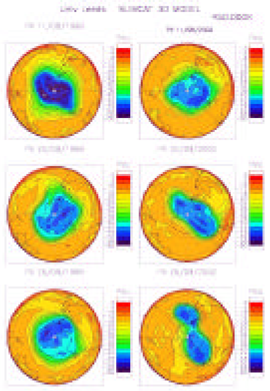

Fig 2. Different polar vortex evolution in 1999 and 2002.

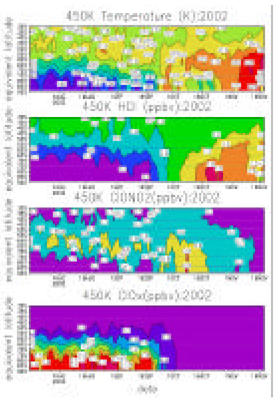

Fig 3. Model time series at 450K (~18 km) of T, HCl, $ClONO_2$ and ClO_x in 2002.

Result 2: Polar Processing

Polar temperatures below 195K before 20 September (**Fig 3**) allow PSCs to transform chlorine from reservoir forms HCl and $ClONO_2$ to O_3-destroying active forms such as ClO. Wintertime heterogeneous processing causes complete removal of HCl poleward of about 65°S, but this recovers after September 20. The $ClONO_2$ is also depleted in the polar region and surrounded by the "collar" region. This depletion of HCl and $ClONO_2$ in the Antarctic leads to ClO_x levels of up to 2.1 ppbv at 450K.

Result 3: Diagnostic of Transport and Mixing

The equivalent length (EL) (*Haynes and Shuckburgh*, 2000) was calculated from modelled N_2O. The time evolution of the log-normalized EL as a function of equivalent latitude (**Fig 4**) show a broad region of weak mixing on 475K between equivalent latitude of 54°S and 78°S separating regions of comparatively strong mixing in the middle latitudes and the vortex core. The region starts to narrow with time after September. Note, the vortex region almost breaks up on 24/09/2002 (**Figs 4 and 5**). Below 400K, the air is well mixed in the high latitudes.

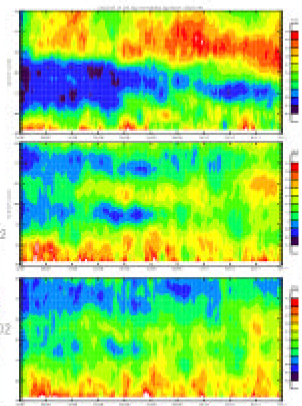

Fig 4. Time evolution of EL in the lower stratosphere

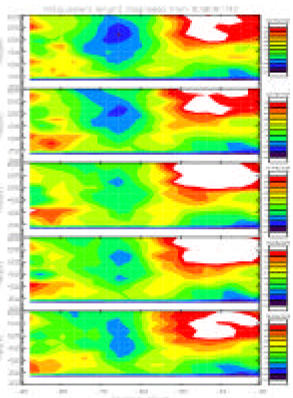

Fig 5: Log-normalized equivalent length distribution

Result 4: Diagnostic of Ozone Budget

There is smaller modelled total O_3 depletion in 2002 compared with 1999, but the disturbed vortex leads to some faster chemical loss *rates* in September (**Fig 6**). Ozone loss by reactions with ClO_x, BrO_x dominate at polar latitudes at 450K in both winters (**Fig 7**), but HO_x reactions also play important role in the mid-high latitude O_3 loss.

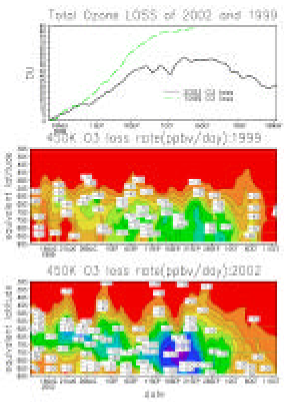

Fig 6. Total O_3 loss and loss rate in 2002 & 1999.

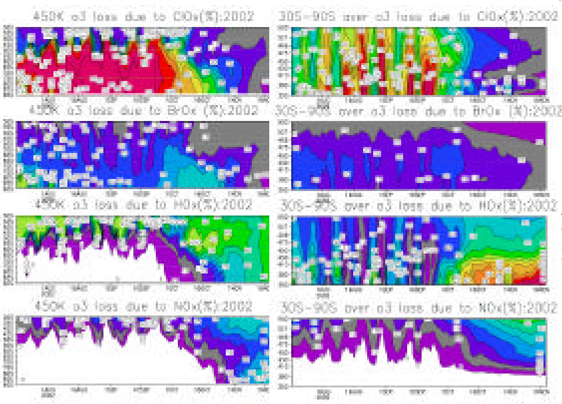

Fig 7. Contribution (%) of catalytic cycles to 450 K (left) and south of 30°S averaged (right) total loss rate.

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References:

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Haynes, P.H., E. F. Shuckburgh, *JGR*, 22,777-22,810, 2000.