Hemispheric differences in the return of midlatitude stratospheric ozone to historical levels

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Why we did this study
• Chemistry-climate models (CCM) project earlier return of NH mid-latitude total column ozone (TOZ) to 1980 values compared to the southern mid-latitudes.
• The 2010 ozone assessment said: “This modelling experiment suggests that the most rapid return to 1980 values in northern mid-latitudes is linked to a more pronounced strengthening of the polarward transport of ozone due to the effects of increased GHG levels, and effects of Antarctic ozone depletion on southern mid-latitudes.”
• We assess the robustness of the return date differences across models and methods for their estimation and assess the relative role of transport and chemistry changes.

How we did it
• We use: 1. an ensemble of 12 CCMs from CCMVal2 e the CCM, NIWA-Socol and E39CA that are equipped with diagnostics to separate effects of chemistry and transport. 3. different methods of smoothing the time series to estimate the return dates.

What we find
• Earlier return of TOZ to 1980 values in the NH is a robust result across models and methods, but the return date differences range from 0 to 30 years (Fig. 1).
• Return date differences stem from stronger positive ozone trends in the NH than SH in the LMSMR (tropopause-100hPa) and the LSTR (100-10hPa) (Fig. 1+2).
• Spread of hemispheric differences in return dates between models can only in small parts be explained by spread in asymmetric BDC trends (Fig. 3).
• The drivers of asymmetric ozone trends are: 1. transport differences, present around 100 hPa (Figs. 6+7). 2. production differences (asymmetric NOx destruction changes cause a strong positive trend in the SH but a negative trend in the NH (Fig. 6). Nonetheless, enhanced destruction efficiency in the SH due to heterogeneous ozone depletion (Fig. 10) north of 60°S caused by temperature changes (Fig. 11).

MULTI-MODEL ANALYSIS

Return date differences 45-60°S - 45-60°N from 12 models (crosses) and the mean (triangles) for their estimation and assess the relative role of transport and chemistry changes.

ATTIBUTION TO CHEMICAL AND DYNAMICAL DRIVERS

Lowermost Stratosphere (Tropopause to 100 hPa; LMSMR)
• use E39CA (in NIWA-Socol only stratospheric reaction rates are saved)

Growth in SH Cly loss efficiency

Increase in SH Cly loss efficiency

Linear Trends in NOx (1960 to 2049)

Growth in CH4 loss efficiency

Strong increase in CH4 loss efficiency

PRODUCTIVITY CHANGES IN NOx AND Cly LOSS CYCLES

Temperature trends (1960-2049) at 70 hPa in July: decrease in temperature north of 60°S causes for heterogeneous chemistry and thus enhanced ozone loss.