Geophysical Research Abstracts
Vol. 20, EGU2018-10229, 2018
EGU General Assembly 2018

Estimating Stratospheric Ozone Return Dates from Chemistry-Climate Modelling Initiative (CCMI) Simulations

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Following a period of depletion due to the effects of chlorine and bromine, the stratospheric ozone layer is starting to recover. Stratospheric ozone levels are expected to return to their 'pre-depletion' values later this century. However, the timing of this return will vary with location and will depend on many other factors, notably climate change. Quantification of ozone return dates depends on predictions using coupled chemistry-climate models (CCMs). We present an analysis of such simulations performed under the framework of the Chemistry-Climate Modelling Initiative (CCMI) in support of the WMO/UNEP 2018 Ozone Assessment.

We analyse a total of 154 CCMI simulations from 20 models, including a range of sensitivity studies which examine the impact of climate change on ozone recovery. For the control simulations there is a large spread in the predictions of the absolute ozone column which requires a bias correction to obtain a useful quantification of uncertainty in return dates. The CCMI models project that global total column ozone will return to 1980 values in 2047 (with a 1-σ uncertainty of 2026-2059). At mid-latitudes, Southern Hemisphere is projected to return to 1980 values in 2046 (2037-2053), and Northern Hemisphere ozone in 2034 (2011-2048). In the polar regions, the return dates are 2061 (2051-2069) in the Antarctic in October and 2033 (2011-2051) in the Arctic in March. The earlier return dates in the NH reflect the smaller depletion and larger dynamical variability. In the tropics only around half the models predict a return to 1980 values, at around 2040, while the other half do not show a return to 1980 values. All models show a negative trend in tropical total column ozone towards the end of the 21st century.

The CCMI models generally agree in their simulation of the time evolution of stratospheric inorganic chlorine (Cly), which is the main driver of ozone loss and recovery, although there is considerable inter-model variability. Throughout the stratosphere the spread of ozone return dates to 1980 values between models tends to correlate with the spread of the return of Cly to 1980 values. In the upper stratosphere, greenhouse gas-induced cooling speeds up the return by about 10-20 years. In the lower stratosphere, and for the column, there is a more direct link in the timing of the return dates, especially for the large Antarctic depletion. Comparisons of column ozone between the models is affected by different predictions of the evolution of tropospheric ozone within the same scenario, presumably due to differing treatment of tropospheric chemistry. Therefore, clear conclusions can only be drawn for stratospheric ozone columns.

Lessons learned on how to perform multi-model intercomparisons to quantify ozone recovery will also be discussed.