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Comparison of observed lower stratospheric ozone changes with free-running chemistry climate models

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The ozone layer was damaged last century due to the emissions of long-lived ozone depleting substances (ODSs). Following the Montreal Protocol that banned ODSs, a reduction in total column ozone (TCO) ceased in the late 1990s. Today, ozone above 32 km displays a clear recovery. Nevertheless, a clear detection of TCO recovery in observations remains elusive, and there is mounting evidence of decreasing ozone in the lower stratosphere (below 24 km) in the tropics out to the mid-latitudes (30-60°). Chemistry climate models (CCMs) predict that lower stratospheric ozone will decrease in the tropics by 2100, but not at mid-latitudes.

Here, we compare the CCMVal-2 models, which informed the WMO 2014 ozone assessment and show similar tendencies to more recent CCMI data, with observations over 1998-2016. We find that over this period, modelled ozone declines in the tropics are similar to those seen in observations and are likely driven by increased tropical upwelling. Conversely, CCMs generally show ozone increases in the mid-latitude lower stratosphere where observations show a negative tendency. We provide evidence from JRA-55 and ERA-Interim reanalyses indicating that mid-latitude trends are due to enhanced mixing between the tropics and extratropics, in agreement with other studies.

Additional analysis of temperature and water vapour further supports our findings. Overall, our results suggest that expected changes in large scale circulation from increasing greenhouse gases may now already be underway. While model projections suggest extra-tropical ozone should recover by 2100, our study raises questions about their ability to simulate lower stratospheric changes in this region.