QOS2016-241, 2016
Quadrennial Ozone Symposium of the International Ozone Commission

Future Arctic ozone recovery: the importance of chemistry and dynamics

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Future trends in Arctic springtime total column ozone, and its chemical and dynamical drivers, are assessed using a 7 member ensemble from the Met Office Unified Model with United Kingdom Chemistry and Aerosols (UM-UKCA) simulating the period 1960-2100. The Arctic mean March total column ozone increases throughout the 21st century at a rate of ∼11.5 DU/decade, and is projected to return to the 1980 level in the late 2030s. However, the integrations show that even past 2060 springtime Arctic ozone can episodically drop by ∼50-100 DU below the long-term mean to near present day values. Consistent with the global decline in inorganic chlorine over the century, the estimated mean halogen induced chemical ozone loss in the Arctic lower atmosphere in spring decreases by around a factor of two between 1981-2000 and 2061-2080. However, in the presence of a cold and strong polar vortex elevated halogen losses well above the long-term mean continue to occur in the simulations into the second part of the century. The ensemble shows a radiatively-driven cooling trend modelled in the Arctic winter mid- and upper stratosphere, but there is less consistency across the seven ensemble members in the lower stratosphere (100-50 hPa). This is partly due to an increase in downwelling over the Arctic polar cap in winter, which increases transport of ozone into the polar region as well as drives adiabatic warming that partly offsets the radiatively-driven stratospheric cooling. However, individual years characterised by significantly suppressed downwelling, reduced transport and low temperatures continue into the future. We conclude that despite the future long-term recovery of Arctic ozone, the large interannual dynamical variability is expected to continue thereby facilitating episodic reductions in springtime ozone columns. Whilst our results suggest that the relative role of dynamical processes for determining Arctic springtime ozone will increase in the future, halogen chemistry will remain a smaller but non-negligible contributor for many decades.

References: Bednarz, E. M., Maycock, A. C., Abraham, N. L., Braesicke, P., Dessens, O., and Pyle, J. A.: Future Arctic ozone recovery: the importance of chemistry and dynamics, Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2015-998, in review, 2016.