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The Impact of Polar Stratospheric Ozone Loss on Southern Hemisphere Climate and Stratosheric Circulation – A Chemistry Climate Model Study

James Keeble (1), Peter Braesicke (1,2), Howard Roscoe (3), John Pyle (1,2)

(1) Centre for Atmospheric Science, University of Cambridge, UK, (2) National Centre for Atmospheric Science, University of Cambridge, UK, (3) British Antarctic Survey, Cambridge, UK

It is now well established that the large spring time stratospheric ozone loss which occurs in the Southern Hemisphere is the result of the liberation of chlorine from the reservoir species HCl and $ClONO_2$ through heterogeneous reactions occurring on Polar Stratospheric Cloud (PSC) particles. Here we investigate the impact this ozone loss has on Southern Hemisphere climate and the Brewer Dobson Circulation (BDC) using a fully coupled chemistry climate model, UM-UKCA. Two, 20 year time slice integrations were run, the first a reference year 2000 integration, and the second an identical integration in which heterogeneous chemistry on PSCs is suppressed. In the model, chlorine activation through reactions occurring on PSC particles results in a 70% decrease of vortex averaged ozone from October to November at 20km. This ozone loss leads to a large cooling of the lower stratosphere from mid September to late February, with a maximum cooling of 12K from November to December. Associated with the cooling is a decrease in geopotential height of greater than 500m over the polar cap, and a strengthening and poleward shift of the polar jet. The temperature, geopotential height and zonal wind changes are significant at the 95% confidence level, and all three propagate down to the surface in December. The surface temperature response is highly asymmetric; while much of the polar cap cools by more than 1K, the Antarctic Peninsula warms by approximately 0.5K.

The change in the strength and position of the polar jet alters the propagation and breaking of planetary and gravity waves. This results in changes to the BDC, particularly increased downwelling over the polar cap during Southern Hemisphere spring and summer, measured using changes to the residual mean vertical velocity. Increased downwelling causes the middle and upper polar stratosphere to warm due to dynamical heating and increases ozone concentrations between 25 and 30km in DJF. Changes in the amplitude and phase of planetary waves are analyzed to determine the change to the climatological mean state of the vortex. The changes in stratospheric circulation result in significant changes to ozone distribution beyond the spring time vortex, reducing equatorial total column ozone by 10-20 DU, as well as leading to significant changes in the distribution of long lived tracers.