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Attribution of upper stratospheric ozone changes from 1984 to 2014 using the Whole Atmosphere Community Climate Model

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In the next century decreased stratospheric halogen abundance is expected to trigger stratospheric ozone recovery. However, there exist other anthropogenic and natural forcings that affect stratospheric ozone concentrations. For instance, greenhouse gases (GHG) emissions may indirectly drive changes in stratospheric ozone in the same direction as mitigation of ozone depleting substances (ODS). Ozone increases alone, therefore, do not demonstrate recovery from halogen-induced destruction. The upper stratosphere is an ideal region to study attribution of ozone changes because ozone abundances there are chemically controlled by gas-phase reactions alone. {I deleted this because it's a strong claim and I'm not really sure we could prove it. . . there are quite a lot of questions about the robustness of the satellite data and in some cases I'm more convinced by the sondes – anyway, it's not your focus so let's leave it out} In this study we use historical ensemble simulations from the Whole Atmosphere Community Climate Model (WACCM) in a fingerprint-based approach to study the attribution of ozone changes. We perform simulations with i) all anthropogenic forcings active, ii) GHG single forcing, and iii) ODS single forcing. From these simulations we identify both the combined and single forcings's spatial and temporal patterns of change in latitude and height, and determine if the space-time response (fingerprint) is present in observations. We also determine if the signal is above that of climate variability, which is estimated from a pre-industrial control run. We use the { I am not sure if it is a NOAA dataset but it is definitely not a NASA dataset} Stratospheric Water and OzOne Satellite Homogenized (SWOOSH) data set for a combined record of ozone observations. Only a few attribution studies have been previously performed for ozone. We expand on past work by comparing attribution through signal detection commonly accomplished by linear regression to that of regression to the equivalent effective stratospheric chlorine curve (EESC). Results show that we can confidently attribute observed ozone changes in the upper stratosphere throughout the period from 1984 to 2014 to ODS forcing changes, including both the period of growth of ozone loss and the subsequent recovery, with no significant signal detected in the GHG only forcing. The use of EESC provides a novel tool to better detect anthropogenic forcings in observations, which has not been previously accomplished with with ozone and allows separate attribution of GHG and ODS effects.