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On the attribution of stratospheric ozone and temperature changes to changes in ozone-depleting substances and well-mixed greenhouse gases

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Abstract. The vertical profile of global-mean stratospheric temperature changes has traditionally represented an important diagnostic for the attribution of the cooling effects of stratospheric ozone depletion and CO_2 increases. However, CO_2-induced cooling alters ozone abundance by perturbing ozone chemistry, thereby coupling the stratospheric ozone and temperature responses to changes in CO_2 and ozone-depleting substances (ODSs). Here we untangle the ozone-temperature coupling and show that the attribution of global-mean stratospheric temperature changes to CO_2 and ODS changes (which are the true anthropogenic forcing agents) can be quite different from the traditional attribution to CO_2 and ozone changes. The significance of these effects is quantified empirically using simulations from a three-dimensional chemistry-climate model. The results confirm the essential validity of the traditional approach in attributing changes during the past period of rapid ODS increases, although we find that about 10% of the upper stratospheric ozone decrease from ODS increases over the period 1975–1995 was offset by the increase in CO_2, and the CO_2-induced cooling in the upper stratosphere has been somewhat overestimated. When considering ozone recovery, however, the ozone-temperature coupling is a first-order effect; fully 2/5 of the upper stratospheric ozone increase projected to occur from 2010–2040 is attributable to CO_2 increases. Thus, it has now become necessary to base attribution of global-mean stratospheric temperature changes on CO_2 and ODS changes rather than on CO_2 and ozone changes.

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