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The effect of nonlinearity in CO_2 heating rates on the attribution of stratospheric ozone and temperature changes

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Abstract. An analysis of the attribution of past and future changes in stratospheric ozone and temperature to anthropogenic forcings is presented. The analysis is an extension of the study of Shepherd and Jonsson (2008) who analyzed chemistry-climate simulations from the Canadian Middle Atmosphere Model (CMAM) and attributed both past and future changes to changes in the external forcings, i.e. the abundances of ozone-depleting substances (ODS) and well-mixed greenhouse gases. The current study is based on a new CMAM dataset and includes two important changes. First, we account for the nonlinear radiative response to changes in CO_2. It is shown that over centennial time scales the radiative response in the upper stratosphere to CO_2 changes is significantly nonlinear and that failure to account for this effect leads to a significant error in the attribution. To our knowledge this nonlinearity has not been considered before in attribution analysis, including multiple linear regression studies. For the regression analysis presented here the nonlinearity was taken into account by using CO_2 heating rate, rather than CO_2 abundance, as the explanatory variable. This approach yields considerable corrections to the results of the previous study and can be recommended to other researchers. Second, an error in the way the CO_2 forcing changes are implemented in the CMAM was corrected, which significantly affects the results for the recent past. As the radiation scheme, based on Fomichev et al. (1998), is used in several other models we provide some description of the problem and how it was fixed.

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