Are stratospheric ozone chemistry feedbacks critical for the determination of climate sensitivity?

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The Community Earth System Model (CESM1-WACCM) is used to assess the importance of including chemistry feedbacks in determining the equilibrium climate sensitivity (ECS). Two 4xCO_2 model experiments were conducted; one with interactive chemistry and one with chemical constituents other than CO_2 held fixed at their pre-industrial values. The ECS determined from these two experiments agrees to within 0.01 K. Similarly, the net feedback agrees to within 0.01 $Wm^{-2}K^{-1}$. This agreement occurs in spite of large changes in stratospheric ozone found in the simulation with interactive chemistry: a 30% decrease in the tropical lower stratosphere, and a 40% increase in the upper stratosphere, consistent with other published estimates. Off-line radiative transfer calculations show that ozone changes alone account for the difference in radiative forcing. We conclude that, at least for determining global climate sensitivity metrics, the exclusion of chemistry feedbacks is not a critical source of error in CESM.

In comparison to studies of the chemistry feedback effects in other ESMs, the CESM chemistry feedback is significantly lower than previously reported (up to a 20% reduction in ECS). While the changes in ozone from the abrupt increase in ozone appear to be consistent across the various models, the subsequent RF and water vapor changes and its forcing can be radically different. Understanding why these models respond so differently to ozone changes will be critical in the evaluation of model spread in simulations used to estimate the response of our climate to increasing greenhouse gases. In particular, the differences will need to be considered when interpreting the results of the proposed DECK (Diagnostic, Evaluation and Characterization of Klima) experiments conducted as part of the next CMIP that include both 1% y^{-1} until doubling and abrupt 4xCO_2 increase simulations.

Key words: climate sensitivity, feedbacks, ozone, WACCM