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Investigating the uncertainty of simulated climate engineering

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Many climate engineering studies are based on the results of Earth system model simulations. However, these models are simplistic representations of reality and contain many poorly constrained parameterizations and further limitations imposed by model resolution. In addition, the data used to force the models, especially for future scenarios, is often idealized. The results of all Earth system model runs, thus, contain some degree of uncertainty even if they compare well with observations. Several approaches are commonly used to better understand model results and reduce their uncertainty. In this study we performed a parameterization sensitivity analysis to better understand idealized afforestation, artificial ocean alkalinization, and solar radiation management climate engineering during a high CO_2 emission scenario (RCP 8.5) simulation with the University of Victoria Earth system climate model, a model of intermediate complexity. The parameterizations that are individually analyzed include: biological terrestrial and marine responses to changes in temperature, CO_2 air-sea gas exchange, marine stoichiometric and terrestrial vegetation response to changes in atmospheric CO_2, oceanic vertical mixing, the response of winds to climatic change, and the absorption of short wave radiation in the atmosphere by water vapor, dust, ozone, clouds, etc.. In addition, we analyzed the effect of some of the forcing associated with the RCP 8.5 scenario by individually turning off the land use, sulphate aerosol, and non-CO_2 greenhouse gas forcing. The results of these analyzes provide a better understanding of the minimum and maximum potential of these idealized climate engineering methods. They also show that even when this range of possible effectiveness is taken into account, the methods are still, individually, either relatively ineffective and/or have potentially severe side effects.