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How uncertainty in aerosol forcing and transient climate response affects uncertainty of the 1.5-degree carbon budget?

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In Paris, nations agreed to limit the increase in global mean surface temperature relative to the preindustrial era below 2 degrees Celsius and pursue efforts to a more ambitious goal of 1.5 degrees Celsius. To achieve these goals, it is necessary to estimate the amount of cumulative carbon emissions compatible with these temperature targets, i.e. so called carbon budgets. Many previous estimates of carbon budgets are based on arbitrary assumptions on the strength of aerosol forcing. However, there is a considerably uncertainty in present-day and future aerosol forcing, and this uncertainty creates previously unquantified uncertainty in carbon budgets.

In this work, we use the intermediate complexity University of Victoria Earth System Climate Model (UVic ESCM) to assess how uncertainty in aerosol forcing and transient climate response transfers to uncertainty in the carbon budget for keeping the global mean temperature increase below 1.5 degrees. We create a perturbed parameter ensemble of model simulations by scaling aerosol forcing and transient climate response, and assess the likelihood of each simulation by comparing the simulated historical cumulative carbon emissions to observations.

By weighting the results of each simulation with the likelihood of the simulation, the preliminary results give a carbon budget of 178 Pg C to reach 1.5 degree Celsius temperature increase. The small weighted mean is due to large fraction of simulations with strong aerosol forcing and transient climate response giving negative carbon budgets for this time period. The carbon budgets after temperature stabilization at 1.5 degrees are even smaller with a weighted mean of -42 Pg C until the year 2200. The main reason for the negative carbon budgets after temperature stabilization is an assumed strong decrease in aerosol forcing in the 21st century. Conversely, simulations with weak aerosol forcing and transient climate response give positive carbon budgets after temperature stabilization. Our results highlight both the importance of reducing uncertainty in aerosol forcing and transient climate response, and of taking the non-CO_2 forcers into account when estimating carbon budgets.