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The importance of present-day aerosol forcing for estimates of the 1.5-degree carbon budget

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In the Paris Agreement, 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. Carbon budgets (i.e. the amount of carbon that is emitted consistent with a given temperature target) are strongly influenced by the forcing of anthropogenic aerosols. Previous estimates of carbon budgets, for example in the IPCC Special Report on the 1.5-degree target (SR15), are calculated with aerosol forcing scenarios that do not take into account whole range of present-day aerosol forcing uncertainty.

In this work, we used an intermediate complexity Earth System Model (UVic ESCM) to assess how uncertainty in present-day aerosol forcing and in the transient climate response transfers to estimates of the 1.5 carbon budget. To do so, we created a perturbed parameter ensemble of model simulations scaling present-day aerosol forcing and the transient climate response, and assessed the likelihood of each simulation by comparing the simulated historical carbon budget to observational estimates.

Considering the uncertainty range of present-day aerosol forcing from the IPCC AR5, our estimate for the 1.5-degree carbon budget since 1870 was 740 (465 –1043) Pg C (with a 95% credibility interval). Given that by 2017, we have already emitted about 615 Pg C, our results indicate a real chance of the remaining 1.5 carbon budget being negative. Using a narrower estimate for aerosol forcing uncertainty based on more recent work, the estimate for the 1.5-degree carbon budget increased slightly to 770 (635 – 973) Pg C, the uncertainty range accordingly becoming narrower. Aerosol forcings in the SR15 database are stronger in the 21st century than what most global aerosol-climate models predict. When using these forcings in a sensitivity experiment, we found that this lead to clearly higher future carbon budgets than with the baseline aerosol forcing used in our study. This means, that the carbon budgets presented in SR15 scenarios are potentially biased high due to strong aerosol forcing late in the 21st century.

Furthermore, we found that keeping a stable global mean temperature after reaching 1.5 degrees C above the preindustrial level requires negative emissions in our simulations, in order to counter the effect of decreasing aerosol forcing. Our results highlight the importance of quantifying and reducing uncertainty in aerosol forcing and transient climate response to get accurate and reliable estimates for carbon budgets.