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Carbon-climate sensitivity: A well-constrained metric of the climate response to carbon emissions

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Climate sensitivity and transient climate response characterise climate feedbacks on the response to equilibrium and transient changes in radiative forcing, but do not relate directly to emissions of carbon dioxide, and do not account for carbon cycle feedbacks. Previous experiments with climate-carbon models have shown that the time-integrated radiative forcing per unit CO_2 emission is approximately independent of the background CO_2 concentration, due to reduced effectiveness of carbon sinks at higher CO_2 concentration cancelling the logarithmic dependence of radiative forcing on CO_2 concentration; that the allowable cumulative emissions for climate stabilisation are independent of the emissions pathway; and that global mean temperature remains approximately constant on multi-centennial timescales in simulations in which CO_2 emissions cease completely. Here we generalise these results to show that Carbon Climate Sensitivity (CCS), defined as the ratio of temperature change to cumulative emissions, is approximately independent of both the atmospheric concentration of CO_2 and its rate of change, and is well-constrained by observations to be in the range 1.0 – 2.0 K/EgC, consistent with estimates based on climate-carbon models of 1.0 – 2.1 K/EgC. CCS therefore aggregates information about climate feedbacks and carbon cycle feedbacks, and represents a simple yet robust metric for comparing models. CCS may also have more general applications in the fields of climate change mitigation and policy, since it allows CO_2-induced global mean temperature change to be inferred directly from emissions.