Impact of cumulative emissions of carbon dioxide: the trillionth tonne

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The eventual equilibrium global mean temperature associated with a given stabilization level of atmospheric greenhouse gas concentrations remains uncertain, complicating the setting of stabilization targets to avoid potentially dangerous levels of global warming. Similar problems apply to the carbon cycle: observations currently provide only a weak constraint on the response to future emissions. These present fundamental challenges for the statistical community, since the non-linear relationship between quantities we can observe and the response to a stabilization scenario makes estimates of the risks associated with any stabilization target acutely sensitive to the details of the analysis, prior selection etc. Here we use ensemble simulations of simple climate-carbon-cycle models constrained by observations and projections from more comprehensive models to simulate the temperature response to a broad range of carbon dioxide emission pathways. We find that the peak warming caused by a given cumulative carbon dioxide emission is better constrained than the warming response to a stabilization scenario and hence less sensitive to underdetermined aspects of the analysis. Furthermore, the relationship between cumulative emissions and peak warming is remarkably insensitive to the emission pathway (timing of emissions or peak emission rate). Hence policy targets based on limiting cumulative emissions of carbon dioxide are likely to be more robust to scientific uncertainty than emission-rate or concentration targets. Total anthropogenic emissions of one trillion tonnes of carbon (3.67 trillion tonnes of CO₂), about half of which has already been emitted since industrialization began, results in a most likely peak carbon-dioxide induced warming of 2°C above pre-industrial temperatures, with a 5–95% confidence interval of 1.3–3.9°C.