Abstract

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Can Global Temperature Rise be Limited to 2 Degrees?
What do we need to know and how well do we need to know it?

Stephen E. Schwartz
Brookhaven National Laboratory
Upton NY 11973
ses@bnl.gov

The key question facing the policymaking community charged with developing approaches to limit climate change is how much emissions have to be reduced to achieve a target outcome, for example, for the increase in global mean surface temperature above preindustrial ΔT not to exceed 2 K. The job of the science community is not to advise what should be done, but to provide answers to "what if" questions. Armed with answers to those questions the policymaking community (in principle representatives of the peoples of the world) would make decisions that would take into account not just questions of climate but questions such as meeting the world's energy needs and feeding the people of the planet. From the climate perspective the key "what if" questions are:

1) What would the world look like if ΔT were 2 K? 3 K? 4K? (Present ΔT = 0.8 K)?
2) What mixing ratio of equivalent CO_2 (ECO_2; forcings by other greenhouse gases expressed in CO_2 equivalents) would be required to achieve a given ΔT?
3) What would be the maximum amount of future emissions consistent with achieving such a value of ECO_2?

At present the answers to all these questions are all uncertain, but that should not let the scientists off the hook. It is still the responsibility of the scientists to provide answers to these questions along with uncertainty estimates, perhaps framing the uncertainties as a cone of uncertainty, borrowing from the hurricane forecasters.

With respect to limiting ΔT to 2 K (or any other value) then questions 2 and 3 still come into play. Question 3 is fairly easy if you know the answer to question 2; the fraction of emitted CO_2 that remains in the atmosphere against draw down by oceans and the terrestrial biosphere is about half. The real question is the "allowable" increment in forcing consistent with a given ΔT. To first order this depends on climate sensitivity, the increase in GMST that would result from a sustained doubling of CO_2, and that sensitivity is uncertain to a factor of 3 (best estimate 3 K; uncertainty range 1.5 – 4.5 K). Reasonable back-of-the-envelope calculations indicate that if other forcings were to remain constant, future allowable ECO_2 emissions corresponding to these three values of climate sensitivity would be 900, 245, and 25 PgC, equivalent, at present CO_2 emission rate 10 PgC yr^{-1}, to 90, 25, and 2.5 years. Attributing the inconsistency between present greenhouse gas forcing and observed ΔT for a given climate sensitivity to forcing by anthropogenic aerosols, and assuming aerosol forcing becomes zero when CO_2 emissions are halted brings these numbers to 81, -10, and -41 years; negative time represents the number of years by which the maximum allowable emission for a given ΔT is exceeded at the present emission rate. For ΔT = 3 K the corresponding numbers are 165, 39, and -2.7 years. This is the sort of information that needs to be conveyed to the policymaking community.