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Does climate uncertainty mean we will need large-scale air capture?

Niel Bowerman (1), David Frame (1,2), and Myles Allen (1)

(1) Atmospheric, Oceanic & Planetary Physics, Department of Physics, University of Oxford, Oxford OX1 3PU, UK, (2) Smith School of Enterprise and the Environment, University of Oxford, Oxford OX1 2BQ, UK

The uncertainty in the climate response to carbon emissions implies a strong likelihood that a temperature target such as limiting global warming to 2˚C or even 4˚C may be exceeded almost irrespective of emission policies adopted today. Due to the thermal inertia in the climate system, however, a period of negative emissions might stabilise temperatures if the response turns out to be higher than expected. We explore the likelihood of such a scenario and the magnitude of negative emissions in light of the current understanding of the climate response to cumulative carbon emissions.

We consider an adaptive learning scenario in which society's understanding of the climate system improves over time. In this scenario, society responds to improvements in understanding by adapting its emissions pathways in order to reach a static temperature target. The magnitude by which temperatures rise faster or slower than previously considered is used to determine how much society perturbs its emission scenarios in the positive or negative direction. We consider initial unperturbed emission scenarios that will result in a best-guess carbon-dioxide-induced global warming of 2˚C, noting that this also allows a high-likelihood of greater, or lesser, warming due to the uncertainty in the temperature response. Two strategies are explored: in one case society perturbs emissions if it finds itself living in a world that might not have 2˚C of warming, and in another society perturbs emissions only if it finds itself living in a world where temperatures might rise above 4˚C. We assess the relative likelihood of different levels of negative emissions during the 21^{st} Century for each of these cases. We find significant likelihood that emissions must become negative in order to avoid more than 2˚C of warming.

These findings suggest that, in the absence of albedo modification, we cannot rule out the need to use large-scale air capture to avoid 2˚C of warming in the future. If such large-scale carbon capture turns out to be technologically and economically unfeasible, then we cannot rule out temperatures rising by more than 2˚C in the future, even on an initial emissions pathway with a best-guess warming of only 2˚C.