In assessing the level of global warming that constitutes DAI, we must bear in mind that estimated climate sensitivity of 3 ± 1°C for doubled CO_2, based mainly on paleoclimate data but consistent with models, refers to a case in which sea ice, snow, water vapor, and clouds are included as feedbacks, but ice sheet area, vegetation cover, and non-H_2O GHGs are treated as forcings or fixed boundary conditions. On long time scales, and as the present global warming increases, these latter quantities can change and thus they need to be included as feedbacks. Indeed, climate becomes very sensitive on the ice-age time scale, as feedbacks, specifically ice sheet area and GHGs, account for practically the entire global temperature change (17).

Vegetation cover is already expanding poleward in the Northern Hemisphere causing a positive climate feedback (42). Global warming could result in release of large amounts of GHGs, e.g., from melting permafrost or destabilized methane clathrates on continental shelves (43). Some of the largest warmings in the Earth's history and mass extinctions may be associated with such GHG releases (39, 43). Although such disastrous GHG releases may require many centuries, our ignorance of GHG climate feedbacks demands caution in estimating requirements to avoid DAI.

The AS is based on the rationale that positive feedbacks such as GHG release, as well as sea level rise, will be limited if global temperature stays within the range of recent interglacial periods. Ice core data reveal a positive GHG feedback, GHG changes lagging temperature change, but the feedback magnitude is moderate (CO_2, +20 ppm per °C; CH_4, +50 ppb per °C) even if the entire observed gas change is a feedback (44). However, paleo data do not constrain the magnitude of feedbacks under BAU warming, which is far outside the range of interglacial temperatures.

Such feedbacks enhance the dichotomy between AS and BAU scenarios. If global warming is not limited to <1°C, feedbacks may add to BAU emissions, making a "different planet" (17), including eventual ice-free Arctic, almost inevitable. The AS requires concerted efforts to both slow CO_2 emissions and reduce atmospheric amounts of CH_4, O_3, and BC (17, 34). Achievement of the AS should limit positive climate feedbacks. However, continuation of BAU growth of CO_2 emissions (≈2% per year) through 2015 yields +35% CO_2 emissions relative to 2000 CO_2 emissions and +40% CO_2 emissions relative to AS 2015 CO_2 emissions. Given the long life of CO_2 and the impact of feedbacks on the plausibility of CH_4 reductions, another decade of BAU emissions probably makes the AS infeasible.

Inference of imminent dangerous climate change may stimulate discussion of "engineering fixes" to reduce global warming (45, 46). The notion of such a "fix" is itself dangerous if it diminishes efforts to reduce CO_2 emissions, yet it also would be irresponsible not to consider all ways to minimize climate change. Considering the evidence that aerosol effects on clouds cause a large negative forcing (10), we suggest that seeding of clouds by ships plying selected ocean regions deserves investigation. However, given that a large portion of human-made CO_2 will remain in the air for many centuries, sensible policies must focus on devising energy strategies that greatly reduce CO_2 emissions.

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