Nonlinearity in Climate Responses

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Developing appropriate local and regional adaptation and planning activities in response to climate variability arising from increased anthropogenic greenhouse gas emissions/concentrations requires producing forecasts of future climate change and its regional impacts. Many times, these forecasts rely upon a comparison between the current climate state and its final state, under the assumption that the relevant climate parameters will evolve in a quasi-linear sense from one to the other. However, given the complexity of the climate system this evolution may instead follow a non-linear path that could result in either "tipping-point" (i.e., increased sensitivity to forcing) or "turning point" (i.e., reduced or even reversed sensitivity to forcing) behavior. Examples of non-linear behavior in historical and projected climate parameters include: accelerated melting of Arctic sea ice; reversal of initial soil moisture tendencies; increasing trends in the rate of sea-level rise; and discontinuous shifts in ecosystem communities. Compounding this complexity is the fact that in certain regions, the inconsistency between individual model forecasts, introduced either through natural climate variability or initial-state dependence, poses inherent limits to climate predictability even on multi-decadal time-scales.

Here we emphasize the need to identify and analyze regions with the propensity for highly non-linear and/or non-robust long-term climate evolutions. The reasons for doing so are three-fold:

1) For certain regions and certain parameters the adaptation and planning strategies developed in response to near-term changes (over the coming decades) may need to differ from those developed in response to long-term changes (over the coming century);
2) Where identified, delayed responses to anthropogenic forcing are ones that can be avoided if mitigation strategies are employed that prevent the CO_2 concentrations and/or global temperatures from reaching a particular threshold; and
3) Conversely, it must be recognized that early-onset responses to anthropogenic forcing cannot be avoided through mitigation alone and will in fact occur much sooner than the century time-scale considered in most linear analyses.