Geophysical Research Abstracts
Vol. 19, EGU2017-12850-1, 2017
EGU General Assembly 2017

Partitioning the influence of regional warming and feedbacks in the global response to abrupt CO_2 forcing

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We present a new analytical framework for diagnosing the regional causes of state-dependence in global radiative feedbacks. We apply this framework in long runs ($\sim$1000 years) with the coupled climate model MPI-ESM-LR 1.2, subject to abrupt increases in CO_2 concentration, including 2-, 4-, 8- and 16-times the pre-industrial levels. Two existing theories link a changing global feedback parameter to regional processes: either changing regional warming patterns activate constant regional feedbacks – "the pattern effect" – or the regional feedbacks themselves change –"regional state-dependence". Previous studies have typically tested one theory under particular conditions; we apply our method to diagnose both effects across a range of timescales and forcing strengths. Preliminary results indicate that the influence of the pattern effect is restricted to the initial warming phase. During the first decades of warming, ocean heat uptake allows regional warming to be non-linear with respect to the global mean, which our framework indicates is a necessary condition for the pattern effect. The evolution of global feedbacks over the remainder of the warming response is dominated by regional state-dependence and determined by the forcing strength. By identifying the conditions necessary for these effects to influence the global radiative response, we propose a link between both theories.