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# Time-Dependent Feedback in a 2-Region Energy Balance Model

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Abrupt $CO_2$ MPI-ESM experiments show a nonlinear relationship between global-mean TOA energy imbalance and the global-mean surface air temperature change which can be attributed to nonconstant global feedback. Especially on centennial time scales the climate response to radiative forcing is a transient phenomenon which can be captured by the instantaneous global radiative response per degree global mean surface temperature change: the time-dependent effective feedback diagnosed by a simple linearization of the energy budget. Bringing together different conceptual frameworks to explore the time-dependent response, we developed a 2-Region Energy Balance model with feedback temperature dependence and dynamical interaction to theoretically investigate climate sensitivity and global effective feedback. The 2-Region Energy Balance model can reproduce the MPI-ESM1.2 Gregory plot for a wide range of abrupt $CO_2$ input while isolated components break down in the limit of stronger forcing. Besides the dependence of the radiative response on the regional feedbacks with an evolving pattern of surface warming, the changes in feedback strength together with the dynamical interaction between the regions allow for new simple insights to infer effective sensitivity.