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Increase of uncertainty in transient climate response to cumulative carbon emissions after stabilization of atmospheric CO_2 concentration

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We analyzed a dataset from an experiment of an earth system model of intermediate complexity, focusing on the change in transient climate response to cumulative carbon emissions (TCRE) after atmospheric CO_2 concentration was stabilized in the Representative Concentration Pathway (RCP) 4.5. We estimated the TCRE in 2005 at 0.3–2.4 K/TtC for an unconstrained case and 1.1–1.7 K/TtC when constrained with historical and present-day observational data, the latter result being consistent with other studies. The range of TCRE increased when the increase of CO_2 concentration was moderated and then stabilized. This is because the larger (smaller) TCRE members yield even greater (less) TCRE. An additional experiment to assess the equilibrium state revealed significant changes in temperature and cumulative carbon emissions after 2300. We also found that variation of land carbon uptake is significant to the total allowable carbon emissions and subsequent change of the TCRE. Additionally, in our experiment, we revealed that equilibrium climate sensitivity (ECS), one of the 12 parameters perturbed in the ensemble experiment, has a strong positive relationship with the TCRE at the beginning of the stabilization and its subsequent change. We confirmed that for participant models in the Coupled Model Intercomparison Project Phase 5, ECS has a strong positive relationship with TCRE. For models using similar experimental settings, there is a positive relationship with TCRE for the start of the period of stabilization in CO_2 concentration, and rate of change after stabilization. The results of this study are influential regarding the total allowable carbon emissions calculated from the TCRE and the temperature increase set as the mitigation target.