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Evaluation of transient response of climate system based on the distribution of climate system parameters constrained by observed climate change.

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Transient climate response (TCR, i.e. temperature change in the time of CO_2 doubling) and transient climate response to cumulative carbon emission (TCRE, defined as the ratio of surface warming to cumulative implied carbon emissions at the time of CO_2 doubling) are often used to quantify climate system response to a non-stationary forcing.

TCR and TCRE are not directly observable characteristics of the climate system and their available estimates are obtained using results of simulations with climate models and, in case of TCRE, estimates of historical carbon emissions. In this study, we present estimates for TCR and TCRE obtained in the simulations with the MIT Earth System Model of intermediate complexity (MESM). First, the MESM was used to create a joint probability distribution for climate system parameters that define climate system response to the external forcing (e.g. climate sensitivity and rate of ocean heat uptake). This distribution was calculated by comparing results from a large ensemble of historical MESM simulations with available observations for changes in surface air temperature and oceanic heat content. To evaluate the estimated distribution, we carried out an ensemble of historical (1861-2010) simulations using 400 samples of climate parameters and examined where observations appeared within the distribution.

Distributions for TCR and TCRE were calculated from an ensemble of 400 runs in which MESM was forced by increasing CO_2 concentration. In our simulations, the median value of TCR (1.7K) is close to that of the CMIP5 models (1.8K). Simultaneously, the 90% probability range of TCR (1.4 - 2.0K) is significantly narrower than estimates based on CMIP5 models (1.2 – 2.4K). The relatively narrow range of TCR in our simulations is explained, in part, by the correlation between climate sensitivity and the rate of oceanic heat uptake imposed by observations. In the MESM simulations, the values of TCRE vary (90% range) from 1.3 to 2.0 K/ EgC, a similar range from 1% per year CO_2 increase experiment with CMIP5 models is 0.8-2.4K/EgC. At the same time an observationally constrained 5%-95% range, obtained by Gillett et al. (2013), using CMIP5 simulations and observed temperature is 0.7–2.0K/ EgC.

We also present results on dependency of TCR and TCRE on the rate of CO_2 increase.