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Examining uncertainties in equilibrium climate sensitivity and transient climate response using an impulse-response model

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Some of the most anticipated and avidly discussed numbers in each iteration of the IPCC Working Group 1 assessment reports are the uncertainty estimates on the equilibrium climate sensitivity (ECS) and the transient climate response (TCR). Together these two numbers determine the time dependent global mean surface temperature response of the climate system to a radiative forcing perturbation. Constraining these two numbers is vital not only for understanding changes in any variable (such as precipitation) that scales well with changes in global mean temperature, but also for policy-relevant economic analysis of climate change impacts, adaptation and mitigation, where the TCR and ECS are crucial parameters.

Despite the media attention paid to the IPCC's quantification of the TCR and ECS, it can be difficult to envisage the impact of the changes in TCR and ECS uncertainties between the 4th assessment report (AR4) and the fifth assessment report (AR5) on projections of future climate.
We present an inversion of the two time constant impulse-response model for global mean surface temperature change under radiative forcing in which the TCR and ECS are supplied as explicit parameters to the model. Using this formulation we examine the impact of the new AR5 TCR and ECS ranges on future climate projections and further go on to show that the AR5 "likely" ranges in TCR and ECS space are more consistent with the dynamics shown by general circulation models than AR4's.

An alternative to the use of general circulation models to estimate the TCR and ECS is attempting to constrain the two quantities using observations of the climate system in the 20th and 21st century. In contrast to the often-used "climate resistance" approximation, in which the temperatures respond immediately to changes in radiative forcing, we employ the two time-constant impulse-response function formulation to examine the importance of time lags on the surface temperature response to radiative forcing when estimating a likelihood profile for the TCR from observations. Early results indicate that the use of the "climate resistance" approximation when estimating TCR from the observations leads to a non-negligible underestimate of the transient response.