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A lower and more constrained estimate of climate sensitivity using updated observations and detailed radiative forcing time series

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A key question in climate science is to quantify the sensitivity of the climate system to perturbation in the radiative forcing (RF). This sensitivity is often represented by the equilibrium climate sensitivity, but this quantity is poorly constrained with significant probabilities for high values. In this work the equilibrium climate sensitivity (ECS) is estimated based on observed near-surface temperature change from the instrumental record, changes in ocean heat content and detailed RF time series. RF time series from pre-industrial times to 2010 for all main anthropogenic and natural forcing mechanisms are estimated and the cloud lifetime effect and the semi-direct effect, which are not RF mechanisms in a strict sense, are included in the analysis. The RF time series are linked to the observations of ocean heat content and temperature change through an energy balance model and a stochastic model, using a Bayesian approach to estimate the ECS from the data. The posterior mean of the ECS is 1.9˚C with 90% credible interval (C.I.) ranging from 1.2 to 2.9˚C, which is tighter than previously published estimates. Observational data up to and including year 2010 are used in this study. This is at least ten additional years compared to the majority of previously published studies that have used the instrumental record in attempts to constrain the ECS. We show that the additional 10 years of data, and especially 10 years of additional ocean heat content data, have significantly narrowed the probability density function of the ECS. If only data up to and including year 2000 are used in the analysis, the 90% C.I. is 1.4 to 10.6˚C with a pronounced heavy tail in line with previous estimates of ECS constrained by observations in the 20th century. Also the transient climate response (TCR) is estimated in this study. Using observational data up to and including year 2010 gives a 90% C.I. of 1.0 to 2.1˚C, while the 90% C.I. is significantly broader ranging from 1.1 to 3.4 ˚C if only data up to and including year 2000 is used.