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Bayesian Learning of Climate Sensitivity I: Synthetic Observations

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ABSTRACT

The instrumental temperature records are affected by both external climate forcings—in particular, the increase of long-lived greenhouse gas emissions—and natural, internal variability. Estimates of the value of equilibrium climate sensitivity—the change in global-mean equilibrium near-surface temperature due to a doubling of the pre-industrial CO_2 concentration—and other climate parameters using these observational records are affected by the presence of the internal variability. A different realization of the natural variability will result in different estimates of the values of these climate parameters. In this study we apply Bayesian estimation to simulated temperature and ocean heat-uptake records generated by our Climate Research Group's Simple Climate Model for known values of equilibrium climate sensitivity, T_{2x} direct sulfate aerosol forcing in reference year 2000, F_{ASA}, and oceanic heat diffusivity, ΔT_{2x}. We choose the simulated records for one choice of values of the climate parameters to serve as the synthetic observations. To each of the simulated temperature records we add a number of draws of the quasi-periodic oscillations and stochastic noise, determined from the observed temperature record. For cases considering only values of ΔT_{2x} and/or κ, the Bayesian estimation converges to the value(s) of ΔT_{2x} and/or κ used to generate the synthetic observations. However, for cases studying F_{ASA}, the Bayesian analysis does not converge to the "true" value used to generate the synthetic observations. We show that this is a problem of low signal-to-noise ratio: by substituting an artificial, continuously increasing sulfate record, we greatly improve the value obtained through Bayesian estimation. Our results indicate Bayesian learning techniques will be useful tools in constraining the values of ΔT_{2x} and κ but not F_{ASA} In our Group's future work we will extend the methods used here to the observed, instrumental records of global-mean temperature increase and ocean heat uptake.

KEYWORDS

Climate Uncertainty; Bayesian Estimation; Internal Variability

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