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A statistical model for global surface temperature response to radiative forcing with long-range dependent noise

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Understanding the global mean surface temperature response to radiative forcing is essential to assess the risks of global climate change. We present the statistical methodology for a realistic stochastic model that includes forcing contributions and accounts for chaotic atmospheric dynamics. This is achieved by using a long-memory stochastic process to model the temporal dependence observed in global temperature variability. This implies that inference on the resulting model becomes computationally challenging, which is resolved by introducing an approximation for the long memory process. The resulting model is incorporated in a latent Gaussian modeling framework and Bayesian inference is obtained using the methodology of integrated nested Laplace approximations (INLA). As an example of application the model will be fitted to the historical runs of the Earth System Models (ESMs) in the CMIP5 ensemble. The resulting model parameters will be used to obtain estimates of the transient climate responses (TCRs), which are compared to the responses that arise from the ESMs directly. Estimations of the TCR for instrumental temperature data is also obtained using forcing from the different ESMs. The presented method is implemented within the `R`-package `INLA.climate`.