Optimal Estimates of Radiative Forcing Due to Long-Term Solar Variability and Anthropogenic Sulfate Emissions in an Upwelling-Diffusion Model

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Previous studies have shown that radiative forcing due to both solar variability and anthropogenic sulfate emissions may significantly impact the global climate on decade-to-century (Dee-Cen) time scales. It is important, therefore, to reduce the current, relatively large range of uncertainty associated with the magnitude of both these effects. We compare global temperat urc variations over the last 140 years with the output of a one-dimensional upwelling-diffusion model (1 D-UDM) to scale the radiative forcing due to both long-term variations in solar irradiance and global sulfate emissions. The former arc modeled as the output of a first-order autoregressive process driven by interdecadal variations in the solar-cycle decay rate, while the latter are obtained from a recent compilation of anthropogenic sources extending back to 1850.

Optimal estimates for the radiative scaling parameters are calculated by minimizing a quadratic cost function applied to the upper-layer temperature error in a finite-difference formulation of the 1 D-UDM. These estimates are compared with those obtained by multivariate regression of the output of the 1D-UDM, driven by the individual forcings, against the observed temperature series. This regression also yields confidence ellipsoids for the optimal parameter values. For a small and reasonable range of climate sensitivities (2-3 deg C for doubled CO2), the model output, using the optimized scaling parameters for the forcings, yields a good fit to the low-frequency component of the instrumental temperature record. implications for the relative role of forced and free climate variability on the Dcc-Cen time scale will be discussed.