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Atmospheric Temperature Responses to Solar Spectral Irradiance Variations

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Atmospheric temperature responses to decadal solar variations are computed for two scenarios of solar spectral irradiance (SSI), SIM-based out-of-phase and proxy-based in-phase variations, using a time-dependent radiative-convective model (RCM), and also GISS modelE (GCM.) For both scenarios and both models, maximum responses occur in upper stratosphere, decreasing downward to the surface. Upper stratospheric temperature peak-to-peak responses to out-of-phase forcing are $\sim$0.6 K in RCM and $\sim$0.9 K over tropics in GCM, $\sim$5x as large as responses to in-phase forcing. Stratospheric responses are in-phase with TSI (Total Solar Irradiance). Modeled upper stratospheric temperature responses to SIM-based forcing are similar to 11-year temperature variations observed with HALOE (Halogen Occultation Experiment). For both RCM and GCM, surface responses to the two scenarios are significantly smaller than stratospheric responses.

On centennial timescales, SSI variations are poorly known. However, two scenarios of reconstructed TSI, one based on 11-year cycle with background [Lean 2000] and the other on flux transport with much less background [Wang, Lean, and Sheeley, 2005], provide a potential range of TSI variations. We apply phase relations among different SSI bands both from SIM observations and proxy reconstructions to the two scenarios of historical TSI to derive associated historical SSI, which then drives the RCM. The updated atmosphere and ocean mixed coupled RCM including diffusion to deep-ocean provide a first order estimate of temperature responses to SSI variations on centennial time scales. We discuss potential mechanisms for atmosphere-ocean and stratosphere-troposphere couplings responsible for the climate responses to spectral solar variations.