The Stratospheric Response to 11-Year Solar Variability: Direct UV Forcing and the Possible Role of Ocean-Troposphere Feedbacks

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An 11-year variation of upper stratospheric ozone and temperature is observed that is primarily a response to the direct photochemical and radiative effects of solar UV variations. However, an additional 11-year variation of these quantities is observed in the tropical lower stratosphere that appears to be dynamical in origin and is much less well understood. The latter variation has not yet been fully simulated by chemistry climate models that consider only radiative, photochemical, and dynamical processes in the stratosphere. Observational studies have also identified 11-year surface climate signals in the tropical Pacific that resemble those observed during cold ENSO events although there are important differences. The latter signals can be simulated by models that include both solar UV forcing of the stratosphere and an amplifying, coupled ocean-troposphere response (driven by indirect effects of solar UV forcing as well as direct effects of total irradiance forcing). This raises the possibility that the observed tropical lower stratospheric response to 11-year solar forcing may be amplified by feedbacks from the coupled ocean-troposphere response. During cold ENSO events, for example, the stratospheric mean meridional circulation is weakened, resulting in relative downwelling in the tropical stratosphere, which produces ozone and temperature increases there. A similar process may occur near solar maxima leading to an enhanced positive tropical lower stratospheric response to 11-year solar forcing. The enhanced lower stratospheric response would, in turn, result in additional perturbations of tropospheric circulation. The observed tropical lower stratospheric response to 11-year solar forcing may therefore represent an additional positive feedback mechanism for solar forcing of climate.