GISS GCMAM Modeled Climate Responses to Total and Spectral Solar Forcing on Decadal and Centennial Time Scales

Guoyong Wen,1,2 Robert F. Cahalan,1 David Rind,3 Jeffrey Jonas,2 Peter Pilewskie,4 Jerald W. Harder,5 Natalie Krivova6
1NASA Goddard Space Flight Center, 2GEST/Morgan State University, 3NASA/GISS, 4University of Colorado/LASP, 5Max Planck Institutes

In-phase and Out-of-phase Solar Forcing from SATIRE and SIM-Based SSI

Figure 1 (a) (top): SATIRE-T reconstructed SSI [Krivova et al., 2010]. (b) (bottom): SIM-derived SSI based on current relationships between TSI and SSI from Harder et al. [2009]. In both (a) and (b) the purple blue curves are for MFI-UVID (200-300 nm); blue curves are for near-UV (300-400 nm); green curves are for the VIS (400-700 nm); red curves are for NIR (>700nm); the black curves are for TSI. Note the variations in TSI (black) are identical in both scenarios.

Temperature Responses since 1610

Figure 2a. Temperature responses to SATIRE spectral solar forcing. Top panel for temperature responses in the upper stratosphere (dark blue for Zmb) and lower stratosphere (lighter blue for 20 mb). Bottom panel for temperature responses near the tropopause (red for 100 mb) and surface (brown). The temperature trends are 0.1 °C/century and 0.06 °C/century for upper stratosphere and lower stratosphere, respectively. And the temperature trends are 0.04 °C/century and 0.05 °C/century for the tropopause and surface, respectively. The number of years required to detect those trends are about 260 years for the stratosphere and 310 years for the tropopause and the surface.

Temperature Responses to 11-Year Activity

Figure 3. Zonal mean temperature responses to average 11-year solar activity in SATIRE spectral solar forcing. Left: temperature responses. Right: the ratio of temperature response to standard deviation of temperature of the control run without change of solar forcing.

Ozone Responses to 11-Year Activity

Figure 4. Similar to Fig. 3 but for temperature responses to SIM-based spectral solar forcing.

Coupled Ocean-Atmosphere GCMAM

• Full Coupled Ocean-Atmos Model (Rind et al., 2007)
• Upper boundary 0.002mb (~85km), 4 x 5 (lat x long) 53 atmosphere layers
• Dynamic ocean with 13 layers
• LINOZ scheme for photochemistry in the stratosphere with online photochemistry tracer. In troposphere, ozone is calculated using monthly mean ozone production rates archive from GEOSCHEM, a globalphotochemical transport model.
• Model has a sensitivity of 2.8°C to doubling of CO2

References


Conclusion

1. On centennial and longer time scales for the in-phase solar forcing, the global average surface air temperature increases at a statistically significant rate of 0.05 °C/century, contributing a warming of ~0.06 °C since 1880 to 2005, about 7% of observed global temperature anomaly. For the out-of-phase solar forcing, the global average surface air temperature increases with a statistically insignificantly trend of 0.02 °C/century, contributing about 3% of observed global temperature anomaly. Solar variations under either scenario do not cause the temperature increase since the industrial revolution.

2. The zonal mean temperature has very different response to the 11-year activity of the two solar forcing inputs. The response to the out-of-phase solar forcing is similar to an earlier study by Ineson et al. (2011).

The stratospheric ozone has very different response to the 11-year activity of the two solar forcing inputs. The stratospheric and mesospheric ozone responses to the out-of-phase solar forcing are about 5 time as large as those to the in-phase solar forcing. We do not find the reversed upper stratospheric and mesospheric ozone response to SIM-like solar forcing reported in earlier studies (e.g., Haigh et al., 2010 and Merkel et al., 2011).