TSI Findings, Implications and Recommendations

Results based on:

- Andronova, N. G. and M. E. Schlesinger, Causes of Global Temperature Changes During the 19th and 20th Centuries, Geophysical Research Letters, 27:14, 2137-2140, 2000.
- Andronova, N. G. and M. E. Schlesinger, Objective Estimation of the Probability Distribution for Climate Sensitivity, J. Geophys. Res., 106, D19, 22,605-22,612, 2001.

What Was Done and Found

Simulations by a simple climate model to reproduce the observed hemispheric-mean surface-air temperature changes since 1856 show that:

- If the TSI varied before 1978 as has been (re)constructed, the sun contributed about 20% to the observed near-surface temperature increase since 1856.
- 2. If the TSI varied before 1978 as has been (re)constructed, the climate sensitivity, ΔT_{2x} , needed to reproduce the observed increase in near-surface temperature since 1856 is reduced by about 50% compared to the value required if there was no variation in solar TSI.

Implications and Recommendations

1. There is a factor 2 uncertainty in the value of climate sensitivity, ΔT_{2x} , due to uncertainty in TSI over and above all other uncertainties in this quantity. Climate sensitivity is the "zeroth-order" quantity upon which the severity of anthropogenically induced climate change scales. Such "deep uncertainty" in climate sensitivity has been used as a reason to not begin efforts to reduce greenhouse-gas emission in the near term. This is a policy decision which may have the consequence of foreclosing long-term options for abating climate change should we eventually learn that the problem is severe. Thus it is critically important to determine the variation in the *absolute value* of TSI from at least 1856 to 1978, when satellite observations of TSI began.

Schlesinger's Recommendations for Sun/Climate Workshop 5/19/11

- 2. It has been speculated for several decades that the Maunder Minimum in sunspot number during 1645 1715 was the cause of the Little Ice Age through its effect on TSI. But recent studies suggest that the (re)constructed reduction in TSI for the Maunder Minimum may be a factor of 5 larger than reality. If this is true, then it is highly unlikely that the Little Ice Age was caused by the Sun. Thus, it is critically important to determine the TSI for the Maunder Minimum.
- 3. Climate simulations with the TSI at Maunder Minimum should be performed to determine whether the reduced TSI caused the Little Ice Age.

SUV Findings, Implications and Recommendations

Results based on:

Rozanov, E. V., M. E. Schlesinger, T. A. Egorova, B. Li, N. Andronova, and V. A. Zubov, Atmospheric response to the observed increase of solar UV radiation from solar minimum to solar maximum simulated by the University of Illinois at Urbana-Champaign climate-chemistry model, J. Geophys. Res., 109, D01110, doi:10.1029/2003JD003796, 2004.

What Was Done and Found

Simulations by the UIUC Stratospheric/Tropospheric General Circulation, Photochemistry Model with average spectral irradiance (control) and with the average spectral irradiance plus the spectral irradiance difference, solar maximum minus solar minimum (experiment), show that:

- 1. Ozone increases by 3% in the upper stratosphere and 2% in the lower stratosphere.
- 2. Temperature warms in the tropical stratosphere by 1.2K
- 3. The polar night jet intensifies in both hemispheres
- 4. The observed downward and poleward propagation of the stratospheric response is reproduced by the model such that there is a warming of December surface air temperature in northern Eurasia. This warming resembles the December warming

Schlesinger's Recommendations for Sun/Climate Workshop 5/19/11

observed and simulated by the model in response to the heating of the stratosphere by the Pinatubo eruption in June 1991.

Implications and Recommendations

- 1. This and other similar simulations indicate that variations in solar UV radiation over the 11-year Schwabe cycle influence climate on this time scale through the photochemical influence of solar UV on ozone, temperature and dynamics. This suggests that solar UV variations on longer time scales encompassing the period of the Maunder Minimum can similarly influence climate.
- 2. Thus it is critically important to determine the variation of solar UV from at least the Maunder Minimum to the time of initial satellite observations of solar UV.
- 3. Simulations by climate models with interactive photochemistry should be performed with this spectrally resolved solar irradiance at Maunder minimum to determine the effect of reduced solar UV on climate, particularly whether it amplifies the influence of non-spectrally resolved TSI in creating the Little Ice Age.
- 4. Detection and attribution studies have been performed to determine whether the sun has influenced climate since 1856. This has been done by statistically comparing the geographical patterns of observed climate change since 1856 with the geographical patterns of climate change simulated by coupled atmosphere/ocean GCMs in response to the (re)constructed changes in TSI since 1856. These studies should be repeated with models that include interactive photochemistry to simulate climate change in response to (re)constructed variations of spectrally resolved solar irradiance.

EEP Findings, Implications and Recommendations

Results based on:

Work in progress by Rozanov, E. V., Callis, L., M. E. Schlesinger, T. N. Andronova, Yang, F., and V. A. Zubov.

What Was Done and Found

Simulations by the UIUC Mesosphere/Stratospheric/Tropospheric General Circulation, Photochemistry Model with energetic electron precipitation (EEP) in 1979 (control) and in 1984 (experiment) show a "surprisingly" large influence on NO_x , ozone, temperature and dynamics, not only in the mesosphere, but also in the stratosphere and troposphere.

Implications and Recommendations

- 1. These results suggest that the atmosphere may be more sensitive to variations in EEP (particles) than to variations in SUV (photons).
- 2. Our control and experiment simulations are being repeated with a version of the model that better simulates the thermal and dynamical structure of the upper mesosphere, with maximum temperature over the winter pole and minimum temperature over the southern pole. This seemingly counterintuitive temperature distribution and its associated wind distribution are created by small-scale gravity waves that are generated in the troposphere by thunderstorms, jet stream and fronts, propagate vertically upward through the stratosphere and mesosphere where they break and deposit their zonal momentum.
- 3. If the preliminary findings are corroborated by the improved model, it would suggest that not only may TSI and SUV be important in influencing climate, but also EEP and perhaps other particles such solar proton events (SPE's).
- 4. If this is shown to be true, then it will be important to (re)construct the past variations of these particles from the Maunder Minimum to the present.