Accurate monitoring of terrestrial aerosols and total solar irradiance: the NASA Glory mission

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The Earth's climate depends upon the balance between incident solar radiation and the response of the atmosphere and surface via absorption, reflection, and re-radiation. Long-term changes in either the solar irradiance or the composition of the atmosphere can cause global climate change and thereby affect local weather patterns having impact on the quality of human life.

Solar irradiance is a purely natural phenomenon, while the composition of the atmosphere is influenced by both natural and anthropogenic effects, such as the byproducts of modern industrial societies. Over the past century the average temperature at the Earth's surface has increased by approximately 0.7°C (Hansen et al. 2006). Accurately attributing this increase and the concomitant climate change to either natural events or anthropogenic sources (or both) is of primary importance to the establishment of scientifically and economically effective policy (e.g., Hansen et al. 2005). Clearly, the more we find these changes are due to anthropogenic sources, the more impact the results might have on policy.

Total solar irradiance (TSI) is the dominant driver of global climate, whereas both natural and anthropogenic aerosols are climatically important constituents of the atmosphere also affecting global temperature. Although the climate effects of solar variability and aerosols are believed to be nearly comparable to those of the green-house gases (GHGs) (such as carbon dioxide and methane), they remain poorly quantified and may represent the largest uncertainty regarding climate change.

The GHG, TSI, and aerosol effects are exemplified by a recent study by Hansen et al. (2005). In their analysis, the TSI forcing was estimated to be ~ 0.2 W/m^2 with an uncertainty of about a factor of two. The positive sign of the TSI forcing means that it contributes to global warming. The radiative forcing due to black carbon aerosols, via absorption of the solar energy followed by re-radiation of the absorbed energy at infrared wavelengths, is also positive. Nonabsorbing aerosols such as sulfates reflect the Sun’s radiation back to space and typically cause cooling. In addition to these direct interactions of aerosols with radiation, aerosols are also believed to cause an indirect cooling effect by modifying cloud radiative properties and modulating precipitation. The estimated magnitude of the net aerosol forcing and its current uncertainty are comparable to those of the sum of all climate forcings.

The analysis by Hansen et al. (2005) as well as other recent studies indicate that the current uncertainties in the TSI and aerosol forcings are so large that they preclude meaningful climate model evaluation by comparison with observed global temperature change. These uncertainties must be reduced significantly for uncertainty in climate sensitivity to be adequately constrained (Schwartz 2004). Helping to address this challenging objective is the main purpose of the NASA Glory mission, a remote-sensing Earth-orbiting observatory designed to support the U.S. Climate Change Science Program and scheduled for launch in December 2008 as part of the A-Train constellation of Earth-orbiting satellites. Specifically, Glory is intended to meet the following four scientific objectives:

- Improve the quantification of the effect of solar variability on the Earth’s climate by continuing the uninterrupted 28-year satellite measurement record of TSI.
- Facilitate the quantification of the aerosol direct and indirect effects on climate by determining the global distribution of the optical thickness and microphysical properties of natural and anthropogenic aerosols and clouds with much improved accuracy.

- Provide better aerosol representations for use in various remote-sensing retrievals, thereby allowing improvements in aerosol assessments by other operational satellite instruments.
- Provide an improved framework for the formulation of future comprehensive satellite missions for aerosol, cloud, and ocean color research.

These science objectives will be met by implementing two independent instruments. The Total Irradiance Monitor (TIM) will monitor sunlight incident on the Earth's atmosphere by performing measurements of TSI with extremely high accuracy and precision. The Aerosol Polarimetry Sensor (APS) will have the ability to collect accurate multi-angle photopolarimetric measurements of the Earth along the satellite ground track over a broad visible and near-infrared spectral range, thereby providing aerosol retrievals to levels of precision and accuracy heretofore unachievable. The main purpose of this presentation is to explain the scientific rationale of the Glory mission, discuss how the scientific objectives dictate the specific measurement strategy, and describe how the measurement strategy will be implemented by building and flying two state-of-the art satellite instruments.

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