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THE SOLAR RADIATION AND CLIMATE EXPERIMENT (SORCE) MISSION FOR THE NASA EARTH OBSERVING SYSTEM (EOS)

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Abstract. The NASA Earth Observing System (EOS) is an advanced study of Earth's long-term global changes of solid Earth, its atmosphere, and oceans and includes a coordinated collection of satellites, data systems, and modeling. The EOS program was conceived in the 1980s as part of NASA's Earth System Enterprise (ESE). The Solar Radiation and Climate Experiment (SORCE) is one of about 20 missions planned for the EOS program, and the SORCE measurement objectives include the total solar irradiance (TSI) and solar spectral irradiance (SSI) that are two of the 24 key measurement parameters defined for the EOS program. The SORCE satellite was launched in January 2003, and its observations are improving the understanding and generating new inquiry regarding how and why solar variability occurs and how it affects Earth's energy balance, atmosphere, and long-term climate changes.

1. Introduction to the EOS Program

The concepts for the NASA Earth Observing System (EOS) program began in the 1980s as part of the NASA Earth Science Enterprise (ESE) through recommendations from the U.S. Global Change Research Program (USGCRP), the International Geosphere–Biosphere Program (IGBP), and the World Climate Research Program (WCRP). The driving motivation for the EOS program is the Earth science community concerns for potentially serious environmental changes, such as global warming, rising sea level, deforestation, desertification, atmosphere ozone depletion, acid rain, and reduction in biodiversity (King and Greenstone, 1999). Part of the EOS program research is to determine the actual changes in the environment both globally and on local scales and to access the contributions of human activity on the environmental changes as compared to natural variations. The EOS program has provided advanced and integrated scientific observing and data systems to address the hydrologic, biogeochemical, atmospheric, ecological, and geophysical processes that are important for improved understanding of the carbon cycle, water cycle, energy cycle, climate variability, atmospheric chemistry, and solid Earth science (King and Greenstone, 1999).

The series of satellites for the EOS program is based on a set of 24 key measurement objectives that will enable advances in understanding the long-term global changes of the solid Earth, its atmosphere, and oceans. These EOS measurements, as detailed in the *EOS Science Plan* (King, 2000), are grouped into five categories of atmosphere, solar radiation, land, ocean, and cryosphere. The early concept for these measurements was a series of satellites to provide observations over a period of 15 years. While the EOS program originally had several large satellites planned as flagship missions, the program restructured in the 1990s to have fewer large satellites and several small satellites with many of these smaller satellites being funded through the NASA Earth System Science Pathfinder (ESSP) program. Other important components of the EOS program are the archive and distribution of the EOS satellite data through the EOS Data and Information System (EOSDIS), interdisciplinary science research, calibration and validation, education and public outreach, and international cooperation (King and Greenstone, 1999).

2. SORCE Mission Contribution to the EOS Program

The total solar irradiance (TSI) and solar spectral irradiance (SSI) are two of the 24 EOS key measurements, and the Solar Radiation and Climate Experiment (SORCE) mission is now providing these solar irradiance measurements for the EOS program. The TSI is known to vary by a few tenths of a percent, and these small changes are considered a key climate-forcing component as related to Earth's energy budget (King, 2000; Pilewskie, Rottman, and Richard, 2005). The variations of the solar spectral irradiance are highly wavelength dependent, and the deposition of the solar irradiance into the Earth system is also strongly dependent on wavelength. The visible and infrared irradiance and its variation are important for radiation studies involving clouds and aerosols and their influence on climate changes (King, 2000; Pilewskie, Rottman, and Richard, 2005). The ultraviolet irradiance and its variation are important for atmospheric studies involving stratospheric chemistry, heating, and dynamics and the possible coupling to the lower atmosphere (King, 2000; Lean *et al.*, 2005). The accurate measurements of the TSI and SSI over periods of decades are important for establishing the solar influence on Earth's climate.

The SORCE mission is the merger of two EOS mission concepts. The original selection of instruments in 1989 for the EOS solar irradiance measurements included the Solar Stellar Irradiance Comparison Experiment (SOLSTICE) with the Principal Investigator (PI) being Dr. Gary Rottman at the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado (CU) and the Active Cavity Radiometer Irradiance Monitor (ACRIM) with the PI being Dr. Richard Willson, who was at the Jet Propulsion Laboratory (JPL) at that time. The SOLSTICE includes several channels to measure the SSI, and the ACRIM is designed to measure the TSI. Both instruments were selected as "flight of opportunity" instruments without a satellite platform defined. After several iterations in studying various mission concepts, the ACRIM instrument was designed for its own small satellite called the ACRIMSAT, which launched in December 1999, and the SOLSTICE was being designed for a small satellite called the Solar and Atmospheric Variability Explorer (SAVE). NASA recognized in the mid 1990s that the second generation of solar irradiance instruments would need to be selected to follow the ACRIMSAT and SAVE missions and defined the new mission opportunity as the Total Solar Irradiance Mission (TSIM) that included requirements for measuring the TSI and limited bands of the SSI. Following a Phase A study of the TSIM concept, LASP with Dr. Gary Rottman as the PI was selected for the TSIM program. Partly because this TSIM concept included the Solar Irradiance Monitor (SIM) that was also planned for the SAVE mission, the SAVE and TSIM programs at LASP were integrated into a single mission and renamed the SORCE mission in 1999.

SORCE has four different instruments for measuring the solar irradiance in order to meet the SORCE mission objectives (Rottman, 2005). The Total Irradiance Monitor (TIM) measures the TSI (Kopp and Lawrence, 2005). The Spectral Irradiance Monitor (SIM) measures the near ultraviolet, visible, and near infrared SSI in the 200 to 2000 nm range (Harder *et al.*, 2005). The Solar Stellar Irradiance Comparison Experiment measures the far ultraviolet and middle ultraviolet SSI in the 115–320 nm range (McClintock, Rottman, and Woods, 2005). The XUV Photometer System (XPS) measures the soft X-ray (XUV) SSI in the 0.1–34 nm range (Woods, Rottman, and Vest, 2005).

The SORCE mission is a PI-led satellite program with a firm cost cap and is operated much like an ESSP or Small Explorer (SMEX) program. The NASA Goddard Space Flight Center (GSFC) provided the higher-level project oversight, and LASP provided the program management for the instrument development and for the subcontract to Orbital Science Corporation (OSC) for the spacecraft bus and the launch services on a Pegasus XL rocket. The SORCE satellite was successfully launched on 25 January 2003, and its mission will extend for at least 6 years. So far, the SORCE mission has completed two and a half very successful years of operations with the mission operations and data processing activities centered at LASP (Pankratz *et al.*, 2005).

3. Future of the Solar Irradiance Measurements

NASA has plans to transition many of the EOS key measurements into longer term observations using NOAA operational satellites. For example, the SORCE TIM and SIM measurements are currently planned on a series of satellites for the NOAA National Polar-orbiting Operational Environmental Satellite System (NPOESS). These NPOESS solar irradiance measurements are being referred to as the Total Solar Irradiance Sensor (TSIS), which is currently being procured by a contract from Northrop Grumman to LASP for the TIM and SIM instruments and a solar pointing platform. The first flight of the NPOESS TSIS is planned for a 2012 launch. Because of the large time separation between the SORCE launch in 2003 and the first NPOESS TSIS observations, NASA has considered a Solar Irradiance Gap Filler (SIGF) mission or "flight of opportunity" for additional solar irradiance measurements to bridge the potential gap between the SORCE and NPOESS measurements. One of these opportunities is the flight of the TIM instrument on the NASA Glory spacecraft with its launch now planned in 2008. Without the SIM instrument aboard the Glory satellite, additional opportunities are being explored for obtaining the solar spectral irradiance measurements in the 2008–2012 timeframe.

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References

Harder, J., Lawrence, G., Fontenla, J., Rottman, G., and Woods, T.: 2005, *Solar Phys.*, this volume.
King, M. D. (ed.): 2000, *EOS Science Plan*, NASA GSFC, Greenbelt, MD.
King, M. D. and Greenstone, R. (eds.): 1999, *EOS Reference Handbook*, NASA GSFC, Greenbelt, MD.
Kopp, G. and Lawrence, G.: 2005, *Solar Phys.*, this volume.
Lean, J., Rottman, G., Harder, J., and Kopp, G.: 2005, *Solar Phys.*, this volume.
McClintock, W. E., Rottman, G. J., and Woods, T. N.: 2005, *Solar Phys.*, this volume.
Pankratz, C. K., Knapp, B., Reukauf, R., Fontenla, J., Dorey, M., Connelly, L., and Windnagel, A.: 2005, *Solar Phys.*, this volume.
Pilewskie, P., Rottman, G., and Richard, E.: 2005, *Solar Phys.*, this volume.
Rottman, G.: 2005, *Solar Phys.*, this volume.
Woods, T. N., Rottman, G., and Vest, R.: 2005, *Solar Phys.*, this volume.