SORCE

Solar Radiation and Climate Experiment

SORCE URL
lasp.colorado.edu/sorce/

Summary

SORCE observations are improving our understanding and generating new inquiry regarding how and why solar variability occurs and how it affects our atmosphere and climate. This knowledge is used to estimate past and future solar behavior and climate response.

Instruments

- Spectral Irradiance Monitor (SIM)
- Solar Stellar Irradiance Comparison Experiment (SOLSTICE)
- Total Irradiance Monitor (TIM)
- XUV Photometer System (XPS)

Points of Contact

- *SORCE Principal Investigator:* Tom Woods, Laboratory for Atmospheric and Space Physics/ University of Colorado (Boulder)
- *SORCE Project Scientist:* Robert Cahalan, NASA Goddard Space Flight Center
- *SORCE Deputy Project Scientist:* Doug Rabin, NASA Goddard Space Flight Center

Other Key Personnel

- *SORCE Program Scientist:* Donald Anderson, NASA Headquarters
- *SORCE Program Executive:* Lou Schuster, NASA Headquarters
- *SORCE Program Manager:* Tom Sparn, Laboratory for Atmospheric and Space Physics/University of Colorado (Boulder)

Mission Type

Earth Observing System (EOS) Systematic Measurements

Key SORCE Facts

Spacecraft: Based on Orbital Science's LeoStar 2 Spacecraft

Orbit:
- Type: Non-sun-synchronous
- Equatorial Crossing: N/A
- Altitude: 630 km
- Inclination: 40º
- Period: 97 minutes
- Repeat Cycle: N/A

Dimensions: 339.3 cm × 160.3 cm (deployed)

Mass: 315 kg

Power: 120 W (Orbit average)

Downlink: 1.5 Mbps

Design Life: 5 years

Contributors: LASP-CU, Orbital Sciences Corporation

Launch

- *Date and Location:* January 25, 2003, from Kennedy Space Center, Florida
- *Vehicle:* Pegasus XL Rocket

Relevant Science Focus Area

(see NASA's Earth Science Program section)

- Atmospheric Composition
- Climate Variability and Change
- Water and Energy Cycles

Related Applications

(see Applied Sciences Program section)

- Public Health
- Renewable Energy

SORCE Science Goals

SORCE is part of the NASA Earth Observing System of satellites, a series of satellite missions designed to monitor the Earth system from space. These sustained and comprehensive observations include the measurement of solar irradiance as the dominant direct energy input to land, ocean, and atmosphere. As an integral part of this, the SORCE mission aims to:

- Make precise and accurate measurements of the total solar irradiance (TSI). These observations are connected to previous TSI measurements to form a long-term record of solar influences on Earth. SORCE TSI measurements have an absolute accuracy of 0.01% and a long-term relative accuracy of 0.001% (10 ppm) per year.

- Establish a precise data set of solar spectral irradiance (SSI) measurements of the visible and near infrared suitable for future climate studies. These daily SSI measurements are from 200–2000 nm with a spectral resolution ($\Delta\lambda/\lambda$) of < 1/30, an absolute accuracy of 0.03% and a precision and relative accuracy of better than 0.01% per year.

- Make daily measurements of the solar ultraviolet irradiance from 115–320 nm with a spectral resolution of 0.1 nm. This measurement has an absolute accuracy of better than 5% and a long-term relative accuracy of 0.5% per year. The stellar comparisons to a number of bright, early-type stars are used as an in-flight calibration to correct possible changes in the instrument responsivity.

SORCE observations are improving our understanding and generating new inquiry regarding how and why solar variability occurs and how it affects our atmosphere and climate. This knowledge is used to estimate past and future solar behavior and climate response.

SORCE Mission Background

Solar radiation, Earth's average albedo, and long wave infrared emission are key to determining Earth's global average equilibrium temperature. Measurements obtained during the past 25 years show that the total solar irradiance, TSI, varies ~0.1% over the solar cycle, with larger short-term variations. The variations occur over all time scales up to and exceeding the 11-year solar cycle. Climate models including a realistic sensitivity to solar forcing indicate corresponding global surface temperature changes on the order of 0.2° C for recorded solar variations over the last century. However, global energy balance considerations may not provide the entire story. How TSI variations are distributed in wavelength is critically important in understanding Earth's response to solar variations.

Because of selective absorption and scattering processes in the atmosphere, different regions of the solar spectrum affect Earth's climate in distinct ways. Approximately 20–25% of the TSI is absorbed by atmospheric water vapor, clouds, and ozone, influencing convection, cloud formation, and latent heating via processes that are strongly wavelength dependent. Wavelengths below 300 nm are completely absorbed by Earth's atmosphere and contribute the dominant energy source in the stratosphere and thermosphere, establishing the upper atmosphere's temperature structure, composition, and dynamics. The Sun's radiation at these short wavelengths can vary by a factor of two or greater and lead to significant changes in atmospheric chemistry. The solar ultraviolet radiation influences stratospheric chemistry and dynamics, which in turn control the ultraviolet radiation that reaches the surface. Radiation at visible and infrared wavelengths, containing the bulk of the solar energy, penetrates into the lower atmosphere. The non-reflected portion of this radiation is absorbed in the troposphere or at Earth's surface,

SORCE Instruments

SIM
Spectral Irradiance Monitor

SIM incorporates an entirely different technique than previous solar irradiance measurement instruments to obtain the first continuous record of the top of the atmosphere SSI in the visible/near infrared region.

SOLSTICE
Solar Stellar Irradiance Comparison Experiment

The Solar Stellar Irradiance Comparison Experiment (SOLSTICE) instrument measures solar ultraviolet irradiance in the band 115–320 nm. SORCE SOLSTICE is an evolution and refinement of the SOLSTICE on the Upper Atmosphere Research Satellite (UARS), and both the UARS and SORCE SOLSTICE instruments observe the same bright blue stars as long-term calibration standards.

TIM
Total Irradiance Monitor

TIM provides a measurement of TSI with an absolute accuracy of 0.01% and a relative stability of 0.001% per year. Imperative for climate modeling, this instrument reports the average daily value of the Sun's radiative input at the top of Earth's atmosphere.

XPS
XUV Photometer System

XPS measures the solar soft X-ray (XUV) irradiance from 1–34 nm and the bright hydrogen emission at 121.6 nm (Lyman-α). This is an upgraded version of the XPS that extends the solar XUV irradiance measurements with improvements in accuracy, spectral range, and temporal coverage.

becoming a dominant term in the global energy balance and an essential determinant of atmospheric stability and convection. To understand the effects solar variability has on Earth's climate, it is important to monitor both the TSI and its spectral components accurately.

The Sun has both direct and indirect influences on the terrestrial system, and SORCE's comprehensive total and spectral solar measurements are providing the requisite understanding of this important climate system variable.

SORCE carries four instruments to measure the solar radiation incident at the top of Earth's atmosphere. The SORCE mission is a joint effort between NASA and the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado. LASP developed, calibrated, and tested the four science instruments and integrated them onto the spacecraft provided by Orbital Sciences Corporation. The SORCE science and mission operations are conducted from LASP's Mission Operations Center.

SORCE Mission and Science Operations

The SORCE satellite is orbiting Earth every 97 minutes, or 15 times daily. Ground stations at Wallops Island, Virginia, and Santiago, Chile, are providing the communication links to the satellite two times each day. The LASP Mission Operations Center (MOC) provides the computer hardware and software necessary to conduct spacecraft operational activities, including command and control of the satellite, mission planning, and assessment and maintenance of spacecraft and instrument health. The science operations include experiment planning, data processing and analysis, validation, and distribution of the finished data product.

Within 48 hours of data capture, all instrument science data and spacecraft engineering data are processed to derive Level 3 science data products in standard geophysical units (W/m^2 or $W/m^2/nm$). The Level 3 data consist of daily and 6-hour average solar irradiances, with higher time resolution data available to meet secondary science objectives, such as studying the passage of bright faculae and dark sunspots across the visible surface of the Sun. All validated data are delivered to the NASA Goddard Space Flight Center Earth Sciences (GES) Distributed Active Archive Center (DAAC) for distribution and long-term storage.

Key SIM Facts

Heritage: New technology developed for SORCE

Instrument Type: Dual Fèry Prism Spectrometer

Scan Type: Solar pointing

Calibration: ESR detector is an absolute detector, and prism transmission calibrations

Field of View (FOV): 1.5° × 3.5°

Instrument IFOV: 1.5° × 3.5°

Transmission Rate: N/A

Swath: N/A

Spatial Resolution: N/A

Spectral Range: 200–2000 nm

Dimensions: 19 cm × 33 cm × 81 cm

Mass: 30.3 kg

Power: 25.3 W

Duty Cycle: 100%

Data Rate: 1001 bps

Contributor: LASP–CU

Key SOLSTICE Facts

Heritage: Upper Atmosphere Research Satellite (UARS) SOLSTICE

Instrument Type: Grating spectrometer

Scan Type: Solar and stellar pointing

Calibration: NIST Synchrotron Ultraviolet Radiation Facility (SURF-III)

FOV: 1.5° × 1.5°

Transmission Rate: N/A

Swath: N/A

Spatial Resolution: N/A

Spectral Range: 115–320 nm

Dimensions: 18 cm × 39 cm × 88 cm

Mass: 21.1 kg

Power: 13 W

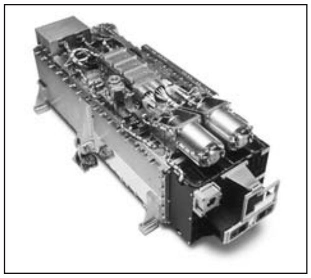
Duty Cycle: 100%

Data Rate: 521 bps

Contributor: LASP–CU

SIM

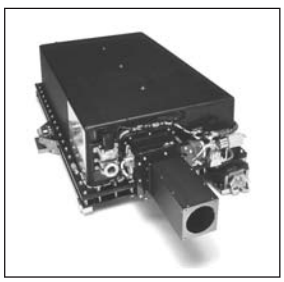
Spectral Irradiance Monitor



The newly developed SIM instrument incorporates an entirely different technique to make the first continuous record of the top of the atmosphere SSI in the visible/near infrared region. It uses a prism as the self-calibrating, single optical element and a miniature absolute ESR as the primary detector. This instrument provides spectral measurements over the range 200–2000 nm. Solar variability models, with the additional constraint of TSI observations, predict very small fractional changes—only 0.01–0.1% —in the visible/near infrared irradiance spectrum. Understanding the wavelength-dependent solar variability is of primary importance for determining long-term climate change processes.

SOLSTICE

Solar Stellar Irradiance Comparison Experiment



There are two identical SOLSTICE instruments that measure solar ultraviolet irradiance over the range 115–320 nm. These instruments are an evolution and refinement of the Upper Atmosphere Research Satellite's (UARS) SOLSTICE, and they observe the same bright blue stars as long-term calibration standards. These stellar targets establish corrections to the instrument sensitivity, since these stars remain extremely constant. Previous solar measurements show that far ultraviolet irradiance varies by as much as 10% during the Sun's 27-day rotation, while the bright 121.6 nm hydrogen Lyman-α emission may vary by as much as a factor of two during an 11-year solar cycle, dramatically affecting the energy input into the Earth's upper atmosphere.

TIM

Total Irradiance Monitor

TIM uses the best heritage of previous electrical substitution radiometers (ESRs), but is enhanced with state-of-the-art technologies including phase-sensitive detection, metallic absorptive materials, and digital electronics. The TIM provides a measurement of TSI with an absolute accuracy of 0.01%

Key TIM Facts

Heritage: The TIM is a new instrument to continue the TSI measurements of ACRIM, VIRGO, and ERBS.

Instrument Type: Electrical Substitution Radiometer (ESR)

Scan Type: Solar pointing

Calibration: Absolute detector, characterized at LASP, University of Colorado

FOV: 12.8°

Transmission Rate: N/A

Swath: N/A

Spatial Resolution: N/A

Spectral Range: Integrated solar spectrum

Dimensions: 20 cm × 30 cm × 34 cm

Mass: 10.7 kg

Power: 14 W

Duty Cycle: 100%

Data Rate: 713 bps

Contributor: LASP–CU

Key XPS Facts

Heritage: Student Nitric Oxide Explorer (SNOE) Solar XUV Photometers (SXP), Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics (TIMED) Solar EUV Experiment (SEE)

Instrument Type: Set of 12 spectrophotometers

Scan Type: N/A

Calibration: NIST Synchrotron Ultraviolet Radiation Facility (SURF-III)

FOV: 4°

Transmission Rate: N/A

Swath: N/A

Spatial Resolution: N/A

Spectral Range: 1–34 nm and 121–122 nm

Dimensions: 16 cm × 22 cm × 17 cm

Mass: 4.5 kg

Power: 9 W

Duty Cycle: 70%

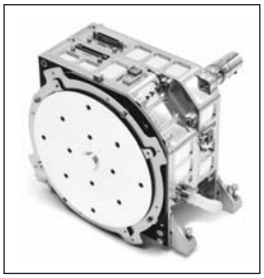
Data Rate: 204 bps

Contributor: LASP–CU

and a relative stability of 0.001% per year. Imperative for climate modeling, this instrument reports the total daily value of the Sun's radiative input at the top of the Earth's atmosphere. .

XPS

XUV Photometer System



The XPS instrument measures the solar soft X-ray (XUV) irradiance from 1–34 nm and the bright hydrogen emission at 121.6 nm (Lyman-α). The solar XUV radiation is emitted from the hot, highly-variable corona on the Sun, and these high-energy photons are a primary energy source for heating and ionizing Earth's upper atmosphere. The XPS is also sensitive to solar flare events, during which the solar XUV radiation can change by a factor of 2–10. The SORCE XPS, which evolved from earlier versions flown on SNOE and TIMED, extends the solar XUV irradiance measurements with improvements in accuracy, spectral range, and temporal coverage.

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SORCE Data Products

Product Name or Grouping	Processing Level	Coverage	Spatial/Temporal Characteristics
TIM *Data Set Start Date: February 25, 2003*			
Total Solar Irradiance (TSI)	3	Measured at the top of the atmosphere	4 times daily
SIM, SOLSTICE, XPS *Data Set Start Date: March 5, 2003*			
Spectral Solar Irradiance (1–2000 nm)	3	Measured at the top of the atmosphere	4 times daily

SORCE Data Products