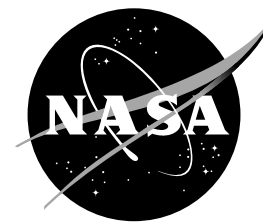


NASA Facts

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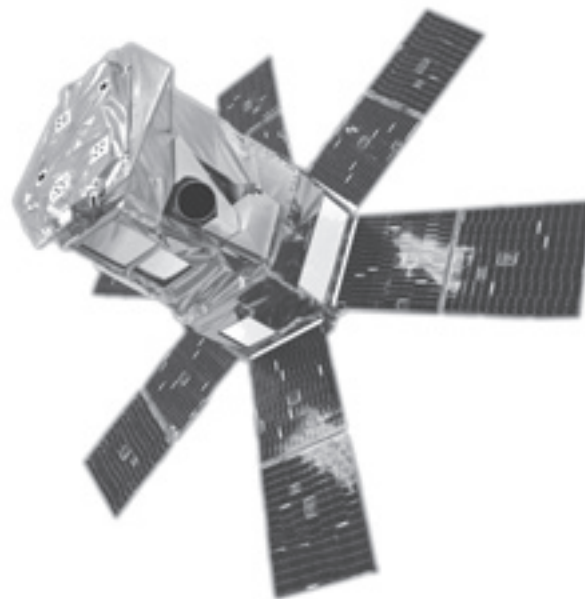
FS-2002-12-052-GSFC

Solar Radiation and Climate Experiment (SORCE)

SORCE Mission

To further understand the influence of the Sun on the Earth system, NASA will launch the SORCE satellite in January 2003. SORCE is a joint partnership between NASA and the University of Colorado's Laboratory for Atmospheric and Space Physics (LASP) in Boulder, Colorado. SORCE is a key component of NASA's Earth Observing System (EOS) program, and will address long-term climate change, natural variability and enhanced climate prediction, and atmospheric ozone and UV-B radiation. The small free-flying satellite will carry four scientific instruments to measure the solar radiation incident at the top-of-the-Earth's atmosphere. This research is critical to studies of the Sun, its affect on our Earth, and its influence on humankind.

The Sun is the dominant energy source for the entire Earth system, and solar radiation is one of the key climate system variables. Measuring and understanding the total energy output from the Sun or Total Solar Irradiance (TSI) and Spectral Solar Irradiance (SSI) addresses two difficult questions — whether the Sun itself varies and if so, how. For hundreds of years scientists have been observing and learning about our Sun. Empirical models of the TSI based on very early observations (sunspot darkening, and facular and networking brightening) compare favorably with current actual TSI observations. This translates to a better understanding of the Earth's energy balance. For example, ozone is especially sensitive to



The SORCE satellite will carry four instruments to study the Sun. TIM, SIM, and SOLSTICE will measure solar irradiance and the solar spectrum to help scientists understand the Sun's role in climate change. The XPS will measure high-energy radiation from the Sun.

changes in the Sun's ultraviolet radiation, and both observations and models show a close relationship of their concentrations to solar irradiance. Similarly, water vapor absorbs infrared radiation, and SORCE will provide the first extensive infrared SSI measurements from space.

The spectral measurements of SSI identify the irradiance of the Sun by characterizing the Sun's energy and emissions in the form of colors, i.e. wavelengths, that are absorbed by certain molecules in Earth's atmosphere, land and oceans. Ozone, water vapor and liquid, carbon dioxide,

methane, etc, each absorb their own set of characteristic wavelengths. It is important to know how the energy in each wavelength varies, since that tells us how the heating varies in different parts of Earth's atmosphere, land, and ocean. Using the most advanced equipment available, data obtained by **SORCE** will be used to model the Sun's output and to explain and predict the effect of the Sun's radiation on the Earth's atmosphere and climate.

SORCE will continue a history of TSI measurements with greatly improved accuracy. Monitoring TSI using electrical substitution radiometers (ESRs) from the vantage point of space began with the launch of the Nimbus 7 satellite in November 1978. This was soon followed by an Active Cavity Radiometer Irradiance Monitor (ACRIM) instrument on the Solar Maximum Mission and by the Earth Radiation Budget Experiment. More recently, second and third ACRIM instruments have been launched, in addition to the launch of two instruments on the NASA / ESA Solar Heliospheric Observatory. The various data sets are in basic agreement and show conclusively that variations of TSI track the passage of sunspots across the solar disk with an amplitude of about 0.2%, and that long-term solar cycle variations are only on the order of 0.1%. **SORCE** will continue these important TSI observations, and will further improve their accuracy to the order of +/- 0.01%.

SORCE also continues earlier SSI measurements carried out in the 1990's. The UARS/SUSIM and SOLSTICE experiments provided ultraviolet SSI. The SOHO/VIRGO experiment measures SSI at selected wavelengths in the ultraviolet (402 nm), visible (500 nm), and near infrared (862 nm). **SORCE** will greatly extend the spectral coverage, continuously covering the wavelengths from 1 to 34 nm (XPS) and also from 115 to 2000 nm (SOLSTICE and SIM). **SORCE** will also improve the SSI accuracy using a similar ESR technique to that described above for the TSI measurements of TIM. Accurate knowledge of the Sun's variations at all

wavelengths that are heating important parts of Earth's atmosphere, land and oceans is an essential step to understand, model and predict impacts of the Sun on Earth.

SORCE Spacecraft

The **SORCE** satellite consists of a spacecraft bus and four instruments funded by NASA. The four instruments on-board were designed and built by LASP at the University of Colorado in Boulder. They are the Total Irradiance Monitor (TIM), the Spectral Irradiance Monitor (SIM), two identical Solar Stellar Irradiance Comparison Experiments (SOLSTICE), and the XUV Photometer System (XPS). TIM, SIM, and SOLSTICE will measure total solar irradiance and the solar spectrum to help scientists understand the Sun's role in climate change. The XPS will measure high-energy radiation from the Sun.

The spacecraft carrying the instruments was developed by the Orbital Sciences Corporation in Dulles, Virginia, under contract to LASP. This spacecraft is three-axes stabilized with a control system to point the instruments at the Sun and the calibration stars. The stowed spacecraft is 39.4 inches (100 centimeters) wide x 63.1 inches (160.3 centimeters) high. With solar arrays deployed, **SORCE** is 133.6 inches (339.3 centimeters) wide x 63.1 inches (160.3 centimeters) high. The spacecraft, at launch, weighs 632.7 pounds (287 kilograms). The spacecraft is powered by 348 watts of electric power from its solar array.

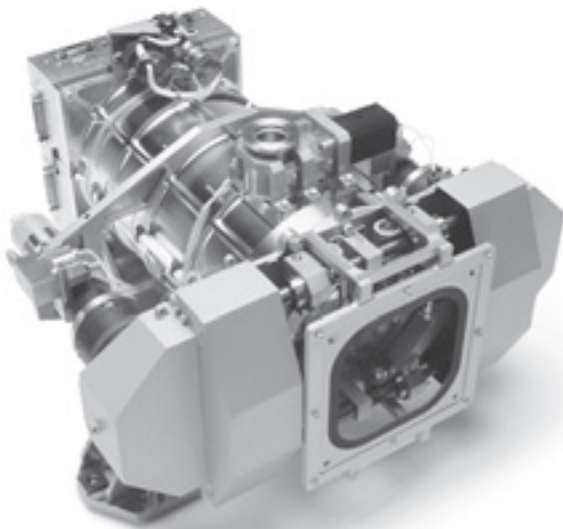
SORCE Instruments

Total Irradiance Monitor (TIM)

The TIM will measure the TSI for the duration of the **SORCE** mission, monitoring changes in incident sunlight to the Earth's atmosphere via an ambient temperature active cavity radiometer. Using a new development that incorporates improvements and state-of-the-art technologies of the electrical substitution radiometer (ESR) and taking full advantage of new materials

and modern electronics, TIM measures TSI to an absolute accuracy of 100 ppm. TIM will report 4 measurements per day of the total radiative input at the top-of-the-Earth's atmosphere. Sunlight to any one of the four ESRs is modulated by an oscillating shutter. A precision aperture behind each shutter accurately determines the area over which sunlight is collected, absorbing nearly all of the Sun's energy as heat. This radiant power is then measured by a black absorptive ESR. The ratio of power to area provides an extremely accurate TSI measurement.

The accuracy of TIM's readings will allow scientists to observe the subtle changes in solar radiation brought on by the sunspot cycles. They will use these numbers to determine just how much the Sun varies on a day-to-day, a month-to-month, and a year-to-year basis and then compare these variations to changes in the climate. The new readings will also help improve climate models.



The Total Irradiance Monitor (TIM) will measure the energy emitted by the Sun ten times more accurately than previous sensors.

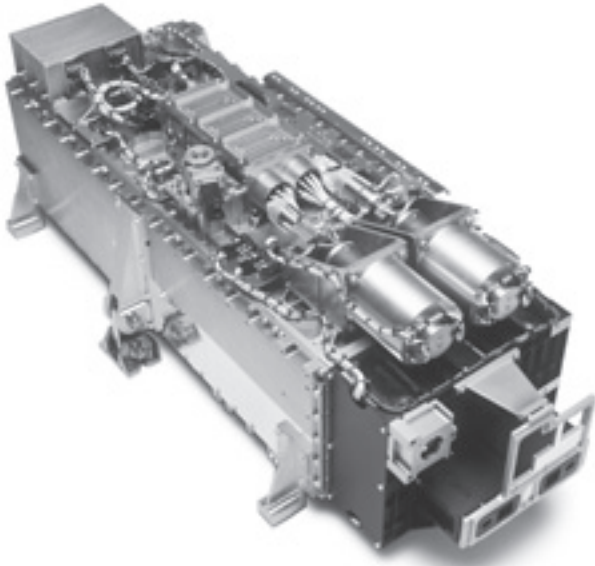
Spectral Irradiance Monitor (SIM)

SIM is a newly developed prism spectrometer that will make the first continuous record of the top-of-the-atmosphere solar spectral irradiance in the visible and near infrared. The wavelength

coverage is primarily from 300 to 2000 nanometer range, with an additional channel to cover the 200 to 300 nm, and thereby overlap with the observations of SOLSTICE. SIM's range includes the peak of the solar spectrum. The total energy carried by all the visible and infrared wavelengths measured by SIM (from 300 to 2000 nm) adds up to more than 95% of the Total Solar Irradiance.

SIM will measure the SSI 4 times per day throughout the SORCE mission. This prism spectrometer uses only a single optical element to both disperse and focus solar radiation. The single optical element minimizes the susceptibility to deterioration of sensitivity on orbit. Sunlight entering this instrument is directed into a prism, which then directs different wavelengths of ultraviolet, visible, and near infrared into separate directions. The separate wavelengths of light will then illuminate five separate detectors including four photodiodes and one absolute detector - a miniaturized version of the TIM electrical substitution radiometer. The photodiodes measure the specific wavelengths of light between ultraviolet radiation and near infrared radiation.

To date, the time history of spectral irradiance variability in the visible and near infrared part of the spectrum is not nearly as complete, or as reliable, as the total solar irradiance and the solar ultraviolet radiation records. Understanding the wavelength-dependent solar variability is of primary importance for long-term climate change studies. By reviewing data from SIM, scientists may be able to tell how the solar cycles affect both visible and near-infrared wavelengths. Combined with improved measurements by ground and by aircraft, they also may be able to discern just how much of this light goes into heating up the lower layers of the Earth's atmosphere and how much goes into the land and oceans. SIM will also aid in efforts to discern exactly how much of the Sun's energy is reflected by industrial aerosols and clouds.



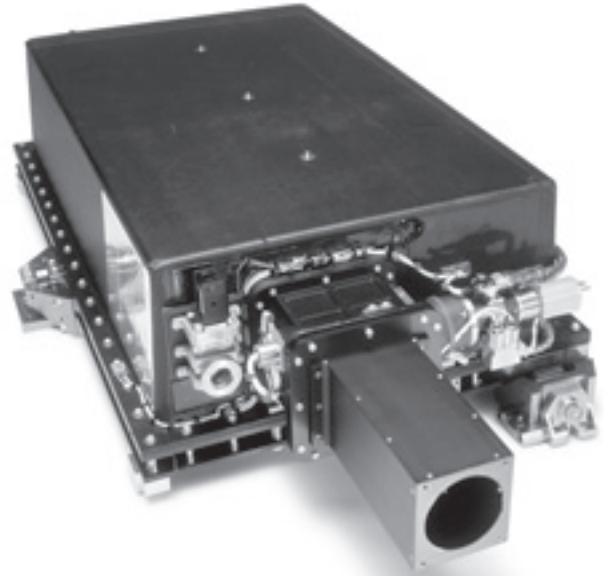
The Spectral Irradiance Monitor (SIM) will measure the solar spectrum in ultraviolet, visible, and near infrared wavelengths.

Solar Stellar Comparison Experiment (SOLSTICE)

There are two SOLSTICE instruments (for redundancy and for cross calibration) on-board *SORCE* that will measure solar ultraviolet irradiance from 120 to 320 nm daily. This SOLSTICE is a follow-up to the very successful SOLSTICE launched aboard the Upper Atmospheric Research Satellite (*UARS*) in 1991. The instrument observes the Sun and 18 bright, blue early-type stars using similar optics and detectors. Observing the very same stars as the *UARS* SOLSTICE, the *SORCE* SOLSTICE will make measurements with greatly improved accuracy and stability. The SOLSTICE on *SORCE* will continue to monitor ultraviolet radiation well after the *UARS* satellite is taken out of service.

The calibration for this instrument is unique. The stellar targets establish long-term corrections to the instrument sensitivity, as well as providing a basis for solar-stellar comparison for future generations. As *SORCE* passes through the nighttime portion of its orbit, SOLSTICE will measure the ultraviolet radiation coming from these selected blue stars. These stars emit spectra that have significant energy in the ultraviolet range measured by SOLSTICE, that are known to be

constant in time. So if SOLSTICE's measurements from these stars change over time, then scientists know that the instrument's response has changed. They can then use the knowledge to make adjustments to their data.



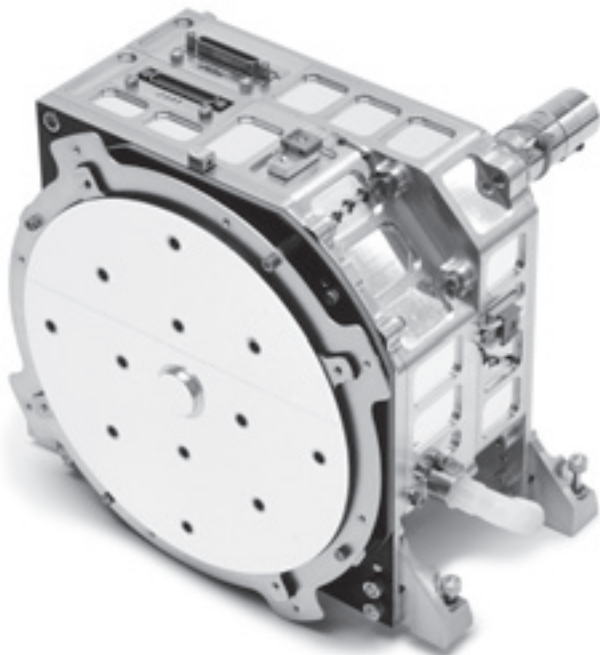
*There are actually two independent SOLSTICE instruments onboard *SORCE*, referred to as SOLSTICE A and SOLSTICE B.*

Extreme Ultraviolet Photometer System (XPS)

The XPS measures the solar soft x-ray (XUV) irradiance from 1 to 34 nm and the bright hydrogen emission at 121.6 nm. 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 the most sensitive to solar flare events as the solar XUV radiation often changes by a factor of 2 to 10 or more during these flares.

Studies of the solar XUV radiation began in the 1950's with space-based experiments, but the knowledge of the solar XUV irradiance, both in absolute magnitude and variability, has been questionable due largely to the very limited number of observations. With the launch of the Solar and Heliospheric Observatory (*SOHO*) in 1995, Student Nitric Oxide Explorer (*SNOE*) in

1998, and Thermosphere-Ionosphere-Mesosphere-Energetics-Dynamics (TIMED) spacecraft in 2001, there is now a continuous data set of the solar XUV irradiance. With this history, significant advances in the understanding of the solar XUV irradiance have begun. The SORCE XPS, which evolved from earlier versions flown on SNOE and TIMED, will continue these XUV irradiance measurements with improvements to accuracy, spectral image, and temporal change.



Scientists will use XPS to study the Sun's corona and transition zone by monitoring solar radiation in extreme ultraviolet and low-energy x-ray wavelengths.

Operations

The launch will occur in January 2003 from the Kennedy Space Flight Center in Cape Canaveral, Florida aboard a Pegasus XL launch vehicle. The satellite will fly at an altitude of 640 km in a 40 degree-inclination orbit around the Earth. All four SORCE instruments will take readings of the Sun during each of the satellite's 15 daily orbits. The information will be transmitted to ground stations at NASA's Wallops Flight Facility in Virginia and a station in Santiago, Chile. The SORCE satellite will be operated from LASP's Mission Operations Center for the mission duration. SORCE will operate on orbit for a period of five years, with a design goal of six years.

Management

SORCE is a principal investigator led mission with NASA's Goddard Space Flight Center providing management and scientific oversight and engineering support. LASP at the University of Colorado has full programmatic responsibility for the SORCE mission. Scientists and engineers at LASP designed, built, calibrated, and tested the four science instruments on SORCE. LASP subcontracted to Orbital Sciences Corporation in Dulles, Va. for the spacecraft and observatory Integration and Test. NASA's Kennedy Space Center is responsible for all launch operations. LASP is responsible for the acquisition, management, processing, and distribution of the science data. SORCE is an example of how NASA, universities, and industry can partner together and create successful science missions.

Data Processing

The LASP Mission Operations Center contains all hardware and software necessary to conduct real-time spacecraft operational activities, including command and control of the instruments and satellite, mission planning, and assessment and maintenance of spacecraft and instrument health. Following spacecraft and instrument commissioning activities during the first 30 days after launch, normal operations will consist of two contacts per day with SORCE. Data that have been continuously recorded will be retrieved during these contacts. The nominal data volume received from the SORCE spacecraft is approximately 120 megabytes (1 billion bits) per day. Within 48 hours of data capture, the LASP Science Operations Center will process all science data with the associated instruments. SORCE will produce two principal scientific data products: Total Solar Irradiance (TSI) data and Spectral Solar Irradiance (SSI) data.

Science data processing will commence automatically within 24 hours of data reception from the spacecraft. Preview (unfinished) versions of the SORCE data products will be made available to the public within approximately 48 hours,

with finished research-grade data products being produced approximately 3 months later, after sufficient in-flight calibration data have been collected. Data products will be delivered to the Goddard Distributed Active Archive Center located at NASA Goddard Space Flight Center for subsequent distribution to the public.

Science Objectives

NASA's Earth Science Enterprise identified several high-priority objectives for their EOS missions to facilitate a better understanding of the Sun and its impact on the Earth. SORCE objectives include:

- SORCE will make precise and accurate measurements of the Total Solar Irradiance (TSI). These measurements will be connected with previous TSI measurements to continue a long-term record of solar influences on the Earth. SORCE will measure TSI with an absolute accuracy of 0.01% and with a long-term relative accuracy of 0.001% per year.
- SORCE will make precise measurements of the visible and near infrared Spectral Solar Irradiance (SSI) suitable for future climate studies. SORCE will obtain daily measurements of the SSI from 300 to 2000 nm, with a spectral resolution of approximately 30 nm, an absolute accuracy of 0.03%, and a precision and relative accuracy of better than 0.01% per year.

- SORCE will make daily measurements of the ultraviolet solar irradiance from 120 to 300 nm with a spectral resolution of 1 nm. It will achieve this measurement with an absolute accuracy of better than 5% and with a long-term relative accuracy of 0.5% per year.
- SORCE observations will improve our understanding of how and why solar variability occurs and how it affects our atmosphere and climate. This knowledge can be used to estimate past and future solar behavior and climate response.

Related Websites

SORCE Website

<http://lasp.colorado.edu/sorce>

SORCE Reference Article

<http://earthobservatory.nasa.gov/Library/SORCE/>

The Earth Science Enterprise Series

These articles focus on the overarching science priorities of the Earth Observing System.

<http://earth.nasa.gov>