TSIS / SORCE News

Total & Spectral Solar Irradiance Sensor / Solar Radiation & Climate Experiment

February – June 2018

2018 Sun-Climate Symposium: Meeting Summary –

"The State of the TSI and SSI Climate Records at the Junction of the SORCE and TSIS Missions"

Lake Arrowhead, California
March 19-23, 2018

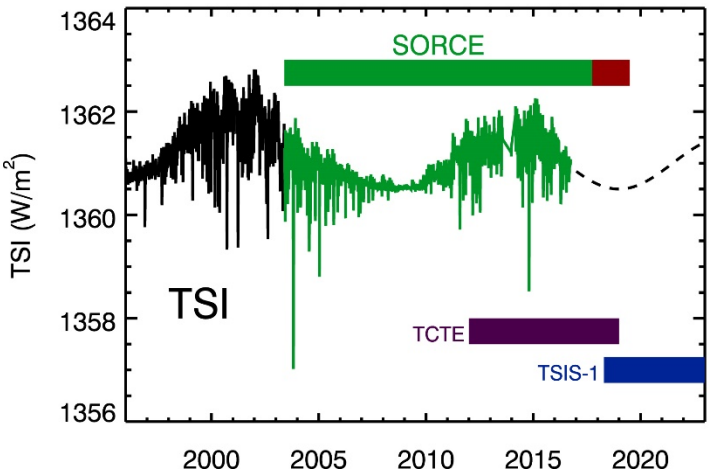
Sunset over the San Bernardino Mountains in southern Cal.

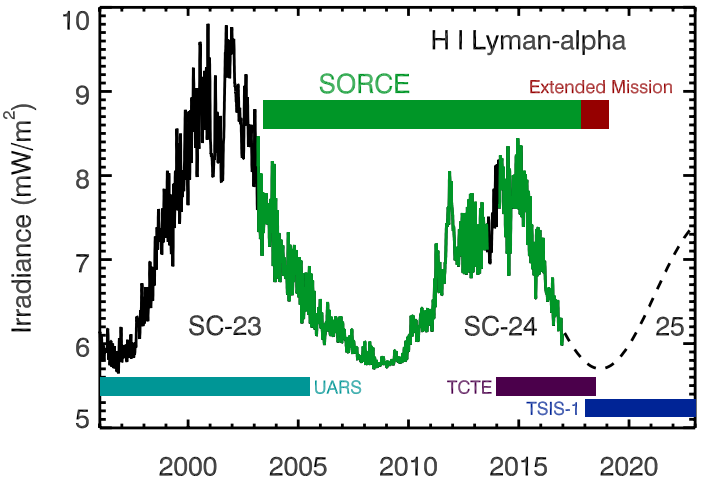
The 2018 Sun-Climate Symposium, was held at the UCLA Conference Center in Lake Arrowhead, California, from 19-23 March. The Sun-Climate Research Center— established as a collaboration between NASA's GSFC and LASP/CU— organized this gathering of experts from the solar terrestrial community and various Sun-Climate disciplines. The timely theme of the symposium was ***The State of the TSI and SSI Climate Records at the Junction of the SORCE & TSIS Missions.*** There were six oral sessions that covered solar and climate observations, models, solar variability, and expectations for the next solar cycle, in addition to two poster sessions spanning these same topics. Over 80 scientists and students from around the world gathered to present their findings and to engage in spirited discussions. Most of the 2018 Sun-Climate Symposium presentations are available online at http://tinyurl.com/y7jku7zu.

Introductory remarks by Peter Pilewskie and Tom Woods, the TSIS-1 and SORCE PIs respectively, put the unique timing of this year's symposium into perspective. Measurements of solar irradiance from space began four decades ago with the launch of the Nimbus 7 satellite that carried the ERB and SBUV sensors. Remarkable progress has been made since that time in our ability to monitor ever smaller changes in the Sun's output, integrated over the entire spectrum and in individual wavelength bands, and with increased radiometric accuracy. This has improved our understanding of the Sun's influence on past and present climate, our ability to predict future climate and helped us gain insight into the mechanisms by which the Earth system responds to subtle variations in solar irradiance.

This meeting occurred during an important juncture in the measurement record of solar irradiance. SORCE recently

celebrated the 15-year anniversary of its launch, a feat that was celebrated at the symposium with birthday cake. SORCE not only ushered in advanced capabilities for measuring total and spectral solar irradiance, accompanied by a large number of science achievements, it has persevered for 10 years beyond its scheduled mission lifetime. In so doing, SORCE has helped preserve the 40-year solar irradiance data record from space.





The solar observations over the SORCE mission, shown for TSI (top) and the UV H I Lyman-alpha (bottom), include solar cycles 23 and 24, and an extended mission that will include the start of cycle 25. The higher frequency variations, such as the large dips in the TSI, are caused by the presence of solar active regions rotating with a period of ~27 days. The larger 11-year solar cycle variation is a key forcing in Earth's atmosphere and climate.

As SORCE winds down, the Total and Spectral Solar Irradiance Sensor-1 (TSIS-1) is just beginning its mission. TSIS-1 was launched to the International Space Station on December 15, 2017. The SORCE-heritage Total Irradiance Monitor (TIM) and Spectral Irradiance Monitor (SIM) on TSIS-1 have both experienced first light. Preliminary data from the TSIS-1 TIM and SIM were presented at the symposium.

During opening remarks, Tom and Peter represented the linkage between SORCE and TSIS with a relay baton that was symbolically passed from SORCE to TSIS, one measurement program to the next in the four-decade long solar irradiance climate date record. We are currently in a one-year overlap period between the SORCE and TSIS-1 missions. SORCE still has a firm grasp on the baton that it has ever so gently laid in the hand of TSIS-1. It won't let go for several months after completion of the overlap.

For the full program, please visit the 2018 Sun-Climate Symposium website. The final agenda is posted with links to most of the presentation. You can also find a meeting summary, courtesy of NASA's *The Earth Observer* (May-June issue 2018).

http://lasp.colorado.edu/home/sorce/news-events/meetings/2018-scs/

NASA Earth Science missions, including the SORCE and TSIS-1 missions, are critical for advancing our understanding of the complex Earth systems and their connection to the encompassing solar environment, and new climate missions are required to continue these valuable climate records. The 2018 Sun-Climate Symposium emphasized the connections between solar variability and Earth climate at an important juncture in the measurement record during overlap of the SORCE and TSIS-1 missions. Moreover, we are also approaching a minimum in the Sun's activity cycle – how the Sun will vary over the next cycle and the Earth system response are intense areas of study. The Sun-Climate Symposium addressed these issues in the context of present-day climate change and its anthropogenic and natural drivers. The multi-disciplinary nature of the meeting brought together specialists in measuring and modeling the Sun's output and Earth's radiation budget, climate and atmospheric modelers who interpret those and other forcings and quantify Earth's changing environment, solar physicists who study how the Sun varies, and other specialists developing new instruments and missions to answer some of the questions that were addressed in the meeting. We look forward to our next meeting, when updates on some of the most vexing issues in Sun-Earth connections will be discussed, and new questions are sure to arise. Stay tuned…

Additional 2018 Sun-Climate Symposium photos appear on the next page.

A rainy afternoon trip to Big Bear Solar Observatory.

An inside view of the Big Bear Solar Observatory to see the world's highest-resolution solar telescope.

In addition to six oral sessions, two poster sessions were held during the week.

The poster sessions also provided valuable networking time for colleagues to catch-up.

The UCLA Conference Center provided a perfect meeting venue with great facilities and accommodations, within a retreat-like setting on 42 acres tucked in the San Bernardino Mountain foothills on the shores of Lake Arrowhead.

GSFC's Candace Carlisle selling her latest favorite mission – TSIS. Everyone is excited about upcoming science results!

TSIS-1 Update –

The Total and Spectral Solar Irradiance Sensor (TSIS-1) has officially transitioned to science mode. Since launching on Friday, Dec. 15, 2017, TSIS has been on an adventure – it arrived at the International Space Station on Sunday, Dec. 17, and 2 weeks later TSIS was installed on the ISS to begin solar viewing. Instrument commissioning began in early January with the TIM and SIM acquiring *first-light* data on January 11 and March 3-5, respectively. The team was thrilled to begin normal science operations on March 14, marking the official start of the 5-year prime mission. The TSIS era is officially here!

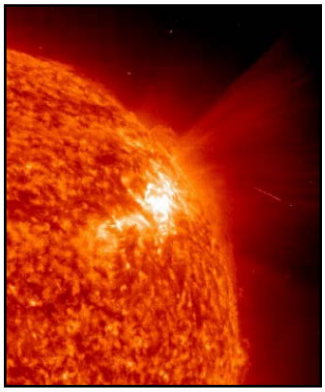
The TSIS hardware is performing flawlessly and preliminary total and spectral solar irradiance data are looking good. All systems are operating within their expected ranges. The ISS structure itself has made data collection interesting, as it imposes time-variable obstructions into the instrument fields-of-view. While these and other interruptions were expected, they do require monitoring by the science team. LASP at the University of Colorado is handling the instrument operations and science data processing for TSIS.

MuSIL Analysis Technique –

Tom Woods et al., recently published a paper in *Solar Physics* (May 2018) called "Decoupling Solar Variability and Instrument Trends using the Multiple Same-Irradiance-Level (MuSIL) Analysis Technique." The complete reference is: Woods, T. N., F. G. Eparvier, J. Harder, and M. Snow (2018), *Solar Physics*, 293, 76. It is available at: https://doi.org/10.1007/s11207-018-1294-5.

Abstract: The solar spectral irradiance (SSI) dataset is a key record for studying and understanding the energetics and radiation balance in Earth's environment. Understanding the long-term variations of the SSI over timescales of the 11-year solar activity cycle and longer is critical for many Sun–Earth research topics. Satellite measurements of the SSI have been made since the 1970s, most of them in the ultraviolet, but recently also in the visible and near-infrared. A limiting factor for the accuracy of previous solar variability results is the uncertainties for the instrument degradation corrections, which need fairly large corrections relative to the amount of solar cycle variability at some wavelengths. The primary objective of this investigation has been to separate out solar cycle variability and any residual uncorrected instrumental trends in the SSI measurements from the *Solar Radiation and Climate Experiment* (SORCE) mission and the *Thermosphere, Mesosphere, Ionosphere, Energetic, and Dynamics* (TIMED) mission. A new technique called the Multiple Same-Irradiance-Level (MuSIL) analysis has been developed, which examines an SSI time series at different levels of solar activity to provide long-term trends in an SSI record, and the most common result is a downward trend that most likely stems from uncorrected instrument degradation. This technique has been applied to each wavelength in the SSI records from SORCE (2003 – present) and TIMED (2002 – present) to provide new solar cycle variability results between 27 nm and 1600 nm with a resolution of about 1 nm at most wavelengths. This technique, which was validated with the highly accurate total solar irradiance (TSI) record, has an estimated relative uncertainty of about 5% of the measured solar cycle variability. The MuSIL results are further validated with the comparison of the new solar cycle variability results from different solar cycles.

SIST Meeting Summary –



SORCE scientists and collaborators participated in the 3rd and final NASA SIST Workshop for the 2014-2017 three-year award. The primary purpose of the Solar Irradiance Science Team (SIST) research is to support the development of space-based data sets of total and spectral solar irradiance (TSI and SSI). The data sets will be used as input to global models to investigate solar variations and their impacts on the Earth climate and atmospheric composition.

The team met in early May 2018 to summarize their primary results. Each team presented a summary of their project goals, results, and future plans. One common theme was on how the various teams can work together for mutual benefit.

The SIST team discusses missions from the entire satellite era.

ROSES 2017 offered a second 3-year opportunity for SIST proposals for 2018-2021, with the following description: “The primary purpose of the Solar Irradiance Science Team (SIST) is to support the development of consistent multi-instrument/multi-platform space-based data sets of solar irradiance (both total and spectrally resolved)”. Selections were announced in March 2018. Tom Woods will be the SIST program leader for the new 3-year SIST award.

2018 EGU General Assembly –

Three SORCE/TSIS representatives attended the 2018 European Geosciences Union (EGU) General Assembly, held April 8-13 in Vienna, Austria. SORCE science data processing representative Tom Baltzer had the opportunity to meet with many scientists to discuss TSI and SSI data dissemination options. He also attended many interesting talks covering various topics related to spectral irradiance and the importance of these measurements for meteorological and climate models.

Peter Pilewskie and Odele Coddington participated in the session, “Solar Total and Spectral Irradiance, Recent Observations and Results, Links with Models, and Possible Consequences for Climate.” As part of this session, they presented SORCE and TSIS contributions towards improving our understanding of the Sun’s influence on past and present climate. Peter’s invited talk, *TSIS-1 and Continuity of the Total and Spectral Solar Irradiance Climate Data Record*, joined other oral presentations on satellite observations of incoming and outgoing Earth radiant energy, solar irradiance reconstructions, and solar influences on climate. These themes continued into the poster session. Odele’s presentation, *Recent Advances of the NOAA Solar Irradiance Climate Data Record and Comparisons with Independent Datasets*, further demonstrated the importance of the SORCE observations that form the basis of the NOAA Solar Irradiance CDR. Odele identified areas where new and ongoing satellite observations, such as by TSIS-1 and the Ozone Monitoring Instrument (OMI), are expected to contribute to a more complete understanding of solar irradiance variability as reproduced by models.

Jerry Harder Retires –

With a grin from ear to ear, Jerry Harder announced his retirement. Jerry has been at CU/LASP for over 20 years where he has made invaluable contributions to the LASP SORCE and TSIS solar missions. Jerry led the development of the game-changer instrument for SORCE called the Spectral Irradiance Monitor (SIM) and continues to analyze data from SIM.

Colleagues, friends, and family helped Jerry celebrate with a special lunchtime gathering on Friday, May 18. Although Jerry’s official last day in the office was May 18, Jerry will still be part of the SORCE team working remotely from his new home on Colorado’s western slope. He and his wife are looking forward to more free time to enjoy their view in a much quieter part of Colorado. Jerry’s contact information at LASP will remain the same.

2018 AGU: Solar Session –

SORCE and TSIS scientists have submitted a session topic for the 2018 Fall AGU Meeting focusing on solar irradiance measurements and modeling. This year’s meeting will be held in Washington, DC, Dec. 10-14, and we hope you will consider submitting an abstract to the following SPA-Solar and Heliospheric Physics session:

Solar radiative variability: from minutes to millennia. The Sun’s influence on the Earth’s space environment, atmosphere, and climate (#48481)
Primary Convener: Marty Snow (LASP).
Co-conveners: Peter Pilewskie, Natalie Krivova, and Odele Coddington

Description:

Variability of the incoming solar irradiance and its effects on the terrestrial environment and climate have received wide attention in recent years. There is a

continuous effort to reduce measurement uncertainties of the total and spectral solar irradiances. Physical and empirical modelling have also made considerable progress in reconstructing accurate and reliable records. At the same time, models and observations have been extensively used to characterize the influence of solar irradiance variability on Earth's atmosphere and climate. This session invites abstracts on measurements and models of solar spectral and total irradiance on all time scales – including the recently launched Total and Spectral Solar Irradiance Sensor (TSIS-1) – as well as abstracts on the response of the surface, atmosphere and the heliosphere to solar radiative forcing. Abstracts focused on comparisons of surface and atmospheric effects to different solar radiative forcing are particularly welcome.

SORCE Selects Summer Undergrad Research Students –

Each summer, the SORCE mission funds student research projects in concert with the University of Colorado's Research Experience for Undergraduates (REU) program. For ten weeks, the students come to Boulder, Colorado, to work with SORCE scientists on a research project involving measurements from SORCE. The program pays for the students' travel costs and housing, plus a $500/week stipend.

This year the program started the week of May 29th at LASP with a 1-week lecture series on Solar and Space Physics from experts in the field. The program will run through August 3rd, ending with a student symposium where the students present their findings. Marty Snow is the REU Program Organizer for the entire program which includes 27 REU students working interesting solar and space physics projects in several Boulder locations.

The first week of the program, the 2018 REU students and mentors enjoyed a Welcoming BBQ, hosted by REU program leader Marty Snow at his mountain home.

For 2018, three SORCE-related projects were selected for the REU program. The project title, mentors, and the REU student selected are:

- ***Machine Learning for the Prediction of Solar Flares***
  REU Student: Caroline Mather, Carleton College, Northfield, MN
  Mentor: Laura Sandoval (LASP)
- ***Walking the Line: Investigating the Impacts of Different Linear Regression Techniques on Proxy Model Estimates of Solar Irradiance***
  REU Student: Ian McComas, Red Rocks Community College, Lakewood, CO
  Mentor: Odele Coddington (LASP)
- ***Understanding Solar Activity During the Last 400 Years***
  REU Student: Sam Hollenbach, Macalester College, St. Paul, MN
  Mentors: Andres Muñoz-Jaramillo (SwRI) and Marty Snow (LASP)

As an REU introductory group project during the first week students had the opportunity to launch a stratospheric balloon (above) and then watch the telemetry (below).

GOES-17/S Sees First Light –

On May 10, after a week and a half of off-pointing and baking to outgas contaminants, a cooled-off EXIS FM-2 was pointed back at the Sun and got first light on the Extreme Ultraviolet Sensor (EUVS) channels. The team ran through EUVS-C integration time tests, flat field lamp tests, ASIC gain tests, and filter checks. Everything looked great and there were no surprises or anomalies. Scientists are now happily combing through the new data. Start-up activities will continue over the coming months.

Launched on March 1, 2018, GOES-S is the 2nd in a series of NOAA's GOES satellites that include the Extreme ultraviolet and X-ray Irradiance Sensors (EXIS) built at LASP. The EUVS and the X-Ray Sensor (XRS) are the two instruments on EXIS. They continually monitor the Solar Spectral Irradiance (SSI) of the Sun. High cadence measurements (1-second and 3-second cadence) are averaged to produce a full spectrum every 30 seconds in X-ray and UV light – wavelengths that are absorbed by the outer-most layers of Earth's atmosphere and ionosphere.

Like SORCE SOLSTICE, EXIS is able to measure changes in the Magnesium Index, but with better precision and much higher frequency (every 3 seconds) than for any previous satellite. It measures Lyman alpha every 1 second. GOES also is tracking rapid changes in the Sun associated with solar flares.

GOES-S launch on March 1, 2018, from Kennedy Space Center.

Upcoming Meetings / Talks –

SORCE scientists will present papers or attend the following 2018 meetings/workshops:

2018

Triennial Earth-Sun Summit (TESS 2018), May 20-24, Leesburg, Virginia

Conference on Space Operations (SpaceOps 2018) May 28-June 1, Marseille, France

Scientific Computing with Python, July 9-15, Austin, Texas

AMS 15th Conference on Atmospheric Radiation, July 9-13, Vancouver, BC, Canada

COSPAR 2018, July 14-22, Pasadena, California

IAU General Assembly, August 20-31, Vienna, Austria

European Space Weather Week, Nov. 5-9, Leuven, Belgium

Astronomical Data Analysis Software and Systems (ADASS), Nov. 11-15, College Park, Maryland

AGU Fall Meeting, Dec. 10-14, Washington, DC