TSIS / SORCE News

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

Jan.-March 2019

Save the Date!

Please mark your calendar <u>today</u> to join us in January 2020! That sounds like a long ways a way, but time flies! We encourage your participation and hope that you will share this "Save the Date" announcement with colleagues.

2020 Sun-Climate Symposium
Tucson, Arizona
Jan. 27-31, 2020

We are pleased to announce the 2020 Sun-Climate Symposium, which is sponsored by the Sun-Climate Research Center – a joint venture between NASA GSFC and CU/LASP. Our focus topic for this 3.5-day meeting is ***"What is the Quiet Sun and What are the Subsequent Climate Implications?"*** Like our past meetings, the format will consist of invited and contributed oral and poster presentations in several themed sessions. The Call for Abstracts will be advertised in spring – stay tuned.

The sunset in beautiful Saguaro Natl. Park, just west of Tucson.

Science Overview

What is the quiet Sun? Is it a time-invariant base level or is there secular variability in the Sun's radiative output? What do those alternate scenarios imply for Earth-climate responses? The current solar minimum provides an opportunity to answer these and related questions.

Observations of the Sun and Earth from space have revolutionized our view and understanding of how solar variability and other natural and anthropogenic forcings impact Earth's atmosphere and climate. For more than four decades the total and spectral solar irradiance and global terrestrial atmosphere and surface have been observed continuously, providing unprecedented high-quality data for Sun-climate studies. The 2020 Sun-Climate Symposium will convene experts from across the solar-terrestrial community, including the disciplines of climate research, atmospheric physics and chemistry, heliophysics, and metrology, to discuss solar and climate observations and models over both spacecraft-era and historical timescales. Sessions will be organized around the following tentative themes:

1. **The Sunset of SORCE:** This NASA mission has provided some of the longest solar-irradiance data sets in the 40-year record.
2. **Recent/Space Era Solar Cycle Timescales:** How well is the quiet Sun understood and how have recent solar cycles influenced Earth's climate and atmosphere?
3. **Secular Timescales:** What are the long-term changes in solar variability? What are the paleo-climate effects?
4. **Observational Predictions:** What are expectations for the next solar cycle and what are climate-change scenarios for the upcoming decades? What future measurements are expected to improve knowledge of Sun-climate connections?
5. **A New Reference Spectrum for Remote Sensing:** What solar spectra are being used by the model and remote sensing communities?
6. **Looking Ahead – Future Observations of the Sun and Earth:** What is planned for the next generation of solar and terrestrial observations?

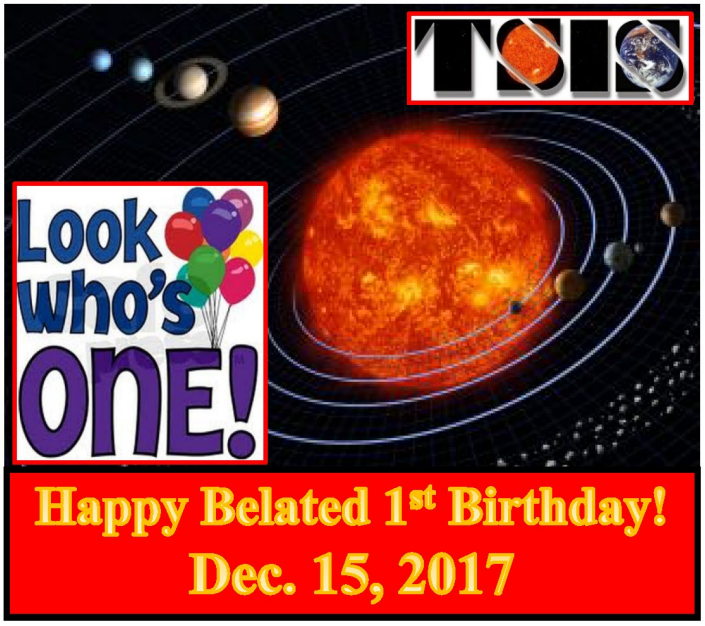
Location / Venue

Tucson, Arizona is most famous for its dramatic beauty! The Sonoran Desert covers this region with spectacular cacti – including the giant saguaro, a symbol of the American Southwest. They have captivated visitors for decades. To complement the legendary year-round sunshine and saguaro- and sunset-landscape, there are scenic mountain ranges surrounding the city. On the flip-side to its Old West heritage, Tucson offers a thriving visual and performing arts scene, not to mention the amazing restaurants (UNESCO designated City of Gastronomy). Once you immerse yourself in the laid-back atmosphere of Tucson, you may never want to leave!

We will be meeting at the ***Tucson Marriott University Park Hotel,*** a state-of-the-art full service conference facility near the University of Arizona campus. The hotel was opened in 1996 in a 9-story historical building and renovated in 2008. The hotel is undergoing another major renovation (just for us!) which will be completed this fall.

2020 Sun-Climate Symposium Website

The 2020 Sun-Climate Symposium website is under development and will be updated with new information regularly. Check it out at: http://lasp.colorado.edu/home/sorce/news-events/meetings/.



TSIS: The 1st Year –

By Peter Pilewskie – LASP, University of Colorado

The Total and Spectral Solar Irradiance Sensor (TSIS-1) has officially been in normal science mode for one year – as of March 14 – of its 5-year mission. While the Sun has been quiet as it approaches a minimum in its 11-year activity cycle, the TSIS total and spectral irradiance monitors – the TIM and SIM, respectively – continue to acquire valuable data while they observe simultaneously with their SORCE counterparts. This overlap period will continue through the remainder of this year after which the TSIS-1 solo journey begins. So even though we've not seen much change in the Sun since TSIS began making measurements, the data provides valuable information about the performance of both sets of instruments.

What we have learned so far about the TSIS-1 TIM and SIM is promising. Comparisons between the TSIS and SORCE TIM instruments show that they agree within their respective uncertainties, even though they were calibrated at the component level 15 years apart. The performance of TSIS-1 SIM, the first rebuild of the trail-blazing SORCE SIM, has been equally impressive. The changes in design of the TSIS-1 SIM, based on lessons learned from SORCE, appear to have achieved their expected results. Tune in to the next issue for more details of the status of TSIS-1

More details coming!
Our next newsletter will include updates on TSIS TSI and TSIS SSI.

TSIS visible in Dec. 2018 ISS survey photos.
See more ISS images at https://www.nasa.gov/mission_pages/station/images/

SORCE Team Preparing for Final Data Archive –

By Stéphane Béland – LASP, University of Colorado

With the SORCE mission coming to an end, the Mission Operations and Data Systems teams at LASP have been preparing for the decommissioning of the spacecraft and the final processing and archival of the mission data sets. The "Science Data Reprocessing Plan" document has been released and the SORCE Decommissioning Peer Review took place on March 1st 2019. A decommissioning plan was presented to ensure the safe and adequate disposal of the spacecraft. A schedule was proposed for the various upcoming reviews and required documentation with a list of the final science observations, data reprocessing, review and validation, as well as the final data archive. The SORCE mission is planned to enter Phase-F in July 2019, and will stop taking measurements by the end of 2019 and provide the final data release with all the supporting documentations to the NASA GSFC DAAC archive by September 2020.

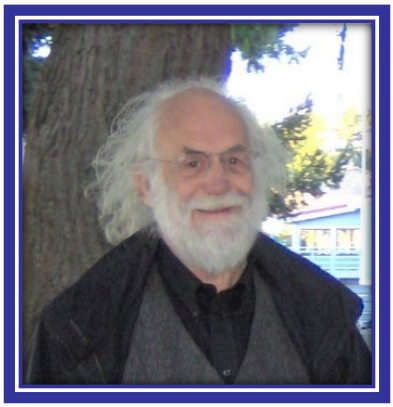
In preparation for the final data re-processing, the SORCE instrument teams are planning several observations and processing updates:

1. Running special calibration experiments during the mini-eclipse season (Dec 2018, June 2019, and Dec 2019).
2. Improve ephemeris and altitude calculations using the SPICE-based method from TSIS-1.
3. Fill in the SORCE SIM data gap between 306nm and 310nm.
4. Use the calibrated TSIS-1 SIM IR irradiance to assign an absolute irradiance to the SORCE-SIM IR data which was never calibrated on the ground.
5. Use TSIS-1 data to investigate possible scattered light in the SORCE SIM.
6. Add stellar observation with SOLSTICE to improve the long-term degradation model.
7. Check if SORCE SOLSTICE grating up-scan and down-scan intensities have consistent differences independent of wavelength and over the mission.
8. Continue to study the TSIS-1 SIM trends and their comparisons to SORCE SIM and SORCE SOLSTICE.

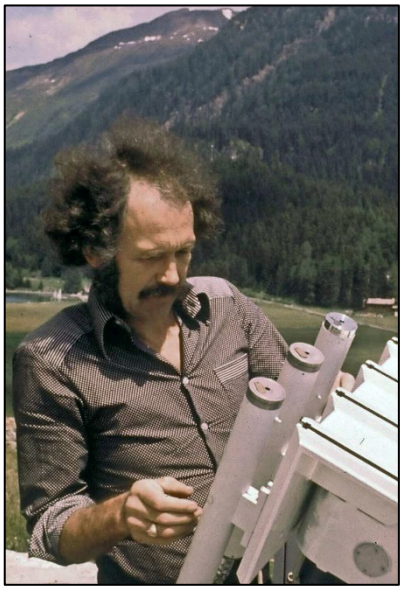
Claus Fröhlich

October 10, 1936 – February 22, 2019

From PMOD / WRC



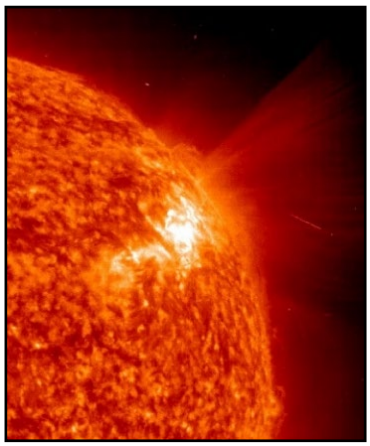
Until almost his last day, Claus Fröhlich put his heart and soul into being a researcher. He came to the Physikalisch-Meteorologisches Observatorium Davos (PMOD) in 1969 as a physicist. His PhD thesis in the field of solid-state physics at the ETH Zurich was awarded a medal in the same year. With his willingness to take over the leadership of the newly created World Radiation Center, the specialist in heat conduction enabled the Center to be established at PMOD and, as such, revived the institute's traditional focus on instrument development. In 1975, Fröhlich took over as institute director and in the same year oversaw the relocation of the now PMOD/WRC institute to the former schoolhouse of Davos Dorf, and subsequently its official opening two years later.



Until his retirement in 1999, Fröhlich was also a lecturer at the ETH Zurich until 2001 when he was 65. An important milestone for the development of the PMOD/WRC was the development of space experiments under the direction of Claus Fröhlich. His most important project, the VIRGO (Variability of Solar Irradiance and Gravity Oscillations) space experiment, was managed by him even after retirement. Through instruments onboard the SOHO (Solar and Heliospheric Observatory) satellite, operating since 1995, he was able to study solar irradiance variability in an eleven-year cycle. As the mission, originally planned for three years, still provides data to this day, Claus Fröhlich was examining the possible variability over an even longer period of time. Only a few days before his death, he was working on the latest calibration parameters, which ensure the continuity of the data.

The SORCE and TSIS teams are going to miss Claus's expertise, insight, optimism, and passion!

SIST-2 –



SORCE scientists and collaborators will be participating once again in a NASA program called the Solar Irradiance Science Team (SIST)". The primary purpose of the SIST research projects 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. SIST-2 is a follow-on to SIST-1, which was a 3-year NASA award given in 2015. For the 2018 SIST-2 program, NASA awarded five of the eight proposals to SORCE scientists:

- *Decoupling Solar Variability and Instrument Trends over SC 21 to SC 24 to Develop an Improved SSI Composite Record* (PI: Tom Woods, LASP)
- *MAGnesium II: Proxy for IrradiancE (MAGPIE). Improving irradiance modeling through better understanding of variability in the facular proxy* (PI: Marty Snow, LASP)
- *SORCE/TSIS Overlap Analysis: Absolute Scale Comparison, Stability Estimates, and Cycle 23/24//25 Record Construction* (PI: Stéphane Béland, LASP)
- *TSI Reconstructions Based on Updated TSI Composite and Sunspot Records* (PI: Greg Kopp, LASP)
- *Next Generation Solar Irradiance Variability Models* (PI: Judith Lean, NRL)

The other three awards went to:

- *Validation and Continuation of the V2 Composite SSI Data Set* (PI: Matt DeLand, SSAI and NASA/GSFC)
- *Comparing spacecraft TSI and SSI with proxies from space- and ground-based images* (PI: Gary Chapman, California State University – Northridge)
- *Improved SUSIM Solar UV Spectral Irradiances* (PI: Harry Warren, NRL)

The first SIST-2 Meeting is tentatively set for Sept. 24-25 in Gaithersburg, MD. The SIST-2 team lead, Tom Woods, envisions a 2-day agenda to include individual project overviews, status of current plans, plenty of workshop time for each project team, and then concluding with a full team gathering to report results and discuss future plans. As in the past, the SIST program is a 3-year award.

Happy Belated Birthday!

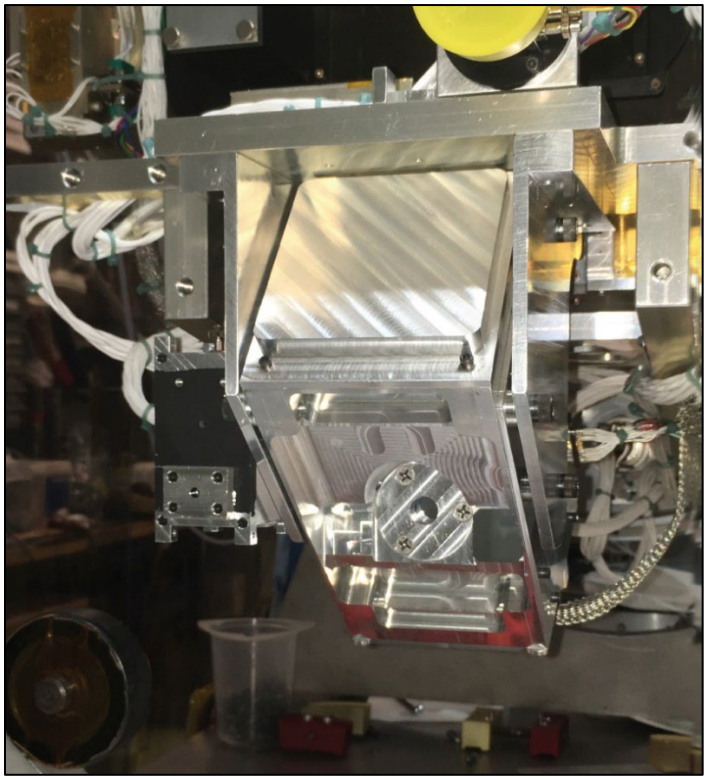
SORCE celebrated its
16th birthday on **Jan. 25!**
Pretty good for a 5-year mission!

Go SORCE!

Compact SOLSTICE –

By Jerry Harder – LASP, University of Colorado

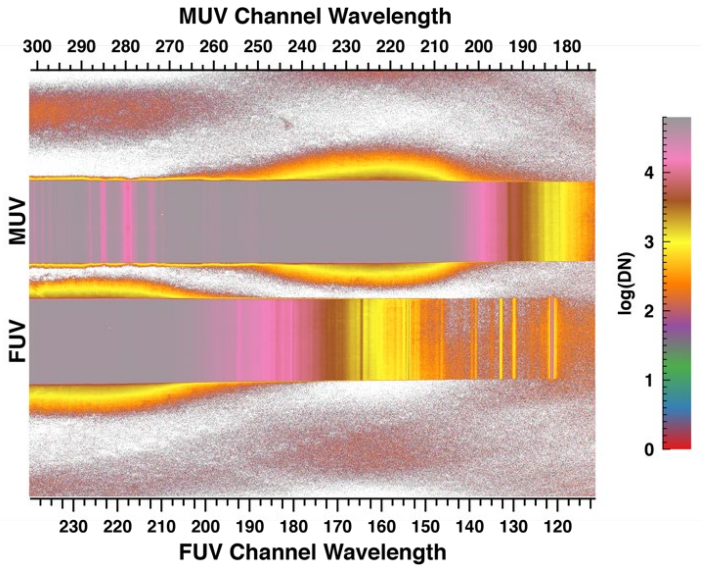
On June 18, 2018, NASA rocket 36.336 was launched from White Sands Missile Range. Onboard this flight was the Compact SOLSTICE (CSOL) instrument, which served as an under-flight calibration for the SORCE SOLSTICE instrument. The SORCE program developed the CSOL and it has capability to acquire the full 110-300 nm spectral range at a 10-sec cadence. The highly compact nature of the CSOL instrument will allow for future developments of FUV/MUV CubeSat-sized instruments that are capable of routine monitoring of solar irradiance. CSOL is also adaptable to other Earth-atmospheric and



CSOL mounted in the observatory section of NASA rocket 36.336.

planetary CubeSat applications that measure the UV spectrum. CSOL occupies about 10% the volume of the SORCE SOLSTICE while providing the same wavelength coverage and more importantly, it can be calibrated at the NIST Synchrotron Radiation User Facility (SURF) the same way that was done for SORCE SOLSTICE.

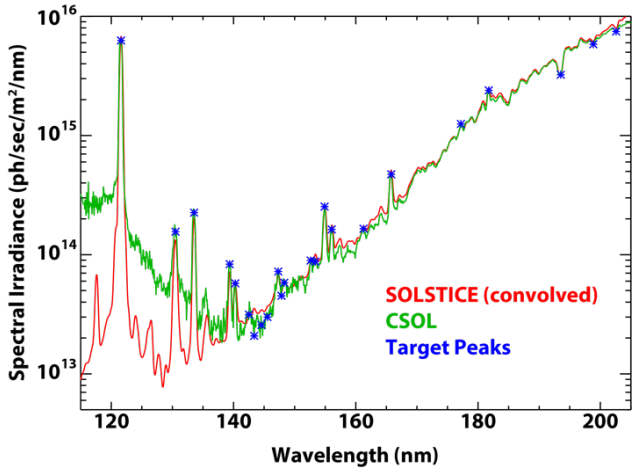
The Quicklook results (log scale) from the rocket flight, show excellent measurements for 115-200 nm and 250-300 nm. It is clear that CSOL got good data and these results meet SORCE calibration minimum requirements for 115-200 nm. Once the rocket payload arrived back at LASP, the SD-card inside the CSOL camera board was extracted. This revealed a full set of CSOL images, since only part of the CSOL images were transmitted in real-time to the ground during the flight.



This is a plot from in-flight data from CSOL acquired 276 seconds into the flight and the plot is a false-color image from the CSOL 2000x1504 CMOS camera showing the dispersion of light in two strips on the detector. The top strip is MUV spectrum from 172 to 300 nm and the bottom strip is the FUV spectrum 112 to 240 nm. The bright 'line' on the left side of the FUV channel is the Lyman-alpha line 121.6 nm. The plot is for a 10.24s integration time and shows detector saturation. The 10s integration period emphasizes the 110-200 nm FUV spectrum and the 270-300 nm portion of the MUV that includes the important Mg II region shown on the MUV portion of the image.

The preflight calibration of CSOL was conducted in April 2018 at NIST SURF and has been applied to a reference spectrum from CSOL. This preflight calibration was applied to the rocket flight data and a comparison with near-concurrent SOLSTICE observation was conducted. One of the challenges of observations in the FUV portion of the spectrum is the large dynamic range need for the detector response; another is properly accounting for scattered light in the spectral regions surrounding the Lyman alpha line at 121.6 nm. For CSOL, large portions of the signal are at or near the saturation limit of the detector, and we are still conducting analysis for these highly sensitive linearity and scattered light corrections.

Currently, the overall agreement between SOLSTICE and CSOL is around 7% over the majority of the spectrum. We are planning a post-flight calibration on CSOL at SURF in mid-March to ensure the validity of the preflight calibration. For our March calibration campaign, we will be emphasizing an understanding of the linearity of our CMOS detectors near the saturation limit of the detector and ensuring that the highly polarized nature of the SURF beam is not introducing additional uncertainty in the calibration. We may be able improve the accuracy of the CSOL rocket flight spectrum by a factor of two with these additional tests.



This is a comparison plot for the rocket flight on June 18, 2018 for the important 115-210 nm spectral range. Shown in red is the SOLSTICE high resolution spectrum convolved to match the lower resolution CSOL spectrum. Note this logarithmic scale on this plot covers about 3 orders of magnitude. Blue dots correspond to well-known absorption and emission features in the FUV spectrum that can be used as calibration points.

Finally, rocket flight 36.336 had two on-board cameras to monitor the flight. James Mason from the NASA GSFC condensed the data from these cameras and posted them for public outreach. The 4-minute video is at: https://www.youtube.com/watch?v=kDx1Huj8sgQ. Since the rocket flight was near the White Sands National Monument, the brilliant white sands can be seen several times during the flight. At the top of the atmosphere the rocket does a back flip, so the down-looking camera then looks towards the Sun. On decent, the situation reverses again. At 55 seconds the vacuum doors opens and solar observations are initiated. That strange looking cylinder on the door is a crush pad for the eventual landing. Look at the left-hand side of image at 1min25sec; on the far left you can see the Baja peninsula giving an indication of how far up in the Earth's atmosphere the rocket has flown. It is fun to watch so take a few minutes to enjoy – all the way to the end for an amusing confirmation on the June heat.

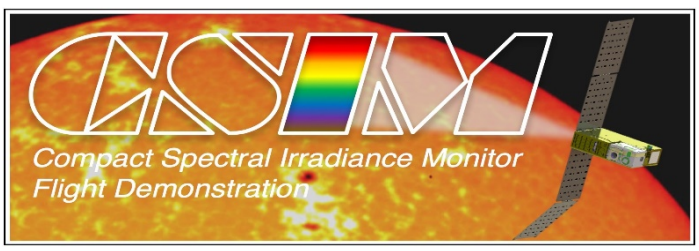
CSIM CubeSat –

By Erik Richard – LASP, University of Colorado

The Compact Solar Irradiance Monitor (CSIM) instrument is a miniaturized, yet fully-capable, version the SIMs flying on SORCE and TSIS. CSIM measures the daily spectrum of the Sun very accurately, continuous from the UV to the IR wavelengths — 96% of the full solar output. After launching on Dec. 3, 2018, CSIM transitioned to commissioning activities in January and will go to full science operations this week! CSIM is alive and healthy! Ground station passes (~10-minutes long) occur two times each day at the new CubeSat Mission Operations Center located on the LSTB 3rd floor.

To add a little background: by the end January commissioning activities demonstrated that all system operations, instrument performance, and communications systems were functioning as expected. But just to keep the team on their toes, in mid-January there was a troublesome hiccup when communication was lost with the CSIM CubeSat. After 2 weeks of brainstorming, trouble shooting and evaluating solutions, the team began to see CSIM radio beacons again, including first contact from an amateur tracker in New Zealand. From the telemetry received, the team was able to diagnose the full problem – a failed XB1 SD memory card. After up-linking a few software changes CSIM was successfully restarted with the SD card deactivated, putting CSIM in limited science mode with real-time passes only. There is a second, redundant SD card onboard and the team is hopeful that it can be used in the future to utilize the full capacity of available on-board storage, which would allow for more data collection.

You can follow CSIM's real-time orbit at: https://satnogs.org. Click on the "DB" tab and enter 43793 for the NORAD Cat ID, then click on the image of CSIM. If you have CSIM questions, please contact PI Erik Richard. Go CSIM!



Upcoming Meetings / Talks –

TSIS and SORCE scientists have or will present papers or attend the following 2019-2020 meetings/workshops:

2019

American meteorological Society (AMS) Annual Meeting, Jan. 6-10, Phoenix, AZ
ISSI Working Group: "Linking Solar and Stellar Variabilities", Feb. 11-15, Bern, Switzerland
Solar Diameter Workshop, Feb. 11-13, LATMOS, Guyancourt, France
Solar Cycle 25 Prediction Panel, March 7, Boulder, CO
Boulder Solar Day, March 12, Boulder, CO
Earth Science Data System Working Group (ESDSWG), March 19-21, Annapolis, MD
Space Weather Workshop, April 1-5, Boulder, CO
European Geosciences Union (EGU), General Assembly, April 7-12, Vienna, Austria
AAS/ SPD, June 9-13, St. Louis, MO
Space Climate 7 Symposium, July 8-11, Canton Orford, Quebec County, Canada
IUGG General Assembly, July 12-18, Montreal, Canada
Solar Irradiance Science Team Meeting, Sept. 24-25, Gaithersburg, MD
AGU Fall Meeting, Dec. 9-13, San Francisco, CA

2020

Sun-Climate Symposium, Jan. 27-31, Tucson, AZ

Gary Rottman, original SORCE PI, is enjoying his retirements in Durango, CO, shoveling out from their record-setting snow totals. Hang in there everyone – Spring is almost here!