SNS • SORCE News Source

Solar Radiation and Climate Experiment Monthly Newsletter December 2006

NIST Hosts TIM Optical Power Measurements –

By Greg Kopp, LASP, University of Colorado

Since the launch of SORCE in early 2003, the Total Irradiance Monitor (TIM) has been measuring total solar irradiance (TSI) values approximately 0.34% lower than the other currently flying TSI instruments ERBE, VIRGO, and ACRIM3 (see Figure 1). Recent optical power measurements of the ground-based SORCE/TIM Witness Unit at NIST do not indicate that the TIM is measuring erroneously low by this amount. Such collaborations with NIST throughout the SORCE mission have been extremely valuable to TIM calibrations and uncertainties.

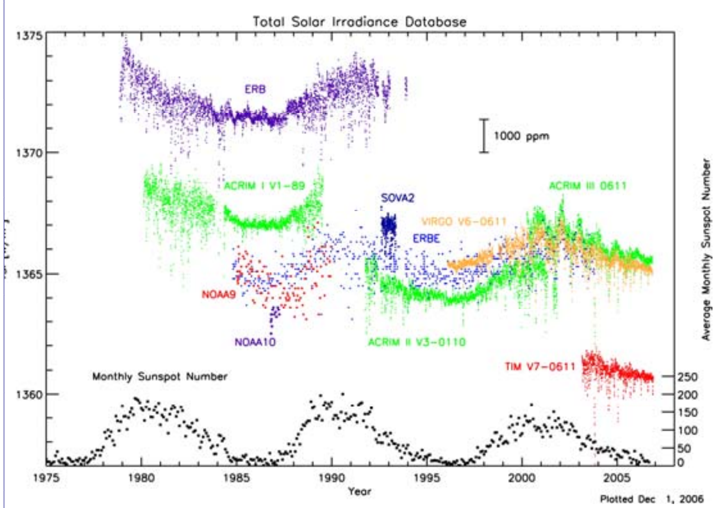


Figure 1. The SORCE/TIM continues the nearly 30-year long TSI record and will be succeeded by the Glory/TIM in 2008. Shown offsets on this absolute scale are due to instrument calibration differences that are not completely understood.

NIST researchers Allan Smith and Joe Rice hosted David Harber, Karl Heuerman, and Greg Kopp from LASP for a productive two weeks in November 2006. Using a meticulously prepared laser input beam at NIST/Gaithersburg, these researchers performed optical power comparisons between the TIM Witness Unit and NIST reference detectors. These are the first end-to-end optical power comparisons of a TSI instrument operating in vacuum to a NIST reference. This comparison was one of several suggestions to come from the TSI Accuracy Workshop hosted by NIST and NASA in 2005.

Figure 2. The NIST laser and optics provide a stable, high-power illumination source for the TIM.

The principal of this experiment is to compare the power measurements of a bright incident laser beam using both the TIM and a NIST-calibrated trap diode. These are not irradiance measurements, as the laser beam significantly underfills the detectors' apertures, which are of similar sizes on both the TIM and trap diode. Allan Smith of NIST created a very uniform, stable laser beam having comparable power level to that expected from the Sun by the TIM (see Figure 2). This beam was directly measured by the TIM instrument, operating in vacuum behind a Brewster window of known (and small) transmission loss. A small percentage of this beam is monitored by a trap diode transfer standard, which cannot operate at the higher power levels of the TIM. The trap diode measurement, corrected by the precisely-known percentage of the beam intensity sampled, indicates the total beam power incident on the TIM. A simplified schematic is shown in Figure 3.

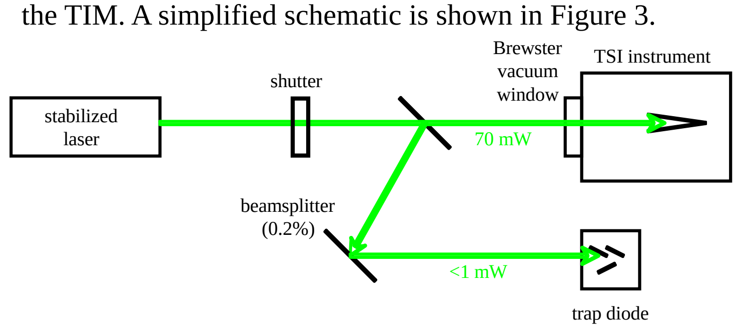


Figure 3. A stabilized, uniform, high power laser beam underfills the apertures of the TIM and a NIST reference trap diode. With corrections for the measured beamsplitter ratio and Brewster window transmission, the optical power measurements from the TIM and the trap diode are compared. The TIM operates in vacuum, as designed. Shuttering the incoming light removes thermal background contributions.

The resulting comparisons indicate that the TIM measures lower than NIST's reference by 0.12%; and there are artifacts of the laboratory comparison that suggest even this difference may be too large. In particular, the laser beam does not heat the interior of a TIM radiometer cavity as uniformly as the Sun does, but deposits its entire power in a small region of the cavity the most distant from the sensing thermistors, causing locally higher temperatures than the more uniform solar illumination seen on-orbit (see Figure 4). These higher temperatures may cause additional radiative losses that would err on the side of the TIM underestimating the power from the narrower laboratory laser beam.

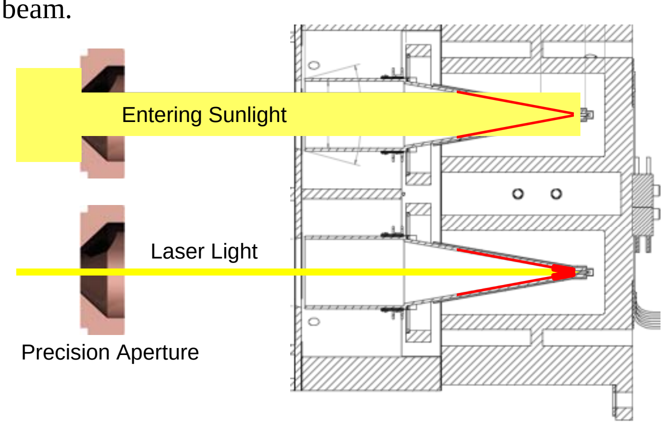


Figure 4. The 3 mm diameter laser beam (bottom) does not illuminate the same region of the TIM radiometer cavity that the 8 mm sunlight (top) does, causing a noticeable effect on the thermal servo system response to heating by the incident laser beam and by applied cavity electrical power.

Even aside from possible artifacts of the laboratory setup, this 0.12% difference is insufficient to explain the 0.34% offsets between the TIM and other TSI instruments, and may suggest the other TSI instruments are erroneously reporting values too high. A NIST calculation presented at the 2005 TSI Accuracy Workshop indicated that the three ACRIM instruments and the ERBE have not accounted for diffraction correctly, making their measurements erroneously high – the ACRIM by as much as 0.13%. Another workshop finding was that scatter off front surfaces of some TSI instruments may erroneously increase their measured TSI signal. All instruments except the TIM allow two to three times the amount of light intended to be measured into the instrument; thus any scatter into the instrument's radiometer cavity can systematically increase the measured signal. NIST is planning experimental validations of these missing diffraction corrections and possible scattering effects.

The results from our NIST measurements are that the SORCE/TIM, as represented by the ground-based TIM Witness Unit, may be low by no more than 0.12%; although even this difference may be too large and is being examined. This NIST comparison with the TIM supports a TSI value of 1362 W/m^2 or less, and does not explain the large discrepancies between on-orbit TSI instruments. Explanations that the other TSI instruments could be systematically too high have been suggested but have yet to be examined.

Future end-to-end TSI measurements are promising, as no flight TSI instrument has been measured end-to-end in irradiance mode and in vacuum to desired accuracy levels. NASA's Glory mission and LASP are creating the TSI Radiometer Facility (TRF) to compare a TSI instrument directly against a cryogenic radiometer. This facility benefits from the accuracies of cryogenic radiometry, works in irradiance (instead of merely power) mode, and allows both the cryogenic reference and the TSI instrument under test to directly measure the same input solar-intensity light beam by operating in a common vacuum. A future TRF modification will accommodate ground-based versions of other TSI instruments. Additionally, NIST is planning optical power and irradiance comparisons between existing TSI instruments and their trap diodes; this was another recommendation of the 2005 TSI Accuracy Workshop. Prelaunch end-to-end measurements of TSI instruments promises to identify and resolve large offsets between instruments and improve absolute accuracy. Until good absolute accuracy is achieved, the long-term TSI record relies on data continuity via mission overlap; and the short-term future for continued measurements is bright, with the SORCE/TIM, VIRGO, and ACRIM 3 funded to last until the launch of the Glory/TIM and the PICARD's TSI instruments in 2008.

SORCE and the Solar Cycle –

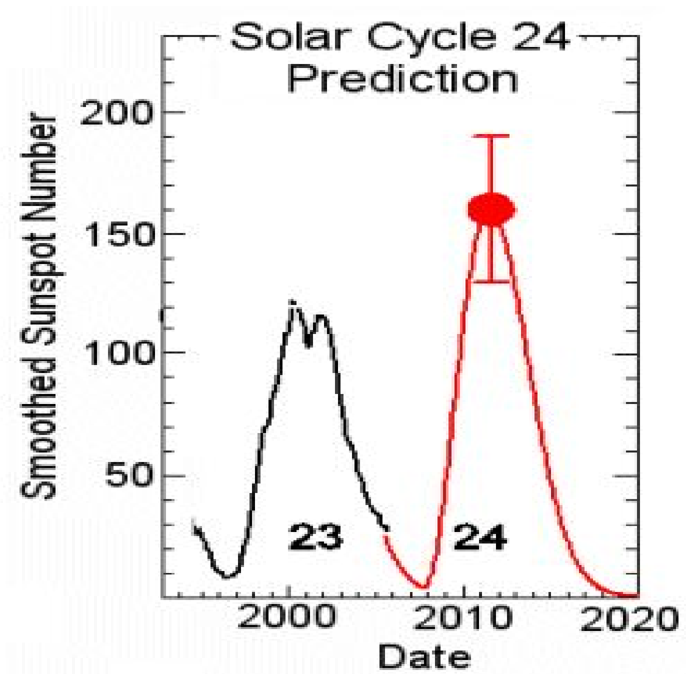
By Tom Woods, LASP, University of Colorado

The Fall 2006 AGU meeting was a buzz of news from the new solar missions (Japanese Solar-B renamed to Hinode and the NASA STEREO satellites), about predictions for the next solar cycle, and concerns about recent solar storm activity. The SORCE solar irradiance measurements contribute to the measurements of the recent solar activity, and an extended SORCE mission would provide measurements during the next solar cycle.

NASA and NOAA have a panel, chaired by Dean Pesnell and Doug Biesecker respectively, for predicting the magnitude of the next solar cycle. While this panel has not reached conclusions yet, some of the individual predictions were presented at the December AGU meeting. Solar irradiance variations, such as the 11-year solar cycle, are driven mainly by solar magnetic activity; consequently, the predictions for the next solar cycle are based primarily on magnetic activity. David Hathaway of MSFC (Marshall Space Flight Center, Huntsville, Alabama) has predicted that solar cycle 24 will be larger than our current solar cycle 23 as shown in the figure below. Hathaway's prediction is based on the geomagnetic activity during the previous solar cycle minimum. Another prediction for a larger solar cycle 24 is by Mausumi Dikpati at NCAR's High Altitude Observatory who uses a solar dynamo model of the past several solar cycles to make her predictions. In contrast, there is a prediction for a smaller solar cycle 24 based on magnetic field strength at the solar poles (e.g., by Todd Hoeksema, Stanford University).

More information about this panel and their initial solar cycle 24 predictions are given at:

- http://www.space.com/spacenews/businessmonday_061218.html
- http://www.space.com/scienceastronomy/060306_solar_cycle.html
- http://science.nasa.gov/headlines/y2006/21dec_cycle24.htm?list57065



Another aspect of the solar cycle is the timing of the peaks, both maximum and minimum. The solar cycle minimum was originally predicted for the fall of 2006. But this time has come and gone, and all data indicates, such as from SORCE solar irradiance instruments, that the solar activity is low but not yet solar cycle minimum level yet. Moreover, there has been significant solar activity in December. The large sunspot in December has produced 4 X (extreme) class flares and 7 M (medium) class flares. The SORCE instruments were making solar observations during many of these flares. For example, the SORCE XPS recorded an increase of the 0.1-7 nm irradiance by a factor of 25 during the X9 flare on 2006/339 (Dec. 5). Considering this recent burst of solar activity, the solar cycle minimum level is not expected until mid 2007 or later.

To submit information to this newsletter, please contact: vanessa.george@ lasp.colorado.edu.

Happy New Year!