NOAA ROSES Semi-Annual Report

Reporting Period: Sept 2021 – Feb 2021 (3rd report)

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Project Title: GOES High-cadence Operational Total Irradiance (GHOTI)

Executive Summary (1 paragraph max)

Analysis of the GOES-R series SPS instrument on EXIS to create a high-cadence proxy for Total Solar Irradiance and use the EUVS-C instrument to create a high-cadence MgII index record. These will be combined to create a high-cadence solar model spectra collection.

We are on schedule in our data calibration milestones.

Progress toward FY21 Milestones and Relevant Findings (with any Figs)

We have created orbital and temperature corrections for the GOES16 and GOES17 SPS detectors. We are continuing to remove some instrumental artifacts and have been fine-tuning our irradiance SPS calibration using TSIS-1 TSI 6-hour measurements. We have created our first high-cadence solar TSI proxy record from 2018-2022, based upon GOES16.

Due to computational demands, we are currently creating a 3-second TSI record, instead of the 4Hz that is possible with GOES-R SPS. Once algorithms are finalized, and sufficient computational resources have been acquired, with will re-consider the final data cadence.

We have begun creating and analysing Solar periodograms using the Lomb-Scargle techniques. This work also requires additional dedicated computational resources, which we are in the process of acquiring.

We presented our project goals and initial results at the European Geophysical Union (EGU21-10348), the Fall AGU 2021 conference, and the 5th Quadrennial Solar-Terrestrial Physics Symposium.

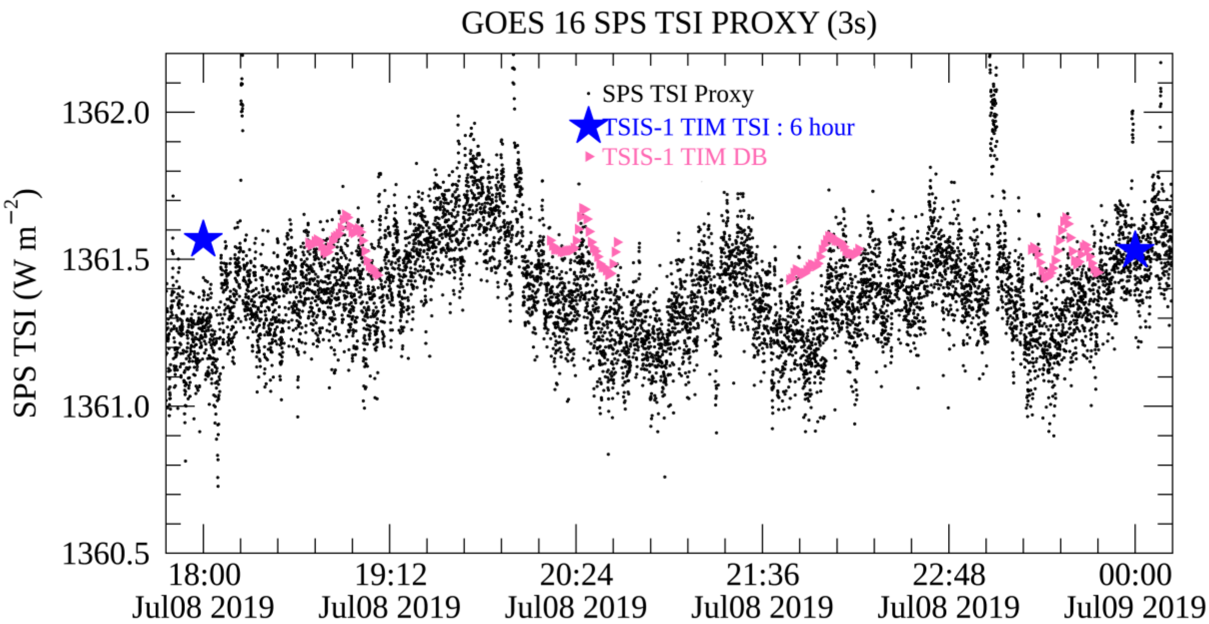

Figure 1: GOES16 SPS TSI proxy from July 2019 (black dots). Blue stars show the publicly available TSIS-1 TIM 6-hour TSI measurements versus the 3-second cadence of the GHOTI measurements. We are currently using the TSIS-1 TIM 6-hour measurements for our long-term SPS degradation correction, using the entire 6-hour window. We are converting to an algorithm that will only use GOES SPS data co-eval with the TSIS-1 TIM measurements, the pink database (DB) points. This should enhance the accuracy of our high-cadence TSI data product

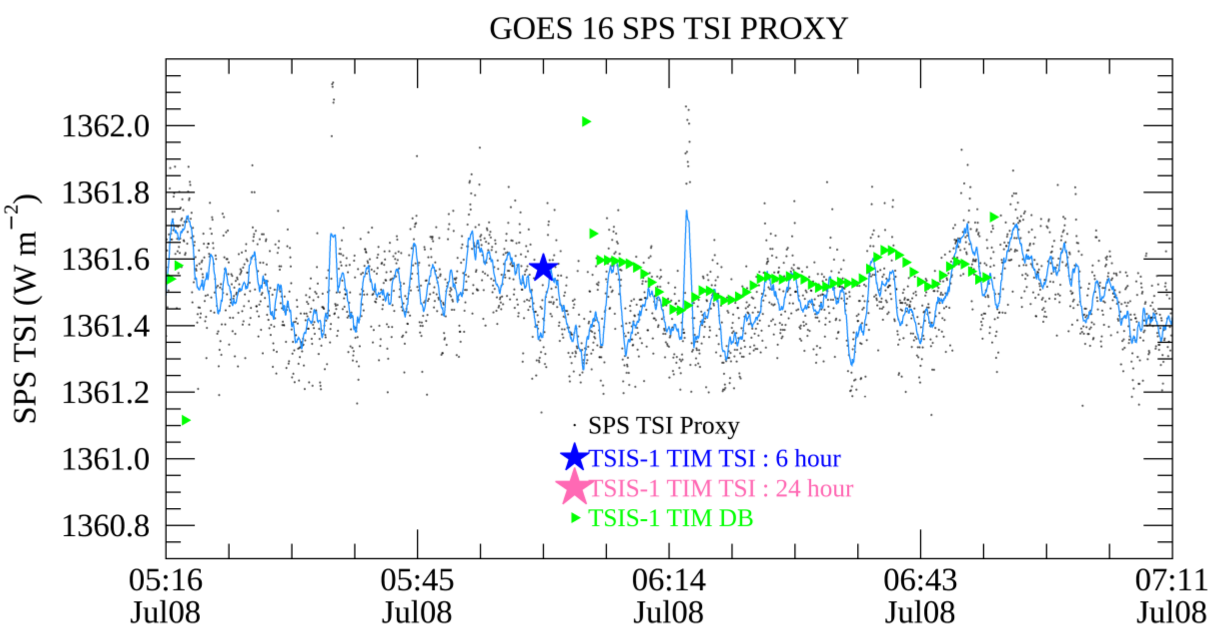

Figure 2: GOES16 SPS TSI proxy from July 2019 (black dots), TSI proxy resampled to TSIS-1 TIM data acquisition cadence (solid blue lines) compared to the TSIS-1 TIM internal database (DB in GREEN) measurements. The Blue star shows the only publicly-available TSIS-1 TIM TSI measurements during this time period (a 6-hour datapoint). We are currently using the TSIS-1 TIM 6-hour measurements for our long-term SPS degradation correction, using the entire 6-hour window.

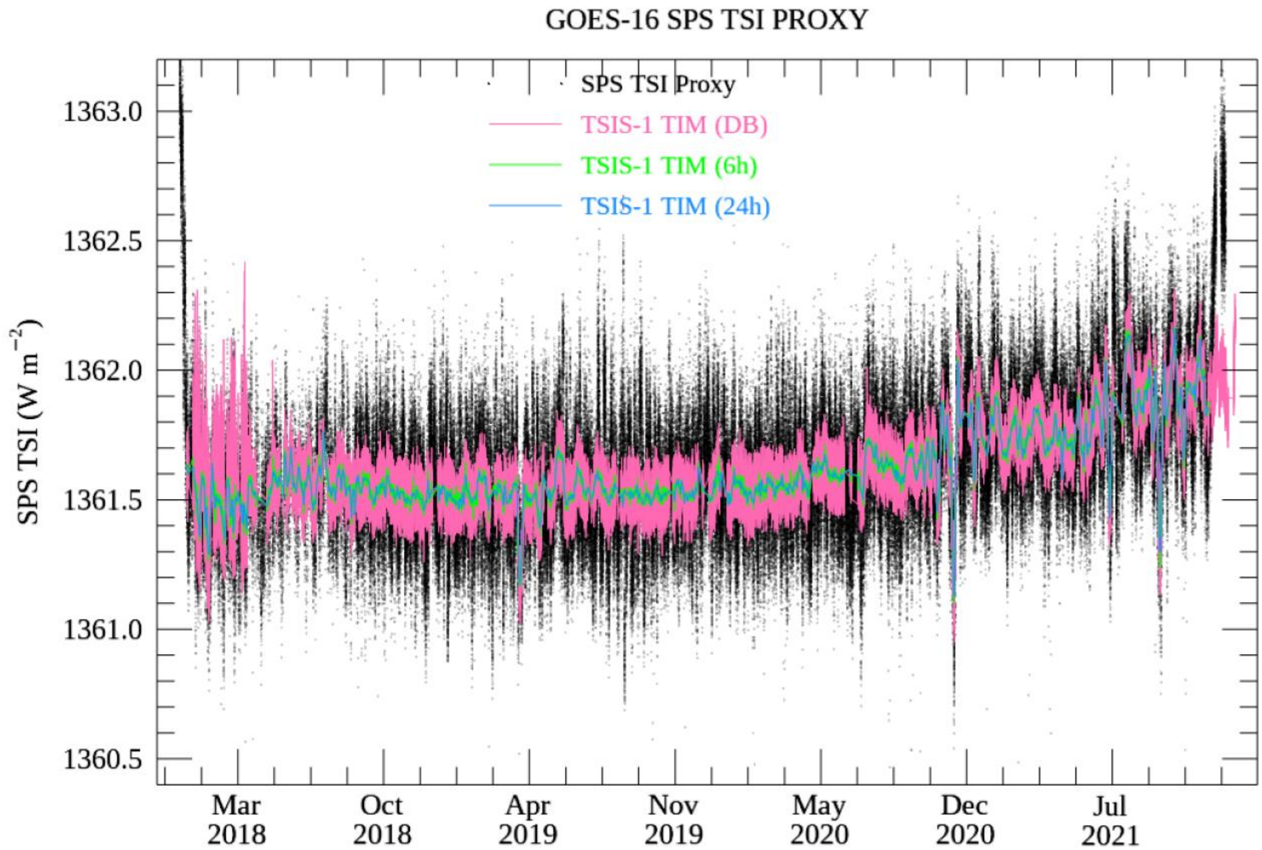

Figure 3: Long-term comparison of TSIS-1 TIM 24-hour (BLUE), TSIS-1 TIM 6-hour (GREEN), TSIS-1 TIM DB (PINK) versus the GOES SPS 3-second TSI-Proxy (Black). All records show the same trend of higher variability with shorter time scales.

Plans for Next Reporting Period

Data Calibration: Our data calibration goals for the next reporting period are

1) Additional corrections for spacecraft (e.g., pointing manuevers) and instrumental artifacts (e.g., noise spikes) for GOES SPS data,
2) We currently use the 6-hour publicly available TSIS-1 TIM TSI measurements to determine and apply a long-term degradation correction (see Figure 1, 2, & 3). We are changing our algorithm to use only the exact times TSIS-1 TIM was observing (the database, DB, measurements), instead of the entire 6-hour TIM window, for this calibration. This requires access to the TSIS-1 TIM databases at CU/LASP.
3) Quantify the accuracy of our calibrations using the real-time TSIS-1 TSI measurements from the internal instrument databases at CU/LASP.
4) Evaluate GOES-T (GOES18) SPS data, when available, and consider its suitability for this program.

Science:

The NRLSSI model (Coddington et al. 2016) creates full spectrum using two components: sunspot blocking and faculae. Using the TSI proxy from SPS and the MgII index from EXIS, we will derive a replacement for sunspot blocking. Using these inputs to the NRLSSI algorithm, we will begin producing a model spectrum at the cadence of our TSI-proxy (currently 3-sec).

Upcoming Presentations:

We are scheduled, or have submitted an abstract to present, or plan to attend the following conferences in 2022, and present work on this project.

1) Sun-Climate Symposium : https://lasp.colorado.edu/home/meetings/2022-sun-climate-symposium/
2) SPIE (Astronomical Telescopes + Instrumentation) (accepted)
3) AGU 2022 – Chicago (planned)

Student Projects : Investigator Martin Snow is recruiting students for two GHOTI related research programs. These are to be operated and funded by the South African National Space Agency. Project Descriptions are:

1. **What Causes TSI Variation?** Total Solar Irradiance (TSI) is the integrated solar spectrum. It has been measured regularly since 1978. It represents the total energy input to the Earth's climate system. It is 10^4 times bigger than all other energy sources combined. The variation in TSI may be small (fractions of a percent), but this variation is still critical to the climate system. We now measure the entire spectrum from space on a daily basis. Which parts of the spectrum are most important for TSI variation? In this project, the student will use the spectrum from the Total and Spectral Irradiance Sensor (TSIS-1) Spectral Irradiance Monitor (SIM) and the Solar Position Sensor (SPS) on the GOES-R series to understand how the spectral measurements can be used to create a proxy for TSI.

2. **Solar global oscillations from GOES measurements**: The Sun vibrates as sound waves move through the different atmospheric layers. On the Earth, geologists listen to seismic waves that travel through the bedrock. We can see these helioseismic waves in variations of the brightness of the Sun. One of the most well-known solar oscillations has a period of five minutes. These oscillations are routinely monitored by ground stations that are spread around the globe. They need to be global to prevent gaps in the time series as the Sun rises and sets on each station. Can we monitor these oscillations effectively from space? Geostationary Operational Environmental Satellites (GOES) measure solar irradiance variations without gaps at high cadence. This project will take data at several wavelengths to measure the periods of waves at different heights in the solar atmosphere.