Validation of Operational TSI using TSIS-1/SIM data

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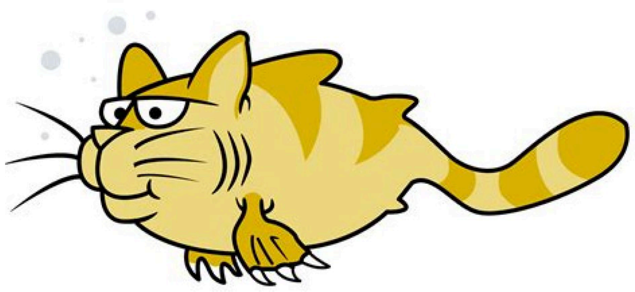
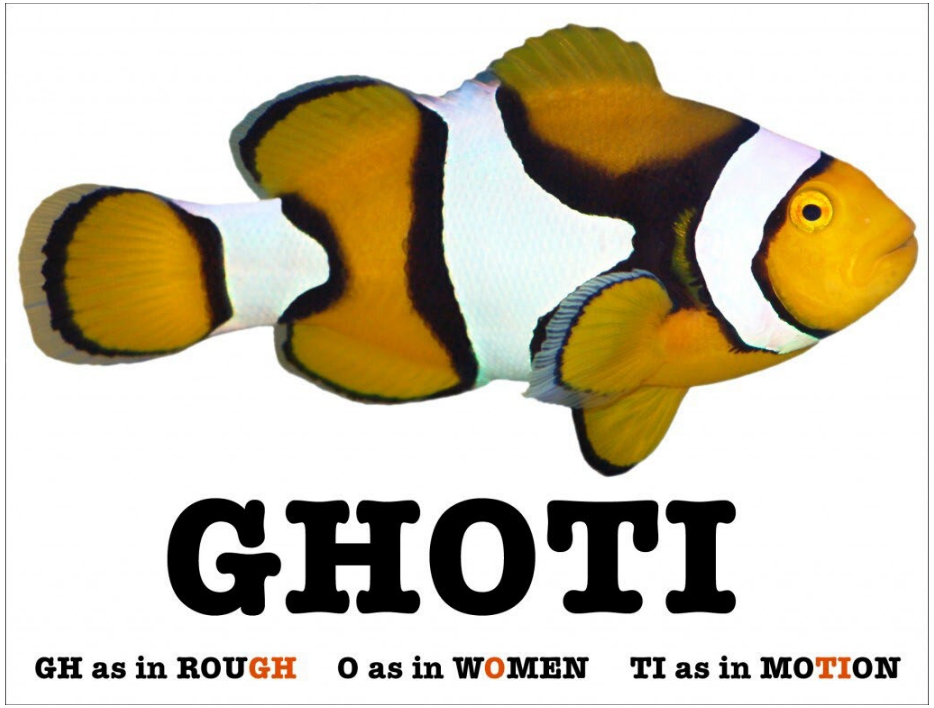
GOES High cadence Operational Total Irradiance

The goal of this NOAA-funded project is to investigate the possibility of producing a proxy for Total Solar Irradiance (TSI) from the Solar Position Sensor (SPS) on the GOES-R series.

This presentation will focus on the model of the SPS instrument output using solar spectral irradiance (SSI) from the TSIS-1 Spectral Irradiance Monitor (SIM).

The Penton et al. poster will show the SPS data.





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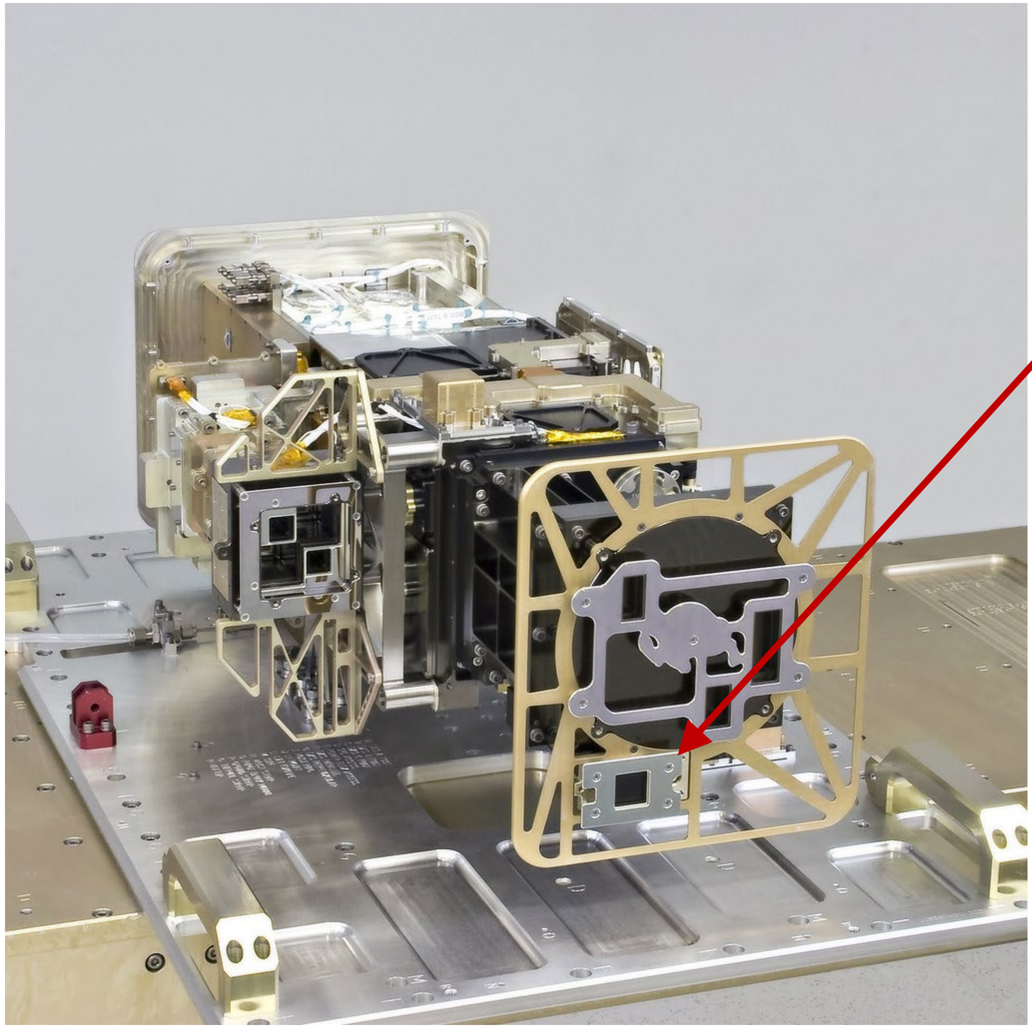
Extreme ultraviolet and X-ray Irradiance Sensor (EXIS)

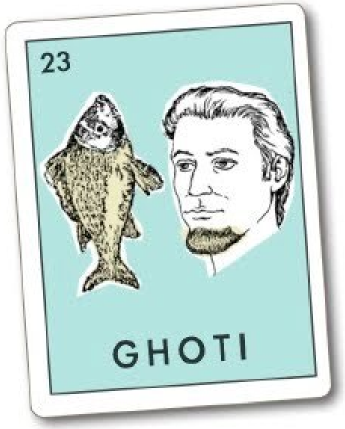


The EXIS instrument package includes the

XRS to measure hard and soft X-rays

EUVS to measure coronal, transition region, and chromospher

SPS to monitor pointing accuracy



GOES-16 Became operational in January 2017

GOES-17 Currently in on-orbit storage

GOES-18 Operational as GOES-West

GOES-U Waiting for launch

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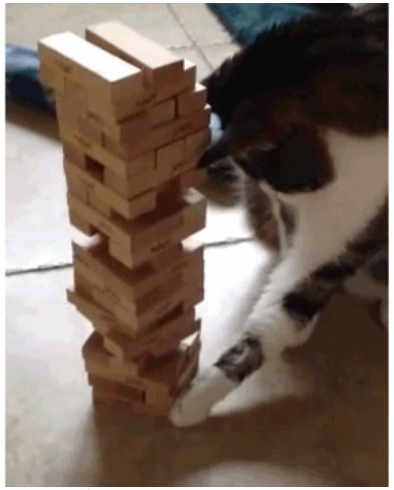
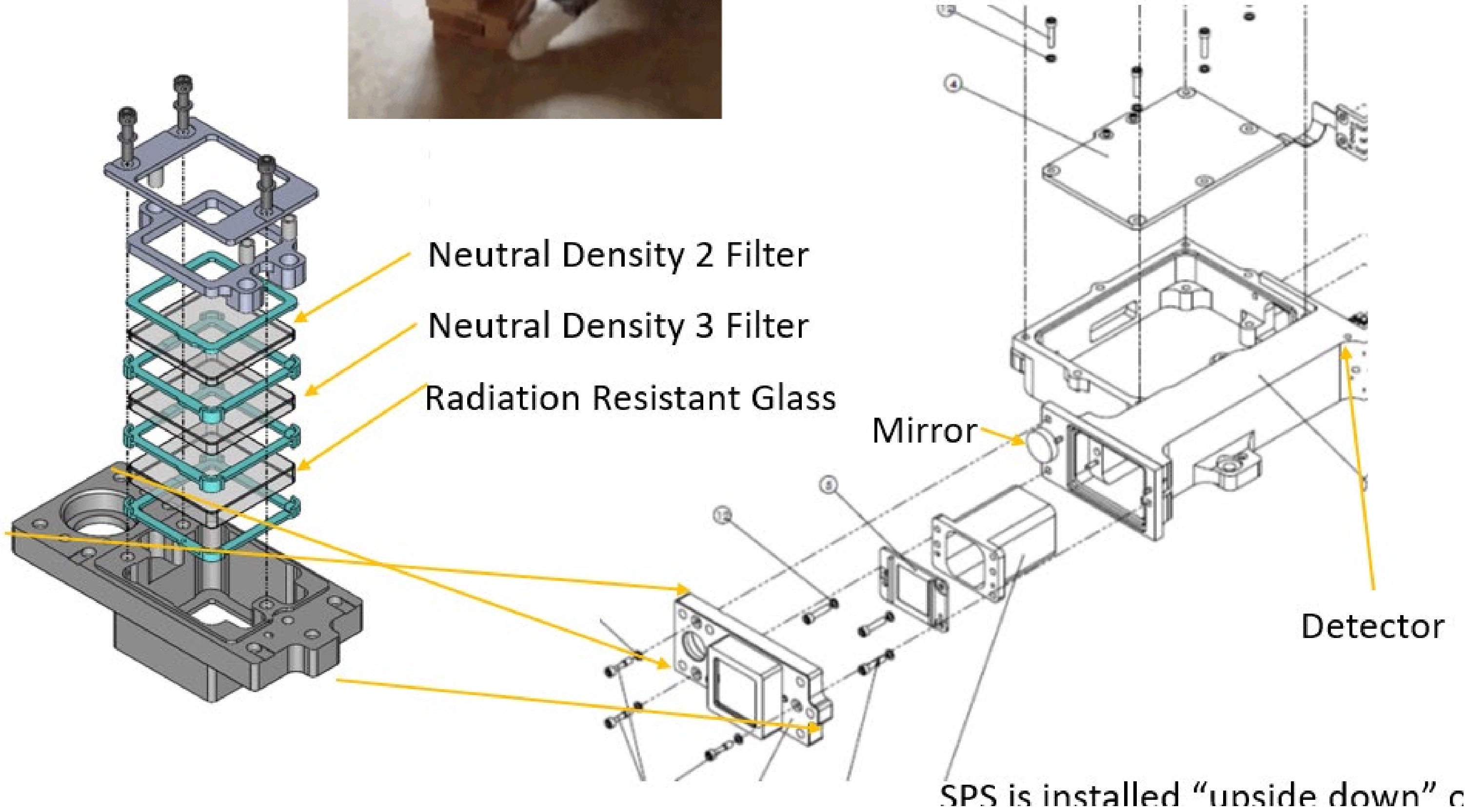
Inside the SPS

The SPS detector is a silicon quad-diode intended t
monitor the location of the Sun in the field of view
the other EXIS instruments.

The detector is protected by two neutral density filters and a radiation resistant glass filter.

Data cadence is 4 Hz.





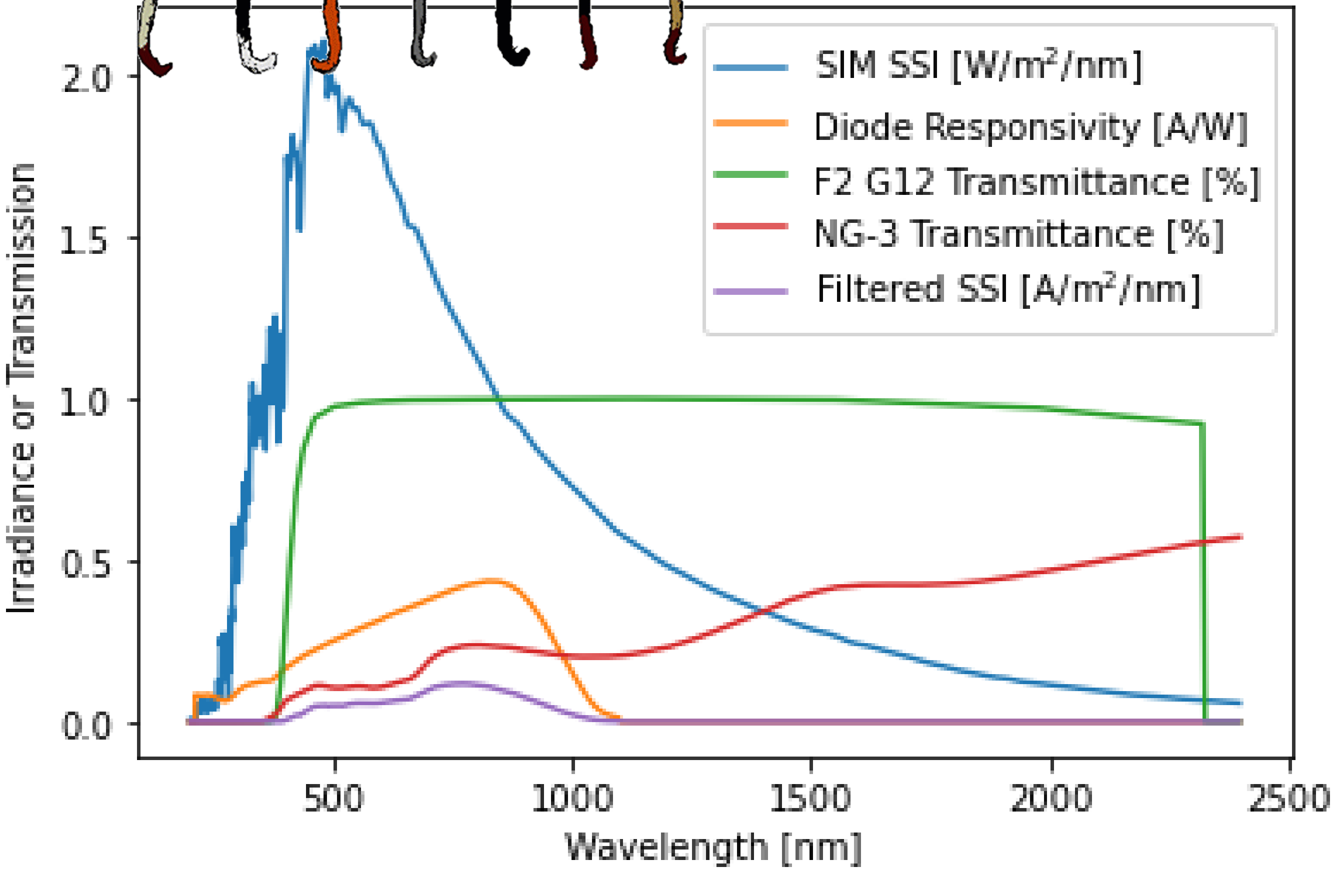
Modeling the SPS output

Using the TSIS-1 SIM full spectrum, we can model the output c the SPS.

- F2 G12 radiation resistant glass cuts out all ultraviolet light.
- The two neutral density filters (NG-3 and NG-2) reduce the remaining signal.
- The responsivity of the silicon diode includes contribution from 200-1000 nm.

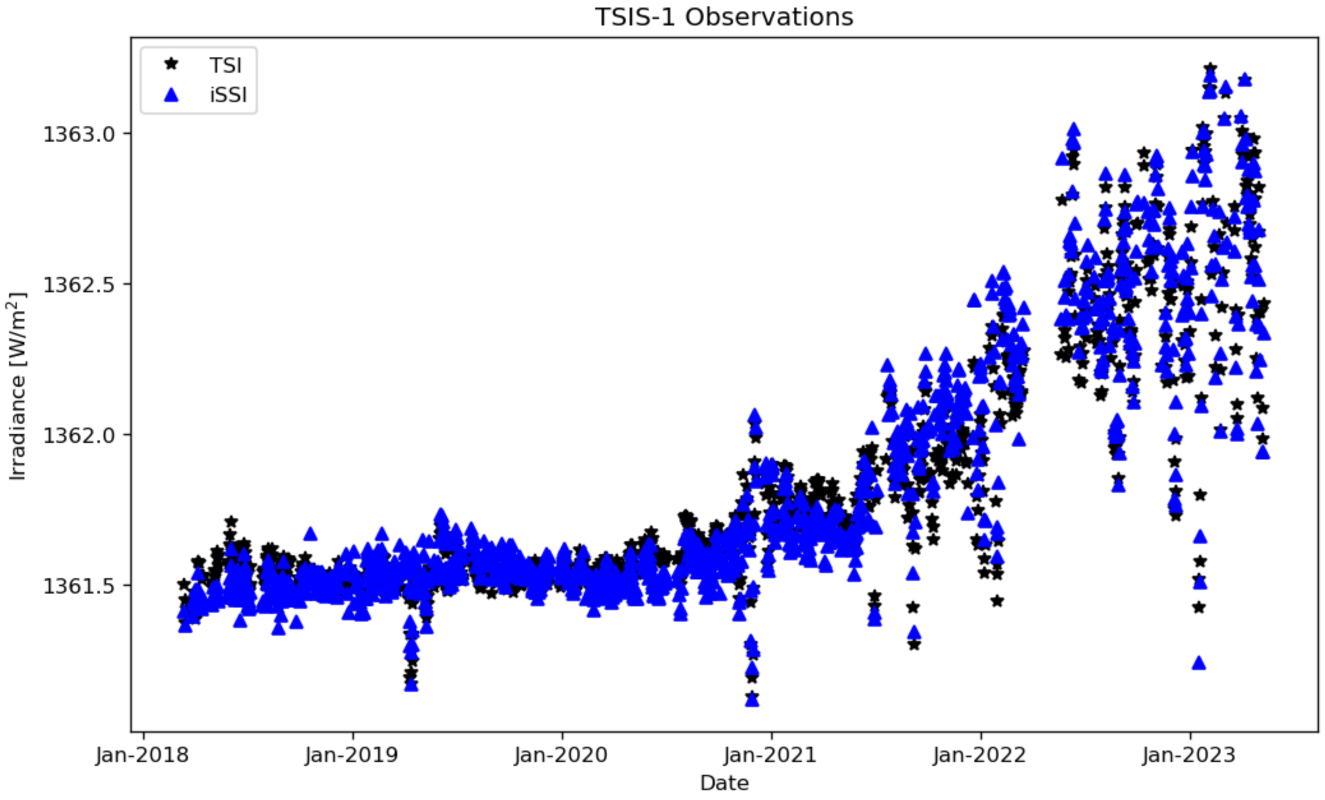
The responsivity of the SPS is the product of all of these, and it is shown as the purple curve on the right.

The signal from the SPS will be the integral of the filtered SSI.



Integrated SSI -- iSSI

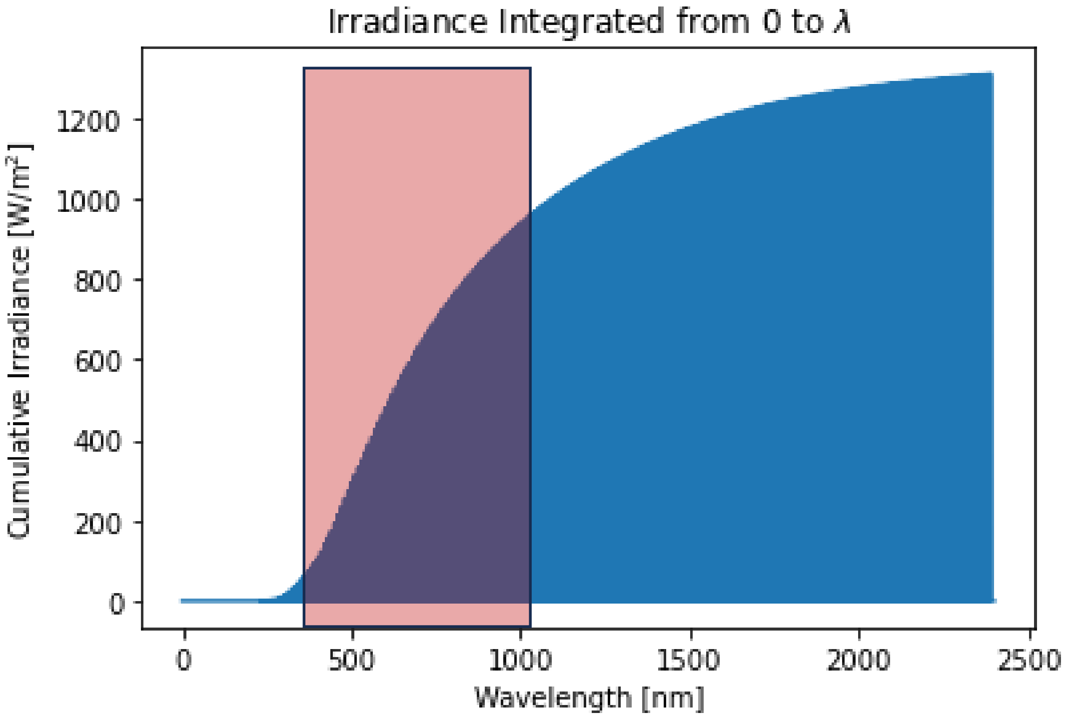
- The spectrum measured by SIM includes 96% of the energy contained in TSI.
- The missing fraction is primarily in the far IR.
- The missing fraction has very little variation in time.
- The variation of the integral of the SIM spectrum matches the variation of TSI. (Richard et al. 2023)
- Uncertainty analysis on a future slide.



Do you need the full spectrum to replicate the TSI variation?

The full spectrum measured by SIM can be integrated to match TSI (iSSI)

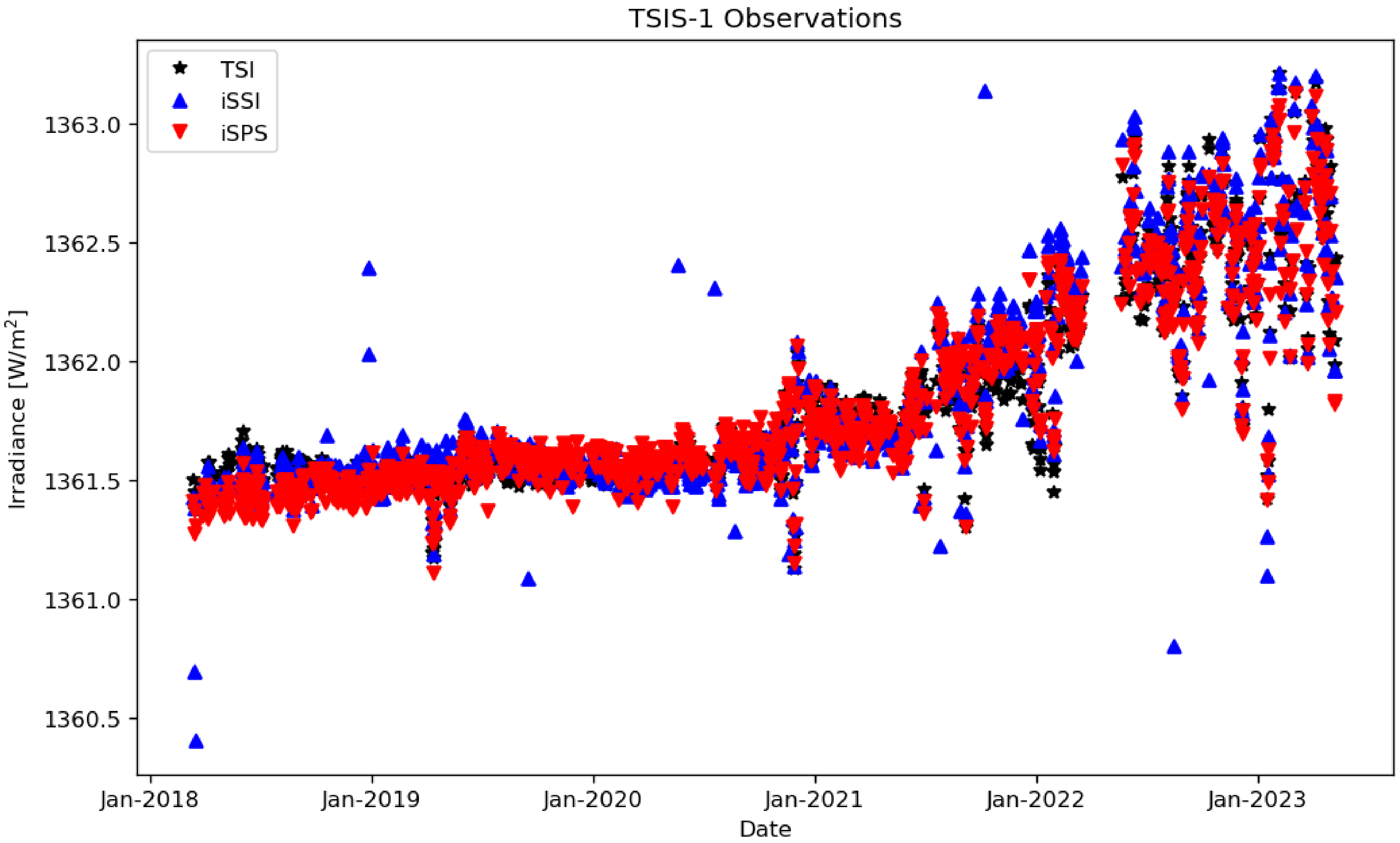
What about integrating just the part of the spectrum measured by SPS (iSPS)?



iSPS Daily Average

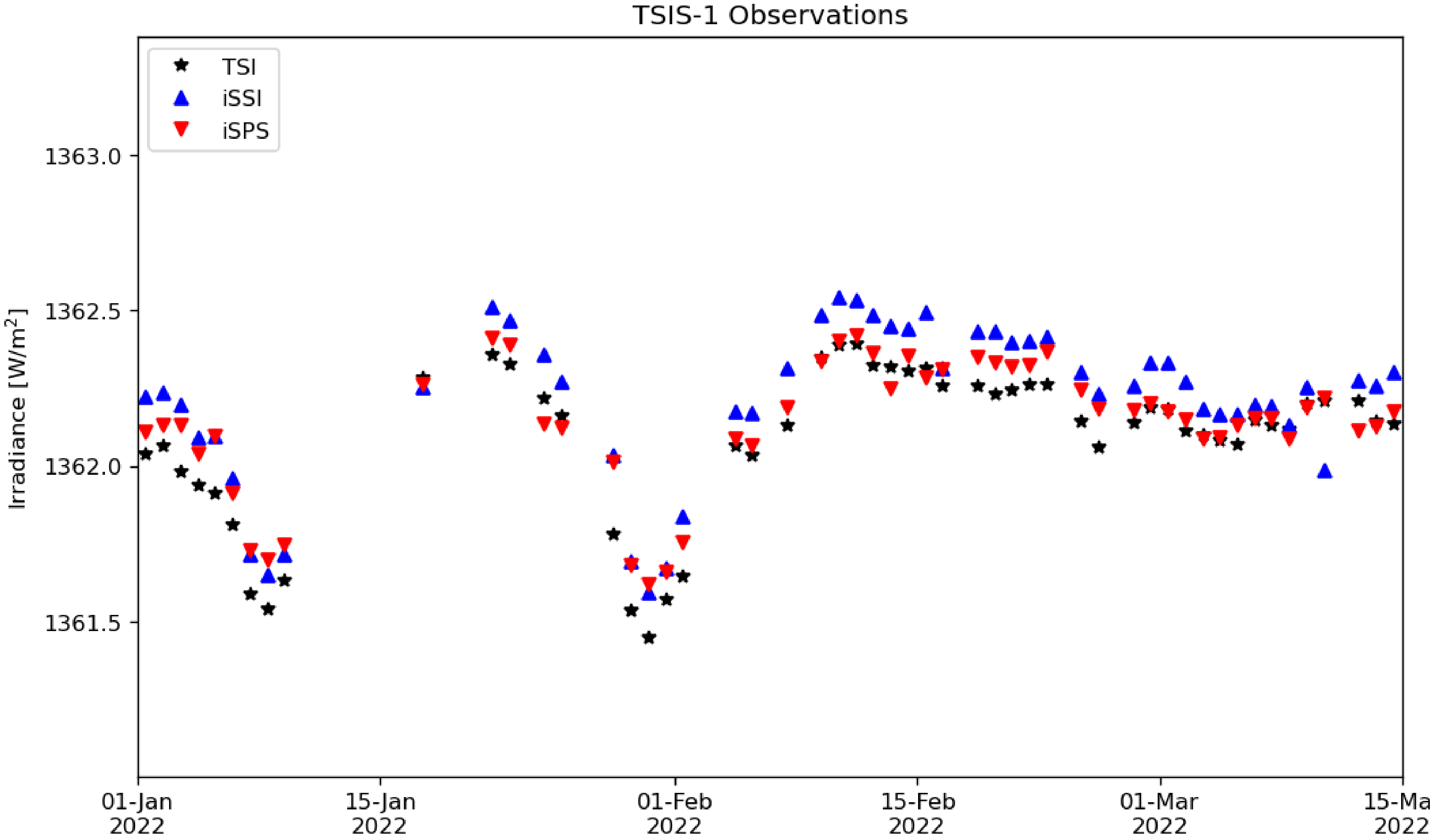
The integrated subset of SSI that SPS observes also matches the variability in TSI.

iSPS uses the SIM long-term degradation correction. It has been adjusted by a multiplicative factor to convert to W/m^2



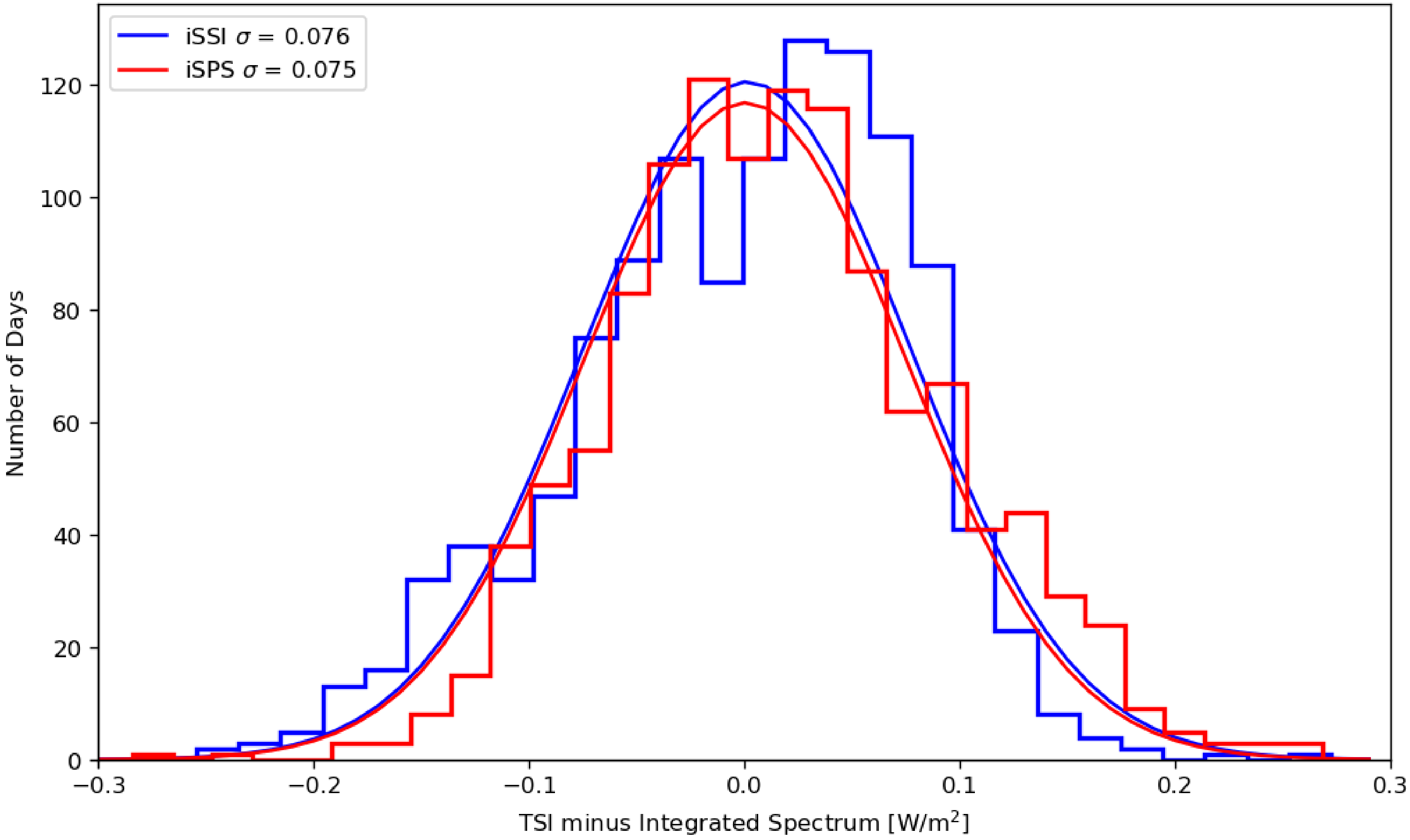
Rotational variation

iSPS captures rotational variation.



Uncertainty

The deviation of the iSPS from TSI is virtually identical to the deviation of iSSI from TSI.



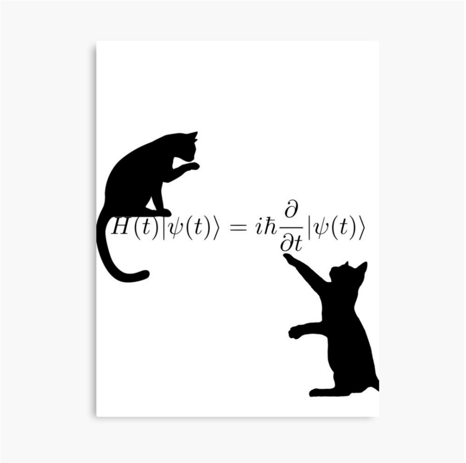
What is the long-term goal?

Modeling the solar spectrum: The NRLSSI and NRLTSI models use linear combinations of facular brightening, $\Delta T_F(t)$, and sunspot darkening, $\Delta T_S(t)$, relative to a Quiet Sun reference spectrum (T_Q, Coddington et al. 2016, Coddington and Lean 2015). We can infer the sunspot darkening from TSI(t) :

$$TSI(t) = T_Q + \Delta T_F(t) + \Delta T_S(t)$$

$\Delta T_F(t) = a_F + b_F \times [F(t) - F_Q]$; F_Q = Facular Brightening at Solar Minimum

$\Delta T_S(t) = a_S + b_S \times [S(t) - S_Q]$; S_Q = Sunspot Darkening at Solar Minimum



S(t) is the sunspot darkening, **F(t)** is the facular brightening, and for TSI, we use our GHOTI TSI-proxy ($\boldsymbol{T_{\odot}}$). Other constants are described in Coddington and Lean (2015). Solving for S(t):

$$S(t) = S_Q + \frac{\boldsymbol{T_{\odot}} - T_Q - \boldsymbol{\Delta T_F(t)} - a_S}{b_S}$$

F(t) is determined from EUVS-C MgII observations. Knowing S(t) and **F(t)** at high cadence, we compute the high-cadence spectrum, $I_{\odot}(\lambda, t)$, according to Coddington and Lean 2015:

$$I_{\odot}(\lambda, t) = I_Q(\lambda) + \Delta I_F(\lambda, t) + \Delta I_S(\lambda, t)$$

$\Delta I_F \propto \boldsymbol{F(t)}$ $\Delta I_S \propto S(t)$ **bold** indicates measured quantities

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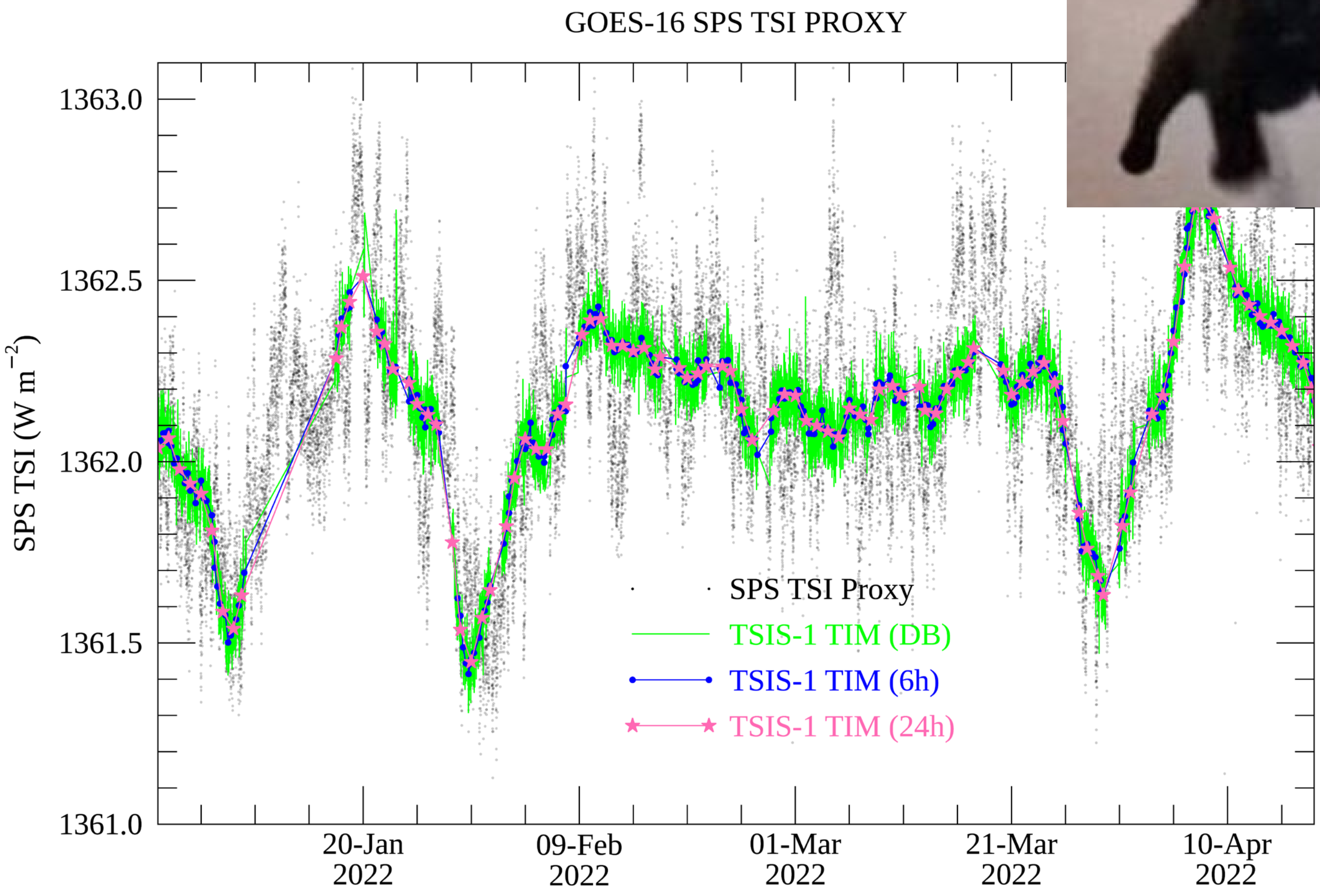
Does it really work?

The Penton et al. poster shows the current status of calibration of the SPS data. The SPS data certainly reproduces the daily variation of TSI.

The model described here shows why this is the case.

Further uncertainty analysis is underway to characterize the best time cadence to reduce the statistical uncertainty of the SPS measurement to produce the full spectral model.



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Questions?

A Multi-Point View of the Sun: Advances in Solar Observations and in Space Weather Understanding

August 6-8, CTICC, Cape Town, South Africa

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