

# SOLAR SPECTRAL IRRADIANCE DURING WHPI AND COMPARISON TO WHI AND WSM

M SNOW, S BELAND, E RICHARD, T WOODS, F EPARVIER, P CHAMBERLIN

UNIVERSITY OF COLORADO BOULDER

LABORATORY FOR ATMOSPHERIC AND SPACE PHYSICS

[SNOW@LASP.COLORADO.EDU](mailto:SNOW@LASP.COLORADO.EDU)

# OUTLINE

- Datasets
- Irradiance variations during Campaign 1
- Application to Planetary locations
- Comparison to WHI (and WSM)

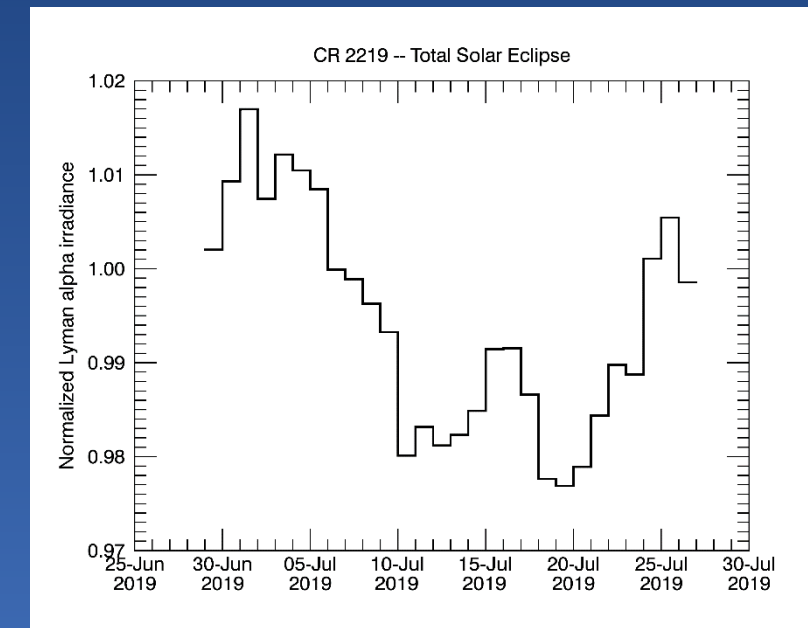
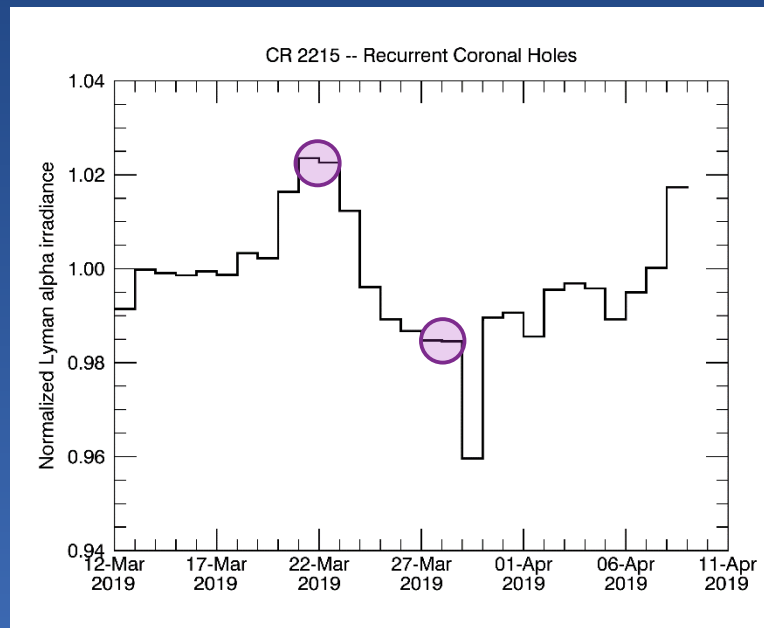


# PRELIMINARY LIST OF IRRADIANCE DATASETS

- SDO/EVE and TIMED/SEE 0.1-115 nm
- SORCE/SOLSTICE 115-300 nm
- TSIS/SIM 200-2400 nm

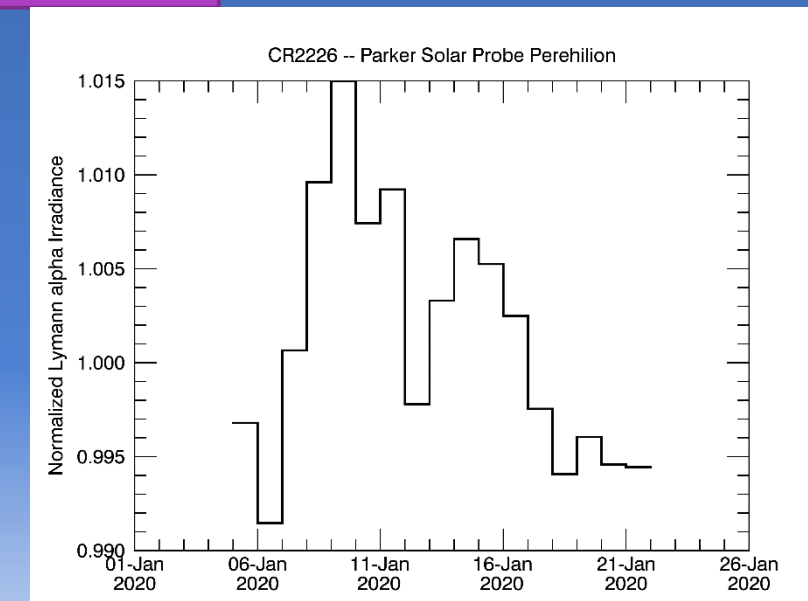


# WHPI CAMPAIGNS

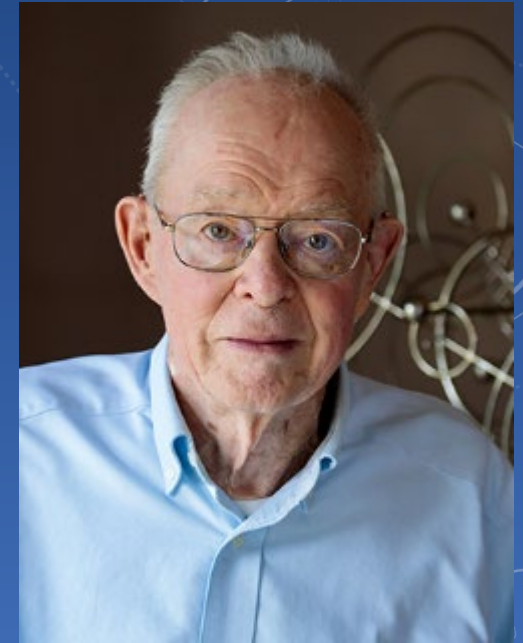


- Recurrent Coronal Holes/High Speed Wind Streams (CR 2215) March 12-April 8, 2019
- Total Solar Eclipse Campaign (CR 2219) June 29-July 26, 2019
- Parker Solar Probe 4<sup>th</sup> Perihelion Campaign (CR2226) Jan 6-Feb 2, 2020

Last night PSP was only 37 solar radii from the surface.



# PARKER WINS!



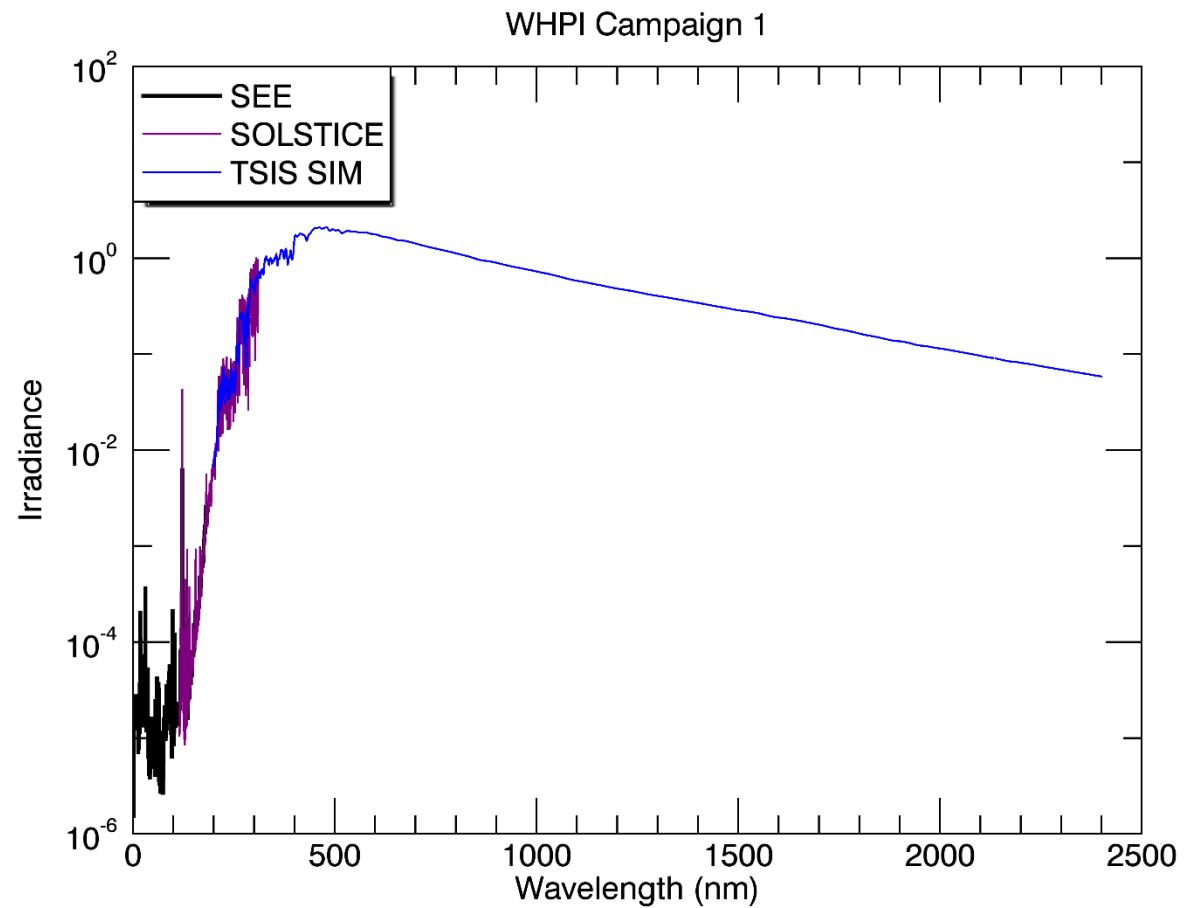
## The Crafoord Prizes in Mathematics and Astronomy 2020

 [Contacts](#)  [Links](#)

**30 January 2020**

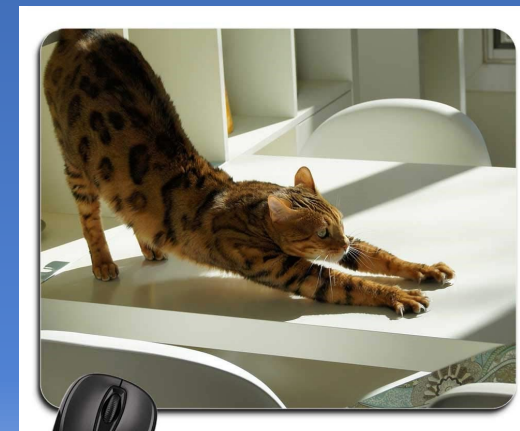
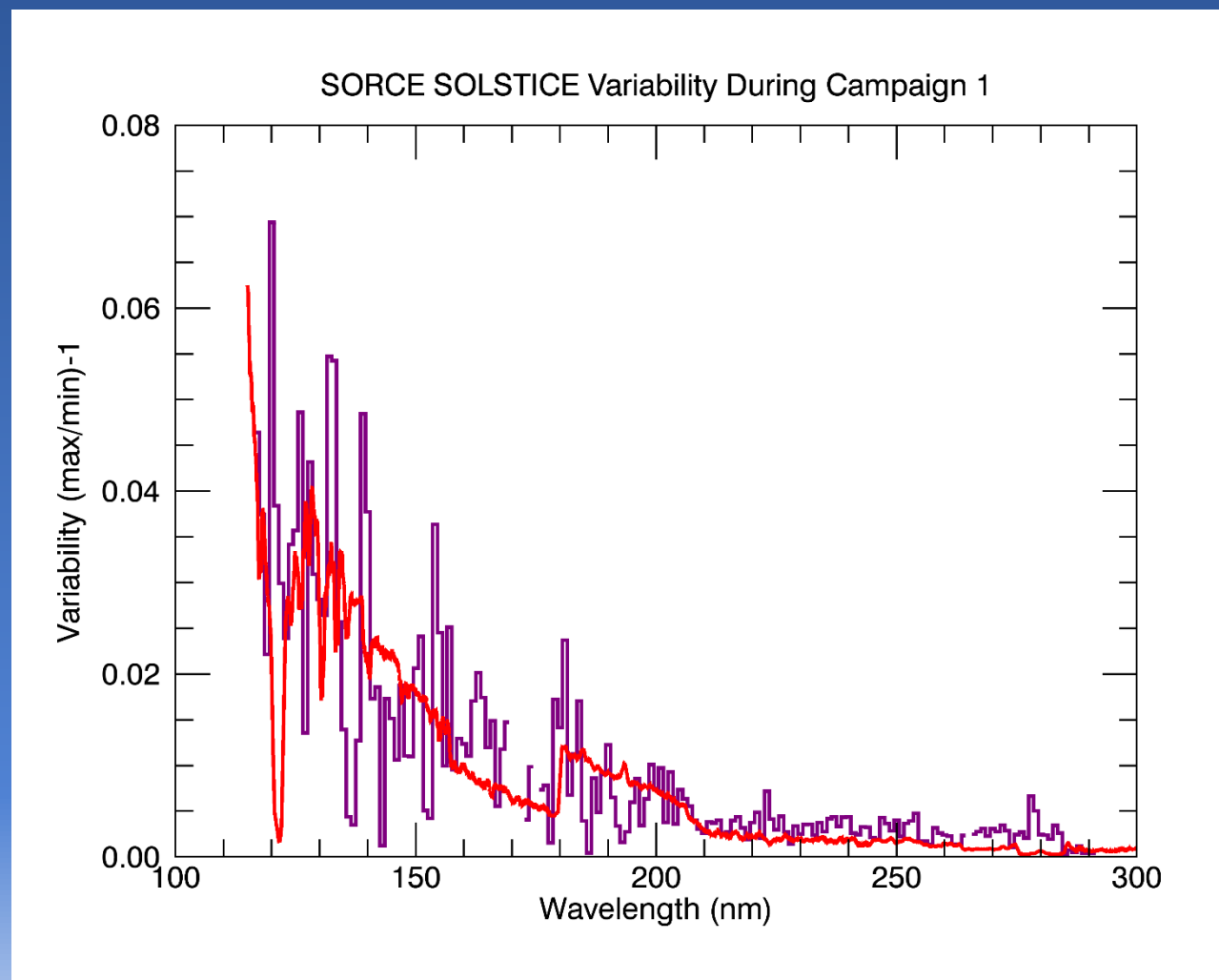
The man who discovered the solar wind, **Eugene Parker**, and one of mathematics' great problem-solvers, **Enrico Bombieri**, will receive this year's Crafoord Prize in Astronomy and Mathematics, respectively. The Crafoord Prize is worth six million Swedish krona and is awarded by the Royal Swedish Academy of Sciences in partnership with the Crafoord Foundation in Lund.

# SOLAR SPECTRAL IRRADIANCE



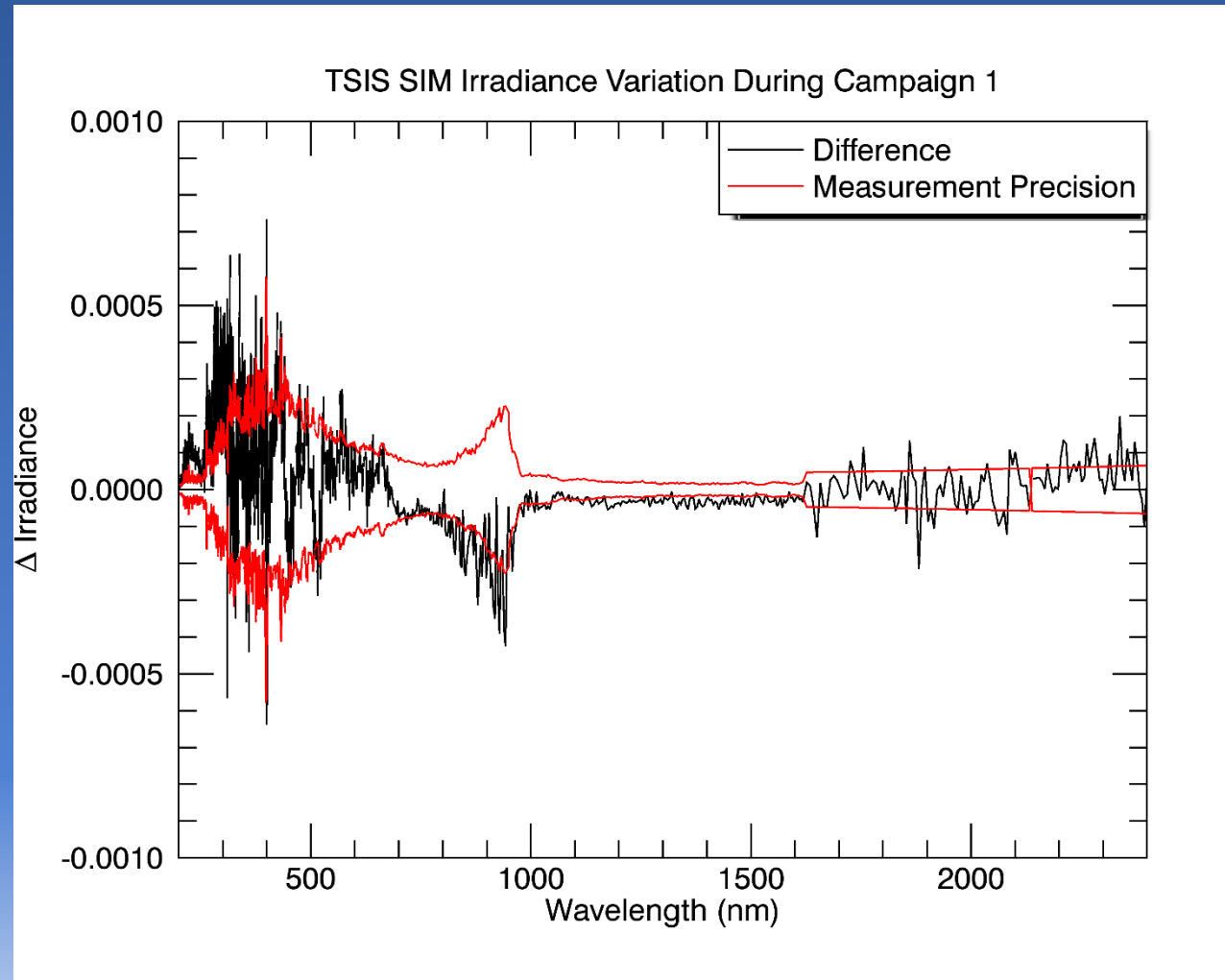
# SPECTRAL VARIABILITY DURING CAMPAIGN 1: UV

Red line shows the 1-sigma measurement uncertainty of the ratio of two days.



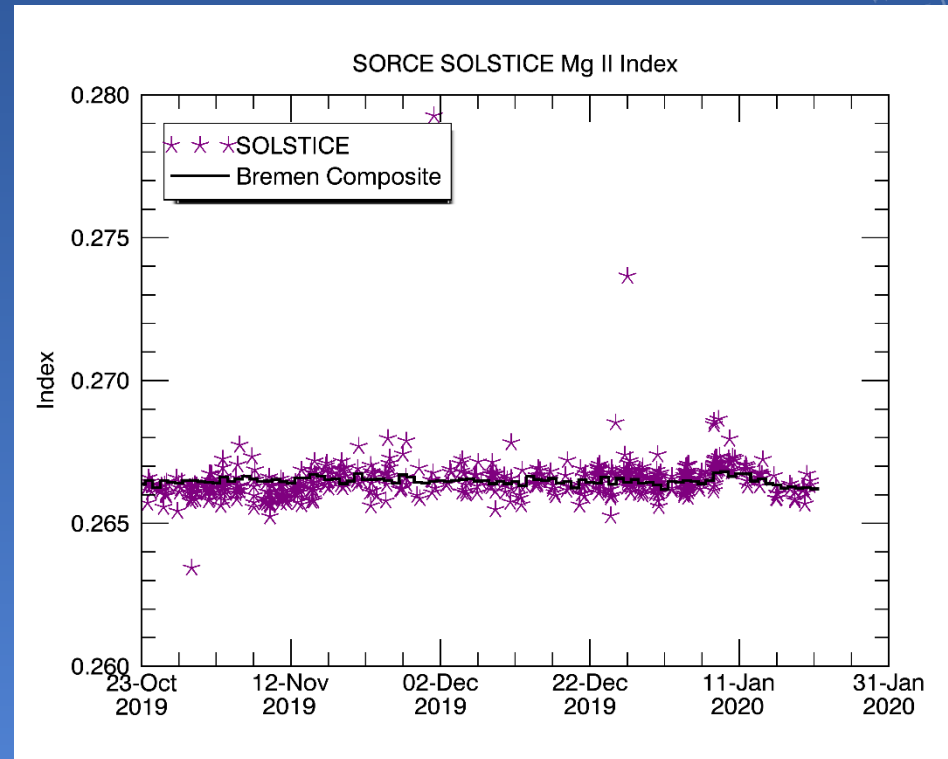
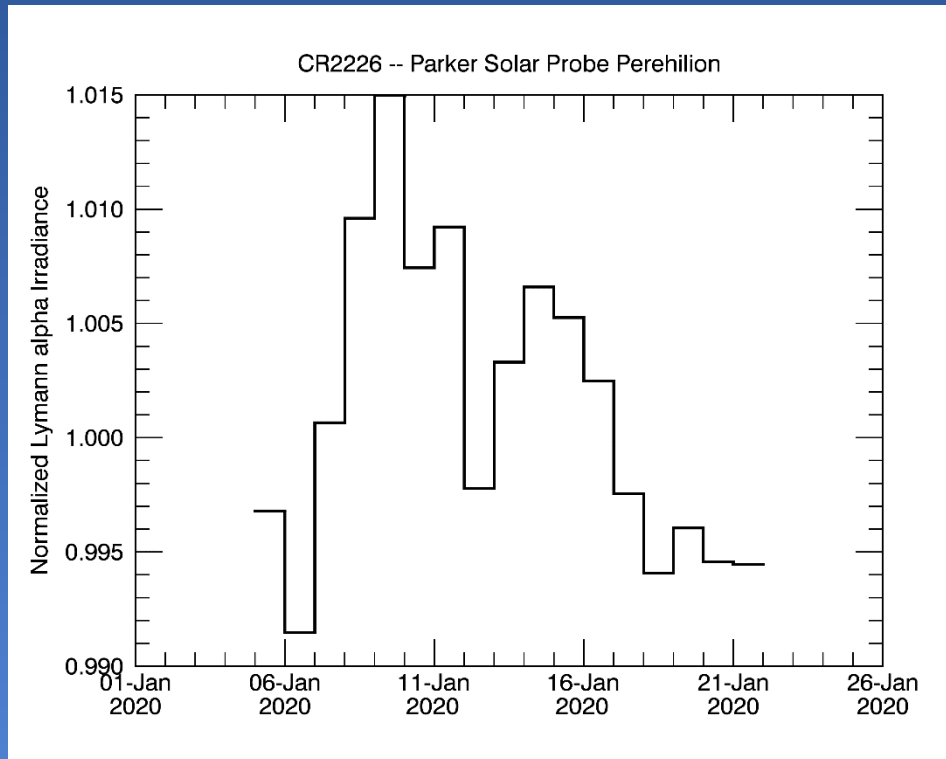
# VARIATION IN TSIS SIM

Red line shows the 1-sigma measurement uncertainty during the campaign.





# CAMPAIGN 3: PARKER SOLAR PROBE 4<sup>TH</sup> PERHELION

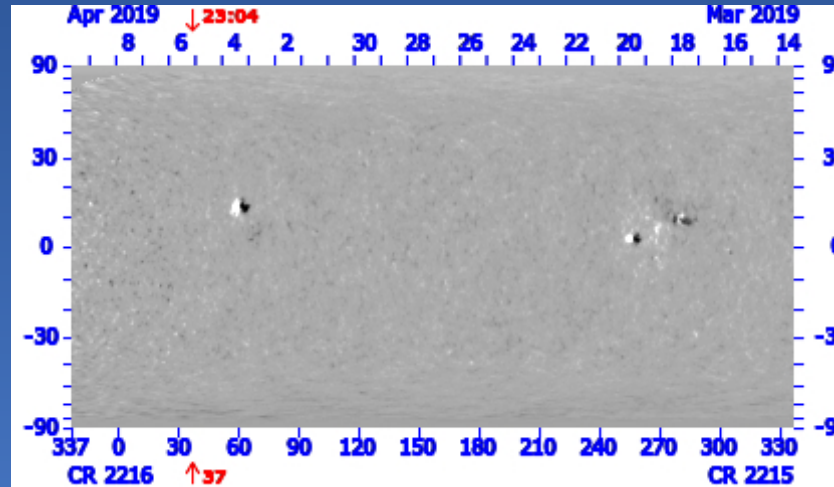


# CONCLUSION: CAMPAIGN PSP IS VERY QUIET SO FAR

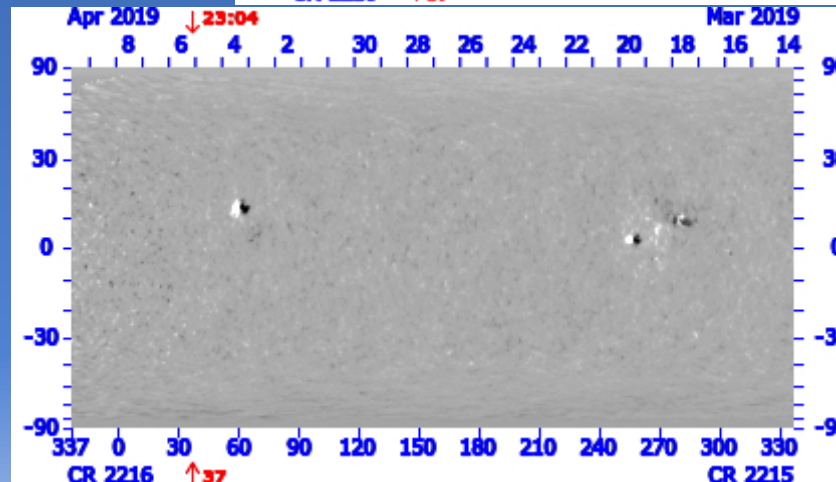
This time period is the best candidate for a new solar minimum reference spectrum.



# APPLICATION TO OTHER PLANETS



As seen from Mars about 7 days earlier



As seen from Earth

# OTHER PLANETS

Quémerais et al. 2019 found that the standard method of time-shifting was within 5% of the true value 75% of the time for Lyman alpha.

During the very quiet WHPI campaign 1, the uncertainty from time shifting should be negligible.

**Table 1**

*Accuracy of the Predicted Flux Toward Mars*

Accuracy	Fraction of values	
	SWAN method	Position-shifted method
0.01	0.19	0.12
0.02	0.35	0.25
0.03	0.47	0.45
0.04	0.59	0.63
0.05	0.67	0.74
0.06	0.76	0.80
0.07	0.83	0.87
0.08	0.87	0.92
0.09	0.90	0.95
0.10	0.93	0.96

*Note.* SWAN = Solar Wind ANisotropies.

# SSI DATASETS CAN BE PREPARED FOR EACH PLANET AND WILL BE AVAILABLE ON LISIRD



Sun-Climate Symposium 2020

## Planet positions during WHPI campaign periods

### 1. Recurrent Coronal Holes/High Speed Solar Wind Streams

Carrington Rotation 2215

12 Mar - 8 Apr, 2019; PSP 2nd perihelion on April 4 (on map below as 1)

### 2. Total Solar Eclipse

Carrington Rotation 2219

29 Jun - 26 Jul, 2019; Eclipse is on July 2nd (2)

### 3. Parker Solar Probe 4th Perihelion

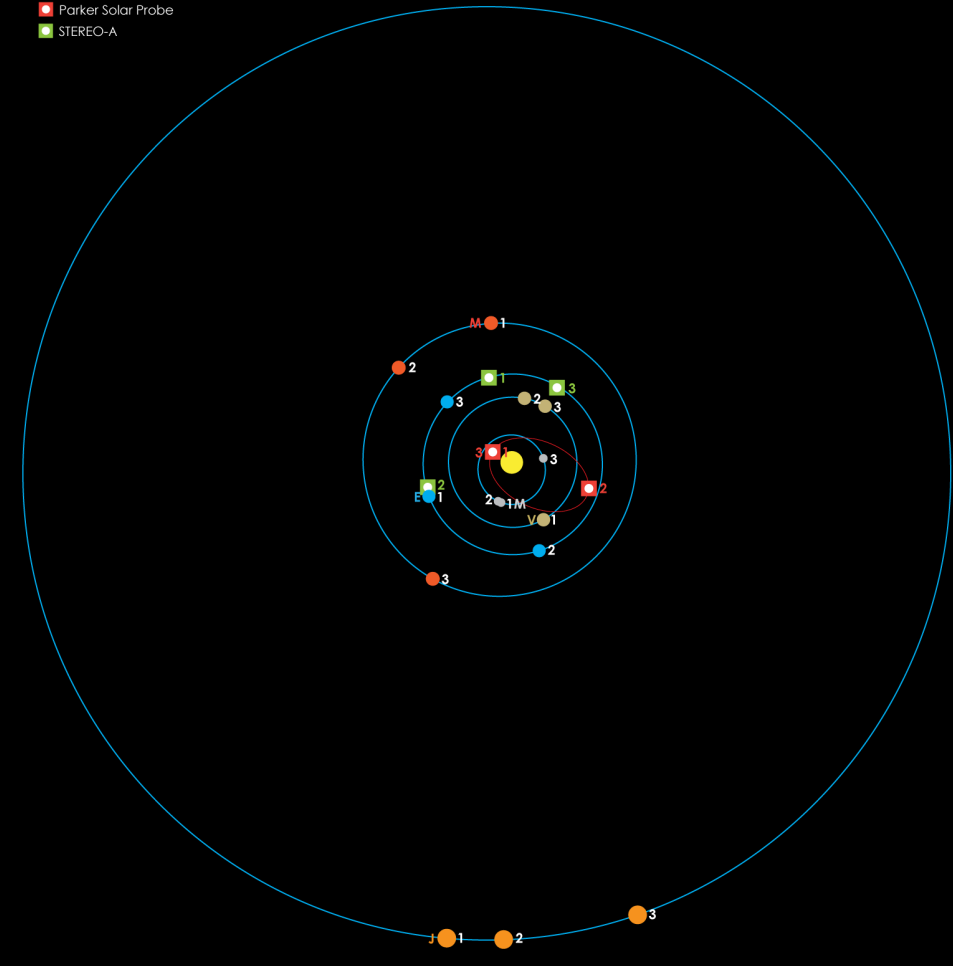
Carrington Rotation 2226

6 Jan - 2 Feb, 2020; on Jan 29 (3)

Solar system plot shows planet and  
probe positions for campaign dates

■ Parker Solar Probe

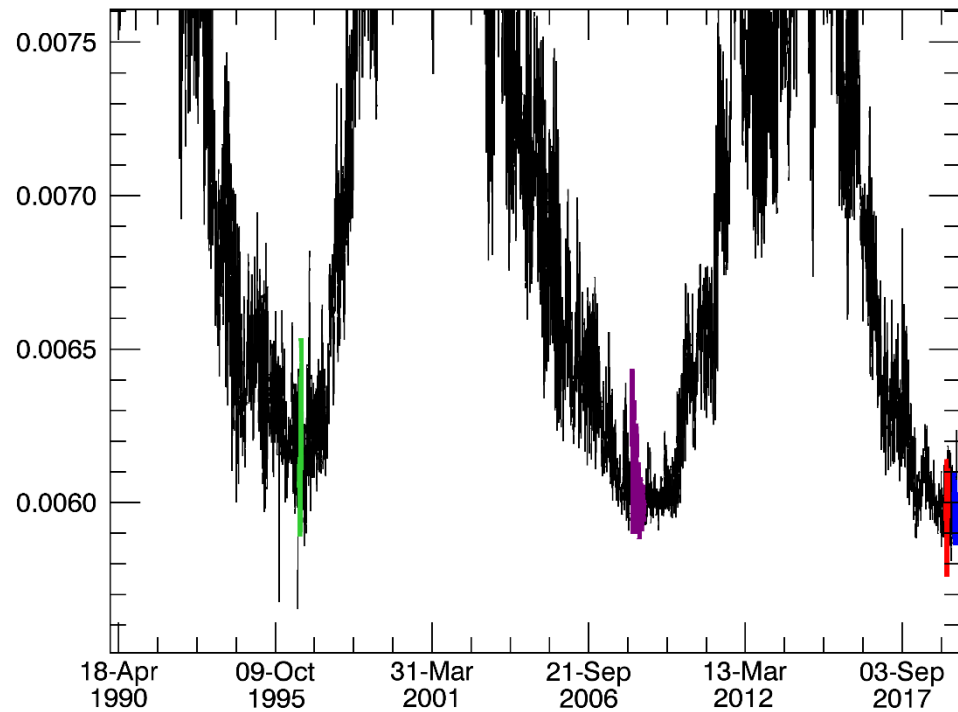
■ STEREO-A





# COMPARISON TO EARLIER MINIMA: WHI AND WSM

Lyman alpha composite



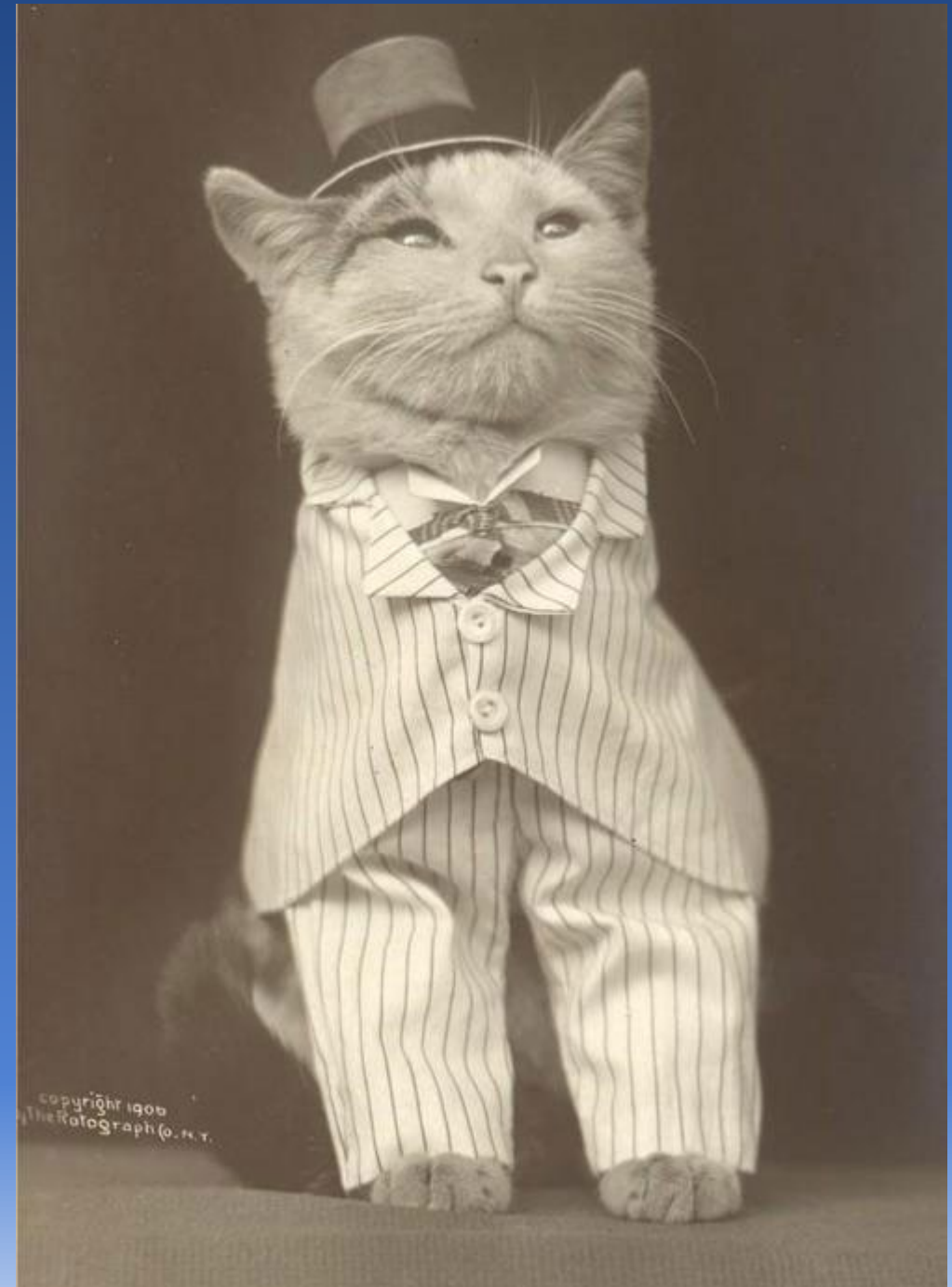
# WHI/SIRS

- Three time periods originally considered (Woods et al. 2008):
  - March 25-29, 2008: low TSI, but 3 active regions, SSN=33.4
  - March 29-April 4, 2008: higher TSI, also 3 active regions, SSN=16.2
  - April 10-April 16, 2008: quiet Sun, low TSI, SSN=2.0

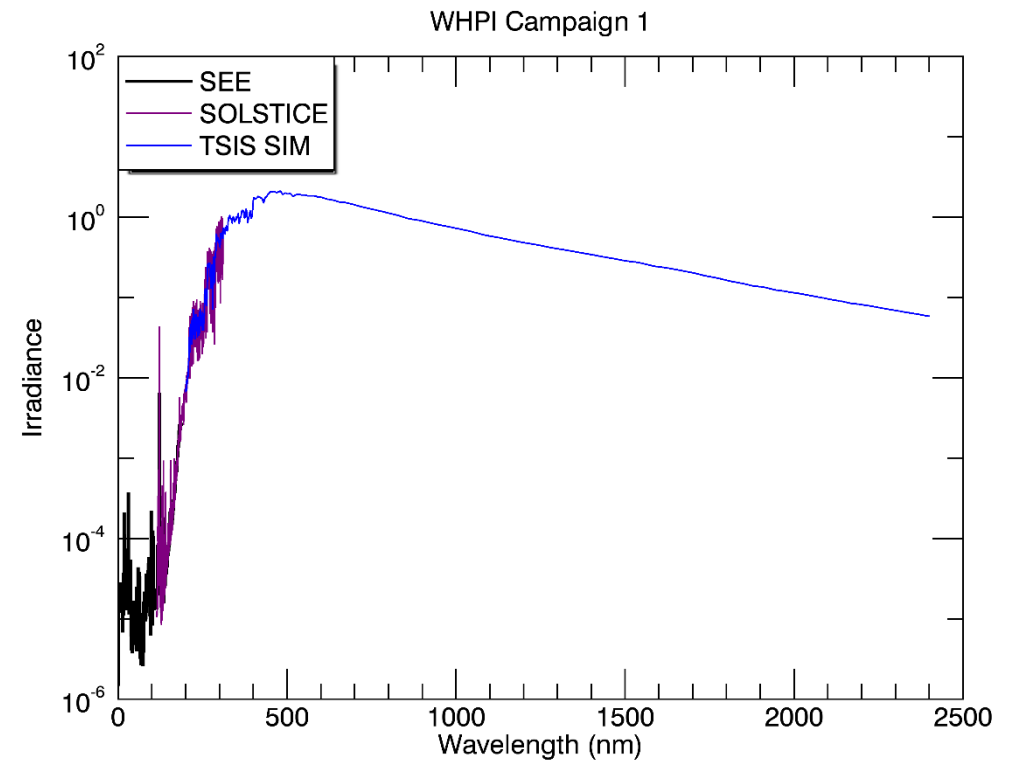
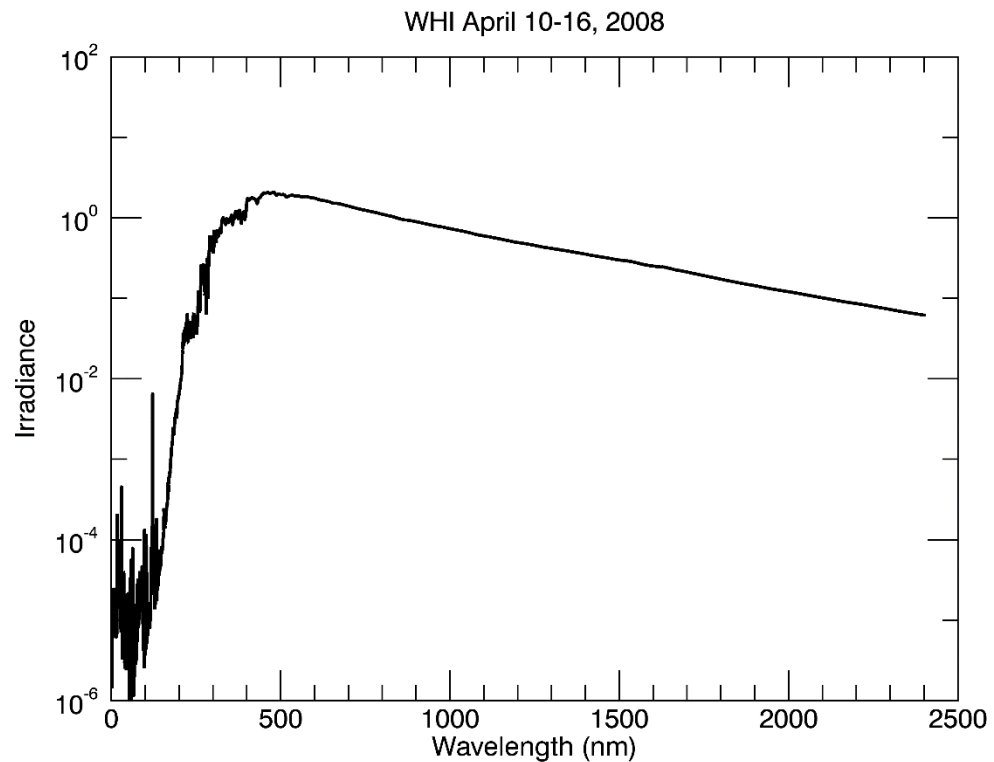
## Used

- Rocket EVE
- SORCE SOLSTICE
- SORCE SIM

Woods et al. (2008) Solar irradiance reference spectra (SIRS) for the 2008 Whole Heliosphere Interval (WHI), GRL, 36, L01101

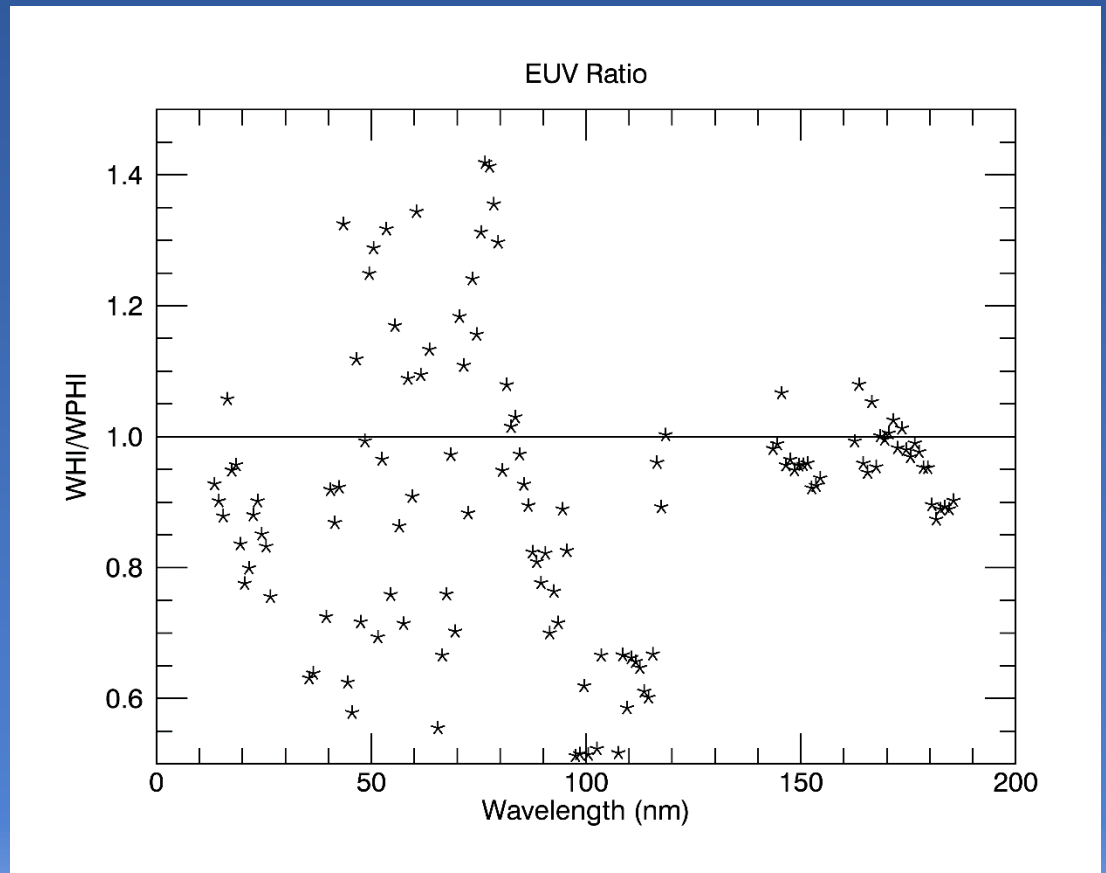
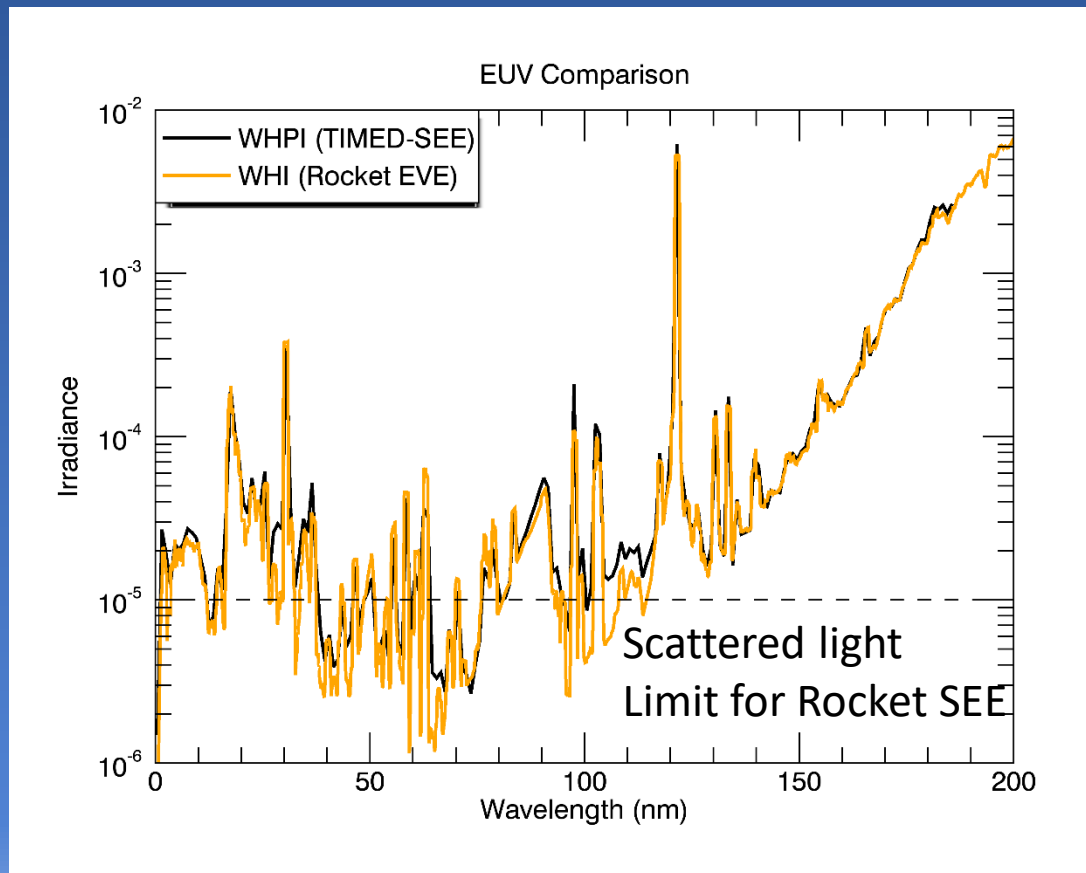


# WHI AND WHPI

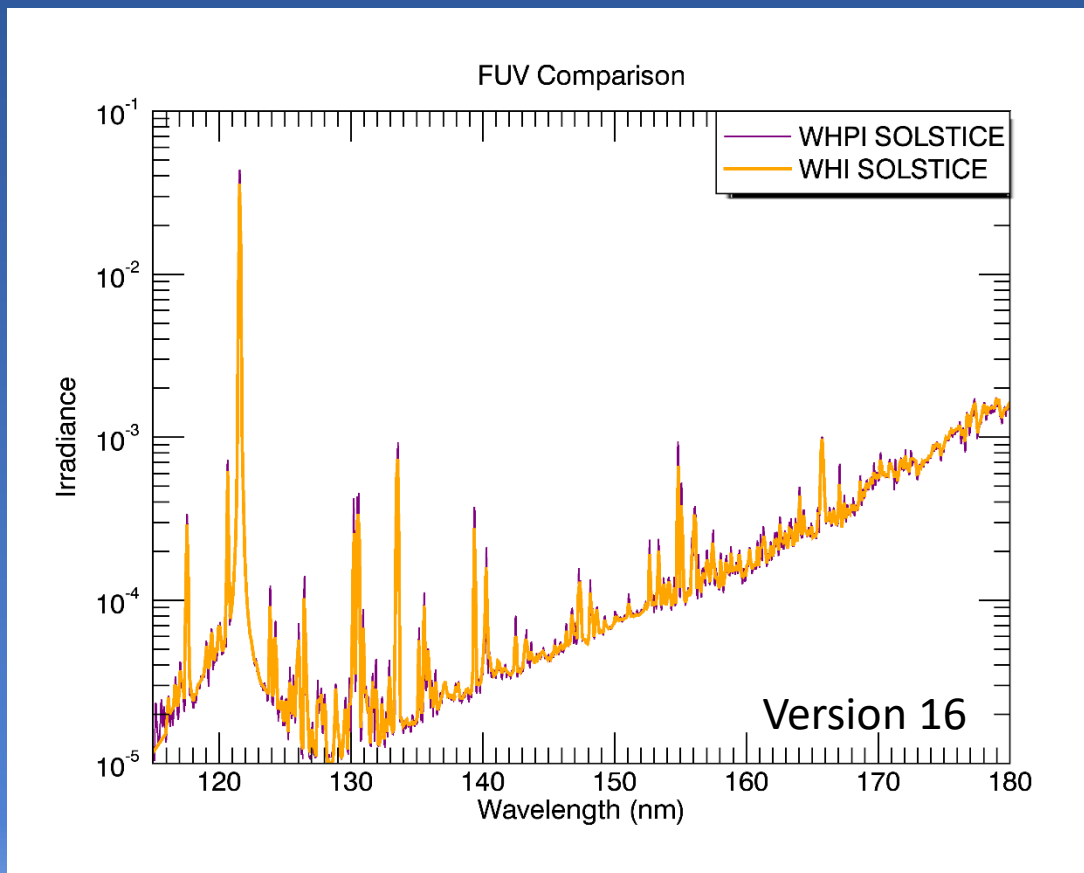




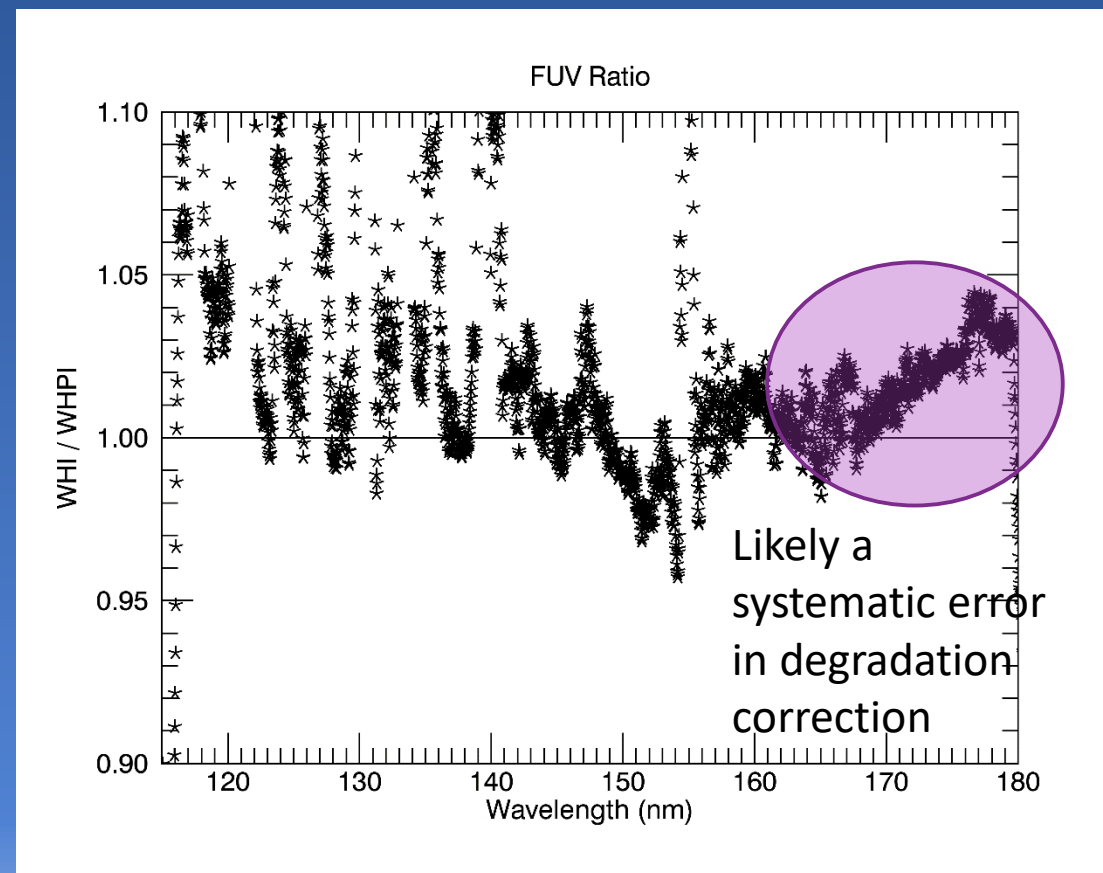
# WHI/WHPI RATIO - EUV



# WHI/WHPI RATIO - FUV

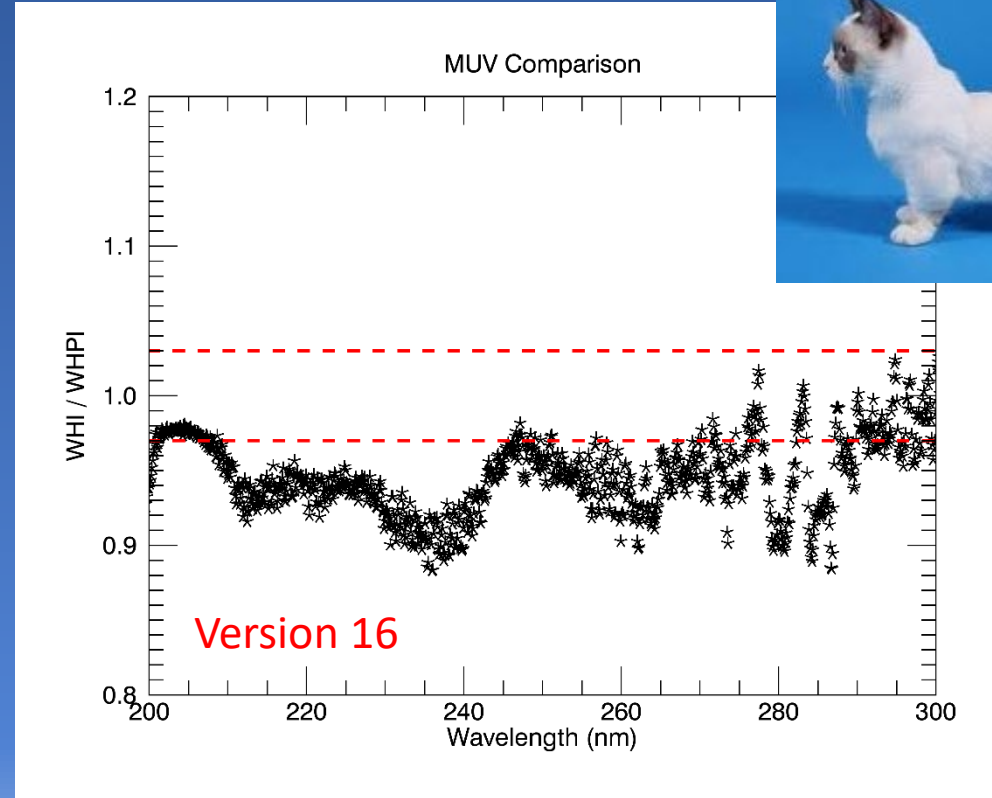
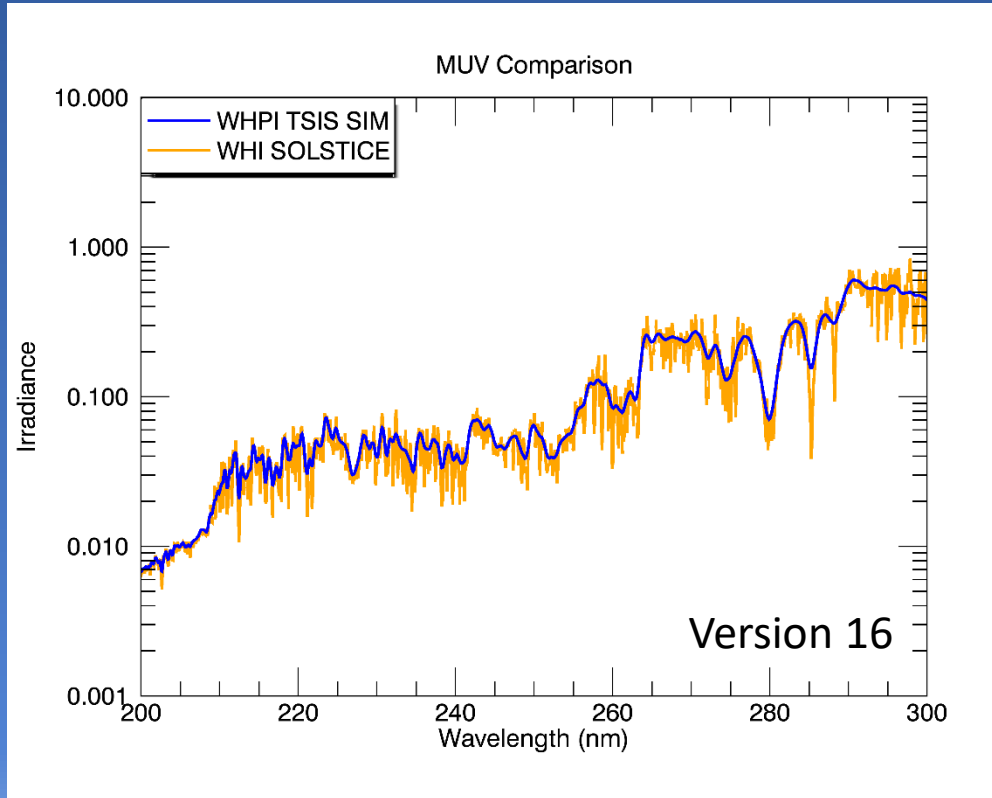


Emission lines are systematically higher during WHPI



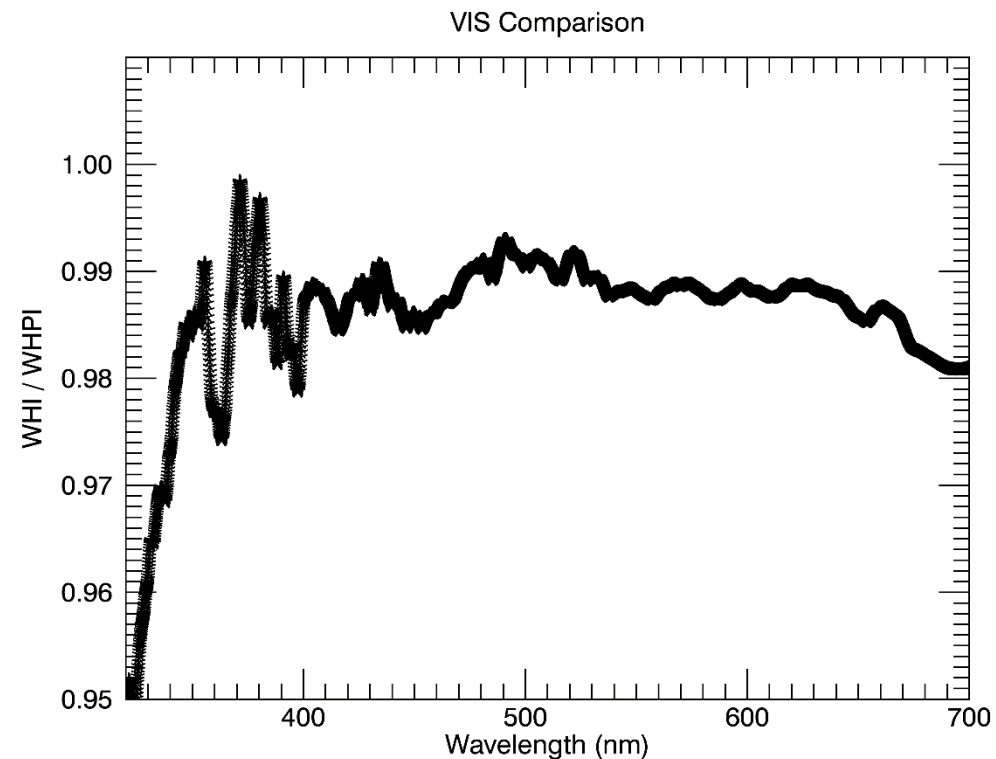
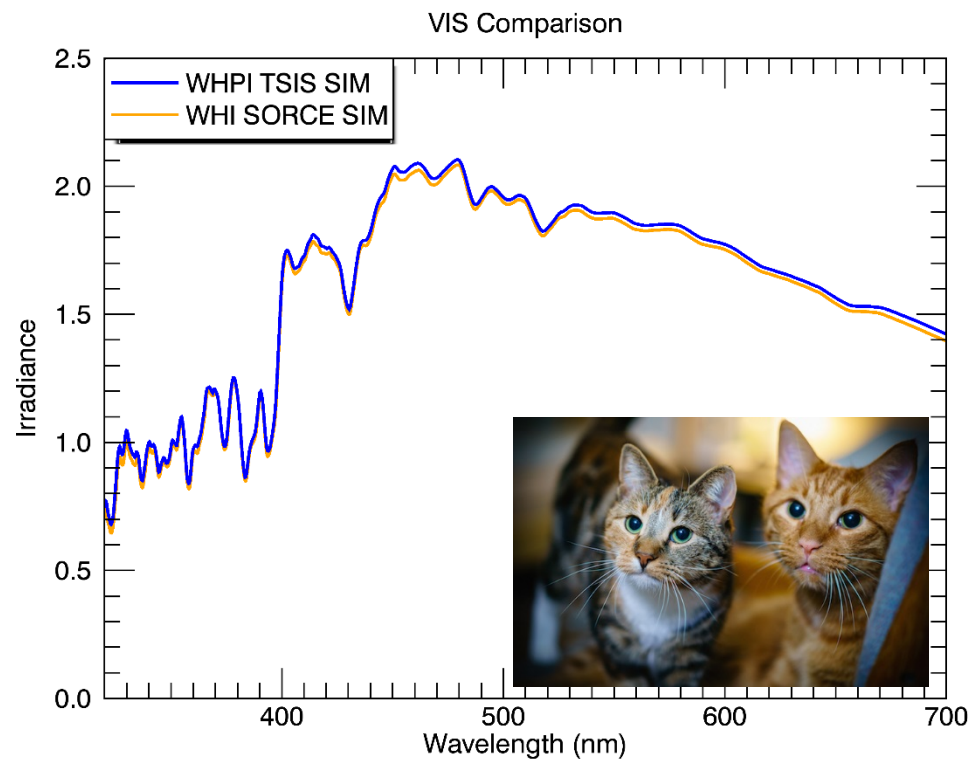
# WHI/WHPI - MUV

Red dashed lines are estimates for SOLSTICE trend uncertainty. Comparison to recently-launched TSIS SIM shows that the SOLSTICE Irradiances are systematically low during WHI compared to TSIS/SIM during WHPI



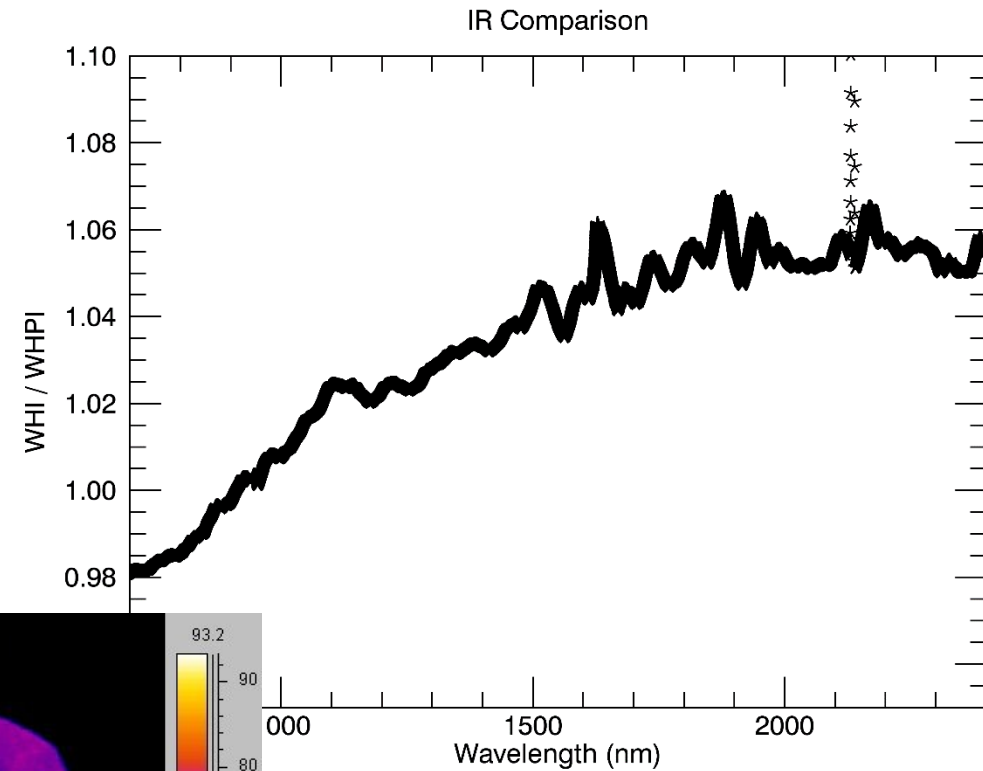
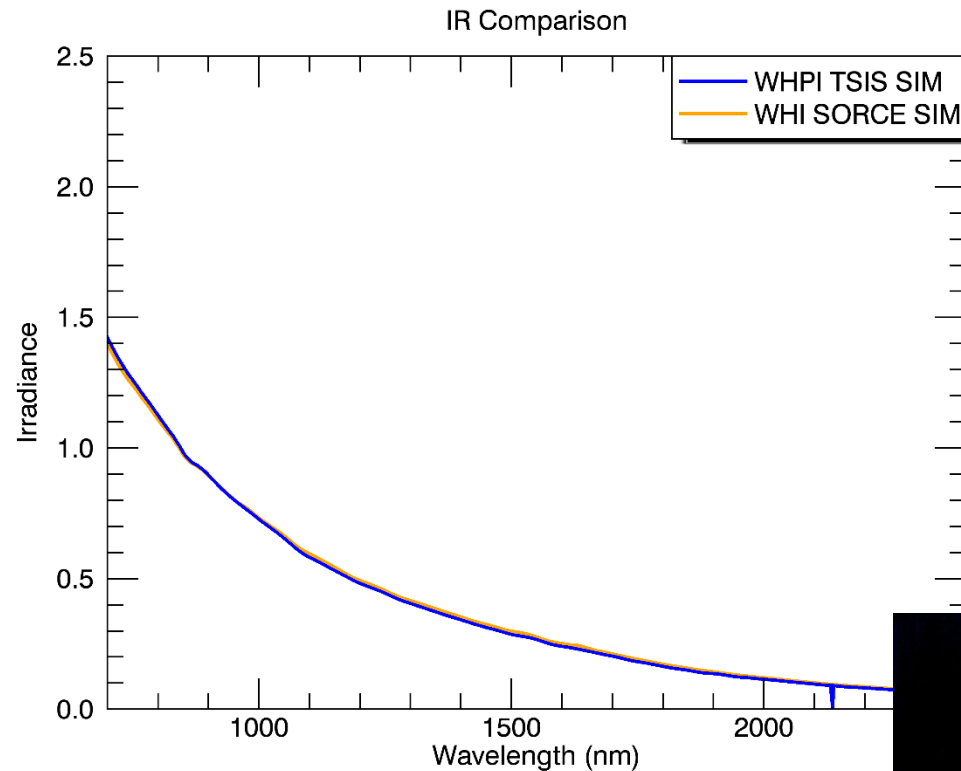
# WHI/WHPI - VISIBLE

Calibration difference between TSIS and SORCE  
See Joel Tibbetts' poster



# WHI/WHPI – INFRA-RED

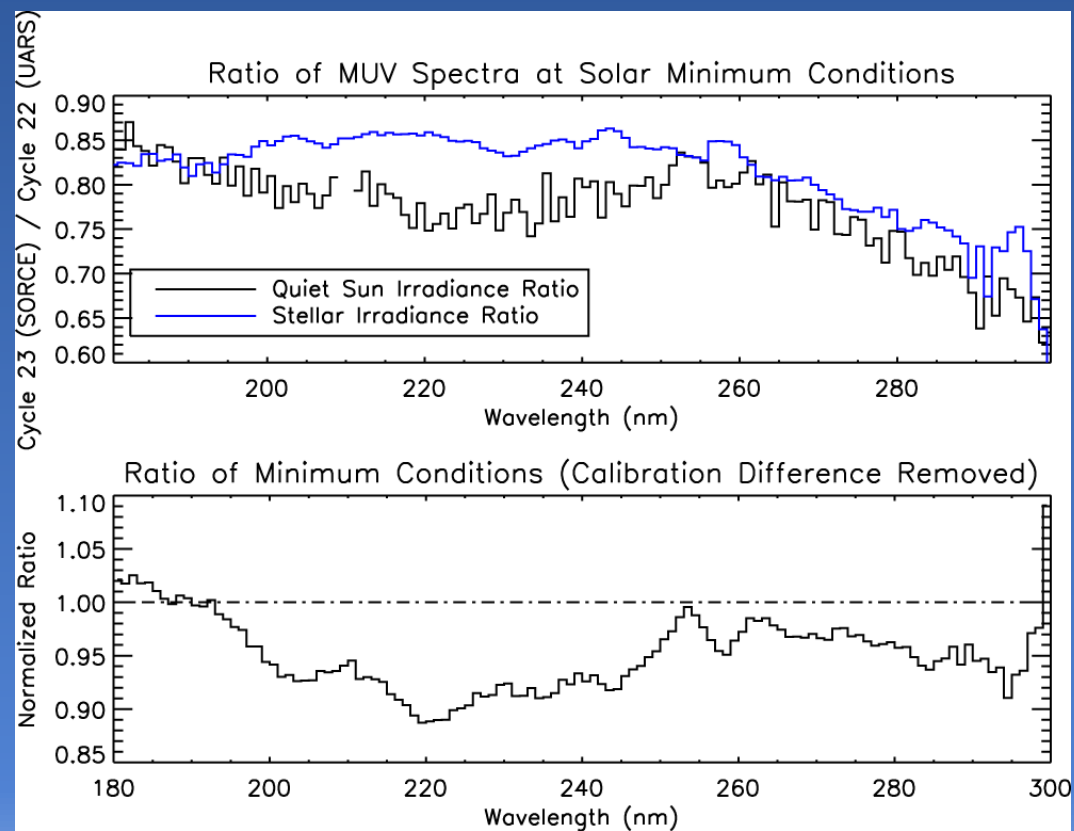
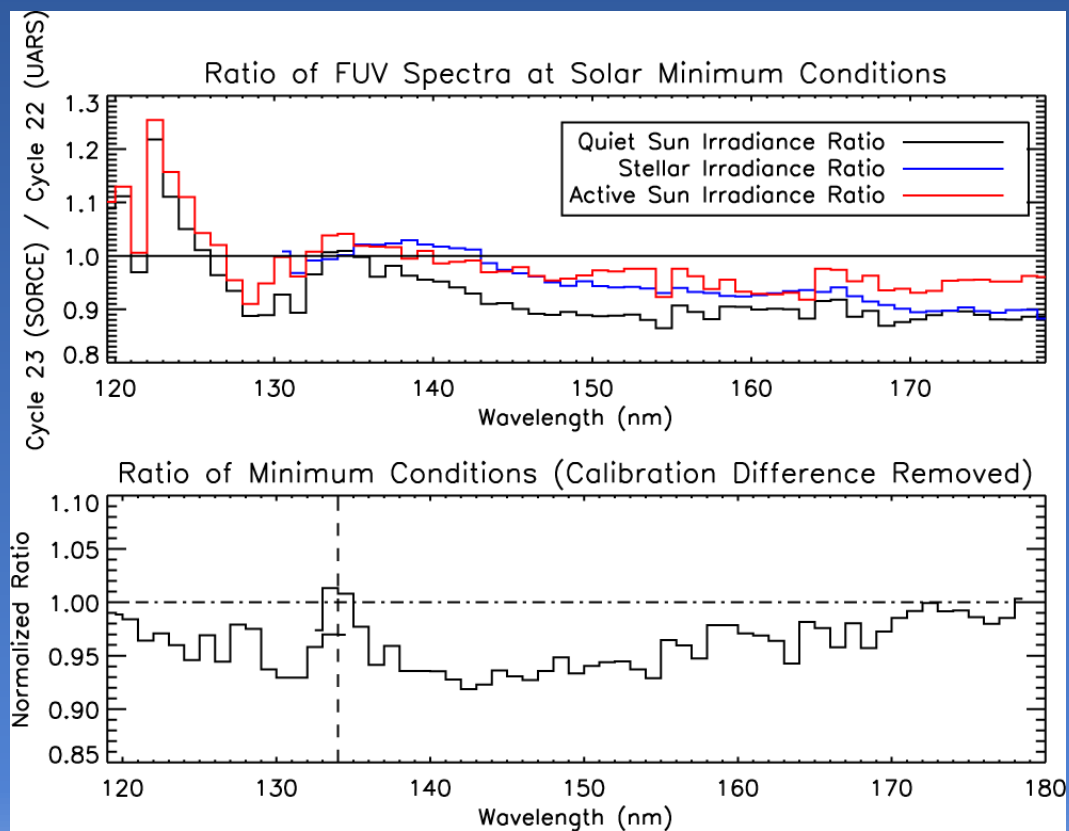
Calibration difference between TSIS and SORCE  
See Joel Tibbets' poster for further analysis



# COMPARING WHI TO WHOLE SUN MONTH

- UARS SOLSTICE vs SORCE SOLSTICE
- In both cases, solar minimum was several years into the mission
- Both instruments observed the same set of bright stars for cross calibration

# WHOLE SUN MONTH: UARS AND SORCE SOLSTICES



# WHERE WILL THIS DATA BE AVAILABLE?

- LASP Interactive Solar Irradiance Datacenter (LISIRD)
- WHPI Collection





# SUMMARY



- Solar Spectral Irradiance datasets covering the first two WHPI campaigns exist, and will be packaged for easy use by the scientific community.
- Soon the data for the third WHPI campaign will exist and will form the basis of the WHPI reference spectrum.
- The SORCE mission was extended in order to collect data during the third campaign. Thanks WHPI!
- Comparisons between WHPI and WHI show very little difference after taking uncertainties into account.
- WHPI will be an excellent opportunity for cross calibration between SORCE and TSIS