TIMED Solar EUV Experiment: Phase E Annual Report for 2004

Submitted for NASA Grant NAG5-11408
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SEE Science Team

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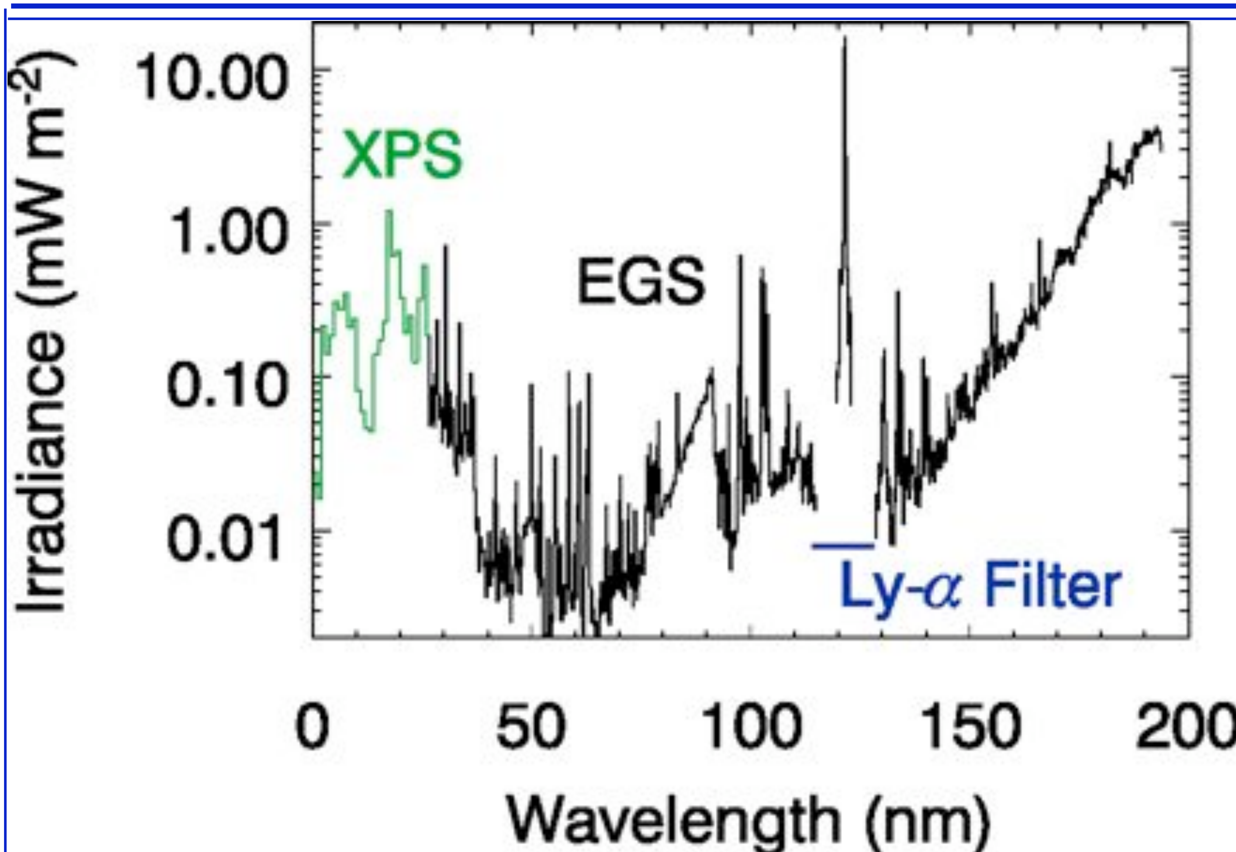
Report Outline

- SEE Instrument Operations and Instrument Status
- SEE Data Products
- SEE Science Overview
- Summary of SEE Results
  - Validation, solar variability, atmospheric modeling, and solar irradiance modeling
- Summary of SEE Related Talks and Papers
- Summary of SEE Solar Observations
- Future Plans for SEE Team

Overview of Operations and Data Processing

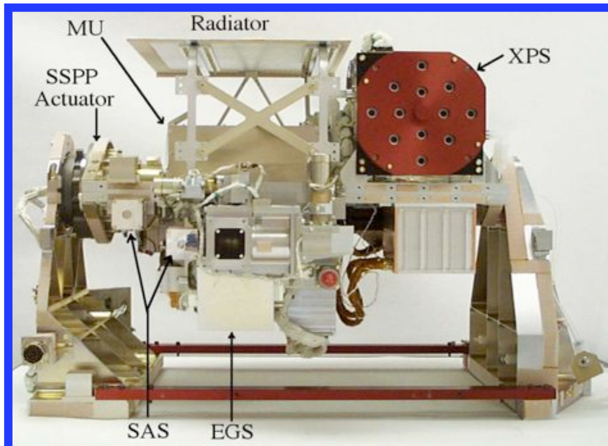
SEE Measures the Solar VUV Irradiance



XUV	EUV	FUV

EGS 27-194 nm with $\Delta\lambda$=0.4 nm

XPS 0.1-34 nm with $\Delta\lambda$=7-10 nm and Ly-α (121.6 nm) with $\Delta\lambda$=2 nm



EGS = EUV Grating Spectrograph
Rowland-circle grating spectrograph with 64x1024 CODACON (MCP-based) detector

XPS = XUV Photometer System
Set of 12 Si photodiodes - 8 for XUV, 1 for Ly-α, and 3 for window calibrations

FUV = Far UltraViolet: 115-200 nm
EUV = Extreme UltraViolet: 30-115 nm
XUV = X-ray UltraViolet: 0-30 nm

EGS = EUV Grating Spectrograph
XPS = XUV Photometer System

Summary of SEE Flight Operations

- Planned Experiments (through November 1, 2004)
  - Total for solar experiments : 906 hours 48 min 30 s
  - Number of experiments = 16207 : Normal solar = 14368
- Actual Experiments (through November 1, 2004)
  - Total for solar experiments : 888 hours 40 min 30 s (98.0%)
  - Number of experiments = 15899 (98.1%) : Normal solar = 14074 (98.0%)
- Special SEE Operations in 2004 --> Flight software patch on Feb. 26, 2004
  - Changed default science observation so there is no XPS filter wheel movement
    - Successful test of patched software in flight.
    - Default observation is set to run if all loaded observations have been executed.
- SEE calibration rockets have been successful
  - NASA 36.192 launched on Feb. 8, 2002, complete success
    - Rocket results incorporated into Version 6 data
  - NASA 36.205 launched on Aug. 12, 2003, complete success
    - Rocket results incorporated into Version 7 data
  - NASA 36.217 launched on Oct. 15, 2004, complete success
    - Rocket results will be included in future SEE data products
  - Next calibration flight is planned for April 2006

List of SEE Data Gaps

Date	State	Sensor(s)	Science Data Affected
March 1, 2002	Safe Mode	Both	Part day
March 2, 2002	Safe Mode	Both	All day
March 4, 2002	Ground SW Anomaly	EGS	All day
March 5, 2002	Ground SW Anomaly	EGS	Part day
March 19, 2002	Safe Mode	Both	Part day
March 29, 2002	Safe Mode	Both	Part day
July 24 - 30, 2002	XPS Filter Wheel Anomaly	XPS	All days
Nov. 18-19, 2002	Leonid Safing	Both	Part day
Sept. 16 - 21, 2004	TIMED Flight Software Load	Both	Sept. 16,21: Part day Sept. 17-20: All day
Sept. 29 - Oct. 1, 2004	TIMED Flight Software Load	Both	Sept. 29, Oct. 1: Part day Sept. 30: All day

Status of SEE Instruments

No recent changes for SEE

- **EUV Grating Spectrograph (EGS) - fully functional**
  - The EUV ($\lambda < 115$ nm) has degradation mostly at the bright lines on the CODACON (MCP-based) detector, but it is being tracked with on-board redundant channel and flat-field detector lamp weekly experiments
  - The FUV (115-195 nm) has recovery that is corrected using UARS and XPS comparisons, but it is not fully understood at the longer wavelengths
    - need more UARS/SORCE data and next SEE rocket calibration (Aug 12, 2003)
- **XUV Photometer System (XPS) - 3 channels functional**
  - Fully functional until 2002/205 when there was a filter wheel anomaly (filter wheel stuck in position 6)
  - Three channels providing solar measurements
  - SORCE, with almost identical XPS, launched on Jan. 25, 2003
    - SORCE XPS data are incorporated into SEE version 7 products in the 0.1-27 nm range
- **Microprocessor Unit (MU) - fully functional**
- **SEE Solar Pointing Platform (SSPP) - fully functional**

SEE Version 7 Data Products

- SEE Version 7 data products - released July 7, 2004
  - SEE Level 2, 2A, 3, and 3A data products are available on public FTP site
  - EGS improvements
    - Better wavelength scale determination, dark correction, higher order line suppression, flare detection, long-term responsivity correction, flat-field correction, FOV correction is daily-based, gain has better temperature
    - Incorporate first two rocket calibration results
  - XPS revisions
    - Incorporate first two rocket calibration results
    - Improved visible light subtraction, dark correction, gain/degradation correction, FOV maps, data selection algorithm for averaging
    - Improved 0-27 nm irradiance algorithm (more accurate model scaling in the 11-27 nm range)
    - Include SORCE XPS solar XUV irradiances in the TIMED SEE L3 data product spectrum
  - New SEE observation average data products (3-min average every orbit)
    - Producing observation averaged solar UV irradiances that are needed for solar storm / flare studies and useful for space weather studies by NOAA and Air Force
      - New products are called EGS L2A, XPS L2A, and SEE L3A
      - Similar format as the daily average SEE data products (EGS L2, XPS L2, SEE L3)
      - Unlike the daily average results, no flares are removed from the observation averages

http://lasp.colorado.edu/see/

Improved web site released Aug. 2004

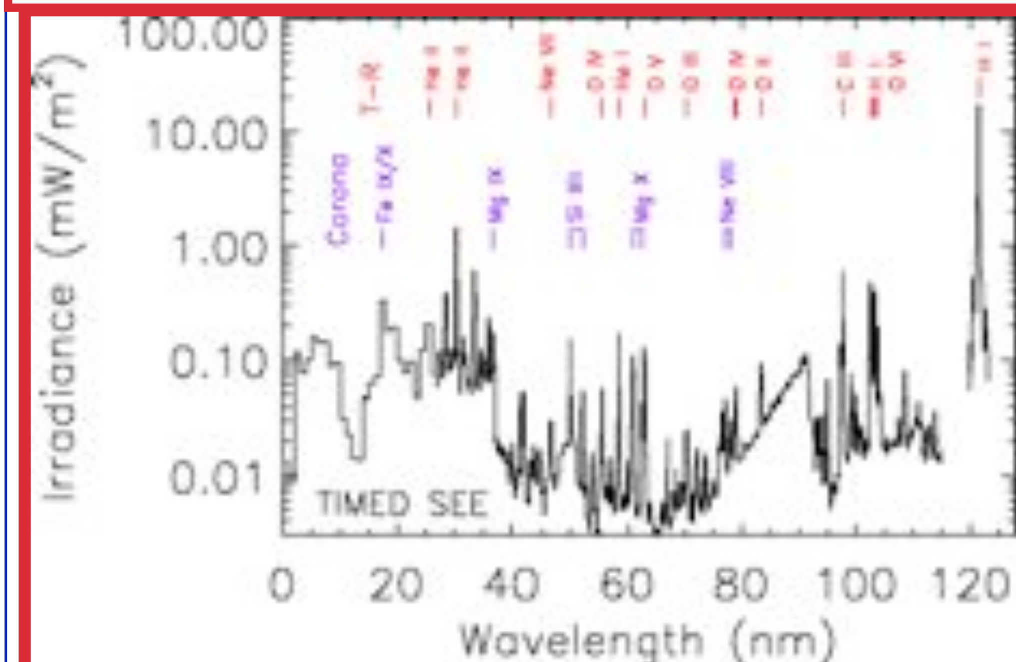
Future Plans for SEE Data Products

- Plans for SEE Version 8 data products - release to be in 2005
  - EGS revisions
    - Incorporate latest rocket calibration results
    - Improved flat-field corrections, wavelength scale algorithm, and field of view correction
  - XPS revisions
    - Incorporate latest rocket calibration results
    - Improved solar irradiance model for the Level 3 and 3A data products
  - New SEE occultation data product
    - Produce atmospheric transmission / density from EGS occultation measurements (100-500 km range)
      - New product will be called EGS L2occ

SEE Science Overview

SEE Science Plans

Solar UV Irradiance Measurements



Obj. #1

Validations

Internal Calibrations,
Underflight Calibrations
SOHO, SNOE,
UARS, SORCE

Eparvier, Woods,
Bailey, Rottman

Obj. #2

Solar UV Variability

Function of wavelength
Over time scales of minutes to years

All

Obj. #4

Modeling Solar Variation

Study variations related to active region evolution derived from solar images
Improve the **NRLEUV, SOLAR2000,** and **SunRise** solar irradiance models

Lean, Tobiska,
Chamberlin, Woods

Obj. #3

Obj. #5

Study Earth's Response

Photoelectron analysis with FAST data and using the ***glow*** model
Atmospheric response studies using HAO's **TIM-GCM**

Solomon, Roble,
Bailey, Eparvier

Overview of SEE Science Objectives

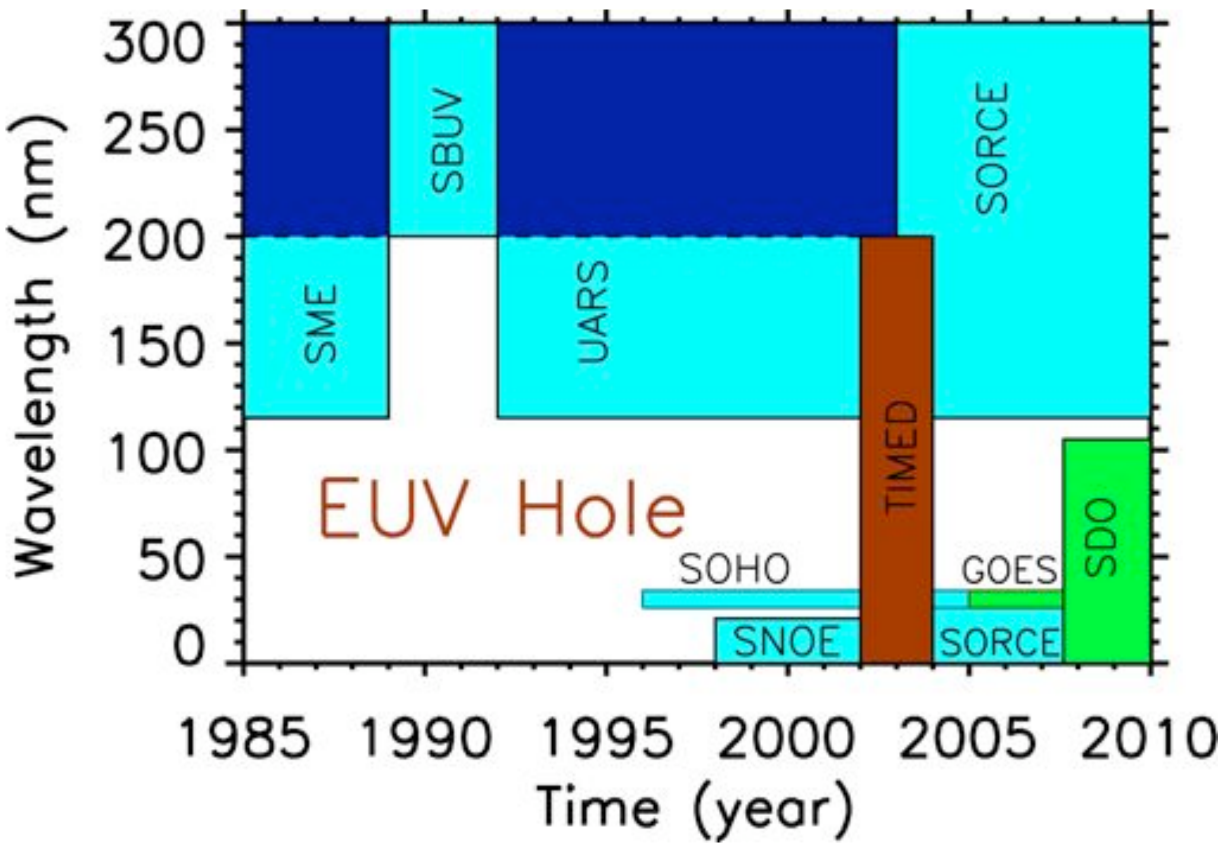
1. Accurately and precisely determine the time-dependent solar vacuum ultraviolet (VUV: below 200 nm) spectral irradiance
2. Study solar VUV variability (27-day rotations, solar cycle changes) and its sources
3. Study the solar-terrestrial relationships utilizing atmospheric models, primarily the TIME-GCM at HAO/NCAR
4. Improve proxy models of the solar VUV irradiance
5. Determine the thermospheric neutral densities (O_2, N_2 and O) from solar occultations

Summary of SEE Results

- **Objective 1: solar VUV spectral irradiance measurements**
  - Daily measurements since Jan. 22, 2002 are filling the "EUV Hole"
  - Validation effort verifies 10-20% accuracy and 2-4% precision
- **Objective 2: solar variability**
  - New results on 27-days and 13.5-days variability showing interesting enhancements for coronal emissions and phase shifts of 2-7 days for the coronal emissions relative to the other emissions
  - New results on flare variability as SEE has observed more than 200 flares
- **Objective 3: model solar response in Earth's atmosphere**
  - Use of *glow* model with SEE solar data and photoelectron data (FAST, GUVI)
  - Use of HAO TIME-GCM for atmospheric response to SEE's solar input
  - Comparison of GUVI Q_{EUV} and SEE solar irradiance measurements
- **Objective 4: solar irradiance modeling**
  - SOLAR2000 model improvements
  - NRLEUV model improvements
  - New Flare Irradiance Spectral Model (FISM) being developed at LASP

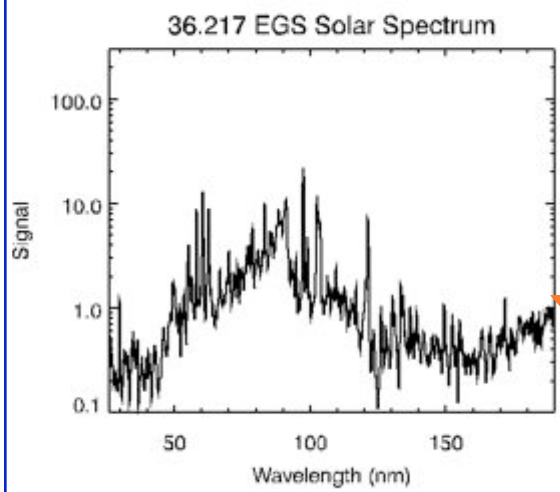
SEE is Filling the "EUV Hole"

- The "EUV Hole" is the lack of measurements of the solar irradiance over the full EUV range from 1981 (AE-E) until TIMED was launched in December 2001

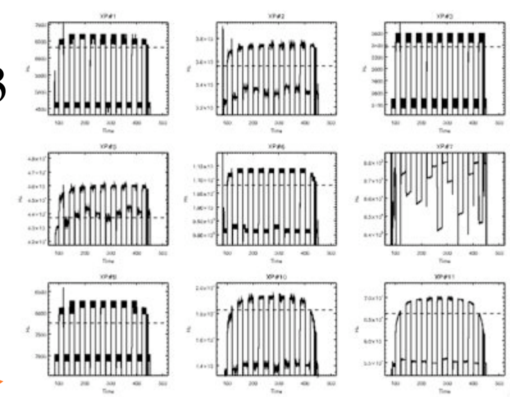


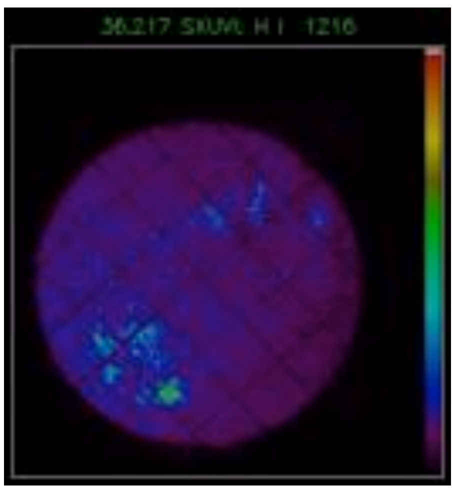
Calibrations and Validation Results

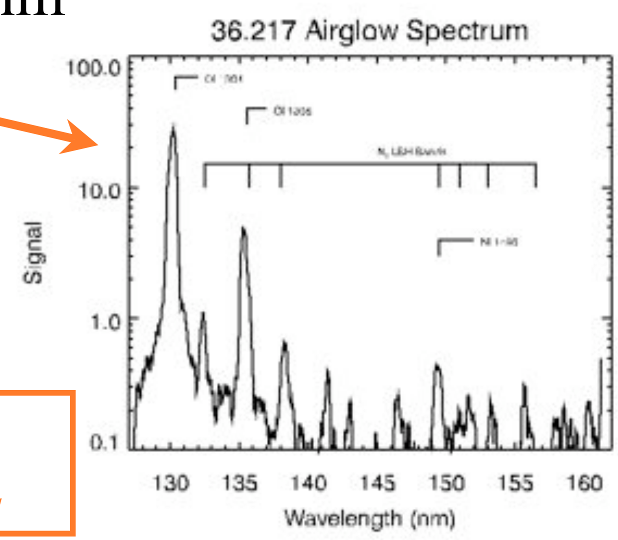
2004 Calibration Rocket Is Successful



- SEE Calibration Flights
  - NASA 36.192: Feb. 8, 2002
  - NASA 36.205: Aug. 12, 2003
  - NASA 36.217: Oct. 15, 2004
- Prototype EGS
  - 26-190 nm, $\Delta\lambda$=0.4 nm
- Prototype XPS
  - 0.1-35 nm, $\Delta\lambda$=~7 nm
- FUV Airglow
  - 128-160 nm
- Solar Imager
  - H I 1216



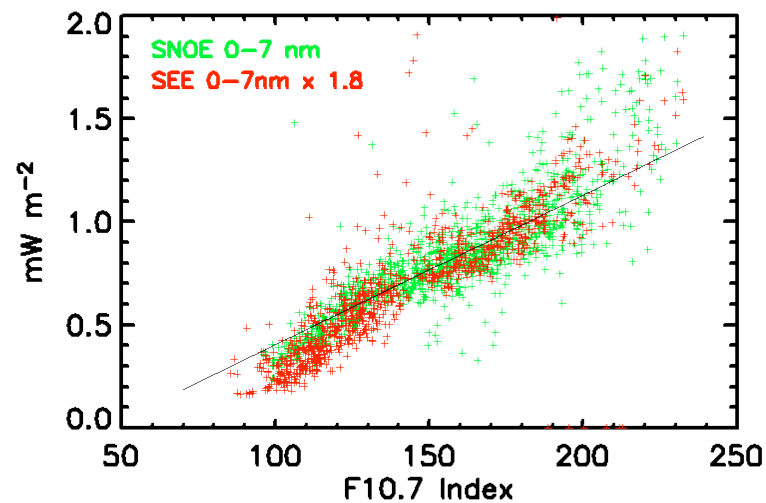


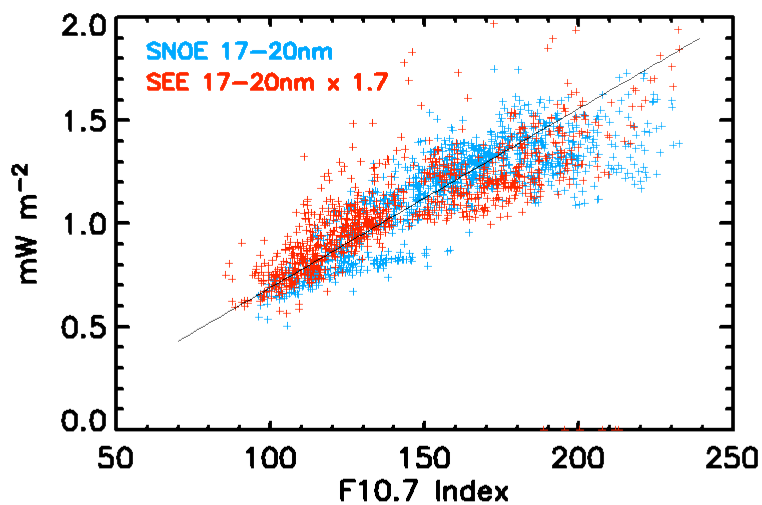


Also coordinated observations
with UARS, SOHO, TRACE, SORCE

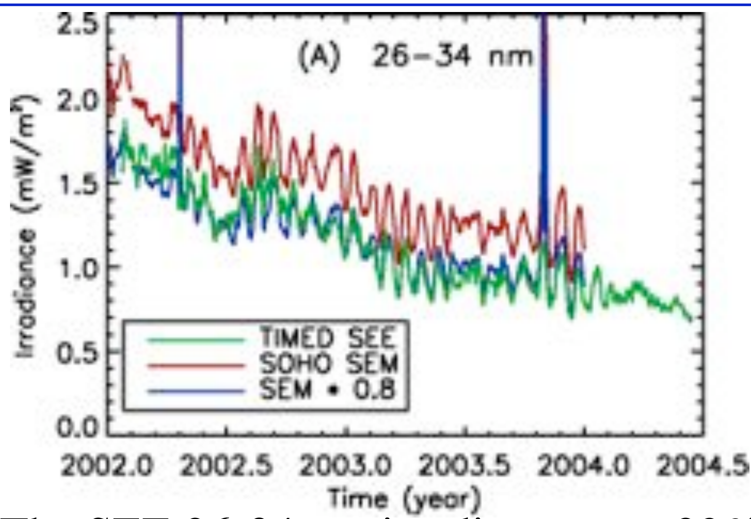
Validation of SEE Version 7 Data - XUV

- SEE and SNOE XUV observations can be compared directly because they use the same measurement technique
- Initial comparisons reveal differences on the order of a factor of 2
- Discrepancies are likely due to errors from calibration and assumptions regarding reference spectrum used to interpret broadband measurements
- New calibrations from SURF and results from sounding rocket experiments are being used to help solve discrepancy
- SEE and SNOE are in agreement about solar variability on both 27–day and solar cycle time scales

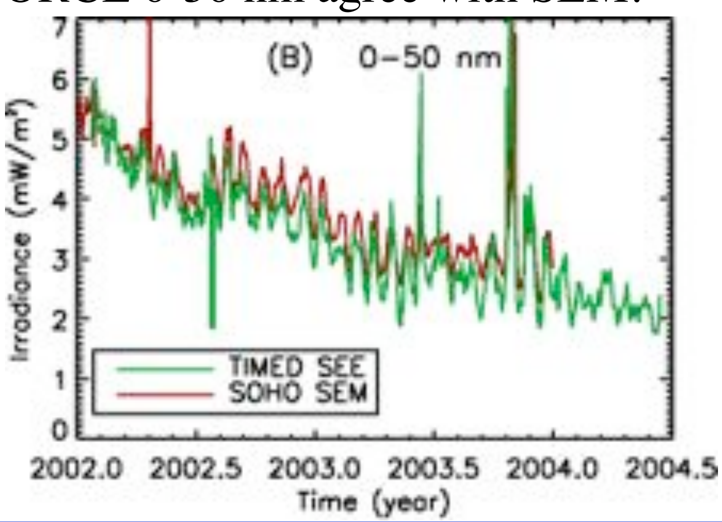


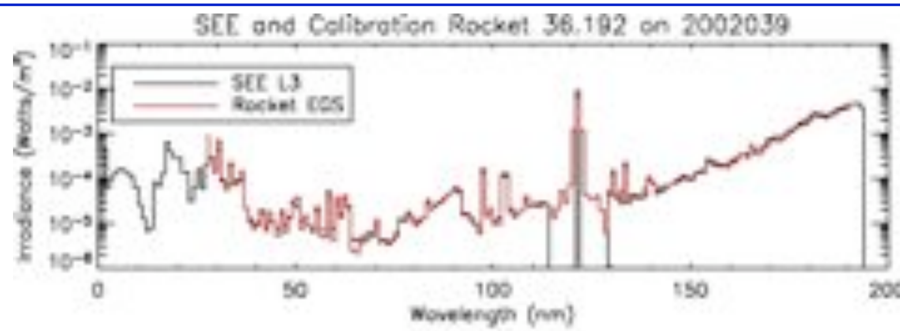


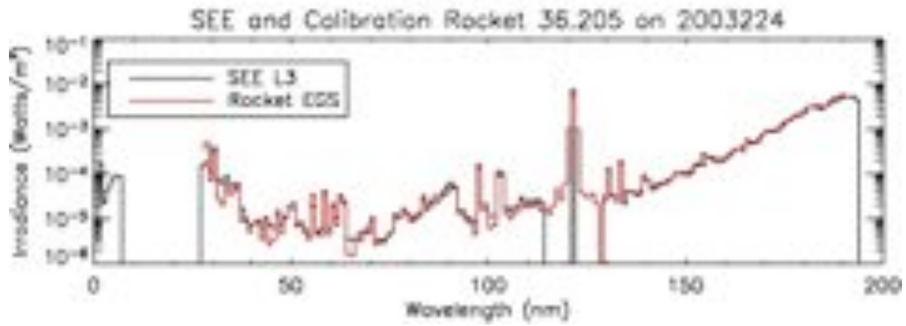
Validation of SEE Version 7 Data - EUV



The SEE 26-34 nm irradiances are 20% less than the SOHO SEM values. The SEE and SORCE 0-50 nm agree with SEM.





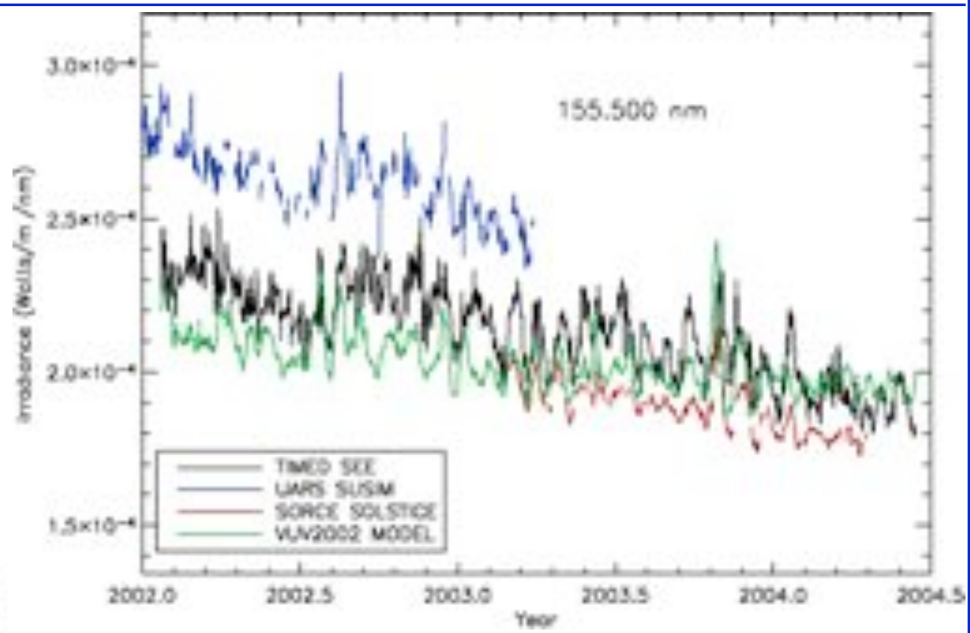


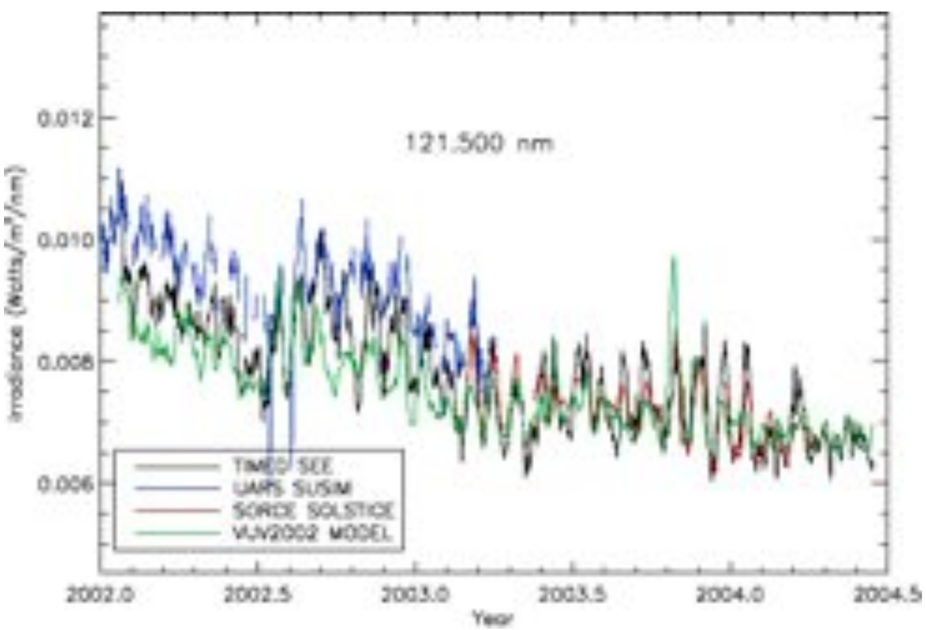
Rocket calibration results are transferred to SEE to establish absolute values and the long-term degradation.

Validation of SEE Version 7 Data - FUV

The FUV recovery function is included in the new SEE Version 7 data products.

Differences are less than 10% in the FUV between SEE, SUSIM, and SOLSTICE.





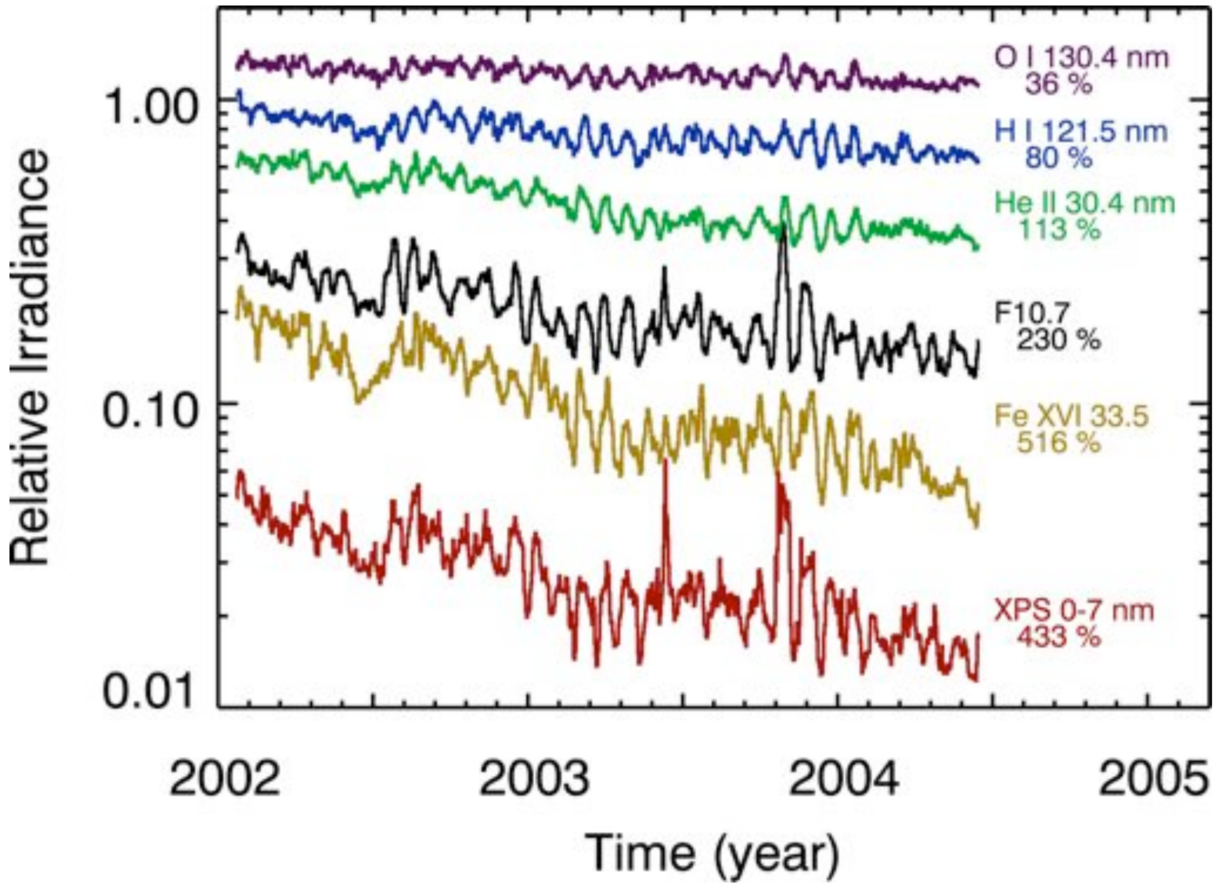
The H I Lyman-α (121.6 nm) irradiances are in very good agreement.

Solar Variability Results

Variability Overview
Solar Rotational Variability
Solar Flares

SEE is Providing New, Accurate Solar EUV Irradiances

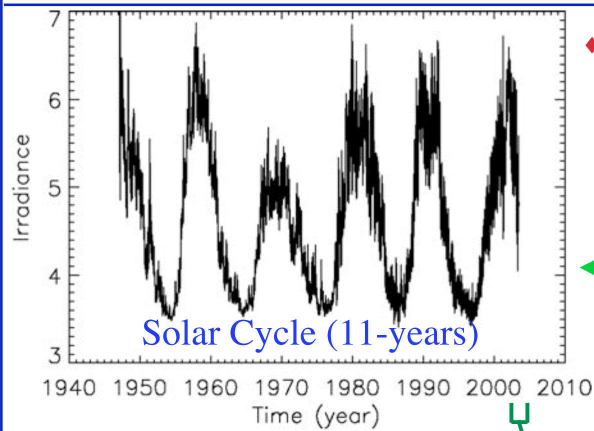
- SEE measures the solar irradiance from 0.1 to 194 nm
  - Daily measurements since Jan. 22, 2002
- Annual rocket underflight calibrations enable long-term accuracy for the SEE measurements



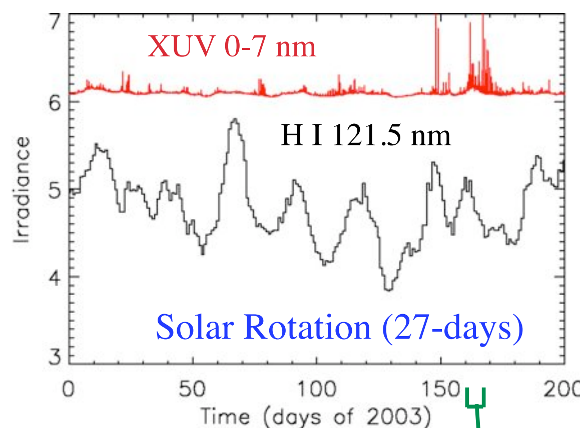
Chromosphere

Corona

Examples of Solar Variations from SEE

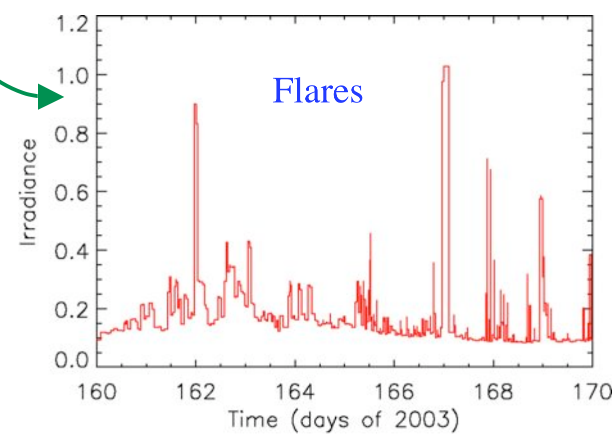


- Solar Cycle - months to years
  - Evolution of solar dynamo with 22-year magnetic cycle, 11-year intensity (sunspot) cycle
  - Long-term H I Lyman-α time series has been extended with TIMED SEE measurements



SEE is providing new information on solar VUV variability

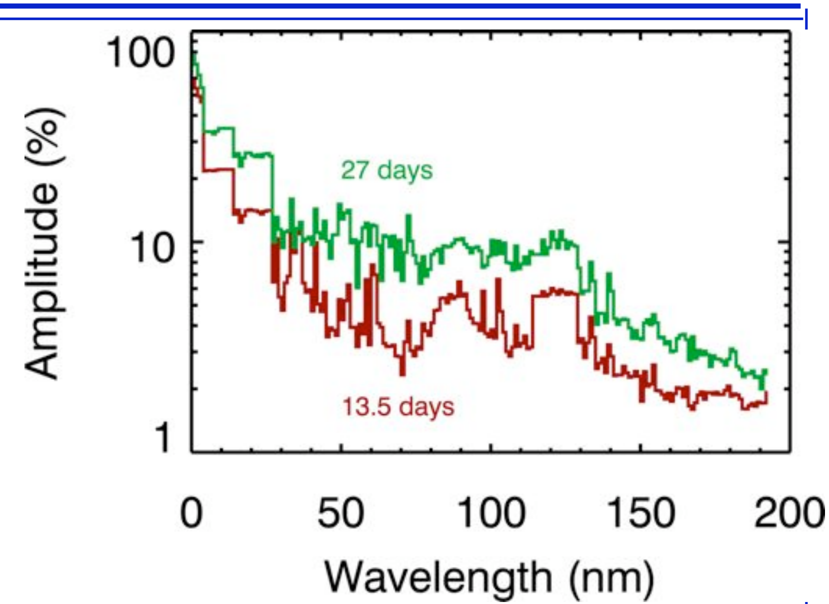
- Solar Rotation - days to months
  - Beacon effect of active regions rotating with the Sun (27-days)

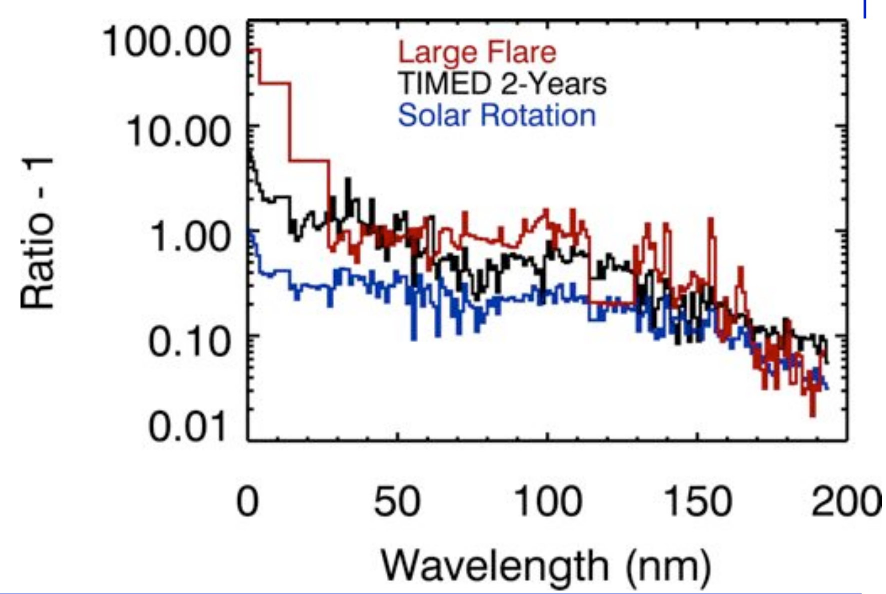


- Flares - seconds to hours
  - Related to solar storms (such as CMEs) due to the interaction of magnetic fields on Sun

SEE is Providing New Results on Solar Variability

- Solar Rotation
  - New results on both 27-days and 13.5-days variations
    - Can derive solar center-to-limb variations for the EUV
- Solar Cycle
  - New results for Solar Cycle 23
  - TIMED has NOT observed solar cycle minimum yet
- Solar Flares
  - Variations for the large flares are as large as solar cycle variations in the EUV

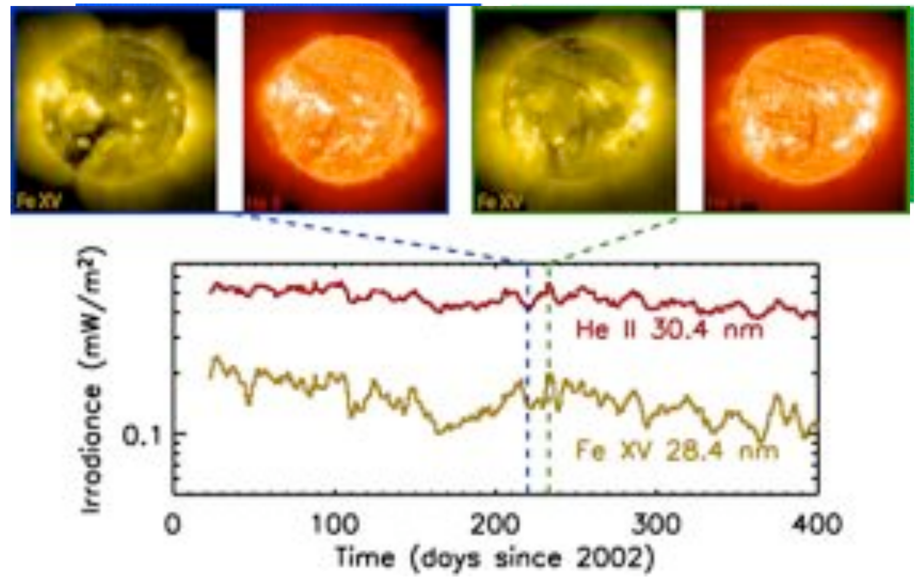


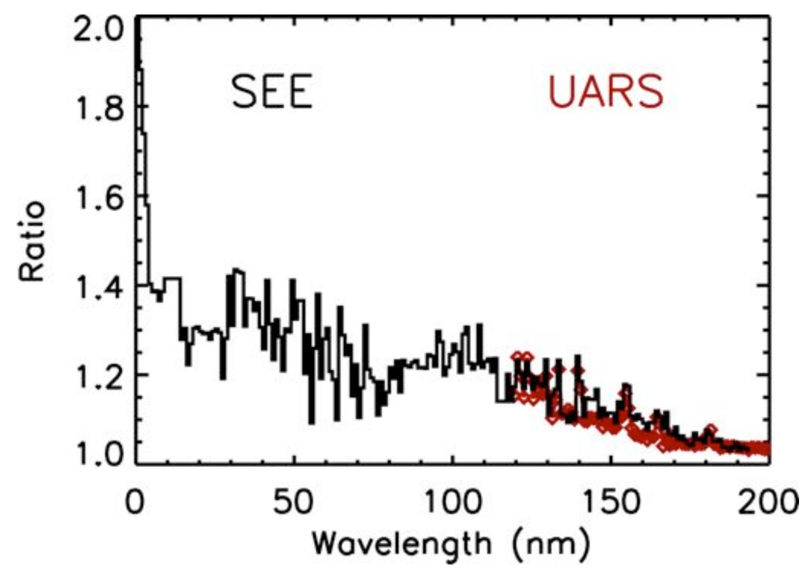


New Results for Solar Rotation Variability

- One of the larger solar rotation variations during the TIMED mission is during August 2002

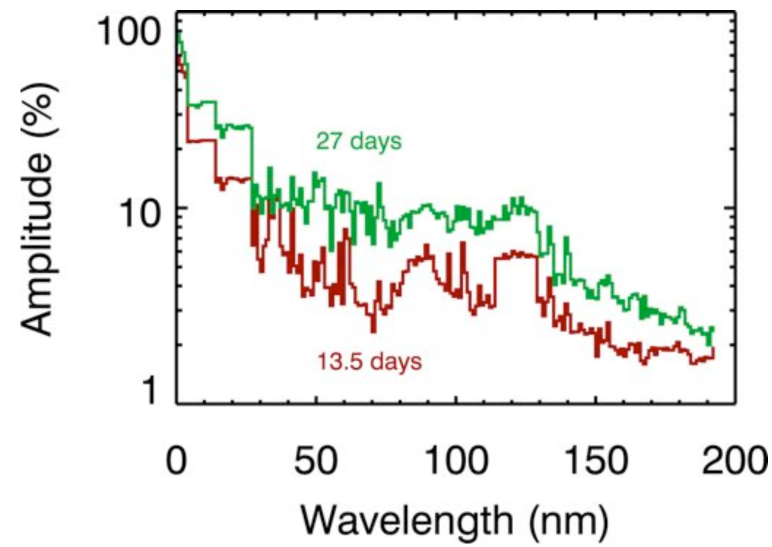
- The SEE solar rotation variations, shown for August 2002, are new results for the EUV range and are consistent with the UARS measurements in the FUV

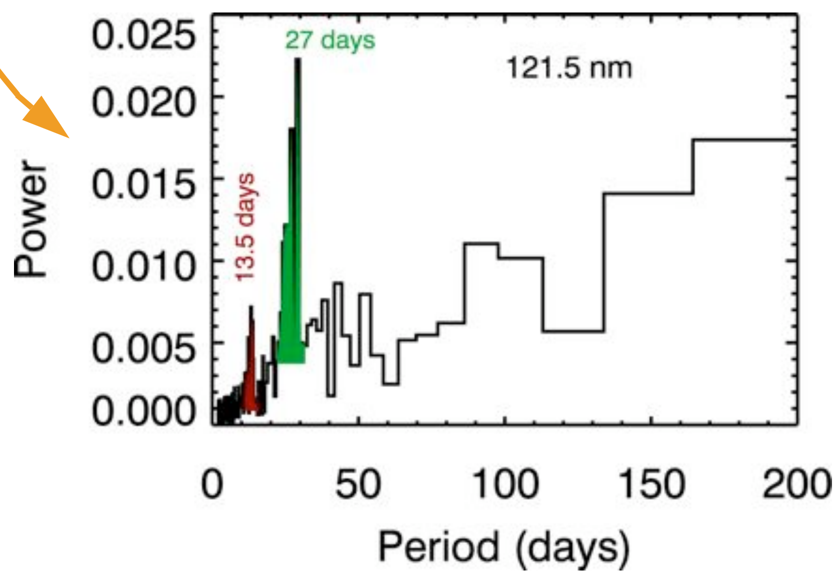


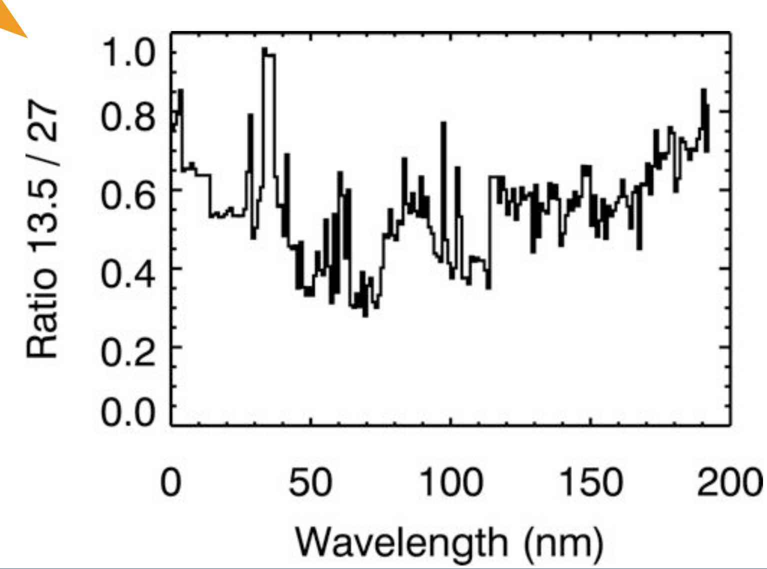


New Results on 27-days and 13.5-days Variations

- Fourier analysis of the SEE time series indicates strong 27-days and 13.5-days variations
- Variations with wavelength indicate larger 13.5-days variations for the coronal emissions

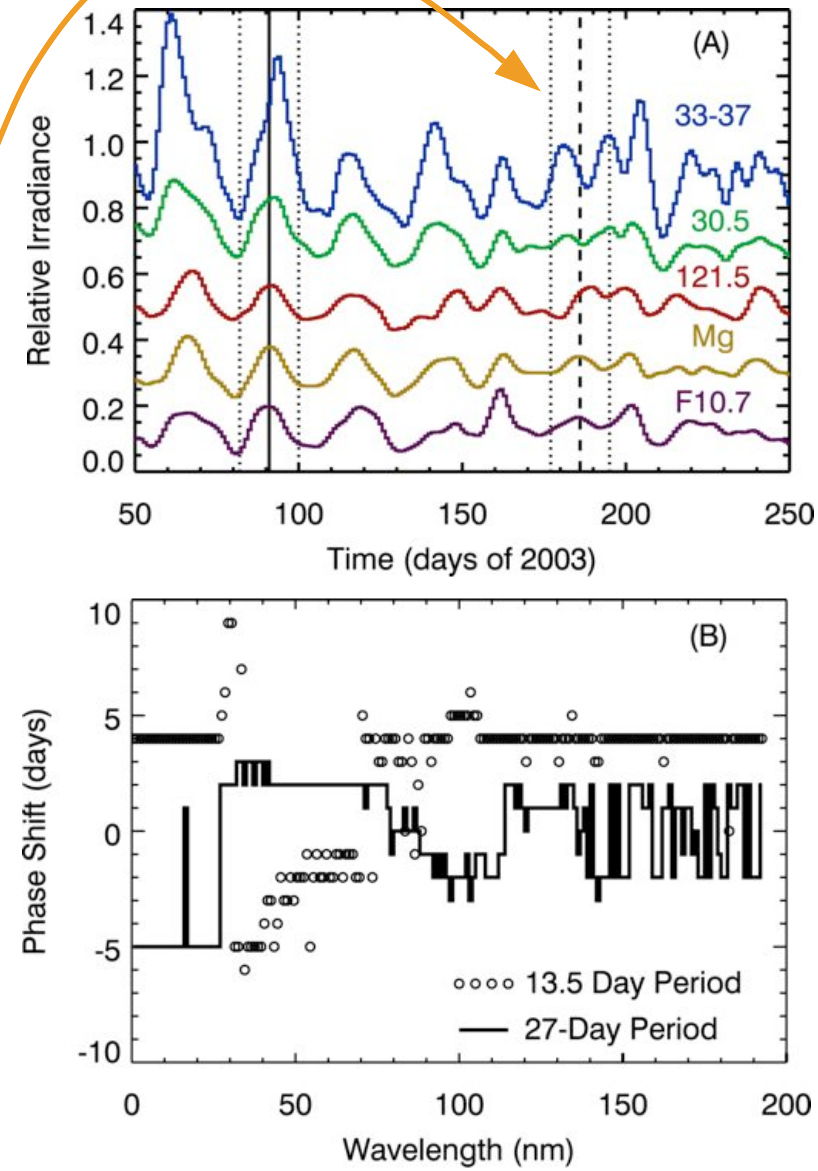






Discovery of Phase Shifts for Coronal Emissions

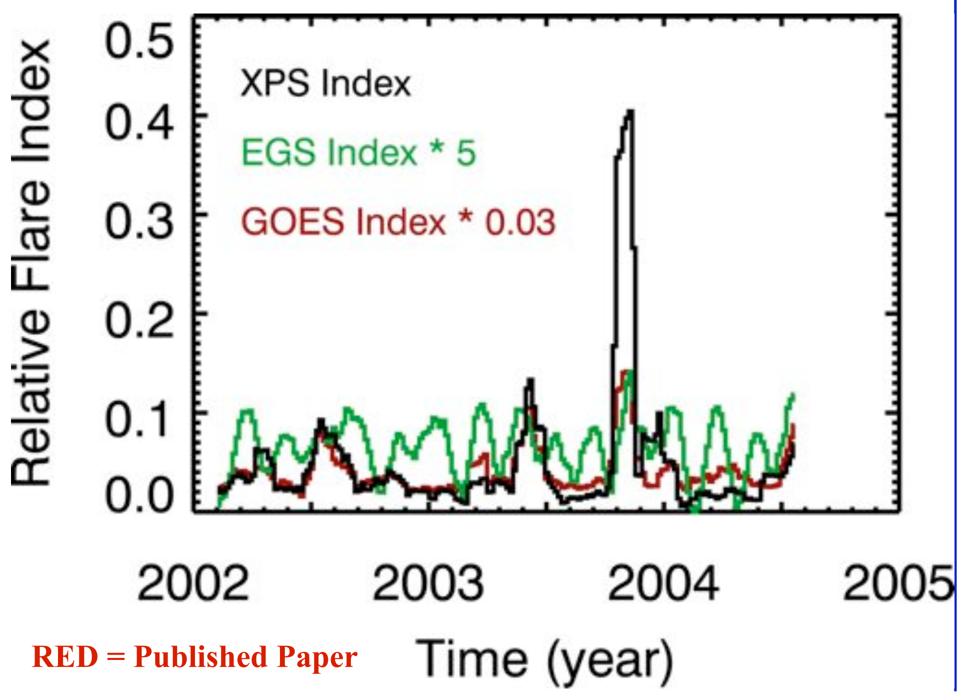
- The coronal emissions, such as in the 33-37 nm range, often have a phase shift of -6 days or +6 days relative to other emissions
  - More prevalent when there is strong 13.5-days periodicity
- Cause of these phase shifts is from the coronal emissions having strong limb brightening
  - That is, active regions near the limb cause peaks for coronal emissions, but active regions near disk center cause peaks for other emissions



Several Solar Storms During the TIMED Mission

SEE Observation Date - Time (UT)	GOES Class (Peak Time)	Flare Ratio 0-7 nm	Flare Ratio 102.5 nm
4/21/02 02:13	X1.5 (01:51)	8.3	1.10
7/23/02 00:51	**X4.8 (00:35)**	**7.8**	**1.14**
8/24/02 01:38	**X3.1 (01:12)**	**5.9**	**1.07**
5/27/03 23:10	**X1.3 (23:07)**	**12.1**	**1.26**
5/29/03 01:05	**X1.2 (01:05)**	**8.5**	**1.38**
6/17/03 22:59	**M6.8 (22:58)**	**6.4**	**0.98**
10/26/03 07:29	**X1.2 (06:54)**	**4.6**	**1.08**
10/26/03 18:50	**X1.2 (18:19)**	**6.6**	**1.07**
10/28/03 11:19	X17 (11:10)	30.1	1.82
10/29/03 21:20	**X10 (20:49)**	**7.1**	**1.24**
11/02/03 17:38	**X8.3 (17:25)**	**13.4**	**1.23**
11/03/03 09:50	**X3.9 (09:55)**	**2.7**	**1.40**
11/04/03 19:50	X28 (19:48)	52.7	1.50
7/15/04 02:08	**X1.8 (01:41)**	**2.7**	**1.13**
7/16/04 02:25	**X1.3 (02:06)**	**3.8**	**1.18**
7/22/04 00:53	**M9.1 (00:32)**	**3.5**	**1.24**

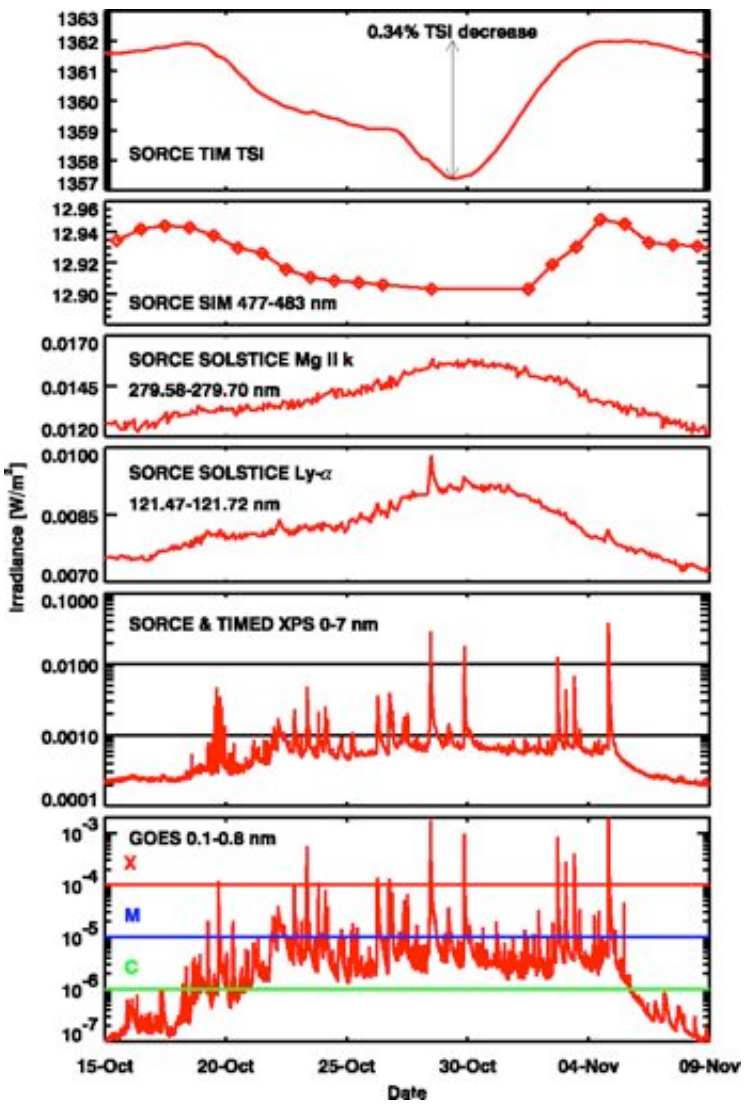
- Interesting Periods
  - April 2002
  - July 2002
  - June 2003
  - October-November 2003
  - July 2004
- SEE has observed > 200 flares



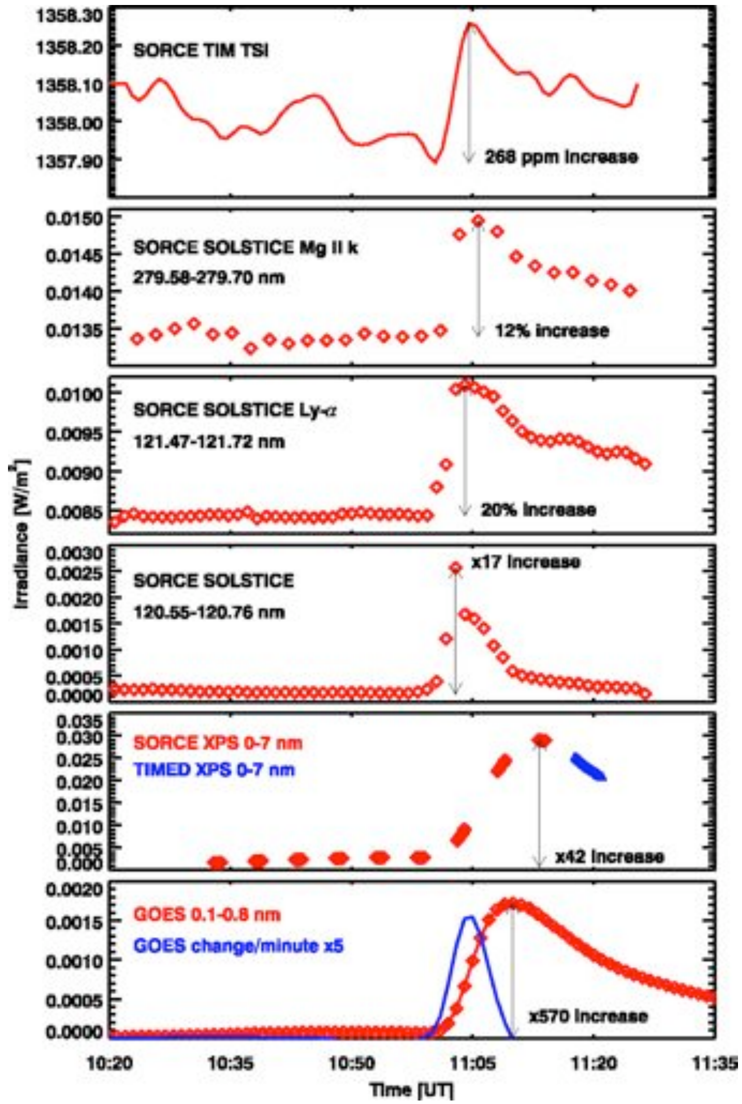
RED = Published Paper

SEE Observed the Large Flares in Oct. 2003

55 Large Flares in 2-week Period



X17 Flare on 28 Oct 2003



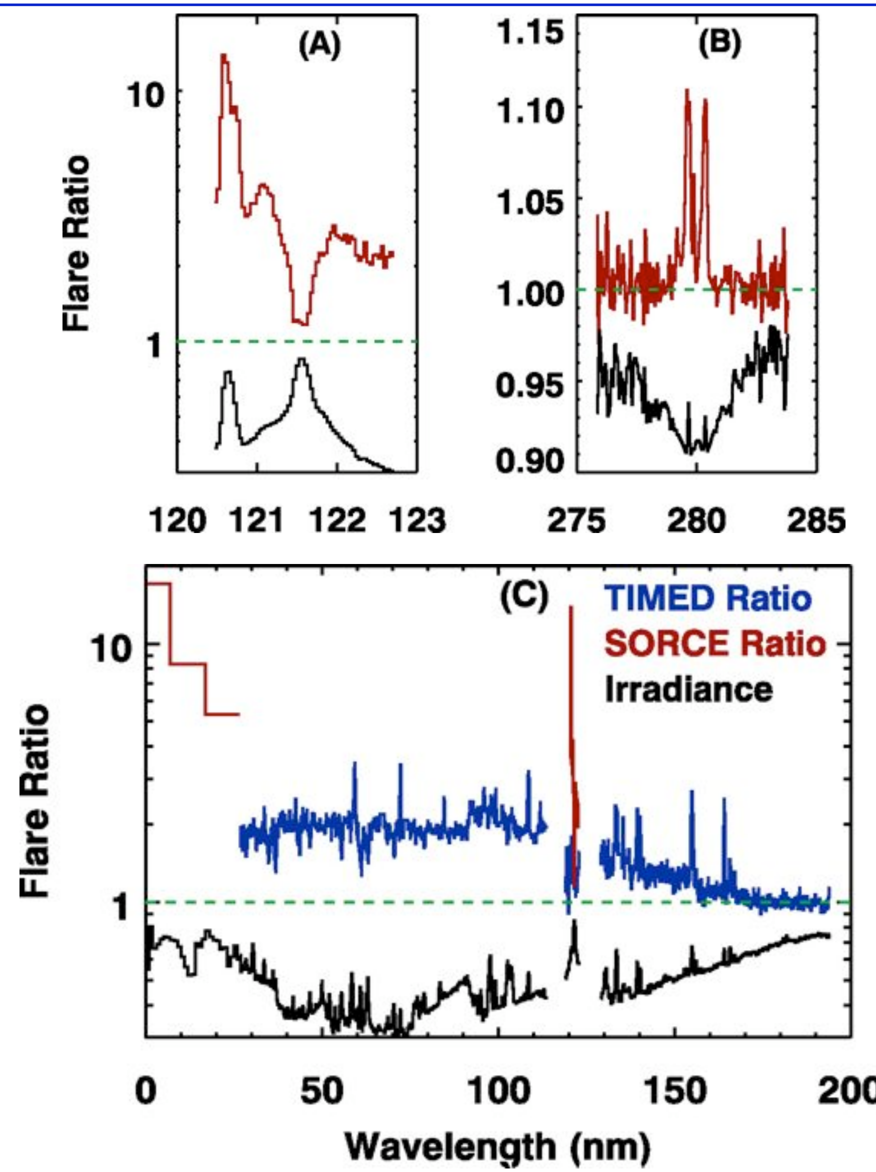
First Detection of a Flare in the TSI

55 Large Flares Observed During Period that Normally has Less Than 7 Large Flares

Full Spectral Coverage by TIMED and SORCE for the X17 Flare on Oct. 28

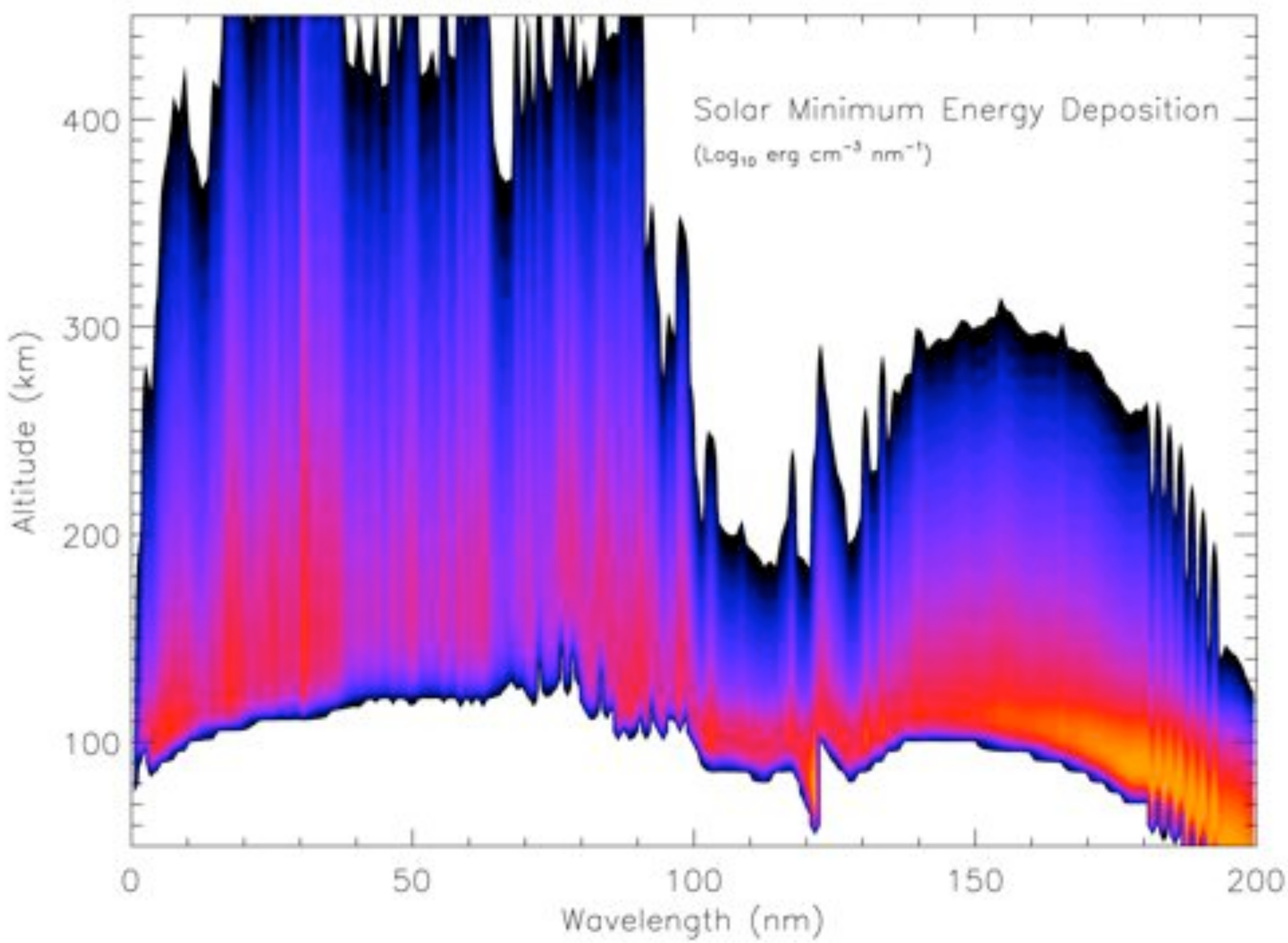
The X17 Flare Variation is as Large as Solar Cycle Variation

- Panel A: FUV Ly-α
  - 20% at Ly-α core
  - x 2 for Ly- α wings
  - x 17 for 120.6 nm emission
- Panel B: MUV Mg II
  - 12% for Mg II lines
- Panel C: VUV
  - x 2 for EUV and some FUV lines
  - > 10 for X-rays



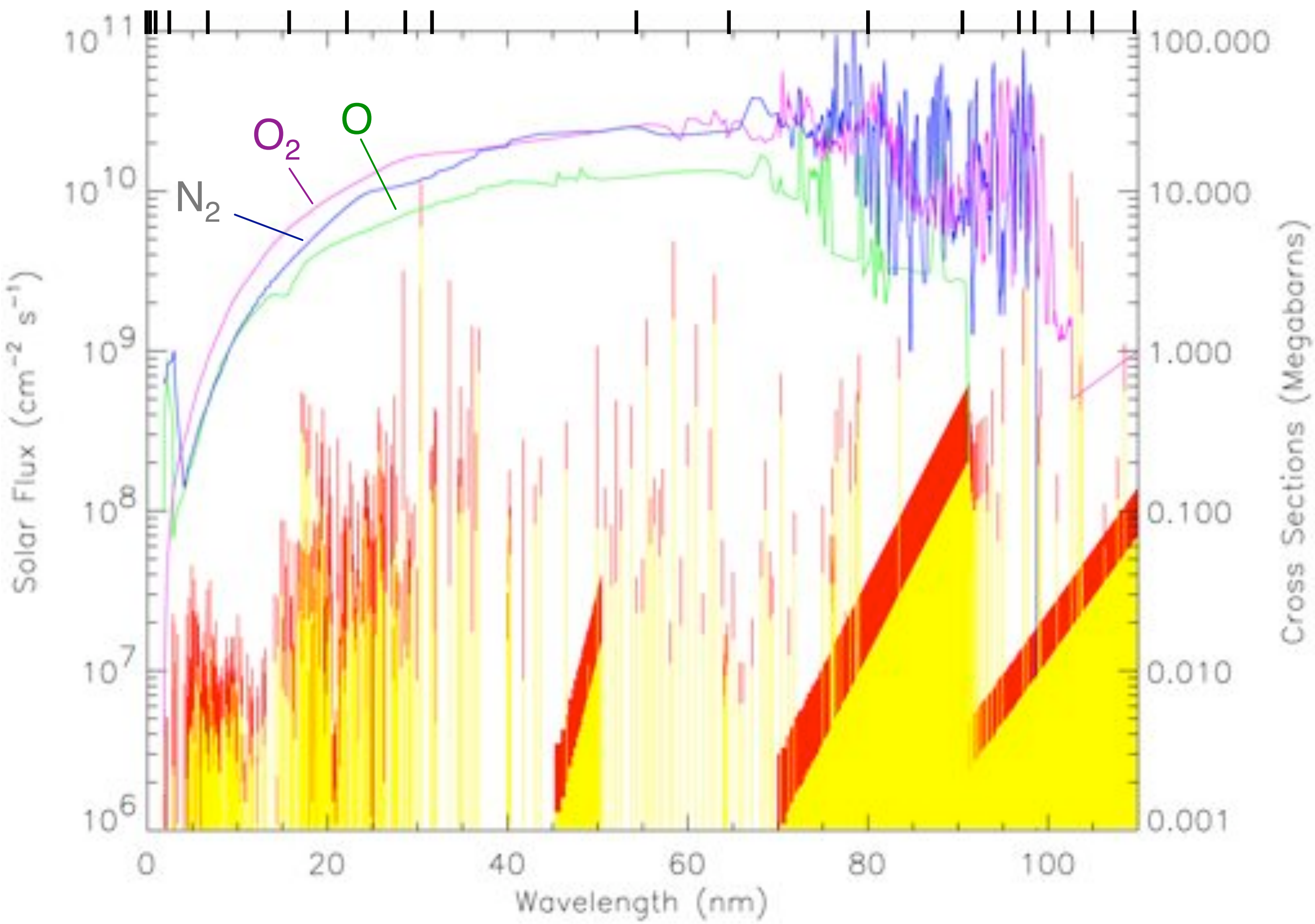
Atmospheric Modeling Results

SEE Solar Measurements Applied to Ionosphere/Thermosphere General Circulation Models



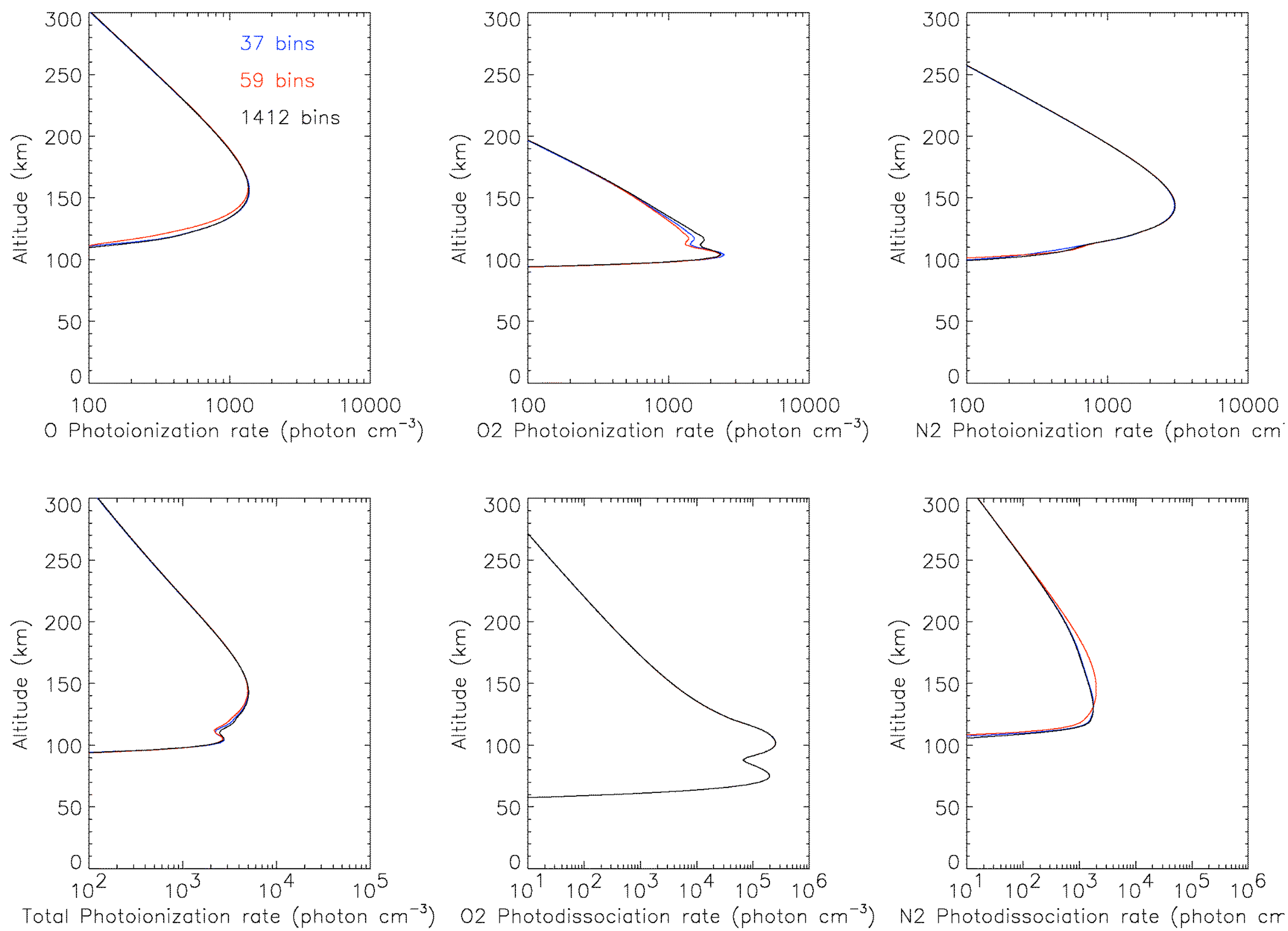
Schematic showing the wavelength dependence of energy deposition in the upper atmosphere

Solar Spectrum and Atmospheric Cross-Sections

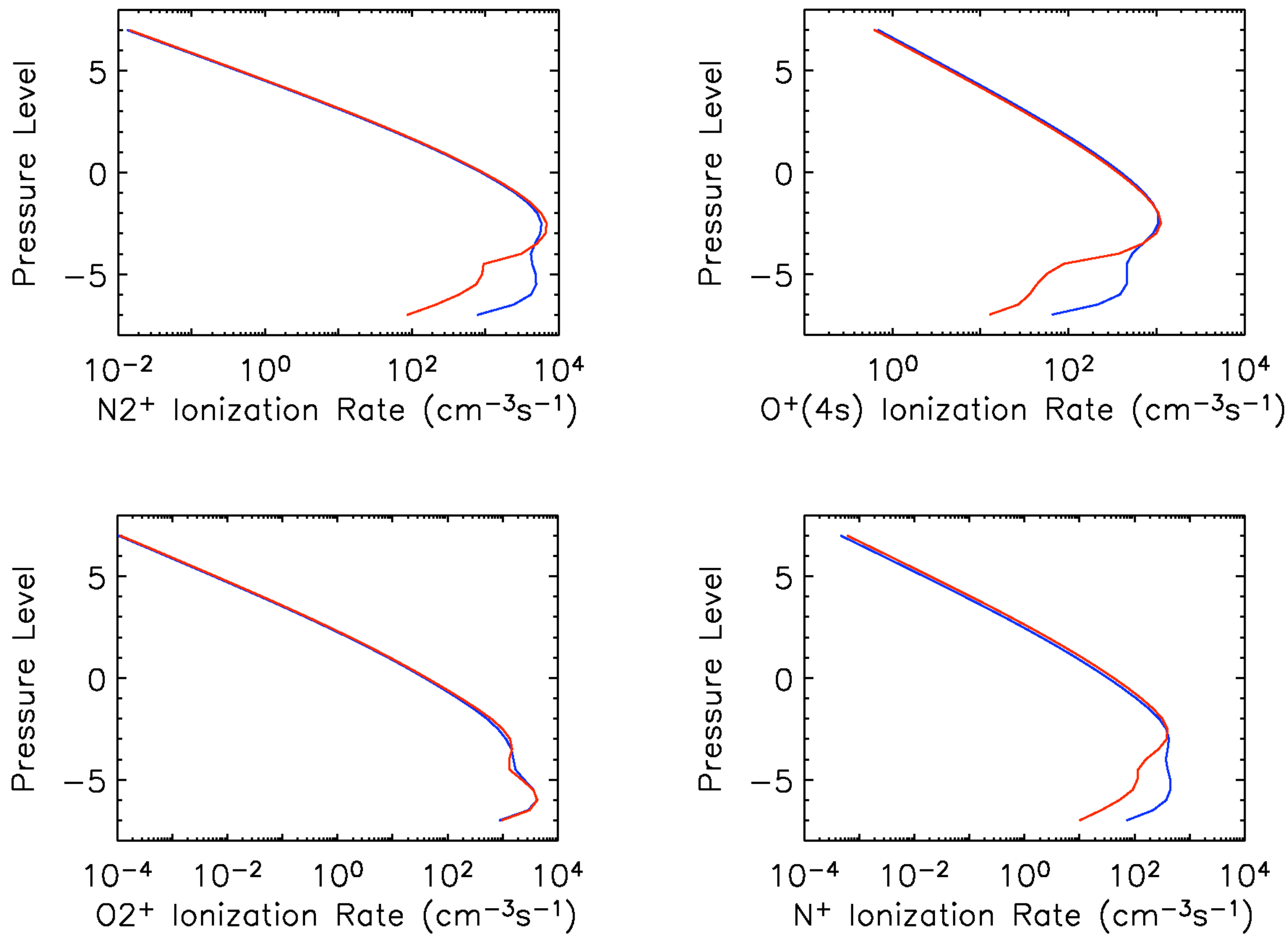


This plot shows a model solar spectrum, the atmospheric constituent cross sections that control energy deposition in the upper atmosphere, and the low-resolution bin structure developed for use in the NCAR TIE-GCM

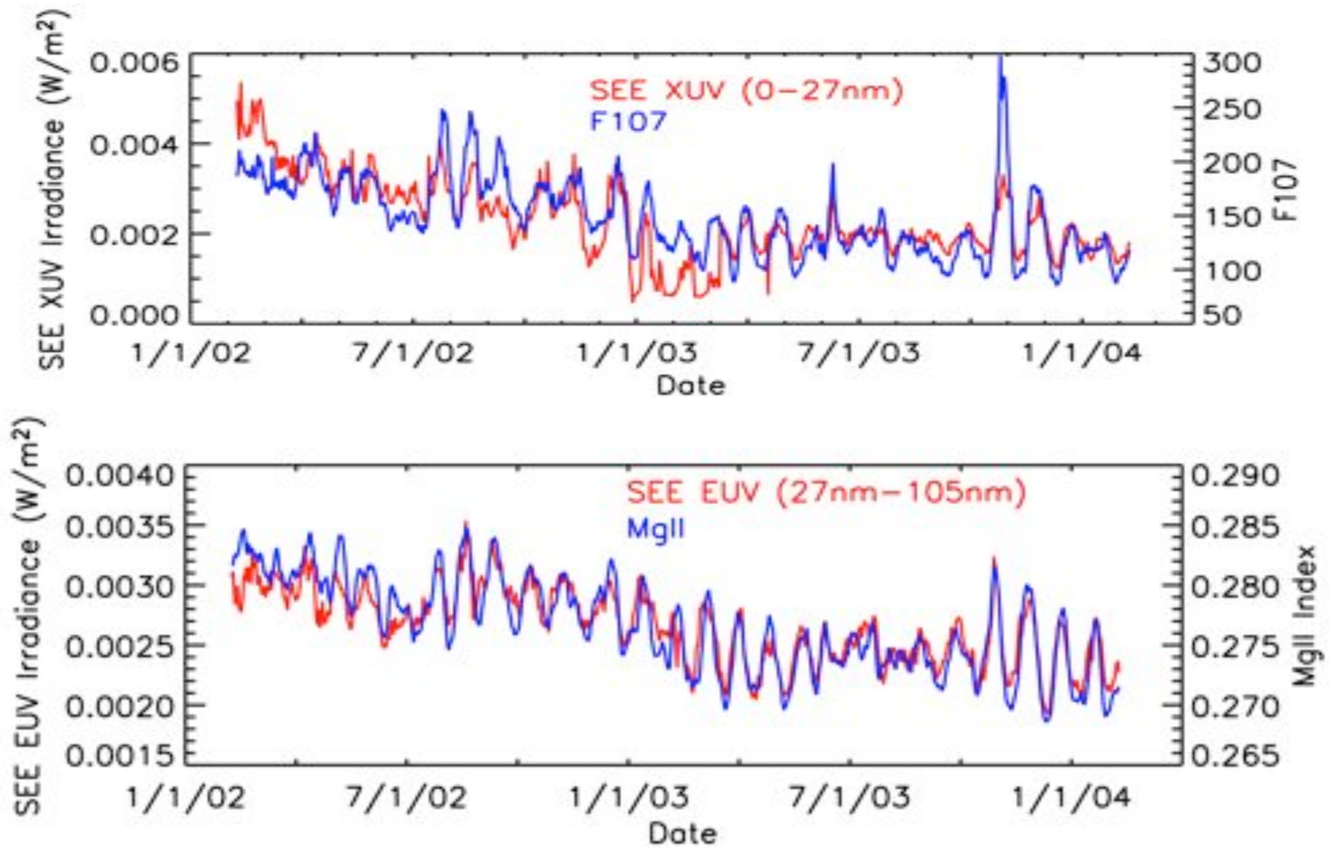
Photoionization and Photodissociation Rates Calculated by the GLOW Model Using Different Wavelength Bin Structures



New Parameterization Including Accurate Photoelectron Ionization Rates Increases Lower Atmosphere Energy Deposition in the NCAR TIE-GCM

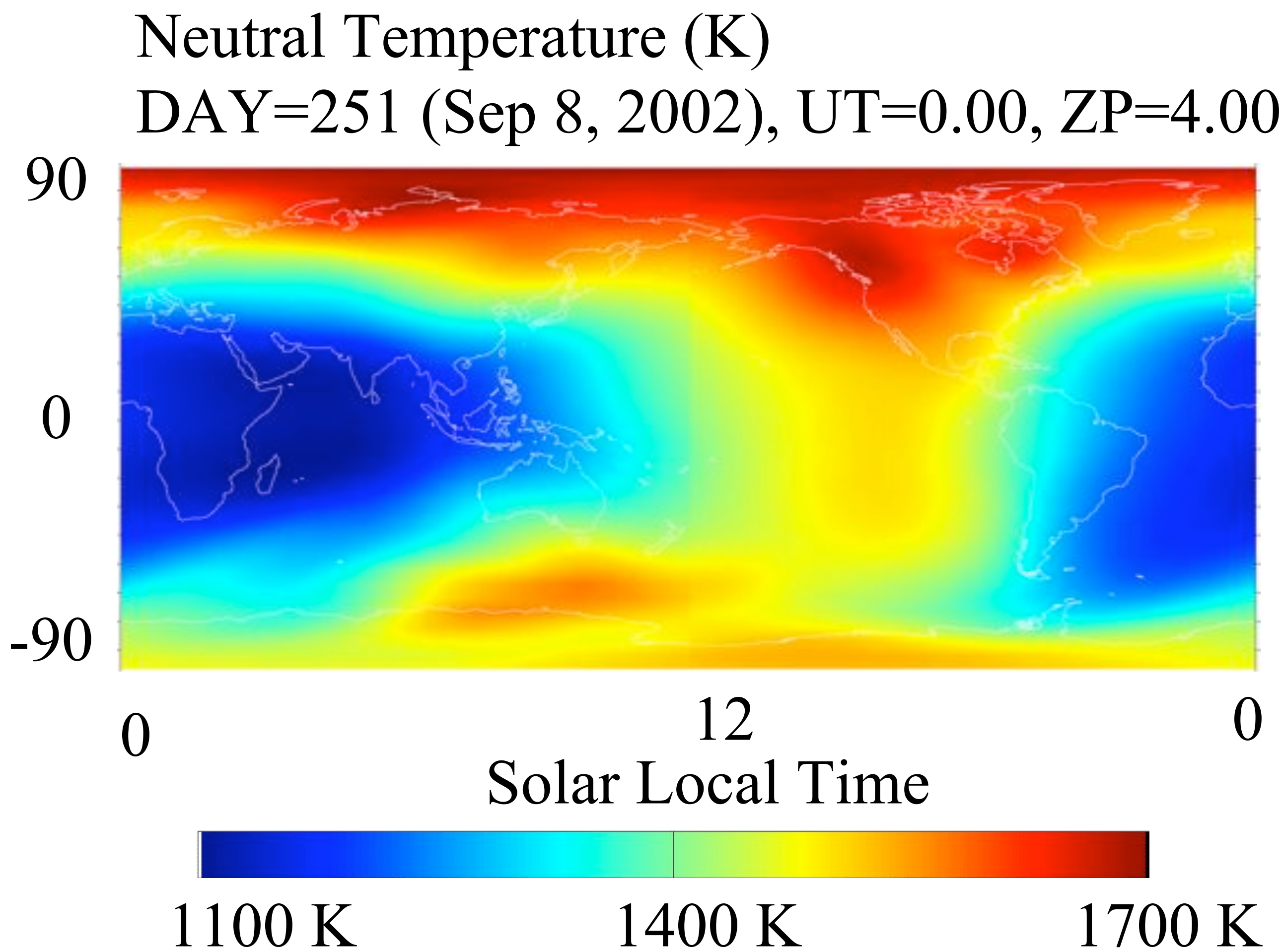


SEE Data Compared to Solar Indices



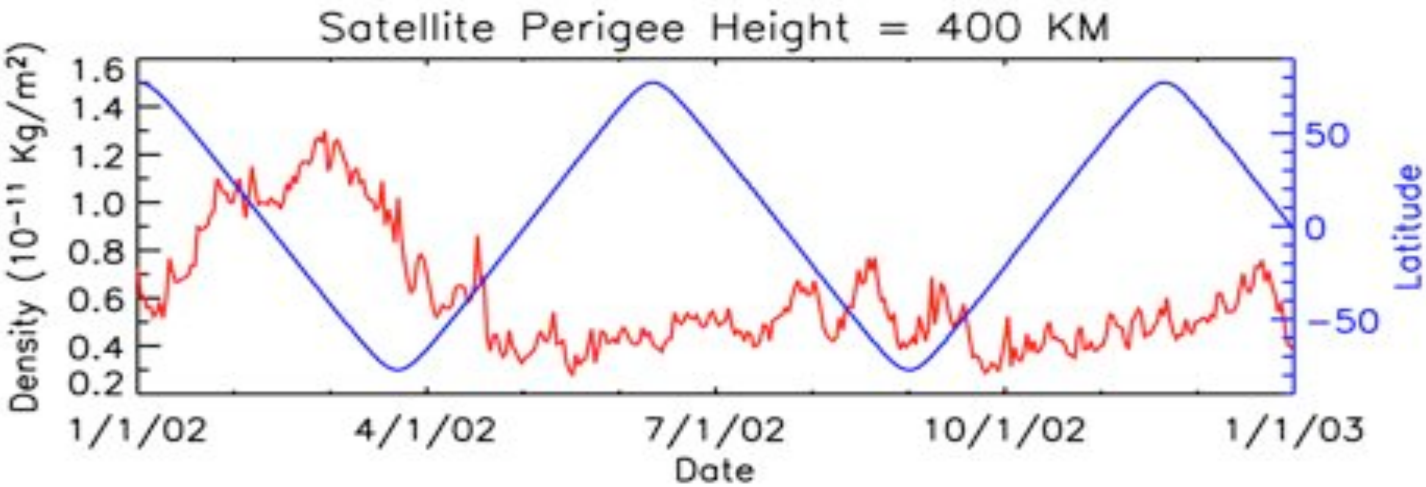
SEE measurements are employed as direct daily input to the NCAR TIE-GCM, using the new parameterization scheme, for comparison to proxy-driven models such as EUVAC

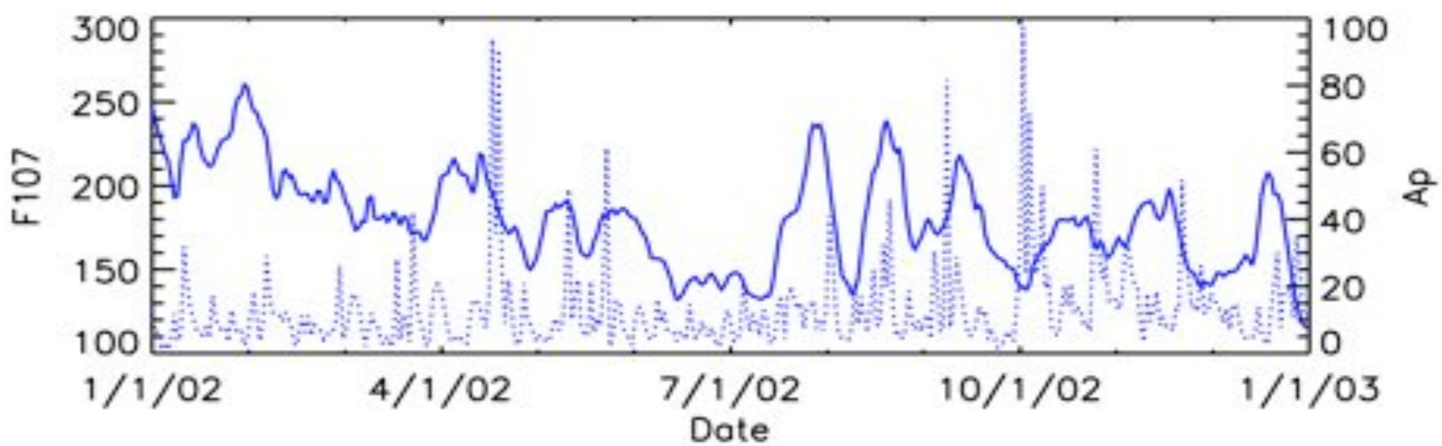
Modeling Thermosphere Neutral Temperature and Density



Example NCAR TIE-GCM calculation of the neutral temperature near 300 km using SEE data as input

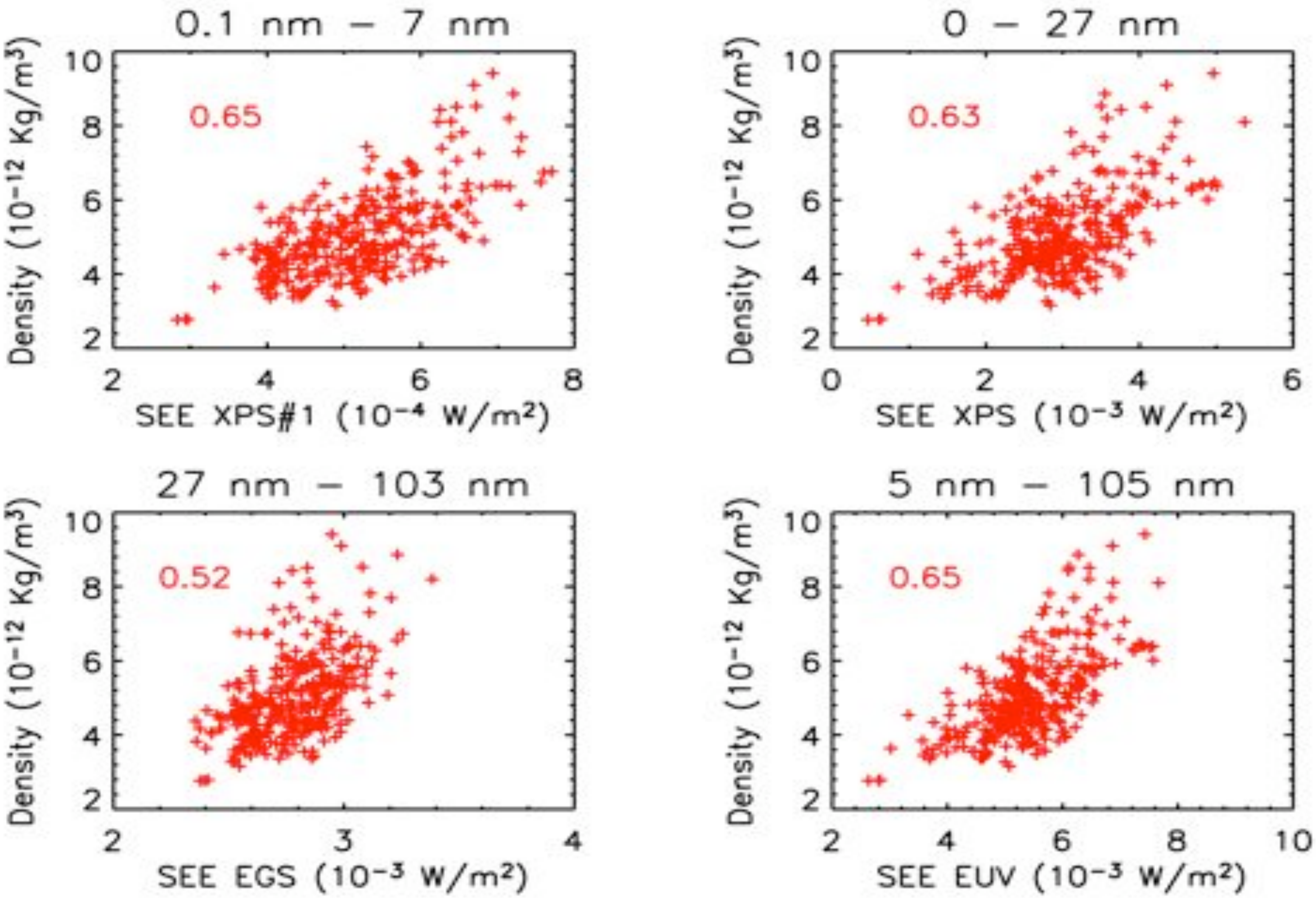
Thermospheric Density Measured by Atmospheric Drag on Orbiting Satellites





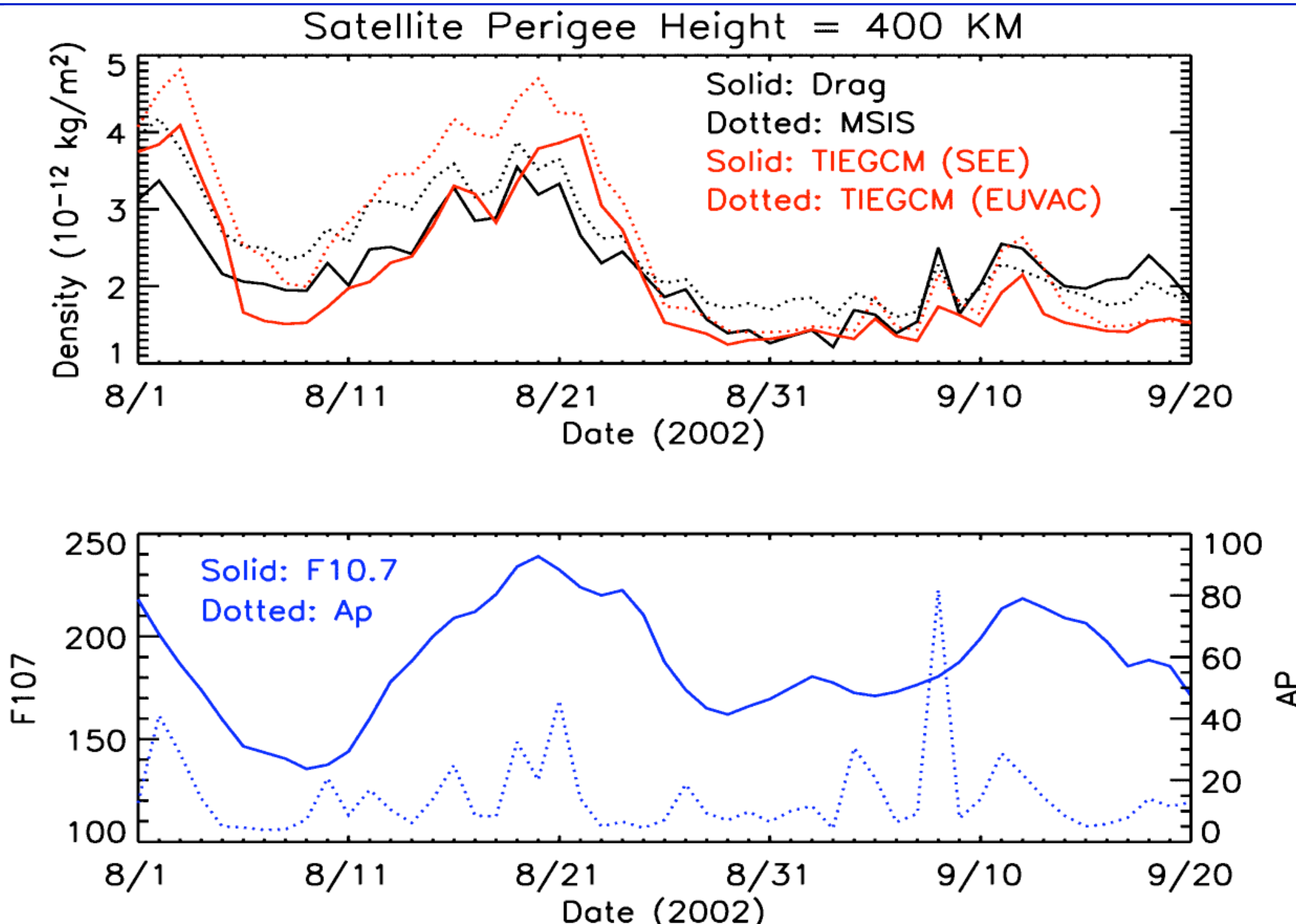
This is an example of drag-derived density measurements from one of the 15 satellites analyzed by Frank Marcos, AFRL, for analysis in conjunction with the SEE measurements and NCAR models

Correlation of Satellite Drag Data from 2002 to Various Bands in the SEE Solar Spectrum



All bands correlate fairly well, but none stand out as particularly strong. There is considerable scatter due changes in satellite latitude, solar time, and auroral heating.

Preliminary Comparison of Satellite Drag Density Measurements Compared to Model Calculations



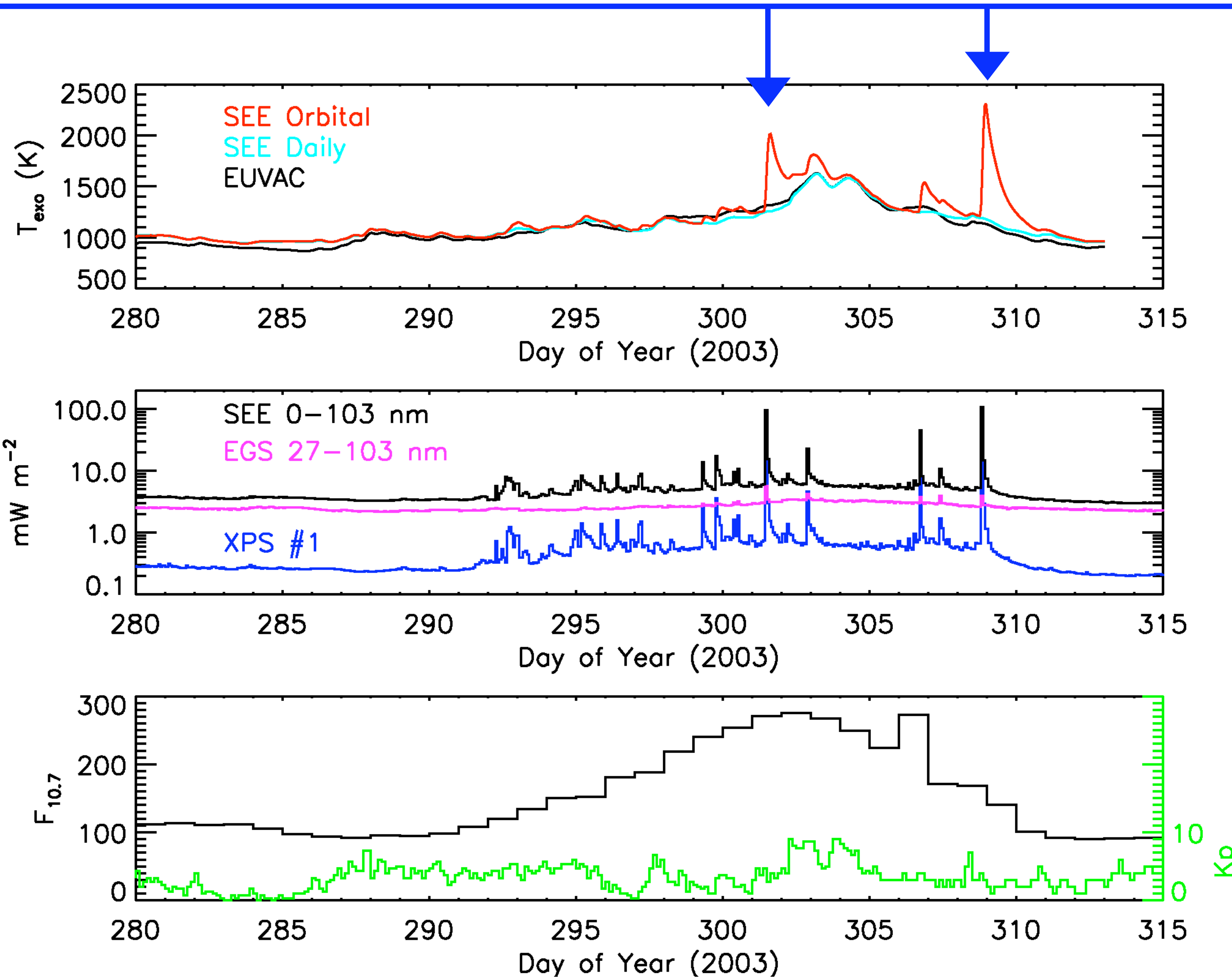
Comparison of drag-derived density measurements during two months in 2002 to three model calculations: MSIS, the TIE-GCM using the EUVAC solar proxy model as input, and the TIE-GCM using SEE data as input.

Thermosphere Responds Quickly to Solar Flares

SEE orbital data are needed for modeling the atmospheric response to large flares

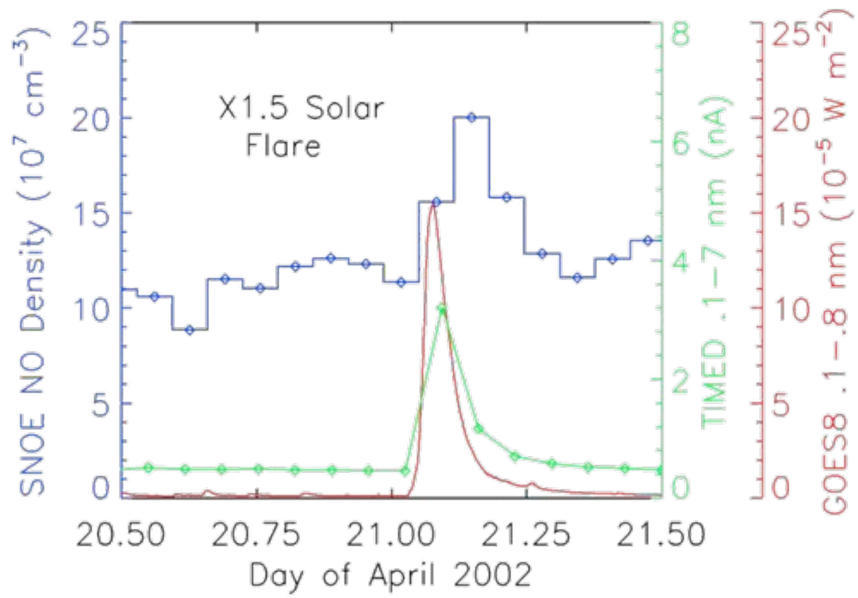
TIME-GCM Predicted Temperature

SEE Irradiances are inputs for TIME-GCM



Understanding the Influence of the Solar Soft X-ray Irradiance from Solar Flares on the Atmospheric NO

- Equatorial lower thermospheric chemistry is controlled by XUV irradiance
- Significant enhancements observed in response to flares
- UAF team is working to use physics based models of solar spectrum (Warren et al.) in conjunction with observations by TIMED SEE to infer solar flare energy deposition
- Results are being compared to SNOE observations of NO and FAST observations of photoelectron fluxes
- SEE is showing us that solar flares are a significant source of energy to the upper atmosphere



X1.5 Solar Flare, Comparison of SNOE NO density, TIMED-SEE current and GOES-8 irradiance observations of flare on April 21, 2002.

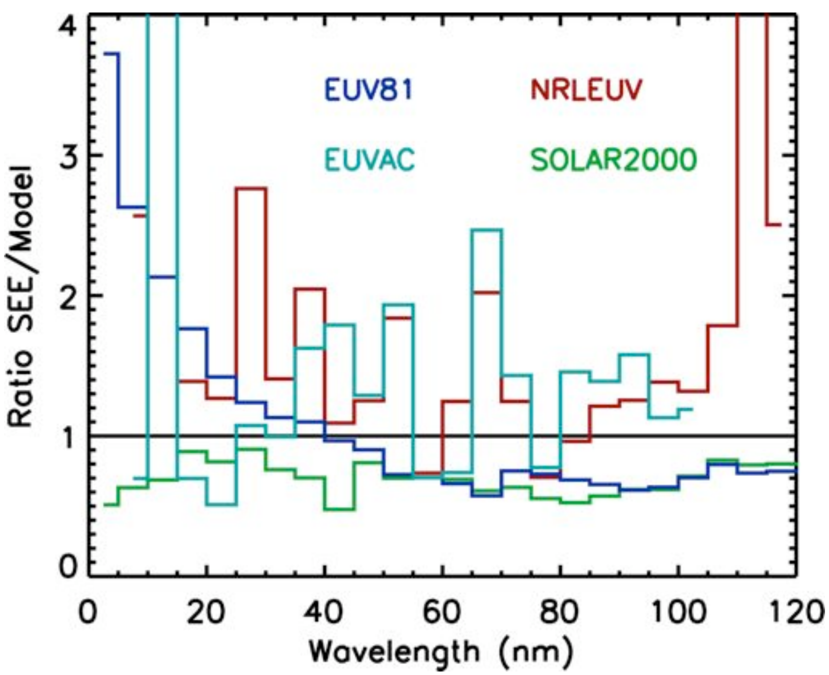
Solar Irradiance Modeling

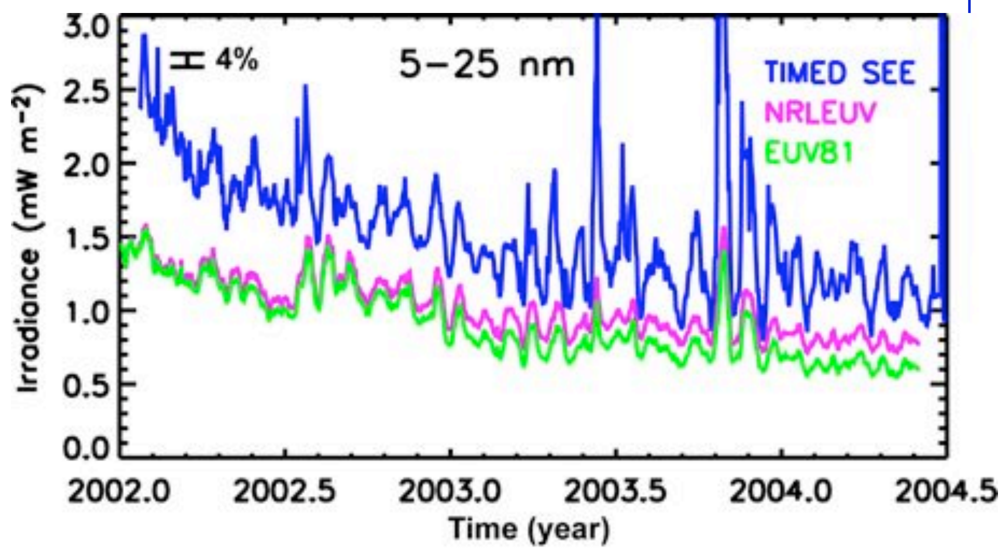
Improvements to Existing Models

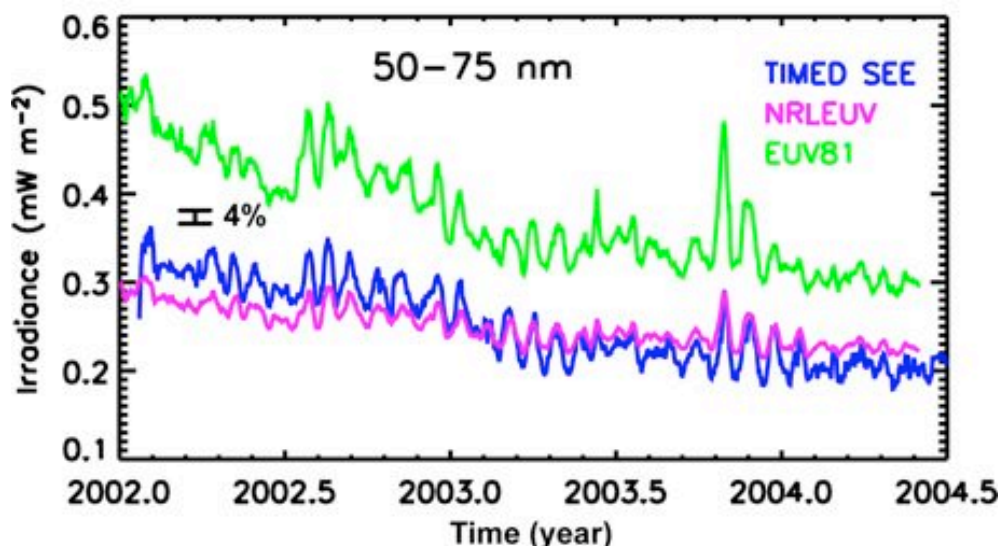
New FISM Model

Solar Models Can Be Improved With SEE Results

- Differences between models of the solar EUV irradiance and SEE are as large as factor of 4 at some wavelengths
- Variability from models also differ with SEE results
  - SEE measures more XUV variability than the models







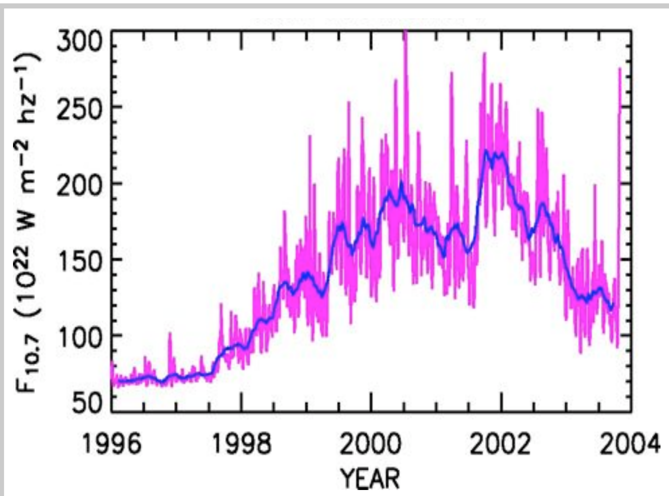
SOLAR2000 Model Improvements

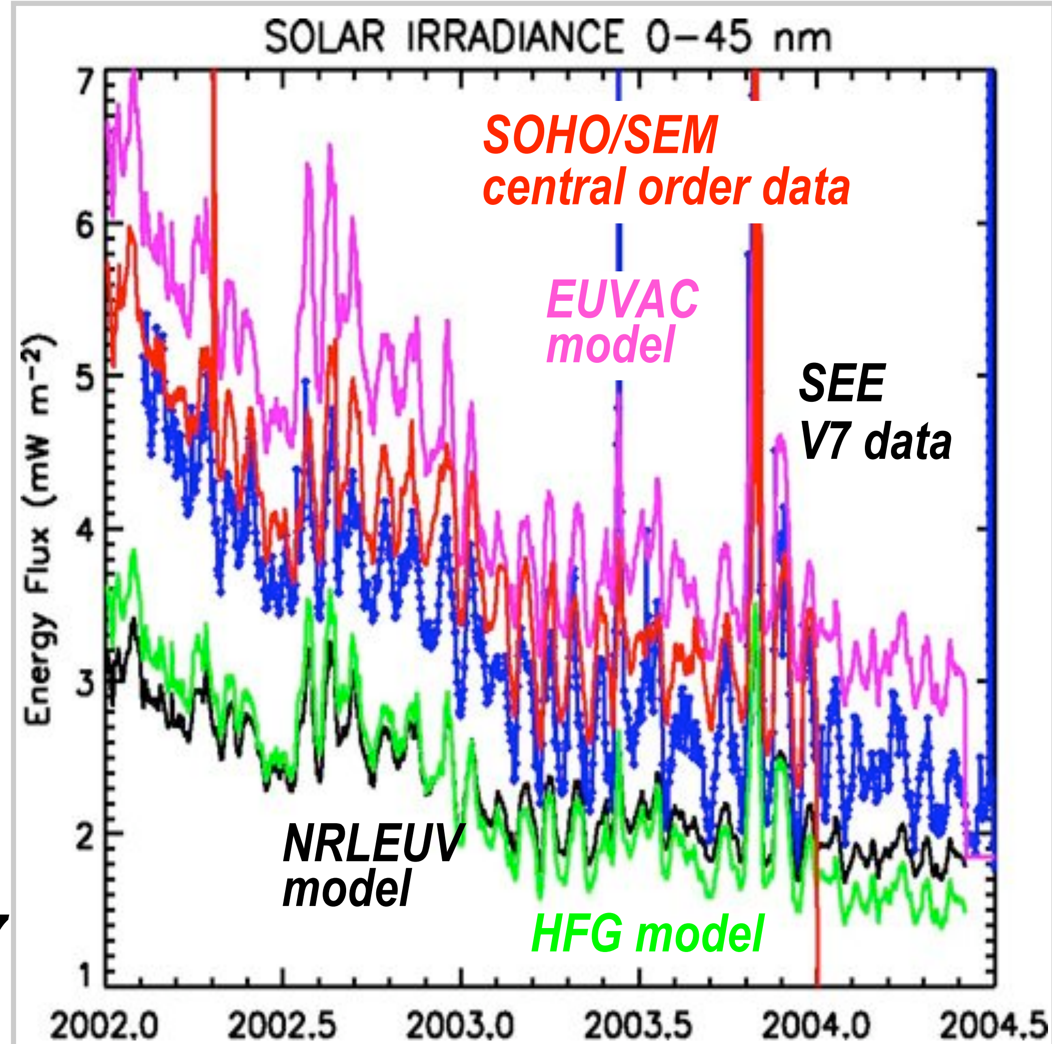
- Version 2.24 released in 2004
  - Included SEE Version 7 data to improve the model
  - Improved FUV-UV variability out to 420 nm
  - Model now available as IDL Virtual Machine (VM) so it can be operated without an IDL license
  - Provides 13 (7 new) integrated irradiance proxies
  - Improvements for nowcast and forecast tools
  - Model is ISO 21348 compliant
- See separate report from Kent Tobiska for additional details about SOLAR2000

Comparison of SEE and NRLEUV

TIMED

Solar Cycle 23

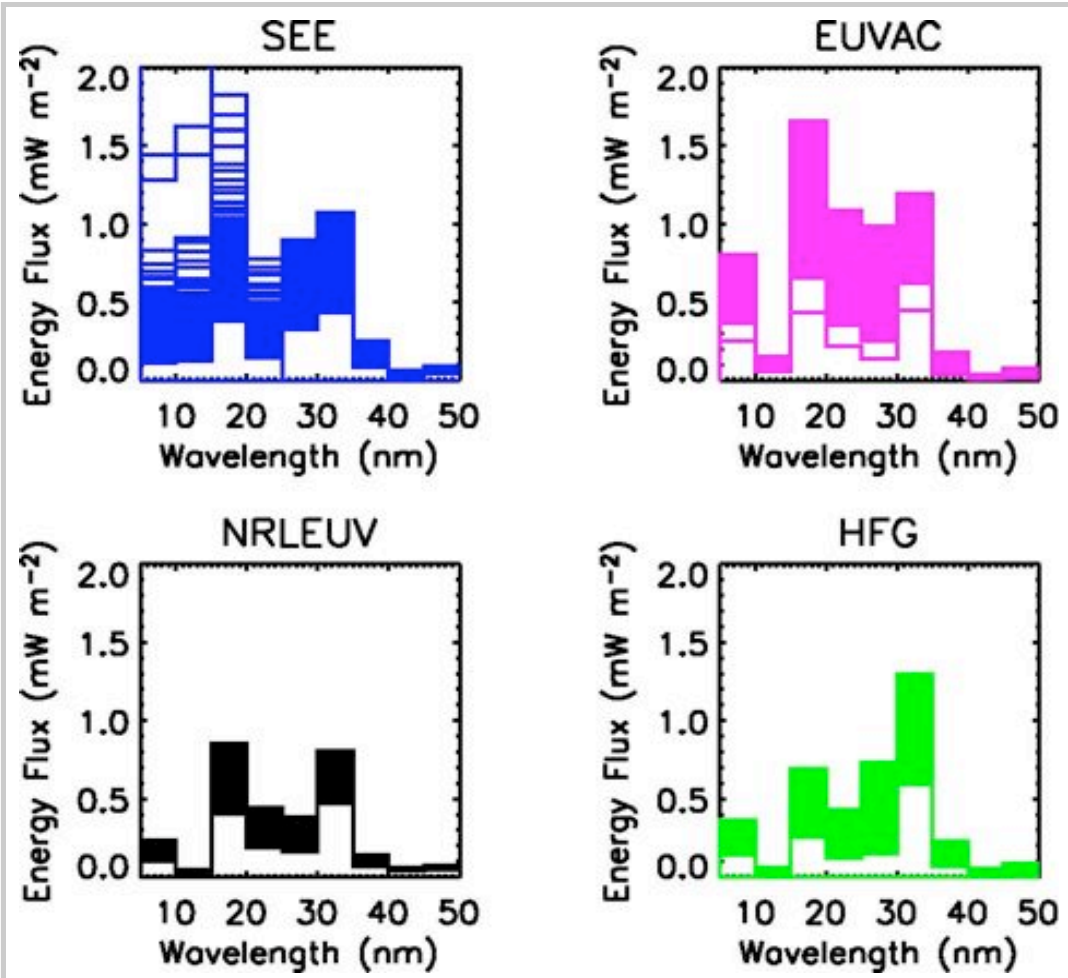




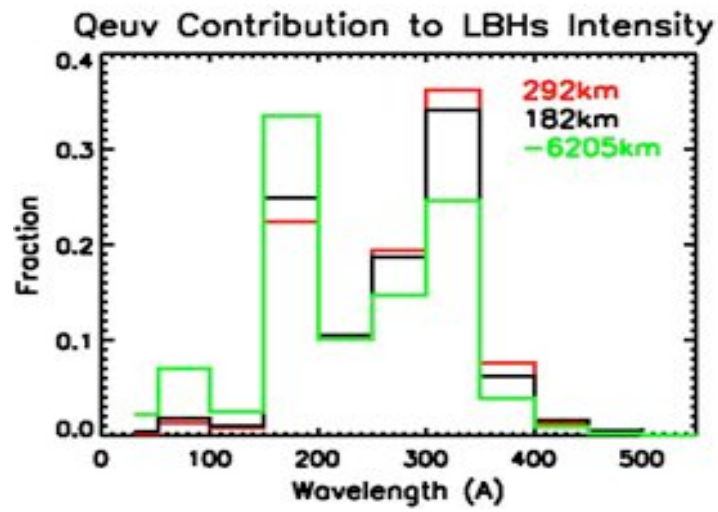
SEE__L3_merged_2004243_007
SEM X 8.3495E-11

NRLEUV Comparisons in 5 nm Intervals

range of all daily mean EUV spectral fluxes during TIMED mission 2002-2004



TIMED/GUVI atmospheric dayglow and QEUV depend differently on solar EUV bands at different wavelengths



SEE XPS measures high solar irradiance in the important 15-20 nm band

FISM - a new flare model

- FISM = Flare Irradiance Spectral Model
- New empirical model that can be used near real-time to predict the solar EUV irradiance with 1-minute time cadence
- Being developed by graduate student Phil Chamberlin using the TIMED SEE data and proxies being the F10.7 and Mg II C/W index for daily variations and the GOES 0.1-0.8 nm irradiance for the flare (1-min) variations
- FISM is expected to be available in summer 2005

FISM Algorithms

Main Algorithm:

$$\frac{E(\lambda,t)}{E(\lambda)_{min}} = C_1(\lambda) + C_{SC}(\lambda)P_{SC}(t) + C_{SR}(\lambda)P_{SR}(t) + \left[C_{GP}(\lambda)P_{GP}(t) + C_{IP}(\lambda)P_{IP}(t)\right]\cdot CLV(\mu,\lambda)$$

Long Term Variations: Solar Cycle (SC) and Solar Rotation (SR)

Short Term (Flare) Variations: Gradual Phase (GP) and Impulsive Phase (IP)

$CLV(\mu,\lambda)$: Center-to-Limb Correction Function (1.0 if no flare is active)

C_X: Adjustment parameter for the given proxy, P_X, at wavelength λ

The SEE data are used to determine C_x

FISM can then predict the solar irradiance with 1-min cadence from 1978 to the present (nowcast).

P_{SC} and P_{SR} Proxies for FISM

P_{SC} is the relative change of the 54-day trailing average for each day over the solar cycle minimum value, P_{min}.

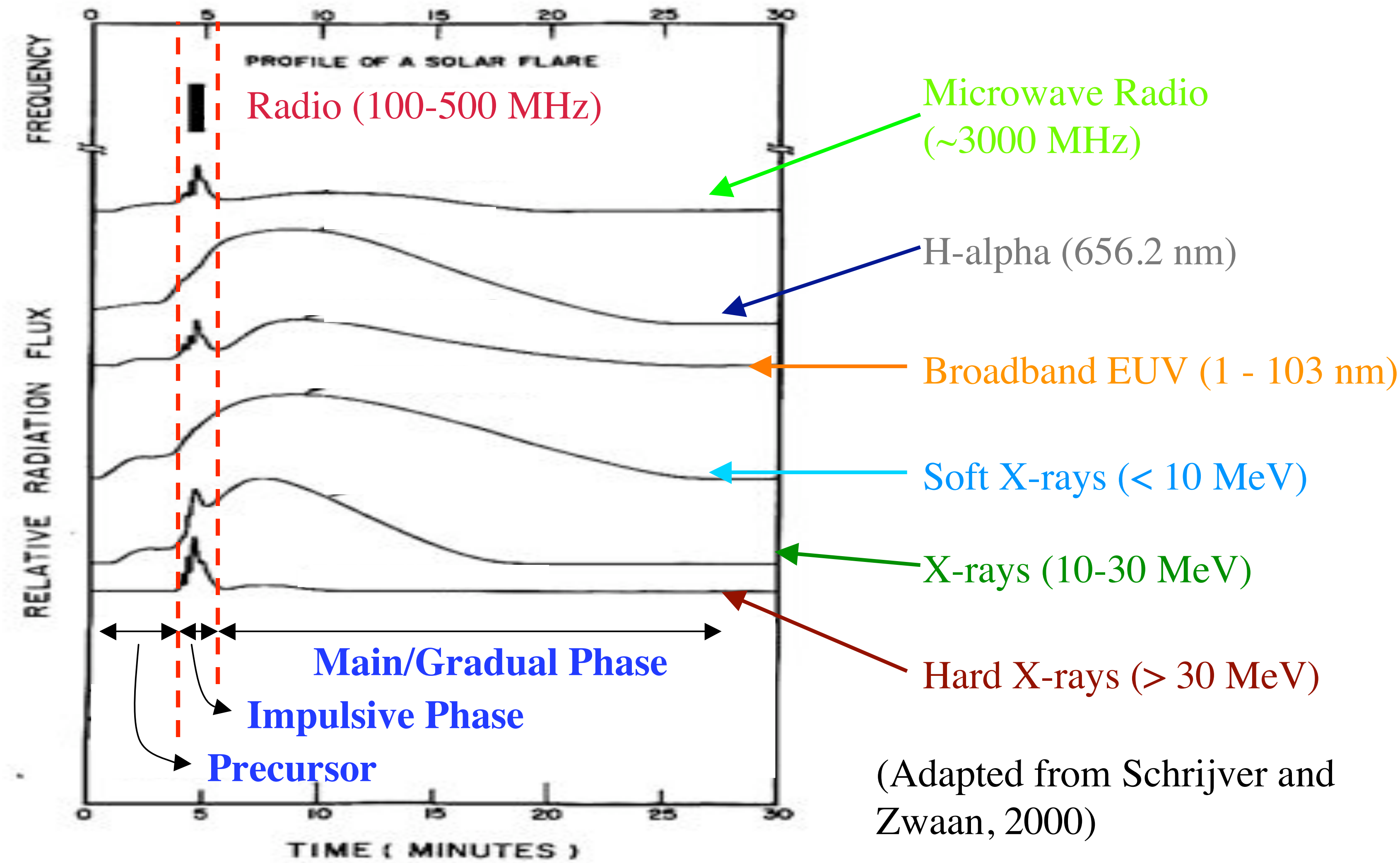
$$P_{SC} \equiv \frac{\langle P_d \rangle_{54} - P_{SC\,min}}{P_{SC\,min}}$$

P_{SR} is the relative change of the residual of the daily proxy value minus the 54-day trailing average for each day over the solar cycle minimum value, P_{min}.

$$P_{SR} \equiv \frac{P_d - \langle P_d \rangle_{54}}{P_{SC\,min}}$$

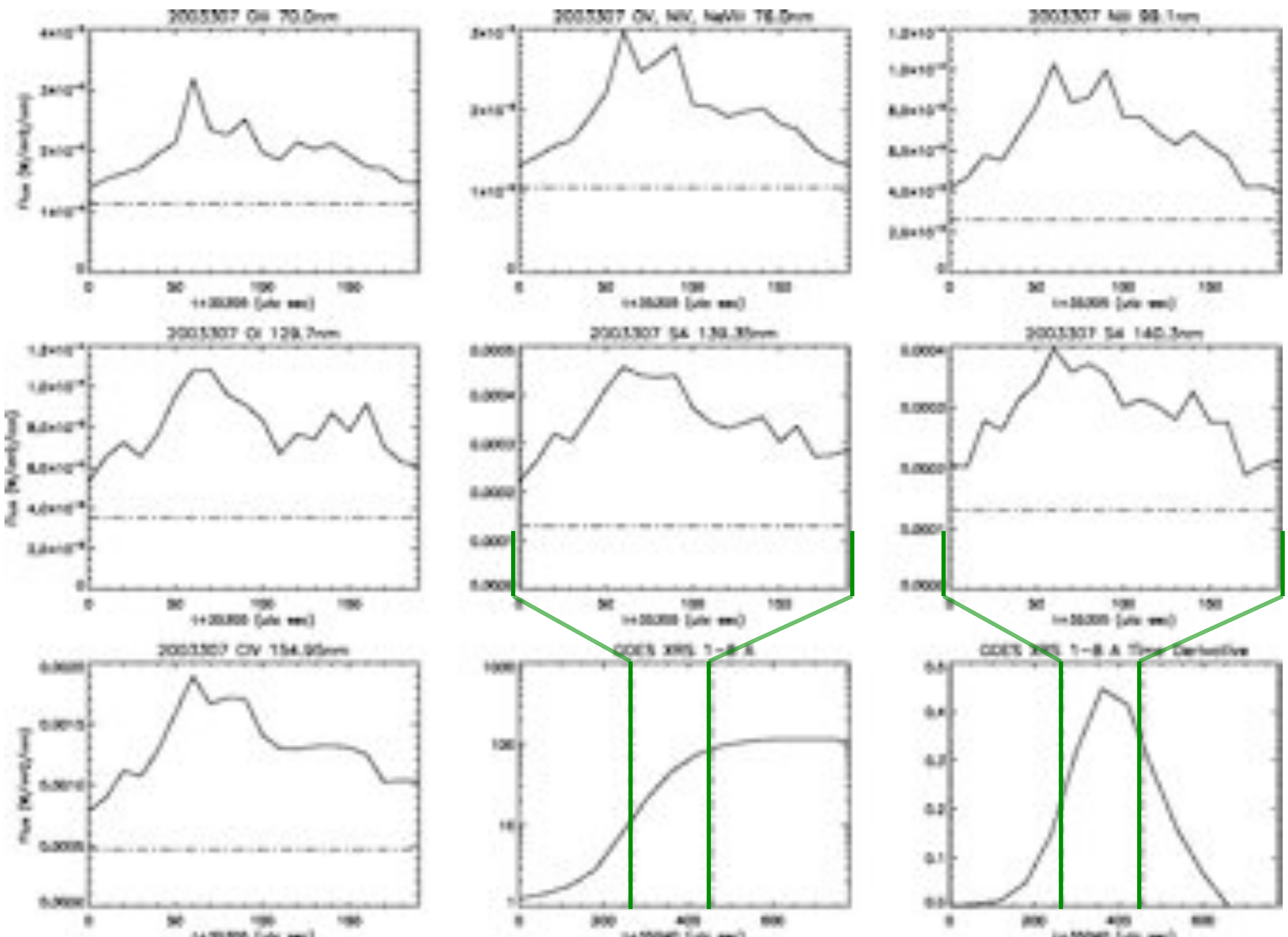
FISM Needs to Model all Flare Phases

- SEE has several good flare measurements of the impulsive phase and gradual phase and also a few flare measurements showing EUV increases but no X-ray increases



(Adapted from Schrijver and Zwaan, 2000)

Example Impulsive Phase from SEE



(Q_{EUV}) Solar XUV and Airglow Validation Workshop

Workshop Agenda and Topics

GUVI Q_{EUV} and SEE Comparisons

(Q_{EUV}) Solar XUV and Airglow Validation Workshop Agenda

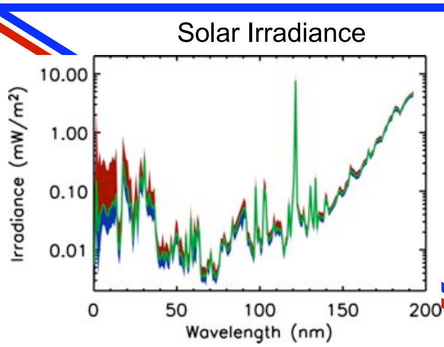
September 27, 2004 Workshop at SwRI (organized by Tom Woods)

8:30	**ALL**	**Define Workshop Objectives**
SOLAR SESSION		
9:00	T. Woods	SEE XPS Validation - 0-27 nm
9:20	F. Eparvier	SEE EGS Validation - 27-194 nm
9:40	B. Meier, J. Lean	Qeuv Comparisons
10:00	K. Tobiska	SOLAR2000 Model Results
10:15	ALL	Discussion of Solar Irradiance Issues
		(calibration uncertainties, model comparisons, etc.)
PHOTOELECTRON SESSION		
11:00	P. Richards	Photoelectron Modeling & EUVAC Comparisons
11:30	S. Solomon, S. Bailey	Photoelectron Modeling & SNOE Results
12:00	LUNCH	
1:30	ALL	Discussion of Photoelectron Issues
		(cross sections, cascade, transport, etc.)
AIRGLOW SESSION		
2:00	R. Gladstone	Simulated Airglow Modeling
2:30	D. Morrison, L. Paxton	GUVI Airglow Validation and Qeuv Modeling
3:00	B. Meier, D. Strickland	Airglow and Qeuv Modeling
3:30	ALL	Discussion of Airglow Issues
		(cross sections, irradiance sensitivities, Qeuv range, etc.)
5:00	**ALL**	**Summarize Progress --> Action Items Assignments**

Validation Dates for Q_{EUV} Workshop

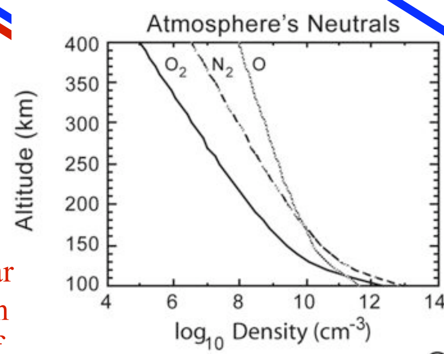
- **Seasonal Effects:**
  - See Strickland *et al., JGR, 109*, A01302, 2004 (doi:10.1029/2003JA010220)
    - 17 March 2002 2002/076
    - 15 July 2002 2002/196
    - 21 Sept 2002 2002/264
    - 16 Jan 2003 2003/016
- **Solar Rotation:**
  - See Strickland *et al., GRL, 31*, L03801, 2004 (doi:10.1029/2003GL018415)
    - 12 July - 8 Aug 2002 2002/193 - 2002/220
  - Oct Storm Period
    - 10 Oct - 11 Nov 2003 2003/285 - 2003/315
- **Quiet Days:**
  - 22 March 2003 2003/081 F10.7 = 88.3, Ap = 16
  - 14 Sept 2003 2003/257 F10.7 = 95.8, Ap = 4
- **Flares:**
  - See Woods *et al., Sp. Wx., 1*, 1001, 2003 (doi:10.1029/2003SW000010)
    - 21 Apr 2002 2003/111 photoelectron data, but not good β angle for GUVI
  - See Woods *et al., GRL, L10802*, 2004 (doi:10.1029/2004GL019571)
    - 28 Oct 2003 2003/301
    - 4 Nov 2003 2003/308

Overview of Processes for Q_{EUV} Workshop



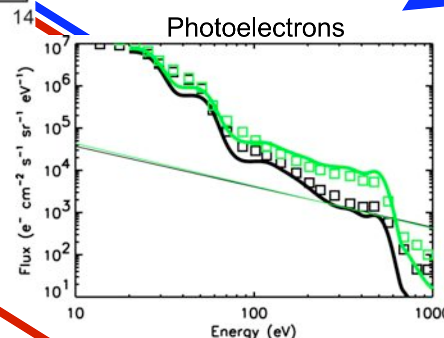
Forward Modeling

1. Measure or model the solar XUV and EUV irradiance (TIMED SEE L3: 0.1-194 nm, 1 nm intervals, daily; EUV81, EUVAC, NRLEUV, SOLAR2000)

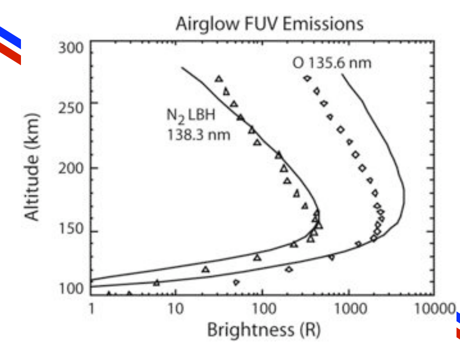


2. Measure or model the atmospheric density (GUVI derived density; MSISE-90, NRLMSISE-00)

3. Measure the photoelectrons or model them using #1 and #2 results (FAST; glow, FLIP)



4. Calculate the airglow FUV brightness using all 3 results



2. Derive the Q_{EUV} (0-45 nm solar irradiance) using the O/N_2 column density ratio and the brightness of either the 1356 or LBH emission

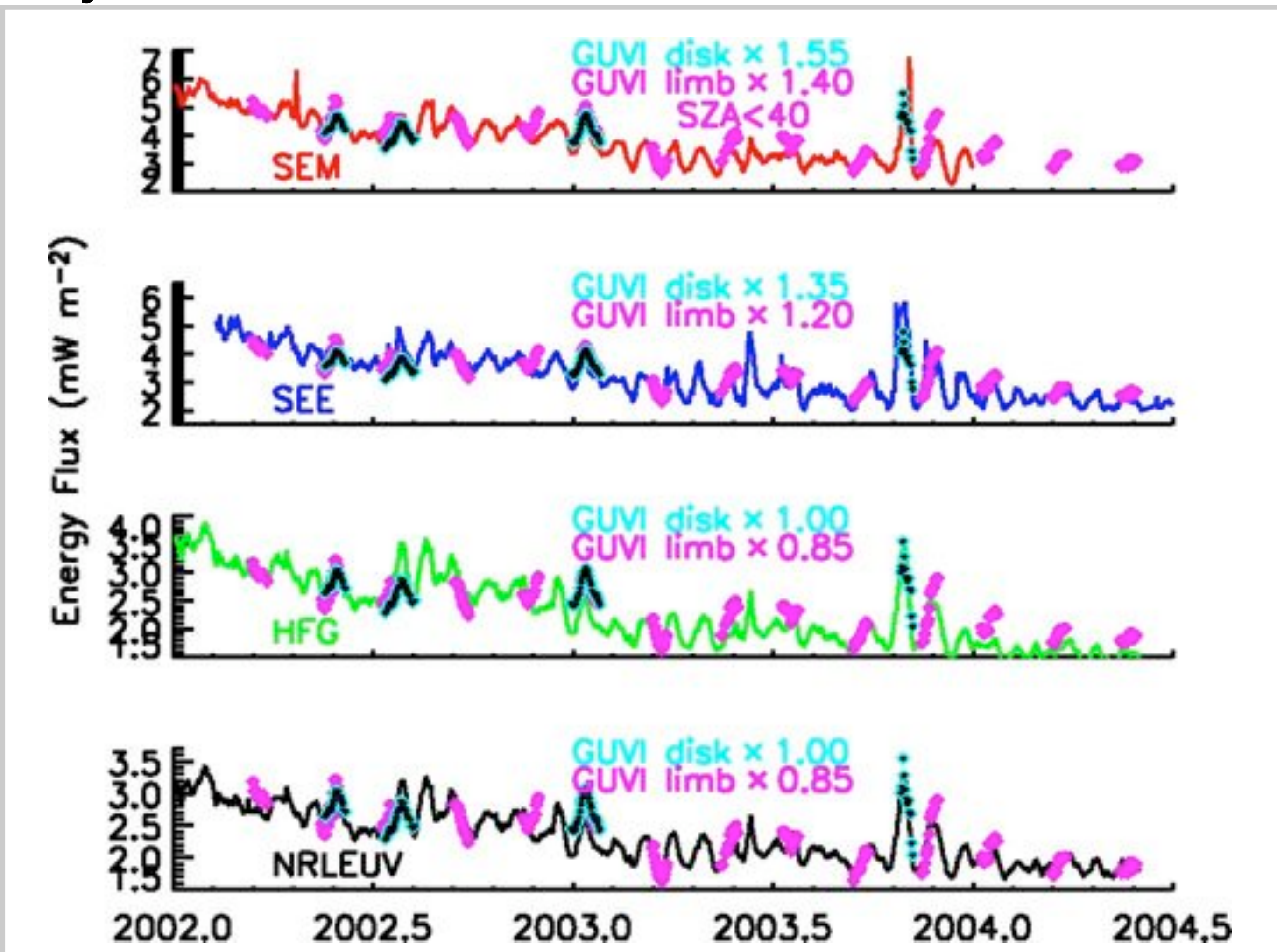
1. Derive the O/N_2 column density ratio derived from nadir airglow brightness ratio (1356/LBH)

Reverse Modeling

Strickland *et al.* (*JGR*, *100*, 12217, 1995)

GUVI and Solar Q_{EUV} Daily Variations

daily means



SEM

central order 0-45 nm

SEE

0-45 nm

HFG

0-45 nm but many missing soft X-ray lines

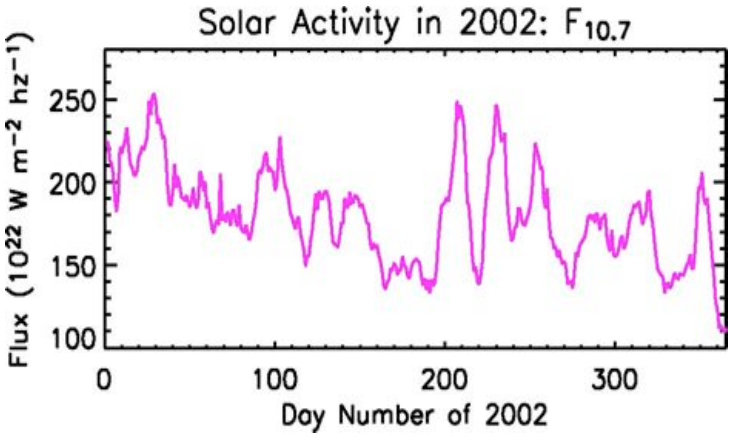
NRLEUV

5-45 nm × 1.15

~ 50% decrease from 2002 to 2004

GUVI and Solar Q_{EUV} Variations: July-August 2002

Jul-Aug 2002



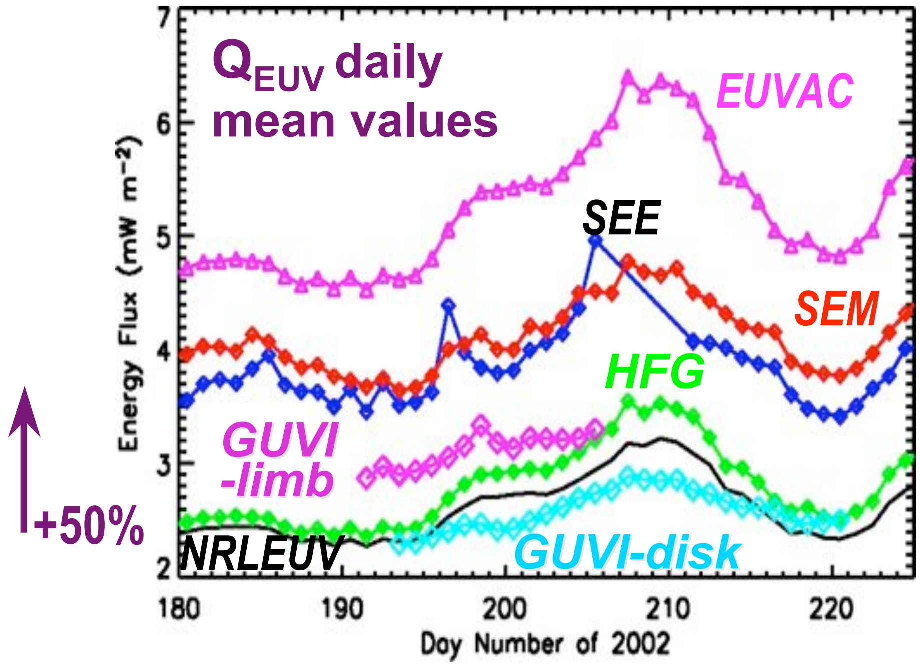
Absolute Uncertainties

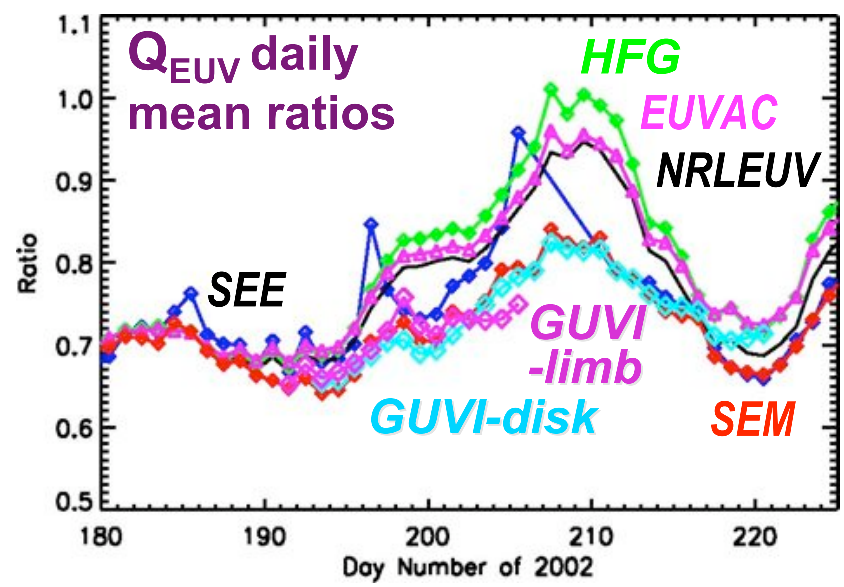
GUVI ± 15%

SEE ± 10% - goal

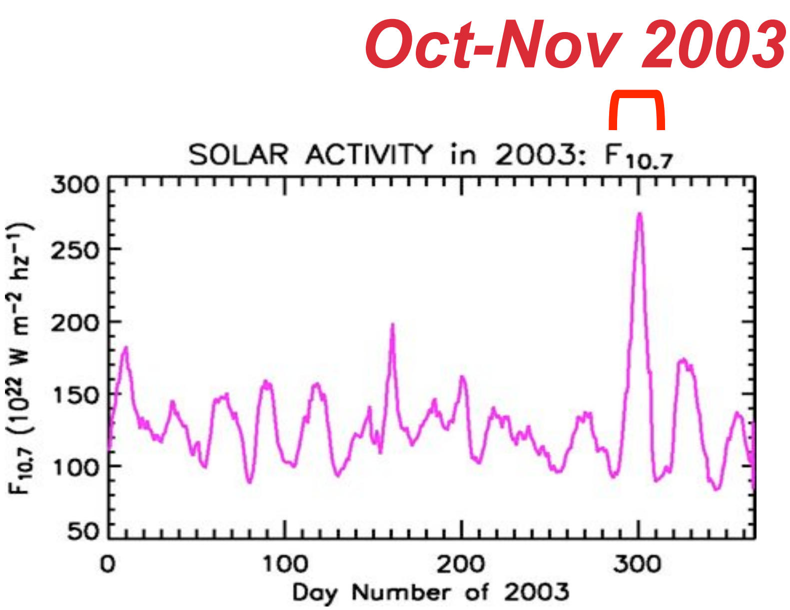
NRLEUV ± 50%

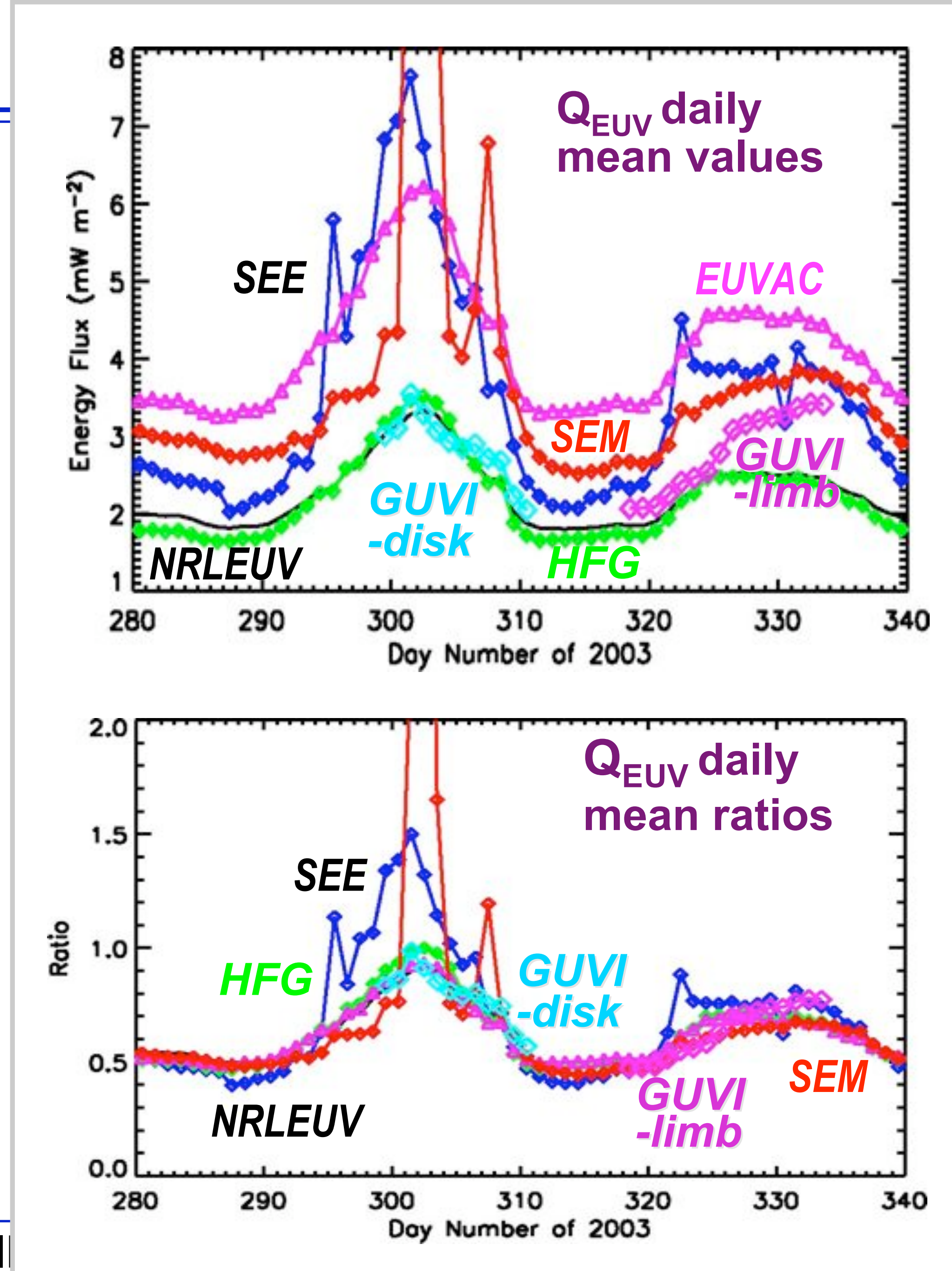
updated from Strickland et al., GRL, 2004



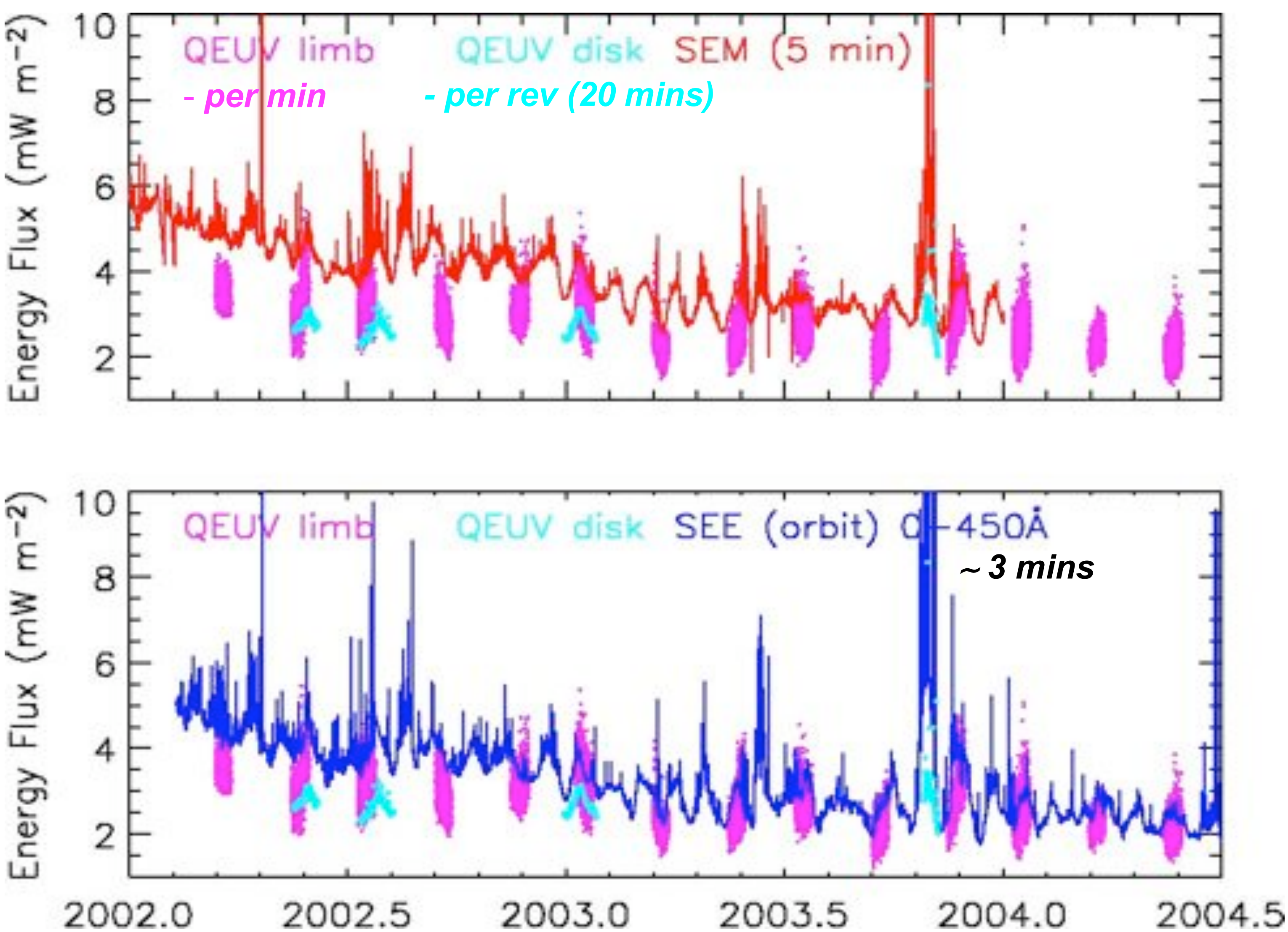


GUVI and Solar Q_{EUV} Variations: October-November 2003 Rotations

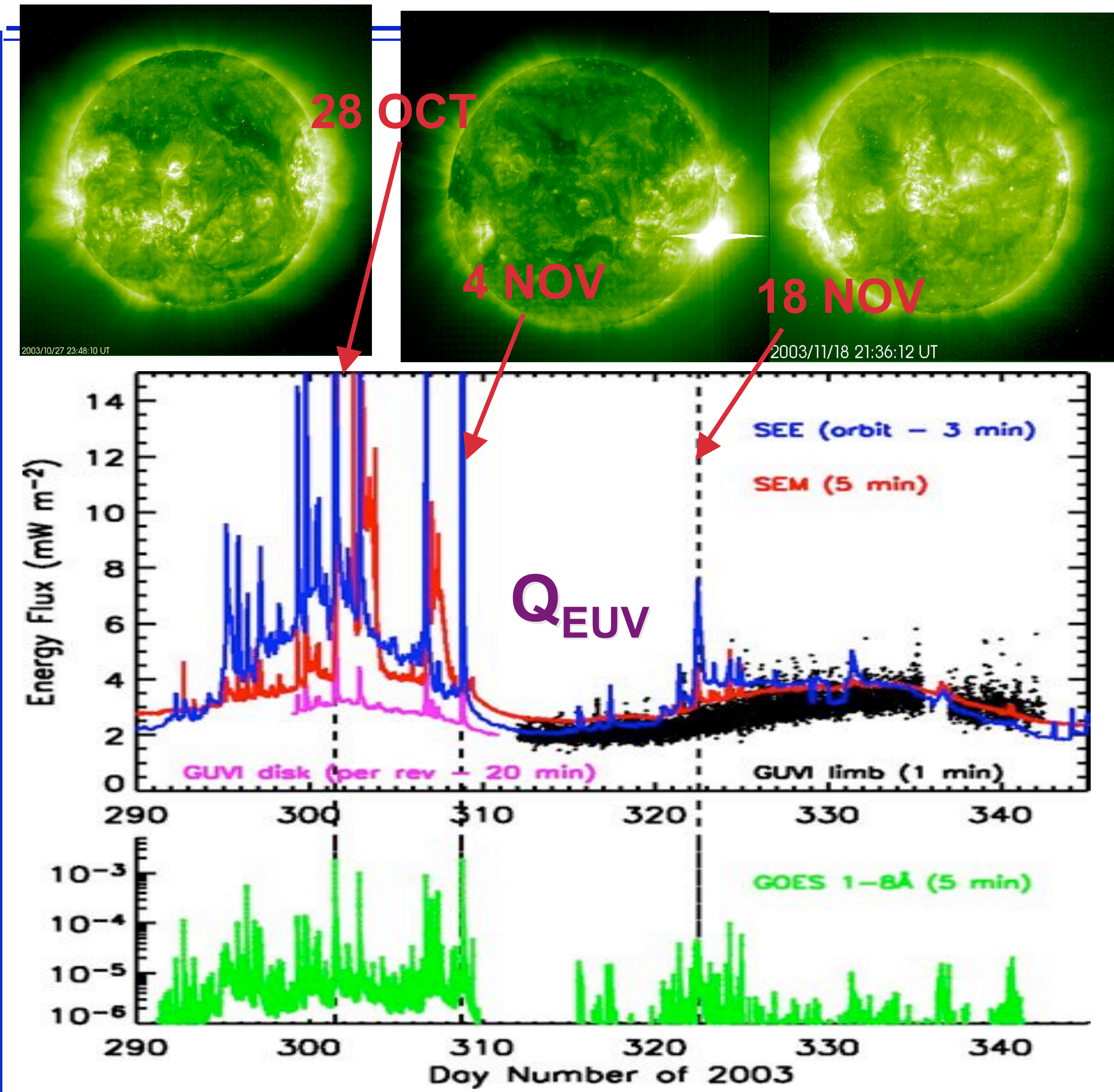




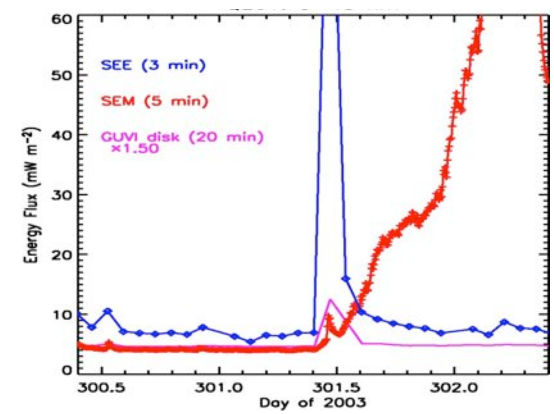
GUVI and Solar Q_{EUV} Variations During Solar Flares



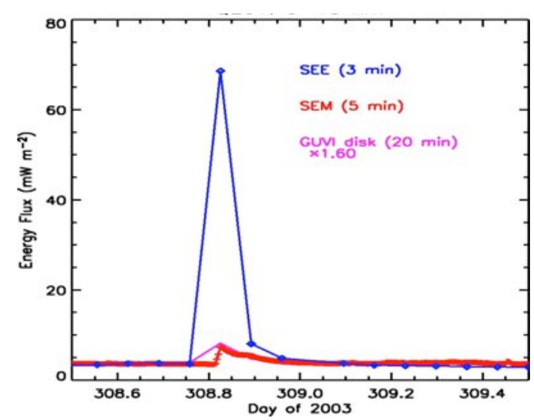
GUVI and Solar Q_{EUV} Variations: Oct-Nov 2003



28 OCT



4 NOV



SEE Related Workshops, Meetings, Talks, and Papers

SEE Related Talks in 2004

- TIMED Science Team Meeting: March 2004, 4 talks
- Living With a Star (LWS) Workshop: March 2004, 3 talks
- AGU Spring Meeting: April 2004, 5 talks
- AAS Meeting: May 2004, 1 talk
- NSF CEDAR Meeting: June 2004, 1 talk
- COSPAR Meeting: July 2004, 12 talks
- GUVI-SEE Validation Workshop: Sept 2004, 12 talks
  - **Overview of this workshop is included in this report as separate file**
- TIMED Science Team Meeting: Sept 2004, 2 talks
- AGU Fall Meeting: Dec 2004, 3 talks
- Public Seminars: LASP/CU

SEE Related Papers in 2004 - 1

- Bailey, S., T. Woods, E. Rodgers, S. Solomon, and F. Eparvier, Observations of the solar soft X-ray irradiance by the Student Nitric Oxide Explorer (SNOE), Adv. Space Res., C1.2-0003-04, submitted, 2004.
- Eparvier, F. G., T. N. Woods, D.L. Woodraska, S.M. Bailey, and S.C. Solomon, Spectral irradiance measurements from the TIMED Solar EUV Experiment, *Advances in Space Research*, in press, 2004.
- Eparvier, F. G. and T. N. Woods, Solar EUV spectral irradiance: Measurements and variability, in *Proceedings of the International Solar Cycle Study 2003 Symposium*, ed. J. Pap, in press, 2004.
- Eparvier, F. G., and T. N. Woods, Calibration of the solar EUV spectral irradiance instruments aboard the TIMED and SDO satellites, Adv. Space Res., C1.2-0007-04, submitted, 2004.
- Eastes, R., S. Bailey, B. Bowman, F. Marcos, J. Wise, and T. Woods, The correspondence between thermospheric neutral densities and broadband measurements of the total solar soft X-ray flux, Geophys. Res. Lett., 31, L19804, doi: 10.1029/2004GL020801, 2004.
- Gladstone, G. R., W. R. Pryor, W. K. Tobiska, W. K., A. I. F. Stewart, K. E. Simmons, and J. M. Ajello, Constraints on Jupiter's hydrogen corona from Galileo UVS observations, Planet. Space Sci., 52, 415-421, 2004.
- Knipp, D.J, T. Welliver, M.G. McHarg, F.K. Chun, W.K. Tobiska, and D. Evans, Climatology of extreme upper atmospheric heating events, Adv. Space Research, published Oct, 2004.
- Pardini, C., K. Tobiska, and L. Anselmo, Analysis of the orbital decay of spherical satellites using different solar flux proxies and atmospheric density models, Adv. Space Research, submitted, 2004.
- Pardini, C., W.K. Tobiska, and L. Anselmo, *Pilot Service for Improving Satellite Re-Entry Predictions and Orbital Decay Modeling*, in press, 2004.
- Pryor, W.R., A.I.F. Stewart, K.E. Simmons, W.E. McClintock, W.D. Sweet, J.M. Ajello, G.K. James, W.K. Tobiska, G.R. Gladstone, J.H. Waite, T. Majeed, D.E. Shemansky, A.R. Vasavada, and J.T. Clarke, Jupiter's ultraviolet aurora on Galileo orbit G7, Icarus, in press, 2003.
- Rottman, G., T. Woods, and W. McClintock, SORCE Solar UV Irrradiance Results, Adv. Space Res., C1.2-0002-04, submitted, 2004.
- Schmidtke, G., F. G. Eparvier, S. Solomon, W. K. Tobiska, and T. N. Woods, Introduction to the TIGER (Thermospheric/Ionospheric Geospheric Research) Program, Adv. Space Res.,, C1.2-0001-04, in press, 2004.

SEE Related Papers in 2004 - 2

- Solomon, S. C. Numerical models of the E-region ionosphere. Adv. Space Res., submitted, 2004.
- Strickland, D. M., J. L. Lean, R. R. Meier, A. B. Christensen, L. J. Paxton, D. Morrison, J. D. Craven, R. L. Walterscheid, D. L. Judge, and D. R. McMullin, Solar EUV irradiance variability derived from terrestrial far ultraviolet dayglow, Geophys. Res. Lett., 31, L03801, doi: 10.1029/2003GL018415, 2004.
- Thuillier, G., T. N. Woods, L. E. Floyd, R. Cebula, M. Hersé, and D. Labs, Reference solar spectra during solar cycle 22, in *Solar Variability and Its Effect on Earth's Atmospheric and Climate System,* eds. J. Pap, C. Fröhlich, H. Hudson, J. Kuhn, J. McCormack, G. North, W. Sprig, and S. T. Wu, Geophys. Series, Wash. DC, pp. 171-194, 2004.
- Thuillier, G., L. Floyd, T. N. Woods, R. Cebula, E. Hilsenrath, M. Hersé, and D. Labs, Solar irradiance reference spectra for two solar active levels, Adv. Space Res., 34, 256-261, 2004.
- Tobiska, W. K. and A. A. Nusinov, Status of the ISO draft standard for determining solar irradiances, *Adv. Space Research*, in press, 2004.
- Tobiska, W.K., SOLAR2000 irradiances for climate change research, aeronomy, and space system engineering, Adv. Space Research, 34 (8), 1736-1746, 2004.
- Tobiska, W. K. and A. A. Nusinov, Status of ISO Draft International Standard for Determining Solar Irradiances (DIS 21348), Adv. Space Research, submitted, 2004.
- Tobiska, W.K. and S.D. Bouwer, New developments in SOLAR2000 for space research and operations, Adv. Space Research, submitted, 2004.
- Tsurutani, B. T., D. L. Judge, F. L. Guarnieri1, P. Gangopadhyay, A. R. Jones, J. Nuttall, G.A. Zambon, L. Didkovsky, A.J. Mannucci, B. Iijima, R. R. Meier, T.J. Immel, , T. N. Woods, S. Prasad, J. Huba, S. C. Solomon, P. Straus, R. Viereck, The October 28, 2003 extreme EUV solar flare and resultant extreme ionospheric effects: Comparison to other halloween events and the Bastille day event, Geophys. Res. Lett., submitted, 2004.
- Woods, T., L. W. Acton, S. Bailey, F. Eparvier, H. Garcia, D. Judge, J. Lean, D. McMullin, G. Schmidtke, S. C. Solomon, W. K. Tobiska, and H. P. Warren, Solar extreme ultraviolet and x-ray irradiance variations, in *Solar Variability and Its Effect on Earth's Atmospheric and Climate System,* eds. J. Pap, C. Fröhlich, H. Hudson, J. Kuhn, J. McCormack, G. North, W. Sprig, and S. T. Wu, Geophys. Monograph Series, Wash. DC, pp. 127-140, 2004.

SEE Related Papers in 2004 - 3

- Woods, T. N., F. G. Eparvier, J. Fontenla, J. Harder, G. Kopp, W. E. McClintock, G. Rottman, B. Smiley, and M. Snow, Solar irradiance variability during the October 2003 solar storm period, Geophys. Res. Lett., 31, L10802, doi:10.1029/2004GL019571, 2004.
- Woods, T. N. and F. G. Eparvier, Solar ultraviolet variability during the TIMED mission, COSPAR-TIGER Symposium, C1.2-0004-04, in press, 2004.
- Woods, T. N., F. G. Eparvier, S. M. Bailey, P. C. Chamberlain, J. Lean, G. J. Rottman, S. C. Solomon, W. K. Tobiska, and D. Woodraska, The Solar EUV Experiment (SEE): Mission overview and first results, J. Geophys. Res., in press, 2004.

Conclusions and Future Plans

Summary of SEE Observations

- TIMED SEE has been very successful in obtaining new, accurate measurements of the solar EUV irradiance
  - SEE data available from http: //lasp.colorado.edu/see/
- More than 200 flares have been observed by SEE
  - Extreme flare periods are April 2002, May-June 2003, Oct.-Nov. 2003, and July 2004
  - Large flares vary as much as 11-year solar cycle variations
- More than 45 solar rotations have been observed by SEE
  - Variability of 5-70% observed (wavelength dependent)
- TIMED mission has observed solar maximum and declining phase of solar cycle 23
  - Extended TIMED mission should observe solar cycle minimum conditions that is predicted in the 2006-2008 timeframe

SEE Plans for 2005

- Daily mission operations and data processing for SEE
  - A new data product of the atmospheric density from the EGS occultation experiments is planned for SEE Version 8 data processing
- Additional validations
  - Incorporate Oct. 2005 rocket calibration into SEE Version 8
  - Validate SEE Version 7 data products with new SORCE solar UV measurements
  - Next underflight rocket calibration planned for April 2006
    - Have calibrations of the rocket instruments planned in 2005 at NIST SURF-III
- Detailed solar variability studies
  - Improve models of the solar UV irradiance, include flares
- Detailed modeling of Earth's response to solar irradiance changes
  - Composition, dynamics, temperature using TIME-GCM
  - Photoelectrons using *glow* model
- Occultation data analysis