A Combined SUSIM / SBUV UV Solar Spectral Irradiance Dataset from 1991 to 2012

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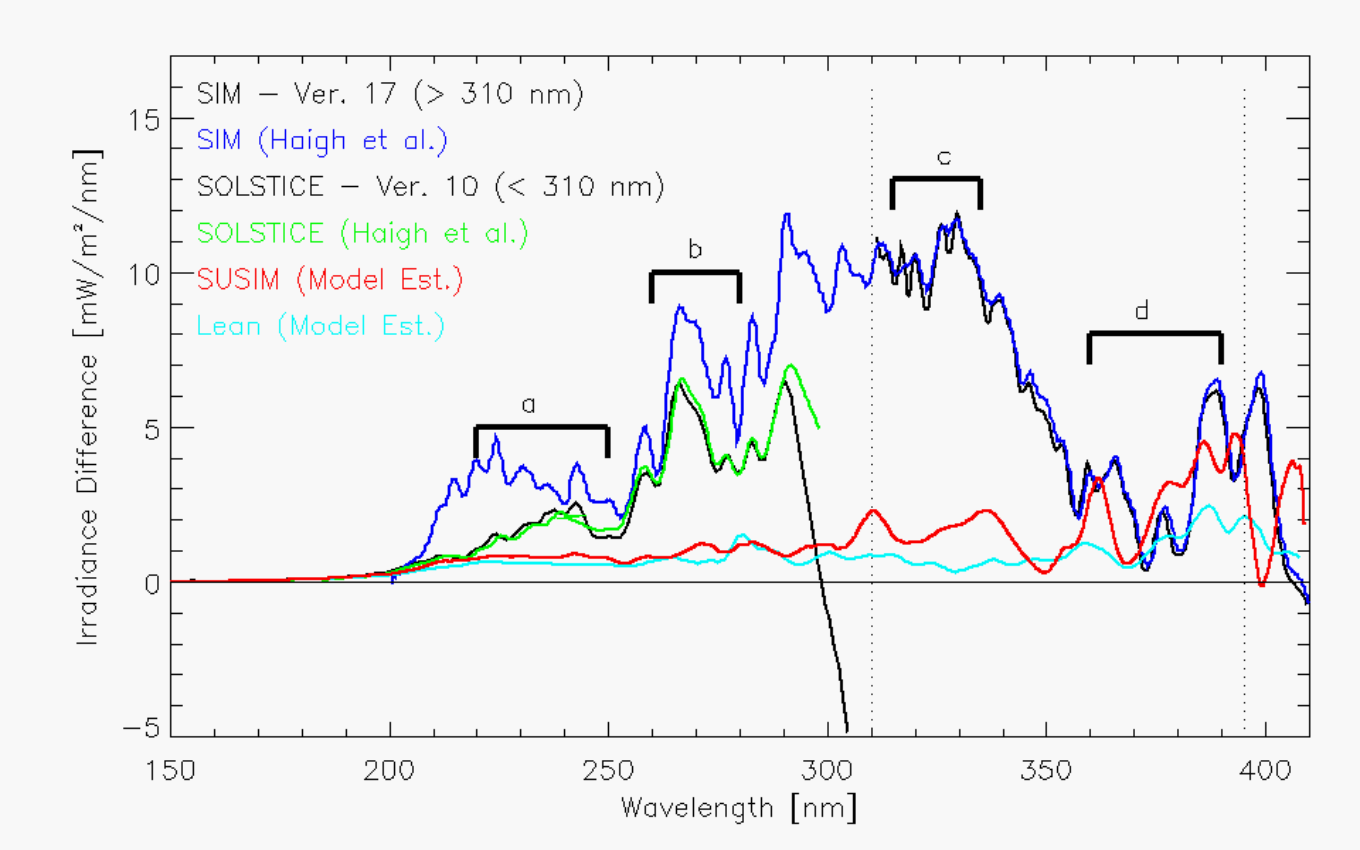
Abstract

- The accurate determination of long-term atmospheric behavior requires the characterization of solar ultraviolet (UV) irradiance variability, which directly influences stratospheric ozone and atmospheric heating. Recent solar irradiance data taken by the Solar Radiation and Climate Experiment (SORCE) during the declining phase of Cycle 23 show significantly larger solar UV variations than previously observed. Solar UV irradiance models based on proxy index relationships yield much smaller variations for the same time period. The use of SORCE UV irradiance in atmospheric models gives very different changes in stratospheric ozone, temperature, and other quantities compared to model results using other UV irradiance values (e.g the NRLSSI model). Since stratospheric ozone plays a dominant role in the chemistry and circulation of the stratosphere through radiative heating, this result represents a concern for the accuracy of predictions of future ozone and climate changes.
- In order to critically evaluate the reported SORCE UV irradiance we are planning to develop a concurrent solar irradiance dataset by using UARS/SUSIM reference channel data to calibrate NOAA SBUV/2 observations. The SUSIM instrument aboard UARS measured the solar UV irradiance during the period 1991-2005 with a daily working channel as well as monthly and longer cadence channels which were less frequently exposed. These "reference" channels degraded much less and were calibrated using four onboard deuterium lamps. The plan of action is to improve the quality of the SUSIM data product during 2003-2005 and then use the SUSIM reference data to fully calibrate NOAA-16 and NOAA-17 SBUV/2 solar irradiance data sets that begin in 2001 and 2002 respectively. This will provide an alternative UV irradiance dataset that covers the entire time period of Cycle 23. We anticipate that corrections can be extended forward with NOAA-18 SBUV/2 data to examine solar changes during the current rising phase of Cycle 24. This presentation will discuss current plans and activities for the development of this combined UV irradiance dataset. This work is sponsored by NASA Earth Science Division and the NASA Living With a Star (LWS) program.

Value of TSI vs. SSI

- TSI
  - Long time series with several Solar Cycles of observations for atmospheric/climate modelers
  - Recent results have resolved differences to the lower TSI value.
- SSI
  - Solar variability is wavelength dependent
  - Absorption of solar radiation by the atmosphere is wavelength dependent.
  - Accurate models will eventually need high quality SSI to accurately model atmosphere & climate.

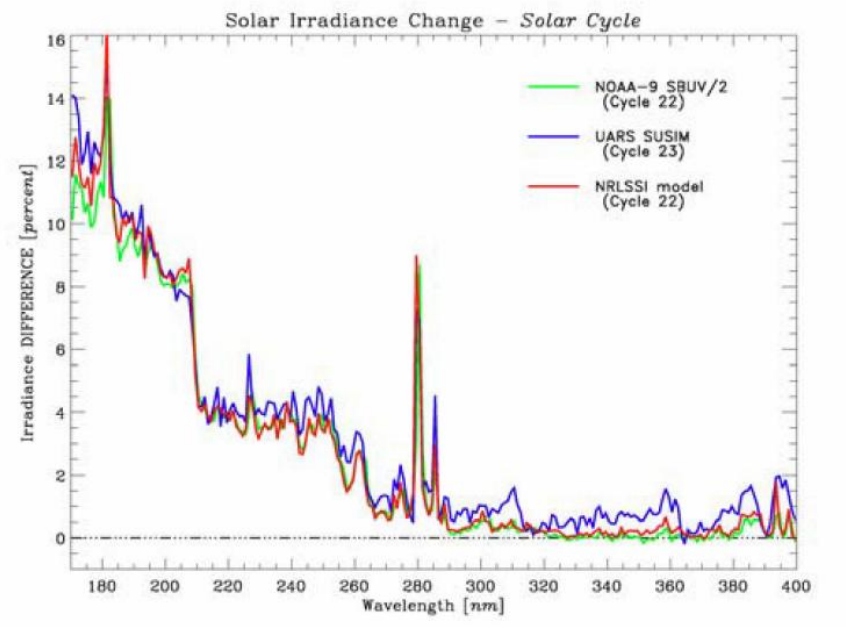
The Problem



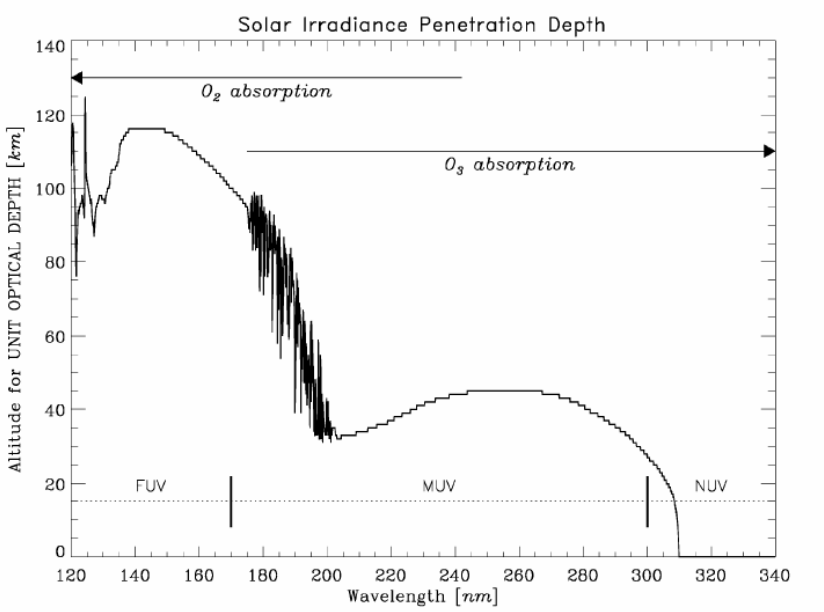
- Recent (SORCE) UV observations differ significantly from previous observations and models (e.g. SUSIM)

Wavelength Variability

- Both the Sun's spectrum and the atmosphere have characteristic wavelength variability

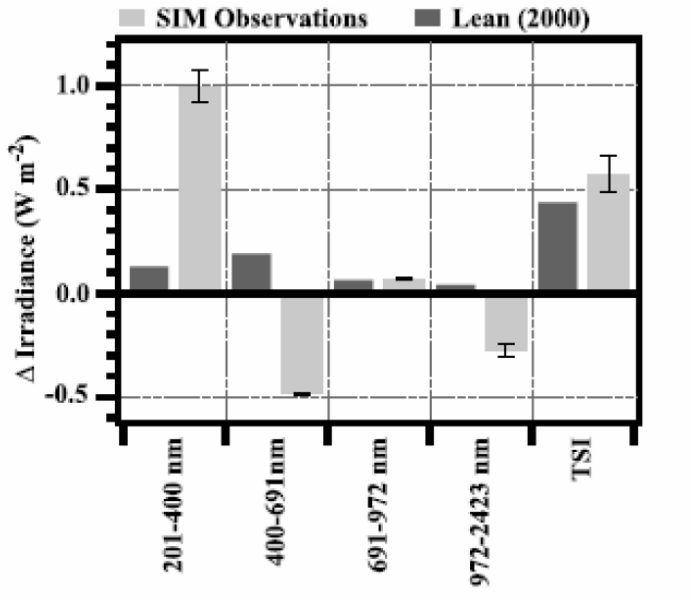


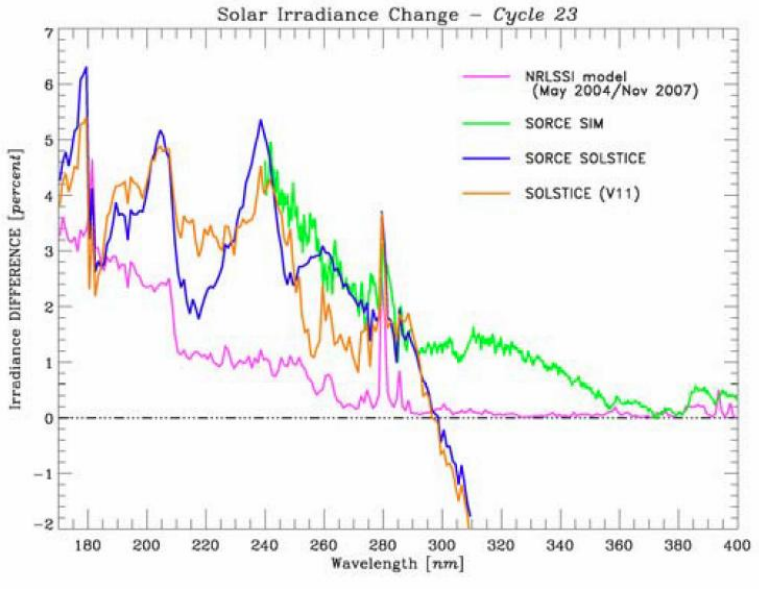
The Solar UV Spectrum



The Earth's Atmopshere

UV Variation in the Recent Solar Cycle

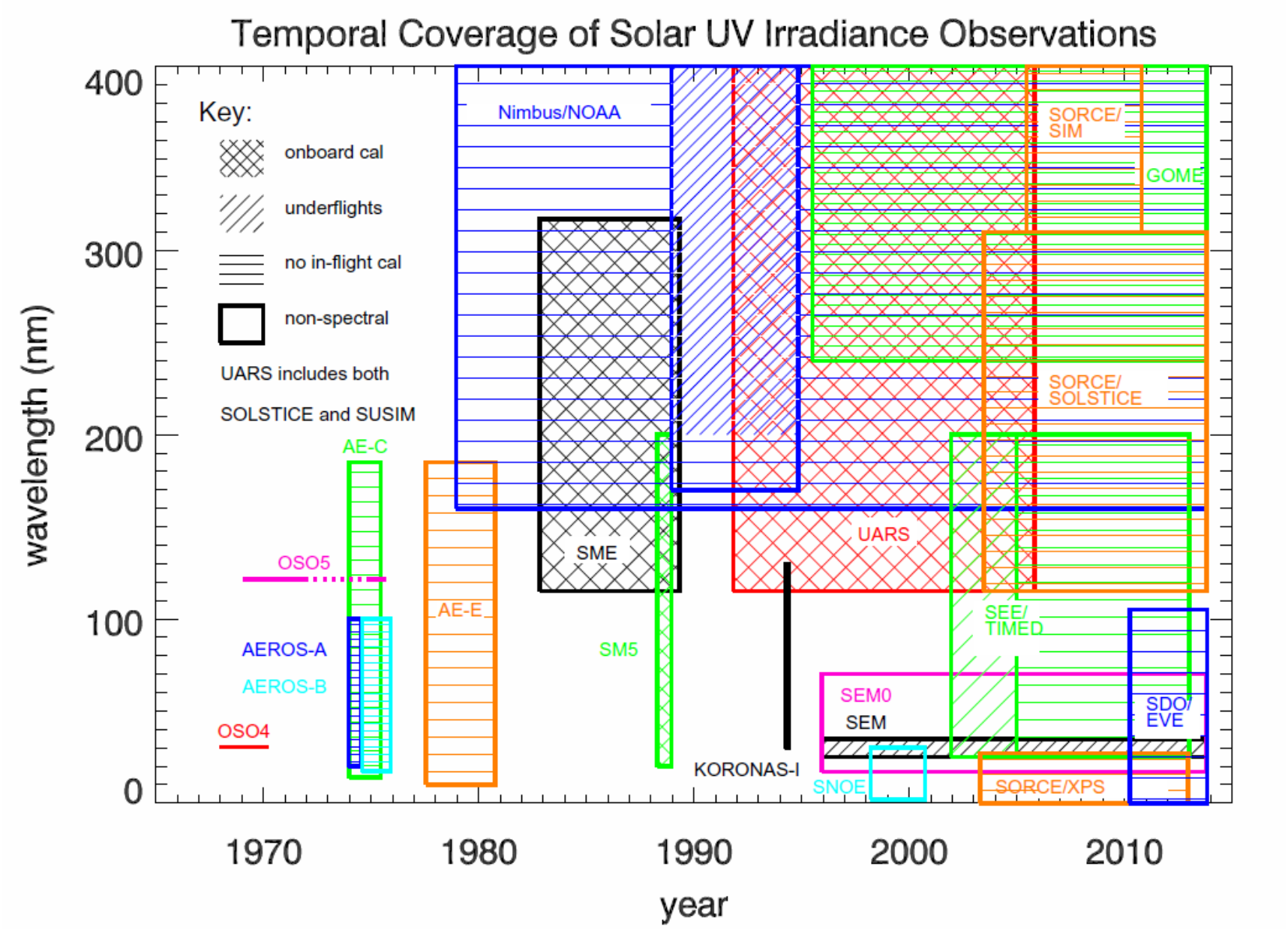




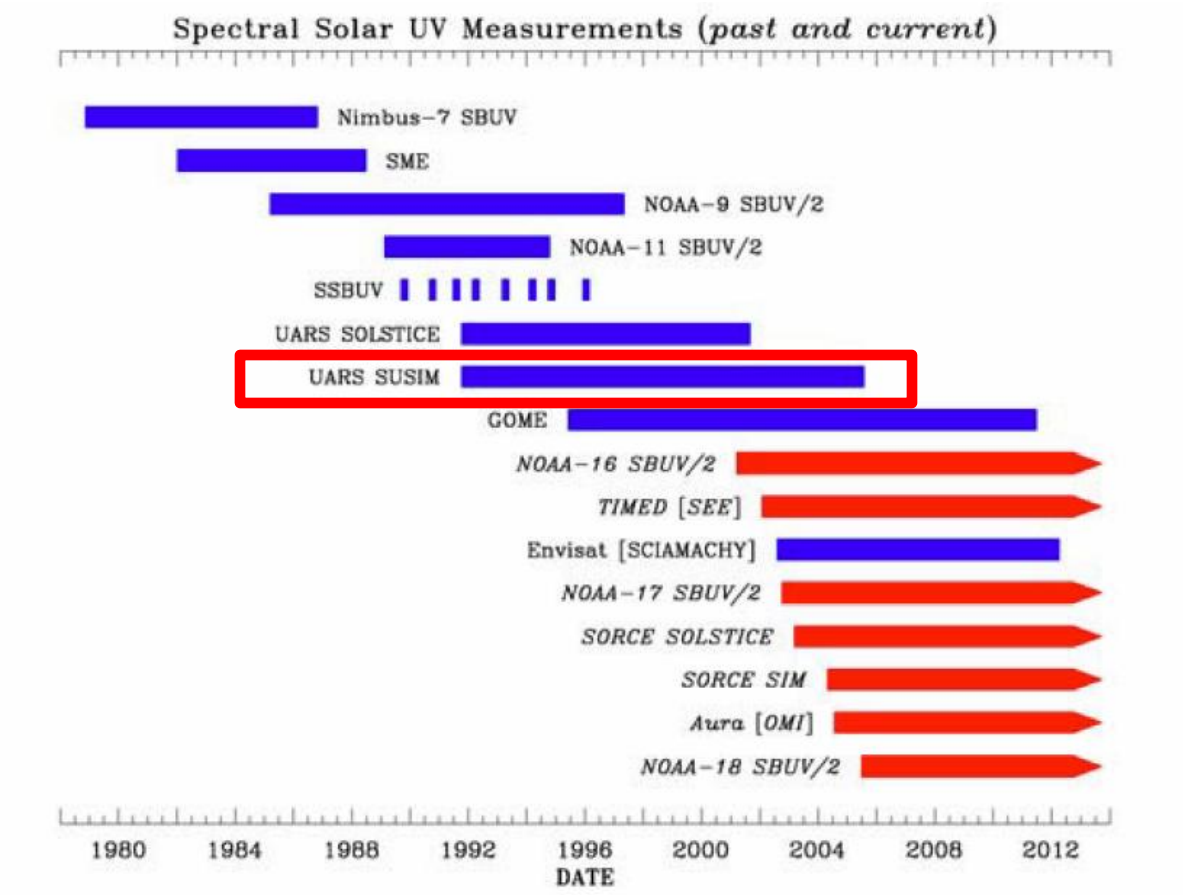
- SORCE has reported a different variability of the solar spectrum in the UV and visible/IR.

One Solution

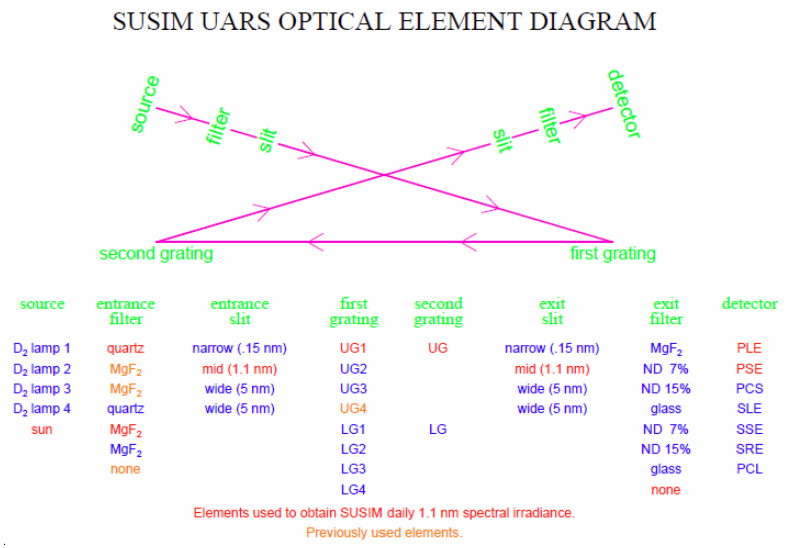
- SUSIM carried onboard calibration lamps for maintaining long term calibration
- SUSIM observations occurred from late-1991 to mid-2005.
- Apply calibrations during that time period to overlapping observations by other instruments.
- Specifically, NOAA/SBUV2


Temporal Coverage of Solar UV Irradiance Observations
Key:
onboard cal
underflights
no in-flight cal
non-spectral
UARS includes both
SOLSTICE and SUSIM
wavelength (nm)
400
300
200
100
0
1970
1980
1990
2000
2010
year
Nimbus/NOAA
SME
UARS
SORCE/
SIM
GOME
SORCE/
SOLSTICE
AE-C
AE-E
SM5
SEE/
TIMED
OSO5
AEROS-A
AEROS-B
OSO4
SEM0
SEM
SDO/
EVE
KORONAS-I
SNOE
SORCE/XPS

Solar Spectral UV Measurements (Past and Current)



SUSIM Data Processing and Analysis



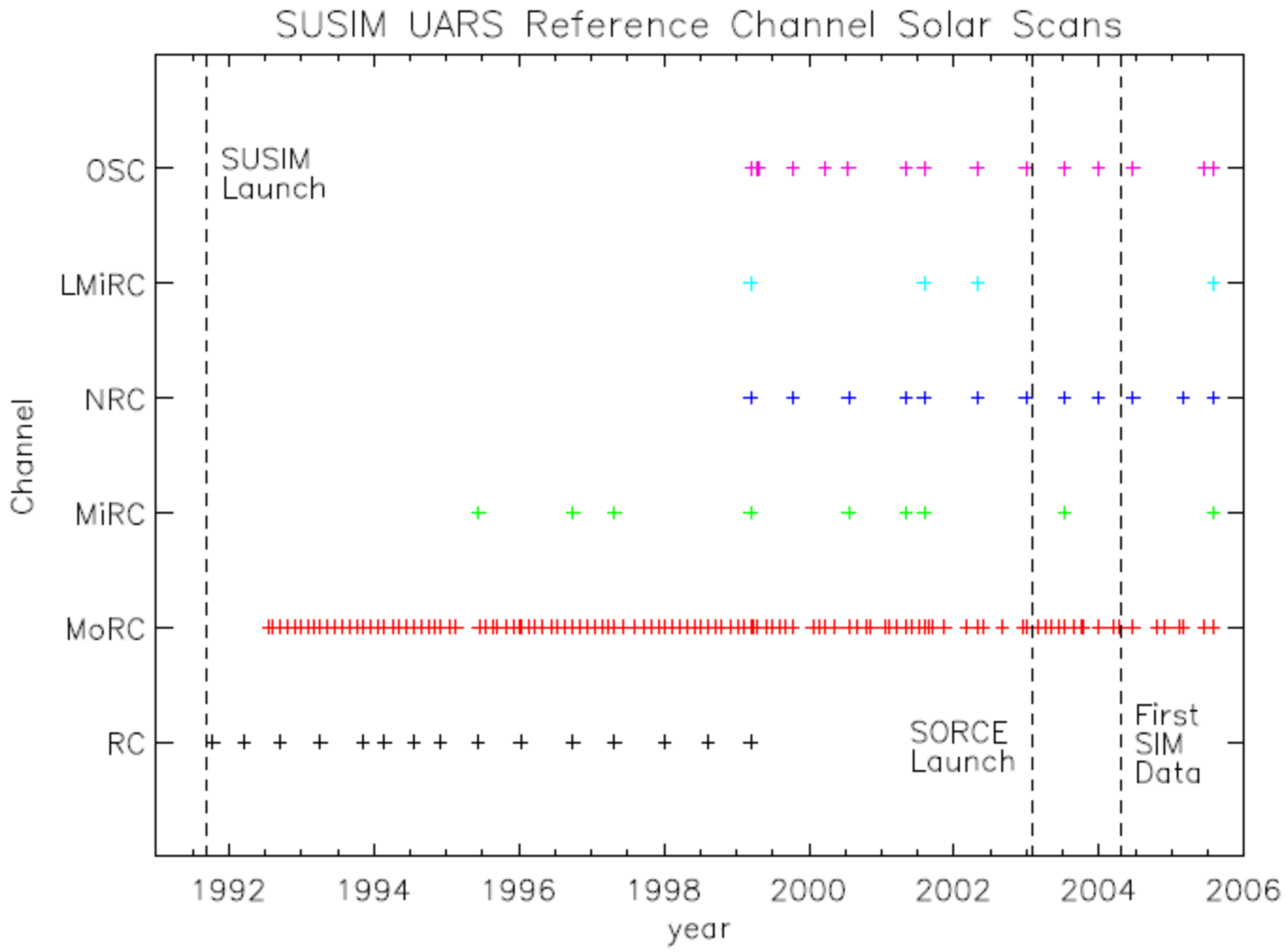
ID	Optical Path Ent	Xit	Slit	Gra	Det	Cadence ~/year	λ range (nm)
RC	M4	–	WW	UG1	SSE	2	110–265
	Q2	–	WW	UG1	SLE		235–410
nRC	M4	–	WW	LG2	SSE	2	110–265
	Q2	–	WW	LG2	SLE		235–410
MoRC	–	–	WW	UG2	PLE	11	410–235
	–	–	WW	UG2	PSE		265–110
MiRC	–	–	WW	UG3	SLE	1	410–235
	–	C2	WW	UG3	SLE		410–300
	–	–	WW	UG3	SRE		265–110
LMiRC	–	–	WW	LG3	SLE	0.7	410–235
	–	C2	WW	LG3	SLE		410–300
	–	–	WW	LG3	SSE		265–110
oSC	Q1	–	MM	UG4	PLE	2	410–235
	M1	–	MM	UG4	PSE		264–110

Simplified SUSIM optical diagram

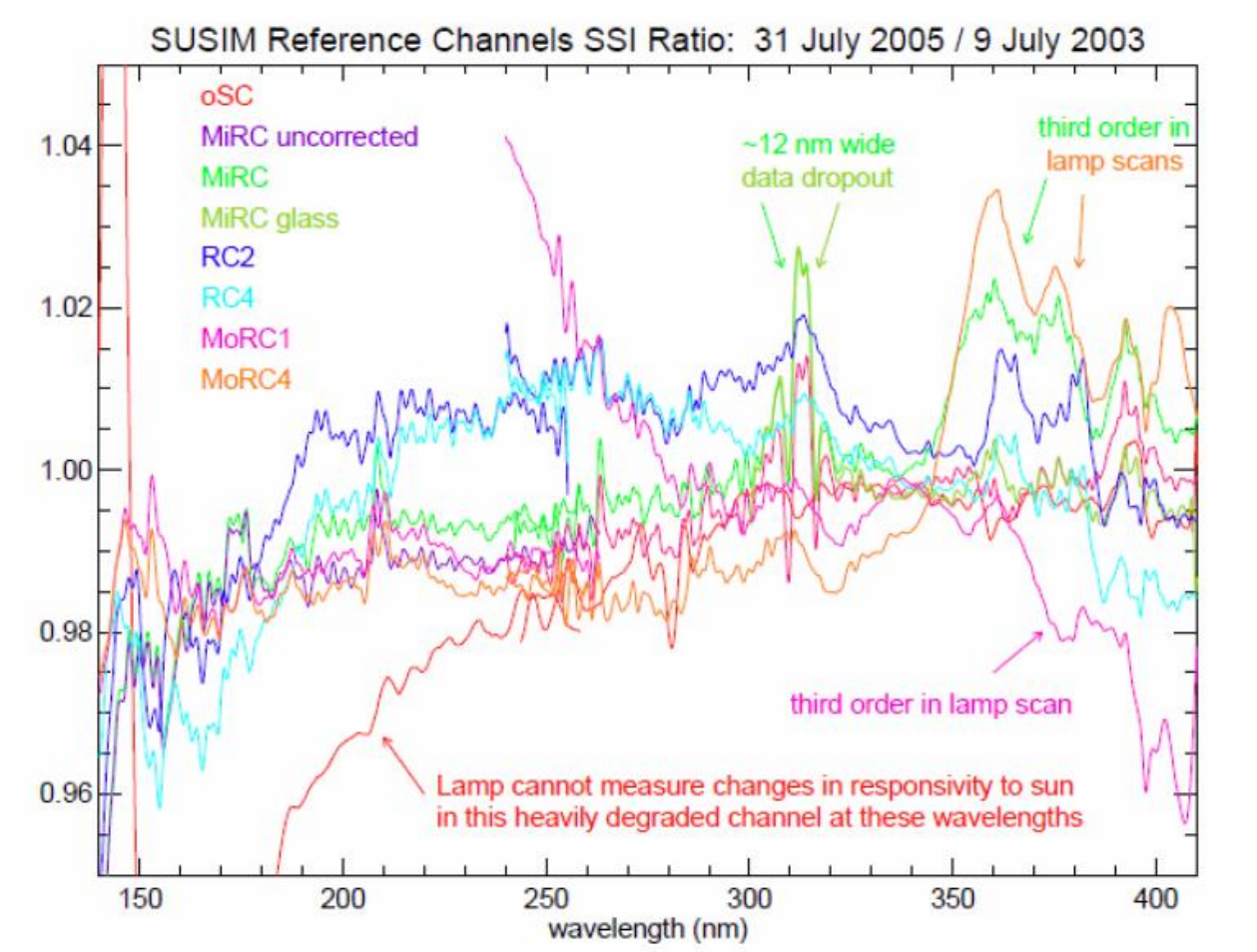
Specific combination of optical elements
For SUSIM reference channels

SUSIM Reference Channel Solar Scans

channels and dates

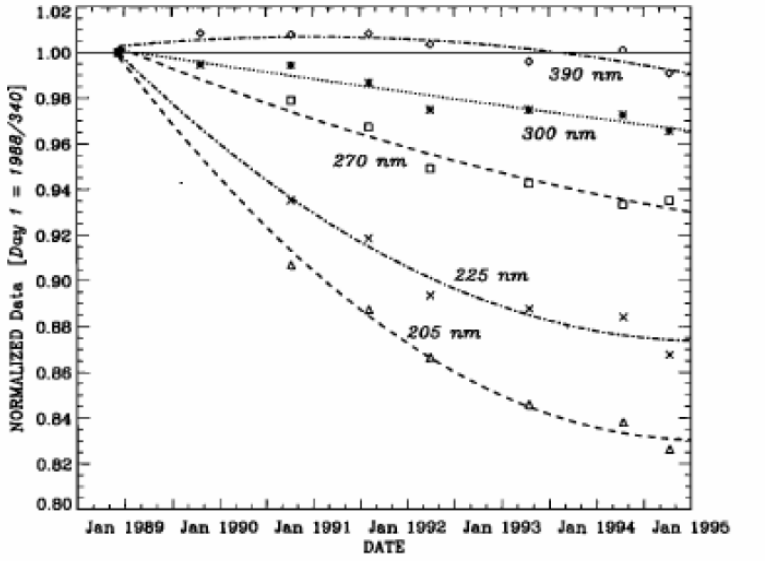


Solar Irradiance Changes:7/03 – 7/05

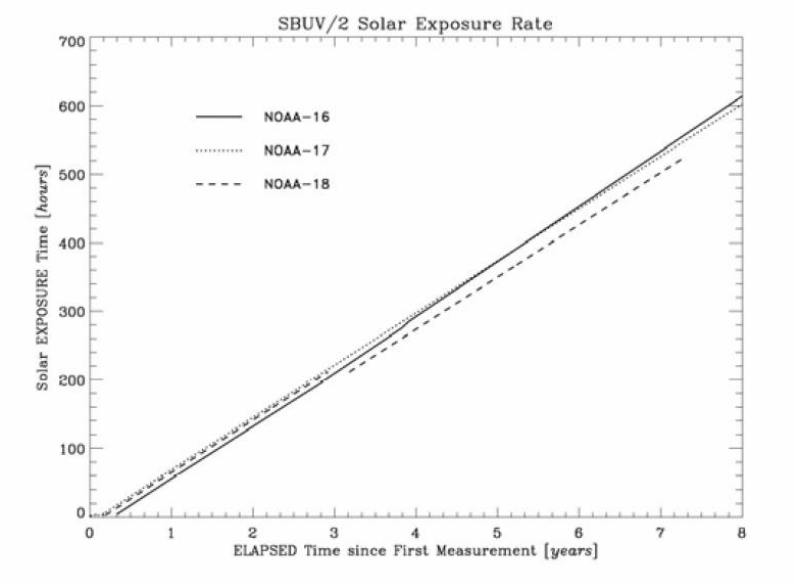


Comparison of different reference channels for two different days.

Correction of the NOAA SBUV/2 Calibrations



NOAA-11 SBUV/2 instrument throughput changes during 1984-1994 at different wavelengths using SSBUV flights,



Accumulated SBUV/2 diffuser exposure time since first solar measurement for NOAA-16, -17, & -18

Conclusions

- By utilizing coincident solar observations of UARS-SUSIM and NOAA-SBUV/2 the SUSIM calibration can be transferred to the various SBUV/2 data sets.
- Agreement between SSBUV and SUSIM will provide validation for the UARS / Shuttle era.
- Development of methods between overlapping SBUV data sets will allow extension to time periods outside the UARS-SUSIM observations.