SSI comparison of SATIRE-S with NRLSSI and SORCE/SOLSTICE

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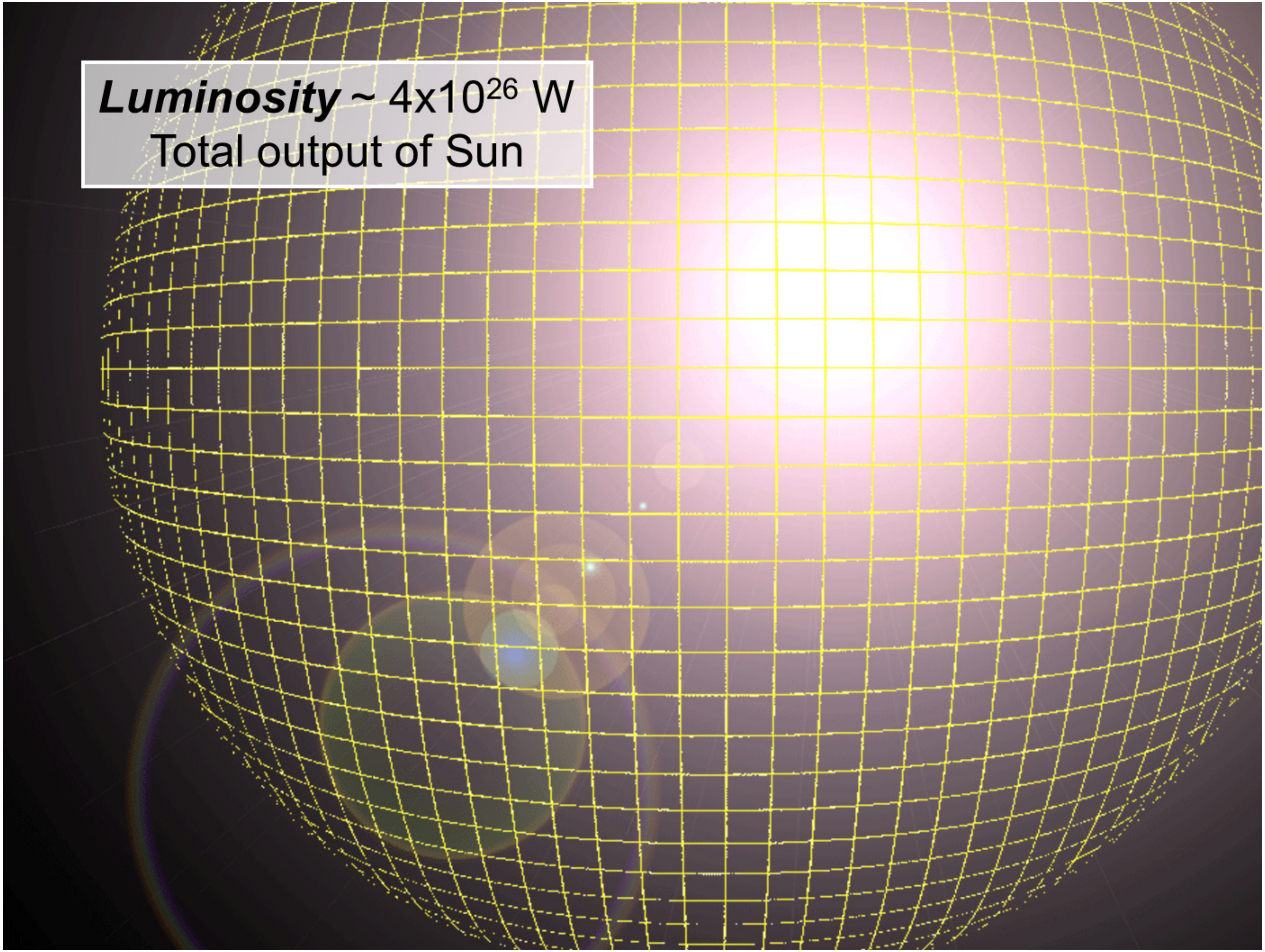
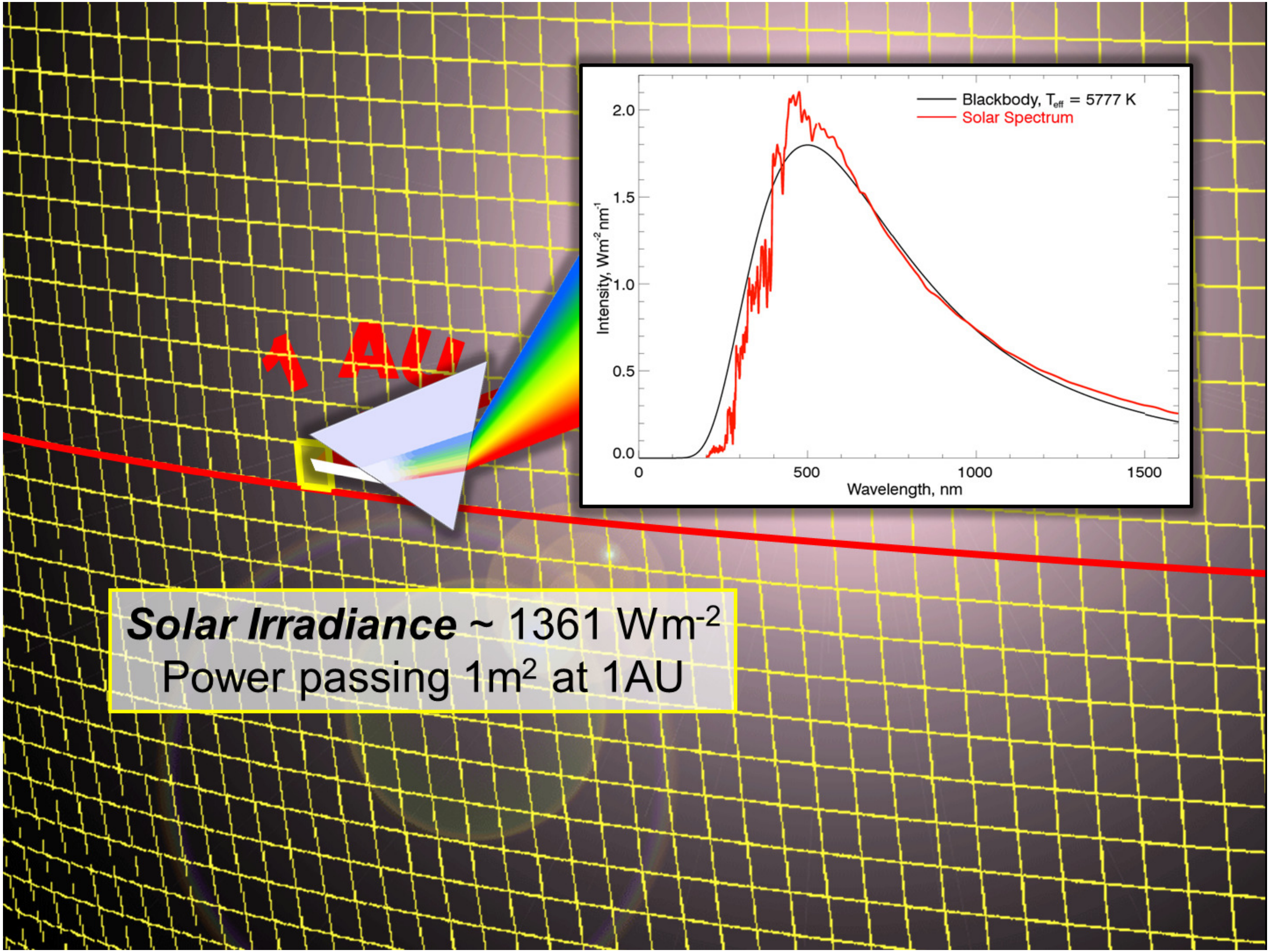
Outline

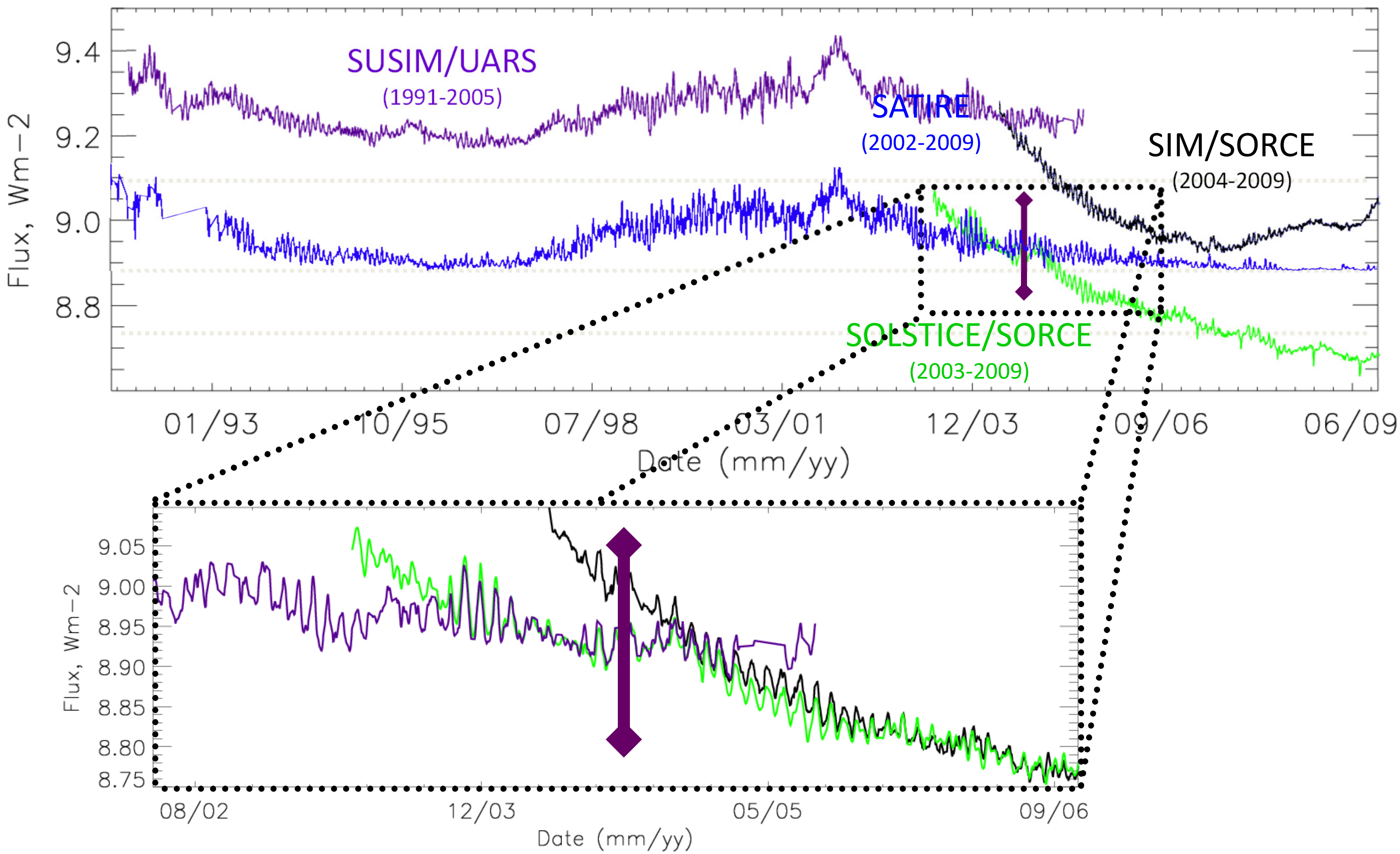
- Motivation
- SATIRE-S Model
- NRLSSI and SORCE/SOLSTICE
- Spectral irradiance comparisons
- Impact on Stratospheric Ozone
- Summary


Luminosity ~ 4×10^{26} W
Total output of Sun



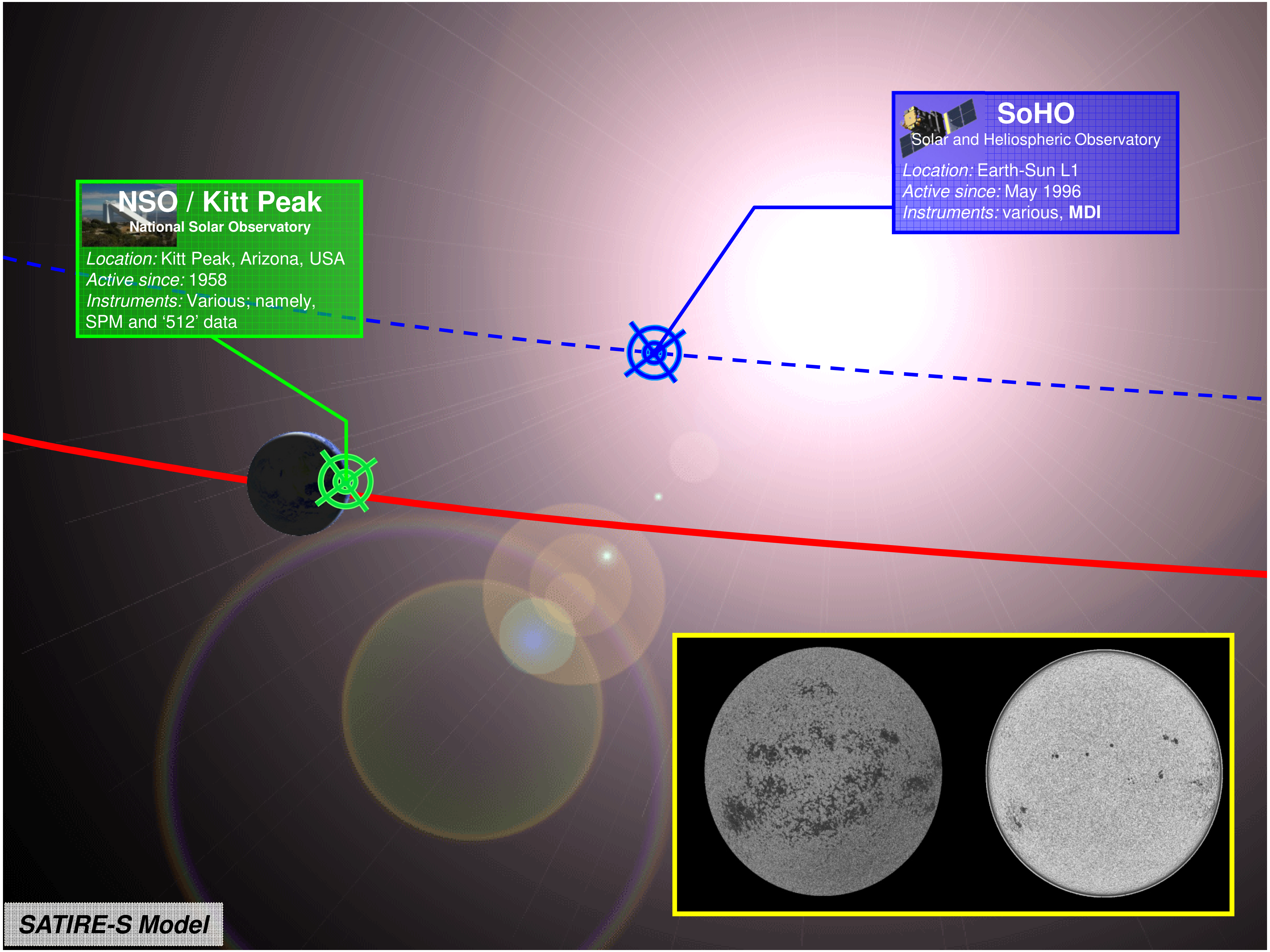
1 AU
Blackbody, T_eff = 5777 K
Solar Spectrum
Intensity, Wm^-2 nm^-1
2.0
1.5
1.0
0.5
0.0
0
500
1000
1500
Wavelength, nm
Solar Irradiance ~ 1361 Wm^-2
Power passing 1m^2 at 1AU

Motivation



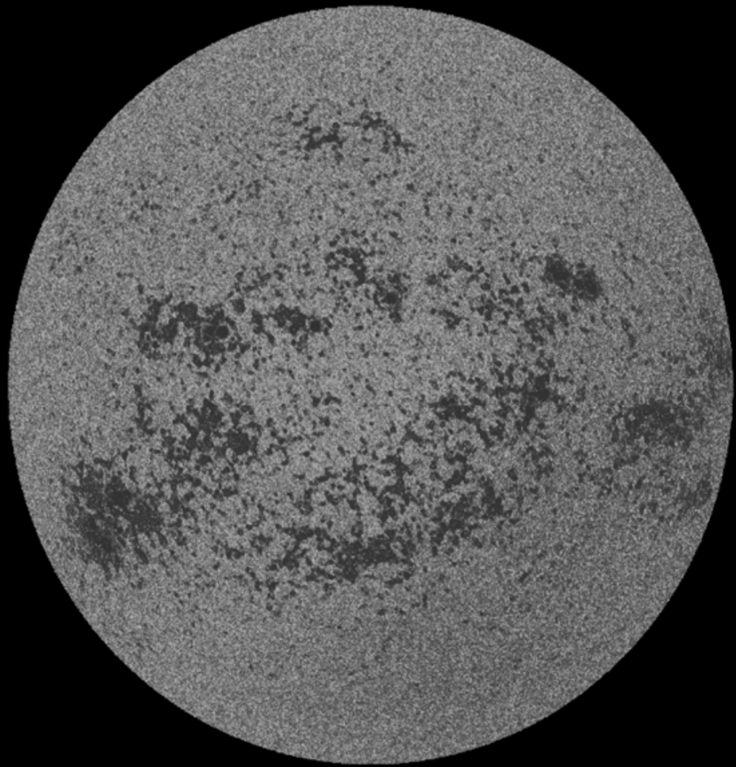
Motivation: SSI

SATIRE-S Model

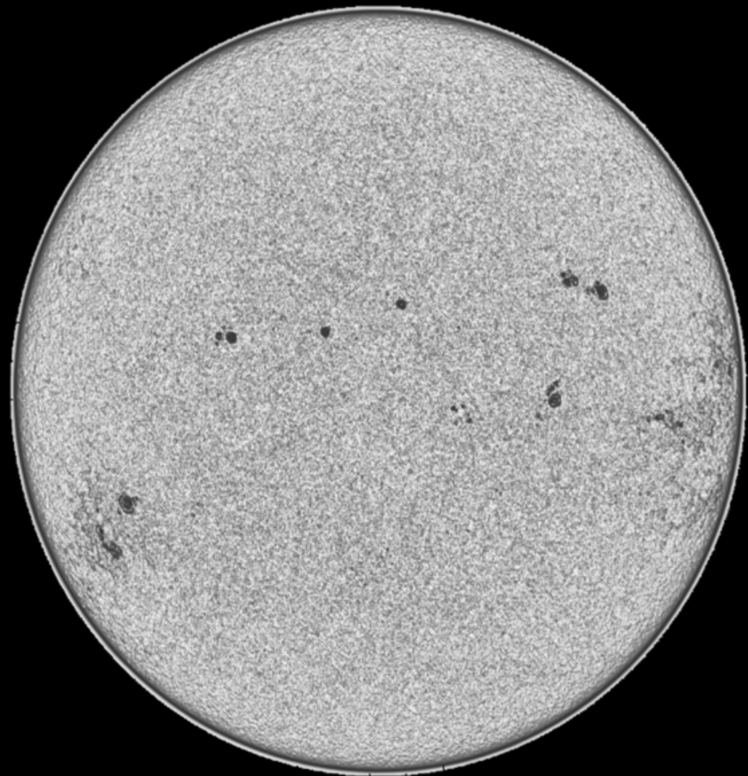


NSO / Kitt Peak
National Solar Observatory
Location: Kitt Peak, Arizona, USA
Active since: 1958
Instruments: Various; namely, SPM and '512' data
SoHO
Solar and Heliospheric Observatory
Location: Earth-Sun L1
Active since: May 1996
Instruments: various, MDI
SATIRE-S Model

Magnetogram



Continuum Image

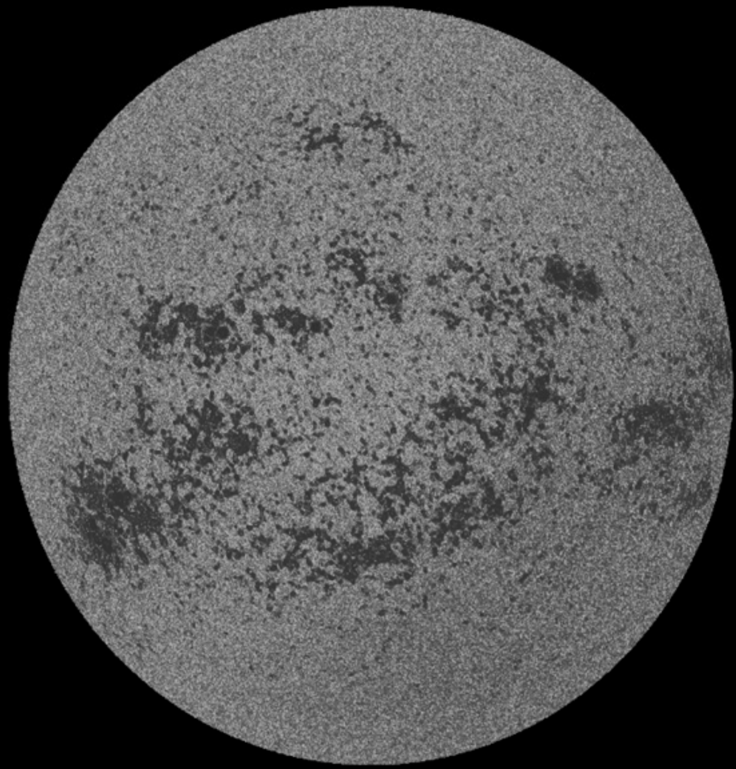


SATIRE-S Model

Fligge et al., 2002; Krivova et al., 2003

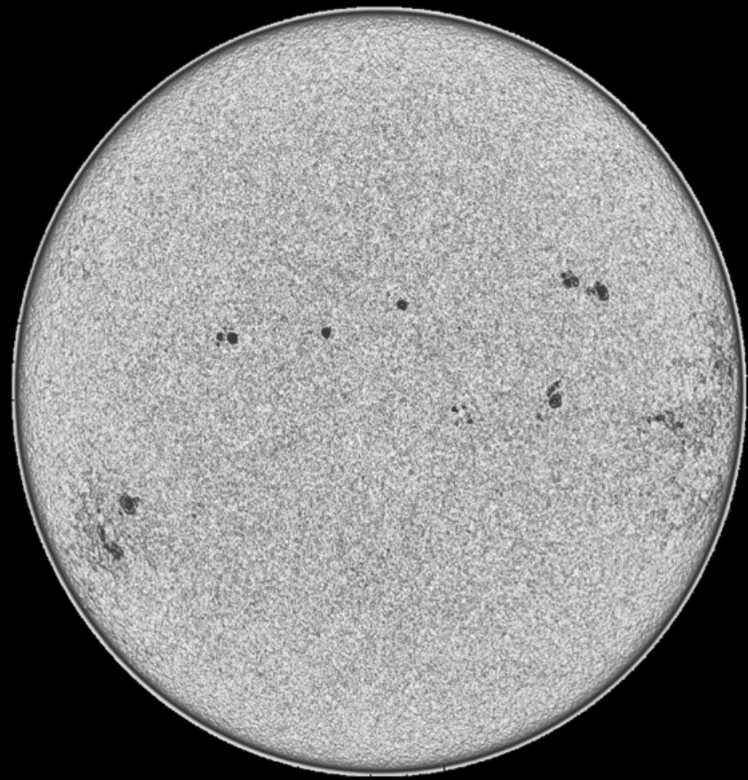
Magnetogram

Line-of-Sight Magnetic Field Correction



Continuum Image

Limb-darkening Correction

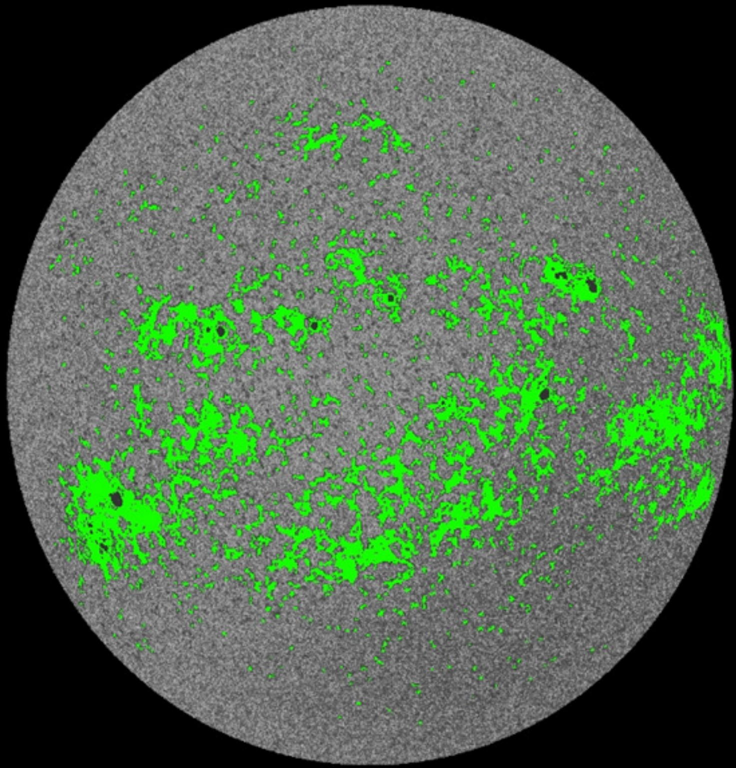


Fligge et al., 2002; Krivova et al., 2003

SATIRE-S Model

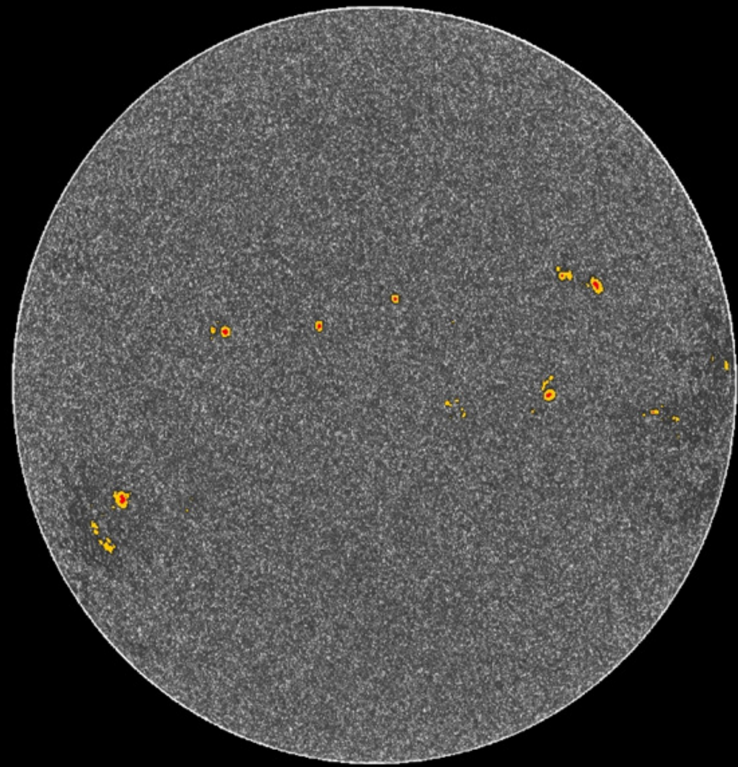
Magnetogram

Identify **Facular** Pixels



Continuum Image

Identify **Umbral** and **Penumbral** Pixels

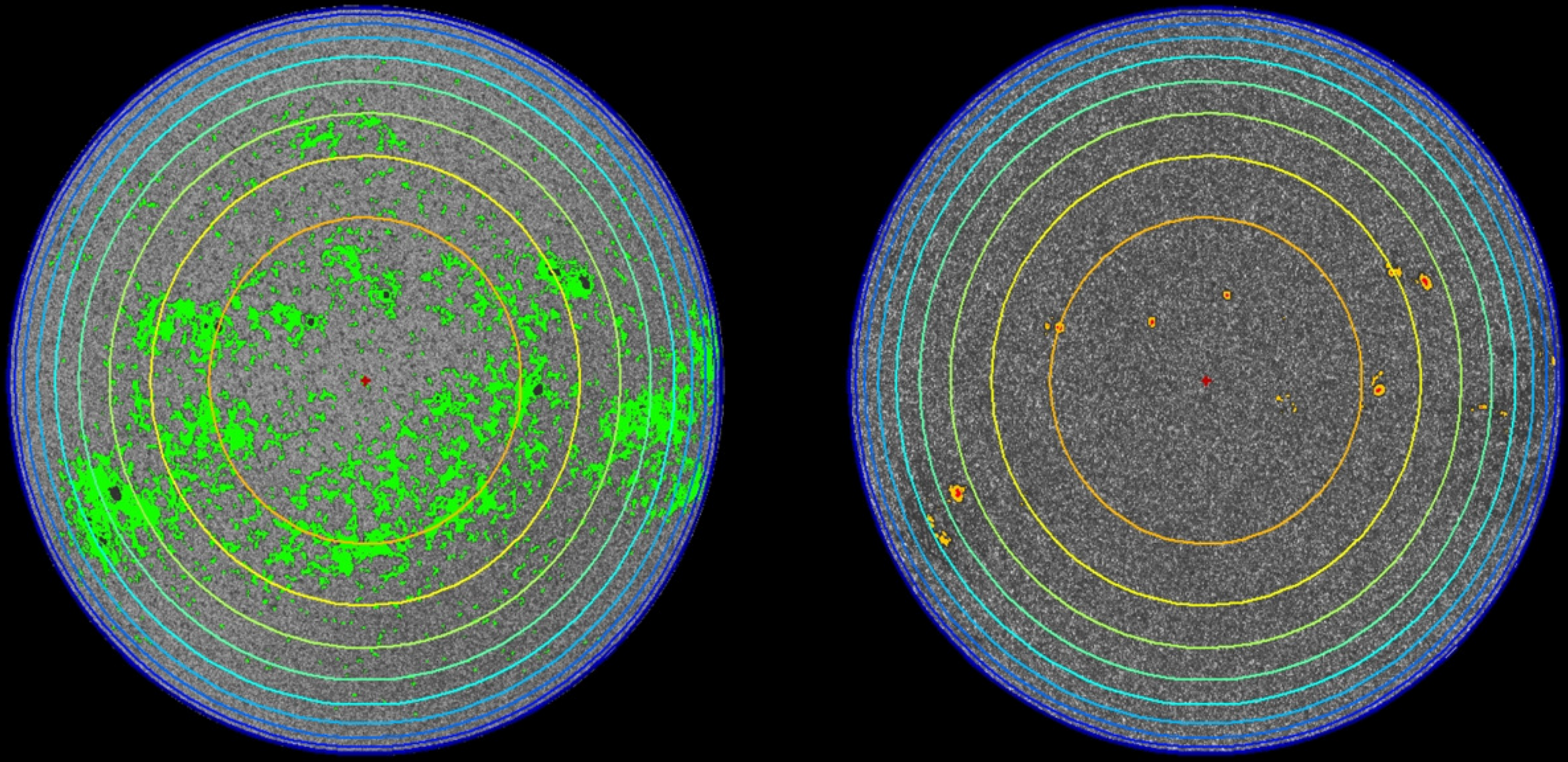


Fligge et al., 2002; Krivova et al., 2003

SATIRE-S Model

Magnetogram Continuum Image

Bin pixel type with limb-angle



SATIRE-S Model

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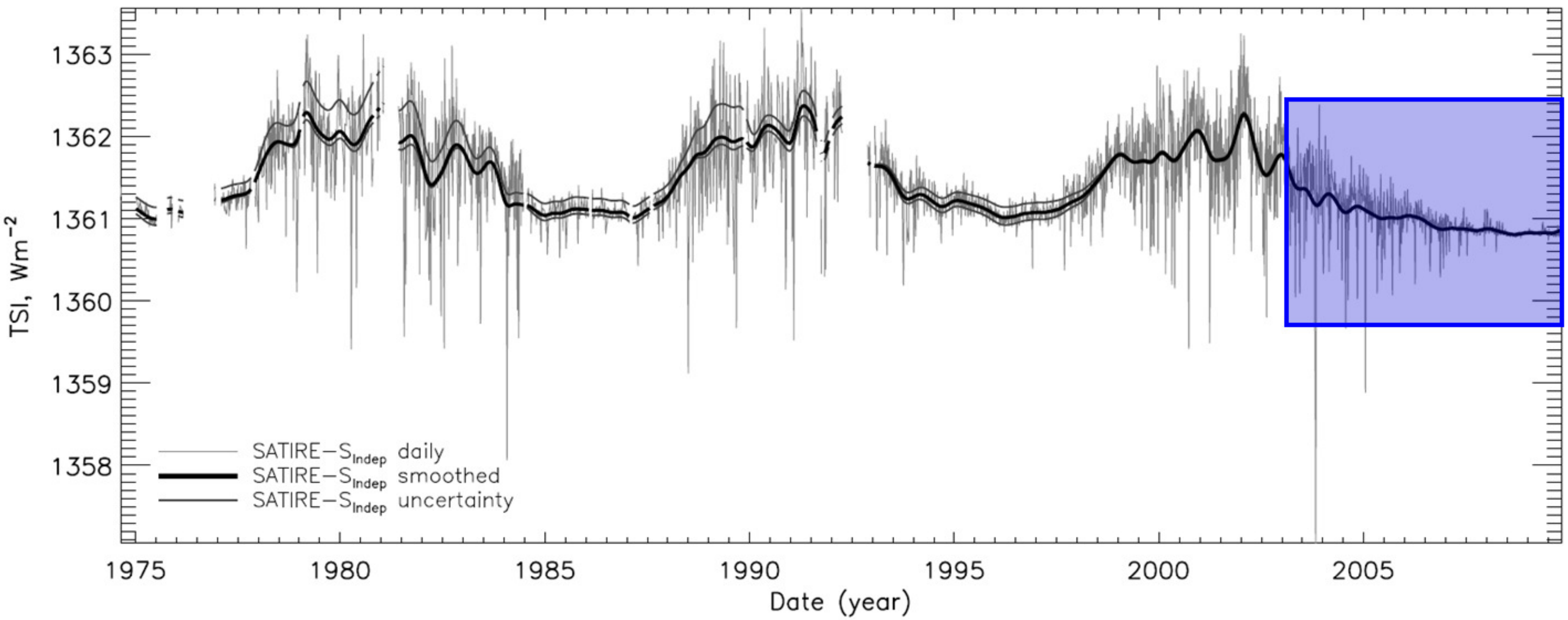
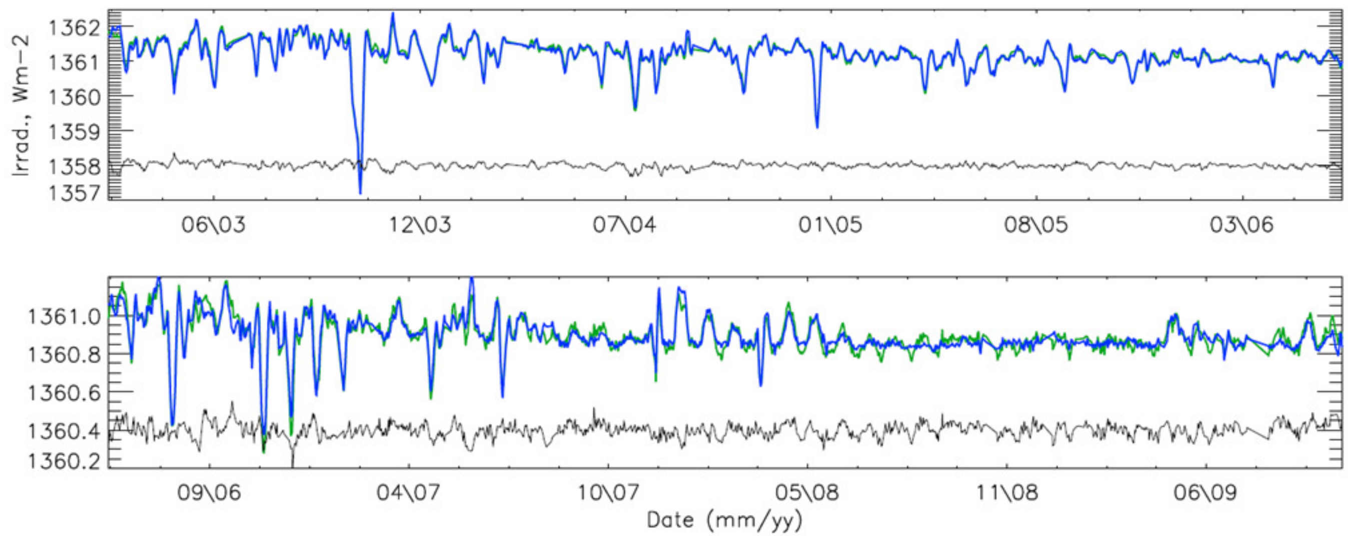
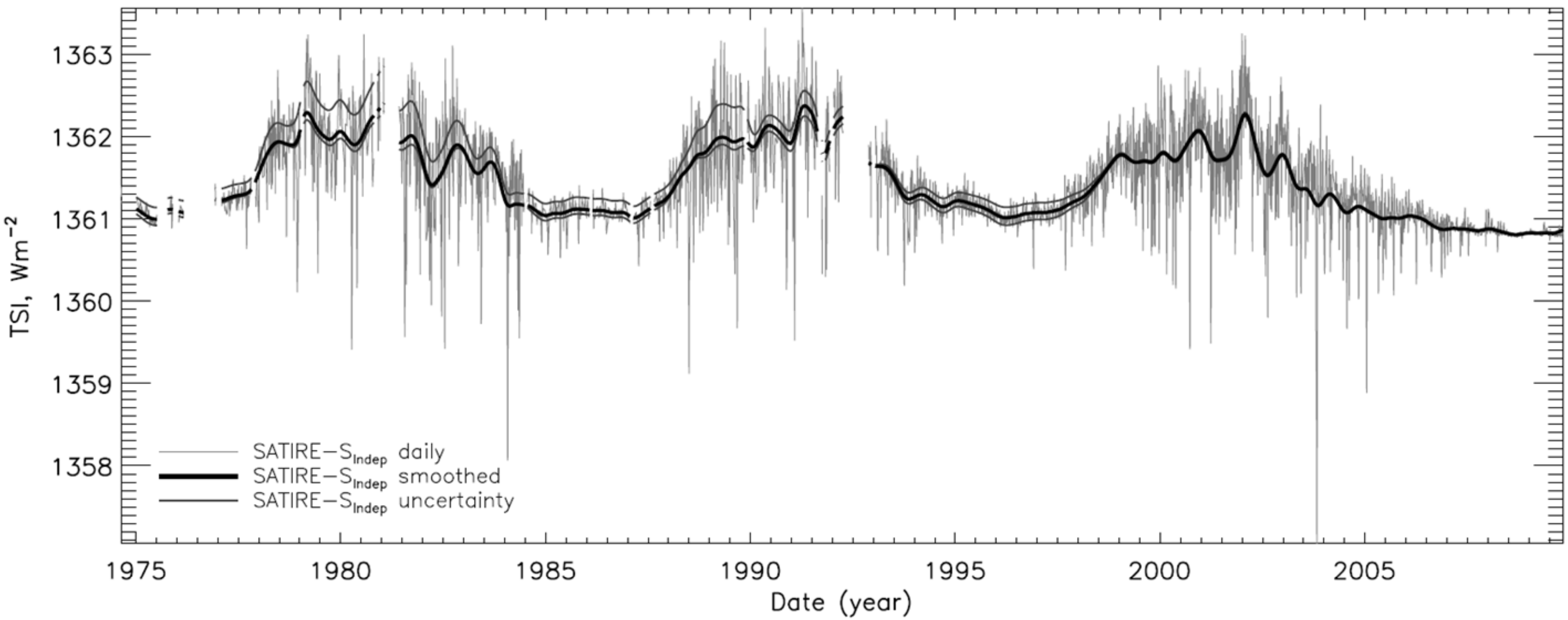




SATIRE
compared with
TIM/SORCE
Feb 2003 –
Oct 2009

Ball et. al., 2011, 2012

New SATIRE-S Reconstruction of 1974-2009

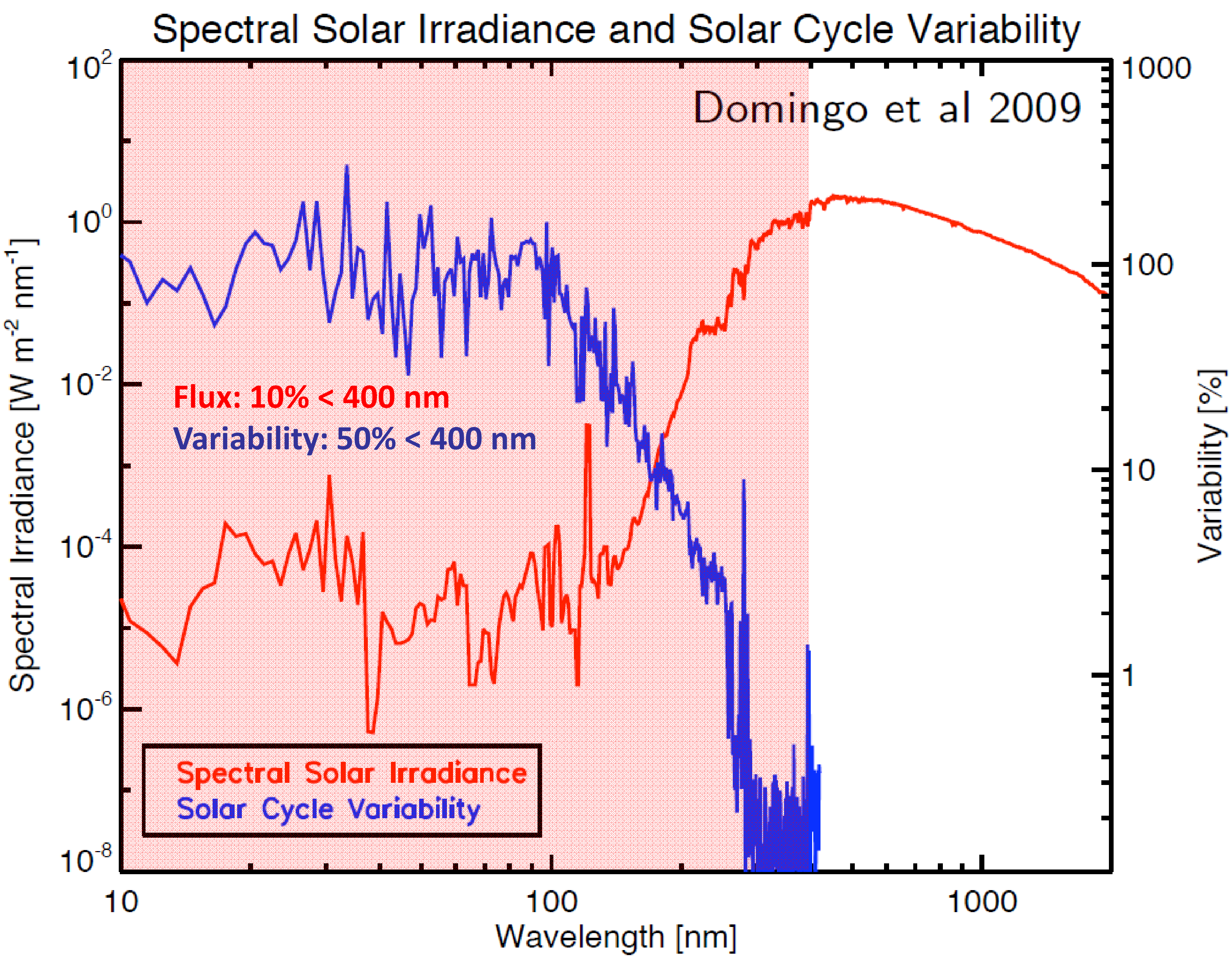


Old version (Ball et al. 2012)
TSI only; data gaps

New version (Ball et al., 2013, in prep.)
SSI + TSI
Fill all data gaps with MLR and proxies
NLTE correction < 270 nm (Krivova et al., 2006)
Uncertainty range at all wavelengths

Ball et. al., 2011, 2012

New SATIRE-S Reconstruction of 1974-2009



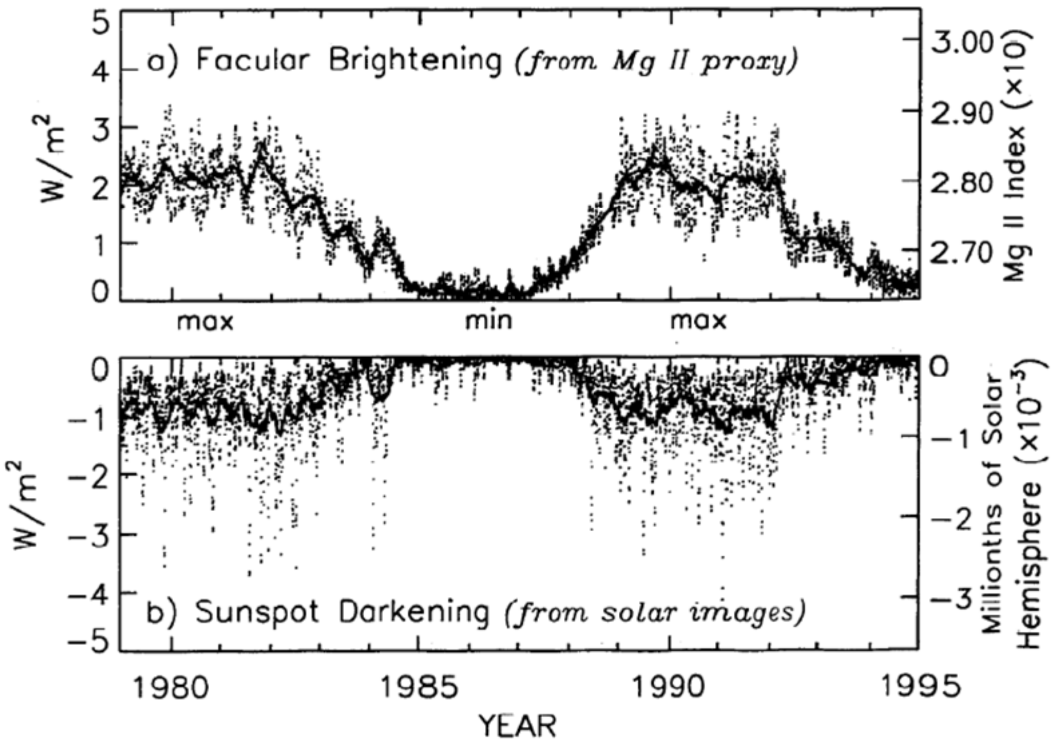
Spectral solar irradiance

NRLSSI Model
&
SORCE/SOLSTICE

Naval Research Laboratory SSI Dataset

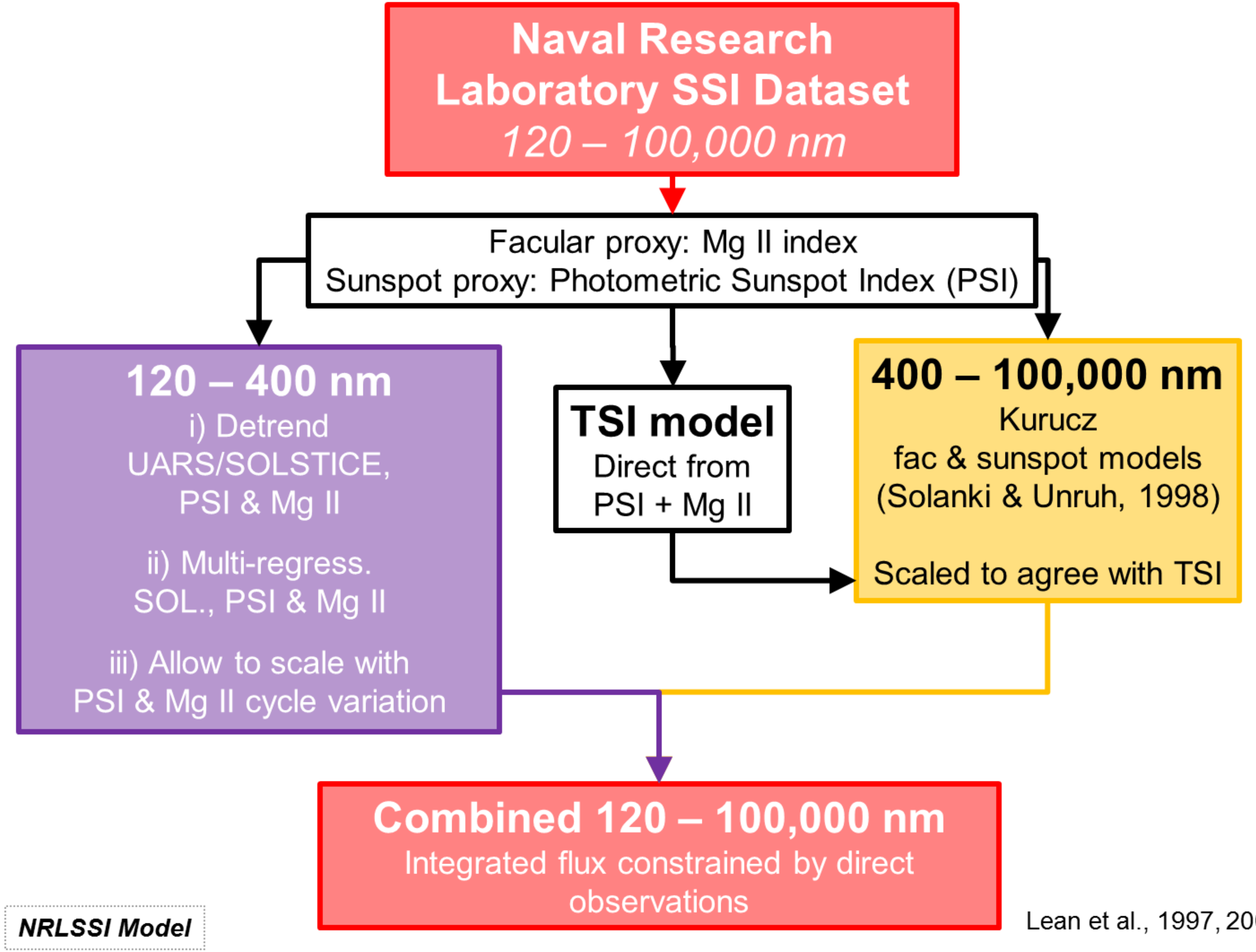
120 – 100,000 nm

Facular proxy: Mg II index
Sunspot proxy: Photometric Sunspot Index (PSI)



NRLSSI Model

Lean et al., 1997, 2005



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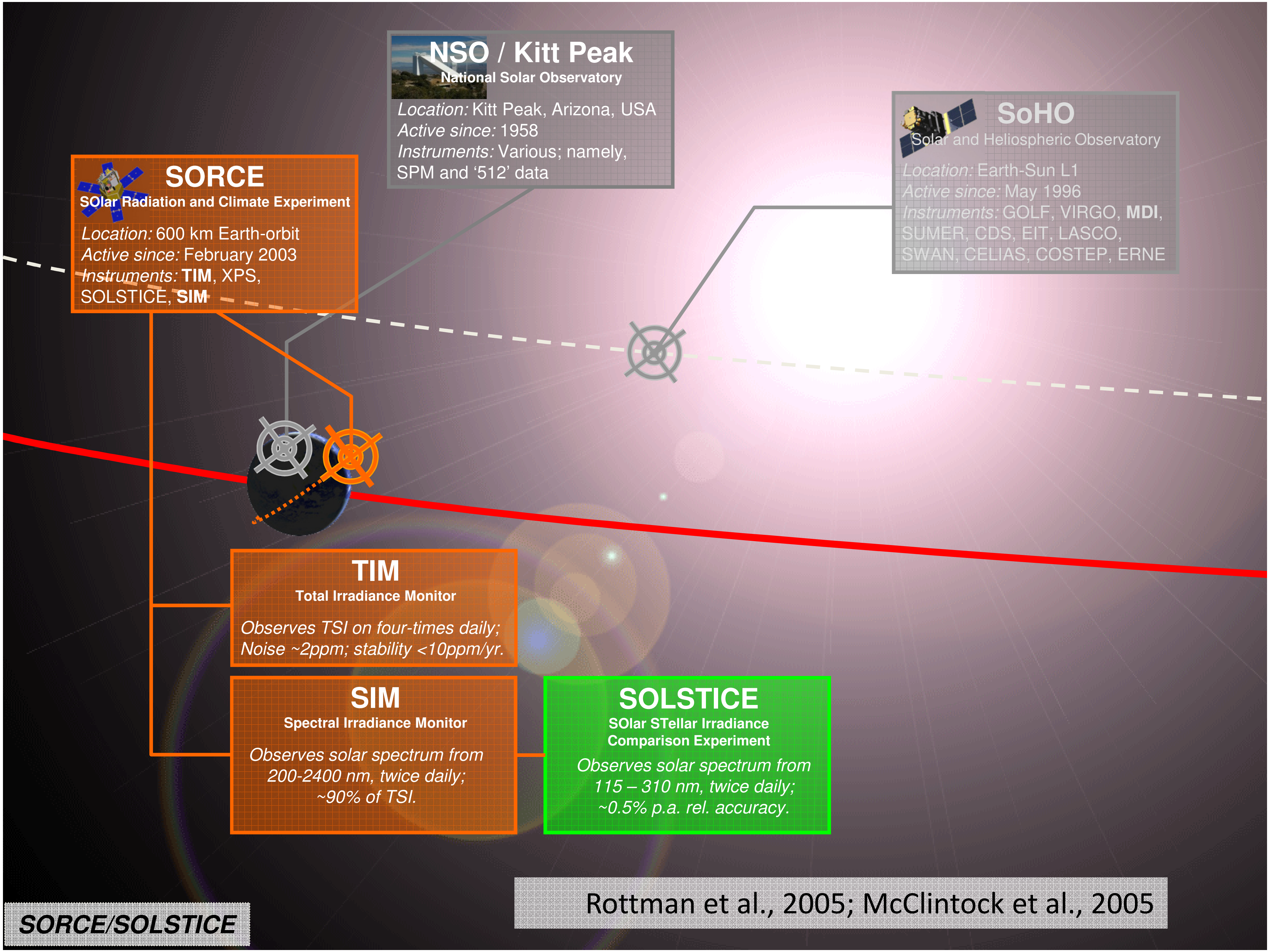

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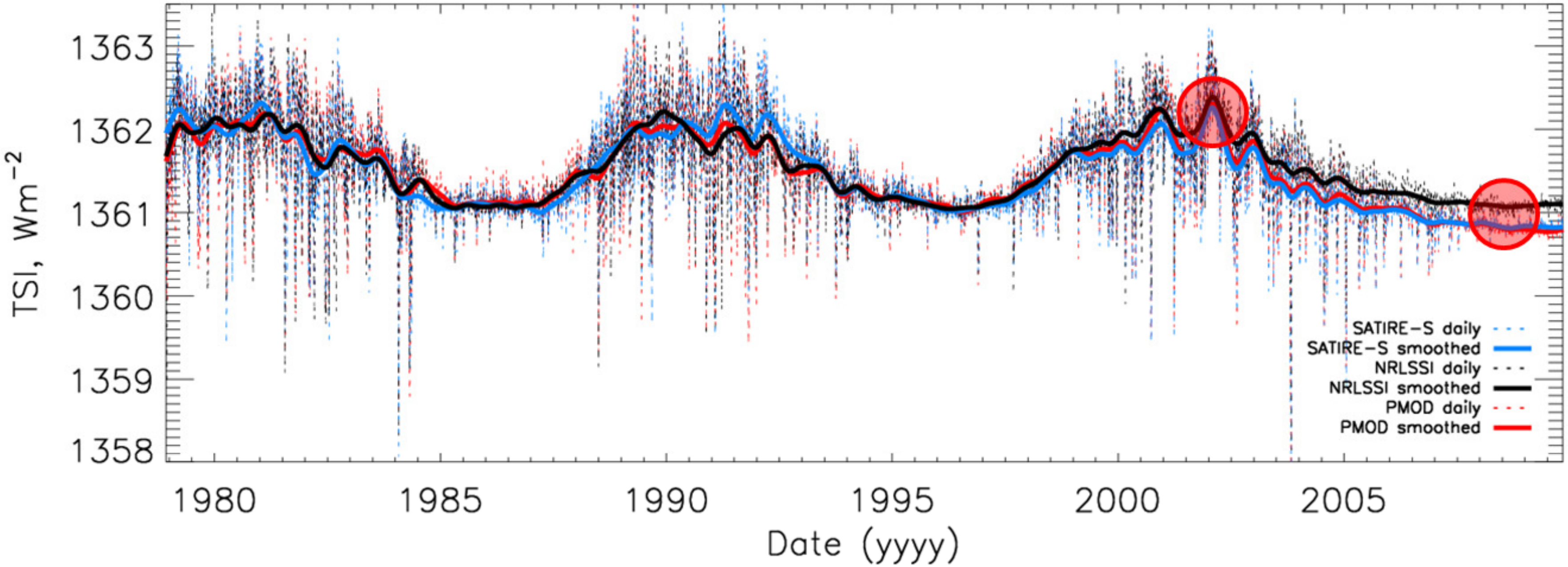
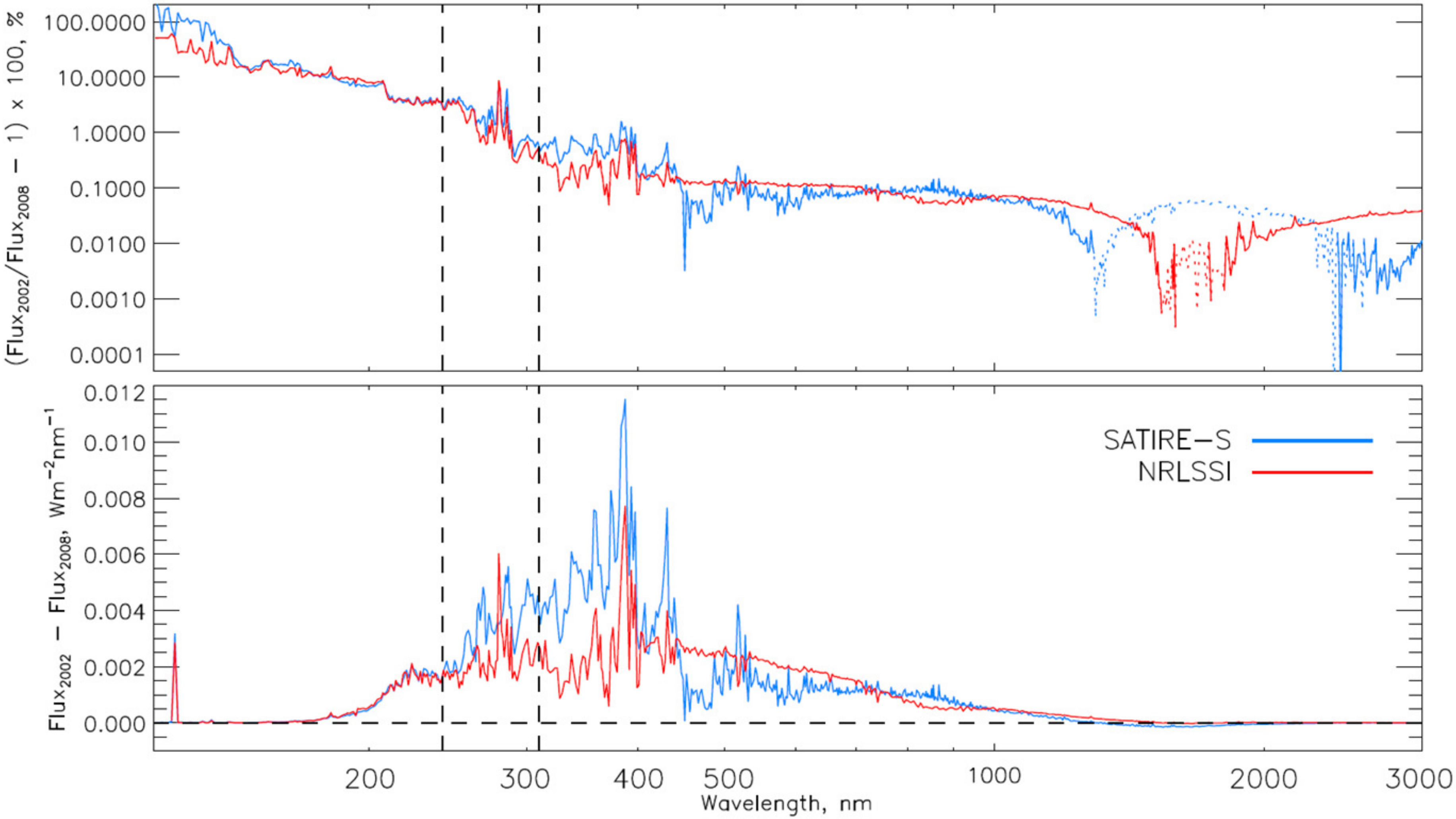
SoHO
Solar and Heliospheric Observatory
Location: Earth-Sun L1
Active since: May 1996
Instruments: GOLF, VIRGO, MDI, SUMER, CDS, EIT, LASCO, SWAN, CELIAS, COSTEP, ERNE
SORCE
SOlar Radiation and Climate Experiment
Location: 600 km Earth-orbit
Active since: February 2003
Instruments: TIM, XPS, SOLSTICE, SIM
TIM
Total Irradiance Monitor
Observes TSI on four-times daily; Noise ~2ppm; stability <10ppm/yr.
SIM
Spectral Irradiance Monitor
Observes solar spectrum from 200-2400 nm, twice daily; ~90% of TSI.
SOLSTICE
SOlar STellar Irradiance Comparison Experiment
Observes solar spectrum from 115 – 310 nm, twice daily; ~0.5% p.a. rel. accuracy.
Rottman et al., 2005; McClintock et al., 2005
SORCE/SOLSTICE

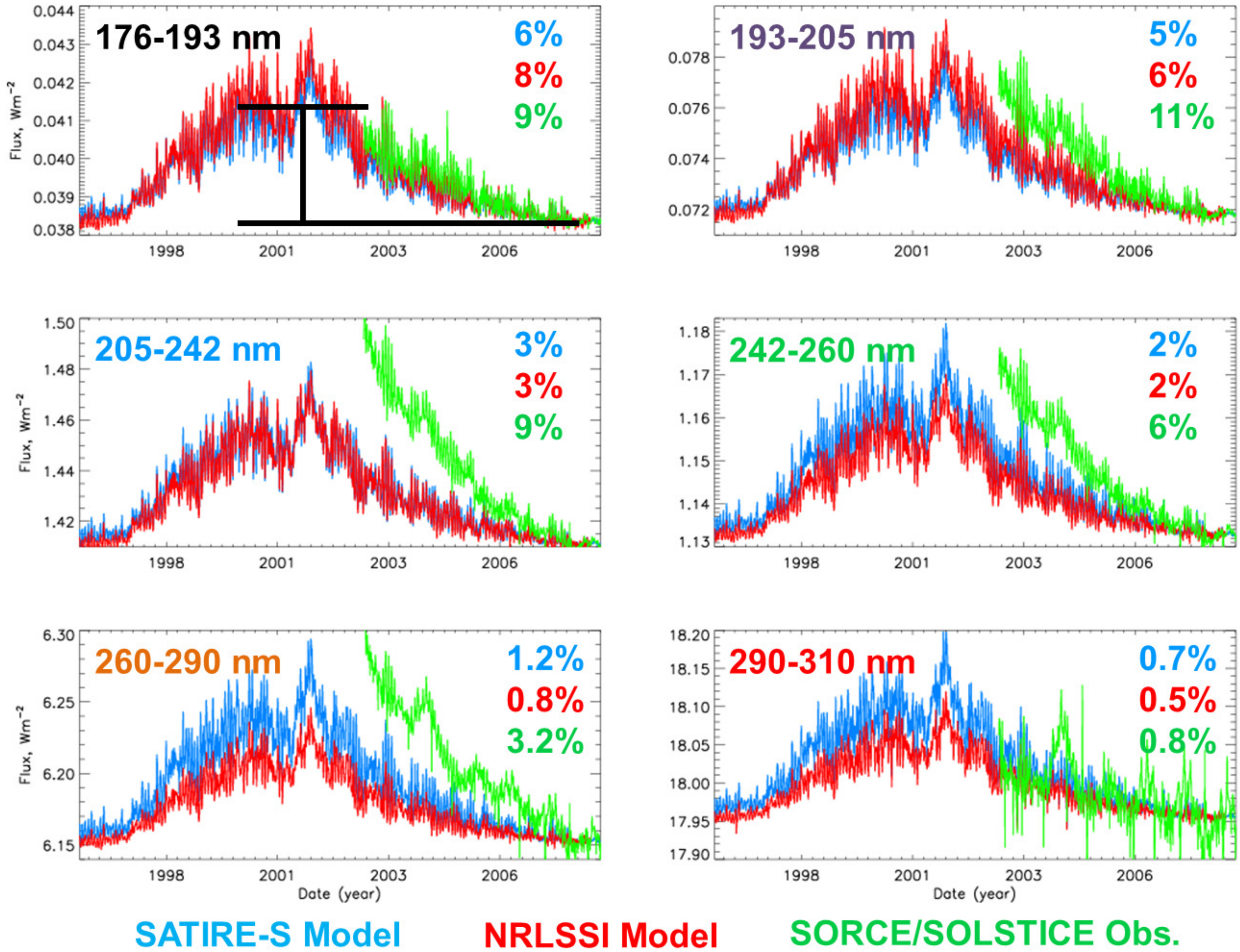


TSI r_c	All data	Detrended
PMOD: NRLSSI	0.92	0.87
PMOD: SATIRE	0.96	0.95

Spectral solar irradiance: SATIRE, NRLSSI

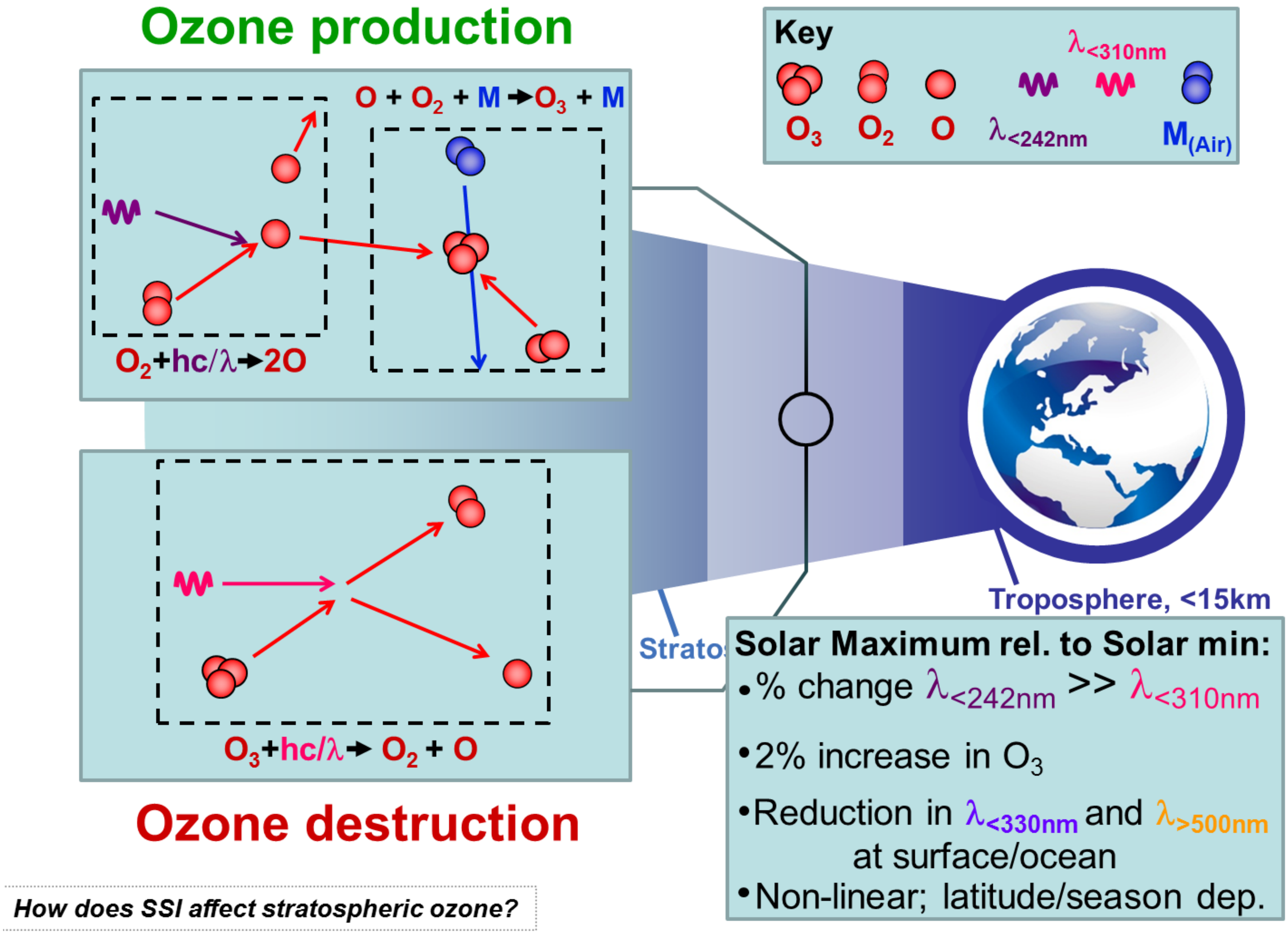


Spectral solar irradiance: SATIRE, NRLSSI

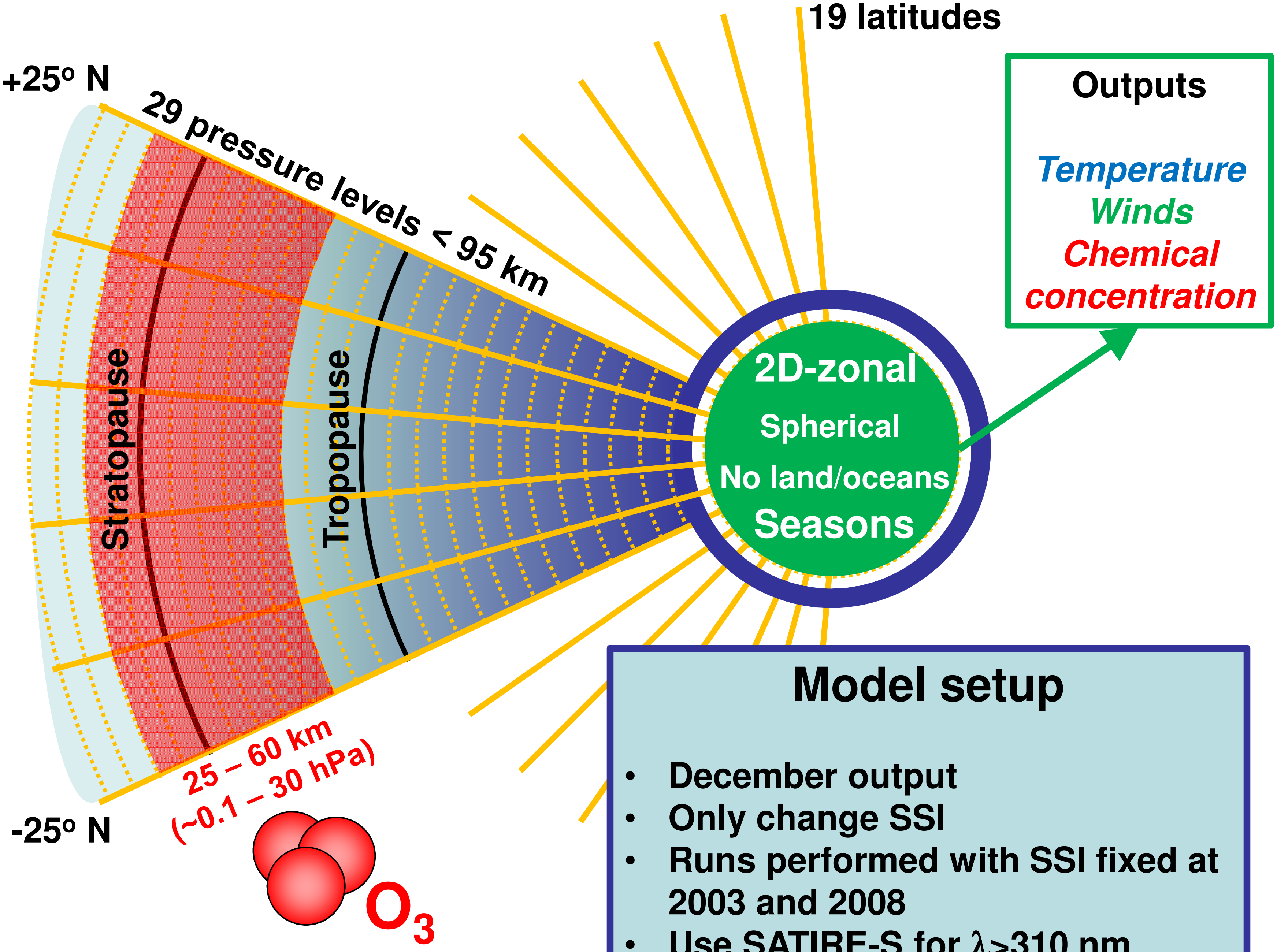


Spectral solar irradiance: SATIRE, NRLSSI, SORCE/SOL.

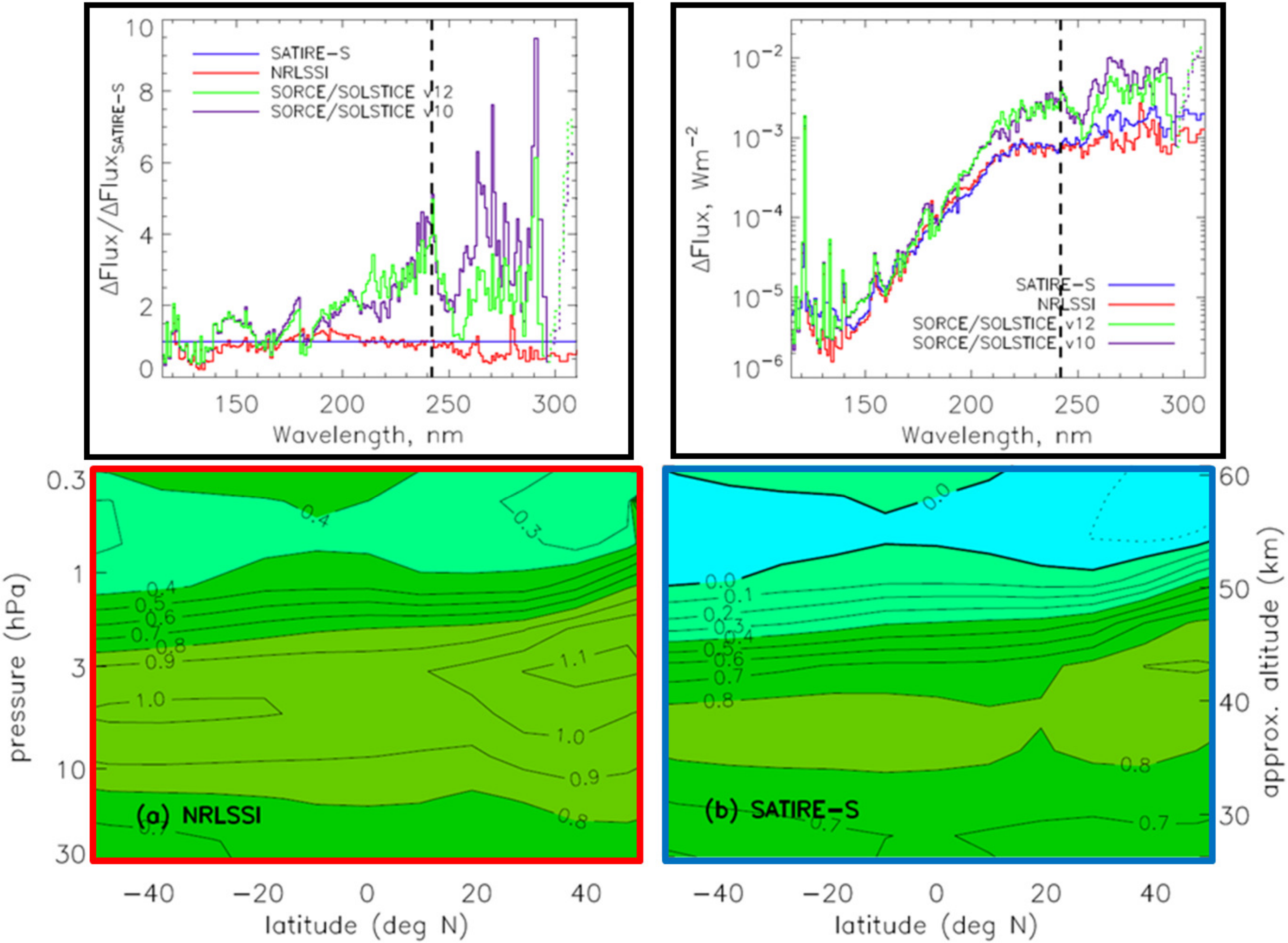
An example:
SSI Impact on Stratospheric Ozone



Ozone production
O + O2 + M → O3 + M
O2+hc/λ→2O
Key
O3
O2
O
λ<242nm
λ<310nm
M(Air)
Troposphere, <15km
Strato
Solar Maximum rel. to Solar min:
• % change λ<242nm >> λ<310nm
• 2% increase in O3
• Reduction in λ<330nm and λ>500nm at surface/ocean
• Non-linear; latitude/season dep.
O3+hc/λ→ O2 + O
Ozone destruction
How does SSI affect stratospheric ozone?



2D atmospheric model (Harwood & Pyle 1975)



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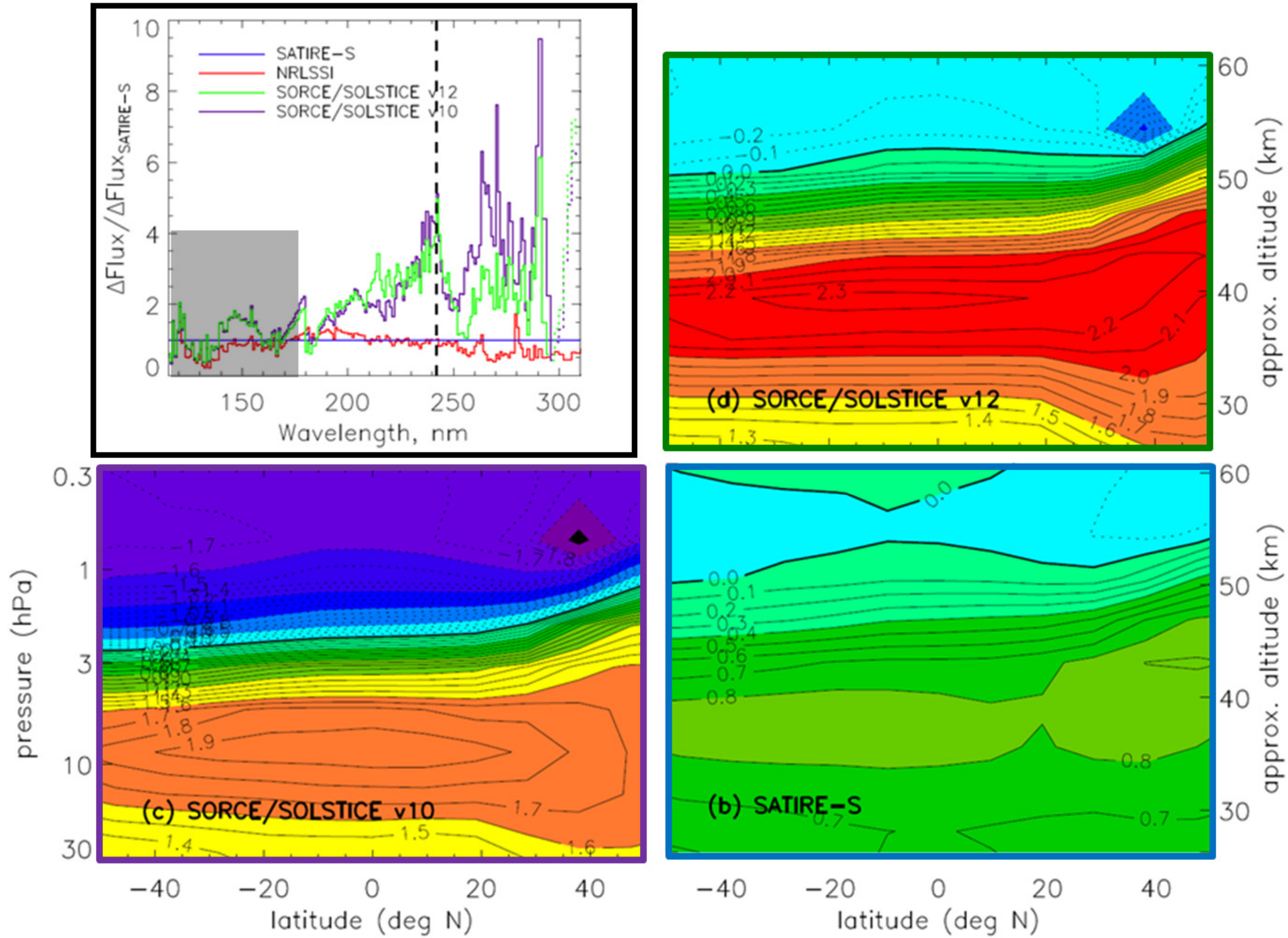

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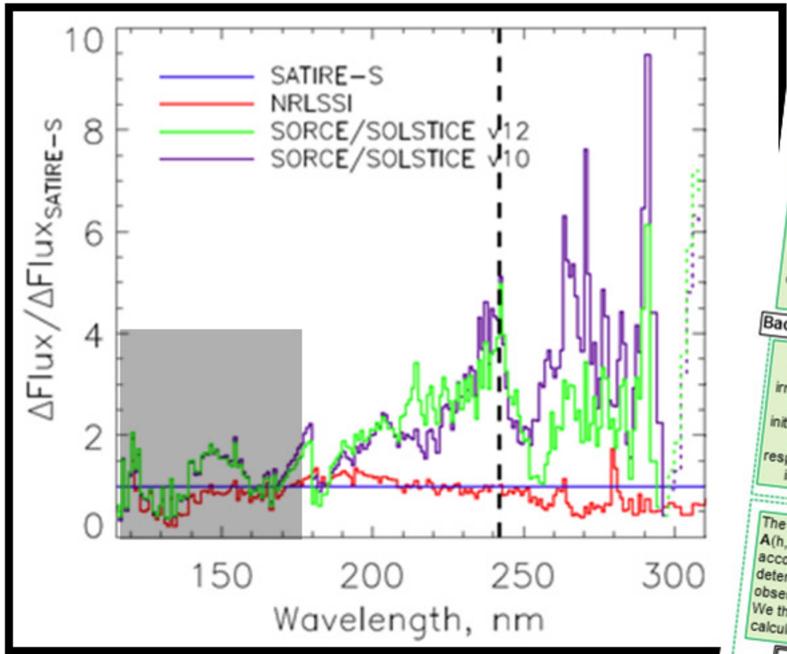

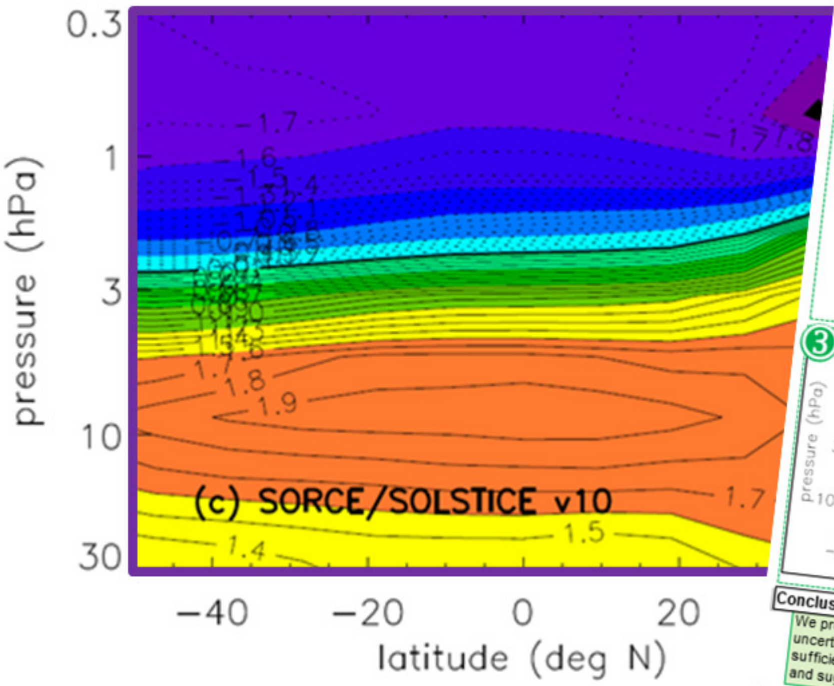

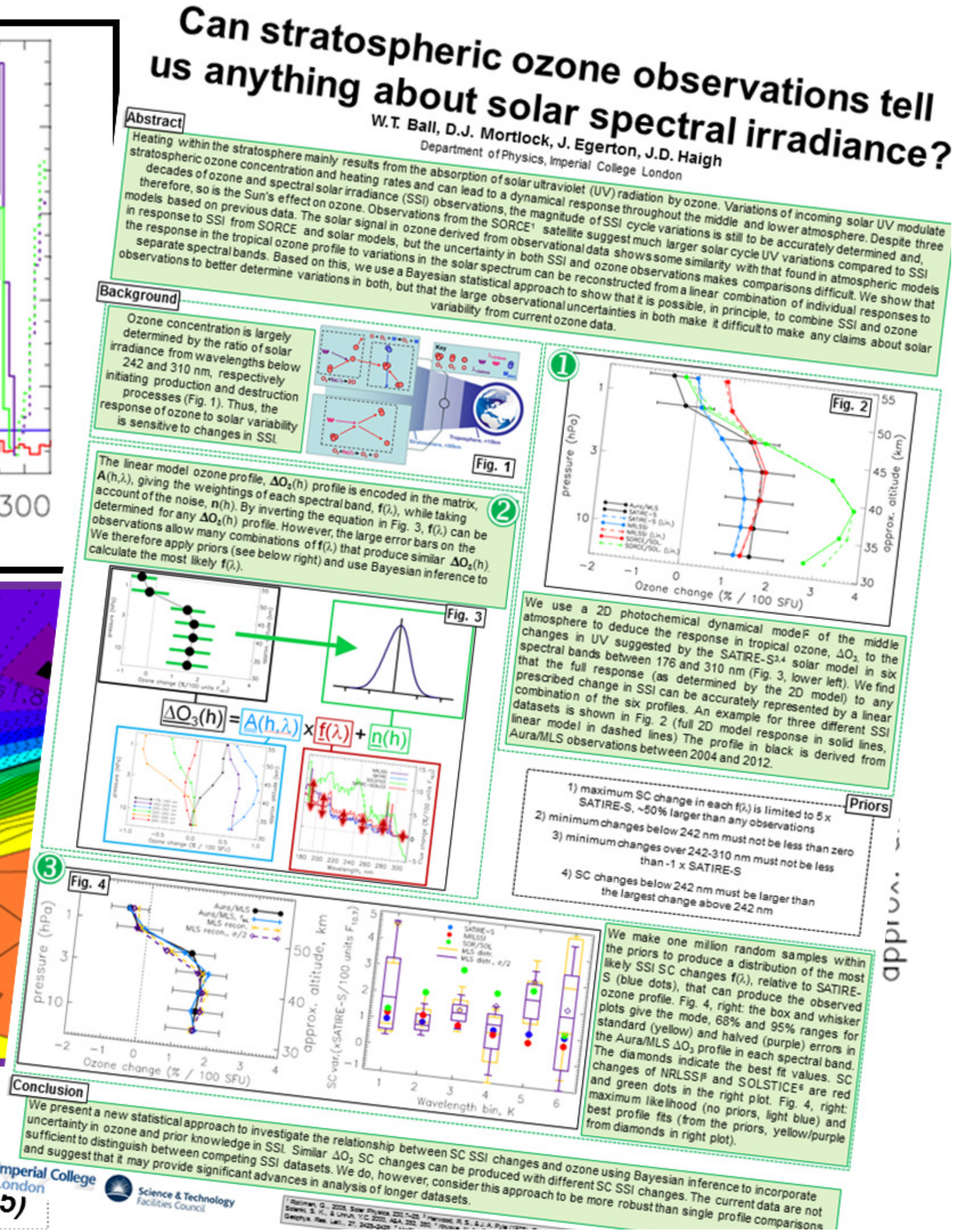

2D atmospheric model (Harwood & Pyle 1975)

Summary

- New SSI dataset (SATIRE-S)
  - last three cycles (extension underway)
  - different SSI variability w.r.t. NRLSSI
- SSI models and recent observations disagree
  - differences up to 4x cycle variability
  - models more similar than SORCE observations
- SSI is important for studies of the atmosphere, e.g. stratospheric ozone
  - model and SOLSTICE O3 response very different
  - large difference in O3 between SOLSTICE versions
- Errors on SSI observations are large
  - cycle SSI variability is still uncertain

Data available very soon on **LASP LISIRD** & **www.mps.mpg.de/projects/sun-climate**