Solar Spectral Irradiance Variability in Cycle 24: Model Predictions and OMI Observations

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Climate change - known major forcing factors (no ranking…):

- solar
- volcanoes
- aerosols (+ clouds)
- green house gases
- ozone.

"…most of the global warming in the 1st half of the 20th century was natural in origin, and much of this can be attributed to solar forcing."

Gray et al., Rev.Geophys. (2010)

… and then the green-house gases took over …

Both the total energy input and its spectral distribution are important for climate studies.

	Solar-cycle changes (~11 yrs)	**Short-term (~monthly/weekly) changes**
Total Solar Irradiance **1360.54 ± 0.36 W/m²** (G. Kopp, 2016, priv.comm)	~0.10-0.15%	up to ~0.3%
Solar Spectral Irradiance (SSI) at ~ 100 nm at ~ 250 nm **at > 400 nm**	 ~100% ~1-10% **< 0.1% (?)**	 comparable or [much] below ? it depends…

The climate-study wish list:

regular (~weekly, at least), long-term (>10 years) spectrally resolved (to $\Delta\lambda <$ 1-10 nm) solar observations in ~100 nm - 2 μm range, accurate (**long-term!**) to

~ 1% - 0.1% (MUV-NUV)
~ 0.01% (Vis-NIR)

… good luck with that …

The Cycle-24 hardware (data in public domain, UV-Vis range):

SORCE (**SOLSTICE & SIM**, since Jan. 2003); multiple/day observations; 115-2400 nm, variable spectral resolution, 0.1-24.6 nm; planned long-term accuracy ~0.2%; achieved accuracy ~1-2%.

GOME-2 A (since Oct. 2006); daily solar observations; 240-790 nm range with 0.3-0.5nm resolution; high degradation, uncertain to >~ 1%.

OMI (since Jul. 2004); daily solar observations; 265-500 nm, 0.4-0.6 nm resolution; **long-term degradation (y2007-current) characterized to ~0.2%.**

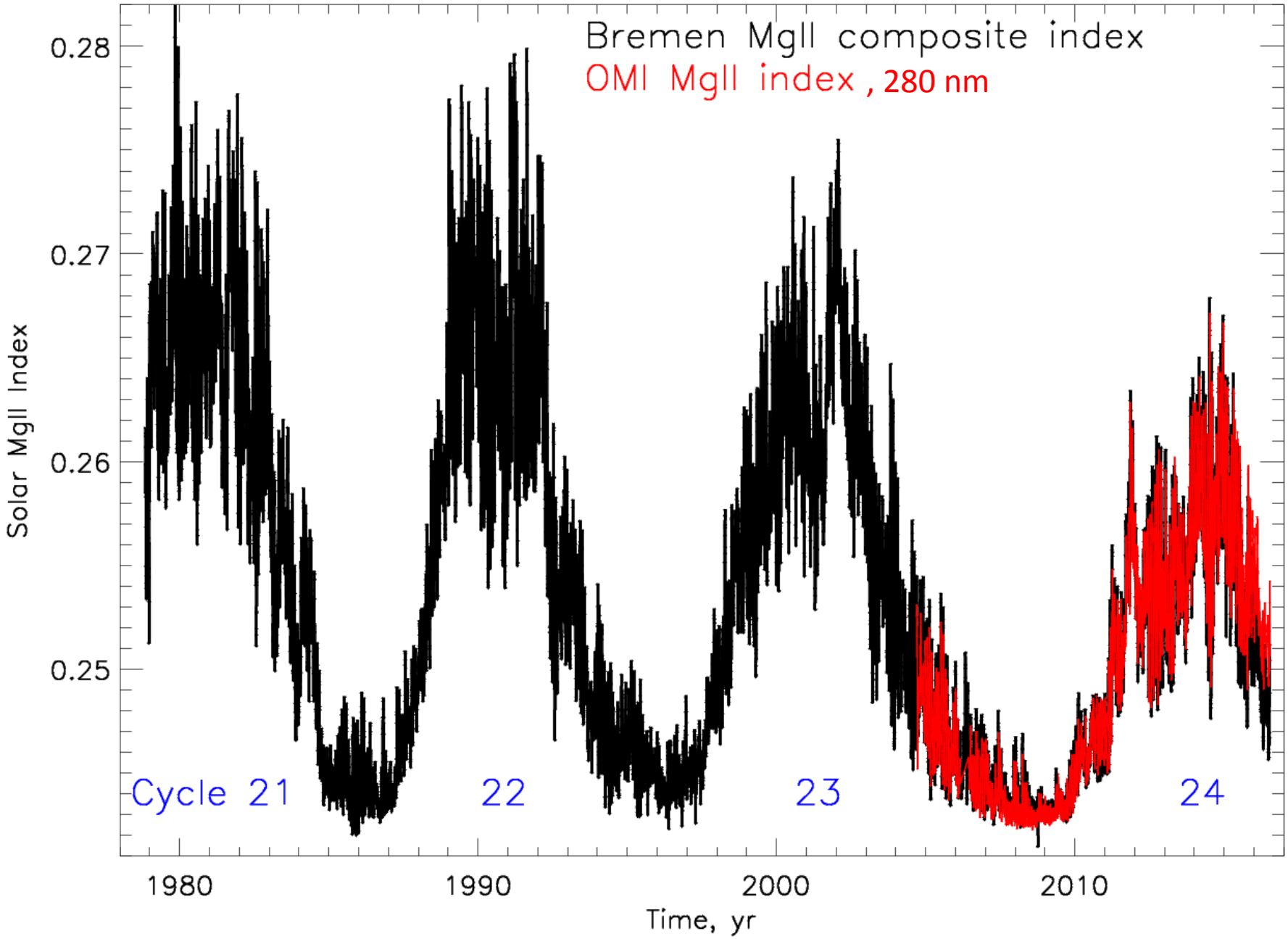
The software:

NRLSSI2 (Coddington et al., BAMS, 2016) – the purely empirical class

Naval Research Laboratory Solar Spectral Irradiance; **an operational NOAA (USA) Solar Irradiance Climate Data record**

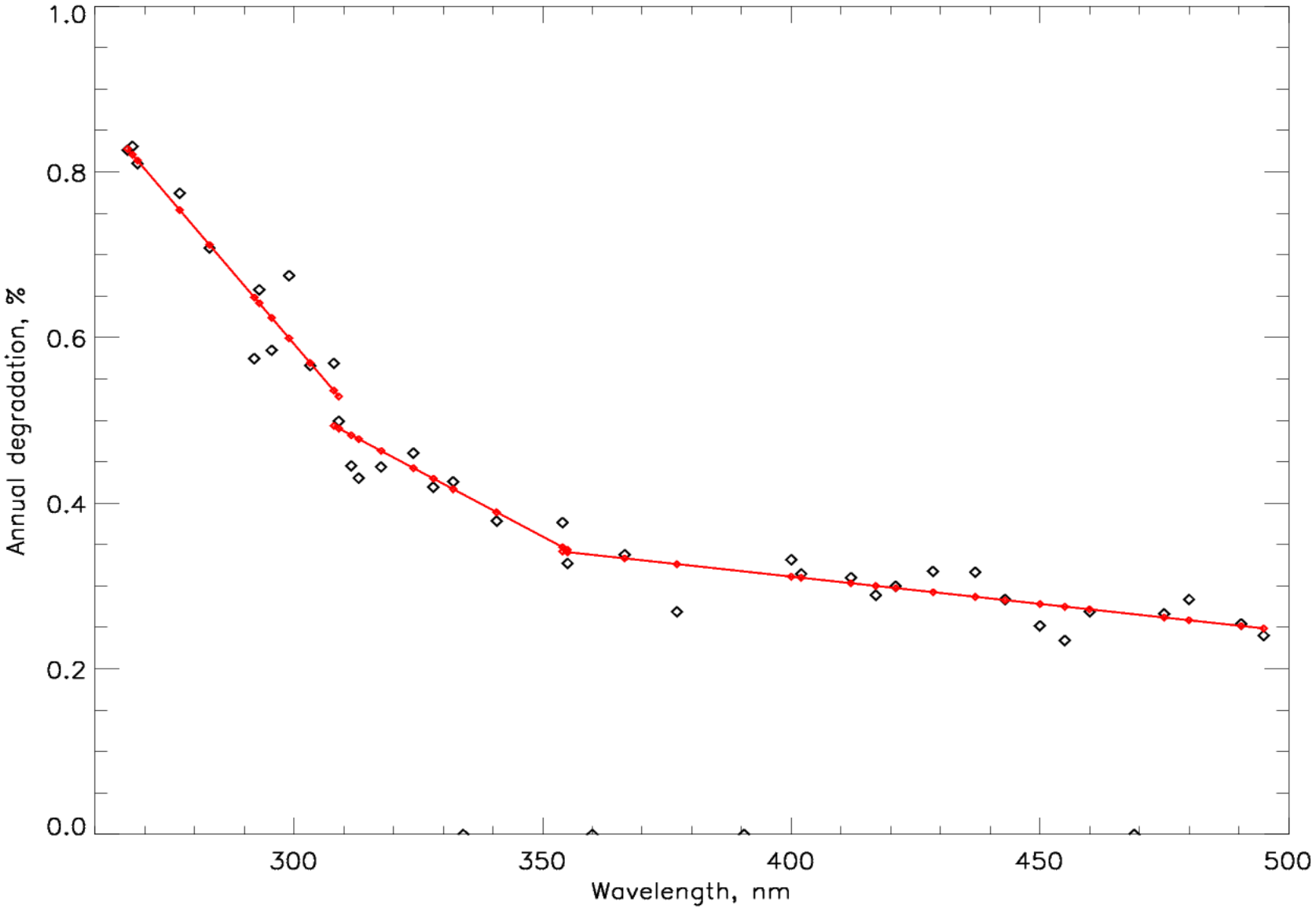
SATIRE-S (Yeo et al., JGRA, 120, 2015) – a representative of the semi-empirical class

Spectral And Total Irradiance REconstruction for the Satellite era



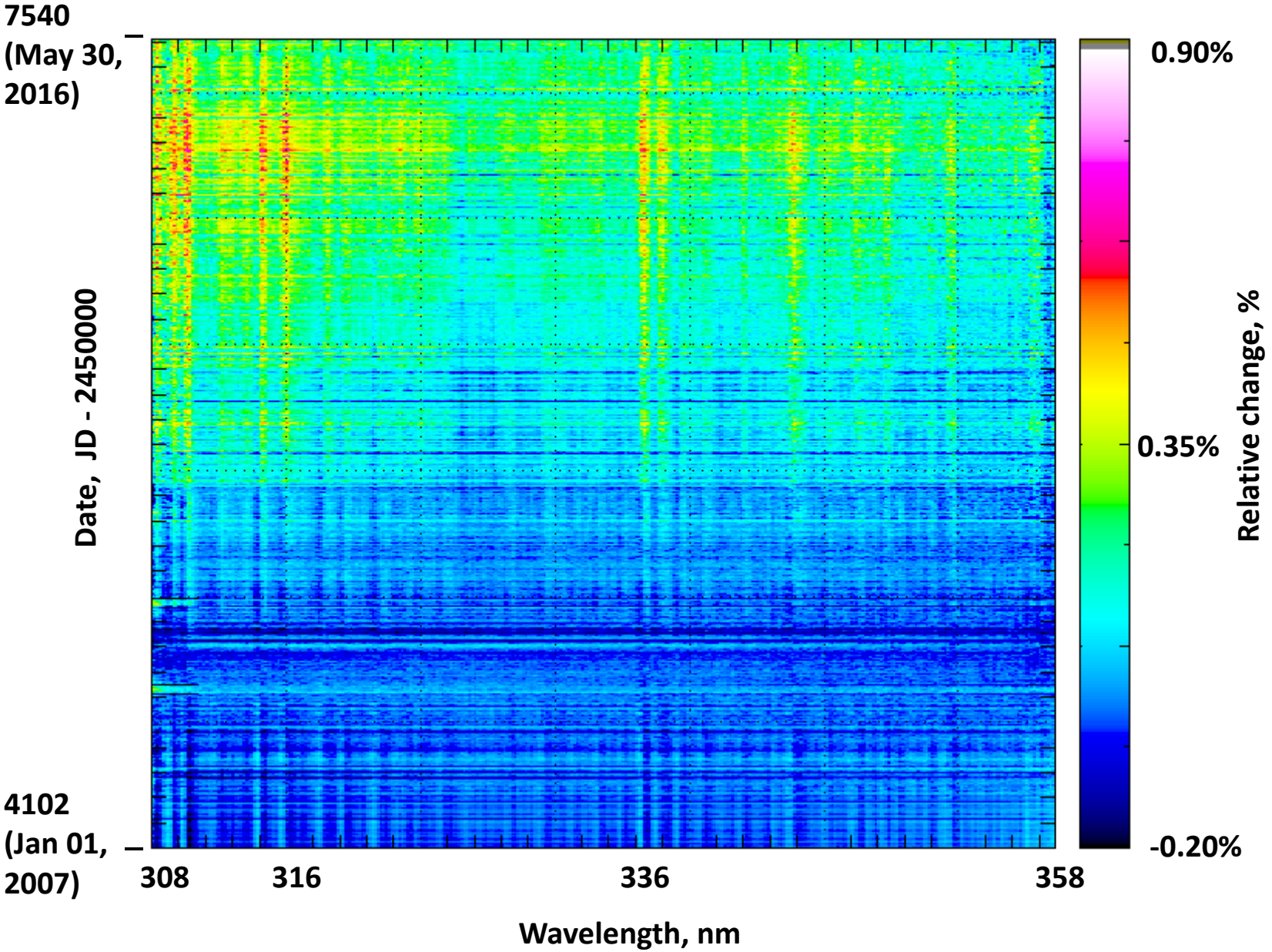
Bremen composite (M. Weber): *http://www.iup.uni-bremen.de/gome/gomemgii.html*

OMI's annual degradation: irradiances

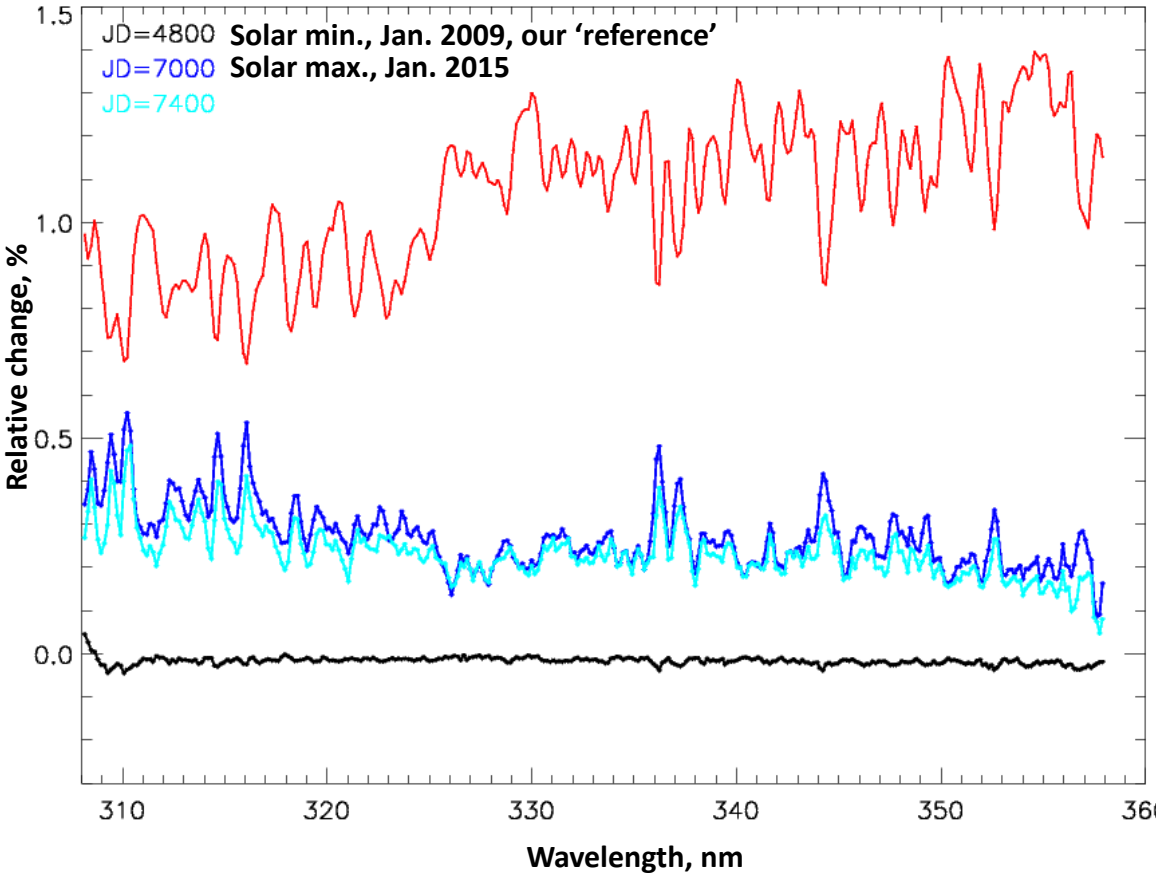


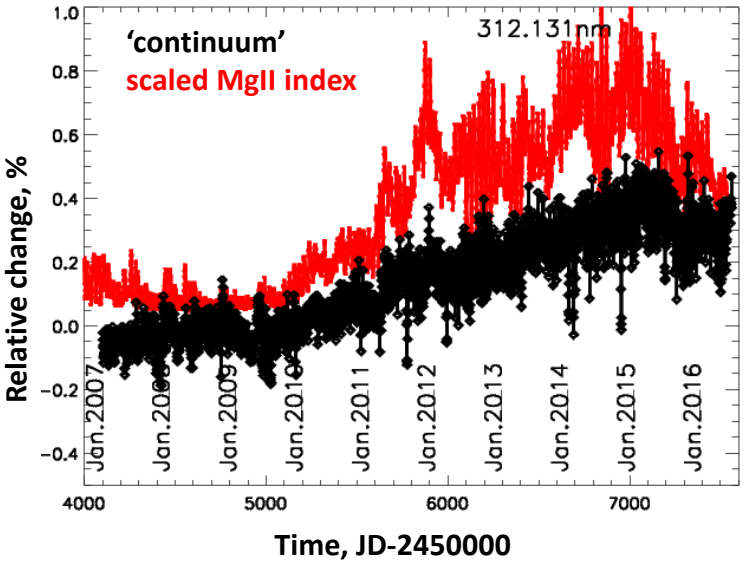
More details in: Marchenko & DeLand, 2014, ApJ,789, 117

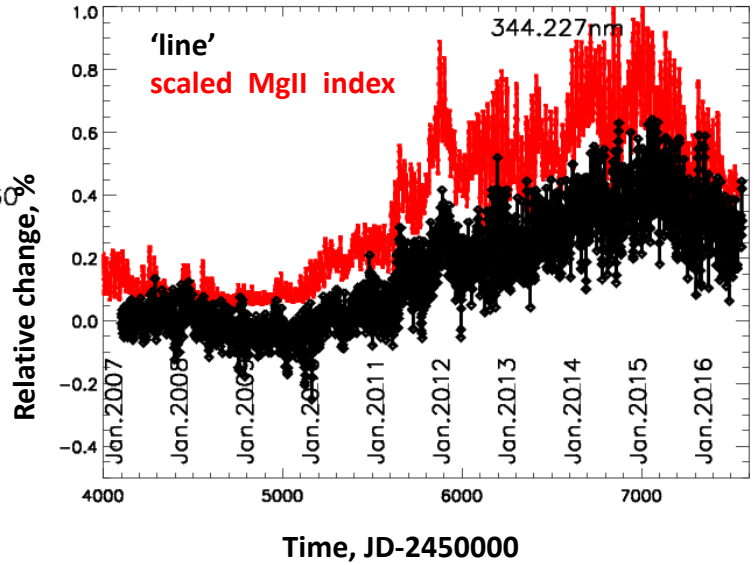
Normalized daily SSI changes from OMI data (relative to yy2007-2009 reference)



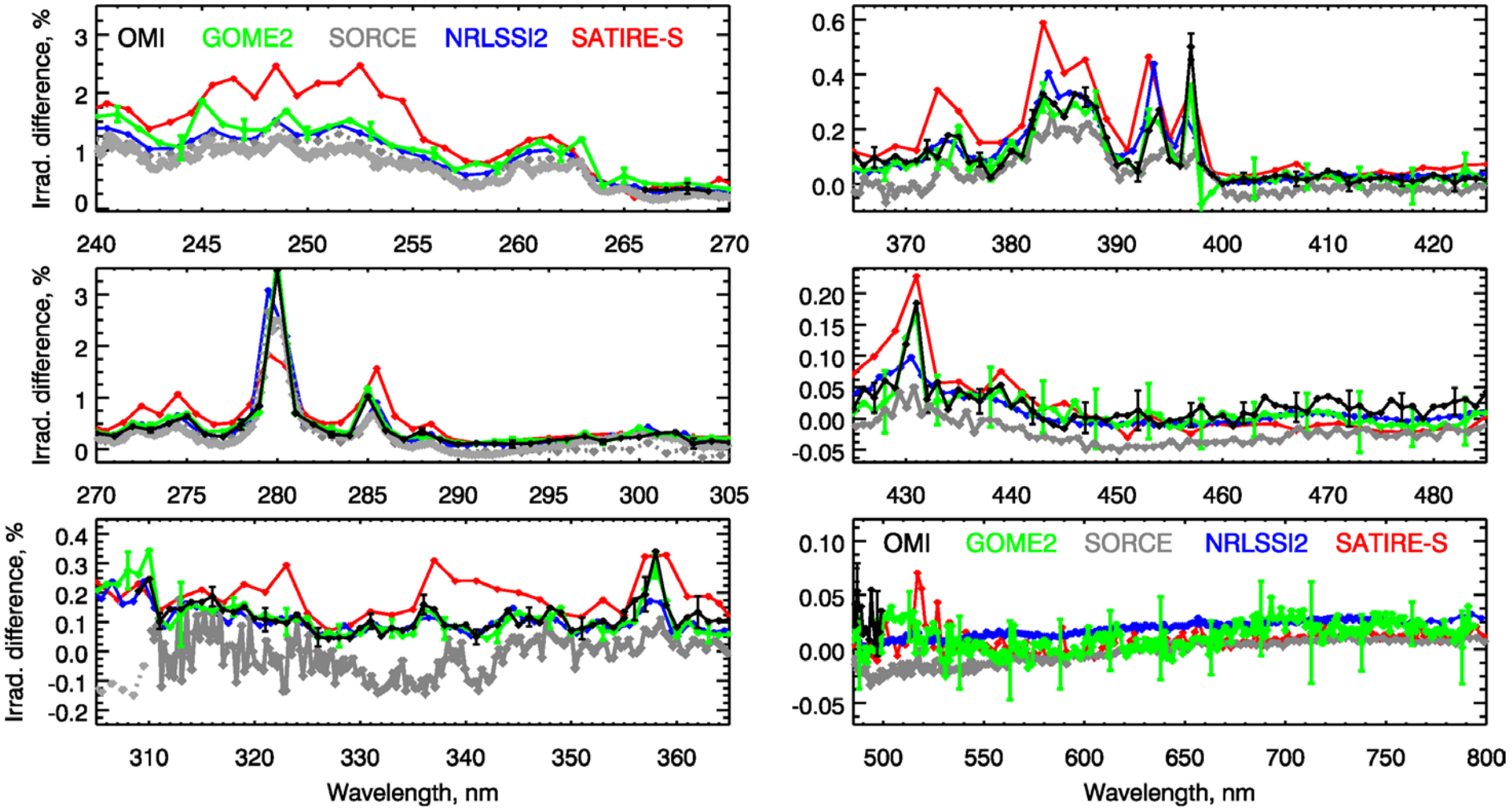
Normalized daily SSI changes (relative to yy2007-2009 reference)



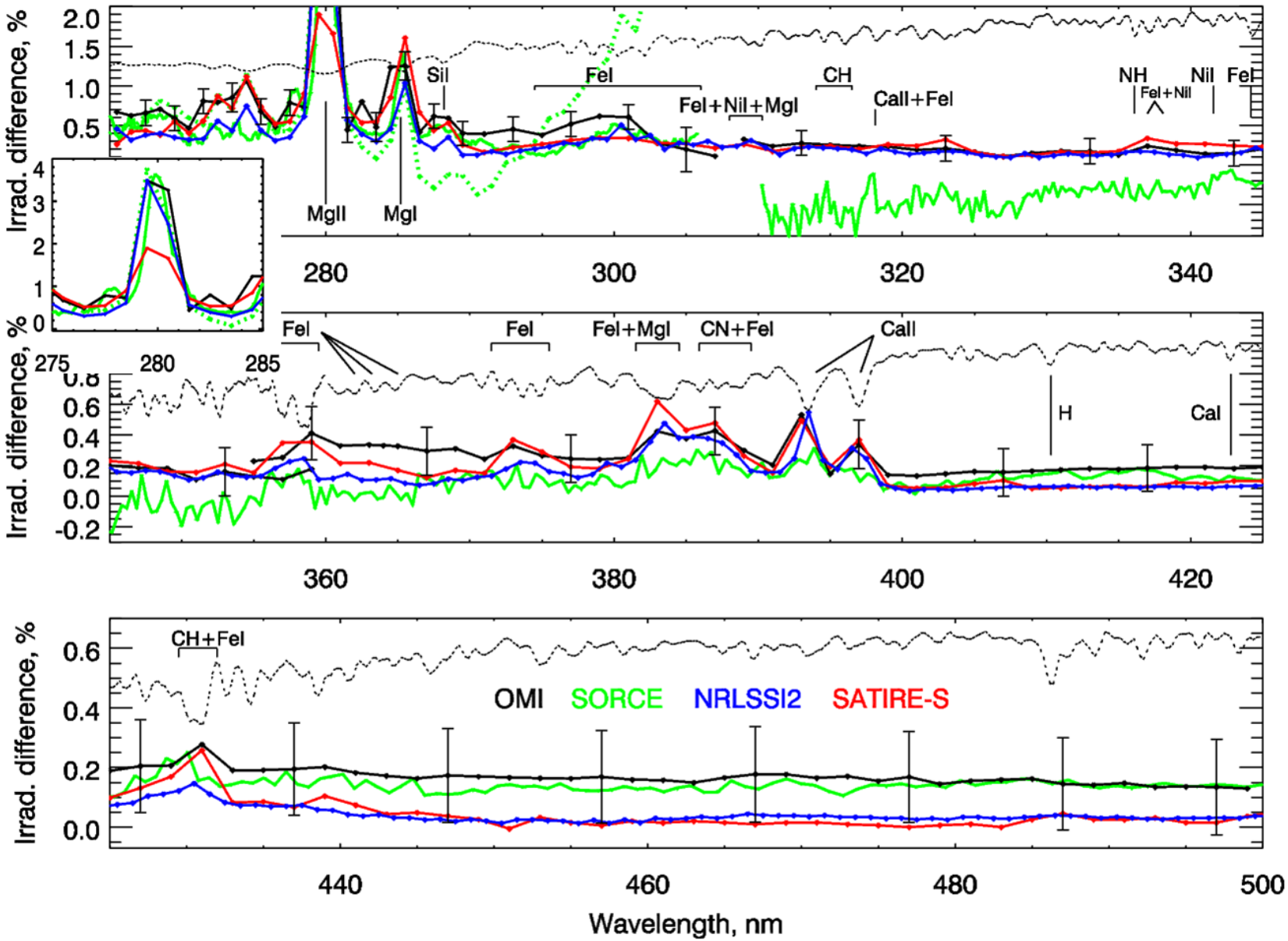




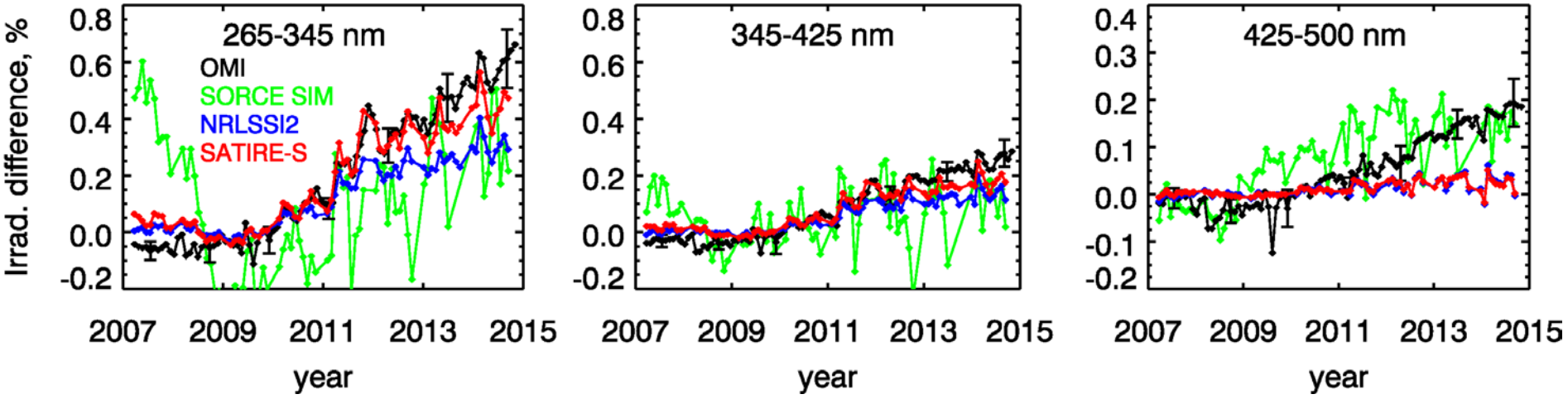
Normalized short-term (~weekly) SSI changes from yy2012-2013



Normalized long-term (yy2012-2014 vs. yy2007-2009) SSI changes



The normalized and binned OMI fluxes and the models



Short-term (~weeks) SSI variability:

OMI, SORCE, GOME-2 and NRLSSI2 [mostly] agree to ~1-2 σ (~0.1-0.2%); problems with strong spectral lines in SATIRE-S.

Long-term (~solar cycle) changes:

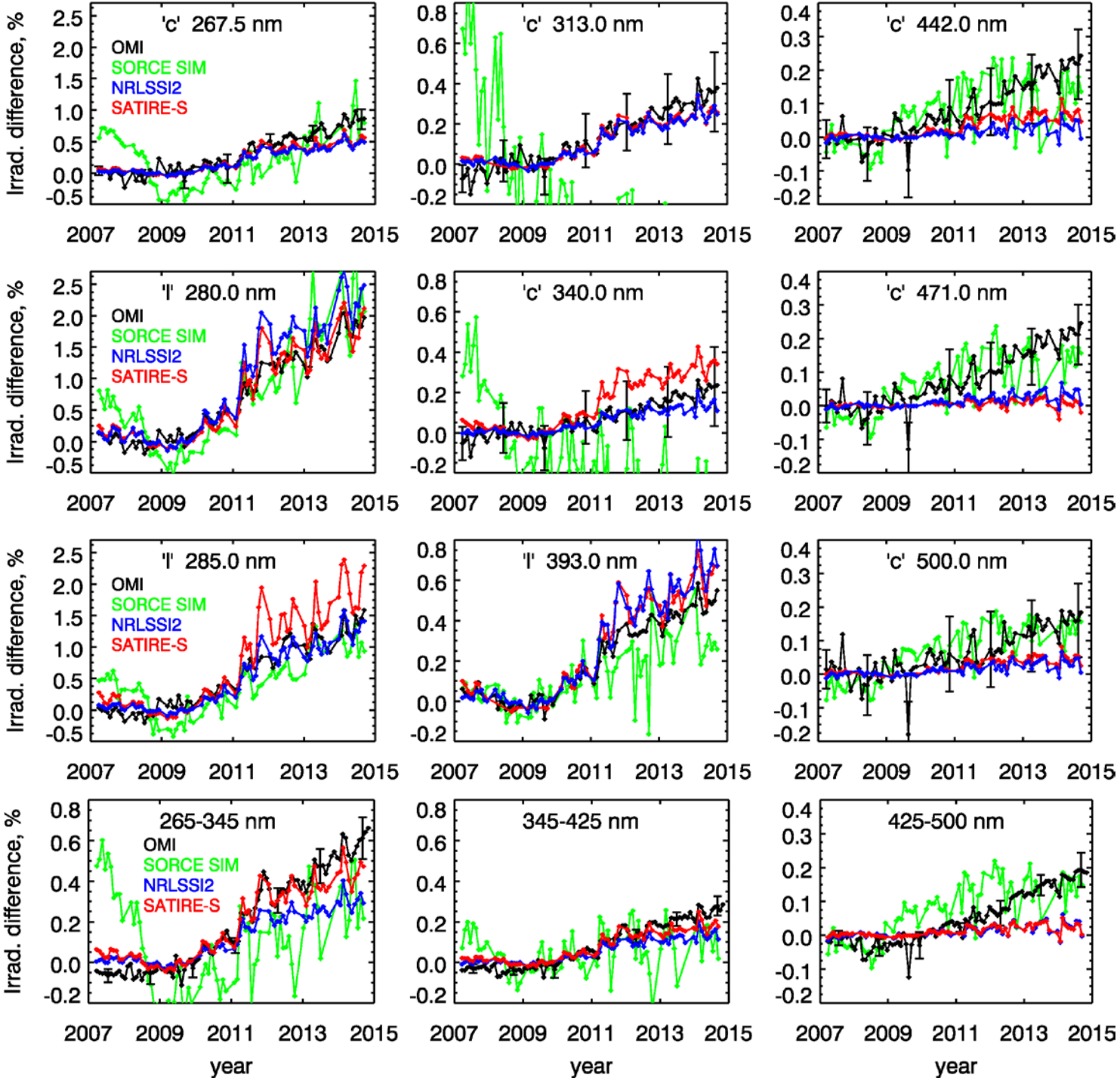
- OMI agrees with the model output at ~1-2 σ level (~0.2-0.4)%;

- SORCE data cannot be reconciled with model predictions in the 290-340 nm range.

If OMI lasts through the Cycle 24-25 minimum (at least 3 years on; ideally, ~5 years), then we may be able to improve long-term accuracy of the SSI measurements to ~0.05% - 0.10%, thus

- providing a unique long-term SSI record;
- enabling further model refinements in the UV-Vis region.

Backup



'c' = 'continuum'
'l' = spectral line/blend