



Observing the Sun with OMI: Spectral Irradiance Changes in the on-Going Cycle 24

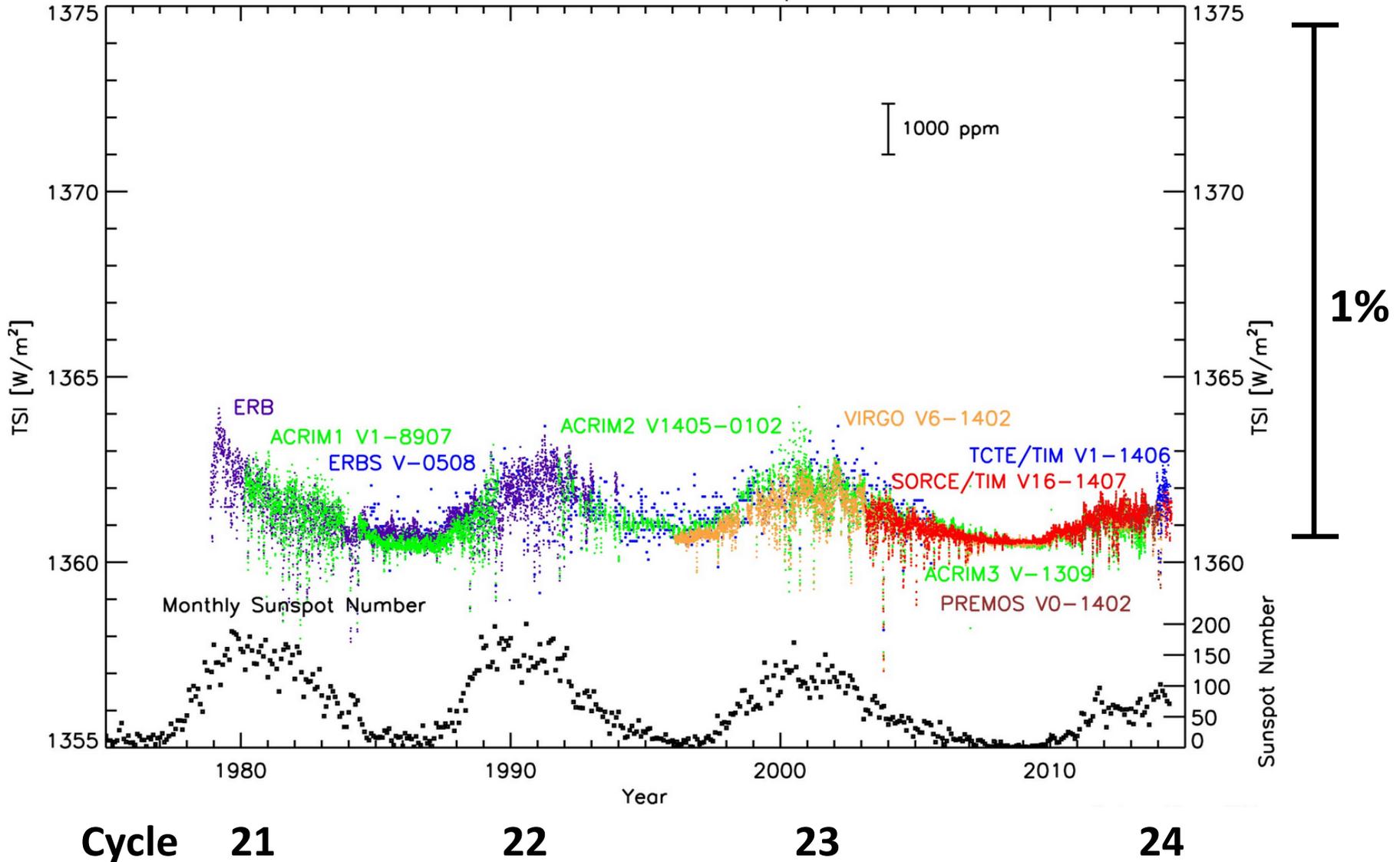
S.V. Marchenko, M.T. DeLand
SSAI & NASA/GSFC

Aura STM, 09/18/2014

The Sun and the solar (Sun-as-a-star) variability:

- Important factor in the climate studies (the atmospheric chemistry inclusive!);
- A universal standard in the remote-sensing studies of the Earth atmosphere;
- A unique astrophysical 'laboratory'.

Total Solar Irradiance Composite



The TSI update by G.Kopp: http://spot.colorado.edu/~koppg/TSI/TSI_Composite.jpg

The daily **solar spectral irradiance (SSI)** data from the Aura OMI help to solve two outstanding problems:

- The Cycle 23-24 SSI controversy brought by SIM & SOLSTICE of SORCE (see Ermolli et al., 2013, Atm.Chem.Phys., 13, 3945)

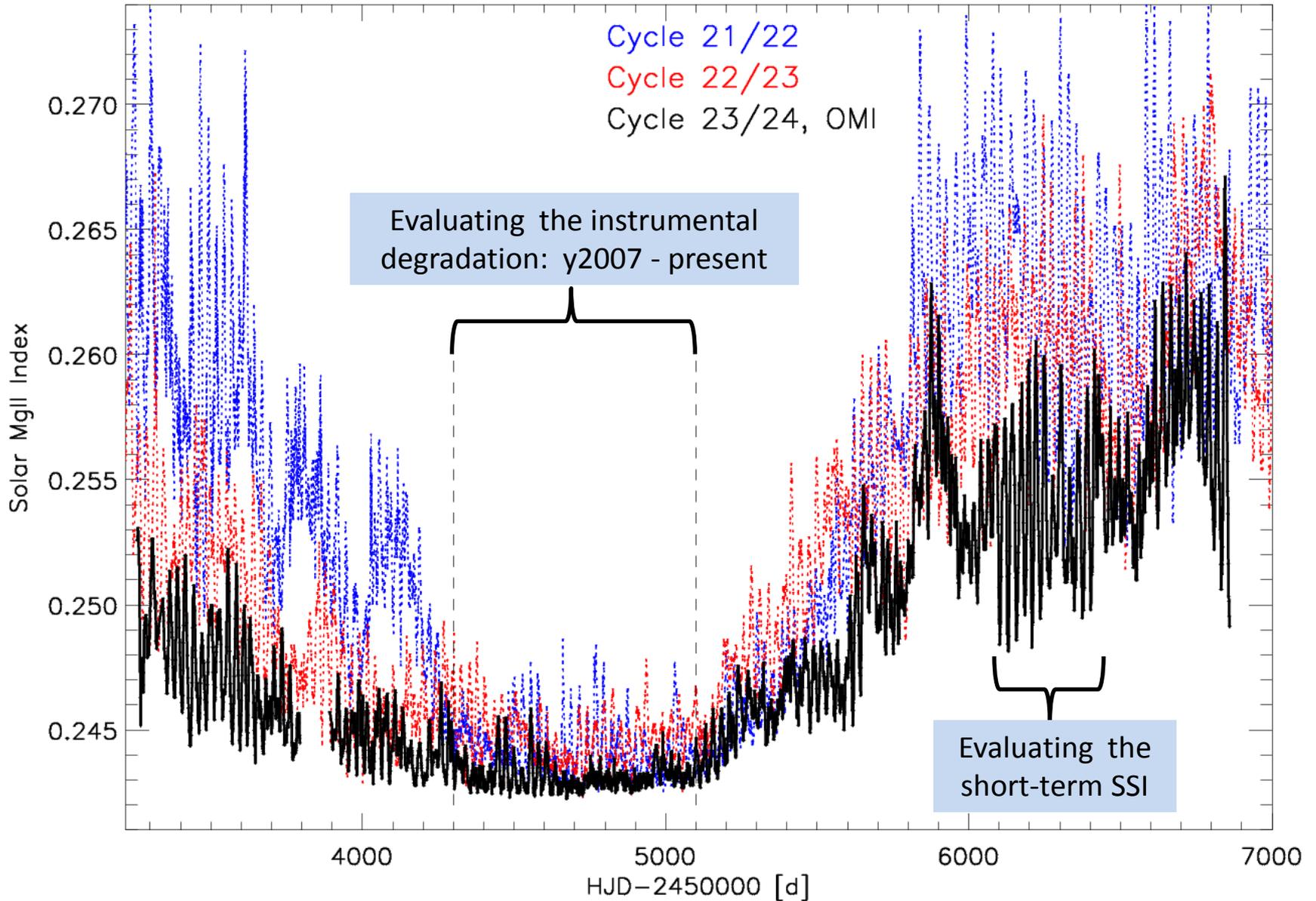
[should we revise the solar-cycle models?] ;

- The relationship between the short-term (solar rotation: weeks) and long-term (solar cycle: years) SSI changes.

*“In estimating long term changes, it is implicitly **assumed** that scale factors do not change significantly from the time scales varying from the 27 day solar rotation to the 11 year solar cycle”.*

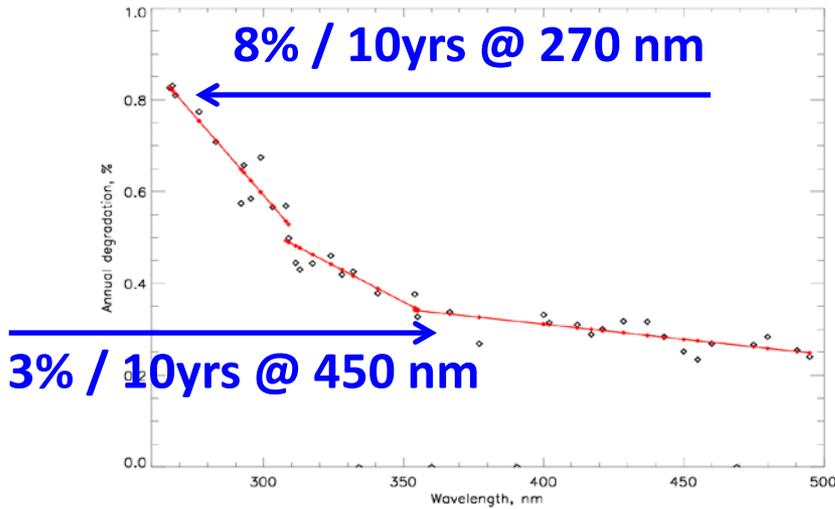
Chandra, S., et al. 1995, GRL, 22, 2481

Solar MgII Index



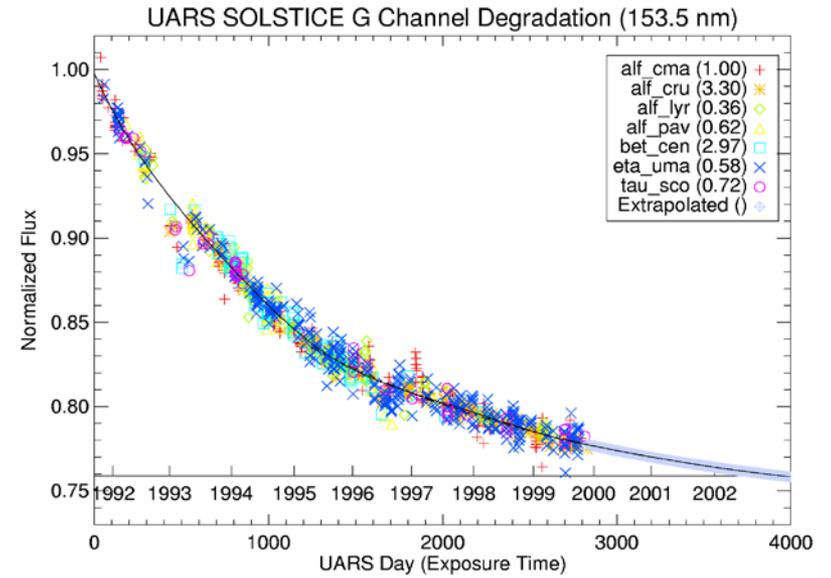
Cycle 21-23 data copied from : <http://www.iup.uni-bremen.de/gome/gomemgii.html> (M. Weber)
OMI Solar indices: DeLand & Marchenko, 2013, JGR-Atmospheres, 118, 3415

OMI: spectral degradation model

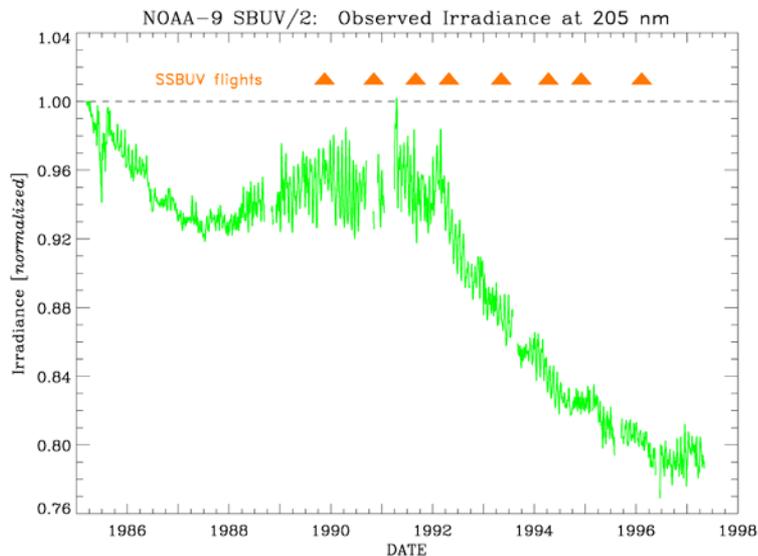


25%

SOLSTICE: Stellar Observations

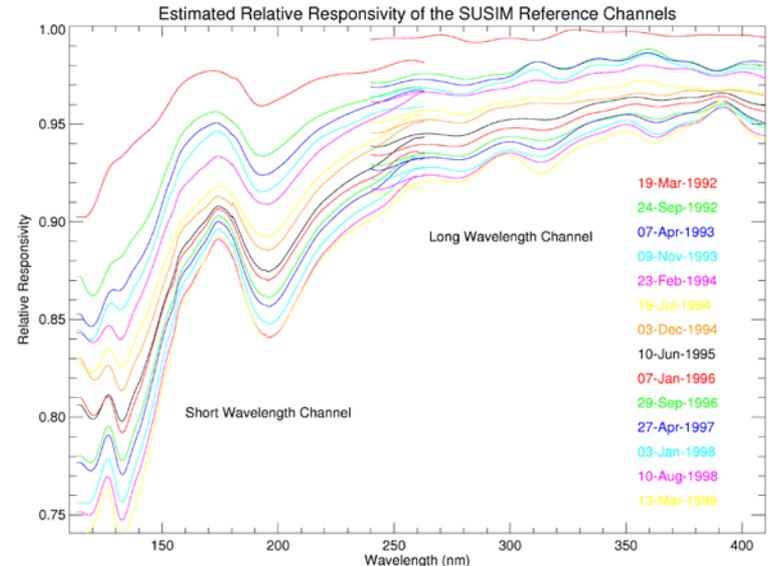


SBUV/2: Reference Flights



25%

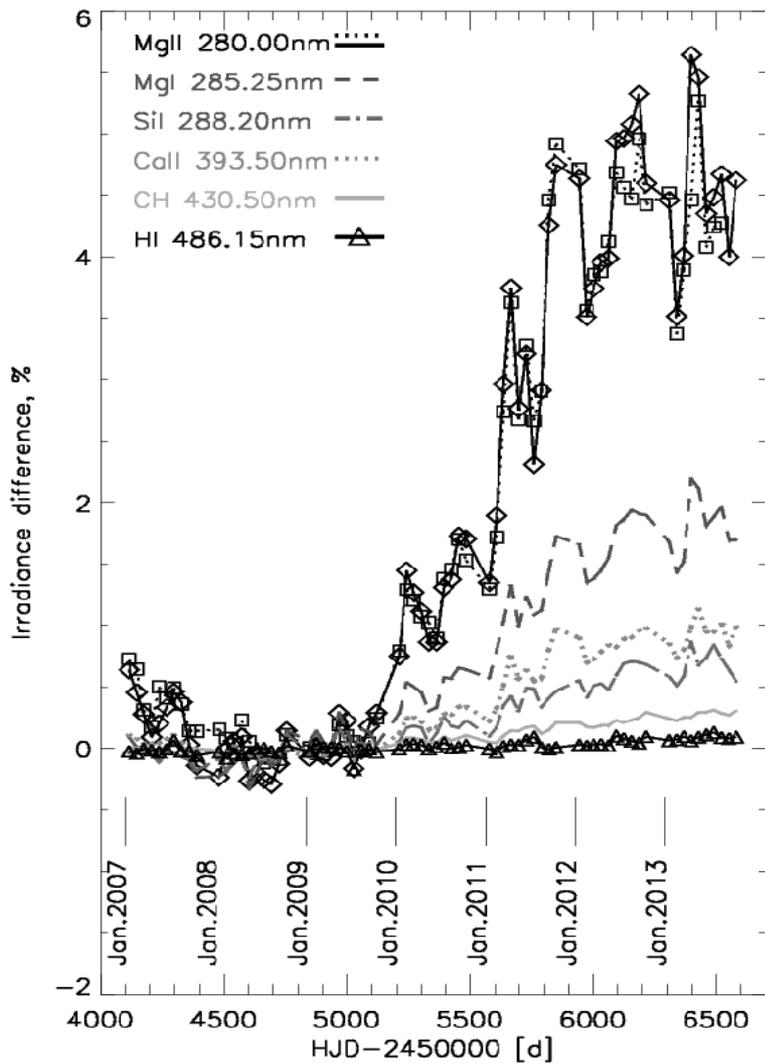
SUSIM: Onboard Calibration



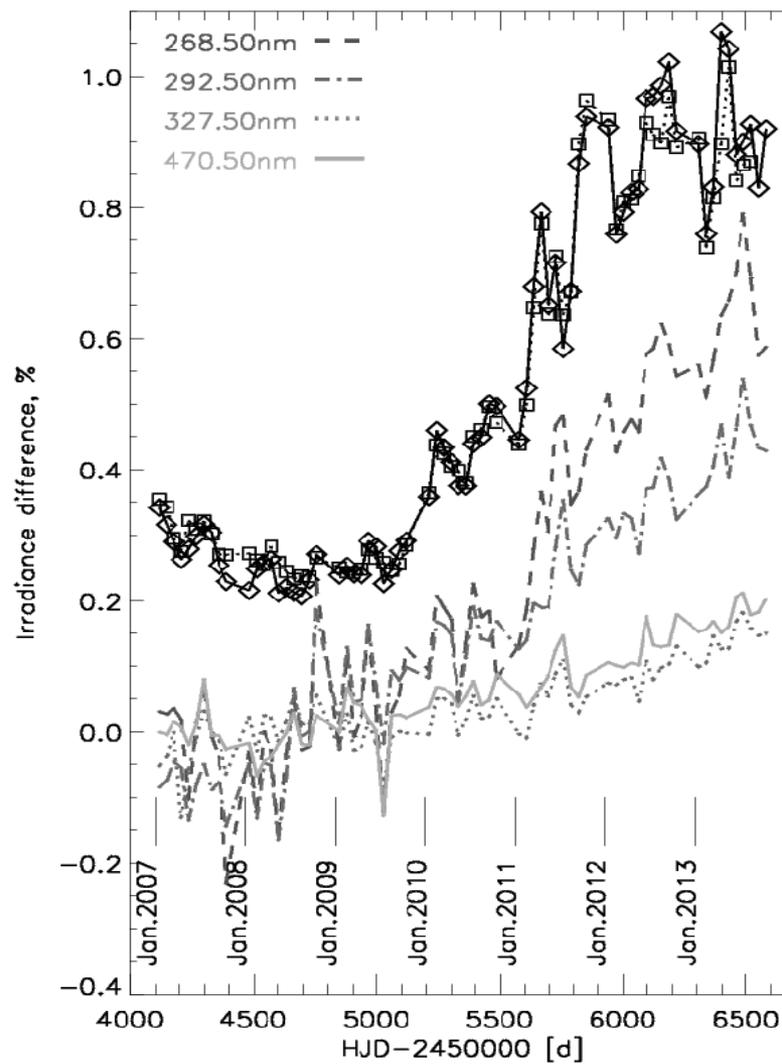
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Long-term (solar cycle) SSI

Prominent line blends

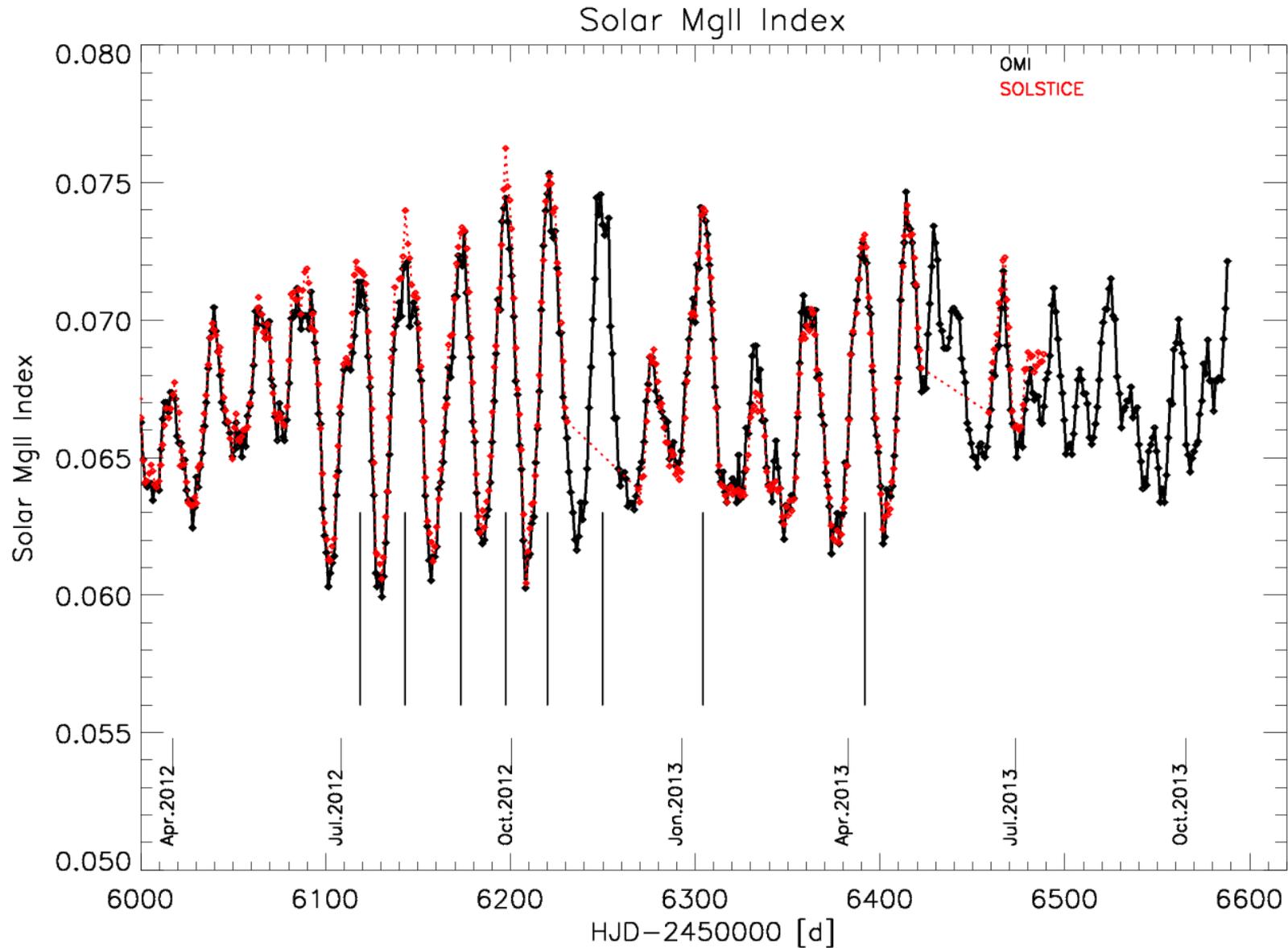


Solar 'continuum'

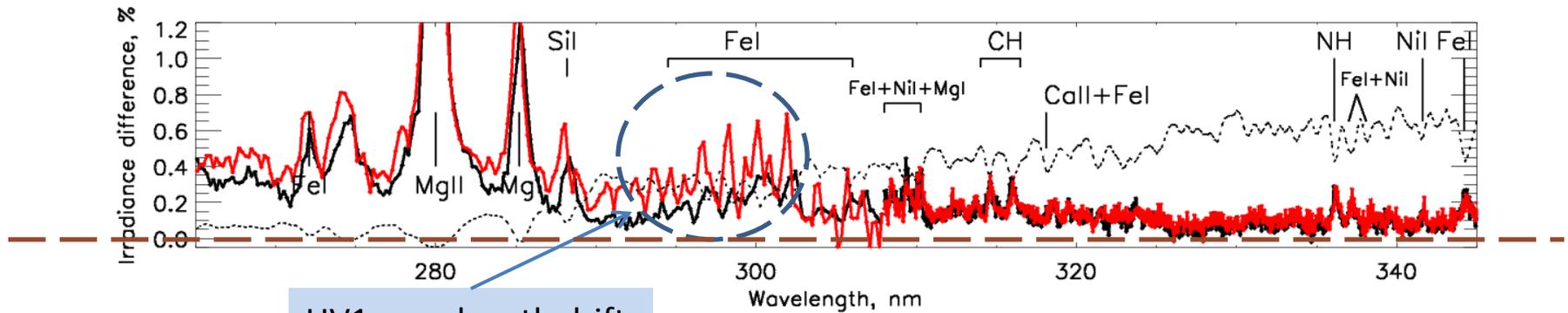


SSI changes in Cycle 24; diamonds - average flux in Mg II, squares - the Mg II indices. See more details in: **Marchenko & DeLand, 2014, ApJ, 789, 117**

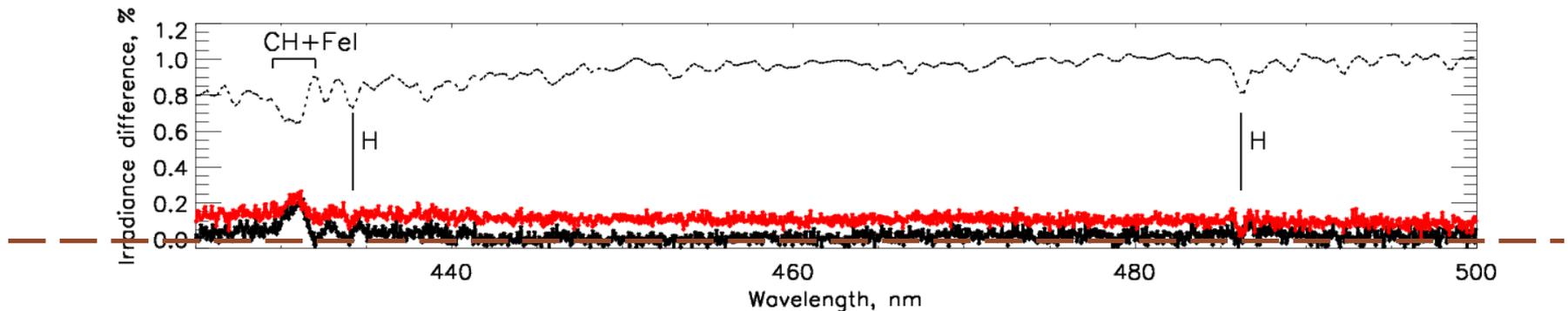
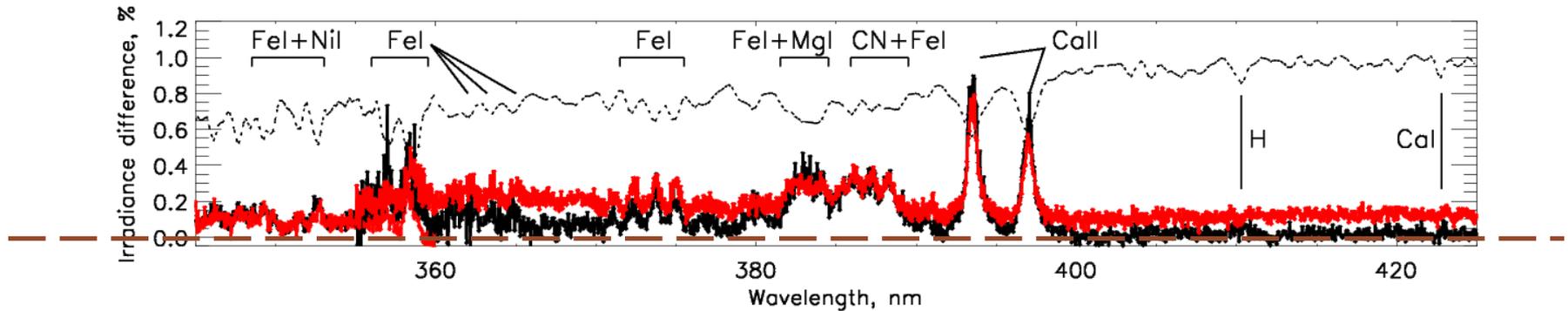
Short-term (27-day: solar rotation) variability



Short-term and long-term SSI

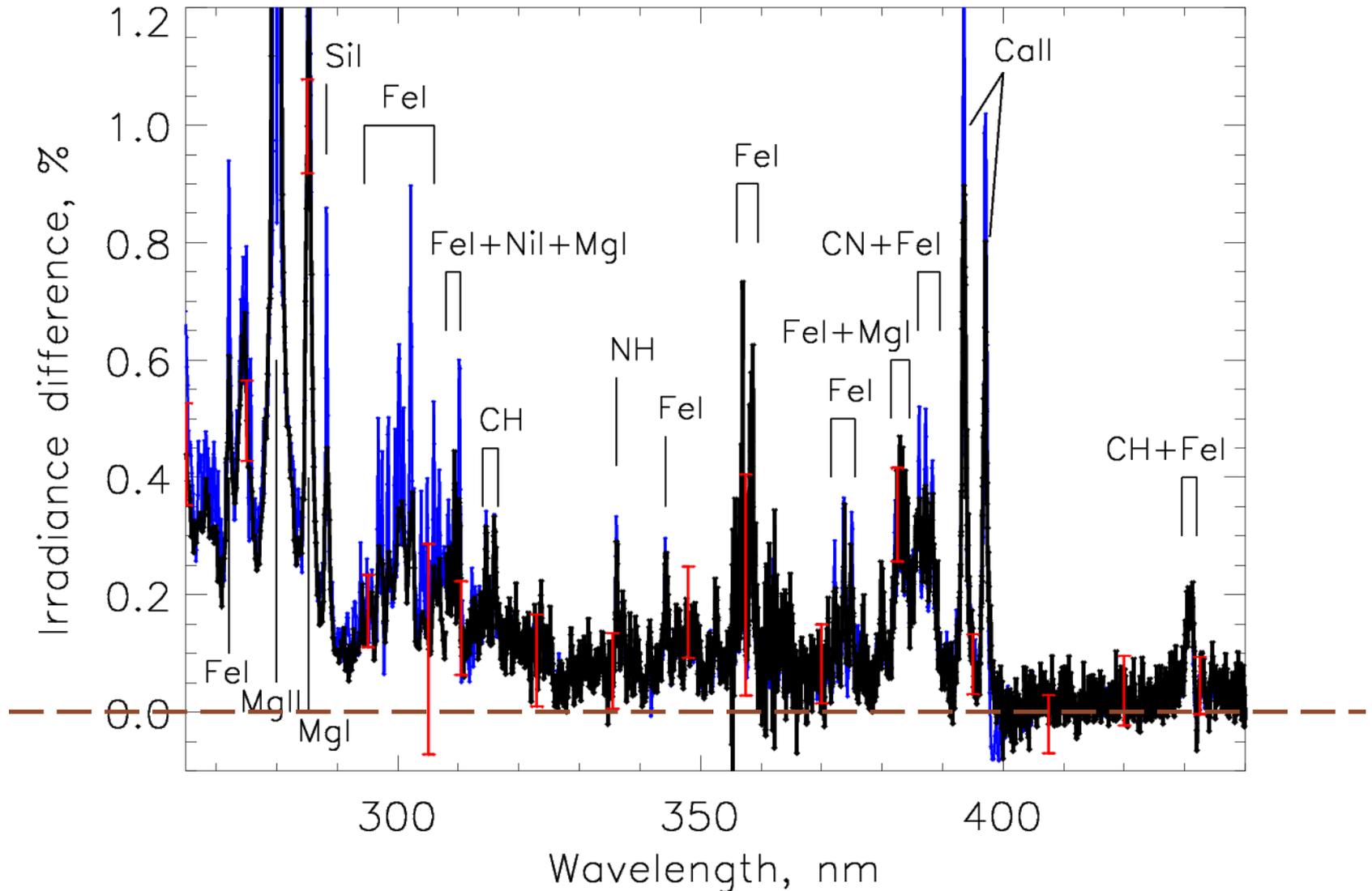


UV1 wavelength drift



Red line: the long-term (Solar cycle) SSI variability. Black line: the short-term (27-day) SSI changes. Dotted black line: a scaled solar spectrum

Short-term SSI from Cycle 24: OMI vs. GOME-2

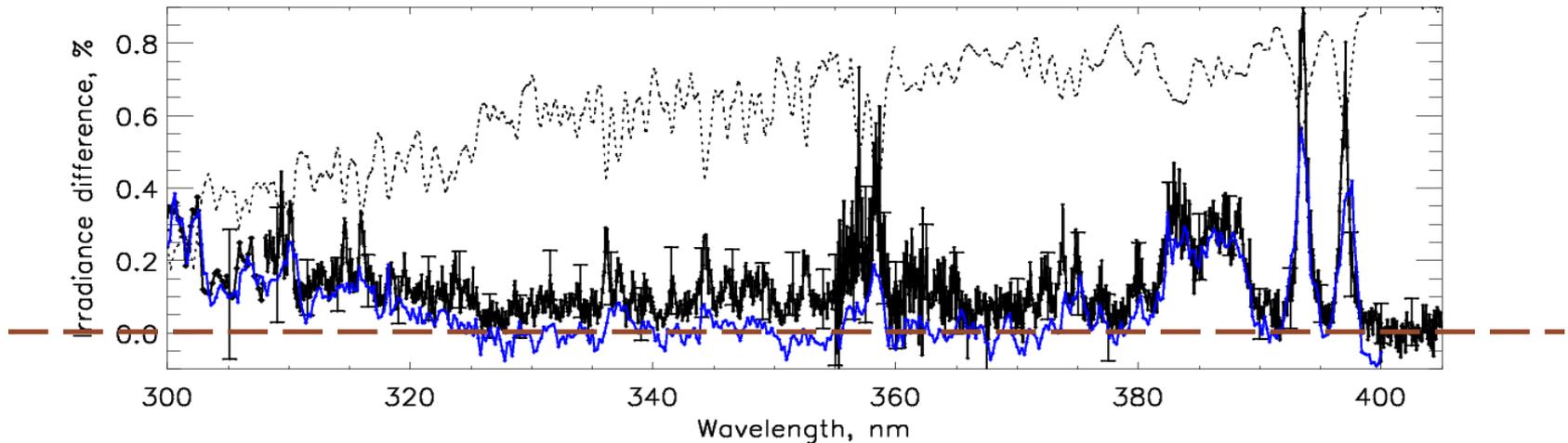
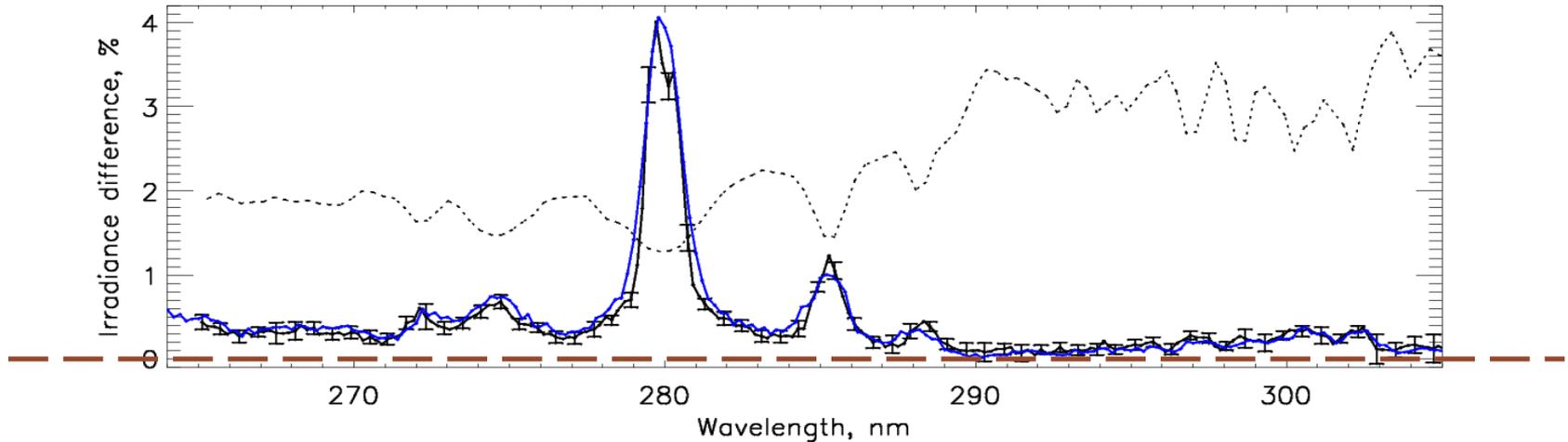


Black line: the 27-day SSI changes from OMI.
Red bars: representative 2-sigma uncertainties.

Blue line: the similar GOME-2 27-day SSI changes.

How 'typical' is Cycle 24?

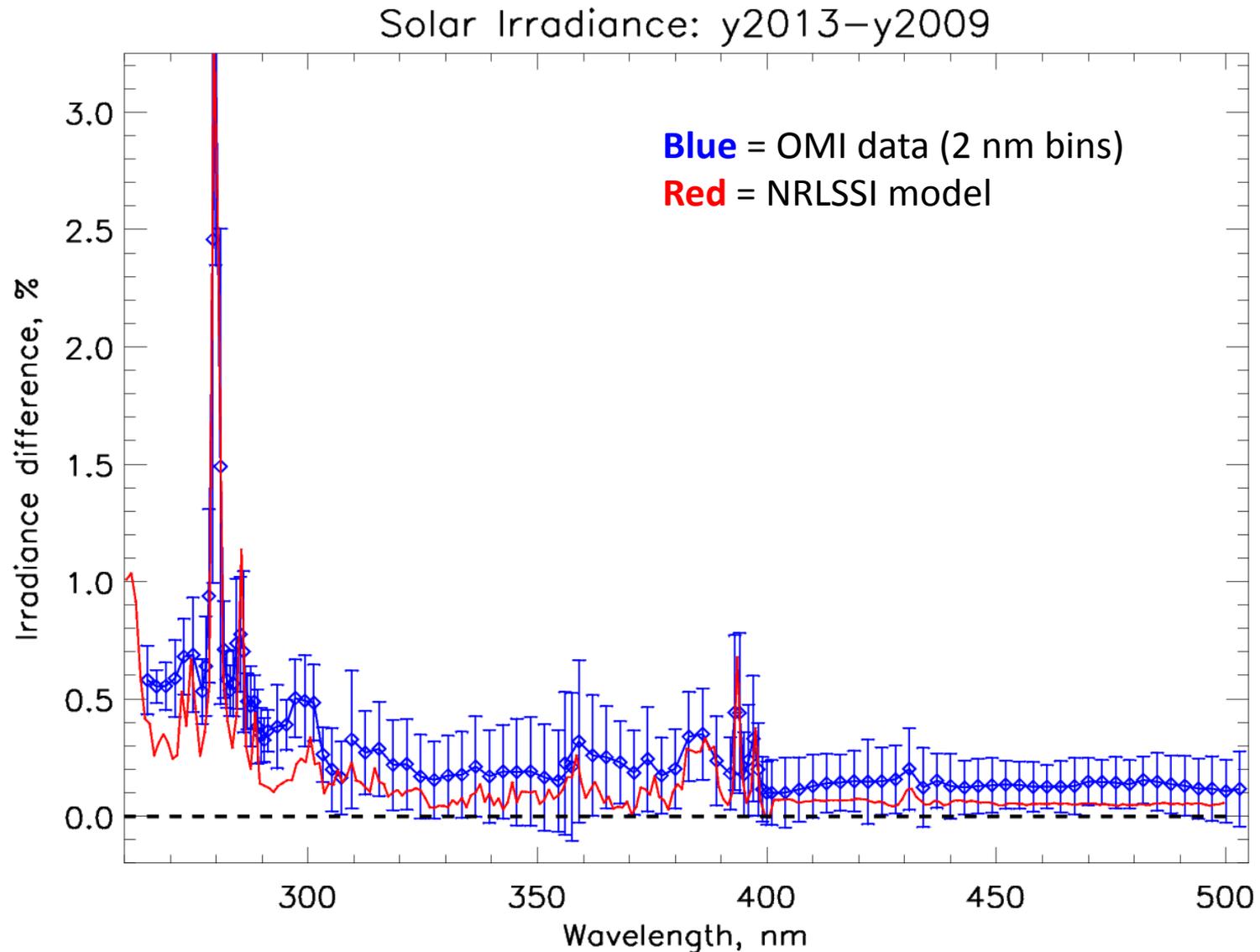
OMI short-term SSI (Cycle 24) vs. compilation from Cycle 21



Blue line: the properly adjusted scale factors from DeLand and Cebula (1993). Black line: the 27-day SSI changes from OMI, with representative 2-sigma uncertainties. Dotted line: scaled solar spectrum

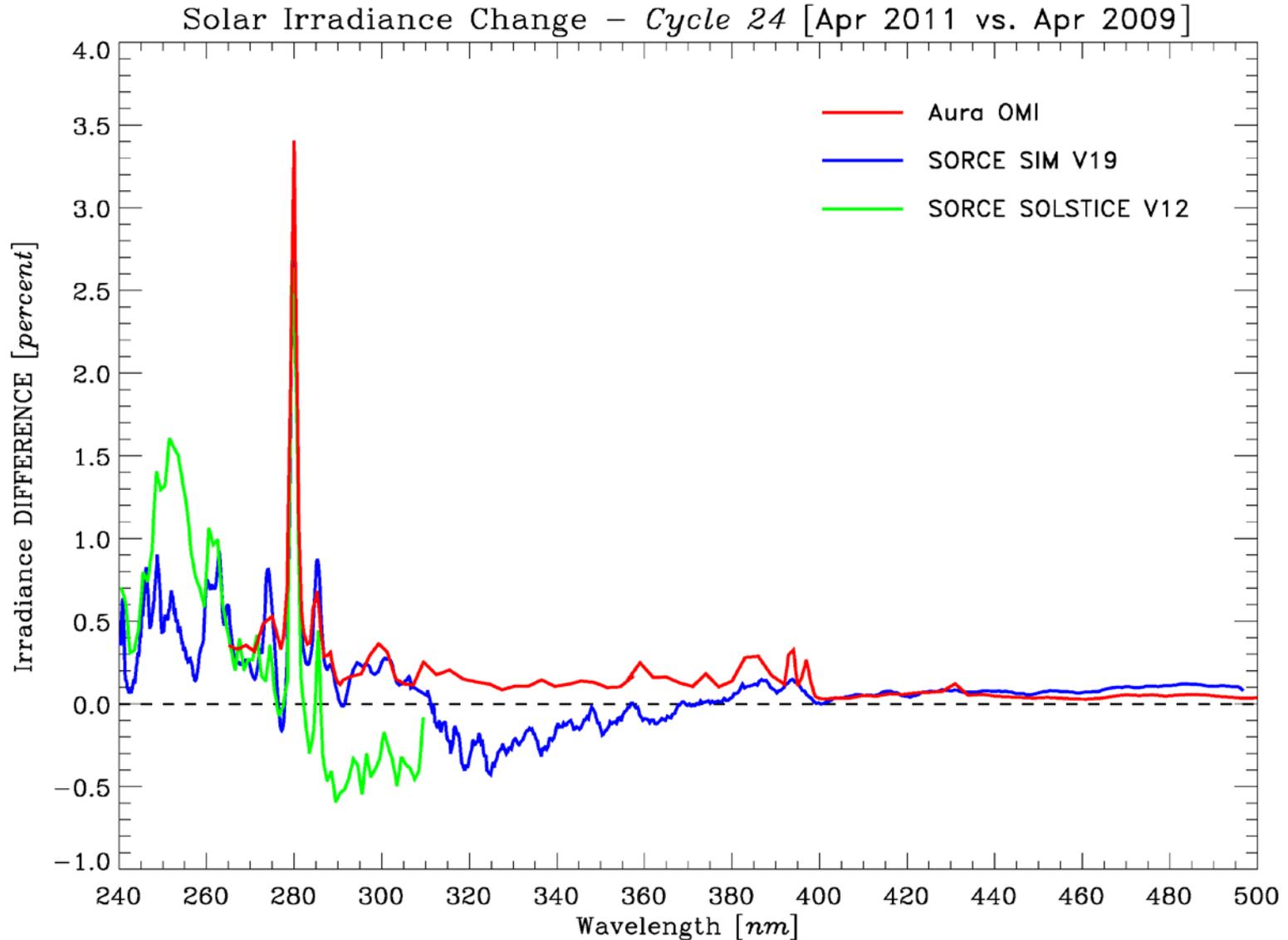
How 'typical' is Cycle 24?

OMI long-term SSI (Cycle 24) and NRLSSI model

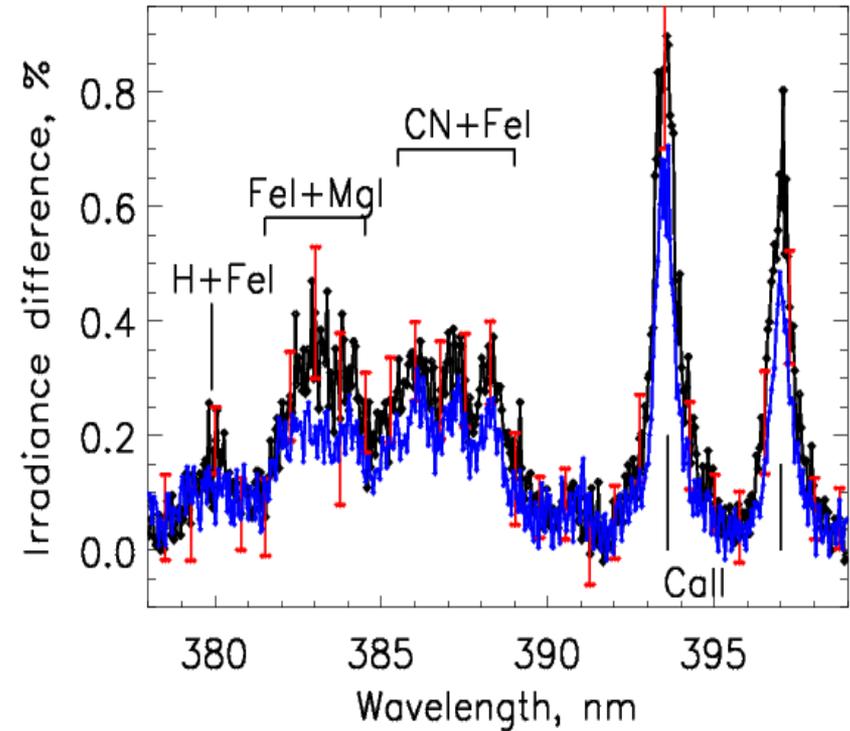
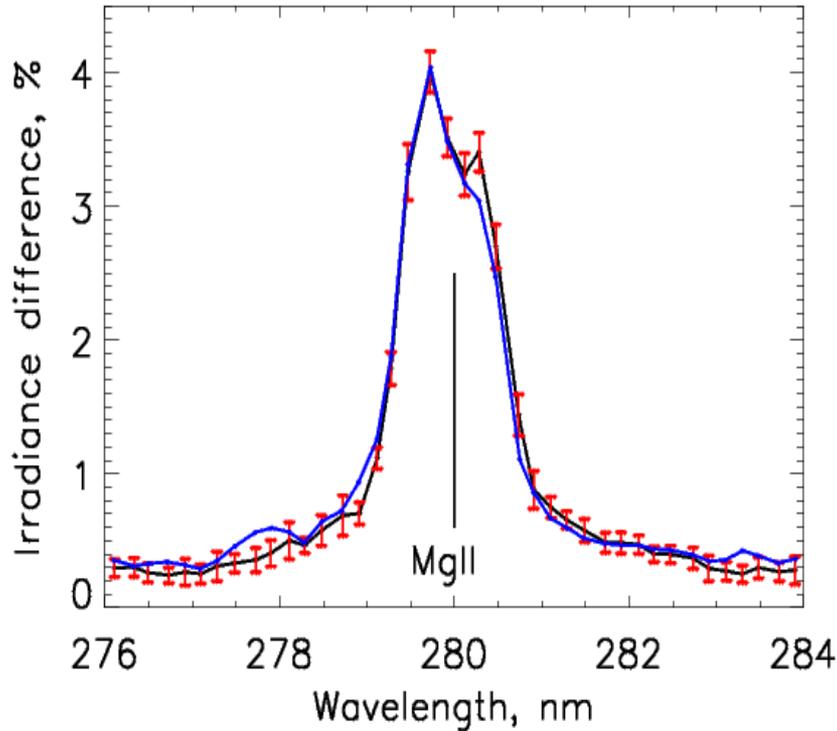


How 'typical' is Cycle 24?

OMI vs SORCE



The Sun as a 'reference': the short-term (27-day) and the long-term (solar cycle) SSI variations



Blue line: the long-term SSI variability.

Black line: the 27-day SSI changes, with 2-sigma uncertainties.

Solar variability in Cycle 24

- **Short-term (rotational) SSI variations:** excellent agreement of the OMI data with the historic (Cycle 21) and contemporaneous (GOME-2) observations.
- **Long-term (Solar cycle) changes:** the OMI data is consistent with NRLSSI model results. However, there is a clear disagreement with the long-term trends derived from SORCE SIM & SOLSTICE.

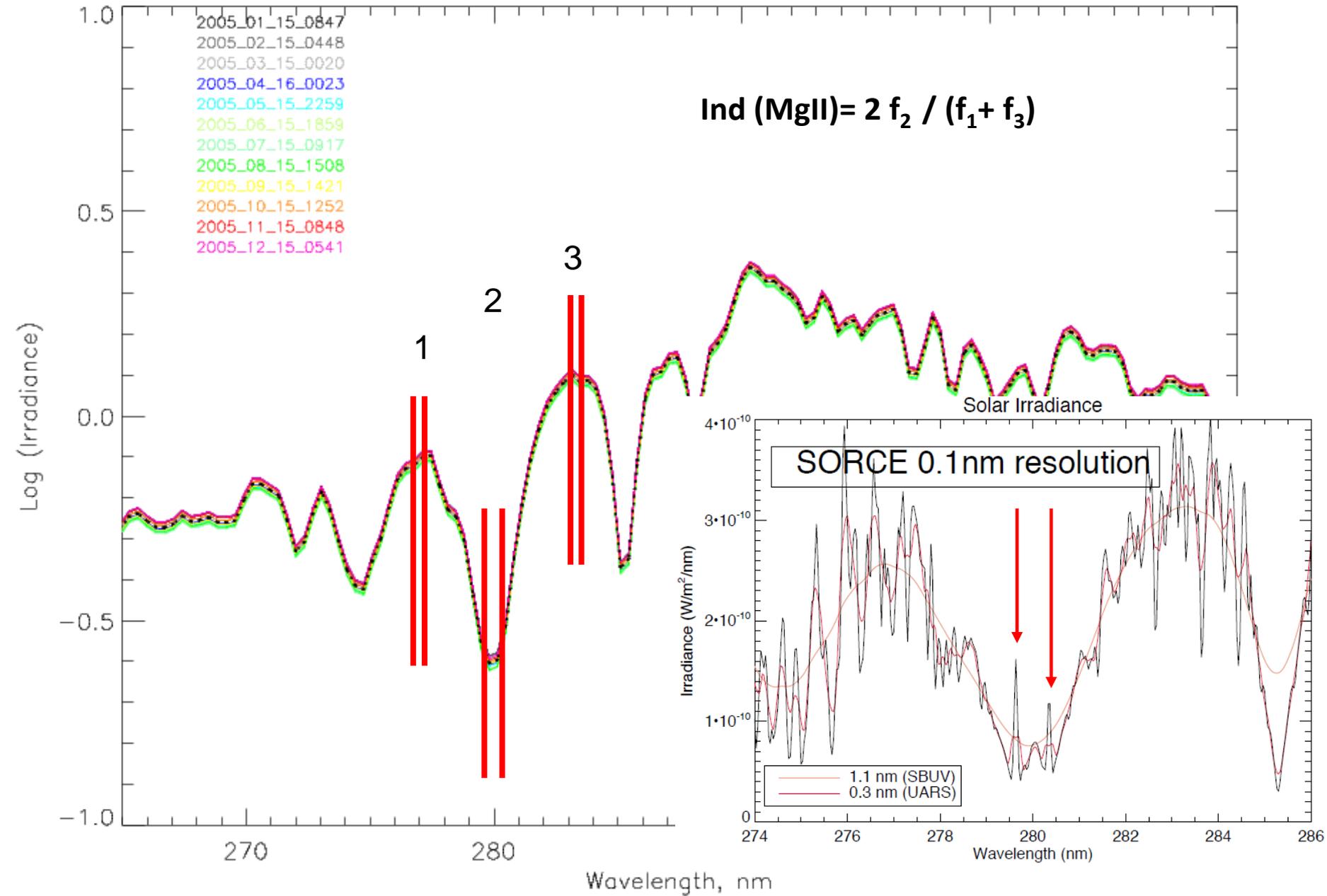
**We claim the congruency of the
UV-Vis SSI in Cycles 21-24**

- see also DeLand & Cebula 2008,2012

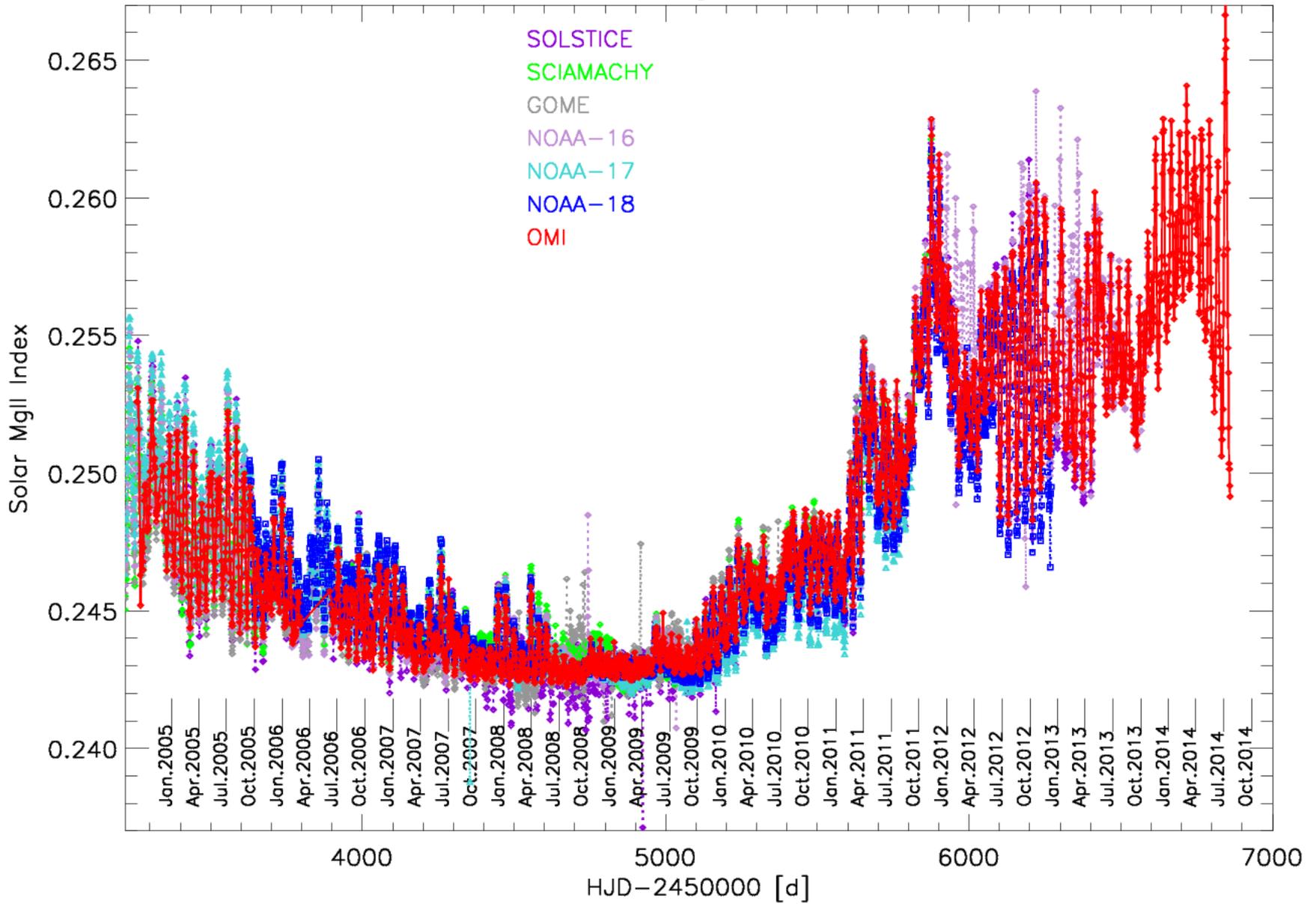
BACKUP



Solar irradiance



Solar MgII Index

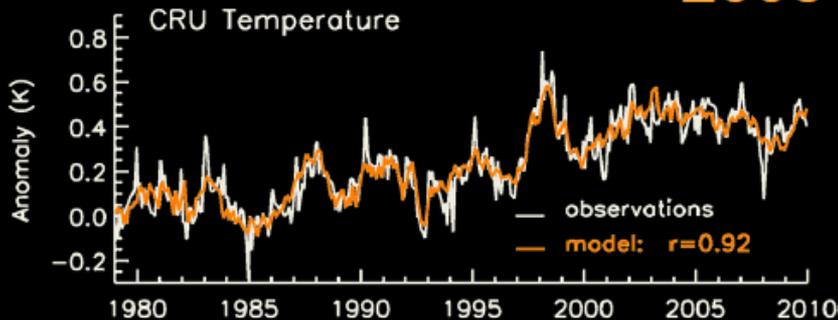


See more details in: **DeLand & Marchenko, 2013, JGR-Atmospheres, 118, 3415**

Contributions to Global Surface Temperature Response

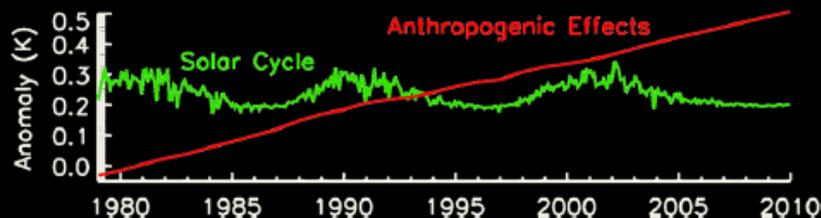
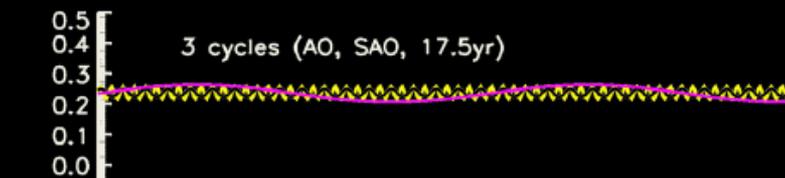
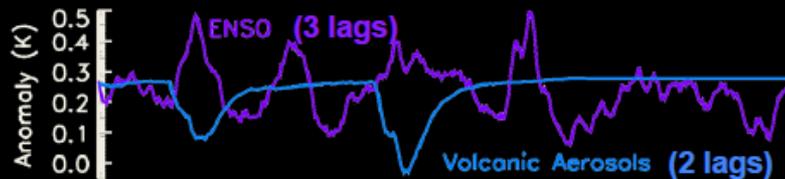
Global Surface Temperature Response to Natural and Anthropogenic Influences: 1980-2008

(Kopp and Lean, GRL, 2011)



... CRU temperature data, Univ. East Anglia, UK

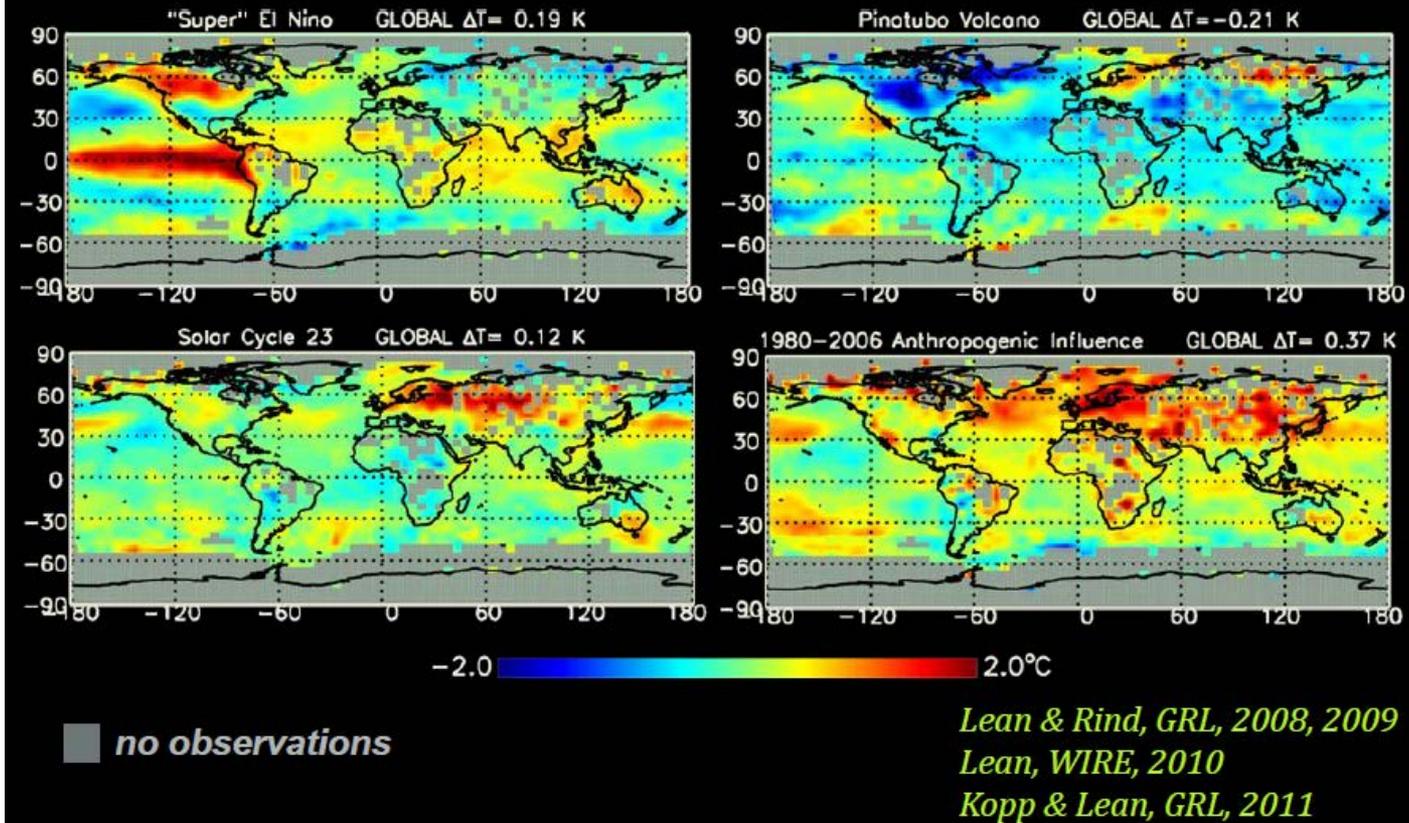
***NRL's General Linear Model:
ENSO + volcanic aerosols +
solar activity + anthropogenic
effects explain 85% of
observed temperature variance***



From J. Lean, 2011 *SORCE* Science Meeting

Regional Variation of Surface Temperature Response

Annual Surface Temperature Regional Response Patterns (5°×5° lat-long)

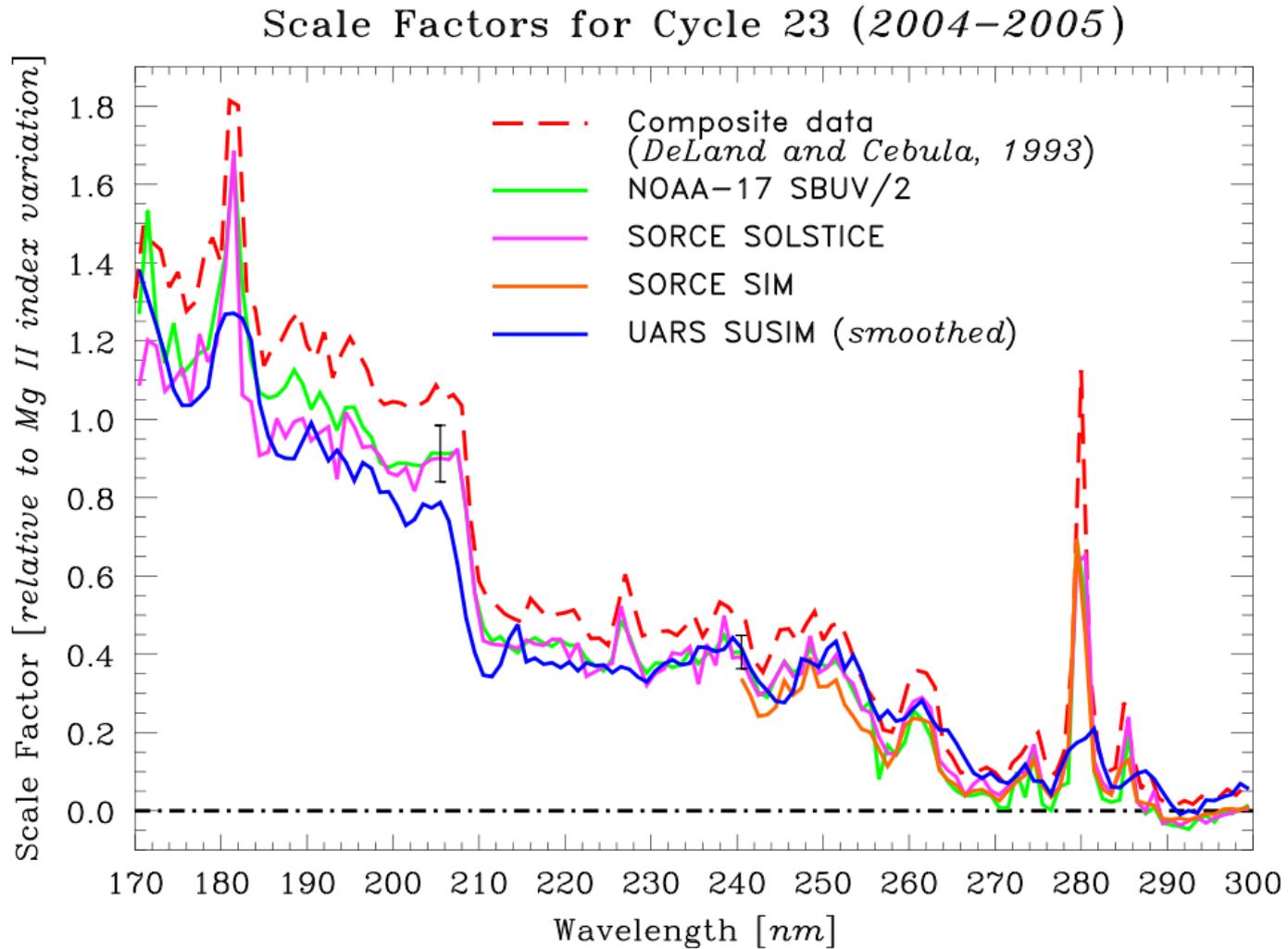


From J. Lean, 2011 SOFCE Science Meeting

“... if there is a solar effect on climate, it is manifested in terms of changes in the general circulation, rather than in a direct temperature signal.”

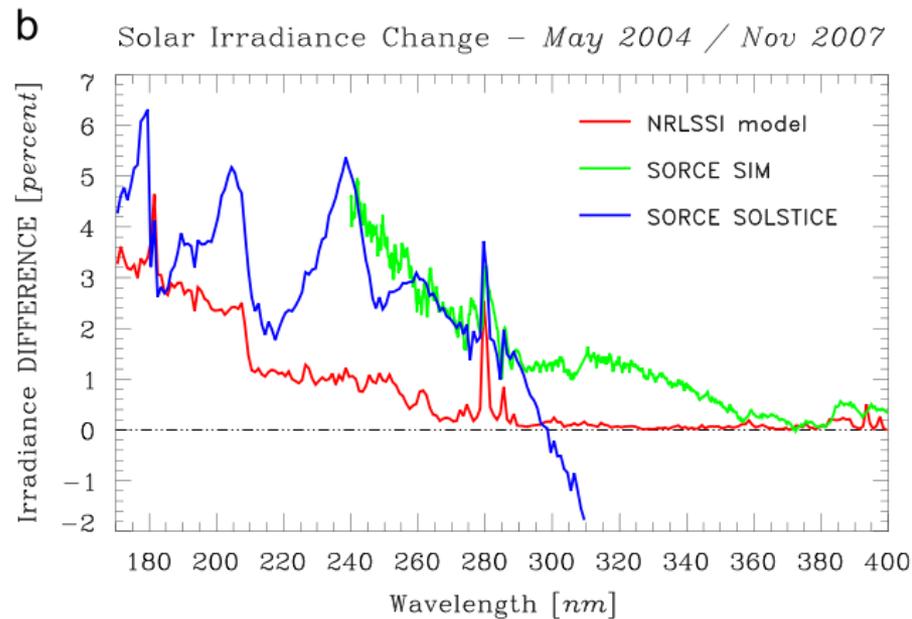
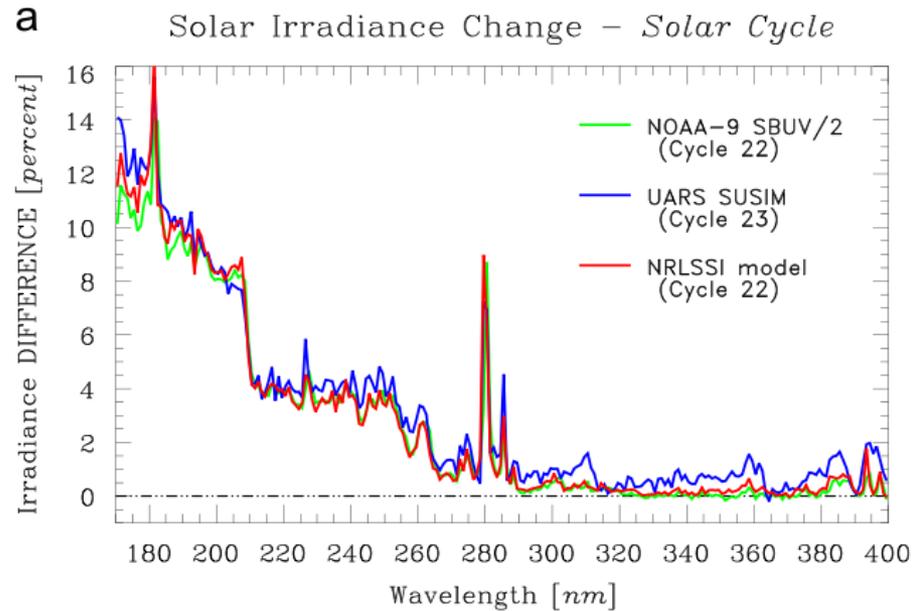
R.S. Bradley, in: The Effects of Solar Variability on Earth's Climate: A Workshop Report, THE NATIONAL ACADEMIES PRESS, Washington, D.C., 2012

Short-term SSI changes in Cycle 23

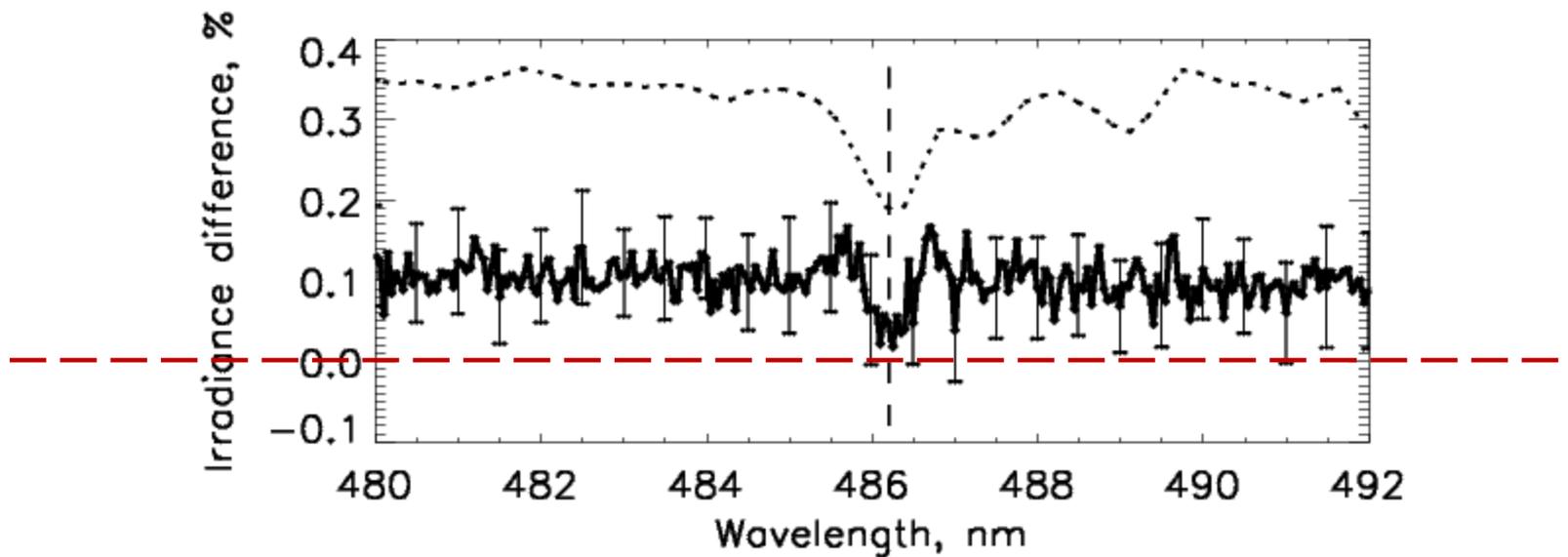
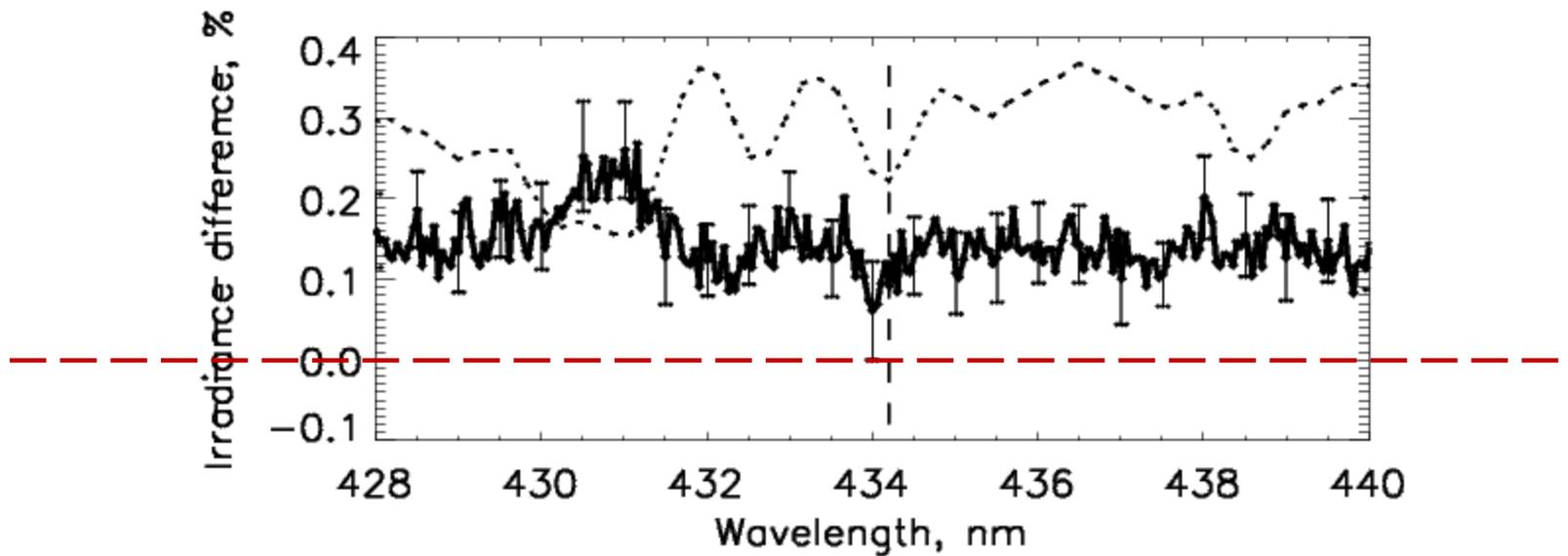


Copied from: DeLand and Cebula [2012]

Long-term SSI changes in Cycles 22, 23



Copied from:
DeLand and Cebula [2012]



Peculiar long-term (Solar cycle) changes in Hydrogen lines: Balmer H γ and H β