Solar Cycle 24 Variability Observed by Aura OMI

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# Solar Measurements from Ozone Instruments

- Determine stratospheric, total column ozone abundance by measuring backscattered UV radiation.

- Solar measurements used to determine top-of-atmosphere irradiance (for calculation of I/F), long-term calibration changes.

- Typically use same optical path as radiance measurements, with addition of solar diffuser.

- Limited measurements available (typically once per day at best). Balance science opportunity from solar data with instrument degradation effects on performance and lifetime.

- **No provision for on-orbit end-to-end characterization** (although light sources are often carried and used).

- Creation of calibrated irradiance data sets from SBUV and SBUV/2 instruments has required modified measurement sequence or external reference data to characterize throughput changes.

OMI Solar Measurements

- Launched on EOS Aura satellite 15 July 2004. Sun-synchronous orbit, 1:30 p.m. Equator-crossing time.

- Single monochromator covers 264-504 nm with three overlapping detectors (UV1, UV2, VIS). Spectral resolution = 0.4-0.6 nm for each detector.

- 2-D CCD collects multiple simultaneous spectra in spatial direction for every exposure (30 for UV1; 60 for UV2, VIS). 70+ exposures (2-second integration time) available in single measurement sequence.

- Solar measurements are made through special viewing port, using reflecting diffusers with different duty cycles (quartz volume = daily; aluminum = weekly, monthly).

- Standard observations are well-suited for creating solar activity indexes (DeLand and Marchenko, *JGR-Atmo.* [2013]).
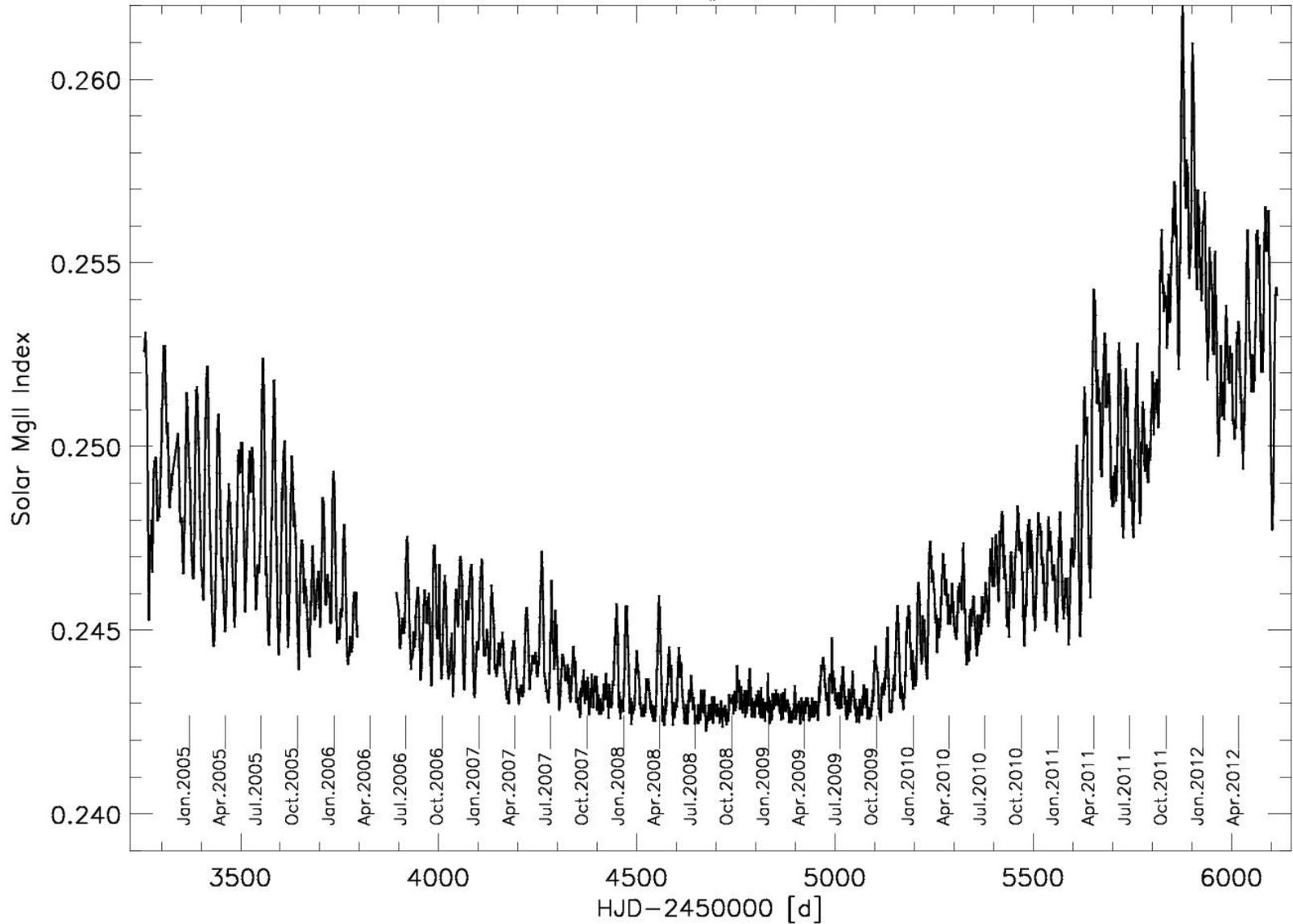
Sample OMI Spectrum

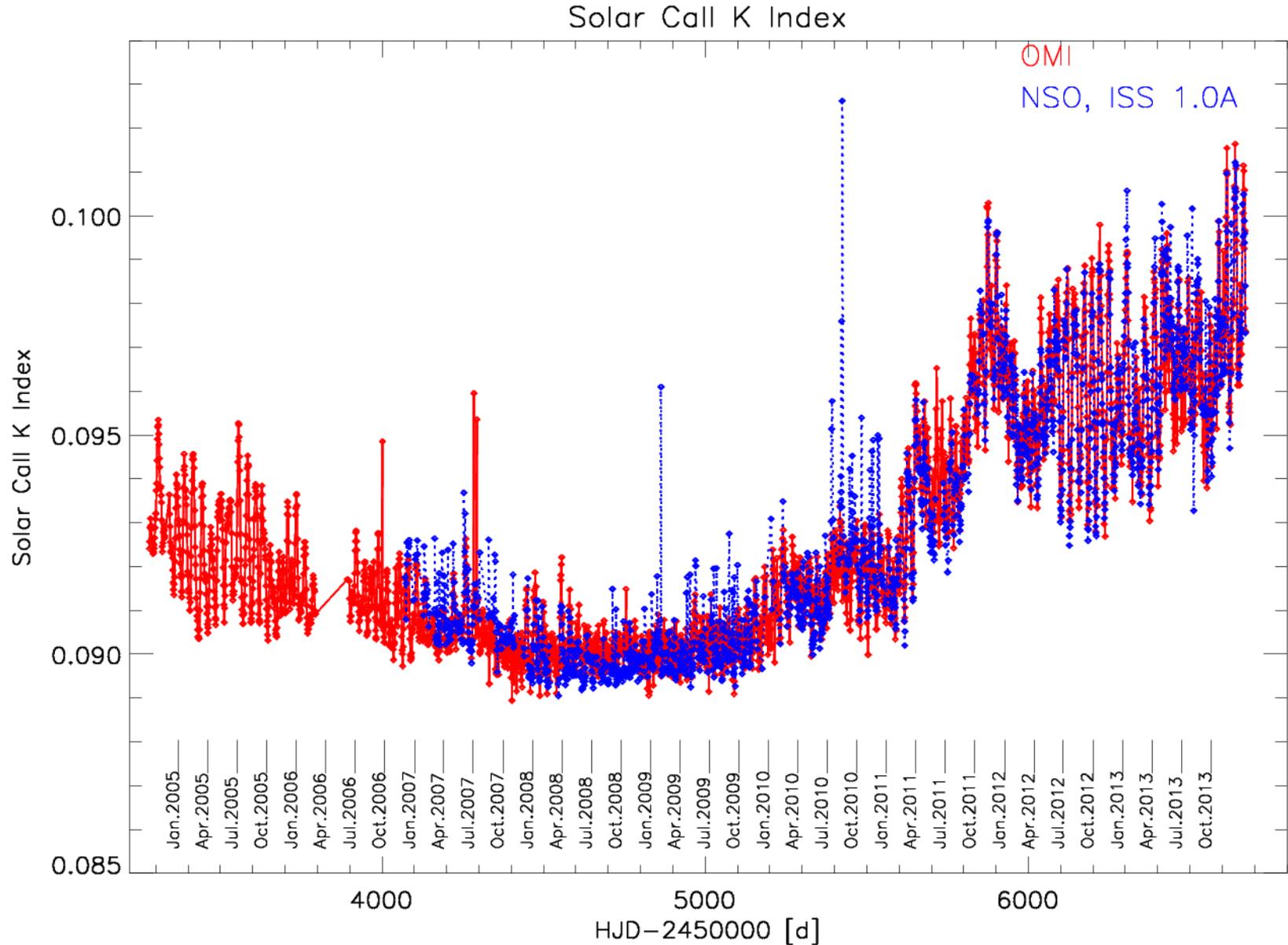OMI Solar Irradiance Spectrum for 31 December 2004
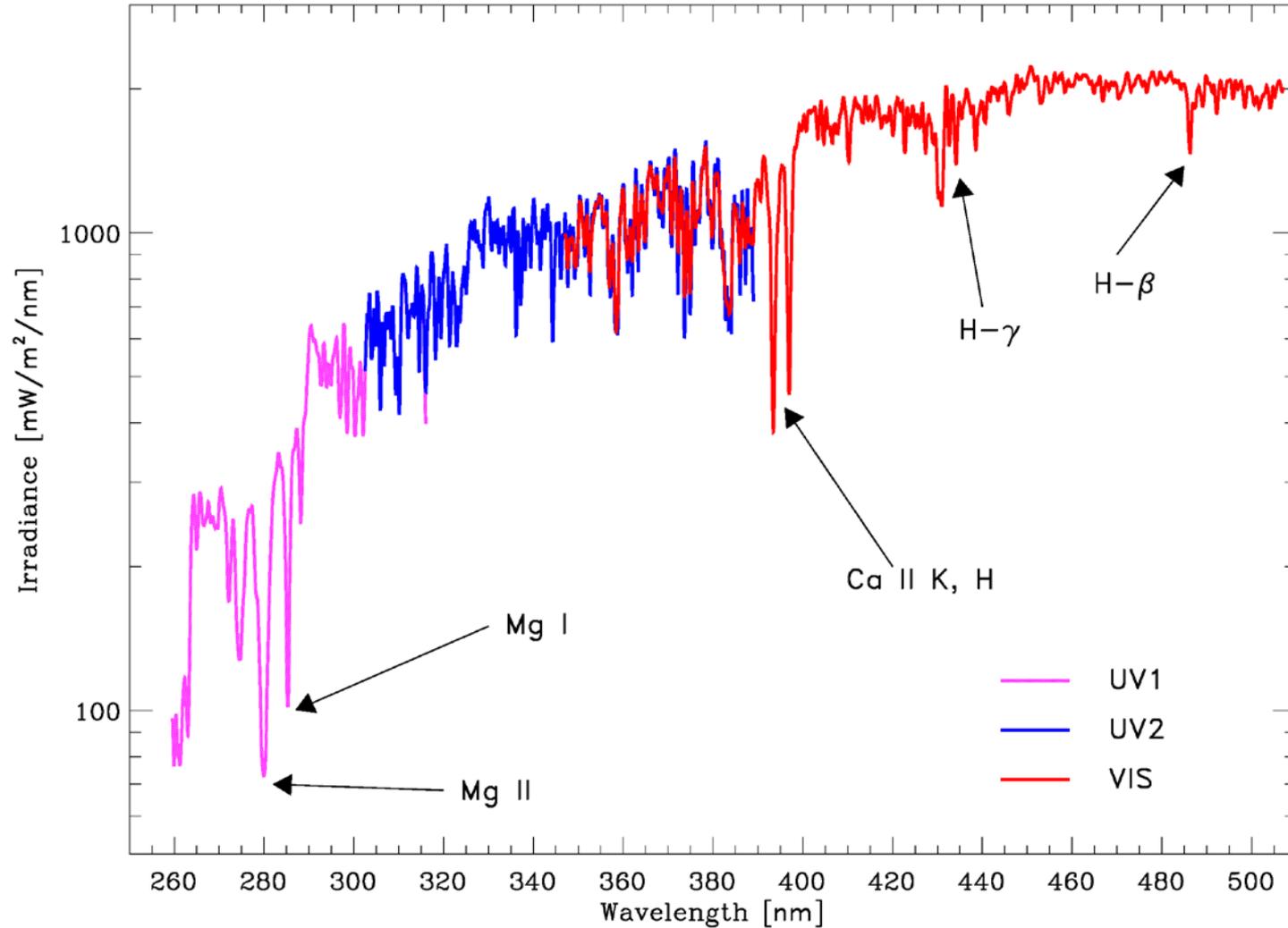
DeLand and Marchenko [2013, *JGR-Atmospheres*]

OMI Mg II Index

Solar MgII Index

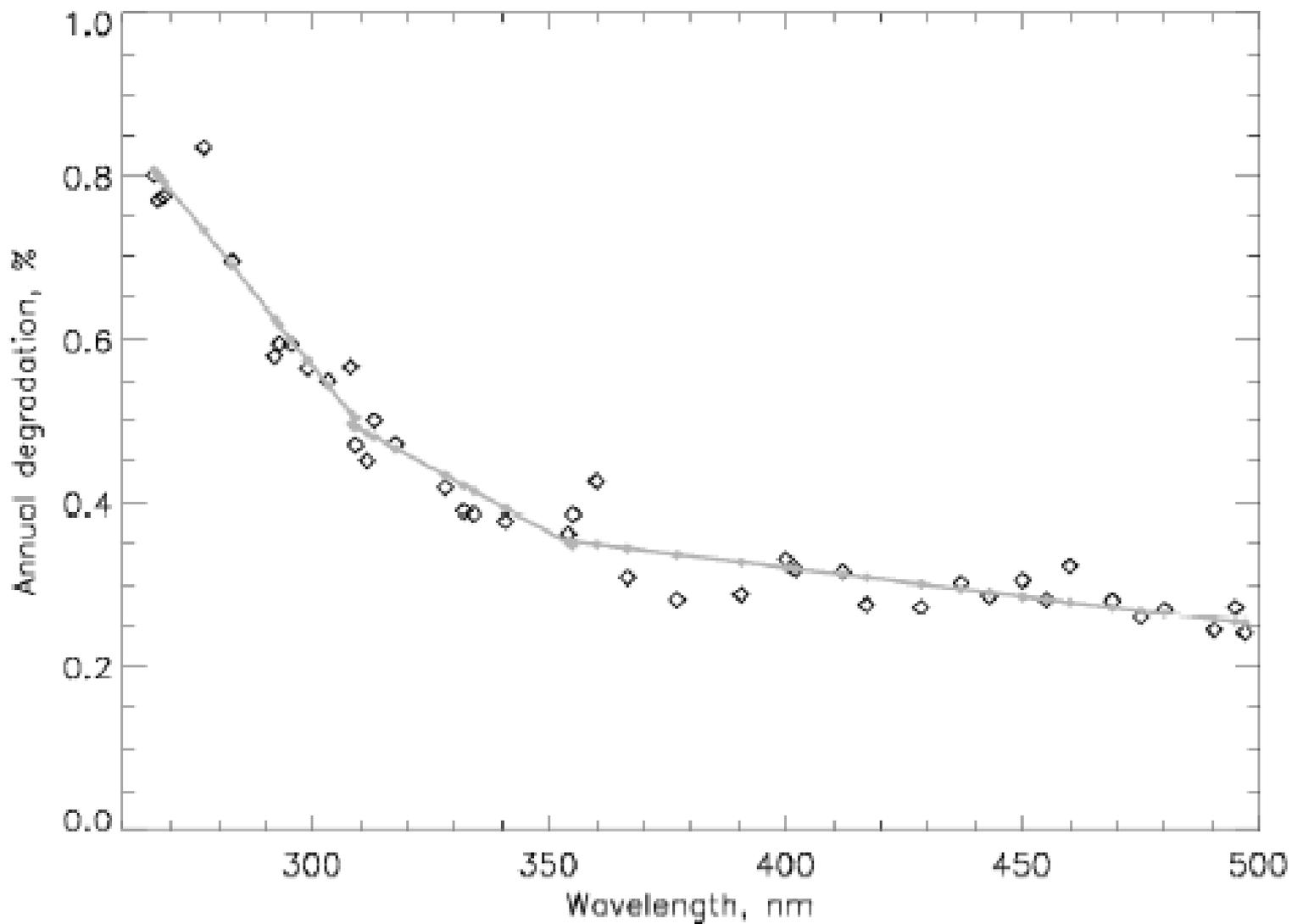# Ca II K Index: OMI and NSO

Solar Call K Index

Analysis of OMI Irradiance Data

- Observed throughput changes are fairly small (~2-3% total in near-UV), but do show different behavior during 2005-2006 compared to later period.

- **Assume that change in measured irradiance during solar minimum (mid-2007 → mid-2009) is only caused by instrument degradation.**

- Derive degradation rates and project forward to estimate solar variations for Cycle 24. Small seasonal variations (~0.3-0.5%) due to goniometry must be addressed.

- Solar irradiance sampling is improved from nominal design due to "spectral smile" between different rows.

- Wavelength scale drift has been minimal (< 0.01 nm), and is tracked using solar spectral features.

- "Row anomaly" does not affect solar measurements directly, but does impact degradation analysis.

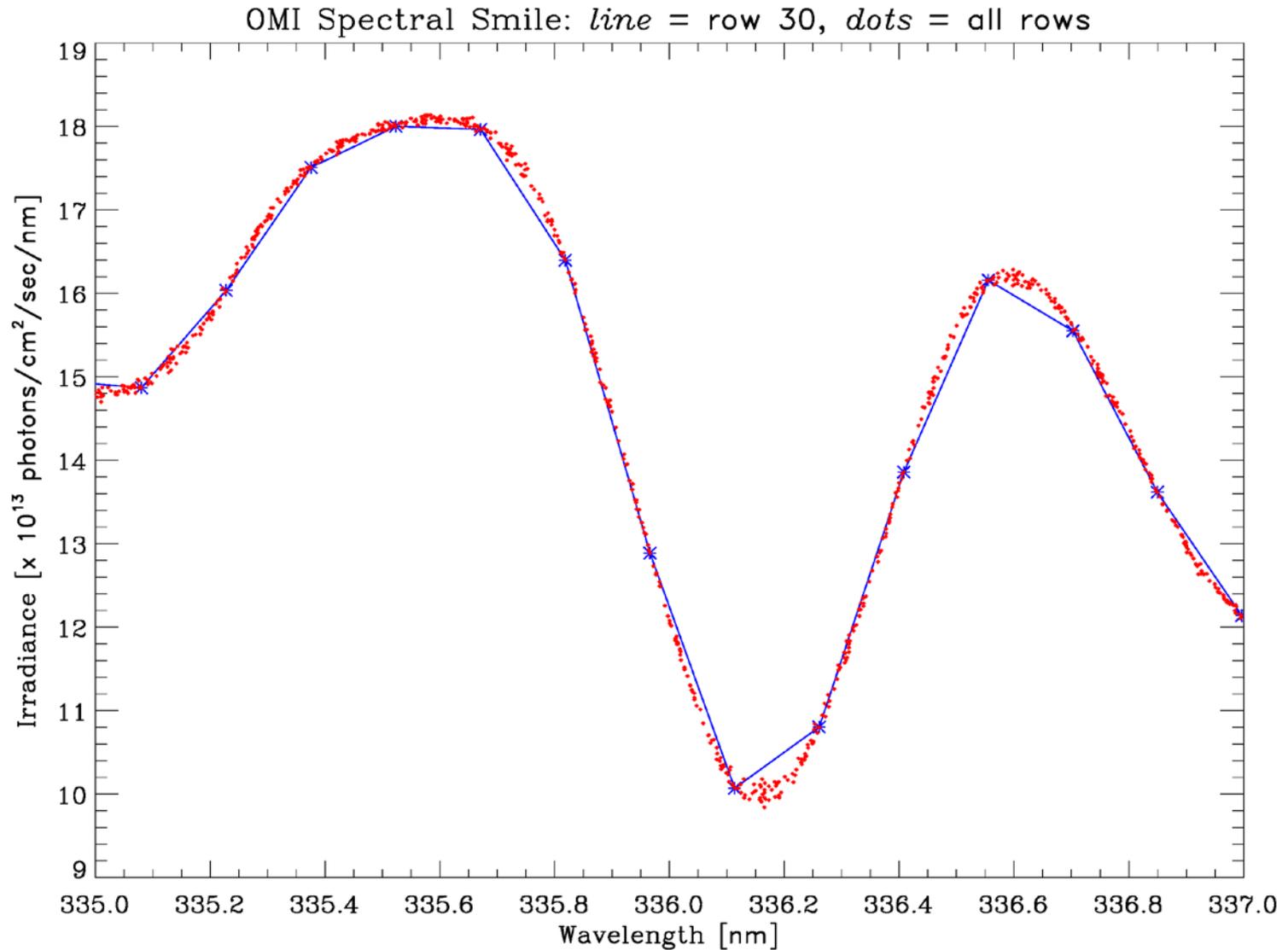# Unadjusted OMI Time Series
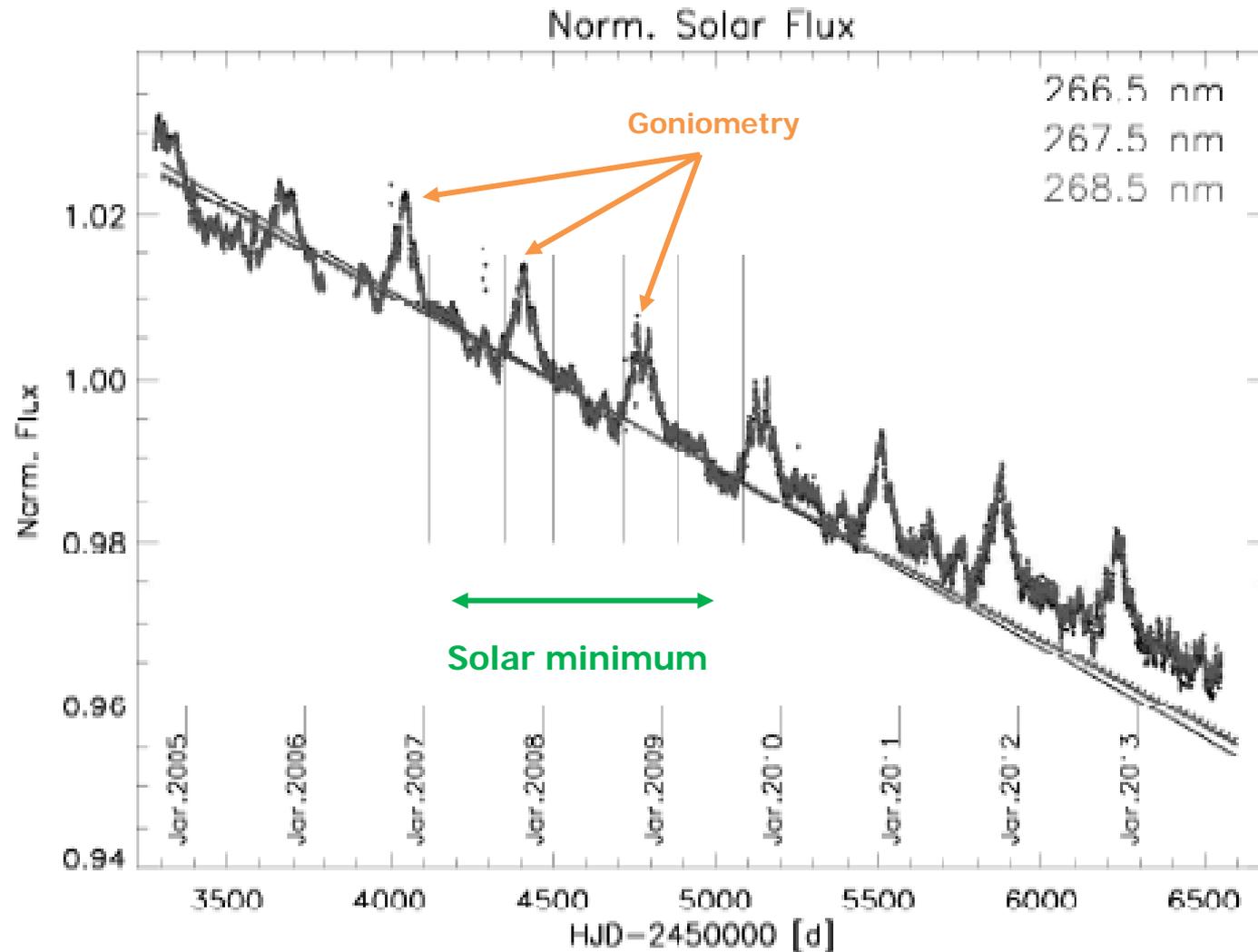
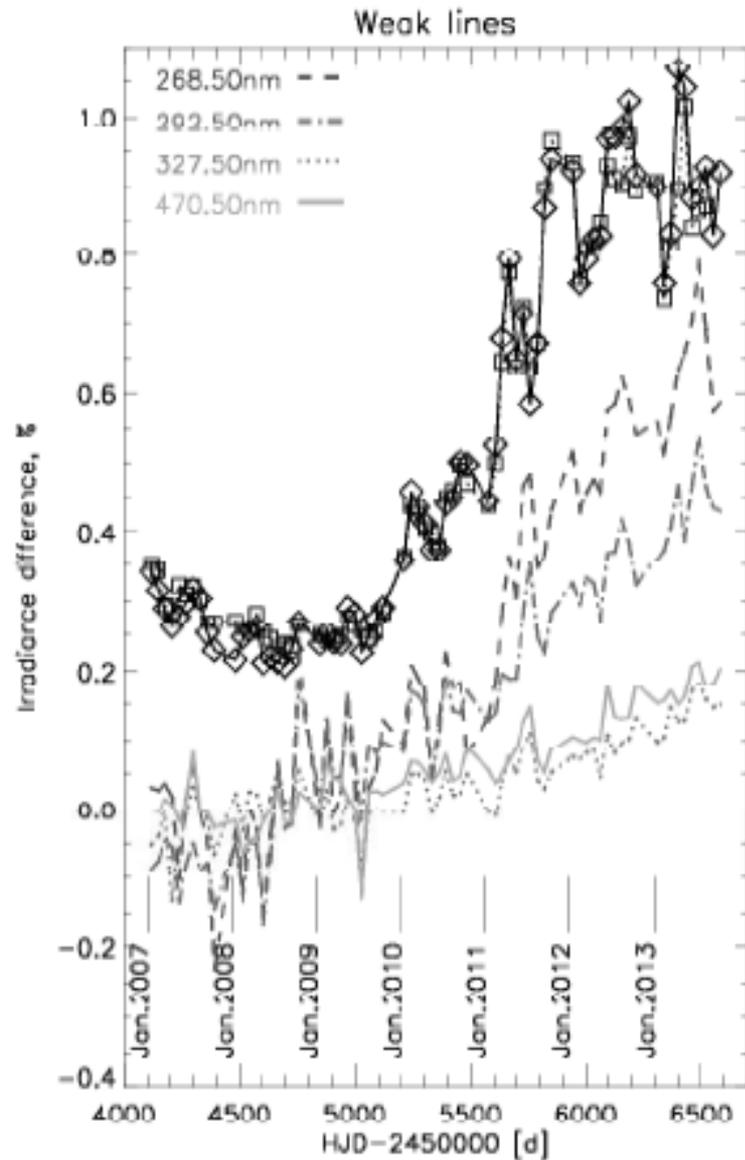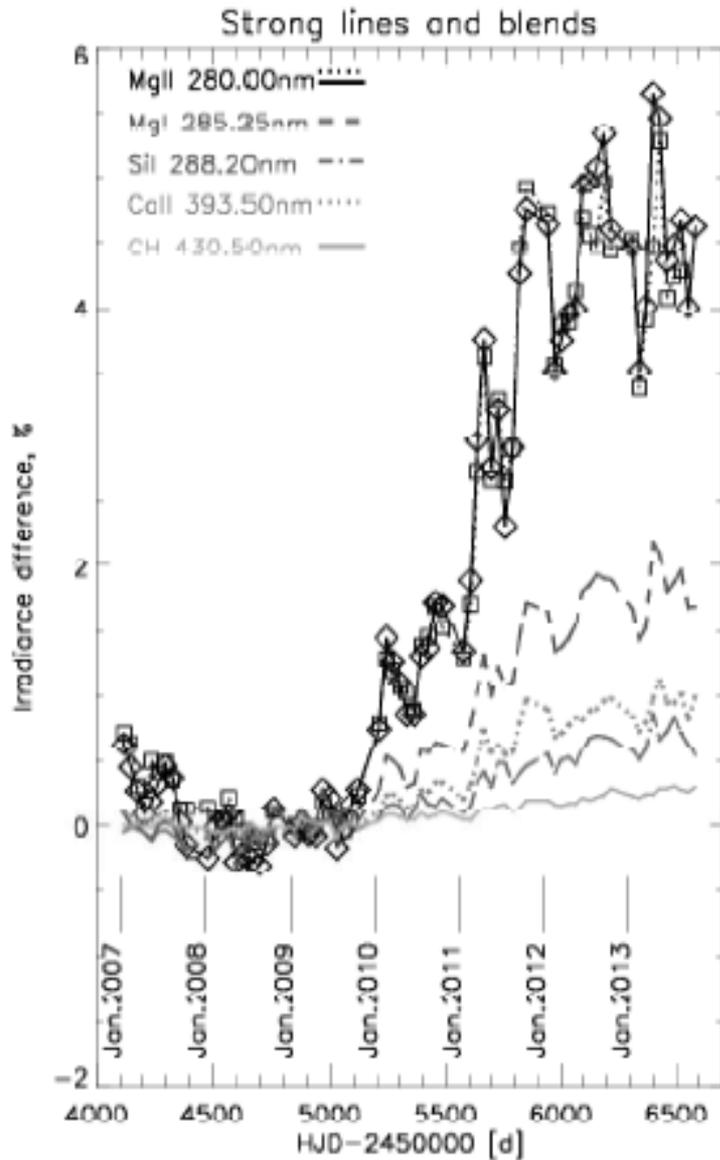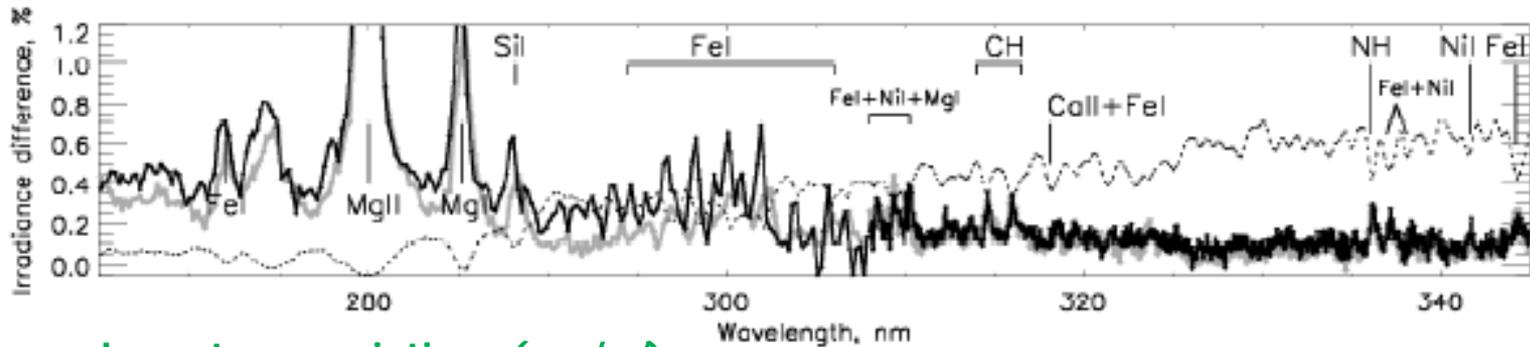**Marchenko and DeLand [2014]**

Degradation - Spectral Dependence

Spectral Smile

Wavelength Variation for OMI UV2 Detector: index=193

Spectral Sampling

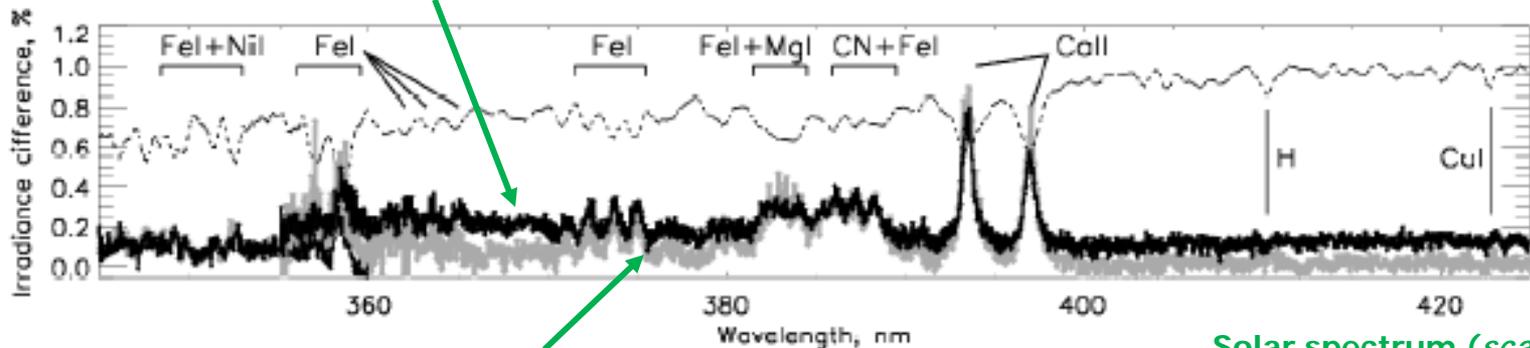OMI Spectral Smile: *line* = row 30, *dots* = all rows
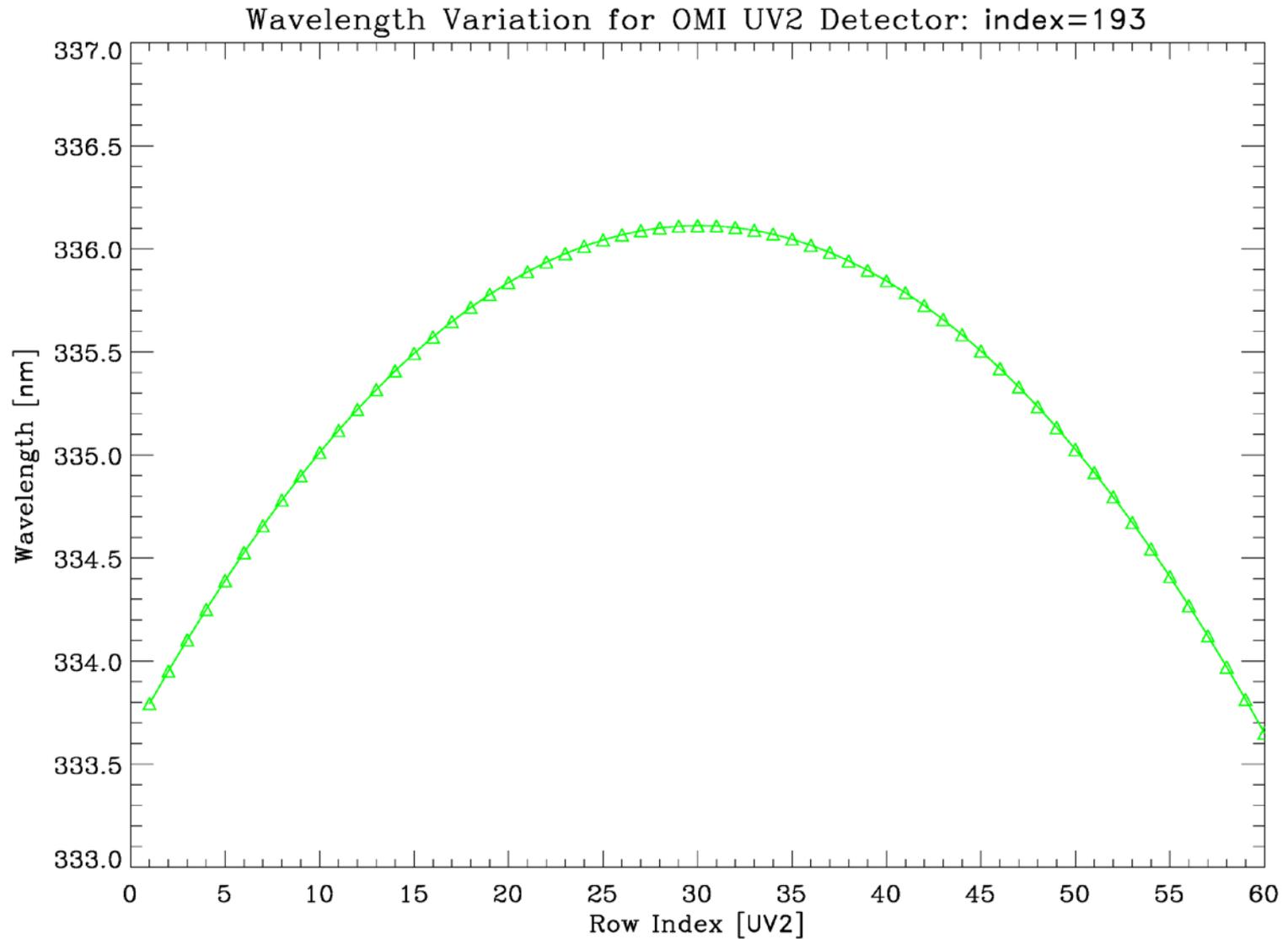
Irradiance Time Series
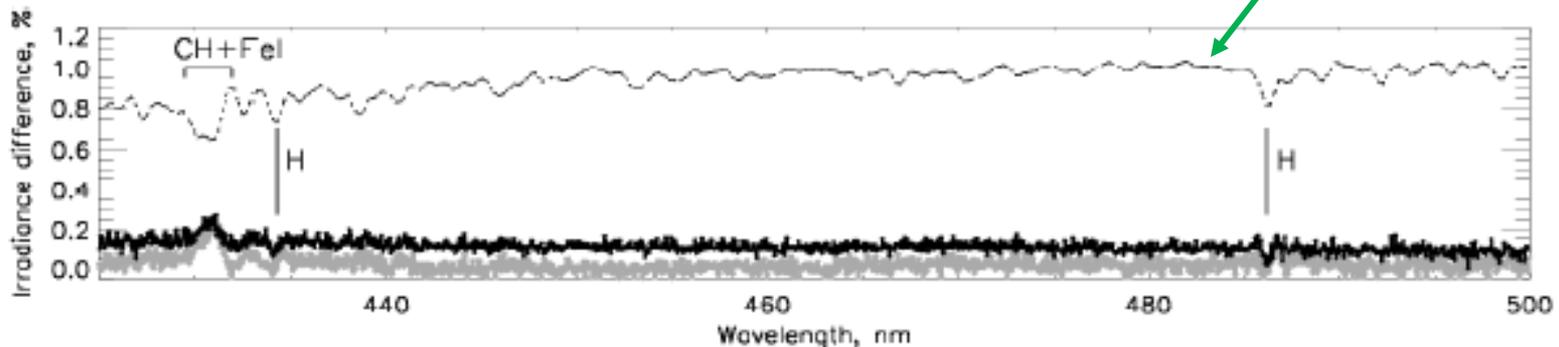
Spectral Dependence – Cycle 24

Long-term variations (*scaled*)

Short-term variations

Solar spectrum (*scaled*)

Short-term Variability

Solar spectrum (*scaled*)
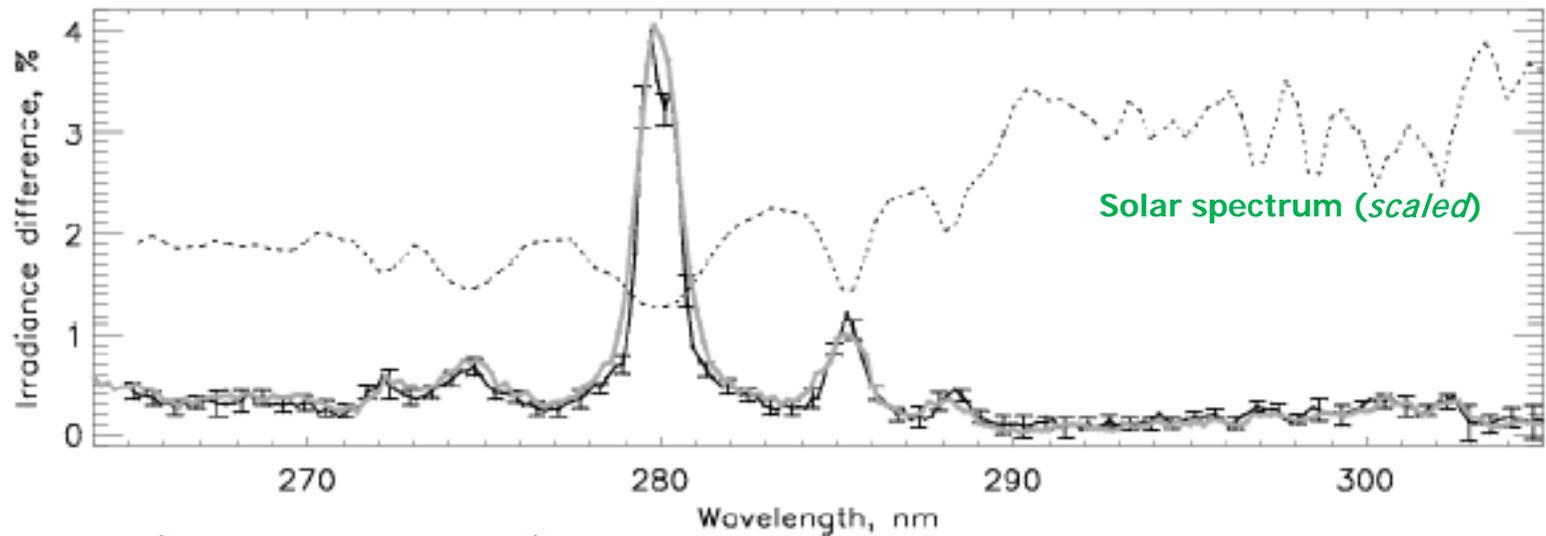
OMI data (*2012-2013 average*)
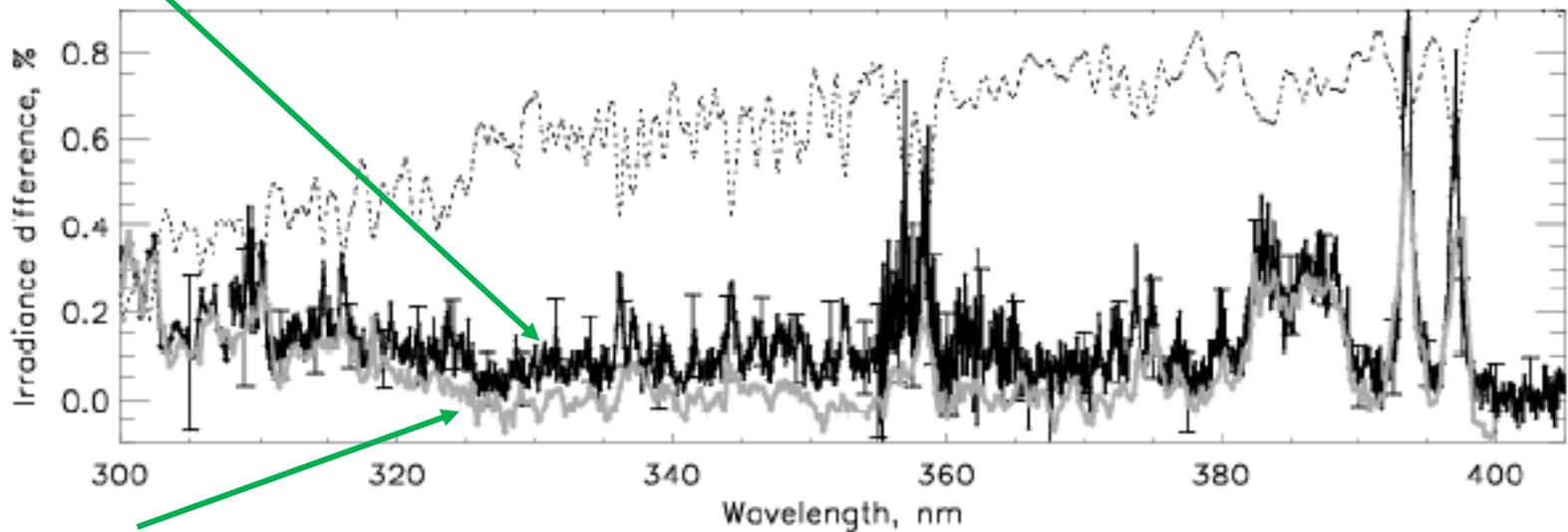
Scale factors (*Cycle 21-22 data*)

Extended Spectral Coverage
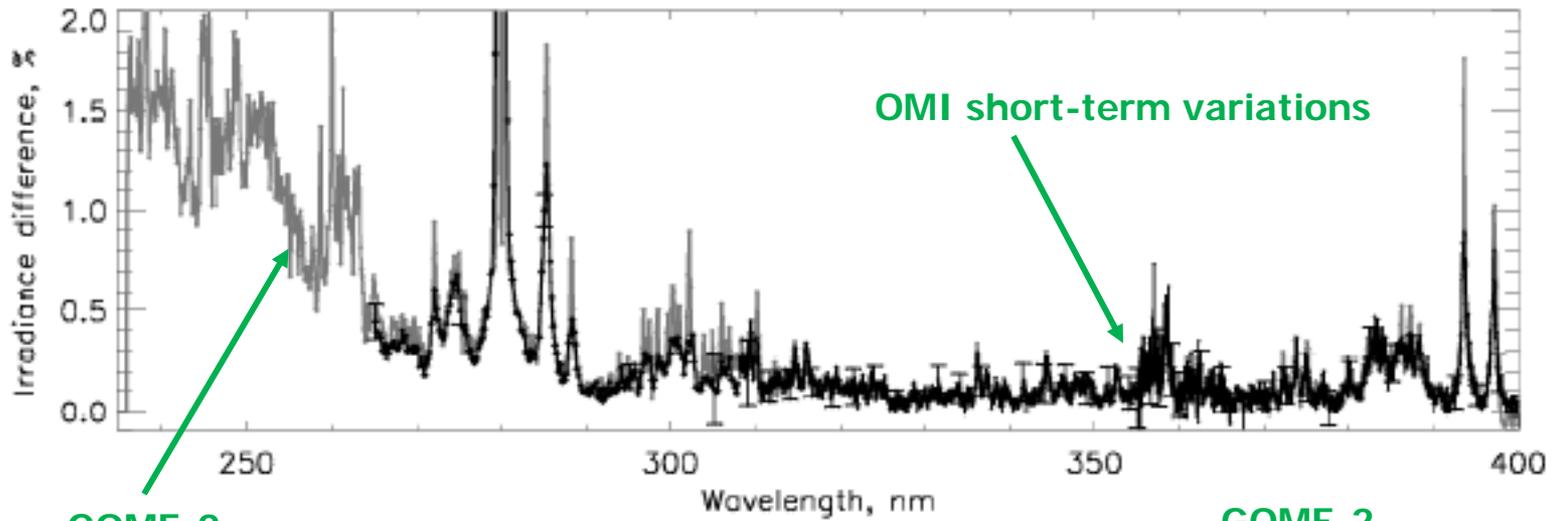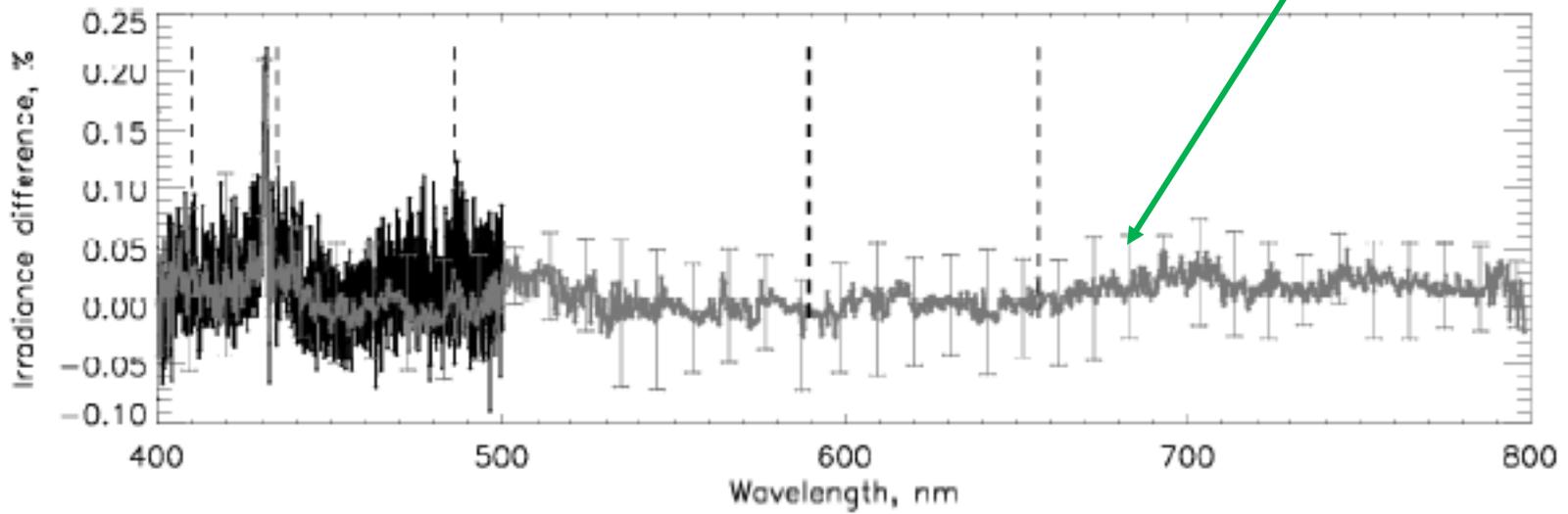
Variations at Visible Lines
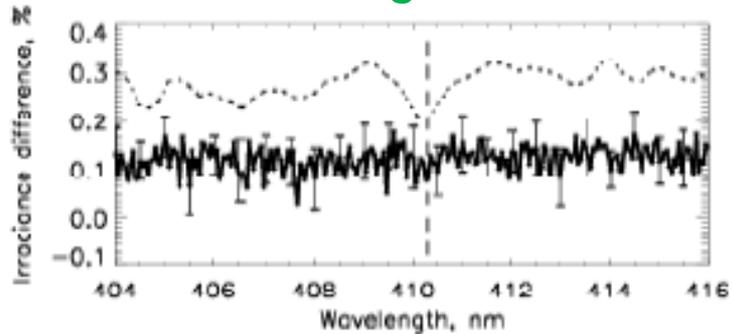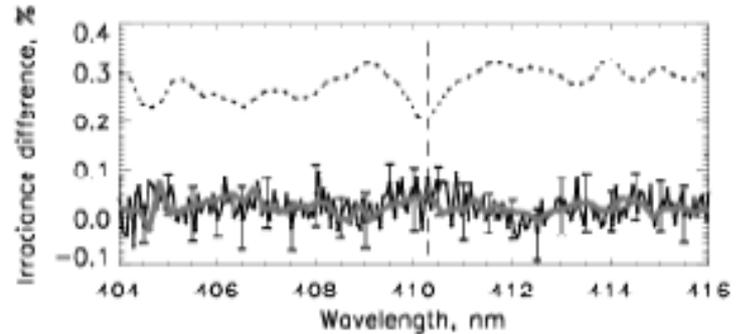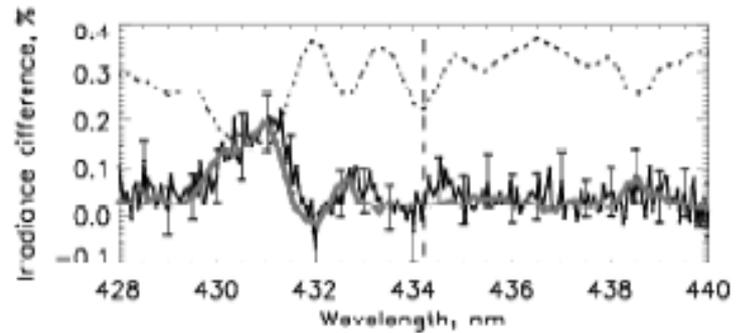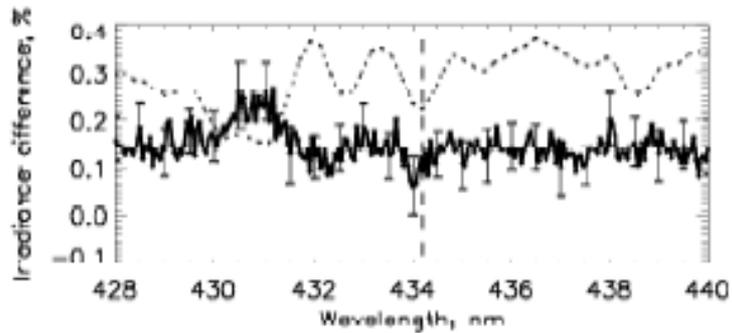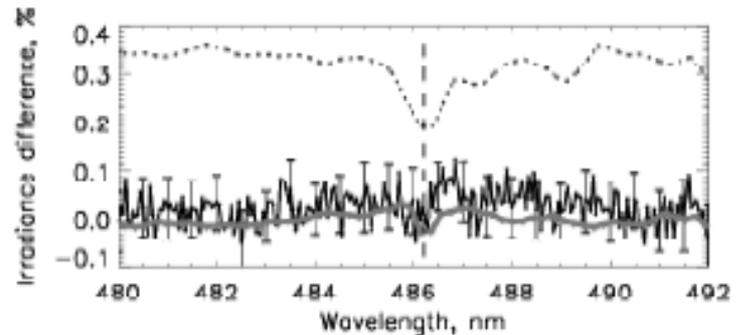
Line-Filling *vs.* Time

- Calculate line depth for main features from monthly average spectra and normalize to solar minimum value.
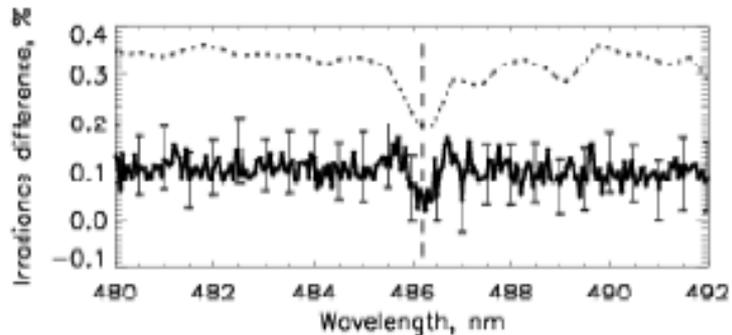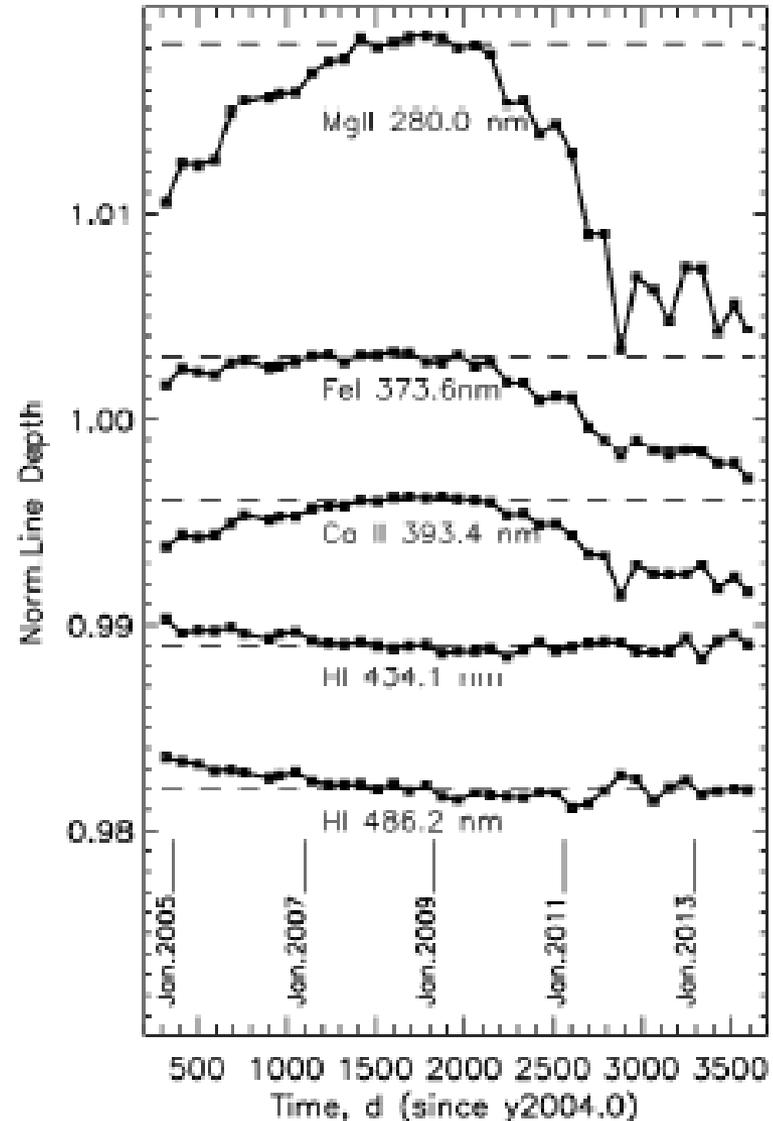- Shift reference levels of each line for clarity on plot.
- Most lines get shallower with increasing solar activity (*e.g.* Mg II, Ca II).
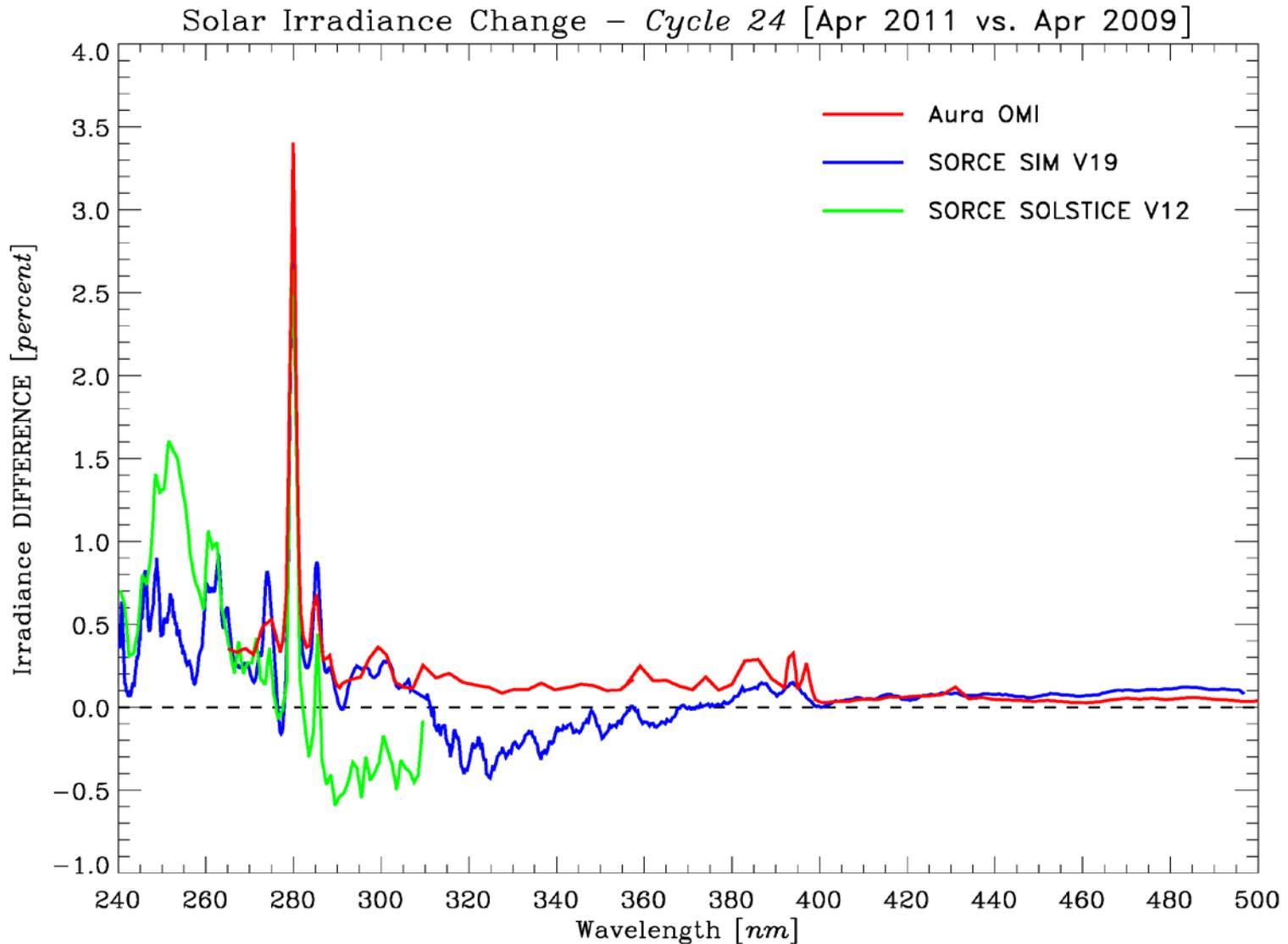- H I lines do not follow this pattern. Non-LTE effects?

Cycle 24 – Comparison to Model

Solar Irradiance: y2013−y2009

Blue = OMI data (2 nm bins)
Red = NRLSSI model

Cycle 24 - Observations

Solar Irradiance Change – *Cycle 24* [Apr 2011 vs. Apr 2009]
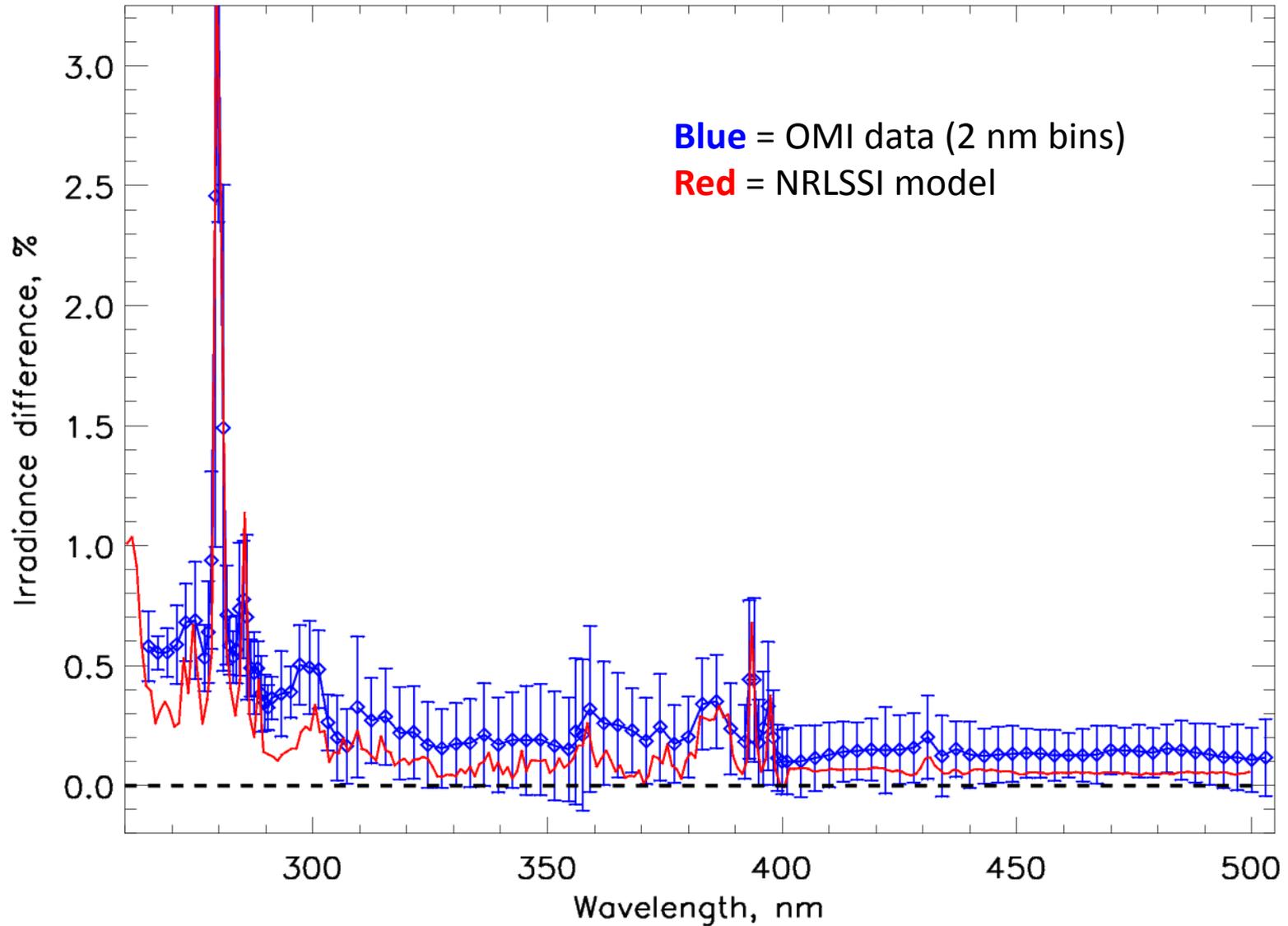
OMI Summary and Status

- Instrument health is good. Continued satellite operations through 2015 recently approved by NASA Senior Review.

- Solar activity index data sets are posted on-line at http://sbuv2.gsfc.nasa.gov/solar/omi/.

- Calibrated irradiance data for Cycle 24 have been created by characterizing throughput changes during solar minimum in 2007-2009.

- Spectral and temporal dependence of irradiance variations over 265-500 nm is consistent with NRLSSI model results.

- Some unexpected results for line-filling behavior observed at visible wavelengths.

- Irradiance manuscript submitted to *Astrophysical Journal*.

- Expect continuation of similar solar data with TROPOMI instrument, scheduled to launch on ESA Sentinel 5 Precursor mission in December 2014.