OMI (and TROPOMI) Solar Activity Time Series

Matthew DeLand[1], Sergey Marchenko[1]
[1]Science Systems and Applications, Inc. (SSAI)

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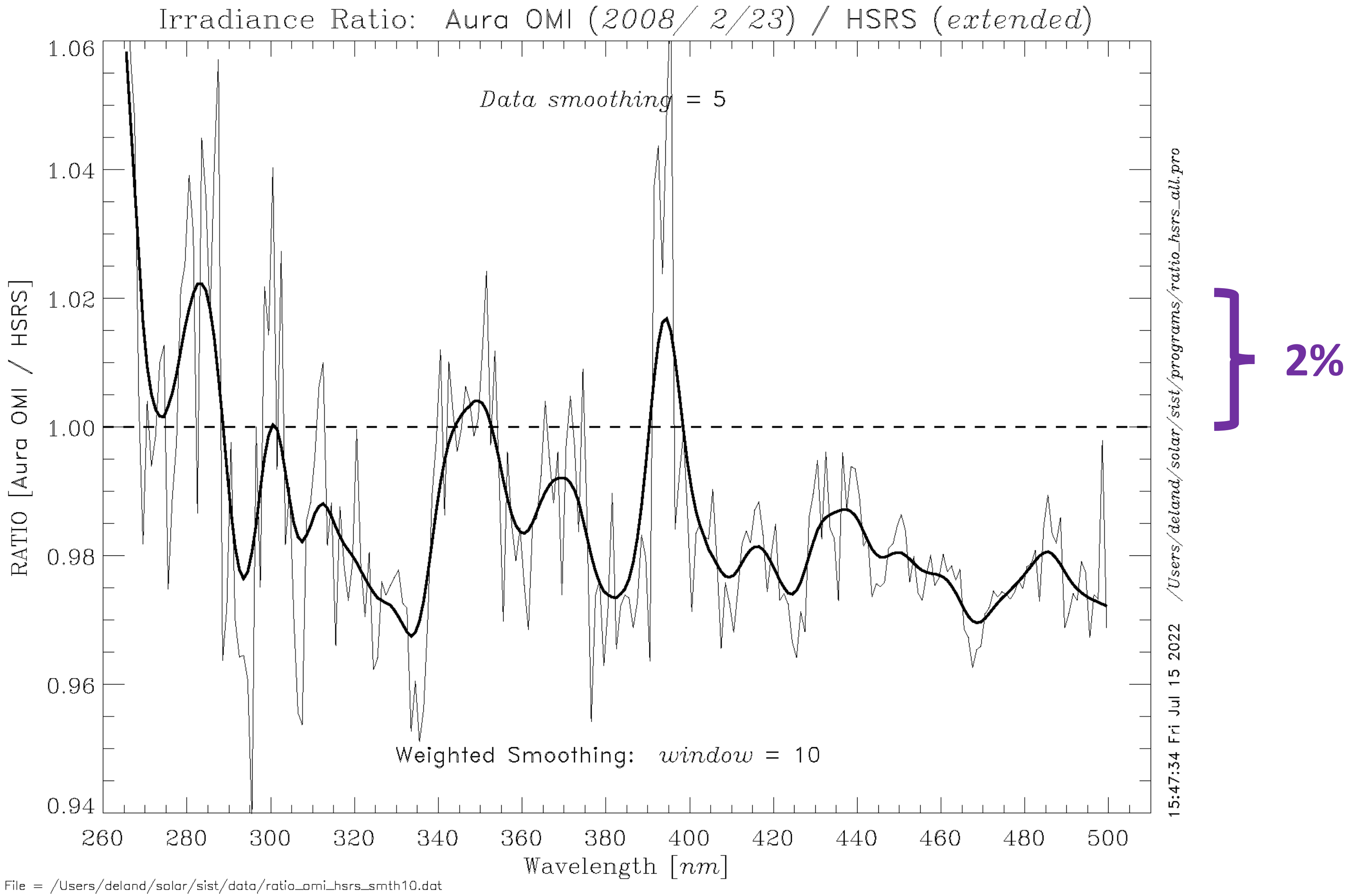
Aura Ozone Monitoring Instrument (OMI)

- Launched 15 July 2004; More than 105,000 orbits so far!
- Spectral coverage: 265-500 nm
  - UV1 band: 265-309 nm, $\Delta\lambda = 0.63$ nm
  - UV2 band: 309-380 nm, $\Delta\lambda = 0.42$ nm
  - VIS band: 380-504 nm, $\Delta\lambda = 0.63$ nm
- Nadir-viewing pushbroom spectrometer with wide field of view → 30 (UV1) or 60 (UV2, VIS) cross-track views per image
- Solar measurements use diffusers (quartz volume, aluminum reflective) in approximately daily [15 orbits] and monthly cadence
- Optical design (spectral shift between cross-track views) gives highly oversampled solar irradiance spectrum

Absolute Irradiance Comparison: OMI *vs.* HSRS

Both spectra represent solar minimum conditions



OMI Advantages for SSI Measurements

- Low overall degradation is easier to correct to high precision
  - 10% at 270 nm, 4% at 400 nm during mission lifetime
- Average many spectra for excellent signal-to-noise performance
  - ~250-500 spectra per daily sequence
- Spectral resolution helps characterization of solar activity in key absorption features (Mg II, Ca II, molecular bands)
  - $\Delta\lambda$ = 0.4-0.6 nm
- Long-term wavelength stability
  - 0.02-0.03 nm drift during mission lifetime

SSI Requirements for Climate Studies

Stability / year	**0.05% (λ < 400 nm), 0.01% (λ > 400 nm)**
Relative precision	**0.01%**

O. Coddington et al., 2016, BAMS, 97, 1265

- Long-term (decades), uninterrupted SSI records
- Preferably ~daily SSI observations

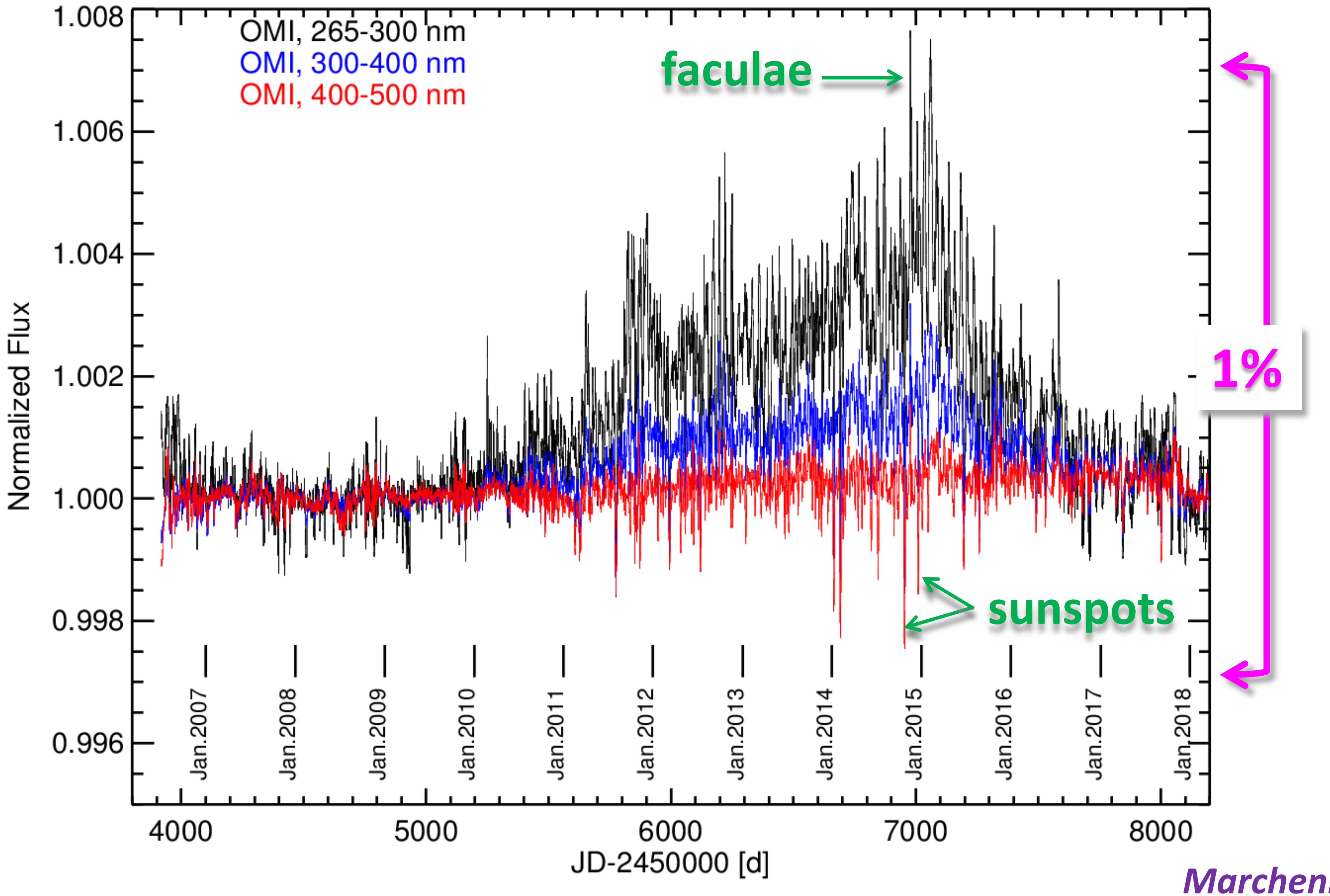
Daily OMI Solar Cycle 24 SSIs (2006-present, **V3** [*Marchenko et al.*, 2019]):

Stability / year *	**≤ 0.02% (λ < 400 nm),**	**≤ 0.01% (λ > 400 nm)**
Relative precision	**~ 0.1% (λ < 400 nm),**	**~0.02-0.1% (λ > 400 nm)**

* Comparisons between adjacent solar minima, i.e., relative change

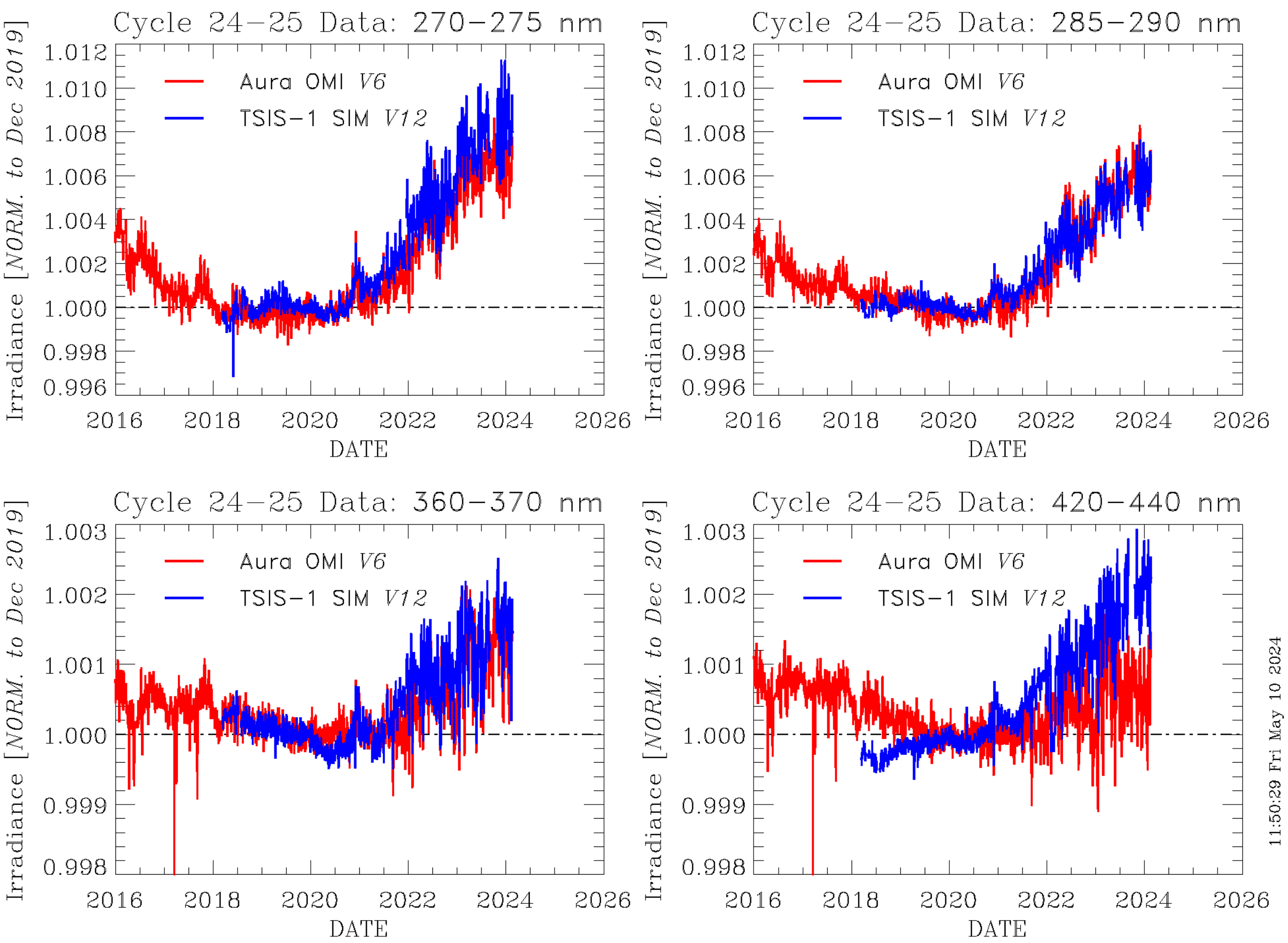
- We have developed alternative L1 degradation corrections to try to meet these goals

OMI SSI Time Series (Cycle 24 band averages)



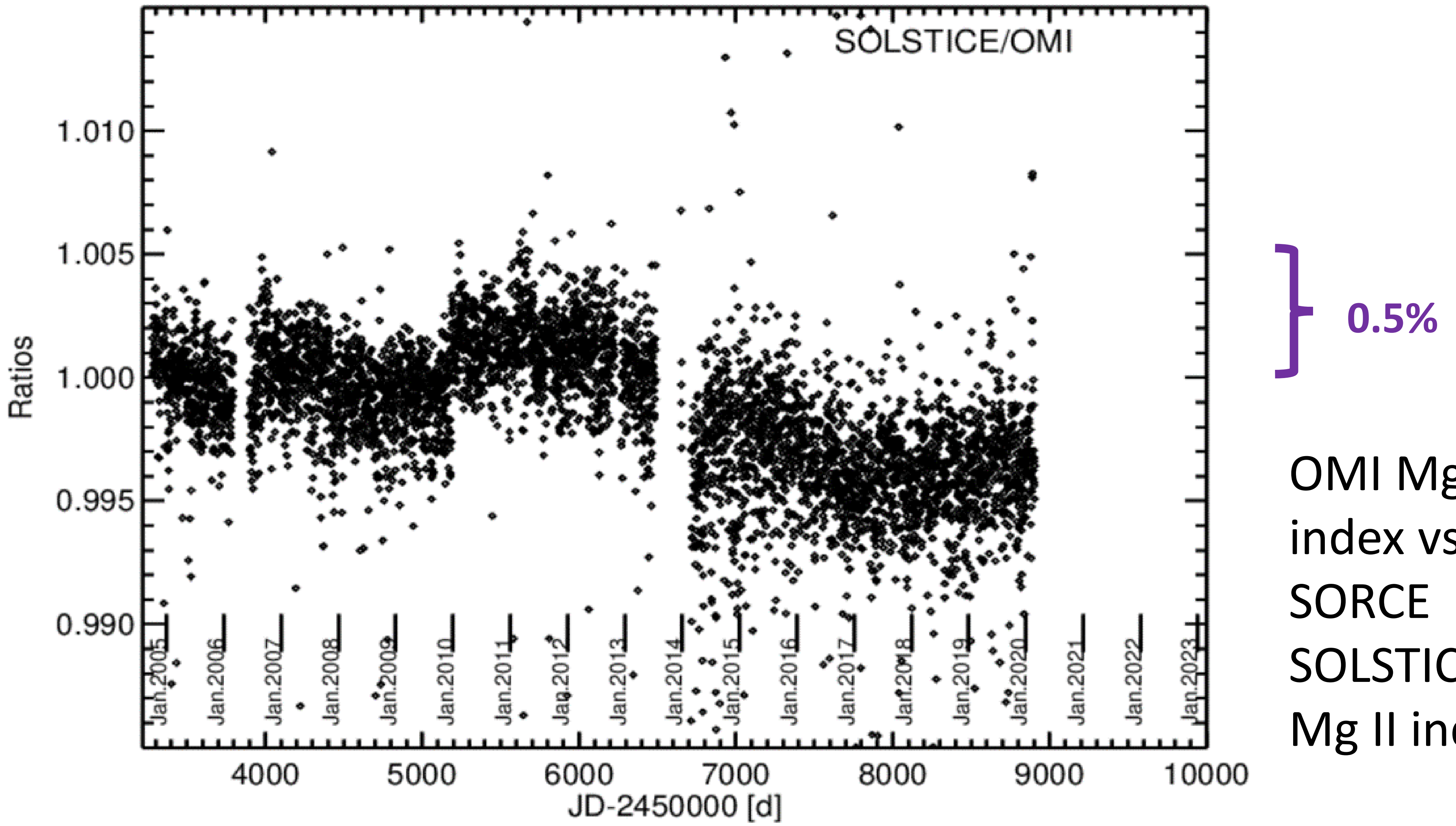
Marchenko et al. [2019]

OMI [V6] Comparison to TSIS-1 SIM [V12]



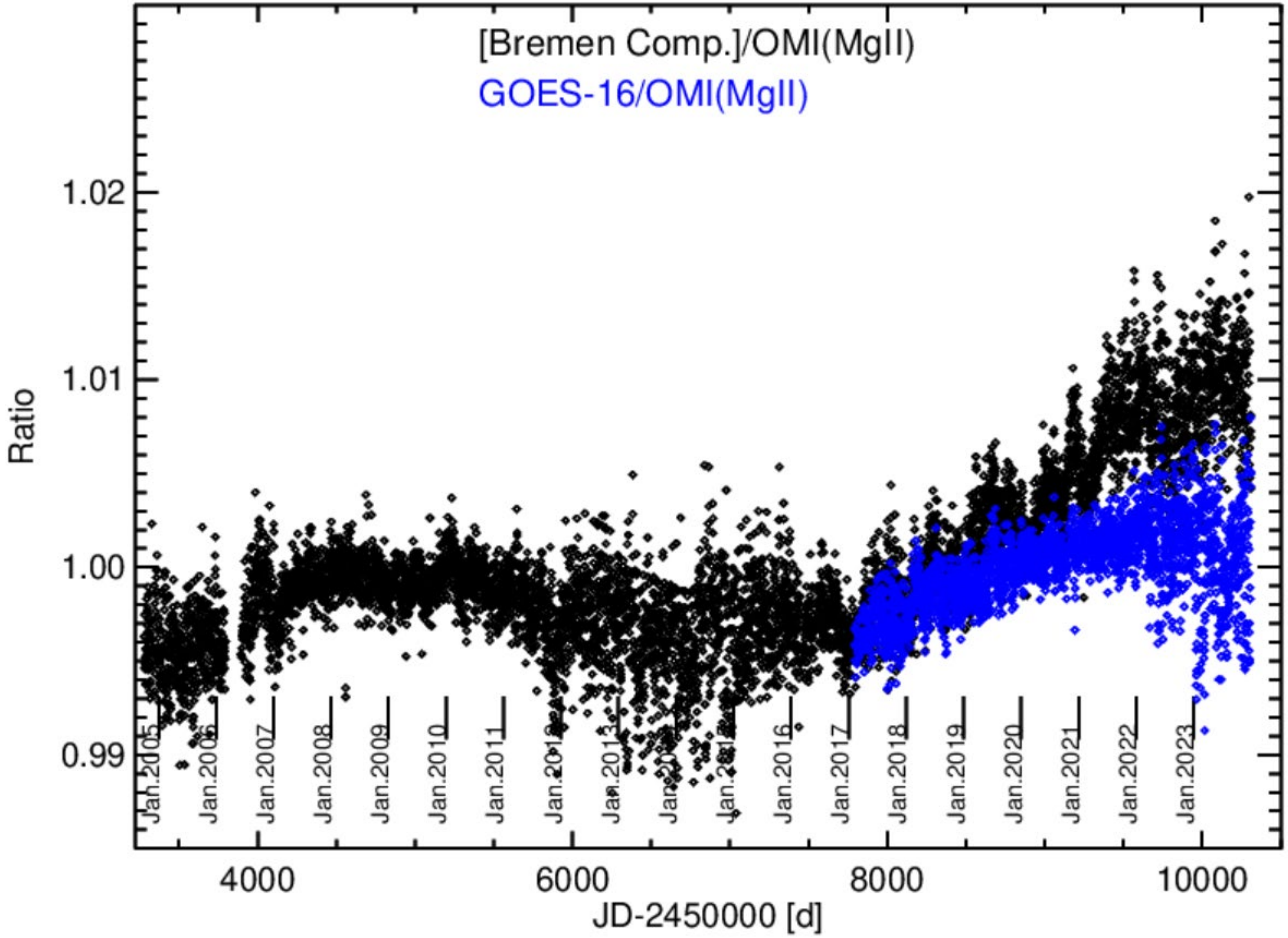
- Use narrow spectral bands ($\Delta\lambda$ = 5-10 nm)
- Agreement between concurrent measurements is within long-term stability (0.1-0.2%)

Solar Activity: Mg II Line Cycle 24



OMI Mg II index vs. SORCE SOLSTICE Mg II index

Solar Activity: Mg II Line Cycles 24-25

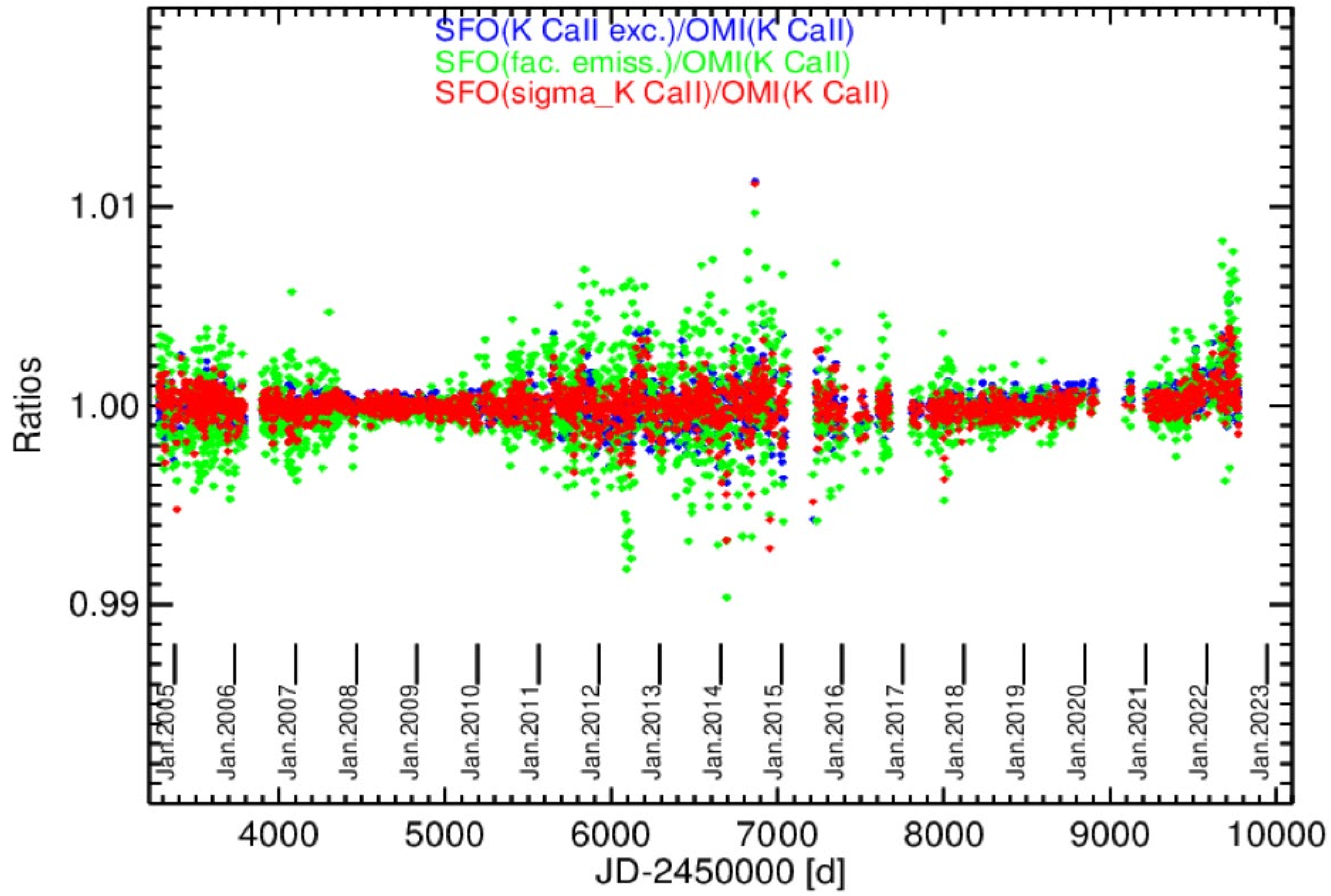


OMI Mg II index vs. Bremen Mg II index

1.5%

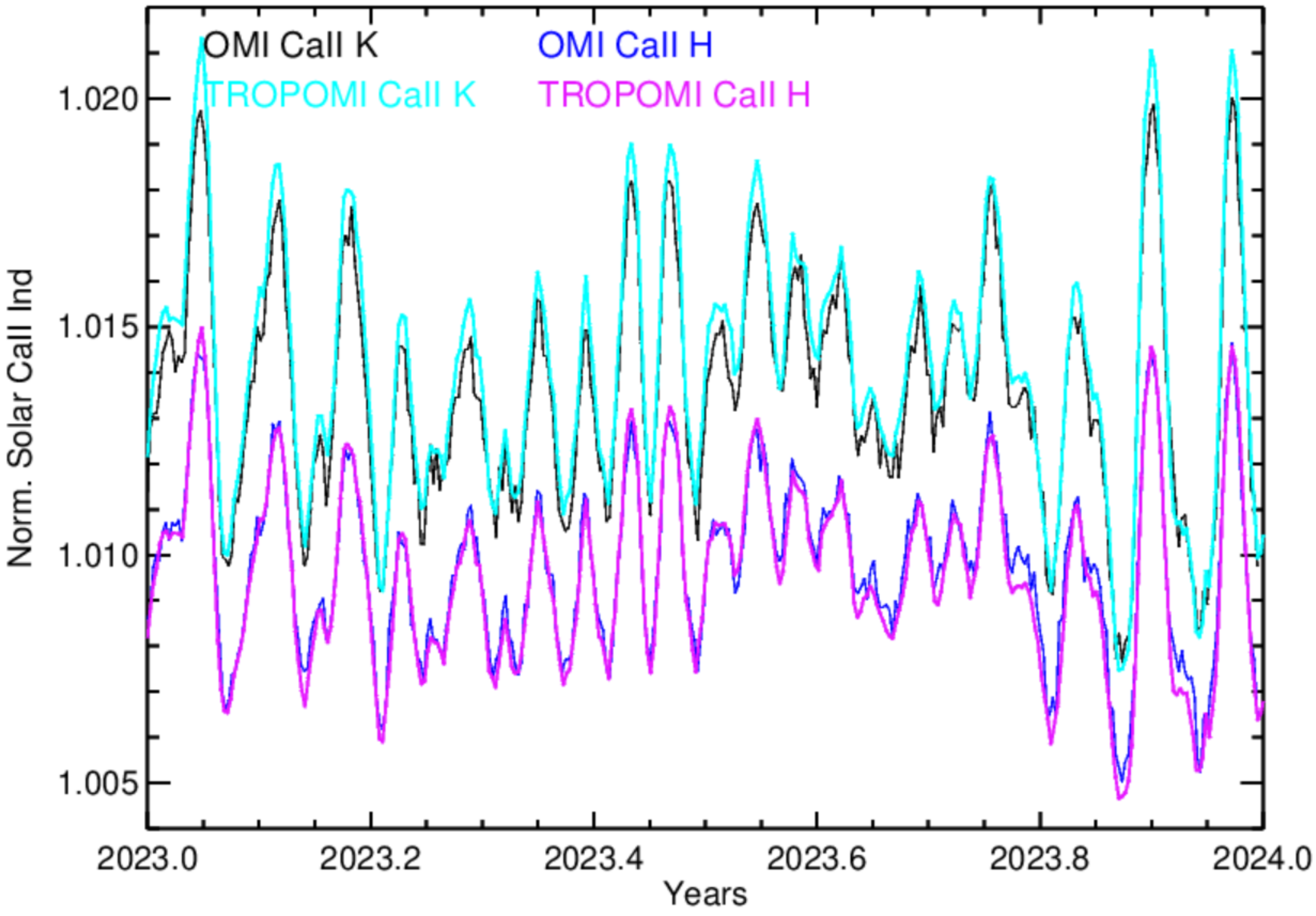
OMI Mg II index vs. GOES-16 Mg II index

Solar Activity: Ca II Lines Cycles 24-25



OMI Ca II K index vs. SFO Ca II K products

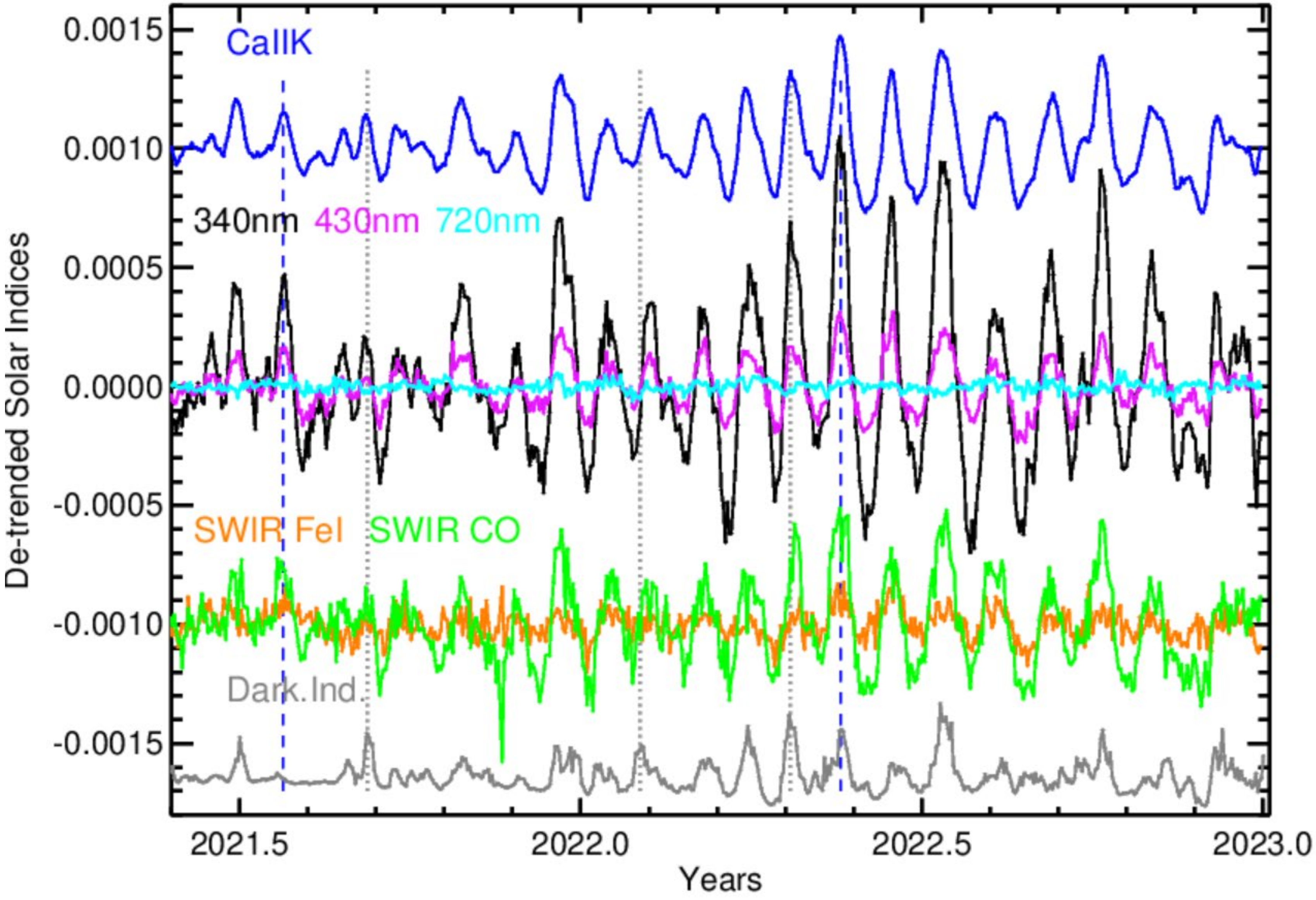
Solar Activity: Ca II Lines Short-term



No adjustments made for slightly different spectral resolution between OMI and TROPOMI

OMI and TROPOMI Ca II index products agree to ~0.03% on average

Solar Activity: Other Indexes



- Use additional TROPOMI bands (658-782 nm, 2300-2388 nm) to construct indexes using Fe I, CO lines
- Identify short-term signals down to ~0.02% peak-to-peak response
- Examine spectral dependence (e.g. quiet activity at 700-800 nm)

Future Plans

- OMI operations have been approved through mid-2025
  - Aura orbit drift is causing periodic goniometric calibration issues for solar irradiance measurements
  - First episode (October-December 2023) has been treated in our SSI product
- TROPOMI operations continue
  - Ca II index product is being archived at LISIRD site
  - Artifacts in released irradiance data (particularly for $\lambda < 300$ nm) exceed desired threshold for long-term use
  - We are working with KNMI team to understand these features
  - Also hope to get access to uncorrected irradiance data for possible development of alternative degradation correction