

Solar Spectral Irradiance Variability in Solar Cycle 25: Observations and Context

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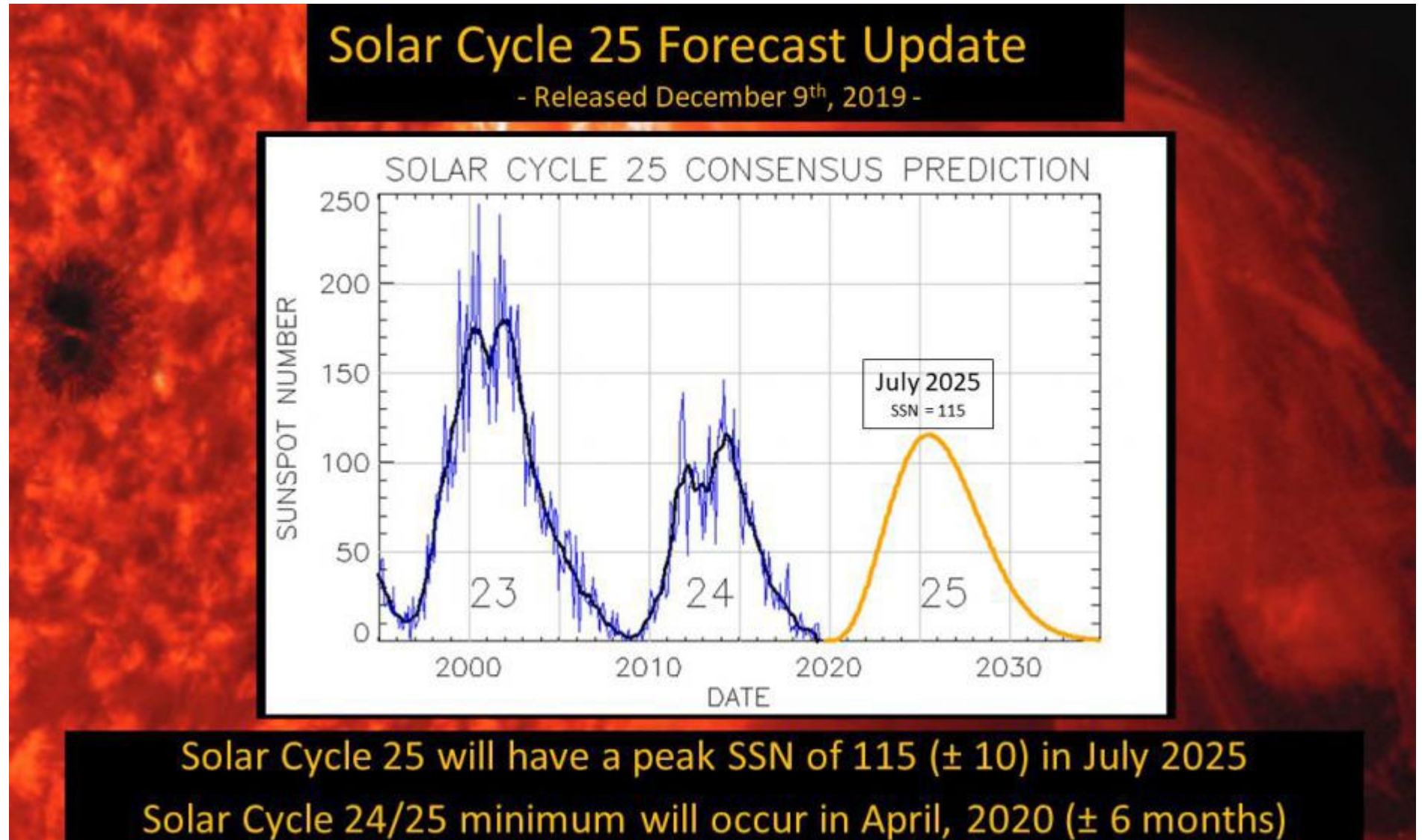
2023 Sun-Climate Symposium

Flagstaff, AZ 16-20 October 2023

NASA Grant 80NSSC21K1946

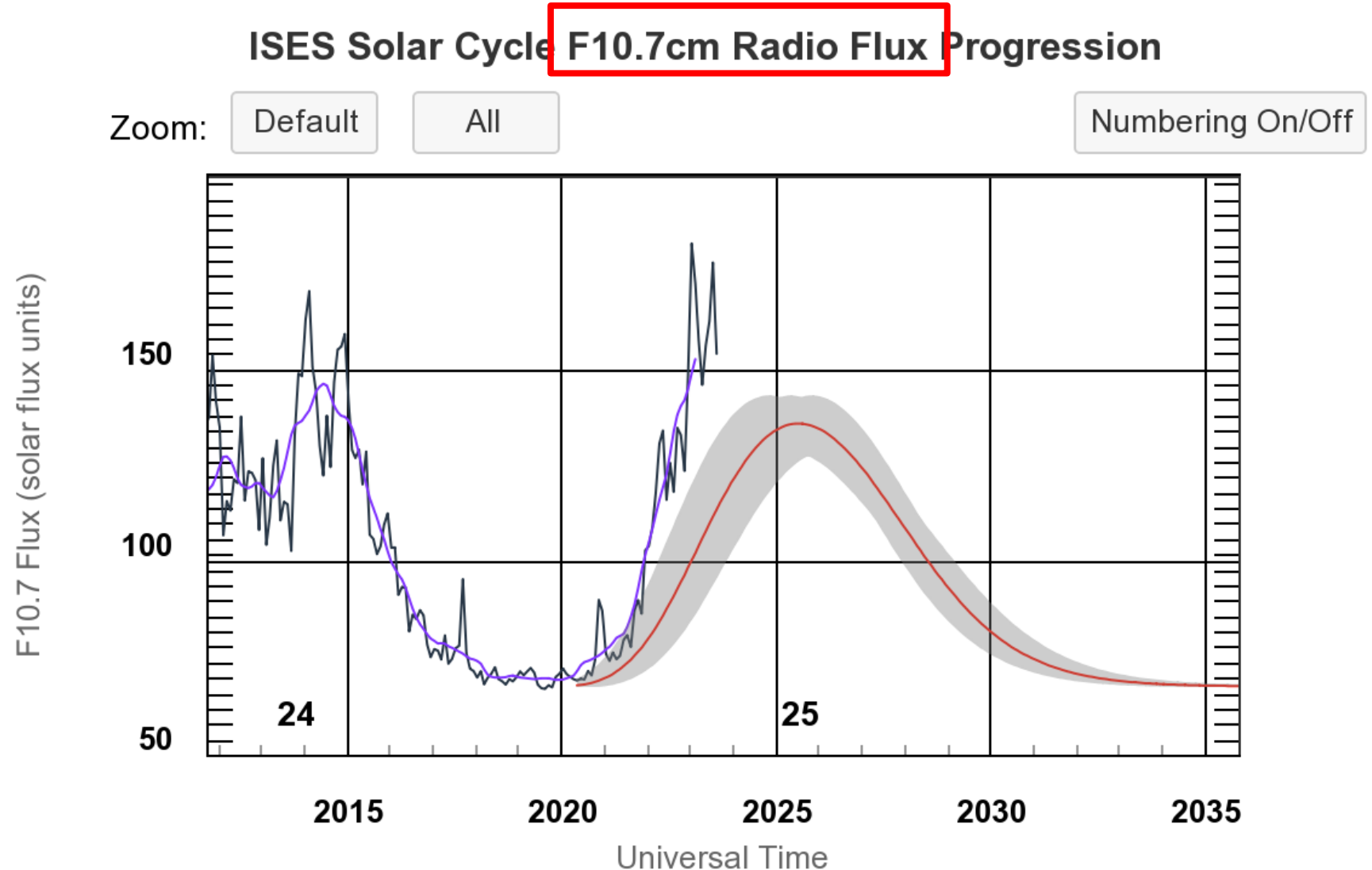
Expert Consensus for Cycle 25 Solar Activity

- NOAA + NASA panel results announced December 2019
- Predicted relatively quiet cycle, comparable to Cycle 24



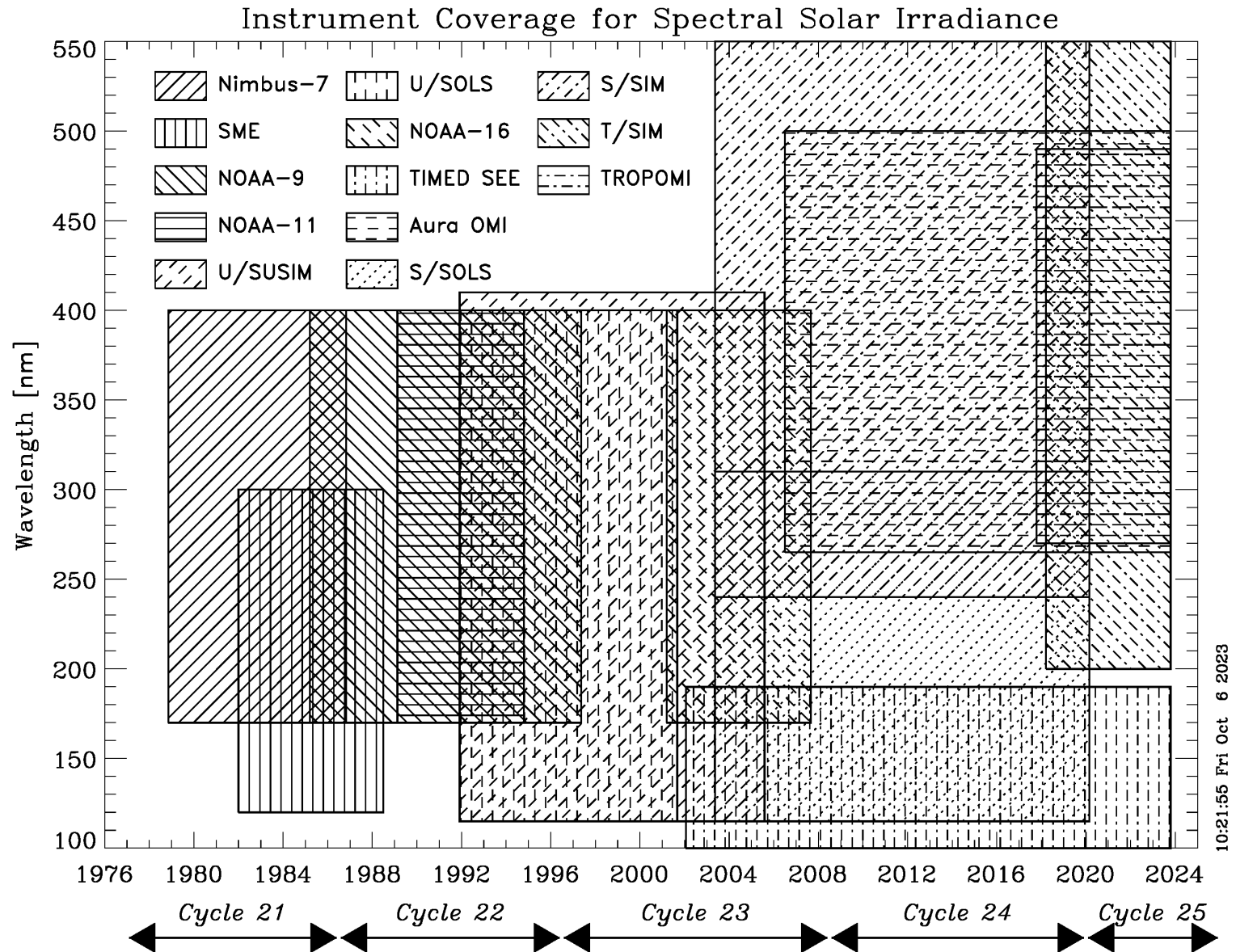
Cycle 25: Current Status (August 2023)

- Many indicators (e.g. sunspot number, 10.7 cm flux) are already above Cycle 24 peak values
- Solar maximum not expected for 1.5-2 years!
- **What about solar spectral irradiance?**



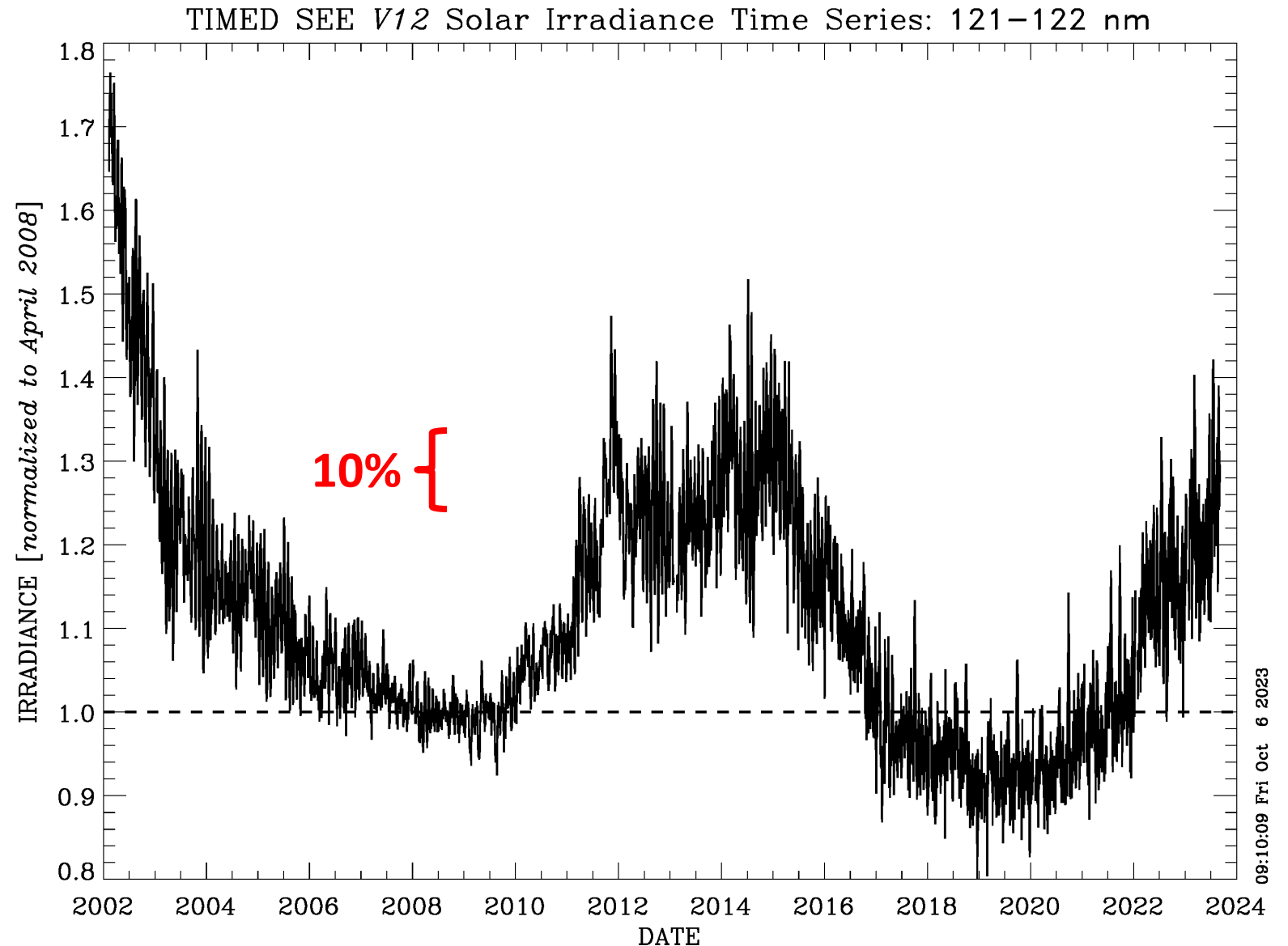
Available SSI Data Sets

- Currently active instruments cover wide spectral range (EUV → NIR)
- Look at TIMED SEE, TSIS-1 SIM, Aura OMI
- Some data sets cover Cycle 24 as well



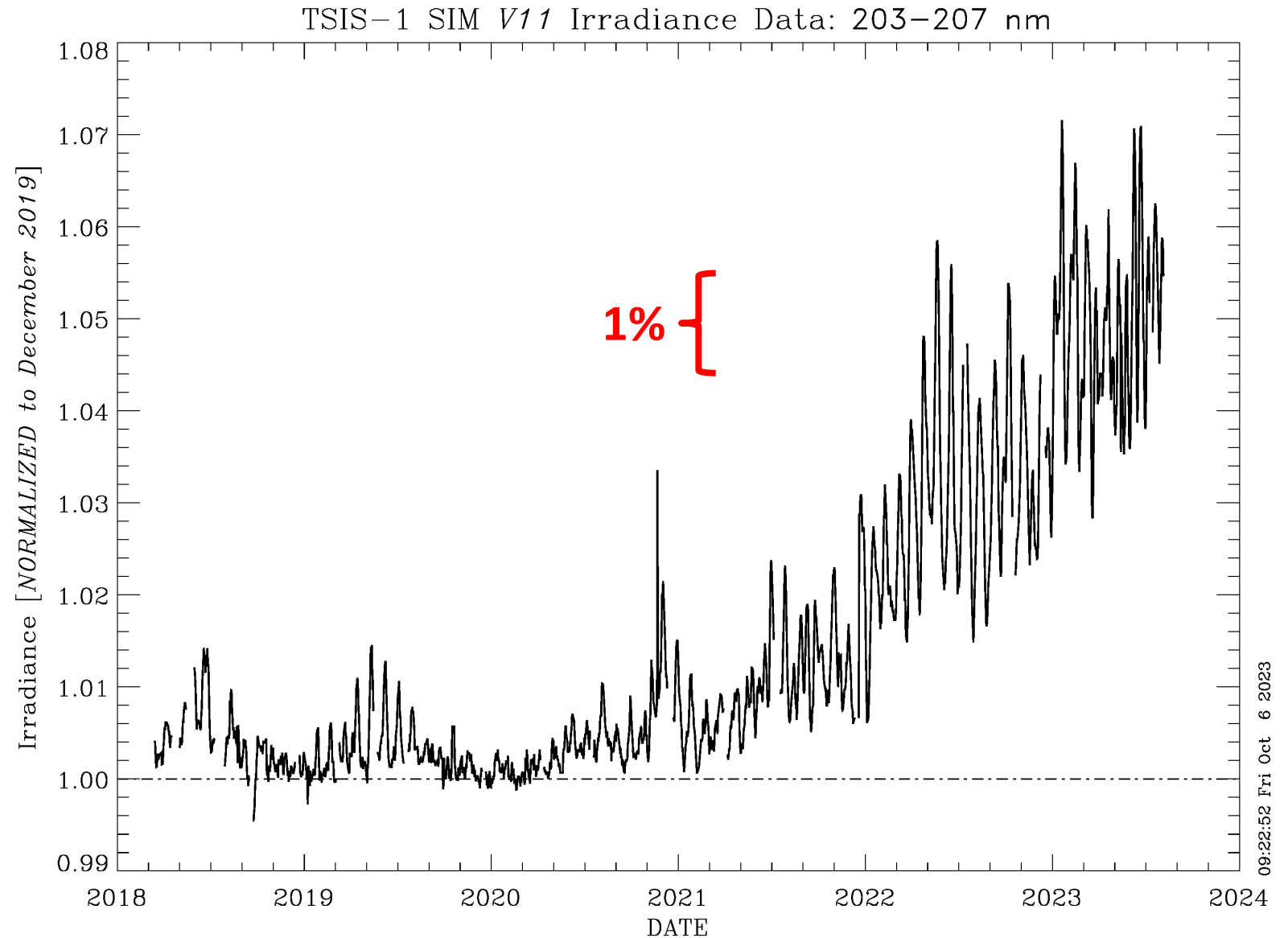
121.5 nm (Ly α) – TIMED SEE, Cycle 24-25

- Sharp decrease in 2002 (also declining phase of Cycle 23)
- Minimum in 2019 is ~10% lower than minimum in 2008; calibration issue?
- Current values are lower than Cycle 24 maximum (but see previous point)



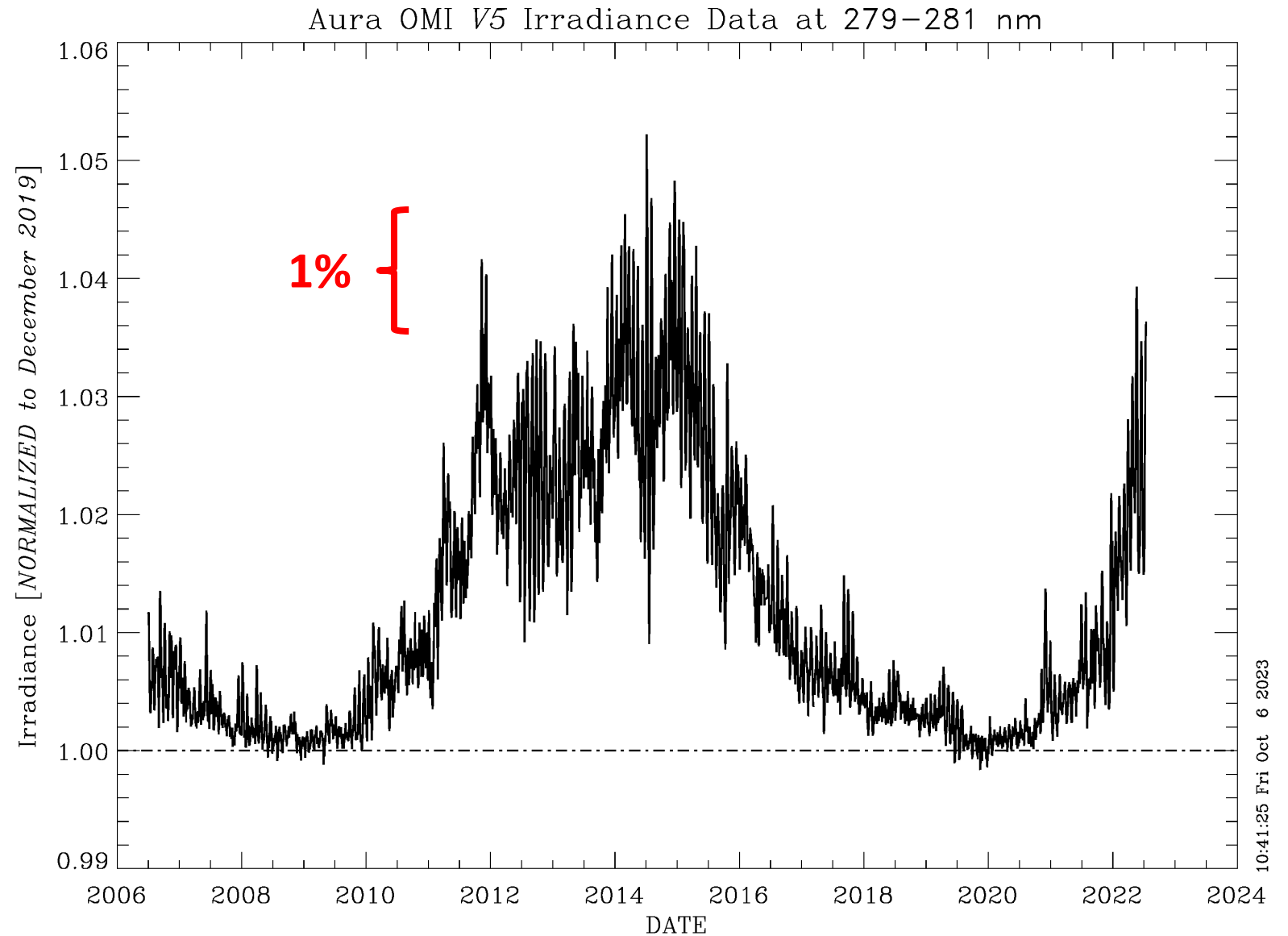
203-207 nm – TSIS-1 SIM, Cycle 25

- Some rotational activity in 2018 and 2019, much stronger in 2022
- Overall level increases in January 2022 and January 2023
- Small annual oscillation in data set (known to instrument team)



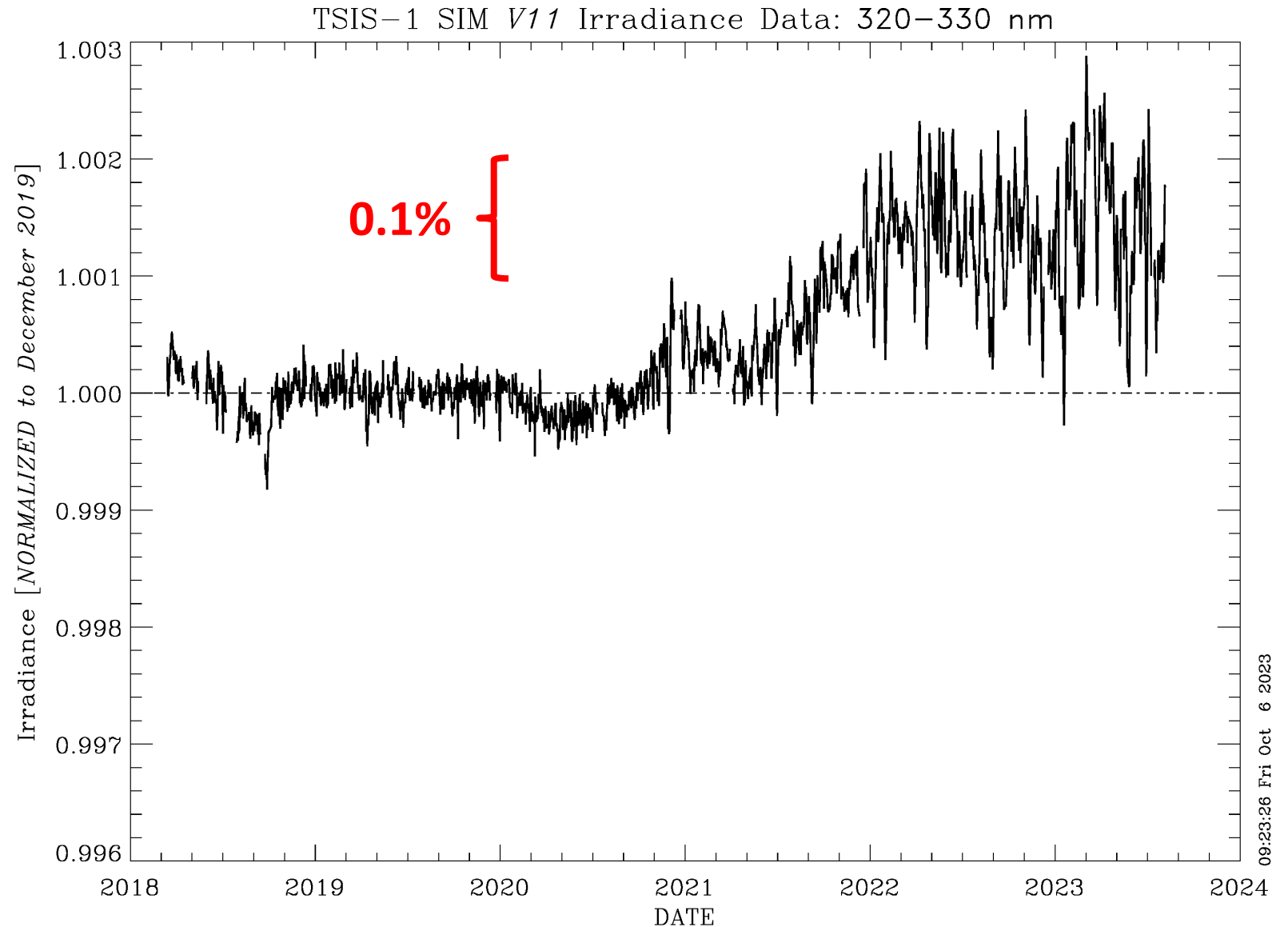
279-281 nm (Mg II) – Aura OMI, Cycle 24-25

- Cycle 25 (through August 2022) not up to Cycle 24 peak yet, but close



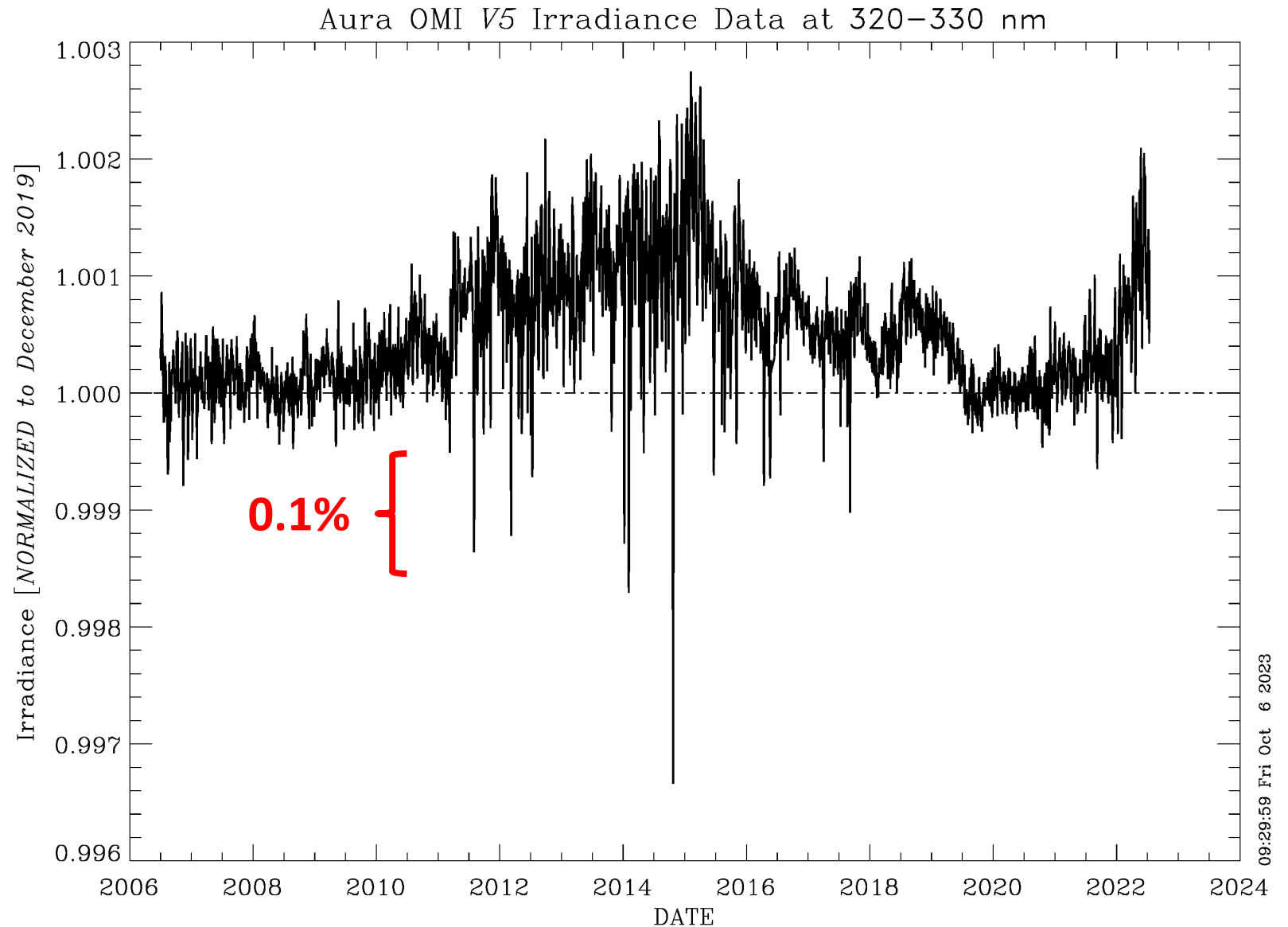
320-330 nm – TSIS-1 SIM, Cycle 25

- Increasing activity during 2021, relatively constant during 2022-2023
- Some strong sunspots (decrease in irradiance) during 2022-2023?



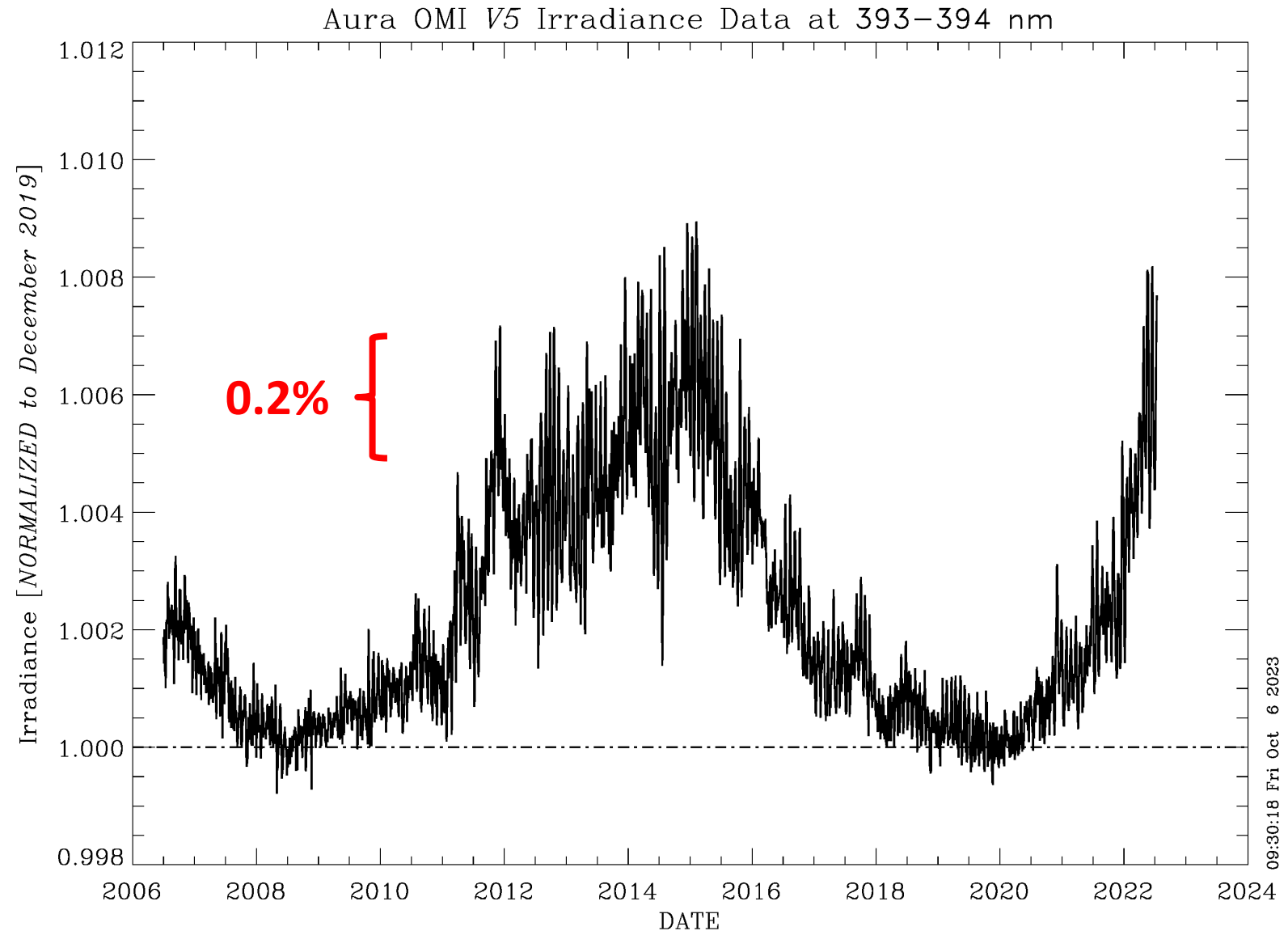
320-330 nm – Aura OMI, Cycle 24-25

- Increasing activity during late 2021
- Cycle 25 not yet up to Cycle 24 maximum
- Note strong sunspots (0.2-0.4% decrease in irradiance) during maximum of Cycle 24



393-394 nm (Ca II K) – Aura OMI, Cycle 24-25

- Cycle 25 (through August 2022) not up to Cycle 24 peak yet, but very close

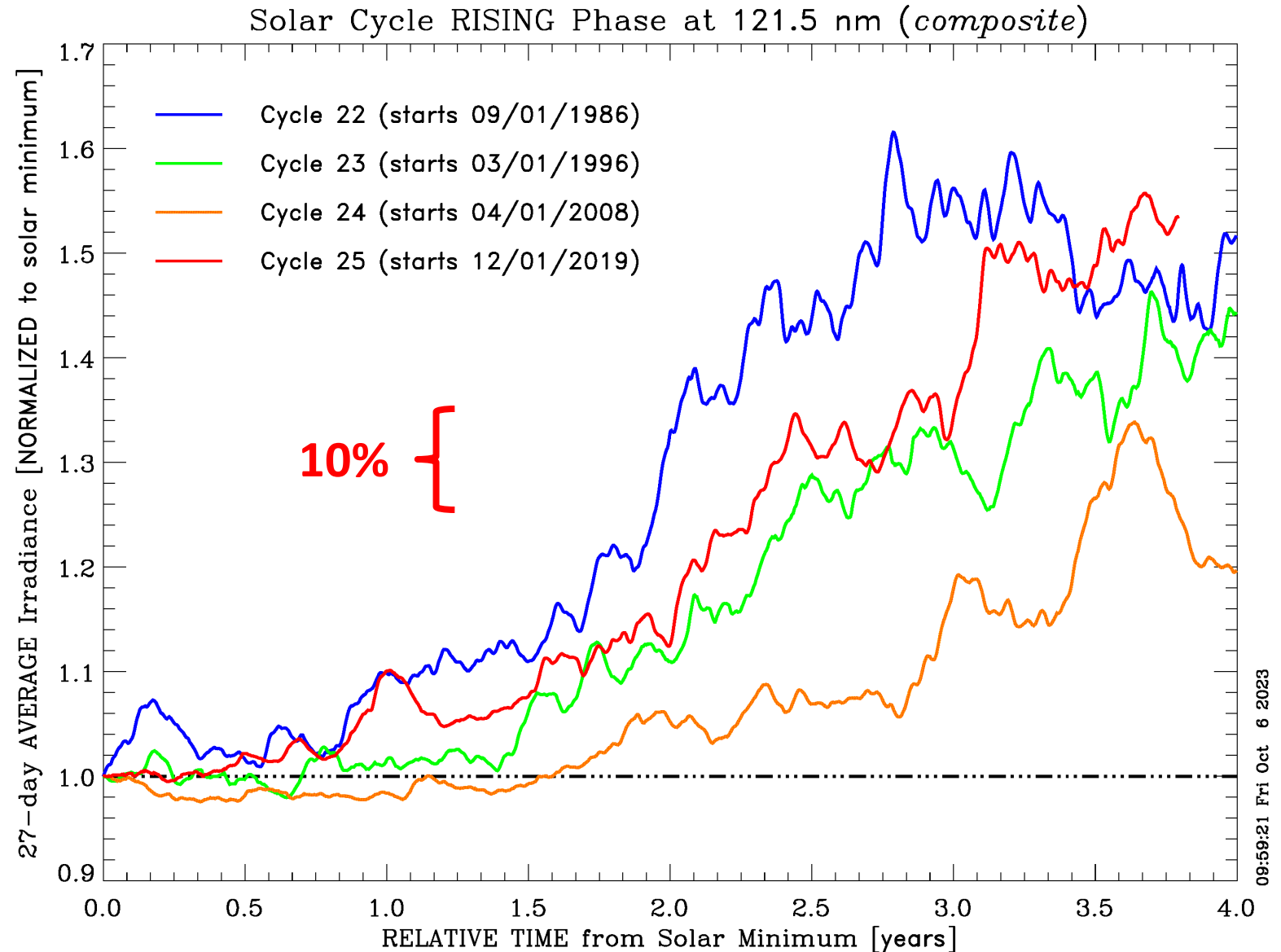


Comparison of Rising Phase Between Cycles

- Look at first few years of solar activity for multiple cycles
- Use 27-day smoothed data for clarity
- Need composite product to cover multiple decades
- Definition of starting date within extended solar minimum period (*e.g.* using raw data vs. smoothed data) will affect how “fast” activity appears to increase

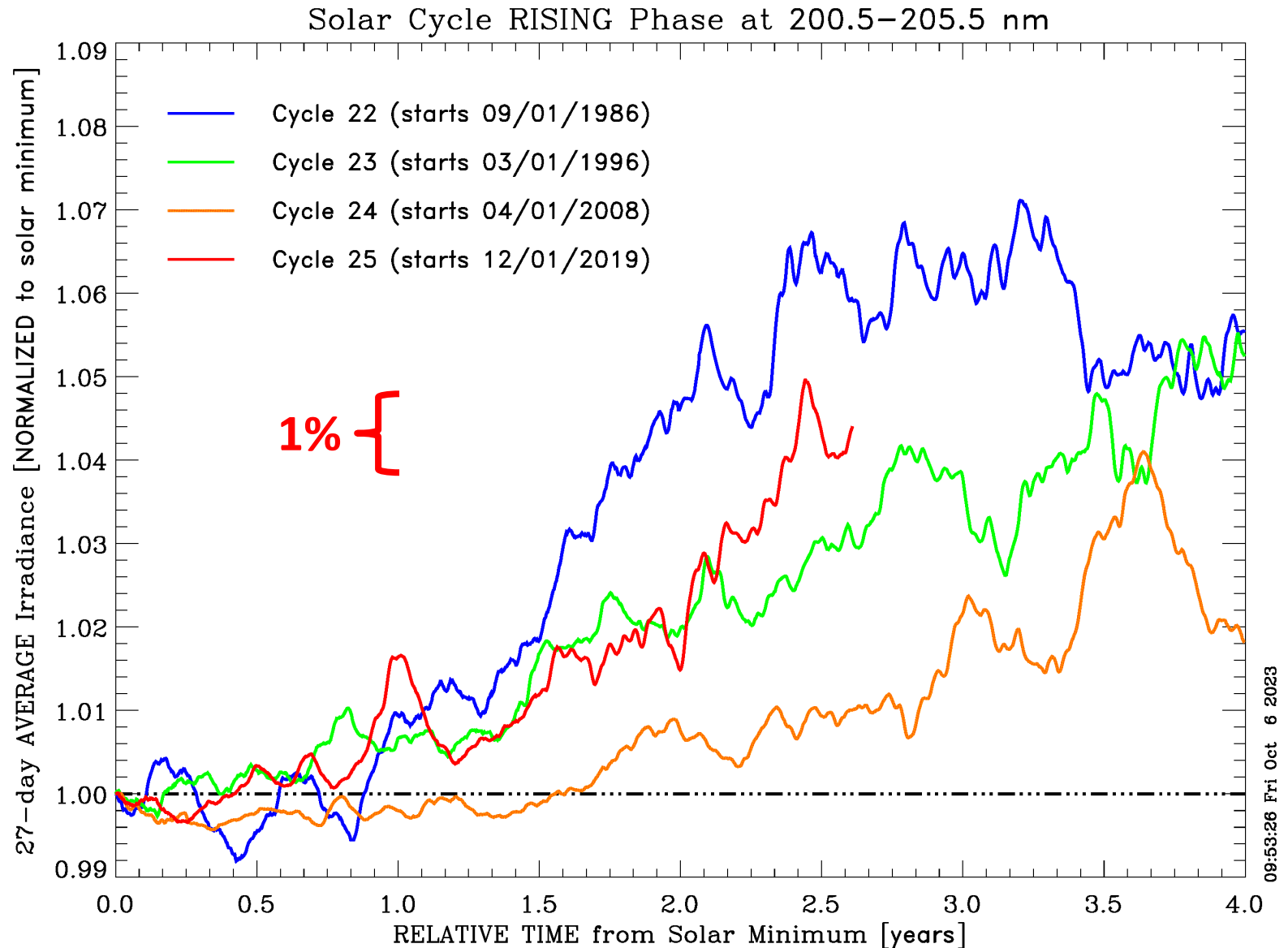
Lyman alpha – Rising phase, Cycles 22-25

- LASP composite data set [SME, UARS SOLSTICE, SORCE SOLSTICE, more]
- Cycle 25 is ahead of Cycle 24 and 23
- Possibly larger than Cycle 22?



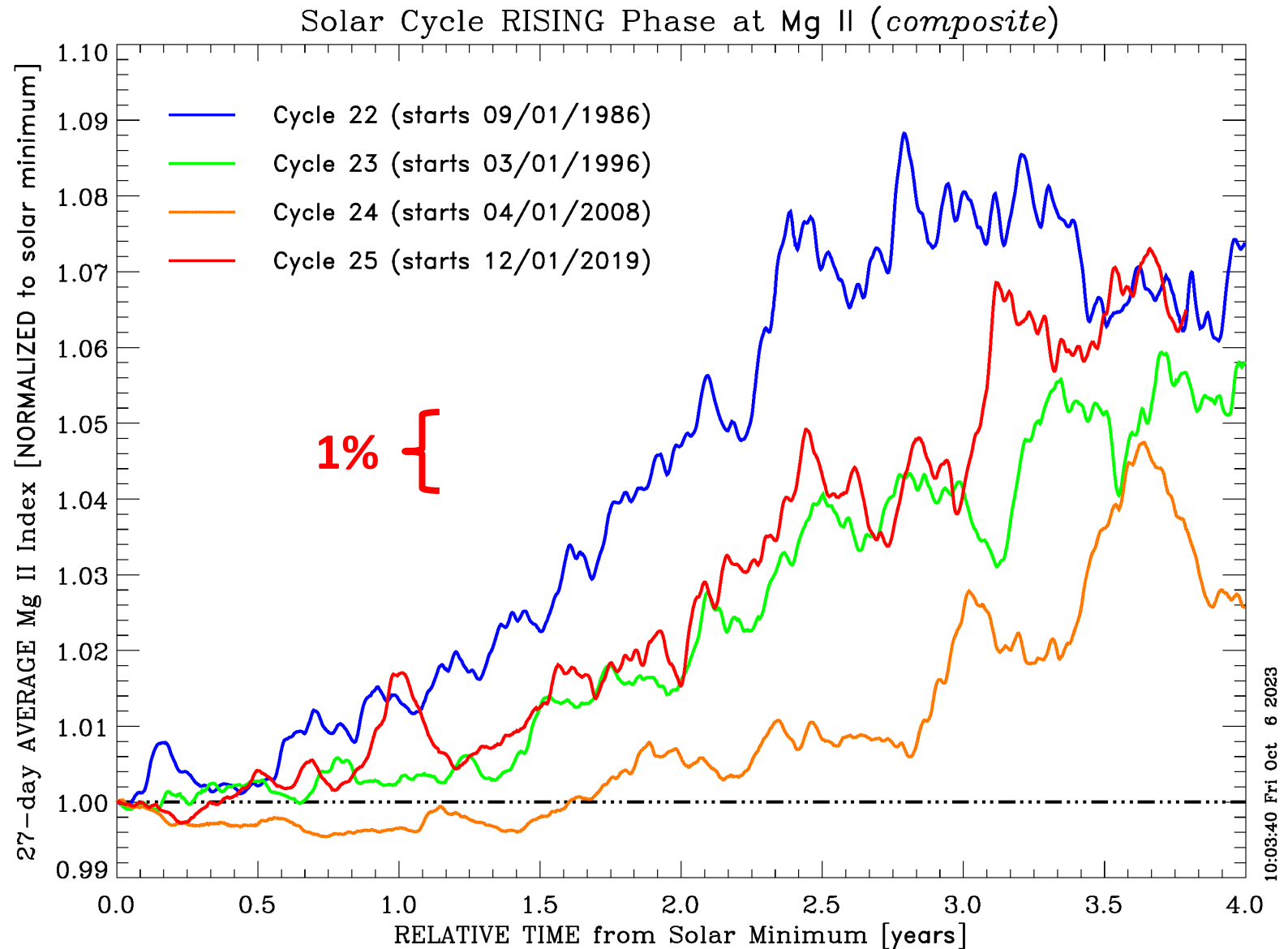
200-205 nm – Rising phase, Cycles 22-25

- GSFCSSI2 composite
- Synthetic data currently used for Cycle 25 (through July 2022)
- Larger than Cycle 24 and Cycle 23



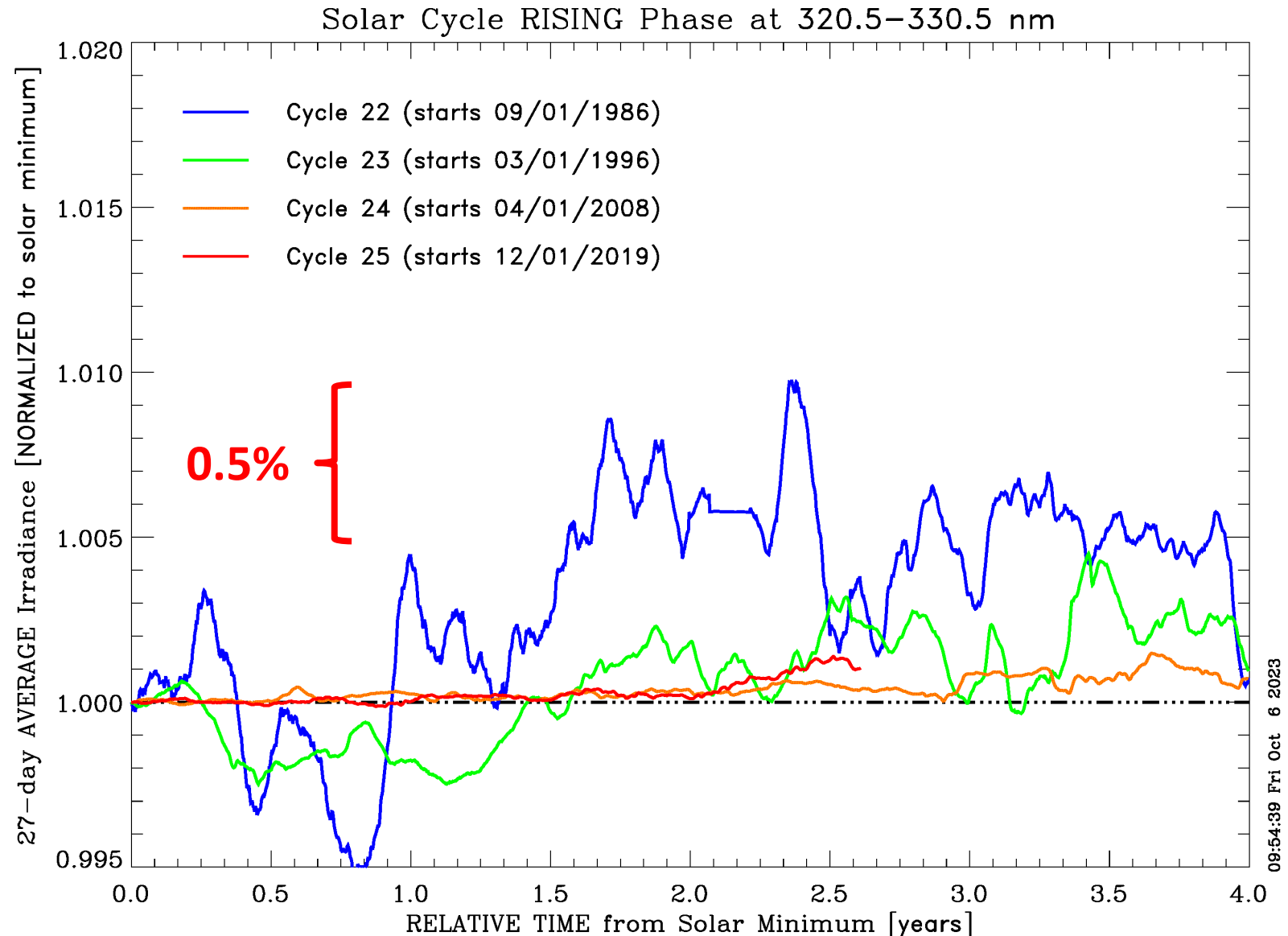
Mg II Index – Rising phase, Cycles 22-25

- Bremen composite Mg II index (converted to “classic” scale)
- Cycle 25 is larger than Cycle 24 and Cycle 23



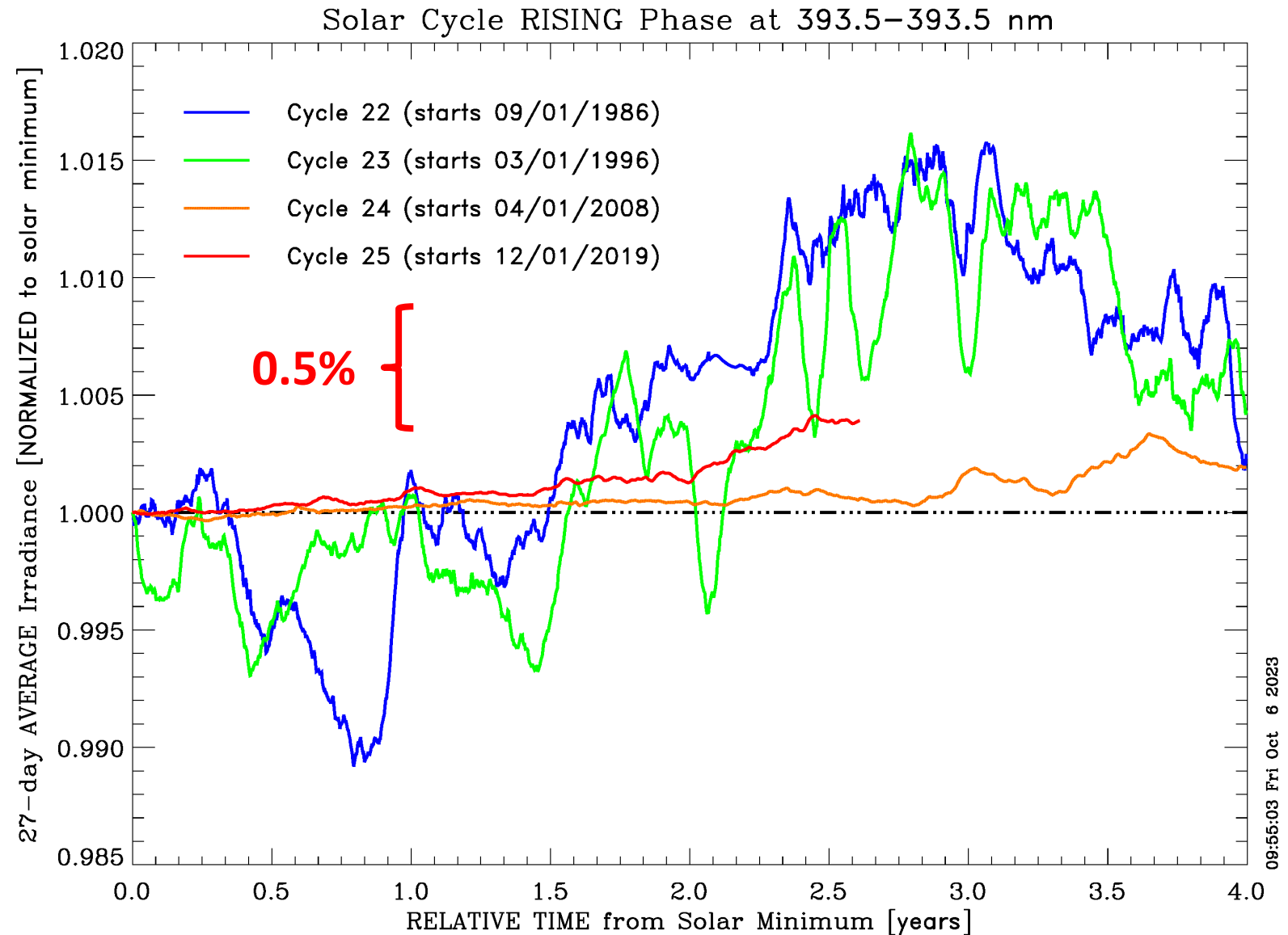
320-330 nm – Rising phase, Cycles 22-25

- GSFCSSI2 composite
- Aura OMI data for Cycle 25 (and 24)
- Cycle 25 is larger than Cycle 24
- Instrument noise limits evaluation of Cycles 22 and 23



393.5 nm (Ca II K) – Rising phase, Cycles 22-25

- GSFCSSI2 composite
- Aura OMI data for Cycle 25 (and 24)
- Cycle 25 is larger than Cycle 24
- Instrument noise limits evaluation of Cycles 22 and 23



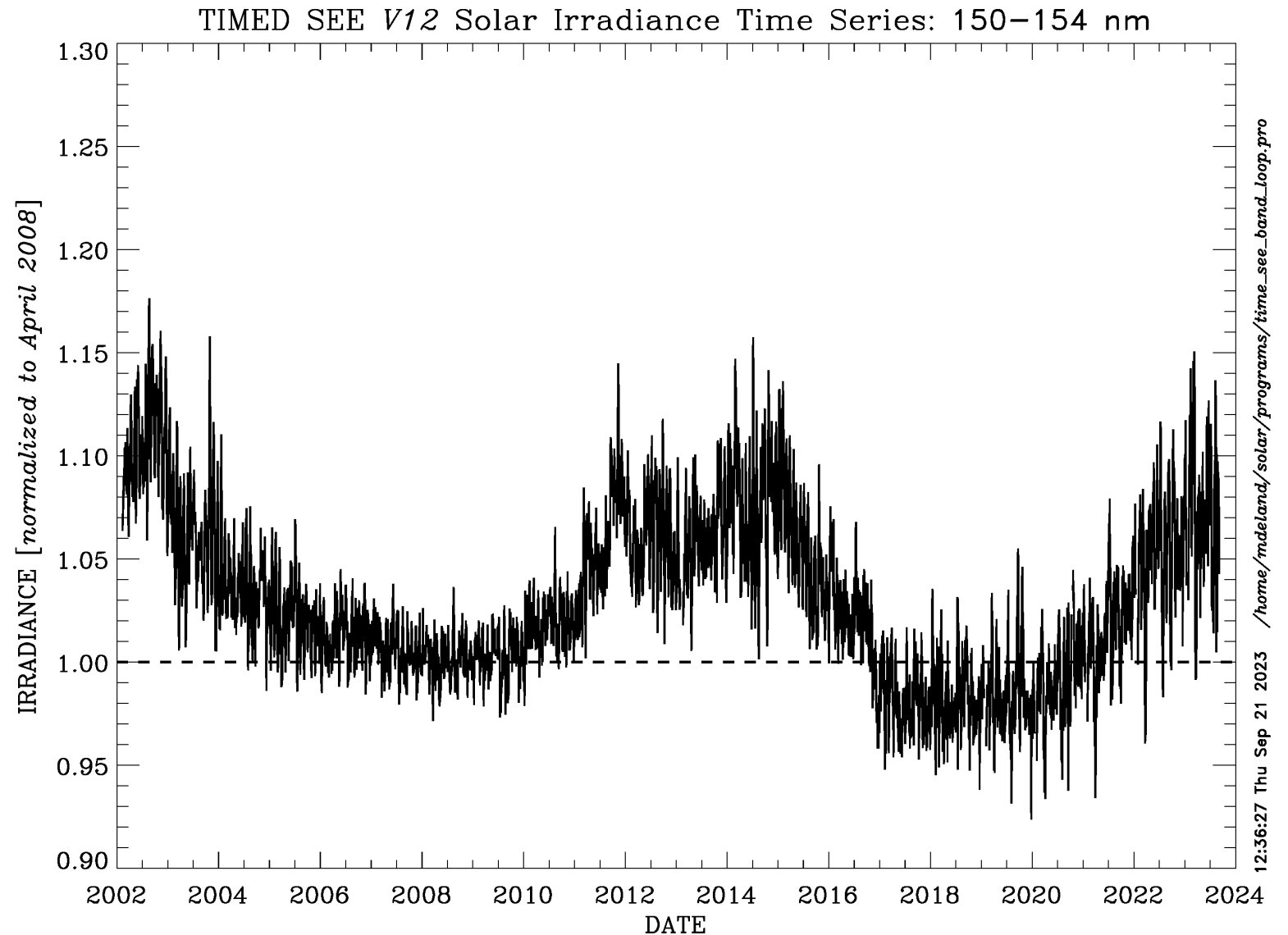
Conclusions

- Cycle 25 SSI activity has already exceeded Cycle 24 maximum, despite prediction of “quiet” cycle
- Many wavelengths have also reached or exceeded Cycle 23 maximum values
- Peak of Cycle 25 activity not expected for 1.5-2 years → Could reach Cycle 22 values (largest cycle observed with satellite instruments)
- *Stay tuned for more!*

Backup Slides

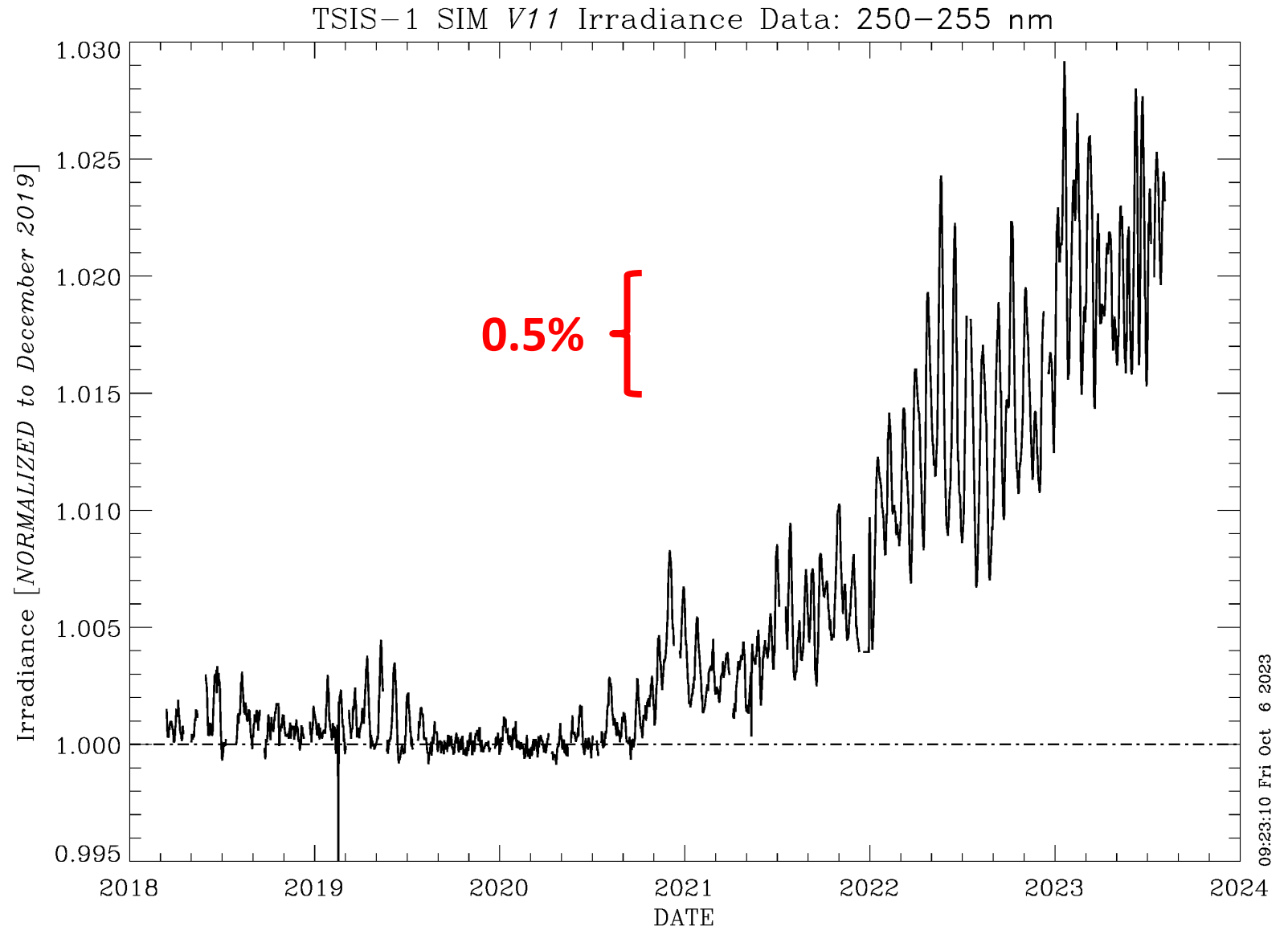
150-155 nm – TIMED SEE, Cycle 24-25

- Minimum in 2019 is ~2% lower than minimum in 2008
- Step change of -3% in late 2016?
- Current values are close to Cycle 24 maximum



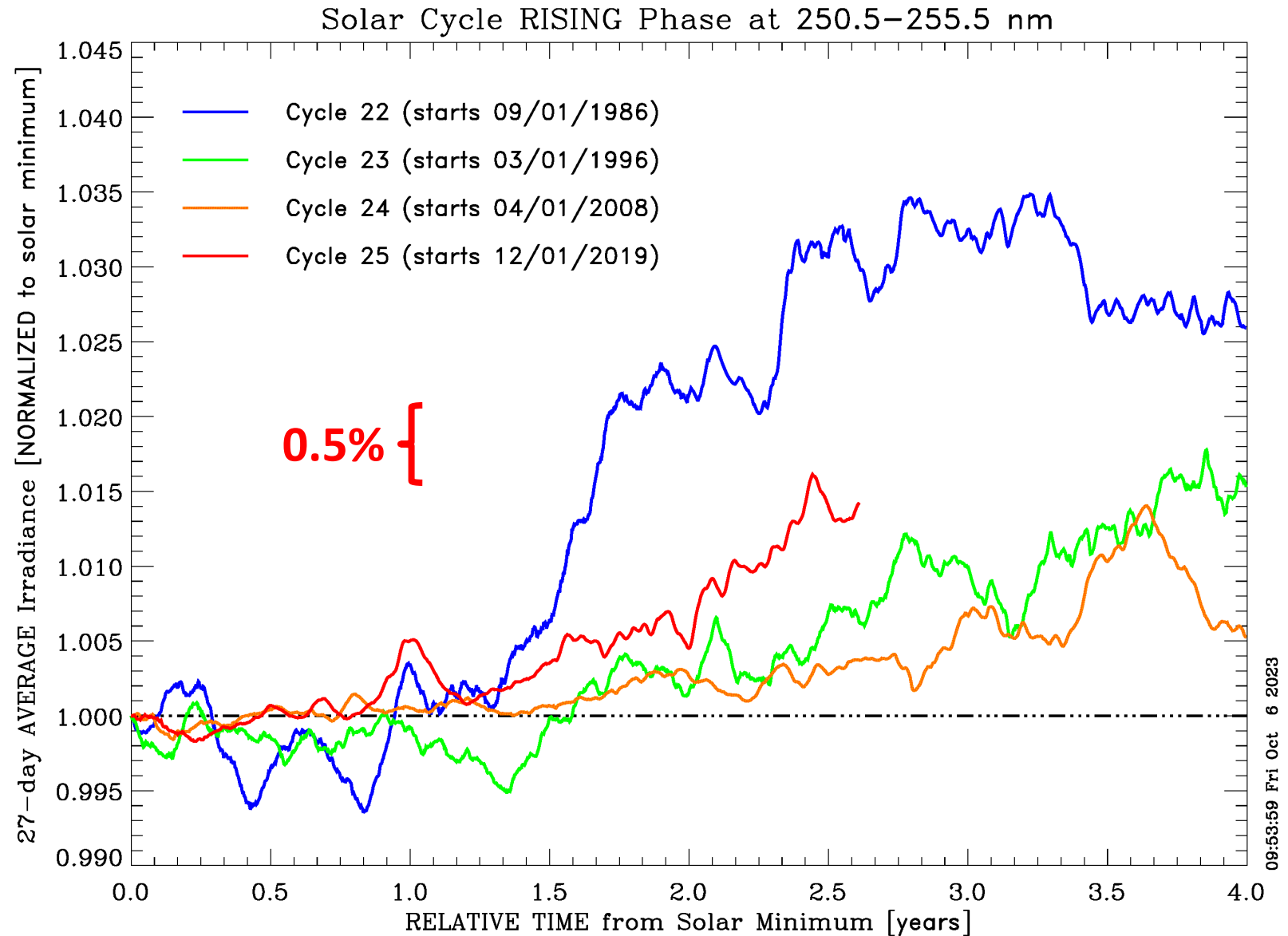
250-255 nm – TSIS-1 SIM, Cycle 25

- Some rotational activity in 2018 and 2019, much stronger in 2022
- Overall level increases in January 2022 and January 2023
- Small annual oscillation in data set



250-255 nm – Rising phase, Cycles 22-25

- GSFCSSI2 composite
- Synthetic data for Cycle 25 (through July 2022)
- Larger than Cycle 24 and Cycle 23



Comparison of Rising Phase Between Cycles

Bremen composite Mg II index

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