

About one-order of magnitude **smaller**,  
**but still challenging and breakthrough:**  
the case for **solar telescopes**

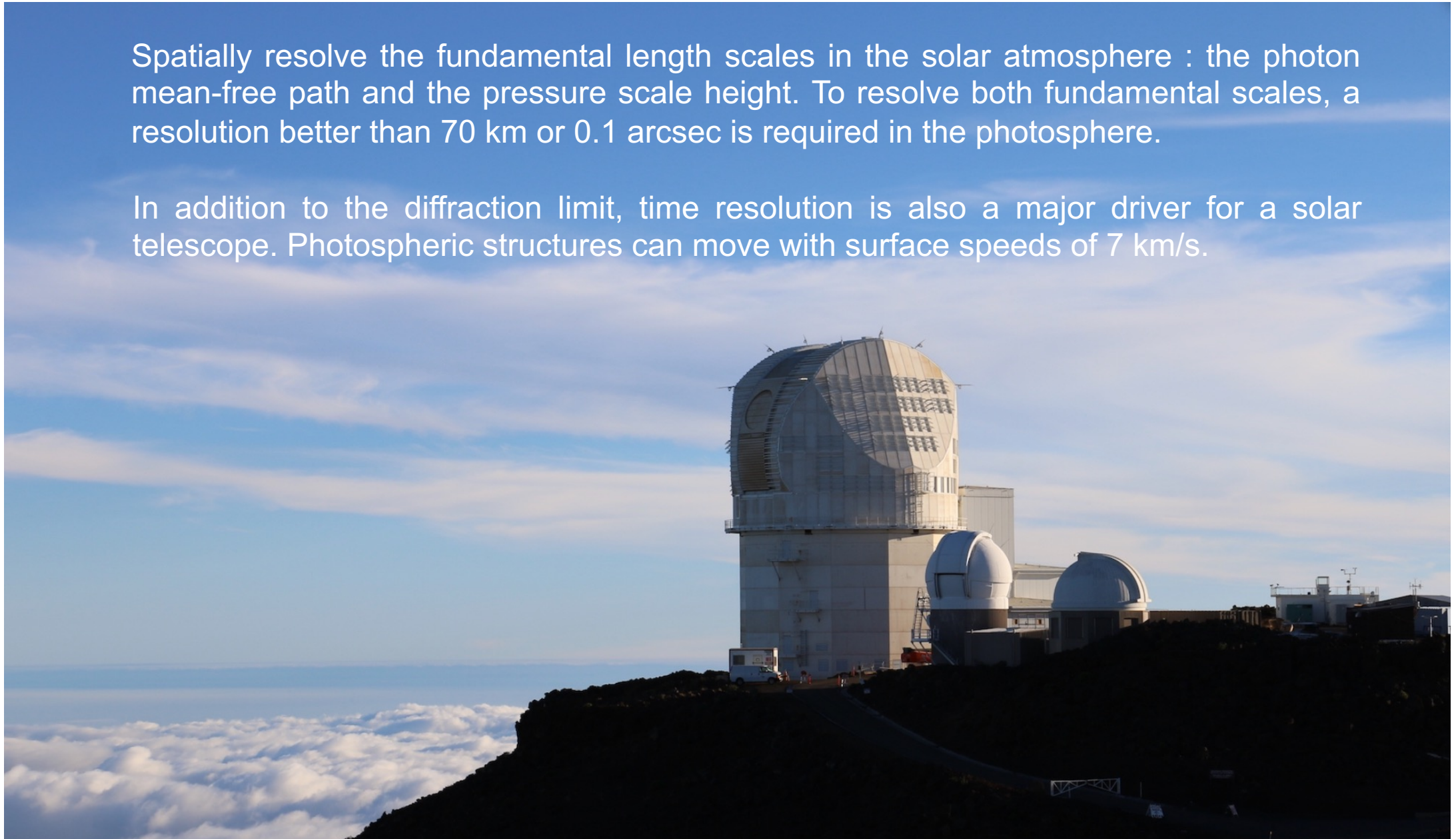
**Ilaria Ermolli**

INAF Osservatorio Astronomico di Roma

Chianti Topics VI – 27/02/2024

Spatially resolve the fundamental length scales in the solar atmosphere : the photon mean-free path and the pressure scale height. To resolve both fundamental scales, a resolution better than 70 km or 0.1 arcsec is required in the photosphere.

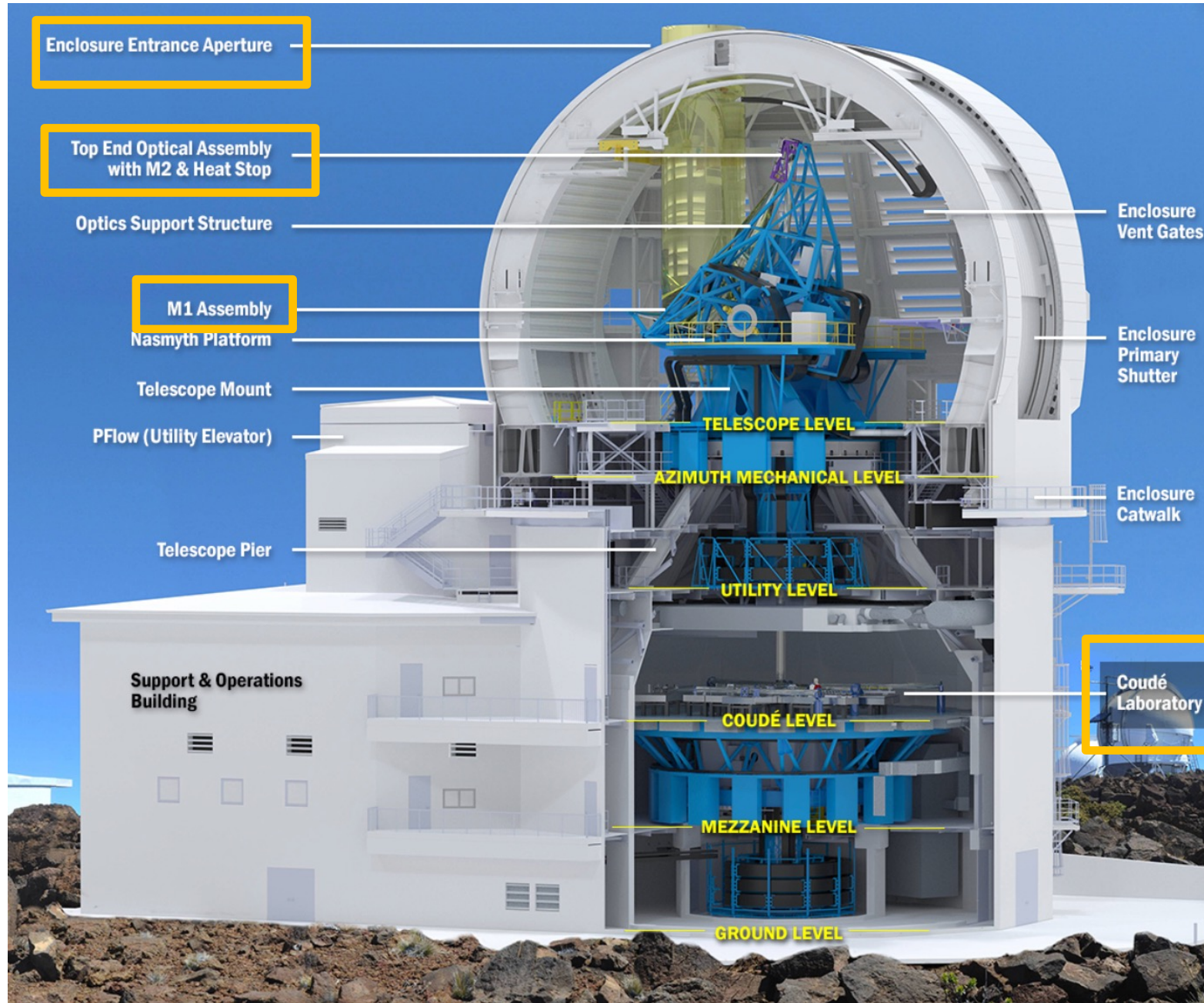
In addition to the diffraction limit, time resolution is also a major driver for a solar telescope. Photospheric structures can move with surface speeds of 7 km/s.



DKIST Daniel K. Inouye Solar Telescope, Haleakala, Maui, HW

Passing only 5 arcmin circular FOV  
 Reduces heat load from 12000W to 300 W on subsequent optics.  
 Actively cooled with liquid  
 12 mm diameter

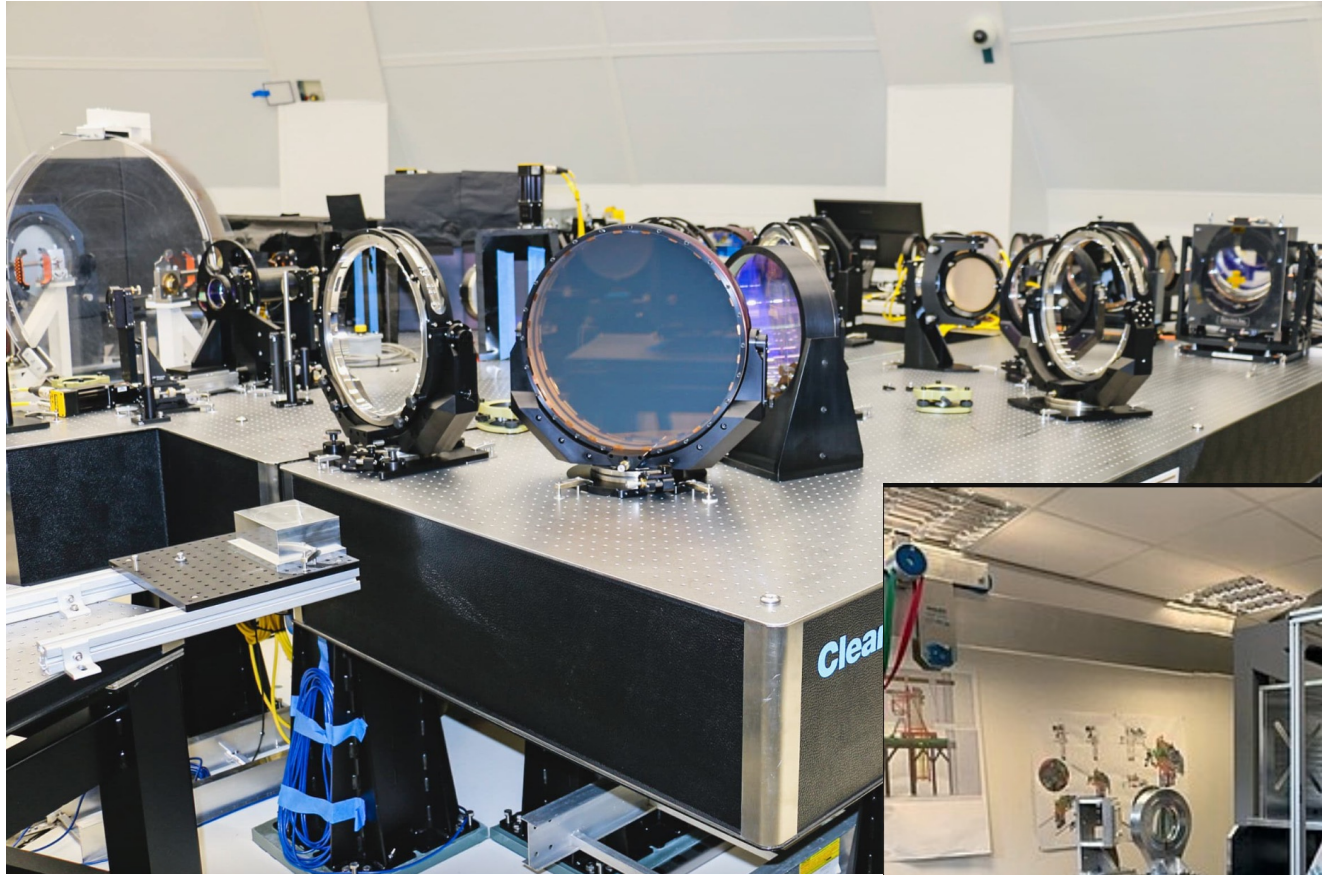
4m clear aperture  
 actively cooled from rear side with chilled air  
 Active shape control



Rotating platform  
 16.5m diameter  
 150-ton  
 First light facility  
 Instruments and  
 Wave-front  
 correction system  
 (WFC)

1600-actuator DM, a correlating Shack-Hartmann WFS, a fast tip-tilt mirror, and an FPGA-based control system. Running at a nominal rate of 1975 Hz.

Credits: NSO, USA; KIS, D

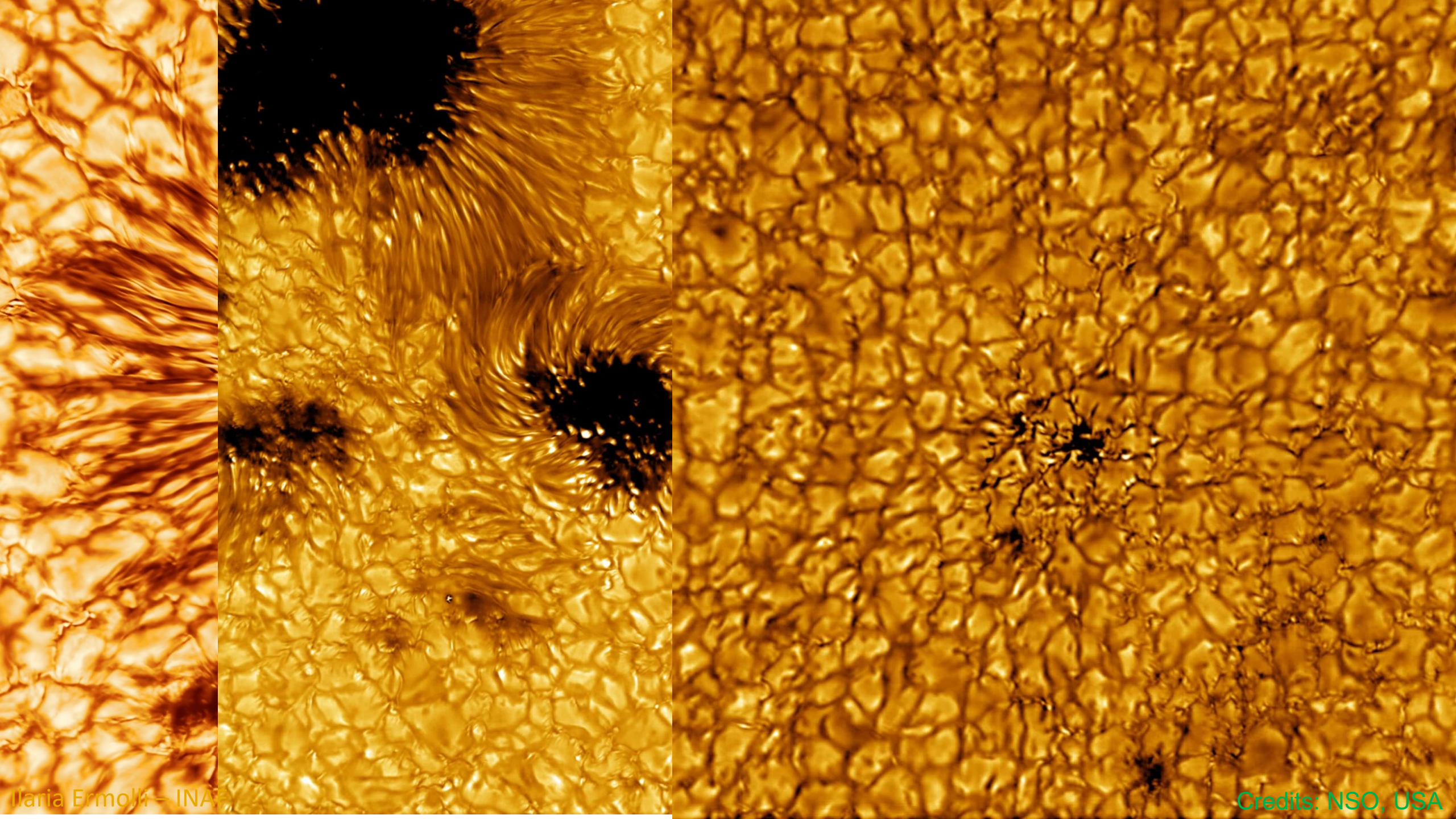


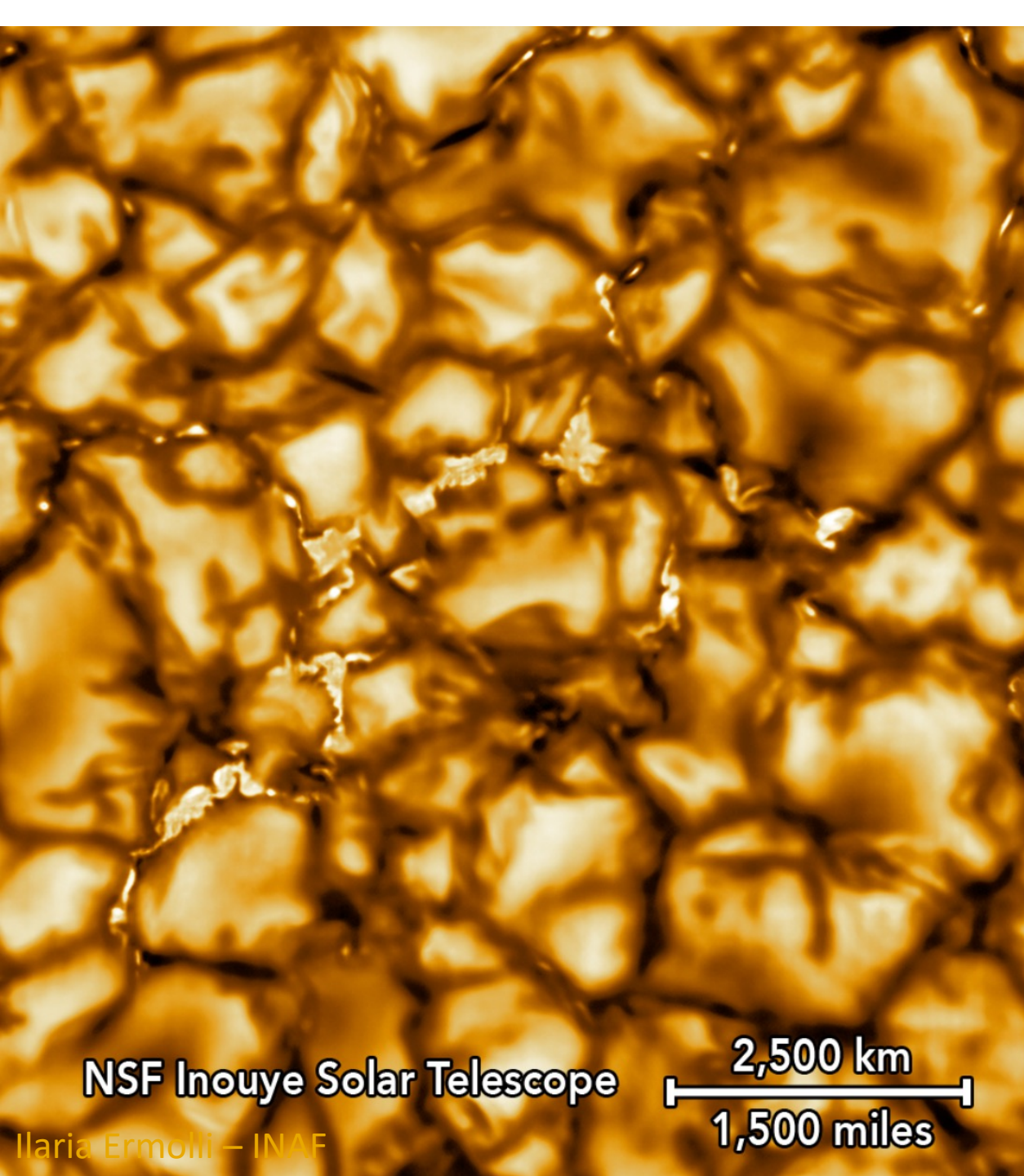
VBI Visible Broad Band Imager



Credits VTF team/KIS

VTF Visible Tunable Filter @ KIS

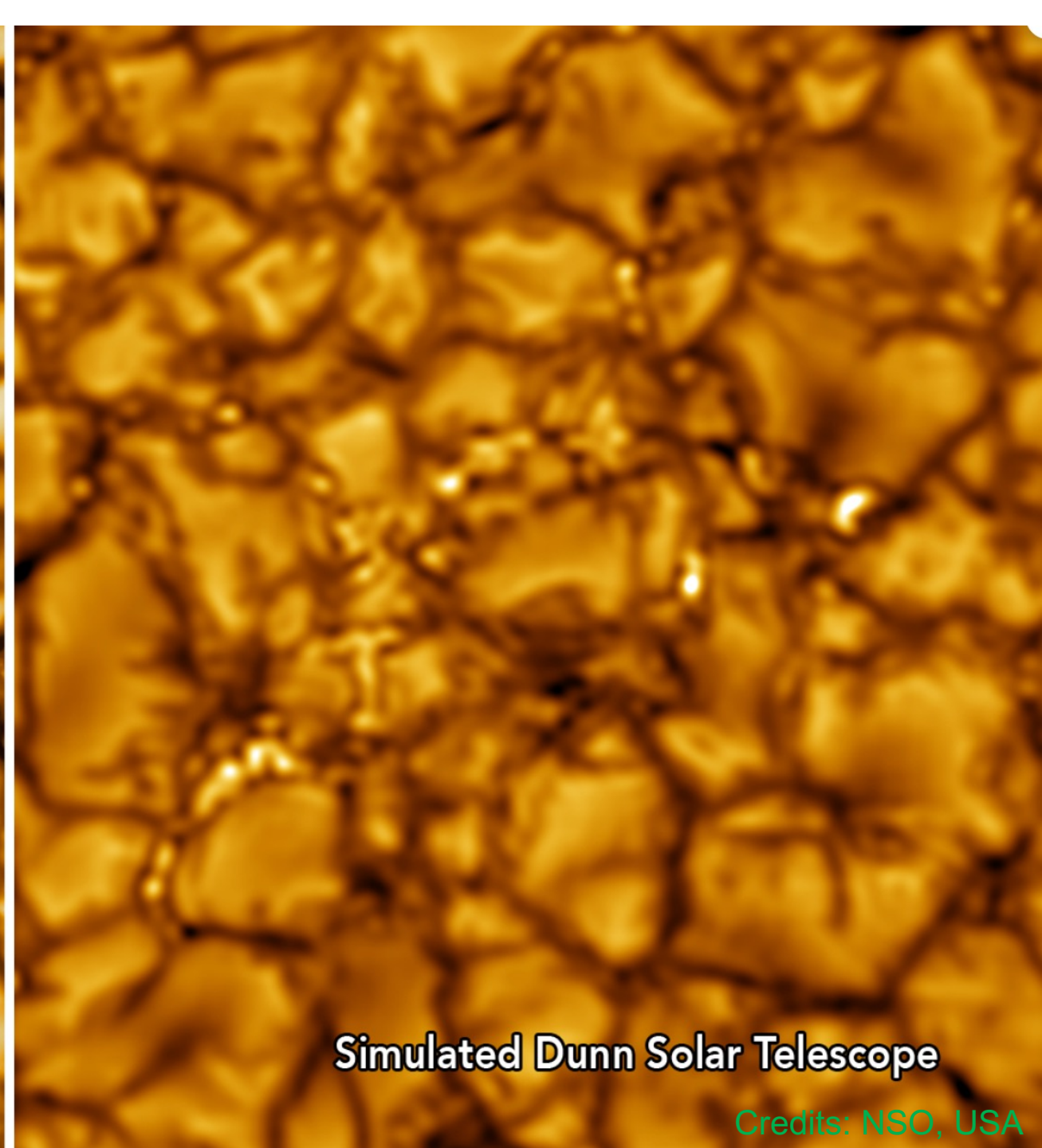




**NSF Inouye Solar Telescope**

2,500 km  
1,500 miles

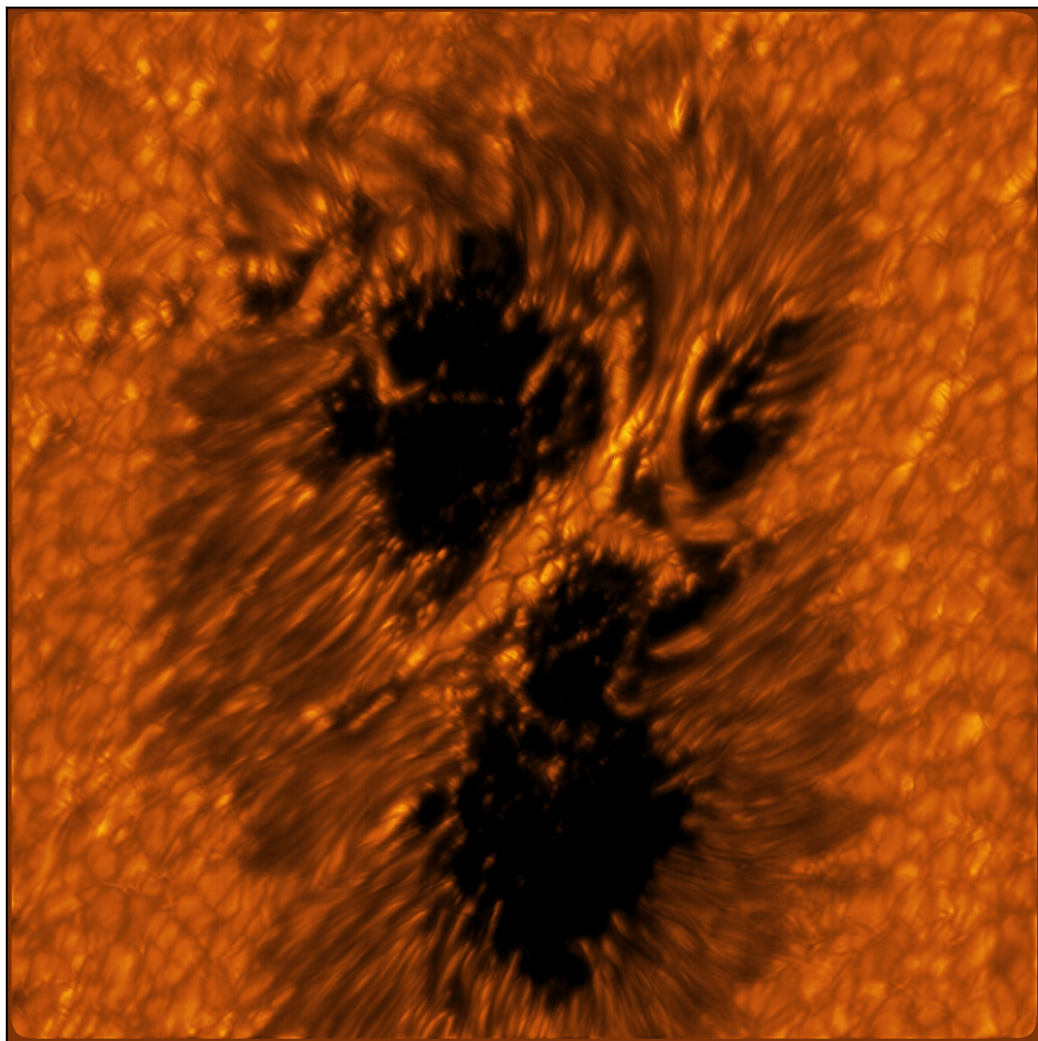
Ilaria Ermoli – INAF



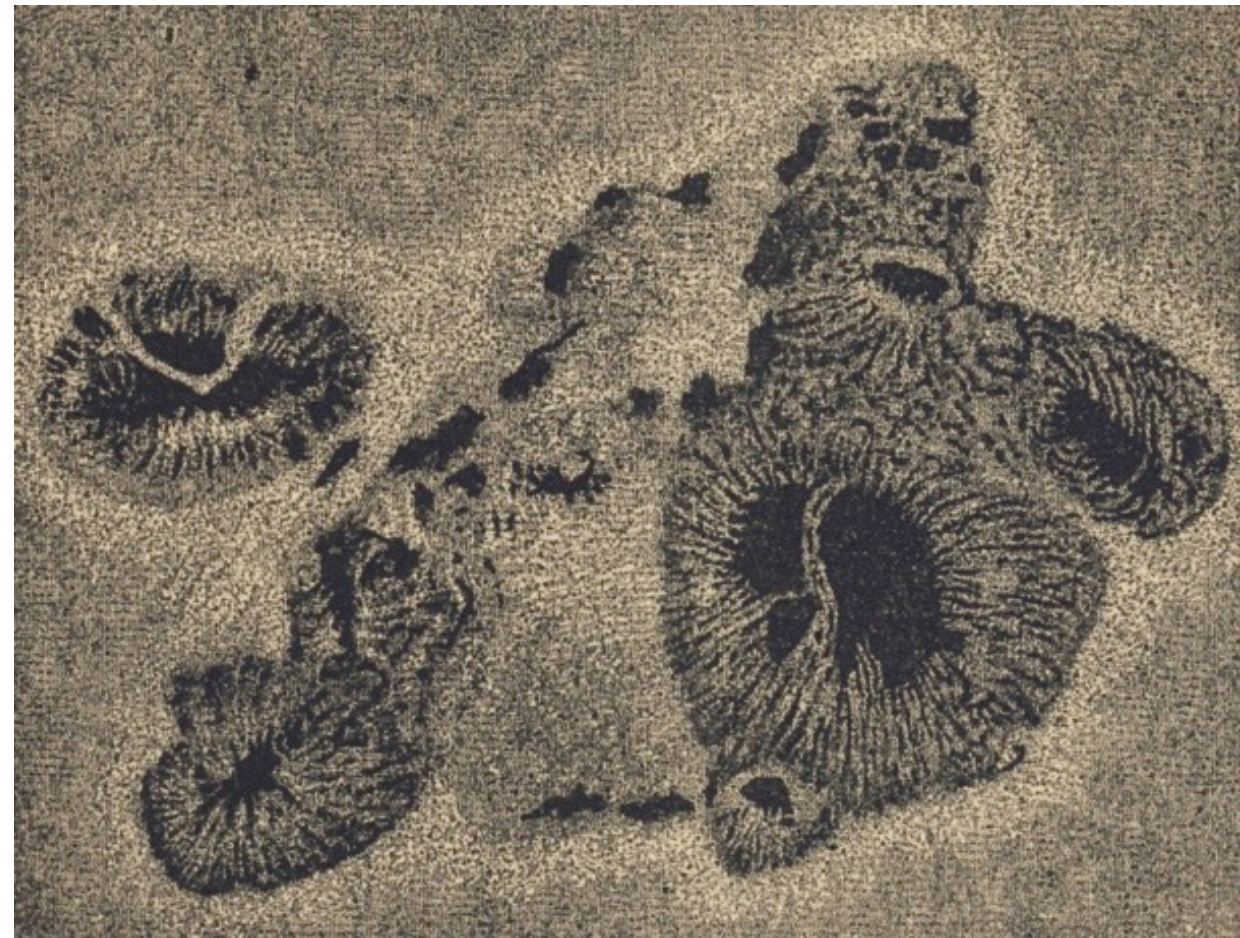
**Simulated Dunn Solar Telescope**

Credits: NSO, USA

2022-12-27T19:32:49.000 WVL= 450.4 nm

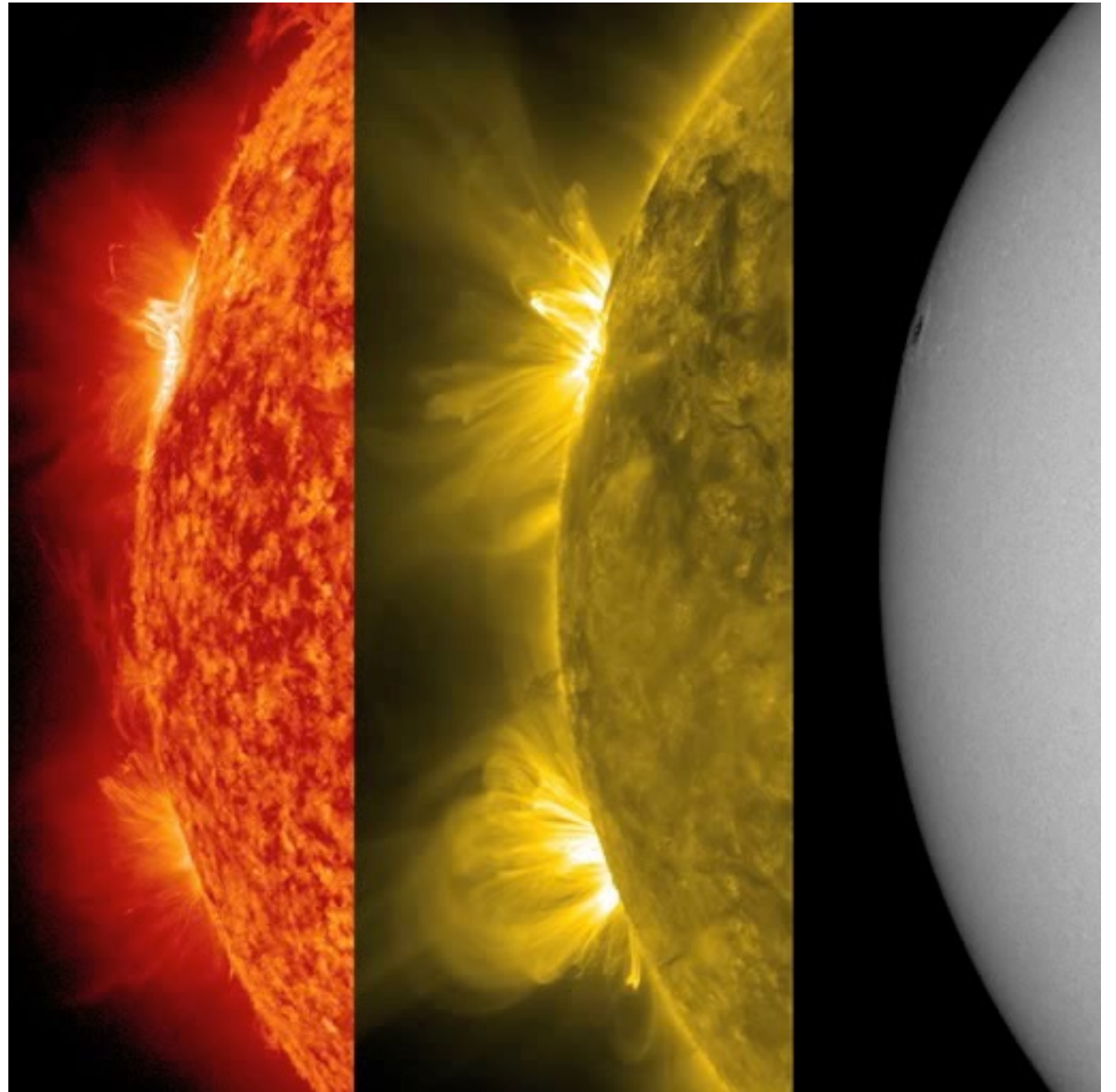


DKIST



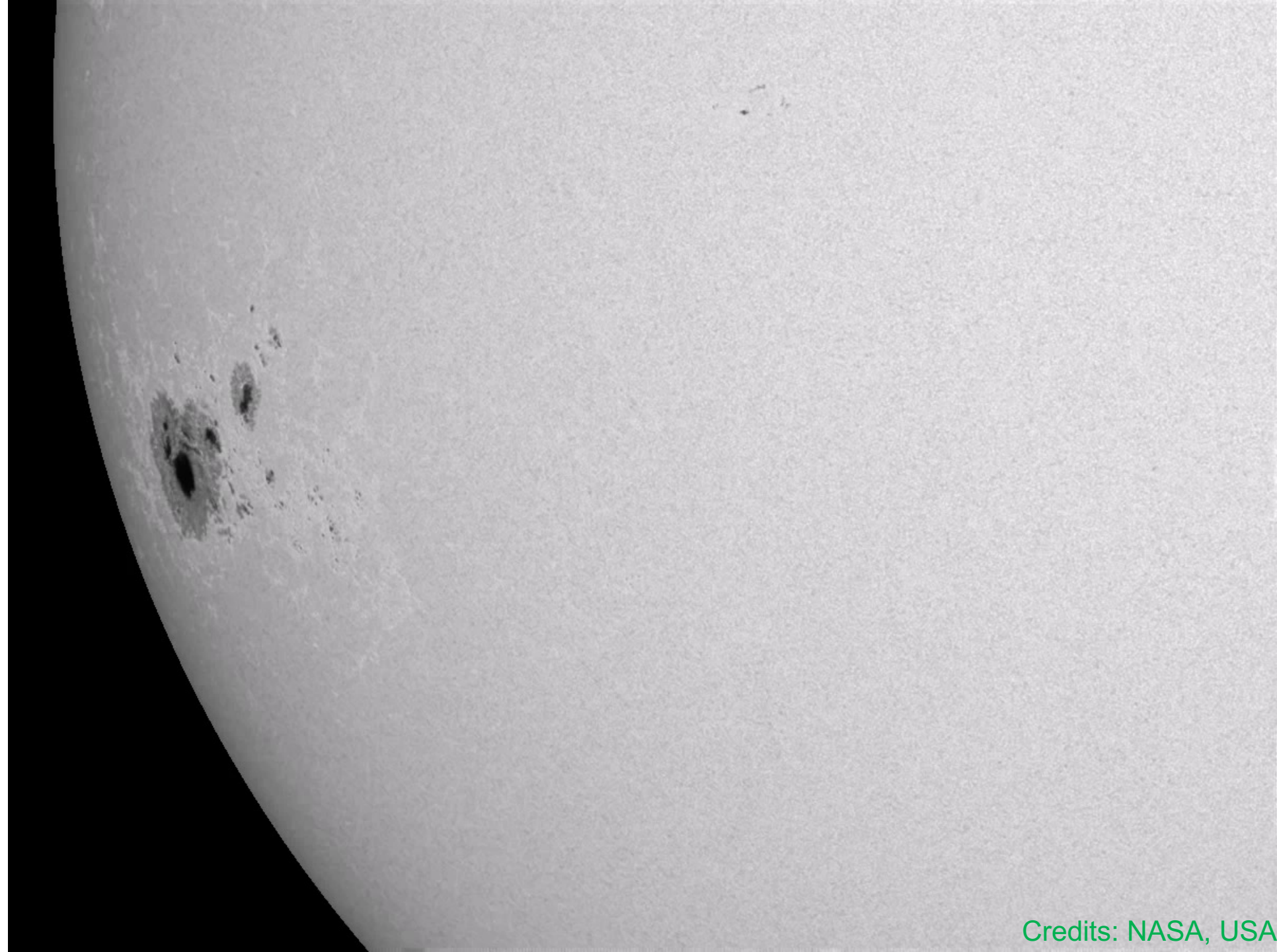
Angelo Secchi 1858

**Study  
fundamental  
astrophysical  
processes** at  
their fundamental  
length scales

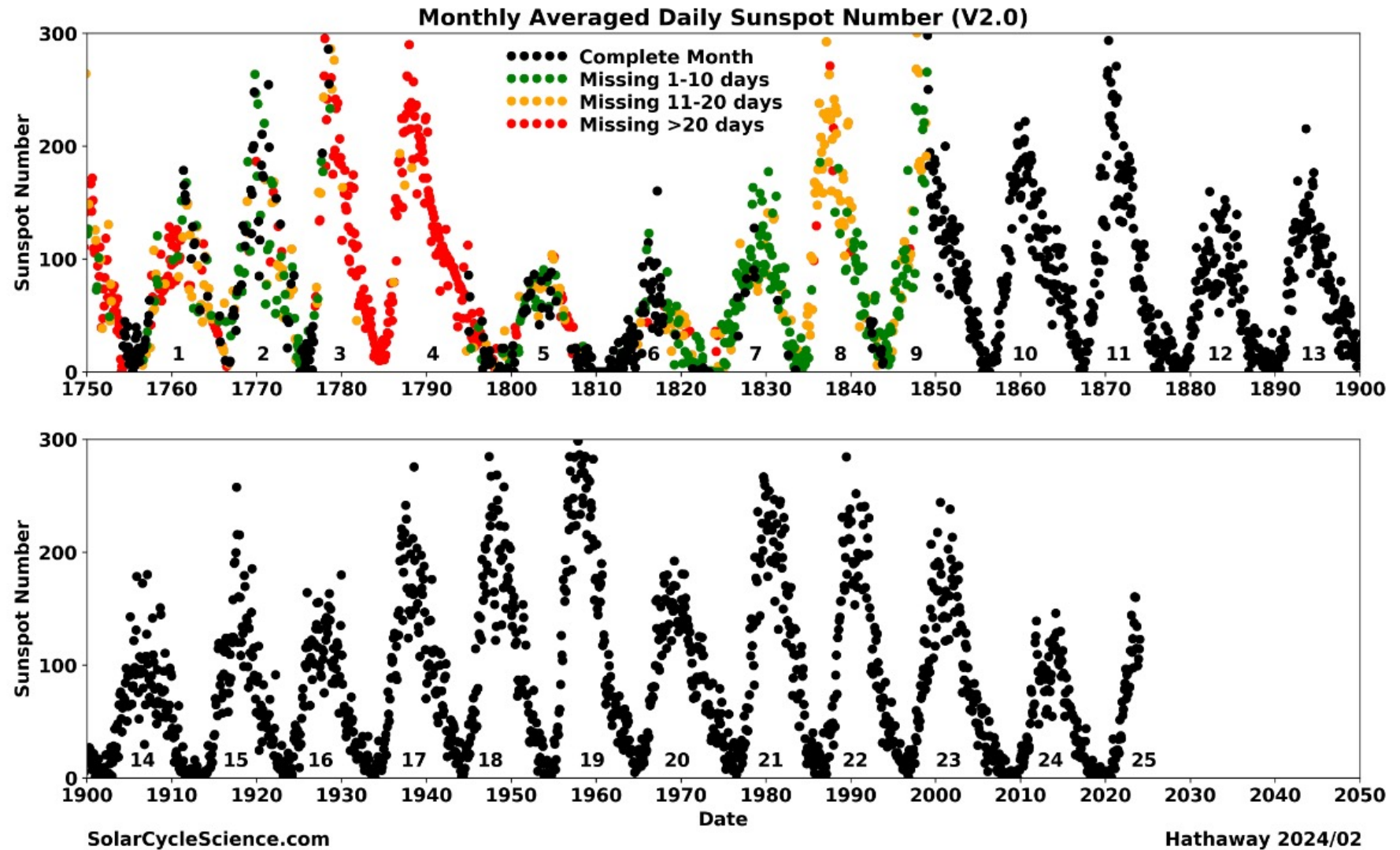




Understand  
the  
**plasma-  
magnetic  
field**  
**interplay**  
driving the  
**evolution**  
of magnetic  
regions

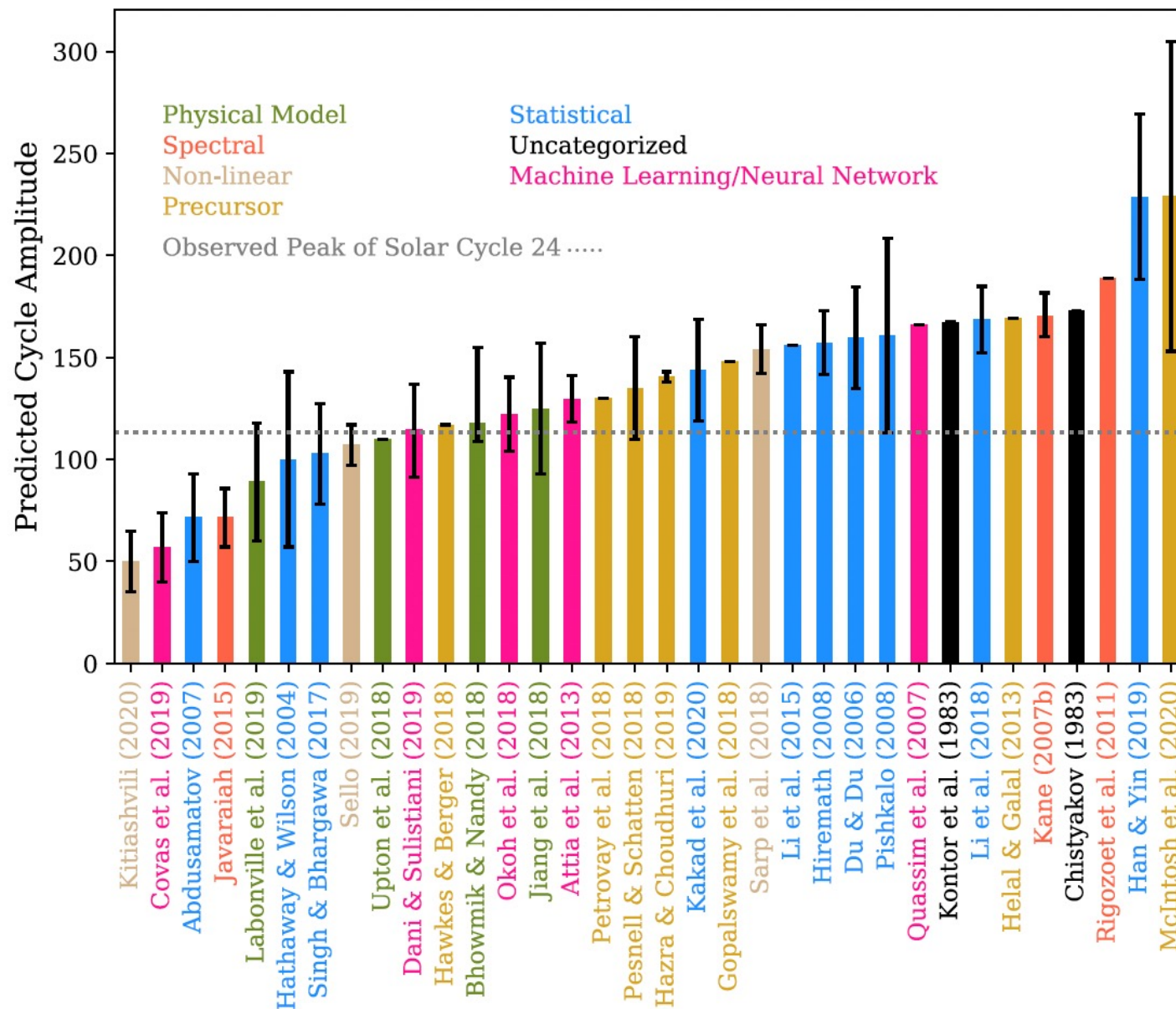


# Understand solar variability

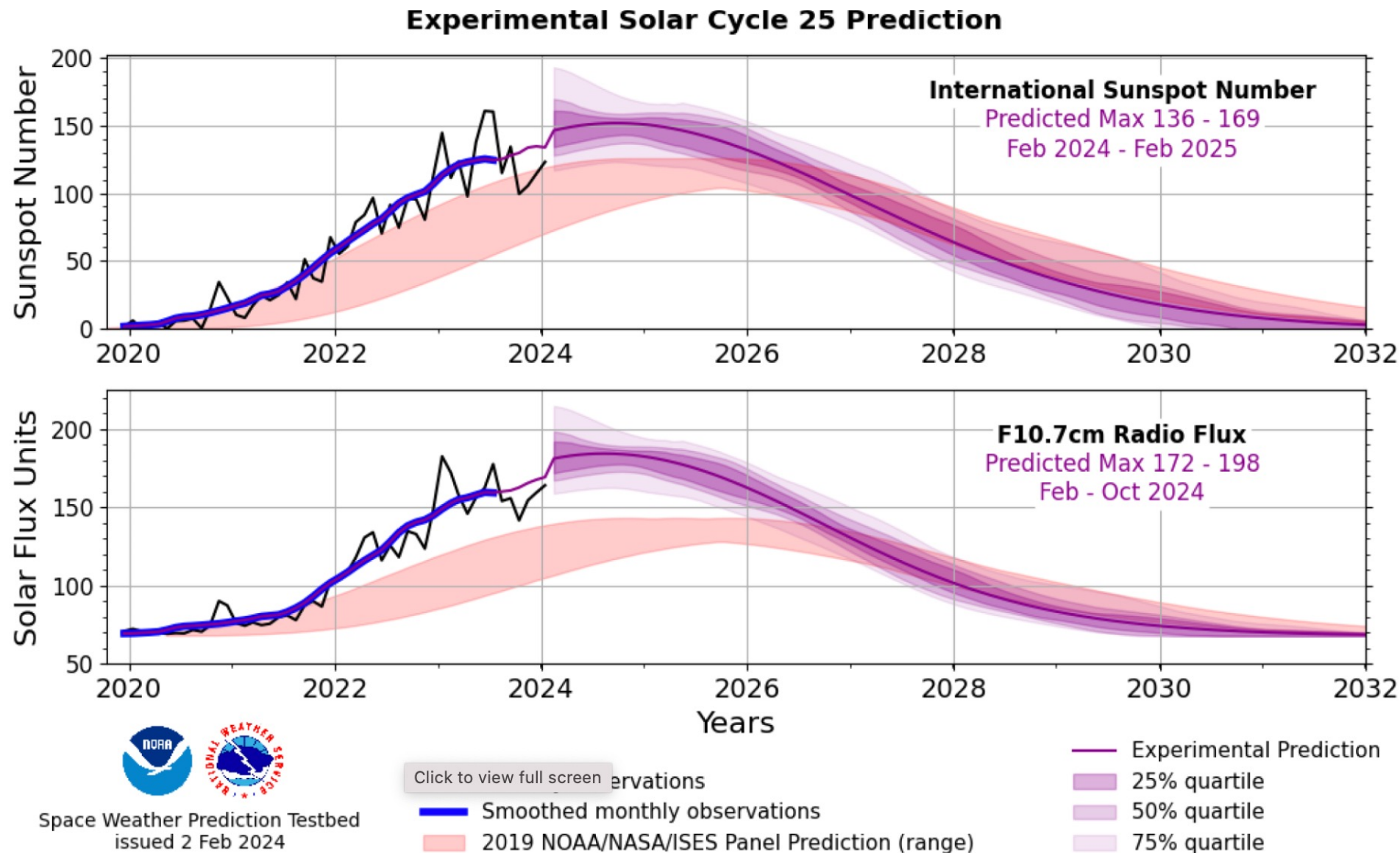


Understand  
solar  
variability  
and  
**accurately  
predict its  
basic  
aspects**

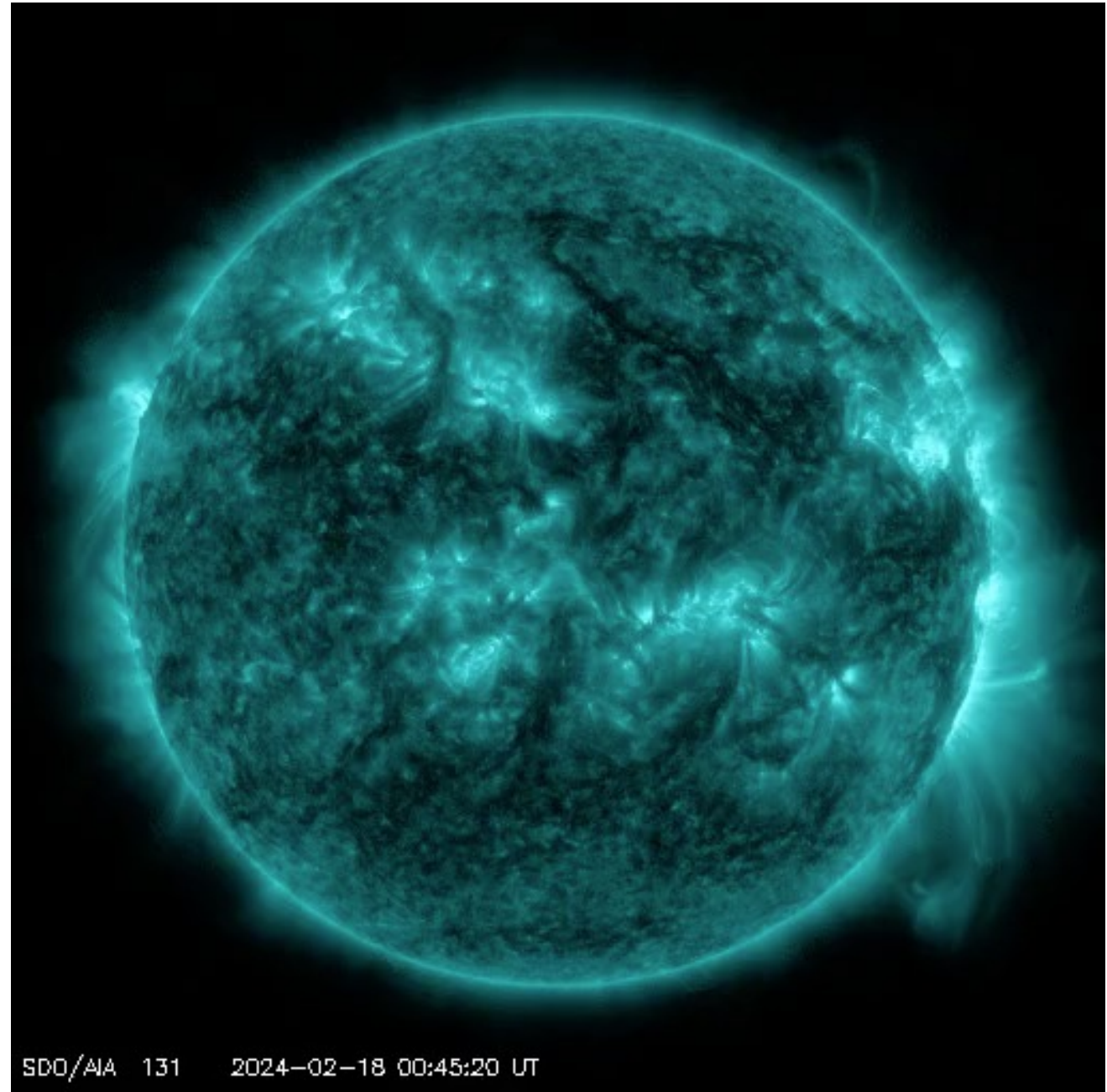
SOLAR CYCLE 25 PREDICTIONS



Understand solar variability and accurately predict its basic aspects



# Predict disturbances of the space environment induced by the Sun



# Predict disturbances of the space environment induced by the Sun

**NOAA NATIONAL WEATHER SERVICE**  
**SPACE WEATHER PREDICTION CENTER**  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Monday, February 26, 2024 11:43:15 UTC

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### SPACE WEATHER CONDITIONS on NOAA Scales

24-Hour Observed Maximums	Latest Observed	Predicted 2024-02-26 UTC
<b>R1</b> minor	<b>S</b> none	<b>G</b> none
<b>S</b> none	<b>S</b> none	<b>G</b> none
<b>G</b> none	<b>G</b> none	<b>G</b> none

Solar Wind Speed: **430** km/sec      Click the scale value for more information      Solar Wind Magnetic Fields: Bt **5** nT, Bz **3** nT      Noon 10.7cm Radio Flux: **181** sfu

#### STRONG Flare Event

Updated 22 Feb 2024 1800 EST  
WHAT: X6.3 Flare Occurred from NOAA/SWPC Region 3590

**R3**

**EVENT:**  
A flare is an eruption of energy from the Sun that generally lasts minutes to hours. Flares of this magnitude are not frequent.

**TIMING:**  
The flare peaked at 22/1734 EST

**EFFECTS:**  
Users of high frequency (HF) radio signals may experience temporary degradation or complete loss of signal on much of the sunlit side of Earth. The general public need not be concerned.

#### Strongest Flare of the Current Solar Cycle

published: Thursday, February 22, 2024 23:44 UTC  
Another X-class flare from Region 3590 peaked at approximately 1734 EST on Feb. 22, 2024.

#### Two Major Solar Flares; Effects on Cellular Networks Unlikely

published: Thursday, February 22, 2024 19:30 UTC  
The Sun emitted two strong solar flares (both R3 on the NOAA Space Weather Scales), the first one peaking at 6:07 p.m. EST on Feb.

#### 21 & 22 Feb R3 Events

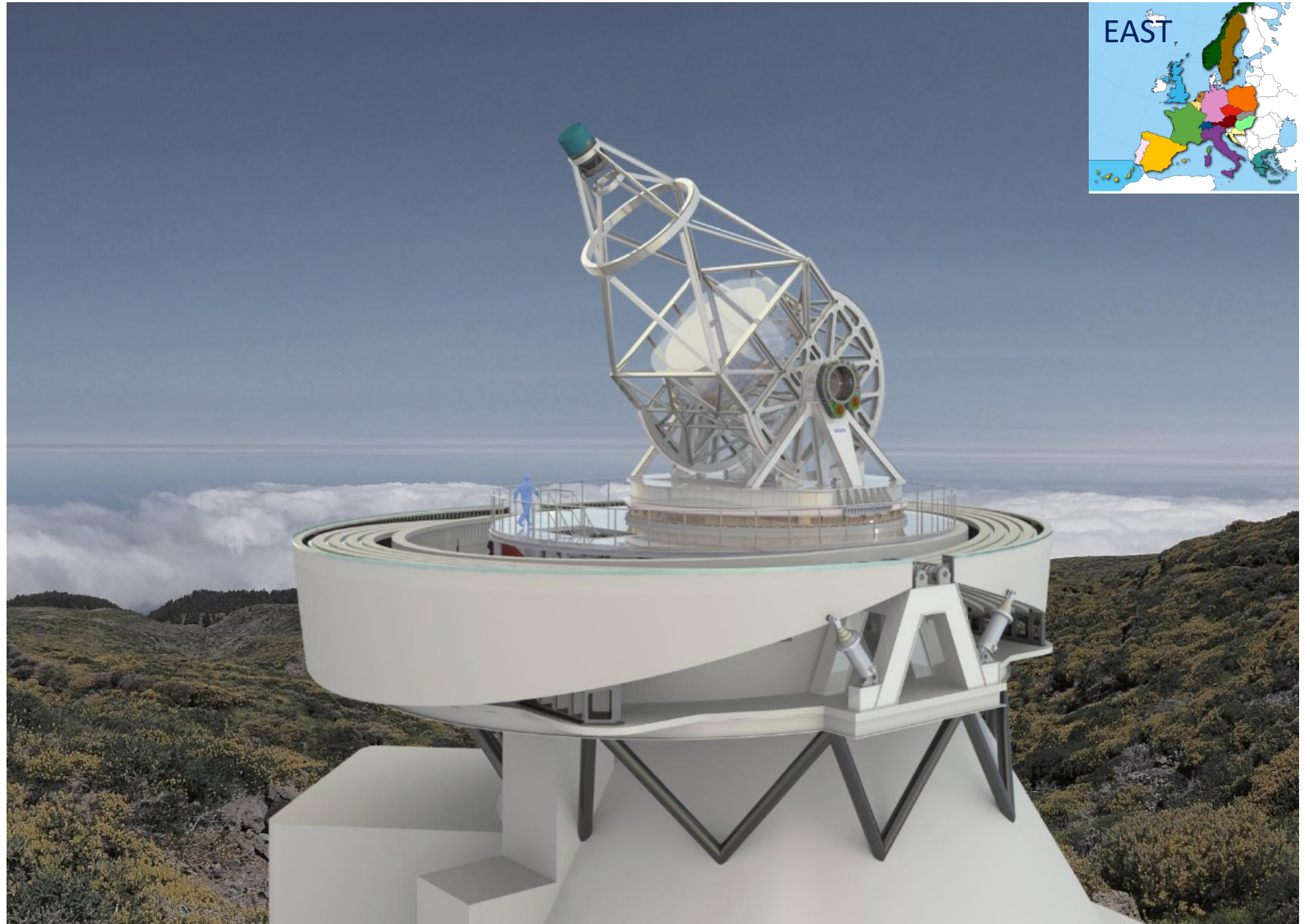
published: Thursday, February 22, 2024 06:52 UTC  
X1.8 and X1.7 flares from Region 3590 occurred at 21/2307 UTC and 22/0632 UTC.

#### Are You Ready for the April 8 Total Solar Eclipse?

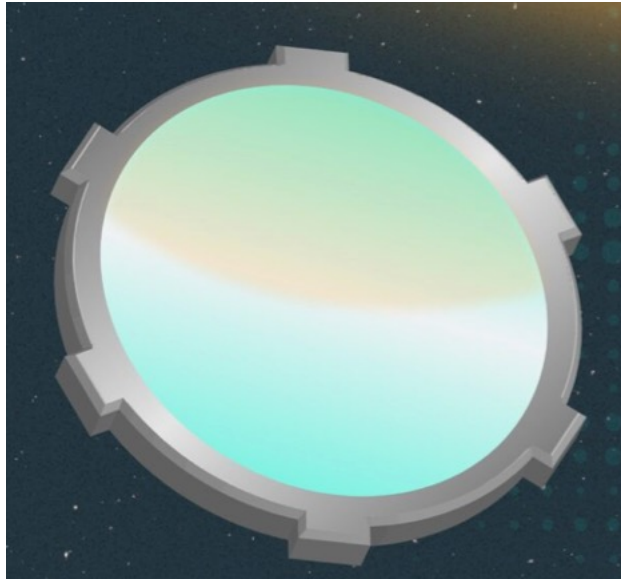
published: Wednesday, February 21, 2024 20:24 UTC  
The National Environmental Satellite, Data, and Information Service (NESDIS) has created an interactive map.

National Oceanic and Atmospheric Administration      Safeguarding Society with Actionable Space Weather Information      Space Weather Prediction Center; Boulder, CO

# EST European Solar Telescope



# GIANT



DKIST/4m



# LARGE



NGST/1.6m  
GREGOR/1.5m



SST/1.m  
THEMIS/0.9m



DST/0.7m  
VTT/0.7m





NGST



THEMIS



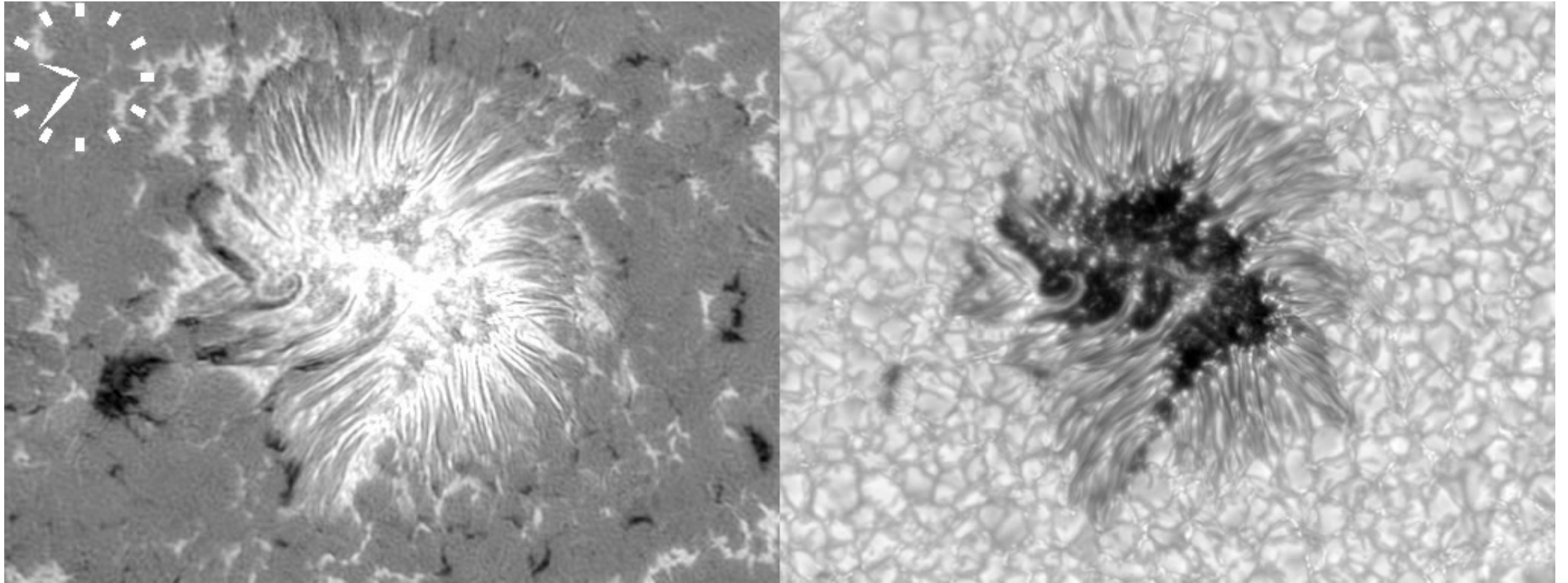
SST



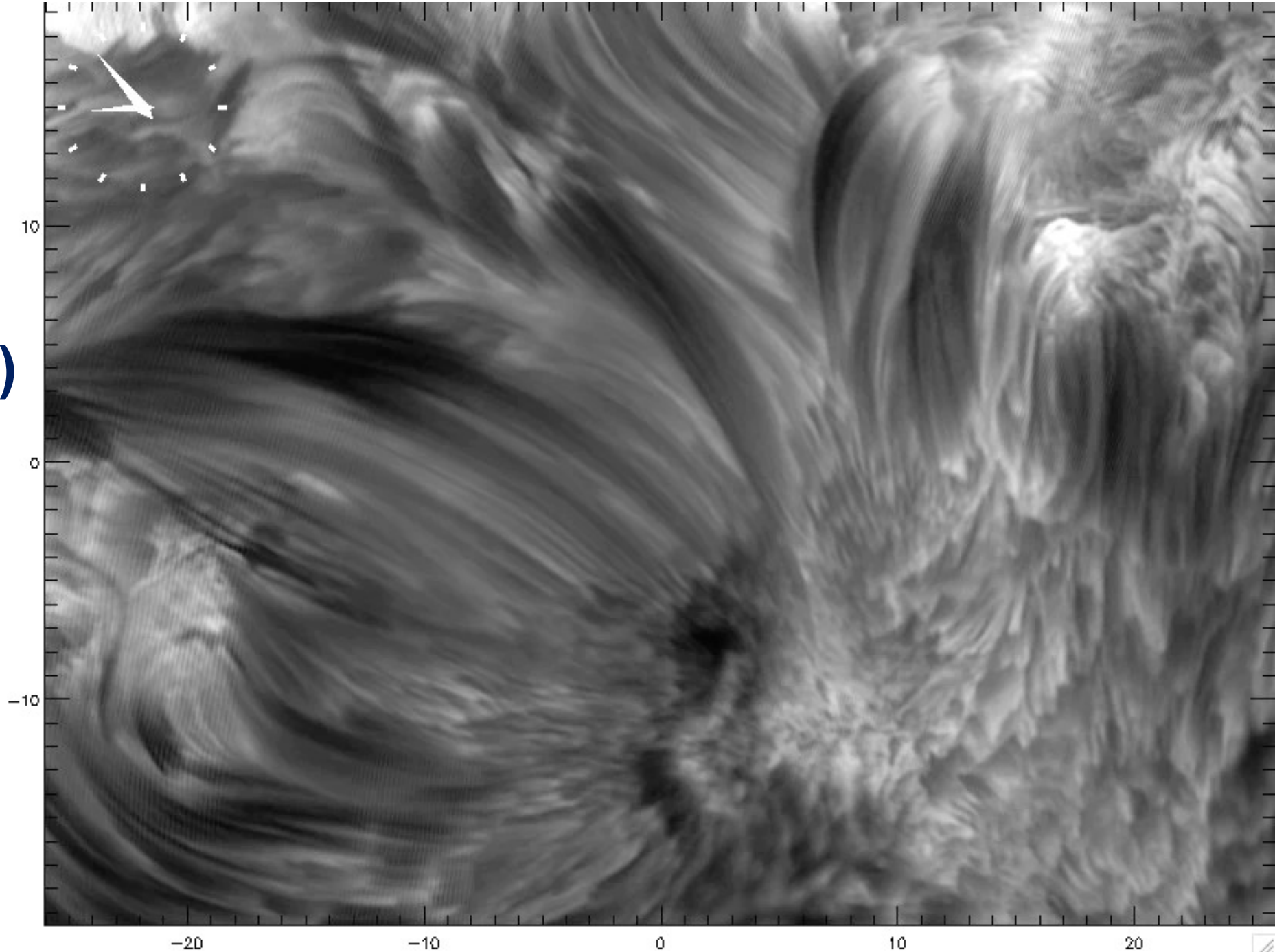
DST



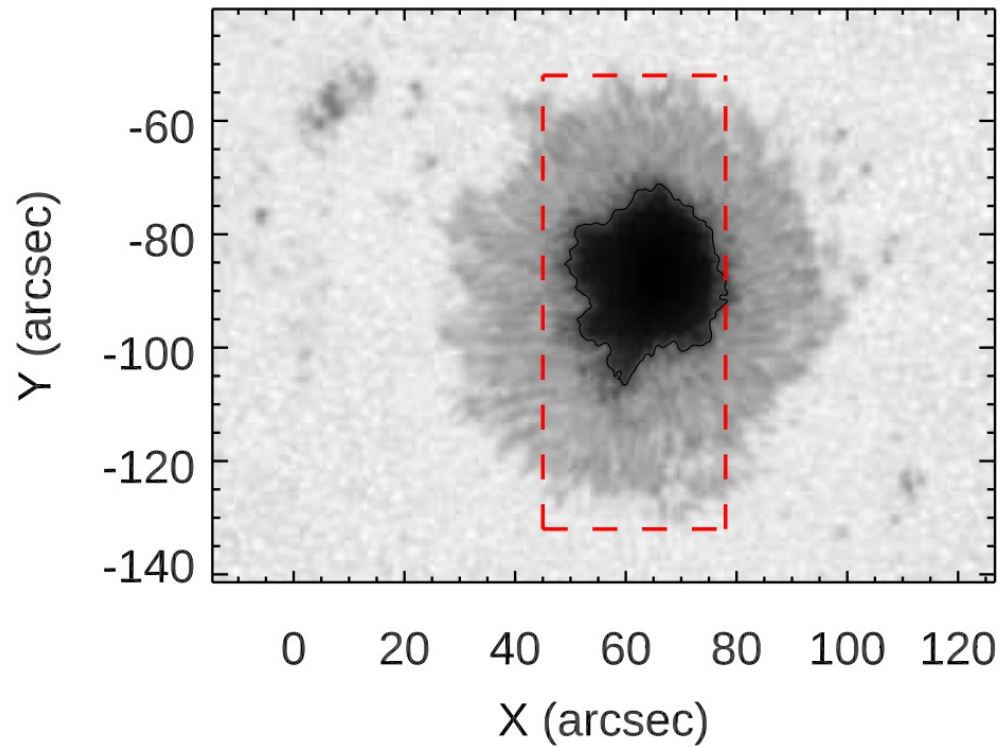
# Spectro-polarimetry



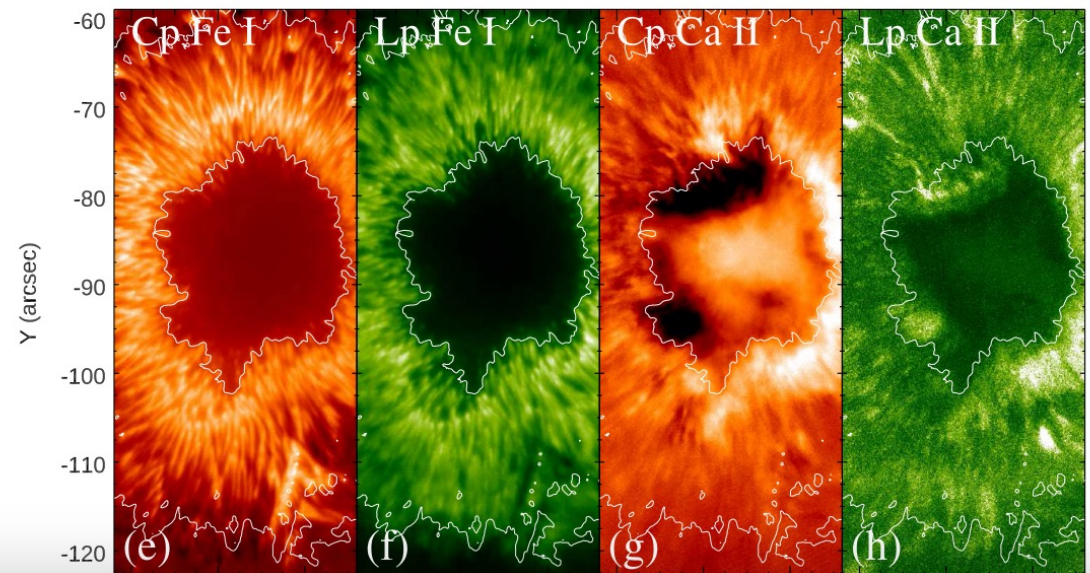
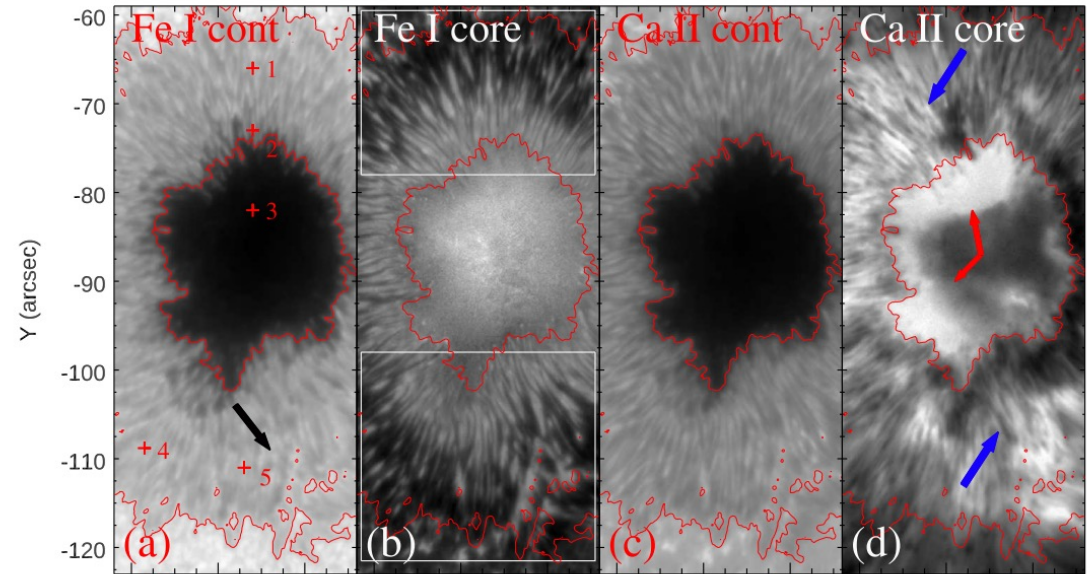
# High-resolution (spectropolarim) imaging of the chromosphere



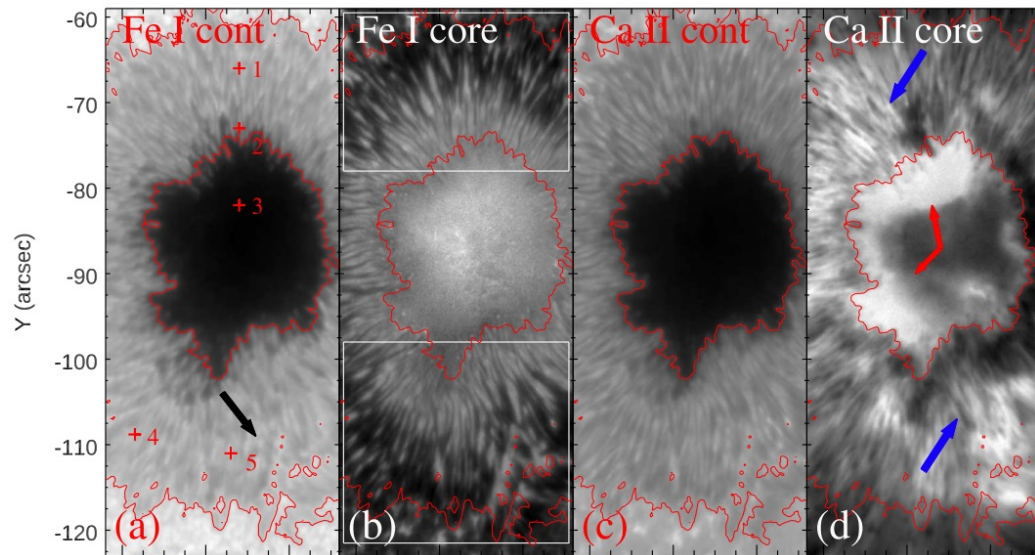
# Height Dependence of the Penumbral Fine-scale Structure in the Inner Solar Atmosphere



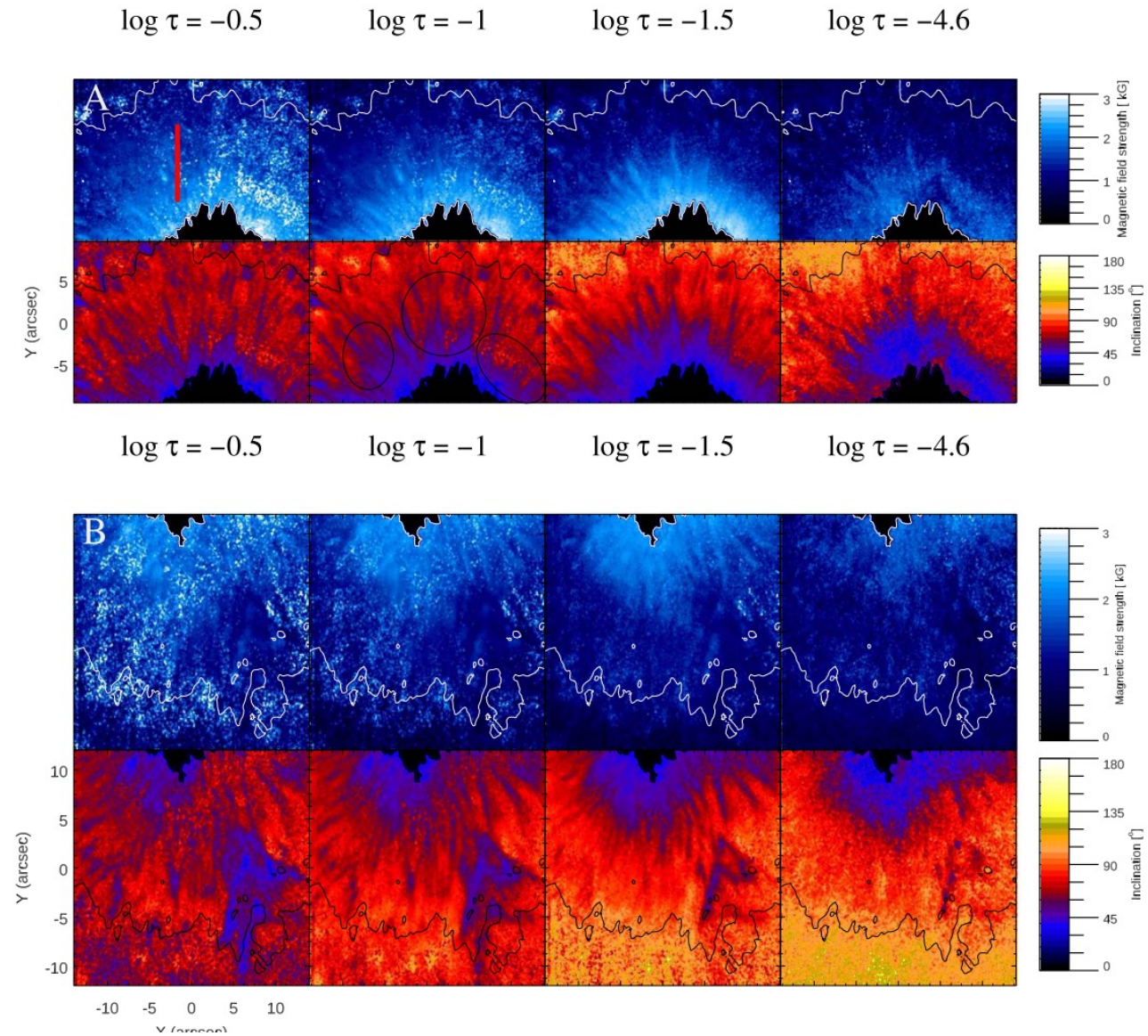
Murabito et al. 2019, A&A



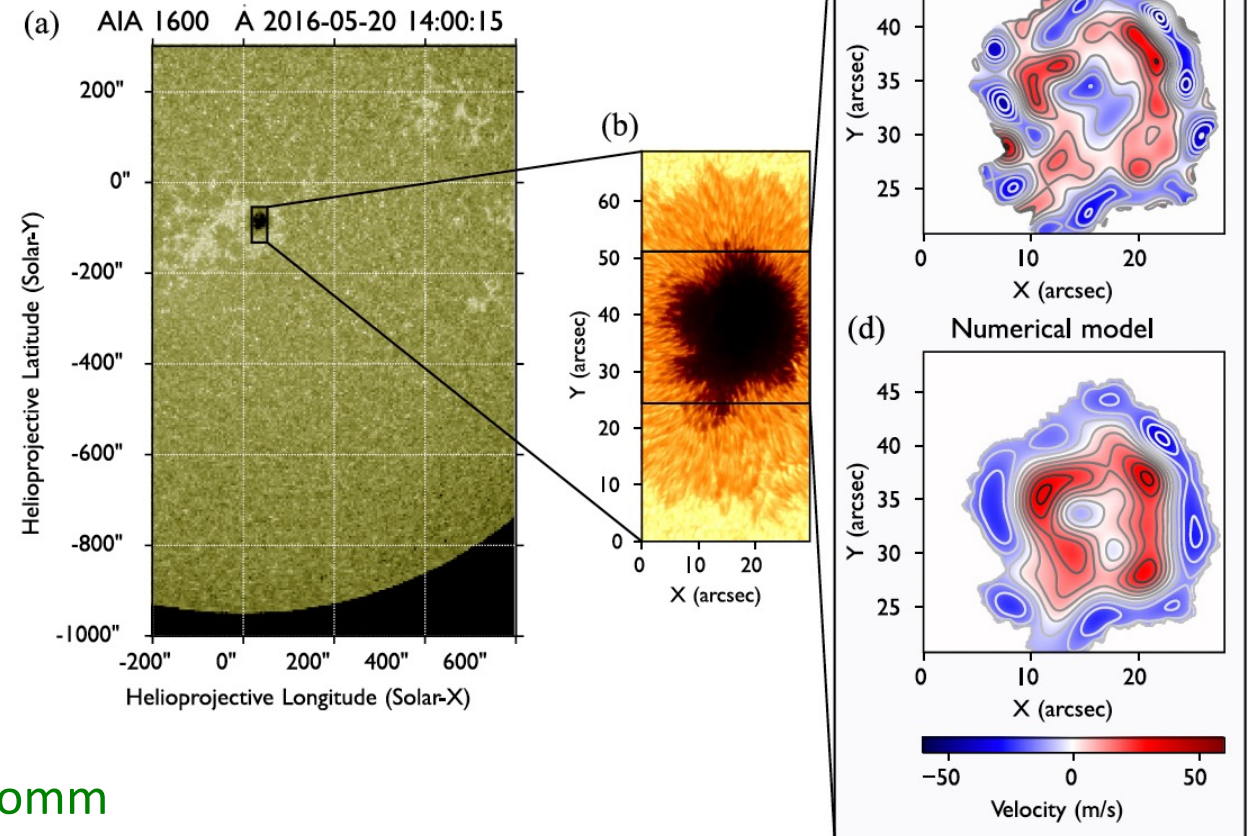
# Height Dependence of the Penumbra Fine-scale Structure in the Inner Solar Atmosphere



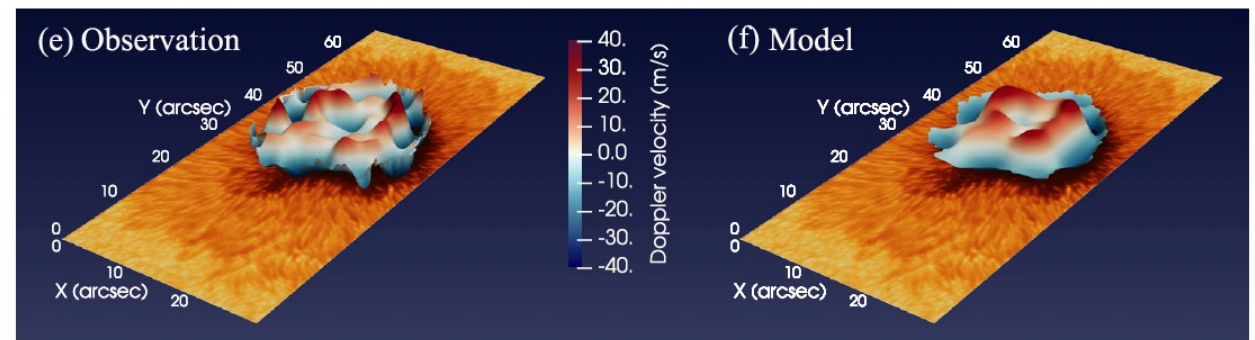
Murabito et al. 2019, A&A



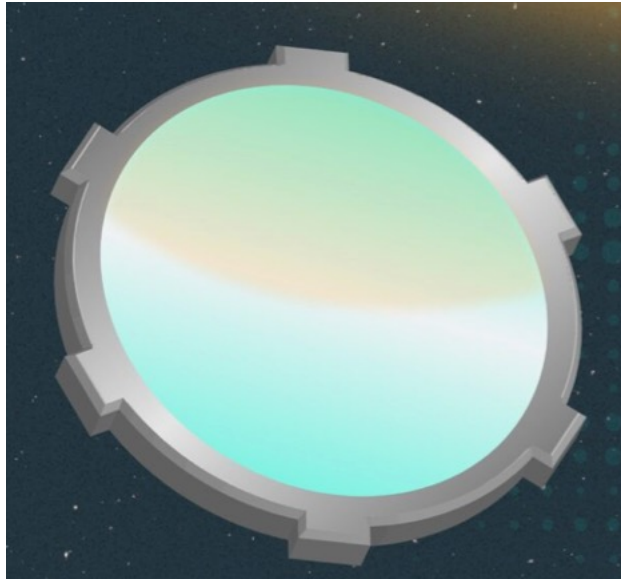
# Large scale coherent MHD oscillations in a sunspot



Stangalini et al. 2022, Nature Comm



# GIANT



DKIST/4m



# LARGE



NGST/1.6m  
GREGOR/1.5m



SST/1.m  
THEMIS/0.9m



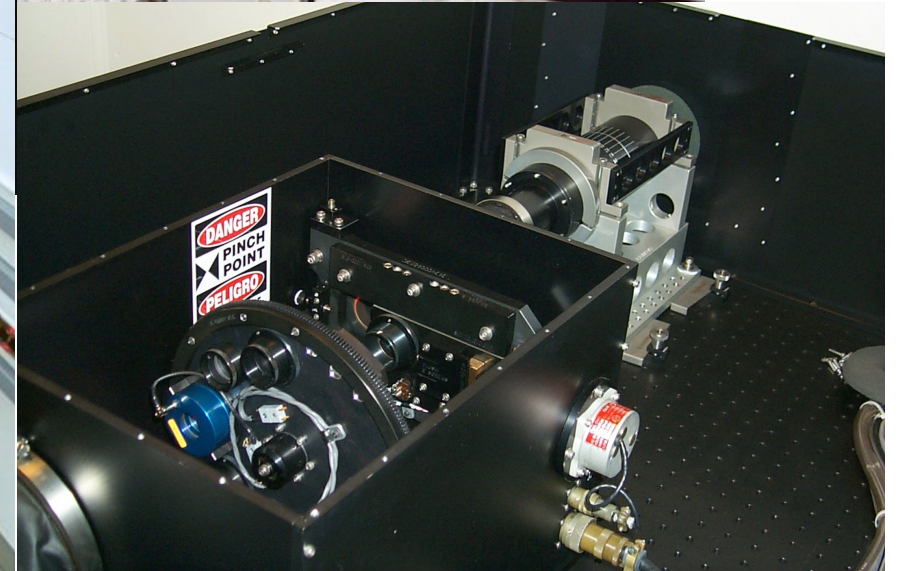
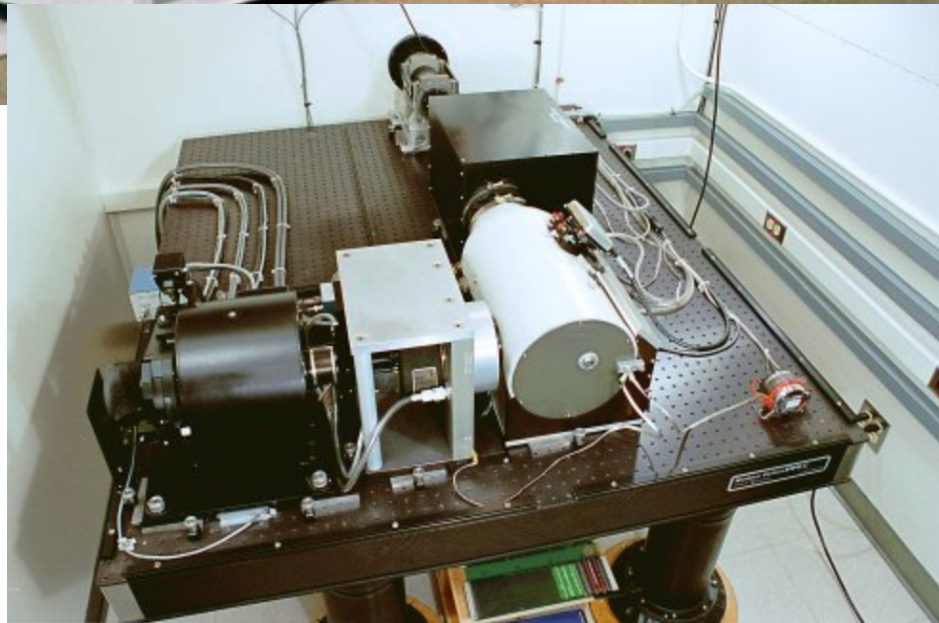
DST/0.7m  
VTT/0.7m



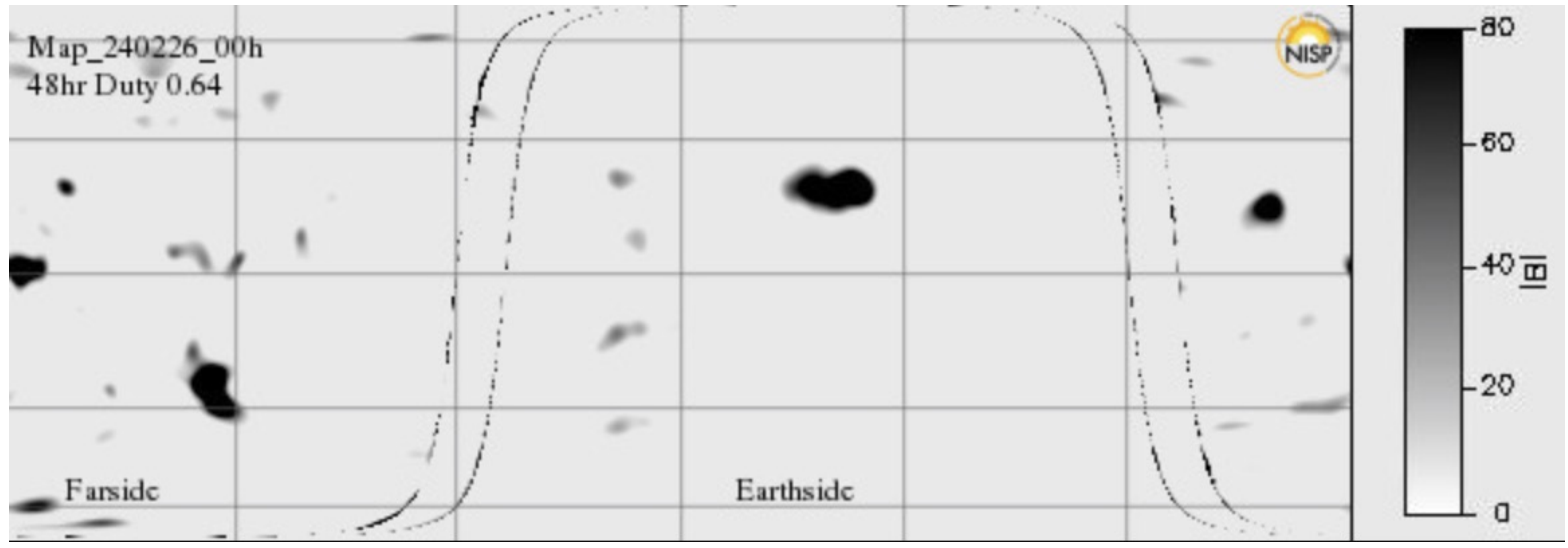
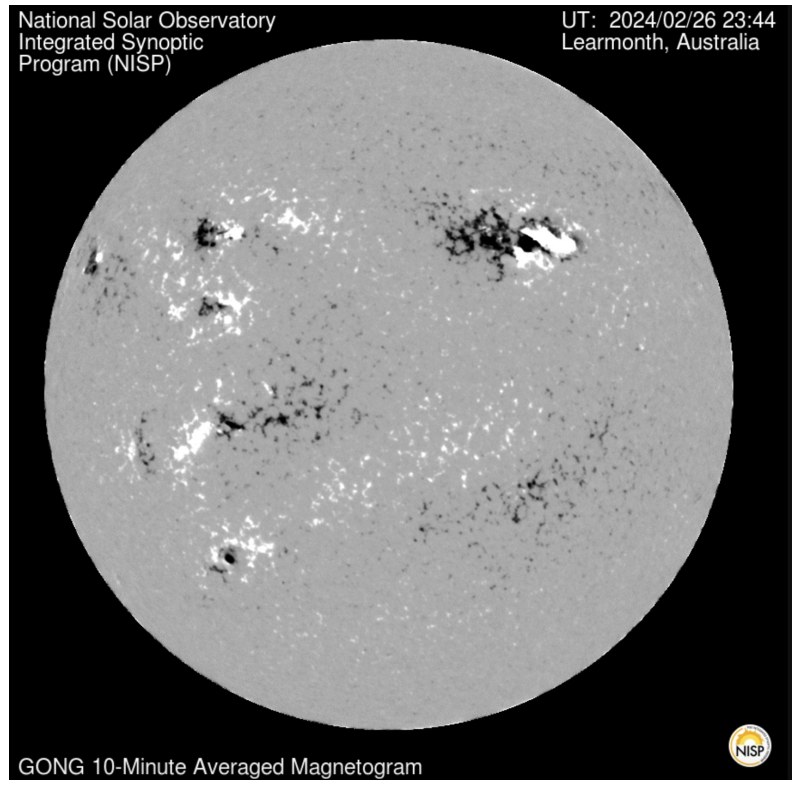
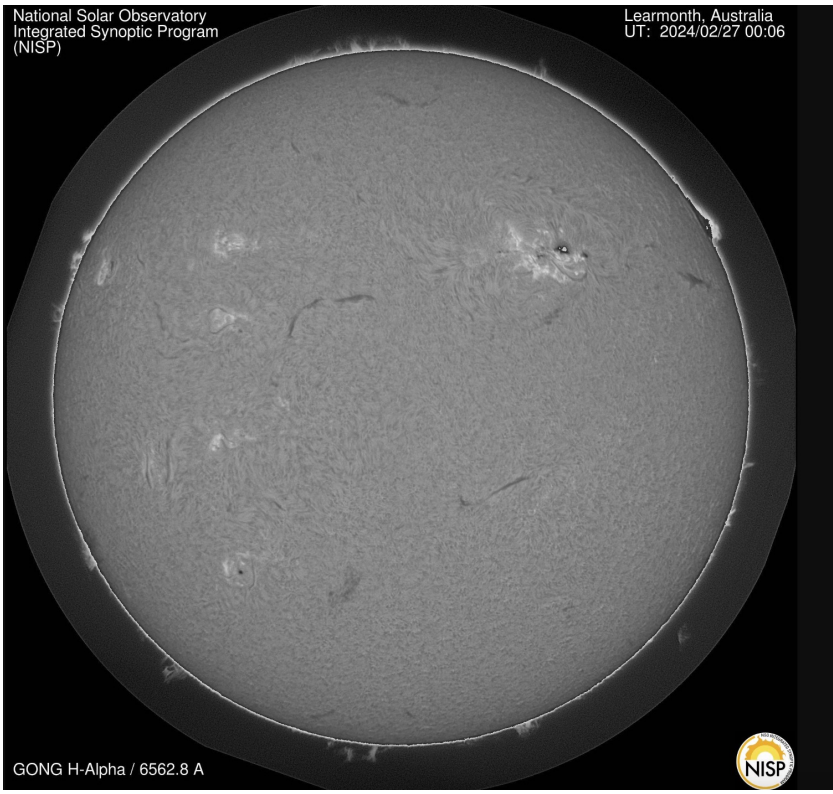
# SMALL



0.20m  
0.03m







26 February 2024

NOAA Search

Date Search

←20240225 ←Week ←Rotation

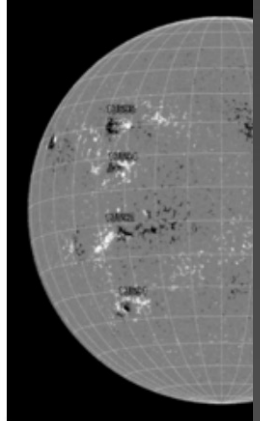
Main

NOAA  
6 Active  
Regions

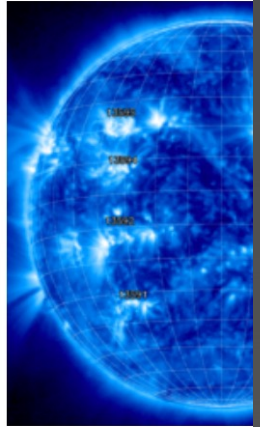
Flare  
Forecast

Coronal  
Holes

HMI Mag 20240



SWAP 174Å 2024



Date Search

←20240225 ←Week ←Rotation

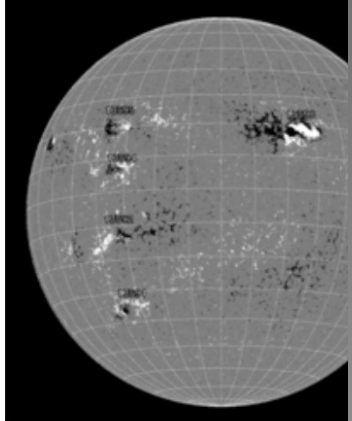
Main

NOAA  
6 Active  
Regions

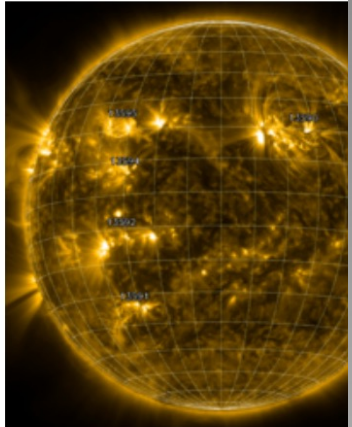
Flare  
Forecast

Coronal  
Holes

HMI Mag 20240226 18:58



AIA 171Å 20240226 20:24



26 February 2024

NOAA Search

Date Search

←20240225 ←Week ←Rotation

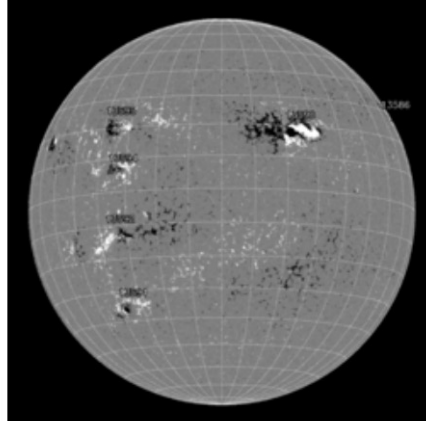
Main

NOAA  
6 Active  
Regions

Flare  
Forecast

Coronal  
Holes

HMI Mag 20240226 18:58



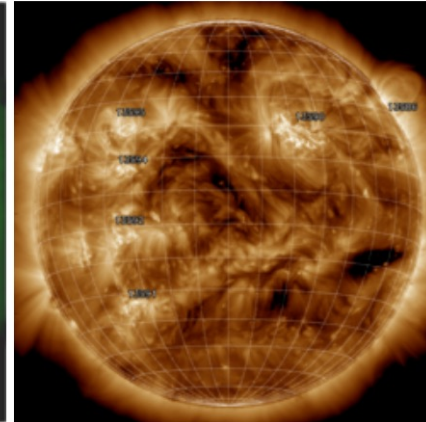
No Time Data Available



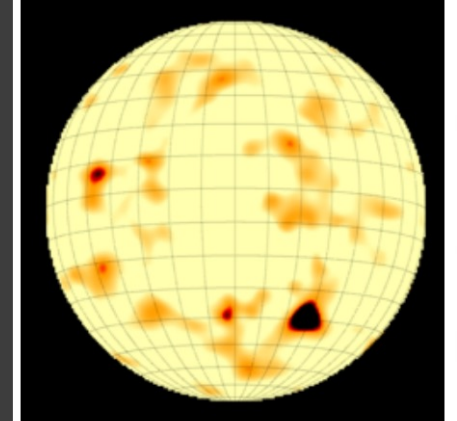
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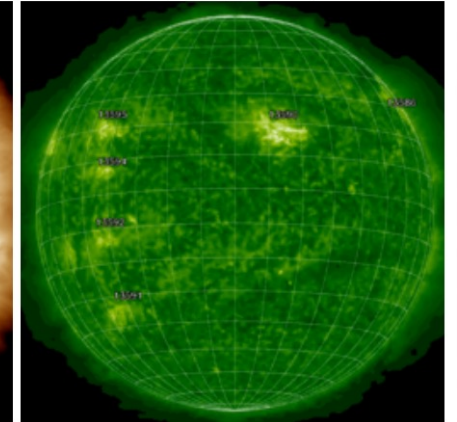
AIA 193Å 20240226 20:24



GONG Farside 20240225 12:00



STEREO A 20240226 17:45



26 February 2024

NOAA Search

Date Search

←20240225 ←Week ←Rotation

Main

Today

Far-side

SDO short-wave

Rotation⇒ Week⇒ 20240227⇒

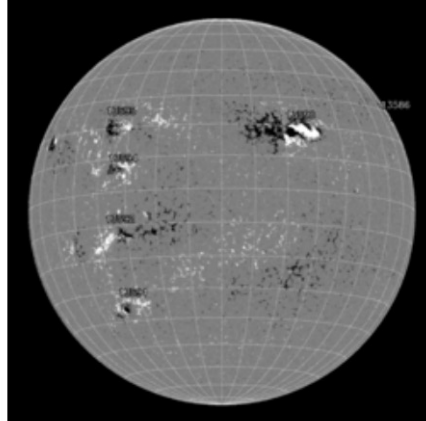
SDO long-wave

NOAA  
6 Active  
Regions

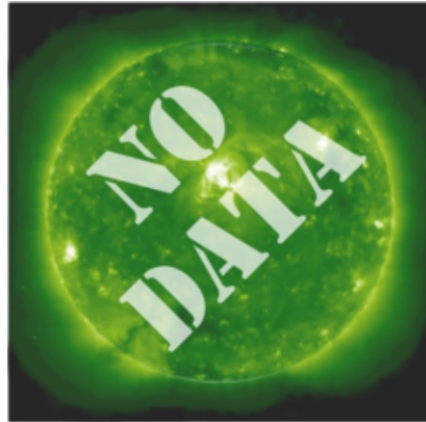
Flare  
Forecast

Coronal  
Holes

HMI Mag 20240226 18:58



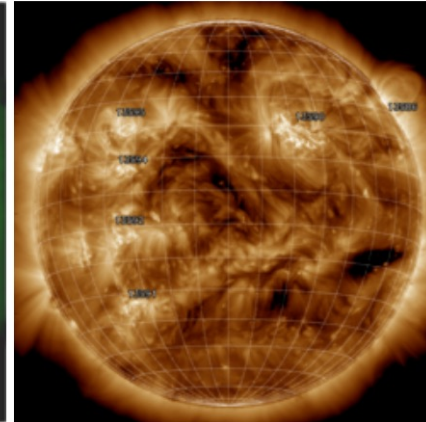
No Time Data Available



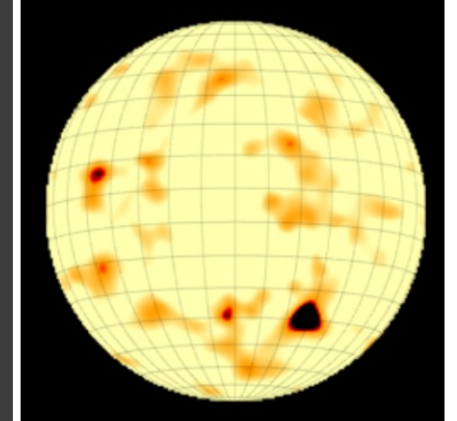
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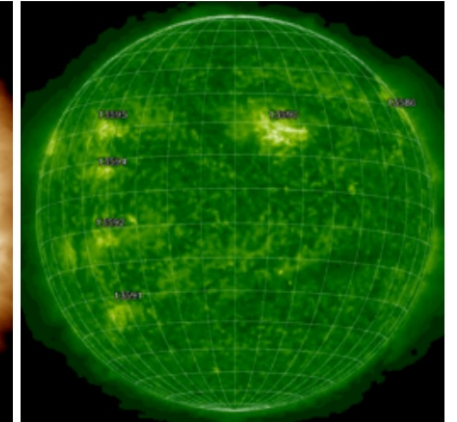
AIA 193Å 20240226 20:24



GONG Farside 20240225 12:00

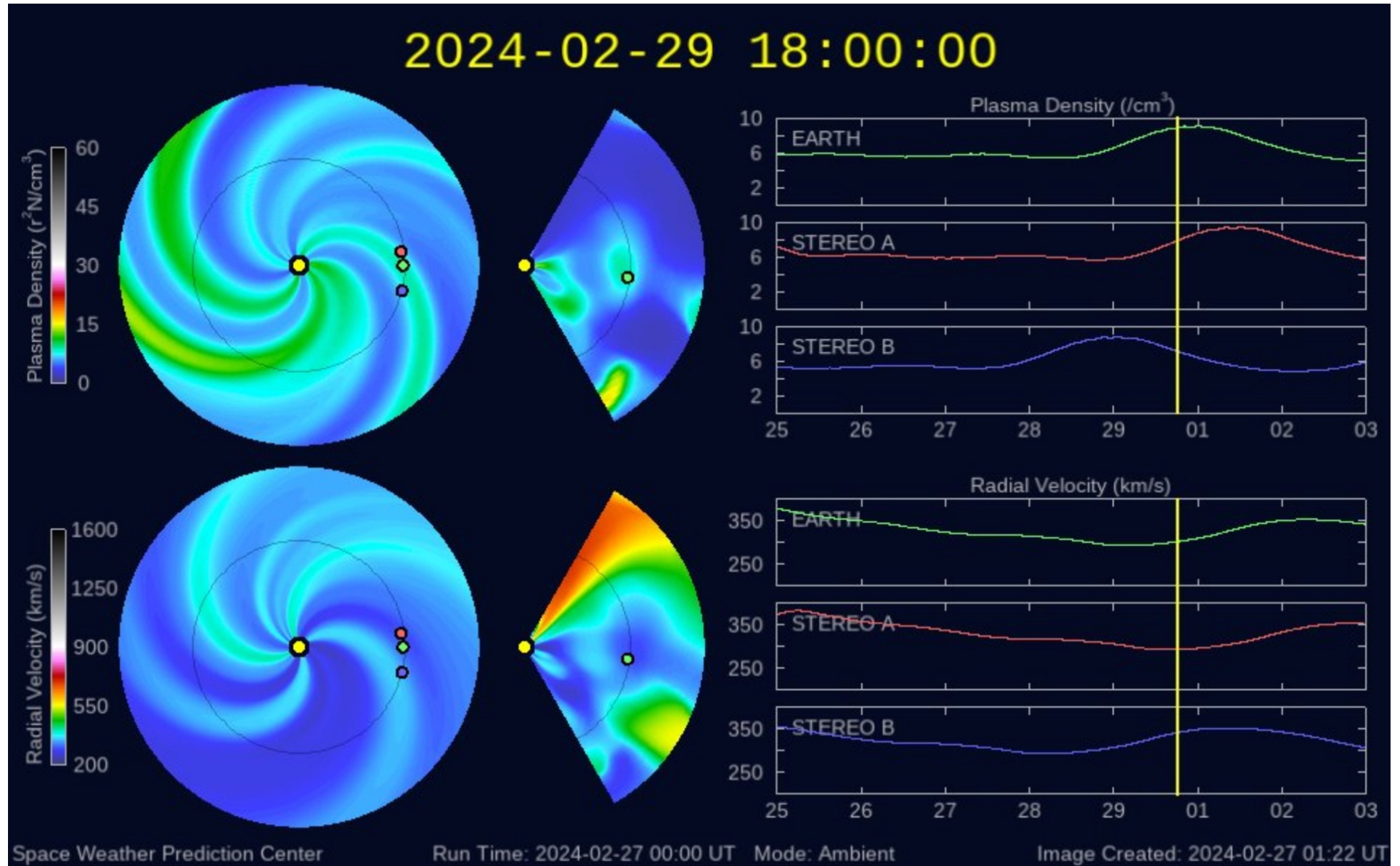


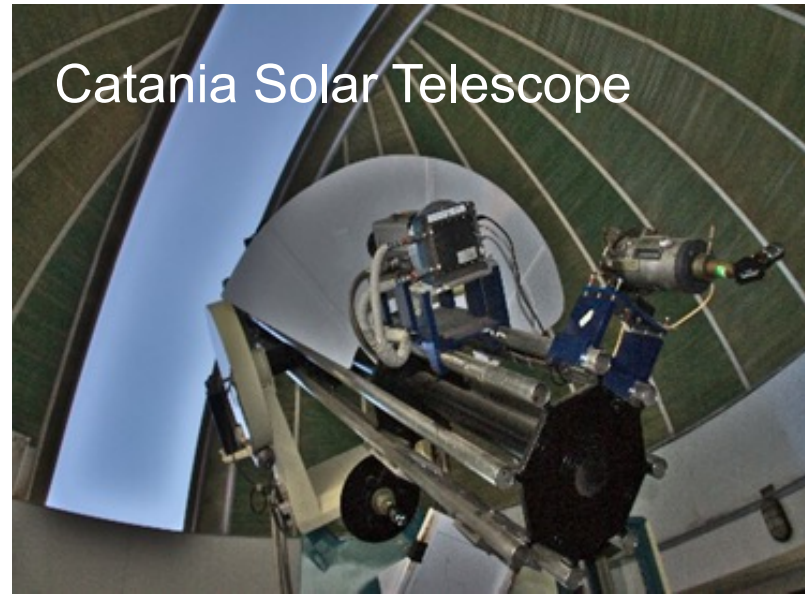
STEREO A 20240226 17:45

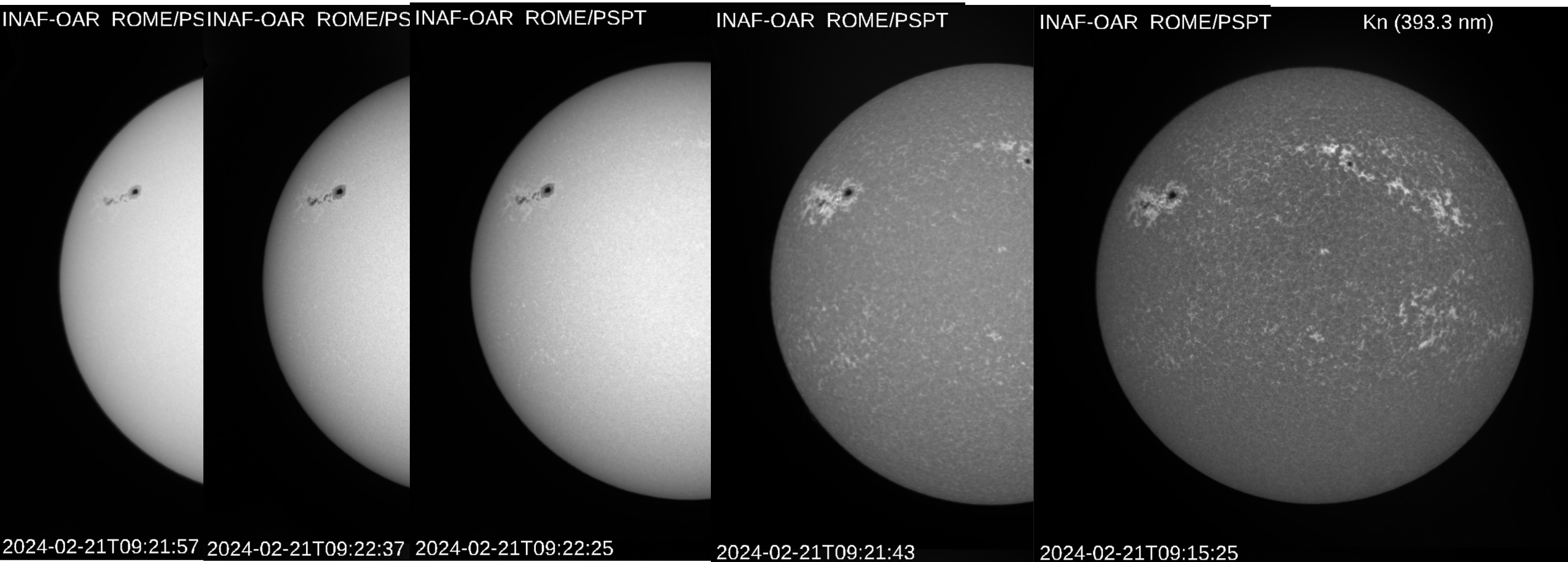


GOES  
ACE  
SDO/EVE  
Events

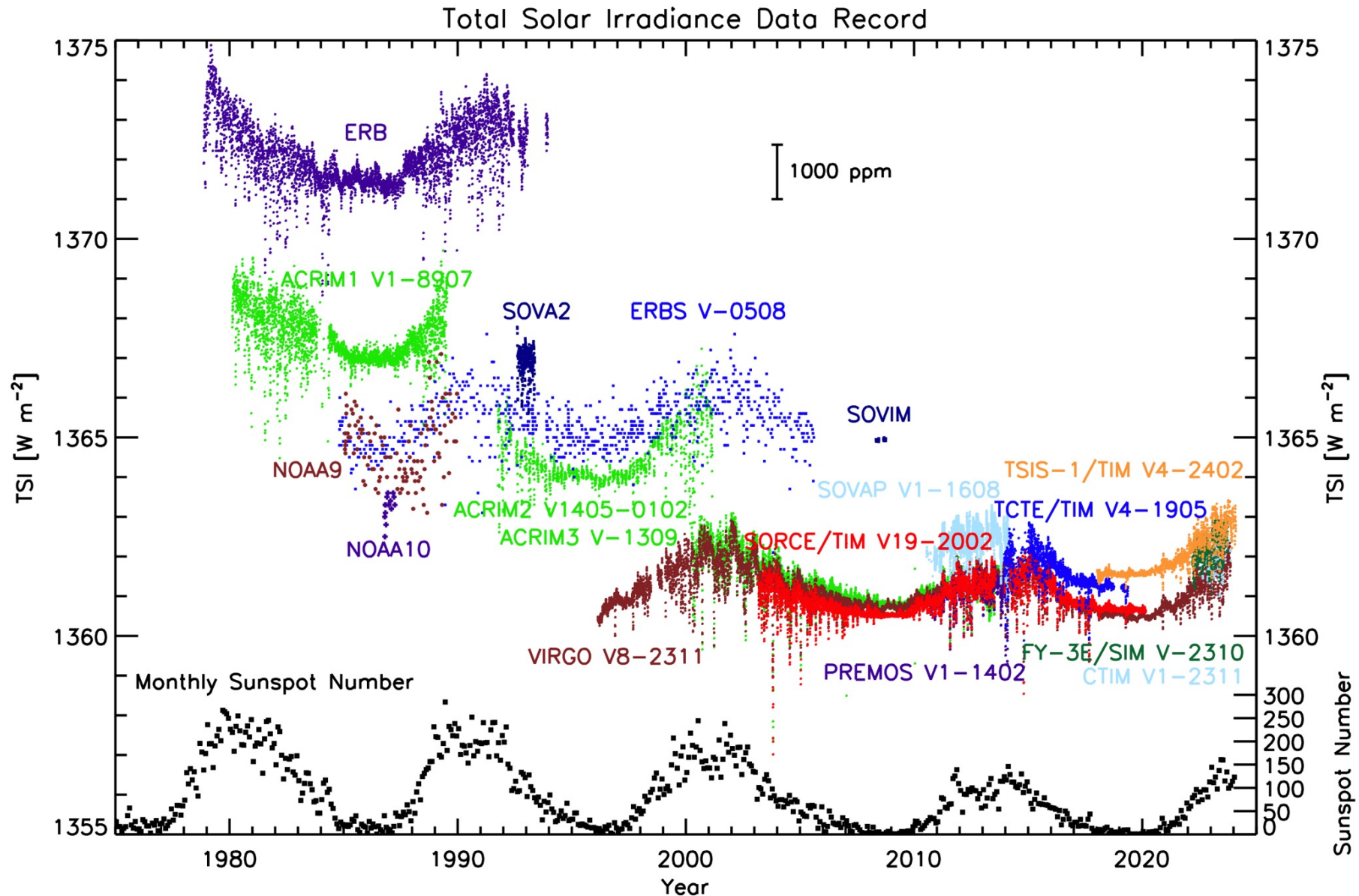
# WSA-Enlil Solar Wind Prediction



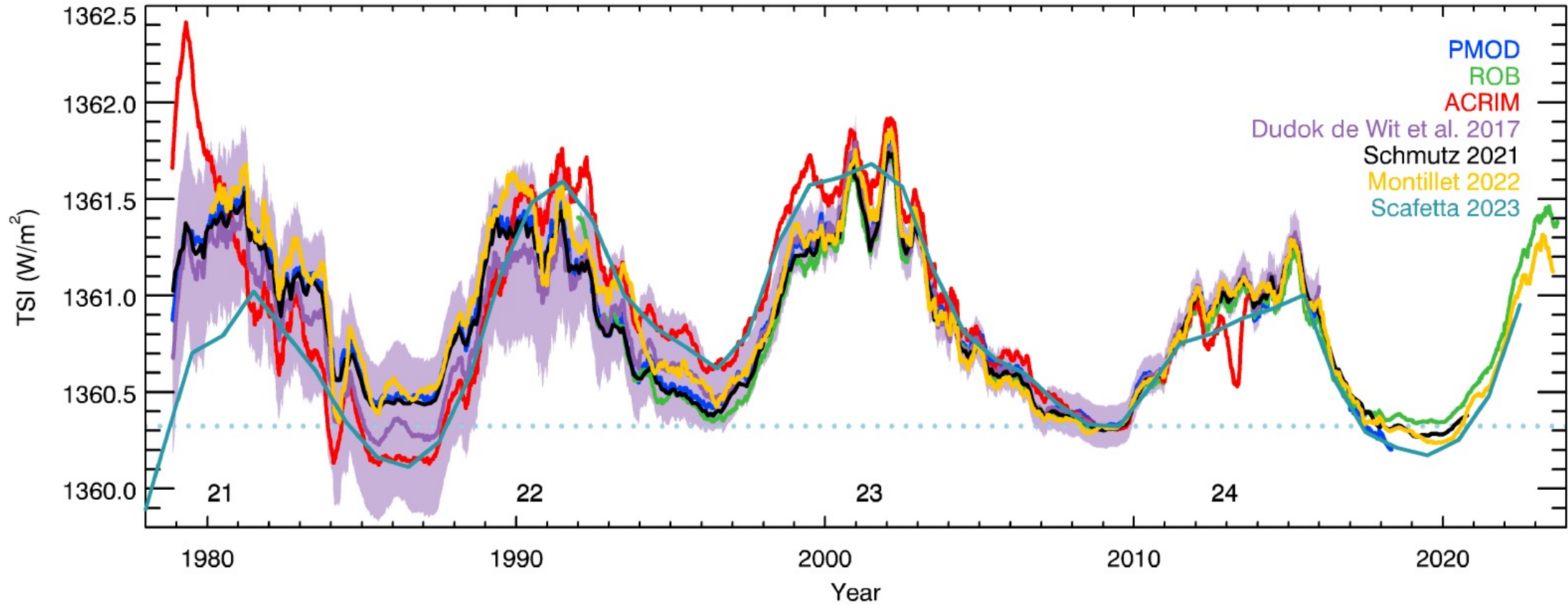




# Total Solar Irradiance measurements

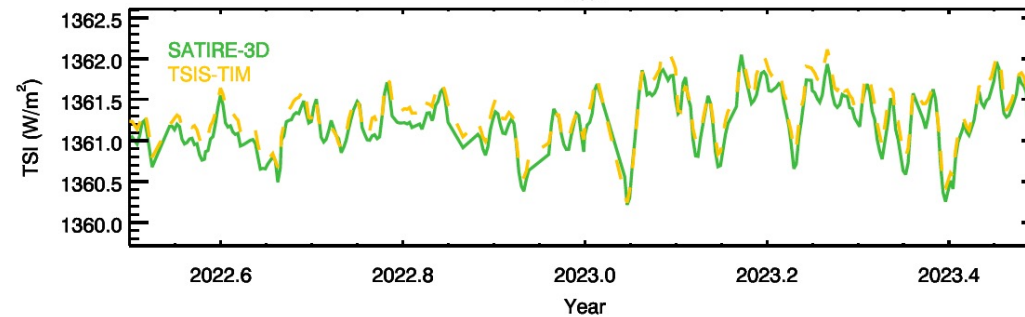
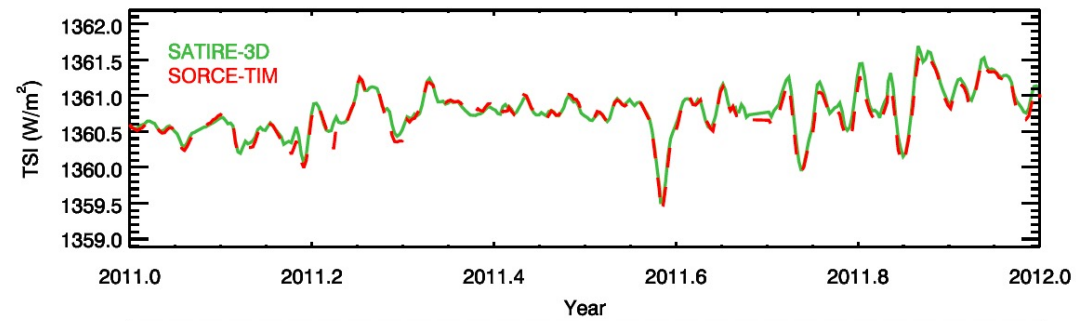
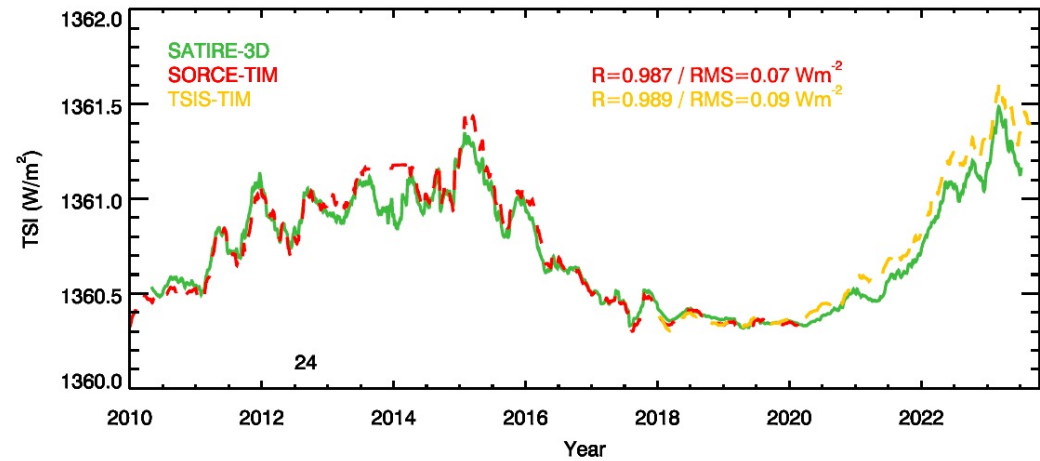


# Total Solar Irradiance variations 1978-present



Chatzistergos et al. 2023, JASP

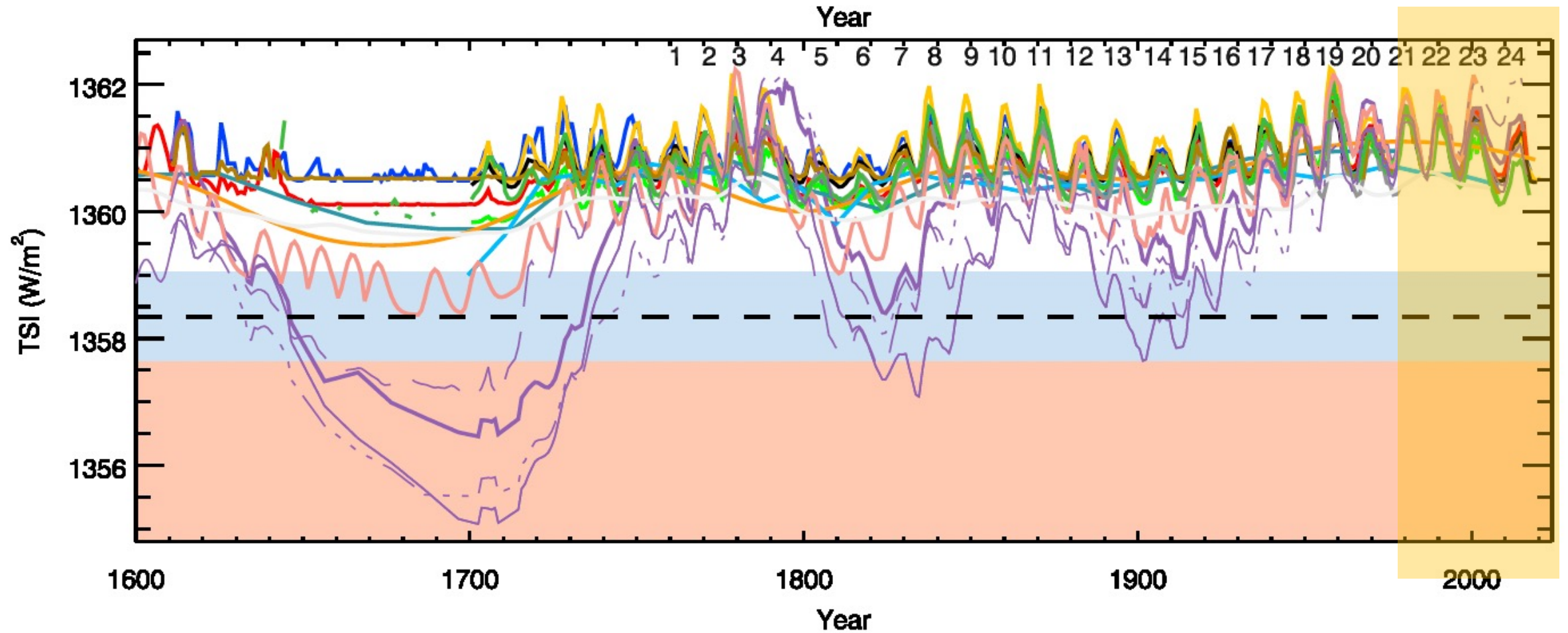
# Total Solar Irradiance reconstructions based on magnetograms



Chatzistergos et al. 2023, JASP

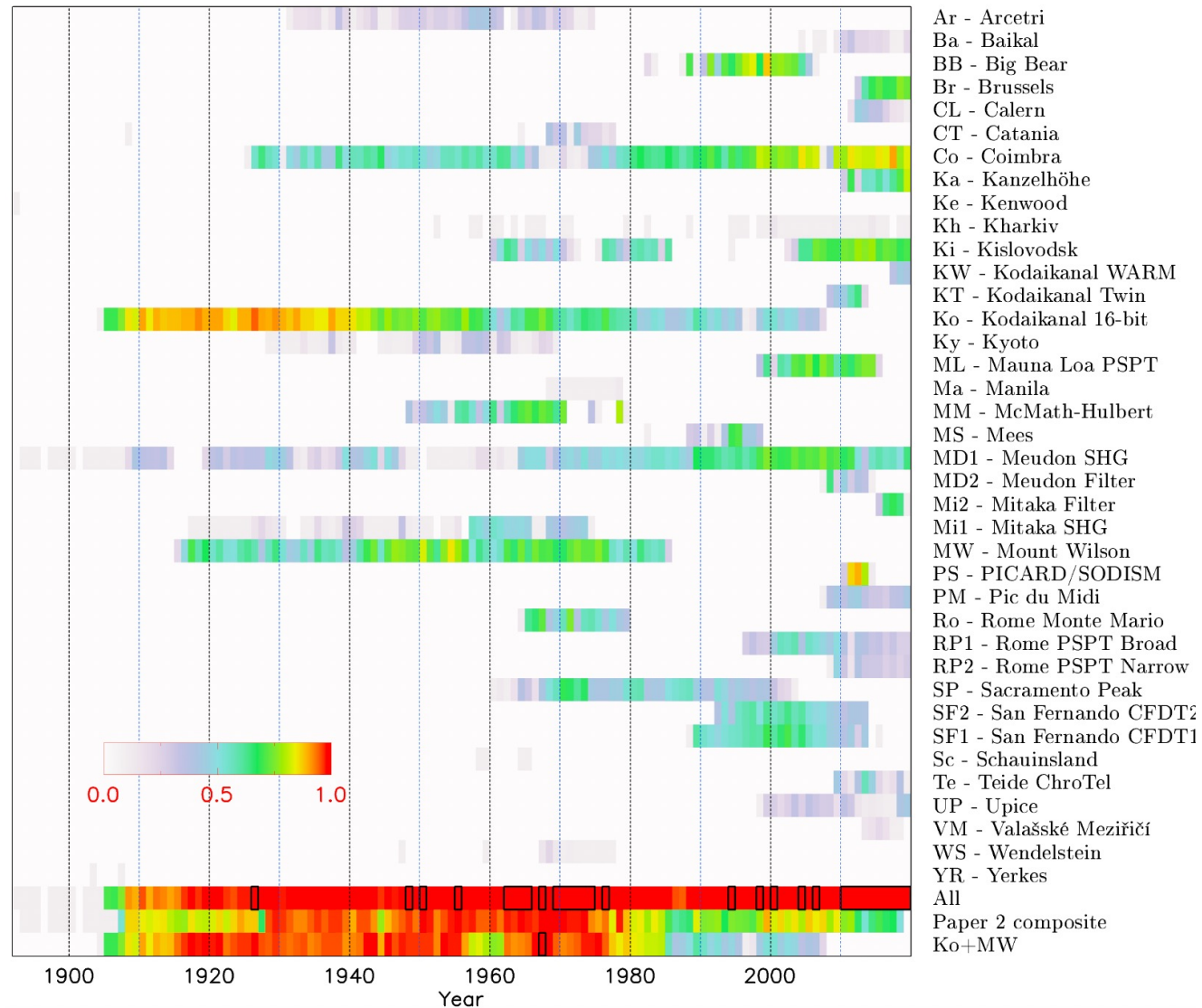


# Current estimates Total Solar Irradiance variations back to 1600

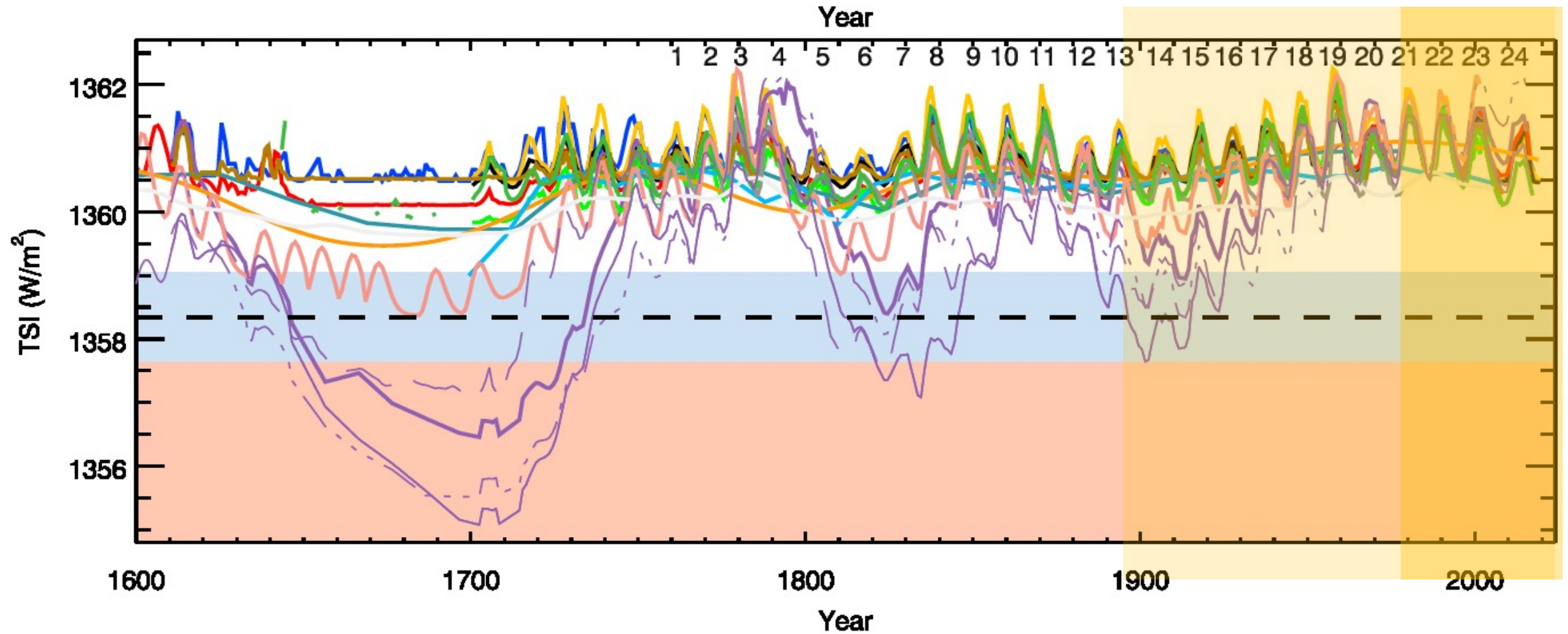


Adapted from Chatzistergos et al. 2023, JASP

# Ca II K observations 1892-present

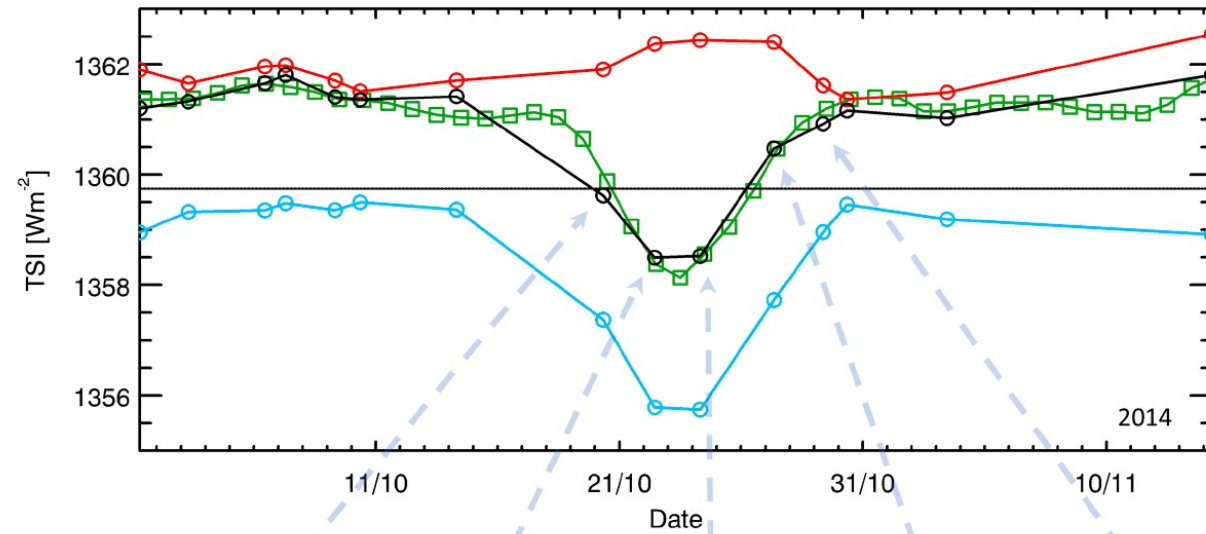


# Current estimates Total Solar Irradiance variations back to 1600

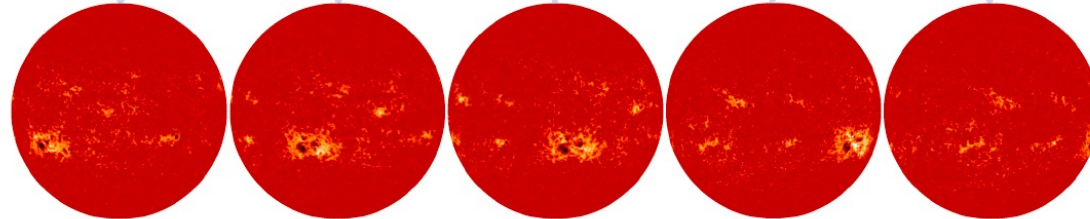


Adapted from Chatzistergos et al. 2023, JASP

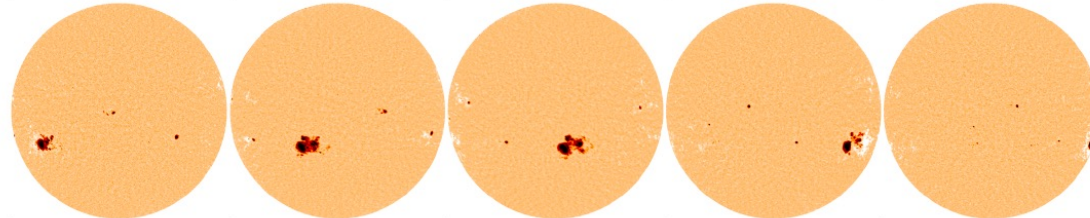
# Total Solar Irradiance reconstructions based on CaIIK+red images



Rome/PSPT  
Ca II K

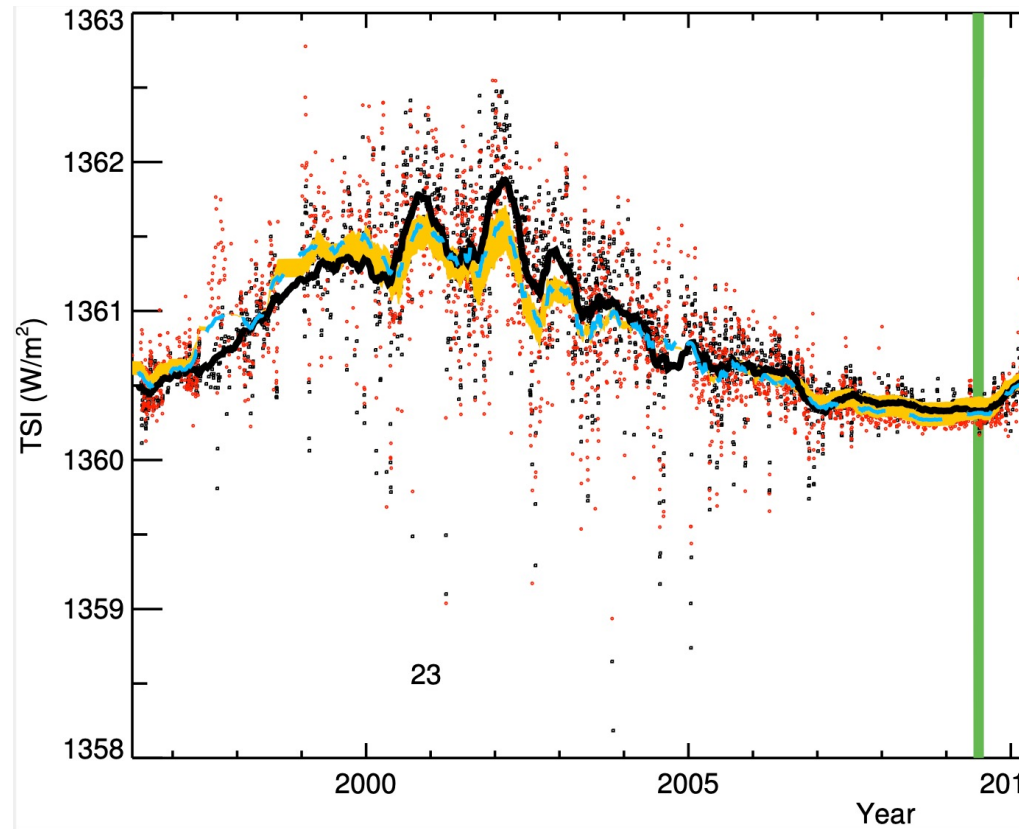


Rome/PSPT  
Red continuum

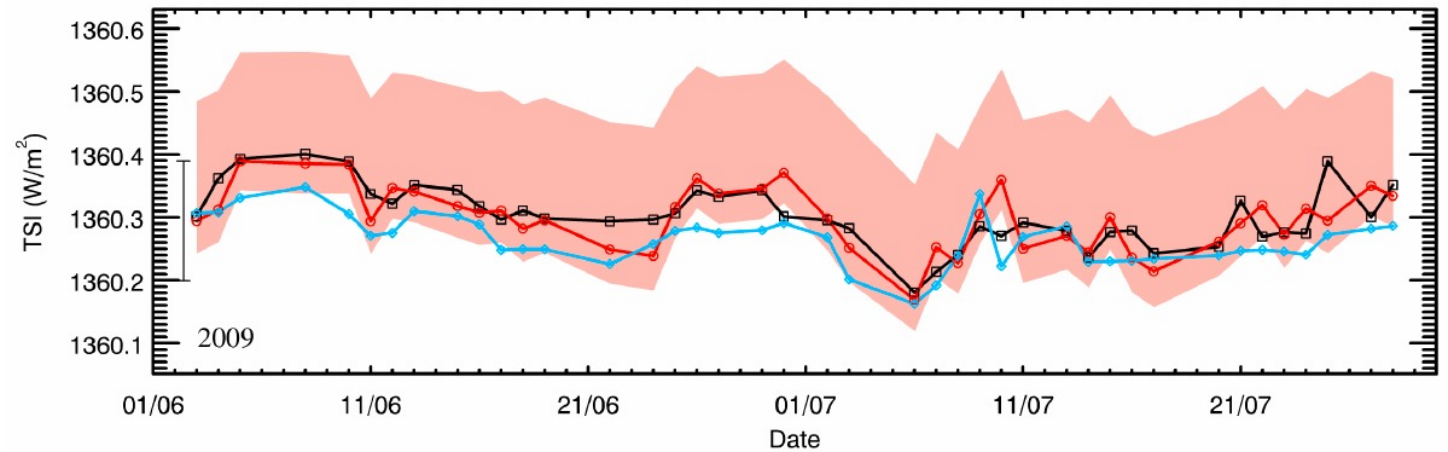
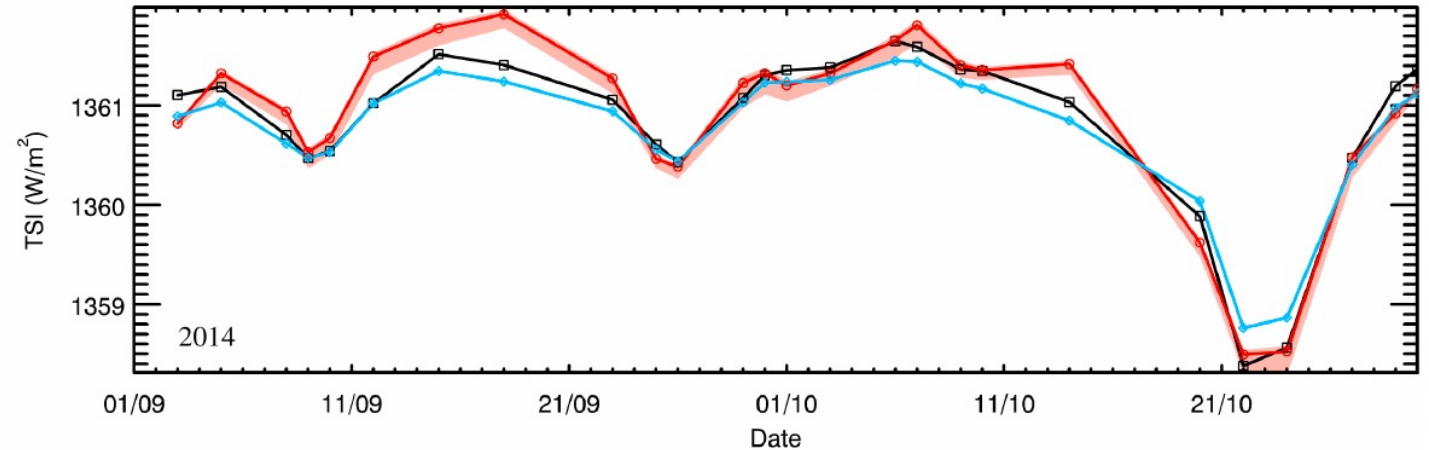


Chatzistergos et al. 2023, JASP

# Total Solar Irradiance reconstructions based on CaIIK+red images



Chatzistergos et al. 2021, A&A



Black = TSI measurements

Blue = magn based reconstruction

Yellow/Red = CaIIK+red based reconstruction

# SCIENCE

**Helioseismology** as a window to the Sun's far side and interior

**Nature** of solar/stellar **magnetic fields**

**Solar Eruptions** and Space Weather

**Magnetic connectivity** throughout the heliosphere

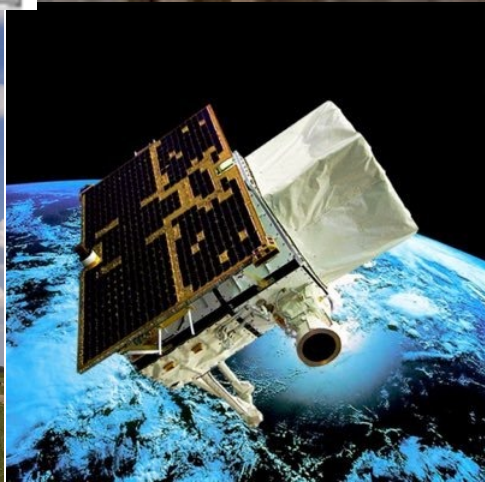
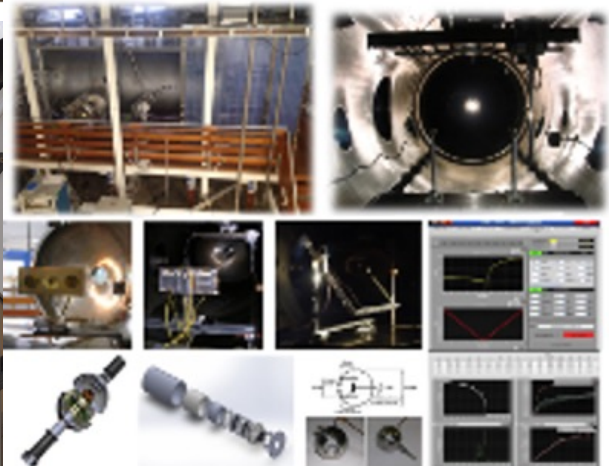
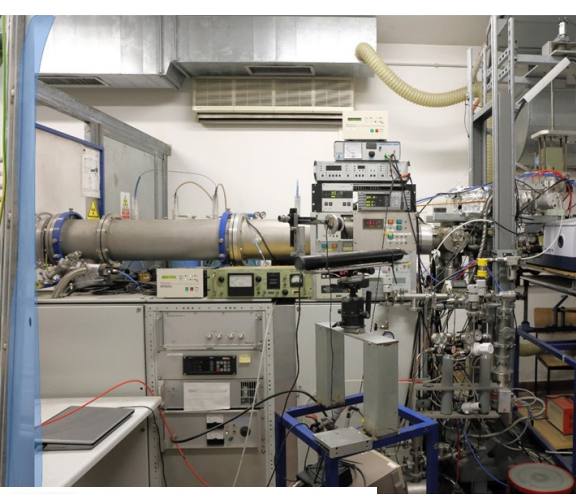
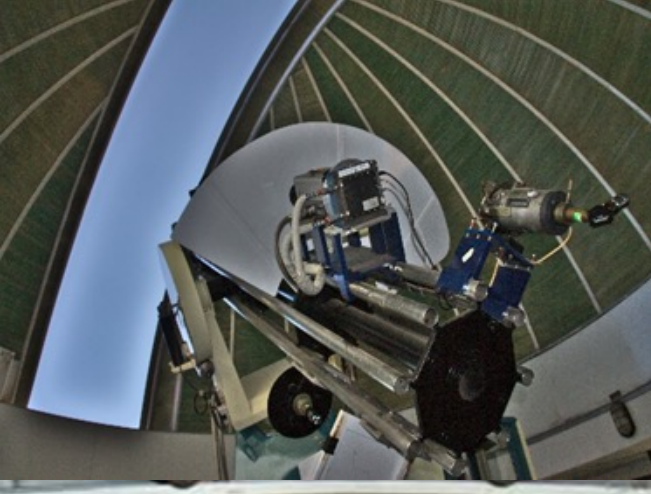
**Context images** for high-resolution obs and space missions

**Sun-as-a-star** research --> [next talk!](#)

# BROADER IMPACT

**Earth's Climate** Studies

**Space Weather Operations** Services



# Thank you!

