

SDO/AIA 4500 2011-12-07 12:00:03 UT

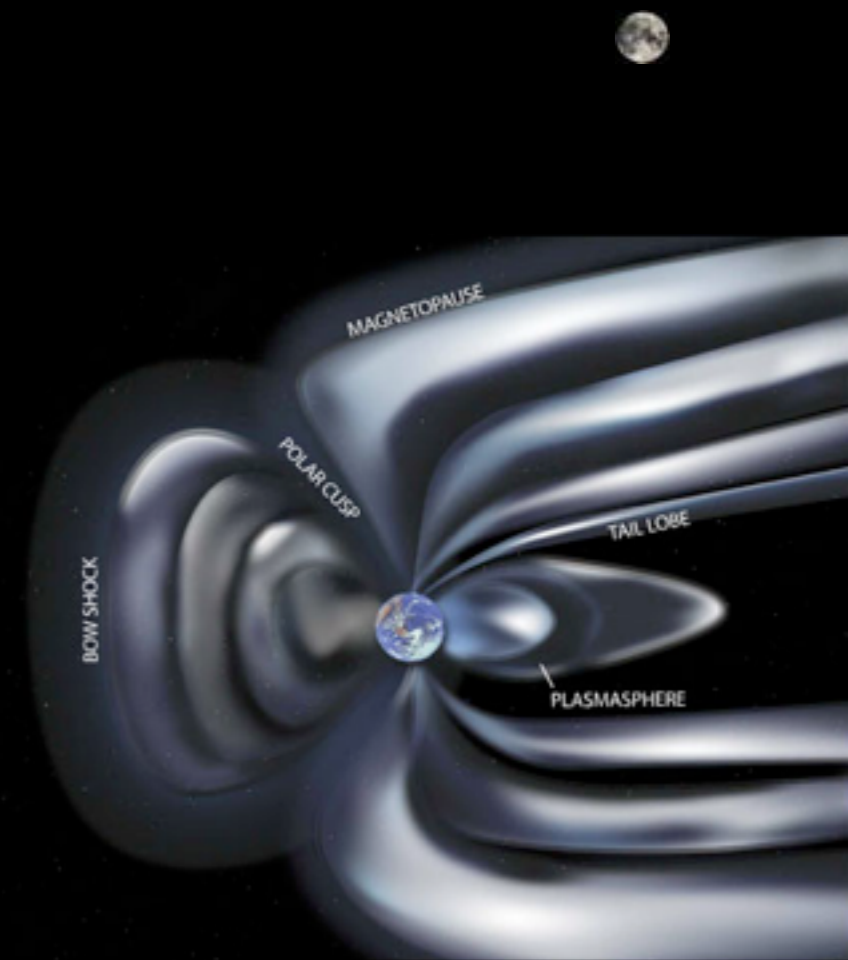
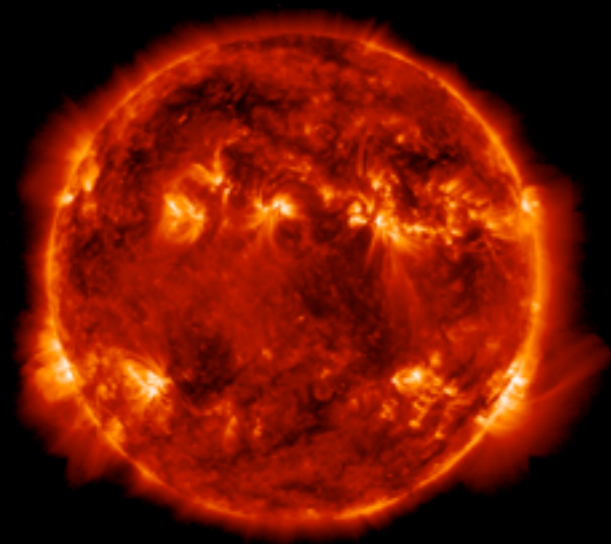
# The Physics of the Sun

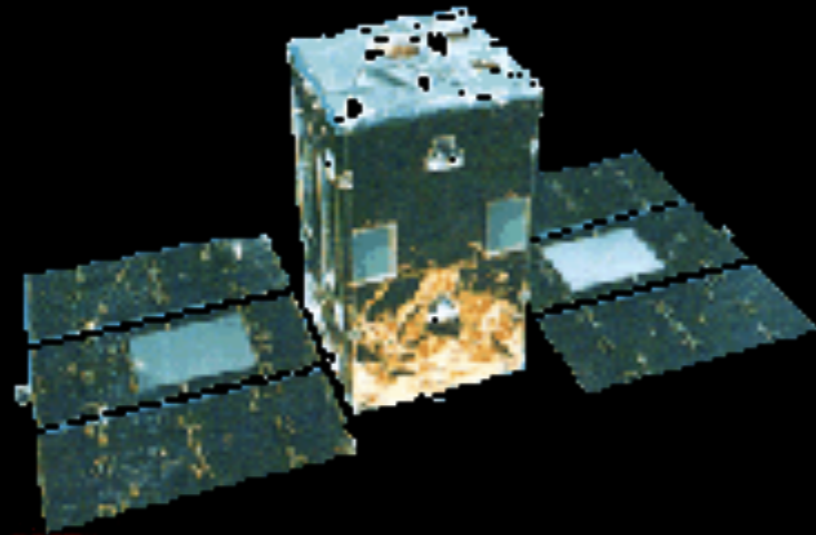


# Heliophysics System Observatory (HSO)

---

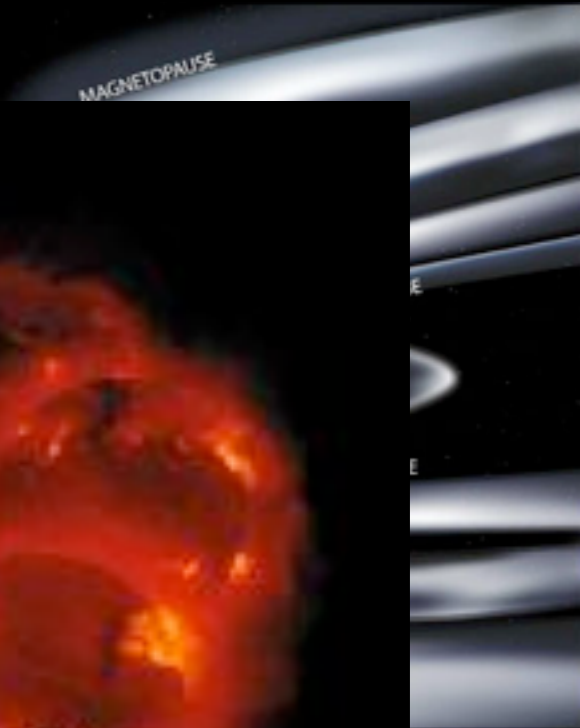
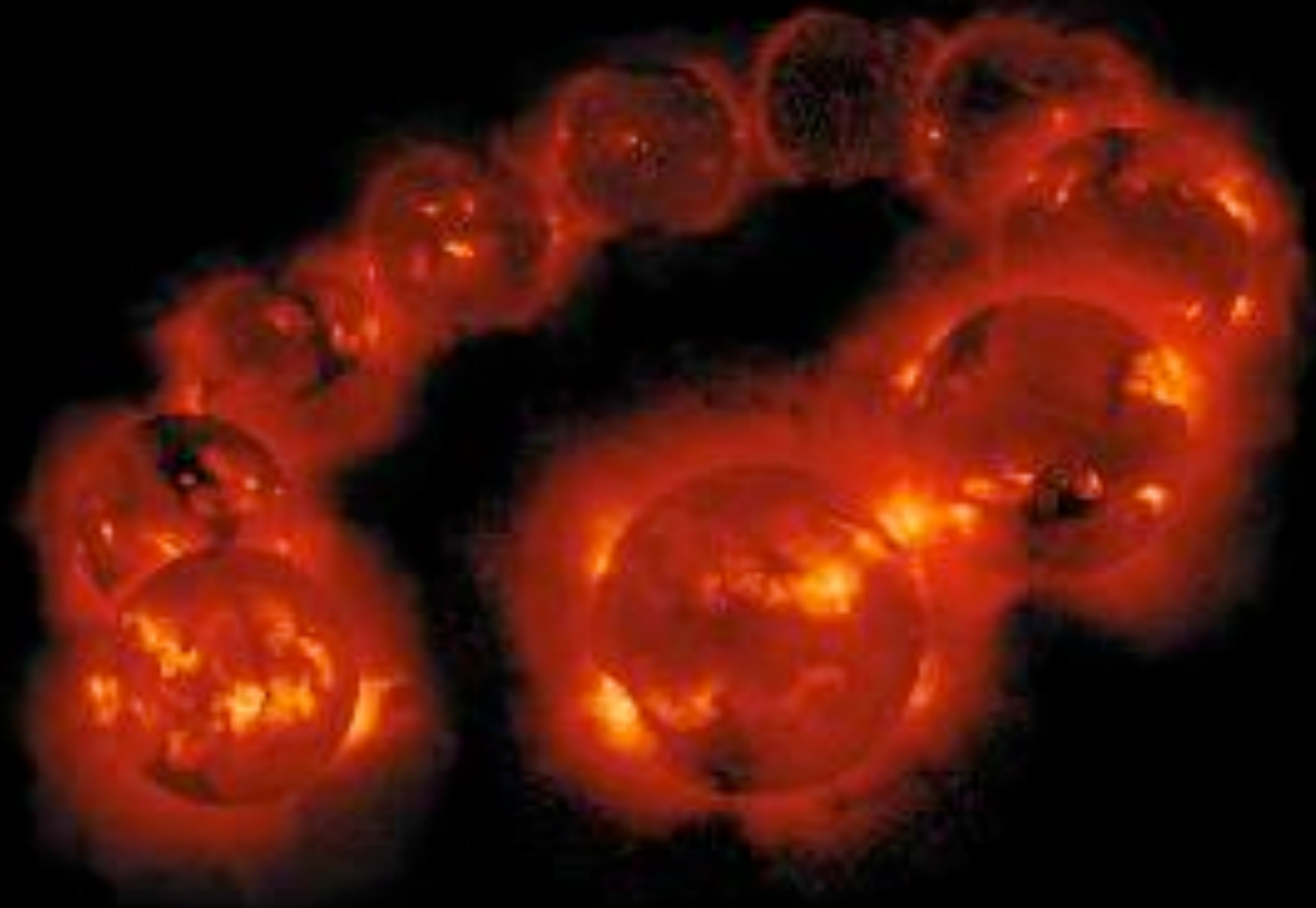
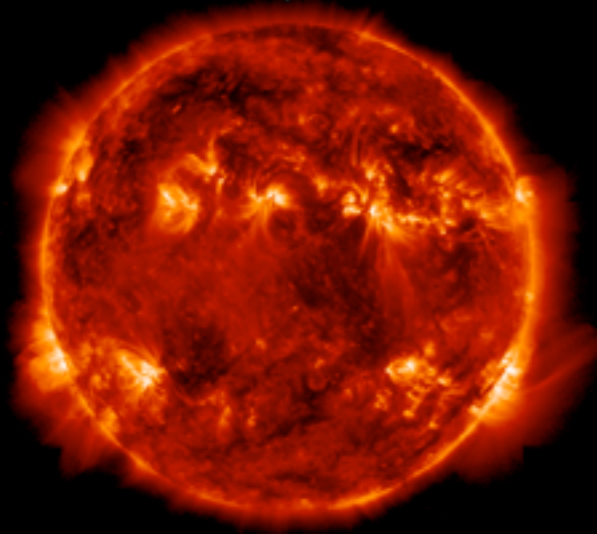
- Fleet of solar, heliospheric, geospace, and planetary satellites designed to work independently while enabling large-scale collaborative investigations.

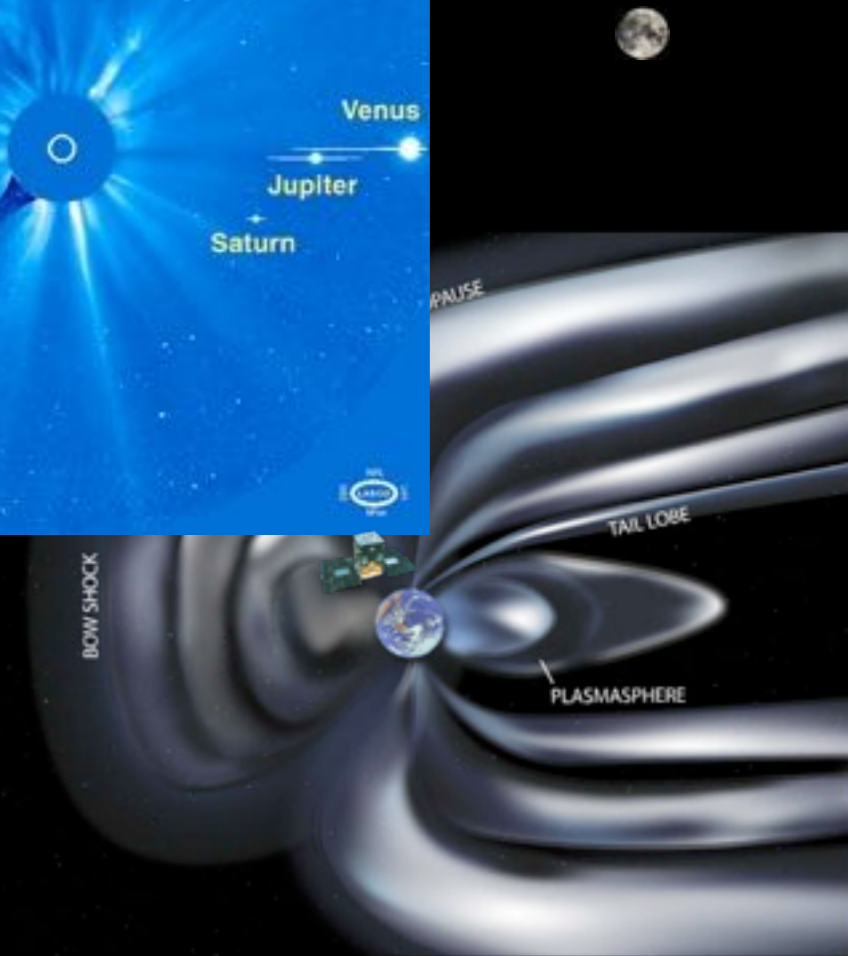
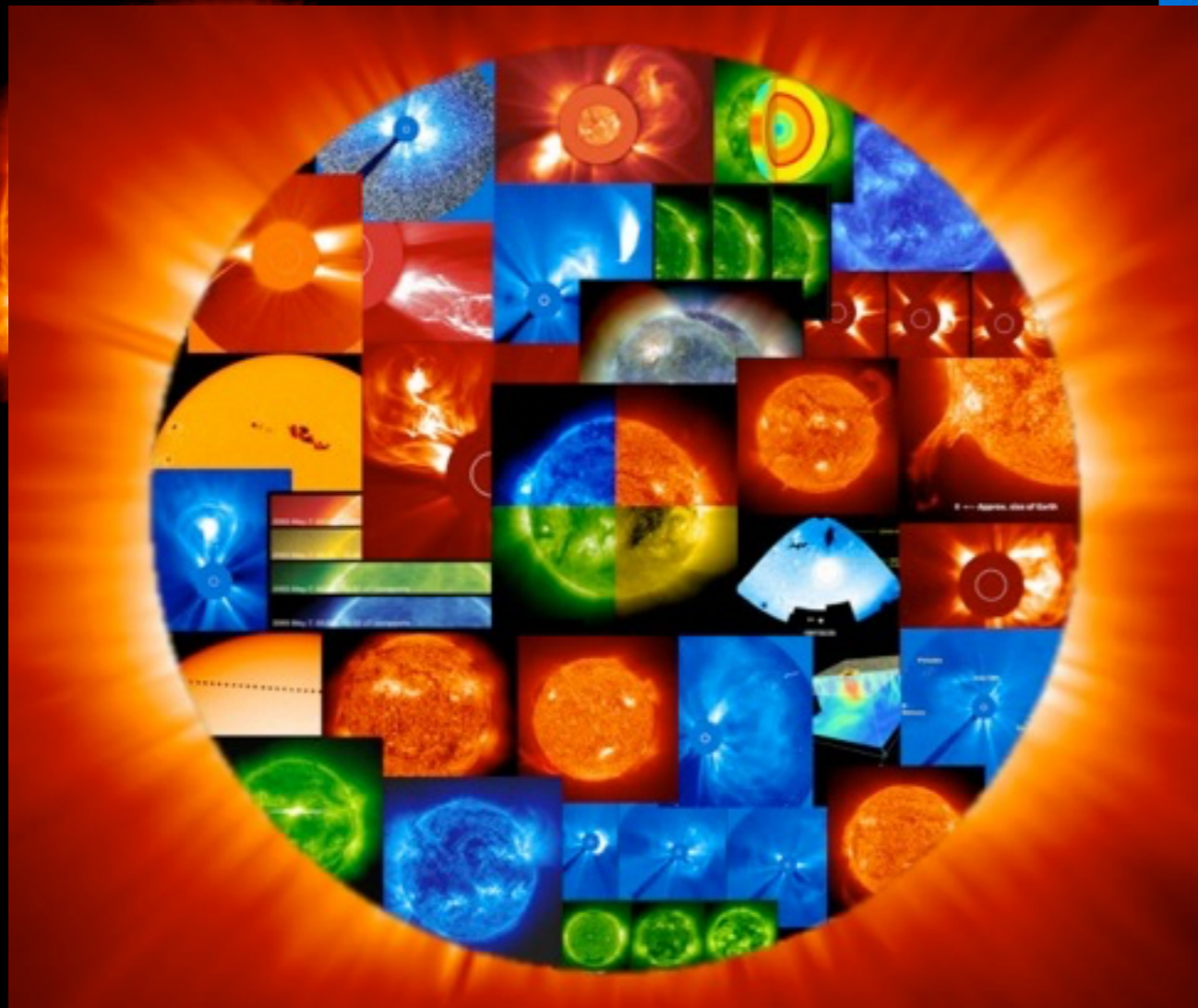
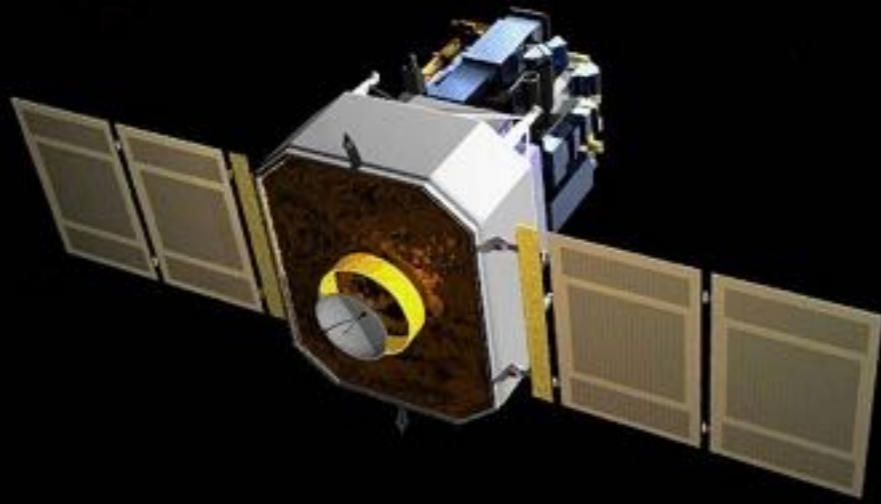




*Yohkoh*  
[SXT/HXT]

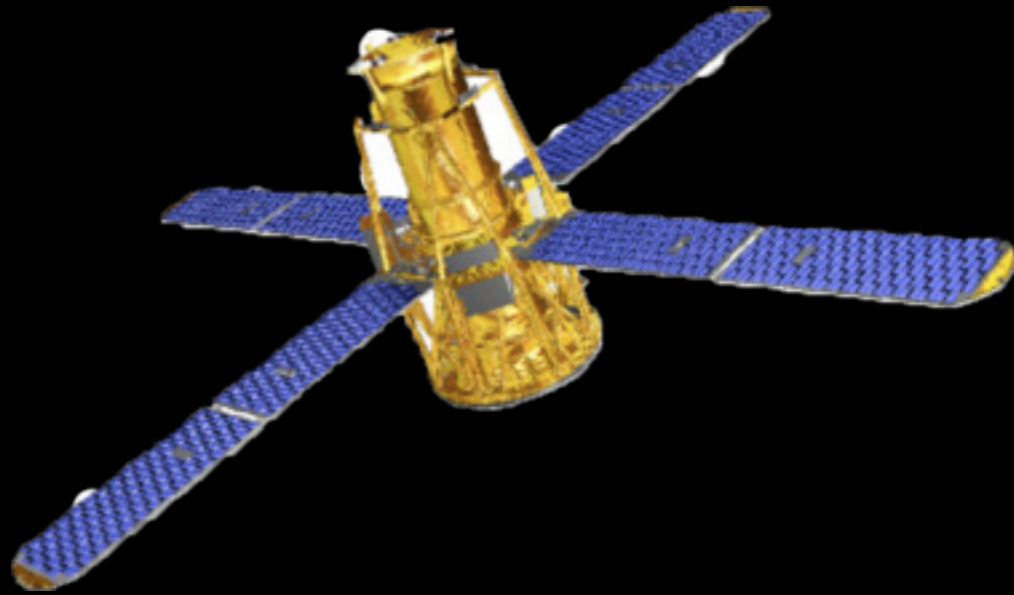
1991 - 2001





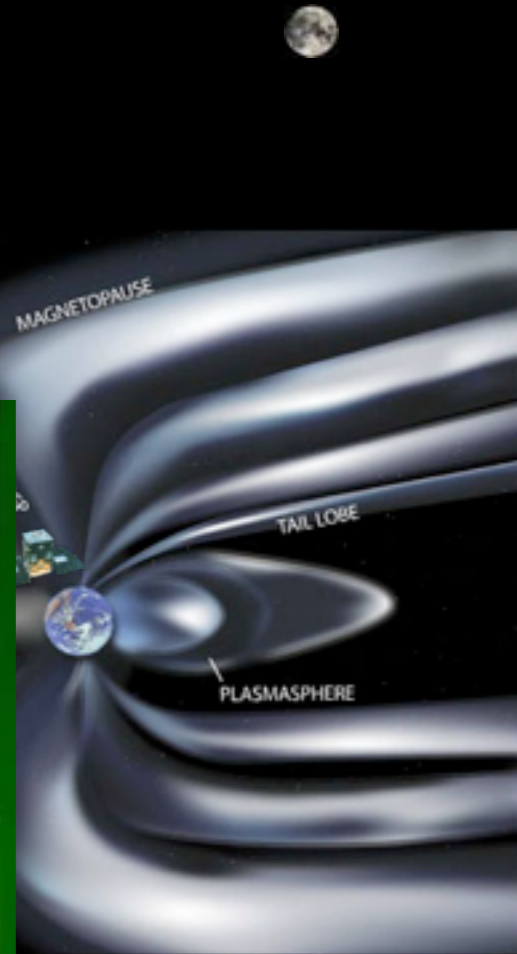
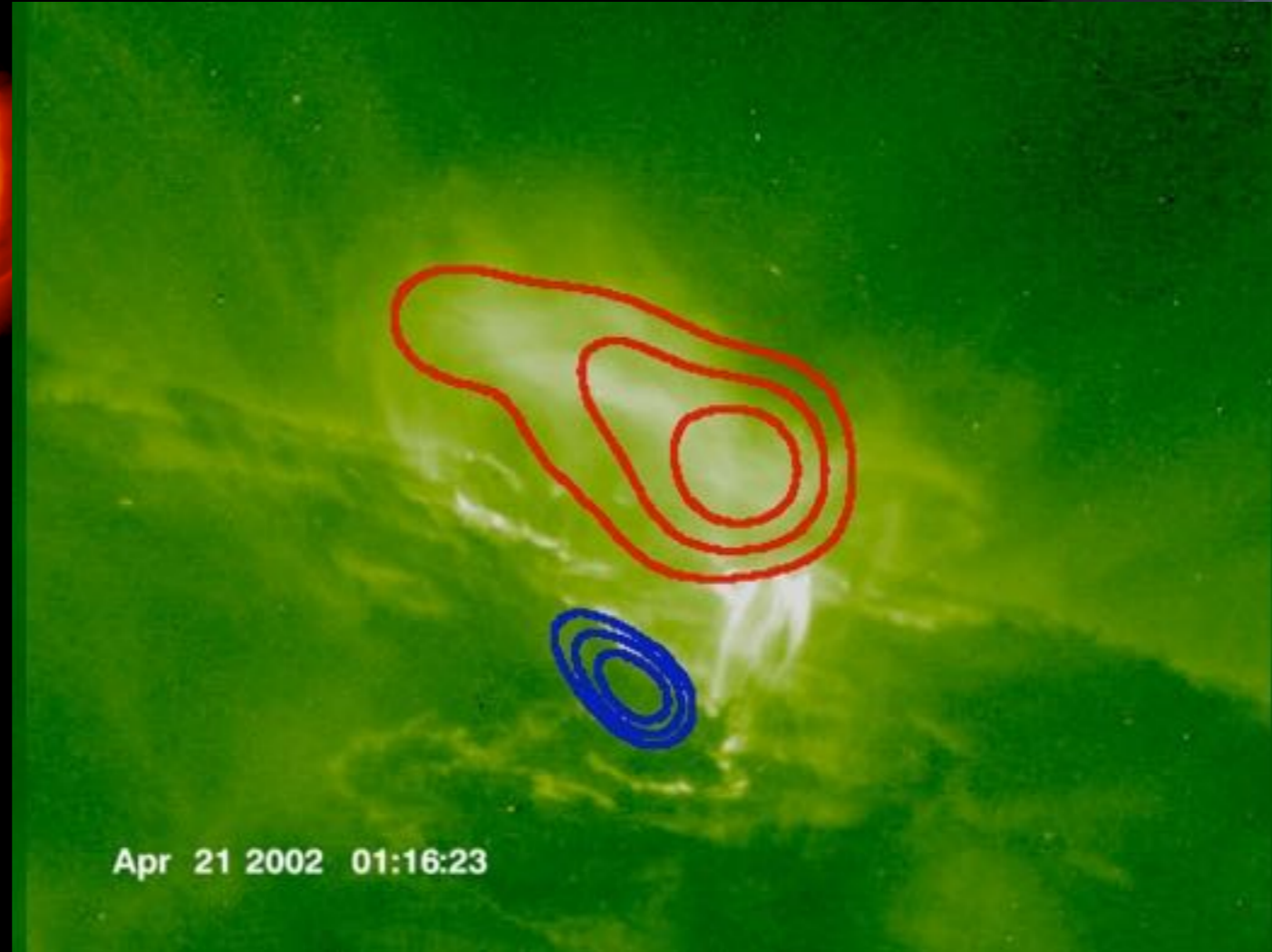
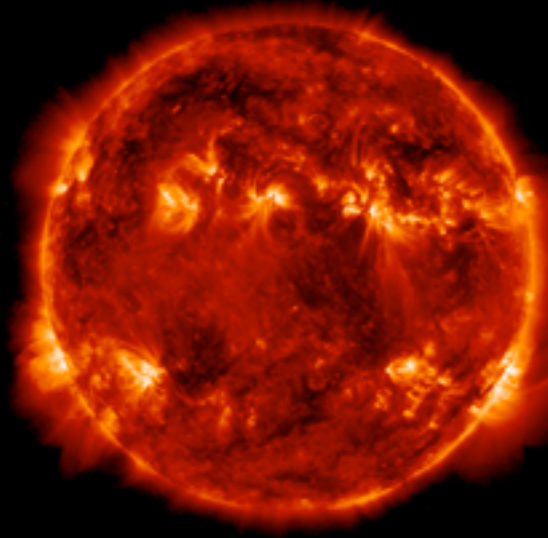
*SOHO*  
[LASCO/EIT/SUMER/MDI]

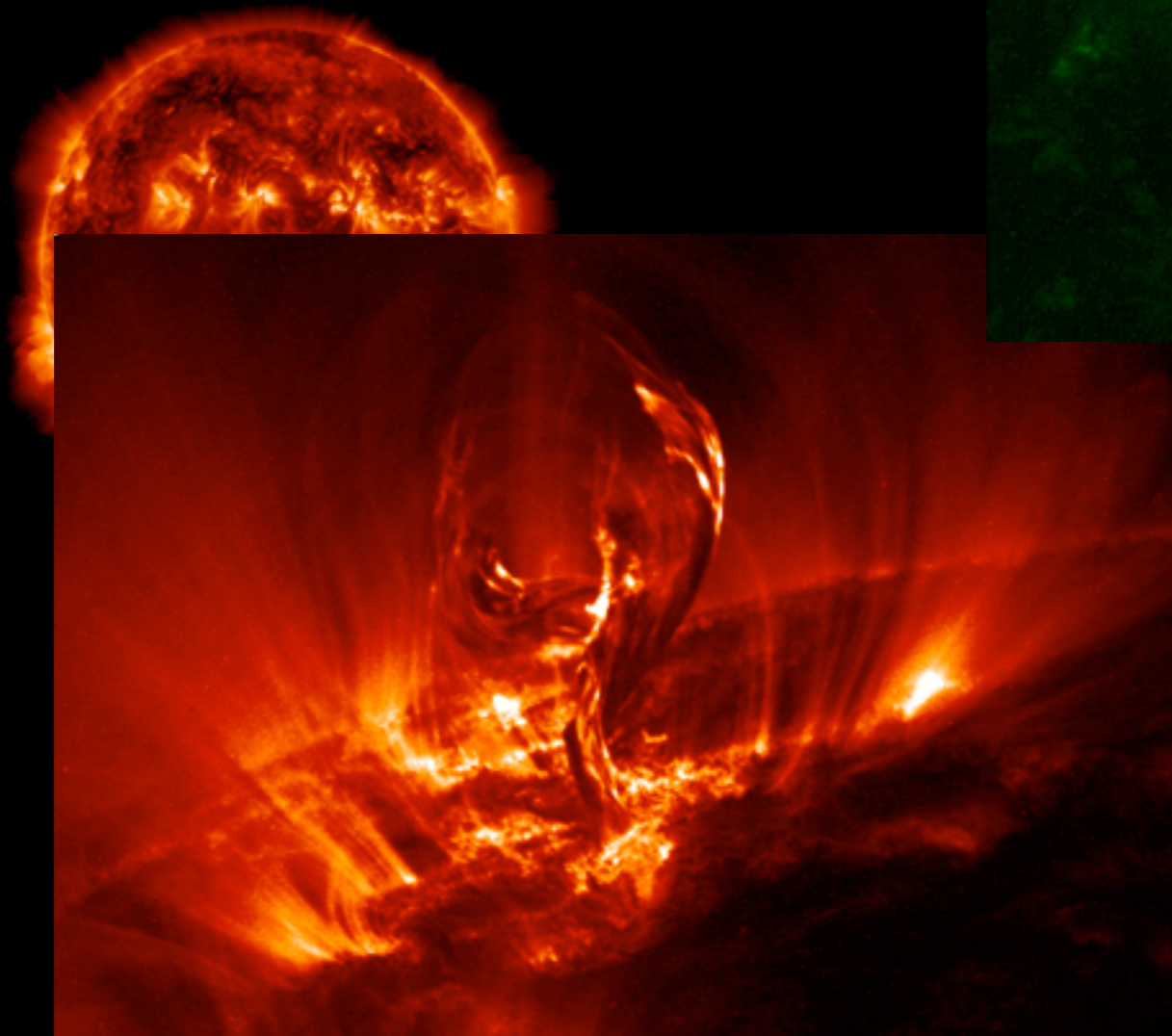
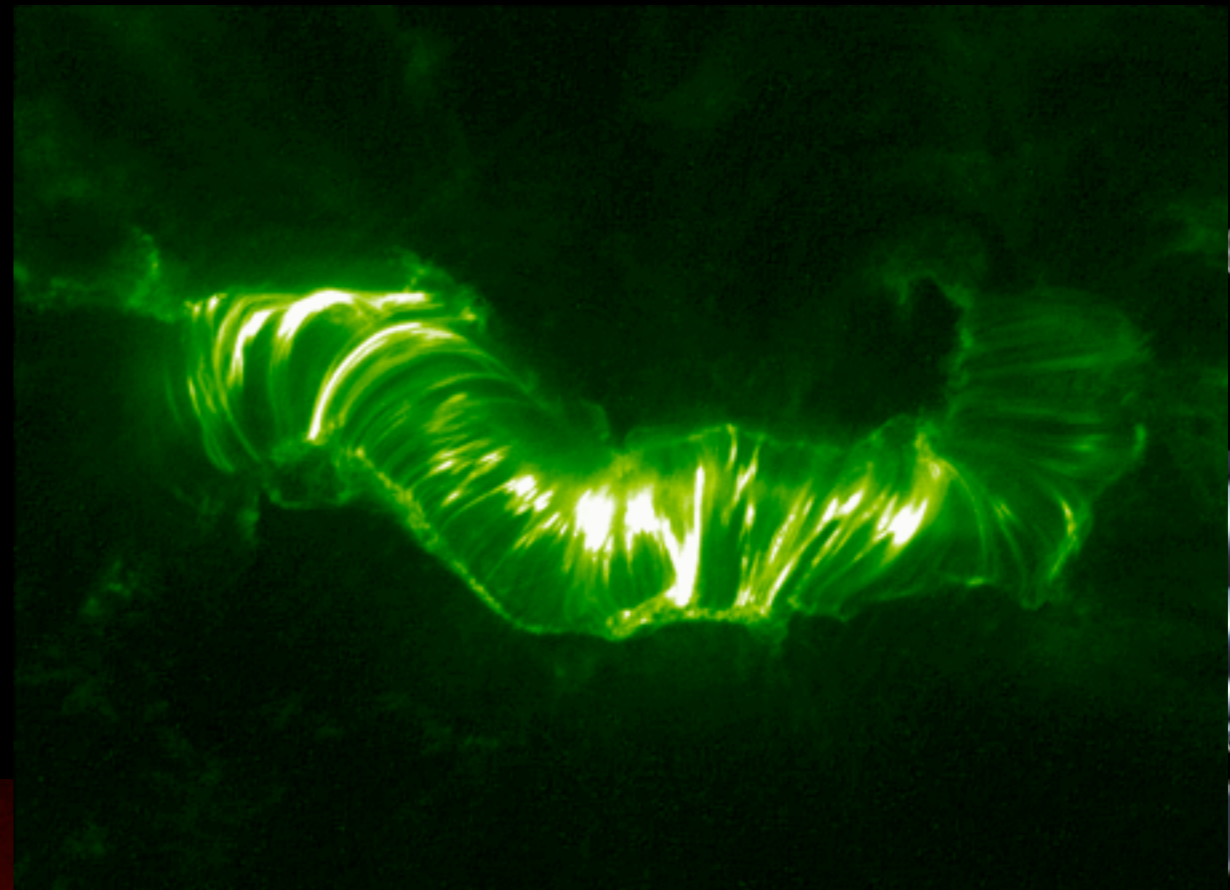
1995 -



*RHESSI*

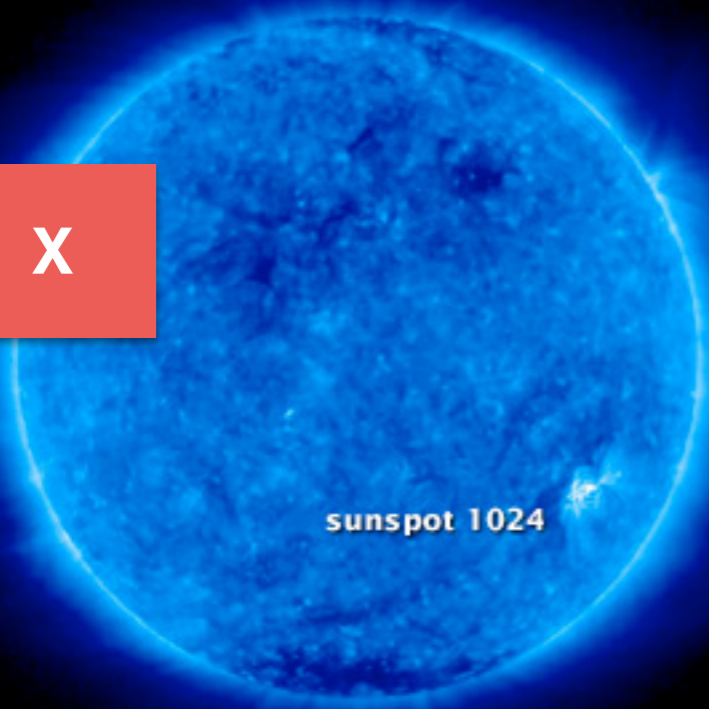
2002 -





*TRACE*

1998 - 2010



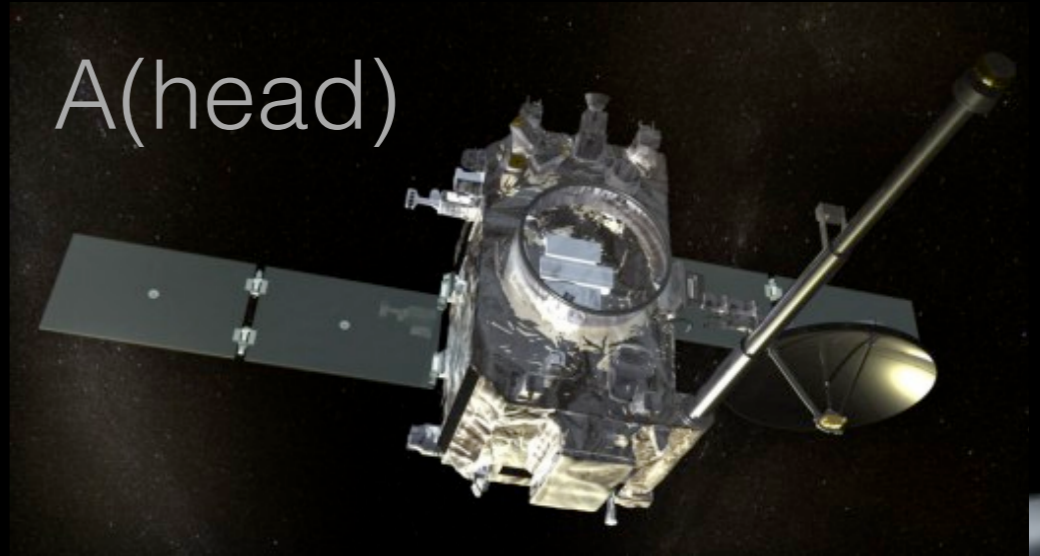
STEREO Ahead



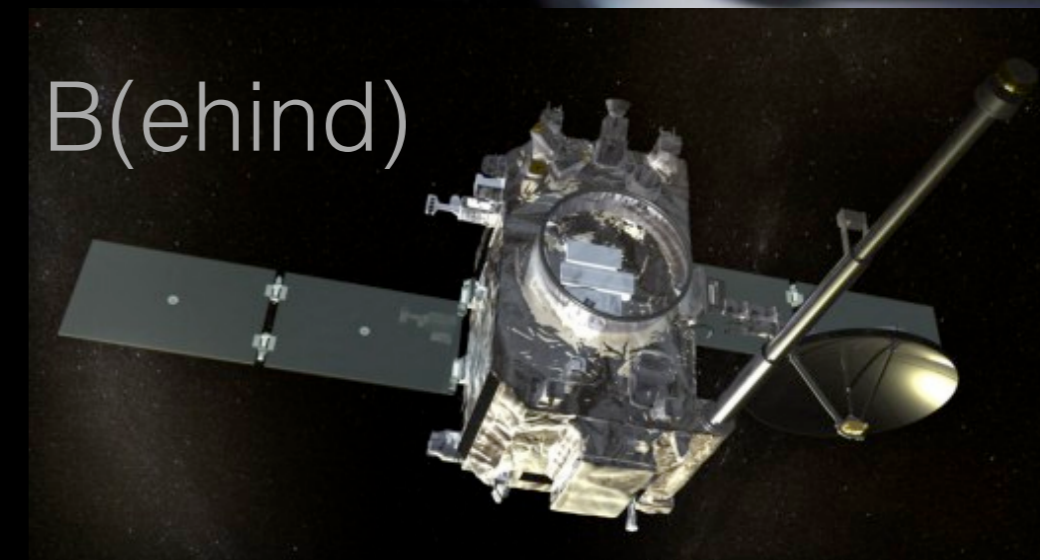
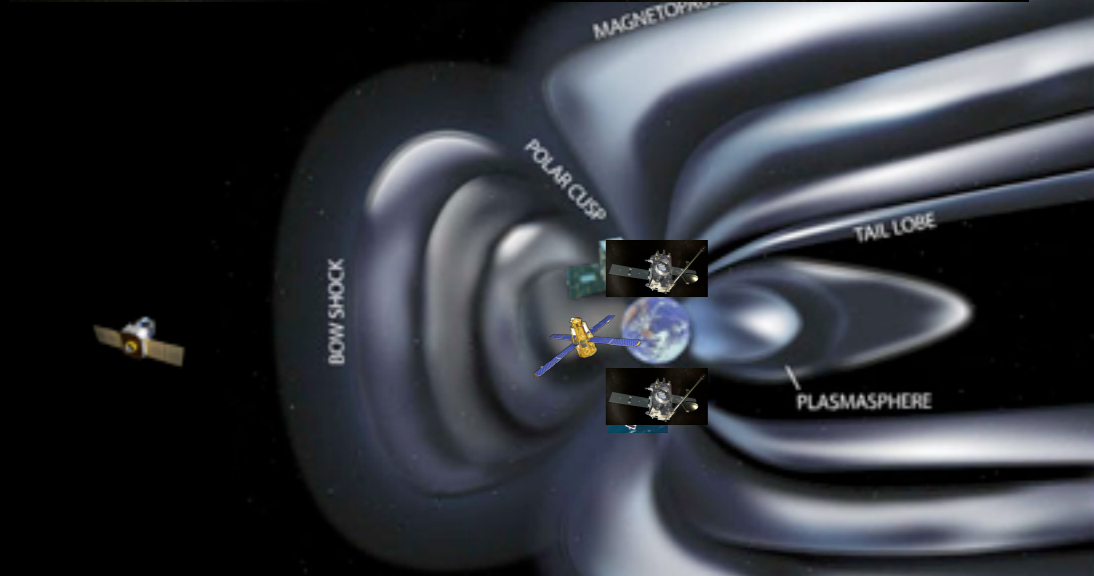
STEREO Behind

# STEREO [SECCHI]

2006 -



A(head)



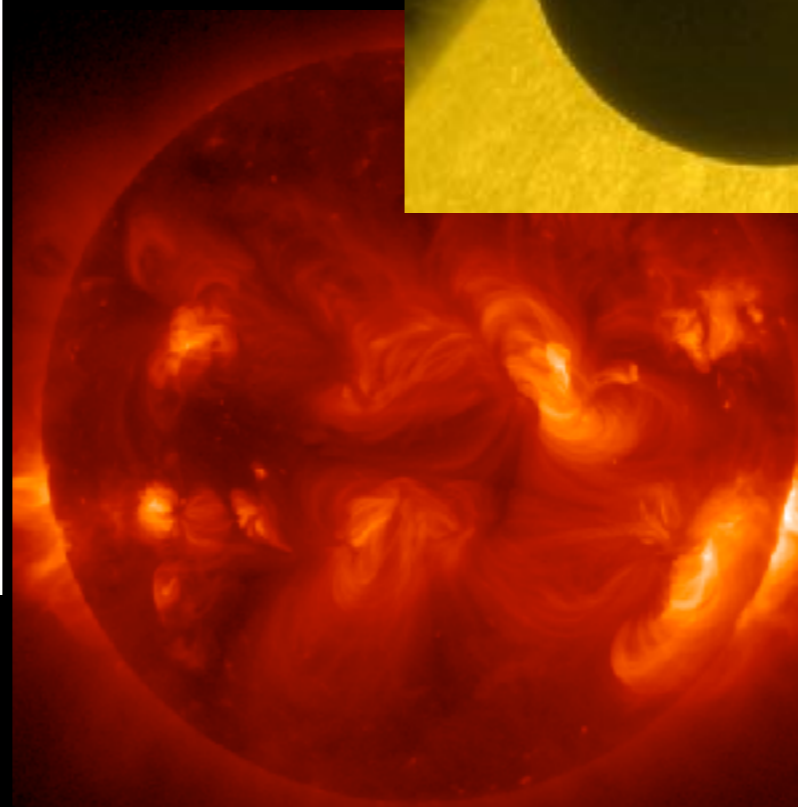
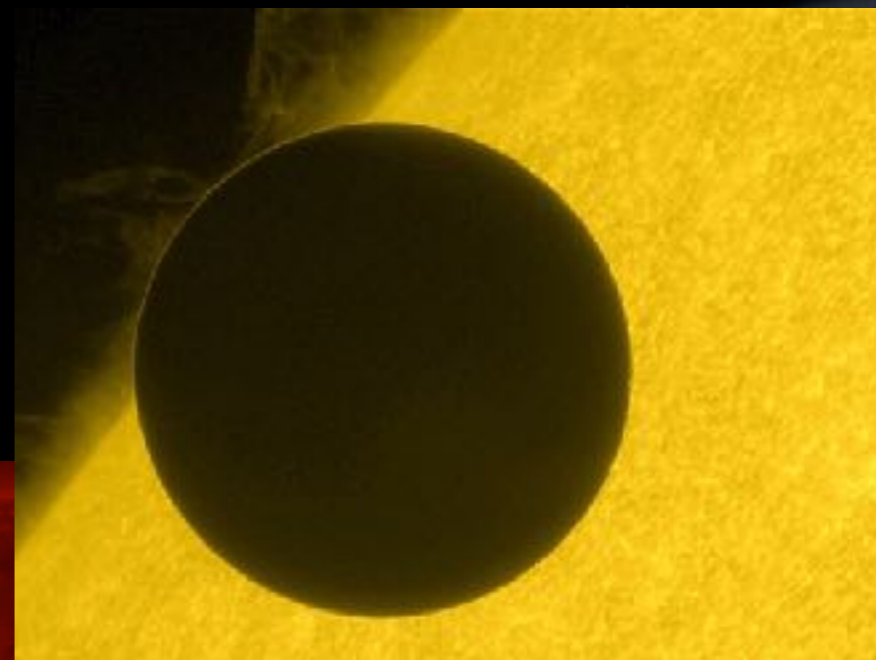
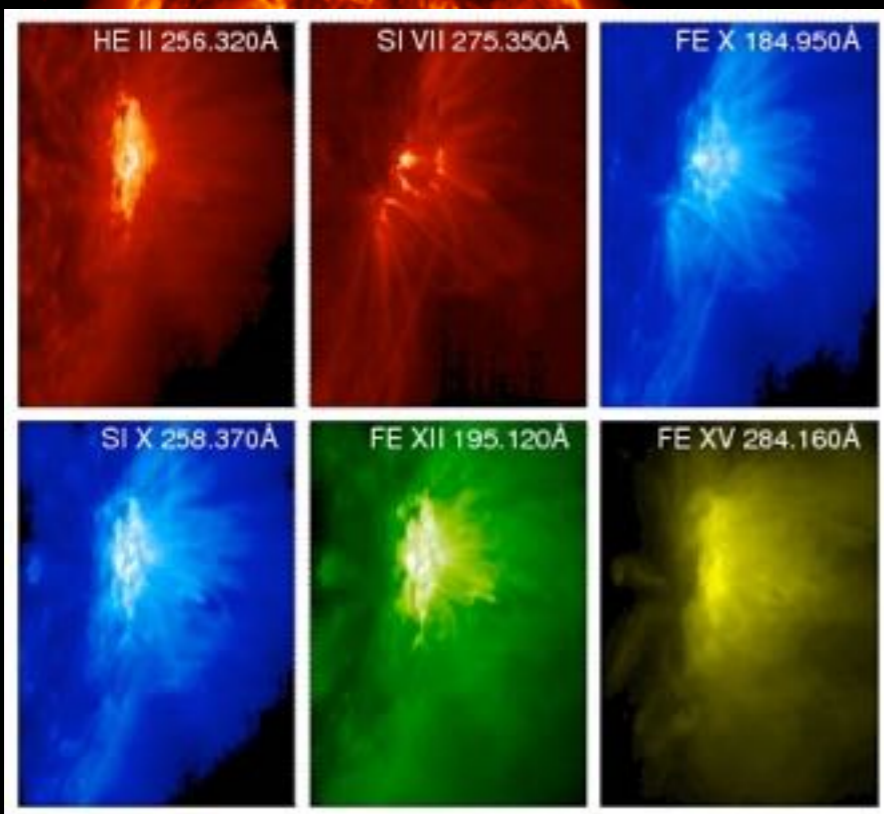
B(ehind)



# Hinode

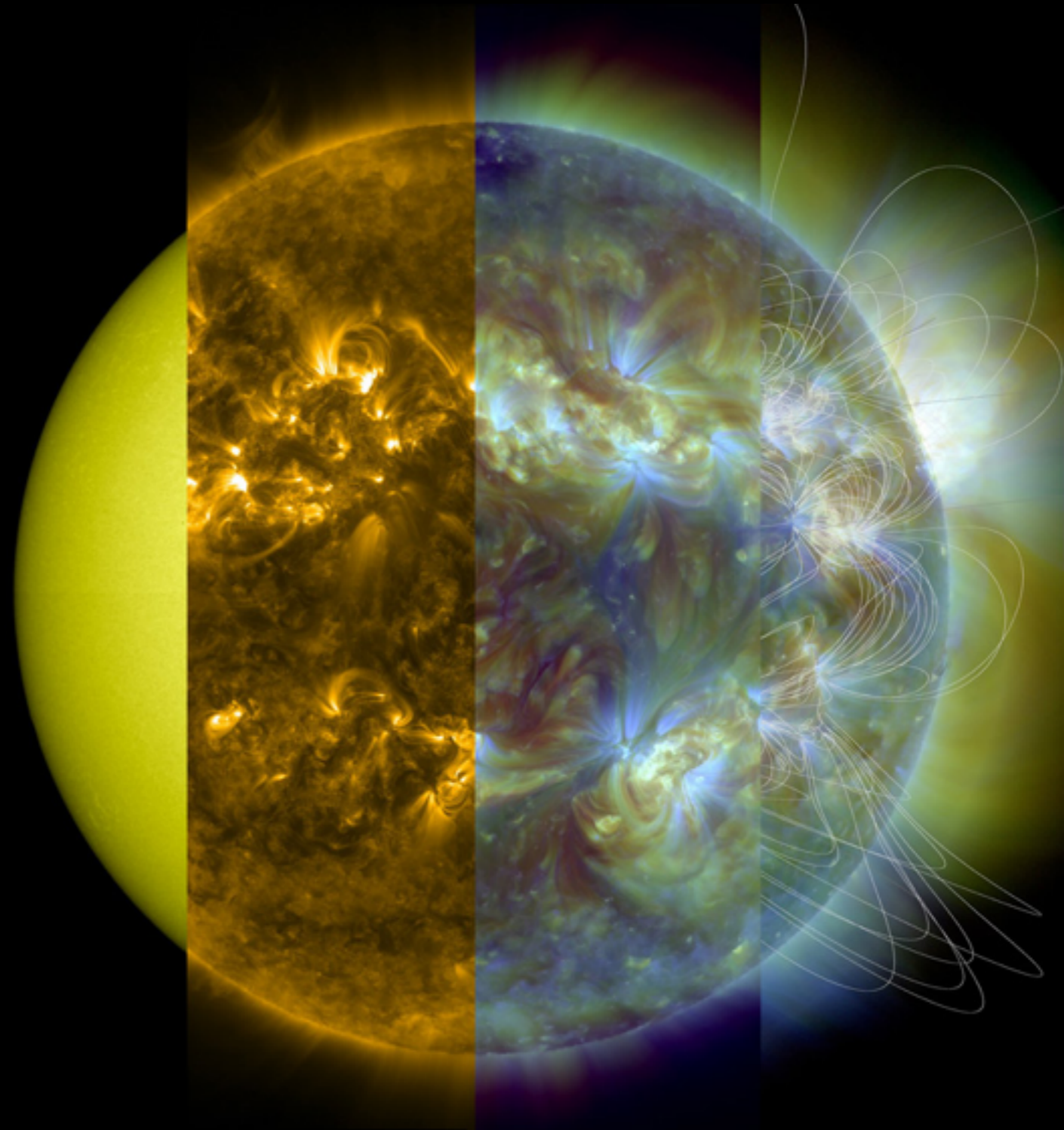
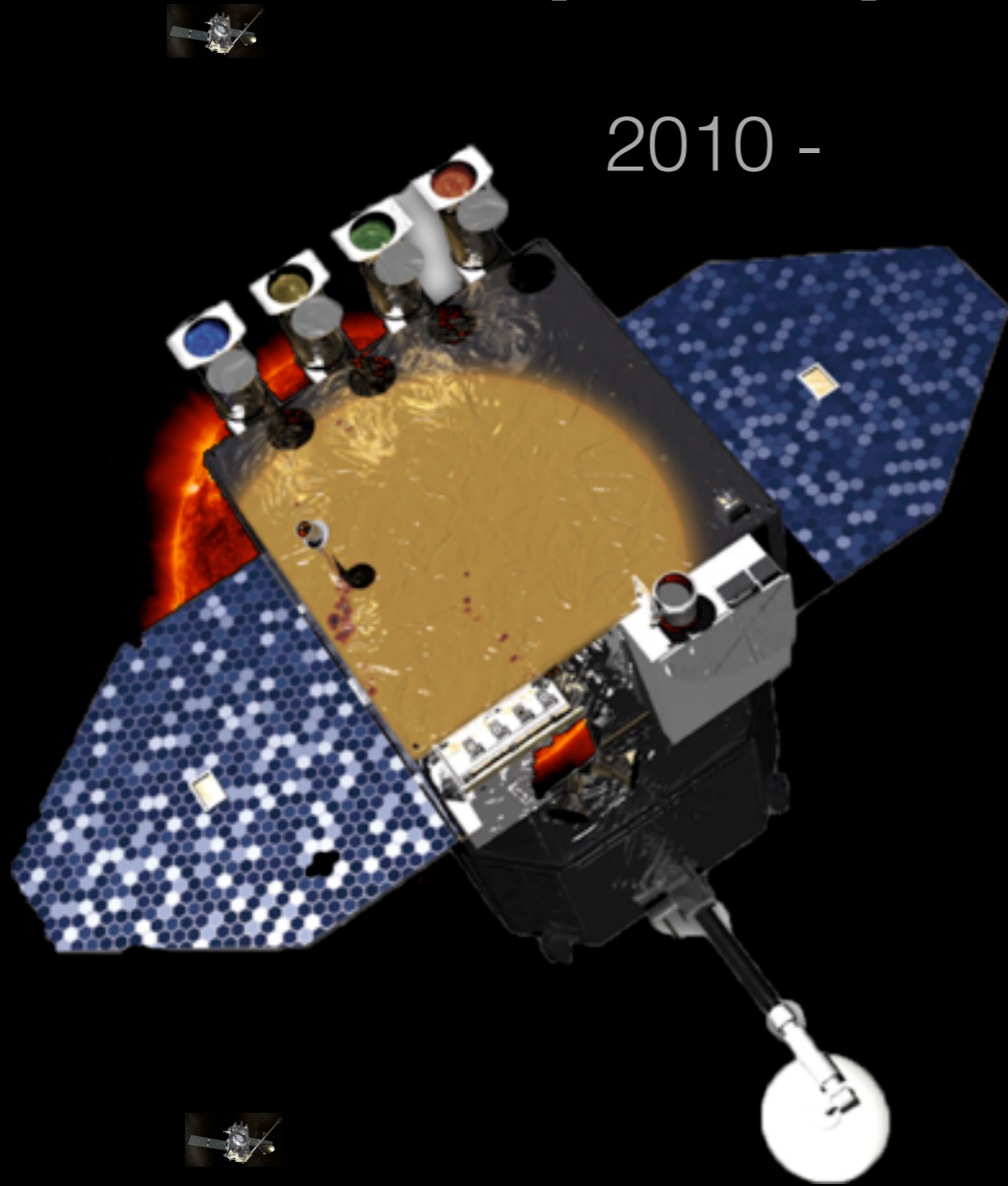
[SOT/EIS/XRT]

2006 -



*SDO:*  
[AIA/HMI]

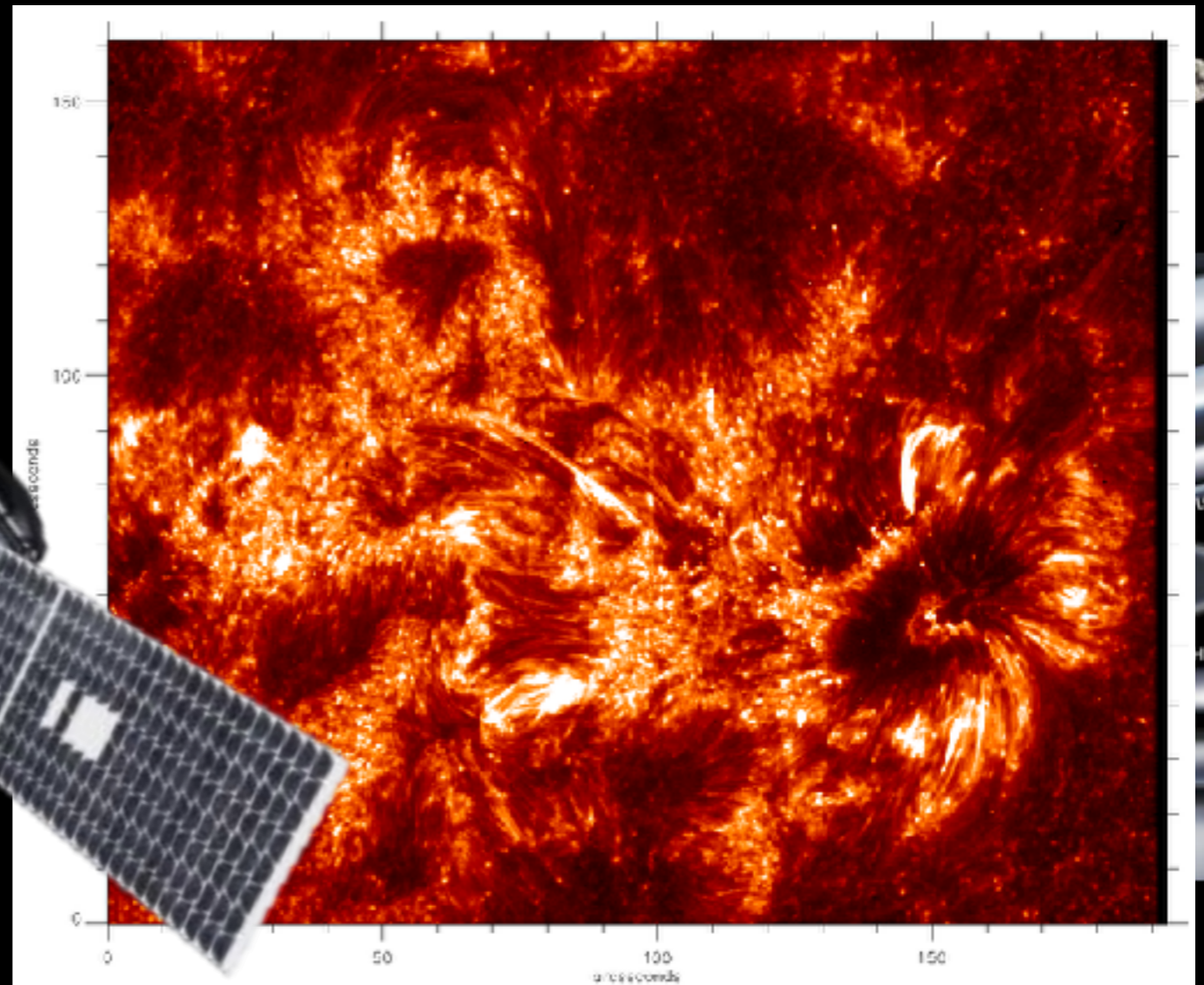
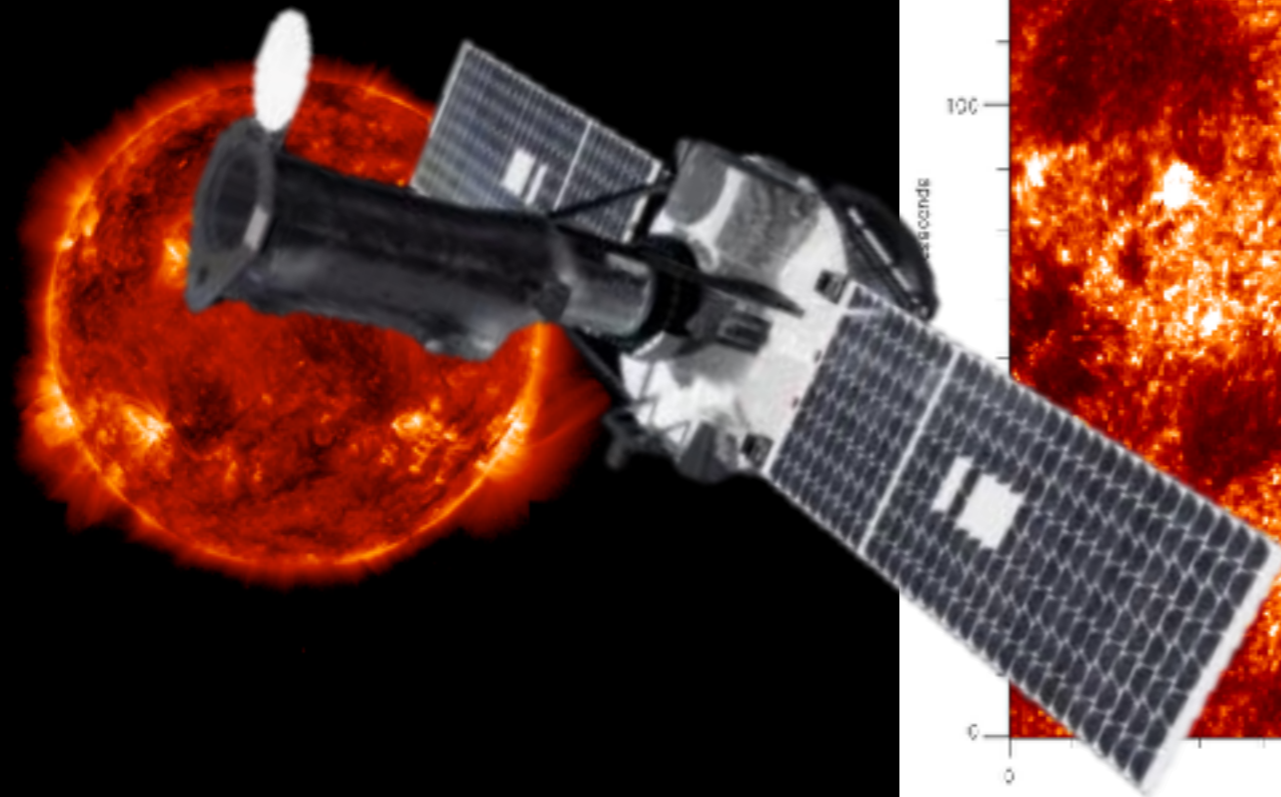
2010 -



# IRIS

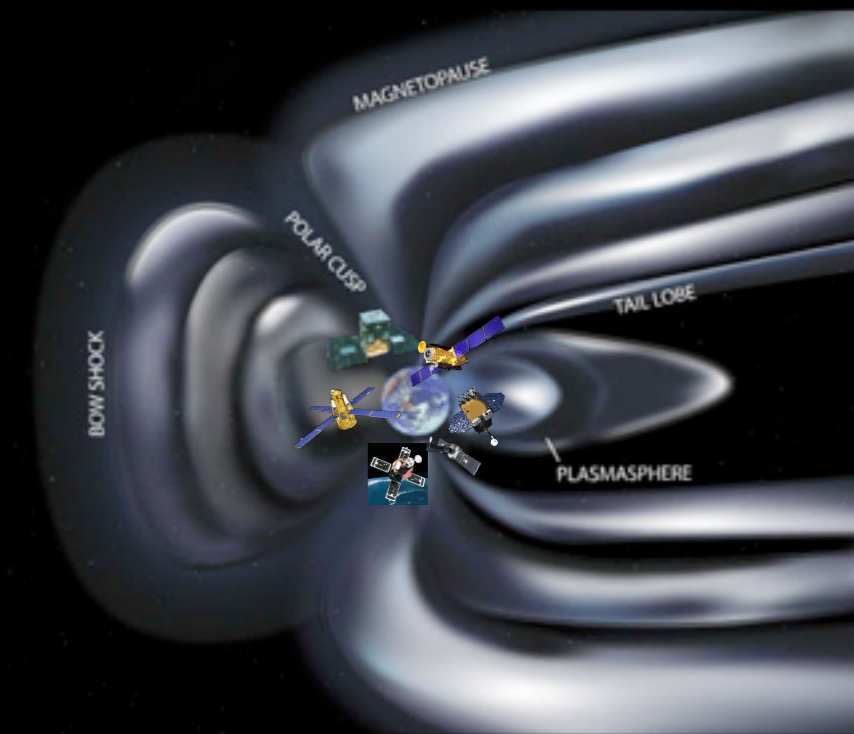
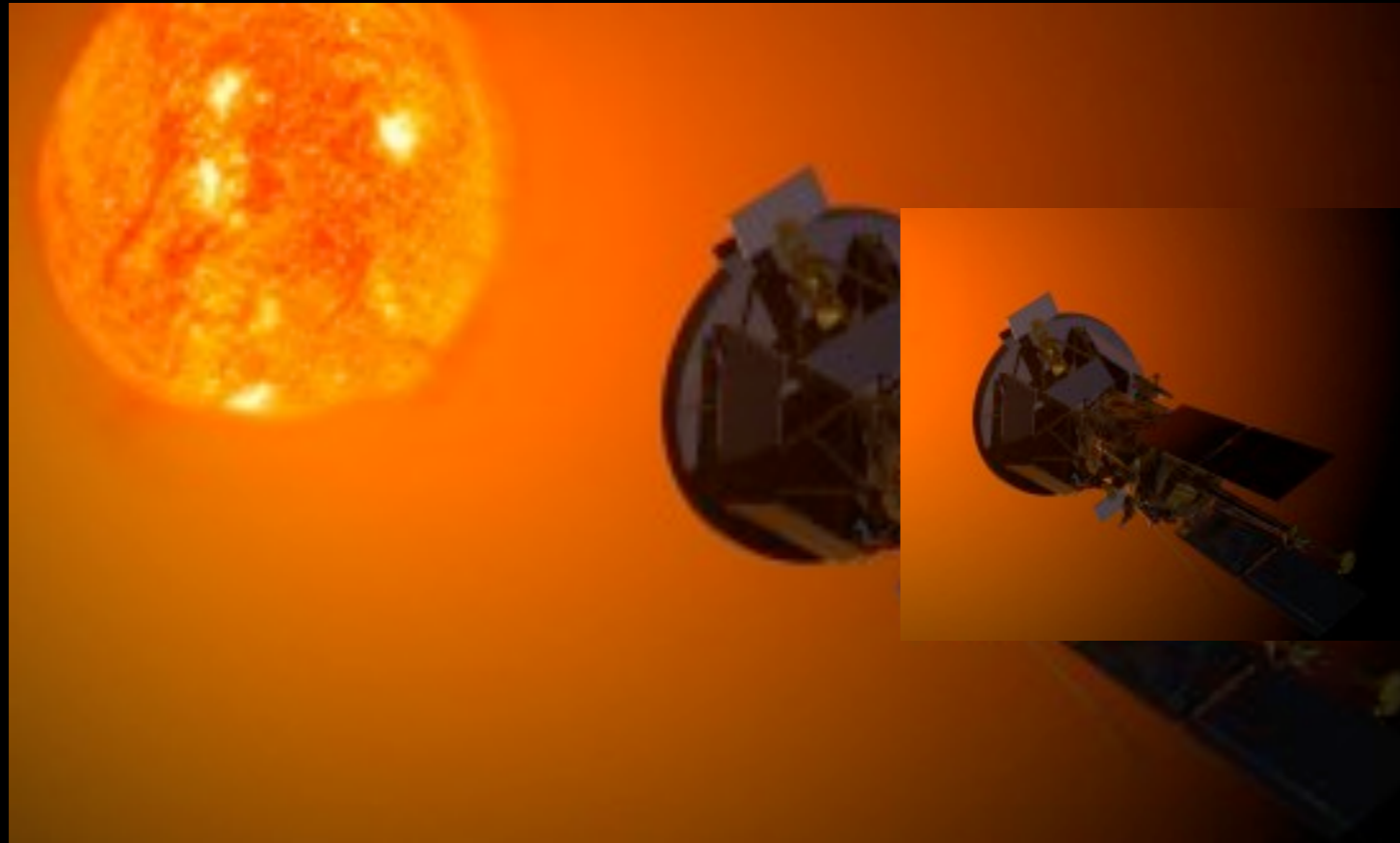


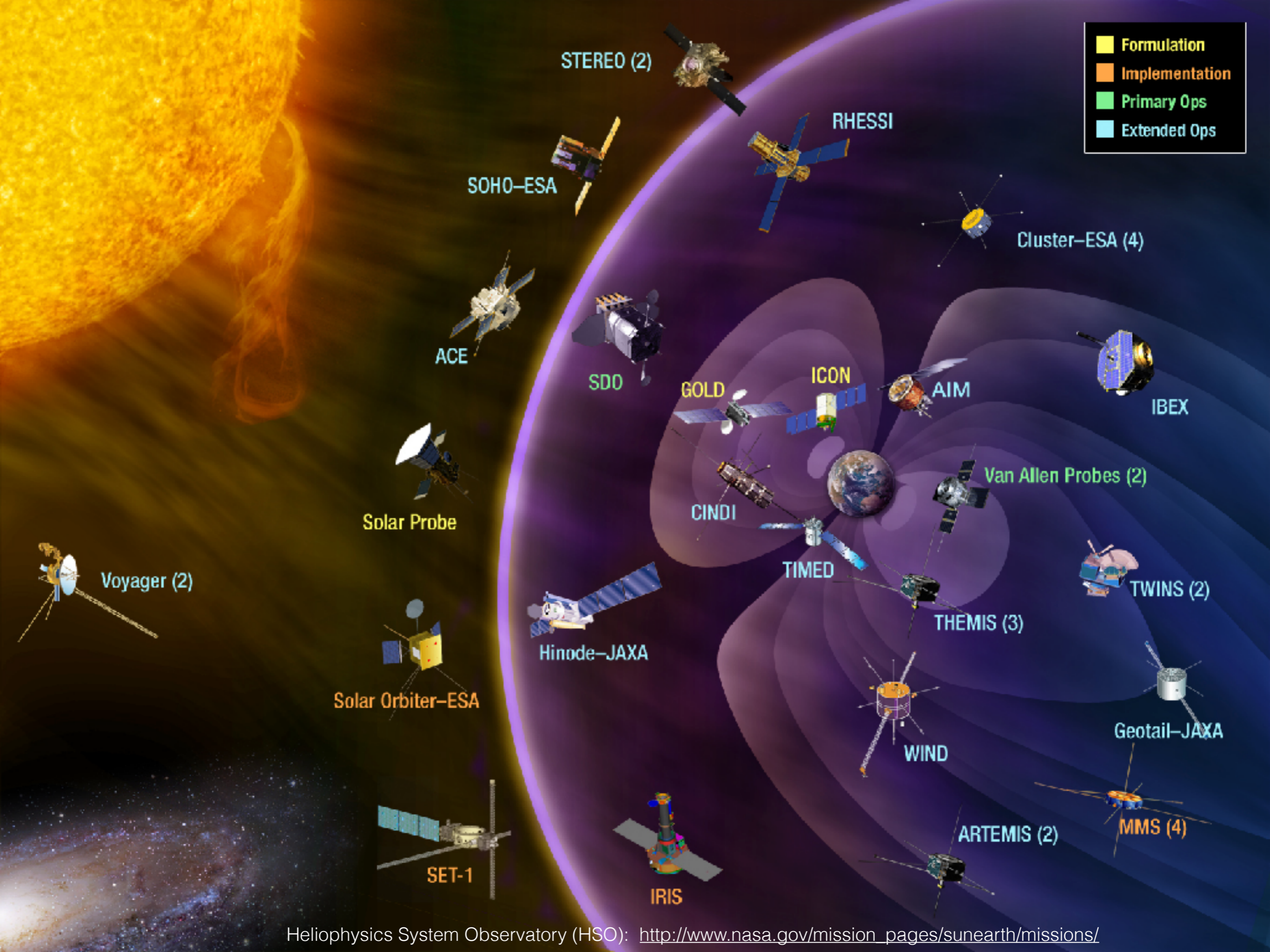
2013 -



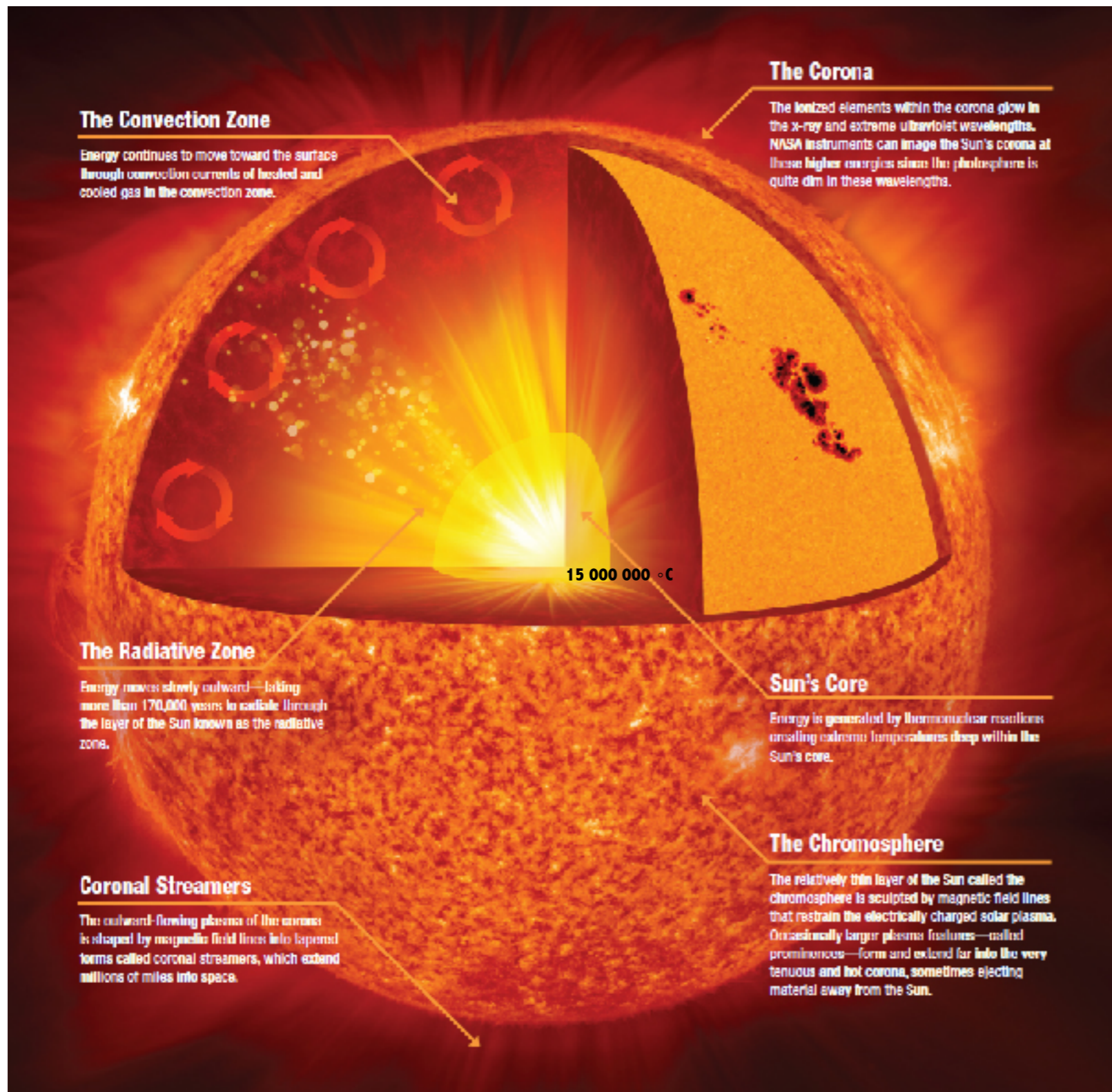
# Solar Probe+

2018? -





# The Sun in Layers



Converts 4 million tons of matter into energy every second.

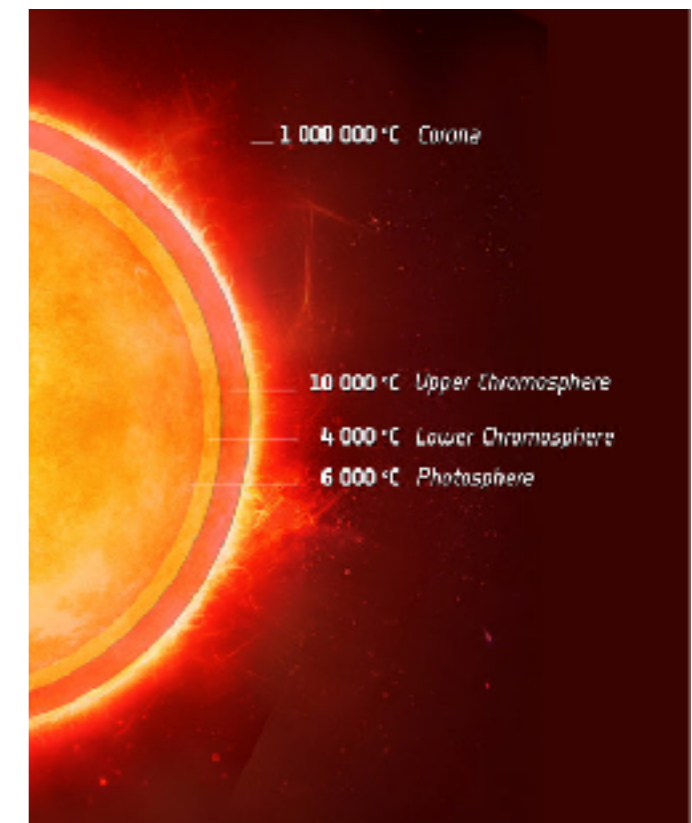
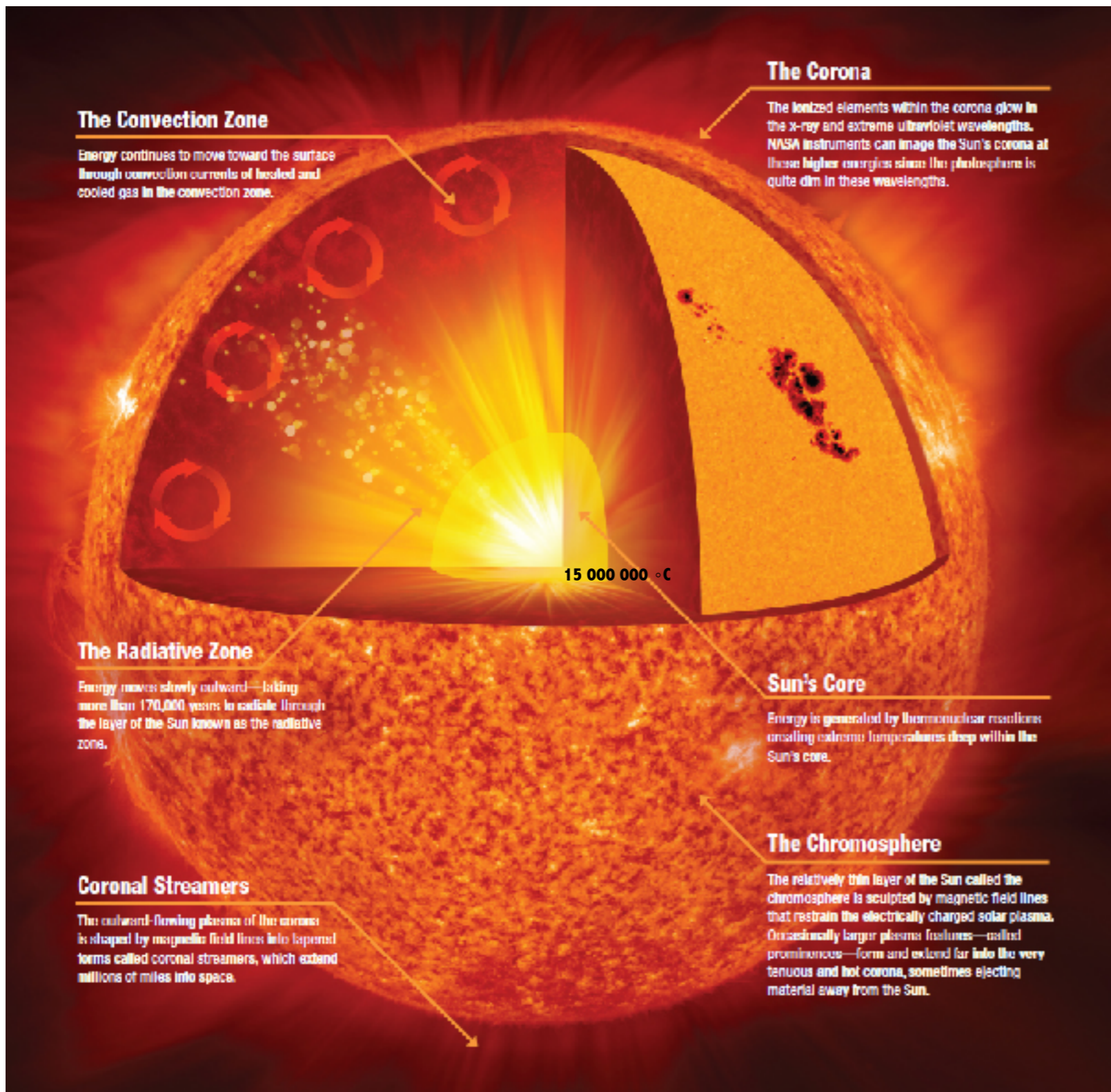
Core is as dense as lead.

Interplay between magnetic pressure and gas (plasma) pressure.

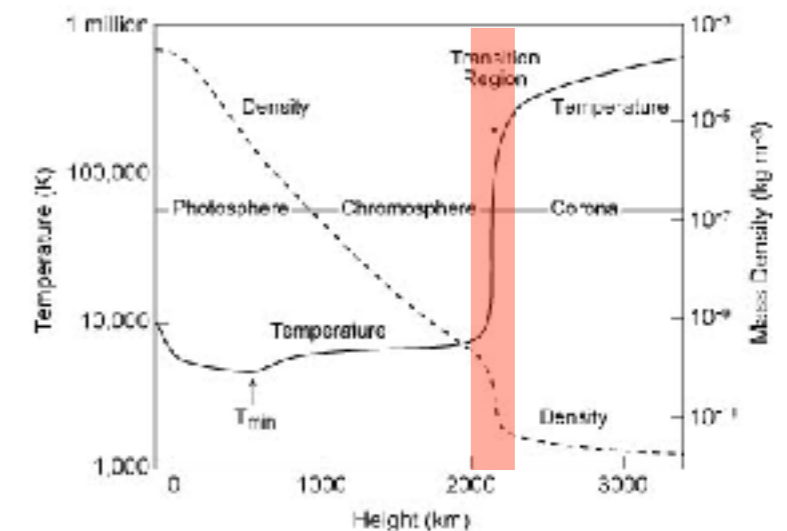
“Mysteries of the Sun”: NASA / Jenny Mottar

Sun Facts: <http://solarscience.msfc.nasa.gov/>

# The Sun in Layers



European Space Agency (ESA)



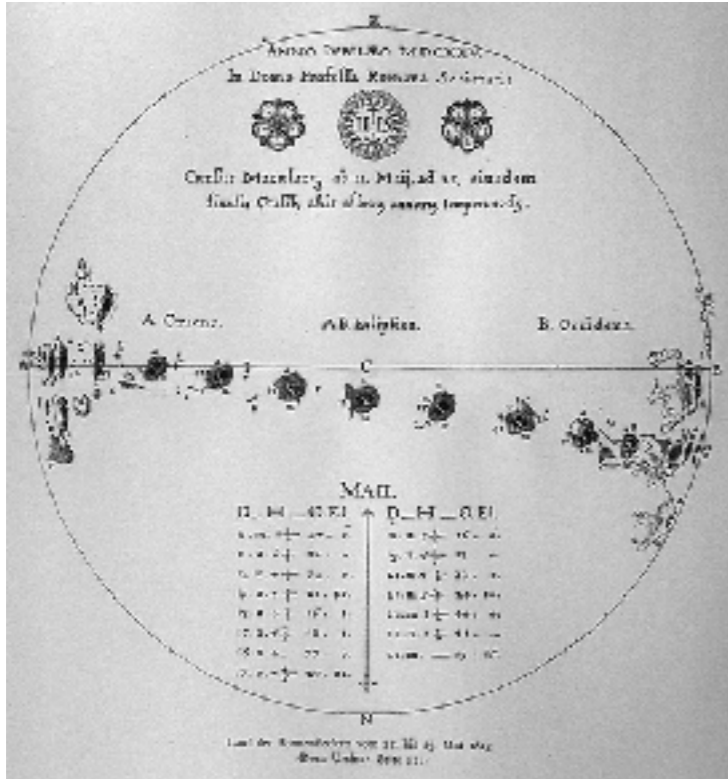
Smithsonian Astrophysical Observatory (SAO)

“Mysteries of the Sun”: NASA / Jenny Mottar

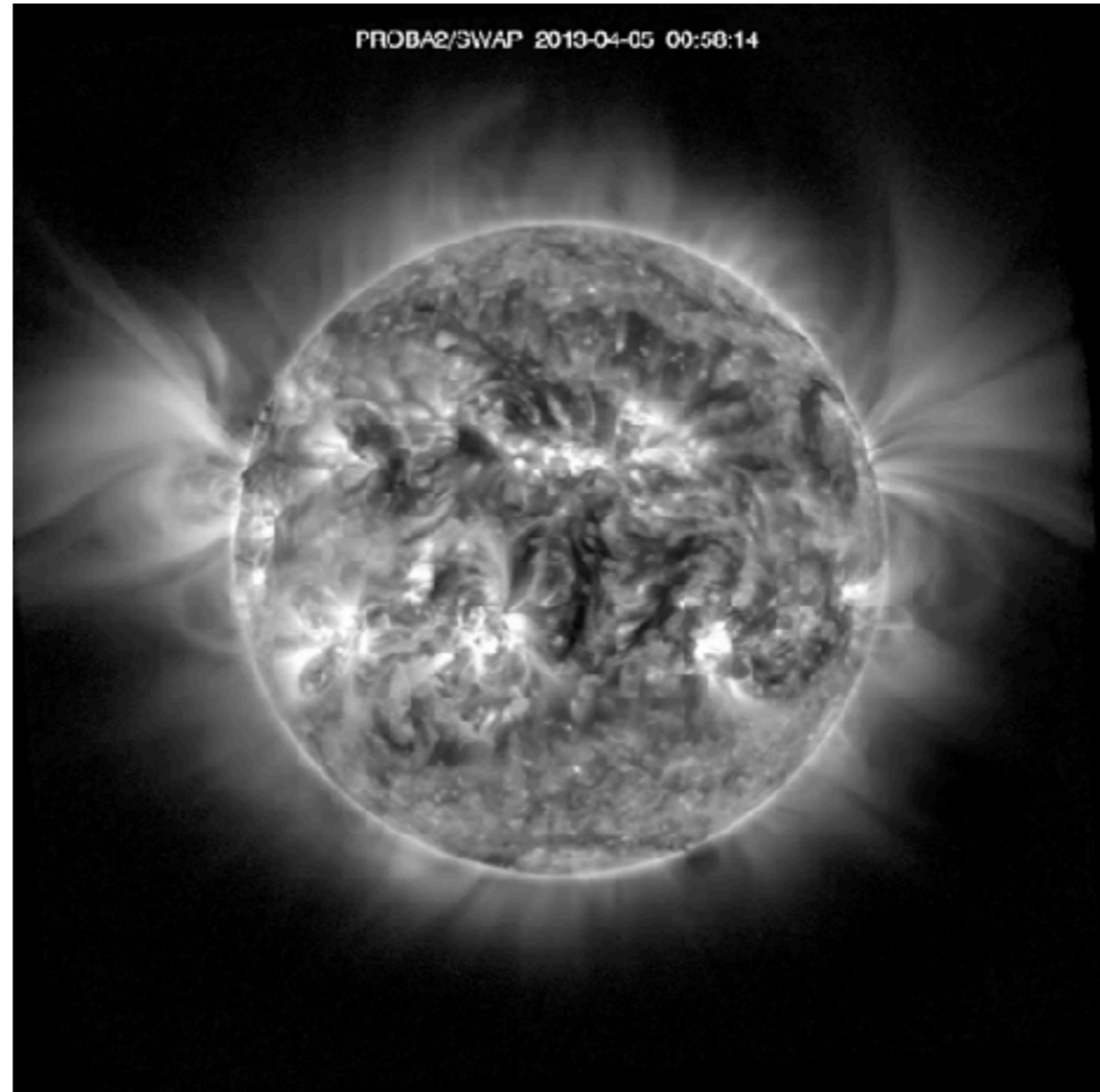
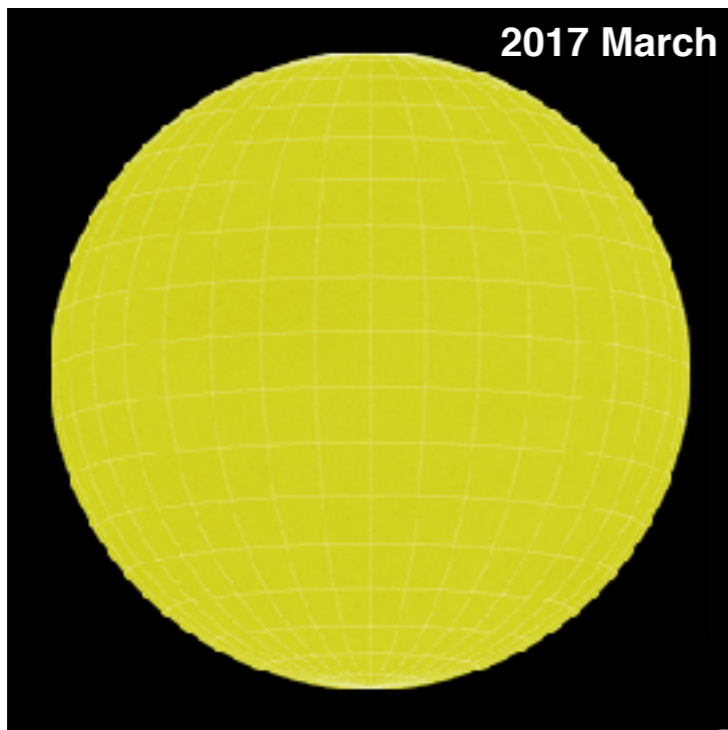
Sun Facts: <http://solarscience.msfc.nasa.gov/>

# Sunspots & Active Regions

1625 May: Christoph Scheiner



SDO HMI 6173 A



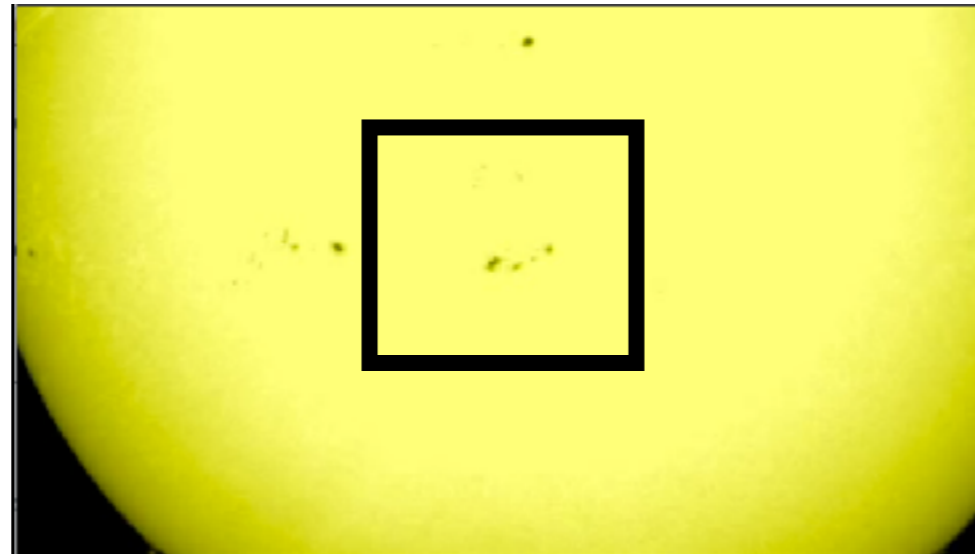
European Space Agency (ESA) / Royal Observatory Belgium (ROB)



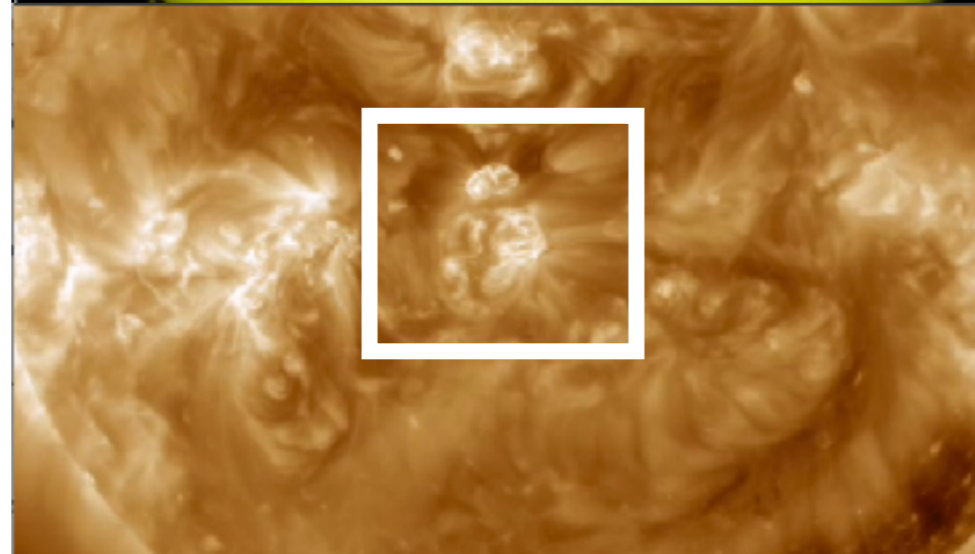
# Sunspots & Active Regions

Formation

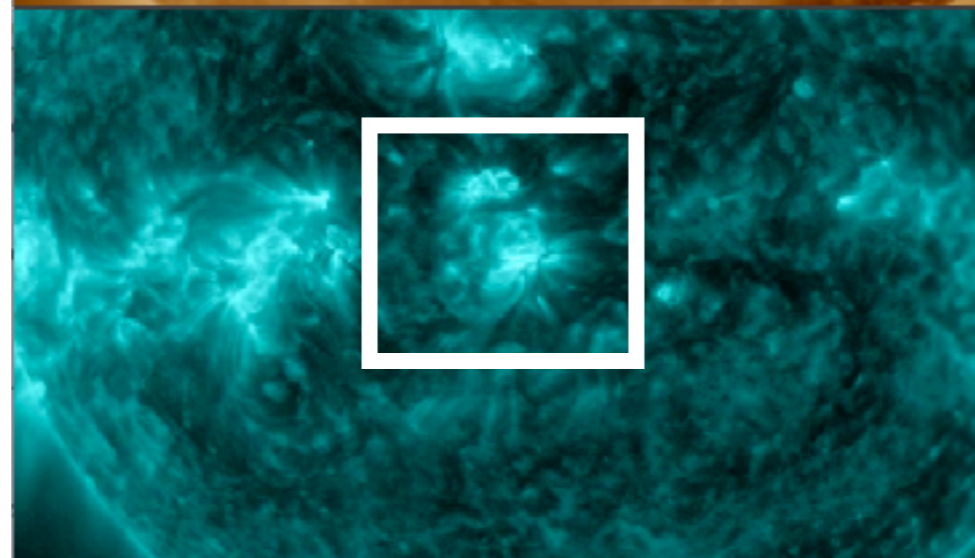
4500 Å



193 Å

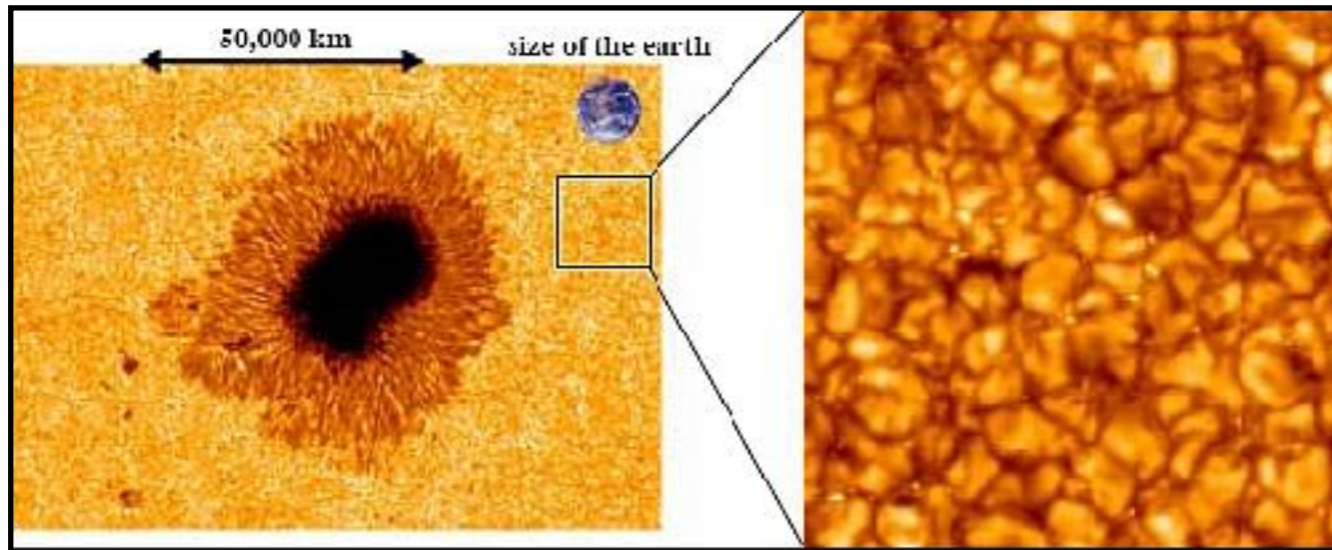


131 Å



SDO / AIA  
2014 Apr 13 - 15

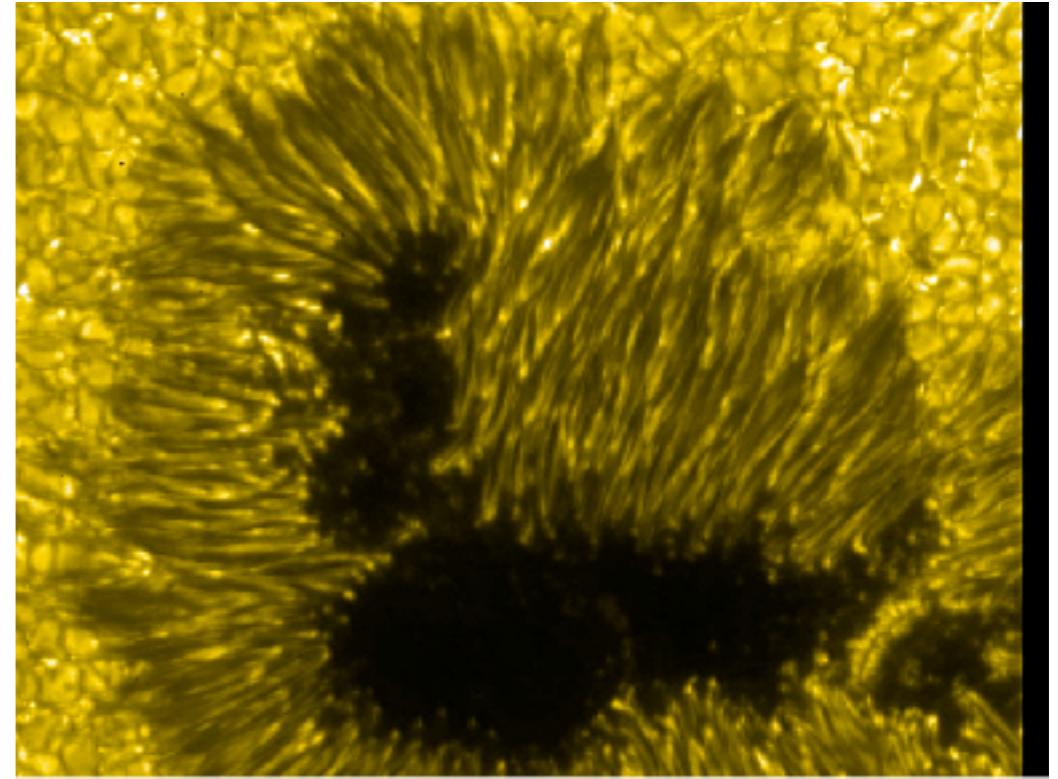
# Sunspots & Active Regions



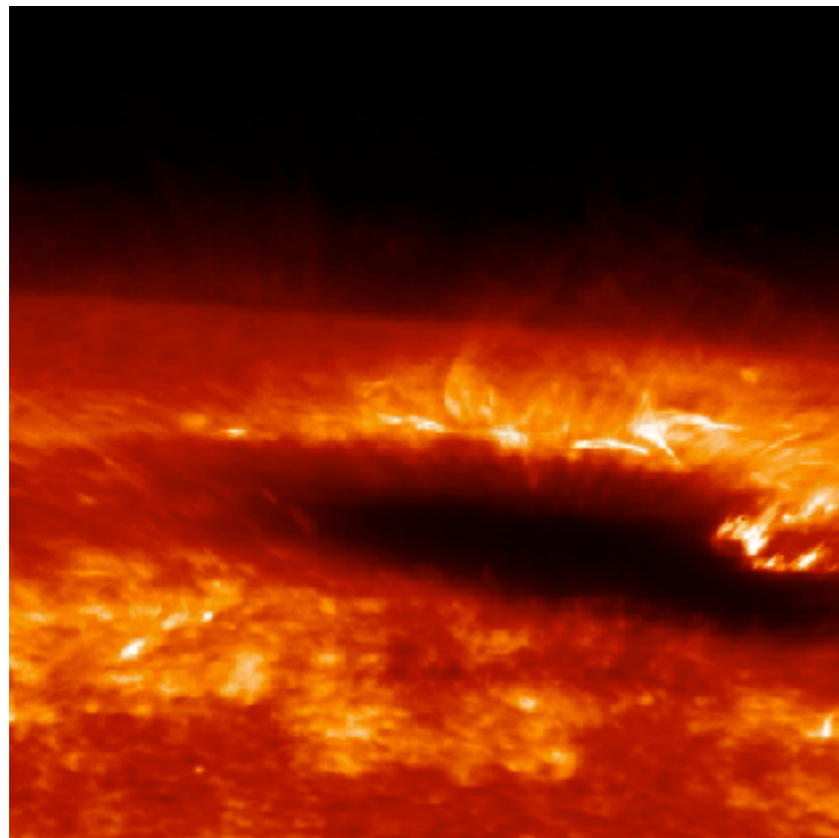
*Hinode* SOT: NASA / JAXA / NAOJ

Magnetic fields ~ 6000 times stronger than Earth's field.

Magnetic pressure dominates gas pressure in spot, thus inhibiting convective flow of heat.



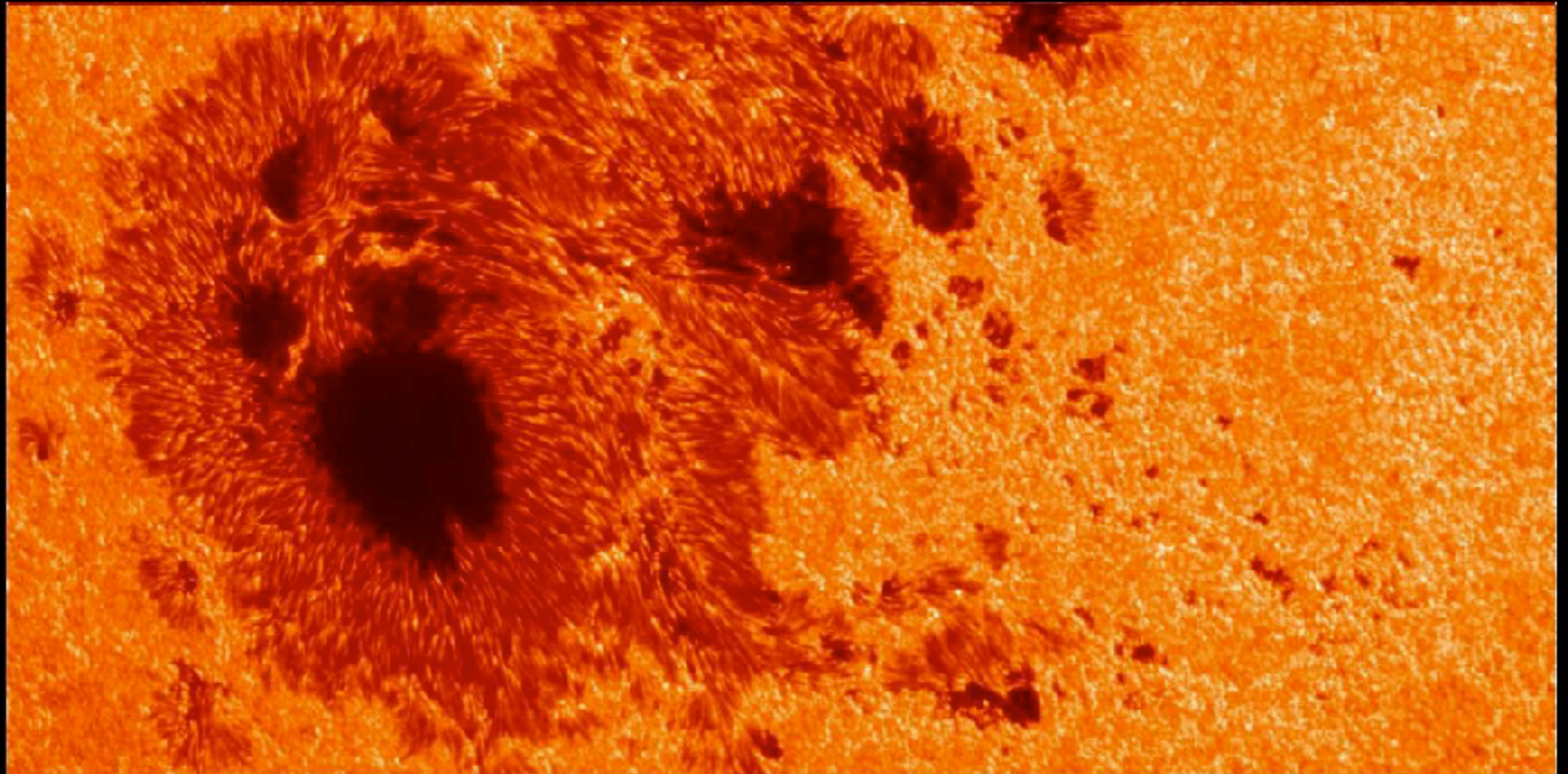
SOT (CN line 3883 A); 2007 May 2



SOT (Ca H-line); 2006 Nov 20

# Sunspots & Active Regions

---



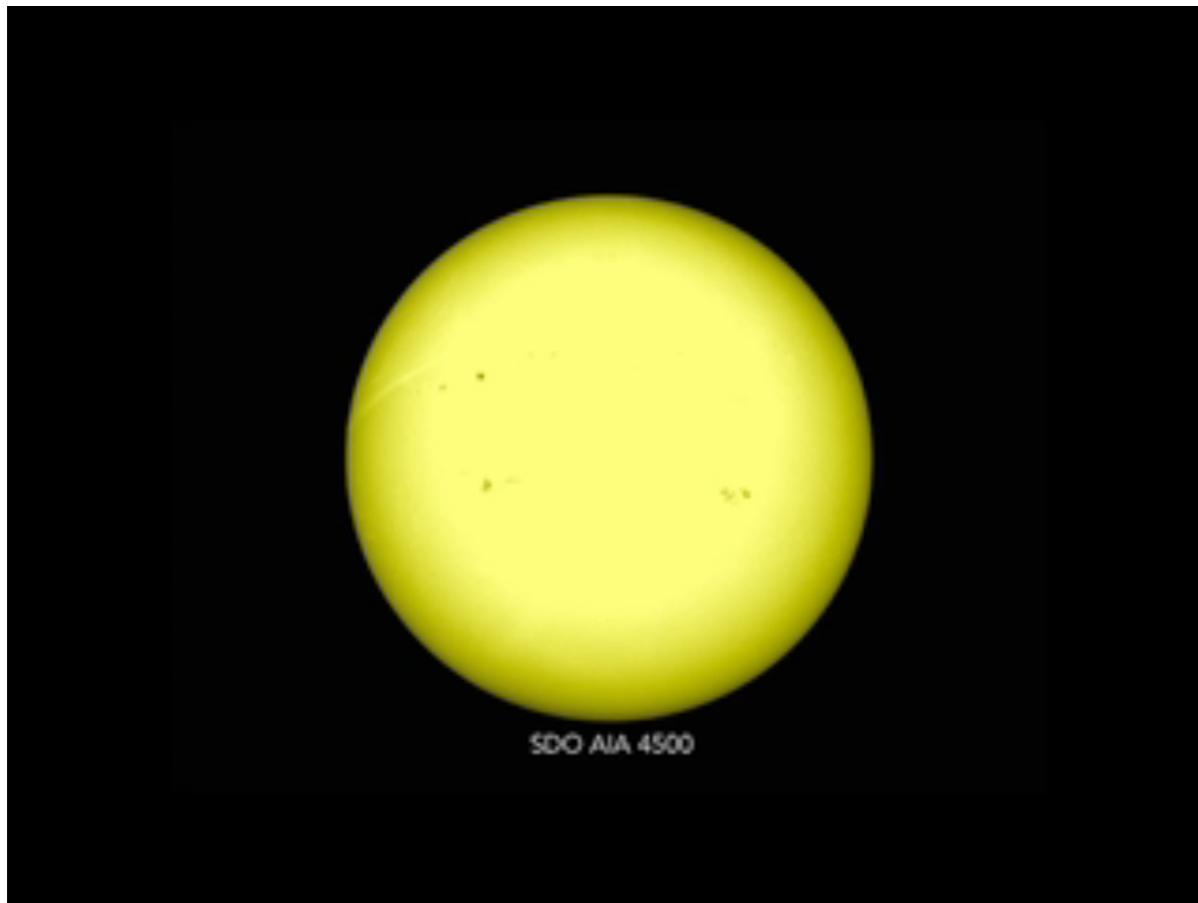
---

*Hinode* / SOT: Disk crossing of AR 12192, the largest sunspot group to appear on the Sun in 25 years.

# Sunspots & Active Regions

---

JHelioviewer *SDO* / AIA 2014 Apr 04

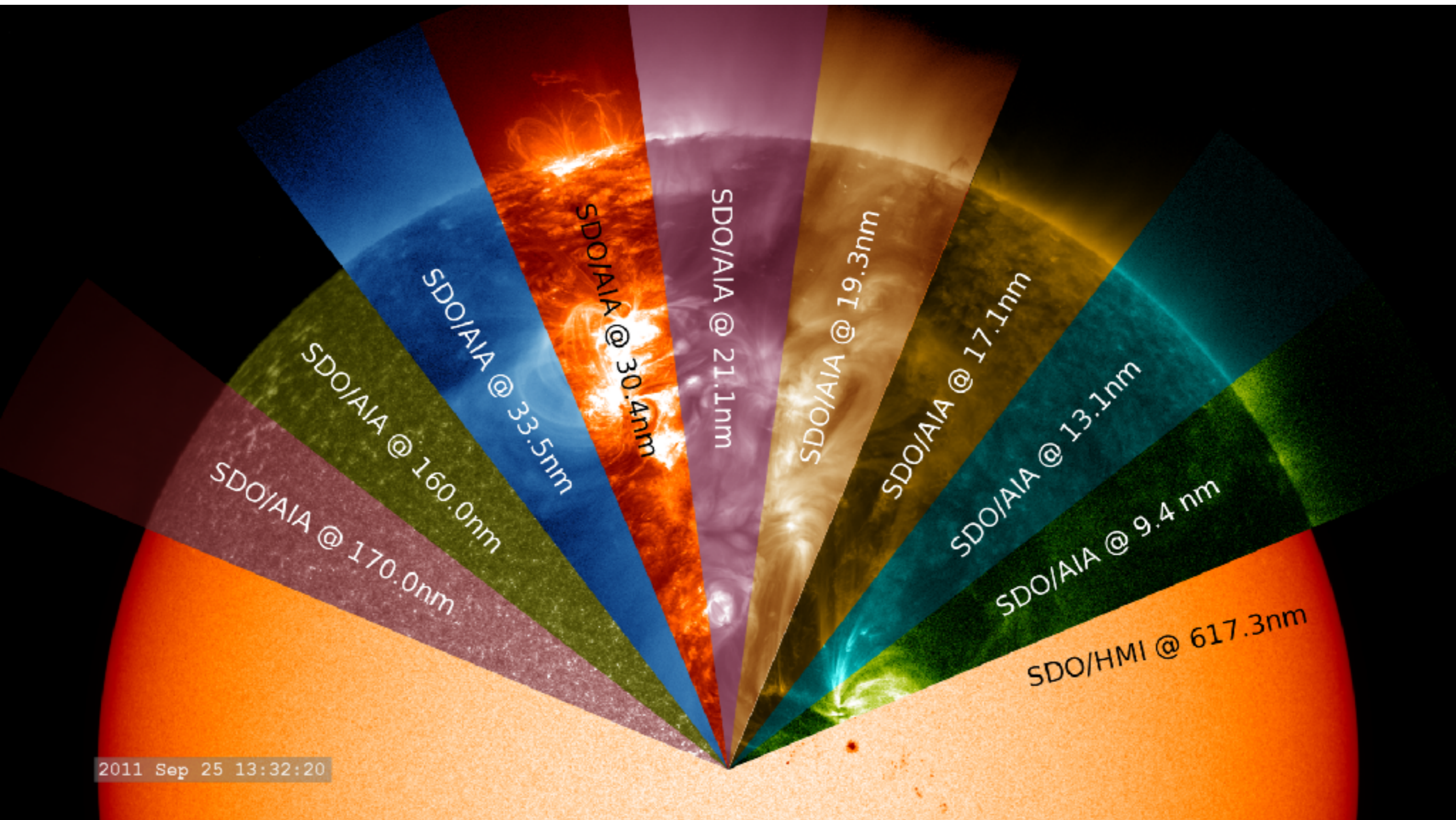


*SOHO* animation gallery

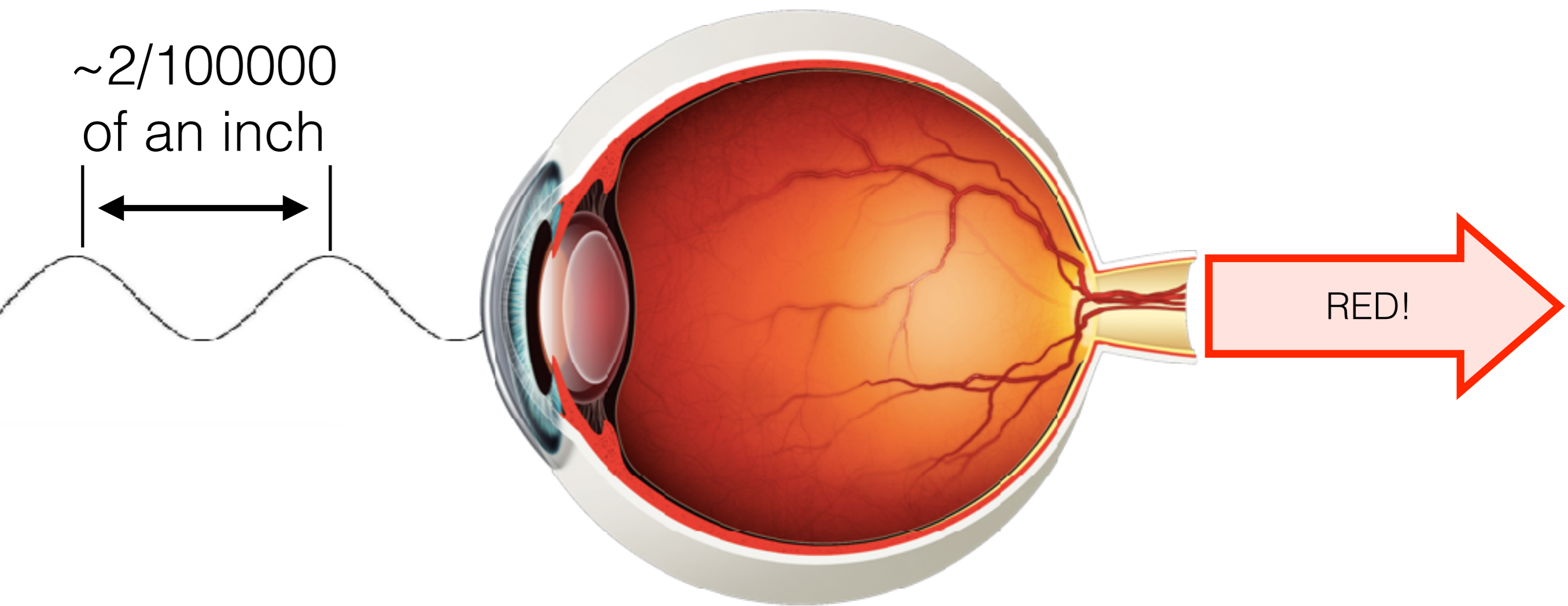


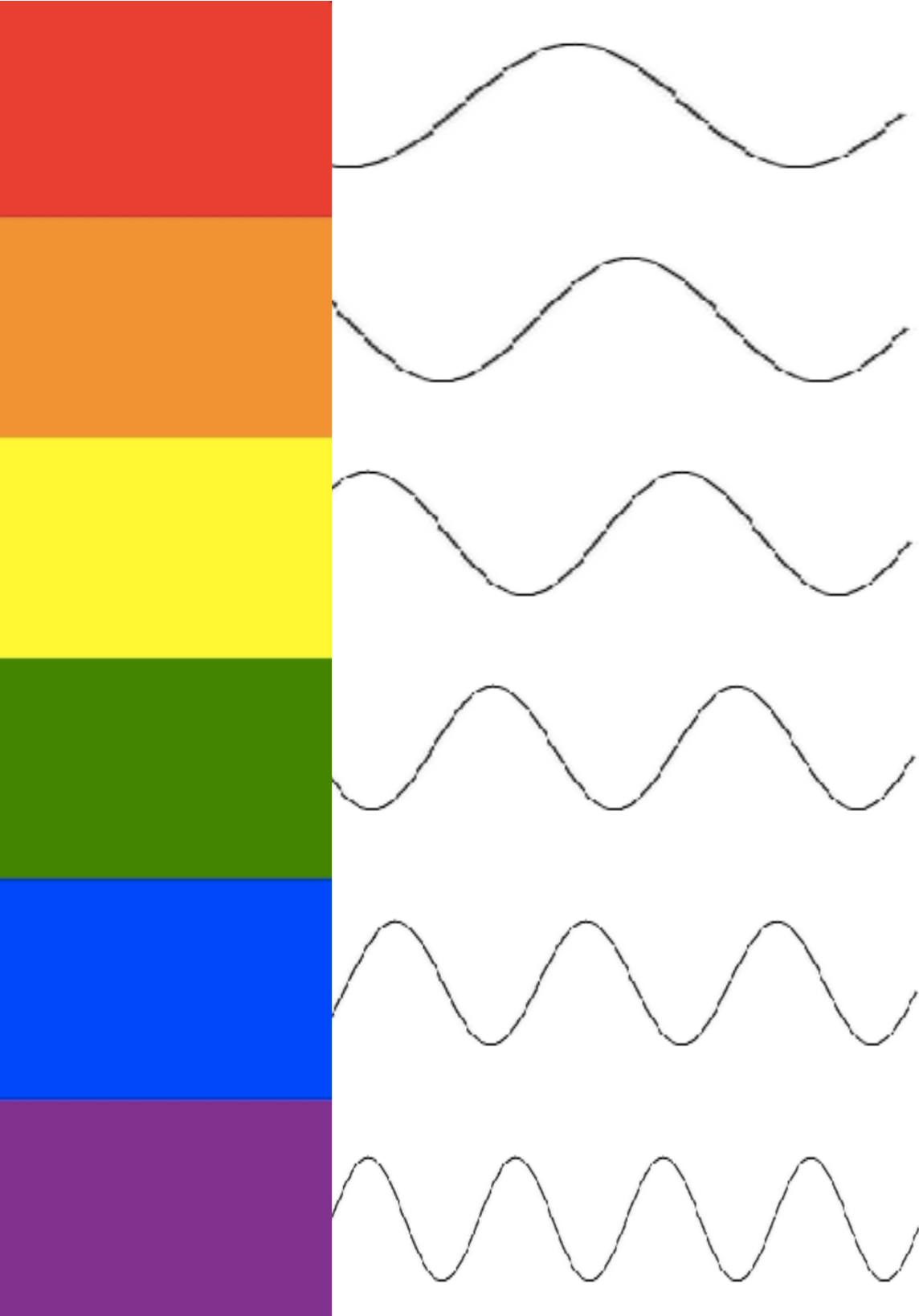
# Sunspots & Active Regions

---

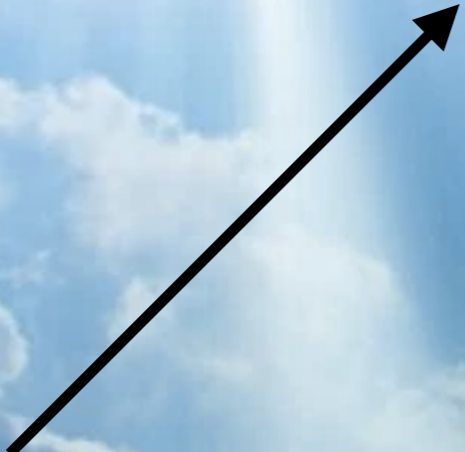
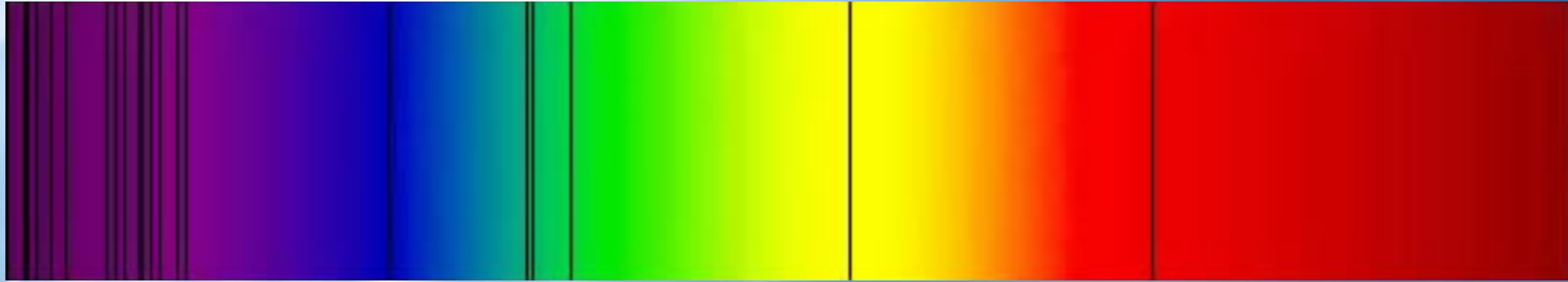


~2/100000  
of an inch





We see **COLOR** because the message that our eyes send to our brain is different for different **WAVELENGTHS** of light



**Magnesium**

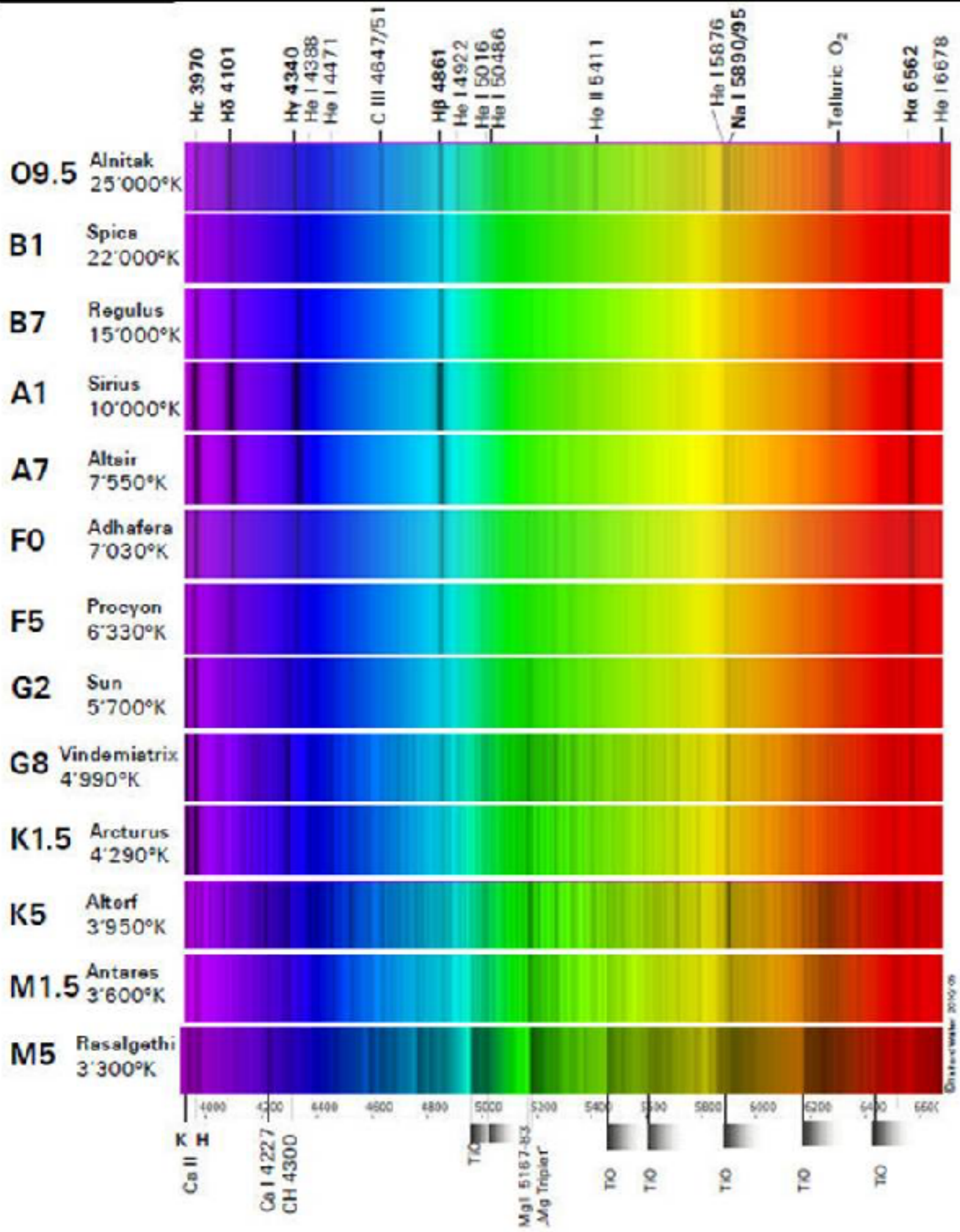


**Sodium**



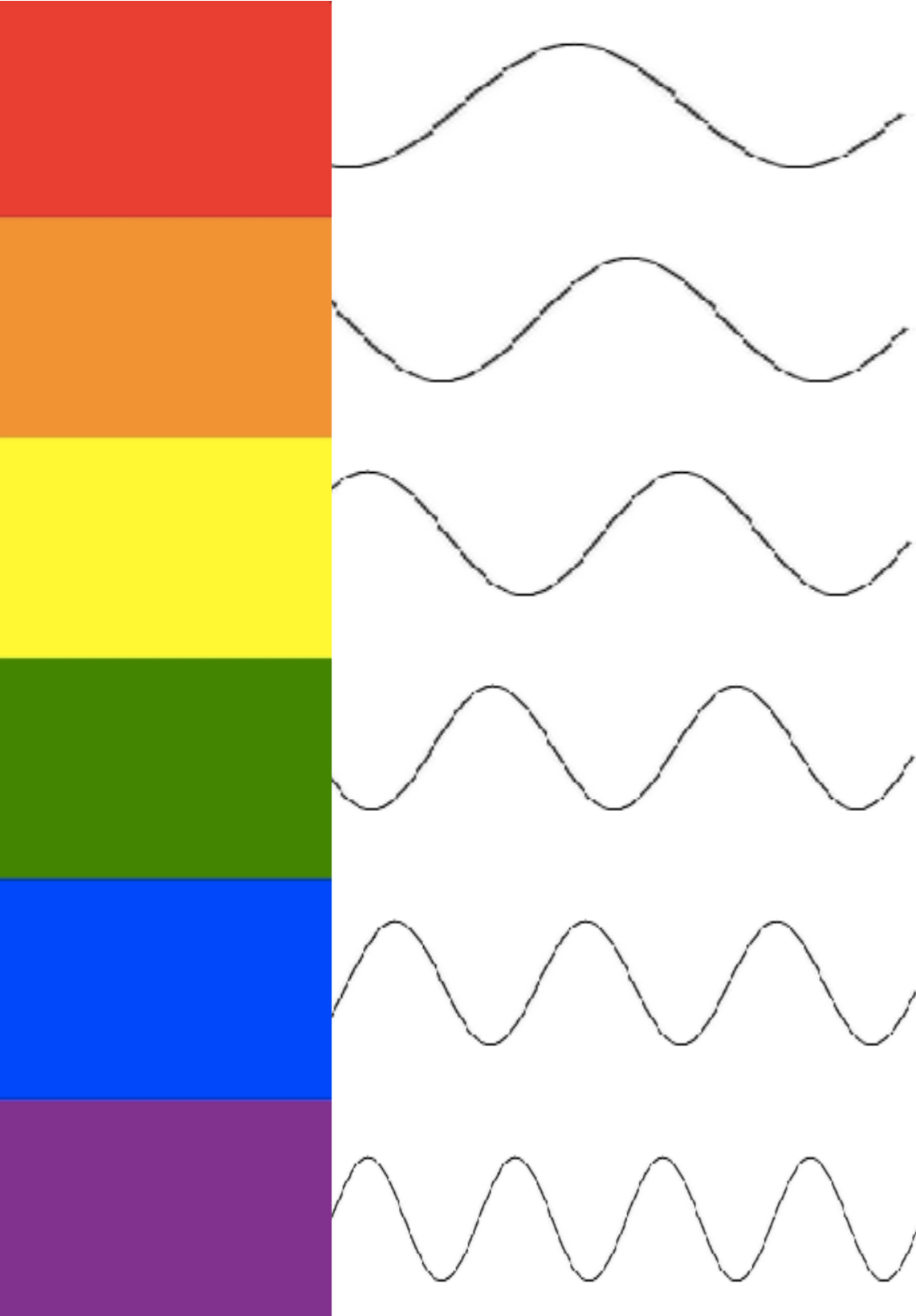
**Hydrogen**





© 2010 NASA



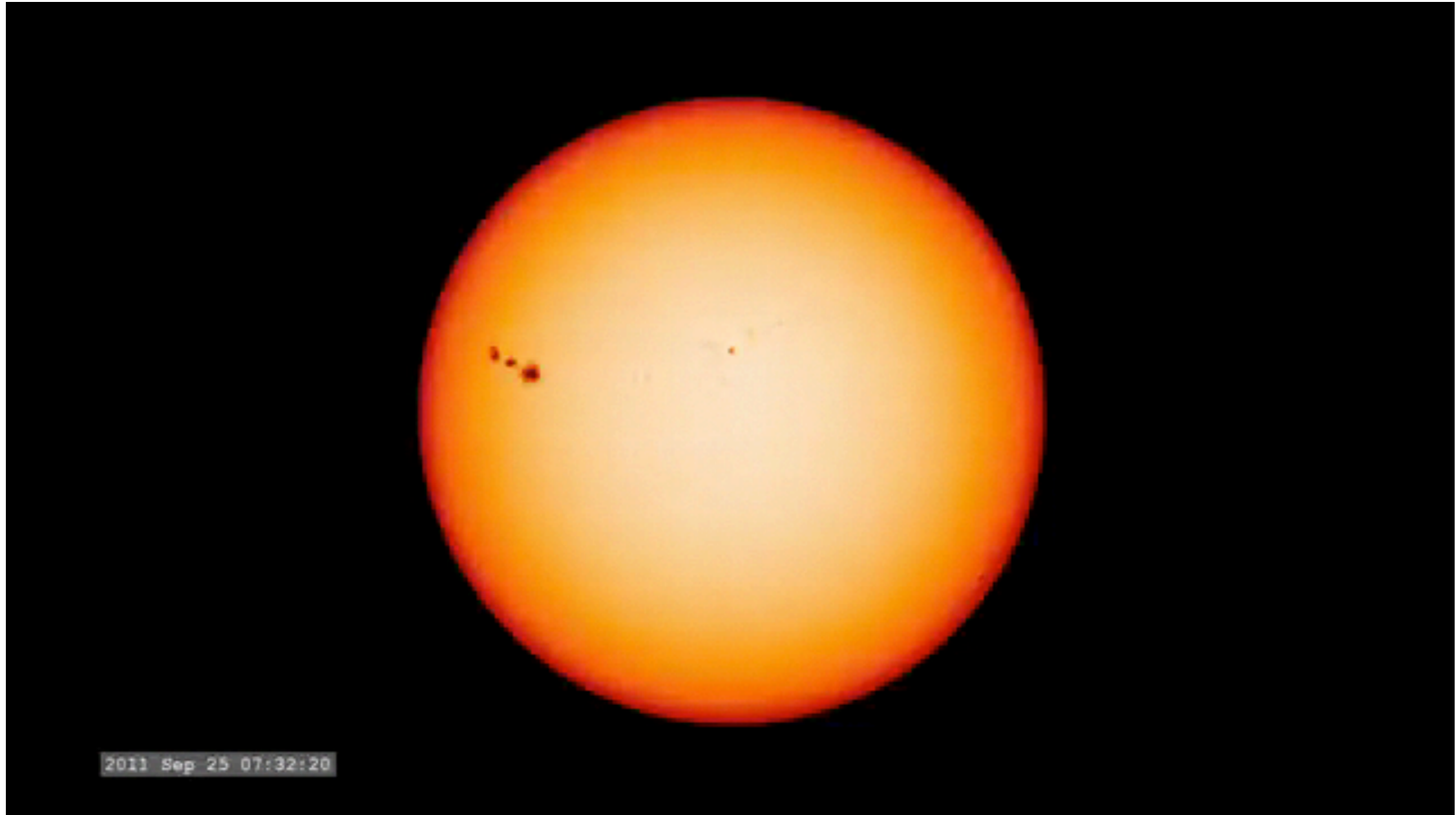


What if we **stretch** the wavelength longer than **RED**?

What if we **squish** it to be shorter than **VIOLET**?

# Sunspots & Active Regions

---

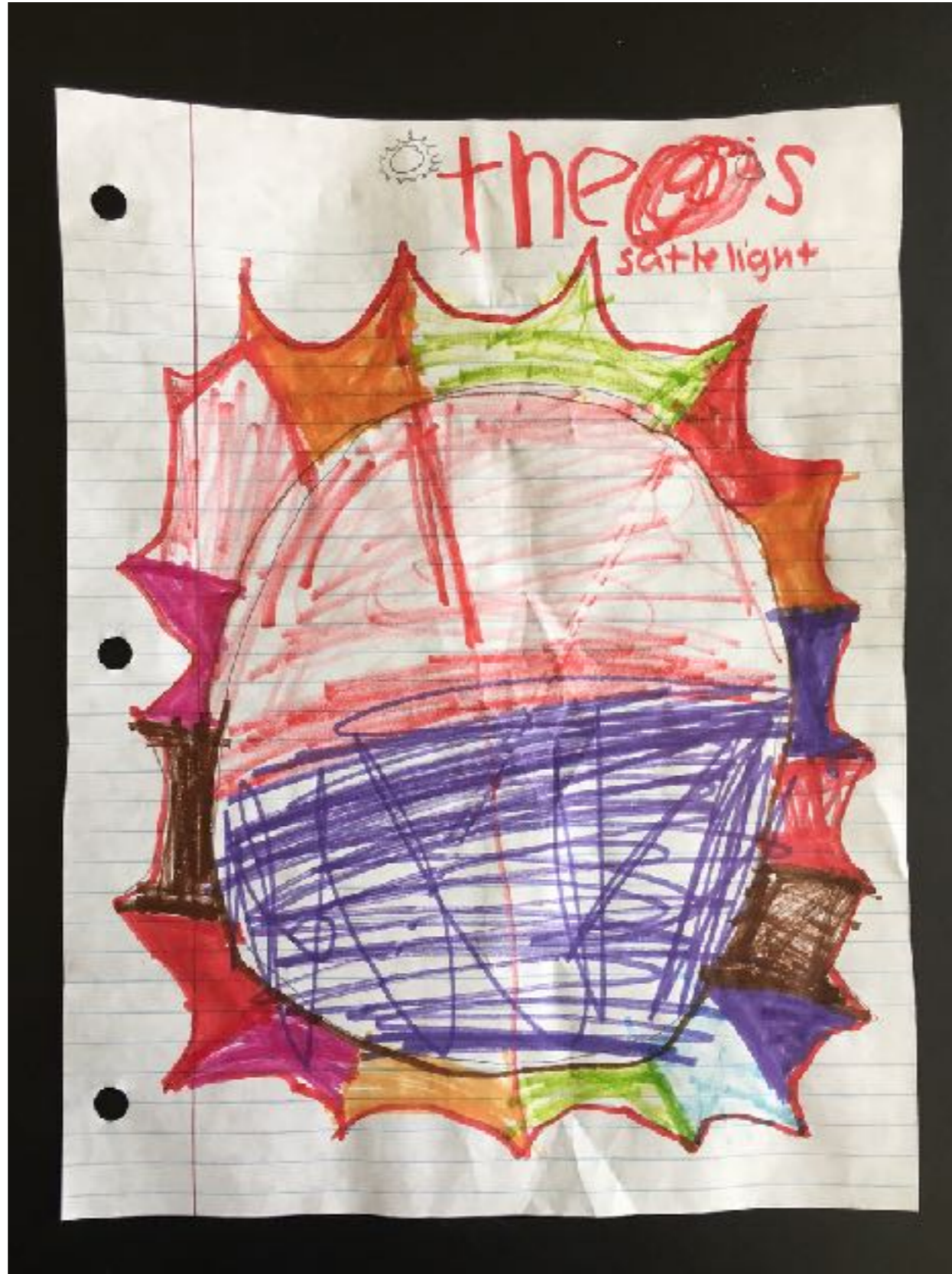


**“SDO Jewel Box”**

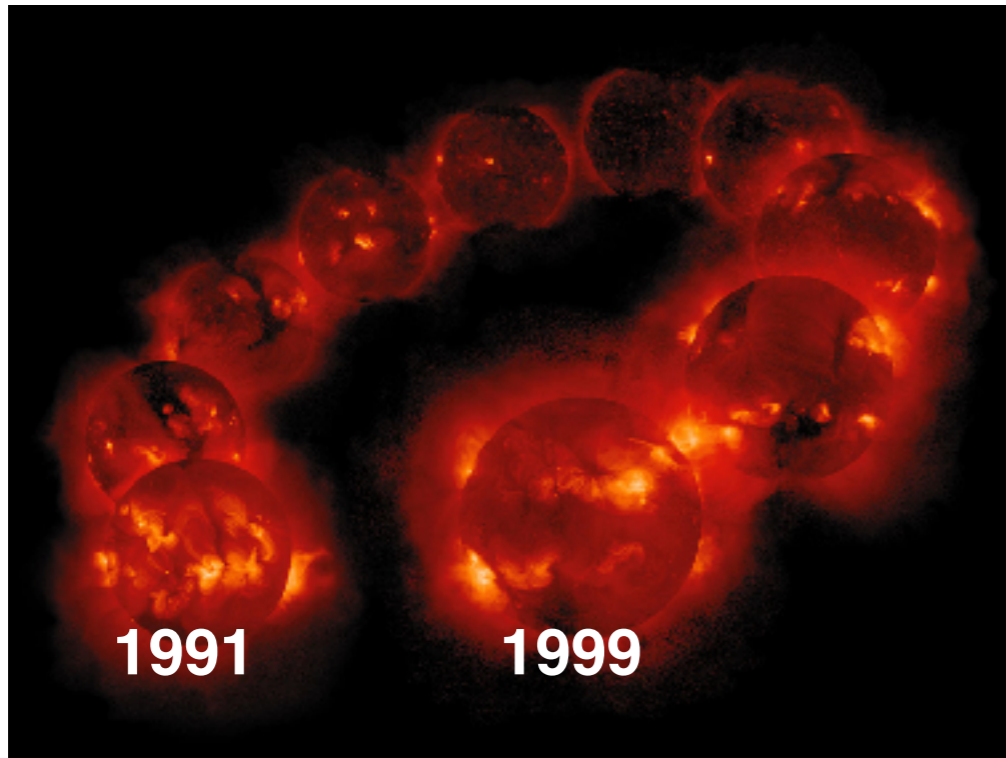
Solar features as seen with 10 different filters (i.e., plasma at different temperatures).

# Sunspots & Active Regions

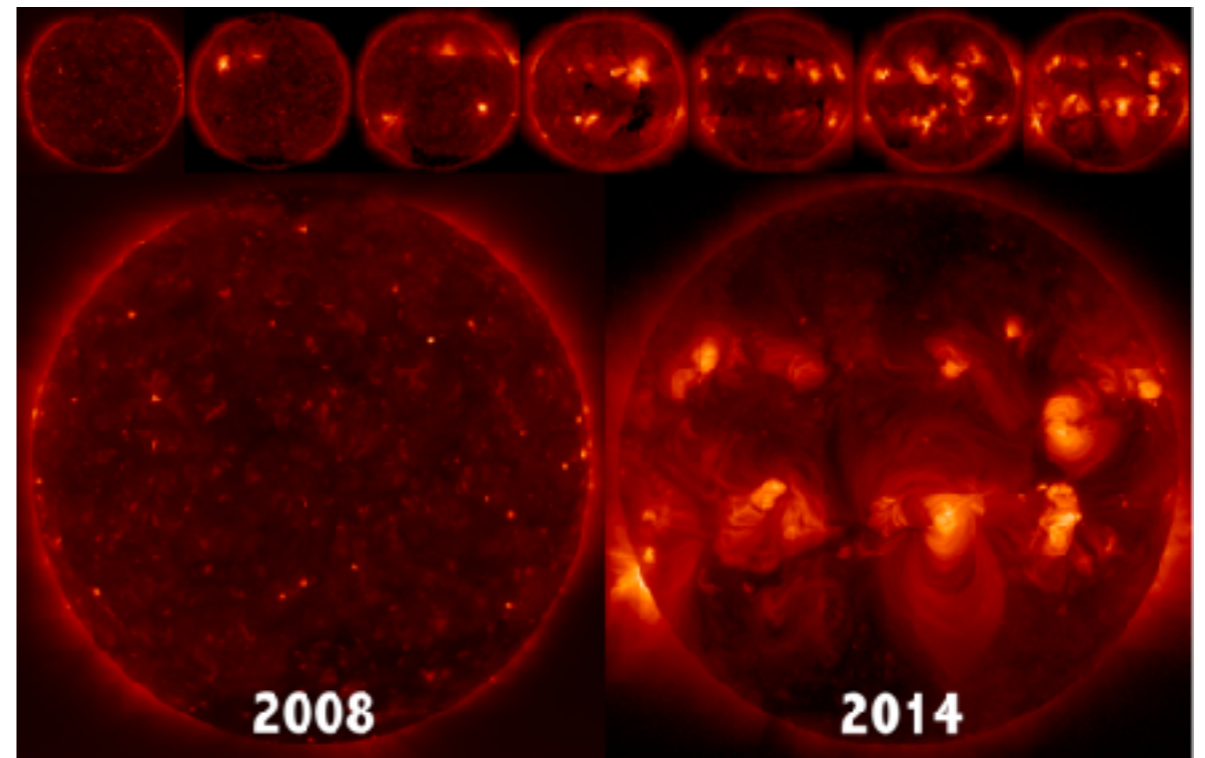
---



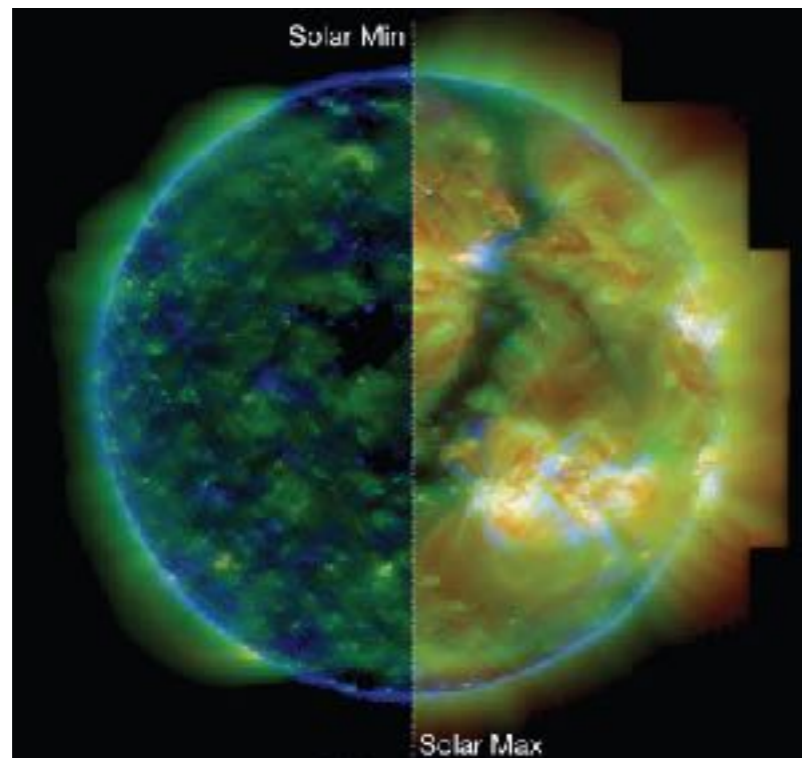
# Solar Cycle (9-14 years)



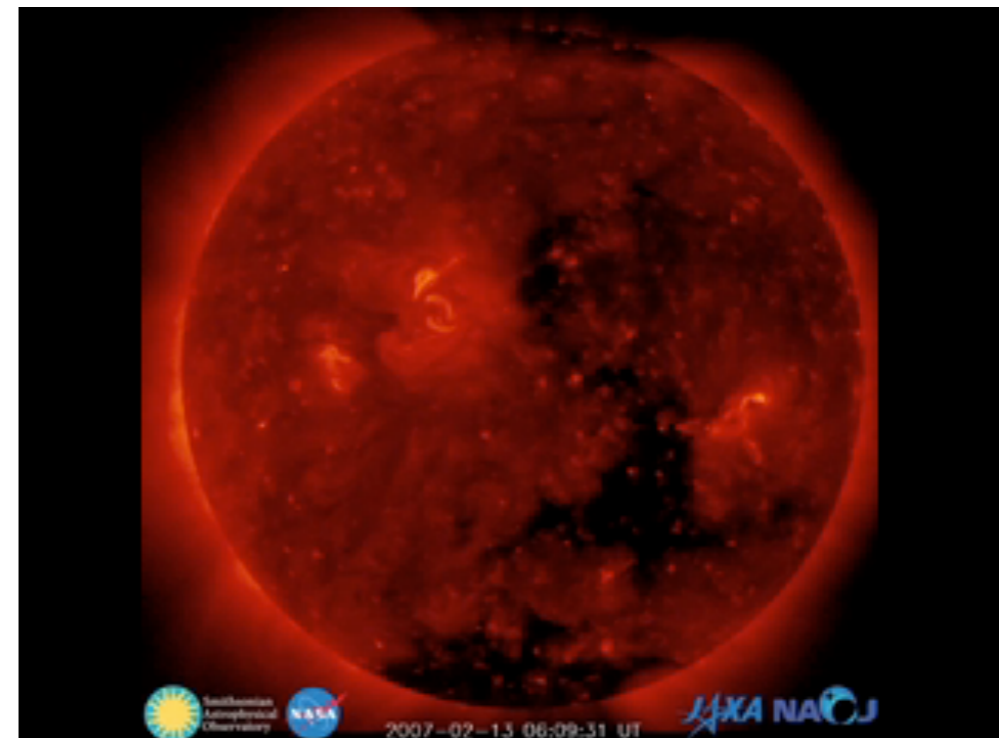
Yohkoh / SXT, ~ Full cycle



Hinode / XRT, ~ Half cycle



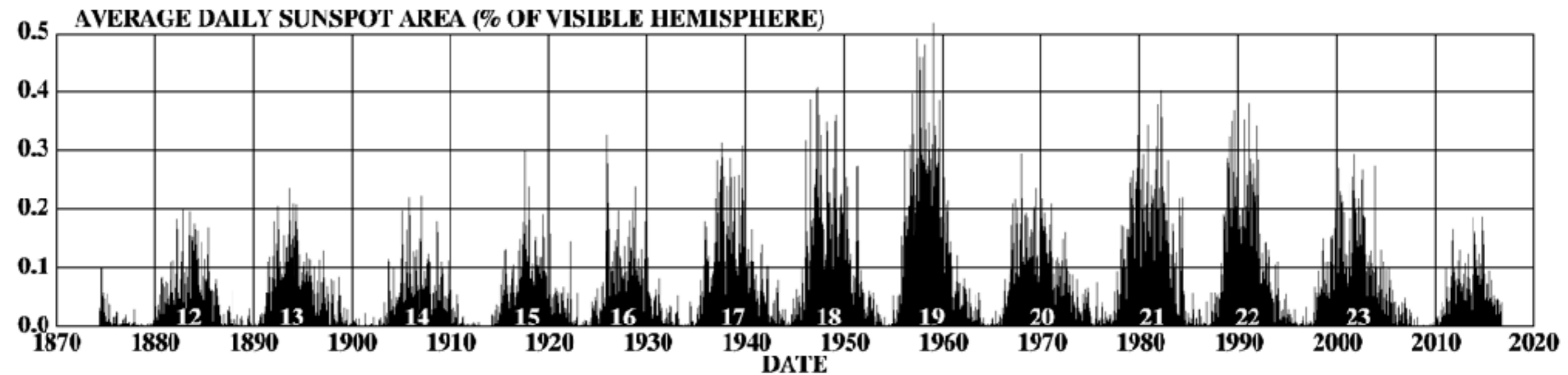
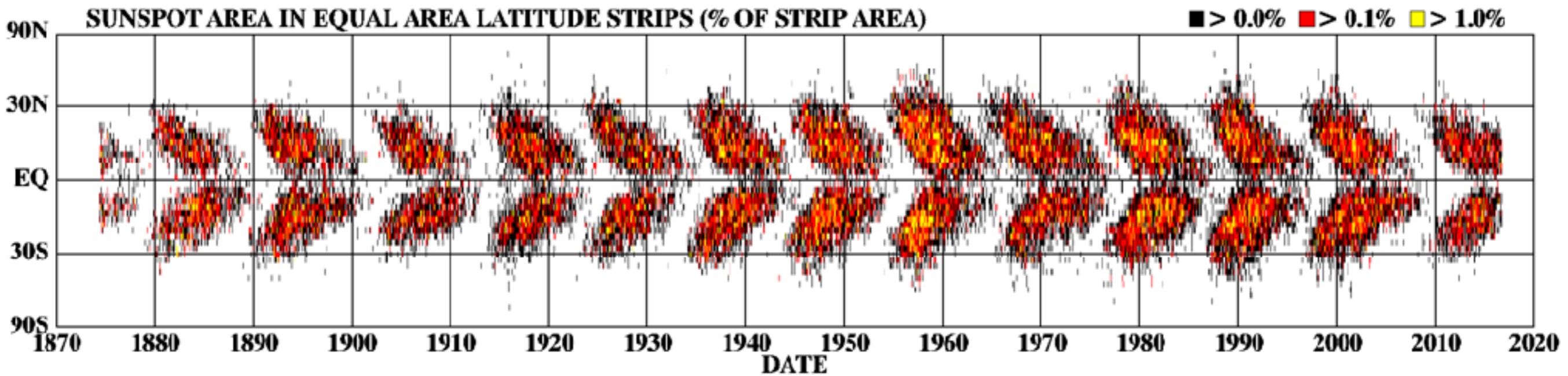
Hinode / EIS, ~ Half cycle



Hinode / XRT 2007 - 2012

# Solar Cycle

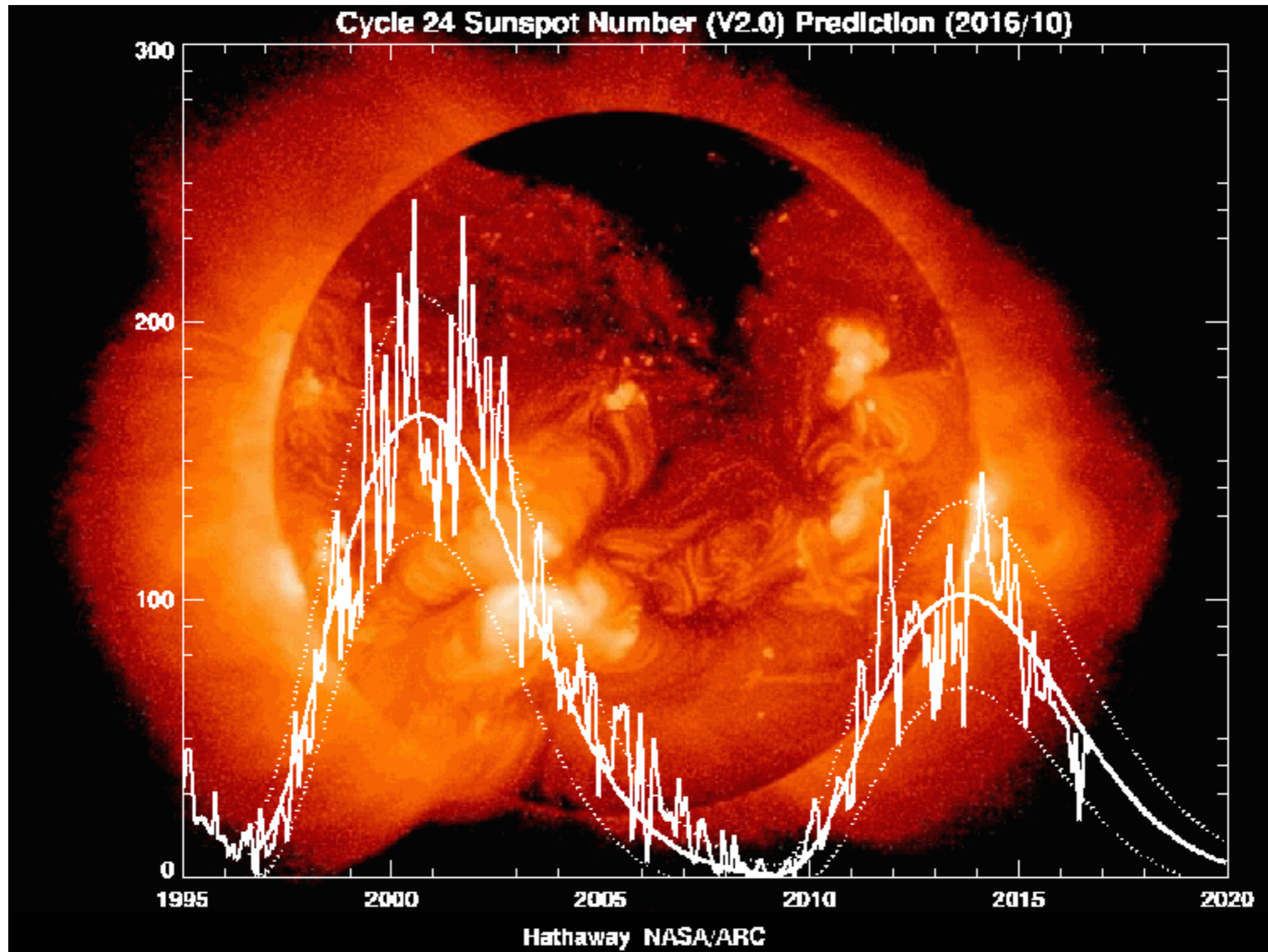
## DAILY SUNSPOT AREA AVERAGED OVER INDIVIDUAL SOLAR ROTATIONS



<http://solarscience.msfc.nasa.gov/>

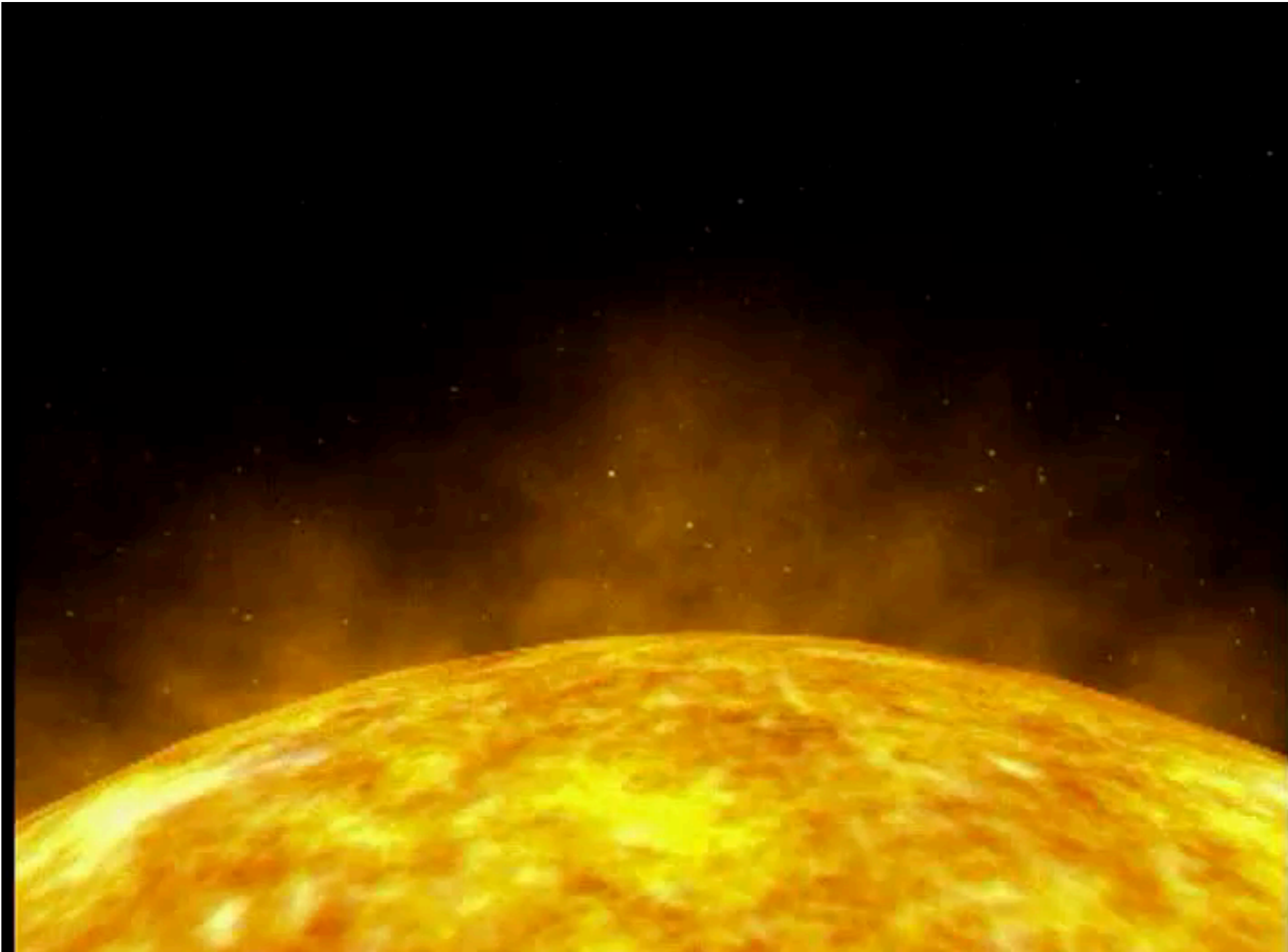
HATHAWAY NASA/ARC 2016/10

# Solar Cycle



# Sun-Earth Interaction

---



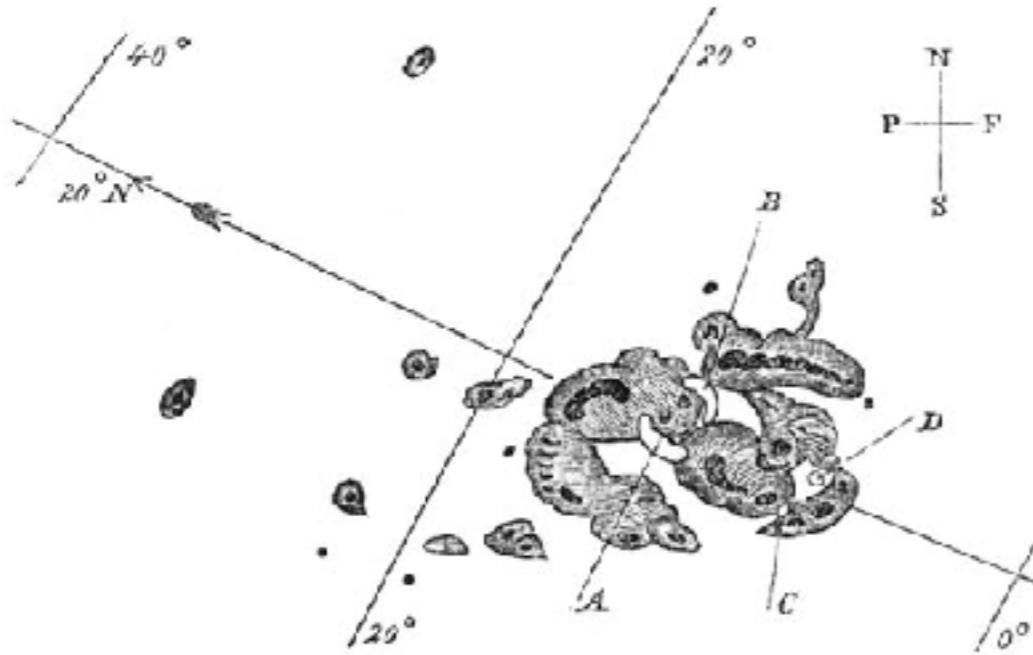
Solar storms cause the *Earth* to lose up to 100 tons of atmosphere into space.

Aurora mostly caused by ionospheric particles disrupted by currents induced from the coronal mass ejection — not the solar wind directly.

Aurora can generate up to 100 trillion watts of power.



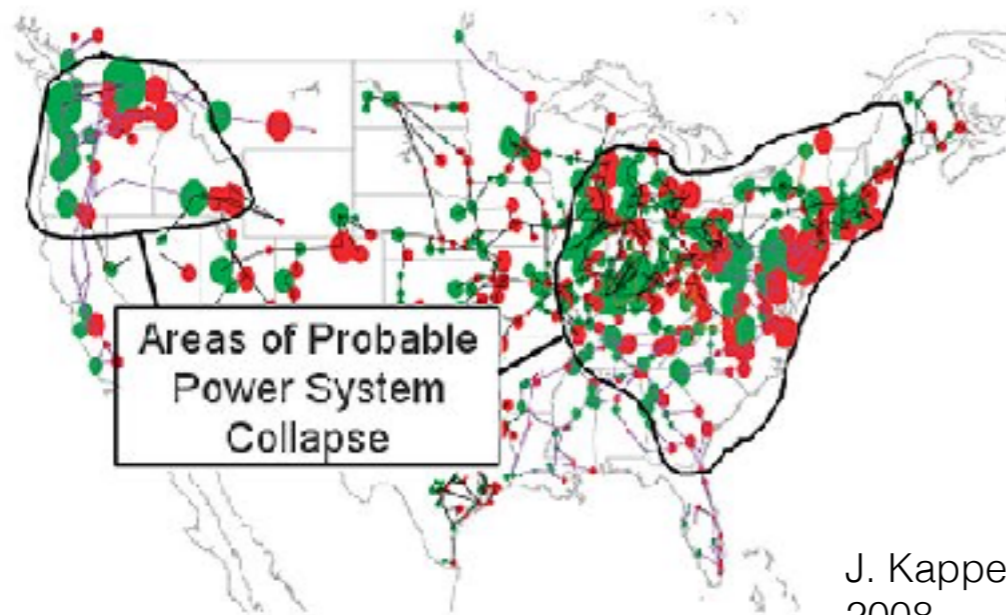
# Impacts of Space Weather



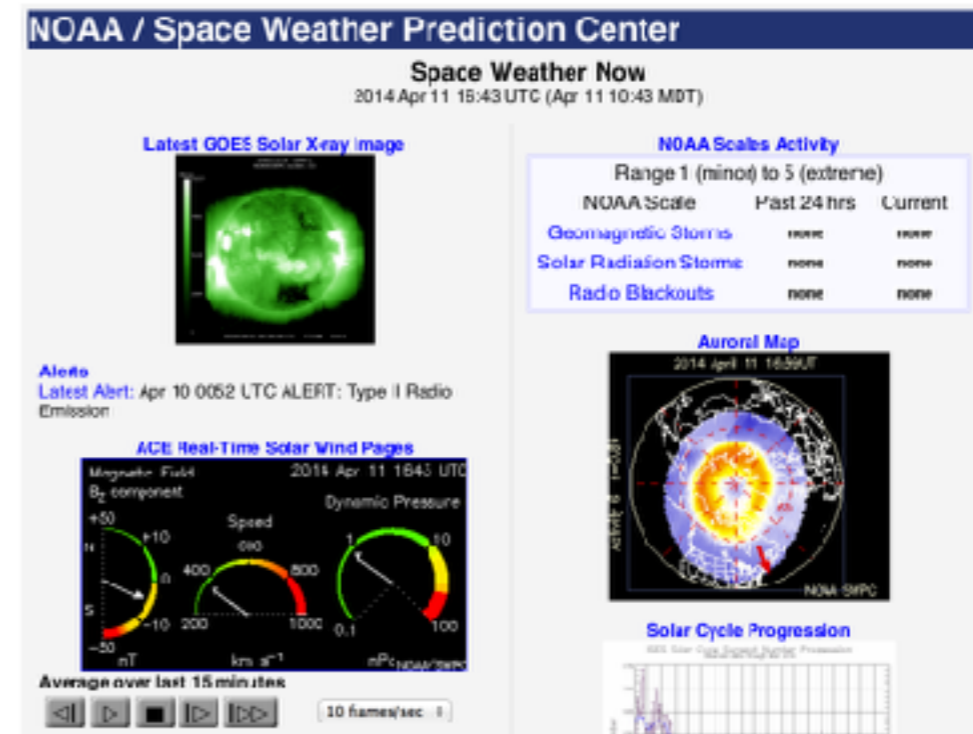
1859 Carrington Event  
Largest Geomagnetic storm recorded



M. A. Shea, Geophysics Directorate, Phillips Laboratory  
1989 Superstorm Blackout, \$6 Billion loss to economy



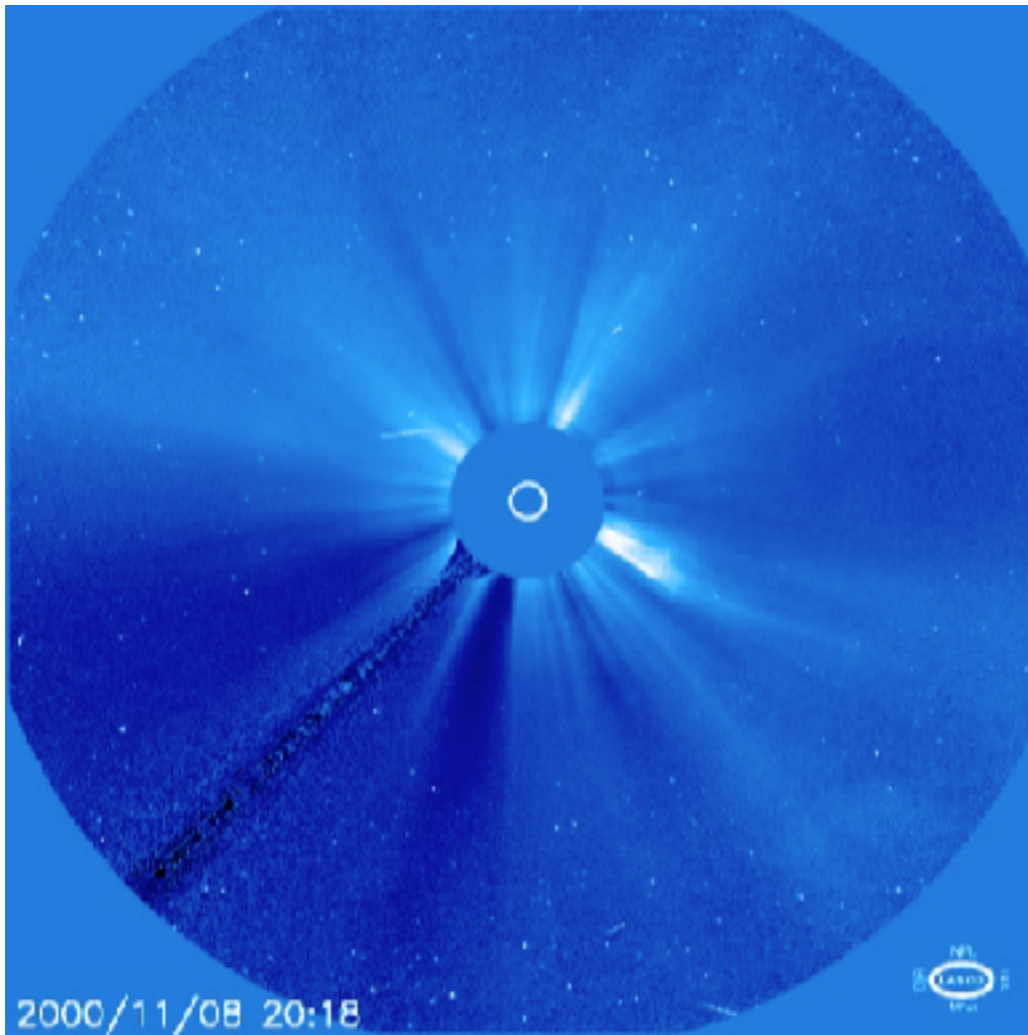
J. Kappenman  
2008



<http://www.swpc.noaa.gov/SWN/>



# Impacts of Space Weather



SOHO Large Angle and Spectrometric Coronagraph Experiment (LASCO)

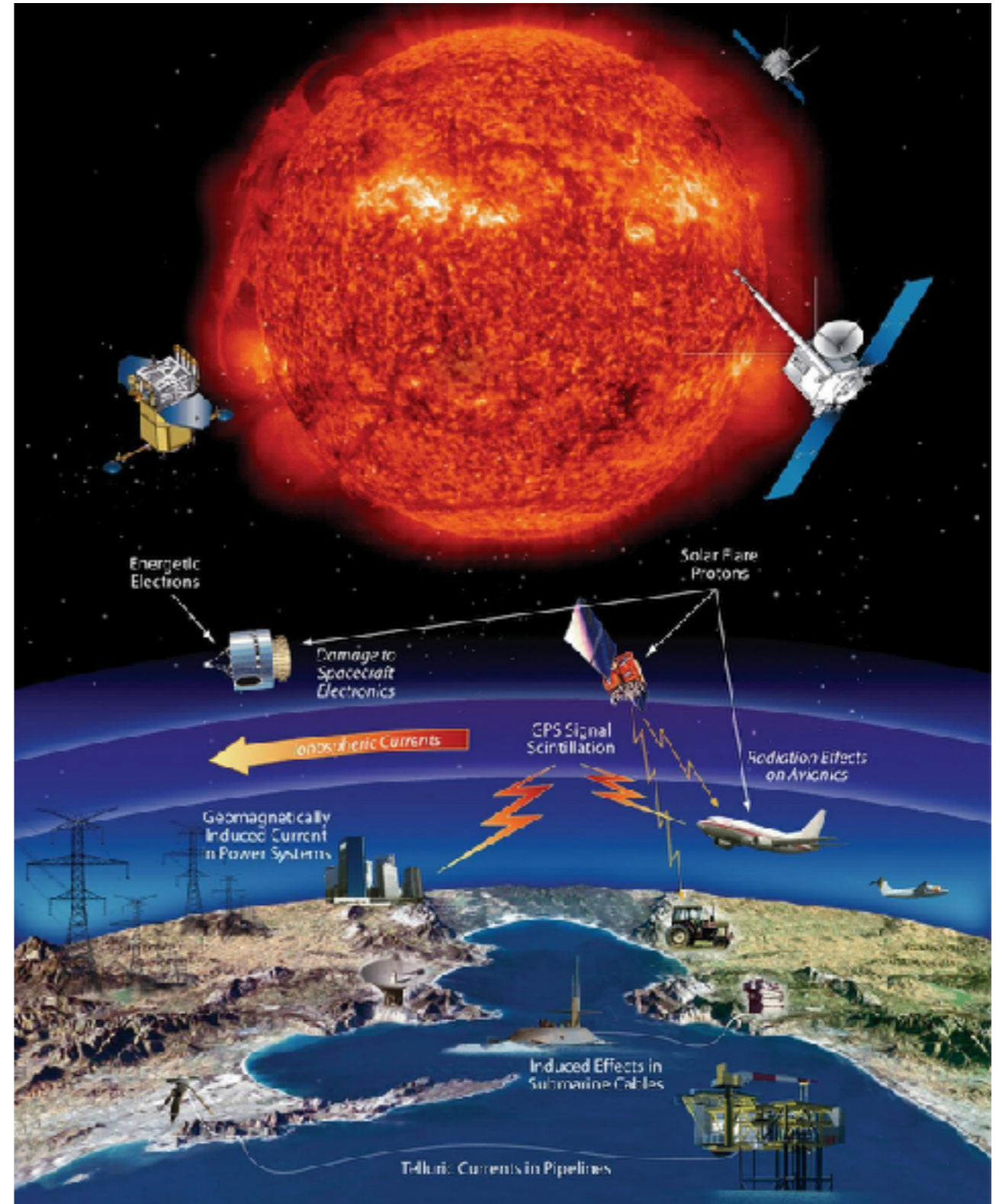
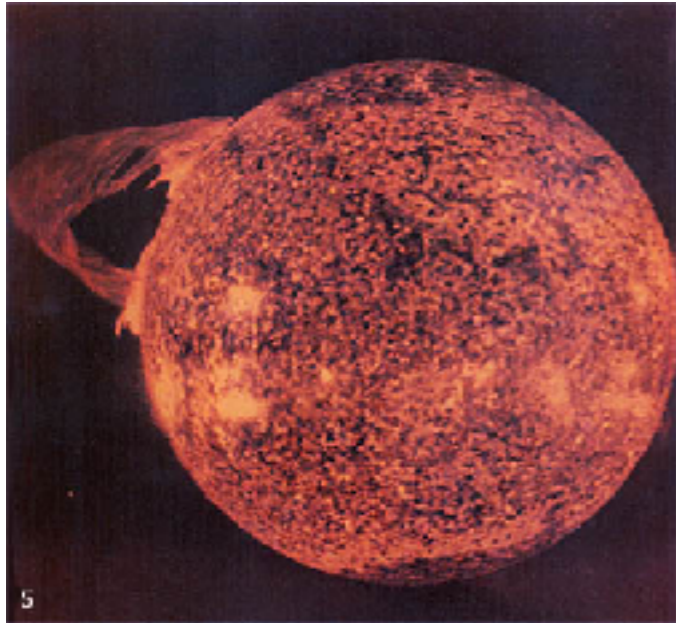
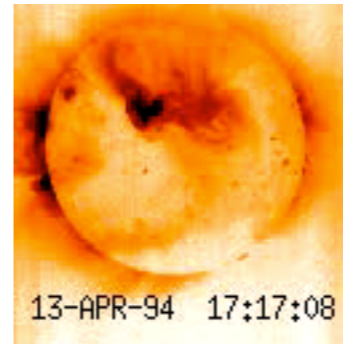


Image credit: NASA & L. Lanzerotti (NJIT)

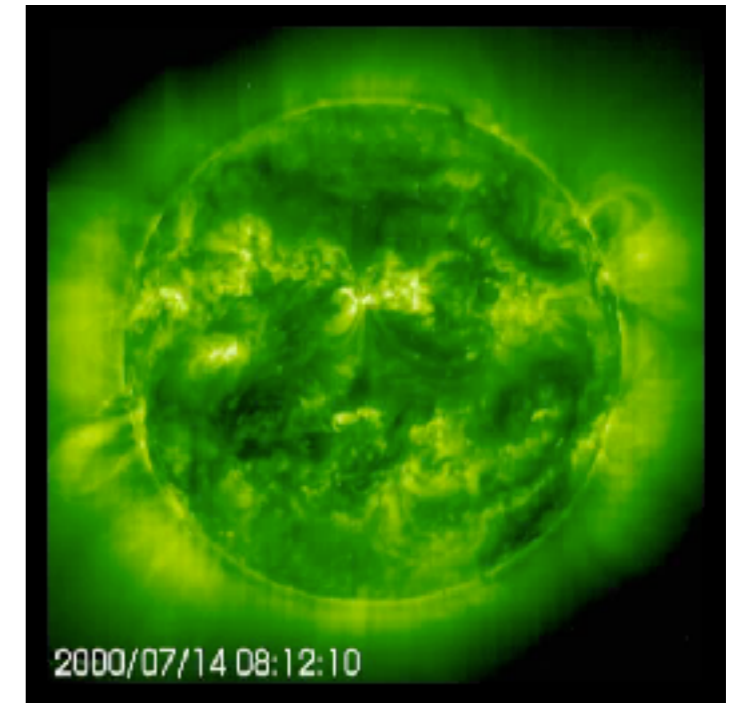
# Solar Flares (A Space-Based Tour)



Skylab

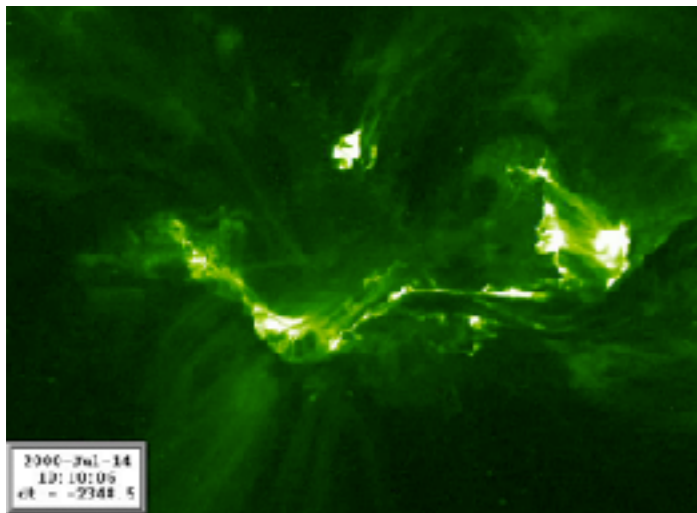


Yohkoh / SXT

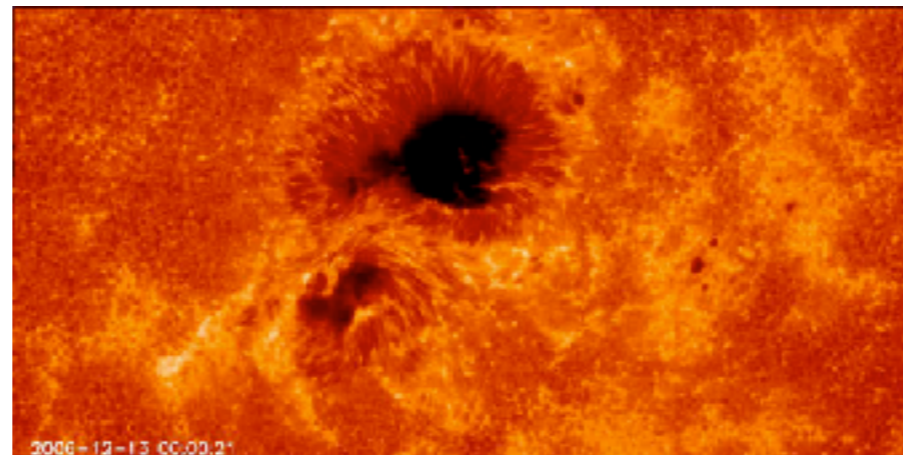


SOHO / EIT+LASCO

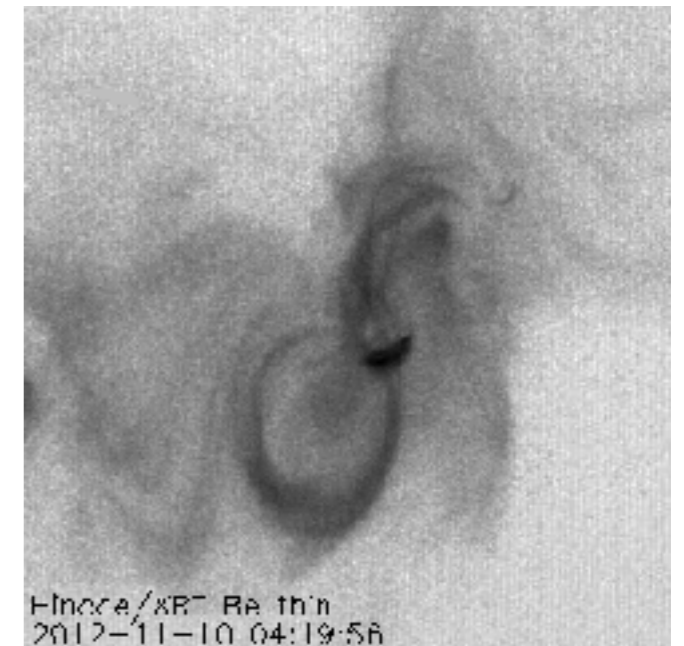
TRACE



Hinode / SOT

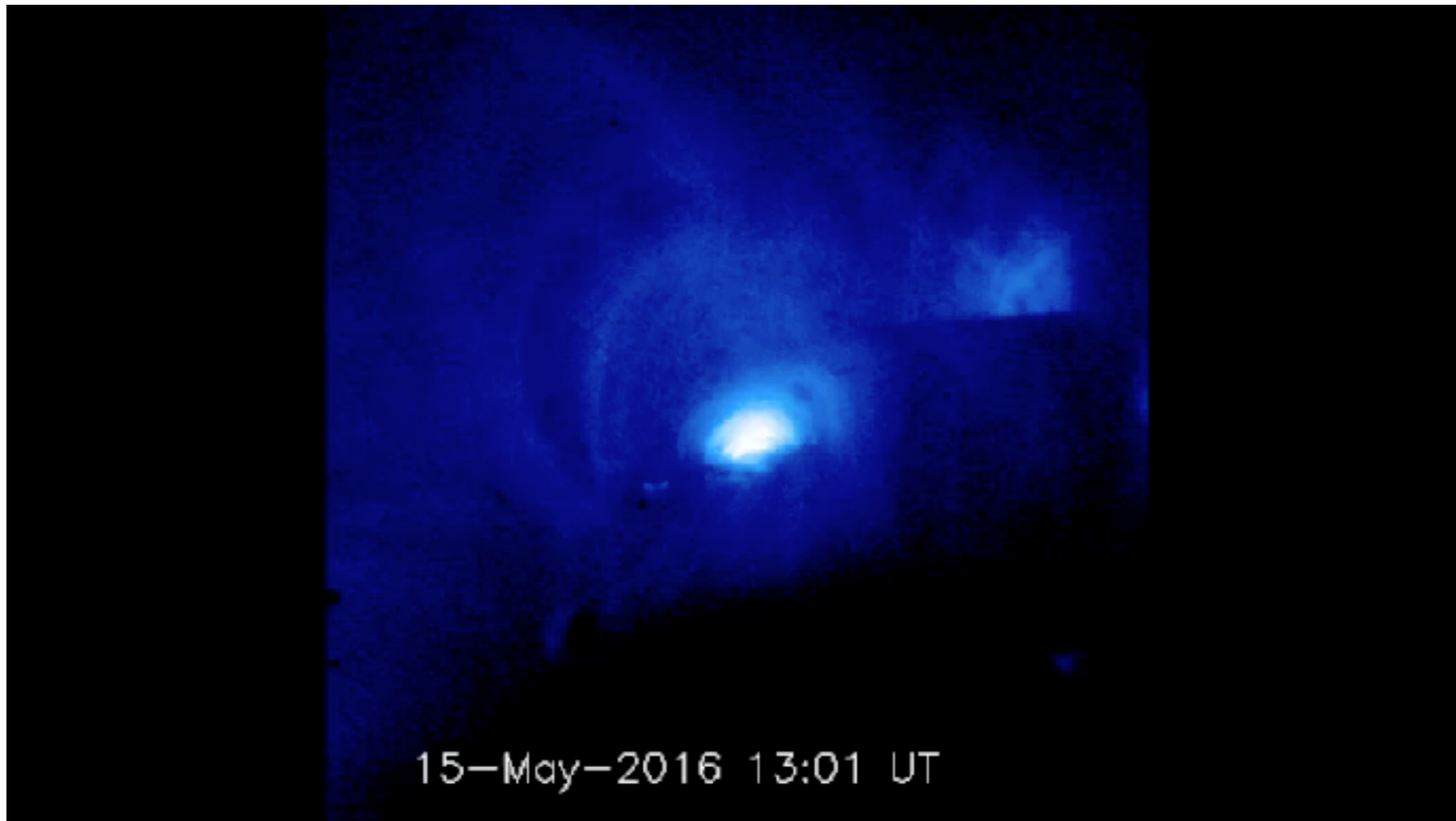


Hinode / XRT



# Solar Flares (A Space-Based Tour)

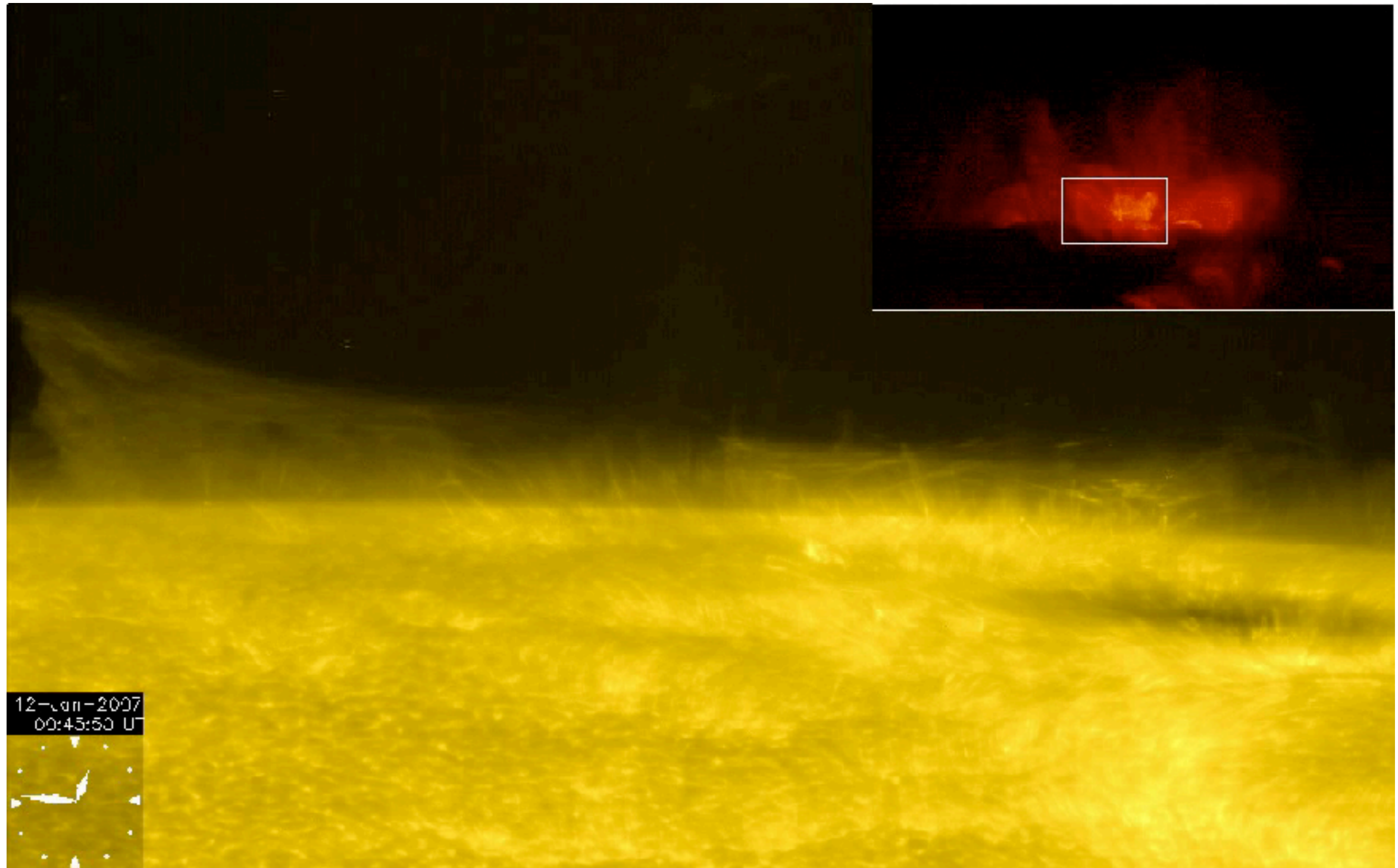
---



*Hinode / XRT*

# Solar Flares (A Space-Based Tour)

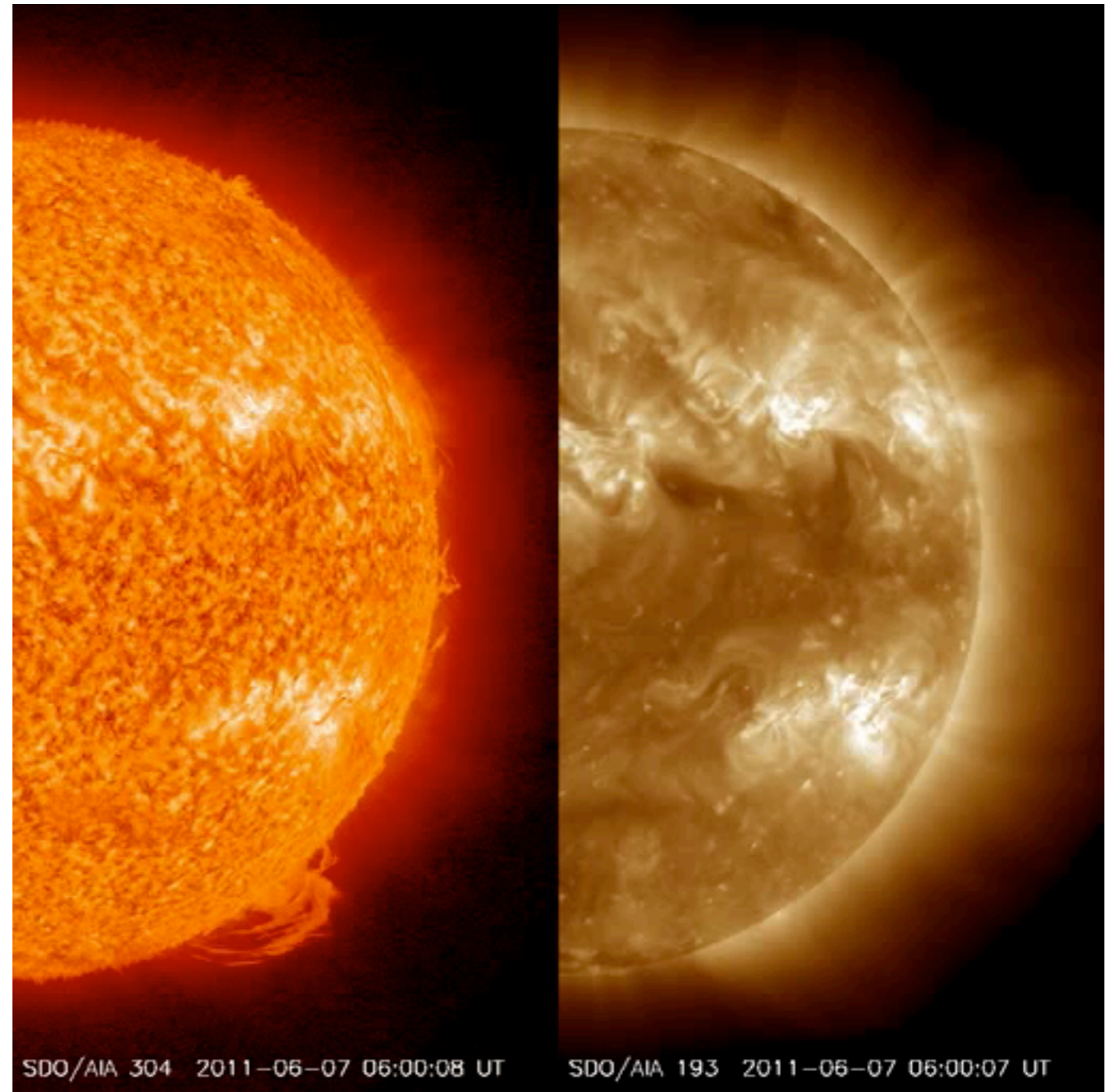
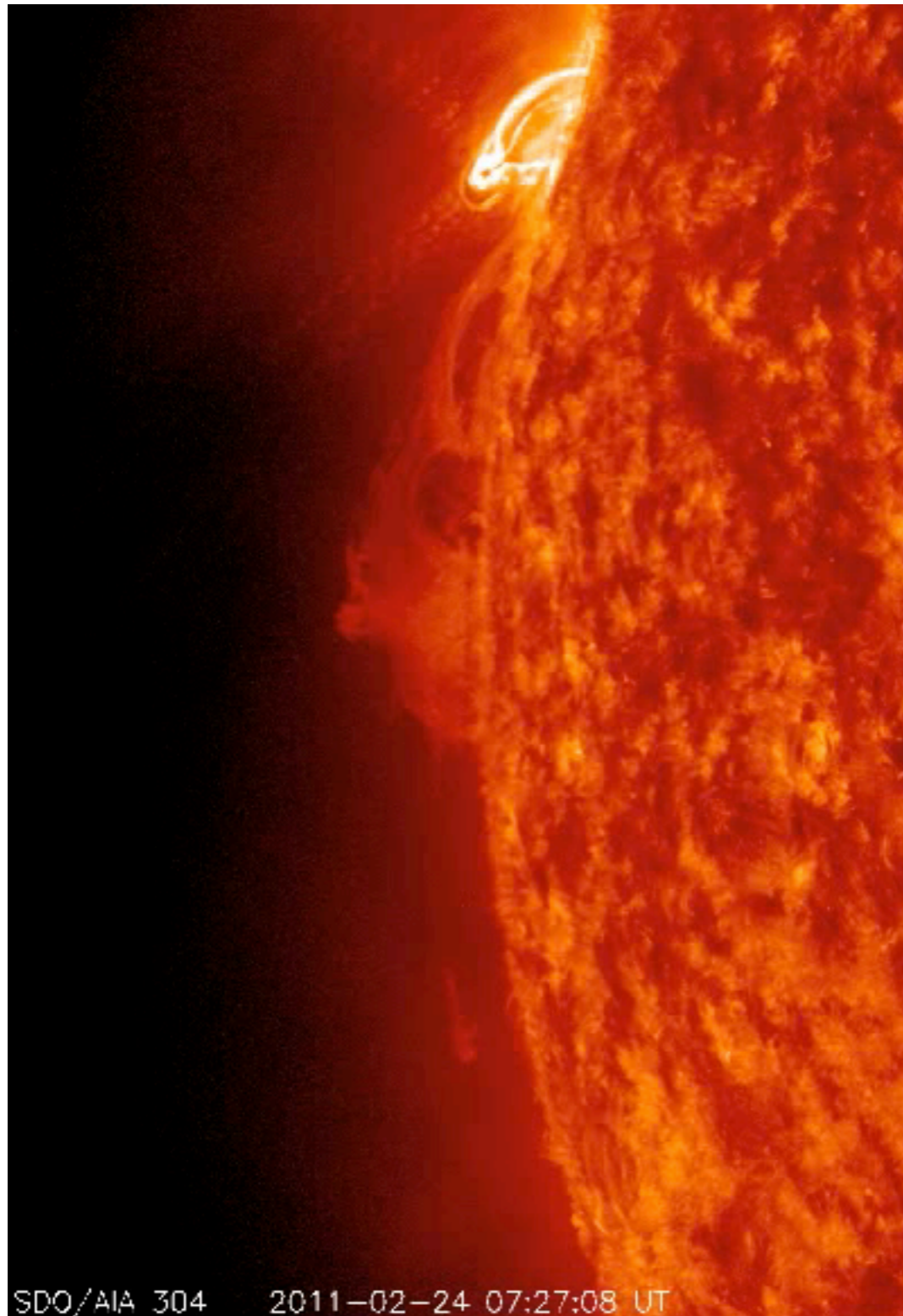
---



*Hinode / SOT*

# Solar Flares (A Space-Based Tour)

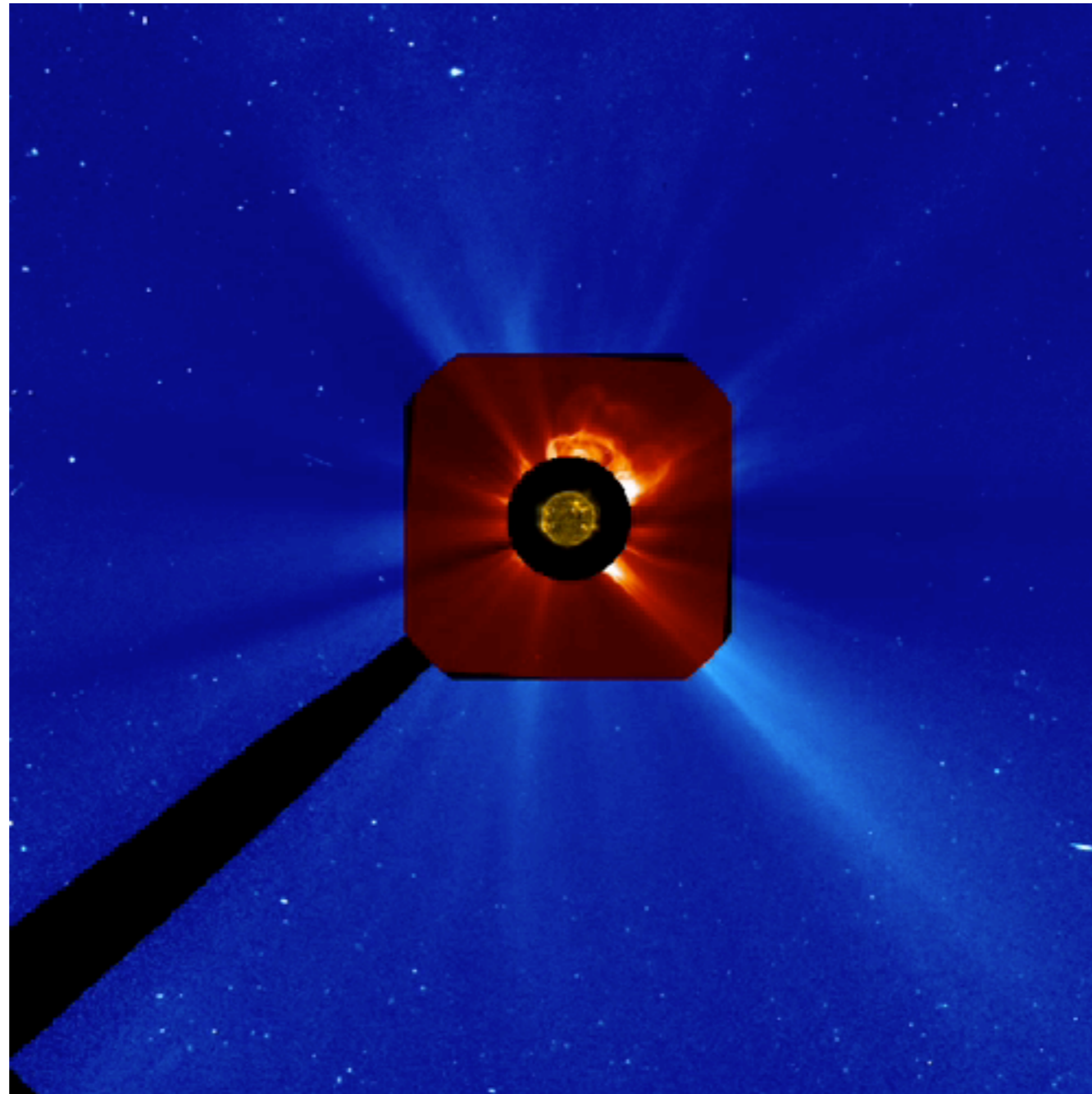
---



SDO / AIA

# Solar Flares (A Space-Based Tour)

---



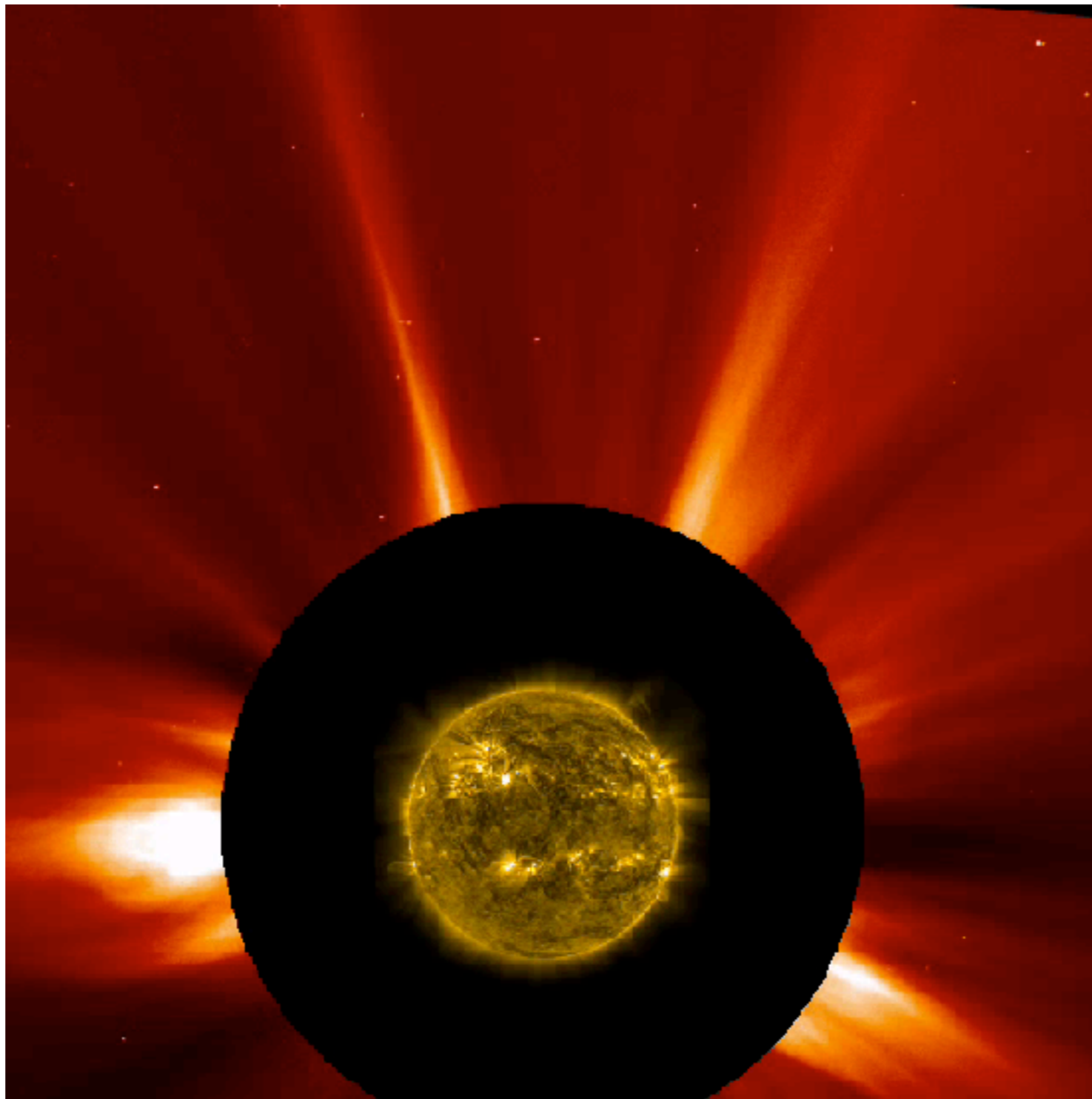
*SDO / AIA + SOHO / LASCO*





# Solar Flares (A Space-Based Tour)

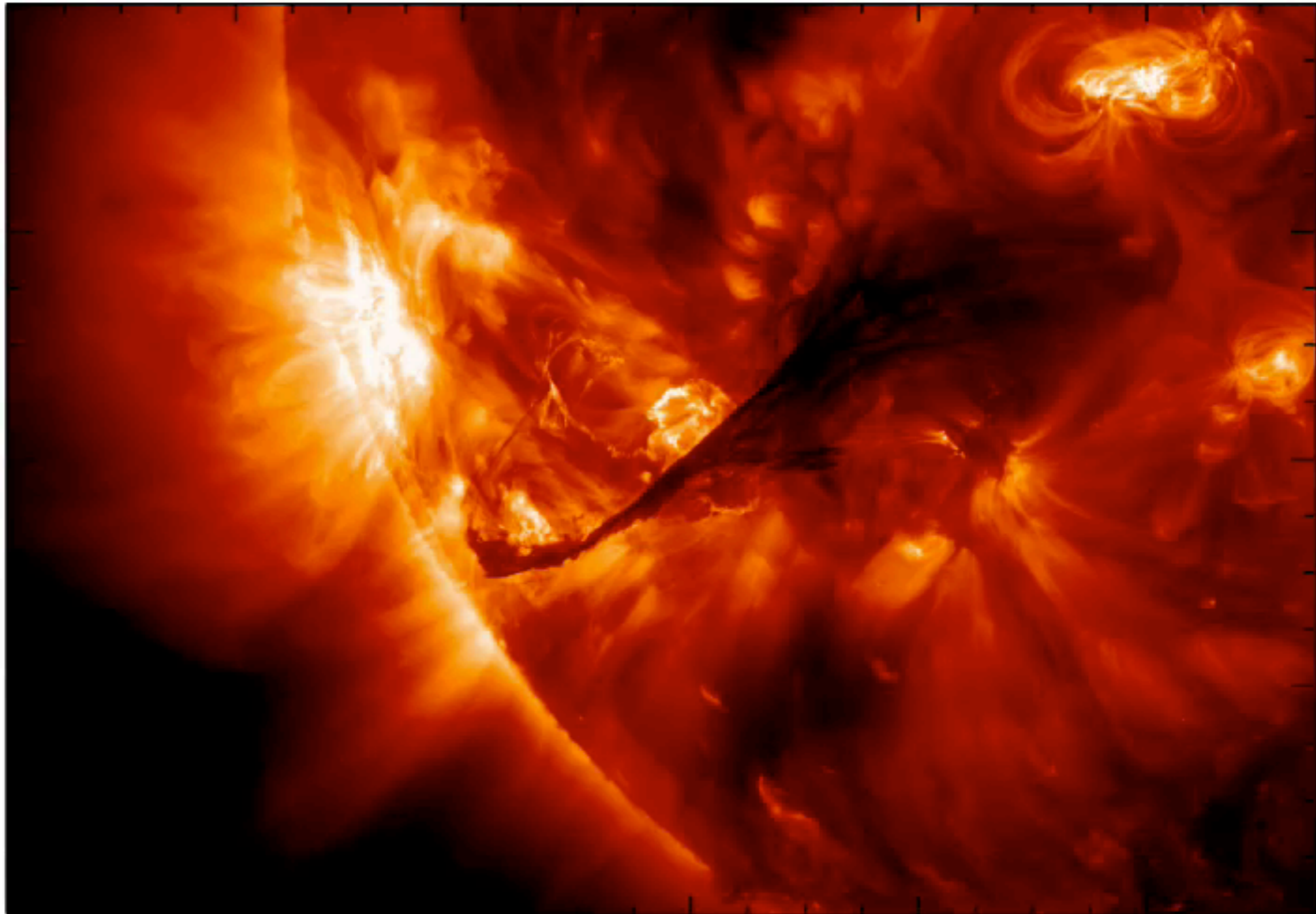
---



*SDO / AIA + SOHO / LASCO*

# Solar Flares (A Space-Based Tour)

---

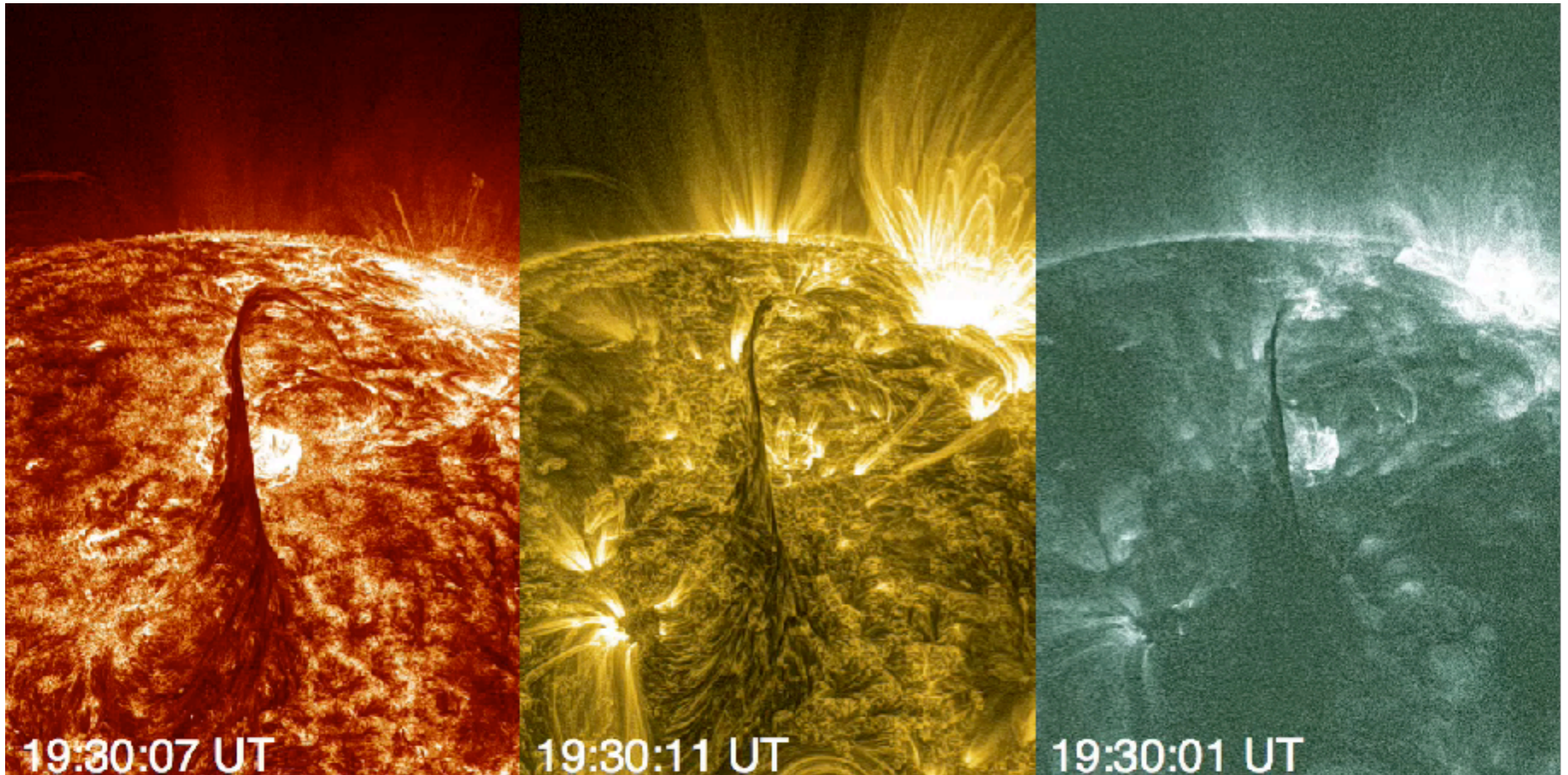


*SDO / AIA + Hinode / EIS*

# Solar Flares (A Space-Based Tour)

---

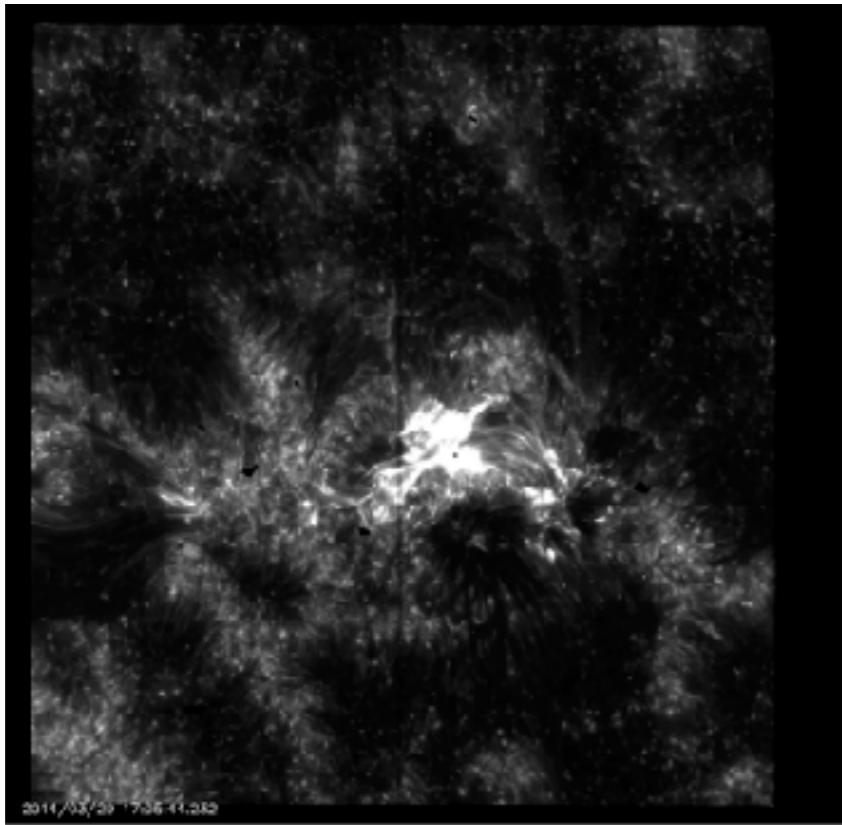
Same flare as previous slide but in 3 different AIA channels and enhanced for contrast.



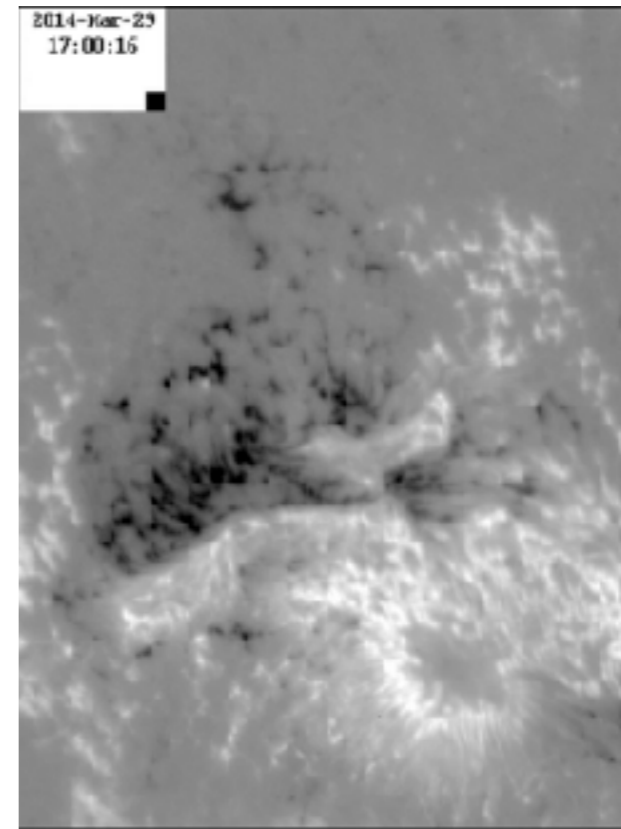
SDO / AIA

# Solar Flares (A Space-Based Tour)

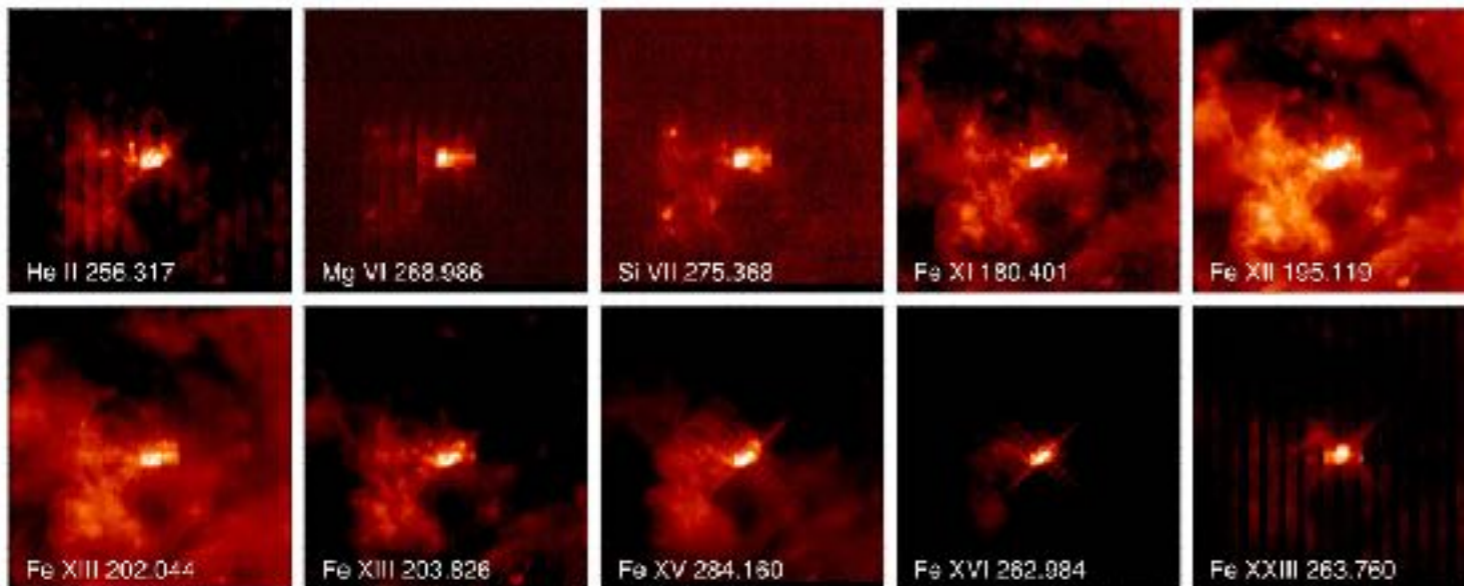
IRIS



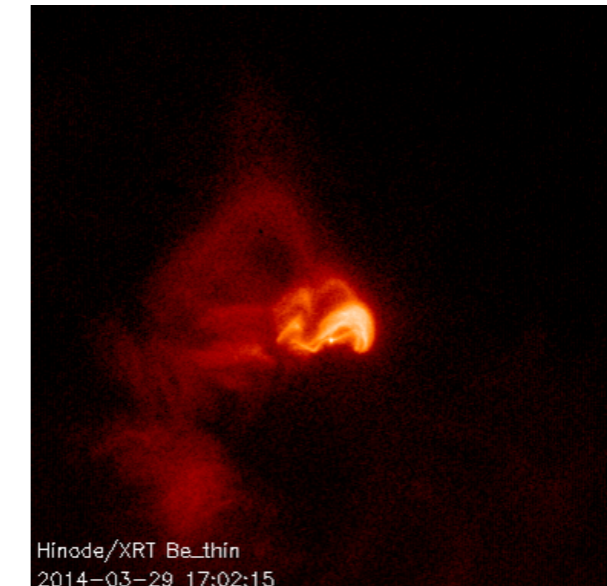
Hinode / SOT [Magnetogram]



Hinode / EIS



Hinode / XRT



# How is this happening?

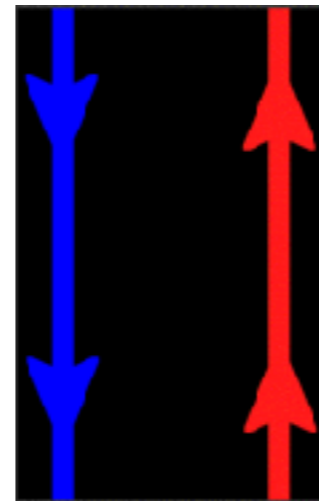
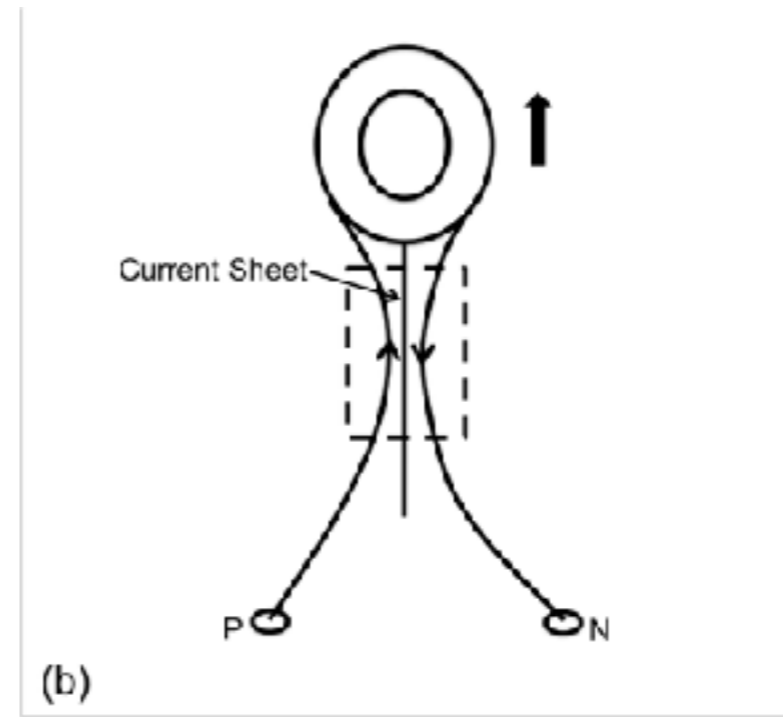
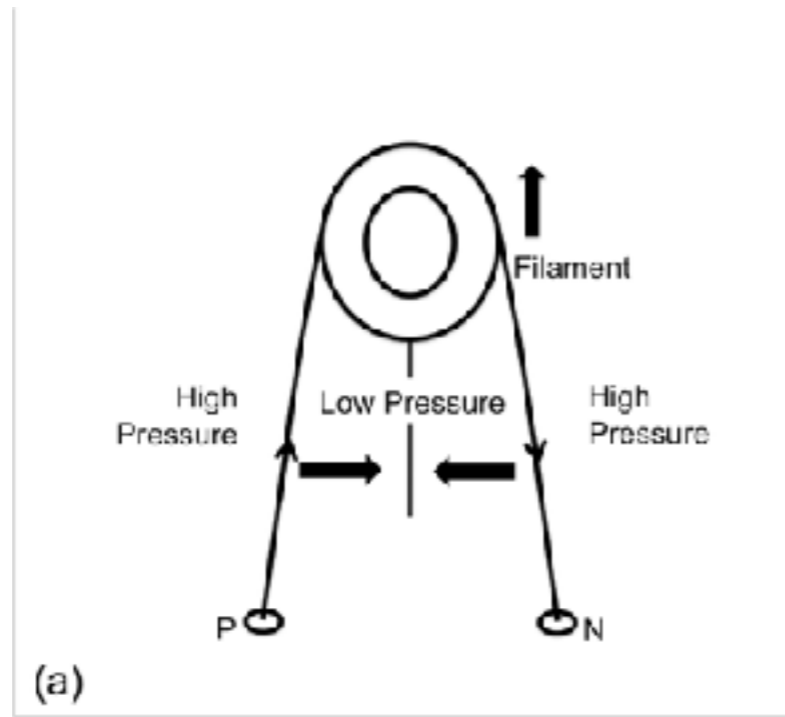
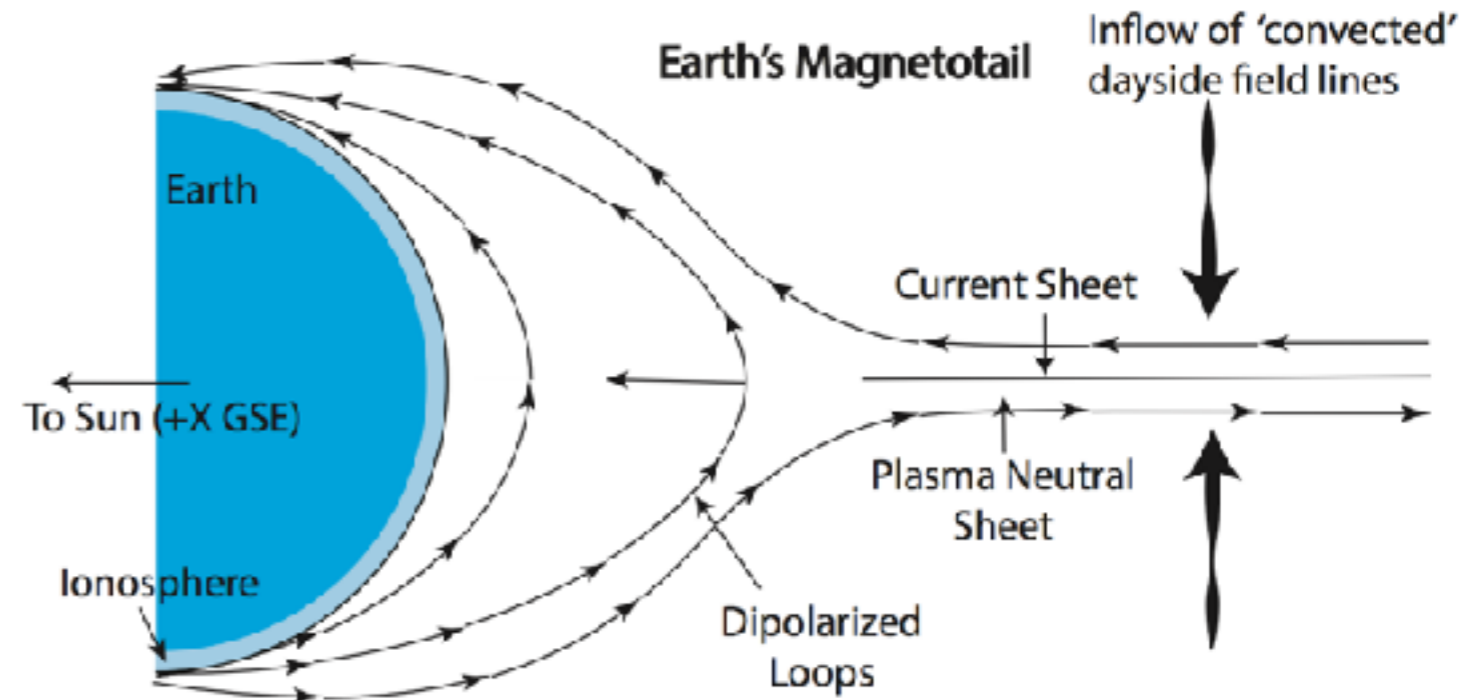
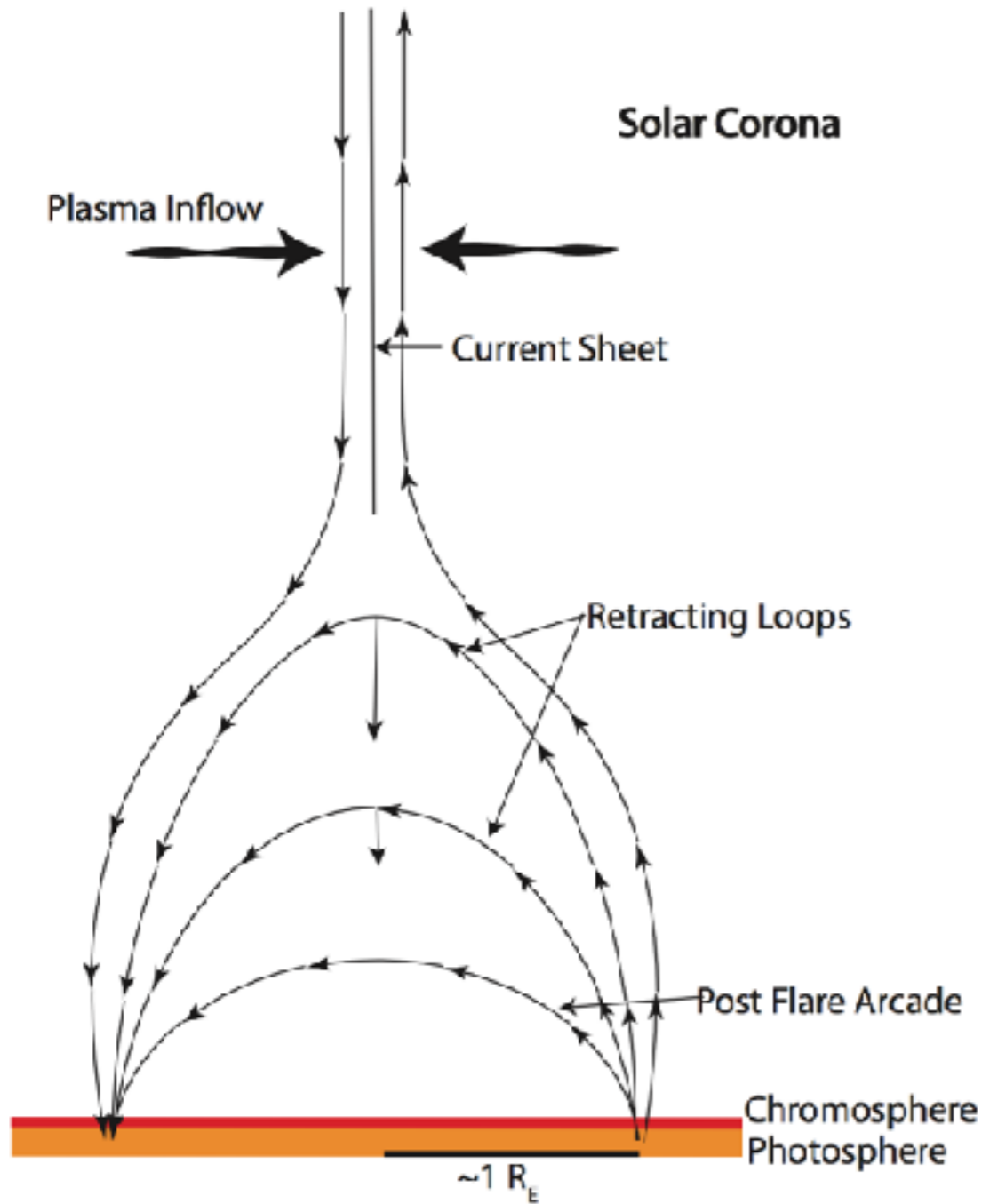


Image Credit: ESA

# Beyond the Sun



Simplified cartoons comparing the basic 2D geometry in the corona (left) and magnetosphere (above). While the language is different, the systems are notably similar.

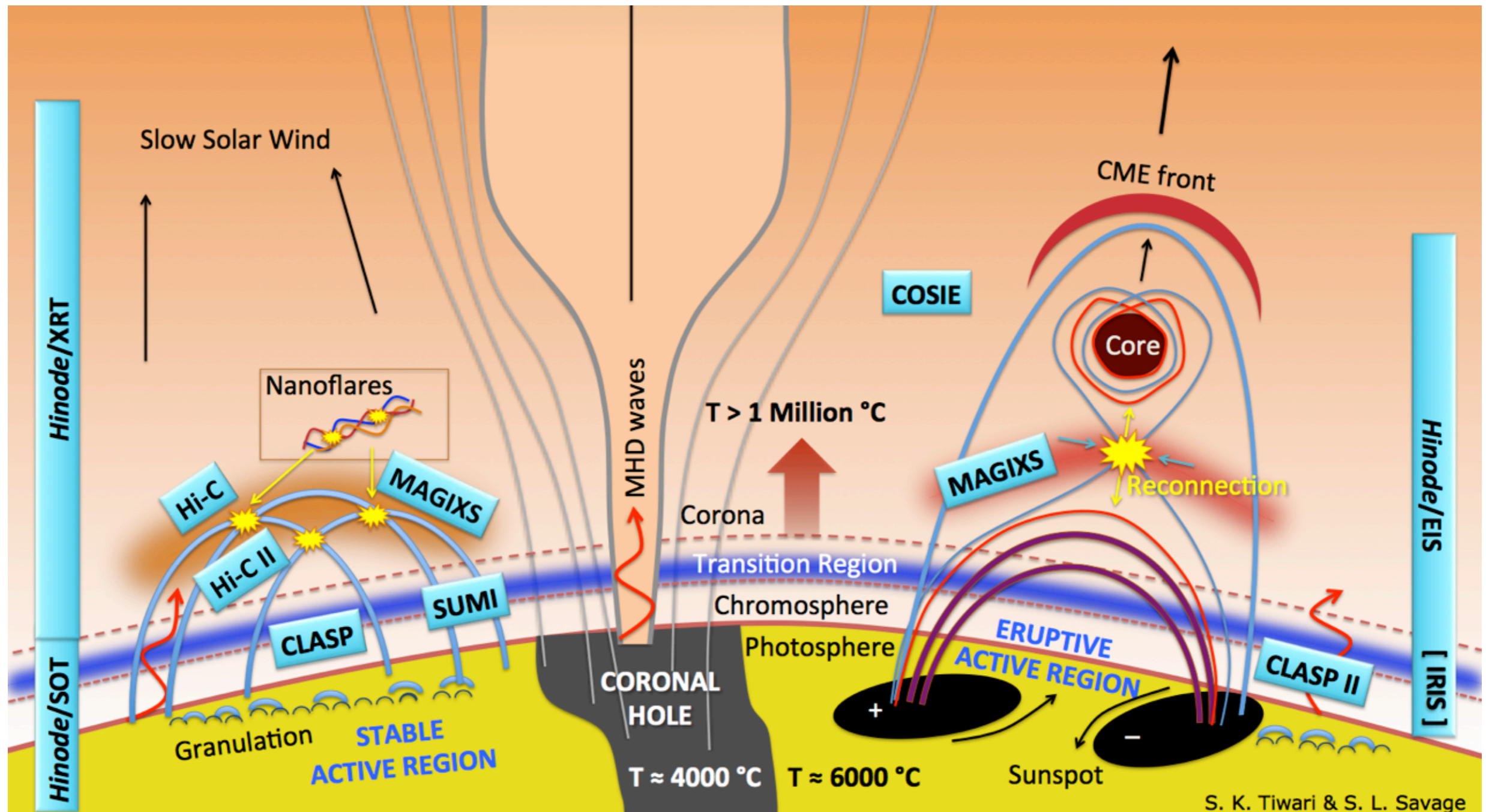
# Role of Marshall Space Flight Center

---





# Role of Marshall Space Flight Center



# Role of Marshall Space Flight Center

---

## Hi-C

Active Region 11520

July 11, 2012

**22 publications for 5 minutes of data!**

Science highlights:

Braided loops triggering energy release through magnetic reconnection (*Cirtain et al. 2013, Nature*)

Subflare triggers

Nanoflare heating

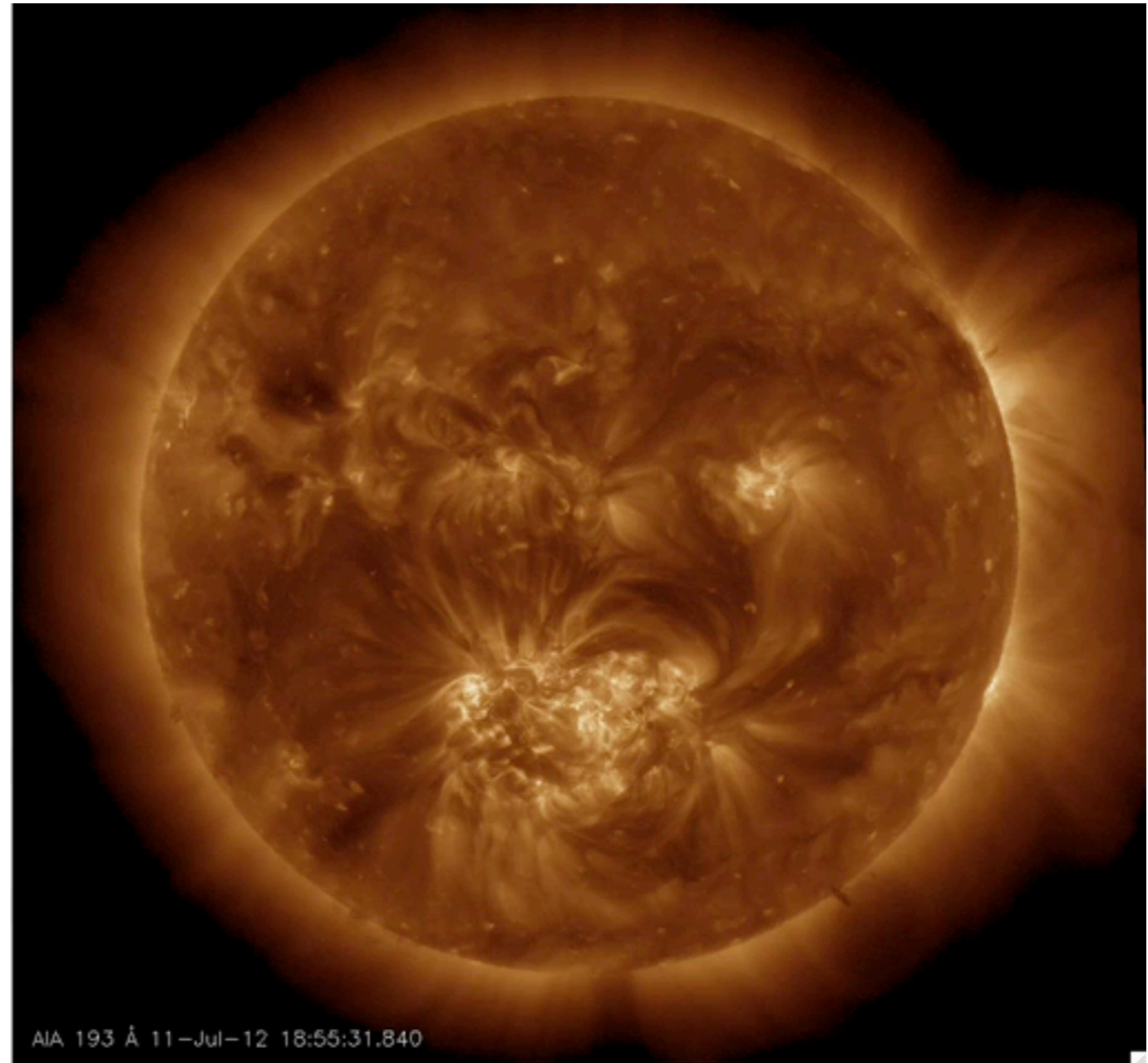
Loop sub-structure

Moss dynamics

Penumbral jets

Flows along filament threads

MHD waves



# Sounding Rockets for Technology Development



**t = -47.67 sec**

2015/09/03 11:00:13.58 MDT

**-45.0 sec**

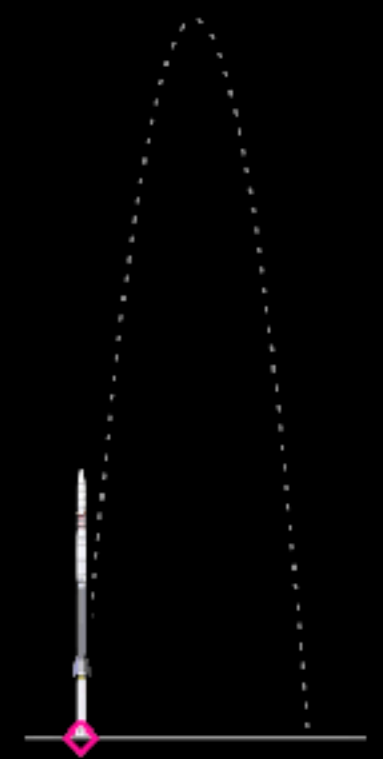
**Switch SPARCS to Coarse Mode**

**-30.0 sec**

**SPARCS - Load RRCF's**



**Expected Altitude  
1.2 km**



# Role of Marshall Space Flight Center

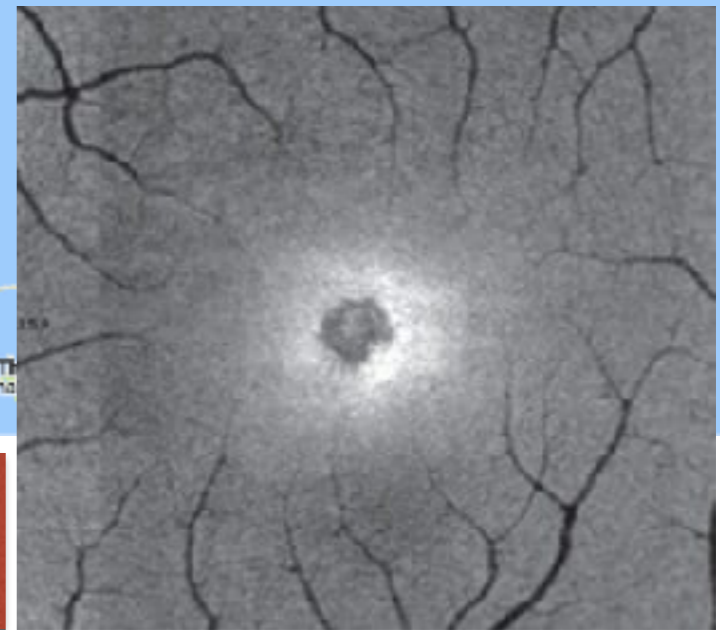
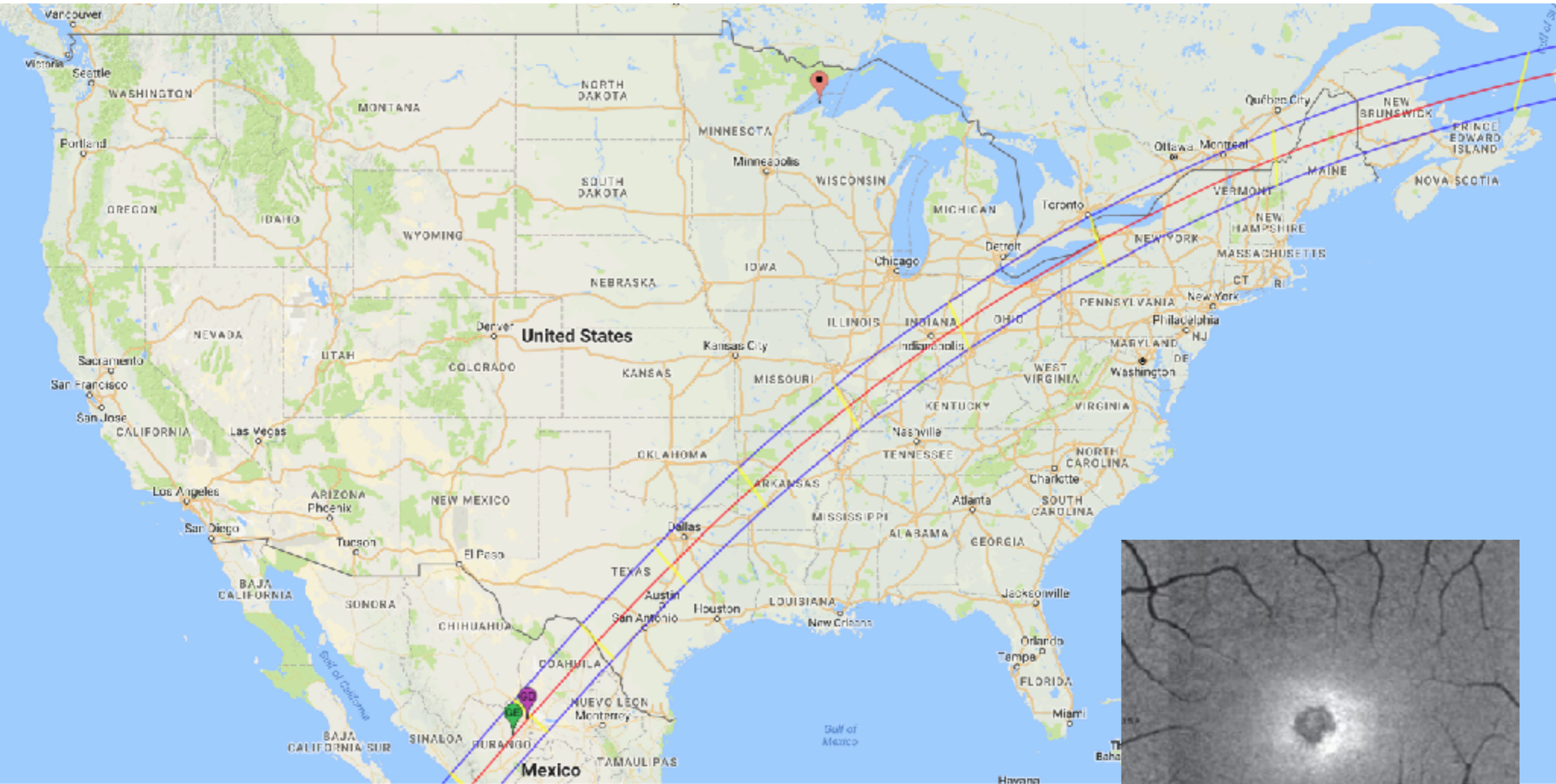
---



---

Hi-C II rocket launch at White Sands Missile Range, New Mexico.

# The Next Great American Solar Eclipse



**USE PROTECTIVE EYE WEAR!**  
<https://eclipse2017.nasa.gov/safety>

# *Thanks!*

---

