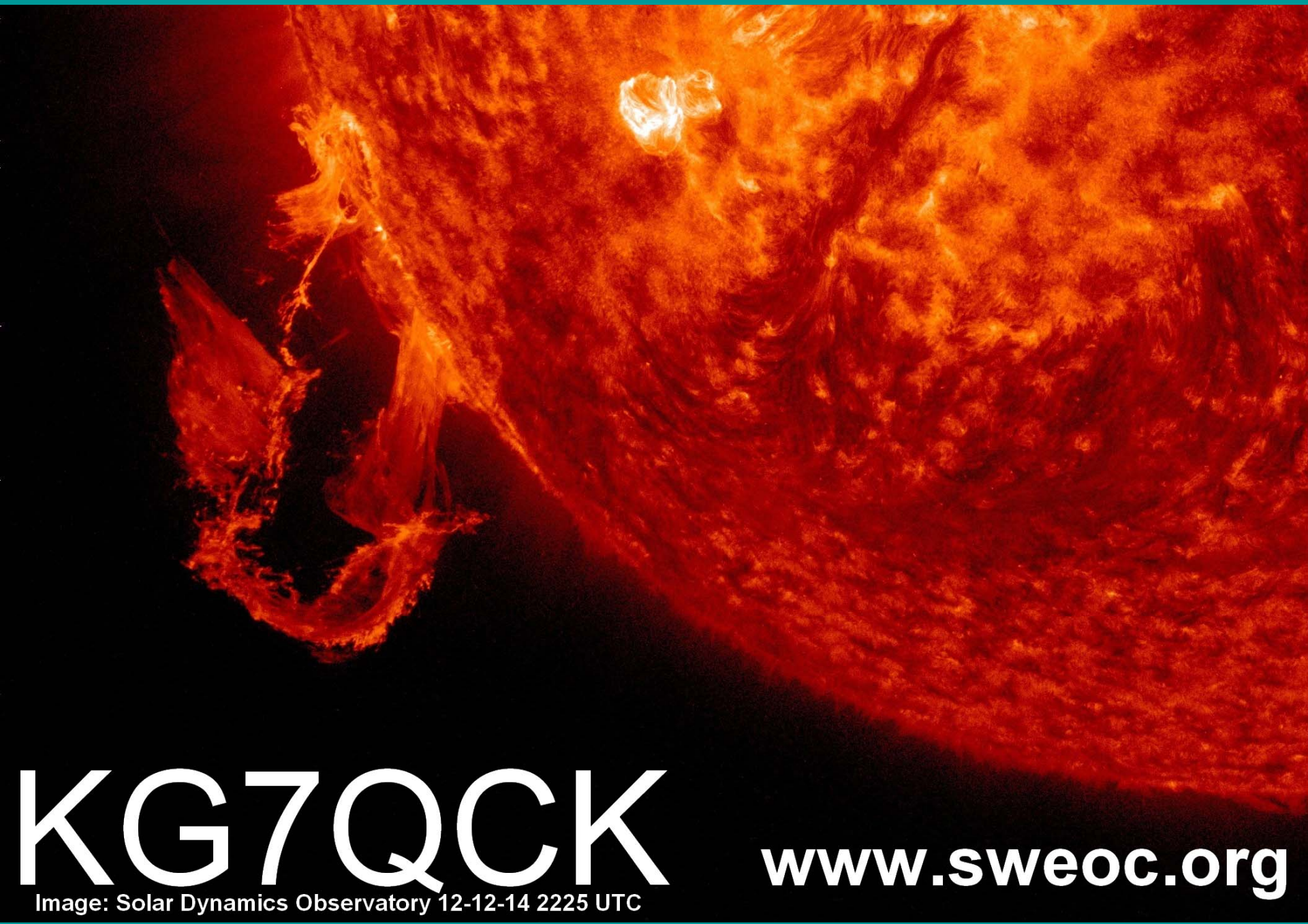

KG7QCK
www.sweoc.org
Image: Solar Dynamics Observatory 12-12-14 2225 UTC

NASA G2 Project

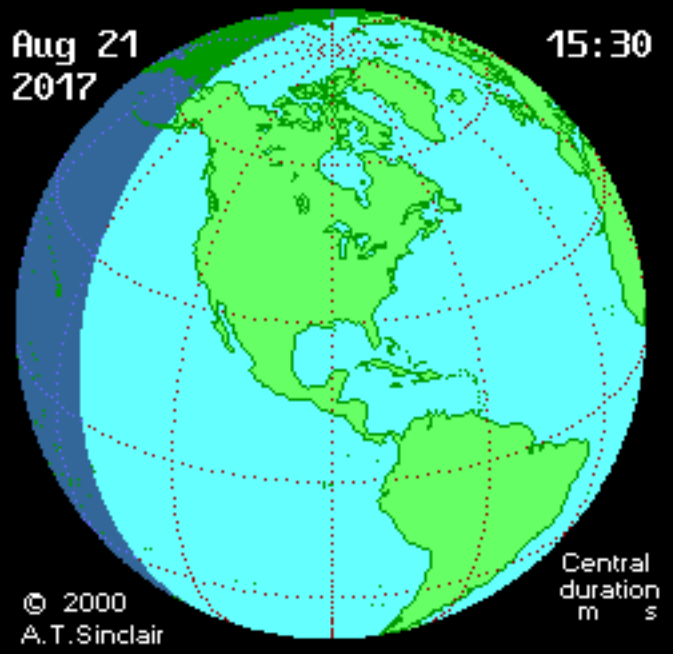
What is Space Weather

Observing SWE's

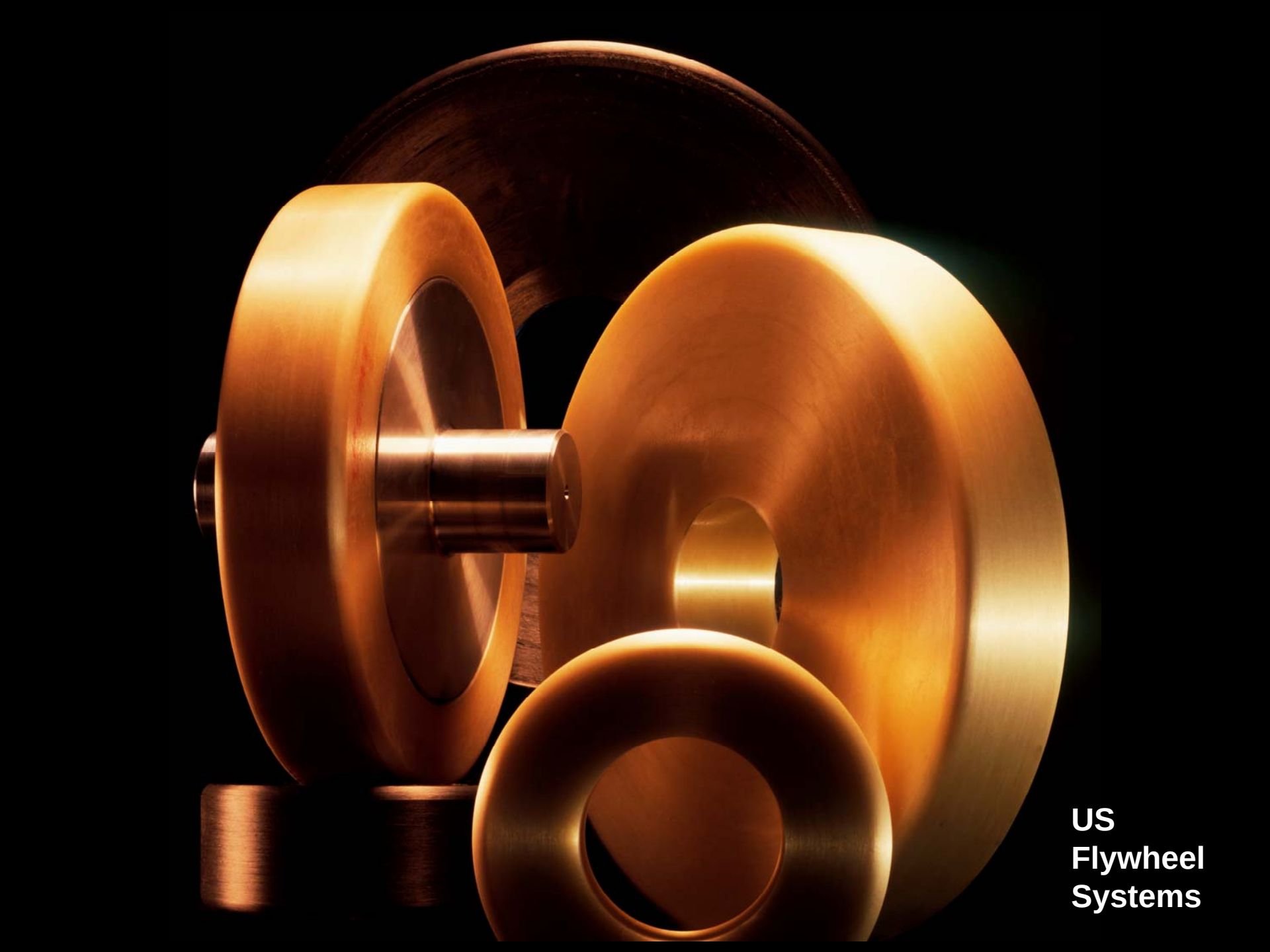
Sunspot History

Space Observatories

Kitt Peak



sunearth.gsfc.nasa.gov/eclipse


US
Flywheel
Systems

NASA G2 Project

The Space Metric System

Time

Universal Time (UT or UTC) = LT + 7 Hours

Distance

1 kilometer = 3,280 feet

Speed

1 kilometer per second = 2,236.94 MPH

The Speed of Light and Electromagnetic Waves

Speed of Light-Meters per sec	299,792,458			
Speed of Light-Miles per hr	11,160,000			
Speed of Light-Miles per sec	186,000			
Earth Sun Distance-Miles	Seconds	Minutes	Earth	Month
93,000,000	500.0000	8.333333333	Perihelion	July
95,000,000	510.7527	8.512544803	Median	
97,000,000	521.5054	8.691756272	Aphelion	January

A solar flare is the only disaster that can effect half of the Earth in *500 seconds* from the time of the event *without warning*.

Natural Disaster Events

Earthquakes

Fire

Floods

Excessive Heat

Hurricanes and Coastal Floods

Landslides and Mudflows

Severe Thunderstorms

Tornados

Tsunamis

Volcanoes

Winter Storms

Nuclear Power Plant Emergencies

Pandemic Influenza

What is Space Weather?

Electromagnetic and Mechanical Waves

Sunspots and Solar Flare Events

Coronal Mass Ejection (CME) Events

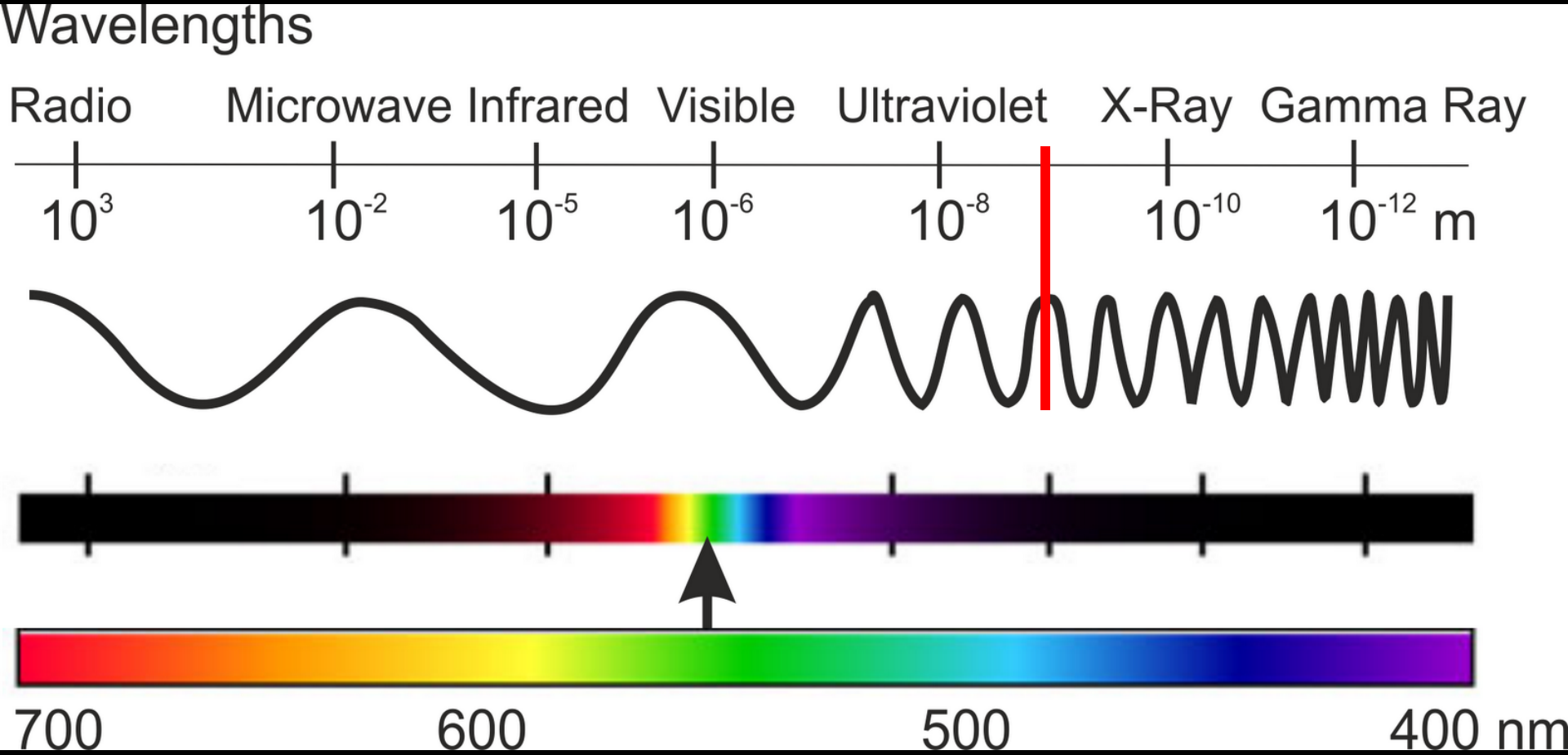
Filament Eruption Events

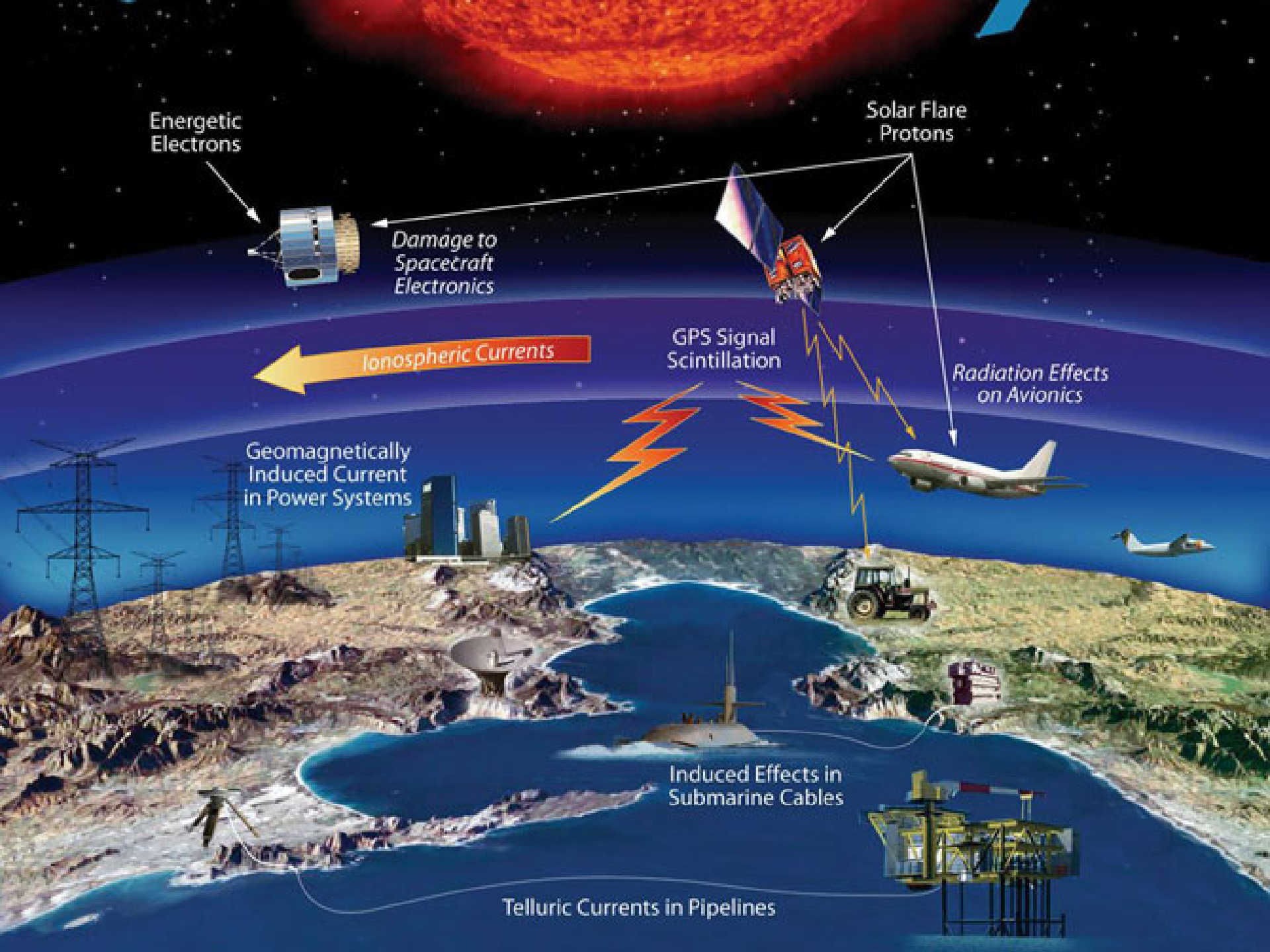
Coronal Holes and Solar Wind Events

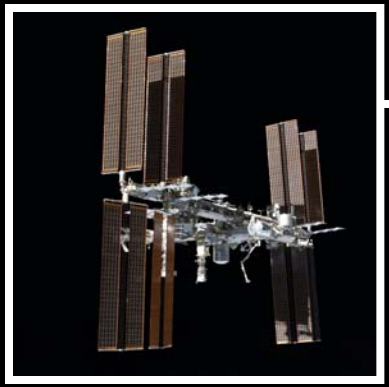
Events can occur independently or together

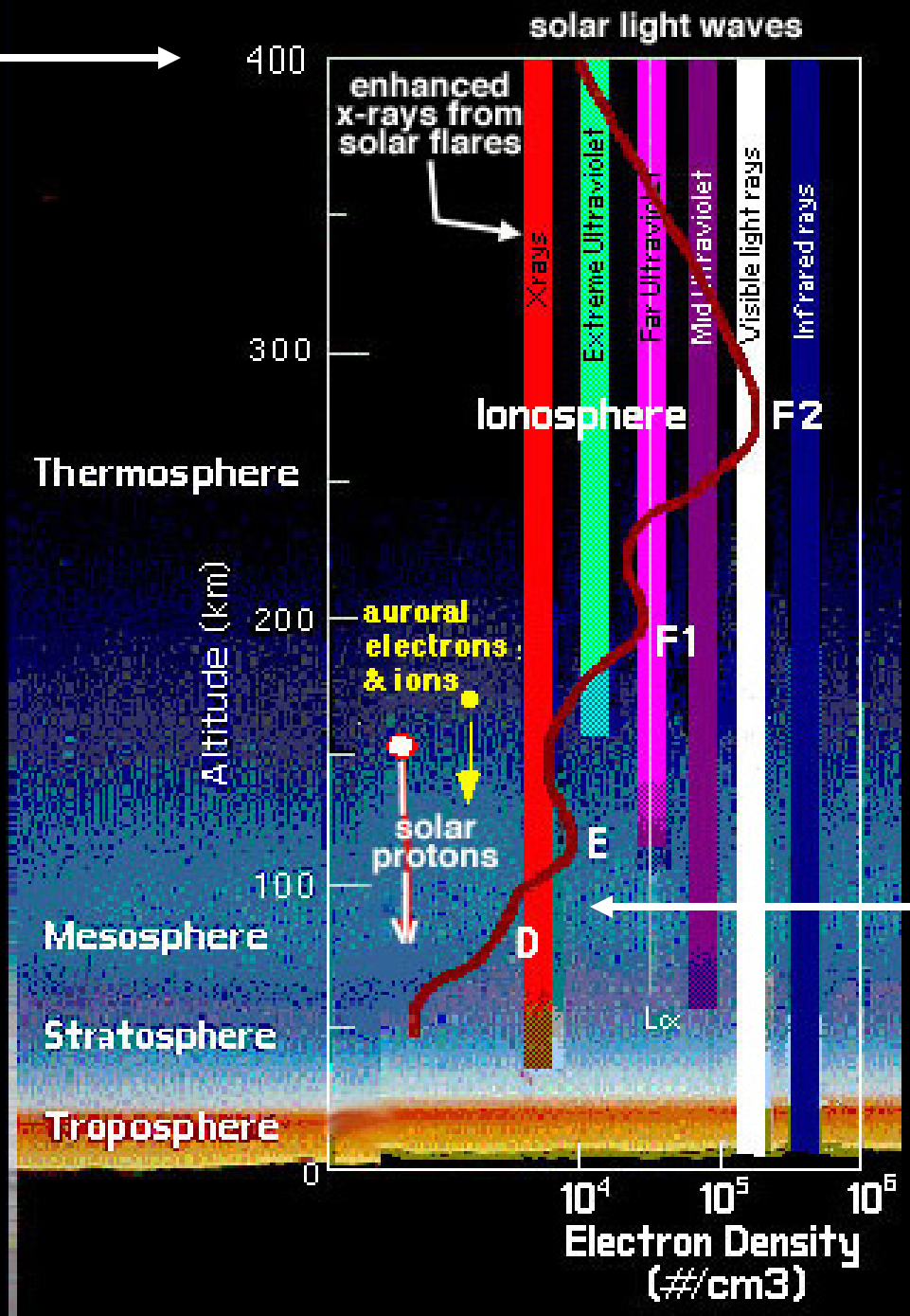
Comprised of Ions (Electrons and Protons)

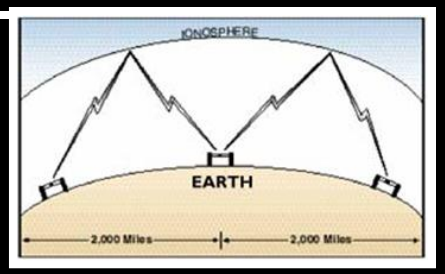
Electromagnetic Waves

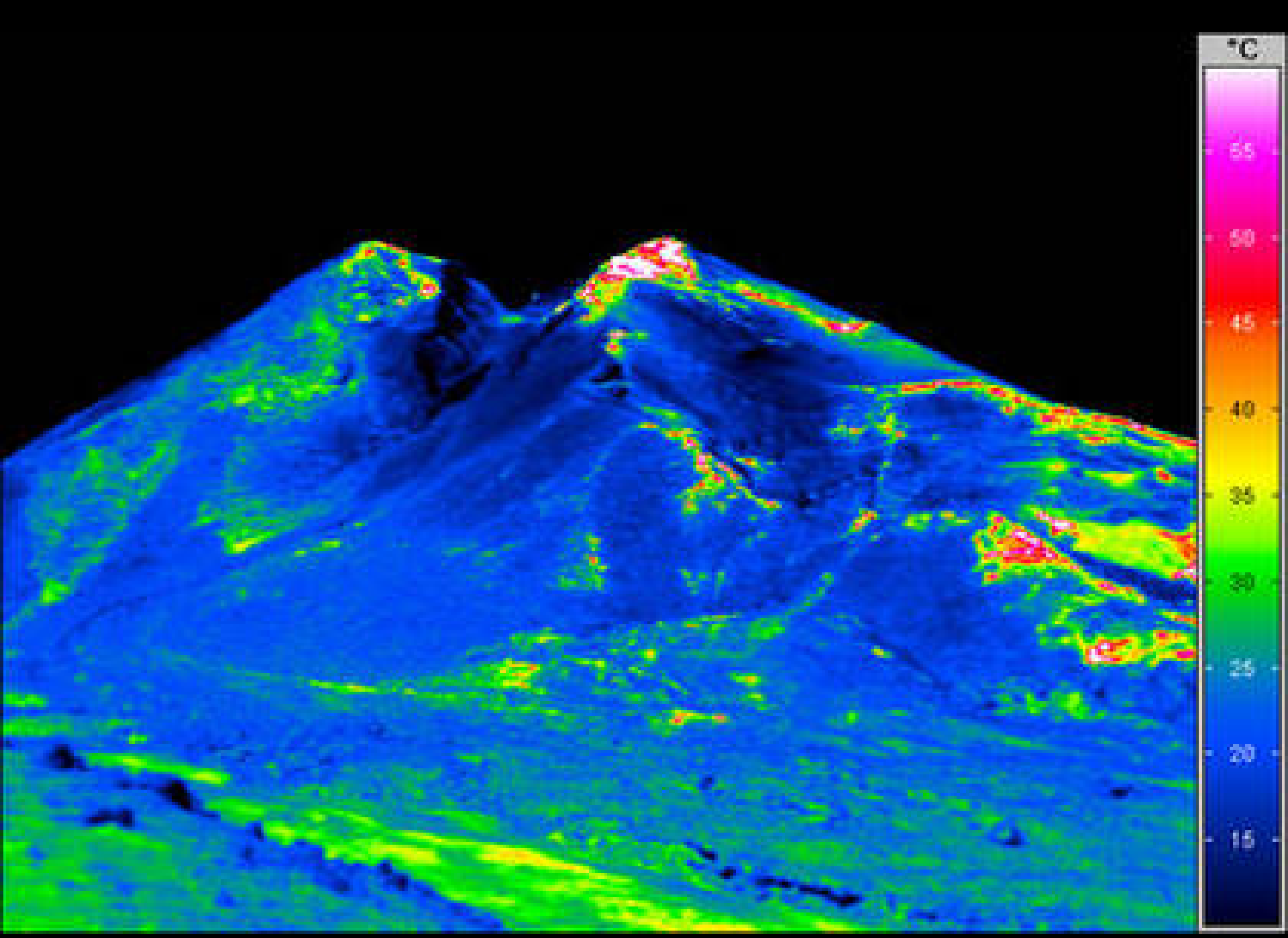


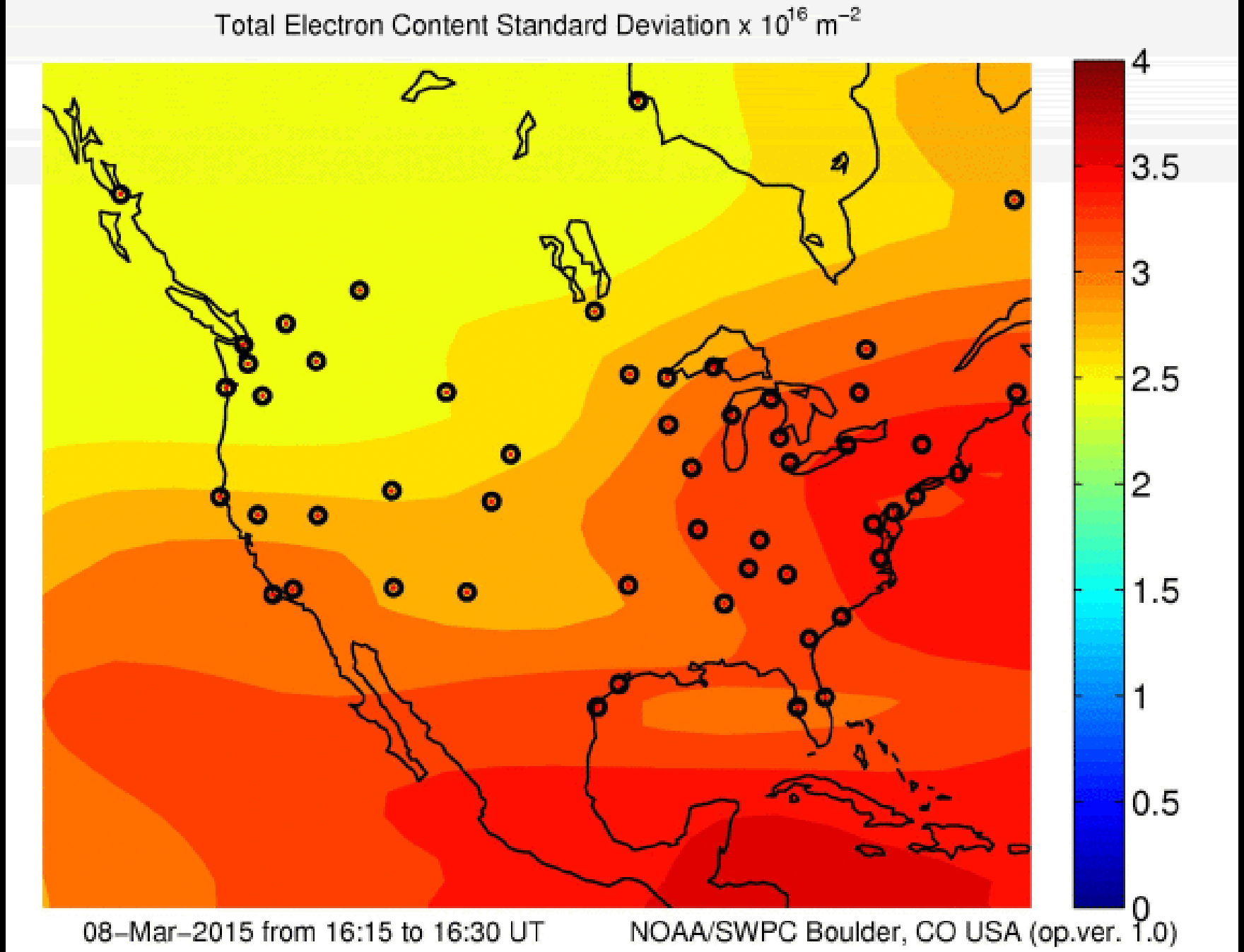

Energetic Electrons
Solar Flare Protons
Damage to Spacecraft Electronics
Ionospheric Currents
GPS Signal Scintillation
Radiation Effects on Avionics
Geomagnetically Induced Current in Power Systems
Induced Effects in Submarine Cables
Telluric Currents in Pipelines



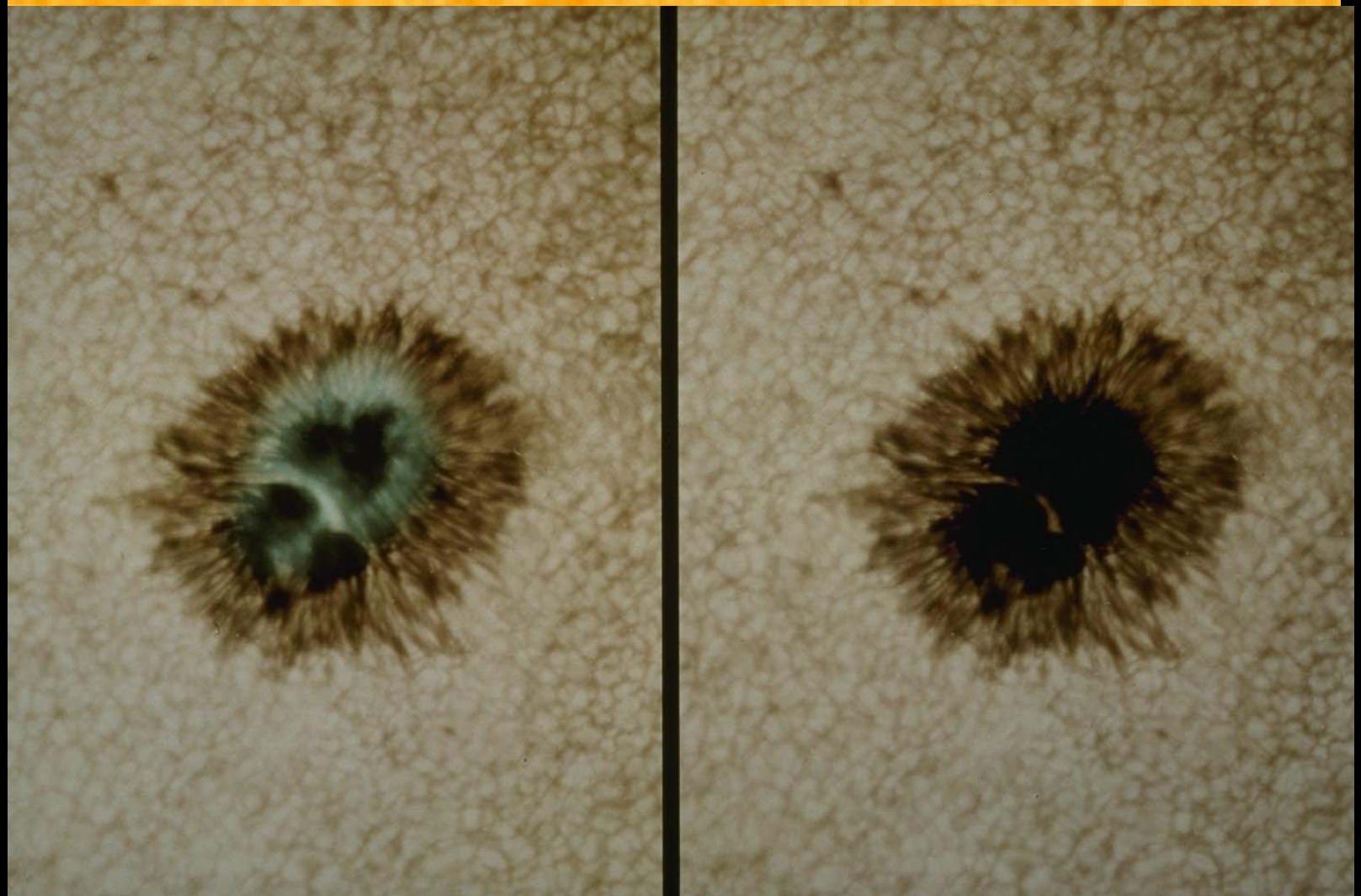

solar light waves
enhanced x-rays from solar flares
X rays
Extreme Ultraviolet
Far Ultraviolet
Mid Ultraviolet
Visible light rays
Infrared rays
Ionosphere
F2
F1
E
D
Lα
Thermosphere
Mesosphere
Stratosphere
Troposphere
Altitude (km)
400
300
200
100
0
auroral electrons & ions
solar protons
10^4
10^5
10^6
Electron Density (#/cm3)

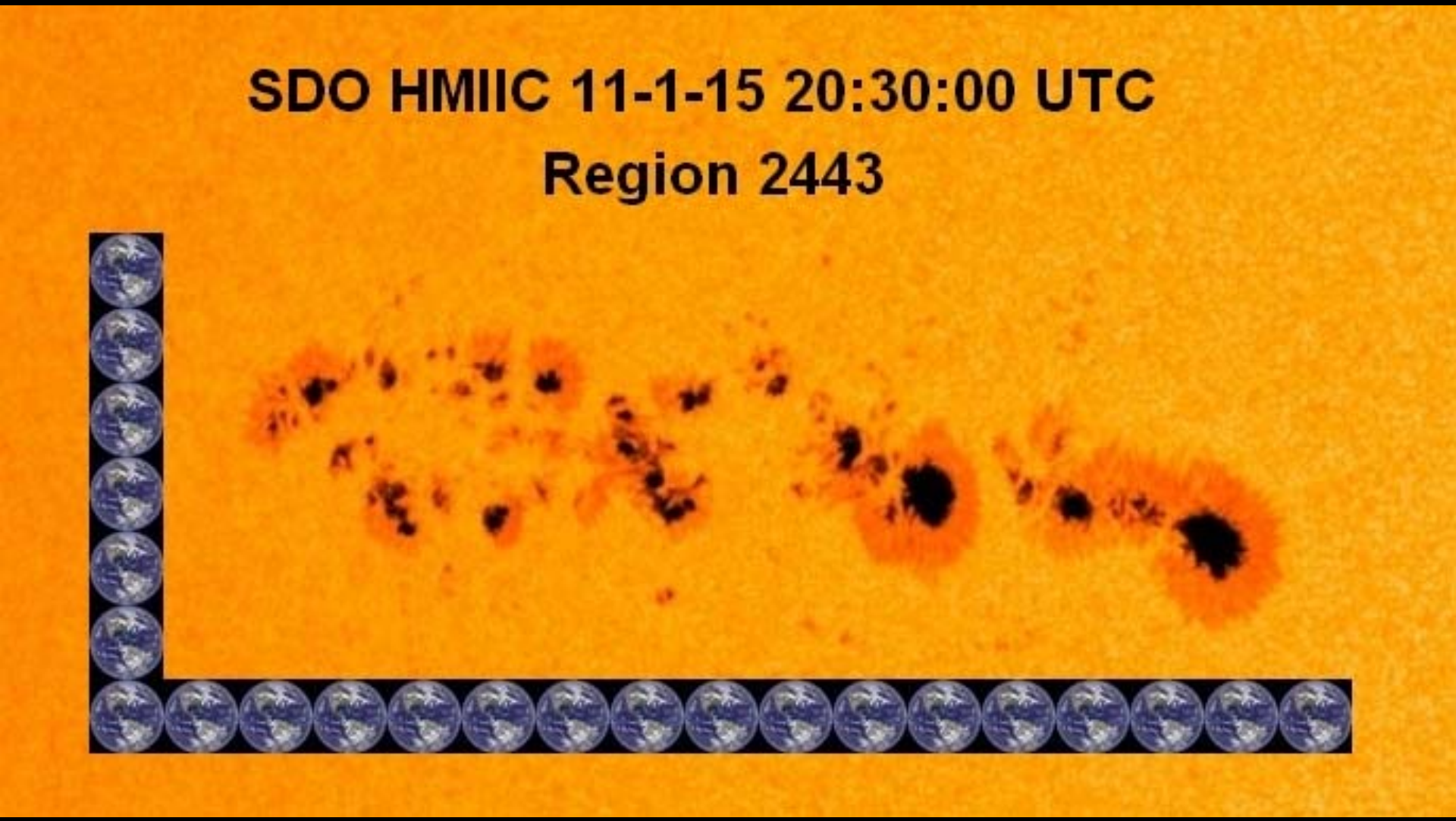

IONOSPHERE
EARTH
2,000 Miles
2,000 Miles

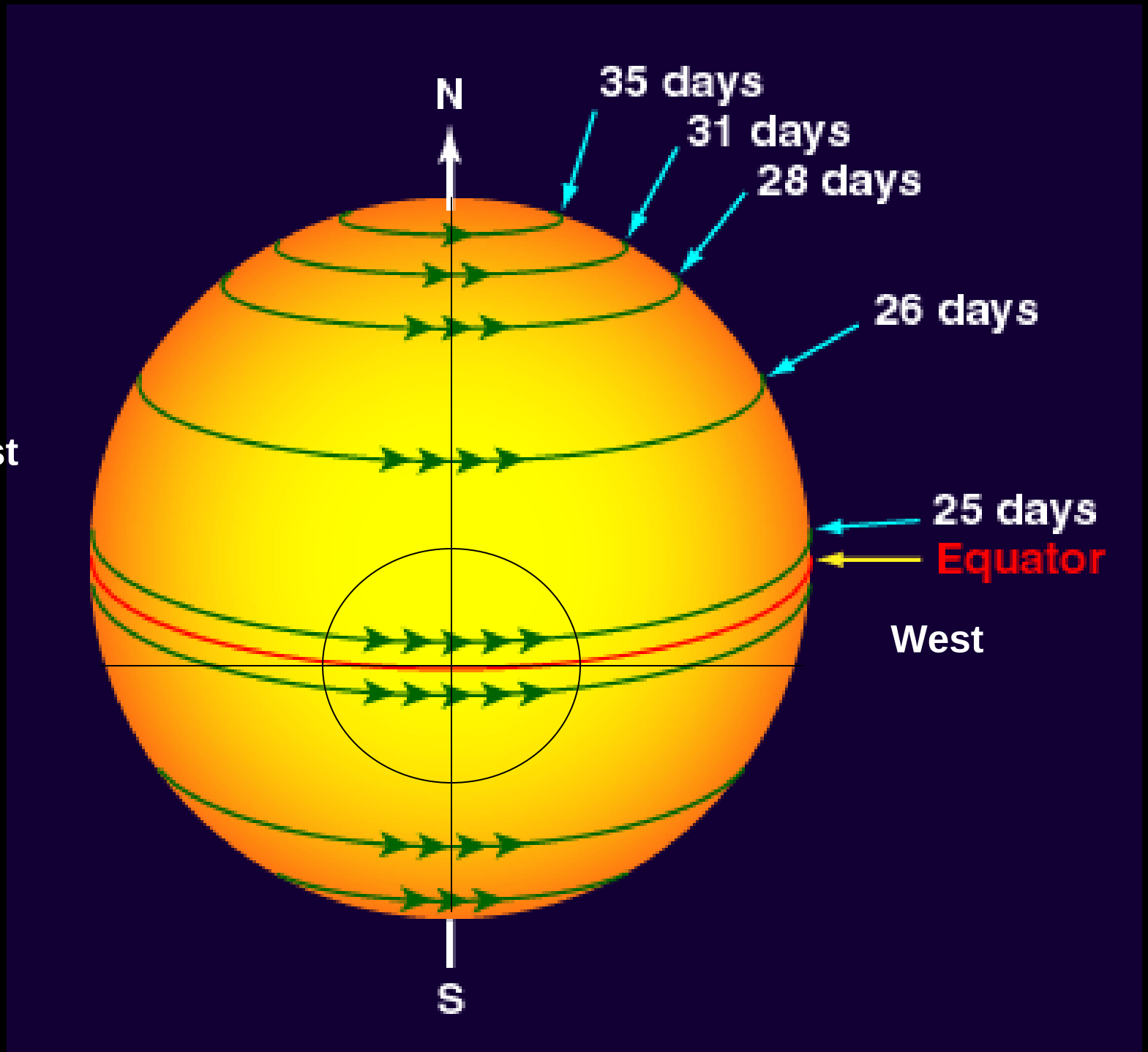

°C
55
50
45
40
35
30
25
20
15

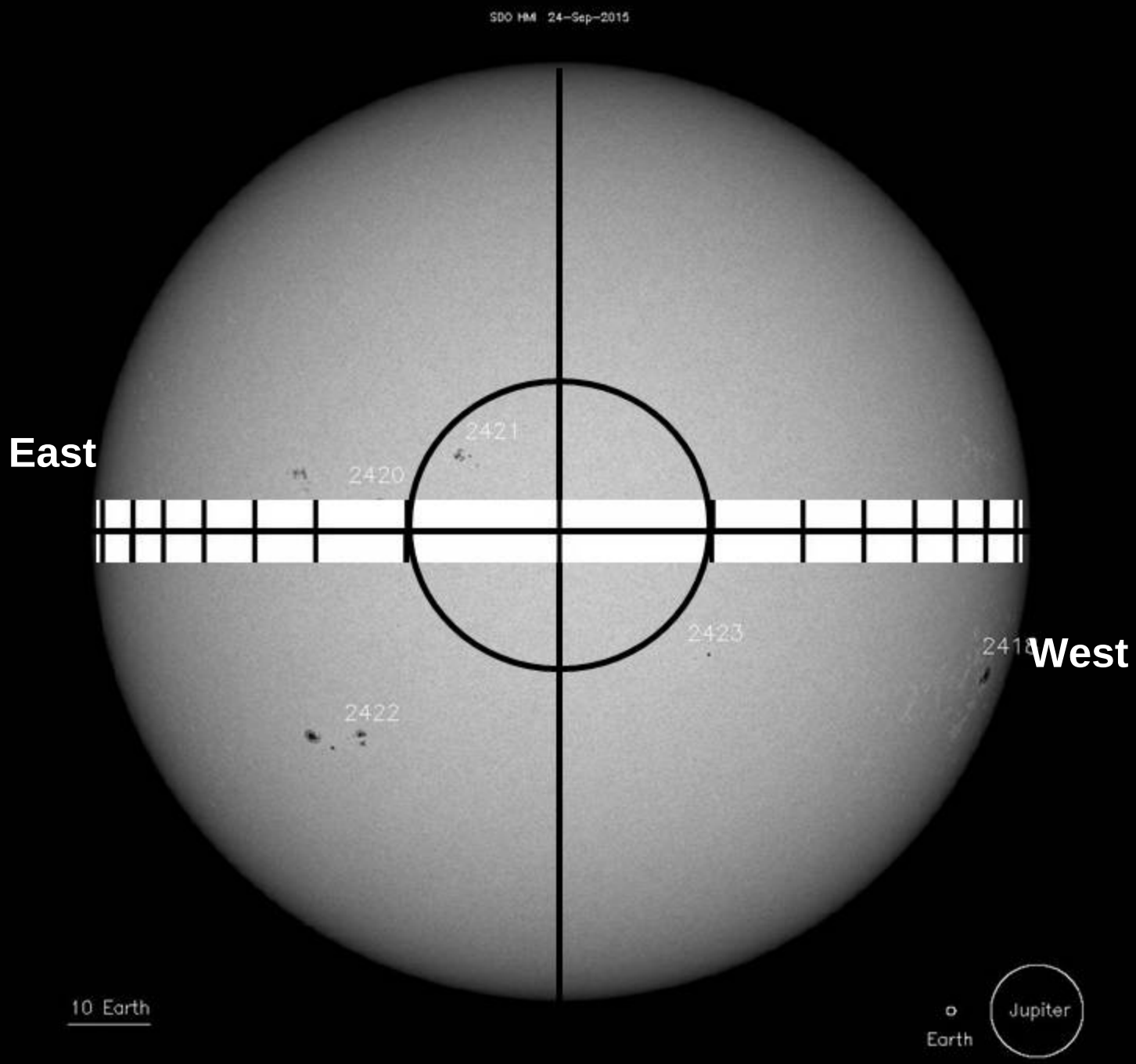

Total Electron Content Standard Deviation x 10^{16} m^{-2}
4
3.5
3
2.5
2
1.5
1
0.5
0
08–Mar–2015 from 16:15 to 16:30 UT
NOAA/SWPC Boulder, CO USA (op.ver. 1.0)

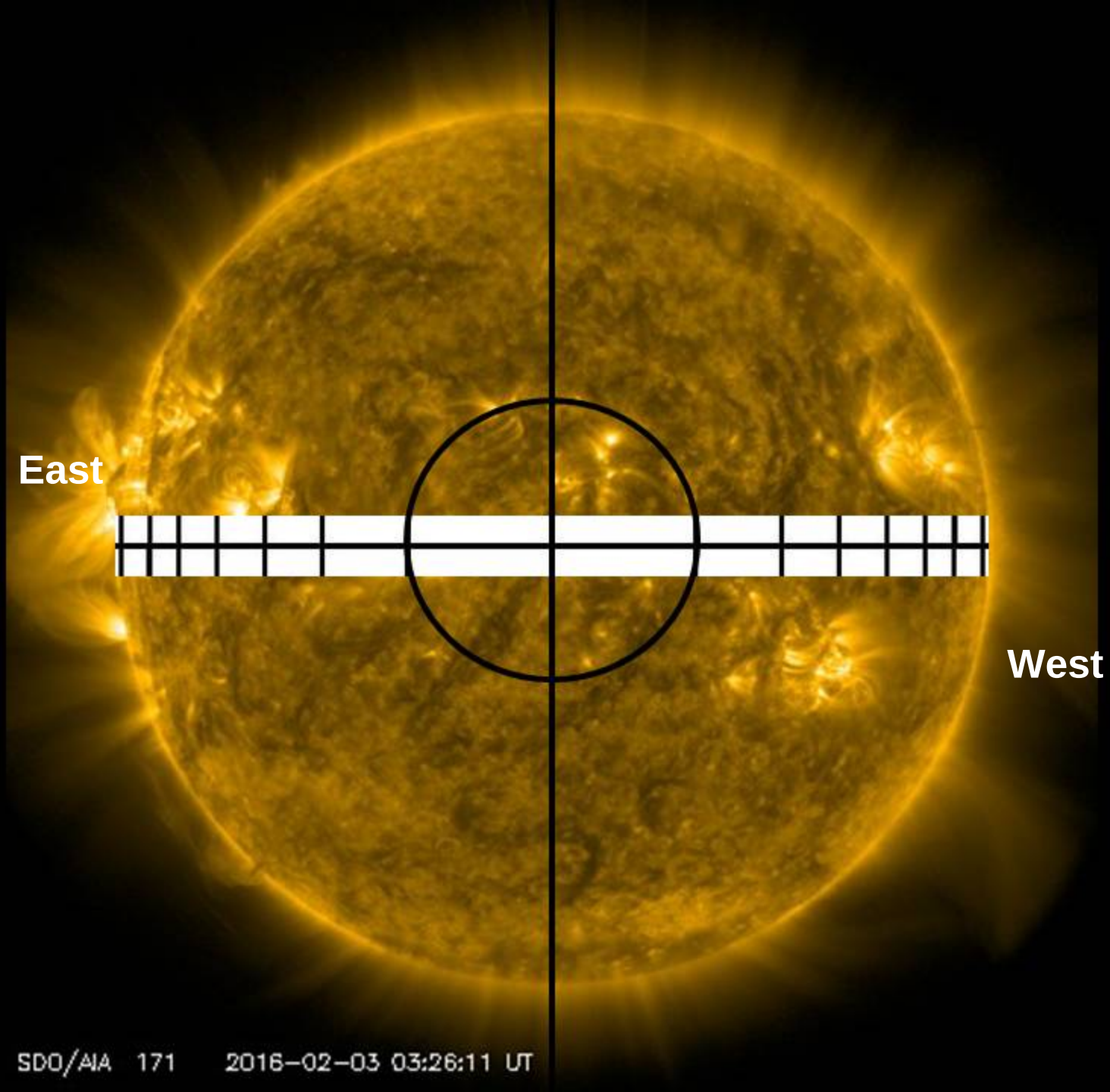
Sunspots

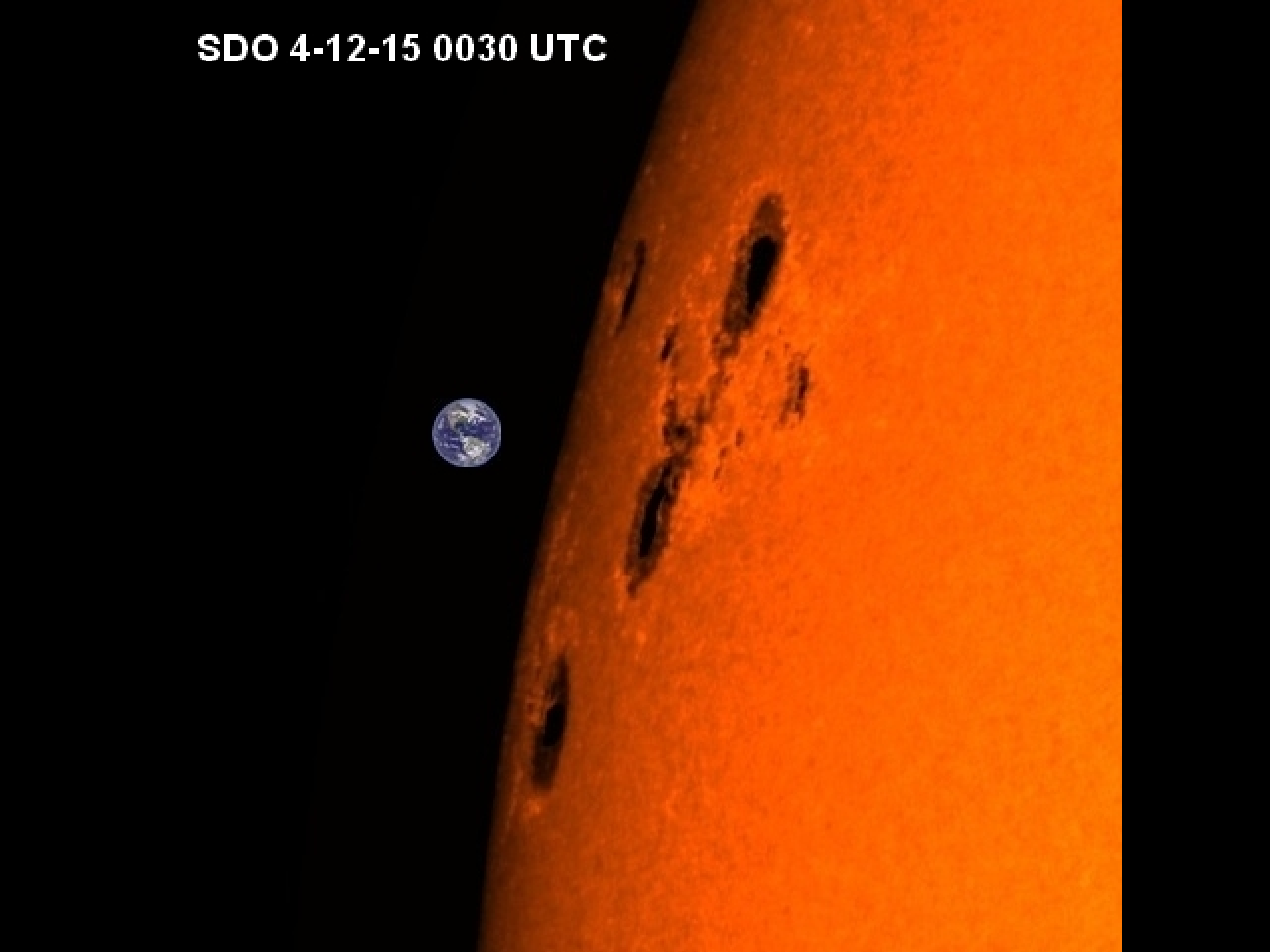


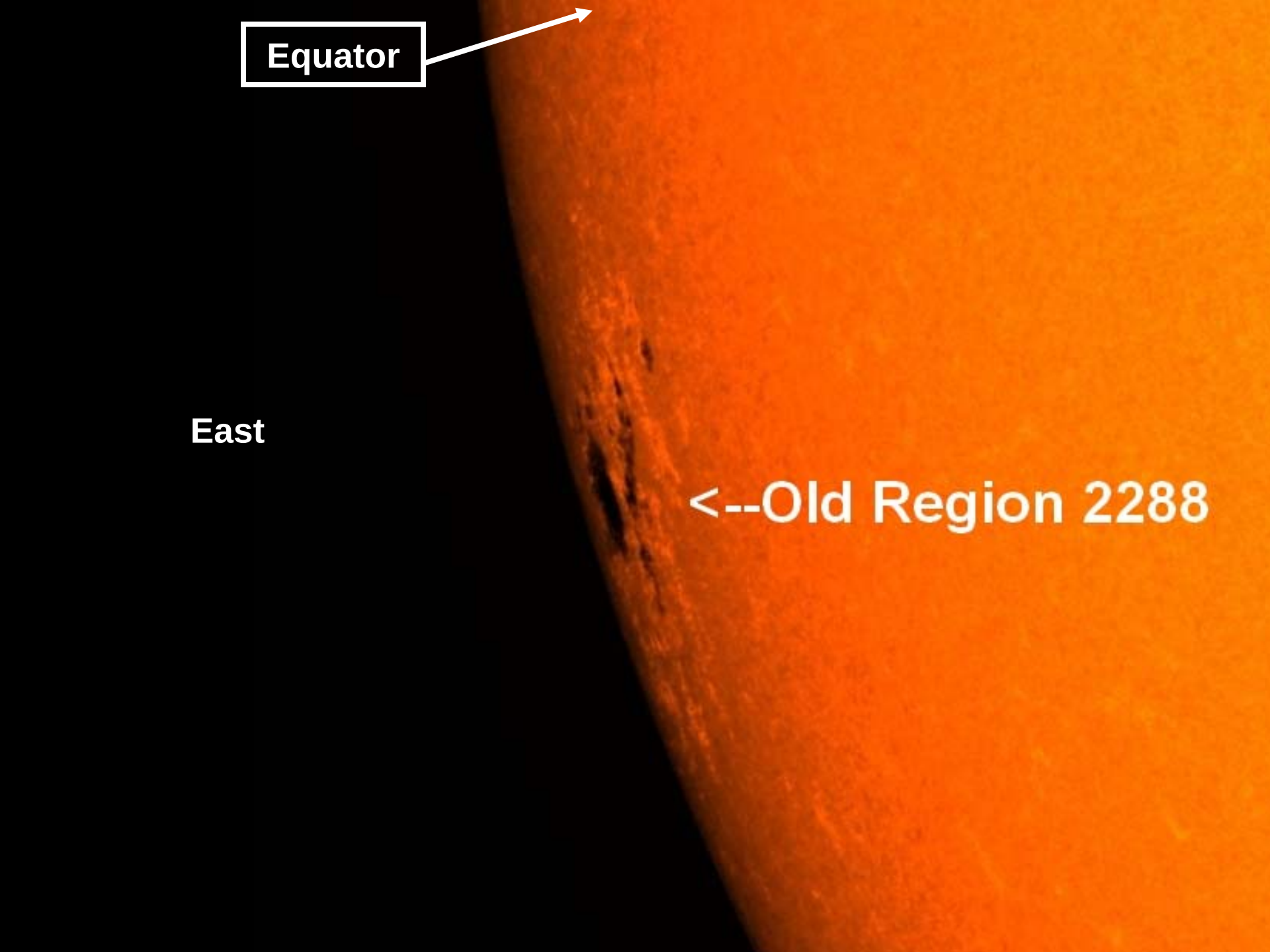

SDO HMIIC 11-1-15 20:30:00 UTC
Region 2443


N
35 days
31 days
28 days
26 days
East
25 days
Equator
West
S

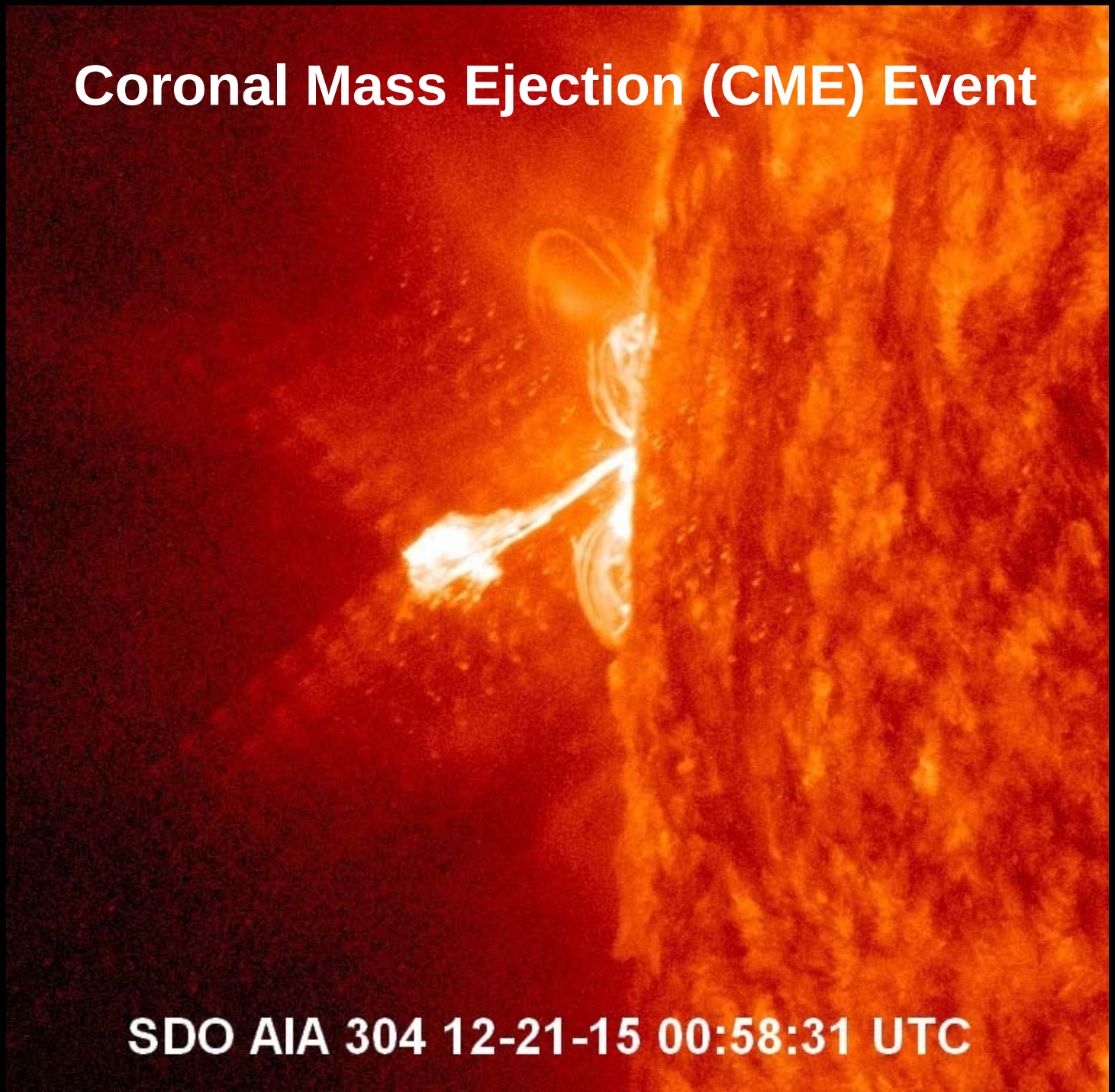

SDO HMI 24-Sep-2015
East
West
2421
2420
2423
2422
10 Earth
Earth
Jupiter

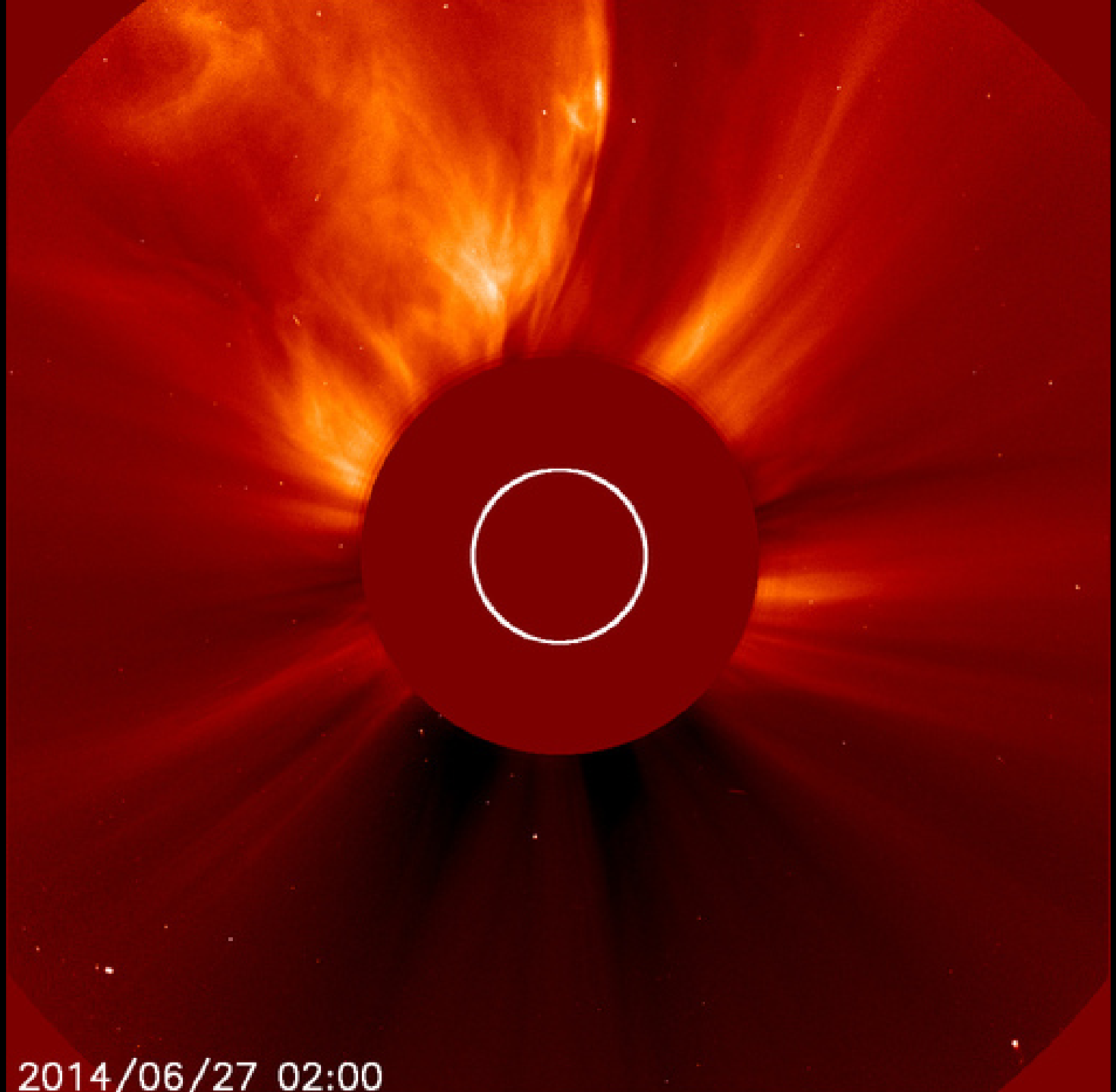

East
West
SDO/AIA 171 2016-02-03 03:26:11 UT

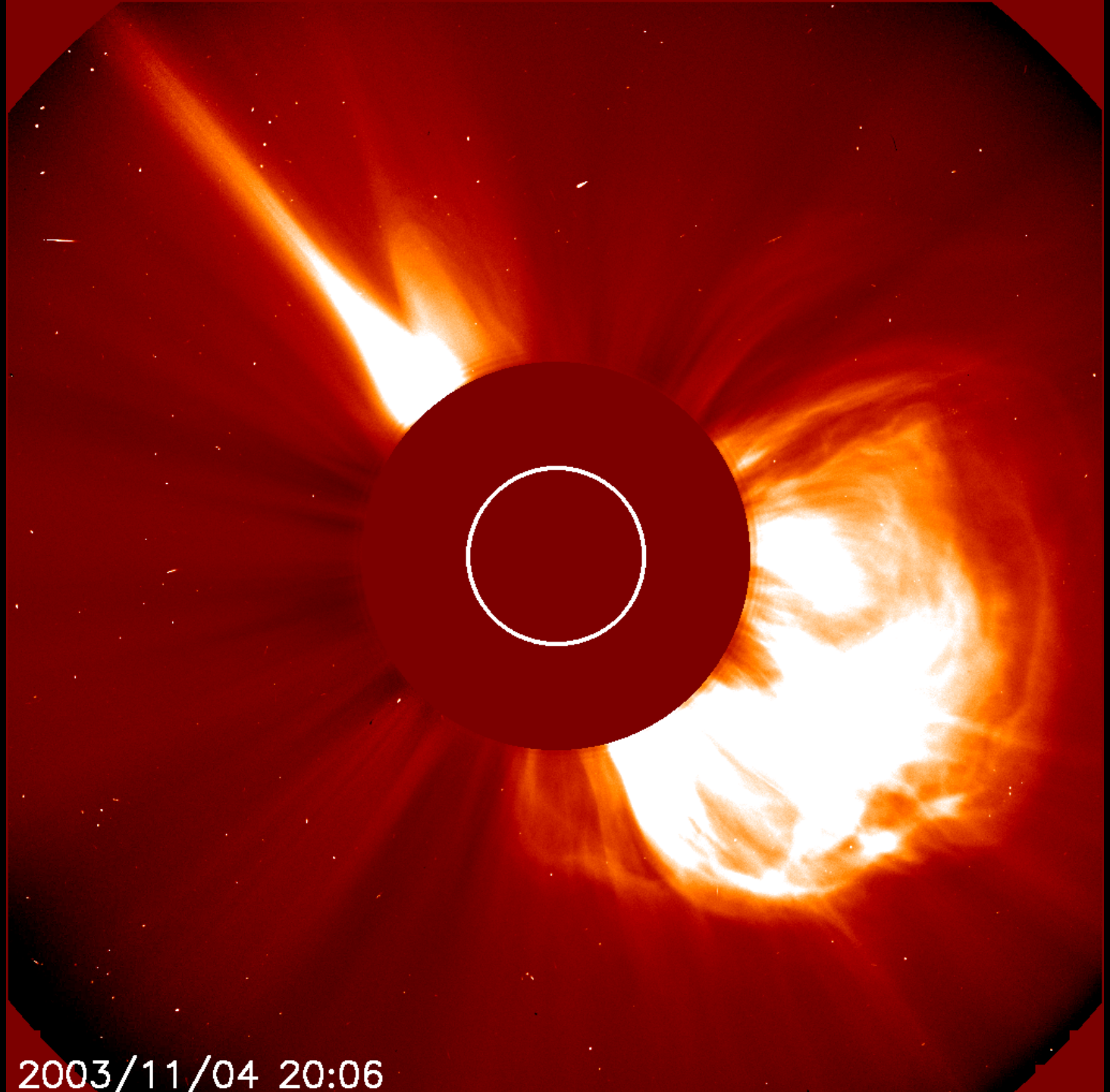

SDO 4-12-15 0030 UTC

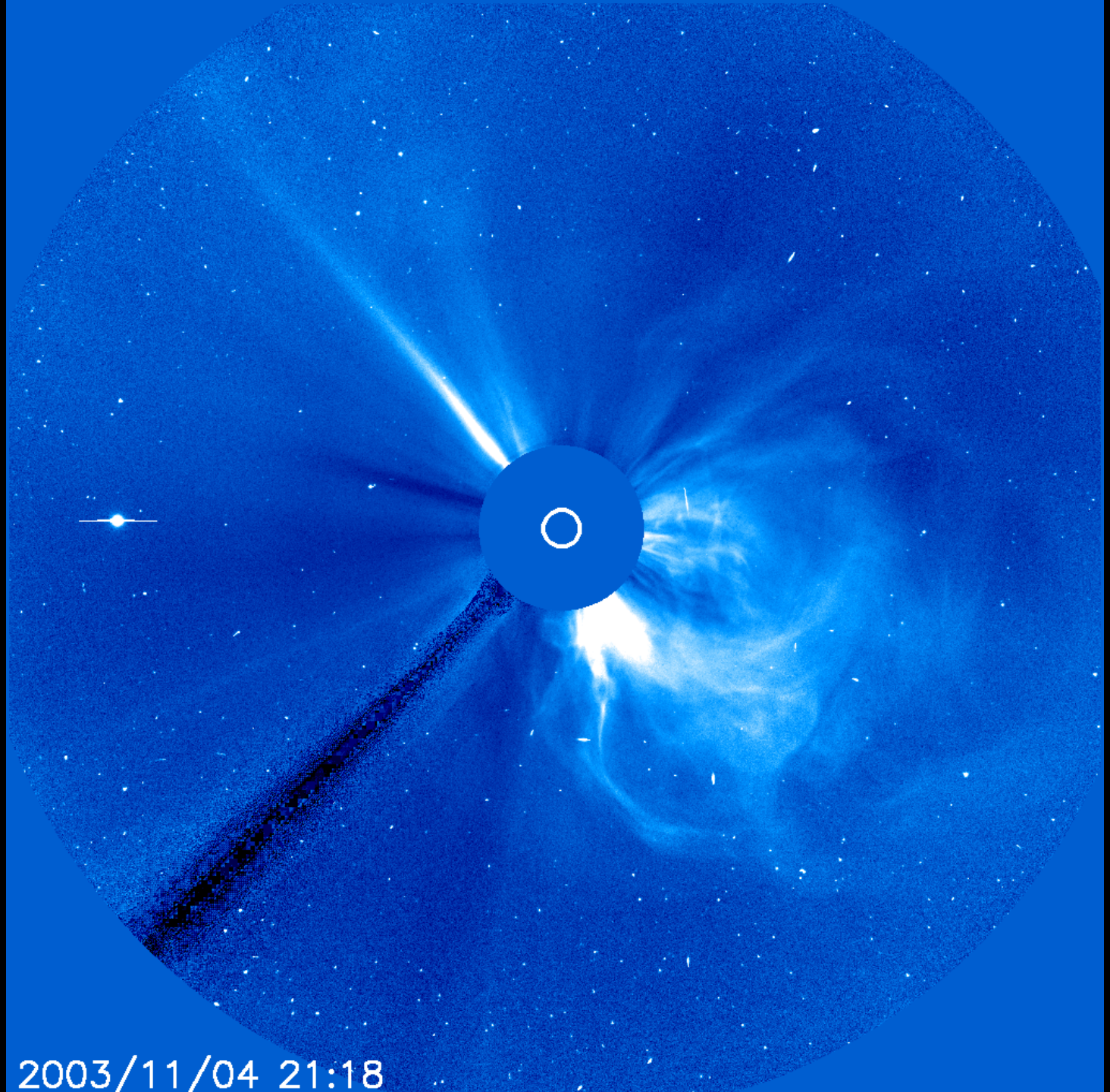

Equator
East
<--Old Region 2288

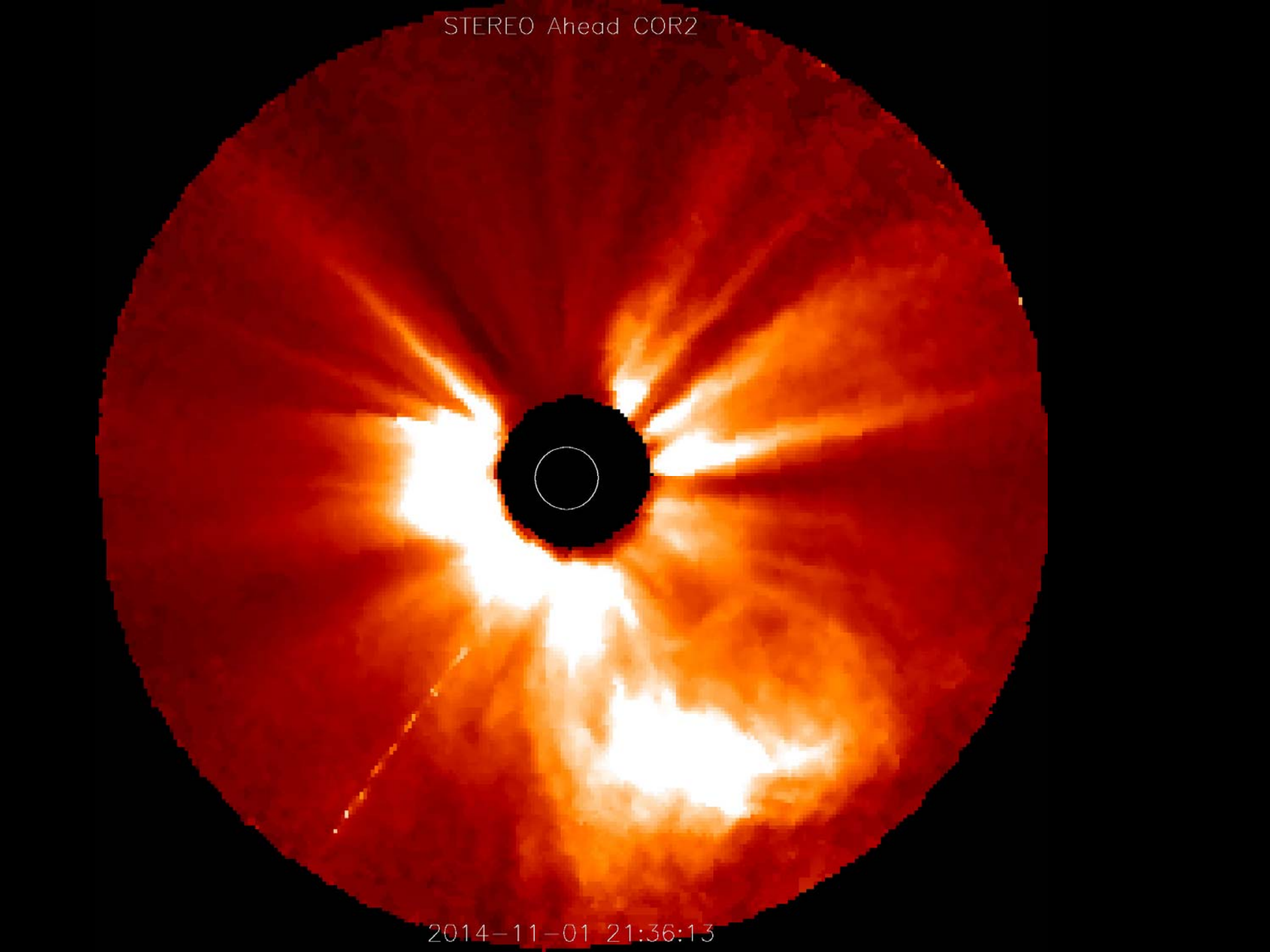
Coronal Mass Ejection (CME) Event



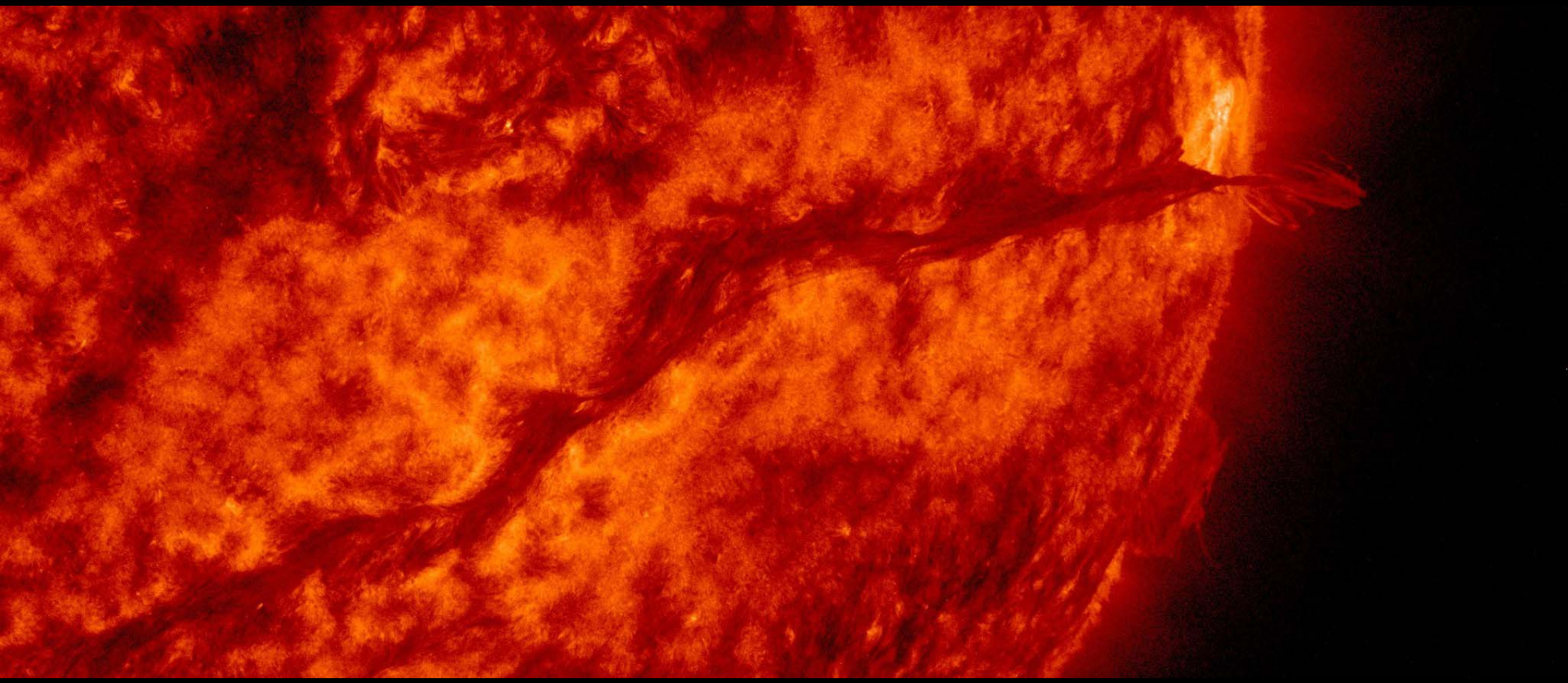

2014/06/27 02:00

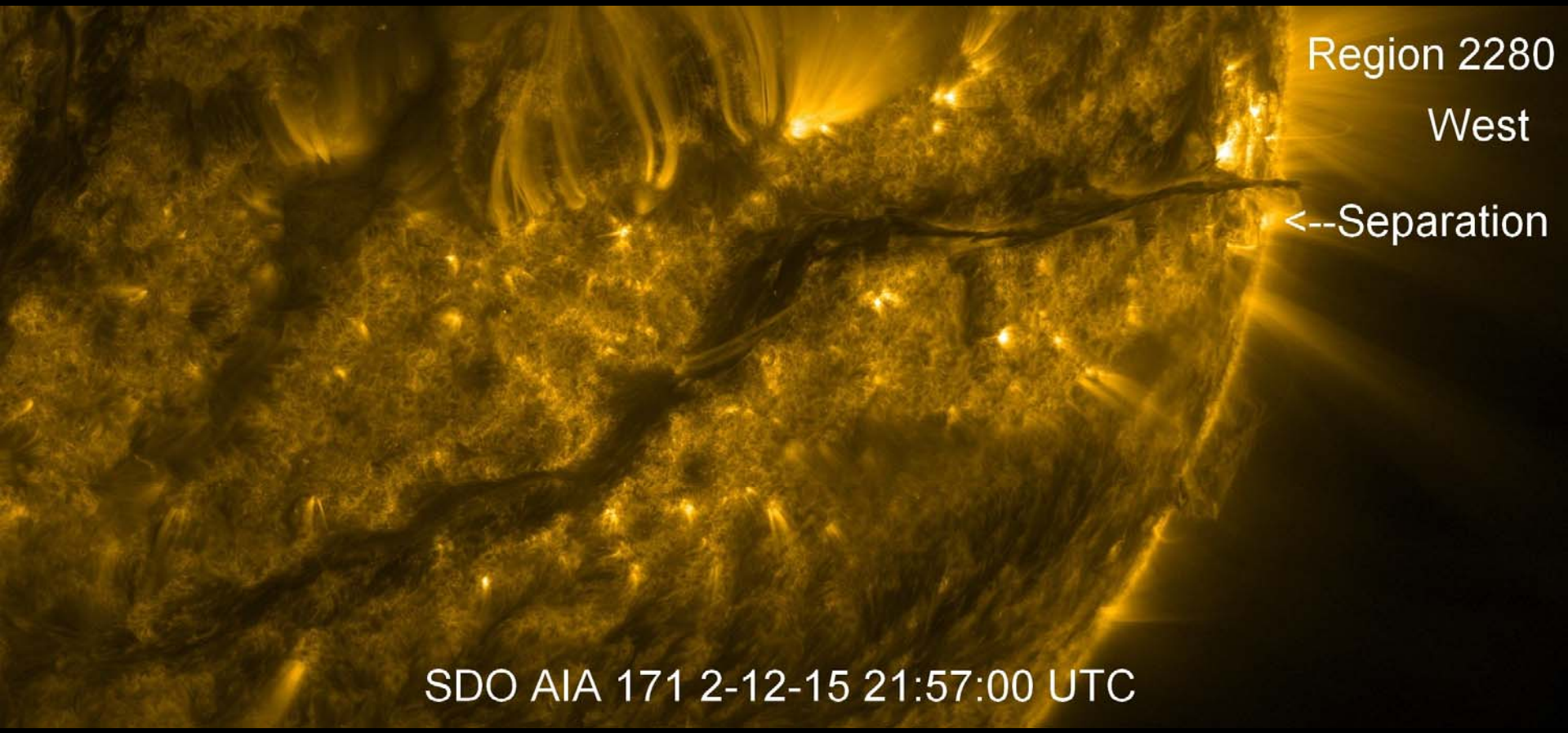

2003/11/04 20:06


2003/11/04 21:18

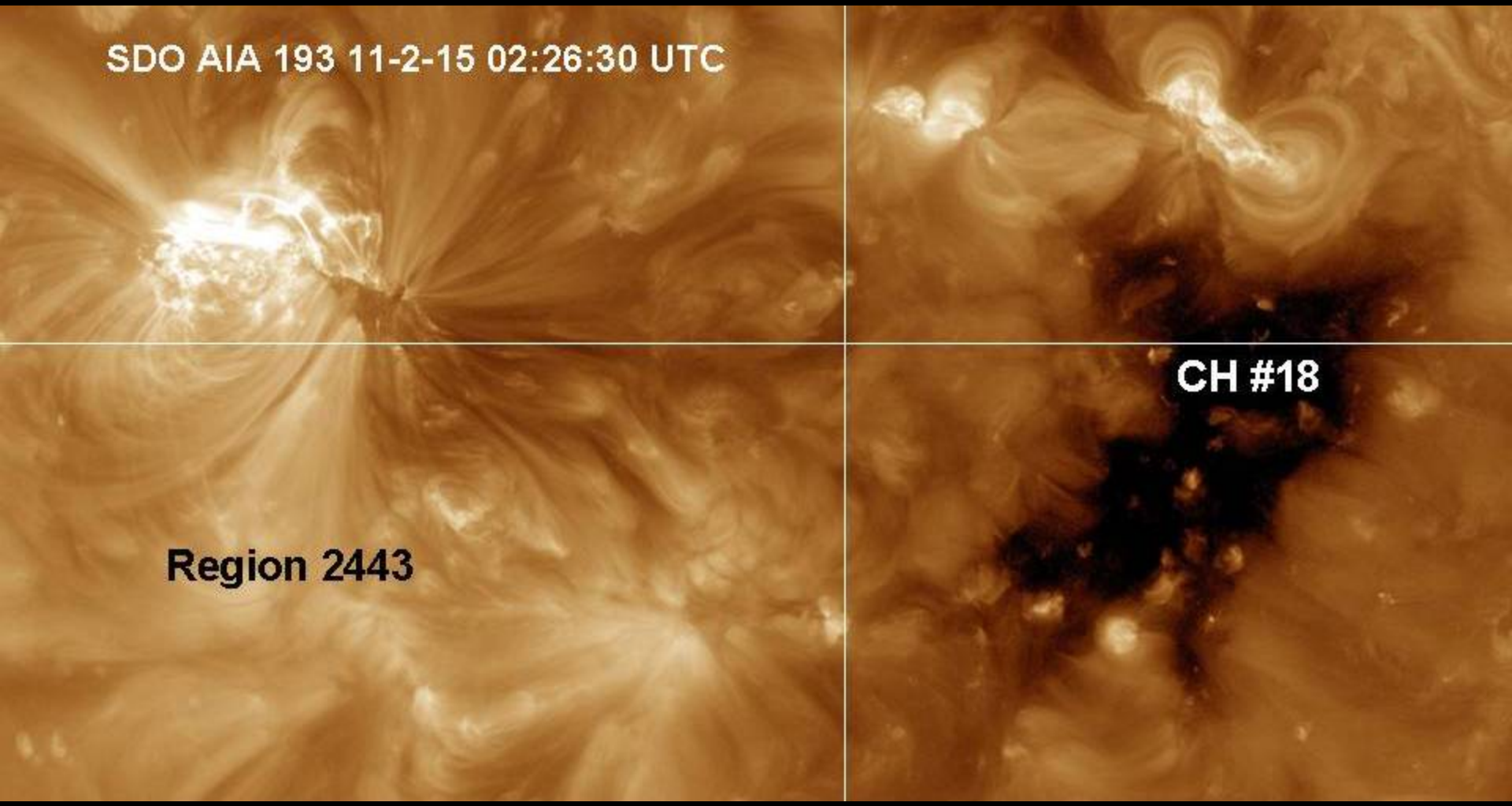

STEREO Ahead COR2
2014-11-01 21:36:13

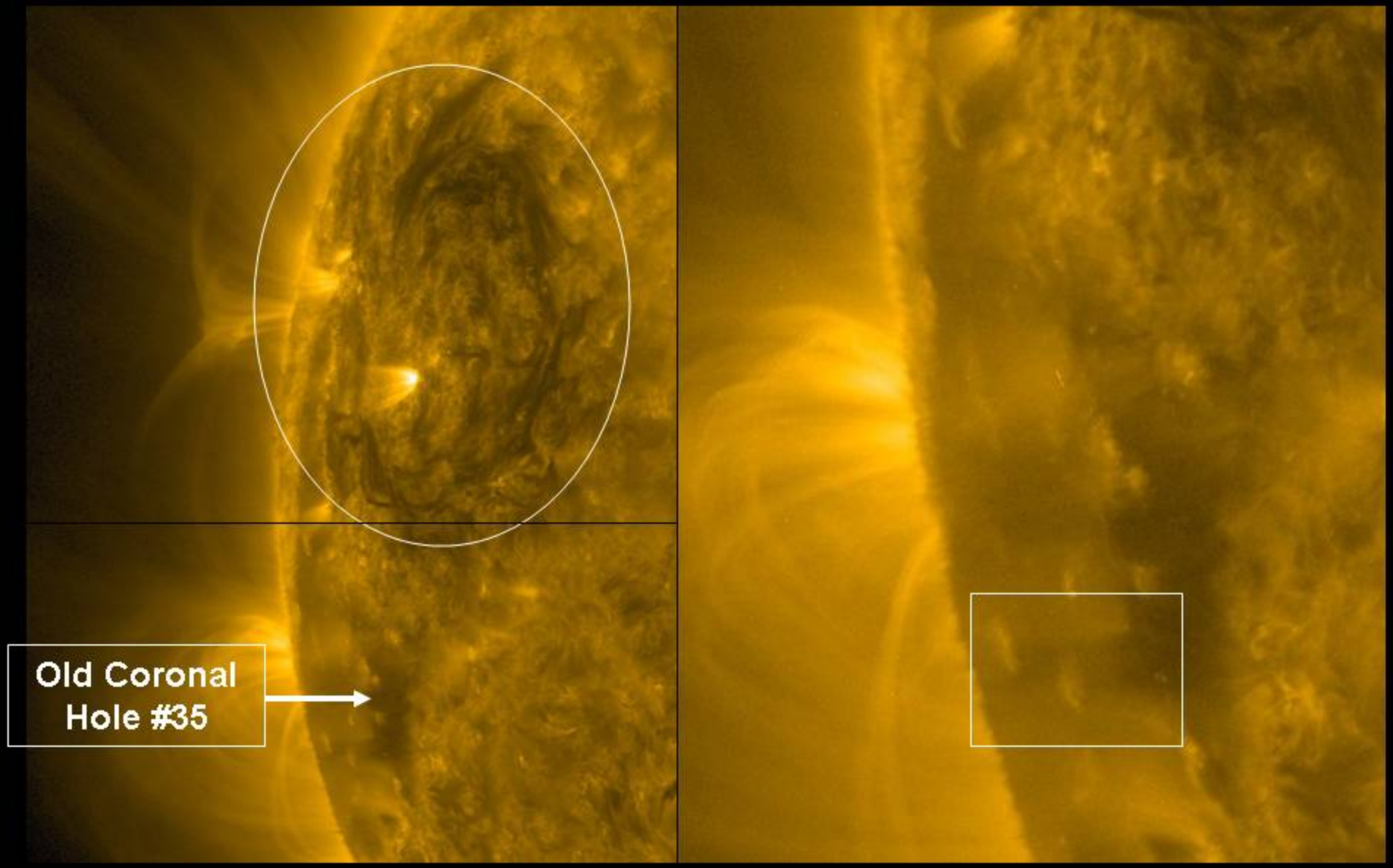
Filament Eruption Event



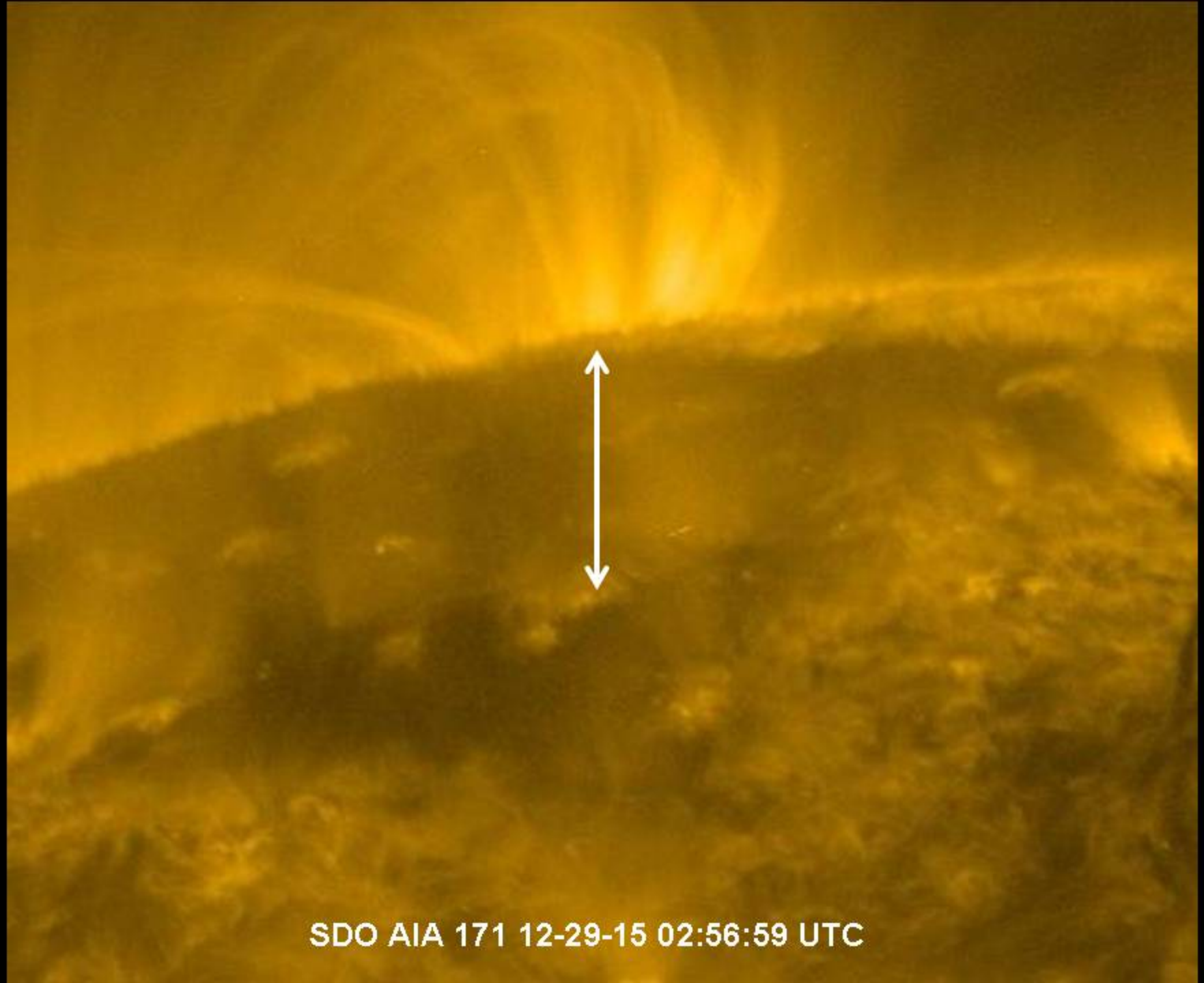

Region 2280
West
<--Separation
SDO AIA 171 2-12-15 21:57:00 UTC

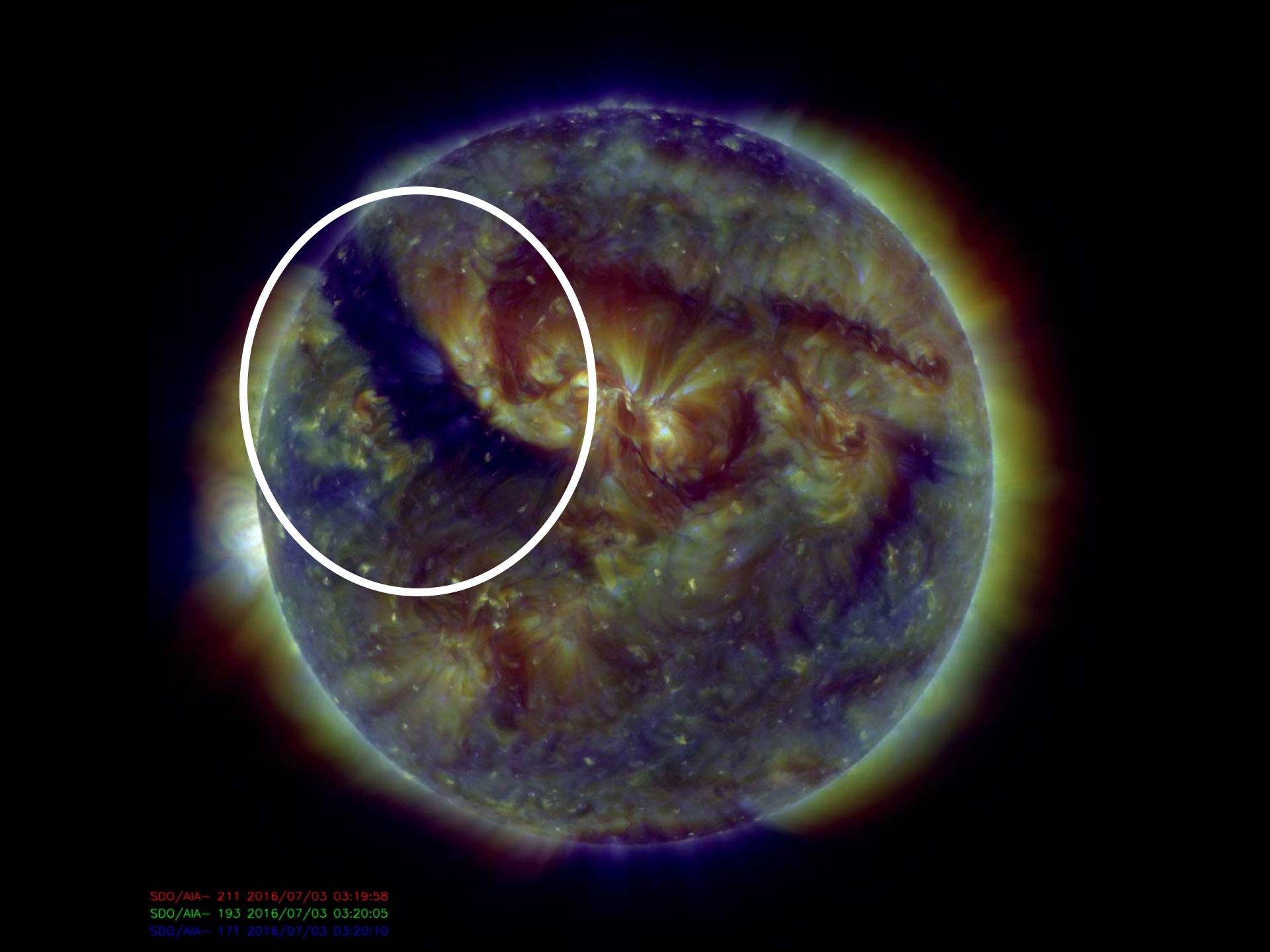
Solar Wind &Coronal Holes



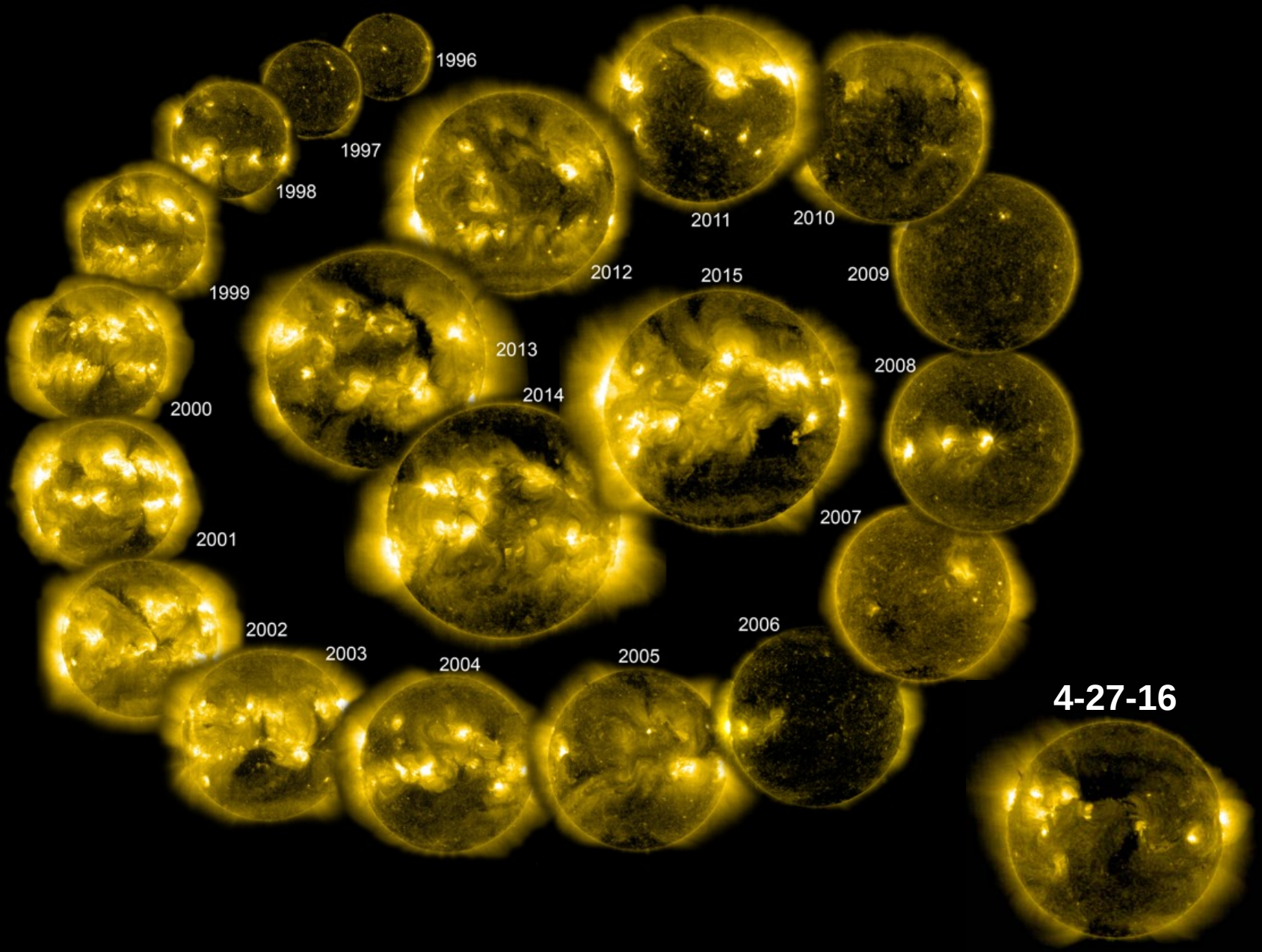


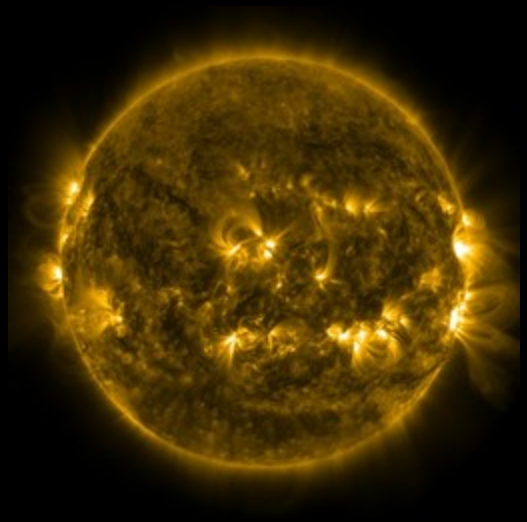
SDO AIA 171 12-29-15 02:56:59 UTC


SDO AIA 171 12-29-15 02:56:59 UTC


SDO/AIA- 211 2016/07/03 03:19:58
SDO/AIA- 193 2016/07/03 03:20:05
SDO/AIA- 171 2016/07/03 03:20:10

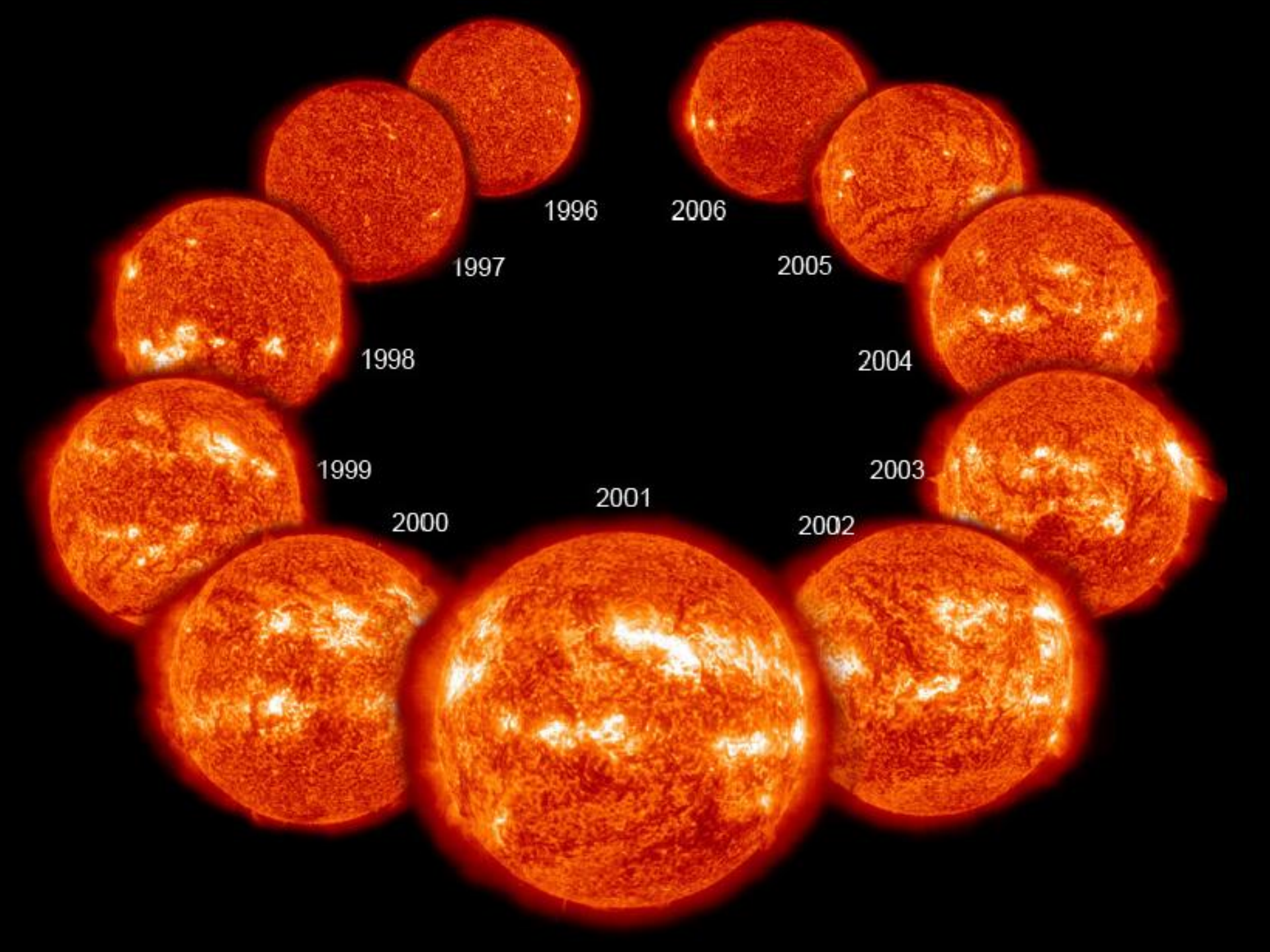
SOHO Observes the Sun for 20 Years





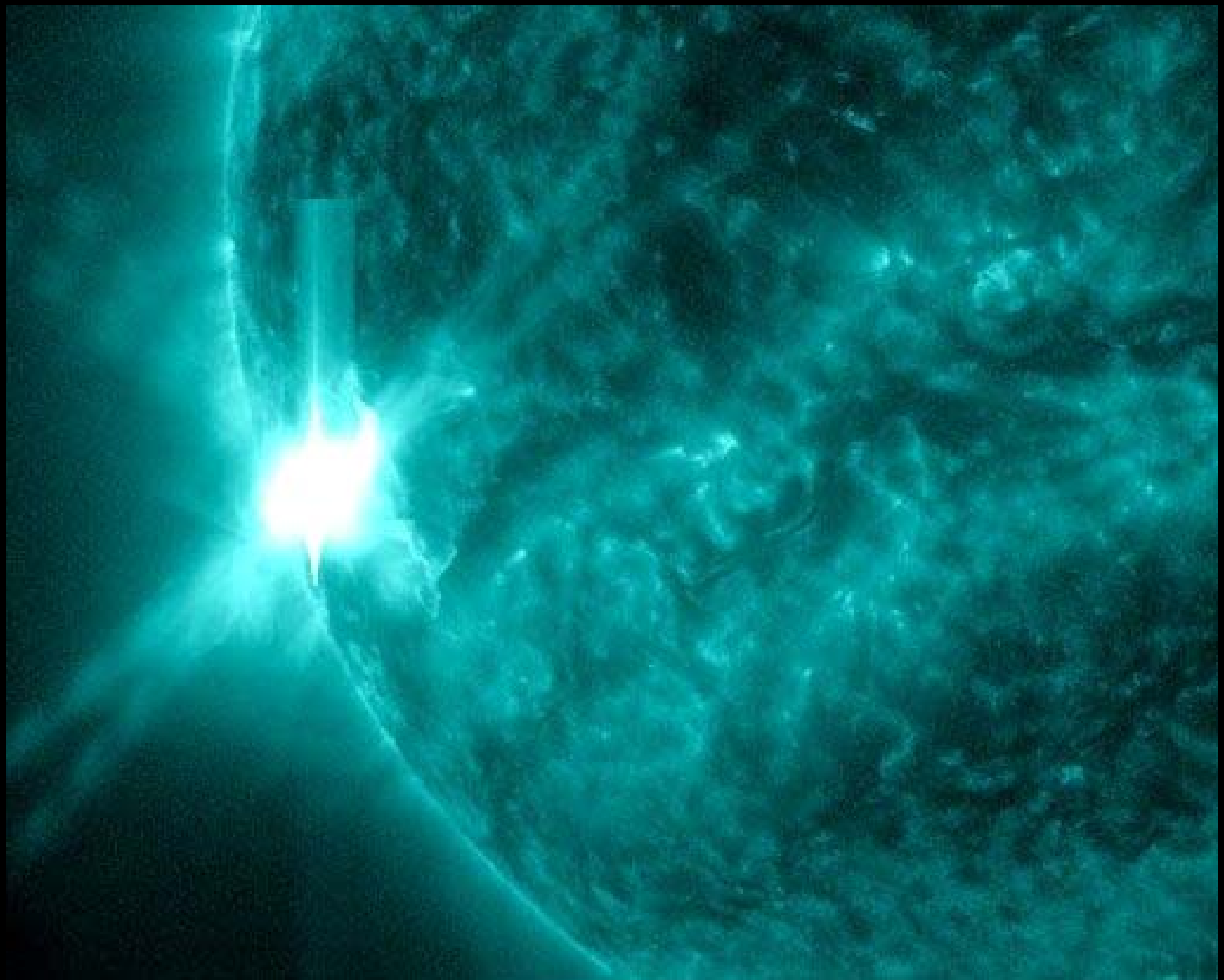
AIA 171

Where: Quiet corona and upper transition region
Wavelength: 171 angstroms (0.0000000171 m) = Extreme Ultraviolet
Primary ions seen: 8 times ionized iron (Fe IX)
Characteristic temperature: 1 million K (1.8 million F)


1996
2006
1997
2005
1998
2004
1999
2003
2001
2000
2002

AIA 304

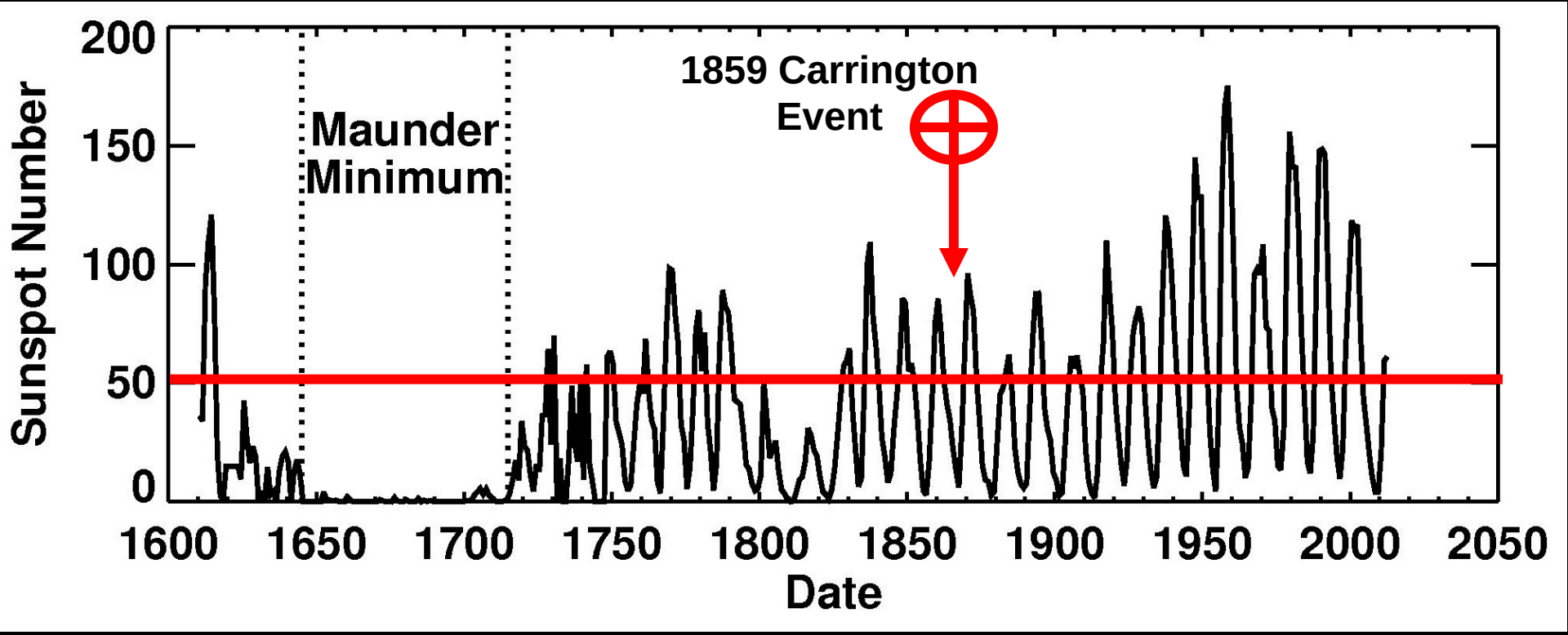
Where: Upper chromosphere and lower transition region
Wavelength: 304 angstroms (0.0000000304 m) = Extreme Ultraviolet
Primary ions seen: singly ionized helium (He II)
Characteristic temperature: 50,000 K (90,000 F)

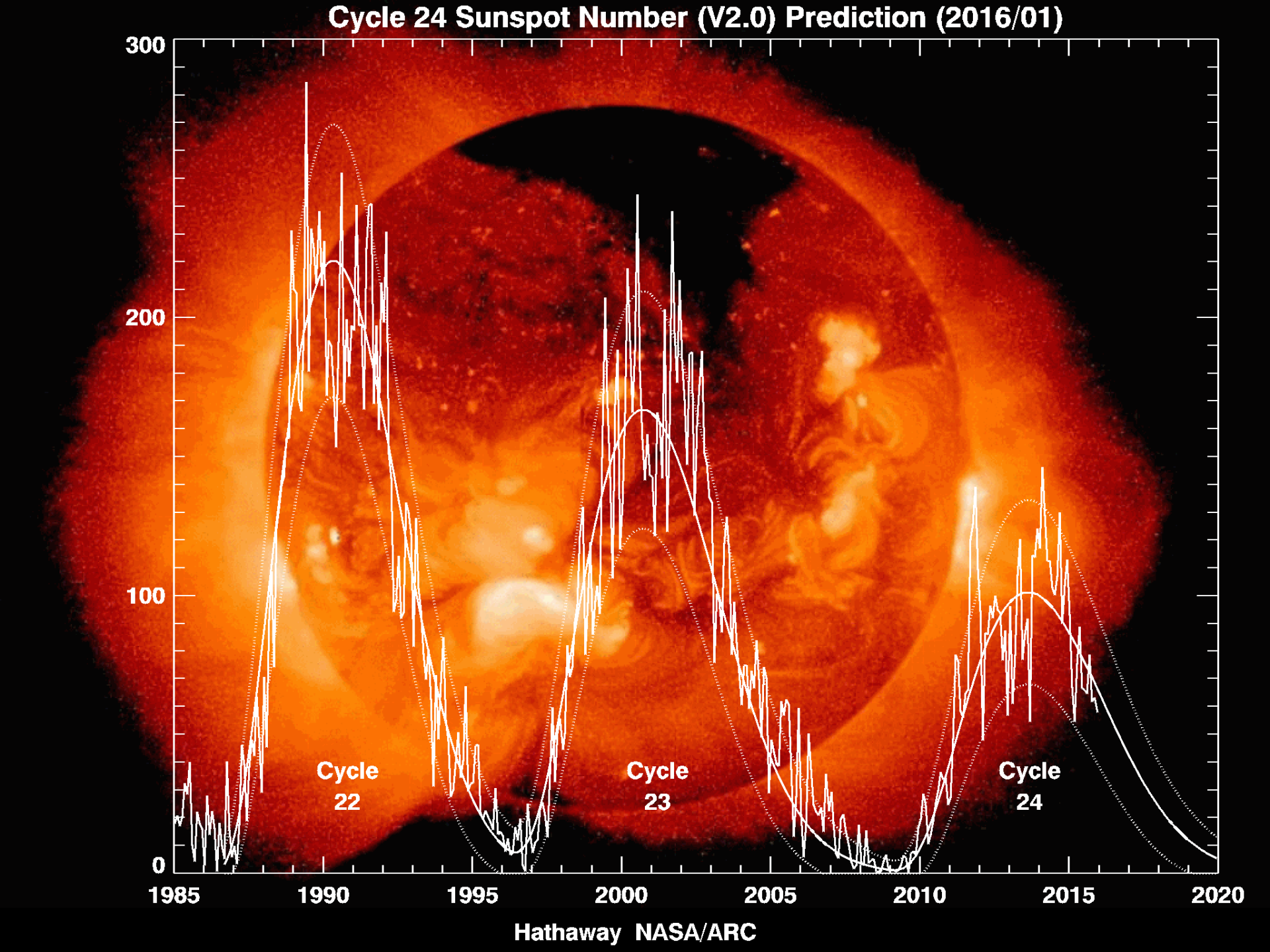


AIA 131

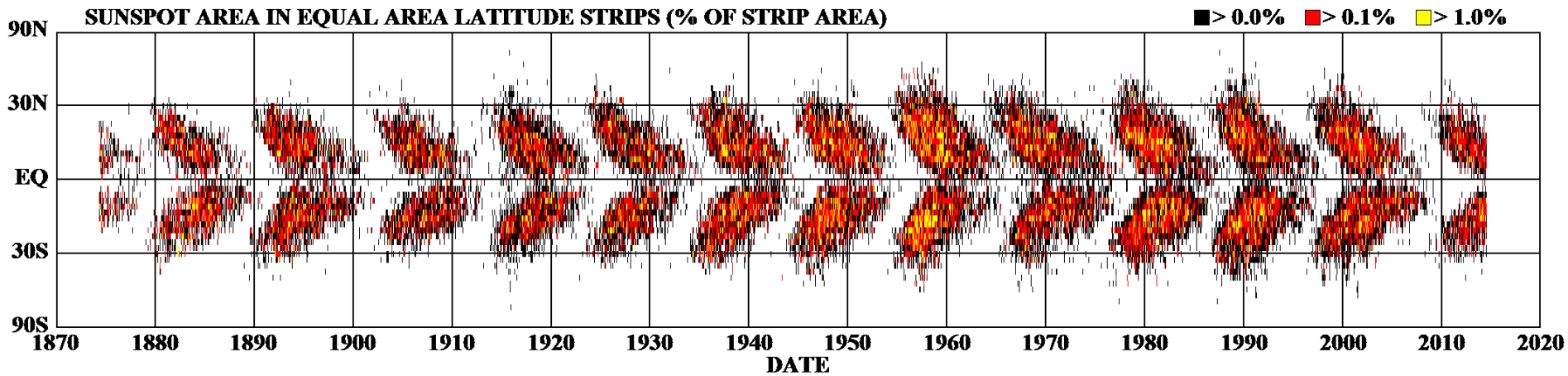
Where: Flaring regions of the corona
Wavelength: 131 angstroms (0.0000000131 m) = Extreme Ultraviolet
Primary ions seen: 20 and 7 times ionized iron (Fe VIII, Fe XXI)
Characteristic temperatures: 10 million K (18 million F)

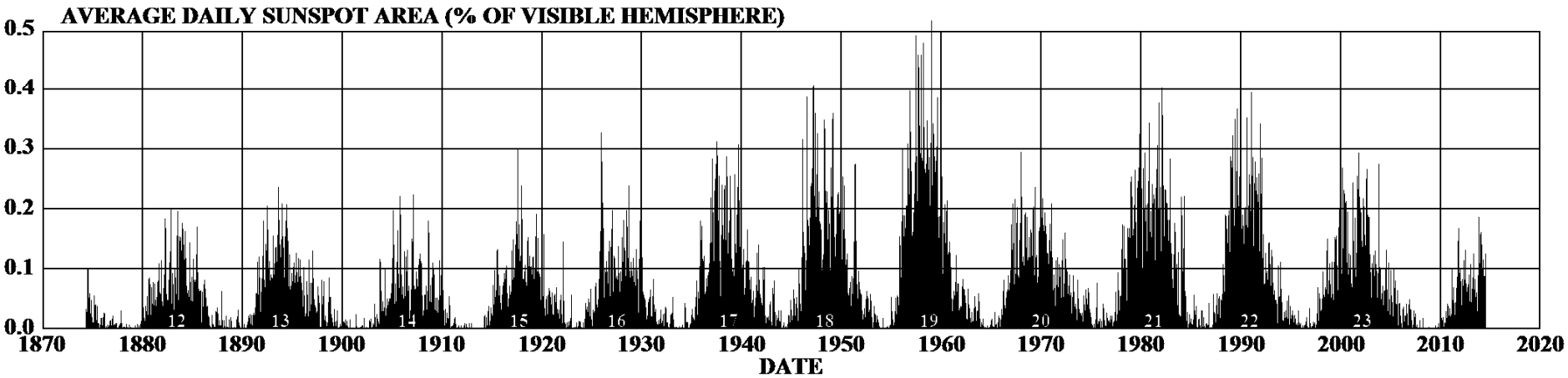
During the Maunder Minimum, Europe experienced a mini-ice age.




Cycle 24 Sunspot Number (V2.0) Prediction (2016/01)
300
200
100
0
1985
1990
1995
2000
2005
2010
2015
2020
Cycle 22
Cycle 23
Cycle 24
Hathaway NASA/ARC

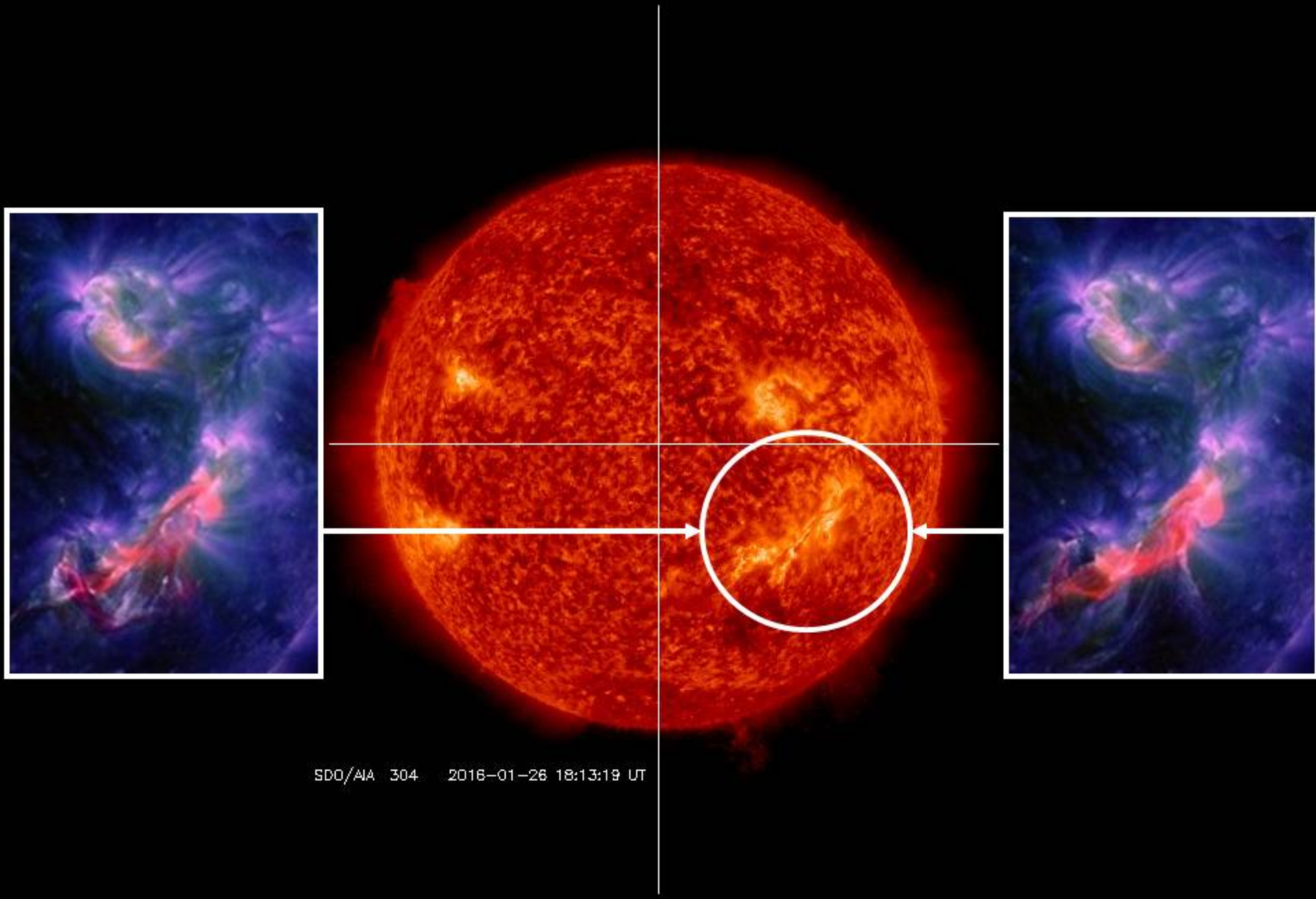
DAILY SUNSPOT AREA AVERAGED OVER INDIVIDUAL SOLAR ROTATIONS

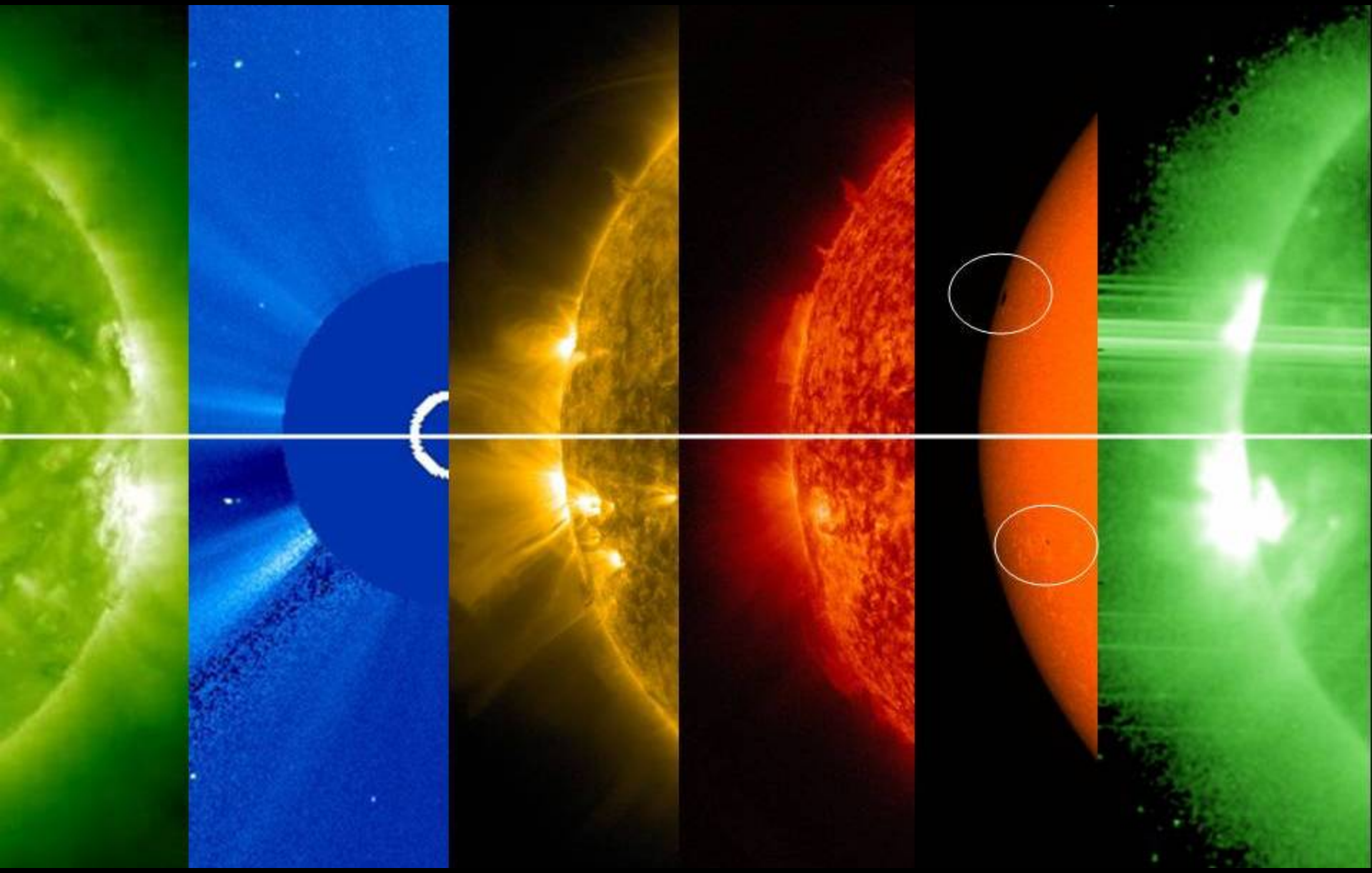


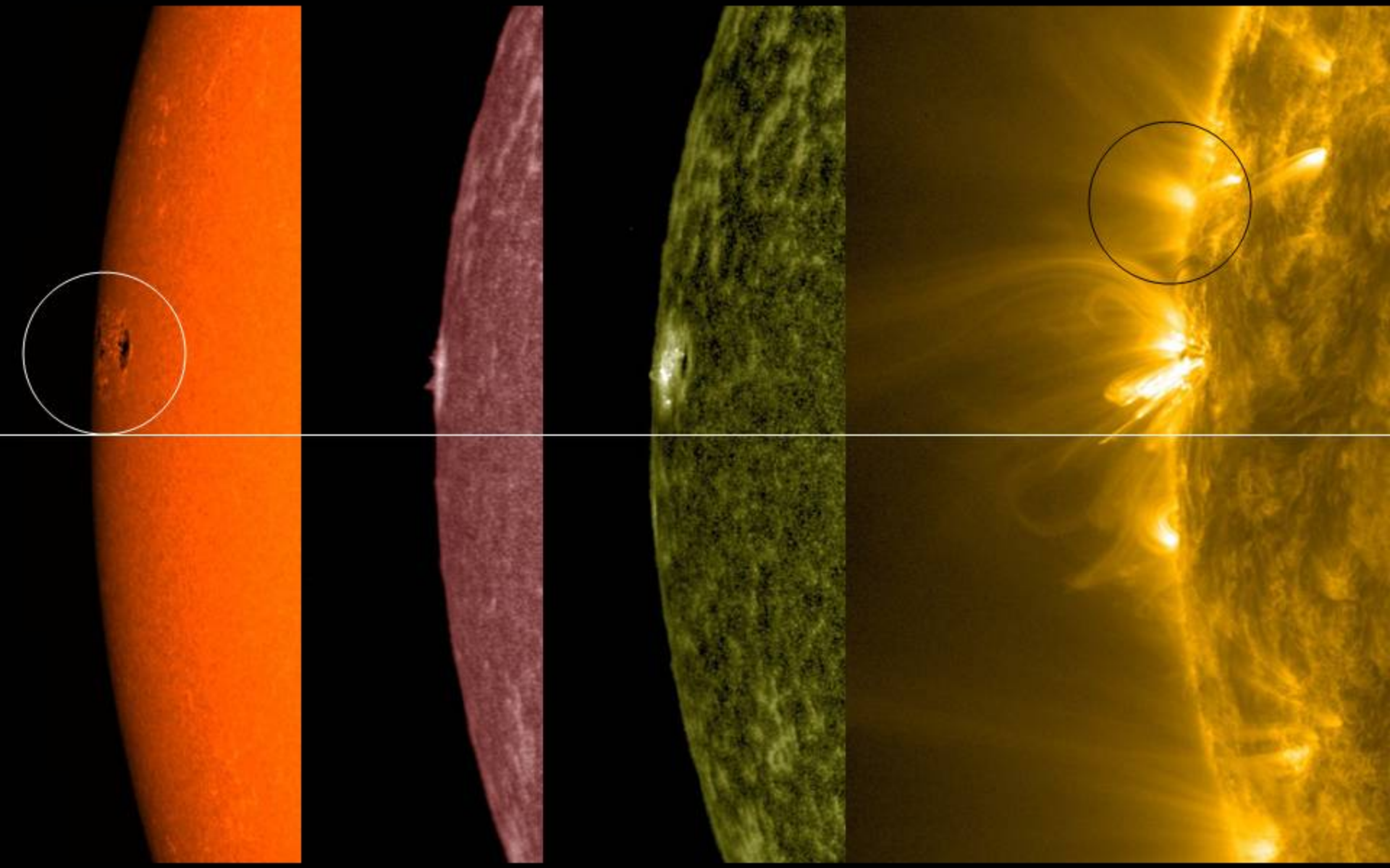


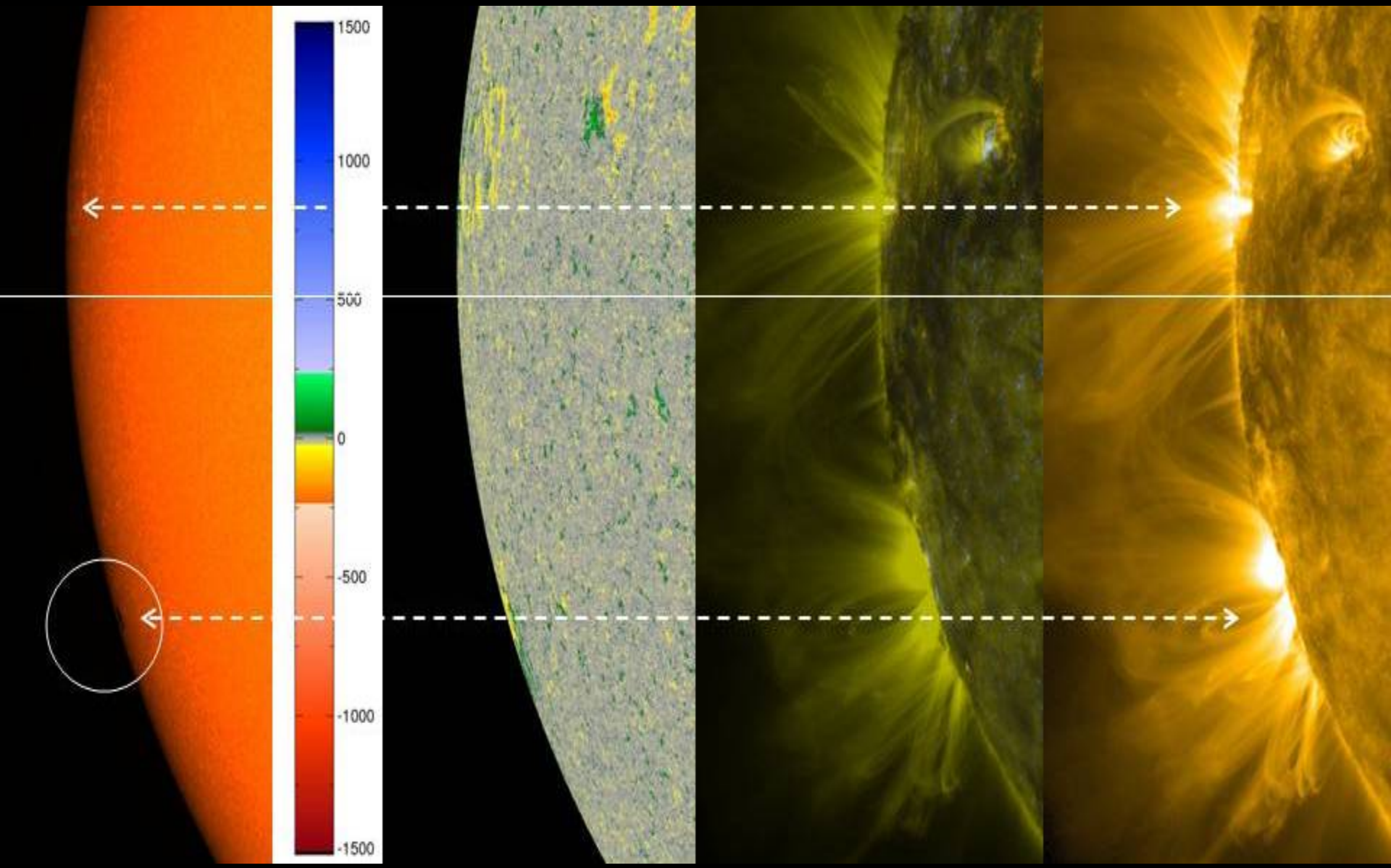
http://solarscience.msfc.nasa.gov/

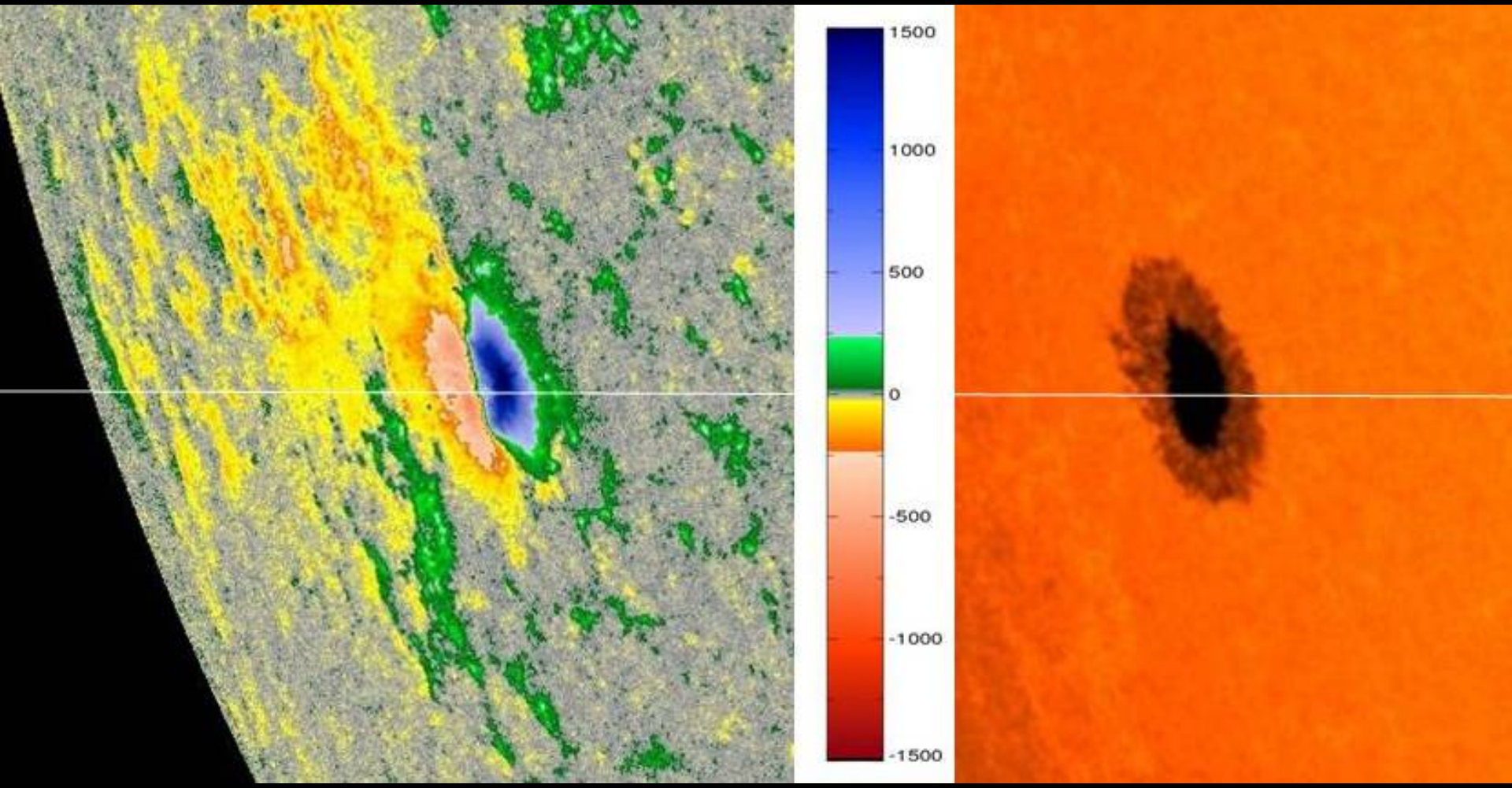
HATHAWAY/NASA/ARC 2014/08


SDO/AIA 304 2016-01-26 18:13:19 UT






1500
1000
500
0
-500
-1000
-1500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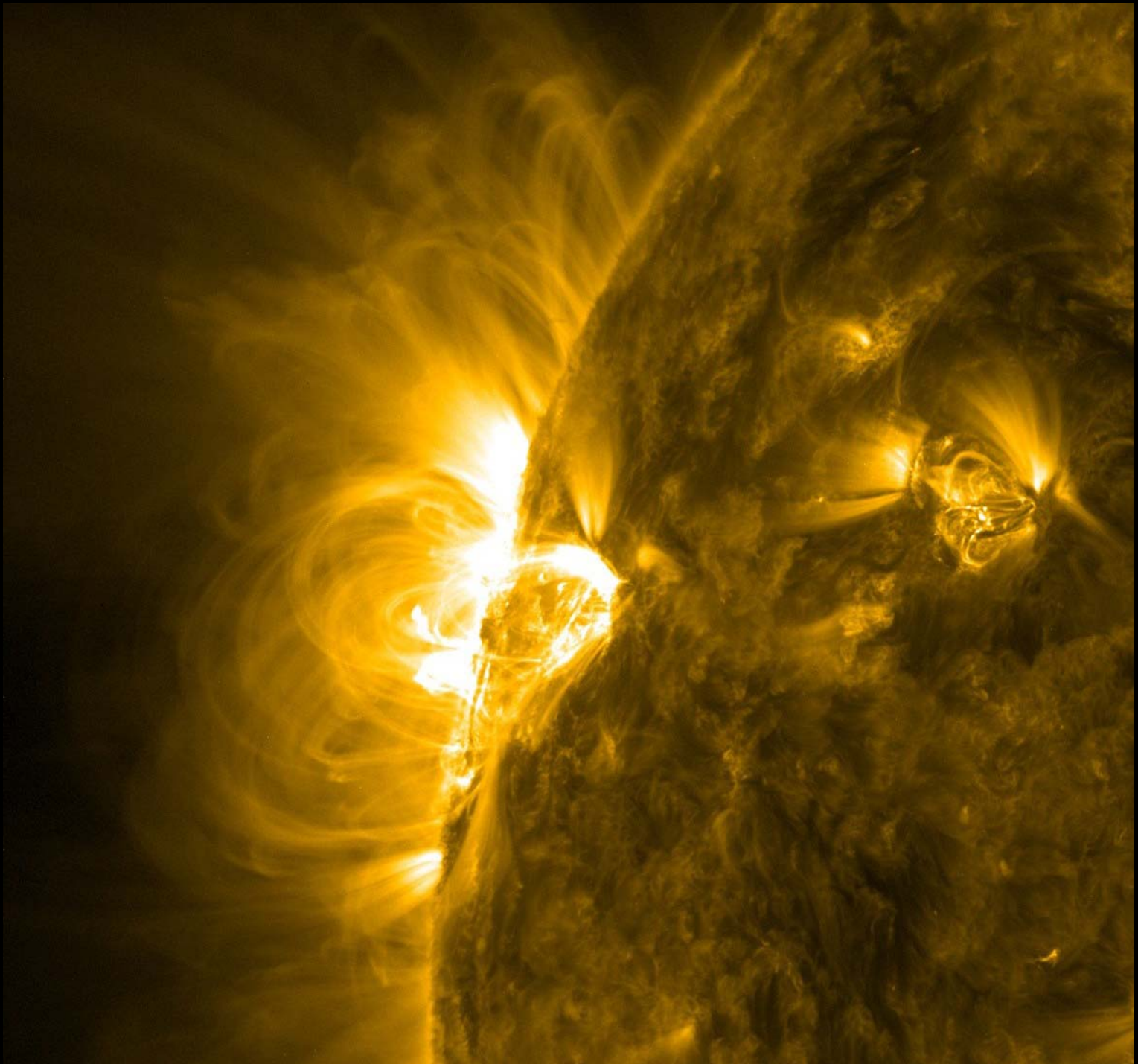
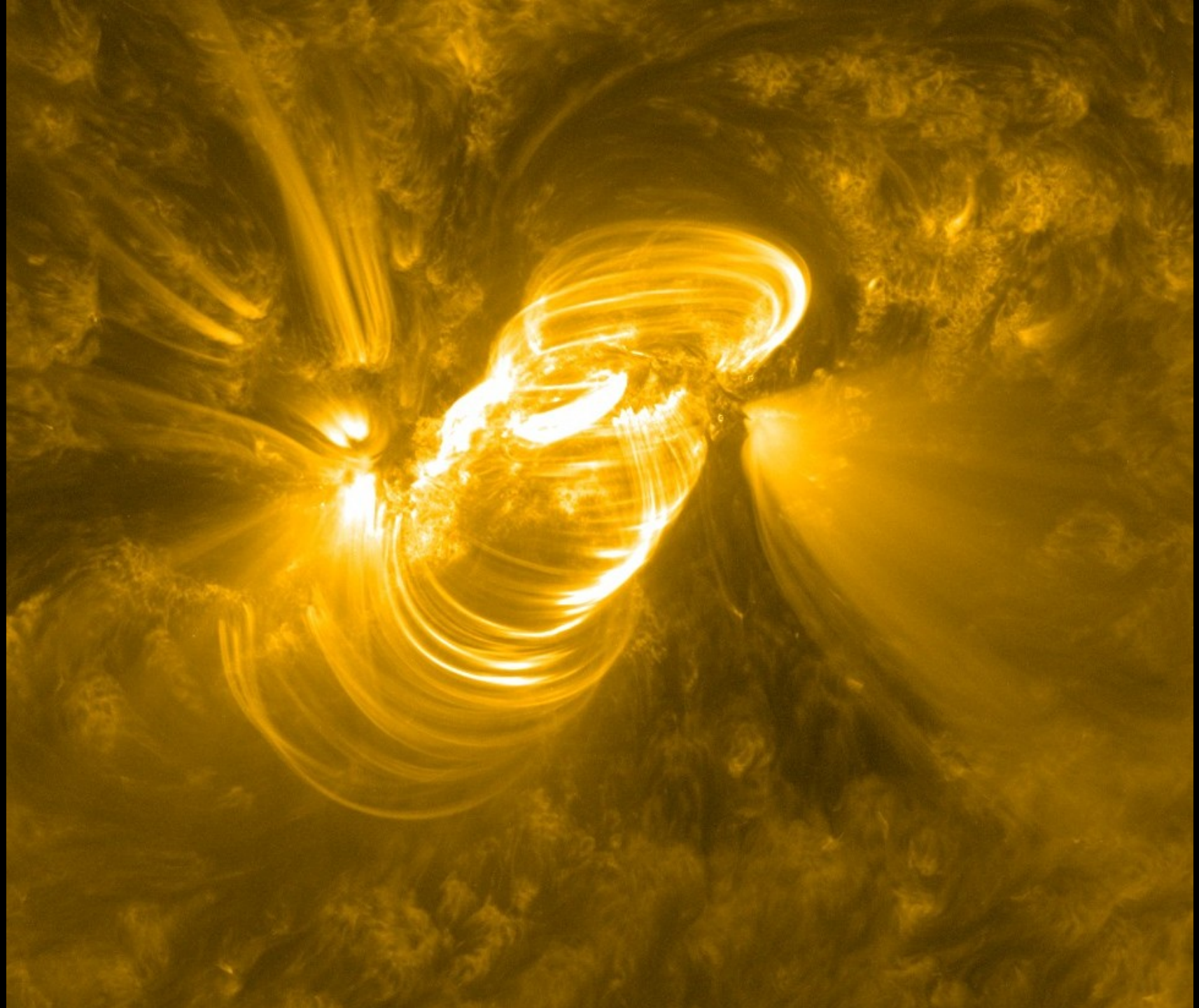
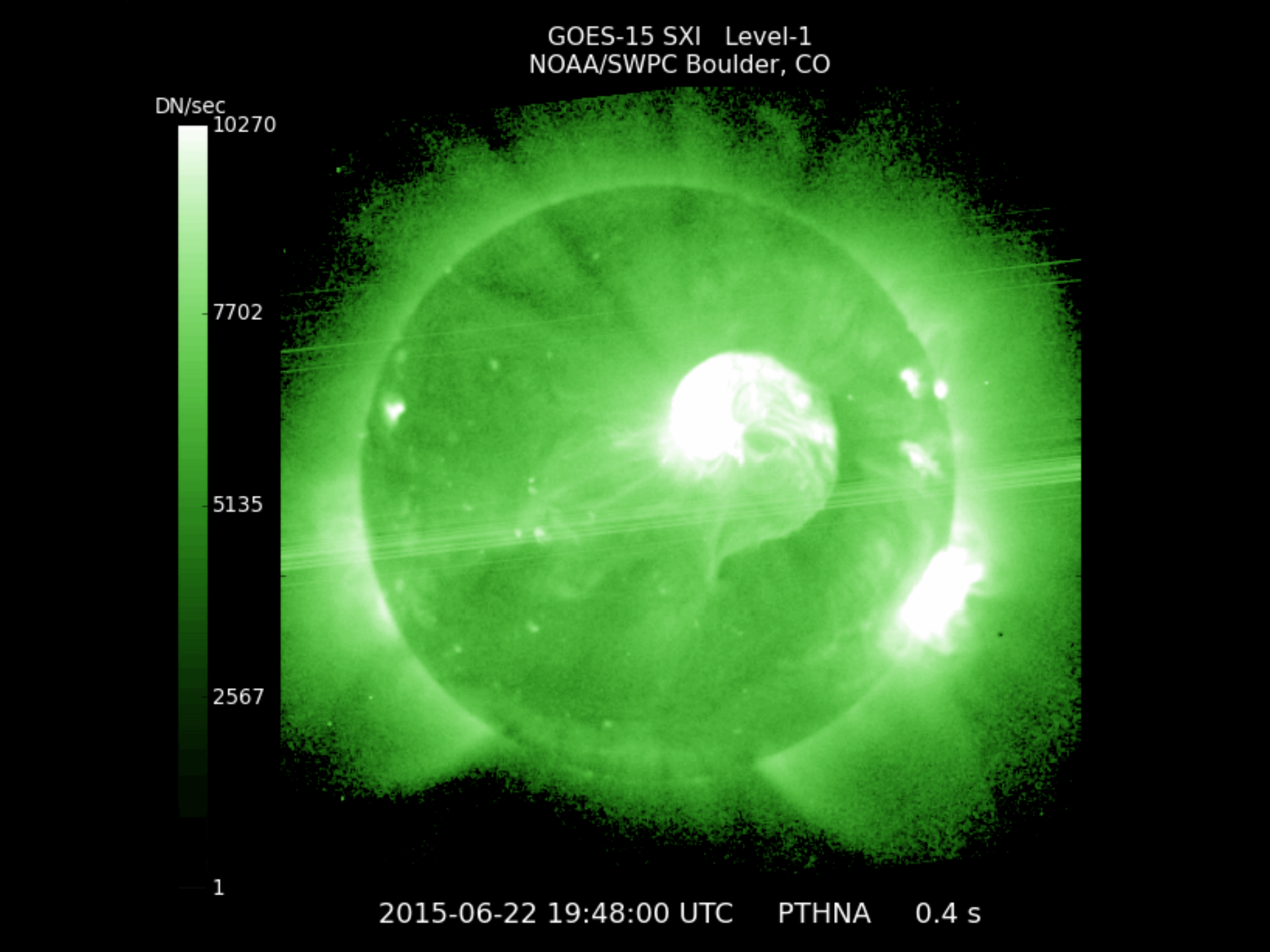
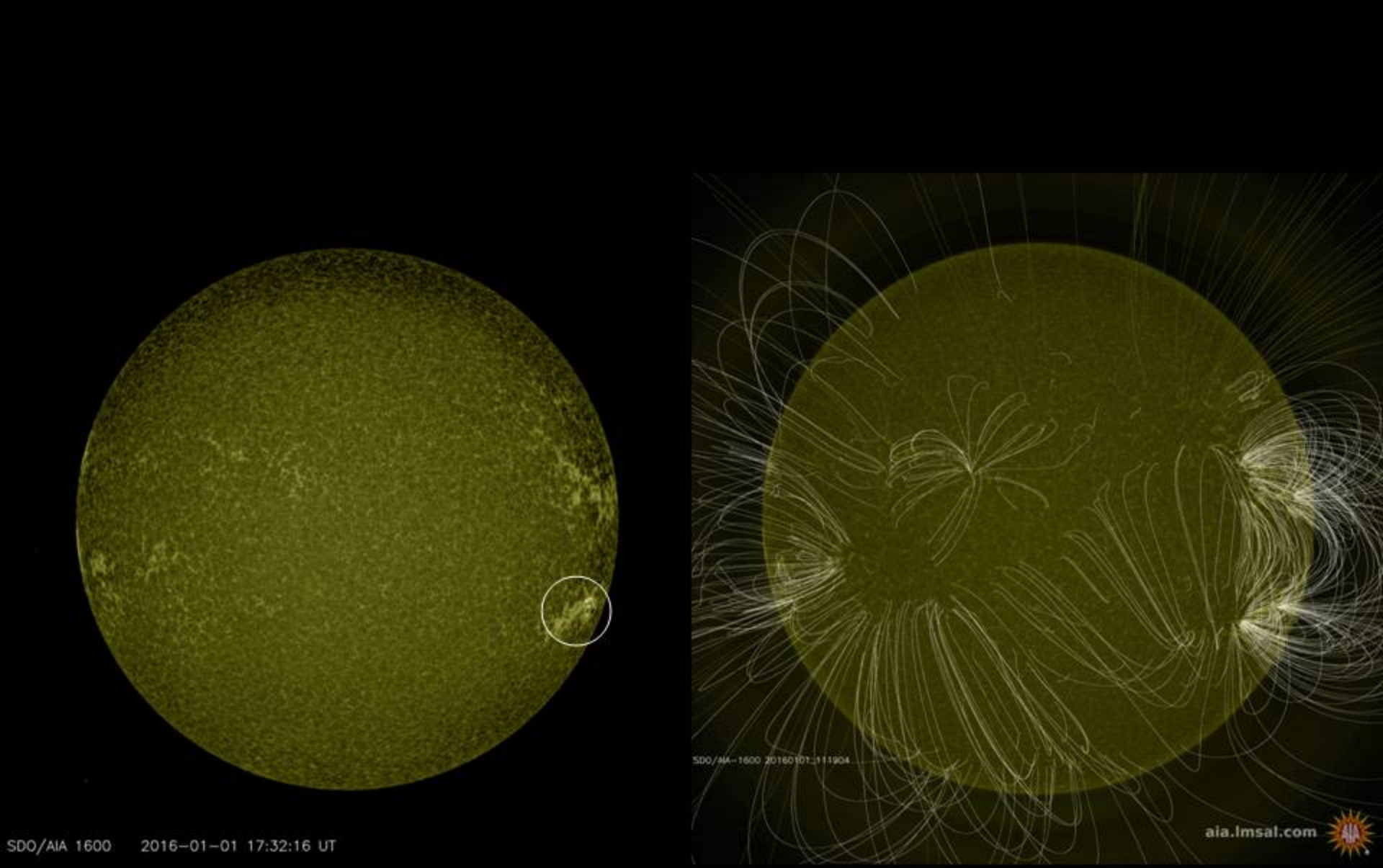





GOES-15 SXI Level-1
NOAA/SWPC Boulder, CO
DN/sec
10270
7702
5135
2567
1
2015-06-22 19:48:00 UTC PTHNA 0.4 s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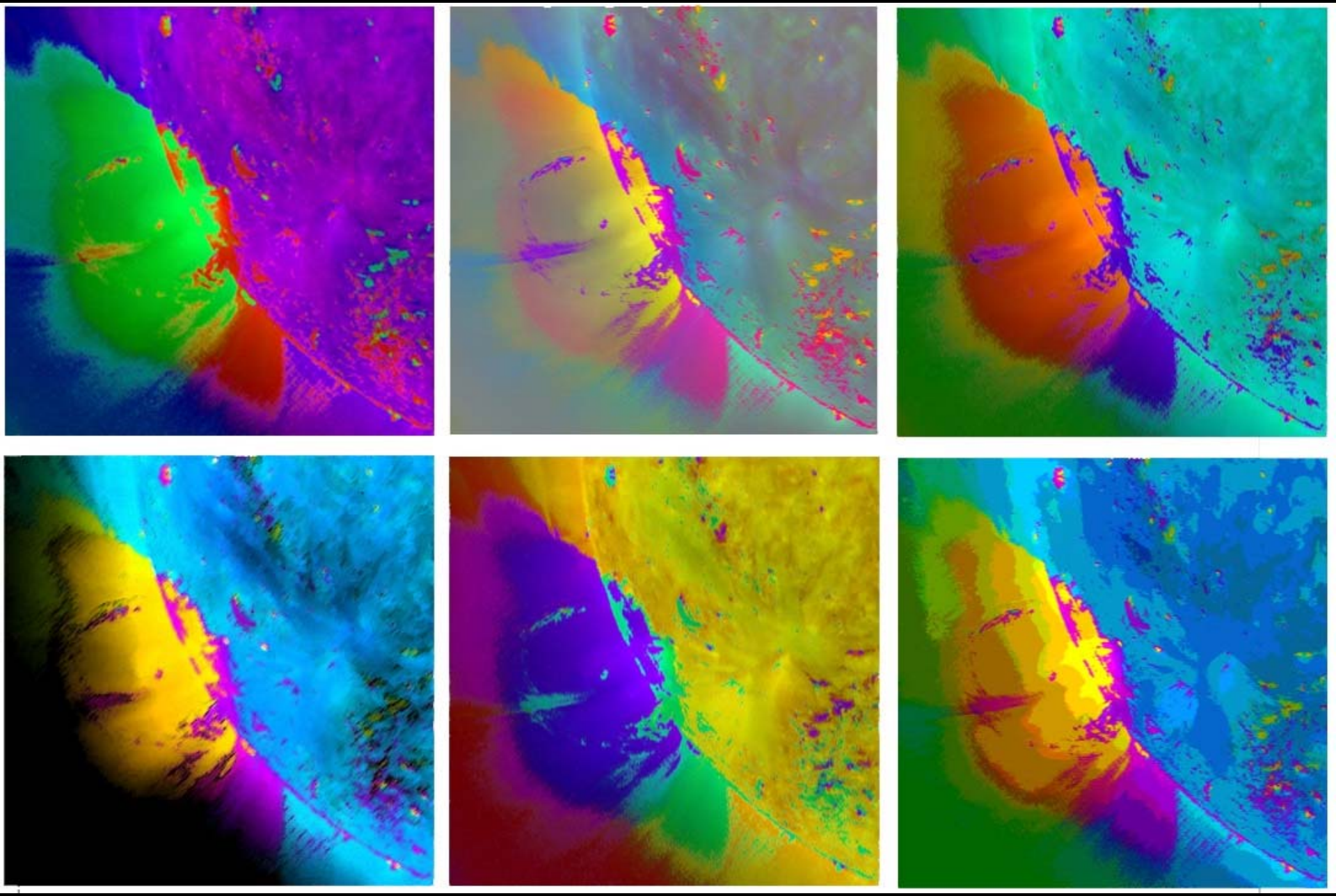
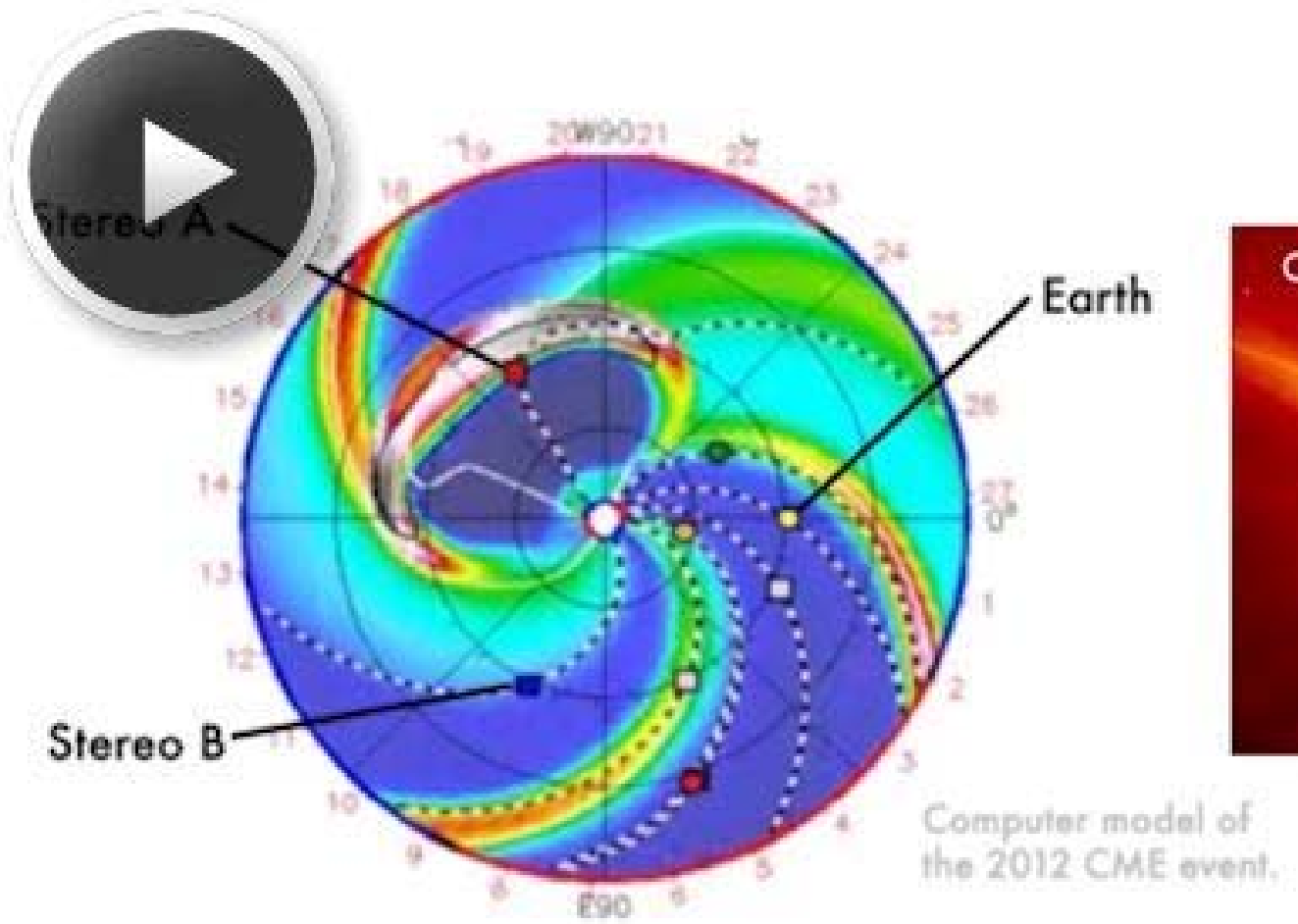
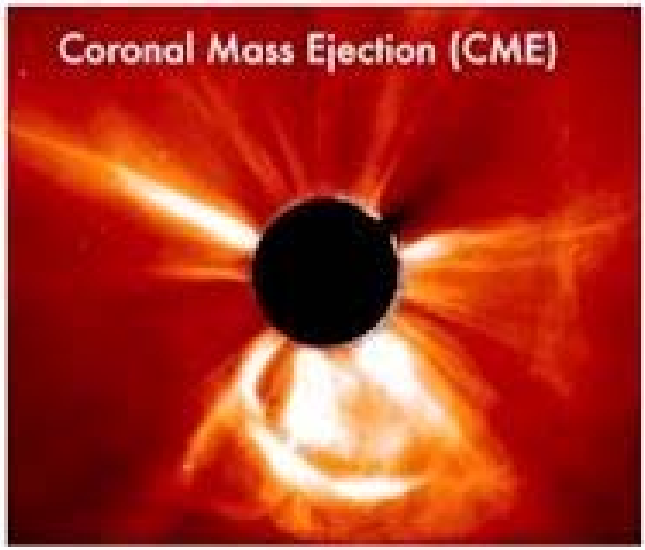
aia.lmsal.com

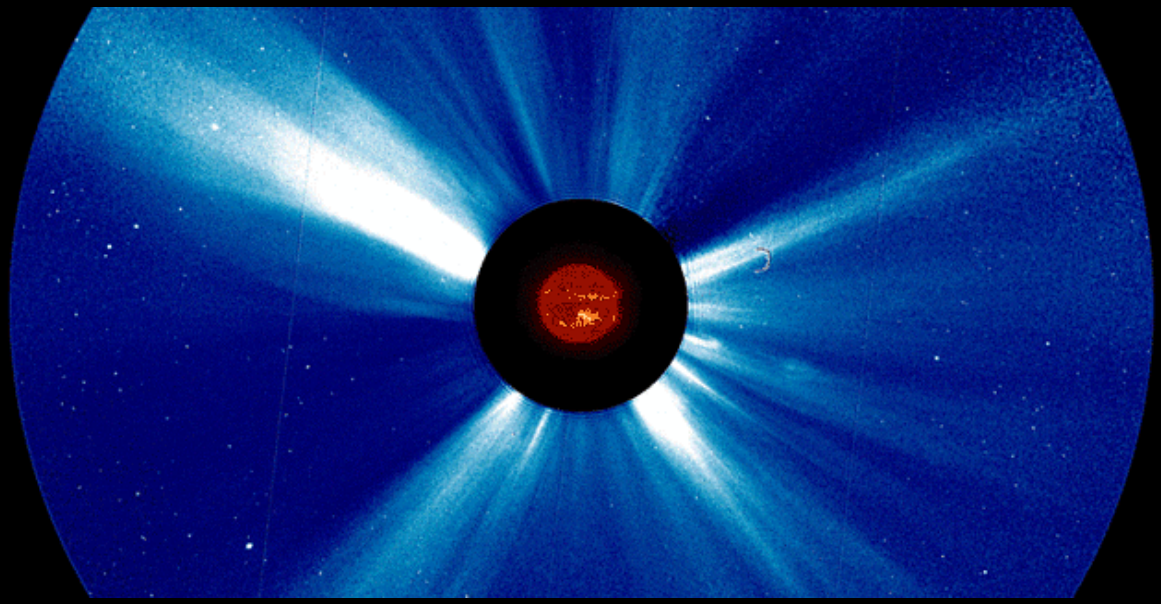


A Near Miss





Credits:
Author: Dr. Tony Phillips | **Production editor:** Dr. Tony Phillips |
Credit: Science@NASA



Study of a Near Miss July 23. 2012

In February 2014, physicist Pete Riley of Predictive Science Inc. published a paper in *Space Weather* entitled "On the probability of occurrence of extreme space weather events." In it, he analyzed records of solar storms going back 50+ years. By extrapolating the frequency of ordinary storms to the extreme, he calculated the odds that a Carrington-class storm would hit Earth in the next ten years.

The answer: 12%.

Credits:
Author: Dr. Tony Phillips **| Production editor:** Dr. Tony Phillips **|**
Credit: Science@NASA

Web Links:
Severe Space Weather: Social and Economic Consequences **-- Science@NASA**
Carrington-class Solar Storm Narrowly Misses Earth **- ScienceCast video**

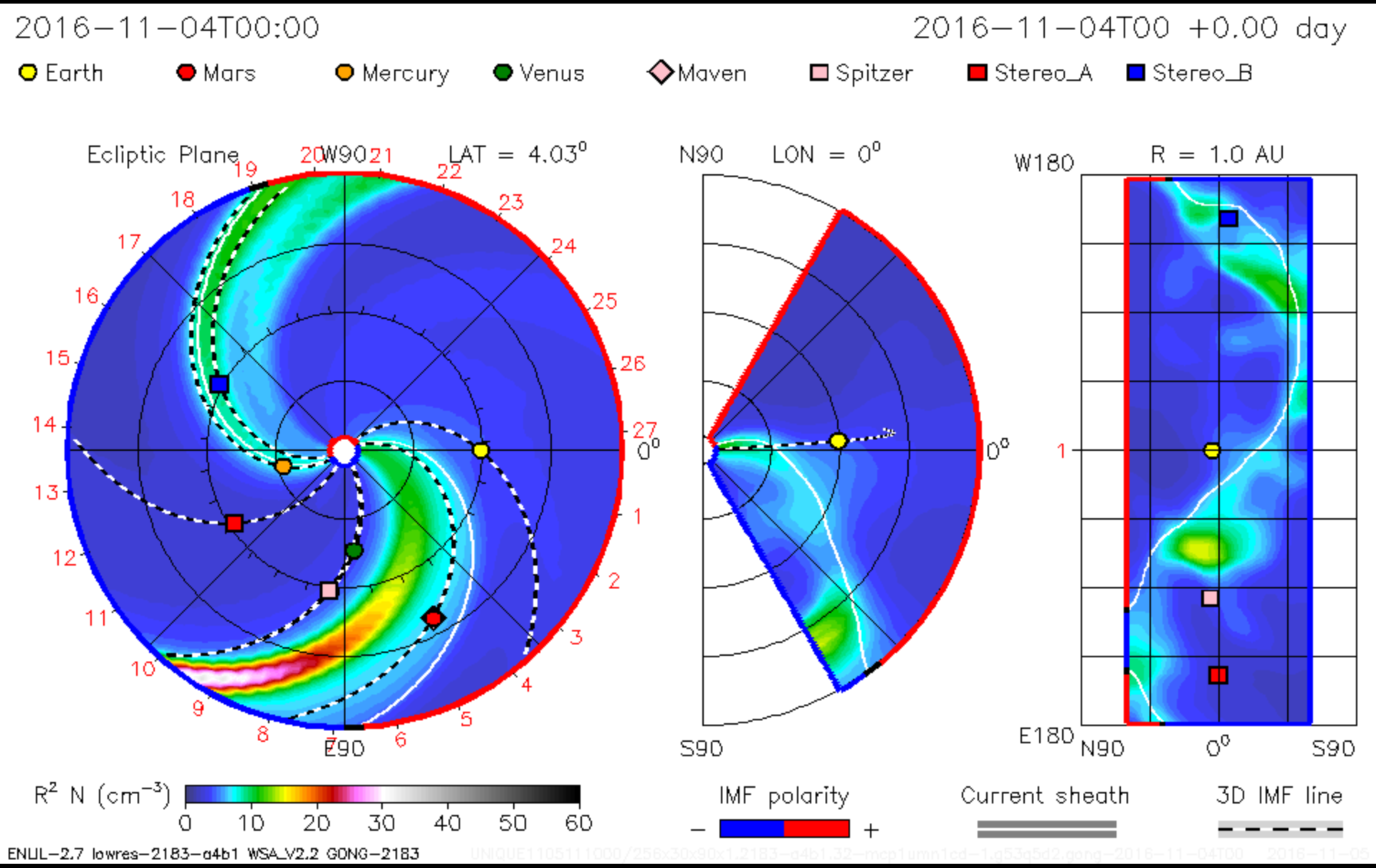
"In my view the July 2012 storm was in all respects at least as strong as the 1859 Carrington event," says Baker. "The only difference is, it missed."

In their Dec. 2013 paper, Baker et al. estimated Dst for the July 2012 storm. "If that CME had hit Earth, the resulting geomagnetic storm would have registered a Dst of -1200, comparable to the Carrington Event and twice as bad as the March 1989 Quebec blackout."

Dst = “Disturbance storm time”

Credits:
Author: Dr. Tony Phillips | **Production editor:** Dr. Tony Phillips |
Credit: Science@NASA

Web Links:
Severe Space Weather: Social and Economic Consequences -- Science@NASA
Carrington-class Solar Storm Narrowly Misses Earth -- ScienceCast video


2016-11-04T00:00
2016-11-04T00 +0.00 day
Earth
Mars
Mercury
Venus
Maven
Spitzer
Stereo_A
Stereo_B
Ecliptic Plane
LAT = 4.03°
W90
E90
N90
S90
LON = 0°
W180
E180
R = 1.0 AU
R² N (cm⁻³)
0 10 20 30 40 50 60
IMF polarity
Current sheath
3D IMF line
ENLIL-2.7 lowres-2183-a4b1 WSA_V2.2 GONG-2183

DHS S & T Directorate

RecT Project

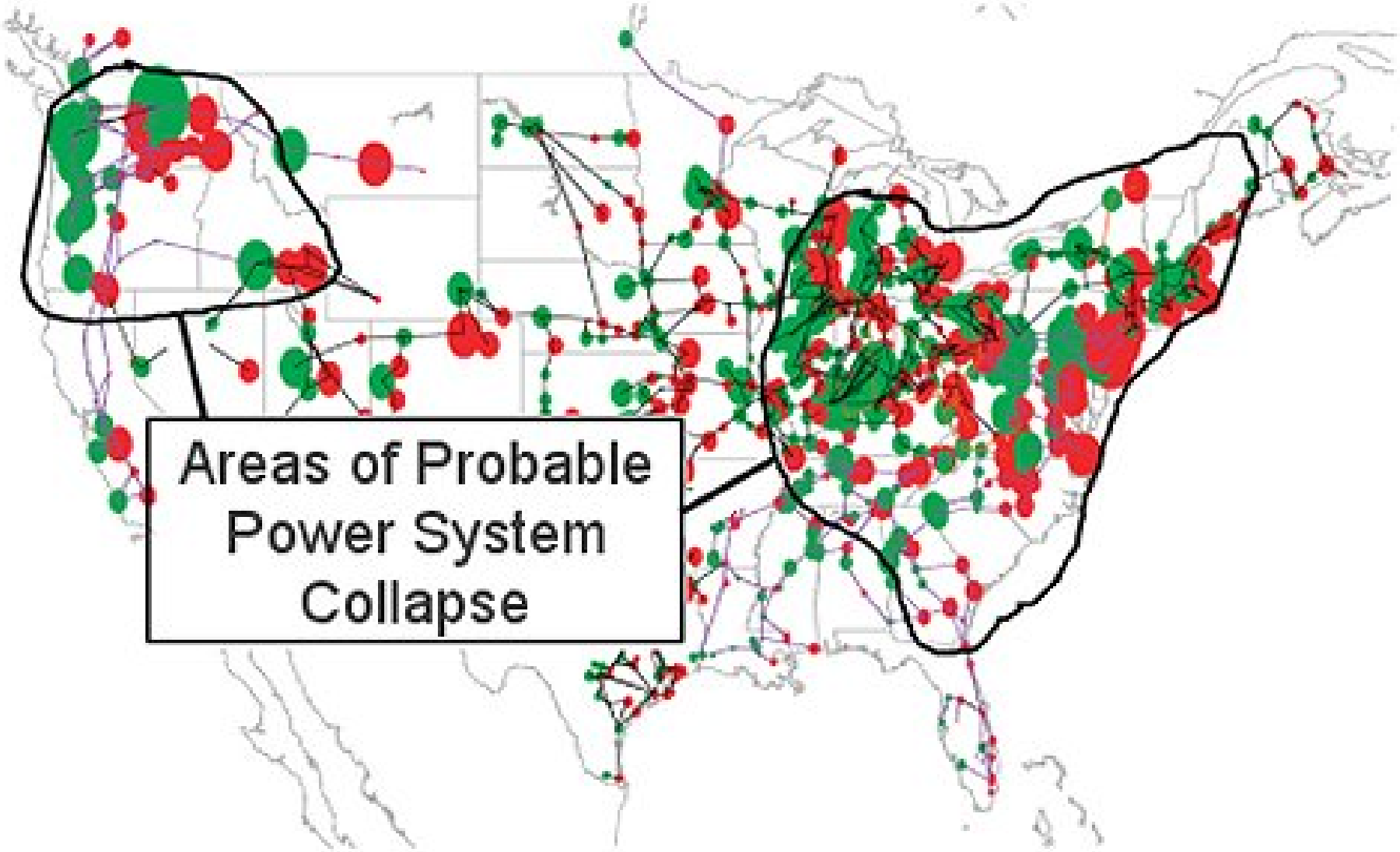
310,000 Unit System

Hand Made Multi-Ton

No US Sources

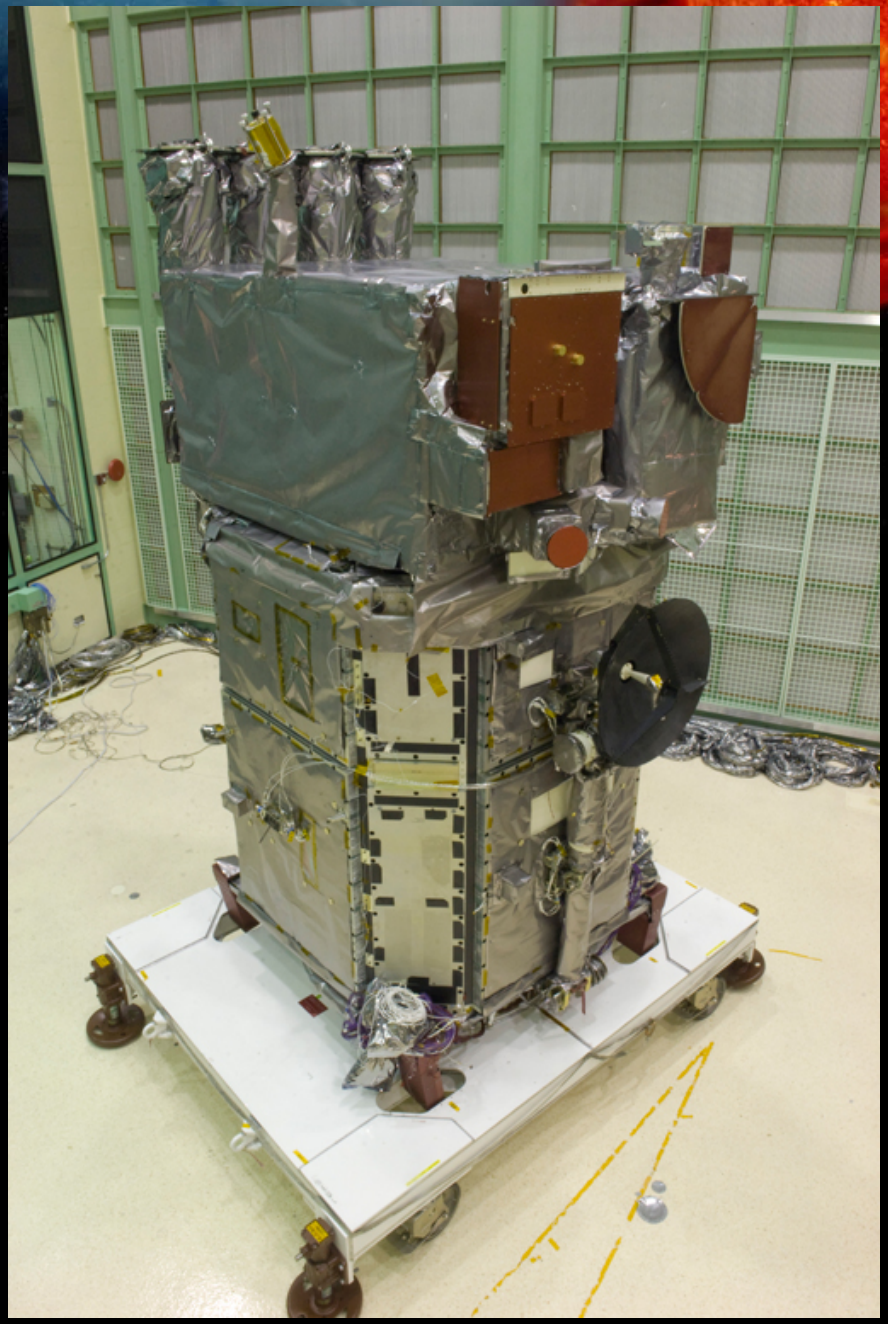
1 Year Lead Time

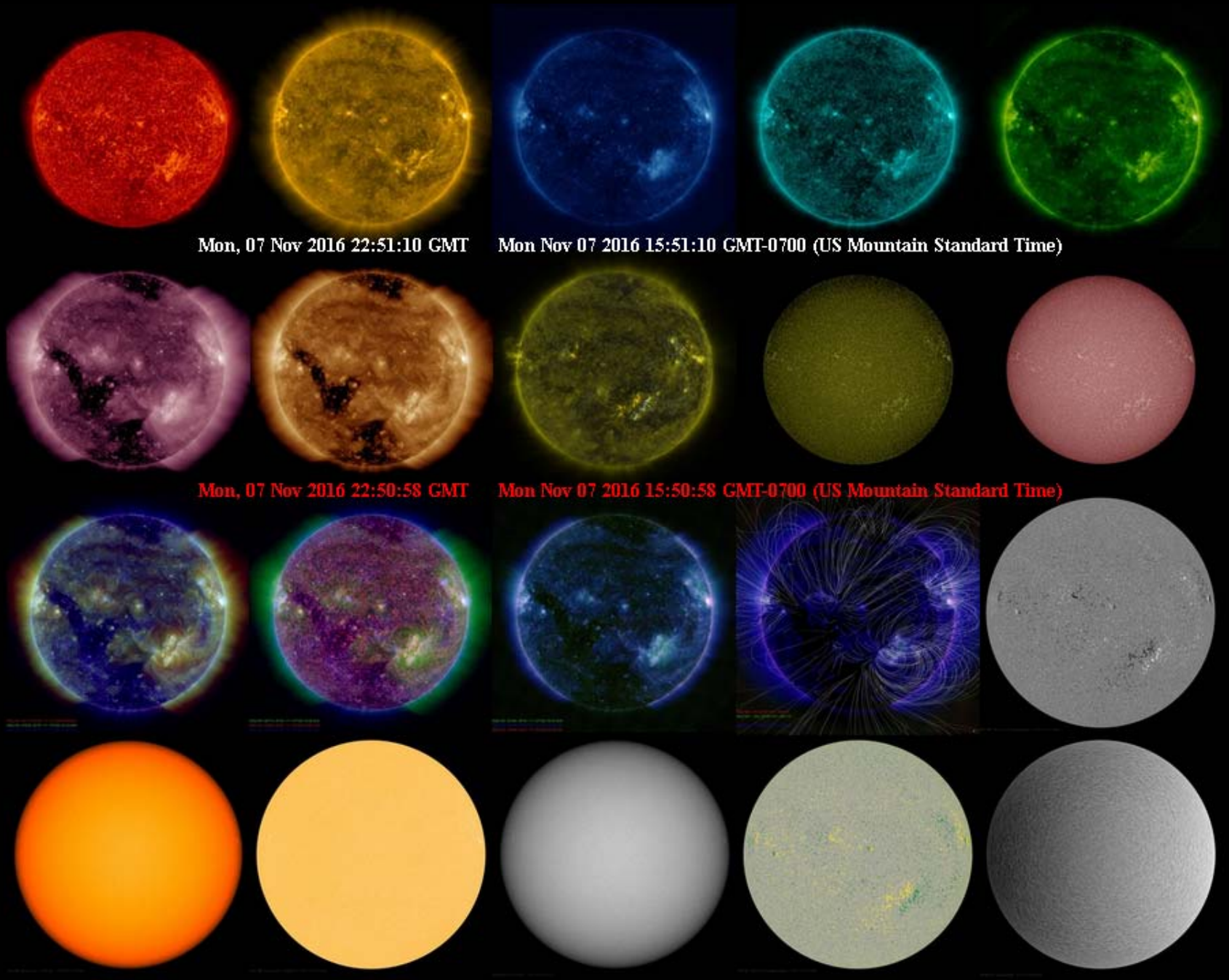
Limited Inventory



Credits:
Author: Dr. Tony Phillips | **Production editor:** Dr. Tony Phillips |
Credit: Science@NASA

Solar Dynamics Observatory




Mon, 07 Nov 2016 22:51:10 GMT
Mon Nov 07 2016 15:51:10 GMT-0700 (US Mountain Standard Time)
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GOES-R
AMERICA'S
NEXT GENERATION
WEATHER SATELLITE

Mon, 07 Nov 2016 23:01:20 GMT Mon Nov 07 2016 16:01:20 GMT-0700 (US Mountain Standard Time)

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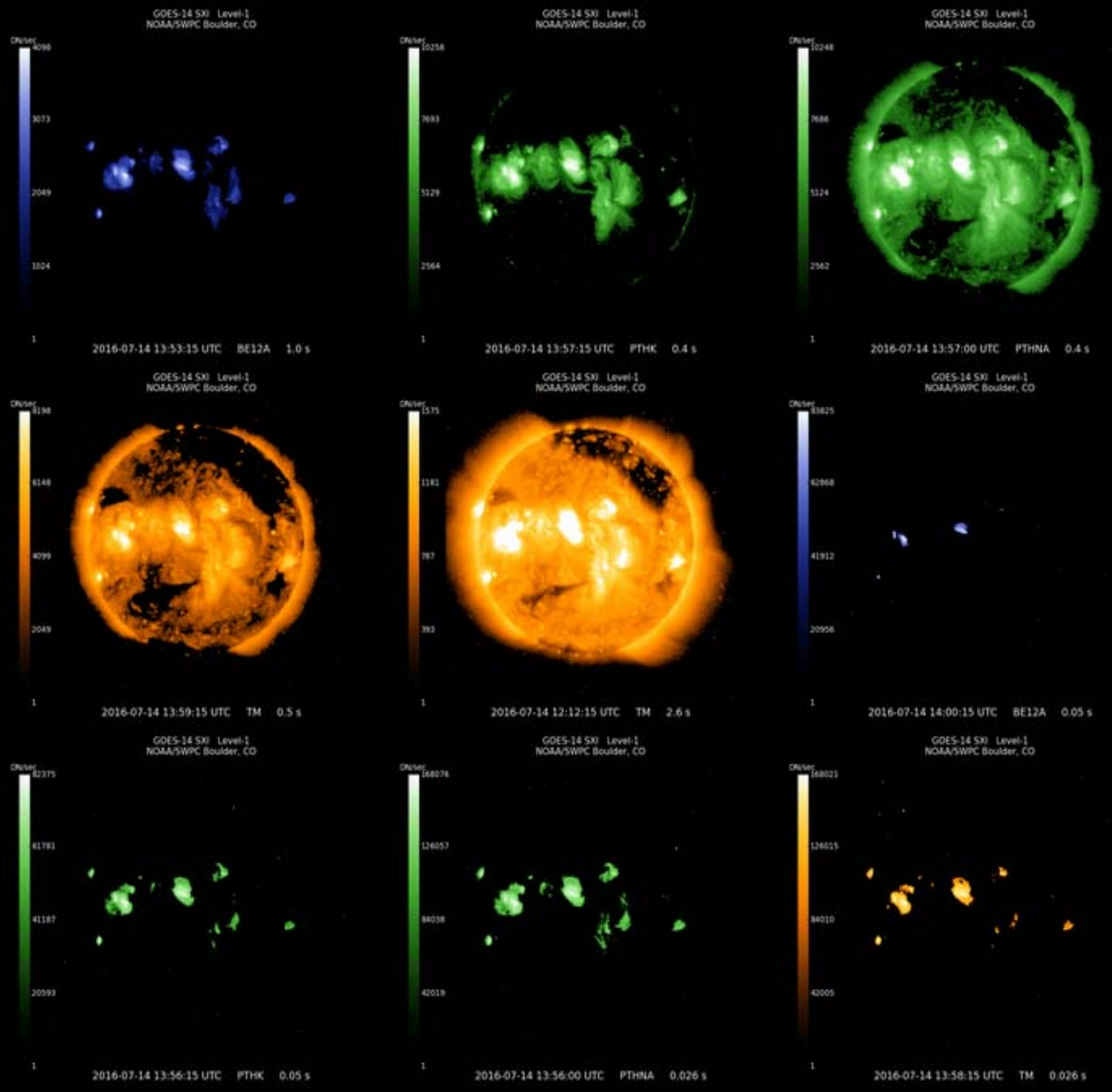
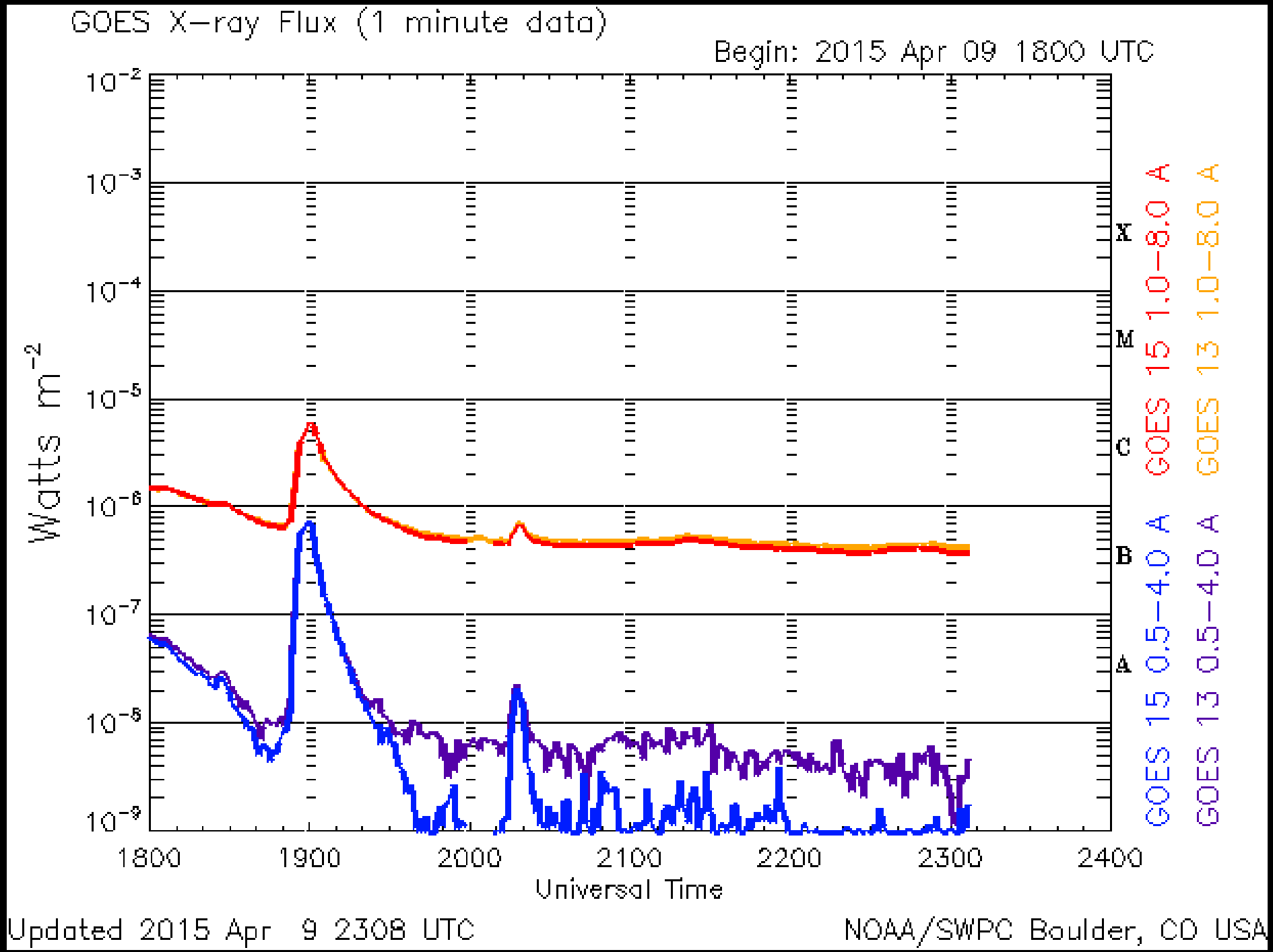
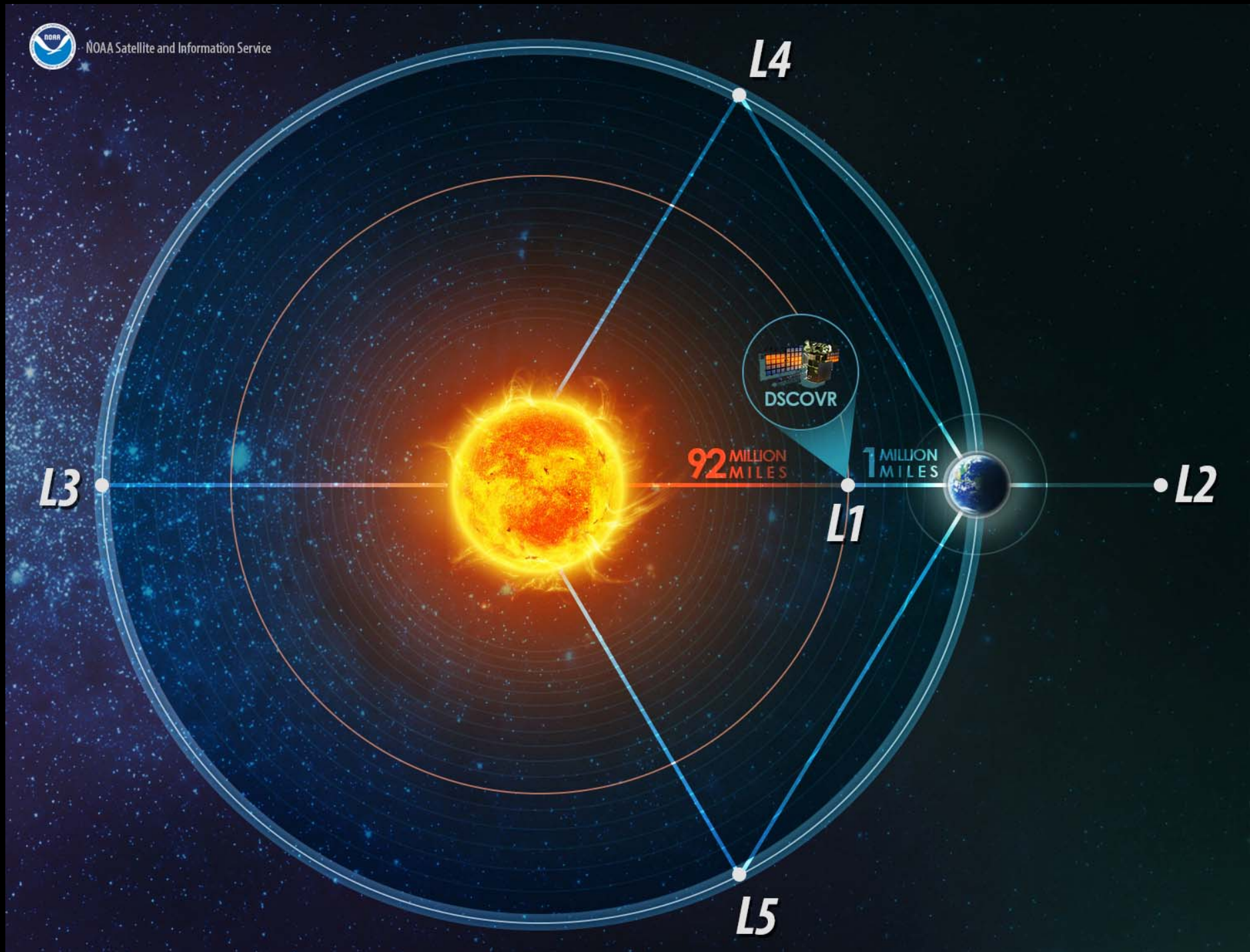
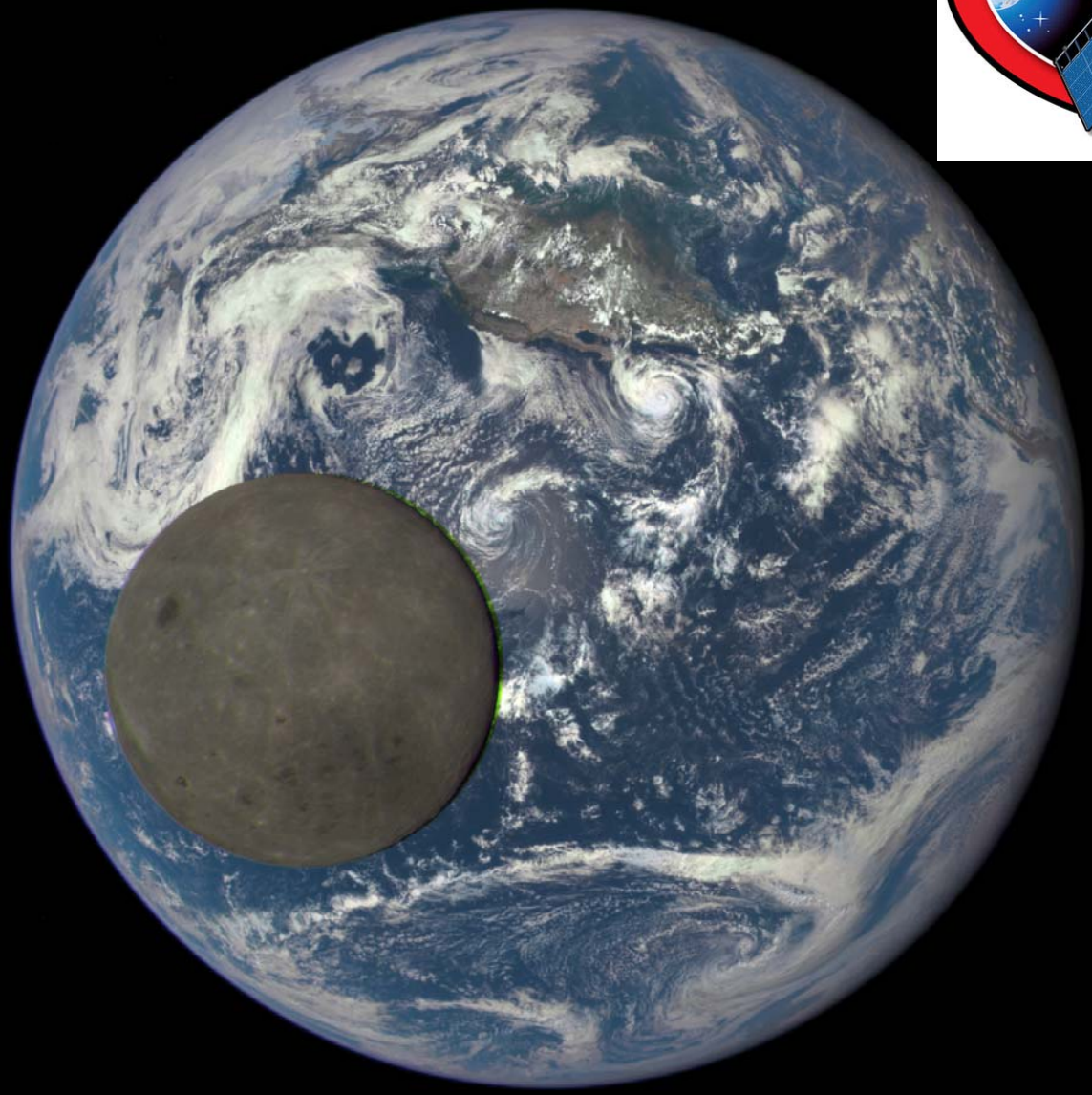



GOES X-ray Flux (1 minute data)
Begin: 2015 Apr 09 1800 UTC
Watts m^{-2}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
X
M
C
B
A
1800
1900
2000
2100
2200
2300
2400
Universal Time
GOES 15 1.0-8.0 A
GOES 13 1.0-8.0 A
GOES 15 0.5-4.0 A
GOES 13 0.5-4.0 A
Updated 2015 Apr 9 2308 UTC
NOAA/SWPC Boulder, CO USA

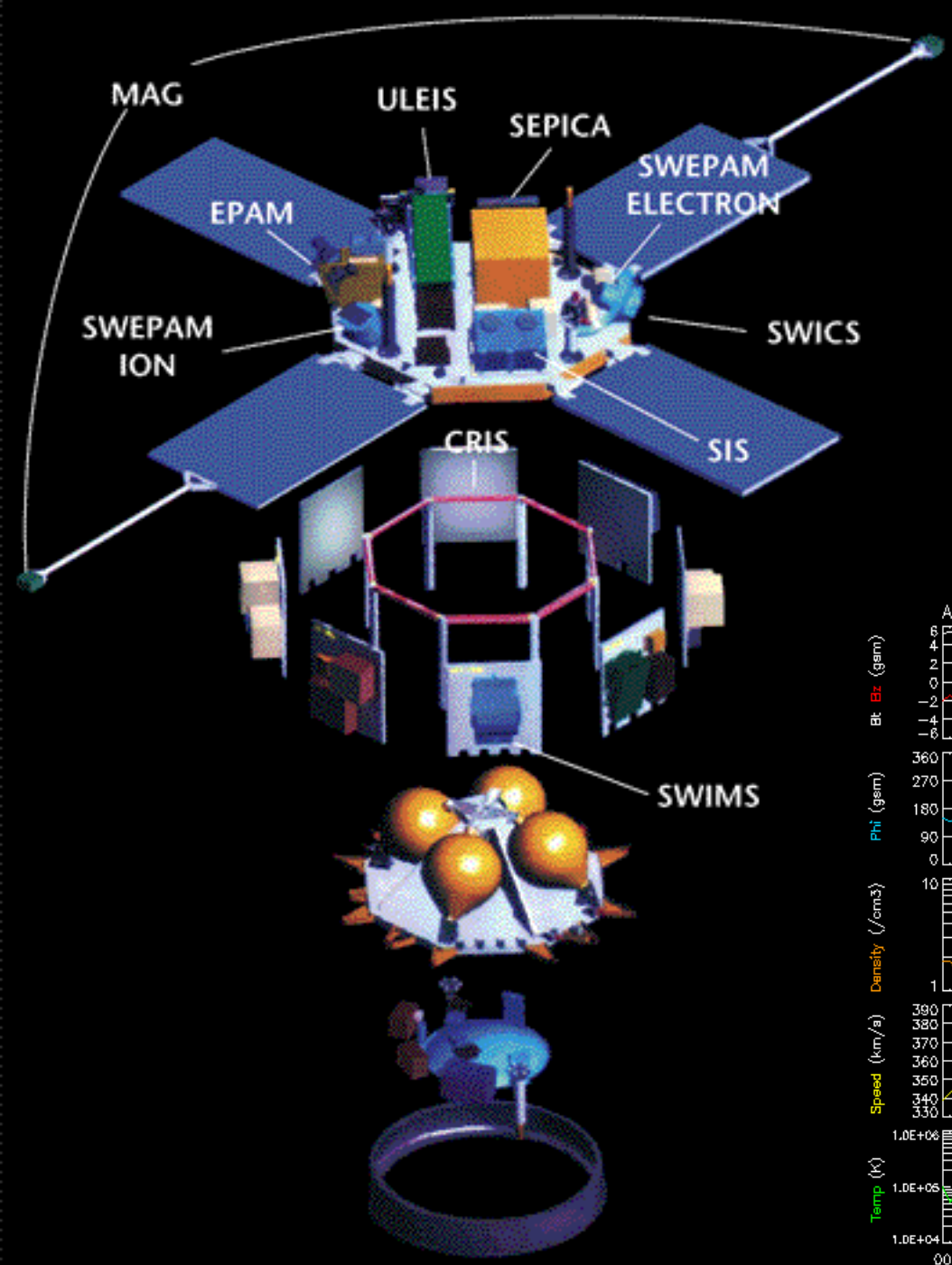

NOAA Satellite and Information Service
L4
DSCOVR
92 MILLION MILES
1 MILLION MILES
L3
L1
L2
L5



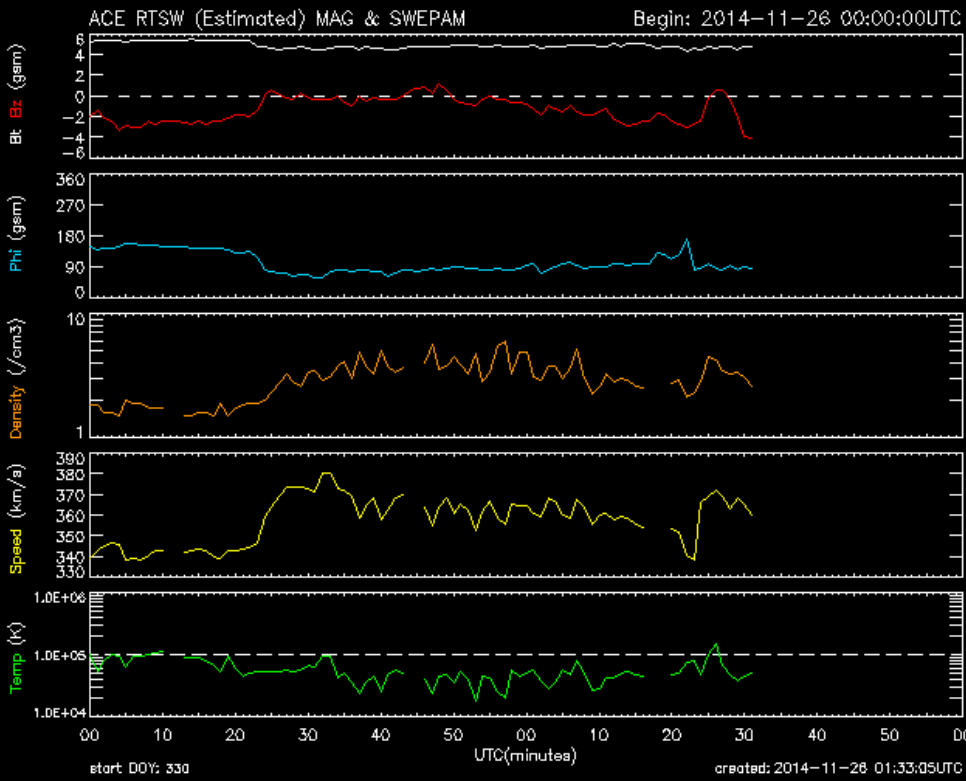
DEEP SPACE CLIMATE OBSERVATORY

DSCOVR

NOAA • NASA • USAF


MAG
ULEIS
SEPICA
SWEPAM
ELECTRON
EPAM
SWEPAM
ION
SWICS
CRIS
SIS
SWIMS

ADVANCED COMPOSITION EXPLORER
ACE
NASA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Begin: 2014-11-26 00:00:00UTC
Bt Bz (gsm)
Phi (gsm)
Density (/cm3)
Speed (km/s)
Temp (K)
UTC(minutes)
start DOY: 330
created: 2014-11-26 01:33:05UTC

Mon, 28 Nov 2016 20:32:22 GMT Mon Nov 28 2016 13:32:22 GMT-0700 (US Mountain Standard Time)
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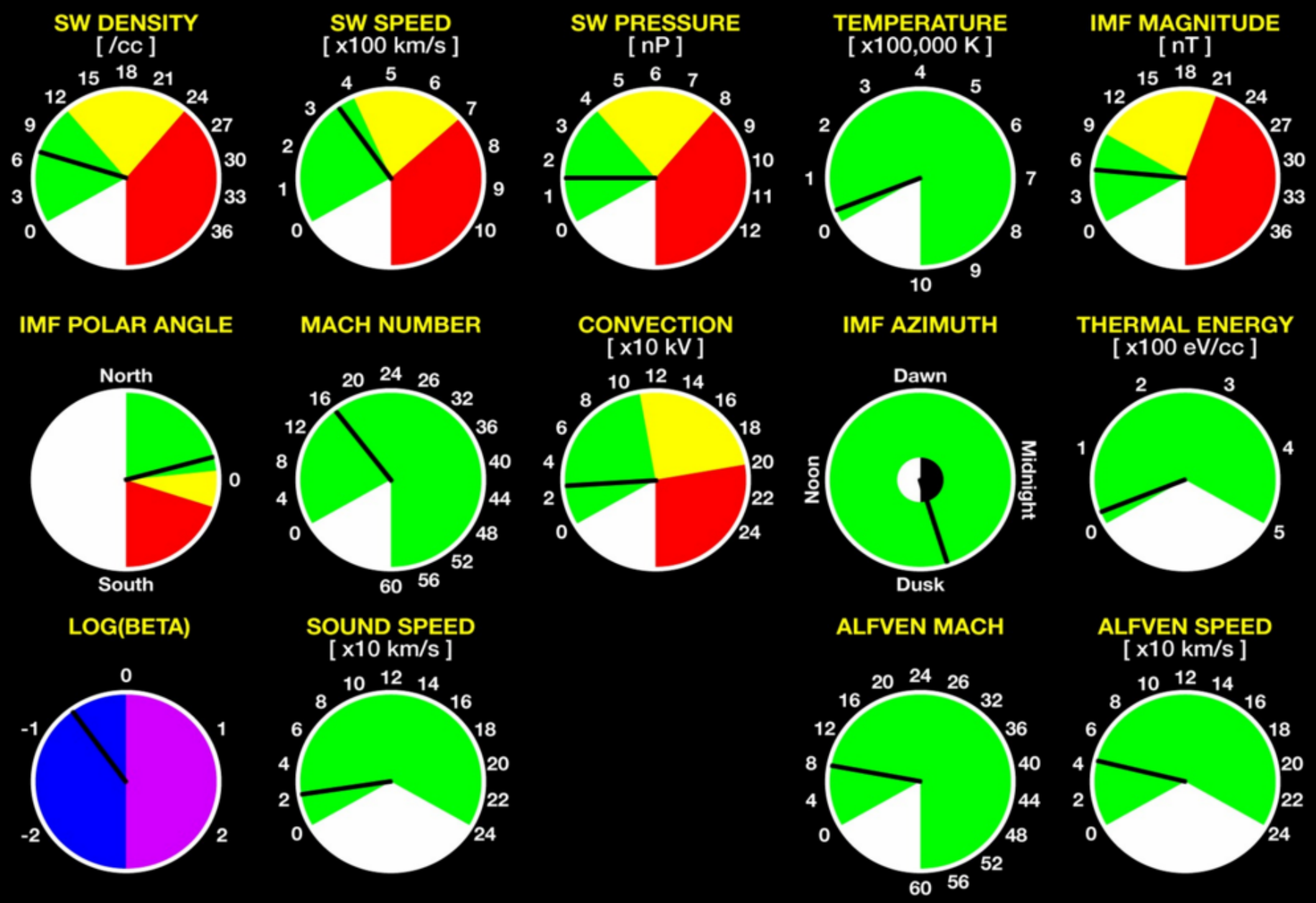
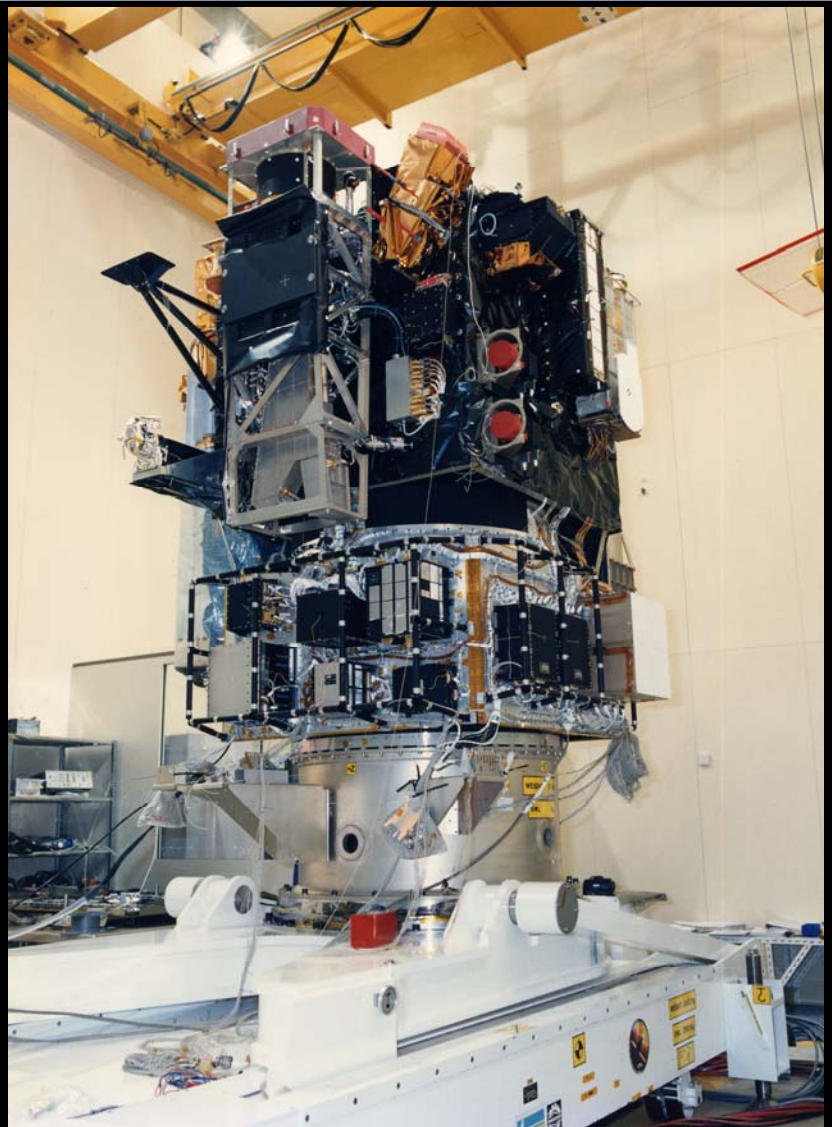
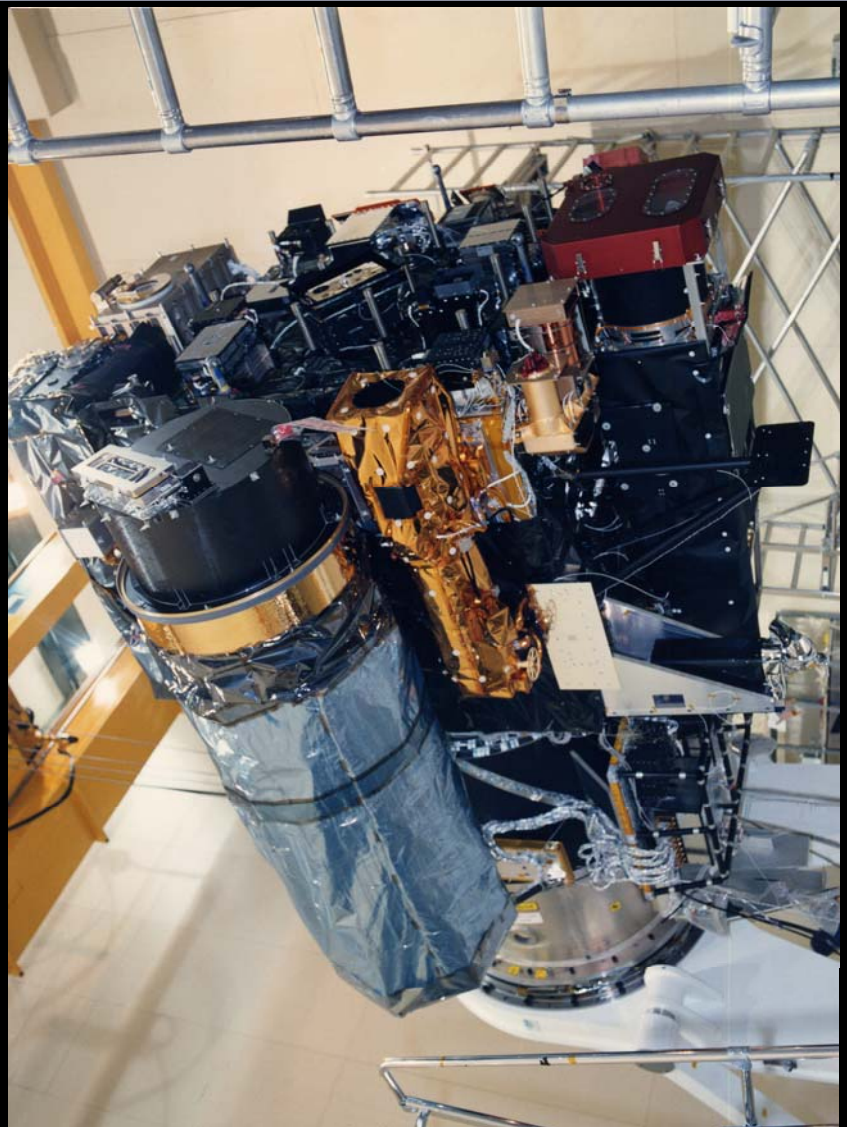
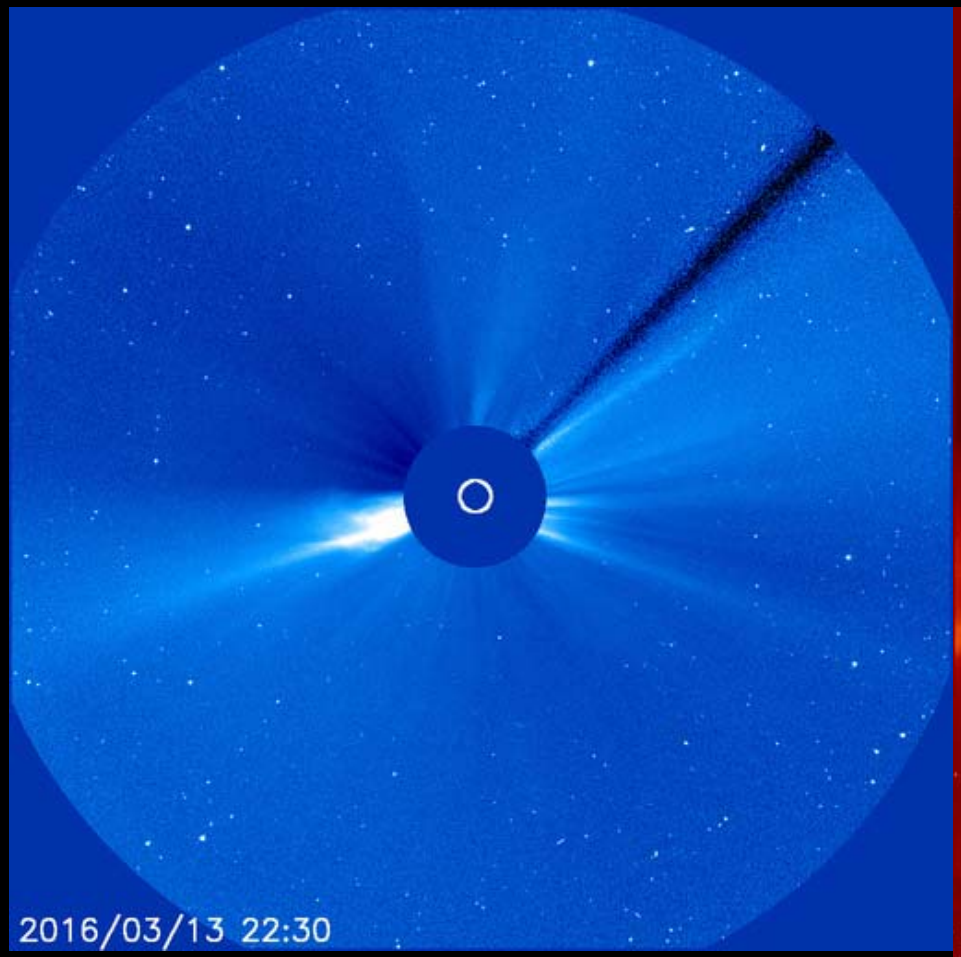
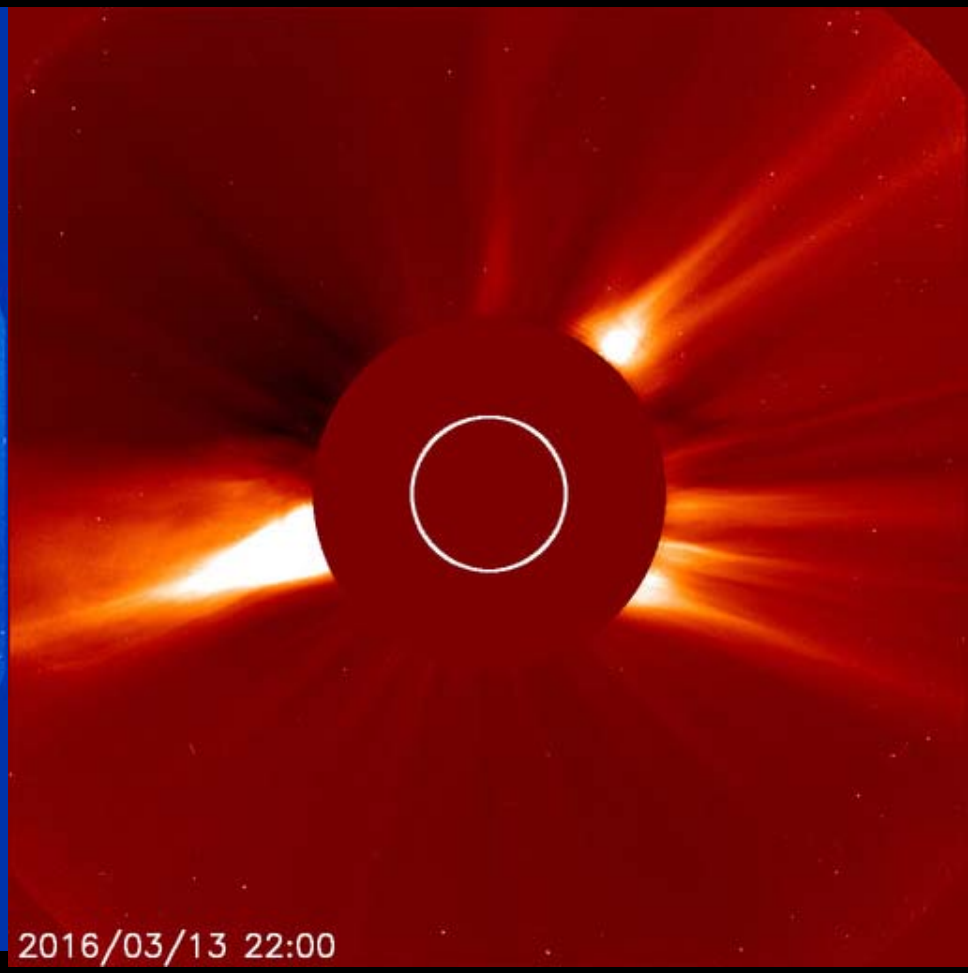


SOHO
SOLAR AND HELIOSPHERIC OBSERVATORY





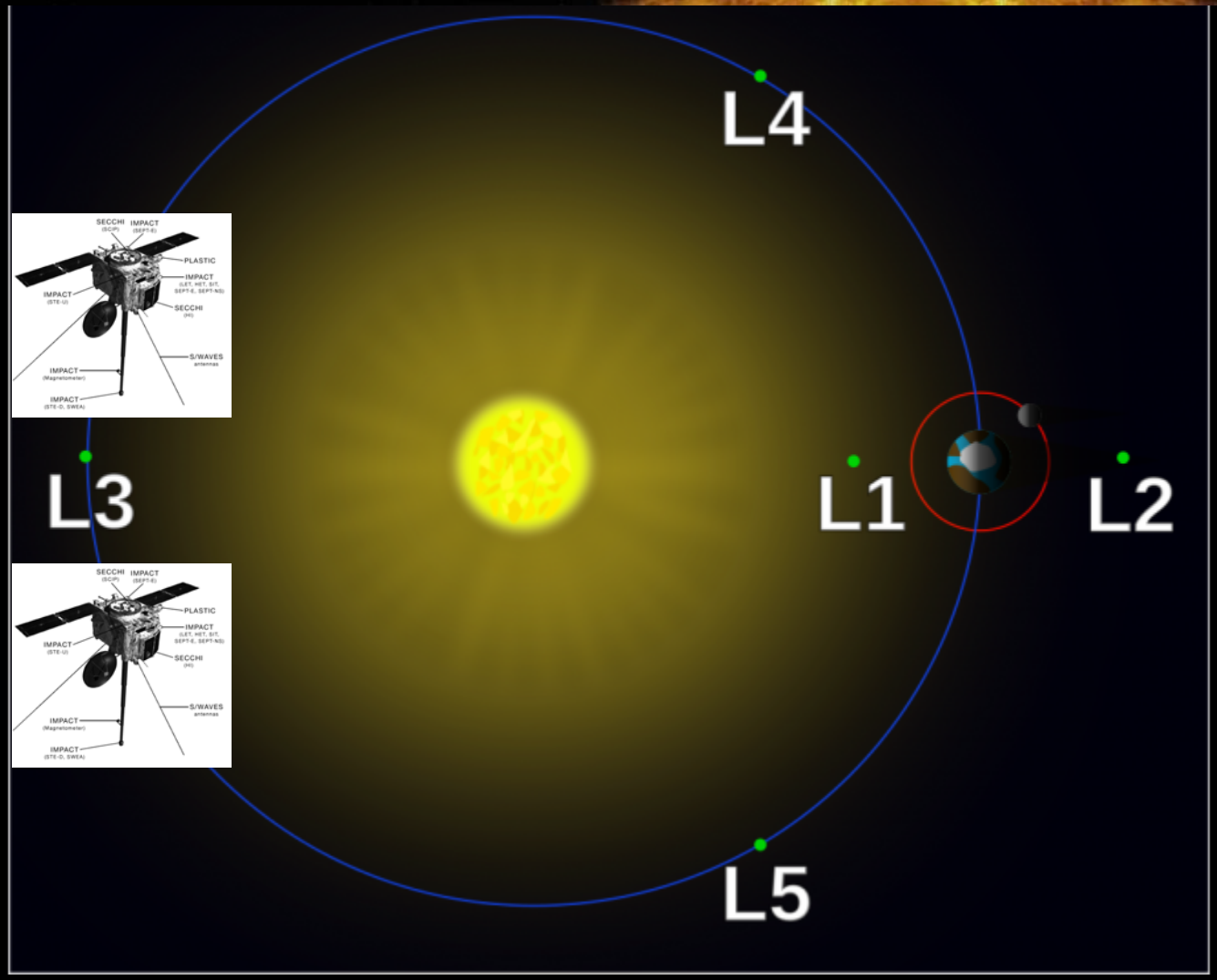

2016/03/13 22:30

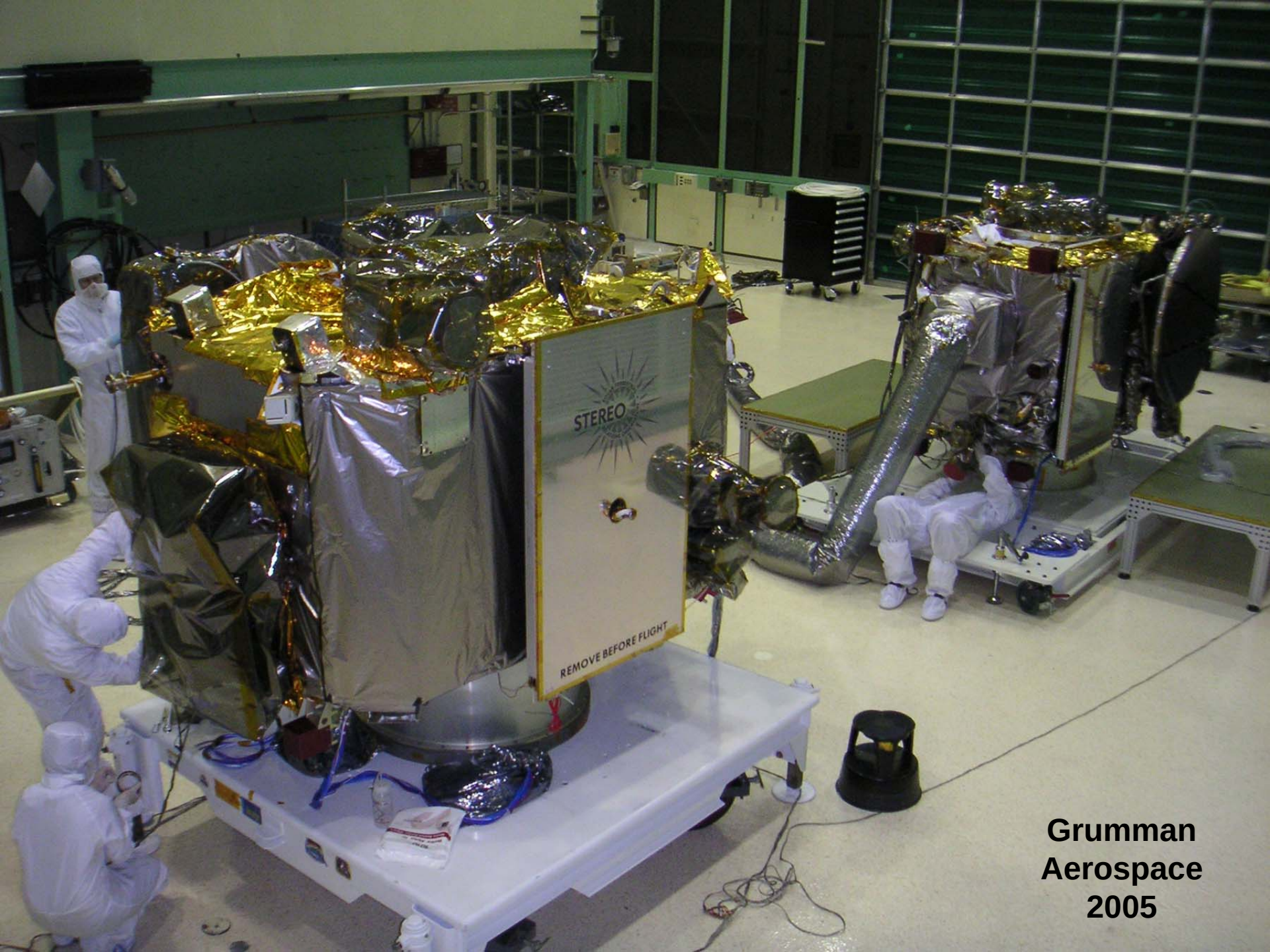

2016/03/13 22:00

STEREO

Solar **TE**rrestrial **RE**lations **O**bservatory

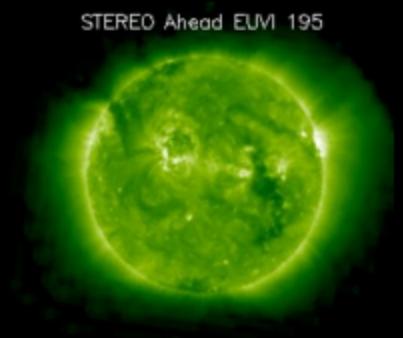
Capturing the Sun in 3-D

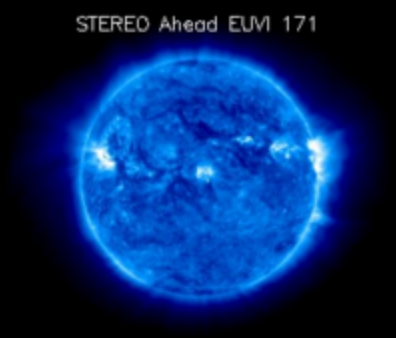


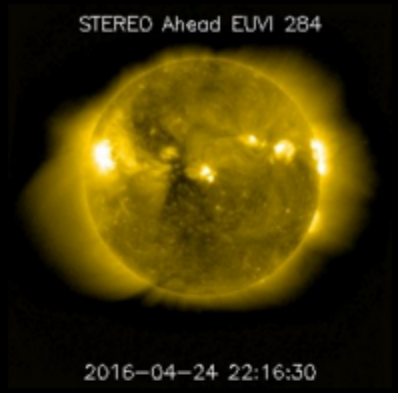


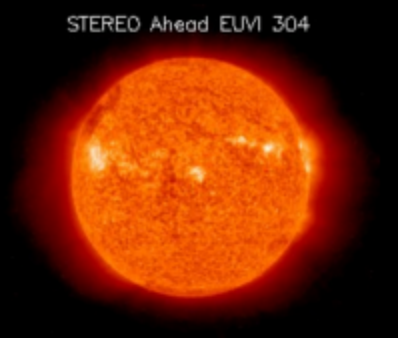
Grumman
Aerospace
2005

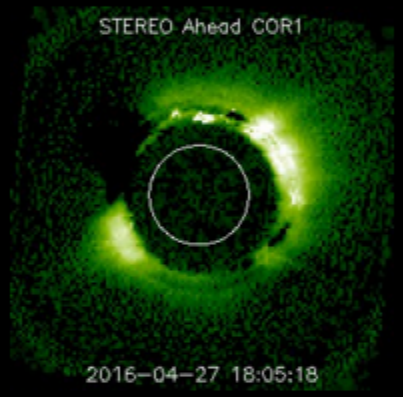
Thu, 28 Apr 2016 02:14:41 GMT Wed Apr 27 2016 19:14:41 GMT-0700 (US Mountain Standard Time)

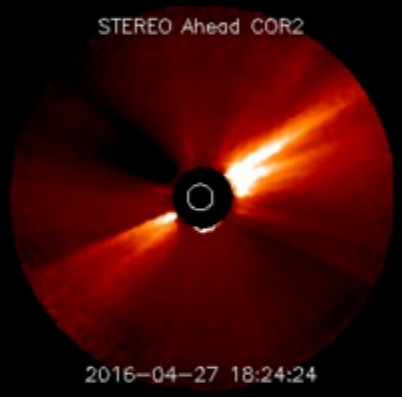


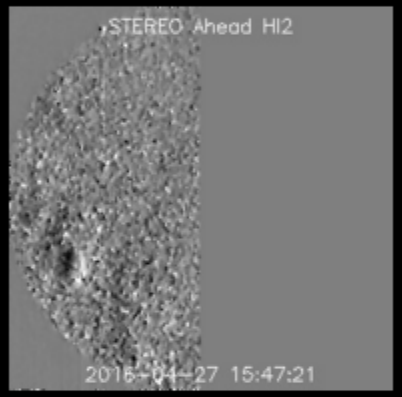


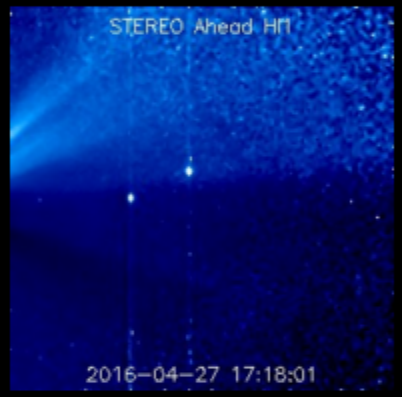


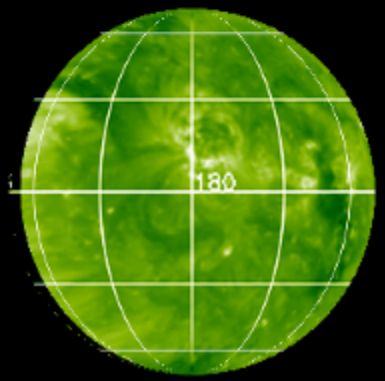


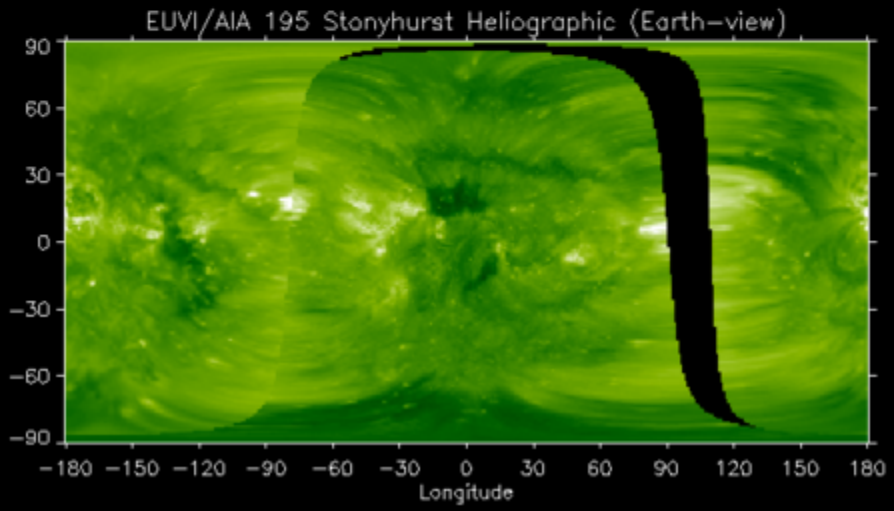






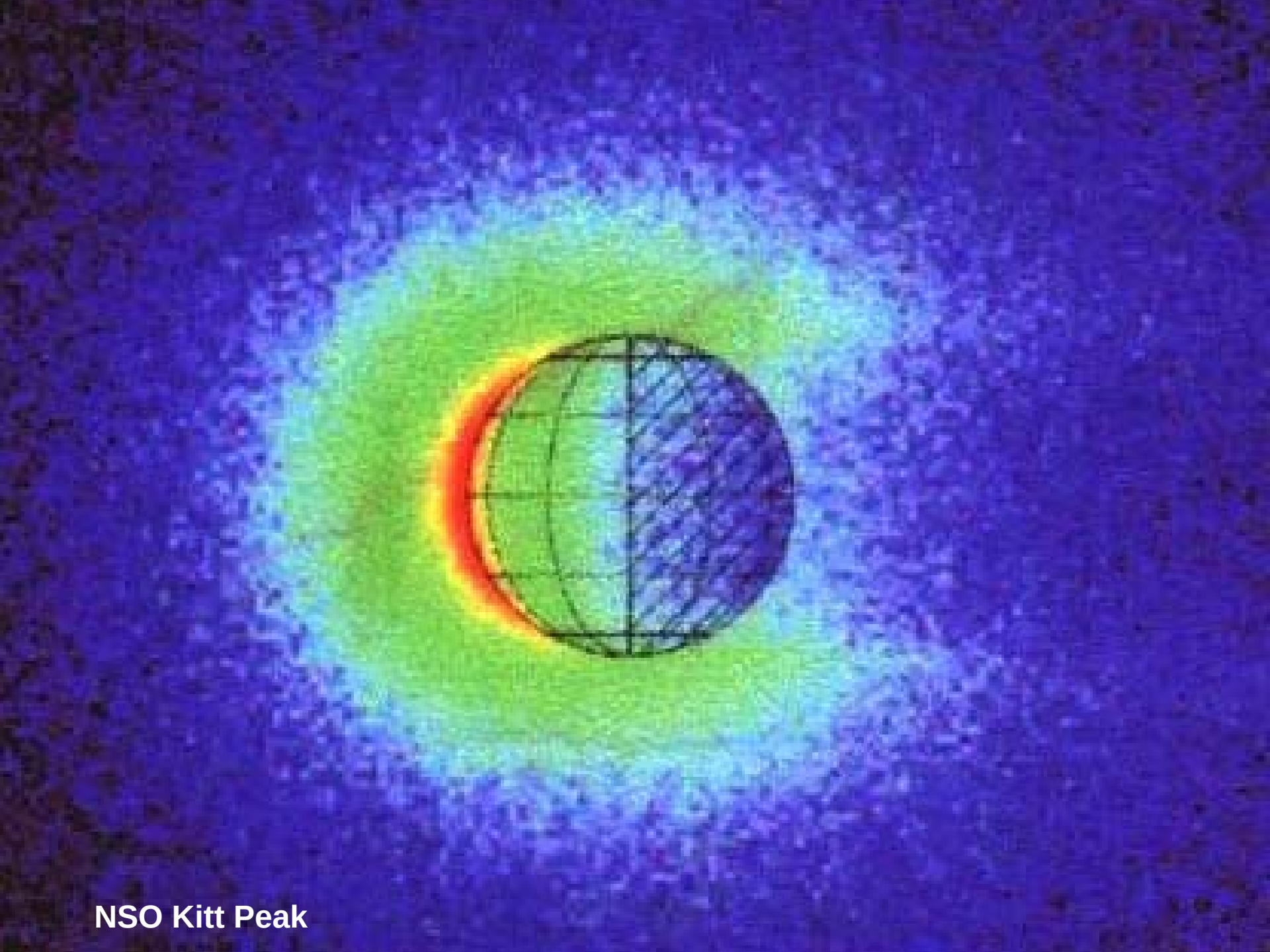


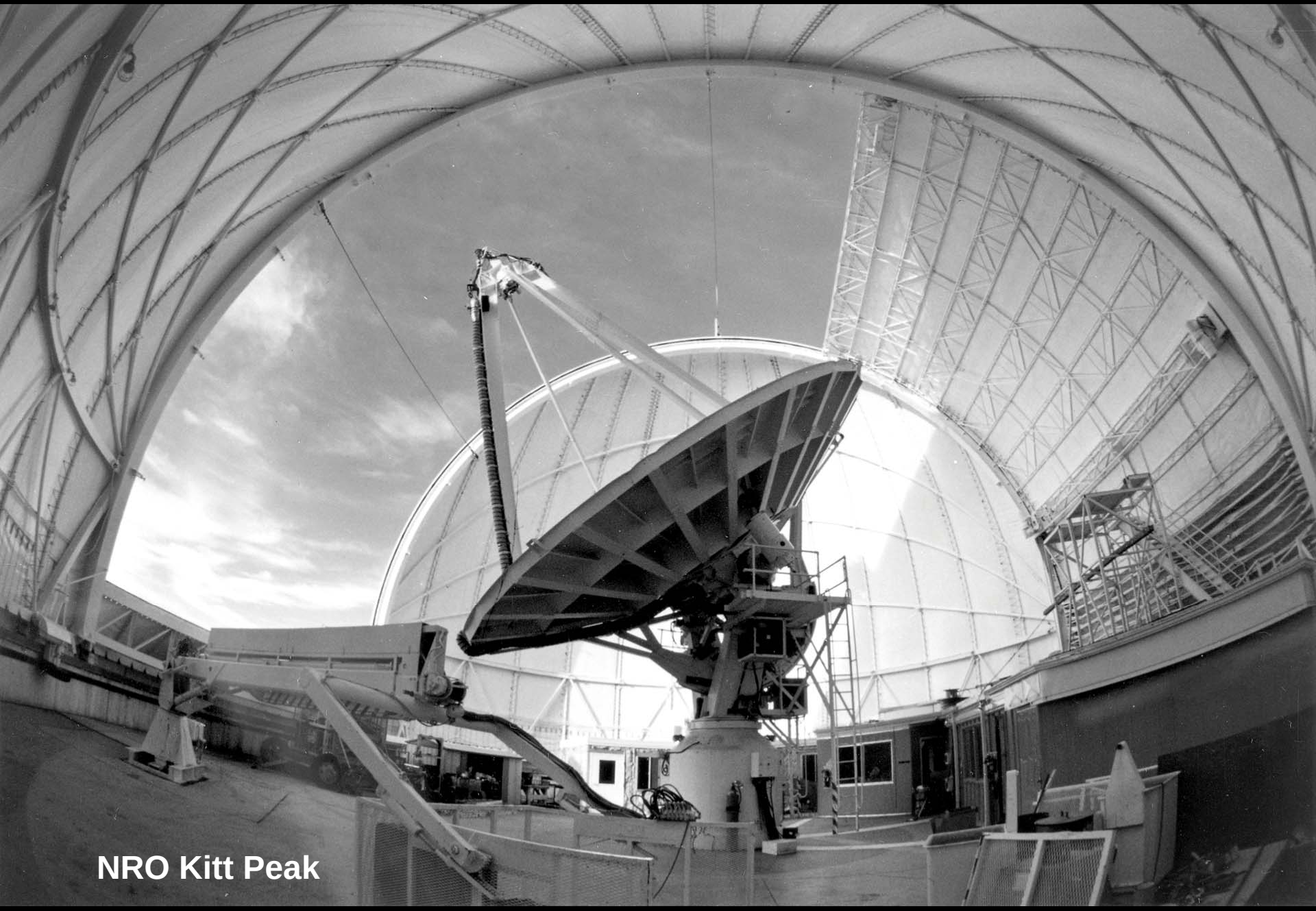


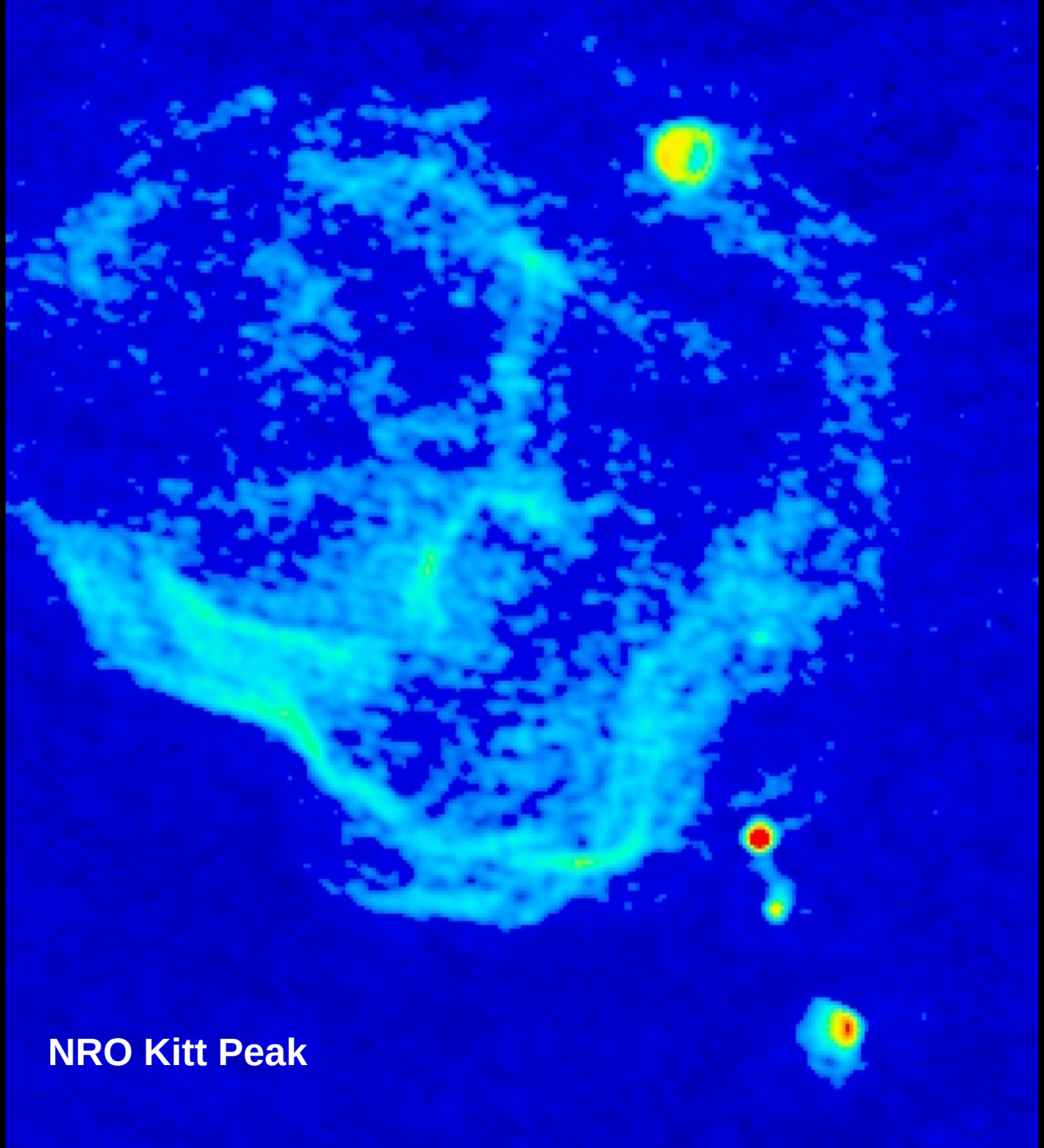


NSO Kitt Peak

Heliostat (left image): 2.03 Focal Length: 87 f-ratio: 54


NSO Kitt Peak


NRO Kitt Peak


NRO Kitt Peak

Observatory Credits

Spacecraft Observatories

Solar Dynamics Observatory (SDO)

NOAA Geostationary Satellites – (GOES 13, GOES 14, GOES 15)

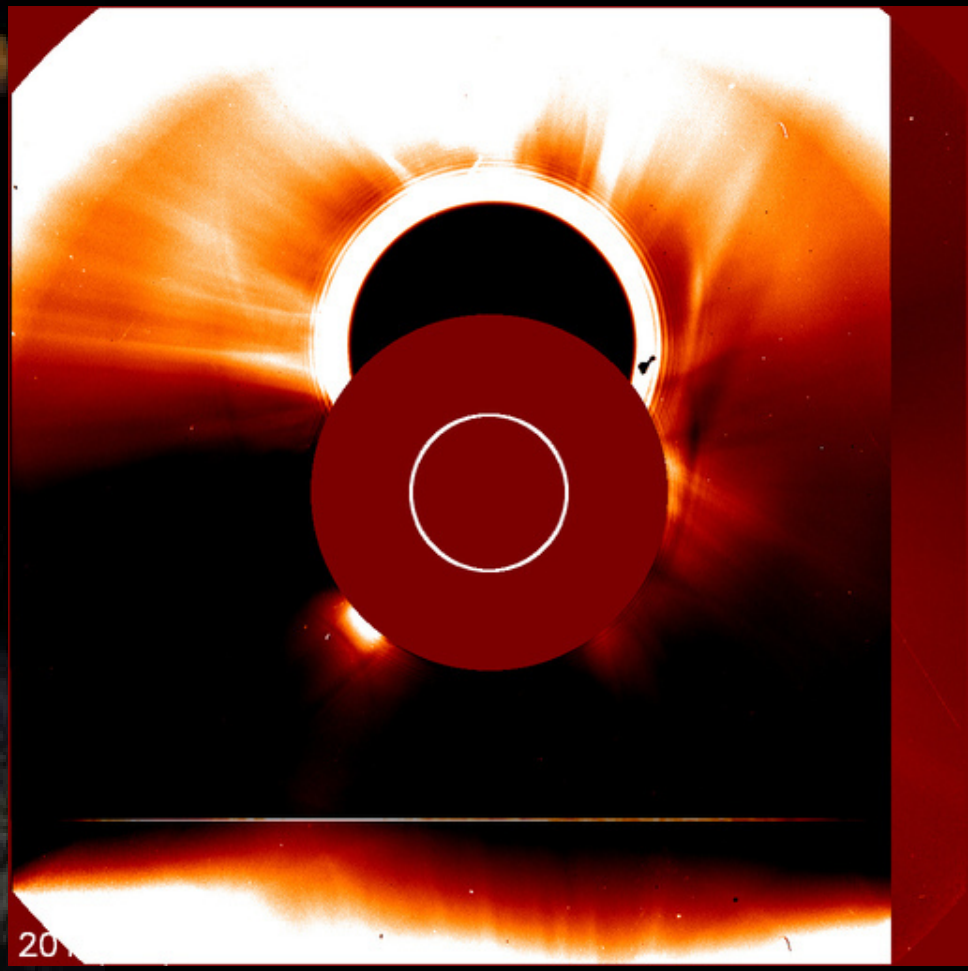
NOAA Deep Space Climate Observatory (DSCVR)

Advanced Composition Explorer (ACE)

Solar and Heliospheric Observatory (SOHO, LASCO C2-C3)

Solar Terrestrial Relations Observatory (STEREO A and STEREO B)

Ground Based Observatory

McMath – Pierce National Solar Observatory, Kitt Peak

Thank You!