

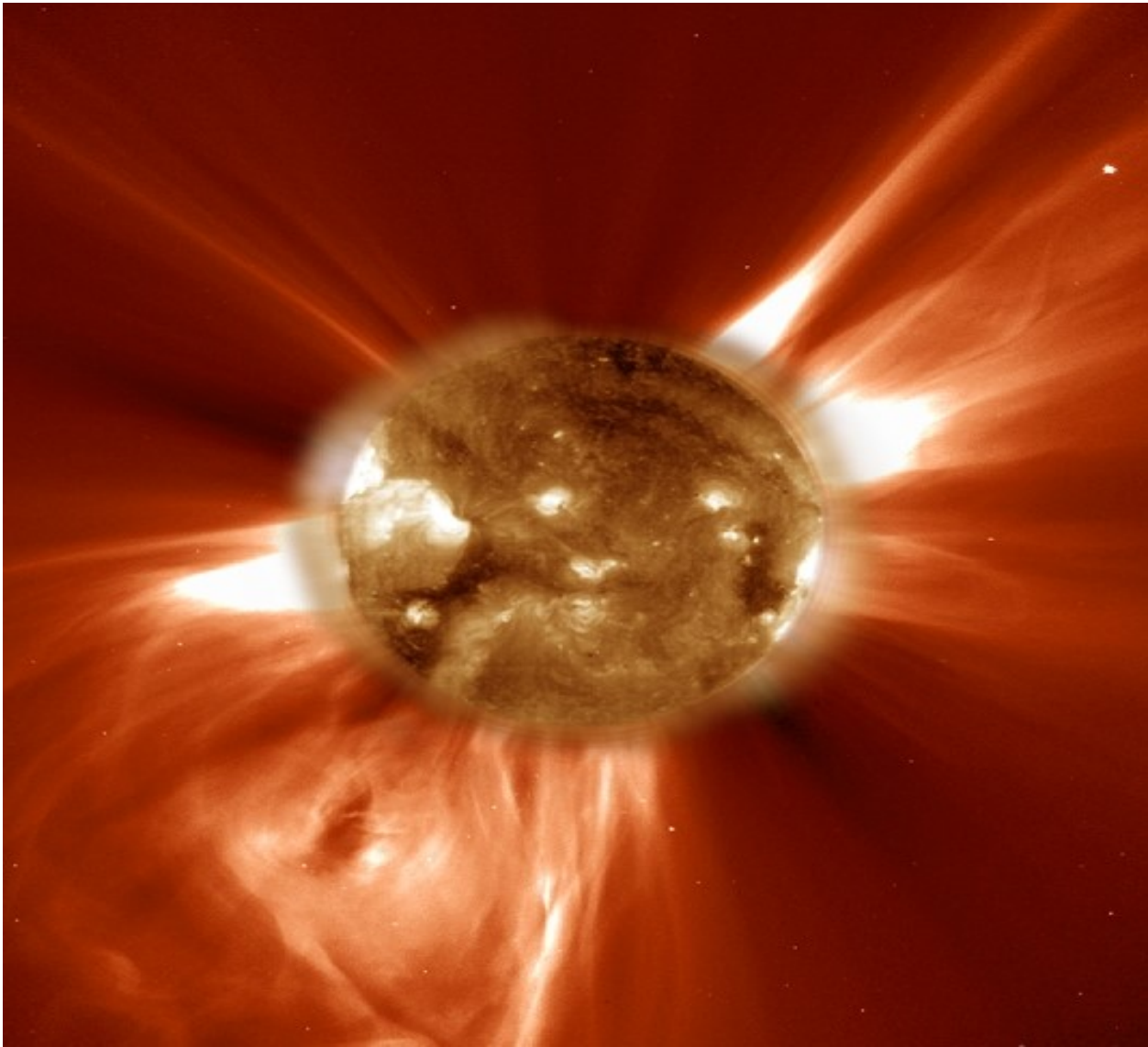


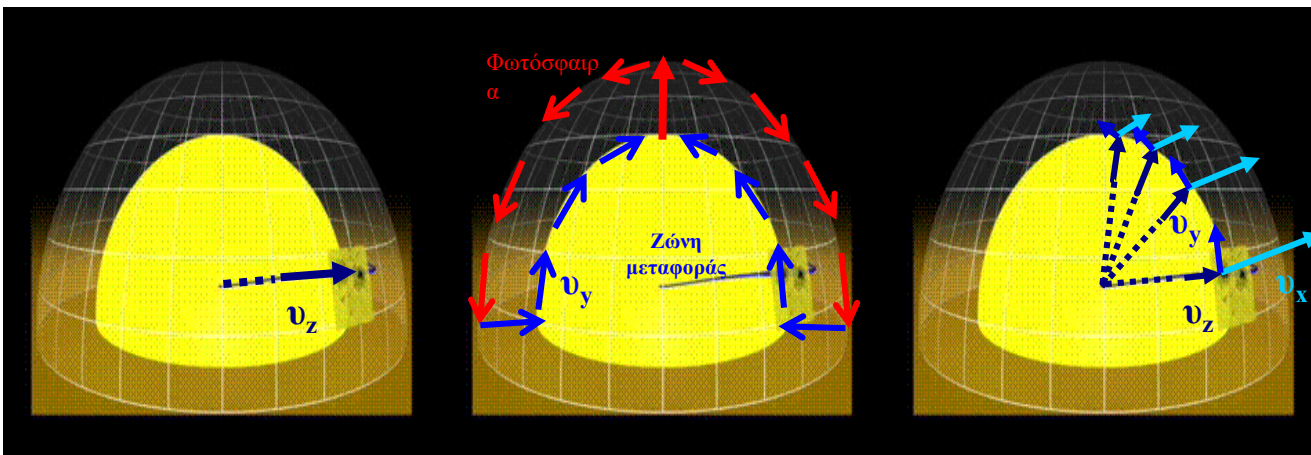
ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
Εθνικόν και Καποδιστριακόν
Πανεπιστήμιον Αθηνών

Εισαγωγή στην Αστροφυσική

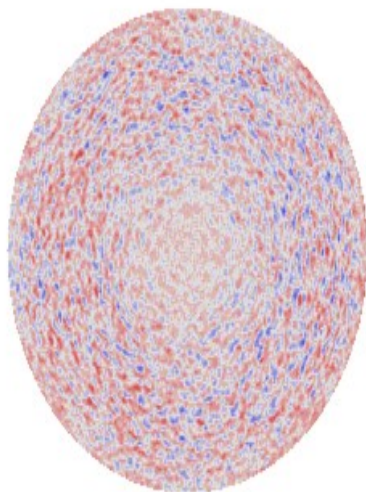
Ενότητα 3: Ο Ήλιος ως Αστéρας

Παναγιώτα Πρέκα
Σχολή Θετικών Επιστημών
Τμήμα Φυσικής



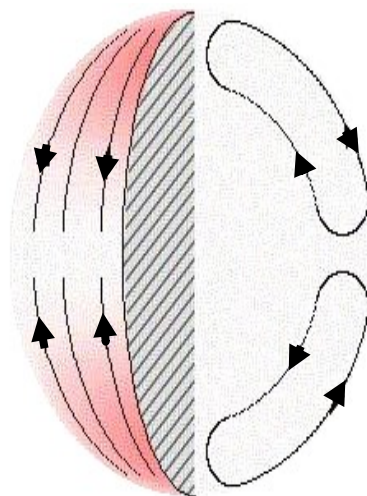


Εικ. Η κατακόρυφη συνιστώσα της ταχύτητας v_z .



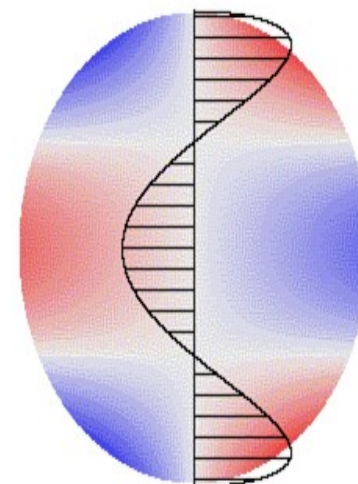
Εικ. Το αποτέλεσμα των ανισοτροπικών ρευμάτων (υπερκοκκίαση)

Εικ. Η δημιουργία της κάθετης συνιστώσας της ταχύτητας v_y .



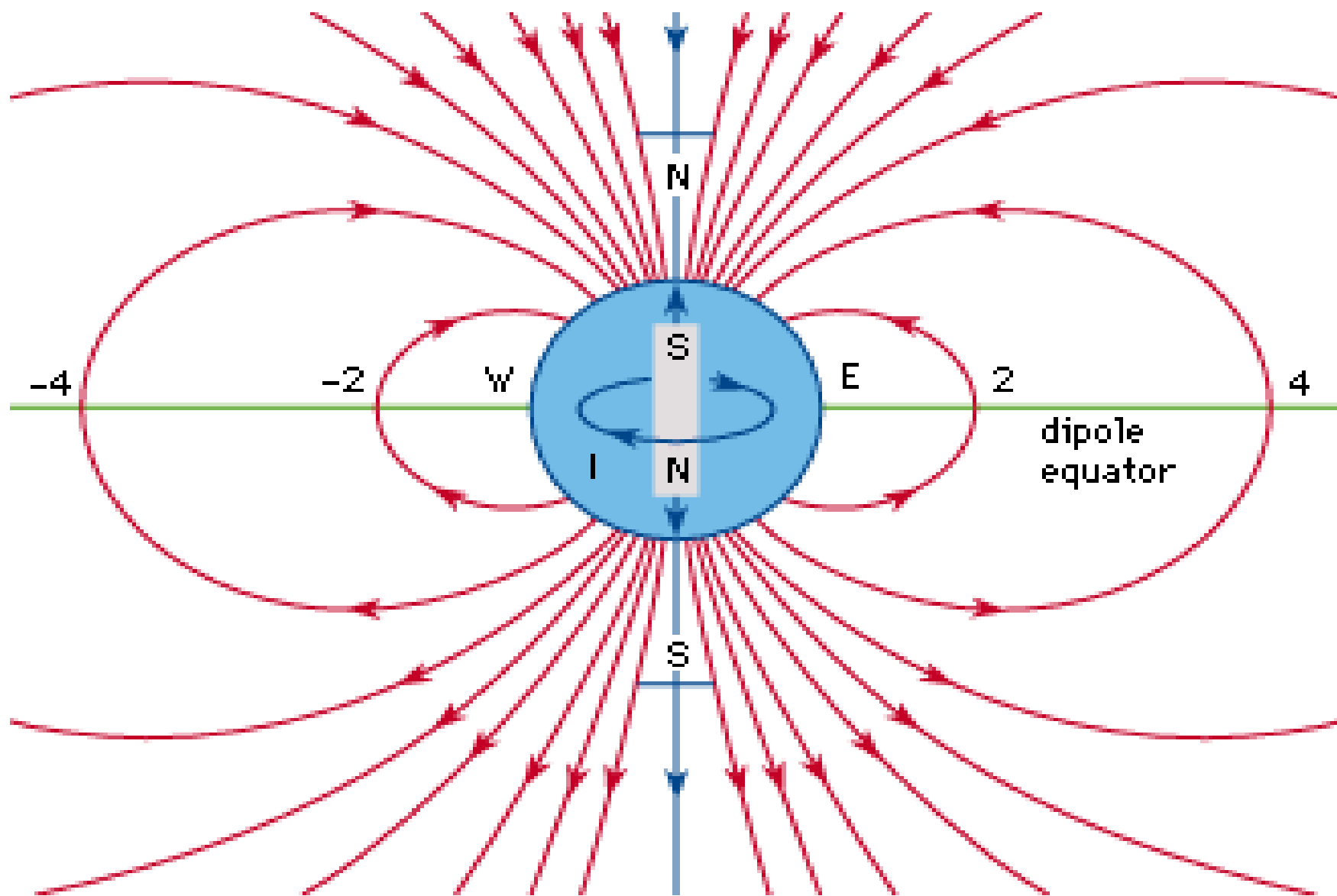
Εικ. Η ροή των μεσημβρινών ρευμάτων

Εικ. Οι 3 συνιστώσες της ταχύτητας v_z , v_y και v_x .

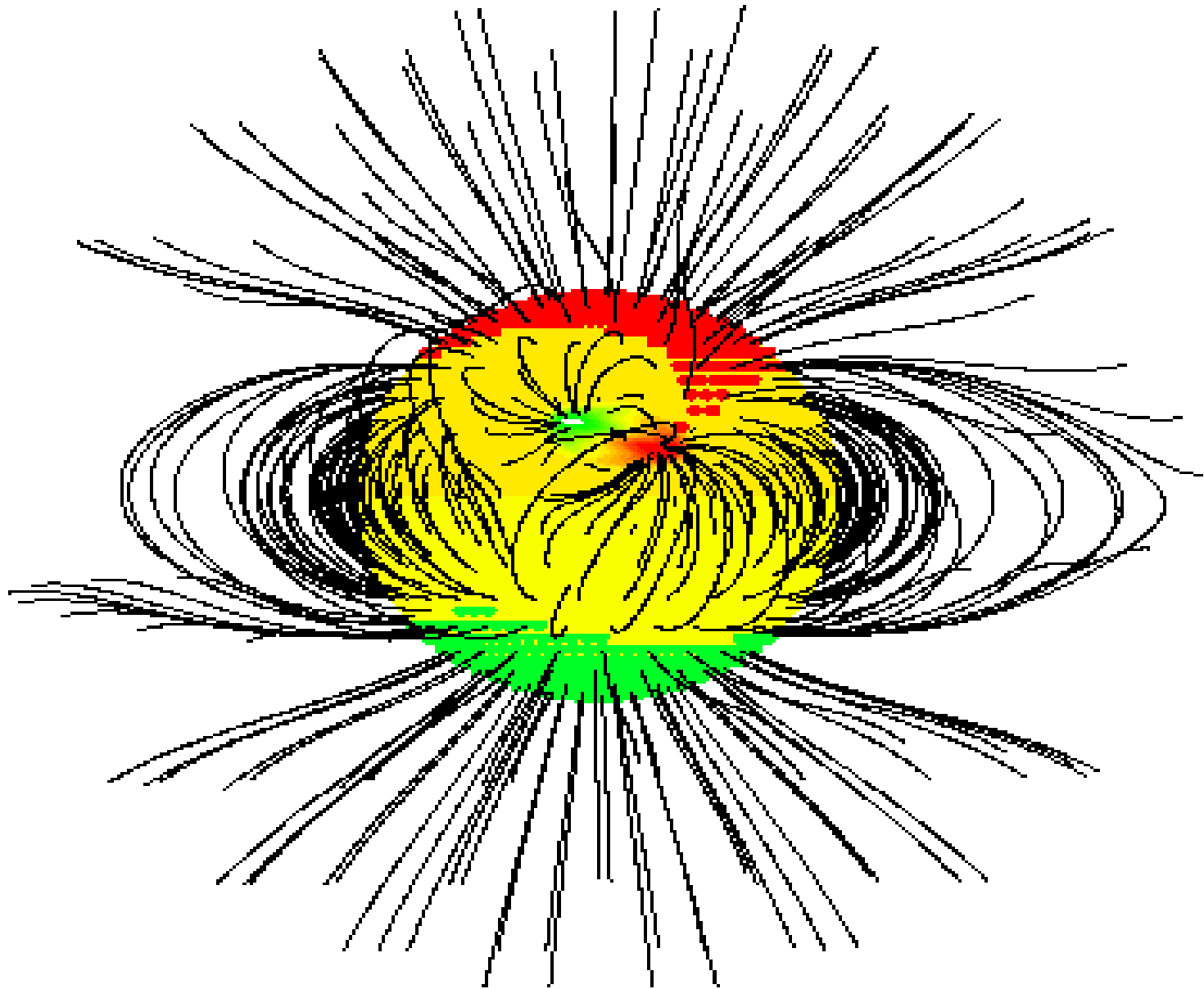


Εικ. Η οριζόντια συνιστώσα της ταχύτητας





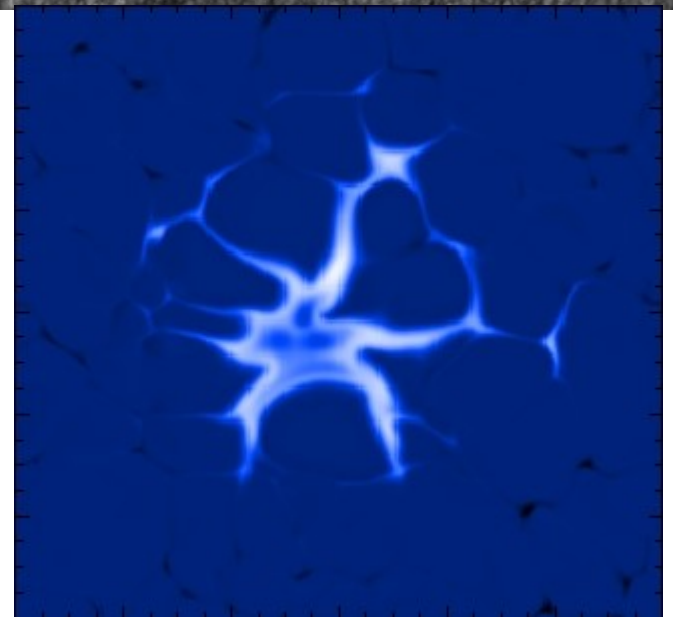
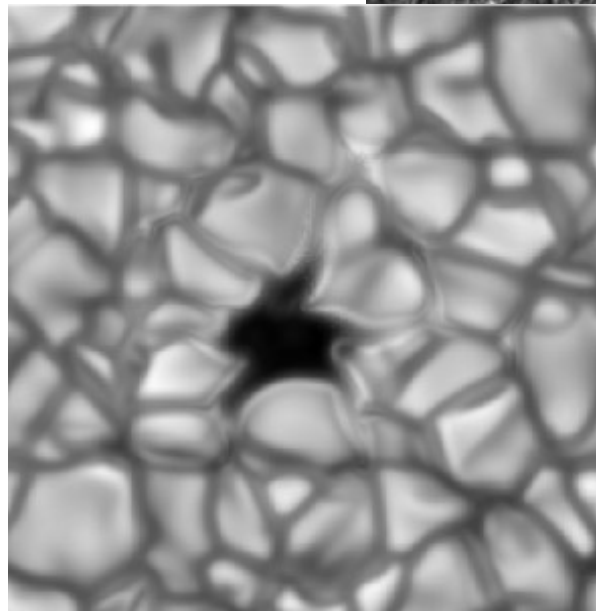
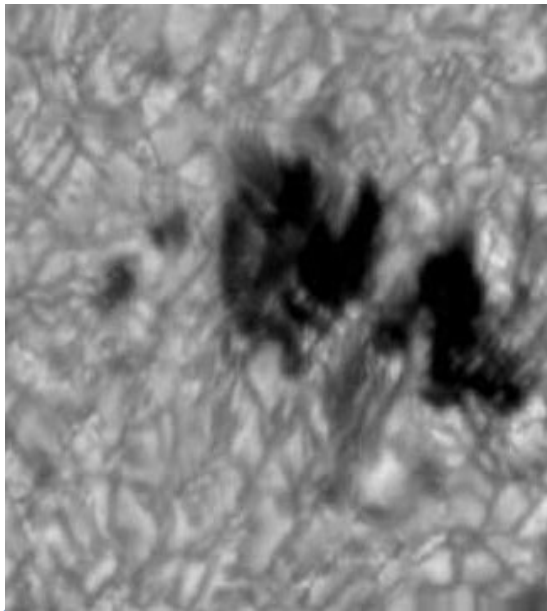
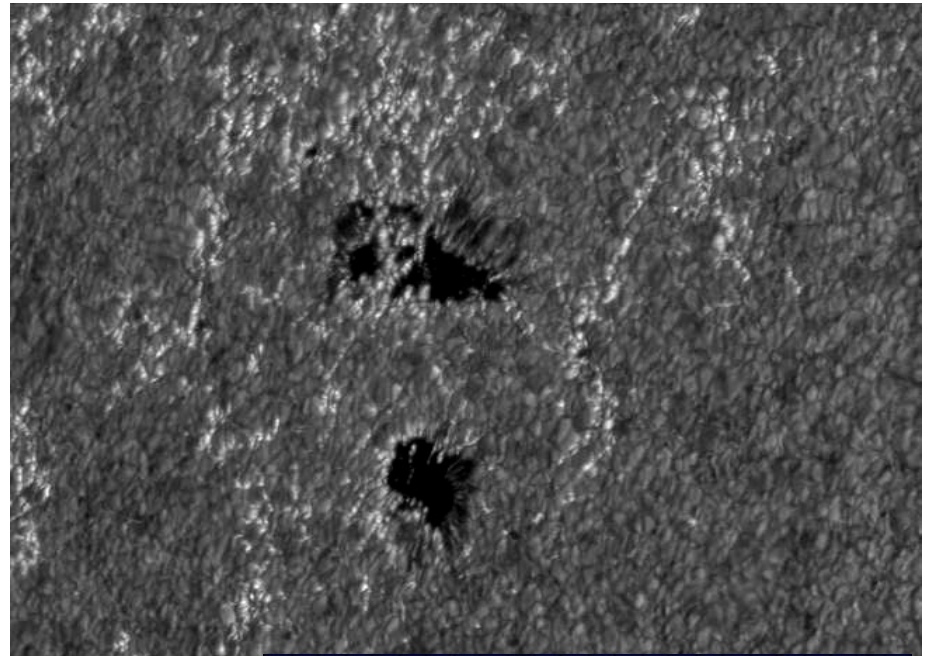
©1994 Encyclopaedia Britannica, Inc.

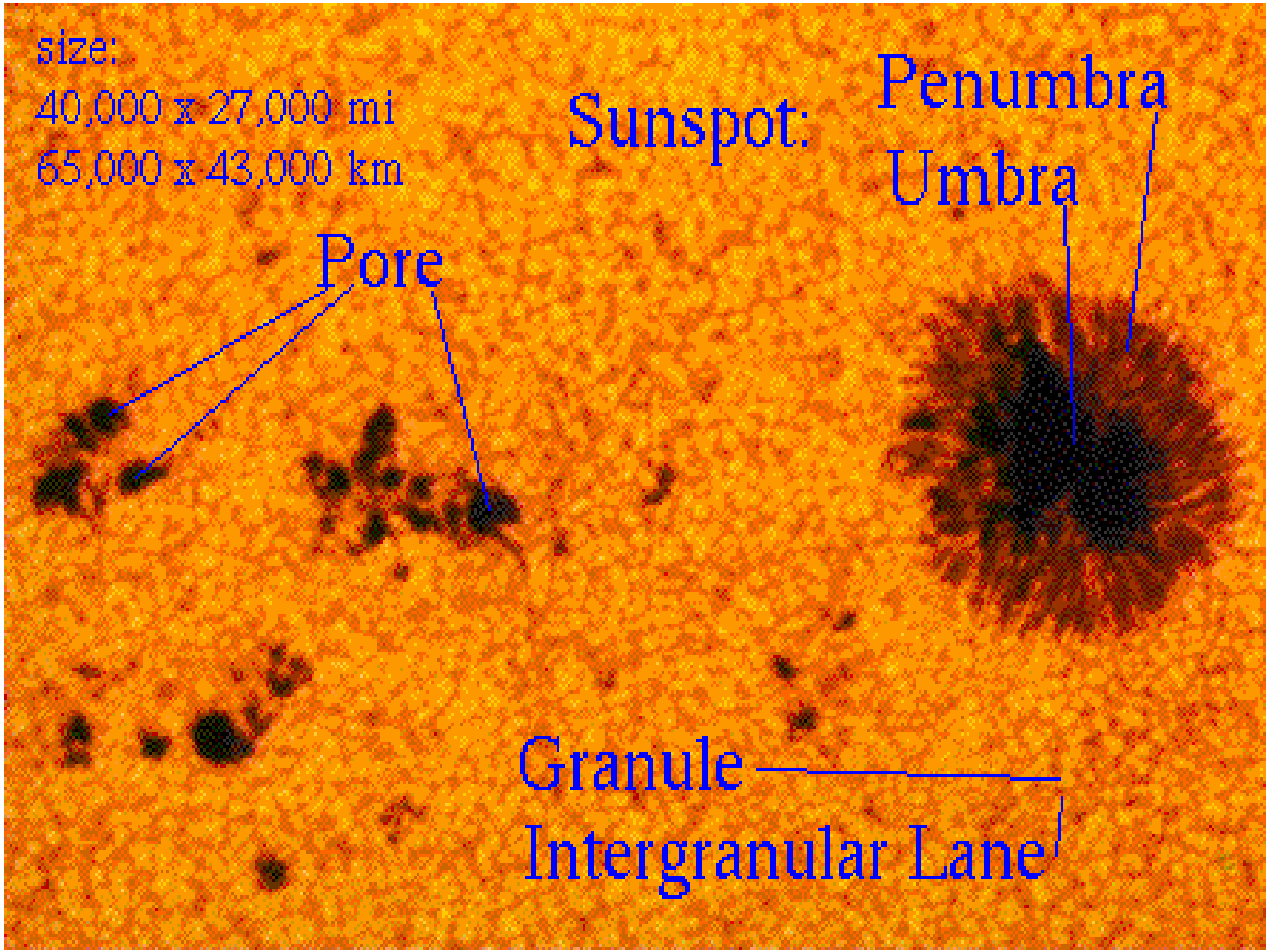






ΚΕΝΤΡΑ ΔΡΑΣΗΣ ΠΥΡΣΟΙ ΚΑΙ ΠΟΡΟΙ (Faculae-Pores)





size:

40,000 x 27,000 mi

65,000 x 43,000 km

Sunspot:

Penumbra

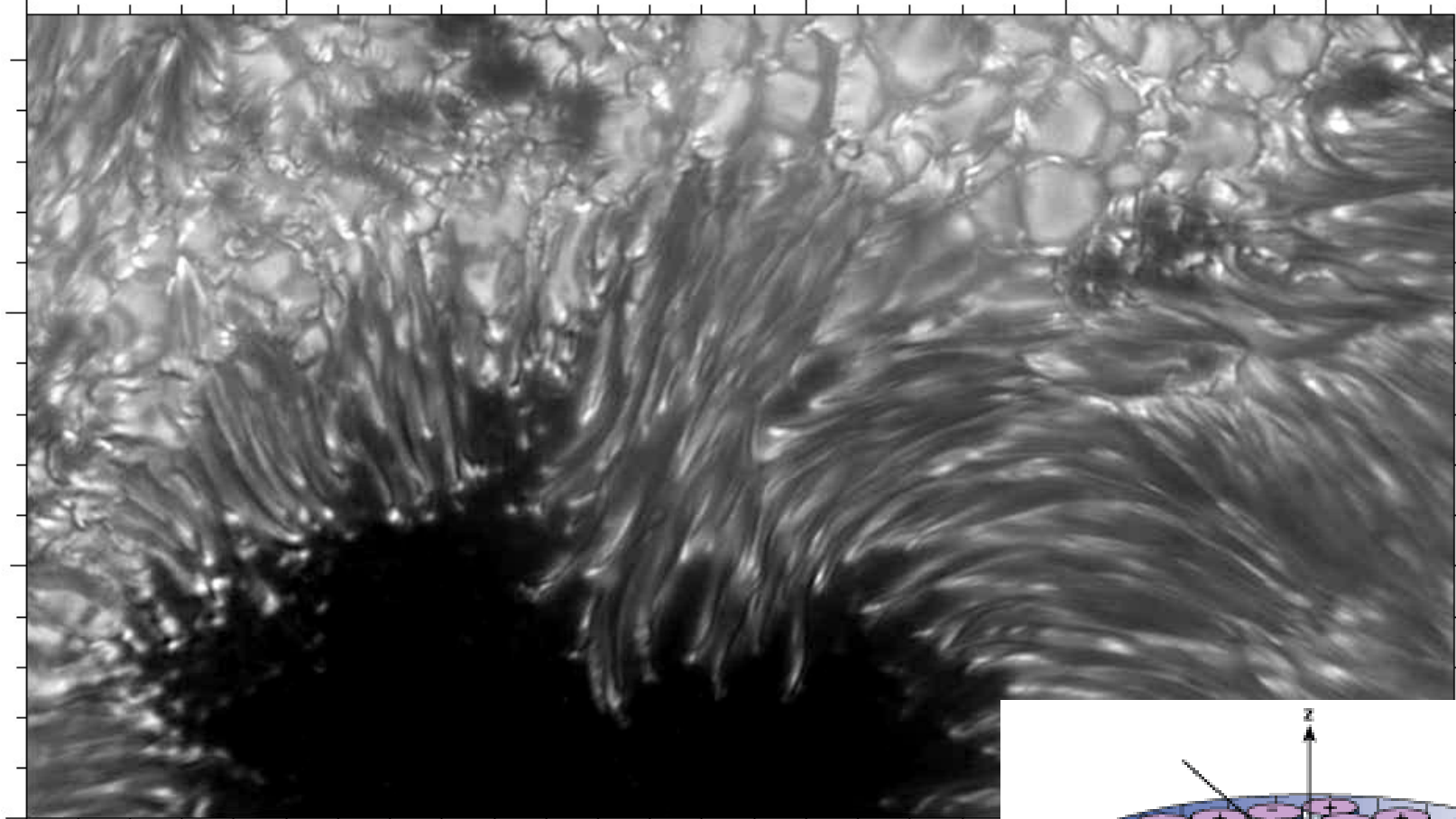
Umbra

Pore

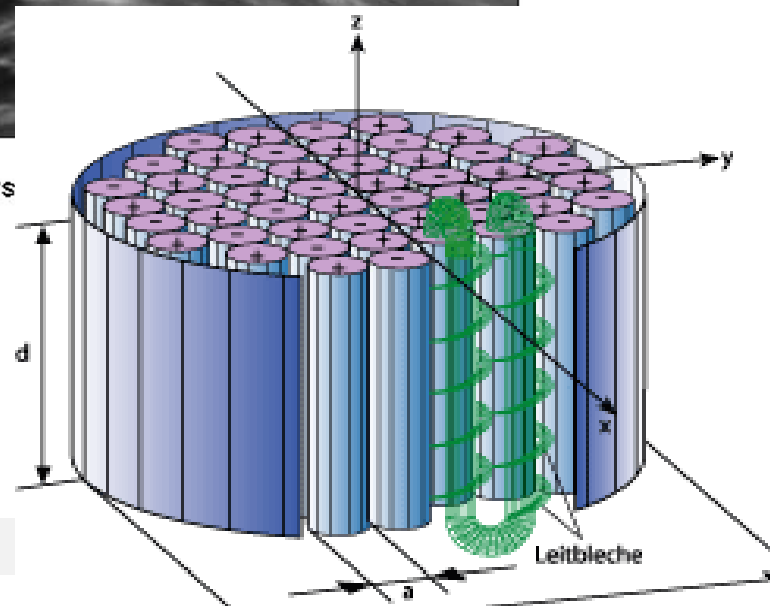
Granule

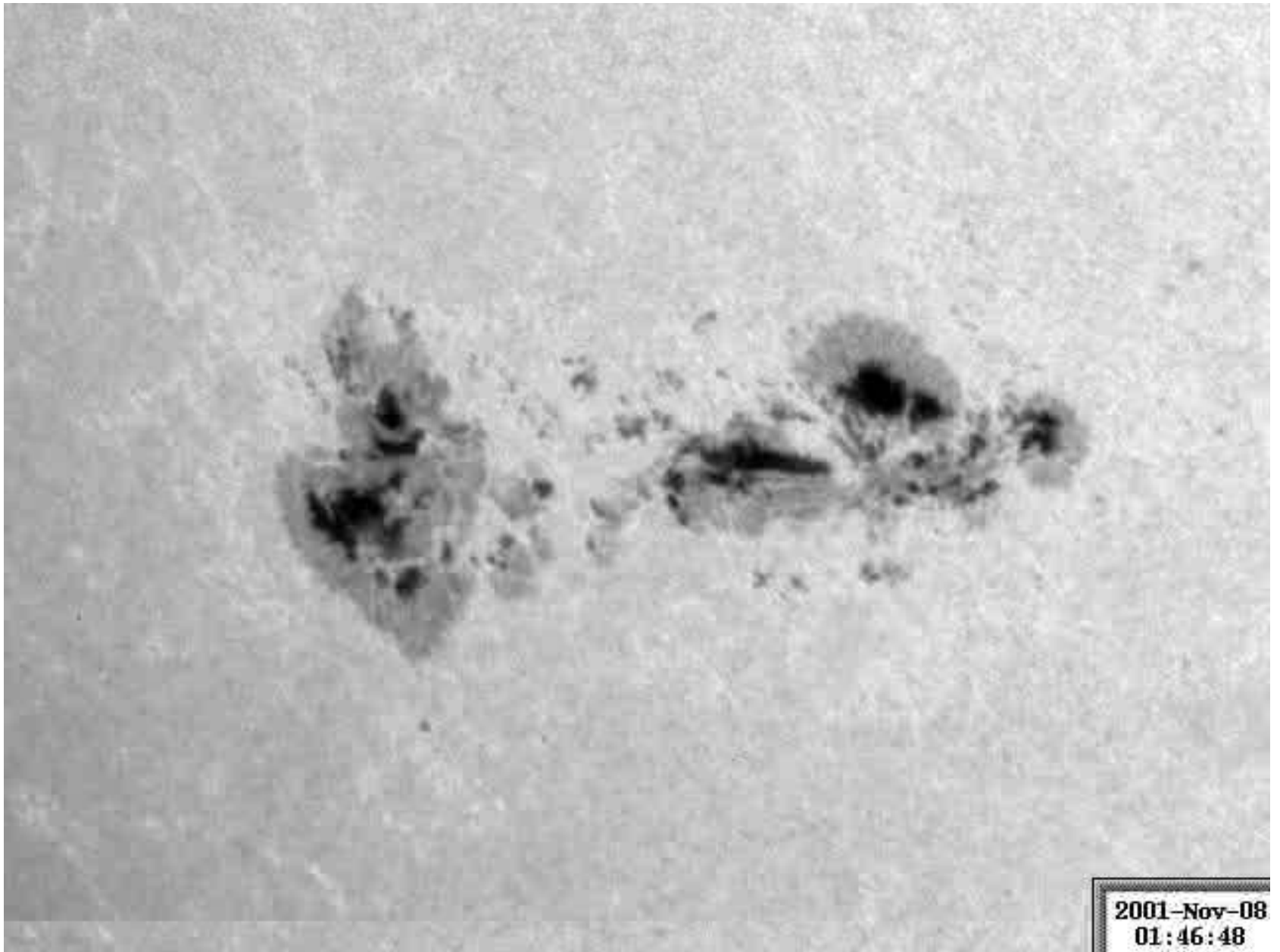
Intergranular Lane





distance in units of 1000 kilometers





2001-Nov-08
01:46:48



ΚΗΛΙΔΑ
(sunspot)

bar magnet

SN NS

N

S N

S N

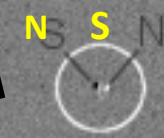
ΚΕΝΤΡΟ
ΔΡΑΣΗΣ



Ι Σ Η Μ Ε Ρ Ι Ν Ο Σ

ΑΛΛΗΛΟΑΝΑΙΡΕΣΗ

N S N S



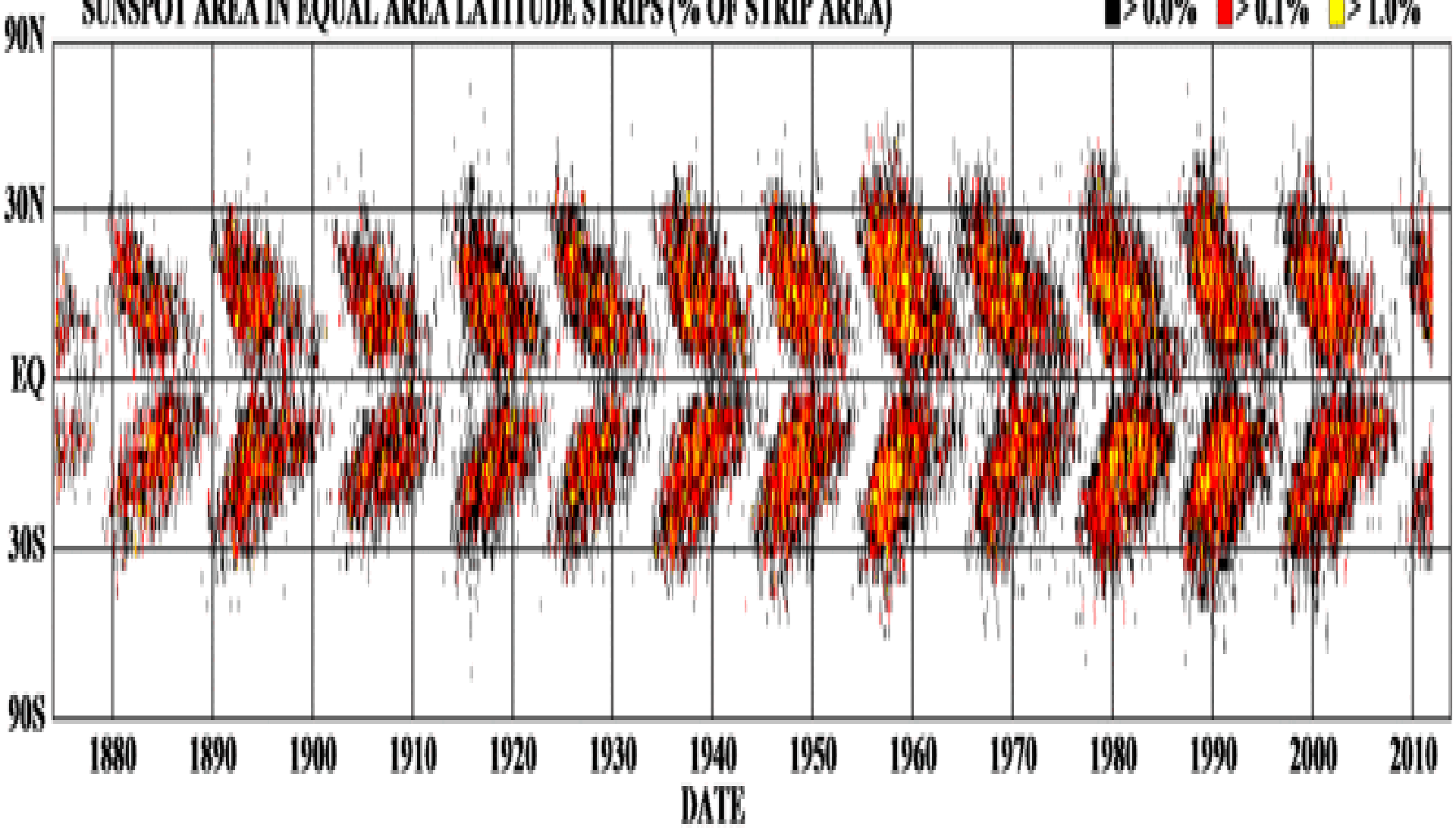
ΚΕΝΤΡΟ
ΔΡΑΣΗΣ

S

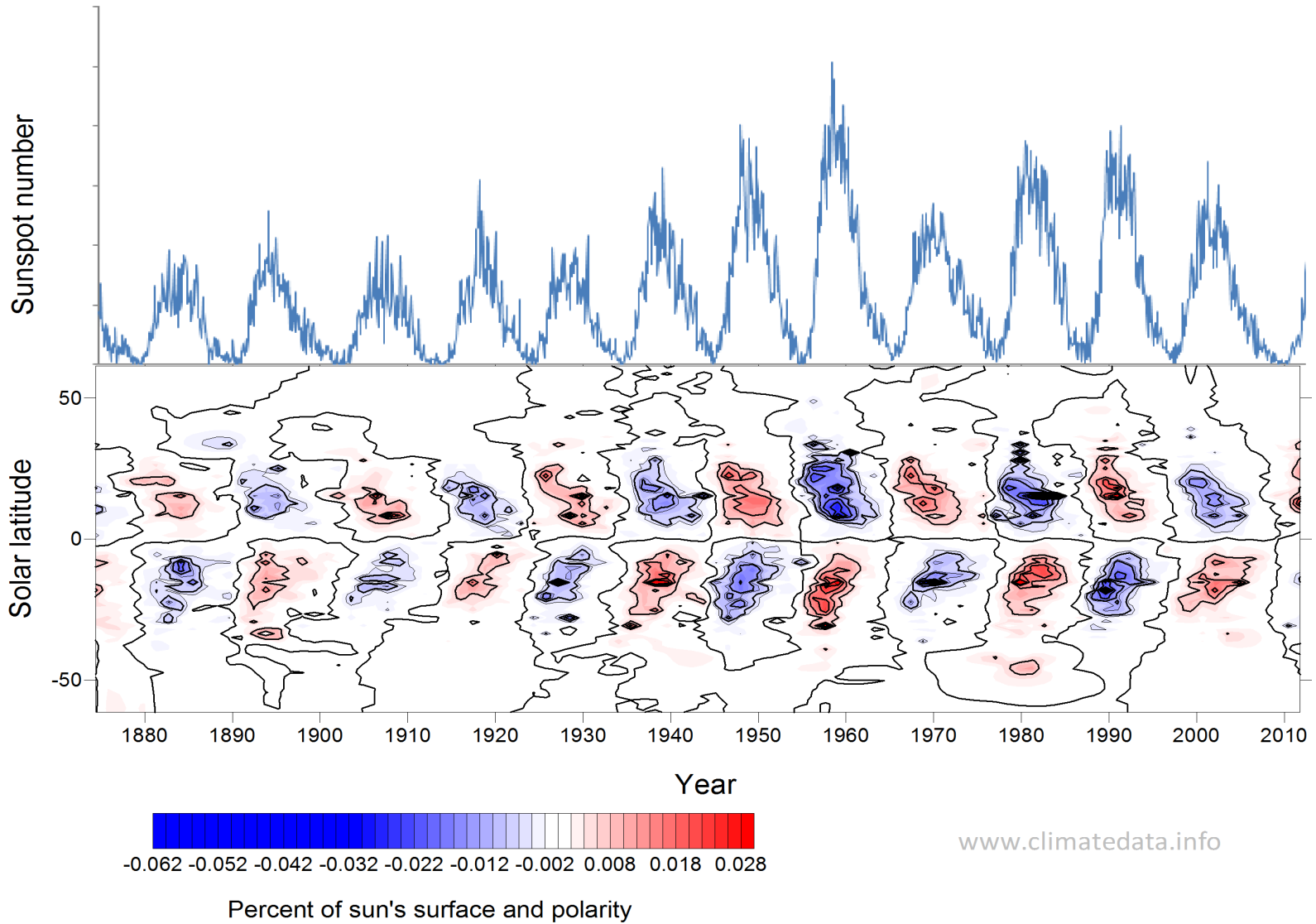
2006/07/31 00:00

SUNSPOT AREA IN EQUAL AREA LATITUDE STRIPS (% OF STRIP AREA)

■ > 0.0% ■ > 0.1% ■ > 1.0%



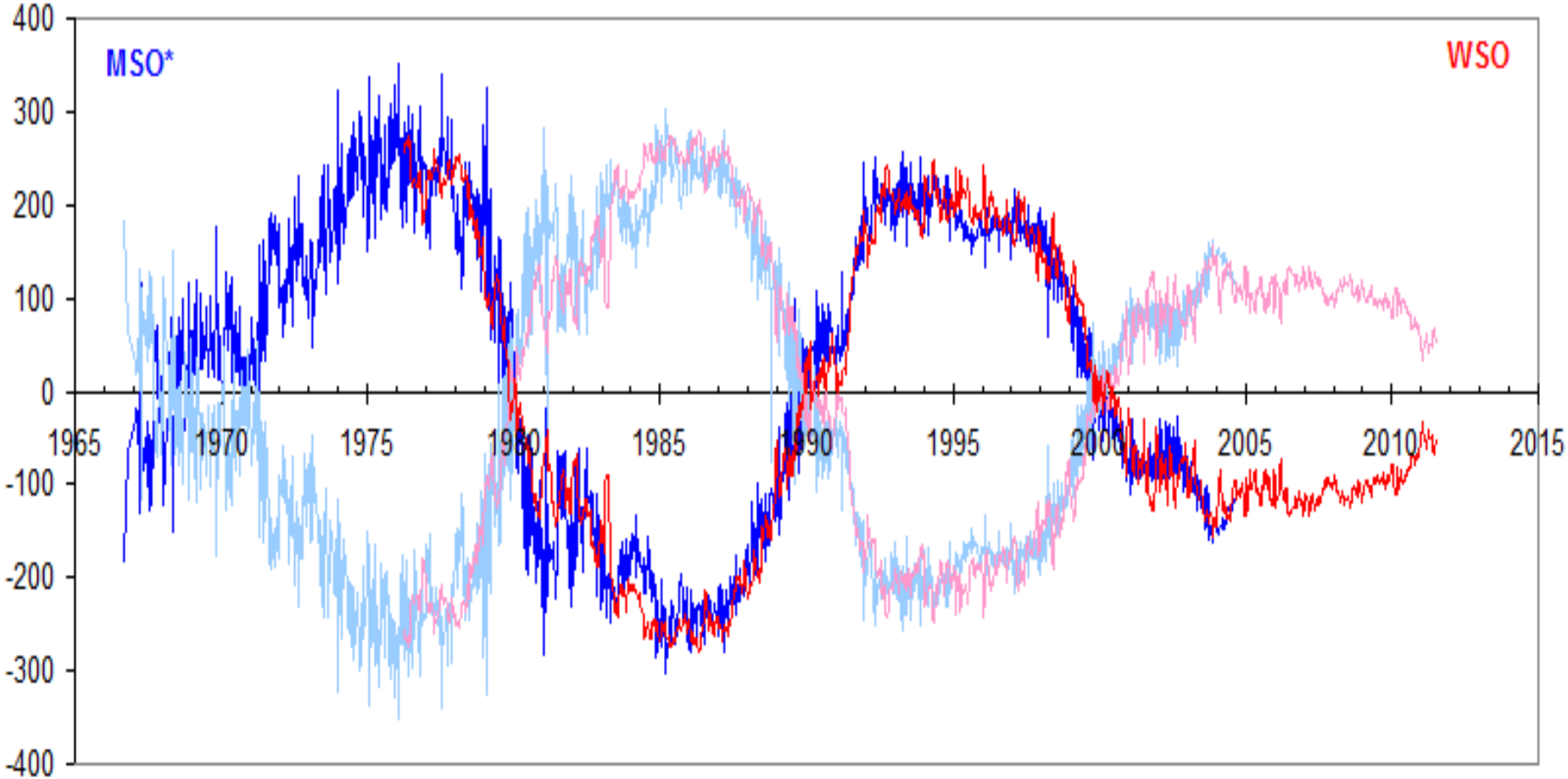
Solar cycles - variation with solar latitude and time



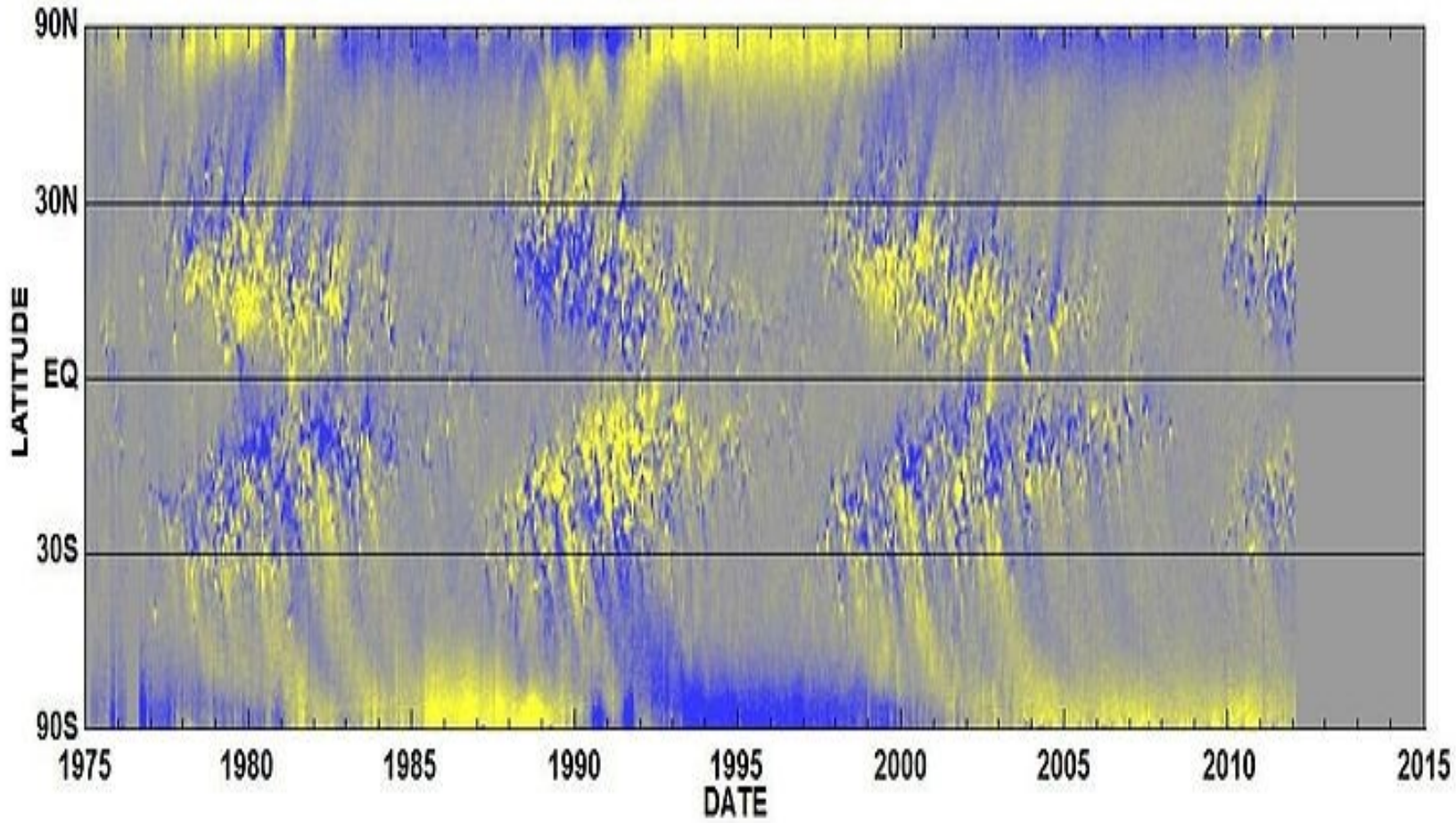
www.climatedata.info



North - South Solar Polar fields [microTesla]



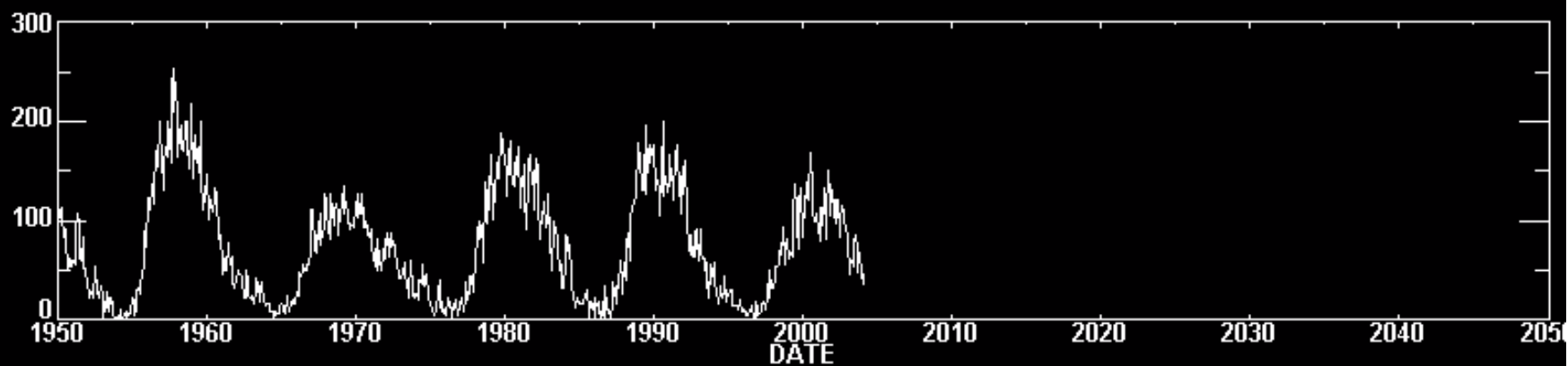
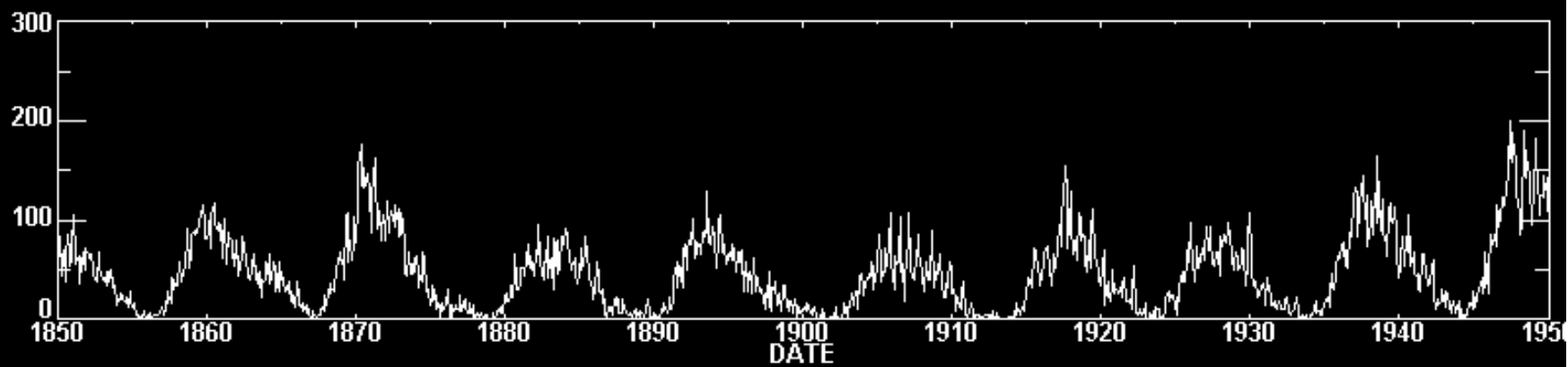
-10G -5G 0G +5G +10G

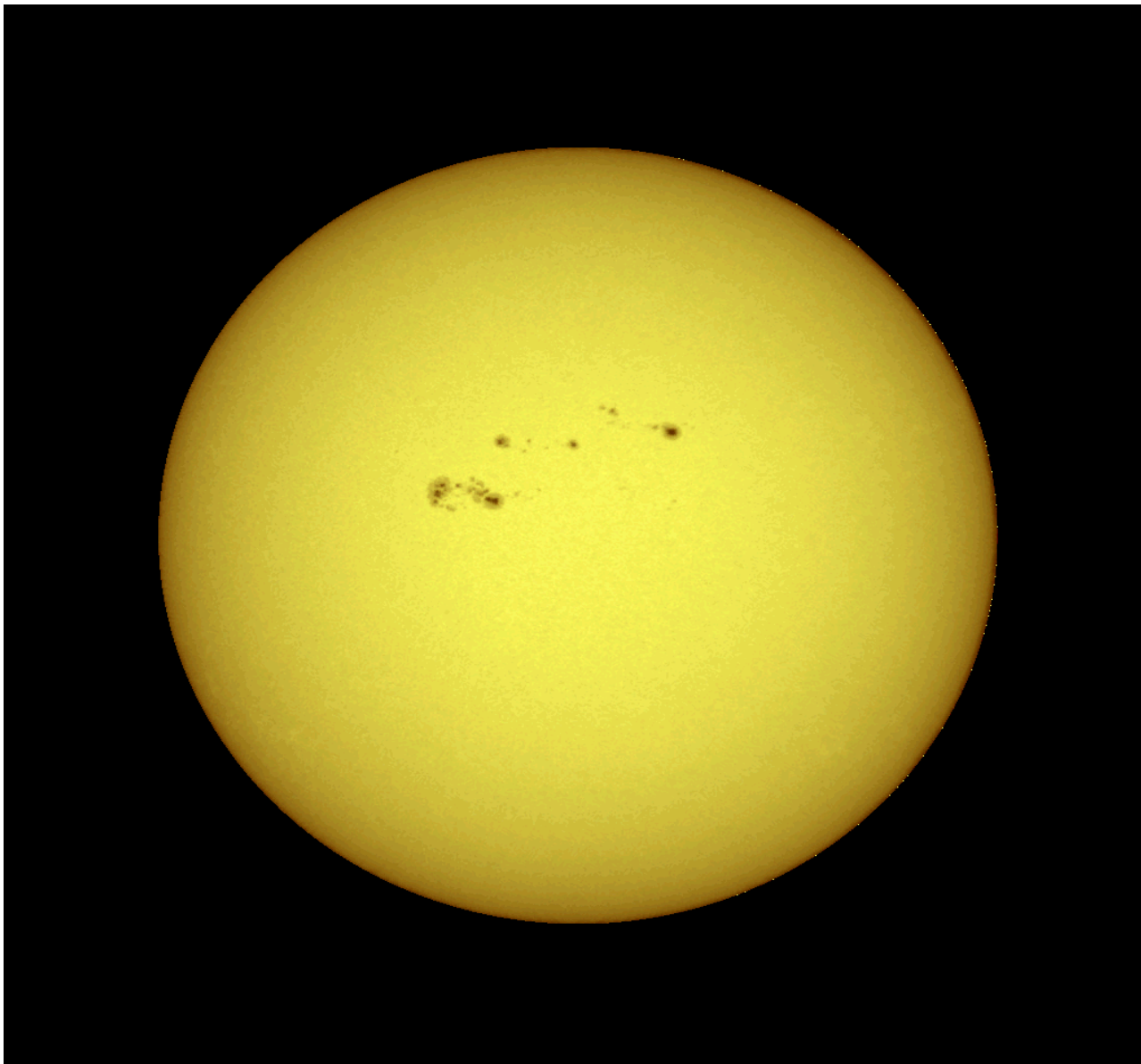


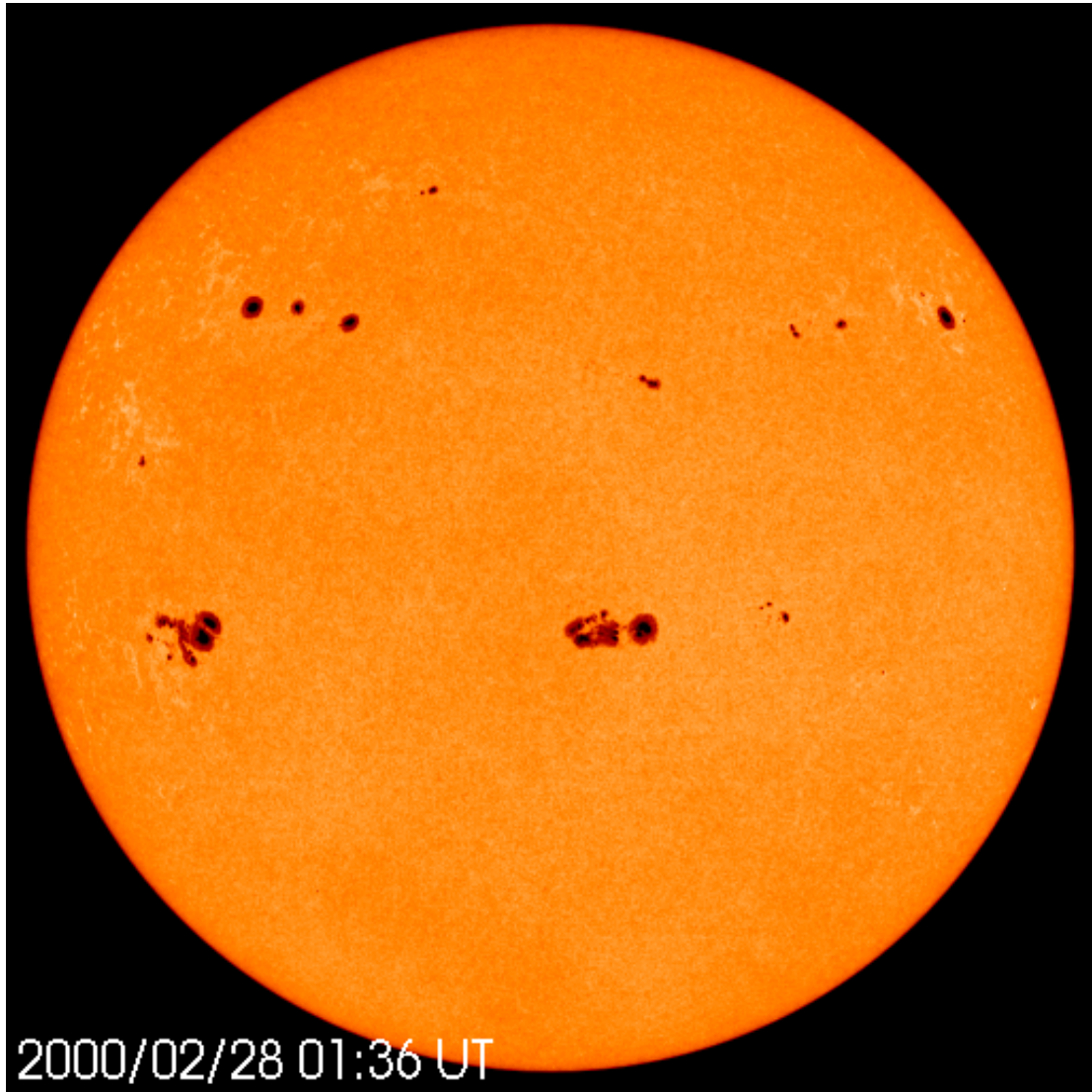
Hathaway/NASA/MSFC 2012/03



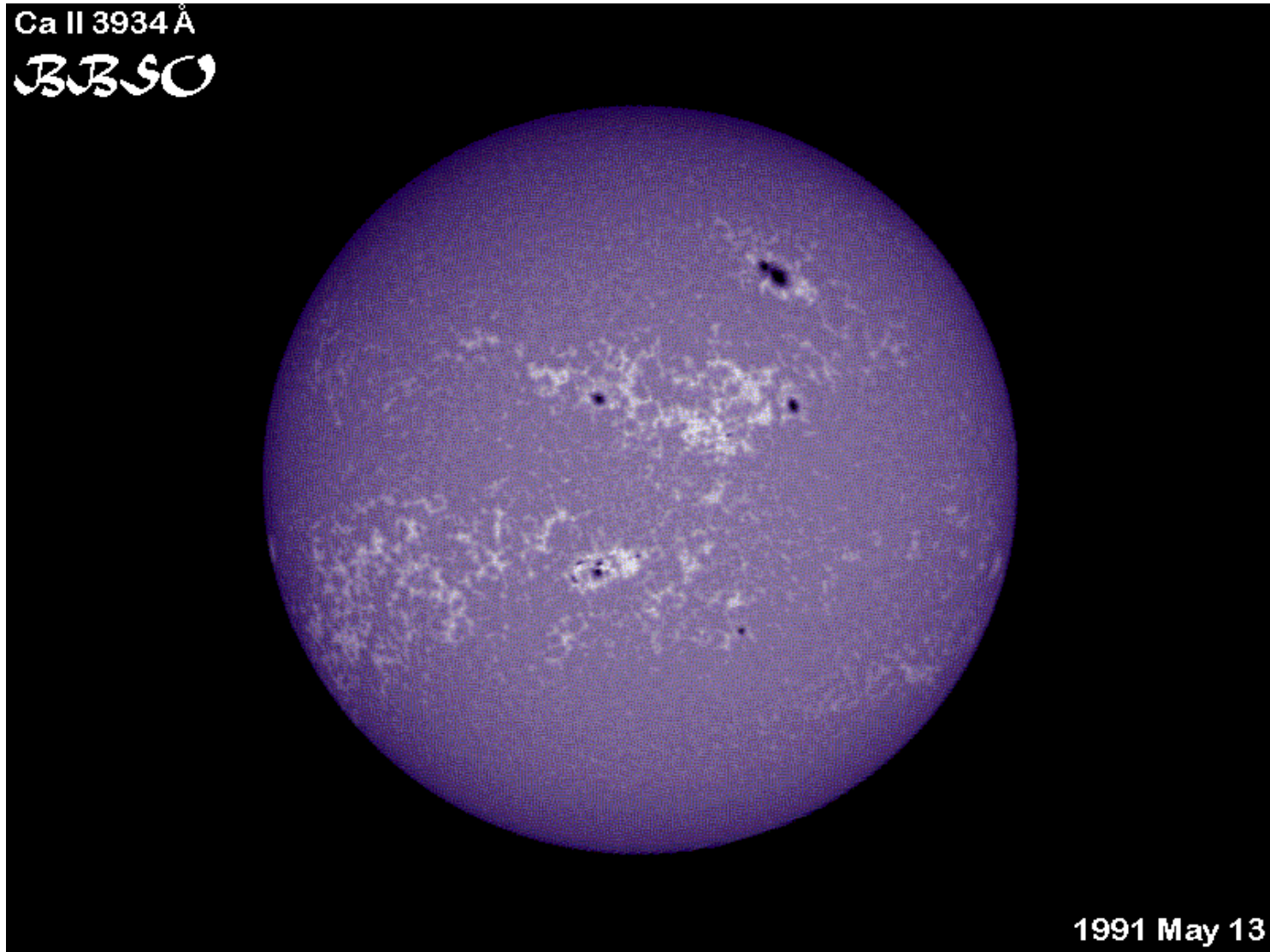
MONTHLY AVERAGE SUNSPOT NUMBER



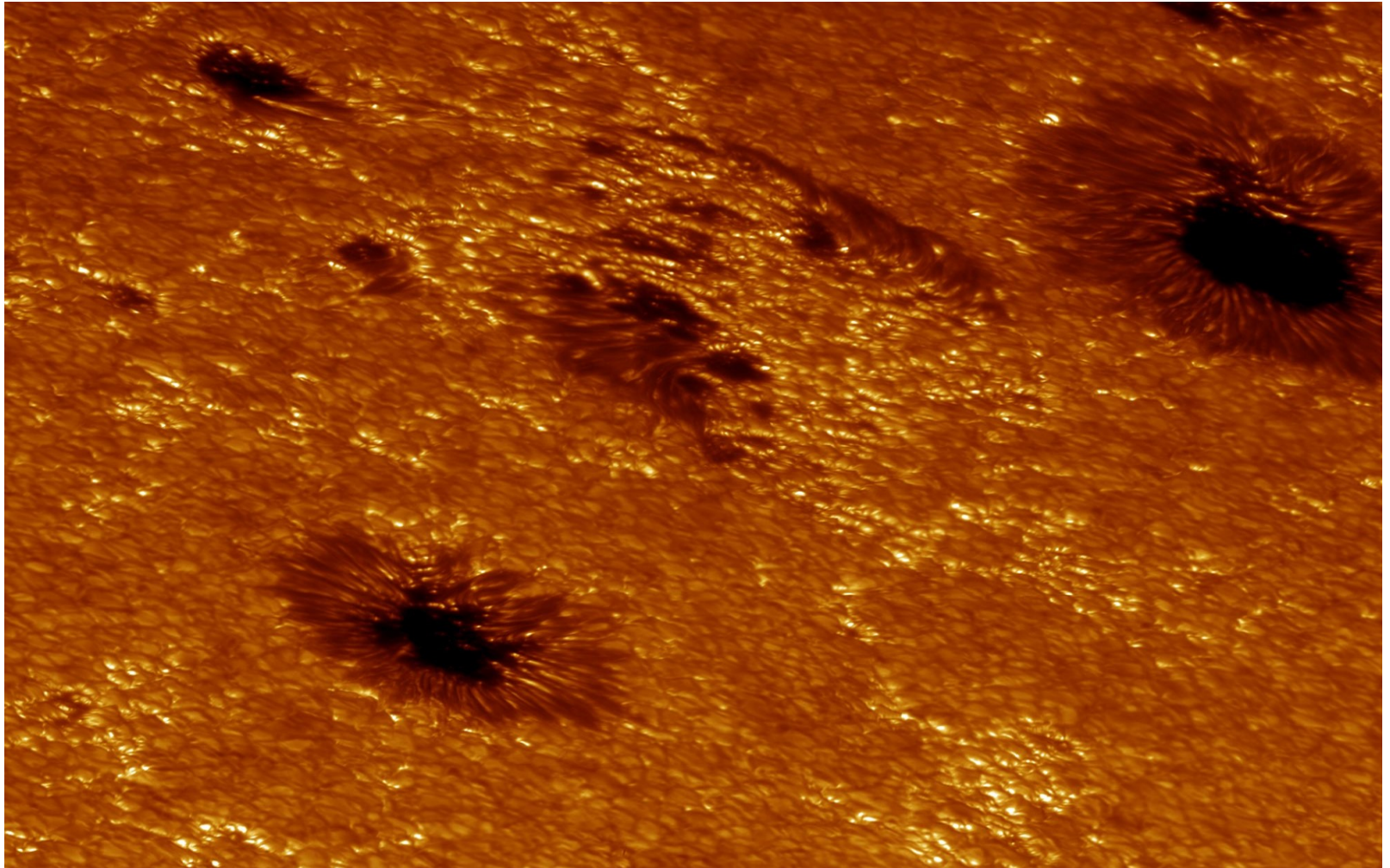




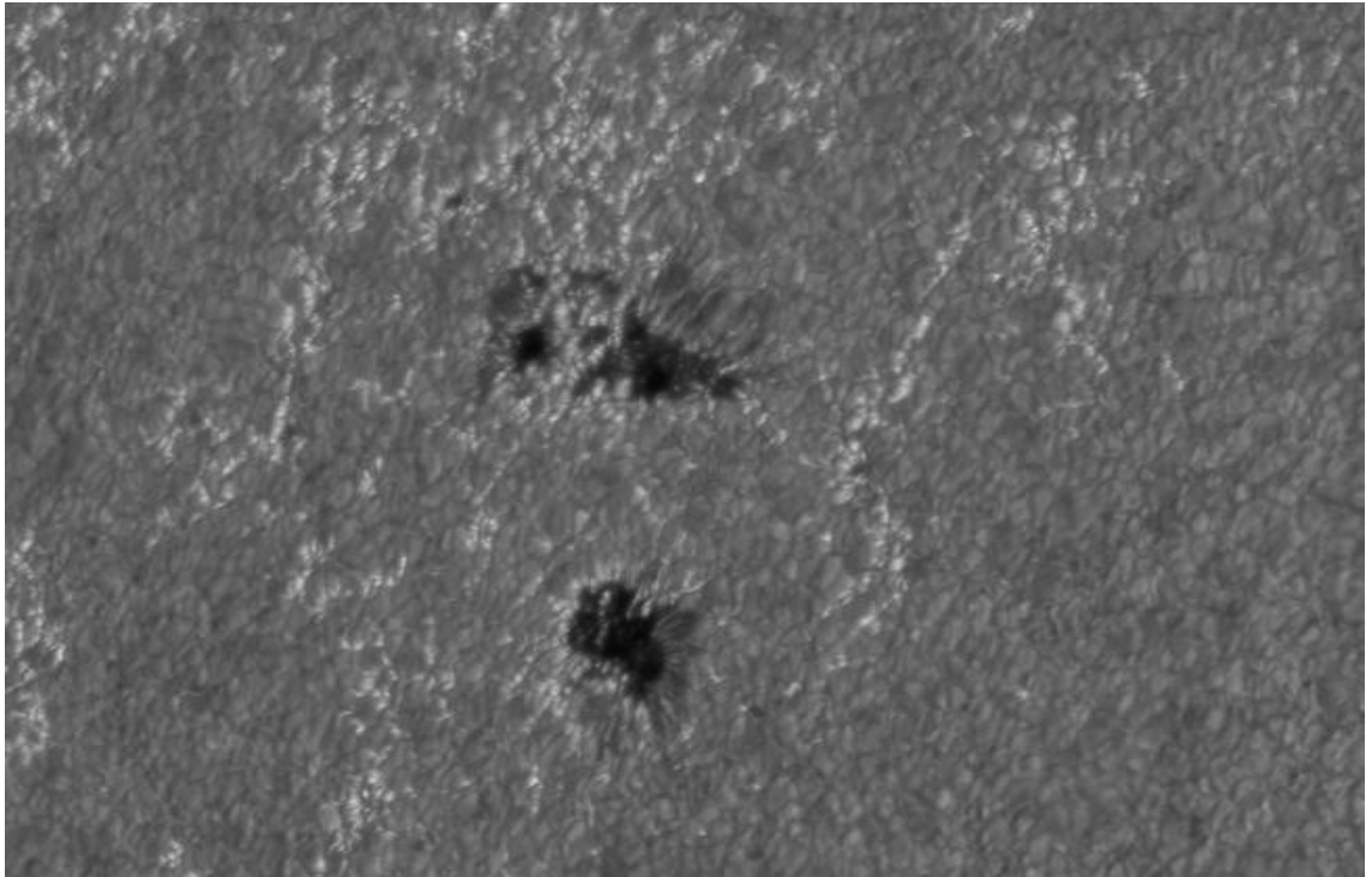
CHROMOSPHERIC NETWORK

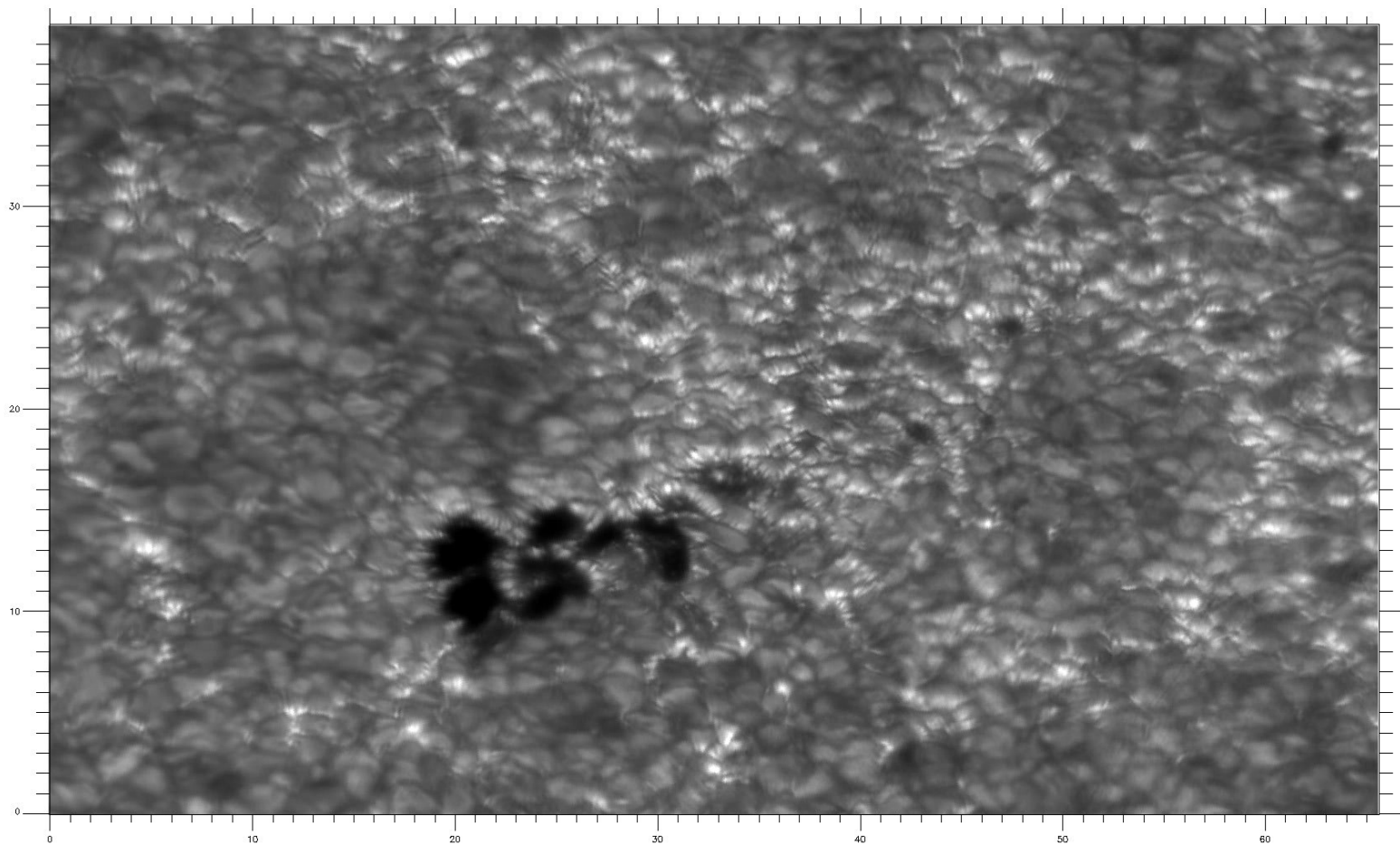


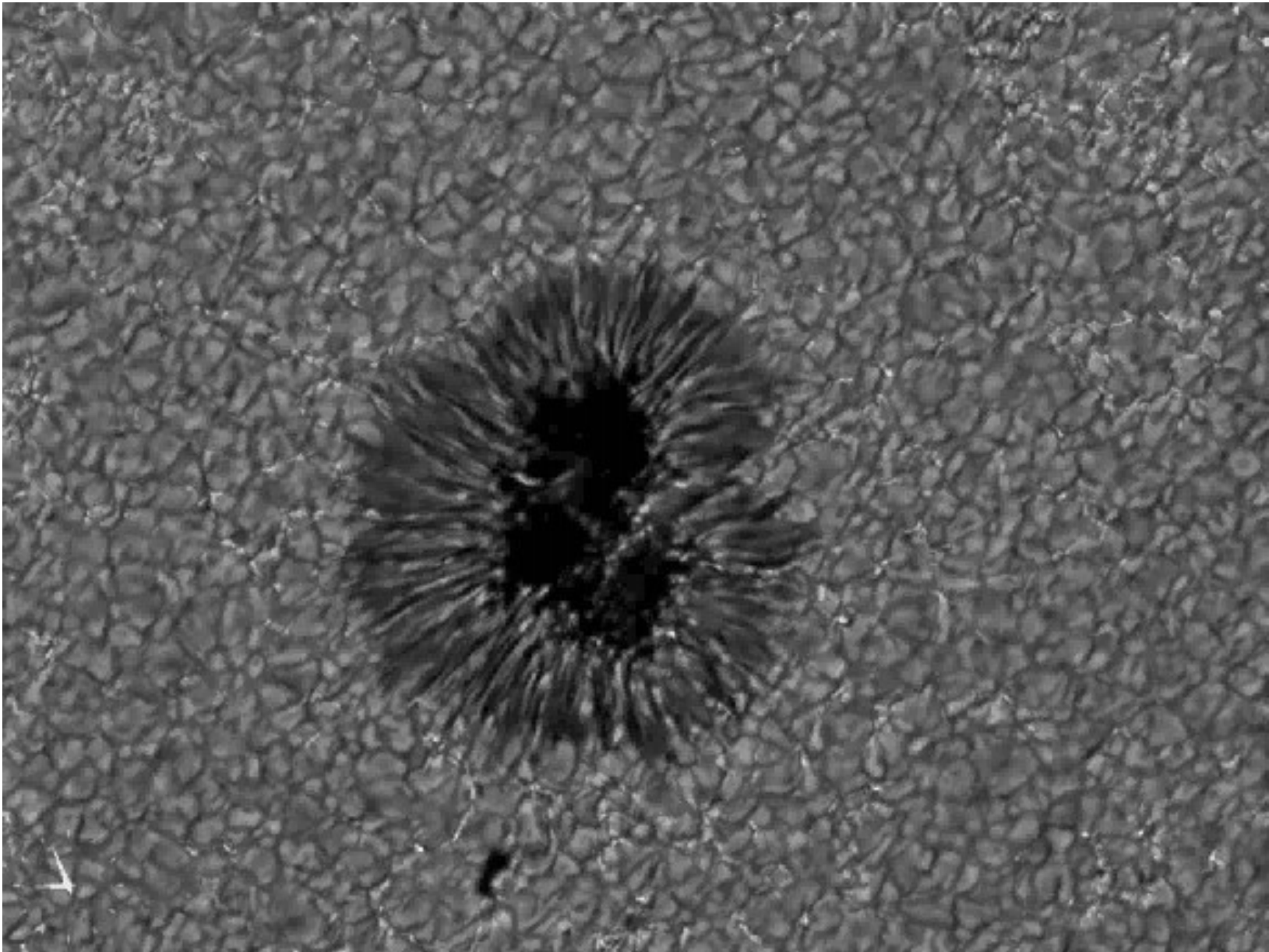
PHOTOSPHERE FACULAE

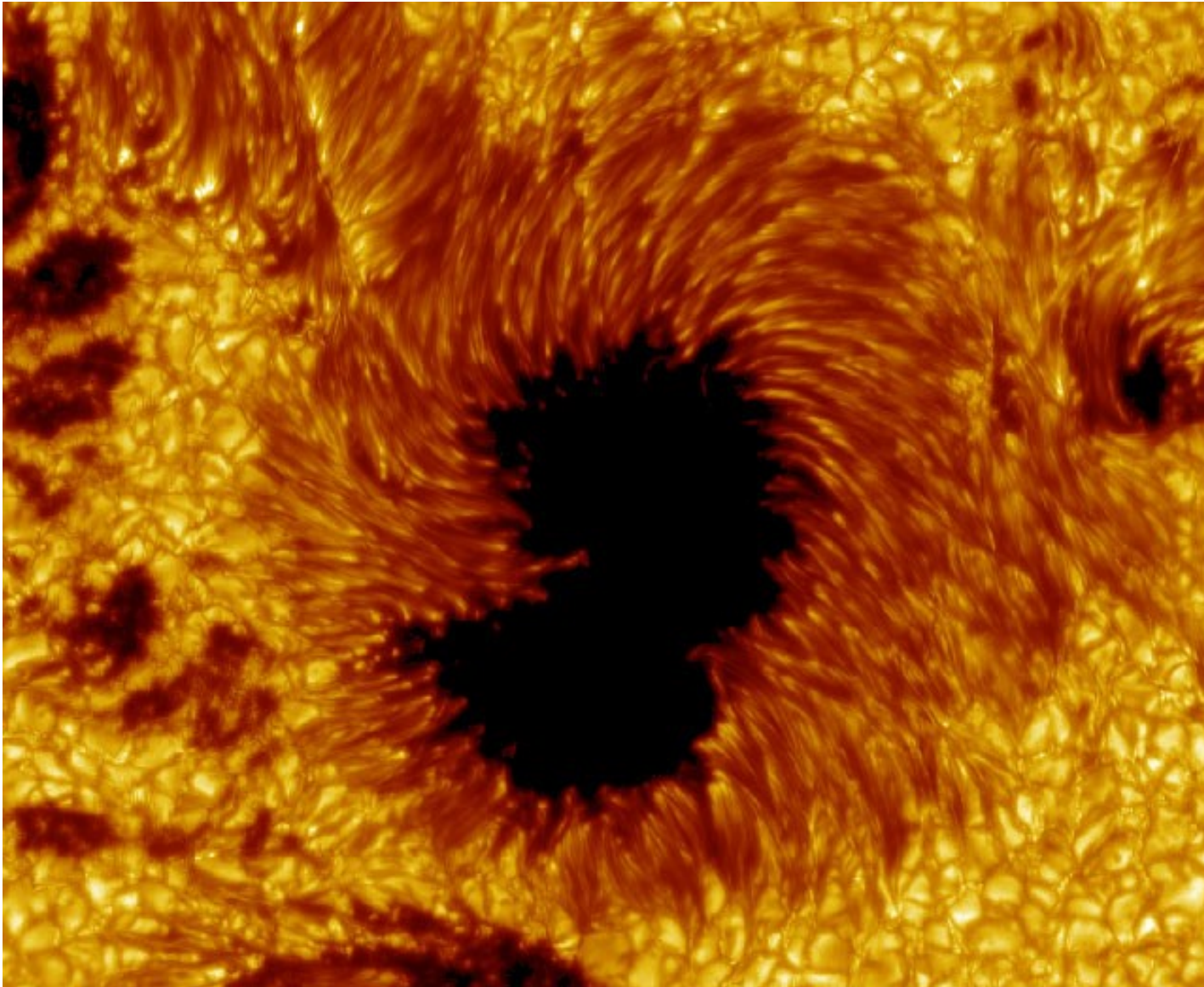


CHROMOSPHERE-PLAGE

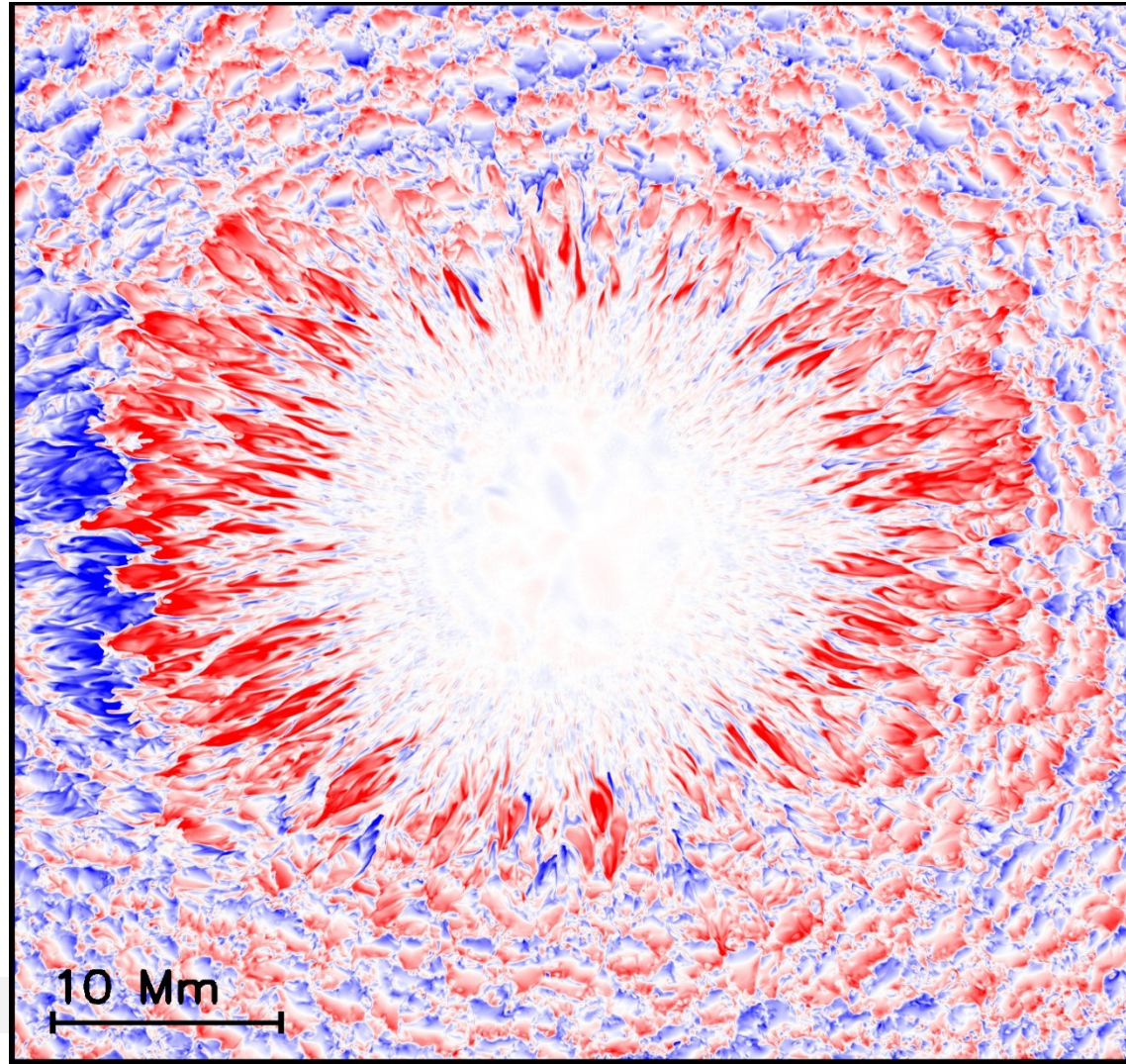
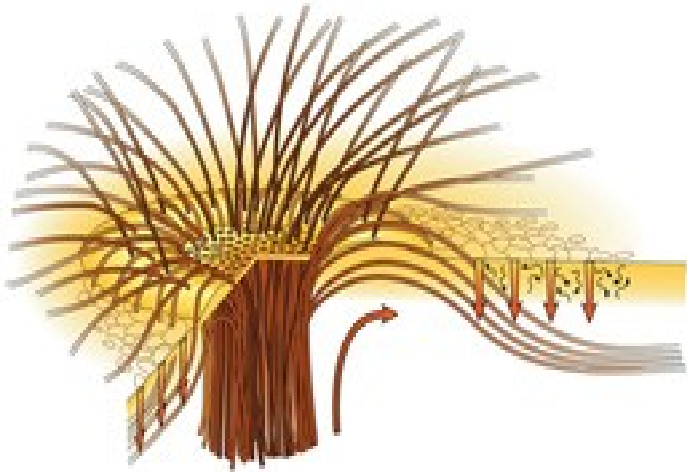




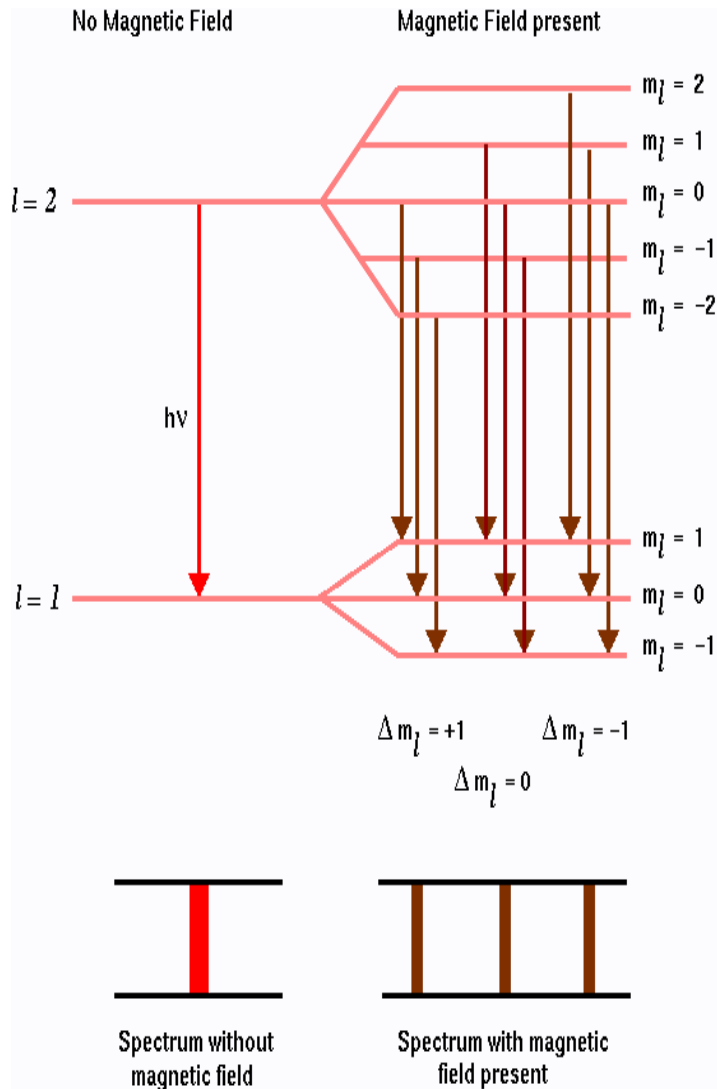




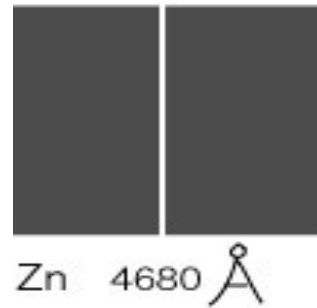
EVERSHED EFFECT



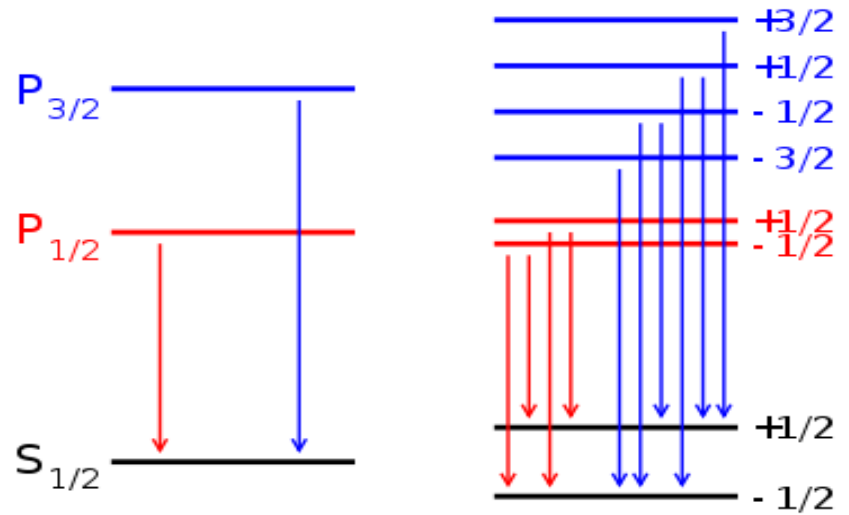
ZEEMAN EFFECT

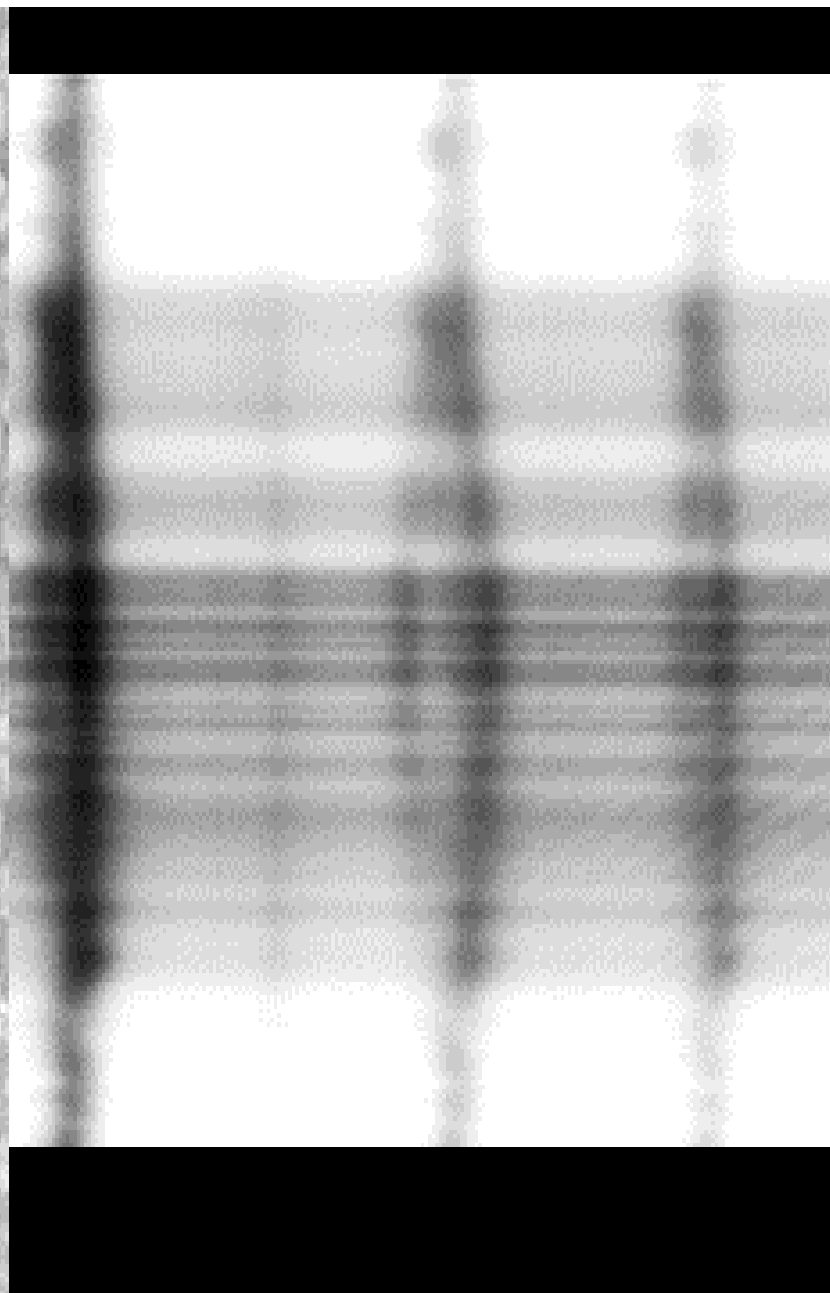
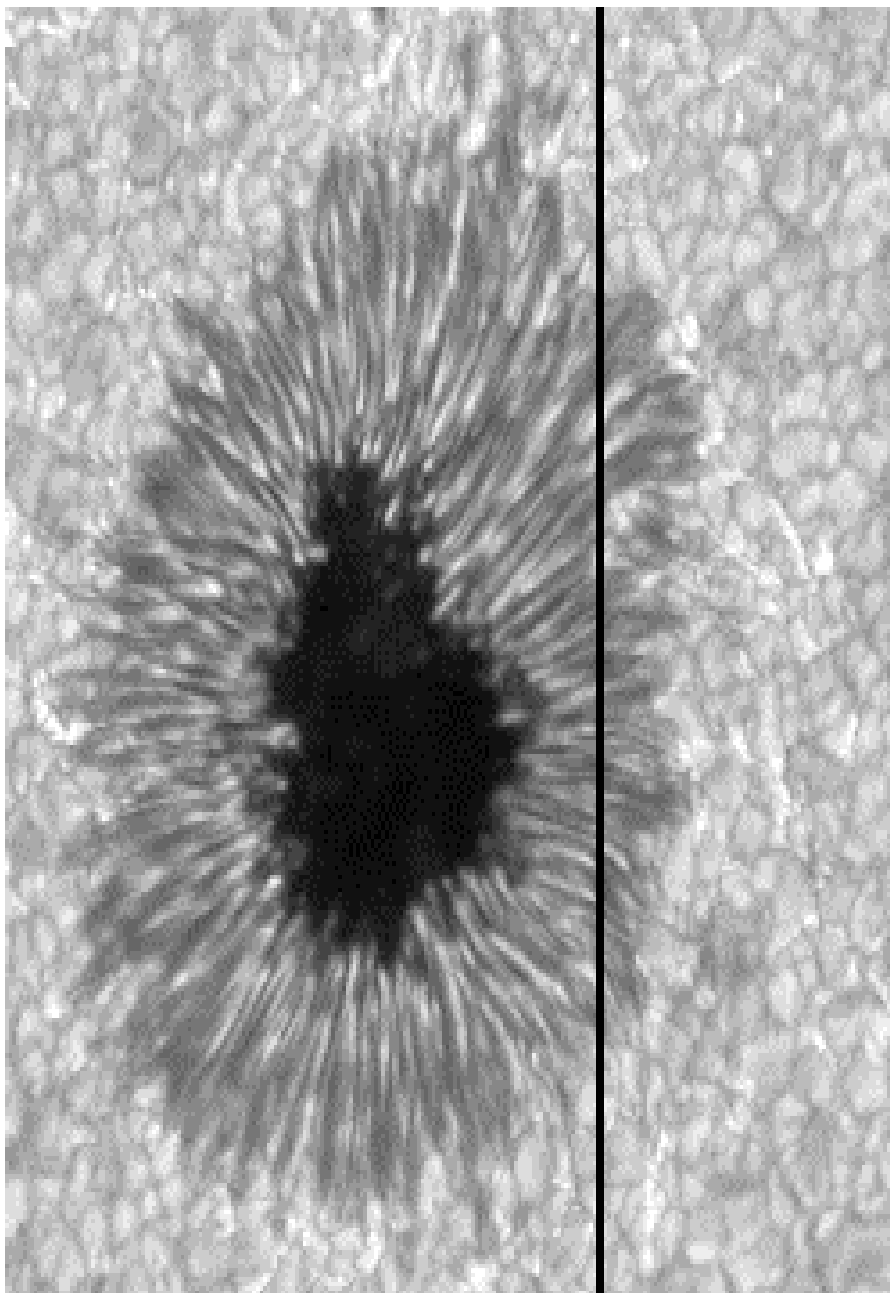


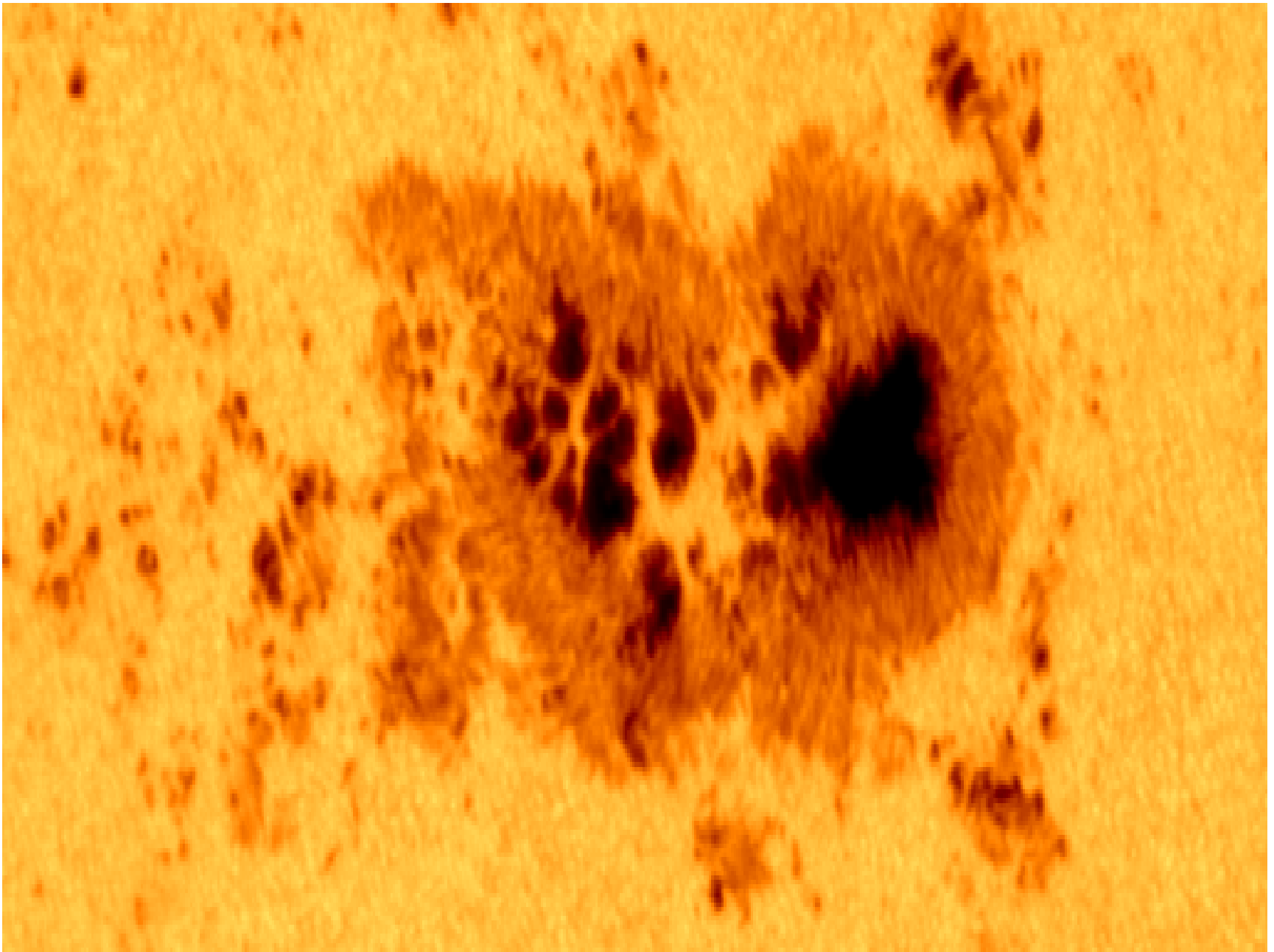
ZEEMAN EFFECT

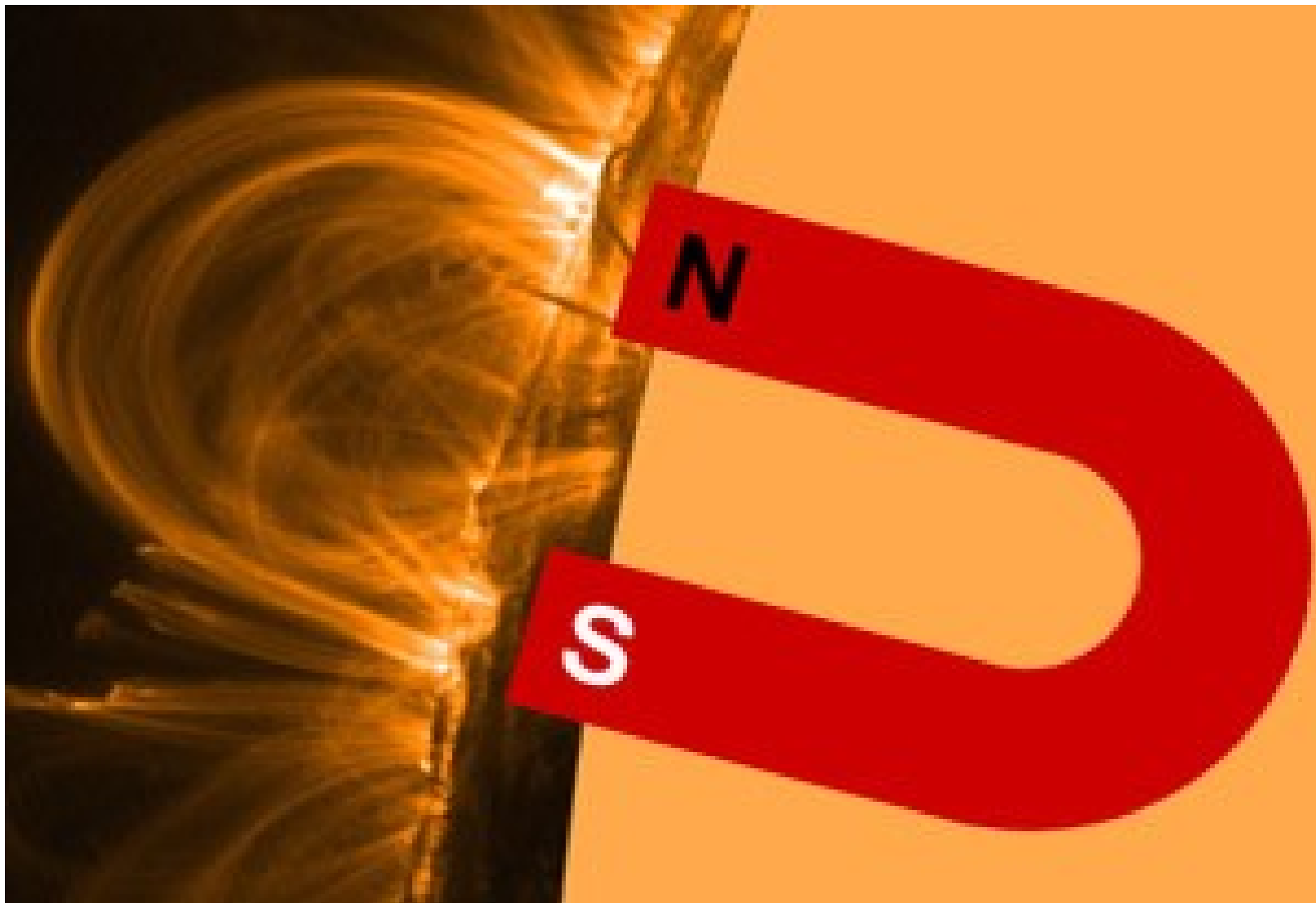


In a magnetic field the original line splits into three

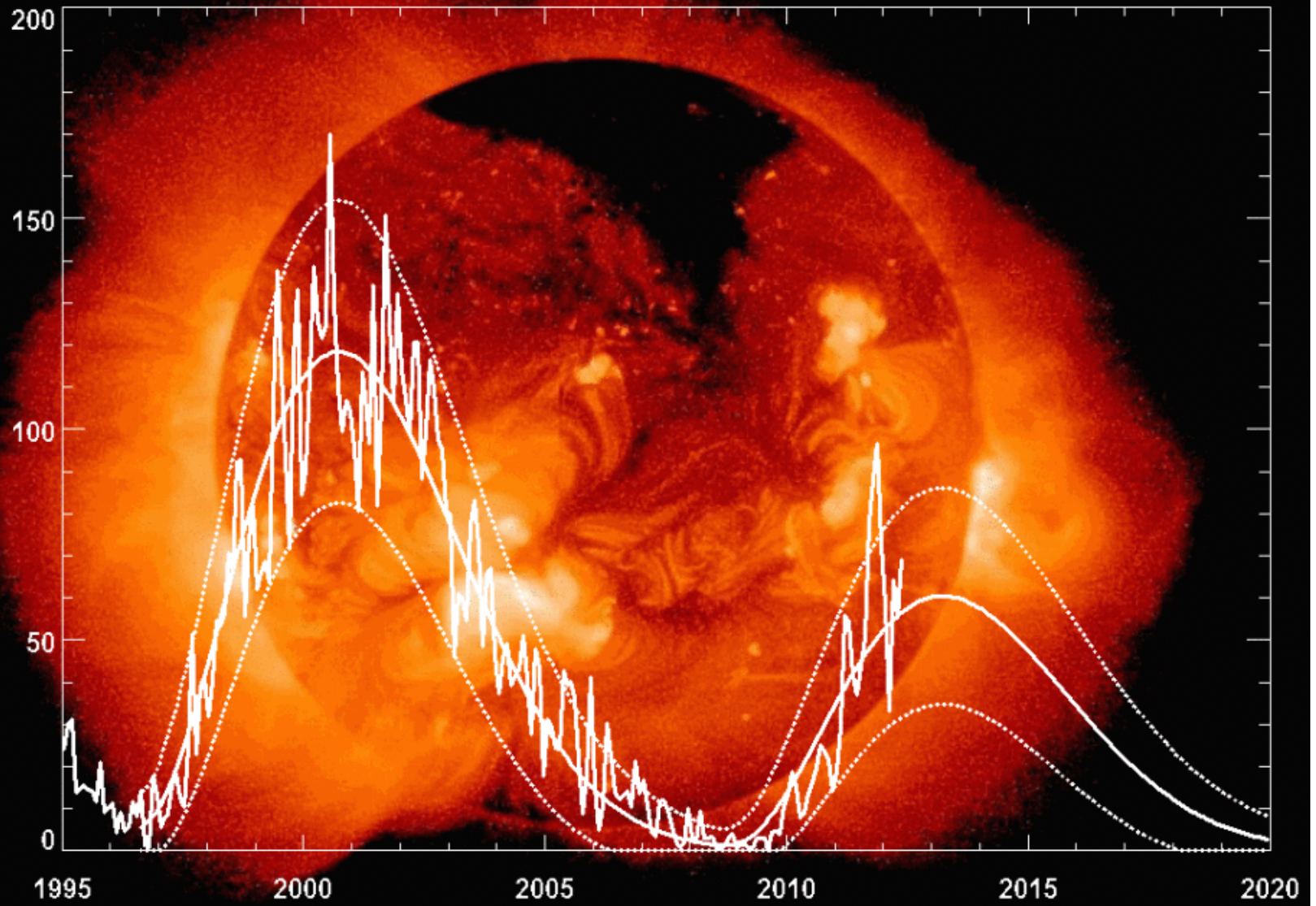




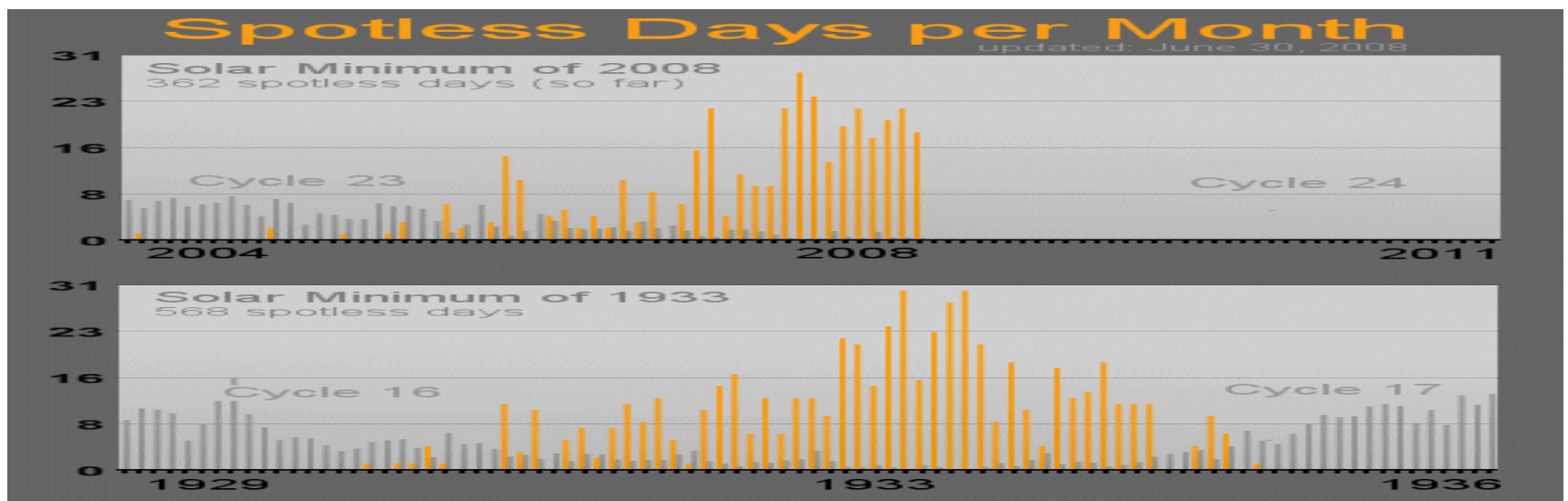
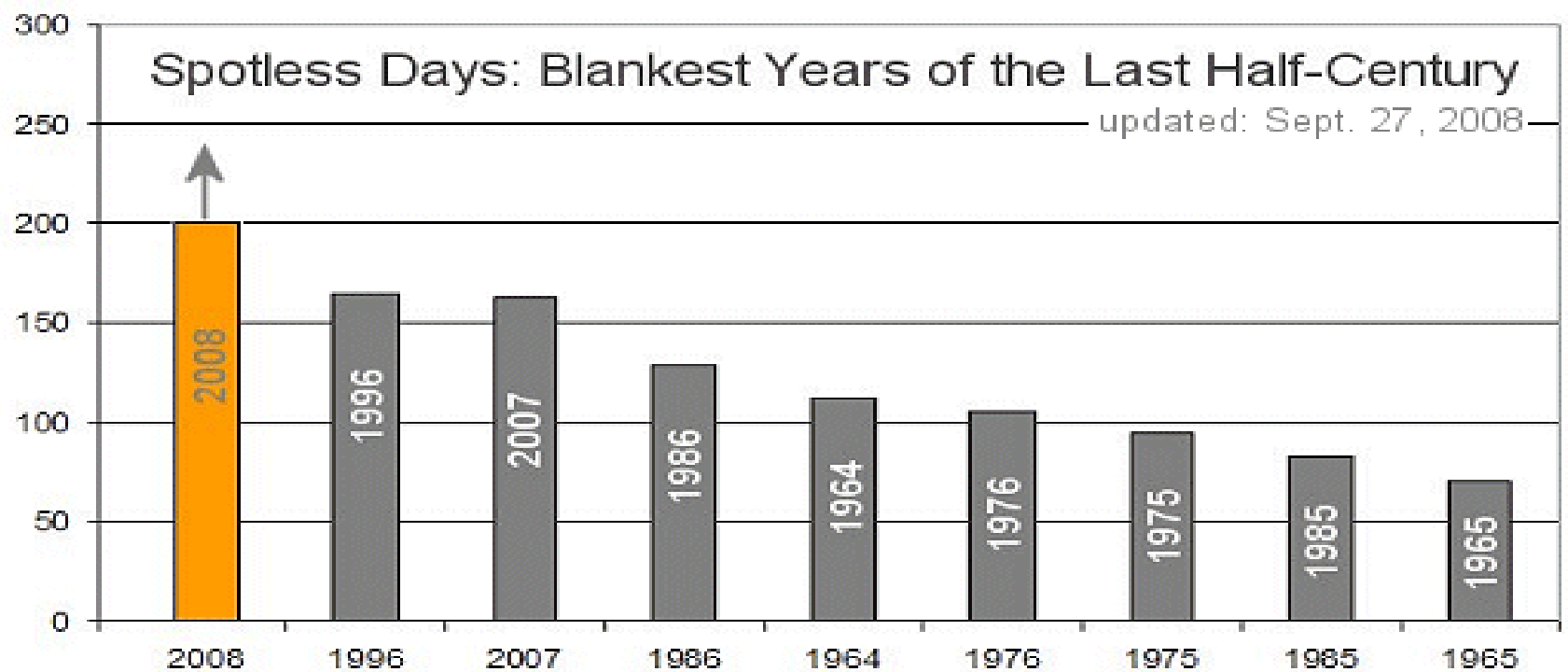




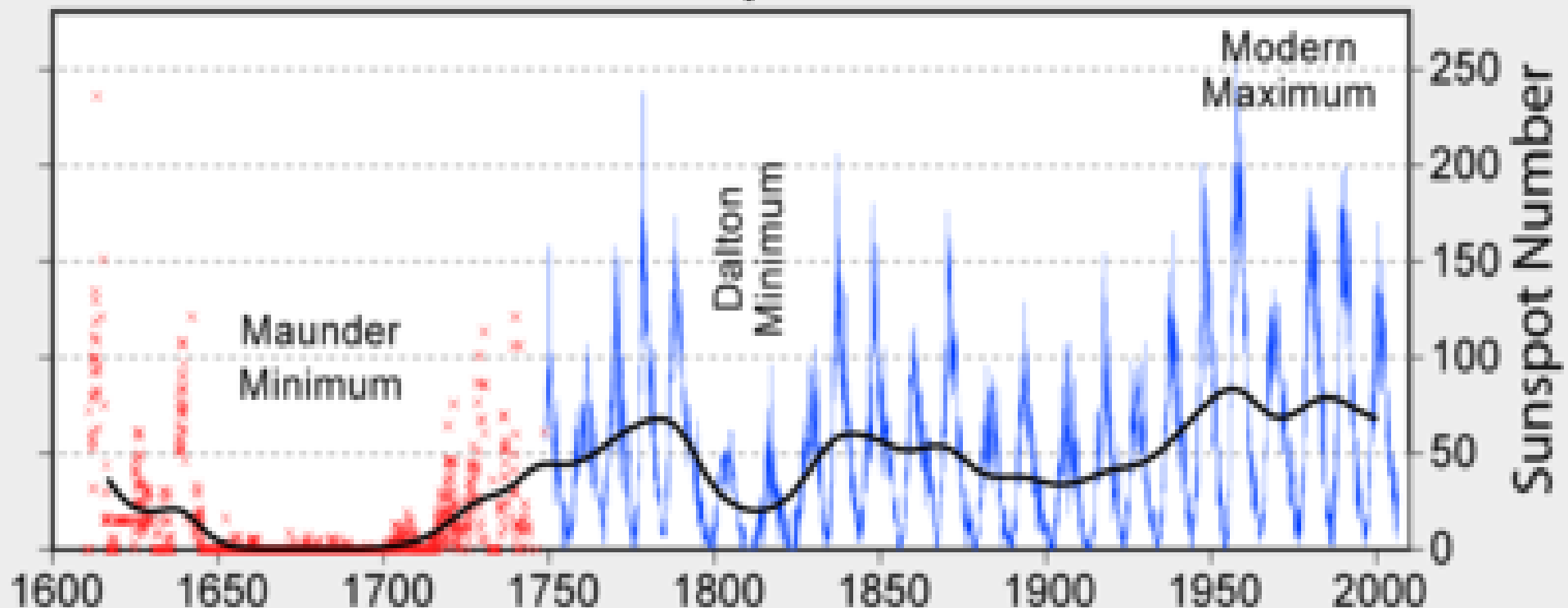
Cycle 24 Sunspot Number Prediction (June 2012)

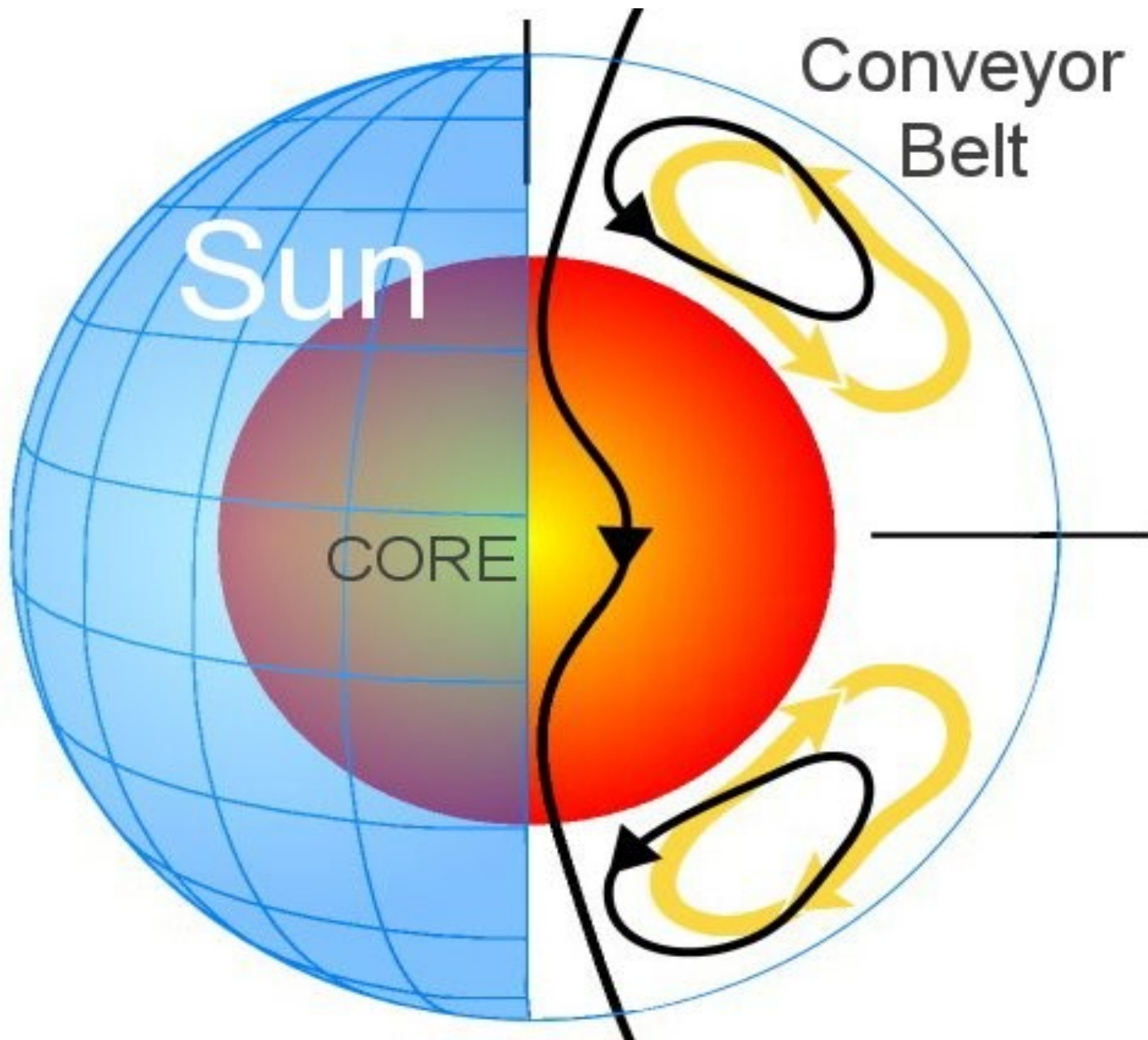


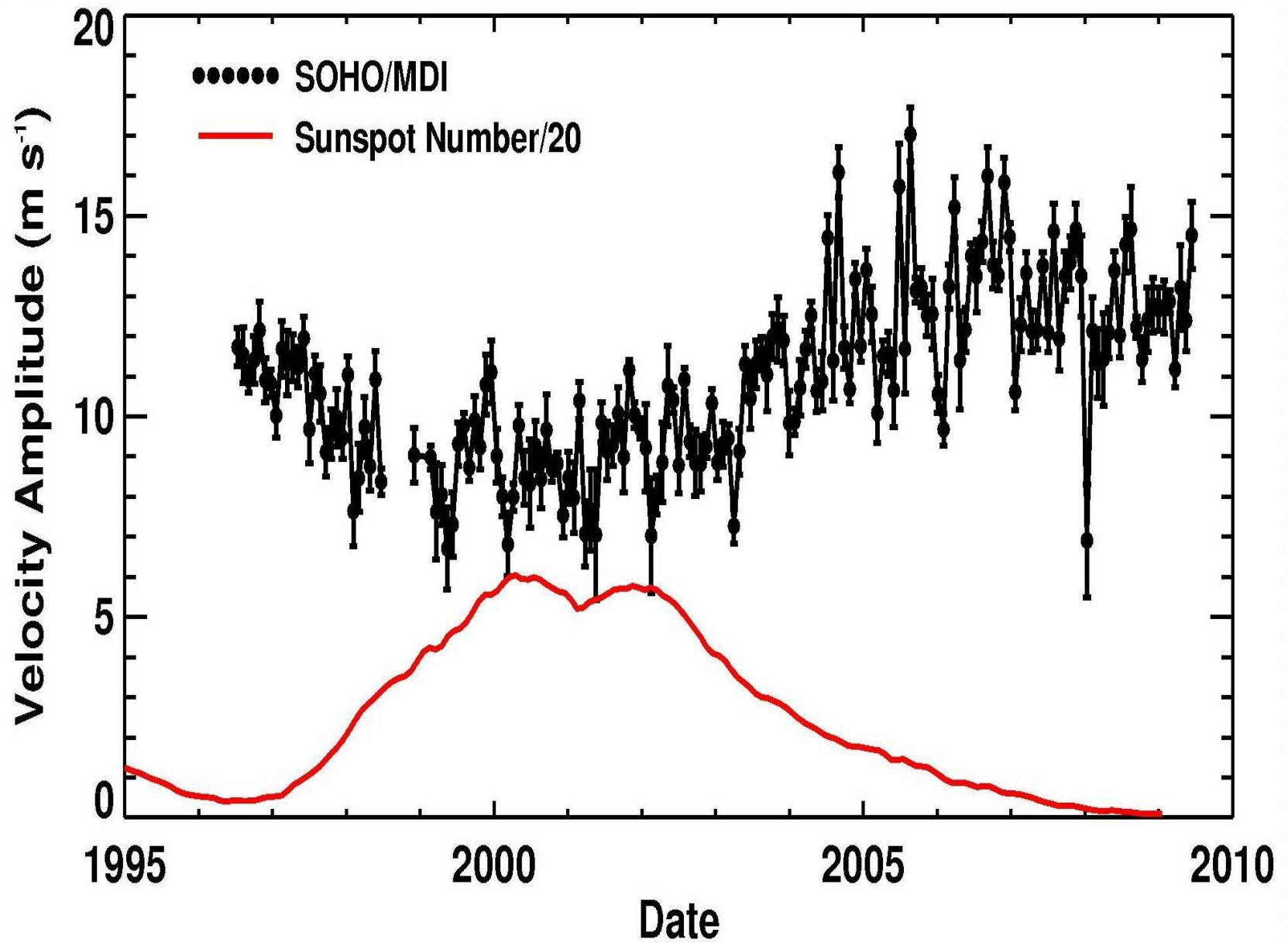
Hathaway/NASA/MSFC



400 Years of Sunspot Observations

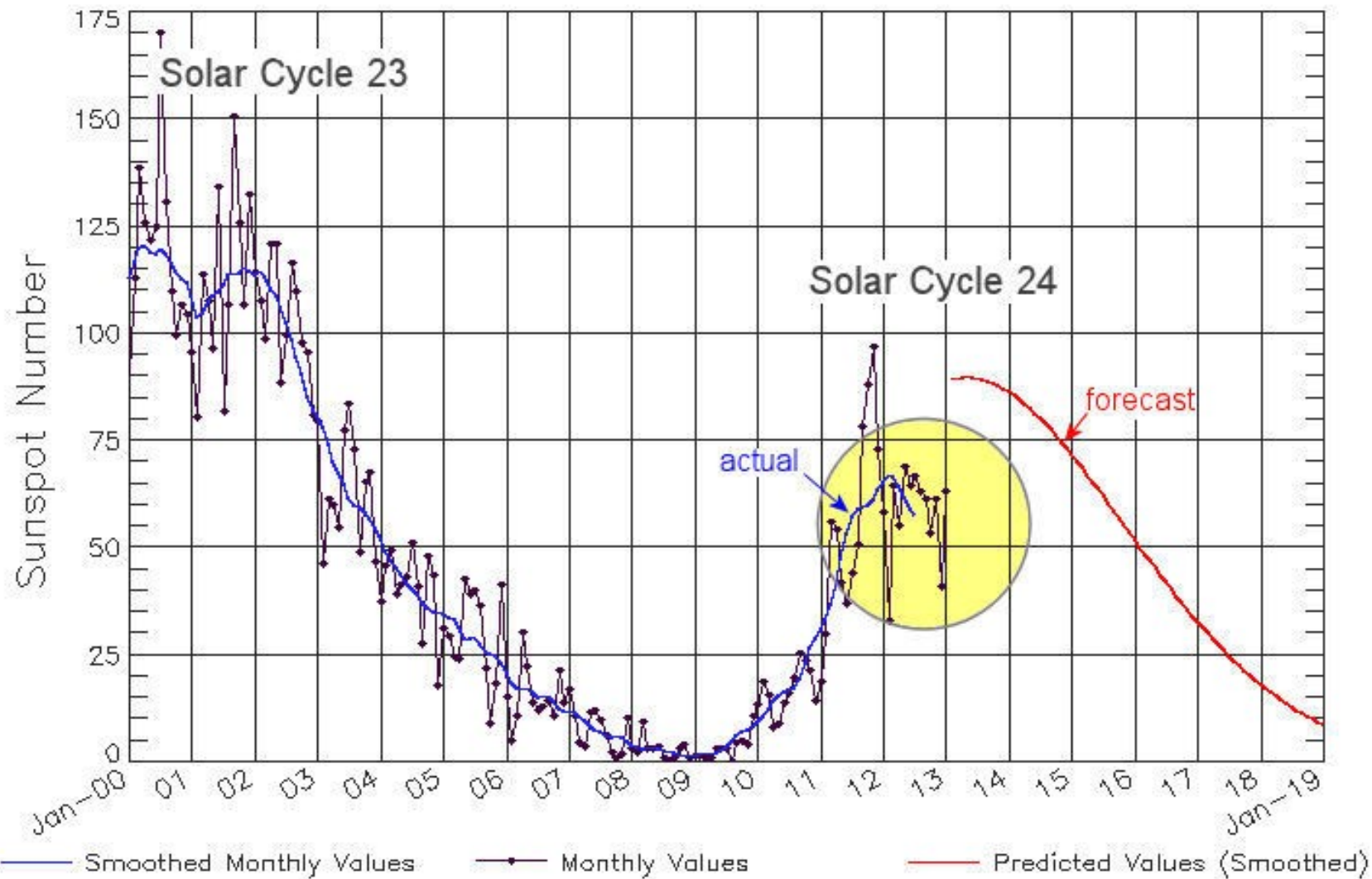






ISES Solar Cycle Sunspot Number Progression

Observed data through Jan 2013

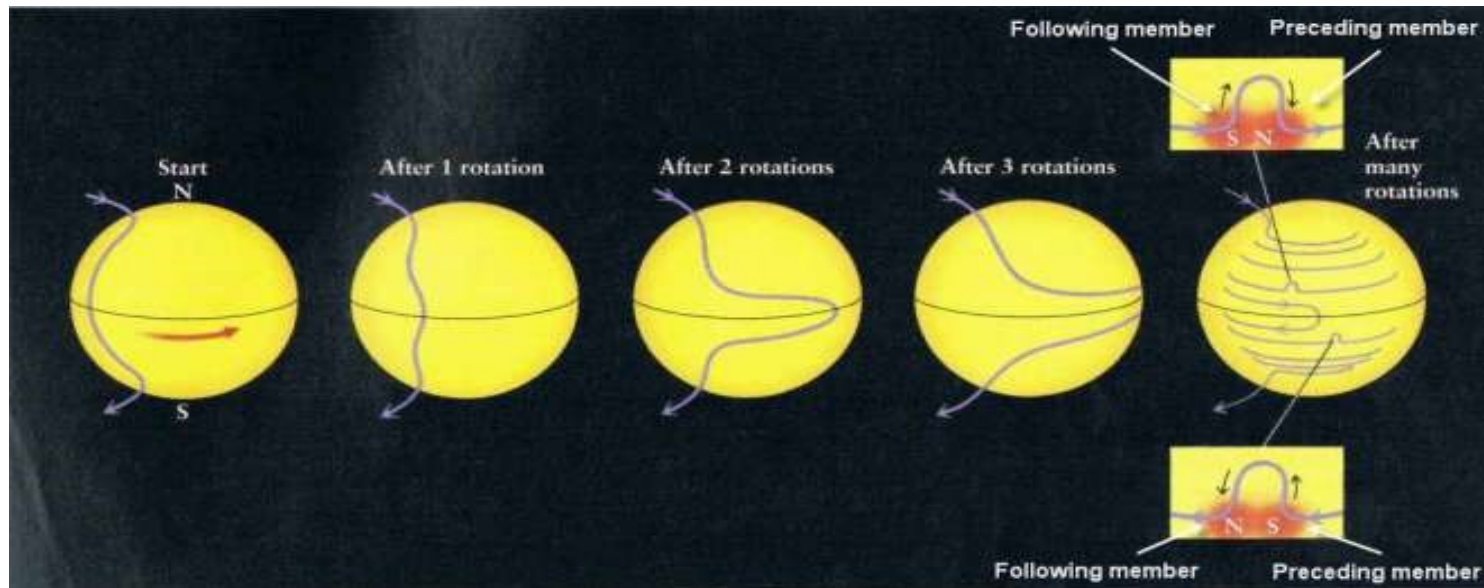
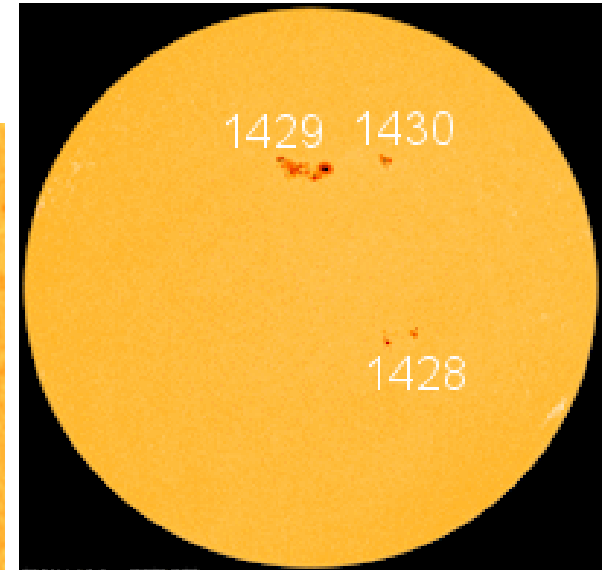
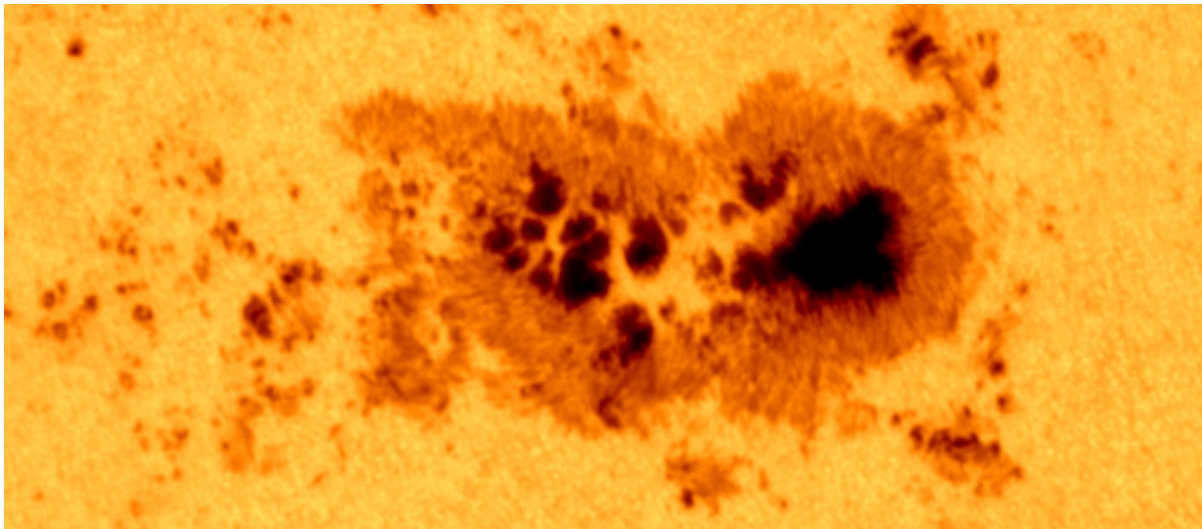


Updated 2013 Feb 4

NOAA/SWPC Boulder, CO USA

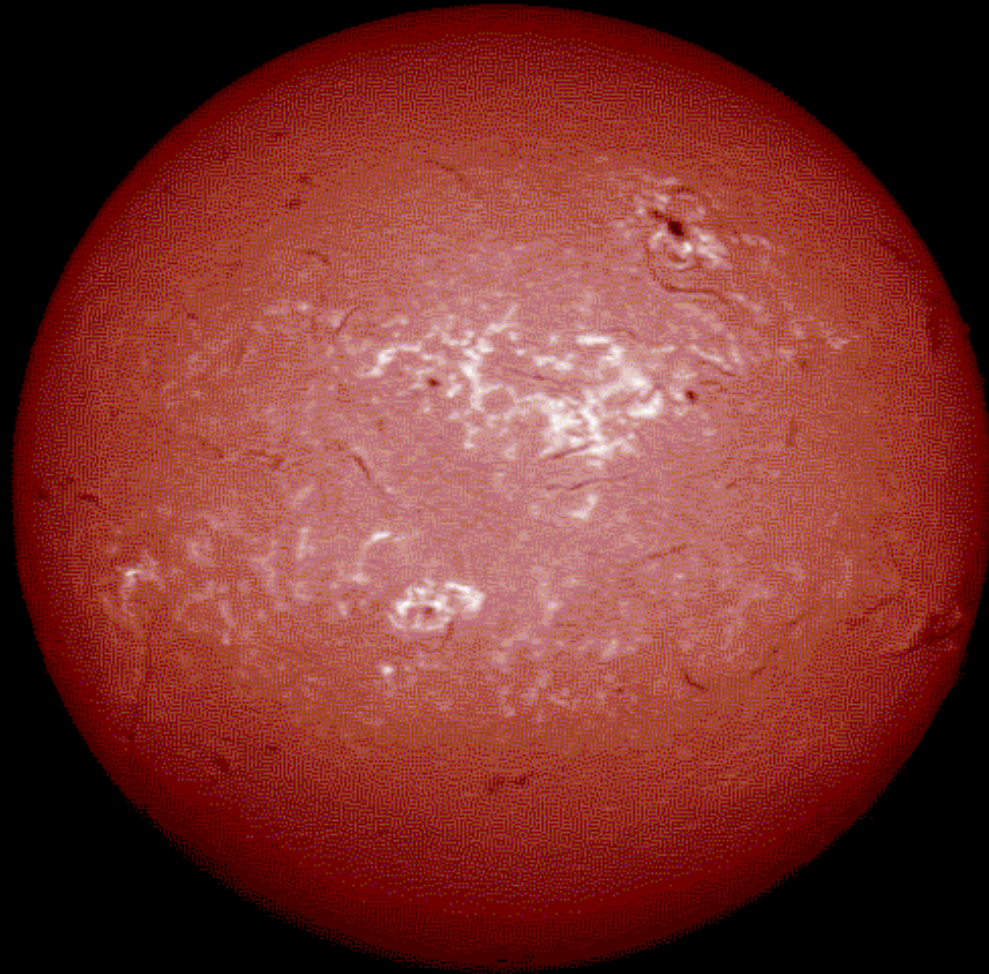


MARCH 2012



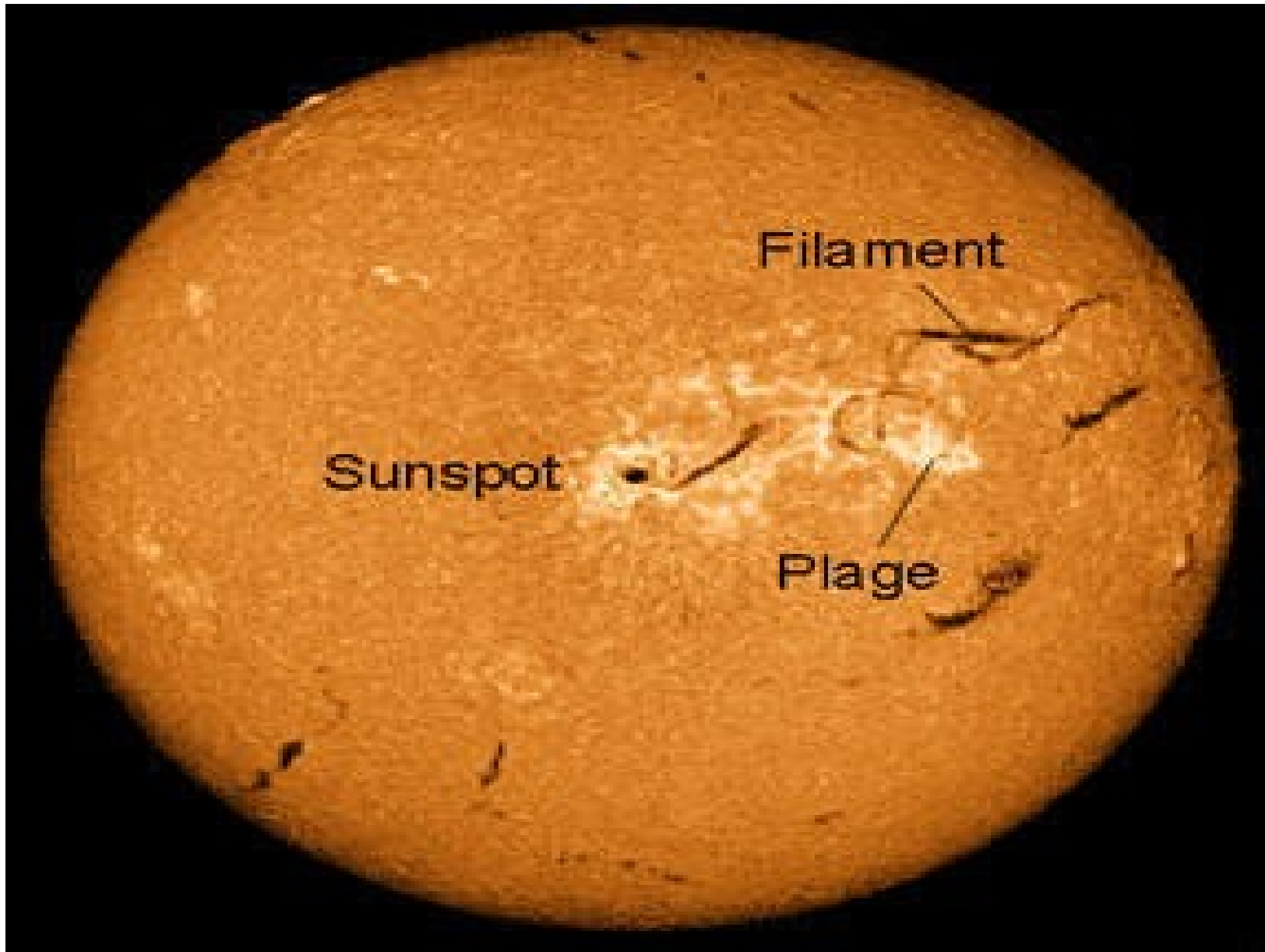
HI 6563 Å

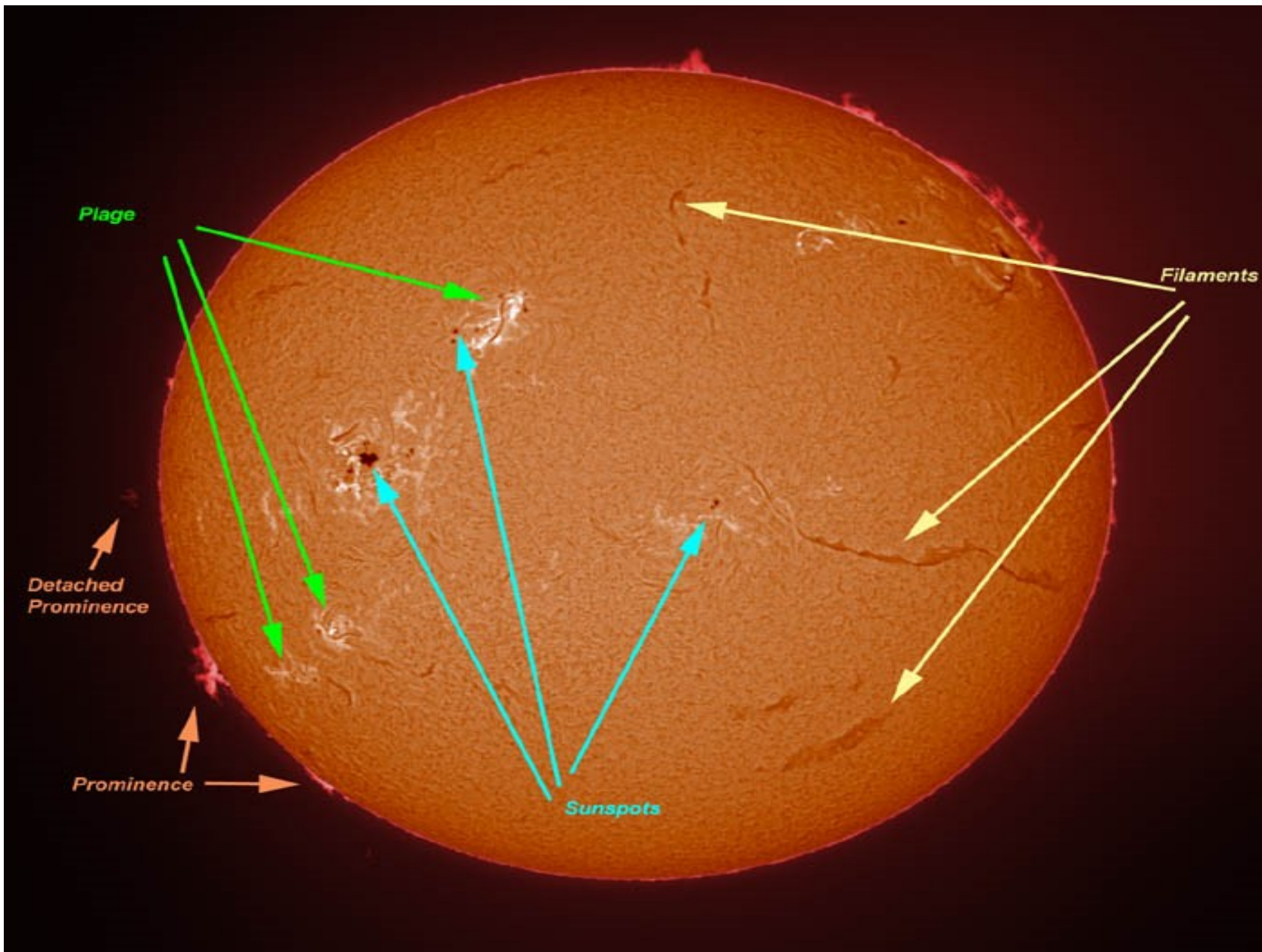
BBSO



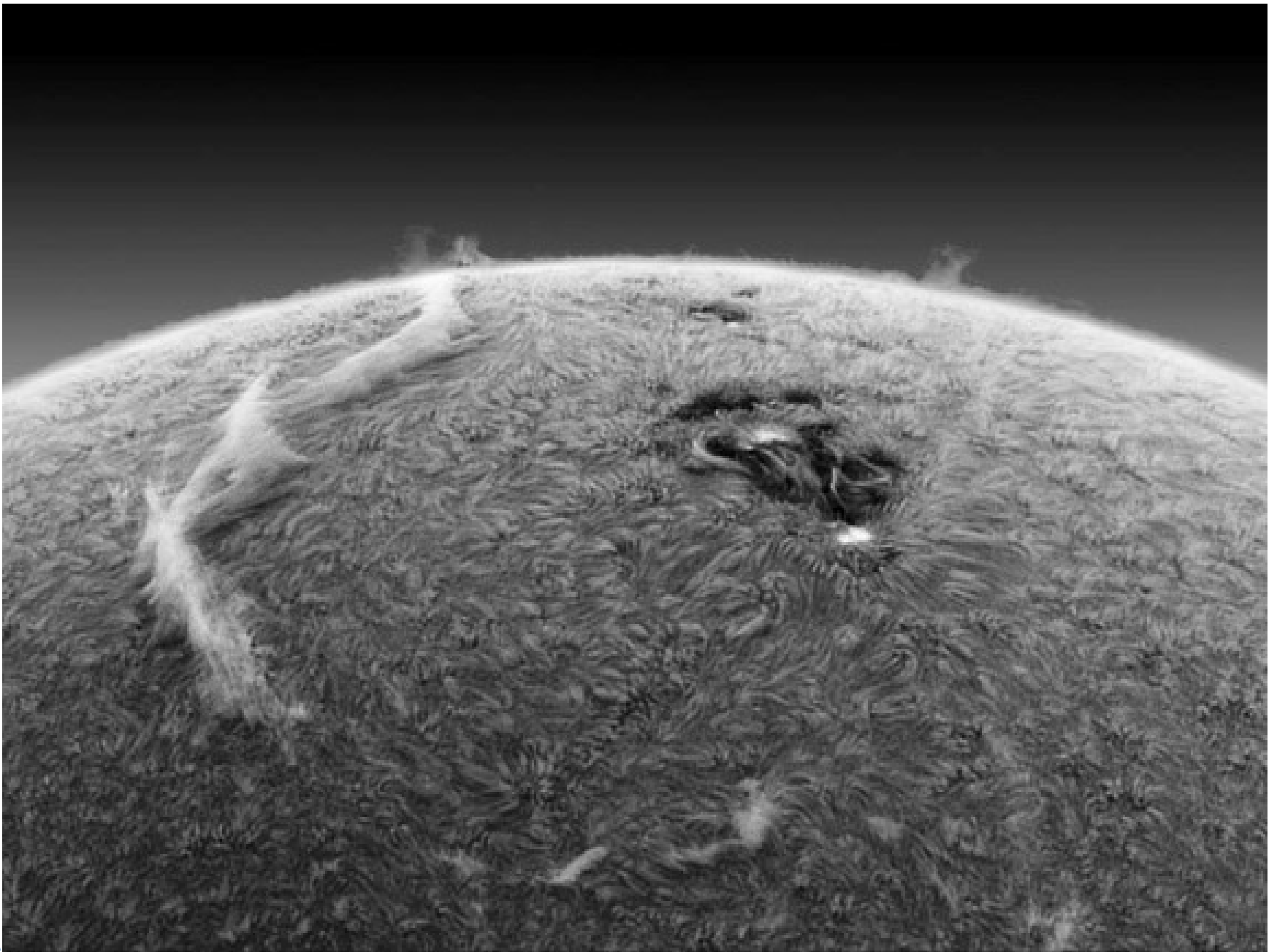
1991 May 13

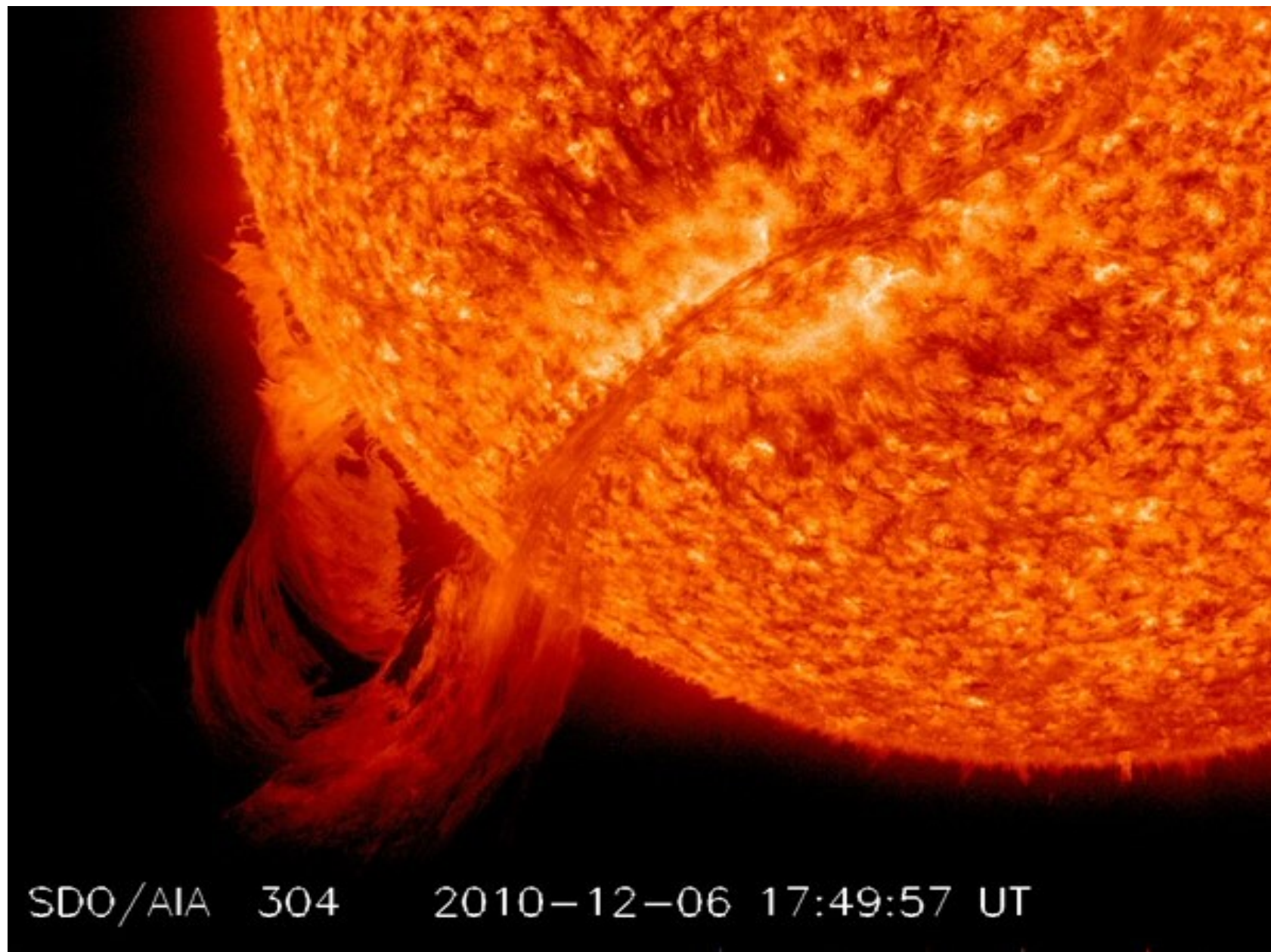


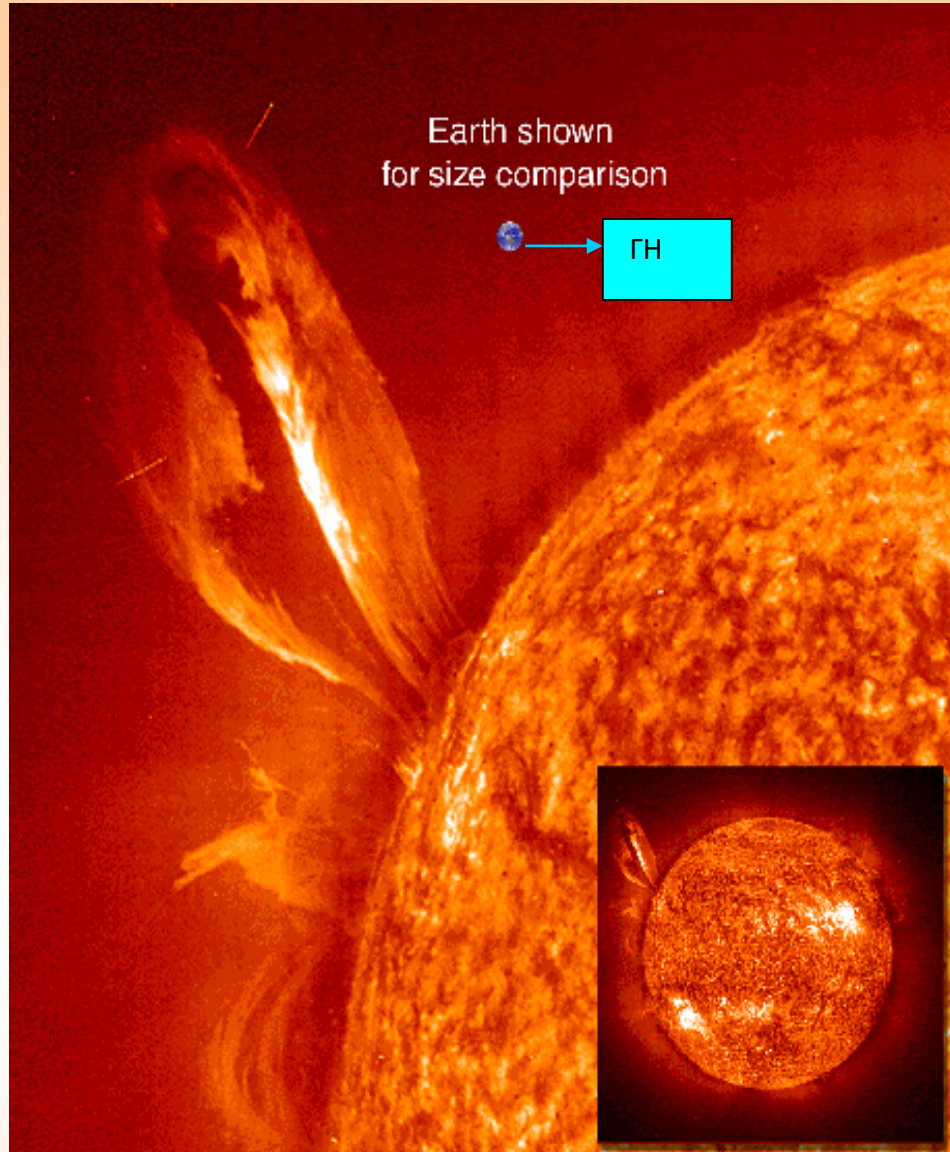






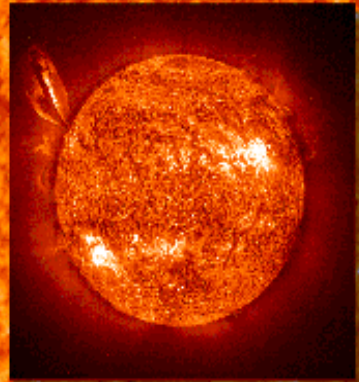


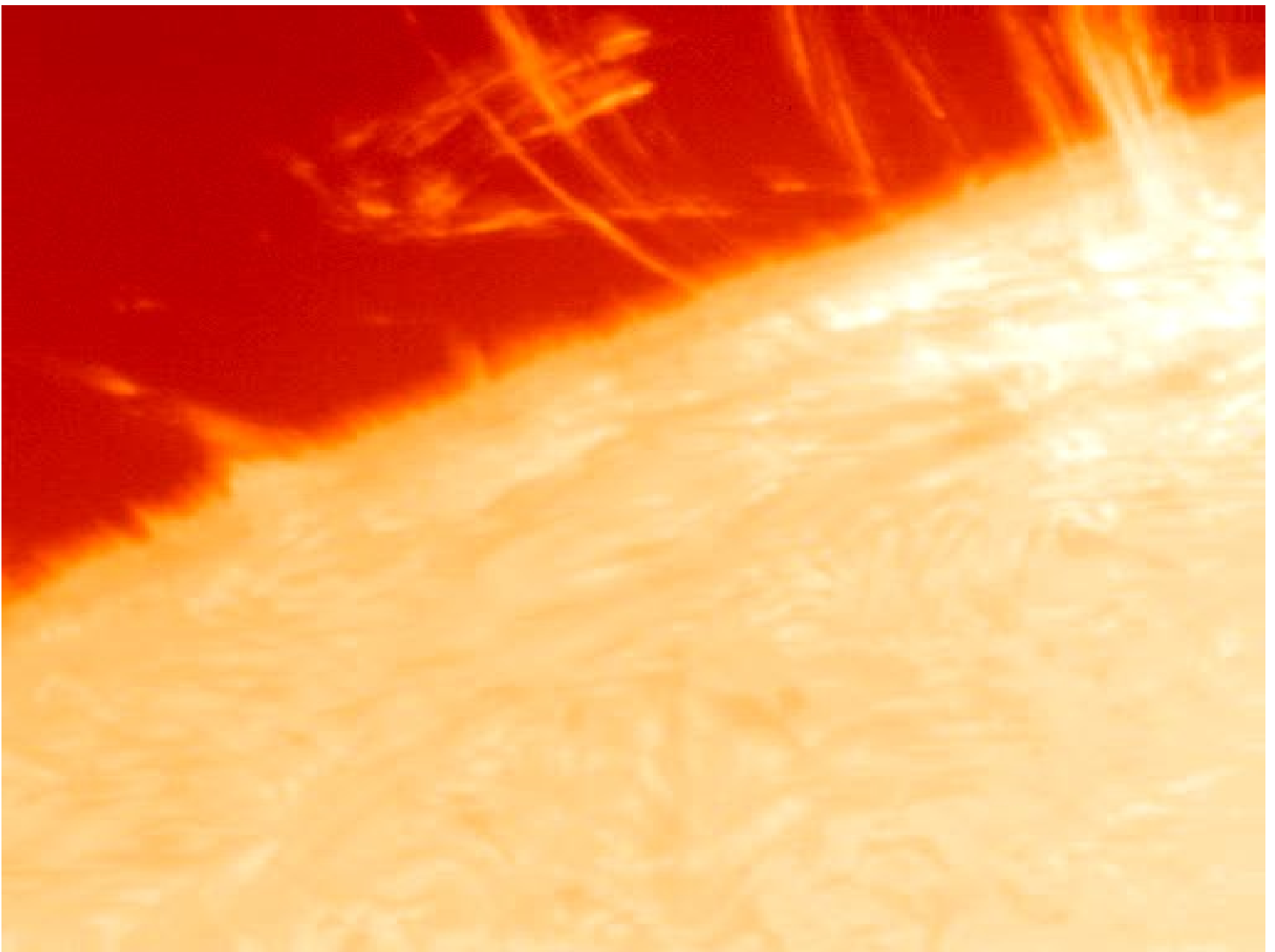




Earth shown
for size comparison

ΓΗ



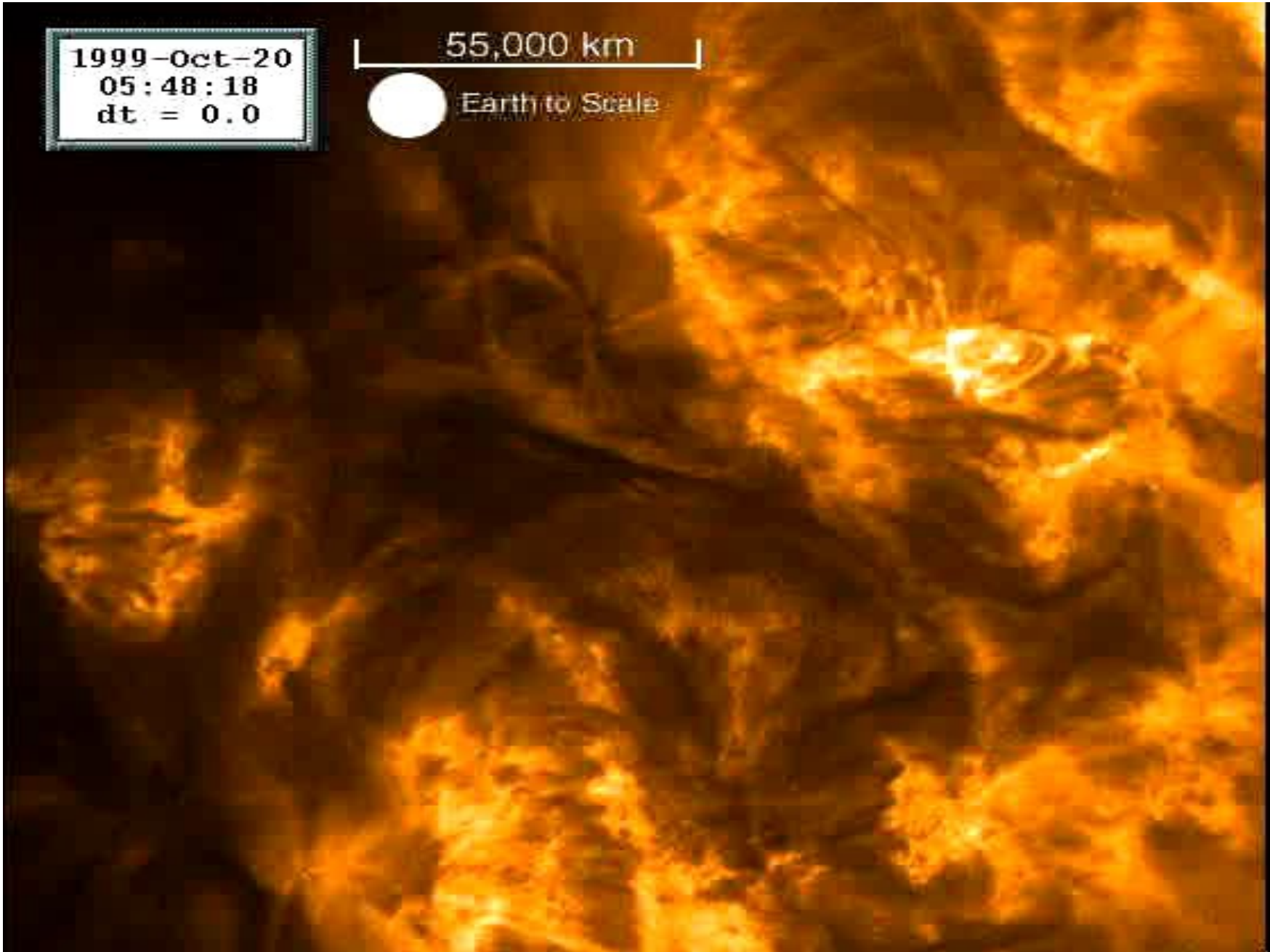


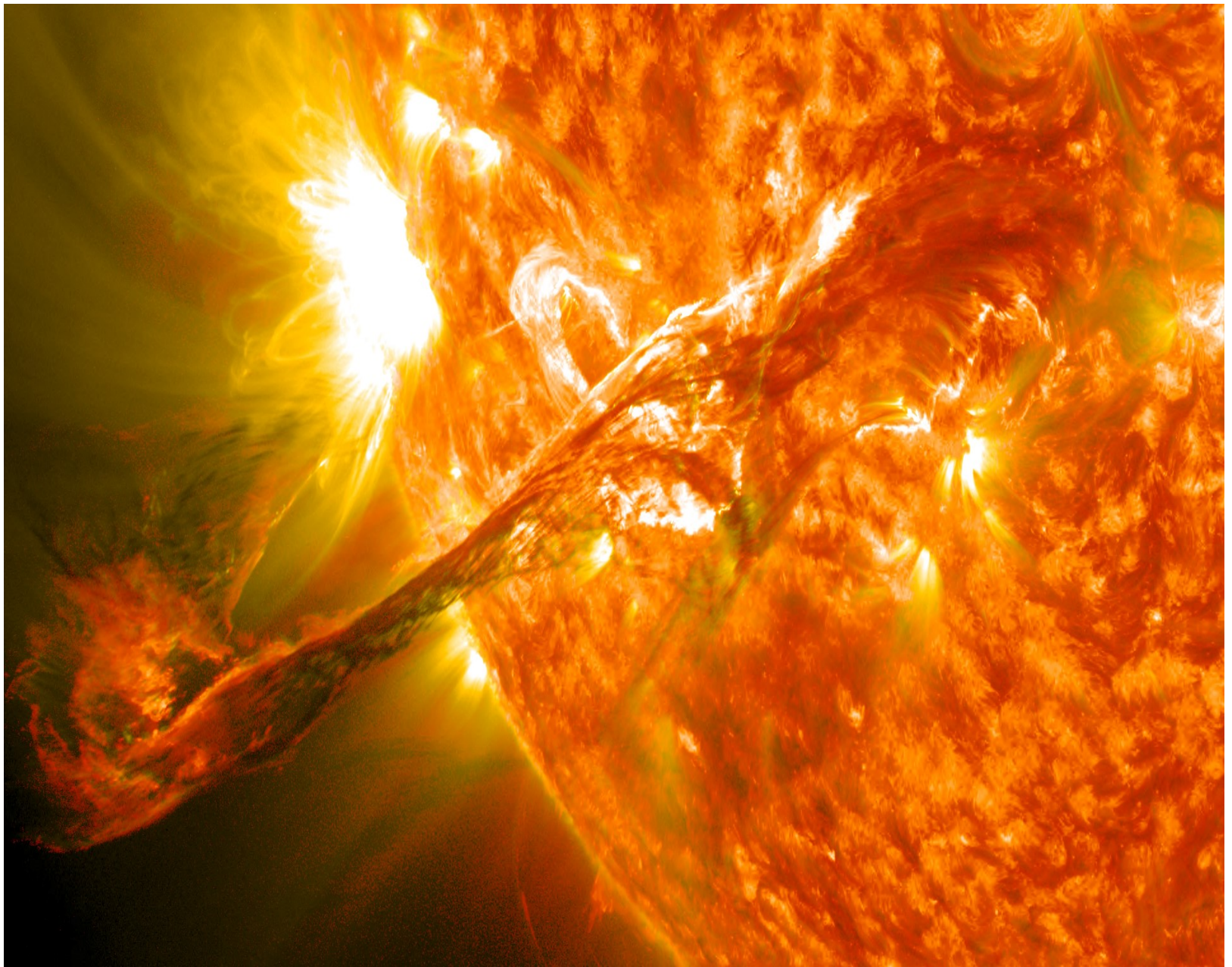
1999-Oct-20
05:48:18
dt = 0.0

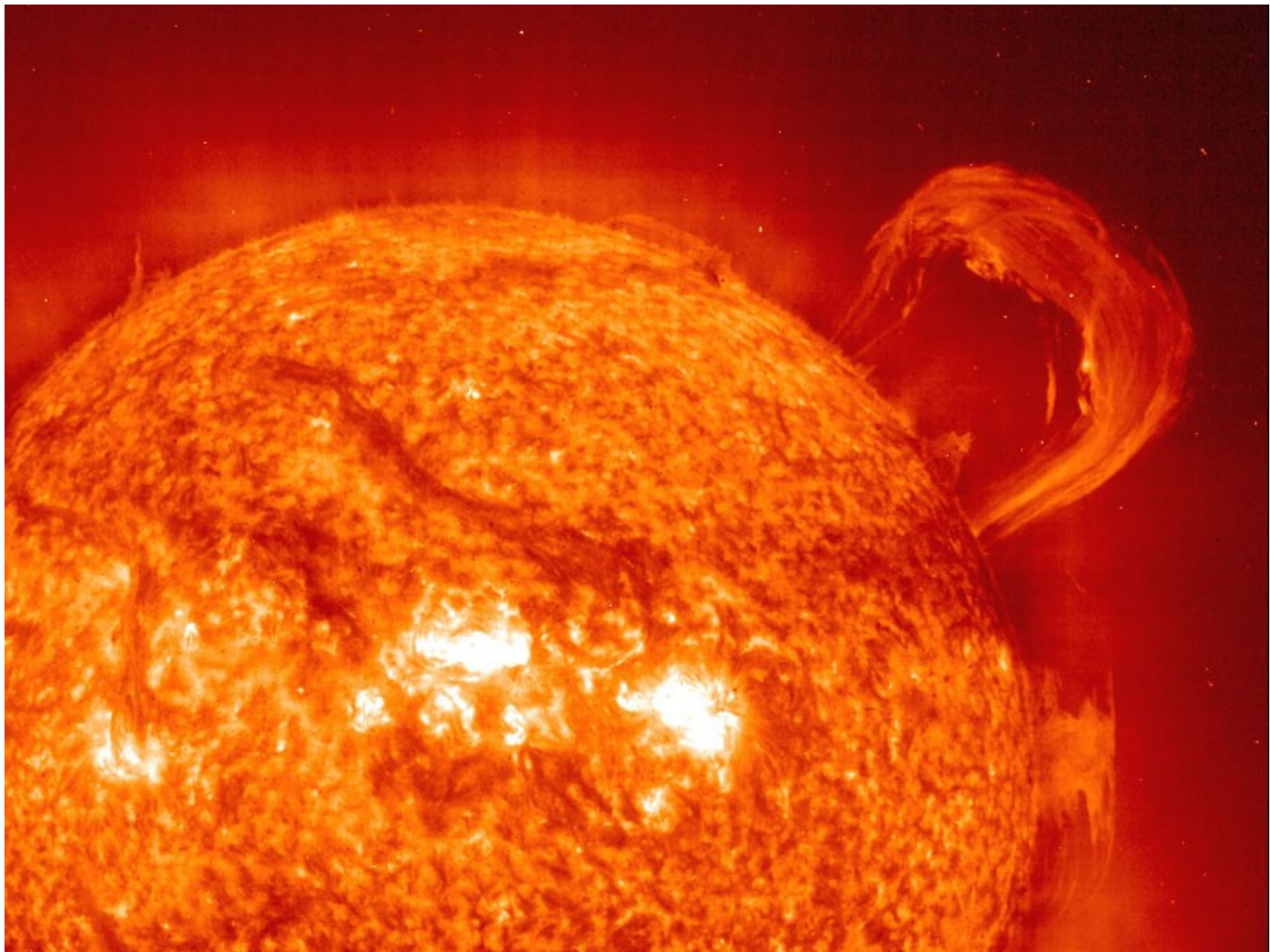
55,000 km

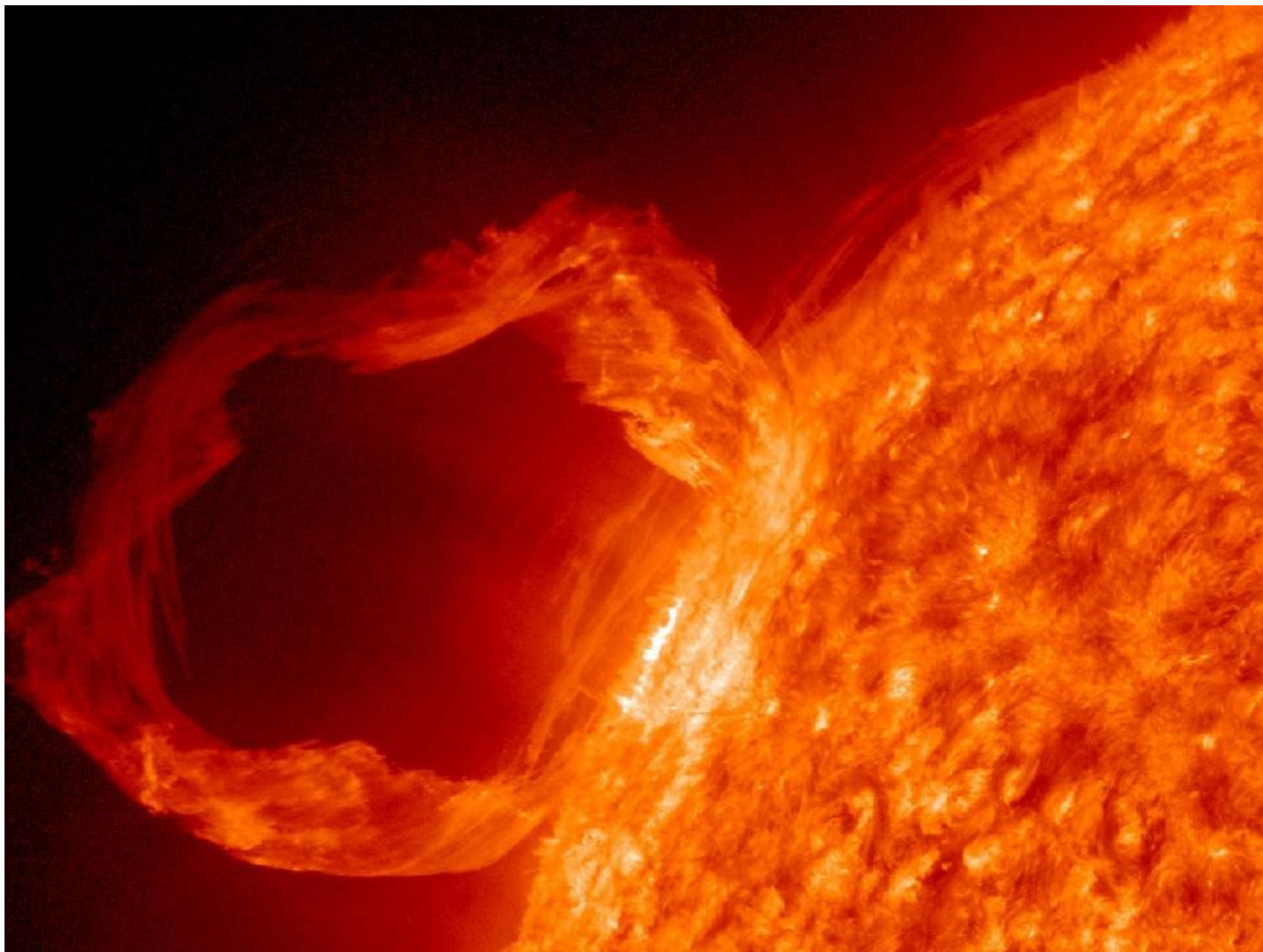


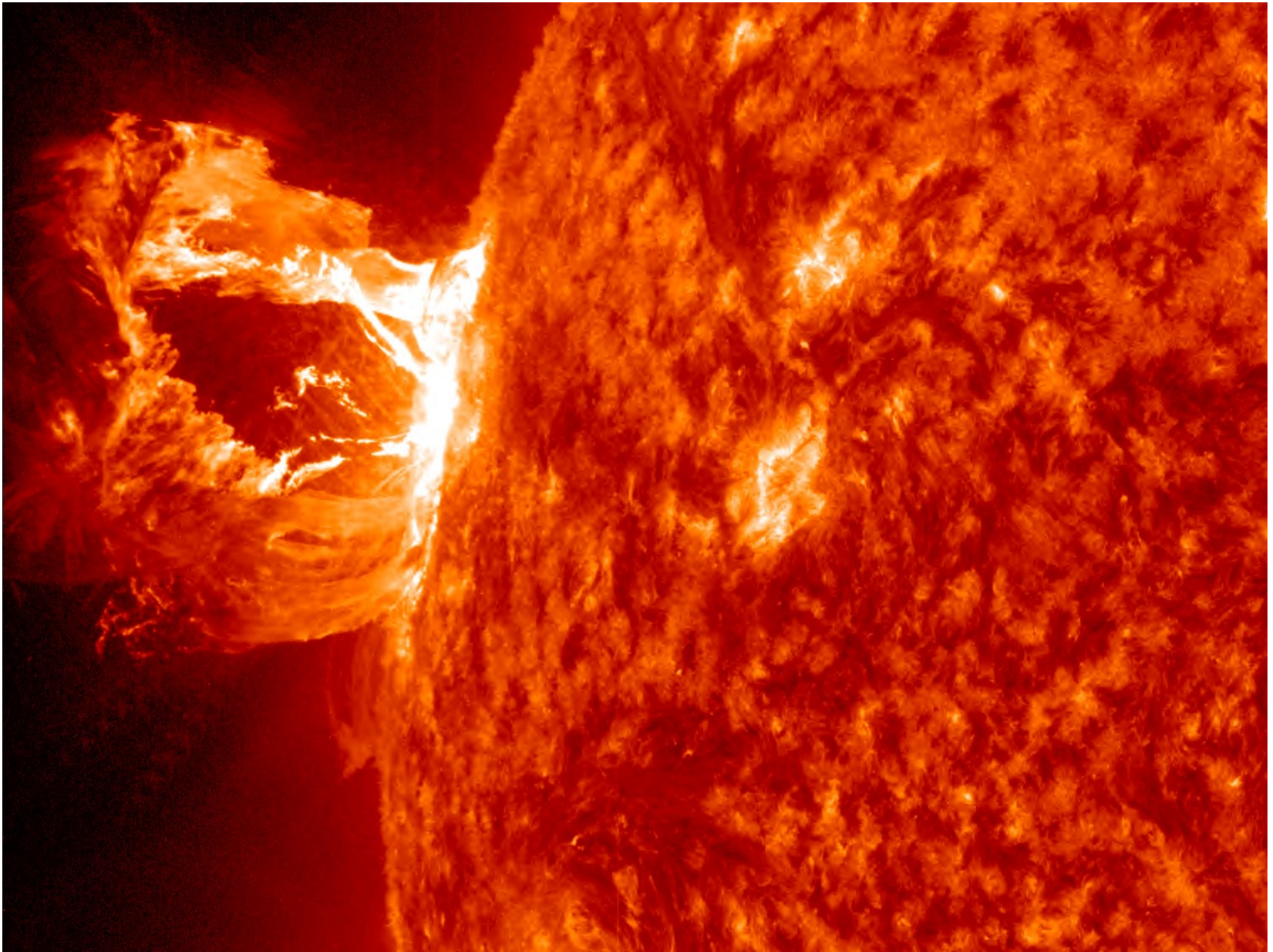
Earth to Scale

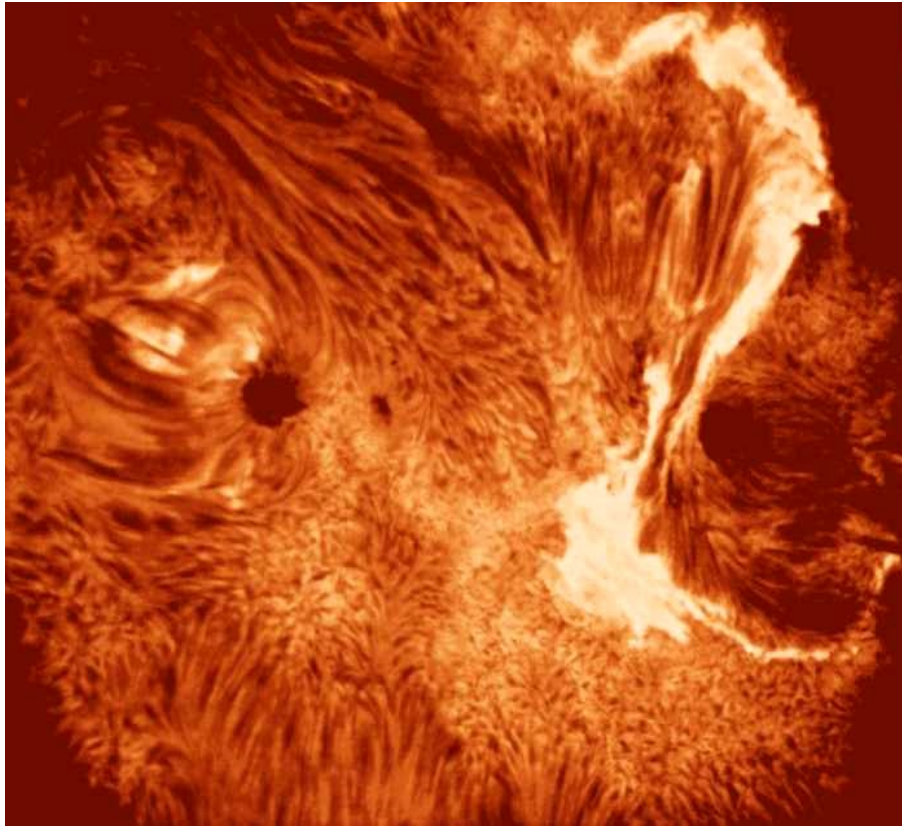




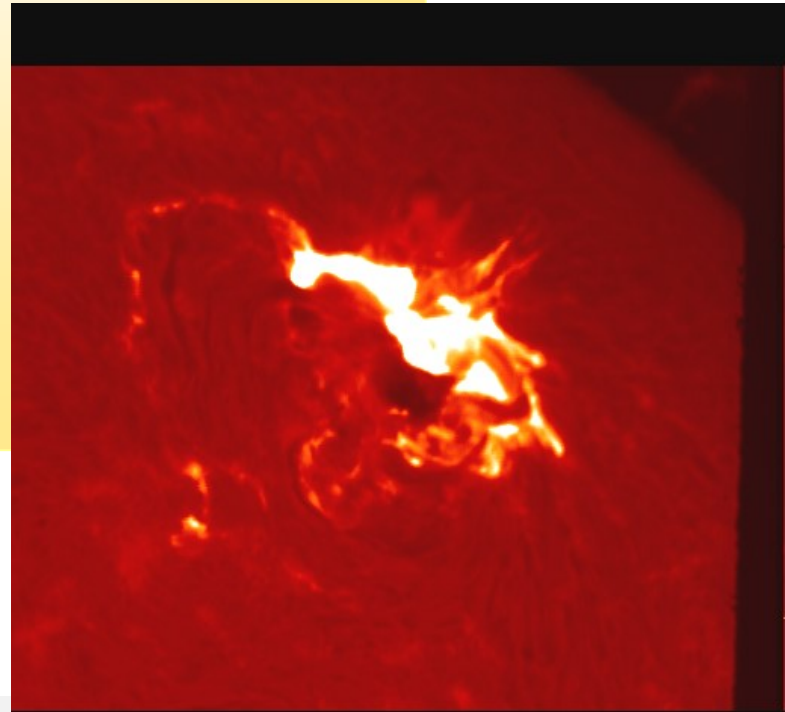


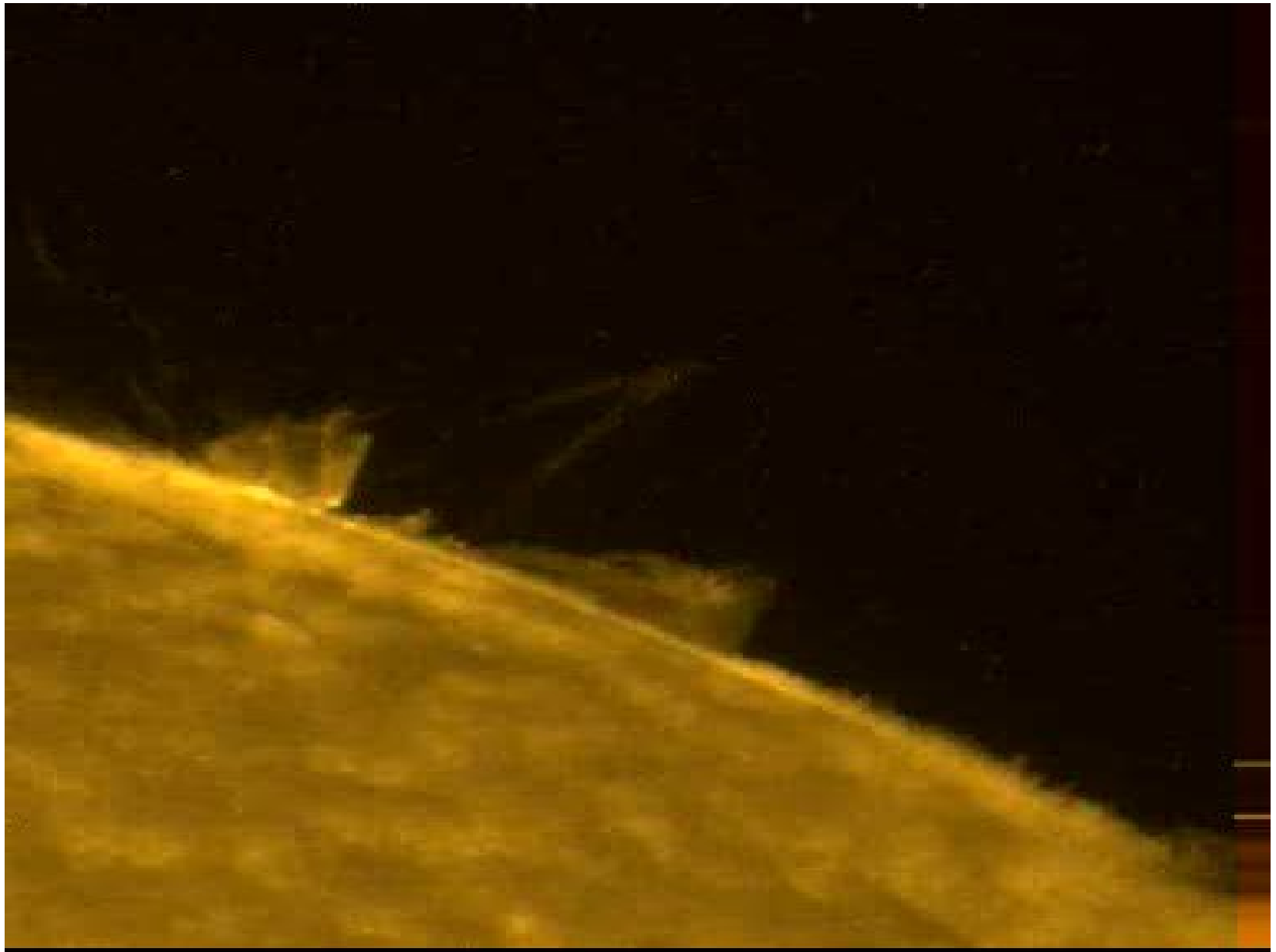




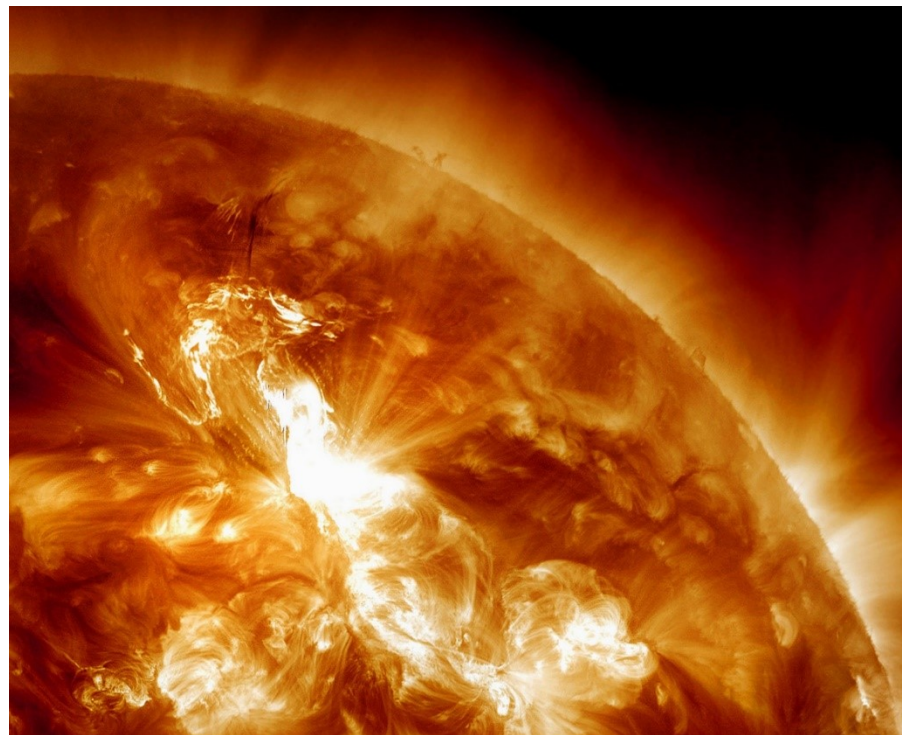
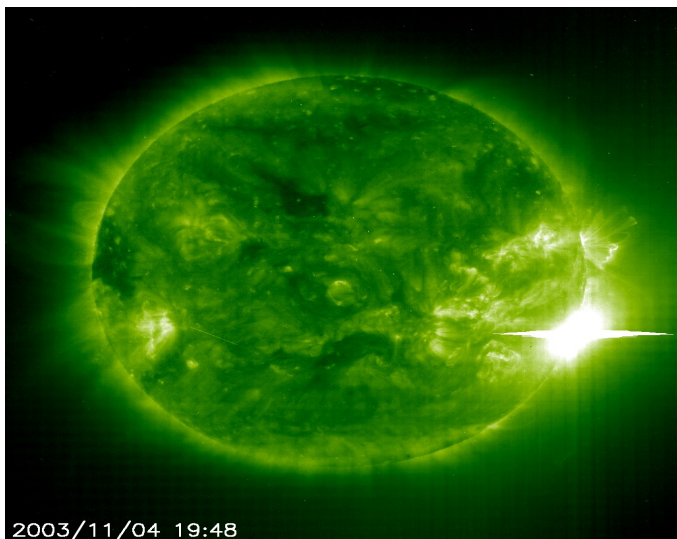
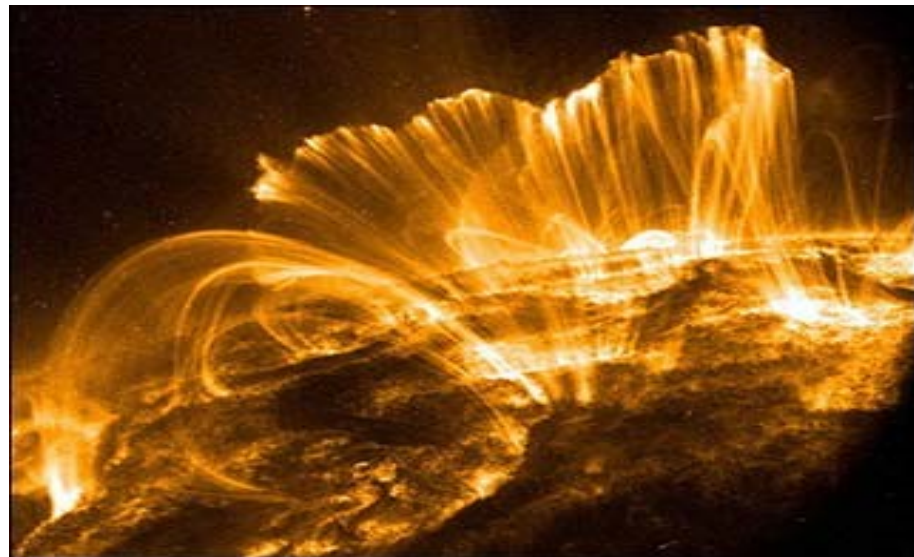
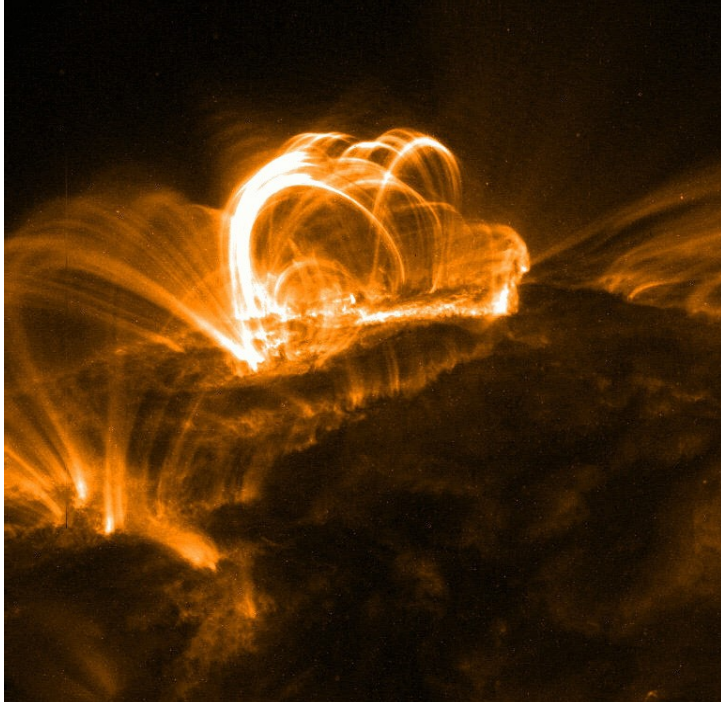


H α .

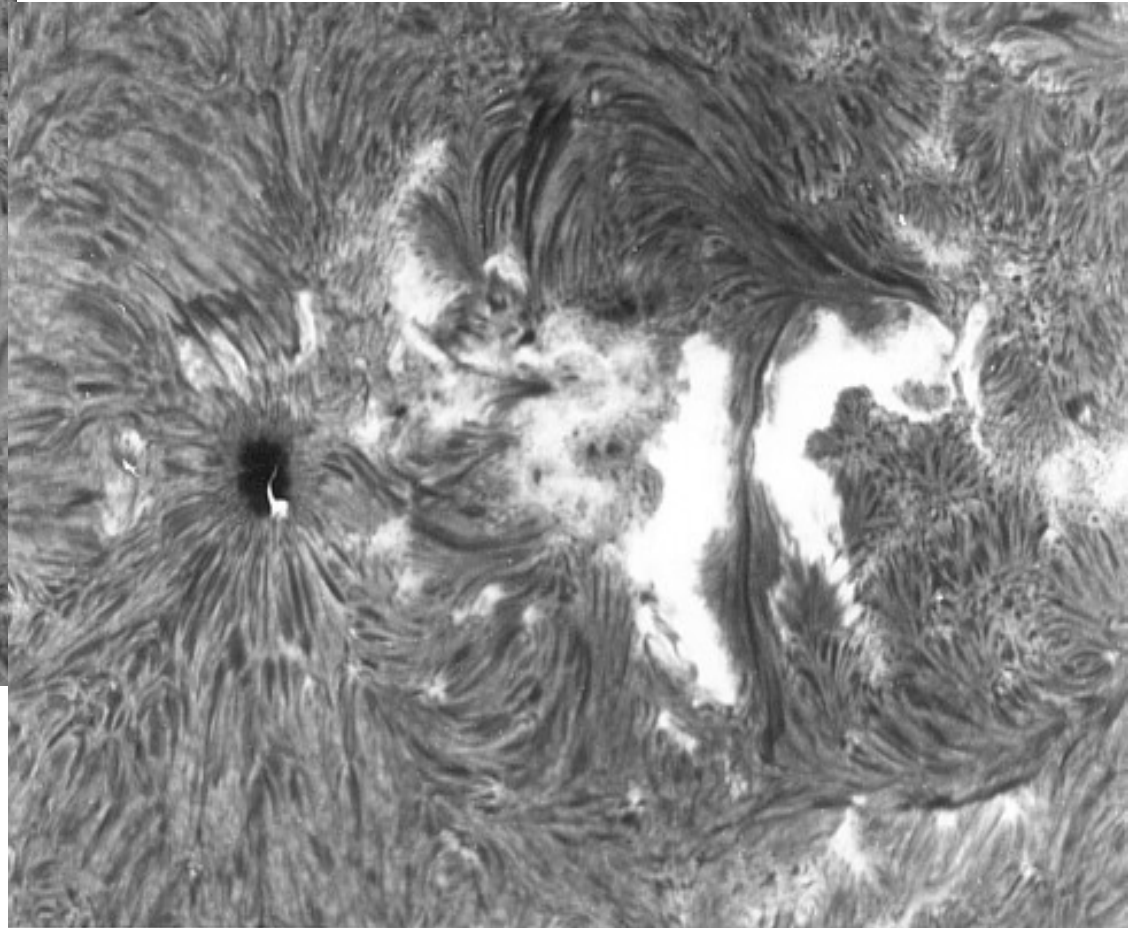
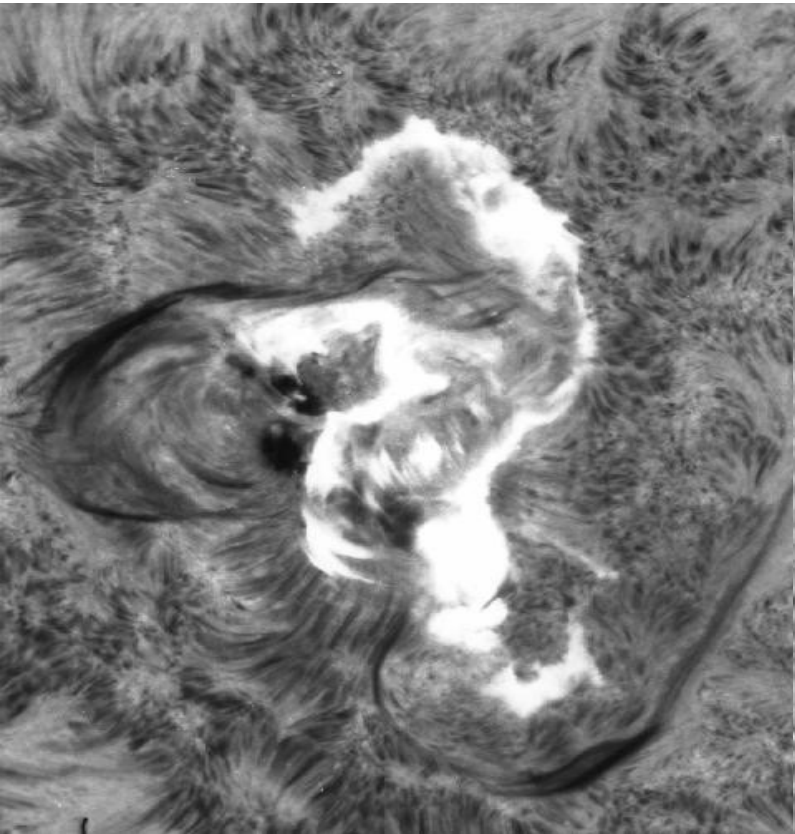




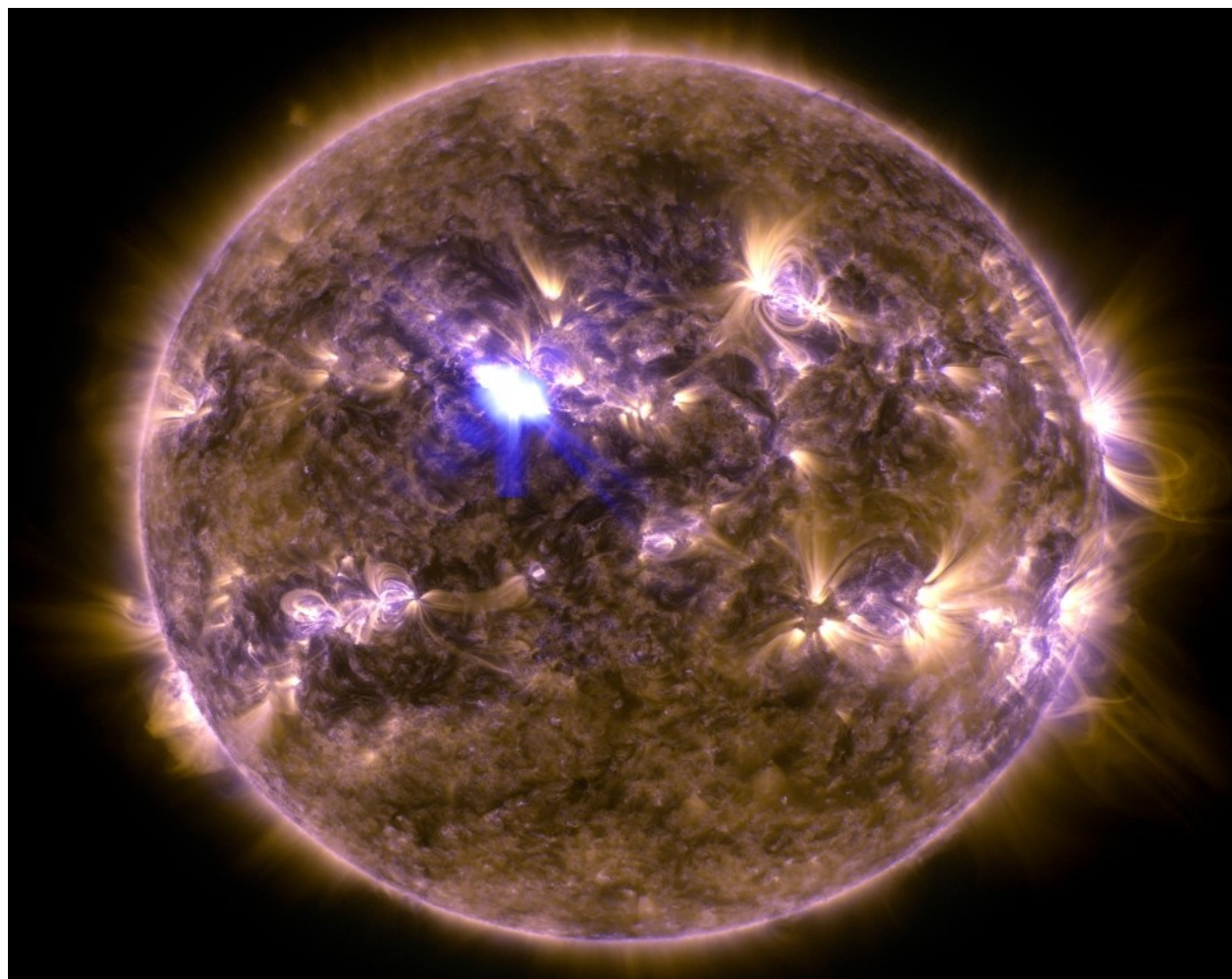
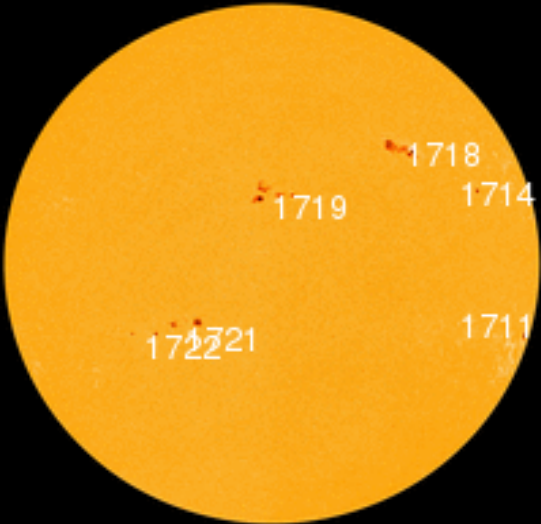




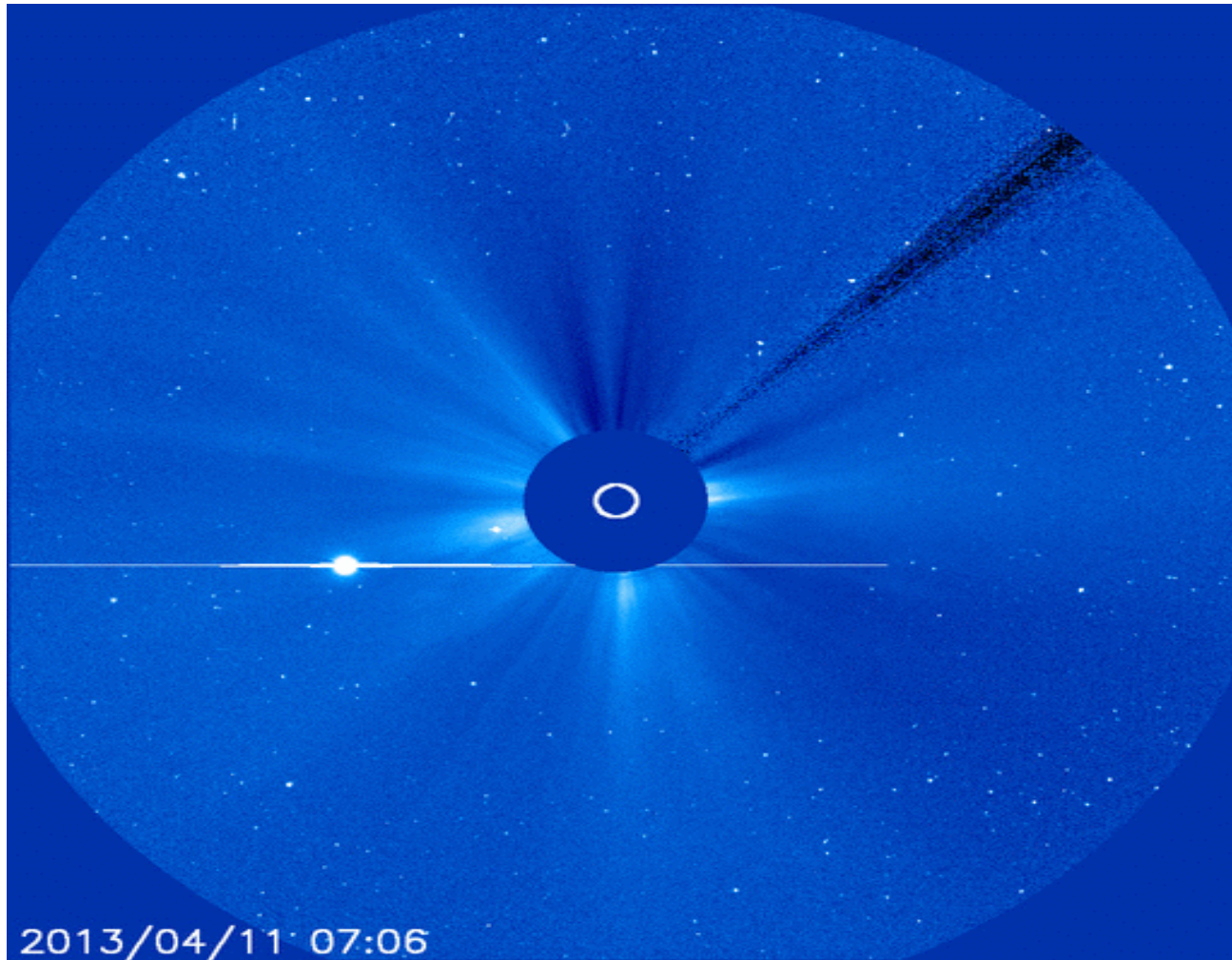
7 AUGUST 1972



11 APRIL 2013

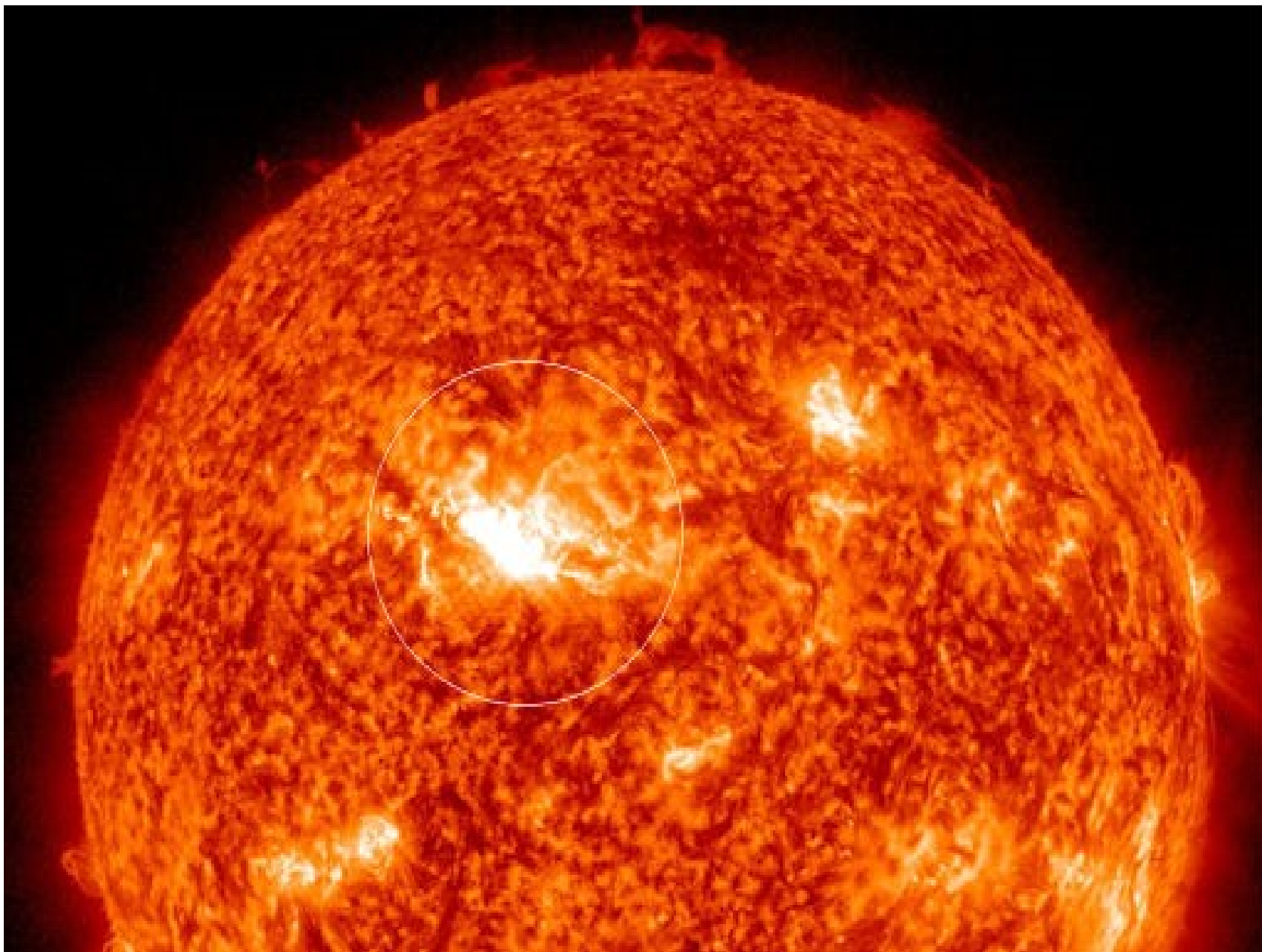


11 APRIL 2013



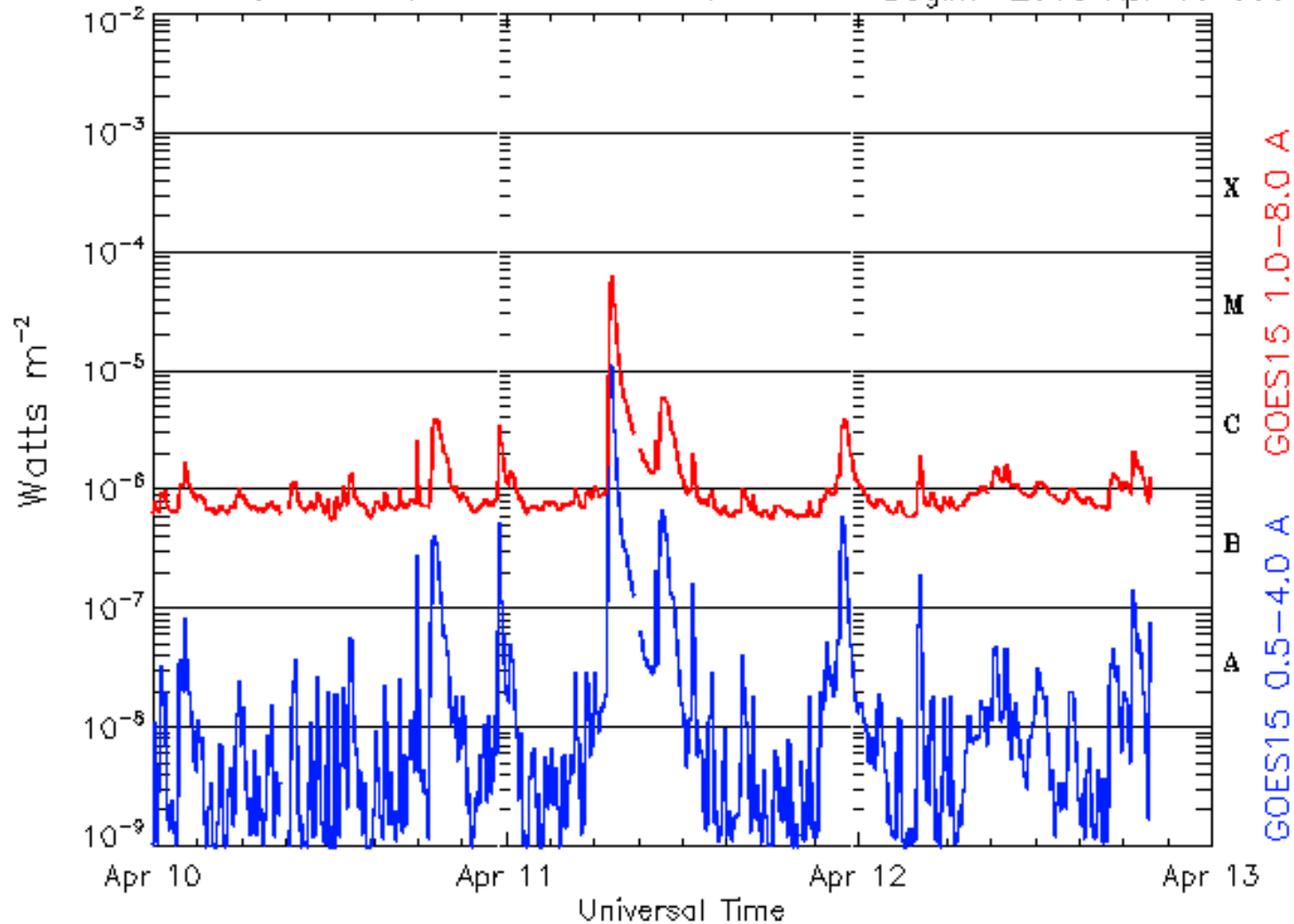
2013/04/11 07:06





GOES Xray Flux (5 minute data)

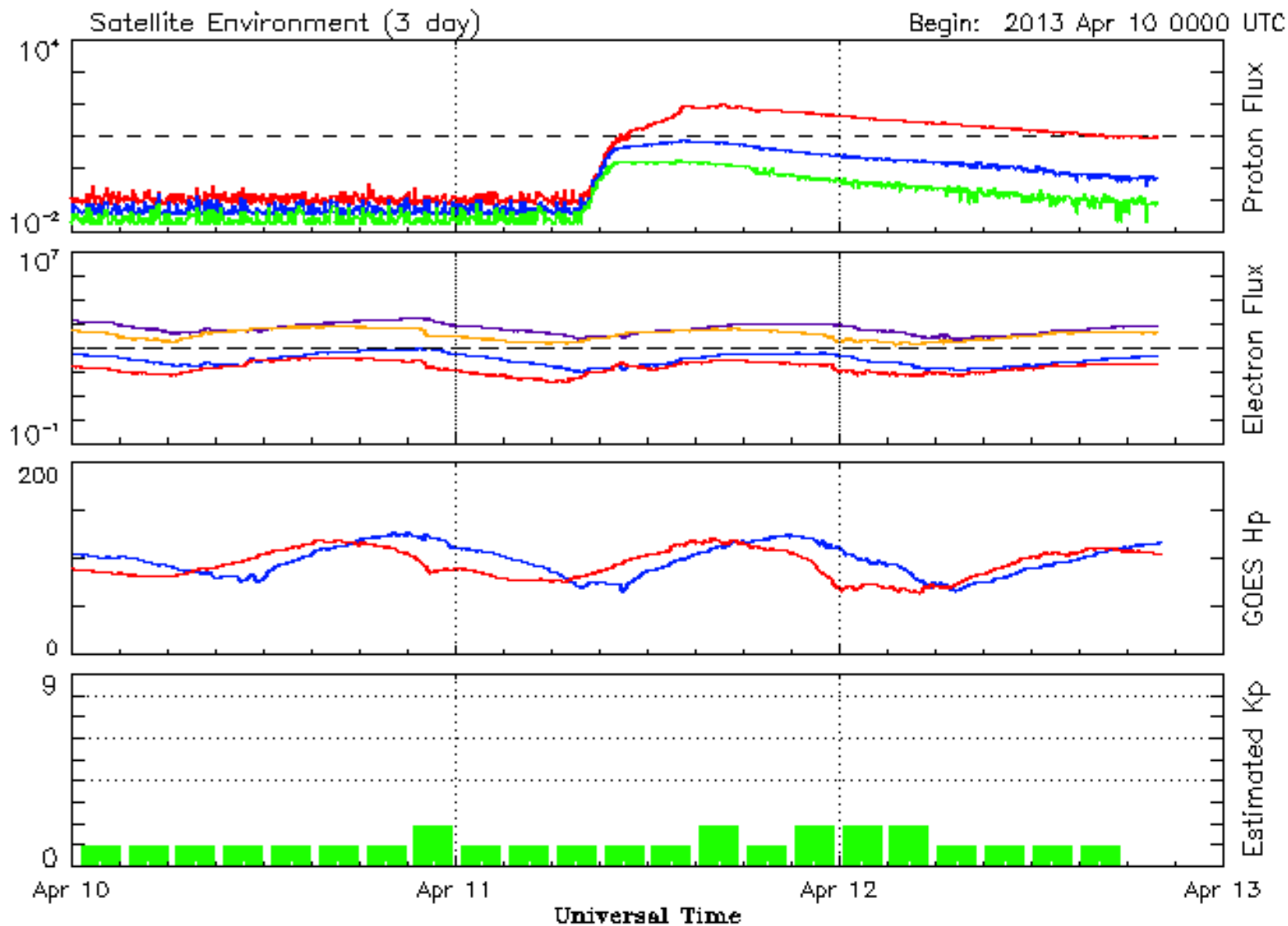
Begin: 2013 Apr 10 0000 UTC



Updated 2013 Apr 12 20:05:12 UTC

NOAA/SWPC Boulder, CO USA





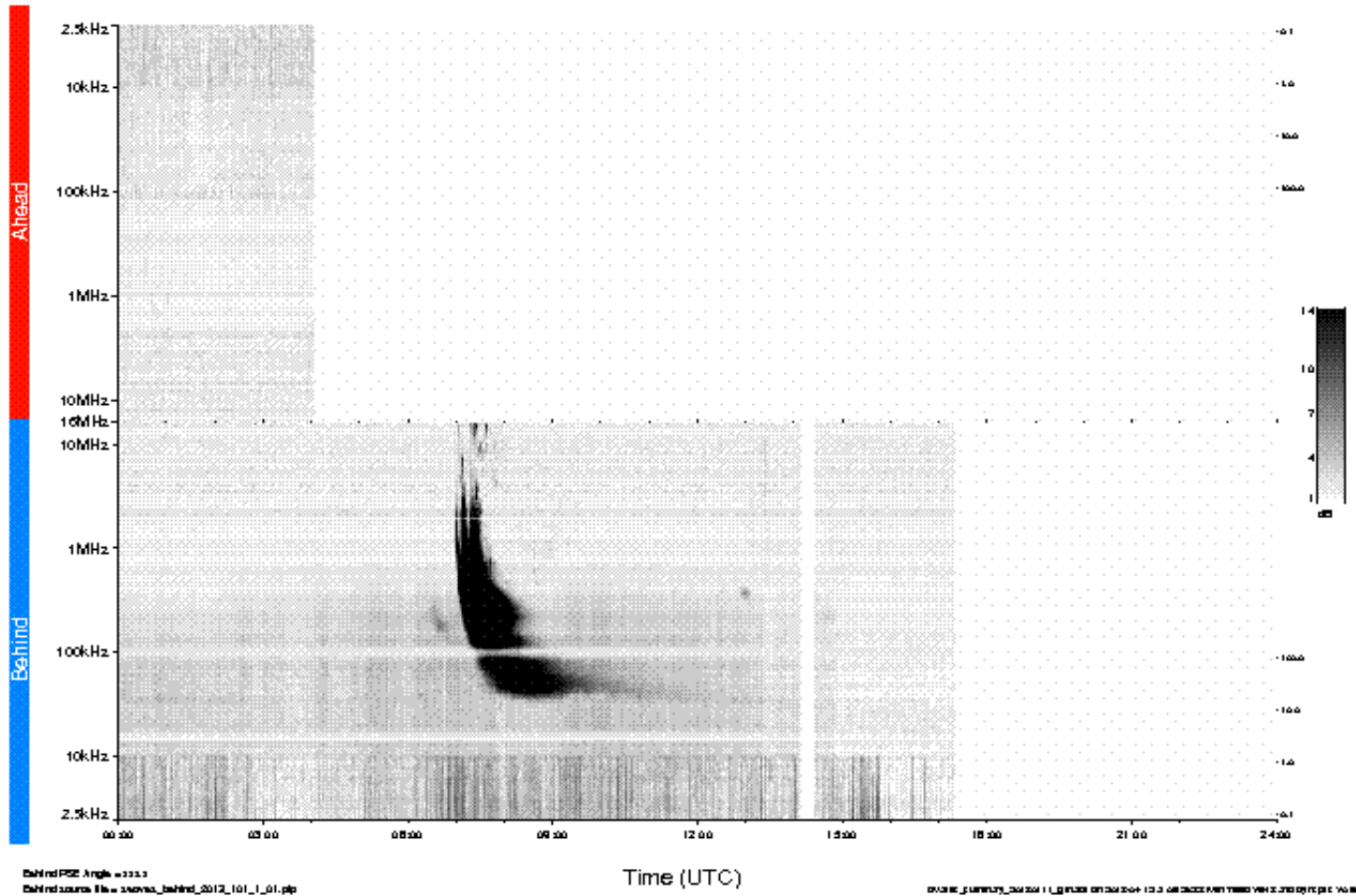
Updated 2013 Apr 12 20:06:07 UTC

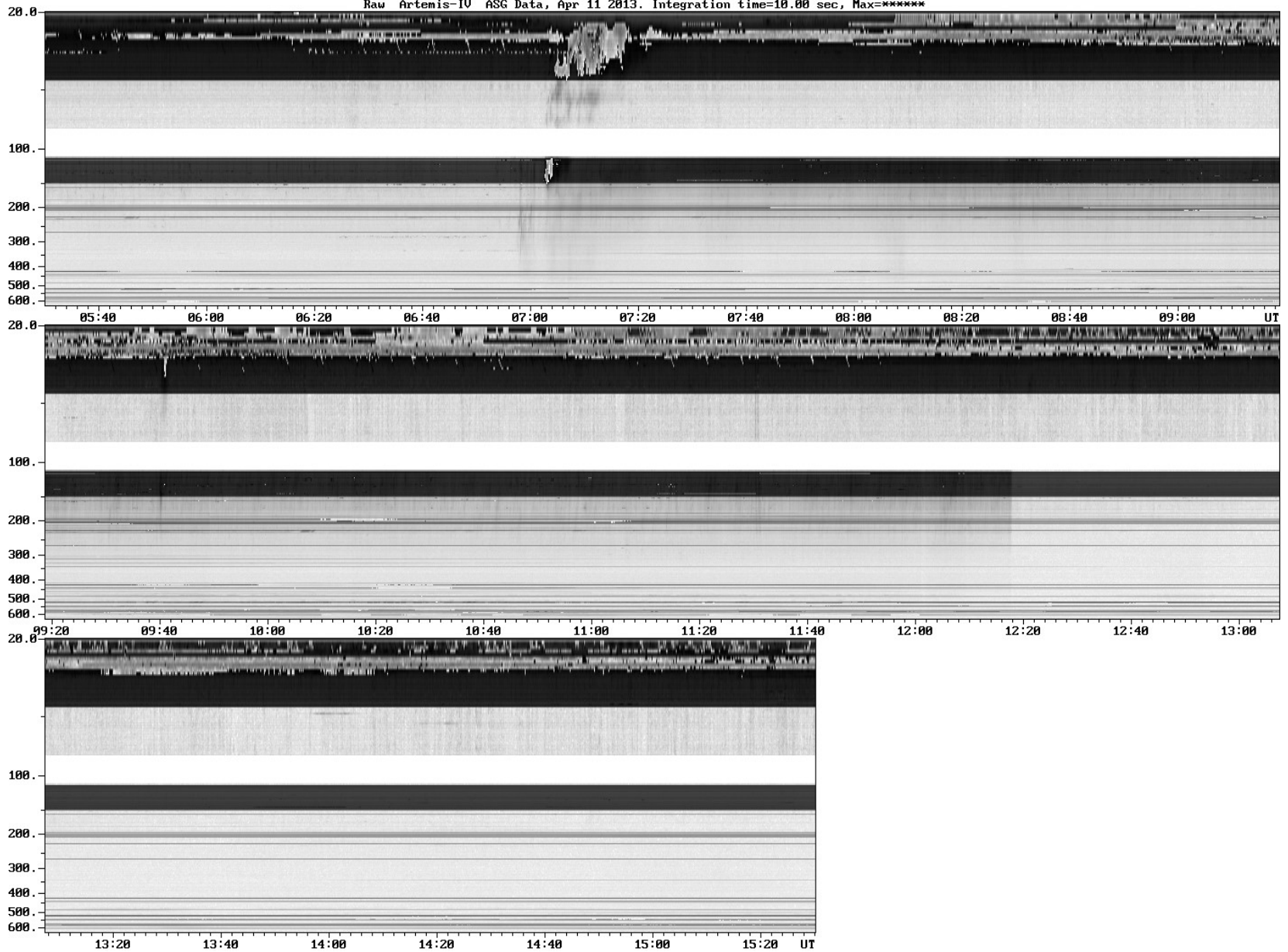
NOAA/SWPC Boulder, CO USA



STEREO/WAVES Daily Summary - 11-Apr-2013 (DOY 101)

Ahead source file = swaves_ahead_2013_101_1_01.pfp
Ahead P2Z Angle = 333.3





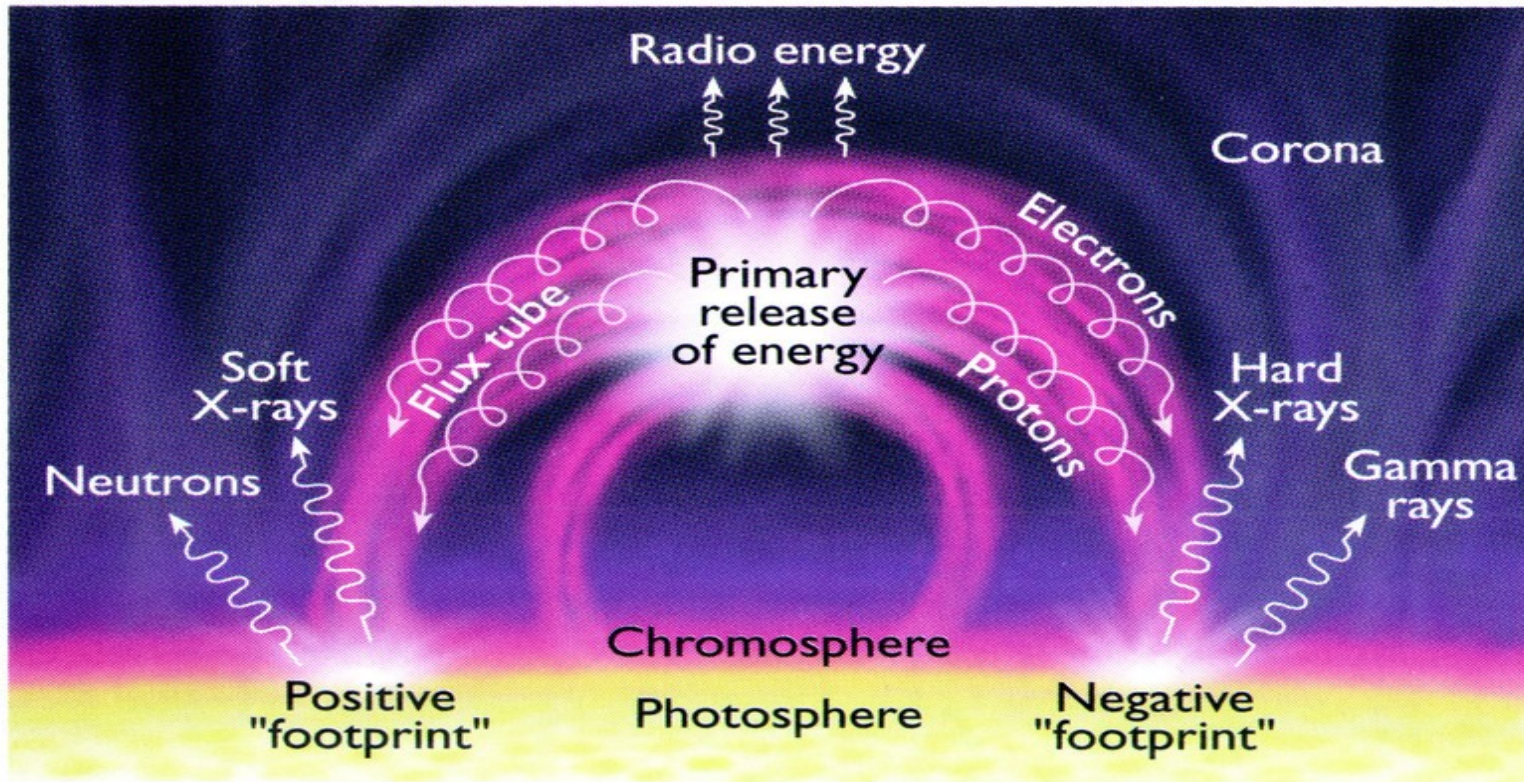
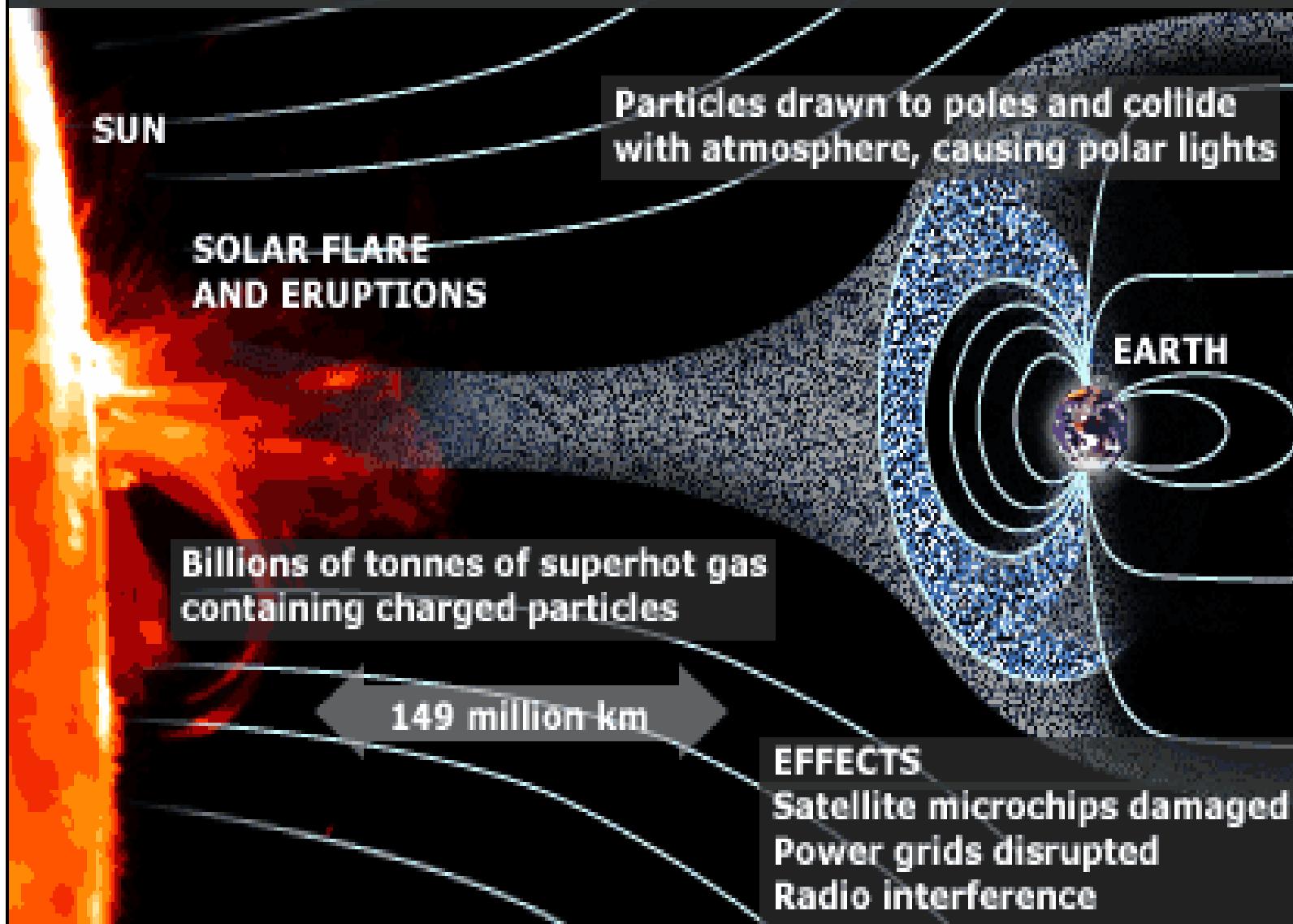


Figure 10 (bottom). Solar flares tend to occur within concentrated magnetic loops extending from the photosphere into the corona. Energy released at the top of the loop creates a burst of radio energy. It also accelerates great numbers of electrons and protons. These are channeled down the loop and strike the chromosphere at relativistic speeds, which creates X-rays and gamma rays.



SOLAR ACTIVITY AND ITS EFFECTS ON EARTH



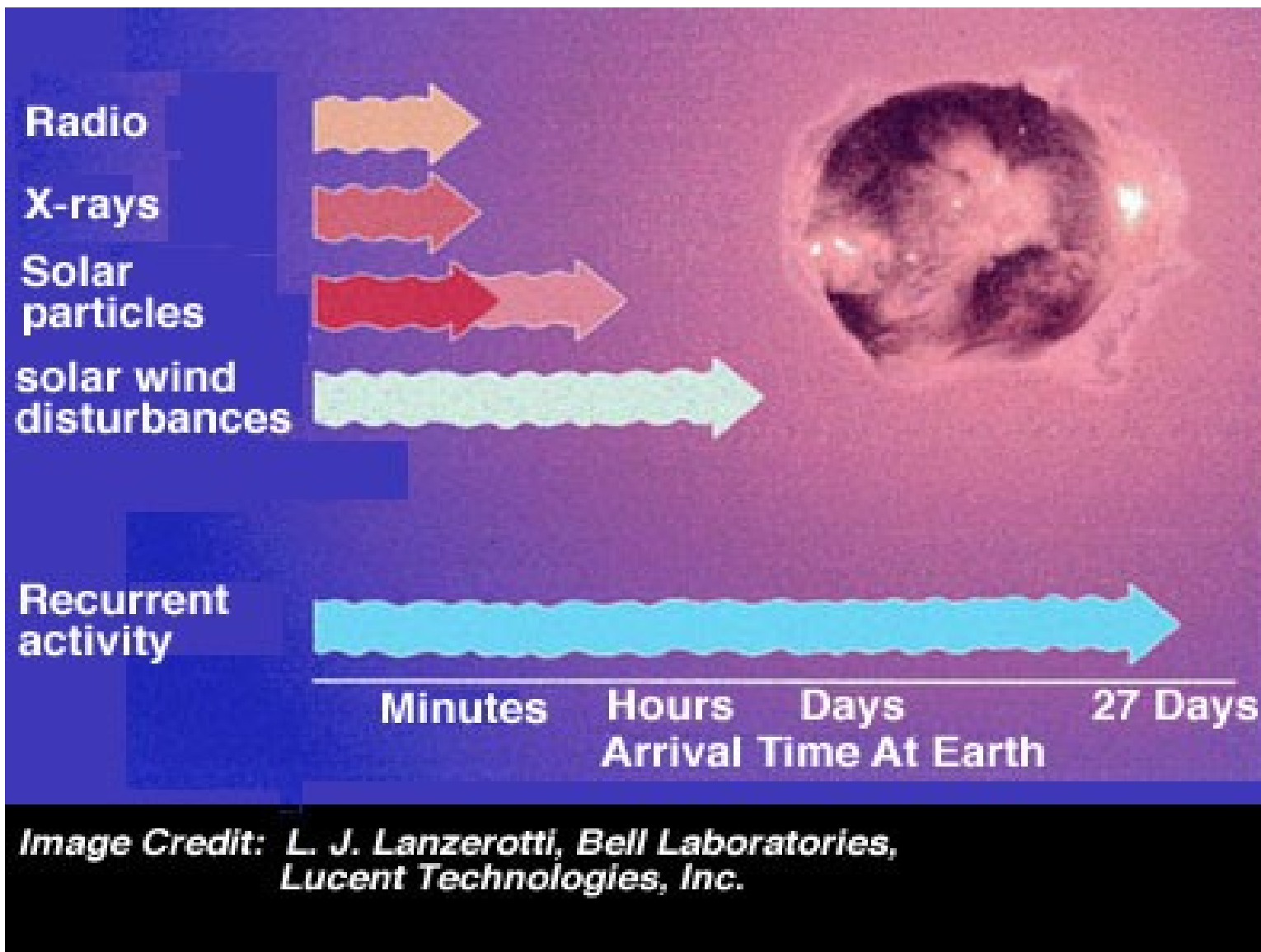
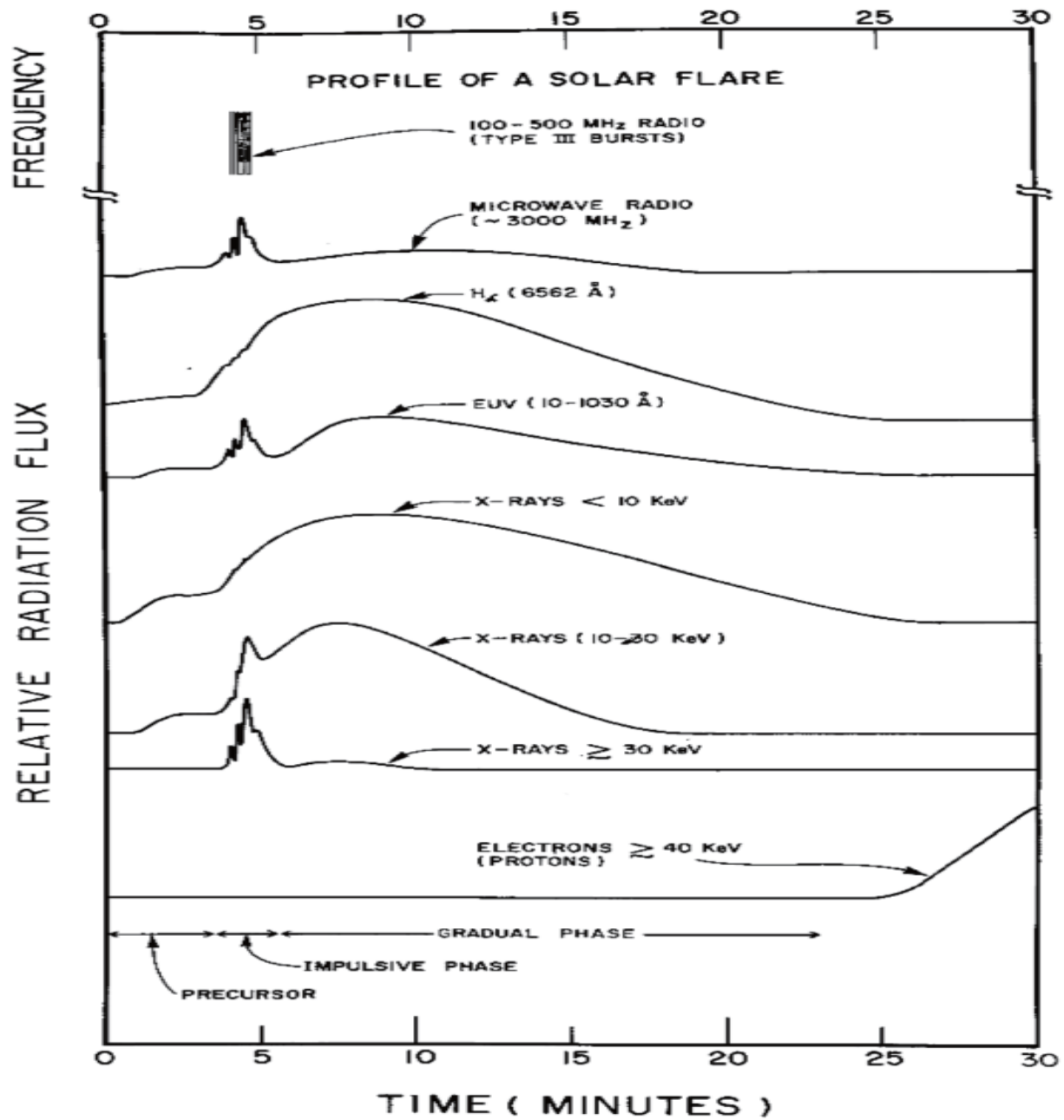
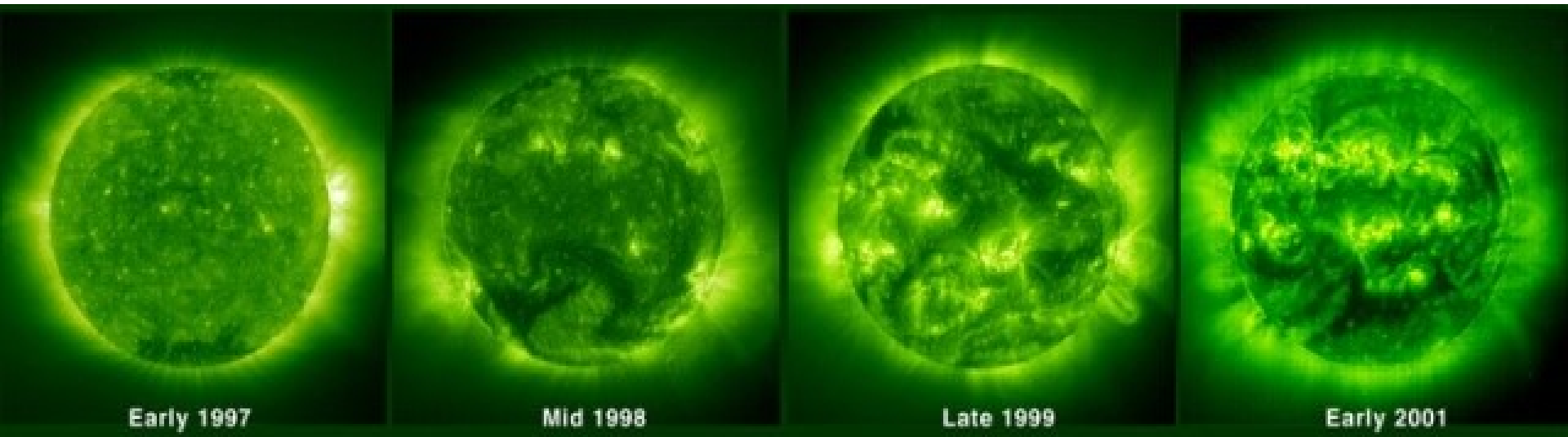


Image Credit: L. J. Lanzerotti, Bell Laboratories, Lucent Technologies, Inc.







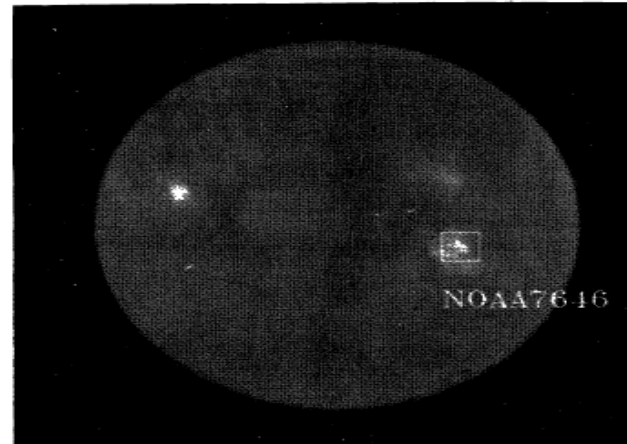
Early 1997

Mid 1998

Late 1999

Early 2001





(a)

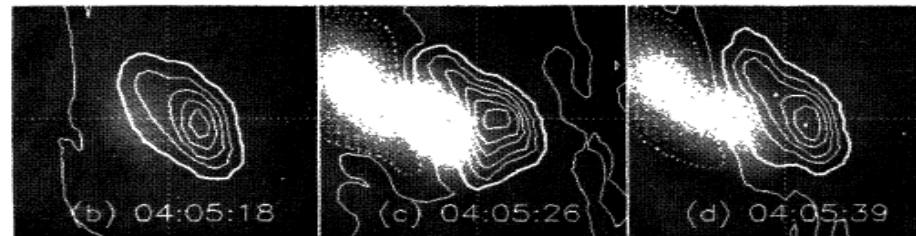


Figure 2. Radio images obtained by Nobeyama Radioheliograph. (a) is a full disk image. (b), (c) and (d) are partial images of the first peak and the second peak just before the onset, of the burst.

emitting electrons was derived and was 3.6 and 4.2, where we assumed thick target model. The results that the indices of radio emitting electrons and hard X-ray emitting electrons have similar values and decrease with similar ratios between the first and the second peaks imply that the electrons emitting the microwave and the hard X-ray are accelerated by the same mechanism at the same site.

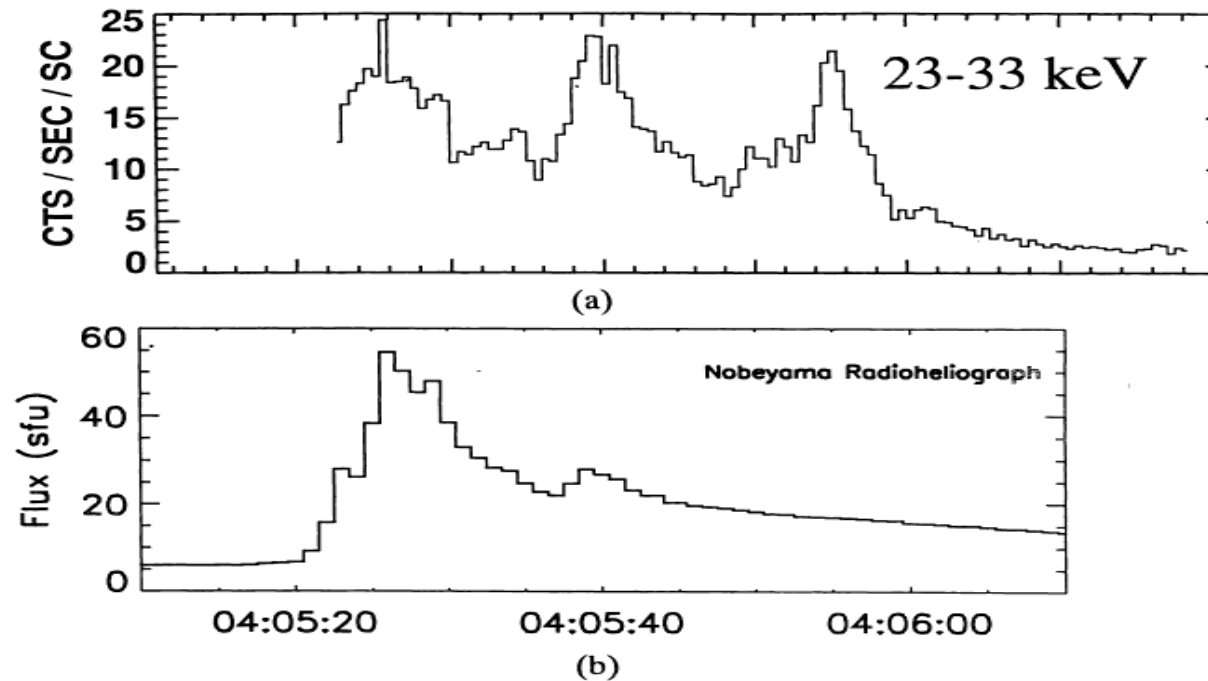
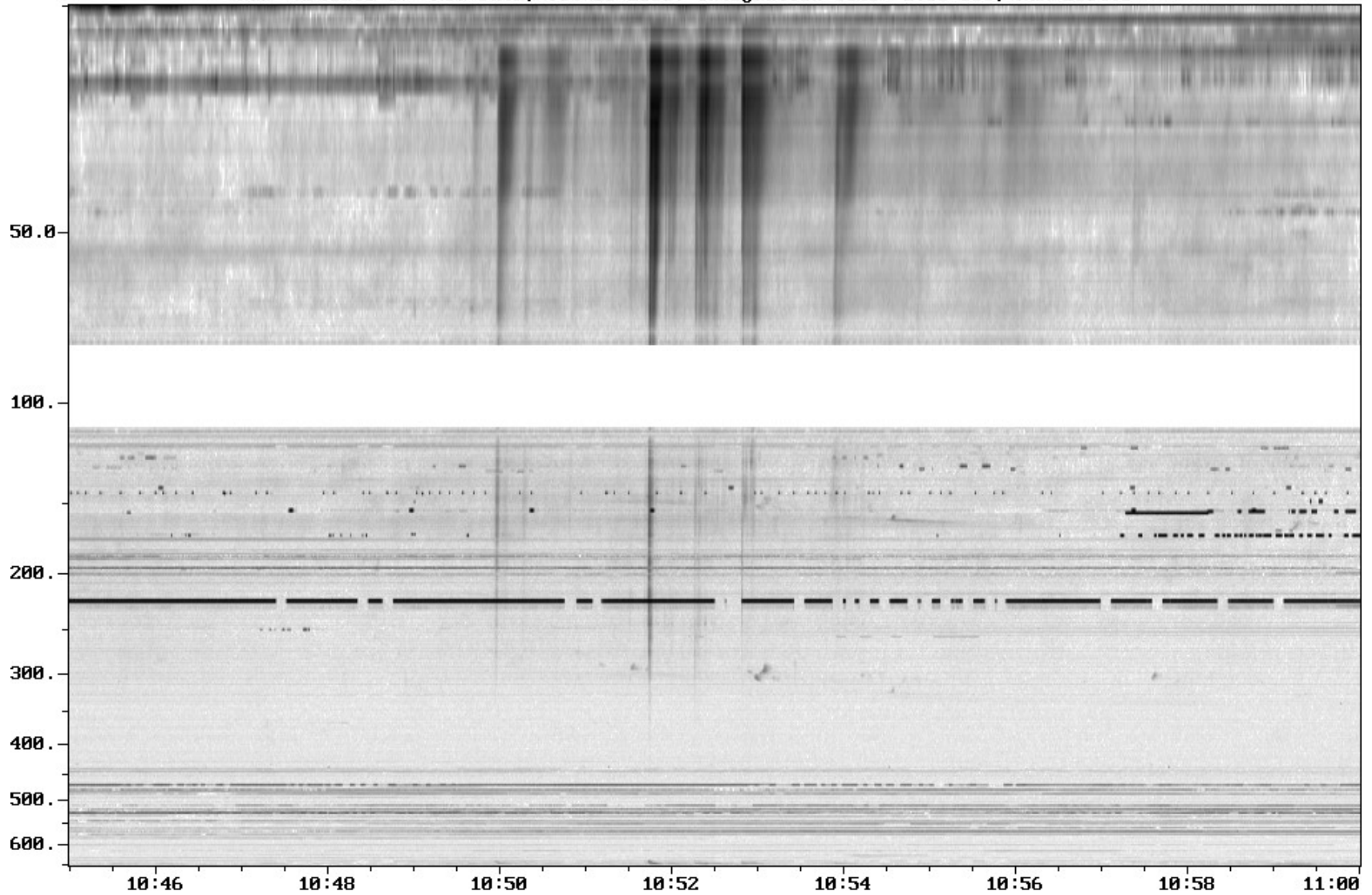
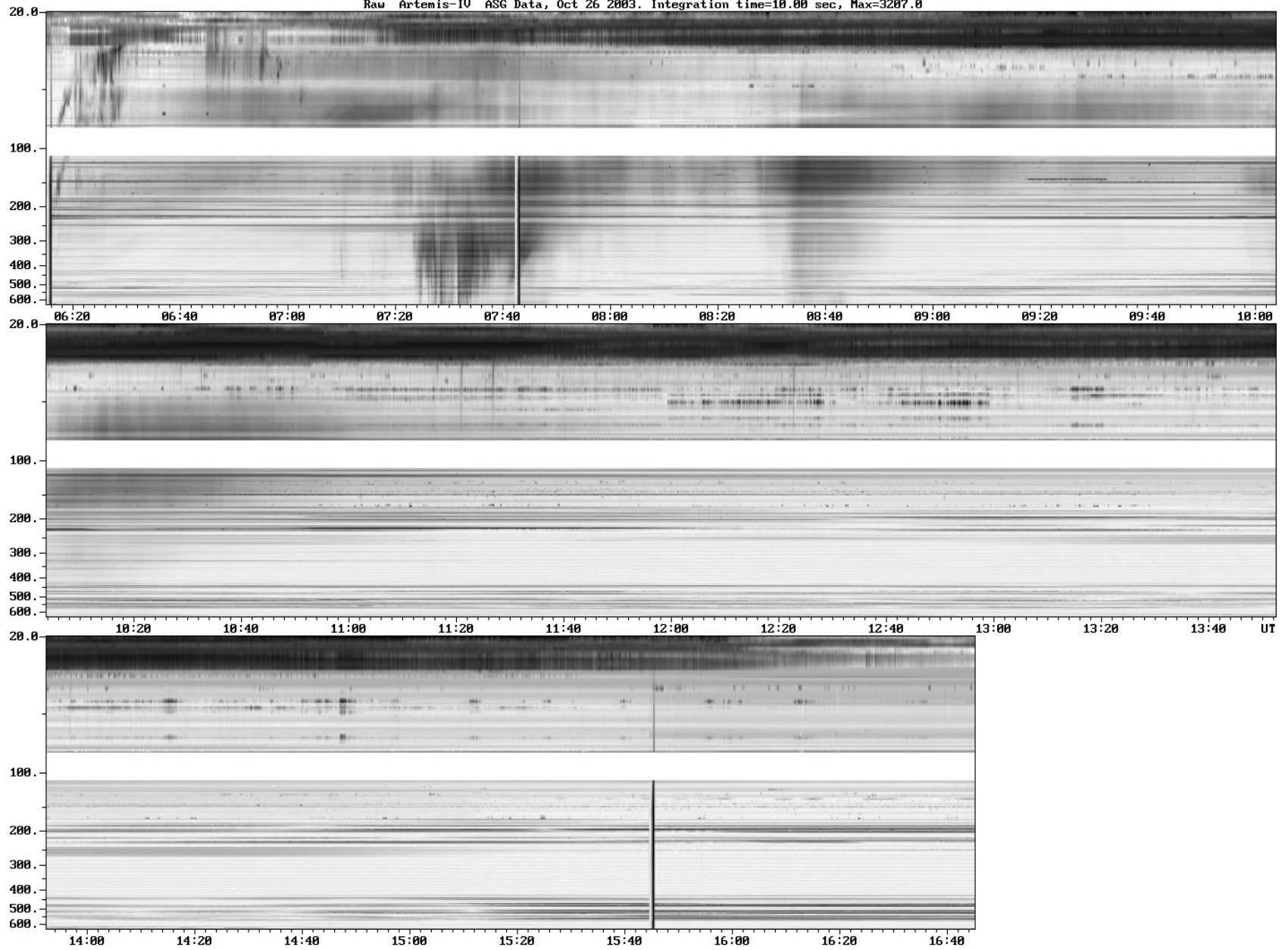
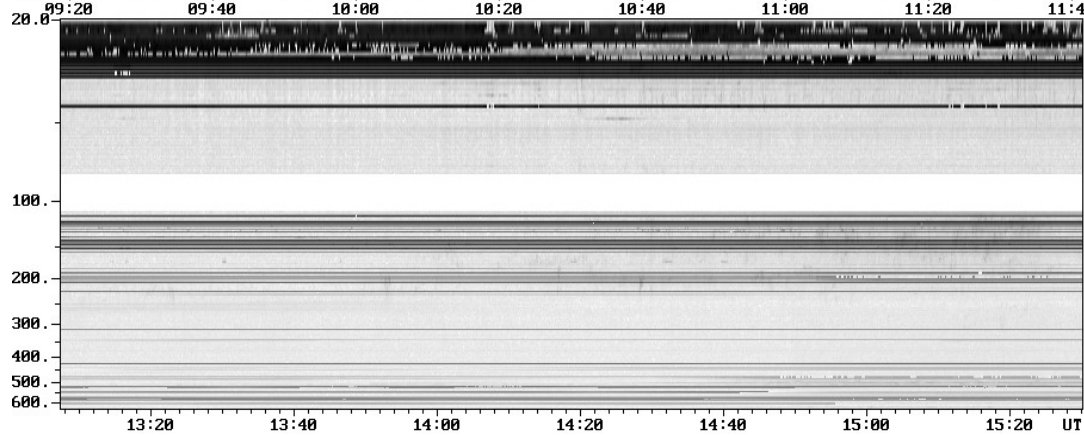
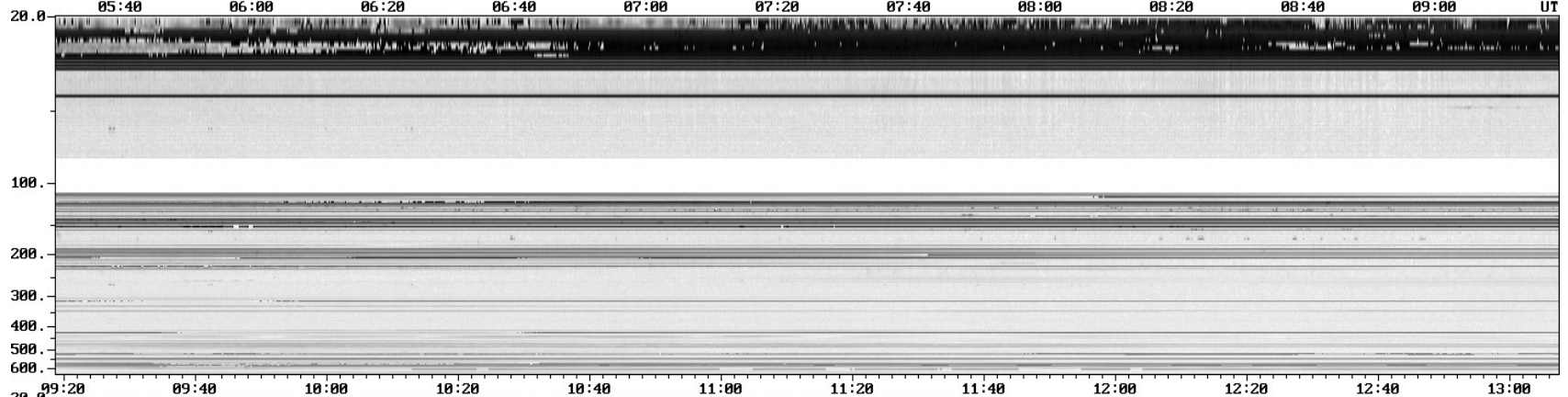
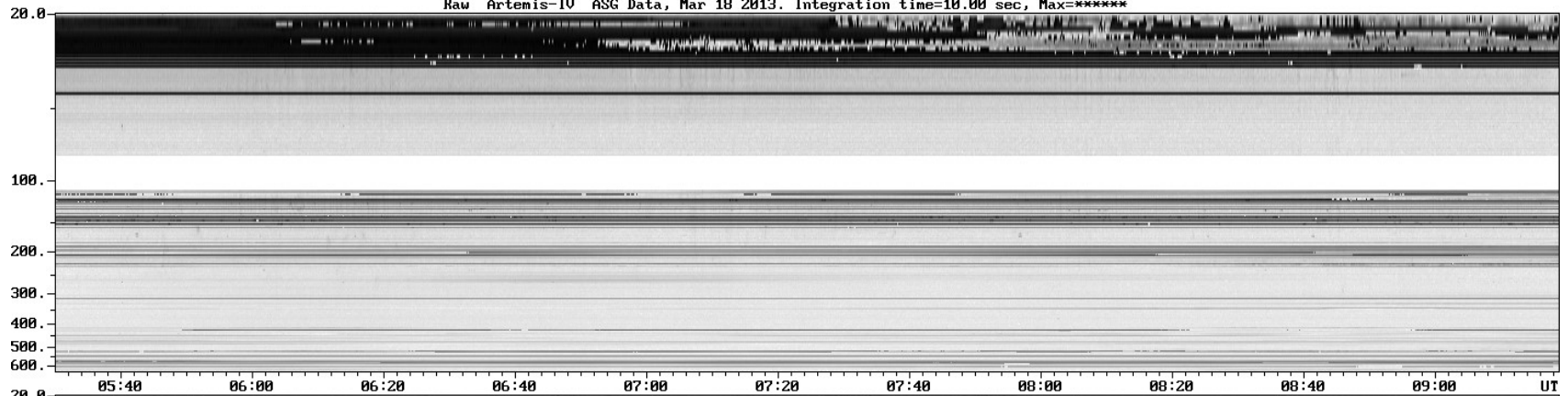


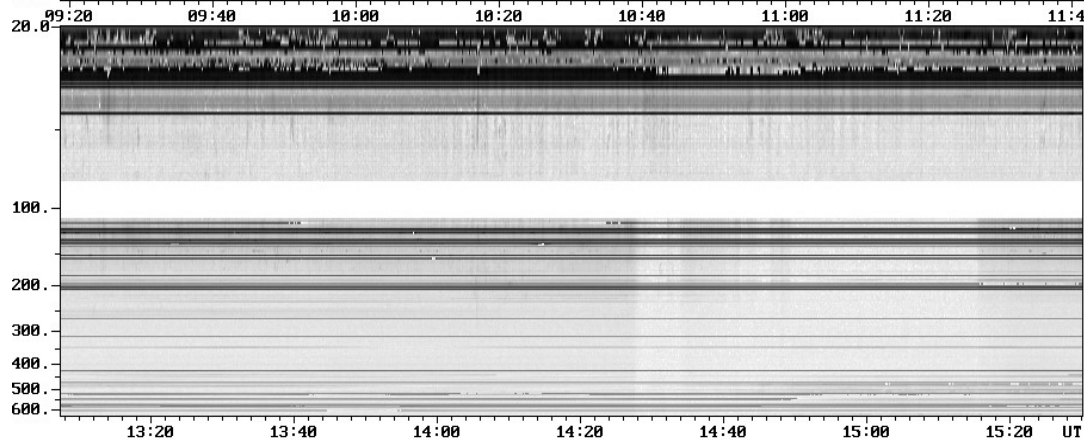
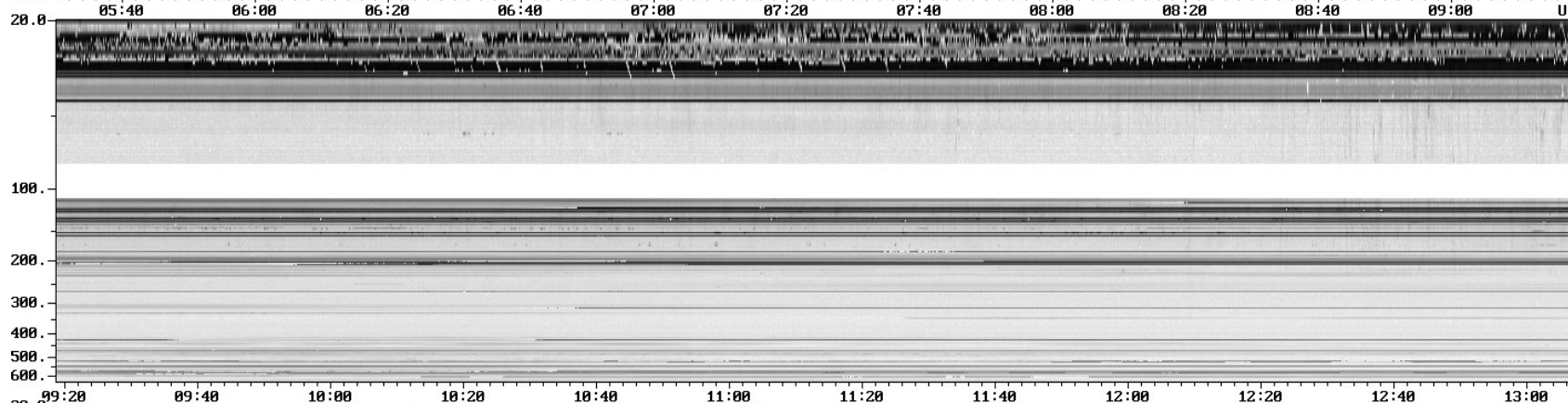
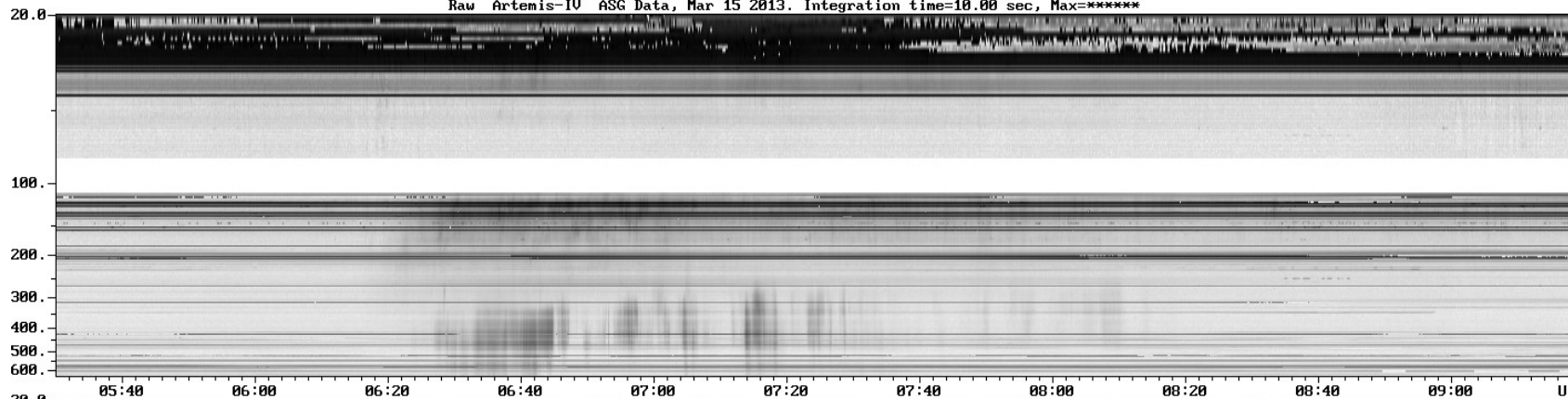
Figure 1. Time profiles of the burst on January 6, 1994. (a) Yohkoh HXT M1 channel, and (b) flux density at 17 GHz.

Spiky flux variations and high brightness temperature of the radio sources imply that the emission is accounted for by gyrosynchrotron radiation from a power-law distribution of electrons. The radio flux spectrum of the burst obtained by the radio polarimeters at Nobeyama and Toyokawa give a peak frequency between 3.75 GHz and 9.4 GHz, and the flux spectral index in the optically thin part was -1.8 and -2.4 at first and second peaks. Assuming the gyrosynchrotron radiation, the energy spectral index of radio emitting electrons is 3.3 and 4.0 (Dulk 1985). From the Yohkoh HXT observations, the energy spectral index of hard X-ray





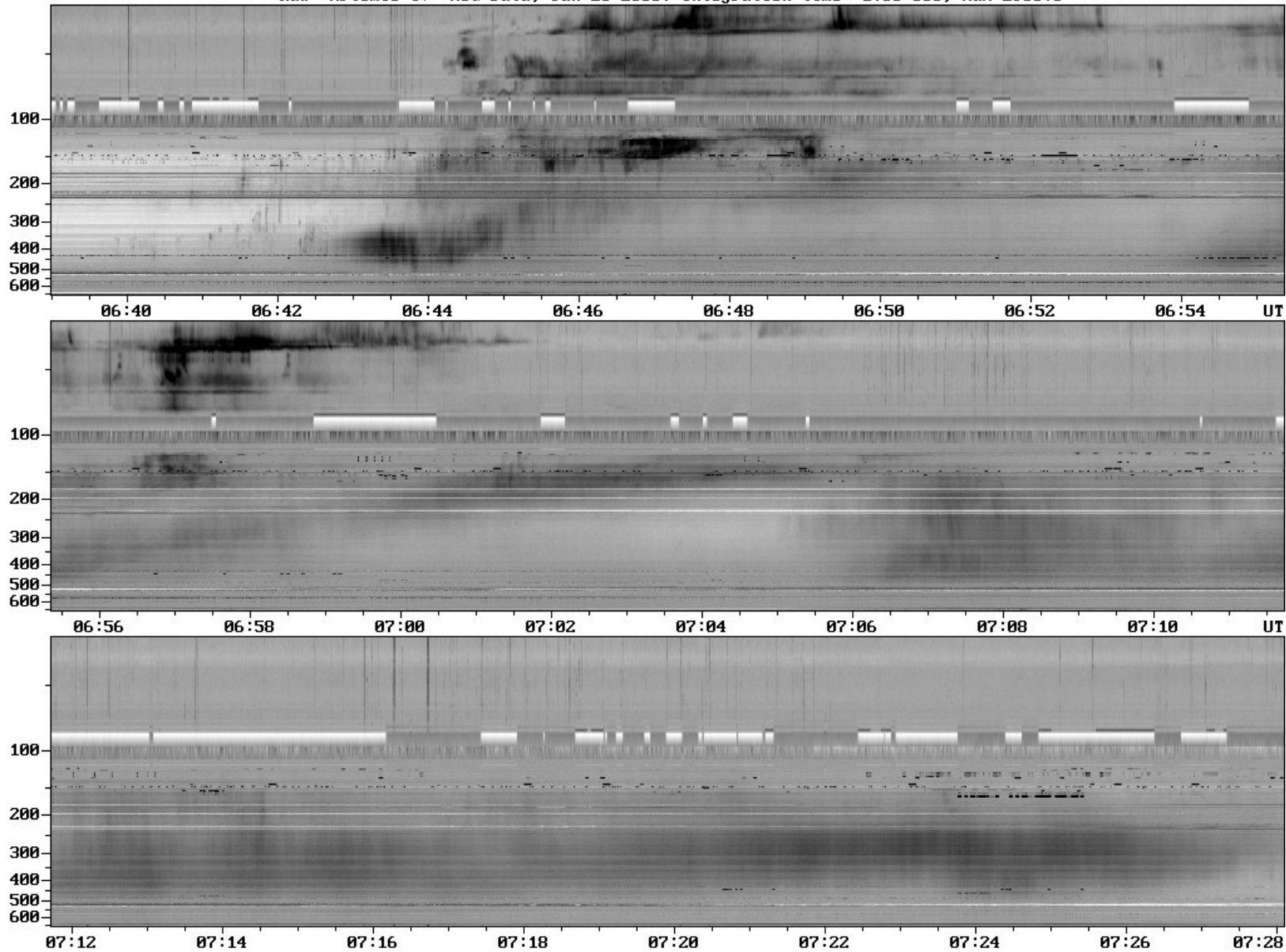




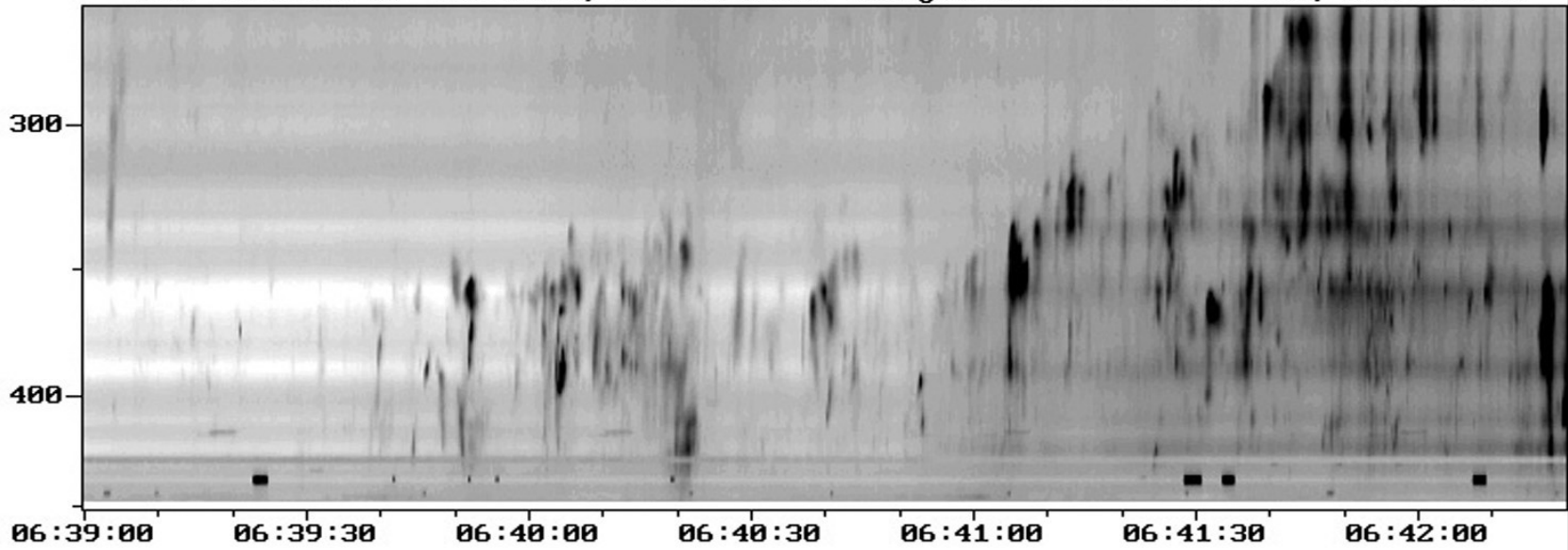


Εικόνα 1: Οι δύο κεραίες του ARTEMIS IV στις Θερμοπύλες

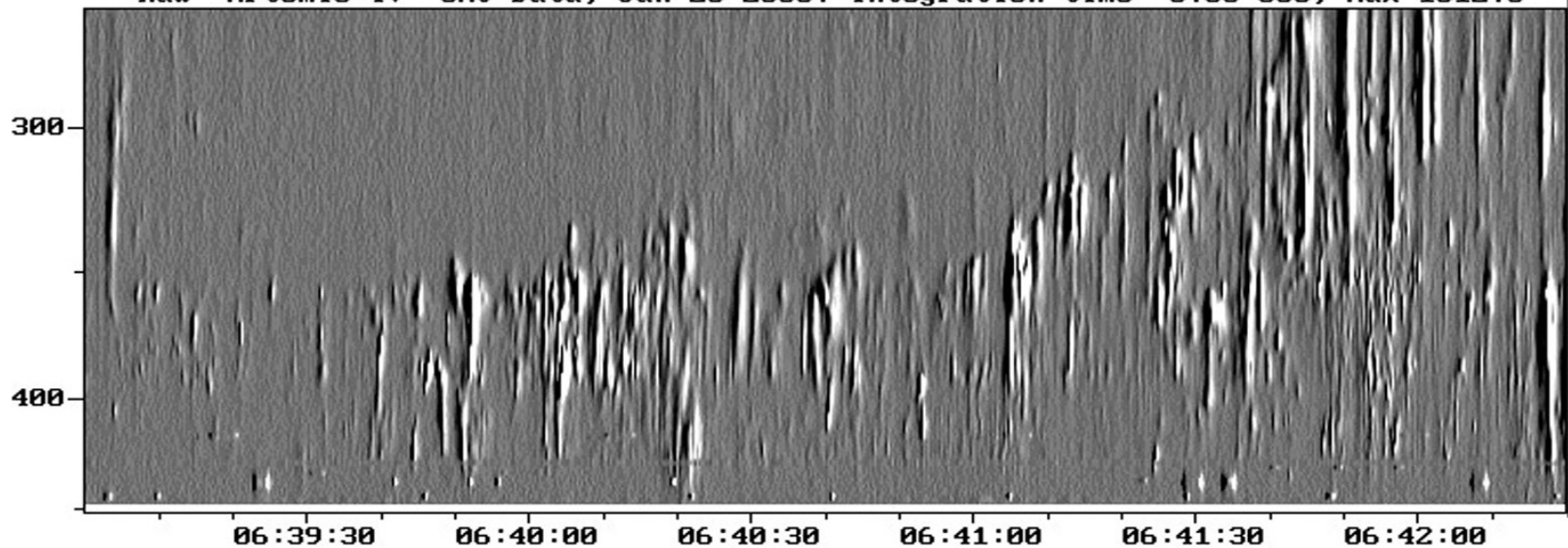




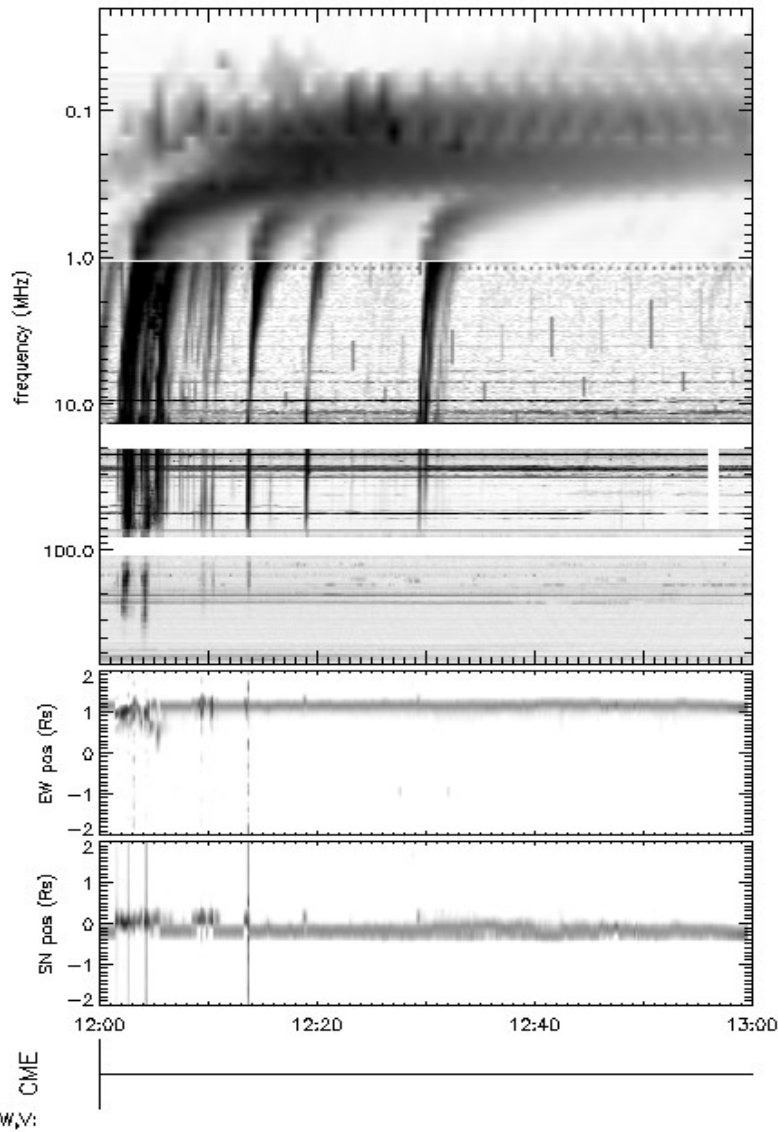
Raw Artemis-IV SAO Data, Jan 20 2005. Integration time= 0.30 sec, Max=1166.0



Raw Artemis-IV SAO Data, Jan 20 2005. Integration time= 0.30 sec, Max=1012.0

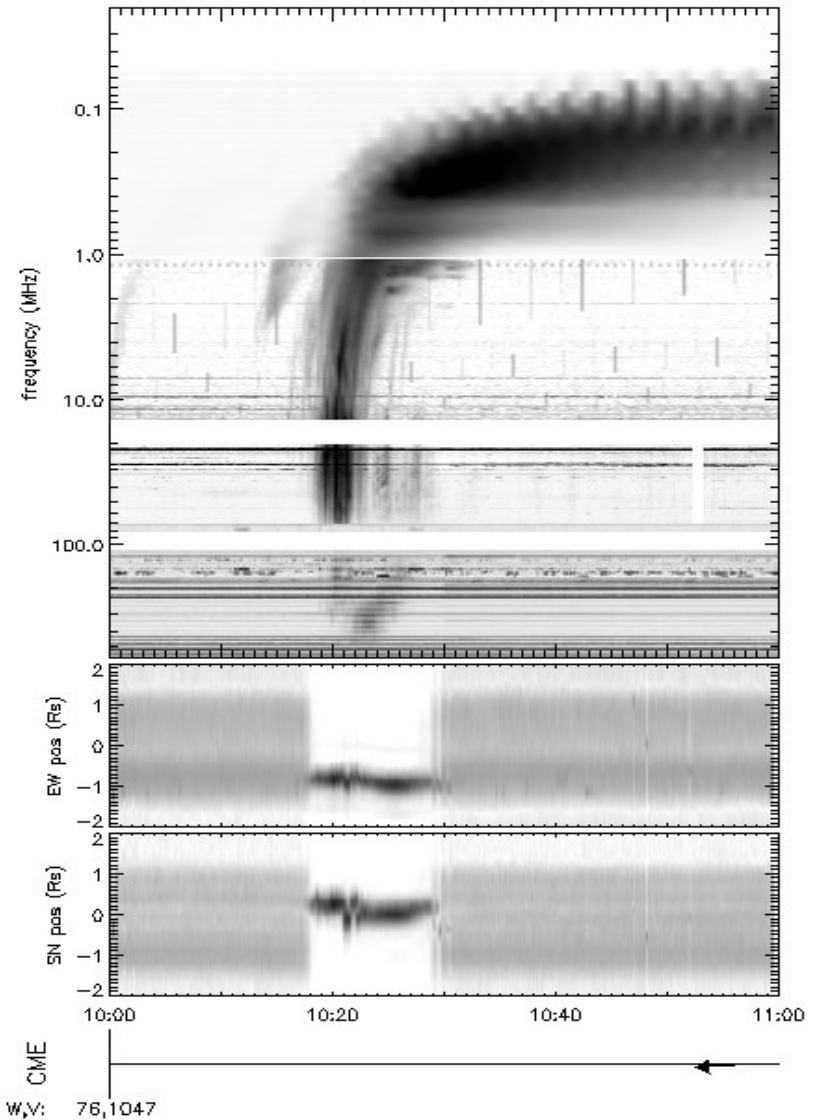


WIND/WAVES, DAM, ARTEMIS, NRH, CME, 07JUL2006



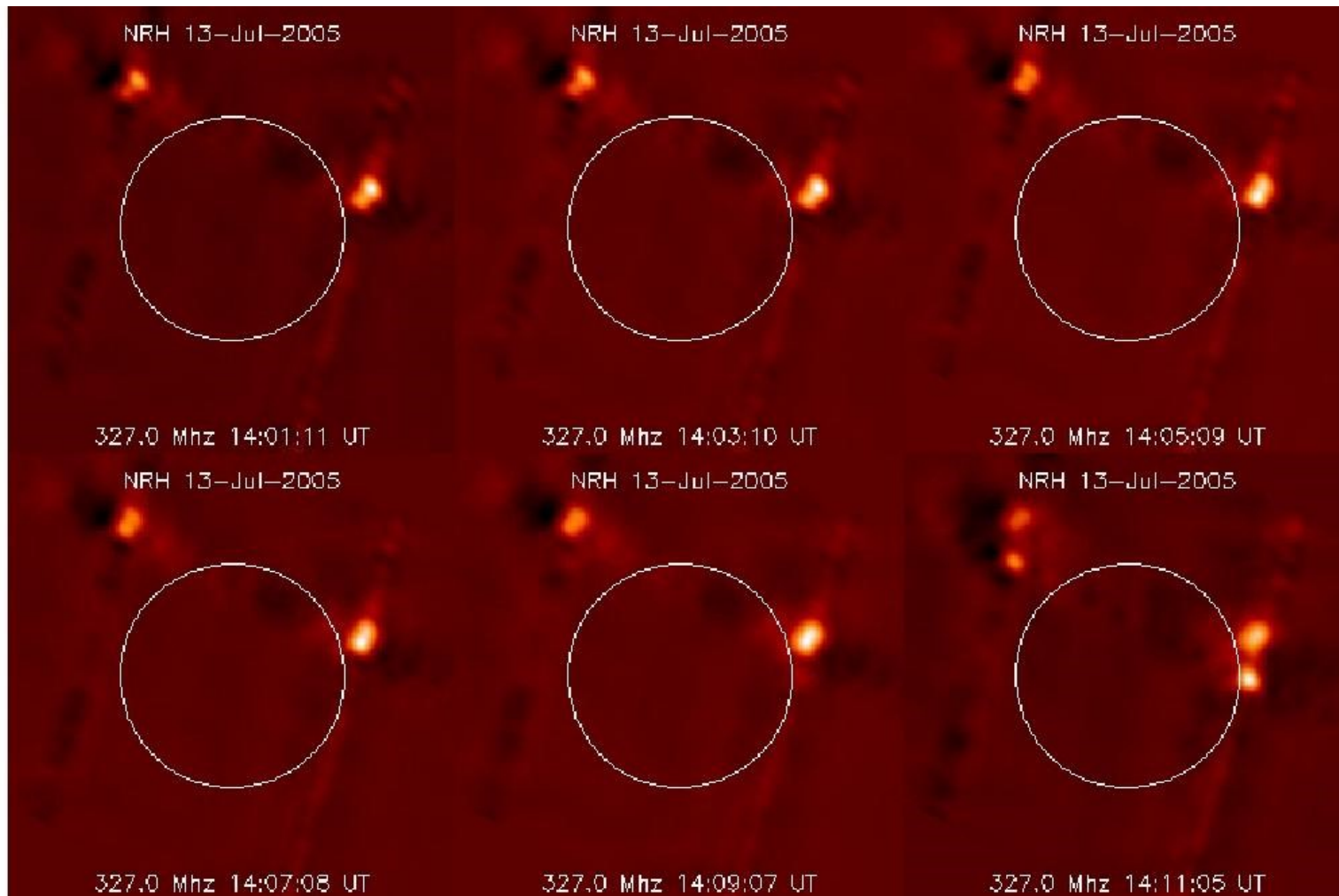
Assembled the 20DEC2006

WIND/WAVES, DAM, ARTEMIS, NRH, CME, 28AUG2005

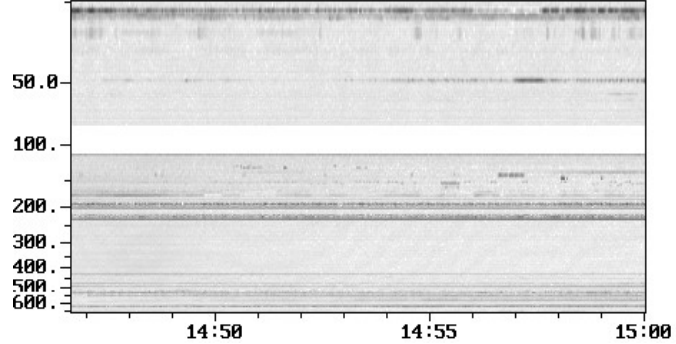
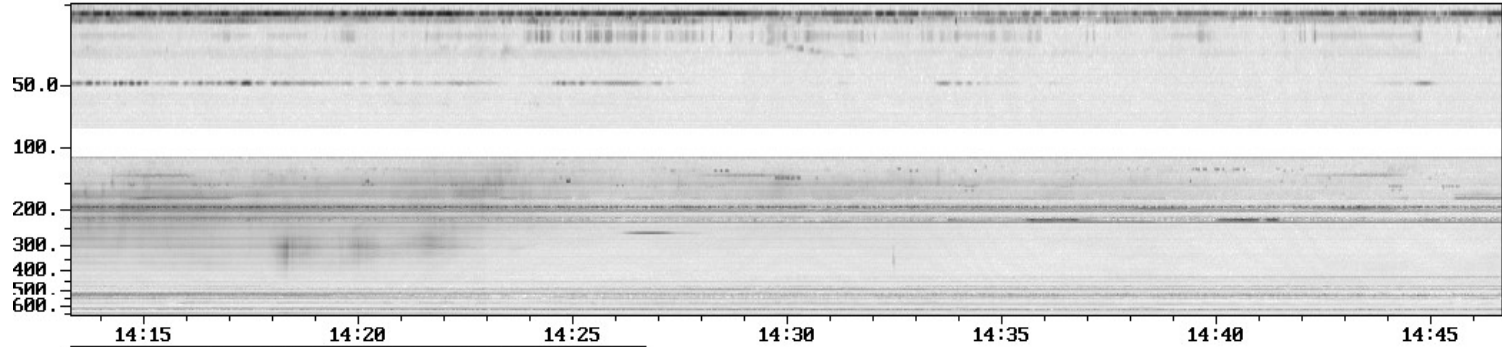
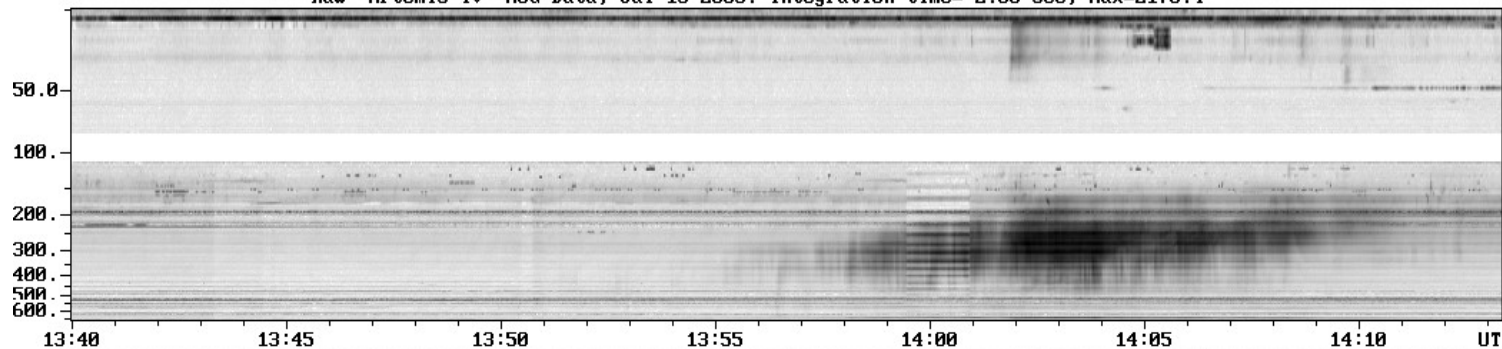


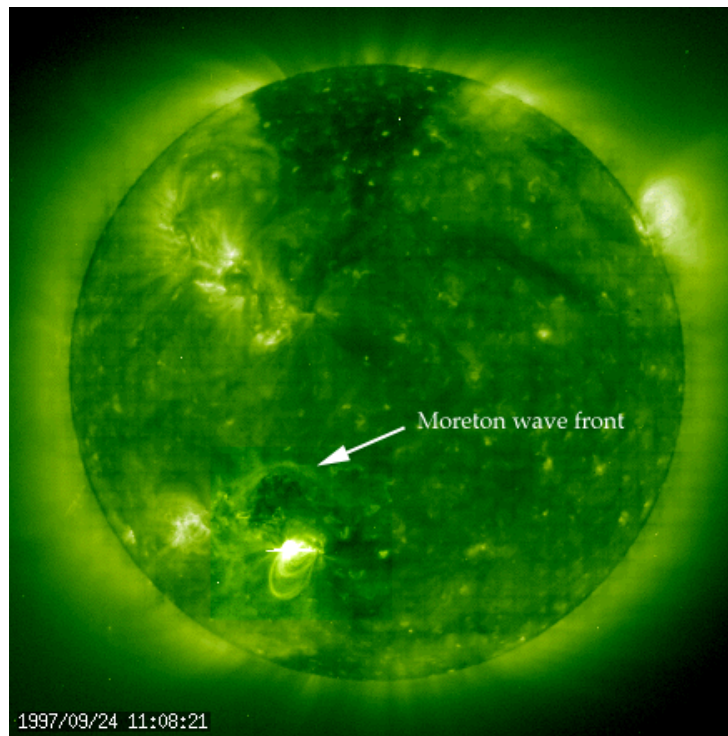
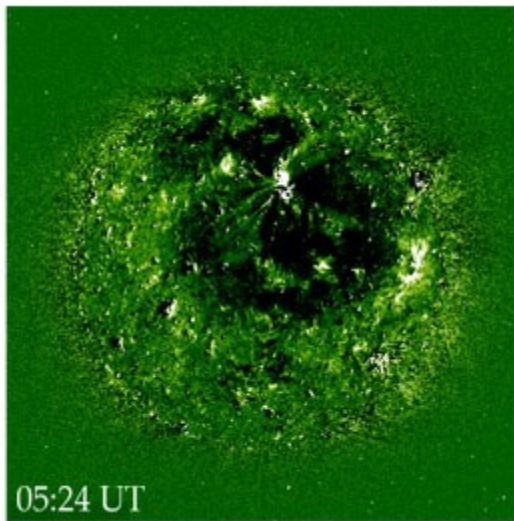
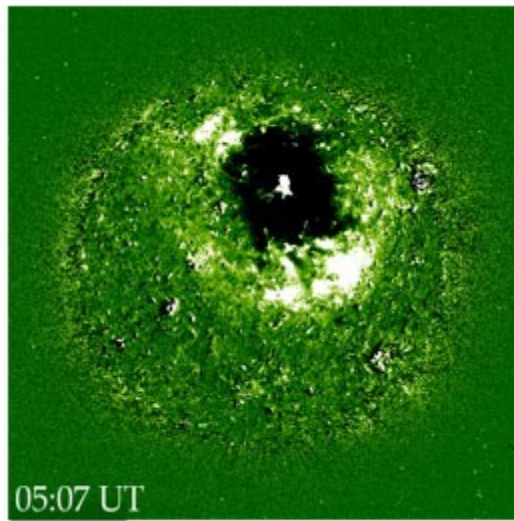
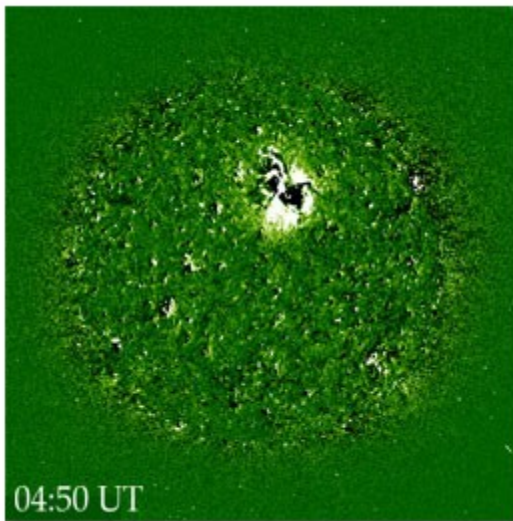
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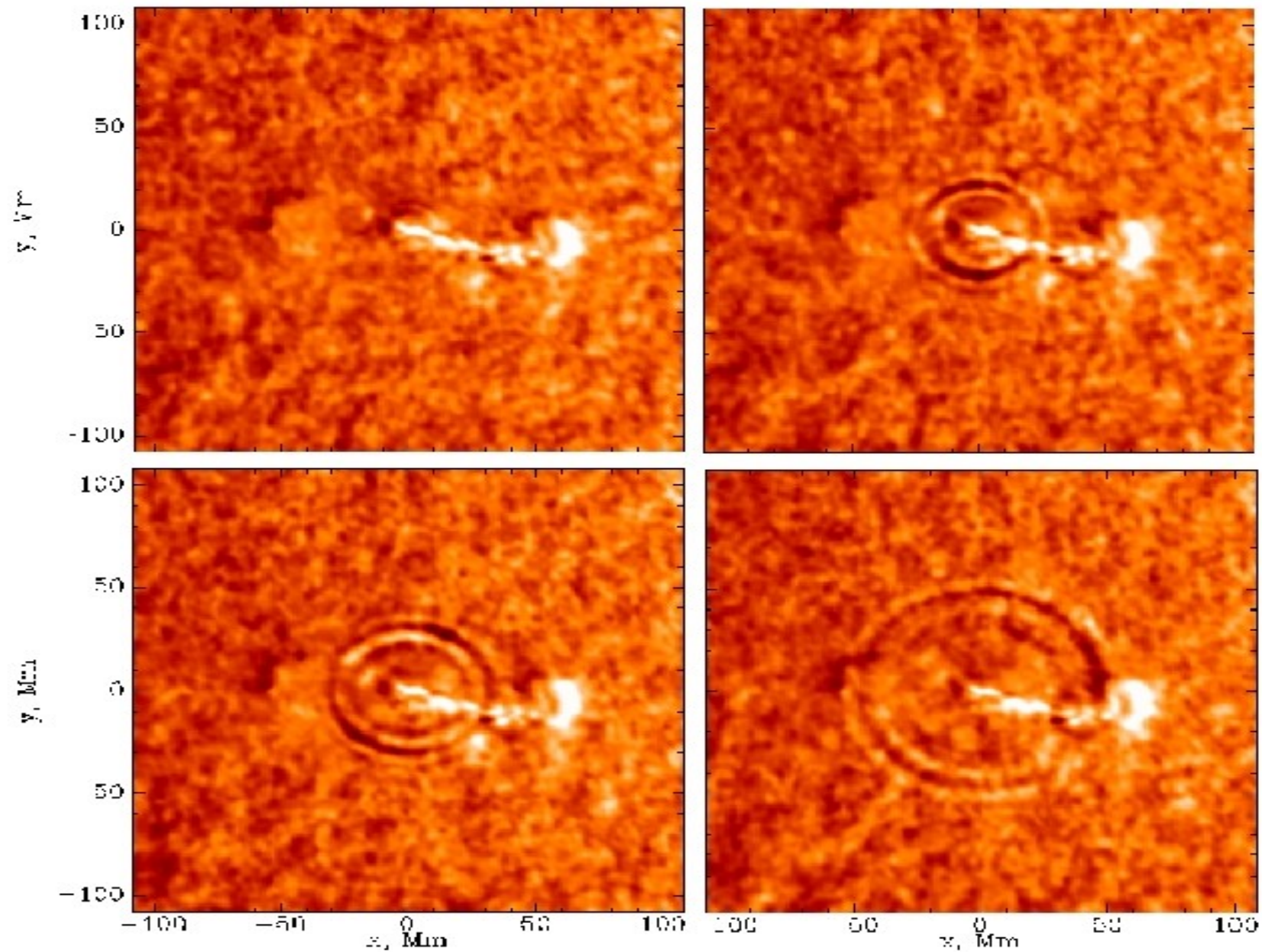


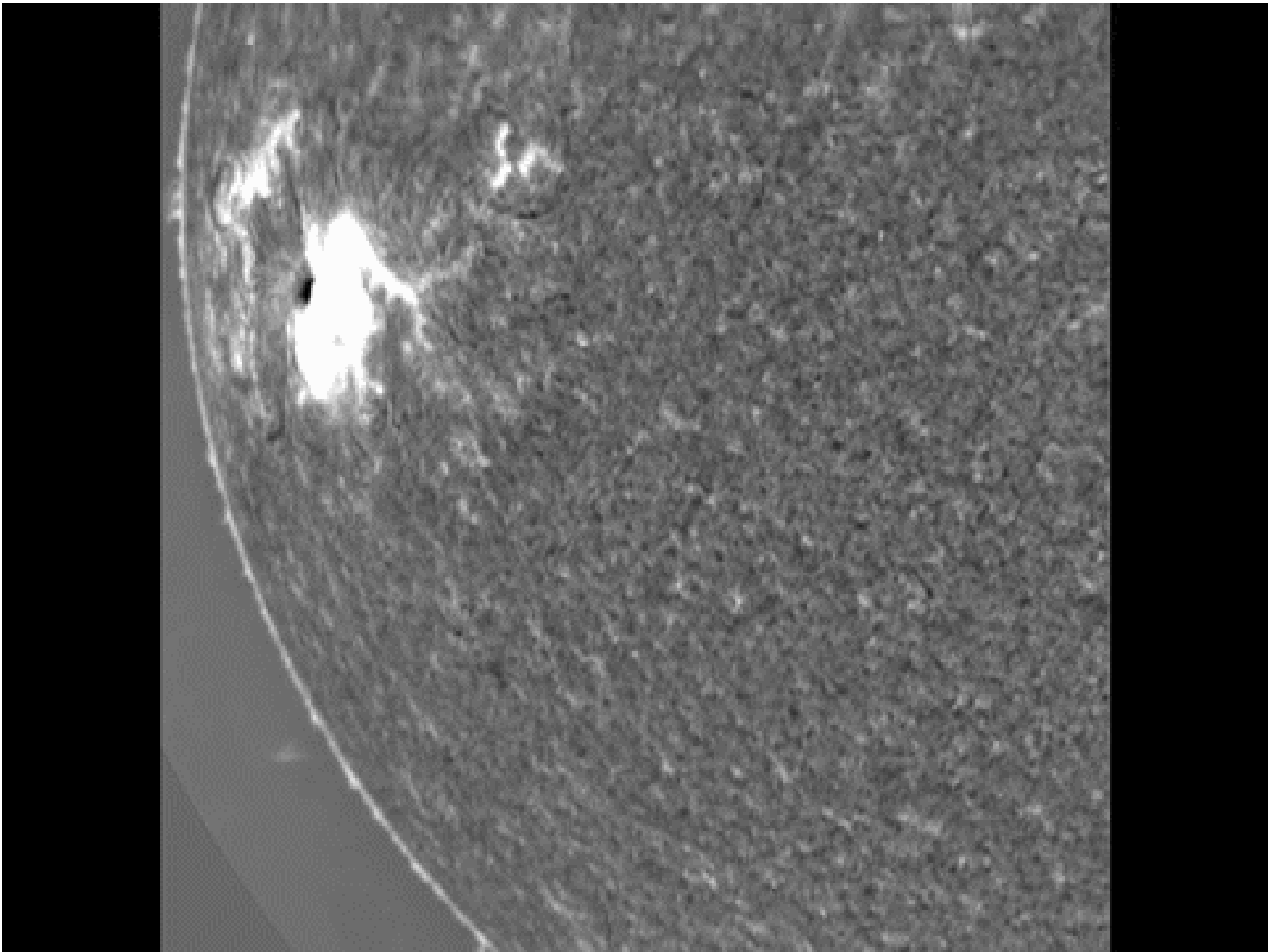


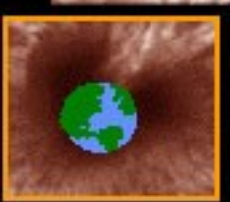
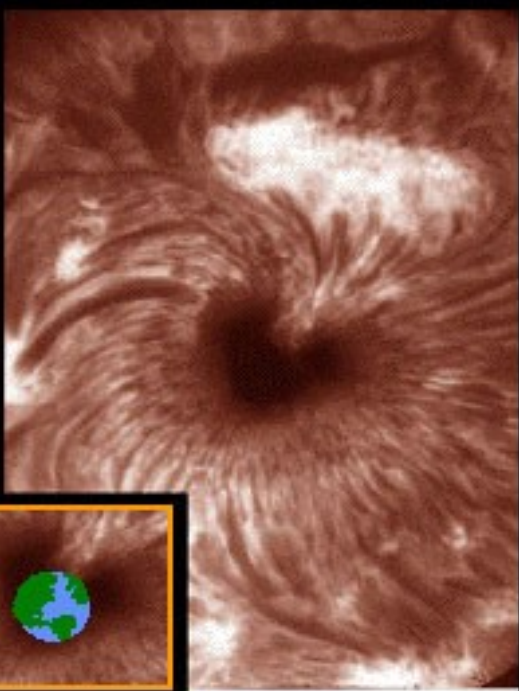
Raw Artemis-IV ASG Data, Jul 13 2005. Integration time= 2.00 sec, Max=2170.4



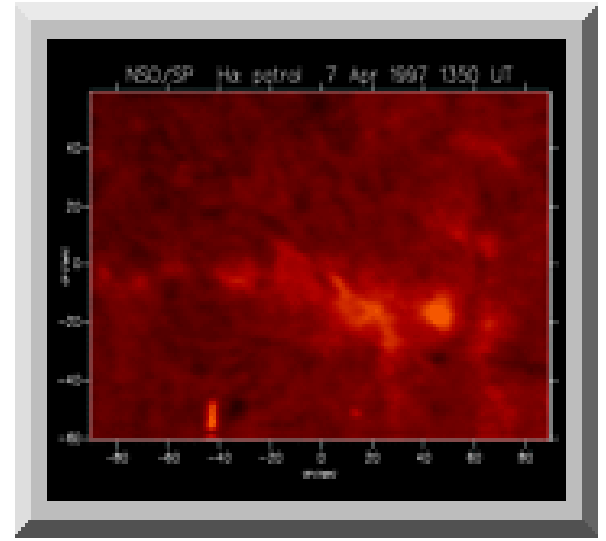
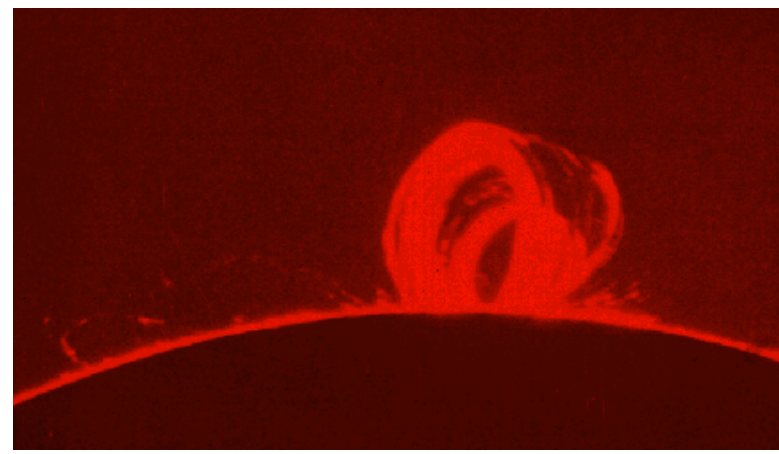
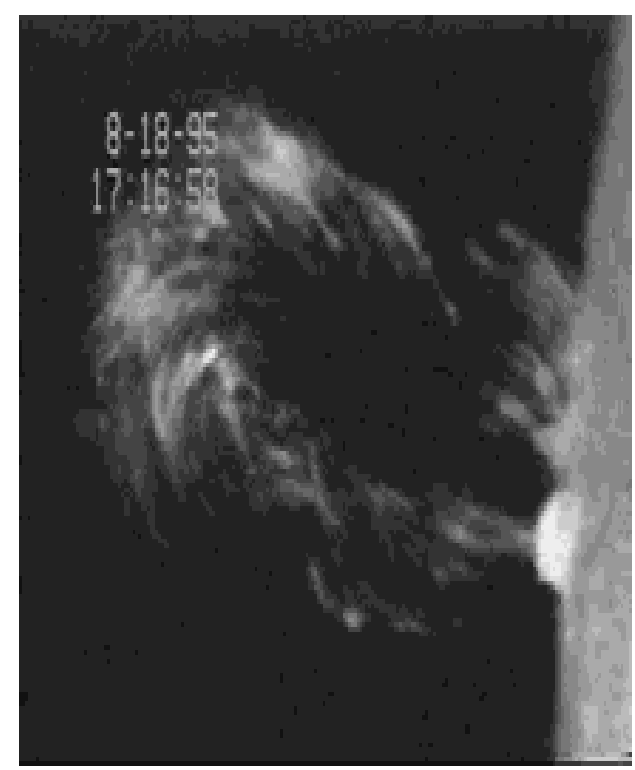
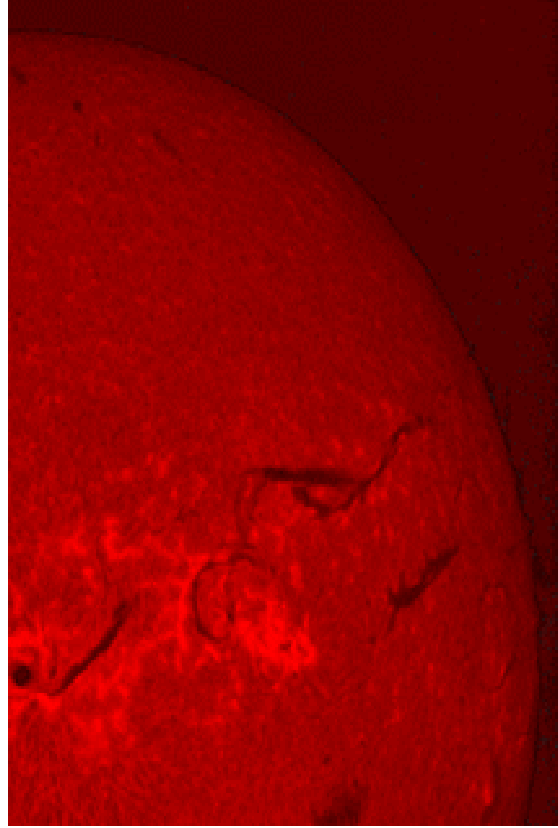


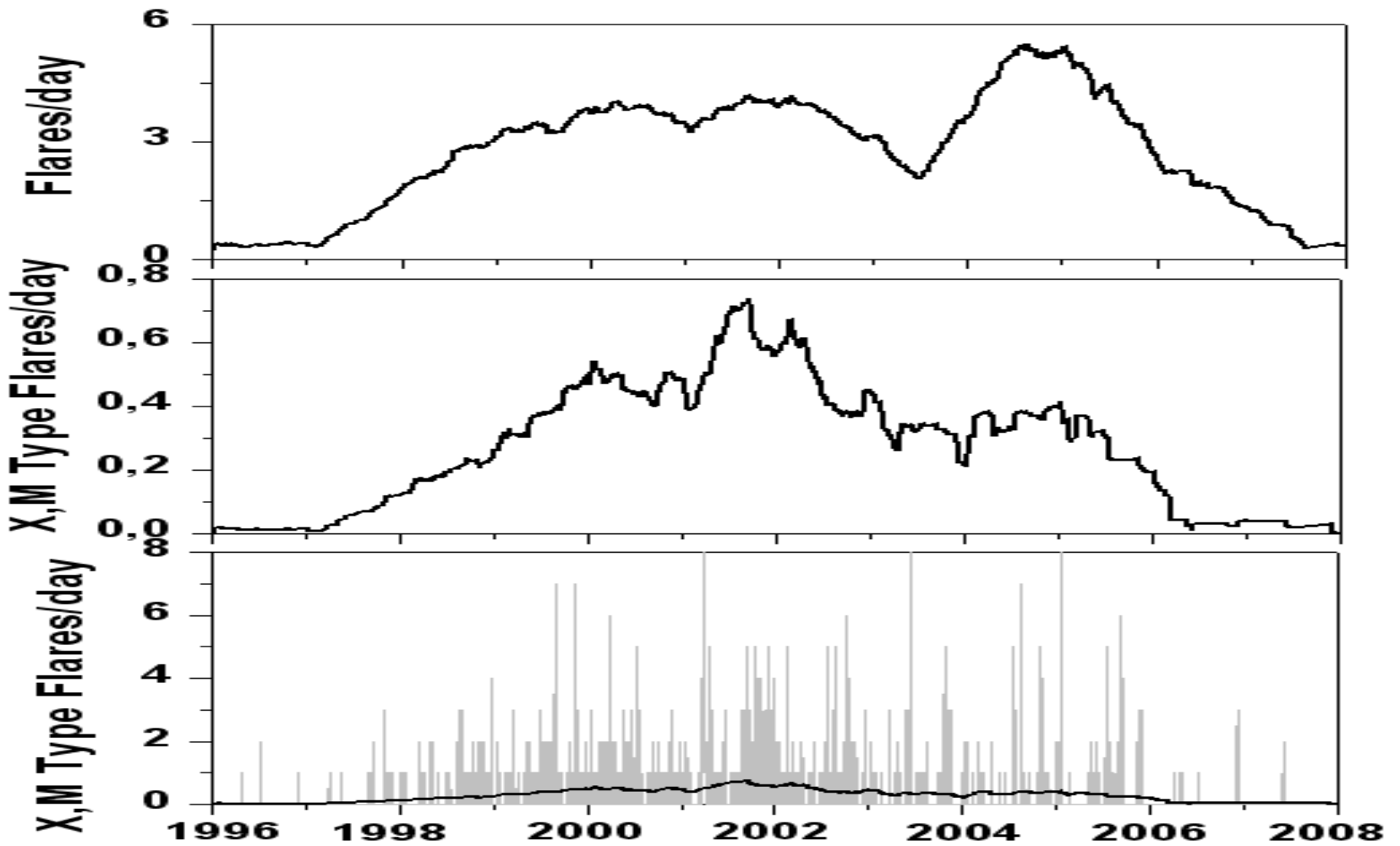






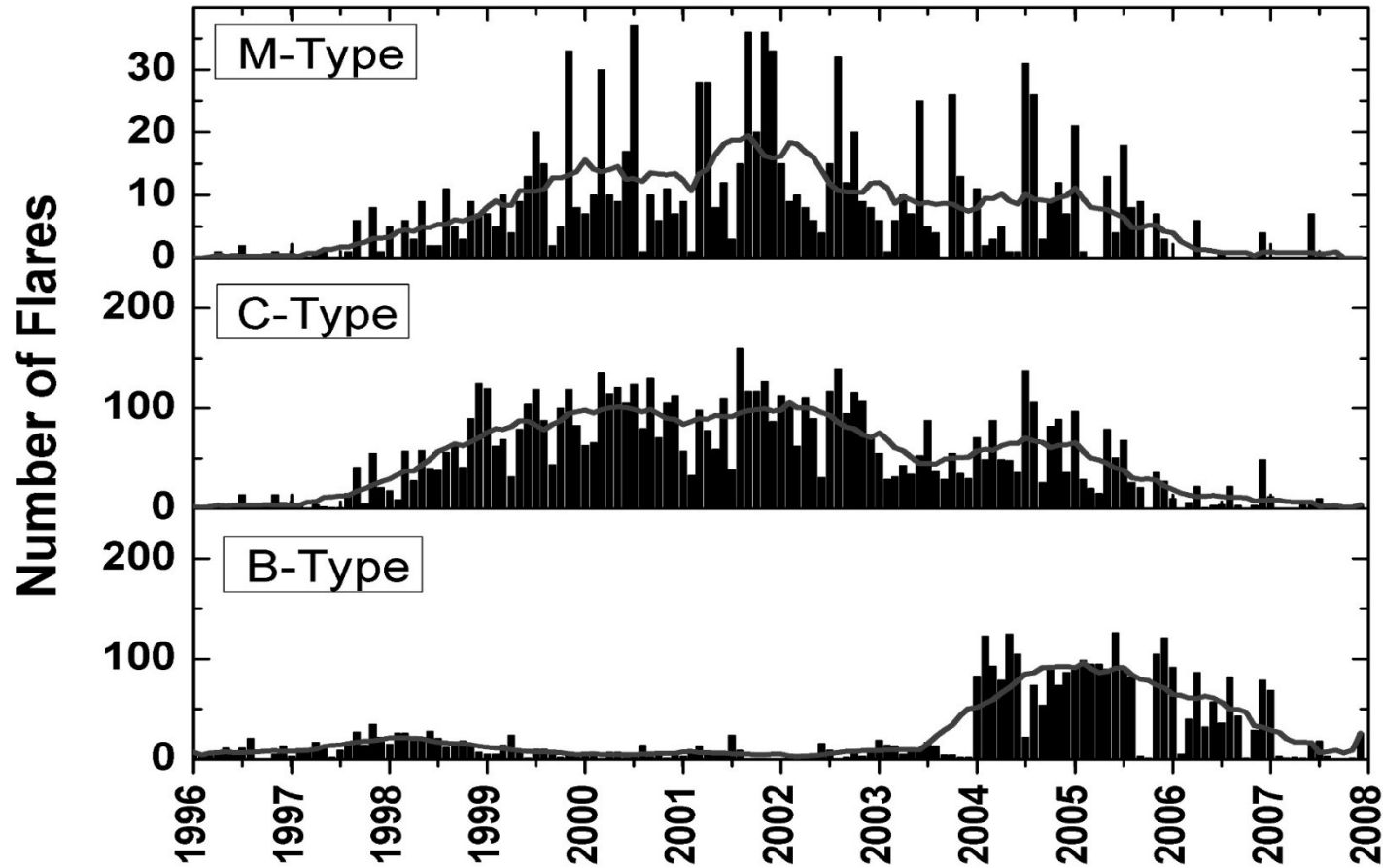
Approximate size





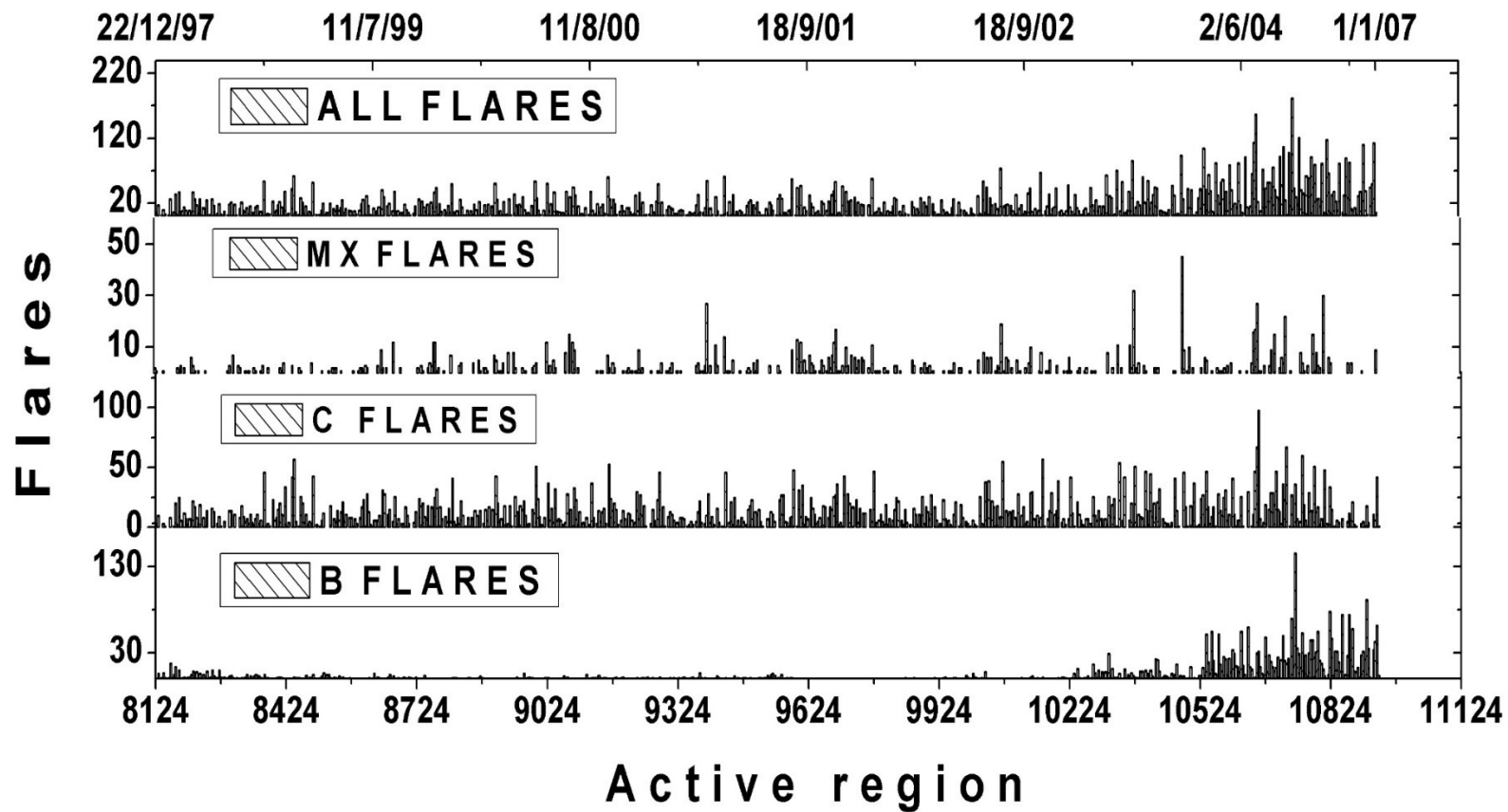
38th COSPAR Scientific Assembly Bremen, Germany, 18-25 July 2010





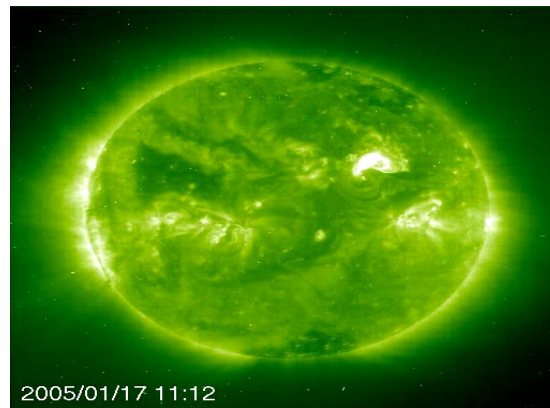
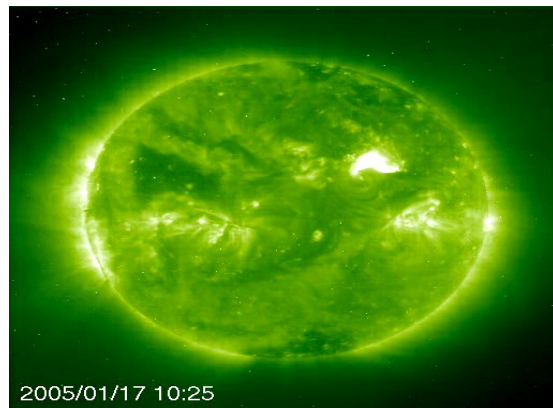
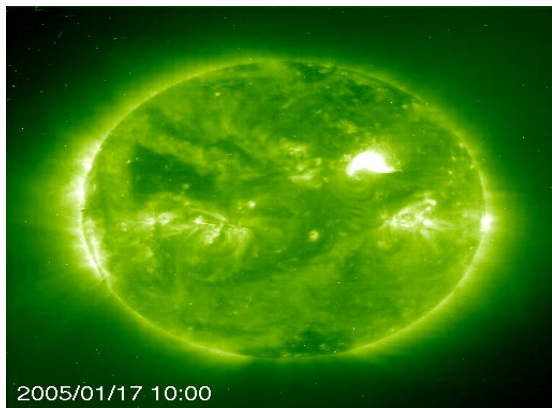
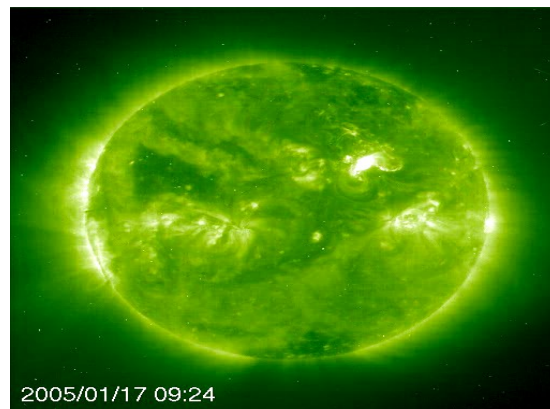
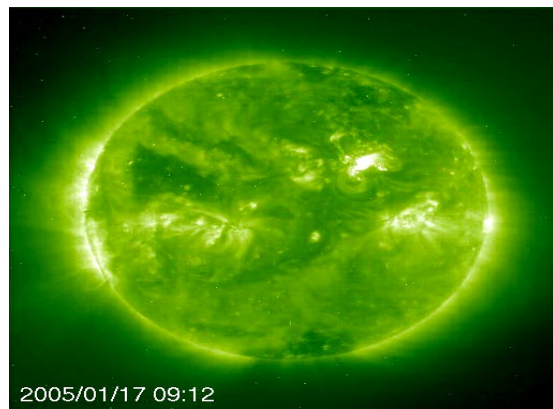
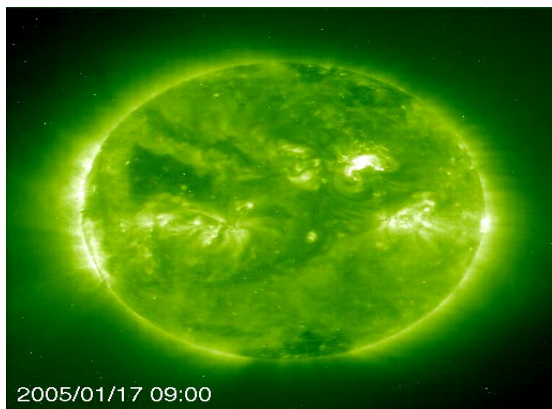
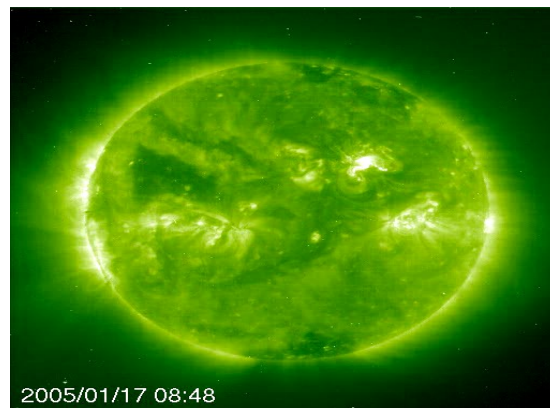
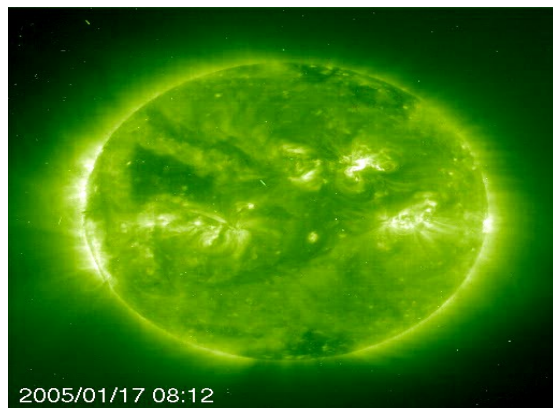
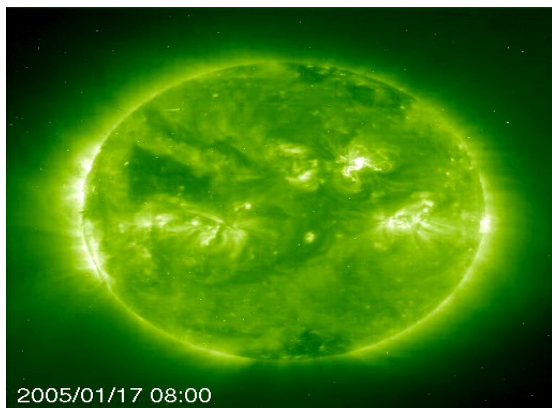
38th COSPAR Scientific Assembly Bremen, Germany, 18-25 July 2010



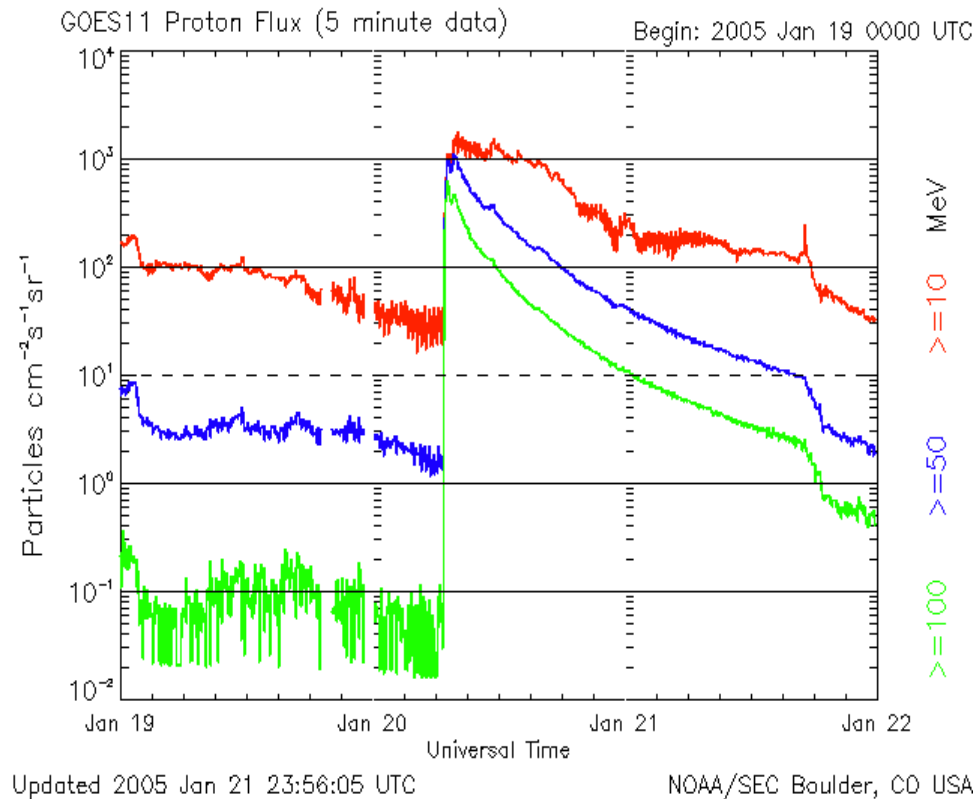
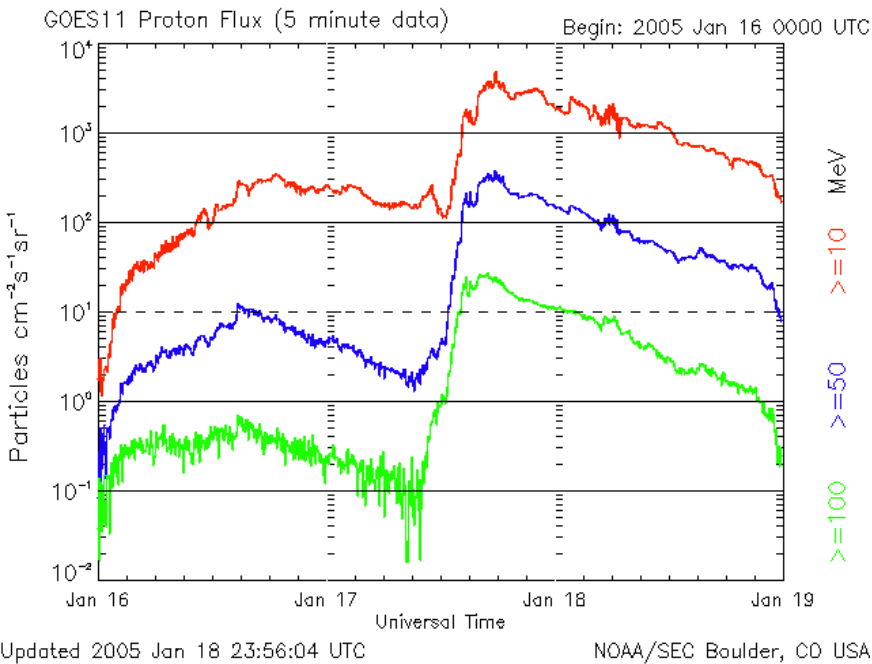


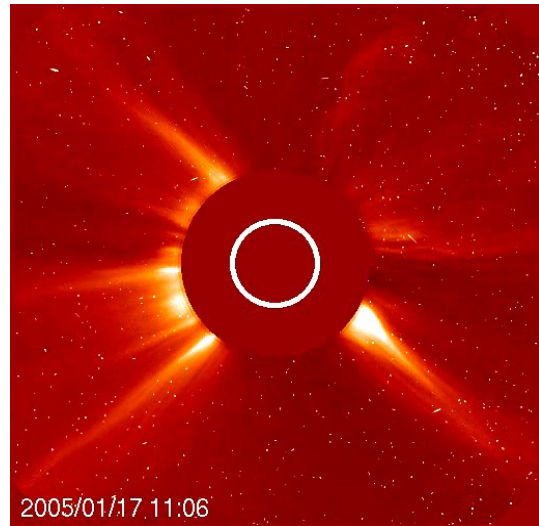
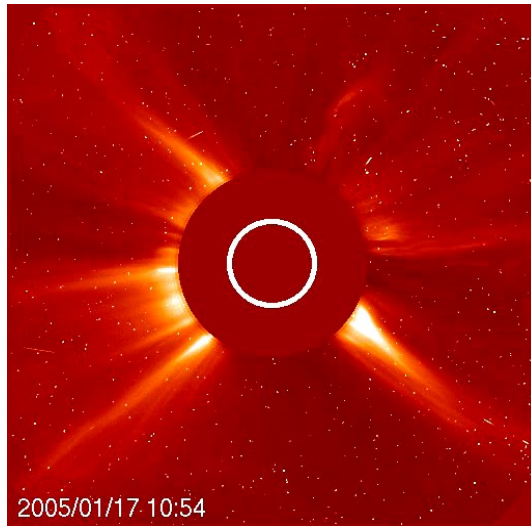
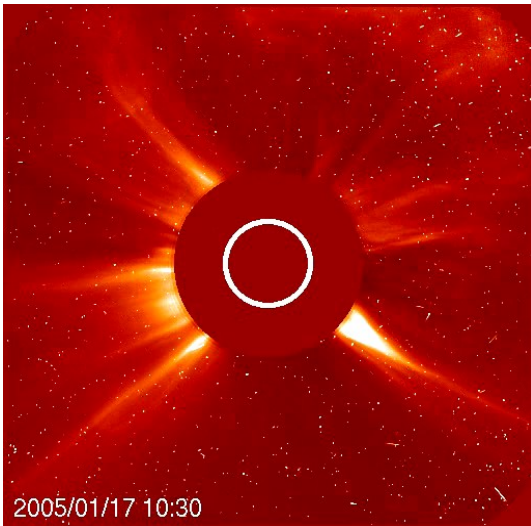
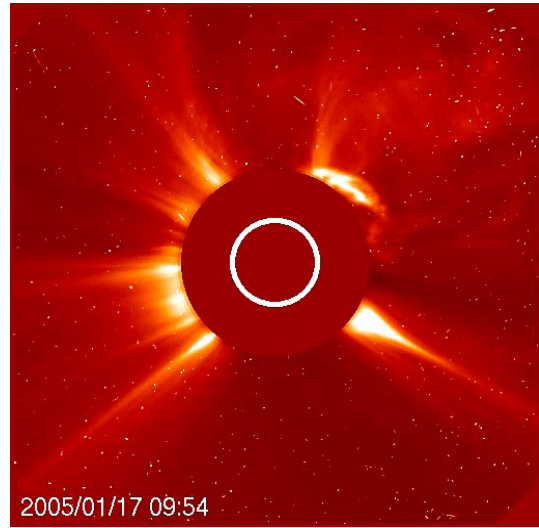
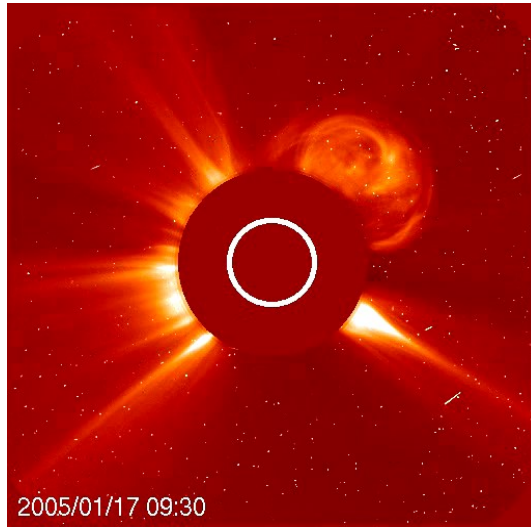
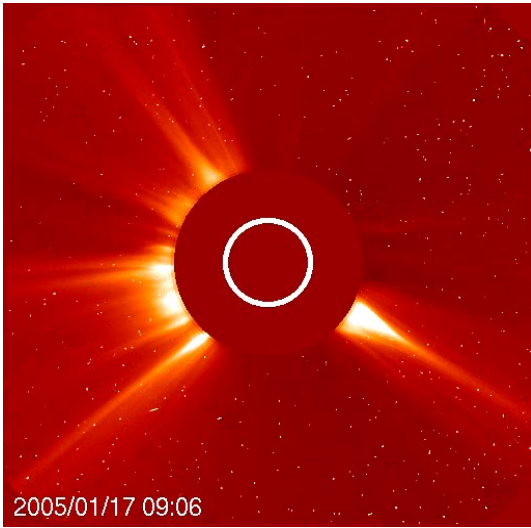
38th COSPAR Scientific Assembly Bremen, Germany, 18-25 July 2010

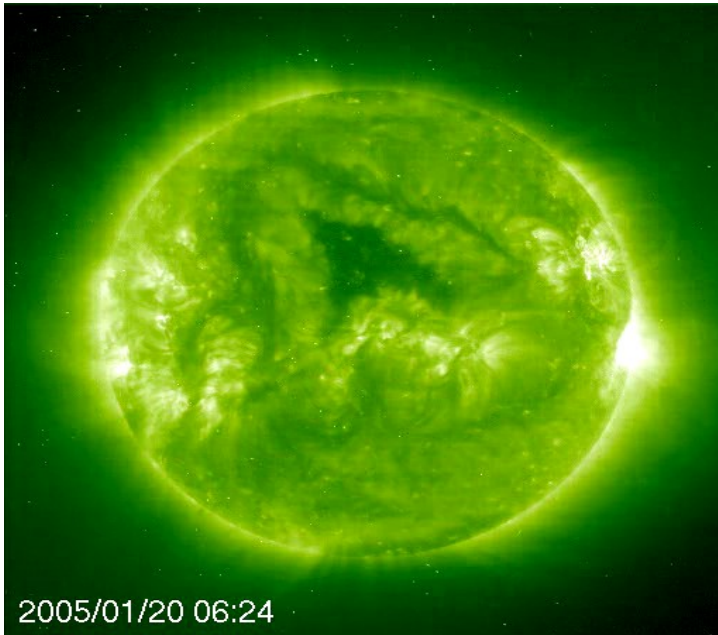




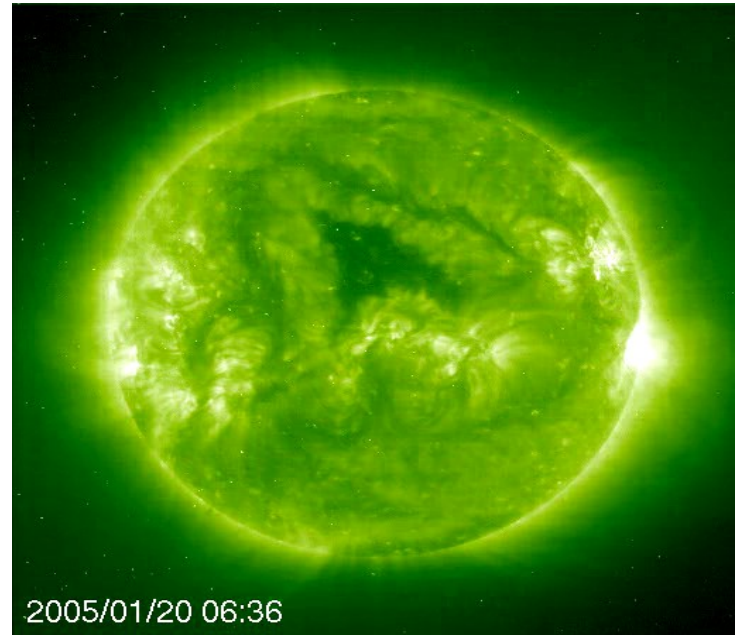
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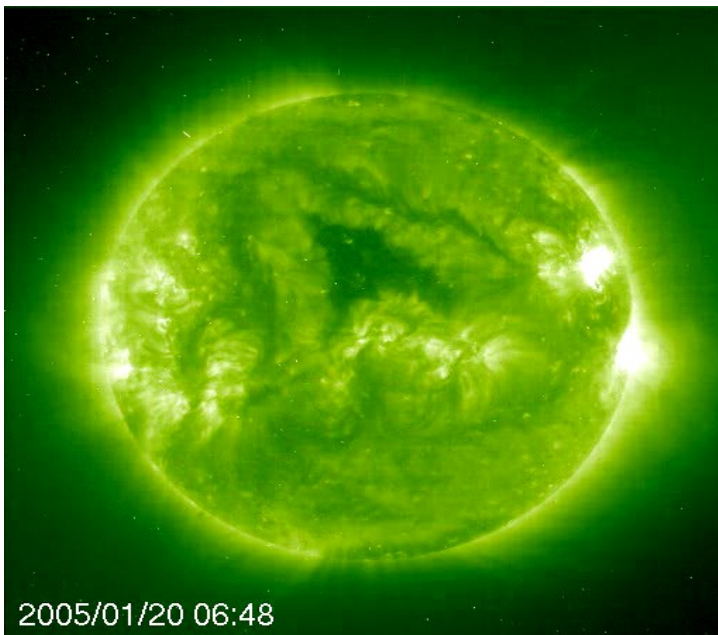




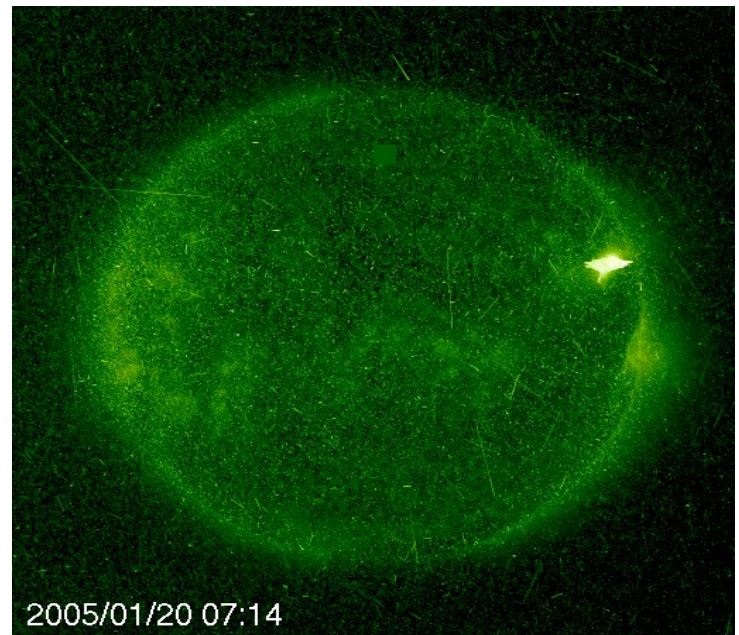
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2005/01/20 06:36

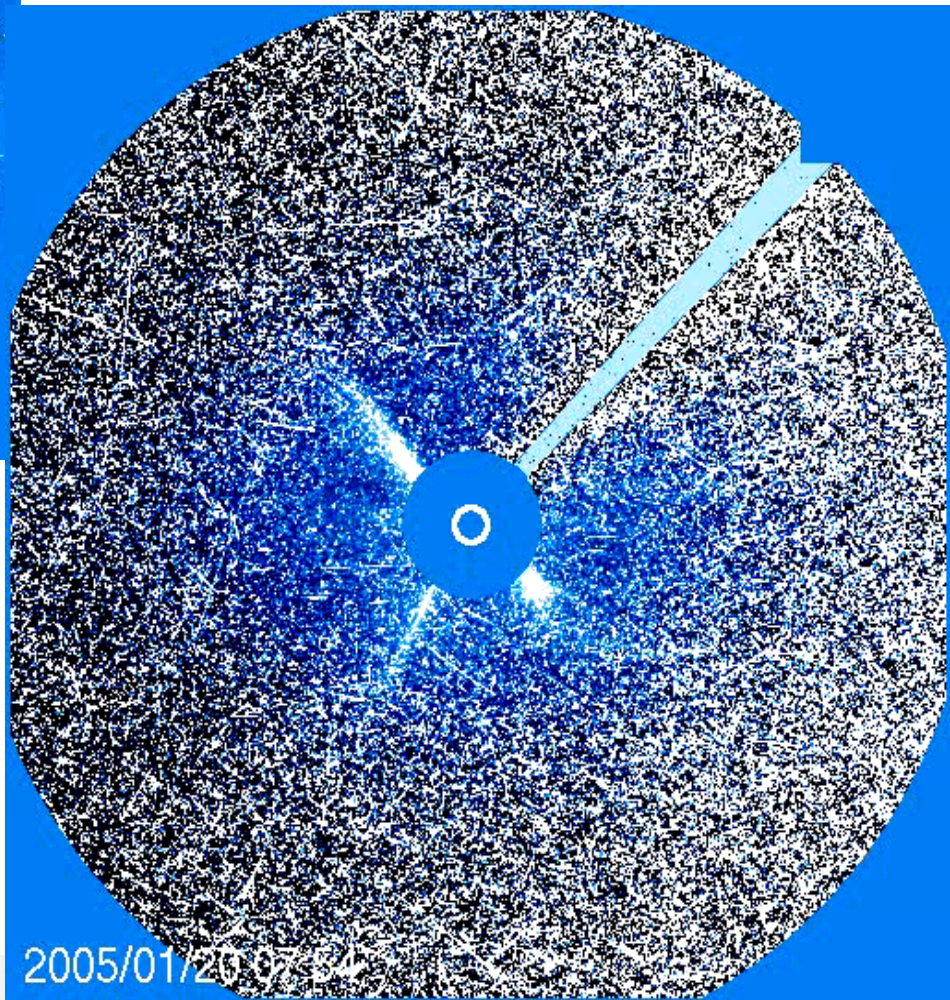
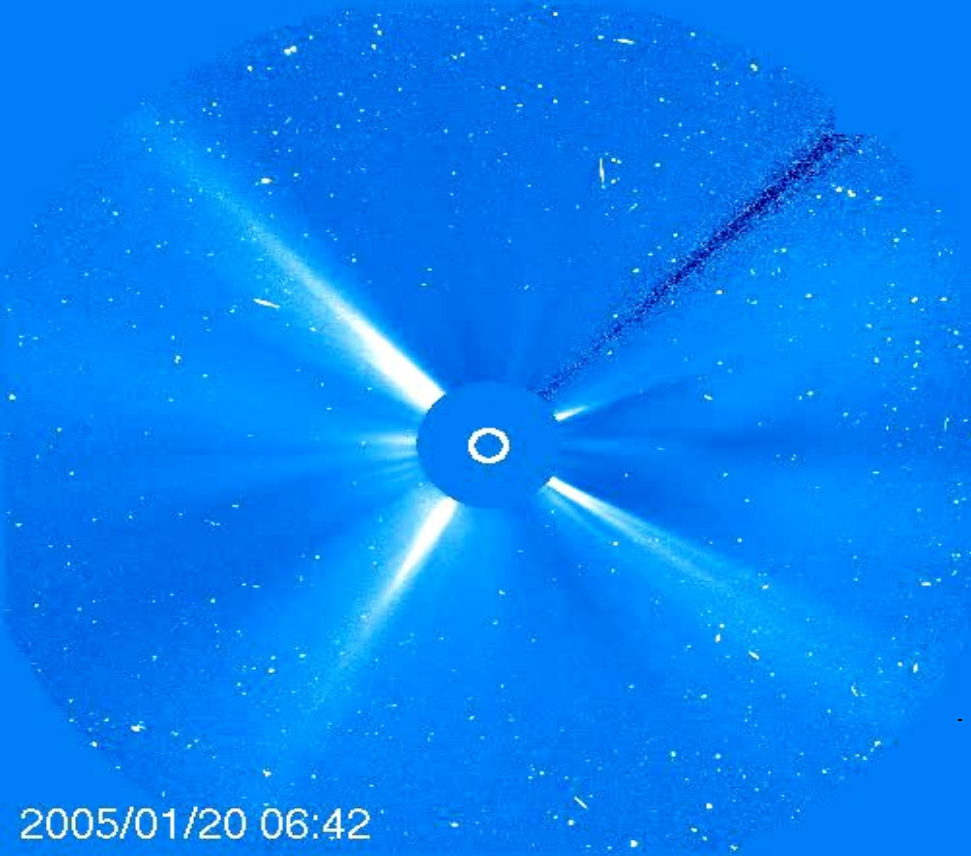


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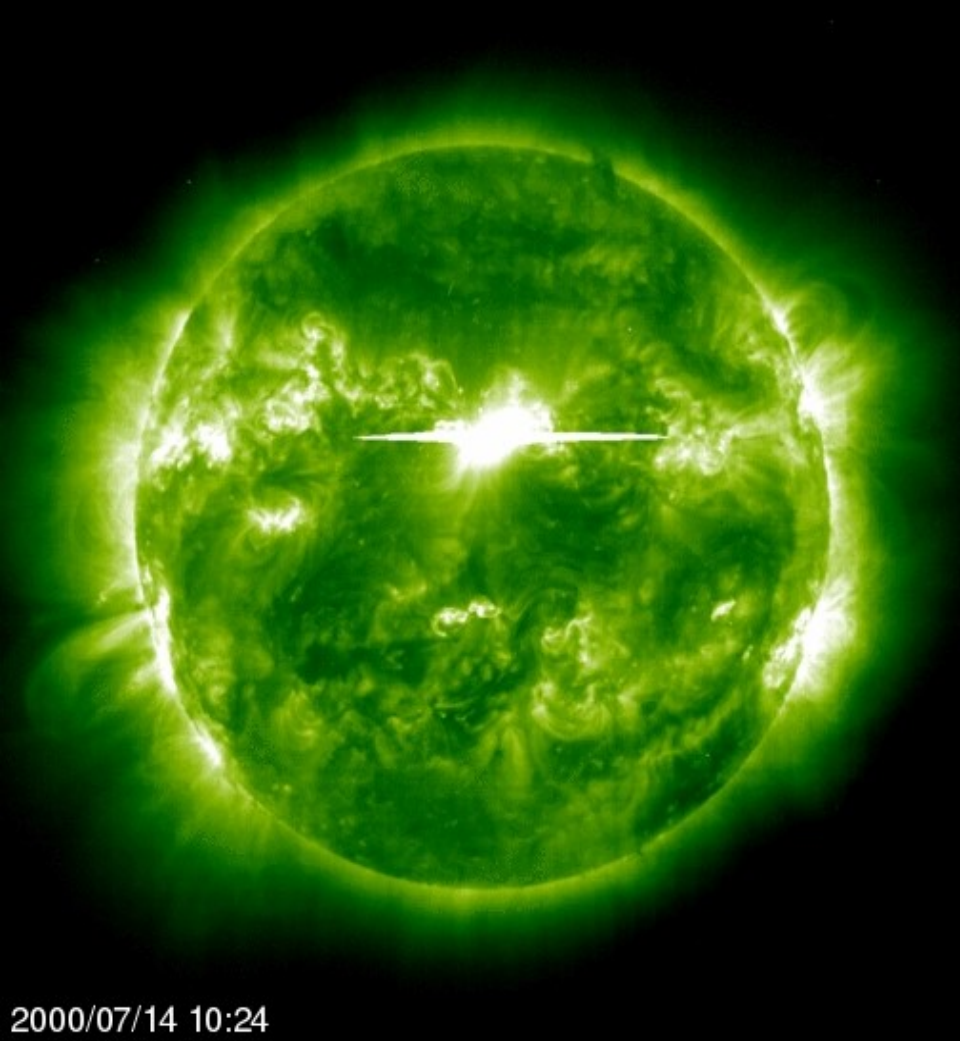


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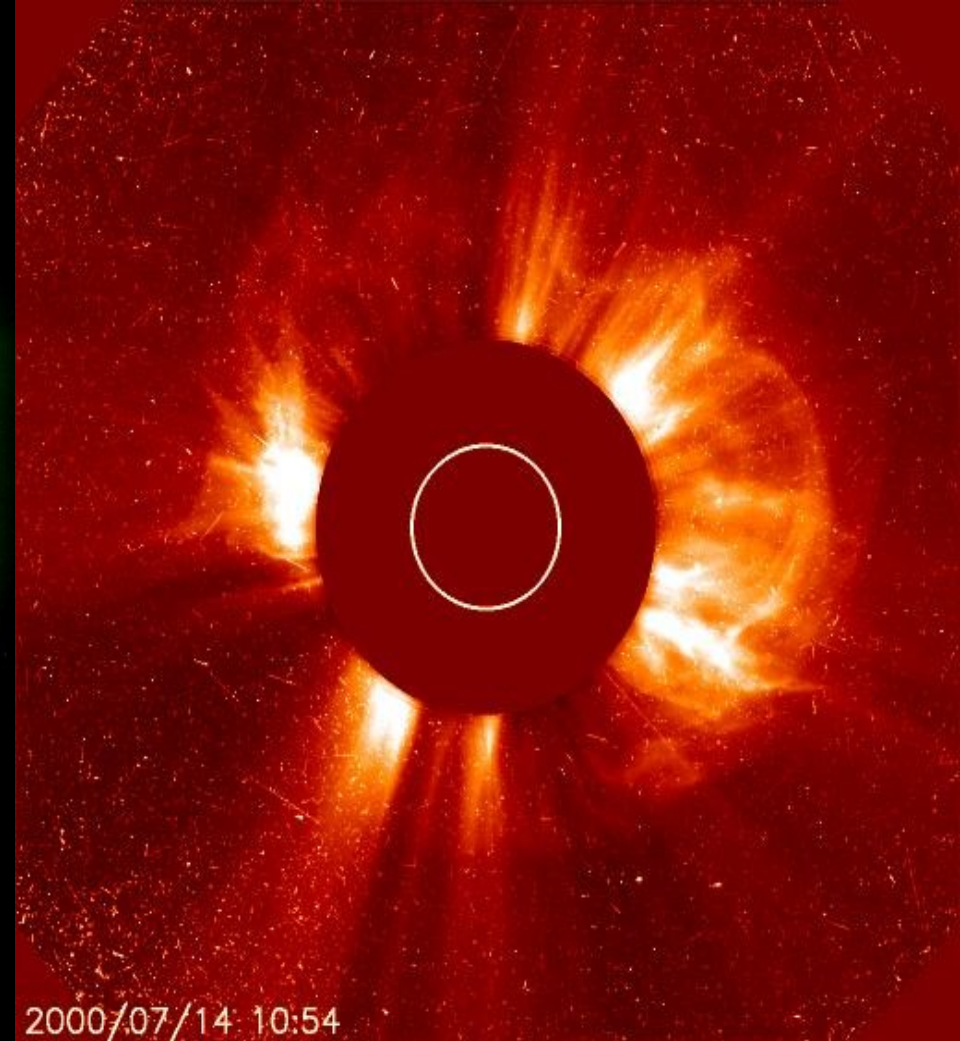




14 ΙΟΥΛΙΟΥ 2000 BASTILLE EVENT

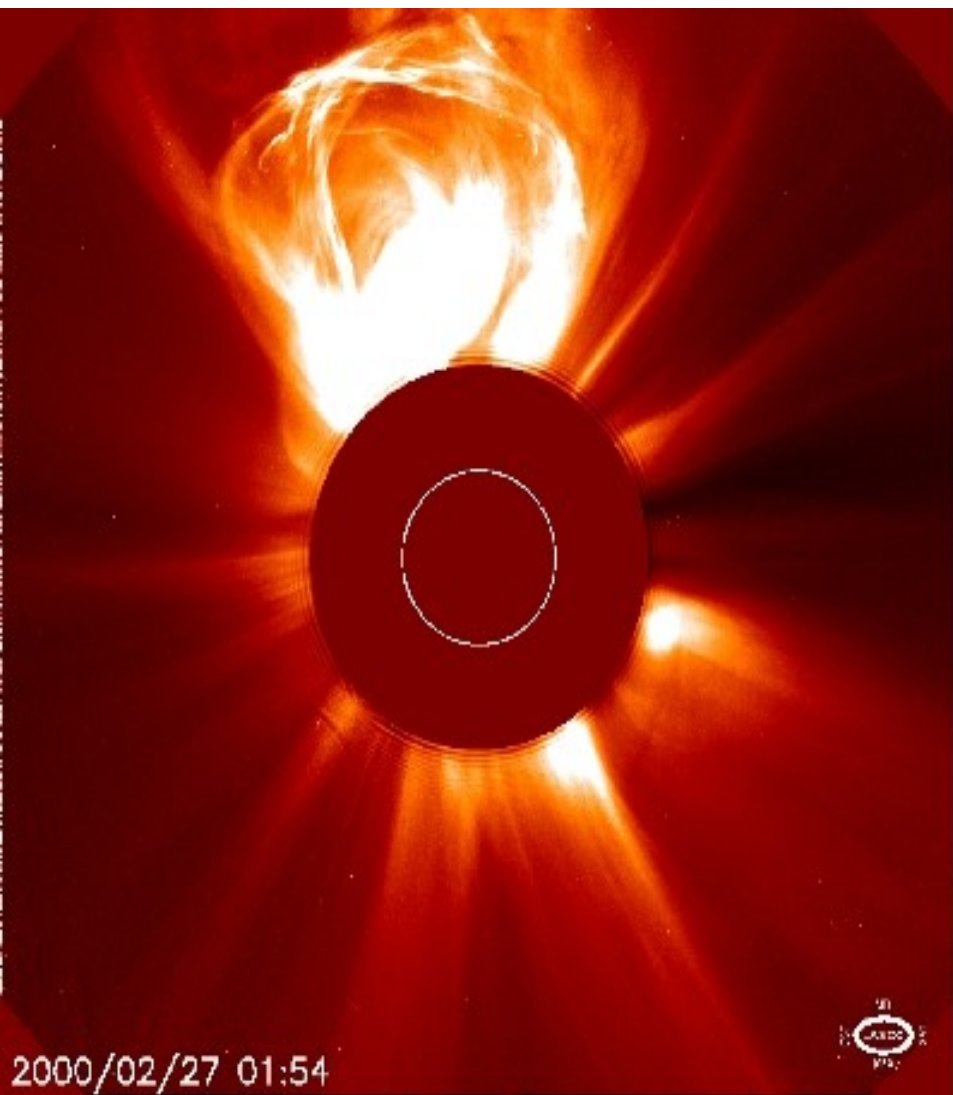


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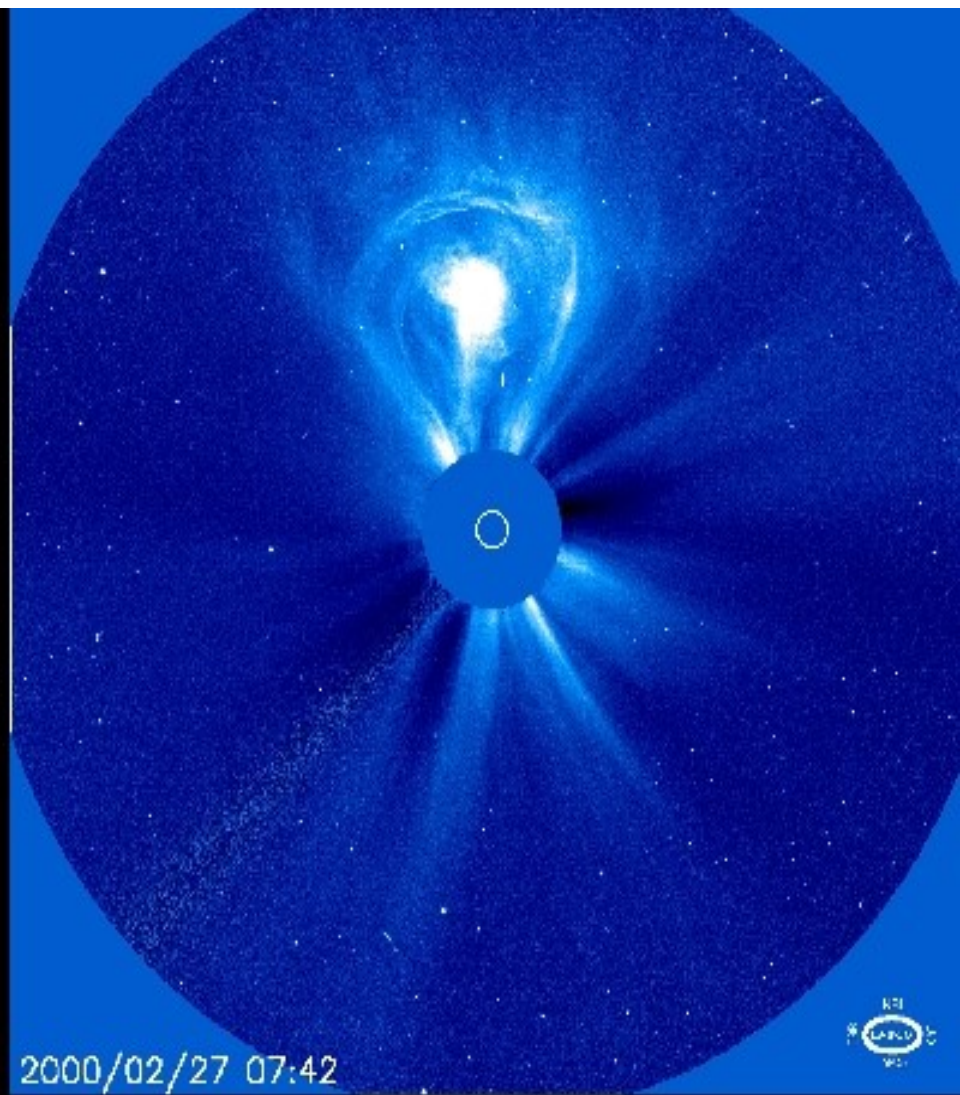


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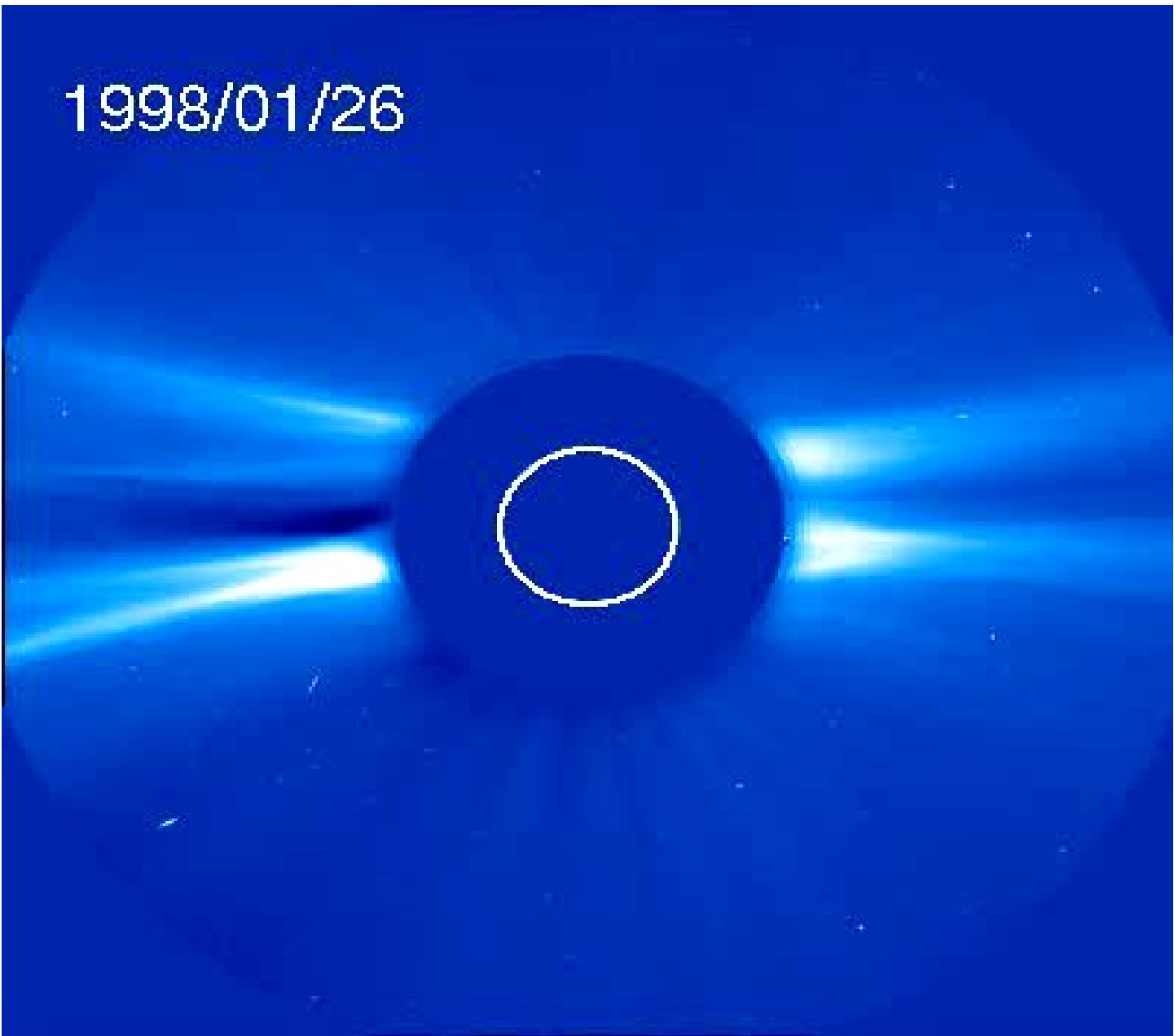
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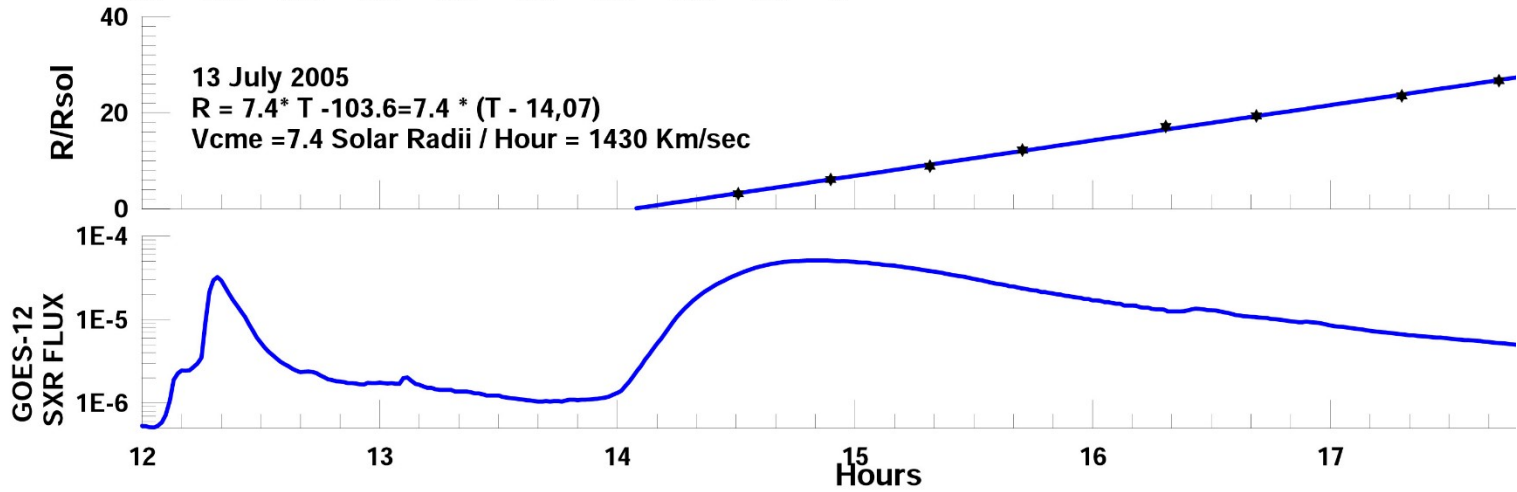
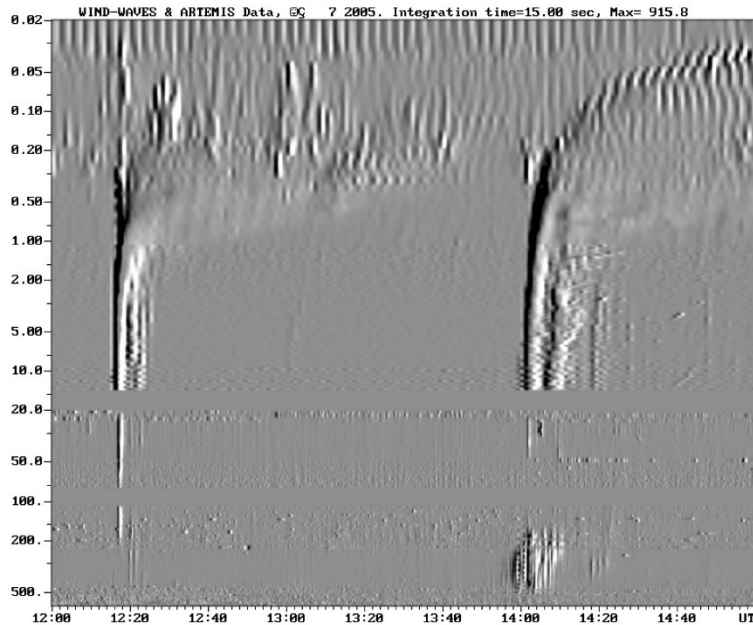


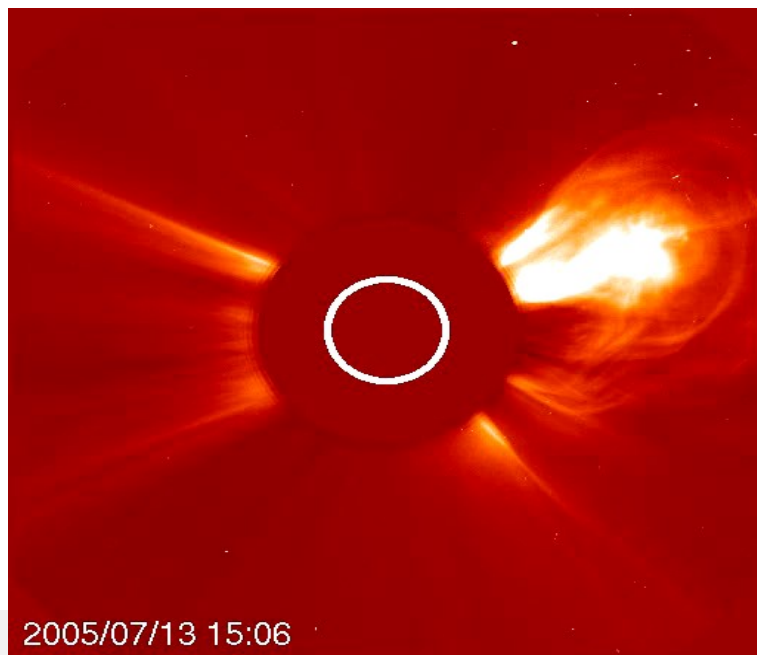
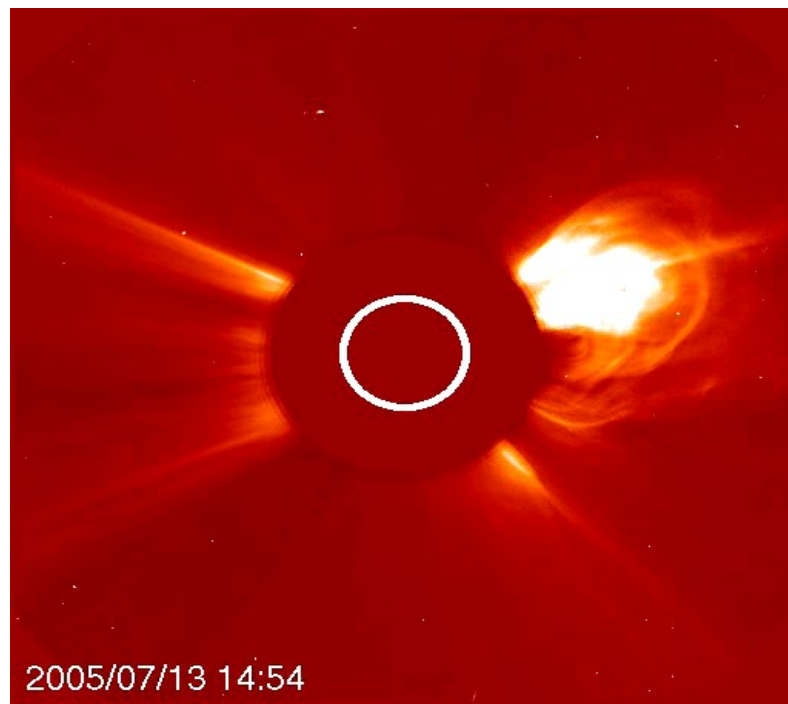
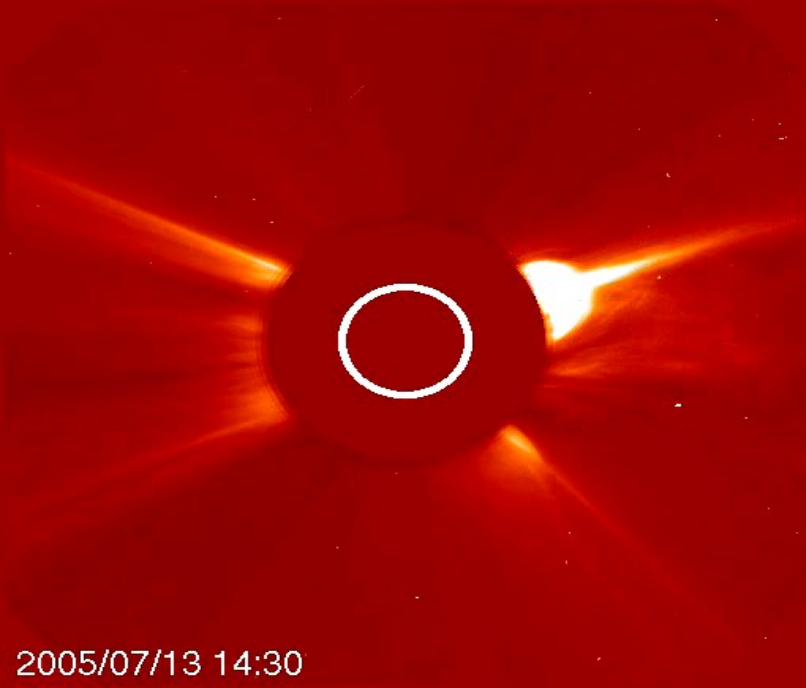
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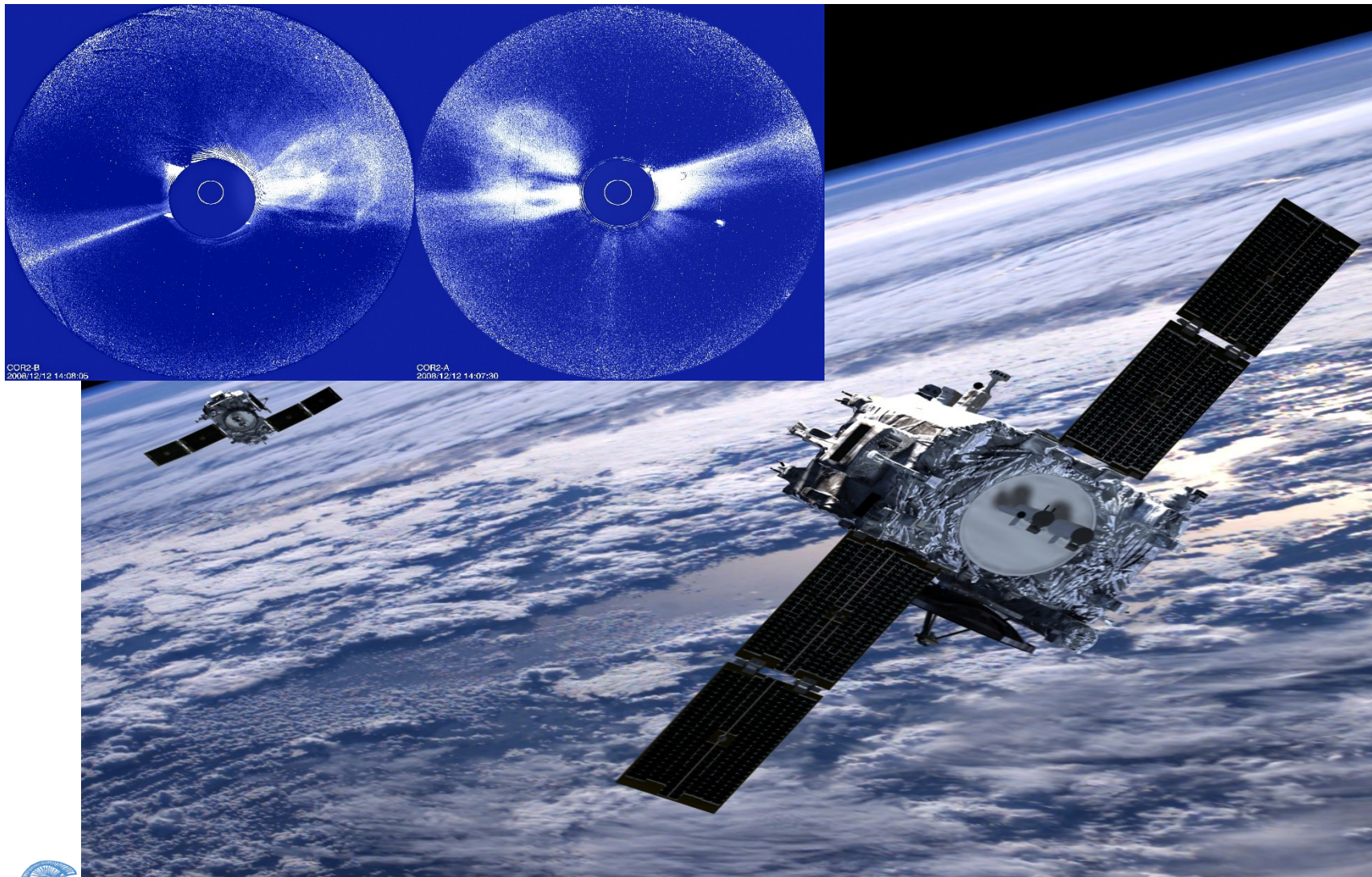
1998/01/26



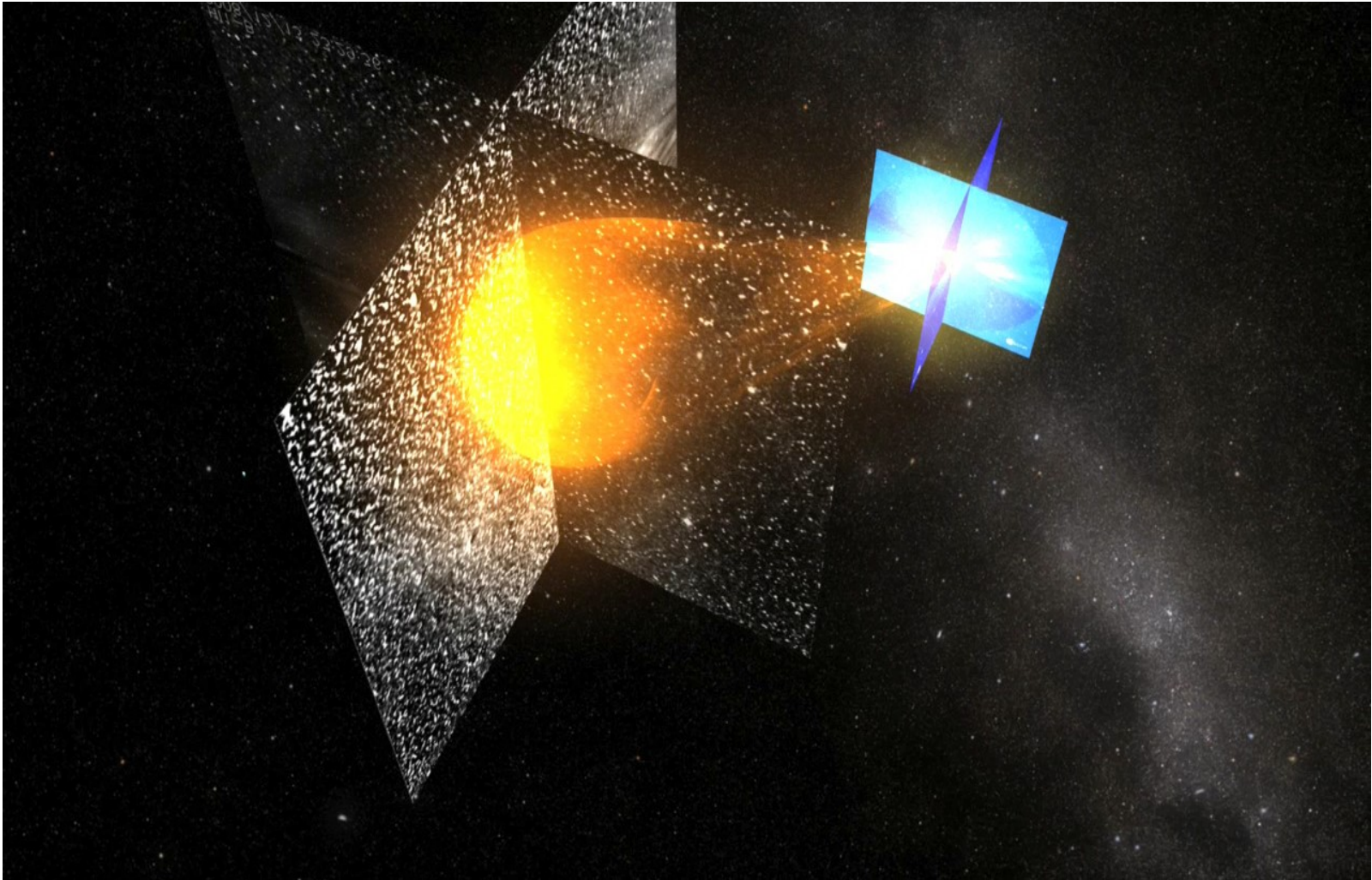


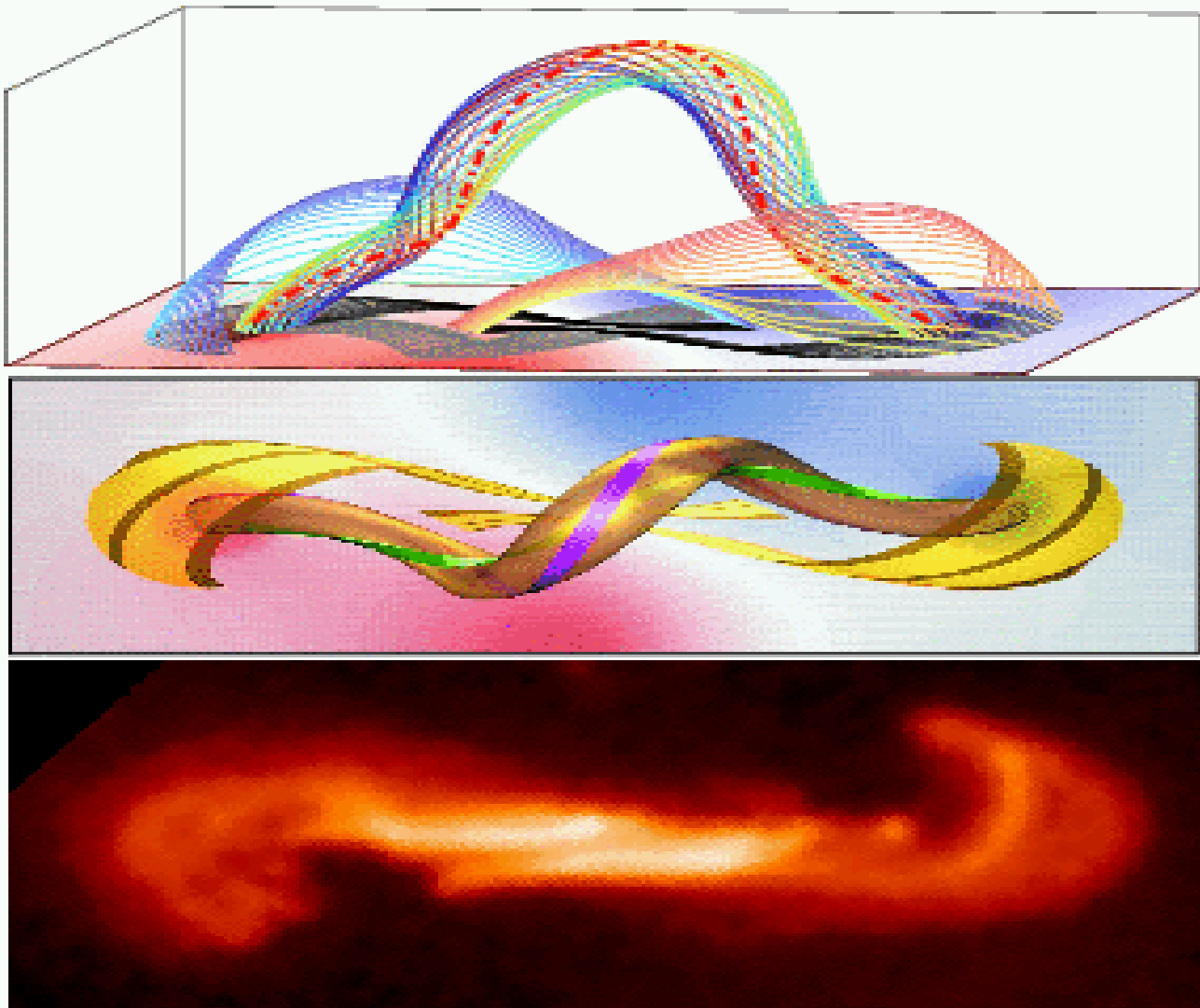


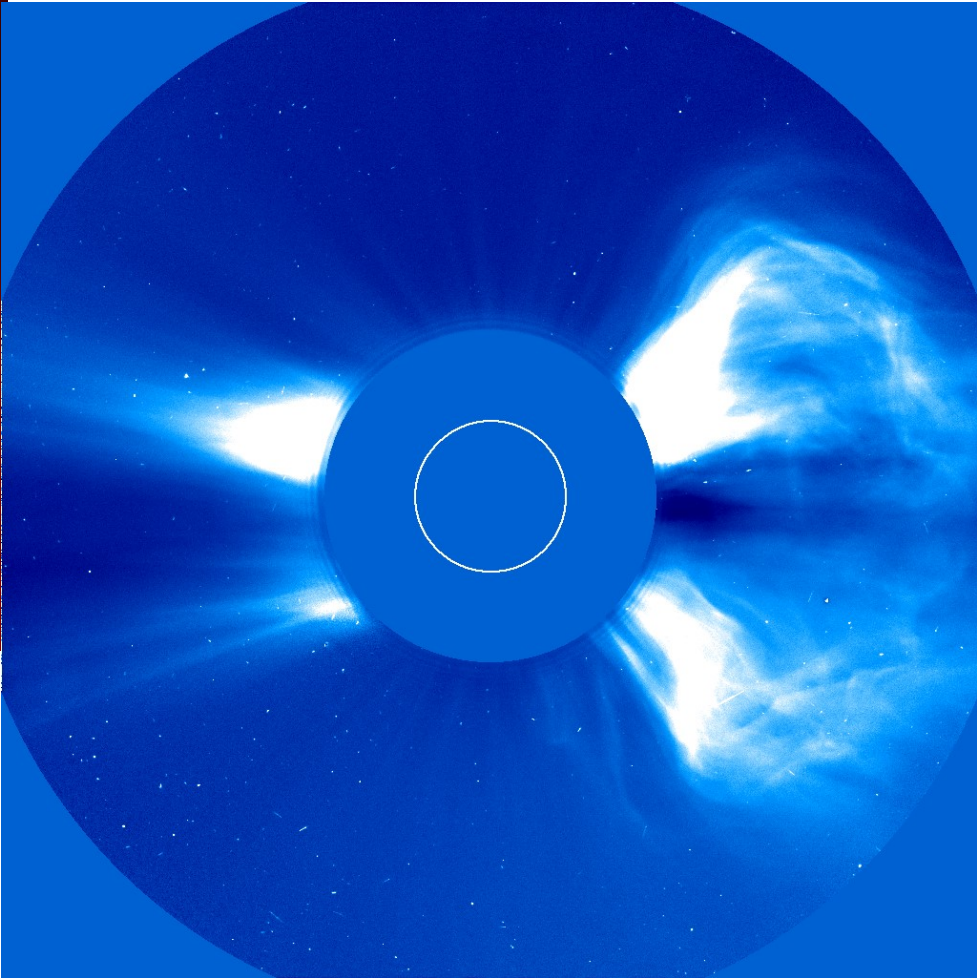
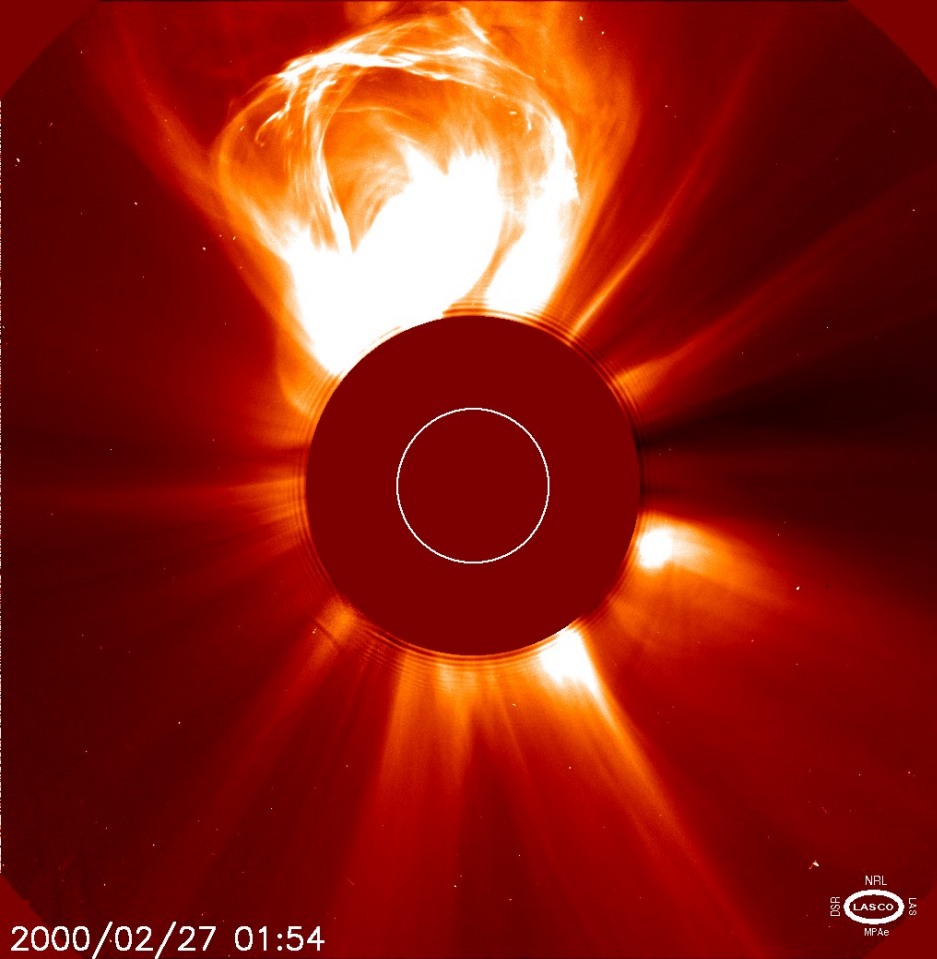
STEREO CME 12/12/2008



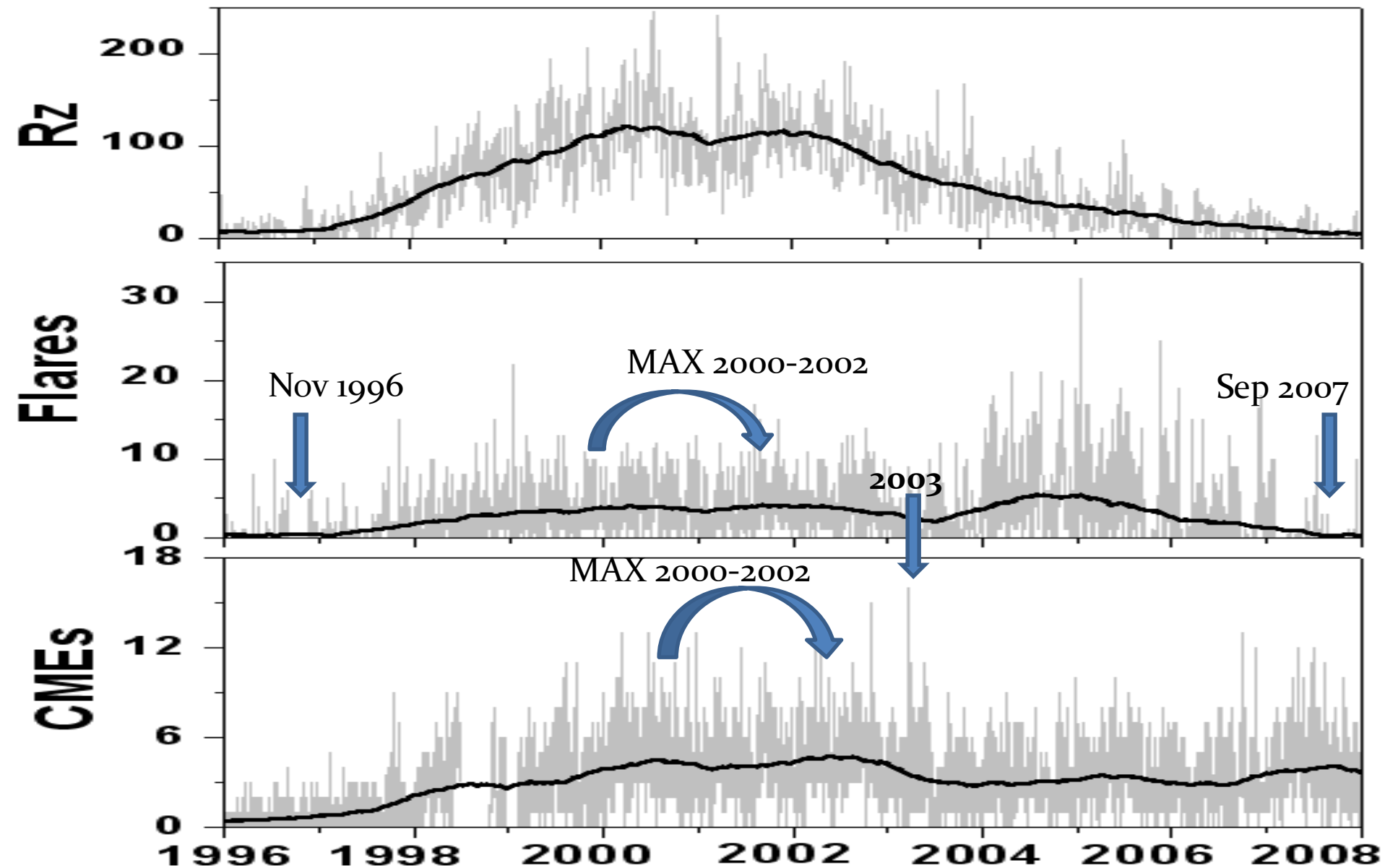
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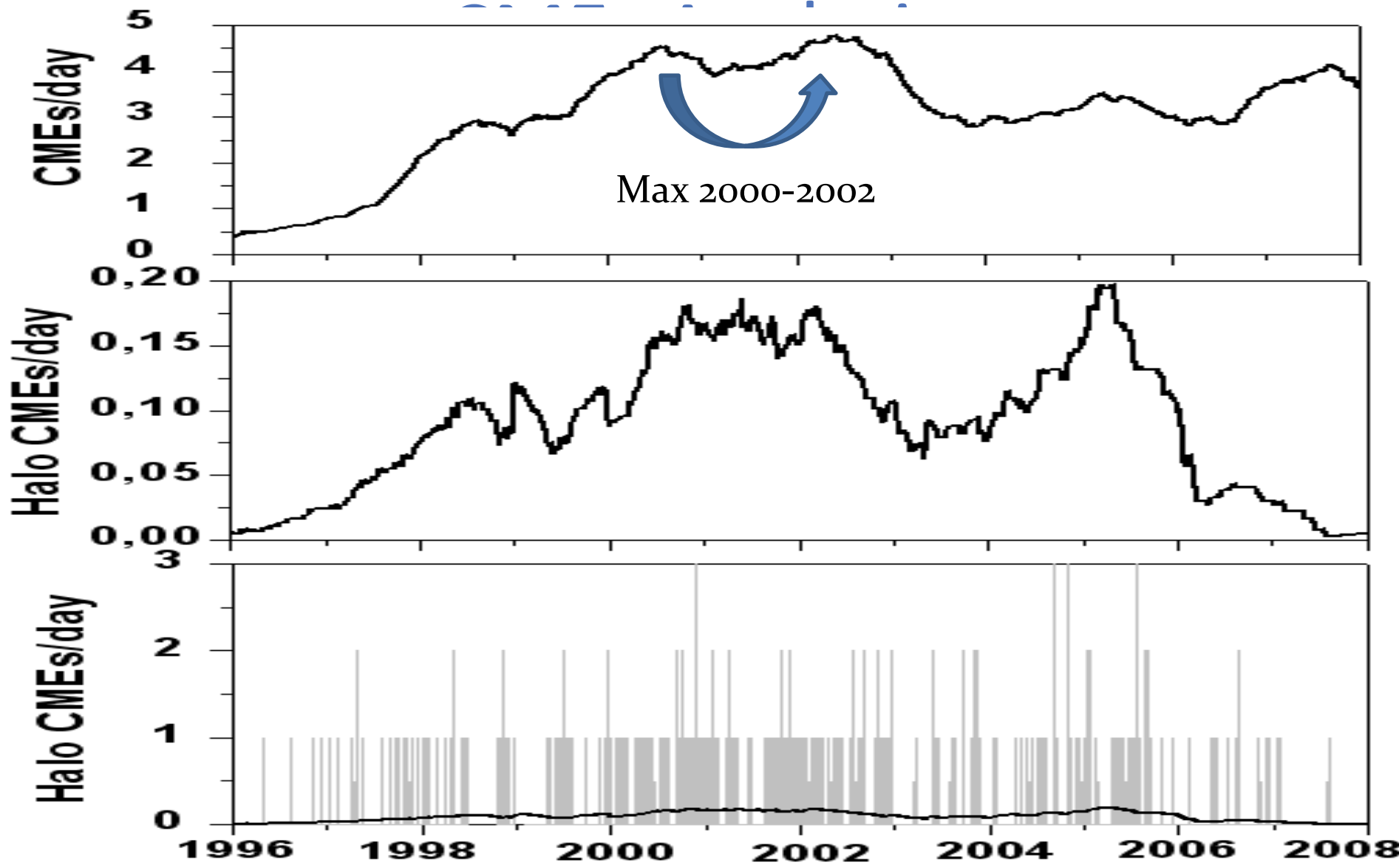






Solar Flares and Coronal Mass Ejections





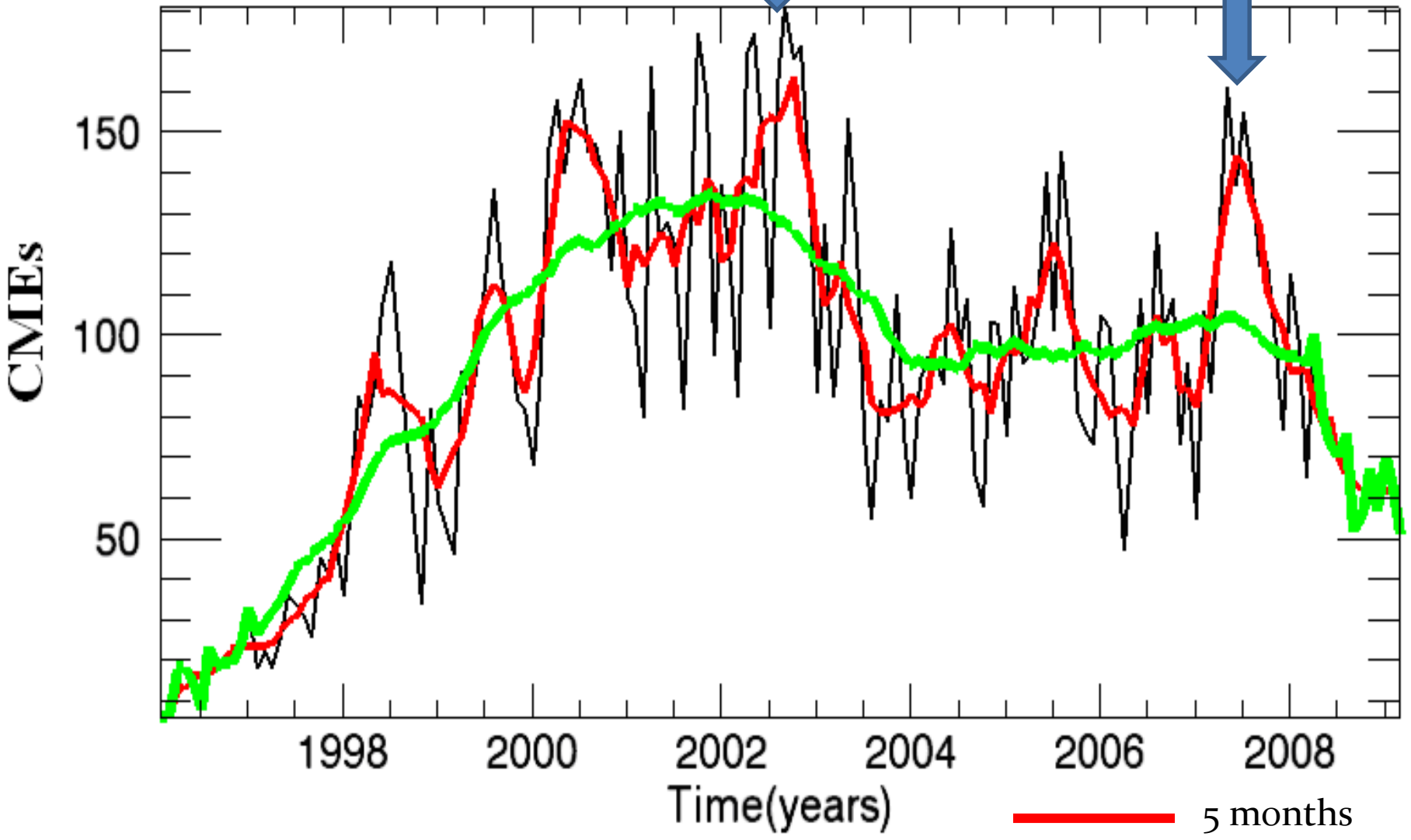
Monthly Distribution CMEs



Aug 2002

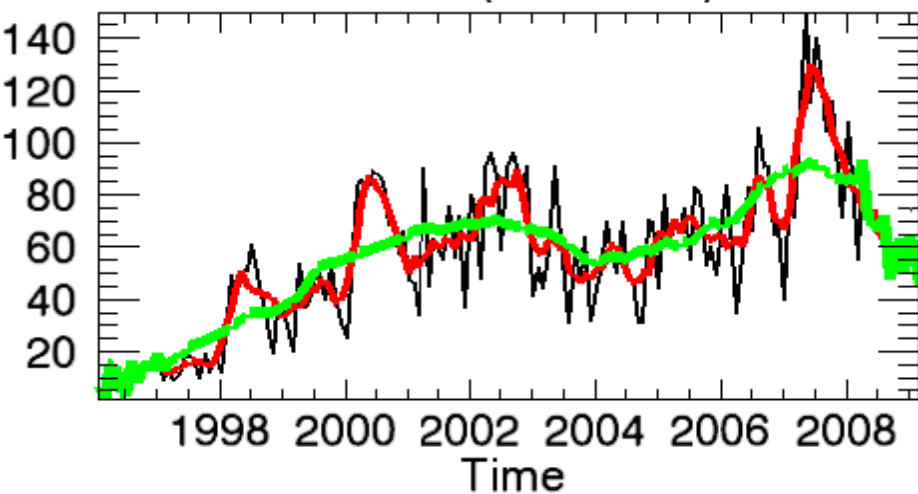


April 2007

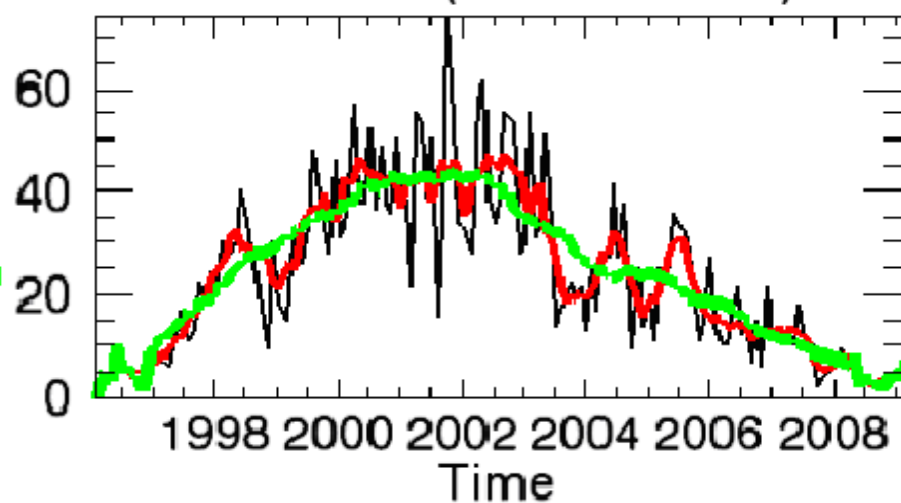


— 5 months
— 25 months

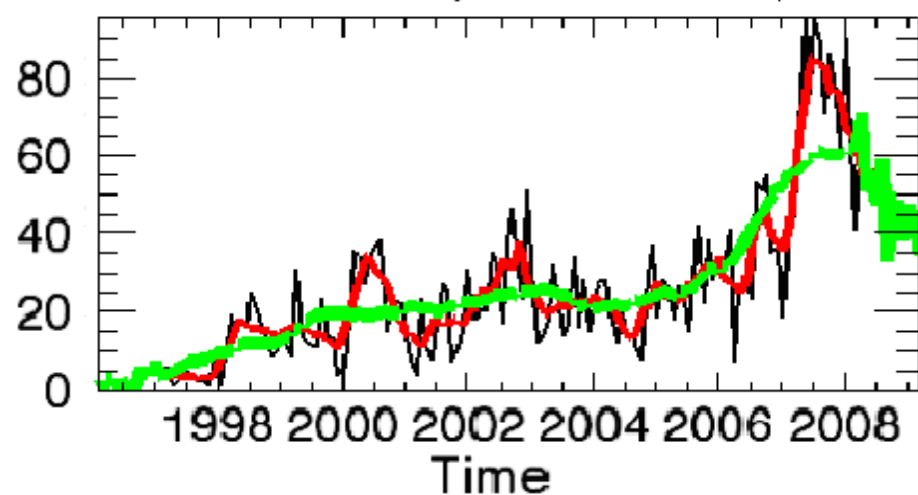
CMEs (width < 50)



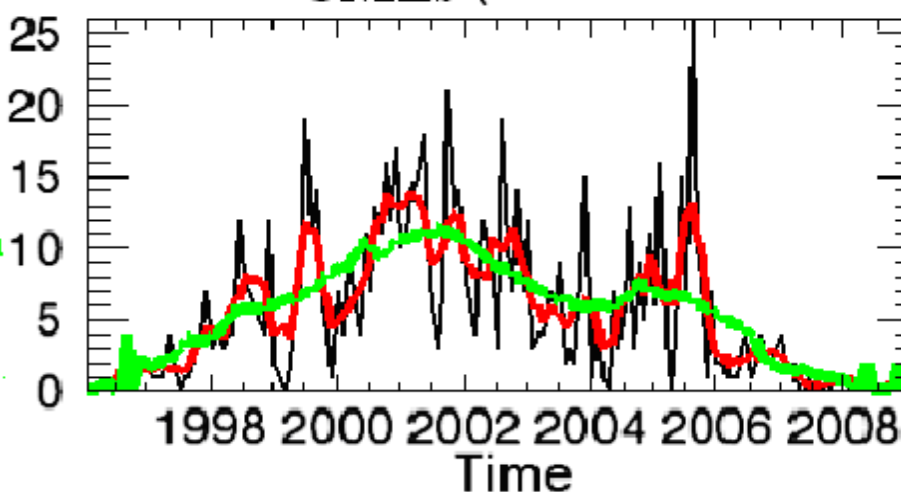
CMEs (50 < width < 100)



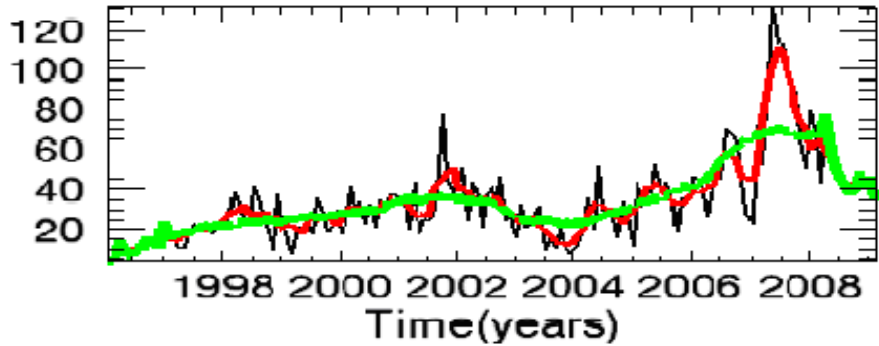
CMEs (0 < width < 20)



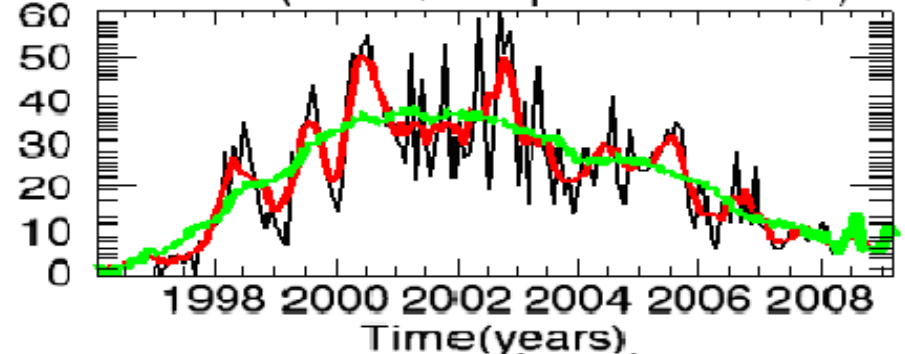
CMEs (width > 150)



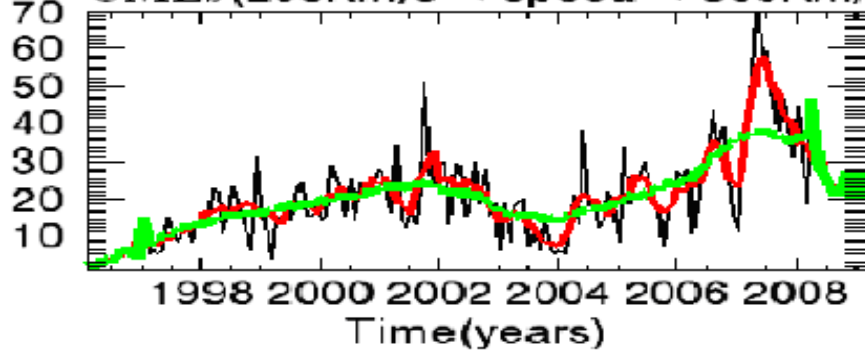
CMEs (speed < 300Km/s)



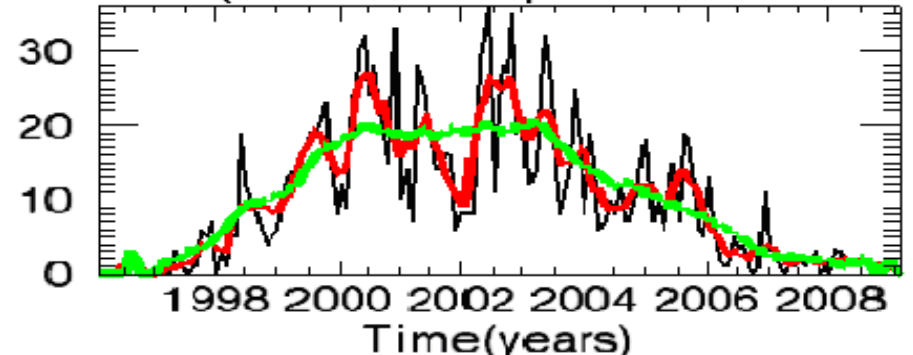
CMEs (400Km/s < speed < 600Km/s)



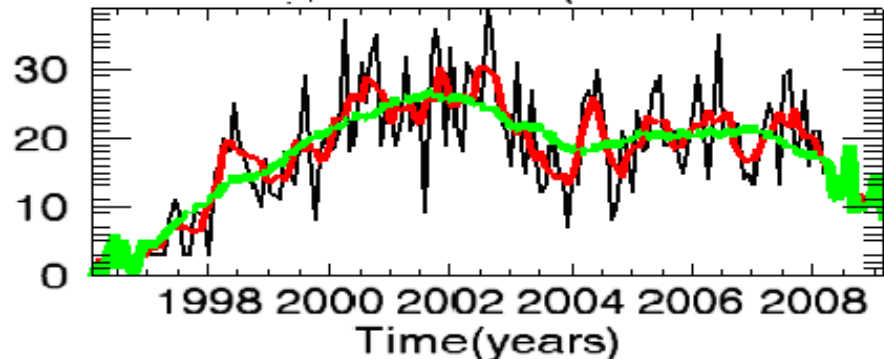
CMEs (200Km/s < speed < 300Km/s)



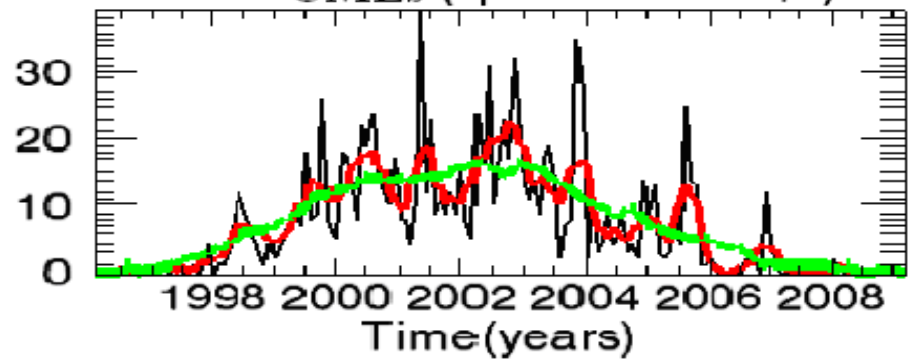
CMEs (600Km/s < speed < 1000Km/s)



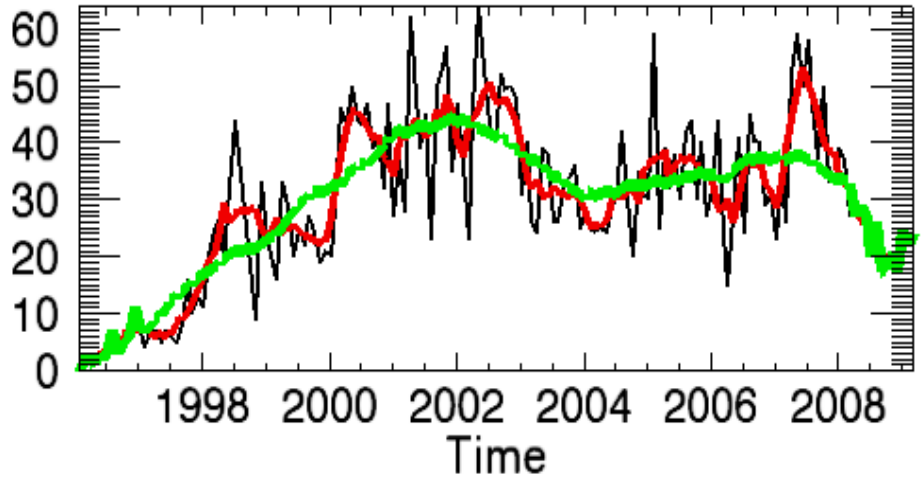
CMEs (300Km/s < speed < 400Km/s)



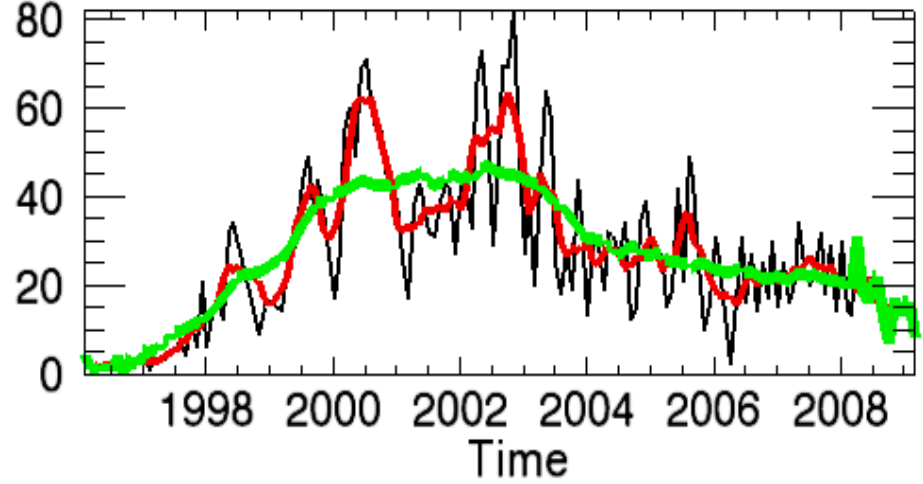
CMEs (speed > 800Km/s)



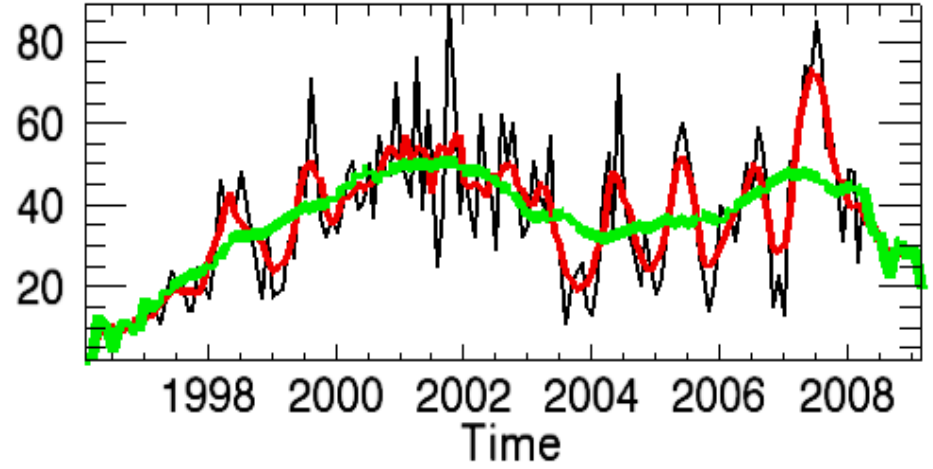
CMEs (accel. > 5 m/s²)

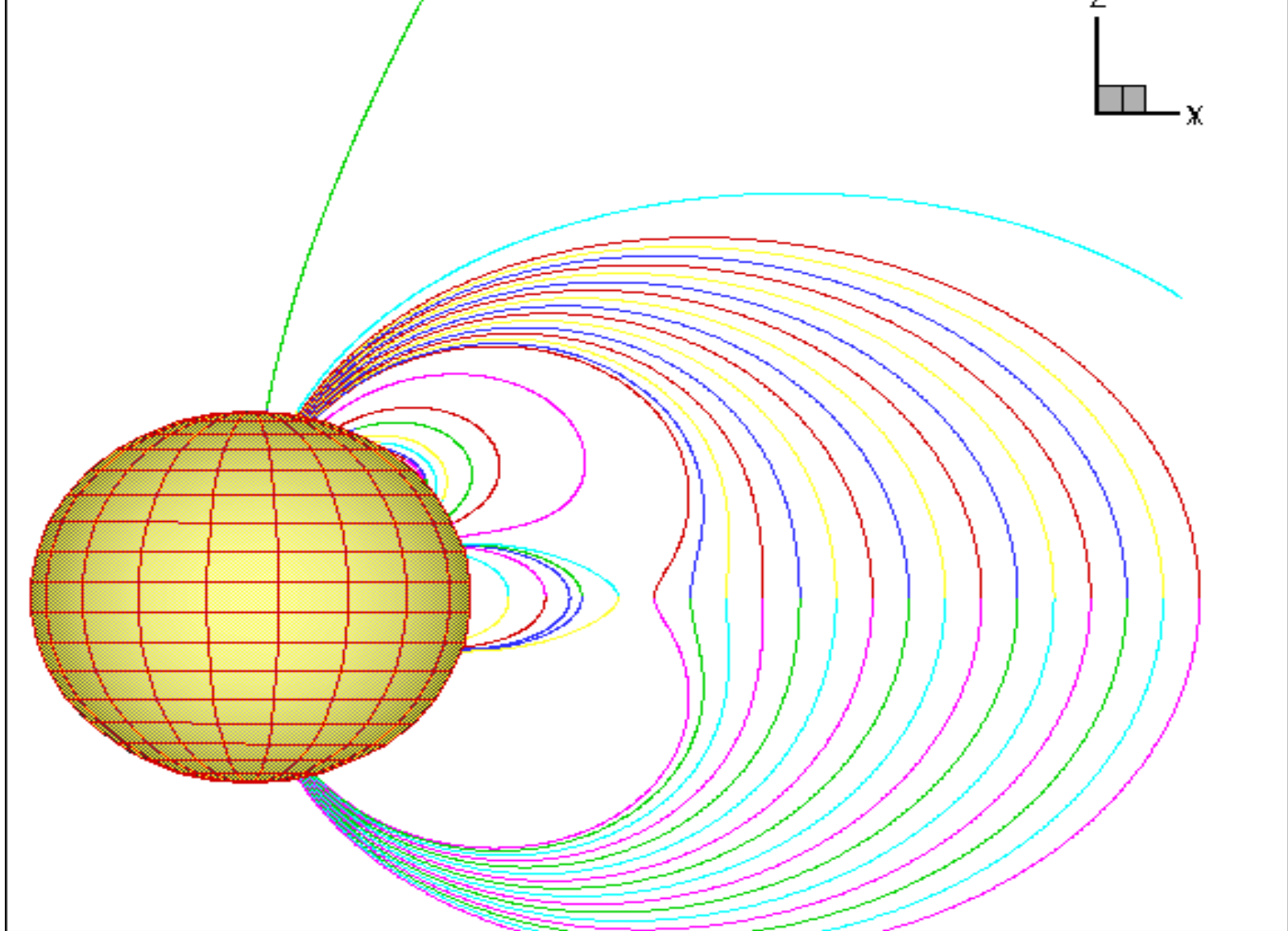


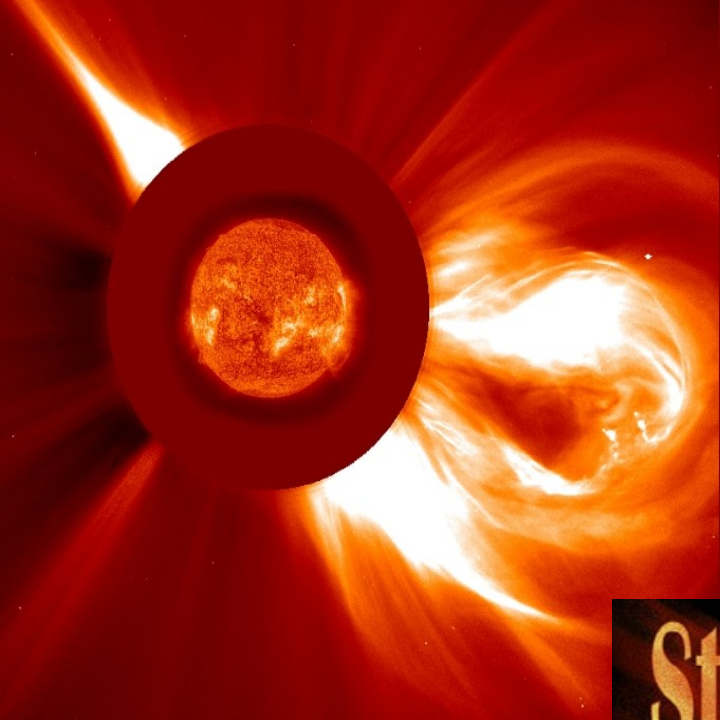
CMEs (accel. < -5 m/s²)



CMEs (-5 m/s² < accel. < 5 m/s²)







Storms from the Sun

Coronal Mass Ejections Light Up the Sky



Particles are blasted from the Sun...

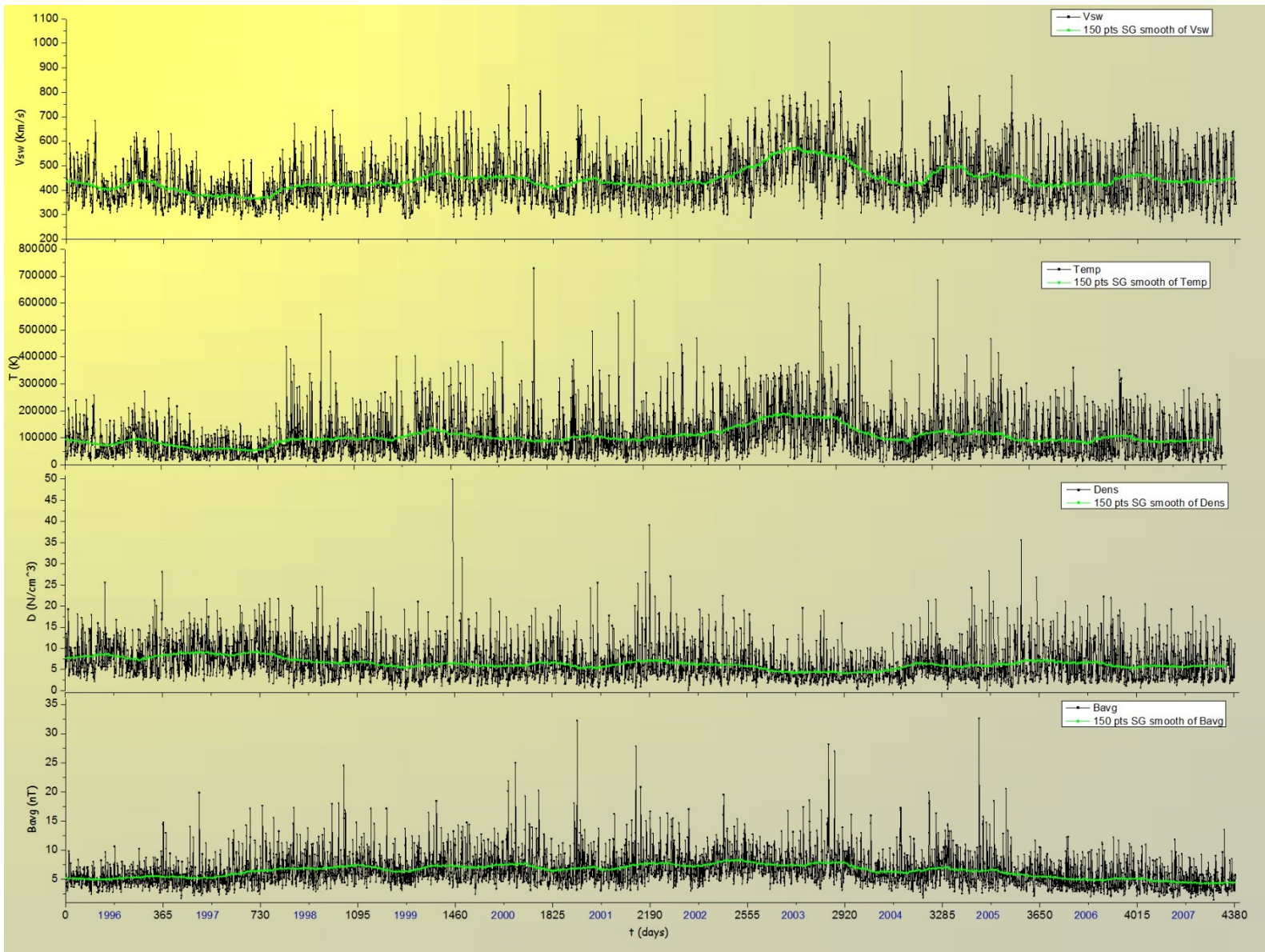


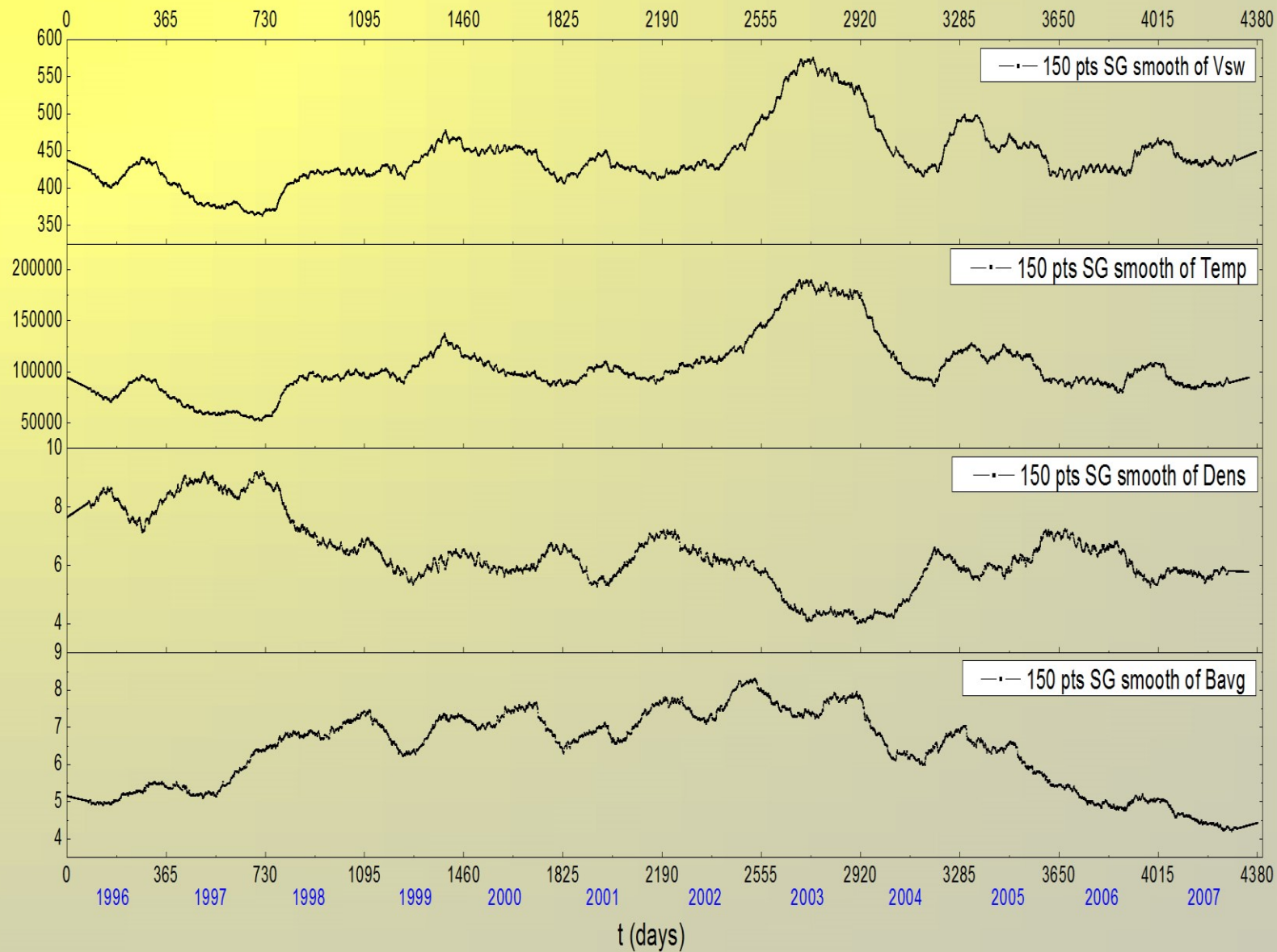
Millions of amps surge through our atmosphere ...



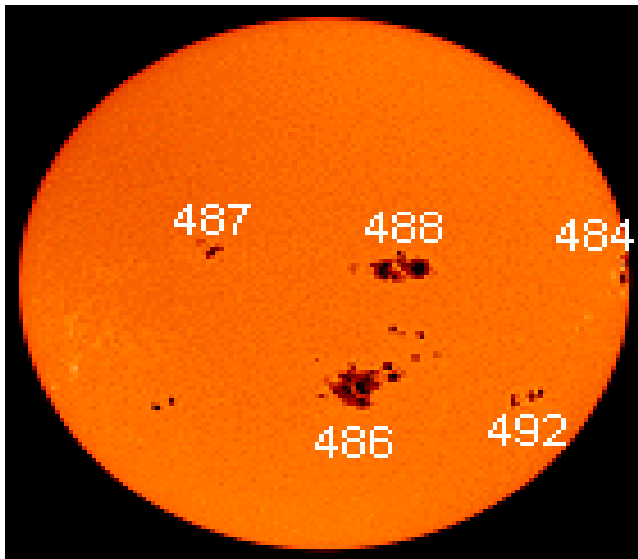
...And make bright Northern lights





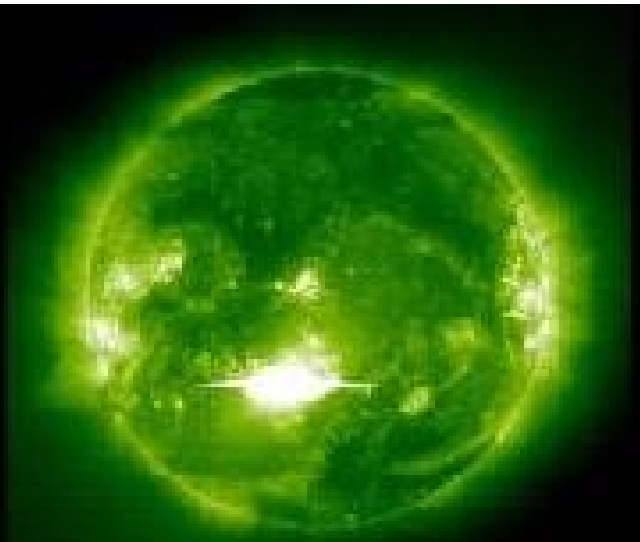


SUNSPOTS OCT-NOV 2003

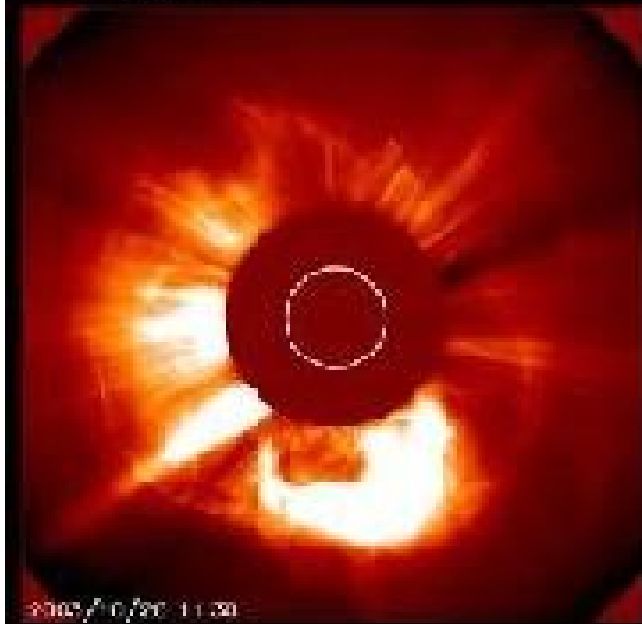




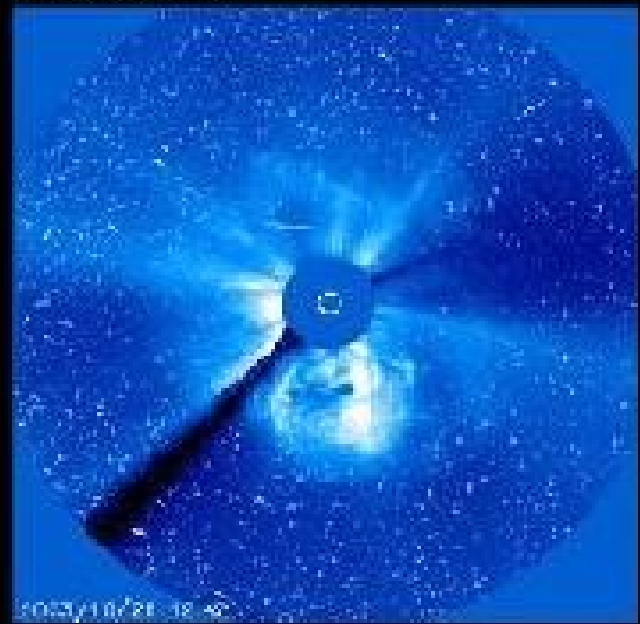
2003,10,28 08:24



2005,11,07 00:11:12



2005,11,07 00:11:30

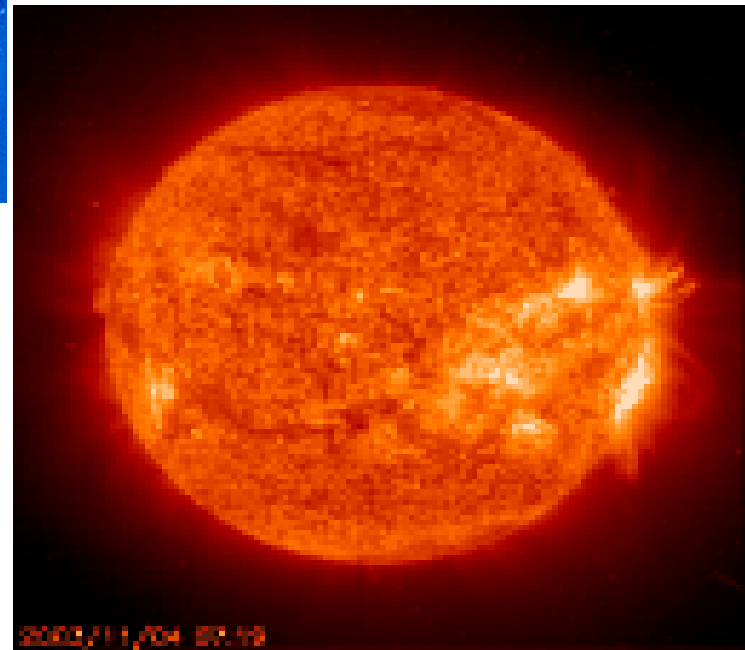
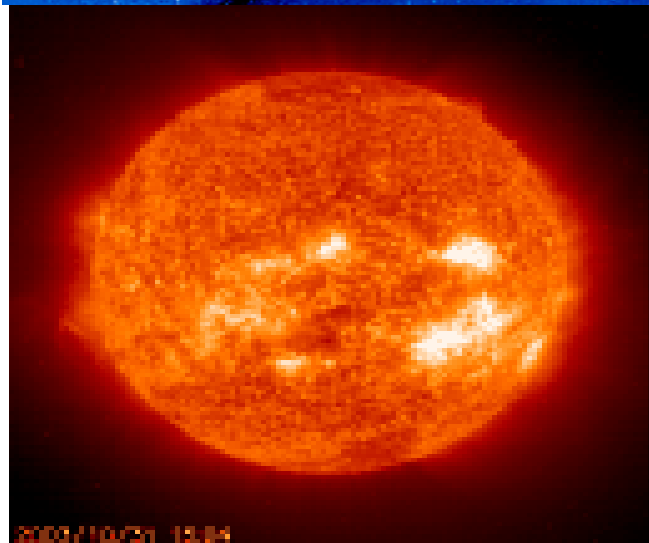
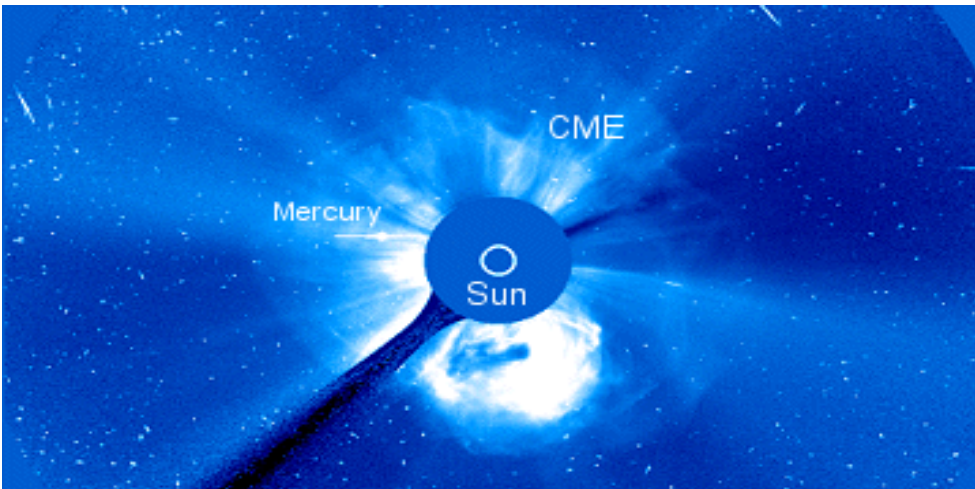


2005,11,07 00:18:40

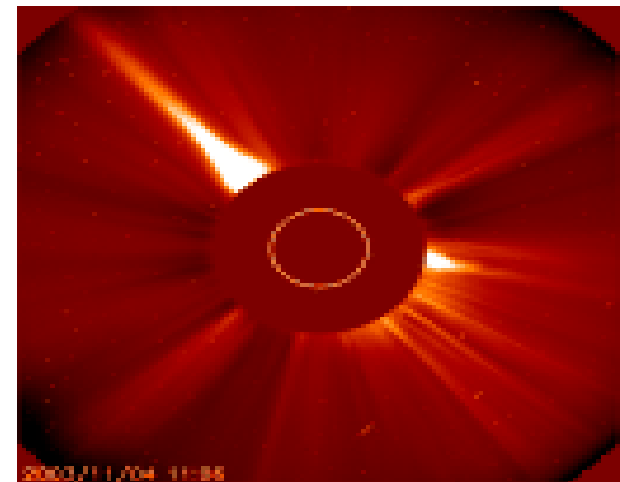
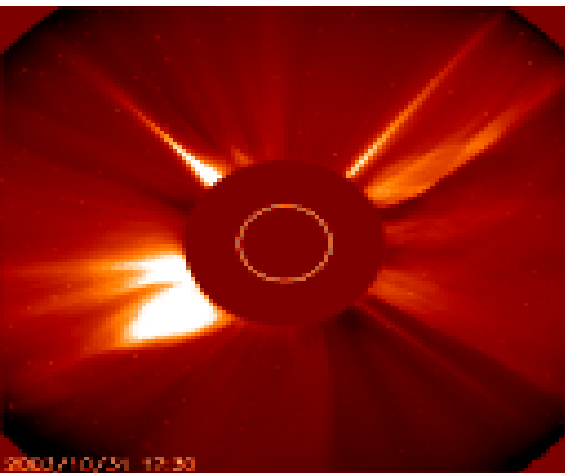
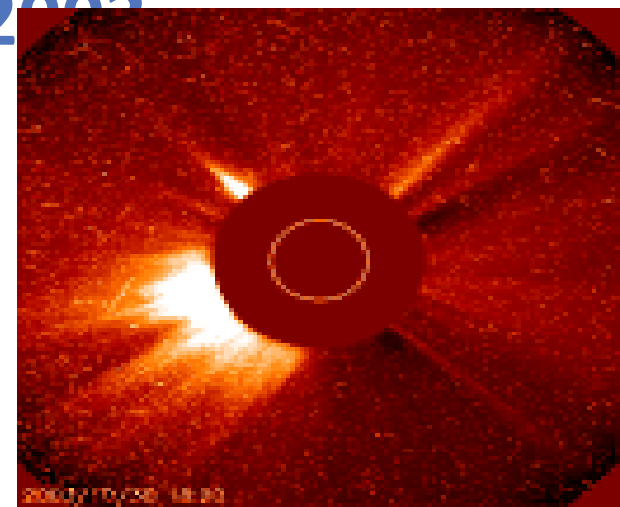
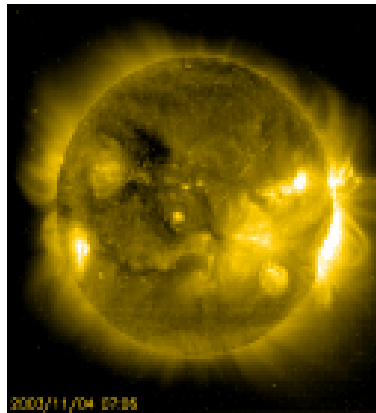
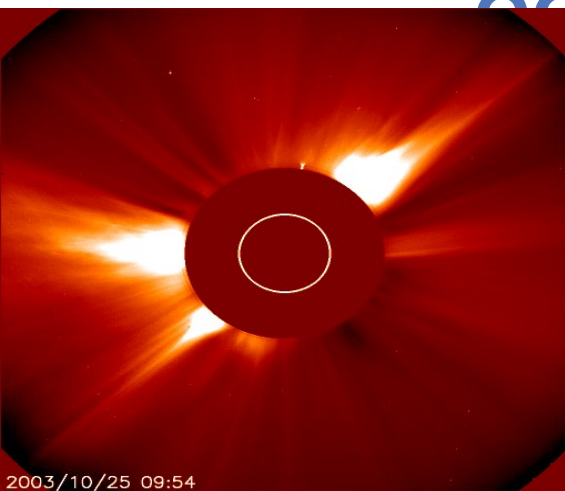


SOLAR ACTIVITY

OCTOBER-NOVEMBER 2003

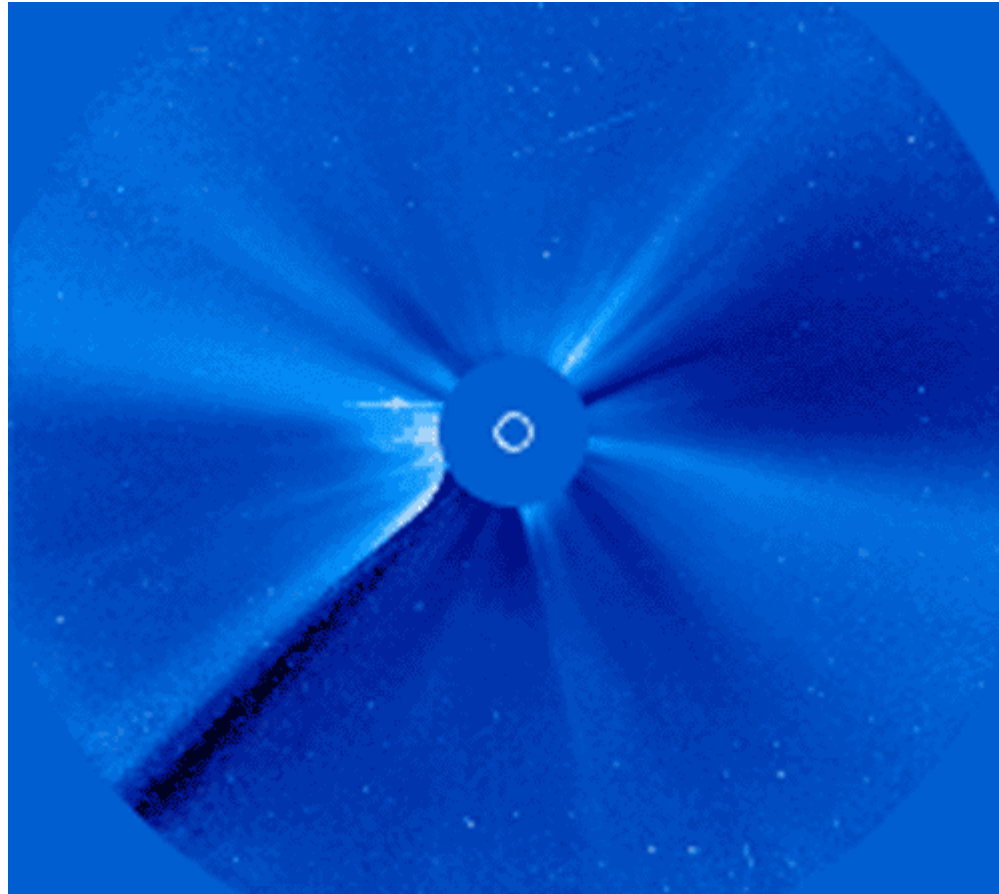


CORONAL MASS EJECTIONS OCTOBER-NOVEMBER 2003

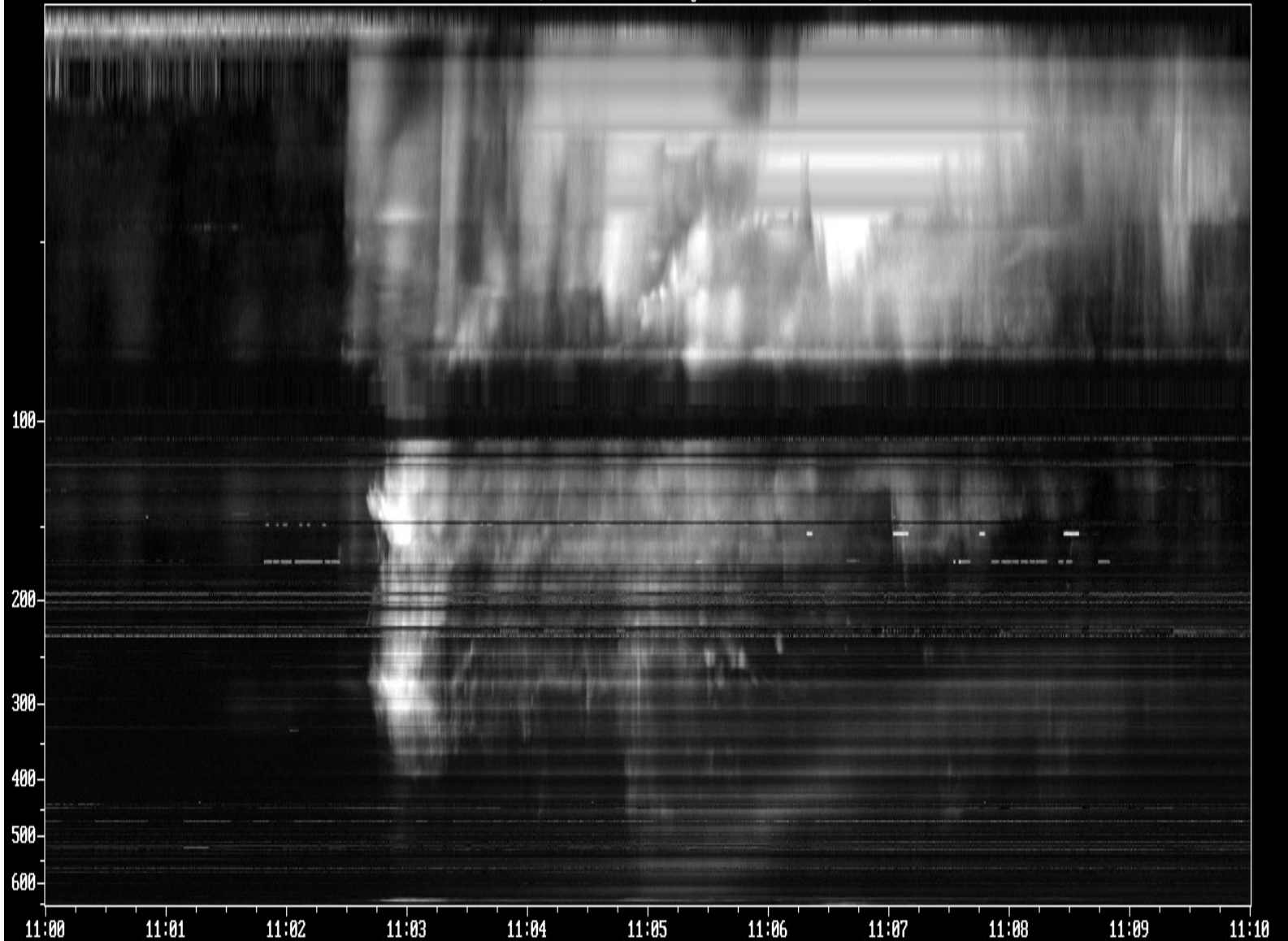


CME (SOHO/LASCO)

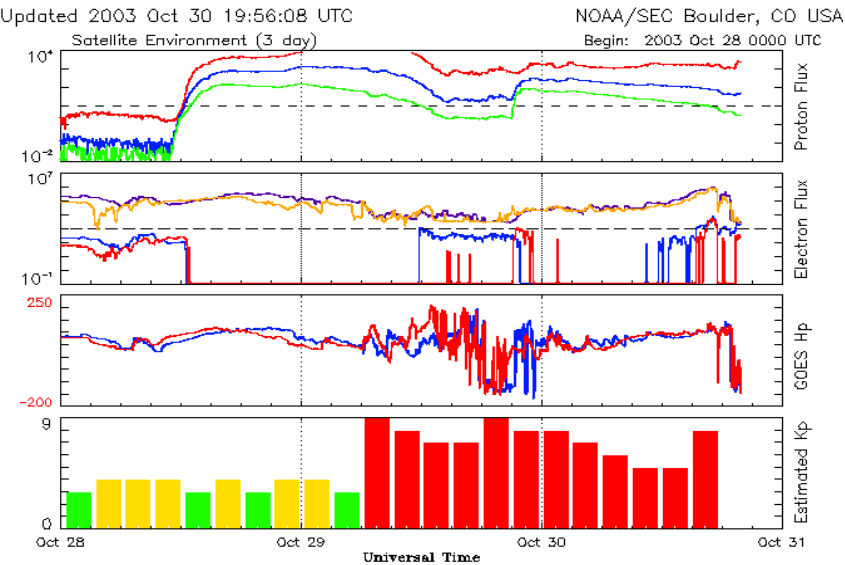
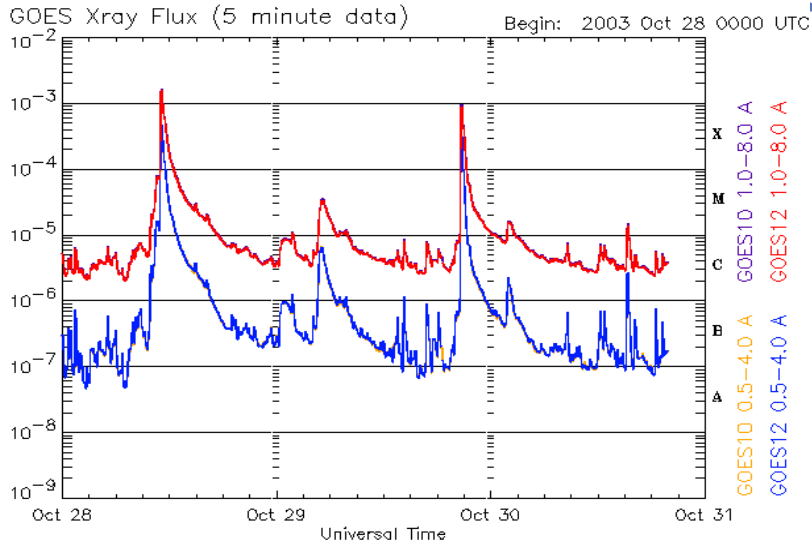
29/10/2003



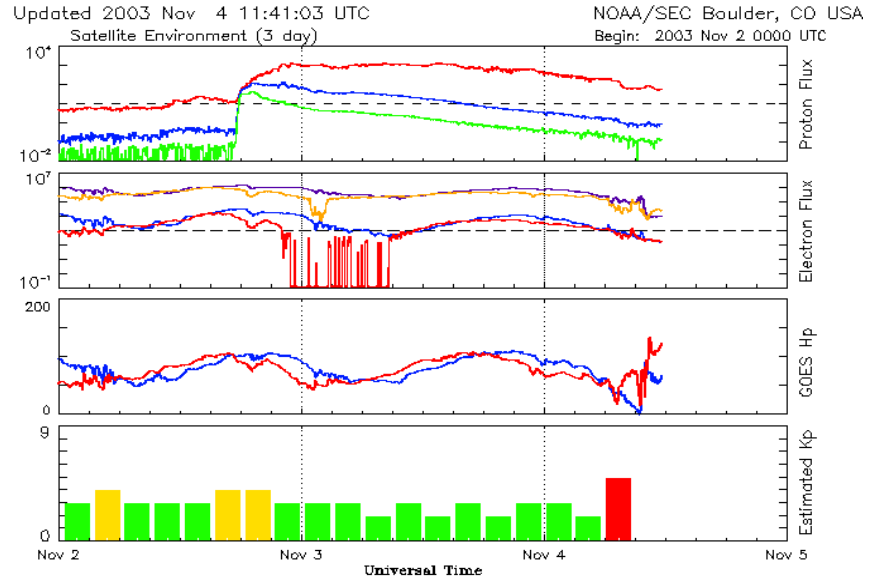
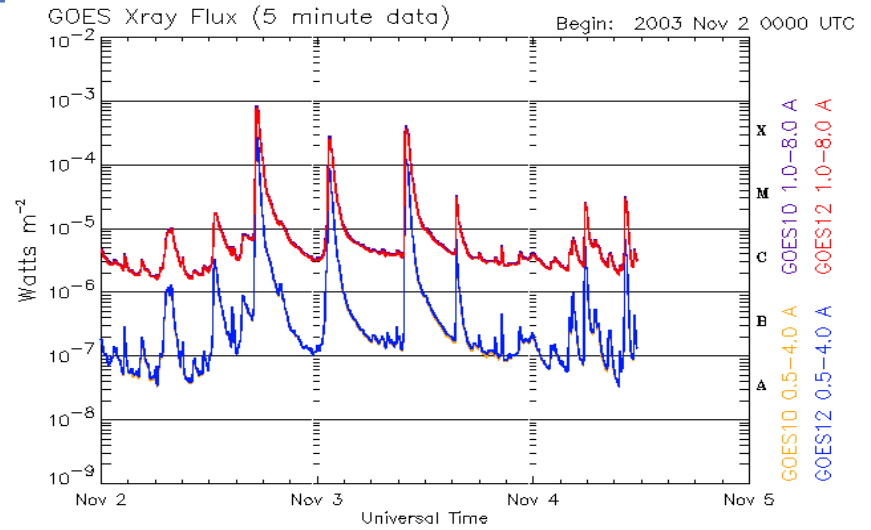
Raw Artemis-IV ASG Data, Oct 28 2003. Integration time= .50 sec, Max=3052.0



FI ΔRFS-PROTONS-Kp INDEX

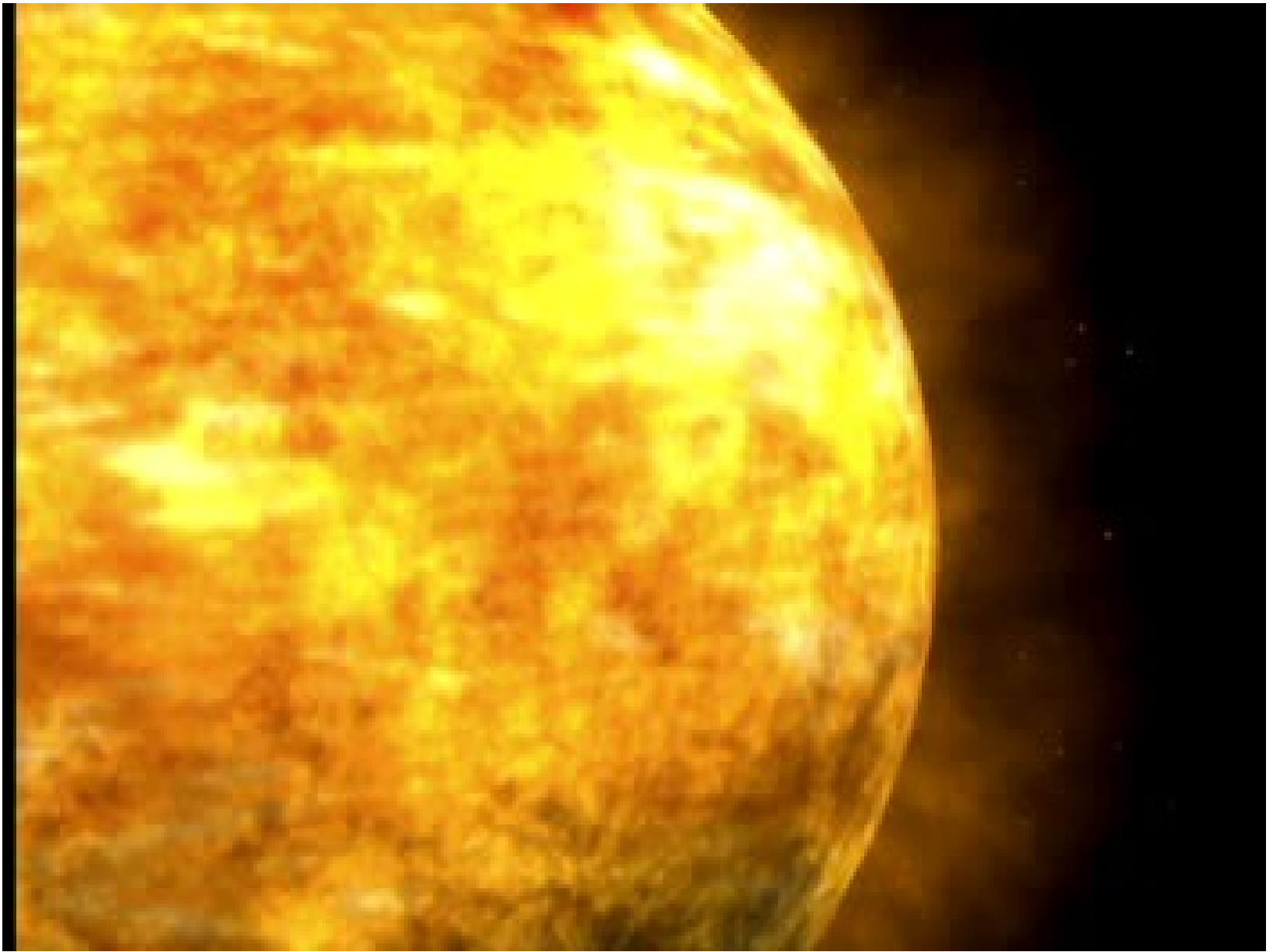


Updated 2003 Oct 30 19:56:11 UTC NOAA/SEC Boulder, CO USA



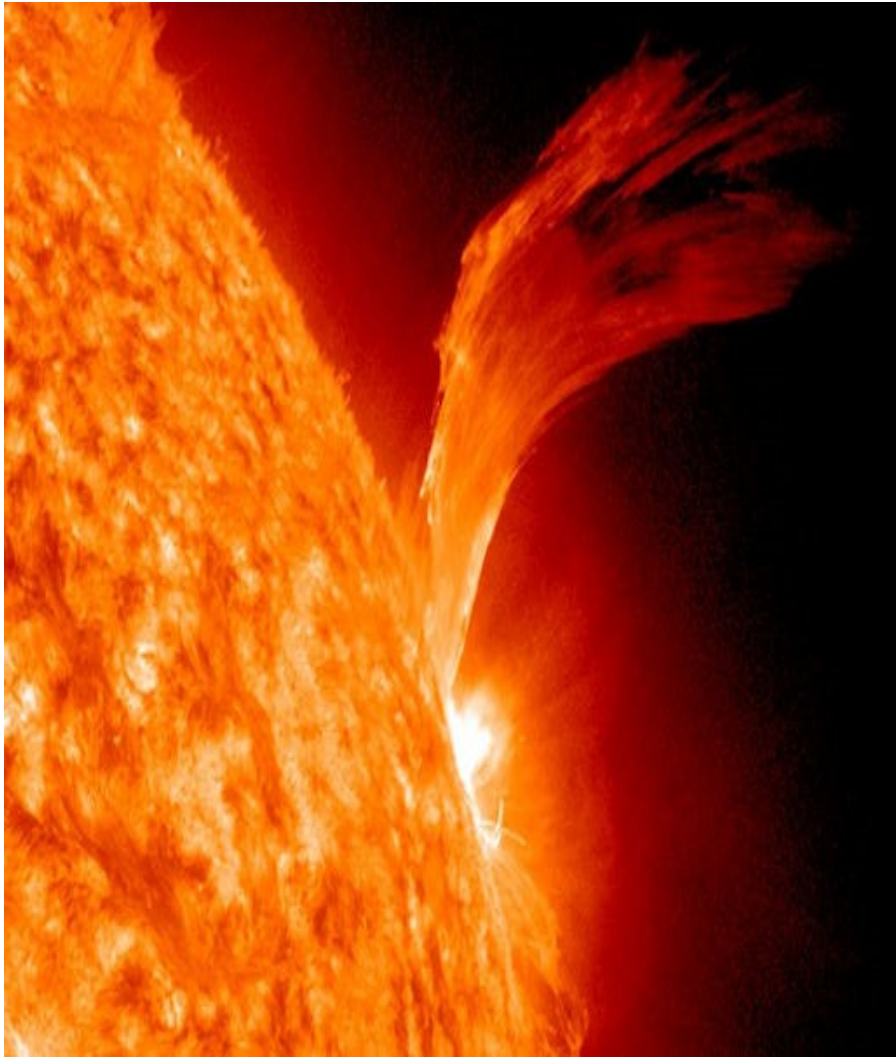
Updated 2003 Nov 4 11:41:10 UTC NOAA/SEC Boulder, CO USA



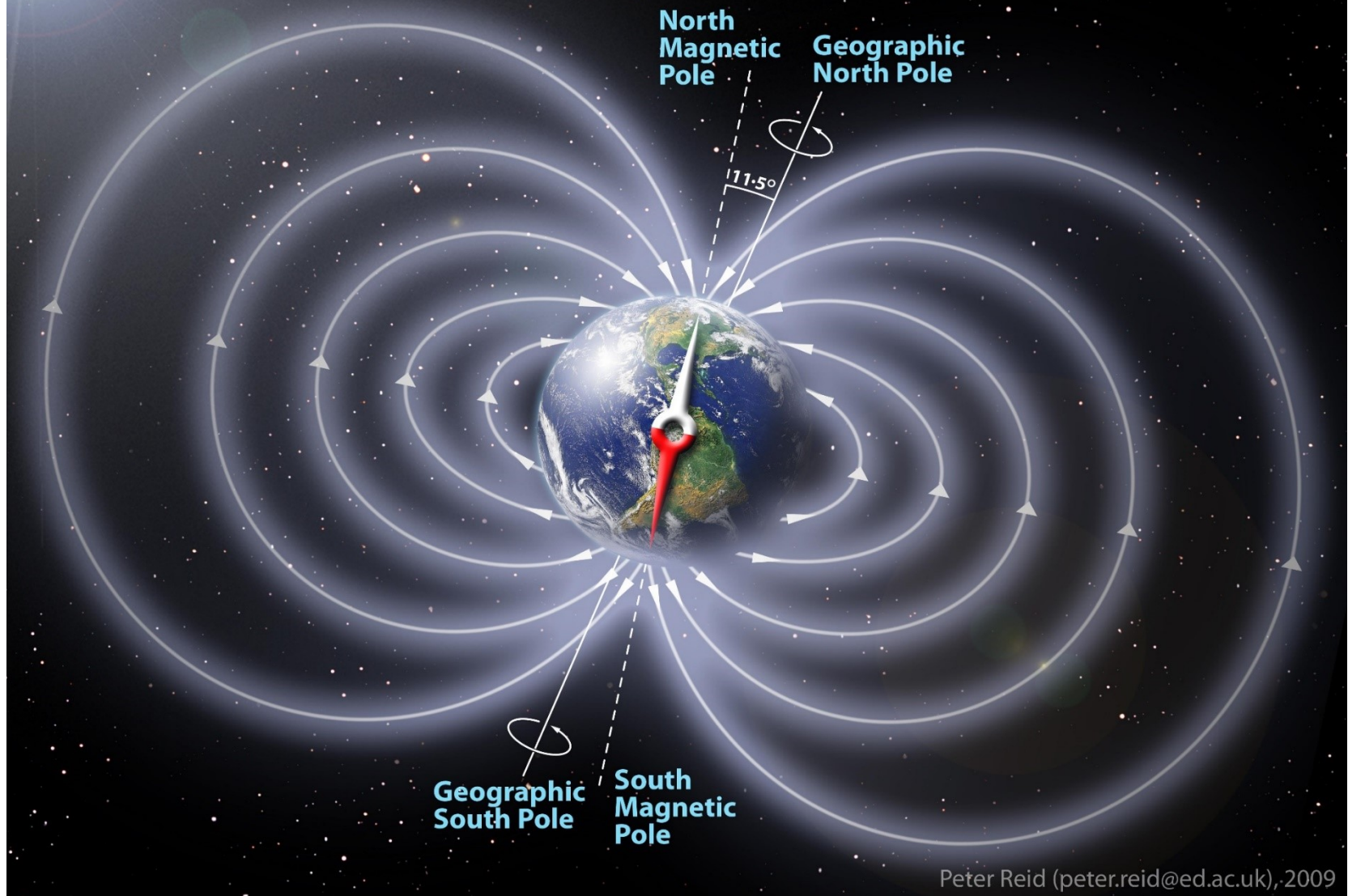


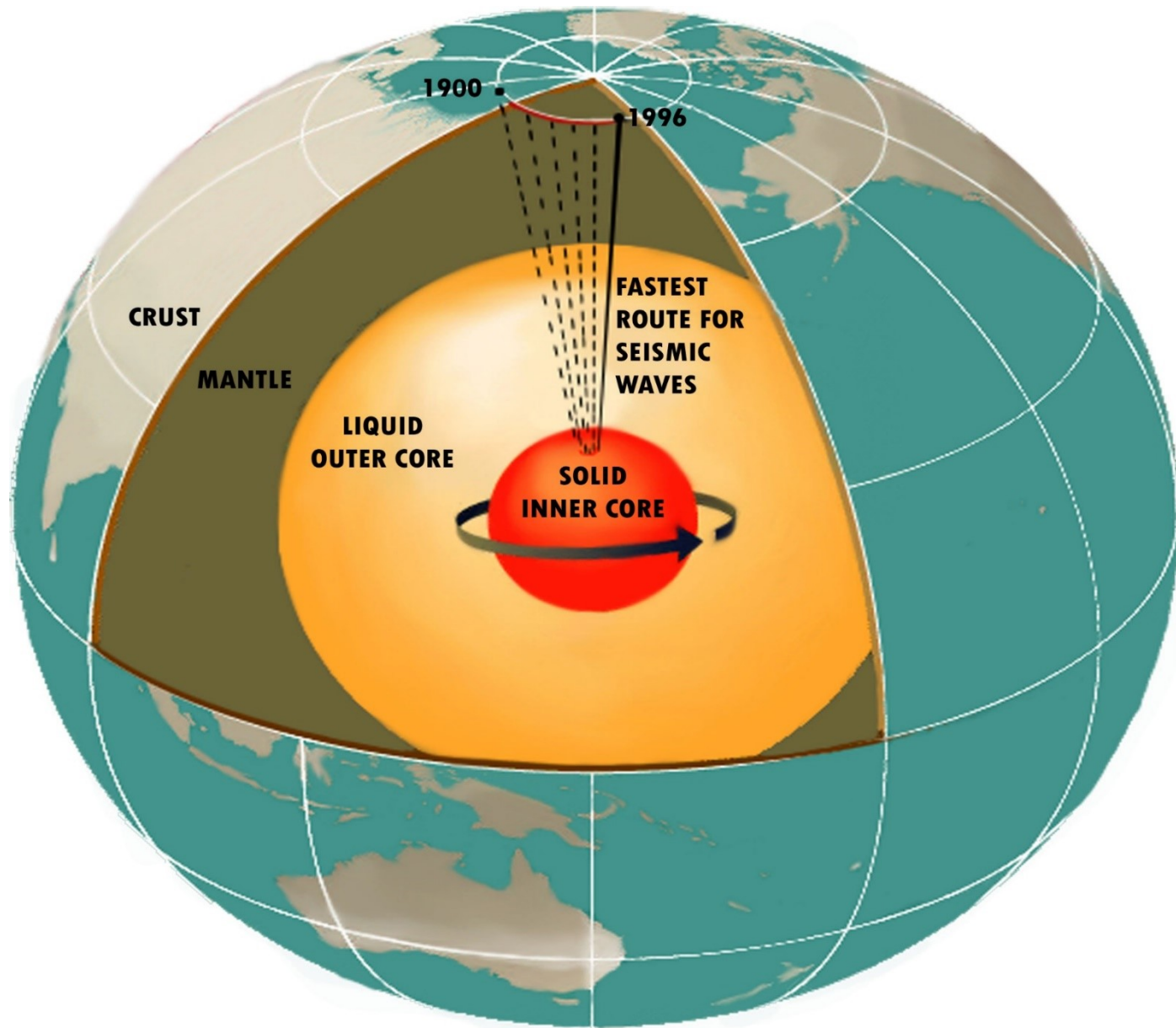


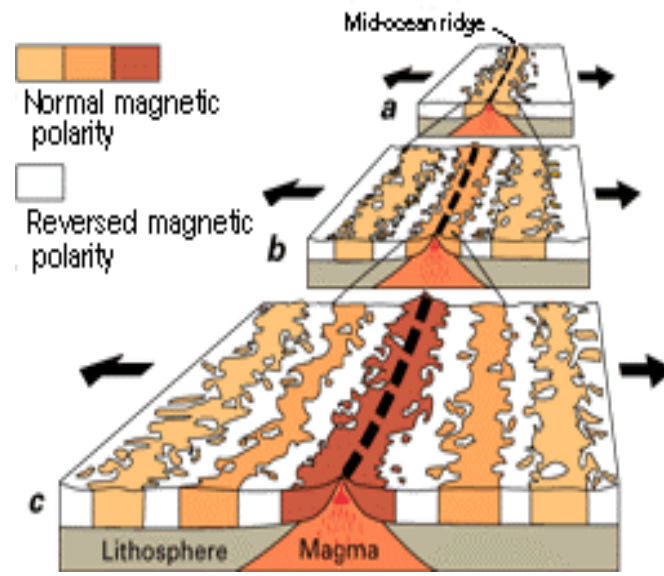
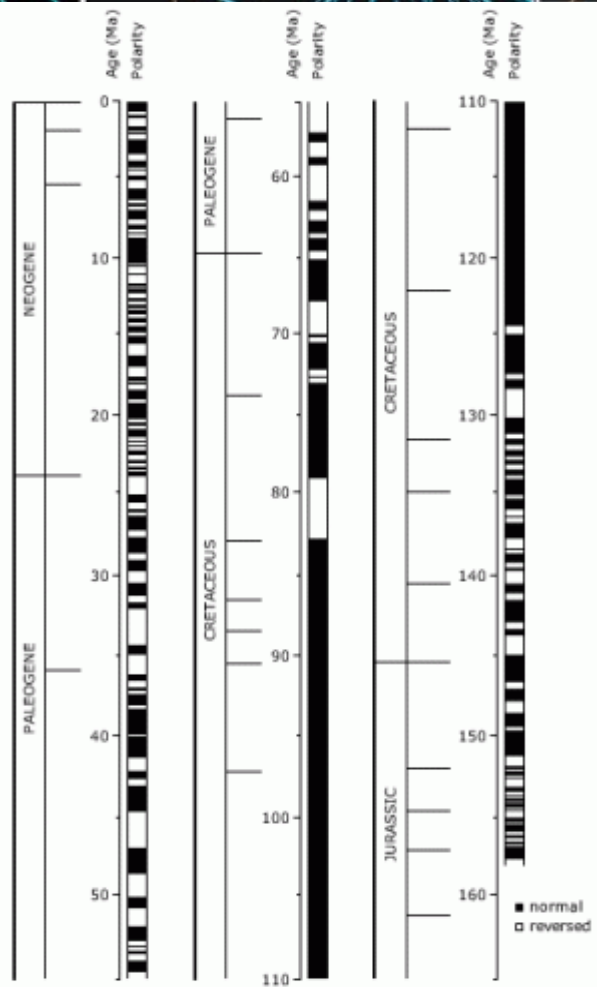
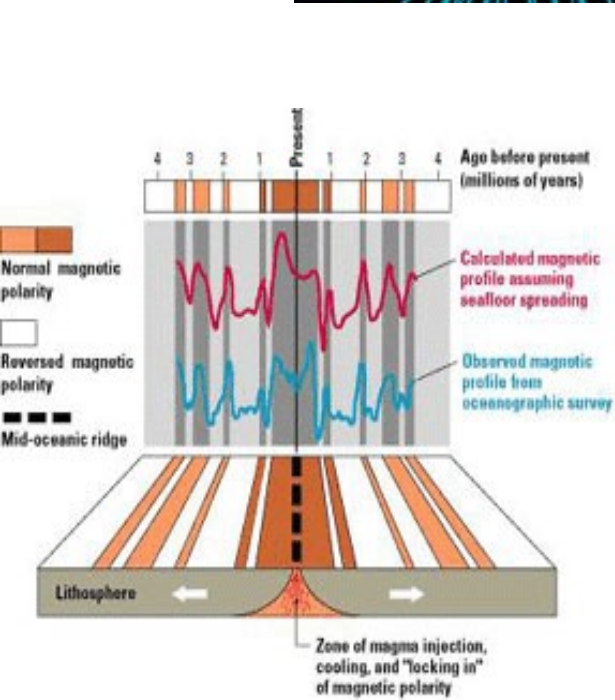
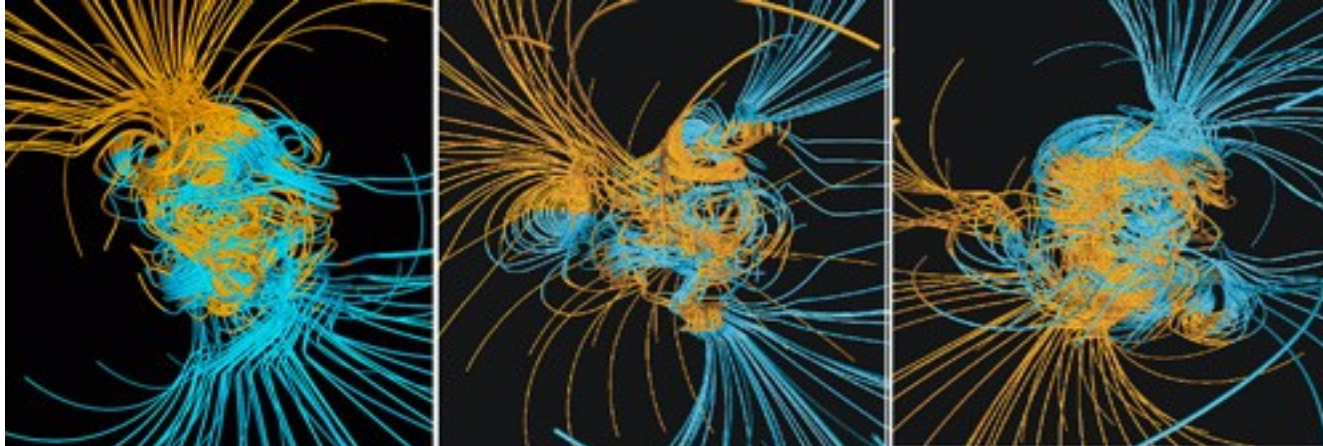
8-13 SEPTEMBER 2010

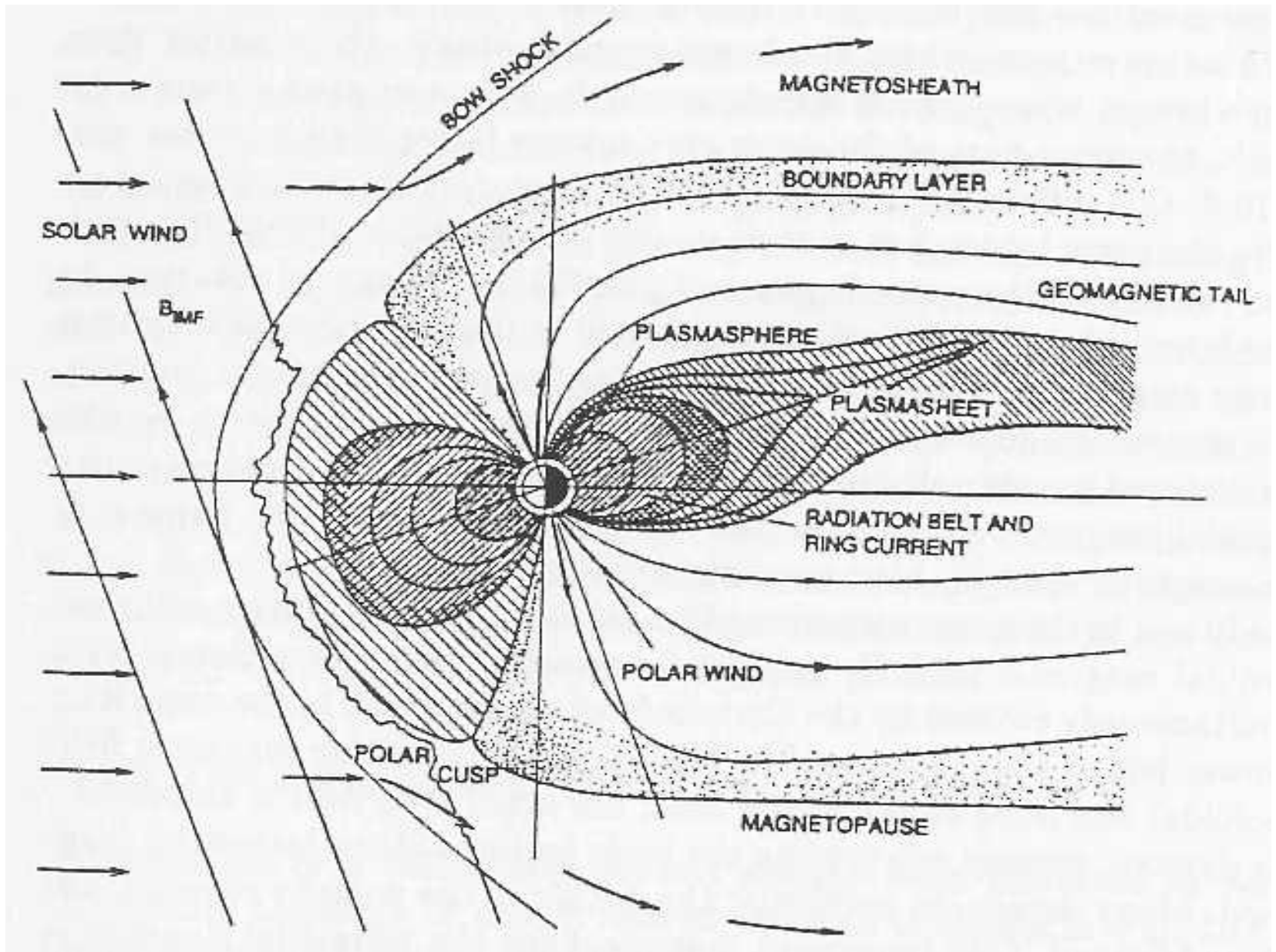


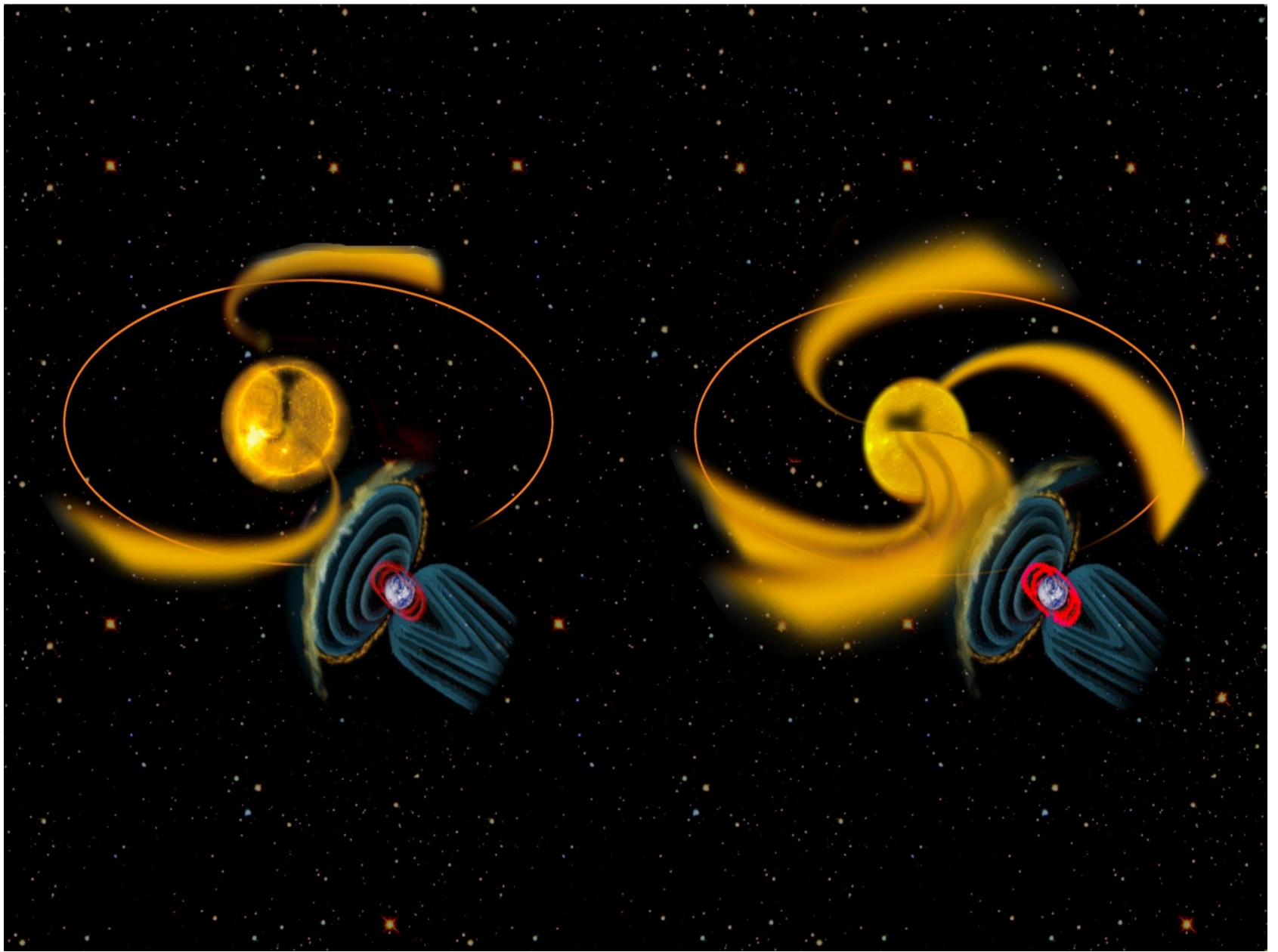
The Earth's Magnetic Field



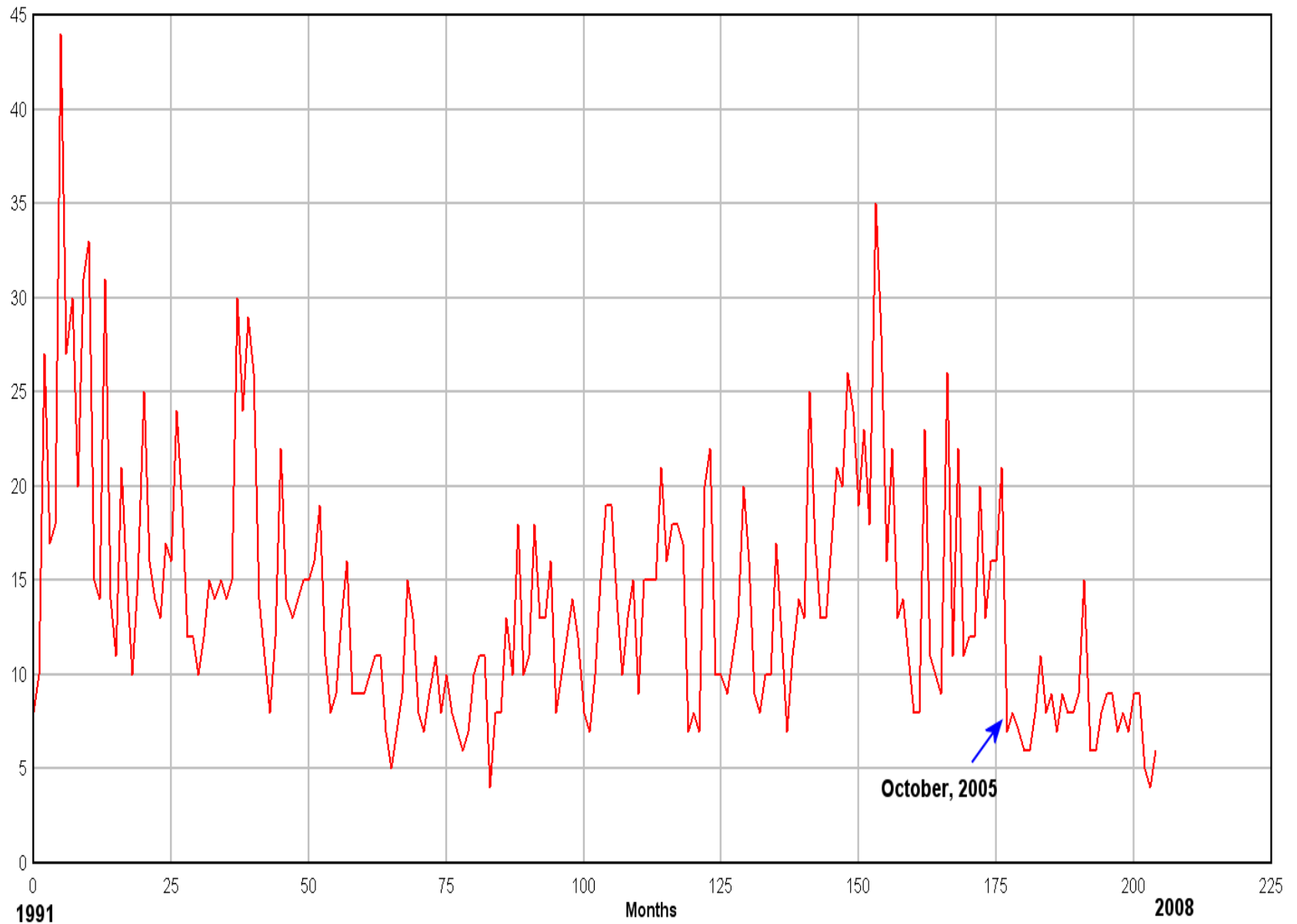








Observed Geomagnetic Averaged Planetary Index (Ap)



October, 2005

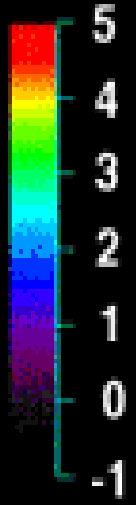
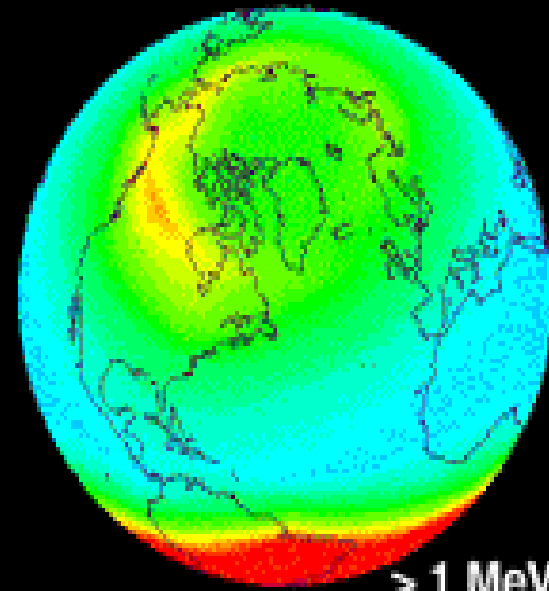
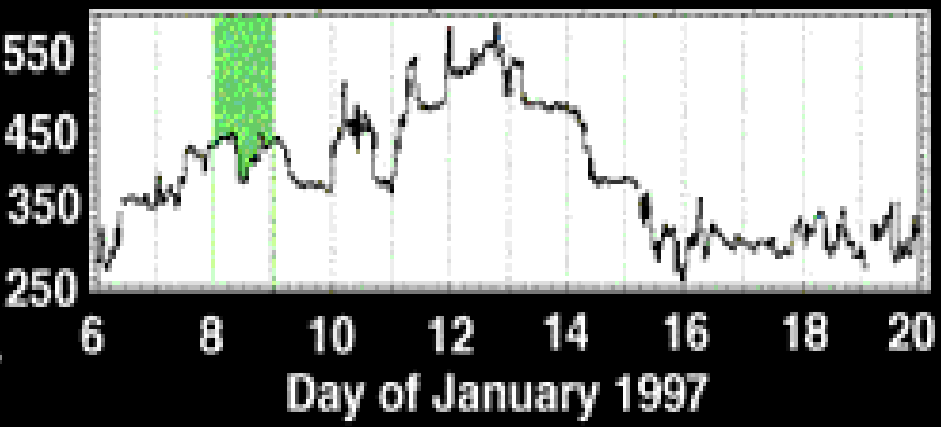


Jan. 8
log flux

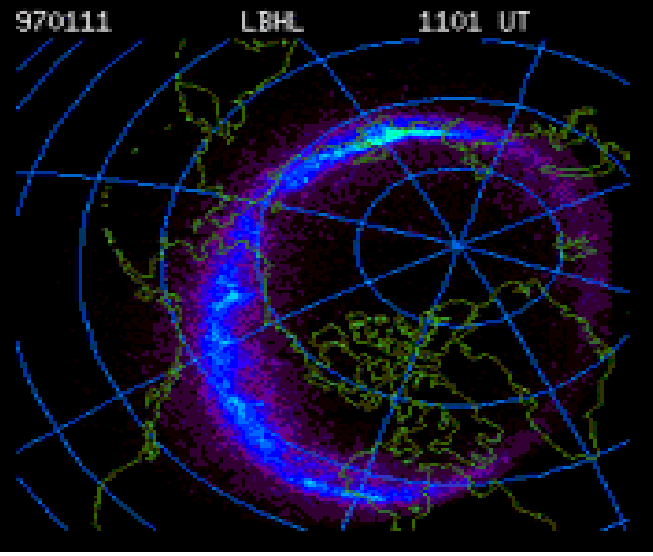
University of Maryland soho / celiac / mtof / PM

SAMPEX

Solar Wind Speed
(kilometers/sec)

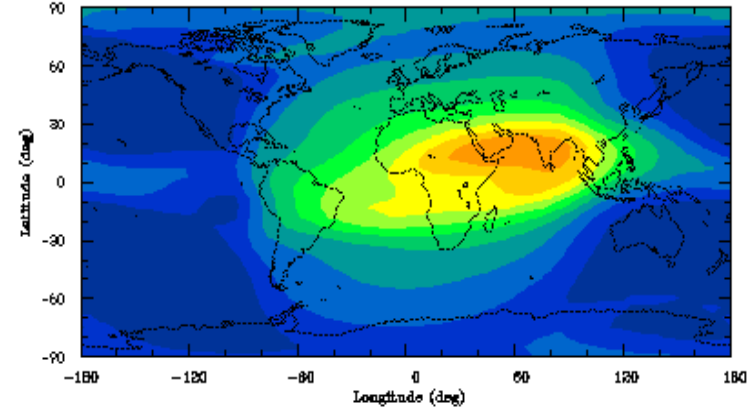


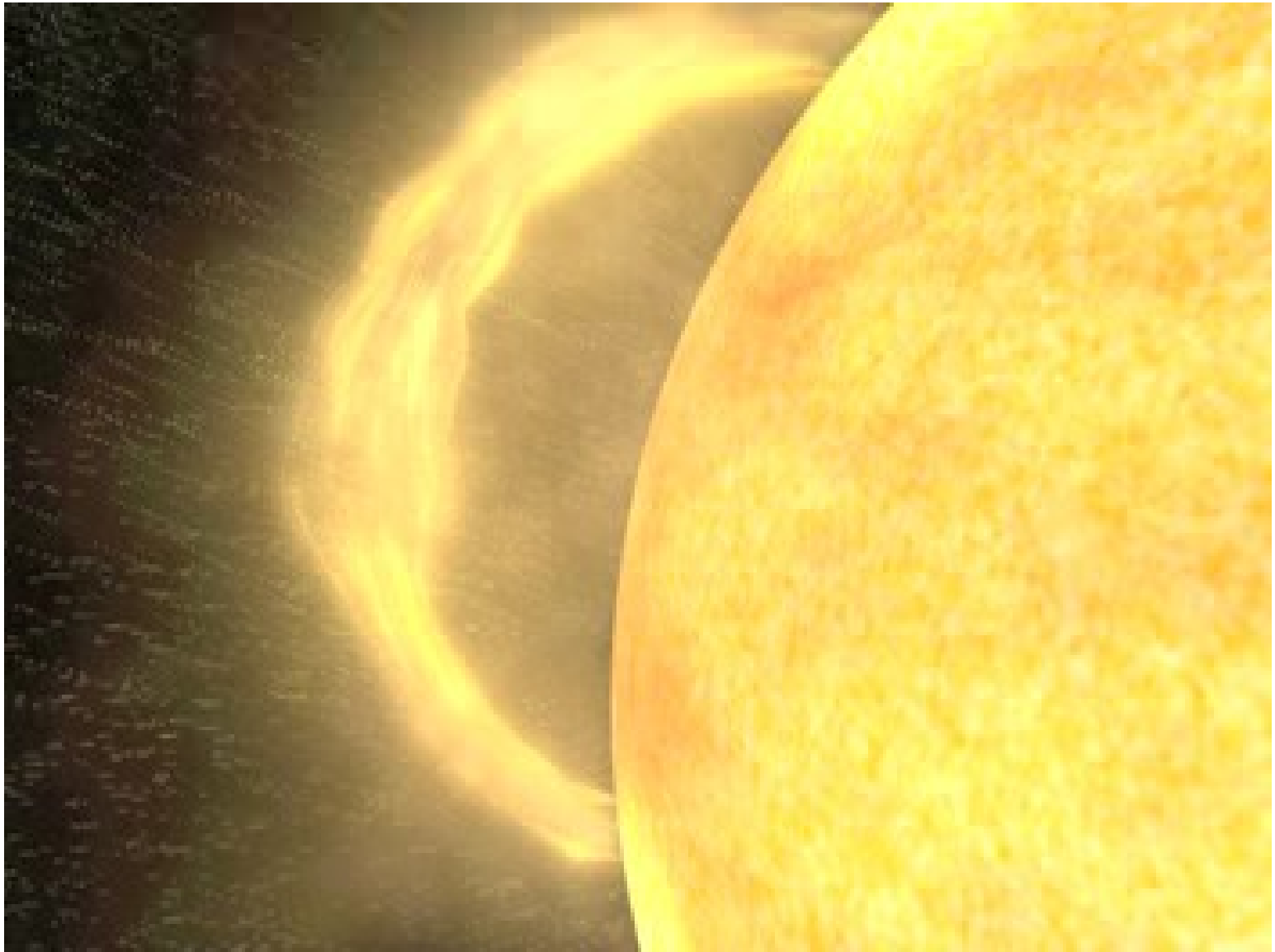
> 1 MeV electrons

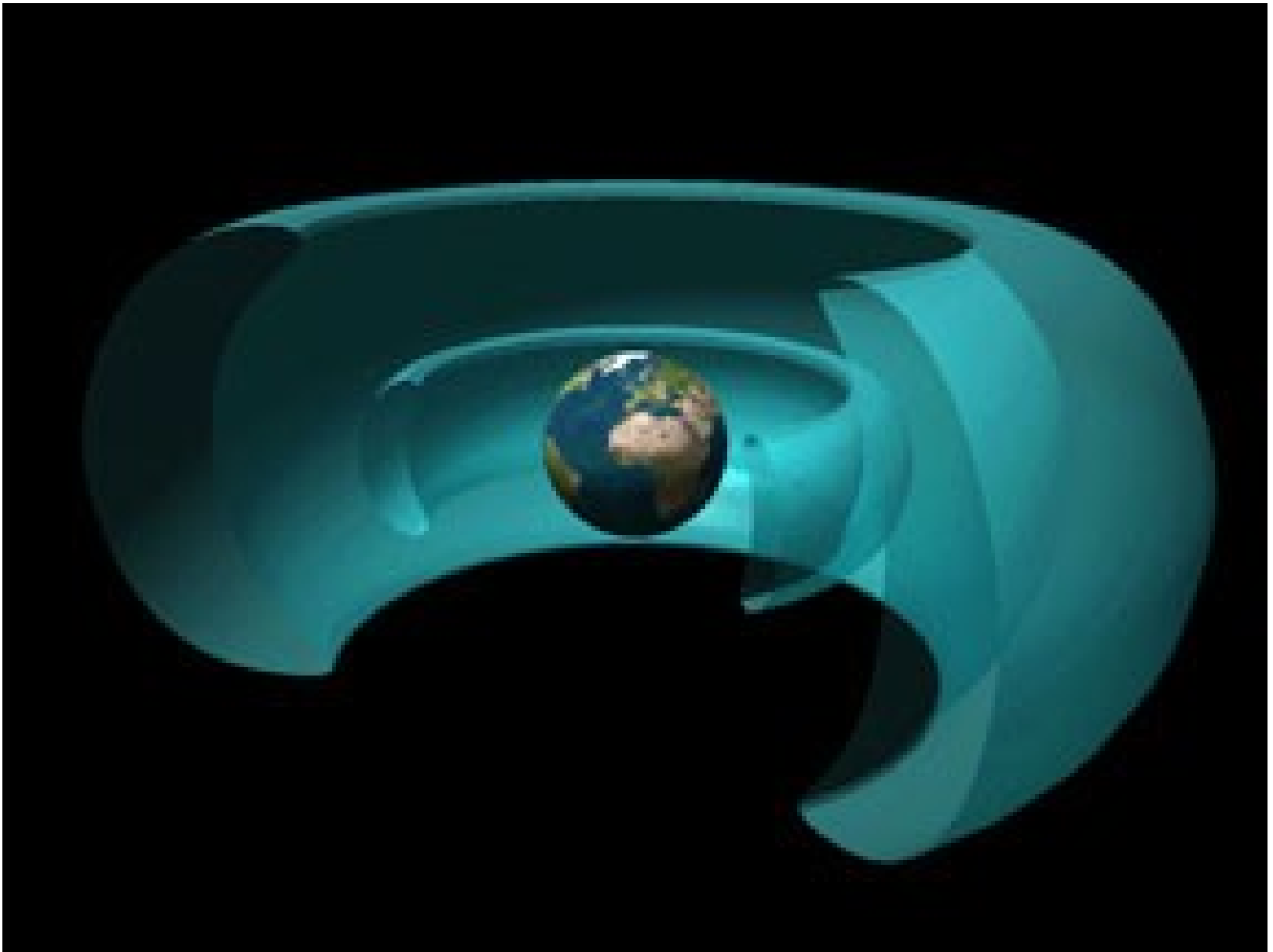


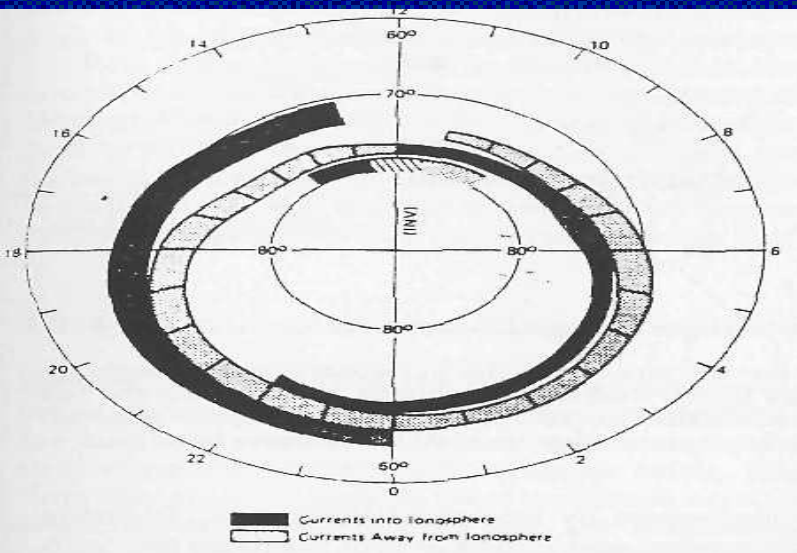
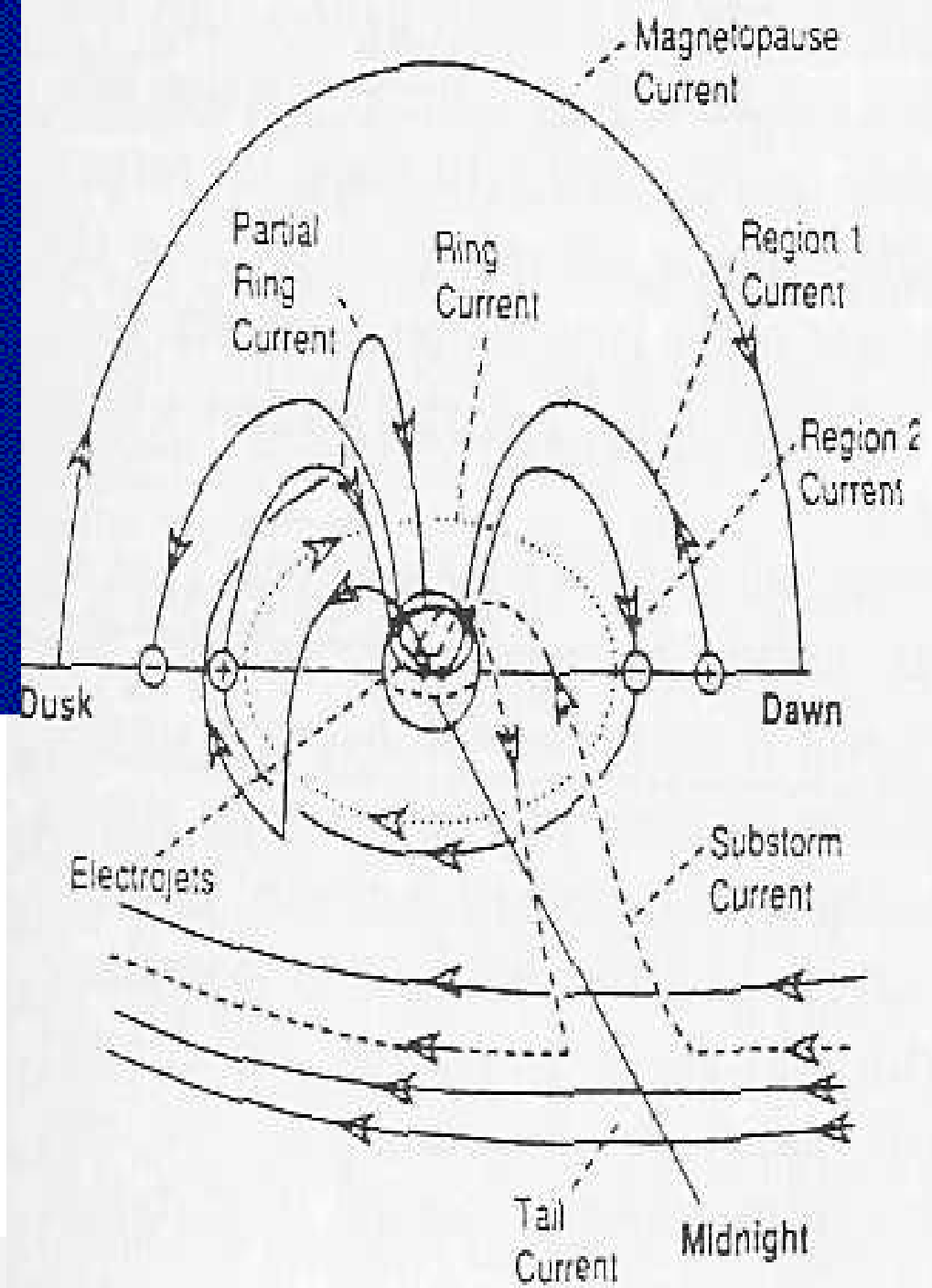
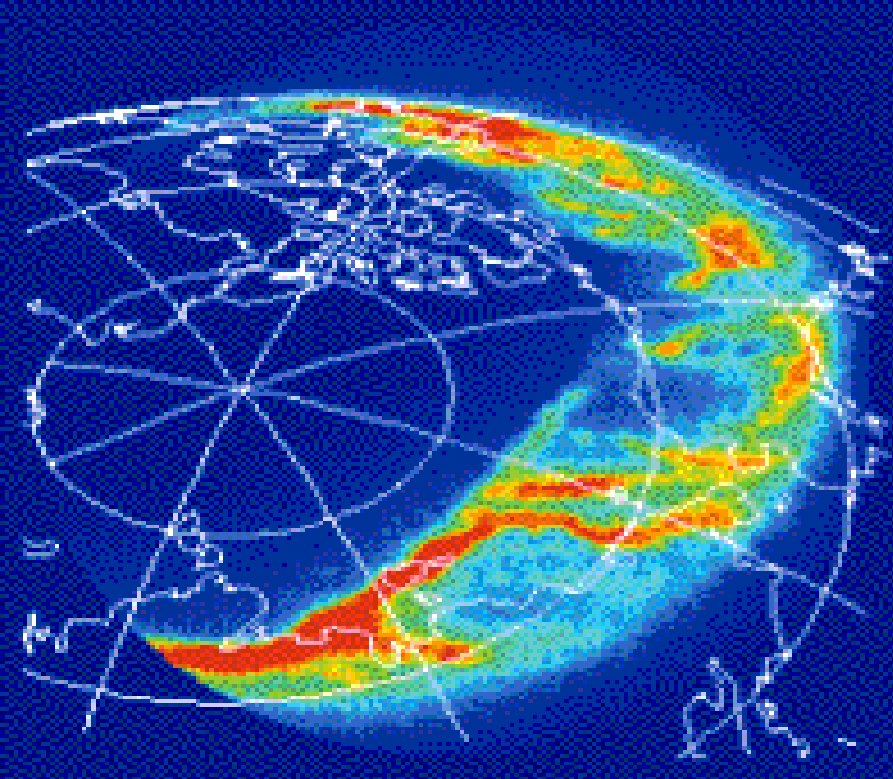
Ionospheric Storm UT = 12h 00m

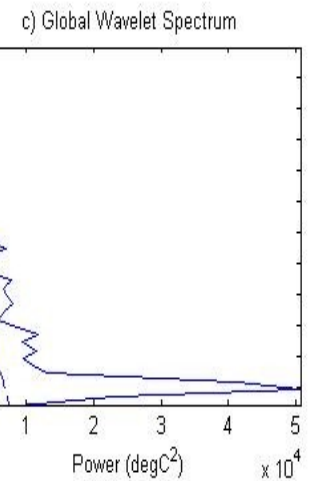
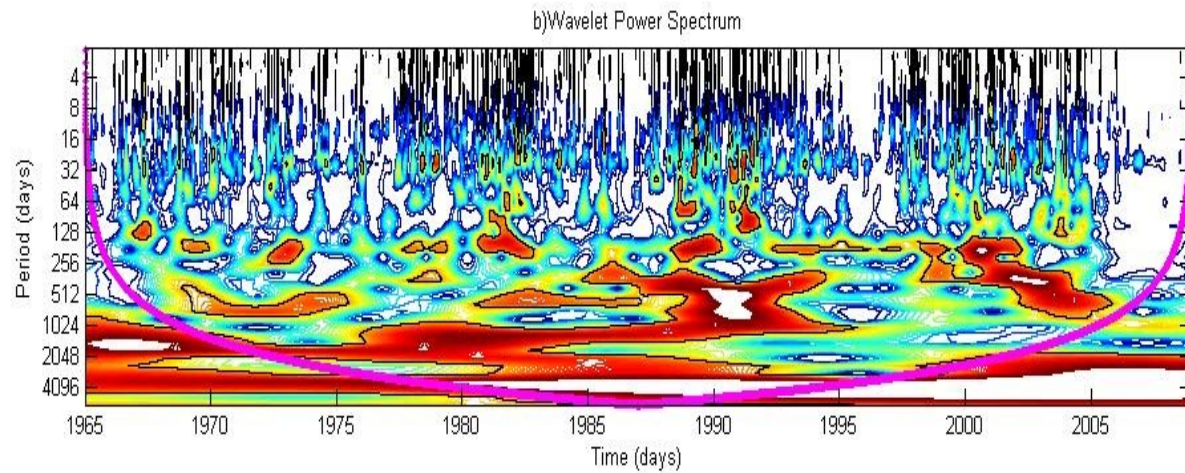
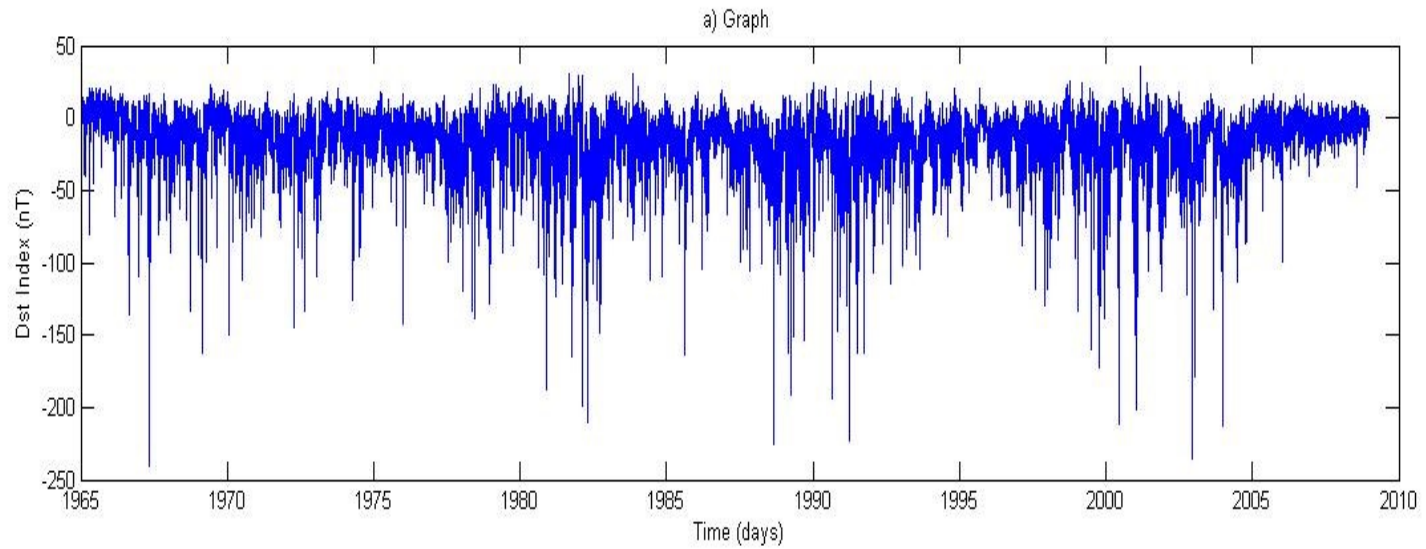
Electron Column Density 100Km to 400Km (m⁻²)
UT = 12h 00m

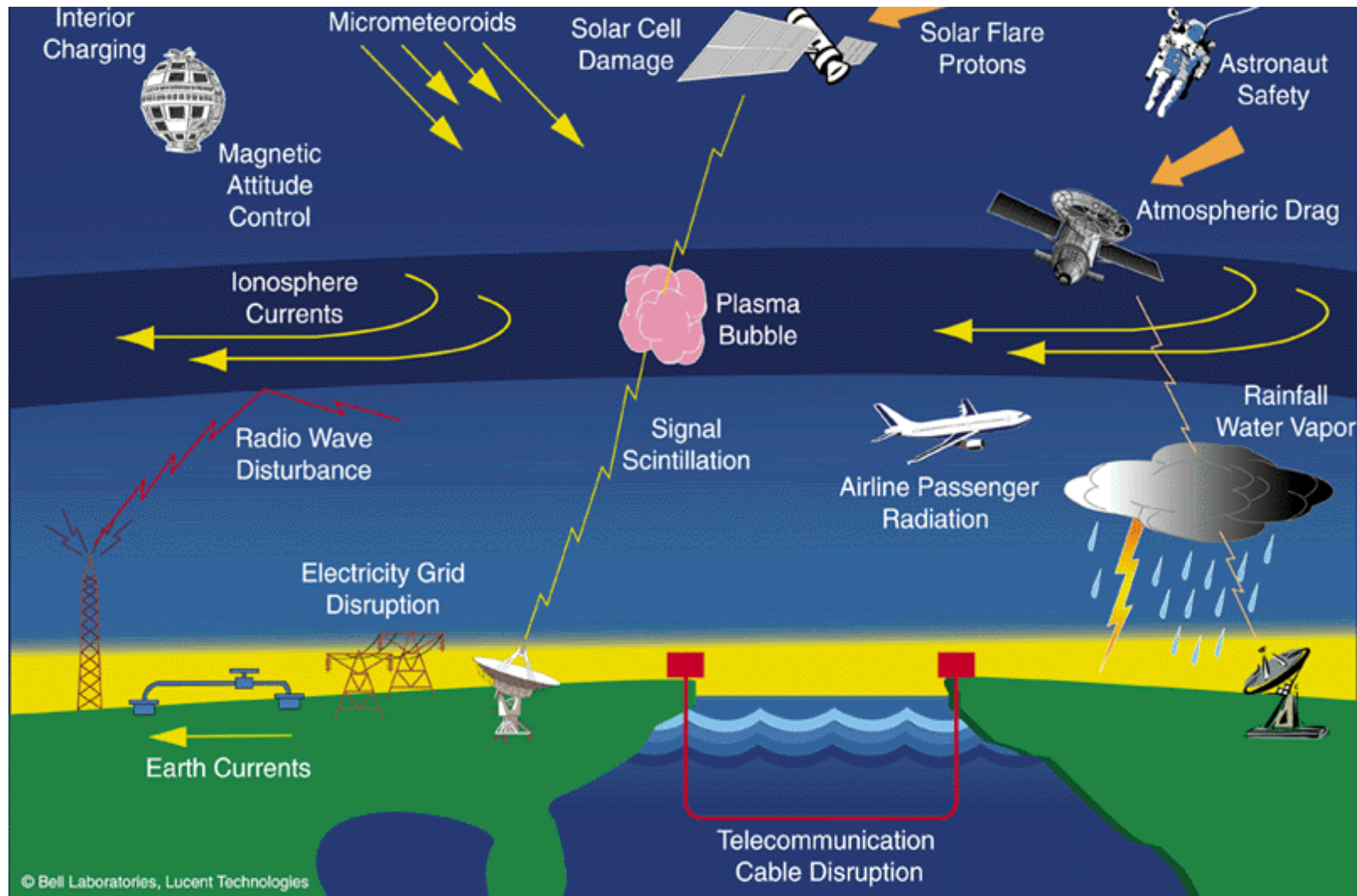










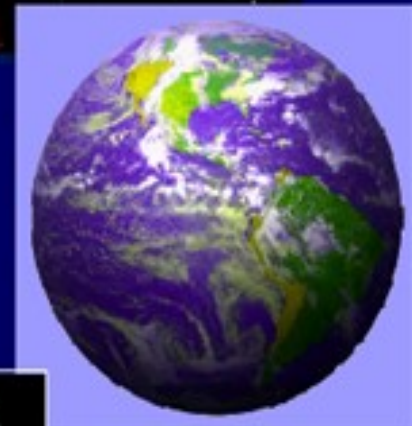


The effects of magnetic storms - what scientists call space weather - extend from the ground to geostationary orbit and beyond.



Why Do We Care?

- **Solar Variability Affects Human Technology, Humans in Space, and Terrestrial Climate.**
- **The Sphere of the Human Environment Continues to Expand Above and Beyond Our Planet.**
 - Increasing dependence on space-based systems
 - Permanent presence of humans in Earth orbit and beyond



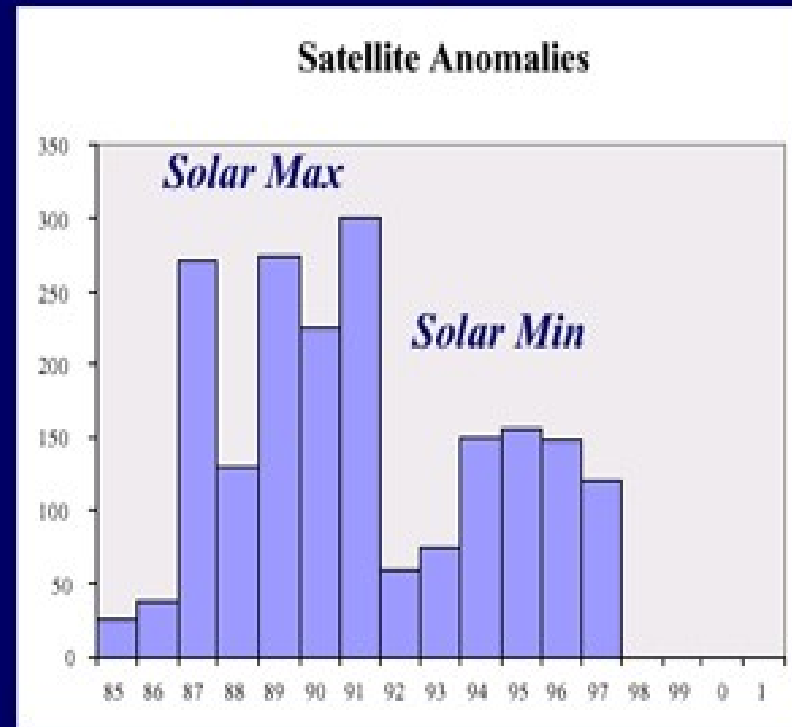
Solar Variability Can Affect Space Systems

How?

- Spacecraft charging.
- Solar cell damage.
- SEU's & damage to electronics.
- Atmospheric drag.

So What?

- Society's dependence on space assets is increasing.
- Space assets vital to world economy, communications, weather forecasts.
- *Prudence demands that we understand the space environment affecting space systems.*

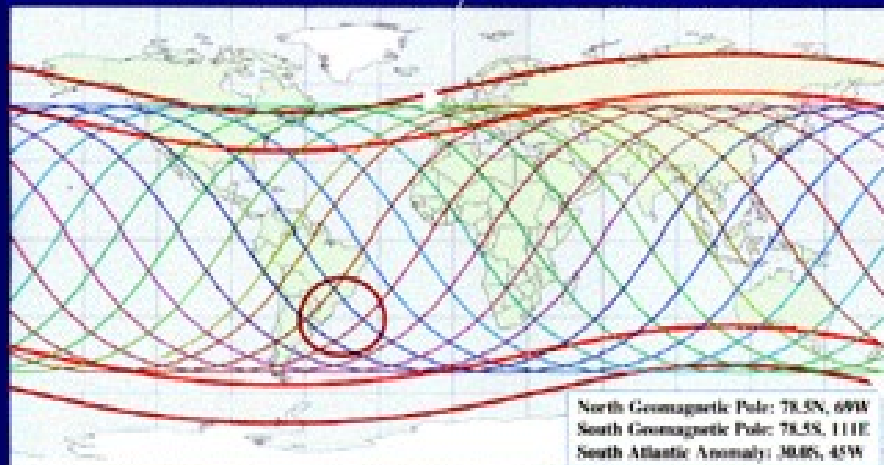


Solar Variability Can Affect Human Space Flight

- Biological effects of energetic particle radiation are largely unknown. [Goal: To make radiation exposure *As Low As Reasonably Achievable*.]
- Space Station: "Solar energetic particle events have a significant impact on crew exposures and station operation related to crew safety."
- Mars: "The capability to predict solar particle events 8 hours in advance of their occurrence is thought to be an operational requirement for a safe interplanetary mission."



Space Station Orbit is Exposed to High Energy Solar Particles



Exclusion Regions: 30.0, 45.0 For Geomagnetic Poles
15.0 For South Atlantic Anomaly



Geomagnetic Storm

Quiet Conditions



Chart courtesy Ron Turner, ANSER





Communications

Intelsat V
Intelsat K

Weather

GOES East (75 W Long)
NOAA-11

Navigation

GPS

Scientific Research

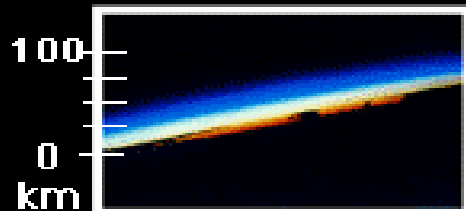
SOHO
Sarpex

Remote Sensing

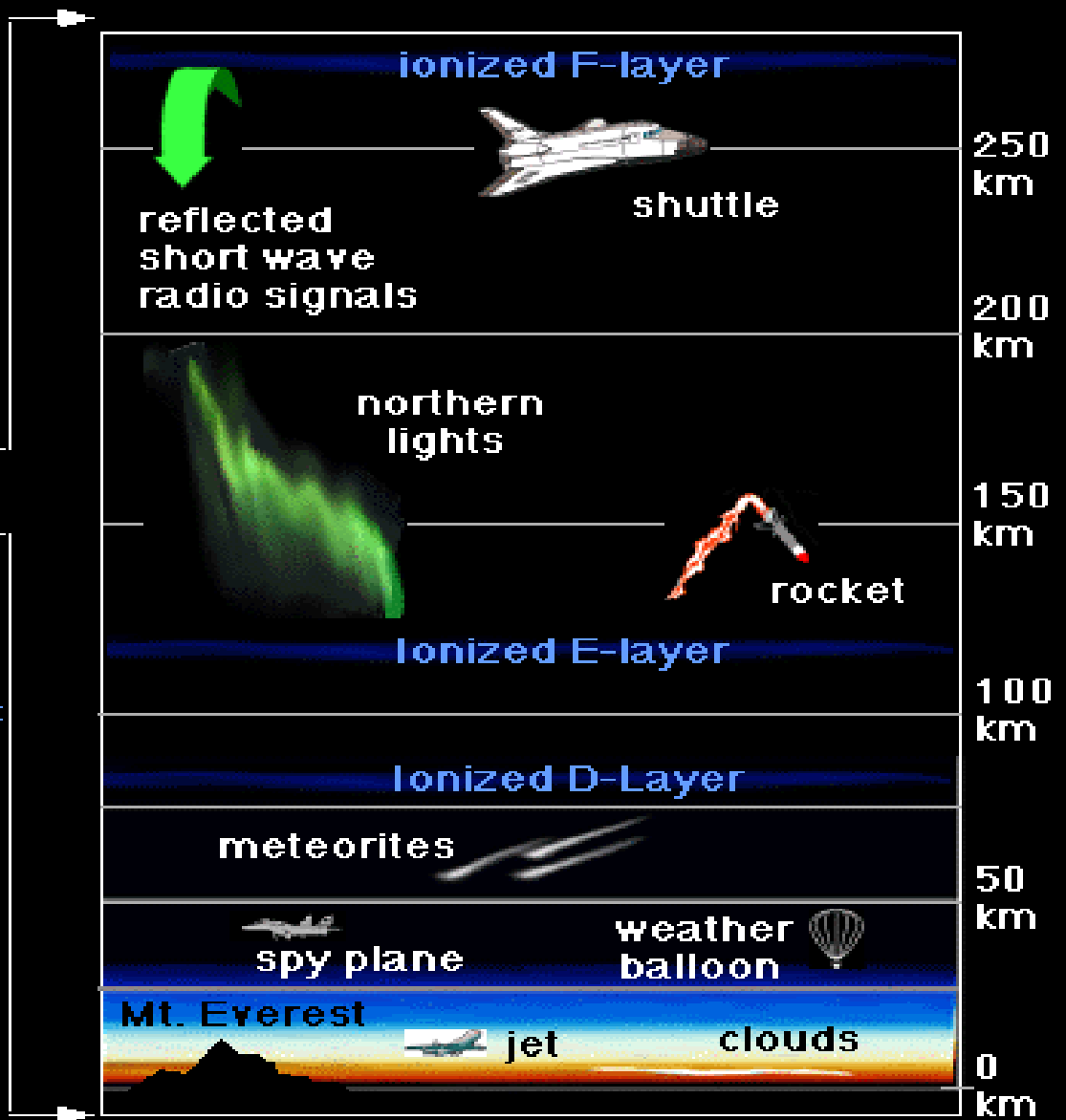
DMSP
Landsat

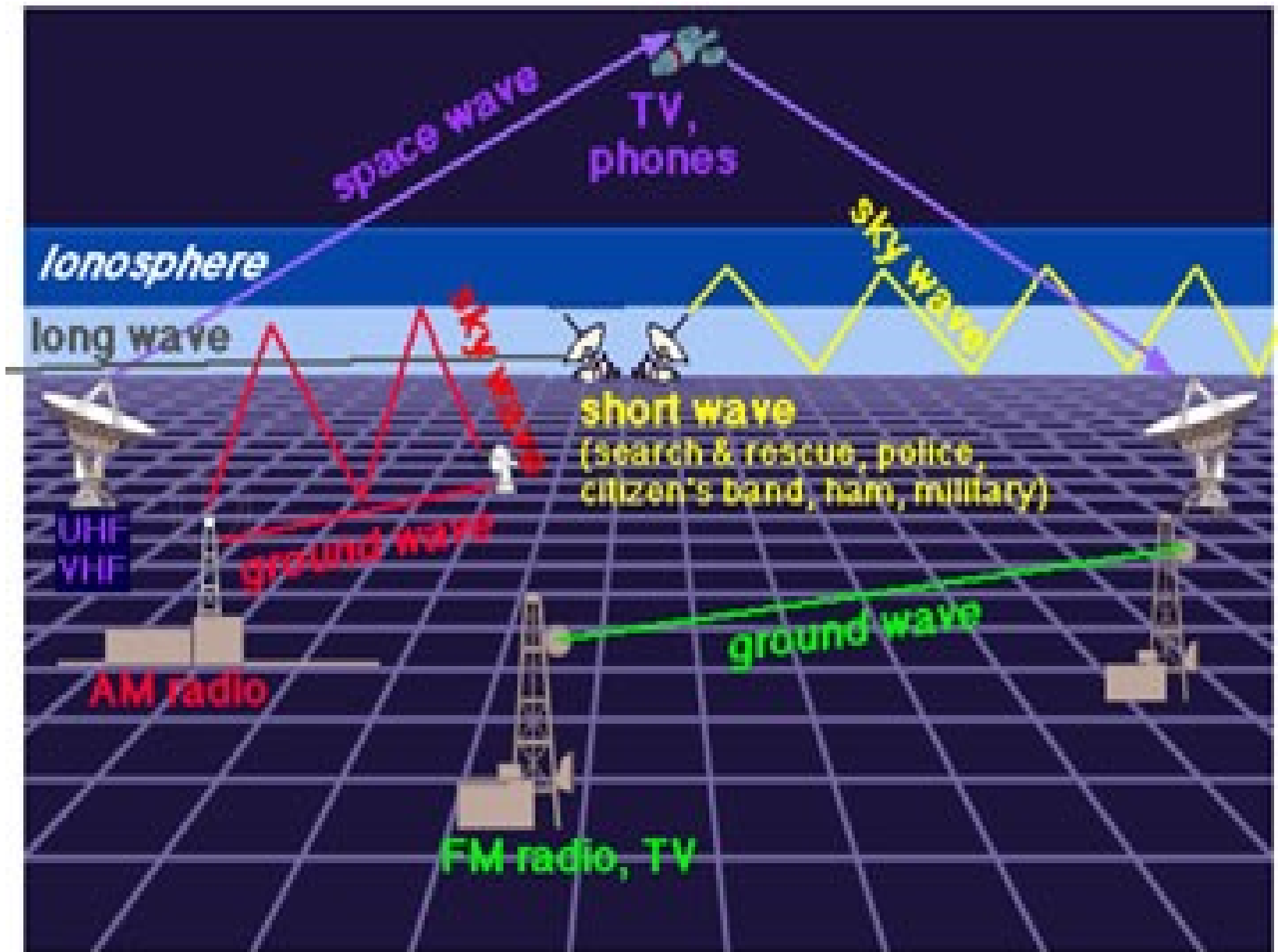


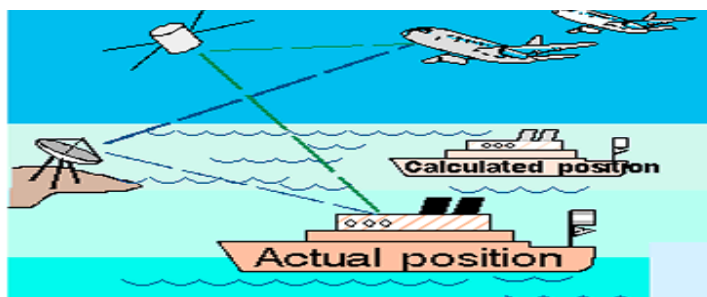
The Atmosphere and the Earth-Space Interface



View of the entire atmospheric layer from the space shuttle (courtesy of NASA)







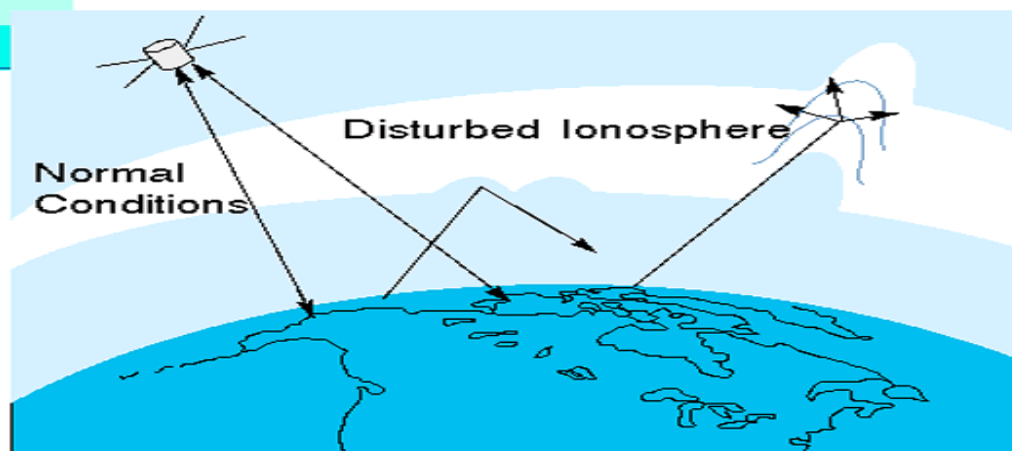
Precision GPS and LORAN signals are adversely affected by a varying ionosphere.



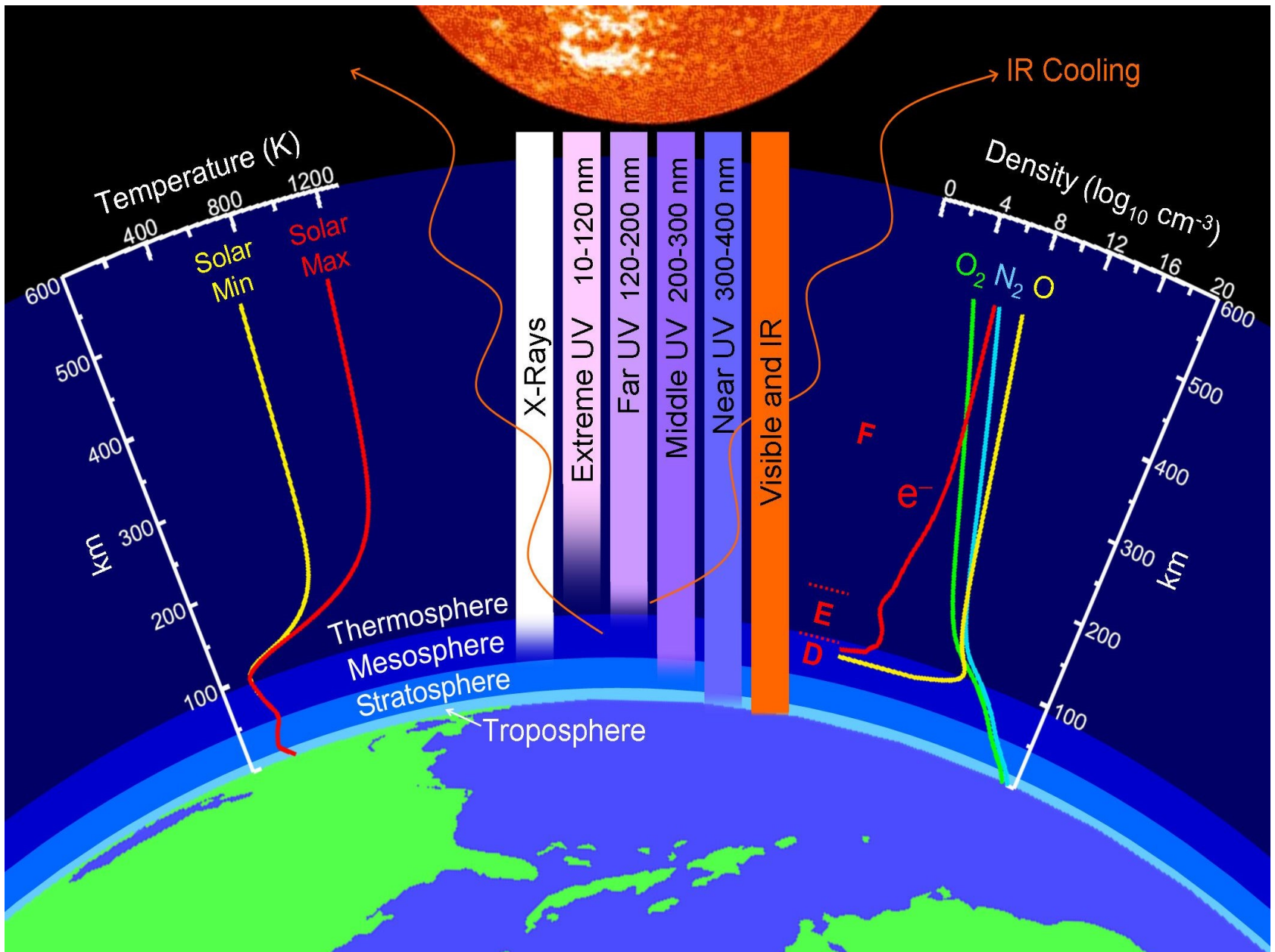
Communications can break down in critical areas and times:

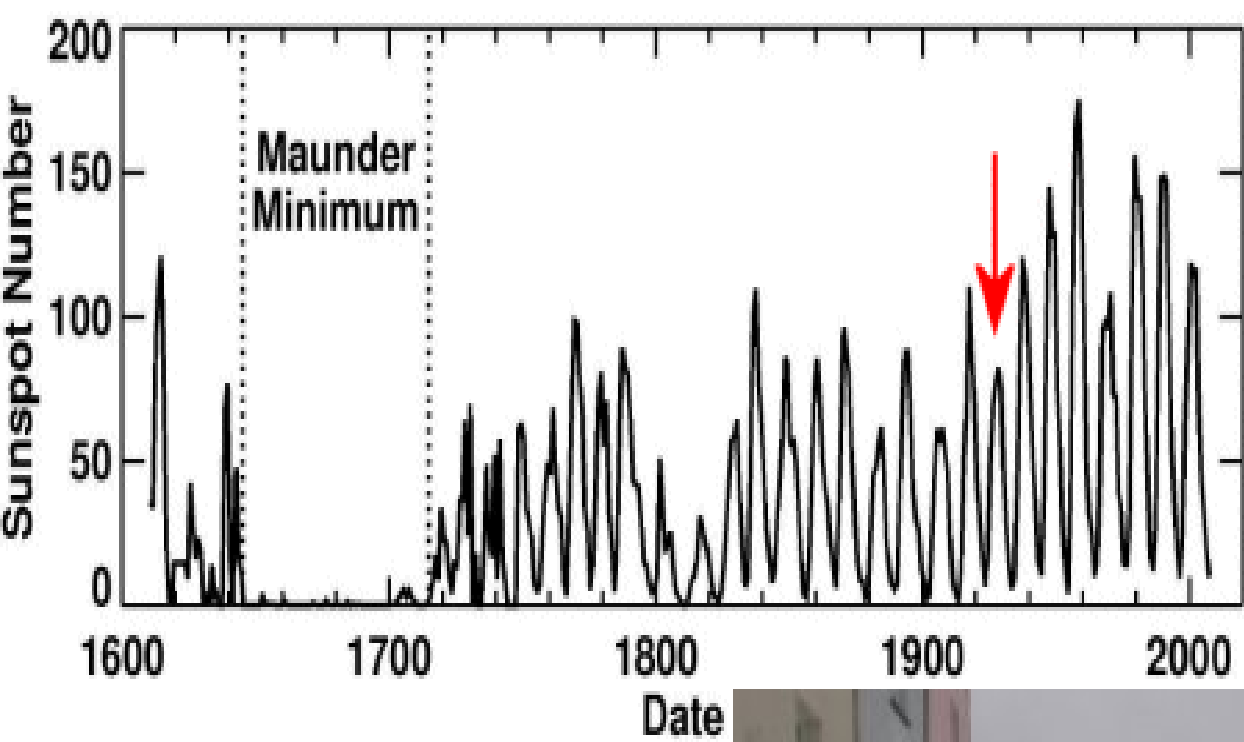
- Desert Storm
- Alaska
- Satellite pagers and Cellular Phones

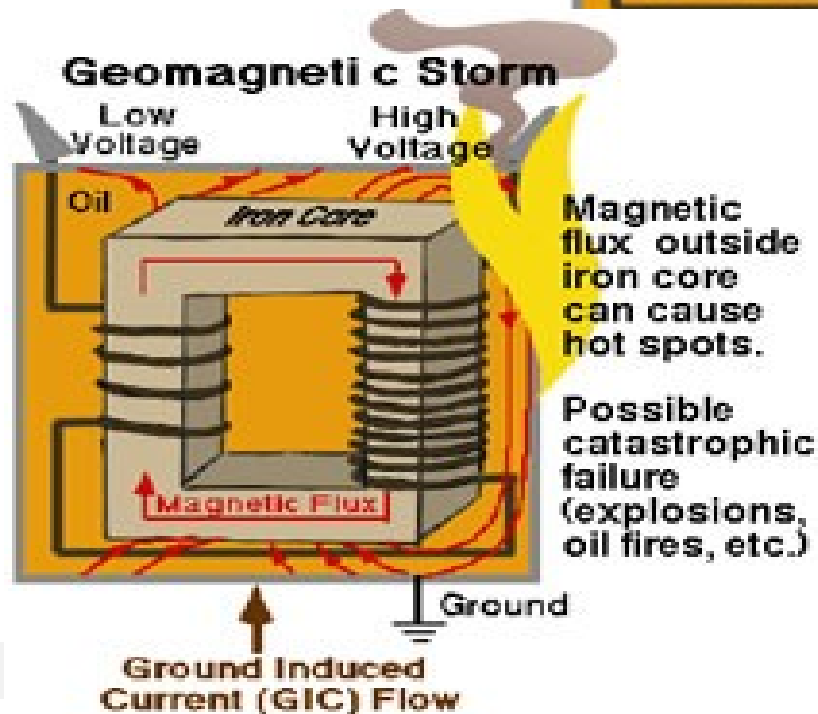
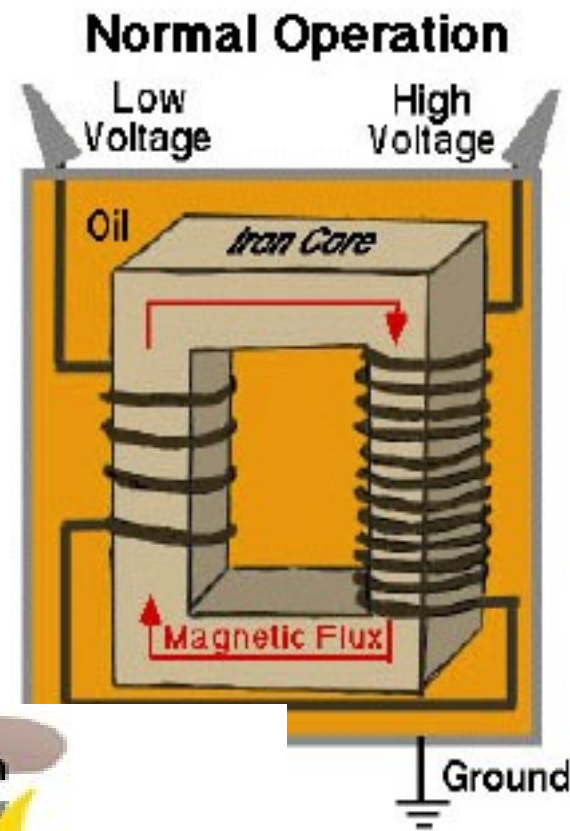
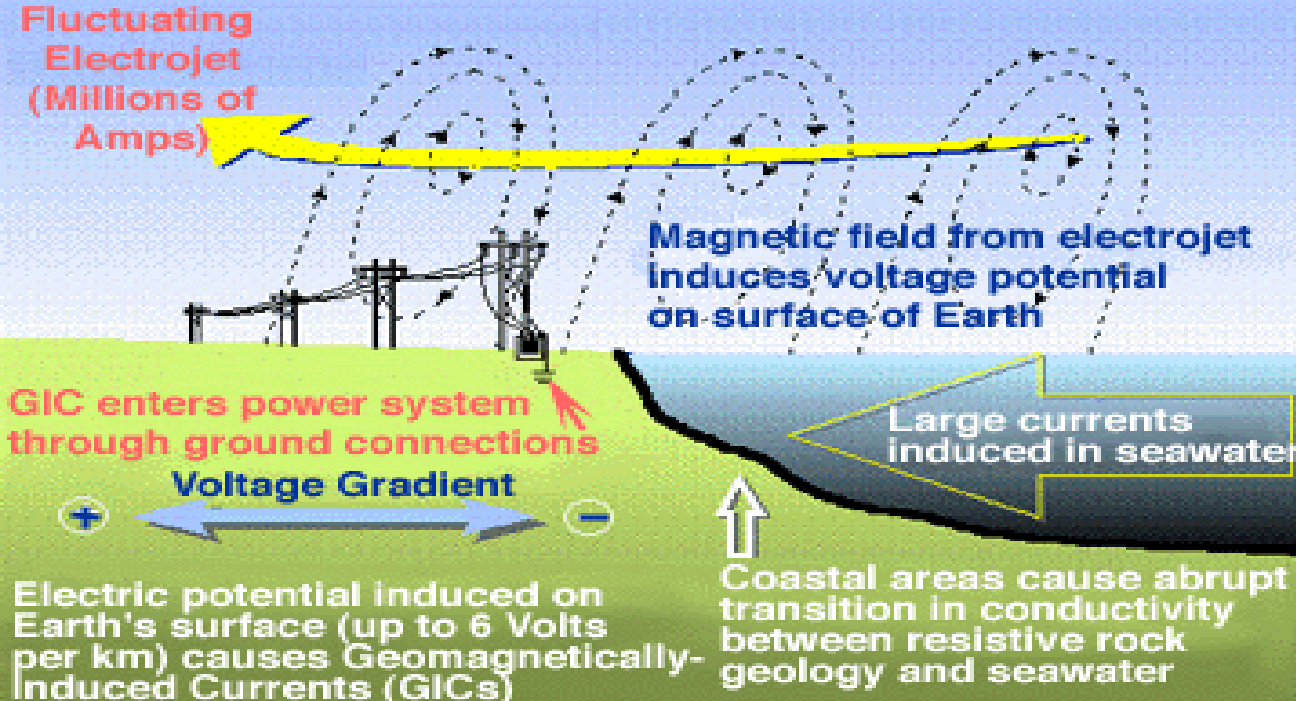
Over-the-horizon radars are also degraded by ionospheric variation.







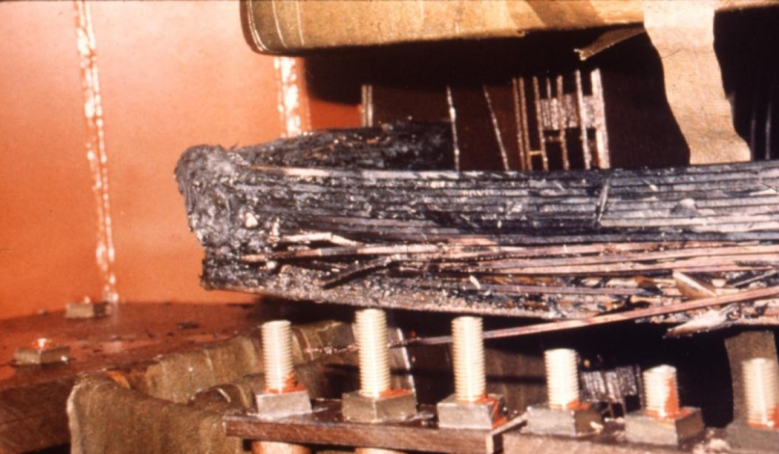




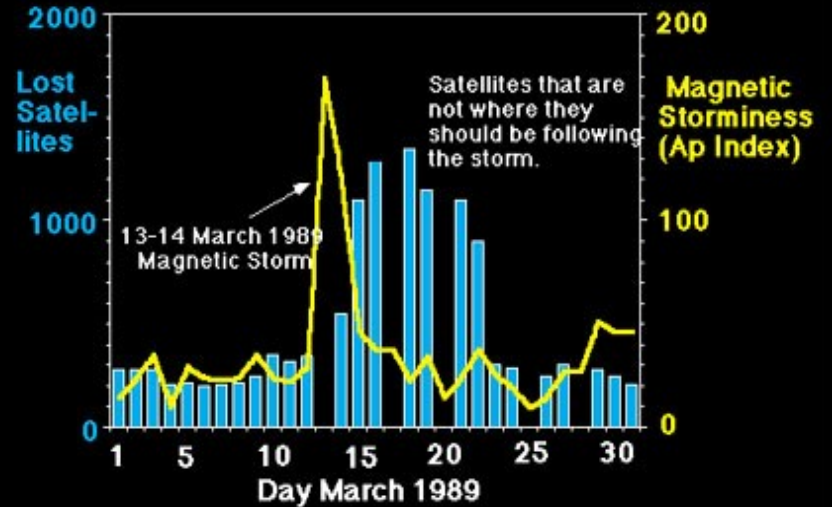
13 MARCH 1989 0745 UT



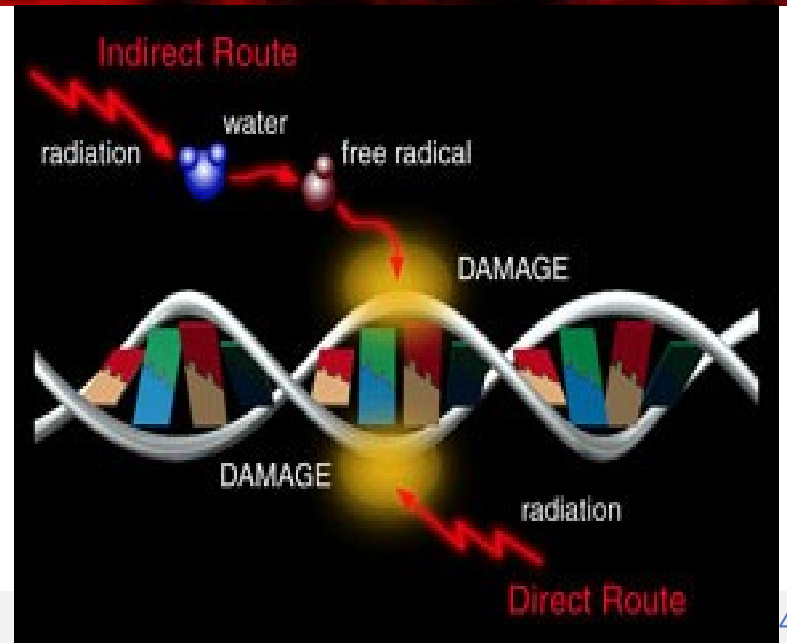
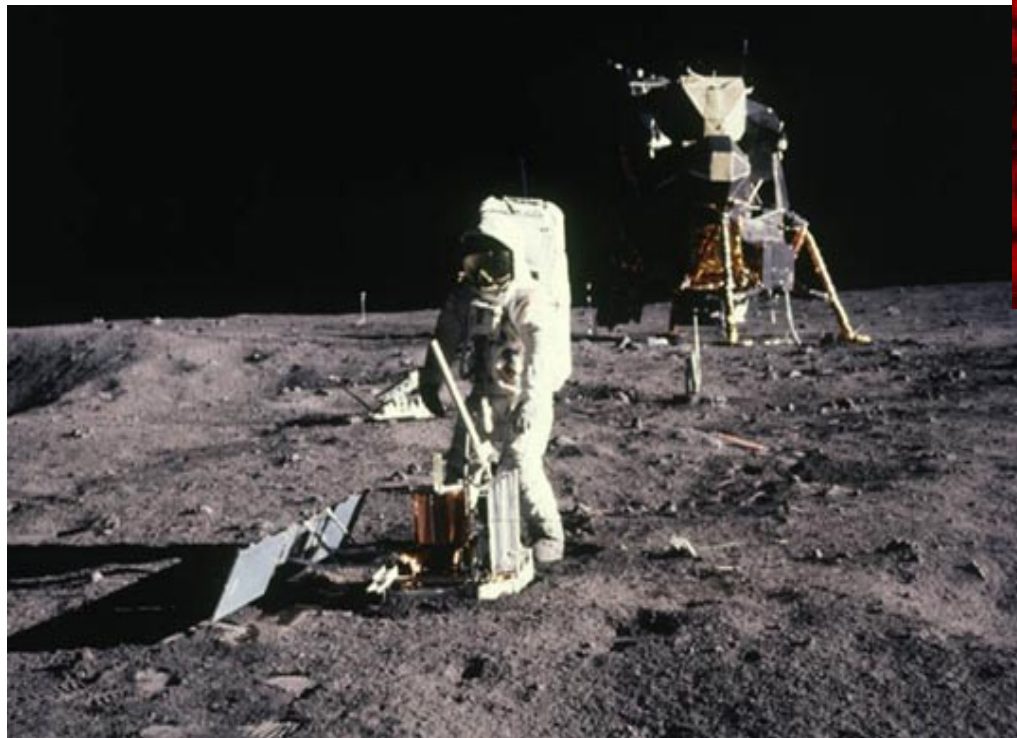
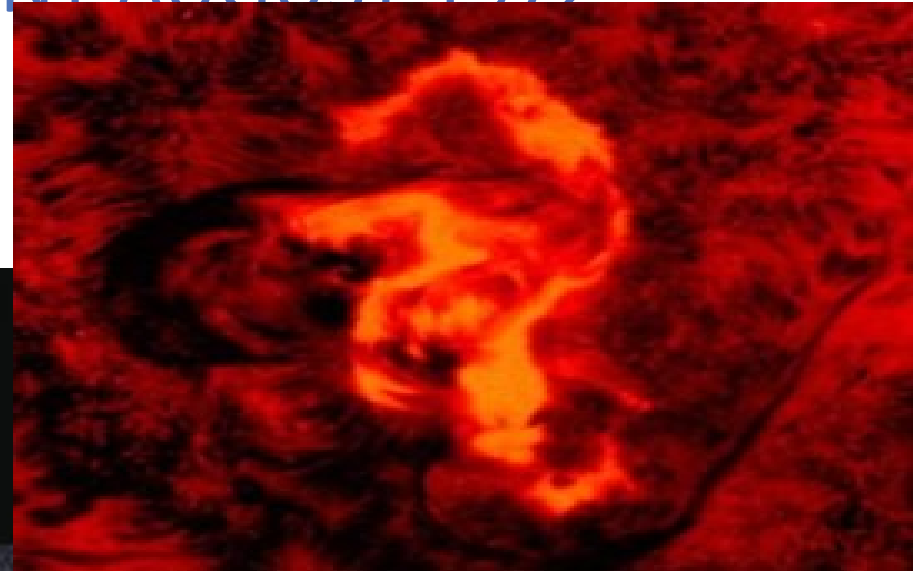
Courtesy of M. A. Stanley, Geological Observatory, Appleton Laboratory



Satellite Tracking Problems After March 13-14, 1989 Storm



SOLAR PROTON EVENT AUGUST 1972



ΗΛΙΟΒΙΟΛΟΓΙΑ (HELIOBIOLOGY)



- Η επίδραση της ηλιακής δραστηριότητας στην ανθρώπινη υγεία

Photic solar effects

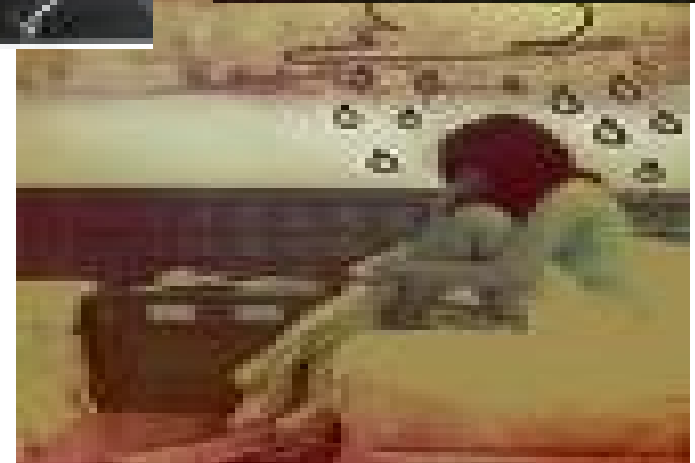
Non-photic solar effects

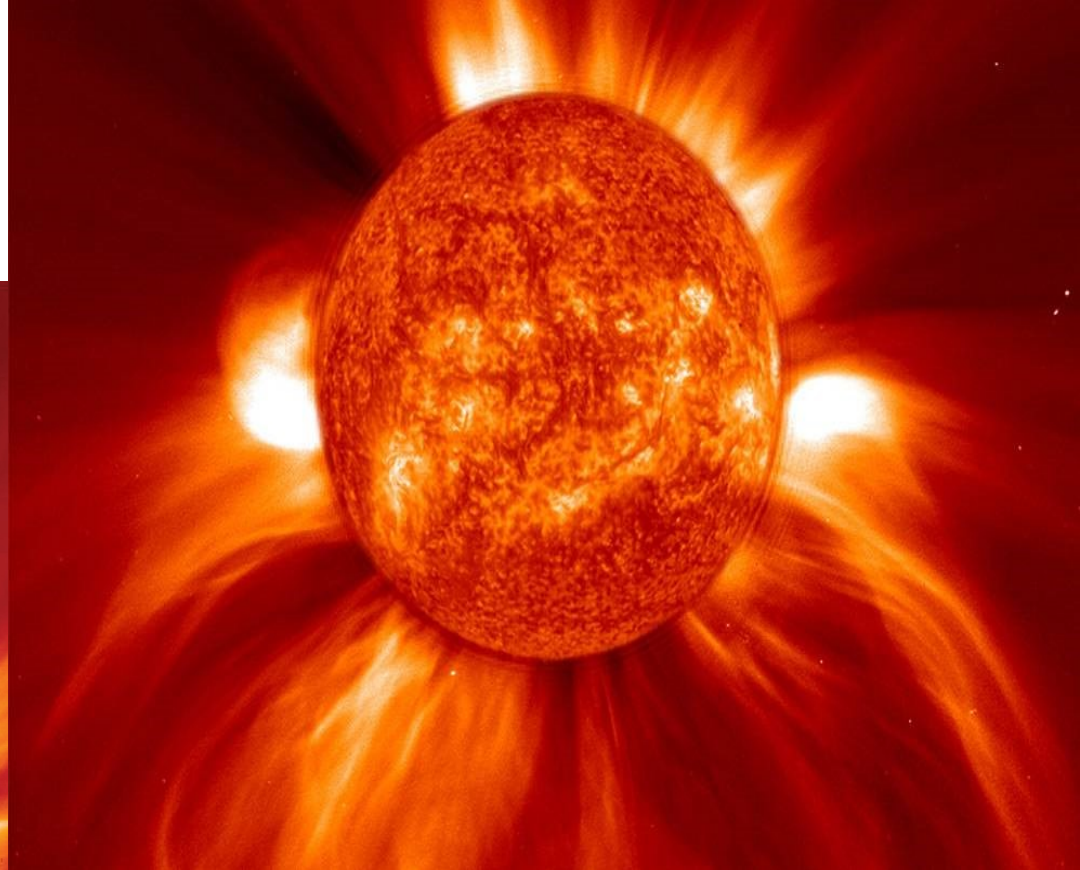
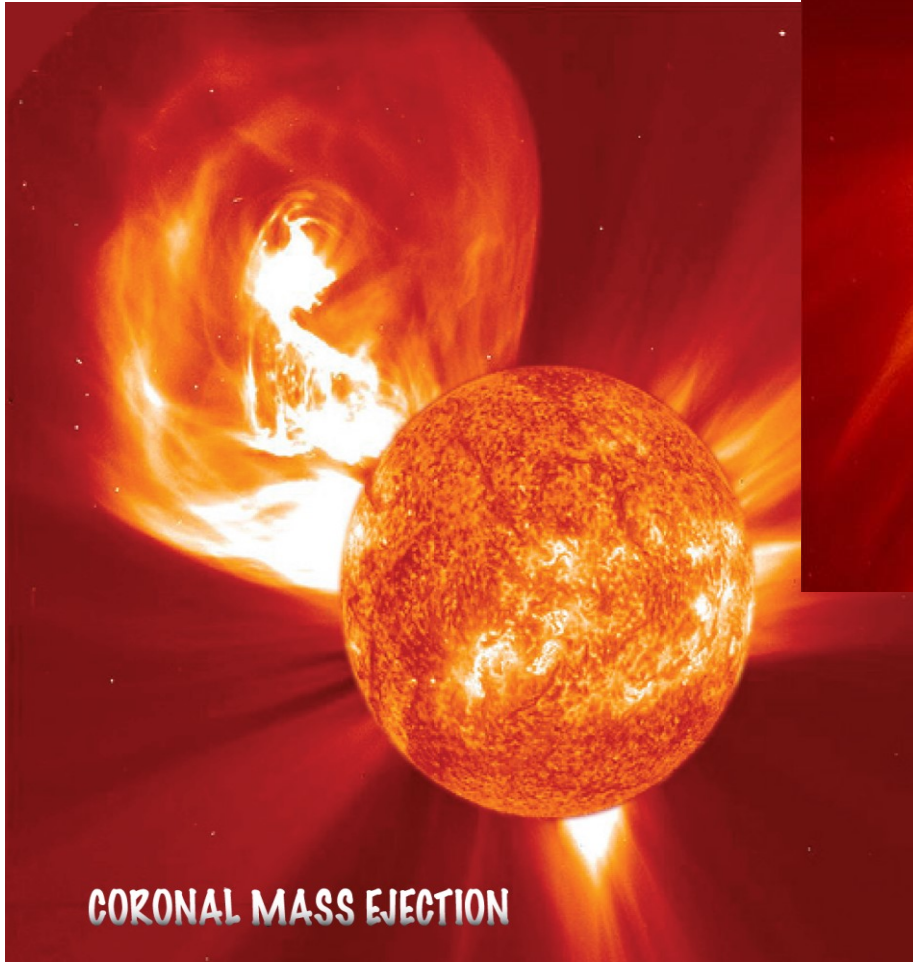


Κατανόηση της σχέσης μεταξύ ηλιακής και γεωμαγνητικής δραστηριότητας και της ανθρώπινης υγείας



ΔΙΕΘΝΗ ΒΙΒΛΙΟΓΡΑΦΙΑ





Τέλος Ενότητας

Χρηματοδότηση

- Το παρόν εκπαιδευτικό υλικό έχει αναπτυχθεί στο πλαίσιο του εκπαιδευτικού έργου του διδάσκοντα.
- Το έργο «**Ανοικτά Ακαδημαϊκά Μαθήματα στο Πανεπιστήμιο Αθηνών**» έχει χρηματοδοτήσει μόνο την αναδιαμόρφωση του εκπαιδευτικού υλικού.
- Το έργο υλοποιείται στο πλαίσιο του Επιχειρησιακού Προγράμματος «Εκπαίδευση και Δια Βίου Μάθηση» και συγχρηματοδοτείται από την Ευρωπαϊκή Ένωση (Ευρωπαϊκό Κοινωνικό Ταμείο) και από εθνικούς πόρους.



Σημειώματα

Σημείωμα Ιστορικού Εκδόσεων Έργου

Το παρόν έργο αποτελεί την έκδοση 1.0.0.



Σημείωμα Αναφοράς

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<http://opencourses.uoa.gr/courses/PHYS1/>



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- το Σημείωμα Αναφοράς
- το Σημείωμα Αδειοδότησης
- τη δήλωση Διατήρησης Σημειωμάτων
- το Σημείωμα Χρήσης Έργων Τρίτων (εφόσον υπάρχει)

μαζί με τους συνοδευόμενους υπερσυνδέσμους.

