

Zonneactiviteit en ruimteweer tijdens zonnecyclus 24

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Solar-Terrestrial Centre of Excellence

2 September 2016



VVS / De Sterrenjutters - Koksijde



Inhoud

- Zonneactiviteit
 - Zonnevlekken, zonnecyclus,...
- Ruimteweer
 - Wat, effecten,...
 - Voorbeelden
 - Hoe voorspellen
- Zonnestormen tijdens SC24

De Zon

- Een ster

- Groot

- 1.392.000 km
- 109 * Diameter Aarde

- Zwaar

- $1,99 * 10^{30}$ kg
- 332.980 * Massa Aarde

- Dichtstbij

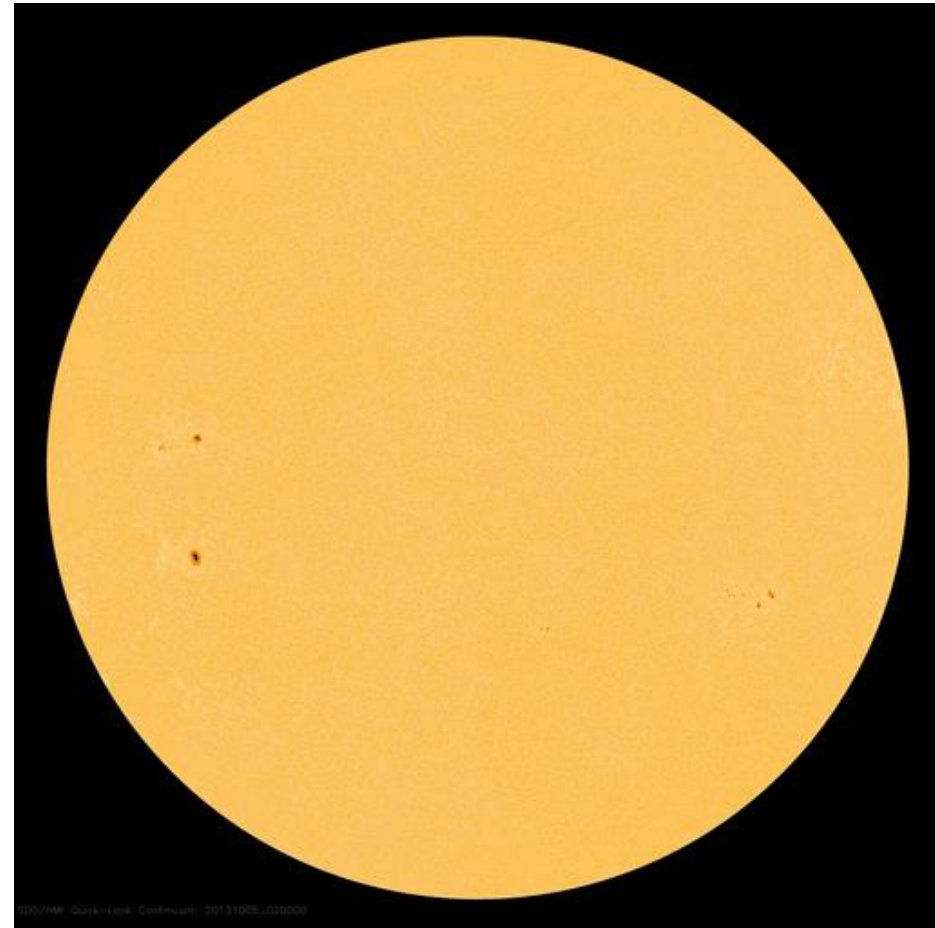
- 149.597.870 km
- = 1 Astronomische Eenheid
- +/- 8 lichtminuten

- Stralend

- $3,84 * 10^{26}$ Watt
 - = 1362 W/m² op aardatmosfeer
- Volledig EM-spectrum

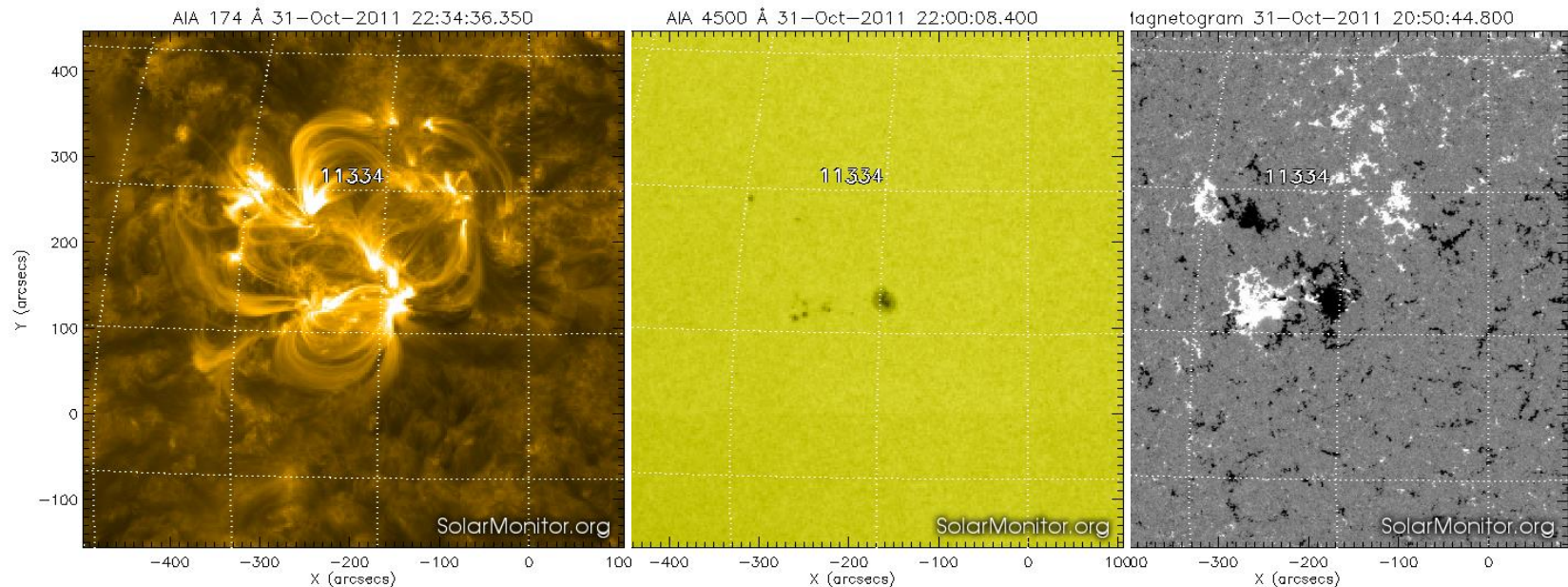
- Zonnewind

- Stroom van geladen deeltjes
- +/- 400 km/s



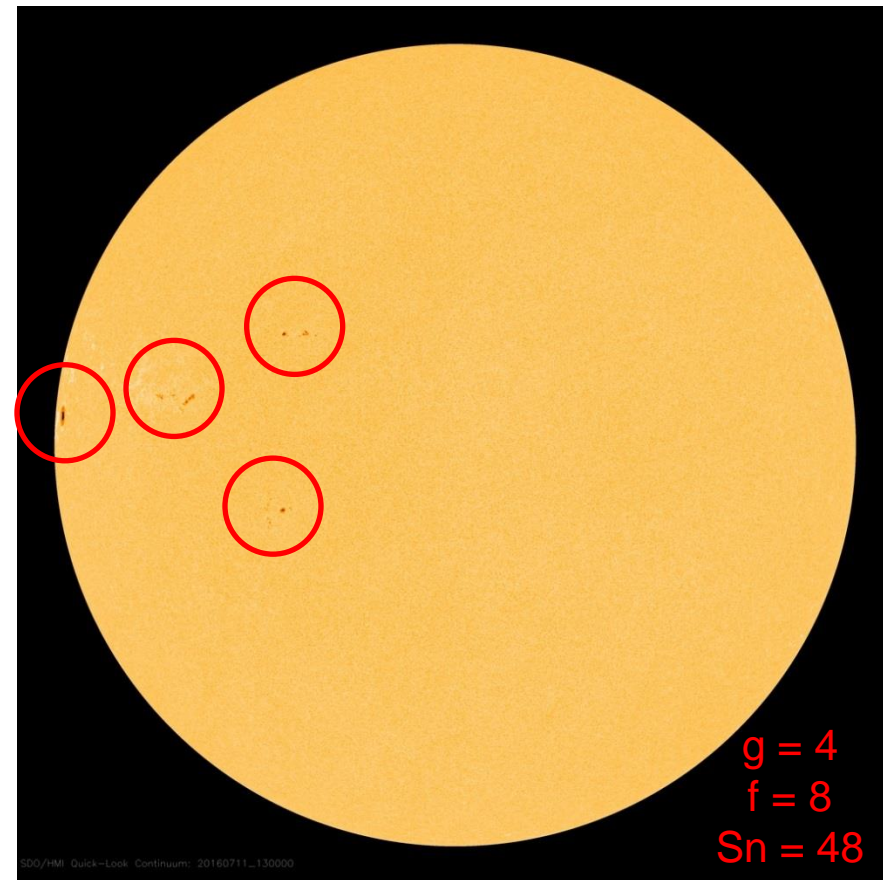
Zonnevlekken

- Magnetische storingen
 - 3000* sterker dan ongestoord zonneoppervlak
 - Koeler
- Bipolair
 - Tegengestelde polariteit
- Differentiële rotatie
 - Polen roteren trager dan evenaar



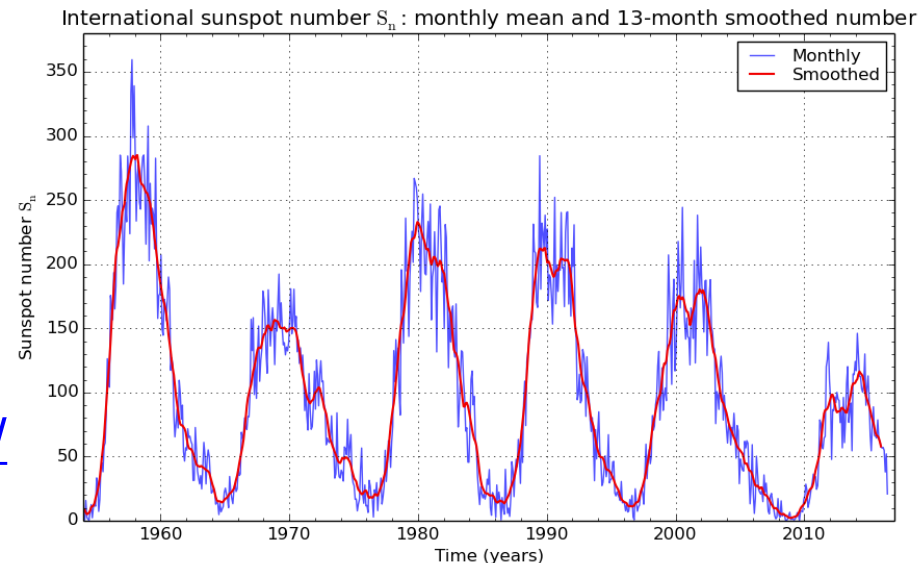
Zonnevlekkengengetal

- $S_n = 10 \cdot g + f$,
 - met g het aantal groepen, en f het aantal vlekken
 - Bepaald door SIDC / SILSO in Ukkel!
 - <http://www.sidc.be/silso/>

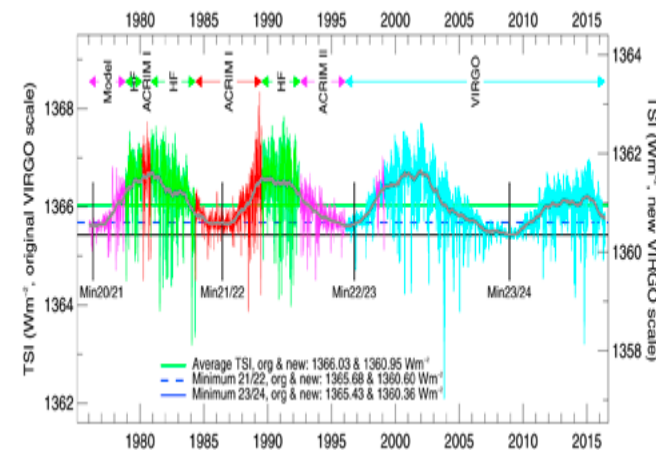


Zonnevlekkencyclus

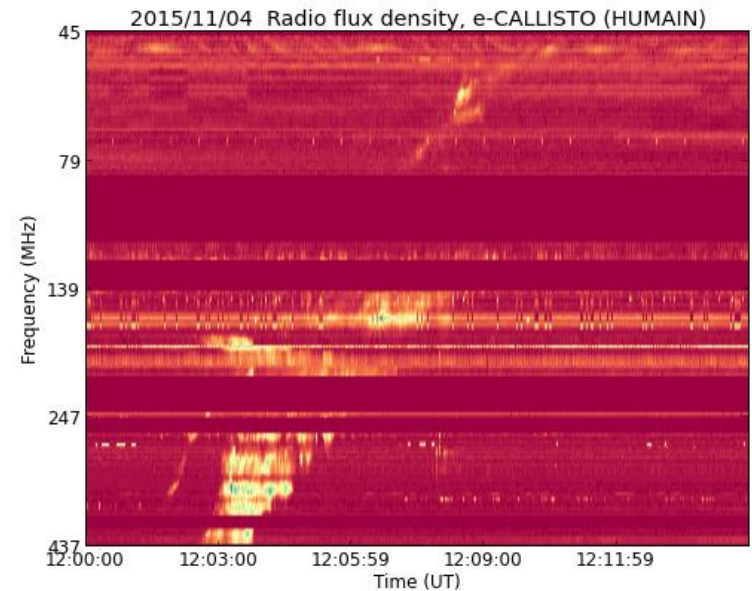
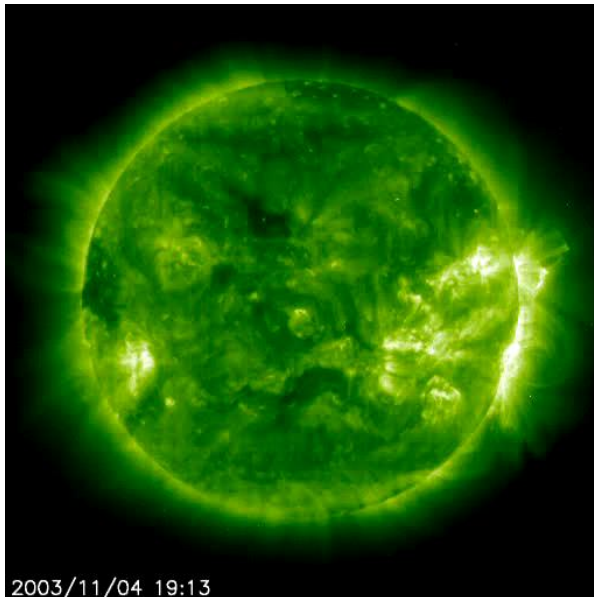
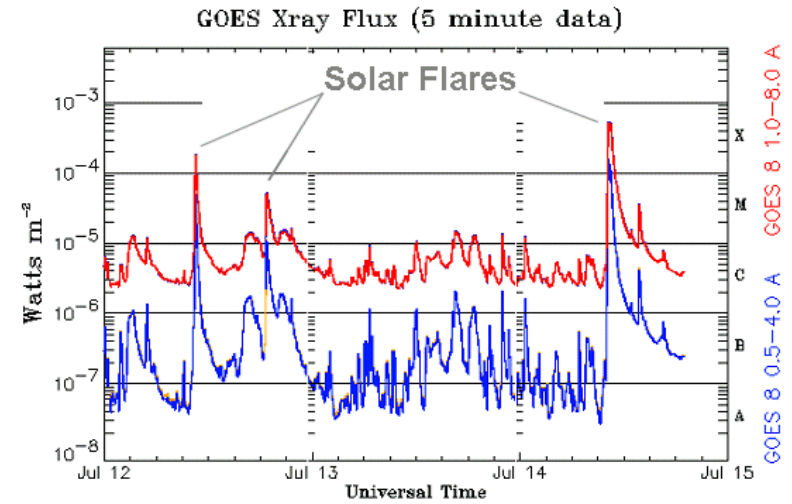
- $S_n = 10 \cdot g + f$
 - met g het aantal groepen, en f het aantal vlekken
 - Bepaald door SIDC in Ukkel!
 - <http://www.sidc.be/silso/>
- Zonnecyclus
 - +/- 11 jaar
 - Stijg-/daaltijd: +/- 4/7 jaar
 - Maximum: 184 (+/- 59)
 - Ook in andere parameters
 - Complexe zonnevlekken oorzaak van zonne-uitbarstingen



SILSO graphics (<http://sidc.be/silso/>) Royal Observatory of Belgium 2016 July 1

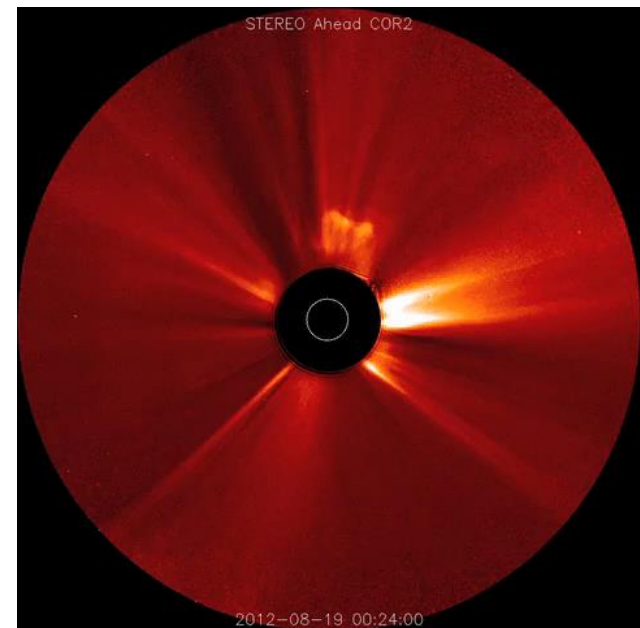
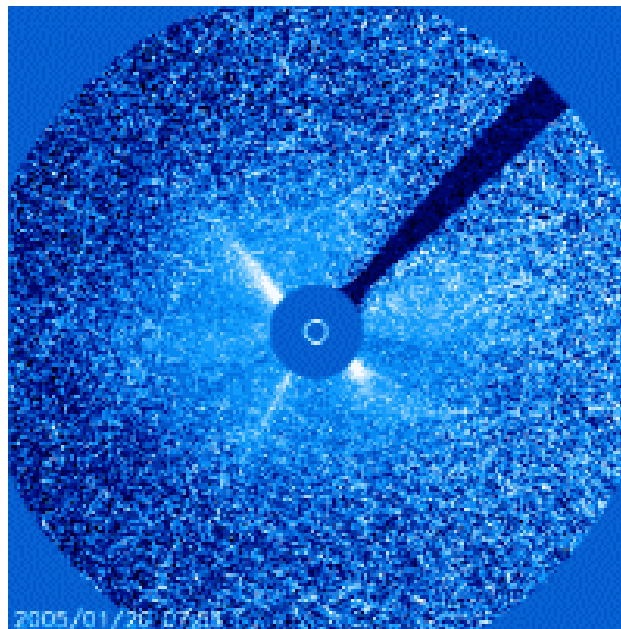


Zonneuitbarstingen (straling)

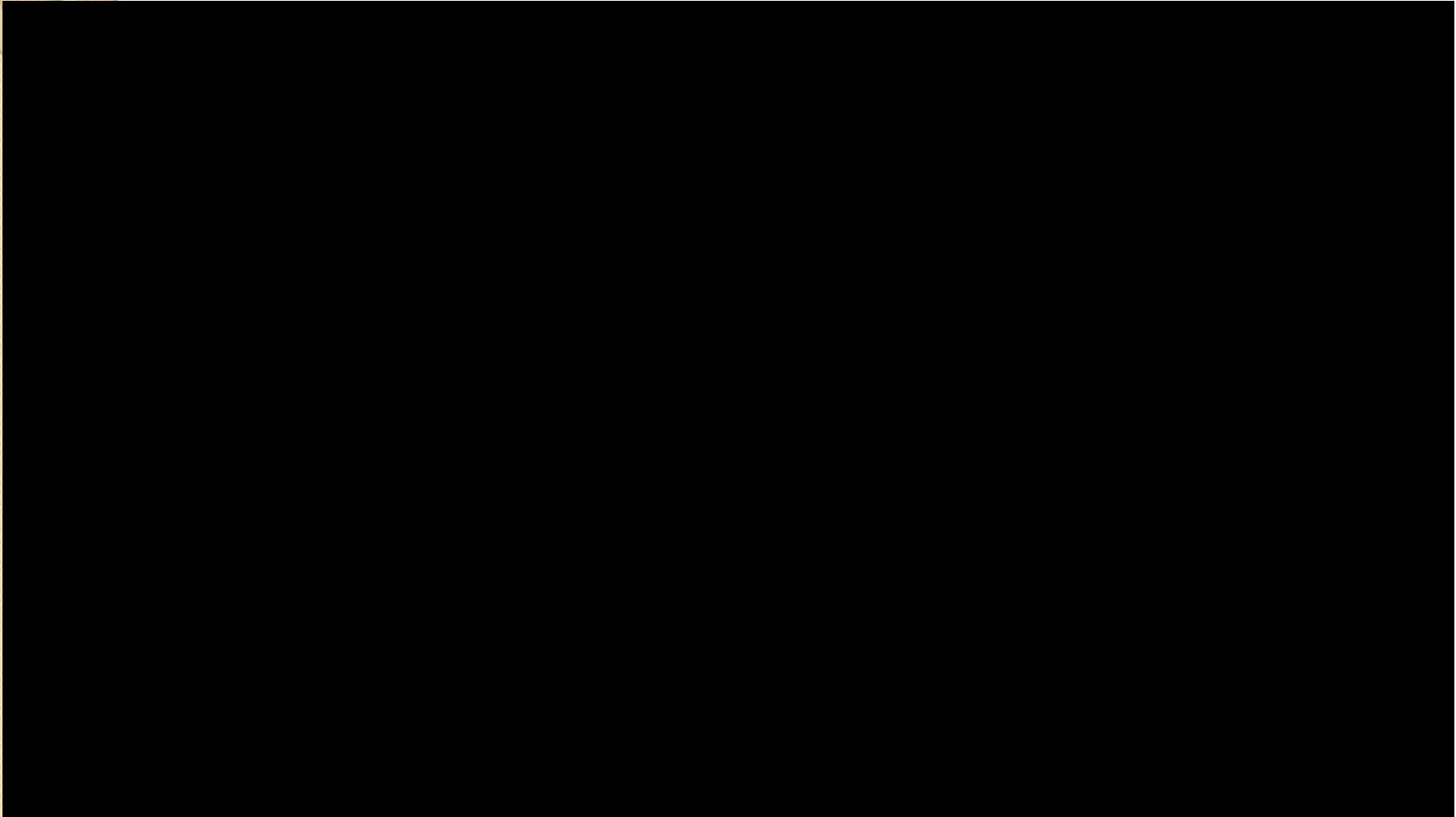


Zonnewitbarstingen (deeltjes)

- Protonstormen
 - Energierijke deeltjes
 - Snel
 - 15-120 minuten
 - Magnetisch veld Aarde
- Coronale Massa Ejecties
 - « CME »
 - Trager
 - 40-75 uur
 - Magnetisch veld Aarde

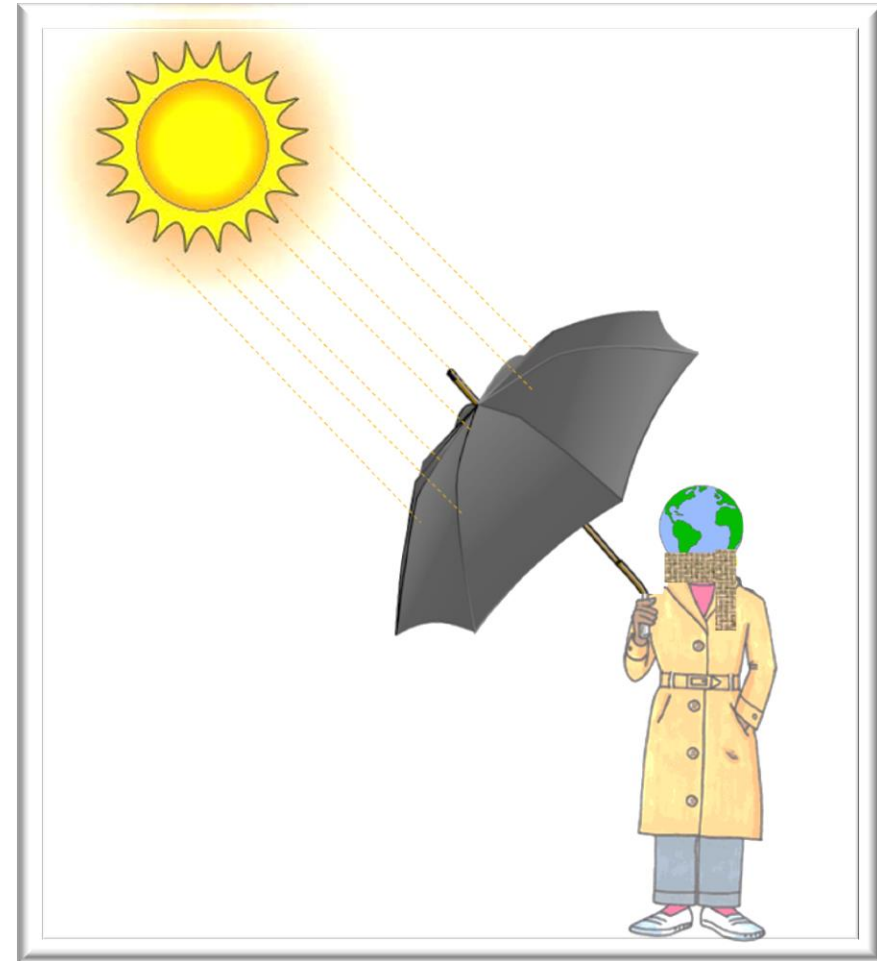


Van de Zon naar de Aarde...



Het Ruimteweer (SW)

- ...alle omstandigheden op de zon en in de zonnewind, magnetosfeer, ionosfeer en thermosfeer die de prestaties en de betrouwbaarheid van technologische systemen in de ruimte en op grond kunnen beïnvloeden en die een gevaar kunnen betekenen voor het menselijk leven of de gezondheid.



Dit doen we beter goed...

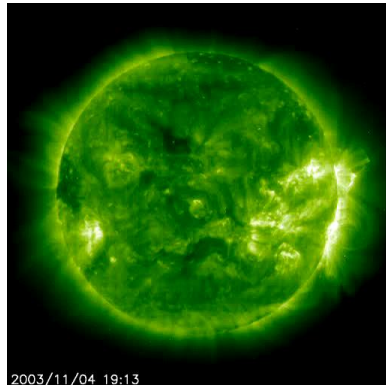


Zonne-uitbarstingen

Reconnectie

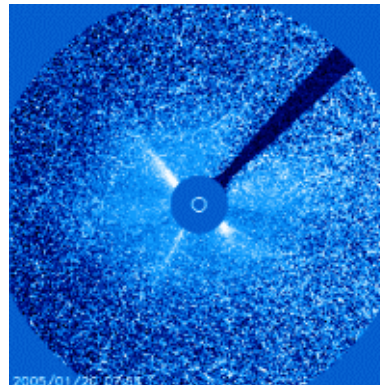
Straling

Zonnevlammen

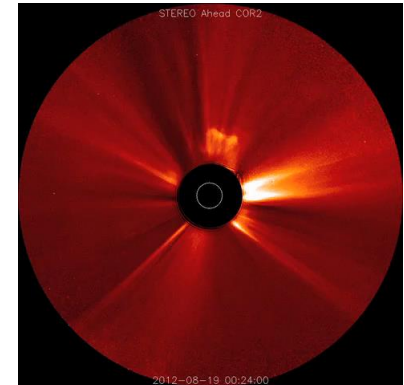


Deeltjes

Protonstormen



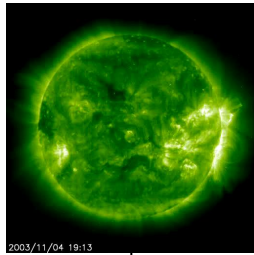
Coronale Massa Ejecties



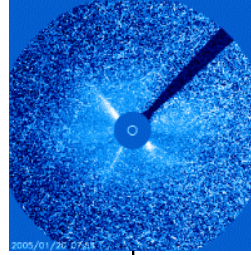
Effecten van verstoord ruimteweer

Oorzaak

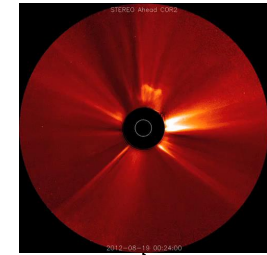
Zonnevlammen



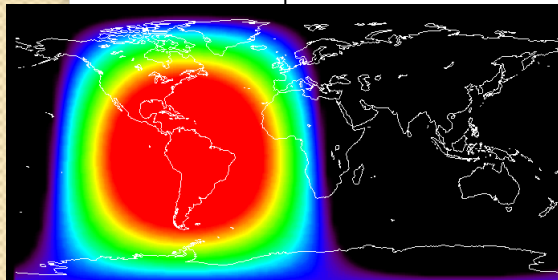
Protonstormen



Coronale Massa Ejecties

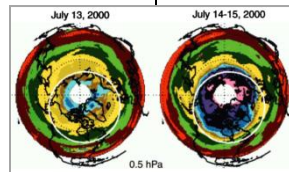


Gevolgen



Strong X-ray flux
 Product Valid At : 2015-03-11 16:22 UTC

Normal Proton Background
 NOAA/SWPC Boulder, CO USA



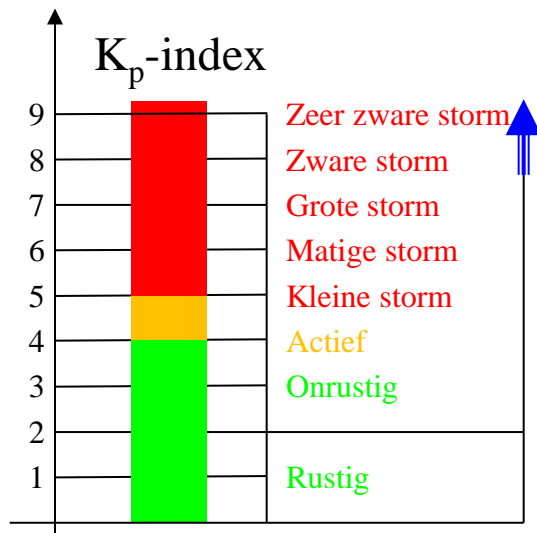
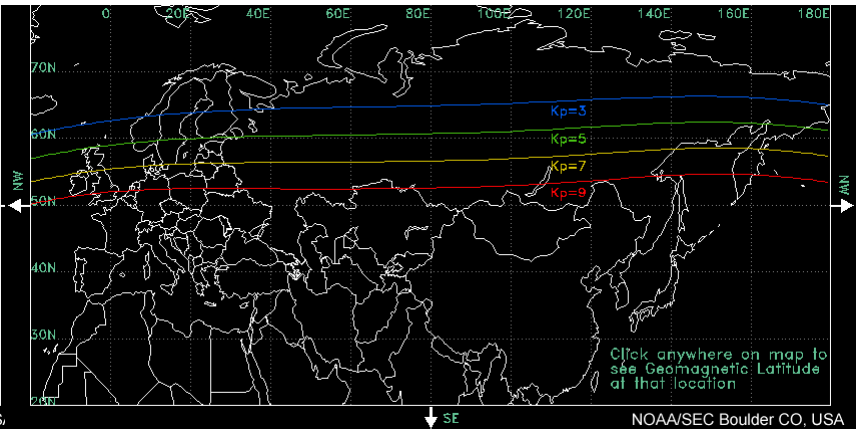
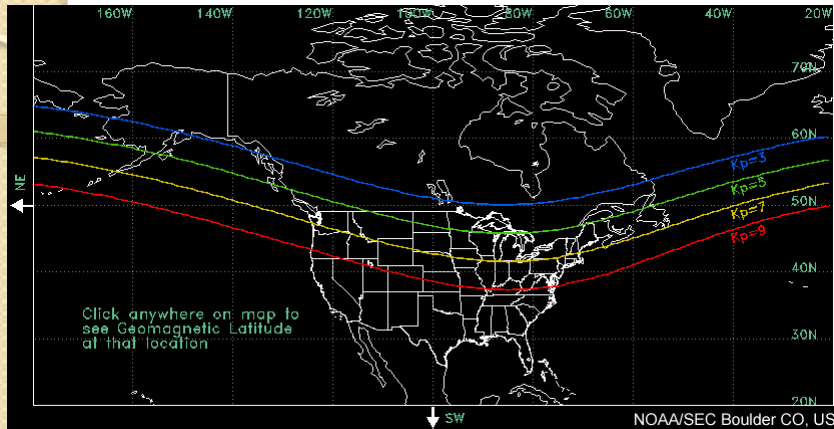
Geomagnetische stormen

- Poollicht
 - Als energetische deeltjes langs de veldlijnen van het geomagnetische veld bewegen en botsen met deeltjes uit de atmosfeer
 - Zuidwaarts gericht
 - Substormen
 - Zowel noord- als zuidpool
 - Noordelijk, middernacht
 - Kleuren
 - In België: 5-tal keer per SC



Poollicht in België

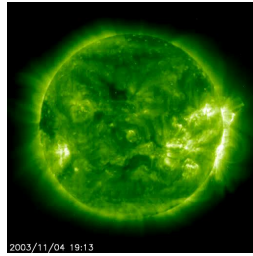
Voorwaarde: $K_p > 8$; Fotografisch: $K_p \geq 6$



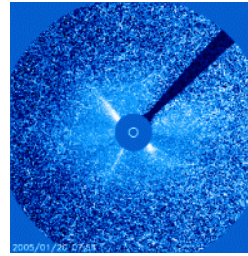
Franky Dubois 27 Februari 2014 (K_p=6)
http://www.youtube.com/watch?v=_cw-tys0Ax8

Ruimteweer : NOAA schalen

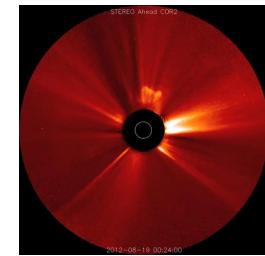
Zonnevlammen



Protonstormen



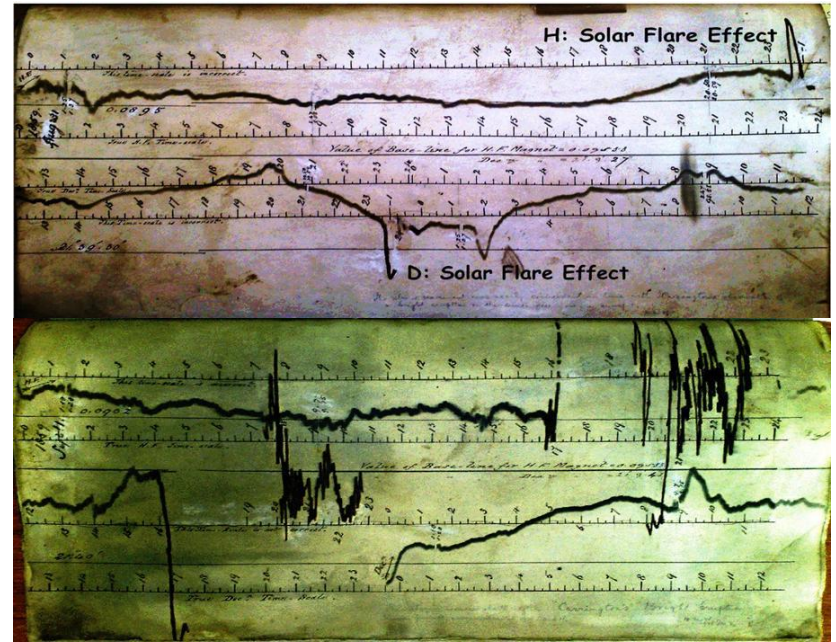
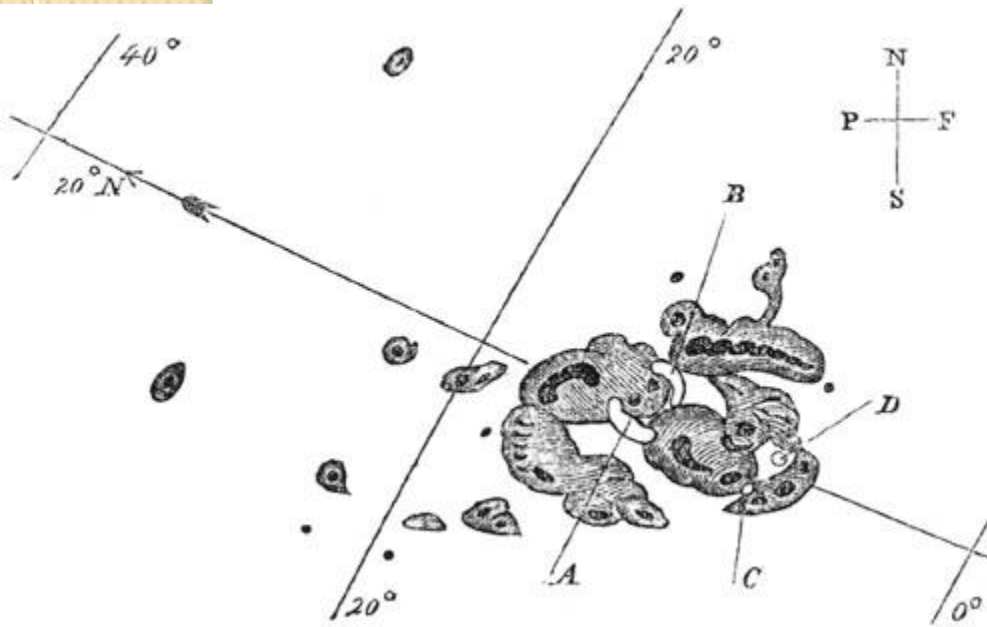
Coronale Massa Ejecties



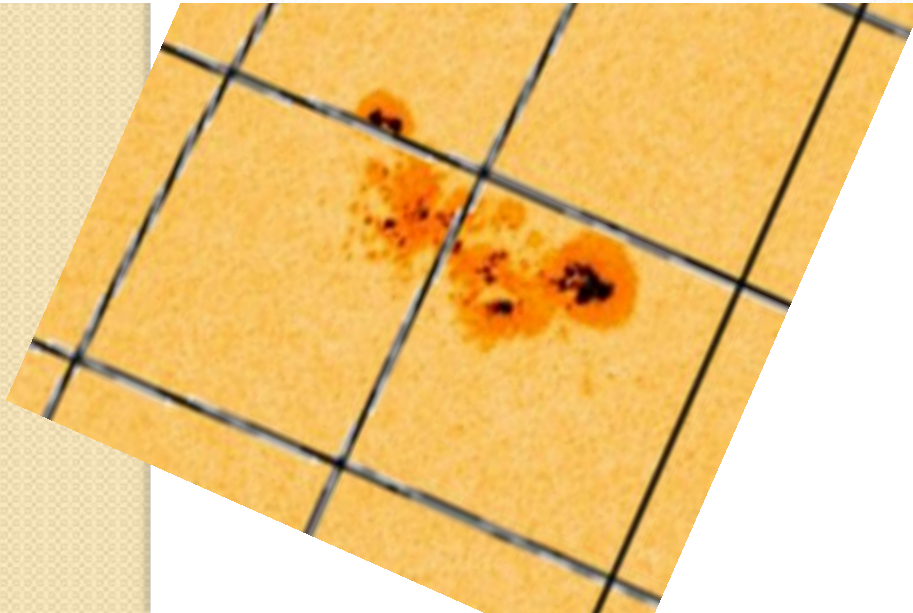
Niveau	Radio blackouts			Protonstormen			Geomagnetische stormen		
	Schaal	X-ray	Effect	Schaal	Pfu*	Effect	Schaal	Kp	Effect
Extreem	R5	X20	HF radio ; Navigatie (GPS, radar,...)	S5	100000	Biologisch; satelliet operaties; HF radio (polen); Navigatie	G5	9	Elektricitetsnetwerken; satelliet operaties; Pijpleidingen; HF & LF comms.; aurora
Zwaar	R4	X10		S4	10000		G4	8	
Groot	R3	X1		S3	1000		G3	7	
Matig	R2	M5		S2	100		G2	6	
Klein	R1	M1		S1	10		G1	5	

Pfu*: Particle flux unit: aantal deeltjes met een energie ≥ 10 MeV

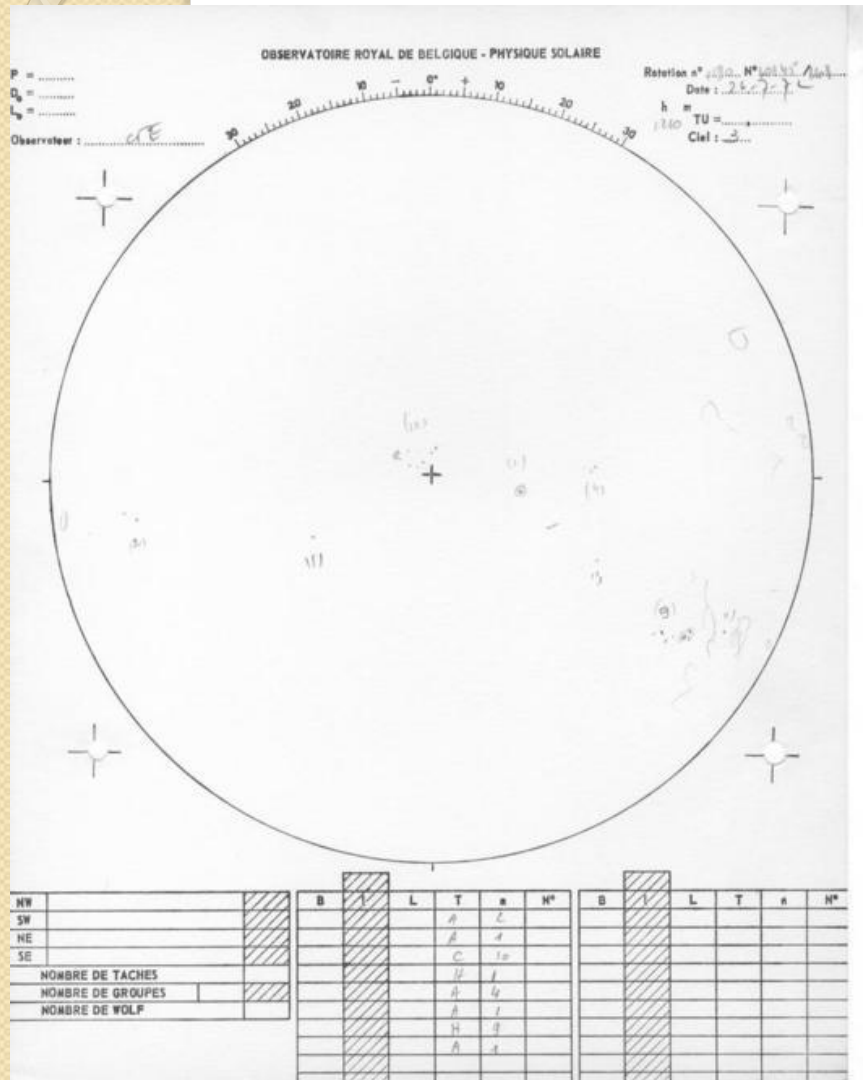
1 September 1859: Carrington event



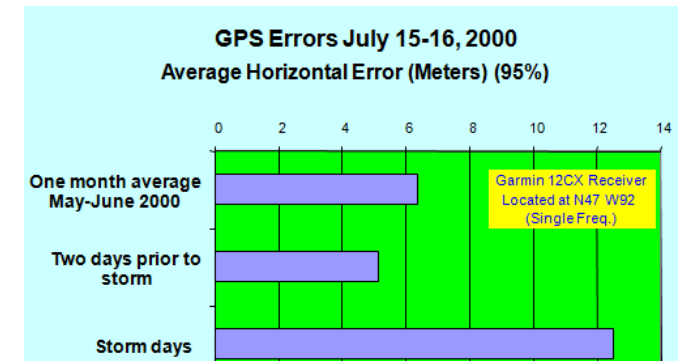
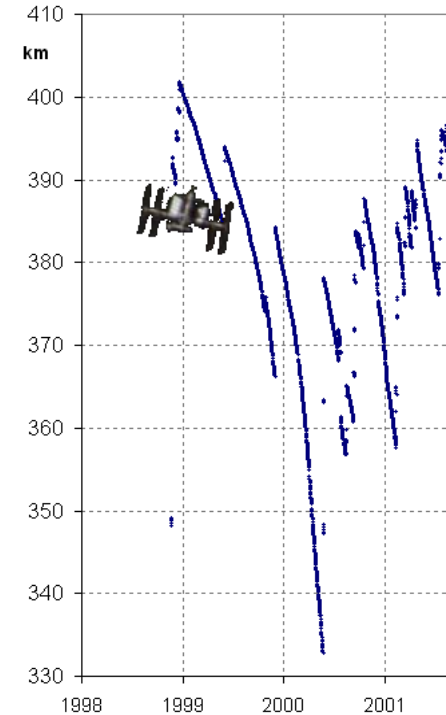
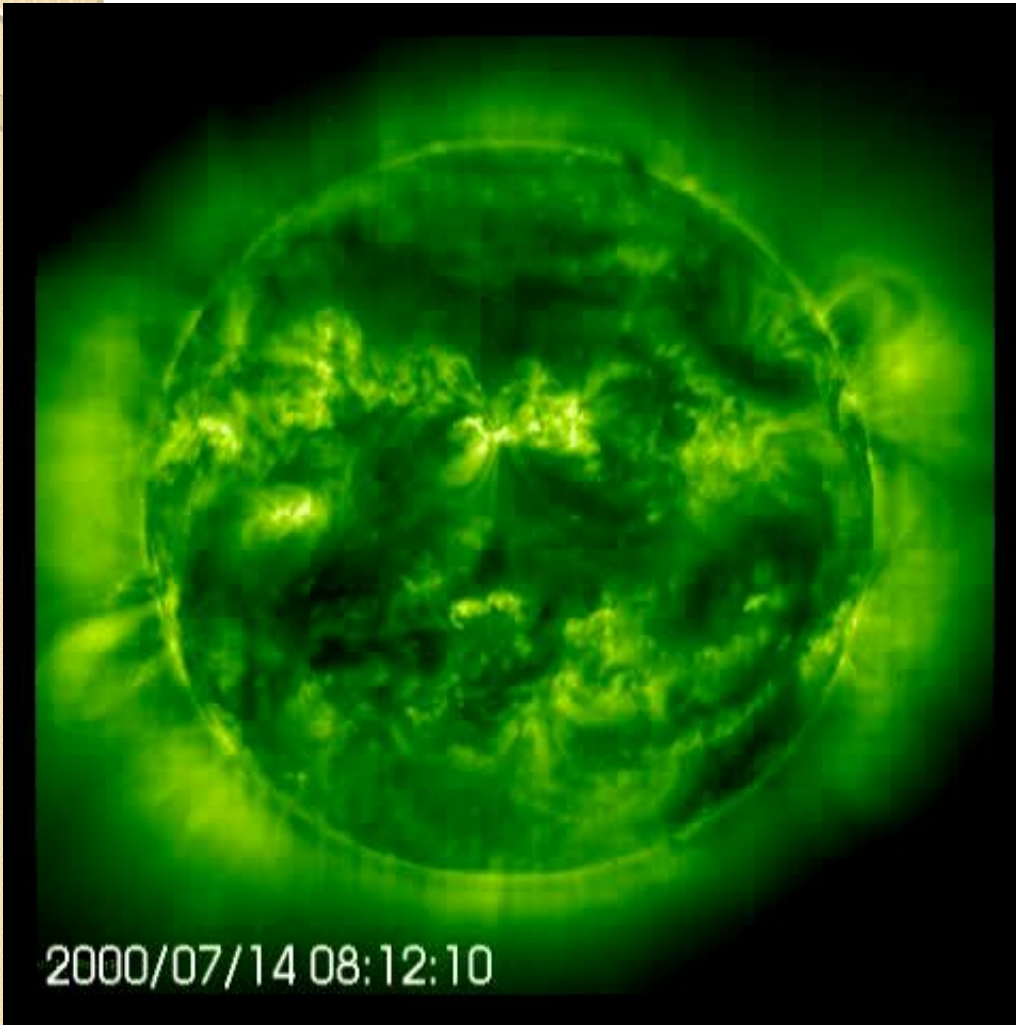
<http://www.geomag.bgs.ac.uk/education/carrington.html>



4 Augustus 1972



14 Juli 2000: Bastille Day Event



28 Oktober 2003: Halloween event



Het SIDC / RWC

Het team ruimteweervoorspellers



Het SIDC / RWC

Het team ruimteweervoorspellers

- Team van 6-8 voorspellers
 - Wetenschappers
 - In cumul
 - Experts
 - Wekelijkse tour of duty
 - 7/7, 14/24
 - Back-up van geautomatiseerde diensten
 - IT ondersteund
 - Previweb
 - Interface
 - Web pagina
 - Mail service
 - Maandelijkse SWOP mtg



The screenshot shows the SIDC website interface. At the top, it says "SIDC - Solar Influences Data Analysis Center" with a navigation bar for "Flares: Eruptive", "Geomagnetism: Quiet", "Protons: Quiet", and "Predicted". A sidebar on the left lists various sections like "Home", "General info", "Jobs and Students", "Projects", "Publications", "Software", "Educational", "Local Solar Observations", "Space Weather services", "Real Time Data", and "Seminars". The main content area features a "Welcome to the Solar Influences Data Analysis Center (SIDC)" message, followed by a news item titled "INFO FROM SIDC - RWC BELGIUM 17 Oct 2012, 0710UT" which reports on solar activity and flare forecasts. Below the news are four panels: "Latest SWAP image" (a solar image), "Latest LYRA curve" (a line graph), "Latest USET H-alpha image" (a solar image), and "Latest Callisto Observations" (a solar image). At the bottom, there is a "Most recent alerts" section with a timestamp "2012 Oct 16 15:19 UTC" and a brief alert description.

Het SIDC/RWC: Previweb

Forecast Weekly Presto Cactus All quiet CME arrival Monthly bulletin Quarterly Links

UTC time: 12:17:21 Date: 2015-11-08 Forecaster: Janssens Jan You are logged in as: janjans [Logout](#)

Catania is up to date. Click [Click here](#) if you want to refresh the regions anyway.

Forecast regions Forecast 10cm flux Forecast K Finish forecast

Day/Hours	0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Prediction local K-index for day 2015-11-08:	1	1	2	2	2	3	4	5
Prediction local K-index for day 2015-11-09:	4	4	5	4	3	4	5	4
Prediction local K-index for day 2015-11-10:	3	4	5	4	3	4	4	3

Geomagnetic forecast: Minor storm expected ($A \geq 30$ or $K=5$)

Quiet to active geomagnetic conditions were recorded in the aftermath of the passage of the coronal mass ejection (CME). Solar wind speed declined slowly from its initial 550 km/s to its current values near 460 km/s. Bz was near zero until about 19:00UT and after 07:00UT, while in between it was fairly positive with a maximum around +11 nT during the 00-02UT interval. It dipped again to -9 nT between 10:00 and 11:00UT.

Further quiet to active geomagnetic conditions are expected, until the arrival of the co-rotating interaction region and high speed stream associated with the northern coronal hole later today or tomorrow, which could produce minor storming episodes.

Extra geomagnetic information:

1:17 PM 11/8/2015

Het SIDC/RWC...

- Voorspelt:
 - Zonne-activiteit
 - X-ray zonnevlammen
 - Per type (C, M, X)
 - Per groep
 - Proton flares
 - 10,7 cm zonneflux
 - 3 dagen
 - Geomagnetische activiteit
 - Lokale K-index (Dourbes)
 - 3 dagen
- Verspreidt:
 - Bulletins
 - Dagelijks (12:30UT)
 - Gratis, vast formaat
 - Wekelijks
 - Bulletin + Webex briefing
 - Alerts & Warnings
 - Event triggered

SIDC - Solar Influences Data Analysis Center

5 Flares: C-class Geomagnetism: Quiet Protons: Quiet

Home
General info
Jobs and Students
Projects
Publications
Sunspots (SILSO)
Software
user guide
Local Solar Observations
Space Weather services
Real Time Data
Seminars

LEGAL NOTICES

ESWW
Classroom
SWSC

Welcome to the Solar Influences Data Analysis Center (SIDC), which is the solar physics research department of the Royal Observatory of Belgium. The SIDC includes the World Data Center for the sunspot index and the ISES Regional Warning Center Brussels for space weather forecasting.

Aug 18, 2015 DB: [The Sunspot Number, the "longest ongoing scientific experiment" revisited](#)

INFO FROM SIDC - RWC BELGIUM 2015 Oct 31 12:30UTC

Solar activity was low. Catania group 62 (NOAA region 2443) has a complex gamma-beta-delta configuration of its magnetic field and produced a number of higher C level flares. The strongest was a C7.8 flare peaking at 20:16UT.

Catania group 62 remains complex and is expected to produce C flaring with also a reasonable chance for an M flare.

A small filament eruption occurred in the southeastern quadrant around 13:58UT as well as a larger one at the southeast limb around 8:00 UT. No Earth directed CME's have been recorded.

Proton levels are further recovering from the October 29 event. A positive polarity equatorial coronal started crossing the central meridian around midnight. It may become geoeffective from November 3 onwards.

Solar wind speed was mainly in the 340-260 km/s but saw some peaks near 400 km/s. Total magnetic field saw a short dip to around 5 nT but was mostly in the 7-10 nT range. Bz was variable and later mostly positive and remained above -5nT. Magnetic field phi angle was mostly in the negative sector,

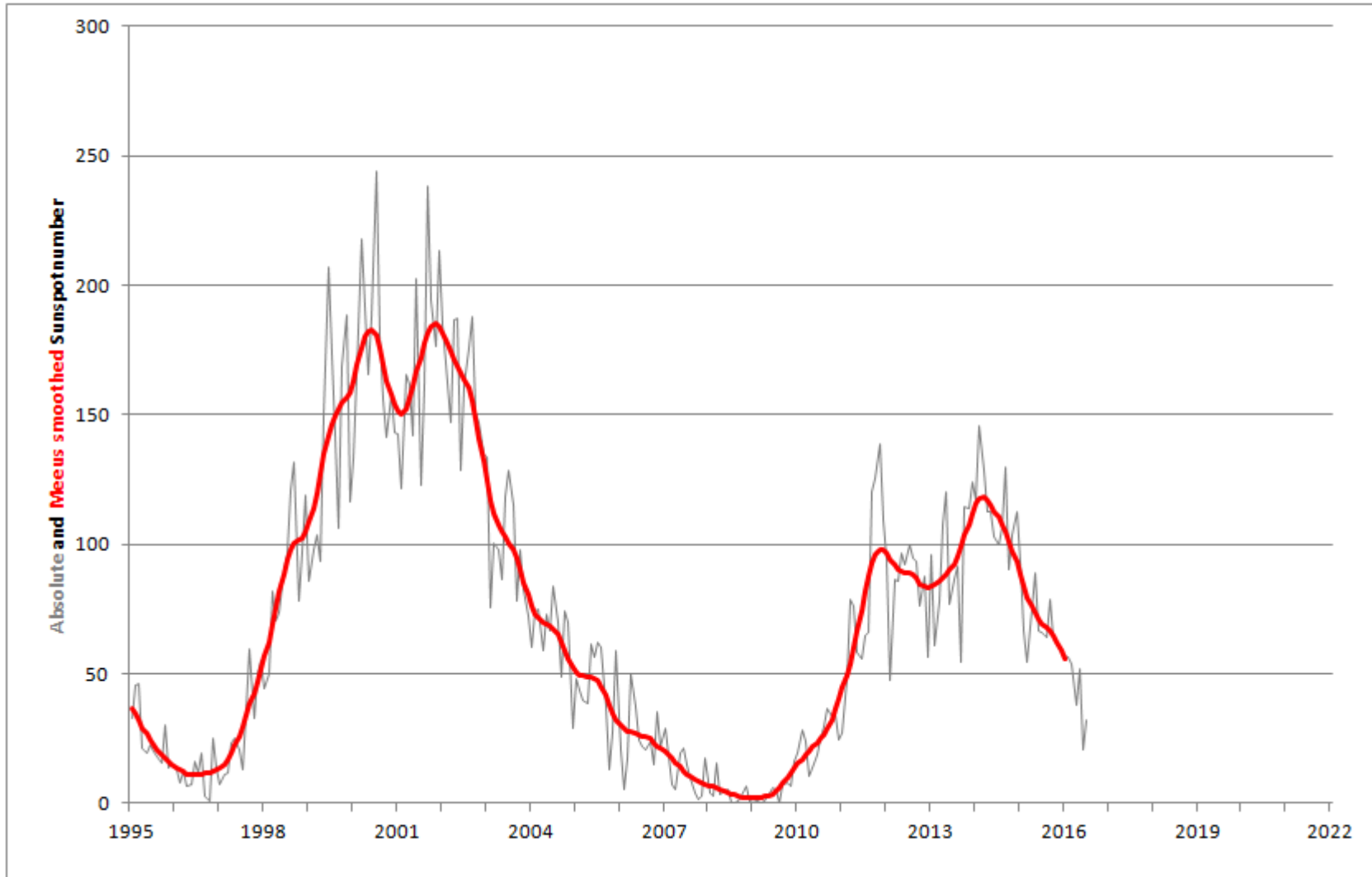
Latest SWAP image
Latest LYRA curve
Latest USET H-alpha image
Latest Callisto Observations
Daily estimated sunspot number

Wekelijkse SW briefing



Uit de TV5 documentaire: "La météo de l'espace: l'émergence d'une nouvelle science"

Zonnecyclus 24 (SC24)

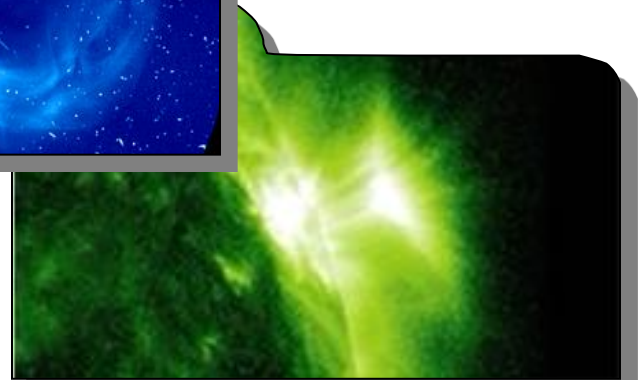
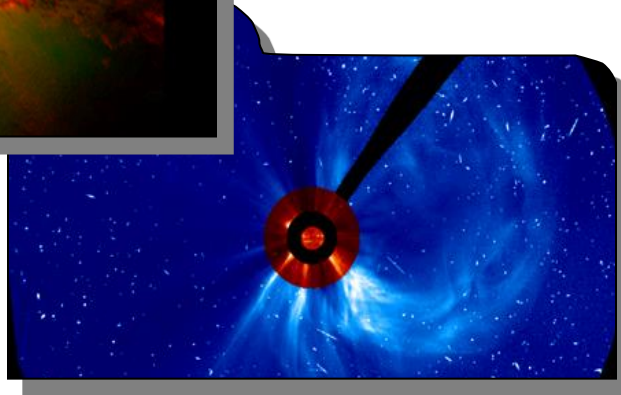
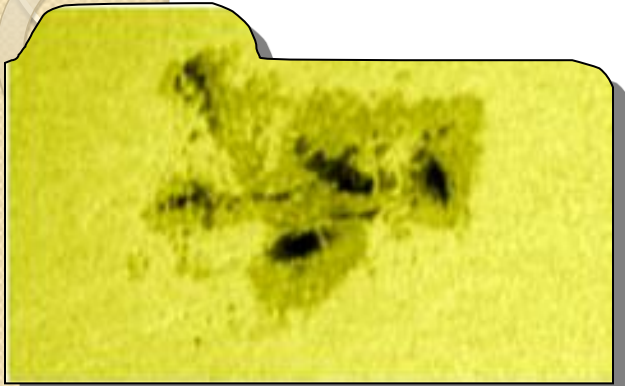


Vergelijking met SC23

(Data SC24 tot April 2016)

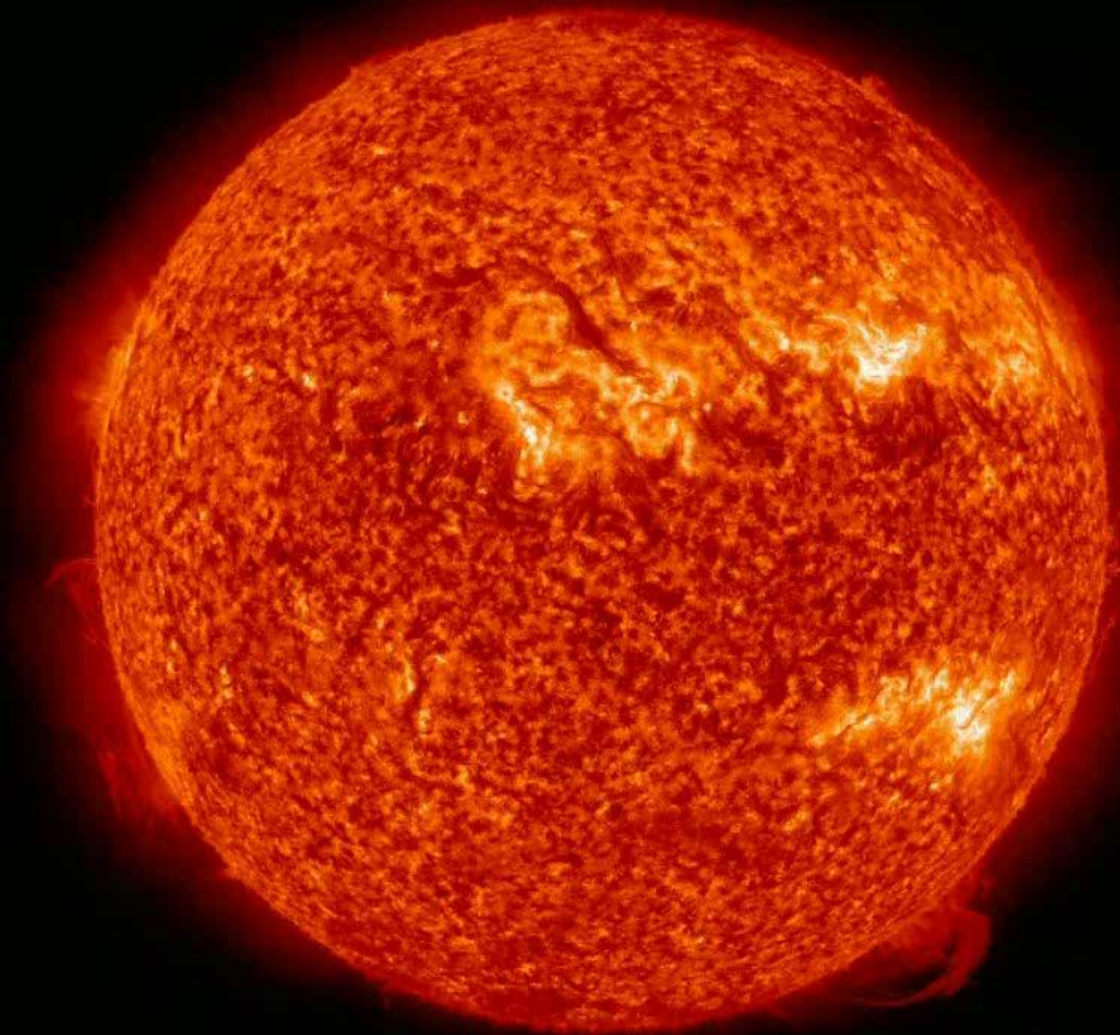
<i>Niveau</i>	Radio blackouts			Protonstormen			Geomagnetische stormen		
	Schaal	SC23	SC24	Schaal	SC23	SC24	Schaal	SC23	SC24
<i>Extreem</i>	R5	2	0	S5	0	0	G5	3	0
<i>Zwaar</i>	R4	4	0	S4	6	0	G4	40	7
<i>Groot</i>	R3	120	45	S3	11	5	G3	78	15
<i>Matig</i>	R2	150	72	S2	26	8	G2	189	63
<i>Klein</i>	R1	1292	606	S1	49	26	G1	487	165

De grote zonnestormen van SC24



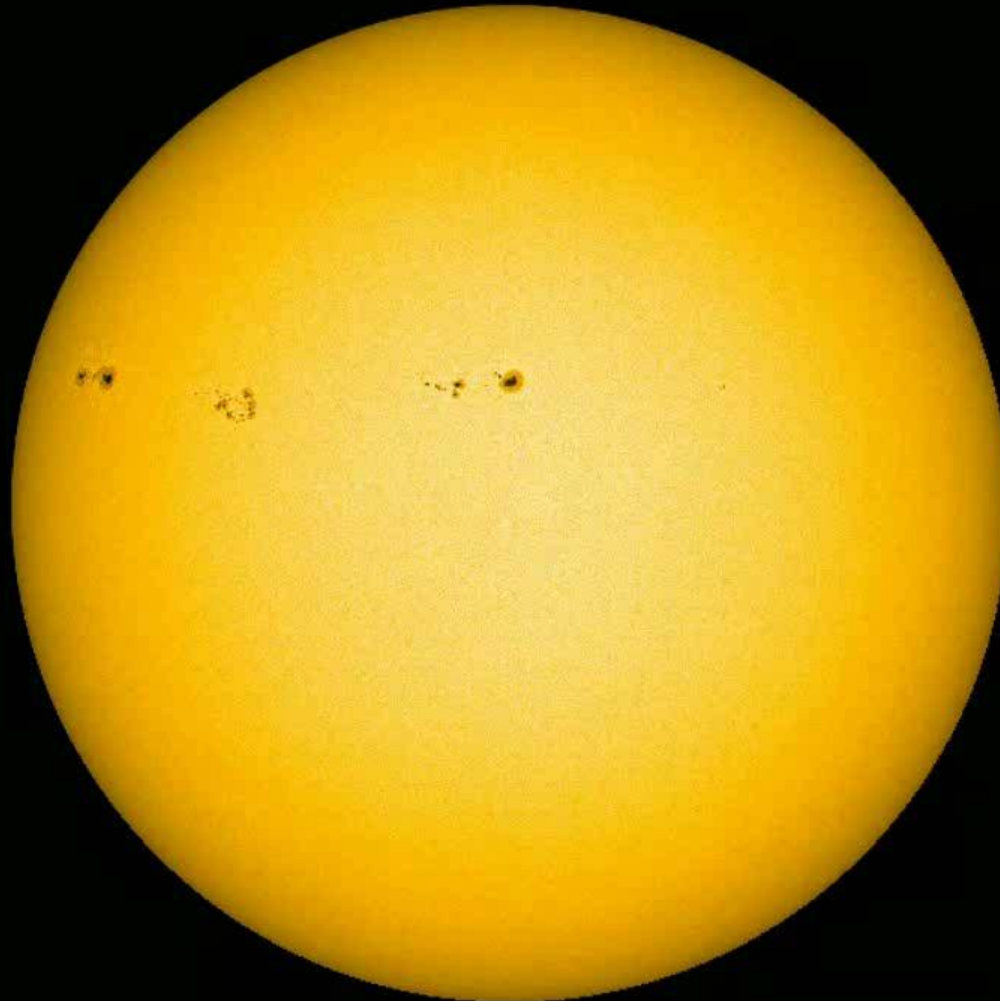
7 Juni 2011

NOAA 1226 filament eruption



3-4 Augustus 2011

Dubbele eruptie in NOAA 1261





5-6 Augustus 2011:Aurora

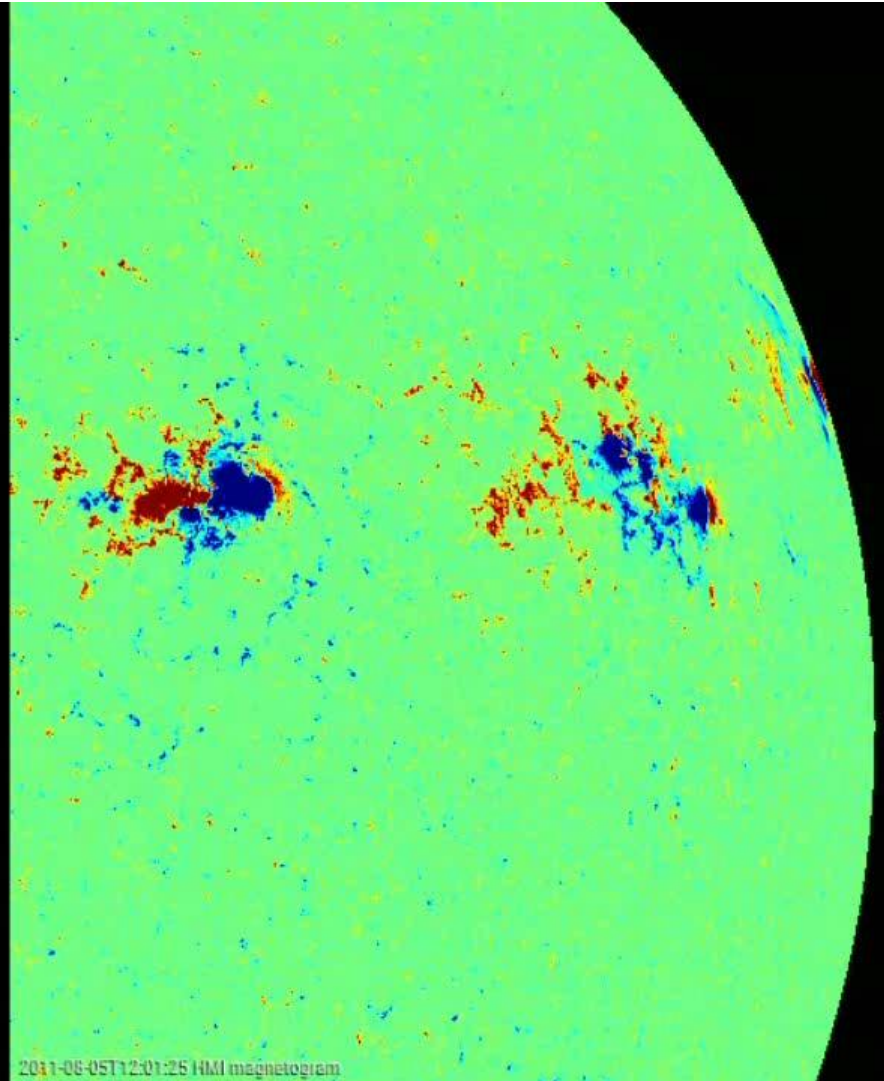


5-6 Augustus 2011:Aurora



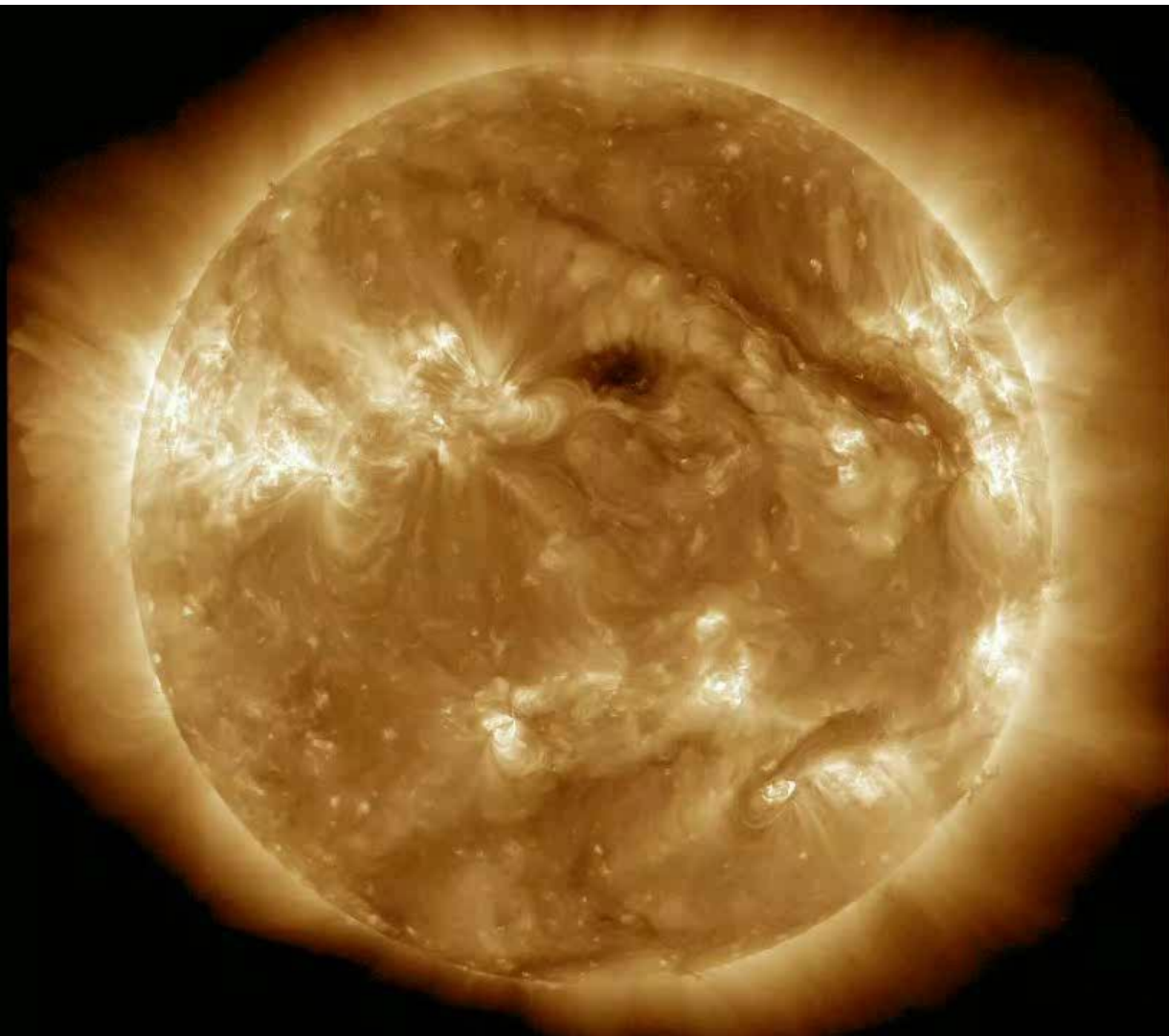
9 Augustus 2011

X6.9 flare in NOAA 1263



SWx effects!

21-22 Oktober 2011



SWx effects!

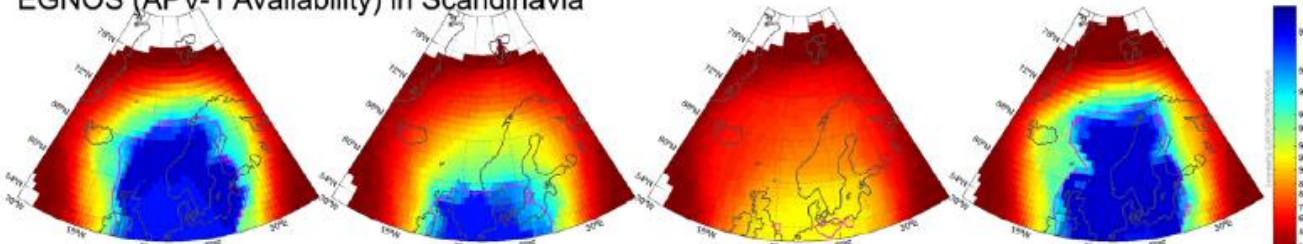
24-25 Oktober 2011

APV gereduceerd/onbeschikbaar (EGNOS/WAAS)

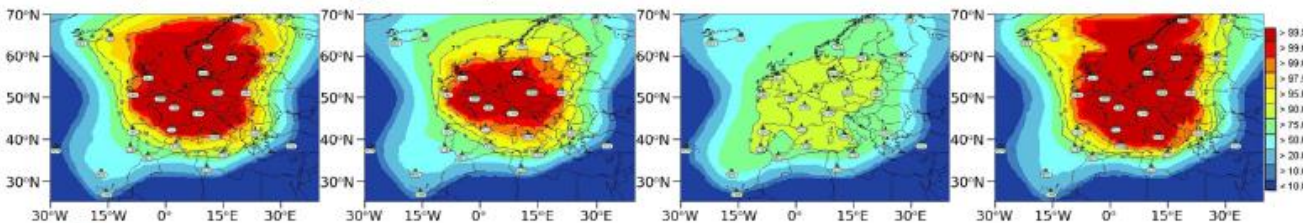
23 October 24 October 25 October 26 October

Geomagnetic storm

EGNOS (APV-1 Availability) in Scandinavia



EGNOS (APV-1 Availability) in Europe



ESSP
ECLAYR v5.2.3
Produced by ESSP SAS



Airport Legend GIVE Legend

LPV 200	$\leq 10 = 3.6m$
LPV	= 11 = 4.5m
LP	= 12 = 6m
LVNAV	= 13 = 15m
RNP 0.1	= 14 = 45m
ER/NPA	= 15 = NM
Not Monitored	= - = DNU

SWx effects!

24-25 Oktober 2011

Bloedrode aurora



SWx effects!

24-25 Oktober 2011

Bloedrode aurora

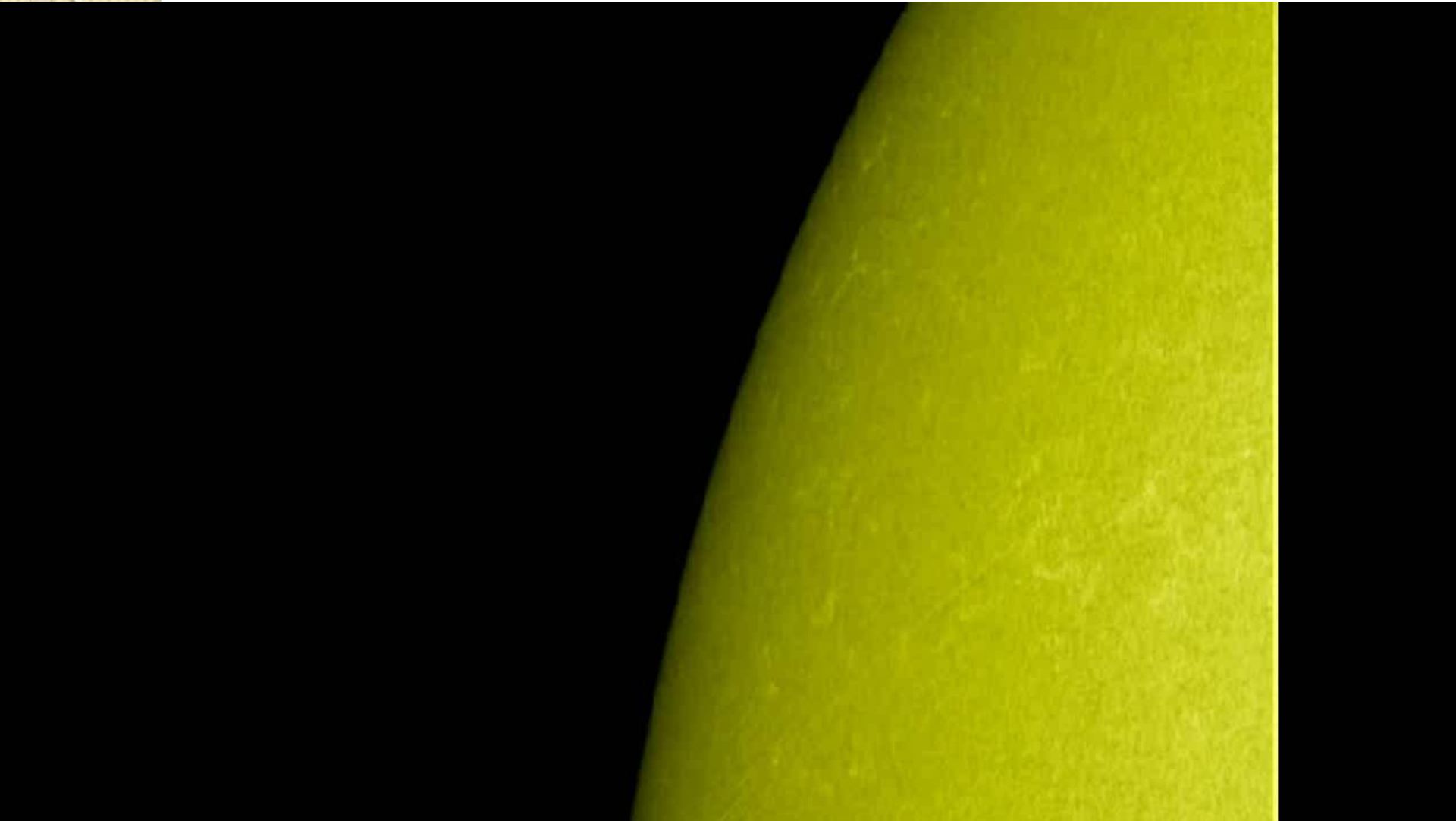
SevereStudies.com
TempestGallery.com
Stephen Locke



SWx effects!

Maart 2012

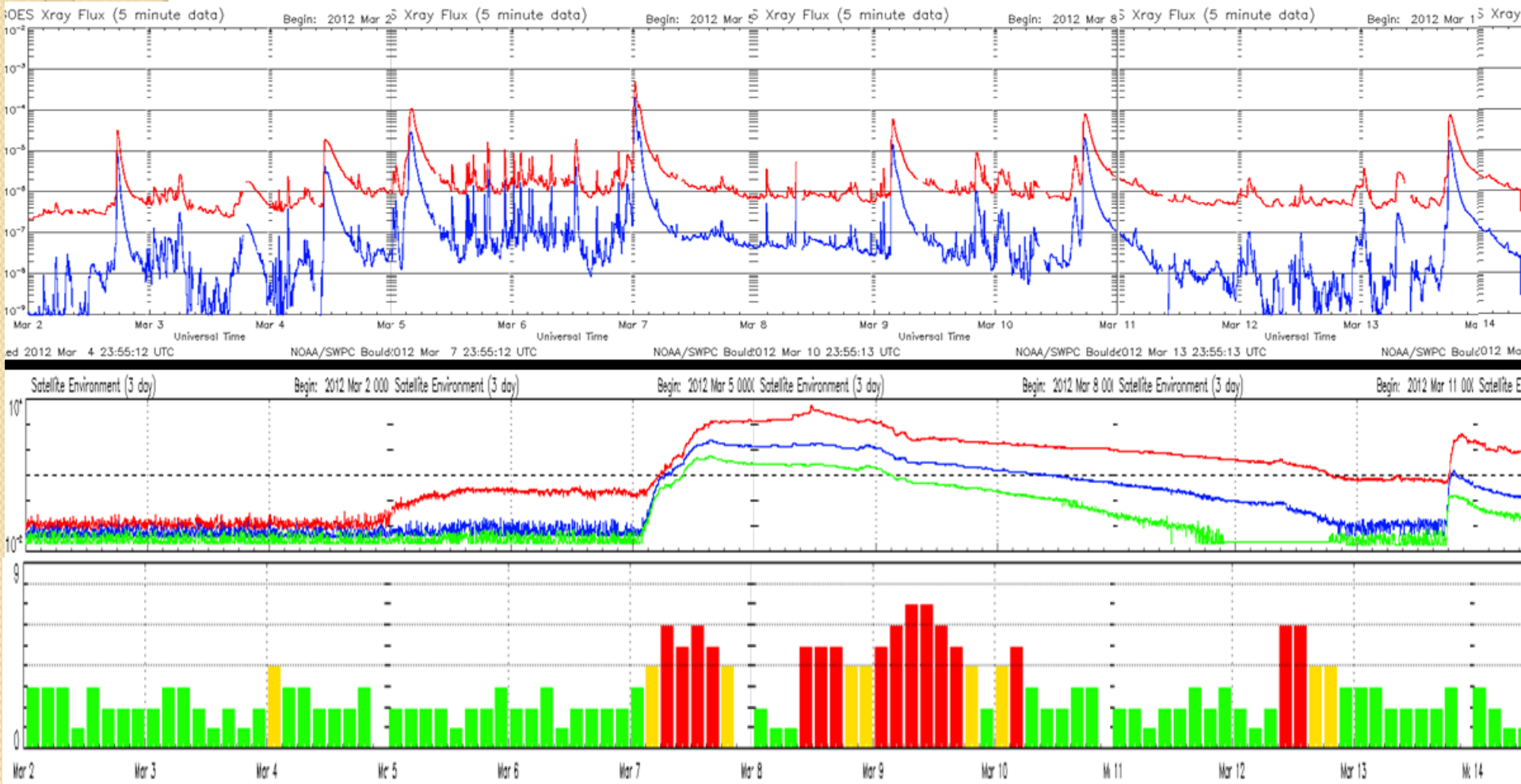
NOAA / 429



Maart 2012

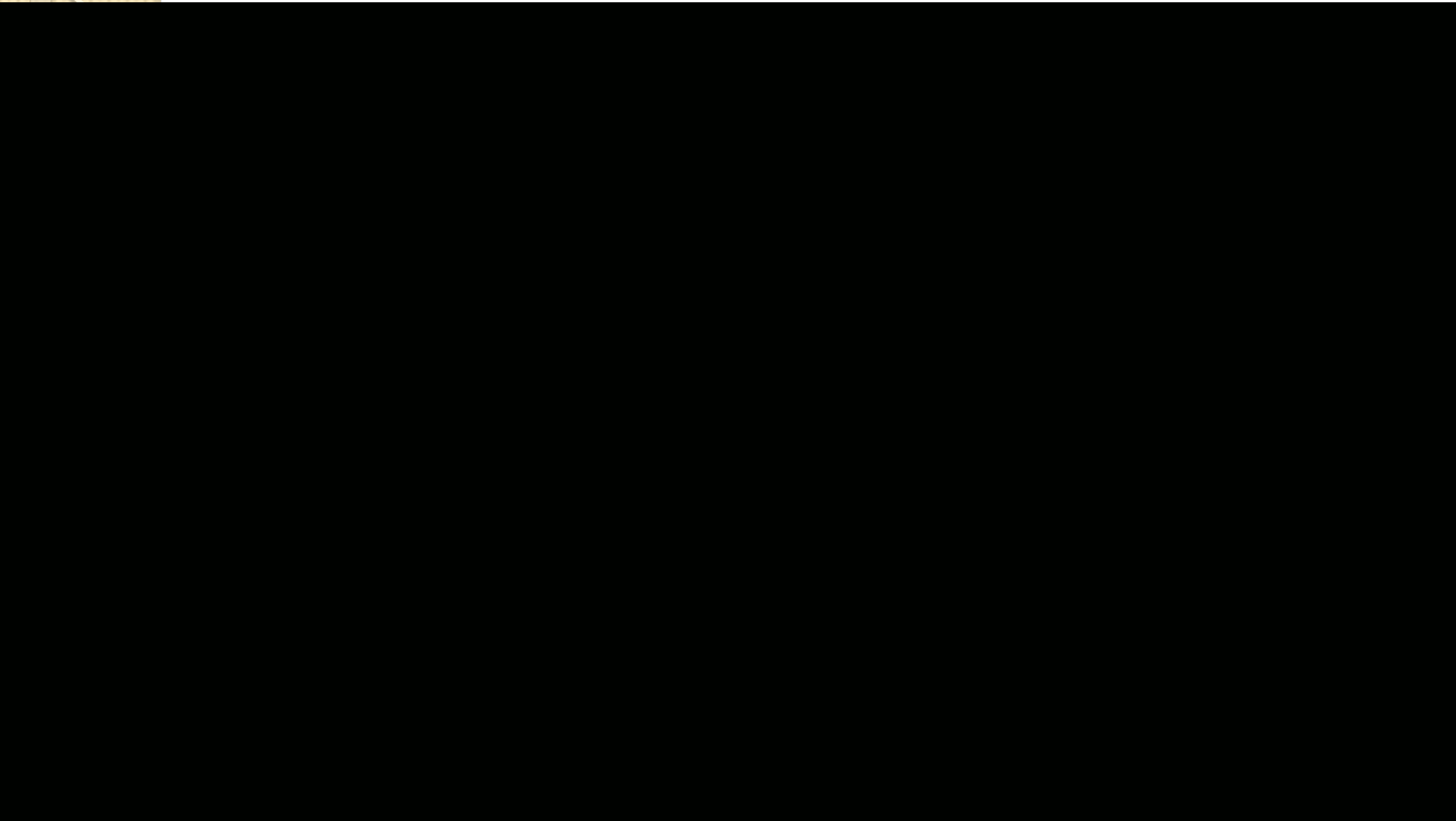
NOAA/429

SWx effects!





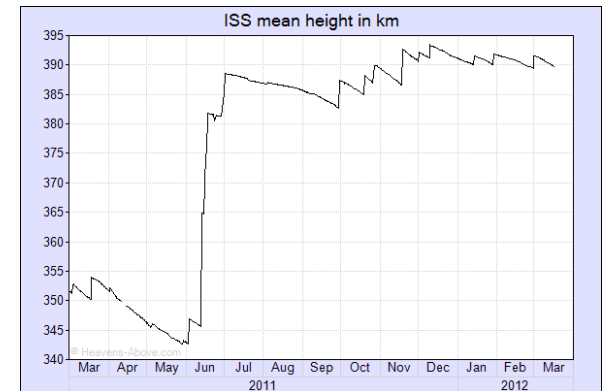
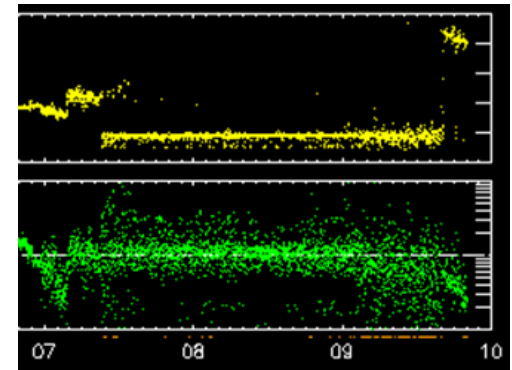
9 Maart 2012: Aurora



NOAA 1429

Ruimteweer & andere geomagnetische effecten

- Zonnevlammen (R3)
 - Slechts kortstondige radio black-outs
- Protonstormen (S3)
 - Omlegging poolvluchten
 - Niet straling, maar communicatie
 - Astronauten veilig
 - Satelliet-instrumenten tijdelijk down
 - ACE, Venus Express
- Geomagnetische stormen (G3)
 - Poollicht niet spectaculair
 - Niet in België
 - Geen invloed op GPS, ISS,...

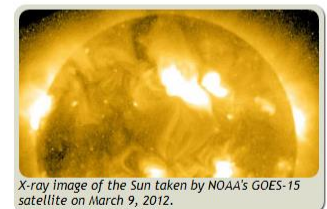


Solar Storm Leaves GPS Service Intact

The solar storm that occurred in early March 2012 disrupted satellite communications and forced airlines to reroute some flights.

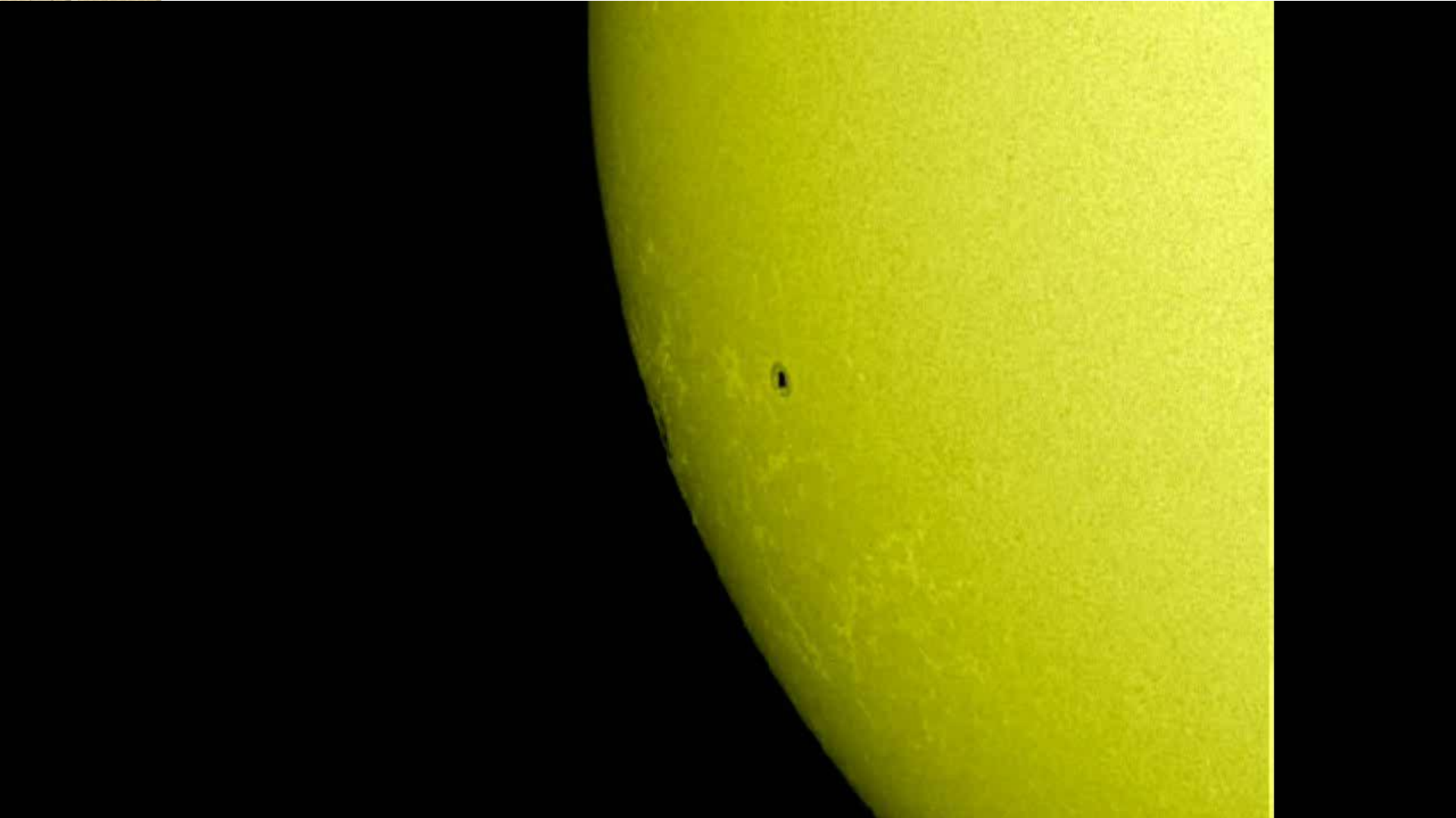
But so far, no major GPS problems have been reported as a result of the event.

The U.S. network of Continuously Operating Reference Stations (CORS), which monitors GPS daily from over 1,800 locations, observed only slight changes to GPS reception in some parts of Alaska on March 7 and 9. [LEARN MORE ABOUT CORS...](#)



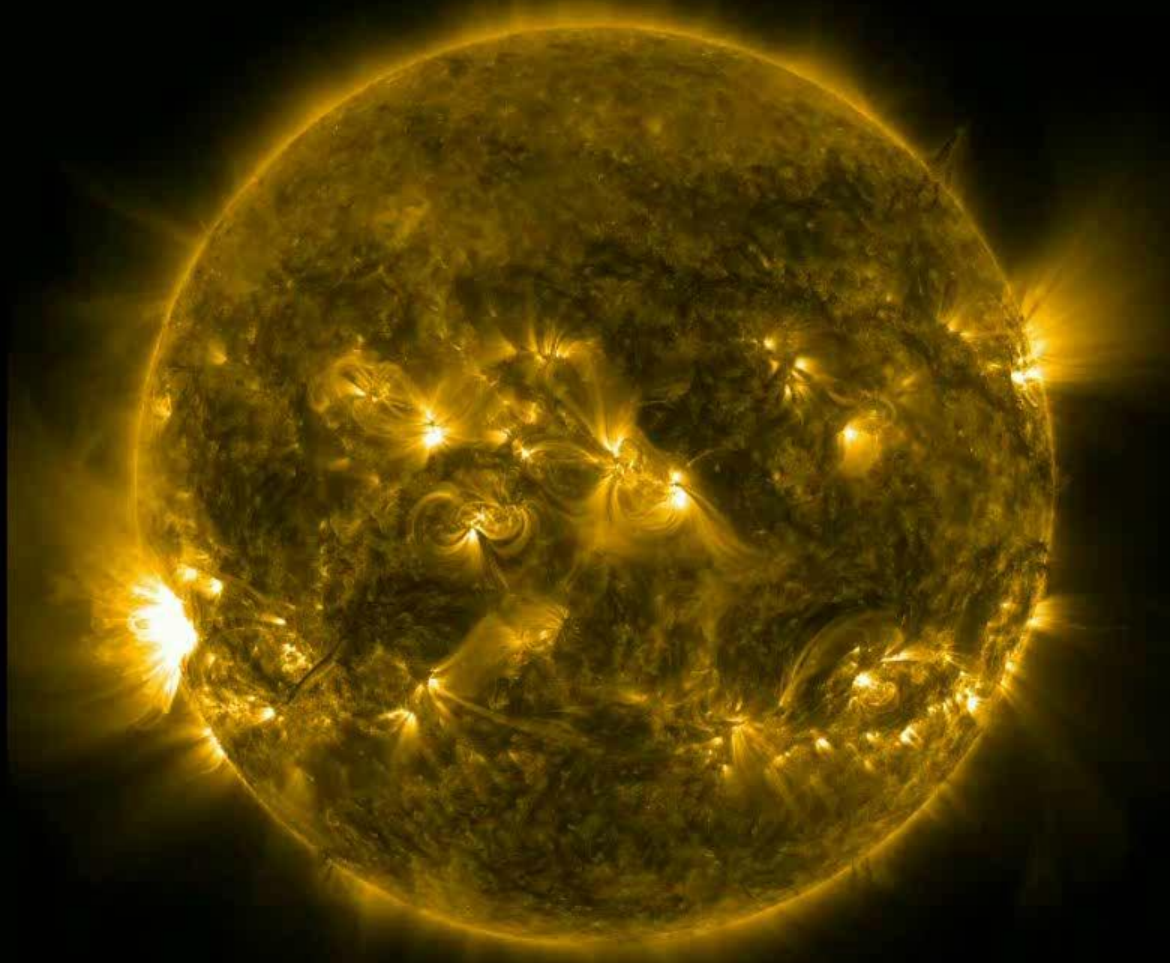
X-ray image of the Sun taken by NOAA's GOES-15 satellite on March 9, 2012.

19 & 23 Juli 2012
NOAA/520



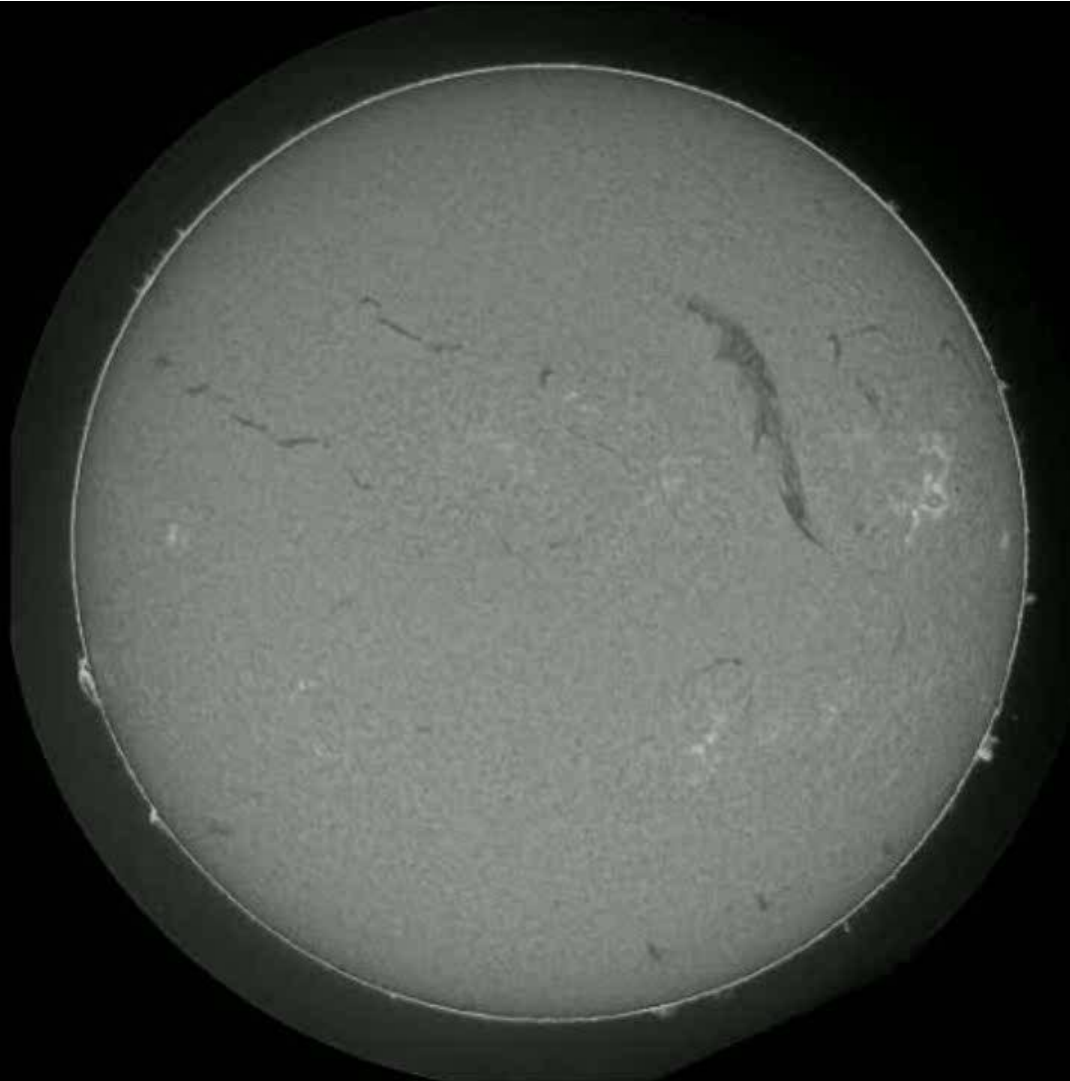
31 Augustus 2012

Filament uitbarsting



29 September 2013

Filament uitbarsting

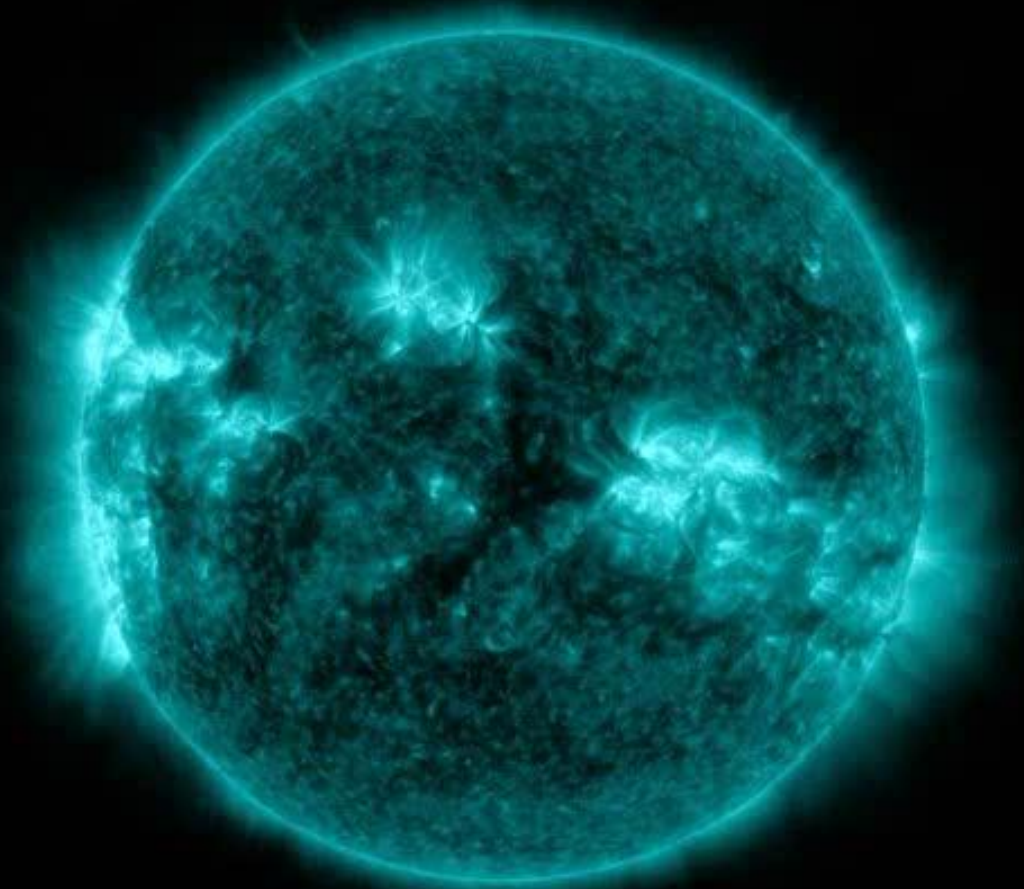


2 Oktober 2013:Aurora



25 Februari 2014

X4.9 in NOAA 1990





25 Februari 2014

Gerelateerde CME

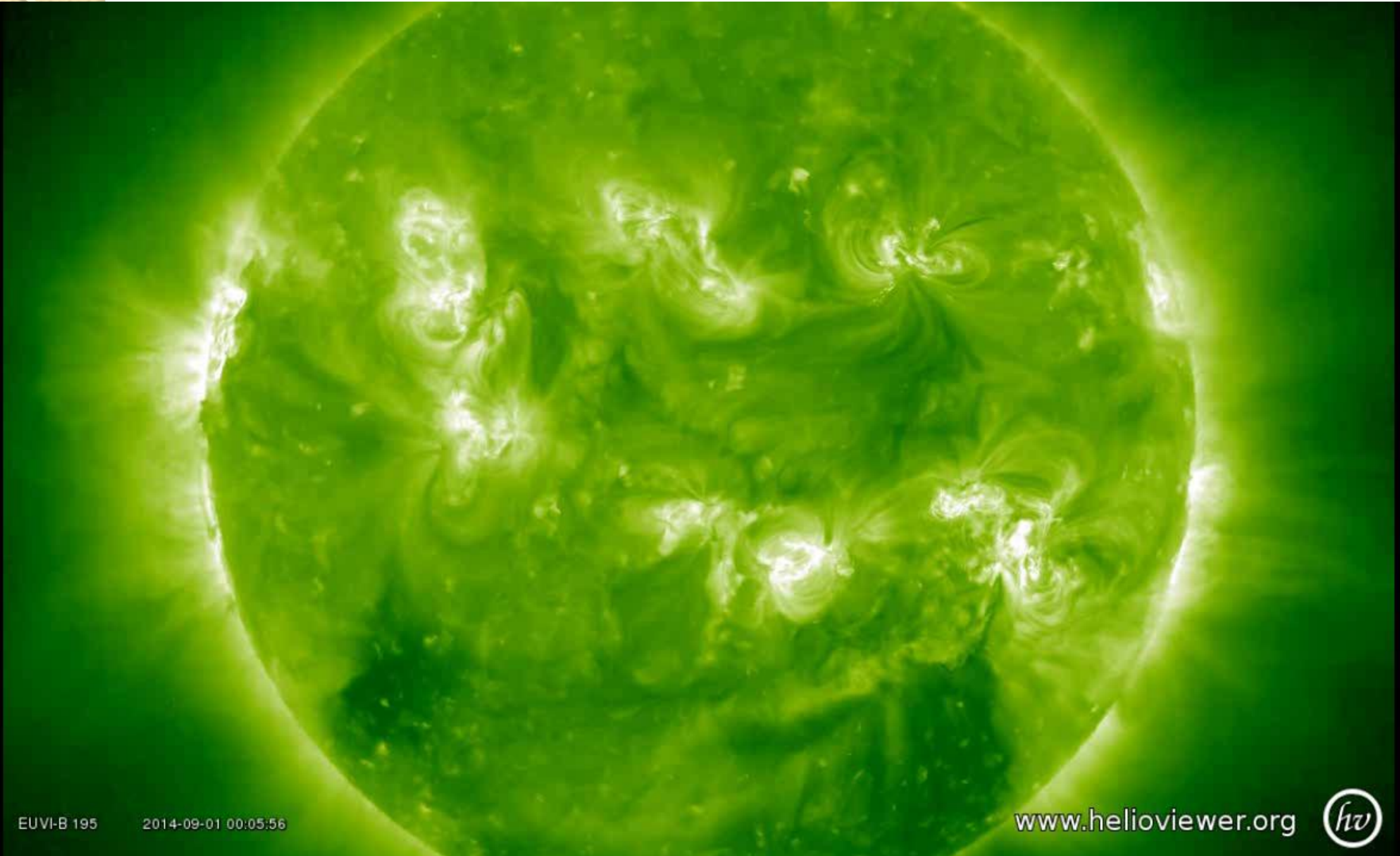


27 Februari 2014:Aurora

SWx effects!

01 & 10 September 2014

Stevige zonnevlammen in NOAA 2158



SWx effects!

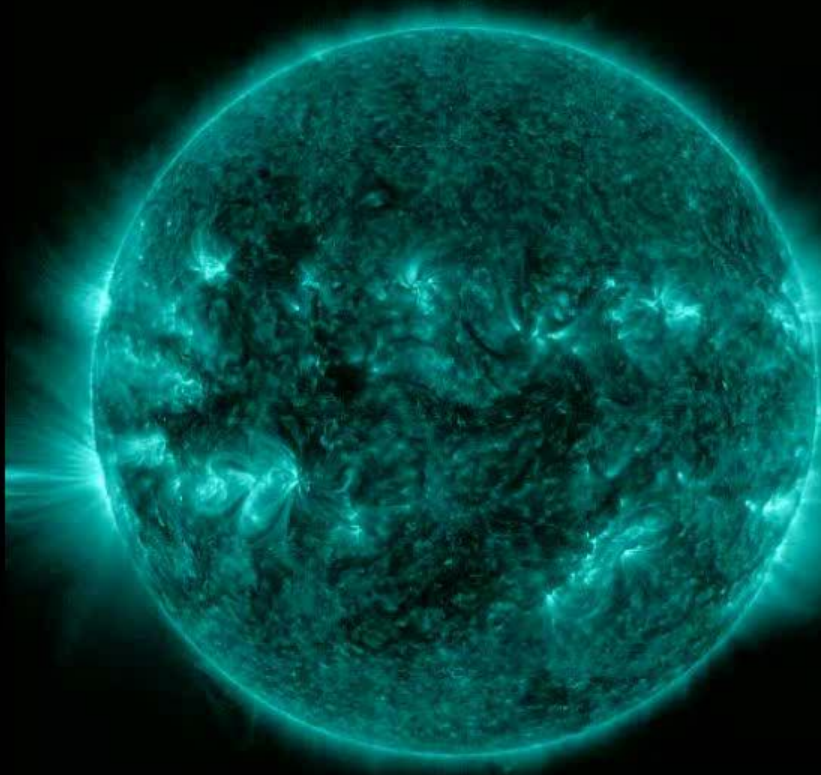
11-12 September 2014: Aurora



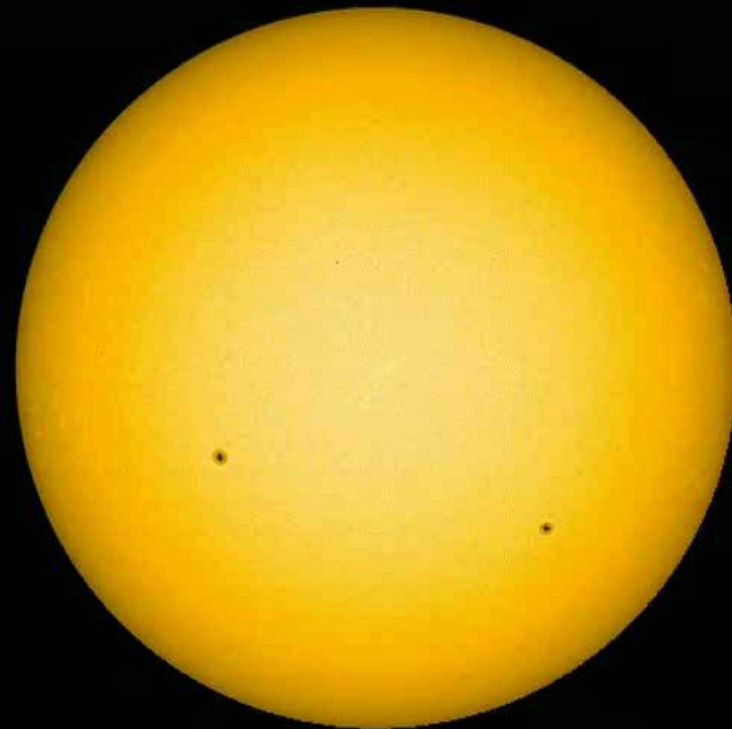
Presents

16-30 Oktober 2014

NOAA 2192 en 6 X-klasse zonnevlammen



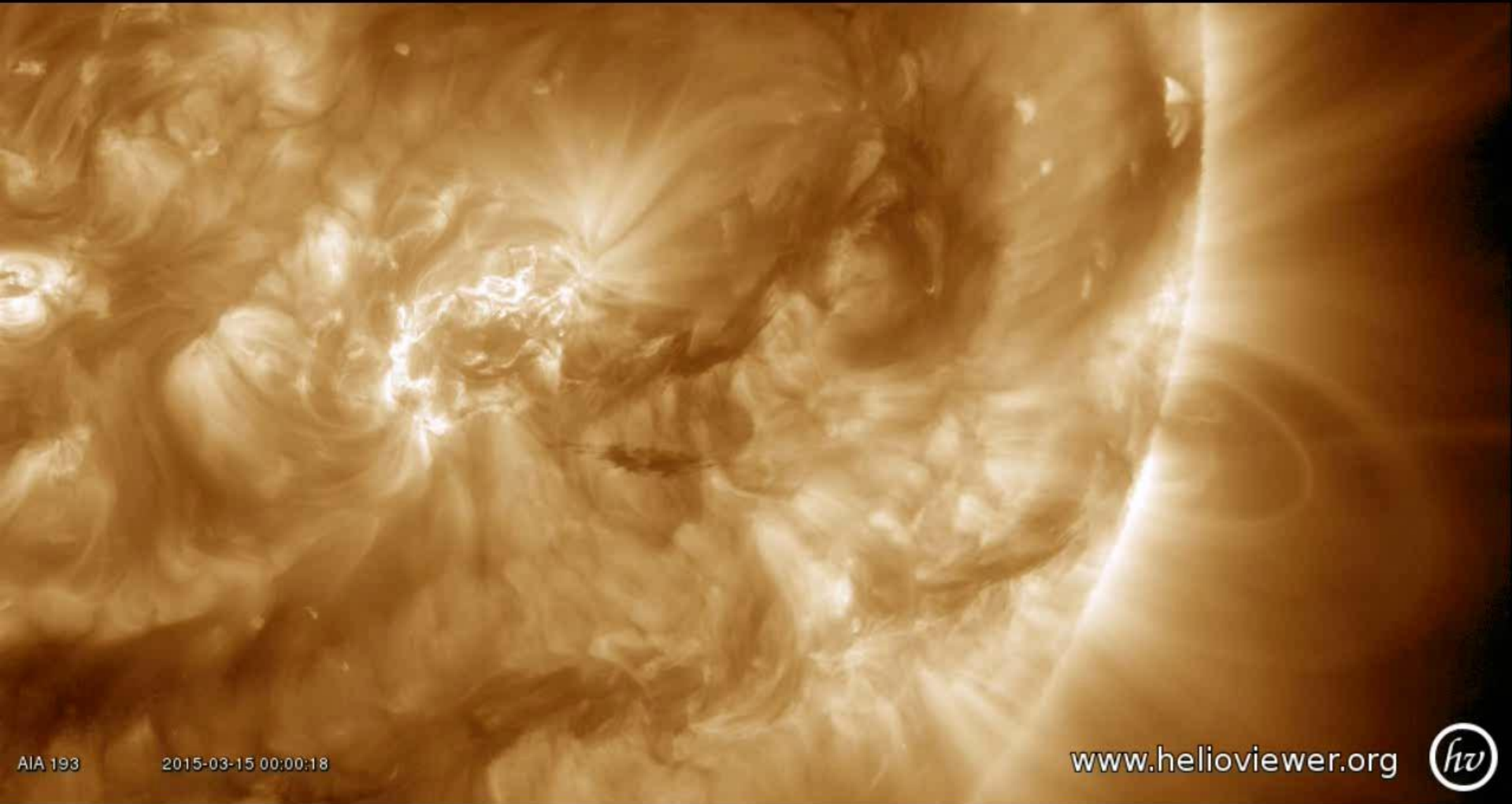
2014-10-16T00:00:20 AIA 131



2014-10-16T00:00:31 HMI continuum

15 Maart 2015

Filament uitbarsting (C9, LDE) in NOAA 2297

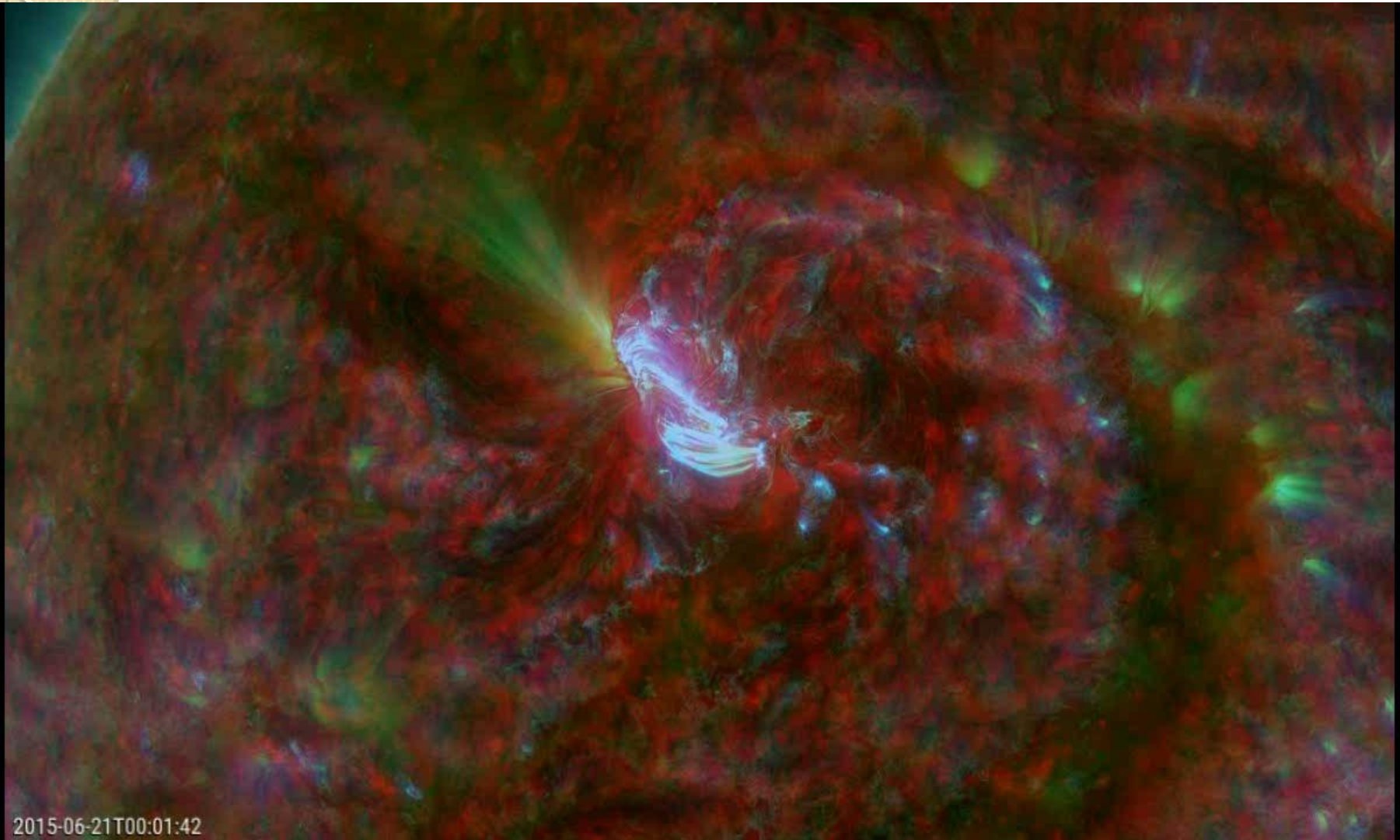




17 Maart 2015 (*St-Patrick's day*)
Zwaarste geomagnetische storm van SC24

21-25 Juni 2015

M-klasse uitbarstingen in NOAA 2371



22-23 Juni 2015

Solstice storm

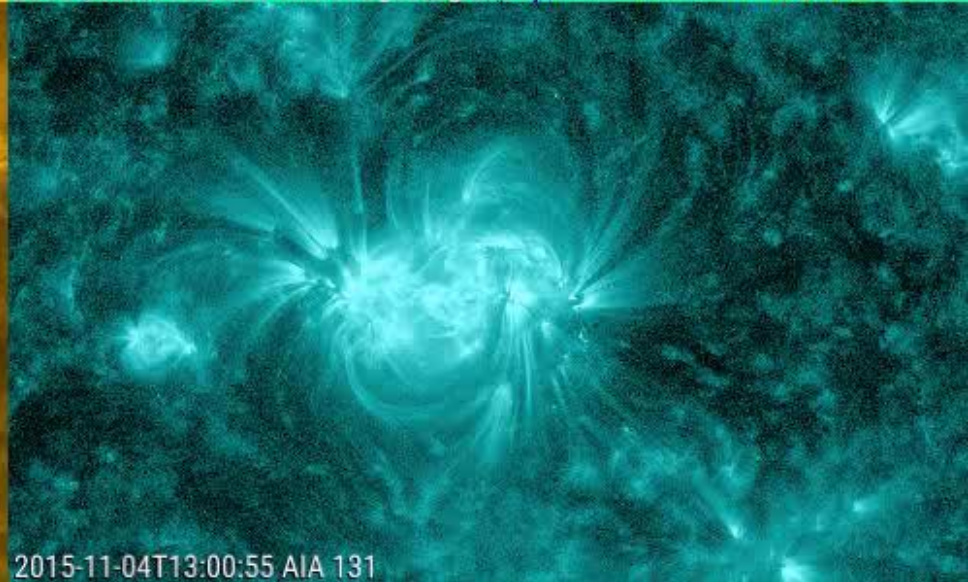
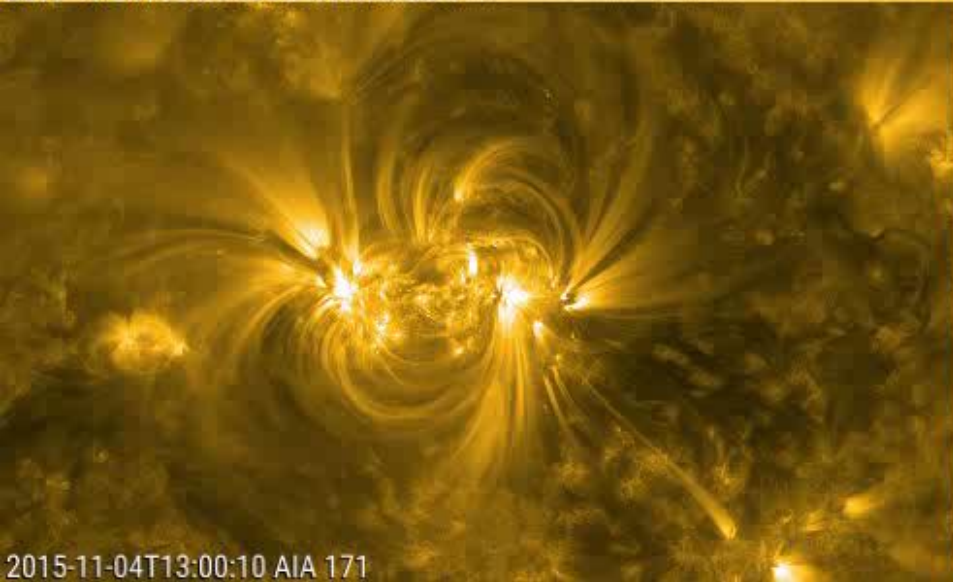
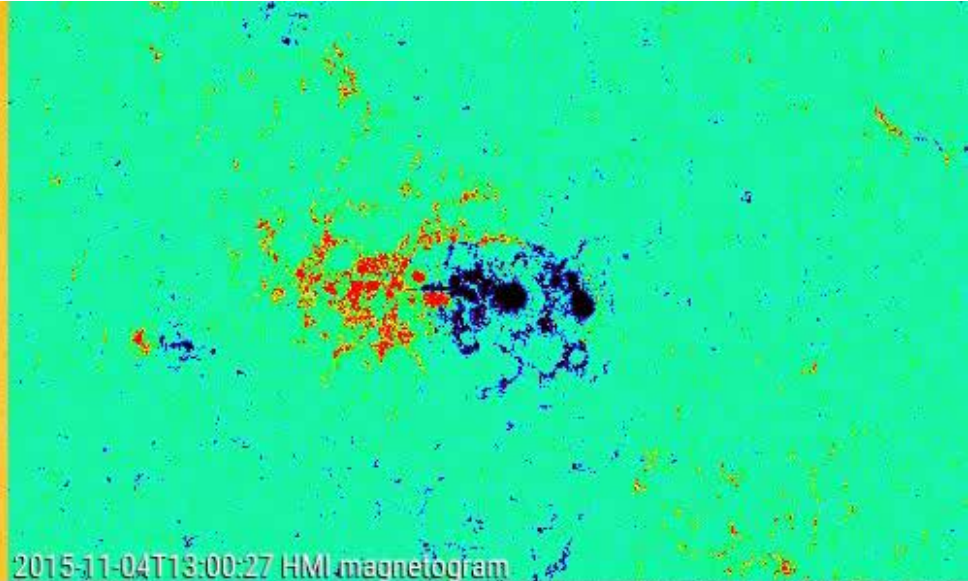
Copyright James Hammett

STORMING.com

SWx effects!

4 November 2015

M3 zonnevlam in NOAA 2443

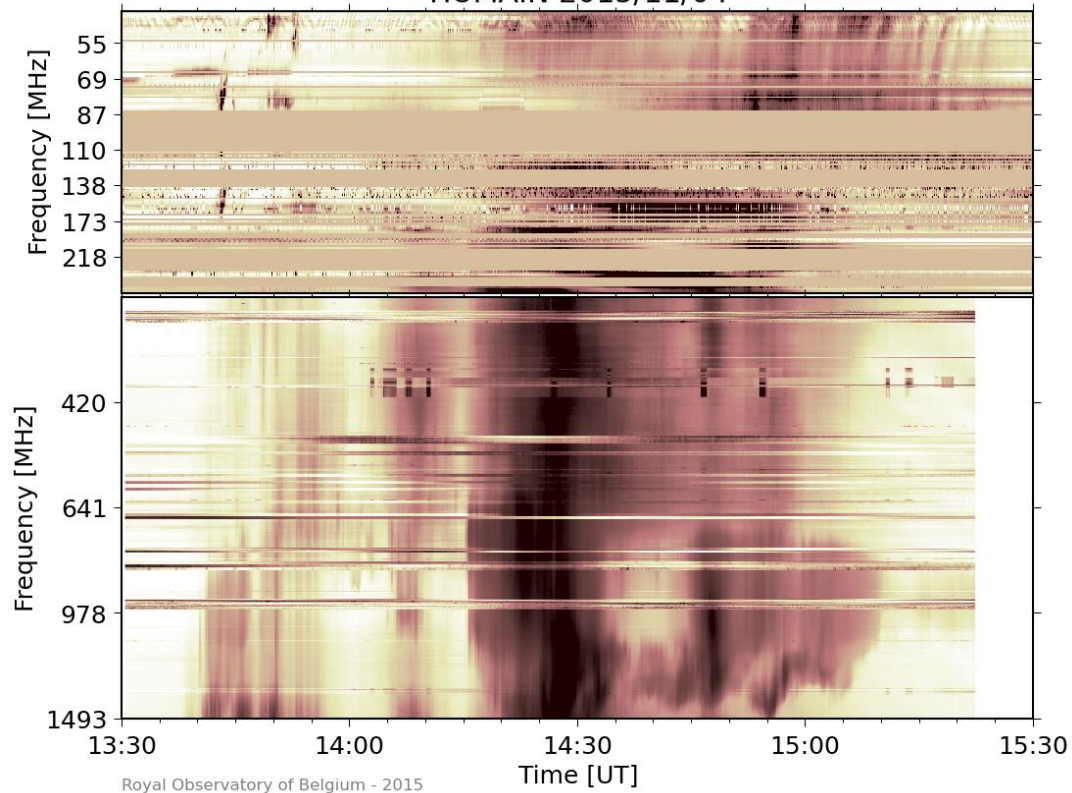


SWx effects!

4 November 2015

M3 zonnevlam legt Zweeds luchtverkeer lam

HUMAIN 2015/11/04



Vragen?

- **SIDC:**
 - <http://www.sidc.be/>
- **SSCC:**
 - <http://swe.ssa.esa.int/web/guest/contact>
 - helpdesk.swe@ssa.esa.int
- **STCE:**
 - <http://www.stce.be/>
 - jan.janssens@oma.be
- **Adres:**
 - Space Pole
 - Avenue Circulaire - Ringlaan, 3
1180 Uccle - Ukkel
 - BELGIUM



Solar-Terrestrial Centre of Excellence Search...

HOME PROJECTS PEOPLE NEWSLETTER NEWS PRESS LINKS GOOD TO KNOW

SC24 highlights page NEW
Every year, the STCE publishes a news item with an overview of the most memorable solar and space weather highlights.

Backside eruptions NEW
Once again, solar observers were

STCE Annual meeting GOOD
November 14-16, 2014
Oostende, BELGIUM

European Space Weather Week GOOD
13TH EUROPEAN SPACE WEATHER WEEK
November 14-16, 2014
Oostende, BELGIUM
At ESWW13 we try to make the