STCE Newsletter

23 Dec 2013 - 29 Dec 2013

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The Solar-Terrestrial Centre of Excellence (STCE) is a collaborative network of the Belgian Institute for Space Aeronomy, the Royal Observatory of Belgium and the Royal Meteorological Institute of Belgium.

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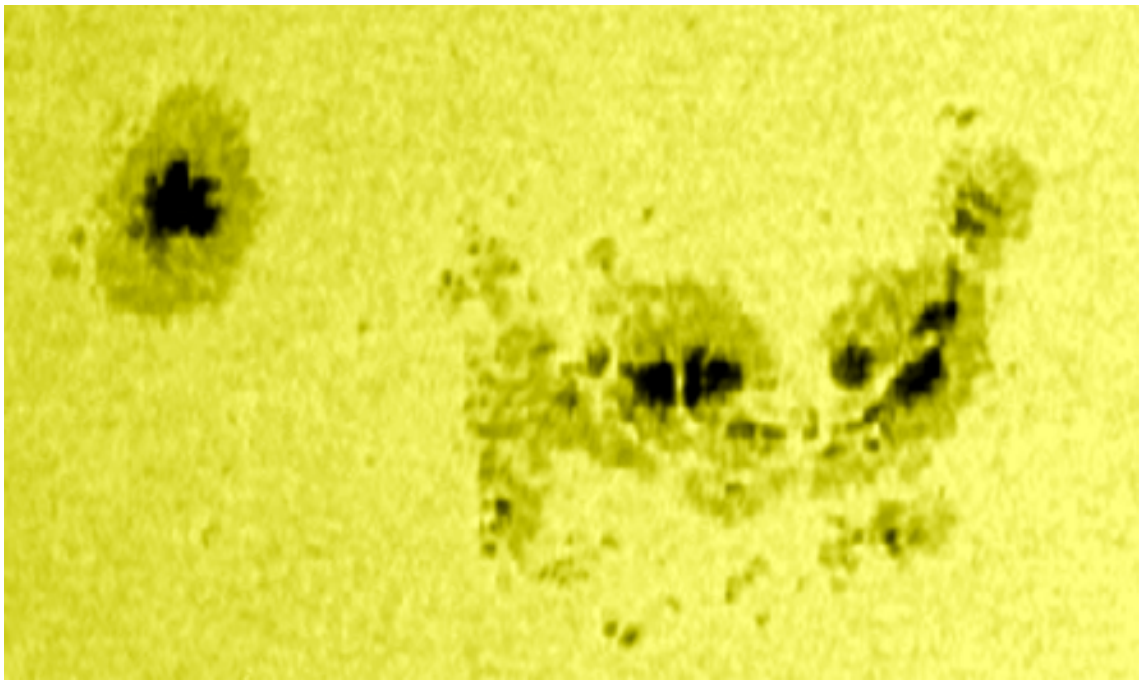
1. The solar hotshots of 2013! (23 Dec 2013 - 29 Dec 2013)

During 2013, long stretches of solar inactivity alternated with brief spurts of high flaring activity levels. The periods of solar calm featured numerous filament and prominence eruptions, with so many spectacular events they could easily fill this review. There were 12 X-class solar flares, almost as many as 2011 and 2012 combined. Yet, only 5 sunspot regions were responsible for these extreme explosions on the Sun, and most of them took place during the latter part of 2013.

Underneath a selection of the most impressive solar events that spiced up the past year. Using Helioviewer (http://www.helioviewer.org/) and JHelioviewer, a movie at http://www.youtube.com/watch?v=nsoRNeeHVL8 was created containing one or more clips of each event. Usually, SDO-images (http://sdo.gsfc.nasa.gov/) were used, occasionally supplemented with imagery from STEREO (http://stereo.gsfc.nasa.gov/), PROBA2 (http://proba2.oma.be/ssa), SOHO (http://sohowww.nascom.nasa.gov/), GOES/SXI (http://www.swpc.noaa.gov/sxi/), and the GONG H-alpha Network (http://halpha.nso.edu/).
Well aware this selection gives only a glimpse on what 2013 had to offer, we do hope this review provides a good idea of the evolving activity of ongoing solar cycle 24. More details on the discussed highlights can be found in the archive of news items on the STCE website (http://www.stce.be/).

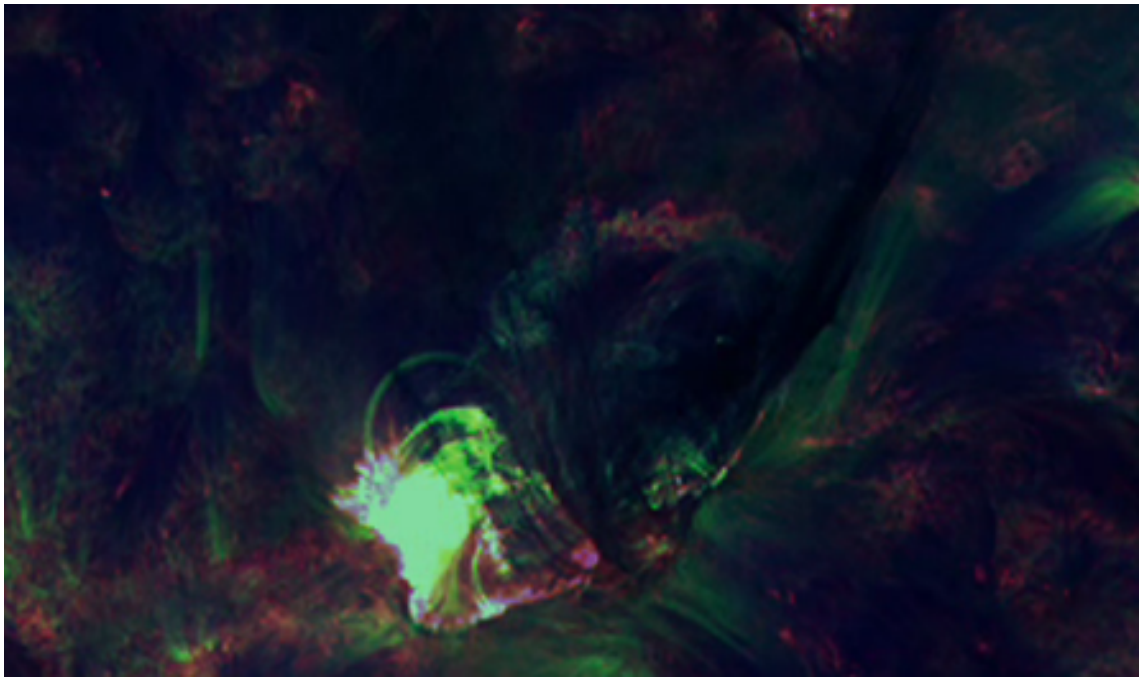
Happy reading, and the best wishes for a spectacular New Year!

Event 1: 11 January 2013 - Impressive NOAA 1654 produces only 2 M-flares



The year opened with the largest sunspot group of 2013, NOAA 1654. According to the NOAA data, it reached its maximum sunspot area on 11 January, when it was more than 6 times as large as the surface of the Earth. Despite its size and its complex outlook, this sunspot group produced only 2 medium flares during its solar transit (on 11 January). The reason for this relatively meager flaring activity was that the opposite magnetic fields were nicely separated from each other, thus preventing the reconnections necessary to produce strong flares. Later in 2013, a few sunspot regions of similar size had mixed magnetic polarities leading to much more entertaining transits...

Event 2: 6 February 2013 - Batman returns!...

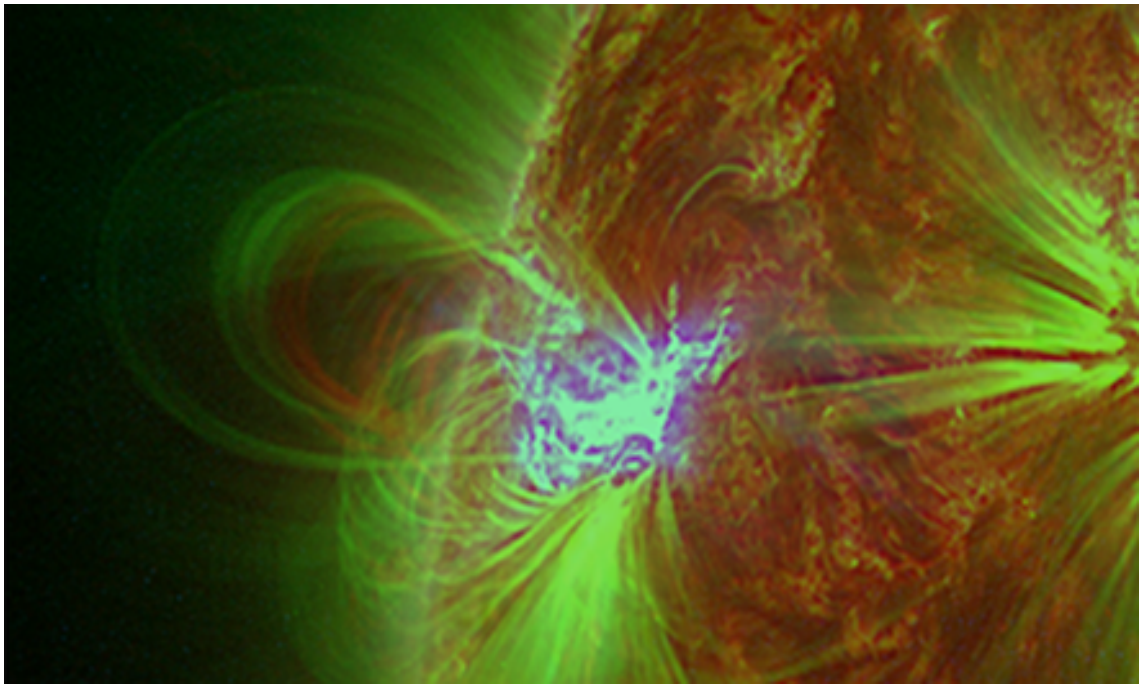


A C8-flare in the relatively small and simple active region NOAA 1667 was accompanied by the ejection of the group's filament. This material was dark and dense, indicating low temperatures of "only" about 10.000 degrees. Due to the helical ("corkscrew") movement of the material, the ejected filament got the shape of Batman's cape before it finally departed from the solar surface as a tenuous, non-Earth directed coronal mass ejection (CME).

Event 3: 16 March 2013 - Spectacular filament eruption

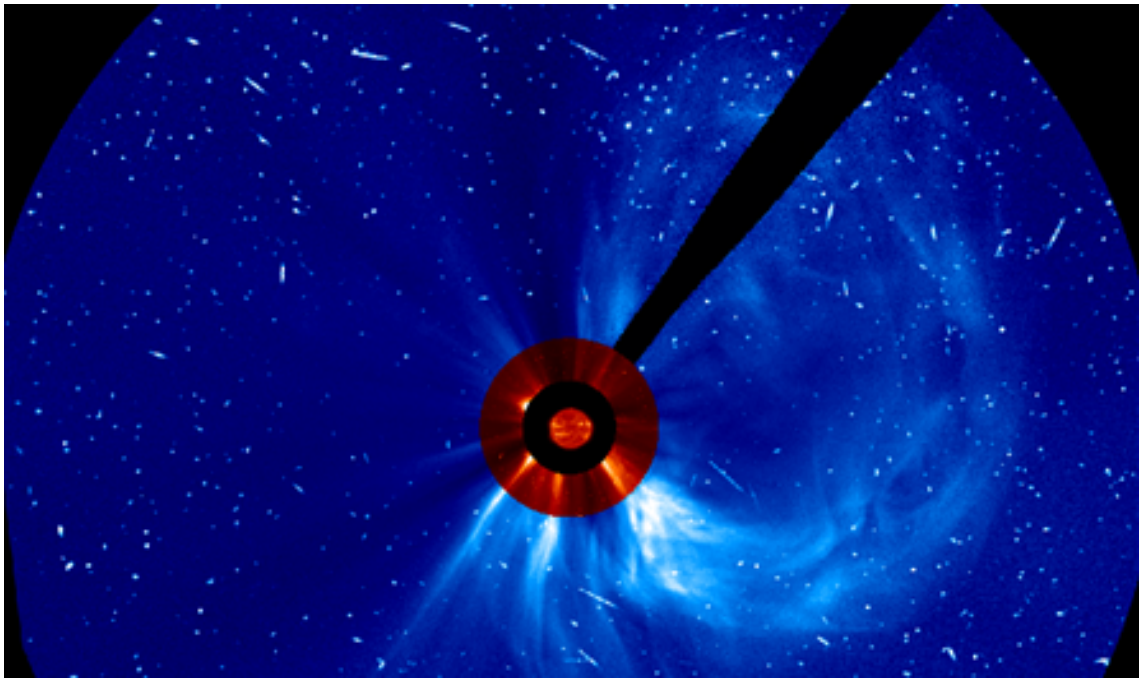
The first few months of 2013 featured several filament and prominence eruptions, and on the average about half a dozen CMEs every day. Quite a few CMEs were truly spectacular, but most were not directed to Earth or occurred on the Sun's backside. On 16 March, a filament to the west of spotless region NOAA 1690 erupted in a spectacular fashion. The associated CME was weak and not directed to Earth.

Event 4: 13-15 May 2013 - An explosive 48 hours



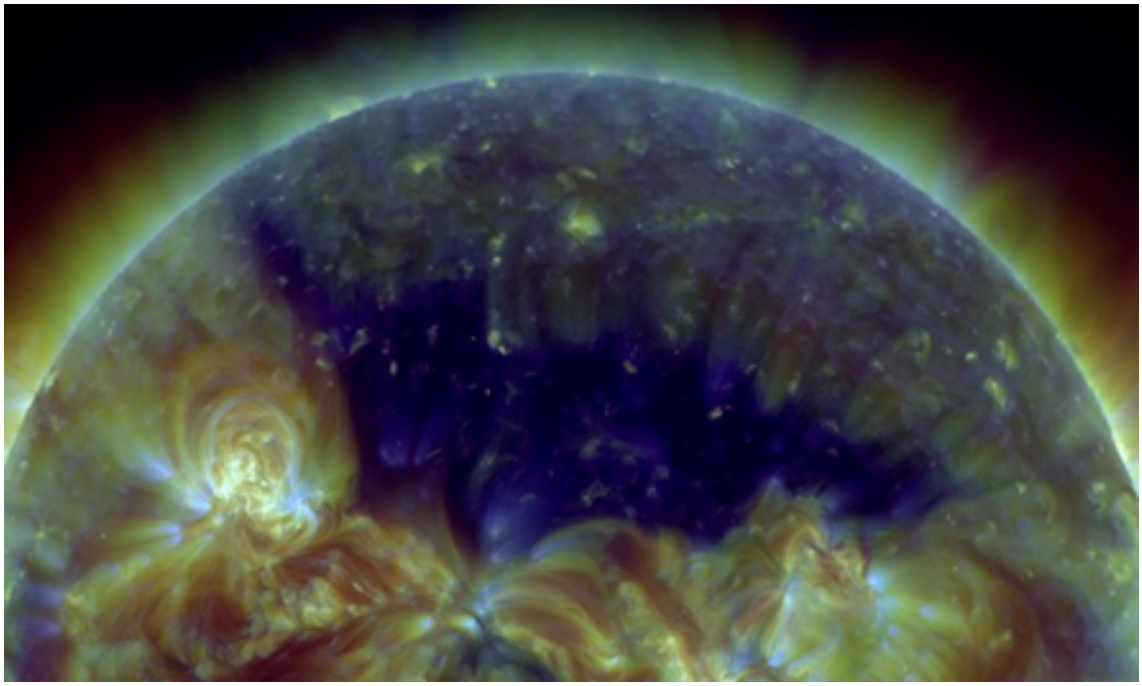
The first spurt of high flaring activity occurred near mid-May, when in a time-span of only 48 hours NOAA 1748 managed to produce 4 X-class solar flares. This sunspot region was relatively small (4-5 times smaller than the aforementioned NOAA 1654), but was magnetically very complex. The first X-flare occurred when NOAA 1748 was still behind the east limb, and the 2 subsequent X-class events were actually white light flares (WLF) as seen by SDO's telescopes in visible light. During the last flare early on 15 May, NOAA 1748 had already rotated far enough onto the solar disk such that the associated CME became geo-effective on 18 May, sparking a minor geomagnetic storm.

Event 5: 22 May 2013 - M5 proton flare in NOAA 1745



After some magnetic interaction with NOAA 1748, a long duration event (LDE) took place in NOAA 1745 on 22 May. The M5 flare was associated with a solid CME of which a glancing blow initiated a minor geomagnetic storm on 24-25 May. More importantly, it was the source of the strongest proton flare in 2013. These protons can be seen as numerous white dots and stripes on the imagery from SOHO's coronagraphs. The event was 4 times less intense than the strongest proton event so far this solar cycle (March 2012).

Event 6: July 2013 - Big coronal hole

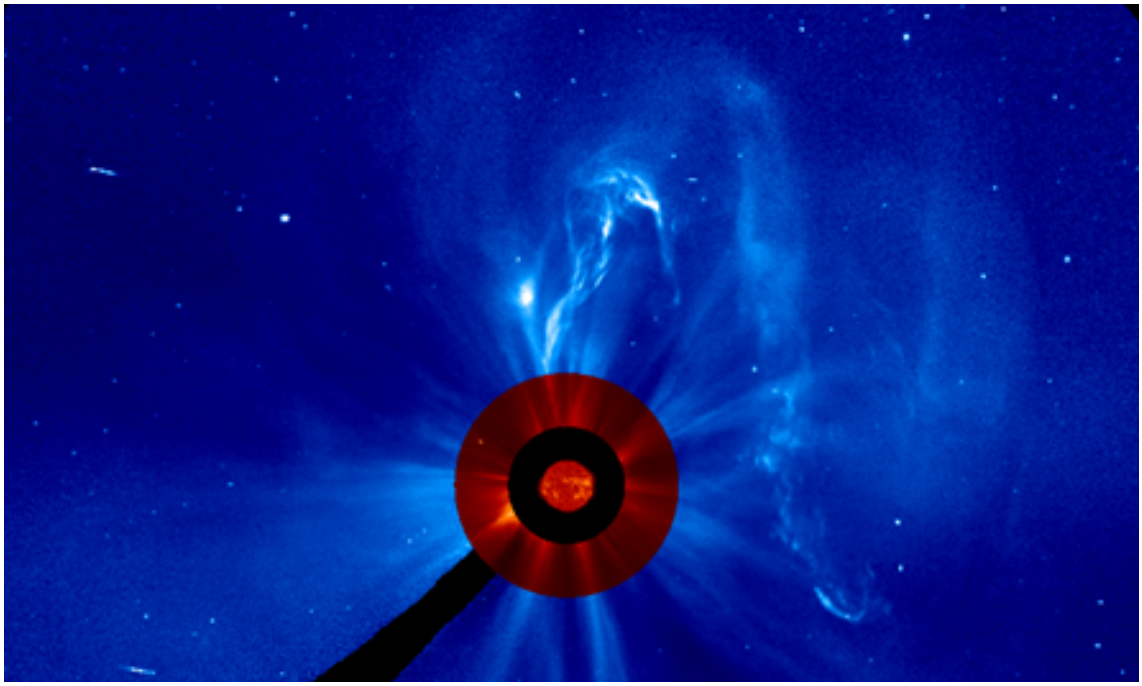


A huge coronal hole (CH) is transiting the solar disk. This CH had an area equivalent to more than 300 times the surface area of the Earth. It managed to survive 8 solar rotations, with the first central meridian passage around 23 May, and the last one on 30 November (8 transits). It sparked geomagnetically active to minor storm conditions during the first 5 transits. The high-speed (700 km/s) stream also brought a whole bunch of high-energy electrons with it, and satellite operators noted a significant increase in anomalies during these periods, thought to be due to repeated electrostatic discharges. Fortunately, none of the spacecraft was permanently damaged. During its October and November transits, the CH had become too small to have a significant space weather impact.

Event 7: 10 September 2013 - Almost a spotless day!

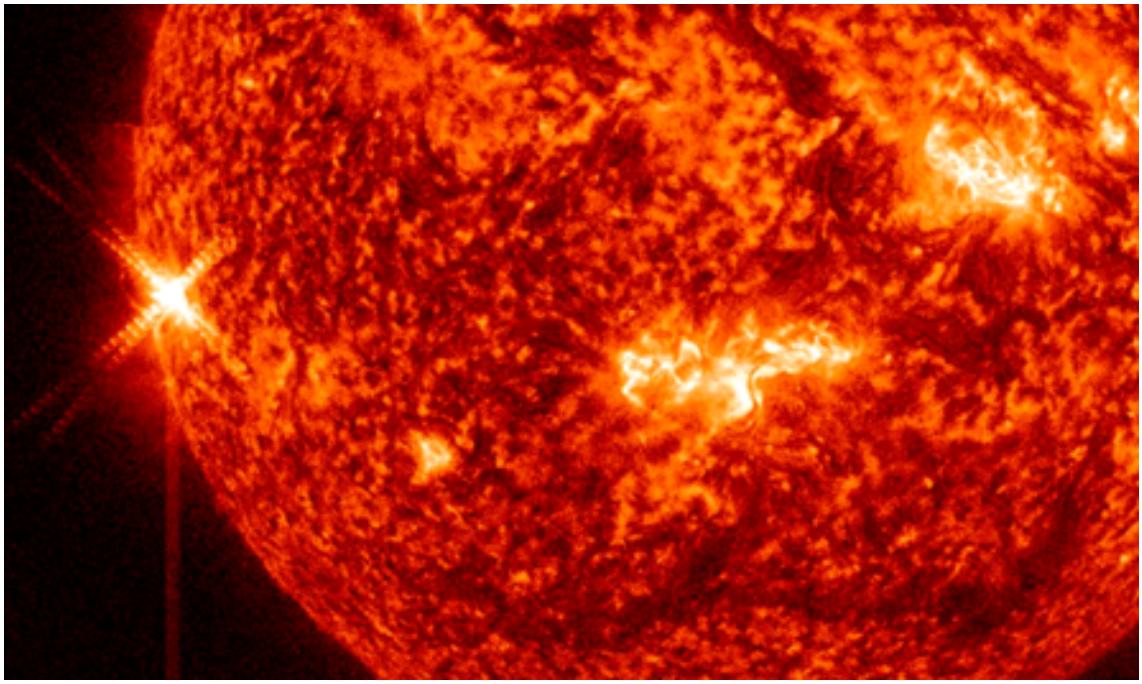
As small sunspot group NOAA 1838 was falling apart, another active region NOAA 1839 appeared just in time to avoid a spotless day, which would have been the first since 14 August 2011! A spotless day during a solar cycle maximum is not uncommon, but it remains of course a rare event. This absolute low in sunspot number highlighted a period of very low solar activity, with hardly any flares (no C-flares from 7 till 17 September: 11 consecutive days) and no (minor) geomagnetic storms for a full month! Meanwhile, the magnetic field near the solar north pole (finally) completed its reversal, whereas this magnetic flip is still ongoing at the south pole. These reversals testify we're close to the maximum of solar cycle 24.

Event 8: 29 September 2013 - A filament's whip



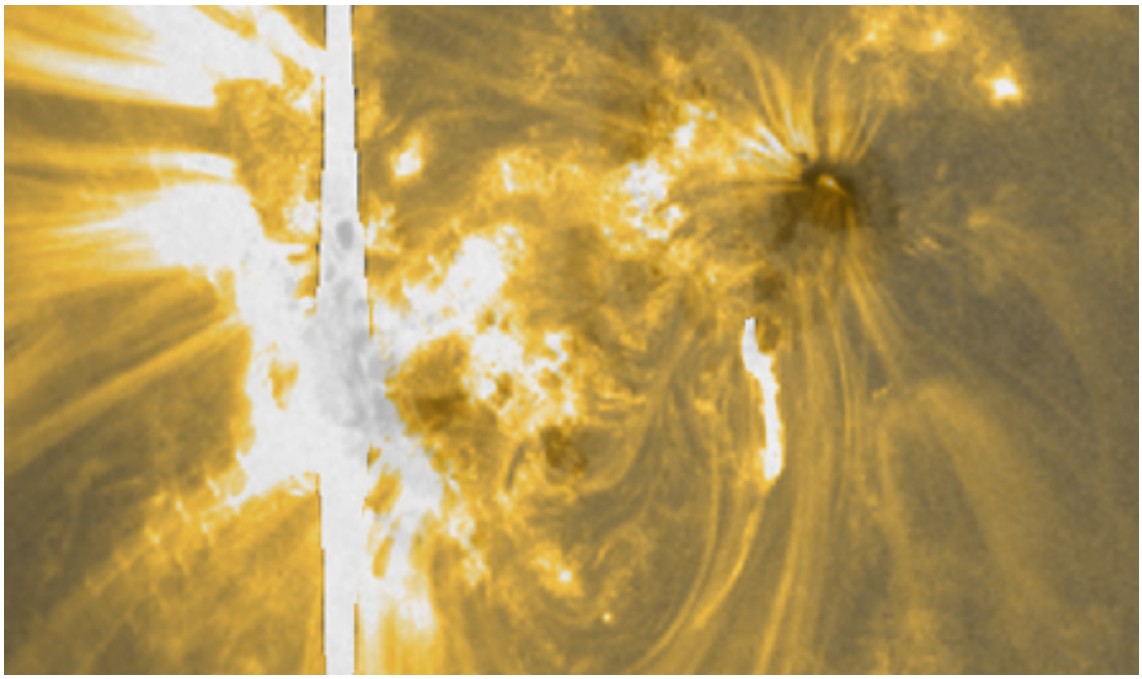
Late on 29 September, a long and solid filament in the Sun's northwest quadrant erupted in a spectacular way. The modest C1-flare (a so-called "Hyder flare") lasted for more than 3 hours, and was also a moderate proton event. This LDE was accompanied by a CME shaped like a whip, making some observers recall Balrog's whip in a famous battle story about a ring. But that's probably coincidence... In the end, the CME delivered a glancing blow to the Earth on 2 October, resulting in a strong geomagnetic storm (locally even severe levels). Together with the storms of 17 March and 1 June, it belonged to the strongest geomagnetic disturbances of 2013.

Event 9: 22-29 October 2013 - Triumvirate wreaks havoc!



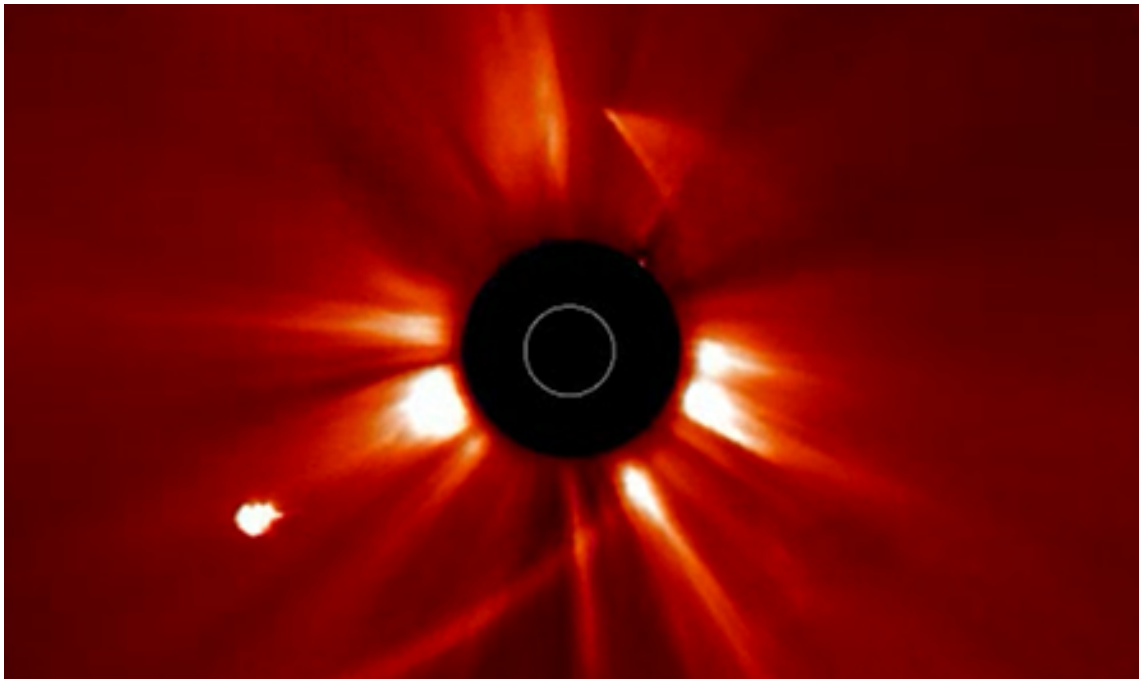
A trio of complex sunspot groups significantly beefed up the flaring activity during the last week of October. From 22 till 29 October, no less than 26 M- and 4 X-class flares took place over the solar surface, making it one of the most flare intense periods so far this solar cycle. Responsible active regions NOAA 1875, 1877 and 1882 also destroyed a million km long solar filament in the process, and NOAA 1875 would stay very active during its subsequent backside transit of the Sun, as nicely recorded by the two STEREO-spacecraft.

Event 10: 5 November 2013 - Strongest solar flare of 2013



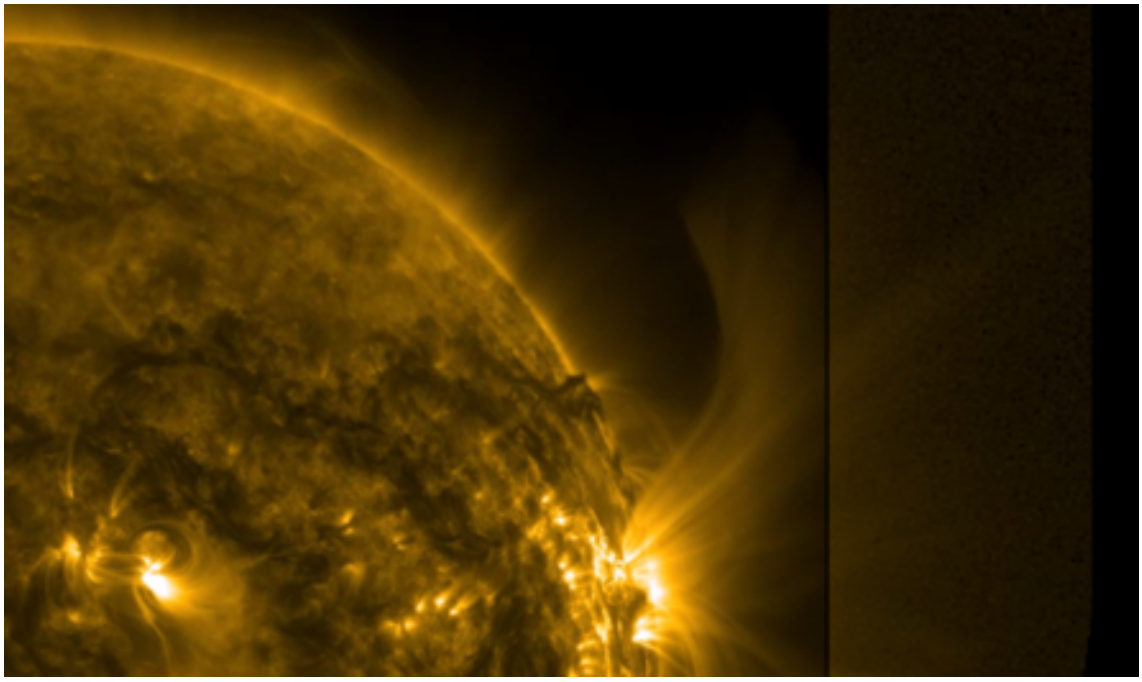
On 5 November, NOAA 1890 produced an X3.3 flare, the strongest of the year and the number 3 -so far- in solar cycle 24. NOAA 1890 was a big sunspot group with a magnetically complex trailing part, and would produce another 2 X-class solar flares during its passage over the solar disk. All three were impulsive flares lasting 10 minutes or less, but they were each associated to a non-Earth directed CME. In total, there were 12 X-class flares in 2013, bringing the total for SC24 on 27.

Event 11: 28 November 2013 - Comet ISON's perihelion passage



It was the talk of the year but eventually, when comet ISON soared less than 2 million km over the solar surface on 28 November, nothing of it could be seen in the EUV-imagery of the solar satellites that were keeping an eye on this intruder from outer space. Unlike comet Pan-STARRS earlier in 2013, ISON's nucleus turned out to be fragile and almost completely disintegrated just hours before it made its closest approach to the Sun. It may also have consisted of material different than that from previous comets that were visible in EUV. The post-perihelion coronagraph images revealed only a rapidly fading ghost-like comet, and on 18 December, the Hubble Space Telescope couldn't even find a trace of it. No CME was harmed during ISON's perihelion passage...

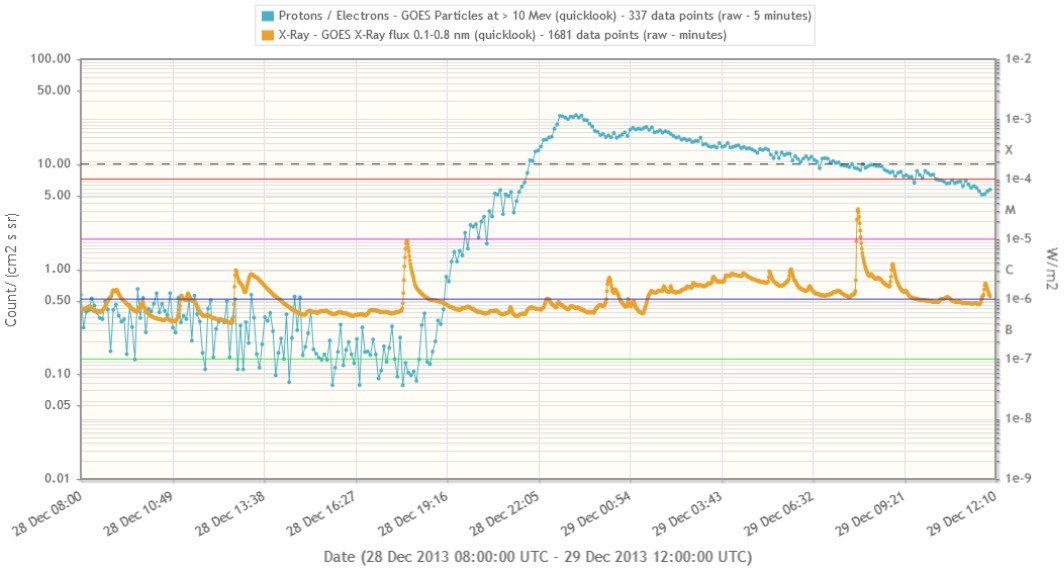
Event 12: November-December 2013 - Towering coronal structures



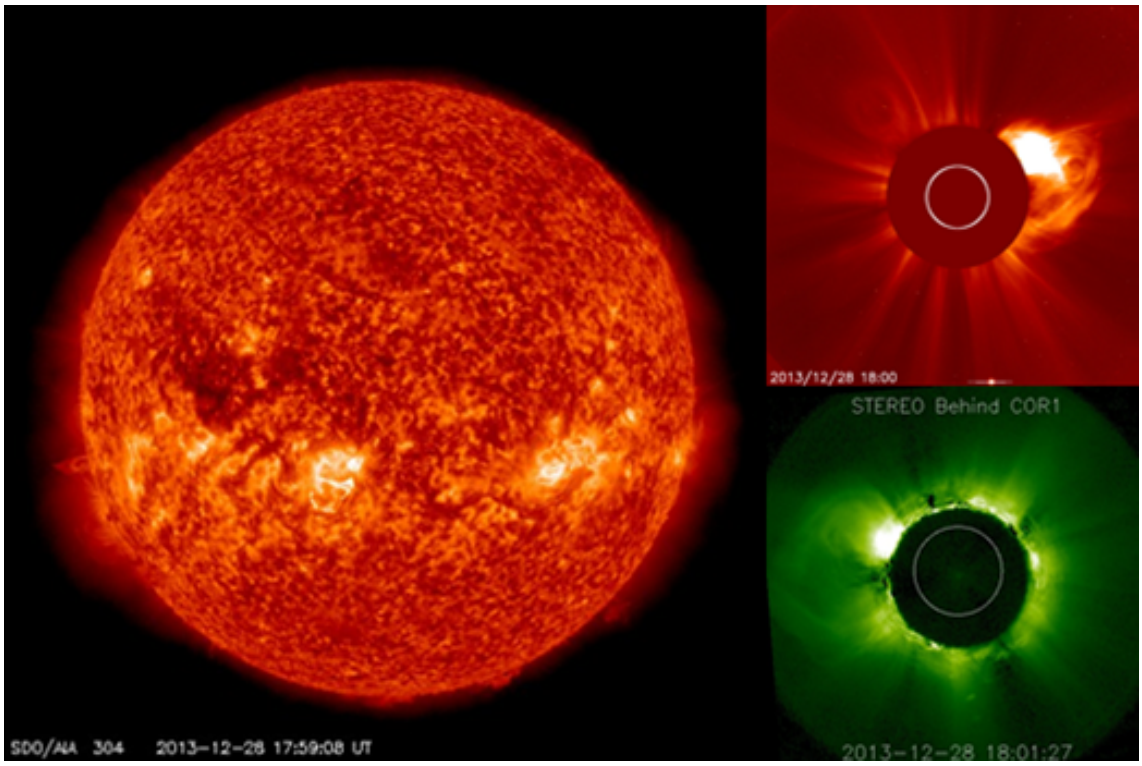
Throughout the year, some impressive structures in the solar corona were visible. These delicate, wavy, several 100.000 km tall curtains exist as the hot solar plasma traces the fine magnetic field lines. Usually at some point, magnetic reconnection occurs leading to a simplification or disappearance of the structure. On some occasions though, they can continue to exist for many weeks, as was the case late 2013.

2. Review of solar activity (23 Dec 2013 - 29 Dec 2013)

Solar activity was high during the week of December 23 to 29, 2013. In total, 2 M flares and 51 C flares were observed. On December 23 and 24, the large majority of the flares (including the first M-flare) were produced by beta-gamma active region (AR) NOAA 11928 near the west limb. Beta-gamma regions NOAA 11934 and 11936 started releasing several C flares as well from December 25 onwards.
Following substantial flux emergence in AR NOAA 11934 and especially NOAA 11936, the daily number of flares increased in the days afterwards, with NOAA 11936 producing an M3 flare on December 29.



The > 10 MeV proton flux as observed by GOES13 started rising near 18:50 UT on December 28. It exceeded the threshold level of 10 pfu around 21:50 UT, and attained a peak value of 29 pfu at 23:15 UT. It went under the 10 pfu threshold again at 7:50 UT on December 29. The > 50 MeV and > 100 MeV proton flux increased as well, but did not exceed the 10 pfu threshold. This proton event is most probably associated with the CME first observed by LASCO C2 at 17:36 UT on December 28 (event near or just behind the west limb), and not with the C9 flare in NOAA 11936 near the central meridian that peaked at 18:02UT.



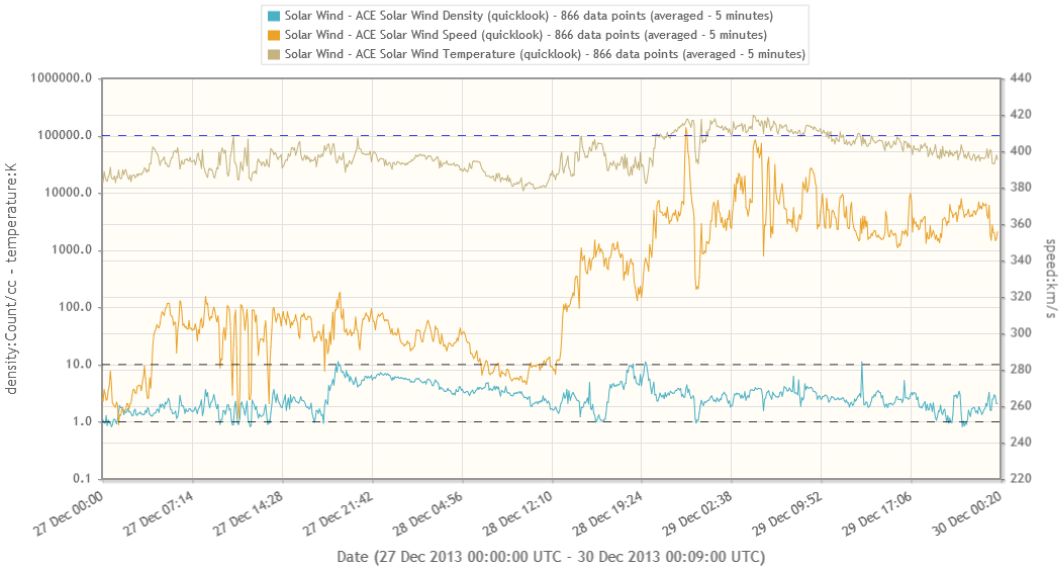
3. Noticeable Solar Events (23 Dec 2013 - 29 Dec 2013)

DAY	BEGIN	MAX	END	LOC	XRAY	OP	10CM	TYPE	Cat	NOAA
23	0859	0906	0909	S18W64	M1.6	1N			87	1928
29	0749	0756	0800	S18E1	M3.1	1N	110	V/2III/2		1936

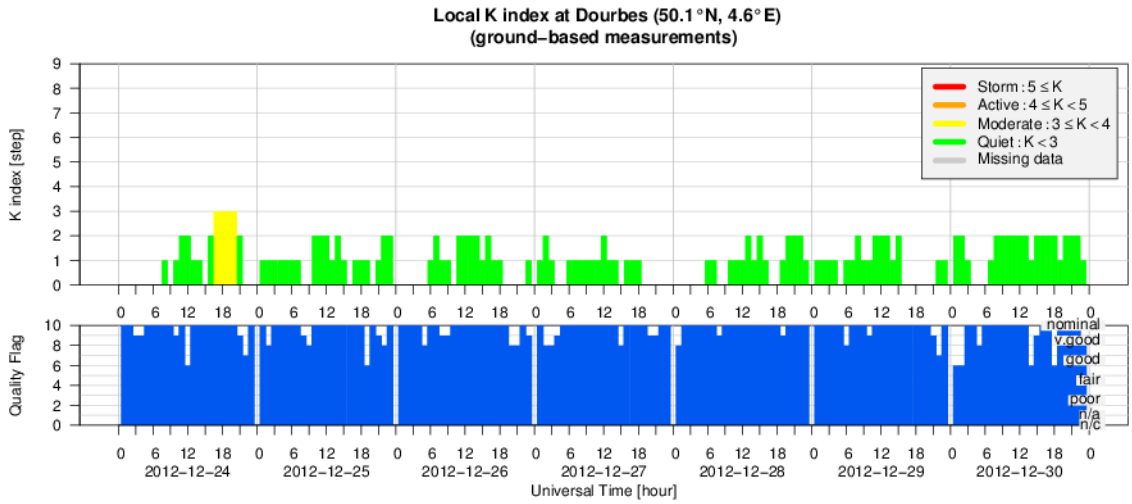
LOC: approximate heliographic location
XRAY: X-ray flare class
OP: optical flare class
10CM: peak 10 cm radio flux
TYPE: radio burst type
Cat: Catania sunspot group number
NOAA: NOAA active region number

4. Review of geomagnetic activity (23 Dec 2013 - 29 Dec 2013)

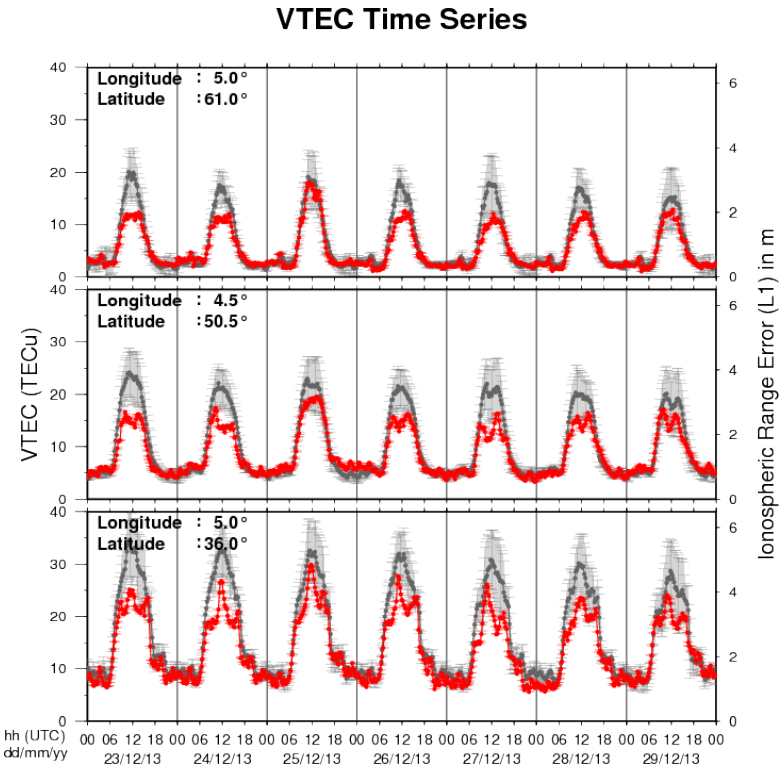
Solar wind speed as observed by ACE was nominal throughout the week, with values ranging between 240 and 390 km/s. The magnitude of the Interplanetary Magnetic Field varied between 1 and 12 nT. Around 3h UT on December 27, the solar wind speed increased quickly from about 265 to about 310 km/s. Around 13h UT on December 28, the solar wind speed increased further from its plateau of around 300 km/s to a plateau of around 370 km/s. These observations may have been the effect of a predicted weak coronal hole high speed stream arriving at Earth. Geomagnetic activity has been quiet (K Dourbes and NOAA Kp smaller than 4) throughout the whole week.



5. Geomagnetic Observations at Dourbes (24 Dec 2012 - 30 Dec 2012)



6. Review of ionospheric activity (23 Dec 2013 - 29 Dec 2013)



The figure shows the time evolution of the Vertical Total Electron Content (VTEC) (in red) during the last week at three locations:
a) in the northern part of Europe(N61°, 5°E)
b) above Brussels(N50.5°, 4.5°E)
c) in the southern part of Europe(N36°, 5°E)

This figure also shows (in grey) the normal ionospheric behaviour expected based on the median VTEC from the 15 previous days.

The VTEC is expressed in TECu (with TECu=10^16 electrons per square meter) and is directly related to the signal propagation delay due to the ionosphere (in figure: delay on GPS L1 frequency).
The Sun's radiation ionizes the Earth's upper atmosphere, the ionosphere, located from about 60km to 1000km above the Earth's surface.The ionization process in the ionosphere produces ions and free electrons. These electrons perturb the propagation of the GNSS (Global Navigation Satellite System) signals by inducing a so-called ionospheric delay.

See http://stce.be/newsletter/GNSS_final.pdf for some more explanations ; for detailed information, see http://gnss.be/ionosphere_tutorial.php

7. Future Events

For more details, see http://www.spaceweather.eu/en/event/future

EGU General Assemby in Vienna, Austria

Start : 2014-04-27 - End : 2014-05-02
The EGU General Assembly 2014 will bring together geoscientists from all over the world to one meeting covering all disciplines of the Earth, planetary and space sciences. The EGU aims to provide a forum where scientists, especially early career researchers, can present their work and discuss their ideas with experts in all fields of geosciences.

8. New documents in the European Space Weather Portal Repository

See http://www.spaceweather.eu/en/repository

eHEROES - CMEs in the inner heliosphere – propagation and interaction with the solar wind

http://www.spaceweather.eu/en/repository/show?id=485

eHEROES - Evolution of the flare loop system of the X1.4 class flare of 22 September 2011

CMEs and flares are transient phenomena with huge energy releases originating from the solar corona. We investigate and analyze the evolution of the X1.4-class flare/CME event of 22 September 2011 that produced a distinct system of flare loops. Viewed from Earth, the event was observed on the solar limb, enabling us to derive height-time curves of the evolving loops. For a continuous tracking of the loop system in high-temporal resolution EUV data using SDO/AIA data, we developed a method that automatically detects the height of the loop tops over a given reference point by analyzing the intensity profile perpendicular to the solar limb. With this method, we measure the height-time profiles of the loop system in the different wavelength channels over a time period of 12 hours after the flare onset. We identify characteristic features in the height-time curves which stem from a non-uniform growth of the flare loop system related to the ongoing magnetic reconnection process. We put special focus on the early phase of the event for which we compare the growth of the loop system with the kinematics of the associated CME and aim to connect the physics behind the rapid growth of the loop system with changes in the kinematical behavior of the CME or enhanced soft X-ray flux.
http://www.spaceweather.eu/en/repository/show?id=486