

# STCE Newsletter

31 Mar 2014 - 6 Apr 2014



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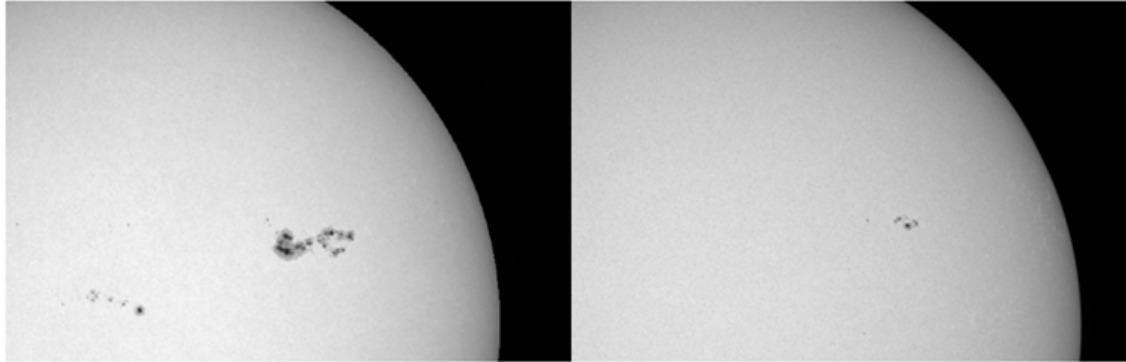
The Solar-Terrestrial Centre of Excellence (STCE) is a collaborative network of the Belgian Institute for Space Aeronomy, the Royal Observatory of Belgium and the Royal Meteorological Institute of Belgium.

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## 1. Small groups, big flares

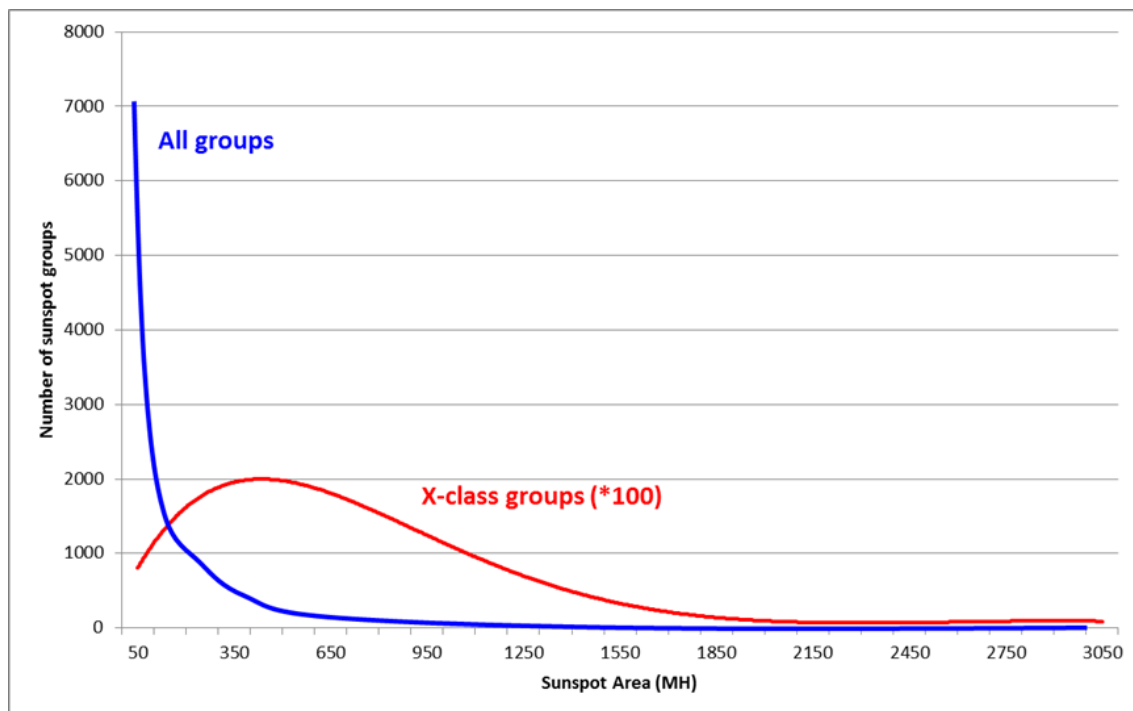
Usually, strong solar flares (X-class) are associated to big and complex sunspot groups, reaching maximum areas equivalent to 15 times the surface area of the Earth. That's why it was interesting to see that two recent X-class flares were produced in regions which were much smaller. Indeed, the X-class flares on 25 February and in particular on 29 March this year took place in sunspot regions that hardly reached an area similar to that of the Earth's surface (about 170MH, see Note 1).



NOAA 10375 – 9 June 2003

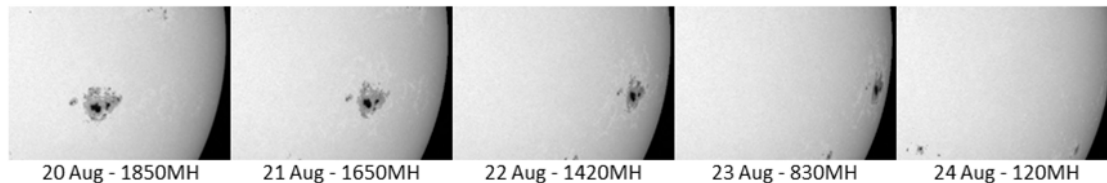
NOAA 12017 – 29 March 2014

Since systematic GOES x-ray measurements began in 1976, more than 450 X-class flares have been recorded. These were produced by a bit more than 200 individual sunspot groups. According to the NOAA numbering, almost 11,000 sunspot groups were observed over those 38 years, so it is quite impressive that only 2% of the sunspot groups are responsible for all the eXtreme solar flares. Graph underneath shows per area bin (per 100MH) the smoothed number of sunspot groups (blue curve) as well as the smoothed number of groups producing an X-class flare (\*100 for display purposes; red curve). Clearly, most of the X-class groups have a sunspot area several times that of the Earth.

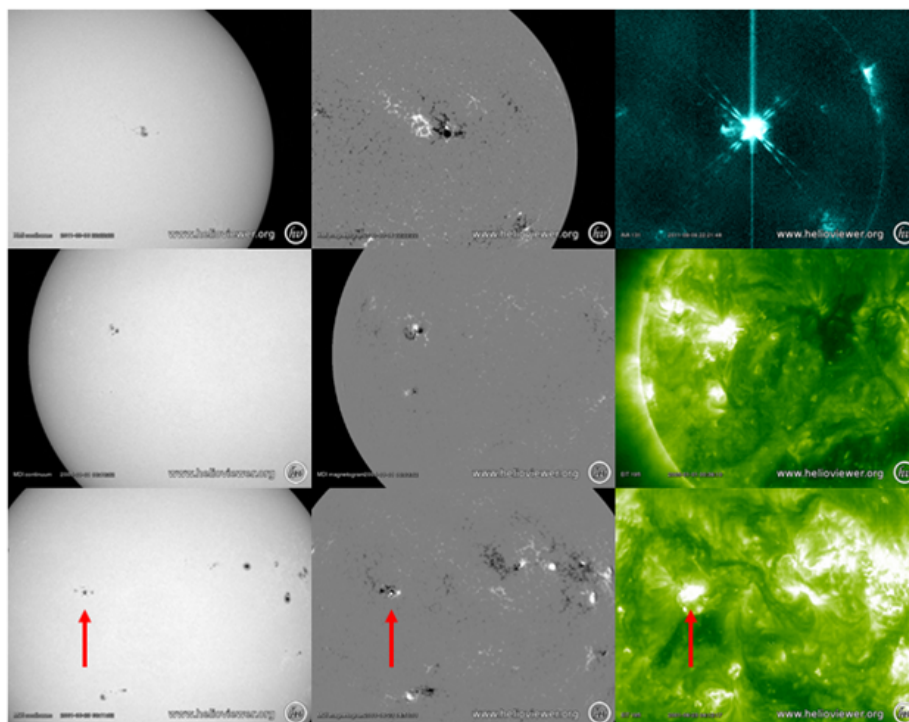


Nonetheless, about 10% of the X-class flares were produced in sunspot groups that had a surface area of 200MH or less. A quick review reveals that half of these are not really small, but have a sunspot area that actually does not reflect the true area. Indeed, when a large sunspot group is near the solar limb, it may take a day or more before it rotates completely in or out of view. If such a group happens to produce an X-class flare at that time, the associated sunspot area may seem very low. An example is big NOAA 10069 (imagery underneath), which produced an X3 flare while having nearly rounded the west limb early on 24 August 2002.

### NOAA 10069 – 20-24 August 2002

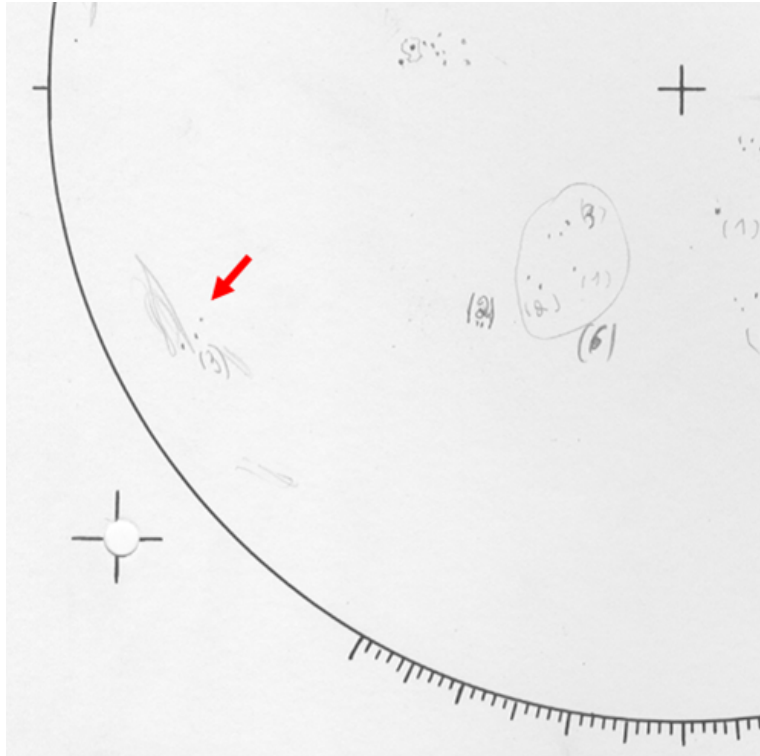


So, what's so special about the remaining two dozen of X-class flare producing groups that have a small size but are located relatively far (more than 10 degrees) from the solar limb? As usual, taking a look at the magnetogram of the sunspot group reveals already a lot. Often, within the small group, spots of opposite magnetic polarity (black and white) can be seen very close to each other, often within the same penumbra. These "delta" spots (see <http://stce.be/news/222/welcome.html>) are known to be the source of strong flaring activity, so space weather forecasters keep an eye on them. A few examples from this and previous solar cycle can be found underneath: NOAA 11283 (6 September 2011; 200MH; top row), NOAA 10715 (1 January 2005; 180MH; middle) and NOAA 9511 (23 June 2001; 110MH; bottom row).



Note that delta spots do not explain all of the aberrant cases. Interaction with nearby sunspot groups, or when a group is in the growing/decaying phase of its life are just a few of the other possible reasons.

One of the smallest groups that produced an X-class flare was NOAA 7012 on 26 January 1992. This isolated group measured hardly 10MH (ten!), consisting only of a few small sunspots (see annotated part of USET drawing underneath), and was visible for barely two days. Yet, it produced an X1-flare that was observed by the telescopes onboard the Yohkoh satellite in both x-ray and white light. In such flare events, there may be other physical processes at play.



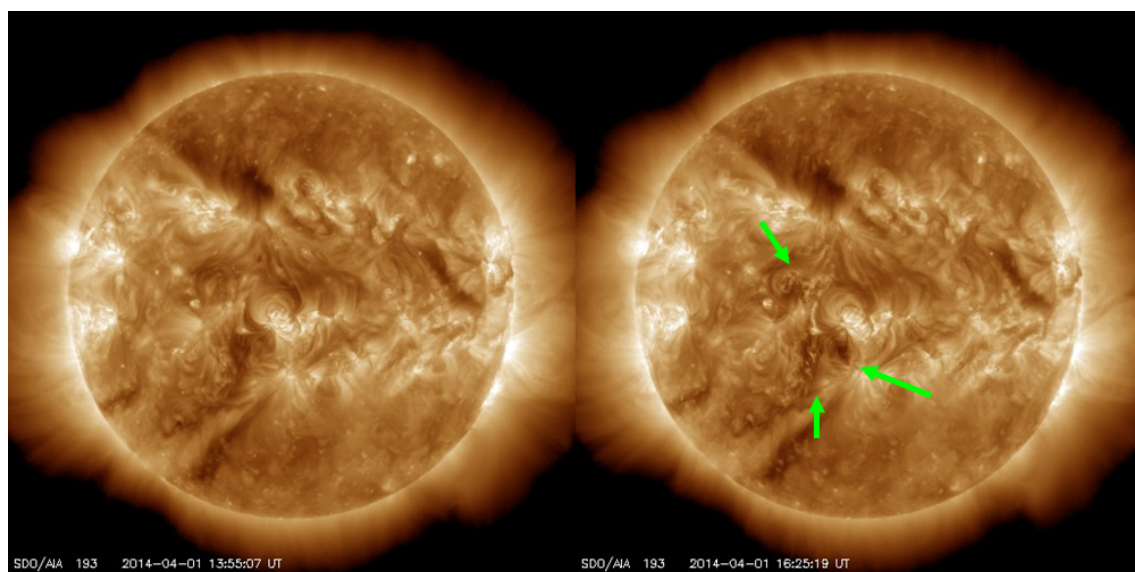
Note 1 - The area of sunspot groups is expressed in "millionths of a solar hemisphere" (MH), with 1000MH corresponding to 3.043,7 million km<sup>2</sup>. The total area of the Earth corresponds to almost 170MH.

Credits - Images were taken from SDO (<http://sdo.gsfc.nasa.gov/data/aiahmi/>), SOHO ([http://sohodata.nascom.nasa.gov/cgi-bin/data\\_query](http://sohodata.nascom.nasa.gov/cgi-bin/data_query)), USET (<http://www.sidc.oma.be/uset/index.php>), and (J)Helioviewer (<http://helioviewer.org/>). USAF/NOAA sunspot data are available at NASA/MSFC (<http://solarscience.msfc.nasa.gov/greenwch.shtml>), and x-ray flare data at NOAA/NGDC (<http://www.ngdc.noaa.gov/stp/space-weather/solar-data/solar-features/solar-flares/x-rays/goes/>).

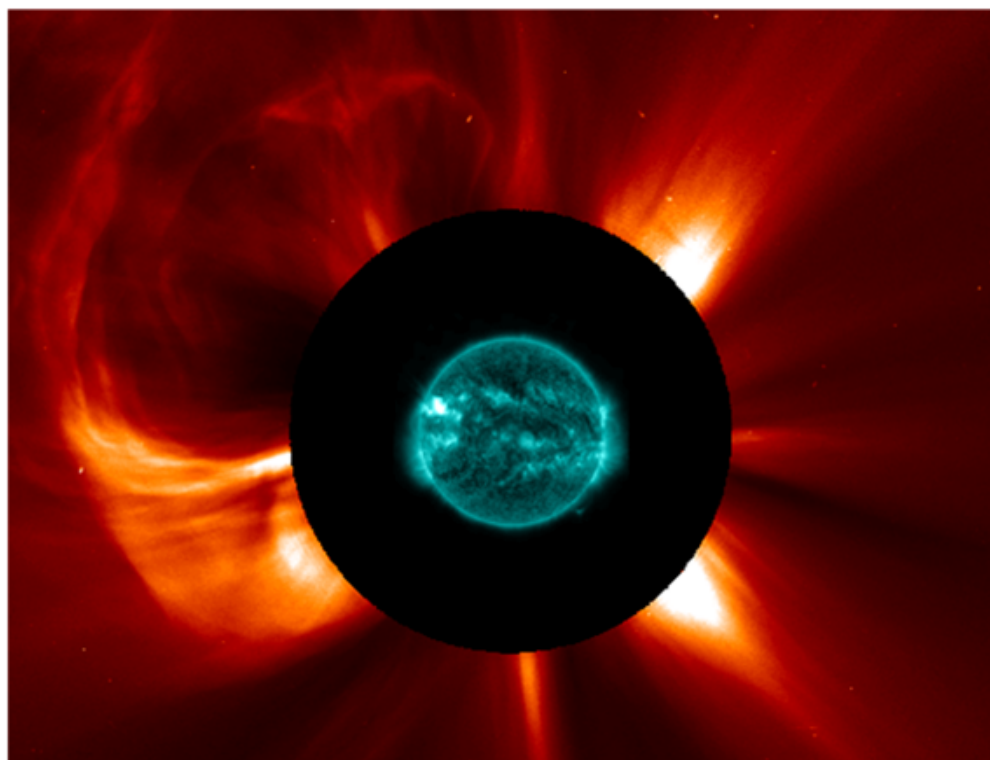
## 2. Review of solar activity (31 Mar 2014 - 6 Apr 2014)

Solar activity has been moderate in the past week. The highlights were two M-class flares, a filament eruption and a strong C-class flare.

The first M-class event had its source in active region (AR) NOAA 2014 close to the west limb (M1.4 on 31 March, peaking at 08:07UT). It was associated to a relatively slow coronal mass ejection (CME). On 1 April, a small filament erupted to the East/South-East of AR NOAA 2021 which was close to the central meridian. SDO/AIA 193 images underneath show the area before (13:55UT) and after (16:25UT) the event, with a few subtle changes highlighted. The filament eruption was accompanied by a slow moving CME with an Earth-directed component.



The second M-class event took place in active region NOAA 2027. The M6.5 flare peaked at 14:05UT on 2 April. It was accompanied by an EUV coronal wave, a strong radio burst (observed with the Humain solar radio telescope), and a fast halo CME (about 1500km/s). The image underneath combines the CME (SOHO/LASCO C2) with the flare site (SDO/AIA 131) as seen around 14:38UT. The very same region produced a C8.3 flare peaking at 13:48UT on 4 April. It was also accompanied by an EUV coronal wave and a partial halo CME.





### 3. Noticeable Solar Events (31 Mar 2014 - 6 Apr 2014)

| DAY | BEGIN | MAX  | END  | LOC    | XRAY | OP | 10CM | TYPE     | Cat | NOAA |
|-----|-------|------|------|--------|------|----|------|----------|-----|------|
| 31  | 0720  | 0807 | 0818 | S15W77 | M1.4 | SF |      | IV/1     | 92  | 2014 |
| 02  | 1318  | 1405 | 1428 | N14E53 | M6.5 | 2B | 3700 | II/1IV/2 | 9   | 2027 |

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. PROBA2 Observations (31 Mar 2014 - 6 Apr 2014)

The level of solar activity was low to moderate this week. Two M-flares were recorded, one on Monday from AR12014 (M1.4), and one on Wednesday from AR 12027 (M6.5).

In order to view the activity of this week in more detail, we suggest to go to the following website from which all the daily (normal and difference) movies can be accessed: <http://proba2.oma.be/ssa>.

This page also lists the recorded flaring events.

A weekly overview movie can be found here: [http://proba2.oma.be/swap/data/mpg/movies/WeeklyReportMovies/WR210\\_Mar31\\_Apr06/weekly\\_movie\\_2014\\_03\\_31.mp4](http://proba2.oma.be/swap/data/mpg/movies/WeeklyReportMovies/WR210_Mar31_Apr06/weekly_movie_2014_03_31.mp4) (SWAP week 210). Occasionally in this movie, the Sun is not centered due to off-point campaigns (twice).

Details about some of this week's events can be found further below.

#### Monday Mar 31st



M1.4 flare Eruption, West limb @ 08:27 - SWAP difference image

Find a movie of the event here: [http://proba2.oma.be/swap/data/mpg/movies/WeeklyReportMovies/WR210\\_Mar31\\_Apr06/20140331\\_EruptionWestLimb\\_0827\\_SWAPdiff.mp4](http://proba2.oma.be/swap/data/mpg/movies/WeeklyReportMovies/WR210_Mar31_Apr06/20140331_EruptionWestLimb_0827_SWAPdiff.mp4) (SWAP difference movie)

The expelled material could be followed up to the edge of the SWAP field of view.

## **Tuesday Apr 1st**

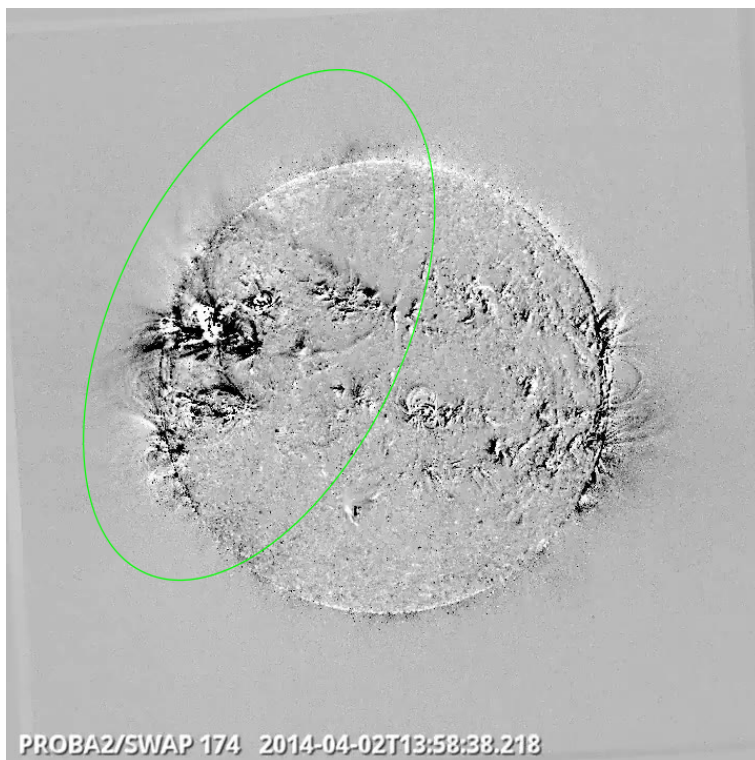
A cavity/cusp-like feature can be seen at relatively high altitude above the North Western Limb. The feature is hard to see, but definitely present.

We suggest having a look at the SWAP daily movie here: [http://proba2.oma.be/swap/data/mpg/movies/WeeklyReportMovies/WR210\\_Mar31\\_Apr06/20140401\\_swap\\_movie\\_offpoint.mp4](http://proba2.oma.be/swap/data/mpg/movies/WeeklyReportMovies/WR210_Mar31_Apr06/20140401_swap_movie_offpoint.mp4).

Note that the Sun is not centered in this movie, because of an off-pointing campaign, lasting the whole day.

Such features can be seen sporadically, but \*not\* at such a high altitude.

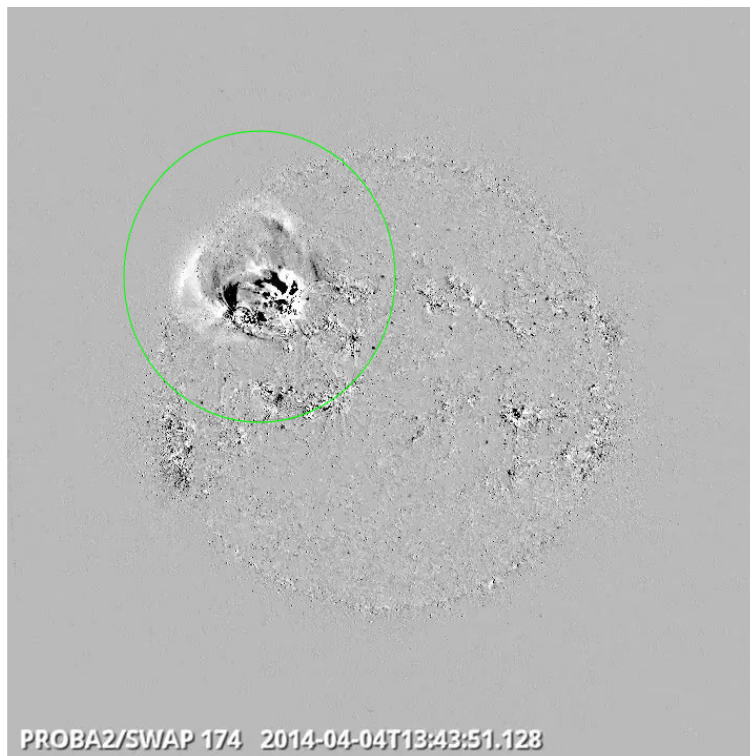
## **Wednesday Apr 2nd.**



M6.5 flare Eruption, North East Quadrant - AR12027 @ 13:58 - SWAP difference image

Find a movie of the event here: [http://proba2.oma.be/swap/data/mpg/movies/WeeklyReportMovies/WR210\\_Mar31\\_Apr06/20140402\\_M65EruptionNELimb\\_1358\\_SWAPdiff\\_annotated.mp4](http://proba2.oma.be/swap/data/mpg/movies/WeeklyReportMovies/WR210_Mar31_Apr06/20140402_M65EruptionNELimb_1358_SWAPdiff_annotated.mp4) (SWAP difference movie)

**Friday April 4th**



C8.3 flare Eruption, North East Quadrant - AR12027 @ 13:43 - SWAP difference image



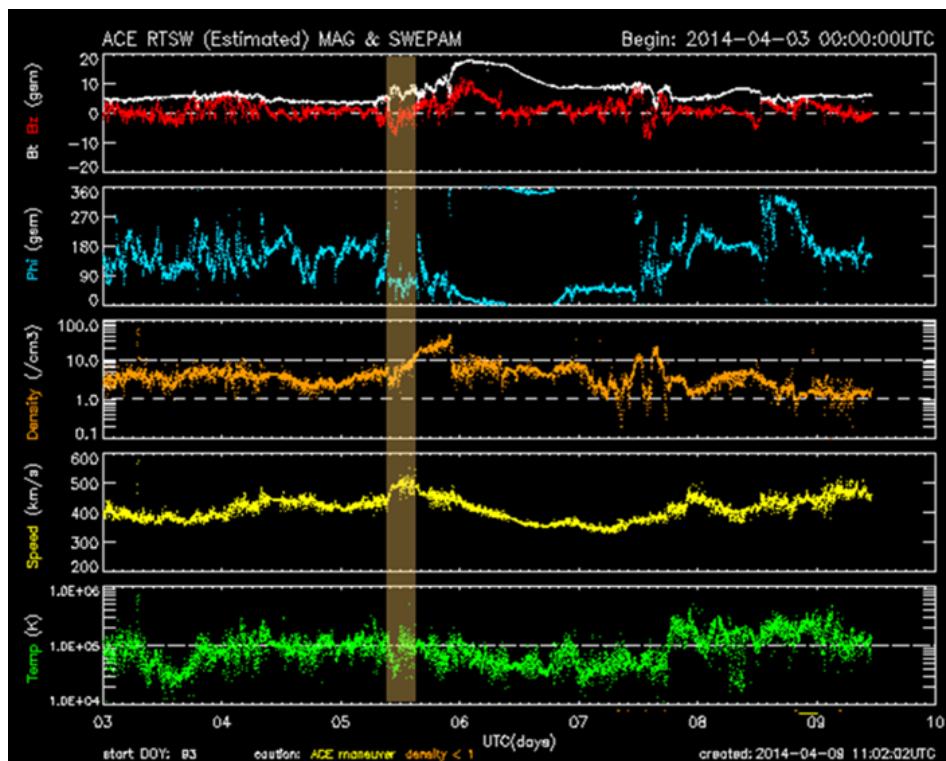
**Saturday April 5th**



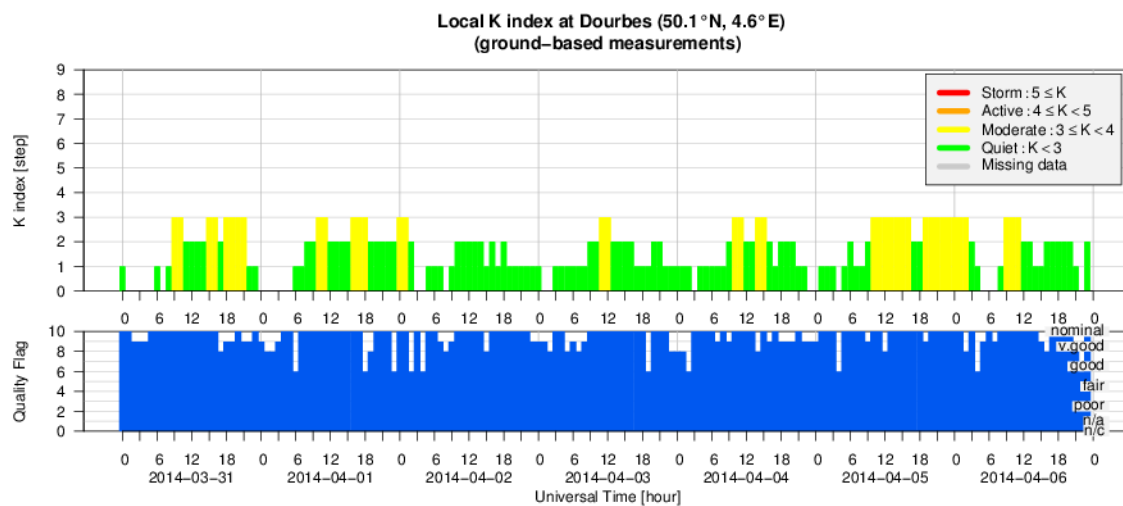
Prominence Eruption, South East Limb @ 00:09 - SWAP difference image

## **5. Review of geomagnetic activity (31 Mar 2014 - 6 Apr 2014)**

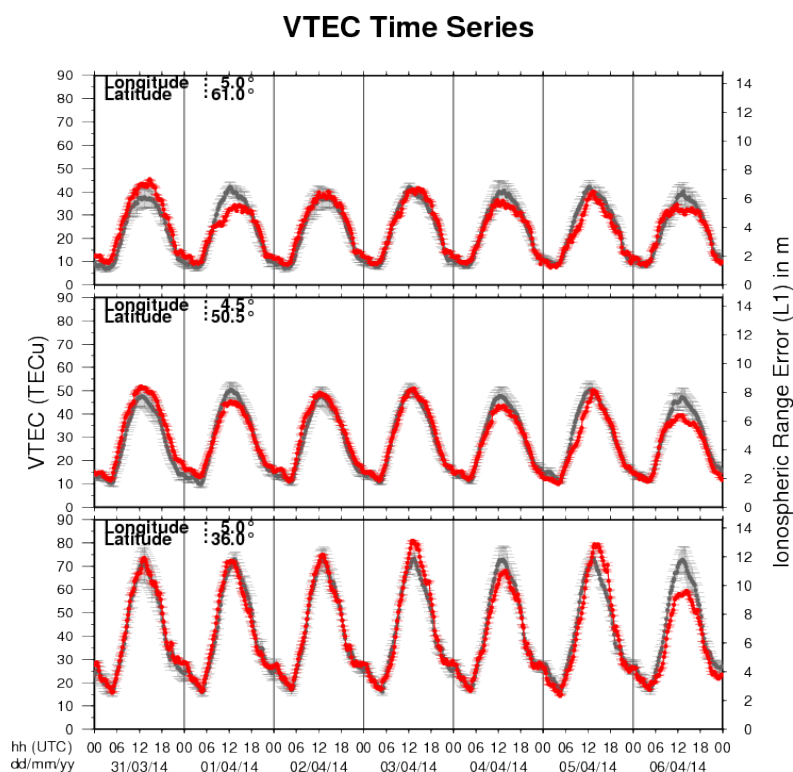
Geomagnetic activity was mostly quiet during the week. Active conditions ( $K=4$ ) were observed at planetary levels on 5 April from 9 to 15 UT in response to the arrival around 09:30UT that day of a moderate shock associated to the CMEs of 1-2 April. An ICME signature was observed subsequently on 5 and 6 April. In image underneath, the period with active geomagnetic conditions (light orange bar) has been overlaid on the solar wind parameters as measured by the ACE spacecraft.



## 6. Geomagnetic Observations at Dourbes (31 Mar 2014 - 6 Apr 2014)



## 7. Review of ionospheric activity (31 Mar 2014 - 6 Apr 2014)



The figure shows the time evolution of the Vertical Total Electron Content (VTEC) (in red) during the last week at three locations:

- in the northern part of Europe (N61°, 5°E)
- above Brussels (N50.5°, 4.5°E)
- 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  $\text{TECu} = 10^{16}$  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](http://stce.be/newsletter/GNSS_final.pdf) for some more explanations ; for detailed information, see [http://gnss.be/ionosphere\\_tutorial.php](http://gnss.be/ionosphere_tutorial.php)

## 8. Future Events

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

### EGU General Assembly 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.

### **STCE workshop on degradation and inter-calibration of instruments observing in the SXR-EUV range in Brussels, Belgium**

Start : 2014-06-10 - End : 2014-06-11

The STCE workshop 'Inter-Calibration and Degradation of EUV Instruments' aims at understanding the differences observed between the various instruments observing in the SXR-EUV range and at analyzing the ageing effects that affect their results. It targets imagers as well as spectrometers and photometers. The workshop will be followed by two days of working sessions (June 12-13) organized by the Solar EUV Irradiance Working Group (also supported by the STCE). These working sessions are in the continuity of similar events organized in 2011, 2012 and 2013, but they are open to new participants and you are welcome to join if you are interested.

Website:

<http://www.stce.be/euvworkshop2014/>

### **3rd SWARM science meeting in Copenhagen, Denmark**

Start : 2014-06-19 - End : 2014-06-20

During the summer of 2014 DTU Space will host the 3rd Swarm Science Meeting, sponsored by the European Space Agency, ESA . This meeting will take place at the IDA Conference Centre in Copenhagen on June 19th to 20th 2014 and is open to the science community at large.

Website:

<http://congrexprojects.com/2014-events/Swarm/home>

## **9. New documents in the European Space Weather Portal Repository**

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

### **eHEROES -Investigating a possible connection between the evolution of flare loop systems and the kinematics of an associated CME**

<http://www.spaceweather.eu/en/repository/show?id=491>

### **eHEROES - Comparing tools for heliospheric CME propagation: ENLIL versus DBM**

<http://www.spaceweather.eu/en/repository/show?id=493>

### **STCE Annual Report 2012**

The STCE Annual Report 2012 is a compilation of the activities done in 2012 within the frame of the Solar-Terrestrial Centre of Excellence (STCE). This report continues the style from the previous edition. Hence, as it is targeting a more general public, it presents only a selection of the 2012-activities in easy-to-digest summaries. These summaries emphasize the intense collaboration between the institutes at the Space Pole, as well as with our external partners. We hope you enjoy this report, which features articles on the evolution of the solar activity, the 9th European Space Weather Week, PROBA2, Integrated Water Vapor observations, SIMBA the nanosatellite, user applications such as STAFF, LIDAR, and ionospheric models, and much more... Happy reading!

<http://www.spaceweather.eu/en/repository/show?id=494>

### **eHEROES - CME tracking from STEREO image data de-projected by different methods**

<http://www.spaceweather.eu/en/repository/show?id=492>

**eHEROES - Systematic testing of different de-projection methods for STEREO imagery**

<http://www.spaceweather.eu/en/repository/show?id=497>

**eHEROES - Review on remote-sensing observations of successive CMEs and CME-CME interaction**

<http://www.spaceweather.eu/en/repository/show?id=498>