STCE Newsletter

9 Dec 2013 - 15 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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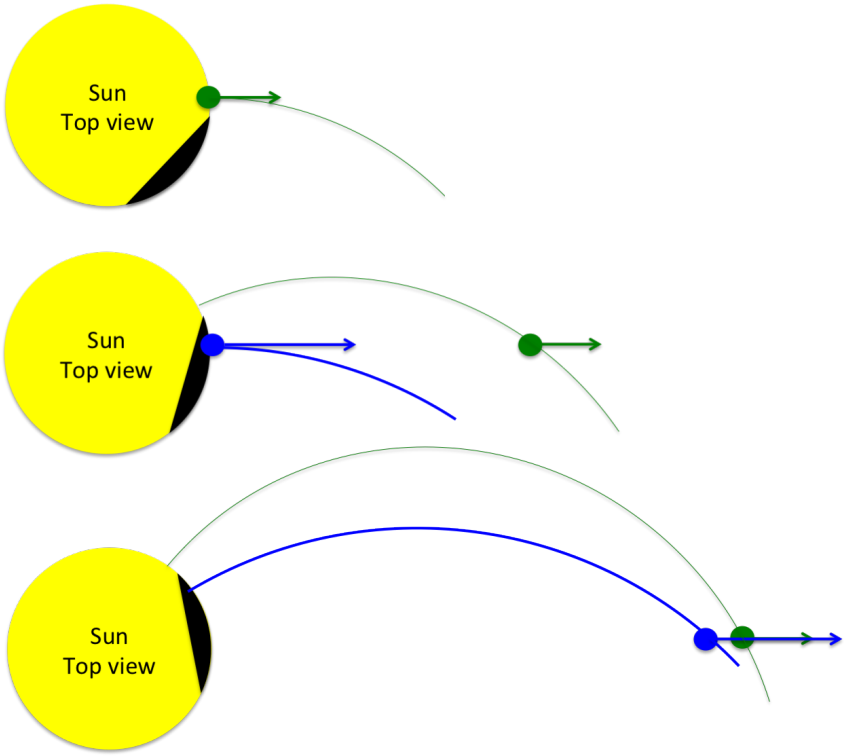
1. Shocking News

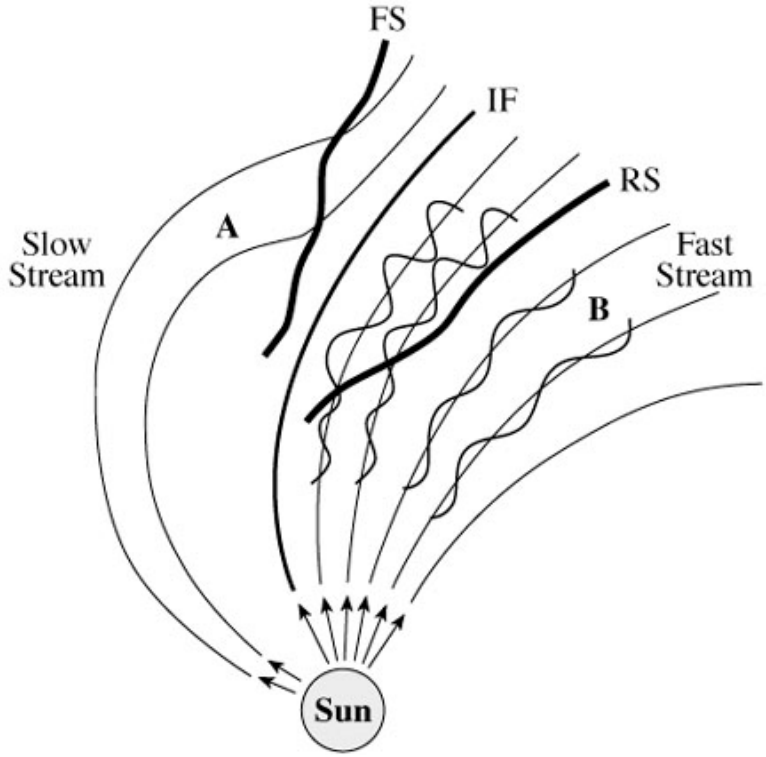
On December 8 and 13, something particularly interesting happened in the solar wind: ACE in situ solar wind data showed a shock and both times the shock was driven by a coronal hole. Shocks driven by a coronal mass ejection are common. But this was shocking news.

Fast catches up with slow

The solar wind flowing from a coronal hole is boosted in speed. In the cartoon you see a fast blue solar plasma particle from a coronal hole (black structure) catching up with the slow green solar plasma particles that left the Sun earlier. The Sun rotates and as such the coronal hole turns with the Sun. The green and blue line represent the magnetic tentacles of the Sun that even reach the boundary of the heliosphere. The green line is more curved because it is linked with a slower solar wind, while the blue line is slightly more radial because of a faster solar wind.



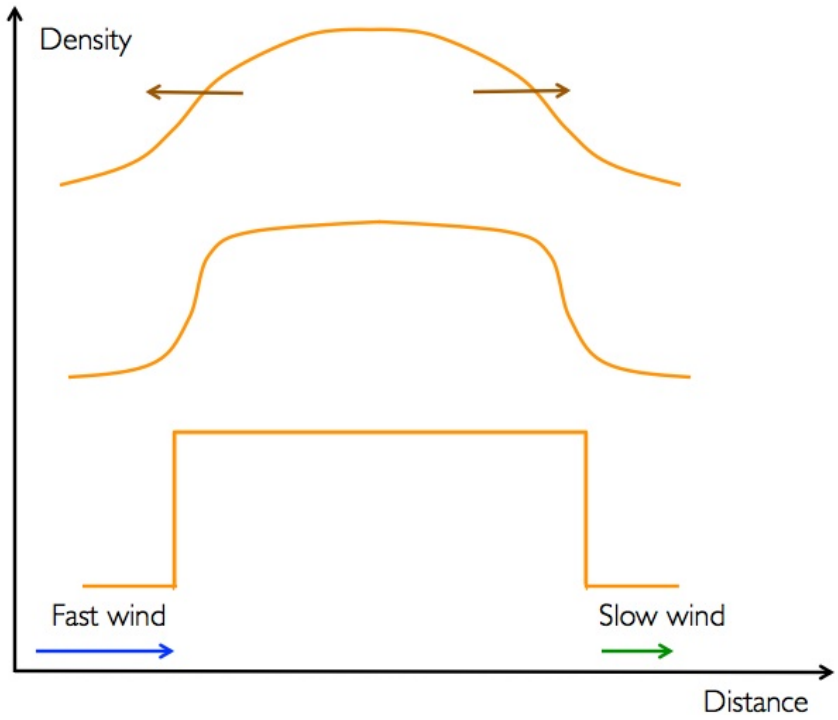
Fast and slow interact in the region between the green and blue line resulting in an increased magnetic field strength and density in the region between A and B in the figure by Gonzalez (1999) with structures like a Forward Shock, InterFace, Reserved Shock.



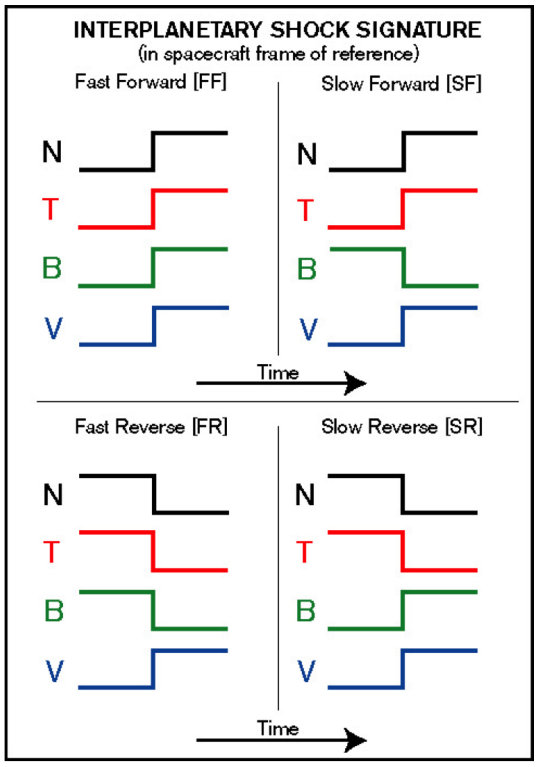
Let's try to explain this in terms of density.

Attention - Levelling works ahead

The density profile of the interaction region (co-rotating interaction region, CIR) looks like a hill that moves away from the Sun. In front of the hill, you have a slow wind while a fast wind is trailing. Nature tries to expand the dense structure to get rid of the density hill and put a flat landscape in place. By moving the front flank to the right and the behind flank to the left, the density curve is stretched and flattened; and both flanks will be steepened to finally result in a crude passage from low/high to high/low density which mathematicians like to call a step function and solar physicians have a mouth full of a shock.



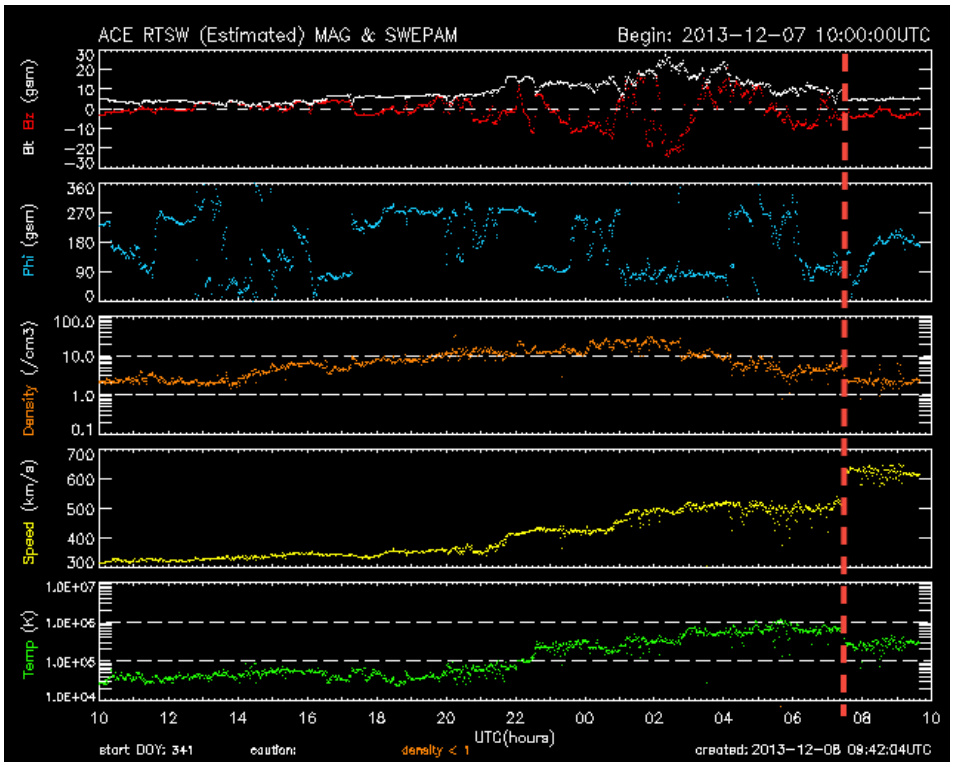
The front flank needs to move of course faster than the slow plasma in front of it. The shock in the front is called a forward shock, the shock trailing the high density region is called a reversed shock. For all shocks, it is the difference in speed between the slow and the fast solar wind that drives the whole system. When a forward shock driven by a CIR passes an instrument that makes in situ measurements, the speed, density and temperature suddenly increase. When a reversed shock passes, the speed increases, but density and temperature decrease.

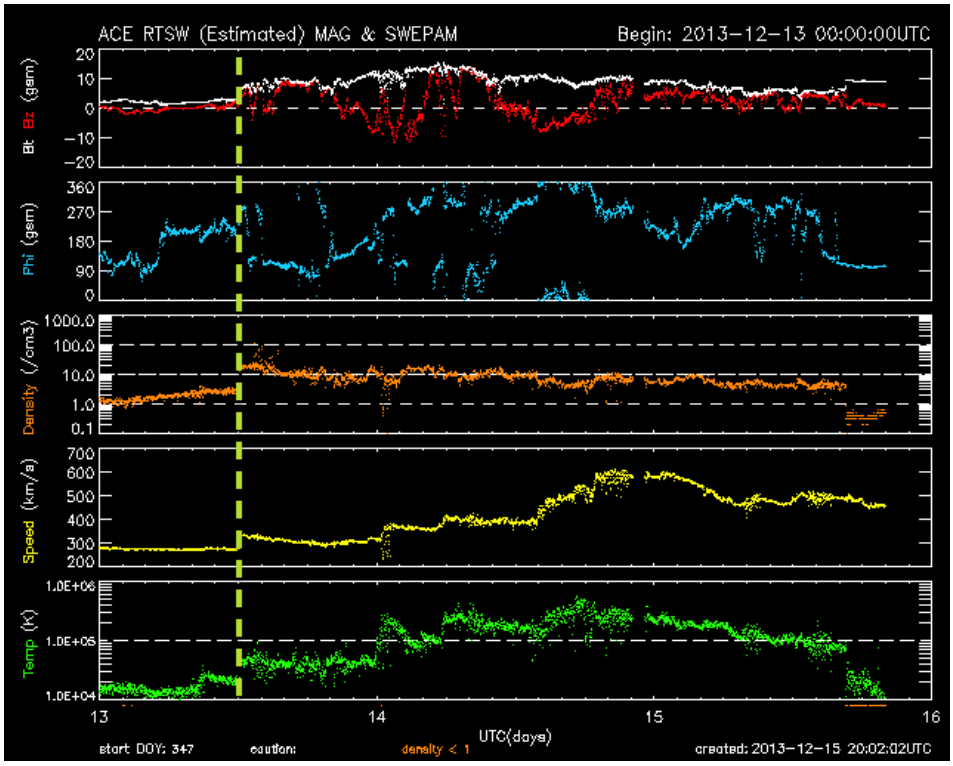


Once passed the reversed shock, you end up in the fast stream emanating from the coronal hole with a typically low density and high speed such that the plasma flux is the same and in the part where you have a slow but dense plasma.

What really happened

Forward and Reversed Shocks are usually formed well behind Earth which is at 1AU. So, the reversed shock on December 8 and the forward shock on December13 recorded by ACE were exceptional.


ACE RTSW (Estimated) MAG & SWEPAM
Begin: 2013-12-07 10:00:00UTC
Bt Bz (gsm)
Phi (gsm)
Density (/cm3)
Speed (km/s)
Temp (K)
UTC(hours)
start DOY: 341
caution:
density < 1
created: 2013-12-08 09:42:04UTC


ACE RTSW (Estimated) MAG & SWEPAM
Begin: 2013-12-13 00:00:00UTC
Bt Bz (gsm)
Phi (gsm)
Density (/cm3)
Speed (km/s)
Temp (K)
UTC(days)
start DOY: 347
caution:
density < 1
created: 2013-12-15 20:02:02UTC

2. PROBA2 Observations (9 Dec 2013 - 15 Dec 2013)

Solar Activity

Solar flare activity stayed low during the week.
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 (SWAP week 194).
http://proba2.oma.be/swap/data/mpg/movies/WeeklyReportMovies/WR194_Dec09_Dec15/weekly_movie_2013_12_09.mp4
Details about some of this week's events, can be found further below.

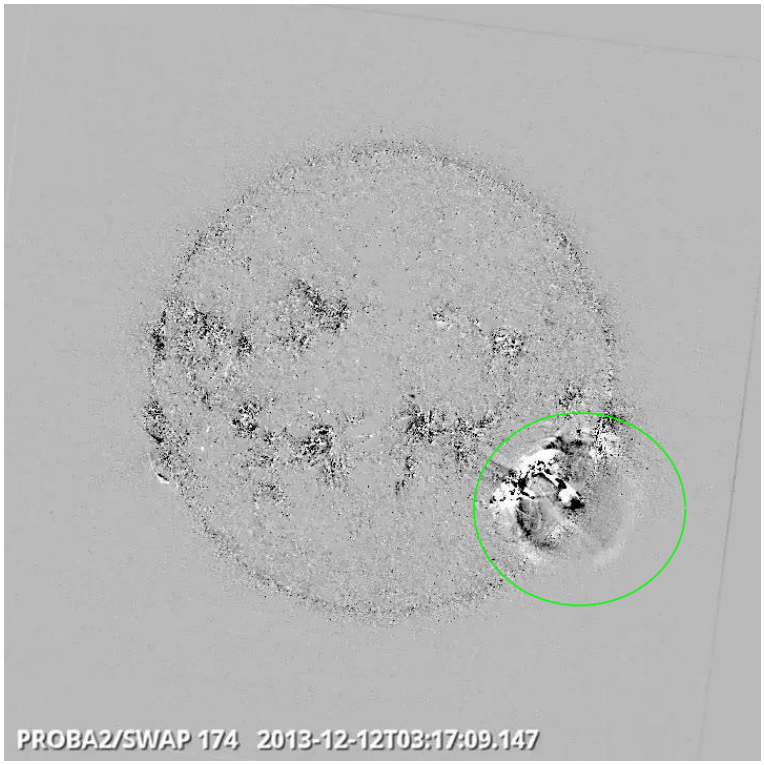
Monday Dec 09:

Outflow in South East Quadrant @ 11:31 - SWAP difference image
Find a movie of the events here (SWAP difference movie)
http://proba2.oma.be/swap/data/mpg/movies/WeeklyReportMovies/WR194_Dec09_Dec15/Events/20131209_Eruption_SoutEastQuad_1131_swap_diff.mp4
Find a movie of the events here (SWAP movie)
http://proba2.oma.be/swap/data/mpg/movies/WeeklyReportMovies/WR194_Dec09_Dec15/Events/20131209_Eruption_SoutEastQuad_1131_swap_movie.mp4

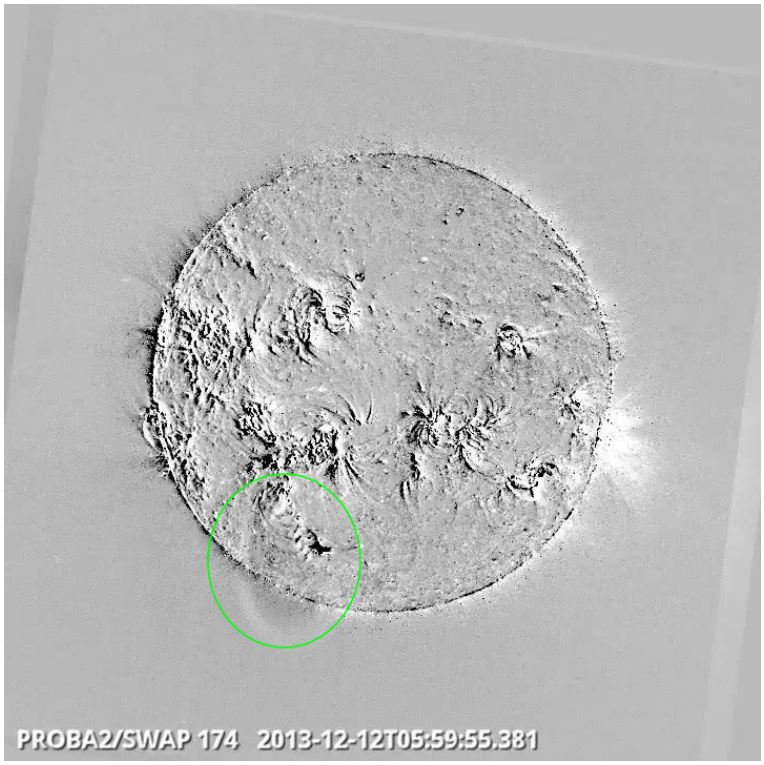
Wednesday Dec 11:

Thursday Dec 12:

Eruption on South East Quad @ 07:04 - SWAP difference image
Find a movie of the event here (SWAP difference movie)
http://proba2.oma.be/swap/data/mpg/movies/WeeklyReportMovies/WR194_Dec09_Dec15/Events/20131211_Eruption_SouthEastQuad_0704_swap_diff.mp4
Find a movie of the event here (SWAP movie)
http://proba2.oma.be/swap/data/mpg/movies/WeeklyReportMovies/WR194_Dec09_Dec15/Events/20131211_Eruption_SouthEastQuad_0704_swap_movie.mp4



Eruption on South West Quad @ 03:17 - SWAP difference image
Find a movie of the event here (SWAP difference movie)
http://proba2.oma.be/swap/data/mpg/movies/WeeklyReportMovies/WR194_Dec09_Dec15/Events/20131212_Eruption_SouthWestQuad_0317_swap_diff.mp4



Eruption on South East Quad @ 05:59 - SWAP difference image
Find a movie of the event here (SWAP difference movie)
http://proba2.oma.be/swap/data/mpg/movies/WeeklyReportMovies/WR194_Dec09_Dec15/Events/20131212_Eruption_SouthEastQuad_0559_swap_diff.jpg.png

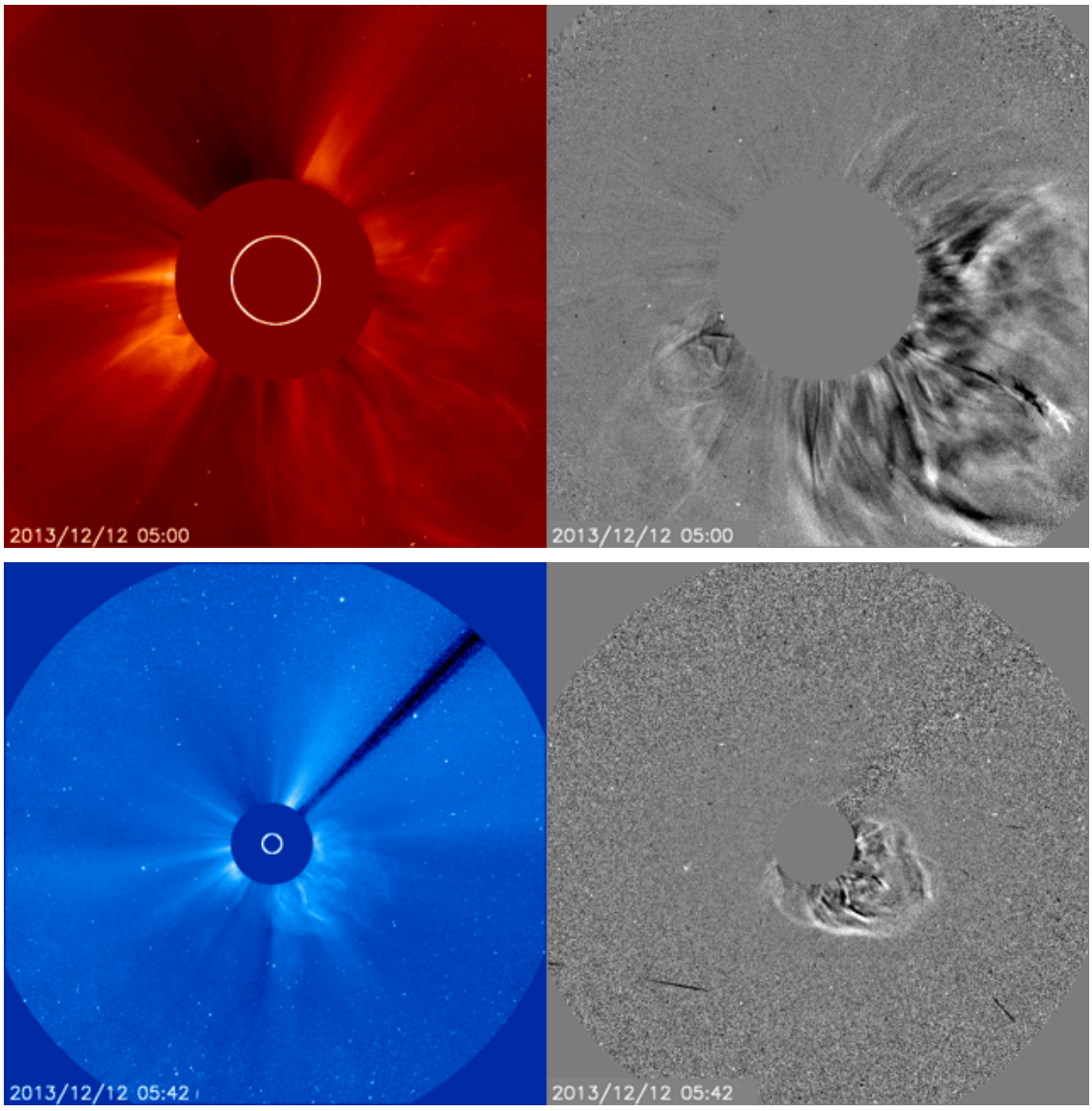
3. Review of solar activity (9 Dec 2013 - 15 Dec 2013)

C-flares and more C-flares

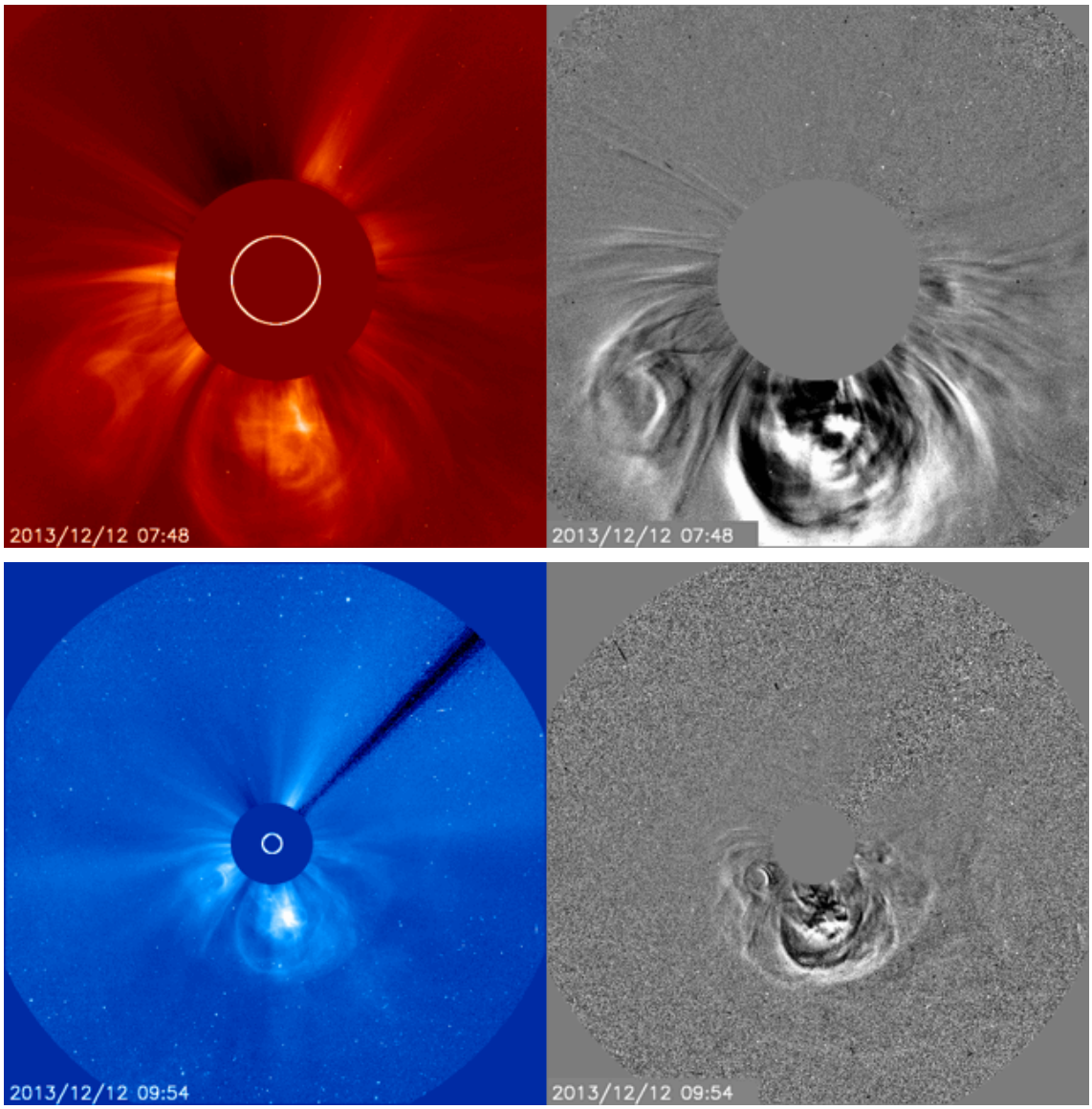
We had a variety of active regions that pushed the X-ray background radiation to the upper B level. It was NOAA AR 1917 that dominated the C-flaring scenery by being present the whole week.

Front and back sided CME's

December 12, late 13 and 14 were CME top days.
NOAA AR 1912 released a long duration C4.6 flare peaking at 03:36UT on December 12. The filament in its neighbourhood became unstable and erupted. The south-west directed CME came into the LASCO/C2 field of view at 3:36UT. The speed was estimated to be around 1000 km/s by the soho-halo-alerts.



A little later, a filament situated on the solar disk beneath the NOAA AR 1917 erupted in the south-east direction and came into the LASCO/C2 view at 6:24UT. The CME had an estimated speed of around 700km/s according to the soho-halo-alerts. It was the second time this week that a filament and an active region in each others neighbourhood are the ingredients of a recipe for an eruption.



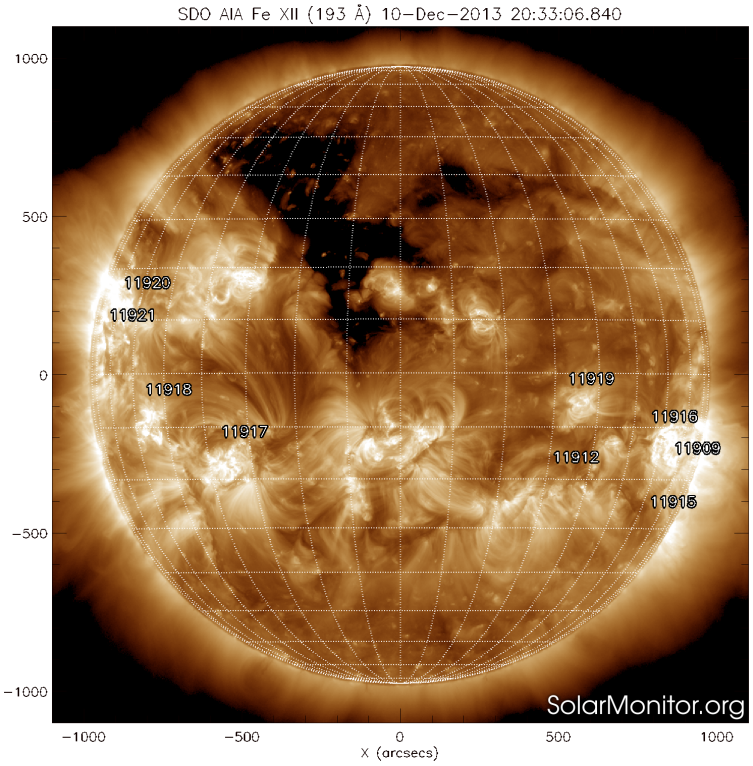
Late December 13, two CME's lighted up the south-east part of LASCO/C2 between 20UT and 21UT. This trend continued on December 14 on both the south-east and south-west limb. On disk however, there was not much to see. This is an argument to say that the source regions were just behind the limb. As a result, the December 13,14 CME's were not geoeffective.

Protons

There was a slight proton flux increase on December 14 and 15. The cause of this increase is unclear. It might be an eastern hemisphere event produced by an eruption in a far side active region linked with a plasma eruption early December 14. It might be linked with the co-rotating interaction region induced shock - see tab geomagnetic activity.

A coronal hole you can't neglect

On December 10, a recurrent northern coronal hole dominating the solar SDO/AIA images reached the central meridian. It was very likely to become geoeffective and it did (see tab geomagnetic activity).

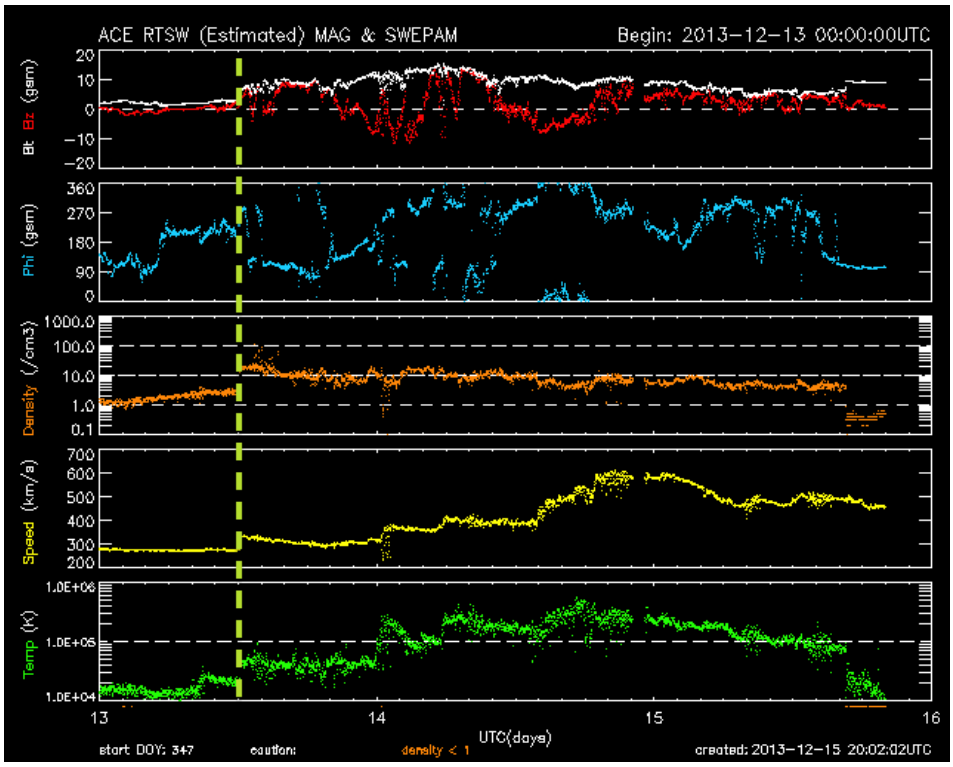


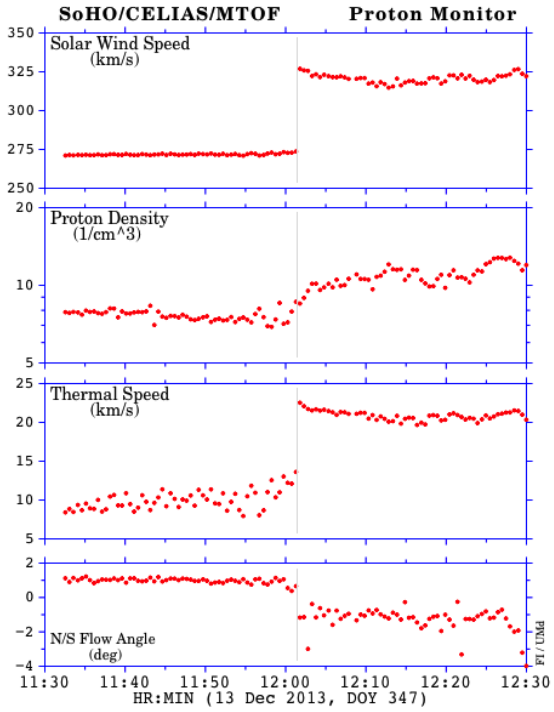
4. Review of geomagnetic activity (9 Dec 2013 - 15 Dec 2013)

If there was something happening in the geomagnetic field of the Earth, it was on December 13, 14 and 15: a shock driven by a co-rotating interaction region (CIR) and an ICME without a preceding shock. Shocking, isn't it?

Fast and slow wind interaction as a driver of a shock

A forward shock was seen in ACE solar wind data on December 13 around 12UT: temperature, density and magnetic field increased, the speed increased from around 270 km/s to 330 km/s.



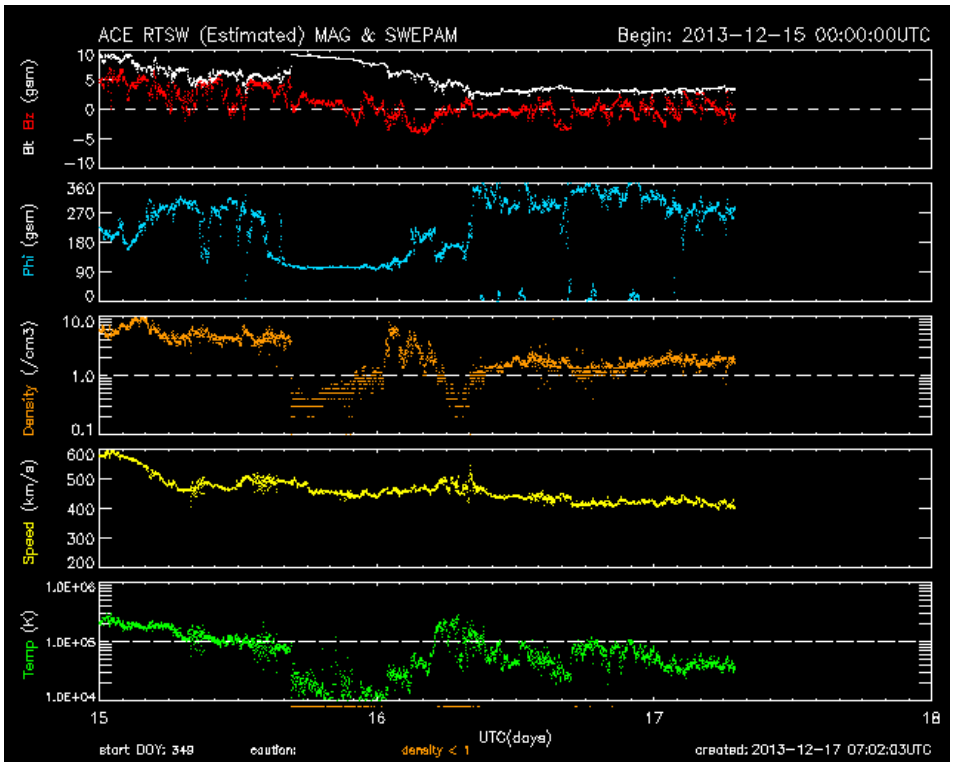


The driver of the shock was probably the fast stream emanating from the coronal hole that reached the central meridian on December 10. It is unusual that a shock driven by a CIR is formed at 1 AU. This depends on the speed of the fast stream compared with the background solar wind speed: when the difference is larger, the shock is formed closer to the Sun. Due to the increased magnetic and plasma

pressure and the negative Bz component of the magnetic field, the planetary K index became 4 during two 3-hour intervals on December 14.

Coronal mass ejection without a shock

On December 15, between 16UT and 17UT, a few solar wind parameters suddenly jumped to a lower/ higher value: the magnetic field increased, while the temperature and density dropped. The magnetic field strength had a smooth profile indicating that ACE passed through a flank of an interplanetary CME (ICME).



As the CME travels further in space, ACE located at 1AU (Astronomical Unit) 'sees' that part of the CME along the path of the red line in the cartoon.

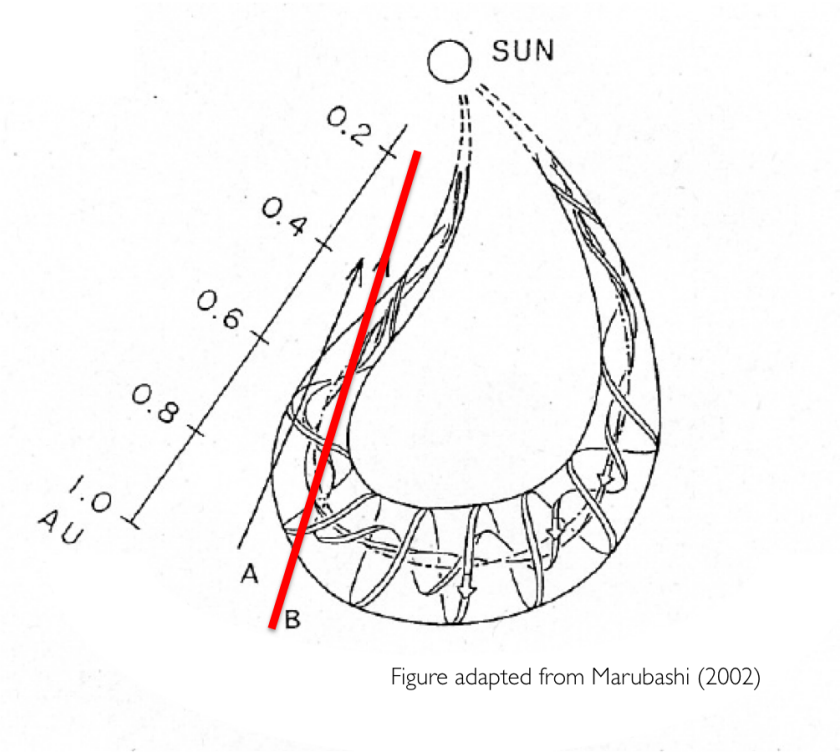
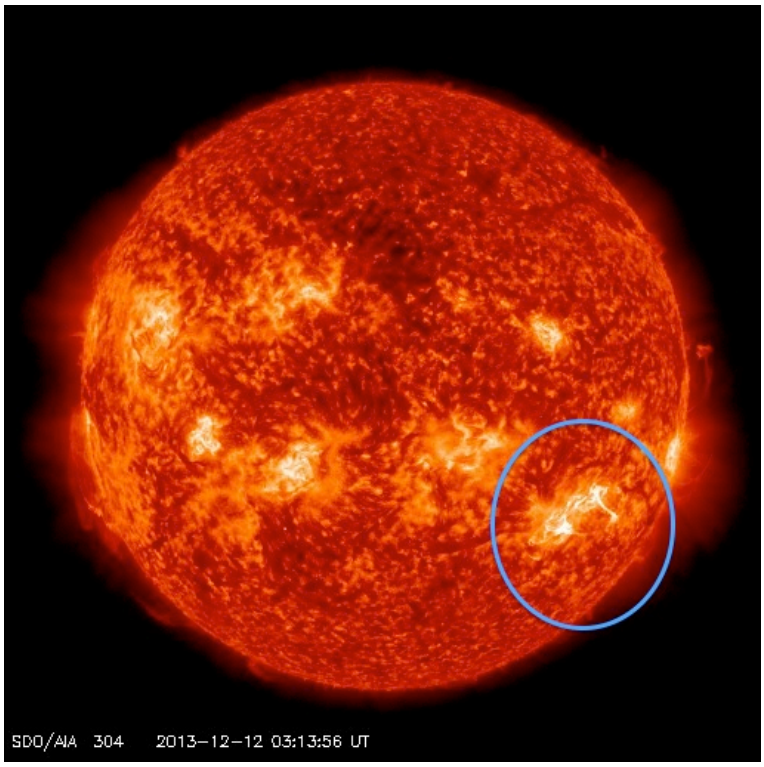
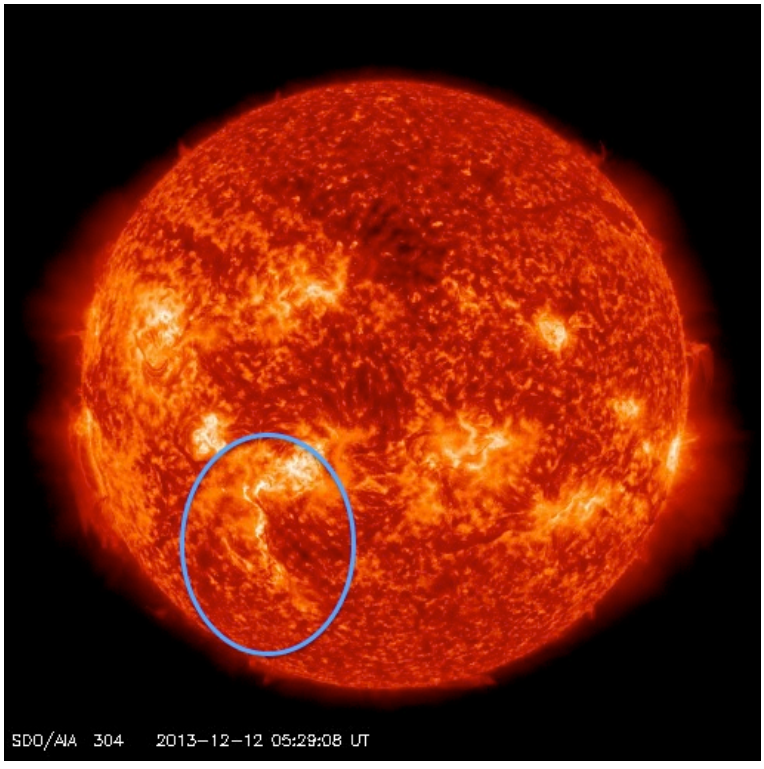


Figure adapted from Marubashi (2002)

It is a speed difference between plasmas that causes shocks to be formed. In this case, there was no preceding shock formed because the solar wind and the CME had comparable speeds of around 500 km/s.

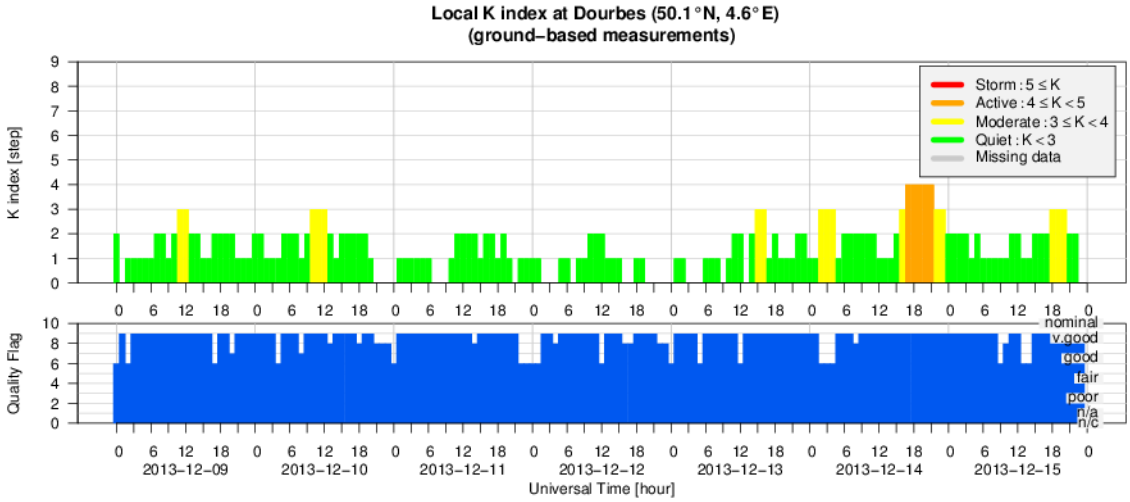
It takes plasma travelling at a speed of 500 km/s a little more than 3 days to bridge the distance between the Sun and the Earth. Counting back 3 days, we arrive at December 12: the day that 2 partial halo CME's left the Sun's surface. The time of occurrence is an argument to link the ICME with the first CME (3:36UT), the position of the filament on the solar disk is an argument to link the ICME with the south-west CME of 6:24UT.



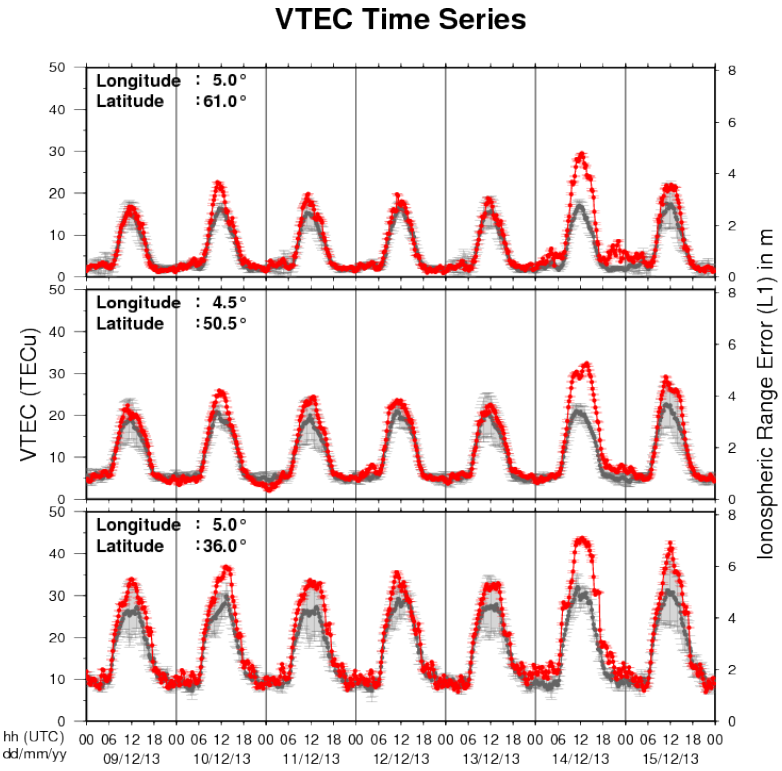


But no worries, the passage through the flank of the ICME had almost no geomagnetic impact (Kp = 3).

5. Geomagnetic Observations at Dourbes (9 Dec 2013 - 15 Dec 2013)



6. Review of ionospheric activity (9 Dec 2013 - 15 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

ESWW10: Splinter "Next Generation SPENVIS"

Slides presented during the ESWW10 Splinter "Next Generation SPENVIS" on Tuesday November 19th, 2013, by Kruglanski Michel The Space Environment Information System (SPENVIS, http://www.spenvis.oma.be/) is a ESA web-based interface for assessing the space environment and its effects on spacecraft systems and crews under continual development since 1996 and used by a worldwide community. This ESWW10 splinter meeting offered the opportunity to SPENVIS users and model developers to meet the SPENVIS development team and share their feedback and questions. Latest updates on the development of the new system (Next Generation SPENVIS) were reported.
http://www.spaceweather.eu/en/repository/show?id=484

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