Solar-Terrestrial Centre of Excellence

Annual Report 2014

Belgian Science Policy Office belspo

Royal Observatory of Belgium

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STCE

Solar-**T**errestrial **C**entre of **E**xcellence

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Front-page: *In 2014, NOAA 2192 -the largest sunspot group in more than 20 years- transited the solar disk. It was also the year during which PROBA2 celebrated its lustrum, BISA its 50th anniversary, and the ESWW its 11th edition. Some STCE colleagues travelled all the way to Antarctica to perform critical scientific experiments.*

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Preface

Dear reader,

The Solar-Terrestrial Centre of Excellence unifies the Sun-Space-Earth expertise present in Belgium, creating a gateway to excellence. We did indeed very well in the past years and especially in 2014.

Year after year, we build upon our knowledge and know-how to tackle numerous and exciting new projects. By doing so, we validate our leading role in Europe and even worldwide. This year, we faced our challenges head-on and celebrated our successes and achievements. We did amazing things, too many to mention in a few sentences, but all with one common denominator: excellence.

It is therefore with pride that I present to you this annual report. I hope you enjoy reading it as much as I did and that it invigorates your enthusiasm about the STCE.

As such, we are looking forward to meet you at one of our forthcoming activities.

Kind regards
Ronald Van der Linden
General Coordinator of the Solar-Terrestrial Centre of Excellence
Director General of the Royal Observatory of Belgium

Structure of the STCE

The Solar-Terrestrial Centre of Excellence is a project of scientific collaboration that focuses on the Sun, through interplanetary space, up to the Earth and its atmosphere.

The solid base of the STCE is the expertise that exists in the 3 Federal Scientific Institutes of the Brussels Space Pole: the Royal Observatory of Belgium, the Royal Meteorological Institute and the Belgian Institute for Space Aeronomy. The STCE supports fundamental solar, terrestrial and atmospheric physics research, is involved in earth-based observations and space missions, offers a broad variety of services (mainly linked to space weather and space climate) and operates a fully established space weather application centre. The scientists act at different levels within the frame of local, national and international collaborations of scientific and industrial partners.

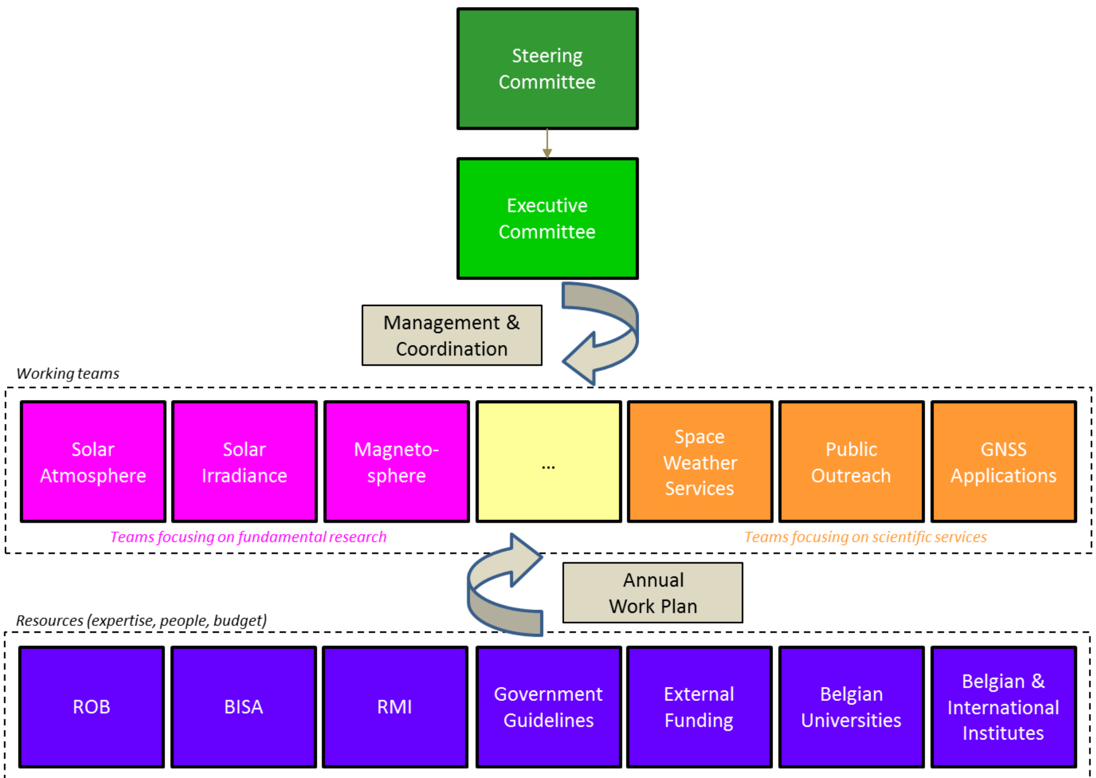


Figure 1: The STCE management structure

The STCE's strengths are based on sharing know-how, manpower, and infrastructure.

In order to optimize the coordination between the various working groups and institutions, as well as the available resources such as ICT, personnel and budget, a management structure for the STCE was put into place, consisting of a steering committee and an executive committee.

The ***steering committee*** takes all the final decisions on critical matters with regard to the STCE. It assures the integration of the STCE into the 3 institutions and the execution of the strategic plans. It is composed of:

- BELSPO Director General "Research Programs and Applications"

  Dr. Frank Monteny (BELSPO)

- Director General of each of the 3 institutions at the Space Pole

  Dr. Ronald Van der Linden (ROB)
  Dr. Daniel Gellens (RMI)
  Dr. Martine De Mazière (BISA)

The ***executive committee*** assures the global coordination between the working groups and the correct use of the budgetary means for the various projects. It also identifies new opportunities and is the advisory body to the Steering Committee. It is composed of:

- STCE Coordinator

  Dr. Ronald Van der Linden

- Representatives of the research teams in the 3 institutes

  Dr. David Berghmans (ROB)
  Dr. Carine Bruyninx (ROB)
  Dr. Johan De Keyser (BISA)
  Dr. Michel Kruglanski (BISA)
  Dr. Stanimir Stankov (RMI)
  Dr. Steven Dewitte (RMI)
  Dr. Hugo De Backer (RMI)

A promotional movie giving a flavor of the STCE's tasks, interactions and various research programs can be found via the STCE website (in English, and subtitled in French and Dutch).

Figure 2: An international team of researchers and ICT specialists enjoying a piece of pie… just for the fun of it!

Monitoring Space Weather: Solar-Terrestrial Highlights in 2014

The official annual sunspot number (SSN) for 2014, as determined by the WDC-SILSO (World Data Center - Sunspot Index and Long-term Solar Observations), was 78.9. This is a 21% increase compared to the previous year.

February was not only the month with the highest monthly sunspot number in 2014, but also of the entire solar cycle so far. With 102.3, it's also the only month with a sunspot number above 100. Analysis by the [WDC-SILSO] indicates that the smoothed SSN reached a new maximum (81.9) in April 2014. This is higher than the previous peak in February 2012 (66.9), indicating that April 2014 is probably the month at which Solar Cycle 24 (SC24) reached its true maximum. Also, this smoothed SSN corresponds rather well with the prediction from the international prediction panel back in 2009, albeit occurring significantly later than expected. Throughout the year, the official daily SSN ranged between 0 (17 July; a spotless day) and 154 (27 February), being mostly dominated by the southern solar hemisphere.

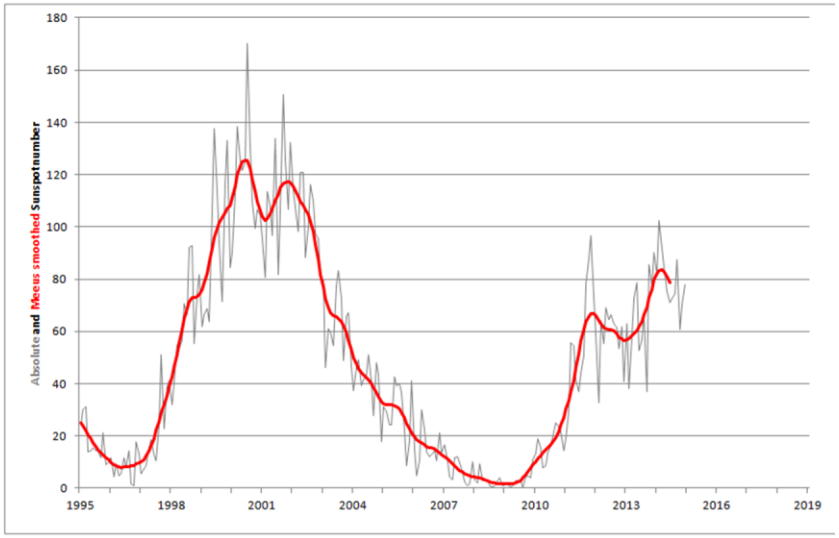


Figure 3: The evolution of the monthly and monthly smoothed SSN (1995-2014). SC24 reached its maximum during the spring of 2014, driven essentially by the continued high activity on the southern hemisphere.

If anything, 2014 will especially be remembered for the giant sunspot group NOAA 2192, visible from 16 till 30 October. While it was still 2 days behind the Sun's southeast limb, the region already produced a complex M2 flare on 14 October, lasting an impressive 5 hours and 12 minutes, and developing huge post-flare coronal loops well outside SDO's field-of-view (FOV).

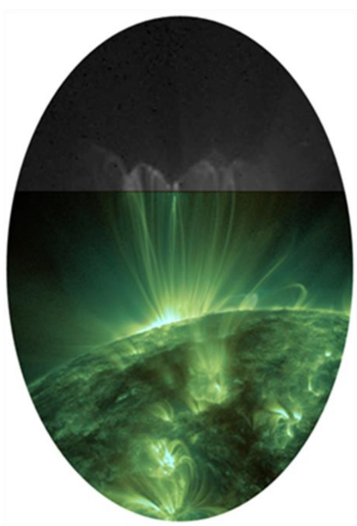


Figure 4: A combined PROBA2/SDO image showing the huge coronal loops following the M2 flare of 14 October. This long duration arcade was visible for about 60 hours (!), and the loops were towering at least 340.000 km above the solar surface. That's close to the average Earth-Moon distance!

With an area of 16 times the surface area of the Earth, NOAA 2192 was the largest sunspot group since NOAA 6368 in November 1990. Its size caused the Total Solar Irradiance (TSI) to drop from 1361 to 1358 W/m^2 as it transited the solar disk. NOAA 2192 would produce 6 X- and 35 M-class flares during its transit, dwarfing flare activity from any other SC24 sunspot region (so far).

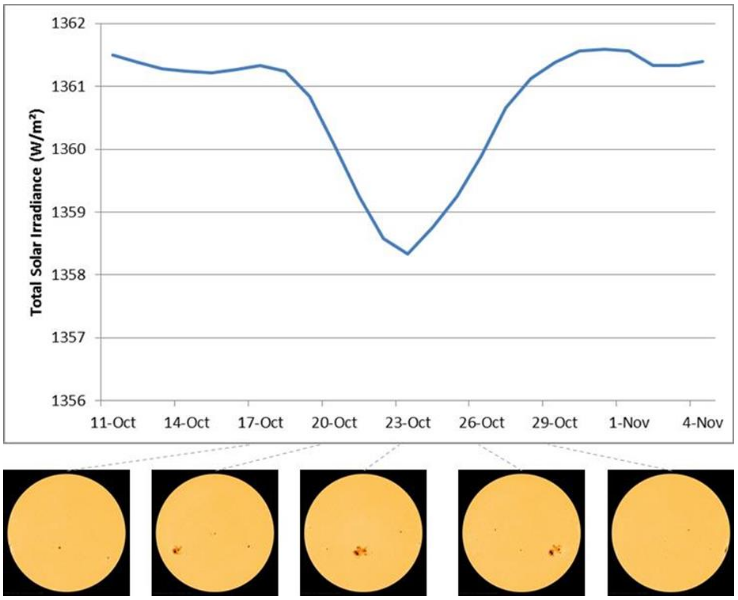


*Figure 5: **PMOD/WRC measurements** showed a significant drop in the TSI as NOAA 2192 transited the solar disk. It was the largest drop so far this solar cycle, and the largest since the transit of the Halloween groups in October 2003.*

Interestingly, no proton events and only one CME were associated with these flares. During its second transit as NOAA 2209 , the group had simplified significantly and had become much smaller, the main spot resembling very much a bear claw. It produced only 3 M-class flares. The coronal structure towering above the active region could be followed for more than 2 complete solar rotations.

Strong solar flare activity was not confined to these two October weeks, but happened throughout the year. NOAA 1944, another large-sized sunspot group, produced an X1 flare on 7 January which was accompanied by a proton event that would reach 1030 pfu (particle flux units) two days later. This would become the strongest proton event of 2014, and the only strong solar radiation storm of the year (S3 – see the NOAA scales), but still 6 times less intense than the strongest event so far this solar cycle (8 March 2012).

On 25 February, NOAA 1990 would produce the strongest flare of 2014. The X4.9 flare was the third strongest of SC24 so far and was accompanied by a small proton event and a relatively fast asymmetric halo coronal mass ejection (CME). The shock from this CME caused a moderate geomagnetic storm on 27 February.

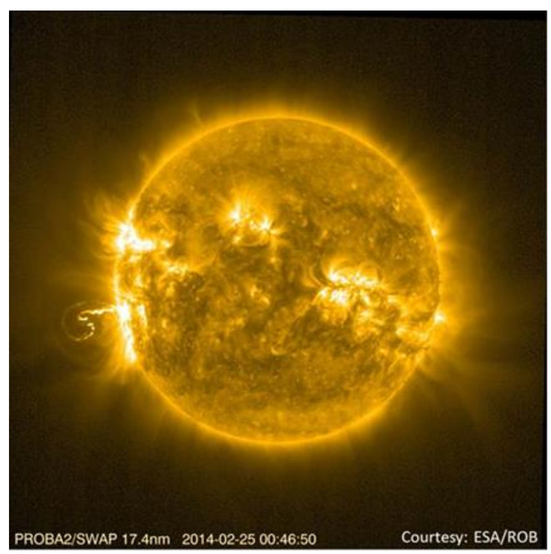


Figure 6: PROBA2/SWAP captured this image in extreme ultraviolet (EUV) of the strongest flare of the year on 25 February.

On 10 and 11 June, NOAA 2087 released 3 X-class flares. In particular the first two were interesting, as the peaks of the X2 and X1 flare were separated by only 70 minutes. Also, the X2-flare lasted only 8 minutes, the shortest duration for any X-class flare in 2014. None of these were exceptional, as every solar cycle has had a few of these impulsive X-class flares. According to CACTus, the CME associated with the X1 flare was also one of the fastest in 2014, with a plane-of-the-sky speed of 1531 km/s.

Another explosive event took place on 1 September, when the STEREO-B spacecraft observed a strong flare in an active region on the backside of the Sun, estimated to be a low-level X-class flare. The flare was associated with a strong proton flux increase. Amazingly, so many particles were slamming into STEREO-B's camera pixels (creating the white dots in

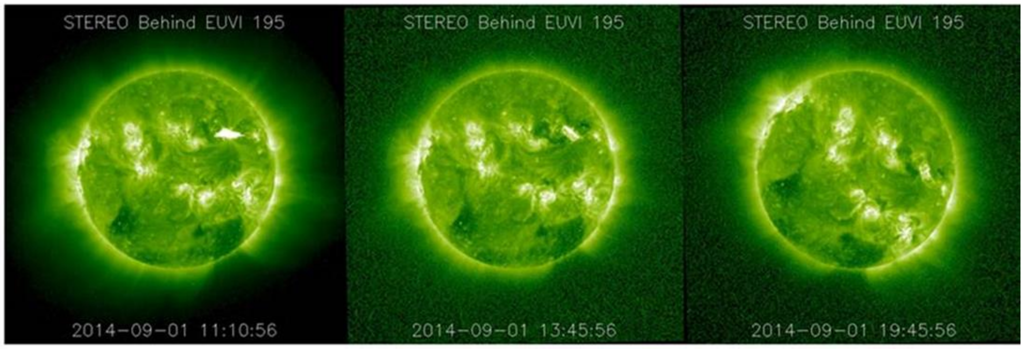


*Figure 7: STEREO-B captured these EUV images of a strong proton flaring event on 1 September 2015. The particles saturated the spacecraft star-trackers, and STEREO-B lost lock on the Sun for about 4 hours (see image on the right). One month later, contact with the STEREO-B space craft was **lost**.*

the images) that they saturated the star-trackers onboard the spacecraft, making them lose lock on the Sun for about 4 hours. This resulted in a not correct orientation of the solar images. On Earth, the proton flux stayed just beneath event threshold, but the large number of particles would enhance proton fluxes for more than a week!

NOAA 2158, the region responsible for this strong backside event, produced a long duration M4 flare peaking early on 9 September, followed by an X1 flare on 10 September. Both were associated with halo CMEs, which arrived at Earth resp. late on 11 September and during the afternoon of 12 September. Initially, the magnetic field of the CME associated to the X1 flare was pointing southward (Bz = -18 nT), resulting in a major geomagnetic storm – one of the strongest of 2014. Then the field turned northward weakening the effects of the passing CME. So far this solar cycle, no extremely severe geomagnetic storms (Kp = 9) have been observed.

Important filament eruptions were observed throughout the year, with some directed to Earth causing considerable geomagnetic activity. Typical examples included the events from 19 February, 4 June, and 12 September. A peculiar eruption occurred on 24 August, when a moderate flare (M5.9) took place in the rather small sunspot group NOAA 2151. The associated CME seemed to be tied to the solar surface at its four outer ends, giving it the outlook of a parachute. Amazingly, though most of the material was ejected into space, some of it reached heights of 4 solar radii before eventually falling back to the solar surface. The filament eruption of 1 November bore quite some resemblance with a similar event on 31 August 2012.

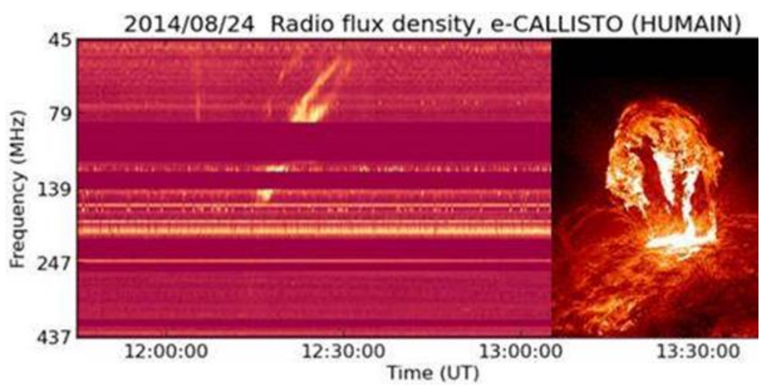


Figure 8: The peculiar outlook of the 24 August CME (inset on the right). A type II radio burst was recorded by the Humain Solar radio Observatory, indicating that a shock travelled through the solar atmosphere.

On 13 January at 06:45UT, the ACE spacecraft recorded the highest near-Earth solar wind speed for 2014, with maximum values of 903 km/s (5-minute average). The source of this high-speed stream was a

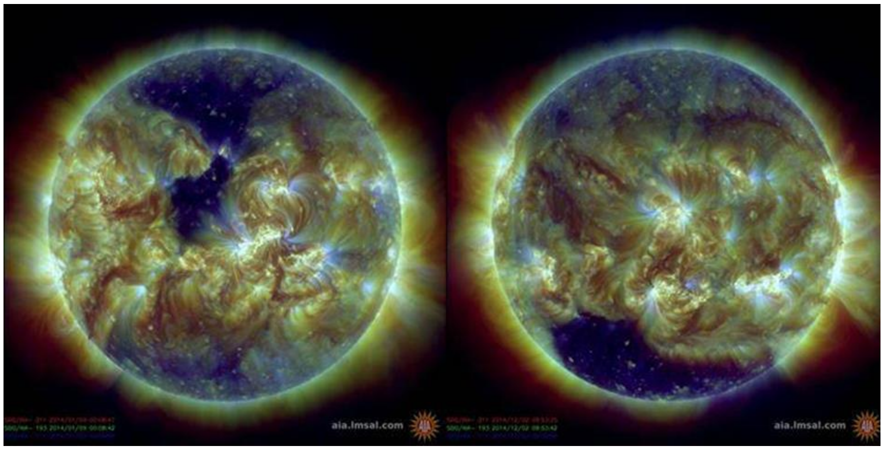


Figure 9: Two large coronal holes in resp. January and December produced a very high solar wind speed (13 January) and a minor geomagnetic storm (7 December). These coronal holes were several hundred times larger than the total surface area of the Earth.

huge trans-equatorial coronal hole (CH) that passed the central meridian on 9 January. According to HEK/Spoca, this CH reached its largest area on 11 January, measuring the equivalent of nearly 370 times the surface area of the Earth. The passing of the wind stream did not result in any geomagnetic storming, due to its mostly northward directed magnetic field.

The largest coronal hole of the year appeared near the Sun's south pole early December. It was so large that the total area of 650 Earths would be needed to cover its surface. It extended from the south pole all the way up to a latitude of about -30 degrees. That was close enough to the solar equator for its high speed wind stream to cause a minor geomagnetic storm on 7 December, with solar wind speeds up to around 800 km/s.

For 6 consecutive days starting on 17 December, the pair of complex sunspot groups NOAA 2241/2242 produced a series of M-class flares culminating in an X1.8 flare on 20 December. The CMEs related to the strongest of these flares had an Earth directed component, and their passing resulted in a minor geomagnetic storm on 22 December. However, the succession of these Earth-directed CMEs also deflected the cosmic rays (high-energetic particles from outside our solar system). Indeed, similar to a multi-layered polar jacket that keeps out the cold, so can one or more well-directed CMEs prevent the cosmic rays from reaching Earth. On 22 December, the neutron monitors (NM) recorded a large drop in (secondary) particles reaching Earth (6-8% - Oulu NM), a so-called Forbush decrease. The December event was similar in intensity than the one from 12 September, but of considerably longer duration. The strongest Forbush decrease so far this solar cycle occurred in March 2012 (10-12%).

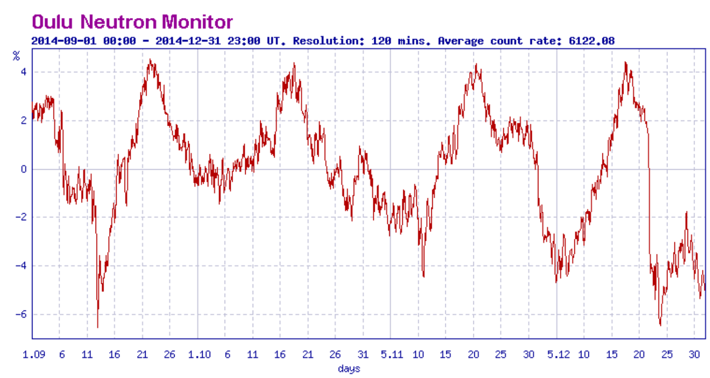


Figure 10: The graph above shows an abrupt decrease in the number of secondary particles (neutrons) reaching the Earth surface on 22 December (right), as %-deviations from the average. The graph covers the period September-December 2014.

SIP7 and ESWW11: Two successful international conferences

Once again, the STCE's Local Organizing Committee (LOC) managed to efficiently organize two international conferences in one year: the seventh Solar Information Processing Workshop (SIP7) and the eleventh European Space Weather Week (ESWW11).

The 7th Solar Information Processing Workshop

From 18 till 21 August 2014, the seventh Solar Information Processing Workshop (SIP7) took place in the lovely town of La Roche-en-Ardenne, Belgium. About 80 solar and space scientists, statisticians, and data processing experts from all over the world convened to discuss the challenges of optimizing the science return of solar and heliospheric missions and to address the data analysis issues of these missions.

Figure 11: A vivid discussion during one of the SIP7 sessions.

Five sessions were distributed over 4 days. Topics included power laws in solar physics, the prediction of solar flares and disturbances, the tracking of small scale magnetic features, the variability of the solar wind, and the optimal combination of in-situ and imaging data. Most sessions were introduced with a tutorial, providing the necessary background and context for further discussions. These introductions were then followed by invited and contributing talks highlighting the latest results and advances. Often, these talks resulted in extensive and high-level Q&A-sessions.

Figure 12: The participants enjoying a game of Kubb.

In order to avoid overheating of the participants' brains, timely coffee breaks provided the necessary relieve and possibility to get more acquainted with each other and each other's work on an informal base. During these breaks as well as over the lunch pause, participants had also the opportunity to play a game of Kubb. This is a game with wooden blocks that seemed even more complex than some of the statistics and algorithms that were presented during the sessions!

The afternoons usually started with a few more talks. These were followed by poster sessions and working group (WG) splinter sessions. The three working groups focused on specific problems related to the tracking of magnetic features, the prediction of solar disturbances, and the optimal combination of in-situ/remote sensing data. The WGs aimed at encouraging informal discussions by all participants to spark collaborations and how to improve the accuracy of predictions and tracking. The WGs convened in specific break-out rooms on Monday and Wednesday, and the results were presented at the end of the workshop.

Figure 13: A visit of the "Battle of the Bulge" Memorial preceded the conference dinner.

On Monday, there was also a 2-hour demo session, during which as many as six software applications were presented in parallel. Hence, the participants had ample opportunity to learn more on JHelioviewer, SoFAST, SunPy, SWAMIS,… just to name a few. On Tuesday, micro workshops addressed five specific problems related to SIP. The aim was to exchange ideas how to tackle issues such as the study of Quasi-Periodic Pulsations (QPP) in solar flares, the detection of Coronal Mass Ejections, to-do's for SunPy,… The identified problems and potential solutions echoed through into the animated panel discussion that ended the SIP7 workshop.

From the program above, it may be clear that these were long and intense days. Fortunately, social activities came to the rescue. There was a beer-tasting event on Monday evening, and a conference dinner on Wednesday evening near Bastogne (including a visit to the Mardasson "Battle of the Bulge" Memorial). On Thursday afternoon, there was a nice hike in the surrounding woods, and the conference ended with a barbecue, after which some of the participants went out to catch a glimpse of the dreaded ghost of the castle (whooo!...).

Figure 14: Dr. Véronique Delouille graciously chaired the SIP7 and made sure that related papers got published in the SWSC Journal.

The program of SIP7, links to the various presentations, and pictures of the meeting and social activities can be found at the website of SIP7. Papers related to this workshop are published in a topical issue of the SWSC Journal. The next SIP workshop ("SIP8") will take place in Boulder in 2016.

The 11th European Space Weather Week

Figure 15: ESWW is the ultimate space weather experience of science and fun.

Each year, scientists from all over the world gather in Belgium to discuss the newest insights in space weather during the European Space Weather Week (ESWW) conference, an organization of the STCE and the European Space Agency. The 2014 edition was the eleventh one with more than 400 participants and took place in Liège. Space weather science, space missions, data, products and services were presented to the space weather community and discussed trying to find an appropriate answer to the challenges and threats that space weather imposes. Scientists have a theoretical approach and want to understand the physical processes, engineers look for space weather proof techniques, space weather forecasters predict and warn for space weather impacts, companies look for user-friendly solutions, etc. Each community is involved in a particular part of the space weather chain.

ESWW11 had 14 science sessions, 21 working meetings, a space weather fair followed by the "Science Café", and a daily live space weather forecast by the main forecast centers. One of the strengths of the conference is that the participants make up the content of the ESWW by proposing sessions and working meetings.

Figure 16: Just during ESWW11, a very big sunspot was present on the solar disk. At the end of October, this spot, which was visible with the naked eye, caused commotion because it produced many extreme solar flares. Satellite operators were alarmed and prepared for potentially large particle storms that luckily did not materialize. The return of this super sunspot group was observed live from Liège!

The space weather medal award is becoming an established event during the ESWW. Three medals were attributed. The medal for outstanding scientific or technological results went to Prof. Reinisch. The medal rewarding efforts to structure the space weather community at an international level was for Dr. Davila, and Dr. Plainaki received the medal for "outstanding research and/or service development as a young researcher".

The keynote “The Sun among the stars” was very much appreciated, similar as the tutorial “Solar Space instrumentation, from lab to space”. ESWW is also characterized by simply having fun: activities such as the conference dinner with a space weather bingo, a test of strength with a rocket quiz, the award for “the best contribution per session”, and a “Bad conference practices” movie showing in an ironic way how (not) to give a presentation that drew many cheers from the audience.

Figure 17: A crowd attending the live space weather forecast.

Every year, we try to re-invent ESWW. In 2014, e-posters were introduced. An e-poster is a dynamical poster shown on a digital screen allowing the author to show movies. It has the advantage that you don’t have to carry a bazooka-like poster tube.

To conclude, ESWW is a platform for the different communities in the space weather chain to blend and tries to offer a perfect mixture of science, work, serious fun and simply fun.

Public Outreach

The Space Pole opens its doors… again!

In 2014, the Belgian Institute for Space Aeronomy (BISA) celebrated its 50th anniversary . On that occasion, an Open Door was organized during the weekend of 11 and 12 October. Despite the bad weather on Saturday, an estimated 7000 people visited the Space Pole. This can be considered as a big success. The STCE participated extensively with numerous activities.

Figure 18: After a brief introduction on solar activity and space weather, visitors got a view of the solar telescopes and the Sun.

An estimated 2000 people visited the ***Solar Dome***. About 10 scientists took turns in guiding groups of about 15 people each. First, there was a short explanation on the sunspot number, the solar cycle and solar eruptions. Then, in a separate room, a short demo was given on the solar images taken by the solar telescopes at Uccle. Obviously, the highlight was the visit of the solar telescopes and -weather permitting- real-time observation of the Sun and the sunspots on a projected solar image. The tours lasted 10-12 minutes and were mostly given in French and Dutch, but there were also a few tours in English and even Spanish, courtesy of our visiting international scientists. Quite a few people stayed after the tour asking additional questions to the tour guides.

In the ***STCE/ROB tent***, scientists gave talks during the entire open door weekend. Each lecture lasted for about 20 minutes and was followed by a 5-minute Q&A-session. Emphasis was on solar activity and its influence on Earth, but also other themes were addressed such as the planets, earthquakes (seismology) and the ionosphere. Links to the various presentations can be found directly at the repository of the European Space Weather Portal (search string "open door"). An estimated total of 350 visitors attended the lectures, with the lectures in French drawing the largest audiences - often a full house!

Figure 19: The series of short talks got a lot of attention from the visitors.

The SSCC-room hosts the European coordination centre for space weather ***SSCC***. Experts explained the functioning of the centre and gave an overview of their daily activities. Co-located was the ***PROBA2 Science Center*** (P2SC) from which all the operations of the PROBA2 satellite are managed. There was a life-size scale model of the PROBA2 satellite, and hundreds of posters and bookmarks were handed out to the enthusiastic crowd. Some kids got so inspired they started themselves giving explanations to other visitors!

Figure 20: Visitors invading the SSCC-room for explanations on space weather, posters of PROBA2, and much more!

In the ***"educative" tent***, numerous experiments were presented by the three institutes. The STCE participated in two experiments. The Planeterrella experiment focused on the research on polar lights. Some technical issues got resolved just in time, and visitors were able to enjoy the soft-pinkish glow of the simulated aurora. There was also a set-up on solar spectroscopy, with a run-of-the-mill spectroscope introducing the visitors to the solar spectrum and in what domains of solar research it is actually used. Though the experiment tent got a lot of competition from the nearby weather balloon launches, they were continuously visited by a very interested audience.

Figure 21: The set-up on solar spectroscopy in the "educative tent".

The Open Door 2014 was a big success. This would not have been possible without the efforts of all the speakers, guides, and other experts patiently explaining and answering all the questions from the crowd. But also the IT-specialists, the helpdesks, and all - and there were many- involved in the logistics and practical organization of the event played a very important role. The thousands of "Thank you's" and smiles from happy visitors certainly testified of the success of the Open Door 2014.

The STCE Annual Meeting

The STCE wants to bring together people around sun-space-earth issues and offers the necessary support and tools to work together on these topics. Workshops are one of the favorite tools and are being organized as such in anticipation of the annual STCE meeting. Radio scientists found each other discussing the modelling of antennas and calibration of radio instruments. During another workshop, a more mathematical discourse was provided on the physical processes in solar-terrestrial plasmas. Other workshops addressed observational facts underlying long term solar changes, and 3D reconstruction in space science and tomography. In a fifth and final workshop, the PROBA family discussed operational, programmatic and technical strategies and concepts. These workshops reflect on the common interests of scientists, technicians and engineers working at the STCE and reveal the overlaps. We aim at putting together and redirecting our expertise towards an efficient use under the moto "the whole is greater than the sum of its parts".

Figure 22: The VIPs of the Meet & Greet stands: Antonio Martinez, Pepijn Cardoen, Julie Berckmans and Dan Ryan.

At the STCE, we like to think that everybody is a celebrity in his or her own field of expertise. As it is a custom procedure that celebrities gather and say "Hi!", this STCE annual meeting also had a "Meet & Greet" session. Participants were guided in small groups to stands on the troposphere (GNSS applications), the mysteries of LYRA, radio science fiction, and the Picasso space technology. Four young employees presented enthusiastically what they had achieved and what future challenges they expect.

Fundamental Research

Radio triangulation and CME physics

The largest eruptive processes in the solar corona are solar flares and coronal mass ejections (CMEs). A solar flare is a process of rapid energy release which causes extensive plasma heating and non-thermal particle acceleration. A CME is the ejection of plasma confined in erupting magnetic flux ropes, propagating from the inner solar corona into the interplanetary space.

The major energy release during the CME/flare process is followed by the formation of large scale disturbances and shock waves that travel through the corona and the interplanetary space. Electrons, accelerated at the propagating shock waves, can induce radio emission: the so-called type II radio bursts (Figure 23). Radio observations cover a broad frequency domain, and since different wavelengths correspond to different heights in the solar atmosphere, radio events can be traced from the low corona up to large distances in the interplanetary medium.

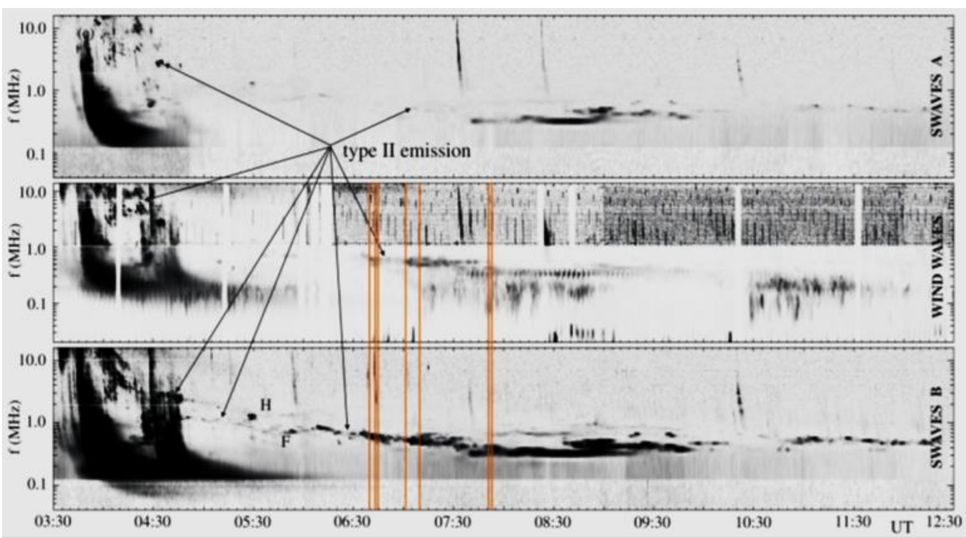


Figure 23: The dynamic spectrum or radio spectrogram is a graphical presentation of the radio emission intensity, recorded at a number of closely spaced single frequencies. In the spectrograms, the horizontal x-axis represents time increasing from left to the right and the vertical y-axis represents frequency. The dynamic spectrum shows radio emission (dark structures) in decameter to kilometer wavelength range. The two top panels show the observations by STEREO/Waves, and the bottom panel shows observations by WIND/Waves. The orange lines indicate times for which radio triangulation analysis was performed.

The understanding of the physics of the propagation of the CMEs and the CME-driven shock waves is of the utmost importance for the space weather forecasting community and consequently a lot of effort is being put in the related studies. However, the relative position of the CME, the associated shock wave and its radio signatures (type II bursts) remains a subject of debate.

One of the important missing information is radio imaging observations (allows positioning of the radio emission) in the interplanetary range. In order to compensate for this lack of spatial information the specific radio observations, so called radio triangulation measurements (also referred to as direction-finding measurements) from two or more widely separated spacecraft are being studied. With the help of different direction-finding methods the radio triangulation observations allow obtaining the position of the radio emission.

In the multi-wavelength study of the 5 March 2012 solar eruptive event (Magdalenić et al., 2014), radio triangulation observations from STEREO-B/Waves and WIND/Waves spacecraft were employed in order to obtain the position of the radio signatures of the shock wave (type II burst) in the interplanetary space. Because of the different types of antenna on these spacecraft, different direction-finding methods were applied for observations from different spacecraft.

An extensive radio triangulation analysis was for the first time applied to different types of radio bursts in the same event. The results of radio triangulation were compared with the CME propagation path reconstructed in three dimensions using SOHO/LASCO coronagraph observations and STEREO COR and HI instruments. It was found that the interaction of the shock wave and a nearby coronal streamer resulted in the intensification of the interplanetary type II radio emission. The source of the type II radio burst was determined to be situated on the southern flank of the CME (Figure 24), and not close to the leading edge of the CME as it is most often assumed. Such a relative position of the radio signatures of the shock wave and the CME explains why, in this and probably also in the majority of other CME/flare events, a strong discrepancy can be found between the CME speeds (usually speeds measured at the nose of the CME) and the shock wave speeds inferred from the radio observations (type II bursts).

This type of the study is currently possible only for the CME/flare events observed by STEREO/Waves A and WIND/Waves spacecraft due to the, hopefully only temporary loss of STEREO-B observations.

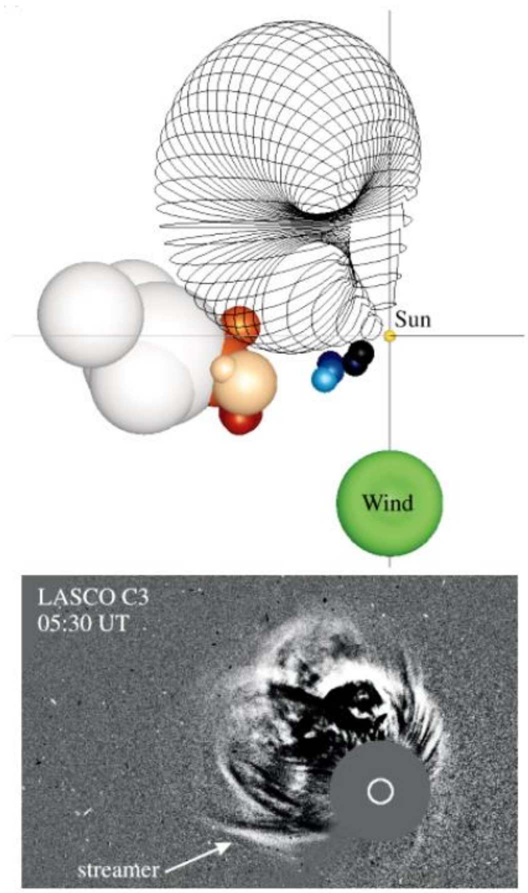


Figure 24: The reconstructed propagation path of the type II radio burst. The view of the reconstructed type II burst sources (orange to gray spheres) together with the reconstructed CME flux rope, as seen from Earth (upper panel). The green sphere is the position of the WIND/Waves spacecraft. The CME flux rope, obtained from the 3D reconstruction with self-similar expansion, is presented as a black grid croissant. The 3D reconstruction of the streamer situated close to the southern flank of the CME is plotted in dark and light blue spheres. The yellow sphere represents the Sun. For comparison, the SOHO/LASCO C3 coronagraph image shows the CME as seen from Earth. The radio source sizes are relative as well as the size of Earth and the Sun.

Helmet and other streamers

ROB runs the Science Center (P2SC) for the Sun-observing instruments on PROBA2. PROBA2 is the second satellite in the European Space Agency's series of PRoject for OnBoard Autonomy (PROBA) missions. The SWAP instrument (Sun Watcher Using APS Detectors and Image Processing) is an EUV imager that detects light at a wavelength of 17.4 nm which is emitted by solar coronal plasma at a temperature of about one million degrees Kelvin. PROBA2 was launched in 2009 and since then, SWAP has been taking high quality data of the solar corona out to a nominal field-of-view (FOV) of 1.7 solar radii.

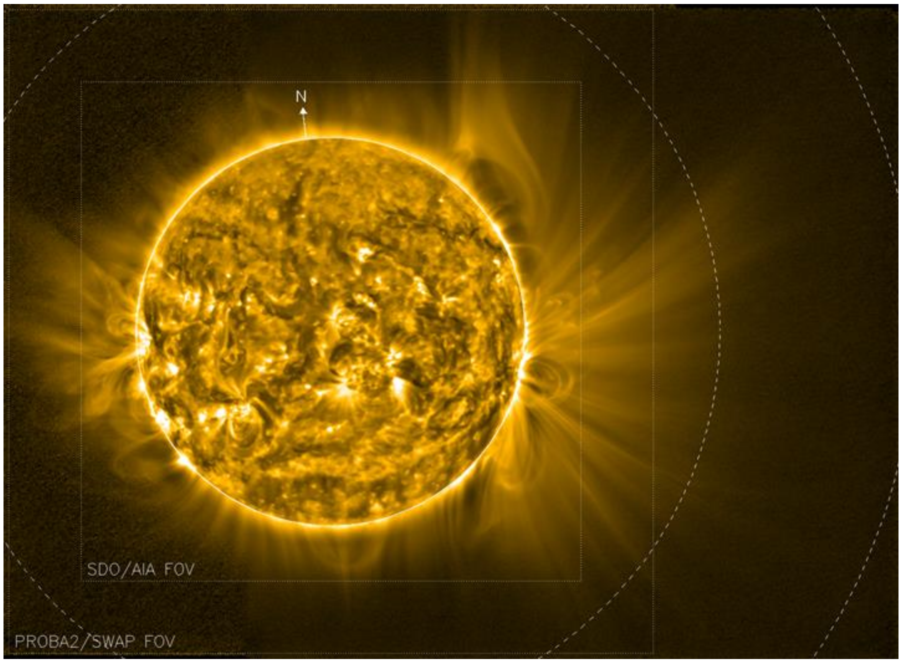


Figure 25: SWAP's large field-of-view (FOV) and off-point capabilities capture solar coronal signal out to nearly three solar radii. Data for this mosaic image, which is made from several SWAP images, was taken on 26 November 2014. Dotted lines indicate the field of view of SWAP and NASA's AIA EUV imagers. The dashed lines are drawn at intervals of one solar radius.

The strength of SWAP compared to other solar EUV imagers relies on its large FOV and its ability to off-point to view the corona at even higher heights, as seen in Figure 25. The extent of the brightness in the corona above the solar disk is dependent on the solar cycle. More features are present at large heights near solar maximum (Seaton et al., 2013). By processing the data to bring out the brightness in the upper corona, the SWAP team at ROB is able to analyze the long-lived features in that region in a more comprehensive way. To facilitate this analysis, we make movies of each Carrington rotation (one full rotation of the Sun, about 27 days). Using the Carrington movies it is easy to identify large structures, and the 3D nature of the corona is clearly visible as these structures rotate with the Sun.

One long-lived structure that we identified using this type of movie was a pseudostreamer, which is a magnetic structure consisting of two side-by-side closed loop tunnels surrounded by open magnetic field, where all of the open field is of the same polarity. Figure 26 shows a SWAP image of this pseudostreamer, where the cusp-shaped boundary between the open field and the closed loop-tunnels is clearly seen in the corona. Pseudostreamers are not uncommon in the corona. However, this one is interesting because it was part of a larger stable structure.

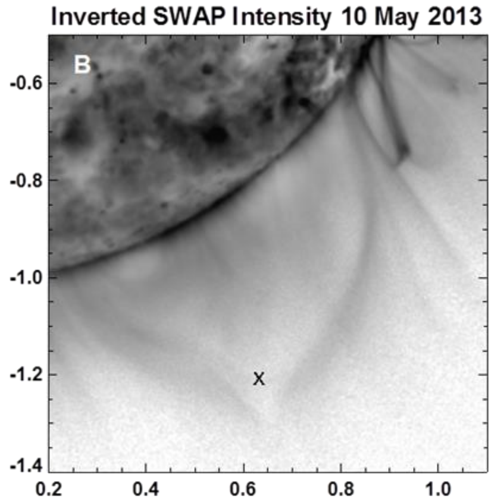


Figure 26: SWAP image of a pseudostreamer. The color-table has been inverted so that bright coronal features appear dark. The boundary of the closed and open field forms a cusp-shape. The 'x' marks the uppermost extent of the closed magnetic field.

This pseudostreamer had, as usual, two photospheric neutral lines (one in the center at the bottom of each loop-tunnel), which separate different polarities of magnetic field. However, these two neutral lines diverge along the length of the structure (see Figure 27). As they diverge, eventually a volume of open field forms between the loops. This field is in the opposite direction of the original pseudostreamer open field. Thus, the single pseudostreamer splits into two streamers, with two current sheets in the upper corona where the various domains of open field meet. The split occurs in space as opposed to in time, so both the pseudostreamer and the streamers are present concurrently.

This elongated structure was visible on the Sun for several rotations, and was seen to reform after eruptions occurred along its length. Rachmeler et al. (2014) presented analysis of SWAP and CoMP (Coronal Multichannel Polarimeter) data to support its magnetic structure identification. This was also the first use of CoMP data for pseudostreamer identification. Unlike EUV imagers, CoMP measures emission line polarization, which is directly sensitive to the magnetic field in the corona.

Following this work, investigations are ongoing for other structures identified in the Carrington movies that have heretofore not been discussed in the scientific literature including coronal fans, and a pseudostreamer at the south pole, both of which are visible in Figure 25.

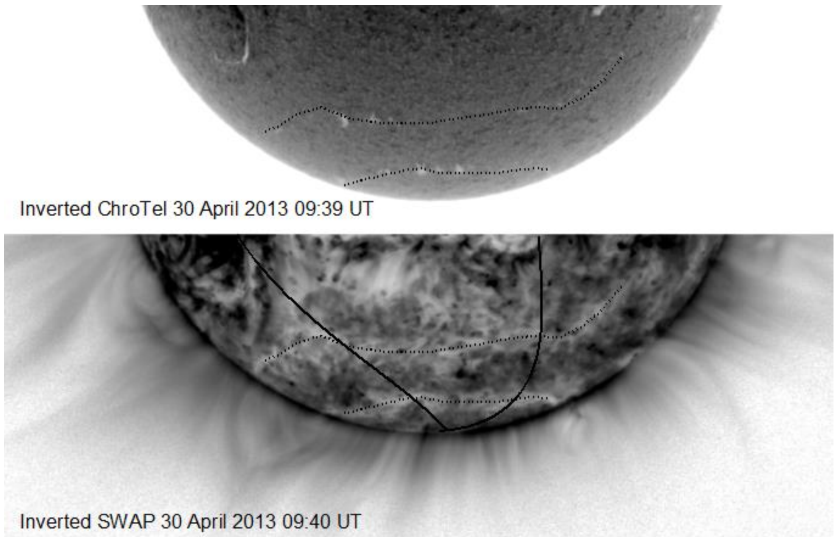


Figure 27: (top) An inverted Hydrogen-alpha (Hα) image of the solar disk. (bottom) An inverted SWAP image of the solar disk. On both images, the dotted lines trace diverging filament channels and closed-loop tunnels, which lie above photospheric neutral lines.

Scientific results from SPoCA

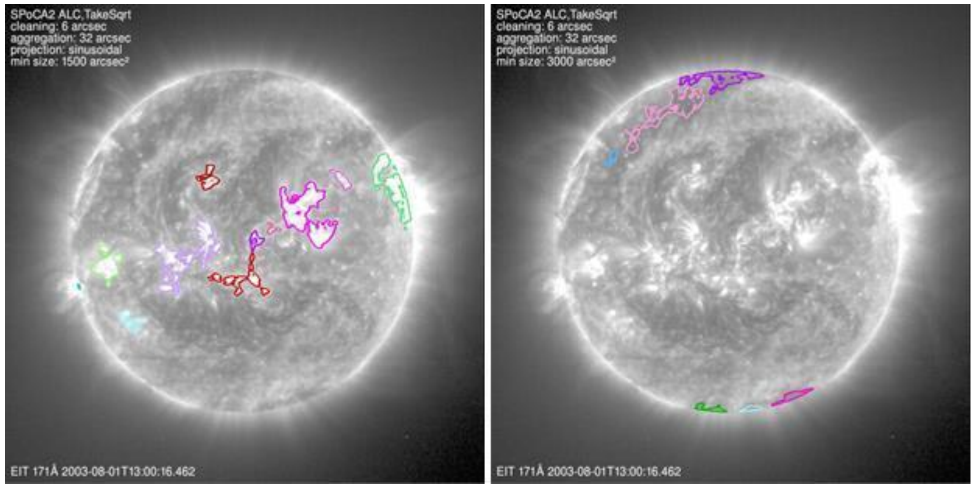


Figure 28: Overlay of active regions (left) and coronal holes (right) as detected by the SPOCA-suite on a 171 Å image from the EUV imager EIT onboard SOHO on 1 August 2003.

Accurate determination of active region (AR) and coronal hole (CH) properties on coronal images is important for a wide range of applications. Active regions appear as bright regions on x-rays and EUV images. As regions of locally increased magnetic flux, they are the main source of solar eruptions. A catalog describing their key parameters such as location, shape, area, mean, and integrated intensity allows for example to relate those parameters to the occurrence of solar eruptions.

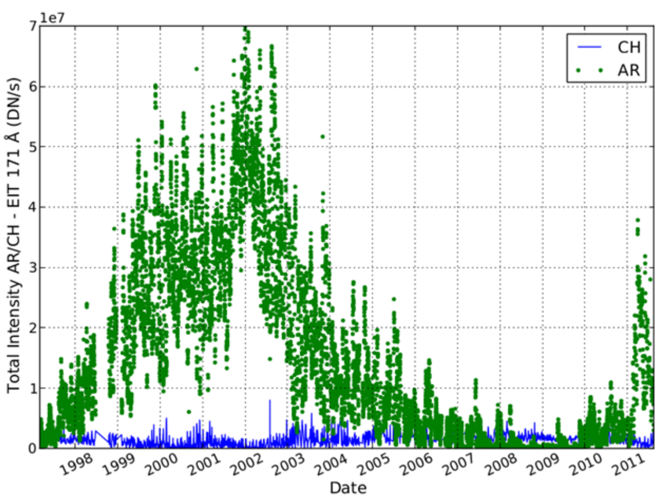


Figure 29: Total intensity of AR and CH pixels in 171 Å images from EIT onboard SOHO, from 1 March 1997 until 17 August 2011.

Coronal holes on the other hand appear as relatively dark regions in x-rays and EUV images and therefore are typically defined as regions of low emission in the solar corona. There is a strong association between coronal holes and high-speed solar wind streams which has been known since the 1970s. Coronal holes are usually identified as the sources of the fast wind from where the wind flows out in the corona and is accelerated in open expanding magnetic funnels. Solar eruptions and fast solar wind can cause several problems for technologies on Earth and in space, and can endanger astronauts. In this way, the Sun causes what we call “space weather”. Almost all space weather originates either from an AR or a CH.

The SPoCA-suite -short for “Spatial Possibilistic Clustering Algorithm”- was developed at the Royal Observatory of Belgium (Verbeeck et al. 2014) and allows decomposition of a solar EUV image into regions of similar intensity, typically active regions, coronal holes, and the quiet Sun (QS, i.e. the part of the solar disk that is neither an AR or CH). Two dedicated SPoCA modules are running in near real-time and produce entries into the Heliophysics Event Knowledgebase (HEK), a database of solar features and events maintained by Lockheed Martin Solar & Astrophysics Laboratory (LMSAL).

Various preprocessing steps are performed before applying the SPoCA algorithm, including calibration and normalization of the images by their median values, and map segmentation. The images are also corrected for the limb brightening effect by fitting a smooth transition function and inverting it.

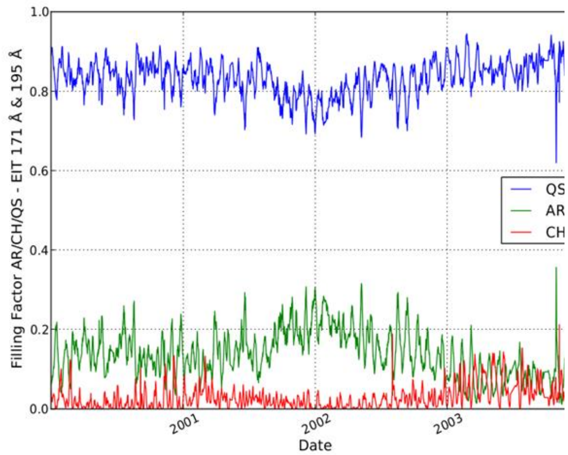


Figure 30: The fraction of the solar disk occupied by ARs, CHs, and the QS from 1 January 2000 until 31 December 2003, as derived from EIT observations.

Various SPoCA studies have been performed on four different EUV imagers: EIT, AIA, SWAP, and EUVI ([Verbeeck et al. 2014]()). Figure 28 shows a typical AR and CH detection by the telescope EIT onboard SOHO. Figure 29 presents the variation of the total EIT 171 Å pixel intensity in ARS respectively CHs over more than a solar cycle. Throughout this period, four EIT 171 images were considered per day and for every image, SPoCA calculated the sum of all pixel values for pixels in ARs respectively CHs, yielding a time series containing over 9500 data points. The double solar maximum around 2000 and 2002 can clearly be observed in the active region plot.

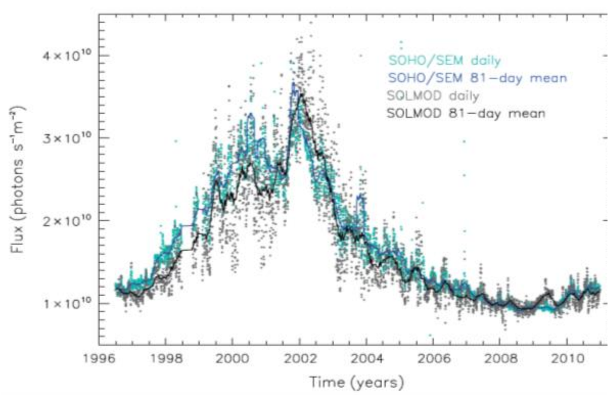


Figure 31: Comparison of the SOLMOD reconstruction of the solar irradiance (gray) with the SOHO/SEM observations (light blue) in a 260-340 Å passband, from 1996 till 2010. The 81-day mean is also given for the reconstruction (black line) and the SOHO/SEM data (dark blue line). The data gaps in the SEM data as well as in the reconstruction are a result of SOHO's "holiday" in the summer and fall of 1998, when contact with and control of the spacecraft was temporarily lost.

Figure 30 shows the fraction of the solar disk occupied by ARs, CHs, and the QS from 1 January 2000 until 31 December 2003, as derived by SPoCA from EIT observations. A period of about 27 days is clearly visible in this plot. This effect is caused by the 27-day solar rotation, which brings long-living ARs and CHs back into the same view after 27 days.

In the paper from [Haberreiter et al. (2014)]() , SPoCA segmentations from 1996 to 2010 were used to estimate the fractions of the solar disk occupied by various types of features in the solar atmosphere. These fractions were plugged into SOLMOD, a semi-empirical model of the solar atmosphere, which predicts the spectrum produced per type of feature. Combining these predicted spectra with the fractions of the solar disk that each one occupies, a reconstruction of the total irradiance of the Sun over that period was obtained. Figure 31 shows the comparison between the SOLMOD reconstruction and the irradiance observation by SOHO/SEM.

Instrumentation and experiments

ASPIICS: A huge and dynamical new solar coronagraph

After the success of the PROBA-1, PROBA2, and PROBA-V missions, the European Space Agency (ESA) is aiming to launch the next spacecraft of the PROBA series (PRoject for On-Board Autonomy). The ROB/STCE will take a leading role in its scientific endeavors. The new PROBA (PROBA-3) is to be launched in 2019 and will be again a technology demonstration mission led by the Department of Technical and Quality Management of ESA. PROBA-3 will feature a unique telescope to observe the corona of the Sun: a giant coronagraph.

A coronagraph is a telescope that allows us to observe the corona in a way very similar to that used during solar eclipses. During a natural total eclipse, the solar disk is occulted by the Moon and one can see the faint corona around it. Instead of the Moon, a ground-based or space coronagraph uses an occulting disk placed inside the telescope. For the PROBA-3 mission, the telescope will be installed on a spacecraft, and the Moon will be replaced by an occulter that will be placed on another spacecraft. This will form a giant coronagraph that will be as close as ever to reproducing the conditions of a natural total solar eclipse. The coronagraph is called ASPIICS, which stands for Association of Spacecraft for Polarimetric and Imaging Investigation of the Corona of the Sun.

To ensure the quality of images taken by ASPIICS, the two spacecraft of the PROBA-3 mission will be moving together as a nearly rigid system along a part of the orbit, thanks to novel technologies of the satellite formation flying. Formation flying means that the two spacecraft will move in coordination and maintain relative distances and orientations with a high precision. The distance between the two spacecraft will be around 150 m, and the position control accuracy for the alignment will be around a few millimeters.

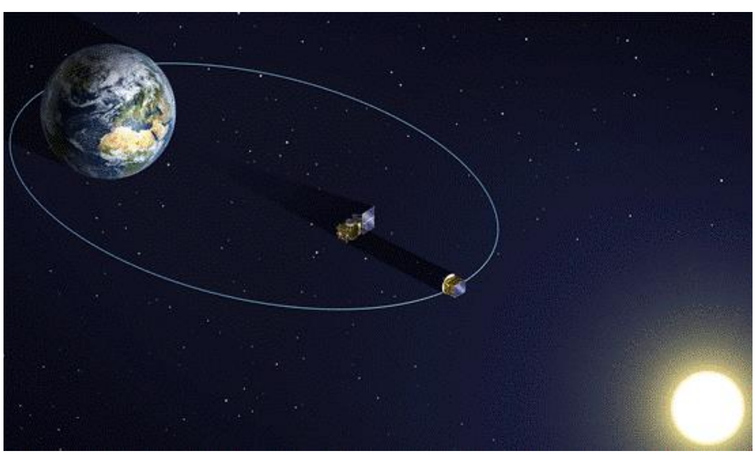


Figure 32: An artist's representation (not to scale) of PROBA-3 in a high elliptical orbit observing the solar corona (courtesy: ESA).

The resulting length of the coronagraph (around 150 meters) is unprecedented for solar observations. This will lead to a dramatic reduction of the coronagraph stray light and allow us to see the corona very close to the solar limb, similarly to what is done during a total eclipse. The duration of a total solar eclipse is less than seven and a half minutes, and they occur at most twice per year. ASPIICS will observe the solar corona for two years during six-hour intervals out of the orbit duration of 19.5 hours. The increase in observing time in comparison with eclipses is enormous and will allow us to track the detailed evolution of the large-scale solar corona. ASPIICS will occasionally reach a very high cadence of observations (up to 1 image per 2 seconds), which will allow us to track the physical processes at fine coronal scales, including coronal waves and magnetic reconfiguration processes that may be responsible for the slow solar wind acceleration. The eclipse-like field of view of ASPIICS will allow us to track the onset and early evolution of coronal mass elections (CMEs), which are the primary drivers of disturbed space weather in our solar system in general and on Earth in particular.

The work on the PROBA-3 mission started in 2007, but after several years the progress stalled due to programmatic reasons. Only in 2014, the implementation phase (phase C) was kicked off both for the spacecraft and for the coronagraph. The spacecraft development is led by SENER, Spain, with QinetiQ Space Belgium responsible for the onboard computer and avionics. The industrial consortium building the coronagraph consists of seven countries and is led by the Centre Spatial de Liège (CSL), Belgium. Solar-Terrestrial Centre of Excellence at the Royal Observatory of Belgium hosts the ASPIICS Principal Investigator, Dr. Andrei Zhukov. The ROB/STCE team will guide the industrial team developing the instrument hardware, provide the PROBA-3 Science Operations Center, and lead the science exploitation of the ASPIICS data.

Anomalous high tropospheric ozone in ozonesonde data at Uccle

Already more than half a century, ozonesondes, light-weight instruments attached to weather balloons and electronically coupled with a standard meteorological radiosonde for data transmission to a ground receiver, constitute the most important data source to derive long-term ozone trends with sufficient vertical resolution up to about 20 km.

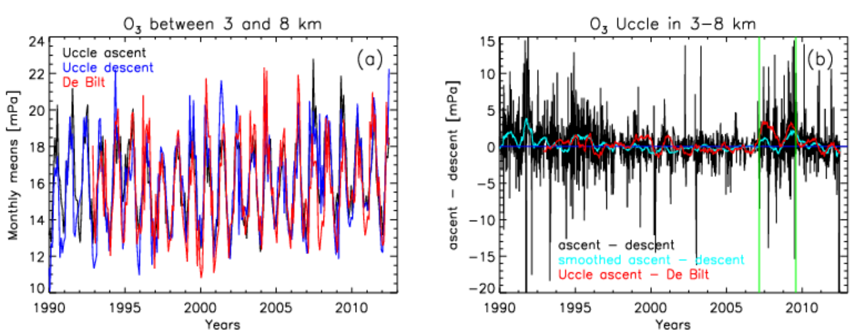


Figure 33: (a) Monthly mean time series of free tropospheric ozone at Uccle and De Bilt, along with Uccle ozonesonde descent data. (b) Time series of the differences of the same free tropospheric ozone values between an Uccle sounding's ascent and descent data, if the data transmittance during the descent was guaranteed below 3 km. The cyan curves shows the boxcar average (width = 50 days) of these differences; the red curve is the same boxcar average of the deviations in integrated ozone amounts in the 3–8 km layer for quasi-simultaneous (dt < 1.5 day) observations at Uccle and De Bilt.

The ozonesonde stations at Uccle (Belgium) and De Bilt (Netherlands), separated by only 175 km, offer a unique opportunity to test the influence of different ozonesonde types and different correction strategies, as well as to detect the presence of inhomogeneities in the ozonesonde time series resulting from changes in sounding equipment (chemical solution, radiosonde, ozonesonde, electronic interface, sounding software, etc.). In particular, Van Malderen et al. (2014) highlighted a 2.5 year period (beginning of 2007 to mid-2009) of anomalous high tropospheric ozone values measured by ozonesondes at Uccle and compare these with the observations from De Bilt, see Figure 33a.

Because the ozone deviations are only observed in the free troposphere where ozone concentrations are relatively low, and not in the boundary layer or the stratosphere, this issue is directly related to the sensitivity of ozonesondes. Therefore, the effect of every instrumental change, even though small, during this 2.5 year anomalous period is analyzed considering a change in the radio-sounding equipment, different ozonesonde batches, operational differences at the stations, differences on ascent and descent during the anomalous period; an environmental cause is also examined.

A very surprising outcome of the analysis is that the largest discrepancies between Uccle and De Bilt occurred during Uccle ascent ozone profiles and when using ozonesondes for the first time from three distinct batches (with serial numbers Z10…, Z11…, and Z12…, mostly used during the beginning of 2007 to mid-2009 period). The discrepancies are smaller for the Uccle descent ozone profiles (see Figure 33) and when the ozonesondes from these batches were re-used. This is a very puzzling result and therefore, unfortunately, one single, specific cause for the observed high tropospheric ozone values at Uccle could not be identified.

There are two explanations consistent with the observations and not ruled out by the analysis: 1) the majority of the ozonesondes used at Uccle between March 2007 and August 2009 needed longer conditioning of their sensors and, therefore, behaved more accurately at low ozone concentrations during their descent or when used a second time, and 2) an environmental origin arising from a local difference in the air mass between Uccle and De Bilt and between the ascent and descent.

The auroral spectropolarimeter

In 2014, in collaboration with IPAG (Grenoble, France), we continued our efforts to develop and calibrate a spectropolarimeter designed to measure simultaneously the polarization of several auroral emission lines between 400 and 700 nm. The wavelength calibration can now easily be made using specific Mercury Argon and Neon calibration sources from Ocean Optics that can be directly fed to the optical fibers. The controller of the motor for rotating the Half Wave Plate (HWP) was tested with the appropriate software and works fine. Figure 30 shows one part of the instrument.

Figure 34: Box containing the telescope, the optical elements and the two fiber collimators on the right hand side. The box is controlled in temperature and located outside in harsh conditions (wind, temperature). The two optical fibers transmit the signal to a spectrograph and a CCD camera located 50 meters away inside the observatory in Skibotn.

The two remaining problems with the current design that we had to face, were:

- to align the optical bench (containing HWP and the Wollaston prism) with the collimators for the optical fibers;
- to obtain a beam less divergent at the exit of the telescope (too much light was already lost at the entrance of the HWP which has a diameter of 10 mm).

Despite these two remaining limitations, we ran an observing campaign in Skibotn, Norway in December 2014, together with simultaneous incoherent scatter radar observations with EISCAT and with optical observations with the ALIS (Auroral Large Imaging System) cameras located in Sweden. The idea behind using ALIS observations is:

- to use tomography-like techniques to obtain the precipitating fluxes of electrons along each magnetic field line;
- to help us interpret the polarization measurements that are integrated along the line of sight, hence crossing several magnetic field lines at various heights.

The weather was bad over Sweden with the sky mostly covered during all nights, hence nothing useful came out of the ALIS observations. On the other hand, the sky was clear for a few hours during 3 consecutive nights in Skibotn and a lot of activity was observed during a few hours each night. This allowed us to obtain auroral spectra during quiet periods, moderate activity and intense activity (when an auroral arc was inside the FOV of the instrument). From these observations we are now able to estimate the integration times needed to obtain sufficient signal-to-noise ratio to measure the polarization in several lines, such as the red lines at 630 and 634 nm and the N2+ 1NG band (blue line) at 428 nm. Hα was also clearly visible during intense aurora and its polarization could possibly be measured as well in the future.

Figure 35: Observation campaign in Skibotn in December 2014.

The polarization measurements are very uncertain due to the two problems mentioned above. Most of the ordinary spectrum at the exit of the Wollaston prism was missing the corresponding collimator beam, hence giving a very small signal-to-noise ratio in this spectrum. However, a very preliminary and rough analysis assuming that the green line should be unpolarized, then scaling the spectrum by the same factor at 630 nm, gives an estimate of the polarization of the red line of the order of 3%, which is roughly in agreement with previous measurements obtained by the group of IPAG using a photopolarimeter equipped with a narrow interference filter and a rotating polarizer. These results must however be considered with caution and must be confirmed.

In 2015, efforts will be devoted to solving these two problems. For the alignment we will use two separate plates to place the fiber collimators. Currently they can only move together in the x direction (along the optical axis). These plates will be able to move along the x and y direction and to rotate along the z axis. In case of a slight misalignment (due to the transport, hard to resolve on site), these plates will allow us to collect the light much more easily. These plates also will be able to move closer to the Wollaston prism if necessary, such that the beams at the exit of the Wollaston prism do not diverge too much. For the first problem, we will use a diaphragm at the exit of the telescope in order to select only the light that goes into the HWP aperture. These modifications will be done in the second part of 2015 and tests will be made using the instrument outside looking at either white diffuse clouds as unpolarized source or at some specific regions of the blue sky to identify the polarization patterns. Finally, a second observation campaign in Skibotn is planned during the first week of March 2016.

Twenty years DIARAD/VIRGO

Nearly twenty years ago – on 2 December 1995 – the Solar and Heliospheric Observatory (SOHO) satellite was launched. Among the instruments on board we have the Belgian DIARAD/VIRGO instrument built by Verhaert NV – now Qinetiq Space NV – in collaboration with the Royal Meteorological Institute of Belgium (RMIB). The instrument was designed for a lifetime of 2 to 6 years, but after twenty years in space it is still working flawlessly. Thus the DIARAD/VIRGO instrument is a masterpiece of Belgian technology.

Figure 36: The DIARAD/VIRGO instrument built by Verhaert NV in collaboration with the Royal Meteorological Institute of Belgium (RMIB).

The DIARAD/VIRGO instrument measures the energy that the Earth receives from the Sun – the so-called Total Solar Irradiance (TSI). The TSI is an Essential Climate Variable (ECV) which determines the climate on Earth. The RMIB TSI measurements are renowned at the international level, they are e.g. used by NASA. The DIARAD/VIRGO measurements have revolutionized our knowledge of the influence of the Sun on climate changes on Earth.

The DIARAD/VIRGO has delivered excellent services, but it does not have the eternal life. It is time to prepare the change of the guard. Thanks to its excellent reputation, the RMIB received as first non-Chinese partner the invitation to deliver an instrument to fly on an operational Chinese meteorological satellite, with a design lifetime of 8 years. Our Chinese partners are top level. The National Satellite Meteorology Center (NSMC) of the China Meteorological Administration (CMA) is comparable to Eumetsat in Europe. The Changchun Institute of Optics, Fine Mechanics and Physics (CIOMP) launched on 7 October this year the first commercial Chinese remote sensing satellite and plans to launch by 2020 a total of 60 satellites.

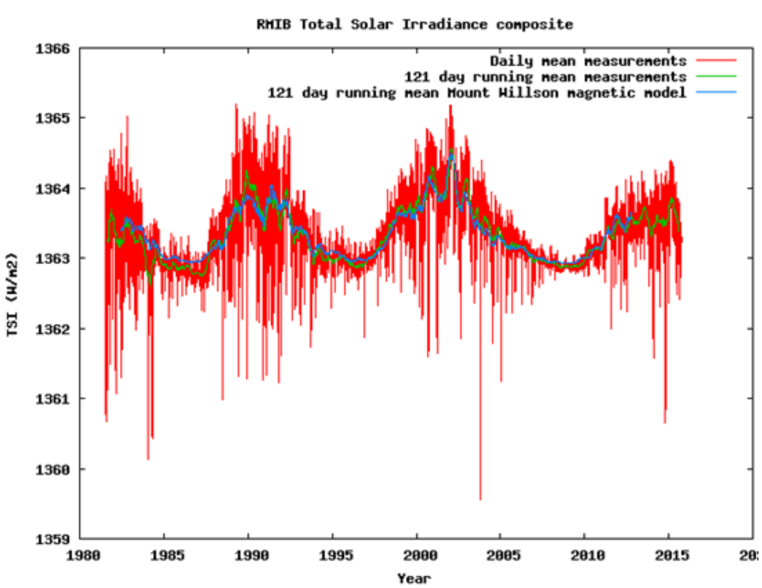


Figure 37: RMIB TSI composite measurements spanning more than 30 years. The last 20 years are covered by the DIARAD/VIRGO instrument.

This is an opportunity to guarantee the succession of DIARAD/VIRGO we should not miss. We will fly on the operational early morning satellite FY3E with the dusk-dawn orbit which is ideal for solar observation. Since the launch is scheduled as early as 2018, we have no time to lose to start working on the instrument design and realization. Depending on the financial support we can get, we will develop the instrument with our own means – this is the more risky and least preferred option – or in collaboration with our proven industrial partner Qinetiq Space NV – this is the preferred option.

Figure 38: Visit of a Chinese delegation to the RMIB with the invitation to deliver a TSI instrument to fly on the operational FY3E dusk-dawn weather satellite in 2018.

Applications and Modeling

Space weather information for space missions

The European Space Agency (ESA) has put in place a Space Situational Awareness (SSA) network consisting of European space weather products. These are available for end users through a [web portal](). The products include ESA owned applications as well as European space weather products developed by different European expert groups. The SSCC (SSA Space Weather Coordination Centre) serves as the first point of contact, interlaying between the expert centres and the users of European Space Weather products available through the SSA network.

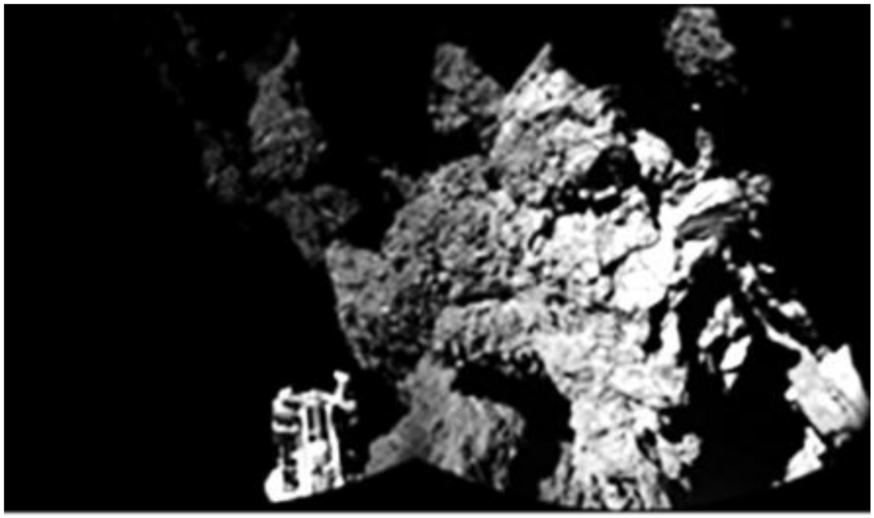


Figure 39: The lander Philae is approaching Rosetta.

One of the purposes of the SSCC is to provide support to end users on aspects related to space weather. An excellent example is the regular delivery of space weather bulletins to the operations teams of both the Rosetta and Venus Express spacecraft.

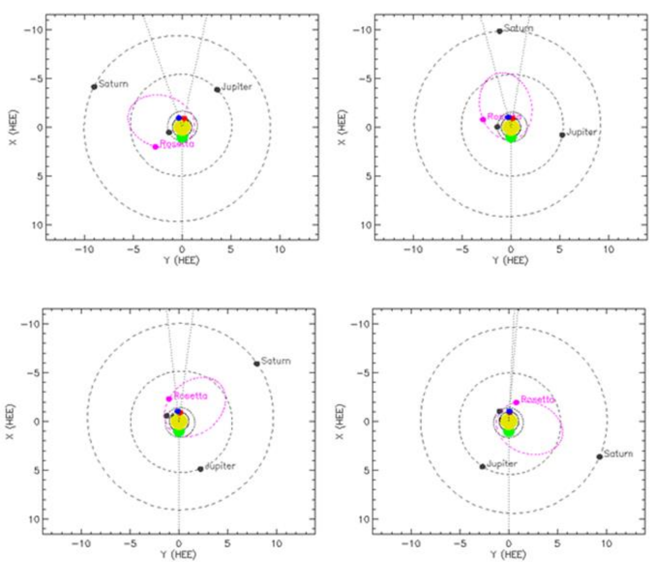


Figure 40: Evolution of the relative position of Earth (green), Rosetta, STEREO A (red) and B (blue) spacecraft from 11 September 2014 (top left) till 11 March 2015 (bottom right). (source: NASA SSC)

The [Rosetta mission]() is an interplanetary mission whose main objective was to rendezvous with and make in-situ measurements of comet 67P/Churyumov-Gerasimenko. The spacecraft was launched on 2 March 2004 and achieved its rendez-vous from 6 August 2014 onwards. The lander Philae landed successfully on the comet's surface on 12 November 2014 (Figure 39). The Rosetta mission accompanies the comet along its orbit around the Sun through its perihelion (August 2015) until the nominal mission ends in December 2015 (Figure 40). The spacecraft includes eleven scientific instruments on board as well as a lander (Philae) that includes another ten additional instruments. The Rosetta orbiter and lander spacecraft are controlled by the

== Space Weather bulletin for Rosetta operations ==
Bulletin #8
prepared by Andy Devos (SSCC), Mark Dierckxsens (BIRA) and Jasmina Magdalenic (SIDC forecaster) on November 12, 2014 at 14:00 UTC
Valid until November 14, 2014 at 14:00 UTC
….

=== Comment ===
Solar Activity:
The activity is still dominated by the NOAA active region which was the source of majority of the flares reported during last 24 hours. The NOAA active region 2092 currently facing ROSETTA shows signs of possibly significant flaring activity and was most probably the source of the partial halo CME, directed towards the ROSETTA spacecraft, observed on November 11.

Radiation:
At present, the magnetic footpoints of Earth and Rosetta are close to each other. No increase in proton count was observed in the SREM instruments near Earth and on Rosetta during the past 48 hours.
…

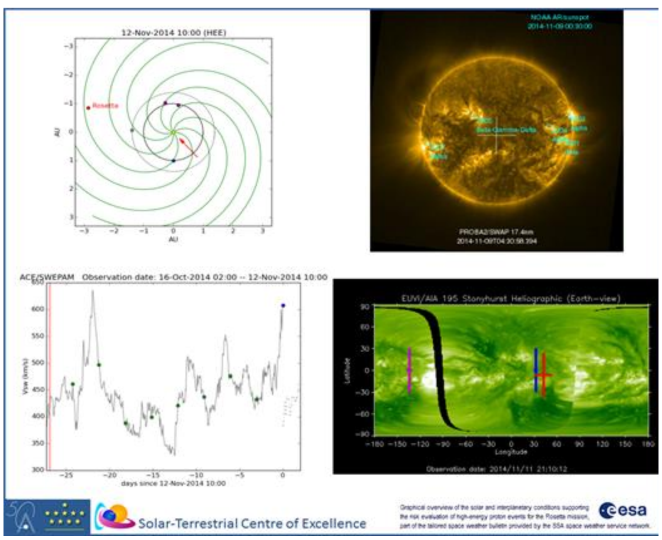


Figure 41: Example bulletin with part of the text (top) and the figure (bottom) included in the communication sent on 12 November 2015 to the Rosetta Spacecraft Operations team. The figure is made of four panels. Top left panel shows the solar wind spiral and the relative location of Rosetta (red), Earth (blue), STEREO A/B (purple) and Mars (gray). Bottom left panel shows the solar wind velocity measured near Earth used when deriving the solar wind spiral. Each circle corresponds to a spiral leg in the upper panel. The vertical red line corresponds to a leg passing through Rosetta location. Top right panel shows a former PROBA2/SWAP image of the solar disk centered on the region magnetically connected to Rosetta. The corresponding viewpoint is indicated by a red arrow on the first panel. Bottom right panel shows a composite heliographic map of the corona based on SDO/AIA and STEREO/EUVI data. The crosses mark the regions respectively connected to Earth (blue), Rosetta (red) and STEREO A (purple).

Rosetta Mission Operations Centre (RMOC) located at ESOC using the ground station New Norcia (Australia).

Starting 13 October, the SSCC provided 20 bulletins in 2014 to support the Rosetta mission operations team. Each week one bulletin was sent, while during the month of November one bulletin was sent every two working days. One special bulletin was sent on 1 November at the occurrence of a significant rise in the number of protons.

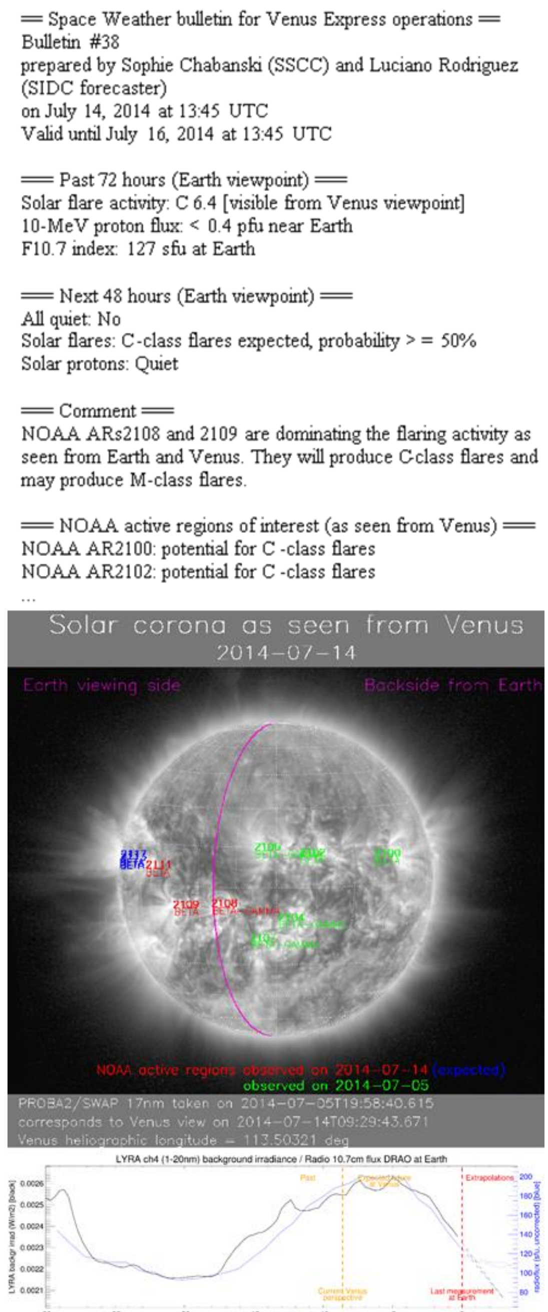
The bulletins (Figure 41) included a description of the past space weather activity and a forecast for the next 2 days, focusing on the activity that could occur near the Rosetta spacecraft. Due to the comet orbit and the Earth orbit around the Sun, the relative position of the spacecraft with respect to the Earth is changing. A solar wind model (top left figure of the example bulletin) was implemented to determine the magnetic connectivity of the Rosetta spacecraft with the active regions on the Sun. This enabled to assess which active regions potentially could create a radiation storm at Rosetta. An instrument was on board of the Rosetta spacecraft to measure any increase of the amount of protons in its environment, due to space weather activity. On disk observations from the viewpoint of Earth taken by PROBA2/SWAP and SDO/AIA and from the backside of the Sun taken by STEREO/EUVI were combined to identify solar activity in regions that were magnetically connected to Rosetta and that could potentially cause space weather events near Rosetta.

Venus Express was an ESA spacecraft designed to observe the atmosphere of Venus. The spacecraft was launched in November 2005 from Baikonur, Kazakhstan and arrived at Venus in April 2006. It had seven scientific instruments on board, measuring and sending data to the ground stations at Earth. The spacecraft was controlled from ESOC using the two ground stations Cebreros (Spain) and New Norcia (Australia). The Venus Express Science Operation Centre (VSOC) at ESTEC in the Netherlands was coordinating the scientific operations.

The time window for the aerobraking campaign started on 18 May 2014 with the core of the experiment between 18 June and 11 July 2014. The spacecraft manoeuvred into the upper atmosphere of the planet to perform engineering experiments before raising its orbit in order to continue the mission. Venus Express was at an altitude of about 200 km at the start of the experiment and went as low as 130 km. After 11 July 2014 the spacecraft was raised again. The purpose of the aerobraking experiments was to further understand the structure of the Venus atmosphere and provide information which can be used for future ESA missions. The atmospheric density is one of the measures the mission aims to observe.

Venus is in orbit around the Sun at a distance of about 0.72 AU (about 108 million km). In May 2014, Venus was positioned west of the Sun-Earth line. The planet has no internal magnetic field and experiences directly the influence of solar wind and coronal mass ejections (CMEs).

The SSCC support was provided during the aerobraking manoeuvres, by sending 66 tailored bulletins (Figure 42). Information on the recent space weather activity was included as well as a forecast for the next two days, focusing on two risk factors coming from solar active regions connected to Venus. The first risk was the increased amount of solar energetic particles, which could introduce errors in onboard memories and cause background radiation on star trackers. The second risk was the variation of atmospheric density at aerobraking altitude due to enhanced solar irradiance. The Venus Express Operations team confirmed the space weather information was very useful to relate (potential) activity to measurements recorded by the spacecraft instruments and to verify the cause of specific anomalies.


== Space Weather bulletin for Venus Express operations ==
Bulletin #38
prepared by Sophie Chabanski (SSCC) and Luciano Rodriguez (SIDC forecaster)
on July 14, 2014 at 13:45 UTC
Valid until July 16, 2014 at 13:45 UTC

== Past 72 hours (Earth viewpoint) ==
Solar flare activity: C 6.4 [visible from Venus viewpoint]
10-MeV proton flux: < 0.4 pfu near Earth
F10.7 index: 127 sfu at Earth

== Next 48 hours (Earth viewpoint) ==
All quiet: No
Solar flares: C-class flares expected, probability >= 50%
Solar protons: Quiet

== Comment ==
NOAA ARs2108 and 2109 are dominating the flaring activity as seen from Earth and Venus. They will produce C-class flares and may produce M-class flares.

== NOAA active regions of interest (as seen from Venus) ==
NOAA AR2100: potential for C-class flares
NOAA AR2102: potential for C-class flares
...

Figure 42: Example bulletin with part of the text (top) and the figure (bottom) included in the communication sent on 14 June to the Venus Express Spacecraft Operations team. Middle: Past solar disk image matching Venus current viewpoint annotated with currently active regions. Bottom: Time variation of Earth observed background irradiation [black] and uncorrected 10.7 cm radioflux F10.7 index [blue] with current Venus shift.

Five years PROBA2 science

PROBA2, the second satellite in the European Space Agency's series of PRoject for OnBoard Autonomy, was launched on 2 November 2009. Consequently, on Sunday 2 November 2014, PROBA2 was 5 years in orbit! Congratulations, PROBA2!

Figure 43: Celebrating 5 years PROBA2.

The PROBA2 spacecraft hosts 17 technical developments and four scientific instruments. The latter four concern two particle detectors to monitor the plasma environment of the spacecraft (DSLP and TMPU) and two complementary instruments to observe the Sun (SWAP and LYRA).

The solar instruments SWAP (Sun Watcher using Active Pixel System detector and Image Processing) and LYRA (Large Yield RAdiometer) are being operated from the PROBA2 Science Center at the Royal Observatory of Belgium, part of the Solar Terrestrial Centre of Excellence (STCE) in Uccle, in collaboration with the Mission Operations Center in Redu.

In the five years since its launch, the spacecraft has orbited the Earth more than 25.000 times, covering more than a billion km in space. The solar instruments onboard took over 1 million images of the Sun, and recorded over 6000 solar flares!

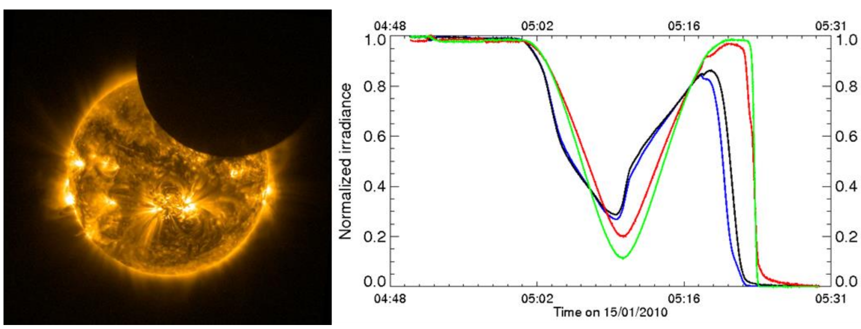


Figure 44: SWAP image and LYRA irradiance plot of the annular solar eclipse on 23 October 2014.

After all these years in the harsh environment of space, PROBA2's solar images and data are still of such high quality that they are regularly used for scientific research both by the space weather community as in solar physics. The PROBA2 team gratefully took this occasion to express their appreciation to all PROBA2 collaborators who made this possible. On Friday 7 November 2014, a small celebration "5 years of PROBA2 science" was organized at the STCE. The celebration started with a small toast on PROBA2, where the EUV data proofed not only to be scientifically useful but also tasty (Figure 43). The team made use of the opportunity to look back on some of the highlights of PROBA2's scientific achievements. Indeed, the SWAP and LYRA observation campaigns resulted not only in a continuous stream of solar data, but provided several high quality data sets of specific events such as solar eclipses (Figure 44) and the passage of comet Lovejoy. More details on some highlights are provided on PROBA2's webpage.

During these exciting first five years of PROBA2 in space, Katrien Bonte had the pleasure to work on her PhD in a collaboration between the University of Leuven and the Royal Observatory of Belgium (STCE/ROB). She accepted the challenge to exploit mainly the images from SWAP for monitoring the Sun in the 17.4 nm EUV bandwidth, the principal aim being to further develop the capabilities of automated image processing methods for detecting solar flares and CMEs. Flares and CMEs are both believed to be different manifestations of magnetic field restructuring, through reconnection (flares) and the expulsion of mass (CMEs). Both of these explosive events are important drivers of space weather.

As part of her thesis, Katrien Bonte developed the Solar Feature Automated Search Tool (SoFAST), a software package that automatically processes the SWAP EUV images and localizes and identifies dynamic events in near real-time. The SoFAST event list is available online. On the one hand, the output of this software tool is intended as a potential service to the Space Weather Segment of ESA's Space Situational Awareness (SSA) program. On the other hand, the PROBA2/SWAP images were considered as a model for the data from the Extreme Ultraviolet Imager (EUI) prepared for the future Solar Orbiter mission, where onboard intelligence is required for prioritizing data to fit in the extremely limited telemetry quota. Within the frame of the PhD, also the first SoFAST EUV event catalogue was compiled by running the tool over more than three years of SWAP data, acquired during the period from April 2010 to June 2013. Not only solar flares have been revealed in the SWAP images in an automated way, the resulting catalogue lists 2171 events covering a variety of typical EUV dynamics, ranging from the smallest EUV brightening and post-flare loops to jets and large eruptions. Figure 45 provides some example images showing the appearance of the different event types detected by SoFAST in SWAP EUV images.

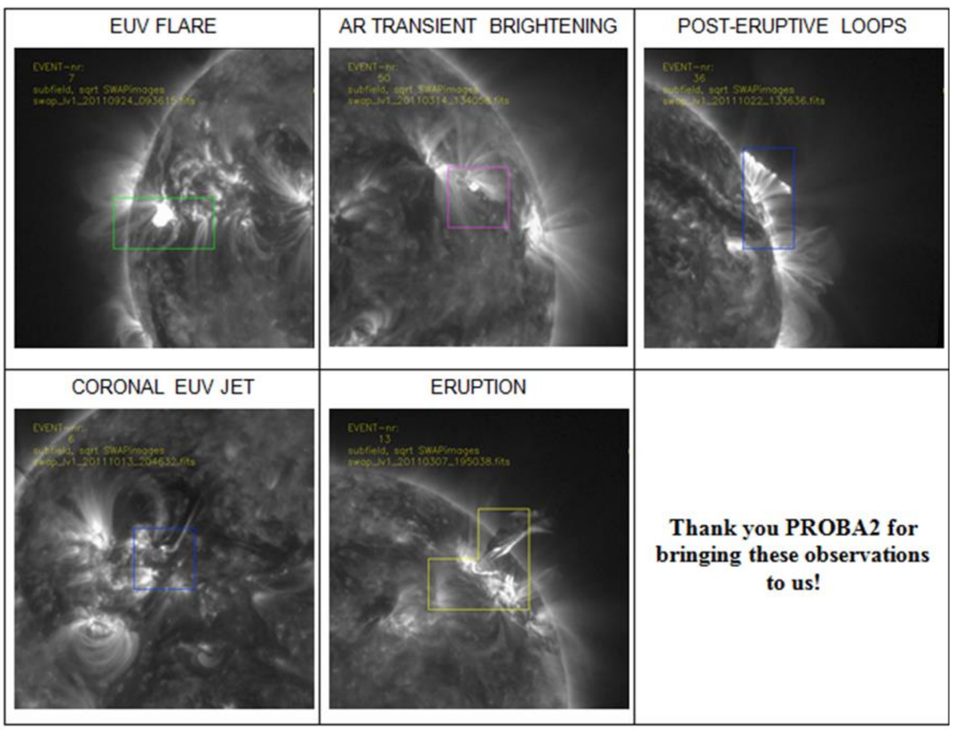


Figure 45: Example images showing the appearance of the different event types detected by SoFAST in SWAP EUV images.

Benefits of the Belgian ALC network

In 2014, RMI finished the installation of its automatic LIDAR ceilometer (ALC) network in Belgium. This new network with its high sensitivity offers the opportunity to monitor the vertical profile of aerosols on a continuous temporal scale. It is of great benefit to the aviation and also to the monitoring of air pollution.

In recent years, several meteorological services in Europe (amongst them also the RMI) replaced or improved their traditional cloud-base ceilometer network to be able to monitor aerosol plumes such as volcanic ash clouds which might be a hazard for air traffic. The Eyjafjallajökull and the Grimsvötn volcanoes in Iceland erupted in April 2010 and in May 2011 respectively causing massive disruption of the European air traffic. These events contributed to the development of a European ALC network.

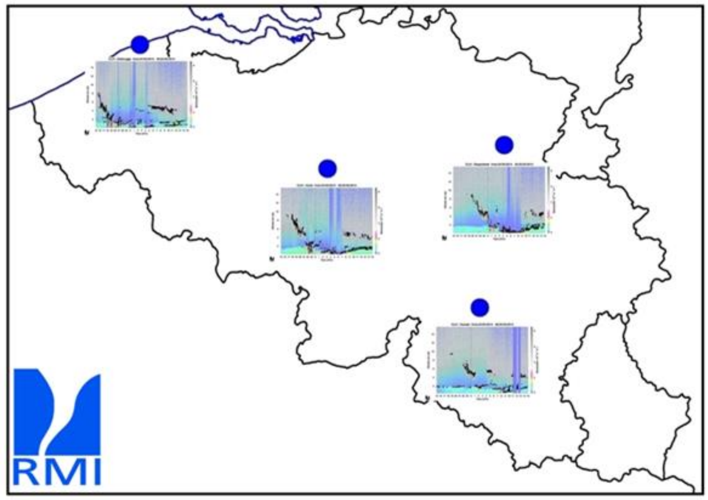


Figure 46: Map of Belgium with the location of ALC at Zeebrugge, Uccle, Diepenbeek and Humain station.

To coordinate and to make available the ALC measurements of each national network to the European meteorological community in near real-time, two major European projects supported by EUMETNET (E-PROFILE) and by COST (TOPROF) have been established in 2013. The participation of RMI in these two projects is very active especially in the development of new methods to predict radiation fog formation.

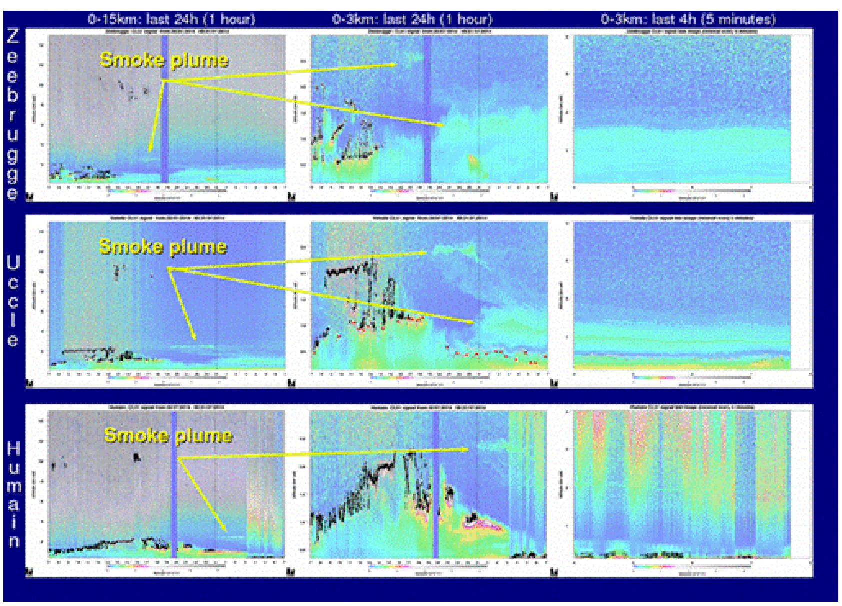


Figure 47: ALC measurement plots of Zeebrugge, Uccle and Humain created at 7:50 (UTC) on 31 July 2014. The last 24 hours of ALC measurements between 0 and 15 km in height and between 0 and 3 km in height is represented in the left column and in the middle column respectively. The last 4 hours between 0 and 4 km in height is represented in the right column. The color code represents the intensity of the backscatter signal.

This method is based on the ALC measurement offering the opportunity to analyze the backscatter signal in the boundary layer that potentially contains major information to predict radiation fog formation. Fog is the most frequent cause of surface visibility below 1 km, and is one of the most common and persistent weather hazards encountered in aviation and to nearly all forms of surface transport. The financial and human losses related to fog became comparable to the losses from other hazardous weather events e.g., tornadoes or, in some situations, even hurricanes. Forecasting fog can be difficult, a number of approaches have been used to integrate the satellite data, numerical modeling, and standard surface observations. Successful numerical modeling and forecasting of fog depends on the fog type that has to be predicted. Radiation fog events are typical examples of fog that is particularly difficult to predict by comparison with advection fog or orographic fog.

In the framework of TOPROF, RMI and the Pierre-Simon Laplace Institute (IPSL, SIRTA) developed a forward stepwise screening algorithm to help prediction of radiation fog formation based on the hygroscopic growth function of aerosol scattering coefficient deduced from ALC measurements.

An ALC network can monitor not only ash plumes, but also other types of aerosol plumes (dust, smokes...) less innocuous for the aviation but whose monitoring enables to validate and improve the dispersion models.

Figure 47 shows the monitoring of an aerosol cloud above Belgium observed by the ALC network of RMI on 30-31 July 2014. This cloud consisted of smoke coming from large forest wildfires which occurred during the summer of 2014 in northern Canada (Northwest Territories). The transport of these aerosols over Europe was due to the production of pyrocumulonimbus clouds by these wildfires that injected the aerosols at the top of the troposphere where the configuration of the Jet Stream was suitable for blowing the aerosols across the North Atlantic.

SPENVIS-NG and COMESEP

SPENVIS-NG: The Next Generation SPace ENVironment Information System

Satellites are exposed to the hazardous space environment, consisting of high energetic particles, space debris and extreme radiation. SPENVIS (Space ENVironment Information System) is a web application mainly used by spacecraft designers to simulate the effects of the space environment on spacecraft components. Based on these simulation results, the design of the spacecraft can be adapted even before it is actually built and tested.

BIRA-IASB started SPENVIS in 1996 and continued developing it for ESA under the GSTP (General Support Technology Programme). Today, almost 13.000 users worldwide are registered and a staff of 5 employees at BIRA-IASB maintains the system. In addition to the space industry support, SPENVIS is widely used as an educational tool by various universities and technical colleges and for research.

In 2011, ESA decided to re-develop SPENVIS using current web technologies. BIRA-IASB took the lead in this project, with the support from renowned partners in the space industry (DEIMOS, DH Consultancy, ETAMAX and Space Applications Services). The team is now finishing the new release providing a more flexible SPENVIS-NG (Next Generation) system with a modern look-and-feel. A prototype of this system has been presented and demonstrated during the industrial exhibition at NSREC/RADECS in Paris (2014) and during the fair at ESWW11 in Liège (2014).

COMESEP: COronal Mass Ejection and Solar Energetic Particles

The development of the COMESEP Alert System was funded by a three-year EU FP7 grant (European Union Seventh Framework Program) that concluded in January 2014. The project was led by BIRA-IASB and consisted of a collaboration with KSB-ORB and 5 other European institutes. Tools for forecasting geomagnetic storms and solar energetic particle radiation storms were developed, validated and implemented into an operational space weather alert system that runs without human intervention. The alerts are based on the COMESEP definition of risk that combines the likelihood of occurrence of the predicted event with its estimated impact at the Earth. The full details of the 24/7 alert service can be accessed by the space weather community from the COMESEP Alert System webpage and alerts are also sent by email to subscribed users. Since the successful ending of the project, the Alert System and other tools have been presented at the EGU General Assembly, the European Solar Physics Meeting and the European Space Weather Week meeting. A detailed paper describing the COMESEP alert system and its performance during the first two years of operation is forthcoming.

Cosmic rays monitoring in Dourbes

The interplanetary space is continuously traversed by energetic nuclear particles called cosmic rays - consisting mostly of protons (about 90%) and helium nuclei (about 9%), with a few nuclei of heavier elements (about 1%). The Sun and solar wind alter the intensity and energy spectrum of the galactic cosmic rays that enter the solar system. When the Sun is active, fewer galactic cosmic rays reach the Earth than during times when the Sun is quiet. As a result, the intensity of galactic cosmic rays follows an 11-year cycle like the well-known solar activity but in the opposite direction, i.e. higher intensity of cosmic rays corresponds to lower solar activity, and vice versa (Figure 48).

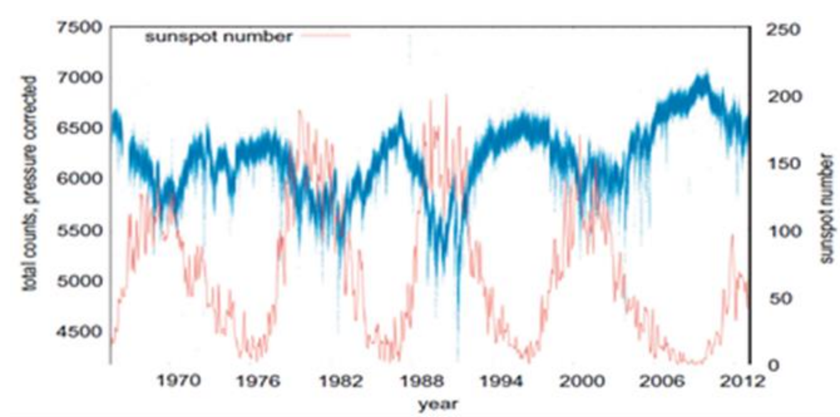


Figure 48: Cosmic ray intensity measurements (blue) from the Dourbes observatory compared with solar activity data, the sunspot number (red).

Cosmic rays, their existence and effects, are key components of space weather. Therefore, permanent high-quality monitoring is important for identifying and helping the mitigation of the adverse space weather effects on modern-day technological society. For several decades, the RMI ionospheric section team carries out research and works on various ionosphere and space weather research projects, monitoring applications and services.

At the RMI Geophysical Centre in Dourbes, a standard NM64 neutron monitor (with 9 counters) is in operation since 1965. The ground-based neutron monitor (NM) measures by proxy the intensity of cosmic rays striking the Earth, and its variation with time. In fact, the neutron monitor measures the secondary neutron component of the cosmic rays on the ground. After pressure correction, this component follows closely the primary cosmic rays intensity, i.e. reproduces the variations of the cosmic rays intensity (high) above the station. The ground-based neutron monitors remain the state-of-the-art instrumentation for measuring cosmic rays. They are sensitive to cosmic rays penetrating the Earth's atmosphere with energies from about 0.5-20.0 GeV, i.e. in an energy range that cannot be measured with detectors in space in the same simple, inexpensive, and statistically accurate way.

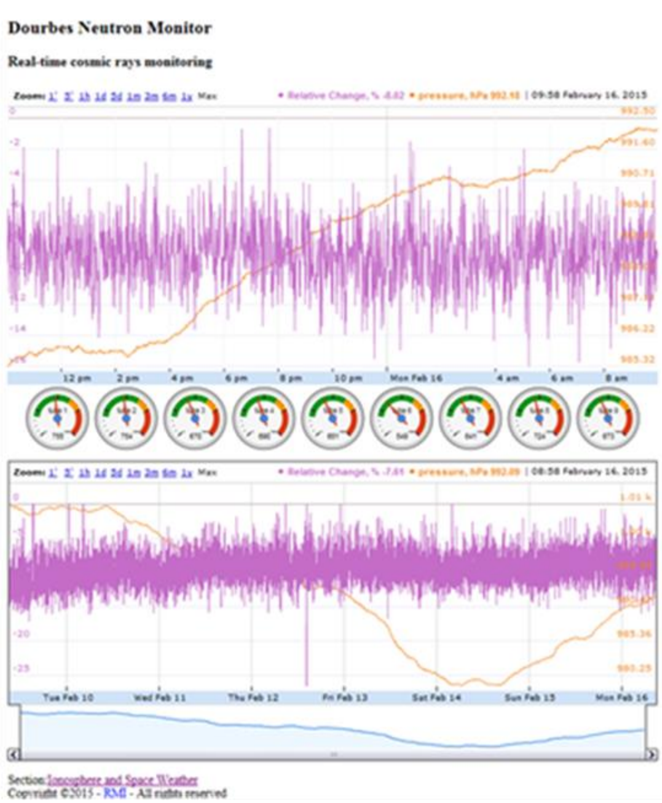


Figure 49: Cosmic ray monitoring at Dourbes: a screenshot of the webpage presenting real-time measurements of the neutron monitor.

Despite all efforts to reduce noise during measurements and recording the data, it is often difficult and sometimes impossible to completely avoid it. This holds true especially when the measurements are carried out over prolonged periods, as is the case here, when the measurement is set for an indefinite time (decades and more).

We have developed (Sapundjiev et al., 2014) a real-time automatic data correction system (RTADC) which will test the recorded information by several criteria. Errors and noise in the data will be corrected before the final total counts and pressure corrected data are stored and displayed. The philosophy behind the data correction algorithm is that if a correction is required at a given instant, it will only be based on measurements in the same time instant and not on measurements of the neighboring moments, before or after. For example, if one or more tubes of the station give an erroneous result at time t, their value will be corrected using the measurements from the other tubes at the same time.

The system is now operational (Figure 49) and real-time results are available online.

Simulations of the origin of auroral particles

The aurora borealis, or northern lights, are caused by electrons that enter Earth's atmosphere along the magnetic field in the polar regions. Atoms and molecules in the atmosphere are excited to higher energy levels in collisions with these electrons. The light that we see appears when the excited atoms return to their ground states.

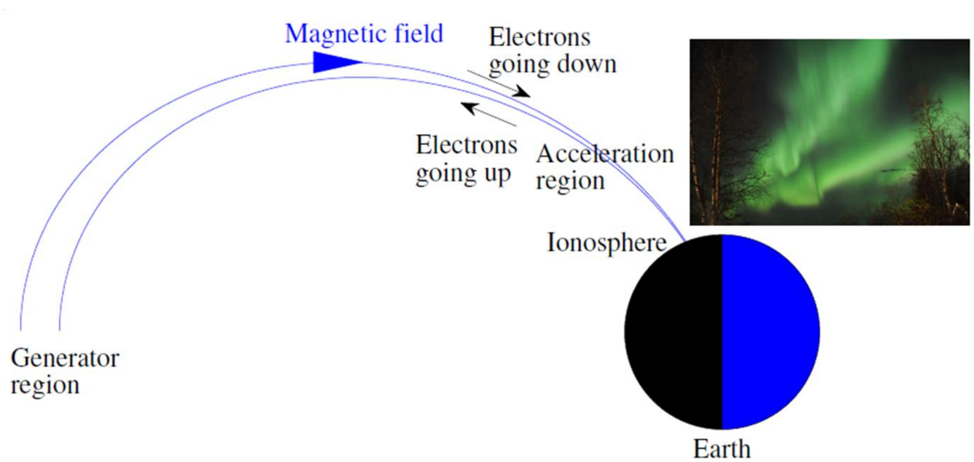


Figure 50: A sketch of the auroral current circuit. The photograph of the northern lights was taken in Kiruna in Sweden on 2 October 2013.

One of the questions in auroral physics is how the electrons are accelerated. At BIRA-IASB, a Vlasov simulation model has been developed to answer this question. In Vlasov simulations, the Vlasov equation is solved repeatedly. One can see what happens to the electrons, where they go and at what speed, and this development can be followed in time. The location of the acceleration region can be seen in Figure 50, which shows a sketch of a magnetic field line above the aurora.

One result of the Vlasov simulations is that most of the acceleration of the electrons that cause the aurora, takes place in a thin sheath at an altitude of about one Earth radius. This is seen Figure 51 at the position where the plasma potential curves are almost vertical. The sheath is known as a double layer because it consists of at least two layers of different charge. Starting from this state, the system can be perturbed in the simulations in order to simulate naturally occurring fluctuations. It is then seen that the double layer moves over distances of about 500 kilometers in response to these fluctuations.

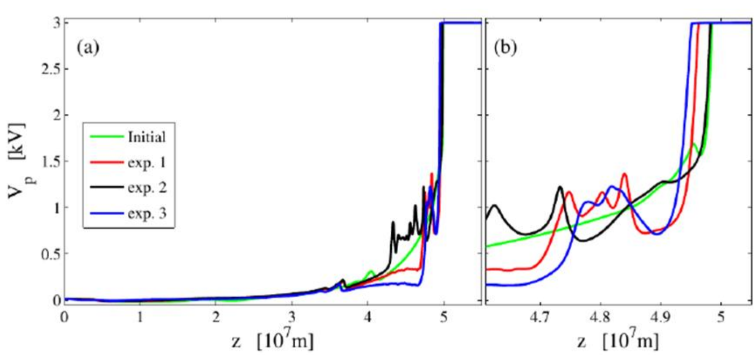


Figure 51: Plasma potential in different numerical experiments. Most of the electron acceleration takes place in a thin sheath, known as a double layer, where the plasma potential curves are almost vertical. The right-hand image is a close-up showing how this sheath moves as a result of the fluctuations.

Satellites can only make measurements along their paths, and since they move at several kilometers per second, they can only get a snapshot -usually less than a second- of the plasma conditions as they move through the acceleration region. However, the simulations also show that the fluctuations have a lasting effect on the electron distributions, for example creating beams both in the upward and downward directions. By making detailed measurements of the electrons, one could therefore obtain information also about what the state of the acceleration region was several seconds before the satellite passed through it.

In the dark space next to the bright auroral light emissions, electrons move upwards, away from Earth. This region is known as the return current region, because it is where electrons return into space to close the current circuit. The Vlasov simulation model has been applied also to this region. It was found that electrons are accelerated by double layers here too, but here there is no steady state solution. The double layers in the return current region are always in motion, starting in the low altitude ionosphere and moving upward to altitudes of 1-2 Earth radii, where they disappear, and, when they do, new ones form again at low altitude.

Publications

This overview of publications consists of three lists: the peer-reviewed articles, the presentations and posters at conferences, and the public outreach talks and publications for the general public. It does not include non-refereed articles, press releases, the daily, weekly and monthly bulletins that are part of our public services, … These data are available at the STCE-website http://stce.be/index.php or upon request.

Authors belonging to the STCE have been highlighted in the list of peer reviewed articles.

Peer reviewed articles

1. **W. Aerts, C. Bruyninx, P. Defraigne**, G. Vandenbosch, P. Zeimetz
On the Influence of RF Absorbing Material on the GNSS Position
GPS Solutions, DOI: 10.1007/s10291-014-0428-y

2. M.J. Aschwanden, **N.B. Crosby**, M. Dimitropoulou, M.K. Georgoulis, S. Hergarten, J. McAteer, A.V. Milovanov, S. Mineshige, L. Morales, N. Nishizuka, G. Pruessner, R. Sanchez, A.S. Sharma, A. Strugarek, V. Uritsky
25 Years of Self-Organized Criticality: Solar and Astrophysics
Space Science Reviews, 2014, DOI: 10.1007/s11214-014-0054-6

3. U. Bak-Steslicka, S.E. Gibson, Y. Fan, C. Bethge, B. Forland, **L.A. Rachmeler**
The spatial relation between EUV cavities and linear polarization signatures
Proceedings of the IAU, Symposium, 300, pp. 395-396

4. **N. Bergeot, J.-M. Chevalier, C. Bruyninx, E. Pottiaux, W. Aerts, Q. Baire, J. Legrand, P. Defraigne**, W. Huang
Near real-time ionospheric monitoring over Europe at the Royal Observatory of Belgium using GNSS data
Journal of Space Weather and Space Climate, 4, A31, DOI: http://dx.doi.org/10.1051/swsc/201402

5. J.P. Byrne, H. Morgan, **D.B. Seaton**, H.M. Bain, S.R. Habbal
Bridging EUV and white-light observations to inspect the initiation phase of a 'two-stage' solar eruptive event
Solar Physics, 289, pp. 4545-4562

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Proceedings of the International Meteor Conference, Giron, France, 18-21 September 2014 Eds.: Rault, J.-L.; Roggemans, P. International Meteor Organization, ISBN 978-2-87355-028-8, pp. 194-196, 2014

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Space Science Reviews, 186, 1-4, pp.35-103

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Time Evolution of the Altitude of an Observed Coronal Wave
Solar Physics, 289, pp.2565-2585

9. **V. De Bock, H. De Backer, R. Van Malderen, A. Mangold, A. Delcloo**
Relations between erythemal UV dose, global solar radiation, total ozone column and aerosol optical depth at Uccle, Belgium
Atmospheric Chemistry and Physics, 14, 12251-12270, DOI: 10.5194/acp-14-12251-2014, 2014

10. **A. Devos, C. Verbeeck, E. Robbrecht**
Verification of Space Weather Forecasting at the Regional Warning Center in Belgium
Journal of Space Weather and Space Climate, 4 , A29, DOI: http://dx.doi.org/10.1051/swsc/2014025

11. **E. D'Huys, D.B. Seaton**, S. Poedts, **D. Berghmans**
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12. Y. Dong, **A. Verdini**, R. Grappin
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The Astrophysical Journal, 793, pp.15

13. R.C. Fear, S.E. Milan, **R. Maggiolo**, A.N. Fazakerley, I. Dandouras, S.B. Mende
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14. G. Gogoberidze, **Y. Voitenko**, S. Poedts, **J. De Keyser**
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Characteristics of the flank magnetopause: Cluster observations
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18. M. Haberreiter, **B. Mampaey, V. Delouille, C. Verbeeck**, S. Wieman, G. Del Zanna
Reconstruction of the solar EUV irradiance from 1996 to 2012 based on SOHO/EIT images
Journal of Space Weather and Space Climate, 4, A30, DOI: http://dx.doi.org/10.1051/swsc/2014027

19. A. Hauchecorne, M. Meftah, A. Irbah, S. Couvidat, R. Bush, **J.-F. Hochedez**
Solar Radius Determination from Sodism/Picard and HMI/SDO Observations of the Decrease of the Spectral Solar Radiance during the 2012 June Venus Transit
The Astrophysical Journal, 783, 2, pp. 127. DOI: 10.1088/0004-637X/783/2/127

20. M. Hernández-Pajares, À. Árágón-Angel, **P. Defraigne, N. Bergeot**, R. Prieto-Cerdeira, J. Sanz, A. García-Rigo
Distribution and mitigation of higher order ionospheric effects on precise GNSS processing
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21. **J.-F. Hochedez**, C. Timmermans, A. Hauchecorne, M. Meftah
Dark signal correction for a lukecold frame-transfer CCD. New method and application to the solar imager of the PICARD space mission
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22. P. Jiggens, H. Evans, P. Truscott, D. Heynderickx, F. Lei, **E. De Donder**
Long-Term Destructive SEE Risk and Calculations Using Multiple "Worst-Case" Events Versus Modelling
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Micro-workshop: Detection of sub-minute quasi-periodic pulsations (QPP) in solar flares
SIP7, La-Roche-en-Ardenne, Belgium, 18–21 August 2014

76. M. Dominique
Solar irradiance measurements with LYRA
STCE workshop on Science and science operations of the

PROBA satellite fleet, Brussels, Belgium, 31 March 2014

77. M. Dominique
Progress towards understanding the degradation affecting the PROBA2/LYRA instrument
CHARM 3rd Annual Meeting, 18-19 September 2014, Brussels, Belgium

78. M. Dominique
The Royal Observatory of Belgium / SIDC
CHARM 2nd Annual Meeting, 30-31 January 2014, Ghent, Belgium

79. M. Dominique, I.E. Dammasch, D.F. Ryan, A.C. Katsiyannis, L. Wauters, M. West
Tutorial: How to use LYRA data
ESWW11 (Tutorial), Liège, Belgium, 17-21 November 2014

80. M. Dominique, A.R. Jones, D. McMullin, I.E. Dammasch, A.C. Katsiyannis, D.F. Ryan
Progress towards understanding the degradation affecting the PROBA2/LYRA instrument
eHeroes 2nd Annual Meeting, Davos, Switzerland, 10-12 March 2014

81. M. Dominique
High-frequency quasi-periodic oscillations/pulsations in solar flares: what can we learn and what are the difficulties inherent to their detection?
CHARM 2nd Annual Meeting, 30-31 January 2014, Ghent, Belgium

82. M. Dominique, V. Zigman
How using the spectral response of instruments in flaring conditions affects the modeling of the impact of flares on the ionization rate in the ionospheric D-region
ESWW11, Liège, Belgium, 17-21 November 2014

83. M. Dominique, L. Wauters, A.R. Jones, D. McMullin, I.E. Dammasch, A.C. Katsiyannis, D.F. Ryan
Cross-calibration of LYRA with SEE and EVE
Inter-calibration and degradation of EUV instruments workshop, 10-13 June 2014, Brussels, Belgium

84. M. Echim and the STORM team
Survey of the spectral properties of turbulence in the solar wind, the magnetospheres of Venus and Earth, at solar minimum and maximum
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014

85. M. Echim and the FP7 STORM Team
Gaussianity versus intermittency in solar system plasma turbulence
AGU Fall Meeting, San Francisco, USA, 15-19 December 2014

86. M. Echim and the STORM Team
Spectral properties of solar wind turbulence, at solar minimum and maximum
AOGS11, Chuo-ku, Sapporo, Japan, 28 July-01 August 2014

87. M. Echim and the STORM team
Investigation of the spectral properties of the solar wind turbulence at solar minimum and maximum
STCE Workshop on Physical Processes in Solar-Terrestrial Plasmas, Brussels, Belgium, 20-23 May 2014

88. D. Fussen, D. Pieroux, S. Ranvier, J. De Keyser, P. Cardoen, E. Dekemper, F. Vanhellemont, H. Saari
The PIC.A.S.S.O. mission: A PICo-satellite for Atmospheric and Space Science Observations
Sixth European CubeSat Symposium, Estavayer-le-Lac, Switzerland, 14-16 October 2014

89. S. Gissot, B. Giordanengo, A. BenMoussa
Critical component degradation and inflight calibration of EUI onboard Solar Orbiter
Inter-calibration and degradation of EUV instruments workshop, 10-13 June 2014, Brussels, Belgium

90. S. Gissot
Differential rotation and meridional flow measurements from high-latitude EUI vantage points
EUI Consortium meeting 14, Royal Library, Brussels, Belgium, 10-12 December 2014

91. S. Gissot, D. Berghmans, D.M. Long, D.R. Williams
EUI Flare Trigger: Test Results
EUI Consortium meeting 14, Royal Library, Brussels, Belgium, 10-12 December 2014

92. S. Gissot, R. Brajsa
High-latitude opportunities for flow measurements with the EUI instrument onboard Solar Orbiter
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014 (poster)

93. G. Guerova, J. Jones, J. Dousa, G. Dick, S. De Haan, E. Pottiaux, O. Bock, R. Pacione, G. Elgered, H. Vedel
Advanced Global navigation Satellite Systems tropospheric products for monitoring severe weather events and climate (GNSS4SWEC)
IGS workshop, Pasadena, USA, 23-27 June 2014

94. H. Gunell, J. De Keyser
Vlasov simulations of auroral processes
STCE Workshop on Physical Processes in Solar-Terrestrial Plasmas, Brussels, Belgium, 20-23 May 2014

95. H. Gunell, L. Andersson, J. De Keyser, I. Mann
Auroral Electrons Trapped and Lost: A Vlasov Simulation Study
AGU Fall Meeting, San Francisco, USA, 15-19 December 2014 (poster)

96. H. Gunell, L. Andersson, J. De Keyser, I. Mann
Vlasov simulation of the trapping and loss of auroral electrons
Geospace revisited: a Cluster/MAARBLE/Van Allen Probes Conference, Rhodos, Greece, 15-20 September 2014

97. H. Gunell, G. Stenberg Wieser, M. Mella, R. Maggiolo, H. Nilsson, F.Darrouzet, M. Hamrin, T. Karlsson, N. Brenning, J. De Keyser, M. André, I. Dandouras
Observations of waves in plasmoids in the magnetosheath
Geospace revisited: a Cluster/MAARBLE/Van Allen Probes Conference, Rhodos, Greece, 15-20 September 2014 (poster)

98. S. Haaland, J. Reistad, P. Tenfjord, L. Maes, J. De Keyser, R. Maggiolo, C. Anekallu, N. Dorville
Characteristics of the flank magnetopause: Cluster results
Geospace revisited: a Cluster/MAARBLE/Van Allen Probes Conference, Rhodos, Greece, 15-20 September 2014

99. M. Haberreiter, V. Delouille, Giulio Del Zanna, I. Ermolli, M. Kretzschmar, B. Mampaey, M. Dominique, W. Schmutz
Reconstruction of the solar EUV irradiance as observed with PROBA2/LYRA
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014

100. M. Haberreiter, V. Delouille, Giulio Del Zanna, I.E. Dammasch, C. Erhardt, M. Dominique, A.R. Jones, M. Kretzschmar, B. Mampaey, G. Schmidtke, C. Verbeeck, S. Wieman, T. Woods, T. Dudok de Wit, W. Schmutz
Solar EUV Modeling Efforts within the FP7 SOLID project
ESWW11, Liège, Belgium, 17-21 November 2014 (poster)

101. B. Heilig, F. Darrouzet, R.H. Friedel, J. Lichtenberger, M. Vellante
Ground based detection of the plasmapause and the density of the plasmasphere
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014

102. B. Heilig, F. Darrouzet, M. Vellante, J. Lichtenberger, H. Lühr
Validation of a new plasmapause model derived from CHAMP field-aligned current signatures
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014

103. L. Hetey, M. Kruglanski, N. Messios, S. Calders S., E. De Donder, E. Parilla-Endrino, I. Grande, N.-D. Ho, P. Beltrami, R. Keil, D. Heynderickx, H. Evans, E. Daly, D. Rodgers
SPENVIS - The SPace ENvironment Information System
IEEE/NSREC Conference 2014, Paris, France, 14-18 July 2014 (poster)

104. K. Hosokawa, R. Maggiolo, Y. Zhang, R. Fear, D. Fontaine, J. Cumnock, A. Kullen, S. Milan, A. Kozlovsky, M. Echim
Multi-instrument observations of multiple auroral arcs in the duskside polar cap region
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014

105. A. Inglis, J. Ireland, M. Dominique
Searching for narrowband oscillations in solar flares in the presence of power-law Fourier spectra
ESPM 14, Dublin, Ireland, 8-12 September 2014 (poster)

106. J. Janssens
Flaring activity in NOAA 2158
ESWW11 (splinter “Forecaster Forum"), Liège, Belgium, 18 November 2014

107. A.R. Jones, M. Dominique
Degradation of the EVE/MEGS-A filters: Do we understand what is happening?
LWS/Hinode/IRIS 2014 Workshop, Portland, Oregon, USA, 2-6 November 2014 (poster)

108. J. Jones, G. Guerova, J. Dousa, S. De Haan, O. Bock, G. Dick, E. Pottiaux, R. Pacione
COST Action ES1206 : Advanced Global Navigation Satellite Systems Tropospheric Products for Monitoring Severe Weather Events and Climate (GNSS4SWEC)
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014 (poster)

109. J. Jones, G. Guerova, J. Dousa, G. Dick, S. De Haan, E. Pottiaux, O. Bock, R. Pacione, G. Elgered, H. Vedel
COST Action ES1206: Advanced Global Navigation Satellite Systems tropospheric products for monitoring severe weather events and climate (GNSS4SWEC)
EUREF symposium, Vilnius, Lithuania, 4-6 June 2014

110. A.C. Katsiyannis, M. Dominique
In situ detections of Space Weather by the LYRA radiometer on-board the PROBA2 satellite
eHeroes 2nd Annual Meeting, Davos, Switzerland, 10-12 March 2014

111. A.C. Katsiyannis, M. Dominique, E. De Donder, I.E. Dammasch, J. De Keyser, M. Kruglanski, A. BenMoussa
In situ detections of Space Weather by the LYRA radiometer on-board the PROBA satellite
ESWW11, Liège, Belgium, 17-21 November 2014 (poster)

112. A.C. Katsiyannis, M. Dominique, A. BenMoussa, I.E. Dammasch, M. Kruglanski, E. De Donder
In situ detections of Space Weather by the LYRA radiometer on-board the PROBA2 satellite
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014

113. T. Katsiyannis, M. Dominique, D. Ryan, E. De Donder, J. De Keyser, M. Kruglanski
In situ detections of Space Weather by the LYRA radiometer on board the PROBA2 satellite
ESWW11, Liège, Belgium, 17-21 November 2014 (poster)

114. I. Kolmasova, O. Santolik, F. Darrouzet, M. Usanova, N. Cornilleau-Wehrlin
Systematic analysis of whistler mode waves in plasmaspheric plumes
Cluster 24th Workshop, Rhodos, Greece, 15-20 September 2014

115. S. Koutchmy, A.N. Zhukov, L. Dolla, P. Heinzel, P. Lamy, C. Bazin, V. Bommier, M. Faurobert
Possible measurements of the magnetic field in eruptive prominences using the PROBA-3 coronagraph
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014

116. E. Kraaikamp, C. Verbeeck, The AFFECTS team
Detecting Flares, Dimmings and EUV waves on SDO/AIA
SIP7, La-Roche-en-Ardenne, Belgium, 18–21 August 2014

117. E. Kraaikamp, C. Verbeeck, The AFFECTS team
Solar Demon - near real-time, Flare, Dimming, and EUV wave Monitoring
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014 (talk & poster)

118. E. Kraaikamp, C. Verbeeck, The AFFECTS team
Detecting Flares, Dimmings, and EUV waves on SDO-AIA images
ESWW11, Liège, Belgium, 17-21 November 2014 (poster)

119. E. Kraaikamp, C. Verbeeck
Solar Demon: Near real-time dimming and EUV wave detection on SDO-AIA
Third AFFECTS General Meeting, Brussels, Belgium, 17-19 February 2014

120. M. Kruglanski
The SSA Space Weather Coordination Centre (SN-IV)
SSA Space Weather Presentation Day, ESOC, Darmstadt, Germany, 4 July 2014

121. M. Kruglanski
SPENVIS-CCMC relationship
CCMC Community Workshop #7, Annapolis, Maryland, USA, 4 April 2014

122. M. Kruglanski
Status of the SSA Space Weather Coordination Centre
ESWW11, Liège, Belgium, 17-21 November 2014

123. M. Kruglanski, N. Messios, S. Calders, L. Hetey, E. De Donder, E. Parilla-Endrino, I. Grande, N.-D. Ho, P. Beltrami, R. Keil, D. Heynderickx, H. Evans, E. Daly, D. Rodgers
Next Generation SPENVIS
ESWW11, Liège, Belgium, 17-21 November 2014

124. M. Kruglanski
SPENVIS-4
TEC-EES Final Presentation Days 2014, Noordwijk, The Netherlands, 5 November 2014

125. M. Kruglanski
SSA Space Weather Coordination Centre - Status
ESOC, Darmstadt, Germany, 16 December 2014

126. Q. Laffineur, A. Delcloo, H. De Backer, M. Adam, D. Klugmann
Observation of an intercontinental smoke plume over Europe on June 2013: some ambiguity in the determination of the source
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014 (poster)

127. Q. Laffineur, M. Haeffelin
Investigate fog prediction capabilities of ALC profiles
COST ES1303-TOPROF WG meeting, Roskilde, Denmark, 18-20 November 2014

128. H. Lamy, S. Ranvier, A. Martinez Picar, E. Gamby, S. Calders, M. Anciaux, J. De Keyser
BRAMS : the Belgian Radio meteor stations
ACM 2014 conference, Helsinki, Finland, 30 June-4 July 2014

129. H. Lamy
COST MP1104 : Polarisation as a tool to study the solar system and beyond
COST Annual Progress Conference, Heraklion, Crete, 7-9 September 2014

130. L. Lefèvre
The sunspot number and beyond: reconstructing detailed solar information over centuries
AGU Fall Meeting, San Francisco, USA, 15-19 December 2014 (poster)

131. L. Lefèvre, F. Clette
A multi-secular sunspot number perspective on the current solar cycle
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014 (invited)

132. L. Lefèvre
Movies for the TOSCA project
TOSCA MC Meeting, Vienna, Austria, 27 April 2014

133. L. Lefèvre
Sunspot behavior in the last solar cycles
SSN Workshop 4, Locarno, Switzerland, 19-23 May 2014

134. L. Lefèvre
Sunspot catalogs: error determination
Second Annual Meeting SOLID, Bremen, Germany, 28-31 October 2014

135. L. Lefèvre, F. Clette
A multi-secular sunspot number perspective on solar activity
TOSCA MC Meeting, Vienna, Austria, 27 April 2014

136. G. Lopez Rosson, V. Pierrard
EPT : first results
URSI Forum, Louvain-La-Neuve, Belgium, 18 November 2014

137. L. Maes, R. Maggiolo, F. Dhooghe, J. De Keyser
Solar ultraviolet radiation and its effect on planetary and cometary mass loss
Meeting of the FNRS Contact Group on Atoms, Molecules and Radiation, BIRA-IASB, 6 February 2014

138. L. Maes, R. Maggiolo, J. De Keyser
The effect of solar illumination on ionospheric outflow composition in the polar cap region
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014

139. L. Maes, R. Maggiolo, J. De Keyser
Effect of solar illumination on ionospheric outflows in field-aligned acceleration regions above the polar caps
General Scientific Meeting of the Belgian Physical Society, Leuven, 28 May 2014

140. L. Maes, R. Maggiolo, S. Haaland, I. Dandouras, J. De Keyser, R. Fear, D. Fontaine
Ionospheric outflow above a sunlit and a dark polar cap
Geospace revisited: a Cluster/MAARBLE/Van Allen Probes Conference, Rhodos, Greece, 15-20 September 2014 (poster)

141. L. Maes, J. De Keyser, S. Haaland, R. Maggiolo, M. Echim
Assessment of possible mechanisms responsible for dawn-dusk asymmetry of the magnetopause
AGU Fall Meeting, San Francisco, USA, 15-19 December 2014

142. J. Magdalenic
Coherent Radio Emission and the now LOFAR radio interferometer
Second RadioSun Workshop & Summer School, Lublin, Poland, 26-30 May 2014 (invited)

143. J. Magdalenic, V. Krupar, C. Marqué, M. Mierla, A.N. Zhukov, L. Rodriguez, M. Maksimovic, B. Cecconi
Mapping the 3D position of solar coronal shock waves using radio triangulation
STCE Workshop on Tomography & 3D reconstruction in space science, Brussels, Belgium, 7 April 2014

144. J. Magdalenic, V. Krupar, C. Marqué, M. Mierla, A.N. Zhukov, L. Rodriguez, M. Maksimovic, B. Cecconi
The CME-driven shock wave on 2012 March 05 and radio triangulation of associated radio emission2012
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014

145. J. Magdalenic, C. Marqué, A. Kerdraon, G. Mann, F. Breitling, C. Vocks, R. Fallows, V. Krupar, L.A. Rachmeler, I.E. Dammasch
Type III radio bursts observed with LOFAR and Nançay radioheliograph
ESPM 14, Dublin, Ireland, 8-12 September 2014

146. R. Maggiolo, D. Fontaine, K. Hosokawa, L. Maes, Y. Zhang, R. Fear, J. Cumnock, A. Kozlovsky, A. Kullen, S. Milan, K. Shiokawa, M. Echim
Connection between high-latitude arcs and the low-latitude boundary layer during periods of northward IMF
AGU Fall Meeting, San Francisco, USA, 15-19 December 2014 (poster)

147. R. Maggiolo, L. M. Kistler, J. De Keyser
Modulation of the plasmasheet O+ density by the solar wind
Geospace revisited: a Cluster/MAARBLE/Van Allen Probes Conference, Rhodos, Greece, 15-20 September 2014 (poster)

148. R. Maggiolo, L. M. Kistler, J. De Keyser
Variation of the plasmasheet O+ and H+ density with solar activity and wind conditions
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014

149. B. Mailyan, Q. Shi, R. Maggiolo, Q. Zong, X. Cao, Y. Zhang, Z. Yao, S. Fu, Y. Wei, Z. Pu
The relationship between solar wind entry processes and transpolar arc formation
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014

150. B. Mailyan, S. Fu, Q. Shi, R. Maggiolo, Q. Zong, S. Fu, Y. Zhang, Z. Yao, W. Sun
On transpolar arc formation correlated with solar wind entry at high latitude magnetosphere
Geospace revisited: a Cluster/MAARBLE/Van Allen Probes Conference, Rhodos, Greece, 15-20 September 2014

151. O.E. Malandraki, A. Tylka, N.B. Crosby, A. Papaioannou, I. Patsou, M. Dierckxsens, K. Tziotziou, C.K. Ng, D. Patterson, T.P. Armstrong, L.J. Lanzerotti, and the COMESEP consortium

Space Weather Forecasting: from the scientific observations to the operational practice – the COMESEP Alert System
AOGS11, Chuo-ku, Sapporo, Japan, 28 July-01 August 2014 (talk & poster)

152. B. Mampaey, V. Delouille
Segmentation of PROBA2/SWAP images in view of the reconstruction of the solar EUV irradiance.
Second Annual Meeting SOLID, Bremen, Germany, 28-31 October 2014

153. A. Mangold, R. Van Malderen, H. De Backer, A. Delcloo, V. De Bock, I. Gorodetskaya, H. Wex, C. Hermans
Observations of atmospheric composition, clouds and precipitation in Dronning Maud Land, East Antarctica
MOZAIC–IAGOS Scientific Symposium on Atmospheric Composition Observations by Commercial Aircraft: 20th Anniversary, Toulouse, 12-15 May 2014 (poster)

154. M. Marsh, S. Dalla, T. Laitinen, M. Dierckxsens, N.B. Crosby
SPARX: a Propagation based Modelling System for Solar Energetic Particle Radiation Space Weather Forecasting
ESWW11, Liège, Belgium, 17-21 November 2014 (talk & poster)

155. A. Martinez Picar
Calibration of BRAMS antennas & solar radio instruments in HuRAS
STCE Workshop on Modelling of antennas and calibration of radio instruments, Brussels, Belgium, 6 June 2014

156. A. Martinez Picar
Directional pattern of the antennas: Simulations and future in-situ measurements with an UAV
BRAMS annual assembly, Volkssterrenwacht MIRA, Grimbergen, Belgium, 5 April 2014

157. N. Messios, M. Kruglanski, S. Calders, L. Hetey, E. De Donder, E. Parilla-Endrino, I. Grande, H. Ngoc-D., P. Beltrami, R. Keil, D. Heynderickx, H. Evans, E. Daly, D. Rodgers
Next Generation SPENVIS
ESWW11, Liège, Belgium, 17-21 November 2014 (poster)

158. M. Mierla, L. Rodriguez, D.B. Seaton, A.N. Zhukov, F.P. Zuccarello
The CMEs morphology and their low coronal origin
Tenth Latin American Conference on Space Geophysics, Cusco, Peru, 8-12 September 2014 (invited)

159. M. Mierla, L. Rodriguez, A.N. Zhukov, F. Zuccarello, E. Kilpua, E. D'Huys, D.B. Seaton
Study of stealth flux-rope CMEs arriving at the Earth in 2009
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014

160. M. Mierla, V. Pant, L. Rodriguez
3D kinematics of two consecutive CMEs
SIP7, La-Roche-en-Ardenne, Belgium, 18–21 August 2014 (poster)

161. M. Mierla
Solar Corona Polarization
PROBA-3 First Science Working Team meeting, ESTEC, The Netherlands, 3-4 July 2014

162. M. Mierla, L. Rodriguez
3D Propagation of Coronal Mass Ejections
STCE Workshop on Tomography & 3D reconstruction in space science, Brussels, Belgium, 7 April 2014

163. K. Moon, J. Li, V. Delouille, F. Watson, A.O. Hero III
Image patch analysis and clustering of sunspots: a dimensionality reduction approach
SIP7, La-Roche-en-Ardenne, Belgium, 18–21 August 2014

164. K. Moon, J. Li, V. Delouille, F. Watson, A.O. Hero III
Image patch analysis and clustering of sunspots: a dimensionality reduction approach
IEEE/ICIP 2014, Paris, France, 27-30 October 2014 (poster)

165. M. Muntean, M. Mierla, D. Besliu-Ionescu, D. Lacatus, A.R. Paraschiv
Interplanetary coronal mass ejections and their geomagnetic consequences during solar cycle 24
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014 (poster)

166. M. Muntean, D. Besliu-Ionescu, M. Mierla
March 2013 ICMEs and their Geomagnetic Effects
ESWW11, Liège, Belgium, 17-21 November 2014

167. C. Munteanu, P. Kovacs, M. Echim, A. Koppan
An Integrated Nonlinear Analysis library - (INA) for solar system plasma turbulence
EGU General Assembly 2014 (STORM splinter), Vienna, Austria, 27 April-02 May 2014

168. V. Pant, D. Banerjee, M. Mierla
Automated tracking Coronal Mass Ejections using CACTus
SIP7, La-Roche-en-Ardenne, Belgium, 18–21 August 2014 (poster)

169. J.M. Pasachoff, M. Lu, A.B. Davis, M. Demianski, V. Rusin, M. Saniga, D.B. Seaton, R. Lucas, B.A. Babcock, R. Dantowitz, P. Gaintatzis, C.H. Seeger, C. Malamut, A. Steele
Coronal Dynamics at Recent Total Solar Eclipses
AGU Fall Meeting, San Francisco, USA, 15-19 December 2014 (poster)

170. V. Pierrard, S. Benck, S. Borisov

Instruments aspects, operations and science of EPT
STCE workshop on Science and science operations of the PROBA satellite fleet, Royal Observatory of Belgium, 31 March 2014

171. V. Pierrard, K. Borremans, G. Lopez Rosson
Flux variations in the Van Allen Belts observed by CLUSTER/RAPID and PROBA-V/EPT
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014

172. V. Pierrard
Kinetic properties of the turbulent solar wind
STCE Workshop on Physical Processes in Solar-Terrestrial Plasmas, Brussels, Belgium, 20-23 May 2014

173. V. Pierrard, K. Borremans, G. Lopez Rosson
Flux Variations in the Van Allen Belts observed by the Energetic Particle Telescope
Geospace revisited: a Cluster/MAARBLE/Van Allen Probes Conference, Rhodos, Greece, 15-20 September 2014

174. S. Poedts and the VSWMC Phase 1 Team
Virtual Space Weather Modelling Centre - Phase 1
ESWW11, Liège, Belgium, 17-21 November 2014

175. S. Poedts, G. Lapenta, A. Lani, H. Deconinck, F. Diet, N.-D. Ho, N. Mihalache, D. Heynderickx, J. De Keyser, N.B. Crosby, L. Rodriguez, R. Van der Linden, P. Jiggens, and A. Hilgers
The ESA Virtual Space Weather Modelling Centre - Phase 1
ESPM 14, Dublin, Ireland, 8-12 September 2014

176. T. Podladchikova, R.A.M. Van der Linden
Short-term variations of the 11-year sunspot cycle as a predictor of the next cycle strength
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014

177. E. Pottiaux, J. Berckmans, S. De Haan, C. Bruyninx
Producing IWV Maps for Guiding Nowcasting of Severe Weather
1st COST ES1206 Workshop (GNSS4SWEC), Munich, Germany, 26-28 February 2014

178. E. Pottiaux, J. Berckmans, C. Bruyninx
Recent Developments towards enhanced Multi-GNSS Processing
1st COST ES1206 Workshop (GNSS4SWEC), Munich, Germany, 26-28 February 2014 (poster)

179. E. Pottiaux, J. Berckmans, C. Bruyninx
Advanced multi-GNSS troposphere modeling for improved monitoring and forecasting of severe weather
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014 (poster)

180. E. Pottiaux, P. Vaclavovic, J. Dousa, C. Bruyninx
Using the IGS Real-Time Service and GNUT/Tefnut For Nowcasting Severe Weather
IGS workshop, Pasadena, USA, 23-27 June 2014 (poster)

181. E. Pottiaux, F. Clette
Climate Related Research, Data and Services at ROB
Study for the Establishment of a federal Climate Centre: Kick-off Meeting, 7 July 2014, Brussels Belgium (invited)

182. E. Pottiaux, S. De Haan
COST ES1206: WG2 Welcome. "Use of GNSS tropospheric products for high-resolution, rapid-update NWP and severe weather forecasting"
3rd COST ES1206 WG Meeting, Varna, Bulgaria, 11-12 September 2014

183. E. Pottiaux, R. van Malderen, H. Brenot, C. Bruyninx, J. Berckmans, A. Duerinckx
Current GNSS-Met and GNSS-Clim Activities in Belgium
3rd COST ES1206 WG Meeting, Varna, Bulgaria, 11-12 September 2014

184. E. Pottiaux, S. De Haan
COST ES1206: Working Group 2. "Use of GNSS tropospheric products for high-resolution, rapid-update NWP and severe weather forecasting"
Second E-GVAP III Joint Expert Meeting, Exeter, UK, 22-23 October 2014

185. E. Pottiaux
Status of GNSS Meteorology Activities at ROB
Second E-GVAP III Joint Expert Meeting, Exeter, UK, 22-23 October 2014

186. L.A. Rachmeler
Forward Modeling as a Tool for Coronal Magnetometry
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014 (invited)

187. S. Ranvier, P. Cardoen, J. De Keyser
SLP: A scanning Langmuir probe for PICASSO
PICASSO SLP meeting, Brussels, Belgium, 11 February 2014

188. S. Ranvier, J. De Keyser, P. Cardoen, D. Pieroux
Development of a novel sweeping Langmuir probe instrument for the monitoring of the upper ionosphere on board a pico-satellite
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014 (poster)

189. S. Ranvier, P. Cardoen, J. De Keyser, D. Pieroux, D. Fussen
Development of a sweeping Langmuir probe instrument for monitoring the upper ionosphere on board a triple CubeSat
Sixth European CubeSat Symposium, Estavayer-le-Lac, Switzerland, 14-16 October 2014

190. M.A. Reiss, S.J. Hofmeister, M. Temmer, A.M. Veronig, R. De Visscher, V. Delouille, T. Rotter
Second order statistics for the analysis of textural properties of coronal holes and filament channels in SDO/HMI and SDO/AIA 193Å images
SIP7, La-Roche-en-Ardenne, Belgium, 18–21 August 2014

191. L. Rodriguez, A.N. Zhukov, S. Dasso, E. Kilpua, M. Mierla
Typical Profile and Density peaks in Magnetic Clouds at 1 AU
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014 (poster)

192. D.F. Ryan
Global Energetics session
RHESSI workshop 2014, Windisch, Switzerland, 1-4 April 2014

193. D.F. Ryan, M. Dominique, K. Stegen
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194. D.F. Ryan, M. Dominique, K. Stegen
LYRAFF: LYRA Flare Finder
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195. D.F. Ryan, M. Dominique, K. Stegen, I.E. Dammasch, A.C. Katsiyannis
New flare detection algorithm and flare list for PROBA2/LYRA
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196. D.F. Ryan, S. Mumford, S. Christe, D. Perez-Suarez, Andrew Inglis, M. Dominique
SunPy: New Scientific Analysis Capabilities for GOES Observations
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197. D.F. Ryan, S. Mumford, S. Christe, D. Perez-Suarez, Andrew Inglis, M. Dominique
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198. D.F. Ryan, S. Mumford, S. Christe, D. Perez-Suarez, Andrew Inglis, M. Dominique
SunPy: New Scientific Analysis Capabilities for GOES Observations SIP workshop
ESWW11, Liège, Belgium, 17-21 November 2014 (poster)

199. D.B. Seaton, K.K. Reeves, T.G. Forbes
PROBA3 Calibration, on the ground and in-flight
PROBA-3 First Science Working Team meeting, ESTEC, The Netherlands, 3-4 July 2014 (invited)

200. D.B. Seaton
The SWAP CMOS-APS: Lessons Learned
EUI Consortium meeting 14, Royal Library, Brussels, Belgium, 10-12 December 2014 (invited)

201. D.B. Seaton
Status of WP6 deliverables and milestones
eHeroes 2nd Annual Meeting, Davos, Switzerland, 10-12 March 2014 (invited)

202. D.B. Seaton, A. De Groof, L.A. Rachmeler, D. Berghmans
Solar Cycle 24 and the large-Scale evolution of the EUV corona
ESPM 14, Dublin, Ireland, 8-12 September 2014

203. D.B. Seaton, T.G. Forbes, K.K. Reeves
The role of magnetic reconnection in flares and
eHeroes 2nd Annual Meeting, Davos, Switzerland, 10-12 March 2014

204. Q. Shi, X. Gou, B. Mailyan, R. Maggiolo, Y. Zhang, S. Fu, Q. Zong, G. Parks, Z.Pu, M. Dunlop
Solar Wind Entry into the magnetosphere lobes and its Related Auroral activities
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205. V.A. Slemzin, A. Ulyanov, K. Gaikovich, S.V. Kuzin, A. Perstov, D. Berghmans, M. Dominique
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COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014

206. S. Stankov
On the local-time variations of the storm-time TEC at European middle latitudes
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207. S. Stankov, D. Sapundjiev, T. Verhulst, A. Gonsette, J.C. Jodogne
Long-Term Solar Changes - influence on geomagnetic, cosmic ray and ionospheric parameters
STCE Workshop on Long Term Solar Changes, Brussels, Belgium, 19 May 2014

208. K. Stegen, E. Kraaikamp, C. Verbeeck, D. Berghmans, S. Gissot, B. Giordanengo, M. West, B. Nicula
EUI Data Centre at the Royal Observatory of Belgium - Challenges and Solutions
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014 (poster)

209. D.C. Talpeanu, L. Stan, M. Mierla, L. Rodriguez, A.N. Zhukov, D. Besliu-Ionescu
Linking CMEs-ICMEs-Geomagnetic Storms during 1996-

2012
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014 (poster)

210. B. Thompson, M.L. DeRosa, R.R. Fisher, L.D. Krista, R. Young Kwon, J.P. Mason, M.L. Mays, N.V. Nitta, N. Savani, M. West
What Do EUV Dimmings Tell Us About CME Topology?
AGU Fall Meeting, San Francisco, USA, 15-19 December 2014

211. M. Usanova, F. Darrouzet, I. Mann, J. Bortnik
Statistical Analysis of EMIC Wave Location in Relation to the Plasmapause from Cluster Observations
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014

212. M. Usanova, I.R. Mann, A. Drozdov, K. Orlova, Y. Shprits, F. Darrouzet, R. Ergun
EMIC Waves in the Radiation Belts
AGU Fall Meeting, San Francisco, USA, 15-19 December 2014 (invited)

213. A.C. Vandaele, E. Neefs, J.J. Lopez-Moreno, J. Rodriguez Gomez, R. Drummond, M. Patel, I. Thomas, S. Gissot, C. Depiesse, A. BenMoussa, B. Giordanengo, G. Belucci
Nomad on the Exomars TGO 2016 Mission: mait and characterisation testing
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014

214. T. Van Doorsseleare, M. Goossens, G. Verth, R. Soler, S.E. Gijsen, J. Andries
Wave Energy Deposition in the Solar Corona
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014 (poster)

215. P. Vanlommel, C. Gressl, G. Lapenta, N.B. Crosby, G. Cessateur, and the eHEROES consortium Team
eHEROES: where Space Weather and Communication meet
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014 (talk & poster)

216. P. Vanlommel, G. Cessateur, N.B. Crosby
Education and Communication: citizen science
ESWW11 (splinter), Liège, Belgium, 17-21 November 2014

217. R. Van Malderen, O. Bock
Inventory of IWV intercomparison sites and papers
3rd COST ES1206 WG Meeting, Varna, Bulgaria, 11-12 September 2014

218. R. Van Malderen, E. Pottiaux, H. Brenot, S. Beirle, T. Wagner, H. De Backer, C. Bruyninx
An integrated water vapour trends analysis based on more than 15 years of world-wide GPS and GOME/SCHIAMACHY/GOME-2 retrievals
NORS/NDACC/GAW workshop, Brussels, Belgium, 5-7 November 2014

219. R. Van Malderen
A literature survey on Integrated Water Vapour (IWV) intercomparison studies
1st COST ES1206 Workshop (GNSS4SWEC), Munich, Germany, 26-28 February 2014 (keynote lecture)

220. R. Vansintjan, M. West, D.B. Seaton, L.A. Rachmeler
A study of successive EUV waves in PROBA2/SWAP observations
ESPM 14, Dublin, Ireland, 8-12 September 2014

221. R. Vansintjan, B. Mampaey, V. Delouille
The SOLARNET Solar Virtual Observatory
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222. C. Verbeeck, K. Stegen, D. Berghmans, M. West, E. Kraaikamp, S. Gissot, B. Giordanengo, B. Nicula
The EUI Data Center at the Royal Observatory of Belgium: challenges and solutions
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014 (poster)

223. T. Verhulst, D. Sapundjiev, S. Stankov
The need for local, high resolution, multi instrument monitoring to study complex effects of space weather disturbances on the ionosphere: a study on the events in February 2014
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014

224. F. Verstringe, B. Nicula, D. Berghmans, B. Bourgoignie
Viewpoint of space weather based on current image data
SIP7, La-Roche-en-Ardenne, Belgium, 18–21 August 2014 (poster)

225. F. Verstringe, B. Bourgoignie, B. Nicula, D. Berghmans, C. Marqué, V. Delouille, P. Jiggens, D. Mueller
Space Weather Helioviewer: Advances in the Visualisation of Heterogeneos Solar Data
ESWW11, Liège, Belgium, 17-21 November 2014 (poster)

226. Y. Voitenko, V. Pierrard, J. De Keyser, G. Gogoberidze, S. Poedts, L. Dolla, A.N. Zhukov
Wave signatures in particle observations
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227. Y. Voitenko, J.S. Zhao, D.J. Wu, J. De Keyser, V. Pierrard
Local versus nonlocal cascade in the solar wind turbulence
STCE Workshop on Physical Processes in Solar-Terrestrial Plasmas, Brussels, Belgium, 20-23 May 2014

228. Y. Voitenko, V. Pierrard, J. De Keyser, J.S. Zhao, D.J. Wu

Solar wind turbulence from MHD to kinetic scales
MAO-2014 70th Anniversary conference, Kyiv, Ukraine, 16-18 July 2014

229. Y. Voitenko, V. Pierrard
Proton beam generation by the solar wind turbulence
STORM 2014 annual meeting, Mamaia, Romania, 7-10 September 2014

230. L. Wauters, M. Dominique
Mid-term Periodicities of the LYRA data spectrum versus solar indices
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231. M. West
The PROBA2 Mission and Five Years of Observations: What Have we Learned?
AGU Fall Meeting, San Francisco, USA, 15-19 December 2014 (poster)

232. M. West, D.B. Seaton, F.P. Zuccarello, M. Mierla, L.A. Rachmeler, R. Vansintjan
Evolution and Dynamics of a failed eruption: Analysis from Multi-instrument Observations
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233. M. West
Sun Watcher using Active Pixel System detector and Image Processing - SWAP
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234. M. West, D. Berghmans, D.B. Seaton
The SWAP EUV imager onboard PROBA2: 3 years of observations
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235. M. West, L. Rodriguez, A.N. Zhukov, L. Dolla
Coronal Seismology Using EIT Waves: Estimation of the coronal magnetic field strength in the Quiet Sun
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014 (poster)

236. M. West, A.N. Zhukov, J.A. Klimchuk
Cross-Sectional Properties of Coronal Loops
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014 (poster)

237. M. Yamauchi, I. Dandouras, N. Paschalidis, J. De Keyser and the NITRO proposal Team
Nitrogen Ion TRacing Observatory (NITRO) concept: a possible mission for next ESA's M-class call
EGU General Assembly 2014, Vienna, Austria, 27 April-02 May 2014

238. M. Yamauchi, I. Dandouras, H. Rème, J. De Keyser and the NITRO Proposal Team
Nitrogen Ion TRacing Observatory (NITRO): Toward understanding the Earth-Venus-Mars difference of N/O ratio
ESWW11, Liège, Belgium, 17-21 November 2014 (poster)

239. A.N. Zhukov
ASPIICS: an Externally-Occulted Coronagraph for the PROBA-3 Mission
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240. A.N. Zhukov
Current and Future Challenges in Space Weather Science
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014 (invited)

241. A.N. Zhukov
Introduction to the PROBA-3 Mission
COSPAR 40th Scientific Assembly, Moscow, Russia, 02-10 August 2014 (invited)

242. A.N. Zhukov
Large-scale Low Coronal Phenomena Associated with Solar Coronal Mass Ejections (CMEs) "EIT Waves"
Huntsville Workshop 2014 "Solar and Stellar Processes from the Chromosphere to the Outer Corona", Orlando, Florida, USA, 23-27 March 2014

243. A.N. Zhukov, L. Rodriguez
Science Objectives of the ASPIICS Coronagraph onboard the PROBA-3 Mission
IPC meeting, ESA HQ, 2014

244. A.N. Zhukov, L. Rodriguez
Science Objectives of the ASPIICS Coronagraph onboard the PROBA-3 Mission
HiSPAC meeting, ESA, 2014

245. A.N. Zhukov
Science Objectives of the ASPIICS Solar Coronagraph onboard the PROBA-3
PROBA-3 First Science Working Team meeting, ESTEC, The Netherlands, 3-4 July 2014

246. A.N. Zhukov
Scientific Goals of the ASPIICS Coronagraph onboard the PROBA-3 Mission
PROBA-3 First Science Working Team meeting, ESTEC, The Netherlands, 3-4 July 2014

Public Outreach: Talks and publications for the general public

1. J. Andries
SIDC: Regional Warning Center Belgium
Visit Eurocontrol, Haren, Brussels, Belgium, 30 April 2014

2. J. Andries
RWC: Regional Warning Centre
Visit of the Belgian military delegation (Meteo) at the SSCC, Brussels, Belgium, 2 September 2014

3. N. Bergeot
Ionosphere and GNSS
Visit of the ministry of Defense of the Netherlands at the SSCC, Brussels, Belgium, 18 April 2014

4. N. Bergeot
La météo de l'espace à l'ordre du jour
La météo spatiale dans l'environnement terrestre, Cours et conférences du Collège Belgique, 8 October 2014

5. N. Bergeot
Pourquoi installer des stations GNSS en Antarctique?
Open Doors (BISA 50th anniversary edition), Brussels, Belgium, 11-12 October 2014

6. D. Berghmans, D.B. Seaton, B. Nicula
De Corona, zonsverduisteringen & PROBA2/SWAP
Werkgroep Eclipsen VVS, Duistere Dag, Urania, Public Observatory, Hove, Belgium, 22 March 2014

7. D. Berghmans
RWC: Regional Warning Centre
Visit of the ministry of Defense of the Netherlands at the SSCC, Brussels, Belgium, 18 April 2014

8. D. Berghmans
SIDC: Solar Influences Data analysis Center
Visit of the Belgian military delegation (Meteo) at the SSCC, Brussels, Belgium, 2 September 2014

9. K. Bonte
Werken met PROBA2 beelden
Sint-Lodewijkscollege Brugge visited the STCE, Brussels, Belgium, 26 September 2014

10. B. Bourgoignie
Toepassing Hough-transform: CACTus
Sint-Lodewijkscollege Brugge visited the STCE, Brussels, Belgium, 26 September 2014

11. S. Calders
Radioastronomie: BRAMS (course in basic astronomy)
Urania, Public Observatory, Hove, Belgium, 19 January 2014

12. S. Calders
I love my Sun
Basisschool De Wingerd, Reet, Belgium, 22 April 2014

13. S. Calders
BRAMS
Visit of VUB students, BIRA-IASB, Brussels, Belgium, 9 May 2014

14. F. Clette
Solar Activity - long and short time scales
Visit of the Belgian military delegation (Meteo) at the SSCC, Brussels, Belgium, 2 September 2014

15. F. Clette
Du Soleil à la Terre: en liaison directe avec une étoile
Union des Anciens Etudiants Ingénieurs, Université Libre de Bruxelles, Brussels, 21 Octobre 2014

16. F. Clette, A.N. Zhukov
Les colères du Soleil: Part 1: Source de l'activité solaire: Cycle de 11 ans
Collège Belgique, Académie Royale des Sciences, Palais Provincial, Namur, 30 September 2014

17. F. Clette
Pourquoi avons-nous un faible cycle solaire? Une perspective sur 400 ans
Société Royale Belge d'Astronomie, RMI, Brussels, 12 March 2014

18. N.B. Crosby, S. Calders, S. Chabanski, M. Dierckxsens
I love my Sun
BIRA-IASB, Open Doors (BISA 50th anniversary edition), Brussels, Belgium, 11-12 October 2014

19. N.B. Crosby, N. Messios, E. De Donder, S. Chabanski
Space Weather & Society - Interactive presentation (in English, French and Dutch)
BIRA-IASB, Open Doors (BISA 50th anniversary edition), Brussels, Belgium, 11-12 October 2014

20. N.B. Crosby
Five Centuries of Exploration: from distant shores to distant planets
BIRA-IASB, Open Doors (BISA 50th anniversary edition), Brussels, Belgium, 11-12 October 2014

21. I.E. Dammasch
Sonnenforschung und Weltraumwetter
Rotary Club, Cuxhaven, Germany, 28 February 2014

22. E. De Donder
Space Radiation Environment (Tutorial)

Visit from Antwerp Space at BIRA-IASB, Brussels, Belgium, 22 September 2014

23. J. De Keyser, S. Stankov, T. Verhulst
Earth's magnetosphere and ionosphere
Review-E, Journal of the Royal Belgian Association of Electric Engineers (SRBE-KBVE), 130(2), 2014

24. J. De Keyser
Bubble Chamber, Planeterella, Cosmic radiation
VTI Ieper (school), BIRA-IASB, Brussels, Belgium, 3 March 2014

25. J. De Keyser
Space science in Belgium
ATV5 Georges Lemaitre Launch Event, Planetarium, Brussels, 30 July 2014 (Invited)

26. J. De Keyser
Going up: Out of the atmosphere and into space
Academic Session on the occasion of the 50th anniversary of the Belgian Institute for Space Aeronomy, Academy Palace, Brussels, Belgium, 25 November 2014

27. A. Devos
COMESEP
Visit of the Belgian military delegation (Meteo) at the SSCC, Brussels, Belgium, 2 September 2014

28. E. D'Huys, P. Vanlommel, C. Verbeeck
De Zon, Ruimteweer en PROBA2
Junior College Introductory Session, KULeuven Campus Kortrijk, Kortrijk, Belgium, 7 January 2014

29. E. D'Huys, P. Vanlommel, C. Verbeeck
De Zon, Ruimteweer en PROBA2
Junior College Introductory Session, KULeuven Campus Leuven, Leuven, Belgium, 9 January 2014

30. E. D'Huys
PROBA2: Ontwikkeling, lancering en exploitatie
PROBA2@school sessions for high school students, Klein Seminarie, Hoogstraten, Belgium, 3 April 2014

31. E. D'Huys
De PROBA2 satelliet
Open Doors (BISA 50th anniversary edition), Brussels, Belgium, 11-12 October 2014

32. L. Dolla, C. Marqué, E. Kraaikamp, B. Bourgoignie
Solar Spectroscopy - Interactive presentation (in English, French and Dutch)
BIRA-IASB, Open Doors (BISA 50th anniversary edition), Brussels, Belgium, 11-12 October 2014

33. M. Dominique
Les éruptions solaires : quand notre astre se fâche
Open Doors (BISA 50th anniversary edition), Brussels, Belgium, 11-12 October 2014

34. E. Equeter, E. D'Huys, P. Vanlommel
The Planeterella - Interactive presentation (in English, French and Dutch)
BIRA-IASB, Open Doors (BISA 50th anniversary edition), Brussels, Belgium, 11-12 October 2014

35. L. Hetey
Geometry Definition Tool (Tutorial)
Visit from Antwerp Space at BIRA-IASB, Brussels, Belgium, 22 September 2014

36. J. Janssens, P. Vanlommel
De verschillende vormen van zonneactiviteit en hun invloed op de mens en zijn technologie
Review-E, Journal of the Royal Belgian Association of Electric Engineers (SRBE-KBVE), 130(2), 2014

37. J. Janssens
De Zon
MIRA, Public Observatory, Grimbergen, Belgium, 19 March 2014

38. J. Janssens
Het voorspellen van zonnevlammen
PROBA2@school sessions for high school students, Klein Seminarie, Hoogstraten, Belgium, 3 April 2014

39. J. Janssens
De voorspelling van zonnevlammen
Sint-Lodewijkscollege Brugge visited the STCE, Brussels, Belgium, 26 September 2014

40. J. Janssens
Zonnestormen tijdens Zonnecyclus 24
COZMIX Public Observatory, Beisbroek, Belgium, 3 December 2014

41. E. Kraaikamp
Solar Demon
Visit of the ministry of Defense of the Netherlands at the SSCC, Brussels, Belgium, 18 April 2014

42. E. Kraaikamp
Solar demon
Visit of the Belgian military delegation (Meteo) at the SSCC, Brussels, Belgium, 2 September 2014

43. M. Kruglanski, N. Messios
Space Weather, 50 Years of Research at the Belgian Institute for Space Aeronomy
Science and Applications (M. Kruglanski editor), BIRA-IASB, 2014

44. M. Kruglanski
SSA Space Weather Coordination Centre

Visit of the ministry of Defense of the Netherlands at the SSCC, Brussels, Belgium, 18 April 2014

45. M. Kruglanski
SSA Space Weather Coordination Centre
Visit Eurocontrol, Haren, Brussels, Belgium, 30 April 2014

46. M. Kruglanski
SSA Space Weather Coordination Centre
Visit of the Belgian military delegation (Meteo) at the SSCC, Brussels, Belgium, 2 September 2014

47. L. Lefèvre
4 siècles de variabilité solaire : compter les taches
Open Doors (BISA 50th anniversary edition), Brussels, Belgium, 11-12 October 2014

48. V. Malisse
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Visit of the Belgian military delegation (Meteo) at the SSCC, Brussels, Belgium, 2 September 2014

49. C. Marqué
Humain and radio sciences
Visit of the ministry of Defense of the Netherlands at the SSCC, Brussels, Belgium, 18 April 2014

50. A. Martinez
Humain and radio sciences
Visit of the Belgian military delegation (Meteo) at the SSCC, Brussels, Belgium, 2 September 2014

51. N. Messios
Geant4 Package in SPENVIS (Tutorial)
Visit from Antwerp Space at BIRA-IASB, Brussels, Belgium, 22 September 2014

52. L. Rodriguez
COMESEP
Visit of the ministry of Defense of the Netherlands at the SSCC, Brussels, Belgium, 18 April 2014

53. D.B. Seaton
The discovery of the Solar Wind
Discoveries in Modern Science: Exploration, Invention, Technology, 2015, v.3, pp. 1027-1030

54. N. Theys
BISA's service activities on "Support to Aviation Control Service (SACS)"
Visit Eurocontrol, Haren, Brussels, Belgium, 30 April 2014

55. R. Van der Linden
About the Uccle Space Pole: mutual relation of BISA, ROB, STCE, SSA, SIDC and SSCC
Visit Eurocontrol, Haren, Brussels, Belgium, 30 April 2014

56. P. Vanlommel
Trip naar de zon
Ziekenhuisschool, Tienen, Belgium, 27 February 2014

57. P. Vanlommel
Ruimteweer
PROBA2@school sessions for high school students, Klein Seminarie, Hoogstraten, Belgium, 3 April 2014

58. P. Vanlommel
De snelheid van een plasma wolk berekenen
PROBA2@school sessions for high school students, Klein Seminarie, Hoogstraten, Belgium, 3 April 2014

59. P. Vanlommel
Luisteren naar de Zonnewind
Public school for higher adult education, Elcker-ik, Antwerpen, Belgium, 3 June 2014

60. P. Vanlommel
Ruimteweer en PROBA2
Zonnekijkdag, Europlanetarium, Genk, Belgium, 6 July 2014

61. P. Vanlommel
Introduction to Space Weather
Sint-Lodewijkscollege Brugge visited the STCE, Brussels, Belgium, 26 September 2014

62. P. Vanlommel
Calculating the speed of a CME
Sint-Lodewijkscollege Brugge visited the STCE, Brussels, Belgium, 26 September 2014

63. P. Vanlommel
Grillen van de Zon en PROBA2
Urania, Public Observatory, Hove, Belgium, 2 December 2014

64. P. Vanlommel
Interpreting the solar wind
Urania, Public Observatory, Hove, Belgium, 16 December 2014

65. C. Verbeeck
STAFF
Visit of the ministry of Defense of the Netherlands at the SSCC, Brussels, Belgium, 18 April 2014

66. C. Verbeeck
Space weather - extreme events
Visit of the Belgian military delegation (Meteo) at the SSCC, Brussels, Belgium, 2 September 2014

67. C. Verbeeck
Ruimteweer: de impact van zonnestormen op Aarde
Open Doors (BISA 50th anniversary edition), Brussels, Belgium, 11-12 October 2014

68. T. Verhulst, S. Stankov, J. Rasson
The geomagnetic field: an actively changing global phenomenon
Review-E, Journal of the Royal Belgian Association of Electric Engineers (SRBE-KBVE), 130(2), 2014

List of abbreviations

3D	Three dimensional
Å	Ångström (0.1 nm or 10^{-10} m)
AAS	American Astronomical Society
ACE	Advanced Composition Explorer
ACM	Asteroids, Comets and Meteors conference
AFFECTS	Advanced Forecast For Ensuring Communications Through Space
AGU	American Geophysical Union
AIA	Atmospheric Imaging Assembly (SDO)
ALC	Automatic LIDAR Ceilometer
AlGaN	Aluminium gallium nitride
ALIS	Auroral Large Imaging System
AlN	Aluminum Nitride
AOGS	Asia Oceania Geosciences Society
APS	Active Pixel Sensor
Ar	Argon
AR	Active Region
ASPIICS	Association of Spacecraft for Polarimetric and Imaging Investigation of the Corona of the Sun (PROBA-3)
ATV	Automated Transfer Vehicle
AU	Astronomical Unit; about 150 million km
BELSPO	Belgian Science Policy Office
BIRA	Belgisch Instituut voor Ruimte-Aëronomie
BISA	Belgian Institute for Space Aeronomy
BRAIN-be	Belgian Research Action through Interdisciplinary Networks
BRAMS	Belgian RAdio Meteor Stations
Bz	Component of the IMF perpendicular to the ecliptic (“north-south” component)
C-class flare	Common x-ray flare
CACTus	Computer Aided CME Tracking software
CALLISTO	Compound Astronomical Low frequency Low cost Instrument for Spectroscopy and Transportable Observatory
CASSIS	Coordination Action for the integration of Solar System Infrastructures and Science
CCD	Charge-Coupled Device
CCMC	Community Coordinated Modeling Center
CH	Coronal Hole
CHAMP	CHAllenging Minisatellite Payload
CHARM	Contemporary physical challenges in Heliospheric and AstRophysical Models
CIOMP	Changchun Institute of Optics, fine Mechanics and Physics (China)
CIS	Cluster Ion Spectrometry (Cluster)
Cluster	ESA/NASA mission to study the Earth’s magnetosphere (no acronym)
CMA	China Meteorological Administration
CME	Coronal Mass Ejection
CMOS	Complementary Metal Oxide Semiconductor
COMESEP	COronal Mass Ejections and Solar Energetic Particles
CoMP	Coronal Multi-channel Polarimeter
COPUOS	COmmittee on the Peaceful Uses of Outer Space (UN)
COR (1/2)	Coronagraph (Inner/Outer) onboard STEREO
COSPAR	COmmittee on SPAce Research
COST	(European) COoperation in Science & Technology
CSL	Centre Spatial de Liège
CubeSat	A small satellite measuring 10cm x 10cm x 10cm
DIARAD	DIfferential Absolute RADiometer
DN	Digital Number (pixel values not calibrated into physically meaningful units)
DOI	Digital Object Identifier
DSLP	Dual Segmented Langmuir Probe (PROBA2)
Dst	Disturbance Storm Time index
E-GVAP	EUMETNET EIG GNSS water VApor Program

ECV	Essential Climate Variable
EGU	European Geosciences Union
eHEROES	Environment for Human Exploration and RObotic Experimentation in Space
EIG	Economic Interest Grouping
EISCAT	European Incoherent SCATter scientific association
EIT	Extreme ultraviolet Imaging Telescope (SOHO)
EPN	EUREF Permanent Network
EPT	Energetic Particle Telescope (PROBA-V)
ES	Earth System (Science and Environmental Management (COST)
ESA	European Space Agency
ESOC	European Space Operations Centre
ESPM	European Solar Physics Meeting
ESTEC	European Space Research and Technology Centre
ESWP	European Space Weather Portal
ESWW	European Space Weather Week
EU	European Union
EUCARA	European Conference on Amateur Radio Astronomy
EUI	Extreme-Ultraviolet Imagers (Solar Orbiter)
EUMETNET	European Meteorological services Network
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
EUREF	EUropean Reference Frame
EUV	Extreme Ultraviolet
EUVI	Extreme Ultraviolet Imager (STEREO/SECCHI)
EVE	Extreme ultraviolet Variability Experiment (SDO)
$F_{10.7\,cm}$	Solar radio flux at 10.7 cm wavelength
FOV	Field-Of-View
FP7	Framework Program 7 (EU)
FNRS	Fonds National de la Recherche Scientifique
FY3E	FengYun: 5th satellite in the 3rd series of Chinese weather satellites

GaN	Gallium nitride
GAW	Global Atmospheric Watch
GeV	Giga electronvolt (10^9 . 1.6 . 10^{-19} Joule)
GNSS	Global Navigation Satellite System
GNSS4SWEC	Advanced GNSS tropospheric products for the monitoring of Severe Weather Events and Climate
G-nut/Tefnut	Software library for GNSS data
GOES	Geostationary Operational Environmental Satellite
GOME	Global Ozone Monitoring experiment (SCIAMACHY)
GPS	Global Positioning System (USA)
GSTP	General Support Technology Programme (ESA)
H	Hydrogen
H-alpha ($H\alpha$)	A red visible spectral line created by Hydrogen
HEK	Heliophysics Events Knowledgebase
HI	Heliospheric Imager (STEREO)
HiSPAC	HIgh level Space Policy Advisory Committee (ESA)
HMI	Heliospheric and Magnetic Imager (SDO)
HuRAS	Humain Radio Astronomy Station
HWP	Half Wave Plate
Hz	Hertz (per second)
IAGOS	In-service Aircraft for a Global Observing System (MOZAIC)
IAS(B)	Institut d'Aéronomie Spatiale de Belgique
IAU	International Astronomical Union
ICME	Interplanetary CME
IceCON	Constraining Ice Mass Change in Antarctica
ICIP	International Conference on Image Processing
ICT	Information and Communication Technologies
IEEE	Institute of Electrical and Electronics Engineers
IGS	International GNSS Service
IMC	International Meteor Conference

IMF	Interplanetary Magnetic Field
INSPIRE	Infrastructure for Spatial Information in the European Community (EU)
IPAG	Institut de Planétologie et d'Astrophysique de Grenoble
IPC	Industrial Policy Committee (ESA)
IPSL	Institut Pierre-Simon Laplace
IRIS	Interface Region Imaging Spectrograph
ISBN	International Standard Book Number
IT	Information Technology
IWV	Integrated Water Vapour
JSWSC	Journal of Space Weather and Space Climate
KBVE	Koninklijke Belgische Vereniging der Elektrotechnici
K_p	A geomagnetic index, ranging from 0 (quiet) to 9 (extremely severe storm)
KSB	Koninklijke Sterrenwacht van België
KUL	Katholieke Universiteit Leuven
kV	kiloVolt (10^3 Volt)
λ	wavelength
LASCO	Large Angle Spectrometric Coronagraph (SOHO); small (C2) and wide (C3) field of view
LDE	Long Duration Event
LEO	Low Earth Orbit
LIDAR	LIght Detection And Radar
LMSAL	Lockheed Martin Solar and Astrophysics Laboratory
LOC	Local Organizing Committee
LOFAR	Low-Frequency Array
LYRA	Lyman Alpha Radiometer (PROBA2)
LYRAFF	LYRA Flare Finder
LWS	Living With a Star
μm	micrometer (10^{-6} meter)
M-class	Medium class satellite
M-class flare	Medium x-ray flare
MAARBLE	Monitoring, Analyzing and Assessing Radiation Belt Loss and Energization
MAO	Main Astronomical Observatory of National Academy of Science of Ukraine (conference)
MASC	Magnetic Activity of the Solar Corona
MC	Management Committee
MEGS-A	Multiple EUV Grating Spectrograph A (SDO)
MEGS-B	Multiple EUV Grating Spectrograph B (SDO)
MeV	Mega electronvolt ($10^6 . 1.6 . 10^{-19}$ Joule)
MHz	Megahertz (10^6/s)
MOZAIC	Measurement of Ozone and Water Vapor by Airbus In-Service Aircraft
MP	Materials, Physical and nanosciences (COST)
N_2^+ 1NG	First Negative Group of ionized molecular nitrogen
NASA	National Aeronautics and Space Administration
NDACC	Network for the Detection of Atmospheric Composition Change
Ne	Neon
NITRO	Nitrogen Ion TRacing Observatory (ESA)
NM	Neutron Monitor
nm	nanometer (10^{-9} meter)
NOAA	National Oceanic and Atmospheric Administration (numbering of sunspots)
NOMAD	Nadir and Occultation for MArs Discovery (Exomars/TGO)
NORS	Demonstration Network Of ground-based Remote Sensing observations in support of the Copernicus Atmospheric Service (FP7)
NSMC	National Satellite Meteorology Center (China)
NSREC	Nuclear & Space Radiation Effects Conference
nT	nano-Tesla (10^{-9} Tesla)
NTC	Non-Thermal Continuum
NWP	Numerical Weather Prediction
O	Oxygen
ORB	Observatoire Royal de Belgique
P2SC	PROBA2 Science Center

PAMIR	Portal to Atmospheric and Marine Information Resources (BRAIN-be)
pfu	particle (proton) flux unit: the number of particles registered per second, per square cm, and per steradian
PhD	Doctor of Philosophy
PI	Principal Investigator
PICASSO	Pico-satellite for Atmospheric and Space Science Observations
PMOD	Physikalisch-Meteorologisches Observatorium Davos
PROBA	PRoject for OnBoard Autonomy
Q&A	Questions and Answers
QPP	Quasi-Periodic Pulsations
QS	Quiet Sun
RADECS	RADiation Effects on Components and Systems
RAPID	Research with Adaptive Particle Imaging Detectors (Cluster)
RF	Radio Frequency
RHESSI	Reuven Ramaty High Energy Solar Spectroscopic Imager
RMI(B)	Royal Meteorological Institute (of Belgium)
RMOC	Rosetta Mission Operations Centre
ROB	Royal Observatory of Belgium
RTADC	Real-Time Automatic Data Correction
RWC	Regional Warning Center
SC24	Solar Cycle 24
SCIAMACHY	SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (ENVISAT)
SDO	Solar Dynamics Observatory
SECCHI	Sun Earth Connection Coronal and Heliospheric Investigation (STEREO)
SEE	Solar EUV Experiment (TIMED)
SEM	Solar EUV Monitor (SOHO)
SEP	Solar Energetic Particle
SFU, sfu	Solar Flux Unit (10^{-22} W m^{-2} Hz^{-1})
SIDC	Solar Influences Data analysis Center
SILSO	Sunspot Index and Long-term Solar Observations
SIP	Solar Information Processing
SIRTA	Site Instrumental de Recherche par Télédétection Atmosphérique (IPSL)
SLP	Scanning Langmuir Probe
SN	Space weather and Near-earth objects
SODISM	SOlar Diameter Imager and Surface Mapper (PICARD)
SoFAST	Solar Flare Automated Search Tool
SOHO	SOlar & Heliospheric Observatory
SOLID	SOLar Irradiance Data exploitation (FP7)
SOLMOD	Solar Modeling (code)
SolO	Solar Orbiter
SPARX	Solar Particle Radiation SWx
SPENVIS (-NG)	Space Environment Information System (- Next Generation)
SPoCA	Spatial Possibilistic Clustering Algorithm
SPORT	Solar Polar ORbit Telescope (China)
sr	steradian
SRBE	Société Royale Belge des Electriciens
SREM	Standard Radiation Environment Monitor (Integral, Rosetta)
SSA	Space Situational Awareness
SSC	STEREO Science Center
SSCC	SSA Space Weather Coordination Centre
SSN	SunSpot Number
STAFF	Solar Timelines viewer for AFFECTS
STCE	Solar-Terrestrial Centre of Excellence
STEREO	Solar-TErrestrial RElations Observatory
STIX	X-ray Spectrometer / Telescope (SolO)
STORM	Solar system plasma Turbulence: Observations, inteRmittency and Multifractals
STSM	Short-Term Scientific Mission (COST)

SunPy	software library for solar physics based on Python	URSI	International Union of Radio Science – Union Radio-Scientifique Internationale
SWAMIS	Southwest Automatic Magnetic Identification Suite	US(A)	United States (of America)
SWAP	Sun Watcher using APS detector and image Processing (PROBA2)	UT(C)	(Coordinated) Universal Time
		UV	Ultraviolet
		V	Volt
SWAVES	STEREO WAVES	Vp	Plasma Potential
SWE	Space WEather	VERSIM	VLF/ELF Remote Sensing of Ionospheres and Magnetospheres
SWSC	Space Weather and Space Climate journal		
SWx	Space weather	VIP	Very Important Person
TEC	Total Electron Content	VIRGO	Variability of solar IRradiance and Gravity Oscillations
TEC-EES	Space Environments and Effects section (ESA/ESTEC)	VLF	Very Low Frequency
TGO	Trace Gas Orbiter (Exomars)	VSOC	Venus Express Science Operations Centre
TIMED	Thermosphere Ionosphere Mesosphere Energetics and Dynamics (NASA)	VSWMC	Virtual Space Weather Modelling Centre
TiN	Titanium nitride	VTI	Ieperse school voor Wetenschap en techniek
TMPU	Thermal Plasma Measurement Unit (PROBA2)	VUB	Vrije Universiteit Brussel
TOPROF	Towards Operational ground based PROFiling with ceilometers, doppler lidars and microwave radiometers for improving weather forecasts	VVS	Vereniging Voor Sterrenkunde
		W	Watt
		W/m²	Watt per square meter
		WAVES	Radio and plasma wave investigation (WIND, STEREO)
		WDC	World Data Center
TOSCA	Towards a more complete assessment of the impact of solar variability on the Earth's climate	WG	Working Group
		WHISPER	Waves of High Frequency and Sounder for Probing of Density by Relaxation (Cluster)
TSI	Total Solar Irradiance		
UAV	Unmanned Aerial Vehicle	WP	Work Package
UK	United Kingdom	WRC	World Radiation Center
ULB	Université Libre de Bruxelles	WS	Workshop
UNCOPUOS	United Nations Committee on the Peaceful Use of Outer Space	X-class flare	Extreme x-ray flare