



## Annual activity report from RWC Belgium for ISES August, 2014

Jesse Andries on behalf of the RWC Belgium team

### **Space Pool in Brussels**

### Belgian Royal Meteorological Institute (RMI)

### Royal Observatory of Belgium (ROB)

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Belgian Institute for Space Aeronomy (BIRA)

# STCE

### **Solar-Terrestrial Centre of Excellence**

A coordination of activities in Belgium to consolidate expertise in Sun-Earth connection

✓ Strengthening of research trough long-term funding
 ✓ Consolidation of know-how and expertise
 ✓ Development & Support of operational activities
 ✓ Stimulate international participation
 ✓ Provide strong visibility through communication
 ✓ Administrative support
 ✓ Yearly evaluation by external experts









### **Space Pool in Brussels**

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Solar Terrestrial Center of Excellence (STCE)

# Int. Sunspot Number



SILSO graphics (http://sidc.be) Royal Observatory of Belgium 01/08/2014

## Daily Space Weather bulletin



:Issued: 2010 Dec 07 1233 UTC :Product: documentation at http://www.sidc.be/products/meu # DAILY BULLETIN ON SOLAR AND GEOMAGNETIC ACTIVITY from the SIDC (RWC Belgium) SIDC URSIGRAM 01207 SIDC SOLAR BULLETIN 07 Dec 2010, 1222UT SIDC FORECAST (valid from 1230UT, 07 Dec 2010 until 09 Dec 2010) SOLAR FLARES : Quiet conditions (<50% probability of C-class flares) GEOMAGNETISM : Quiet (A<20 and K<4) SOLAR PROTONS : Quiet PREDICTIONS FOR 07 Dec 2010 | 10CM FLUX: 089 / AP: 002 PREDICTIONS FOR 08 Dec 2010 10CM FLUX: 089 / AP: 004 PREDICTIONS FOR 09 Dec 2010 10CM FLUX: 090 / AP: 006 COMMENT: The large filament on the south-east side of the Sun has erupted yesterday afternoon around 15:35 UT. This was clearly observed in PROBA2/SWAP and SDO/AIA data. Also STEREO/A COR2 images show the event, starting at 18:54 UT. The direction of the associated CME suggest the impact of this event on the Earth will be limited. The CME speed as measured by CACTUS is approximately 550 km/s. We expect quiet solar conditions for the coming days. A shock in the solar wind speed was observed by ACE yesterday due to a sector boundary change. The solar wind speed is still low around 380 km/s. There may be unsettled geomagnetic conditions towards the end of the forecasting period due to a recurrent coronal hole wind stream.

Products: www.sidc.be



- Flare forecast (region / full disc)
- Geomagnetism forecast (A/K)
- F10.7 forecast
- Textual report/forecast
  - Solar weather
  - Solar wind
  - Geomagnetic conditions

## Fast & automated alerts



:Issued: 2010 Mar 14 1304 UTC :Product: documentation at http://www.sidc.be/products/presto # FAST WARNING 'PRESTO' MESSAGE from the SIDC (RWC-Belgium) A halo CME starting most probably from NOAA AR 11054 (there is an EIT data gap that prevents more definitive conclusions) have been seen on LASCO-C2 at 01:31 UT, it is a fast one according to CACTUS (1656 km/s). It is expected to arrive to the Earth on March 17-18. :Issued: 2007 Jun 04 0551 UTC :Product: documentation at http://www.sidc.be/products/flaremail # Large flare alerts from the SIDC (RWC-Belgium), detected in GOES # X-ray data A class X1.0 solar X-ray flare occurred on 2007/06/04 with peak time 05:13 UT # Solar Influences Data analysis Center - RWC Belgium # Royal Observatory of Belgium # Fax : 32 (0) 2 373 0 224 # Tel.: 32 (0) 2 373 0 491 # For more information, see http://www.sidc.be. Please do not reply # directly to this message, but send comments and suggestions to 'sidctech@oma.be'. If you are unable to use that address, use 'rvdlinden@spd.aas.org' instead.



#### Also for geomagnetism, all quiet,

. . .

\* Restricted userlist

Products: www.sidc.be

# Recent developments



Upgrade of the forecast production platform:

- Back-end data storage
- Unified and centralised management of automated data inflow, processing routines, output procedures ("previmaster")
- The forecaster/operator interface ("peviweb"): web-based interface with better presentation of the input information as well as model guidance
- Allows flexible integration of different output formats
- Allows automation of forecast verification for continuous QC/QA
- Planned: integration of event follow-up workflow management
- Planned: upgrade of the user interface aspect:
  - Message formats
  - User subscription
  - Flexible user interfaces

# Recent developments



Within consortia with external partners through external project funding

- FP7 COMESEP
  - Automated proton/geomagnetic storm alert service. Seeded by SIDC alerts.
  - Proved very useful in February 2014

| 🕢 🗭 Tu                  | e 25 Feb 2014             | • کې   | ★ 🔍          |              |              | Register for COMESEP alerts 🔮 👔 |              |              |  |  |  |  |
|-------------------------|---------------------------|--------|--------------|--------------|--------------|---------------------------------|--------------|--------------|--|--|--|--|
|                         | 24 FEB 06:00 24 FEB 18:00 |        | 25 FEB 06:00 | 25 FEB 18:00 | 26 FEB 06:00 | 26 FEB 18:00                    | 27 FEB 06:00 | 27 FEB 18:00 |  |  |  |  |
| Flare                   |                           | **     | *            |              |              | *                               | *            | * *          |  |  |  |  |
| CME                     |                           |        |              | *            |              |                                 |              |              |  |  |  |  |
| SEP                     |                           | *<br>* | *            |              |              | *                               |              |              |  |  |  |  |
|                         |                           |        |              |              |              |                                 |              |              |  |  |  |  |
| Geomagnetic<br>activity |                           |        |              | * *          |              | *                               |              |              |  |  |  |  |
|                         |                           |        |              |              |              |                                 |              |              |  |  |  |  |

## Recent developments



### • FP7 AFFECTS:

- Alert service tailored to GNSS users (triggered by SIDC alerts)
- Solar Demon: flare (as well as dimming and EUV wave) detection algorithm based on SDO AIA 94 data. Running realtime with flare localisation (with AR matching). Timelag mostly < 20 min.</li>
- Staff: a graphical dynamical time line viewer: with data set/time range selection, on click zoom

#### Solar Demon - Flare Detection

running in real time on SDO/AIA 94 QKL data 3 minute cadence, typical delay 15 minutes (view all Solar Demon detection tools)

| Detector 24h operating status:                    | detected flares in last 30 days | Flare 2668  |  |  |  |  |
|---|---------------------------------|---|--|--|--|--|
| e e M   | m                               | 2014-08-01 18-00-02 (9.4 mm. flare 2668, seq 1)   |  |  |  |  |
| Last processed image:                             |                                 | brightness S1.7 • 10-3  |  |  |  |  |
| 0 hours and 19 minutes ago (2014-08-01 18:06 UTC) |                                 |   |  |  |  |  |
| Last detected flare:                              |                                 |   |  |  |  |  |
| 0 hours and 19 minutes ago (2014-08-01 18:06 UTC) |                                 |   |  |  |  |  |
| Titless (askesse)                                 |                                 |   |  |  |  |  |
| Filters (category)                                | 1.4                             |   |  |  |  |  |
| All classes                                       |                                 |   |  |  |  |  |
| Only C class flares and above                     |                                 |   |  |  |  |  |
| Only M class flares and above                     |                                 |   |  |  |  |  |
| Only X class flares and above                     | Sec. 24                         |   |  |  |  |  |
| Filters (time)                                    |                                 |   |  |  |  |  |
| Show all  |                                 | A STREET, A |  |  |  |  |
| Last week   |                                 |   |  |  |  |  |
| Last 30 days                                      |                                 |   |  |  |  |  |
| Last 365 days                                     |                                 |   |  |  |  |  |
|   |                                 |   |  |  |  |  |

#### **Overview of flares**

|            | est.<br>class | start | peak  | end   | #    | lat | lon | dist.<br>R⊙ | AR      | est.<br>flux | GOES<br>flux | GOE<br>peal<br>time | s<br>k | COMESEP | # det. | dimming |
|------------|---------------|-------|-------|-------|------|-----|-----|-------------|---------|--------------|--------------|---------------------|--------|---------|--------|---------|
| August, 20 | 14            |       |       |       |      |     |     |             |         |              |              |                     |        |         |        |         |
| 1          | M1            | 18:00 | 18:06 | 18:06 | 2668 | -10 | -12 | 0.33        | AR 2127 | 104.5        | 153.0        | 18:12               | 6      | 2       | 3      | 3       |
| 1          | M2            | 14:48 | 14:54 | 15:42 | 2667 | -9  | -36 | 0.66        | AR 2130 | 167.7        | 204.0        | 14:48               | -6     | 98312   | 19     | 1       |
| 1          | B4            | 13:57 | 13:57 | 13:57 | 2666 | -12 | -35 | 0.64        | AR 2130 | 3.6          | 24.7         | 13:56               | -1     | 0       | 1      |         |
| 1          | C2            | 11:39 | 11:42 | 12:06 | 2665 | -9  | -37 | 0.68        | AR 2130 | 19.3         | 48.0         | 11:43               | 1      | 0       | 10     | )       |
| 1          | B5            | 05:24 | 05:27 | 05:30 | 2664 | -19 | -30 | 0.63        | AR 2131 | 4.9          | 14.3         | 05:23               | -4     | 0       | 3      | 3       |
| 1          | В3            | 03:21 | 03:21 | 03:21 | 2663 | -18 | -57 | 0.88        | AR 2132 | 3.4          | 14.1         | 03:18               | -3     | 0       | 1      |         |
| 1          | C2            | 01:18 | 01:21 | 01:48 | 2662 | -18 | -60 | 0.91        | AR 2132 | 24.7         | 31.6         | 01:17               | -4     | 0       | 11     |         |
| 1          | C9            | 00:15 | 00:21 | 01:15 | 2661 | -17 | -60 | 0.92        | AR 2132 | 86.7         | 86.7         | 00:18               | -3     | 98308   | 21     |         |
| July, 2014 |               |       |       |       |      |     |     |             |         |              |              |                     |        |         |        |         |
| 31         | B9            | 21:15 | 21:21 | 21:27 | 2660 | -12 | -48 | 0.79        | AR 2130 | 9.0          | 24.0         | 21:17               | -4     | 0       | 5      | 5       |
| 31         | B6            | 18:54 | 18:57 | 19:03 | 2659 | -17 | -63 | 0.93        |         | 6.3          | 19.8         | 18:55               | -2     | 0       | 4      | L.      |

## **Forecast Verification**



### <u>What:</u>

- F10.7 prediction (1, 2, 3 day lead time)
- Full disc flare predictions
- K predictions (max. over 48 hours) (comparison to Chambon-laforet)

### Compared to:

- Persistence
- Recurrence
- Corrected recurrence

### <u>How:</u>

- Error analysis with skill scores
- Hit/miss statistics: probability of detection, False alarm ratio, Proportion correctness, Biass, Heidke and True skill score

Results submitted to Journal of Space Weather and Space Climate.

# Forecast verification results



#### <u>F10.7:</u>

- 1-day leadtime: SIDC performs best
- 2,3 day leadtime persistence and corrected recurrence perform better (in terms of long term statistics) → what do we conclude from that?

Flaring probability:

- SIDC performs good
- Trend to underestimate M and X flares. Not necessarily bad, this goes hand in hand with few false alerts!
- Error analysis dominated by large periods without flares
- Skill score on hit/miss statistics (M and X) → Proportion correctness is best for SIDC

#### Geomagnetism (K):

- SIDC performs good
- Low K overestimated / high K underestimated: convolution between probability of occurrence and event level
- Skill scores on hit/miss statistics (K>4) → Proportion correctness and also Probability of detection is best for SIDC



## Forecast verification (Flare)



## Forecast verification (K)





### Forecast verification (K)

## Forecast verification (K)



## **Forecast verification**



What are the right statistics to be used?

- What is the meaning of your forecast?: "eruptive= C-flares likely, probability > 50%" often chosen if computed probability=75% → you expect to be wrong 1 out of 4 times!!
- Convolution of event probability and event level (and event timing uncertainty)
- Probability of detection vs. false alerts: What does the user want?
- Communication of error bars to the user?



www.meteo.be

## User impact



User base keeps increasing:

- 2000+ subscriptions
- Most popular: daily bulletin, fast alerts

Increased and more concrete interest/questions from:

- civil protection authorities
- aviation authorities
- Defence
- private communication companies

 $\rightarrow$  Concrete requests for better interfacing to their operations

### **ESA-SSA SWE**



### SSA/SWE Precursor Service System in 2012



### **ESA-SSA SWE**



### SSA/SWE Precursor Service System in 2012



## **ESA-SSA SWE**



### ESA-SSA:

- Optional program: phase 2 started recently
- 3 Segments: Space Weather, Near Earth Objects, Space Surveillance and Tracking

<u>SWE</u>:

- SSCC operation from Space Pole Brussels (BISA lead) (awaiting ESA decision on follow-on contract)
- ESC Solar Weather coordination (awaiting ESA decision on follow-on network development contract)

Concrete activities:

- GAIA launch and insertion manoeuvre support (December, January)
- Support for Venus Express Aerobreaking campaign (May through to July, 2014)

# VEX Aerobreaking support





-15 -10 Days from 2014-07-16 00:00

-5

0.0020 -30

-25

-20

Observations from earth advanced in time for Venus relevance:

- SWAP image with AR annotation
- F10.7 and LYRA background irradiance

Solar activity reports adjusted for Venus position (CME effectiveness)

100.

### Dissemination





A link between all the communities involved in Space Weather and in Space Climate such as (but not limited to) space, solar, and atmospheric scientists, engineers, forecasters, social scientists, economists, physicians, insurance experts...

### A new, international, open access and peer-reviewed journal

### Journal of Space Weather and Space Climate

Publication free of charge for the 1<sup>st</sup> year



- Open access journal realized by COST ES0803
- Financially supported by STCE (Belgium)
- Secretarial office: STCE (Belgium)
- http://www.swsc-journal.org

www.swsc-journal.org

## Dissemination: European Space Weather Week



November 17 - 21, 2014 Liège, BELGIUM



SPACECRAFT · IONOSPHERE & GNSS · FLANETARY SYSTEMS · NUMERICAL SW PREDICTIONS · GEDSPACE · SOLAR PARTICLES · ENTERPRESES · SW SCIENCE, ENGINEERING AND APPLICATIONS · SPACE BASED OBSERVATIONS · SPACE CLIMATE

#### www.stce.be/esww11

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Local Organisation Solar-Terrestrial Centre of Excellence, Belgium





11th edition! When: November 17 – 21, 2014 Where: Liège, Belgium Web: www.sidc.be/esww11

- This year's event will again highlight key innovations in space weather research, applications and services.
- The meeting will also focus on current challenges and actions necessary in moving towards a sustainable Space Weather Infrastructure able to meet the requirements of a diverse end-user community.

## Dissemination: European Space Weather Week

### Previous editions

9th European Space Weather Week

esa \*\*\*\*\*

Third European Space Weather Week 13-17 November, 2006

SWENET

Venue: Royal Library of Belgiu



> November 18 - 22, 2013 Antwerp, BELGIUM

#### 10TH ANNIVERSARY

EXTREME EVENTS - STRATERIC DATA - E-INFRASTRUCTURE - MODELLING - SPACECRAFT OPERATIONS RADIO WAVE RROMBATION - SOLAR FLARE PREDICTION - FOREDAST VERFICATION - AVIATION -SOCIETAL REBLENCE - RAVIERARY SYSTEMS - SPACE EXTORATION - COSMIC RAY DETECTORS

#### www.stce.be/esww10

Programme Committee A. Belakelia Scale, (KOQ), A. Glaver (p. Oral, Edit, M. Happanal (B.K.1970), J. Ulensten (OBS-940) J.-P. Lordwano (B.K. Stal), R. Van der Unden (Strat), P. Vanlammel (Strat), S. Faceta (Britit-dui, Kitavan), B. Zarlar (2017), M. Massmath (Hal), Y. Zapran (ABG), M. Minier (2018), N. Cradby (Bisk/401), J. Watermann ((HoSnak)), M. Wik (Iwangaca), S. Brainsma (OES)

Local Organisation Solar-Terrestrial Centre of Excellence, Belgiur



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Venue: Royal Library of Belgium Brussels Local Organization:Royal Observatory of Belgium - SIDC www.sidc.be/esww4

#### Sixth European Space Weather Week

16-20 November, 2009 Brugge, Belgium

Belehaki IČo-Chair NOA COST ESDA

R. Van der Linden (SDC-STCE

Science-Models Applications-Services-Users Space Stuational Awareness Impacts on Communication Systems Health Issues

http://sidc.be/esww6

9 7TH EUROPEAN SPACE WEATHER WEEK

NOVEMBER 15-19, 2010 BRUGES, BELGIUM WWW.SIDC.BE/ESWW7

**Research - Applications - Products - Services** 

Space Situational Awareness Space Weather in support of Gloropean critical infrastructure Spacecard Environments and Effects New Tachniques for Tracking Heliospheric phenomena Space Weather Fair: perioder meets user Insensiberic effects. direct affects of solar crafts weather.

Programme Connections A. Belanda (Co-Cher, 154) A. Olover (Co-Cher, 154) A. Respect (RAUSTIC) 1.4 Lostens (BAUSTIC) 1.4 Lostens (BAUSTIC) R. Vao de Linden (SDC) P. Verlammed (SDC) B. Jahos (H-GV) III. Messenstri (H-BC COST E5048) V. Jaynen (COST E5048) III. Mass (SUR) III. Costay (SWR), BRA-IsGB) III. Watermann (BrC crack)

Local Organisation: SIDC, Solar-Terrestrial Centre of Excellence, Belgium

## **Dissemination: SW4E**



### **Space Weather School**

- Targeted at engineering personnel from Industry
- Aims to increase awareness of available space weather data that can help them in safeguarding their infrastructure and operations
- First edition 2013
- Second edition 2014, October 15-17
   *HF communication, trans-ionospheric propagation and GNSS signal precision*
- http://www.stce.be/sw4e/



# Data for SW operations



1.PROBA2 – SWAP & LYRA

2.Humain – Radio data

3.USET – White light and chromosphere

4.SDO – Data archive and dissemination

# Data for SW operations



1.PROBA2 – SWAP & LYRA

2.Humain – Radio data

3.USET – White light and chromosphere

4.SDO – Data archive and dissemination

### http://proba2.sidc.be

About the PROBA2 Science Center





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Q) 1 » 🖸 Bookmarks 🔻

#### Welcome to the PROBA2 Science Center

### **Real time Flare curves**

#### About PROBA2

- Mission
- Spacecraft
- Launch and Orbit
- Operations
- Science Payload

#### Science

- Guest Investigator Program
- Publications

#### Data

- LYRA Data
- SWAP Data
- Data analysis software
- Spacecraft Ancillary Data
- Terms of use

#### Community

- Scientific community involvement
- Meetings
- Outreach

#### Highlights

- Latest News
- Gallery

The PROBA2 Science Center, located at the Royal Observatory of Belgium in Brussels, oversees scientific operations and data processing for ESA's PROBA2 spacecraft. The P2SC is the primary archive and distribution center for data from SWAP and LYRA, as well as the primary maintainer of calibration tools, data analysis software, and additional instrument data. The P2SC is also home to the science operations center, where instrument observing plans are devised and, with the help of ESA's Spacecraft Operations Center in Redu, Belgium, loaded onto the spacecraft. Finally, the P2SC serves as the main site for coordination of the PROBA2 Science Working Team, coordinating special scientific campaigns, supporting science data users and guest investigators, and organizing PROBA2 outreach efforts.



PROBA2 is a small ESA satellite with a scientific mission to explore the active Sun and its effect on the near-earth environment and a broader mission to provide a test platform for new instrument and platform technology. The mission overview page provides additional information about PROBA2 and its on board instrumentation and advanced platform technology.

If you require special assistance, you can contact the instrument teams directly using the contact page on this site.

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### **Daily coronal** movies





Click to read more

#### LYRA Latest

# Data for SW operations



1.PROBA2 – SWAP & LYRA

2.Humain – Radio data



3.USET – White light and chromosphere

4.SDO – Data archive and dissemination

### Humain Radioastronomy Station

#### **Royal Observatory of Belgium**

#### Provide near real-time monitoring of solar activity for the SIDC forecasts.

Two kinds of instruments:

- Radiospectrographs: observation of radio bursts linked to flares and CMEs
- Radiometers: Single frequency flux monitoring for flares and daily irradiance variation (e.g.: F10.7cm)
- Callisto spectrograph (45-400 MHz) plugged to a Suntracking log-periodic antenna
- Observations since May 2008
- Data online within 15 min
- Automated Burst detection



- Project started in 2008: refurbishment
- Planned switch to digital receivers
- Part of the CALLISTO network
- Website: http://sidc.be/humain
- Info: Christophe.marque@oma.be

## Autom. Burst detection





Time (UT)

# Data for SW operations



1.PROBA2 – SWAP & LYRA

2.Humain – Radio data

3.USET – White light and chromospher

4.SDO – Data archive and dissemination



### Solar telescope USET





White light Quick-look & FITS ffiles
H-alpha Quick-look & FITS files
Sunspot Digitization completed
drawing
Ca II K-images Successful first light on July 11, 2012!



Data is available via website: www.sidc.be

<u>Planned</u>: production of USSPS data in coordination with Catania

Info: frederic.clette@oma.be

# Data for SW operations



SIDC

1.PROBA2 – SWAP & LYRA

2.Humain – Radio data

3.USET – White light and chromosphere

4.SDO – Data archive and disseminat

### SDO data archive at ROB SIDC



- Download images from ROB: use same routines but specify site='rob'
- IDL> list=vso search('1-aug-2010 00:00','1-aug-

2048 1024 512

PFSS 2048 PFSS 1024 PFSS 512 PFSS

- 2010 00:02', inst='hmi', site='rob')
- IDL> a=vso get(list[6:7])
- http://wissdom.oma.be
- latest movies: www.sidc.
- Info: verodelo@oma.be



4096 2048 1024 512 4096 PFSS 2048 PFSS 1024 PFSS 512 PFSS 48 hr MPEG

4096 2048 1024 512 4096 PFSS 2048 PFSS 1024 PFSS 512 PFSS

48 hr MPEG