Space Weather Data and Services at RWC Belgium

Cis Verbeeck on behalf of the RWC team
Solar-Terrestrial Center of Excellence

From Sun to Earth
Broad support – in house expertise

- Earth Atmosphere
- Operating systems
- Outreach
- Earth magnetic shield
- Instrumentation
- Space/Earth based
- Climate
- Meetings
- Ionosphere
- Services
- Data Management
- Sciences
- GNSS
- Radiation
- Solar Atmosphere
- Space Weather forecast centre
- Internal support
Space Weather Forecasting
Space Weather Forecasting

- RWC Belgium since 2000
- Team of 10 forecasters
- Duty cycle of 1 Week
- 16/24h human monitoring
- Weekly briefing

Necessity of a team
What do we forecast?

- Flares:
  - large and sudden release of energy in the solar atmosphere
  - several classes of flares: C, M and X-flares
  - estimate probability: <50% C, >50% C, >50% M, >50% X-flares

- K-index:
  - overall geomagnetic activity
  - forecast over 3 days in intervals of 3 hours
  - ranges from 0 to 9

- Proton events

- F10.7:
  - solar radio flux at 10.7cm
  - forecast over 3 days
Products & services
Daily Space Weather bulletin

:Issued: 2010 Dec 07 1233 UTC

# DAILY BULLETIN ON SOLAR AND GEOMAGNETIC ACTIVITY from the SIDC
# (Flanders, Belgium)
#---------------------------------------------------------------
SIDC TELEGRAM 01207
SIDC SOLAR BULLETIN 07 Dec 2010, 1222UT
SIDC FORECAST (valid from 1320UT, 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 PROFOMS: Quiet
PREDICTIONS FOR 07 Dec 2010 10CM FLUX: 009 / AP: 002
PREDICTIONS FOR 08 Dec 2010 10CM FLUX: 009 / AP: 004
PREDICTIONS FOR 09 Dec 2010 10CM FLUX: 090 / AP: 006

CONTENTS: The large filament on the south-east side of the Sun has erupted yesterday afternoon around 15:35 UT. This was clearly observed in PEACE/MA/ and SDO/ATI 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 360 km/s. There may be unsettled geomagnetic conditions towards the end of the forecasting period due to a recurrent coronal hole wind stream.
Fast & automated alerts

NEW: AFFECTS machine readable CME arrival alert

www.sidc.be

*since 2011
Monthly & weekly bulletins

- Provisional Sunspot Indices
- Medium-term forecast of sunspot index
- Table of Solar and Geomagnetic activity indices
- Table of noticeable events (> M flare)
- Forecasts of returning major sunspot groups
- Solar and Geomagnetic Activity report: a general description of the solar and geomagnetic conditions during the month.
- If applicable: a “hot items” section
- STCE Newsletter
## SIDC Product matrix

<table>
<thead>
<tr>
<th>Mail header</th>
<th>SIDC code</th>
<th>format</th>
<th>Frequency</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRESTO ALERT</td>
<td>presto</td>
<td>Plain text</td>
<td>ASAP, when needed</td>
<td>SIDC (RWC-Belgium)</td>
</tr>
<tr>
<td>Boumeuss</td>
<td>bms</td>
<td>Encoded data (ISES)</td>
<td>Daily</td>
<td>SEC (RWC-Boulder)</td>
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<tr>
<td>SIDC Indaa message</td>
<td>ind</td>
<td>Encoded data (ISES)</td>
<td>Weekly</td>
<td>SIDC (RWC-Belgium)</td>
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<tr>
<td>SIDC MAA message</td>
<td>maa</td>
<td>Encoded data (special format)</td>
<td>Weekly</td>
<td>SIDC (RWC-Belgium)</td>
</tr>
<tr>
<td>Indices K Canberra</td>
<td>kcan</td>
<td>Encoded data (ISES)</td>
<td>Weekly</td>
<td>Canberra (Australia)</td>
</tr>
<tr>
<td>INDICES K WINGST</td>
<td>wng</td>
<td>Encoded data (ISES)</td>
<td>Daily</td>
<td>Wingst (Germany)</td>
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<td>SIDC Ionospheric Data</td>
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<td>Encoded data (ISES)</td>
<td>Daily</td>
<td>Lannion (France) and Ebre (Spain)</td>
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<td>GEOALERT BOULDER</td>
<td>geo</td>
<td>Encoded data (ISES)</td>
<td>Daily</td>
<td>SEC (RWC-Boulder)</td>
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<tr>
<td>UMAGF Messages from Moscow</td>
<td>mos</td>
<td>Encoded data (ISES)</td>
<td>Daily</td>
<td>RWC Moscow</td>
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<td>SIDC Ursigram</td>
<td>meu</td>
<td>Encoded data (ISES)</td>
<td>Daily</td>
<td>SIDC (RWC-Belgium)</td>
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<td>SIDC Weekly Bulletin</td>
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<td>Plain text</td>
<td>Weekly</td>
<td>SIDC (RWC-Belgium)</td>
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<td>Monthly Ri_hemispheric Report</td>
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<td>SIDC (RWC-Belgium)</td>
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<td>Monthly Ri Report</td>
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<tr>
<td>SIDC Monthly Bulletin of Solar and Geomagnetic Activity</td>
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<td>Plain text</td>
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<td>SIDC (RWC-Belgium)</td>
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<td>SIDC NEWS</td>
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<td>Quarterly</td>
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<td>Indices K Hartland</td>
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<td>Encoded data (ISES)</td>
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<td>Encoded data (ISES)</td>
<td>Daily</td>
<td>SIDC (RWC-Belgium)</td>
</tr>
<tr>
<td>Start/End of all quiet alert from the SIDC/RWC Belgium</td>
<td>quieta</td>
<td>Plain text</td>
<td>ASAP, when conditions warrant</td>
<td>SIDC (RWC-Belgium)</td>
</tr>
</tbody>
</table>
WDC product:
International Sunspot Number Number

(http://www.sidc.be, Nov 1, 2010)

SUNSPOT NUMBER Ri
Daily
Monthly
Smoothed
SM predictions
CM predictions

TIME (years)
Product registrations

- presto
- weekly bulletin
- flare
- CACTUS
- quieta

Graph showing product registrations from 2005 to 2012.
A press release was sent out on Feb 15 at 14 UT to announce the first activity of solar cycle 24. The media attention on 16-17 Feb was enormous. Television interviews, radio interview, newspaper reports ... The central question was: “When and where will we see aurora in Belgium?”

Initial speed of cloud, based on beacon STEREO data was estimated at 1000 km/s, with arrival around morning Feb 17. HI data was crucial in determining the arrival time for around 1 UT 18th.

The media storm stopped before the geomagnetic storm begun. Bz was mostly positive and the CME speed had speed of 800 km/s, not enough to create a big storm.

Forecasters discussed via email to help forecaster in interpreting the data.

Issues: How to cope with large media attention, how to coordinate?
Supporting tools
STAFF – Solar Timelines viewer for AFFects

http://www.staff.oma.be

Plot (18 Feb 2013 07:58:02 UTC - 21 Feb 2013 11:34:02 UTC)
C ACTUs - Computer Aided CME Tracking

CME Parameters
Applicable to different coronagraphs
Difference movies
Halo Alert service

CACTUS
A software package for 'Computer Aided CME Tracking'

Details and graphs for CME0005

<table>
<thead>
<tr>
<th># CME</th>
<th>t0</th>
<th>dt0</th>
<th>pa</th>
<th>da</th>
<th>v</th>
<th>dv</th>
<th>minv</th>
<th>maxv</th>
<th>halo?</th>
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</thead>
<tbody>
<tr>
<td>0005</td>
<td>2010/12/06 18:12</td>
<td>02</td>
<td>127</td>
<td>072</td>
<td>0508</td>
<td>0052</td>
<td>0401</td>
<td>0590</td>
<td></td>
</tr>
</tbody>
</table>

http://www.sidc.be/cactus
CACTus – CME catalogs

- SOHO-LASCO: since 04/1997
- STEREO/COR2 A and B: since 03/2007
- Real-time: based on LASCO Quick-look;
  - STEREO data has a latency of 3 days.

http://www.sidc.be/cactus
Solar Demon: dimming & EUV wave detector

Sector that shows EIT wave and Dimming most prominently advance over time.

03:42 UTC
4 radial sectors

03:42 UTC
03:44 UTC
03:46 UTC
03:48 UTC
Solar Weather Browser

http://www.sidc.be/swb
Interactive solar map

Provides flaring stats and probabilities per AR

Interactive flare tool
CME velocity estimation tool

Pick the satellite and date (format YYYYMMDD starting from 20110816). The date you picked is located in the last 24 hours in the plot.

Press enter or click find points.

Move the mouse over the plot to make sure the correct image is displayed.

Set first point by clicking the JMap.

Set second point by clicking the KMap.

Read your speed.

Click third time to restart.

Speed: 742 km/s
ROB data for SW operations

1. PROBA2 – SWAP & LYRA
2. Humain – Radio data
3. USET – White light and chromosphere
4. SDO – Data archive and dissemination
ROB data for SW operations

1. PROBA2 – SWAP & LYRA
2. Humain – Radio data
3. USET – White light and chromosphere
4. SDO – Data archive and dissemination
Welcome to the PROBA2 Science Center

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

About the PROBA2 Science Center

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.
LYRA (onboard PROBA-2)

- X and UV photometer, 4 passbands

### Preliminary Flare List

**October 2010**

<table>
<thead>
<tr>
<th>Day</th>
<th>Event</th>
<th>Begin</th>
<th>Max</th>
<th>End</th>
<th>Obs O</th>
<th>Type</th>
<th>Loc/Frq</th>
<th>Particulars</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td>5960</td>
<td>0452</td>
<td>0456</td>
<td>0458</td>
<td>G14</td>
<td>XRA 1-8A</td>
<td>B2.4</td>
<td>4.7E-05</td>
</tr>
<tr>
<td>01</td>
<td>5980</td>
<td>0743</td>
<td>0750</td>
<td>0802</td>
<td>G14</td>
<td>XRA 1-8A</td>
<td>B3.7</td>
<td>2.3E-04</td>
</tr>
<tr>
<td>01</td>
<td>6020</td>
<td>0925</td>
<td>1001</td>
<td>1051</td>
<td>G14</td>
<td>XRA 1-8A</td>
<td>B5.3</td>
<td>1.8E-03</td>
</tr>
<tr>
<td>02</td>
<td>6040</td>
<td>0839</td>
<td>0851</td>
<td>0900</td>
<td>G14</td>
<td>XRA 1-8A</td>
<td>B5.0</td>
<td>4.2E-04</td>
</tr>
<tr>
<td>02</td>
<td>6080</td>
<td>2331</td>
<td>2337</td>
<td>2343</td>
<td>G14</td>
<td>XRA 1-8A</td>
<td>B1.9</td>
<td>1.1E-04</td>
</tr>
<tr>
<td>03</td>
<td>6100</td>
<td>0409</td>
<td>0436</td>
<td>0503</td>
<td>G14</td>
<td>XRA 1-8A</td>
<td>B2.3</td>
<td>6.1E-04</td>
</tr>
<tr>
<td>03</td>
<td>6110</td>
<td>1920</td>
<td>1923</td>
<td>1925</td>
<td>G15</td>
<td>XRA 1-8A</td>
<td>B1.2</td>
<td>1.7E-05</td>
</tr>
<tr>
<td>03</td>
<td>6120</td>
<td>2143</td>
<td>2146</td>
<td>2149</td>
<td>G14</td>
<td>XRA 1-8A</td>
<td>B1.7</td>
<td>3.6E-05</td>
</tr>
</tbody>
</table>

Info: mariedo@oma.be
ROB data for SW operations

1. PROBA2 – SWAP & LYRA

2. Humain – Radio data

3. USET – White light and chromosphere

4. SDO – Data archive and dissemination
One goal is to 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 Sun-tracking log-periodic antenna
- Observations since May 2008
- Data online within 15 min
- Part of the CALLISTO network
- Website: [http://sidc.be/humain](http://sidc.be/humain)
- Info: Christophe.marque@oma.be

- Project started in 2008, in the framework of the Solar-Terrestrial Center of Excellence
- Current infrastructure is being refurbished (radiotelescopes, equipment)
- It involves currently a team of 4 people at SIDC
Examples of observations

Type II burst
ROB data for SW operations

1. PROBA2 – SWAP & LYRA
2. Humain – Radio data
3. USET – White light and chromosphere
4. SDO – Data archive and dissemination
**Solar telescope USET**

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>White light</strong></td>
<td>Quick-look &amp; Fitsfiles</td>
</tr>
<tr>
<td><strong>H-alpha</strong></td>
<td>Quick-look &amp; Fitsfiles</td>
</tr>
<tr>
<td><strong>Sunspot drawing</strong></td>
<td>Digitization completed</td>
</tr>
<tr>
<td><strong>Ca II K-images</strong></td>
<td>Quick-look &amp; Fitsfiles (Q3 2011)</td>
</tr>
</tbody>
</table>

Data is available via website: www.sidc.be

Data will be available via the SODA (SOTERIA VSO)

Info: frederic.clette@oma.be
ROB data for SW operations

1. PROBA2 – SWAP & LYRA

2. Humain – Radio data

3. USET – White light and chromosphere

4. SDO – Data archive and dissemination
DO data archive at ROB

- Download images from ROB: use same routines but specify site='rob'
  
  IDL> list=vso_search('1-aug-2010 00:00','1-aug-2010 00:02', inst='hmi', site='rob')
  IDL> a=vso_get(list[6:7])

- http://wissdom.oma.be
- latest movies: www.sidc.be
- Info: verodelo@oma.be
Funding through projects

SEVENTH FRAMEWORK PROGRAMME (EC)

**SOTERIA**

*Solar-terrestrial investigations and archives*

**GOAL:**
Improve forecasting capability through improved data access and modeling

**LEAD:**
K.U.Leuven, Belgium

**ROB:**
- Sunspot indices and proxy studies
- Distribution of data and dissemination (SODA)

**ROB-lead:** D. Berghmans

**COMESEP**

*CMEs and SEPs: forecasting the space weather impact*

**GOAL:**
set up a risk-alert space weather forecasting system

**LEAD:**
BISA, Belgium

**ROB contribution:**
- CME research & historical SSN data
- Automated detection
- Risk alert system (likelihood x impact)

**ROB-lead:** E. Robbrecht
Funding through projects

**SEVENTH FRAMEWORK PROGRAMME**

**AFFECTS**

*Advanced Forecast For Ensuring Communications Through Space*

**GOAL:**
Modeling the chain of effects down to the ionosphere, targeted to GNSS users

**LEAD:**
UGOE, Germany

**ROB:**
- Early SW warning system, timelines, automated detections
- Product dissemination through RWC

ROB-lead: C. Verbeeck

**eHeroes**

*Environment for Human Exploration and Robotic Experimentation in space*

**GOAL:**
set up a risk-alert space weather forecasting system

**LEAD:**
K.U.Leuven, Belgium

**ROB contribution:**
- research: magnetic reconnection
- FAST track analysis group
- Documentation, News, education

ROB-lead: P. Vanlommel
Funding through projects

Grantholder: Ronald Van der Linden

WP 2: Space weather products and services
Lead: R. Van der Linden

WP 3: Exploitation, Dissemination, Education, Outreach
Lead: P. Vanlommel
SSA activities at SIDC

ESA’s Space situational Awareness

Preparatory Programme 2009-2011

**SN-1** – Space Weather Segment Precursor Services - Part 1: Definition and service consolidation

Task 1: European Assets and services review – *finished*

Task 4: Initial 4-month operation of the services
- Data centre located in Redu, Belgium (ESA premises)
- SW Services Coordination Centre is hosted by STCE, Brussels

Task 5: Assessment and user feedback

**CO-1** - Requirements and evaluation

ROB: SW Expert for revision of Customer requirement documents
Space weather journal!

- A realization from COST ES0803
- Financially supported by STCE (Belgium)
- Secretarial office: Sophie Raynal, STCE (Belgium)
- Needs publications!

→ http://www.swsc-journal.org
European Space Weather Week

10th edition
When: November 18 – 22, 2013
Where: Belgium
Web: sidc.be/esww10 (soon)

Focus of ESWW9 on European space weather landscape, innovations and key challenges in space weather science, solar variability effects on climate, coupled space weather modeling, spacecraft operations and space weather, space weather in the solar system.

306 participants during ESWW8 from all over the world
European Space Weather Week

Previous editions

Fifth European Space Weather Week
17-21 November, 2008
Venue: Royal Library of Belgium, Brussels
Local Organization: Royal Observatory of Belgium
www.sidc.be/esww5

Program committee:
A. Gröning, ESA
D. Schuh, DLR
C. Fuchs, KOSMA
M. Hall, Swets & Zeitlinger
P. J. van Ballegooijen, SRON
A. Zrake, University of Zagreb

Fifth European Space Weather Week
17-21 November, 2008
Royal Library of Belgium, Brussels
Local Organization: Royal Observatory of Belgium
www.sidc.be/esww5

Fourth European Space Weather Week
5-9 November, 2007
Venue: Royal Library of Belgium, Brussels
Local Organization: Royal Observatory of Belgium - SICD
www.sidc.be/esww4

Third European Space Weather Week
4-8 November, 2005
Venue: Royal Library of Belgium, Brussels
Local Organization: the Solar-Terrestrial Centre of Excellence, ESA, COST, COSPAR, IOGP, EPOS, ESAC, Belgium

Sixth European Space Weather Week
16-20 November, 2009
Venue: Royal Library of Belgium, Brussels
Local Organization: Royal Observatory of Belgium - SICD
www.sidc.be/esww6
Future plans

- Quality Control: lessons learned
- Collaboration with NOAA-SWPC
- Research to operations
- Virtual modeling center (KUL)
- Improve accessibility of products
Acknowledgments

• The research leading to these results has received funding from the European Commission's Seventh Framework Programme (FP7/2007-2013) under the grant agreement n° 263506 (AFFECTS project).

• The presented work has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 263252 [COMESEP].