THE SOLAR INFLUENCES DATA ANALYSIS CENTER: CURRENT STATUS OF EXPANDING ACTIVITIES

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ABSTRACT

Over the last 24 months, the activities of the SIDC, which is the European Regional Warning Center of the ISES, have steadily expanded. A 7-day/week service has been implemented, the SIDC Web interface has been reworked and expanded and the number of registered users increased further. New image data have been added, including new photospheric and chromospheric CCD images from the Uccle Station. We summarize here the new services provided to the community and some statistics about the success rate of our forecasts. We also outline the orientations of the future SIDC development.

Key words: Sun; solar activity; space weather; data center.

1. A BRIEF HISTORY OF THE SIDC

In 1981, the SIDC (which then stood for "Sunspot Index Data Center") was established in Brussels, as a World Data Center for the International Sunspot index, taking over the duties of the Zurich Observatory (Koeckelenbergh, 1981). Another fundamental transition took place in January 2000, when the SIDC took over the Regional Warning Center of the ISES Network (International Space Environment Service), which was previously based in the Observatoire de Paris-Meudon. The SIDC expanded its initial focus from mid- to long-term solar activity towards short-term space-weather monitoring. To reflect the new activities, it was renamed "Solar Influences Data Analysis Center".

The SIDC is hosted by the Solar Physics Departement of the Royal Observatory of Belgium (ROB), which is closely involved in several space research programs, including EIT/LASCO on the SOHO mission (Co-investigators since 1992), STEREO/SECCHI (Co-investigators; launch in 2004), and more recently, MAGRITTE/SHARPP on the SDO mission (Deputy Principal-Investigator; launch in 2007). Over the last few years, the SIDC largely benefited from this extensive experience of space-based observations of the solar atmosphere, especially as scientists working for the SIDC are conducting research programs, primarily with extreme-ultraviolet imagers.

Figure 1. General view of the Uccle Dome and the buildings hosting the SIDC.

Currently, the SIDC is directed by Dr. P. Cugnon, with a staff of 8 scientists/forecasters (working part-time and in one-week shifts for the Center) and 5 technicians/observers. The funding, which supports mainly the administrative and postal expenses, comes from the ROB, the Belgian Office of Scientific, Technical and Cultural Affairs (OSTC), ESA/PRODEX, and from the International Council for Science (ICSU) and the Federation of Astronomical and Geophysical Data Analysis Services (FAGS).

2. THE SIDC SERVICES

Presently, the SIDC provides the following publications and Web/e-mail products:

- Monthly sunspot bulletin (> 560 subscriptions): sunspot index archive, updates and forecasts
- Weekly bulletin (> 160 subscriptions): weekly review of solar and geomagnetic activity, most

important indices, overview of solar events

- Daily activity report and forecast (> 180 subscriptions): daily review of solar activity and 3-day forecast, 7 days/week
- Fast alert "Presto" messages (> 190 subscriptions): warnings sent as soon as sudden important events or evolutions take place (halo CMEs, storm onset, major flares), 7 days/week.

About 450 users receive the monthly sunspot bulletin by regular mail, while about 250 subscribers receive e-mail messages and bulletins (increasing steadily at a rate of 2 per week). Various additional services (forwarding of specific data, etc.) are also provided on user request.

3. WEB SITE AND FAVOURITE PRODUCTS

The central hub to access SIDC data is now our Web site (**http://sidc.oma.be**) which has been in full development over the last 2 years (Fig.2).

The primary information consists of the SIDC/RWC daily and weekly bulletins and of the alert messages posted within minutes of their release. An interactive solar map, based on the latest EIT FeXV (28.4 nm) image, allows the user to check the status of individual active regions with clickable pop-up data lists from NOAA and the Catania Observatory (Fig. 3). The site gives also full access to the archive of the international Sunspot Number Ri, as well as 6-month global activity forecasts, in numerical and graphical form (Fig. 4). The Ri index, which is the oldest and the primary product of the SIDC, is based on a worldwide network of 80 observing stations. As it is the oldest solar activity index available, it is the only reliable base for long term studies. A crucial aspect of the SIDC mission is to ensure the long-term continuity and consistency of the index, over a period of several centuries.

The SIDC pages are also packed with near real-time imagery, movies and plots from spacecrafts (SOHO, ACE, GOES) and from ground-based solar and geophysical observatories (white-light,Hα, CaII, HeI, magnetographs, ionosonde, radio heliographs and spectrographs). In the near future, solar patrol observations from the Uccle station (full-disc white-light and Hα images) will also be included in near real-time (see Clette et al., 2002; in these proceedings). This offers a panorama of many of the data used for our monitoring and forecasting work, and at the same time, it proves to be an excellent tool for public outreach and education. In 2002, we counted an average of 1500 hits/week on our Web pages.

Recent statistics of our registered users give the following geographical distribution: Europe (56 %), North America (35 %), Asia (4 %), South America (3 %), Oceania (1 %), Africa (1 %), and within Europe, Belgium (13 %), UK (8 %), Germany (7 %),

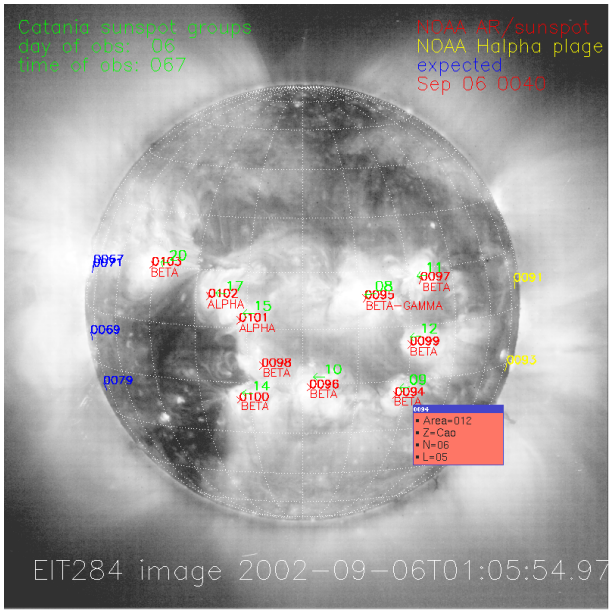

Figure 3. Interactive solar map: EIT FeXV image with overlays and pop-up information windows for each individual active region.

Table 1. Statistics of user profiles (count of registered users).

Scientists	
Space scientists	many (largest group)
Meteorologists	10
Medical scientists	5
Paleo-climatologists	5
Institutional users	
International organis.	UNESCO, IAU, ISES
Private companies	±20
Aircrew	5
Military	3

France (6 %), Netherlands (6 %) and lower percentages in many more countries. Regarding now the kind of users, we can group them into two main classes: scientists and public or private institutions. A more detailed list of user profiles is given in table 1. Moreover, a large number of visitors and data queries come from the wide public, in particular radio amateurs, but only a small fraction of them do register.

4. THE SIDC IN NUMBERS: FORECAST RELIABILITY

Beside the public Web site, a forecaster interface was developed with interactive tools developed in the HTML, PHP and IDL languages. It provides extrapolations of the 10.7 cm flux and active region histories for flare probability forecasts. Moreover, the processing of coded messages (input and output), as

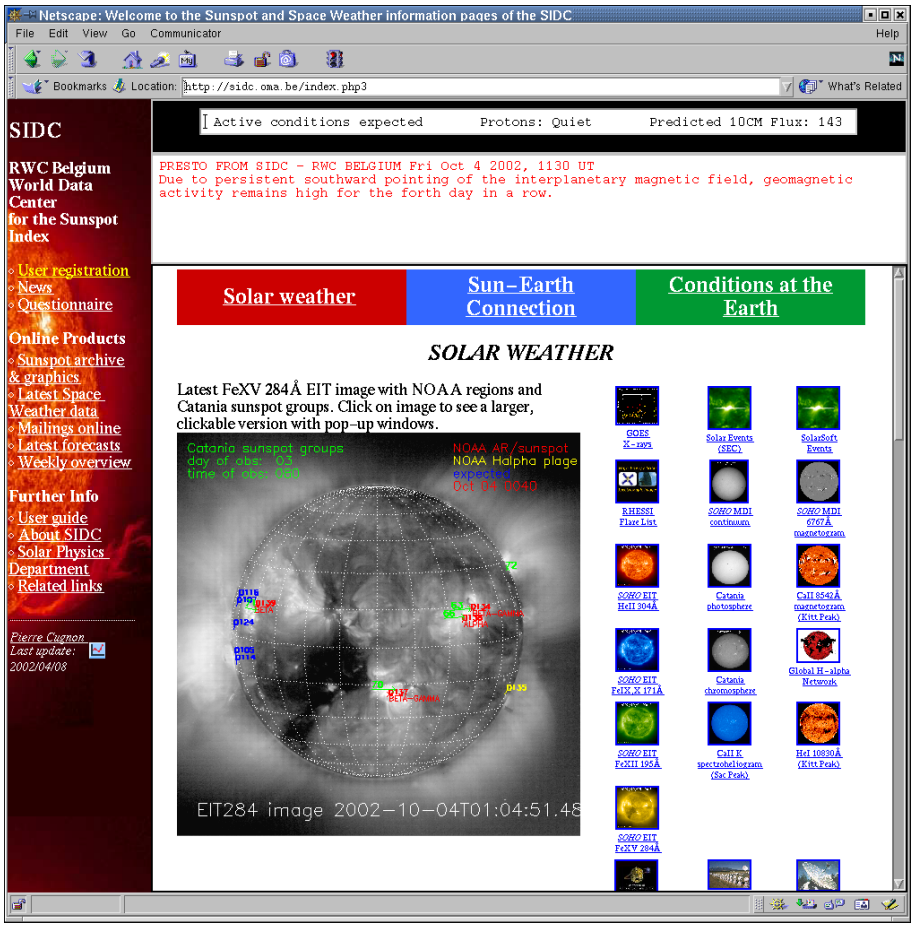

Figure 2. Main page of the SIDC Web site.

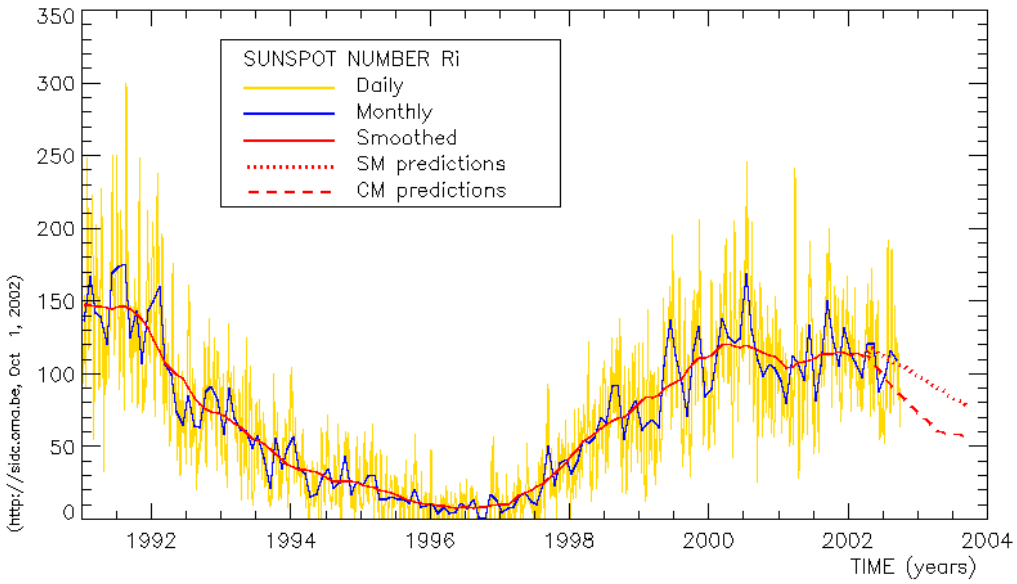

Figure 4. The first mission and still one of the central products of the SIDC: plot of the daily, monthly and smoothed monthly International Sunspot Number and the 6-month forecast (classical and Denkmayr-Cugnon methods).

Table 2. Success rates of daily event forecasts for the next day

Parameter	Success rate	False alerts	Misses
Magnetic storms (Kp)	46 %	23 %	31 %
Flare & proton events	64 %	20 %	16 %

Table 3. Statistics of predicted versus observed 10.7 cm radio flux (DRAO, Canada), from Feb 2, 2001 up to Nov 2001 (bias and standard deviation in sfu).

SIDC forecasts			
	Bias	RMS	Corr. coeff
Day 1	0.745	10.27	0.972
Day 2	1.162	15.25	0.939
Day 3	2.460	20.04	0.896
SEC forecasts			
	Bias	RMS	Corr. coeff
Day 1	-1.507	10.86	0.966
Day 2	-1.718	15.61	0.928
Day 3	-2.069	20.56	0.873

well as the archiving of data and forecasts was entirely rewritten in the form of automated UNIX shell scripts and IDL programs.

This archiving allowed us to monitor the quality and reliability of the SIDC forecast products, by making statistics of the difference "predicted versus observed" for each kind of forecast. Table 2 summarizes our success rates regarding the occurence of flares, proton events and magnetic storms. Table 3 provides a comparison of the accuracy of the predicted 10.7 cm radio flux (1, 2 and 3 days ahead) as provided by SIDC and by the SEC/NOAA, for a comparison. It shows that the 3-day prediction still reaches a 89 % correlation. Overall, we can conclude that the reliability of our forecasts is comparable with those of NOAA, though sometimes slightly better.

5. FUTURE DEVELOPMENTS: AUTOMATED IMAGE PROCESSING

The ROB Solar Physics team is actively developing an expertise in image processing techniques applied to EIT and LASCO images of the solar corona and transition region. The new methods, which are still in development, should lead to new solar monitoring and prediction tools. We can cite the CACTUS project of automated detection of CMEs (Berghmans, 2002), wavelet-based image segmentation and pattern recognition methods and the CME tracking and speed determination by optical flow techniques (Fig. 5).

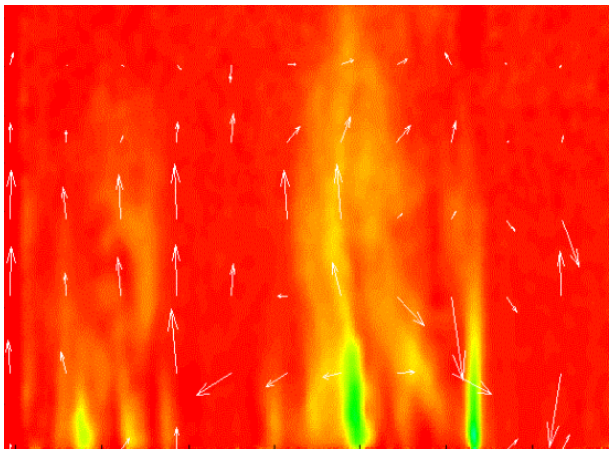

Figure 5. Preliminary test of the optical flow method, applied to LASCO/SOHO images. The velocity field (arrows), derived here for a CME event, is plotted in polar coordinates: polar angle (0 - 360°) horizontally, radial distance (2 - 6 $R_\odot$) vertically).

As a conclusion, the SIDC has experienced a deep evolution since its creation and is now in full development thanks to a team of experienced solar physicists. This succesful effort is based on a well established observation network and client community, and it leads to competitive forecasting success rates. Still, space weather forecasting is still in its infancy and currently relies mostly on human expertise and statistical models. Therefore, in order to further improve our forecasts, new research is needed in the sense of physical models and more efficient use of the wide array of available data. At the SIDC, these future developements will be supported by our close participation to current and future space programs and to various research networks.

Anyone interested by our activities and services is invited to visit our web site (**http://sidc.oma.be**) and to register to our e-mail messaging system.

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