Deliverable 2.1

Provision of a dedicated Web-Interface for EUV data

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Content

1 Introduction

This report describes the provision of a dedicated web interface for EUV data according to DoW, WP 2.

The web interface, developed at ROB, allows users from inside as well as outside the AFFECTS consortium to view and handle EUV data in a dynamical and user-friendly way. These EUV data provide an early warning of solar flares and help to gain a better insight into the effects of flares upon the Earth's ionosphere. Consequently, the web interface is a powerful tool both for space weather forecasting and for studying the chain of events that causes solar eruptions to have a space weather impact on Earth and in space.

The web interface has been designed for dynamical data access not just for EUV data, but in a generic sense. This will allow its extension as specified in future deliverable D2.2 (Online provision of solar activity proxies and solar activity data base). In view of this, the web interface was baptized STAFF (Solar Timelines viewer for AFFects).

2 EUV data

2.1 The importance of EUV data

The Extreme Ultraviolet (EUV) is the part of the electromagnetic spectrum from 10 to 121 nm. This is an important range of the spectrum in solar physics, as different parts of the solar corona are visible in different EUV bands. Since space weather events at Earth are dominated by eruptions in the corona, EUV data are of major importance in predicting space weather.

Solar flares are one of the most energetic phenomena in the solar system. During these short-lived events in the corona, particles can be heated to millions of degrees and ejected in the solar atmosphere. These events appear in radiometer time series as an increase of the solar irradiance, especially in X and UV ranges. Understanding those events is a "hot" science topic, and important for space weather research and forecasting, as large flares can have severe effects on the Earth's ionosphere.

Flares and other solar eruptions typically originate in regions on the Sun with especially strong magnetic field, which stand out bright in X-ray and UV. These regions are called Active Regions (AR).

2.2 EUV data in STAFF

The main EUV data served by STAFF are the four EUV channels on the Lyra radiometer onboard the Proba2 satellite (http://proba2.oma.be/index.html/science/, Hochedez et al. 2006).

In 2009, ESA launched the Proba2 satellite, which carries two EUV instruments: the EUV imager SWAP and the X and UV filter photometer Lyra (Large Yield Radiometer). Lyra was designed and manufactured by a Belgian–Swiss consortium. It monitors the solar irradiance in four passbands relevant to solar physics, space weather and aeronomy:

- the Aluminium filter channel (17-80 nm + a contribution below 5 nm), including the strong He II line at 30.4 nm
- the Zirconium filter channel (6-20 nm + a contribution below 2 nm), rejecting He II
- the 120-123 nm Lyman-α channel
- the 190-222 nm Herzberg continuum channel

While Lyra's Lyman-α and Herzberg channels have shown very severe degradation over time due to solar radiation, the Aluminium and Zirconium channels have undergone very limited degradation. This is due to their wide bandgap detectors based on diamond, rendering the sensors radiation-hard and solar-blind: their large bandgap energy makes them quasi-insensitive to visible light. Lyra benefits of a very favorable acquisition cadence (up to 100 Hz), while most solar instruments acquire a data point only every tens of seconds.

STAFF will also provide novel EUV proxies for solar activity, derived from EUV images, as described in AFFECTS task 2.2. Examples are the total flux observed in the telescope bandpass and the total AR area (extracted automatically by ROB's in-house coronal segmentation algorithm SPoCA (Barra et al. 2009, Verbeeck et al. 2011).

3 The STAFF web interface for EUV data

3.1 Goals

The STAFF web interface should provide the user easy and versatile access to EUV data. Important use-cases include the ability to select a recent timeframe, like the last three days or last Carrington rotation (this is the rotation of the Sun around its axis, and amounts to 27.2753 days), the possibility to specify an arbitrary time range, and the option to zoom in on the plot as desired. It should also allow the user to plot several EUV (and other) timelines on the same plot, so their interdependence can be examined.

3.2 Overview

STAFF is a Java applet, i.e., a program written in the Java programming language that is included in a web page. A user can run STAFF by visiting the corresponding URL in his browser. As outlined above, the STAFF viewer will later serve not just EUV data, but also timelines of solar activity, solar wind and geomagnetic data (D2.2).

The view of STAFF on the screen consists of a "timeline selection frame" on the left, and the main "plot frame" featuring the plot of the selected timelines within the specified time range. When the user has selected one or several timelines and has specified a time range, the corresponding data are plotted on the screen.

Several buttons at the lower end of the plot frame allow the user to specify a time range in three different ways:

1. *Go to*: last minute, last hour, last 3 hours, last 6 hours, last 12 hours, last day, last 3 days, last week, last Carrington rotation, last month, last year.
2. *Update time range*: the user can specify the exact start and end time in the format dd/mm/yyyy hh:mm:ss.
3. *Previous/Next*: select the previous or next period of the same length as the current time range.

A further amenity is the zoom facility, which allows the user to select any rectangle on the plot using the mouse and zoom in on it.

3.3 Examples

Figure 1 shows the plot of the Lyra Aluminium and Zirconium channels around the time of the X2.1 flare on September 6, 2011. This plot shows the importance of Lyra data for early flare alerts and for flare studies. The Lyra Aluminium and Zirconium timelines were selected in the EUV category in the timeline selection frame. The start and end times were entered using the "update time range" button in the plot frame.

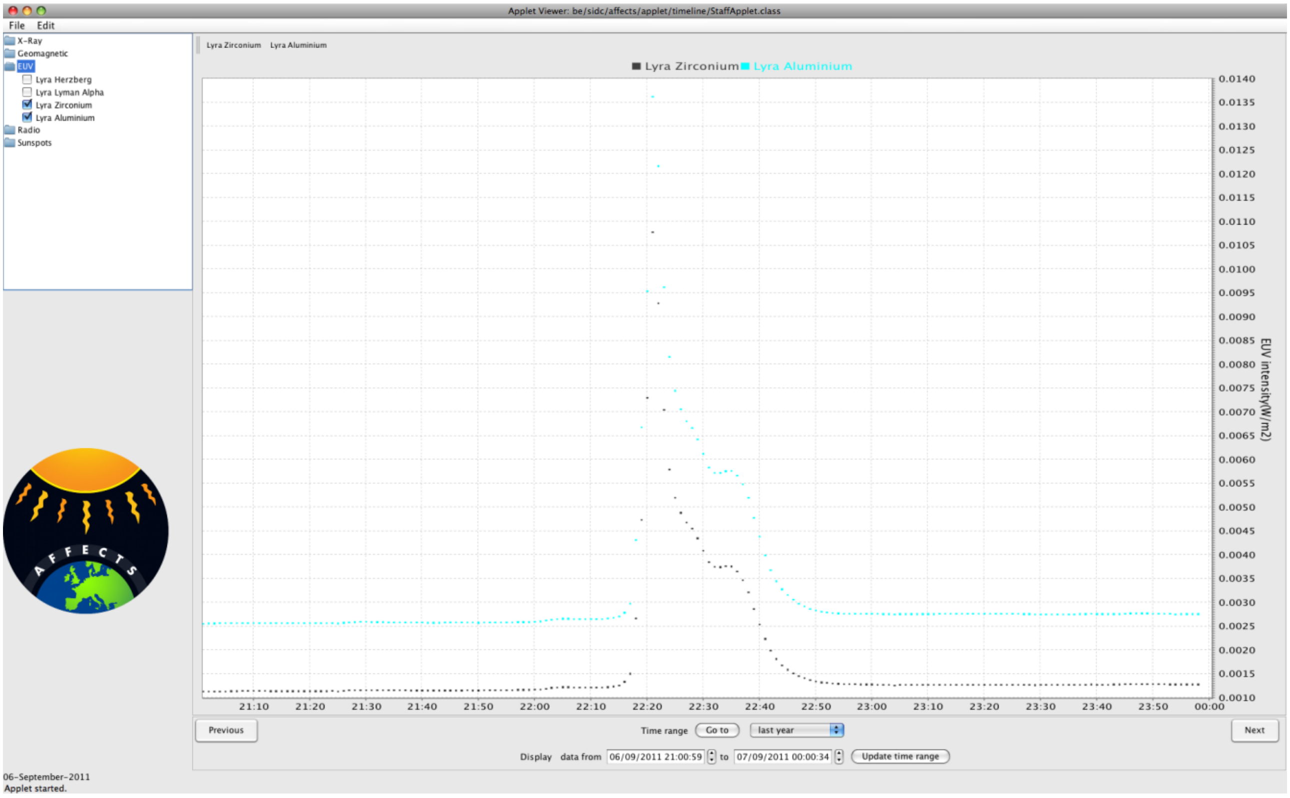

Figure 1 - This figure shows the plot of the Lyra Aluminium and Zirconium channels around the time of the X2.1 flare on September 6, 2011.

In Figure 2, STAFF plots the Lyra Aluminium and Zirconium channels for the last week. This plot was produced by selecting "go to last week" in the plot frame.

Figure 3 features the plot of the Lyra Aluminium and Zirconium channels for the previous week. This plot was created by selecting first "go to last week" and then selecting "previous" in the plot frame.

The STAFF database already includes several non-EUV timelines as well, as illustrated below. An example is given in Figure 4, which plots the daily International Sunspot Number since 1818. The start and end times were entered using the "update time range" button in the plot frame.

The International Sunspot Number (ISN) is a quantity that measures the number of sunspots and groups of sunspots present on the surface of the Sun. The combination of sunspots and their grouping is used because it compensates for variations in observing small sunspots. The ISN is the oldest and most used proxy for solar activity. Note the conspicuous 11 year solar cycle in Figure 1. This cycle is important for space weather, as the most extreme space weather events are typically registered around the solar maximum.

Sunspot activity has a major effect on long distance radio communications, particularly on the shortwave bands (although medium wave and low VHF frequencies are also affected). High levels of sunspot activity lead to improved signal propagation on higher frequency bands, although they also increase the levels of solar noise and ionospheric disturbances. These effects are caused by impact of the increased level of solar radiation on the ionosphere.

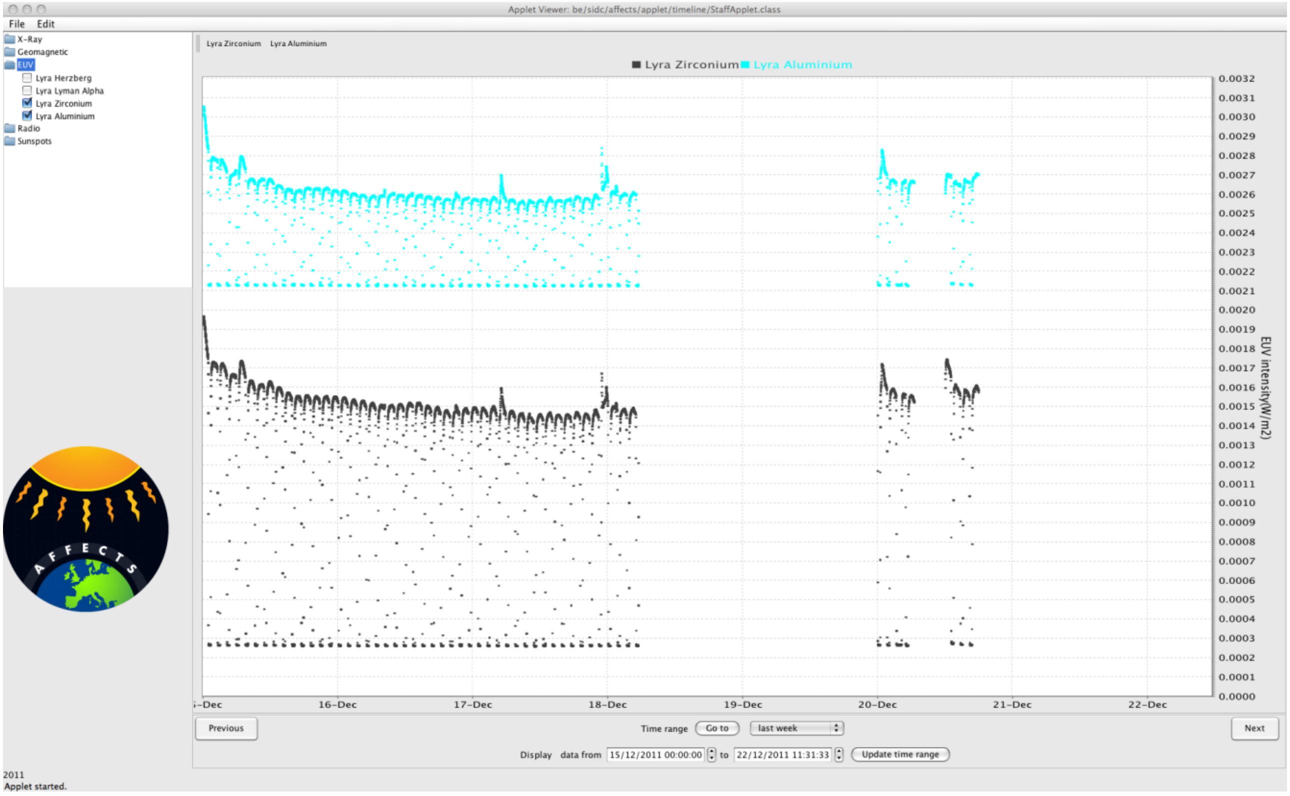

Figure 2 - This figure shows the plot of the Lyra Aluminium and Zirconium channels for the last week.

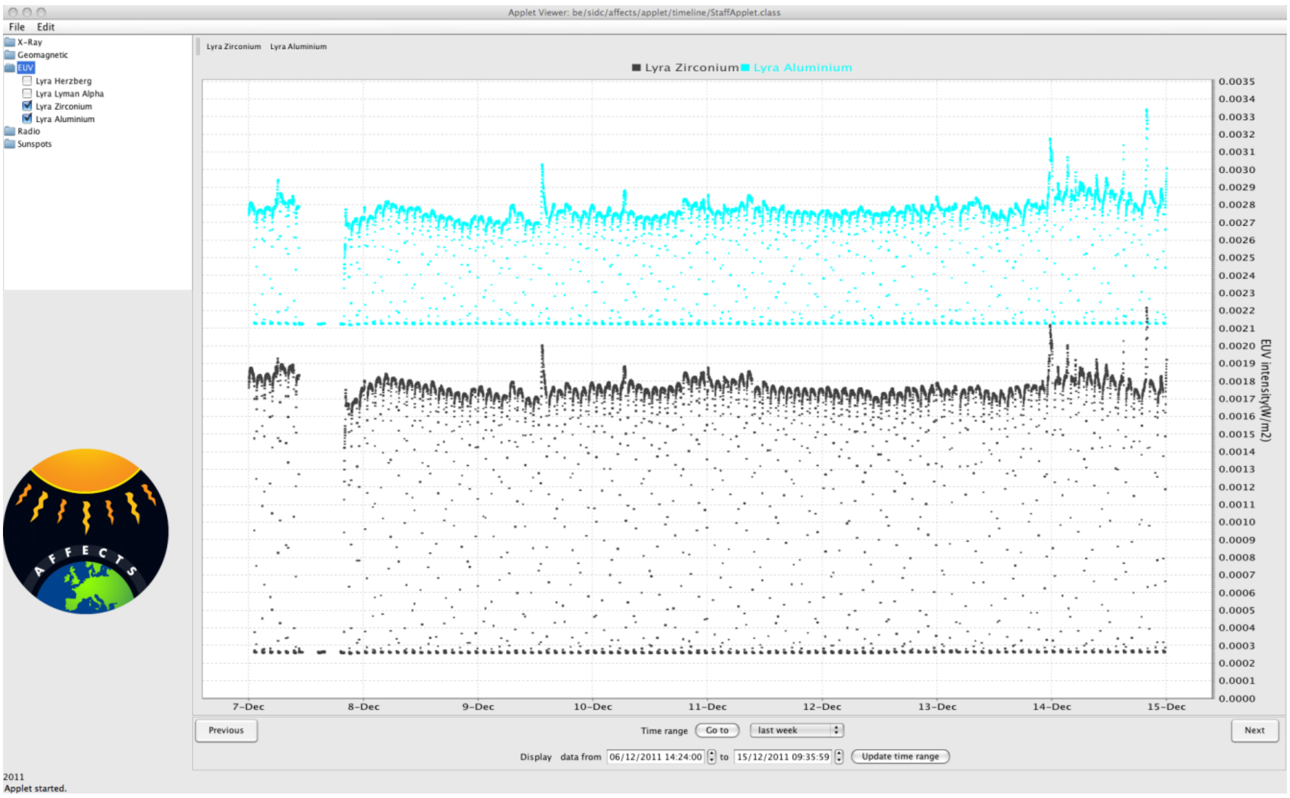

Figure 3 - This figure shows the plot of the Lyra Aluminium and Zirconium channels for the previous week.

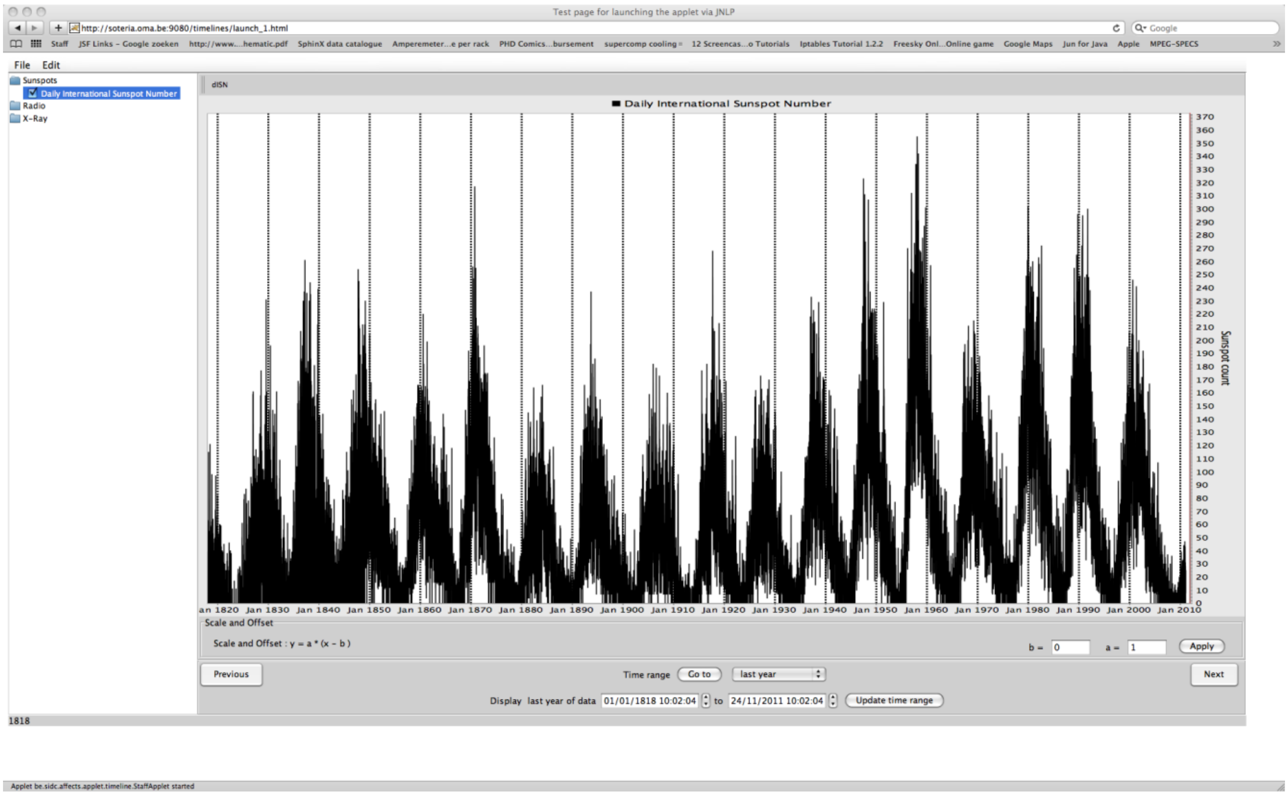

Figure 4 - This figure shows the plot of the daily International Sunspot Number since 1818.

Figure 5 zooms in on the ISN for the last four sunspot cycles. This plot was produced by selecting the proper part of Figure 4 with the mouse in order to zoom in on it.

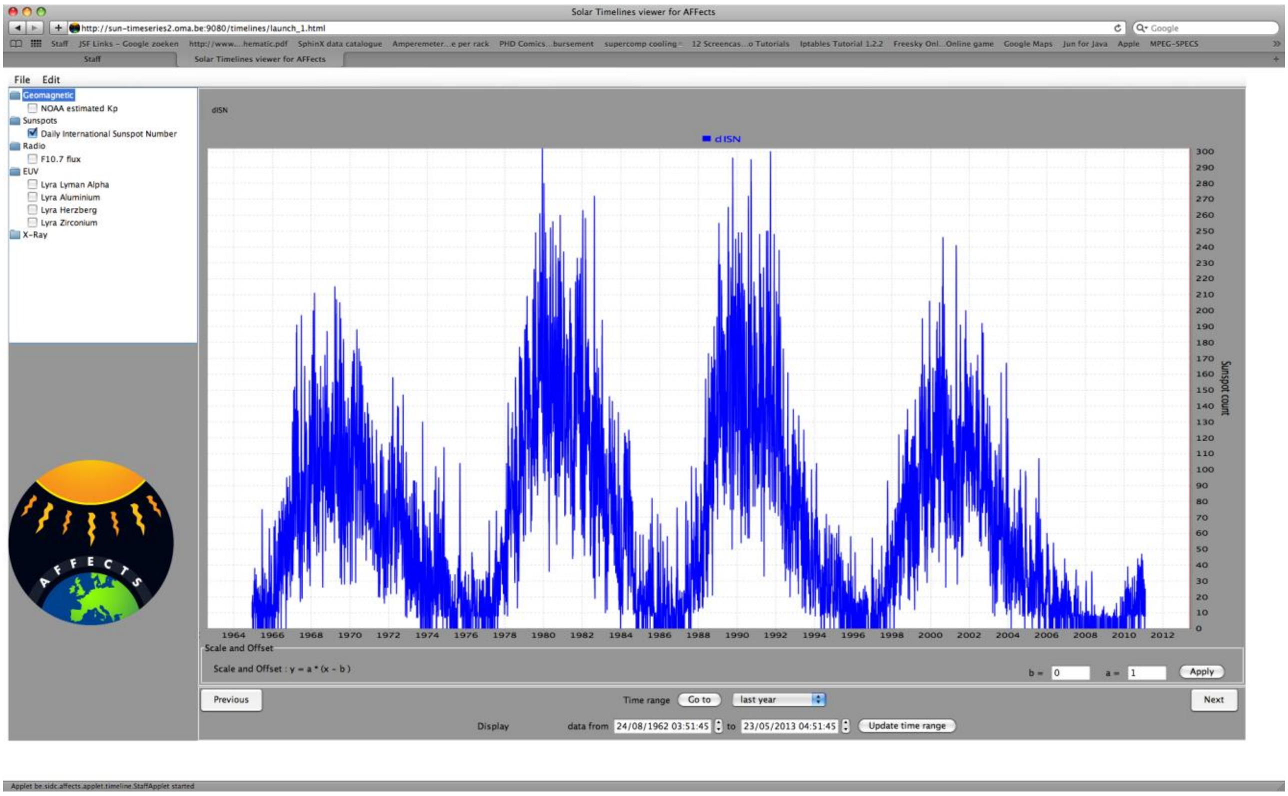

Figure 5 - This figure zooms in on Figure 4 and shows the daily International Sunspot Number for the last four solar cycles.

Another timeline already available in STAFF is the F10.7 radio index, which is also an important proxy for solar activity. Figure 6 offers a comparison between the daily International Sunspot Number and the F10.7 radio index from 2005 to 2011.

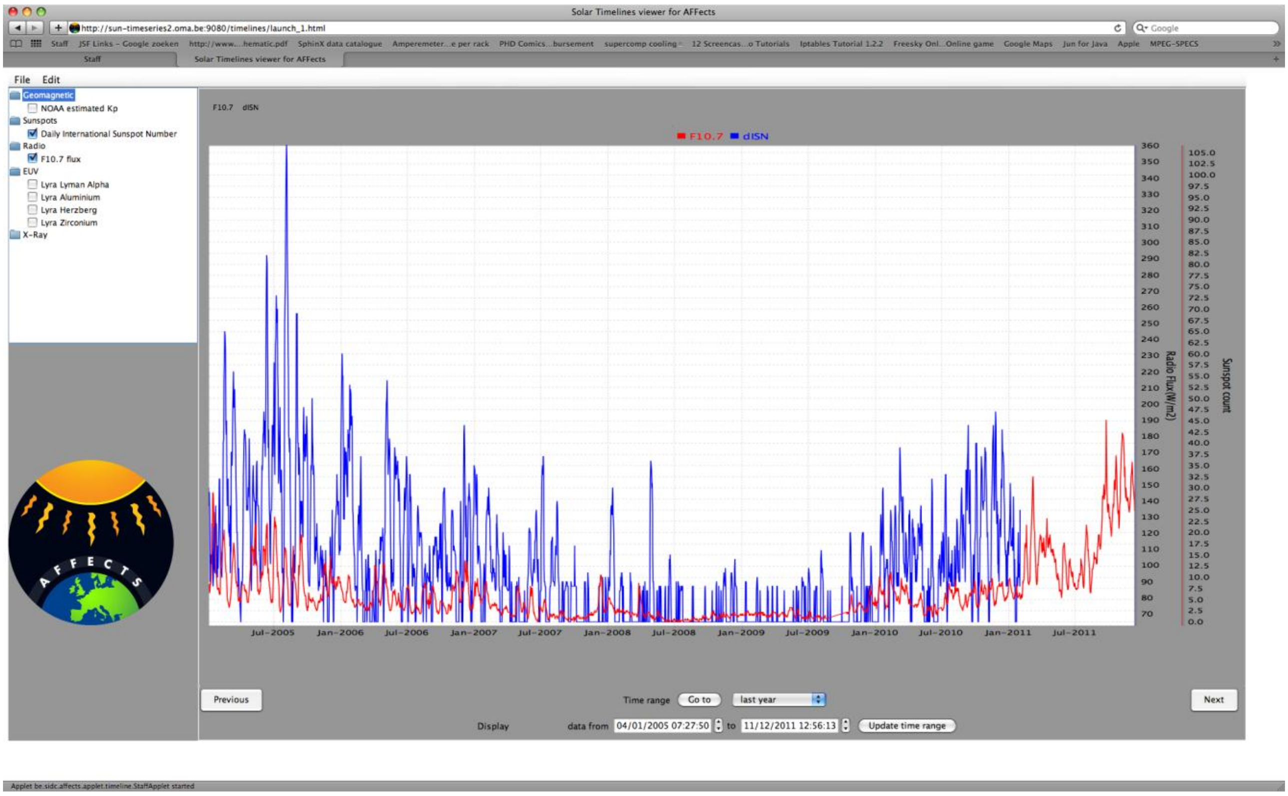

Figure 6 - This figure compares the International Sunspot Number and the F10.7 radio index from 2005 to 2011.

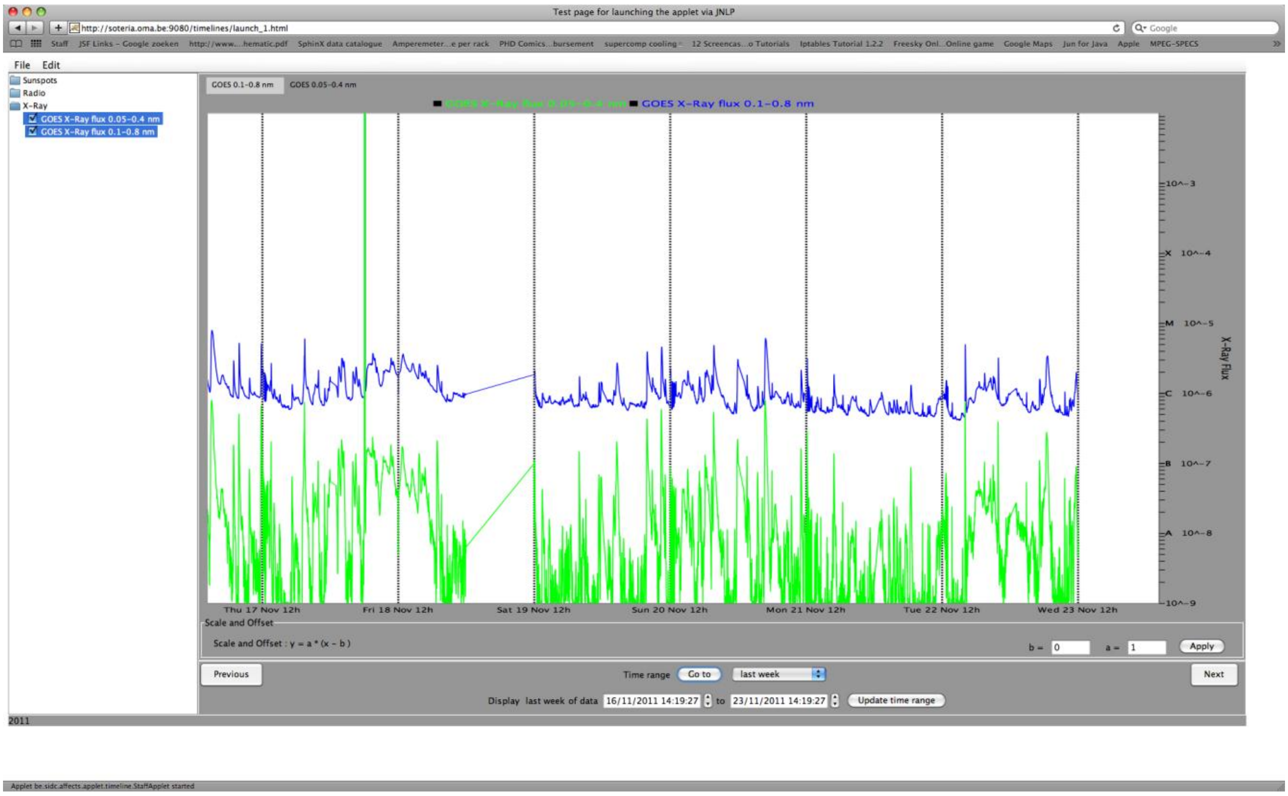

Figure 7 - This figure shows the 3-day history of the GOES 0.1-0.8 nm and 0.05-0.4 nm X-ray flux.

The F10.7 radio index is a measure of the solar radio flux per unit frequency at a wavelength of 10.7 cm, near the peak of the observed solar radio emission. It represents a measure of diffuse, nonradiative heating of the coronal plasma trapped by magnetic fields over AR, and is an excellent indicator of overall solar activity levels. The solar F10.7 cm record extends back to 1947, and is the longest direct record of solar activity available, other than sunspot-related quantities.

Figure 7 shows the 3-day history of the GOES 0.1-0.8 nm and 0.05-0.4 nm X-ray flux. Solar flares are classified as A, B, C, M or X according to the peak flux (in watts per square meter, W/m^2) of 0.1 to 0.8 nanometer X-rays near Earth, as measured on the GOES spacecraft. Each class has a peak flux ten times greater than the preceding one, with X class flares having a peak flux of order 10^{-4} W/m^2. Within a class there is a linear scale from 1 to 9, so an X2 flare is twice as powerful as an X1 flare, and is four times more powerful than an M5 flare. The more powerful M and X class flares are often associated with a variety of effects on the near-Earth space environment.

Figure 8 monitors the Kp index around the time of the geomagnetic storm of October 24-25, 2011.

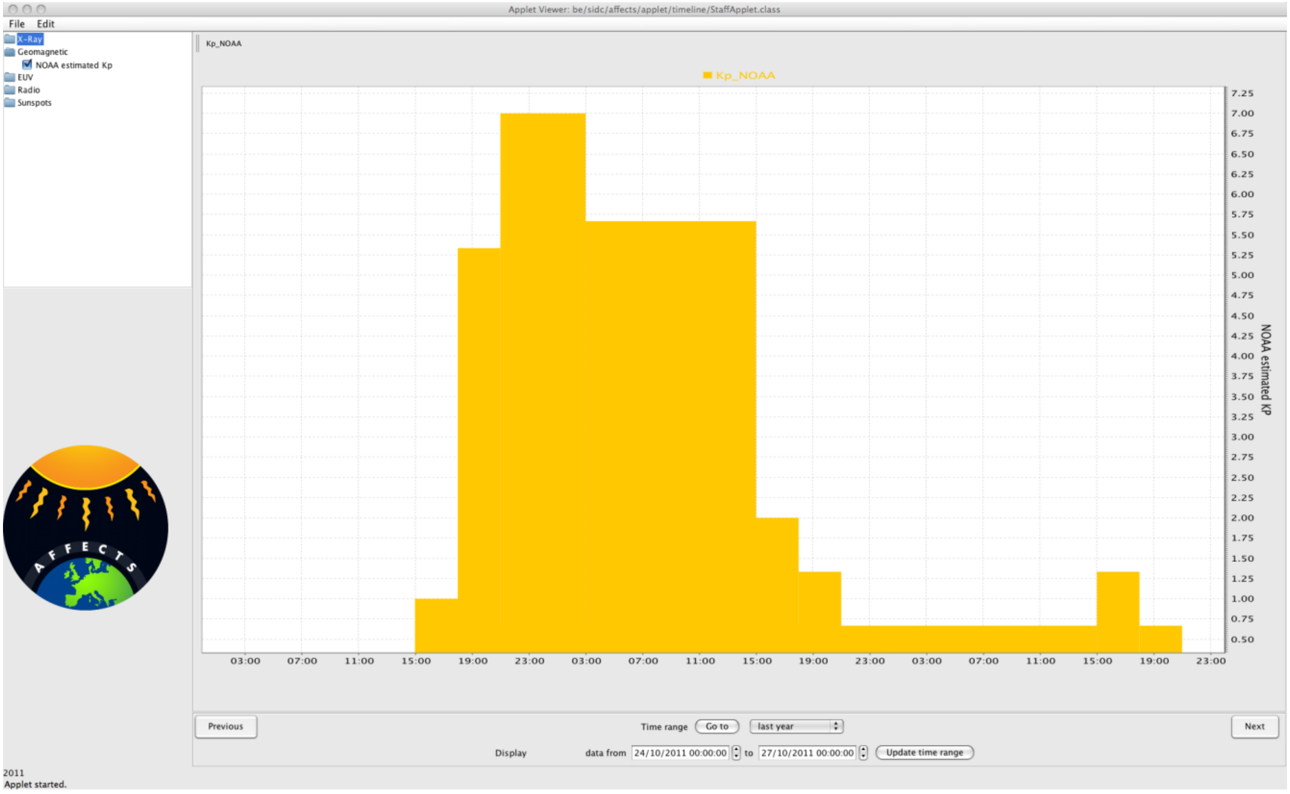

Figure 8 - This figure shows the Kp index around the time of the geomagnetic storm of October 24-25, 2011.

The K-index quantifies disturbances in the horizontal component of the Earth's magnetic field with an integer in the range 0-9 with 1 being calm and 5 or more indicating a geomagnetic storm. It is derived from the maximum fluctuations of horizontal components observed on a magnetometer during a three-hour interval.

The official planetary Kp index was introduced by Bartels in 1939 and is derived by calculating a weighted average of K-indices from a network of geomagnetic observatories. Since these observatories do not report their data in real-time, various operations centers around the globe estimate the index based on data available from their local network of observatories.

3.4 STAFF URL

http://sun-timeseries2.oma.be:9080/timelines/launch_1.html

4 STAFF design and architecture

The STAFF application is a client-server based type of application. This means that there is a server that stores timeline data in a database and returns the proxy data requested by the user to the client part of the application.

The client part of the application is composed of a list of timelines grouped in categories and a chart that is able to display the timelines visually.

4.1 Choices of implementation

We chose to develop the whole application in Java for the following reasons:

- **<u>Homogeneity</u>**: The same language and code can be reused for the server, the web client or for a standalone client. It can also be used easily to integrate with tools like IDL® or Matlab®.
- **<u>Freely usable</u>**: Java and a lot of libraries are available for free. The Java plugin is available and most of the time installed by default on Windows, Mac OSX and Linux.

Implementations of standard protocols like HTTP, XML, SOAP, REST and MathML are available both on the server side and on the client side. This means that we are sure to respect the standard and to avoid compatibility issues.

4.2 Server side

The server is an HTTP server that is able to execute code to generate dynamic content.

As HTTP server, we chose Tomcat. It is a web application container that is able to run web applications and it provides support to access databases as well as libraries to generate Web 2.0 pages (HTML5, AJAX, Javascript, …). It also fully supports protocols like SOAP and REST for WEB Services.

As database, we use PostgreSQL. It is open source (and will stay like that in the long term), provides a wide support of SQL, is performant and contains enterprise level functionalities like automated replication and recovery after failure.

4.3 Client side

The client is an applet (an application running in a browser). It communicates with the server using standard HTTP requests (REST requests).

As charting library, we use JFreechart®, the most widely used open source charting library. It provides us the same kind of functionality as the charts in Excel® for example, is used in well-known applications like JasperReports® and is mature (the project started in 2001 and is stable for already a few years).

We use also JEuclid as MathML implementation to display units such as mathematical formulas and utility libraries from the Apache Foundation.

5 Accessibility of STAFF on different platforms and browsers

A general issue of advanced web applications is that their well-functioning depends on proper support provided by the combination of the chosen browser and platform. We have tested accessibility on a variety of browser/platform combinations, and the results are listed in Table 1.

Operating system	Distribution	CPU architecture	Browser	Java version	works	comments
Windows XP	NA	32 bit	IE 6,IE8,Chrome, firefox, opera	Java 7	yes	
Windows XP	NA	32 bit	IE 7	Java 7	yes	Virtual Machine
Windows 7	NA	64 bit	IE 9,Chrome, firefox, opera	Java 7	yes	
Linux	Ubuntu	32 bit	firefox	java 7	yes	Virtual Machine
Mac						Not tested
Android 2	NA	NA	Android browser, firefox	NA	no	No java plugin available
Android 3	NA	NA	Android browser, firefox	NA	no	No java plugin available
Android 4	NA	NA	Android browser, firefox	NA	no	No java plugin available
Iphone	ios 4.2.1	NA	iPhone browser Safari	NA	no	No java plugin available
Ipad						Not tested

Table 1 - This table shows the accessibility of STAFF for several browser/platform combinations.

In case STAFF would not be accessible on one of the acknowledged browser/platform combinations above, it can probably be fixed by amending one of the situations below:

1. It is required that your network allows access to the URL, and more specifically to port 9080.
2. If your computer does not have the proper Java version (Java 7) installed, your browser will be redirected to a website where you can download the Java plugin needed for STAFF.

In its present form, STAFF contains several known bugs. In order to run STAFF without running into one of these bugs, it is advised to perform the following actions:

1. Select the wanted date (e.g., 01/11/2011-01/12/2011) and push the "update time range" button.
2. Double-click on any of the categories on the left panel (e.g., X-ray) in order to see the available timelines in these categories.
3. Select one or several timelines (e.g., GOES X-Ray flux 0.1-0.8 nm) by checking its box.
4. The timeline(s) should now be plotted. This might take up to a minute, depending on which timeline is loaded.

6 Setbacks and suggestions

ROB has encountered severe setbacks in the development of the STAFF viewer due to the unwillingness and incompetence of its developer. This situation only became apparent well into the project, when it was too late to look for a replacement. Meanwhile, this person has left ROB, meaning that no more work could be done and no bugs could be fixed in the meantime. Since May 15, 2012, his successor has joined ROB and has already made significant progress in developing a new version of STAFF.

We are confident that we will be able to deliver a mature, well-designed dynamic viewer for EUV data by October 2012. That is why we propose:

- to change the deliverable name D2.1 into "Provision of a demo version web-interface for EUV data" (description: "Development of a demo version web-interface for EUV data").
- and to add the new deliverable D2.8 for October 2012 (month 20; "Provision of a dedicated web-interface for EUV data") with description: "Development of a dedicated web-interface for

integrated data access to scientific community in coordination with WP6, including documentation".

This October 2012 version of STAFF will also be presented at the Ninth European Space Weather Week in Brussels, November 5-9, 2012, both in an oral presentation and by an online demo at the space weather fair.

7 Summary and conclusions

The Solar Timelines viewer for AFFects (STAFF) is an AFFECTS web interface that has been designed to provide the user easy and interactive access to EUV data. At present it is just a demo version and contains many bugs, but a fully mature version will be delivered in October 2012, ready to serve EUV data as well as several other timelines related to solar and geomagnetic activity.

8 Perspectives and recommendations

Extension of STAFF is envisaged in deliverable D2.2 (Online provision of solar activity proxies and solar activity data base). The aim is to integrate a whole gamut of solar activity, solar wind and geomagnetic timelines into STAFF, which will then be a very powerful tool for space weather forecasting.

9 References

Barra V., Delouille V., Kretzschmar M., Hochedez J.-F., Fast and robust segmentation of solar EUV images: algorithm and results for solar cycle 23, Astronomy & Astrophysics, 505, 361-371, 2009.

Hochedez J.-F., Schmutz W., Stockman Y. et al., LYRA, a solar UV radiometer on Proba2, Advances in Space Research, 37, 303-312, 2006.

Verbeeck C., Higgins P.A, Colak T., Watson F.T., Delouille V., Mampaey B., Qahwaji R., A multi-wavelength analysis of active regions and sunspots by comparison of automatic detection algorithms, Solar Physics, accepted, 2011.

10 Appendix

10.1 Data links

GOES XRS data:
http://www.swpc.noaa.gov/ftpmenu/lists/xray.html
GOES SEP data:
http://www.swpc.noaa.gov/ftpmenu/lists/particle.html
GOES SXI data:
http://www.swpc.noaa.gov/sxi/
SDO EVE real-time data:
http://lasp.colorado.edu/eve/data_access/sdo_xray_proxy/eve_goes_xray_proxy.html
SDO EVE science data:

http://lasp.colorado.edu/home/eve/data/data-access/

SDO AIA data:

http://sdowww.lmsal.com/suntoday/

STEREO real-time beacon data:

http://stereo-ssc.nascom.nasa.gov/beacon/beacon_insitu.shtml

STEREO/EUV and coronagraph images:

http://secchi.nrl.navy.mil/sccimages/

PROBA2/SWAP and Lyra data:

http://proba2.sidc.be/index.html/Data-download/article/swap-lyra-data-distribution

SOHO/EITdata:

http://sohodata.nascom.nasa.gov/cgi-bin/data_query

10.2 List of acronyms

AR	**A**ctive **R**egion
DoW	**D**escription **o**f **W**ork
EUV	**E**xtreme **U**ltra**V**iolet (emission)
GOES	**G**eostationary **O**perational **E**nvironmental **S**atellite
ISN	**I**nternational **S**unspot **N**umber
Lyra	**L**arge **Y**ield **Ra**diometer
PI	**P**rincipal **I**nvestigator
ROB	**R**oyal **O**bservatory of **B**elgium
SIDC	**S**olar **I**nfluences **D**ata analysis **C**enter
STAFF	**S**olar **T**imelines viewer for **AFF**ects
UV	**U**ltra **V**iolet (emission)
WP	**W**ork **P**ackage