Deliverable 2.2

Online provision of solar activity proxies and solar activity data base

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NOTICE

This report has been prepared under the scope of the AFFECTS project in collaboration of the following participants of Work Package 2 "Data, Calibration, Maintenance and Instrumentation" with Lead of UoT (Chris Hall):

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Content

1 Introduction

This report describes the online provision of the AFFECTS solar activity proxies and solar activity data base according to AFFECTS DoW, WP 2.

The web application *STAFF (**S**olar **T**imelines viewer for **AFF**ects)*, developed at ROB, allows users from inside as well as outside the AFFECTS consortium to view and handle solar timeline data as well as space weather timelines in a dynamical and user-friendly way. The STAFF viewer is built upon a robust database where all timeline data reside.

The STAFF service is made available to users through the website http://www.staff.oma.be and through a link provided at the general AFFECTS website http://www.affects-fp7.eu.

STAFF's solar timeline 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 cause space weather impacts on Earth and in space.

The web interface has been designed to consult vast amounts of novel and state-of-the-art data in a user friendly way allowing exports to txt, csv, xls and image formats.

2 Solar timeline data

2.1 Availability

STAFF provides a whole set of solar activity and space weather timelines, with a focus on solar activity proxies. Timelines can either be *quicklook* data (available soon after the observation, but without the final calibrations; well-suited for space weather forecasts) or *science* data (including the final calibration, sometimes only available a few months after the observation depending on data policy and processing efforts).

The timeline data available in the current production version of STAFF are listed in Table 1.

Category	Timeline	Type
Sunspots	International Sunspot Number (Ri)	Science
Radio	10.7 cm flux	Science
EUV	Lyra Lyman Alpha	Science
	Lyra Aluminium	Science
	Lyra Herzberg	Science
	Lyra Zirkonium	Science

X-ray	GOES X-ray flux 0.1-0.8 nm	Quicklook
	GOES X-ray flux 0.05-0.4 nm	Quicklook
Solar Wind	ACE Solar Wind Density	Quicklook, Science
	ACE Solar Wind Speed	Quicklook, Science
	ACE Solar Wind Temperature	Quicklook, Science
Interplanetary Magnetic Field	ACE Bt	Quicklook, Science
	ACE Bx	Quicklook, Science
	ACE By	Quicklook, Science
	ACE Bz	Quicklook, Science
	ACE phi angle	Quicklook, Science
Particles	GOES Electrons (0.8 MeV)	Quicklook
	GOES Electrons (2.0 MeV)	Quicklook
	GOES Protons (1 MeV)	Quicklook
	GOES Protons (5 MeV)	Quicklook
	GOES Protons (10 MeV)	Quicklook
	GOES Protons (30 MeV)	Quicklook
	GOES Protons (50 MeV)	Quicklook
	GOES Protons (100 MeV)	Quicklook
Geomagnetic	Kp	Quicklook
	K Chambon-La-Forêt	Quicklook
	K Dourbes	Quicklook
	Ak Chambon-La-Forêt	Quicklook
	Ak Dourbes	Quicklook

Table 1 - Current availability of STAFF timeline data sets.

2.2 Solar timeline data in STAFF

Presenting huge amounts of data is a complex task. In order to show the data in a timely manner through a web interface, the data are downsampled to various time cadences ranging from milliseconds, centiseconds, deciseconds, seconds, minutes, 5 minutes, hours, days, Carrington rotations to years to facilitate specific user needs. Depending on the time range and dataset selected the individual downsampling rate is determined. A server module continuously imports data from various resources making sure that the latest data are available. The available archive of past timeline data has to be imported just once to complete the database. For most STAFF timelines this has already been achieved, final completion of all data sets will take place until mid 2013.

The plots produced through the web interface allow a user to view data over a large time period (e.g., years) and drill down on the interesting features of the timeline by zooming in. STAFF can be used for space weather forecasting as well as for aiding research on solar activity and space weather on longer time scales. STAFF allows the user to export datasets in various file formats, hence making the data available offline. STAFF plots can be exported as images too, so the data can be presented visually in research and outreach publications. STAFF is already being used to aid ROB's space weather forecasters and for generating plots for the STCE Newsletter.

3 The STAFF web interface

3.1 Goals

STAFF aims at handling four key problems:

1. Huge amount of data
2. Speed
3. Usability
4. Accessibility

By combining sophisticated web technologies in a server process these four goals are achieved, as described in the following sections.

3.2 Overview

STAFF is a web application written in Java (jsp). By designing it in form of a web page, the accessibility problem has been solved. Combining the java technology with advanced javascript libraries greatly improved both speed and usability. Finally a PostGreSql database was selected to handle the required amounts of data. (PostGreSql is known for its smart handling of large datasets).

3.3 Using STAFF

Using STAFF is surprisingly easy. The user first selects which timelines he likes to display, then selects the time range and finally clicks "Draw". The application takes care of all other processes.

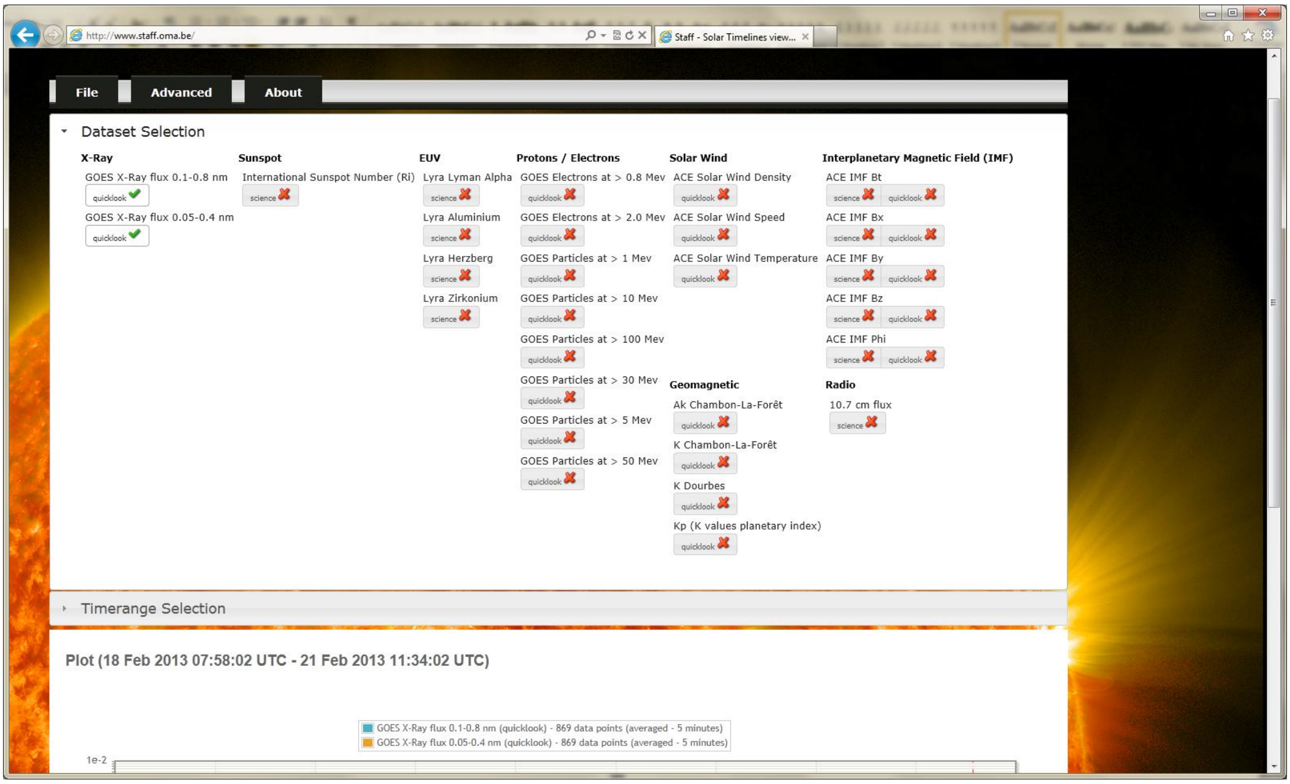

Figure 1: The user can select which timelines he likes to display.

When the plot is drawn, the legend will explain which timeline is labelled in which color, whether it uses science or quicklook data, and if the data points are raw or downsampled (and to which level they are downsampled).

The user has the following options for selecting a time range:

- Entering exact *start and end times*
- Entering a *fixed "Duration"* from the following list: "last minute", "last hour", "last 3 hours", "last 6 hours", "last 12 hours", "last 24 hours", "last 3 days", "last week", "last Carrington rotation", and "last year". When using the duration option, the plot will draw some additional time and indicates the current time by a vertical broken line.
- Navigating time is established by *using the "<<" and ">>" buttons*. This option will shift time backward or forward with exact time ranges as selected.
- *Zooming* in by mouse dragging or out by doubleclicking on the plot. The minimal zooming time range is limited to about one hour due to library constraints. Higher zoom levels can be achieved by selecting the exact start and end times.

Figure 2: Selection of the time range.

Using the menu options "File", "Advanced" and "About", additional features are available.

- The "File" menu allows the selected data to be exported as
  - Images
  - Data to txt, xls, csv format and with the option to download the raw data or the averaged data.
- The "Advanced" menu provides additional information about the plot, such as the source of the data and statistics on the available data for each of the timelines.
- The "About" menu allows the user to consult the STAFF help pages, contact the webmaster, or look at info, links or references on STAFF.

3.4 Examples

We illustrate the use of STAFF by having a closer look at the last one and a half century of solar cycles as provided by the International Sunspot Number, and by investigating space weather in November 2012.

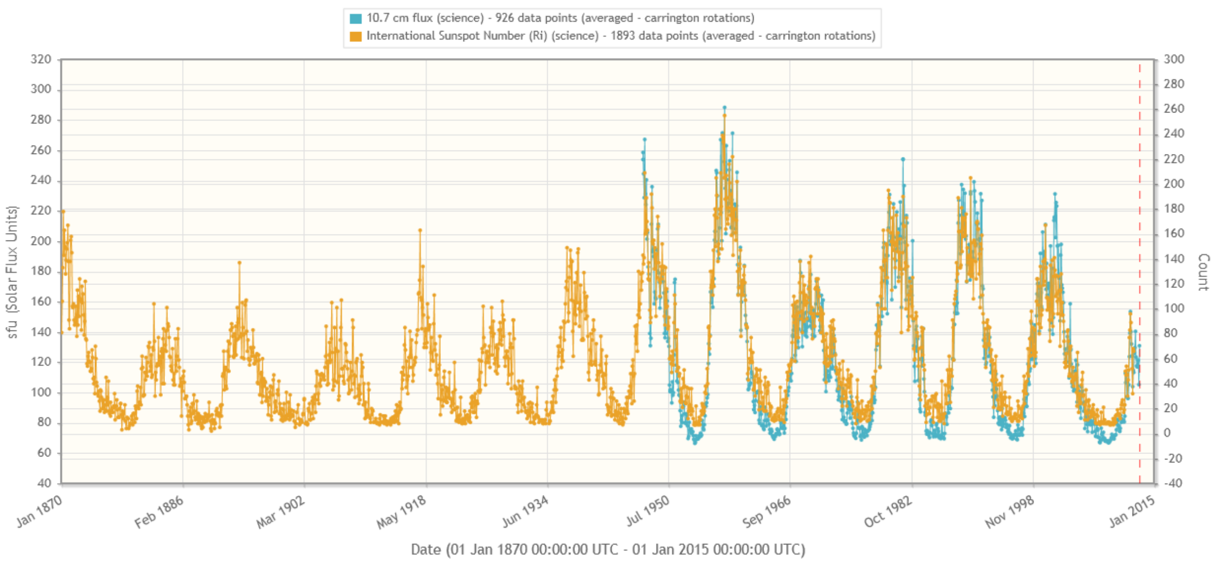

Figure 3: The International Sunspot Number from 1870 and the 10.7 cm radio flux from 1947 till present. The 11-year solar cycle is conspicuous in both timelines.

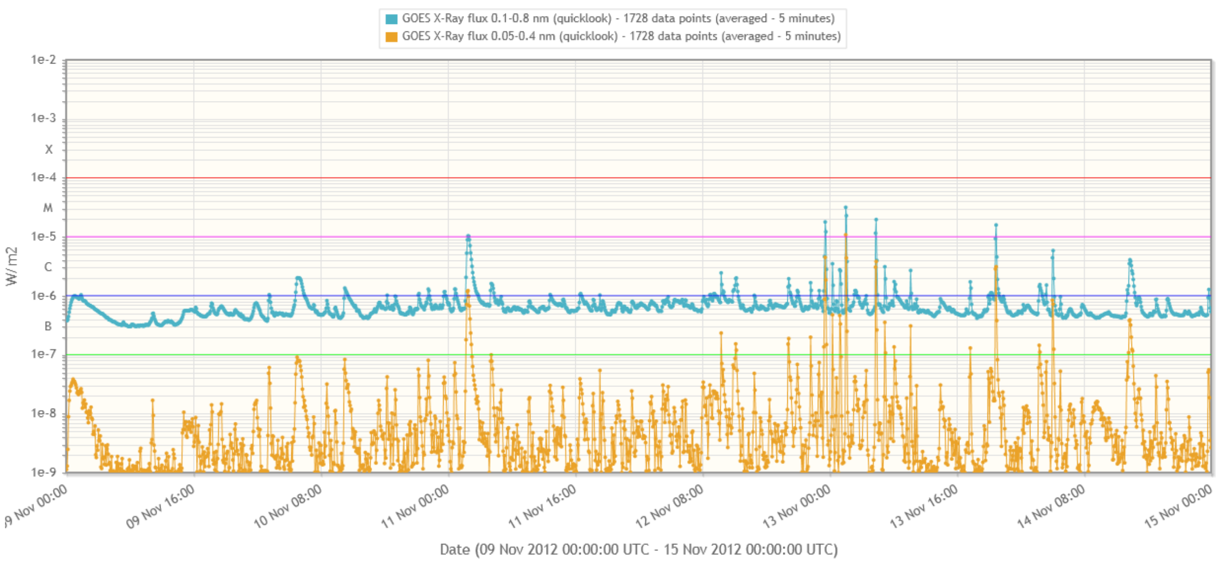

Figure 4: GOES X-Ray data from November 9 to 15, 2012 (5 minute averages). Note the four M flares produced by NOAA Active Region 11613, that clearly stand out from the rest of the GOES curve.

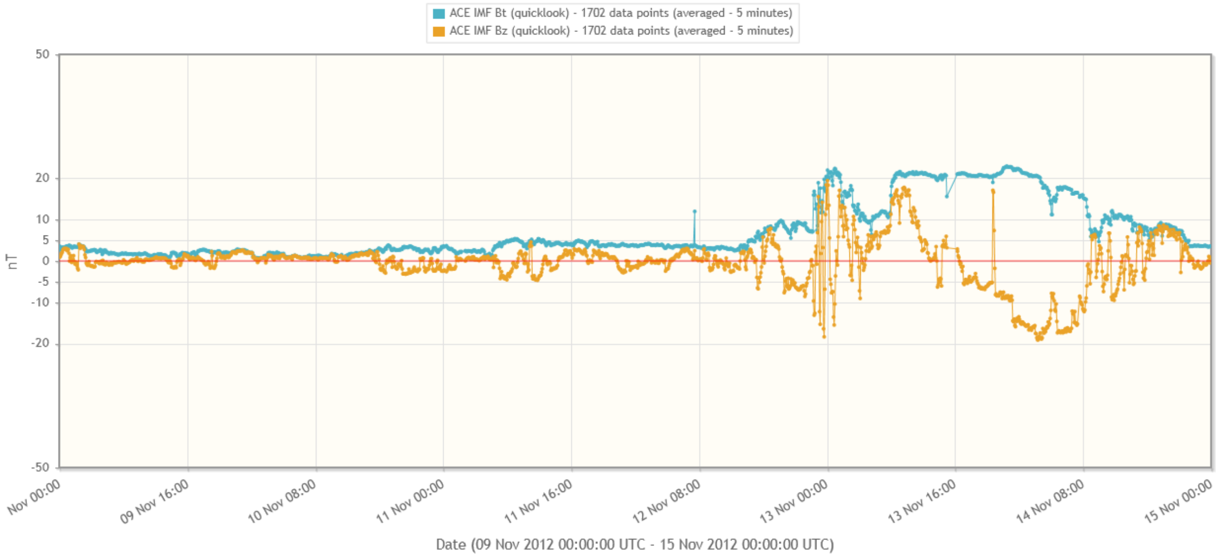

Figure 5: ACE Interplanetary Magnetic Field Bt (total vector) and Bz (north-south component) data from November 9 to 15, 2012 (5 minute averages). A shock was observed just before 0h UT on November 13. The IMF suddenly increased from 7 to about 20 nT and reached nominal values around 20h UT on November 14. Between November 13, 16 UT and November 14, 8 UT the Bz component decreased to almost -20 nT, causing geomagnetic storms of Kp = 5 to 6 (see Figure 8).

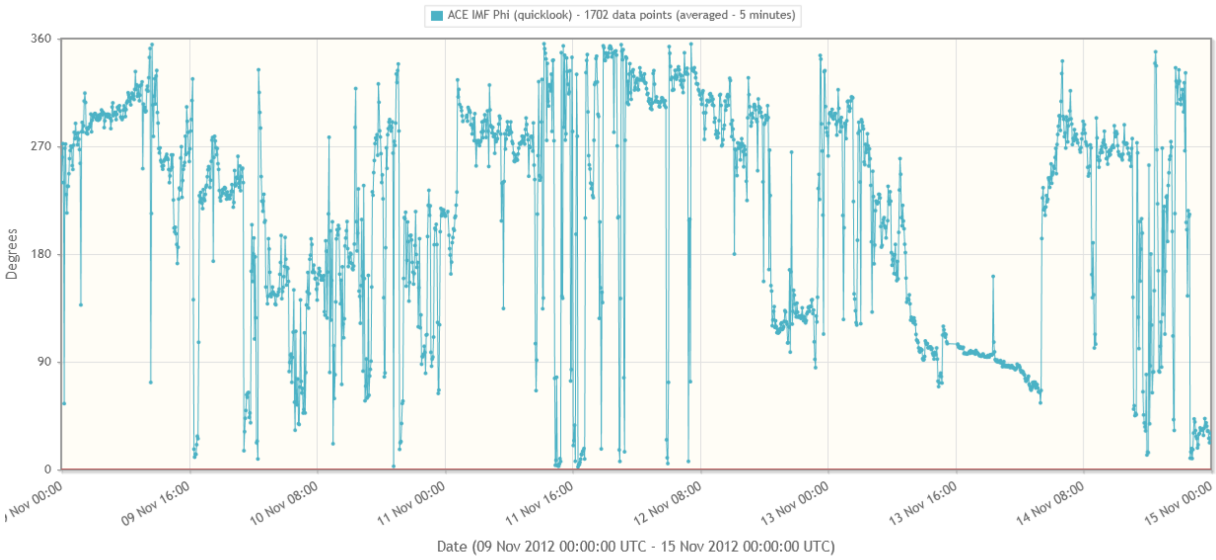

Figure 6: ACE Interplanetary Magnetic Field. The phi angle is displayed from November 9 to 15, 2012 (5 minute averages). It jumped just before 0h UT on November 13, when the solar wind shock arrived. Like Bt in Figure 5, phi was highly variable up to around 9h UT on November 13, when passage from the sheath region into a magnetic cloud occurred.

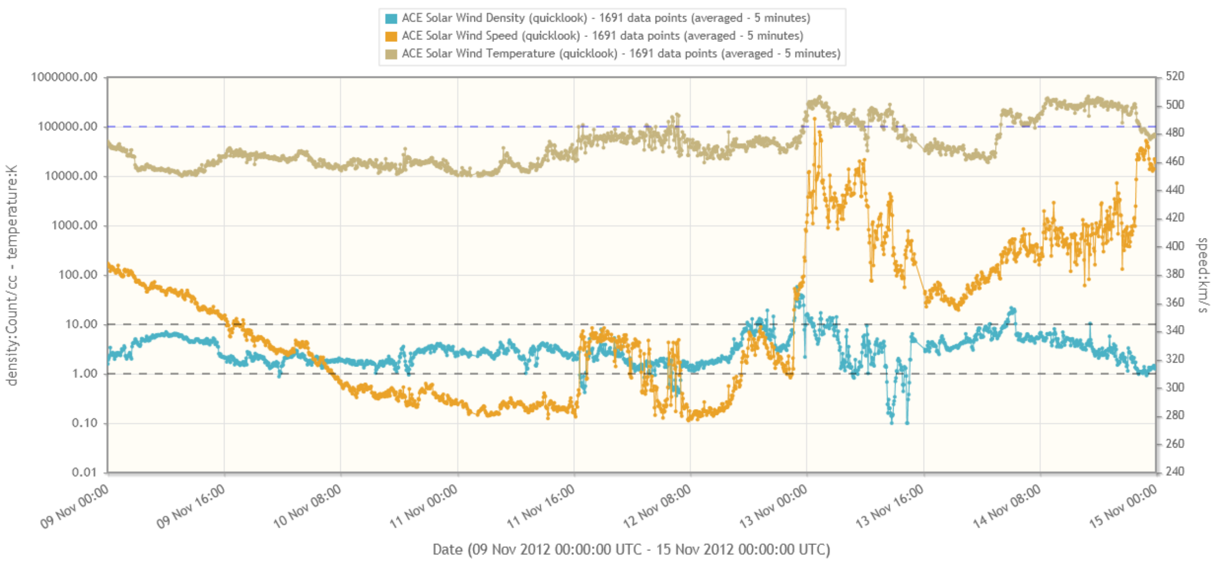

Figure 7: ACE solar wind data from November 9 to 15, 2012 (5 minute averages). A rapid rise in solar wind speed, temperature, and density is observed just before 0h UT on November 13, i.e. at times of the shock.

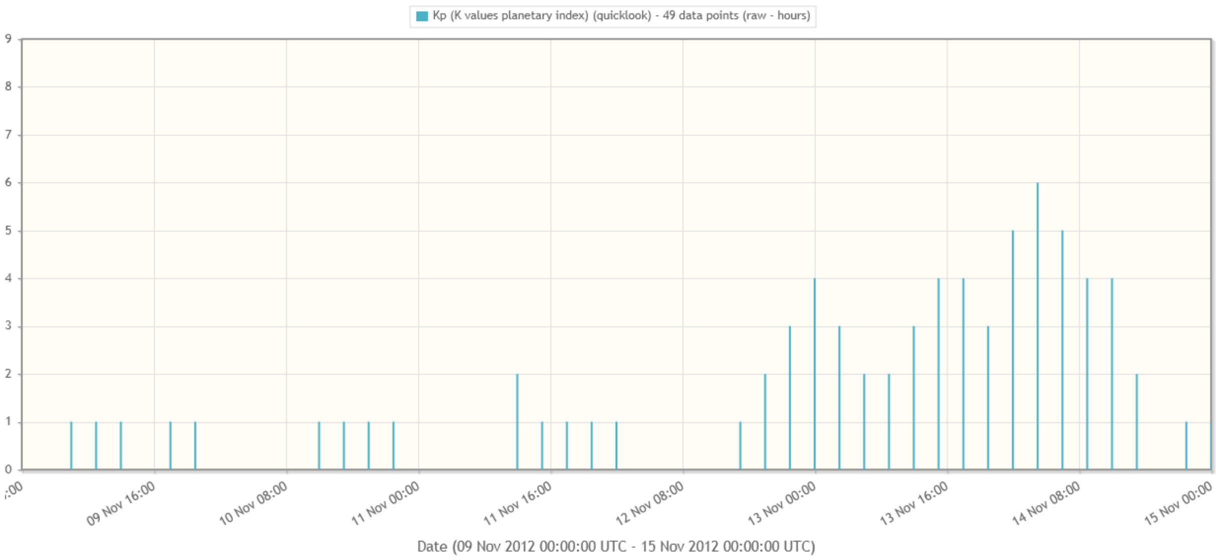

Figure 8: Geomagnetic Kp indices from November 9 to 15, 2012. The index increased when the solar wind speed was high and the z component of the Interplanetary Magnetic Field had negative values.

3.5 STAFF URL

http://www.staff.oma.be

4 STAFF design and architecture

STAFF consists of two major parts:

- The web application
- The import module

The web application reads from the database and is based on java, jquery and jqplot routines. The import module runs on the server. It reads data from several sources (e.g., FITS files, ASCII files, and other databases) and writes these data in a re-structured manner to the database. The import module runs every 5 minutes, checks its *"tasks"* and runs the necessary imports.

4.1 Choices of implementation

Java is chosen because it is a well-supported technology and the syntax closely resembles that of javascript (and therefore the chosen client-side libraries JQuery and JQPlot). It also runs on Linux systems which is the operating system of the server.

PostGreSql was chosen because it is the best free database for handling large quantities of data, which was a requirement of STAFF.

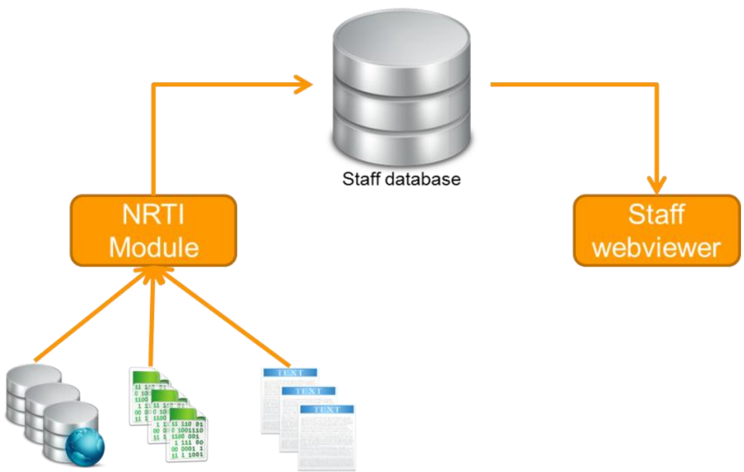

Figure 9: The STAFF architecture.

5 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 solar timeline data. It provides extensive datasets and will continue to grow in the near future. Successful implementation of the four goals (data quantity, speed, usability, accessibility) makes it very powerful and appealing to the space weather operations and research community, and also for educational purposes.

6 Perspectives and recommendations

STAFF has a lot of potential for additional features. On the short term, even more timelines will be added. The following datasets are in the immediate pipeline to be added:

Category	Timeline	Type
Solar Wind	Geotail Solar Wind Density	Science
	Geotail Solar Wind Speed	Science
	Geotail Solar Wind Temperature	Science
Solar Wind	IMP-8 Solar Wind Density	Science
	IMP-8 Solar Wind Speed	Science
	IMP-8 Solar Wind Temperature	Science
Solar Wind	WIND Solar Wind Density	Science
	WIND Solar Wind Speed	Science
	WIND Solar Wind Temperature	Science
Interplanetary Magnetic Field	Geotail Bt	Science
	Geotail Bx	Science
	Geotail By	Science
	Geotail Bz	Science
	Geotail phi angle	Science
Interplanetary Magnetic Field	IMP-8 Bt	Science
	IMP-8 Bx	Science
	IMP-8 By	Science
	IMP-8 Bz	Science
	IMP-8 phi angle	Science
Interplanetary Magnetic Field	WIND Bt	Science
	WIND Bx	Science
	WIND By	Science

	WIND Bz	Science
	WIND phi angle	Science

Additionally, intergration of imager-based data, sunspot indices (North and South hemisphere sunspot numbers, sunspot areas) and ionospheric data from the project SIMONE (Sudden Ionospheric MOnitoring NEtwork) is planned.

ROB's SPoCA algorithm (Verbeeck et al. 2011, 2013) for automatic segmentation of coronal EUV images into Active Region, Quiet Sun and Coronal Hole categories will soon run in near real time on AIA images, producing timelines of a.o. Active Region area and total EUV intensity in Active Regions. These imager-based timelines provide a novel and promising kind of proxies for solar activity. For instance, Figure 10 shows a clear correlation between the AR timelines and both the International Sunspot Number and F10.7.

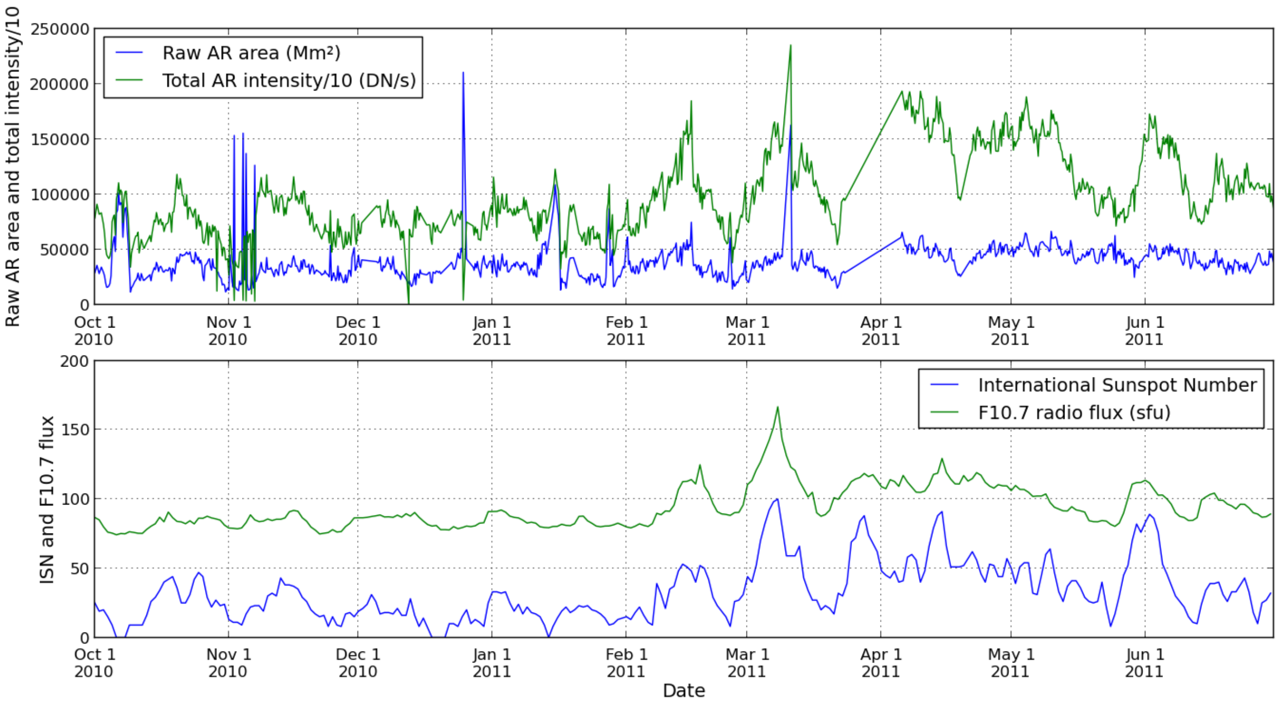

Figure 10: (a) Raw AR area and total AR intensity derived from 174 Å SWAP images, and (b) Daily International Sunspot Number and F10.7 radio flux from October 1, 2010 to June 30, 2011.

In 2013, several usability features will be added, including user settings, transformation of plots, and exports to other file formats.

In addition one can imagine the possibilities for alternative ways to access the data like web services, a guest (read-only) access to the data base or the use of the data base as data source for other software in need of timeline data. The STAFF data base is structured in such a way that it can be used for many other tasks beyond its main function as a web application.

Other appliances could potentially include automatic alerts towards the RWC, automatic alerts towards STAFF users or even a daily or weekly digest of interesting events.

Requests, suggestions and ideas can be sent to staff-viewer-as@oma.be.

7 References

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*, 1-29, 2011, doi: 10.1007/s11207-011-9859-6.

Verbeeck C., Delouille V., Mampaey B., De Visscher R., The SPoCA-suite: software for extraction, characterization, and tracking of Active Regions and Coronal Holes on EUV images, submitted to A&A, 2013.

8 Appendix

8.1 List of acronyms

ACE	**A**dvanced **C**omposition **E**xplorer
ASCII	**A**merican **S**tandard **C**ode for **I**nformation **I**nterchange
DoW	**D**escription **o**f **W**ork
EUV	**E**xtreme **U**ltra**V**iolet (emission)
GOES	**G**eostationary **O**perational **E**nvironmental **S**atellite
IMF	**I**nterplanetary **M**agnetic **F**ield
ISN	**I**nternational **S**unspot **N**umber
Lyra	**L**arge **Y**ield **Ra**diometer
MeV	**M**ega **e**lectron**V**olt
N/A	**N**ot **A**pplicable
PI	**P**rincipal **I**nvestigator
ROB	**R**oyal **O**bservatory of **B**elgium
SPoCA	**S**patial **Po**ssibilistic **C**lustering **A**lgorithm
STAFF	**S**olar **T**imelines viewer for **AFF**ects
STCE	**S**olar-**T**errestrial **C**enter of **E**xcellence
UV	**U**ltra **V**iolet (emission)
WP	**W**ork **P**ackage