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# SWENET – ESA'S PORTAL FOR SERVICES AND DATA ON SPACE WEATHER EFFECTS

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## Abstract

The Space Weather European Network (SWENET) Software Infrastructure is a web based data system providing access to a wide range of services and data related to the space environment and its effects.

The infrastructure has been developed by eta_max space and BIRA in the frame of ESA's Space Weather Pilot Project. It provides a central access point to services developed in the various pilot project activities including applications for the analysis of space weather effects on spacecrafts. SWENET also provides a wide range of data on the space environment, collecting it from various external sources and making it available through a common database. Users can search data from specific time periods and combine different sources, providing a powerful analysis tool. The results can then be either displayed in the web browser, downloaded as text files or plotted graphically. A direct FTP access also allows users to directly interface tools with the space environment database. Daily reports related to space weather conditions and solar activity are provided. The reports can either be viewed as a "Message of the Day" or received by email. Past reports can also be browsed though the web interface. Additionally, an automatic service sends data sets and alerts for the most important space weather indices via email.

This paper provides an overview of the capabilities of the SWENET infrastructure as a space environment information centre, highlighting the most important services and functions.

## Introduction

The main task of the SWENET software infrastructure is to provide users with the data and service resources developed in the Service Development Activities of the Space weather Pilot Project. The software includes a database incorporating the space weather data required by the SDA applications themselves and also the data provided by the SDAs for the SWENET users. The infrastructure also serves as a portal for the SDA applications, providing the user with a central access point to the information and tools developed in the course of the pilot project.

The SWENET infrastructure comprises the following main components:

- A database containing:
  - Space weather data from external resources
  - Data generated by the SDAs in the pilot project
- Tools to access, operate and analyse these data providing:
  - the capability to browse the data through a step-by step web interface
  - ability to combine data from different sources
  - FTP mirror of the unprocessed data
  - overview of the latest space weather indices
  - overview of the latest plots from SEC
  - automated data dissemination via email
- A portal for accessing the services and data generated in SWENET providing:
  - the possibility to search for services and data
  - access to the database including provision of large volumes of space weather data

collected since the beginning of SWENET operations
- detailed descriptions of the SDAs and the services developed
- an overview of the latest data from SDAs integrated in SWENET

The SDA applications were developed independently from each other and thus, do not address common requirements. Their level of integration into the infrastructure varies accordingly for each SDA. The infrastructure therefore includes a series of services (e.g. user login, data download) which can be used by the SDA depending on its necessities.

## The SWENET web portal

An overview of the SWENET Portal pages is given in Figure 1. Some of the sections of the portal (marked with *) require the user to login to access them. The following sections describe the most relevant functionalities of the Portal.

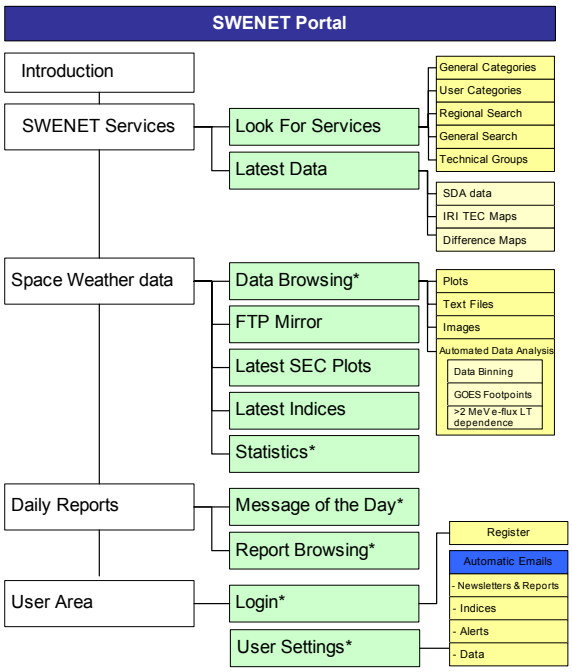


Figure 1 SWENET Site Map

### Look for Space Weather Services

One of the main objectives of the SWENET portal is to provide a centralised access to the results and services of the Service Development Activities (SDA) of the Space Weather Pilot Project. The SWENET Service Portal provides a series of different "access paths" to navigate the services and data provided by the SDAs:

- General Categories
- User Categories
- Regional Search
- General Search
- Technical Group Lists

### SDA descriptions

A standard description is provided for each SDA. The description also includes a link to the project website. The right-hand side menu offers links to additional information related to the SDA, such as latest data or graphics, link to the website, keywords, etc.

### Latest Data

The latest data option provides an overview of the most recent data and plots generated by the SDA services providing data to the common SWENET infrastructure. A preview and a short description of the data are presented for each SDA. A larger view of the graphics and additional information can be obtained by clicking on the preview graphics. It should be noted that this list is only a fraction of the data provided in the SDAs. The complete data can be accessed through the data browsing (see below).

### Space Weather Data

The section "Space Weather Data" provides access to the external data sources [3] and public data uploaded by the SDAs. It is divided into four sub-sections:

- **Data Browsing** providing access to all contents of the database through a flexible web interface. Data can be retrieved as plots, text or images and it is possible to select different time periods and to combine data from different sources. Users are required to log–in for accessing this section of the database.
- **FTP Mirror.** The latest data files from NOAA/SEC and all other data sources that provide their data in file form can be downloaded via anonymous FTP. The data can be accessed via any FTP client or browser with FTP capabilities. The data available is the same as the publicly available data at the NOAA/SEC public ftp. Additionally, other public ftps of interest for the space weather community are also replicated.
- **Latest SEC Plots** provides a summary of the latest plots of space weather data as provided by NOAA/SEC. Further plots can be found through the data browsing option.
- **Latest Indices** section containing a selection of space weather data contained in the SWENET database and provided by both the SDAs and NOAA/SEC. The data is presented

as displaying the data for the last seven days available in the database.

**Automated Data Analysis**

The data browsing section also includes the automated data analysis functionalities. These include:

- Data Binning over numerical data
- GOES Footpoints
- GOES >2 MeV e- flux LT dependence

For the automated data analysis several programs have been implemented which allow the user of the SWENET portal to generate TEC-maps based on the IRI2001 model, for comparison with e.g. TEC-maps generated by the SWIPPA SDA.

**Reports and data dissemination via email**

The report section of the SWENET includes reports and data provided by the SDAs on regular basis. It also provides the capability to search for previous reports stored in the SWENET database.

The data dissemination functionalities can distribute four data types via email:

- **Newsletter** and reports
- Summary emails
- Alerts
- Custom Data

The user can configure these functions in the user settings area depending on his interest and necessities.

**External data resources**

The following list provides an overview of the space weather data imported from sources external to SWENET (i.e. non SDAs) into the SWENET database as listed in [3]. This list is not exhaustive as additional resources may be added in the future depending on the needs of the users.

- NOAA/SEC
- SOHO
- NGDC
- Halo CME mails - ISES
- Space Weather Indices – ISES

## Data provided by the SDAs

Those SDAs actively providing data for incorporation into the SWENET server are listed below. At the time of writing of this report, the integration of some SDAs was still pending and is to be completed as soon as the data becomes available.

| SDA | Data provided to SWENET |
|---|---|
| AurorasNow (FMI) | Delivers hourly text files and plots of the changes in the horizontal magnetic field and the probabilities to observe auroras. |
| BINCASTS (BGS) | Nowcasts and forecasts of geomagnetic indices. |
| DIFS (BAe Systems) | The DIFS SDA uploads 4 report types daily of HF ad satellite communications quality (highlats, lowlats, satcom at 1200h, midlats at 1200h and 2300h). |
| GAFS (DMI) | GAFS contributes geomagnetic data to be stored in the SWENET database updated every hour. |
| GEISHA (ONERA) | The GEISHA SDA provides two daily updated dynamic plots for electron and proton fluxes in GEO. |
| GIFINT (IFSI) | GIFINT provides Dst forecast data and two plots per hour (foF2 and M3000) for the Rome ionosonde. |
| Ionosfera (Amsat-I) | Ionosfera provides services aiming at predicting and analysing radio-propagation through the ionosphere for the Radio-amateur community. |
| Scintillation Quickmaps (CLS) | Provides the scintillation index deduced from the GPS signal at a large number of stations. |
| SIDC (ROB/BIRA) | The SIDC SDA provides 7 plain text reports, a Space Weather status bar, monthly and monthly smoothed SSN. |
| SWIPPA (DLR) | Contributes TEC-Maps over Europe, updated every 5m. |
| TSRS (INAF-Trieste) | Provides Solar Radio Indices data derived by the Trieste Solar Radio System. |
| ISGI (CETP) | Integration of data on geomagnetic indices is in progress. |

Table 1 Data provided to SWENET by the SDAs

For SDAs with a minimum integration, SWENET provides a description of the available products and a link to their website.

## Advantages to the Users

The SWENET software infrastructure offers a series of advantages to the users, especially when accessing space weather data. Even if much of the data is accessible through other locations, the SWENET interface allows a user-friendly browsing through all combined data simultaneously. Of special interest is the capability to compare data from different sources, either by downloading the data as correlated time-series or by plotting with the built in tools provided on the web interface as seen in Figure 2.

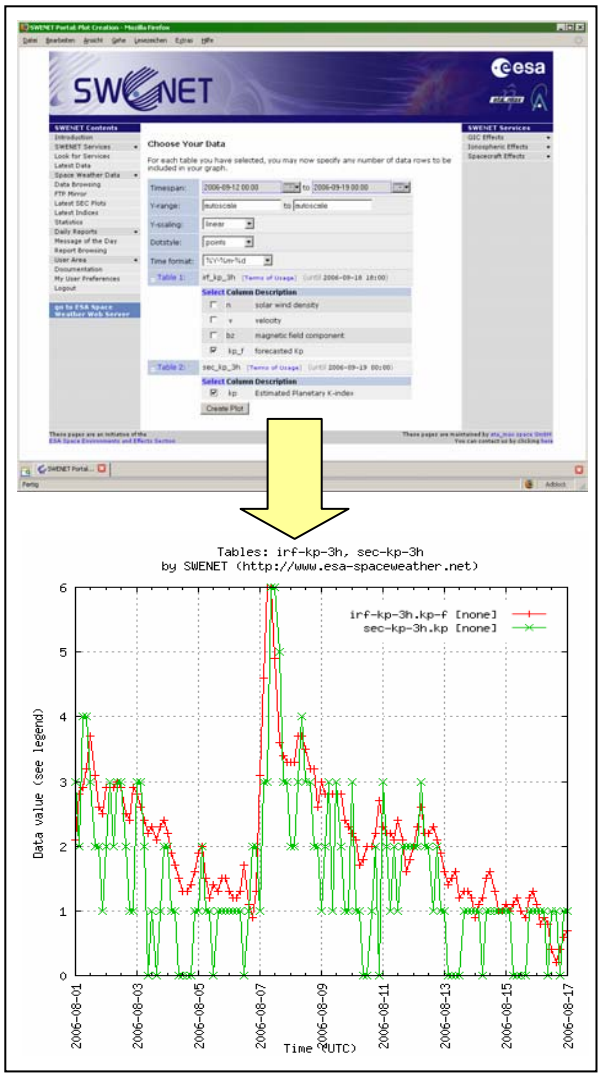


Figure 2 Plotting of datasets from disparate sources: Estimated Planetary K-index generated by the Swedish Institute of Space Physics (red) and by NOAA's Space Environment Center (green).

Another feature is the overview of the latest space weather indices, and the possibility to receive it daily via email. This overview contains indices provided by both, the SDAs and NOAA/SEC. The data is presented as plots displaying the data for the last seven days (Figure 3).

The following plots are included:

- $K_p$_f Nowcasted and 3-day forecasted Kp, courtesy of IRF
- $D_{st}$ Equatorial Dst [nT], courtesy of the University of Kyoto and GIFINT
- $F_{10.7}$ Predicted 10.7cm radio flux, courtesy of NOAA/SEC and BINCAST
- $A_p$ Predicted planetary A index, courtesy of NOAA/SEC and BINCAST
- $K_p$ Predicted largest Kp index, courtesy of NOAA/SEC

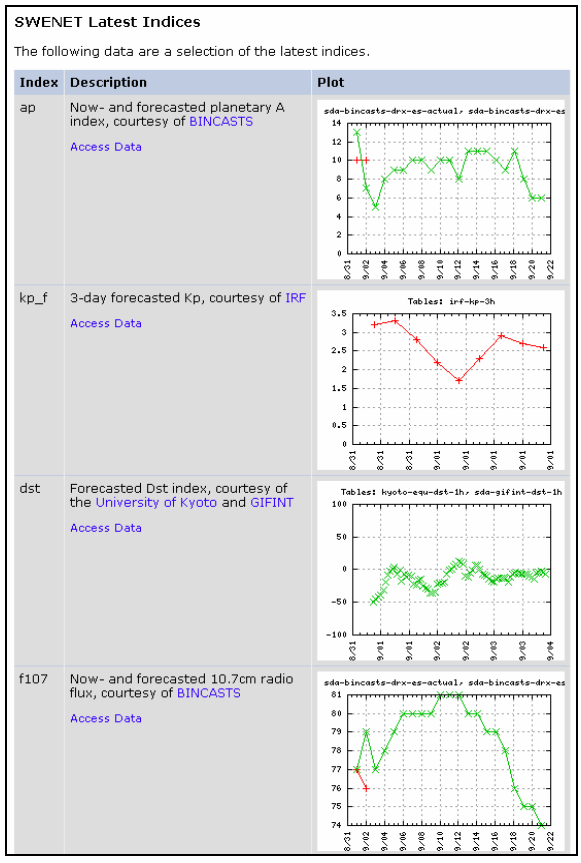


Figure 3 SWENET provides an overview of current space weather indices

The user can also select to receive alerts via email when a given threshold is trespassed. The following table shows the indices/level alerts available, their default value, the characteristic of the default value and the reference for the default value:

| Index/level | default Value | Charac-teristic | Reference |
|---|---|---|---|
| Kp | 7 | Strong Geo-magnetic storm | www.sec.noaa.gov/NOAAscales/ |
| Ap | 50 | Major Geo-magnetic Storm | sidc.oma.be/edu/classification.html |
| Dst | -50 nT | storm-level disturbance | www.lund.irf.se/HeliosHome/spacew9.html |
| GOES flux level of ≥10 MeV particles | 10^3 | Strong Solar Radiation Storm | www.sec.noaa.gov/NOAAscales/ |
| GOES 5-minute Solar X-ray Flux | 10^-4 | Strong Radio Black-out | www.sec.noaa.gov/NOAAscales/ |

Table 2 User customised alerts

## Tool Development and Technology

In order to cope with all requirements resulting for a portal capable of integrating very disparate sources, a very flexible approach was implemented. The three-tier design used is shown in Figure 4. It contains the following components:

- **A Database Tier** formed by two databases:
  - The space weather database contains numerical and binary data (e.g. images)
  - The application/user database contains information on how to run the tools through the application tier and the user settings.
- **An Application Tier**:
  - Provides the interfaces to tools and services. This includes both internal tools (running in the portal server) and external tools (e.g. web sites and on-line applications)
- **An Interface Tier** consisting of two component:
  - The external resource data interface, responsible for automatically extracting data from external resources
  - The user interface, providing access to the data and resources through the web.

The SWENET software infrastructure was developed using the standard V-model according to the ECSS-E40B standard. Major constraints were high network traffic (around 30 GB per month of data files to be replicated), the fine resolution of the data (down to 3 seconds) and the resulting large database (currently approximately 20 GB).

The SWENET portal and surrounding services run on a dedicated Debian Linux server with a conservative access policy. The web interface (preferredly via HTTPS) is the main access possibility; the SDAs can additionally use traditional FTP and SSL encrypted direct database access.

The database management system is a PostgreSQL 8 database which was chosen for both its scalability and ease of maintenance. It has been upgraded from PostgreSQL 7.4 in the course of the study. The data contained in it is automatically backed up on a weekly schedule. An archiving has been estimated as unnecessary because the growth in hardisk sizes on the market is faster than the data growth rate; thus, every 2 years the HDDs must be replaced.

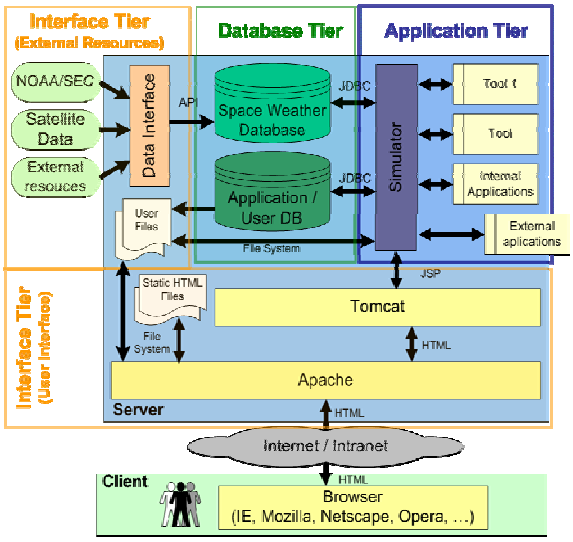


Figure 4 Overview of SWENET's three-tier design

The SWENET portal is realised as a Java Servlet application, which contains both presentation and business logic, and uses the database as persistence layer. The main challenge for the portal was the user friendly presentation of a vast number of data sets, and the various presentation and dissemination methods for the data; all these have been implemented in a generic way such that it allows introducing additional data at zero effort.

Importers for both data files and for a proprietary XML interface to NOAA/SEC servers have been realised as Java applications. Advanced data analysis tools have been developed as database extensions; their results are integrated into the SWENET portal.

The SWENET server integrates all these components as well as a maintenance and monitoring subsystem into a complex but streamlined server architecture.

## Future perspectives

Various ideas have been considered for future developments of the software infrastructure resulting from surveys and meetings, aiming at increasing the usability of SWENET and at broadening its range of capabilities. These r can be summarised as follows:

- Continued maintenance and hosting of SWENET over a longer period of time
- Integrate upcoming SDAs and new data sources
- Increase the range of data sources and improve the automated visualisation and overview capabilities.
- Improve SWENET services with new features like:
  - Improved graphic/plotting tools, including 3D plots
  - Provide access to the database via web service (SOAP)
  - Implement SIDC routines for harmonisation of index nowcast & forecast
  - Provide of a real time data interface

## Summary and Conclusions

The main objective of the SWENET software infrastructure developed in the frame of ESA's Space Weather Pilot Project is the provision of a Central Resource and Information Centre for space weather users and their customers. The SWENET Software Infrastructure is a web based, user friendly resource centre providing a common information and service framework for SWENET members and external visitors. In addition to the software development, ESA's existing Space Weather website was updated and maintained.

The main task of the SWENET software infrastructure developed in the project is to provide users with the data and service resources developed in the Service Development Activities of the Space Weather Pilot Project. The software includes a database incorporating space weather data required by the SDA applications and other SWENET users. It also includes data provided by the SDAs for the SWENET users.
The infrastructure also provides a central access point to the SDA applications including information and tools developed in the course of the pilot project. The SWENET Portal is accessed via a common web browser, enabling vast numbers of people to use it from anywhere in the world.
The SWENET Portal is part of ESA's space weather server and provides access to space weather data from different sources as well as data generated by the SWENET members themselves
The SWENET Software Infrastructure was developed by a team consisting of eta_max space (Germany) as prime contractor, and the Belgian Institute for Space Aeronomy BIRA (Belgium) as sub-contractor.

## References


[1] *Beltrami Karlezi, P. K. Ruhl* The Space Weather Network Software Infrastructure, 2nd European Space Weather Week 14th-18thNovember 2005, ESTEC, Noordwijk, The Netherlands

[2] P. Beltrami, SWENET Software Infrastructure Requirements Baseline, ref. R047rep18-062rep, 7th September 2004, eta_max space, Germany

[3] Stegen, K., Demol, Jo, SWENET External Data Resources, R047rep022, eta_max space/BIRA.

[4] P. Beltrami, Space Weather Pilot Project Coordination and Software Infrastructure - New Service Infrastructure Report, ref. R047-062rep, 14th March 2004, eta_max space, Germany

[5] P. Beltrami, K. Stegen, K. Ruhl, Final Report of the study "Space Weather Pilot Project Coordination and Software Infrastructure Development", R047-rep65, eta_max space, 15th May 2006.