NEW FEATURES OF ESA'S SPACE ENVIRONMENT INFORMATION SYSTEM (SPENVIS)

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ABSTRACT

A crucial part of a space weather programme is providing data to users for evaluating hazardous space weather conditions: this means data in easily useable form and related to effects. The ESA SPace ENVironment Information System (SPENVIS) provides standardized access to models of the environment and its effects through a user-friendly WWW interface (`http://www.spenvis.oma.be`). The interface includes parameter input with extensive defaulting, definition of user environments, streamlined production of results (both in graphical and textual form), background information, and on-line help. The models include those for radiation belts, solar particle events, cosmic rays, plasmas, meteoroids and debris, atmosphere, and magnetic field. SPENVIS Has been operational for two years, with a continuously expanding international user community (more than two hundred registered users). The following new developments have recently started:

1. WWW interface and visualisation tool for satellite data bases;
2. interface to the ECSS Standard on Space Environment;
3. simple three-dimensional shielding code;
4. improvement of the WWW interface, including a dedicated Java client and server;
5. addition of models.

Of particular interest to the space weather community is the data base interface, which features time series plots of selected spacecraft measured quantities, access to a comprehensive data base of geomagnetic and solar indices, and a limited download capability. This allows data from ESA studies and others to be made readily available to space weather users, as well as space weather tool developers.

1. INTRODUCTION

The planning of space missions requires an analysis of the space environment and its impact on space systems. The space environment includes the following hazardous environments:

- radiation environment due to the radiation belts, solar particles, and cosmic rays;
- the plasma environments of the ionosphere and geomagnetic substorms;
- neutral gaseous environments, including atmospheric atomic oxygen;
- micro-meteoroids and space debris;
- magnetic fields;
- solar emissions.

Empirical or quasi-empirical models of these hazardous environments have been developed by different organizations, often independently of one another. As a consequence, the availability of existing models is not always known to potential users. In addition, the issue of updating models and acquiring up-to-date versions is not straightforward.

Several agencies have undertaken the development of integrated systems for analysis of the space environment that are accessible via public computer networks. Examples are the EnviroNET system developed by Goddard Space Flight Center (at `http://envnet.gsfc.nasa.gov`), and the Naval Research Laboratory CREME-96 site (`http://crsp3.nrl.navy.mil/creme96/`). In general, existing systems do not achieve the full scope of environmental tools or are not fully integrated (with orbit generators etc.). The SPace ENVironment Information System (SPENVIS) developed for ESA/ESTEC provides easy access to most of the recent models of the hazardous space environment, in combination with an orbit generator, via an integrated user-friendly World-Wide Web (WWW) interface. The interface includes parameter input with extensive defaulting, definition of user environments, streamlined production of results (both in graphical and textual form), background information and online help. The tools are harmonised with the European standard on the space environment, currently under parallel development.

2. DESCRIPTION OF SPENVIS

The SPENVIS system makes full use of the WWW facilities through the following features:

- access via computer networks to a centralized system;
- easy-to-use input facilities making extensive use of default values for the various input parameters, hierarchical structuring of input, and input validation;
- identification of users allowing for the creation of personalized environments, in which previous results and inputs are retained, even when leaving the system;

- automatic and/or user-specified generation of output, both plots and tables, as in-line images or downloadable graphical formats;
- extensive on-line help and links to in-depth documentation.

The URL of the SPENVIS system installed at BIRA/IASB is `http://www.spenvis.oma.be`.

At the heart of SPENVIS is the project concept. A project is defined as the collective input to and output from the SPENVIS system for a series of related runs. This approach ensures that all the inputs and the outputs of a run are conserved, so that an analysis can be performed over more than one session.

SPENVIS Provides a set of help pages with information on the various models and their implementation in SPENVIS. To each model page in the system there corresponds a help page. Navigation through the help pages is further provided by a menu bar at the top of each page.

3. SPENVIS MODELS

Most of the models implemented in SPENVIS require as input a set of points on a spacecraft trajectory or a user-defined set of geographic points. These sets of points are produced by two tools: the orbit generator and the coordinate grid generator. When running the orbit or grid generator, all outputs previously obtained with models that use the respective coordinate tool, are deleted. This is to ensure consistency between results, and to avoid errors in the plotting routines that produce the graphical output. The input parameters for the models are not deleted, so that they can be run again in the same way. The models in SPENVIS have been organised in packages, which are described in the sections below.

3.1. Radiation analysis

Trapped proton and electron fluxes are calculated over a spacecraft trajectory with the NASA AP-8 and AE-8 models (Ref. 1) and accumulated into fluences. Solar proton fluences can be predicted as well with the King (Ref. 2), JPL-85 (Ref. 3), and JPL-91 (Ref. 4) models. The resulting fluences serve as input for the calculation of radiation effects: ionising doses in different detector materials: SHIELDOSE and SHIELDOSE-2 (Ref. 5); damage-equivalent fluences for Si and GaAs solar cell degradation studies: EQFRUX and EQFRUXGA (Ref. 6); Cosmic Ray Effects on Micro-Electronics: CREME (Ref. 7). The trapped particle models can also be run on a coordinate grid.

3.2. Magnetic field

The most commonly used internal and external magnetic field models have been implemented in SPENVIS. The magnetic field models can be evaluated over a spacecraft trajectory or a coordinate grid. The output from the SPENVIS implementation of the models contains the (B, L) coordinates (Ref. 8), the invariant coordinates (R, Λ), magnetic longitude and latitude, the magnetic field vector components, and the location of the footpoints. In addition, field line traces are plotted, and three-dimensional plots of drift shells are available. The magnetic field models and related utilities have been implemented using the UNILIB subroutine library developed by BIRA/IASB (available at `http://magnet.oma.be/local/unilib/home.htm`).

3.3. Atmosphere and ionosphere

The following neutral atmosphere and ionosphere models have been implemented in SPENVIS: MSISE-90 (Ref. 9); MET (Ref. 10); DTM 78 (Ref. 11); HWM 93 (Ref. 12); IRI-90 (Ref. 13). These models can be evaluated over a grid of points to produce world maps of densities or temperatures, over a coordinate range to produce density profiles, or over a range of one of the model parameters for one geographic point. In addition, number densities can be calculated along a spacecraft trajectory, and particle fluxes and fluences on an oriented surface can be determined.

3.4. Spacecraft charging

Three models of the ESA ESPIRE suite (Ref. 14) have been implemented in SPENVIS to: provide the principal parameters that characterise the low Earth and polar orbital environments; compute the equilibrium potential of a surface using a simple model of differential charging; and estimate the current collection and power loss experienced by a solar array in the low Earth orbit plasma environment. In addition, the GORIZONT/ADIPE and CRRES/LEPA data bases (Ref. 15) of ion and electron fluxes measured during charging events are made available as a series of plots of the particle spectra and tables of the fit parameters of double Maxwellians.

3.5. Meteoroids and debris

The meteoroid model of Grün et al. (Ref. 16) has been implemented. A list of meteor streams is available. The debris models used in SPENVIS are NASA-90 and NASA-96 (Ref. 17). Wall damage models are available as well.

4. NEW DEVELOPMENTS

In an extension to the original contract, the following enhancements to SPENVIS have started:

1. implementation of additional models, including: the trapped radiation models CRRESPRO (Ref. 18) and CRESSELE (Ref. 19); a model for equivalent 10 MeV fluences in CCDs; and the ESA internal charging model DICTAT;
2. development of a dedicated Java-based client and server which allows more flexible interactive inputs, more efficient use of the network bandwith, and installation as a stand-alone package;
3. access to archived satellite data sets, including a full data set of solar and geomagnetic indices, with extensive data base queries and plotting facilities (see Sect. 4.1).
4. interface to the ECSS-10-04 Standard on Space Environment;
5. development of a tool for modelling simple satellite geometries and deriving shielding distributions.

4.1. Data base interface

A number of archived and processed data bases of in-flight measurements of the space environment have been rearranged into the Common Data Format (CDF, Ref. 20), applying IACG/ISTP and CLUSTER guidelines. Figure 1 shows the data bases that will be implemented in SPENVIS.

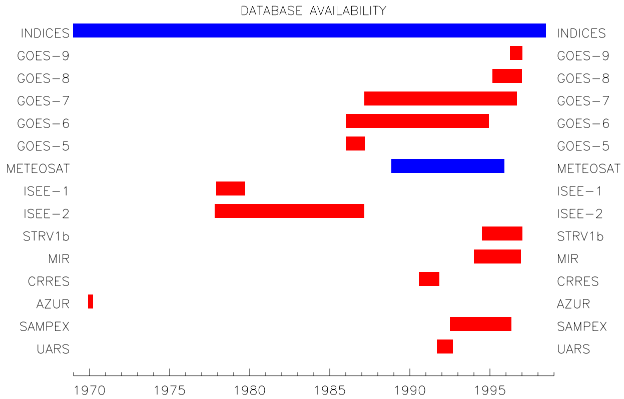

Figure 1. *Overview of the data bases implemented in SPENVIS*

The data bases consist of time series data of energetic particle counts, magnetic field measurements, positional information and derived quantities. Queries of these data sets can be combined with geomagnetic and solar wind data, providing a more comprehensive view of the physical phenomena which are occurring. These queries can be restricted to parameter ranges of interest, e.g. $K_{\rm p} > 4$. Extensive plotting facilities are provided for presenting the requested data. Data averages can be downloaded as ASCII files. A sample plot of Meteosat/SEM-2 data produced with the data base interface is shown in Figure 2.

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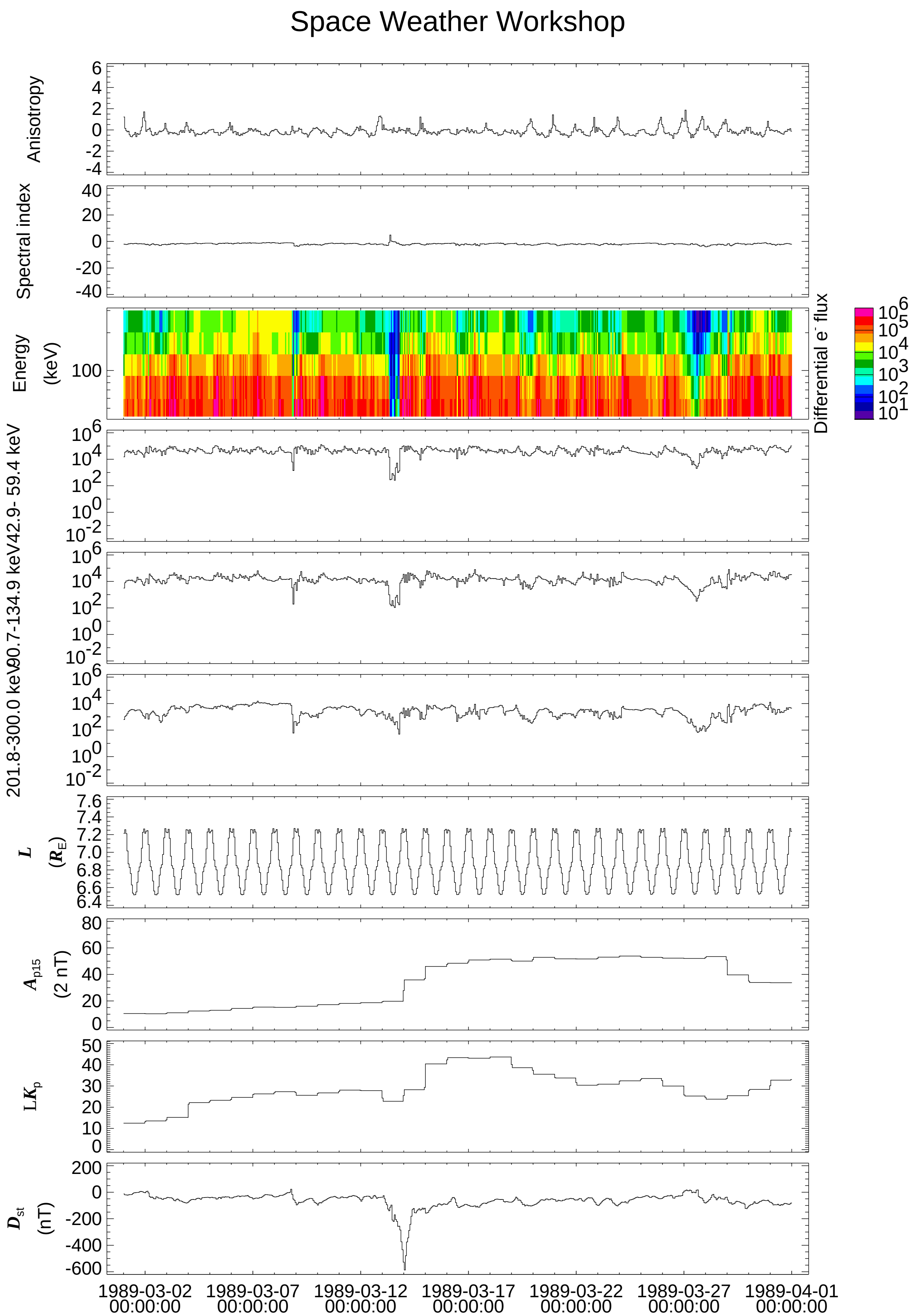

Figure 2. *Sample output of the data base interface*