Space Radiation Effects Nowcast (SREN) platform

Executive Summary Report

Version 1

Issue 1

Administration page

Customer Information	
Document reference	SREN ESR
Project title	Space Radiation Effects Nowcast (SREN) platform
Customer Organisation	ESA – European Space Technology Centre SPARC G.P.
Customer contact	Hugh Evans, ESA/ESTEC TEC-EES Dr Ingmar Sandberg, SPARC G.P.
Contract number	ESA Contract 4000127269/19/NL/BJ/va
Project document reference	FR
Milestone number	MS3
Date due	July 2020

Author list	**E-mail**
Dr. Ingmar Sandberg	sandberg@sparc.gr
Constantinos Papadimitriou	constantinos@sparc.gr

Record of changes		
Issue	Date	Detail of Changes
1.0	10/07/2020	First Version

TABLE OF CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS

GEO	Geostationary Orbit
GUI	Graphical User Interface
EAM	Environment Analysis Module
EDRS-C	European Data Relay Satellite - C
ESA	European Space Agency
ESTEC	European Space Research and Technology Centre
MPS	Magnetospheric Particle Sensor
PHP	Hypertext Preprocessor
HEO	Highly Elliptic Orbit
HTTPS	Hypertext Transfer Protocol Secure
JPL	Jet Propulsion Laboratory
LEO	Low Earth Orbit
LET	Linear Energy Transfer
MAGEIS	Magnetic Electron Ion Spectrometer
MEO	Medium Earth Orbit
MySQL	My Structured Query Language
MVP	Minimum Viable Product
NGRM	Next Generation Radiation Monitor
NIEL	non-ionizing energy loss
NICT	National Institute of Information and Communication Technology
ODI	Open Data Interface
PAM	Pre-analysis module
SEDA	Space Environment Data Acquisition
SEP	Solar Energetic Particle
SREM	Standard Radiation Environment Monitor
SREN	Space Radiation Effects Nowcast
SWE	Space Weather
REM	Radiation Effects Module
URD	User Requirements Document
UQ	User Questionnaire

PREFACE

This Executive Summary Report summarizes work performed during the Space Radiation Effects Nowcast (SREN) platform project under the ESA contract No. 4000127269/19/NL/BJ/va. The work was carried out by Space Applications & Research Consultancy (SPARC) Athens, Greece.

The team members of SREN-p project are:

SPARC

I. Sandberg (Project Manager), C. Papadimitriou, Z. Iqbal and S. Aminalragia-Giamini.

ACKNOWLEDGMENTS

SREN-p team acknowledges the contribution and the feedback received by Dave Pitchford (SES) for the analysis of the Users Questionnaire and the preparation of URD. SREN team acknowledges the contribution and the feedback received by Athina Varotsou (TRAD), Henning Wulf (OHB System AG) and Dave Pitchford (SES), during the preparation of the User Questionnaire. SREN-p team acknowledges the contribution of Wojtek Hadjas (PSI) for the provision of NGRM response functions.

EXECUTIVE SUMMARY REPORT

Space environment includes severe radiation and plasma storms - driven by solar activity and its effect on the Earth's magnetosphere – affecting satellite systems. For the real-time and the post analysis of the space environment effects on satellite components, a series of actions is required each time by satellite operators and analysts in order to access and combine the required but heterogenous resources, identify critical particle flux enhancements using reliable measurements and couple them with state of the art radiation environment and effect tools. The objective of the project was the design, the initial development and the demonstration of the Space Radiation Effects Nowcast (SREN) platform.

A User Questionnaire was prepared and distributed to collect relevant input from potential end users of the SREN system. The questionnaire responses were analyzed in order to prioritize the radiation environment and effects tools to be addressed into SREN. It was concluded that each of the proposed Nowcast / Forecast & Post Event Analysis products that were presented to the potential User Community are seen to be of value and should be developed.

For the needs of the present de-risking activity it was decided by the SREN team to introduce a Solar Array Degradation radiation effect tool. In the fully fledged SREN development, it is planned to introduce all the products proposed in the UQ.

The design and the development of the SREN system and its modules were implemented. SREN modules are defined as the software components of SREN-p system that employ the real-time data analysis, radiation environment analysis and the radiation effects analysis. SREN modules are classified into three groups:

- The data pre-analysis module (PAM): responsible for data pre-processing, data cleaning, data flagging and for the raw counts to fluxes calculations.

- The environment analysis module (EAM): responsible for the on-the-fly analysis of energetic particle fluxes, the detection/analysis of events of interest. This module will include submodules to extract and re-process processed-datasets (i.e. fluxes) to detect time periods of enhanced activity. The outputs of the module will include alerts, flags and differential/integral particle flux/fluence dedicated products.

- The radiation effects module (REM): responsible for the calculation of the variables that address the radiation effects on spacecraft sensitive components. The submodules of REM will include a library of radiation effect models.

SREN ingests historical and real time space environment data collected from radiation monitors, runs software to parse the data and allows secure access to the results via a web-based user interface. SREN designed to incorporate the following real time data:

- INTEGRAL/IREM,
- HIMAWARI-8/SEDA,
- GOES-R/MPS
- EDRS-C/NGRM

The Minimum Viable Product (MVP) of SREN uses available real time omni-directional electron fluxes from IREM and SEDA, while it calculates on-the-fly the omni-directional electron fluxes of GOES-16 using available real—time unidirectional electron flux and magnetometer measurements. NGRM electron fluxes will be integrated when the real time products will become available from SWE.

During the de-risking activity, a limited number of submodules was developed and/or integrated. As a result, the following submodules are currently implemented.

- The PAM includes the Data Cleaning Tool - a script that is executed at the post-ingestion phase, by including an appropriate line in the post_ingest.php script, in the cron folder of the target dataset.

- The EAM includes the Time-Averaging and Fluence Calculator Tool; a script that executes MySQL queries in the ODI to compute daily average flux or daily fluence values. The result is a new L4 dataset, that contains the computed results. The tool can be easily extended to other parameters and metrics, using the full arsenal of MySQL functions and capabilities.

- The REM includes the EQFLUX tool which implements the US Jet Propulsion Laboratory (JPL) method for the Solar Cell Degradation in Space Environment. The damage coefficients in the JPL method are calculated using an extensive set of experimental measurements. EQFLUX calculates 1 MeV and 10 MeV damage equivalent electron and proton fluences, respectively, for exposure to the fluences predicted by the trapped radiation and solar proton models, for a specified duration. The end-result of EQFLUX is a determination of the equivalent 1 MeV electron fluence, which would cause the same level of degradation as the actual space environment.

In the fully fledged SREN Platform development, each module will contain several sub-modules to perform the functionalities of the internal SREN back-end.

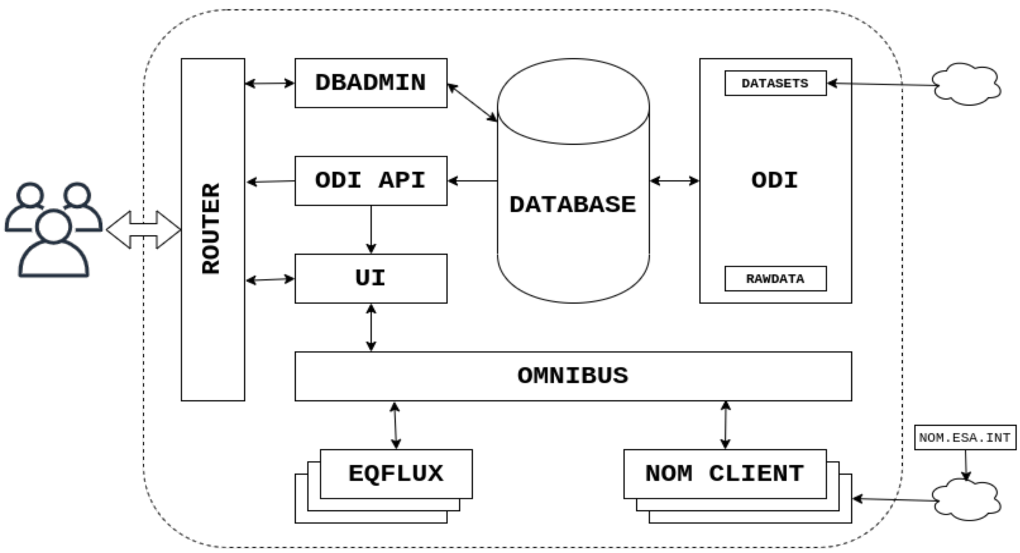


Figure 1: SREN System Architecture

The SREN Platform is composed of a system of components that, at their core use the Open Data Interface (ODI), ingests real time space environment data collected from satellite instruments (DATASETS and RAWDATA) and runs software to parse the data which is then stored in the database (DATABASE).

Supporting infrastructure allows for easy access to the data (ODI API and DBADMIN) and to run SREN modules on-demand via a user interface (UI) that benefits from an asynchronous distributed job queue (OMNIBUS), which manages the run on-demand tasks to maintain a good user experience and allow high scalability. Furthermore, simple and secure access for users to internal components is provided by the router (ROUTER).

All components are conveniently packaged and can be easily deployed, internally or online, in a very flexible and scalable manner using container or virtual machine technologies with minimal software and hardware dependencies – saving time in both setup and maintenance. The architecture created for the SREN platform is built on a robust and state-of-the-art foundation, which will serve well for future works.

The following are actual screenshots, taken of an actual interactive session with the UI using real time data and the results of the analysis performed by the SREN modules.

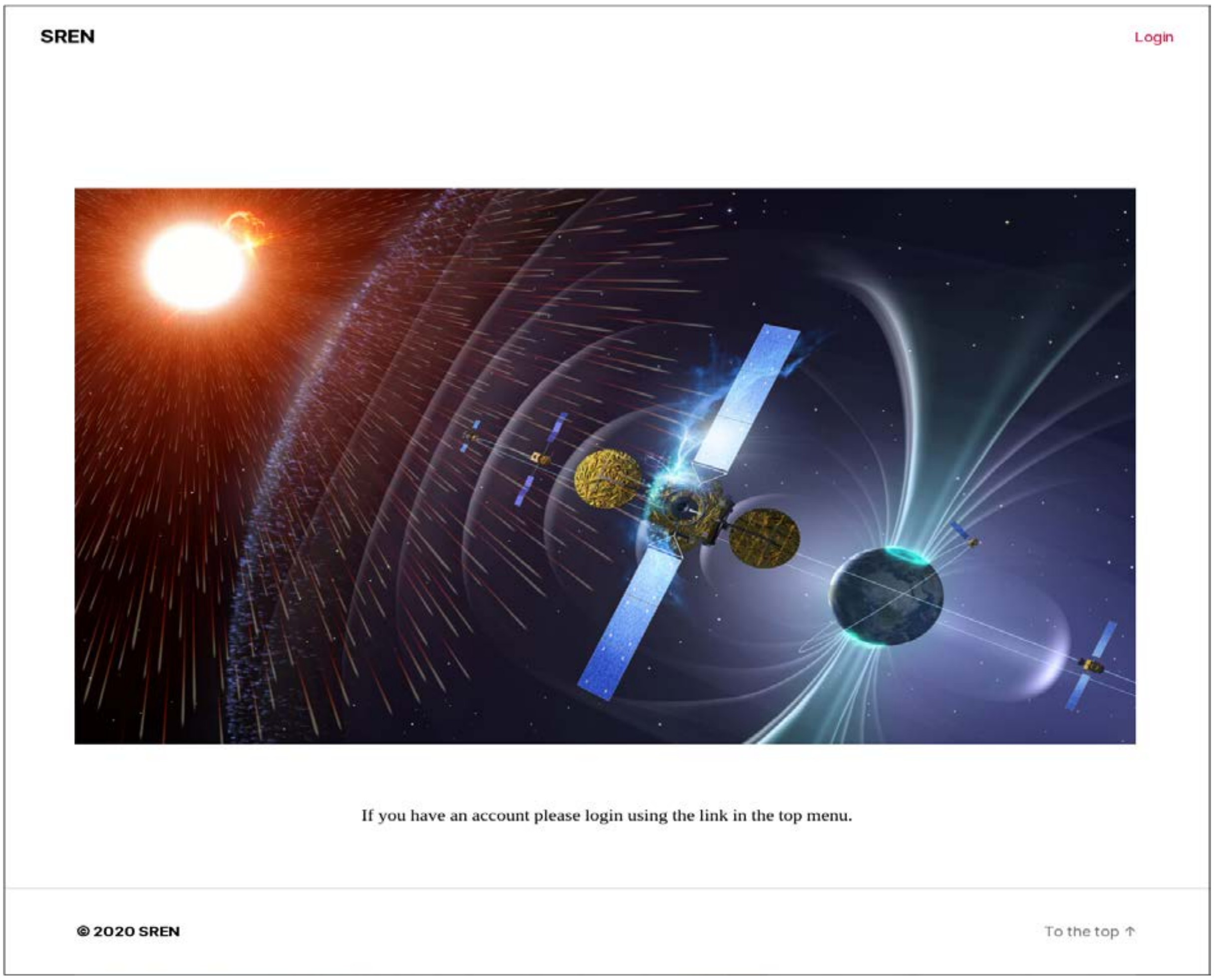


Figure 2: SREN platform initial homepage as shown to an anonymous user

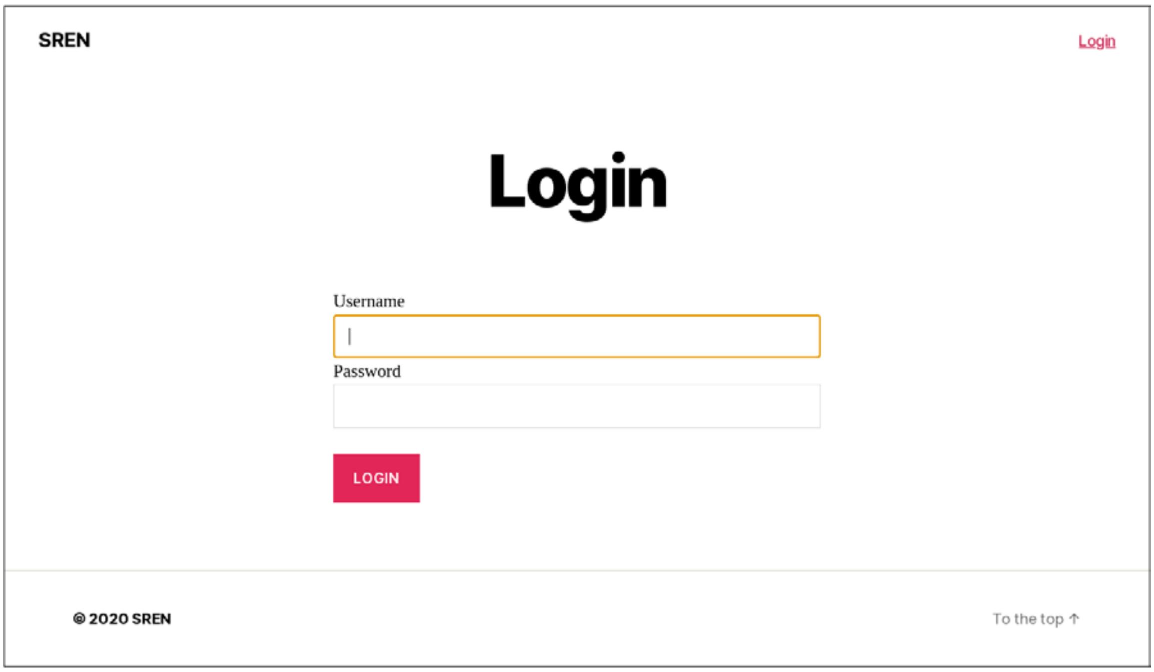


Figure 3: SREN platform Login page

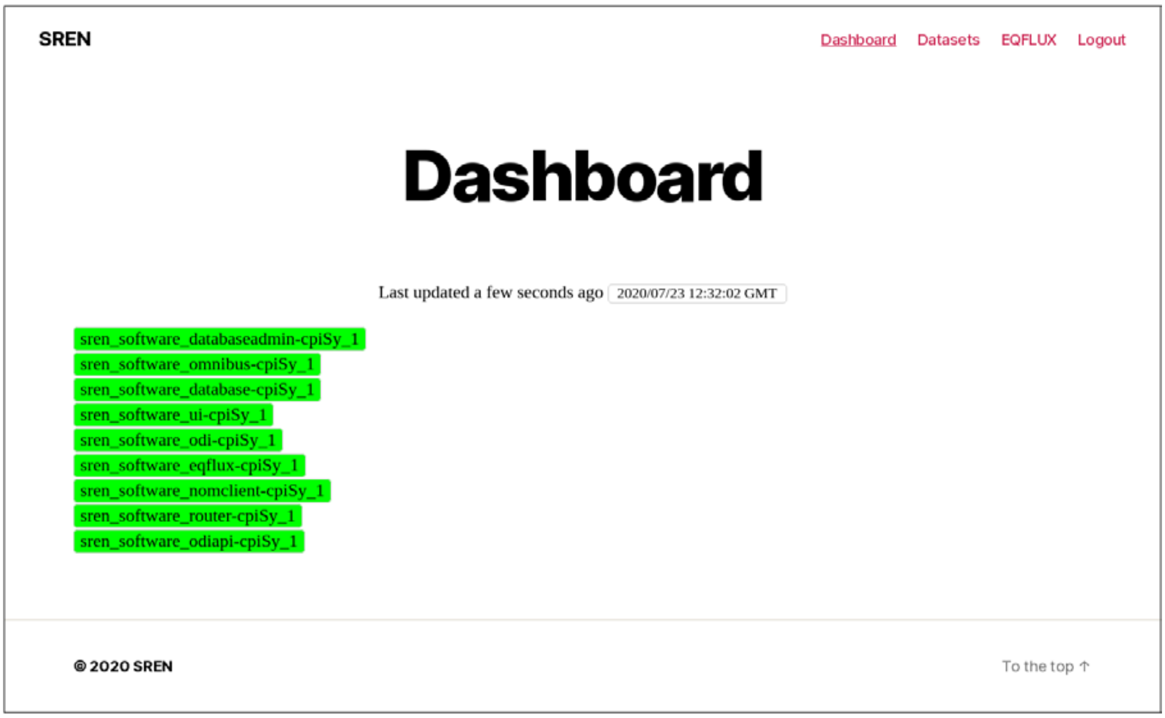
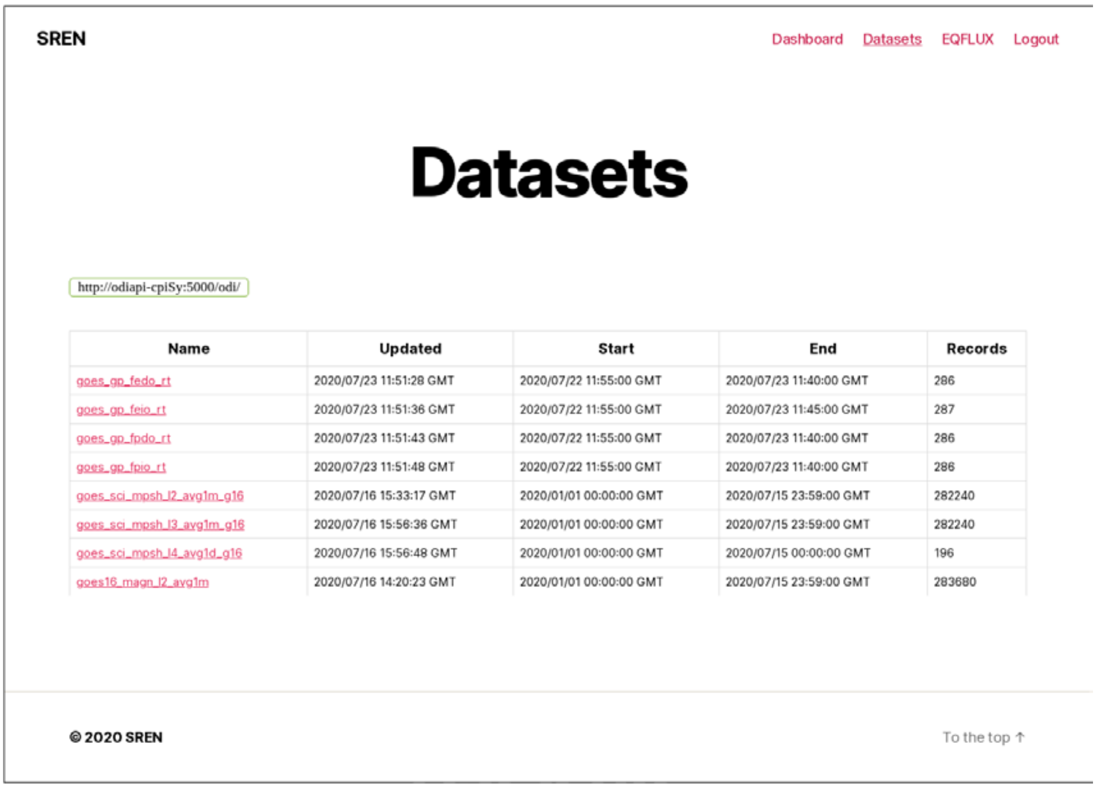


Figure 4: SREN platform Dashboard page


SREN

Dashboard Datasets EQFLUX Logout

Datasets

http://odiapi-cpiSy:5000/odi/

Name	Updated	Start	End	Records
goes_gp_fedo_rt	2020/07/23 11:51:28 GMT	2020/07/22 11:55:00 GMT	2020/07/23 11:40:00 GMT	286
goes_gp_feio_rt	2020/07/23 11:51:36 GMT	2020/07/22 11:55:00 GMT	2020/07/23 11:45:00 GMT	287
goes_gp_fpdo_rt	2020/07/23 11:51:43 GMT	2020/07/22 11:55:00 GMT	2020/07/23 11:40:00 GMT	286
goes_gp_fpio_rt	2020/07/23 11:51:48 GMT	2020/07/22 11:55:00 GMT	2020/07/23 11:40:00 GMT	286
goes_sci_mpsh_l2_avg1m_g16	2020/07/16 15:33:17 GMT	2020/01/01 00:00:00 GMT	2020/07/15 23:59:00 GMT	282240
goes_sci_mpsh_l3_avg1m_g16	2020/07/16 15:56:36 GMT	2020/01/01 00:00:00 GMT	2020/07/15 23:59:00 GMT	282240
goes_sci_mpsh_l4_avg1d_g16	2020/07/16 15:56:48 GMT	2020/01/01 00:00:00 GMT	2020/07/15 00:00:00 GMT	196
goes16_magn_l2_avg1m	2020/07/16 14:20:23 GMT	2020/01/01 00:00:00 GMT	2020/07/15 23:59:00 GMT	283680

© 2020 SREN

To the top ↑

Figure 5: SREN platform Datasets page

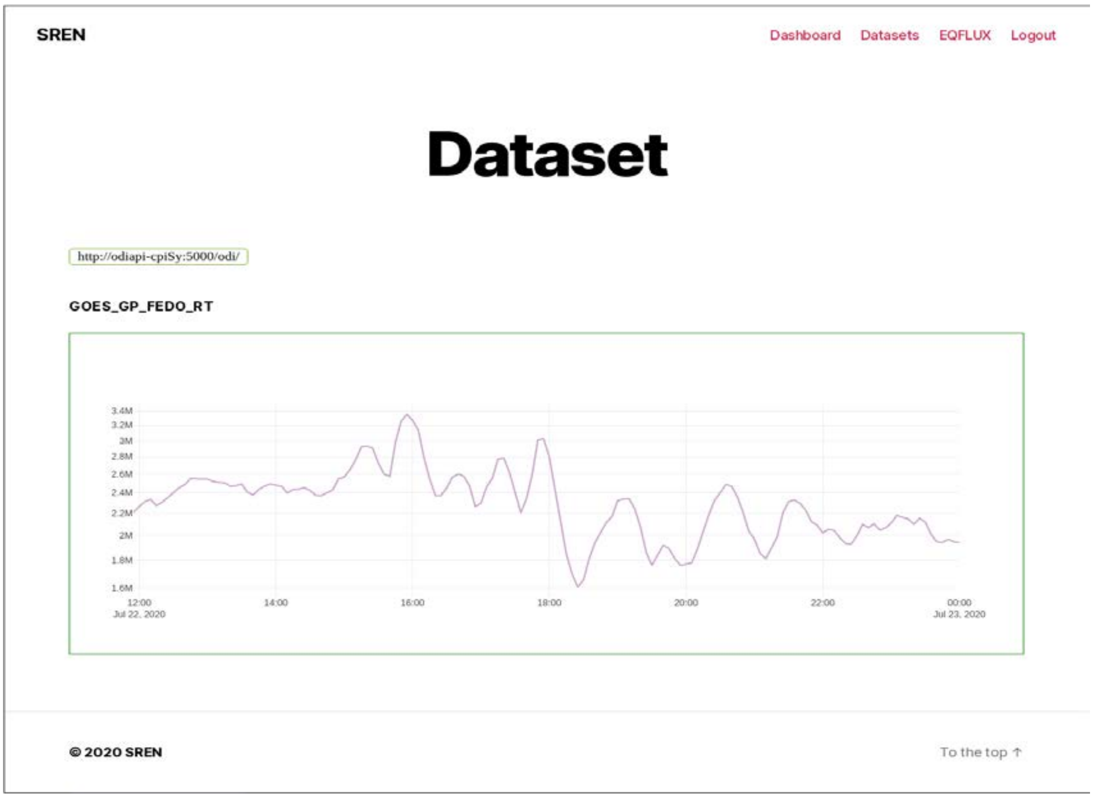


Figure 6: Demonstration of the SREN platform dataset graph functionality

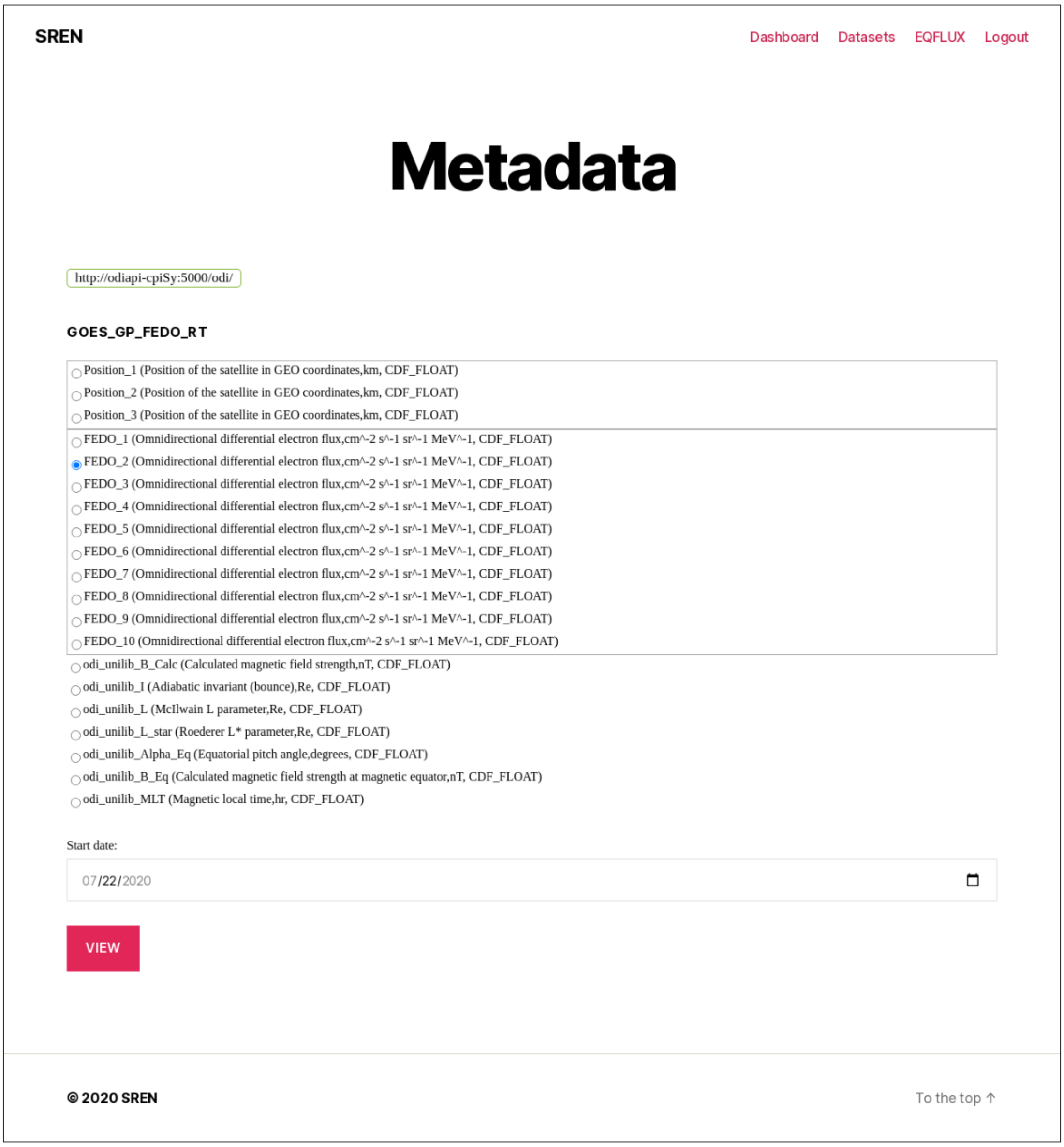


Figure 7: SREN platform Dataset Metadata view

sparc

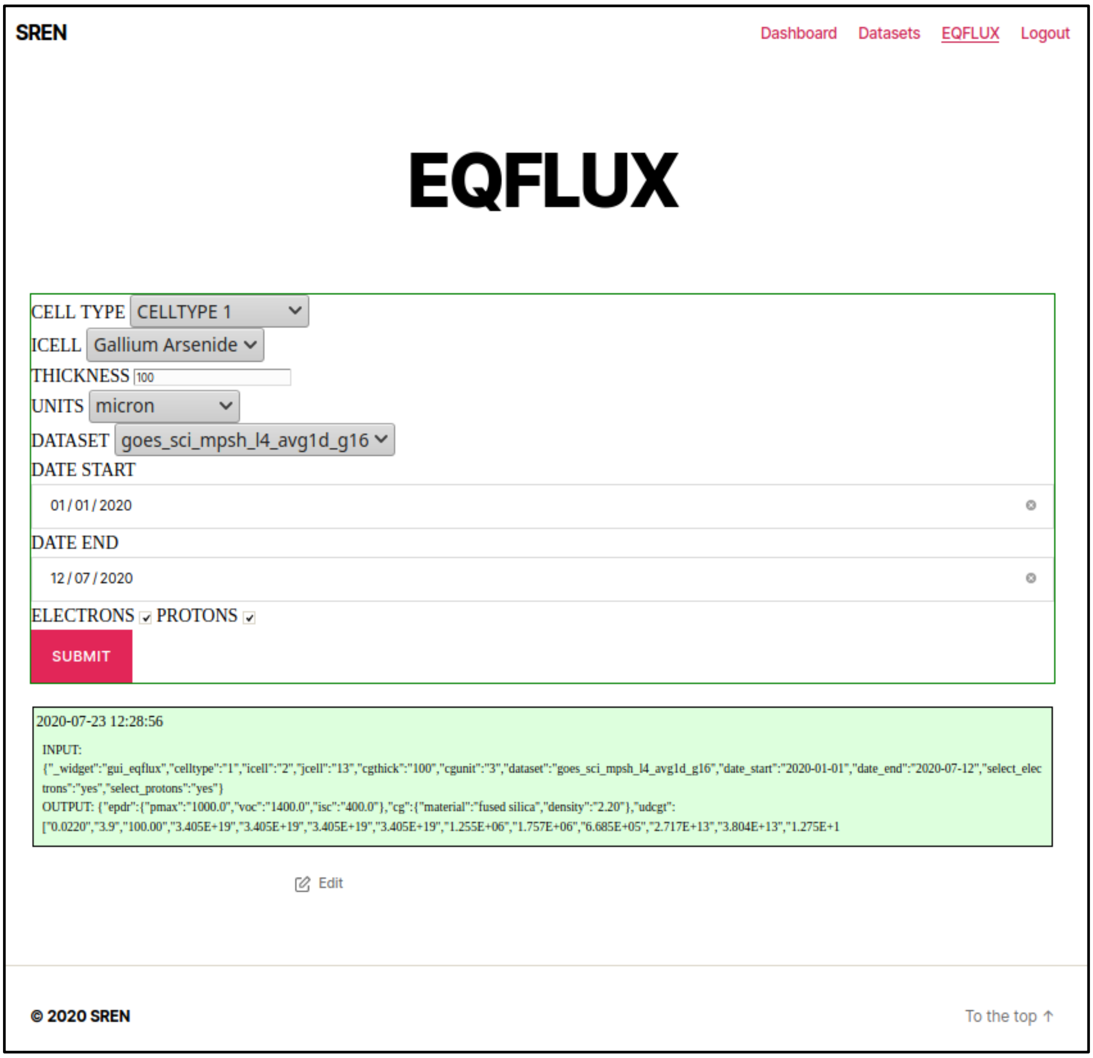


Figure 8: EQFLUX Tool

➢ The fully developed SREN will incorporate additional functionalities on the monitoring, detection, and characterization of extreme energetic particle events and will include an arsenal of data-analysis & state of the art engineering radiation effect tools.