Development of Solar Energetic Particle Prediction Portal (SEP^3)

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Robust prediction of Solar Energetic Particle (SEP) events is among the key priorities of the space weather community. In the framework of NASA's Early Stage Innovation Program, we develop the Solar Energetic Particle Prediction Portal (SEP3: https://sun.njit.edu/SEP3), which hosts web applications that allow the users to retrieve the database records. In particular, SEP^3 lists the API examples to query each data source potentially important for the SEP prediction. The Portal has a search page for browsing the events from the most widely used catalogs (https://sun.njit.edu/SEP3/search.php) and a dedicated space to share the most recent achievements of the team. In addition, we have added a CDAW SEP catalog and a LASCO/SOHO CME catalog and introduced the possibility of displaying the properties of the connected events (parental solar flares and CMEs for SEPs) on the search page. The interactive widget has the capability to display GOES soft X-ray and proton flux time series from different satellites with the GOES flare records on top of them. The data portal has been used to evaluate the forecasts of the solar proton events based on the statistical properties of the GOES soft X-ray and proton fluxes and investigate machine-learning approaches to the SEP prediction.

Project Goals and Objectives

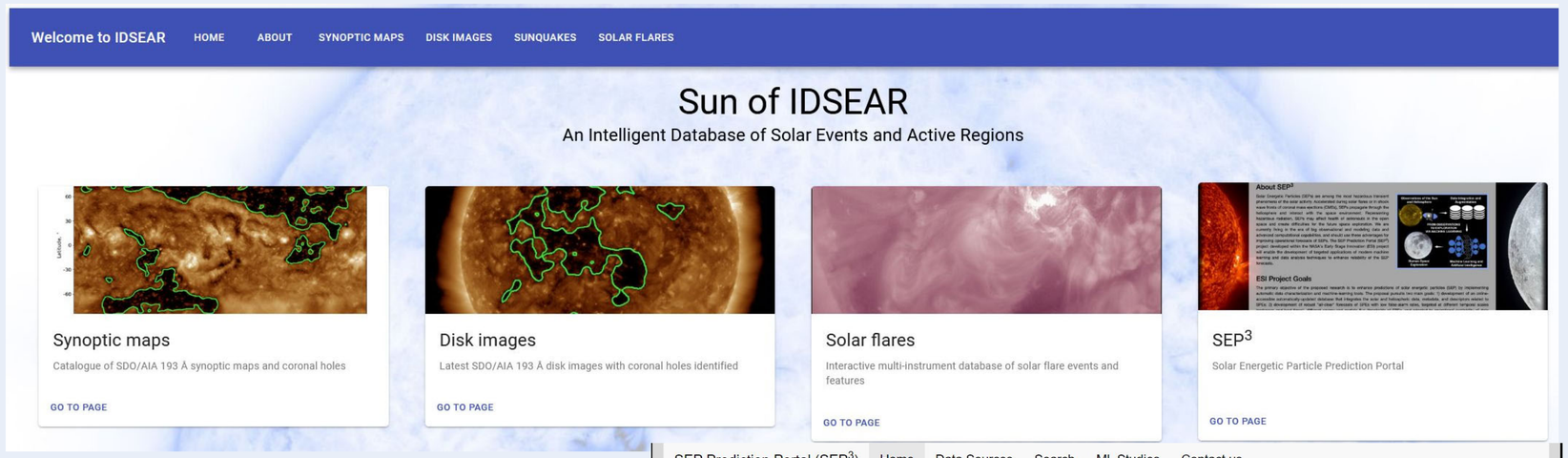
Our primary objective is to develop "all-clear" forecasts of Solar Proton Events (SPEs) with low false-alarm rates using a state-of-art machine learning approach. Specifically, we plan to:

1. develop an online-accessible automatically-updated database that integrates the solar and heliospheric data, metadata, and descriptors related to SPEs;
2. develop robust "all-clear" forecasts of SPEs with low false-alarm rates, targeted at different temporal scales (cadences and lead times), different energy and particle flux thresholds of SPEs, and adapted to the operational availability of data sources and gaps in the data.

Solar Energetic Particle Prediction Portal (SEP^3)

To support the project data needs, we are currently developing an online-accessible database of SPE-related data, metadata, and data products (SEP^3 project). The database is available online for broader research community from the NJIT web server. Core features of the portal include:

- Various SPE-related sources collected in one place: 1) properties of active regions (PIL, SHARP, Solar Region Summary records); 2) GOES proton and SXR fluxes; 3) NOAA records of the radio bursts, flares, and SPEs; 4) SOHO/EPHIN energetic particle data; 5) OULU neutron monitor data; 5) CACTUS CME catalog records
- MySQL database schema developed and optimized to efficiently handle the data queries necessary for the project
- Intuitive Web application with API-based online access to database entries and data products (under development).



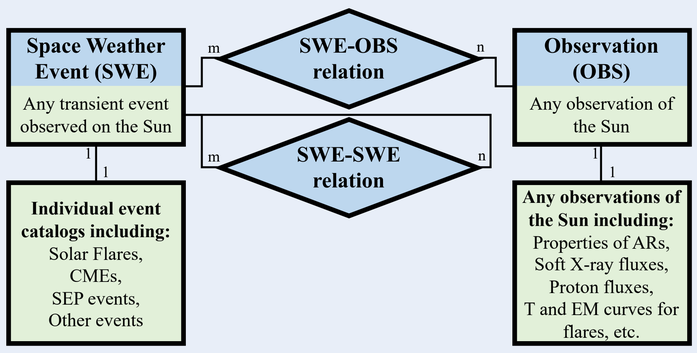


Figure 1. Schematic representation of the MySQL database structure

Figure 2. Solar Energetic Particle Prediction Portal (SEP^3) title page screenshot

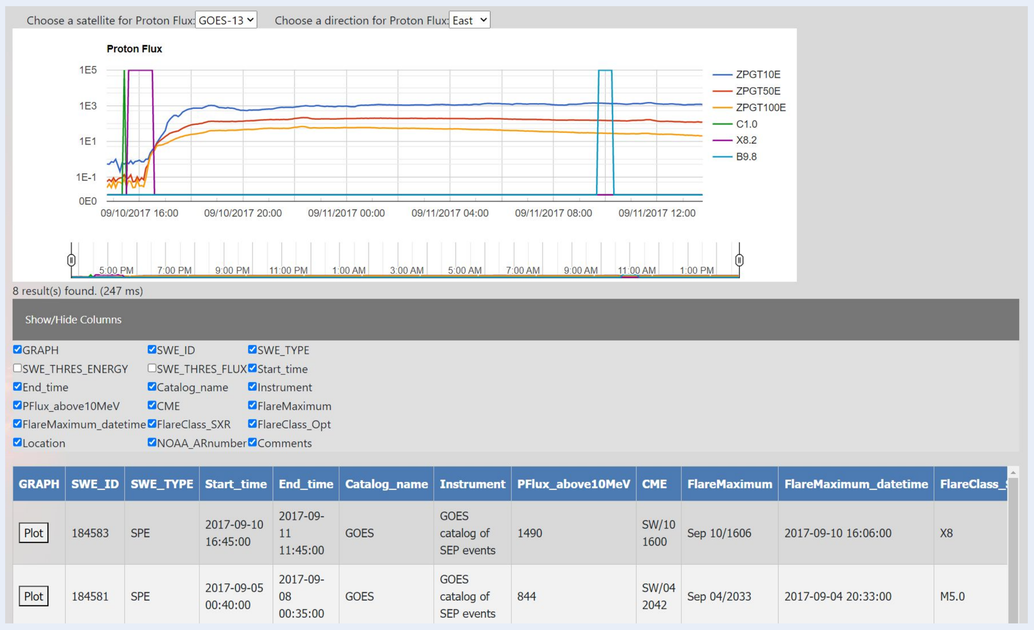
Observational Data and Products

Source Name	Instrument	Time Period	Status	API example	Link to original data and owners
SHARP parameters of Active Regions (Stanford JSOC)	SDO/HMI	May 2010 – June 2020	Complete	API request (January 1, 2016)	Stanford JSOC, Bobra et al. (2014)
PIL parameters of Active Regions	SDO/HMI	May 2010 - December 2017	Complete	API request (January 1, 2016)	Sadykov and Kosovichev (2017)
Solar Region Summary records I (Regions with Sunspots)		January 1996 - January 2021	Complete	API request (January 2016)	NOAA National Centers for Environmental Information archive
Solar Region Summary records IA (H-alpha Plages without Spots)		January 1996 - January 2021	Complete	API request (January 2016)	NOAA National Centers for Environmental Information archive
Solar Region Summary records II (Regions Due to Return)		January 1996 - January 2021	Complete	API request (January 2016)	NOAA National Centers for Environmental Information archive
GOES SXR flux measurements (2-sec original)	GOES/XRS	January 2002 - February 2018	Cross-check required	To be provided	NOAA National Centers for Environmental Information archive
GOES SXR flux measurements (1-min integrated)	GOES/XRS	February 1986 - February 2014	Cross-check required	API request (January 1, 2010)	NOAA National Centers for Environmental Information archive
GOES proton flux measurements (5-min integrated)	GOES/EPS	January 1986 - February 2011	Complete	API request (January 1, 2002)	NOAA National Centers for Environmental Information archive
GOES proton flux measurements (5-min integrated)	GOES/EPEAD	January 2010 - March 2020	Complete	API request (January 1, 2016)	NOAA National Centers for Environmental Information archive
GOES Temperatures and Emission Measures (TEBBS algorithm)	GOES/XRS	January 2002 - February 2018	Cross-check required	API request (January 1, 2016)	Ryan et al. (2012), Sadykov et al. (2019)
Neutron Monitor Measurements (OULU station)	OULU Cosmic Ray Station	April 1964 - December 2020	Complete	API request (January 1, 2016)	OULU cosmic ray station
SOHO EPHIN measurements	SOHO/EPHIN	December 1995 - February 2021	Complete	API request (January 1,2016)	SOHO/EPHIN website

Catalogs of Space Weather Events

Source Name	Instrument	Time Period	Status	API example	Link to original data and owners
Proton events (NOAA Space Environment Services Center)	GOES/EPS, GOES/EPEAD	January 1976 - October 2020	Cross-check required	API request (2016-2017)	List of Solar Proton Events Affecting the Earth Environment
Proton events (NASA Coordinated Data Analysis Workshops Center, CDAW)	GOES/EPS, GOES/EPEAD	November 1997 - September 2017	Complete	API request (2016-2017)	List of major SEPs observed by GOES
GOES flare catalog (NOAA Space Weather Prediction Center)	GOES/XRS	January 2002 - February 2018	Cross-check required	API request (June 2016)	SWPC NOAA FTP Archive
CACTus CME catalog	SOHO/LASCO	January 2002 - February 2018	Cross-check required	API request (June 2016)	CACTus CME catalog
LASCO/SOHO CME catalog	SOHO/LASCO	January 1996 - August 2021	Complete	API request (June 2016)	LASCO/SOHO CME catalog

Example of SEP search output



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