Space Physics

Highlights

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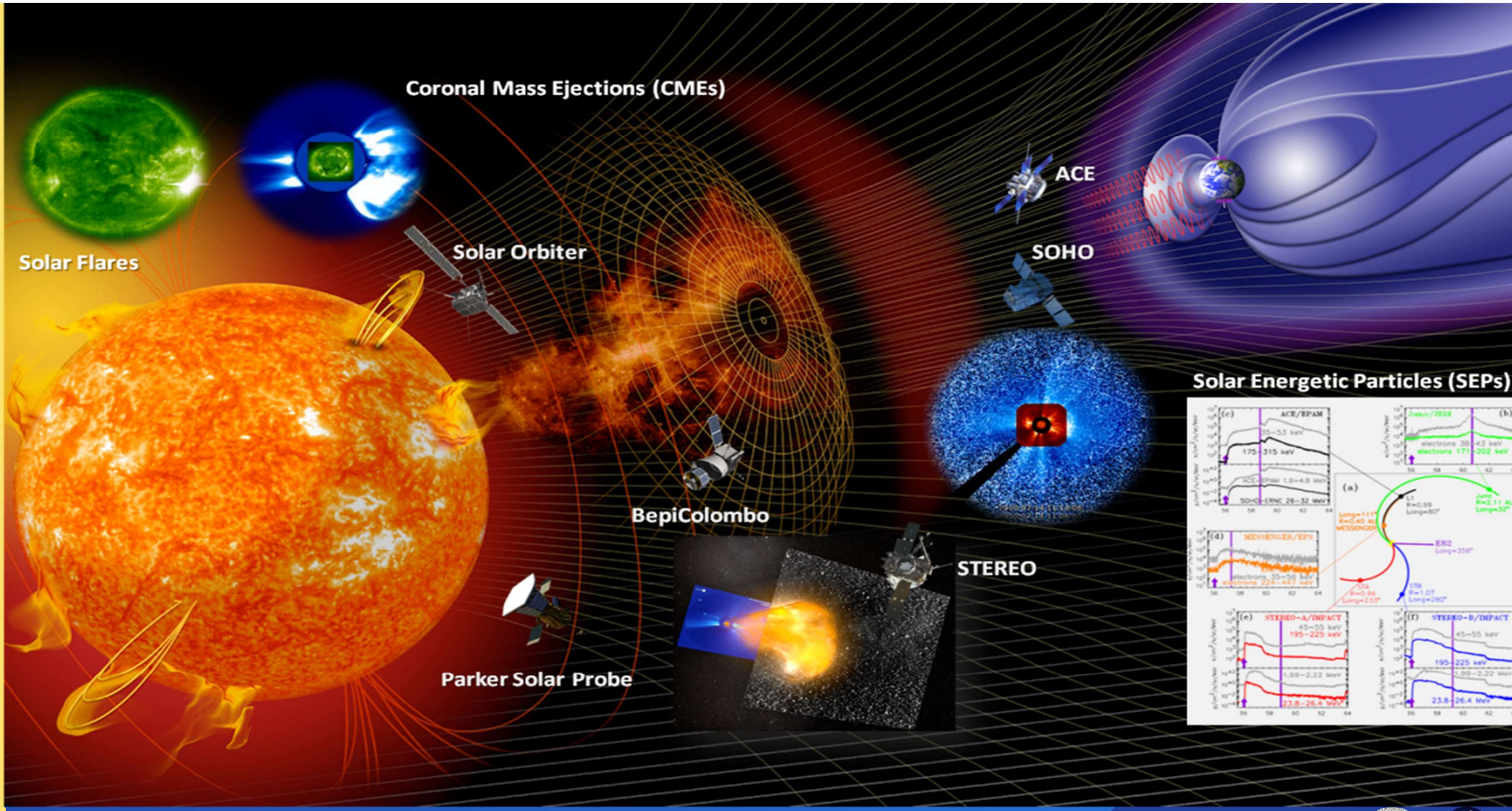
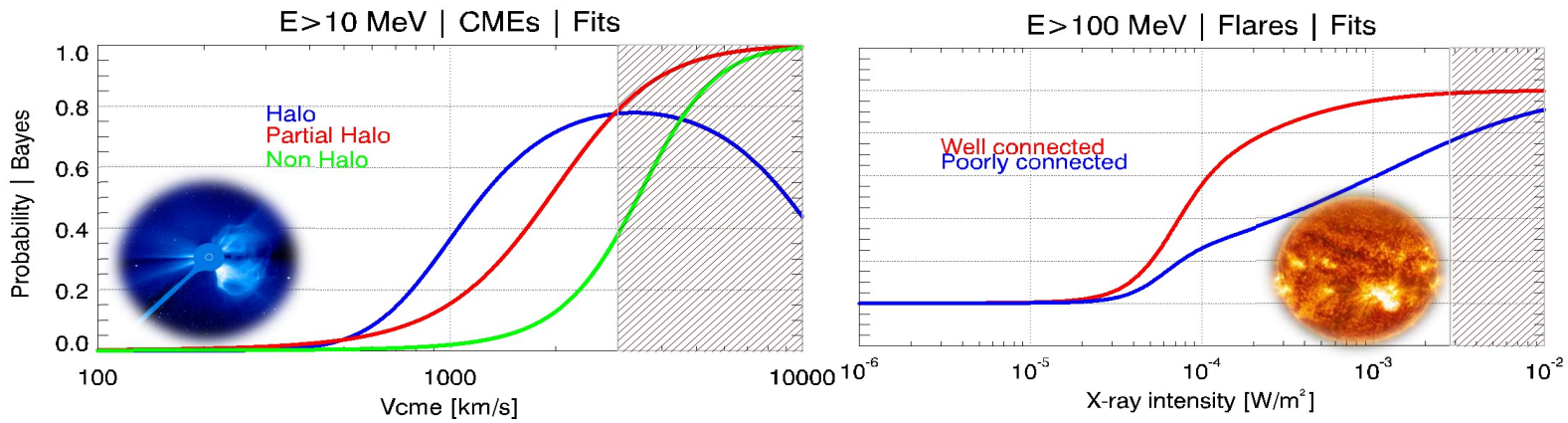

Coronal Mass Ejections (CMEs)
Solar Flares
Solar Orbiter
ACE
SOHO
Solar Energetic Particles (SEPs)
BepiColombo
STEREO
Parker Solar Probe

Research focus - Heliosphere



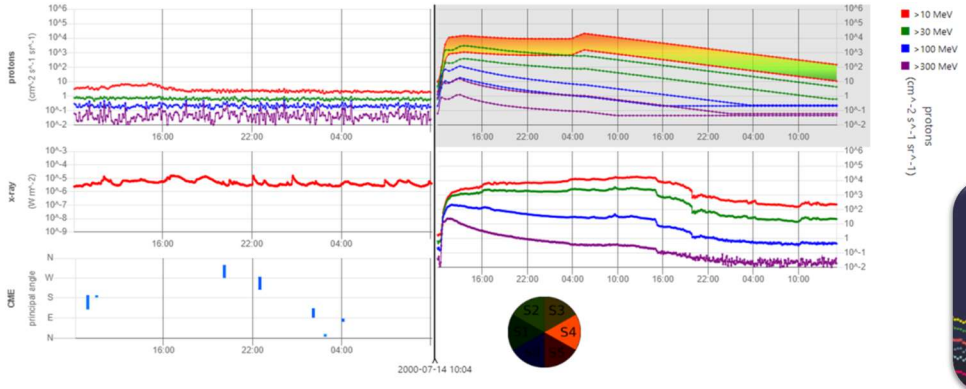
- **Development of novel models for the forecasting (& nowcasting) of Solar Energetic Particles (SEPs)**
  - ***For the first time*** novel *Bayesian Probabilistic models* for **SEP prognosis** (PROSPER) were implemented
  - Improved forecasting concept for SEP forecasting (ML, AI, PCA)
  - Validation of the models and concepts (NASA/CCMC collaboration)

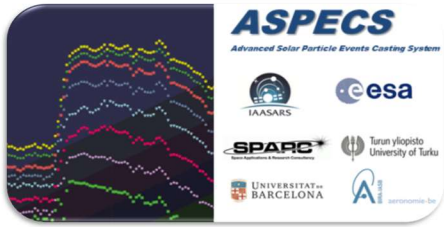
Research focus – Solar Orbiter Mission MADAWG Team

The primary goal of the Solar Orbiter mission is to address big questions in Solar System science to help us understand how the Sun creates and controls the heliosphere, surrounding the Solar System and influencing the planets within it. Our team is:

- ***Involved in the development and operation of a specialized module for the prognosis of the space weather conditions within the MADAWG Team***

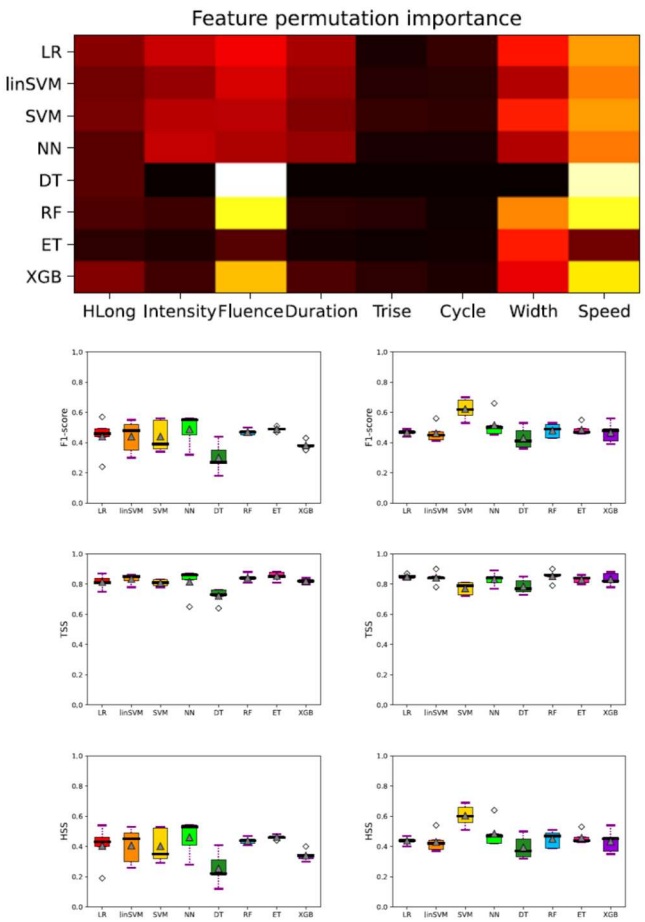
The ESA/NASA Solar Orbiter Mission:
Launched on February 07, 2020





Publications

Machine Learning and Artificial Intelligence applied to the *Prediction of Solar Energetic Particles* (SEPs)



Solar Physics (2021) 296:107
https://doi.org/10.1007/s11207-021-01837-x

EDITORS' CHOICE

Assessing the Predictability of Solar Energetic Particles with the Use of Machine Learning Techniques

E. Lavasa[1,2] · G. Giannopoulos[3] · A. Papaioannou[2] · A. Anastasiadis[2] · I.A. Daglis[1,4] · A. Aran[5] · D. Pacheco[6] · B. Sanahuja[5]

Received: 11 January 2021 / Accepted: 11 May 2021 / Published online: 1 July 2021

Abstract

A consistent approach for the inherently imbalanced problem of solar energetic particle (SEP) events binary prediction is being presented. This is based on solar flare and coronal mass ejection (CME) data and combinations of both thereof. We exploit several machine learning (ML) and conventional statistics techniques to predict SEPs. The methods used are logistic regression (LR), support vector machines (SVM), neural networks (NN) in the fully connected multi-layer perceptron (MLP) implementation, random forests (RF), decision trees (DTs), extremely randomized trees (XT) and extreme gradient boosting (XGB). We provide an assessment of the methods employed and conclude that RF could be the prediction technique of choice for an optimal sample comprised by both flares and CMEs. The best-performing method gives a Probability of Detection (POD) of 0.76(±0.06), False Alarm Rate (FAR) of 0.34(±0.10), true skill statistic (TSS) 0.75(±0.05), and Heidke skill score (HSS) 0.69(±0.04). We further show that the most important features for the identification of SEPs, in our sample, are the CME speed, width and flare soft X-ray (SXR) fluence.

Publications

Detailed analysis of *SEPs'* acceleration, injection & transport in the interplanetary space

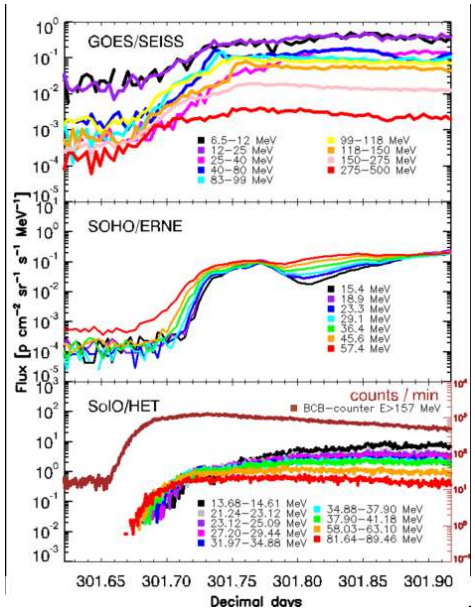
A&A 660, L5 (2022)
https://doi.org/10.1051/0004-6361/202142855

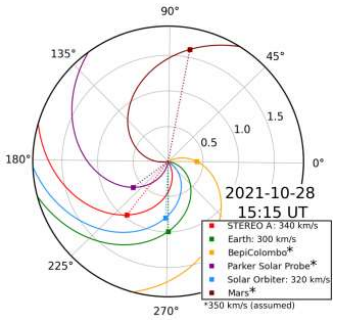
Astronomy & Astrophysics

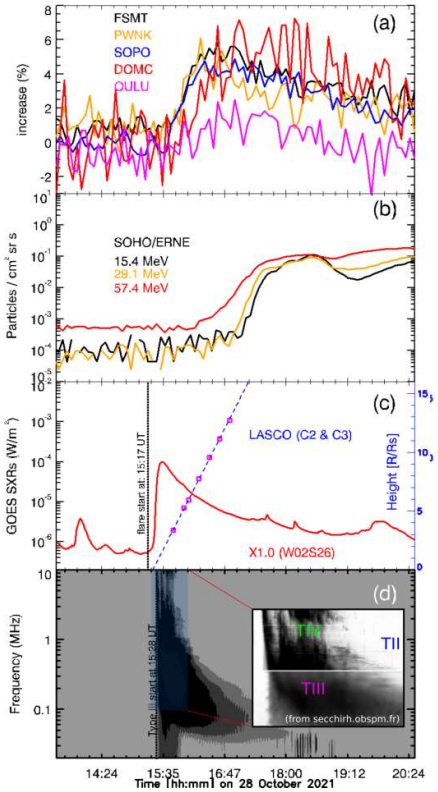
LETTER TO THE EDITOR

The first ground-level enhancement of solar cycle 25 on 28 October 2021*

A. Papaioannou[1], A. Kouloumvakos[2], A. Mishev[3], R. Vainio[4], I. Usoskin[3], K. Herbst[5], A. P. Rouillard[2], A. Anastasiadis[1], J. Gieseler[4], R. Wimmer-Schweingruber[5], and P. Kühl[5]







INTERNATIONAL SPACE SCIENCE INSTITUTE

Publications

PHILOSOPHICAL TRANSACTIONS A

royalsocietypublishing.org/journal/rsta

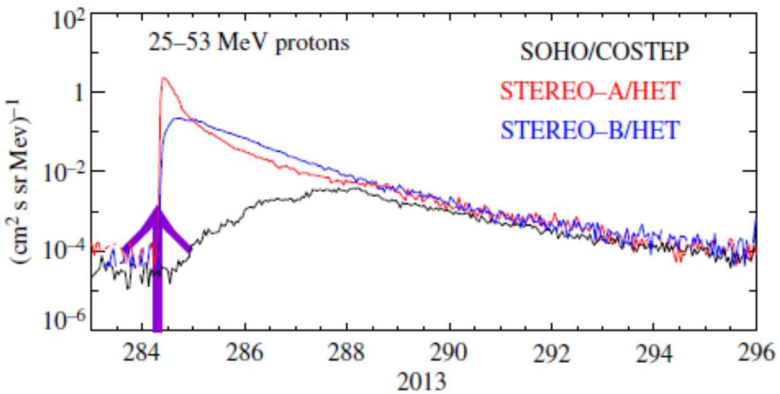
Review

Check for updates

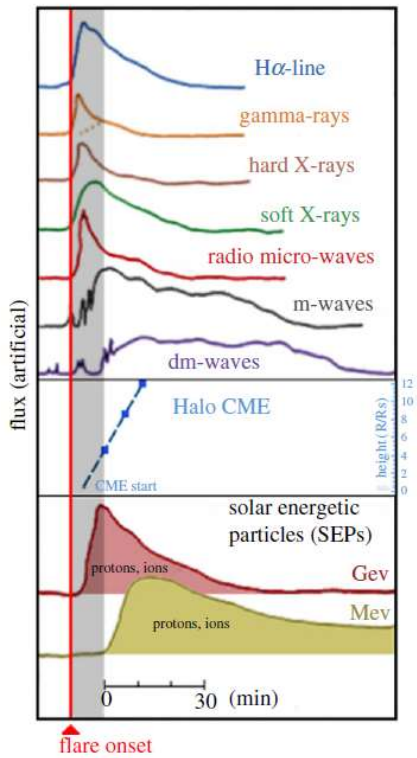
Cite this article: Anastasiadis A, Lario D,

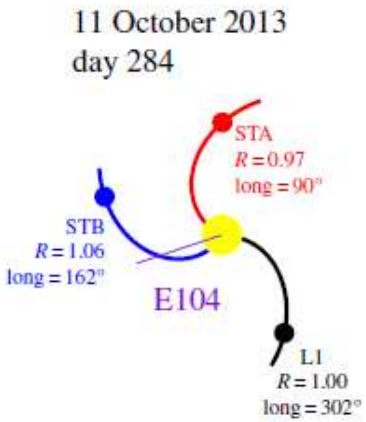
Solar energetic particles in the inner heliosphere: status and open questions

Anastasios Anastasiadis[1], David Lario[2], Athanasios Papaioannou[1], Athanasios Kouloumvakos[3] and Angelos Vourlidas[4,1]



Review and assessment of the necessary future steps in *SEP prediction*, in view of *manned missions*





Services Solar eruptive events nowcast and forecast

- **The Forecasting Solar Particle Events and Flares (FORSPEF) tool**

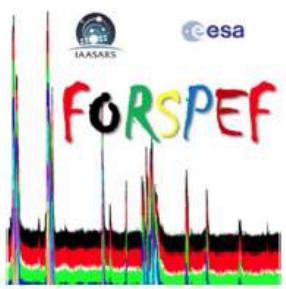
Availability **24/7** - **Open access**

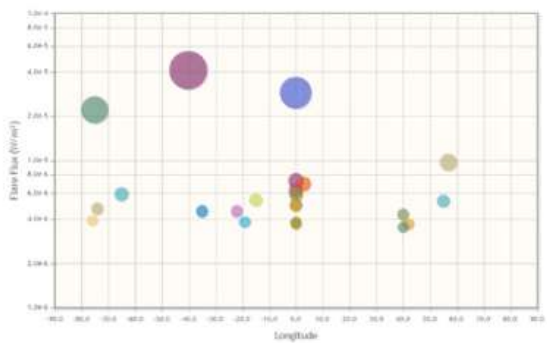
Predictions on the SEP Occurrence and the Peak Proton Fluxes are available in real time

Predictions of the solar flare occurrence in real time for a time window of 24hours

Archived predictions are accessible through the web interface

> *Web-based tool that provides forecasting of solar eruptive events, such as solar flares with a projection to coronal mass ejections (CMEs) (occurrence and velocity) and the likelihood of occurrence of a solar energetic proton (SEP) event. The tool also provides nowcasting of SEP events based on actual solar flare and CME near real-time alerts, as well as SEP characteristics (peak flux, fluence, rise time, duration) per parent solar event.*





Flare Peak Day:Time	LON	Flare Flux	SEP Probability	NOAA AR
20160115-11:06:14	W55	C5.3	0.042	0
20160217-20:35:37	W00	C4.9	0.039	0
20151222-13:45:27	E74	C4.7	0.038	0
20151222-03:40:28	E75	M2.2	0.127	0
20151221-11:10:45	W00	C5.0	0.04	0
20151221-10:29:14	W00	C5.9	0.046	0
20151221-05:40:53	W00	C7.3	0.055	0
20151221-01:07:49	W00	M2.9	0.156	0
20151221-00:00:06	W00	C3.7	0.031	0
20151216-09:08:11	W03	C6.9	0.052	0
20151213-10:41:07	E35	C4.5	0.036	0

The FORSPEF tool is a European Space Weather asset **[http://tromos.space.noa.gr/forspef/]**

Services Solar eruptive events nowcast and forecast e-services

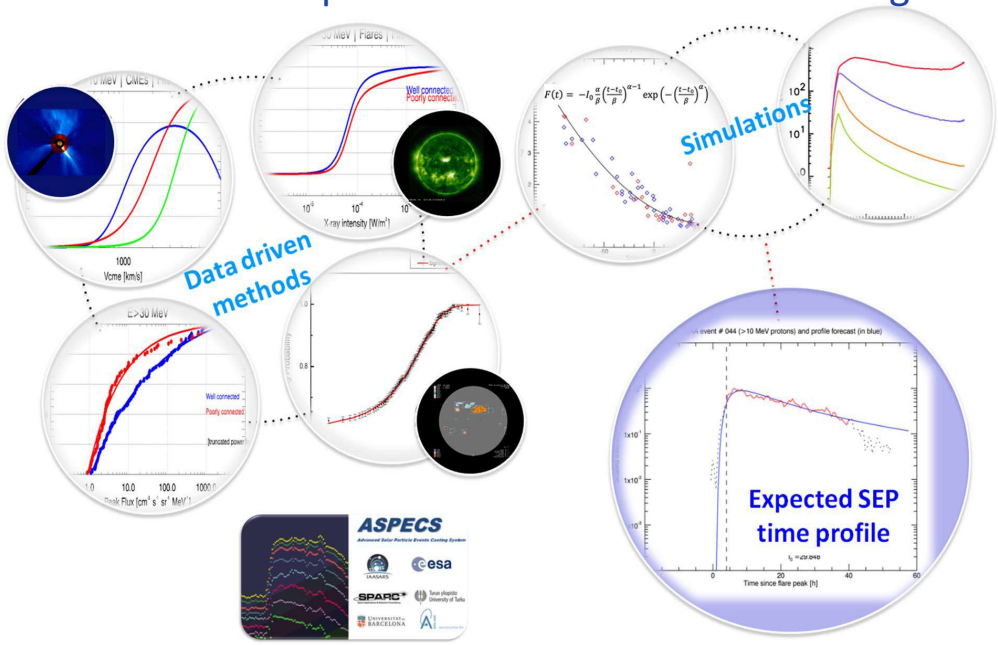
- **The Advanced Solar Particle Events Casting System (ASPECS) tool**

Availability **24/7** - **Open access**

Predictions of the SEP Occurrence, the Peak Flux and the related SEP time profile in real time

Predictions of the solar flare occurrence in real time for 5 time windows

Archived data and predictions are accessible through the web interface



The ASPECS tool is a Space Weather asset [http://phobos-srv.space.noa.gr/]

> Current integrations include:

irap astrophysique & planétologie

NASA

Community Coordinated Modeling Center