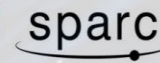
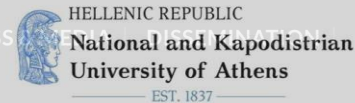


Predicting Outer Van Allen Belt Dynamics with the Prototype SafeSpace Service

Ioannis A. Daglis, Sebastien Bourdarie, Stefaan Poedts, Ondrej Santolik, Fabien Darrouzet, Juan Cueto Rodriguez, Benoit Lavraud, Ingmar Sandberg, George Balasis, Stefanos Doulfis, Christos Katsavrias, [Afroditi Nasi](#), Omiros Giannakis, Marina Georgiou, Fiori-Anastasia Metallinou, Eleftheria Mitsakou, Konstantina Moutsouroufi, Antoine Brunet, Nourallah Dahmen, Vincent Maget, Evangelia Samara, Benjamin Grison, Ivana Kolmasova, David Pisa, Jan Soucek, Viviane Pierrard, Edith Botek, Ion Bueno Ulacia, Gaizka Eiguren Arza, Jesus Angel Oliveros Fernandez, Luis de Pablo, Rui Pinto, Vincent Génot, Rungployphan (Om) Kieokaew, Constantinos Papadimitriou, Sigiava AminaIragia-Giamini, and Zafar Iqbal



SafeSpace

Radiation Belt Environmental Indicators for the Safety of Space Assets

Space Safety Service





SafeSpace: Making Space a Safer place for Europe's assets

The service designed by SafeSpace pertains to the **safety** of space assets **from the natural hazards** of space weather.

However, the scientific basis of the SafeSpace service, which includes the use of spacecraft measurements, models, simulations and innovative algorithms for the comprehensive understanding, nowcasting and forecasting of the acceleration, transport and loss of highly energetic electrons in geospace, may well be used for future efforts regarding **security** from human-driven (intentional) hazards.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 870437



HELLENIC REPUBLIC
National and Kapodistrian
University of Athens
EST. 1837

Single Event Effects (SEEs)

- inner (proton) belt and higher L shells with solar particle event
- quiet-times from galactic cosmic rays

Internal charging and resulting electrostatic discharges (ESD)

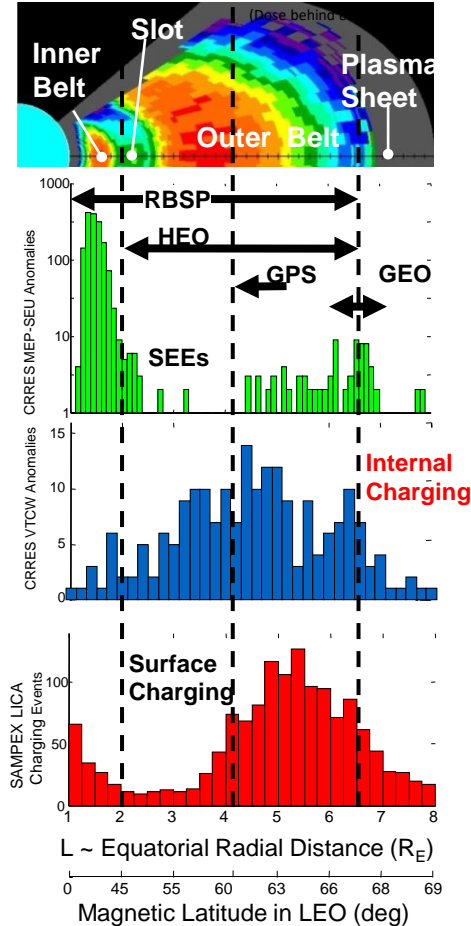
- broad range of L values
- corresponding to the outer belt
- where penetrating electron fluxes are high

Surface charging and resulting ESD

- spacecraft or surface potential elevated
- 2000-0800 local time in the plasma sheet
- regions of intense field-aligned currents
- observed, but not explained, at very low L

Total ionizing dose

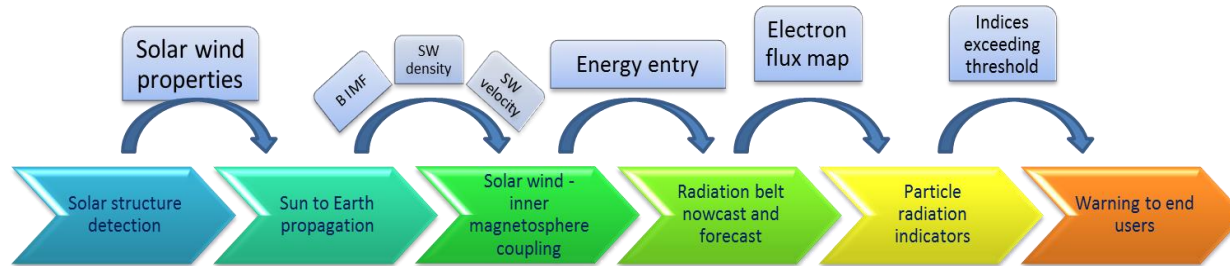
- electronics and solar panels degrade over time

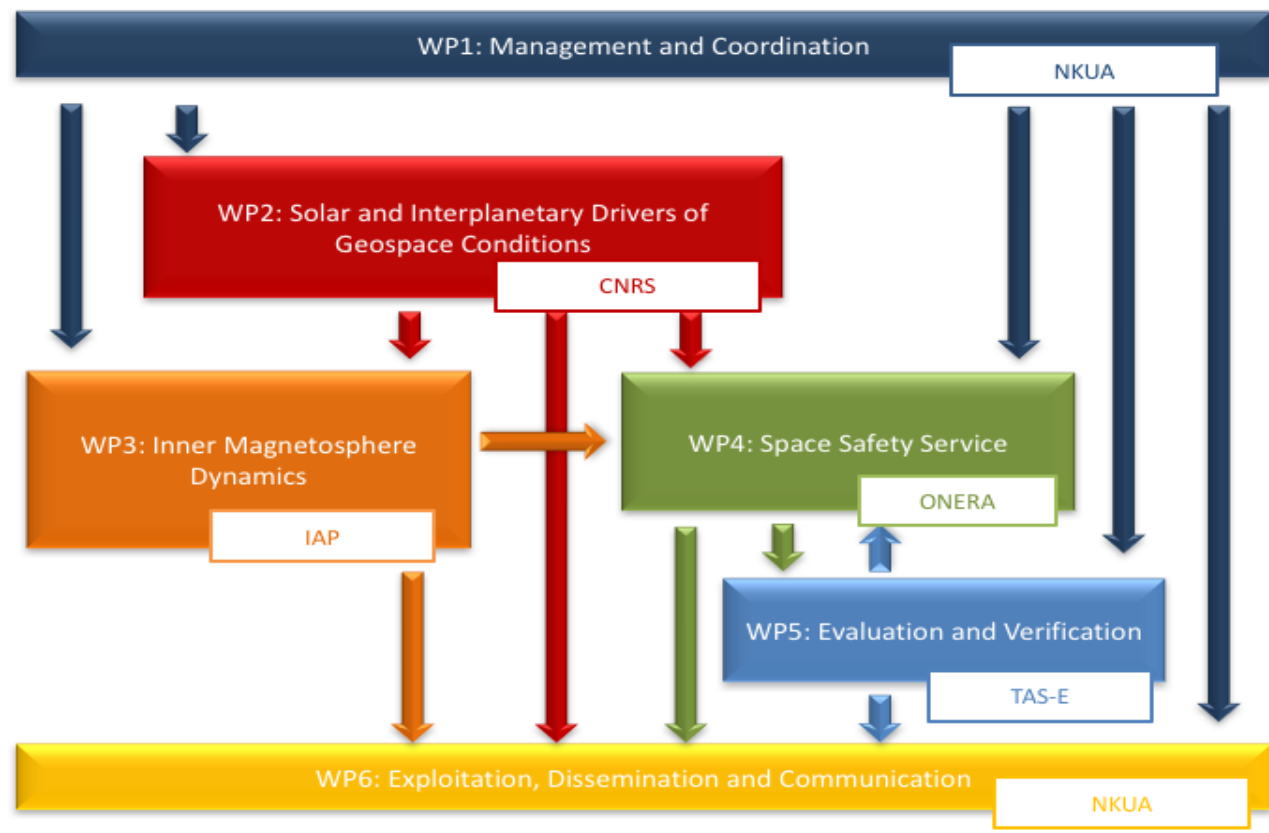


Goals of SafeSpace



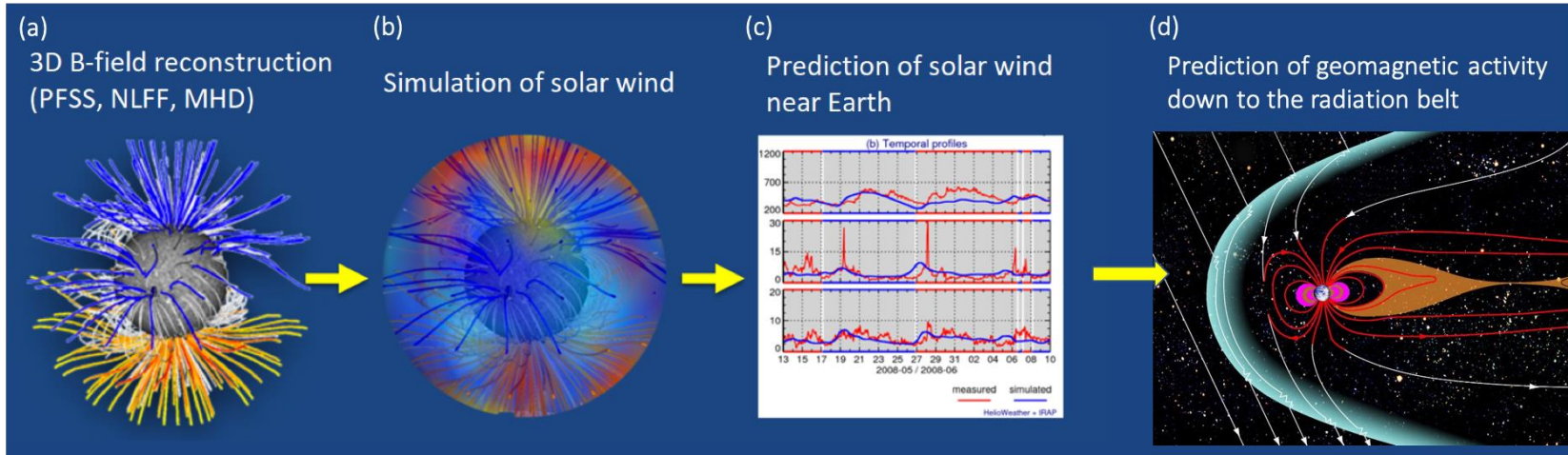
1. Deliver a **prototype forecast service** of particle radiation indicators, based on a **sophisticated upgraded model of the (outer) Van Allen electron belt**.
2. Enable **forecast capabilities with lead times of 2 to 4 days**.





Objective A

- Mapping and propagation of solar disturbances, all the way from the Sun to the Earth, including uncertainties in the propagation
- Mapping the obtained interplanetary space conditions into geospace through the use of neural networks.

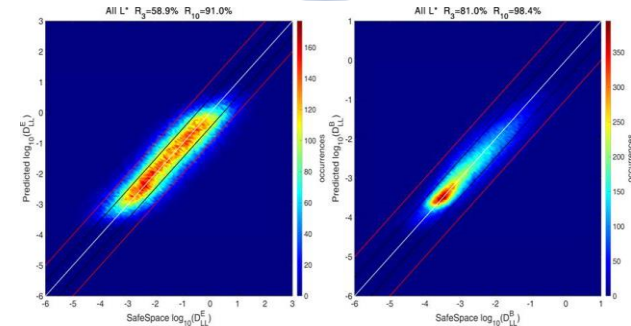
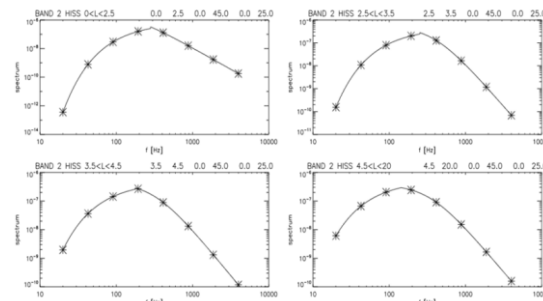
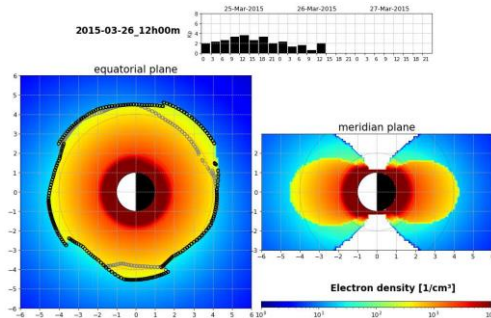
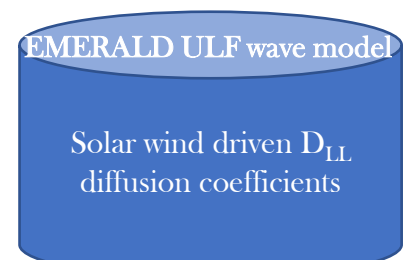
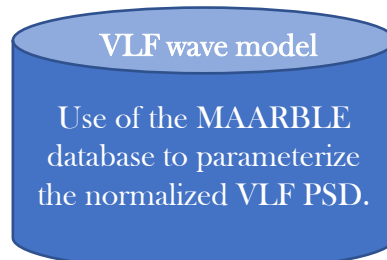
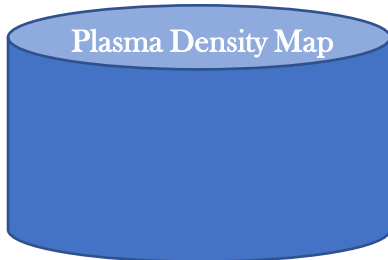


Objectives



Objective B

- Detailed map of plasma density in the inner magnetosphere parameterized by geomagnetic activity levels
- Accurate definition and prediction of VLF/ULF wave diffusion coefficients.

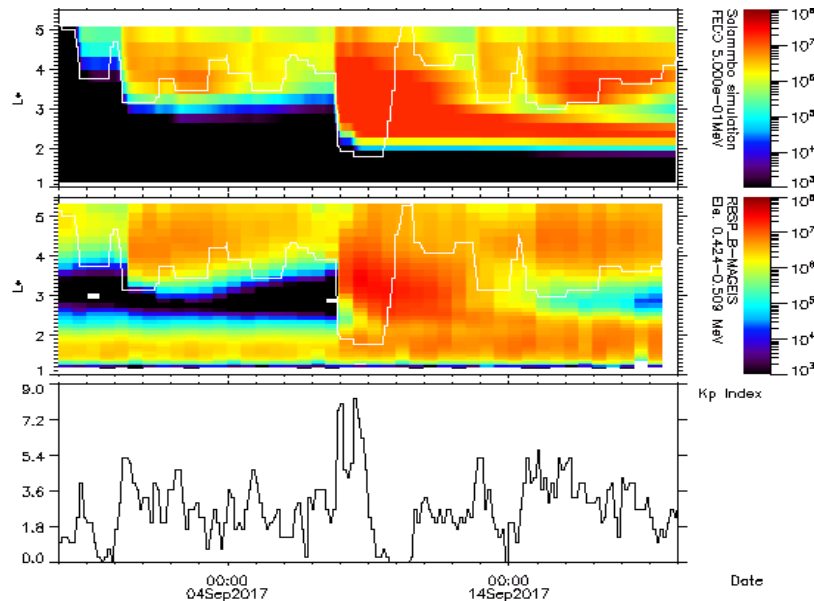


Objectives



Objective C

- Predict a time-dependent state of the outer radiation belt energetic electrons.
- Produce information on physical quantities such as radiation belt fluxes along specific spacecraft orbits (LEO, MEO, GEO)



Objectives

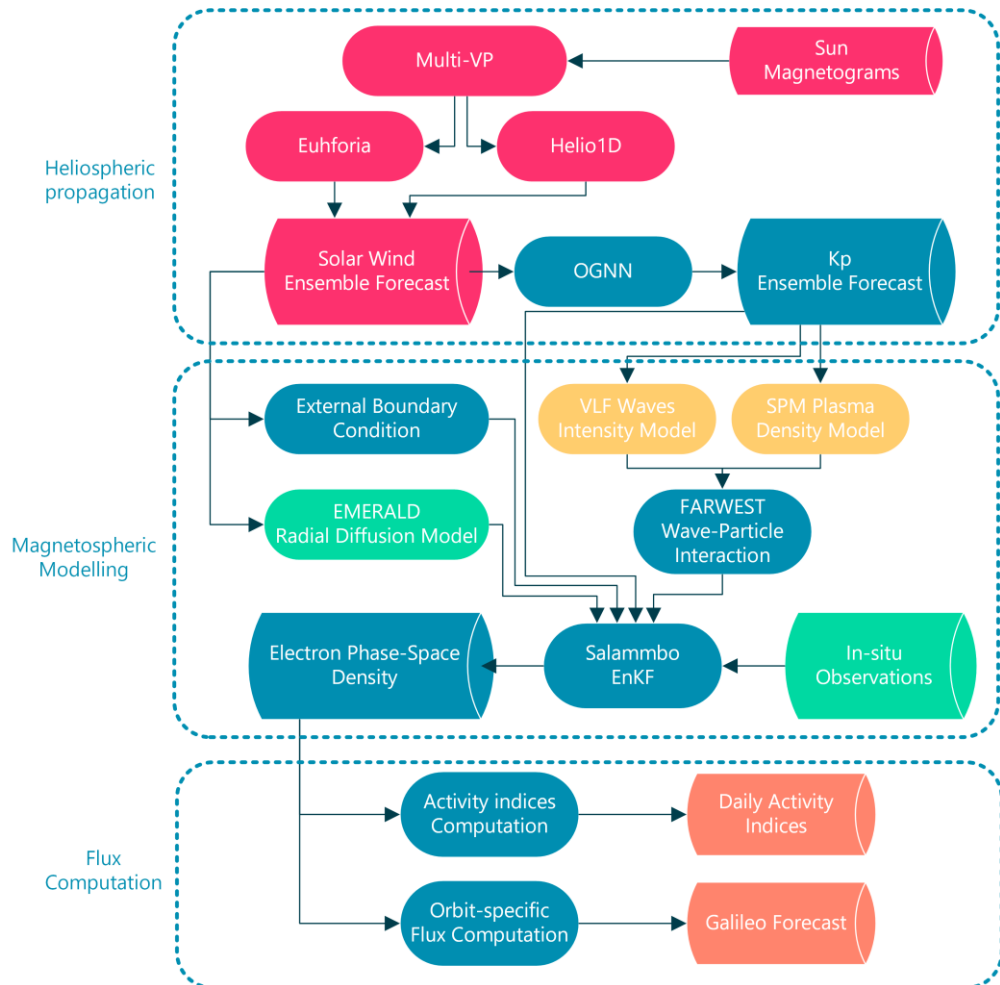


Objective D

- Definition, in collaboration with space industry, of radiation belt environmental indicators.
- Design of a prototype service of such indicators and provide them to spacecraft operators for evaluation.



SafeSpace Space Weather Service Pipeline



Radiation Belt Activity Indices and Warning

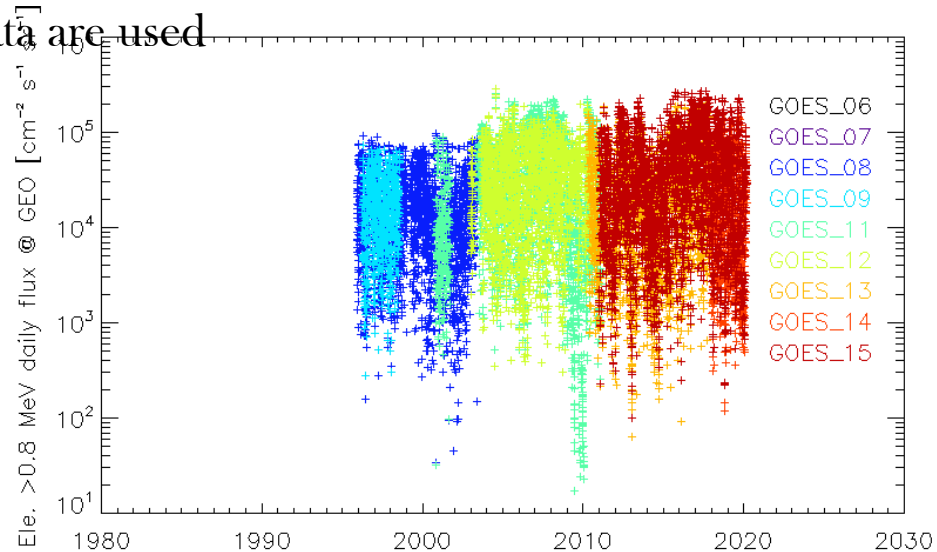


- Internal charging induced by >400 keV electrons (typical time-range hours to days)
- Indices are prepared on the basis of long term in-situ data:
 - @GEO GOES electron data are used
 - @Navigation GPS (*and Galileo*) electron data are used
 - @LEO POES electron data are used

Radiation Belt Activity Indices and Warning



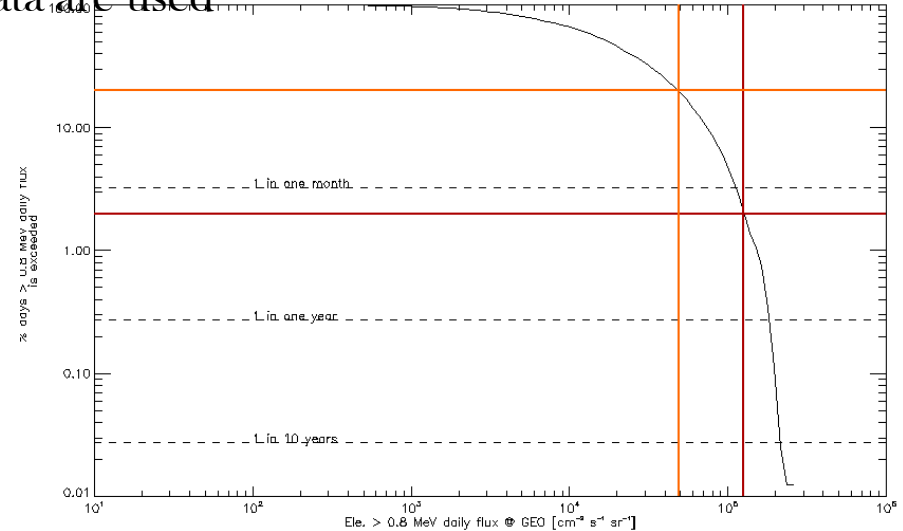
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Radiation Belt Activity Indices and Warning



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SafeSpace Service



<http://www.safespace-service.eu/>

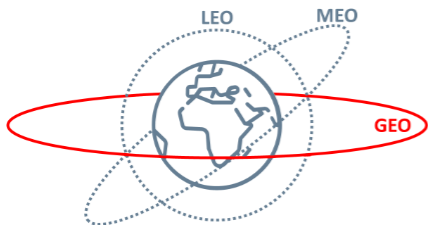
SafeSpace User Guide Login Register

SafeSpace

Radiation Belt Environmental Indicators for the Safety of Space Assets

Welcome to the Space Safety Service page of [SafeSpace](#), a [Horizon 2020](#) scientific research programme. Our goal is to produce a prototype service dedicated to adverse space weather events impacting near-Earth space and threatening space-borne assets. For more information about the Service products and their scientific background, please read the Rules of the road. The past, current and predicted space weather conditions can be previewed below, for LEO, MEO, and GEO trajectories. To use the full Space Safety Service and view our scientific products, please select the trajectory of interest.

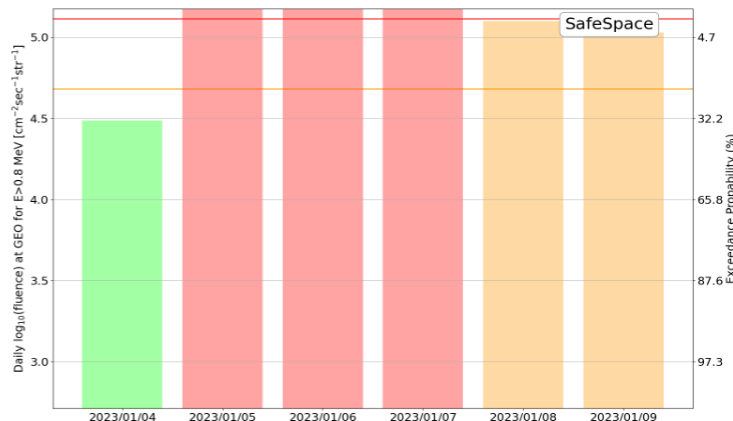
Last Synchronization of data: Sept. 25, 2022, 4:58 p.m. UTC



[View Cumulative Distribution Function](#)

[View Historical data for GEO orbit](#)

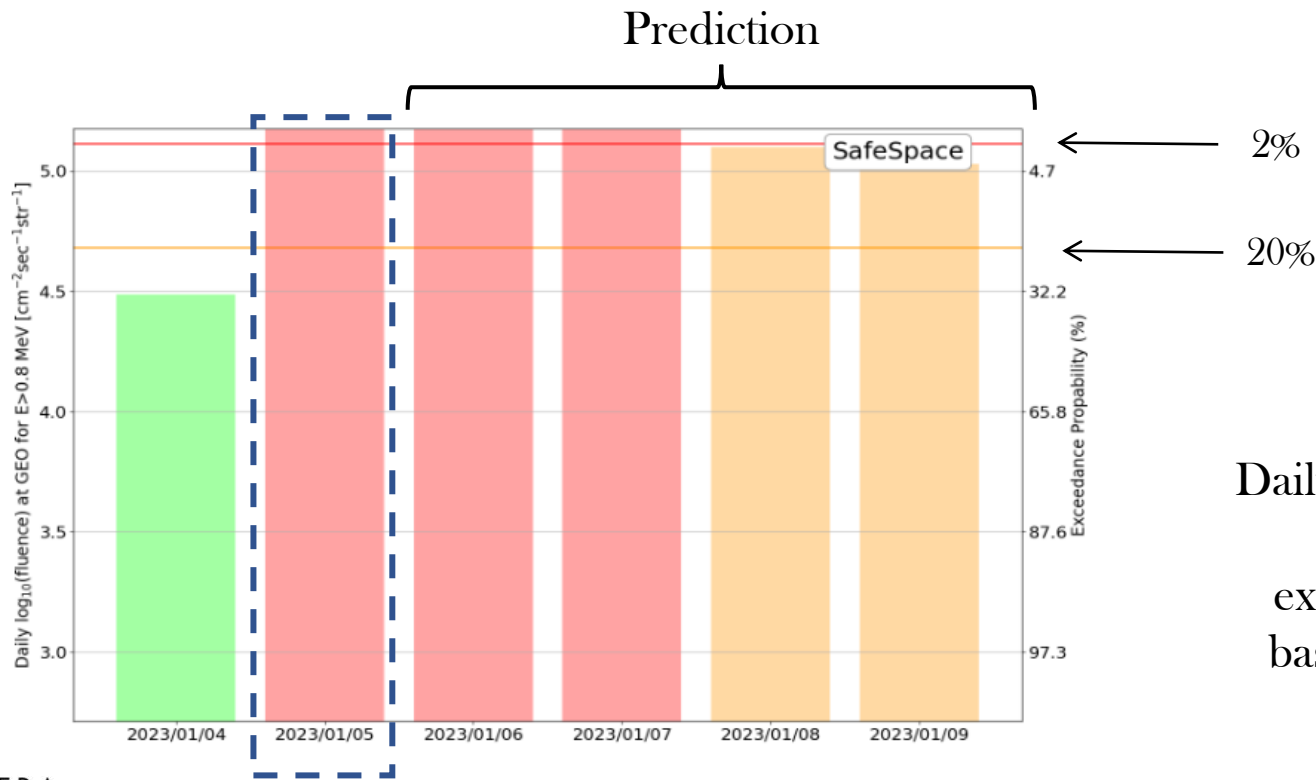
Current Thresholds: Moderate Events at 20.0 % , Extreme events at 2.0 %



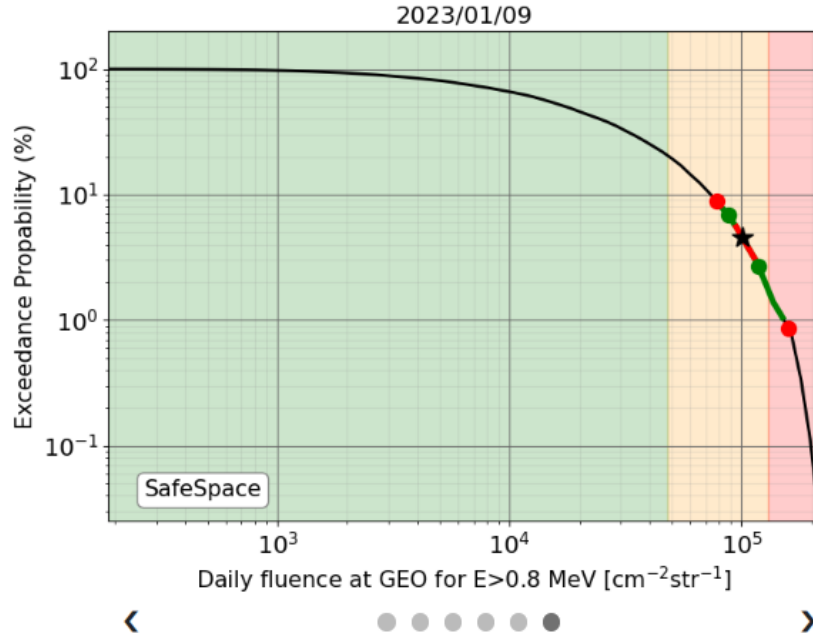
SafeSpace Service



<http://www.safespace-service.eu/>



Daily mean flux values and the corresponding exceedance probability based on historical data



Daily distribution of flux values and the corresponding exceedance probability based on historical data.

The black star corresponds to the median value.

The colored dots correspond to the 25th-75th and 5th-95th percentile range.

Summary



- SafeSpace Service is a prototype service of radiation belt environmental indicators corresponding to internal charging induced by >400 keV electrons.
- These environmental indicators are prepared on the basis of long-term in-situ data.
- Three orbits of interest: **GEO / GNSS-MEO / LEO**.
- Complementary nowcasting/forecasting of Kp index
- User-defined thresholds for the **low / moderate / intense** activity.
- Provision of daily mean electron flux up to 4 days ahead.
- Provision of daily cumulative distribution function.
- Provision of historical in situ data for the past 2 weeks.