Scenario based radiation belt forecasts using ground based input data: results of the FARBES project

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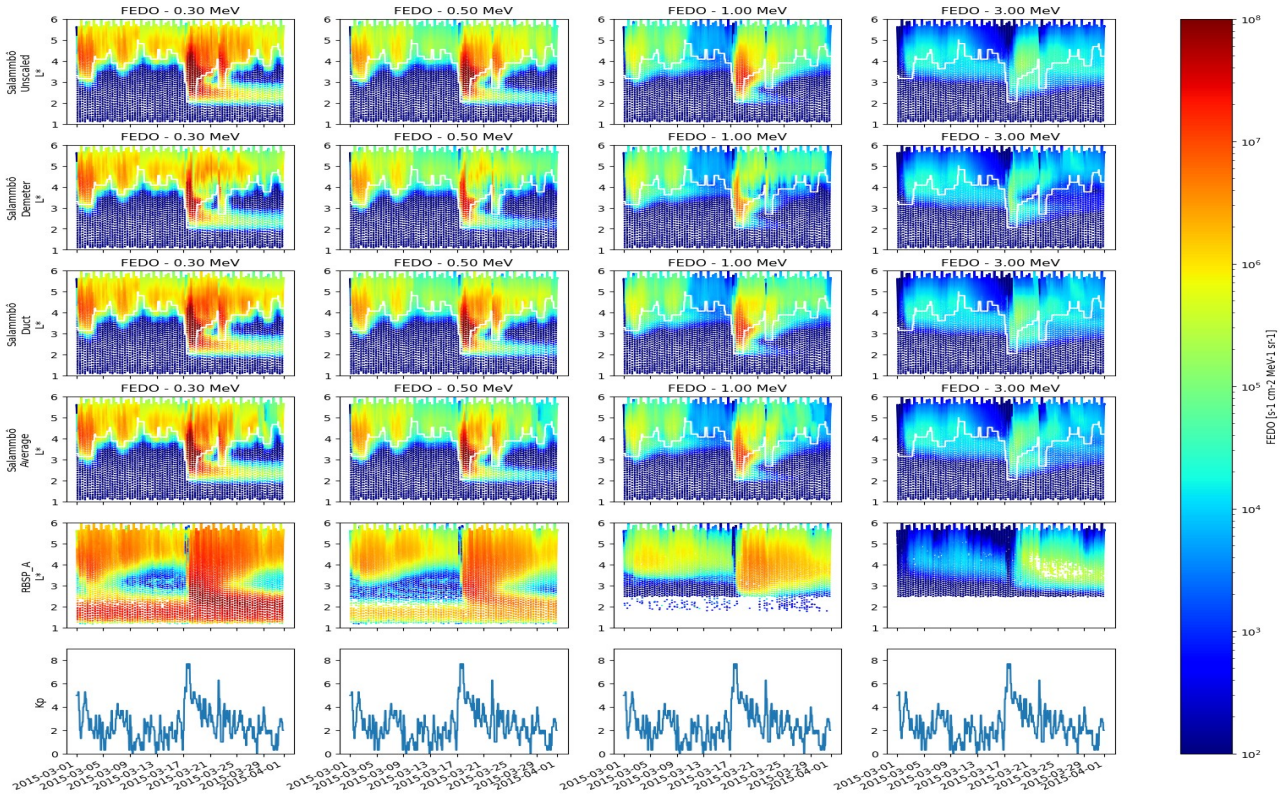
The current state of the art in relativistic electron radiation belt models for operational needs come in two flavours – a "nowcast" based on data assimilation of relevant and timely measurements into a physics based model, and limited "forecasts" based on statistical forecasts of indices or solar wind parameters that govern the dynamics in physical models. The FARBES ( ***Forecast of Actionable Radiation Belt Scenarios***, https://farbes.eu) project (2023-2025) limits its ambition to simple, achievable prediction goals that are of utility to satellite operators while avoiding the pitfalls of past projects. We hold that while it may be impossible to accurately predict the outbreak of a space weather event, once an event has started we have the tools to predict subsequent behavior and to update our predictions during the event. While we may not be able to globally predict in detail the subsequent dynamic behavior, we can provide actionable forecasts for satellite operators on a few key event characteristics:

- Time to most severe environment
- Most severe flux reached
- Time to the end of the event.

In the project we have

- developed a new scenario definition based on Ca index, which is automatic and provides realistic boundary conditions for RB events and is based on near-real time ground data
- enhanced the Salammbō wave-particle interaction model to low energy and outer boundary conditions
- developed an Analog Ensemble forecasting methodology for prototyping of an hourly forecast of the evolution of an ongoing event.
- compiled a new wave power statistics based on RBSP EMFISIS WFR data
- developed a new parametrization method for $D_{LL}^{E}$ from ground based ULF wave measurements
- developed a chorus wave propagation method from the equator to the ground and used it to estimate the equatorial wave power from ground based chorus data for VLF diffusion coefficients calculations by scaling the wave power statistics




*Simulations of the March 2015 storm using dynamic diffusion coefficients computed from RBSP wave data. The unscaled simulations are compared with simulations scaled according to the chorus ground measurements and RBSP measurements.*

The FARBES project is funded by the European Union in the Horizon Europe programme under the project No. 101081772.