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The real-time SEP prediction tools within the framework of the 'HESPERIA' HORIZON 2020 project

Olga E. Malandraki (1), Bernd Heber (2), Johannes Labrenz (2), Marlon Nunez (3), Arik Posner (4), Nikos Milas (1), Georgia Tsiropoula (1), and Evgenios Pavlos (1)

(1) National Observatory of Athens, IAASARS, Athens, Greece (omaland@astro.noa.gr), (2) IEAP, Christian-Albrechts-Universitaet, Kiel, Germany, (3) Universidad de Malaga, Spain, (4) Heliophysics, NASA Headquarters, Washington DC, USA

We describe the two real-time prediction tools, that have been developed in the framework of the HESPERIA project based upon the proven concepts UMASEP and REleASE. Near-relativistic (NR) electrons (1 MeV electrons have 0.95c) traveling faster than ions (30 MeV protons have 0.25c) are used to forecast the arrival of protons of Solar energetic Particle (SEP) events with real-time measurements of NR electrons. The faster electrons arrive at L1 30 to 90 minutes before the slower protons. The Relativistic Electron Alert System for Exploration (REleASE) forecasting scheme (Posner, 2007) uses this effect to predict the proton flux by utilizing the actual electron flux and the increase of the electron flux in the last 60 minutes. Within the HESPERIA project, a clone of the REleASE system was built in the open source programming language PYTHON and the same forecasting principle with use of the same forecasting matrices were in addition adapted to real-time electron flux measurements from the ACE/EPAM experiment. >500 MeV solar protons are so energetic that they usually have effects on the ground, producing what is called a Ground Level Enhancement (GLE) event. Within HESPERIA a predictor of >500 SEP proton events at near-Earth has been developed, using the UMASEP scheme (Núñez, 2011, 2015). UMASEP makes a lag-correlation of solar electromagnetic (EM) flux with the particle flux at near-earth. If the correlation is high, the model infers that there is a magnetic connection through which particles are arriving. If the intensity of the flux of the associated solar event is also high, then the UMASEP scheme issues a SEP prediction. In the case of the prediction of >500 MeV SEP events, the implemented system, HESPERIA UMASEP-500, correlates X-ray flux with each of the differential proton fluxes measured by the GOES satellites, and with each of the neutron density fluxes collected by neutron monitor stations around the world. When the correlation estimation surpasses a threshold, and the associated flare is greater than a specific X-ray peak flux, a >500 MeV SEP forecast is issued. Both forecasting tools are operational under the HESPERIA server maintained at the National Observatory of Athens (https://www.hesperia.astro.noa.gr/). This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 637324 (HESPERIA project).