The use of observations of Soft X-Rays and protons in the UMASEP Scheme for making real-time predictions of the SEP Events that took place in July and September 2017

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The UMASEP-10 tool [Núñez, 2011] works in an operational level since 2010, and its >10 MeV Solar Energetic Proton (SEP) predictions are diseminated by NASA's integrated Space Weather Analysis system (iSWA). This presentation shows the real-time predictions of the SEP events that took place in July and September 2017. The UMASEP-10 tool predicts the occurrence and intensity of the first hours of >10 MeV SEP events using the Well-Connected prediction (WCP) model and the Poorly-Connected prediction (PCP) model. The WCP model infers the observer's interplanetary magnetic field connection to the shock source by correlating remote sensing SXR and proton data at near-Earth. This poster also presents a summary of the predictions of the UMASEP-100 [Núñez, 2015] and HESPERIA UMASEP-500 [Núñez et al., 2017] tools for predicting >100 MeV and >500 MeV events, respectively, during the aforementioned period.

The WCP model empirically finds a magnetic connection by correlating the GOES SXR flux and each of the six differential proton channels (9-500 MeV). This model constructs two sequences of "1s" from the (yes/no) occurrences of sufficiently large SXR flux derivatives and sufficiently large in-situ proton flux derivatives. Instead of the SXRs - protons correlation, other solar electromagnetic and particle fluxes have been recently explored: Microwaves - protons [Zucca et al., 2017], SXRs - electrons [Núñez, 2018] and Extreme Ultraviolet - protons (Núñez et al., submitted].

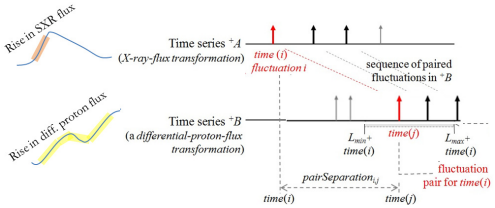

Figure 1. The UMASEP's WCP model infers a magnetic connection by making a correlation between the time derivatives of the SXR flux and each of the differential proton fluxes (9-500 MeV). It identifies the occurrence of the largest derivates, transforming then into "1s". An ideal magnetic connection is a sequence of SXR-based "1s" followed by a sequence of proton-based "1s".

Table 1. >10 MeV forecast performance summary of the UMASEP-10 tool for the events that took place in July and September 2017. During 2017 no false alarm was recoded by the iSWA system from UMASEP-10.

Date	Prediction Result	Warning time	Intensity error at 7 h after the SEP start (log-10 scale)
July 14th 2017	Hit	3 h 38 min	0.53
September 5th 2017	Hit	33 min	-0.44
September 10th 2017	Hit	11 min	0.48

UMASEP tool result for the events on July and September 2017

During the period from July to September 2017, three >10 MeV SEP events occurred in July 14th, September 5th and September 10th 2017. The NASA's iSWA recorded the predictions from the UMASEP-10 tool (See Figures 2 and 3), which were finally successful with anticipation times of 3 h 38 min, 33 min and 11 minutes, respectively. The mean absolute error of the forecasted >10 MeV intensities (at 7h after the SEP event start) was 0.48 orders of magnitude in a log-10 scale. During the period July-September, 2017 the iSWA system did not record any false alarm from the UMASEP-10 tool.

Real-time prediction of high-energy SEP events

Regarding the >100 MeV event that took place on September 10th, it was sucessfully predicted by UMASEP-100 with an anticipation time of 10 minutes; however, two >100 MeV false alarms were issued by this tool during the period July-September.

Table 2. Summary of real-time >100 MeV forecast performance summary of the UMASEP-100 tool for the events on 2017.

	UMASEP-100 prediction	
	Result	Warning time
July 14th 2017	Correct all clear	
September 5th 2017	Correct all-clear	
September 10th 2017	Hit	8 min

During this period, a faint Ground Level Enhancement (GLE) took place on September 10th; however the corresponding >500 MeV integral proton flux did not surpass the >500 MeV SEP threshold of 0.8 pfu; the real-time time HESPERIA UMASEP-500 succesfully predicted an all-clear situation regarding >500 MeV SEP events and no false alarm was issued. The aforementioned >500 MeV SEP threshold, established in the H2020 European HESPERIA project with GOES HEPAD data, was used as reference to callibrate the HESPERIA UMASEP 500 tool for predicting the corresponding events using 1986-2016 data.

Table 3. Summary of real-time >500 MeV forecast performance summary of the HESPERIA UMASEP-500 tool for the events on 2017.

	UMASEP-500 prediction	
	Result	Warning time
July 14th 2017	Correct all-clear	-
September 5th 2017	Correct all-clear	-
September 10th 2017	Correct all-clear >500 MeV and missed GLE event	-

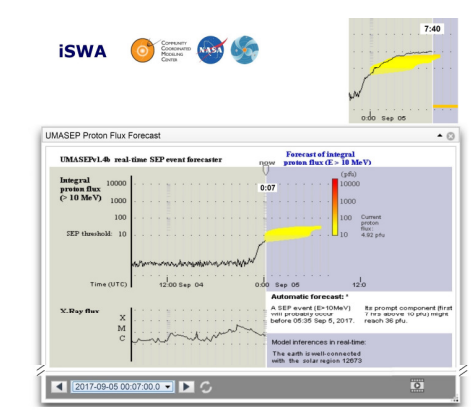

Figure 2. Prediction of the WCP and PCP models: At 5:22 on September 4th, iSWA recorded a prediction from UMASEP-10 which was finally successful with an anticipation time of 3 h 38 min.

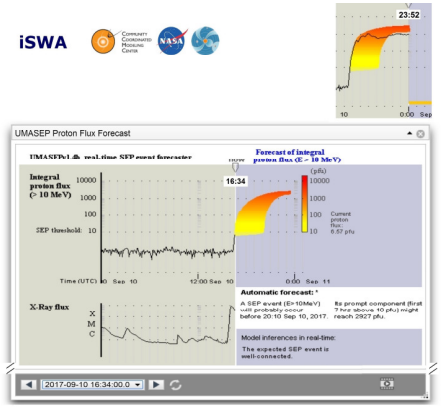

Figure 3. Prediction of the WCP model: At 16:34 UT on September 10th, 2017, the NASA's iSWA system recoded a prediction from UMASEP-10 which was finally successful with an anticipation time of 11 min.

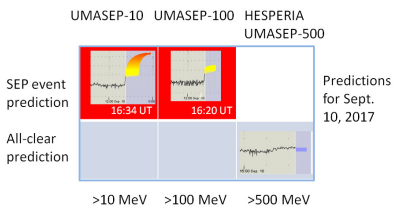

Figure 4. Summary of the >10, >100 and >500 MeV SEP forecast outputs of the UMASEP-based tools for the event that took place on Sept. 10 2017.

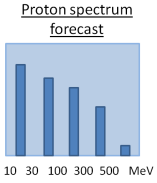

Figure 5. From the real-time UMASEP-based predictions of the occurrence and intensity of the first hours of >10 MeV, >100 MeV and >500 MeV SEP events presented in Figure 4, a real-time proton spectrum forecast migth be constructed; this forecast output is our next goal.

Current research

- Very recently, we have carried out a study which presents for the first time, a quantitative assessment of the use of Extreme Ultraviolet (EUV) observations in the prediction of >10 MeV SEP events. In this study, we explore the possibility to replace the SXR time history with the EUV time history from GOES-EUVS and SDO-AIA instruments in the UMASEP scheme. This study presents the results of the prediction of the occurrence of well-connected >10 MeV SEP events, for the period from May 2010 to December 2017, in terms of POD, FAR, AWT and Critical Success Index (CSI). The best results were obtained by those models that used EUV data in the range 50–340 Å. We conclude that these UMASEP/EUV-based models yield similar or better POD results, and similar or worse FAR results than those of the current real-time UMASEP/SXR-based model.
- From the real-time UMASEP-based predictions of the occurrence and intensity of the first hours of >10 MeV, >100 MeV and >500 MeV SEP events (e.g. Figure 4), a real-time proton spectrum forecast might be constructed (see Figure 5); this forecast output is our next goal.

Main references

Núñez (2011), *Space Weather*, 9, S07003. The Real-time >10 MeV SEP forecasts are presented inin the iSWA system (https://ccmc.gsfc.nasa.gov/iswa/ and http://spaceweather.uma.es/forecastpanel.htm.
Núñez (2015), *Space Weather*, 13, 11. The Real-time >100 MeV SEP forecasts are presented in http://spaceweather.uma.es/forecastpanel.htm.
Núñez, Reyes-Santiago, Malandraki (2017), *Space Weather*, 15, 7. The Real-time >500 MeV SEP forecasts are presented in https://www.hesperia.astro.noa.gr/index.php/results/real-time-prediction-tools/umasep.