The ESPERTA (Empirical model for Solar Proton Event Real Time Alert) model

Forecasting all SEP events (≥10 pfu)

Inputs (only for ≥M2 SXR bursts):
1. Time integrated SXR flux
2. Time integrated 1 MHz Radio emission
3. Flare Longitude (west, central and east ranges)

Technique: Logistic regression
⇒ evaluation of the probability of SPE occurrence as a function of the SXR and Radio fluences

Output: Yes/No binary result for the SPE occurrence if the input parameters are above a selected probability contour (28%, 28% and 23% for west, central, and east longitudes, respectively)

Warning time: 10 min after the ≥M2 SXR peak time

Forecasting ≥S2 events (≥100 pfu)

Same inputs and technique with the following modifications:
- selected probability contours at 35%, 28% and 23% for west, central, and east longitudes, respectively
- after the occurrence of a ≥M2 SXR burst, a warning is issued if the proton flux reaches the S1 threshold within 6/15/30 hr from the SXR peak time for west/central/east longitudes, respectively
- if the background is already at the S1 level at the time of the flare, a forecast is issued at the normal SXR peak + 10 min time
- the forecast applies to shock spikes leading ≥S2 storms as well

Model results: July 2017

Max proton flux = 22 pfu ⇒ S1 event

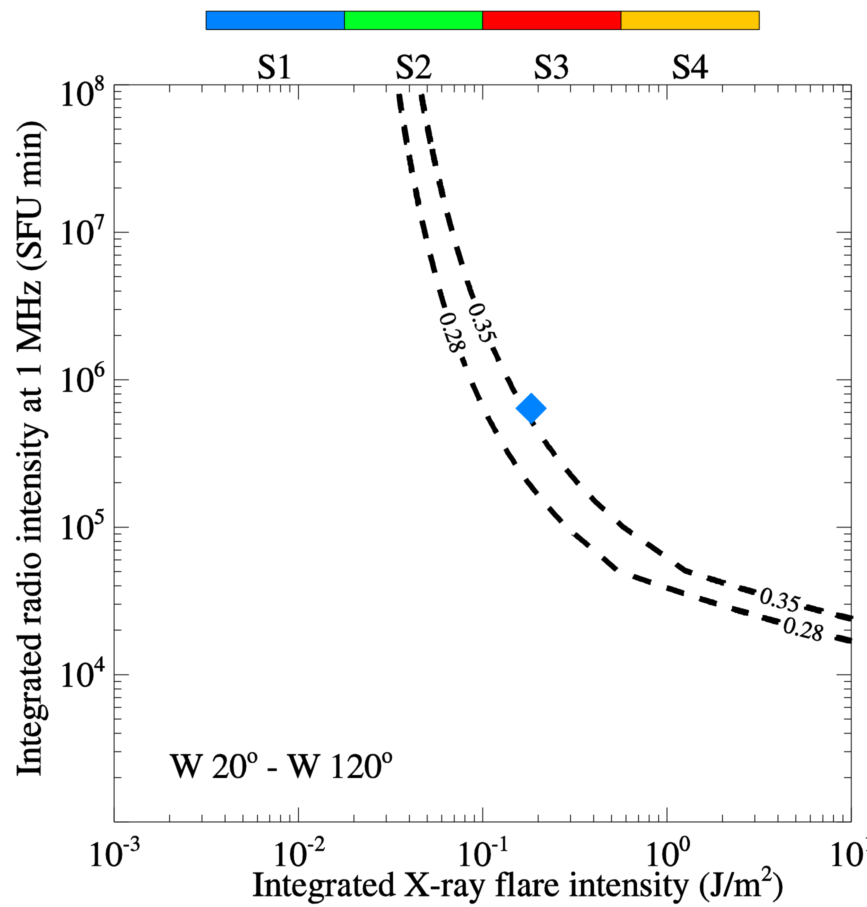
Evaluation of ESPERTA parameters

SXR fluence: X = 1.8 x 10^{-1} J/m^2
Radio fluence: R = 5.41 x 10^5 SFU min
Location: S06W29
Warning time: ~7 hr before the event onset

Model results

Hit S1 event
⇒ the (X,R) point is above the 28% probability contour

Correct null for ≥S2 model
⇒ the (X,R) point is above the 35% probability contour, but a warning is not issued because the S1 threshold is reached in 7 hr from the SXR peak time, which is greater than 6 hr time window required for west longitudes.



Discussion questions

- What aspects of the event does your model capture well, and what aspects were more difficult to capture?

Generally speaking, the basic inputs to the model (SXR fluence as a measure of flare size, 1 MHz radio fluence as an idicator of escaping particles, and flare location to take propagation effects into account) are sound and variants of these are necessary for any short-term model. The main innovation for the ≥S2 alerts was to delay forecasts until the S1 level was reached, which still provide an early warning for ≥S2 events.

Most difficult to capture are SEP events with weak solar antecedents. For these events more reliance will have to be placed on CME/shock parameters (e.g., CME speed / type II occurrence) which are difficult to capture given the timing constraint on forecasts.

Specifically, the model applied to the 14 July 2017 provides a lead time of about 7 hr and it captures the maximum intensity, as it is forecasted to remain an S1 event without reaching higher radiation levels.

The model could not be applied to the 10 September 2017 SEP event due to lack of WIND radio data.

Discussion questions

- What are the next steps for your modeling technique?

Use new radio data (e.g., STEREO data) to improve the forecast and make it operational in real time.

The delayed forecasts of ≥S2 events may allow more time to refine the flare SXR and radio fluences or, alternatively, to use CME/shock parameters instead.