

METHOD FOR SEP EVENT ONSET TIME UNCERTAINTY EVALUATION APPLYING POISSON-CUSUM COUPLED WITH BOOTSTRAPPING

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Onset times of Solar Energetic Particle (SEP) events are key information in relating the remote-sensing observations of a solar eruption to the in-situ measurements of the same phenomenon. Without precise knowledge of the onset time of an event, one can't identify the acceleration processes or the source region that set the high-energy stream of particles in motion. A limitation of several available methods to determine onset times is the lack of reasonable uncertainties for the quantity. The method presented here is a hybrid that employs Poisson-CUSUM (CUMulative SUM) and statistical bootstrapping.

The CUSUM methods are statistical quality control schemes that give an early warning if the process or variable under inspection diverges too far from the normal state. Poisson-CUSUM refers to the specific CUSUM method that assumes the monitored variable to be Poisson-distributed.

Our method chooses random samples from the pre-event background of SEP intensity-time profiles and uses them to create distributions of mean and standard deviation, which are the two critical parameters that CUSUM needs to identify the onset time. The two distributions of parameters thus yield a distribution of possible onset times, allowing one to statistically assess attributes of the distribution, such as mode, median and the standard deviation of the possible onset times. By further resampling the original data to coarser resolution and repeating the statistical bootstrapping analysis, we are able to see if and how the confidence intervals derived from these distributions change with varying time resolution, and especially if they seem to converge to a specific time interval. This underlying time interval is interpreted as a fundamental uncertainty to the onset of the event.

The uncertainty of the onset times in varying energies is directly connected to the uncertainty of Velocity Dispersion Analysis (VDA) results, which is a further motivator behind the development of this method.

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