Statistical analysis of solar energetic particle events

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Solar energetic particles (SEPs), which originate in powerful eruptions in the solar corona, give rise to critical radiation hazards for astronauts and airline passengers, causing damages to satellites, which result in serious societal impacts. The SEP phenomenon encompasses many cross-disciplinary fields, so collaborative research is indispensable. As a part of the Japanese space weather project PSTEP (Project for Solar-Terrestrial Environment Prediction), a Coordinated Data Analysis Workshop (CDAW) was held at Kyoto University in August 2018. As a first step toward building the capabilities to predict SEP events, we need to better understand what solar eruptions lead to SEP events of varying magnitudes. One approach, as adopted by this CDAW, is to start from energetic coronal mass ejections (CMEs) regardless of SEP occurrences, rather than from the actual SEP events. We first identified 197 CMEs between 2006 and 2017 that were faster than 900 km/s and wider than 60 degrees, as determined using data from SOHO/LASCO.

Our first objective is to characterize the basic properties of SEP events, such as the occurrence, proton flux intensity, and their time variations. We examined proton peak intensity, duration, and onset time with respect to the extrapolated CME onset time, using GOES >10-MeV proton data. STEREO LET and HET data were also analyzed to study the longitudinal distribution of the SEPs. We investigated the correlations of these SEP properties with the source longitude and speed of the CMEs, and soft X-ray intensity of the associated solar flares. We found that the SEP onset time is correlated with the source longitude of the CMEs. There were correlations between other parameters that we found in our statistical analysis, which will also be discussed. Finally, we will present examples of peculiar SEP events that were found as outliers in some scatter plots.

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