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Effects of Source Distribution on Propagation of Solar Energetic Particles in Three-dimensional Interplanetary Magnetic Fields

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Abstract: With a model of solar energetic particle (SEP) propagation in the three-dimensional interplanetary magnetic fields, we study how the characteristics of particle source on the sun, such as its location, coverage of latitude and longitude, and the spatial variation of source particle intensity, can affect both parallel and perpendicular diffusion of SEPs. From our calculations, we find that perpendicular diffusion mechanism plays a very important role. We show that the location and the longitudinal/latitudinal coverage of source particles have great effects on SEP flux and anisotropy profiles observed by a spacecraft. When a spacecraft is directly connected to the solar sources by the interplanetary magnetic field lines, the observed SEP flux tends to be larger than when the spacecraft is not directly connected. When a spacecraft is not directly connected to the particle sources, we find that on field lines with footpoints farther away from the source the observed flux usually gets smaller and its onset and maximum intensity occur later. Sometimes when the magnetic footpoint of spacecraft is too far away from the particle source, the anisotropy of particles in the early stage of a SEP event can point towards the Sun, which indicates that the first arriving particles come from outside of the observer through perpendicular diffusion at large radial distances. The observed particle flux is larger and its onset appears earlier if the particle source covers a larger range of latitude and longitude. There is east-west azimuthal asymmetry in SEP intensity profiles even when the source distribution is east-west symmetric. However, the detail variation of particle distribution inside the source does not very much affect the profiles of SEP flux and anisotropy.

Keywords: Sun: particle emission — Sun: coronal mass ejections (CMEs) — Sun: flares — Sun: magnetic fields — interplanetary medium