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Utilizing galactic cosmic rays as signatures of coronal mass ejections

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Coronal mass ejections (CMEs) are the most violent eruptions in the solar system. They are one of the main drivers of the heliospheric variability and cause various interplanetary as well as planetary disturbances. One of their very common in-situ signatures are short-term reductions in the galactic cosmic ray (GCR) flux (i.e. Forbush decreases), which are measured by ground-based instruments at Earth and Mars, as well as various spacecraft throughout the heliosphere (most recently by Solar Orbiter). In general, interplanetary magnetic structures interact with GCRs producing depressions in the GCR flux. Therefore, different types of interplanetary magnetic structures cause different types of GCR depressions, allowing us to distinguish between them. In the interplanetary space the CME typically consists of two structures: the presumably closed flux rope and the shock/sheath which is formed ahead of the flux rope as it propagates and expands in the interplanetary space. Interaction of GCRs with these two structures is modelled separately, where the flux-rope related Forbush decrease can be modelled assuming that the GCRs diffuse slowly into the expanding flux rope, which is initially empty at its center (ForbMod model). The resulting Forbush decrease at a given time, i.e. heliospheric distance, reflects the evolutionary properties of CMEs. However, ForbMod is not yet able to take into account complex, non-self-similar evolution of the flux rope. Nevertheless, Forbush decreases can undoubtedly give us information on the CMEs in the heliosphere, especially where other measurements are lacking, and with further development, Forbush decrease reverse modelling could provide insight into the CME evolution.