Precursors of geomagnetic storms observed by muon detectors

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We report the first systematic survey of cosmic ray precursors of geomagnetic storms. After eliminating events for which the muon detector network had poor coverage of the sunward IMF direction, we determined that 15 of the remaining 22 events (0.68) had identifiable cosmic ray precursors with typical lead times ranging from 5 to 10 hours prior to the Storm Sudden Commencement (SSC). The incidence of precursors increases with storm size; for instance 0.89 storms with peak Kp greater than or equal to 8.0 had precursors. Our results show that muon detector networks can be a useful tool in space weather forecasting.

We report the first systematic survey of cosmic ray precursors of geomagnetic storms. Our dataset comprises the 14 "major" geomagnetic storms (peak Kp  8–) identified by Gosling et al. (1990) together with 25 large storms (peak Kp  7–) observed from 1992 through 1998. After eliminating events for which the muon detector network had poor coverage of the sunward IMF direction, we determined that 15 of the remaining 22 events (0.68) had identifiable cosmic ray precursors with typical lead times ranging from 5 to 10 hours prior to the Storm Sudden Commencement (SSC). Of the 15 precursors, 10 were of the "loss cone" (LC) type which is characterized by an intensity deficit confined to a narrow pitch angle region around the sunward IMF direction. Cosmic rays in the loss cone presumably originate in the cosmic ray depleted region downstream of the approaching shock. The remaining 5 precursors were of the "enhanced variance" (EV) type which is characterized by intensity increases or decreases that do not systematically align with the IMF direction. The incidence of precursors increases with storm size; for instance 0.89 of storms with peak Kp greater than or equal to 8.0 had precursors. Our results show that muon detector networks can be a useful tool in space weather forecasting. However, new detector (s) installed to fill major gaps in the present network are urgently required for better understanding the nature of precursors and for reliable space weather forecasting.