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Event Study of a Persistent Coronal Hole, its Solar Wind Signatures at L1, and Recurrent Relativistic Electron Enhancements at Geostationary Orbit

Juan Rodriguez and Larisza Krista
Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, Colorado USA
(juan.rodriguez@noaa.gov)

Enhancements of relativistic electrons in Earth's radiation belts statistically exhibit a 27-day periodicity that is attributable to the interaction of corotating interaction regions (CIRs) with the Earth's magnetosphere. These CIRs are the interfaces between tenuous, high-speed solar wind streams (HSS) emitted by coronal holes (CH) and the denser, slower solar wind emitted from the quiet Sun (QS). At these stream interfaces (SI), the plasma is compressed, resulting in increased number density and magnetic field. Subsequent relativistic electron enhancements have been attributed to southward interplanetary magnetic field (IMF Bz). This includes southward Bz intensified within the CIR as well as southward Bz associated with Alfvenic turbulence in the following HSS. Although this chain of events is broadly accepted, few studies have studied in depth the evolution of a single persistent CH, its solar wind signatures at L1, and associated recurrent relativistic electron enhancements in the radiation belts.

During the second half of 2003, a persistent CH was observed in the northern hemisphere of the Sun. The resulting CIR caused recurrent enhancements in the relativistic electron fluxes observed by the GOES satellites. During these enhancements, the >2 MeV electrons increased from dropout (instrument background) levels to hazardous levels more than an order-of-magnitude greater than the NOAA SWPC alert level. Moreover, for the first time in Solar Cycle 23 (SC23) the >4 MeV electron fluxes exceeded 100 electrons/(cm**2 s sr). This happened in five recurrent extended relativistic electron enhancement events during this period. In context, only five such events with >4 MeV electron fluxes exceeding 100 electrons/(cm**2 s sr) occurred during the rest of SC23, and not in a recurrent fashion. Using this as a geoeffectiveness criterion, neither other CHs during this period, nor the coronal mass ejections (CMEs) in later October and November were as geoeffective as this persistent CH.

This paper addresses the question: how do the properties of this particularly geoeffective CH and its solar wind manifestations at 1 AU vary from rotation to rotation and how is it distinguished from less geoeffective CHs (and ICMEs) during the same period? The Coronal Hole Automated Recognition and Monitoring (CHARM; Krista and Gallagher, 2009) algorithm is used to identify CHs and to quantify their physical properties (e.g., boundary, area, magnetic field strength and polarity). The Minor Storm (MiSt) algorithm is used to link the CHs to their in situ signatures (e.g., IMF, velocity, number density, temperature) observed by the Advanced Composition Explorer (ACE) satellite. The properties of the CHs and associated geoeffective solar wind properties are evaluated and compared, as well as the Dst geomagnetic index. With these results, we determine whether any of the characteristics of the CHs and their in situ solar wind signatures distinguish them in their relative geoeffectiveness.