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Modeling the Magnetopause Shadowing Loss during the October 2012 Dropout Event

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The relativistic electron flux in Earth's outer radiation belt are observed to drop by orders of magnitude on timescales of a few hours, which is called radiation belt dropouts. Where do the electrons go during the dropouts? This is one of the most important outstanding questions in radiation belt studies. Radiation belt electrons can be lost either by precipitation into the atmosphere or by transport across the magnetopause into interplanetary space. The latter mechanism is called magnetopause shadowing, usually combined with outward radial diffusion of electrons due to the sharp radial gradient it creates. In order to quantify the relative contribution of these two mechanisms to radiation belt dropout, we performed an event study on the October 2012 dropout event observed by Van Allen Probes. First, the precipitating MeV electrons observed by multiple NOAA POES satellites at low altitude did not show evidence of enhanced precipitation during the dropout, which suggested that precipitation was not the dominant loss mechanism for the event. Then, in order to simulate the magnetopause shadowing loss and outward radial diffusion during the dropout, we applied a radial diffusion model with electron lifetimes on the order of electron drift periods outside the last closed drift shell. In addition, realistic and event-specific inputs of radial diffusion coefficients (DLL) and last closed drift shell (LCDS) were implemented in the model. Specifically, we used the new DLL developed by Cunningham [JGR 2016] which were estimated in realistic TS04 [Tsyganenko and Sitnov, JGR 2005] storm time magnetic field model and included physical K (2nd adiabatic invariant) or pitch angle dependence. Event-specific LCDS traced in TS04 model with realistic K dependence was also implemented. Our simulation results showed that these event-specific inputs are critical to explain the electron dropout during the event. The new DLL greatly improved the model performance at low L* regions (L*<3.6) compared to empirical Kp-dependent DLL [Brautigam and Albert, JGR 2000] used in previous radial diffusion models. Combining the event-specific DLL and LCDS, our model well captured the magnetopause shadowing loss and reproduced the electron dropout at L*=4.0-4.5. In addition, we found the K-dependent LCDS is critical to reproduce the pitch angle dependence of the observed electron dropout.