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Deep penetration of energetic electrons and ions into the low L region (L<4)

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Energetic electrons in the inner magnetosphere are distributed into two regions: the inner radiation belt and the outer radiation belt. The slot region in between separating the two belts is usually devoid of energetic electrons, while during geomagnetic active times energetic electrons can also penetrate into the slot region and even inner belt. The outer radiation belt is highly dynamic and usually attracts a lot of attention, while the inner radiation belt and slot region have been significantly neglected for the past several decades mainly due to limited observations. As the launch of Van Allen Probes, a number of new characteristics regarding electrons in the low L region have been unveiled, including the abundance of 10s-100s of keV electrons in the inner belt, the frequent deep penetrations of 100s of keV electrons, and 90°-minimum pitch angle distributions of electrons in the low L region. These observations show the complexity of energetic electron dynamics in the low L region which has not been well understood. Using multi-point measurements from the Van Allen Probes and other satellites, the deep penetration of energetic particles into the low L region is studied in detail. Features of deep penetration regarding energy dependence, timing, and MLT dependence are revealed through both case studies and statistical analysis. Comparative study of deep penetration of electrons and ions are also conducted and the underlying physical processes responsible for different behaviors of electron and ion deep penetration are examined. The measurements from the Van Allen Probes shed lights on the physical processes responsible for the energetic particle penetration into the low L region.