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The importance of energetic particle injections and cross-energy and -species interactions to the acceleration and loss of relativistic electrons in Earth's outer radiation belt (invited talk)

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Earth's radiation belts provide a natural laboratory to study a variety of physical mechanisms important for understanding the nature of energetic particles throughout the Universe. The outer electron belt is a particularly variable population, with drastic changes in relativistic electron intensities occurring on a variety of timescales ranging from seconds to decades. Outer belt variability ultimately results from the complex interplay between different source, loss, and transport processes, and all of these processes are related to the dynamics of the inner magnetosphere. Currently, an unprecedented number of spacecraft are providing in situ observations of the inner magnetospheric environment, including missions such as NASA's THEMIS and Van Allen Probes and ESA's Cluster and operational monitors such as NOAA's GOES and POES constellations. From a sampling of case studies using multi-point observations, we present examples showcasing the significant importance of two processes to outer belt dynamics: energetic particle injections and wave-particle interactions. Energetic particle injections are transient events that tie the inner magnetosphere to the near-Earth magnetotail; they involve the rapid inward transport of plasmasheet particles into the trapping zone in the inner magnetosphere. We briefly review key concepts and present new evidence from Van Allen Probes, GOES, and THEMIS of how these injections provide: 1. the seed population of electrons that are subsequently accelerated locally to relativistic energies in the outer belt and 2. the source populations of ions and electrons that produce a variety of ULF and VLF waves, which are also important for driving outer belt dynamics via wave-particle interactions. Cases of electron acceleration by chorus waves, losses by plasmaspheric hiss and EMIC waves, and radial transport driven by ULF waves will also be presented. Finally, we discuss the implications of this developing picture of the system, namely how variations in the flux of relativistic electrons in Earth's outer radiation belt are intricately tied to particle injections from the magnetotail, electrons and ions in the ring current, and the wave environment throughout the inner magnetosphere.