A New Method to Combine Spacecraft and Incoherent Scatter Radar Measurements to Examine Particle Precipitation Mechanisms

E. R. SANCHEZ[(1)], R. H. VARNEY[(1)], S.R. KAEPPLER[(1)], R. MARSHALL[(2)], J. BORTNIK[(3)], Q. MA[(3)]

(1) SRI International, 333 Ravenswood Ave., Menlo Park CA 94025

(2) University of Colorado, Boulder CO 80309

(3) University of California Los Angeles, Los Angeles CA 90095

One of the most challenging issues in radiation belt physics at the present time is identifying and understanding the physical processes that cause electron acceleration up to relativistic energies as well as loss out of the system. Current theories of particle precipitation assume that energetic particles in the magnetosphere precipitate into the atmosphere after suffering pitch-angle scattering into the loss cone due to interactions with plasma waves at or near the geomagnetic equator. However, the experimental verification of the effects of the multiple candidate waves on the particles' pitch-angle distributions has not been definitively established.

We present initial results from a method to address this outstanding issue. The method involves two independent tests of precipitation mechanisms applied for temporally coincident spacecraft measurements of particles and waves in the outer radiation belt (or ring current) and particle precipitation measurements near the ionospheric foot-point of the spacecraft obtained with the Poker Flat Incoherent Scatter Radar (PFISR). Demonstrating consistency or inconsistency between the PFISR observations and the loss-cone distributions calculated according to different candidate wave-particle interactions allows us to validate or invalidate wave modes involved in precipitation mechanisms.

The first step of our method is to calculate the loss-cone distribution functions determined by candidate wave-particle mechanisms for pitch-angle scattering using the quasi-linear diffusion equations. We apply the fully validated UCLA Full Diffusion Code to Van Allen Probe, ERG, MMS or THEMIS observations of particles and fields to quantify the changes in the phase-space distribution of electrons that are produced by the electric and magnetic wave fields in the frequency range from a few Hz to several kHz (EMIC to ECH range). The second step of our analysis is to compare the ionization profiles produced in the atmosphere by loss-cone distributions calculated from the quasi-linear diffusion code with the D-region ionization profiles directly measured with PFISR. This determination can be done in two independent ways: forward comparison and inverse comparison. In the forward comparison, the loss-cone distribution determined at the spacecraft is propagated to the top of the ionosphere. Forward electron transport models (Monte Carlo and GLOW with a D-region chemistry model) are used to predict the D-region ionization enhancements that can be directly compared with PFISR observations of ionization. In the inverse comparison, the distributions of precipitating particles at the top of the ionosphere are inferred from PFISR-measured electron density profiles and mapped back to the magnetosphere for comparison with the loss-cone distributions estimated from spacecraft measurements. We describe first results of the direct comparison for two events that occurred for moderate storms and discuss the implications of the results.