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Energetic electron loss process associating with oblique chorus emissions in the outer radiation belt

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Energetic electron acceleration and precipitation in the Earth's outer radiation belt are highly related to whistler mode chorus waves. We perform test particle simulations to investigate electron dynamics interacting with both parallel and oblique chorus emissions at L=4.5. We build up a database of the Green's functions for a large number of electrons interacting with whistler mode chorus emissions. The loss process of electron fluxes interacting with consecutive chorus emissions in the outer radiation belt is traced by applying the convolution integrals of distribution functions and the Green's functions. Oblique chorus emissions lead to more electron precipitation than that led by parallel chorus emissions. By checking the resonance condition and resonant energies at loss cone angle, we find that the nonlinear scattering via cyclotron resonance is the main process that pushes energetic electrons into the loss cone. Electrons are difficult to be scattered into the loss cone directly by Landau resonance, but Landau resonance helps electrons moving toward the loss cone. We propose a 2-step precipitation process for oblique chorus emissions that contributes to more electron loss: (1) During the first chorus emission, the nonlinear trapping of Landau resonance accelerates an electron close to the loss cone. (2) During the second emission, the nonlinear scattering of cyclotron resonance scatters the electron into the loss cone. The combination of Landau resonance and cyclotron resonance by oblique chorus emissions results in a higher precipitation rate than the single cyclotron resonance by purely parallel chorus emissions.