A self-consistent particle simulation of VLF triggered emissions

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A self-consistent particle simulation is carried out to investigate the generation mechanism of VLF triggered emissions. Recent studies have suggested that the triggering mechanism is deeply related to the nonlinear cyclotron resonance between narrow band whistler mode waves and energetic electrons. Both wave amplitude and wave frequency of coherent whistler mode waves are strongly affected by nonlinear resonant currents formed by resonant electrons in an inhomogeneous magnetic field. In the present study, generation and frequency variation of narrow band whistler mode waves are examined by a self-consistent particle code, and the role of resonant currents in the triggering mechanism is clarified. The evolution of a wave packet propagating along a reference magnetic field line is solved by Maxwell's equations while the bounce motion of energetic electrons in a non-uniform magnetic field is taken into account. By using Electron Hybrid Model, we simulate the nonlinear wave particle interaction between narrow band whistler mode waves in a cold plasma medium and energetic electrons having a loss cone distribution with a temperature anisotropy. Our model successfully reproduces the triggered emission with a rising tone. We find that the triggered emission is generated near the equatorial region after the wave packet passes through the magnetic equator. The simulation result shows 0.136 Ω_e rising from the frequency of the triggering wave packet (0.525 Ω_e). The generation process simulated in the present study is explained by the role of resonant currents related to an electromagnetic electron hole in the phase space, where an electromagnetic electron hole is formed by the nonlinear wave particle interaction between the triggering wave and energetic electrons. Especially, the simulation result suggests that the phase bunching of untrapped electrons is essential in the triggering mechanism.