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A 会場 ：11/7　 PM1 （13:45-15:30）
15:15～15:30

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Energetic electron precipitation induced by very oblique chorus waves in the Earth’s inner magnetosphere

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Electrons trapped in the Earth’s magnetic field can be scattered by whistler-mode chorus emissions and precipitate into the Earth’s upper atmosphere. Whistler mode chorus waves propagating in the Earth’s inner magnetic field are not always parallel or quasi-parallel to the magnetic field line. Sometimes the waves are observed with very large wave normal angles. We aim to figure out the relation between the large wave normal angles and electron precipitation. In this study, our target chorus emissions contain large wave normal angles, which are 90 percent of the resonance cone angle. We use test-particle simulation to trace the behaviors of electrons interacting with the waves and create a Green’s function set for electrons initially at kinetic energies 10-6000 keV and equatorial pitch angles 5-89 degrees. We also calculate the Green’s function sets for parallel and slightly oblique chorus waves for comparison. The simulation results show that the very oblique chorus waves contribute to more electron precipitation than the other two chorus wave models, especially at 50-100keV. At this range, the electron precipitation rates of the very oblique case are about 1.5 and 1.2 times those of the parallel and slight oblique cases, respectively. Checking the highest initial equatorial pitch angles of the precipitated electrons, we find that the very oblique chorus waves can precipitate electrons from greater than 45 degrees. In contrast, the other chorus waves can only precipitate electrons from less than 30 degrees. Furthermore, we theoretically derive the precipitation rate and verify that nonlinear trapping via the n=-1 anomalous cyclotron resonance contributes to effective electron precipitation in the very oblique chorus wave-particle interactions.