OBSERVATIONS AND ANALYSIS OF DISCRETE AND DIFFUSE WHISTLER MODE ECHOES RECEIVED BY RPI ON IMAGE

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We report on observations and analysis of discrete and diffuse whistler mode echoes received by RPI on IMAGE. Discrete whistler mode echoes have been identified on a number of days during the period when IMAGE was at low altitude (< 2000-6000 km) near its perigee in the southern hemisphere. The observed whistler echoes have frequencies below local electron cyclotron frequency. The echoes are in the frequency range ~13-300 kHz and show time delays of a fraction of a second, and longer time delays at lower frequencies, typical of whistler mode propagation. Out of the ~300 cases examined, discrete echoes were detected in 24 cases. Ray tracing simulations performed in a limited number of cases indicate that these echoes are the result of reflections of RPI signals from the Earth-ionosphere boundary. By comparing measured time delays of RPI signals with those from ray tracing simulations it is possible to determine (1) nature of propagation, i.e., ducted or nonducted, and (2) the electron density along the ray paths. In one case, 5 May 2000, when IMAGE was at an altitude of ~4000 km and invariant latitude of ~70 degrees, the ray tracing analysis leads to an electron density of ~800 el/cc at the satellite altitude (~ 4000 km) with a 1/R^4.5 dependence. These results indicate that whistler mode propagation analysis performed on discrete whistler mode echoes obtained on IMAGE at high latitude can be used to obtain improved electron density models in the high latitude magnetosphere. The diffuse whistler echoes have frequencies below local electron cyclotron frequency and are characterized by an apparent spread in their time delays. The echoes are in the frequency range ~10-300 kHz and show well defined lower and upper cutoff frequencies. Out of 35 cases examined, diffuse echoes were observed in 13 cases, with 9 of them identified during the period when IMAGE was at low altitude (<1500 - 5000 km) near its perigee in the southern hemisphere, and three when IMAGE was at relatively high altitude (~10,000 km) and at geomagnetic latitudes ranging between 40-50 degrees. In several instances, the diffuse echoes were accompanied by z-mode radiation and in some cases by free space mode echoes. The Z-mode radiation upper and lower cutoff are used to obtain local electron plasma frequency and gyrofrequency. We propose that diffuse whistler mode echoes are the result of scattering of RPI signals by field aligned small-scale (~10-100 m) plasma density irregularities, commonly found in the low altitude magnetosphere. A linear mode conversion mechanism, first proposed to explain spectral broadening of ground transmitter signals observed on satellites, can account for many observed features of these echoes including the diffuse nature and cutoff frequencies. The lower and upper cutoff and the time delay and its spread as a function of frequency can be used to determine the location and nature of plasma irregularities responsible for wave scattering.