Modeling of whistler amplification by energetic electrons observed on Siple

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Results from a numerical study of interactions between electromagnetic waves in the very-low-frequency (VLF) range (whistlers) and energetic electrons in the inner magnetosphere of the Earth are presented. This problem has been studied for more than four decades and one of the main focuses of these studies is generation of so-called secondary (triggered) emissions, which were observed in number of experiments conducted at the Siple station in Antarctica during 1970-1980. These experiments established that under certain conditions injected VLF signals trigger larger amplitude whistler waves and cause enhanced precipitation of the relativistic electrons. Although the basic features of the triggering process have been revealed, many important questions remain unanswered and require detailed numerical studies. To model interactions between whistlers and energetic electrons we use a hybrid fluid-particle model with two populations of electrons with different temperatures and densities and account for a broadband VLF spectrum. The simulation results show that the generation of secondary emissions with amplitudes significantly larger than that of the triggering signal is achieved when the distribution function of the energetic particles has a sharp gradient in the velocity space, which efficiently drives the instability. In this case small-amplitude triggering waves are amplified via cyclotron resonance interactions with the unstable part of the distribution. Therefore the shape of the distribution function and the energy of the hot electrons play very important roles in the amplification of the initial signal. In this study we are focusing on the reconstruction of the distribution function of energetic electrons which produces results closely matching the observation. Results from our simulations agree with some observations of amplification VLF signal launched from the Siple station in Antarctica and received in the magnetically conjugate point near Lake Mistissini.