Abstract. Ground-based VLF observations show evidence that strong whistler-mode waves in the magnetosphere are often stimulated by harmonic radiation from electrical power transmission lines. These stimulated emissions sometimes dominate the wave activity in the kHz range. A VLF transmitter at Siple, Antarctica has been used to simulate these power line effects with ~0.5 W radiated power at a given frequency. Occurrence statistics of power line effects are also summarized.

1. Introduction

Harmonic power line radiation (PLR) in the kHz range has been observed to stimulate strong wave-wave interactions in the magnetosphere (Helliwell et al., 1975; Park, 1977). As a result of such interactions, the PLR wave may be amplified by ~30 dB during one passage through the interaction region and when the intensity exceeds a certain threshold level, may trigger free-running emissions whose frequency may deviate from the stimulating PLR frequency by hundreds of Hertz or more. PLR waves also interact with other man-made or naturally-occurring waves by entraining them or cutting them off.

The amplified PLR waves and triggered emissions often echo from hemisphere to hemisphere inside whistler ducts. Each time these waves pass through the wave-particle interaction region near the equator, they may be further amplified or trigger new emissions, thus adding to the complexity of the spectra of received signals. It should be pointed out that without amplification, magnetospherically propagating PLR waves are usually below the threshold of detection on normal broadband spectrograms. When they are amplified up to detectable levels, the nonlinear amplification process results in frequency broadening that clearly distinguishes magnetospheric PLR from monochromatic induction lines originating in local transmission lines.

In the next section, we shall review several different spectral forms of PLR-induced wave activity in the magnetosphere, including some wave-wave interaction effects. In Section 3 we shall present some results from VLF transmitter experiments that were designed to simulate PLR effects. Section 4 summarizes the PLR statistics, followed by discussion and conclusion in Section 5.

2. Examples of PLR-Induced Wave Activity

PLR-stimulated waves in the magnetosphere show a variety of spectral characteristics, some of which are illustrated in this section. Figure 1 shows simultaneous records from
 conjugate stations Siple, Antarctica (76° S, 84° W) and Roberval, Quebec (48° N, 73° W). Line radiation is seen to alternate between the two stations with the whistler echo period.

Figure 2 illustrates another type of line radiation recorded at Siple and Roberval showing continuous lines at several frequencies. Roberval records show the contrast between sharp, local induction lines and magnetospheric lines that have been broadened and shifted upward by nonlinear amplification process. Helliwell et al. (1975) studied