MODELLING AND ANALYSIS OF SUBSTORM-RELATED CHORUS EVENTS OBSERVED AT SANAE

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ABSTRACT

The substorm-related chorus event (SCE) is a recognised VLF signature of the substorm expansion phase. Simulations support the contention that these events are generated by cyclotron resonance between whistler mode waves and energetic electrons which drift into a station's field of view from an injection site around midnight.

INTRODUCTION

Substorm-related chorus events [2] are VLF radio emissions confined to a band of frequencies increasing at rates in the range 10 to 1000 $\mathrm{Hz/min}$. A typical SCE is shown in Fig. 1(a). These events are predominantly detected in the midnight-dawn local time sector during periods of moderate to high geomagnetic activity. Observations of SCE's have been documented at a number of high-latitude stations including Halley, Siple, Roberval and SANAE; they have been recorded simultaneously at conjugate stations as well as by satellites near geosynchronous orbits.

The SCE is thought to arise from cyclotron resonance between whistler mode waves and energetic electrons injected into the inner magnetosphere at the onset of the magnetospheric substorm expansion phase. The guiding-centre motion of these particles is influenced by energy-dependent drift (due to the gradient and curvature in $\mathbf{B}$) and energy-independent $\mathbf{E} \times \mathbf{B}$ drift, where $\mathbf{E}$ is the dawn-dusk convection electric field. The former disperses the particles in energy, resulting in progressively higher resonance frequencies as lower energy particles enter the station's field of view. In addition, the $\mathbf{E} \times \mathbf{B}$ drift, which has an inward radial component in the midnight-dawn sector, causes particles to drift to lower L, resulting in higher upper cutoff frequencies for ducted whistler mode waves.

MODELLING

A simulation of particles moving under the combined drift motions mentioned above has been constructed. The magnetic field is represented as a dipole, which is not an unreasonable approximation during substorm expansion for the range of L under consideration. Particle tracks are started on an empirical injection boundary [1]. Data from the SOPA and MPA instruments on LANL geosynchronous satellites are used to estimate the injection time and parameters for the distribution used to sample initial particle energy. Frequencies are calculated for Doppler-shifted electron cyclotron resonance, and only those which lie below half the local electron gyrofrequency are retained.

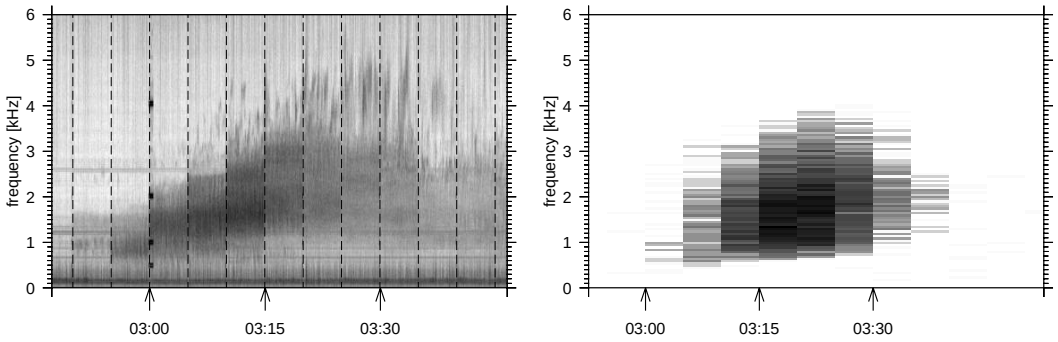
CONCLUSION

The simulation produces results which are in good qualitative and quantitative agreement with observed phenomena—see, for example, Fig. 1(b). Furthermore, an extended set of simulations indicate that the relative importance of the two drifts motions in determining the temporal evolution of the SCE is local time dependent.

References

[1] B. H. Mauk and C. E. McIlwain. Correlation of Kp with the substorm-injected plasma boundary. *Journal of Geophysical Research*, 79(22):3193–3196, August 1974.

[2] A. J. Smith, M. P. Freeman, and G. D. Reeves. Postmidnight VLF chorus events, a substorm signature observed at the ground near $L = 4$. *Journal of Geophysical Research*, 101(A11):24641–24653, November 1996.



(a) Spectrogram of synoptic (1-in-5) VLF recording.

(b) Simulated event.

Fig. 1: Substorm-related chorus event recorded at SANAE on 12 June 1994.