SEVEM

Survey of ELF and VLF Experiments in the Magnetosphere

References about Wave Models for the Magnetosphere

Meredith, N.P., R.B. Horne, R.M. Thorne, D. Summers, and R.R. Anderson, Substorm dependence of plasmaspheric hiss, *Journal of Geophysical Research*, **109**, A06209, doi:10.1029/2004JA010387, 2004.

CRRES data are used to look at the substorm dependence of plasmaspheric hiss (0.1 < f < 2 kHz) as a function of AE*, where AE* is the maximum value of the AE index in the 3 hours immediately prior to the observation. This study is relevant to modelling the acceleration and loss of relativistic electrons during storms and understanding the origin of the waves. The authors find that the plasmaspheric hiss amplitudes depend on spatial location and substorm activity, with the largest waves being seen during high levels of substorm activity. This survey of the global distribution of hiss indicates a strong day-night asymmetry with two distinct latitudinal zones of peak wave activity, primarily on the dayside. Equatorial hiss (ABS(MLAT) < 15 degrees) is strongest during active conditions (AE* > 500 nT), with an average amplitude of 40 ± 1 pT observed in the region 2 < L < 4 from 06 to 21 MLT. Mid-latitude hiss (15 < ABS(MLAT) < 30 degrees) is strongest during active conditions with an average amplitude of 47 ± 2 pT in the region 2 < L < 4 from 8 to 18 MLT but extending out beyond L = 6 from 12 to 15 MLT.

Meredith, N.P., R.B. Horne, R.M. Thorne, and R.R. Anderson, Favored regions for chorus-driven electron acceleration to relativistic energies in the Earth's outer radiation belt. *Geophysical Research Letters*, **30**, 16, 1871, doi:10.1029/2003GL017698, 2003.

Data from the CRRES spacecraft are used to produce global maps of the lower-band chorus magnetic field wave intensities and the important ratio fpe/fce as a function of L, MLT and magnetic activity and also as a function of x, GSM z, and MLT region for active conditions (AE > 300 nT). The purpose is to seek regions where high lower-band chorus activity coincides with regions of low fpe/fce since these regions are likely to be most effective in the acceleration of a seed population of electrons with energies of the order of a few hundred keV to relativistic energies. Outside of the plasmapause, both the lower-band chorus activity and fpe/fce are dependent on magnetic activity with regions of enhanced lower-band chorus and low fpe/fce occurring over a wide range of geospace during active conditions. Enhanced waves in these regions could play an important role in electron acceleration to relativistic energies during periods of prolonged substorm activity.

Darrouzet, F., W. N. Spjeldvik, J. F. Lemaire, G. Gustafsson, C. Hann, and C. Dyck, Towards statistical and empirical models of the distribution of VLF waves at high latitude from the observations of the Viking spacecraft, *Advances in Space Research*, **32/3**, 323-328, 2003.

The V4H experiment of the Swedish Viking spacecraft is used to make statistical models of the electrostatic power spectral density in the VLF band (10-46 kHz) in the high-latitude region in the northern hemisphere. The highest wave energy are found preferentially at low frequencies (10-19 kHz) and at relatively low altitudes (less than 5000 km).

André, R., F. Lefeuvre, F. Simonet, and U. S. Inan, A first approach to model the low-frequency wave activity in the plasmasphere, *Annales Geophysicae*, **20**, 981-996, 2002.

Magnetic field data from the Plasma Wave Instrument onboard the Dynamic Explorer 1 spacecraft are used to model the average spectrum amplitude of waves in the 1Hz-500kHz frequency band, as a function of the spatial position (MLT, -30° < Mlat < 30° and 1 < L < 5) and the magnetic activity (Kp < 3 and Kp > 3).

Fraser, B. J., and T. S. Nguyen, Is the plasmapause a preferred source region of electromagnetic ion cyclotron waves in the magnetosphere?, *Journal of Atmospheric and Solar-Terrestrial Physics*, **63**, 1225-1247, 2001.

Magnetic field data from the AFGL magnetometer onboard CRRES are used to study the occurrence of the electromagnetic ion cyclotron (EMIC) waves in the plasmasphere to compare with the plasmapause location. This indicates that the plasmapause is a region of wave generation and propagation, but not necessarily the preferred region.

Kasahara, Y., T. Hosoda, T. Mukai, S. Watanabe, I. Kimura, H. Kojima, and R. Niitsu, ELF/VLF waves correlated with transversely accelerated ions in the auroral region observed by Akebono, *Journal of Geophysical Research*, **106**, 21123-21136, 2001.

ELF wave data from the spacecraft EXOS-D (Akebono) from February 1989 to December 1998 are used to make a statistical study of the electrostatic broadband noise at all local time in the auroral region and in function of Kp-index. The authors show that the intensity is larger in the cusp than it is in the nightside, and it is largest in winter and weakest in summer.

Meredith, N. P., R. B. Horne, and R. R. Anderson, Substorm dependence of chorus amplitudes: Implications for the acceleration of electrons to relativistic energies, *Journal of Geophysical Research*, **106**, 13165-13178, 2001.

Data from 939 orbits of the CRRES satellite are used to study chorus emissions as a function of substorm activity (as measured by AE). The chorus amplitudes are divided into two frequency categories - upper-band (0.5fce < f < fce) and lower-band (0.1fce < f < 0.5fce). The amplitudes in these two bands are shown as a function of magnetic local time, L-shell and AE index for equatorial (chorus observed within 15 degrees of the equator) and high-latitude (chorus observed from 15 degrees to 30 degrees of the equator) chorus. In addition, the chorus amplitudes are shown as a function of magnetic latitude, L-shell and AE index for two local time sectors (21:00 -> 06:00 MLT and 06:00 -> 15:00 MLT).

Erlandson, R. E., and A. J. Ukhorskiy, Observations of electromagnetic ion cyclotron waves during geomagnetic storms: Wave occurrence and pitch angle scattering, *Journal of Geophysical Research*, **106**, 3883-3895, 2001.

Dynamics Explorer 1 data from 1981 to 1991 are used to make a statistical analysis of the electromagnetic ion cyclotron (EMIC) waves in the region 3.5 < L < 5 as a function of the geomagnetic storm activity. This indicates that EMIC waves in the equatorial magnetosphere occur 5 times more often during magnetic storms than during quiet times. The authors show also the simultaneous occurrence of EMIC waves and enhanced proton fluxes in the loss cone.

Lakhina, G. S., B. T. Tsurutani, H. Kojima, and H. Matsumoto, "Broadband" plasma waves in the boundary layers, *Journal of Geophysical Research*, **105**, 27791-27831, 2000.

Data from Geotail, Polar and FAST are used to describe the main characteristics and the possible generation mechanisms of the broadband plasma waves (with frequency of 1 Hz) observed in different boundary layers (magnetopause, plasma sheet and polar cap).

Meredith, N. P., R. B. Horne, A. D. Johnstone, and R. R. Anderson, The temporal evolution of electron distributions and associated wave activity following substorm injections in the inner magnetosphere, *Journal of Geophysical Research*, **105**, 12907-12917, 2000.

CRRES satellite data are used to map electron cyclotron harmonic (ECH) wave amplitudes in the equatorial region 3.8 < L < 7. Both ECH and whistler mode amplitudes are seen to be enhanced following substorm injections and have different behaviour and property in the regions 3.8 < L < 6 and 6 < L < 7.

Zhang, Y., H. Matsumoto, and H. Kojima, Whistler mode waves in the magnetotail, *Journal of Geophysical Research*, **104**, 28633-28644, 1999.

The magnetic waveforms captured onboard Geotail show frequently whistler mode waves in the magnetotail. They are narrowband and short-lived. Their frequencies range mainly from 0.05 to 0.5 times the electron cyclotron frequency.

Green, J. L., and S. A. Boardsen, Confinement of nonthermal continuum radiation to low latitudes, *Journal of Geophysical Research*, **104**, 10307-10316, 1999.

4 years of Hawkeye satellite data are used to map the latitudinal distribution of plasma wave nonthermal continuum radiation (at frequencies between 5 and 110 kHz). The resulting map clearly identifies the source region of the nonthermal continuum radiation, which are mostly confined at low latitudes.

Erlandson, R. E., and L. J. Zanetti, A statistical study of auroral electromagnetic ion cyclotron waves, *Journal of Geophysical Research*, **103**, 4627-4636, 1998.

Freja satellite data are used to form a statistical study of narrowband auroral electromagnetic ion cyclotron (EMIC) waves. The authors found that the EMIC wave occurrence peaked in the premidnight sector at auroral latitudes.

Parrot, M., World map of ELF/VLF emissions as observed by a low-orbiting satellite, *Annales Geophysicae*, **8**, 135-146, 1990.

2 years of Aureol-3 satellite data are used to map ELF and VLF emissions (at frequencies between 10 Hz and 15 kHz) at low altitudes onto a `world map'. Using geomagnetic coordinate representations, the author show that ELF hiss is maximum between 6 and 20 MLT and in the invariant latitude range 50° - 70°.

Saito, H., T. Yoshino, and N. Sato, Narrow-Banded ELF Emissions over the Southern Polar Region, *Planet Space Science*, **35**, 745-752, 1987.

One extensive statistical investigation is made, using ISIS 1 and 2 satellite data from 1122 orbits over the southern auroral region, to map the distribution of narrow-banded ELF emissions. The authors found that emissions mostly occurred during premidnight hours and in the region 65°-75° invariant latitude.

Tsurutani, B. T., and E. J. Smith, Two Types of Magnetospheric ELF Chorus and Their Substorm Dependences, *Journal of Geophysical Research*, **82**, 5112-5128, 1977.

OGO 5 satellite data are used to examine the mapping of ELF magnetospheric chorus events. The authors found that the chorus events occur principally near the equator and at magnetic latitudes above 15°.

Hughes, A. R. W., T. R. Kaiser and K. Bullough, The frequency of occurrence of VLF radio emissions at high latitude, *Space Research*, **XI**, 1323-1330, Akademie-Verlag, Berlin 1971.

General statistics of occurrence of VLF radio emissions at high latitudes are shown for data recorded onboard Ariel 3 at frequencies 3.2 and 9.6 kHz. The authors showed that emissions occur at all magnetic local times, but are most frequently observed at midnight and in the early afternoon. There is a minimum in occurrence at about 68° invariant at all MLT.

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