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Remote sensing of plasma density fluctuations and wave source characteristics by means of chorus waves multi point phase correlation analysis: Cluster and THEMIS measurements

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We present the case study of multi spacecraft observations of the whistler wave emissions in the outer Earth magnetosphere near the geomagnetic equator. The Cluster project WBD data and THEMIS project Electric Field Instrument (EFI) and Search Coil Magnetometer (SCM) measurements were used to determine the spatial correlation scale of the chorus source region. We analyze simultaneous observations of the same chorus elements registered onboard four THEMIS spacecraft in 2007 when all the spacecraft were on the same orbit and onboard four Cluster spacecraft during 2001-2002. The transverse to the background magnetic field cross spacecraft distances were from 200 to 6000 km.
The events chosen for analysis satisfy the conditions allowing the estimation of the chorus generation region spatial scale. The electron density fluctuations correlation scale is found to be much smaller then the chorus source region scale. The quasi-longitudinal to magnetic filed propagation gives rise to an opportunity for distinguishing the parallel and transverse perturbation scales and estimating the distance to the source along the magnetic field.
The discrete chorus elements were observed in the frequency range 0.15—0.25 of the local electron gyrofrequency that is typical for the outer magnetosphere. The field-aligned Poynting flux of whistler emissions shows that they propagate along the magnetic field lines in the direction away from the magnetic field minimum that is consistent with the waves being generated there. The averaged amplitude correlation analysis allows to estimate the characteristic spatial half-width of the source region transverse to the local magnetic field to be about 2800—3200 km. The correlation scale of electromagnetic permeability and corresponding electron density fluctuations are estimated in the frame of geometrical optics approximation. The phase cross correlation time dependence gives correlation scale from 250 to 500 km transverse to the local magnetic field. The increasing of the fluctuation correlation scale with the geocentric distance is found. The distance to the source region is found to vary from 400 to 2000 km. From this one can suggest that the source can move with the characteristic velocity about 1—2 thousands km/sec along the magnetic field line.