Numerical Modeling of ULF Waves in Earth's Magnetosphere: Ionospheric Effects

Robert L. Lysak (1), Yan Song (1), Colin L. Waters (2), Murray D. Sciffer (2)
(1) School of Physics and Astronomy, University of Minnesota, Minneapolis, MN 55455
(2) University of Newcastle, Callaghan, NSW, Australia

Ultra-low-frequency (ULF) waves are a major means to transport energy through the magnetosphere and play an important role in energization and transport of radiation belt particles. In the inhomogeneous inner magnetosphere, ULF waves frequently are affected by the density structure of the magnetosphere as well as by the ionospheric boundary conditions. Inhomogeneities in the density couple the fast mode with the shear Alfvén mode, particularly at sharp boundaries such as the plasmapause. We have developed a new three-dimensional numerical code using a spherical geometry to describe the propagation of ULF waves in the inner magnetosphere. This model covers the entire inner magnetospheric region within 10 Earth radii, and allows for the variation of plasma parameters as a function of local time. This model includes a height-resolved ionosphere with parameters that vary with solar illumination and particle precipitation. The location of the subsolar point can be varied so that conditions during solstice can be compared with equinox conditions. We compare the excitation of field line resonances and cavity modes on the dayside due to interplanetary shock excitation with nightside Pi2 waves driven by dipolarization events during magnetospheric substorms. A special case of field line resonances occurs near the terminator during solstice conditions when one end of the field line is sunlit while the other end is in darkness. Under these circumstances, quarter-wave modes can result in which one end of the field line is a node of the electric field while the other end is an antinode. The model results compare favorably with observations from the Van Allen Probe satellites as well as fields measured by ground magnetometers.