Observed Propagation Route of VLF Transmitter Signals in the Magnetosphere

Lunjin Chen*, Zhenxia Zhang, and Zhiyang Xia
Department of Physics, University of Texas at Dallas, Richardson, TX, 75080

Signals of powerful ground transmitters at various places have been detected by satellites in near-Earth space. The study on propagation mode, ducted or non-ducted, has been attracting much attentions for several decades by numerous observations and simulations. Based on the combination of statistical results from Van Allen Probes (nearly five year period from Oct. 2012 to Mar. 2017) and DEMETER satellite (from Jan. 2006 to Dec. 2007), we present the ground transmitter signals distributing clearly both in ionosphere and magnetosphere, with deviation from the field lines corresponding to ground stations. For the first time we have constructed the signal propagation route projected in respective meridian plane of nine stations (NWC, GQD, NDT, NAA, NPM, DHO, HWU, NLK and NLM).

Ray tracing simulation reproduces the observed propagation route. Our ray tracing simulation has greater advantages in that we use observed spatially-broad source instead of hypothetically a single point sources, and that more realistic IGRF field than dipole magnetic field is adopted. The agreement of propagation characteristics between satellite observation and ray tracing simulation demonstrates that the propagation of VLF ground-based transmitters in magnetosphere is strongly prone to be nonducted wave. This work not only provides observed ground transmitter signal intensity distribution but also answers the question of the ducted or non-ducted propagation mode in magnetosphere. Our findings not only enable accurate quantification of the role of VLF ground transmitters in the radiation belt electron loss, but also take significant role in the many research fields, including human adjustment of the trapped electron population and long distance communication.