F-region Magnetospheric ULF Generation by Modulated Ionospheric Heating

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Current modulation of D/E region ionospheric currents at ULF frequencies results in generation of Shear Alfven Waves injected upwards and guided by the magnetic field lines towards the conjugate ionosphere. Under particular ionospheric conditions frequencies in the PC1 range (.2-6Hz) are reflected by the gradient in the Alfven velocity above the F-region resulting in the well-known Ionospheric Alfven Resonator (IAR) structure. Ground detection of ULF waves due to current modulation on the ground is thus limited to the vicinity of the heated spot since at these frequencies the coupling to the earth ionosphere waveguide is evanescent. Propagation of ULF waves at significant lateral distances requires generation of magnetosonic waves since they are the only mode that propagates isotropically and can thus couple efficiently in the Alfvenic duct. In this paper we present a completely new mechanism to generate magnetosonic waves by modulated ionospheric heating that does not require the presence of electrojet currents. The process relies in anomalous electron heating near the F-region peak by preferably using O-mode upper hybrid heating modulated at ULF Pc-1 frequencies. The modulation in the electron pressure drives a $\mathbf{B}\times\nabla\mathbf{p}$ oscillatory current. The resultant field aligned magnetic moment generates predominantly magnetosonic waves that are injected laterally into the Alfvenic duct and can also detected above the F-peak by over-flying satellites over distances larger than spanned by the field lines connecting to heated area. In addition to the concept and analytic results the paper will present simulations results using the ZEUS-MP MHD. Non-uniform grids are used to adapt to non-uniform ionospheric plasma density and thin layer of heating source. The effective heating region is placed at about 200-300 km in altitude (F-layer ionosphere). The modulated heating source is modeled as a source with perturbed density, temperature and magnetic field and it transmits modulated-HF electromagnetic waves into a stable ionosphere. Ratios of perturbed magnetic field and density to their background values are extracted from simulations. Different radiation patterns from different polarization component of magnetic field perturbation are investigated. Effects of different profiles of non-uniform ionospheric plasma density on ULF wave propagation are also studied through simulation. Preliminary experimental evidence of the process will also be presented.