

VLF Transmitter Signals Observed by the DEMETER Spacecraft: Doppler Shifts and Effects on the Ionosphere

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We investigate very low frequency (VLF) transmitter signals observed by the low-altitude DEMETER spacecraft and their effects on the nearby ionosphere. First, we focus on the NWC transmitter radiating at 19.8 kHz, which is one of the most powerful transmitters over the world. Despite a normally continuous operation, the transmitter was off during the second half of 2007. We use this to evaluate the ionospheric effects of the transmitter by comparing the situation during the times when it was on with the corresponding times when it was off. We demonstrate that, as a result of the transmitter operation, the mean plasma density at the spacecraft altitude remains nearly unchanged and the mean electron temperature only slightly increases. However, significant small-scale perturbations of these quantities are induced. Second, we investigate the observations of Alpha navigation transmitters radiating with a specific coding at frequencies of 11.9, 12.6, and 14.9 kHz. We show that the frequencies of the signals observed in the conjugate hemisphere may depart significantly from the radiated frequencies due to a Doppler shift. This allows us to estimate wave normal angles upon the wave arrival to DEMETER. A raytracing analysis is used to obtain wave trajectories matching the observations.