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Artificial Ionospheric Perturbations Studied During HAARP May-June 2014 Campaign

Abstract:
Preliminary results of the HAARP HF heating campaign in May-June, 2014 concerning (i) Doppler (phase) sounding of the ionosphere heated volume and (ii) some features of the stimulated electromagnetic emission (SEE) are presented. On June 4 at about 16:00 AST several 2 min long pumping sessions were run as follows. During the 30 second of a long quasi-continuous pumping, high duty cycle pulse (pulsewidth t = 70 ms, interpulse period (IPP) T = 100 ms) was radiated vertically at the frequency f0=5.5 MHz. Simultaneously, short (20 μs) pulses with the same IPP and effective radiated power (~400 MW) at two frequencies fDW = f0 and fDW = f0 – 200 kHz were used for probing structure of the perturbed ionospheric region. The low duty cycle was used during the whole 2 min session including 30 s of the quasi-continuous pumping. During the pumping, the short pulses were radiated within 30 ms pauses. The power of the sounding transmitters was sufficient to create a wide spectrum of diagnostic waves (up to 300 kHz for each transmitter), with an average power far below the thresholds of the generation and maintenance of the pump-induced ionospheric plasma instabilities. The use of broadband radio receiver and specially developed signal processing algorithms have allowed the study of the evolution of amplitude and phase of the various spectral components of the reflected probing signals, which passed the perturbed region twice, in a wide (totally ~500 kHz) band. Similar experiments but with lesser ERP were run earlier at the SURA facility. It was found that after pump wave turns on, plasma is pushed out from the perturbed region near the wave reflection point. Later, after 10-15 s, the plasma expulsion stops, but much stronger expulsion occurs near the upper hybrid height of the pump wave. The relative expulsion reached 1-1.5% and disappeared in ~15s after pump wave turns off. The results obtained are compared with the temporal evolution of different SEE spectral features. (ii) The SEE spectral feature called Broad Downshifted Emission (BDE) was studied during nighttime (near 00:00 AST) with the pump frequency sweep in the range 5.46 – 5.66 MHz. According to the SEE spectrograms, the 4th electron gyroresonance occurred at f0=4fce=5.60 MHz, which corresponds to the altitude ~ 270 km. The BDE was first detected in 2011 campaign and found to be in the frequency range fBDE – f0= – (50–180) kHz. In the experiment described, the BDE appeared for the pump frequencies below 4th electron gyroharmonic, and the BDE peak position approaches to the pump frequency as the pump frequency approaches to the gyroharmonic according to fBDE - f0 ≈1.2(f0 – 4fce) – 36 kHz.

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