

HF, Scintillation and TEC Measurements using CASSIOPE/ePOP Overpasses above HAARP

The Canadian CASSIOPE satellite that carries the Enhance Polar Outflow Probe (ePOP) suite of plasma diagnostic instruments is ideally suited to study the effects of high power HF waves on the ionosphere. The ePOP sensors were operated in coordination with the High-Frequency Active Auroral Research Program (HAARP) Facility in campaigns in 2014 and more recently in 2017. CASSIOPE/ePOP carries both a Radio Receiver Instrument (RRI) capable of measuring the in-situ HAARP HF transmissions and a Coherent Electromagnetic Radio Tomography (CERTO) used to measure ionospheric Total Electron Content (TEC) and Scintillations of VHF, UHF and L-band signals. CASSIOPE/ePOP was launched into an elliptical Low-Earth Orbit with perigee of ~326 km, apogee of ~1470 km, and inclination of ~80.1°. The orbit allows for overpasses of the HAARP facility on a regular basis. CERTO receivers near HAARP recorded scintillation and Total Electron Content (TEC) on the propagation between ePOP and the ground during the 2014 HAARP operations. Most interesting is a pass where the TEC increased by 2-TECU (1016 m²) as the satellite crossed directly over the disturbed region. During this pass the 150 MHz VHF signal suffered phase scintillations of up to 18 Radians and amplitude scintillations of up to 25 dB while the 400 MHz VHF signal recorded amplitude scintillations of 20 dB.

The measurements reported here are accompanied by in-situ measurements of the HAARP HF by the RRI on ePOP and numerous ground-based diagnostics including the HAARP Ionosonde and measurements of Stimulated Electromagnetic Emissions (SEE). The combination of these diagnostics gives us insight into the interactions that are occurring in the disturbed region. We will discuss the ePOP HF, scintillation and TEC measurements and their implications.

The HAARP facility has been transferred to the University of Alaska Fairbanks (UAF) and the February 2017 campaign was the first operation by UAF. A new heating mode was attempted where HAARP was operated near gyro-frequencies with Frequency Modulation Continuous Wave (FMCW) similar to operations of Over the Horizon Radars (OTHR). In some cases enhanced SEE was observed with this mode of operation.

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