Transionospheric Oblique Sounding using Ground Transmitters with the Radio Receiver Instrument on CASSIOPE/e-POP

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Introduction

The Radio Receiver Instrument (RRI) is part of the enhanced Polar Outflow Probe (e-POP) payload on the Canadian Smallsat CASSIOPE [1], which is in an elliptic 325 x 1500 km orbit inclined at 81°. The RRI is a four-channel digital receiver fed by four 3-metre monopoles, arranged in a crossed configuration, each connected to a high input impedance preamplifier. The RRI total bandwidth extends from 10 Hz to 18 MHz. The receiver measures the electric fields of either spontaneous waves or waves created by ground transmitters, such as ionosondes, radars or ionospheric heaters. In order to accurately measure pertinent parameters of such waves over the broad frequency range, modern digital receiver technology is employed. The amplified signals from the monopoles are digitized at a rate of 40 megasamples per second, and from there on, the signal is down-converted, filtered, time-stamped and communicated purely in digital form [2,3]. The scientific objectives of RRI experiments are to improve understanding in the following areas: (1) the morphology and dynamics of density structure in the ionosphere**;** (2) the generation of spontaneous radio emissions created by auroral processes*;* and (3) the nonlinear plasma physics of the HF-modified ionosphere.

Transionospheric Propagation Results

Given the purview of Sessions GH02 and GH03 at this meeting, we report on results pertinent to objective (1). Waves from HF transmitters on the ground have been observed with RRI when CASSIOPE made an orbital pass through the ionosphere near a transmitter. The objective has been to measure four basic quantities of the waves: the magnitude of the electric field **E**, the Doppler frequency shift, the direction of arrival (DOA) and the signal-delay time. We wish to apply these measurements to "imaging" ionospheric density structure that also produces backscattered or reflected signals at those ground locations. To start, we are investigating observations of direct ground to satellite propagation. We liken the series of connecting transionospheric rays obtained during an overpass at fixed frequency to the collection of rays obtained with a conventional point-to-point oblique sounder as frequency is swept.

Fixed-frequency signals from different HF ground transmitters have been received by RRI. The first such transmission was from the Saskatoon SuperDARN coherent scatter radar at 14.01 MHz on November 7, 2013. The unique eight-pulse sequence of the Saskatoon SuperDARN radar was clearly observed throughout the pass. In addition, the RRI has also received signals from the SPEAR and EISCAT ionospheric heaters on other occasions. A preliminary comparison between some parameters of the signal received by the RRI (e.g., time delay, signal strength, and differential mode delay) and ray tracing simulations of the same parameters shows good agreement. Further analysis of these and future passes using different transmitter frequencies will provide both a better understanding of capabilities of this type of experiment and a method of measuring ionospheric parameters.

References

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