The International Beacon Satellite Symposium *BSS2010*
P. Doherty, M. Hernández-Pajares, J.M. Juan, J. Sanz and A. Aragon-Angel (Eds)
Campus Nord UPC, Barcelona, 2010

A COMPARISON OF GROUND RECEIVERS FOR RADIO BEACON MEASUREMENTS OF IONOSPHERIC MODIFICATION BY THE CARE CHEMICAL RELEASE FROM A ROCKET

PAUL A. BERNHARDT*, CARL L. SIEFRING*, MATT WILKENS*, ROBERT LIVINGSTON†, CHUCK RINO° AND MAMORU YAMAMOTO+

*Plasma Physics Division, Naval Research Laboratory
Washington, DC 20375
†Scion Associates, Port Townsend, WA

°Chuck Rino Associates, Palo Alto, CA

+RISH, Kyoto University, Japan

Key words:

Abstract.

On 19 September 2009, the Charged Aerosol Release Experiment (CARE) used a 330 kg solid rocket motor to modify the ionosphere with 110 kg of Al2O3 dust particles and 220 kg of molecules including H2, H20, C02, CO, N2, and HCl. The rocket payload carried a Coherent Electromagnetic Radio Tomography (CERTO) beacon operating with continuous wave transmissions at 150 and 400 MHz. Three types of beacon receivers were used to receive the beacon signals that were converted into total electron content (TEC) and amplitude fluctuation measurements. The ITS30 receiver from North West Research Associates, Inc. used analog technology to lock on to the beacon signals and provide differential phase measurements proportional to TEC. The GNU Radio Beacon Receiver (GRBR) receiver provided by Kyoto University uses one down converter stage and digital sampling to provide complex amplitude data for the received beacon signals. The SCION-3 receiver with hybrid (Analog/Digital) open-loop tracking of the beacon signals was also used to record the complex amplitudes from the rocket-borne radio beacon.

The analysis of the CARE data was complicated by the 3 to 4 Hz spin of the rocket that introduced a constant frequency offset to the signals at the ground receivers. This spin was seen as a constant phase rate enhancement in the differential phase provided by the receiver outputs. Once the spin frequency shift is removed from the measurements, each of the three receivers has provided good measurements of TEC from the rocket showing the effects of the chemical release. The sample results from the ITS30 are illustrated in Figure

1. The slant TEC is converted into equivalent vertical TEC and then differentiated with respect to rocket altitude to provide a good representation of the background electron density profile in all regions except where the chemical release occurred. The advantages of an analog receiver for this type of experiment are that the data storage is minimized and the TEC is available with minimum processing. The primary disadvantage the fully analog receivers is that if the receiver fails to lock on the beacon, the data are lost. The advantage of the software based receivers is that the raw in-phase and quadrature-phase data is stored for future processing and data optimization. The disadvantages are large storage requirements for raw sampled signals and the amount of post processing need to extract TEC for the observations.

After TEC was obtained from the three receivers located at widely separated ground sites, the data were combined to reconstruct a 3-D image of the ionospheric disturbance produced by the CARE release. This reconstruction is compared with independent measurements by the Millstone Hill incoherent scatter radar located 1000 km to the north of the release.

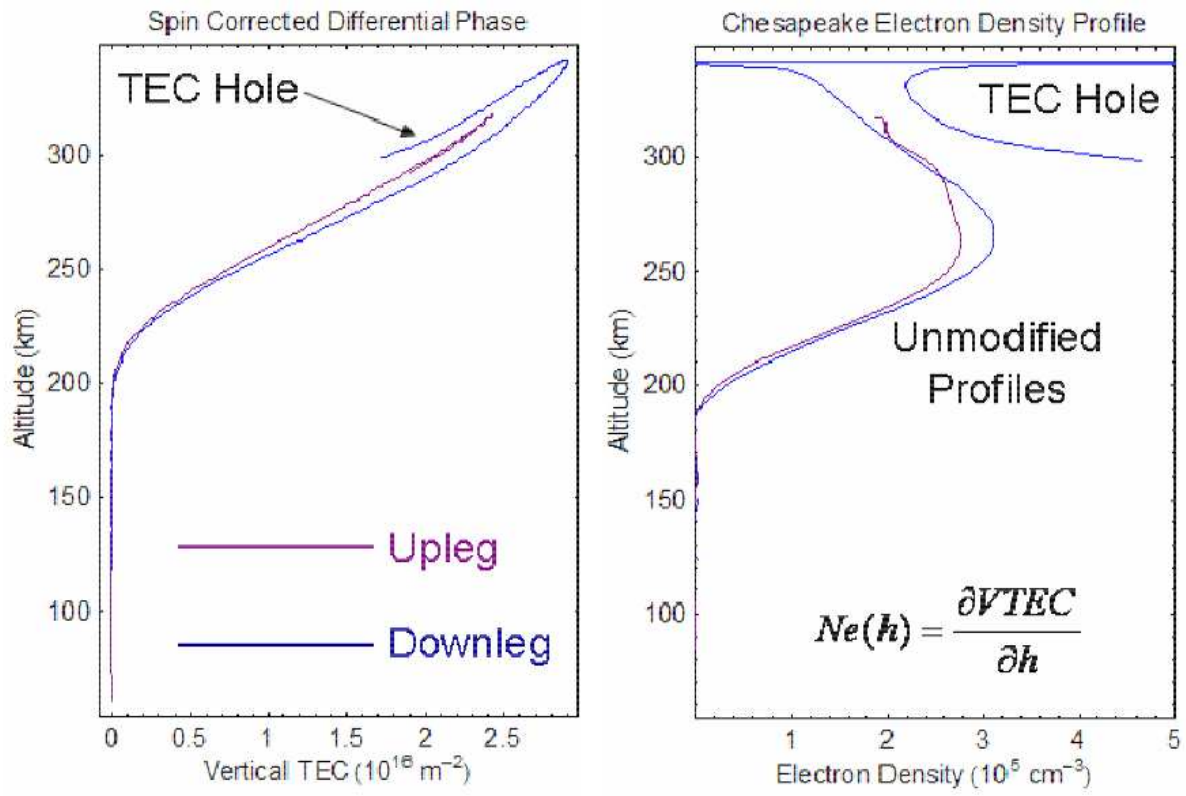

Figure 1: Data products derived from radio beacon differential phase assuming horizontal stratification.