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Session 4B Paper 1
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The International Heating Experiments (HEX) Campaign at Arecibo

The primary objective of the Heater Experiments (HEX) Campaign was to detect artificial ionospheric irregularities generated with the Arecibo HF transmissions. From 13 to 19 March 2017, a multi-institutional mission was conducted using the HF Facility at Arecibo, Puerto Rico and a large number of supporting diagnostics. With transmitter powers up to 450 kW, the 300 meter dish was used to beam 5.1 and 8.175 MHz into the ionosphere over the Arecibo Observatory. Multiple radio sensors islands in the Caribbean recorded the effects of the high power radio waves to create density changes and irregularities in the F-Layer ionosphere. Ground HF receivers on Trinidad, Culebra, and Puerto Rico recorded transmissions from the over-the-horizon (ROTHR) sites located in Virginia, Texas and Puerto Rico. HF beams from Virginia and Texas were place directly over Arecibo to detect the artificial changes in the ionosphere. Omni azimuth transmissions from ROTHR VA, TX and PR were recorded and analyzed to provide oblique ionograms and HF scatter from the F-Layer. All of the plasma disturbances over Arecibo were records using the Arecibo Incoherent Scatter Radar (ISR) operating at 430 MHz. Finally, imagers located at Culebra and Arecibo recorded 630 nm emissions to observe horizontal structures in the ionosphere as artificial changes in the airglow.

The ISR directly observed heated induced irregularities with UHF radio scatter from natural and artificially generated ion acoustic waves giving the Ion Line and Enhanced Ion Line profiles, respectively. During the day, photo electrons excited Langmuir Waves in the ionosphere and, during heating times, the electromagnetic waves excited artificial Langmuir waves at the HF

reflection altitude. These Plasma Lines and Enhanced Plasma lines were measured with the 430 MHz ISR to yield high resolution profile of the electron densities and to provide the location and strength of the HF interaction region.

The Radio Receiver Instrument (RRI) on the Canadian ePOP satellite was tasked to record both the HF pump signals at 5.1 and 8.175 MHz and the ROTHR HF radar transmissions at pre-defined frequencies in the 5 to 18 MHz range. The HF transmissions were modulated with "chirp" waveforms to allow determined of the group delays and Doppler shifts introduced by propagation through the disturbed ionosphere. The satellite data show significant Range and Doppler spreading when the signals pass through the disturbed plasma regions.

Radio beacons from several satellites were employed to monitor both total electron content (TEC) changes and scintillations from the for UHF and L-Band signals passing through the ionosphere. A ground TID Network using GPS satellite L-Band transmissions was set up to record natural Gravity Wave Disturbances. There seems to be some correlation of these traveling ionospheric disturbances (TIDs) with the effects of the Arecibo HF facility. The PROPCUBE Beacon provided UHF (380 to 400 MHz) transmissions for scintillations through the ionosphere above Arecibo.

The full set of Oblique Ionogram, ISR and TID data provide a comprehensive picture of the natural and modified ionosphere around Puerto Rico. The HF propagation measurements will compare radar clutter produced artificially with that from natural sources. Artificial irregularities using ionospheric modification with high-power radio waves will be designed to test techniques used to remove radar clutter from natural irregularity sources.

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