MID-LATITUDE IONOSPHERIC RESPONSE TO ACTIVE EXPERIMENTS

NAG 5 669

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Completed Project Summary 5/90 - 4/92
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Understanding the ion chemistry and conditions leading to the formation of ionospheric depletions (ionospheric holes) has been an important objective of the NASA active ionospheric experiment program. Millstone Hill radar observations have been used to monitor the magnitude and temporal extent of the plasma holes produced under varying conditions. The major objective of the completed project was to provide radar diagnostic support for individual NASA rocket campaigns flown from Wallops Island. Two rocket programs, NICARE and REDAIR 2, were selected by NASA for radar support during the proposal period and pre-launch and in-flight radar observations were provided for each as well as basic reduction of the acquired data for scientific analysis. Radar operations and analysis for both of these experiments were performed as proposed and the work on these projects at M.I.T. has been completed.

A). NICARE (FY 90, P. Bernhardt, PI): The Millstone Hill radar provided the required real-time diagnostics for this experiment to quantify ionospheric convection in the vicinity of the release point and to observe both the ionospheric characteristics at the time of the chemical release and the details of the ionospheric perturbation generated. Analysis of the radar results for inclusion in several papers describing the chemical release chemistry has been completed.

B). REDAIR (FY 92, M. Mendillo, PI): The Millstone Hill radar provided extensive pre-launch diagnostics of the background ionosphere and determined that conditions were appropriate for this chemical release experiment which was aimed at the investigation of airglow emission mechanisms. Two rockets were flown with release altitudes above and below the peak of the ambient F layer as determined by real-time radar observations. The Millstone Hill radar also provided the primary diagnostic of the plasma characteristics of the plasma depletion and the emission generation region.

The NICARE-1 experiment took place on October 23, 1989. A Terrier-Black Brant V sounding rocket flown from Wallops Island, Va. released a payload of 30 kg of trifluoromethyl bromide (CF_3Br) near 300 km altitude. Pre-event diagnostics of the ambient electric field conditions were provided by the Millstone Hill incoherent scatter radar, as were direct observations of the subsequent ionospheric depletion. During the reporting interval, the data taken during this event were reduced to geophysical parameters and were delivered to the NICARE experimenter team.

Figure 1 shows pre- and post-event Millstone Hill data for the experiment. Pre-event data (dashed lines) is an average of twenty-one 14-second records, and post-event data (solid lines) is a representative average of three 14-second records. The left panel shows an overall peak depletion in the ambient electron density of 24%, corresponding to a ~15% Br^- concentration in the right panel. A typical error bar for the derived Br^- concentration fraction of 4% is in the lower right of the panel. The background 'system noise' level in the NICARE-1 data is ≤3%. The substantially decreased background level here is likely due to improved radar data taking techniques (documented by Holt et al., 1988; 1990) used during NICARE-1, which substantially increased the quality of the observed data, as compared to the previous experiments.

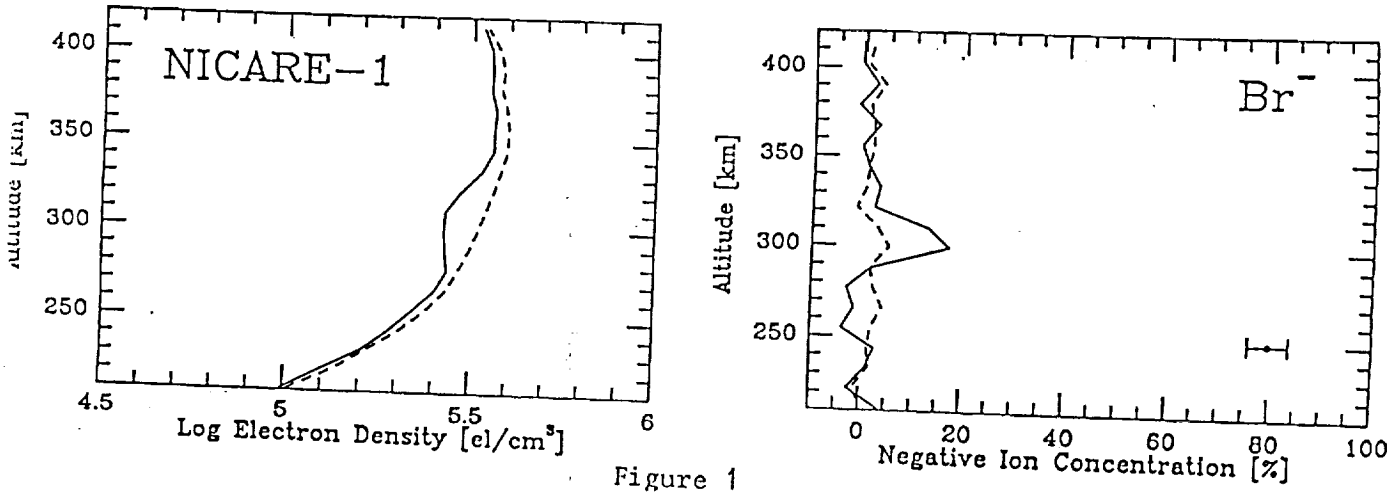

Figure 1

Figure 2 is taken from Sultan et al. [Sultan, P. J., M. Mendillo, W. L. Oliver, and J. M. Holt, Detection of Artifically Created Negative ion Clouds with Incoherent Scatter Radar, *J. Geophys. Res.*, *97*, 4085-4097, 1992] and displays the results of Millstone Hill radar diagnostics taken during the NICARE and other ionospheric chemical release experiments flown from Wallops Island.

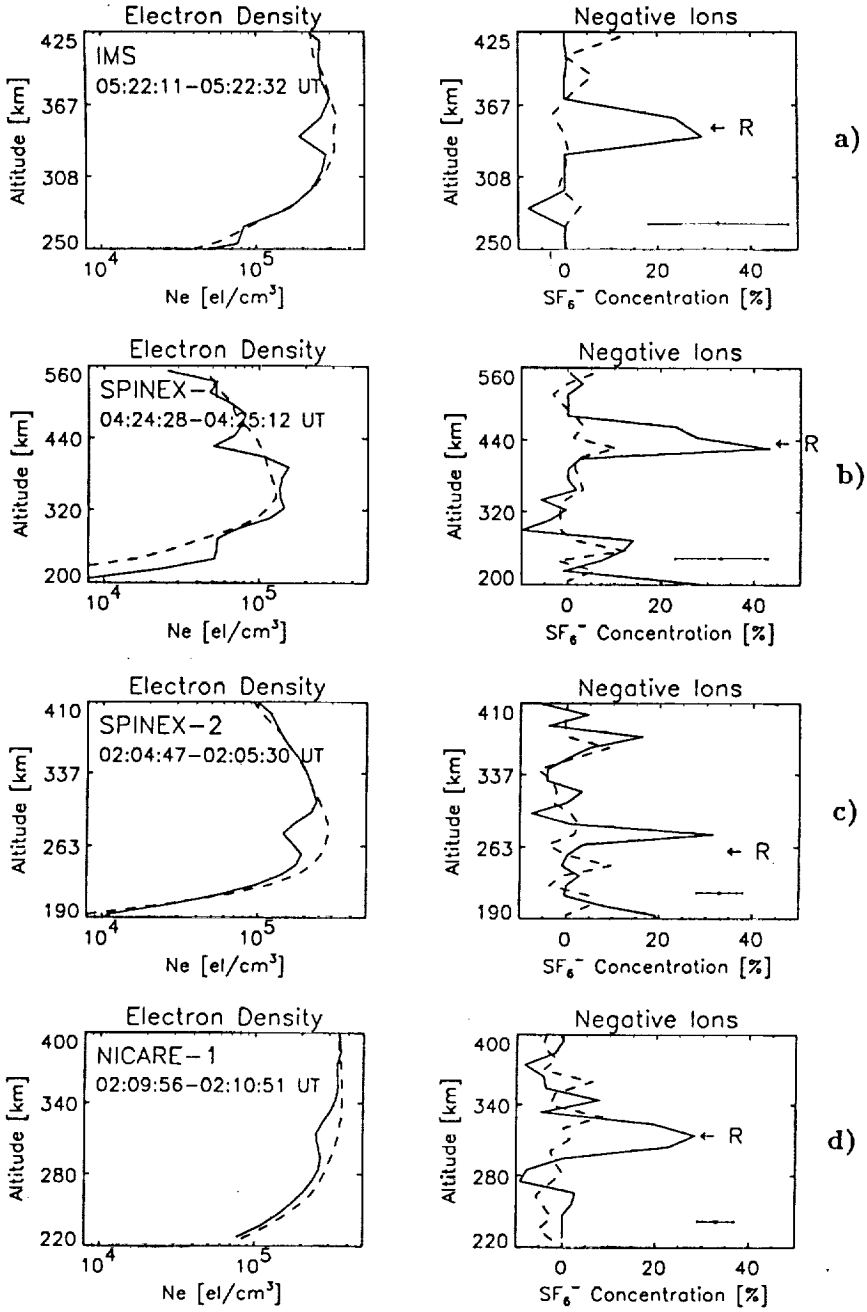

Fig. 2 Millstone Hill IS data from four active chemical release experiments. Averaged postevent records (solid lines) show depletions in electron density (left panels) which correspond to enhancements in negative ion concentration (right panels). Both are compared with preevent background measurements (dashed lines). Representative negative ion concentration error bars are shown in the lower right of the right panels. The altitudes of the chemical releases are indicated by the "R" labels. (*a*) IMS: Average of 16 20-s preevent records (0513:42-0518:49 UT) and two postrelease records (0522:11-0522:32 UT). (*b*) SPINEX 1: Average of 26 20-s preevent records (0413:16-0422:38 UT) and three postrelease records (0424:28-0425:12 UT). (*c*) SPINEX 2: Average of 17 20-s preevent records (0154:02-0159:46 UT) and three postrelease records (0204:47-0205:30 UT). (*d*) NICARE 1: Average of 21 14-s preevent records (0150:14-0159:26 UT) and three postrelease records (0209:56-0210:51 UT).

REDAIR-2

The RED AIR 2 experiment consisted of two rockets flown into the topside and bottomside ionosphere in close succession on the evening of December 5, 1991. On several nights preceding the experiment, the radar observed the ionospheric at the prospective release site in order to determine the ambient conditions to be expected at the time of the release. The Millstone Hill radar performed a standard diagnostic experiment, consisting of fixed-position observations at the site of the chemical releases and azimuth and elevation scans to determine the spatial extent of the resulting ionospheric hole. Figure 3 presents preliminary results of the radar observations showing the radar return from the rocket body as it entered the radar beam at the time of the high-altitude chemical release at 00:58 UT on 5 Decenber, 1991. The enhanced echo from the rocket itself was followed by a brief depletion of the ionospheric density at the 350 km height of the release. This experiment is under continued analysis by the PI team at Boston University.

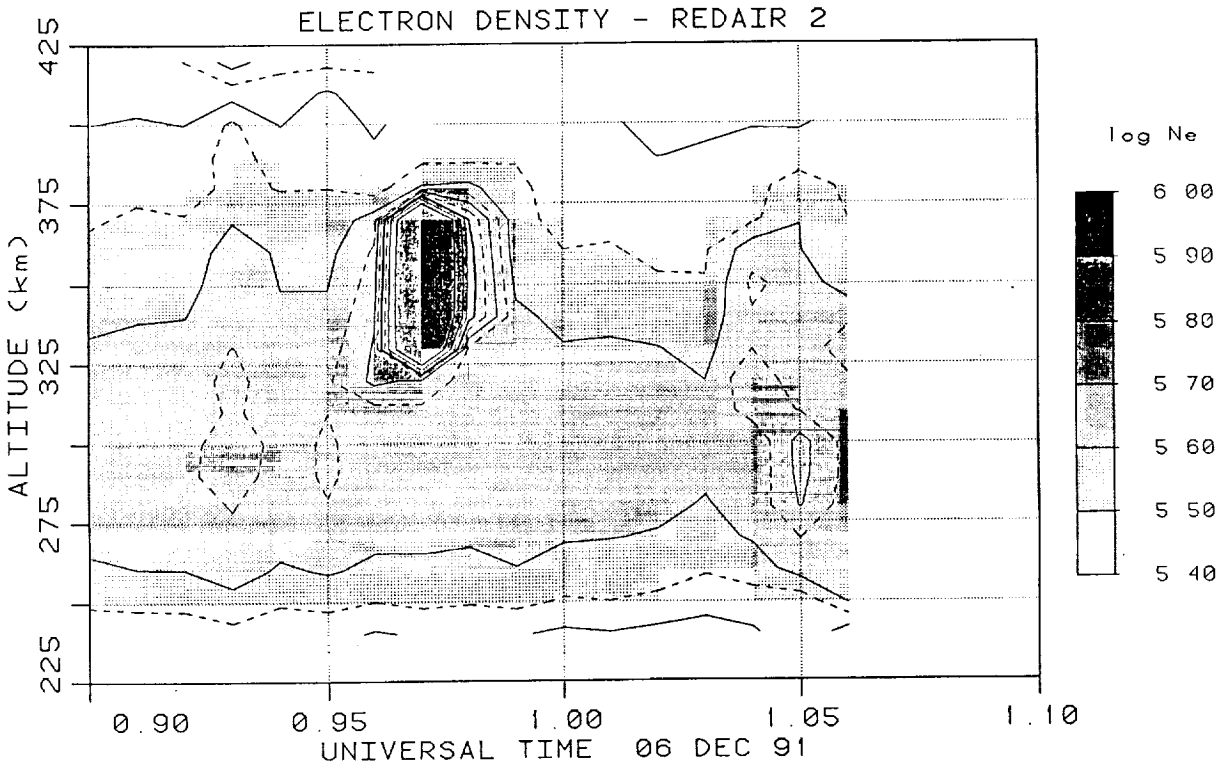

Figure 3