X-621-68-482
PREPRINT

NASA TM X- 63477

RADAR BACKSCATTER AND ROCKET PROBE MEASUREMENTS OF ELECTRON TEMPERATURE ABOVE ARECIBO

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CONTENTS

RADAR BACKSCATTER AND ROCKET PROBE MEASUREMENTS

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Introduction

The two prime sources of information regarding ionospheric temperature behavior are the various types of probe measurements from satellites (and rockets) and the radar backscatter measurements from ground-based installations. The satellites resolve the global structure of the ionosphere while the radar resolves its altitudinal structure and diurnal behavior. Since these methods are so complementary in the task of establishing a comprehensive description of ionospheric behavior, it is clearly desirable to correlate measurements from both methods to uncover and investigate any systematic errors which may exist. This was the prime purpose of the launch expedition to Puerto Rico that resulted in the electron temperature (T_e) comparisons presented here.

In this letter we compare the rocket profiles of T_e obtained at 0330 LT and 1530 LT on March 17, 1968 with temperatures derived nearly simultaneously by the radar method at Arecibo Observatory. A later paper will treat these, and other measurements made from the rocket payload, in greater detail. The other measurements include electron concentration, ion composition, and molecular nitrogen concentration and temperature.

Experimental Methods

The cylindrical probe employed in these ejectable rocket payloads was described fully by Spencer et al, (1965). The same instrument has been employed on numerous rockets and satellites (Brace, Spencer, and Dalgarno, 1965) (Brace and Reddy, 1965) (Brace, Reddy and Mayr, 1967) and (Brace, Mayr, and Carignan, 1969).

The Arecibo facility and its operation have been described by Gordon and LaLonde (1961) and by Carlson (1965). The bulk of the temperature measurements have been made with the autocorrelation technique developed by Perkins and Wand (1965), using single pulse transmissions. The results discussed here were obtained by the double-pulse method which has greater height resolution (Perkins and Wand, 1966).

The Comparisons

The measurement sequence was arranged so that double-pulse radar observations were taken before and after each rocket flight. In the night flight an observation was also centered on the time of launch. During the daytime flight a 'plasma line' radar run was made. The data from this run will be covered in the later paper.

Figures 1 and 2 show the resulting backscatter profiles and rocket profiles. The rocket data in each case is based on the downleg data. Although there was little difference between upleg and downleg data, the latter are less likely to be disturbed by vehicle-borne contamination, since the instrument attains maximum separation from the vehicle during downleg.

The agreement is remarkably good in the daytime flight, the probe values of T_e falling approximately midway between the radar profiles taken about 25 minutes before and after the flight. Since the F_1 region temperature decreased by about 15% between the first and second radar runs, a really precise evaluation of the agreement at this altitude will be feasible after the 'plasma line' data are reduced. At altitudes below 180 kilometers and above 240 kilometers the agreement is within 5%.

The nighttime agreement is not as satisfactory, however. The radar values of T_e are not yet available below 286 kilometers at the time of the flight, owing to return echoes from the vehicle itself. The agreement above this altitude is within 10%, with the radar values systematically lower. The pre-launch and post-launch radar values were lower still.

The reason for this 10% difference is not clear. The three radar runs show that T_e was highly variable near 300 kilometers, the apogee altitude of the flight. Thus it is possible that the difference arises from the different time resolution of the two methods. The rocket profile is taken in only three or four minutes while the radar employs a 20-minute integration time. However, we should not ignore the possibility that the difference may reflect an as yet unidentified systematic error in either or both methods of temperature measurement. If such errors are present in the night flight, it is difficult to understand the agreement found in the daytime flight where the temperature range encompassed the nighttime values.

It should be noted that the nighttime radar values were derived employing preliminary measurements of mean ion mass from the ion spectrometer on the rocket payload (Pharo, private communication). The daytime radar values of T_e were derived in the more usual way by assuming that the ion temperature (T_i) was equal to a model gas temperature (T_g) below 250 kilometers. T_e was then derived from the ratio of T_e/T_i obtained from the radar spectra.

In conclusion, it appears that the electron temperatures derived by the cylindrical probes agree well generally with those derived by the backscatter method employed at Arecibo. A small difference evident only at night may arise from variability of the ionosphere, or this may reflect a real experimental error in either or both methods.

These results are in conflict with a similar intercomparison of electrostatic probe data from Explorer XXXII and radar data from Jicamarca Observatory in Peru. The Jicamarca comparisons revealed probe values of T_e that were approximately 70% greater than backscatter values both day and night (Hanson, et al, 1969).

In statistical comparisons between the same probe experiment on Explorer XVII and measurements at Millstone Radar, Evans (1965) found good agreement in the daytime. At night, the probe values agreed well in about half of the cases but were variably higher in the others. The average nighttime value of T_e from the probe was about 20% higher than the Millstone radar monthly average value.

Unfortunately the measurements employed in the comparison were not simultaneous in the sense of the Arecibo comparisons presented here.

Further investigation of this question, now in progress, includes additional comparisons of satellite probe measurements with simultaneous measurements at all three backscatter stations.

Acknowledgments

This work was performed while one of the authors (K. K. M.) was a NRC-NASA post-doctoral resident research associate.

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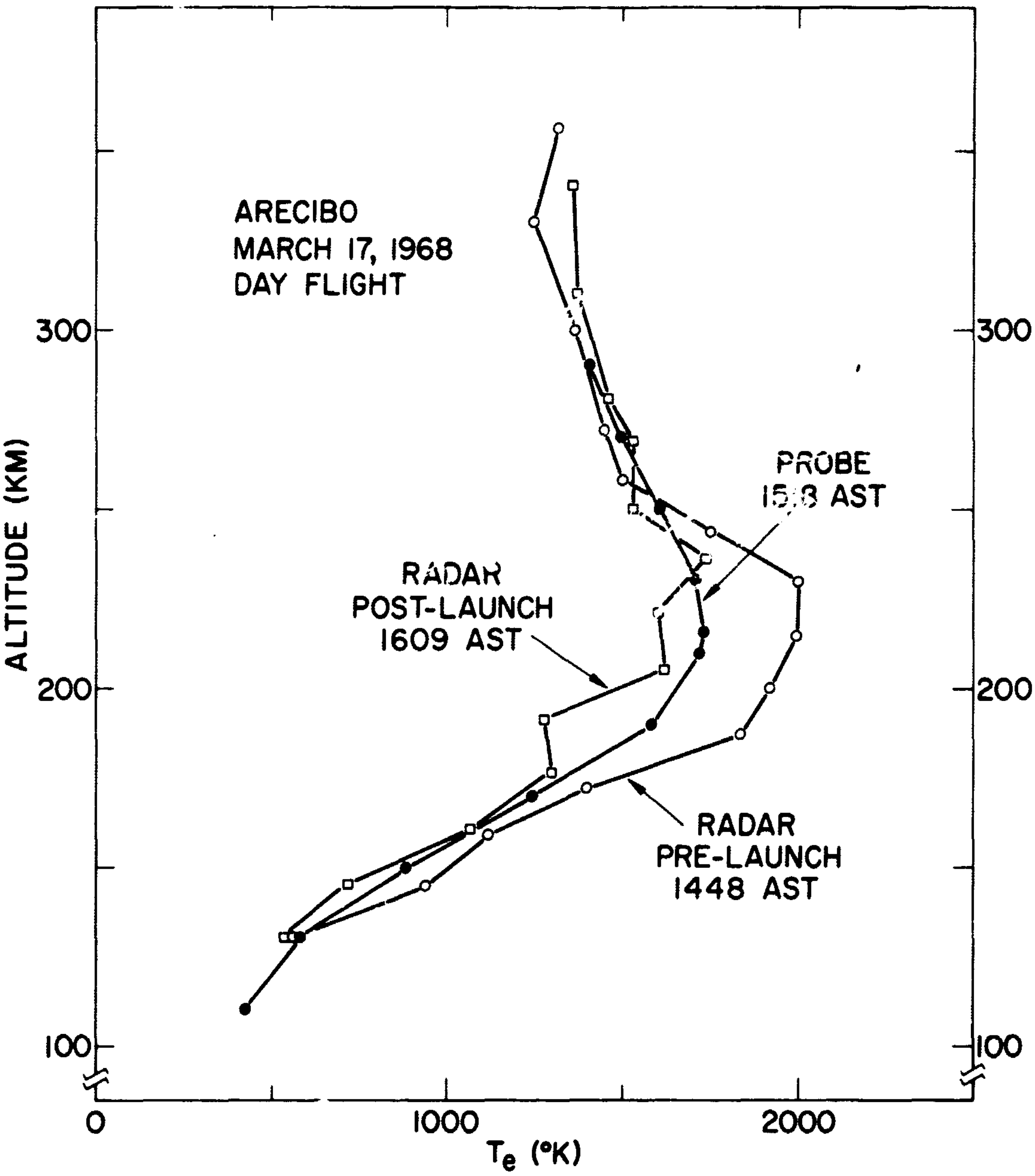

Figure 1-Comparison of daytime probe and backscatter T_e measurements. The measurements are consistent at all altitudes. Each probe-derived point represents a mean of about 10 individual measurements having a standard deviation of less than 100°K.

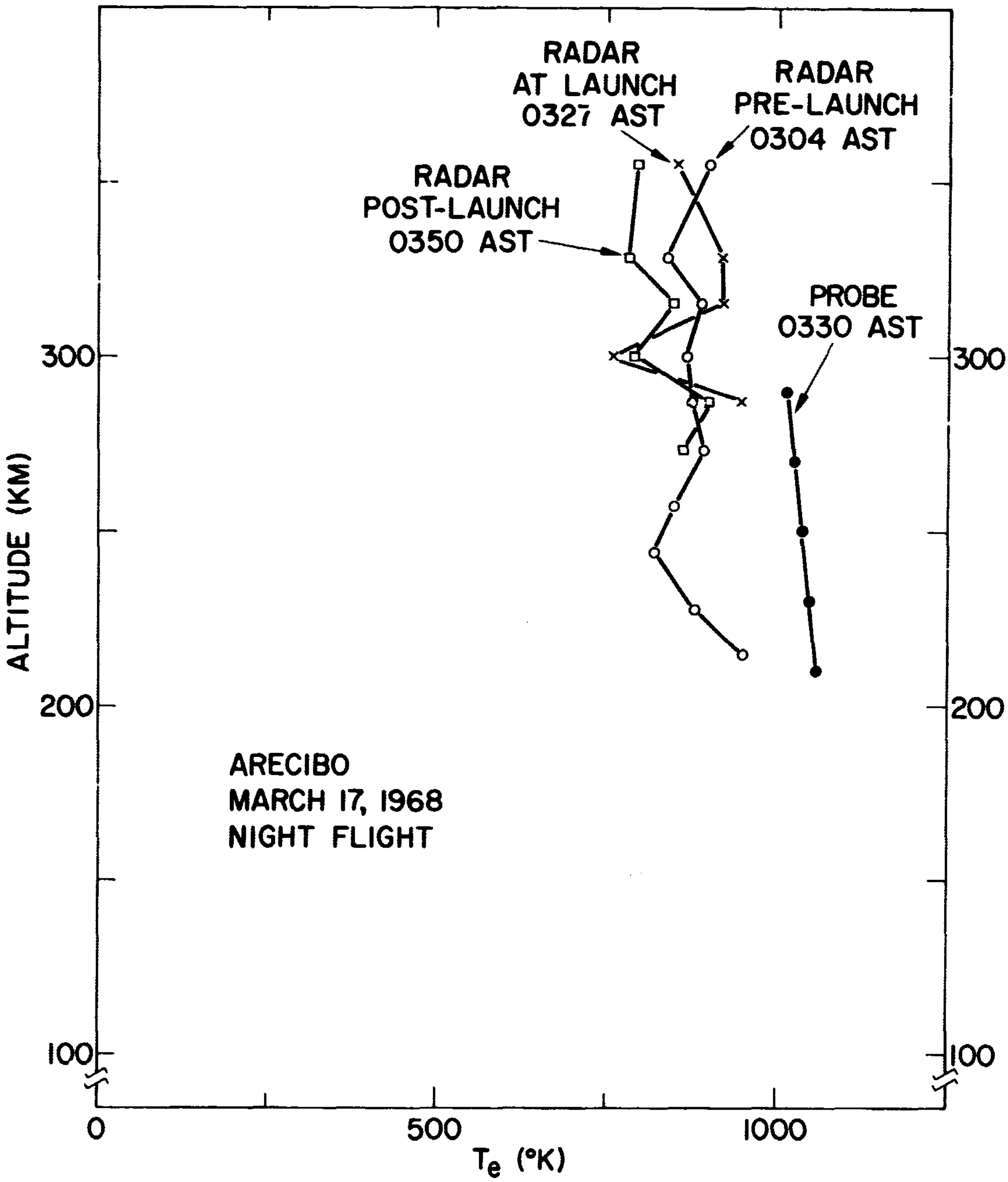

Figure 2-Comparison of nighttime probe and backscatter T_e measurements. The agreement with backscatter measurements is not as good as found in the daytime flight. The radar values taken "at launch" (0327 AST) are 6% lower than the probe values at 290 kilometers. Radar values before and after the launch are systematically lower by about 15%, an amount which approaches the temperature variation between radar runs.