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UNITED STATES ARMY ELECTRONICS COMMAND

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ABSTRACT

Records of cinetheodolite balloon observations at White Sands Missile Range, New Mexico (WSMR) to 8000 feet above the surface have been analyzed in sets of 11- and 20-minute intervals to determine the magnitude of horizontal wind vector changes. The means of the magnitude for the horizontal wind vector changes varied from 1.8 to 2.8 ft sec^{-1} for time intervals of 11 and 20 minutes. The means of the horizontal wind direction change over the same time intervals varied from 7 to 34 degrees. The greatest variability occurred in layers below 3000 feet.

CONTENTS

INTRODUCTION

A need for improvement in the accuracy of impact prediction for unguided rockets and a better understanding of unguided missile and cannon-fire dispersion prompted this investigation of the variability of wind. Data used in previous time variability studies of wind for levels above meteorological towers were obtained by radiosonde, rawinsonde or pilot balloons which were tracked by standard theodolites. Wind data which are believed to be of better quality and used in this study were obtained by tracking pilot balloons with three or more cinetheodolites. Data obtained by this method have been accepted as standard and assumed to be correct for use in comparison with other types of data (e.g., Singer, 1956). This precise method of tracking has been demonstrated by Reisig (1961). Also, the time intervals used in previous time variability studies were 30 minutes or longer, (except Armendariz, 1963), and more information of shorter time variabilities is greatly needed, i.e. the 11- or 20-minute intervals used in this study.

This study indicates the magnitude of horizontal wind changes during 11- and 20-minute intervals and suggests that these changes may differ from those of previous methods because of the difference of raw data treatment. The effect of altitude on time variability is also demonstrated.

COLLECTION AND REDUCTION

The data in this study were collected during daylight hours of random days from August 1964 through January 1965. Sets of data, i.e., two observations 11 or 20 minutes apart, were not taken consecutively, and several minutes to several days elapsed between sets. Thirty-two sets of data with 11-minute intervals and 53 sets with 20-minute intervals were used. Balloons (100-gram) were tracked by three to five cinetheodolites to approximately 9000 feet. Almost continuous tracking of balloon trajectory was obtained since, while the 100-gram balloon was rising approximately 17 ft $\sec^{-1}$, the Contraves camera system recorded at six frames $\sec^{-1}$.

The trajectory data were subjected to 11-point binomial smoothing which provided vertical and horizontal component vectors at one-second intervals. It is believed that this smoothing of raw data in fine detail eliminated some of the spurious oscillations caused by the aerodynamic characteristics of the balloon and resulted in horizontal vector components which more nearly represent the horizontal wind. Self-induced balloon oscillations have been the object of studies by Scoggins (1965) and Wright (1966).

TREATMENT OF DATA

Profiles were plotted from the computed N-S, E-W wind components at one-second intervals in 200-foot layers to 8000 feet. Representative wind components were obtained by analyzing (visual inspection) the plotted profiles for 1000-foot layers, overlapping 500 feet, i.e., 0-1000, 500-1500 etc. to 8000 feet; also, wind components were read from the data for specific levels every 500 feet, i.e., 500, 1000, etc. up to 7500 feet. In each treatment, differences in wind speed and direction were obtained for sets of observations 11 and 20 minutes apart, and means of these differences were computed. The mean differences for the specific levels were 20% to 50% greater than those of 1000-foot layer means.

RESULTS AND DISCUSSION

Mean direction and speed differences for 11- and 20-minute intervals of the 1000-foot layers are shown in Figures 1 and 2. Histograms of these mean differences for the 20-minute interval are shown in Figures 3 and 4; histograms for the 11-minute interval (not shown) are similar. Mean algebraic differences were quite small which indicated no significant bias existed between the first observation and second 11 or 20 minutes later. Quartiles are shown in Figures 5 and 6.

Absolute mean speed differences ranged from 1.8 ft sec^{-1} (20-minute interval) or 1.9 ft sec^{-1} (11-minute interval) in the upper layers to 2.8 ft sec^{-1} in the lower layers. Absolute mean direction differences ranged from 8 degrees (20-minute interval) or 7 degrees (11-minute interval) in the upper layers to 30 degrees (20-minute interval) or 34 degrees (11-minute interval) in the lower layers.

These differences are generally a little less than shown by Singer (1956) and Armendariz (1963, 1965). Absolute mean wind speed and direction changes in an 11-minute interval are approximately the same as shown by Armendariz (1963) for 10-minute intervals for levels from the surface to 1000 feet. Absolute mean wind speed changes in a 20-minute interval are generally one to two ft sec^{-1} less than Armendariz (1965) found using the same time interval but with data collected by single-theodolite pilot balloon and rawinsonde systems; mean wind directions (20-minute interval) compare favorably from the surface to 8000 feet.

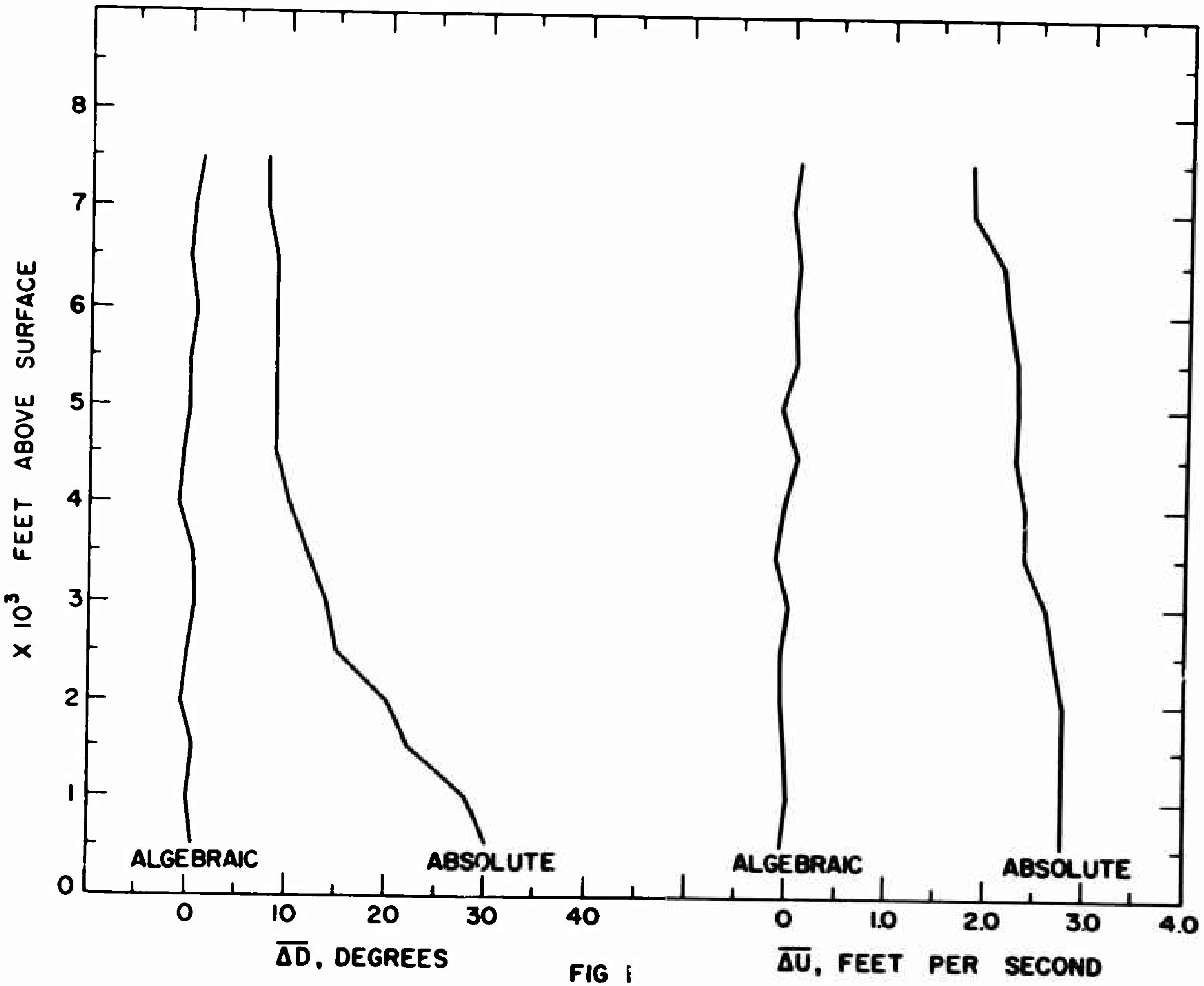

FIG 1

MEAN WIND DIRECTION AND SPEED CHANGE FOR 20-MINUTE INTERVAL

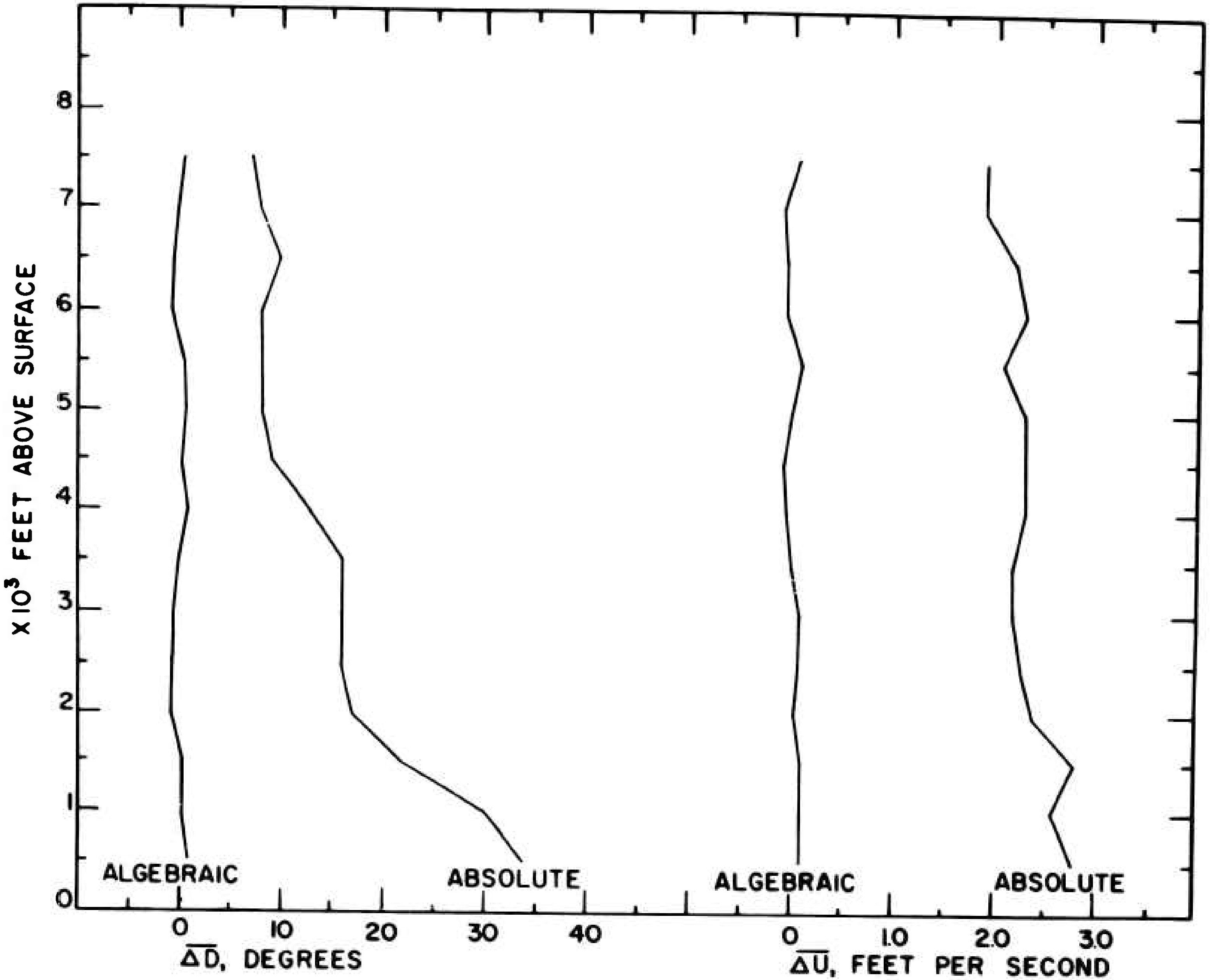

FIG 2

MEAN WIND DIRECTION AND SPEED CHANGE FOR 11-MINUTE INTERVAL

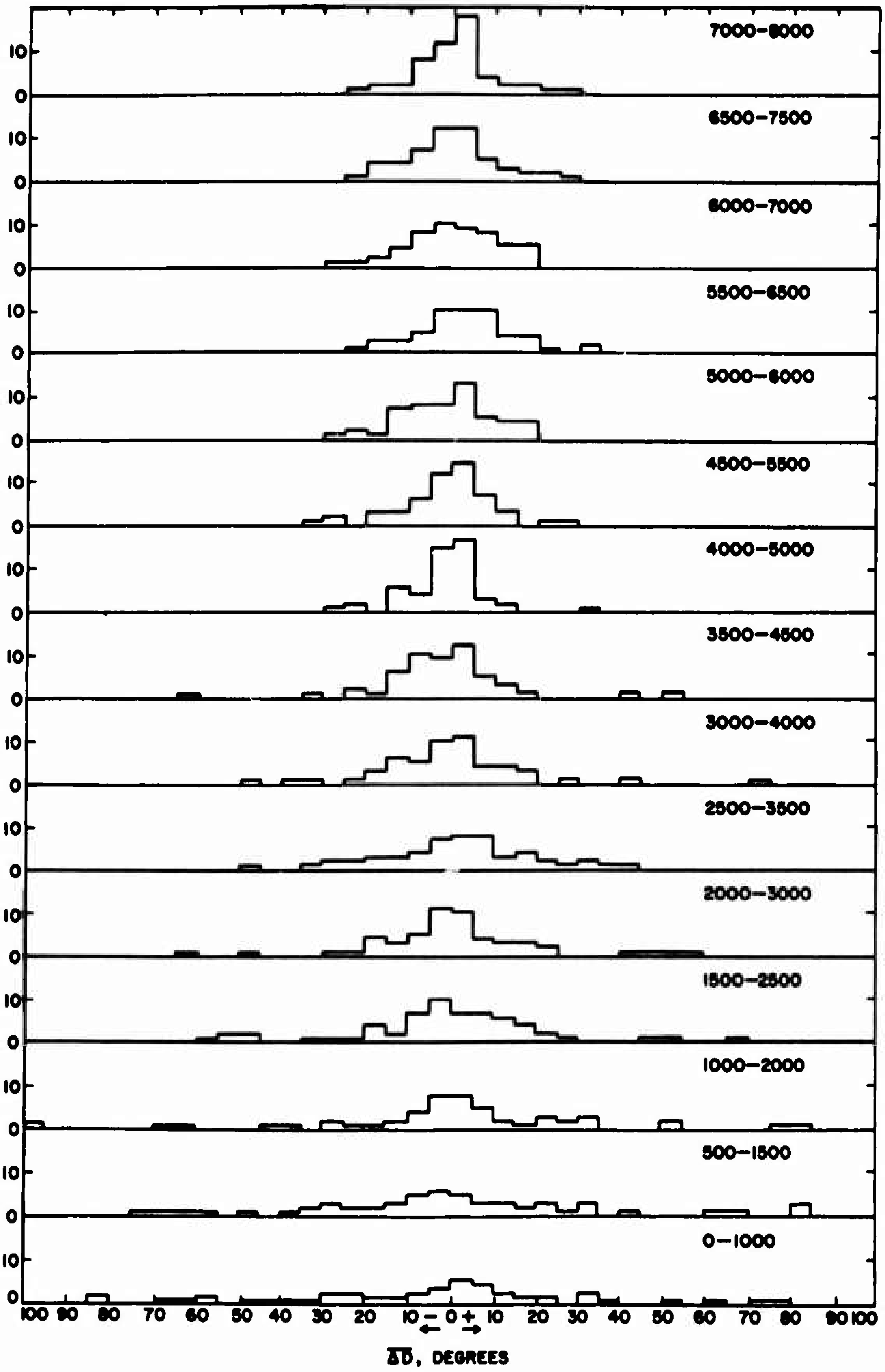

FIG 3
HISTOGRAMS FOR 20-MINUTE INTERVAL

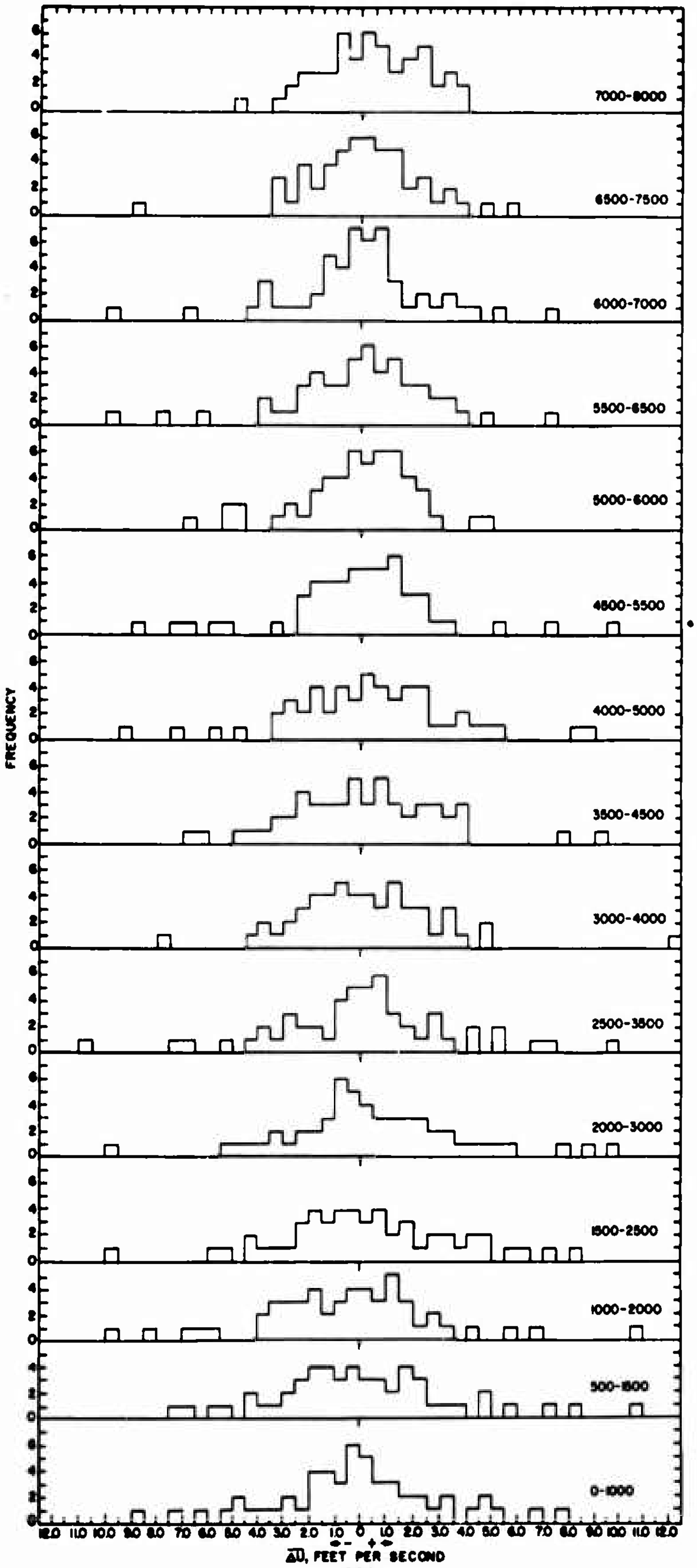

FIG.4

HISTOGRAMS FOR 20-MINUTE INTERVAL

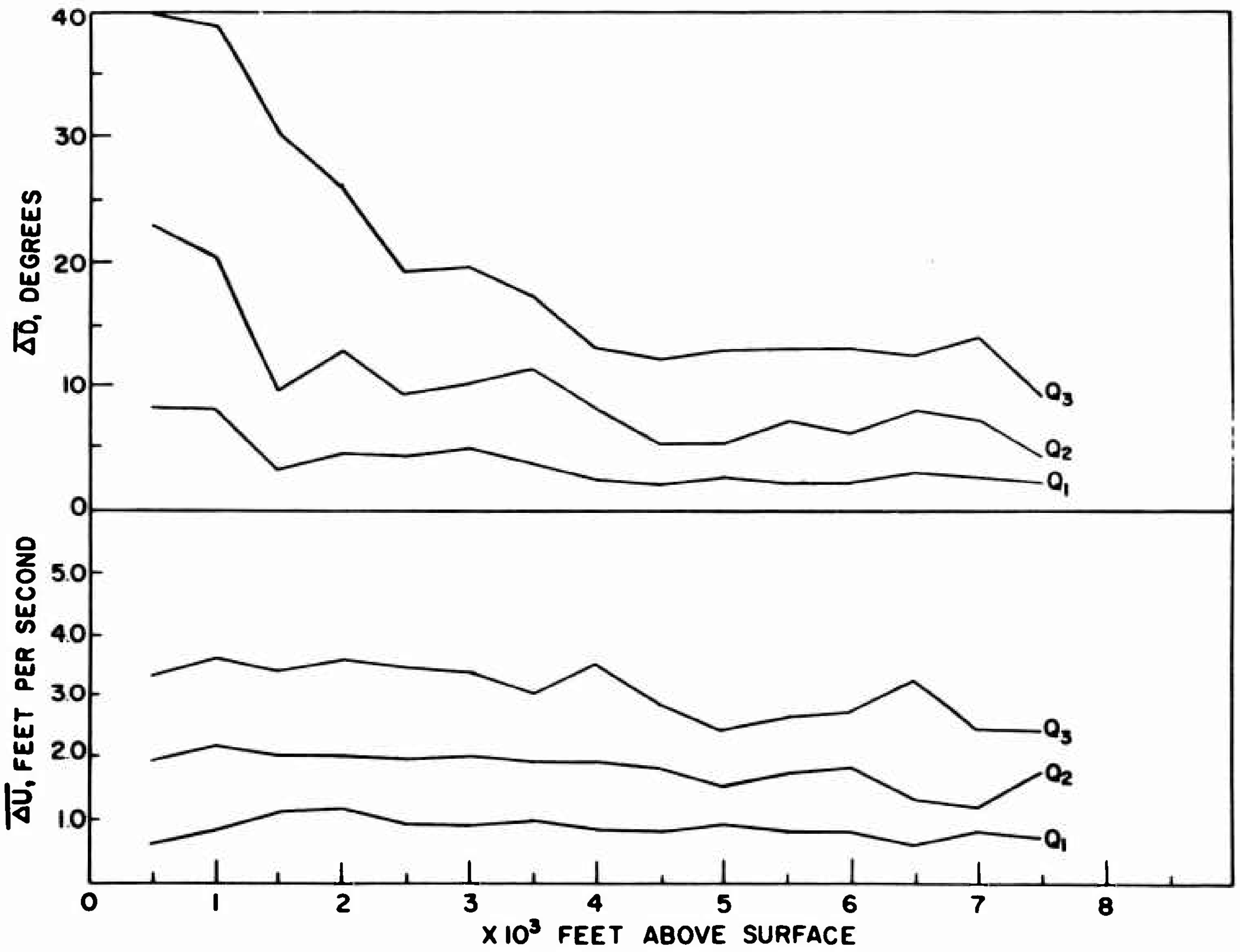

FIG 5

QUARTILES FOR MEAN WIND DIRECTION AND SPEED CHANGE FOR 20-MINUTE INTERVAL

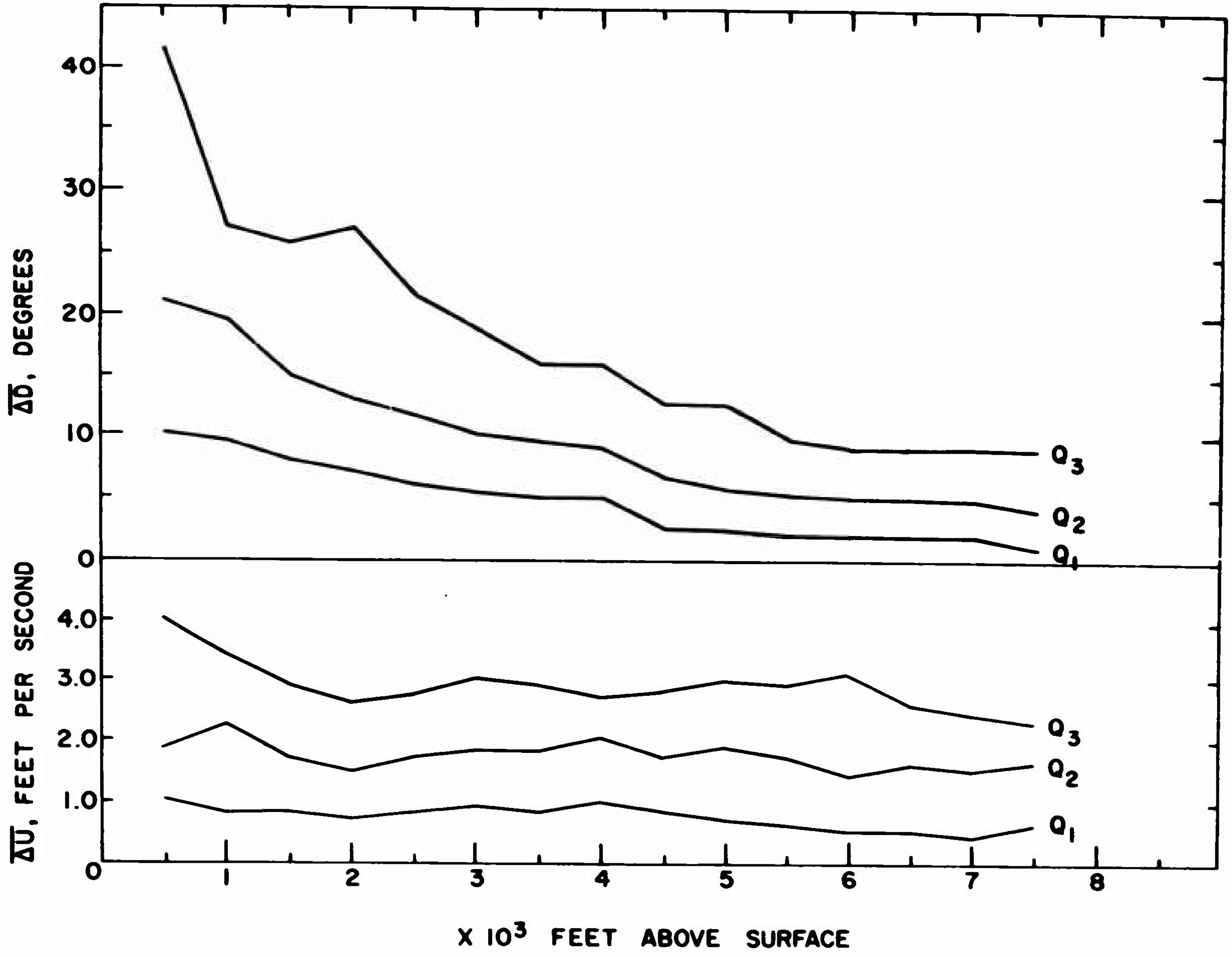

FIG. 6

QUARTILES FOR MEAN WIND DIRECTION AND SPEED CHANGE FOR 11-MINUTE INTERVAL

Mean wind speeds are less than shown by Singer (1956) whose time intervals were longer, ranging from 30 minutes to five hours. Using pibal data obtained by double-theodolite tracking. Danard (1965) demonstrated an increase of wind variability with increasing surface wind speed and height above terrain, where data used in this study for 11- and 20-minute intervals showed a slightly greater mean wind speed change and a significantly greater mean direction change in the lower levels.

Variations in wind direction and speed may be categorized into three main types: small-scale motions, large-scale motions, and local effects. Small-scale motions associated with convective and orographic turbulence, wind shear and frictional effects are random, varying considerably in number, size, strength, and direction. Large-scale motions resulting from gradual changes in the wind circulation pattern due to the movement and changes in intensity of pressure fields are generally gradual and methodical. Some exceptions to this will occur in the vicinity of pressure centers, ridges and troughs, where wind speed and direction changes may be abrupt and variable. Local effects related to the topography include such phenomena as mountain, valley and foehn winds, mountain waves, and nocturnal temperature inversions. Small-scale motions and local effects may begin or terminate suddenly which is common at WSMR. On at least four days when soundings were taken, minor troughs passed through the area causing lower layer winds to change more rapidly than upper layer winds. Several pairs of data with relatively low wind speeds in the lower layers contributed to greater wind direction variability.

CONCLUSION

Mean wind speed differences ranged from 1.8 ft sec^{-1} (20-minute interval) or 1.9 ft sec^{-1} (11-minute interval) in the upper layers to 2.8 ft sec^{-1} in the lower layers. Mean wind direction differences ranged from 8 degrees (20-minute interval) or 7 degrees (11-minute interval) in the upper layers to 30 degrees (20-minute interval) or 34 degrees (11-minute interval) in the lower layers. Thus, wind variability for a 20-minute interval is not significantly different than an 11-minute interval. It should be emphasized that the manner in which raw data are treated can have a marked effect on the magnitude of computed wind variability since 20% to 50% greater variability was obtained by using wind component values for specific levels than that obtained by using average values for 1000-foot layers. It is believed that most, if not all, variations due to large-scale motions resulting from gradual changes in the wind circulation pattern associated with the movements and changes in intensity of pressure fields are eliminated from the results because these data were collected in a random manner over a period of several months. Local effects of the mountainous terrain surrounding the site of the observations are indicated by much greater variability in layers near the surface.

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13. ABSTRACT

Records of cinetheodolite balloon observations at White Sands Missile Range, New Mexico (WSMR) to 8000 feet above the surface have been analyzed in sets of 11- and 20-minute intervals to determine the magnitude of horizontal wind vector changes. The means of the magnitude for the horizontal wind vector changes varied from 1.8 to 2.8 ft sec^{-1} for time intervals of 11 and 20 minutes. The means of the horizontal wind direction change over the same time intervals varied from 7 to 34 degrees. The greatest variability occurred in layers below 3000 feet.

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