2-IV B1

STUDY OF THE RELATIONSHUP BETWEEN RADAR RETURN FROM CLEAR AIR AND THE MECHANICAL ENERGY REGIME IN THE ATMOSPHERE

by

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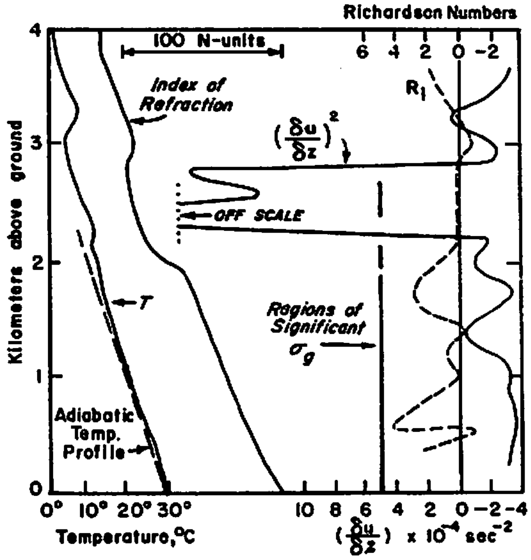
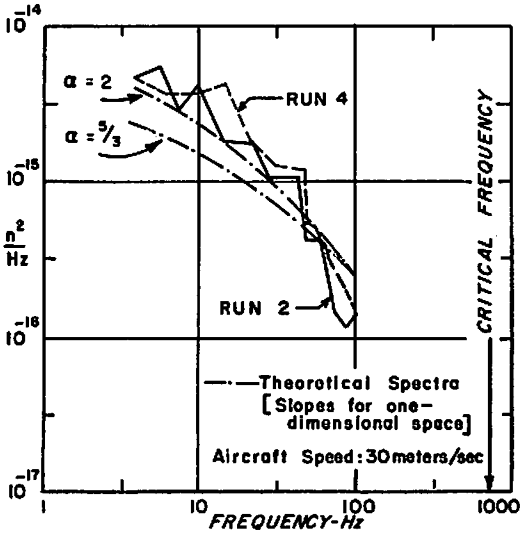
A study has been made to determine the extent to which radar returns from a clear atmosphere can be associated with the mechanical energy regime in the clear atmosphere. The study is limited to the lower 5 kilometers of the atmosphere where it is recognized that moisture has a dominant role in determining radar visibility of a disturbed region. Radar returns are received using a vertically looking 3000 MHz radar. Simultaneous measurements are made with a sounding aircraft instrumented to continuously telemeter to the ground (1) temperature, (2) vertical gust loading (vertical acceleration), (3) index of refraction difference between two refractometers separated vertically 17.5 cm, and (4) the index of refraction at one of the refractometers. Aircraft location is continuously monitored by radar and its position recorded. Pilot balloons carrying corner reflectors are flown and tracked to provide wind velocity profiles.



ATMOSPHERIC PARAMETERS, 5 JUNE 1970
Fig. 1

The principal observations from a data run on June 5, 1970, are presented in Figure 1. The run was made between 3:15 p.m. and 3:32 p.m., local standard time. Temperature, T, index of refraction, n, and regions of important vertical acceleration, σ_g, ($\sigma_g > 0.1g$; $0.1 < f < 4$ Hz) are shown as functions of height. A wind shear profile, $(\partial u/\partial z)^2$, taken about 45 minutes after the data run was completed is also shown. Richardson's numbers, R_i, were computed for the run and found to agree very well with observed regions of significant vertical acceleration. Regions of significant C_n^2, intensity of turbulence, as determined from the index of refraction difference measurements were observed from 1.8 to 2.3 km and from 3.1 to 3.2 km. A radar layer was observed to coincide with the disturbed region detected by the index of refraction difference measurements between 1.8 and 2.3 km but not between 3.1 and 3.2 km. No significant correlation between C_n^2 as observed with the refractometers and regions of significant vertical acceleration, σ_g, was detected. Whether this was due to the patchy nature of disturbed regions or to weak vertical motions in the disturbed air is not known at this time.

Calculated spectra of $[n(t,\vec{r}_1) - n(t,\vec{r}_2)]$ are presented in Figure 2 for refractometer difference measurements made during two runs numbered 2 and 4. (Run No. 4 is the run for which the data in Figure 1 are shown).



CALCULATED SPECTRA FOR REGIONS OF SIGNIFICANT C_n^2.

Fig. 2

These spectra are unique in that they are calculated from the index of refraction difference between two refractometers instead of measurements from just one refractometer. Generally the calculations show that the regions investigated are isotropic through scale sizes 1/3 through 3 meters although departures are found. If a form $k^{-\alpha}$ is assumed for the one dimensional wave structure of index of refraction, then α tends to be nearer a value of 2 than 5/3. This fact is evident when curves for $\alpha = 2$ and $\alpha = 5/3$ are plotted on Figure 2. Refractometer cavity response is causing the computed data for Runs 2 and 4 to fall off at $f > 70$ Hz. The response is down about 3 dB at $f = 100$ Hz which corresponds to wave number $k = 0.206$ cm^{-1}. It should be noted that the parameters of the measurement system are such that calculations of the spectral densities are made at smaller scale values, thus minimizing the errors inherent in extrapolating from large scale spectral densities to small scale spectral densities.

SUMMARY

1. The experimental measurements show, within the accuracy of the probing radar system, that vertical backscatter from reasonably stable layers in the atmosphere is generated by a volume scattering process in regions of disturbed index of refraction.

2. Detectable mechanical turbulence may or may not be present in radar detected layer, that is, the correlation between C_n^2 as obtained from the radar measurements and/or the spaced refractometers with regions of significant vertical acceleration, σ_g, was not good.

3. Richardson's numbers were found to agree quite well with observed regions of significant vertical acceleration.

4. The scattering cross section is a space variable (inhomogeneous) and can be determined from the quantity $\overline{[n(t,\vec{r}_1) - n(t,\vec{r}_2)]^2}$ when the airplane sounds more or less at will (direction) in the region.

5. The most significant factor inasfar as radar returns are concerned is found to be a large lapse rate in vapor pressure, $(\partial e/\partial z)$.

6. A large lapse rate in vapor pressure is also found to be the most significant factor insofar as measured values of $\overline{[n(t,\vec{r}_1) - n(t,\vec{r}_2)]^2}$ are concerned.

7. Values have been observed for $\overline{[n(t,\vec{r}_1) - n(t,\vec{r}_2)]^2}$ as large as $15 \times 10^{-14}\ n^2$ for $|\vec{r}_1 - \vec{r}_2| = 17.5$ cm.