COMMENTS ON THE POSSIBILITY FOR DETERMINING DETAILED ATMOSPHERIC STRUCTURE FROM TRANS-HORIZON RADIO PROPAGATION MEASUREMENTS

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The use of transhorizon radio propagation as a technique for investigation of the detailed structure of the upper atmosphere seems to me to have some serious difficulties. I am not optimistic that much more can be learned about detailed structure by use of transhorizon measurements alone, although in combination with other techniques this type of measurement may continue to provide useful information as it has in the past. At the session on transhorizon propagation Dr. Wheelon advocated the development of better theoretical techniques to relate experimental data to the actual structure of the atmosphere. He expressed some optimism that with a more powerful theoretical treatment, transhorizon measurements might be made to yield increased information as to detailed atmospheric structure. While I agree wholeheartedly on the need for development of better theoretical treatments in order to extract the maximum information from experimental data now available, and in order to intelligently plan future experiments, I cannot see how theoretical techniques can overcome the problems of lack of spatial stationarity of the refractive medium and lack of knowledge about the degree of anisotropy of the structure of the medium.

Transhorizon propagation measurements provide a signal which is related to the integrated properties of the atmosphere over a large volume. There is a definite limit on the minimum size of the common volume which is imposed by the antenna beam width and by scintillation errors in the antenna pointing angle due to the accumulated effects of refractivity variations along the propagation path. In experiments in which a signal of wide bandwidth is employed, such as is achieved with short pulses, a degree of spatial resolution within the common volume of the antenna beams is provided. However, this resolution is provided in only one dimension of an ellipsoidal coordinate system. Under circumstances in which it is known that the wind direction in the common volume does not have an appreciable vertical component, the resolution is improved through the use of coherent Doppler techniques. Although the predominance of the horizontal wind components is undoubtedly a valid assumption under most atmospheric conditions, doubt still remains that it will prevail under circumstances such as the passage of a front or the occurrence of thunder storms.

In order to utilize the information available from a transhorizon experiment to determine the structure of the atmosphere, two approaches can be taken. The first of these, which we might call a deterministic approach, assumes that the detailed structure of the atmosphere at any instant in time is to be determined. This determination is not possible unless some assumption is made as to the degree of anisotropy. In other words, if the atmosphere is assumed to exhibit variability in the structure of the refractive index only in one spatial dimension, then the experimental data can, in principle, be used to determine the structure subject to the limits of resolution of the experiment. The trouble with this type of treatment is that it is appropriate only when it is known from other independent measurements that layered structure is dominant as the scattering mechanism. Even in this case the resolution available from transhorizon measurements is severely limited. This is true because the vertical component of the wave vector, when the scattering angle is small, is itself small. The reciprocal of the vertical component of the wave vector provides a measure of the minimum dimension which can be resolved by the experiment.

A second way to relate the experimental data to atmospheric structure is through the assumption of a statistical model. In this case, the determination of the detailed structure at each instant is not the goal of the analysis of the data, but rather it is desired to determine the three dimensional spectrum of spatial wave numbers of the refractivity fluctuations and to determine the correlations which exist in this spectrum. Experience has shown that the gross structure of a statistical model is somewhat easier to determine from transhorizon propagation data than is the case with the deterministic model. Anisotropy which exists as a difference between the spectrum of fluctuations in vertical and horizontal directions, can, in principle, be measured by means of beam swinging experiments. The limitations of the statistical model have to do with the lack of spatial stationarity of the refractivity fluctuations in the atmosphere. To the degree that spatial stationarity is lacking, the problem is not amenable to a statistical treatment; thus it appears that the most powerful analytic techniques to relate experimental data from transhorizon propagation measurements to the structure of the atmosphere must involve a combination of statistical treatment and deterministic treatment. It does not appear to me, however, that even such a treatment will permit one to determine the detailed structure when both non-stationarity of the medium and possible anisotropy must be accounted for.

SESSION 6

Microwave Radiometry