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FORWARD-SCATTER RADIANT MAPPING

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Abstract

Forward-scatter systems have been much neglected for the study of meteors and meteor streams. A great deal of this neglect stems from the complicated geometry which has made the interpretation of results difficult in the past. This no longer presents a problem because of the computer power now available. There are practical advantages in using forward-scatter in that low-power transmitters are much easier to handle than the high-power ones used in pulsed back-scatter radars. The data reduction of the CW signals is also significantly simpler. Because the forward-scatter reflection geometry increases the duration of the echoes relative to the back-scatter case the problem of the underdense ceiling is partially alleviated. We have built a "short hop" forward-scatter system between Ottawa and London (Ont) for which the transmitter and receiver are separated by about 500 km. With it we are able to measure unambiguously the directions of arrival of the echoes using a 5-antenna interferometer. Morton and Jones (1982, MN, 198, 737) have shown how the echo direction distribution can be deconvolved to yield the meteor radiant distribution for back-scatter data. We have extended the technique to the forward-scatter case and present some preliminary meteor radiant distribution maps.

Introduction

Pulsed back-scatter meteor radars are expensive, dangerous and temperamental because of the high power and voltages required. If range information is not needed, a continuous-wave (CW) forward-scatter offers a much simpler approach since a high-power transmitter is not required to accommodate the large bandwidth associated with pulsed radars. The forward-scatter geometry is such that the echo durations are in general longer than for back-scatter because of the reduced destructive interference of the waves scattered from the electrons in the train. The duration enhancement increases with the forward-scatter angle so partially alleviating the attenuation due to the "underdense ceiling" which has plagued traditional VHF back-scatter studies.

In spite of advantages listed above, forward-scatter systems have not enjoyed much popularity for the study of meteors and meteor streams because data from forward-scatter systems has been difficult to interpret primarily because of the complicated geometry. This is no longer the case since small computers which are easily able to cope with the relatively low data rate are readily available.

The equipment.

Our system consists of a 100W-transmitter operating at 48.7 MHz located in Ottawa and a complex of receivers located in Elginfield close to London(Ont). Identical horizontal two-element antennas directed towards each other are used at both the transmitter and the receivers. The echo directions are determined from the differences in phases of the signals measured from five spaced antennas as shown in Figure 1 below.

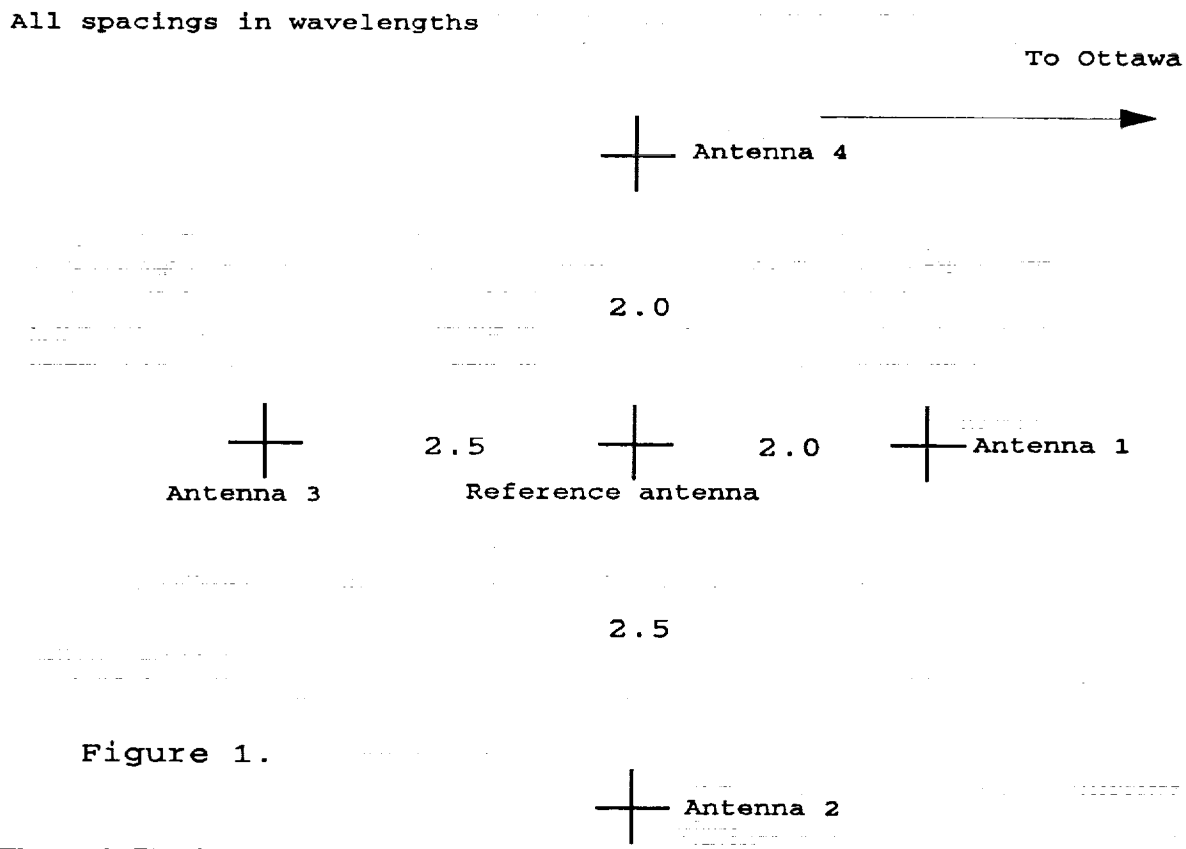

Figure 1. Receiver antenna arrangement at Elginfield (close to London, Ont).

This particular arrangement was chosen because it enabled us to eliminate the ambiguities usually associated with interferometers. Noise in the system introduces errors into determinations of the echo directions and simulations have shown that with a signal ratio of 20 dB, the measured direction will probably be accurate to better than 1° for elevation angles above 20°; below this the measurement errors increase rapidly.

The distribution of normals to the meteor trains is required to determine the radiant distribution. Whereas for the back-scatter case the echo direction is perpendicular to the meteor train, for forward-scatter geometry the normal, n, must be calculated from

$$n=r_1+r_2$$

where r_1 and r_2 are unit vectors from the transmitter and receiver to the reflection point and we have calculated r_2 assuming the reflection point to be at 100 km. The production of the maps such as Figures 2 and 3 above then proceeds exactly as described by Morton & Jones (1982) for back-scatter.

Discussion.

We have demonstrated the feasibility of radiant mapping using a forward-scatter system. The present system could be greatly improved by reducing the receiver bandwidth and we estimate it would not be difficult to increase the sensitivity such that the echo rate could be increased from its present 500/day to 2000/day. We have also become aware of some important problems in a system such as ours. The first is the difficulty of measuring accurate echo directions for angles of elevation much below 20° which makes it very difficult to apply this technique to a long baseline forward-scatter and effectively precludes the exploitation of the reduced attenuation resulting from the geometry. The second is the uncertainty in the geometry caused by the ignorance of the height of the reflection point. We have found that a 10 km change in the assumed height produces about a 5° error in the declination. If the position of the radiant is well known it would be possible to use this to determine the average heights of the reflection points of shower meteors.

Acknowledgment.

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References

Morton, J.D. and Jones, J. (1982) A method for imaging radio-meteor radiant distributions. Mon. Not. R. astr. Soc. 198, 737-746.

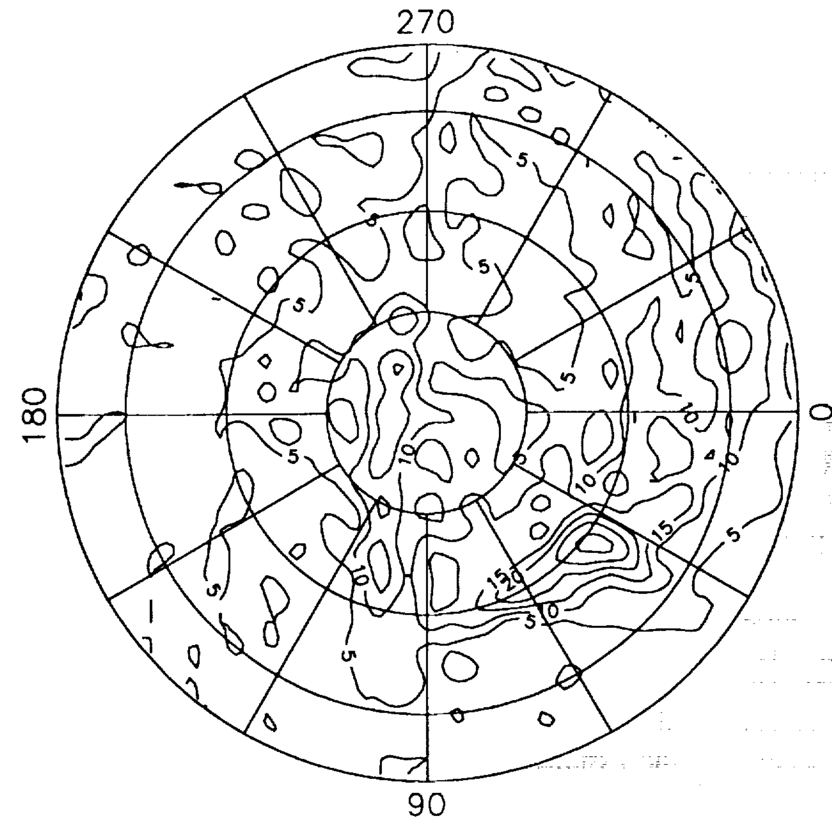

Figure 2. Radiant distribution for June 6, 1991. The circles correspond to declinations of 60°, 30°, 0° and -20°. Note the strong region of activity due to the Arietids close to $\alpha=40°$, $\delta=25°$.

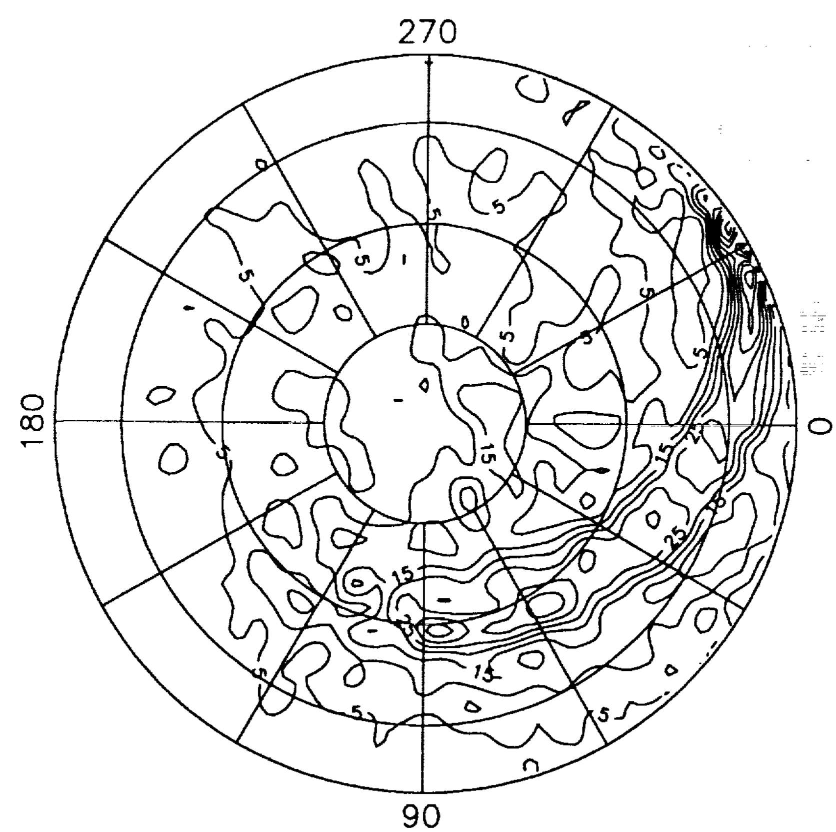

Figure 3. Radiant distribution for July 26, 1991. The circles correspond to declinations of 60°, 30°, 0° and -20°. Note the strong region of activity due to the δ-Aquarids close to $\alpha=330°$, $\delta=-17°$.