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USE OF METEOR SHOWER RADIANTS TO CALIBRATE THE ALIGNMENT OF METEOR RADAR ANTENNAS

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ABSTRACT

Skiymet meteor radars are now operating at three locations in Brazil: São João do Cariri (37 W, 7 S), Cachoeira Paulista (45 W, 23 S) and Santa Maria (54 W, 30 S). These radars provide 24-hour data on upper atmosphere winds between 80 and 100 km, with a time resolution of about 1 hour. All three radars are located at comparatively remote, poorly surveyed sites. For this reason there exist some doubts as to the precision with which their interferometric antennas systems are aligned. A precise knowledge of the alignment of the antennas with respect to geographic north is necessary to be able to accurately determine the meridional and zonal components of the winds. This knowledge is even more important if the radar data is to be used for the study of meteor shower radiants. In this paper we use the radar data for shower meteors to estimate the error in antenna alignment. To do this we make a series of small software adjustments to the assumed antenna alignment and, for each adjustment, calculate the meteor count at the radiant peak. It is then assumed that the adjustment giving maximum meteor count corresponds to the correct value for the antenna alignment. This process was repeated for sequences of days during several different showers for each radar. Averaging the results over the various showers measured provides a final antenna alignment value for each radar.

INTRODUCTION

The radar makes use of the ionized trails left by meteors when entering the Terrestrial Atmosphere. This ionization is the result of attrition between the surface of the meteor and atmospheric molecules. Measurements of echo delay, Doppler shift and angle of arrival are used to determine the location and motion of meteor trails. The radar uses 1 transmitter antenna and five receiving antennas, arranged in the form of a cross, with spacing of 2? and 2,5? (Figure 1). Although this radar can be used for meteor studies, the main interest of this group is in its application to the study of atmospheric dynamics.

There are two ways of verifying the alignment of the antennas through the radiant determination of a shower of meteors. The most obvious method is comparing the right ascension and declination measured by the radar with values already known. The difficulty found in this method, it is that the radiant of the showers varies a little during the shower, year by year, and it is difficult to be sure that the "standard value" is correct. A second method has the advantage that it doesn't demand a knowledge of the correct radiant. This work is aimed at presenting this second method.

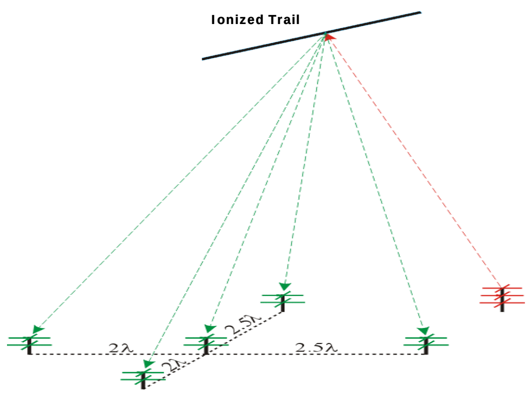

Figure 1 – The SKiYMET's arrangement with five receiving antennas and one transmitter antenna.

METHODOLOGY

The radar cannot determine the radiant of a meteor directly. The echo direction for the radar (azimuth and elevation) it is perpendicular to the meteor trail. Consequently we know that the radiant of the meteor lies somewhere in a plane perpendicular to the meteor echo direction. The intersection of this plane with the celestial sphere defines an arc, and we know that the radiant is located somewhere on this arc. Observing several meteors of the same shower, in different positions in the sky, we can define a different arc for each meteor. If all the meteors belong to the same shower, and neglecting measurement errors, all the arcs will cross at a single point, being this the radiant of the shower.

In reality there are sporadic meteors whose radiants are random, in such a way that not all the arcs will cross at the same point, but nevertheless it is easy to identify the radiant of a shower as corresponding to the point where the largest number of the arcs intersect.

To implement this technique, the sky was divided into bins of 2° x2°, and we counted how many arcs cross each bin. The bin which contains the largest number of arcs indicates the radiant direction of the shower. For each detected meteor, the arc in the celestial sphere is determined as function of the echo's elevation and azimuth, of the latitude and longitude of the radar, and local sidereal time. Any error in the alignment of the antennas will cause a similar error in the measured meteor azimuth. Because of this error, meteors belonging to the same shower, detected at different azimuths and elevations, will correspond to slightly different apparent radiants. In this case, the arcs in the celestial sphere do not cross in the same point, and the number of arcs crossing in the direction of the true radiant will be smaller. This suggests a simple method of identifying any error in the alignment of the antennas. In the program that determines the radiant, using the method explained above, a small delta is added to the azimuth of each meteor. Running the program several times, each time with a different delta, we can seek the delta that results in the highest bin count, that is the largest number of arcs crossing the same bin. This delta value represents the error in the antenna's alignment.

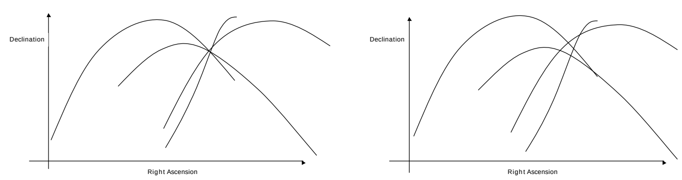

Figure 1 – Graph of Declination X Right Ascension for aligned antennas and not aligned antennas.

RESULTS AND DISCUSSIONS

Analyses were carried out for the Southern Delta Aquarids shower at Cachoeira Paulista – SP and São João do Cariri – PB, for the years of 2003 and 2004, respectively, and the Arietids in Santa Maria – RS in 2004. Alignment errors of between 0.5 and 1 degree were found, which will now be used as corrections in the data analysis software. We conclude that this method provides us with a sensitive technique for checking antenna alignment, and for determining corrections which can be applied in subsequent data reduction.

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