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Results of Draconid 2011 observations from the BRAMS network

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In this paper, the applicability of the Observability Function (OF) to the BRAMS network is presented. Preliminary results are shown taking into account only geometry. Radiation patterns of the antennas are assumed to be isotropic. Manual counts for the Draconids outburst in 2011 obtained with the BRAMS network data are presented. The differences between the different stations are discussed in terms of the OFs and other parameters.

1 Introduction

In 2009, the Belgian Institute for Space Aeronomy (BISA) initiated the development of BRAMS, a Belgian network of radio receiving stations using forward scattering techniques to detect meteors. This project is carried out in collaboration with about 20 Belgian radio amateurs or groups of amateur astronomers which host several receiving stations throughout the country (Calders and Lamy, 2012).

Due to different geometries and radiation patterns of the emitting and receiving antenna, the counts obtained at different stations during a meteor shower are different. The Observability Function (OF) is introduced in Section 2 to compensate for these differences and to enable a direct comparison of these counts. In principle the corrected meteor counts (i.e., observed meteor counts divided by OF) should become quite similar and give a (relative, not absolute) estimate of the real number of meteors. In Section 3, the OF is tentatively applied to the observations obtained by 11 BRAMS observers during the Draconids 2011 outburst.

2 Observability Function

The OF is a function that represents the sensitivity of a particular forward scatter setup to detect underdense meteors of a given shower at a given time t (Verbeeck, 1997). If the OF at time t_1 is twice as big as the OF at time t_2, and the meteor activity is constant, then the set-up will observe twice as many shower meteors at t_1 than at t_2. The OF is a number that varies with each configuration of the transmitter and receiver (each receiving station in the case of BRAMS) and with the position of the radiant of the meteor shower (hence with time).

The calculation of the OF occurs in two steps. First only geometrical aspects are taken into account. Those places in the sky where meteors from a given shower would satisfy the right geometrical conditions to provide a specular reflection of radio waves from the transmitter to the receiver are calculated. This is similar to finding the place on a mirror where an observer (receiver) will see the image of a lamp (transmitter), i.e., where the light from the lamp is reflected straight to the observer (Wislez, 2006). The locus of these places forms a surface in the sky. Figure 1 illustrates the reference frame used to calculate the OF for a given configuration of transmitter (T) and receiver (R).

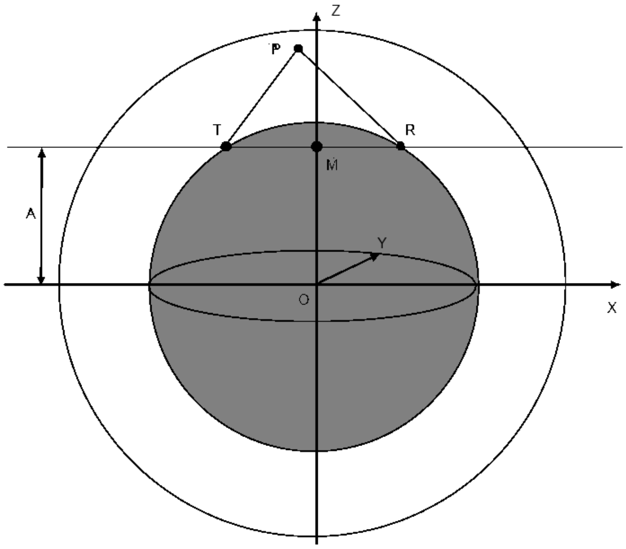

Figure 1 – Choice of the coordinate system in Figures 2, 3, and 4.

The origin of the frame is at the Earth's center. The z-axis is the vertical in the half-distance point between T and R, the x-axis is the line at $z = 0$ parallel to the line joining T and R. The y-axis is defined such that (x, y, z) is a right-handed system. Figures 2, 3 and 4 show the location of the possible reflection points at 100 km altitude for underdense meteors from the Draconid shower when the transmitter is the BRAMS beacon located in Dourbes and the receivers are located in Hove, Harelbeke (BRAMS stations), and Epinay-sur-Orge (France), respectively. Note that when fixing the altitude, we restrict the surface of possible reflection points to a curve.

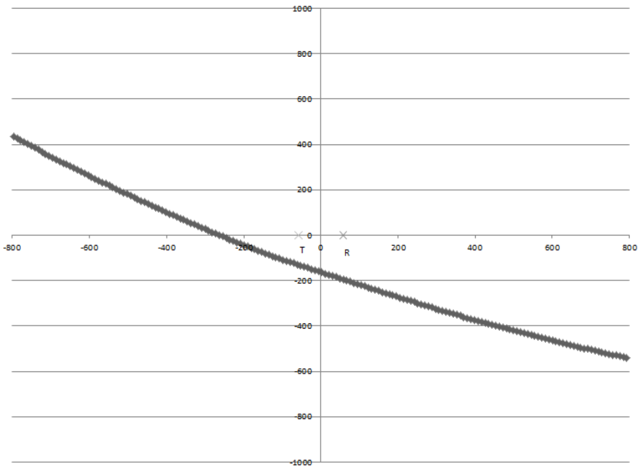

Figure 2 – The potential reflection point curve (projected on the xy-plane) for underdense Draconid meteors during the Draconid peak for Dourbes–Hove. The distance Dourbes–Hove is 117 km.

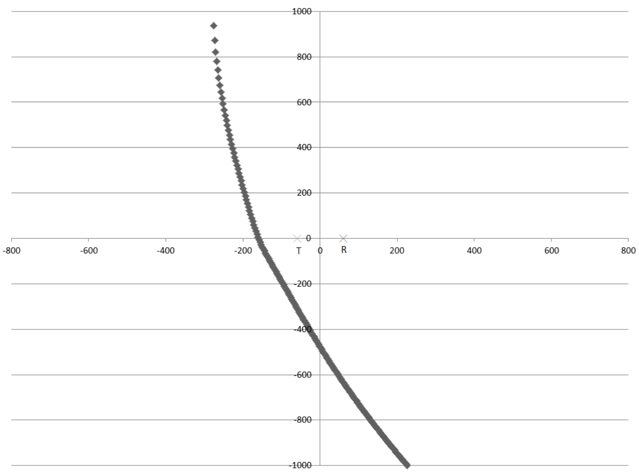

Figure 3 – The potential reflection point curve (projected on the xy-plane) for underdense Draconid meteors during the Draconid peak for Dourbes–Harelbeke. The distance Dourbes–Harelbeke is 120 km.

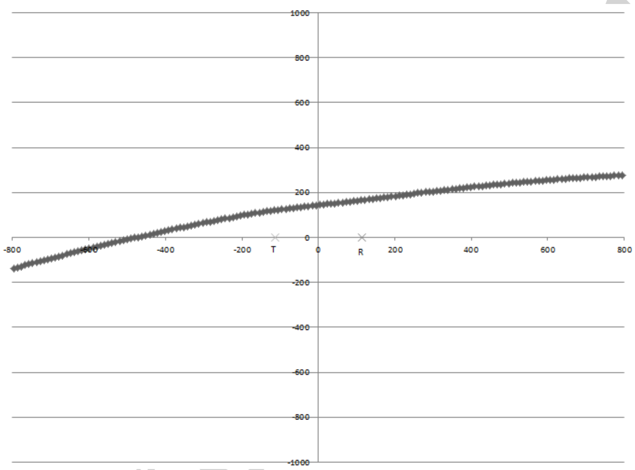

Figure 4 – The potential reflection point curve (projected on the xy-plane) for underdense Draconid meteors during the Draconid peak for Dourbes–Epinay-sur-Orge. The distance Dourbes–Epinay-sur-Orge is 226 km.

As expected, the curves for Hove and Harelbeke are very different because the baselines T–R are almost at 90° to each other and the positions of the possible specular reflection points must be very different. However, since the OF is calculated in a coordinate system centered on T and R, hence different for each station, a direct comparison is not so obvious. The current version of the software does not include a conversion of these curves to a common reference frame (geographical coordinates), but this shall be implemented soon.

The second step in the determination of the OF is to calculate for each point on these curves the strength of the signal received at R. This signal strength depends essentially on three factors (McKinley, 1961):

1. the geometry of the system T–R–meteor path (geometrical distances of T and R to the reflection point, orientation of the meteor path, etc.);
2. the antenna gains in the direction of the reflection points; and
3. the power emitted and the sensitivity of the reception chain (cable losses, receiver noise floor, etc.).

The OF is the integral (or sum in a discrete case) of the signal strength along all the specular reflection points. Unfortunately, at the moment, the exact radiation patterns for the transmitter in Dourbes and the different receivers have not been measured yet, so in the following we will assume as a very preliminary step an isotropic radiation pattern for all antennas.

3 Draconids 2011

The raw counts of meteor echoes during the period from $19^{\rm h}00^{\rm m}$ to $21^{\rm h}00^{\rm m}$ UT are presented in Figure 5 for 11 different BRAMS radio observers. The meteor reflections were counted manually during periods of 10 minutes, without making any distinction between short and long reflections. The main peak around $20^{\rm h}10^{\rm m}$ UT is clearly visible in data of all observers. The total raw counts vary between 178 (J.-L. Rault, Epinay-sur-Orge, France, most distant receiver located south of the beacon at 226 km) and 1177 (F. Dubois, Langemark, located west of the beacon at 150 km). Note that most receiving stations measure total raw counts around 368. It is not clear yet why the Langemark station saw many more echoes than the other BRAMS stations.

The raw counts are corrected by calculating the OF for the different radio observers every 10 minutes and dividing the raw counts by the OF. Note that the corrected counts are a relative measure: they provide the theoretical real number of meteors up to an unknown factor (which is the same for all observers). As mentioned in Section 2, one would expect that the corrected meteor counts for different observers would be quite similar to each other. Looking at Figure 6, this is not the case, however. One very plausible reason is that there was no distinction between underdense and overdense meteors in the counts. As can be seen from the spectrogram shown in Figure 7, there were a lot of long-lasting

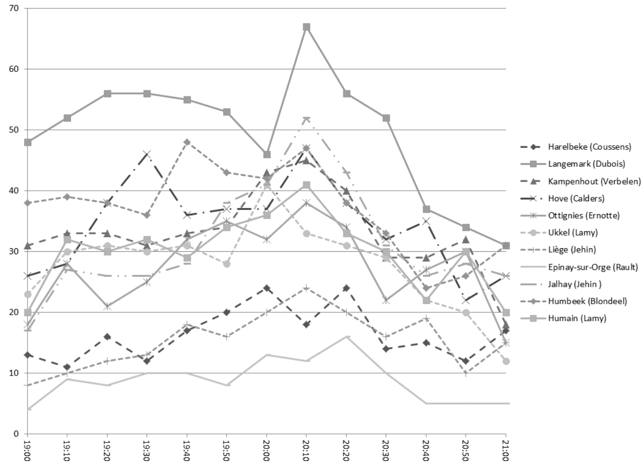

Figure 5 – The raw 10-minute counts from 11 different radio observers for the time around the maximum.

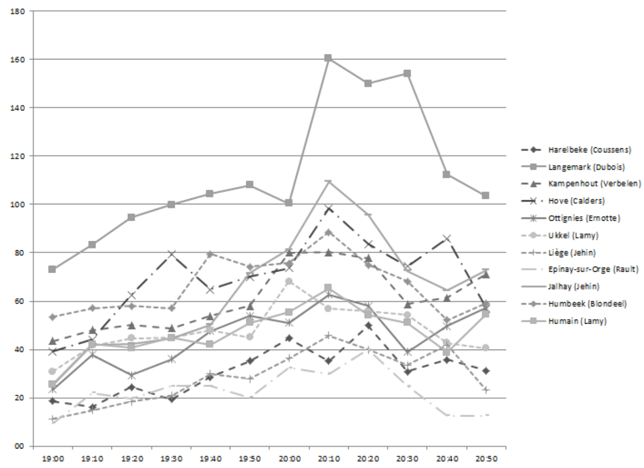

Figure 6 – The corrected 10-minute counts from 11 different radio observers for the time around the maximum.

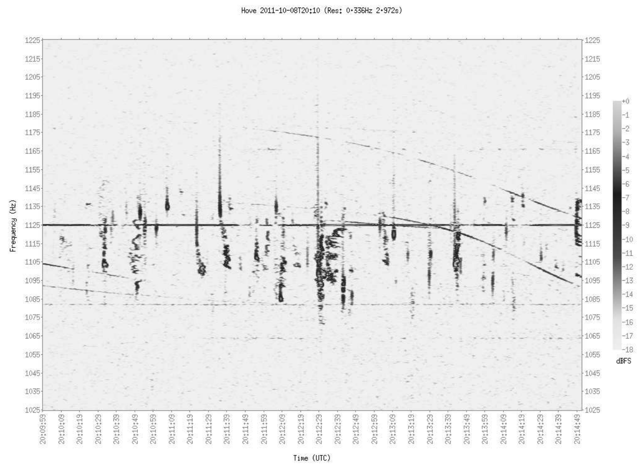

Figure 7 – Spectrogram of the station in Hove at $20^{h}10^{m}$ UT. There were a lot of long-lasting echoes during the Draconids burst with very strange shapes.

echoes during the Draconids burst with very strange shapes. For these echoes, the specular reflection condition is definitely not valid. Another reason could be a contamination of the Draconid meteors by the sporadic background meteors as we did not apply any statistical correction yet. Finally, incorrect assumptions in the calculation of the OF is another important factor, e.g., an isotropic radiation pattern of the beacon and the receiving antenna. It should also be noted that the OF is only a rough estimate of the real sensitivity of the system for detecting underdense shower meteors. More reliable estimates of the real absolute meteor activity can be obtained by flux density calculations (see Suleymanova et al. (2007); Verbeeck and Ryabova (2011); and Belkovich et al. (2006)).

4 Conclusions and future work

Raw 10-minute meteor counts observed during the Draconid peak on October 8, 2011, were presented for 11 stations of the BRAMS network. An attempt was made to correct them with the use of an Observability Function. The corrected counts for the different observers remain very different. This is probably due to a combination of factors: (1) the assumption of an isotropic radiation pattern of the antennas is clearly wrong; and (2) there was no distinction between underdense and overdense meteors, nor between Draconids and sporadic meteors. Nevertheless, we showed the locations of the specular reflection points at a given altitude for three different stations to illustrate that the geometrical part of the OF software is already working. In the future, the radiation pattern of the beacon antenna in Dourbes and of some of the receiving BRAMS antennas will be measured. The sensitivity of the reception chain will be carefully measured as well. With all this information, the OF calculations should in principle provide much better results. The OF software will then be applied to other meteor showers for which a careful distinction will be made between underdense and overdense meteor echoes and for which the sporadic background will be statistically estimated.

The latest information on the project can be found on our website, `http://brams.aeronomie.be`. The OF software has been written by Cis Verbeeck in `C++` and is maintained by Stijn Calders. The source code and the executables that are used to generate the plots can be downloaded from this website.

Acknowledgements

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[1] `http://www.stce.be`

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