Independent identification of meteor showers in EDMOND database

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This paper presents the results obtained by a proposed new independent method of meteor showers identification, which is applied to the current version of the database (EDMOND 5.0). In the first step of the survey we used the D_{SH} criterion to find groups around each meteor within the similarity threshold. Mean parameters of the groups were calculated and compared using a new function based on geocentric parameters (λ, α, δ, and V_g). Similar groups were merged into final clusters (representing meteor showers), and compared with the IAU Meteor Data Center list of meteor showers.

1 Introduction

In this paper, we focus on determining an independent method to associate an individual meteor in the EDMOND database with a given meteor shower (Kornos et al., 2013; Kornos et al., 2014a; Kornos et al., 2014b). The outcome of this method is the confirmation of some of the previously reported meteoroid streams listed in the IAU Meteor Data Center (IAU MDC), and finding potentially the discovery of new ones.

2 Methodology

Our cluster identification procedure links two types of meteor parameters: orbital elements (e, q, i, ω, and Ω) and geocentric parameters (λ, α, δ, and V_g). The first set of parameters is applied using the so called D-criteria that determine similarity between orbits of meteoroids. The second set of parameters measures similarity between meteors at the sky in a given meteor shower activity period. In the first step we use the Southworth and Hawkins D_{SH} criterion (1963), while in the second step a new distance function D_x is applied. The D_x criterion, which involves geocentric parameters, is defined as

$$\begin{aligned} D_x^2 &= w_\lambda \left[2\cdot\sin\left(\frac{\lambda_A-\lambda_B}{2}\right)\right]^2 \\ &+ w_\alpha\left(|V_{g_A}-V_{g_B}|+1\right)\left[2\cdot\sin\left(\frac{\alpha_A-\alpha_B}{2}\cdot\cos\delta_A\right)\right]^2 \\ &+ w_\delta\left(|V_{g_A}-V_{g_B}|+1\right)\left[2\cdot\sin\left(\frac{|\delta_A-\delta_B|}{2}\right)\right]^2 \\ &+ w_V\left[\frac{|V_{g_A}-V_{g_B}|}{V_{g_A}}\right]^2, \end{aligned}$$

where λ_A and λ_B are the solar longitudes, α_A and α_B are the right ascensions, δ_A and δ_B are the declinations, and V_{gA} and V_{gB} are the geocentric velocities of two meteors. The w_λ , w_α, w_δ , and w_V are suitably defined weighting factors. To normalize the contributions of each term in D_x , we used values: $w_\lambda = 0.17$, $w_\alpha = 1.20$, $w_\delta = 1.20$, and $w_v = 0.20$.

Our method may be summarised by the following steps:

Step 1: We probe the database using D_{SH} with a low threshold value D_c = 0.05. Around a meteoroid orbit a sphere of orbital parameters and radius D_c is "created". A set of orbits within the sphere creates a group, from which members are excluded following a search around another meteoroid orbit. In this way, we have independent groups around each reference meteoroid orbit. Next, for each group, a weighted mean of parameters is calculated.

Step 2: Using D_x we merge groups into clusters of similar weighted means of geocentric parameters found in Step 1. The groups are associated if $D_x \leq D_{c'}$, where $D_{c'}$ = 0.15. Next, the new weighted mean of the parameters for the cluster found in Step 2 is calculated. We repeat Step 2 using new means till the groups are no longer linked into clusters.

Step 3: We compare parameters of known meteor showers in the IAU MDC with the final mean values of the same parameters of the clusters found. For this purpose, we use D_{SH} criterion with $D_{c''}$ = 0.15.

3 Results

We present here results for selected cases. Figure 1 shows meteor concentrations of the meteor showers at the sky that are the most prominent showers in the EDMOND database, i.e. Geminids, Perseids, and Orionids (top panel). Their activity period lasts about 25-35 days. The Geminids and Orionids are more compact in comparison to the Perseids meteor shower. However, the Perseids are more prominent than the other two showers.

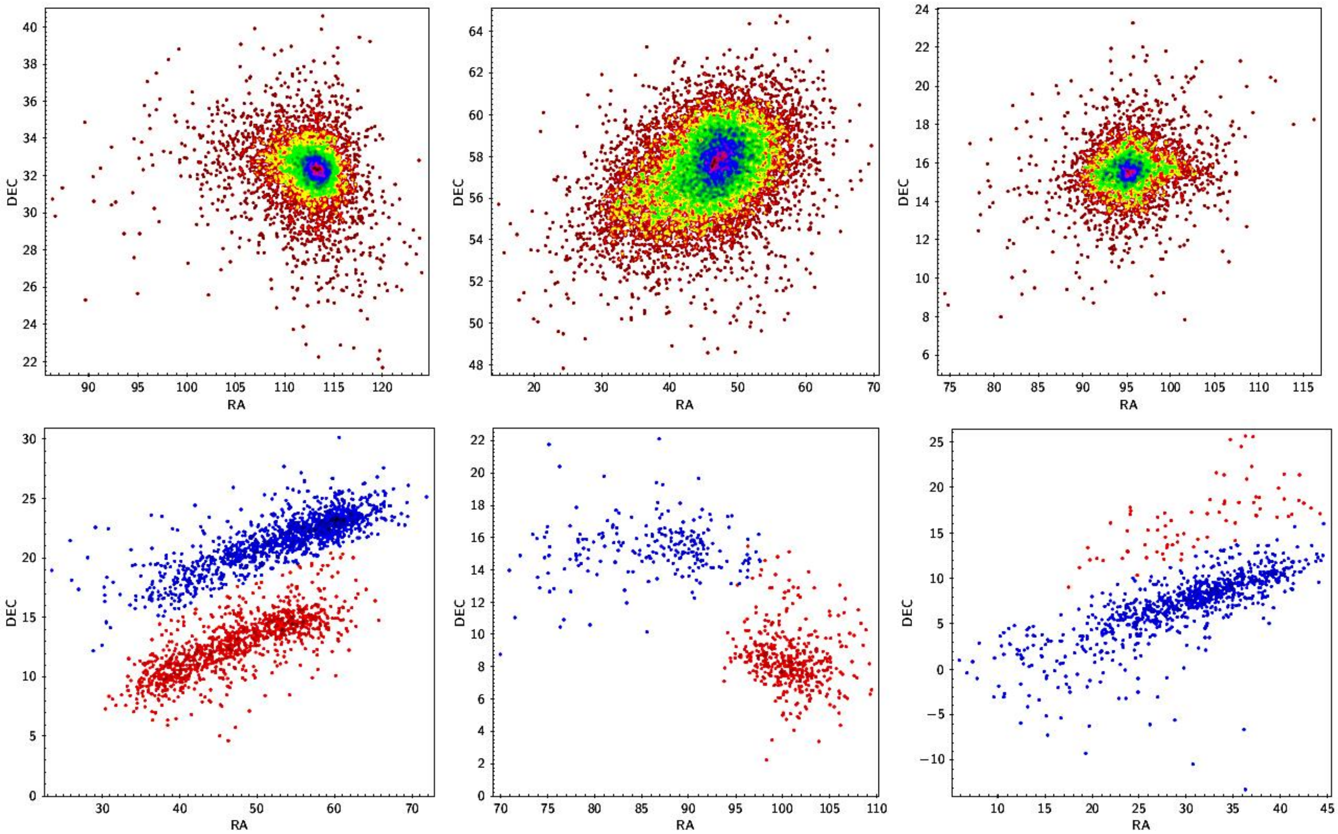

Figure 1 – Identified meteor showers. Top: Geminids (left), Perseids (centre), and Orionids (right). Colors represent meteor concentrations at the sky. Bottom: Southern & Northern Taurids (left), December Monocerotids & November Orionids (centre), and Northern & Southern October δ Arietids (right). Here, colors indicate different showers of the pair – respectively red & blue.

Figure 1 (bottom panel) presents some examples of meteor shower pairs such as: Southern & Northern Taurids, December Monocerotids & November Orionids, and Northern & Southern October δ Arietids. The second listed shower of a given pair is marked in blue. As shown in Figure 2, our identification procedure correctly separates those meteor showers. In other words, our method did not fail on separating the branches of the same meteor shower (e.g. Southern & Northern Taurids). Moreover, the identification step based on geocentric parameters is efficient enough to successfully separate two meteor showers located in close distance to each other at the sky (e.g. December Monocerotids & November Orionids).

4 Conclusion

We have identified 257 meteor showers. The list includes 42 already established streams, 152 from the working list and 63 *pro-tempore* meteor showers. For a higher threshold ($D_{c''}$ = 0.20), we found 284 meteor shower in total (44, 173 and 67, respectively). However, with a higher threshold value some of the showers are more contaminated by the sporadic background in comparison to the results obtained with the lower threshold ($D_{c''}$ = 0.15).

This identification was done only for those meteor showers for which their orbital elements are provided by the IAU MDC (as of June 2014). However, there are 174 meteor showers in the IAU MDC with no orbital data (Andreic et al., 2014). Thus, in those cases we could not apply the D_{SH} function to identify these clusters. We identified a few of them, however, using the D_x criterion instead of D_{SH} in Step 3. Their orbital elements were calculated, and they will be subsequently provided to the IAU MDC.

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