Database of meteoroid orbits from several European video networks

Leonard Kornoš[1], Jakub Koukal[2], Roman Piffl[2], and Juraj Tóth[1]

[1]**Faculty of Mathematics, Physics, and Informatics, Comenius University, Bratislava, Slovakia**
toth@fmph.uniba.sk

[2]**Central European Meteor Network**

EDMOND (European viDeo MeteOr Network Database) is a database of orbits based upon, and computed using, the video data of observed meteors. It is a result of cooperation and data sharing among seven national networks. This is the first version containing processed data from individual stations for the years 2009, 2010, 2011, and the first half of 2012 (until June 30, 2012). A total of 59 stations contributed 267 850 single-station meteors to this database up to date. However, these numbers are not yet final, as data from several stations are still being processed. Combined observations yielded 25 255 reliable orbits, which are published in the first version of the EDMOND database.

1 Introduction

Almost in every European country, there exist a network of video or photographic meteor observing stations. Groups from several countries maintain their own databases of meteoroid orbits obtained from double- or multi-station meteor observations. Single-station meteors largely remain unused. Therefore, it is important to try to find as many common meteors as possible among all neighboring networks.

2 Extended network

The European viDeo Meteor Observation Network (EDMONd) has been established only recently. The network originates from spontaneous cooperation between observers in several parts of Europe. Nowadays, EDMONd consists of observers from the following national networks (in alphabetical order): BOAM (French amateur observers, *Base des Observateurs Amateurs de Metéores*); CEMeNt (Central European Meteor Network, cross-border network of Czech and Slovak amateur observers), HMN (Hungarian Meteor Network or *Magyar Hullócsillagok Egyesület*, network of Hungarian amateur observers; IMTN (Italian amateur observers in Italian Meteor and TLE Network); PFN (Polish Fireball Network or *Pracownia Komet i Meteorów, PkiM*); SVMN (Slovak Video Meteor Network, of the Comenius University); and UKMON (UK Meteor Observation Network, network of UK amateur observers).

The cooperation between individual networks has begun in 2009, when a first orbit was being derived based on shared observations of the same meteor by CEMeNt and SVMN. In Spring 2010, we contacted the Polish and Hungarian networks (PFN and HMN). First data were obtained, combined, and assessed using different detection and processing tools (UFO Tools, MetRec). In the second half of 2011, Italian stations (IMTN) were also incorporated in EDMONd for the 2011 Draconid observing campaign. This collaboration resulted in a paper presenting precise orbits of meteoroids associated with Comet 21P/Giacobini-Zinner (Tóth et al., 2012). Inspired by this success, the UK network UKMON was established in 2012, which shared observing space with the French network (BOAM). This is the latest national network included in EDMONd (Figure 1).

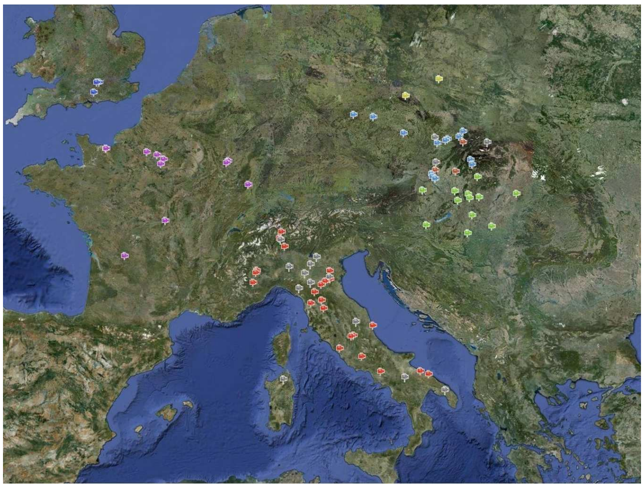


Figure 1 – Stations from national networks included in EDMONd. The stations are from BOAM, CEMeNt, HMN, IMTN, PFN, UKMON, and SVMN.

Amateur stations mostly use sensitive analog Closed Circuit Television (CCTV) cameras based on Sony chips (1/2″ ExView HAD, 1/3″ Super HAD) with a typical resolution of 720 × 576 pixels and a lens with a focal length of 3–8 mm and focal ratio of $f/0.8$–$f/1.4$. Most stations use UFOCapture software (from UFO Tools of SonotaCo, 2009) for automated meteor recognition, with the exception of the Hungarian stations (HMN), which use the MetRec package (Molau, 1999). The typical field of view is around 70° horizontally. These stations are able to detect meteors brighter than magnitude +2.5. However, the detection efficiency and sensitivity depends on the combination of the CCTV camera, lens, and local sky conditions at the observing site.

The main equipment of SVMN is the AMOS camera (All Sky Meteor Orbit System), developed and constructed at the Astronomical and Geophysical Observatory of the Comenius University, located in Modra (Zigo et al., 2013).

The number of stations in the national networks and single meteors shared in EDMONd are presented in Table 1.

Table 1 – Number of stations in particular networks and single meteors shared in EDMONd.

Network	Stations	Meteors (single)
BOAM	9	20 128
CEMeNt	13	17 922
HMN	13	107 582
IMTN	16	105 989
PFN	5	174
SVMN	2	15 840
UKMON	1	215
Totals	59	267 850

3 New database of orbits

As we mentioned above, the presented database of meteoroid orbits is a result of the newly established international network EDMONd of video meteor observers. Meteor data in the database are obtained with various instruments and processing tools (UFO Tools and MetRec).

First of all, it was necessary to convert MetRec data to the UFOOrbit format. The MetRec data were imported via the conversion software INF2MCSV written by SonotaCo[1]. This program supports several conversion methods. To obtain the optimal match with the UFOAnalyzer results, we tested about 230 double-station meteors detected in a direct campaign between April and June 2011 where one station was using MetRec and the second one UFOCapture. Resulting data were uploaded into UFOOrbit. Finally, the UFOOrbit output generated the quality parameter (*QA*), the duration of the meteor (*dur*), and the geocentric velocity (V_g) which have been assessed. Following these parameters, the analysis shows that the best criterion for data conversion from MetRec to a csv file for UFOOrbit is the transfer method (Y). This method provides the best matching data with respect to the UFOAnalyzer output, where errors with respect to V_g and *dur* are minimized. Therefore, this procedure is applied to the Hungarian data, which make up about 35% of all EDMOND entries.

[1] `http://sonotaco.com/soft/e_index.html`.

Output csv files from UFOAnalyzer by individual stations are obtained and assembled by national coordinators. Data analysis is mostly performed by careful manual measurements of each meteor by individual observers. Results are then sent to national coordinators (Stéphane Jouin, BOAM; Jakub Koukal, CEMeNt; Antal Igaz, HMN; Ferruccio Zanotti, IMTN; Przemysław Żołądek, PFN; Juraj Tóth, SVMN; Richard Káčerek, UKMON). Data are collected on the common ftp server. The MetRec conversion is done by Jakub Koukal.

The main computation of orbits is performed with the UFOOrbit software. UFOOrbit allows multiple parameter settings. Our database contains unfiltered data obtained by setting Q_0. Meteors are coupled only when the time of the suspected meteor does not differ more than 5 seconds. The Q_0 parameter provides all possible combinations, and a difference of $dt = 5$ s was chosen because several stations had difficulties with a correct time setting. We thus obtained 37 347 orbits. A more restrictive selection of orbits was needed, however, because many fictional orbits (also according to SonotaCo, pers. comm.) were present in this set. The chosen parameters used to select the data are shown in Table 2. The procedure was carried out in two steps. In the first step, we set up the beginning and terminal heights and overlapping parameter Gm%. The value −100% was taken from SonotaCo (pers. comm.), where the negative value means that the two stations do not see the same part of the observed meteor.

Table 2 – The values of parameters that were used for restriction and their description according to SonotaCo (2009 and UFOOrbit manual).

Parameter	Value	Description
$H_{1,2}$	(15,200) km	beg. and term. heights
Gm%	$> -100\%$	overlap of meteor
Q_0	$> 1°$	angle of obs. trajectory
dur	> 0.1 s	duration of meteor
d*GP*	$< 0.5°$	diff. of two poles of ground trajectory
Q_c	$> 10°$	convergence angle
d*v*12%	$< 10\%$	diff. of two velocities

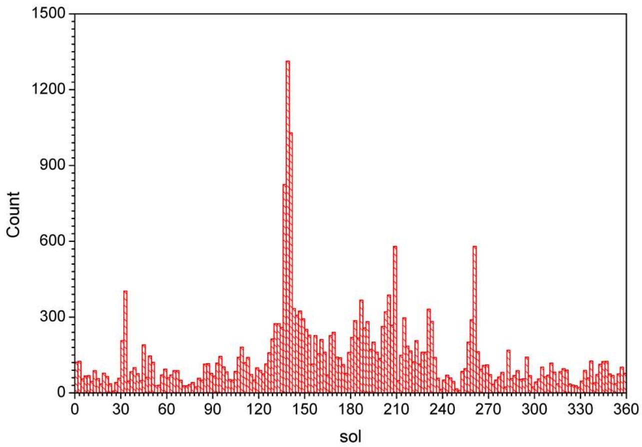


Figure 2 – Meteor activity from the database EDMOND during 2009–mid 2012.

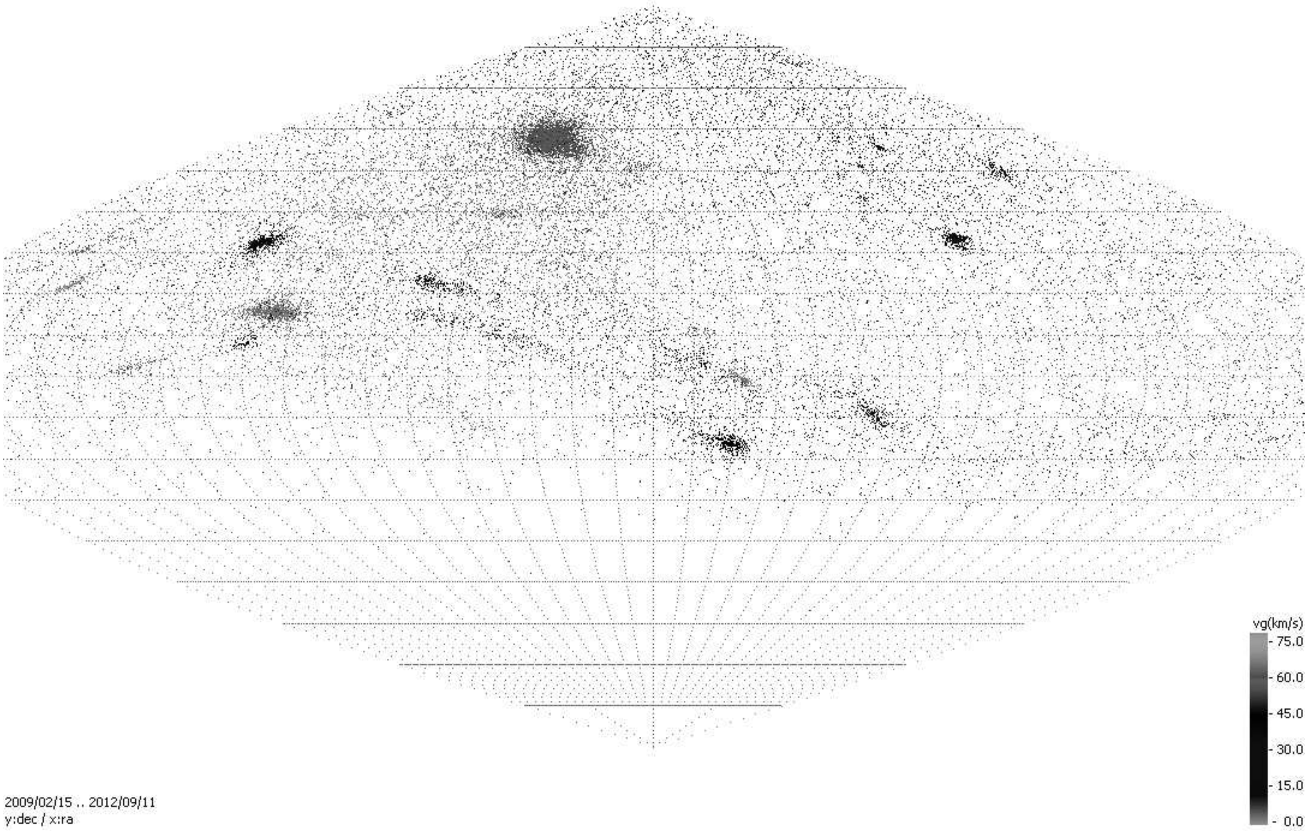


Figure 3 – Radiants for all meteors from the database EDMOND.

In the second step, the values of the selected parameters Q_0, *dur*, d*GP*, Q_c and d*v*12%, described in the UFO-Orbit manual (SonotaCo web page, section "Download"), were set not so strictly (Table 2), thus we could obtain as many real orbits as possible. This way, we have obtained more than 25 250 meteoroid orbits from 2009 to mid 2012. This database named EDMOND (European viDeo MeteOr Network Database)[2] will be updated regularly.

There are 21 833 double-station orbits, 2 666 three-station, 527 four-station and 148 five-station orbits in the database. The precision of multi-station orbits has not been analyzed yet. In total, 15 870 sporadic and 9 385 shower meteors have been identified in the database. From the list of the IAU Meteor Data Center, 33 established showers and 22 working list showers are represented with at least 10 meteors in the database. The activity profile from 2009 to mid 2012 is presented in Figure 2, and all radiants are shown in Figure 3. Observations run continuously throughout the year.

We performed a small analysis of the EDMOND database (Figures 4 and 5). The parameter d*v*12% stands for the difference between the unified velocity and the velocity from one of the observing stations. This parameter is very important, as a difference of about 10% is already considered very large.

We have compared the distribution of the parameter d*v*12% in our database with the distribution in the SonotaCo Q1 2009 database. As can be seen in Figure 4, the drop in the number of meteors with increasing d*v*12% in the SonotaCo data is steeper than in EDMOND, which favors SonotaCo's data. On the other hand, the SonotaCo database contains also meteors with much larger values of d*v*% than 10%. Such meteors are removed from our database.

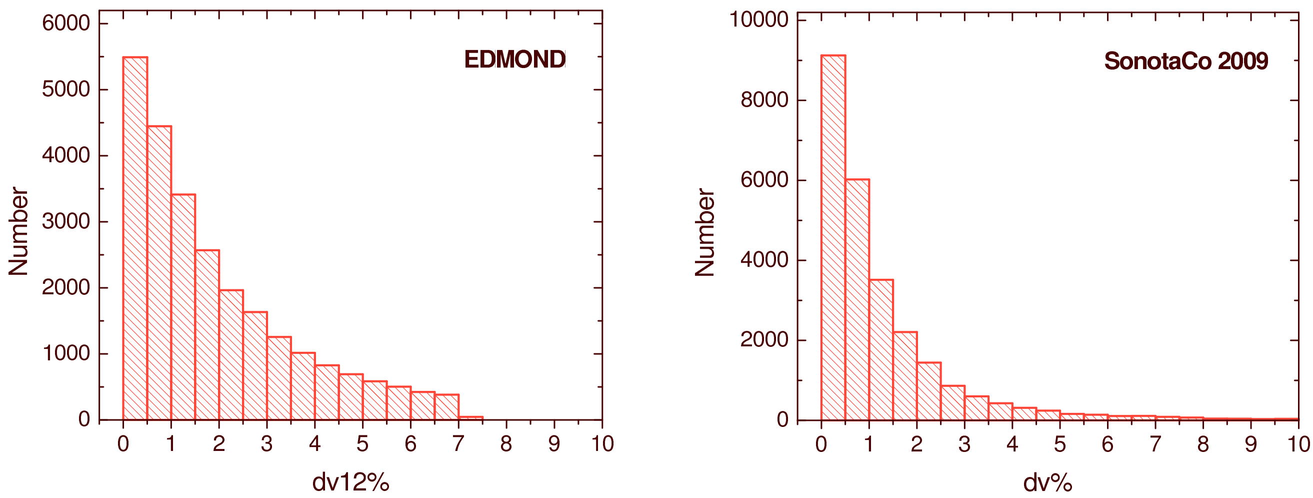
We have also compared the dispersion of the orbital elements e (eccentricity) and i (inclination) for the Lyrids in both databases. The identification of a meteor with the stream is taken from SonotaCo. As can be seen in Figure 5, the SonotaCo database also includes several meteors that do not match the Lyrid stream well, but the dispersion of the core of the distribution (both e and i) is lower than the dispersion of the core of the distribution for the same elements in the new database.

4 Conclusions

The EDMOND data are compiled from 7 networks and 59 stations, and consist of 25 255 orbits collected in the period from 2009 to mid-2012. A lower precision of the data in EDMOND may be caused by several factors, including the following:

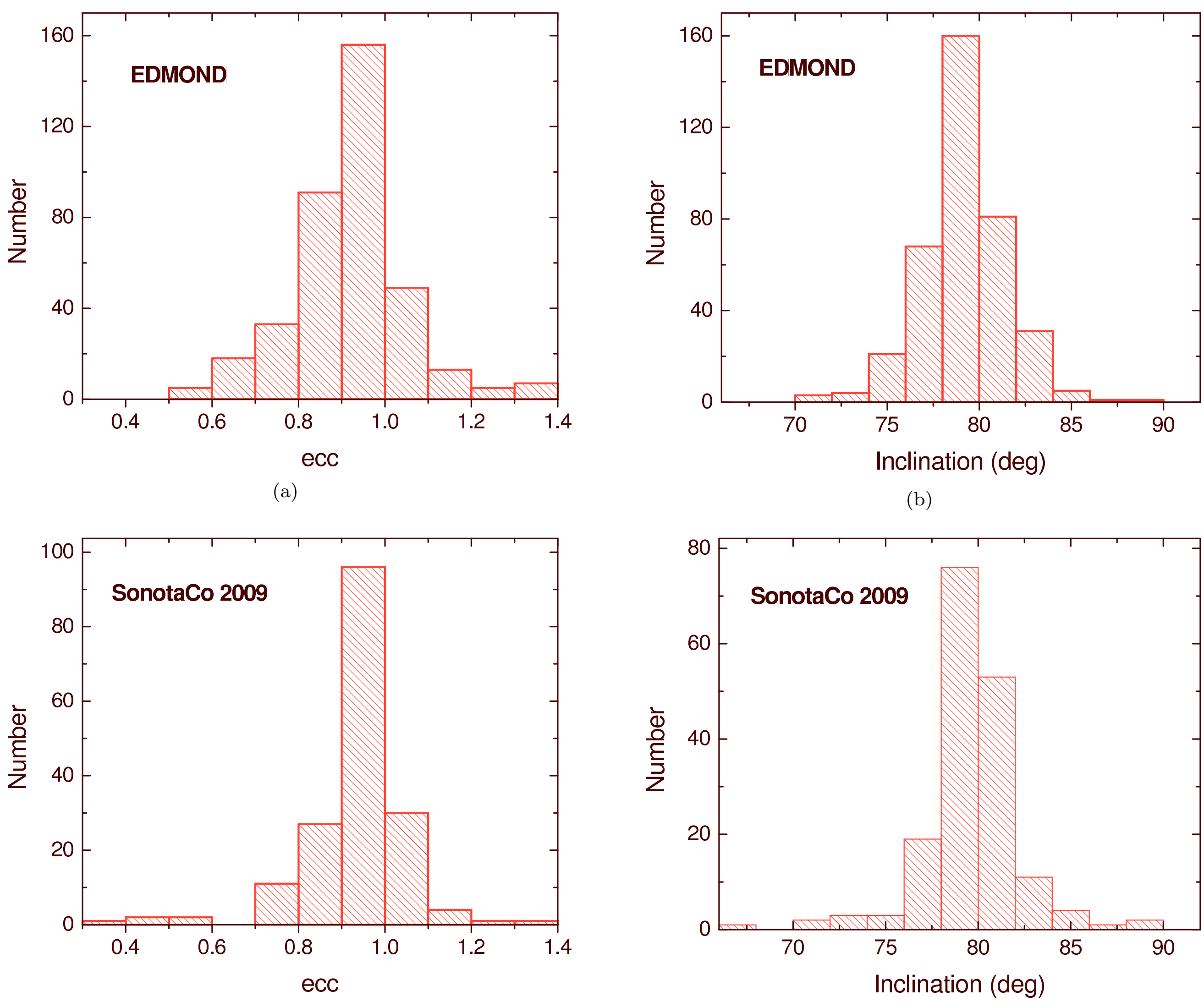
- different equipment (resolution, analog or digital cameras);
- different processing tools (MetRec, UFO); and
- measuring experience.

[2] `http://cement.fireball.sk/`, section "Download".



(a) (b)

Figure 4 – Distribution of the difference dv12% of the unified velocity and the velocity of one of the observing stations for the EDMOND (a) and SonotaCo Q1 2009 (b) databases.



(a) (b) (c) (d)

Figure 5 – Dispersion of orbital parameters (eccentricity and inclination) of the Lyrids in the EDMOND (a, b) and SonotaCo Q1 2009 (c, d) datatabases.

We intend to carry out a more detailed analysis of the precision we have obtained in the near future. For example, the SVMN and CEMeNt observations have been confronted several times with the most precise photographic data available that were obtained by the European Fireball Network, operated by the Ondřejov Observatory. Our data are only about one half of an order of magnitude less precise than the the photographic data. For now, the main result of this effort is that the new database EDMOND includes data from many observers in Europe, and has the potential to be improved and enlarged.

Acknowledgements

The work was supported by the grants VEGA 1/0636/09 and APVV-0516-10. We greatly appreciate the help of professional and amateur astronomers who provided the video observations and data analysis, and appreciate the international cooperation and smooth data sharing.

References

Molau S. (1999). "The meteor detection software MetRec". In Arlt R. and Knöfel A., editors, *Proceedings of the International Meteor Conference*, Stará Lesná, 20–23 August 1998, IMO, pages 9–16.

SonotaCo (2009). "A meteor shower catalog based on video observations in 2007–2008". *WGN, Journal of the IMO*, **37**, 55–62.

Tóth J., Piffl R., Koukal J., Żołądek P., Wiśniewski M., Gajdoš Š., Zanotti F., Valeri D., De Maria P., Popek M., Gorková S., Világi J., and Kornoš L. (2012). "Video observation of Draconids 2011 from Italy". *WGN, Journal of the IMO*, **40**, 117–121.

Zigo P., Tóth J., and Kalmančok D. (2013). "All-Sky Meteor Orbit System (AMOS)". In Gyssens M. and Roggemans P., editors, *Proceedings of the International Meteor Conference*, La Palma, September 20–23, 2012, IMO, pages 18–20.