

# Croatian Meteor Network Catalogues of Orbits for 2008 and 2009

Korado Korlević<sup>1</sup>, Damir Šegon<sup>2</sup>, Željko Andreić<sup>3</sup>, Filip Novoselnik<sup>4</sup>, Denis Vida<sup>5</sup> and Ivica Skokić<sup>6</sup>

The Croatian Meteor Network catalogues of meteor orbits that resulted from data gathered by CMN during 2008 and 2009 are described. The 2008 catalogue contains 4026 orbits and the 2009 catalogue 4382 orbits. The catalogues can be accessed via the CMN web page.

Received 2012 November 5

## 1 Introduction

The years 2008 and 2009 were the second and third year of operation of the Croatian Meteor Network (CMN). The network is described in more detail in (Andrić & Šegon, 2010; Andreić et al., 2010). The already published catalogue for 2007 is described in (Šegon et al., 2012). All CMN catalogues can be downloaded from the download page of the CMN: <http://cmn.rgn.hr/downloads/downloads.html>.

The SKYPATROL program (Vornhusen, 2003) was used for image acquisition. Images were reduced afterwards, with the help of software written especially for this purpose by Peter Gural. This software is described in detail in (Gural & Šegon, 2009). The software automatically scans through the images from a given night collected by SkyPatrol. The MTP driver program scans through an entire night's collected data in a single sweep automatically and provides frame-by-frame focal plane positions of each meteor track. It also estimates positions of stars in each BMP for astrometric calibration and it can operate under partly cloudy conditions. All data gathered is stored in appropriate data files that are used in the next processing step. For details of the data reduction process see (Šegon et al., 2012).

The catalogue compilation process starts by combining the data on meteor tracks obtained from individual cameras to identify meteors recorded by two or more cameras. During this procedure the clock error of each camera is determined and accounted for (Vida & Novoselnik, 2011).

There is an important point that should be noted: while all meteors published in the CMN 2007 catalogue have been manually re-checked, from 2008 onwards some CMN stations started with fully automatic

data processing. In order to minimize eventual coincidence of non-meteor events which could be recognized as meteors, CMN 2008 and later catalogues to follow have also been processed with UFOORBIT Q1 settings but enforced with an additional rule of the meteor trajectory overlap to be at least 2%.

The data in the catalogue is stored in the UFOORbit \*.csv R80 format (SonotaCo, 2008) with the only difference to the standard R80 format of UFOORbit being that the column "LocalTime" is used for storing the CMN meteor identification code, not the local time of the meteor appearance.

## 2 The CMN Catalogue of Orbits for 2008

Fifteen CMN cameras were in operation in 2008 (see Table 3). They covered most of the sky above the northern

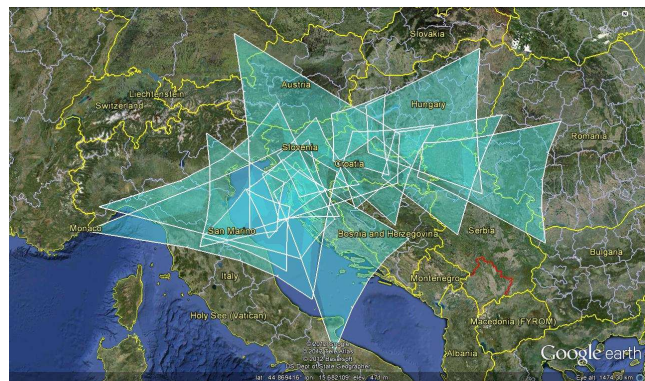


Figure 1 – Locations of CMN cameras that were in operation in 2008, and their fields of view at the typical meteor height of 100 km.

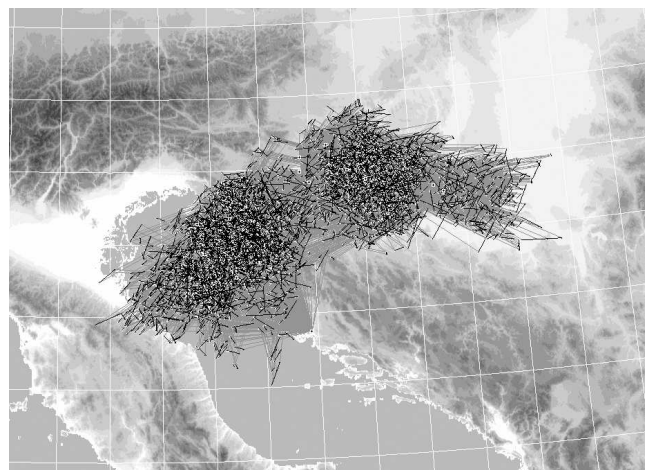


Figure 2 – Plot of ground tracks of meteors from the CMN Catalogue of Orbits for 2008.

<sup>1</sup>Višnja Science and Education Center, Istarska 5, 51463 Višnja, Croatia. Email: [korado@astro.hr](mailto:korado@astro.hr)

<sup>2</sup>Observatory of Astronomical Society Istra Pula, Park Monte Zaro 2, 52100 Pula, Croatia. Email: [damir.segon@pu.htnet.hr](mailto:damir.segon@pu.htnet.hr)

<sup>3</sup>University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, Pierottijeva 6, 10000 Zagreb, Croatia. Email: [zandreic@rgn.hr](mailto:zandreic@rgn.hr)

<sup>4</sup>Astronomical Society "Anonymus", B. Radića 34, 31550 Valpovo, Croatia and Faculty of Electrical Engineering, University of Osijek, Kneza Trpimira 2B, 31000 Osijek, Croatia. Email: [filip.novoselnik@gmail.com](mailto:filip.novoselnik@gmail.com)

<sup>5</sup>Astronomical Society "Anonymus", B. Radića 34, 31550 Valpovo, Croatia and Faculty of Electrical Engineering, University of Osijek, Kneza Trpimira 2B, 31000 Osijek, Croatia. Email: [denis.vida@gmail.com](mailto:denis.vida@gmail.com)

<sup>6</sup>Astronomical Society "Anonymus", B. Radića 34, 31550 Valpovo, Croatia. Email: [ivica.skokic@gmail.com](mailto:ivica.skokic@gmail.com)

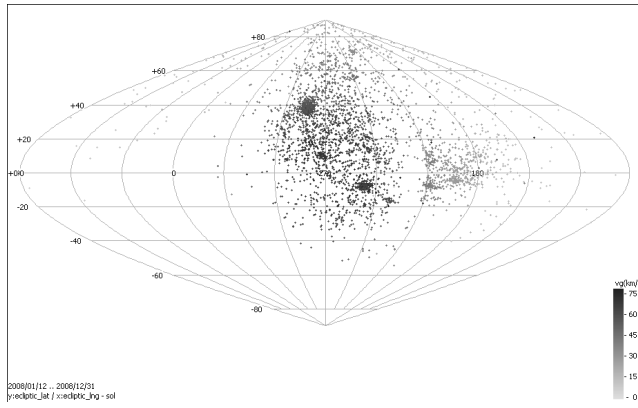


Figure 3 – Radiant plot of orbits from the CMN Catalogue of Orbits for 2008, in ecliptic coordinates. Longitude is given relative to the sun. Geocentric velocities are color coded.

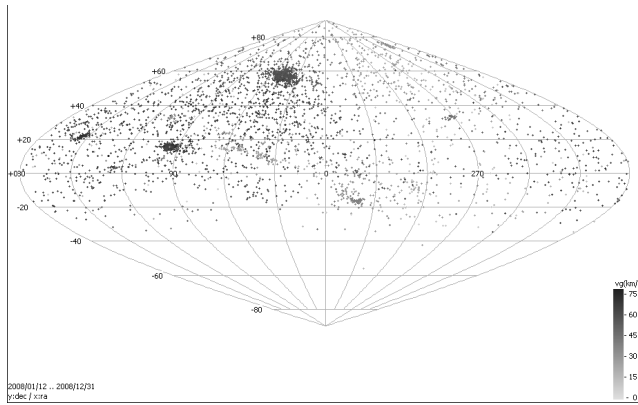


Figure 4 – As Figure 3, but in equatorial coordinates.

part of Croatia (Figure 1). Altogether 8673 double or multiple sightings were recorded, from which 4026 orbits are derived. About half of the orbits (1913) can be attributed to known streams (see Table 1).

The ground tracks of observed double station meteors follow quite closely the sky coverage of CMN cameras (Figure 2). Radiant plots of all orbits are given in ecliptic (Figure 3) and equatorial coordinates (Figure 4).

### 3 The CMN Catalogue of Orbits for 2009

Twenty-two CMN cameras were in operation in 2009 (see Table 4). In this year most of the sky over Croatia was successfully covered by at least two cameras (Figure 5). Altogether 9538 double or multiple sightings were recorded from which 4382 orbits were derived, half of which (1767) attributed to known streams (see Table 2).

The ground tracks of observed double station meteors follow quite closely the sky coverage of CMN cameras (Figure 6). Finally, radiant plots of all orbits in ecliptic (Figure 7) and equatorial coordinates (Figure 8) are also given here.

Table 1 – Double station stream statistics for 2008. The first column gives the IAU stream code, the second the IAU three-letter code and the third the number of orbits in the database.

| IAU No. | Code | No. | IAU No. | Code | No.  |
|---------|------|-----|---------|------|------|
| 266     | ACC  | 1   | 6       | Lyr  | 19   |
| 199     | ADC  | 1   | 142     | MDR  | 1    |
| 331     | aHy  | 1   | 19      | Mon  | 7    |
| 18      | And  | 1   | 229     | NAU  | 4    |
| 55      | ASC  | 1   | 33      | NIA  | 2    |
| 197     | AUD  | 3   | 250     | noO  | 8    |
| 206     | AUR  | 4   | 67      | NSA  | 1    |
| 210     | BAU  | 2   | 66      | NSC  | 1    |
| 232     | BCN  | 1   | 167     | NSS  | 2    |
| 190     | BPE  | 10  | 17      | nTa  | 31   |
| 26      | NDA  | 24  | 337     | nuE  | 2    |
| 1       | Cap  | 24  | 164     | NZC  | 1    |
| 20      | Com  | 24  | 281     | oCt  | 2    |
| 38      | CUR  | 1   | 333     | ocU  | 4    |
| 334     | daD  | 12  | 182     | OCY  | 1    |
| 224     | DAU  | 4   | 228     | OLY  | 3    |
| 47      | DLI  | 1   | 227     | OMO  | 1    |
| 9       | DRA  | 2   | 8       | Ori  | 325  |
| 34      | DSE  | 4   | 241     | OUI  | 1    |
| 221     | dSx  | 1   | 183     | Pau  | 4    |
| 23      | EGE  | 7   | 7       | Per  | 981  |
| 145     | eLy  | 5   | 101     | PIH  | 3    |
| 234     | EPC  | 2   | 10      | Qua  | 3    |
| 191     | Eri  | 18  | 5       | sdA  | 52   |
| 31      | etA  | 7   | 113     | SDL  | 2    |
| 186     | EUM  | 1   | 208     | sPe  | 6    |
| 4       | Gem  | 24  | 2       | sTa  | 80   |
| 343     | hVi  | 1   | 340     | tPy  | 1    |
| 16      | Hyd  | 32  | 192     | TRI  | 1    |
| 248     | IAR  | 1   | 194     | UCE  | 1    |
|         | jug  | 4   | 15      | Urs  | 30   |
| 12      | kCg  | 11  | 205     | XAU  | 4    |
| 380     | kDr  | 3   | 242     | XDR  | 1    |
| 13      | Leo  | 75  | 335     | xVi  | 1    |
| 22      | Lmi  | 8   | 193     | ZAR  | 4    |
| 49      | LVI  | 1   | 40      | ZCY  | 1    |
|         |      |     | spo     |      | 2113 |
|         |      |     | Total   |      | 4026 |

### Acknowledgements

Our thanks go to all members of the Croatian Meteor Network, as listed in Tables 3 and 4. Also, to Peter Gural for the MTP detection software and its adaptation

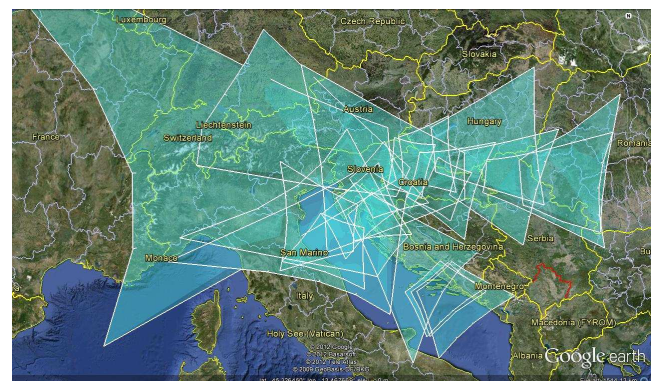


Figure 5 – Locations of CMN cameras that were in operation in 2009, and their fields of view at the typical meteor height of 100 km.

Table 2 – Double station stream statistics for 2009. The first column gives the IAU stream code, the second the IAU three-letter code and the third the number of orbits in the database.

| IAU No. | Code | No. | IAU No. | Code | No.   |      |
|---------|------|-----|---------|------|-------|------|
| 138     | ABO  | 1   | 19      | Mon  | 4     |      |
| 231     | ACM  | 2   | 229     | NAU  | 3     |      |
| 199     | ADC  | 2   | 96      | NCC  | 1     |      |
| 331     | aHy  | 3   | 112     | NDL  | 1     |      |
| 18      | And  | 2   | 245     | NHD  | 1     |      |
| 211     | AOR  | 1   | 33      | NIA  | 2     |      |
| 197     | AUD  | 4   | 250     | noO  | 7     |      |
| 206     | AUR  | 9   | 215     | NPI  | 1     |      |
| 210     | BAU  | 8   | 67      | NSA  | 1     |      |
| 177     | BCA  | 3   | 167     | NSS  | 1     |      |
| 232     | BCN  | 1   | 17      | nTa  | 28    |      |
| 190     | BPE  | 1   | 337     | nuE  | 3     |      |
| 26      | NDA  | 27  | 83      | OCG  | 1     |      |
| 1       | Cap  | 31  | 333     | ocU  | 3     |      |
| 20      | Com  | 22  | 182     | OCY  | 1     |      |
| 38      | CUR  | 1   | 88      | ODR  | 1     |      |
| 334     | daD  | 11  | 227     | OMO  | 2     |      |
| 224     | DAU  | 3   | 8       | Ori  | 236   |      |
| 34      | DSE  | 3   | 241     | OUI  | 1     |      |
| 221     | dSx  | 1   | 244     | PAR  | 1     |      |
| 23      | EGE  | 5   | 183     | Pau  | 2     |      |
| 145     | eLy  | 4   | 7       | Per  | 730   |      |
| 234     | EPC  | 2   | 101     | PIH  | 1     |      |
| 191     | Eri  | 4   | 89      | PVI  | 2     |      |
| 31      | etA  | 19  | 10      | Qua  | 141   |      |
| 11      | eVi  | 14  | 125     | SAL  | 1     |      |
| 65      | GDE  | 1   | 179     | SCA  | 1     |      |
| 4       | Gem  | 84  | 5       | sdA  | 107   |      |
| 236     | GPS  | 1   | 113     | SDL  | 1     |      |
| 343     | hVi  | 2   | 81      | SLY  | 3     |      |
| 16      | Hyd  | 14  | 150     | SOP  | 1     |      |
| 319     | JLE  | 2   | 225     | SOR  | 2     |      |
| 175     | JPE  | 2   | 208     | sPe  | 8     |      |
| 91      | JZA  | 1   | 2       | sTa  | 61    |      |
| 12      | kCg  | 24  | 124     | SVI  | 1     |      |
| 380     | kDr  | 5   | 192     | TRI  | 4     |      |
| 235     | LCY  | 1   | 194     | UCE  | 4     |      |
| 13      | Leo  | 36  | 15      | Urs  | 1     |      |
| 22      | Lmi  | 4   | 205     | XAU  | 1     |      |
| 49      | LVI  | 1   | 242     | XDR  | 1     |      |
| 6       | Lyr  | 27  | 193     | ZAR  | 3     |      |
| 127     | MCA  | 1   | 43      | ZSE  | 2     |      |
|         |      |     |         |      | spo   | 2615 |
|         |      |     |         |      | Total | 4382 |

for CMN images and for extensive discussions about all aspects of video meteor detections, to Igor Terlević for many contributions to the CMN software suite and to Filip Lolić for hardware modifications of the CMN cameras.

This work was supported by the Ministry of Science, Education and Sports of the Republic of Croatia and Višnjan Science and Education Center.

References

Andrić Ž. and Šegon D. (2010). “The first year of Croatian Meteor Network”. In Kaniansky S. and Zimnikoval P., editors, *Proceedings of the International Meteor Conference, Šachtička, Slovakia*,

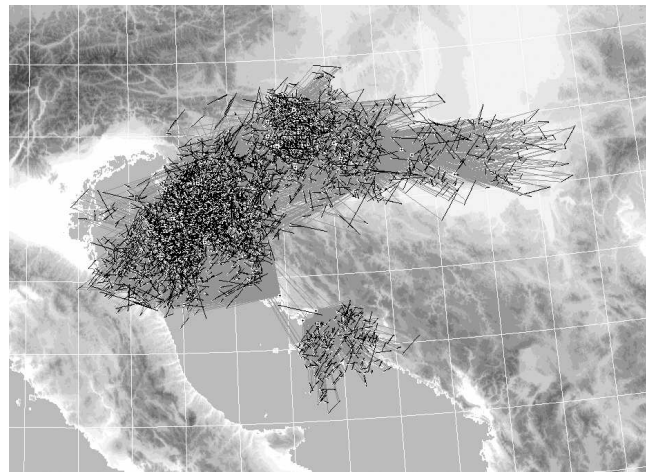


Figure 6 – Plot of ground tracks of meteors from the CMN Catalogue of Orbits for 2009.

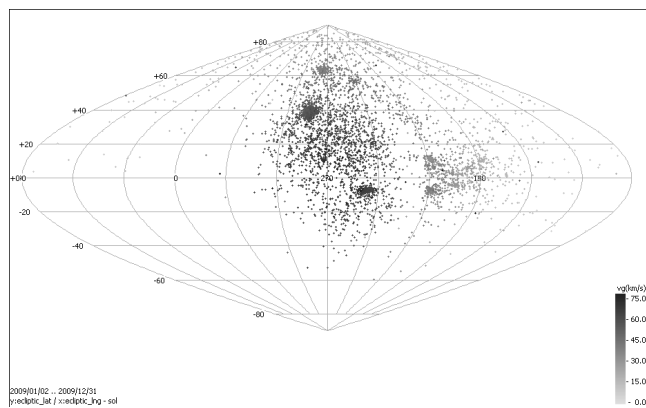


Figure 7 – Radiant plot of orbits from the CMN Catalogue of Orbits for 2009, in ecliptic coordinates. Longitude is given relative to the sun. Geocentric velocities are color coded.

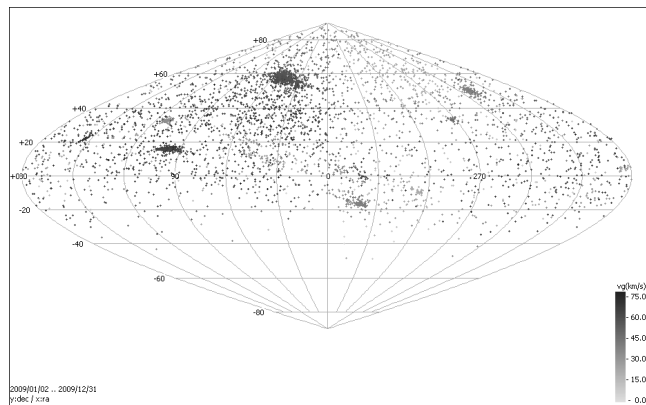


Figure 8 – As Figure 7, but in equatorial coordinates.

18-21 September 2008, pages 16–23. International Meteor Organization.

Andrić Ž., Šegon D., and Korlević K. (2010). “The second year of Croatian Meteor Network”. In Andrić Ž. and Kac J., editors, *Proceedings of the International Meteor Conference, Poreč, Croatia, 24-27 September 2009*, pages 26–30. International Meteor Organization.

Gural P. and Šegon D. (2009). “A new meteor detection processing approach for observations collected

Table 3 – List of CMN cameras that were in operation in 2008. The first two columns give the CMN camera label, its location and principal operator. Coordinates of the camera location are provided in the next three columns. The last column shows the number of double station meteors detected by the particular camera in the corresponding year.

| code    | location and operator                              | longitude | latitude | z (m) | no. meteors |
|---------|--|-----------|----------|-------|-------------|
| CMN_BJA | Rovišće: Denis Štogl, Luka Osokruš                 | 16.7313   | 45.9464  | 134   | 155         |
| CMN_MEA | Merenje: Željko Andreić                            | 15.7825   | 45.9581  | 194   | 910         |
| CMN_MLA | Mali Lošinj: Dorian Božičević                      | 14.4691   | 44.5313  | 10    | 477         |
| CMN_OSA | Osijek: Dario Klarić                               | 18.6167   | 45.5693  | 84    | 933         |
| CMN_PET | Petrovsko: Krunoslav Vardijan                      | 15.7932   | 46.1589  | 255   | 503         |
| CMN_PUA | Pula: Damir Šegon                                  | 13.8520   | 44.8691  | 15    | 609         |
| CMN_PUB | Pula: Damir Šegon                                  | 13.8463   | 44.8655  | 28    | 925         |
| CMN_RIA | Rijeka: Ivica Ćiković                              | 14.3705   | 45.3472  | 98    | 580         |
| CMN_RIB | Rijeka: Ivica Ćiković                              | 14.3705   | 45.3472  | 98    | 473         |
| CMN_SIB | Šibenik: Berislav Bračun                           | 15.8763   | 43.7567  | 33    | 169         |
| CMN_VAA | Varaždin: Željko Andreić                           | 16.3339   | 46.3094  | 172   | 362         |
| CMN_VID | Višnjan: Maja Crnić, Reiner Stoss, Korado Korlević | 13.7217   | 45.2760  | 227   | 1017        |
| CMN_VLA | Valpovo: Denis Vida, Filip Novoselnik              | 18.4225   | 45.6588  | 91    | 214         |
| CMN_VPI | Velika Pisanica: Luka Osokruš                      | 17.0942   | 45.8083  | 171   | 511         |
| CMN_ZGR | Zagreb: Željko Andreić                             | 15.9640   | 45.8071  | 117   | 835         |
| Total   |  |           |          |       | 8673        |

Table 4 – List of CMN cameras that were in operation in 2009. The first two columns give the CMN camera label, its location and principal operator. Coordinates of camera location are provided in the next three columns. The last column shows the total number of meteors detected by the particular camera in the corresponding year.

| code    | location and operator                              | longitude | latitude | z (m) | no. meteors |
|---------|--|-----------|----------|-------|-------------|
| CMN_BPA | Bačka Palanka: Janko Mravik                        | 19.4139   | 45.2500  | 79    | 58          |
| CMN_BRA | Brač: Tomislav Sorić                               | 16.5608   | 43.4306  | 307   | 117         |
| CMN_DAR | Daruvar: Aleksandar Borojević                      | 17.2148   | 45.5902  | 156   | 66          |
| CMN_MEA | Merenje: Željko Andreić                            | 15.7825   | 45.9581  | 194   | 743         |
| CMN_MLA | Mali Lošinj: Dorian Božičević                      | 14.4691   | 44.5313  | 10    | 456         |
| CMN_OSA | Osijek: Dario Klarić                               | 18.6167   | 45.5693  | 84    | 398         |
| CMN_PET | Petrovsko: Krunoslav Vardijan                      | 15.7932   | 46.1589  | 255   | 693         |
| CMN_PUA | Pula: Damir Šegon                                  | 13.8520   | 44.8691  | 15    | 845         |
| CMN_PUB | Pula: Damir Šegon                                  | 13.8463   | 44.8655  | 28    | 1252        |
| CMN_RIA | Rijeka: Ivica Ćiković                              | 14.3705   | 45.3472  | 98    | 316         |
| CMN_RIB | Rijeka: Ivica Ćiković                              | 14.3705   | 45.3472  | 98    | 686         |
| CMN_SIB | Šibenik: Berislav Bračun                           | 15.8763   | 43.7567  | 33    | 676         |
| CMN_SIS | Sisak: Dalibor Brdarić, Zvonko Prihoda             | 16.3014   | 45.5088  | 104   | 39          |
| CMN_SOA | Šolta: Dejan Kalebić                               | 16.2825   | 43.3929  | 110   | 40          |
| CMN_VAA | Varaždin: Željko Andreić                           | 16.3339   | 46.3094  | 172   | 71          |
| CMN_VAB | Varaždin: Alan Pevec                               | 16.3295   | 46.2976  | 171   | 18          |
| CMN_VID | Višnjan: Maja Crnić, Reiner Stoss, Korado Korlević | 13.7217   | 45.2760  | 227   | 1661        |
| CMN_VLA | Valpovo: Denis Vida, Filip Novoselnik              | 18.4225   | 45.6588  | 91    | 136         |
| CMN_VPI | Velika Pisanica: Luka Osokruš                      | 17.0942   | 45.8083  | 171   | 189         |
| CMN_ZGR | Zagreb: Željko Andreić                             | 15.9640   | 45.8071  | 117   | 382         |
| CMN_ZGT | Zagreb: Sonja Janeković                            | 15.9746   | 45.8157  | 173   | 539         |
| CMN_ZRA | Žrnovnica: Filip Lolić                             | 16.5403   | 43.5215  | 25    | 157         |
| Total   |  |           |          |       | 9538        |

by the Croatian Meteor Network (CMN)”. *WGN, Journal of the IMO*, **37:1**, 28–32.

Šegon D., Andreić Ž., Korlević K., Novoselnik F., and Vida D. (2012). “Croatian Meteor Network catalogue of orbits for 2007”. *WGN, Journal of the IMO*, **40:3**, 94–97.

SonotaCo (2008). “UFOOrbit V2 users manual”. [http://sonotaco.com/soft/U02/U021Manual\\_EN.pdf](http://sonotaco.com/soft/U02/U021Manual_EN.pdf).

Vida D. and Novoselnik F. (2011). “Croatian Meteor Network: data reduction and analysis”. In Asher D. J., Christou A. A., Atreya P., and Barentsen

G., editors, *Proceedings of the International Meteor Conference, Armagh, Northern Ireland, 16-19 September, 2010*, pages 96–100. International Meteor Organization.

Vornhusen M. (2003). “Skypatrol software”. <http://www.jostjahn.de/metsoft.html>.

*Handling Editor:* Javor Kac

This paper has been typeset from a L<sup>A</sup>T<sub>E</sub>X file prepared by the authors.

Croatian Meteor Network can be contacted at [cmn@rgn.hr](mailto:cmn@rgn.hr).