Meteor Science

Results of CMN 2013 search for new showers across CMN and SonotaCo databases I

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The first results of a search that compared each meteor to all others in the same database are presented. The database was constructed by combining Croatian Meteor Network databases for 2007 to 2010 and SonotaCo databases for 2007 to 2011. The most significant 24 possible new showers are described in this article.

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1 Introduction

The search described in this paper was initiated by the assumption that one meteor is 'the parent body' and minor stream correlations were then made by finding statistically significant associations of this particular 'parent body' to meteors from our combined database. As a result, each meteor orbit was compared to all other orbits, using several D-criterion methods as the measure of the similarity of the two orbits, namely D_{SH} (Southworth & Hawkins, 1963), D_D (Drummond, 1981) and D_H (Jopek, 1993). The orbits were claimed to be similar if $D_{SH} < 0.15$, $D_H < 0.15$ and $D_D < 0.075$. All three criteria have to be satisfied simultaneously.

The database that was used in the search described here is the same database as in Šegon et al. (2014a), containing over one hundred thousand meteoroid orbits (114 280 from SonotaCo 2007–2011 catalogues plus 19 372 from CMN 2007–2010 catalogues). However, while in the search described by Šegon et al. (2014a) a minor body (comet or Near-Earth Object) orbit was used as a starting point to search for members of a possible minor meteor shower, in the work described here a single meteor orbit from the same database was used as a starting point, requiring a more elaborate search pattern described below. The detailed description of the search method is also given in our paper presented at the Meteoroids 2013 conference (Šegon et al., 2014b).

Additionally, the IMO video meteor database (International Meteor Organization, 2012) that contains nearly one and a half million single station records (1993–2012) was used to provide further statistical relevance to a given shower's existence. Both datasets cover radiants down to declination $-30°$.

An initial run produced a very long list of possible meteor groups (at this stage we do not call them potential showers yet). We set the low limit of the number of meteors in one group to 10. Altogether 56 486 meteors (out of 133 652) were grouped in one of 3172 groups.

In the following runs the groups were sorted by the number of meteors in the group, and the mean orbit for each group was calculated. After that, groups with similar mean orbits were eliminated, leaving only the largest one in the procedure. Finally, starting from the largest group, meteors that belong to it were eliminated from the search, the remaining meteors were checked for association with the next available group, etc.

At the end, the groups were studied individually and a list of potential new minor showers was formed. The potential showers were sorted according to the number of orbits per degree of solar longitude, those with the most orbits being put onto the top of the list. In this way, a final list of 72 potential showers was obtained. The first 24 are described in this paper and the next 48 will be described in two follow-up papers.

Lastly, it should be noted that these results should be reevaluated by working with a different and larger database of meteor orbits that have been accumulated in recent years. Also comparison should be made against the results of other groups doing similar research (e.g. CAMS, EDMOND and similar). The reason is that the use of multiple D-criteria with strict tolerances to determine the similarity of orbits does not always guarantee that the orbits are really part of a stream and not simply chance alignments. So further investigation and analysis are needed on each candidate stream to either confirm or reject the associated meteors belonging to a genuine new shower.

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Table 1 – Mean orbits of the new showers. ID and name are the IAU identification and name of the shower, $\lambda_\odot$ solar longitudes of the activity period, $\overline{\lambda_\odot}$ average solar longitude, RA and DEC are coordinates of the mean radiant, dRA and dDEC are daily motion of the radiant in RA and DEC, v_g is geocentric velocity, q perihelion distance, e eccentricity, ω argument of perihelion, Ω longitude of ascending node, i inclination and N is the number of identified orbits. The error values are standard deviations of the corresponding value. In the case of RA and DEC there is a contribution of the daily motion to the dispersion of the radiants. All angular values are given in degrees, and v_g is in km/s.

ID	name	$\lambda_\odot$	$\overline{\lambda_\odot}$	RA	DEC	dRA	dDEC	v_g	q	e	ω	Ω	i	N
548 FAQ	15 Aquariids	103–120	113	318.2 ± 3	−2.1 ± 1.6	0.84	0.23	37.7±1.3	0.140±0.011	0.929±0.017	322.2±2	112.7±3	34.8±2.8	39
549 FAN	49 Andromedids	108–122	114	20.9 ± 4	46.7 ± 2.0	0.90	0.32	60.1±1.1	0.918±0.016	0.925±0.056	143.1±3	114.0±4	118.2±2.8	35
550 KPC	κ Cassiopeiids	114–122	119	10.5 ± 3	64.2 ± 2.9	0.64	0.40	50.2±1.9	0.970±0.011	0.908±0.035	155.0±3	119.0±3	90.0±4.3	16
551 FSA	47 Andromedids	131–146	139	22.4 ± 4	38.6 ± 2.2	0.95	0.20	63.7±1.1	0.910±0.019	0.929±0.059	217.9±4	138.6±4	132.0±4.0	36
553 DPE	δ Perseids	159–177	168	58.5 ± 4	46.7 ± 1.9	0.89	0.18	64.5±0.8	0.910±0.026	0.922±0.052	216.6±5	168.4±5	134.0±3.2	35
554 APE	α Perseids	166–178	171	50.3 ± 4	49.3 ± 2.2	0.96	0.33	61.4±1.2	0.796±0.026	0.941±0.049	235.2±3	171.2±4	123.9±3.8	31
555 OCP	October γ													
	Camelopardalids	189–196	191	63.3 ± 9	72.9 ± 1.8	2.62	0.15	50.8±1.5	0.897±0.019	0.948±0.053	217.8±4	191.3±2	89.7±3.8	16
556 PTA	ϕ Taurids	187–198	193	63.9 ± 4	29.1 ± 1.1	1.15	0.20	60.2±0.9	0.234±0.019	0.973±0.031	303.7±2	193.1±3	156.3±2.9	22
557 SFD	64 Draconids	208–223	216	302.9 ± 5	65.6 ± 2.5	−0.50	−0.10	26.4±1.2	0.972±0.008	0.961±0.057	196.6±4	216.4±5	38.4±2.3	37
558 TSM	27 Monocerotids	215–229	221	117.9 ± 3	−6.1 ± 1.4	0.79	−0.04	64.2±0.9	0.918±0.020	0.842±0.045	32.9±5	41.3±4	132.8±2.9	29
559 MCB	β Canis Majorids	233–242	237	94.4 ± 3	−21.5 ± 1.7	0.78	0.14	44.2±1.5	0.618±0.029	0.930±0.049	77.2±4	56.8±3	71.5±3.3	20
560 SES	17 Sextantids	251–271	262	150.8 ± 4	−6.9 ± 2.1	0.71	−0.22	67.1±0.7	0.782±0.039	0.929±0.051	54.9±6	82.0±6	146.8±3.6	39
561 SSX	6 Sextantids	251–273	262	146.5 ± 5	−1.9 ± 1.6	0.82	−0.18	66.4±0.9	0.617±0.037	0.966±0.046	76.1±5	82.4±6	150.2±3.1	44
562 BCT	13 Comae Berenicids	255–275	265	186.1 ± 3	26.2 ± 2.6	0.69	−0.39	65.9±1.1	0.982±0.003	0.871±0.059	183.8±4	265.4±5	134.6±3.7	50
563 DOU	December ω													
	Ursae Majorids	263–275	269	159.5 ± 4	43.0 ± 1.8	1.11	−0.40	56.7±1.2	0.534±0.027	0.970±0.049	265.9±3	269.0±3	106.9±2.8	50
564 SUM	61 Ursae Majorids	270–284	275	180.4 ± 3	35.6 ± 2.5	0.85	−0.35	61.0±1.3	0.785±0.018	0.934±0.053	234.4±3	275.2±4	118.7±3.9	33
565 FUM	59 Ursae Majorids	271–285	278	174.2 ± 4	43.9 ± 2.5	0.88	−0.43	55.1±1.3	0.648±0.023	0.955±0.045	252.5±3	277.8±4	100.7±3.4	36
566 BCF	5 Comae Berenicids	271–288	278	184.0 ± 3	20.4 ± 2.2	0.66	−0.27	67.4±0.9	0.863±0.029	0.932±0.055	221.5±5	278.1±4	143.4±3.4	36
567 XHY	ξ Hydrids	278–289	284	171.6 ± 4	−28.0 ± 1.9	1.02	−0.21	64.6±1.1	0.931±0.012	0.903±0.047	27.3±3	104.0±3	129.4±3.6	26
568 FCV	14 Canum Venaticids	306–313	309	200.9 ± 3	29.4 ± 1.5	0.94	−0.53	56.2±1.1	0.627±0.029	0.941±0.050	255.5±3	308.9±2	104.7±2.1	17
569 OHY	o Hydrids	302–316	309	176.3 ± 3	−34.1 ± 1.9	0.80	−0.38	59.1±1.0	0.684±0.025	0.931±0.039	68.6±3	128.9±4	114.3±3.0	29
570 FBH	February β Herculids	309–318	313	247.9 ± 2	24.6 ± 1.7	0.81	−0.10	54.9±1.3	0.904±0.013	0.930±0.061	146.0±3	313.1±2	99.1±3.3	24
571 TSB	26 Bootids	341–345	344	217.6 ± 2	24.0 ± 1.0	0.60	−0.05	49.7±0.8	0.498±0.023	0.968±0.044	270.7±2	343.5±1	83.9±1.8	10
572 TOH	21 Herculids	348–353	350	246.2 ± 1	7.6 ± 1.4	0.27	0.14	63.7±0.7	0.847±0.022	0.963±0.059	225.5±3	349.9±2	127.2±2.6	11

2 New showers

The file with all individual meteor orbits of the new showers described in this article can be downloaded from the CMN download page:
`http://cmn.rgn.hr/downloads/downloads.html`

The orbital elements of showers discussed in this article are summarized in Table 1. Members of all showers discussed here were also detected through analysis of the IMO single station observation database.

The radiant plots (Figures 1–3) are grouped together to save space. The value of generic D-criterion (the mean value of $D_{SH}/2$, $D_H/2$ and D_D, with the additional constraint that all three have to be smaller than the preset limit, as described before) is coded in gray scale (in the electronic edition they are color-coded). Additionally, radiants that belong to known showers active in the same period as the new ones are indicated by larger circles.

2.1 15 Aquariids (548 FAQ)

39 meteors spread over 16 days are associated with this shower. After a slow rise in the first week, the number of orbits per day is about 2.4. Apart from clearly evident daily motion, the radiant plot also shows a concentration of individual meteors around the mean radiant position. Moreover, 23 meteors are observed in only 5 degrees of solar longitude (109–114°). Active July 5 to 23, the mean corresponding to July 15.

2.2 49 Andromedids (549 FAN)

35 meteors spread over 14 days are associated with this shower. The number of orbits per day is more or less constant with about 2.5 orbits per day. Apart from clearly evident daily motion, radiant plot does not reveal any structure. Active July 10 to 25, the mean corresponding to July 17.

The shower 411 CAN is nearby, but mean orbits differ a lot, with a D_{SH} of 0.59, so they are clearly two different showers.

A possible parent body for this shower is comet C/2001 W2 (BATTERS). A D_{SH} of 0.14 indicates that the possibility of connection between 549 FAN and this comet is quite real. Earth MOID of 0.15 AU is rather large, but angular orbital elements of the comet and 549 FAN are very similar (Table 2). Thus, there is clearly a need for further analysis of this comet and its relation to 549 FAN.

Table 2 – Comparison of orbital elements of 49 Andromedids (mean orbit) and the orbit of comet C/2001 W2 (BATTERS).

parameter	549 FAN	C/2001 W2
q	0.918	1.051
e	0.925	0.941
ω	143.1	142.1
Ω	114.0	113.4
i	118.2	115.9
D_{SH}	0.141	
MOID		0.15

2.3 κ Cassiopeiids (550 KPC)

16 meteors spread over 8 days are associated with this shower. The number of orbits per day is more or less constant with about 2 orbits per day. Radiant plot does not reveal any structure, even the daily motion is not noticeable, mainly due to the short duration of the shower and large dispersion of the radiant. Active July 17 to 25, the mean corresponding to July 22.

2.4 47 Andromedids (551 FSA)

36 meteors spread over 15 days are associated with this shower. The average number of orbits per day is 2.4, but the actual number of orbits per day sharply increases just before the mean solar longitude, and falls to about average after that. Apart from clearly evident daily motion, radiant plot does not reveal any structure. Active August 3 to 19, the mean corresponding to August 11.

The shower 534 FOA is nearby, but mean orbits differ by $D_{SH} = 0.33$ so they are clearly different showers.

2.5 δ Perseids (553 DPE)

35 meteors spread over 17 days are associated with this shower. The average number of orbits per day is about 2.0, slowly increasing towards the mean solar longitude and declining in the same way afterwards. Apart from clearly evident daily motion, radiant plot does not reveal any structure. Active September 2 to 20, the mean corresponding to September 11.

208 SPE is nearby, but mean orbits differ by $D_{SH} = 0.53$, too much for them to be the same shower.

2.6 α Perseids (554 APE)

31 meteors spread over 12 days are associated with this shower. The mean number of orbits per day is about 2.6, with a slight increase around the mean solar longitude. Apart from clearly evident daily motion, radiant plot does not reveal any structure. Active September 8 to 21, the mean corresponding to September 14.

Two other showers are nearby, 208 SPE with $D_{SH} = 0.35$ and 553 DPE, also with $D_{SH} = 0.35$.

2.7 October γ Camelopardalids (555 OCP)

16 meteors spread over 8 days are associated with this shower. The number of orbits per day is about 2.0. Apart from clearly evident daily motion, radiant plot does not reveal any structure. Active October 2 to 10, the mean corresponding to October 5.

An interesting fact is that the orbit of this shower is almost perpendicular to the plane of the ecliptic.

2.8 ϕ Taurids (556 PTA)

22 meteors spread over 12 days are associated with this shower. The number of orbits per day is about 1.8. Apart from clearly evident daily motion, radiant plot is quite compact. Active September 30 to October 12, the mean corresponding to October 6.

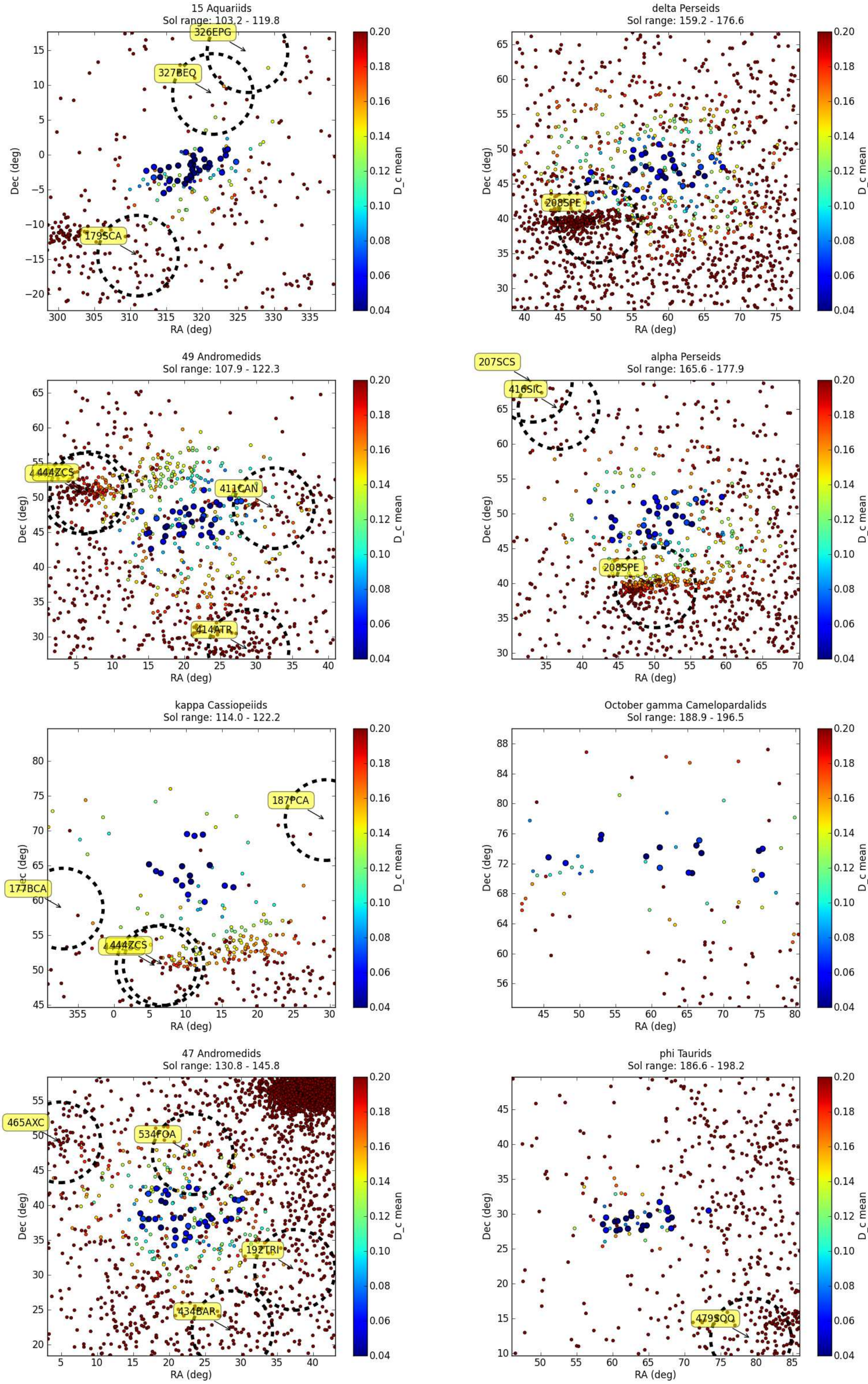

Figure 1 – Radiant plots of showers 548 FAQ to 556 PTA.

2.9 64 Draconids (557 SFD)

37 meteors spread over 16 days are associated with this shower. The number of orbits per day is about 2.3. Apart from clearly evident daily motion, radiant plot does not reveal any structure. Active October 21 to November 6, the mean corresponding to October 30.

The radiants of 525 ICY and 83 OCG are nearby, but at a distance of about 15° still too far away to consider them parts of the same shower.

2.10 27 Monocerotids (558 TSM)

29 meteors spread over 14 days are associated with this shower. The number of orbits per day is about 2.1. Apart from clearly evident daily motion, radiant plot does not reveal any structure. Active October 28 to November 11, the mean corresponding to November 4.

2.11 β Canis Majorids (559 MCB)

20 meteors spread over 9 days are associated with this shower. The number of orbits per day is more or less constant with about 2.2 orbits per day. Apart from clearly evident daily motion, radiant plot does not reveal any structure. Active November 16 to 25, the mean corresponding to November 19.

Despite the radiant plot suggesting a similarity between this shower and 394 ACA, the resulting D_{SH} of 0.37 is too large to consider them as parts of the same shower. 394 ACA was not found by our search, but this can be explained by the fact that 394 ACA is a radar shower.

2.12 17 Sextantids (560 SES)

39 meteors spread over 20 days are associated with this shower. The number of orbits per day is about 2.0. Apart from clearly evident daily motion, radiant plot does not reveal any structure. Active December 3 to 23, the mean corresponding to December 14.

2.13 6 Sextantids (561 SSX)

44 meteors spread over 22 days are associated with this shower. The number of orbits per day is about 2.0, being strongest around the mean solar longitude, with a gradual decrease towards smaller and larger $\lambda_\odot$. Apart from clearly evident daily motion, radiant plot does not reveal any structure. Active December 3 to 25, the mean corresponding to December 14. The meteors of this shower are very bright, with a mean magnitude of about -1.8.

This shower may be related to the previous one, 560 SES. The D_{SH} of 0.39 excludes the possibility of them being identical, but they may be part of a group of related showers.

2.14 13 Comae Berenicids (562 BCT)

50 meteors spread over 20 days are associated with this shower. The mean number of orbits per day is about 2.5, with increasing activity a few days after the mean solar longitude. The daily motion is evident in the radiant plot, as is the concentration of orbits around the mean $\lambda_\odot$ of the activity period. Active December 8 to 27, the mean corresponding to December 17.

20 COM is nearby in RA, DEC and $\lambda_\odot$, but clearly different, with a D_{SH} of 1.2.

2.15 December ω Ursae Majorids (563 DOU)

50 meteors spread over 11 days are associated with this shower. The mean number of orbits per day is about 4.5, thus making this shower about two times as active as the others reported here. Apart from clearly evident daily motion, radiant plot does not reveal any structure. Active December 15 to 27, the mean corresponding to December 21. The meteors of this shower are very bright, with a mean magnitude of about -1.7.

2.16 61 Ursae Majorids (564 SUM)

33 meteors spread over 14 days are associated with this shower. The number of orbits per day is about 2.4. The radiant plot is rather scattered, with a moderate elongation due to the daily motion. Active December 22 to January 4, the mean corresponding to December 27.

2.17 59 Ursae Majorids (565 FUM)

36 meteors spread over 14 days are associated with this shower. The number of orbits per day is about 2.6, being moderately stronger at the beginning of the activity period, with a smooth decrease towards its end. Apart from clearly evident daily motion, radiant plot does not reveal any structure. Active December 23 to January 5, the mean corresponding to December 30.

2.18 5 Comae Berenicids (566 BCF)

36 meteors spread over 16 days are associated with this shower. The number of orbits per day is about 2.3. The radiant plot is diffuse, and the daily motion is not evident. From the radiant plot the possibility can be seen that there may be two branches, but additional analysis should be done to check this hypothesis since it is not conclusive from the radiant plot only. Active December 23 to January 8, the mean corresponding to December 30.

20 COM is nearby in RA, DEC and $\lambda_\odot$, but clearly different, with a D_{SH} of 0.86.

2.19 ξ Hydrids (567 XHY)

26 meteors spread over 10 days are associated with this shower. The number of orbits per day is about 2.6. Apart from clearly evident daily motion, radiant plot indicates slow build-up of activity with time. Active December 30 to January 9, the mean corresponding to January 4.

2.20 14 Canum Venaticids (568 FCV)

17 meteors spread over 7 days are associated with this shower. The number of orbits per day is about 2.4. The daily motion is clearly evident in the radiant plot with an indication of larger activity around the mean solar longitude of the shower. Active January 26 to February 1, the mean corresponding to January 29.

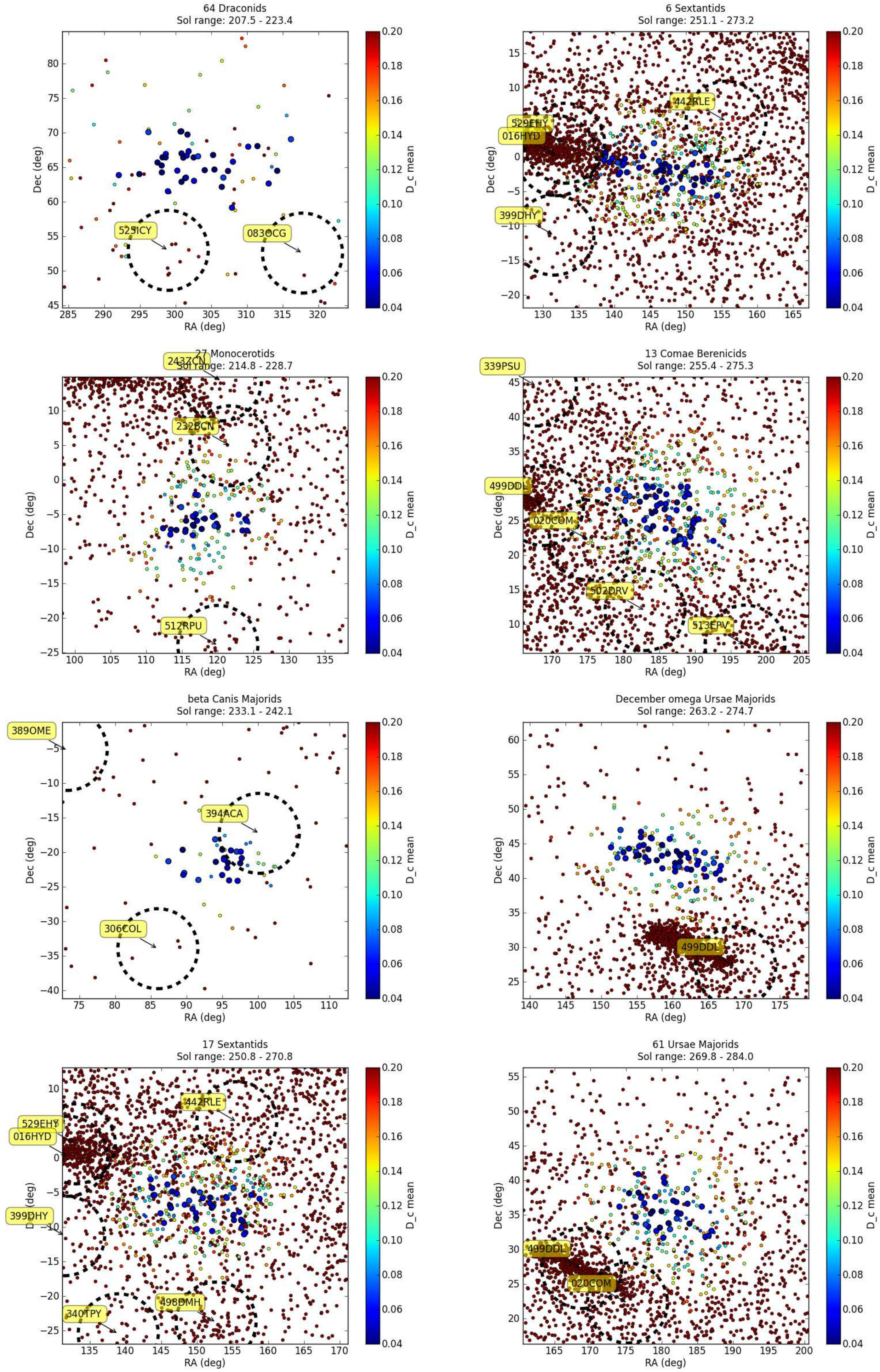

Figure 2 – Radiant plots of showers 557 SFD to 564 SUM.

2.21 o Hydrids (569 OHY)

29 meteors spread over 13 days are associated with this shower. The number of orbits per day is about 2.2. Apart from clearly evident daily motion, radiant plot does not reveal any structure. Active January 22 to February 5, the mean corresponding to January 29.

The 316 BHD radiant is about 15° from the 569 OHY radiant, but possible connections cannot be checked as there are no orbital data for 316 BHD in the IAU MDC database.

2.22 February β Herculids (570 FBH)

24 meteors spread over 10 days are associated with this shower. The number of orbits per day is about 2.4. The radiant plot is concentrated but apart from clearly evident daily motion, it does not reveal any structure. Active January 28 to February 7, the mean corresponding to February 3.

2.23 26 Bootids (571 TSB)

10 meteors spread over 4 days are associated with this shower. The number of orbits per day is about 2.5. The radiant plot is quite concentrated and does not reveal any structure. Active March 2 to 6, the mean corresponding to March 4. The members of this shower are very bright, with a mean magnitude of about −1.6.

2.24 21 Herculids (572 TOH)

11 meteors spread over 5 days are associated with this shower. The number of orbits per day is about 2.2. The radiant plot does not reveal any structure. Active March 8 to 13, the mean corresponding to March 10.

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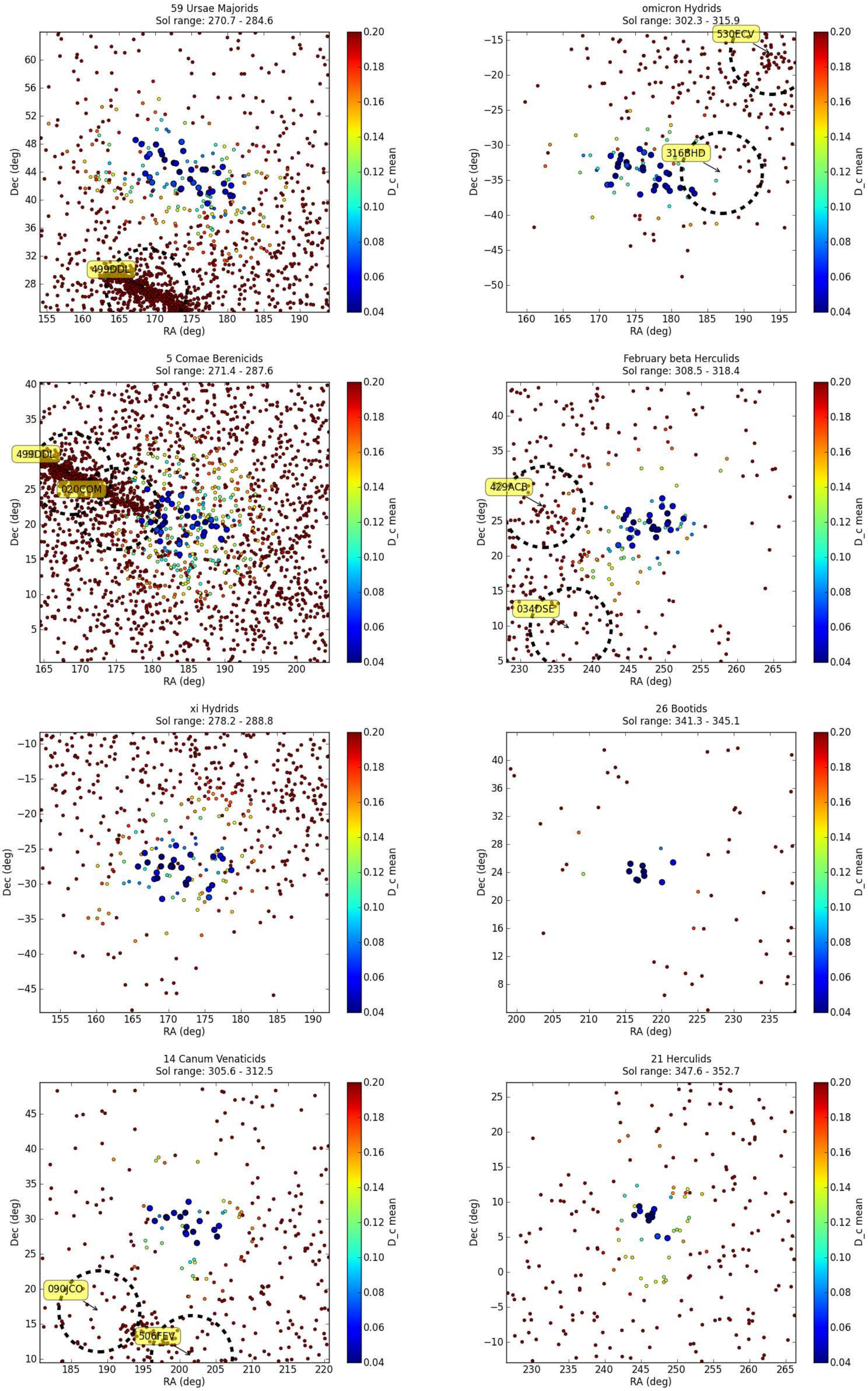

Figure 3 – Radiant plots of showers 565 FUM to 572 TOH.