Daytime meteor showers

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Radiants of daytime meteor showers are located typically about 20–30° west of the Sun. Radiants and orbits are known from radar observations, but information about the activity and the population index or mass index are missing or incomplete. Two of the daytime showers, the Daytime Arietids (171 ARI) in early June and the Daytime Sextantids (221 DSX) end September to early October are active and are accessable with radio (forward scatter), radar and optical methods. Both the ARI and DSX appear in regular video data analyses. Observations obtained with different methods should allow to calibrate and combine data to derive a comprehensive meteoroid stream description.

1 Introduction

The Earth crosses numerous meteoroid streams along its orbit around the Sun with radiants in all regions of the sky. Most of the known radiants are located in the nighttime sky. Radiants of a few showers are best observable only during the evening hours such as the π-Puppids, the Draconids and the Puppid-Velids. Studies of radar and radio data show also radiants close to the Sun's position. From radar and radio forward scatter observations we know that there are numerous radiants in the daytime region. Investigation of radar data shows sources linked to the ecliptical objects, such as the Antihelion source (mainly around a region about 10° east of the solar opposition point and the Helion source (about 60° west of the Sun or about 30° east of the Earth's apex). The other two main sources of sporadic meteors, the (northern and southern) Toroidal and the Apex source provide meteors entirely during the night hours (*Figure 1*).

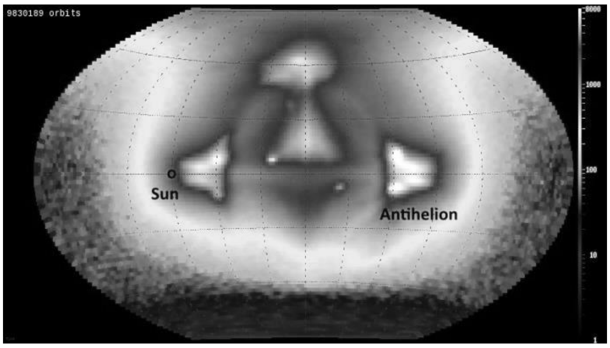

Figure 1 – Sources of sporadic meteors as observed by the Canadian CMOR radar kindly provided by Campbell-Brown.

Radiants of meteor showers within or near the Helion Source of the sporadic background are above the horizon only during daytime. Hence meteors of these showers are generally not observable by optical means from the Earth's surface. The radiants remain very low in the sky even in twilight so that systematic data can only be collected by radio and radar techniques. Our current knowledge of the daytime showers is not as detailed as for most of the nighttime showers.

The motivation for this review and the suggested project came from the preparation of the annual Meteor Shower Calendar of the IMO, edited by Alastair McBeath. It includes a summary of the activity from daytime sources as a basis for forward scatter meteor observers. When compiling the list and completing the full designation including the IAU Meteor Data Center (MDC)[1] codes, a number of inconsistencies was found. Generally, the MDC gives rather few references for most daytime showers. Some showers seem to duplicate other entries. This also led to an additional chapter in the recent Meteor Shower Workbook 2014 (Rendtel, 2014), including information from recent radar meteor studies (Brown et al., 2008; Sanches et al., 2013).

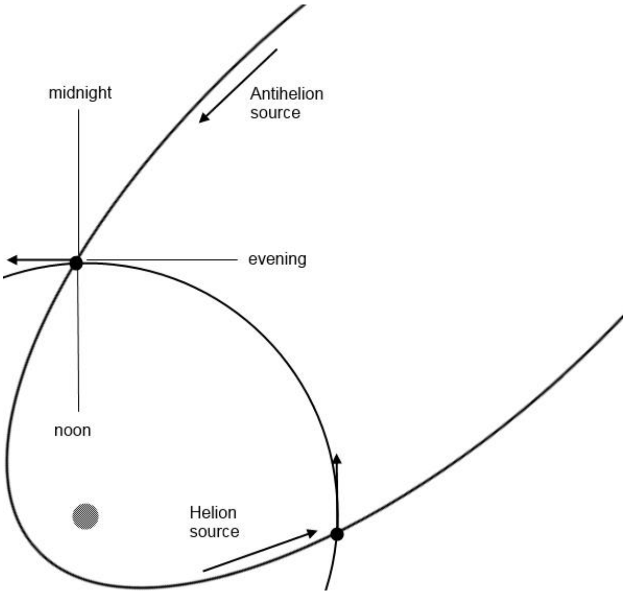

Figure 2 – Typical orbit of a Jupiter family daytime meteoroid and its possible approaches to the Earth's orbit, causing either an antihelion or helion meteor.

[1] http://www.astro.amu.edu.pl/~jopek/MDC2007/index.php

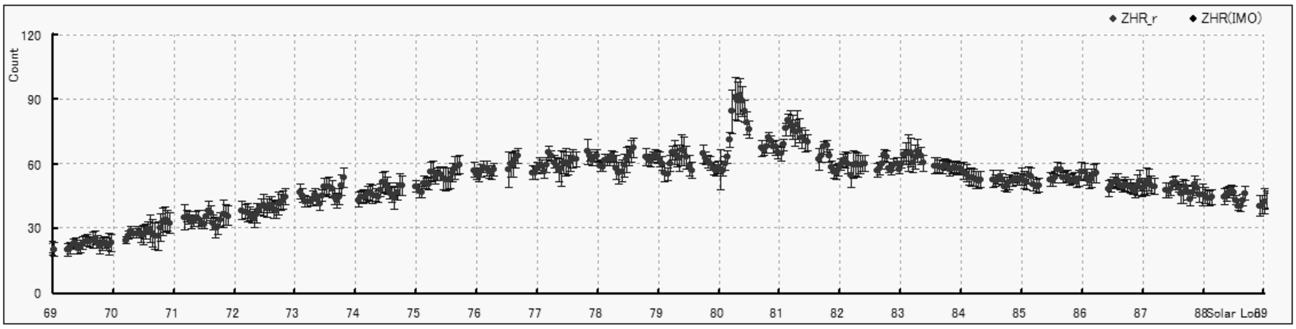

Figure 3 – ZHR profile of the Daytime Arietids in 2011 calculated by Sugimoto (see Sugimoto, 2011).

Table 1 – Current Working List of Daytime Meteor Showers as given in the Workbook (Rendtel,2014). The showers' designations are listed here omitting `Daytime'.

Shower	Activity	Date Max	$\lambda_{\odot(2000)}$	α (°)	δ (°)	Activity
Sgr/Capricornids (115 DSC)	Jan 13–Feb 04	Feb 01	312.5	299	-15	Medium
χ-Capricornids (114 DXC)	Jan 29–Feb 28	Feb 13	324.5	315	-24	Low
April Piscids (144 APS)	Apr 20–Apr 26	Apr 22	32.5	9	+11	Low
ε-Arietids(154 DEA)	Apr 24–May 27	May 09	48.7	44	+21	Low
May Arietids (294 DMA)	May 04–Jun 06	May 16	55.5	37	+18	Low
S. MayArietids (156 SMA)	Apr 20–May 22	May 08	47.5	29	+10	Low
o-Cetids (293 DCE)	May 05–Jun 02	May 20	59.3	28	-4	Low
N. ω-Cetids (152 NOC)	Apr 20–May 20	May 08	47.5	9	+19	Low
S. ω-Cetids (153 OCE)	Apr 24–May 20	May 10	49.5	23	-3	Low
Arietids (171 ARI)	May 14–Jun 24	Jun 07	76.5	42	+25	High
ζ-Perseids (172 ZPE)	May 07–Jun 26	Jun 14	83.5	65	+28	Low
β-Taurids (173 BTA)	Jun 12–Jul 04	Jun 28	96.5	85	+23	Low
γ-Leonids (203 GLE)	Aug 14–Sep 12	Aug 25	152.2	155	+20	Low
κ-Leonids (212 KLE)	Sep 06–Oct 03	Sep 21	178.5	159	+18	Low
Sextantids (221 DSX)	Sep 23–Oct 07	Sep 30	187.5	154	0	Medium

While radiants of the showers and orbits or the streams are well determined and defined, there is little or no information about the activity expressed as a rate or a flux as well as about the population or mass index. Blaauw et al. (2011) provided some data of the mass index of some showers recently, and Campbell-Brown (2004) presented an analysis of the Daytime Arietids with an approach to determine a rate. However, we need to keep in mind that radar `sees' much smaller particles as compared to optical (visual and video) and forward scatter observations.

2 Daytime showers

Daytime shower activity has been observed regularly but a large portion of the recorded data has not yet seen detailed analyses to obtain comparable results to the optical range with rate, flux and population index profiles. A limited attempt was made by McBeath (1998) to perform radio forward scatter data analyses. Sugimoto developed an analyzing method originally for the Japanese International Project for Radio Meteor Observation (IPRMO) project[2]. Sugimoto[3] provided an activity (ZHR) graph for the 2011 return of the Daytime Arietids (*Figure 4*). Sugimoto's method was applied to various meteor shower data, particularly for the Leonids (Ogawa et al., 2002). The idea was continued for a later Quadrantid data analysis by Brower (2006), and a method to determine shower activity was further updated by Steyaert et al. (2006).

Among the currently known sources there are two or three with `moderate' or `high' activity and many others with low activity. *Table 1* gives the list which is currently included in both the 2015 Meteor Shower Calendar (McBeath, 2014) and the Workbook (Rendtel, 2014).

There are close relations between several daytime and nighttime showers. The ζ-Perseids (172 ZPE) and the β-Taurids (173 BTA) both belong to the Taurid complex. The Sextantids (221 DSX) are part of the Phaethon-Geminid complex (Ohtsuka et al., 2006). Another complex is formed by the comet 96P/Machholz and the

[2] International Project for Radio Meteor Observation http://www.amro-net.jp/radio.htm

[3] http://www5f.biglobe.ne.jp/~hro/Flash/2011/ARI/index.html

minor planet (196256) 2003 EH1. The related shower complex includes four well-known meteor showers: Daytime Arietids (171 ARI), Southern δ-Aquariids (005 SDA), Quadrantids (010 QUA), and the Northern δ-Aquariids (026 NDA) as nicely shown by Neslušan et al. (2014). The stream filaments corresponding to the 171 ARI and two Aquariids (005 SDA, 026 NDA) constitute the ecliptical component, and those corresponding to the 010 QUA and their southern counterpart constitute the toroidal component of the complex (Neslušan et al., 2013a; Neslušan et al., 2013b). Further examples are given in Chapter 3 of the Meteor Shower Workbook 2014 (Rendtel 2014).

Table 1 repeats the current compilation of daytime showers as given in the 2015 Meteor Shower Calendar and the recent Meteor Shower Workbook. It is very likely that the list will undergo updates and corrections in the near future.

3 Optical observing possibilities

One attempt to collect data of the above mentioned physical parameters is a combination and thereby calibration of data obtained by different methods. Showers suitable for this attempt should (i) produce a significant activity and (ii) have a radiant with a large elongation from the Sun. The most promising candidates are the Daytime Arietids (171 ARI) and the Daytime Sextantids (221 DSX).

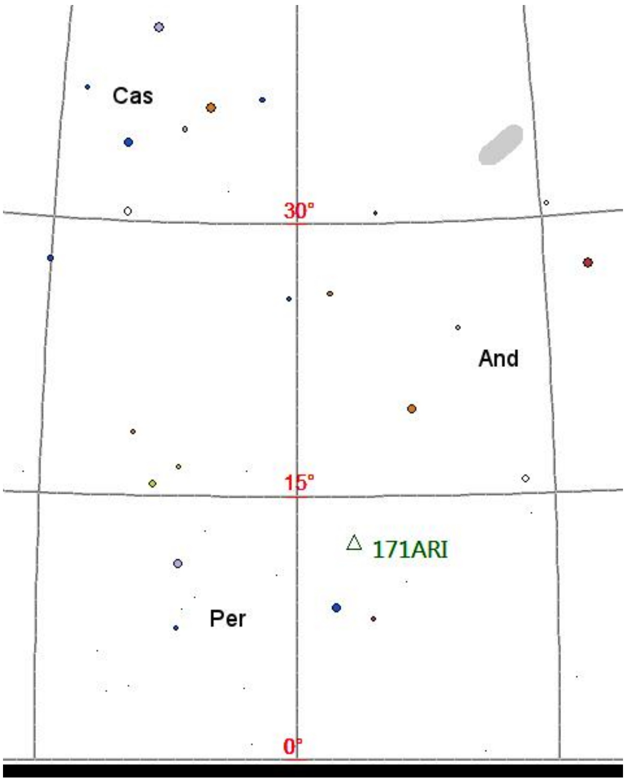

Figure 4 – Radiant position of the 171 ARI close the end of the possible optical observing interval for a location at 30° N.

The general idea that it is possible to collect also optical data of active daytime showers came from the fact that the standard analysis of the EDMOND video data (Rudawska et al., 2014) showed traces of the 171 ARI and the 221 DSX. Data of the IMO Video Meteor Network (Molau et al., 2014) also allowed an analysis of the 171 ARI. So regular observations not expressively extended into the twilight periods catched some of these shower meteors.

The elongation of the radiants from the Sun of the two showers is about 35 degrees. Depending on the geographical latitude, the radiant will rise about two hours before the Sun. Still, this means that the radiant will remain low in the eastern sky and the observing conditions expressed in terms of limiting magnitude. *Figures 4 and 5* show the situation for the Daytime Arietids and the Daytime Sextantids.

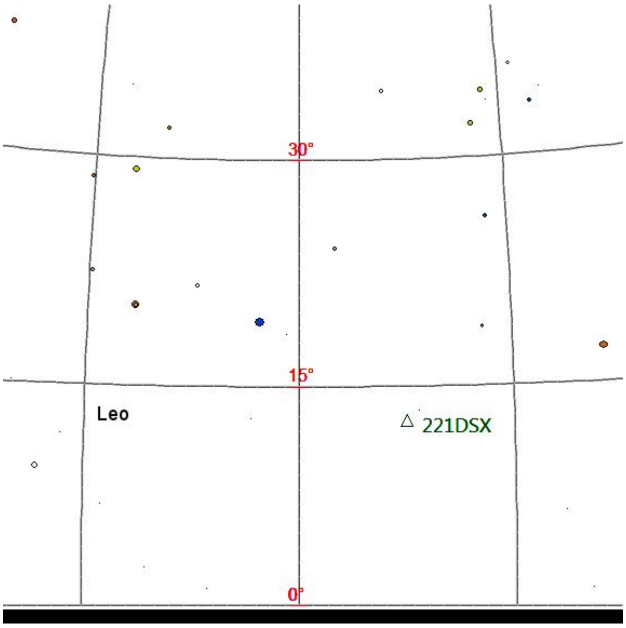

Figure 5 – Radiant position of the 221 DSX close the end of the possible optical observing interval for a location at 30° N.

Daytime Arietids (171 ARI)

The Arietids are one of the showers listed with a high activity level. The original data go back to Clegg et al. (1947), Lovell (1954) and Sekanina (1976). Orbits of stream meteoroids were already published by Almond (1951). Recent CMOR data (Brown et al., 2008) indicate a relatively high flux as the stream is defined by more than 2100 orbits (typical numbers for other streams are of order a few hundred). The shower is also prominent in the SAAMER radar (Janches et al., 2013).

Optical observers roughly between the tropics there have a chance to observe a few shower meteors in early June close to dawn, albeit with low radiant position. Some data of such optical (video) observations have been analysed by Fujiwara et al. (2004), by Jenniskens et al. (2012) and as already mentioned by Rudawska et al. (2014) and Molau et al. (2014). While the radiant and orbital data are well established, there are only estimates of the activity or flux. Campbell-Brown (2004) gives a ZHR of about 200 and compares the shower with the Quadrantids, assuming r=2.75 (s=2.1).

Based on meteoroid orbital data, Jenniskens et al. (2012) suggest an association of the Arietids with the Marsden group comet C/1999 J6 (= 2004 V9 = 2010 H3) and argue that it seems possible that the meteoroids are debris from a breakup which created the Marsden group comets or are connected with an earlier fragmentation that left comet 96P/Machholz.

Daytime Sextantids (221 DSX)

The activity level of this shower is classified as `medium' and it is detected in essentially all radar data (e.g., Galligan and Baggaley, 2002; Brown et al., 2008). The origin of the `medium' activity level comes from Weiss (1960), giving a numerical level like the Jodrell Bank ones for the o-Cetids and β-Taurids. Forward scatter data could even suggest `high' activity, at least occasionally.

The DSX-maximum is expected around September 30 ($\lambda_{\odot}$ = 187.5°) with deviations from one return to another. The CMOR radar data confirm rather the late maximum at 187.5°. Janches et al. (2013) detect activity with their radar between 179° and 184°. Several minor maxima in early October may also be due to this radio shower.

4 Conclusions

Radar and radio (forward scatter) data will be the major source regarding daytime meteor showers. The shower identification (radiant and orbits) found from different observational data sets is consistent. Physical parameters, such as the population/mass index and rate/flux, need to be determined. In the case of two showers, the Arietids (171 ARI) and Sextantids (221 DSX), a limited amount of optical data may be used for calibration purposes.

During the following returns of the two showers, observers should report all available data to the author. The combined data sample will become available for a comprehensive study of the activity and physical parameters of the 221 DSX and the 171 ARI. (A first sample has been recorded and reported for the 2014 return of the Daytime Sextantids).

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