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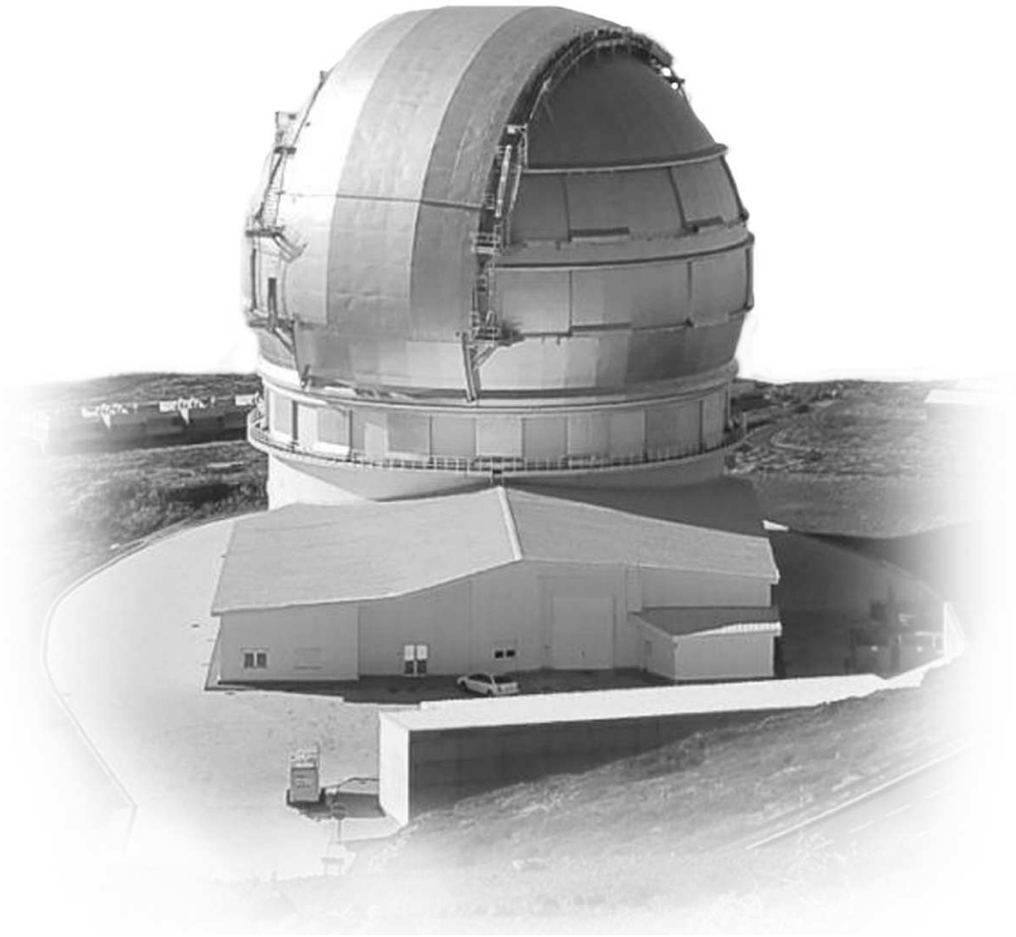

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Draconid 2011 outburst observations from Slovenia

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Our 2011 Draconid outburst observations are presented. From the visual observations, a population index of $r = 2.6 \pm 0.1$ and a maximum ZHR of 460 ± 60 on 2011 October 8 at $20^{\mathrm{h}}11^{\mathrm{m}}$ UT is obtained. Video observations indicate a radiant at $\alpha = 262\overset{\circ}{.}2 \pm 1\overset{\circ}{.}3$ and $\delta = +56\overset{\circ}{.}0 \pm 1\overset{\circ}{.}3$, and a geocentric velocity of $V_{\mathrm{g}} = (21.0 \pm 0.5)$ km/s. A flux profile is presented based on 358 video Draconids, and a maximum flux of 87 Draconids per 1000 km^2 per hour is found at $20^{\mathrm{h}}15^{\mathrm{m}}$ UT.

1 Introduction

Draconids are known for their occasional outbursts. Two Draconid meteor storms were observed during the 20th century. Both the 1933 and the 1946 outburst featured ZHRs in the order of 10 000. Further Draconid outbursts with ZHRs in the order of several hundred happened in 1952, 1985, and 1998. Several predictions of enhanced Draconid activity in 2011 were published (e.g., Vaubaillon et al., 2011; Maslov, 2011). All predictions agreed on the time of the main peak (2011 October 8 at 20^{h} UT), but differed in strength, with maximum ZHRs varrying between 50 and 750.

In the following sections we describe our visual, video, and photographic observations of the 2011 Draconid outburst.

2 Observations

The weather was very unstable in Slovenia around 2011 October 8, making reliable predictions more than a couple of hours ahead impossible. One day before the expected event, potential observing locations were chosen in western Slovenia and northern Italy. Eleven observers gathered in Sežana, Slovenia, a city that served as our headquarters until our last-minute decision of the actual observing site. As the front with thunderstorms passed the site only a couple of hours before the event, we decided to move to a place near the village of Tatre, about 20 km south-east from our headquarters. Near-perfect observing conditions persisted from our arrival at dusk until 21^{h} UT.

2.1 Visual observations

Five observers contributed visual data for the outburst, observing from two different locations (Mitja Govedič observed from Središče ob Dravi in the northeast of Slovenia, whereas the others observed from Tatre). A total of 634 Draconids were recorded in more than 12 hours of observations (Table 1). Draconids were distinctive for their slow speed and very short trains because of the high radiant elevation, and were dominated by fainter meteors.

Table 1 – Visual observers' statistics for 2011 October 8.

Obs.	T_{eff}	DRA	DAU	STA	Spor
ATAJU	$3\overset{\mathrm{h}}{.}346$	238	–	2	15
GOVMI	$1\overset{\mathrm{h}}{.}000$	46	1	–	19
KACJA	$3\overset{\mathrm{h}}{.}571$	137	0	0	10
KOSJN	$2\overset{\mathrm{h}}{.}747$	167	–	–	22
PUCRC	$1\overset{\mathrm{h}}{.}798$	46	–	–	5
Totals	$12\overset{\mathrm{h}}{.}462$	634	1	2	71

A population index of $r = 2.6 \pm 0.1$ was obtained using the method of by Arlt (2003) from magnitude distributions of 634 Draconids collected on 2011 October 8 between $17^{\mathrm{h}}47^{\mathrm{m}}$ and $21^{\mathrm{h}}28^{\mathrm{m}}$ UT. This population index was then used to calculate the ZHR activity profile (Figure 1). A maximum ZHR of 460 ± 60 can be seen on 2011 October 8 at $20^{\mathrm{h}}11^{\mathrm{m}}$ UT. The time of maximum agrees with that reported on the IMO's Draconids 2011 visual data quicklook page[1] as well with those reported by Tóth et al. (2012) and Vandeputte (2012).

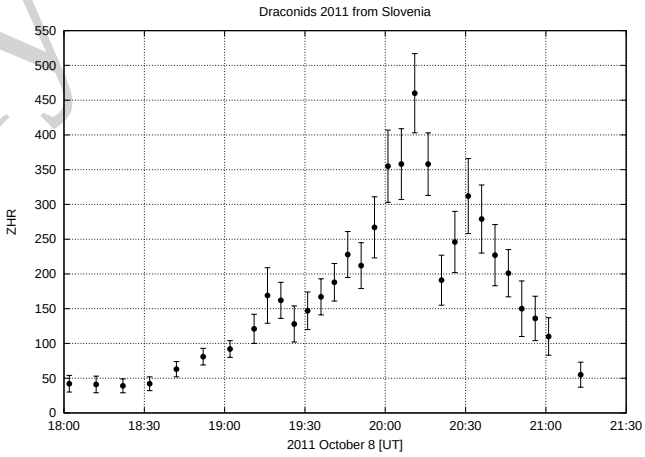

Figure 1 – Visual ZHR activity profile of the Draconids, using a population index of $r = 2.6$.

The maximum rate is somewhat higher than reported by the aforementioned sources, where maximum ZHRs between 306 and 368 were obtained. Possible causes include the use of different population index values, or the application of personal perception coefficients.

[1] See http://www.imo.net/live/draconids2011/ (page generated 2012 January 2, $13^{\mathrm{h}}05^{\mathrm{m}}$ UT).

Table 2 – Video camera statistics for 2011 October 8. All observing sites were in Slovenia, except for the last one, which was in Italy.

Camera	Observing site	DRA	Tot.
Mobcam1*	Nova vas nad Dragonjo	178	305
Orion1	Ljubljana	31	38
Orion2	Središče ob Dravi	76	116
Sraka	Velenje	15	32
NN*	Sgonico/Zgonik	192	394
Totals		492	785

2.2 Video observations

Two cameras (marked with an asterisk in Table 2) were installed and calibrated on 2011 October 7, one night before the expected outburst. Three other cameras permanently installed and affiliated to the IMO Video Meteor Network also contributed observations for this study. All cameras were from Mintron, equipped with either 6- or 8-mm lenses. Almost 800 meteors were recorded by the video cameras, 500 of which were identified as Draconids by the MetRec software. See Table 2 for more details.

2.2.1 Radiant position

The radiant position based on video records was calculated using RadFind from the MetRec package. The following radiant parameters were obtained: $\alpha = 262\overset{\circ}{.}2 \pm 1\overset{\circ}{.}3$, $\delta = +56\overset{\circ}{.}0 \pm 1\overset{\circ}{.}3$, and $V_g = (21.0 \pm 0.5)$ km/s. This compares favorably to those listed in the IMO Working List of Meteor Showers (McBeath, 2011): $\alpha = 262°$, $\delta = +54°$, and $V_g = 20$ km/s, and matches perfectly with the parameters obtained by the IMO Video Meteor Network observers (Molau et al., 2012). The radiant can easily be distinguished in the backward tracing plot shown in Figure 2.

2.2.2 Draconid flux

Only observing intervals with a limiting magnitude of +4.0 or better were used for the flux calculation. Each bin was required to contain at least 20 Draconids and the bin length was allowed to range from 10 to 60 minutes. Only four of the cameras listed in Table 2 were used for the flux calculations, as the limiting magnitude criterion was not met by the Sraka camera due to bad weather.

The flux profile shown in Figure 3 is based on 358 Draconids as automatically recognized by MetRec. Two possible maximum times are found in this profile: one at 19^h52^m UT with a flux of 74 Draconids per 1000 km^2 per hour, and another at 20^h15^m UT with a flux of 87 Draconids per 1000 km^2 per hour. The second (higher) peak in the profile coincides with the peak time as found by the IMO Video Meteor Network study (Molau et al., 2012).

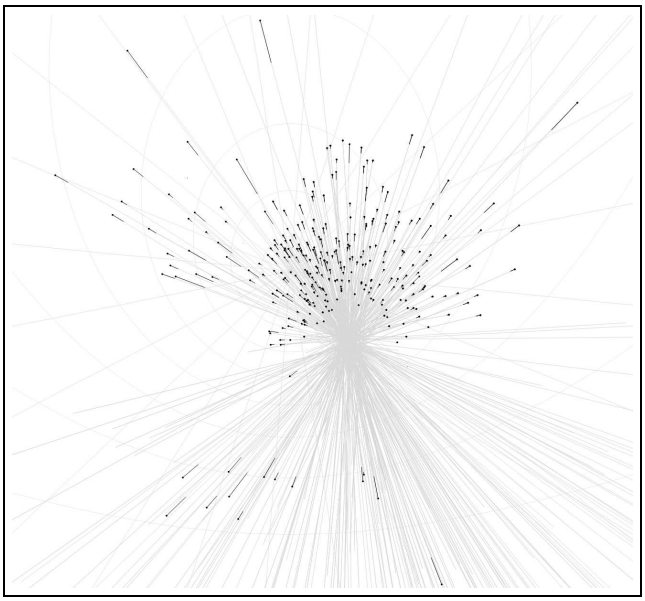

Figure 2 – Backward tracings plot from 492 video meteors recognized as Draconids. The plot was created with the MetVis software.

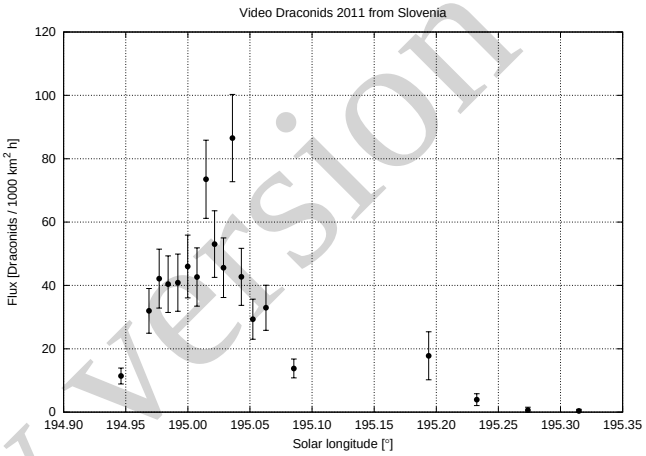

Figure 3 – Video activity flux profile of the Draconids, using a population index of $r = 2.6$.

2.3 Photographic observations

Six observers contributed their photographic observations in this study. They are listed in Table 3 along with camera models, optics used, exposure time, and meteor statistics.

The Draconid photographic activity profile was constructed by counting the number of meteors detected in 15-minute bins. No corrections for camera dead time or radiant height were made. Two ill-defined peaks can be found in the profile (Figure 4). The first peak is centered at $19^h00^m \pm 15^m$ UT, while the main peak occurs at $20^h22^m \pm 22^m$ UT.

3 Conclusions

A strong Draconid meteor shower outburst was observed by means of visual, video, and photographic techniques. The maximum times with all observing modes occurred

Table 3 – Photographic camera statistics for 2011 October 8.

Operator	Camera model	Lens	Exposure time	Meteors
Jure Atanackov	Nikon D80	18 mm $f/3.5$	211 min	3
Javor Kac	Canon 40D	17 mm $f/2.8$	233 min	18
Janez Kos	Nikon D5000	18 mm $f/3.5$	265 min	2
Patricija Pevec	Nikon D70	18 mm $f/3.5$	207 min	3
Matic Smrekar	Nikon D40	10 mm $f/2.8$	241 min	15
Nina Smrekar	Nikon D5000	35 mm $f/1.8$	222 min	6

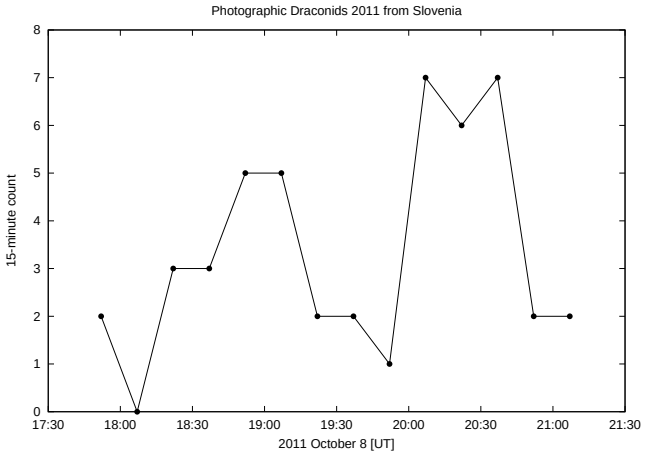

Figure 4 – Photographic meteors per 15-minute bin.

on 2011 October 8 between $20^{\mathrm{h}}11^{\mathrm{m}}$ and $20^{\mathrm{h}}22^{\mathrm{m}}$ UT. A ZHR of above 400 was calculated based on visual observations. The radiant parameters $\alpha = 262\,^{\circ}2 \pm 1\,^{\circ}3$, $\delta = +56\,^{\circ}0 \pm 1\,^{\circ}3$, and $V_{\mathrm{g}} = (21.0 \pm 0.5)$ km/s were obtained from video data. All findings are in agreement with other results published to date.

Acknowledgements

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