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Double-Station Meteor Observations in Ryazan, Russia
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Optical meteor observation methods and observation equipment characteristics are described. Results of CCD-meteor observations of 2011 and 2012 at two stations are presented. The results of wide-angle bright Perseids observations make it possible to estimate the average meteoroid risk over the period 2007–2012.

1 Introduction
Meteor research within the scope of circumterrestrial space ecology at the Ryazan State University astronomical observatory started at the beginning of the 21st Century (Murtazov, 2011):

1. investigating circumterrestrial space mechanisms that influence the terrestrial biosphere;
2. investigating near-space physical processes that are the basis of circumterrestrial space ecology;
3. monitoring meteors, artificial space objects, and space debris in order to assess the state of the circumterrestrial space ecology;
4. implementing the results of these investigations in higher education;
5. organizing research activities for students and pupils in the field of space ecology.

In addition, observations of bright meteors are necessary to assess the risk for natural impacts in space.

2 Observations and reductions
We use two observing sites for monitoring meteor activity: (1) the University Astronomical Observatory in Ryazan (\(\varphi = 54^\circ\,38'\,N, \lambda = 39^\circ\,45'\,E, h \approx 125\) m) and (2) Sazhnevo, about 18 km from Ryazan (\(\varphi = 54^\circ\,28'\,N, \lambda = 39^\circ\,45'\,E, h \approx 200\) m); see also Figure 1.

At both stations, observations were performed using a Watec 902H camera and a Computar T2314FICS lens with an effective field of view of 140\(\times\)100\(^\circ\) directed towards the local zenith. The sky control and meteor detection were provided using a Pinnacle Media Center EN or Contrast as a "grabber" and an AMD Athlon\(^{\circledR}\) 64 \times\)2 Dual Core processor 4200+, 2.21 GHz, 1 Gb RAM (Ryazan), or an Intel\(^{\circledR}\) Core\(^{\circledR}\)2 CPU processor, 1.83 GHz, 500 Mb RAM (Sazhnevo).

This equipment functioned in the mode assigned for registering bright meteors that present a danger for space hardware operating in the circumterrestrial space (Murtazov et al., 2008). A Watec 902H camera and a Computar HG0808AFCS-HSP lens (FOV = 34\(\times\)45\(^\circ\)) were used at both stations in 2012.

For meteor detection, we used free software: AMCAP for making avi-files of all-sky images in continuous operation, and the SonotaCo UFOCAPTURE software to capture meteor events. We next discuss some parameters of the system.

The distortion of the Computar lens according to our measurements is shown in Figure 2, where \(D\) is the true angular distance from the center of the frame, and \(R\) the same as measured with the stars. Thus, the cumulative distortion of the wide-angle Computar lenses amounts up to up to 1\(^\circ\); 1\(^\circ\)5 at a distance of 90\(^\circ\) from the frame center.

The linearity of the magnitude-light flux relation for CCD-systems is very high. This relationship between comparing stellar magnitudes and the light flux obtained for them in every single frame is linear within
a wide flux range of $10^4$. This relationship for the Waterc 902H and Computar HG0808AFCS lens is shown in Figure 3. Here, “$L_g I$” is the relative brightness of the comparison stars measured by means of IRIS aperture photometry (Buil, 2010). Different inclinations of straight lines are the result of different contrast frames measurements. Magnitudes of comparison star magnitudes are taken from Nesterov et al. (1995). The atmospheric extinction was obtained for every frame from avi-files containing meteors.

![Image](image_url)

**Figure 3** – Linearity of magnitude-light flux relation.

### 3 Results

We continued our observations at the country station. As usual, our young astronomers took part in them. The 2011 results of wide-angle bright Perseids monitoring are shown in Figure 4 as compared to the IMO visual data.

![Image](image_url)

**Figure 4** – Number of 2011 bright Perseids as compared to IMO visual data (the latter with error margins).

Haze and fog prevented us from conducting good-quality observations of the 2012 Perseids in the period of the shower maximum with the wide-angle equipment. However, we conducted both visual observations and observations using our TV camera (though we did not manage to measure TV meteor magnitudes). The results of these observations are shown in Figure 5. The limiting magnitude of visual observations is +4, that of TV observations brighter than 0.

Long-time observations of bright (and hazardous) Perseids allow us to calculate the meteoroid impact risk in near-space. Figure 6 shows the average values of the bright meteor spatial density for the period 2007–2012. The maximum of this distribution is around solar longitude $\lambda_{\odot} = 140^\circ - 141^\circ$, and practically coincides with the maximum of all IMO Perseid meteors.

The spatial density of the meteoroid flux here defines the highest possible value of the meteoroid risk for space vehicles in near-space. So, these results give evidence for the fact that the predictable risk increased several times in the period of Perseids’ main maximum.

In 2011, we began meteor observations at the Astronomical Observatory. Wide-angle observations in the center of the city are impossible, because of the bright street lights. So we used the system of Waterc 902H and Computar HG0808AFCS lens with field of view $34^\circ \times 45^\circ$. This system was used for the observations of
Table 1 – Results of meteor monitoring in Ryazan, Russia, in 2011 and 2012.

<table>
<thead>
<tr>
<th>Shower</th>
<th>Site</th>
<th>Date</th>
<th>Field of view</th>
<th>Meteor lm</th>
<th>Meteors</th>
</tr>
</thead>
<tbody>
<tr>
<td>S δ-Aquariids (SDA)</td>
<td>Sazhnevo</td>
<td>2011, Jul 30</td>
<td>140° × 100°</td>
<td>+1</td>
<td>6</td>
</tr>
<tr>
<td>α-Capricornids (CAP)</td>
<td>Sazhnevo</td>
<td>2011, Jul 30</td>
<td>140° × 100°</td>
<td>+1</td>
<td>2</td>
</tr>
<tr>
<td>Perseids (PER)</td>
<td>Sazhnevo</td>
<td>2011, Aug 9–13</td>
<td>140° × 100°</td>
<td>+1</td>
<td>80</td>
</tr>
<tr>
<td>Draconids (DRA)</td>
<td>Ryazan</td>
<td>2011, Oct 8</td>
<td>45° × 34°</td>
<td>+4</td>
<td>36</td>
</tr>
<tr>
<td>Orionids (ORI)</td>
<td>Ryazan</td>
<td>2011, Oct 23</td>
<td>45° × 34°</td>
<td>+4</td>
<td>27</td>
</tr>
<tr>
<td>Perseids (PER)</td>
<td>Sazhnevo</td>
<td>2012, Aug 11</td>
<td>140° × 100°</td>
<td>+1</td>
<td>9</td>
</tr>
<tr>
<td>Perseids (PER)</td>
<td>Sazhnevo</td>
<td>2012, Aug 12</td>
<td>45° × 34°</td>
<td>+3</td>
<td>21</td>
</tr>
<tr>
<td>Perseids (PER)</td>
<td>Ryazan</td>
<td>2012, Aug 11–14</td>
<td>45° × 34°</td>
<td>+3</td>
<td>92</td>
</tr>
</tbody>
</table>

Figure 7 – Results of 2011 Draconids and Orionids observations versus IMO data (the latter with error margins).

Figure 8 – 2012 TV Perseids in Ryazan. The field of view is 34° × 45° and the limiting +3.

Some statistics of the observations conducted in 2011 and 2012 are summarized in Table 1.

References
