A catalog of video records of the 2013 Chelyabinsk superbolide

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Introduction

The Chelyabinsk superbolide of February 15, 2013, was caused by an asteroid with a diameter of about 19 m entering the Earth atmosphere with a kinetic energy of 500 kT TNT just south of the city of Chelyabinsk, Russia. Impacts of similar energy occur on the Earth only a few times per century and impacts near such a large urban area are expected only a few times per 10 000 years. A number of video records obtained by casual eyewitnesses, dashboard cameras in cars, security, and traffic cameras were made publicly available by their authors on the Internet. These represent a rich repository for future scientific studies of this unique event. To aid researchers in the archival study of this airburst, we provide and document a catalog of almost 1000 videos showing various aspects of the event. Among the video records are approximately 400 distinct videos showing the bolide itself and about 100 videos showing the illumination caused by the bolide. Other videos show the dust trail left in the atmosphere, the arrival of the blast wave on the ground, or the damage caused by the blast wave. As these video recordings have high scientific, historical, and archival value for future studies of this airburst, a systematic documentation and description of records is desirable. Many have already been used for scientific analyses. We give the exact locations where more than 750 videos were taken as well as details of the visible/audible phenomena in each video recording. The first version of the catalog was published in [1] and an online version of the published catalog has been developed.

Online version of the catalog

The online version of the catalog is available at the link http://meteor.asu.cas.cz/Chelyabinsk/ and will be regularly updated to provide a long–term database for investigators. Readers can report their findings (errors, locations, new videos and links). A user defined table can be created by selecting the videos of a certain type (bolide, illumination, trail, wave, damage, or a combination) and columns to display. The table can be sorted according to video number, coordinates, or site name and exported in text format. Videos can be searched for the site name, camera type, coordinates, or a combination of these parameters. Since videos located on the Internet are not permanent it was useful to download the videos as soon as possible. We store a collection of 761 downloaded videos (not available online) and provide information on resolution in pixels, number of frames per second, and the time counted from the beginning of the sequence, when the bolide and/or the blast wave occurred. We encourage readers to send their additions and corrections to continue future refinement and development of the database.

Interesting videos

The complete list of records contains interesting videos that were not published and studied individually. For instance, one video captured from the Lake Chebarkul (1.7 km from the impact point of the largest fragment) recorded the sound of cracking ice. Unfortunately, the beginning time of the video is unknown but we cannot exclude from the shape of the trail that the source of the sound was the impact. Small group of videos show halo events created by the bolide light. The majority is the upper pillar but also 22 degree parhelia (proper term might be parbolidum) are presented. These records represent low-resolution spectra of the bolide and the first records of halo phenomena created by the daylight bolide known to us. We have found only one video showing in details (we do not mean hot spots) the turbulent evolution of the early dust cloud (10 seconds after the fireball passage). Unfortunately, the record lasts 3 seconds only.

Usage of the catalog

The catalog contains information about the content of the videos and, in many cases, also geographical coordinates. For example, 72 videos containing both the bolide maximum intensity and the blast wave arrival, so that the time difference could be measured, have been geolocated. The time differences vary from 86 s to 293 s. When plotted on the map, a clear symmetry relatively to the bolide trajectory determined in [2] is seen. The geographical distribution is, however, not very favorable, since most measurements come from the city of Chelyabinsk. Here the time difference ranges from 113 s in the southern suburbs to 174 s in the north of the city. As shown in [3] cylindrical-line source blast theory is needed to explain the observed arrival times of the blast wave in 38 videos. Further studies may concentrate on the secondary booms pointing to individual fragmentation events.

References

[1] Borovička, J., Shrbený, L., Kalenda, P., et al., Astronomy & Astrophysics, Vol. 585, A90, 2016.
[2] Borovička, J., Spurný, P., Brown, P., et al., Nature, Vol. 503, pp. 238-241, 2013.
[3] Brown, P. G., Assink, J. D., Astiz, L., et al., Nature, Vol. 503, pp. 238-241, 2013.