Provision of European Fireball Network Data

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The European Fireball Network (EN) has been continuously operating since the late 60's, recording on average 30-40 fireballs every year. The overall objective of this work is to provide the data on these events recorded by the first generation camera stations of the EN to the European Space Agency (ESA) on a regularly basis. The collected metadata of all fireball events will be updated to meet the required import format and will be ingested into the Fireball Information System (FIS), managed by ESA. This also includes the delivery of the corresponding image data. Furthermore, a fast reporting service on fireball events is currently used to the digital all-sky camera located at German Aerospace Center (DLR) in Berlin-Adlershof. Plans to extend the network by installing new digital camera stations are currently under investigation. At least one additional automated camera system is planned to be installed in the vicinity of the first camera station for simultaneous observations of events, allowing the reduction of double-station fireball image data. Information about recorded and confirmed fireball events will be sent to ESA via e-mail in predefined format.

1 Introduction

The *Space Situation Awareness* (SSA) program was introduced by ESA in 2008, with the goal of supporting Europe's independent utilisation of space through the provision of timely and accurate information and data regarding the space environment, and its hazards to infrastructure in orbit and on the ground.

Atmospheric entries of large meteoroids are frequently observed by casual eyewitnesses in the form of fireballs. To systematically study these events, multiple camera stations covering a large area are required, which will monitor the night sky routinely. The first networks dedicated on the observations of fireballs included those in Europe (Ceplecha & Rajchl, 1965), the United States (McCrosky et al., 1971) and Canada (Halliday et al., 1978). In Europe, optical observations began near Ondrejov Observatory in former Czechoslovakia in 1951 and by 1966 the camera network was extended covering large parts of southern Germany.

These same manually operated camera stations are still active today, although modern digital all-sky systems have replaced the early cameras located in the Czech Republic (Spurný et al., 2007). The operation of the analogue cameras is coordinated by German Aerospace Center (DLR) and currently involves 12 camera stations (Fig. 1), including one in Luxembourg and one in France, covering approximately an area of ∼1 Mio km^2 (Oberst et al., 1998). In the following sections we refer to the data acquired by the camera stations operated by DLR simply as EN data.

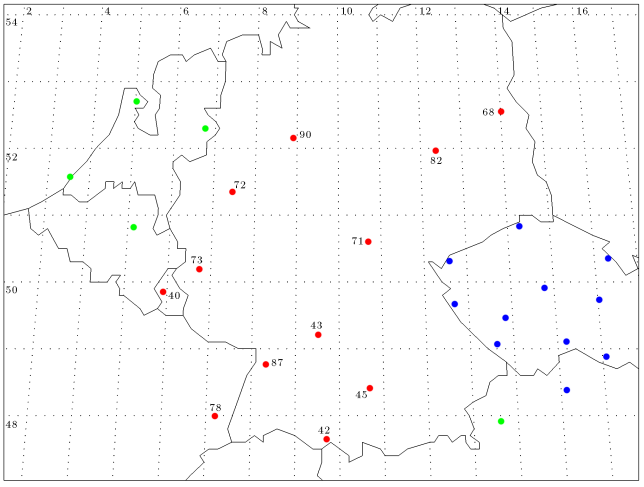

Figure 1 – Locations of all active all-sky camera stations (red numbered dots) of the EN camera network, operated by DLR.

2 Objectives

In past years, only a few exceptionally bright events were selected out of the acquired image dataset for further processing, since the procedure for reducing images obtained by film cameras is rather complex and time

consuming. As a result, a relative large number of fireball events have been not analysed yet. The main objective of this project is to provide formatted EN data to ESA in such a manner that the data remain exploitable in the future. Further objectives include the establishment of a real-time notification service for fireball events and the investigation of expansion strategies of the digital camera network.

Delivering metadata of fireball events to ESA

Under a previous contract a routine was written which converts fireball event metadata to `.xml` files for ingestion into the Fireball Information System (FIS). Following successful testing, the routine will be used to produce formatted EN data which will be delivered every 3 months to ESA. An extended metadata file format has been re-defined including the following information regarding:

- fireball event (e.g. date and time, country, etc.)
- observer (e.g. name, e-mail - optional)
- general observation (e.g. direction, brightness, speed, colour, etc.)
- meteoroid/meteorite (if applicable)
- event location (e.g. azimuth, elevation, etc.)
- camera system (e.g. pointing, focal length, etc.)
- orbital elements

Providing real-time information on fireball events

Another goal of this project is to provide real-time information on fireball events. A bash script checks the operating computer every two minutes for new detections and automatically sends and e-mail to a mailing list providing basic information of the potential event (e.g. date and UTC time, direction, etc.). This script is used at the all-sky camera system located at DLR's Institute of Planetary Research in Berlin-Adlershof and is currently under testing. The planned installation of a second camera at the TUB will allow simultaneous observations of fireball events, removing efficiently false detections. Moreover, additional information of an event can be provided, once the reduction of double-station image data is performed using existing software (Margonis et al., 2018). Information about recorded and confirmed fireball events will be sent to ESA via e-mail in the agreed format. This format will be consistent with the one defined for the classical camera stations of the network.

We will study the possibilities of setting up additional automated camera stations to increase coverage of the monitored areas and chances of fireball detections in the case of sporadic cloud cover. Improvements are necessary regarding the form and the content of the notifications as well as the implementation of strategies to minimise false reports (e.g. clouds, planes etc.).

Archiving previous fireball data

Fireball data from previous years will be delivered at ESA (Fig. 2). The deliveries shall include complete data (metadata and images) from the years 2004-2019 and continue until 2021. The conversion and delivery of the data to ESA will be performed at DLR.

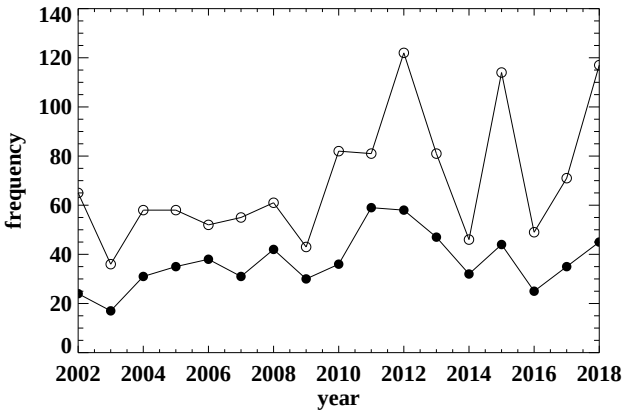

Figure 2 – Number of fireball events recorded by the EN cameras in the time period between 2002-2018 (filled circles). The number of images showing a fireball for each year are shown in open circles. The higher number of images compared to the number of events indicate that several events were recorded by more than one stations.

3 Summary and future work

During the last decades camera stations of the EN network have recorded several hundreds of fireball events observed from northern-central Europe. The images generated by the first generation all-sky cameras are of high geometric and radiometric quality allowing the accurate reconstruction of the atmospheric entry of a particle. This large dataset will be adequately archived and maintainted in the FIS database, managed by ESA. Consequently, preceding data of fireball events will become available to the meteor community for study, further processing or/and reassessment of the recent results. Additionally, the expansion of the network and the replacement of the outdated analogue camera stations with modern digital camera systems will increase the efficiency of the fireball observations and provide a basic platform for real-time information of future events.

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