Commissioning the Desert Fireball Network data pipeline

H.A.R. Devillepoix (1,2), P.A. Bland (1), M.C. Towner (1), M. Cupák (1), E.K. Sansom (1), R.M. Howie (3), M. Cox (1), T. Jansen-Sturgeon (1), J. Paxman (3)

(1) Dept. Applied Geololgy, Curtin Univ., (2) International Centre for Radio Astronomy Research (ICRAR), (3) Dept. Mechnical Engineering, Curtin Univ., (h.devillepoix@postgrad.curtin.edu.au)

Introduction

The Desert Fireball Network (DFN) is triangulating bolides over an area of more than 1.5 million km^2. Thanks to this large sampling area and comparatively clear skies in the Australian outback, the DFN is able to observe a significant number of fireballs, some of which have the potential for a meteorite recovery.

With a rate of data acquisition exceeding 60 TB/month, reducing every fireball requires an automated data pipeline. Although a completely automated pipeline is not needed for meteorite falls calculations, the by-product dataset contains invaluable information about the distribution of meter-sized NEAs [1]. The reduction of the entire dataset is the only way to close the statistical gap between telescope/radar observations of larger asteroids, and dust-size particles observed by meteor networks.

Reduction data pipeline

The 49 Automated Desert Fireball Observatories collectively take $\sim$40,000 still images every night.

New approaches have been developed to make the data pipeline as automated as possible.

Neural network algorithms are used to detect meteors in the images. locally on the cameras, to minimise network usage.

A unique code is embedded in each fireball trajectory by the use of a shutter system modulated with a DeBrujin sequence (patent pending [2]). This provides absolute as well as relative timing for the meteoroid trajectory. Decoding this sequence is currently the last step that requires human eye checking.

Astrometric calibration of the images can be done blindly: no prior knowledge of the optics used nor pointing information is required, the stars present in the image are enough to build a reference system precise down to 1 arcminute.

Triangulation of the trajectory is currently done using modified least squares minimisation approach, the next iteration will use simulations based on bright flight dynamics.

Using data from the top end of the trajectory, software was written to propagate the orbit of the meteoroid back in the solar system. On the bottom end, each fragment can be isolated thanks to the high resolution of the images, and finally traced down to the ground using Weather Research and Forecasting (WRF) wind models for dark flight integration.

At every step, control routines automatically assess the quality of the data, flagging any problems and unusually large uncertainties.

Meteorite fall positions

From final masses calculated based on dynamic flight modelling [3], 12 events have been identified for meteorite searching (criteria from [4]). One of them has already been recovered on December 31 2015 on dried salt lake Eyre.

Orbital dynamics

The current dataset contains 2 fireballs from the recently identified shower Volantids [5], and 7 Geminids fireballs. The 2015 data also shows a large number of Taurids fireballs (37), which seems to confirm the prediction in [4].

References

[1] Brown, P. et al., Icarus, 96-111, March 2016
[2] Howie, R. et al., Australian Patent: 2016900714, issued date Feb. 26, 2016
[3] Sansom, E. et al., MAPS, vol. 50, 1423-1435, 2015
[4] Brown, P. et al., MAPS, vol. 48, 270-288, 2013
[5] Jenniskens, P. et al., in preparation