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Abstrakt

Inštalácia viacstaničných sietí meteorových kamier umožňuje okrem iného aj určenie celkového toku meteoroidných častíc. Priame meranie však nie je možné, pretože získané dáta sú zaťažené značnými systematickými chybami a výberovými efektami. V tejto práci predkladáme dve metódy odstránenia výberových efektov. V práci sme použili dáta z kamier AMOS, vyvinutých a prevádzkovaných na FMFI UK.

Prvá metóda je založená na postupnej identifikácii a odstraňovaní výberových efektov, ktoré ovplyvňujú pozorované frekvencie meteorov v zemskej atmosfére. Vplyv uvažovaných efektov sme odhadli na základe kalibrácie systému s vizuálnymi pozorovateľmi. Druhou popísanou metódou je simulácia meteoroidov vstupujúcich do zemskej atmosféry. Na zaznamenané dráhy virtuálnych meteorov boli aplikované zvolené výberové kritériá a výsledný štatistický súbor bol uložený do databázy. Tieto dáta sme následne analyzovali štatistickými metódami a porovnávali s observačnými dátami z kamier AMOS. Celý proces sme následne mnohokrát opakovali s modifikovanými parametrami až do nájdenia najlepšej možnej zhody s observačnými dátami a následne odhadli výsledný tok pre meteorický roj Perzeíd.

Kľúčové slová: meteor, meteoroid, tok, model, pozorovanie, výberové efekty

Abstract

Deployment of multi-station video meteor networks presents a unique opportunity to measure the total mass flux of meteoroids impinging on the surface of the Earth. However, direct measurement of flux is not possible as raw data are heavily distorted by selection bias. In this thesis, we present two possible methods of debiasing the data used for flux estimation. We used data obtained by AMOS, an all-sky video camera system developed and operated by Comenius University in Bratislava.

The first method is based on sequential identification and elimination of possible sources of bias. Each identified effect is measured and adequate correction procedures are developed. The second presented approach is a simulation of meteoroid particles entering the atmosphere. The trajectory of each virtual meteoroid is tracked and after application of biases the resulting meteor observation is recorded. Once a sufficiently large dataset is obtained, statistical tests are performed and the distributions are compared to observational data. The entire procedure is repeated and the parameters of the simulation are gradually adjusted until best possible agreement with observational data is found.

Keywords: meteor, meteoroid, population, video, flux, model, debiasing, AMOS

Contents

Chapter 1

Introduction

You saw sagacious Solomon,
You know what came of him,

Edsger Dijkstra

1.1 Reduction to Earth's sky

While the primary model describes the actual distribution of meteoroid particles in space around the Earth, it is not possible to compare this directly to observations.

models developed from data obtained from Earth-based observations are different.

Typically we do not consider individual particles, but the entire stream and its elliptical orbit around the Sun.

the ascending or the descending node of the orbit must lie very close to the orbit of the Earth.

The final product would thus be a five-dimensional map of distribution of meteor activity, with independent variables being

- the **temporal coordinate**, representing the variation of meteor activity in time;

- the **mass spectrum**, describing the distribution of meteoroid masses, typically in terms of *mass index s*;

- and the **velocity spectrum**, describing the velocities of objects passing through this point, which can be in turn described by

  – two spatial coordinates, the **right ascension and declination** of the radiant, or α and δ;

  – and **speed** v.

described by the **meteor activity function**

$$M(t, \vec{v}, m) \equiv \rho(\lambda_\odot, \delta, \alpha, v, m). \tag{1.1.1}$$

In visualisations it is natural to keep the spatial and temporal dimensions, that is, right ascension and declination are displayed as spatial coordinates using one of suitable projections, while time evolution of streams is best displayed in sequence of images. Displaying the secular evolution of one stream can be performed by comparing the state of the function M at the same $\lambda_\odot$ in successive years.

[1]

Within this map we are able to distinguish two main features:

- the **sporadic background**, which forms the main contour lines of the maps, the "terrain";

- and the well-defined, sharp peaks, representing the **meteor showers**. very narrow in the speed dimensions;

Due to influences of various acting forces, such as differences in initial velocities with respect to the parent body, tidal disruptions, perturbations arising from close encounters with large bodies of the Solar System, Poynting-Robertson effect, etc., the stream gradually widens and disperses in all components until it can no longer be distinguished from the background.

1.1.1 Time

In examining the evolution we may recognize two distinct components:

- the **periodic component**, emerging as the result of the Earth orbiting the Sun. This coordinate can be thus expressed in terms of the **longitude of the sun** $\lambda_{\odot}$.
- the slowly-varying **secular component**, associated with appearance of new meteoroid streams and gradual decay of older streams which are not replenished.

  The peaks produced by meteor showers appear abruptly after the parent body passes through the vicinity of the Earth, producing small meteoroid due to heating or outgassing. Returns of parents bodies on periodic orbits, such as comets 1P/Halley or 109P/Swift-Tuttle, result in resupply of meteoroid material, and thus form an extra periodic component, included in the secular evolution of the stream.

Bibliography

[1] Martin Baláž, Juraj Tóth, Robert Jedicke, and Peter Vereš. ASMODEUS meteor simulation toolset. **Planetary and Space Science**, in prep.