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Integrated analysis based on all-sky cameras and infrasonic array for the characterisation of small fireballs events

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INTRODUCTION

This study presents the integrated analysis of ~15 small fireball events recorded both by multiple all-sky cameras of the PRISMA meteor surveillance network and by an infrasonic array.

METHODS/DATA

The events are physically characterized based on optical data. Infrasonic signals are analysed with array processing and ray-tracing techniques to locate the source. Optical and infrasonic data are compared.

START

RESULTS

Good agreement between the optical trajectories and the infrasound-based ones. Unclear relations between the recorded infrasonic signal features and the physical parameters of the fireballs.

CONCLUSION

This study highlights the potential of the cooperation between infrasonic and optical networks to detect fireballs. Lots of work still to be done to define accurate laws linking measured infrasound to event parameters for smaller fireballs.

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Introduction

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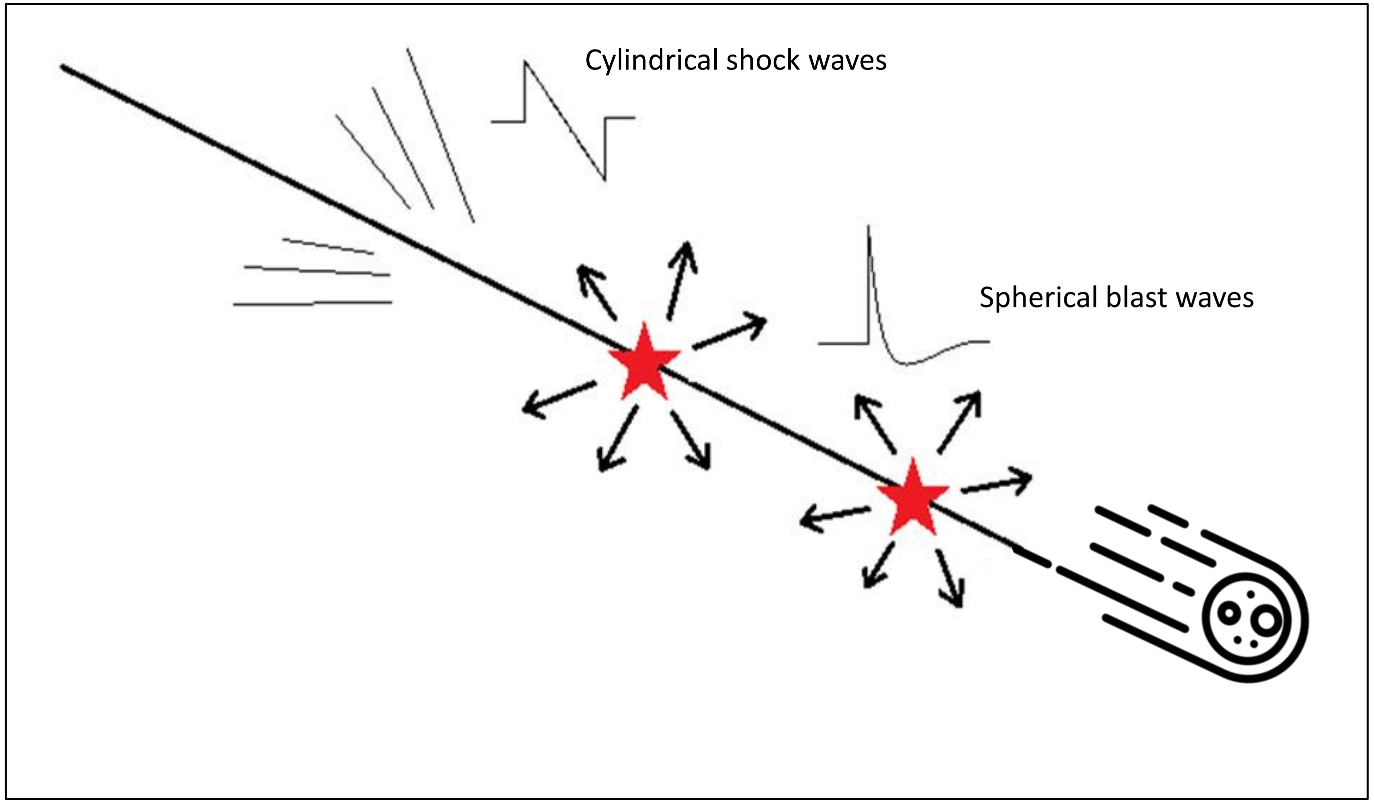
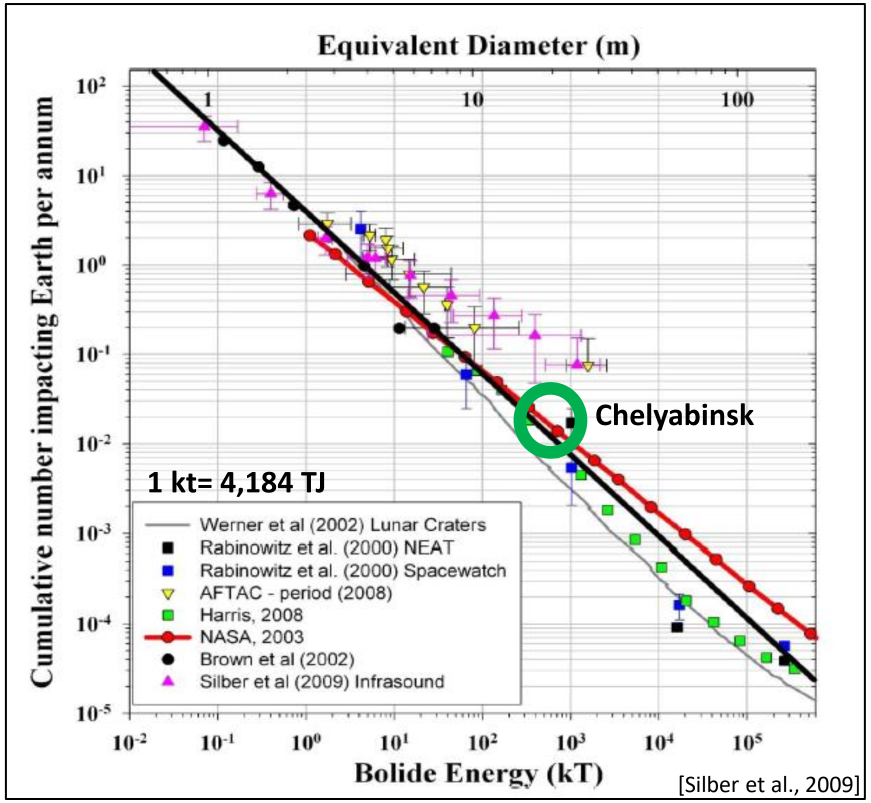
Meteoroids of various size continuously enter the Earth's atmosphere with velocities of a few tens of km/s and with a rate which reversely scales with their size.

Their supersonic flow through the air produces cylindrical shock waves. In the final phase of their fall, meteoroids can fragment, due to the dynamic pressure: each fragmentation episode generates spherical blast waves. Both the wave types are inverted into infrasound with the propagation.





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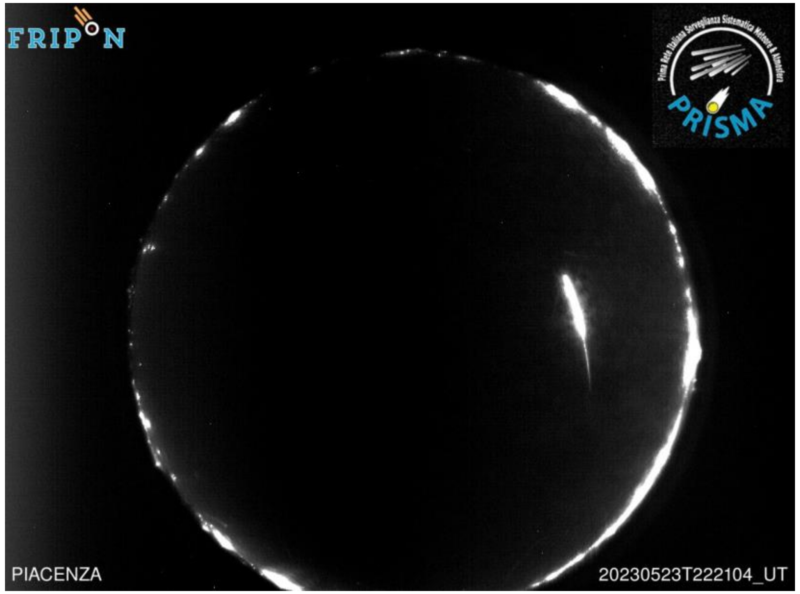
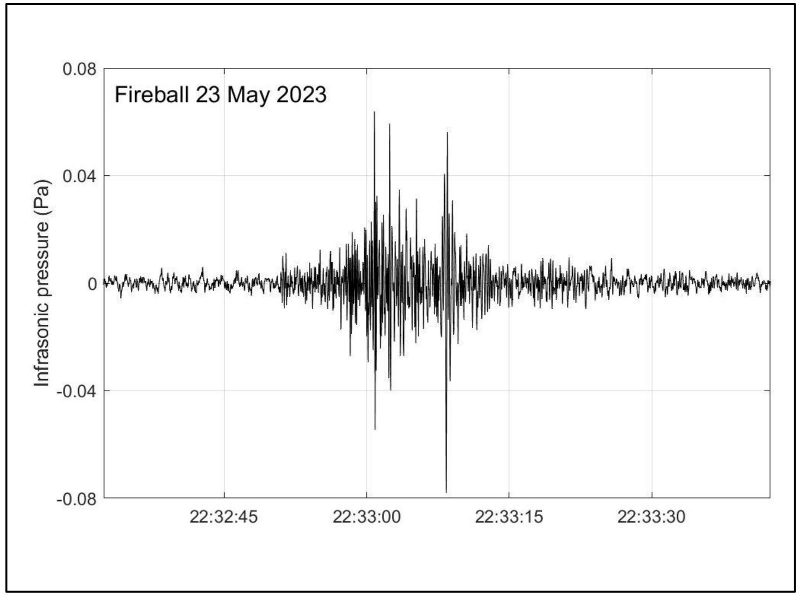
Objectives

Meteoroid observation is traditionally performed with all-sky cameras. This observation is possible only by night and with clear sky.
The use of infrasonic can provide a more complete fireball dataset, providing more details on optically-detected events or also identifying events when the traditional optical observation is prevented.
Several studies has already been carried out on the infrasonic analysis of large fireball events. Less energetic but more frequent events are instead less studied.
This study aims to investigate the potential of a synergetic use of networks of both all-sky cameras and infrasonic arrays to detect and characterize small fireball events.





Methods/Data

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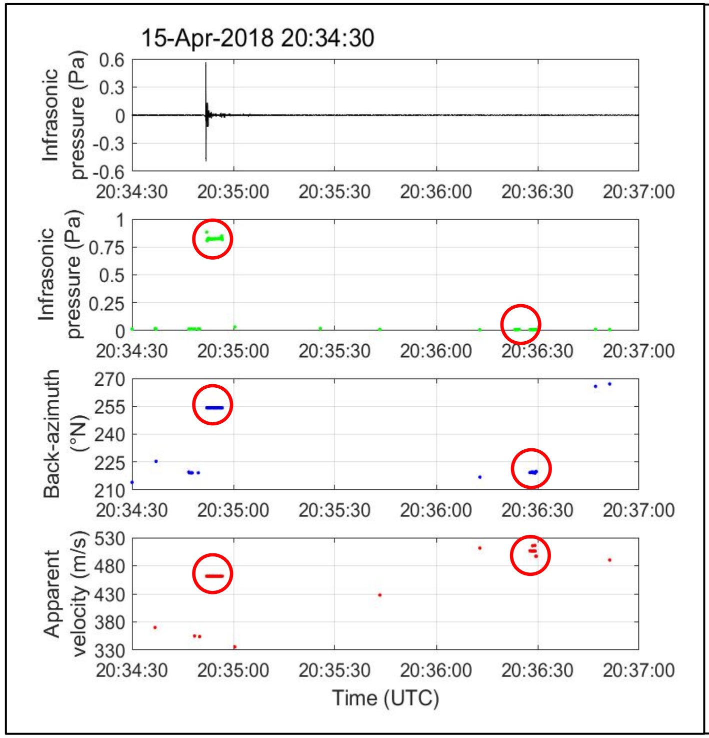
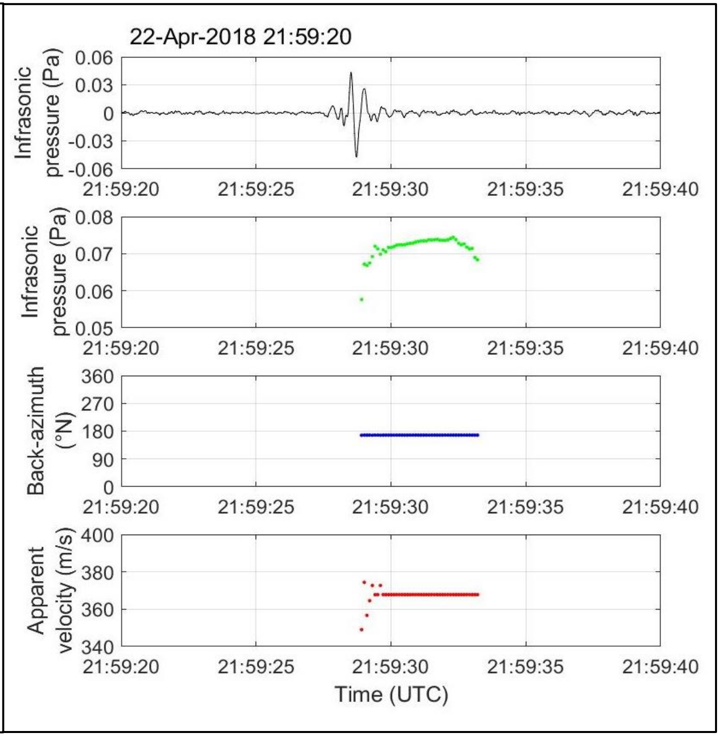
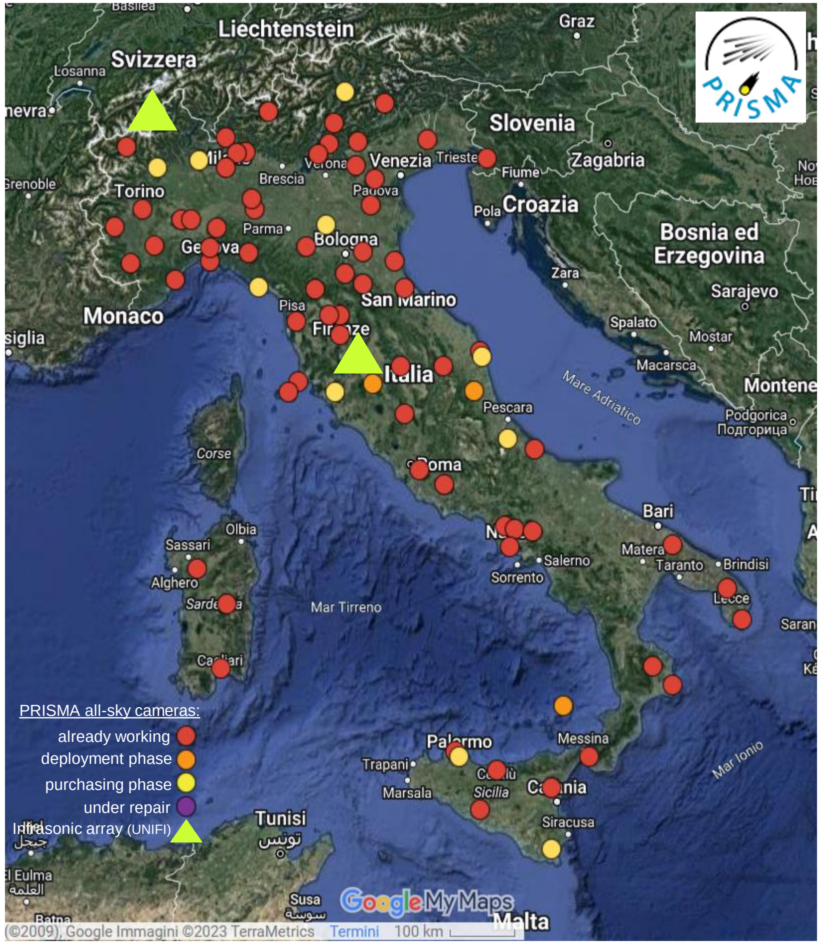
We identified 14 fireball events recorded both with multiple all-sky cameras of the PRISMA meteor surveillance network and with an infrasonic array of the University of Florence. The events are optically characterized in terms of 3D-trajectory, initial velocity, size and mass and kinetic energy. Rather small fireballs: initial mass < 4.3 kg and initial diameter < 13.5 cm (for comparison, Čeljabinsk: mass ~10,000 t and diameter ~15 m). Infrasonic signals are analysed with array processing techniques. The infrasonic wave parameters obtained with a single array are used to locate the source with a 2D ray-tracing, using the exact time of the event provided by all-sky cameras (Belli et al., 2021).







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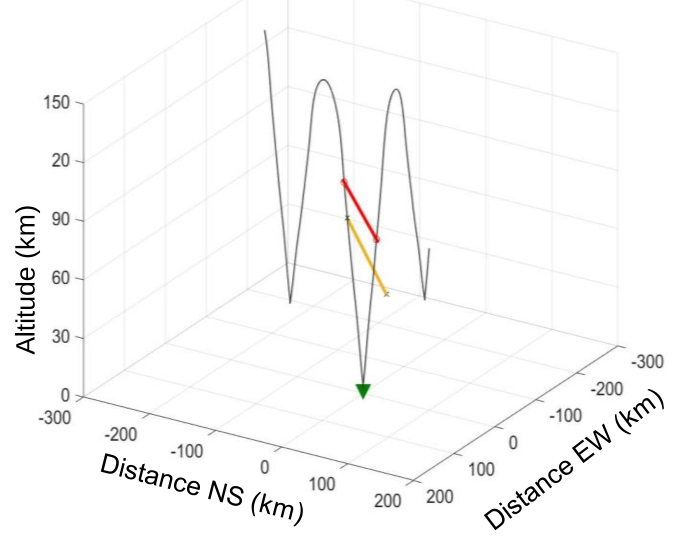
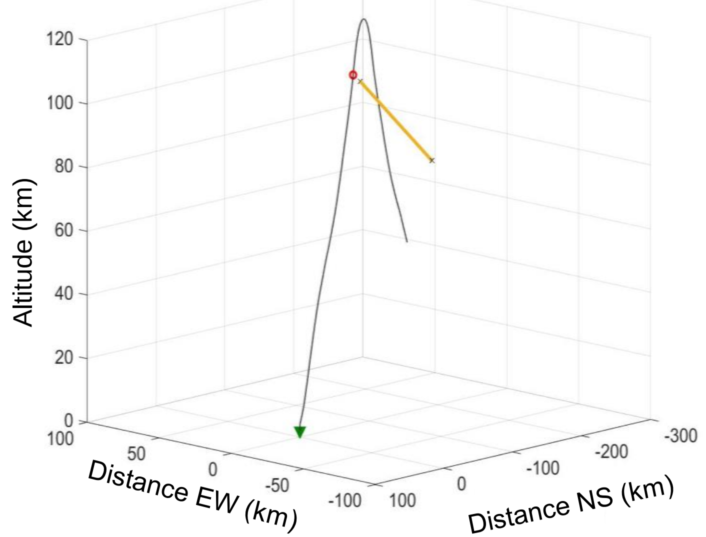
Results

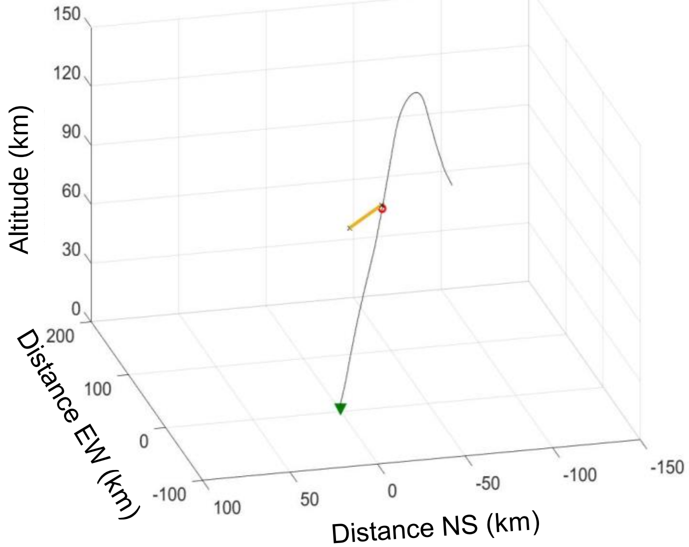
Fireball event on 15 April 2018



Fireball event on 22 April 2018



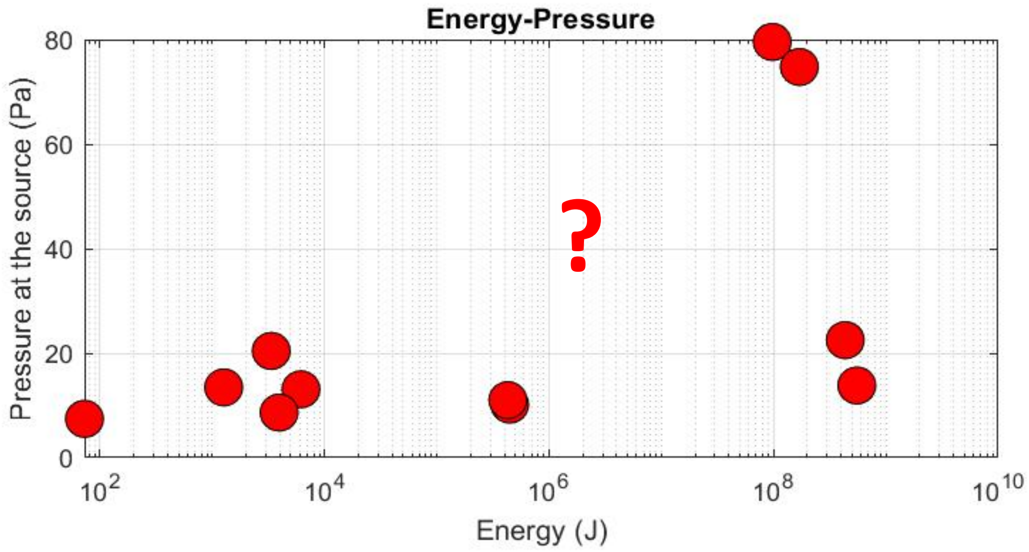
Fireball event on 11 September 2018



Results show a good agreement between the optically determined fireball trajectories (orange) and the infrasound-based source localisations (red).

All recorded signals are direct arrivals.

Lot of uncertainties remain when the infrasonic pressure recalculated at the source (corrected just for geometrical spreading) is compared with the fireball kinetic energy determined with the analysis of all-sky camera images.



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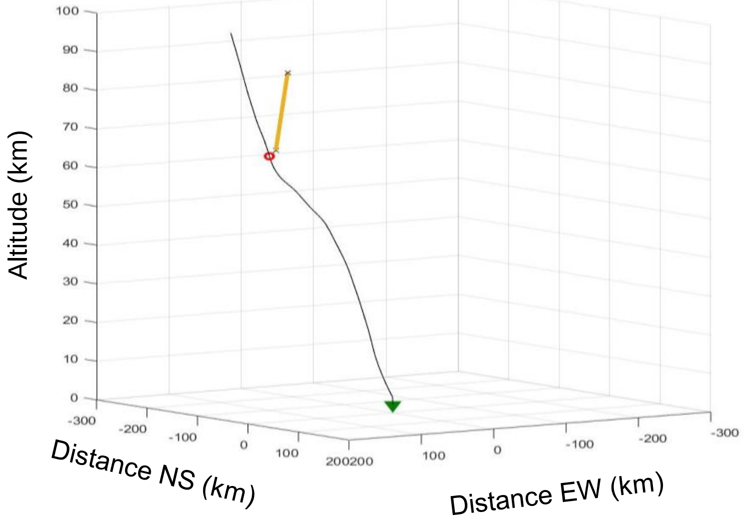
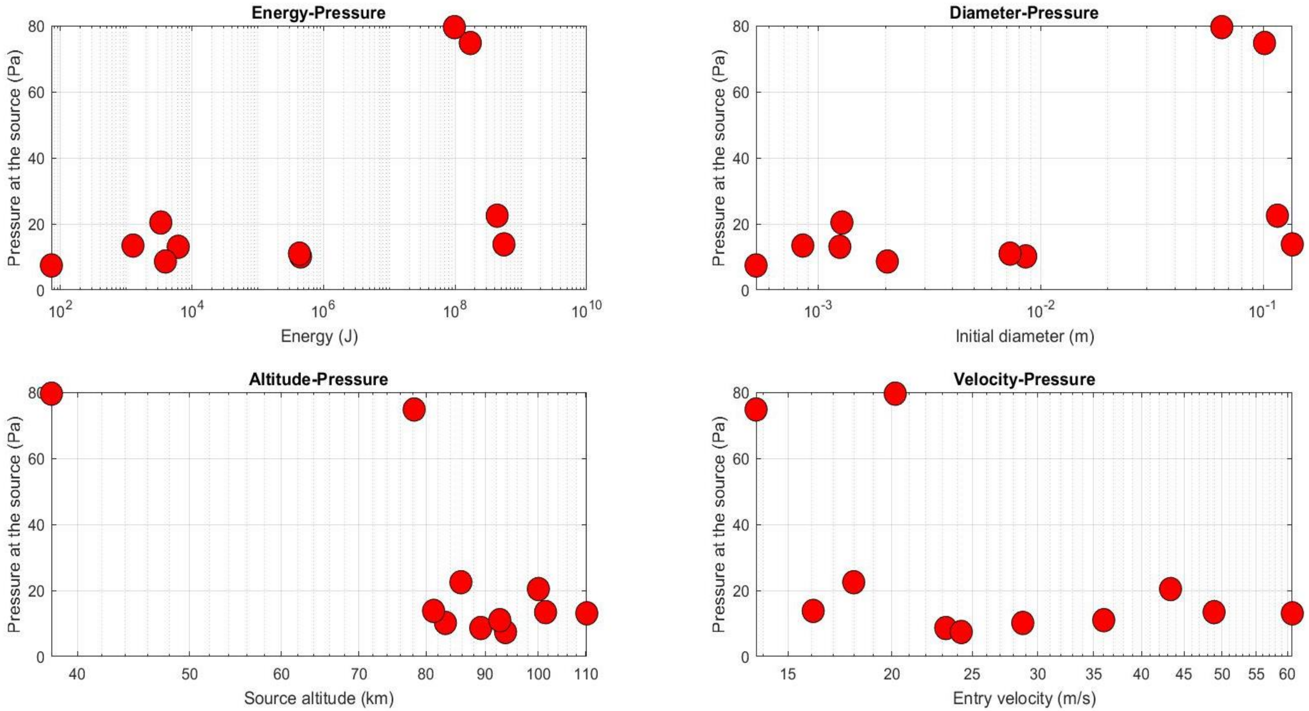
Conclusion

The analysis highlights the high potential of an integrated network of both all-sky cameras and infrasonic array for the meteoroid surveillance and detection.

Infrasonic records allow to locate a bolide using data from a single array, the atmospheric specifications at the time of the event and the event timing provided by an all-sky camera. This allows to locate an event recorded only with a single all-sky camera and one infrasonic array.

Fireball event on 22 August 2018





Open questions remain in estimating the energy of smaller fireball events based on infrasound records.

Not enough events in our database.

The simple correction for the geometrical spreading may not be sufficient.

Probable importance of other parameters: altitude of the meteoroid fragmentation (different air pressure), size of the meteoroid and its velocity.

Lots of work still to do!

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