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Infrasound detection of the earthgrazing fireball over Europe on 22 September 2020

E. A. Silber[1], D. Bowman[1], S. Albert[1]

[1]Sandia National Labs, Albuquerque, NM, USA (esilbe@sandia.gov)

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1. Introduction

- Well-documented observations of earthgrazing meteoroids are exceptionally rare, with only a handful reported in scientific literature over the last five decades [1]. These objects are unique in that they enter the Earth's atmosphere at an extremely shallow angle relative to the horizon.
- An earthgrazing meteoroid might fully ablate, slow down enough to fall towards the Earth, or survive its passage through the atmosphere and exit back into space.
- While interacting with the denser regions of the atmosphere, an earthgrazing meteoroid might undergo ablation and pro-duce a luminous path that could span as much as several hundreds of kilometers [2]. Earthgrazers generally do not penetrate deep into the atmosphere; documented cases had their minimum altitude between ~70 km and ~100 km [1].
- During their passage through the atmosphere, sufficiently large and fast meteoroids produce shockwaves that can decay to very low frequency acoustic waves, also known as infrasound [3].
- While it is relatively rare for high-altitude (≥100 km) meteoroids to produce infrasound detectable at ground-based stations, several instances had been documented in the past [4].

2. Earthgrazer over Europe

- A rare horizon-to-horizon earthgrazer event occurred over northern Europe on 22 September 2020 at 03:53:40 UTC, capturing attention of many eyewitnesses and numerous ground-based cameras aimed at the skies (Figure 1) [5].
- As per the analysis released by the Global Meteor Network [6], the luminous path of the earthgrazing fireball started over Germany and ended over the UK, at the altitude of 101 km and 107 km, respectively.

Figure 1: All-sky camera image of the earthgrazer. Image credit: Cees Bassa [5].

3. Infrasound observations

- The point of the closest approach was at ~90 km. The object's velocity upon the entry was ~34 km/s, and only slightly less, ~30 km/s, when it exited [5,6].
- Despite its high-altitude and apparently silent (to humans) passage, the earthgrazer was detected by infrasound sensors of the Royal Netherlands Meteorological Institute (KNMI) network [7] several minutes after it had entered the atmosphere.
- Three infrasound arrays recorded the signal: EXL, DBN, and CIA. The timeseries at one of the elements of the EXL array is shown in Figure 2 [8].
- The signal arrived at a very steep angle at 03:58:44 UTC, a few minutes after the onset of a luminous path. Such arrival is indicative of a high-altitude shock.

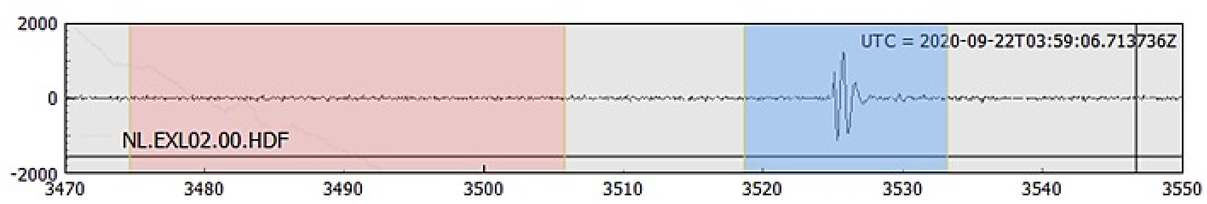

Figure 2: Timeseries [8] showing the signal (blue box) generated by the earthgrazer. The signal arrived at 03:58:44 UTC at a very steep angle.

4. Summary

- This unique earthgrazing fireball event provides valuable constraints for infrasound propagation and characterization of high-altitude meteor events [4].
- The extremely shallow entry angle of the fireball enabled the infrasound wave to readily propagate downward, thus assuming a direct path to the receiver.

References

[1] Shober P. M. et al. (2020) The Astronomical Journal, 159:191. [2] Moreno A. et al. (2016) LPSC 47, Abstract #1088. [3] Silber E. A. et al. (2018) Advances in Space Research, 62:3, 489 - 532. [4] Silber, E. A. and P. G. Brown (2014) JASTP, 119, 116-128. [5] https://sattrackcam.blogspot.com/2020/09/a-very-unusual-fireball-over-nw-europe.html [6] Vida D. et al. (2020) Global Meteor Network. [7] KNMI (1993) Royal Netherlands Meteorological Institute (KNMI). doi: 10.21944/e970fd34-23b9-3411-b366-e4f72877d2c5. [8] Blom P. S. et al. (2016) Report # LA-UR-16-24234, Los Alamos National Lab.