INFRASOUND DETECTION OF THE EARTHGRAZING FIREBALL OVER EUROPE ON 22 SEPTEMBER 2020.

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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 produce 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].

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

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. 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].

Infrasound Observations: 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.

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. Detailed infrasound detection analyses and propagation modeling results will be discussed.

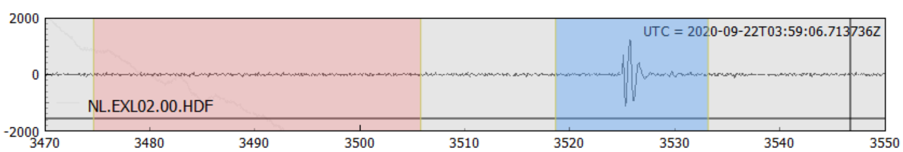

Figure 2: Timeseries [8] showing the signal (blue box) generated by the earthgrazer. The signal arrived at 03:58:44 UTC at a very steep angle

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