THE 2020 EARTHGRAZER: INFRASONIC DETECTION OF A RARE METEOR EVENT. E. A. Silber[1], M. Ronac Giannone[1] and D. C. Bowman[1], [1]Sandia National Labs, Albuquerque, NM, USA (esilbe@sandia.gov).

Introduction: Earth is continuously bombarded by extraterrestrial particles (or meteoroids), which, upon entering the upper atmosphere, produce a visual phenomenon known as a meteor [1,2]. Very bright meteors, or fireballs, are generally produced by objects greater than about 10 cm in diameter. The average entry angle of a meteoroid is ~45°. Extreme entry angles, either very shallow or very steep (relative to the horizon) are rare. Meteoroids entering the atmosphere at such shallow angles that they 'graze' the upper regions of the Earth's atmosphere, are known as earthgrazers. There are very few well-documented observations of earthgrazers recorded in literature over the past 50 years [3]. While some earthgrazers completely ablate, some survive their passage through the atmosphere and return to space [2]. In the latter scenario, meteoroids must have a sufficiently large mass and velocity, and are typically fireballs. In addition to producing a visual phenomenon, fireballs are capable of generating shockwaves that can decay to very low frequency acoustic waves, also known as infrasound [2,5]. While it is uncommon for high-altitude (≥100 km) meteoroids to produce infrasound detectable at ground-based stations, several instances had been documented in literature [5].

The 2020 Earthgrazer: A rare earthgrazing fireball entered at ~34 km/s over northern Europe on 22 September 2020 at 03:53:40 UTC. It captured the attention of many eyewitnesses and was recorded by numerous ground-based all-sky cameras (Fig. 1) [6].

Fig. 1: All-sky camera image of the earthgrazer. Image credit: Cees Bassa [6].

As per the initial analyses provided by the Global Meteor Network [7], the luminous path of the earthgrazing fireball commenced over Germany and terminated over the UK, at an altitude of 101 km and 107 km, respectively. The deepest point of entry was ~90 km [6,7].

Infrasonic Detection: Despite the high-altitude trajectory, the pressure wave from this event reached the ground at low frequencies detectable by infrasonic instruments. The shockwave generated by the earthgrazer was readily detected by three infrasonic stations of the Royal Netherlands Meteorological Institute (KNMI) network [8]. The timeseries recorded by three operational sensors of the EXL array are shown in Fig. 2. The signal arrived with a high trace velocity (>1 km/s), indicative of a near-vertical arrival angle. The infrasonic signature is consistent with a high-altitude shock generated by a cylindrical line source [5]. Most of the energy was concentrated below ~4 Hz (Fig. 3).

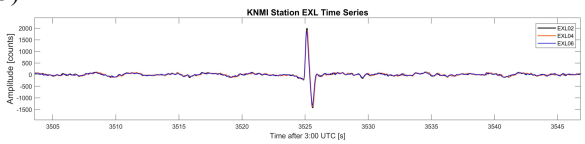

Fig. 2: Time series recorded by three sensors of the EXL array. The signal arrived as an N-wave at 03:58:44 UTC.

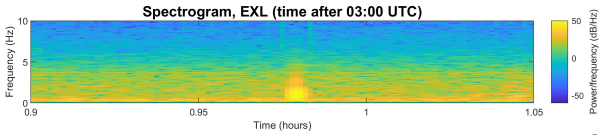

Fig. 3: Spectrogram at channel 2 of the EXL array.

Summary: This rare earthgrazing fireball event provides valuable constraints for infrasound propagation and characterization of high-altitude meteor events [2,5]. The extremely shallow entry angle of the fireball enabled the infrasound wave to propagate downward via a direct path to the receiver. We will discuss infrasound analyses and propagation modeling results.

References: [1] Ceplecha Z. et al. (1998) *Space Science Rev.*, 84:3/4, 327-471. [2] Silber E. A. et al. (2018) *ASR*, 62:3, 489 - 532. [3] Shober P. M. et al. (2020) *Astron. J.*, 159:191. [4] Moreno A. et al. (2016) *LPSC* 47, Abstract #1088. [5] Silber, E. A. and P. G. Brown (2014) *JASTP*, 119, 116-128. [6] https://sattrackcam.blogspot.com/2020/09/a-very-unusual-fireballover-nw-europe.html [7] Vida D. et al. (2020) *Global Meteor Network*. [8] KNMI (1993) *Royal Netherlands Meteorological Institute (KNMI)*.

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