Infrasound detection of bolide 20191013_221816

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A bright meteor appeared above central Switzerland on 13 October 2019. The geometrical trajectory analysis was made by Beat Booz of the FMA group. The bolide emitted a flash (brighter than -5 mag) at $22^h18^m17.8^s$ UT and a luminescent remnant was also visible in some later video frames. The calculated height of this flash was 66.5 km.

1 Introduction

Beat Booz analyzed the whole event[14]. He calculated the arrival times of possible infrasound waves produced by the interaction of the meteoroid with the atmosphere along its path and particularly the waves generated by the flash. In a successive step, infrasound signals have been searched in helicorders of infrasound ground detectors. In Switzerland four stations are equipped with such devices at the locations Bos-cha (BOS), Entfelden (ENT), Locarno (LOC) and Val

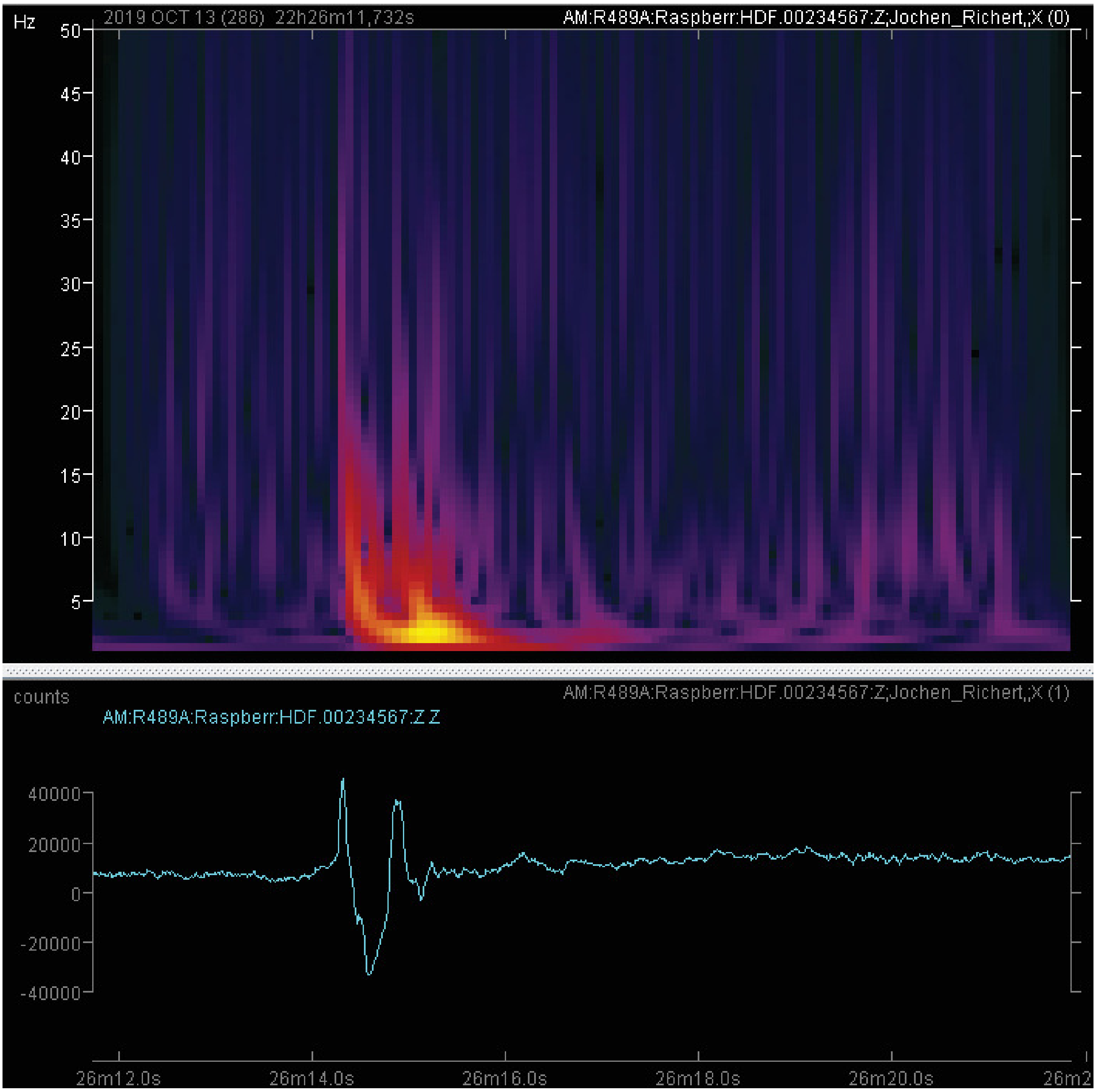

Figure 1 – Spectrogram (Butterworth filter) and signal recorded at BOS (Seisgram2K).

[14] http://www.meteorastronomie.ch/detaildatafk.php?id=139

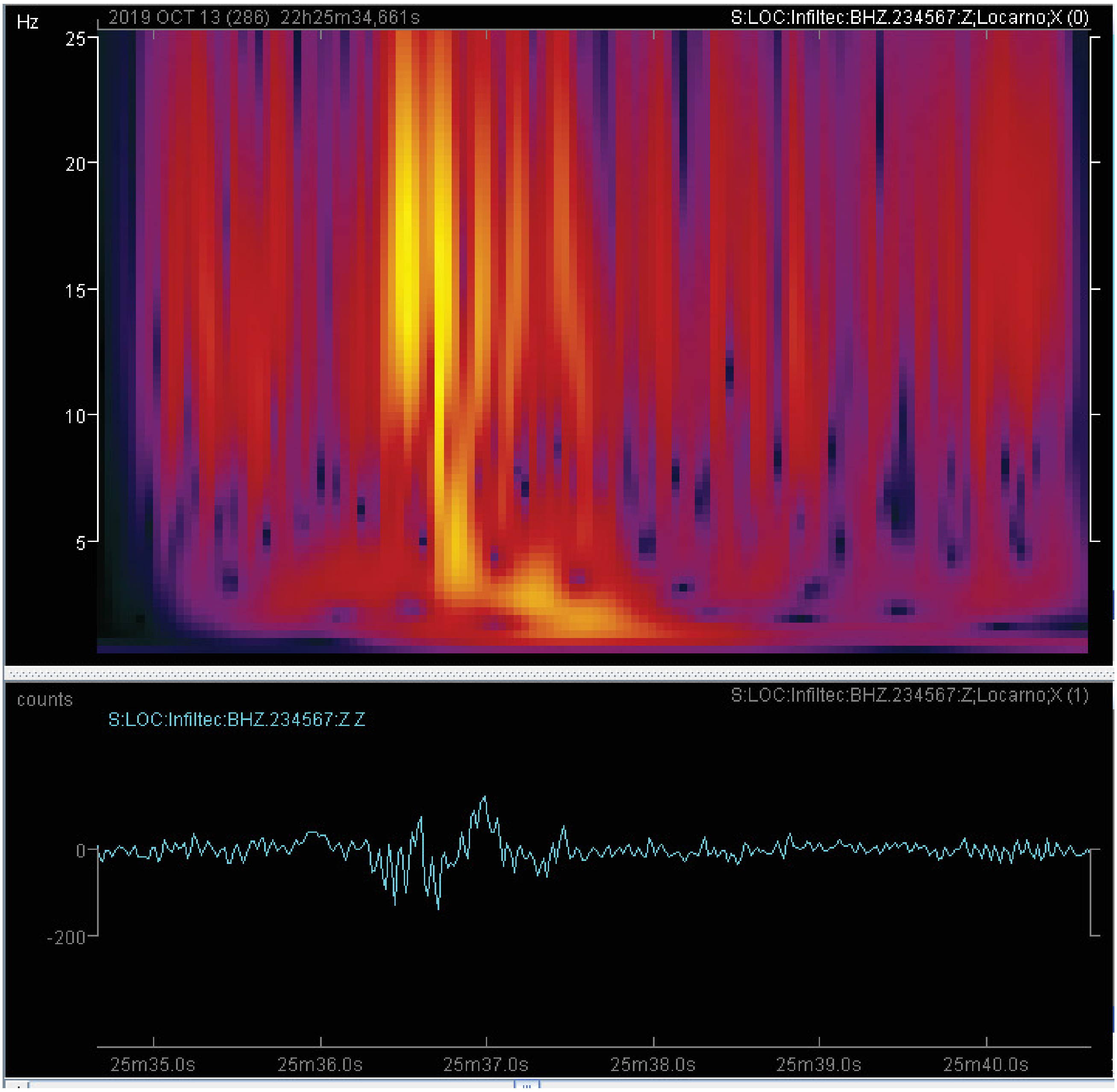

Figure 2 – Spectrogram (Butterworth filter) and signal recorded at LOC (Seisgram2K).

de Terbi (VTE). The helicorders of the stations ENT and VTE do not have evident signals and their spectrograms do not show any predominant frequency. Around the calculated times, the stations BOS and LOC detected small signals with peaks of ~0.5 Pa and ~0.2 Pa respectively.

Their spectrograms (Butterworth method) show a similar pattern with a dominant frequency of ~2 Hz. Both signals lasted ~1 s. (*Figures 1* and *2*). The BOS signal matches the Class I (single N-wave) of the taxonomic classification of Silber and Brown (2014). The measured LOC's arrival time agrees with the calculus. In the case of the BOS station, sound waves apparently arrived about 20 s too early.

Times were calculated assuming an average sound speed of 312 m/s in calm air but winds do influence that speed by some amount. So, we searched for data (speed and direction) of high-altitude winds. Such information is available online[15].

Table 1 – Calculated (without wind correction) and measured arrival times of sound waves emitted by the meteor flash at $22^h18^m17.8^s$ UT.

	Calculated arrival time [UT]	Measured arrival time [UT]
BOS infrasound station	$22^h26^m34.8^s$	$22^h26^m15^s$
ENT infrasound station	$22^h22^m18.0^s$	–
LOC infrasound station	$22^h25^m36.4^s$	$22^h25^m37^s$
VTE infrasound station	$22^h23^m34.6^s$	–

We downloaded data measured with balloons sent from Milano, Italy and Muenchen, Germany at the date 20191014_000000. These data were measured from the

[15] http://weather.uwyo.edu/

ground to about an altitude of 30 km. An average of all the data was calculated. (*Table 2* and *Figure 3*).

Table 2 – Average wind data from the ground to an altitude of 30 km.

	Average windspeed [m/s]	Average wind direction [deg]
Milano	10.1	239
Muenchen	11.8	266

For the signal recorded at BOS, high altitude winds should have increased the speed of sound. When we add the influence of (supposed horizontal) winds projected in the direction of the (supposed linear) propagation of the signal (along the whole line-of-sight) we get the following sound speeds: 319.8 m/s in the BOS direction and 311.9 m/s in the LOC direction.

The results are summarized in *Table 3*. Calculated and measured times agree within some percentage.

Table 3 – Calculated (with wind correction) and measured arrival times of sound waves emitted by the meteor flash at $22^h18^m17.8^s$ UT.

	Calculated arrival time [UT]	Measured arrival time [UT]	Difference [s]	Difference in % of the measured travelling time
BOS station	$22^h26^m21.8^s$	$22^h26^m15^s$	–6.8	1.4
LOC station	$22^h25^m35.8^s$	$22^h25^m37^s$	+1.2	0.3

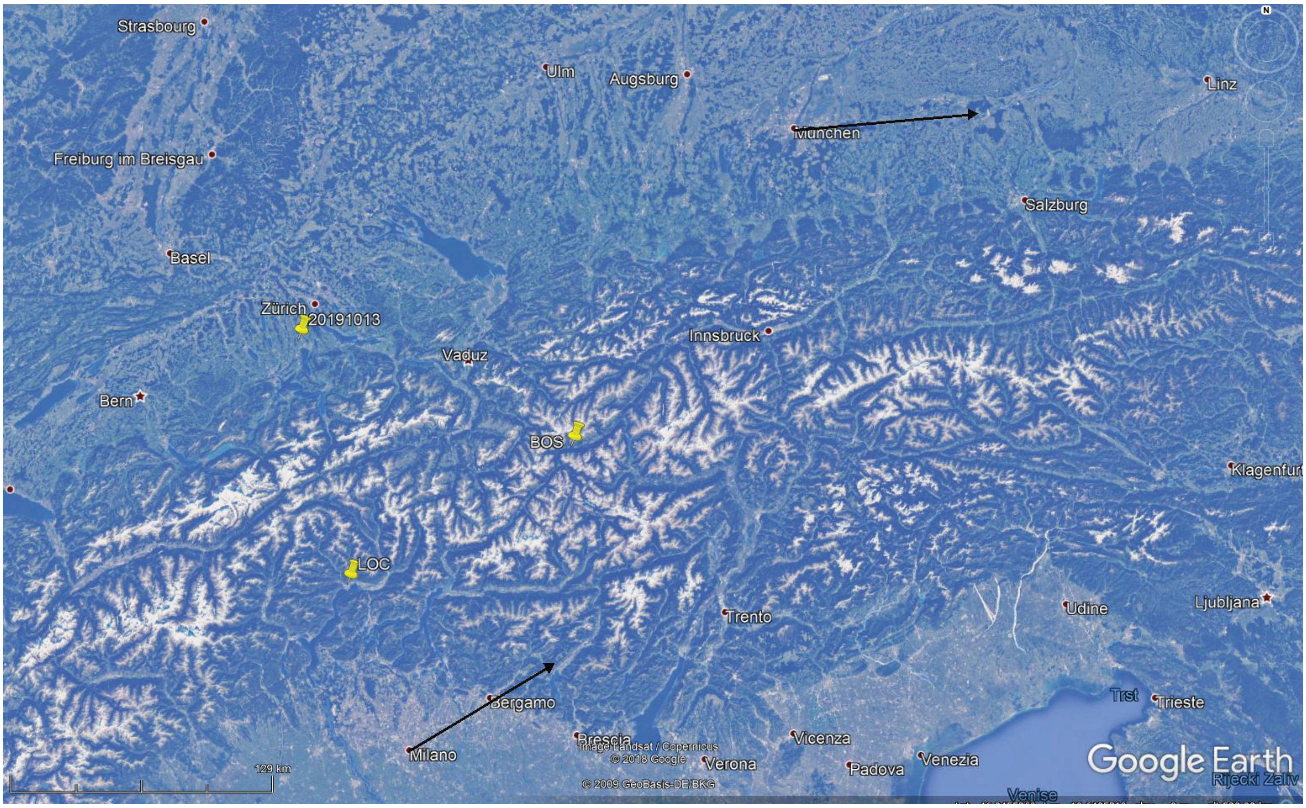

Figure – 3 Wind directions above Switzerland in the night of the bolide (GoogleEarth).

References

Elizabeth A. Silber and Peter G. Brown (2014). "Optical Observations of Meteors Generating Infrasound – I: Acoustic Signal Identification and Phenomenology". *Journal of Atmospheric and Solar-Terrestrial Physics*, **119**, 116–128. Arxiv 1407.6331, 37