Determining the position of the of thunder infrasound source using a large-aperture micro-barometer array

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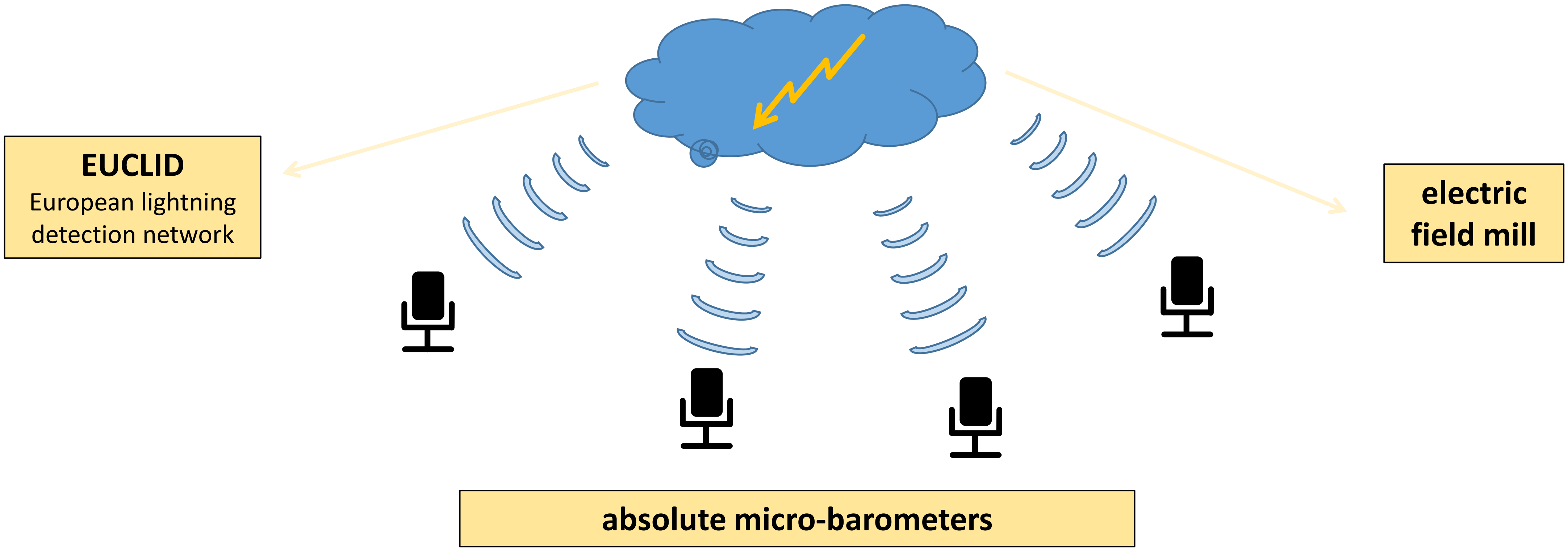
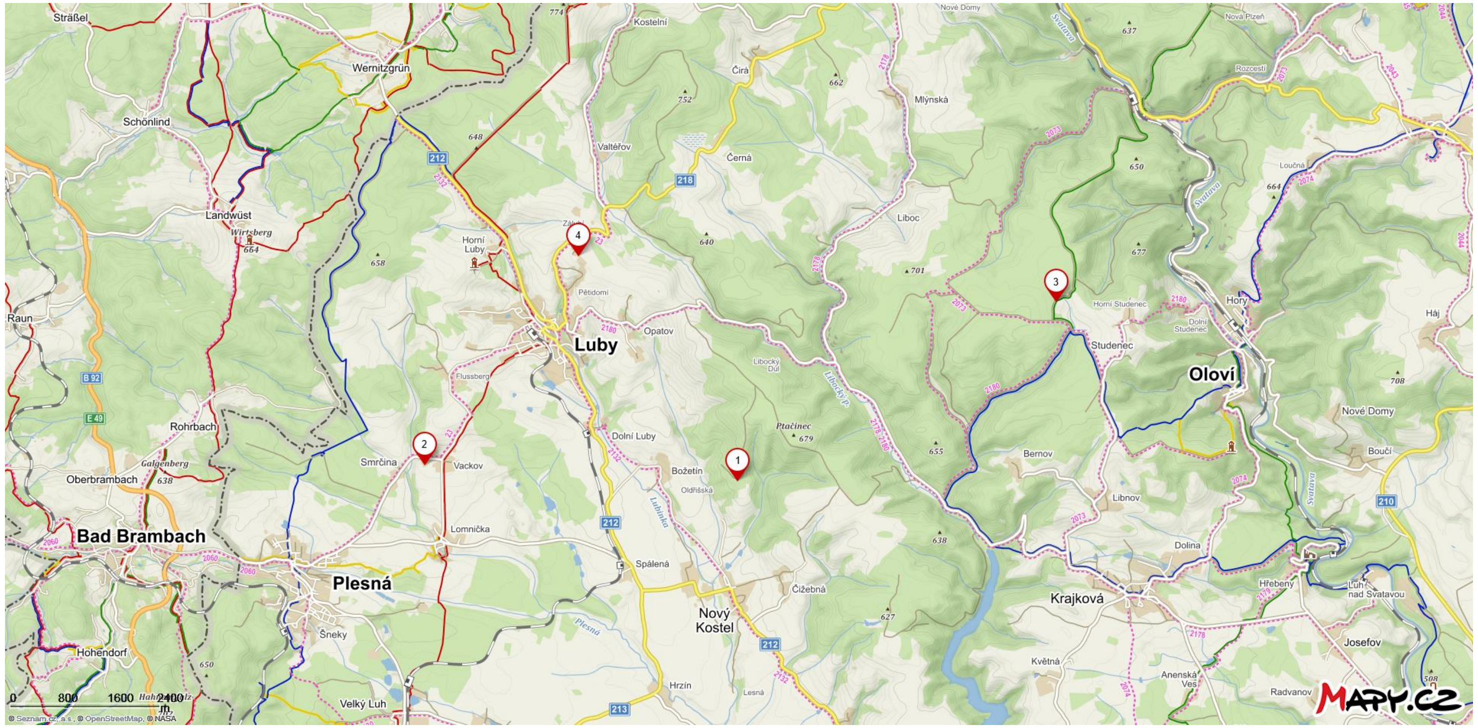


Large aperture array of absolute micro-barometers located in Western Czechia was used to register distinct infrasound pulses generated by thunderstorm activity.



Microbarographs are located in Western Czechia. The distances between four measuring sites are in the range of 4-10 km. Sampling frequency is 50 Hz.

	Location	Latitude	Longitude	Altitude
1	Nový Kostel (NKC)	50°13‘56“	12°26‘49“	564 m
2	Vackov (VAC)	50°14‘04“	12°22‘35“	530 m
3	Studenec (STC)	50°15‘28“	12°31‘06“	666 m
4	Luby (LBC)	50°15‘52“	12°24‘40“	638 m

Using data from the European lightning detection network and electric field monitor, a corresponding flash was assigned to each set of signals.

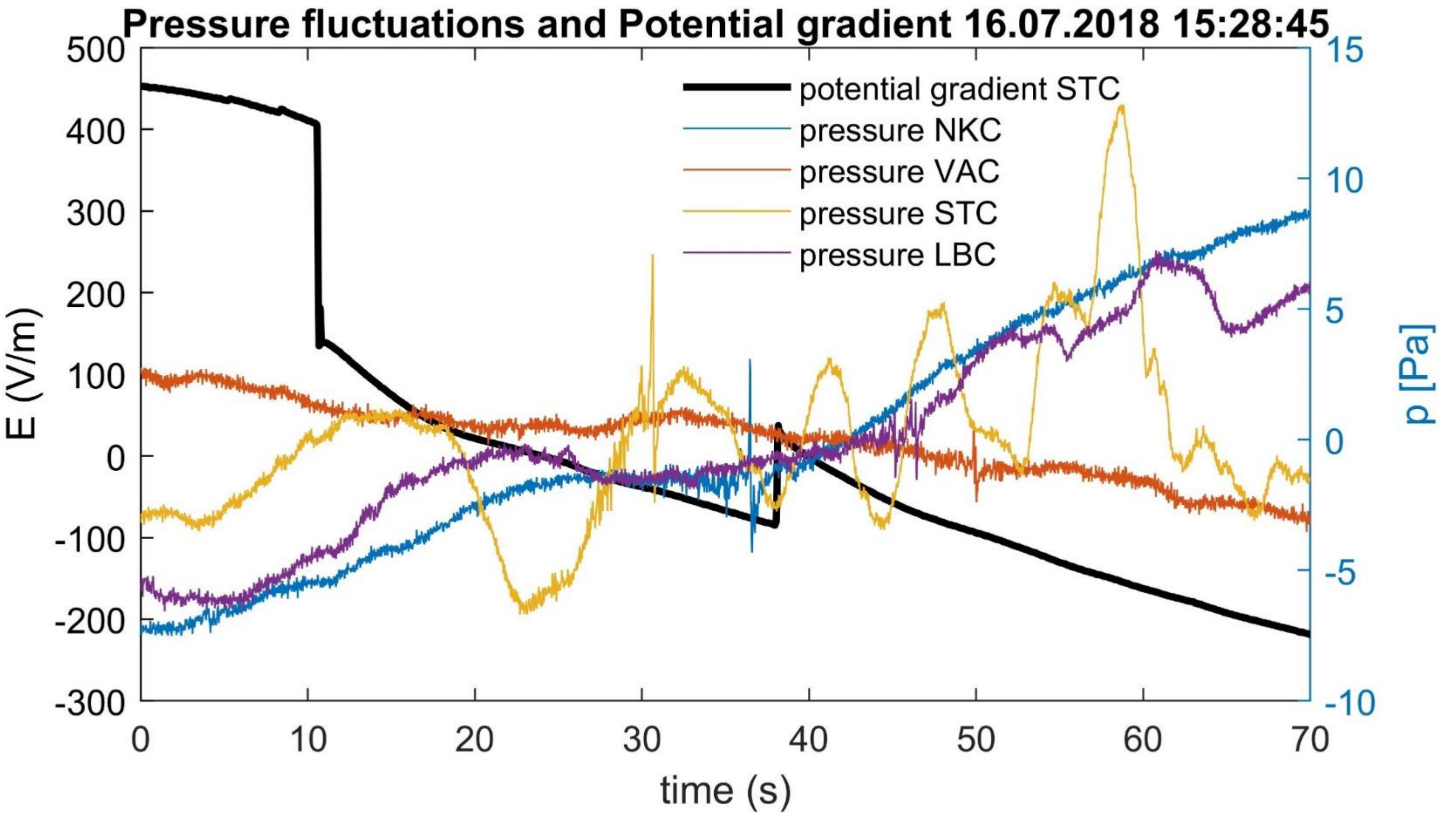


Fig. 1. Flash discharge causes a rapid change in electrical potential at t = 10 s. This event is followed by oscillations on pressure curves after several tens of seconds.

Only cases with a sufficient signal-to-noise ratio on all four micro-barometers were selected for further processing.

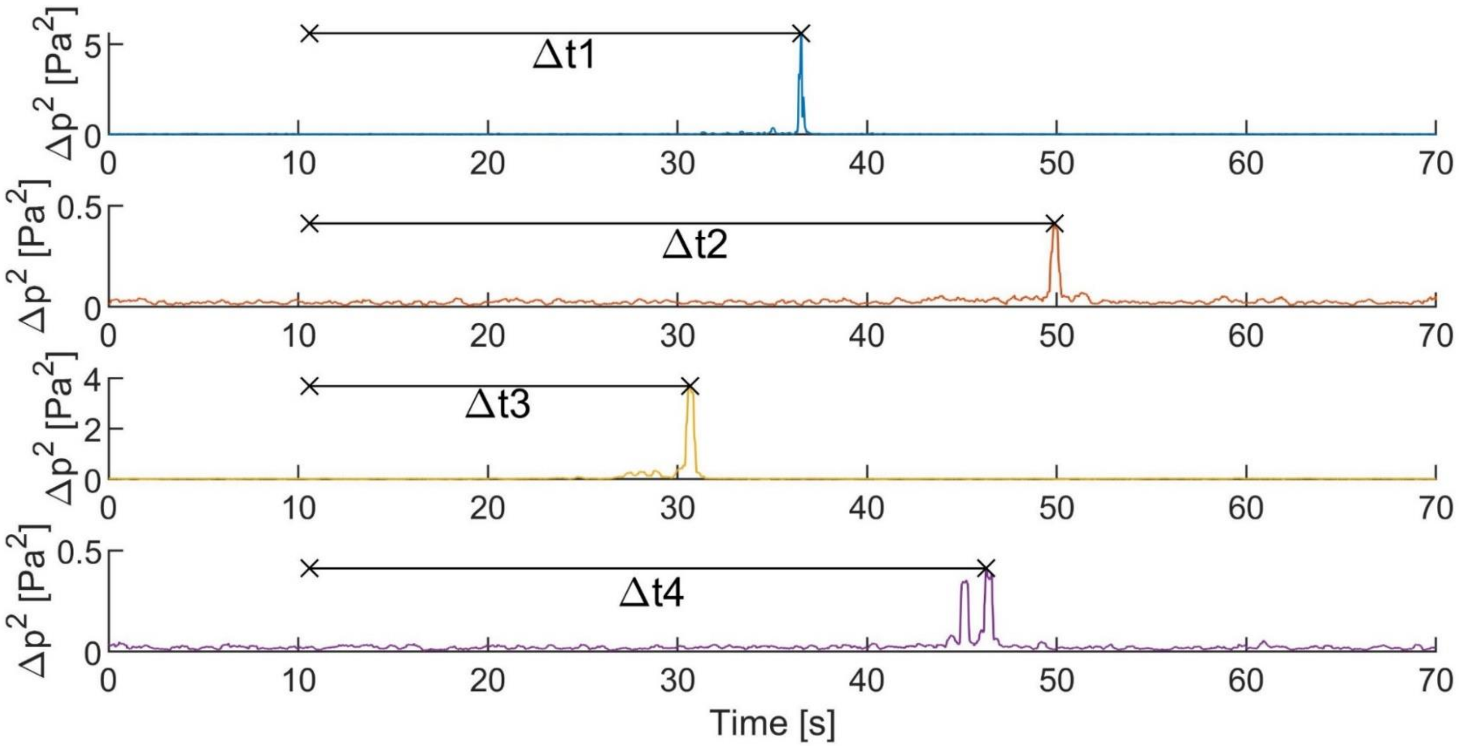


Fig. 2. The square of the pressure deviations (after 2Hz highpass filter). The maximum determines the time of arrival of the infrasonic pulse.

The position of the infrasound source was calculated from the time delay of signal arrival, assuming propagation of spherical waves from the source. The calculation includes changes in sound speed as a function of temperature variation with altitude. Wind speed value and its variance is also taken into account to estimate the uncertainties.

$$(x_n - x_0)^2 + (y_n - y_0)^2 + (z_n - z_0)^2 - \left(c_{avg\_n} \Delta t_n\right)^2 = 0 \qquad (1)$$

Where x_n, y_n and z_n are Cartesian coordinates of the n-th array element (microbarometer), x0, y0 and z0 are coordinates of the source, c_{avg_n} average speed of sound from the source to n-th sensor, and Δt_n are the measured time delays of the signal arrival to the n-th sensor. The relations (1) represent a set of four equations for three unknown coordinates x_n, y_n and z_n that are solved by the weighted least square method.

The calculated vertical positions of the infrasound sources are located at the altitudes between 3-6 km. The horizontal position for most of the selected cases corresponds to the horizontal position of the flash specified by lightning detection network.

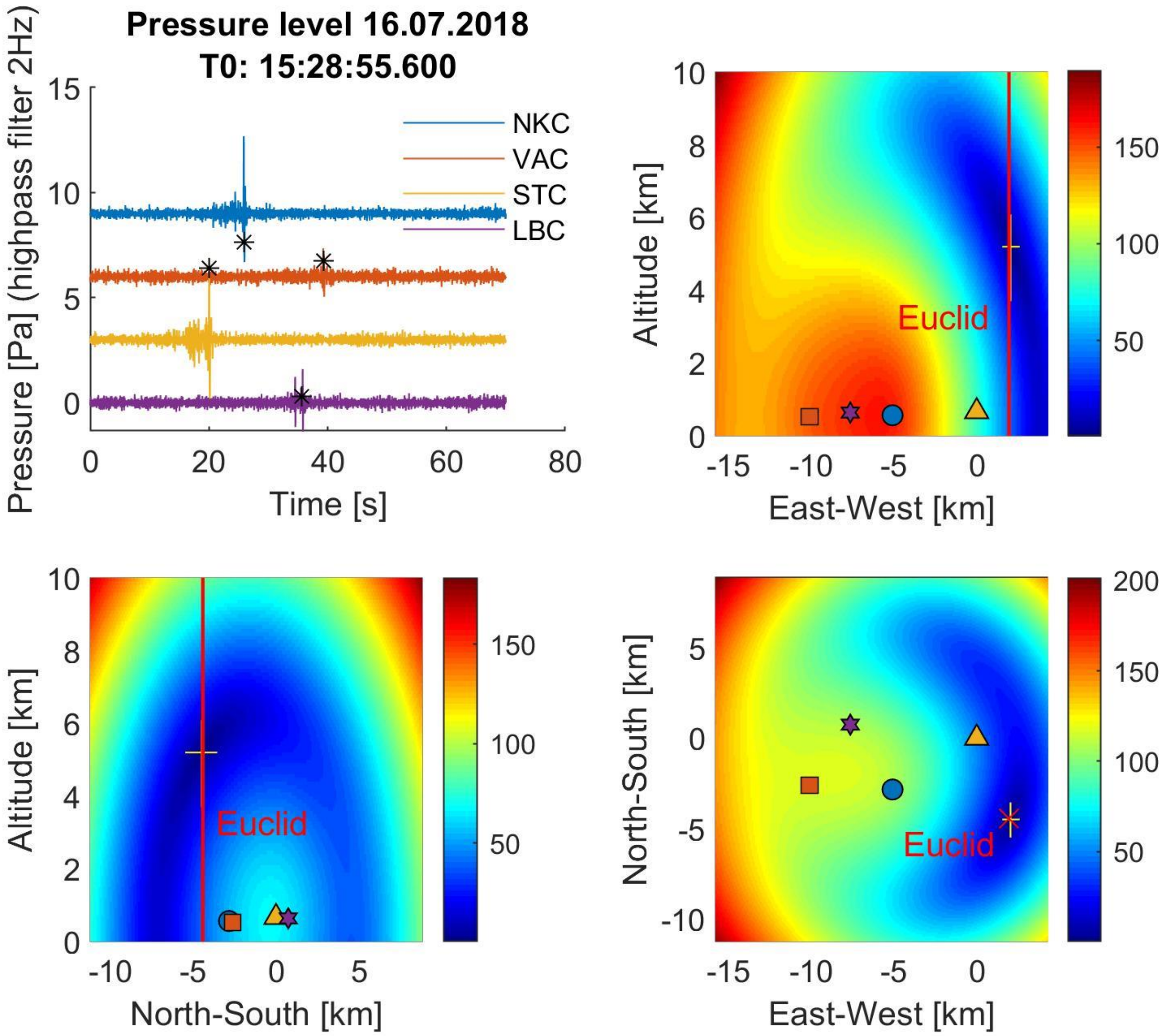


Fig. 3. The position of the infrasound source (with a tolerance of 3σ) is indicated by a yellow cross. The position of the flash detected from the EUCLID is indicated by red.

Summary

Large aperture array of absolute micro-barometers located in Western Czechia was used to register distinct infrasound pulses generated by thunderstorm activity. Data from three periods of storm activity on 23-24.5.2018 and 16.7.2018 were examined. Only cases with a sufficient signal-to-noise ratio on all four micro-barometers were selected for further processing, a total of 106 cases were selected. Using data from the European lightning detection network and electric field monitor, a corresponding flash was assigned to each set of signals. The position of the infrasound source was calculated from the time delay of signal arrival, assuming propagation of spherical waves from the source. The calculation includes changes in sound speed as a function of temperature variation with altitude. Wind speed value and its variance is also taken into account to estimate the uncertainties. The calculated vertical positions of the infrasound sources are located at the altitudes between 3-6 km. The horizontal position for most of the selected cases corresponds to the horizontal position of the flash specified by lightning detection network.

The recorded infrasound signals followed only intracloud (IC) or mixed (multiple IC+CG) lightning strokes. Thus, the sources of the analyzed infrasound events are most likely IC discharges.

References

[1] Chum, J., G. Diendorfer, T. Šindelářová , J. Baše, and F. Hruška (2013), Infrasound pulses from lightning and electrostatic field changes: Observation and discussion, J. Geophys. Res. Atmos., 118, 10,653–10,664, doi:10.1002/jgrd.50805

[2] Arechiga, R., M. Stock, R. Thomas, H. Erives, W. Rison, H. Edens, and J. Lapierre (2014), Location and analysis of acoustic infrasound pulses in lightning, *Geophys. Res. Lett.*, *41*, doi:10.1002/2014GL060375.