EGU2020-446
Session AS1.21

Identification and tracking of storms via infrasound detections

Marcell Pásztor[1,2], Csenge Czanik[2], István Bondár[2]

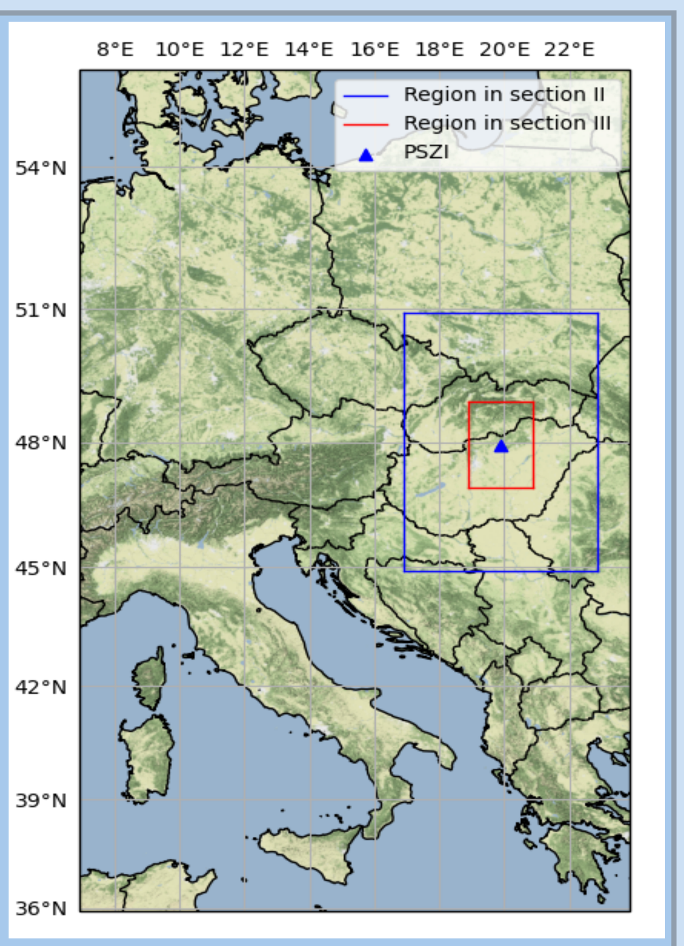
Contact author: pasztorms@gmail.com

1Eötvös Loránd University, Faculty of Sciences, Department of Geophysics and Space Sciences, Hungary
2Geodetic and Geophysical Institute, Research Centre for Astronomy and Earth Sciences

PROJECT FINANCED FROM THE NRDI FUND

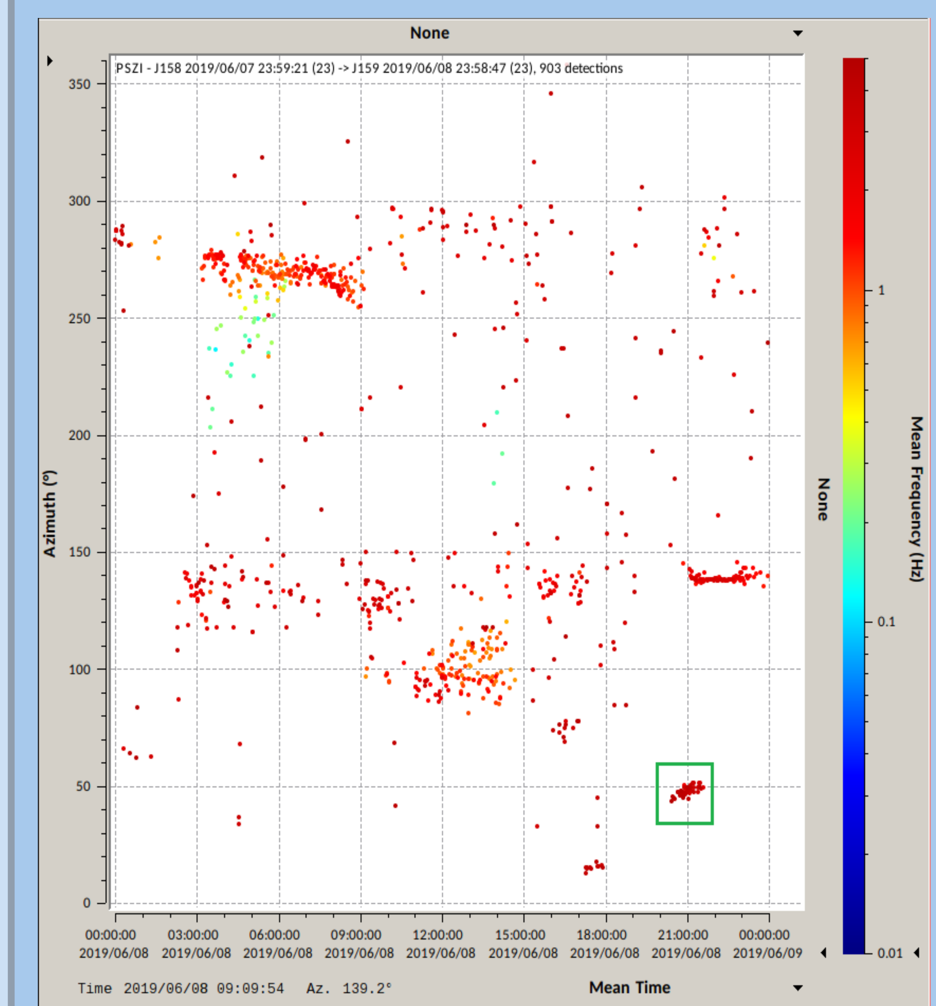
I. Introduction

One of the various sources of infrasound signals are lightnings in thunderstorms. These moving sources can be detected and tracked at infrasound arrays. We correlate lightning data from Blitzortung with the infrasound detections from the Hungarian infrasound station at Piszkes-teto (PSZI) that has been collecting data since May, 2017. The objective of this study is to identify and track storms and to test the station's capability to detect thunderstorm signals. We investigate what conditions affect these detections; in what directions, distances and accuracy can we track storms. In close storms where the distance is less than 50 kilometers we try to associate infrasound detections with lightnings.



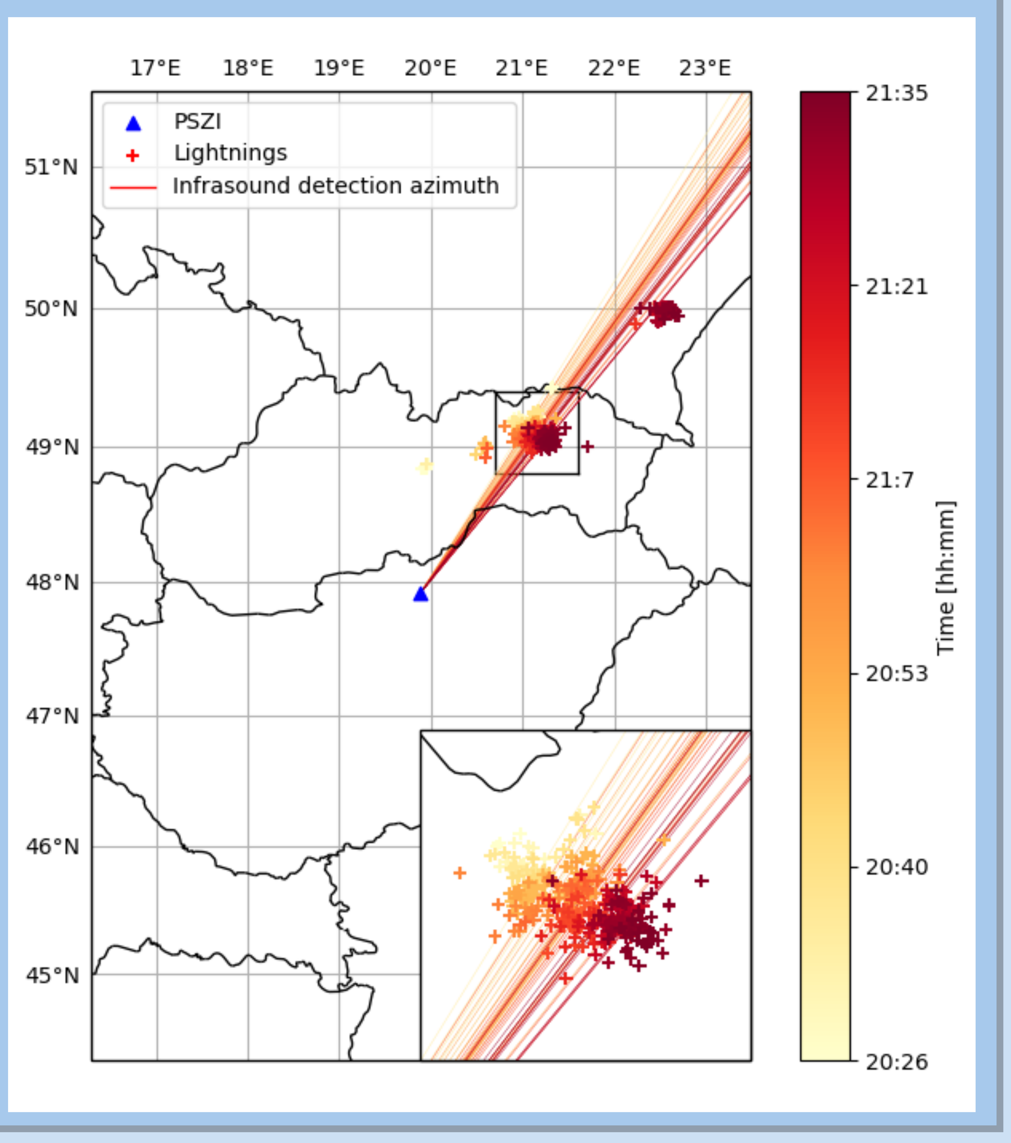
II. Searching for storms

We looked for storms in the summer of 2019 using DIVA and EM detections from Blitzortung database. Due to the fact that in this region in this period of the year eastern detections are dominant, storms were found approximately between 0° and 190° azimuths. Due to other source mechanisms in the case of distant storms it is impossible to associate lightnings with infrasound detections. However, they can nicely be tracked by correlating EM and infrasound detections.



The figure on the left shows PSZI infrasound detections visualized by DTK-DIVA (part of the CTBTO NDC-in-a-box software package) on 06. 08. 2019. The points are color-coded by frequency. The green box in the bottom right marks the detections that are connected to a storm.

The figure on the right shows an example of a distant storm on 06. 08. 2019. (Same storm as above) The lightnings are marked with crosses and the azimuths are represented with lines with the given angles. Both are color-coded by time. The box on the bottom right gives a closer look on the correlation between the EM and infrasound detections.



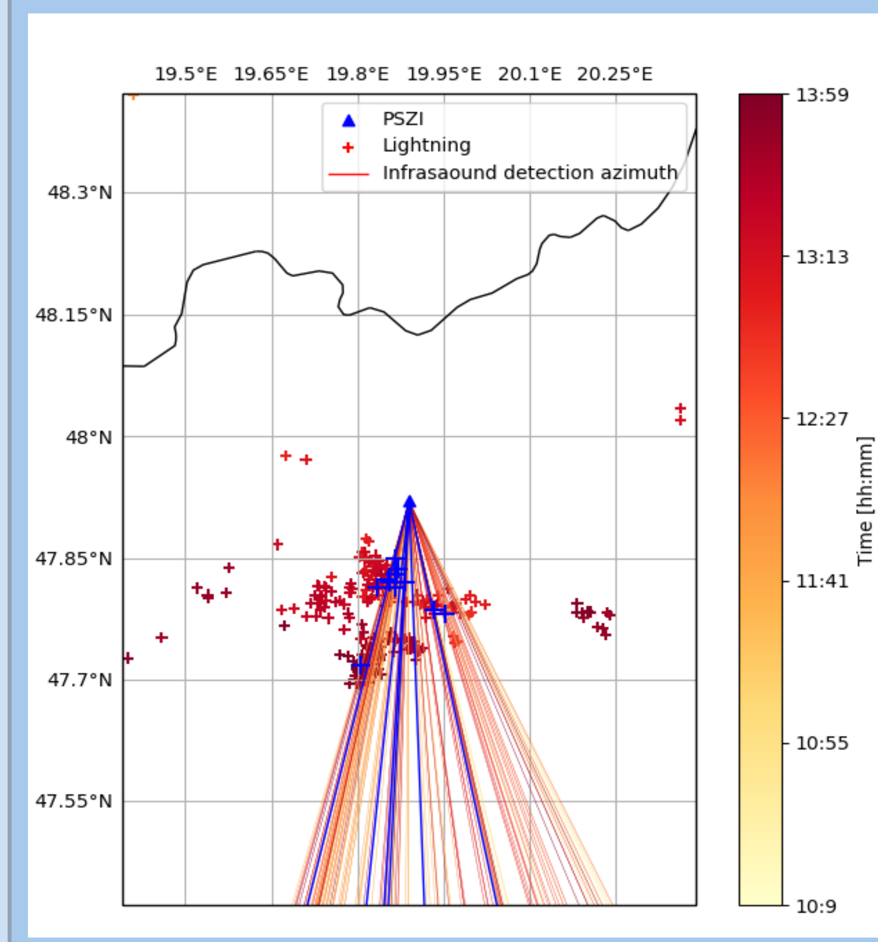
III. Associating infrasound with EM detections

Assuming direct wave propagation the detection time of the infrasound can be expressed with the following terms:

$$t_{infra} = t_{EM} + \frac{d}{c} + \Delta t$$

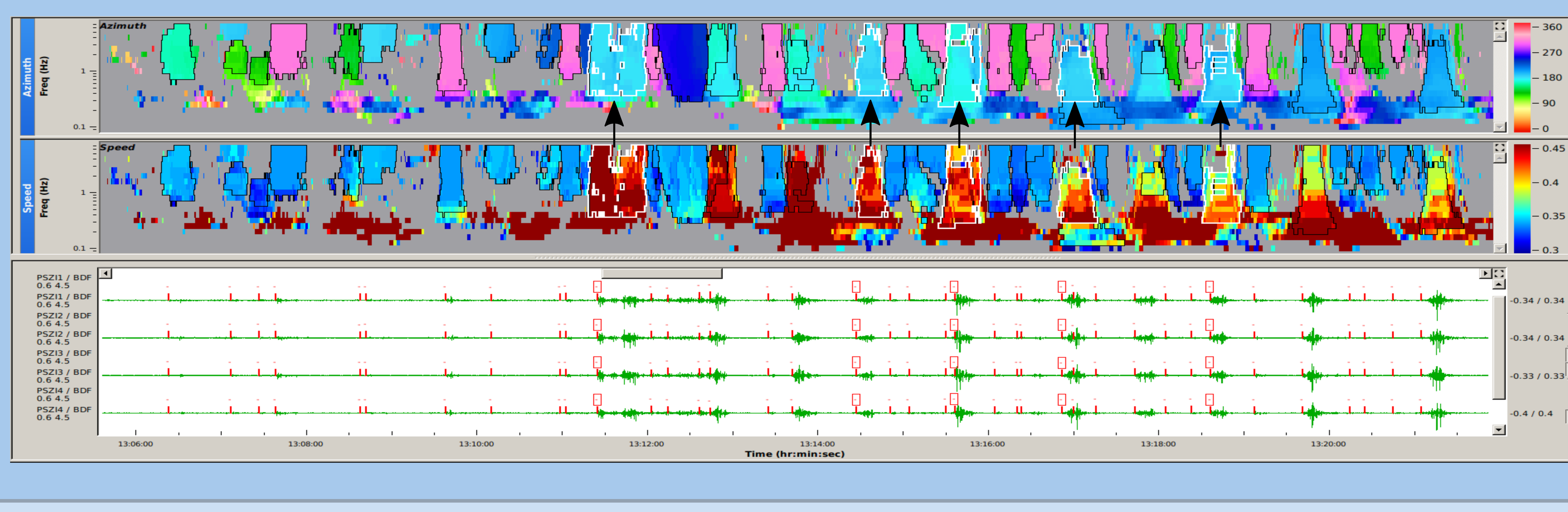
where t_{EM} is the origin time of the lightning, d is the distance between the source and the receiver, c is the speed of sound and Δt is a threshold for association. After rearrangement we looked for events where the following relation is true:

$$t_{infra} - \left(t_{EM} + \frac{d}{c}\right) < \Delta t$$



The figure on the left shows an example of a storm close to PSZI on 30. 08. 2019. Lightnings are marked with crosses and infrasound detection azimuths are represented with lines. Both are color-coded by time. Those infrasound detections that are associated with EM detections are colored with blue. Note that one infrasound detection might belong to multiple EM detections due to uncertainty.

The figure below shows the PSZI infrasound detections between 13:00 and 13:30 on 30. 08. 2019 visualized by DTKG-PMCC (Cansi, 1995). Those detections that have been associated with EM detections are marked with arrows. On the pressure versus time a bandpass filter has been applied.



IV. Calculating altitudes

Still assuming direct wave propagation an estimation can be given to the altitudes of lightnings. Firstly the effective sound velocity was calculated with the following equation using the average of the temperature, wind speed and wind direction for the duration of each infrasound detection. The meteorological data was measured in-situ.

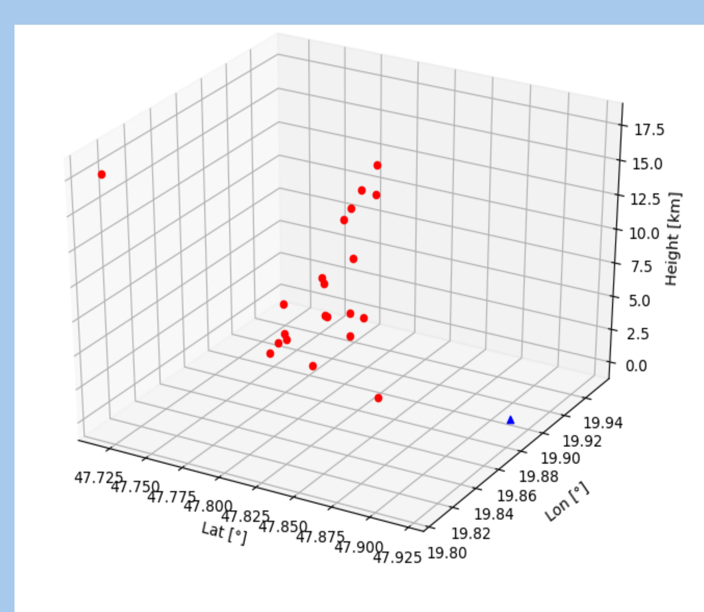
$$c_{eff} = \sqrt{\gamma_g RT} + \mathbf{n} \cdot \mathbf{u}$$

After that we calculated the elevation angle (α) of the arriving wave on the station using the definition of apparent velocity.

$$cos(\alpha) = \frac{c_{eff}}{c_{app}}$$

Elevation [o]	Distance from PSZI [km]	Altitude [km]
9.28	7.99	1.31
41.18	11.19	9.79
41.18	11.41	9.98
41.18	9.94	8.69
41.18	11.14	9.74
38.19	12.33	9.70
35.86	14.65	10.59
35.86	14.31	10.34
35.86	15.30	11.06
35.86	14.66	10.60
35.86	16.16	11.69
34.77	11.86	8.24
34.77	9.47	6.58
34.77	10.15	7.05
28.34	12.69	6.84
28.34	12.74	6.87
28.34	10.49	5.66
28.34	12.49	6.73
28.34	11.96	6.45
28.34	10.07	5.43
37.24	23.33	17.73

The table on the left contains the elevations, distances from PSZI and altitudes for the lightning from section II and the figure below visualizes the same events in 3D. The calculated altitudes are reasonable for intracloud charges.



References

Cansi,Y.(1995)An automated seismic event processing for detection and location: The P.M.C.C. method, Geophys. Res. Lett., 22, 1021–1024.

Acknowledgment

This work was supported by the Hungarian National Research, Development and Innovation Fund (K128152) and by the bilateral agreement between the Czech and Hungarian Academy of Sciences, NKM2018-10 ("Infrasound studies in Central Europe, PIs: István Bondár, Tereza Sindelarova")

Special thanks to Tereza Sindelarova and Jaroslav Chum for their advice.