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INFP

On the infrasound array monitoring in Romania: reprocessing of the data recorded by the national infrasound network

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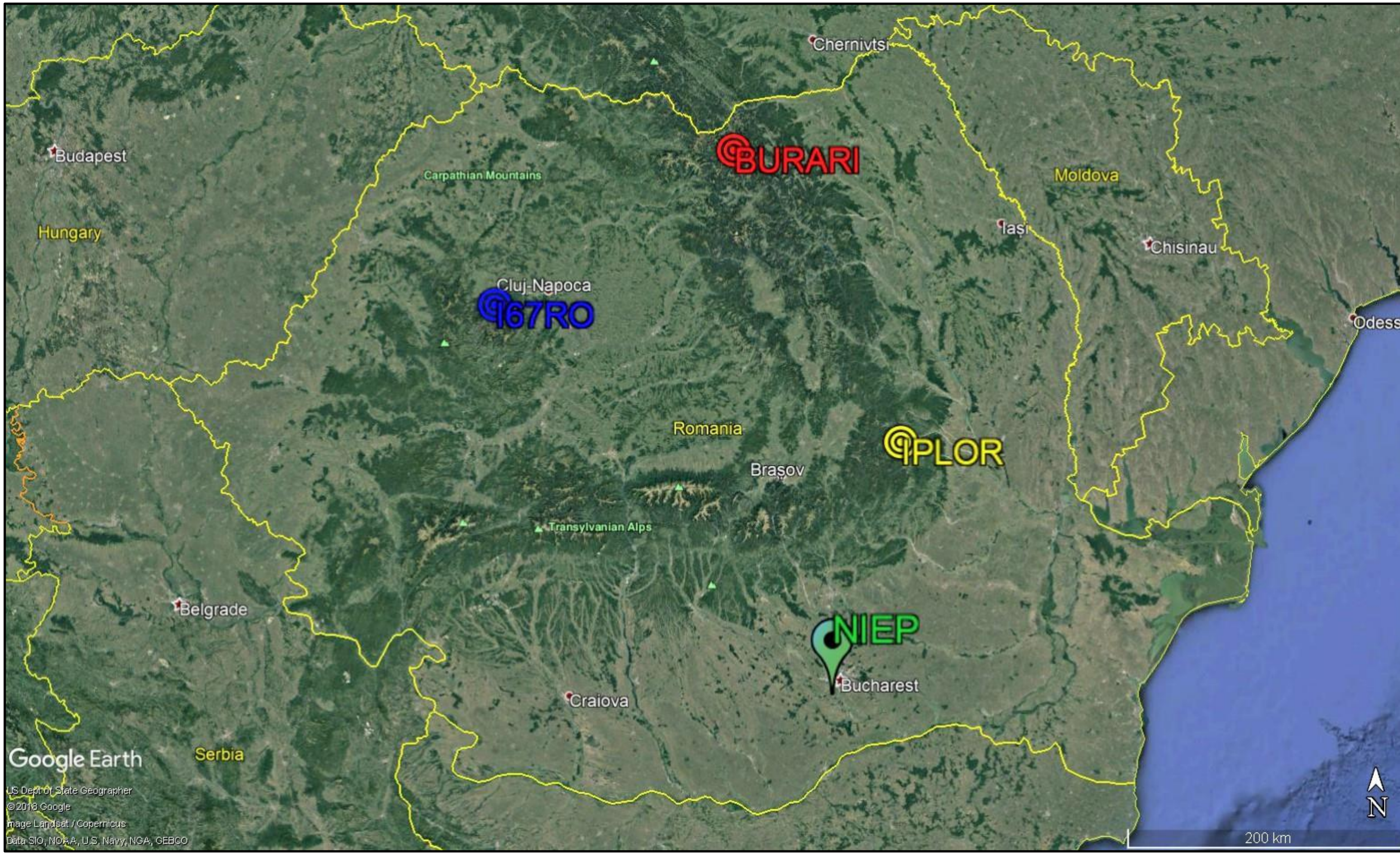
Overview

- We present the results of the reprocessing a 10-year archive of waveform data recorded with the Romanian infrasound network, by using PMCC signal detector
- Starting with 2009, three infrasound stations have been deployed on the Romanian territory by the National Institute for Earth Physics (NIEP): IPLOR, BURARI (under cooperation with Air Force Technical Application Center AFTAC (USA), and I67RO (within a collaboration project with PTS/CTBTO)
- Infrasound data are processed and analysed on routinely basis at NIEP by using a duo of infrasound detection-oriented software – DTK-GPMCC and DTK-DIVA – packaged into CTBTO NDC-in-a-Box
- Since October 2019, a new implementation of PMCC algorithm is available at NIEP, enabling the characterization of the coherent infrasound field in log-spaced frequency with one-third octave bands from 0.1 to 6 Hz.
- The array monitoring performance resulted after the data reprocessing is investigated

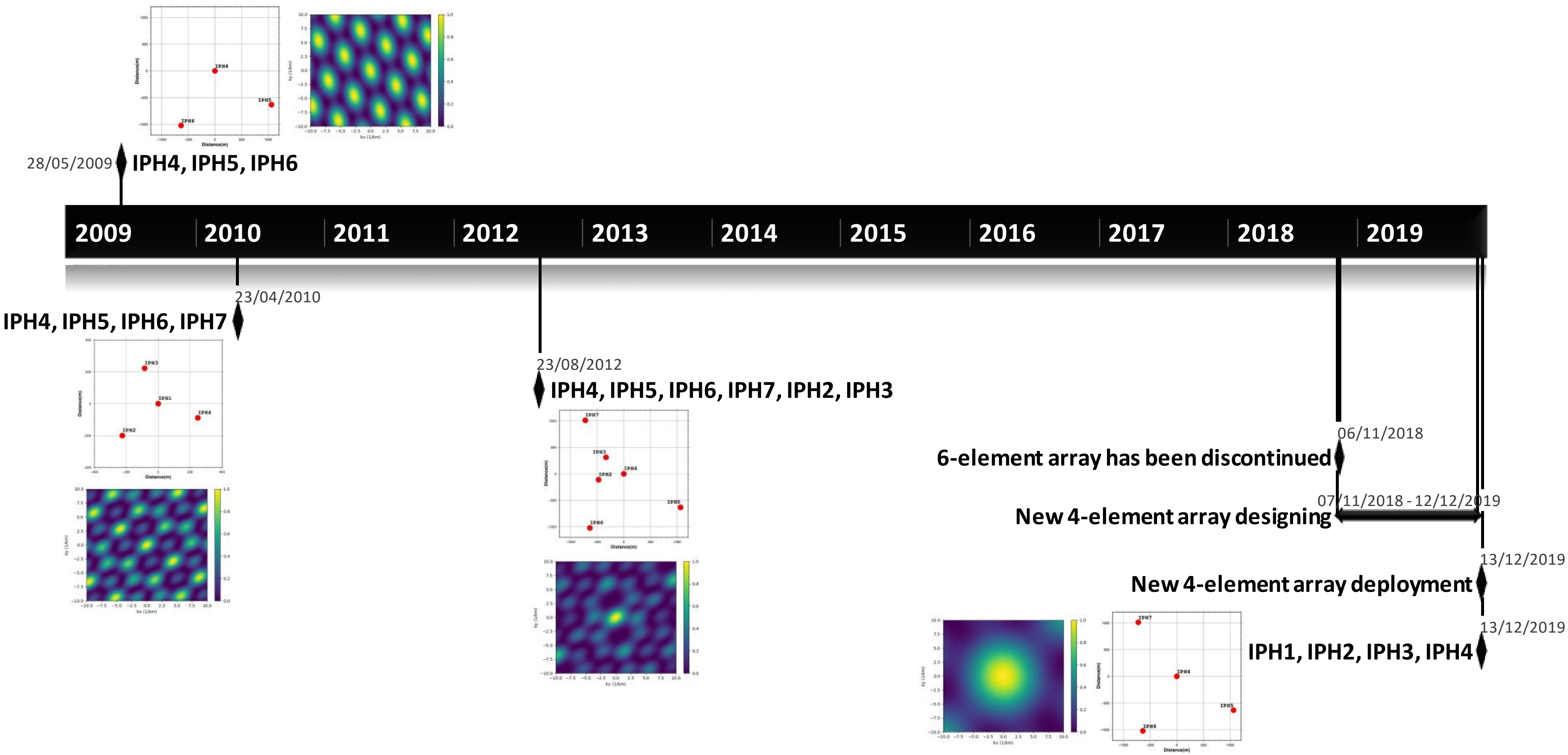
Infrasound stations in Romania



Code	Location	No. of elements	Aperture (km)	Operation period	Status
IPLOR	Plostina, Vrancea County	6	2.5	May 2009 – November 2018	Permanent
		4	0.6	December 2019 – Now	
BURARI	Benea, Suceava County	4	1.2	July 2016 – September 2019	Temporary
		6	0.7	September 2019 – Now	Permanent
I67RO	Marisel, Cluj County	4	0.9	September 2016 – October 2018	Temporary

IPLOR infrasound array

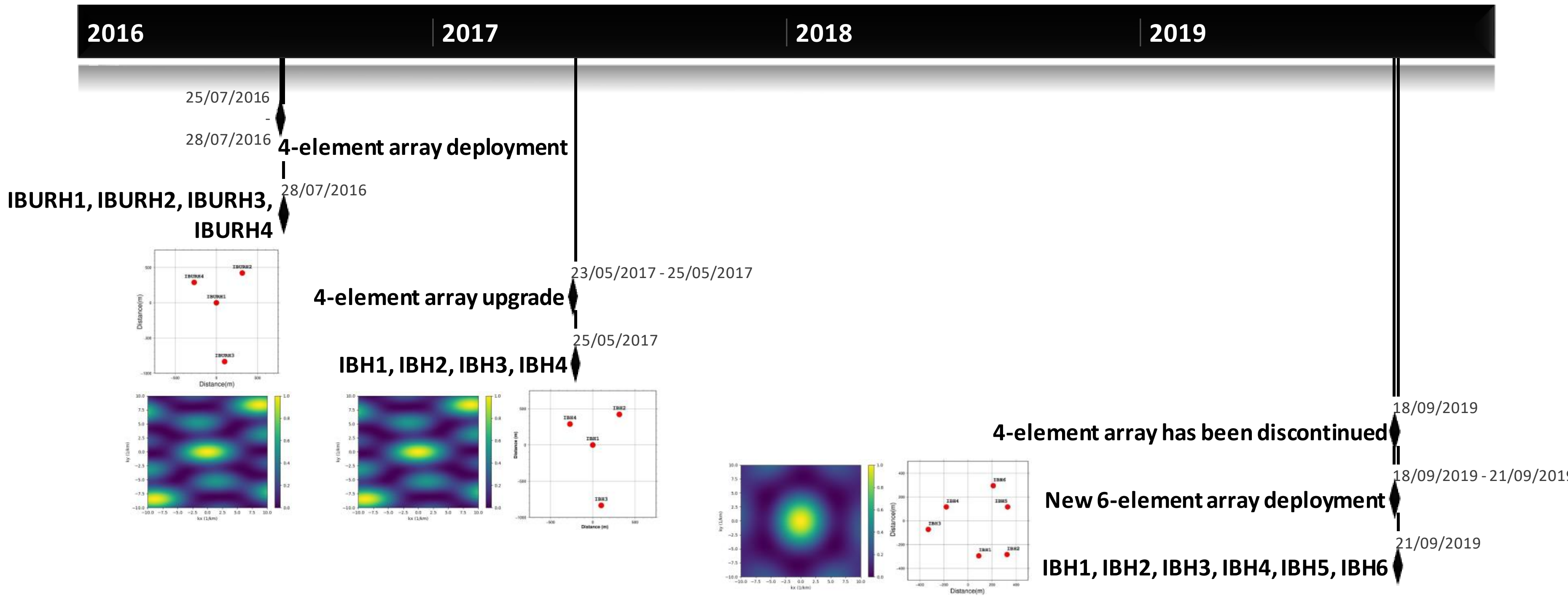
Deployed by NIEP



- Chaparral Physics model 25 microbarometers
- Quanterra Q330 digitizers
- WNRS: rosette pipe array design
- Collocated with seismic array

BURARI infrasound research array

Deployed under a joint effort of AFTAC (USA) and NIEP



- Chaparral Physics model 21 microbarometers (until September 2019)
- Hyperion 5113 microbarometers (since September 2019)
- Digitizers: Reftek RT 130 (until May 2017) & Quanterra Q330HR (since May 2017)
- WNRS: porous hoses, 32-air inlets star WNRS with flexible hoses (to be installed in 2020)
- Collocated with seismic array

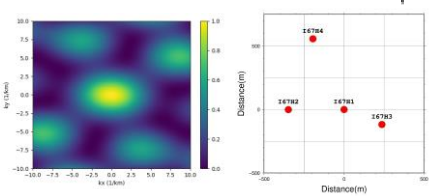
I67RO PTS portable infrasound array

Deployed within a collaboration project between NIEP and PTS/CTBTO

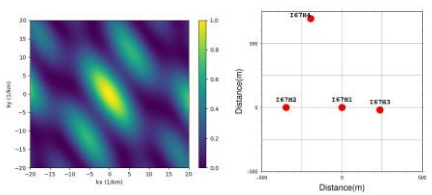
2016 | 2017 | 2018

26/09/2016
-
28/09/2016 **4-element array deployment**

28/09/2016
I67H1, I67H2, I67H3, I67H4



15/06/2017
Relocation of I67H1 element



17/10/2018
4-element array removal from the site

- MB2005 (CEA/DAM) microbarometers
- Reftek 130 RT digitizers
- WNRS: porous hoses

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Array data processing & analysis

NDC-in-a-Box Virtual Machine (Centos release 6.10)

Two detection-oriented software **– DTK-GPMCC 6.3.0 and DTK-DIVA 3.4.3 –** developed by CEA/DASE and packaged into the **CTBTO NDC-in-a-box** – are routinely used at NIEP:

Data Processing

Run DTK-PMCC in automatic mode from command line (Python scripts)

- detection lists (one-day bulletins)
- results (one-day NetCDF4 files)

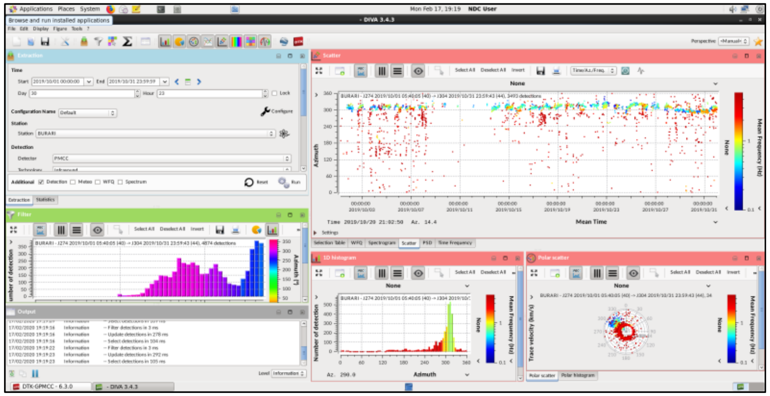
Results Analysis

DTK-GPMCC 6.3.0
visualize the detections in results file

- Interactively display/check results

DTK-DIVA3.4.3
visualize the detections in bulletin files

- Identify and characterize sources of coherent noise/typical sources (station detection background): microbaroms, industrial noise, craft activity etc.
- Identify detections of interest, i.e., special infrasound source/occasionally detected at station: accidental explosions, exploding meteorites, volcanic eruptions etc.
- Recognize station detection patterns (diurnal, weekly, seasonal)



Array data processing & analysis

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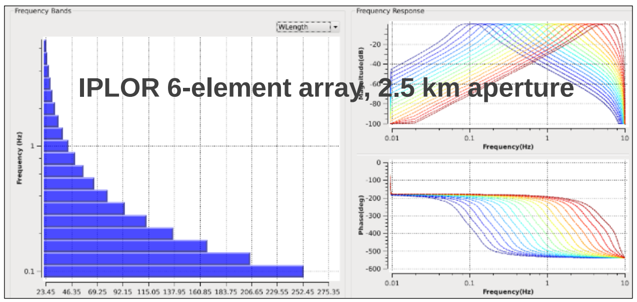
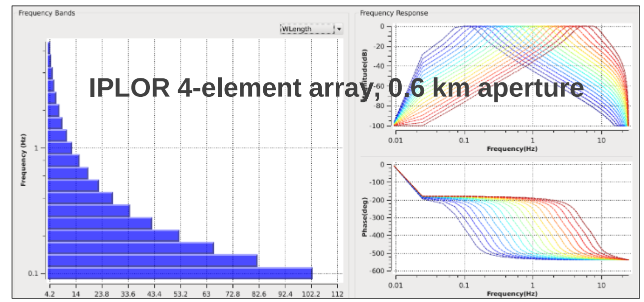
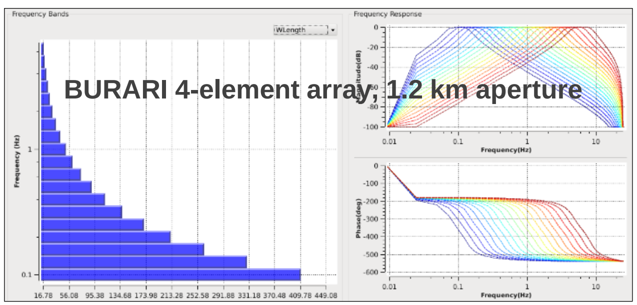
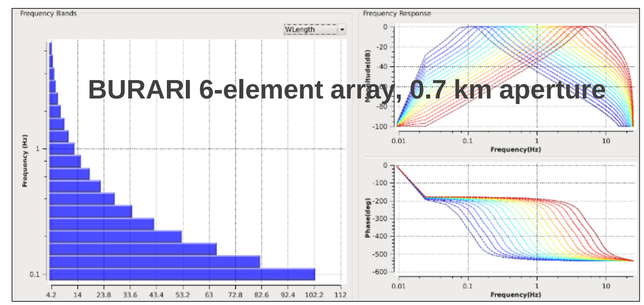
Automatic configuration of the PMCC detector

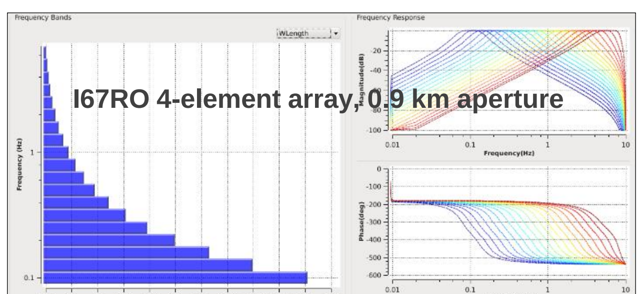
- Data recorded by the infrasound stations deployed in Romania have been reprocessed using the ***third octave band configuration***
- 19 frequency bands between 0.1 Hz (Fmin) and 6.0 Hz (Fmax)
- Bandwidths vary logarithmically with the frequency
- Frequency schema is dependent on station: time window lengths vary proportionally with aperture





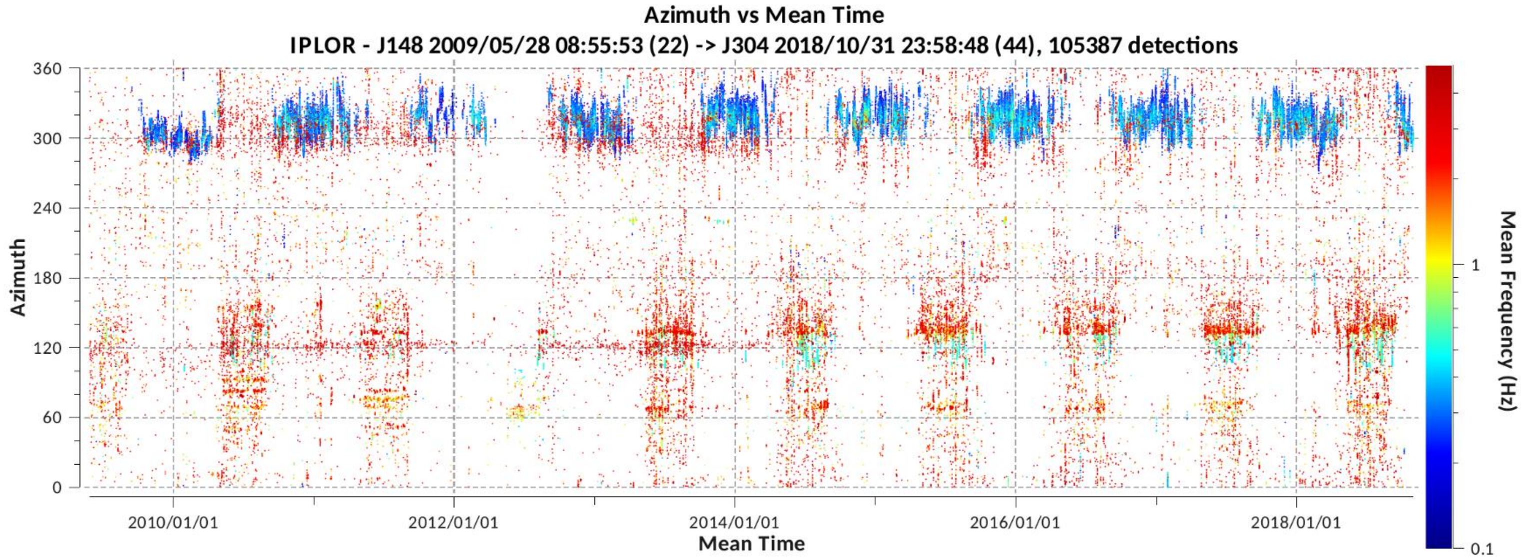


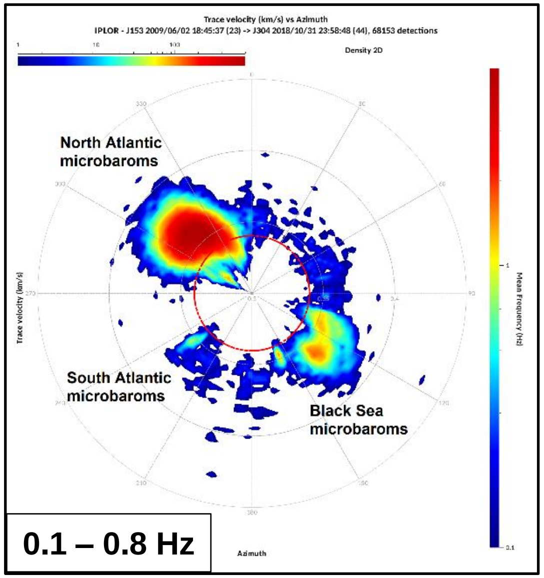


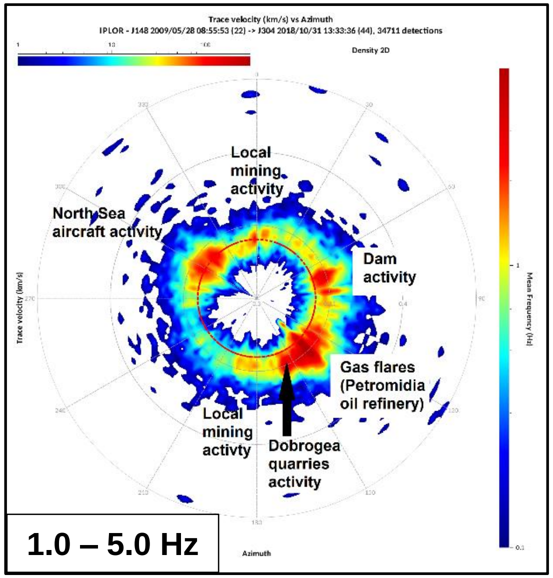


Array data processing & analysis

Results – IPLOR 6-element array

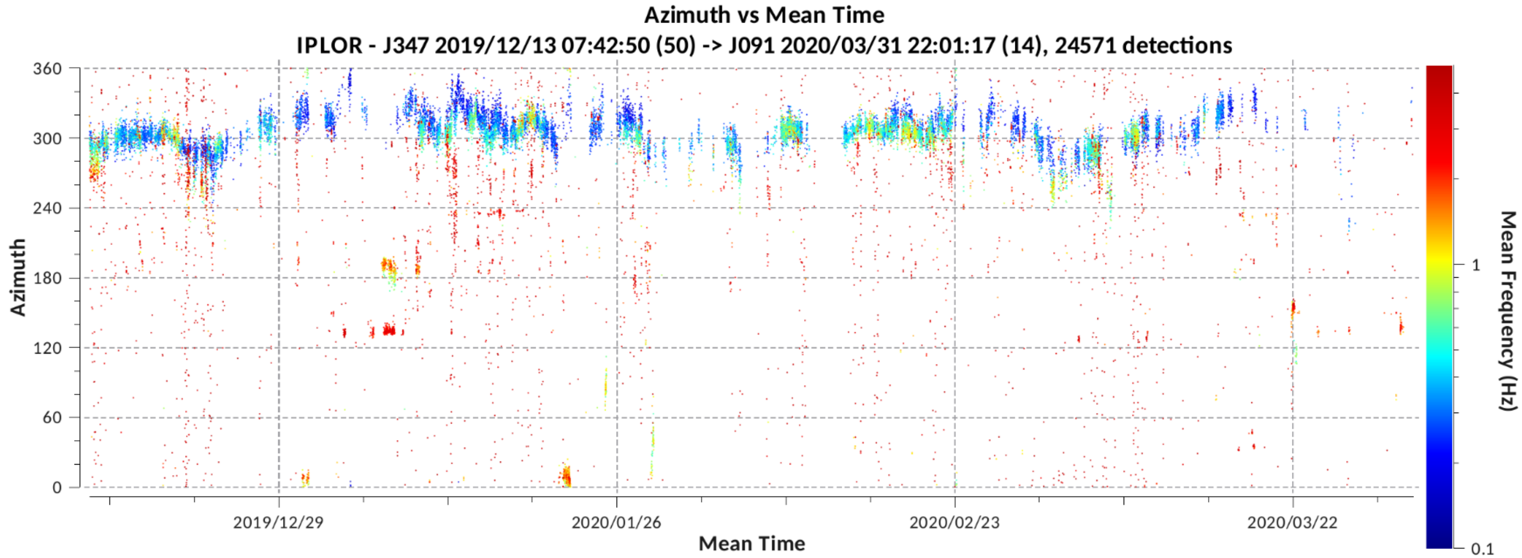


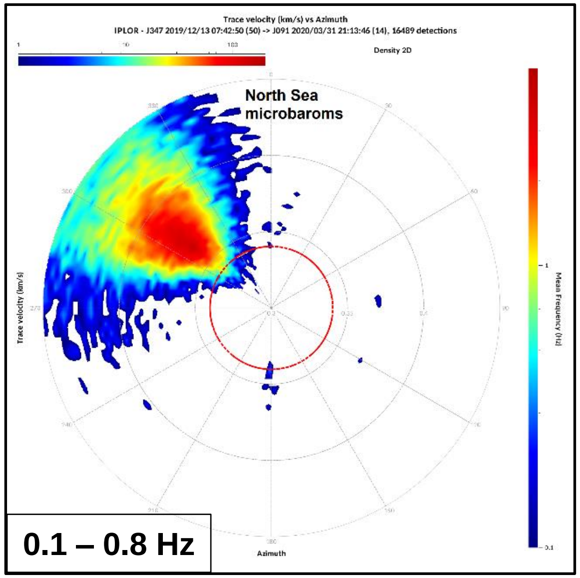


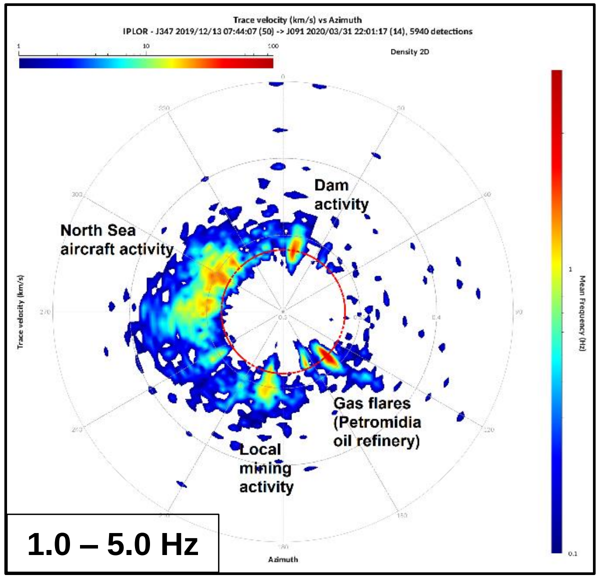


Array data processing & analysis

Results – IPLOR 4-element array

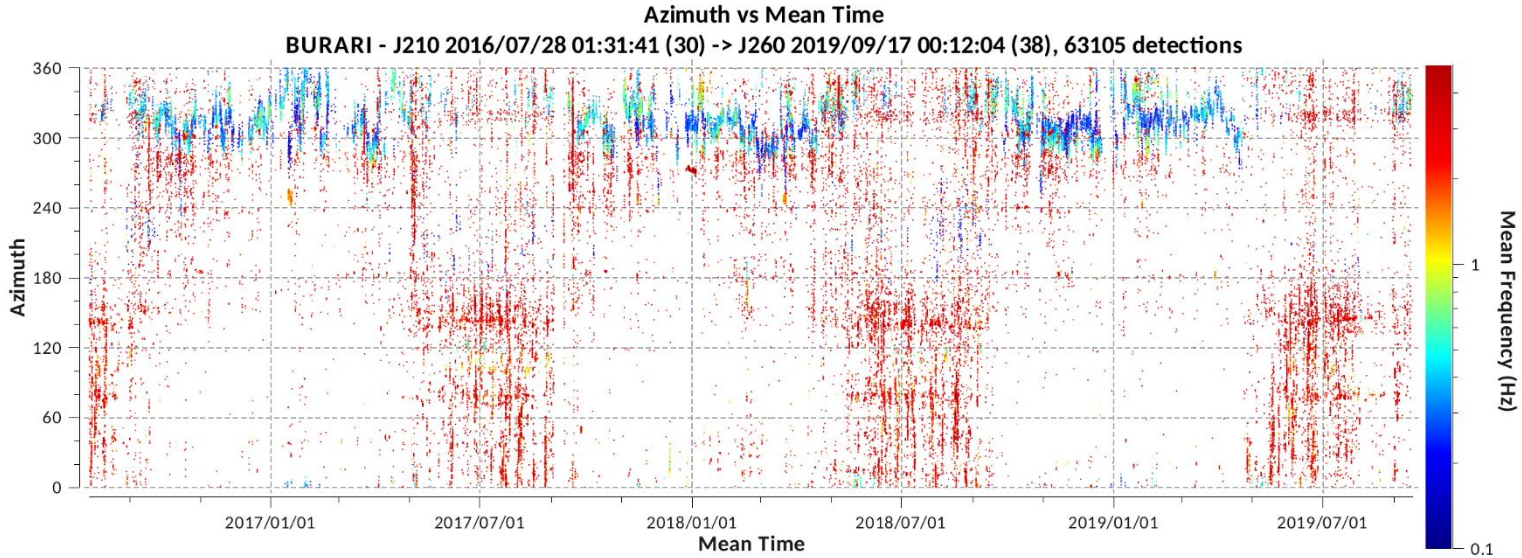


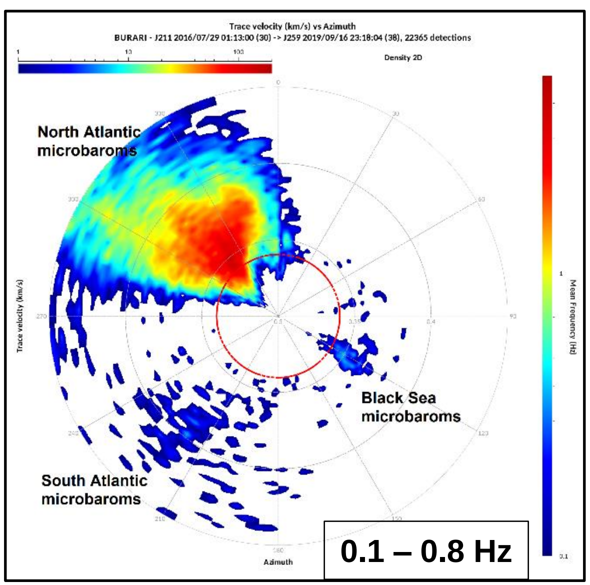


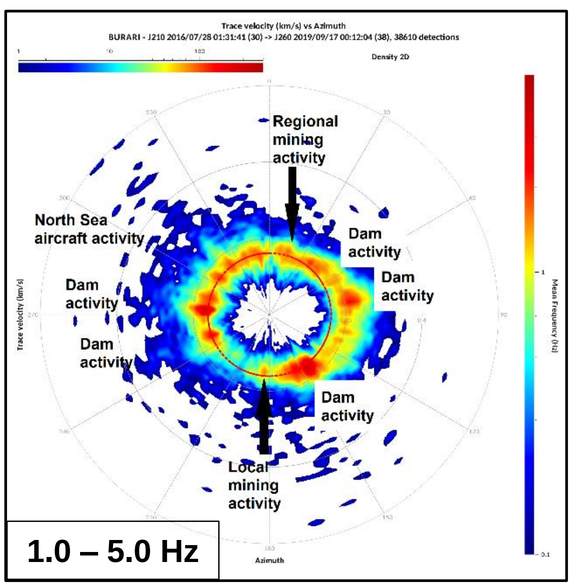


Array data processing & analysis

Results – BURARI 4-element array

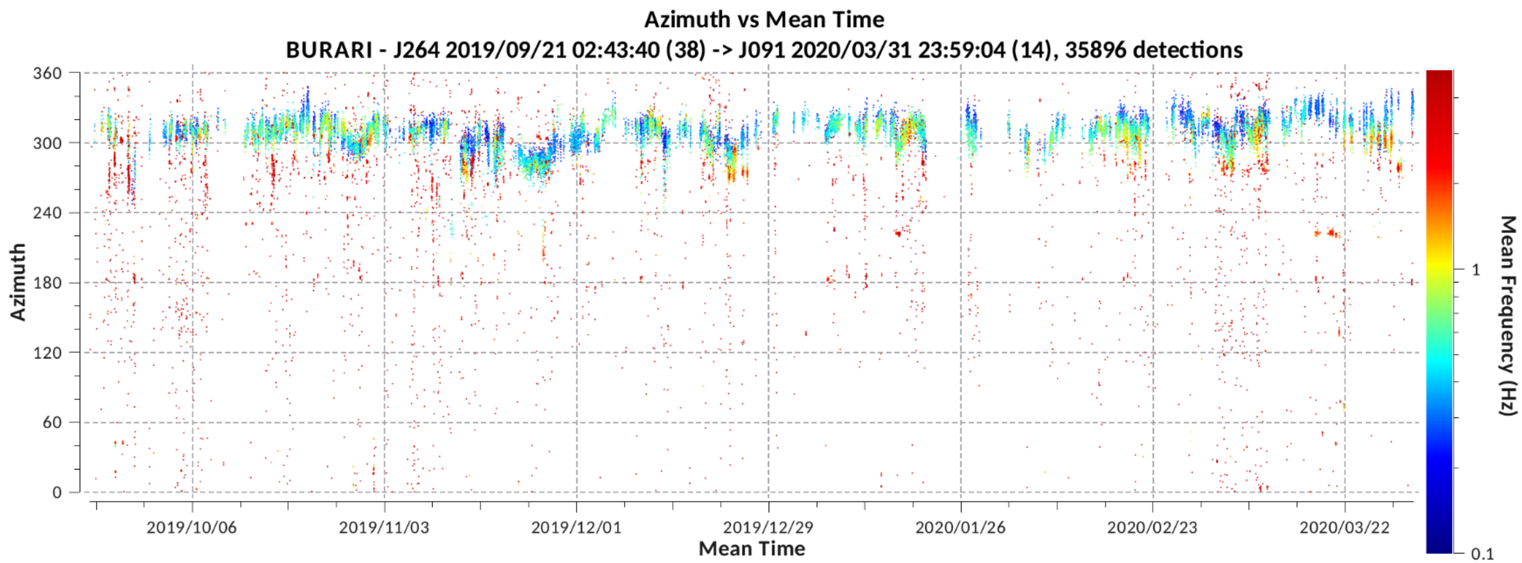


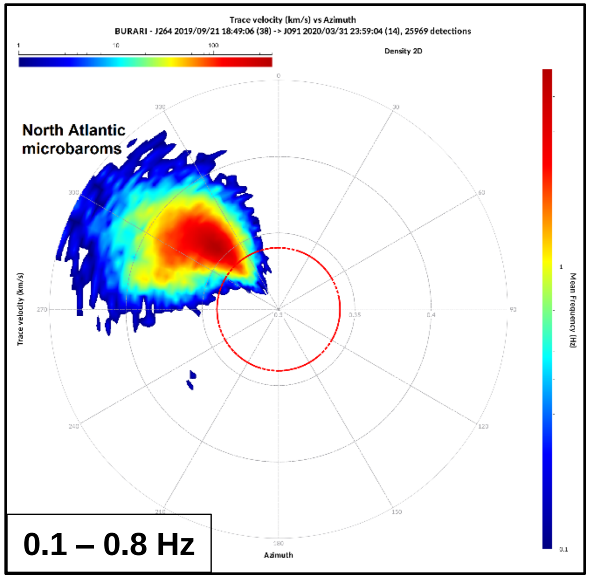


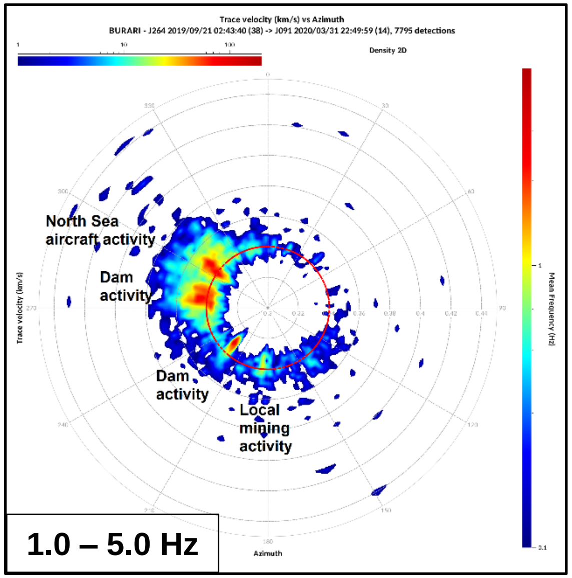


Array data processing & analysis

Results – BURARI 6-element array

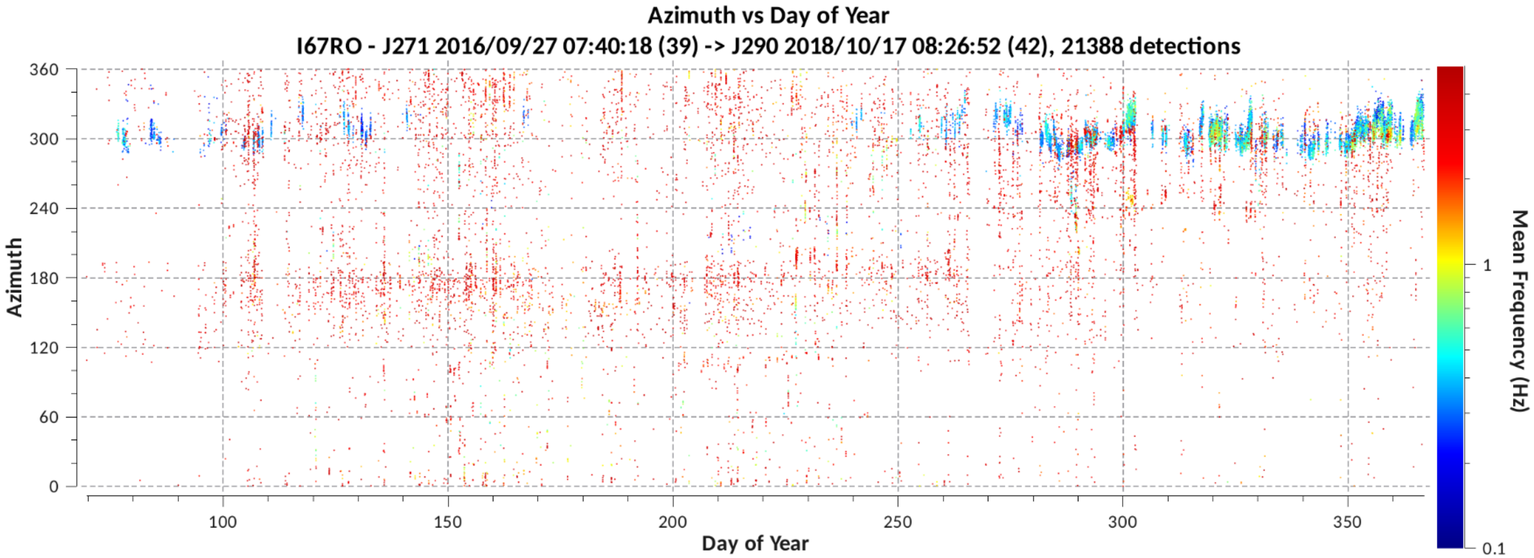


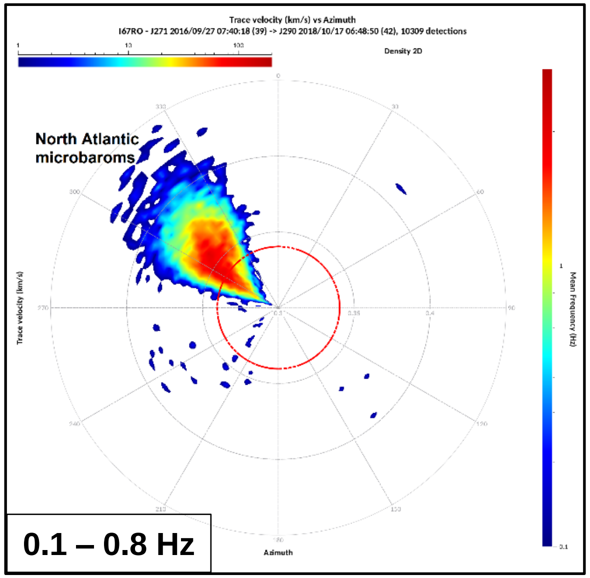


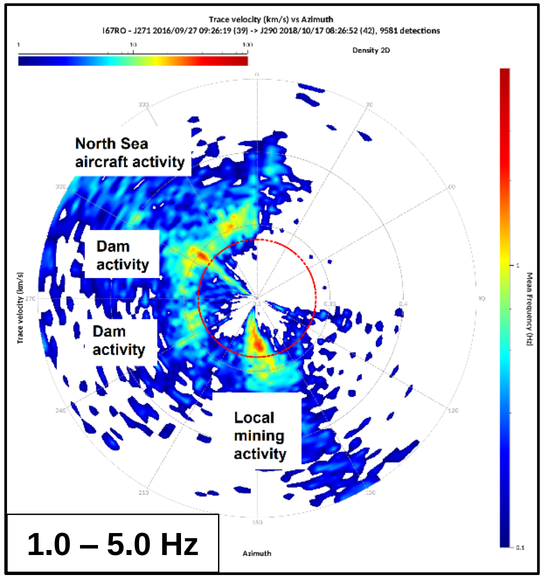


Array data processing & analysis

Results – I67RO 4-element array

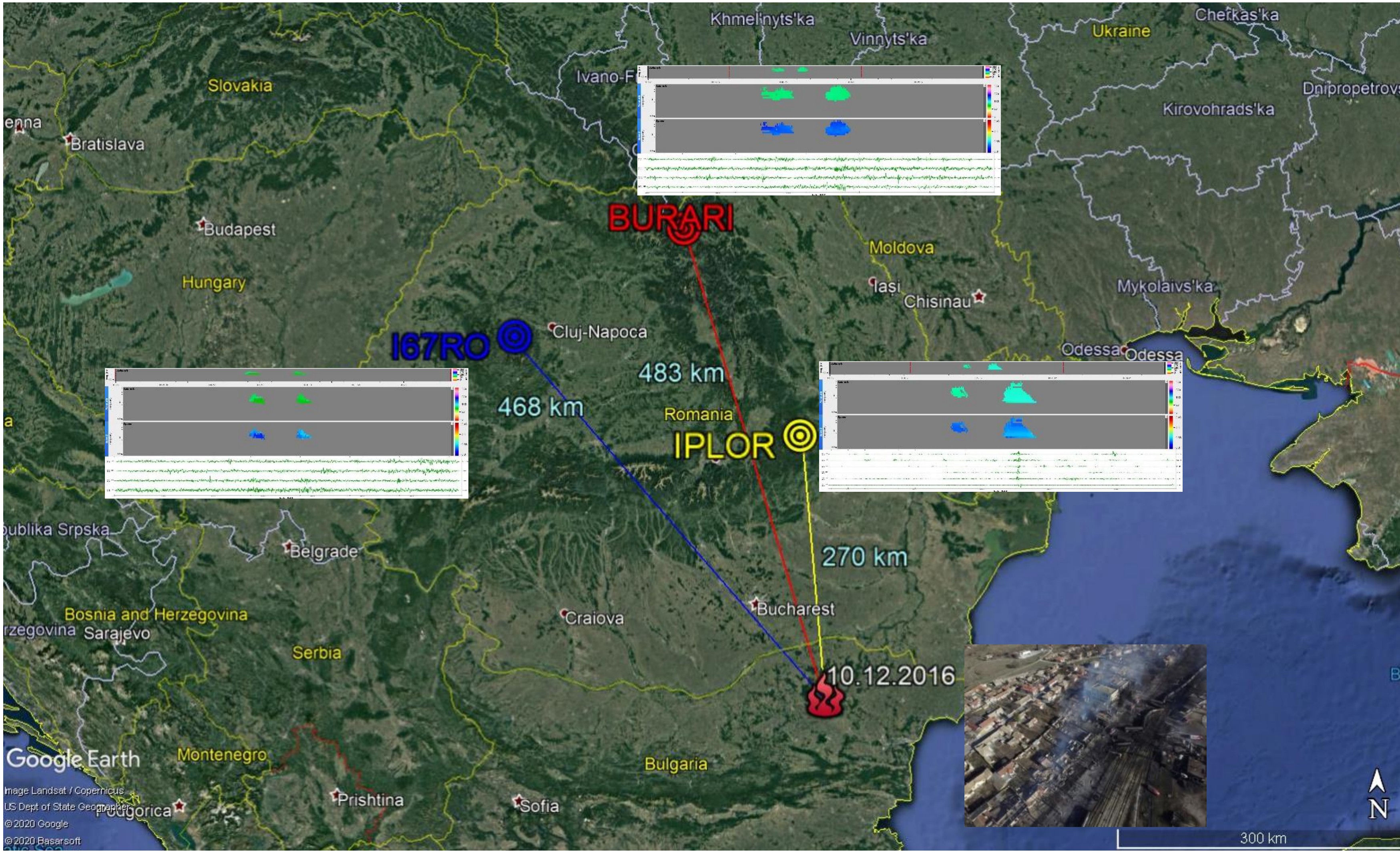






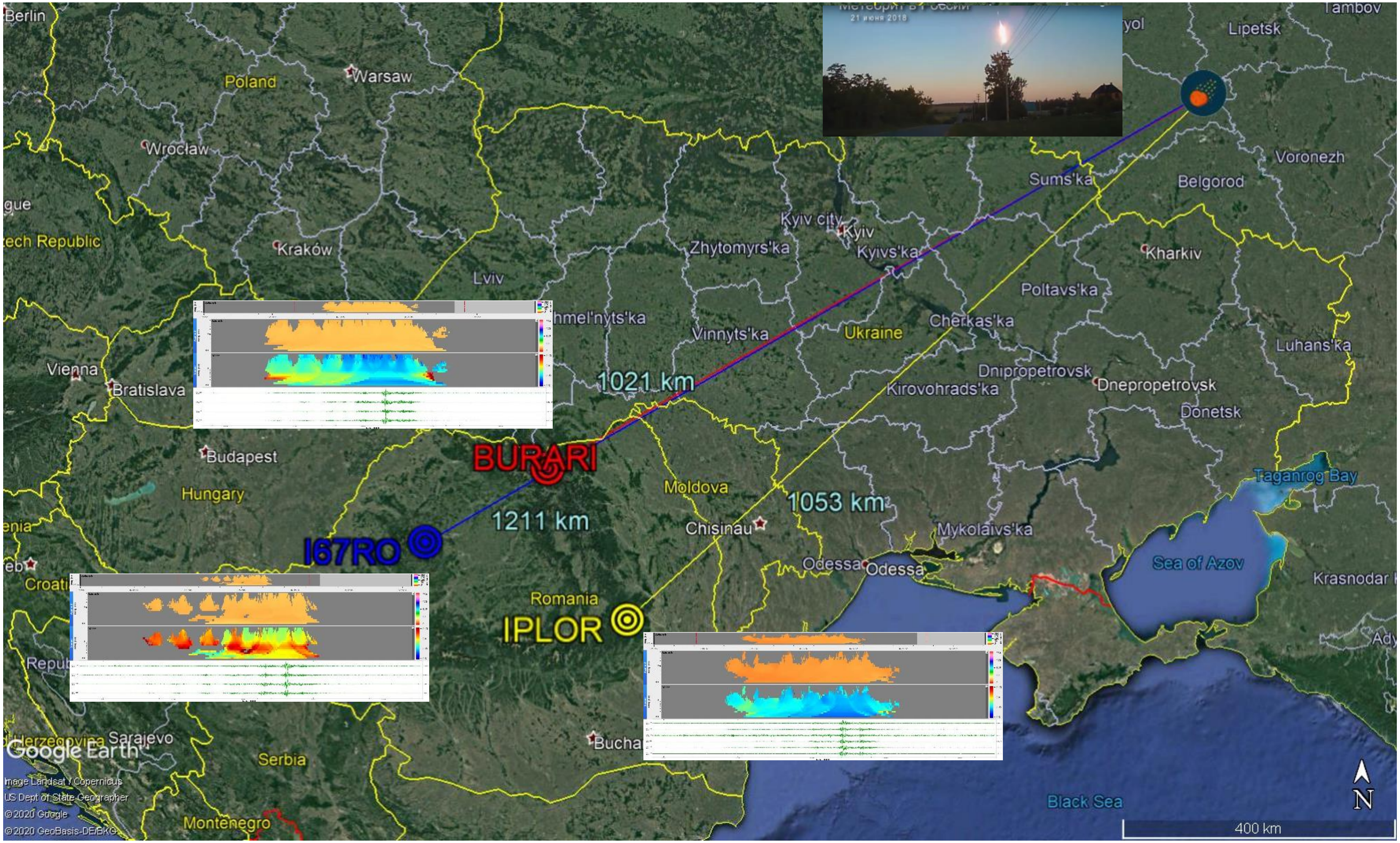
Infrasound sources observed

Hitrino (Bulgaria) gas tank transporter train explosion / 10.12.2016



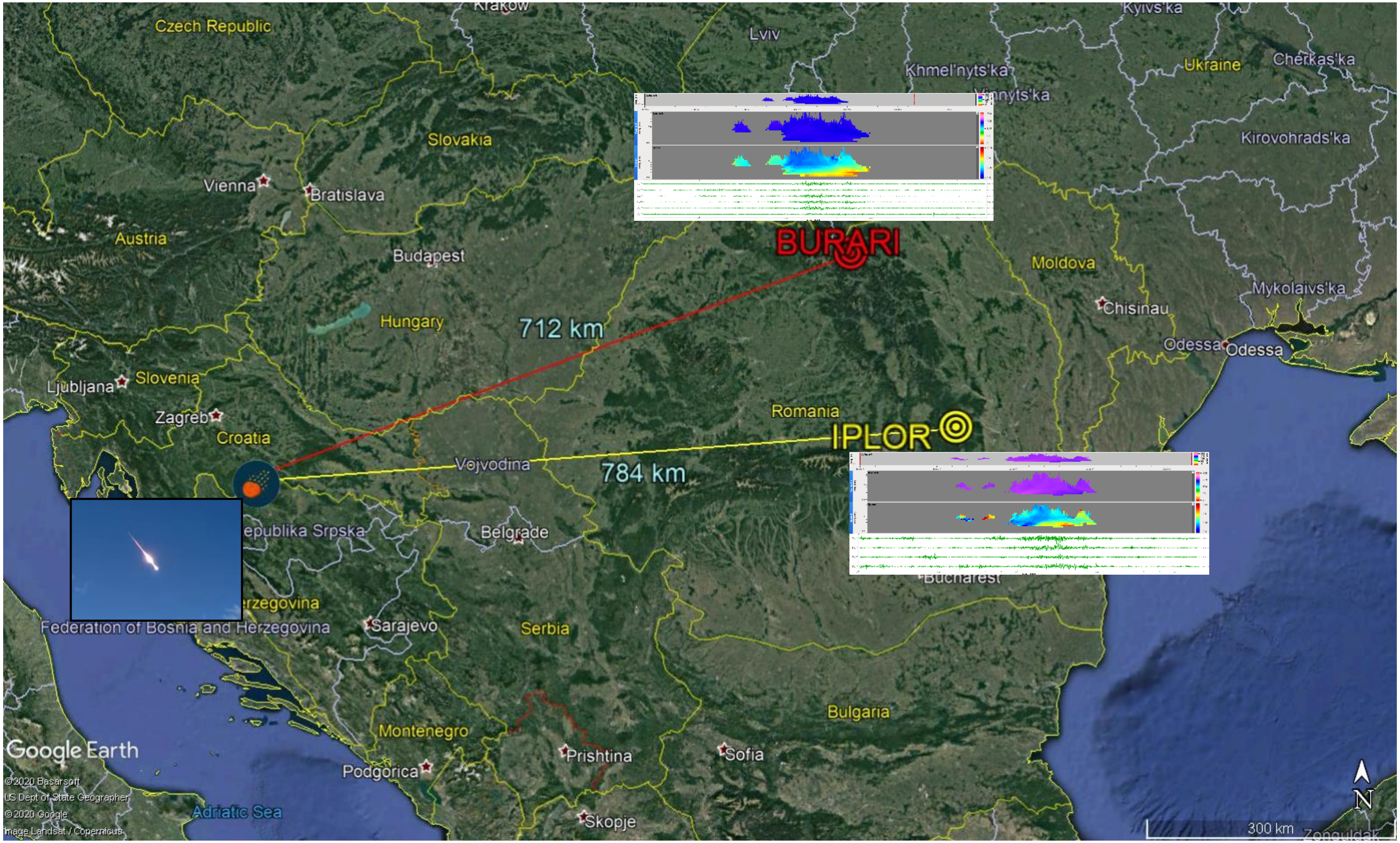
Infrasound sources observed

Large bolide over Russia (near city of Lipetsk) / 21.06.2018



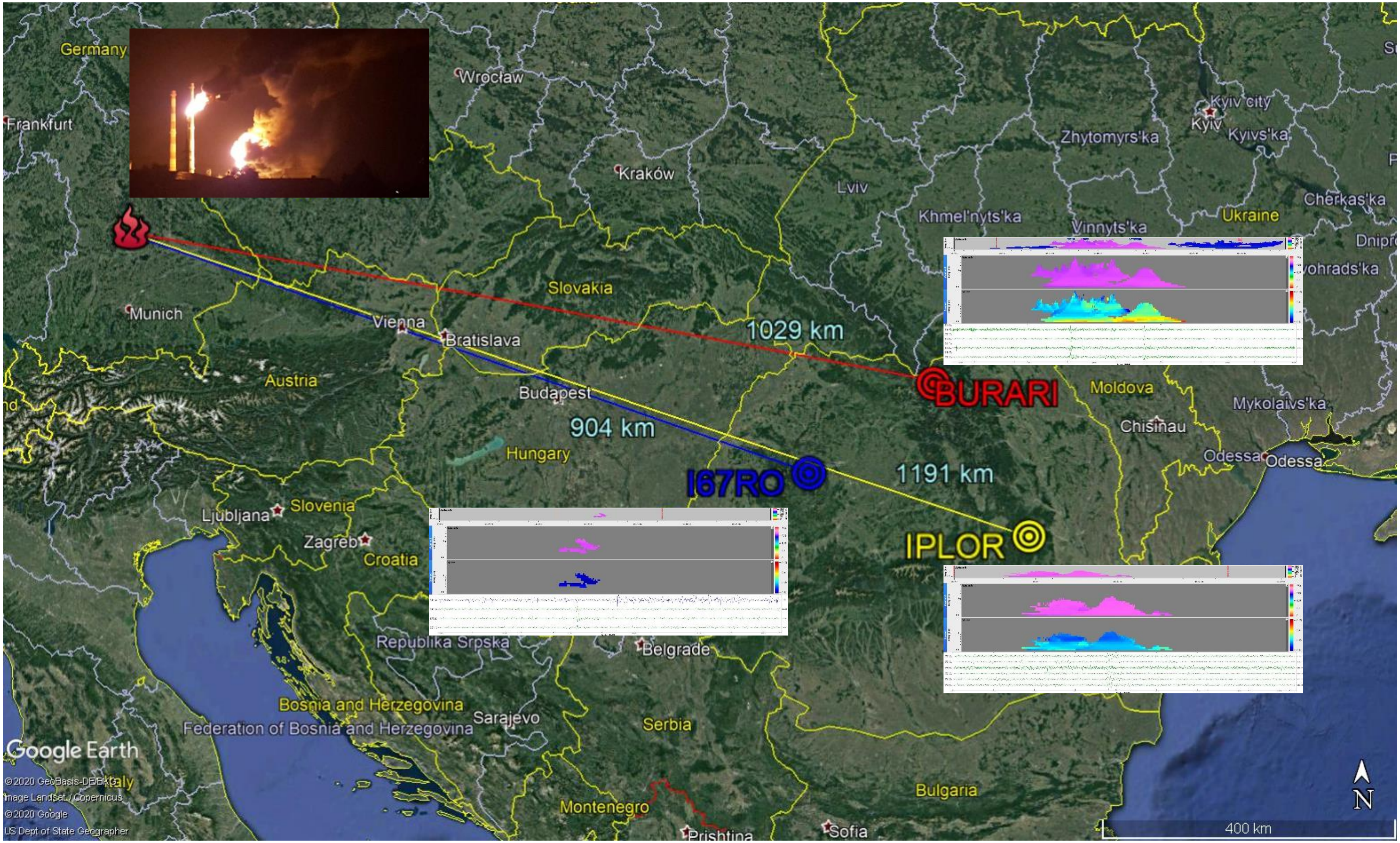
Infrasound sources observed

Large fireball explosion over Slovenia and Croatia / 28.02.2020



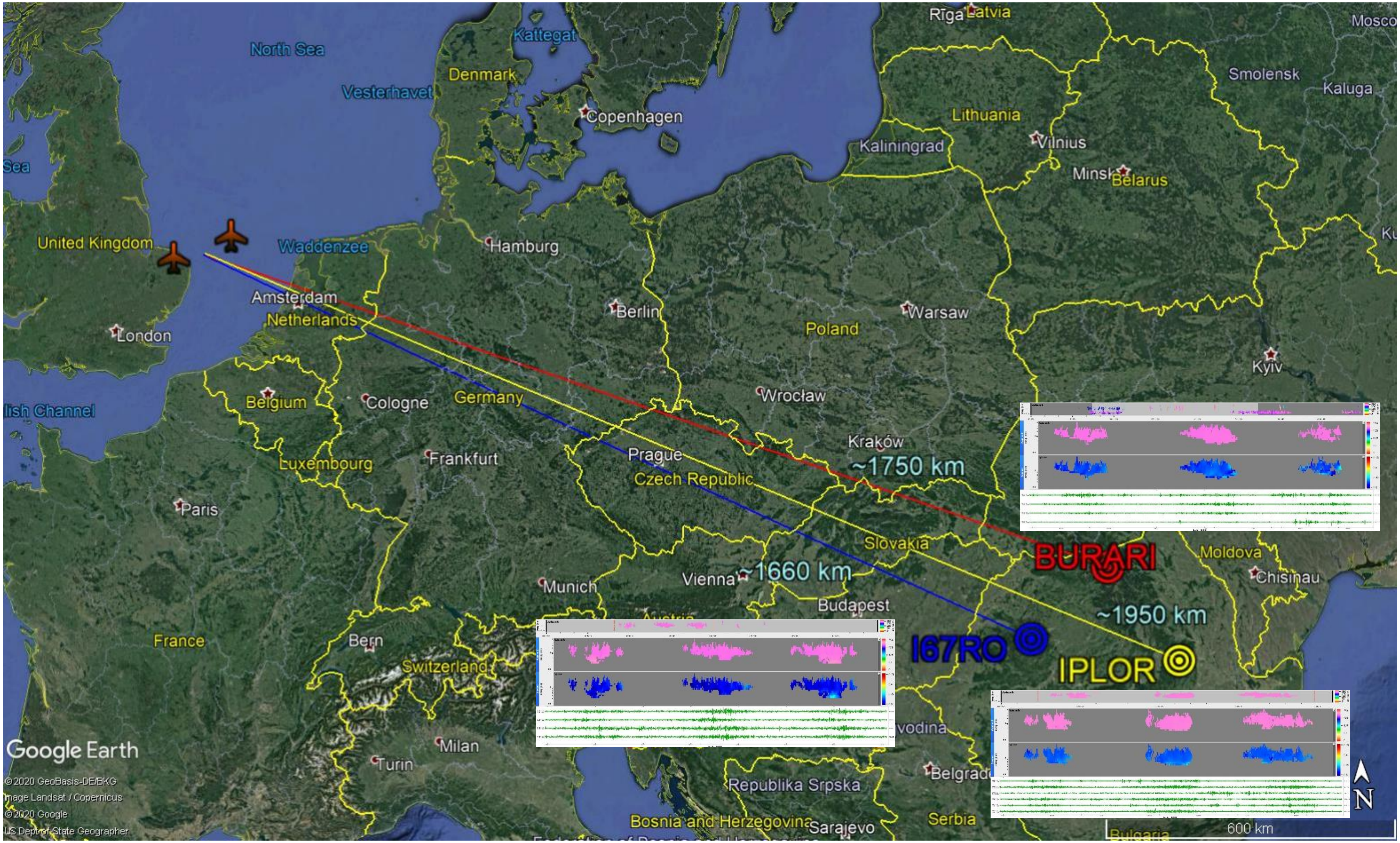
Infrasound sources observed

Explosion at oil refinery in Ingolstadt, Germany / 01.09.2018



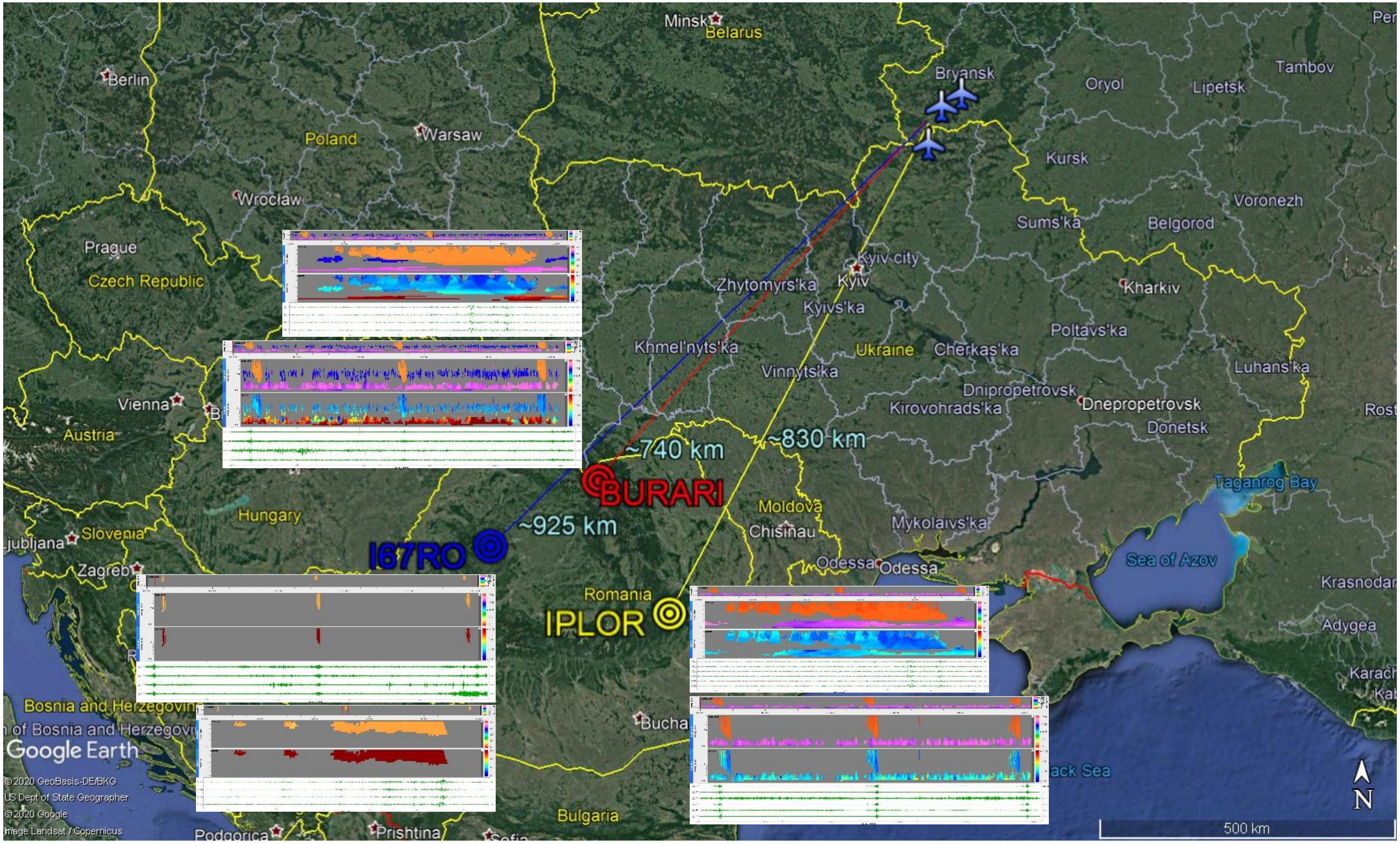
Infrasound sources observed

Supersonic flights over the North Sea region / 21.03.2018



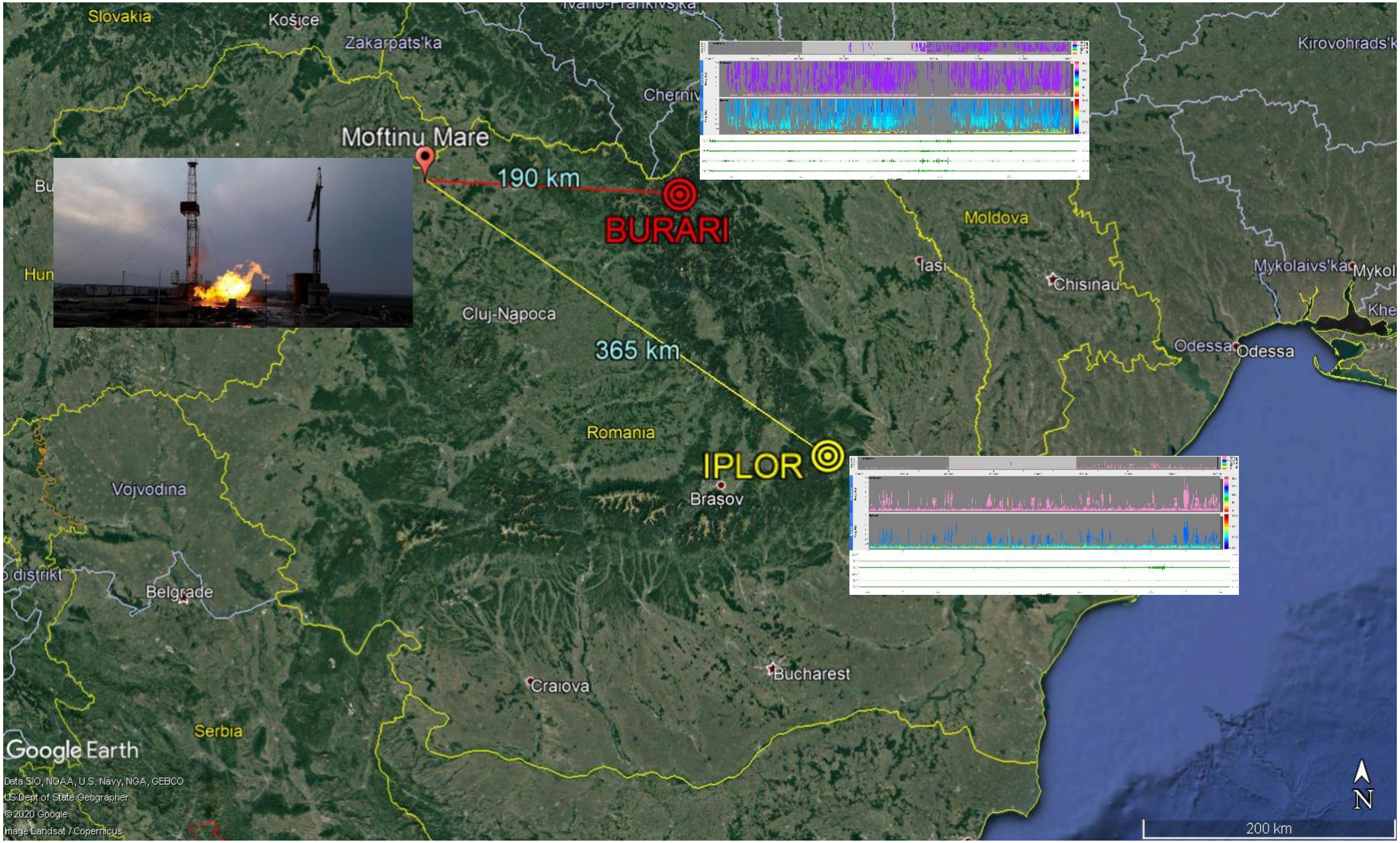
Infrasound sources observed

Anthropogenic events (possible supersonic flights) in Ukraine/Russia region / 16.01.2017



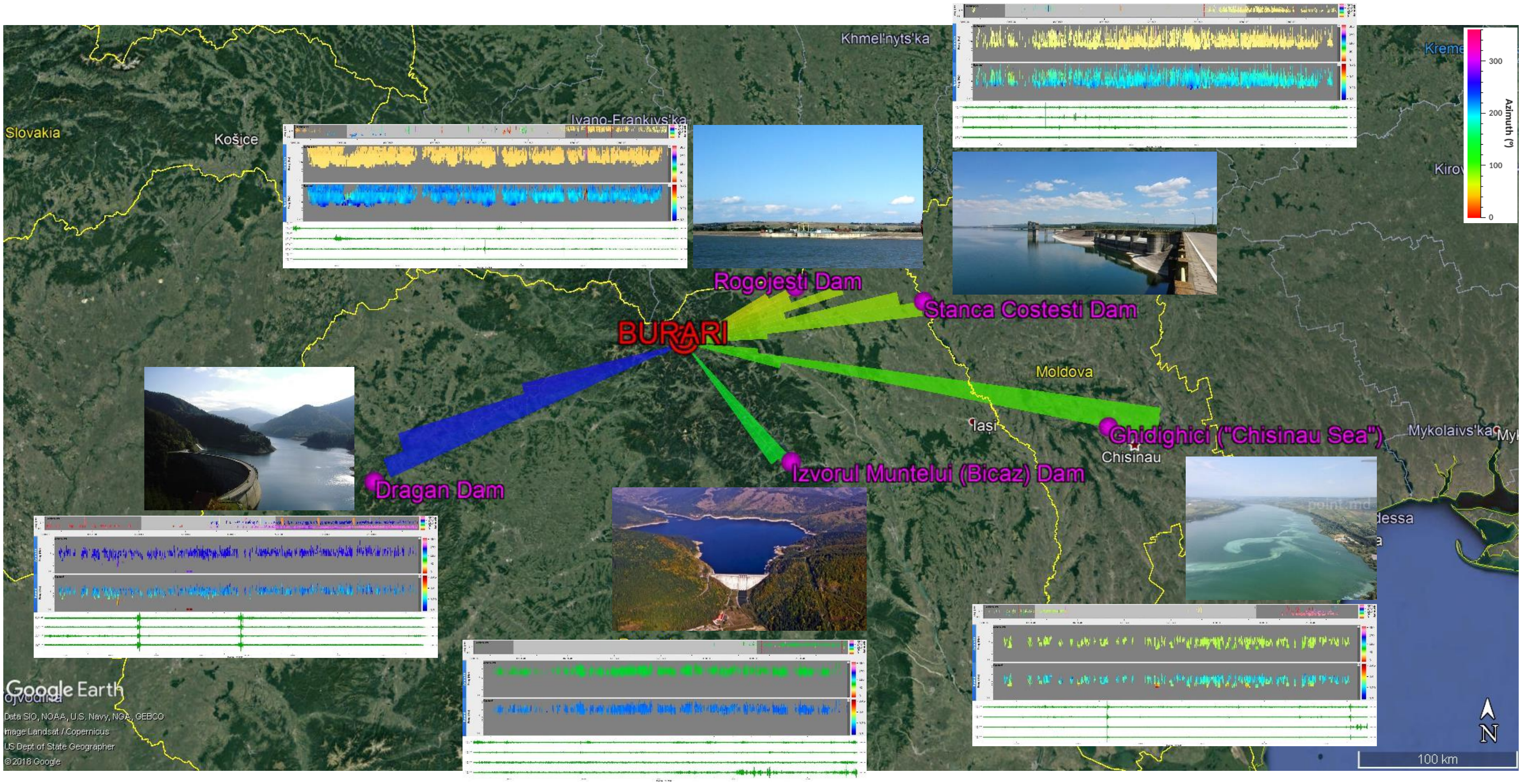
Infrasound sources observed

Gas flares at Moftinu Mare (accidental explosion)
- December 2017 to January 2018 -



Infrasound sources observed

Dam monitoring (BURARI array)



Conclusions

- The monitoring performance of the infrasound stations deployed on the Romania's territory are presented as a result of the reprocessing the 10-year archive of waveform data recorded
- Detection capability assessment, types of sources observed, as well the capacity of fusing the detections into support of understanding various infragenic sources are shown
- A good characterization of the detected signals in the frequency-azimuth space or frequency trace-velocity space is clearly observed
- Infrasonic signals generated by several relevant sources detected with the three arrays deployed on the Romanian territory were presented

Acknowledgements

- The data processed in this paper are recorded by Romanian infrasound network and owned by National Institute for Earth Physics
- Part of the results obtained in this study will be included in the research carried out inside the Project: "Multidisciplinary research to characterize seismic and acoustic events using specific analysis techniques" included in the Nucleu-Programme MULTIRISC supported by the Ministry of Education and Research
- We would like to acknowledge the CTBTO Technical Assistance which consisted of:
  - NDC-in-a-Box SHI Software Package
  - Training courses: Intermediate Level Infrasound Data Analysis Training (15 to 19 July 2019, Bucharest, Romania) and NDC Advanced Training on Infrasound Data Analysis (14 to 18 October 2019, Bruyères-le-Châtel, France)