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The Global and Coherent Infrasound Wavefield: Recent Advances in Reprocessing the Full International Monitoring System Infrasound Data

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P1.1-399

POSTER

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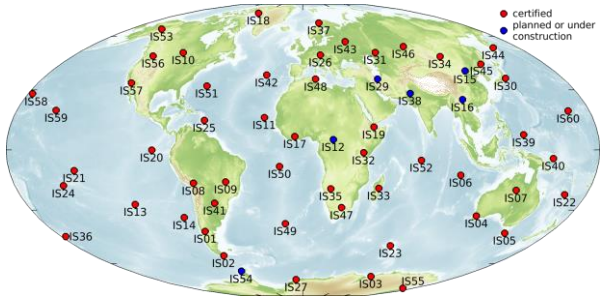
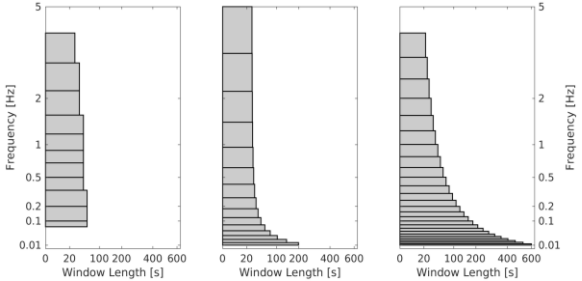
OVERVIEW

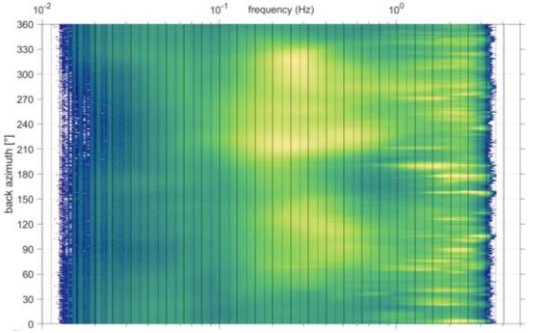
Introduction: data and motivation



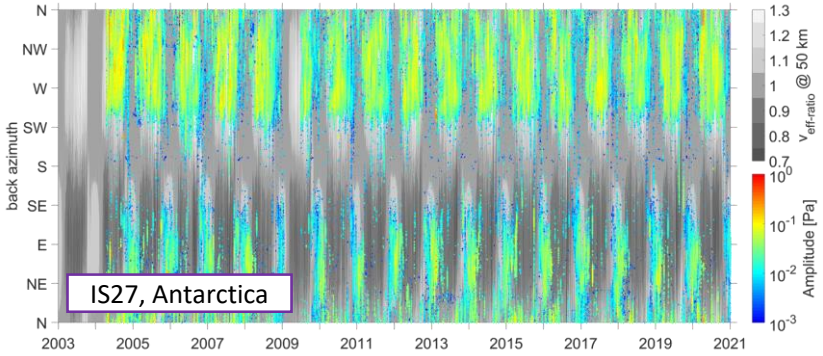
Methods: PMCC processing



Processing results & data quality



Broadband bulletin examples & features of interest



Detection lists used for various scientific applications

- Reference data set for validating a microbarom model (**O1.1-531, M. De Carlo**)
- Identifying signatures from 1001 rocket launches for space missions (**P2.3-232, P. Gaebler**)
- Planned: specific bulletin products for atmospheric research and civilian applications (**O1.1-389, P. Hupe**)

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ABSTRACT

We present recent advances and results of reprocessing the IMS infrasound dataset from its beginning until early 2021. A new implementation of the Progressive Multi-Channel Correlation (PMCC) algorithm enables characterization, with a single processing run, of coherent noise in log-spaced frequency with one-third octave bands from 0.01 to 5 Hz. Such an array processing algorithm enables better characterization of all received signals in their wave parameter spaces (e.g., frequency–azimuth, frequency–trace velocity). This, in turn, permits more accurate signal discrimination and source and propagation studies. The latest comprehensive reprocessing of the IMS infrasound database covers the period from January 2003 to December 2020; in the meantime, the number of stations has increased from 30 to 53. The obtained results clearly indicate a continuous spectrum of coherent signals at IMS stations within the 0.01 to 5.0 Hz frequency range, as well as the wave parameters' relation to middle atmosphere dynamics. Also, more sources are identified when comparing the recent results with those of previous reprocessing approaches or the standard IDC products.

Our comprehensive bulletin lists (up to 18 years) serve as the reference for a microbarom model validation (**O1.1-531** by De Carlo et al.). It also opens up avenues for further studies (**O1.1-389** by Hupe et al.) presenting tailored products for atmospheric and civilian applications. **The indicated talks are scheduled on Wednesday (17:20 MEST).**

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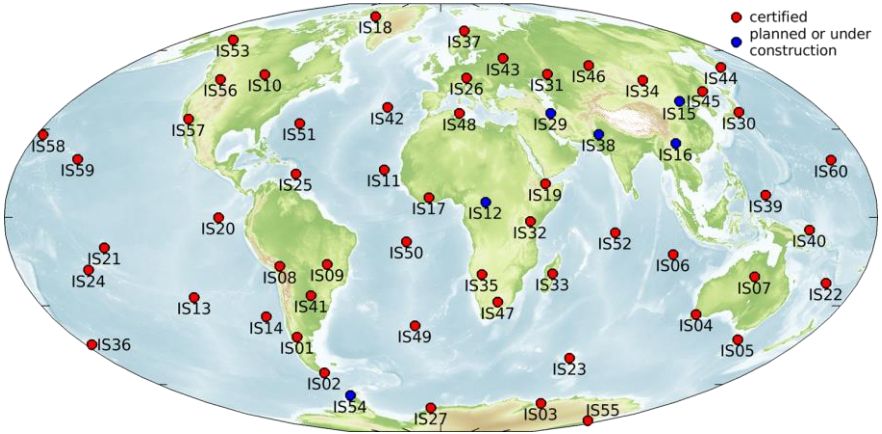
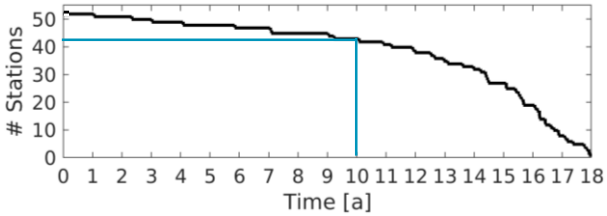
INTRODUCTION

Characterizing coherent ambient noise important for CTBT verification

- IMS infrasound data are routinely processed at the IDC using the Progressive Multi-Channel Correlation method (PMCC; Cansi, 1995)
- Initial implementation: linearly-spaced frequency bands (multiple runs required)
- Single run when implementing a variable window length and log-spaced frequency bands (Brachet et al., 2010)
- First systematic broadband (0.01-5 Hz) analysis of IMS infrasound data by Matoza et al. (2013)
- Potential of IMS data for atmospheric and natural hazard applications has been demonstrated (e.g., Le Pichon et al., 2019)
- Full (and increasing) IMS infrasound data set is regularly reprocessed at German NDC (Ceranna et al., 2019)
- Here: latest advances and results of the reprocessing





end of 2020: 53 IMS stations certified, data of >40 stations available for 10+ years

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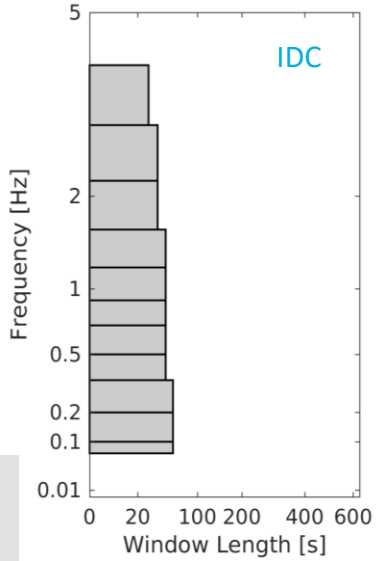
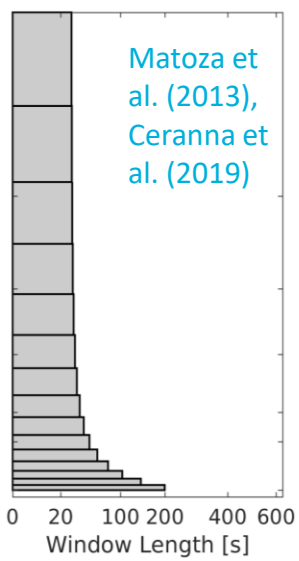
METHODS

Latest reprocessing: PMCC (V5.7.4) configuration with one-third octave frequency bands

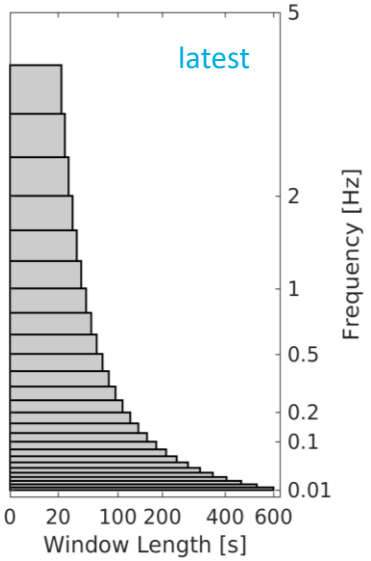
- From linearly-spaced to one-third octave log-spaced frequency bands
- 26 (27) bands between 0.01 and 4 (5) Hz
- Increased window lengths at low frequencies
- 18 years of IMS data: 2003-2020 (2021 in progress)
- Data of up to 53 IMS infrasound arrays



- 11 bands, non-linear
- w-len 60 – 30 s
- step width 10 s



- 15 bands, logarithmic
- w-len 200 – 30 s
- step width 10%



- 26 bands, 1/3 octave width
- w-len 600 – 20 s
- step width 10%

References:

Brachet et al. (2010): Monitoring the Earth's Atmosphere with the Global IMS Infrasound Network, in: Infrasound Monitoring for Atmospheric Studies, 1st ed., pp. 77–118, Springer.

Cansi (1995): An automatic seismic event processing for detection and location: The PMCC method, Geophys. Res. Letters, 22(9), pp. 1021–1024.

Ceranna et al. (2019): Systematic array processing of a decade of global IMS infrasound data; in: Infrasound Monitoring for Atmospheric Studies, 2nd ed., pp. 471–482, Springer.

Le Pichon et al. (2019): Infrasound Monitoring for Atmospheric Studies – Challenges in Middle Atmosphere Dynamics and Societal Benefits, 2nd ed., Springer International, 1167 pp.

Matoza et al. (2013): Coherent ambient infrasound recorded by the International Monitoring System. Geophysical Research Letters, 40, pp. 429–433.

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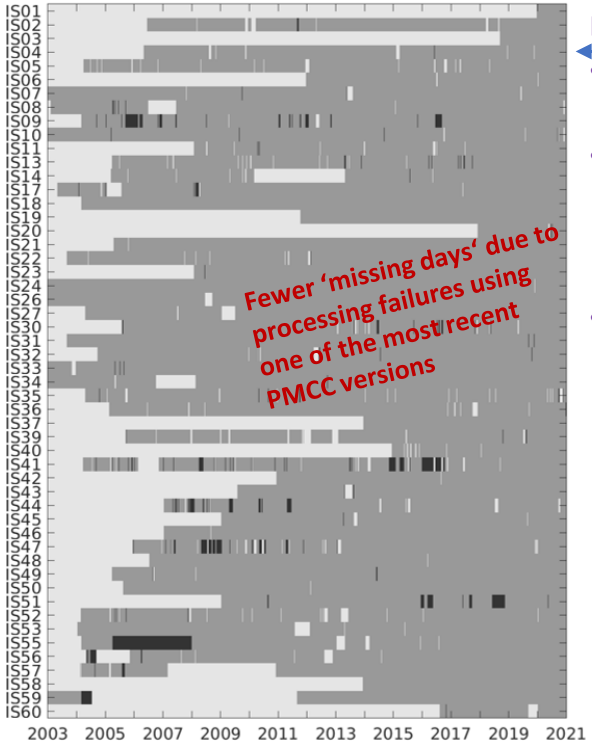
RESULTS I

Comprehensive infrasound detection lists with only a few data gaps – more sources, better source discrimination

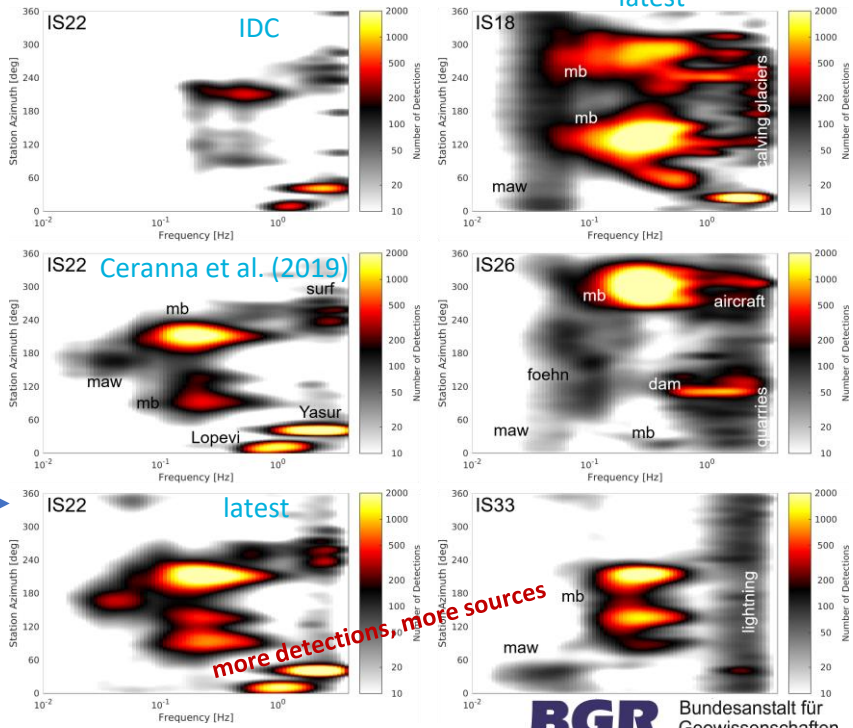


Daily basis: data availability

- White: no data available or archived
- Black: waveform data of (too few) sensors available, no processing results
- Grey: detection lists available

Frequency-azimuth histograms

- Left: configuration-dependent results, IS22
- Right: station examples of latest reprocessing results



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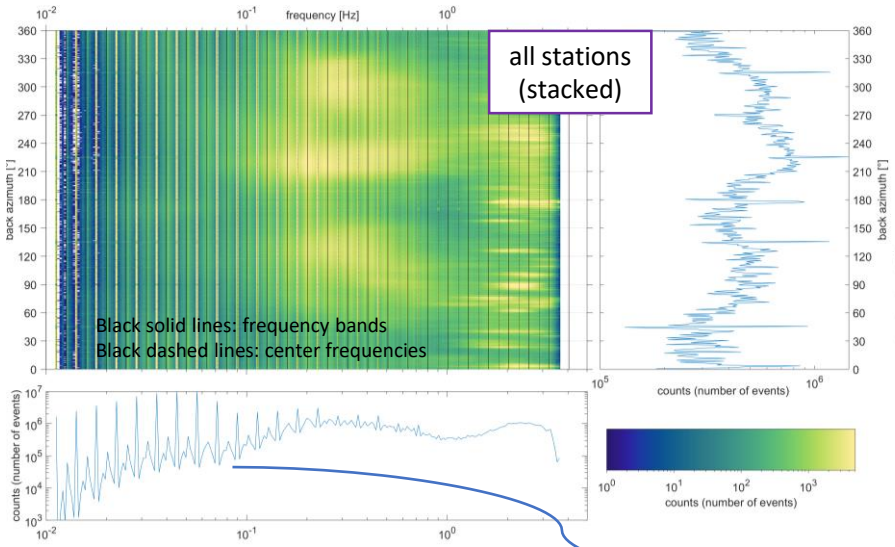
RESULTS II

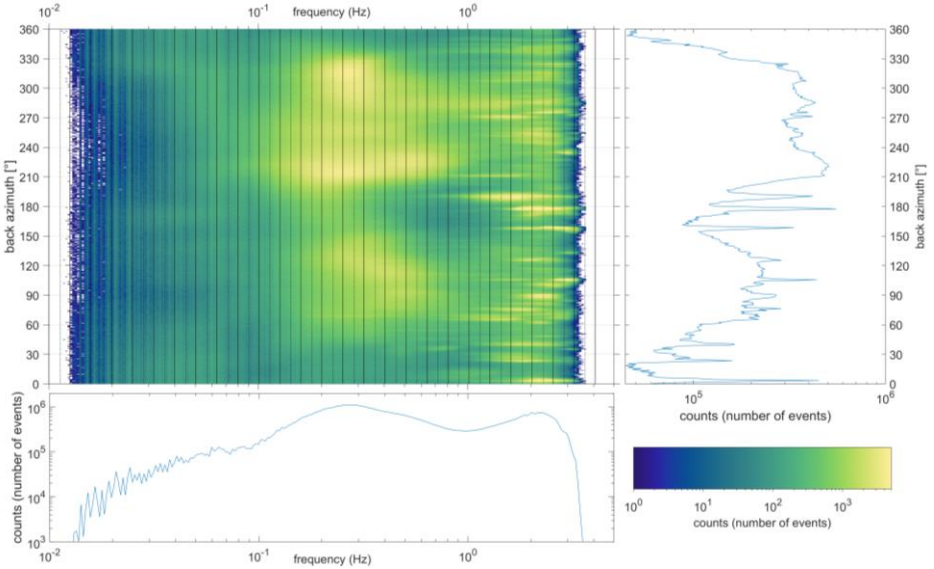
Processing artefacts (almost) removed, cleaned detection lists cover 0.02-3.5 Hz (center frequencies)



artefact: clustering at center frequencies, particularly detections with low family sizes

cleaning the detection lists from artefacts

overall frequency-azimuth distribution highlighting microbaroms and high-frequency sources



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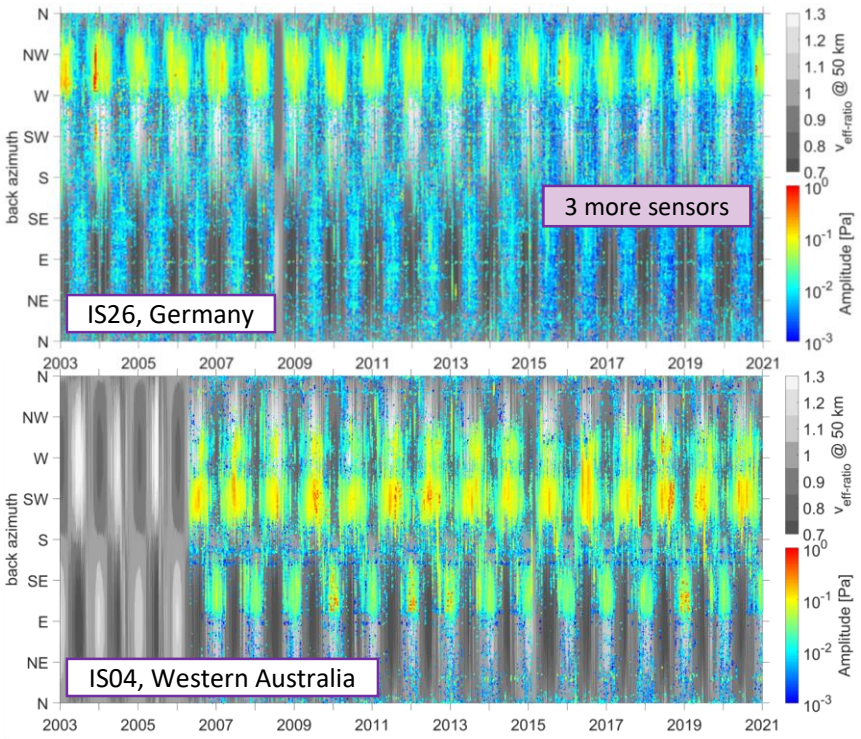
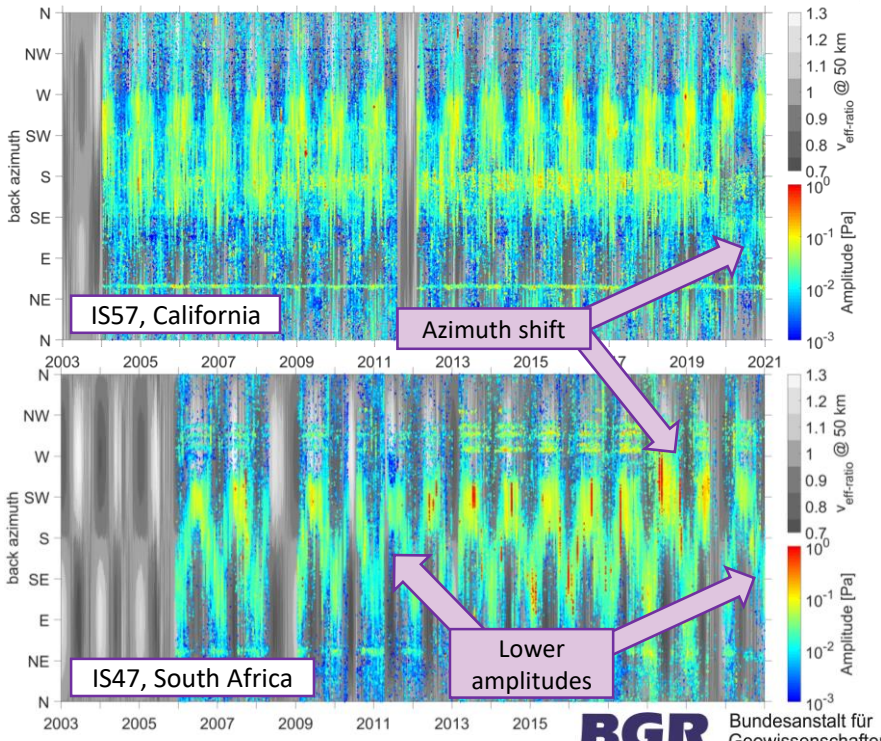
RESULTS III

Bulletin examples: amplitude and propagation conditions color-coded; features remaining to be explained





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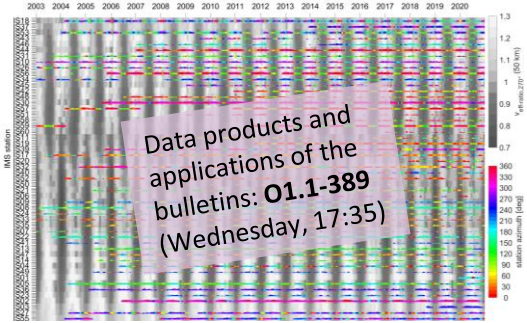
CONCLUSIONS

Processing results can provide useful insight into the overall network performance

- Regularly updated IMS infrasound bulletin lists available since 2003, i.e. for >18 years
- Latest reprocessing with PMCC V5.7.4 and one-third octave configuration: **more accurate estimate of signal parameters**, reduced artefacts, new sources resolved (e.g., microbaroms, mountain-associated waves)
- Better discrimination between interfering signals
- **Improved quality assessment** of the detections lists (both processing and station-health features, e.g. sensors down), but for some stations features such as sudden amplitude discrepancies remain unclassified
- Processing with 26 frequency bands leads to some more artefacts, but the majority of these can be quantified
- Overall, one-third octave processing configuration **outperforms previous approaches**
- Seasonal patterns reflect the stratospheric wind conditions



- Recent and work-in-progress applications of these detection lists: microbarom model validation (**O1.1-531, M. De Carlo**), rocket infrasound signatures (**P2.3-232, P. Gaebler**), volcanic eruptions, lightning activity

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