A bird's-eye view on infrasound

- A novel approach for the reconstruction of ambient infrasonic soundscapes
- Comparisons made between soundscapes and microbarom recordings by the 'INFRA-EAR', a miniature sensor mounted on Wandering Albatrosses, and IMS station I23FR.
- Absolute numbers, new insights in the ambient noise field, total acoustic power summation
- Station-specic cumulative probability distributions can be constructed for infrasound arrays to quantify the array's microbarom exposure.





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First things first..... Albatrosses?!?!

- HFSP SeabirdSound project
- How do seabirds navigate in a featureless landscape?
- Infrasound as a navigational que?



Infrasound and Environmental Atmospheric data Recorder (INFRA-EAR)

- Biologger for the Wandering Albatross
- GPS, Wind, Barometric pressure, Differential pressure, Temperature, Acceleration.
- Calibrated digital MEMS sensors
- 2020 field campaign Crozet Islands



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Atmospheric measurements Crozet Islands



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Oceanic ambient noise

- Evanescent microbaroms (Sea state)
- Primary microseisms (Sea state, water depth, bathymetry)
- Secondary microseisms, Propagating microbaroms (Non-linear wave interaction)



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Oceanic ambient noise

- (1) Evanescent microbaroms
 - Direct waves from sea surface
 - Vertically decaying

• (2) Propagating microbaroms

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• More complex



Microbarom source model

- Waxler et al., 2007, implemented by Smets, 2018
- Previous comparisons between model and data based on directional array processing
- Only comparison between directional peak and model
- Previous work (Hope et al., 2019, Carlo et al., 2020) has focused on normalised power spectra instead of absolute values.
- Here, we compare observed and modeled absolute power spectra for a single, moving sensor.



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(1) Evanescent microbaroms

Reconstruction of Soundscapes

- (1) Evanescent microbaroms
 - 15° cone
 - Scaling of sea surface
 - Vertical exponential decay







(2) Propagating microbaroms

Reconstruction of Soundscapes



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(2) Propagating microbaroms

Reconstruction of Soundscapes

- Omnidirectional soundscape
- Methodology is modular
 - Microbarom models
 - Propagation models
- Total acoustic power summation
 - Computation of acoustic energy from distributed acoustic sources







Comparison between Soundscapes and in-situ measurements

- Integrated soundscapes between 0.1 0.3 Hz
- Measurements (red) and synthetic soundscapes (black)
- Discontinuities (grey area's) are caused by wind turbulence



Spectral comparison



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Spectral comparison

INFRA-EAR

- Moving sensor above ocean surface
- Same trend
- Acoustic components
 - Evanescent microbaroms
 - Propagating microbaroms



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Conclusion and Discussion

- First recordings of microbaroms directly above the sea-surface
- A novel method for the reconstruction of infrasonic ambient soundscapes
 - Evanescent and Propagating microbaroms
- Soundscapes gives insight into how much various source regions contribute to the total acoustic power measured in the microbarom band
- Improves the knowledge in the global infrasonic background noise and better compares infrasound array observations with model outputs
- Contributes to the verification of the CTBT



• Better applicability of infrasound as a remote sensing technique for the upper atmosphere

Human Frontier Science Program (HFSP) SeabirdSound Team



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Open for questions!