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BIOACOUSTIC-CONCEPT

within a sensor network on a heterogeneous grassland site

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1. Introduction

- DAKIS aims to integrate biodiversity parameters into agricultural decision-making and give biodiversity a value
- Solar cell driven, low power and low budget Wireless Sensor Network (WSN) established on heterogeneous grassland close to Mühlenbeck, Brandenburg for soil and climate monitoring (*Fig. 1*)
- Idea: The implementation of microphone sensors within this network for biodiversity detection.

Research questions
- Is the integration of microphone sensors and on-site processing feasible?

2. Bioacoustics

- Provides behaviour, species identification, population density
- Wide frequency range (100 Hz - 24 kHz) for multiple species coverage

Bioacoustics-Indices
- Acoustic Complexity Index (ACI): diversity and complexity
- Normalized Difference Soundscape Index (NDSI): anthropogenic disturbance
- Acoustic Diversity Index (ADI): acoustic heterogeneity
- Acoustic Evenness Index (AEI): unevenness in frequency
- Bioacoustics Index (BI): area under the mean frequency spectrum

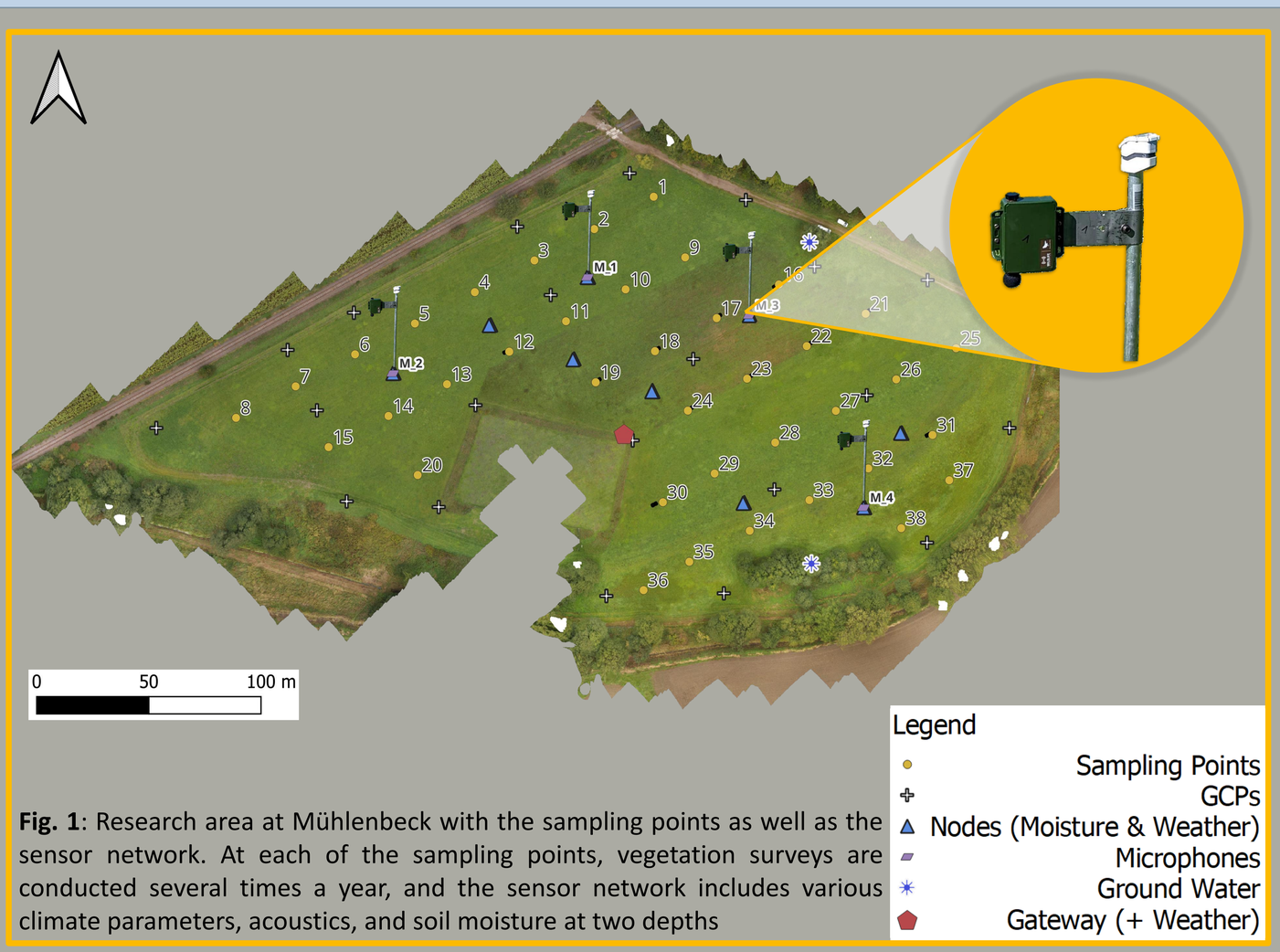

Fig. 1: Research area at Mühlenbeck with the sampling points as well as the sensor network. At each of the sampling points, vegetation surveys are conducted several times a year, and the sensor network includes various climate parameters, acoustics, and soil moisture at two depths

3. The Wireless Sensor Network

- Test site: 9 solar powered *Basic Sensor Nodes (BSN)* and 1 *Gateway* (Fig. 1) with fine granular measurement (mostly once per minute)
- BSN measure UV index, air pressure, humidity, temperature, soil moisture at 2 depths each. Gateway measures wind and precipitation additionally
- Real-time data transmission from test site to servers for analyses and maintenance (Fig. 2)

Acoustic extension
- Long-term goal: integrate microphone sensors, process data on-site (edge computing)
- Experimental phase: 4 BSNs extended with external microphone loggers (Song Meter Mini, Wildlife Acoustics, Inc., USA) recording 10 minutes per hour (Fig. 3)
- Next phase: event/trigger based recording (environment, weather, animal detection, movement), using Bluetooth LE and GAAT protocol; improved hit rate to also record and catch animal sounds; improve battery life time and SD card usage

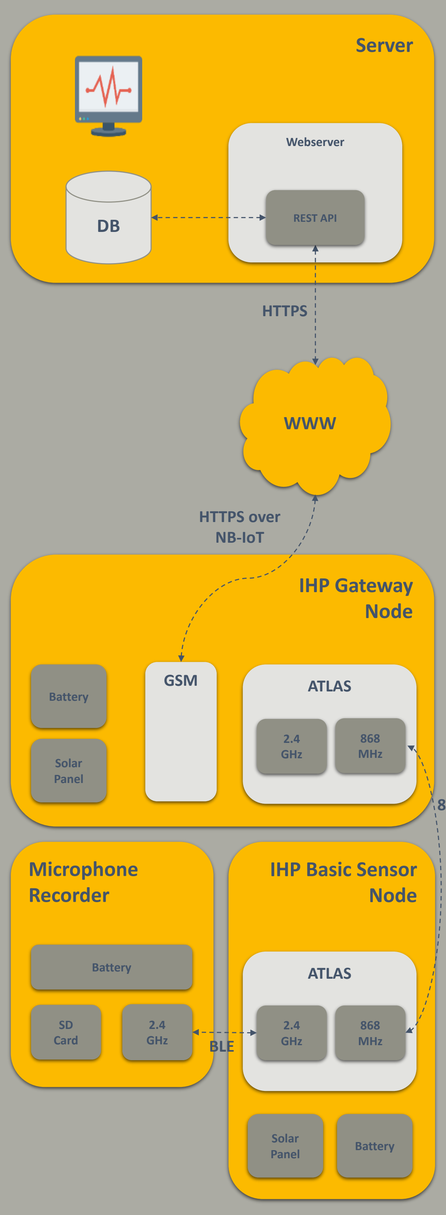

Fig. 2: Microphone recorder attachment, network based control flow and device meta data (battery and SD card status readout)

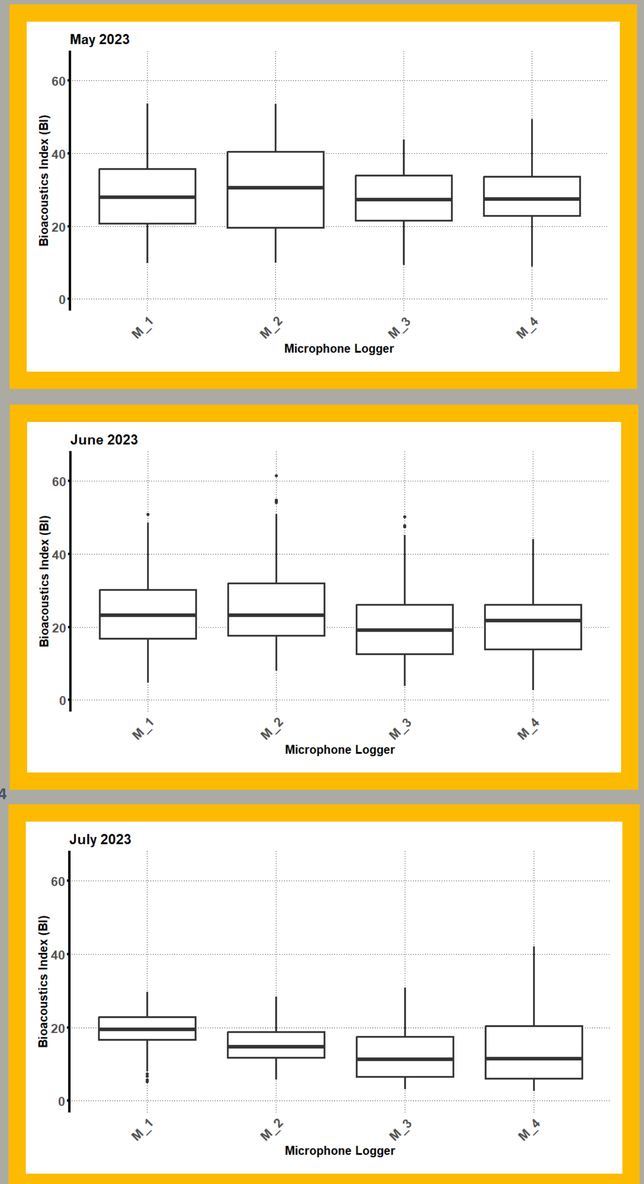

Fig. 3: Boxplots of the acoustic measurements 2023 for May to July with averaged bioacoustics index (BI) of the 4 microphone loggers (M_1-4). Differences can be observed between the loggers as well as the months, noting that at the time of the evaluation (mid-July) only one recorded week of the last month was available

4. Results

- Experimental phase evaluated the bioacoustics index (BI) according to Boelman et al. (2007) for general functionality
- Seasonal change noticeable from May to July despite fewer days in July (*Fig. 3*)
- Differences between loggers, but similar overall trends (*Fig. 3*)

5. Conclusion & Outlook

- Initial successful evaluation at index level
- Calculation of indices feasible with gateway's Python scripts, sound file transfer remains challenging (loggers are using SD-cards)
- Integration of microphones into grassland network shows promising results, but requires further investigation
- Further analysis of sound files, including AI-based species recognition
- Long-term evaluation considering management, habitat, and weather
- Bioacoustics analysis potential for decision-making in management

References

Boelman N.T., Asner G.P., Hart P.J., Martin R.E. (2007). Multi-trophic invasion resistance in Hawaii: bioacoustics, field surveys, and airborne remote sensing. Ecological Applications 17: 2137-2144

For all statistics analyses and graphs, the statistical software R (version 4.3.1, Windows 10) was used
R Core Team (2023). _R: A Language and Environment for Statistical Computing_. Foundation for Statistical Computing, Vienna, Austria.
Villanueva-Rivera L.J., Pijanowski B.C. (2018). _soundecology: Soundscape Ecology_. R package version 1.3.3

For map editing, the GIS software QGIS (version 3.28.6, Windows 10) was used
QGIS.org (2023). QGIS Geographic Information System. QGIS Association

Web links

Homepage DAKIS Project: www.adz-dakis.com
Eberswalde University for Sustainable Development: www.hnee.de/DAKIS
University of Bonn: www.lap.uni-bonn.de/de/forschung/projekte/dakis

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