Photo: René Steinmann

Wildlife monitoring with machine learning and seismic sensors

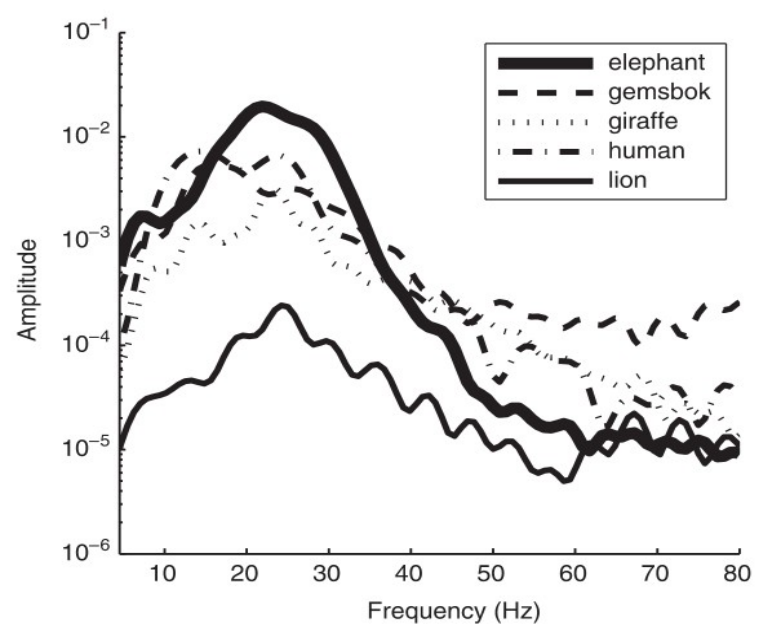
René Steinmann

GFZ Discovery Fellow

GeoINQUIRE Seminar, 22 May 2025

Seismic signals from Wildlife

Footfalls and Vocalization



Wood et al., 2005, first (published) report of footfall signals

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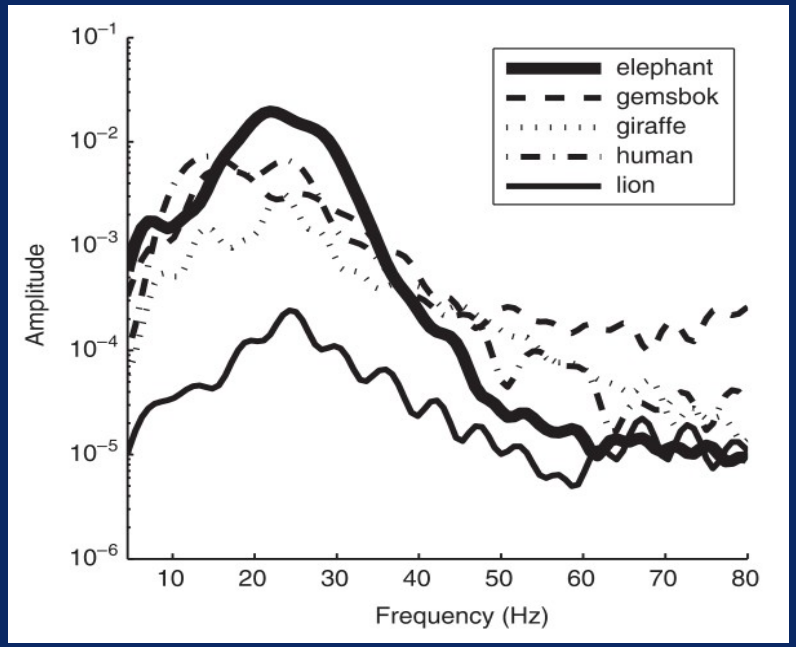

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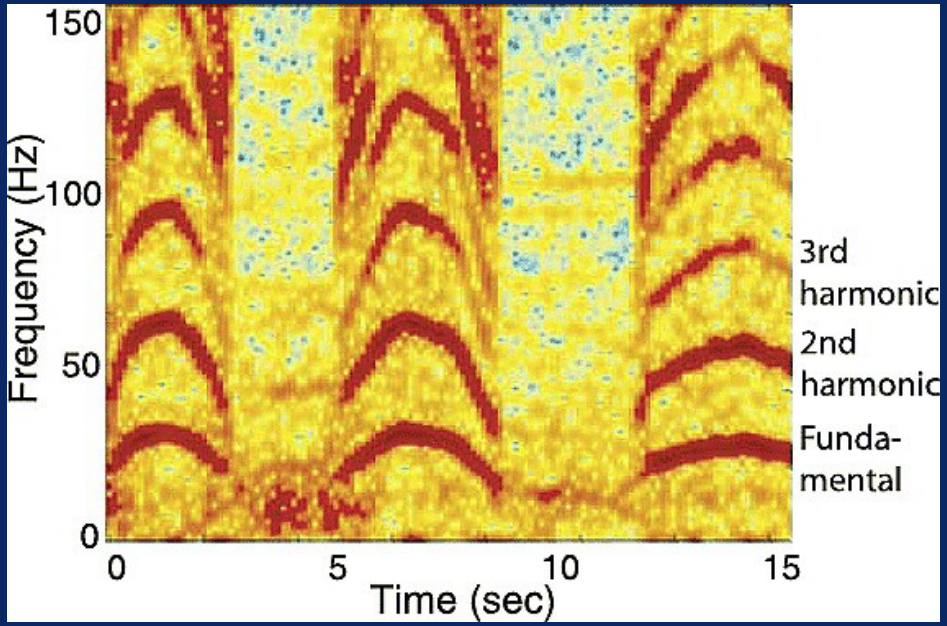

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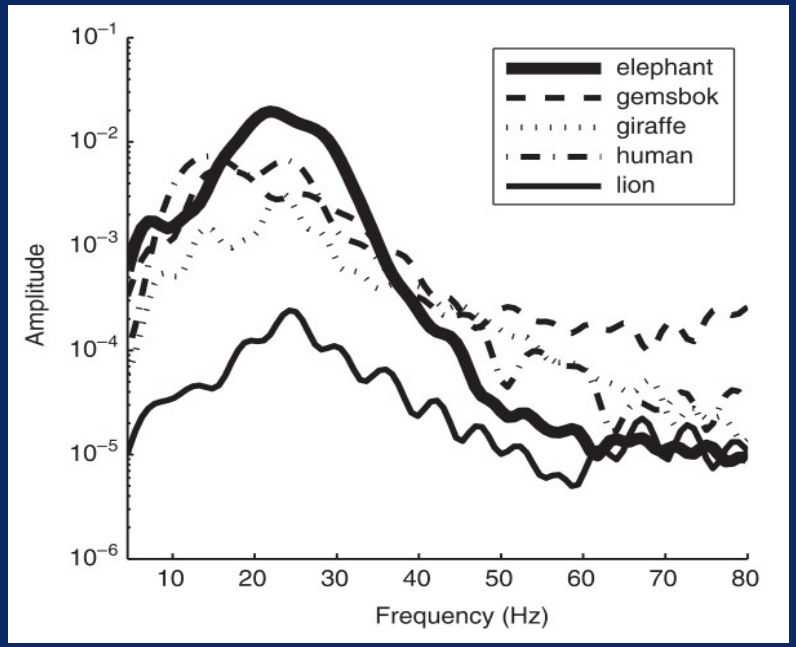

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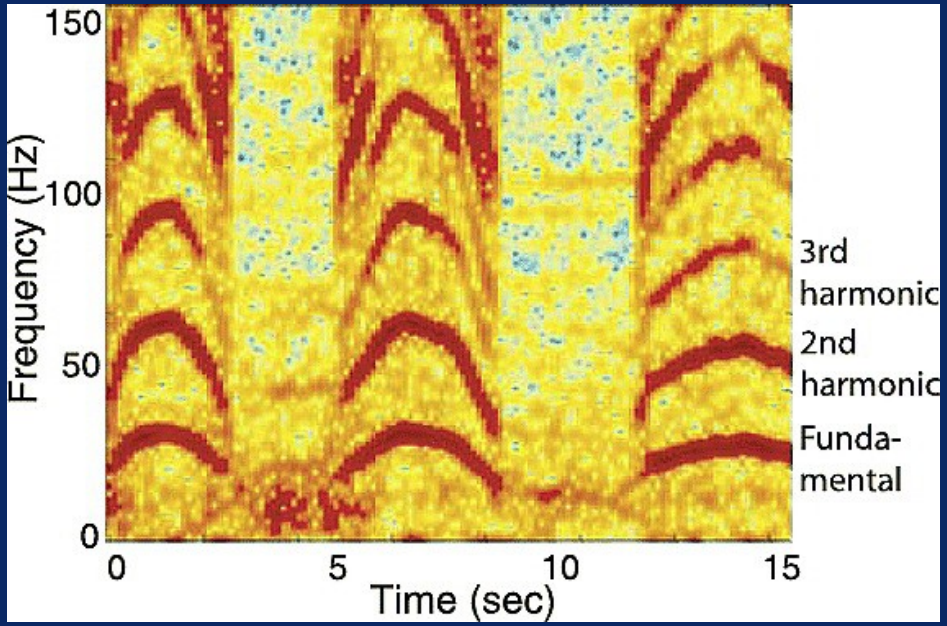

Günther et al., 2004, GRL

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Nowadays AI helps massively to exploit these signals!

What are these signals useful for?

Monitoring wildlife seismically

Monitoring wildlife seismically

Camera Traps
(visual information)
- easy to process
- non-continuous

Non-invasive monitoring methods

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Seismic Monitoring at Mpala Research Centre, Kenya

Savanna Biome with high diversity of large land mammals

Photo: René Steinmann

Photo: Mpala.org

Photo: René Steinmann

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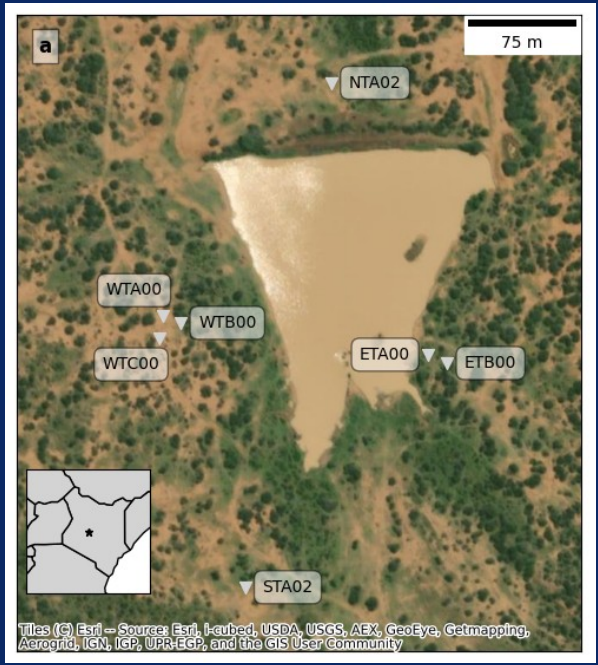
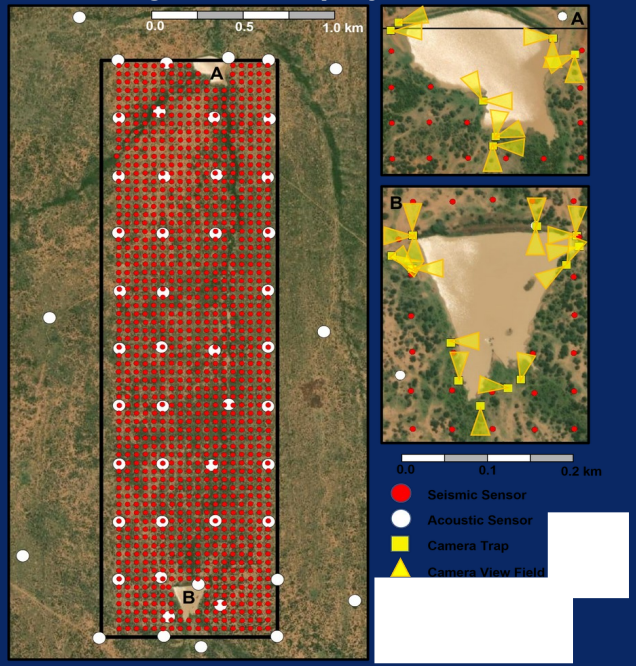
Working at and with Mpala for many years now

2019: first small-scale deployment



~ 100s of Gbs

2023: large-scale deployment



~ 100s of Tbs

2025: video and observation

~ 25 Tb

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René Steinmann

Frederik Tilmann

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Ben Moseley

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Alexandre Szenicer

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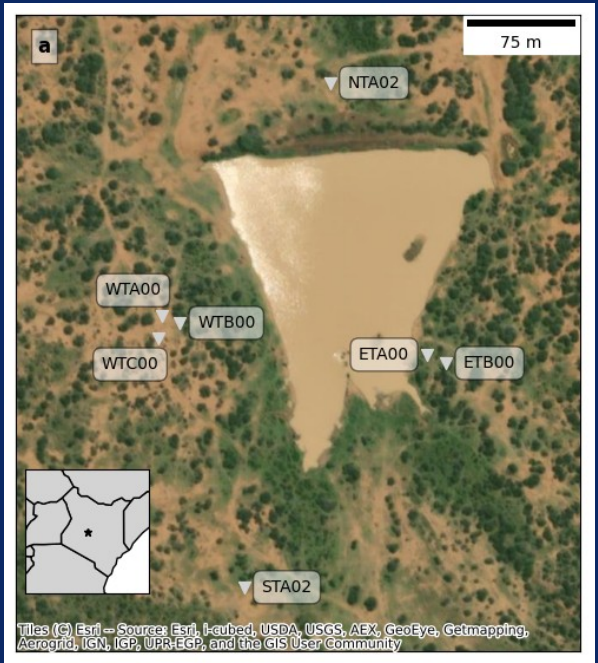
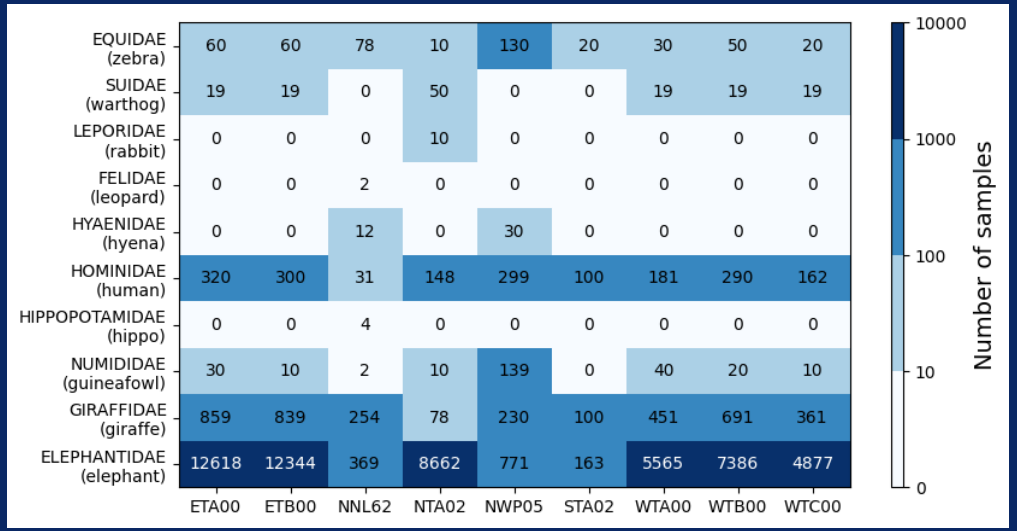
Seissavanna experiment 2019, Mpala, Kenya

Broadband Sensors and Camera Traps





The Seissavanna dataset (>70.000 labeled seismograms)

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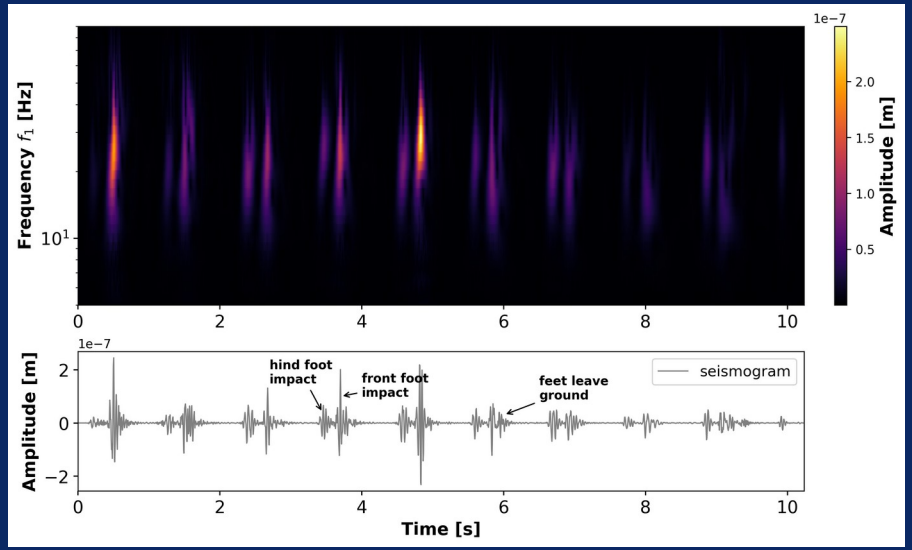
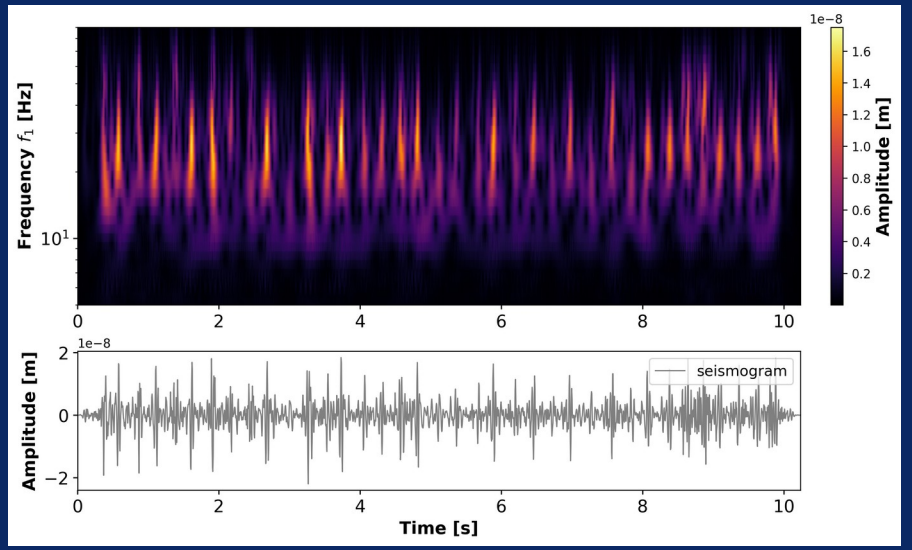
Szenicer et al., 2022 and Steinmann et al., 2025

The seismic signatures of footfalls

Giraffe



Zebra



Different Wildlife = Different Signatures

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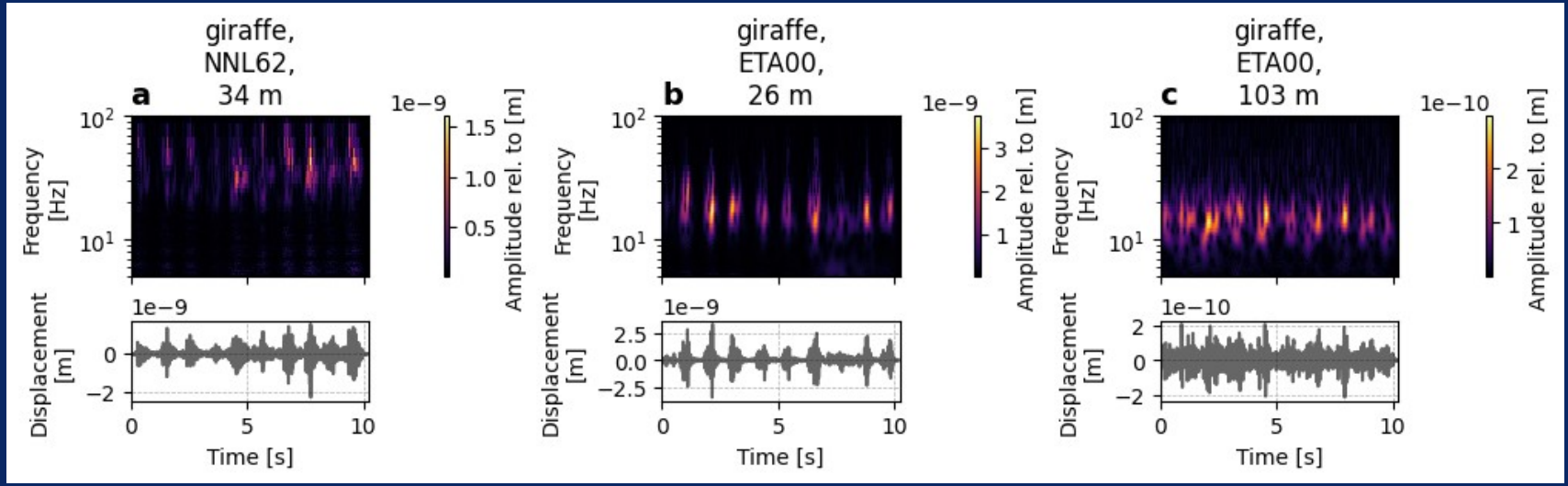
Steinmann et al., 2025

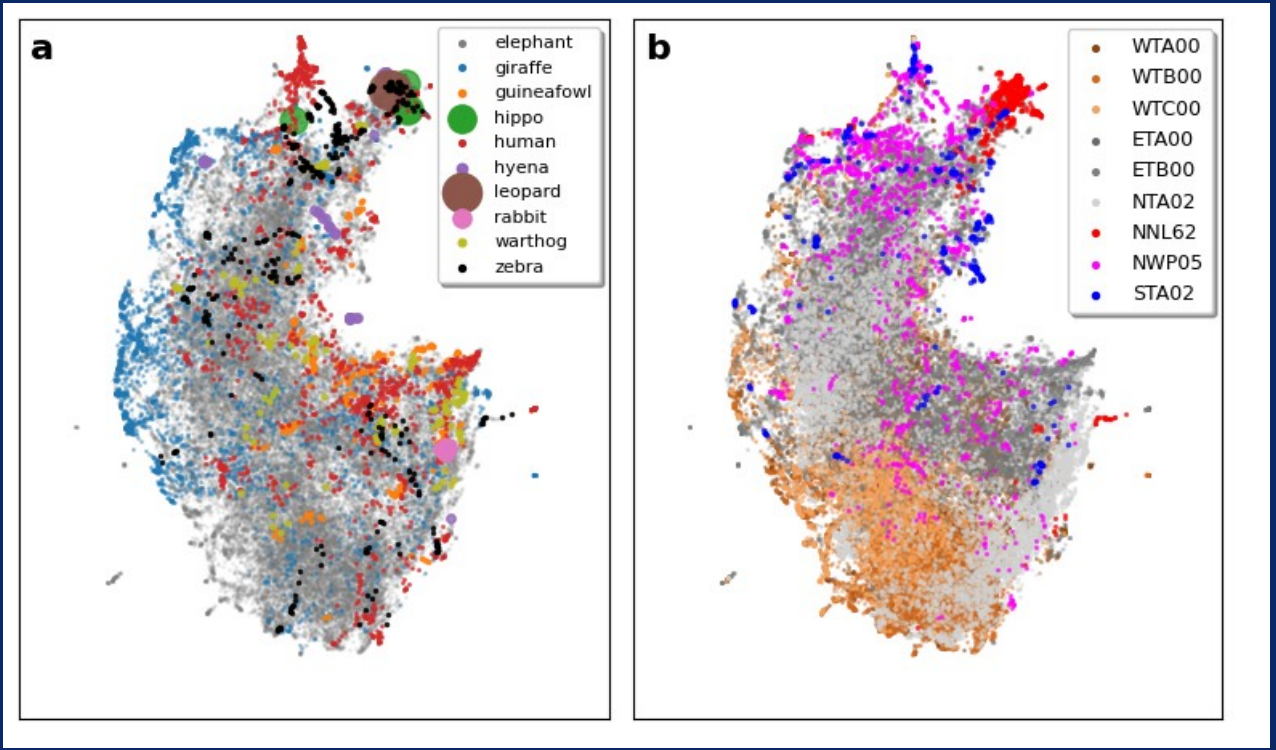
Signals are subject to path and site effects

hard-rock site | **close to water hole** | **distant giraffe at water hole**



Steinmann et al., 2025

Exploring the data with UMAP



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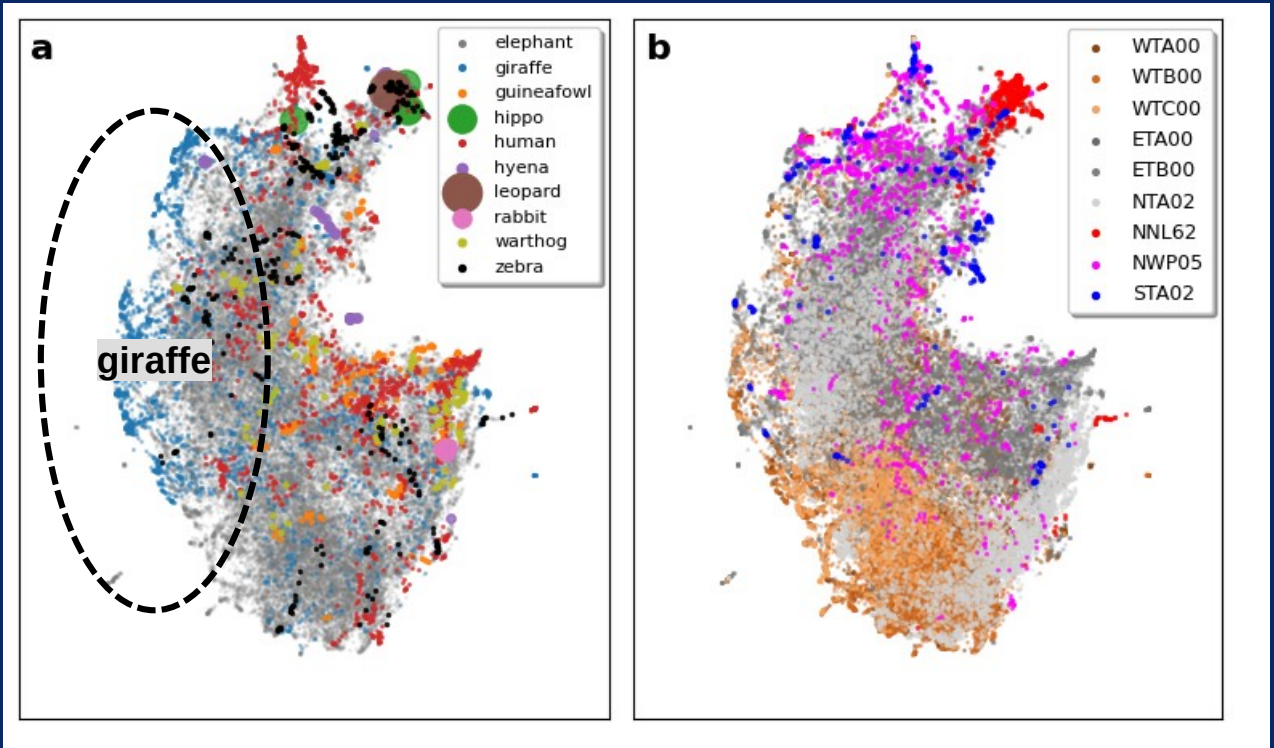

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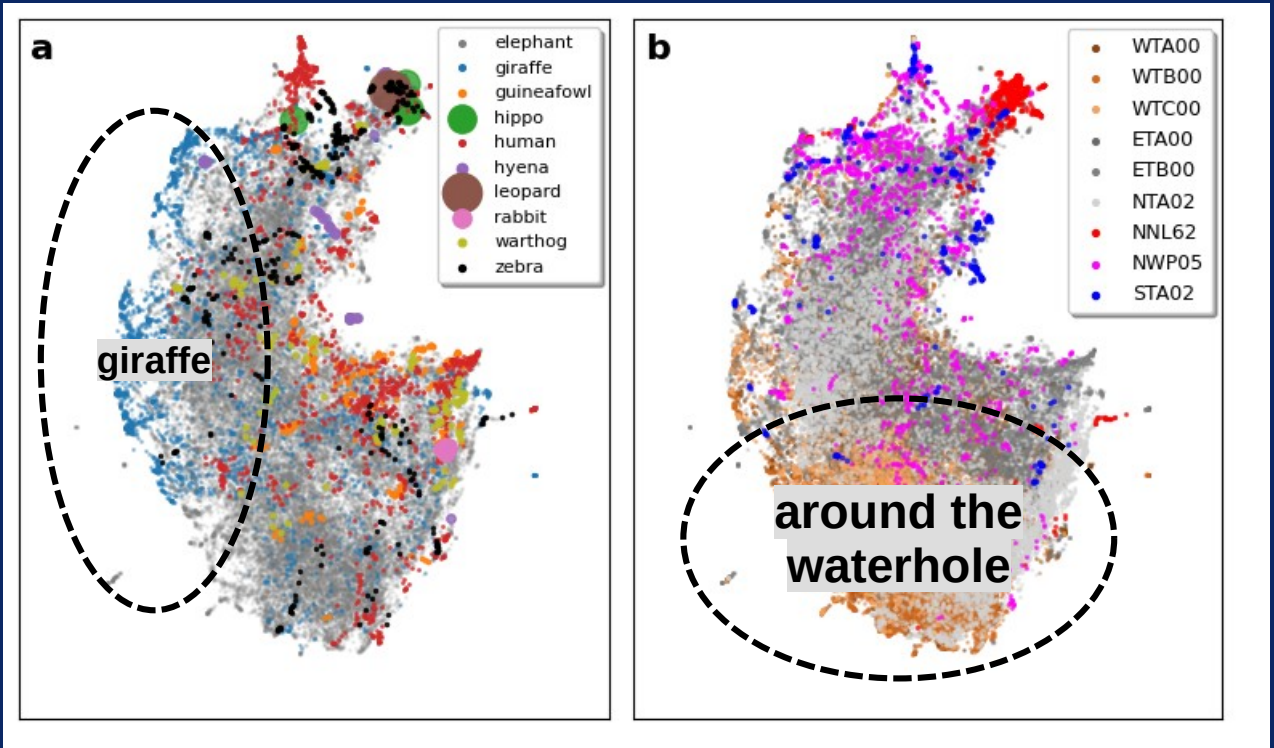

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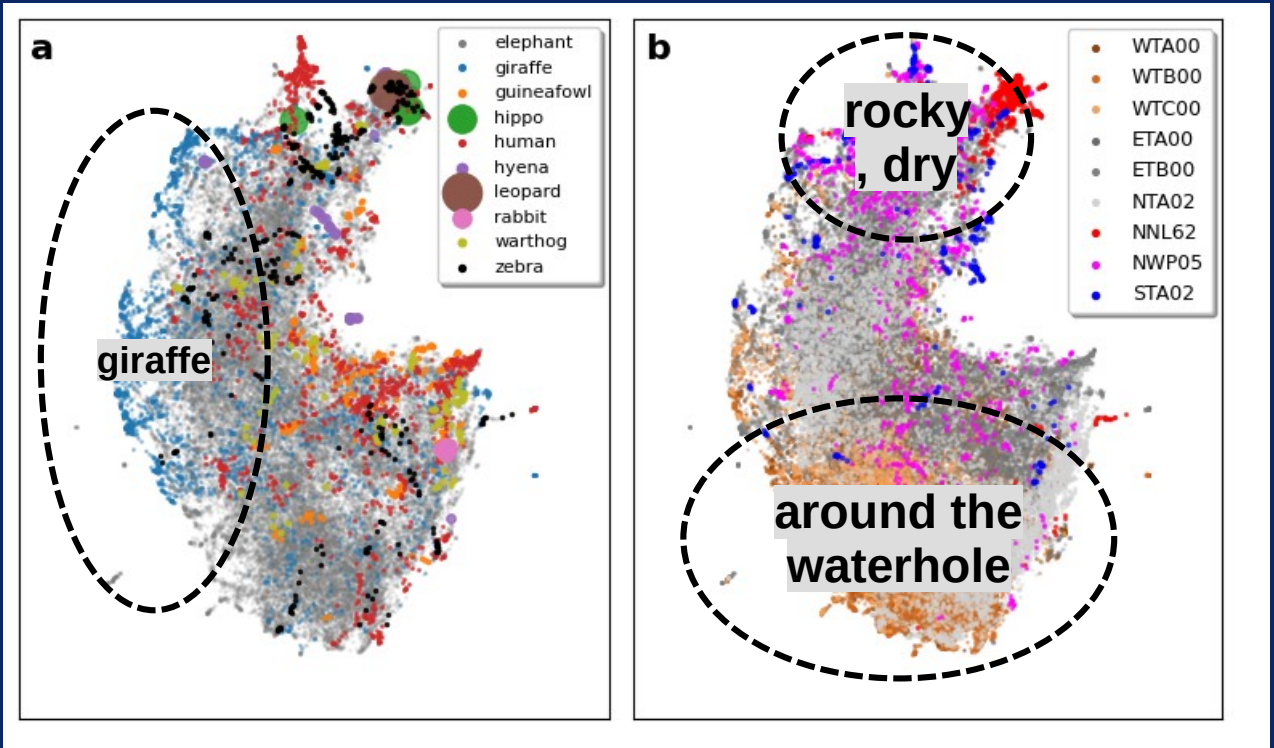

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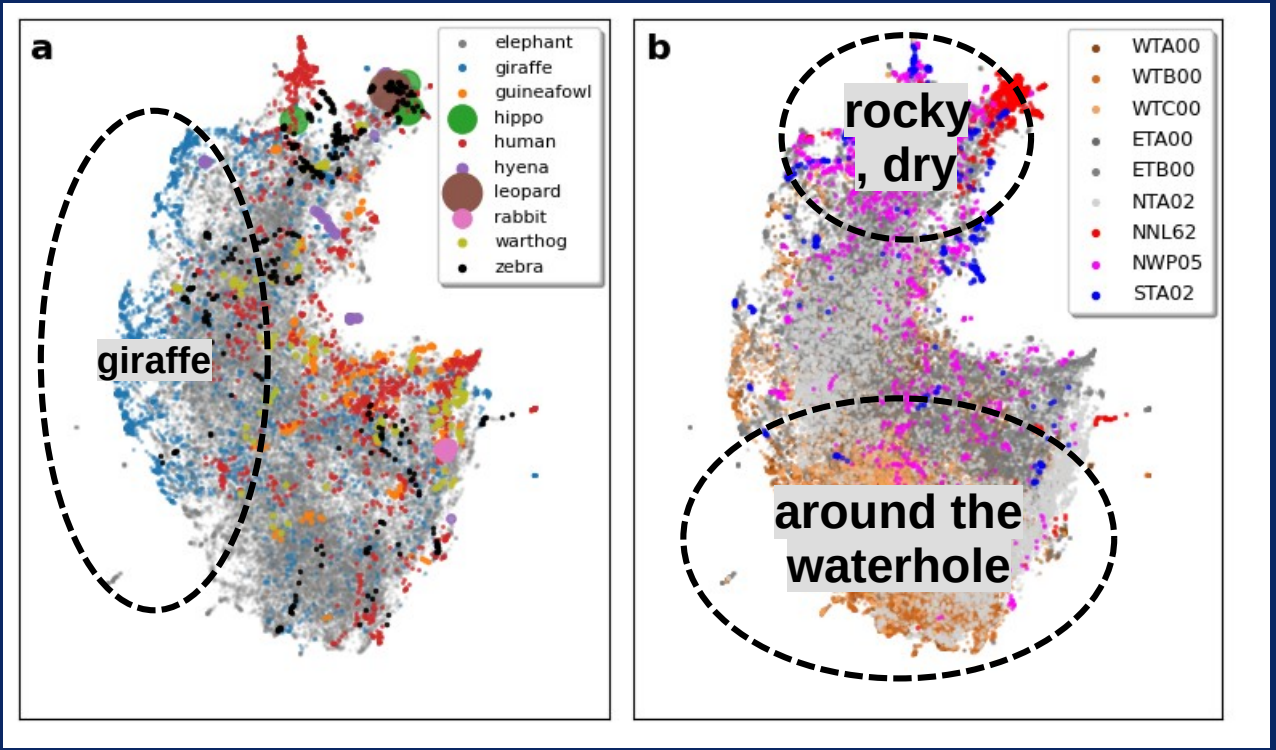

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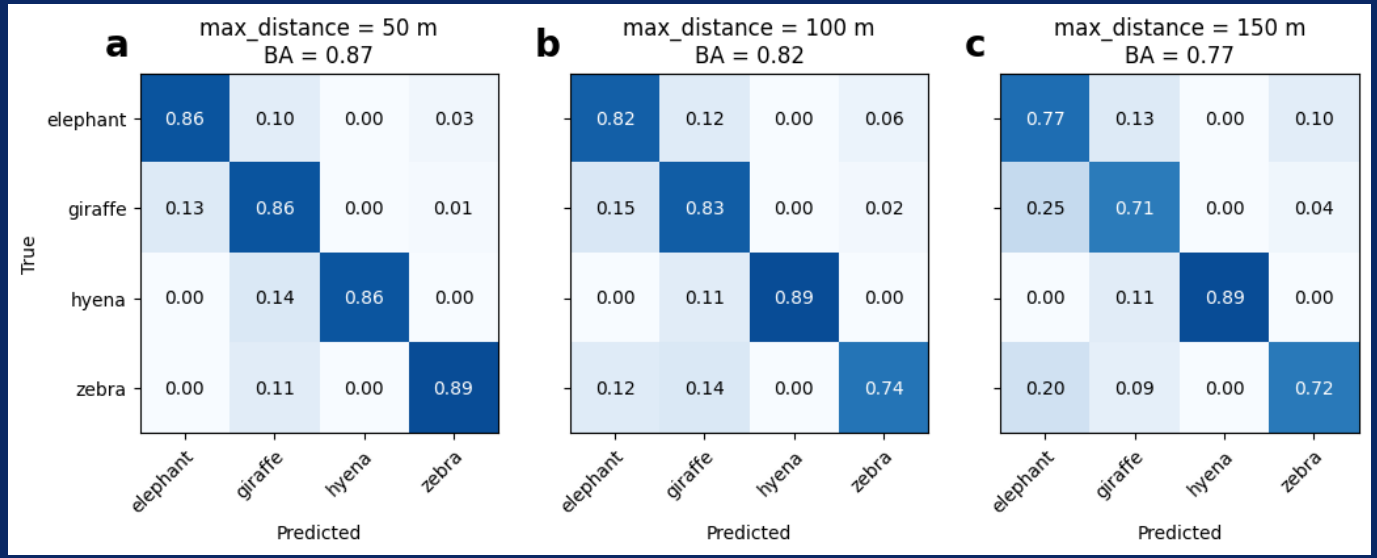
Wildlife classification needs to take into account the site effect!

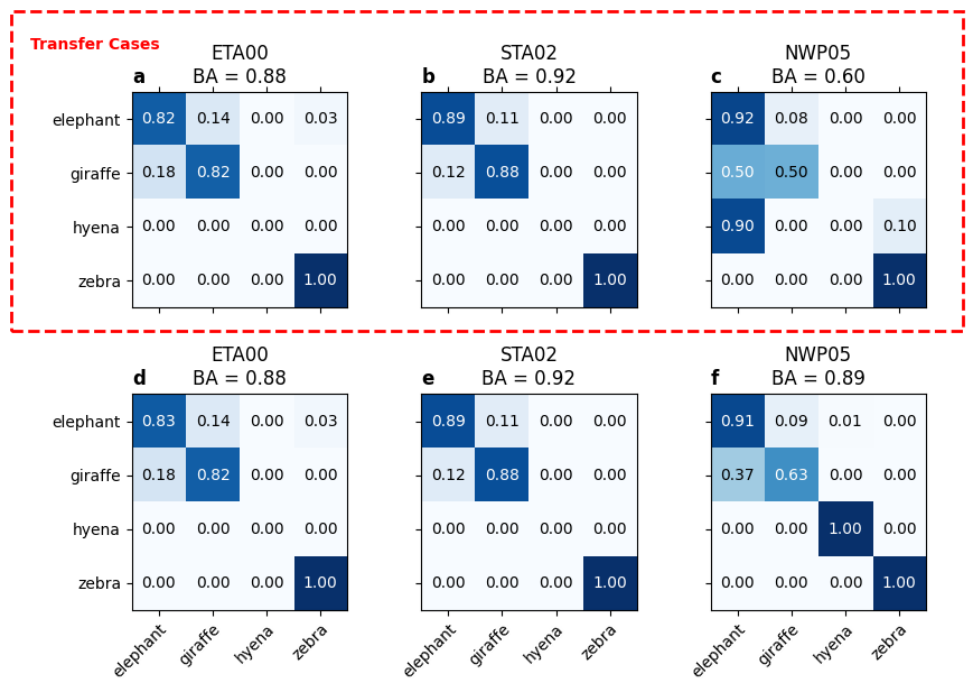
Support Vector Classifier exposed to all sites



increasing animal-sensor distance

Steinmann et al., 2025

Exposing the model to unseen station



Model has not seen test station

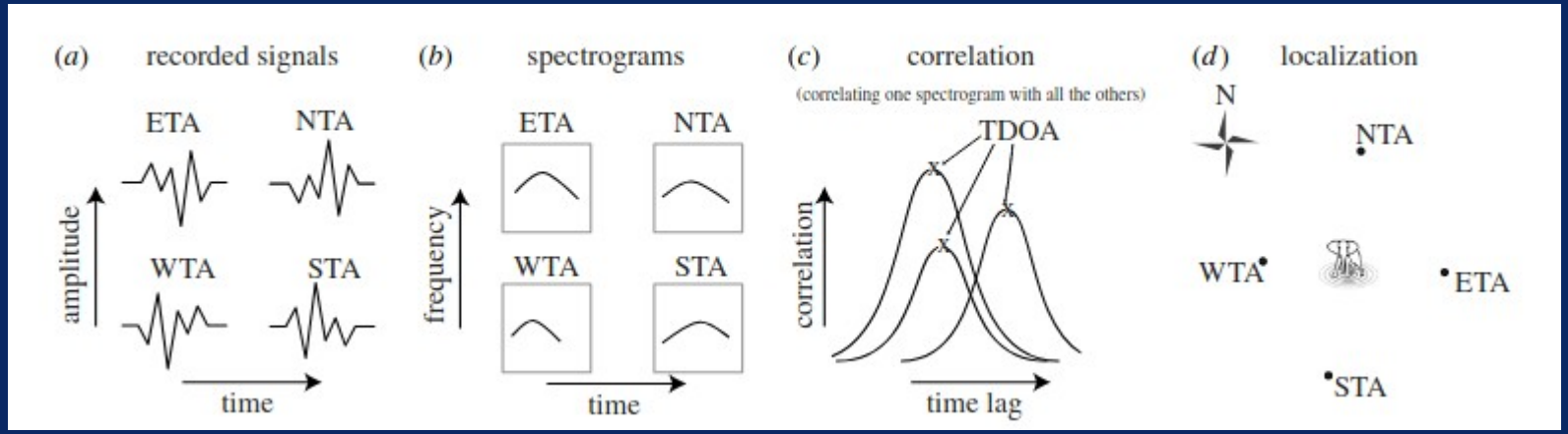
Model has seen test station

other stations nearby

other stations far, similar site

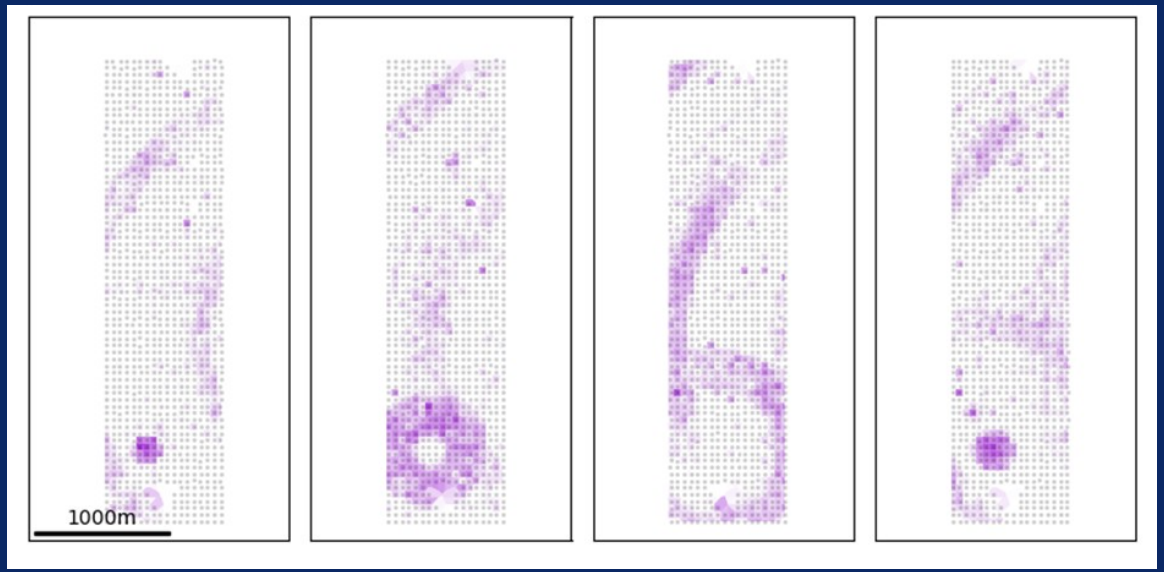
isolated station, different site

This is about footfalls, what about vocalizations?



Reinwald et al., 2021

Recording vocalization with large n-arrays



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Hending et al., in prep.

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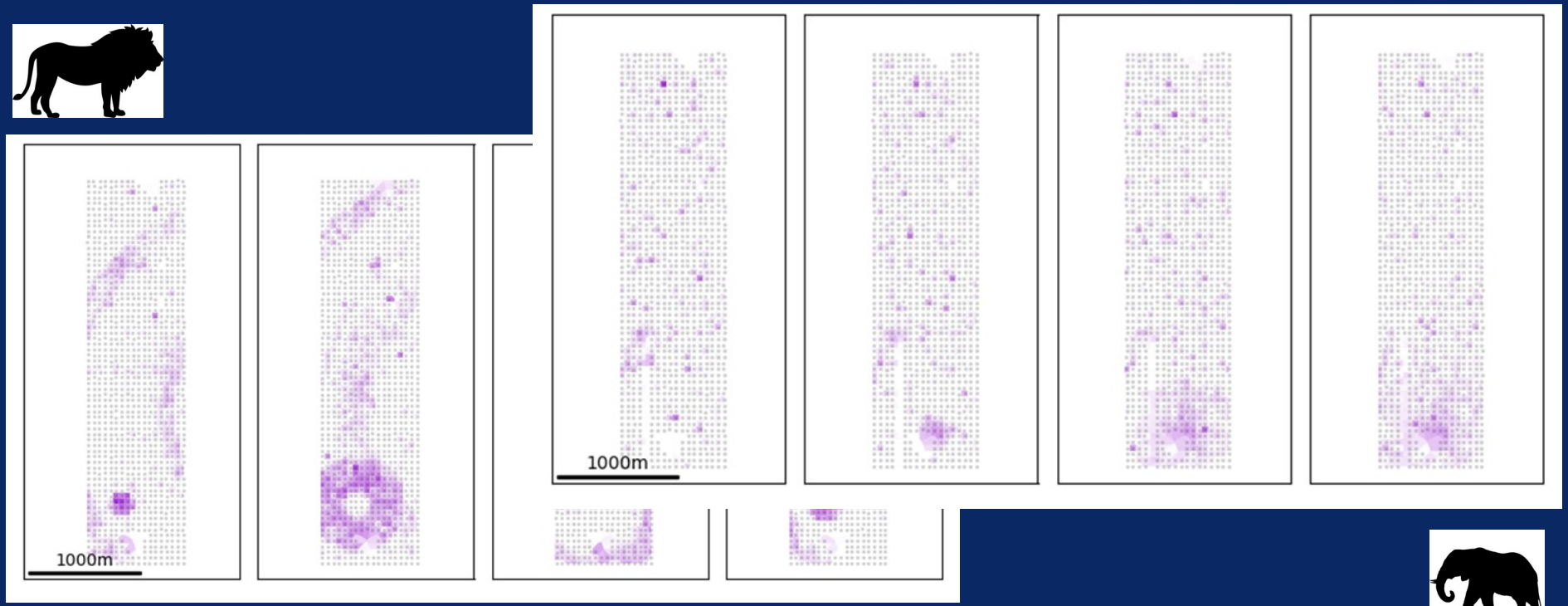

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Hending et al., in prep.

Three Key Messages

- Seismic sensors record footfalls and vocalization

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- Seismic sensors record footfalls and vocalization
- Useful to monitor and study wildlife, but first we need to turn signals into information
- Implications for biology and conservation?
- Next steps:
  - create machine-learning-ready dataset from 2023
  - Test supervised vs. pre-trained vs. self-supervised techniques
  - Monitoring wildlife activity in time and space