SOURCE LOCATIONS OF MICROSEISMS IN THE NORTH ATLANTIC FROM MATCHED FIELD PROCESSING USING FULL GREEN'S FUNCTIONS

Sven Schippkus[1] (sven.schippkus@uni-hamburg.de), **Céline Hadziioannou**[1]

[1] Universität Hamburg
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WHY USE FULL GREEN'S FUNCTIONS?

Matched Field Processing (MFP) is Beamforming in the **spatial domain**. This allows for **arbitrary wave propagation** instead of plane waves. **Usually**, the propagation information that the recorded data is **matched against** are estimated **source-receiver travel times**. We utilize **pre-computed Green's Functions (GFs)** for a 1D Earth and **match directly against them** instead of only single-phase travel times.

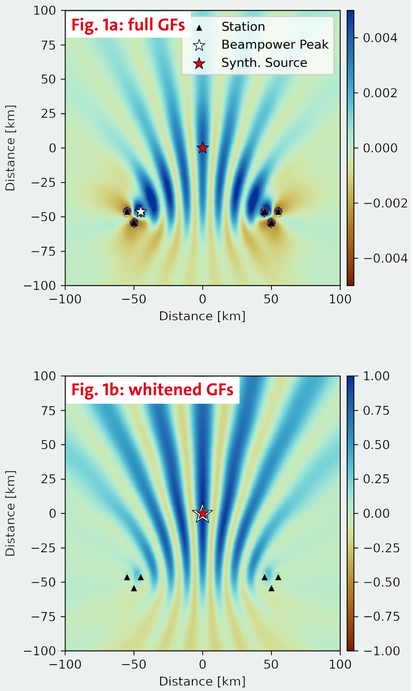
Here, we present some of the **challenges** that arise from this, discuss **potential solutions**, and present **first results** with real data.

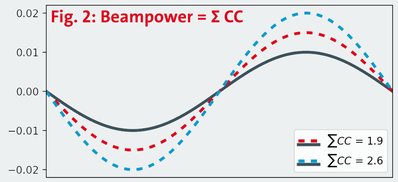
AMPLITUDES IN MATCHED FIELD PROCESSING

Because **MFP** is **correlation-based** (i.e., beampower is estimated as the sum of correlations), **beampower decreases** with distance as GF amplitudes decrease **due to geometrical spreading and attenuation** (**Fig. 1a**).

Beampower similarly **scales linearly with source amplitude**, **even if the waveform fit decreases** (**Fig. 2**). MFP itself is thus not suitable for iterative source inversion, but a useful starting point for other approaches[1].

Spectral whitening of the GFs resolves both of these issues, allowing to properly locate the source (**Fig. 1b**).

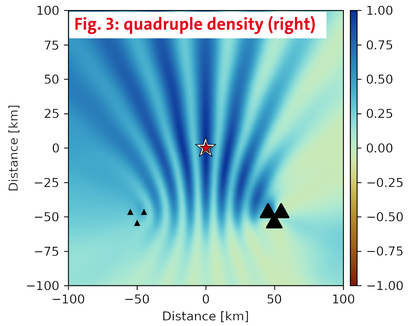




STATION DENSITY

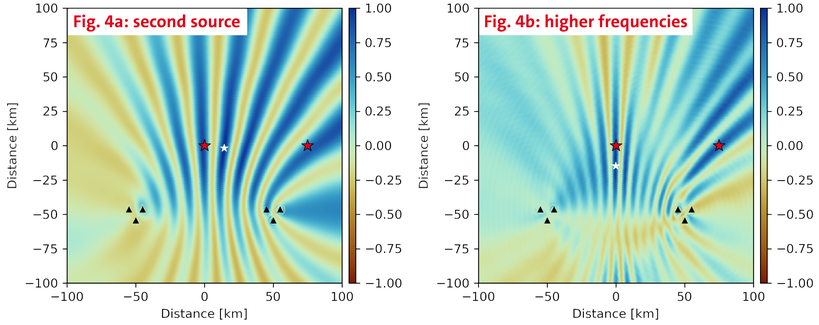
Station **density increases retrieved beampowers**. Counting the stations on one side multiple times shows a clear bias in retrieved beampowers, exclusively due to increased station density (**Fig. 3**).

This demonstrates that **best results** are achieved with **homogeneous** station distribution.



RESOLVING MULTIPLE SOURCES

Multiple sources may **not be well-resolved** even with synthetic data (**Fig. 4**), depending on the frequency band. Further processing may be necessary to improve results when limited to certain frequencies (e.g., microseism).



APPLICATION TO REAL DATA

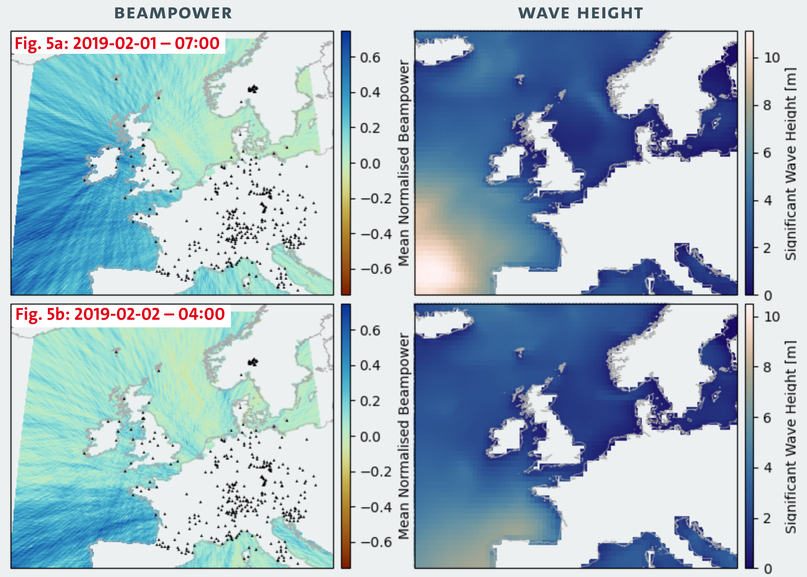
We apply MFP using pre-computed, whitened GFs to the **North-Eastern Atlantic**, matching data recorded on 342 seismic stations across Europe in the **secondary microseism** band (~7s) and **compare** with WaveWatch-III models of **significant wave height**[2] (**Fig. 5**). They **match** only **roughly**, likely biased by station density and geometry, multiple sources, and bathymetry.

TAKE-AWAYS

- "Full" Green's Functions in Matched Field Processing give a **clear way forward** to account for **complex structure** and **matching multiple phases**.
- MFP provides **high time-resolution** with data-focused approach
- Correlation-based measure brings **inherent limitations and challenges** (amplitude treatment, source strength, station density, multiple sources)

QUESTIONS FOR YOU

- What could be strategies to **handle MFP's inherent biases**?
- How could we **quantify uncertainty**/resolution?



REFERENCES

[1] Bowden et al. (2020). Connecting Beamforming and Kernel-based Noise Source Inversion. GJI. doi:10.1093/gji/ggaa539
[2] Ardhuin et al. (2011). Ocean wave sources of seismic noise. JGR. doi:10.1029/2011JC006952