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. 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 (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