

# Enhancement of Seismic Phase Identification using Polarization Filtering and Array Analysis

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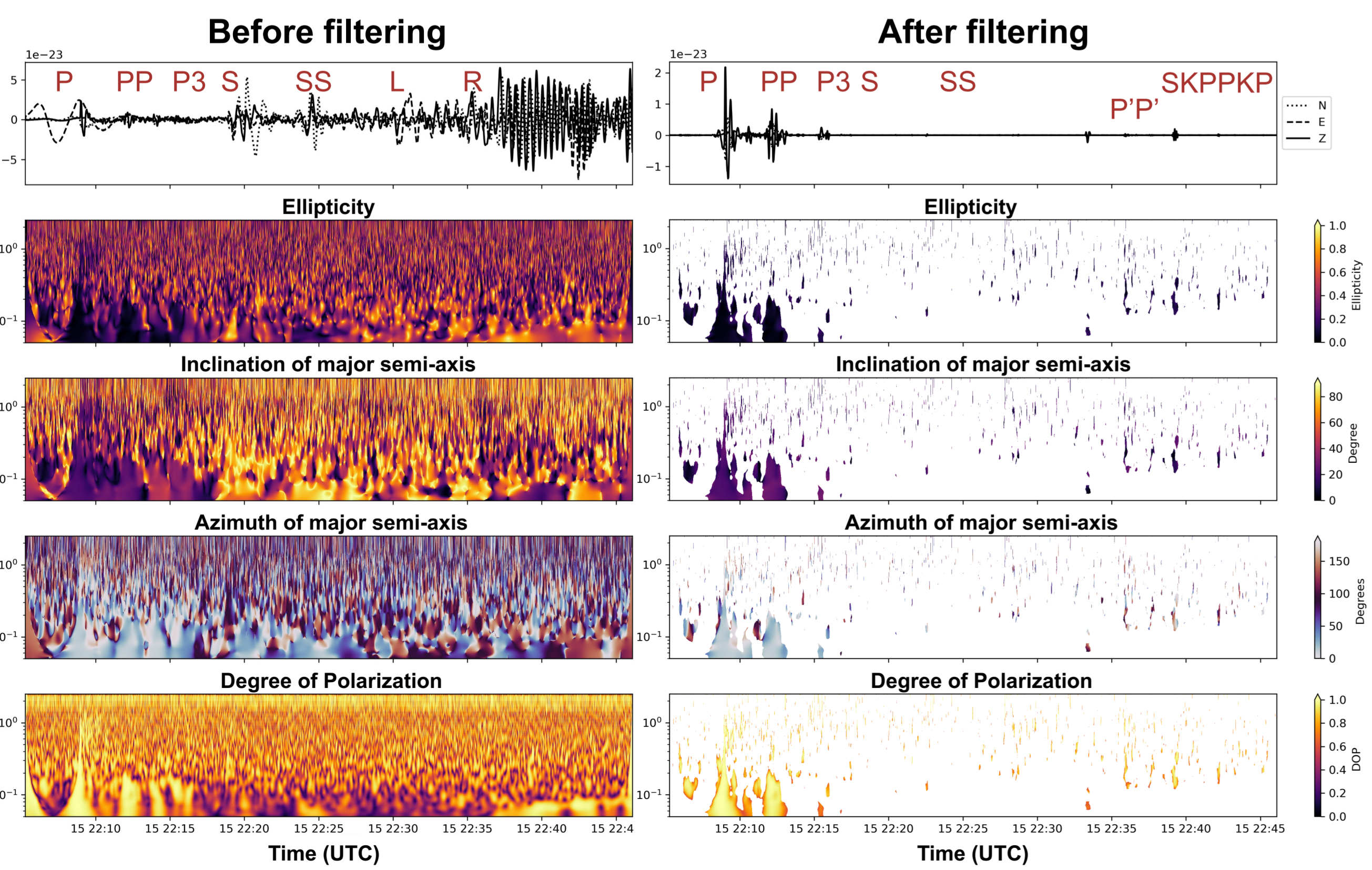
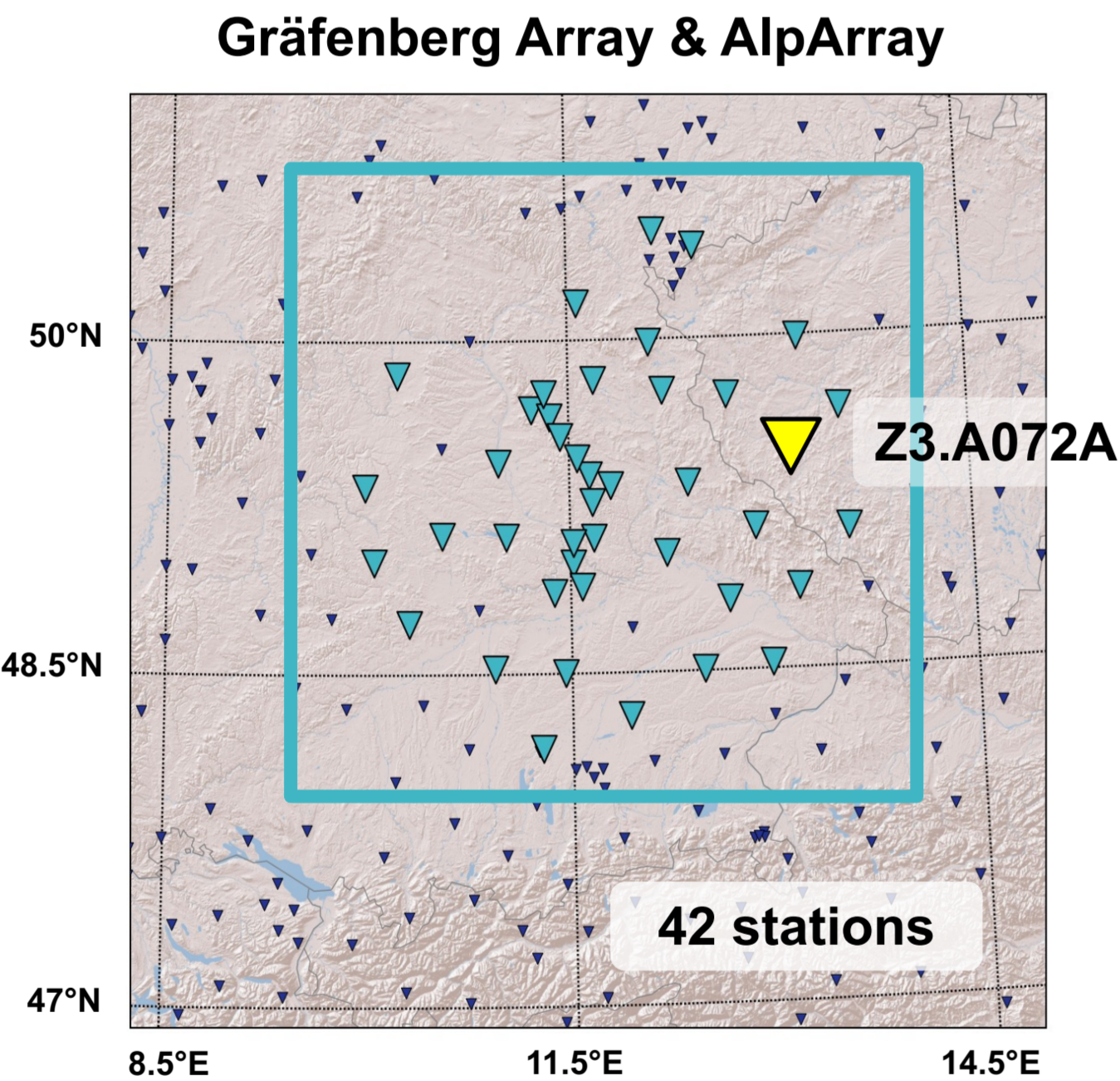
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## Objective

Examine whether the combination of polarization filtering in time-frequency domain with conventional array analysis can further increase the signal-to-noise ratio of coherent signals in a seismic wavefield, **allowing more robust phase identification and extraction.**

## Methods

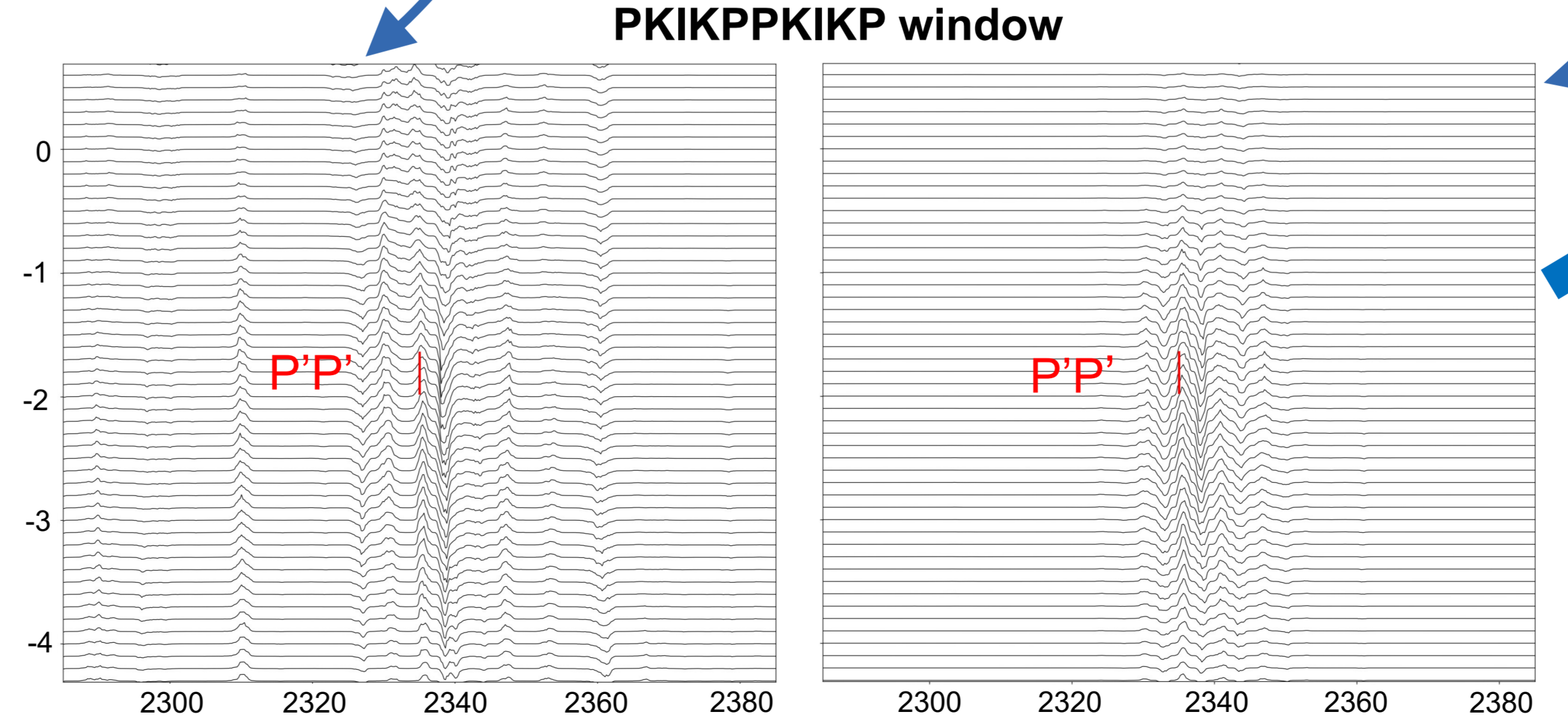
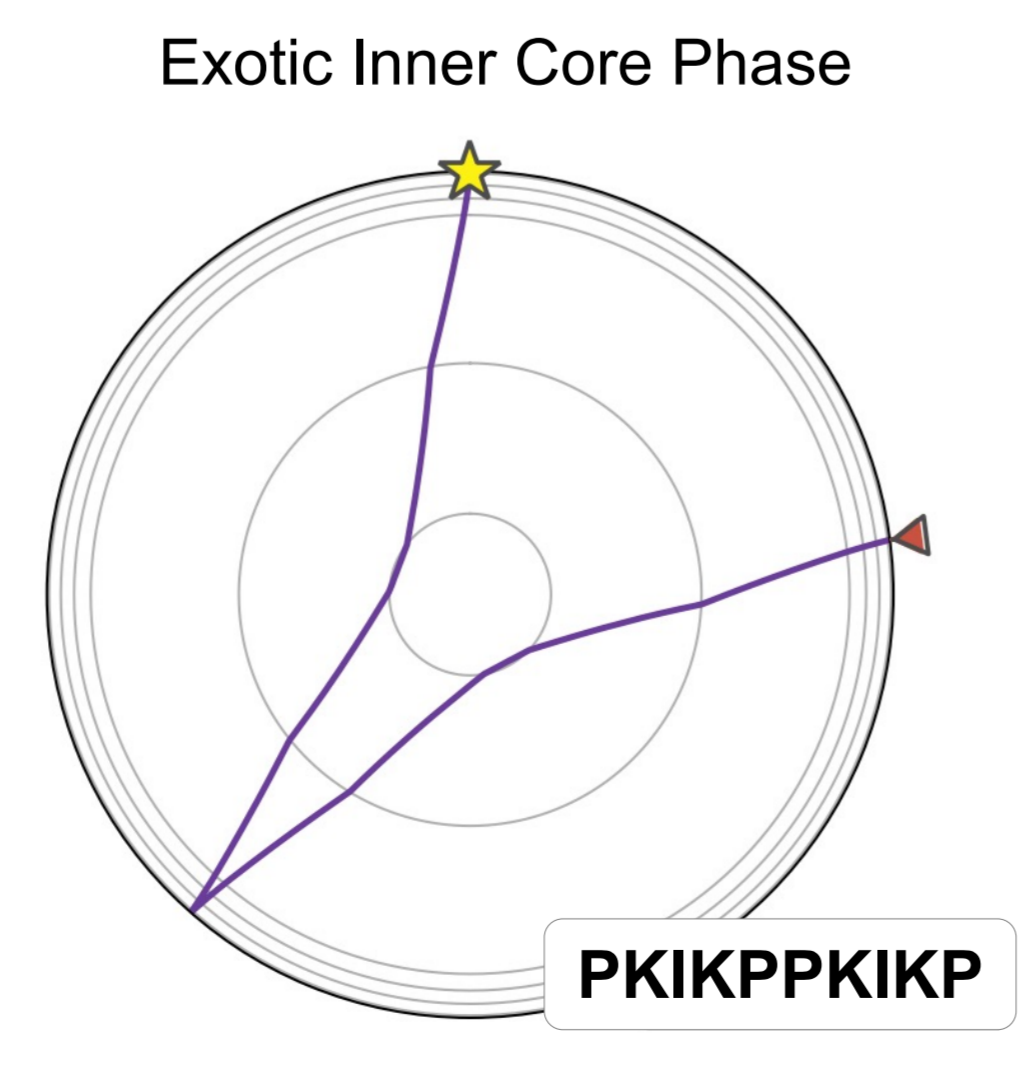
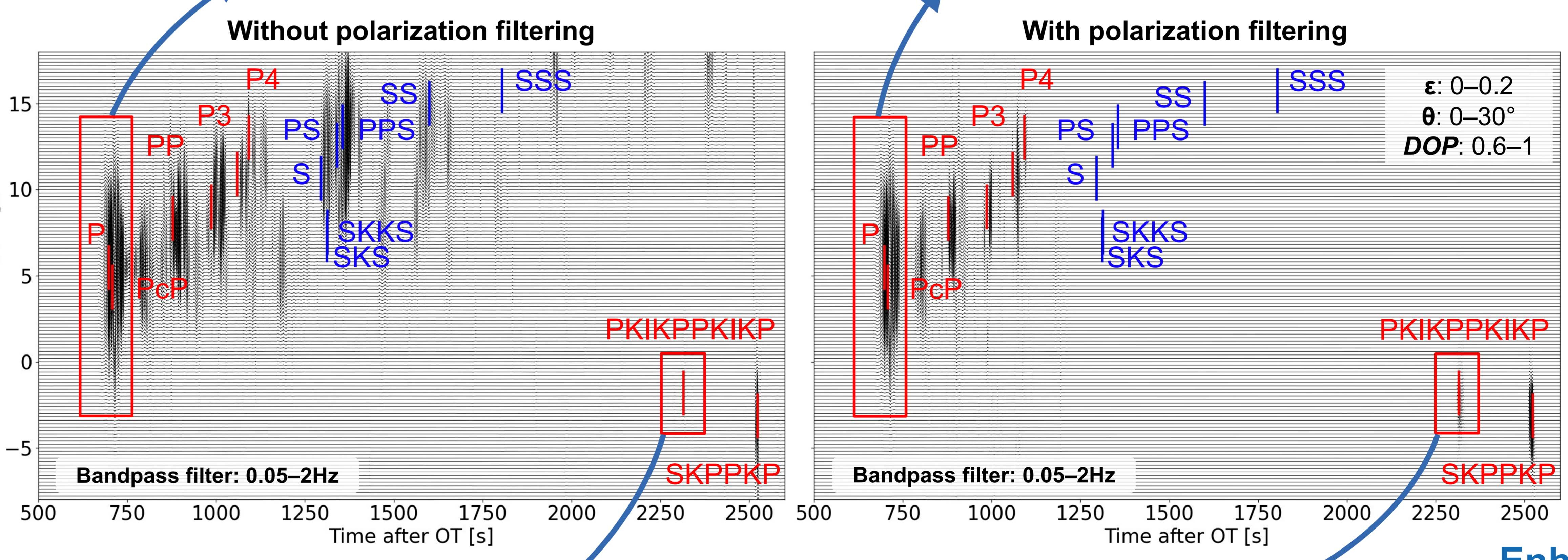
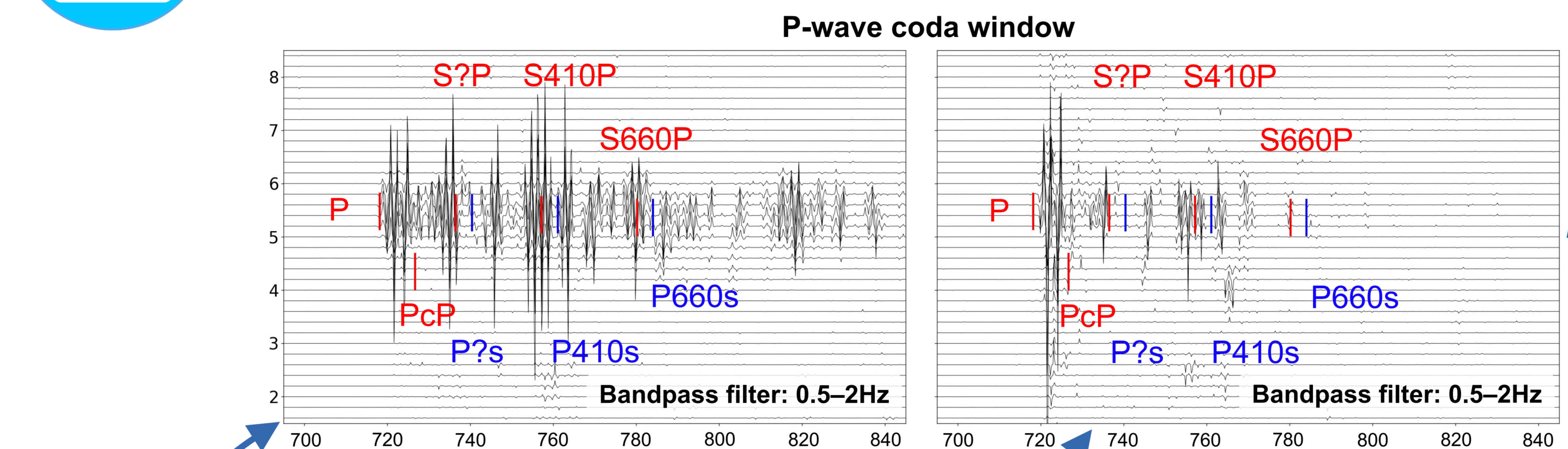
- Step1:** Perform polarization analysis and filtering in the  $t$ - $f$  domain using S-transform powered by *TwistPy* (Sollberger, D et al., 2023).
- Filters are designed based on polarization attributes: ellipticity ( $\epsilon$ ), inclination ( $\theta$ ) and azimuth of the major semi-axis ( $\phi$ ), and the "degree of polarization" (DOP).
- Step2:** Compute 4<sup>th</sup> root vespagrams. Elevation corrections are applied for beamforming.



3-component polarization analysis and filtering in the time-frequency domain of AlpArray station A720A (yellow triangle) of an example earthquake in Alaska in 2018. The waveform and spectrograms on the right are filtered mainly for linearly-polarized waves arriving with high inclination and DOP.

## Example Event

2018/08/15 Alaska  $M_w$ 6.5  
 Depth 33.9km, Distance 79.2°, BAZ 6.2°



The comparison of 4<sup>th</sup> root vespagrams of data with (right panel) and without (left panel) polarization filtering for waves arriving at high inclination, linearity, and DOP. The theoretical travel time and slowness of P and S phases are marked in red and blue based on Earth model ak135, respectively.

## Discussion

### Coherent Noise Suppression

- Polarization filters for waves with high inclination and linearity help **recover some of the weak converted phases** (esp. source-side conversions) at the upper mantle discontinuities buried in the long P-wave coda.
- Application:** It allows the **observation and study of weak SV-signals resulted from conversion** at interfaces with strong impedance contrasts (e.g., slabs) on the vertical component.

### Wavefield Separation

- Using customized polarization filters can **isolate more specific wave types** and study them individually.
- Application:** These wavefield-separated vespagrams are significantly easier to identify different type of phases and can be **used for pick refinements and identification of weak phases** that are usually hard to find in single seismograms.

### Enhancement of Weak Phases

- Coherent signals of the main arrival are enhanced which leads to a more **straightforward extraction of weak phases.**
- An **improved slowness resolution** is achieved without increasing the aperture or decreasing the inter-station spacing of the array.
- Application:** It benefits the remote areas without large/dense arrays.

### Limitations

- Unable to estimate polarization properties accurately when overlapping signals are present in the same analysis window. → **More challenging for analyzing local/regional events**
- Choosing the appropriate polarization filter involves a **trade-off** of reducing noise, time resolution, or preserving the desired signals.
- Accuracy of polarization analysis is **highly dependent on the quality of data and choice of analysis window length.**