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Wave Gradiometry and Continuous Wavelet Transform Thresholding

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A gradiometer array was deployed as part of the wavefields community experiment conducted by IRIS in the summer of 2016 near Enid, Oklahoma, USA. The gradiometer consisted of 7 levels of concentric square rings with each ring being four times the area of the immediate smaller ring; the largest ring spanned an 800X800 km^2 area. Each ring was made up of 16 three-component, 4.5 Hz nodal instruments. In a bid to appraise the effectiveness of the gradiometer in characterizing seismic waves, we computed seismic wave attributes in the form of apparent slowness and signal azimuth from gradiometer records of a magnitude 4.2 event that occurred during the wavefields experiment and compared these attributes with those computed from a coincidental, 3-km aperture phased array by means of a new array analysis method based on the continuous wavelet transform (CWT). Just as in gradiometry, the phased array technique provides wave attributes for all time points, which allows a point-for-point comparison of the gradiometry attributes with those for the phased array method. Prior to analysis, we extracted body wave phases from the gradiometer and phased array data by means of scale-time gating in the CWT space. This step was necessary to reduce the effect of seismic phase interference that can negatively impact gradiometry results. Gradiometry analysis of the vertical component data revealed a P wave horizontal phase velocity of 6.17+-0.04 km/s, which only deviates by 0.03 km/s from the phase array result obtained over an identical time window. The corresponding azimuth computed using gradiometry is 2.2 degrees off the great circle path between the event's epicenter and the gradiometer center. If the smallest gradiometer ring is labelled 1 and the rest progressively labelled based on their sizes up to 7, this optimal result was obtained using the gradiometer subarray that combines rings 1,3 and 5. Thus, the gradiometer with its relative portability may be preferred over a traditional phased array deployment in some geophysical campaigns. Using CWT thresholding techniques finds those areas of the wavelet transform plane that contain high SNR for useful processing using beam forming or gradiometry.