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Separated Wave-Field Imaging: Utilizing the Multiple Wavefield to Improve Sub-Surface Illumination for OBS Surveys

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ABSTRACT

Wave-equation migration consists of numerically extrapolating source and receiver wavefields into the subsurface, where an imaging principle is applied (Claerbout,1971). When imaging primary reflections, the source wavefield is initiated by a point source and propagated into the earth. The wavefield recorded at the surface is used as receiver wavefield. These surface recordings contain not only primary reflections but also multiple-scattered energy. When imaging primary reflections, the multiple-scattered waves are treated as noise that typically is attenuated in processing (e.g., surface-related multiple removal). In the last decade, we have seen the use of multiple reflections for imaging as opposed to removing them as noise (Berkhout and Verschuur,1994; Whitmore et al.,2010; Lu et al.,2015) thus greatly increasing the recovery of sub-surface information. Imaging using primary and multiples, referred to as Separated Wavefield Imaging (SWIM) is an innovative migration technology which takes advantage of the extended illumination provided by sea-surface reflections. The concept behind SWIM is based on using each receiver as a “virtual” source, expanding the surface coverage of the seismic experiment and enhancing the subsurface illumination, particularly for shallow reflectors. As a result, the equivalent survey provides an image with a greater sampling both in terms of spatial extent and in terms of angular reflectivity information. By reciprocity, we adapt the method from towed streamer acquisition to any ocean-bottom seismic survey where the shot distribution for each receiver is typically very wide. Instead of shot-profile migration, receiver-profile migration is applied in a fashion which effectively turns every source point into a virtual receiver (and source) array (Lecerf et al., 2015). This principle is independent of the wave-equation propagation algorithm, which can be based on one-way or two-way solutions. In this paper the application of this technology is shown to OBC/OBN datasets, where imaging was achieved using a one-way wave equation migration. Finally, the pre-stack angle domain output enables AVA analysis and velocity model building, in particular in shallow water areas where imaging using primary only clearly suffers. Since the effectiveness of the method mainly relies on the distribution of shots, we suggest that this technology will benefit in reducing the cost of OBS acquisition which greatly depends on the number of receiver used.