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Continuous Wavefields Method - Results from a Shallow Water Field Test

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Summary

In the autumn of 2019, PGS acquired a small 2D test offshore Malaysia in water depths ranging mainly between 125 and 200m. The primary purpose of this test was to demonstrate the continuous wavefields method in shallow water areas. In addition, different source configurations and time intervals between consecutive actuations of air-guns were tested. In this paper we discuss the different source configurations that were tested, and present preliminary results. The overall sound exposure levels (SEL) are very similar for the different source configurations. The small differences are mainly related to trigger time intervals of the individual air-guns, and to air-pressure. Preliminary results achieved so far indicate that the continuous wavefields method works well in shallow water, and with relatively small differences between the different triggering schemes and source configurations.

Introduction

The continuous wavefields method utilizes continuous wavefields on both the source and on the receiver side. The main objectives with the method are reduced environmental impact of marine seismic sources, improved acquisition efficiency, and denser sampling of source positions both in the inline and cross-line directions. It was first introduced in Hegna et al. (2018) and Klüver et al. (2018), and is further described in Hegna et al. (2019).

In summer 2018, PGS successfully acquired a ~250 km^2 3D pilot survey offshore Brazil using the continuous wavefields method. The results were presented in Klüver et al. (2019). The survey was acquired in water depths ranging between approximately 1,600 and 2,000 m. A small 2D test was acquired offshore Malaysia during the autumn of 2019 in water depths ranging mainly between 125 and 200 m (Figure 1). The primary purpose of this test was to demonstrate the continuous wavefields method in shallow water areas. In addition, different source configurations and time intervals between consecutive actuations of air-guns were tested. In this paper we present source configurations that have been tested with their sound exposure levels (SEL), and the preliminary results.

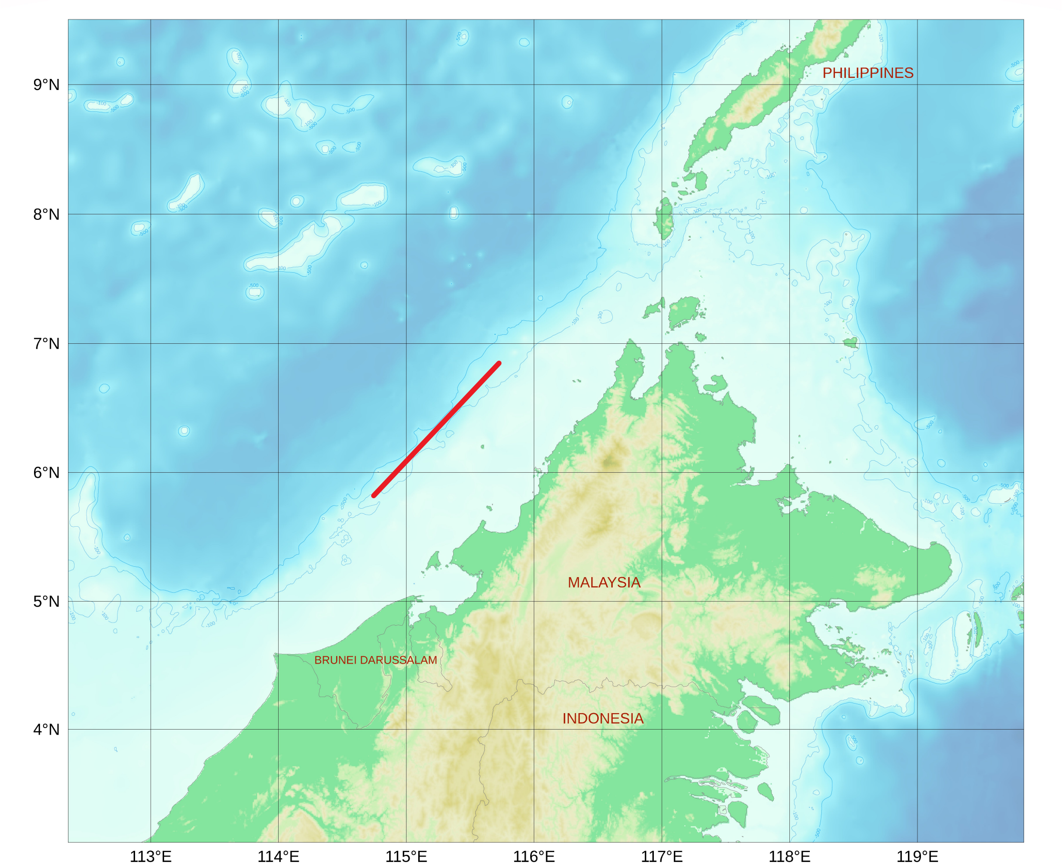

***Figure 1** Map showing the location of the 2D shallow water test line (red) acquired offshore Malaysia.*

Source Configurations

The source configurations used for the deep water 2018 Brazil survey and for the 2019 2D shallow water test are summarized in Table 1. Each air gun is triggered individually with a randomized time interval. The mean trigger time intervals for the different configurations are listed in Table 1. In addition to the different configurations and triggering schemes shown in Table 1, air-pressures of 1,500 and 2,000 PSI, and 5 and 6 m source depths were tested. Streamers of 8,100 m lengths with both motion and pressure sensors were used for both the deep water 2018 Brazil survey and for the shallow water 2019 2D tests.

Survey / Test	No. strings	Nominal string separation (m)	Air-guns per string (CUI)	Mean trigger interval (ms)
Deep water 3D pilot survey	6	16.67	2x45, 2x90, 2x150 (570)	290
Shallow water 2D Test 1	6	16.67	2x40, 2x90, 2x150 (560)	290
Shallow water 2D Test 2	6	16.67	2x40, 2x90, 2x150 (560)	200
Shallow water 2D Test 3	6	16.67	20, 40, 60, 90 (210)	208

Table 1 *Source configurations used for the deep water 2018 Brazil survey, and for the shallow water 2019 2D tests.*

In addition to different mean trigger time intervals between the tests, the randomization window is much larger in Test 3 compared to Test 1 and 2. Figure 2 shows the mean notional source signatures for each air-gun volume derived from the recorded near-field hydrophone data. The maximum amplitude levels of the notional source signatures for Test 3 are slightly lower compared to the other tests due to smaller air-gun volumes.

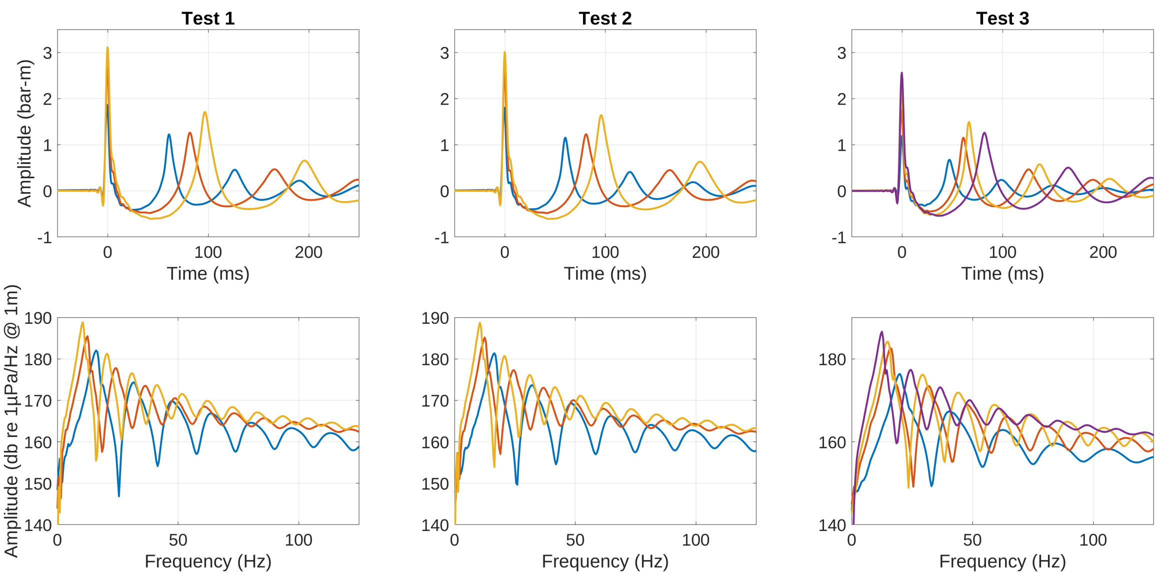

Figure 2 *Notional source signatures for each air-gun volume. Volumes in Test 1 (left) and Test 2 (middle) are 40 (blue), 90 (red) and 150 (yellow) CUI, and volumes in Test 3 (right) are 20 (blue), 40 (red), 60 (yellow) and 90 (magenta) CUI.*

The sound exposure levels (SEL) shown in Figure 3 have been derived from the acquired data for the different tests listed in Table 1 and for 2,000 and 1,500 PSI. These are compared to the deep water 3D pilot survey and a 3D survey acquired in the same deep water area with conventional 4130 cubic inch dual source arrays. The sound exposure levels are determined from the recorded pressure sensor data with a 10 seconds integration length. In contrast to the data acquired in deep water where the amplitude levels for the near offsets are dominated by the direct waves, the amplitude levels in the shallow water case are highly affected by the local geology. Therefore, to make the SEL comparable between the different data sets, the SEL in the shallow water case are computed from the extracted direct waves only, excluding the reflections. The SEL are very similar between the data acquired with the continuous wavefields method in deep water and in shallow water. In general the sound exposure levels are slightly higher for Test 2 compared to 1 and 3 due to the denser trigger time interval compared to Test 1, and larger volumes compared to Test 3.

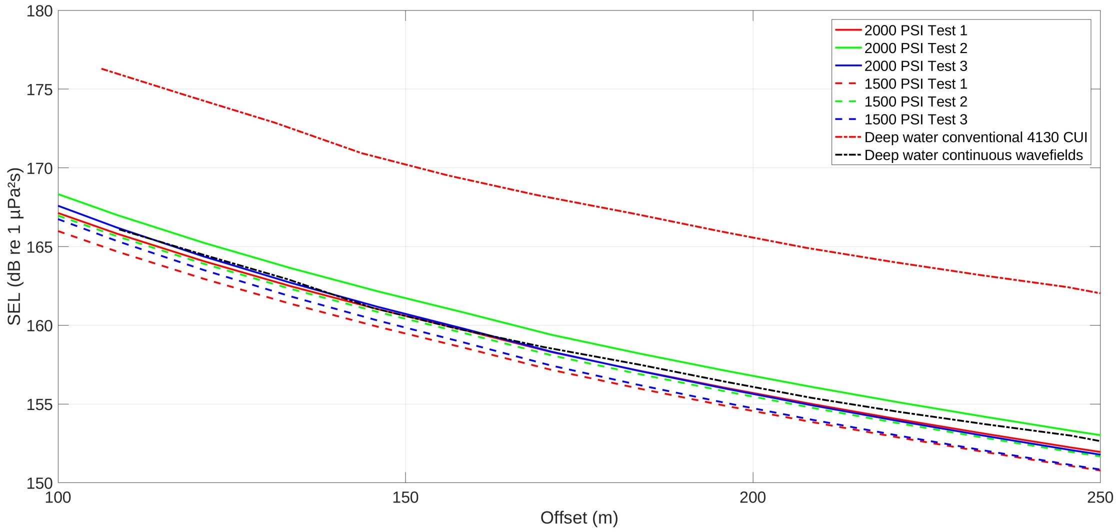

Figure 3 *Sound exposure levels derived from extracted direct waves for Tests 1 (red), 2 (green), 3 (blue), 2000 (solid) and 1500 (dashed) PSI. For comparison, SEL from the 2018 deep water surveys are shown. The red dash-dot line shows the SEL for a conventional 4130 CUI source array triggered with a 25m shot-point interval (flip-flop), and the black dash-dot line shows the SEL for the deep water 3D pilot acquired with the continuous wavefields method.*

Data Examples

Preliminary results from pre-processing of raw data show limited differences between the different source configurations and triggering schemes with perhaps slightly more noise in Test 3. However, since the different tests were acquired in different locations along the same 2D line trajectory, geological variations prevent a detailed comparison of the different configurations. Figure 4 shows a comparison of common receiver gathers for Tests 1, 2 and 3 after source deconvolution.

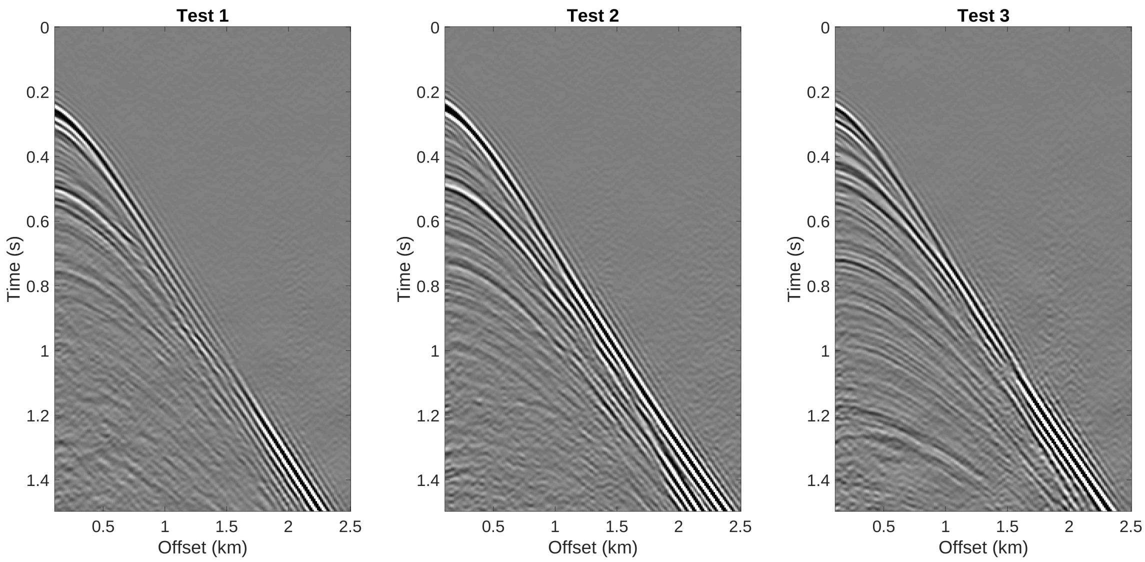

Figure 4 *Common receiver gathers for Test 1 (left), Test2 (middle) and Test 3 (right). The source deconvolution has been applied to raw recorded data with no noise attenuation, and after receiver motion correction. A* T^2 *time variant gain, 2-4 – 50-60 Hz band-pass filter, and filtering of the evanescent region have been applied for display purposes. The gathers are in different locations.*

Figure 5 shows a 2D migrated brute stack with minimal processing of the data from Test 1. These results have been made using a single 1D velocity function for the NMO correction and 2D Stolt migration.

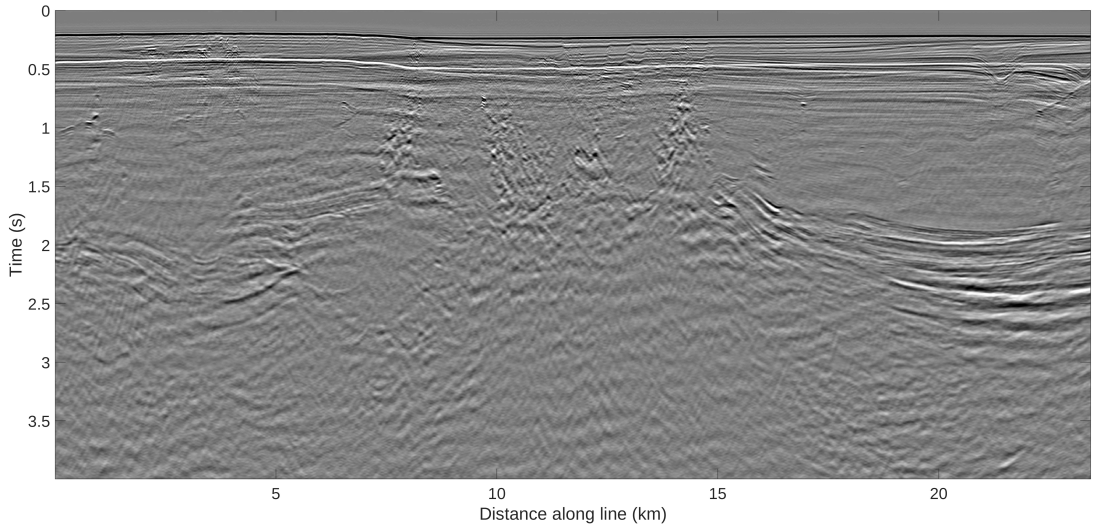

Figure 5 *Brute stack after 2D Stolt migration based on data from Test 1, 5m source depth, 2000 PSI air pressure. A 2.5-5 – 50-60 Hz band-pass filter and a T^2 time variant gain have been applied for display purposes.*

Conclusions

A field test of the continuous wavefields method in shallow water and with different source configurations and triggering schemes was successfully completed offshore Malaysia during the autumn of 2019. The overall sound exposure levels are very similar to data acquired in a deep water area offshore Brazil, when deriving the SEL from the direct waves. The differences in SEL between the different source configurations and triggering schemes tested are related to differences in air-pressure and mean trigger time intervals. The differences between 1500 PSI and 2000 PSI air pressures is 1.5 – 2 dB, whereas Test 2 with a 200 ms mean trigger time interval shows ~ 1 dB higher SEL compared to Test 1 with the same source set-up but 290 ms mean trigger time interval. Preliminary results achieved so far indicate that the continuous wavefields method works well in shallow water, and with relatively small differences between the different triggering schemes and source configurations. More results and detailed comparisons will be presented.

Acknowledgements

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