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Testing multi-component fibre-optic sensors

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Summary

We previously installed (Innanen et al., 2019) and tested (Hall et al., 2020, 2021, 2023) a buried multi-component fibre sensor called the Pretzel at the Carbon Management Canada (CMC) Newell County Facility in southern Alberta. The Pretzel consists of two 10x10 m horizontal squares buried at 2 m depth where each 10 m side of the Pretzel is longer than our typical 7 m gauge length. The Pretzel is too large to feasibly include a vertical component. Following lab tests where test data was recorded on loops of fibre ≤ 7 m gauge length, three 1x1x1 m sensors (the Croissant) were installed in and around the Pretzel and tested in 2023. Initial results show good comparability to Pretzel data as well as to horizontal component surface geophone data after converting from velocity to strain-rate.

Field Method

Takekawa et al. (2022) showed results for a 25x25x25 cm 3C fibre sensor using a gauge length that was smaller than the sides of the sensor, and smaller than is available from our interrogator. We decided to test if we can acquire valid data from sensors with fibre lengths less than the gauge length. Six 1x1 m plastic frames were constructed and wrapped with 28 m of fibre per component. The frames were buried vertically with the tops of the frames approximately 10-15 cm below the surface (Figure 1). Twenty-four Vibe Points (VP) were acquired on the Pretzel, the Croissant, and surface 3C geophones for testing, with full azimuthal coverage and offsets ranging from 72 to 168 m from the centre of the Pretzel.

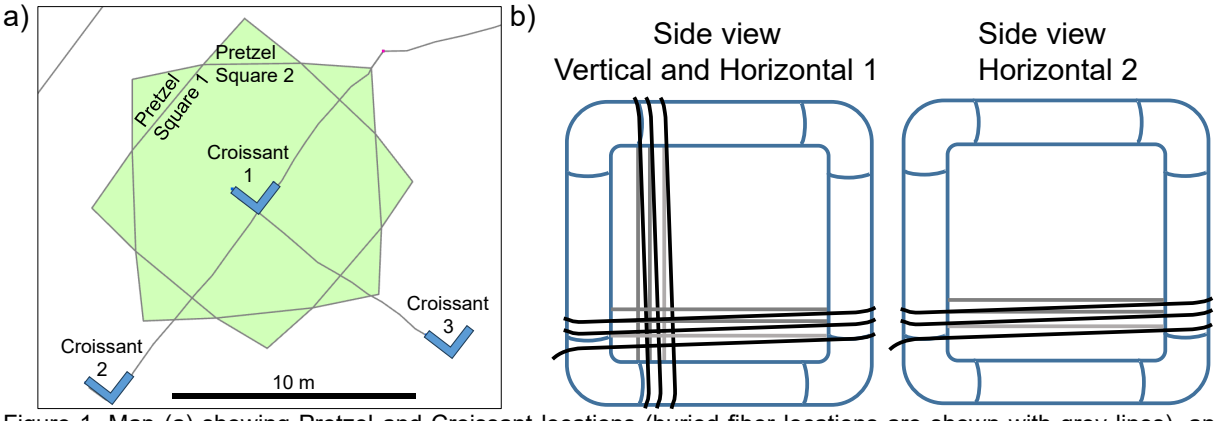

Figure 1. Map (a) showing Pretzel and Croissant locations (buried fiber locations are shown with grey lines), and a schematic (b) showing wrapped fiber orientation on two 1x1 m plastic frames that were installed vertically at each Croissant location (blue chevrons, Figure 1a).

Results and Observations

It is a difficult and interpretive process to pick a representative trace from each side of the Pretzel as it is too large to be considered a point receiver (left side, Figure 2). In contrast,

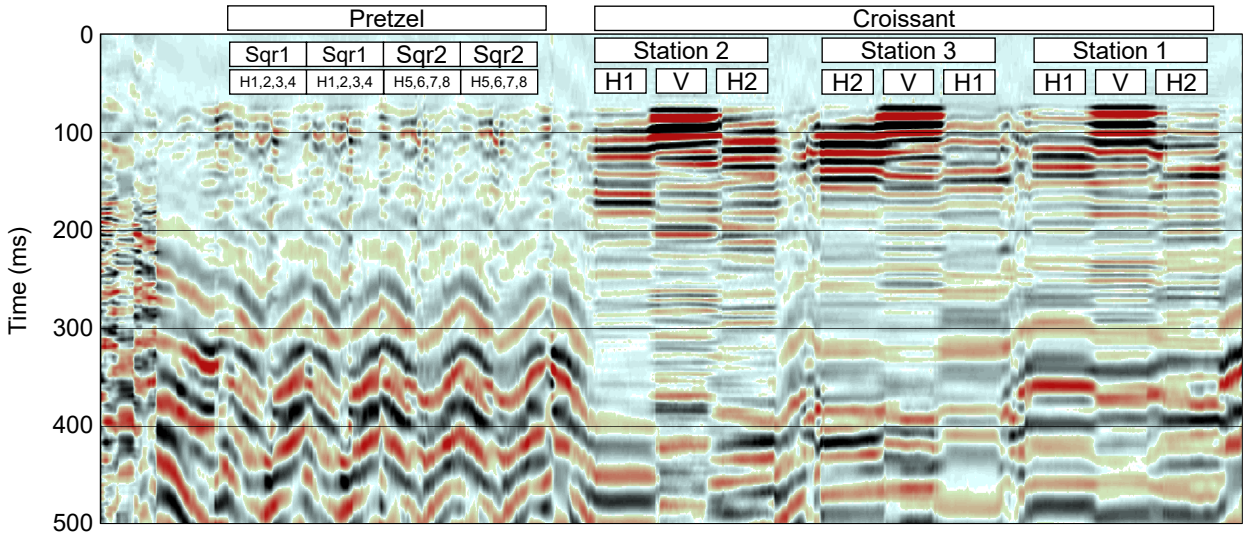

Figure 2. Pretzel and Croissant field data example.

Croissant data is easy to interpret, as the data looks similar across all traces in each loop of each component (right side, Figure 2). Air blast is observed on Croissant data, particularly on the vertical component as the fibre is closer to the surface than the Pretzel fibre. Both sensors exhibit broadside insensitivity for shots that are perpendicular to fibre axes (cf. Mateeva, 2012). Horizontal component Croissant data is very comparable to horizontal component surface geophone data after conversion from velocity to strain-rate.

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