High-resolution 3D seismic acquisition at the Tomakomai CO_2 storage project, offshore Hokkaido, Japan

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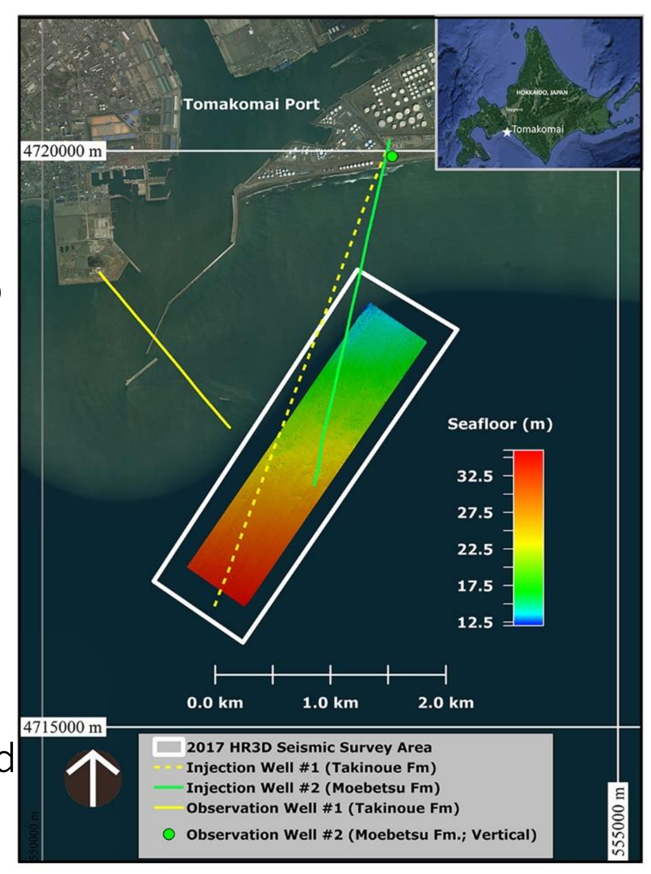
Abstract

Monitoring injected CO2 is an important part of assuring permanence of long term storage to mitigate atmospheric emissions. Three-dimensional (3D) seismic has been shown to be an effective technology for visualizing and measuring subsurface geology and fluids.

In this study, we demonstrate the acquisition, processing and initial interpretation of a high-resolution 3D (HR3D) seismic survey in Tomakomai, offshore Japan, above an active offshore CO2 injection site [1]. The successful deployment of this novel marine seismic monitoring technology validates HR3D as an appropriate characterization and monitoring tool for large-demonstration and commercial-scale offshore Carbon Capture and Storage (CCS) sites.

Introduction

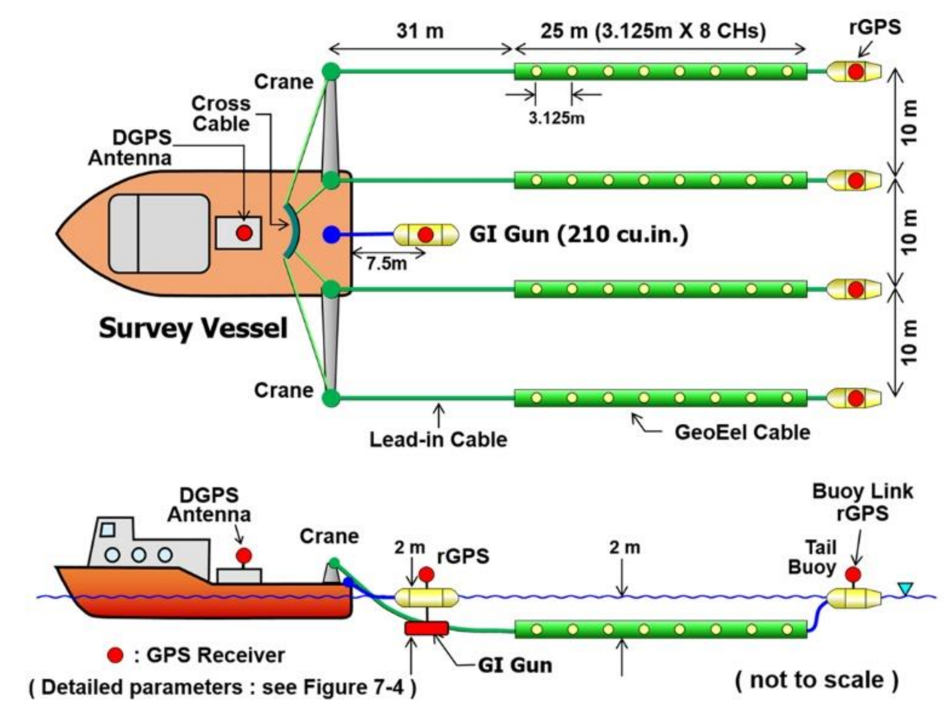
As the first application of marine HR3D seismic technology for CCS monitoring, the goal of the HR3D deployment is to validate the technology for CCS projects monitoring in the following ways: 1) mapping of the geologic overburden above the injection interval in high resolution; 2) attempt to image CO2 injected into the storage reservoir at approximately 1,000 meters below the seafloor; and 3) to evaluate repeatability to inform capabilities for time-lapse studies comparing multiple HR3D acquisitions. The survey location is 1 to 3.5 km offshore Tomakomai city in Hokkaido with water depth of 10 to 35 m, where a CO_2 injection operation has been conducted by JCCS as the first integrated industrial demonstration project of offshore CCS in Japan.



HR3D uses closely spaced, short-offset streamers to achieve high resolution of typically the upper kilometer of stratigraphy [2]. However, the short offset and low-fold coverage creates new challenges in seismic data processing, which demands a different data processing workflow tailored to the HR3D acquisition.

HR3D data acquisition

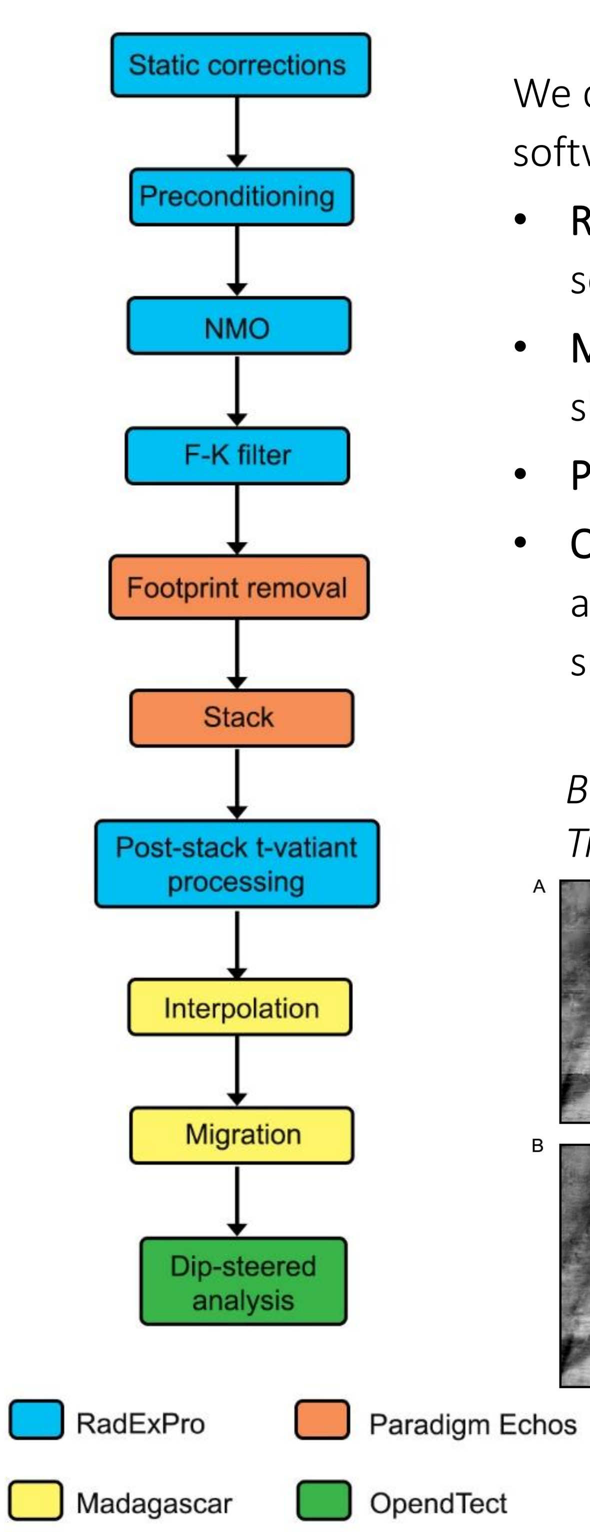
The array design in Tomakomai HR3D survey comprised 4 streamers that are 25 m in length with 10 m inline separation. Each streamer has 8 channels with a 3.125 m group interval, yielding a very small final bin size of 3 x 3 m. Source and receiver positioning were achieved using 5 rGPS units in the water and a DGPS antennae on the vessel.



A 210 cubic inch GI airgun was used as an acoustic source. Over a period of 6 days, approximately 2 square kilometres of data were acquired during daylight hours.

Parameters	Specification
Streamers	4 x 25 m
Channels	8 per streamer = 32 total
Inter-streamer spacing	10 m
Group interval	3.125 m
Source	210 cubic inch GI Airgun
Inline shot spacing	6.25 m
Bin size	3 x 3 m

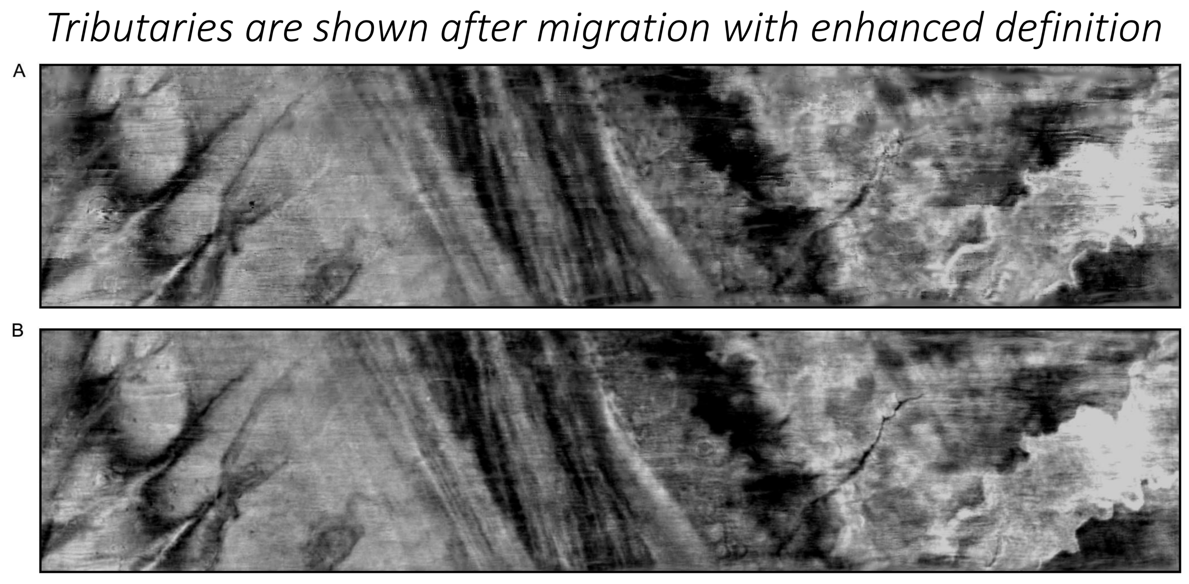
Data processing workflow



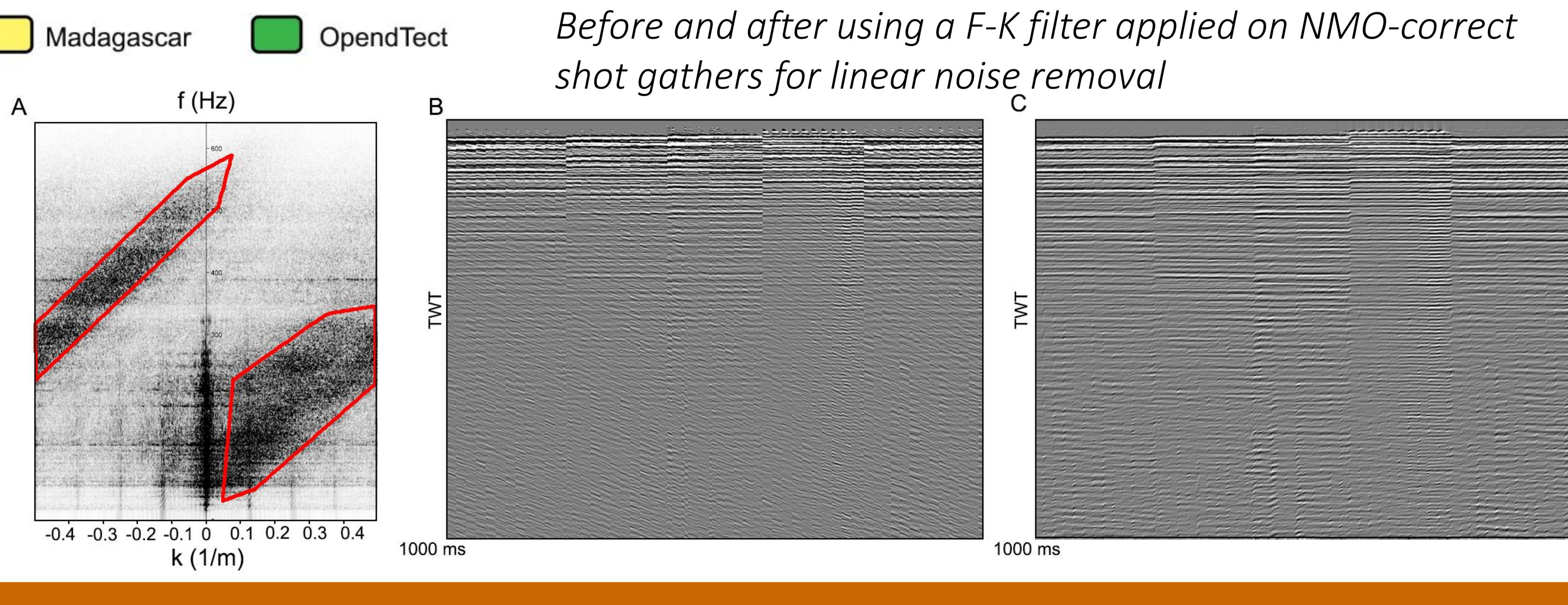
We designed a unique processing workflow which involves four software packages:

- **RadExPro** – used for merging navigation P190 files, geometry setup, and basic data processing
- **Madagascar** – performed interpolation and post-stack phase-shift migration
- **Paradigm Echos** – for prestack footprint removal and stacking
- **OpendTect** – provided dip-steered median filter to suppress acquisition footprint and random noise, and dip-steered similarity volume for fault detection

Before and after phase-shift migration in Madagascar. Tributaries are shown after migration with enhanced definition

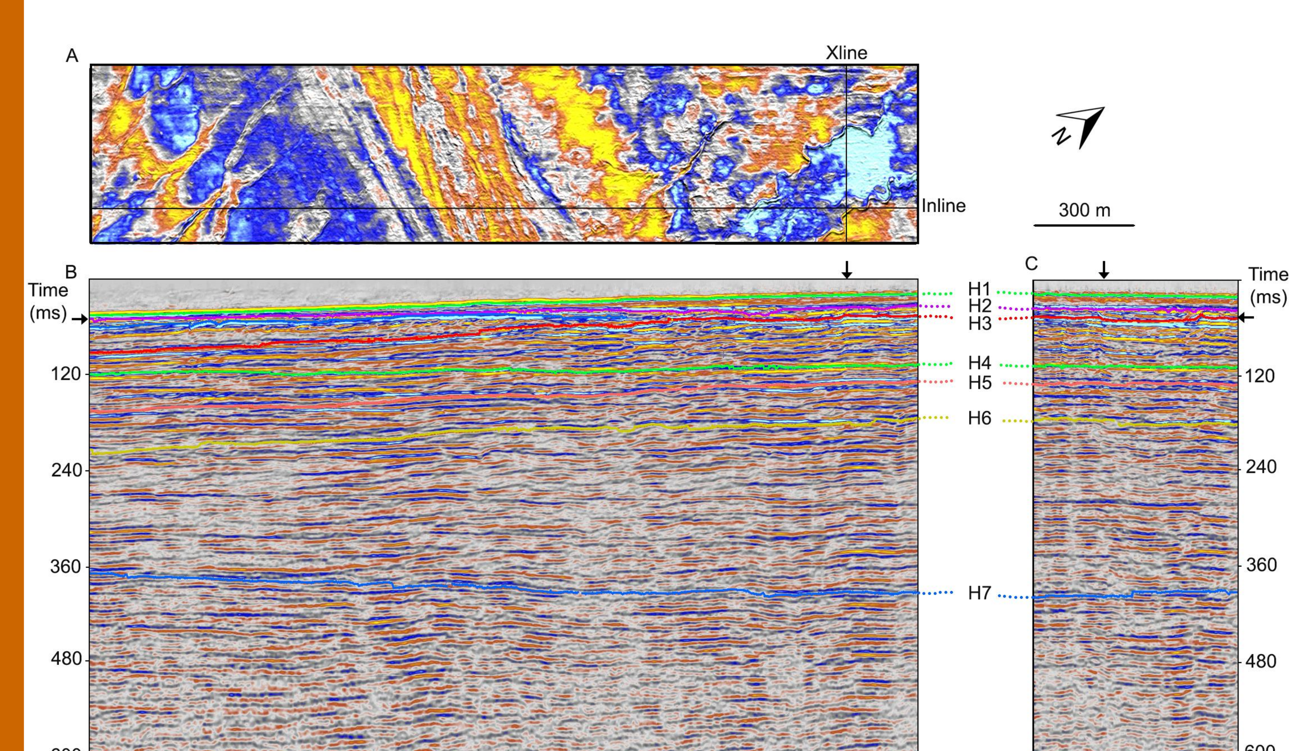


Before and after using a F-K filter applied on NMO-correct shot gathers for linear noise removal



Initial interpretation results

The final processed volume images down to 1000 ms two-way travel time (TWTT). In total eight horizons have been interpreted to date, including seven continuous horizons (H1 to H7) and an erosional horizon beneath H2, which is characterized by multiple channelized systems.



The anticipated generally horizontal stratigraphy is observed, and various recognizable geological features are shown in great detail in the first 70 ms. No major faults are observed throughout the survey area. The figure on the left shows an example of time slice at 47 ms blending with amplitude and dip-steered similarity attributes.

Summary

This study demonstrates the successful acquisition, processing and interpretation of a shallow marine HR3D seismic data, for the first time deployed over an active offshore CO2 injection site. The effective deployment of this novel marine seismic monitoring technology validates HR3D to be an appropriate monitoring tool for large-demonstration and commercial-scale CCS sites.

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REFERENCES

1. Tanaka, Y., Y. Sawada, D. Tanase, J. Tanaka, S. Shiomi, T. Kasukawa, 2017, Tomakomai CCS demonstration project of Japan, injection in process, Energy Procedia, 114:5836-5846.
2. Brookshore, B.N., C. Lippus, A. Parish, B. Mattox, and A. Burks, 2016, Dense arrays of short streamers for ultrahigh-resolution 3D seismic imaging, The Leading Edge, July 2016: 594-599, http://dx.doi.org/10.1190/tle35070594.1.