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Extension of the *In-Situ* Measurement Using Modular Design Seafloor Observatory System

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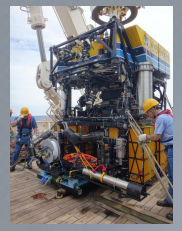
INTRODUCTION

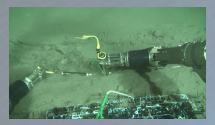
We introduce the underwater technologies developed for adding new sensors. Such technologies include tools for thin fiber-optic cable extension, plugging in underwater connecters, etc. worked by a remotely operational vehicle (ROV). It has been shown that our in-situ measurement can be performed based on the modular design seafloor observatory system and supported by the advanced ROV operations.

METHODS/DATA

Remotely Operational Vehicle

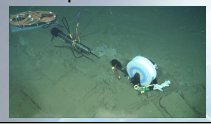


Fiber end



DONET interface

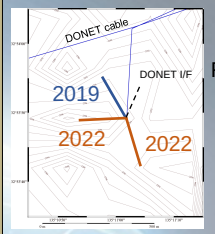
Fiber-optic strain cable



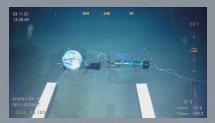
START

RESULTS

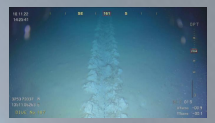
Map of fiber-optic strain-meters



Fiber-optic strain-meter deployed by ROV



Fiber-optic strain cable buried under the seafloor



CONCLUSION

Observation of shallow SSE and VLFE in the vicinity of the faults by the 200m long seafloor fiber-optic strain-meter in the Nankai Trough.

Additional two fiber-optic strain-meters deployed in November 2022 enable to form an array seafloor strain observation.

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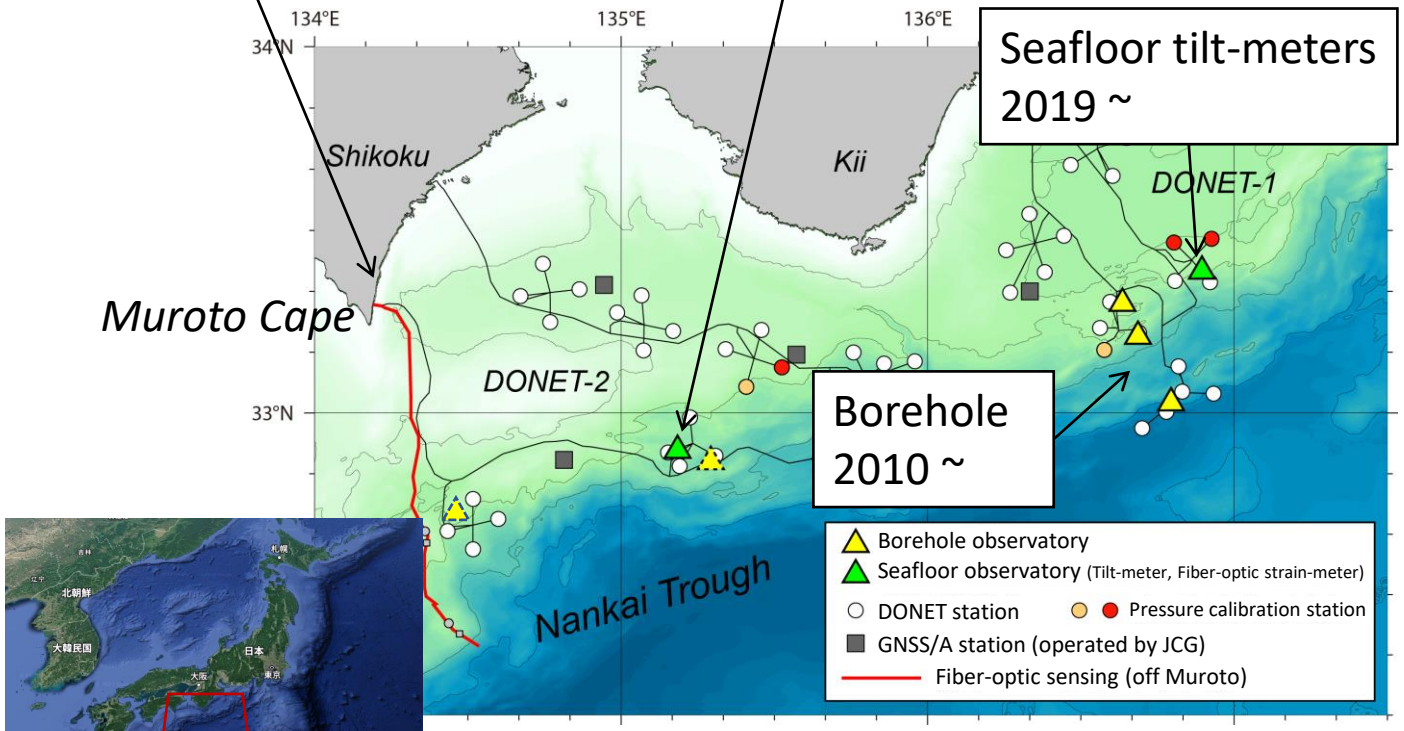
Multiple Long-Term Observatories Installed in the Nankai Trough

Optical fiber sensing using off Muroto cable 2021 ~

Seafloor fiber-optic strain-meters
1st phase: 2019 ~
2nd phase: 2022 ~

Seafloor tilt-meters 2019 ~



Borehole 2010 ~

Real-time seafloor observatories for earthquake and tsunami monitoring, i.e., the DONETs have been installed since 2010. The DONET is capable for adding new sensors with plugging in underwater connectors. Making use of this underwater technology, three borehole observatories, two different-typed tilt meters, and one fiber-optic strain-meter have been connected with the DONET before.

In 2022, two fiber-optic strain-meters have been additionally installed at the same location of the existing fiber-optic strain-meter.

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Installation of Seafloor Fiber-Optic Strain-Meter in 2019

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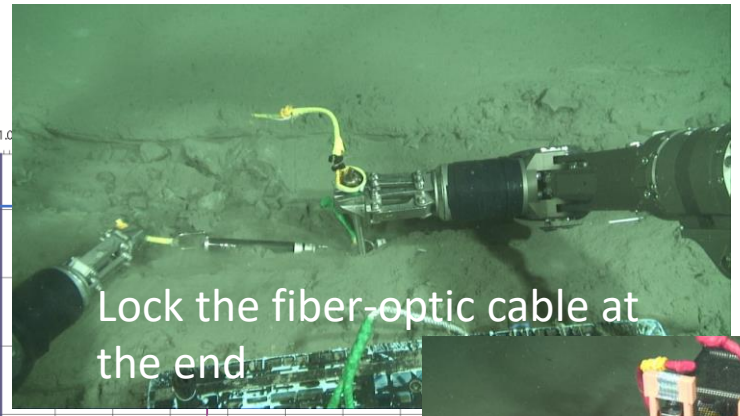
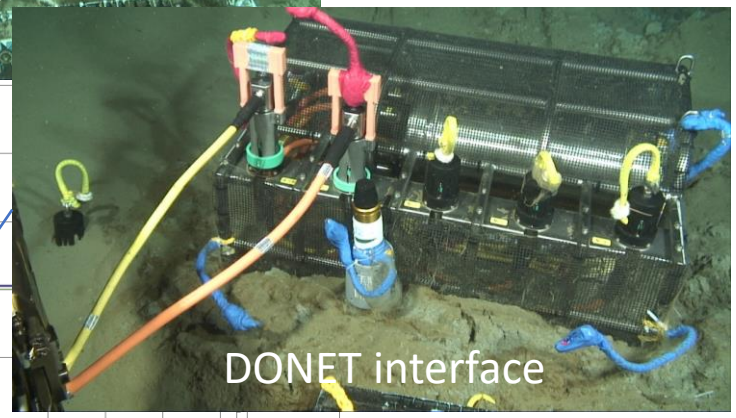
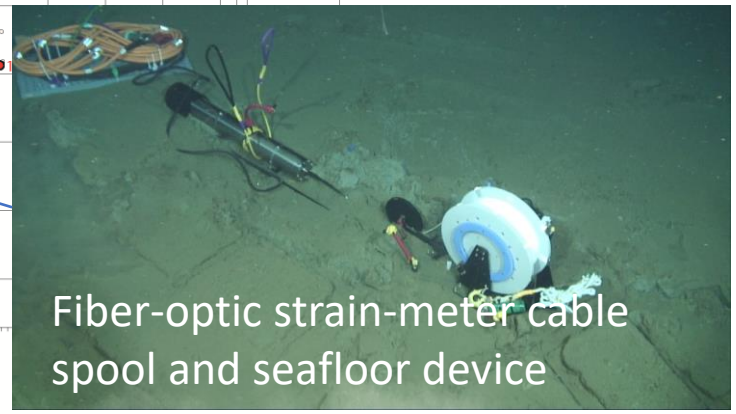
Remotely Operational Vehicle (ROV) carrying instrument


Lock the fiber-optic cable at the end


DONET interface


Fiber-optic cable laid at the seafloor


Fiber-optic strain-meter cable spool and seafloor device

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Extension of Seafloor Fiber-Optic Strain-Meter in 2022

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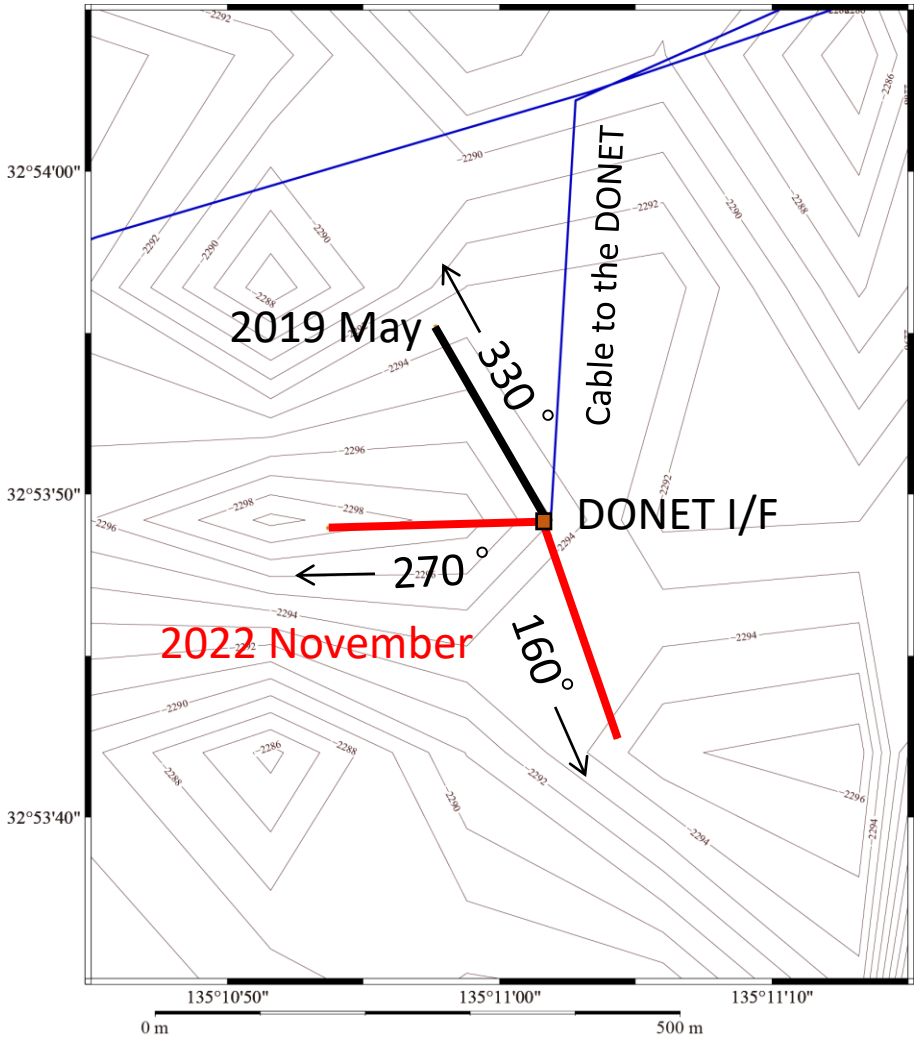
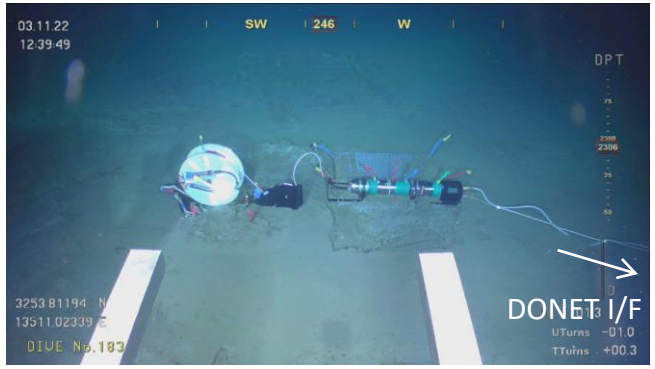
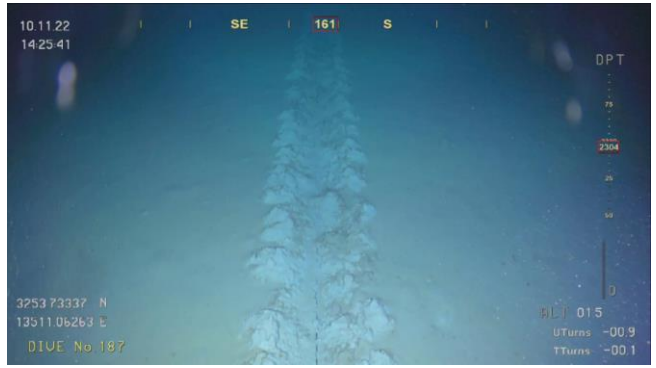


Two 200-m long fiber-optic strain-meters were installed in November 2022. Together with the existing fiber-optic strain-meter, a three-component fiber-optic strain-meter array has been formed at the sealoor and the *in-situ* fiber-optic strain observation has launched.



Fiber-optic strain-meter before laying 200 m



Fiber-optic cable buried 0.3 m below the seafloor

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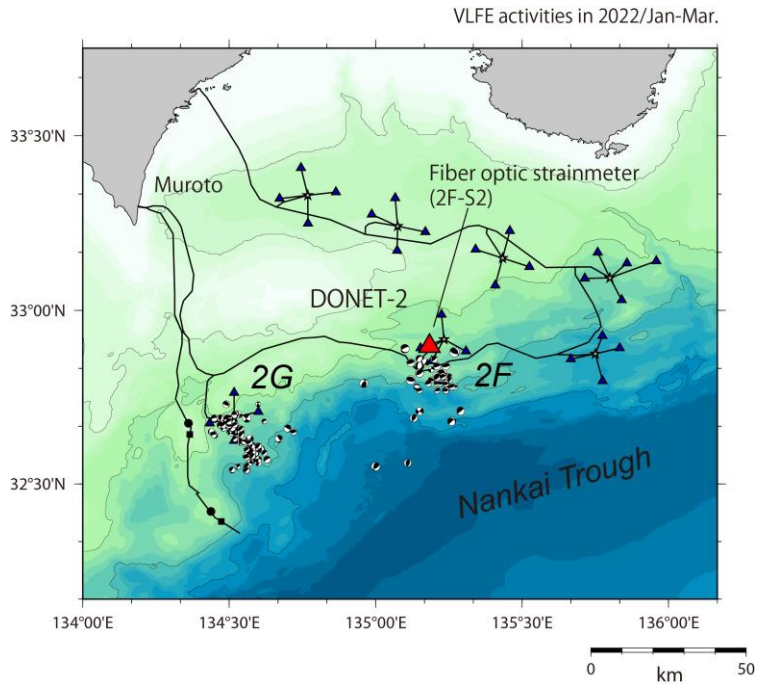
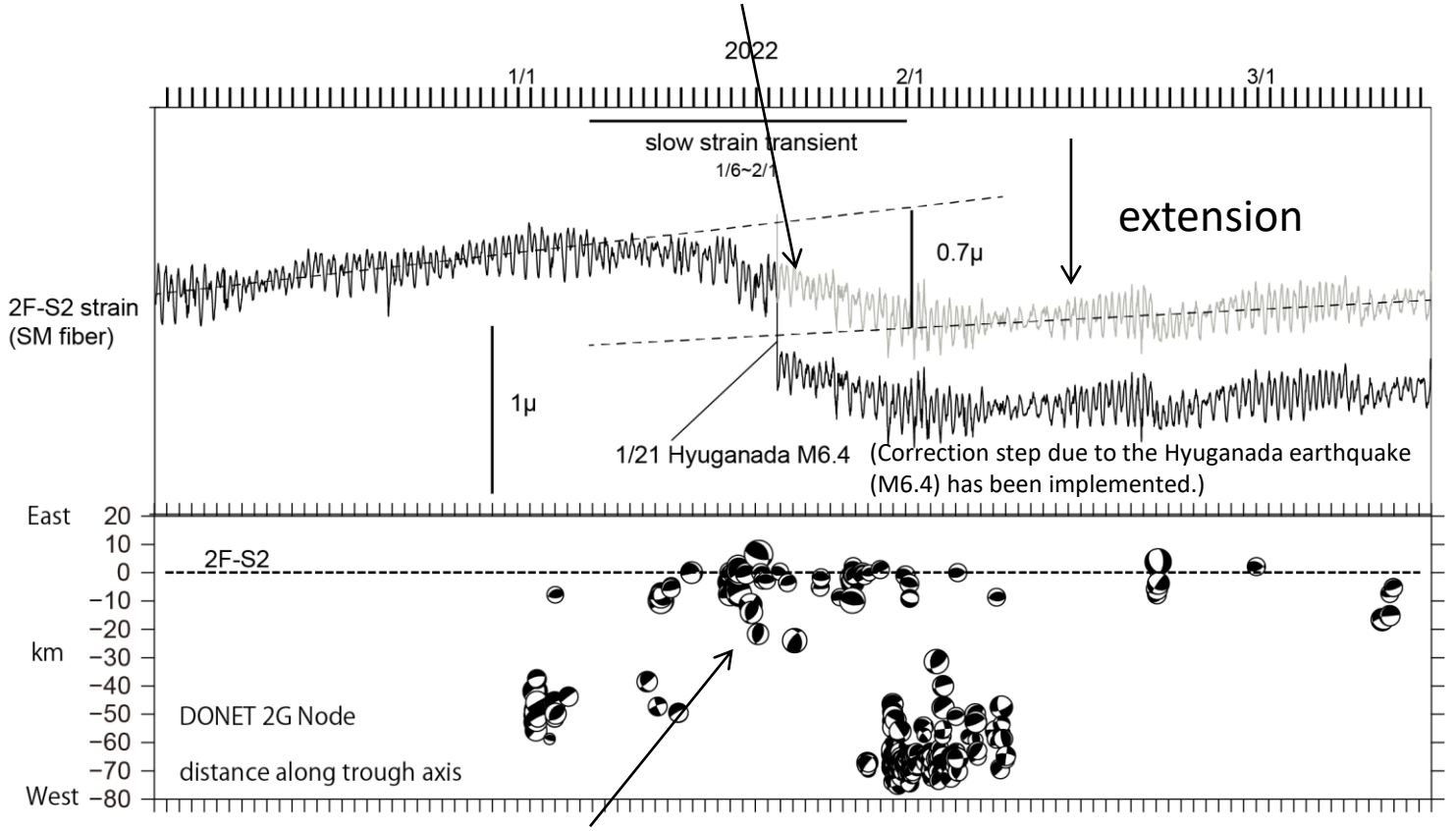
Results: Scientific Implications



Slow strain transient with amplitude of 0.7 micro-strain possibly associated with a shallow-slow slip event (SSE) was detected by a fiber-optic strain-meter firstly installed in 2019.

Seafloor extension with a 3-week duration was observed, suggesting the occurrence of shallow slow slip event (SSE).



Simultaneously, very low-frequency events (VLFEs) were also detected.

Araki *et al.* (2022)

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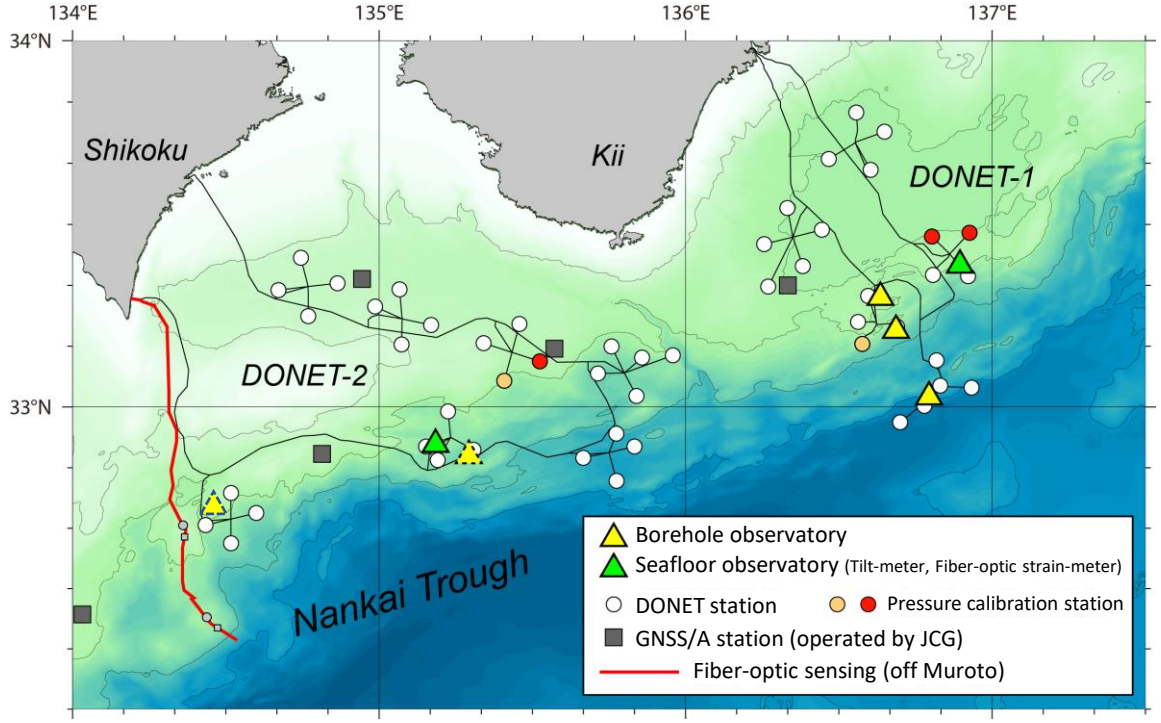
Summary & Future Plans

- A shallow slow slip event (SSE) and very low-frequency events (VLFEs) were detected by the 200-m seafloor fiber-optic strain-meter in the Nankai Trough.
- Two fiber-optic strain-meters were deployed by ROV, and an array seafloor strain observation has been launched.



- We plan to install borehole observatories across the Nankai Trough (one borehole observatory to be installed in 2023) to understand the plate coupling (SSEs, VLFEs etc.) before a megathrust earthquake.

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Acknowledgements

The fiber-optic strain-meters installed in the Nankai Trough were developed by Dr. Mark Zumberge (Scripps Institution of Oceanography, UCSD) (Zumberge *et al.*, 2018). His technical discussions were fruitful to this stud. Distribution of the VLFEs presented in this study were analyzed by Dr. Yojiro Yamamoto (JAMSTEC). The Generic Mapping Tools (GMT) software (Wessel & Smith, 1991) was used to produce some of the figures.

References:

Araki, E., Yokobiki, T., Baba, S., Yamamoto, Y., Zumberge, M., Tsuji, S., Nishida, S., Machida, Y. and Matsumoto, H., Shallow slow slip and associated VLFE observed by seafloor fiber optic strainmeter in the Nankai Trough, *AGU Fall Meeting*, 0154, 2022.

Wessel, P. and Smith, W. H. F., Free software helps map and display data, *EOS Trans. AGU*, 72, 441, 1991.

Zumberge, M. A., Hatfield, W. and Wyatt, F. K., Measuring seafloor strain with an optical fiber interferometer. *Earth and Space Science*, 5, 371– 379, 2018.