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Recent advances in GNSS-A observation technology and networks and latest observation results around Japan Islands

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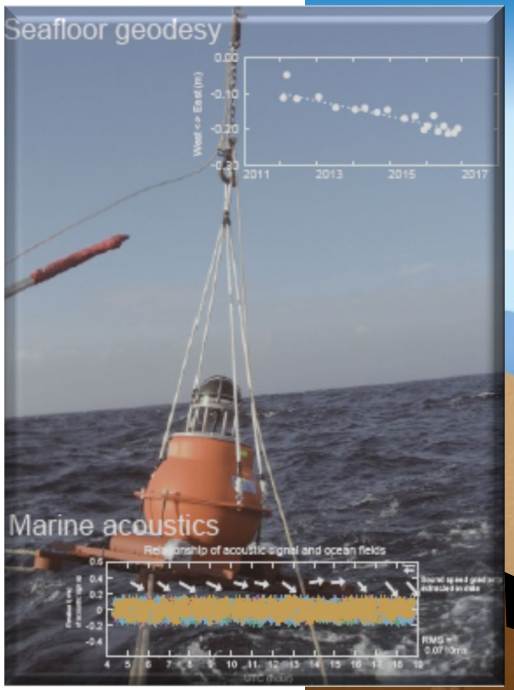
GNSS-A system = “seafloor GNSS”



GNSS positioning

Measure the position of the GNSS antennae

Measure the position of the transducer on bottom of the vessel

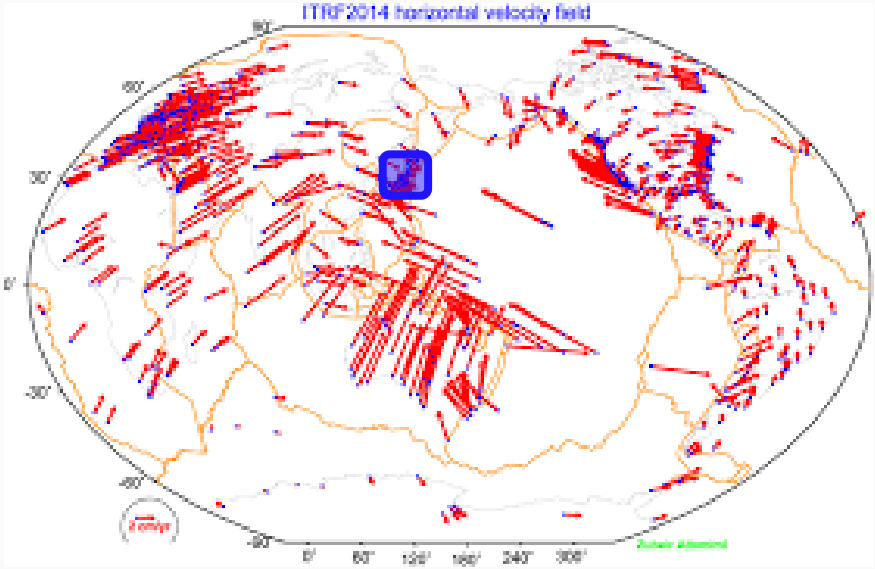
Acoustic ranging

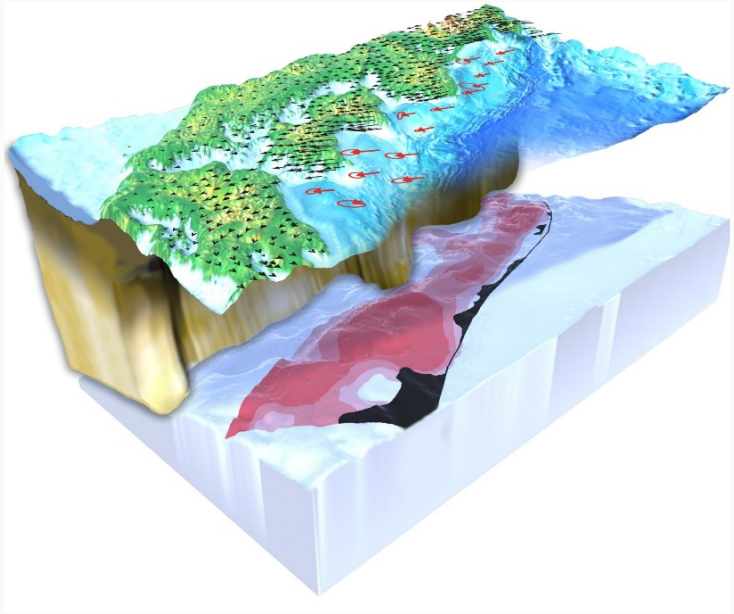
Acoustic signal

Seafloor stations (mirror transponders)

Measure the accurate position

Target of seafloor geodesy



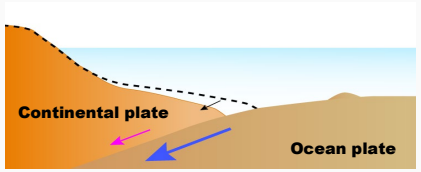


Macroscopic geodesy

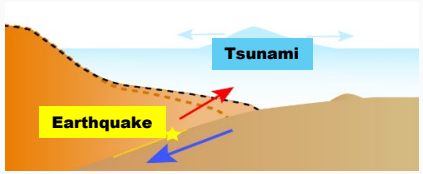
Microscopic geodesy

Target of seafloor geodesy

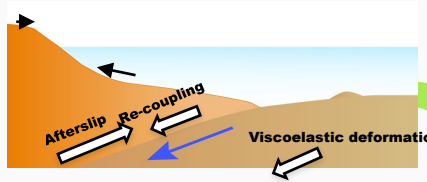
Coupling condition



Earthquake



Postseismic phase



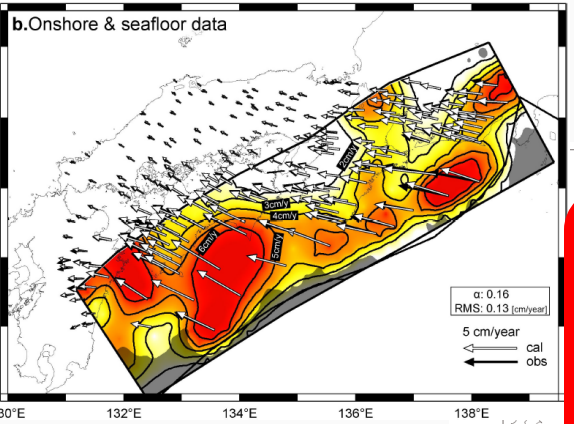
GNSS-A results

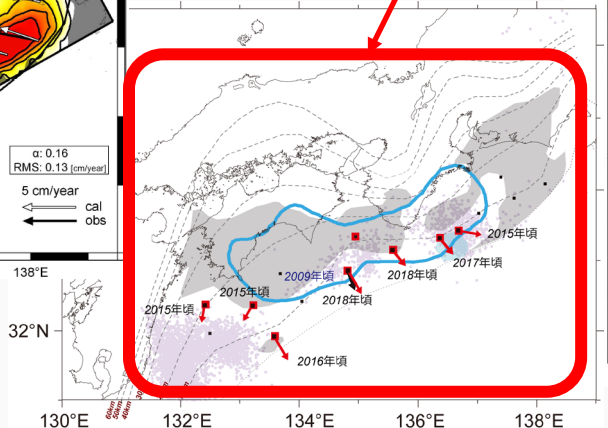
Nankai Trough
Yokota et al. (2016, Nature)
Nishimura et al. (2018, Geosphere)
Yokota & Ishikawa (2020, Sci Adv)

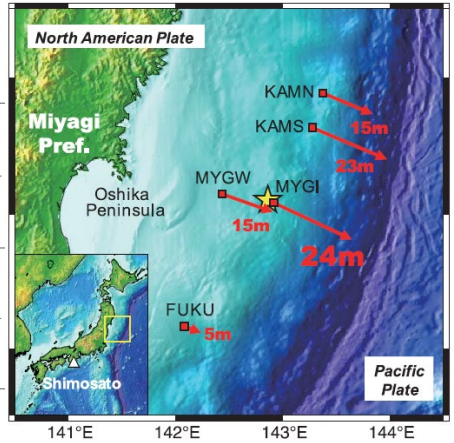
2011 Tohoku-oki earthquake
Sato et al. (2011, Science)

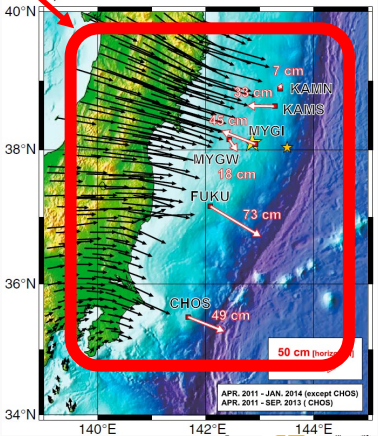
following to Tohoku-oki earthquake
Watanabe et al. (2014, GRL)

Next target is "time variation".









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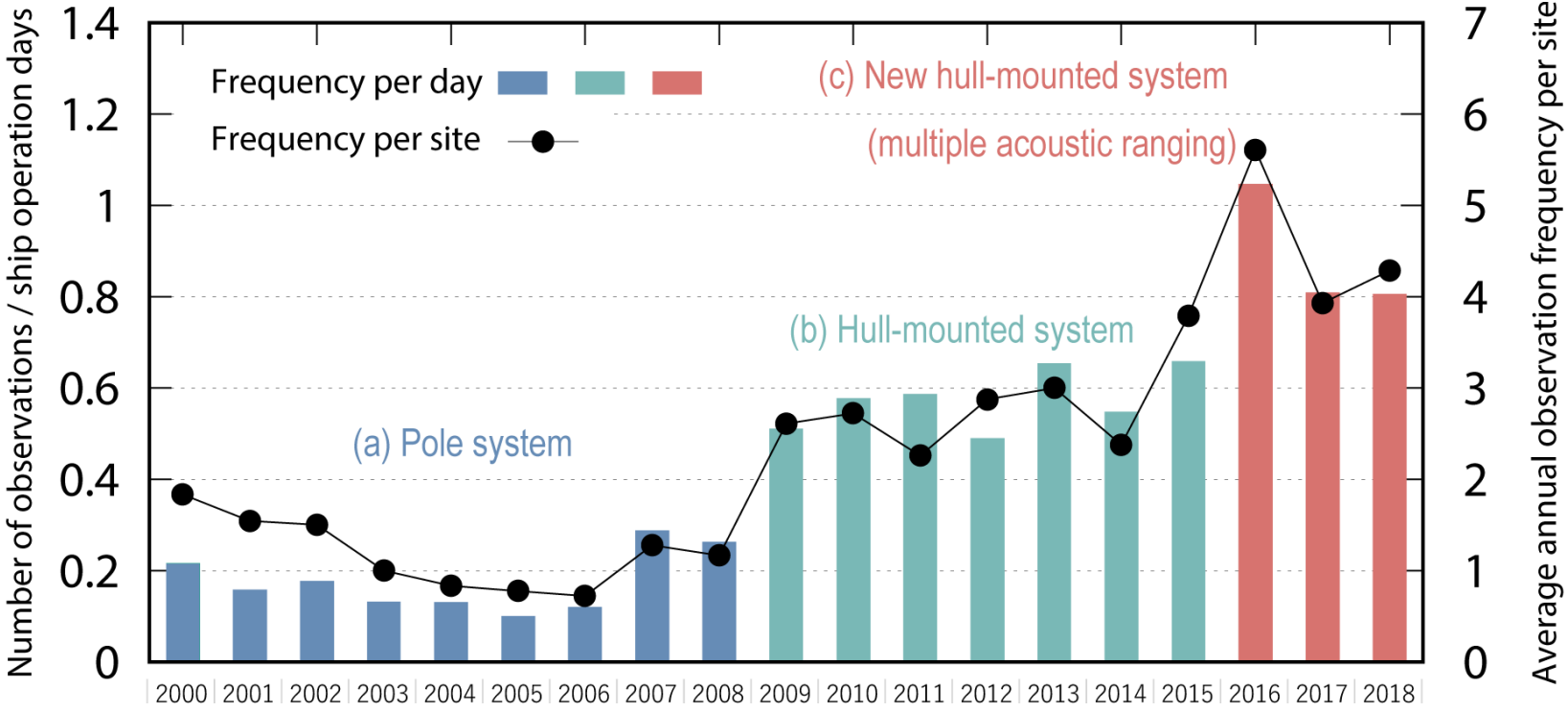
Ishikawa et al., 2020, Frontiers in Earth Science

GNSS-A: Frequency



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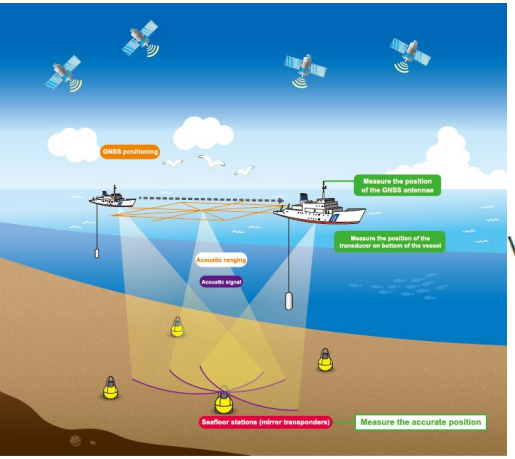
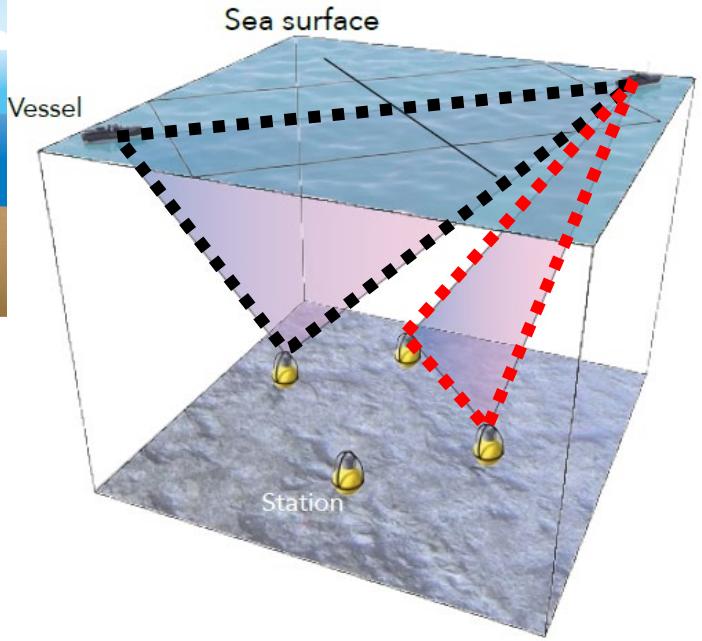
Yokota & Ishikawa, 2019, SN Applied Sciences

Yokota et al., 2019, MGR

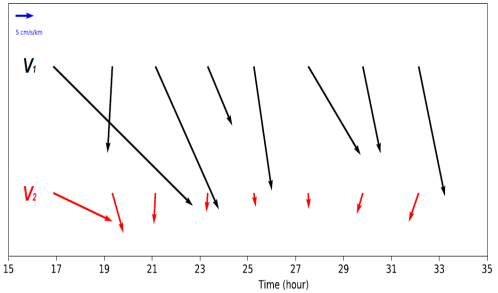
GNSS-A: Accuracy



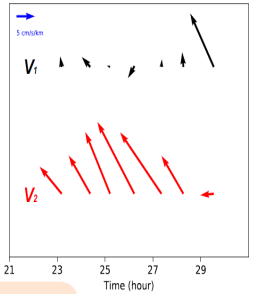
Gradient field was extracted from upper and lower.



Epoch A: ***Aug. 2011***



Epoch B: ***Apr. 2017***



→<u>shallow SSE</u> detection

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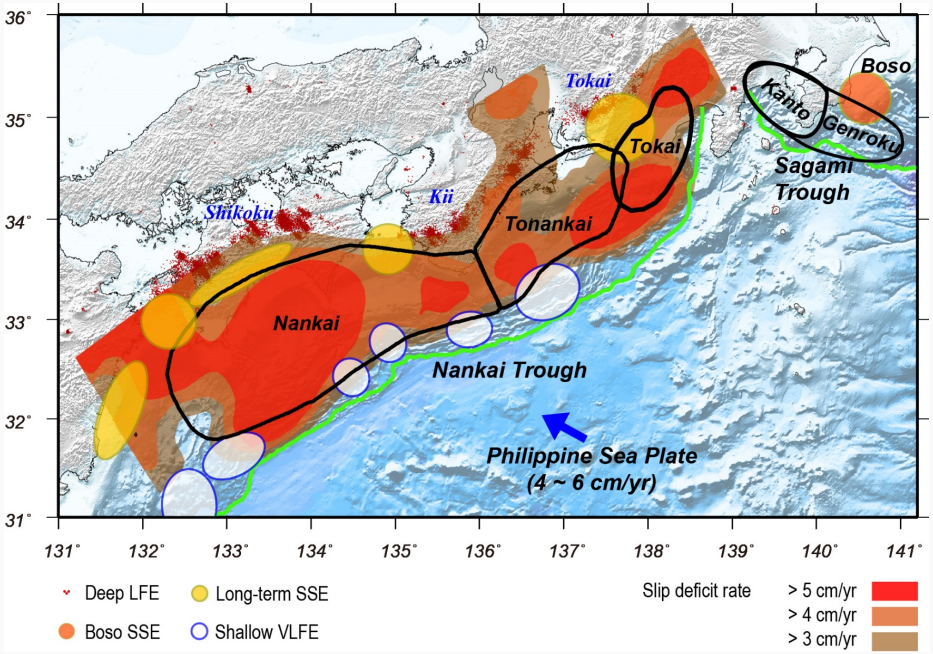
Monitoring of slow earthquakes along the Nankai

Around strong coupling regions



Kato (2019, Proc. Int. Sch. Phys. Fermi)
(Obara and Kato (2016, Science) + Yokota et al. (2016, Nature))

Seismometer
Strainmeter/Inclinometer or GNSS
Deep LFE (tremor) **Shallow VLF**

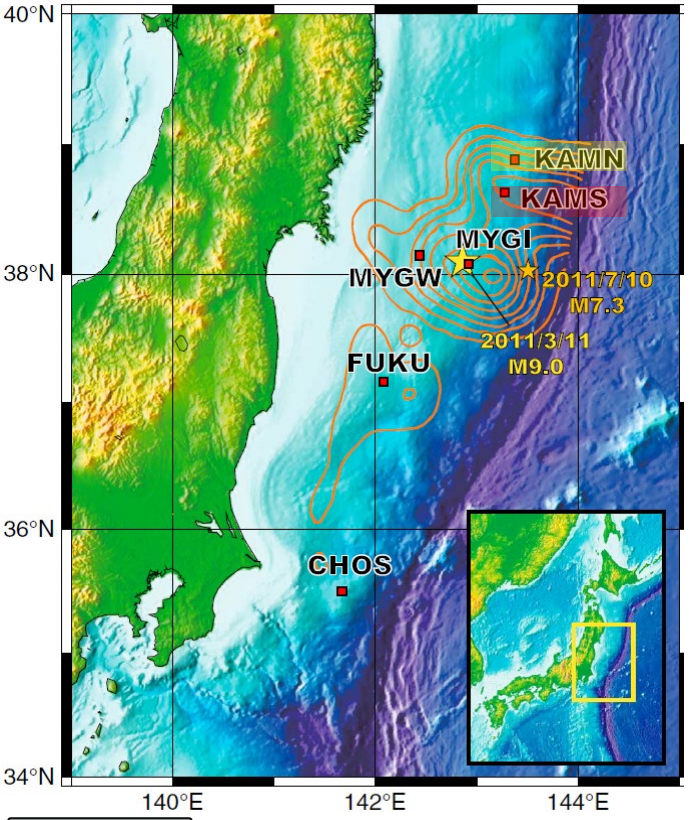
GNSS
Deep long-term SSE

>> Shallow side (trough axis region) ...

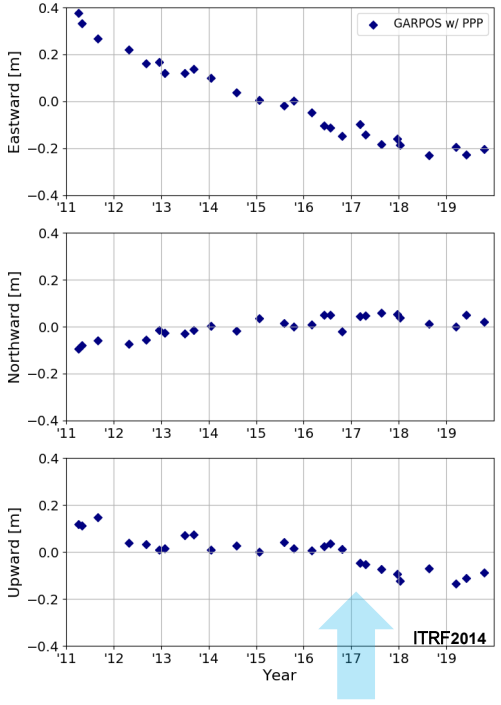
GNSS-A

Latest results were shown in Yokota & Ishikawa (2020, Sci Adv)

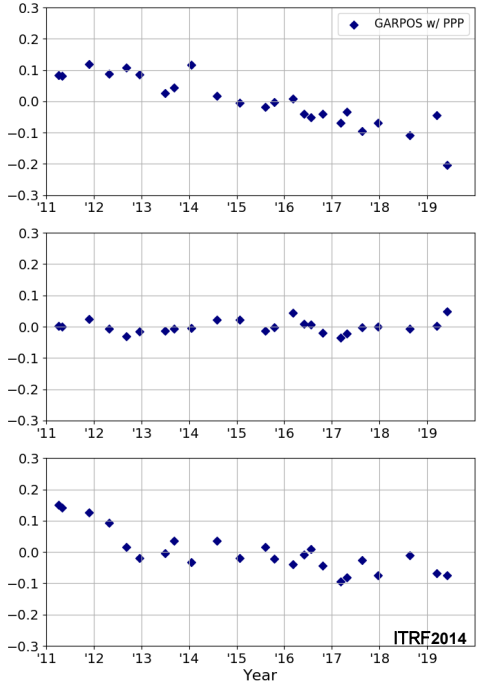
Continuous monitoring: time variation of postseismic deformation



Seafloor displacement at KAMS



Seafloor displacement at KAMN



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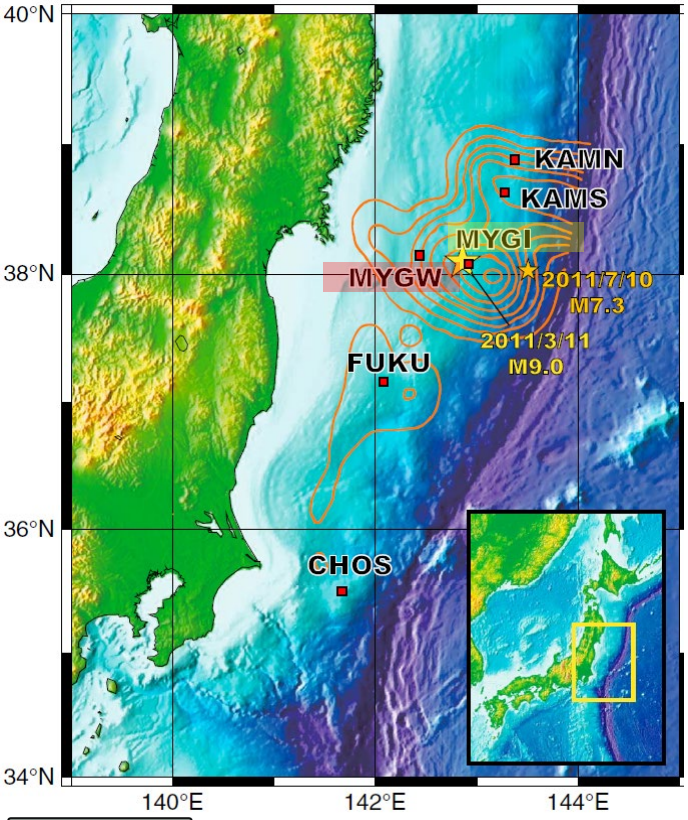
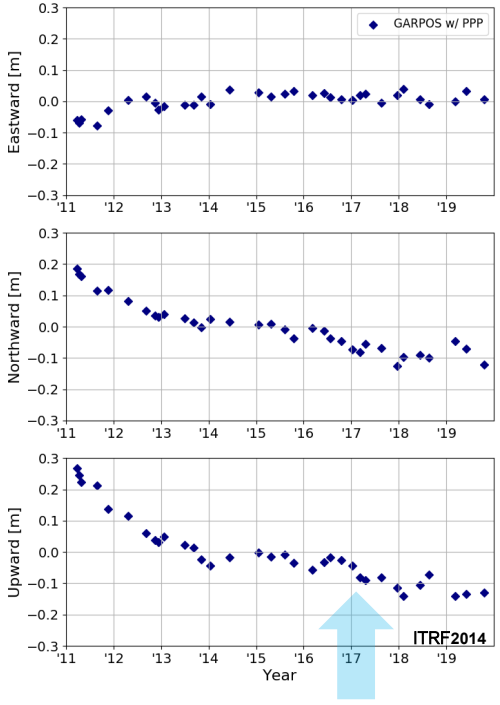
Watanabe et al., 2014; Iinuma et al., 2012

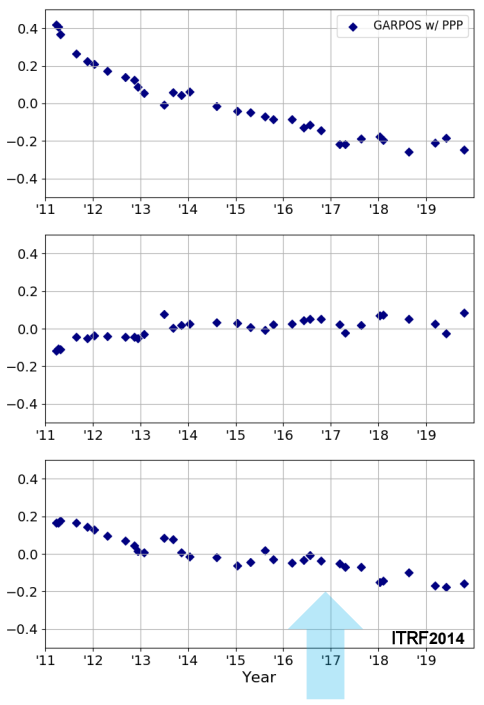
Continuous monitoring: time variation of postseismic deformation



Seafloor displacement at MYGW



Seafloor displacement at MYGI



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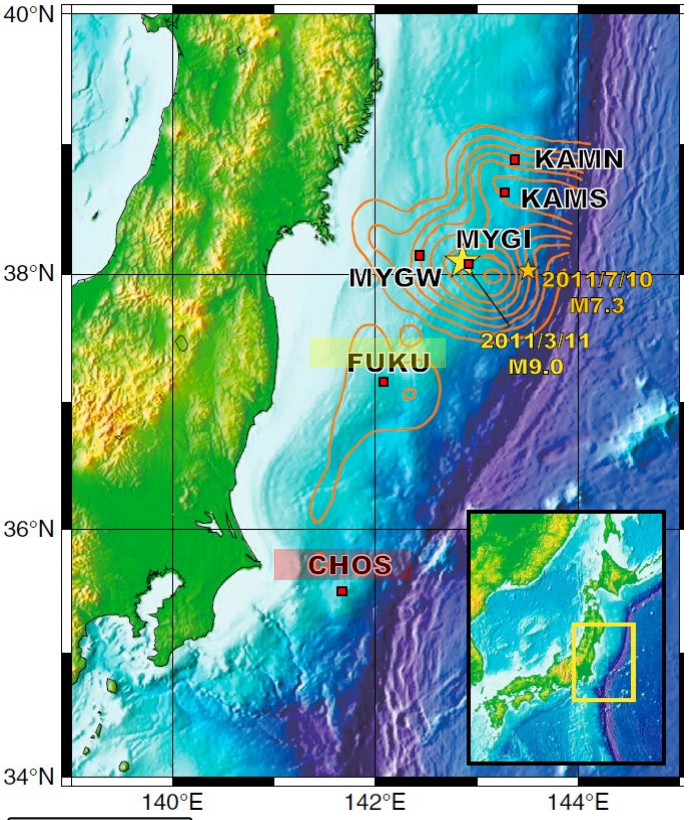
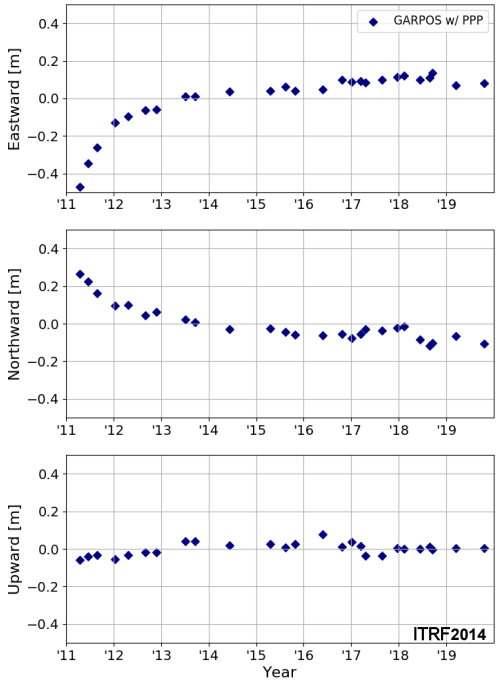
Watanabe et al., 2014; Iinuma et al., 2012

JCG

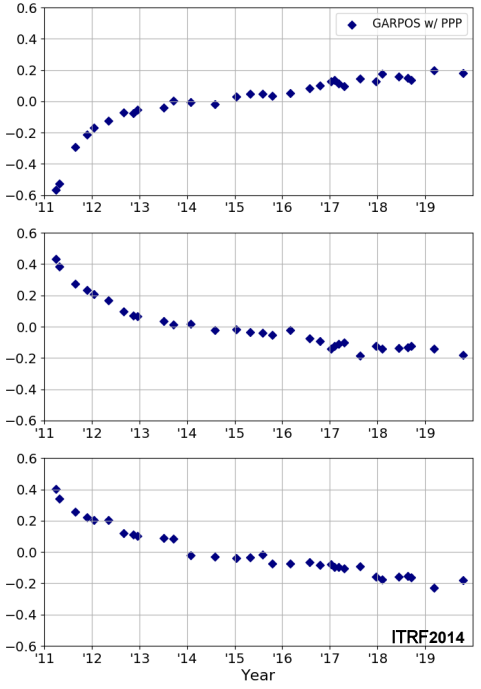
Continuous monitoring: time variation of postseismic deformation



Seafloor displacement at CHOS



Seafloor displacement at FUKU



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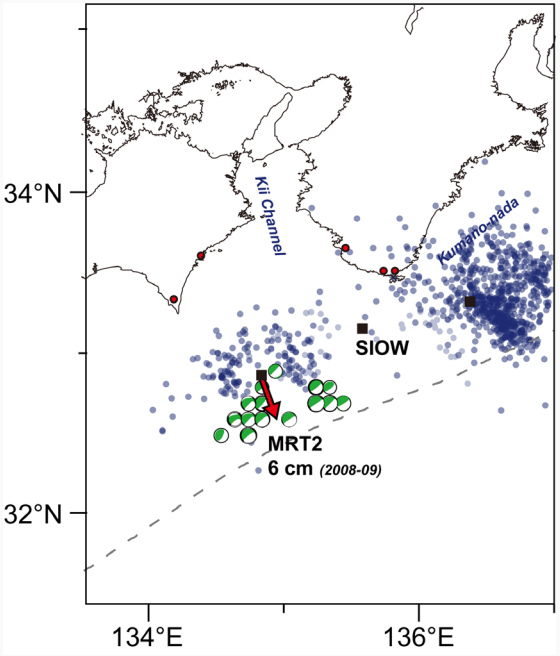
Watanabe et al., 2014; Iinuma et al., 2012

Observation network density & next-generation platform

2008-2009: only one-site observation



One-site observation cannot determine "SSE model".

We need "observation density"

Present: 80-100 km >> Ideal: 30 km

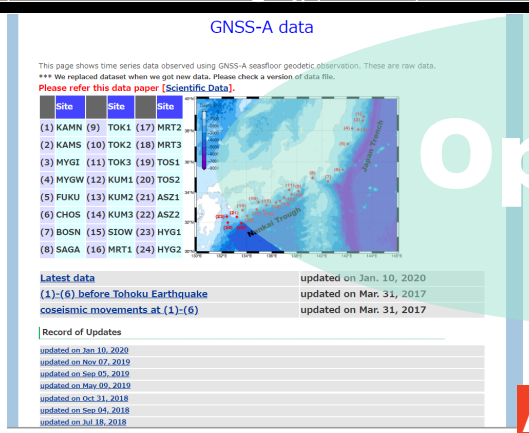
In present data, we cannot detect "time-constant".

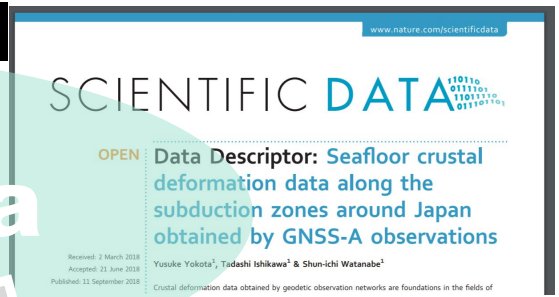
Higher Frequency:
We need "next-generation platform" (not vessel?)

Present: 4-8 times/year >> Ideal: everyday

Open data strategy & future works

https://www1.kaiho.mlit.go.jp/KOHO/chikaku/kaitei/sgs/datalist_e.html





Open Data

Understanding of km-scale ocean

Acoustic analysis

Analysis

Monte Carlo filtering

Machine learning

Event detection method

Time series analysis technique

Data construction system

Postseismic effect

Output

Coupling condition

Slow slip event

Expression method

Address list

Pamphlet: http://sgoi.iis.u-tokyo.ac.jp/figure/pamphlet_190724e.pdf

Data site: https://www1.kaiho.mlit.go.jp/KOHO/chikaku/kaitei/sgs/datalist_e.html

Latest papers:

Yokota & Ishikawa (2020, Science Advances) — Shallow slow slip event

Yokota, Ishikawa, Watanabe (2018, Scientific Data) — GNSS-A data paper

Yokota, Ishikawa, Watanabe (2019, Marine Geophysical Research) — GNSS-A analysis method: Ocean structure

Yokota & Ishikawa (2019, SN Applied Sciences) — GNSS-A analysis method: Interpretation of ocean structure

Ishikawa, Yokota, Watanabe, Nakamura (2020, Frontiers in Earth Science) — Review: GNSS-A frequency history