リスク・レジリエンス工学　学位プログラム
Master's / Doctoral Program in Risk and Resilience Engineering

Transient small displacement since the end of 2020 at Noto peninsula, Japan, revealed by Sentinel-1 InSAR time series analysis

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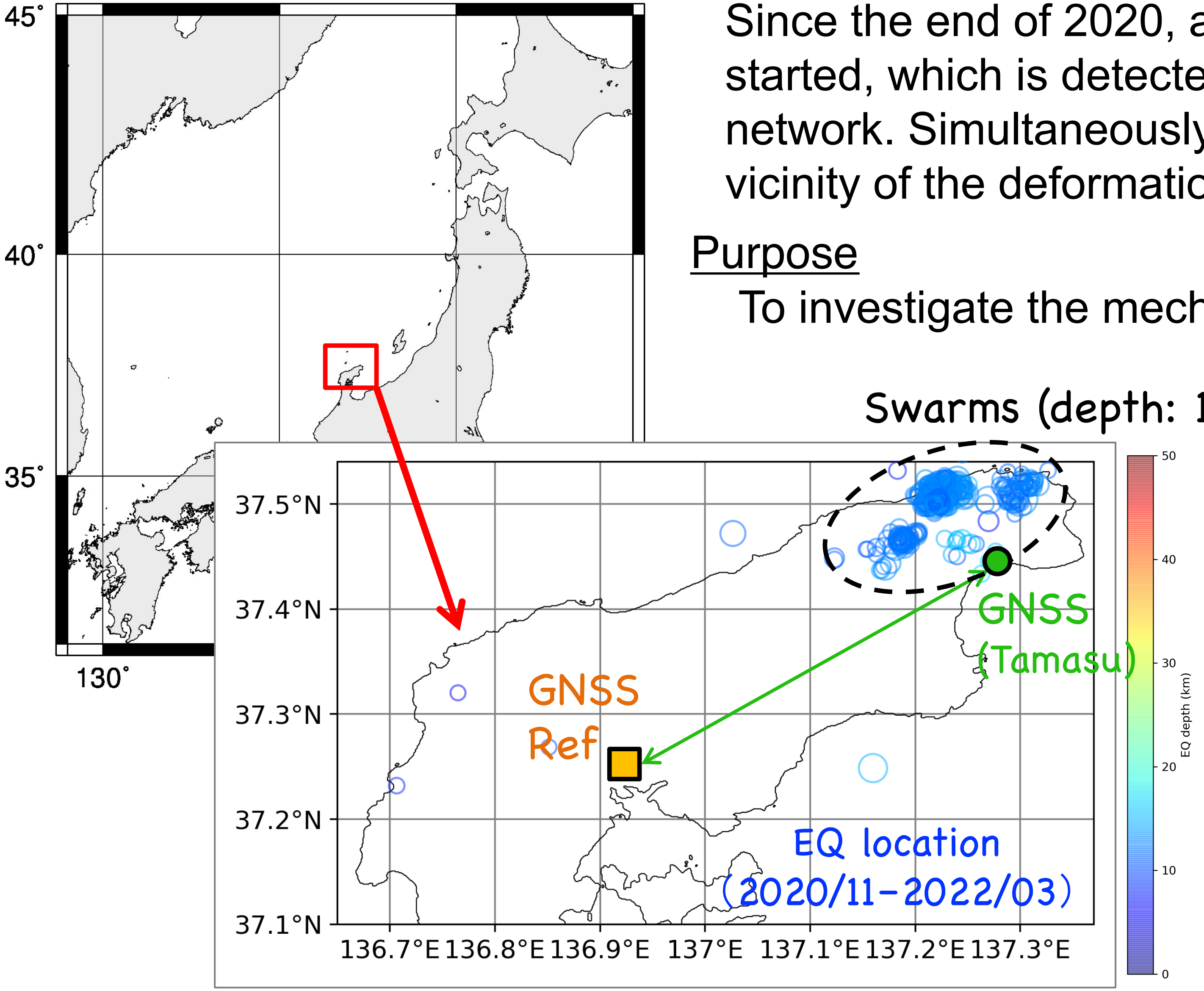
Transient displacement at Noto Peninsula

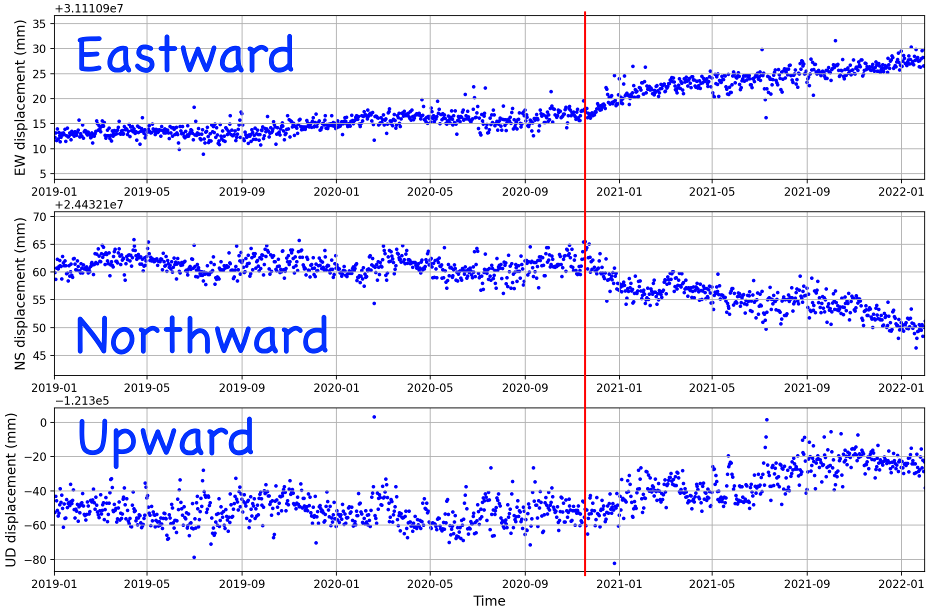
Since the end of 2020, a transient continuous displacement have started, which is detected by the Japanese operational GNSS network. Simultaneously, earthquake swarms are observed in the vicinity of the deformation area.

<u>Purpose</u>

To investigate the mechanism of this displacement by geodetic tools.

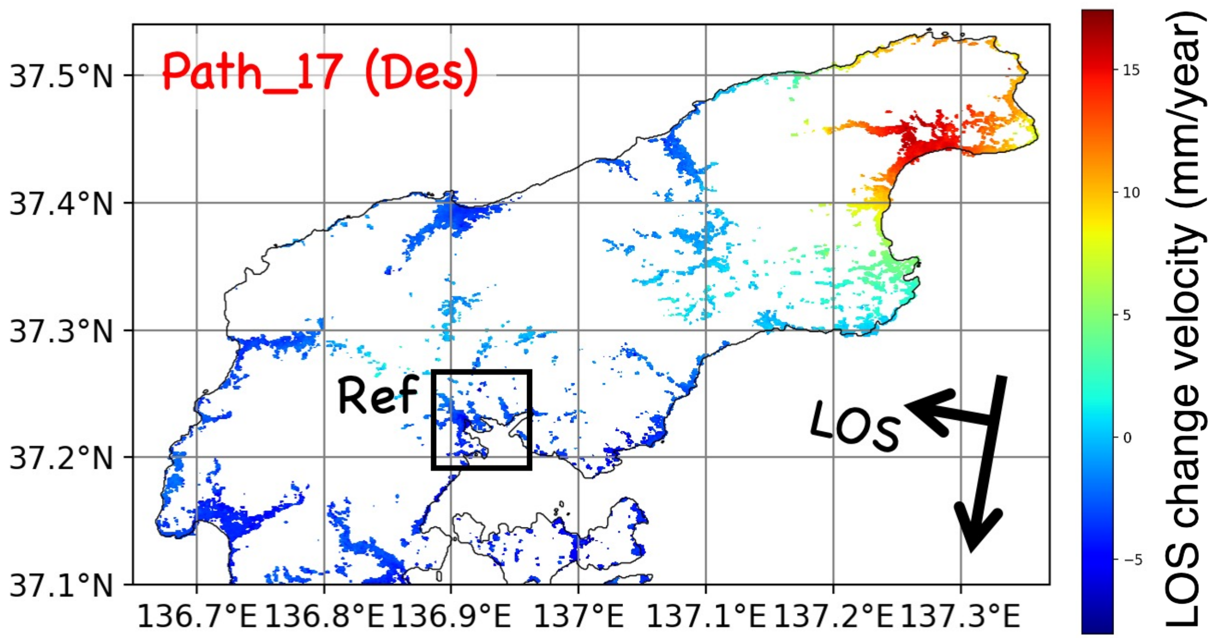


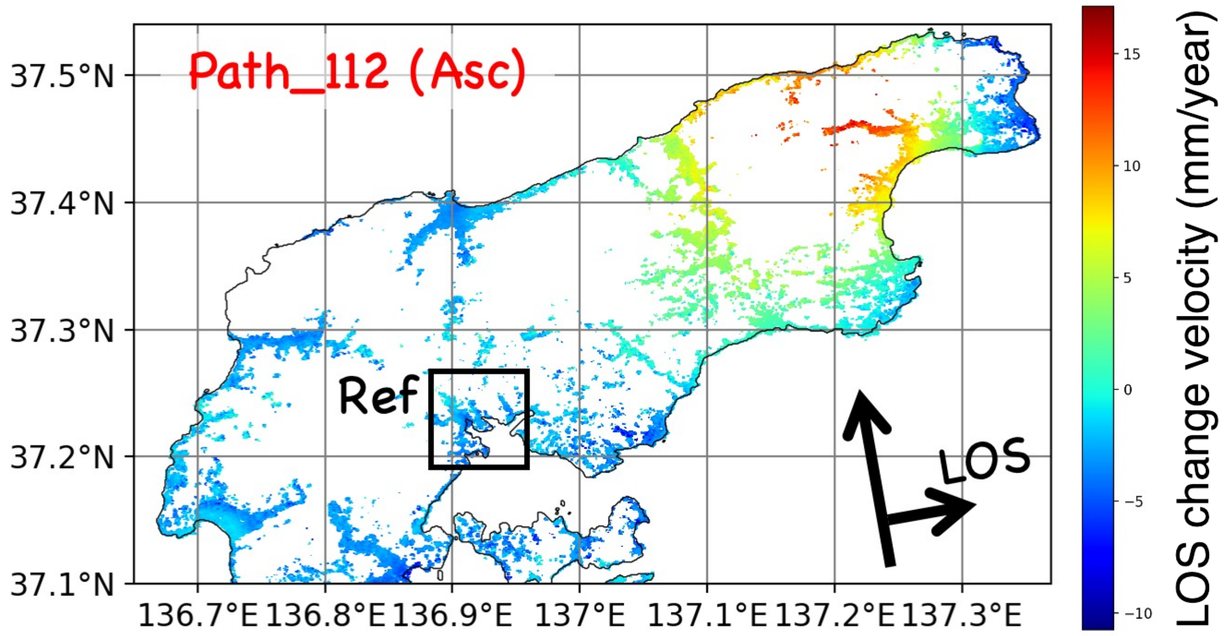
GNSS daily time series @ Tamasu



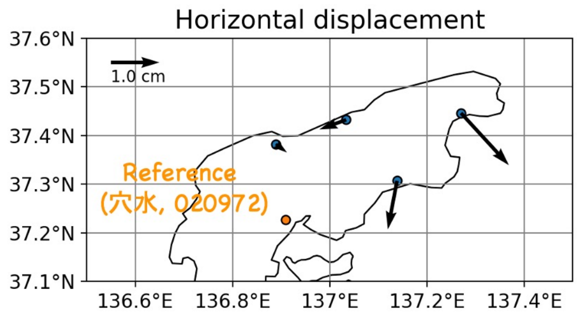
InSAR TS analysis with delay correction

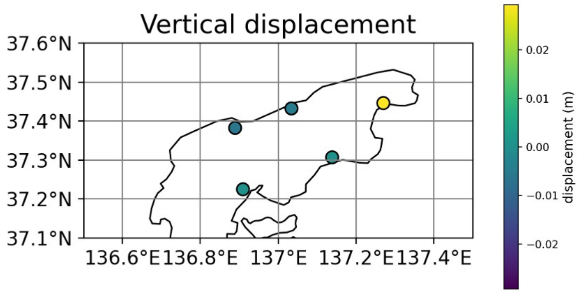
- Sentinel-1A & 1B with LiCSBAS
- All ifgs were delay-corrected by a model of Kinoshita (under revision)





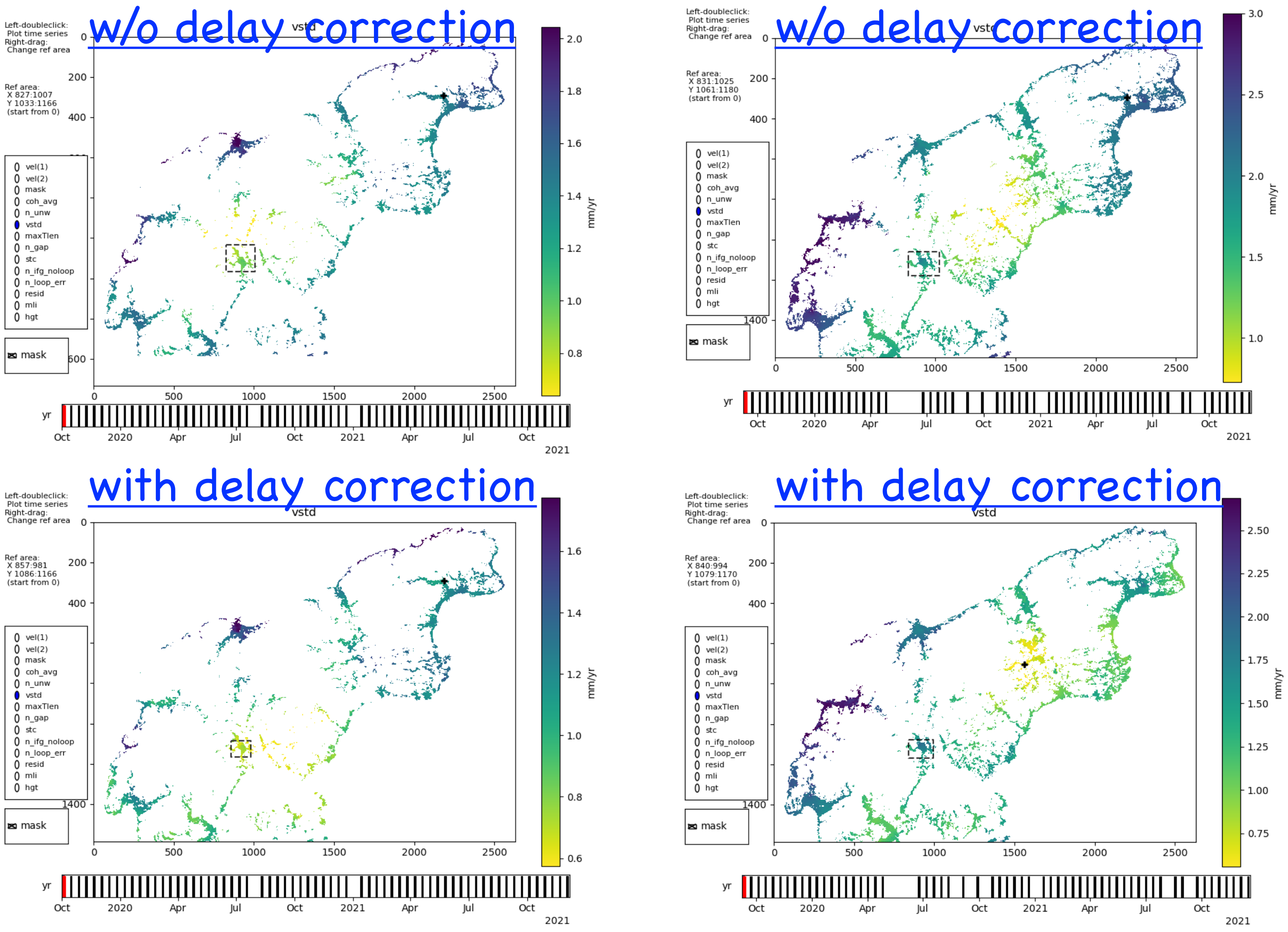
<u>GNSS disp.</u>





Velocity uncertainty in InSAR TS

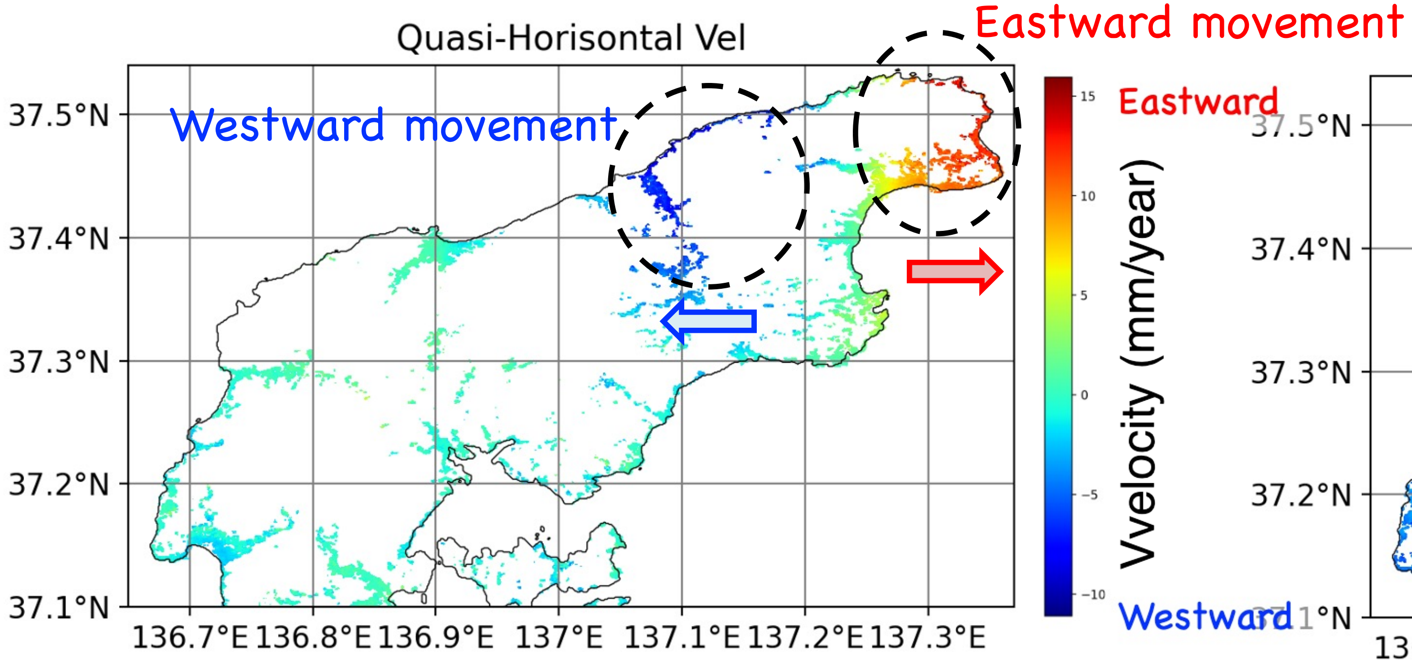
Decsending(Path: 17) Asending(Path: 112)



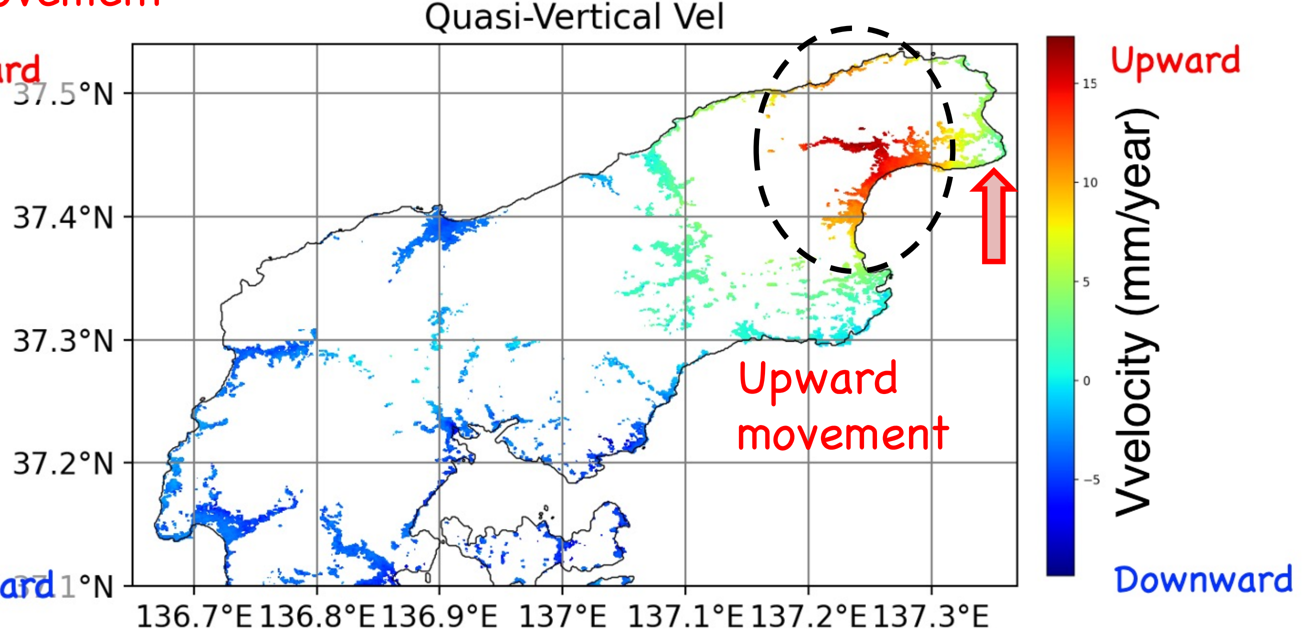
In this case, the atmospheric delay correction didn't change velocity estimates (not shown), but it reduced uncertainties of velocity estimation.

InSAR 2.5D analysis (Fujiwara et al. 2000)

Quasi-Eastward displacement

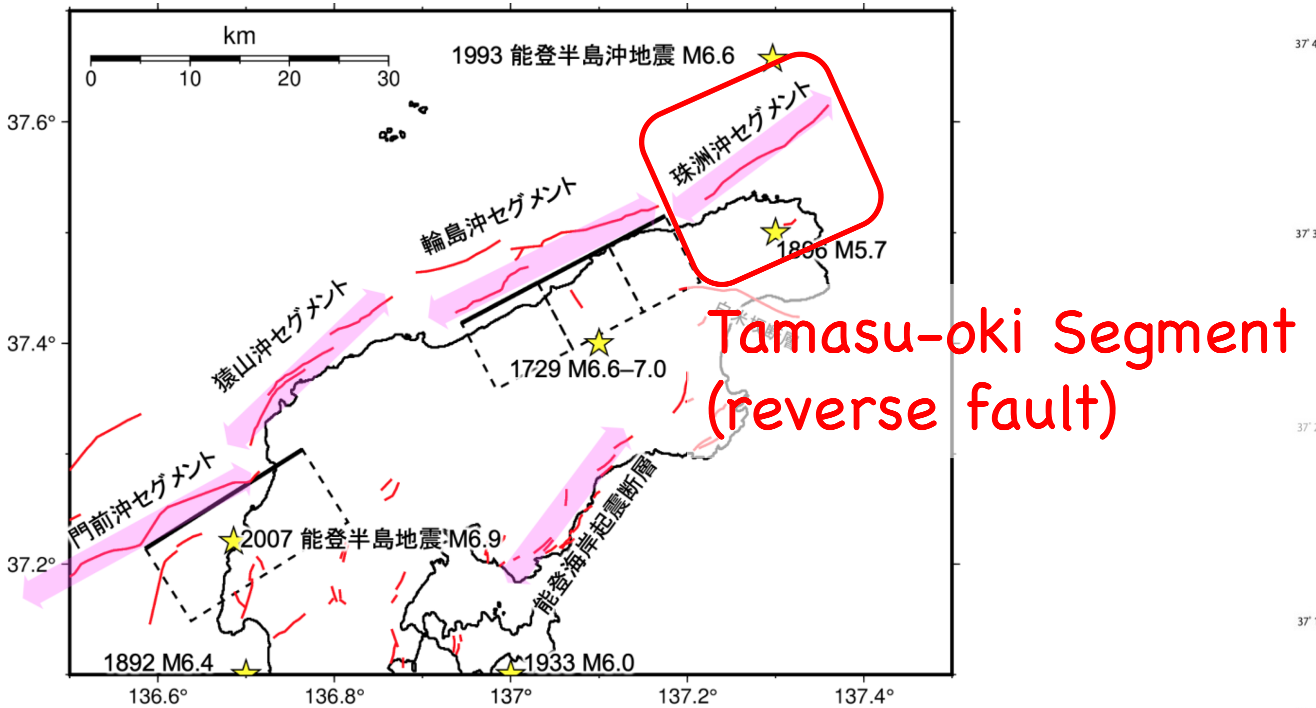


Quasi-Upward displacement

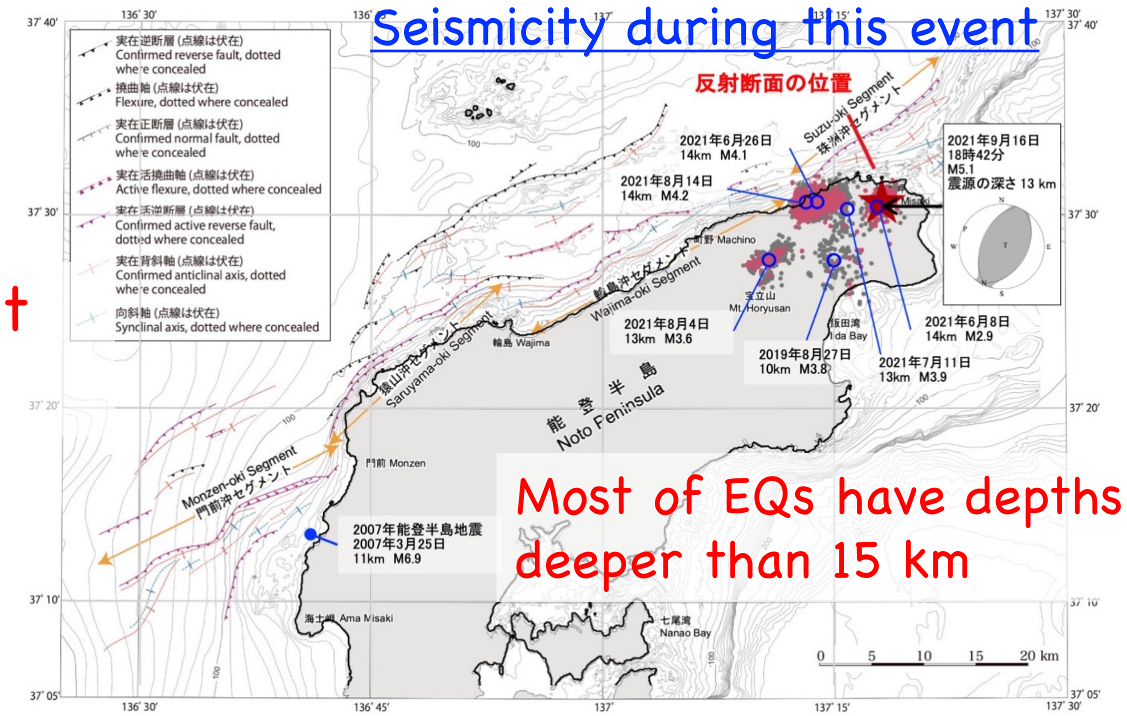


Does the InSAR data indicate Inflating source?

Modelling strategy



The Coordinating Committee for Earthquake Prediction, Japan Report number 107（Hiramatsu, 2022）



364th report of The Promotion of Earthquake Research（GSJ, 2021）

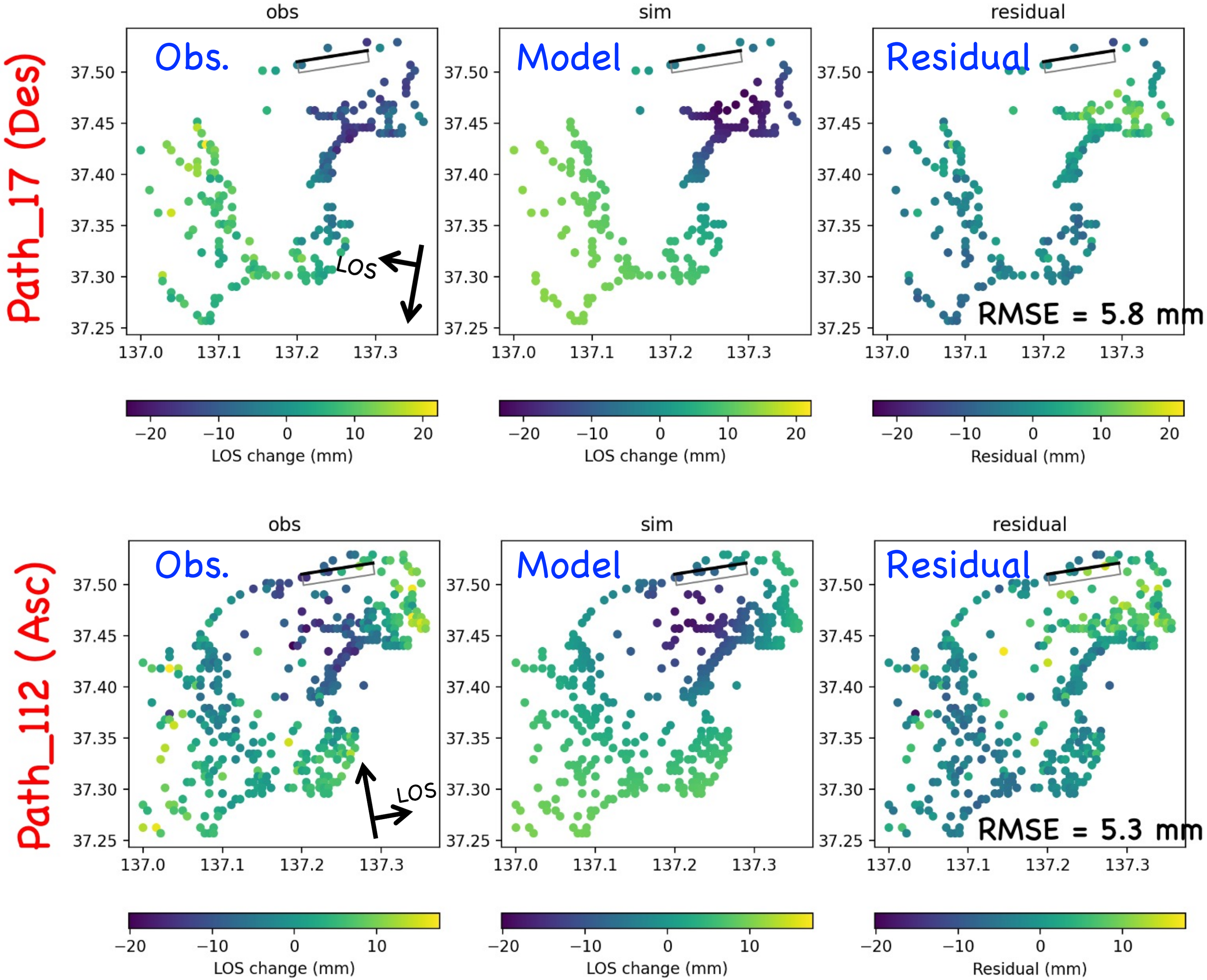
From geologic and seismic observations, I suspect that the Tamasu-oki segment may have started slipping.
→ Forward modelling (next page)

Forward modelling with finite dislocation model

- InSAR data were thinned out for computational efficiency.
- Assume the fault geometry as the “Tamasu” segment (reverse fault).

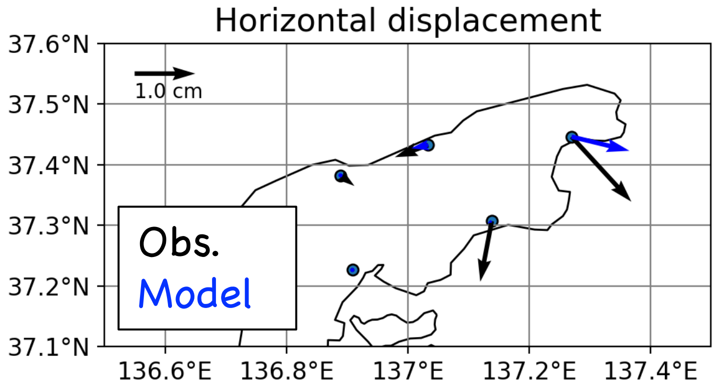
Source parameters

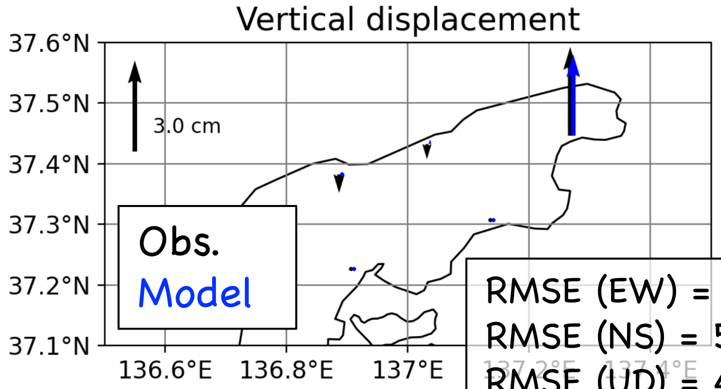
longitude	137.2	degree
latitude	37.51	degree
depth（上端）	20000	meter
strike angle（from N）	80	degree
dip angle	80	degree
Fault length	8000	meter
Fault width	7000	meter
dip slip	1.2	meter
strike slip	0.0	meter
opening	0.0	meter



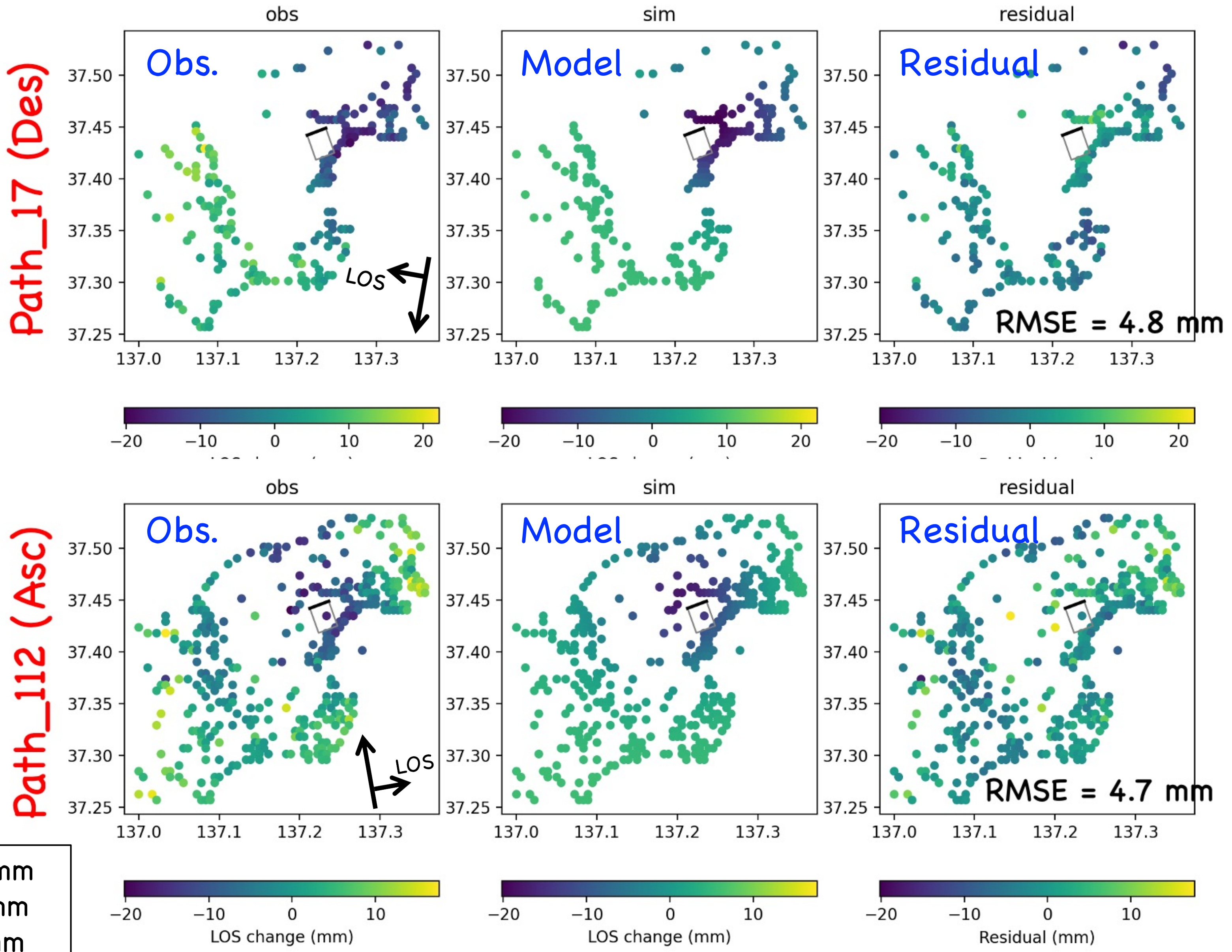
Joint Bayesian inversion (finite dislocation)

- Fukuda and Johnson (2008, GJI)
- InSAR (Des&Asc) & GNSS
- 3,000,000 samples
- reverse-type faulting was estimated



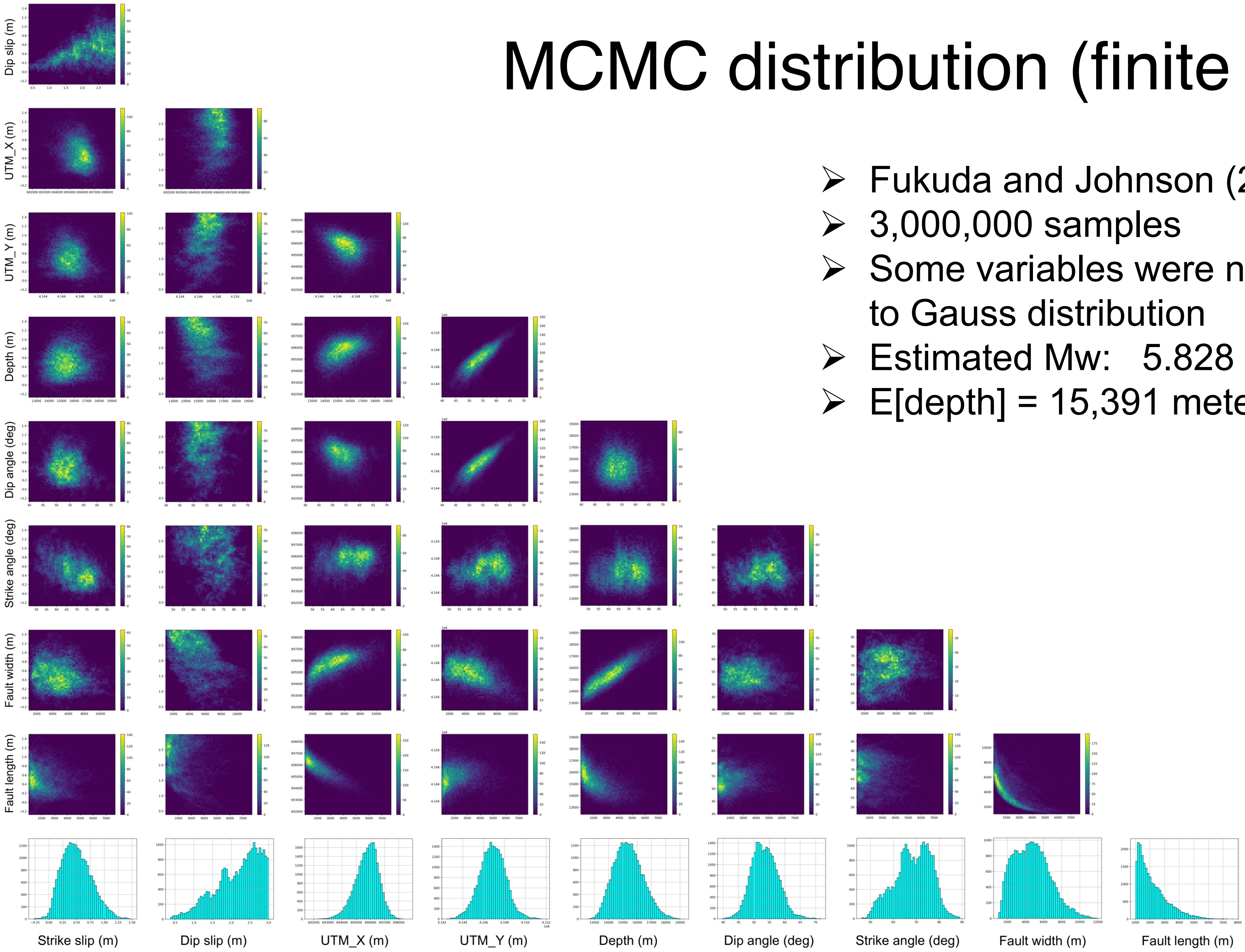


RMSE (EW) = 1.85 mm
RMSE (NS) = 5.79 mm
RMSE (UD) = 4.13 mm



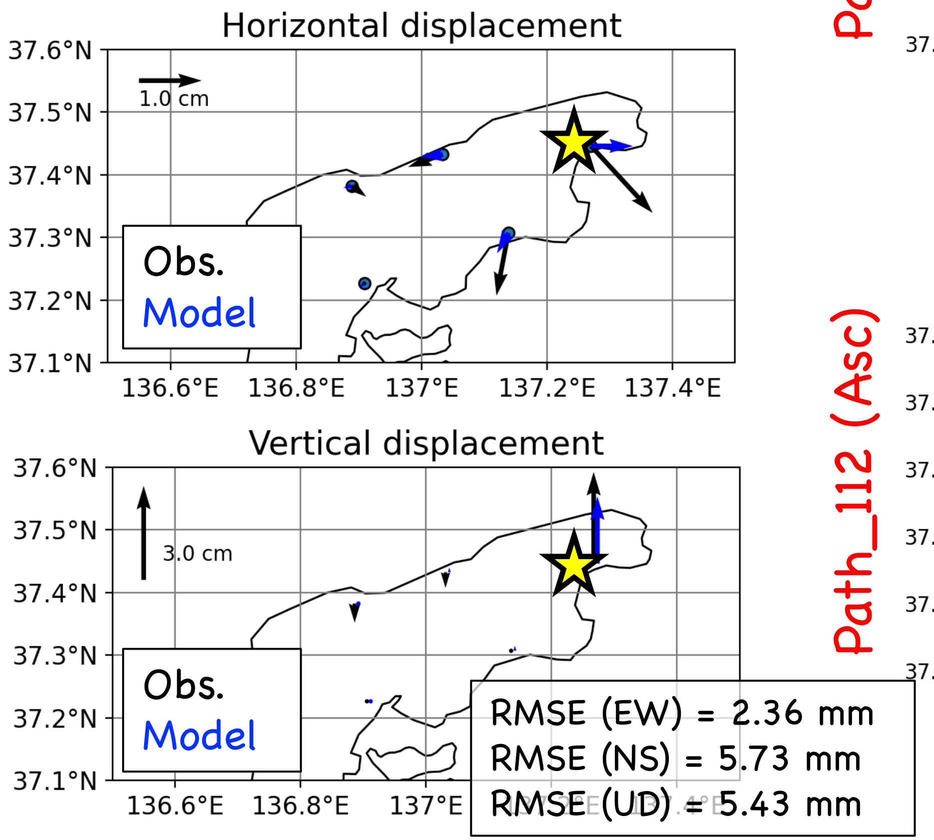
MCMC distribution (finite dislocation)

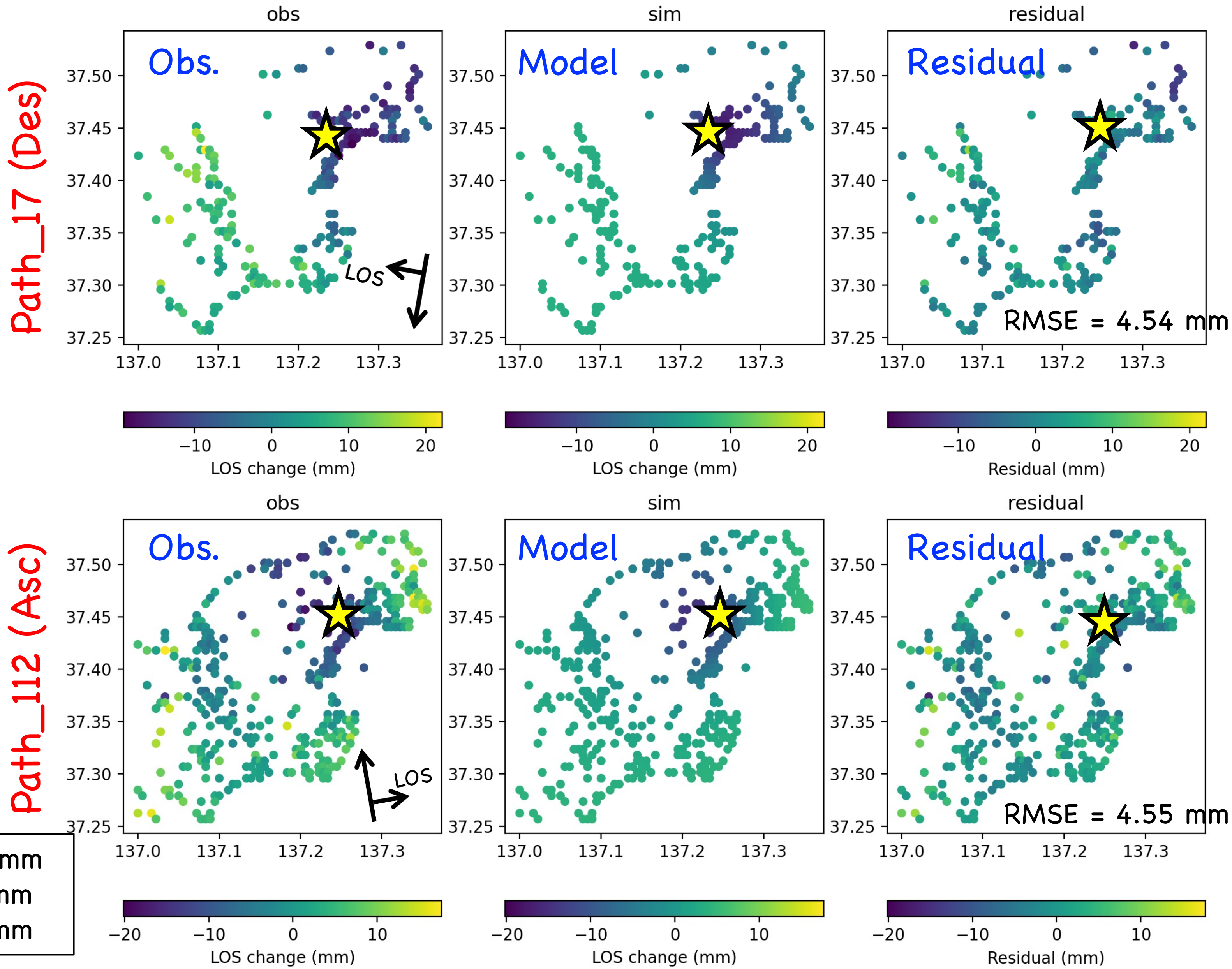
- Fukuda and Johnson (2008, GJI)
- 3,000,000 samples
- Some variables were not converged to Gauss distribution
- Estimated Mw: 5.828
- E[depth] = 15,391 meter



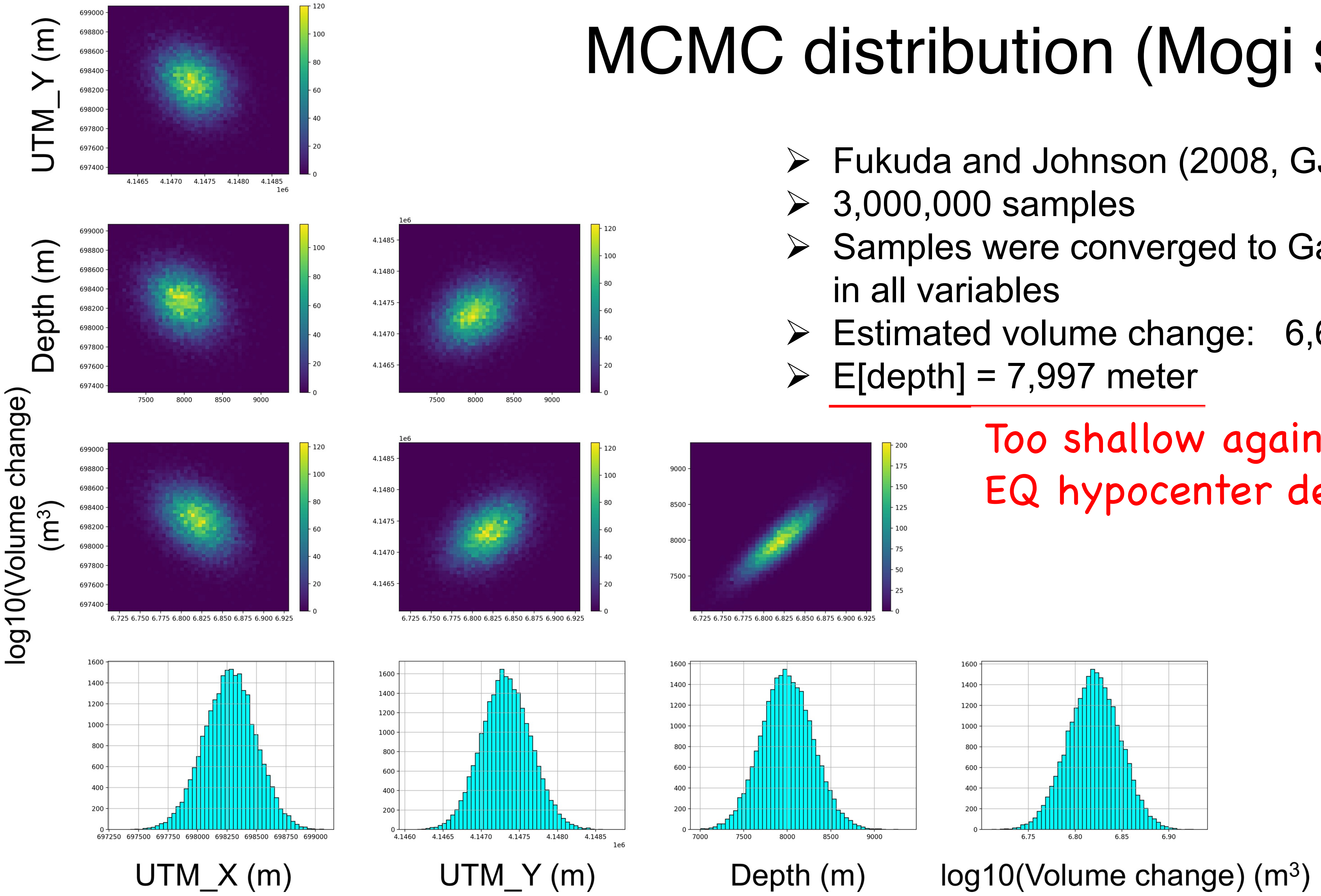
Joint Bayesian inversion (Mogi source)

- Spherical source was a little bit better than the Okada model for InSAR, but worse for GNSS.





MCMC distribution (Mogi source)



- Fukuda and Johnson (2008, GJI)
- 3,000,000 samples
- Samples were converged to Gauss distribution in all variables
- Estimated volume change: 6,606,233 m^3
- E[depth] = 7,997 meter

Too shallow against EQ hypocenter depths

Summary

- Sentinel-1 time series analysis & delay correction could detect continuous displacement at Noto peninsula, whose results were consistent with GNSS observations.
- Forward modelling indicated that a single finite dislocation model along with the Tamasu reverse segment could explain large part of observed displacements, but there remains residual displacements.
- Joint Bayesian inversion suggested that the Mogi spherical source model better explained observed displacements than the dislocation model in terms of RMSE, but their difference was not so large.

Acknowledgement

Sentinel-1 data were derived from the Alaska University Vertex system. I used ISCE software for InSAR processing, which is provided by WInSAR. 1-arcsecond SRTM DEM provided by USGS. GNSS data was originally provided by Japan Geospatial Information Authority. For the delay calculation, I used PPP-processed propagation delay data processed and provided by the Nevada Geodetic Laboratory, University of Nevada, Reno. I also used the DC3D Fortran source code of the finite rectangular fault model. This work was supported by JSPS KSKENHI Grant-in- Aid for Early-Career Scientists (JP21K14006).