School of Earth and Environment
Institute of Geophysics and Tectonics

Capturing the Surface Deformation of the 112 km Deep M_w 6.8 2020 Earthquake, Chile, using InSAR time series analysis

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Outline

- Background
- Study Area: Northern Chile
- InSAR Processing
  - Tropospheric Correction
  - Ionospheric Correction (Split Spectrum & CODE)
- Earthquake Study
  - Coseismic Deformation Field Retrieval (ICA)
  - Source Modelling
  - Intraslab Earthquake Detectability & Velocity Structure

Introduction

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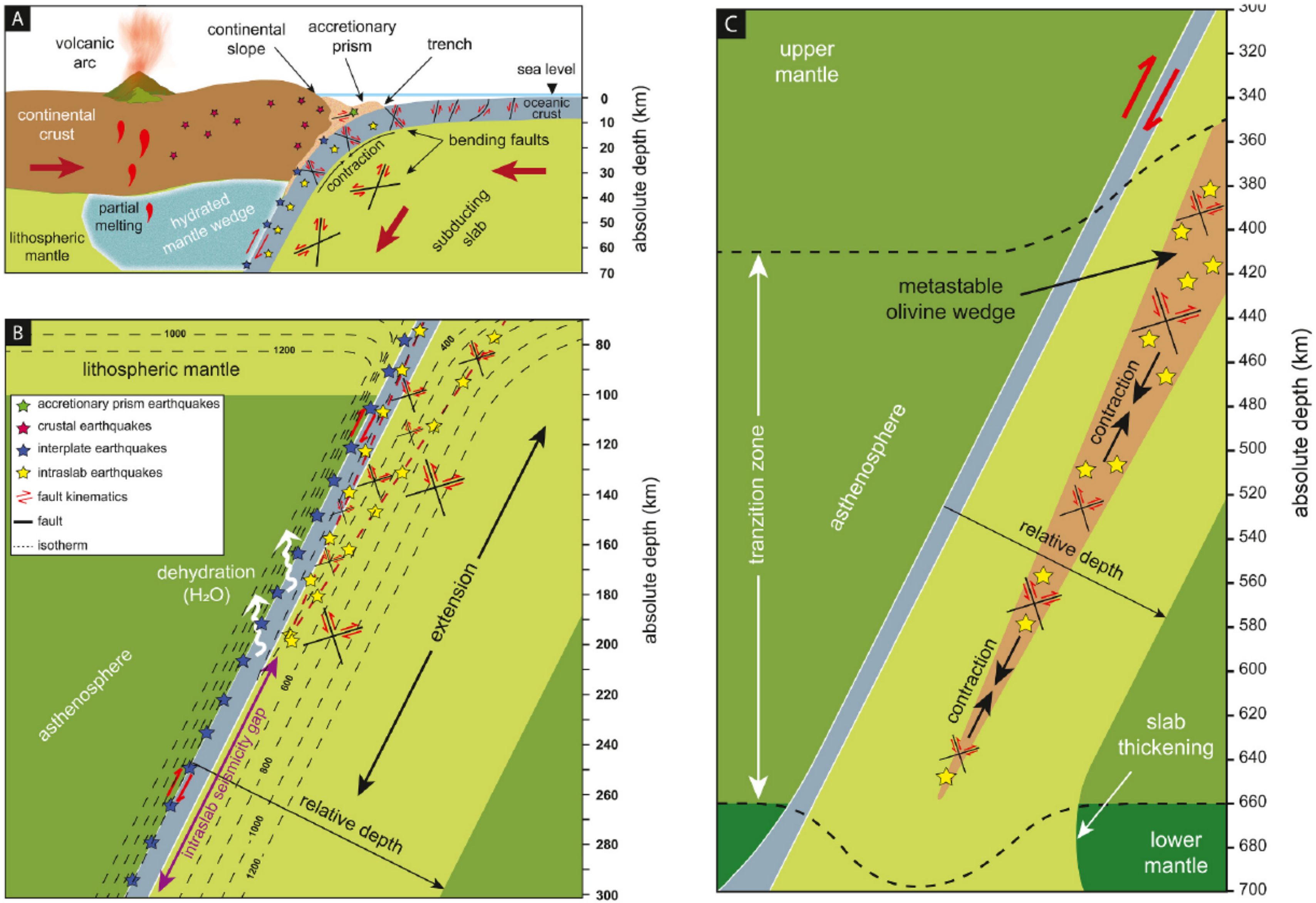
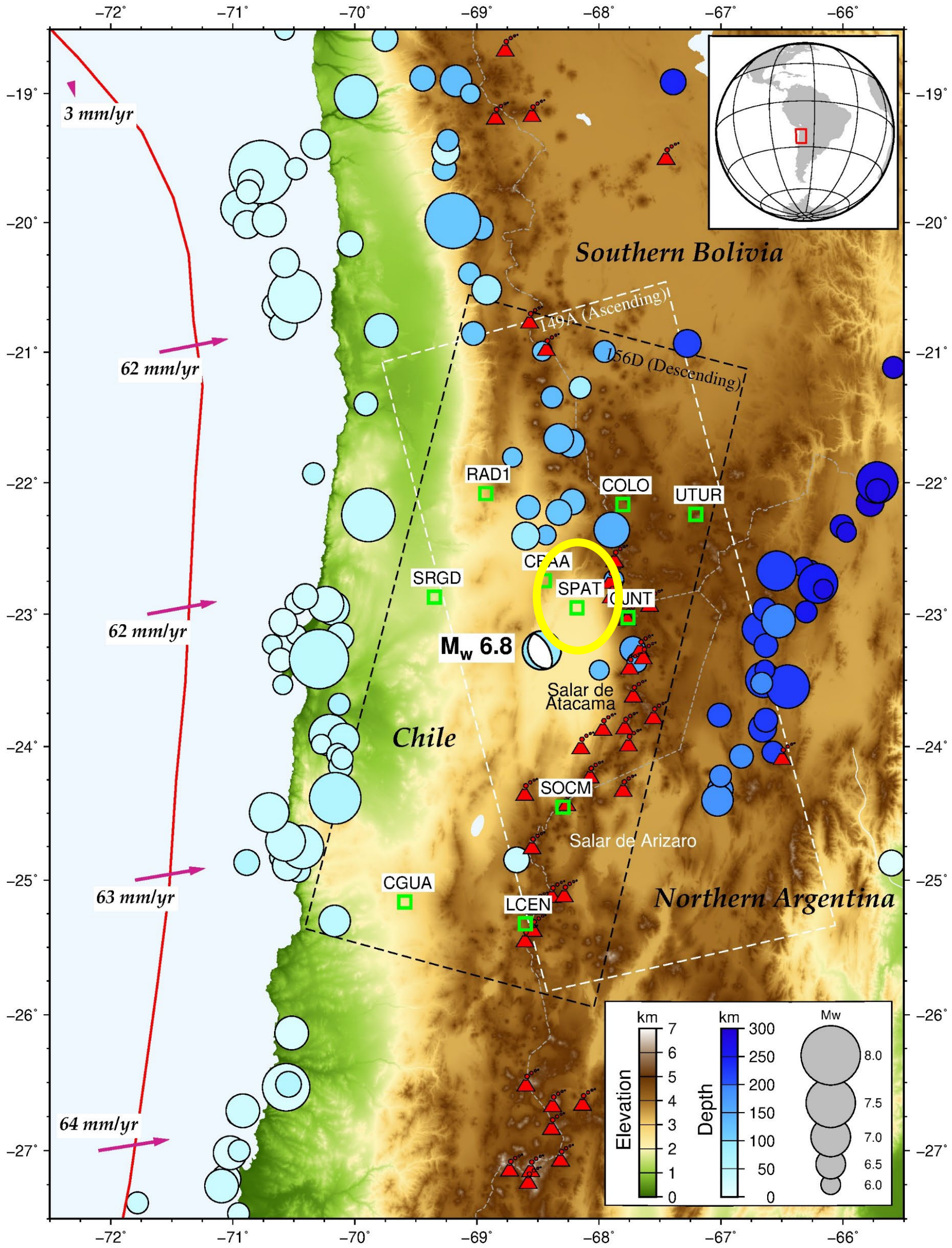


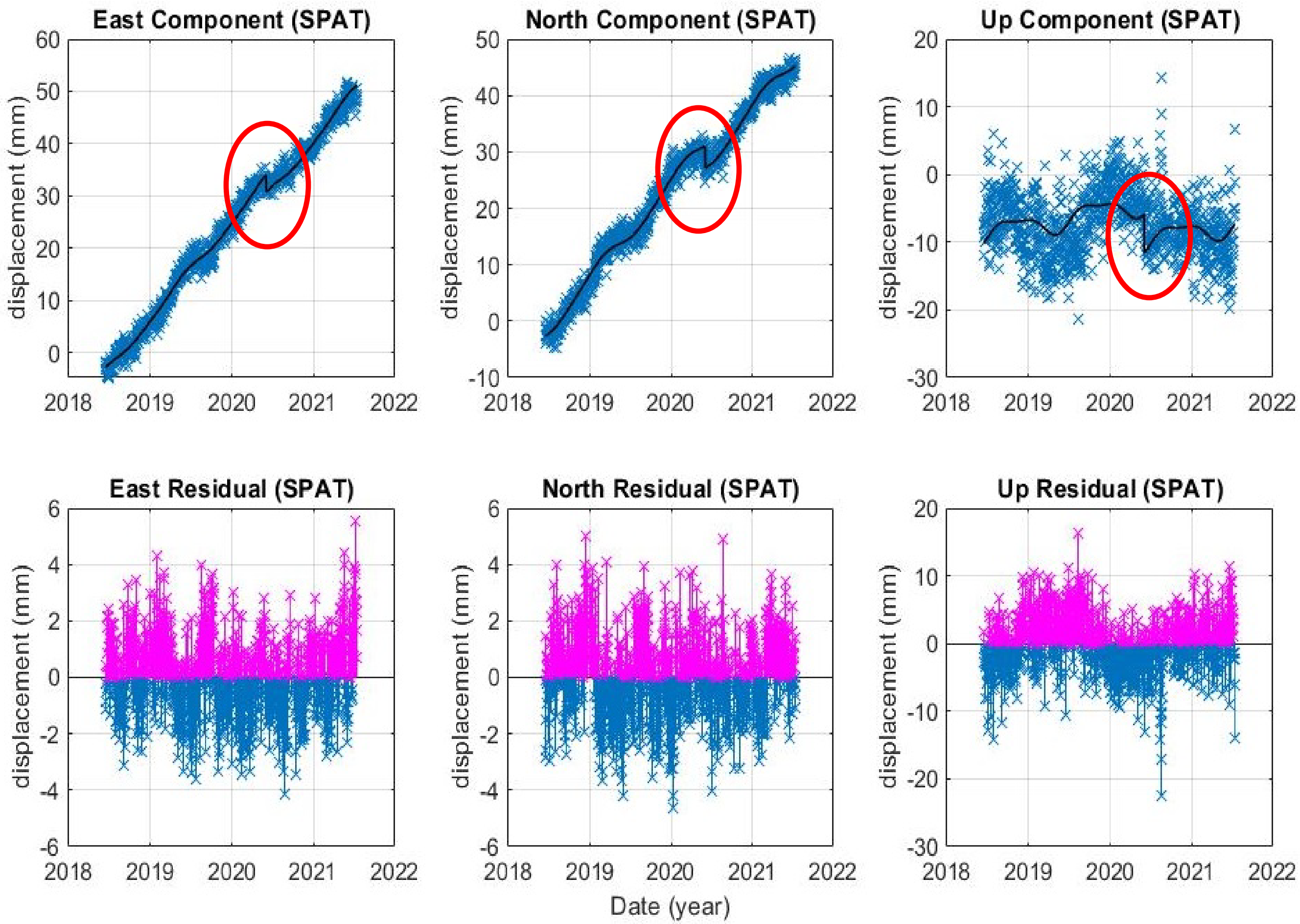
Figure from Hosseinzadehsabeti et al., 2021.

Why do we care about the intraslab earthquake?

Study Case: Northern Chile



Can we observe the coseismic deformation of this intraslab earthquake from InSAR?



Workflow: Data Processing

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InSAR Processing

Sentinel-1 SLC Images

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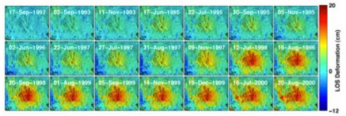
Interferograms Formation



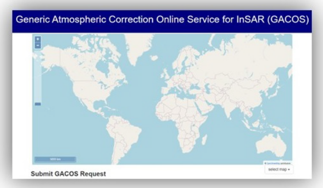
Multilooking (10*40)

No spatial filtering

6-60 days baseline

⇨

Atmospheric Correction



Troposphere (GACOS)

Ionosphere

(Split Spectrum)

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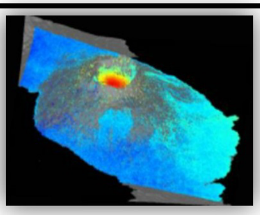
Time Series



Unwrapping iteratively

SBAS inversion

Earthquake Modelling

Deformation Model

$$\psi(t) = H(t - t_0)C + A_1 \sin(2\pi t) + A_2 \cos(2\pi t) + Vt + b$$

Potential velocity change

⇨

Coseismic Deformation Fields Retrieval

Parameterized time series fitting

Independent Component Analysis (ICA)

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Earthquake Modelling

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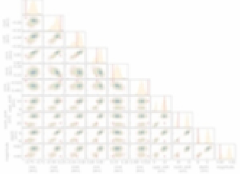
Bayesian Earthquake Analysis Tool



Layered half-space

InSAR & GPS

Atmospheric Correction: Example

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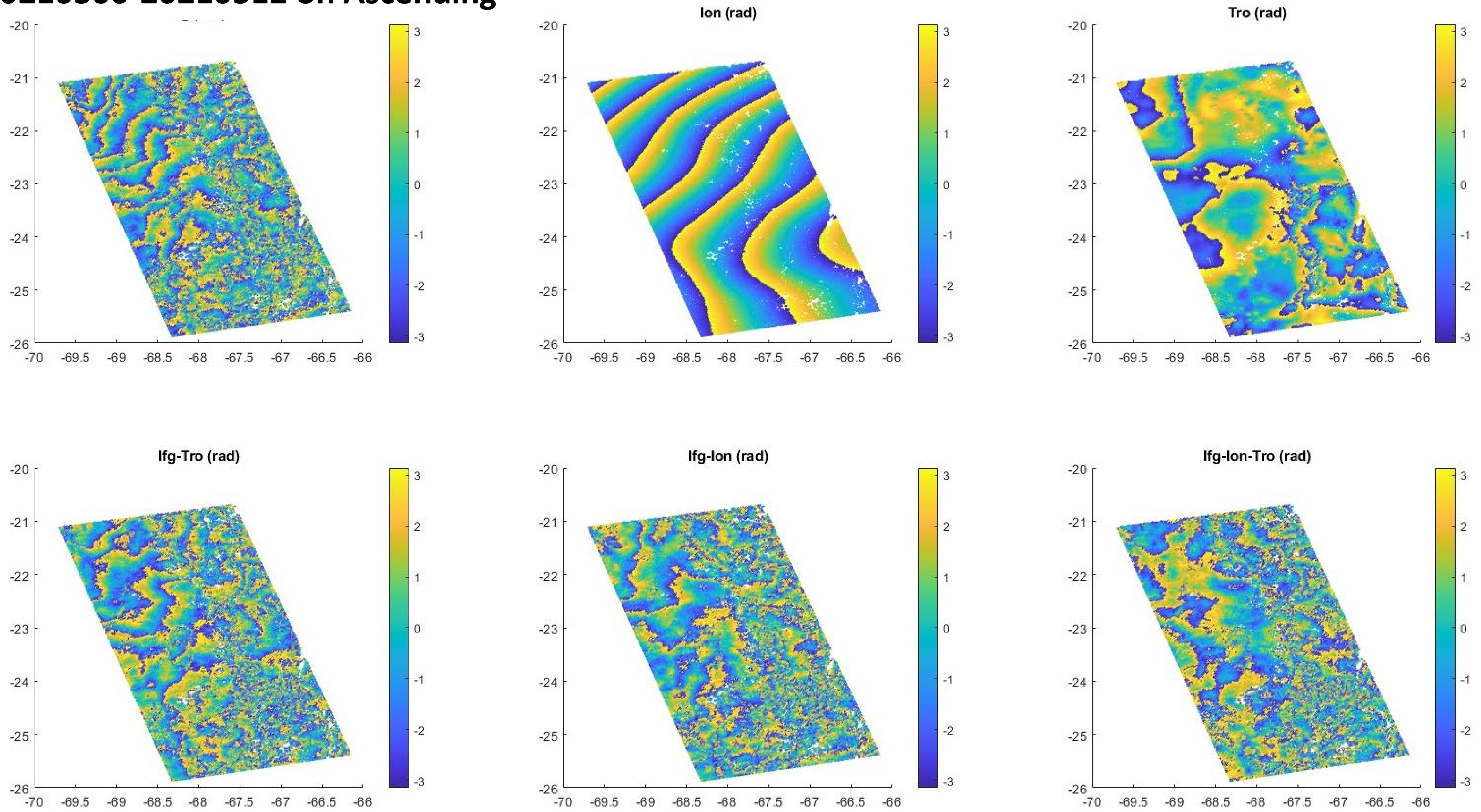
Ifg 20210306-20210312 on Ascending



Ionospheric Correction

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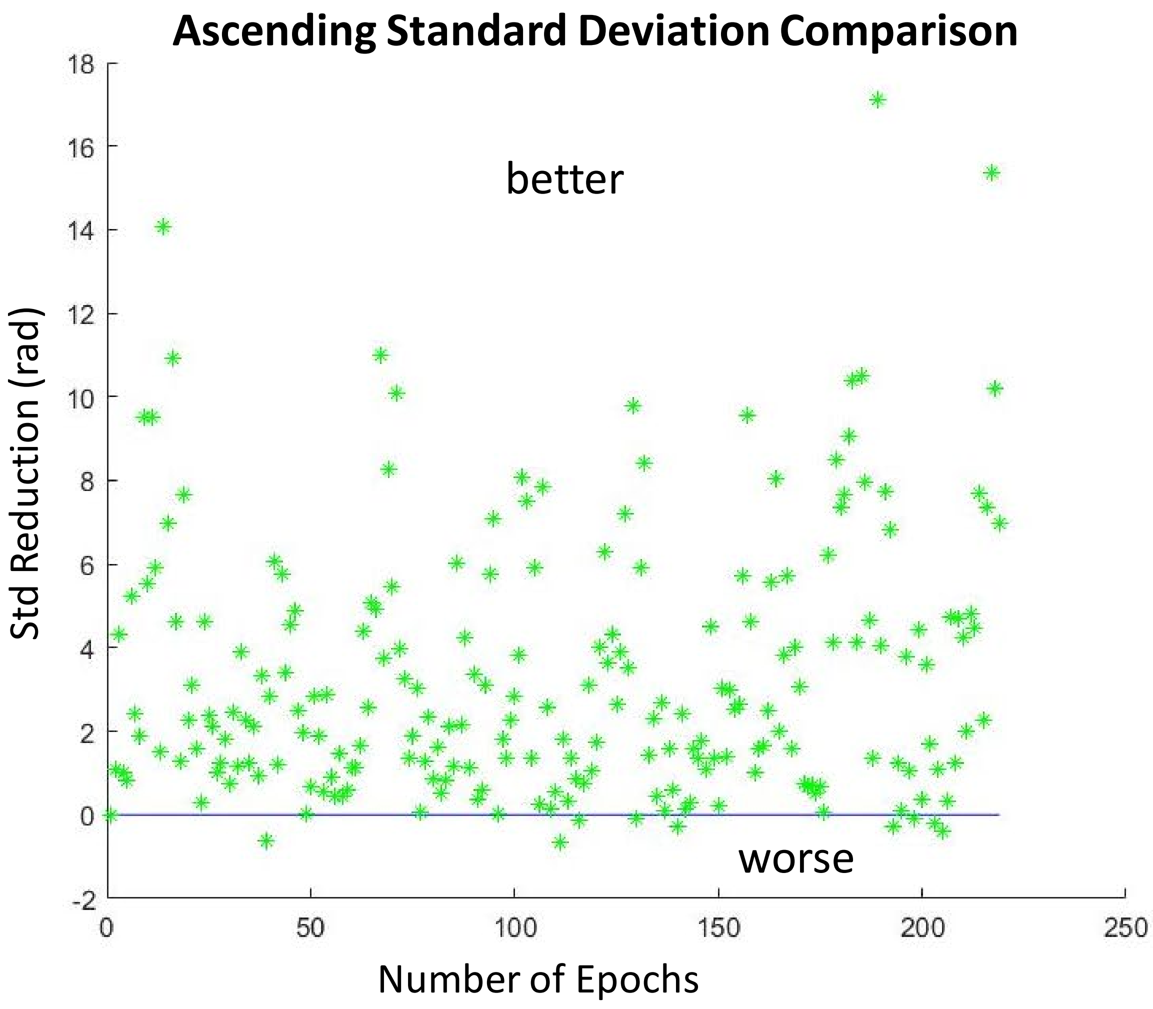

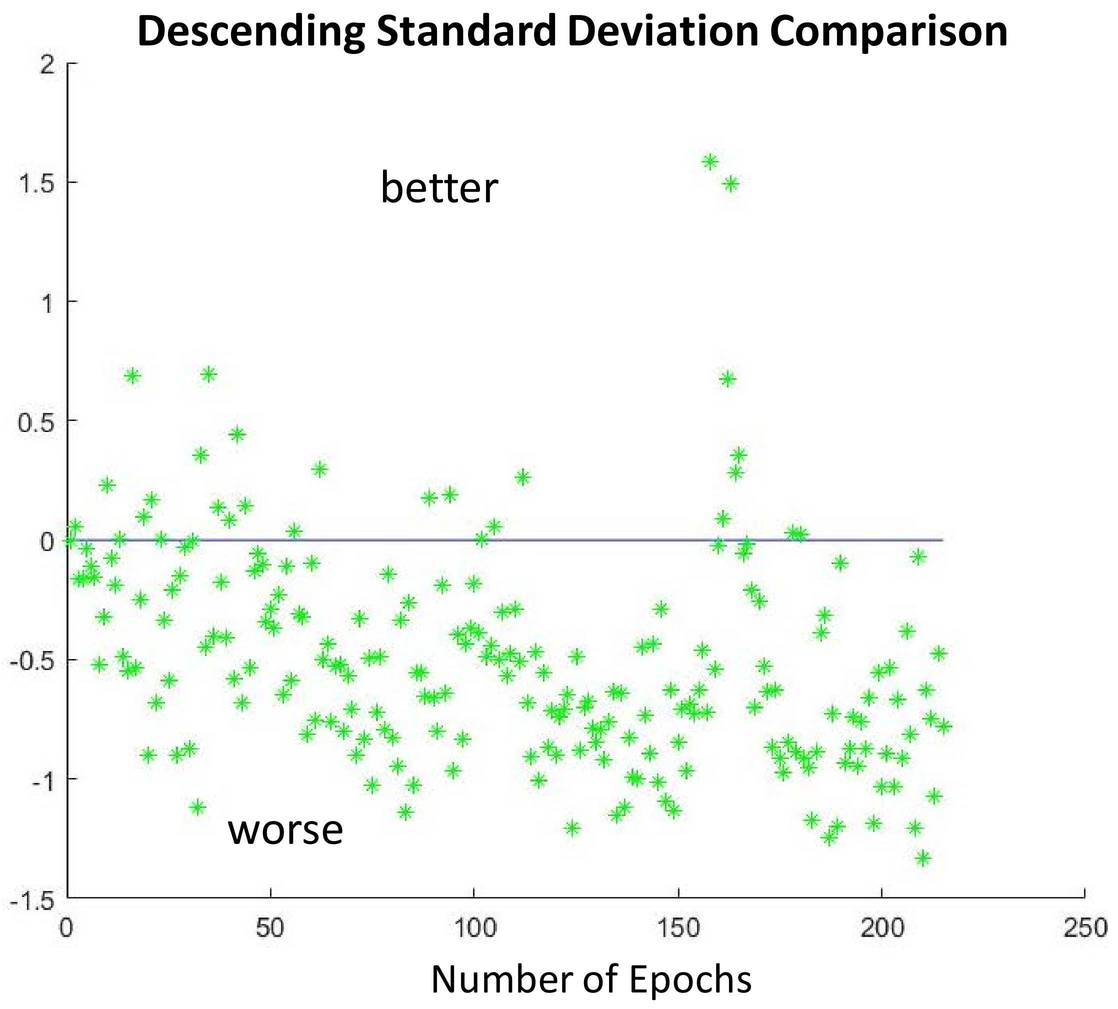

Average 33% std reduction

Average -5% std reduction

Mainly due to the different acquisition time
(6 pm for ascending and 6 am for descending, local time)

Atmospheric Correction: Overall Improvements

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Ascending	Average Standard deviation (mm)	Average RMSE for time series fitting (mm)
ifg	6.54	17.49
ifg-tropo	6.21 (5.11%)	14.25 (18.49%)
ifg-ion	4.34 (33.70%)	10.20 (41.64%)
ifg-tropo-ion	2.86 (56.20%)	8.10 (53.67%)

Descending	Average Standard deviation (mm)	Average RMSE for time series fitting (mm)
ifg	5.90	18.26
ifg-tropo	3.42 (42.04%)	8.42 (53.89%)
ifg-ion	6.20(-4.96%)	17.85 (2.25%)
ifg-tropo-ion	3.92(33.47%)	8.27 (54.71%)

Ionospheric Correction: Split Spectrum vs CODE

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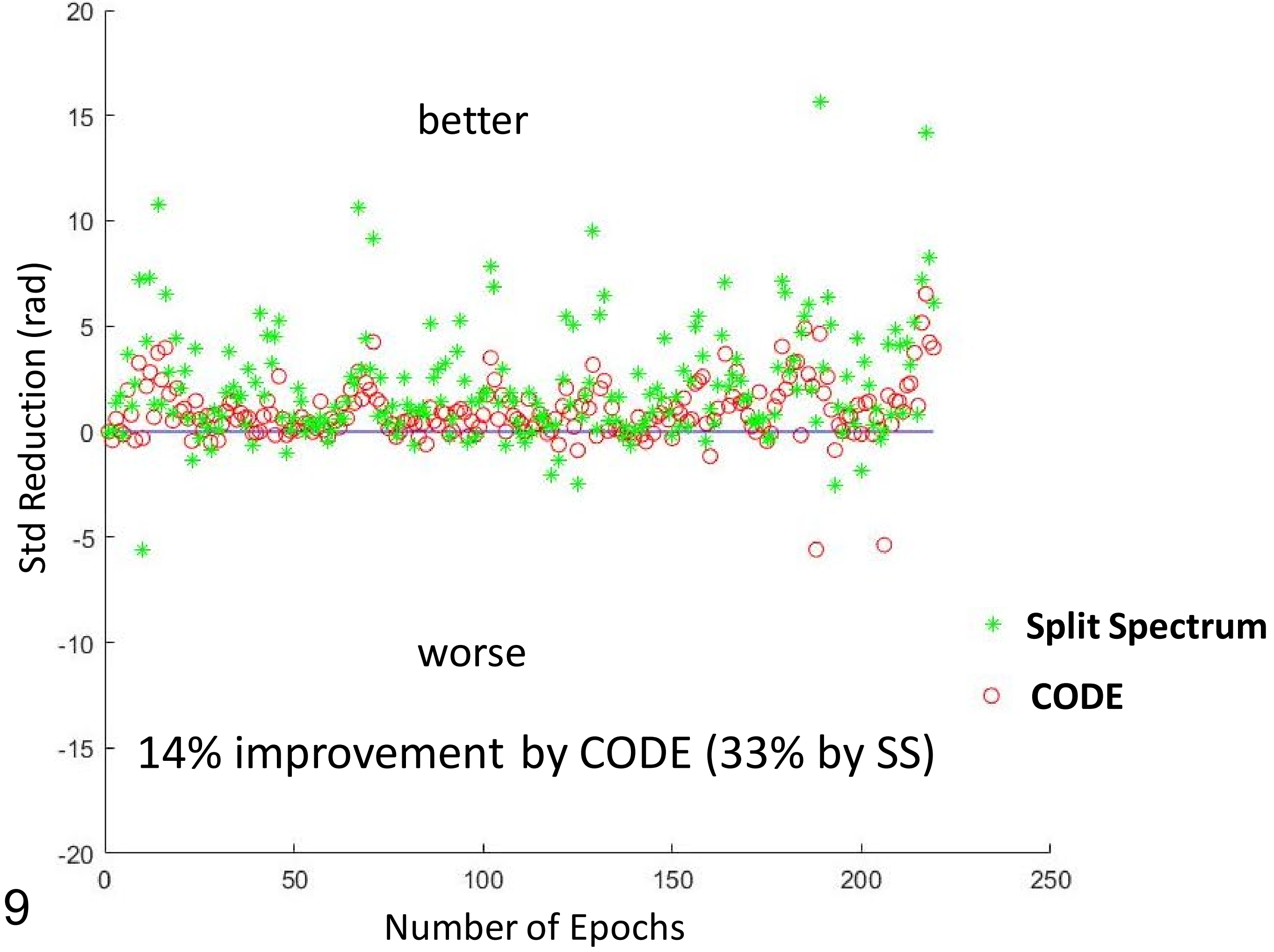
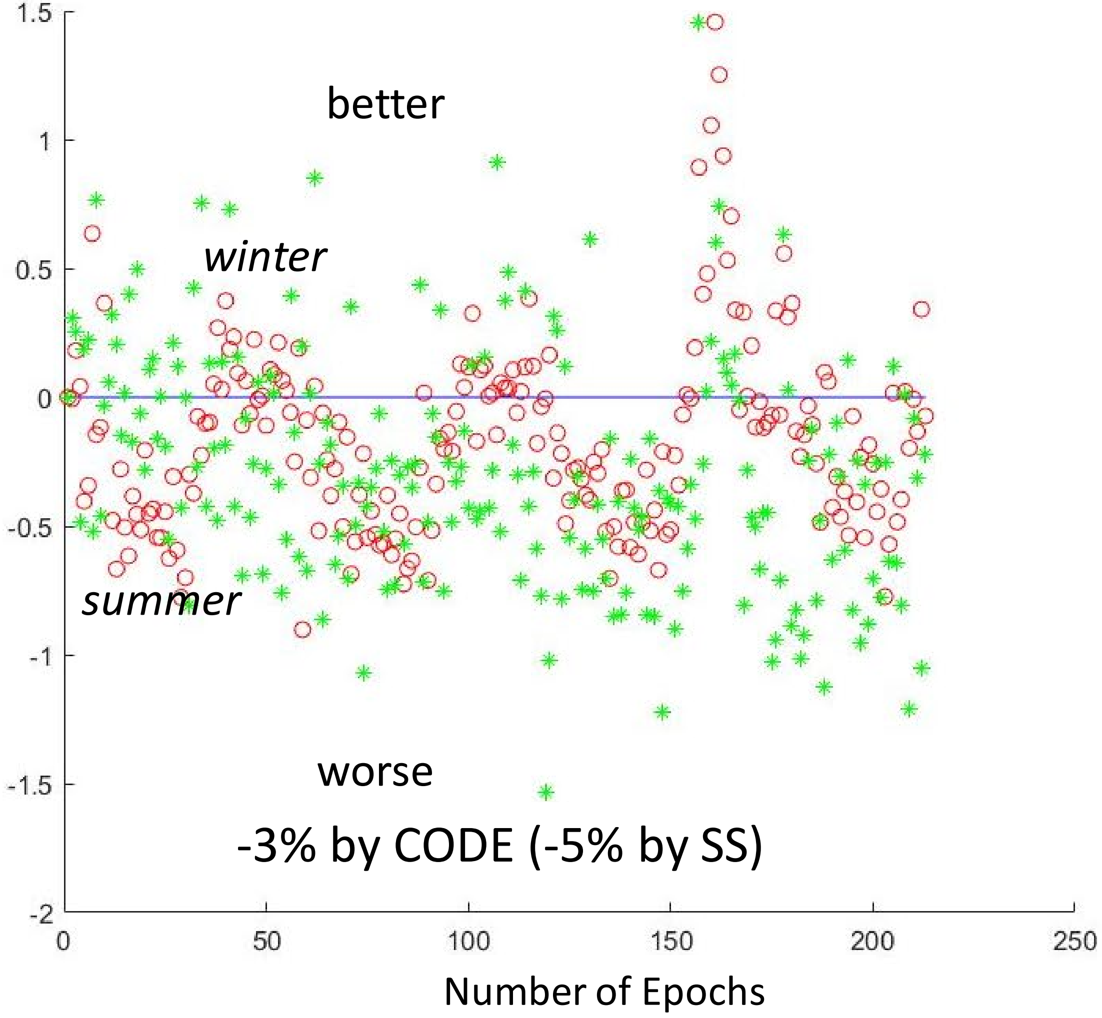
Vertical Total Electron Content (vTEC) product of Center for Orbit Determination in Europe (CODE), which is also used for ETAD ionospheric correction.

Ascending Standard Deviation Comparison



Descending Standard Deviation Comparison



Ionospheric Correction: Split Spectrum vs CODE

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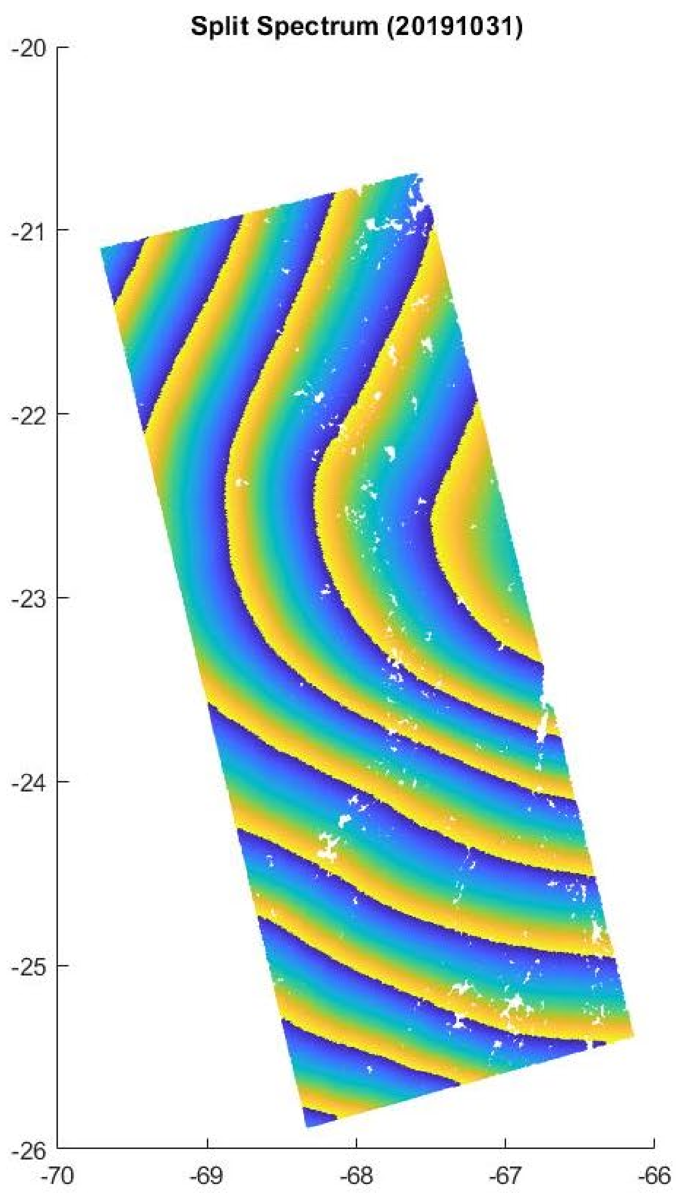
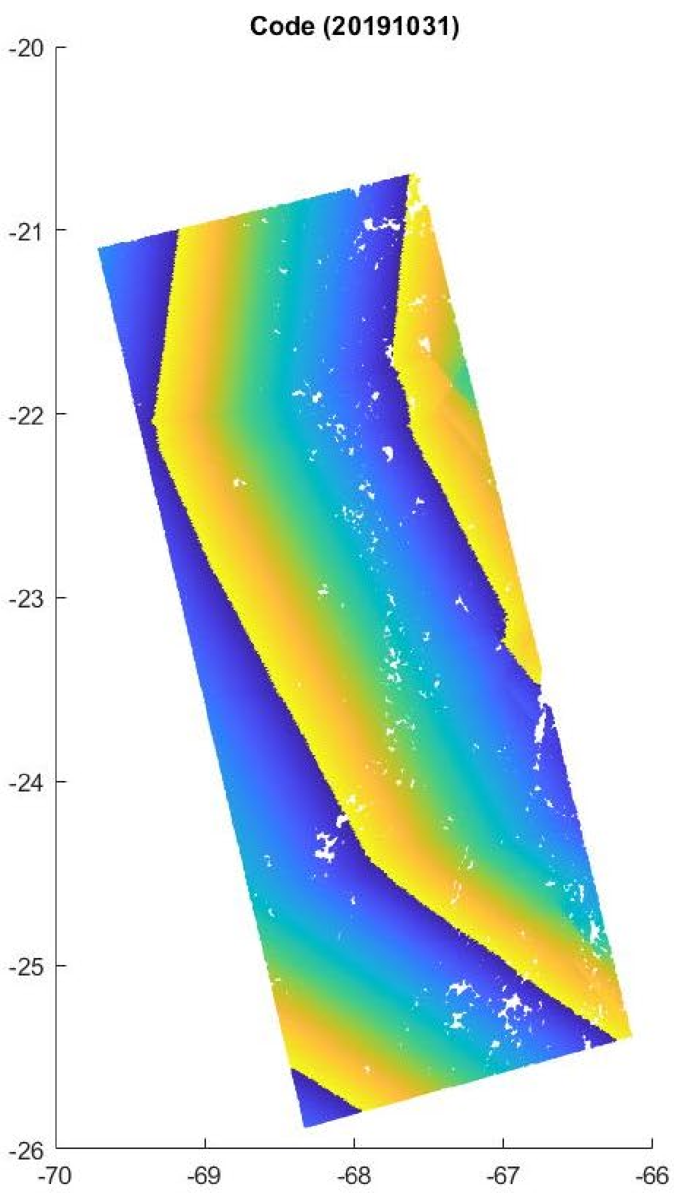
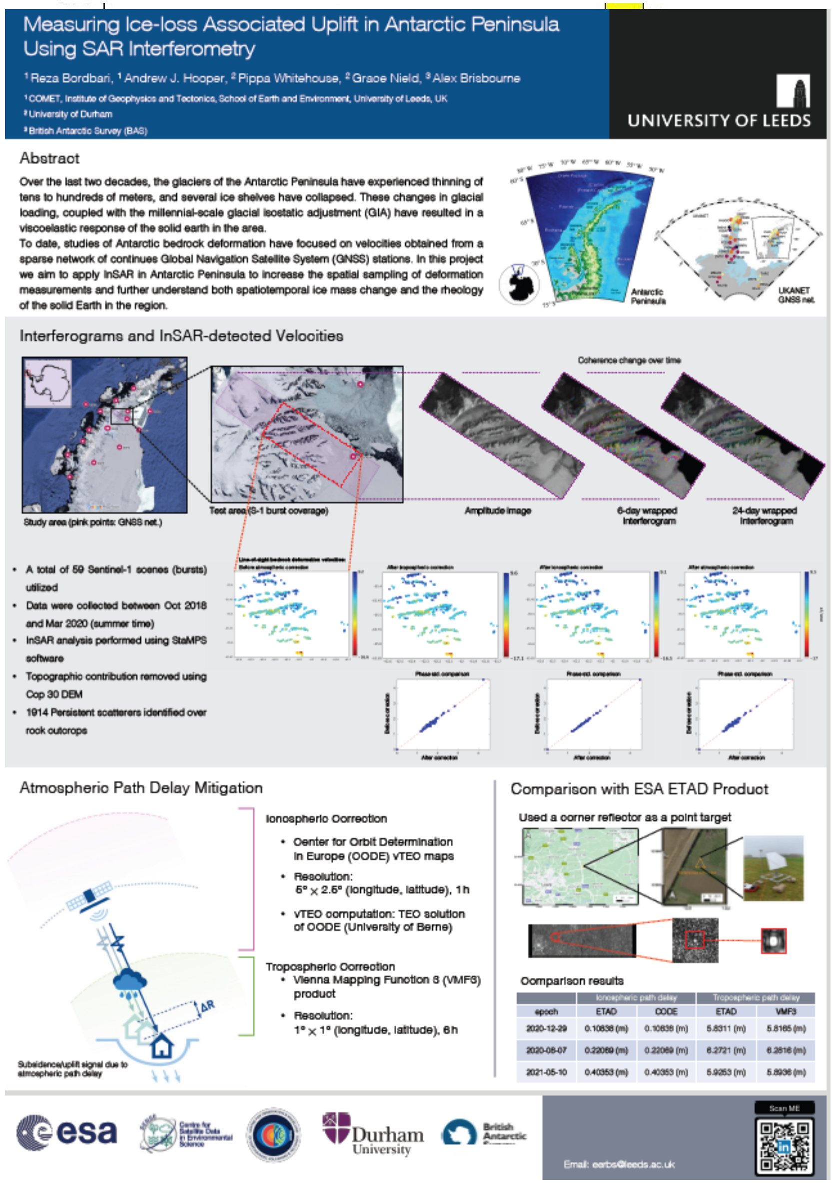




Check **Reza**'s poster (**ID 140**)!



Workflow: Earthquake Modelling

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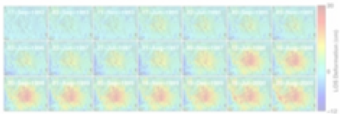
InSAR Processing

Sentinel-1 SLC Images ⇨



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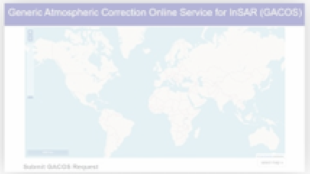


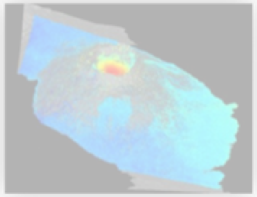
Atmospheric Correction

Troposphere (GACOS)

Ionosphere

(Split Spectrum)

⇨



Time Series

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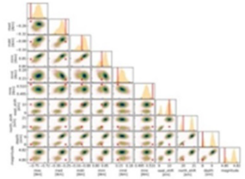

Layered half-space

InSAR & GPS

Coseismic Deformation Field Retrieval

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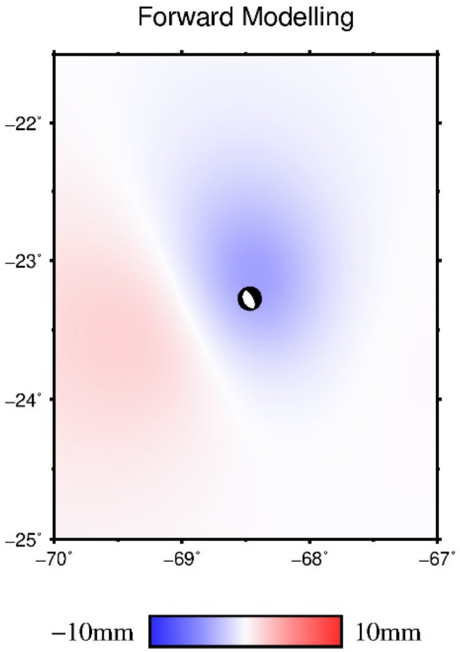
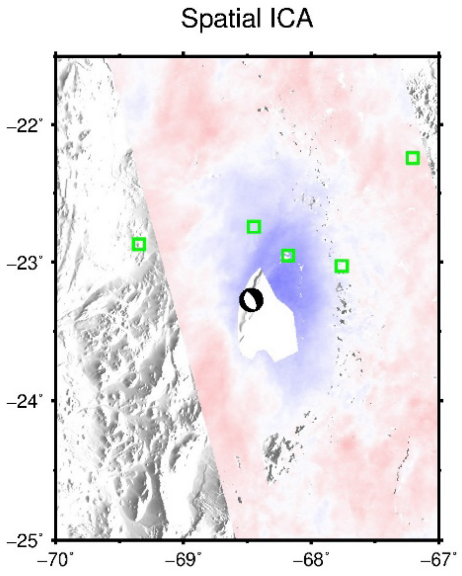
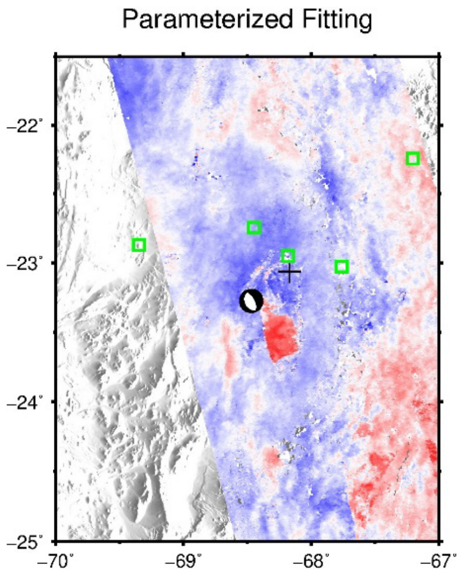
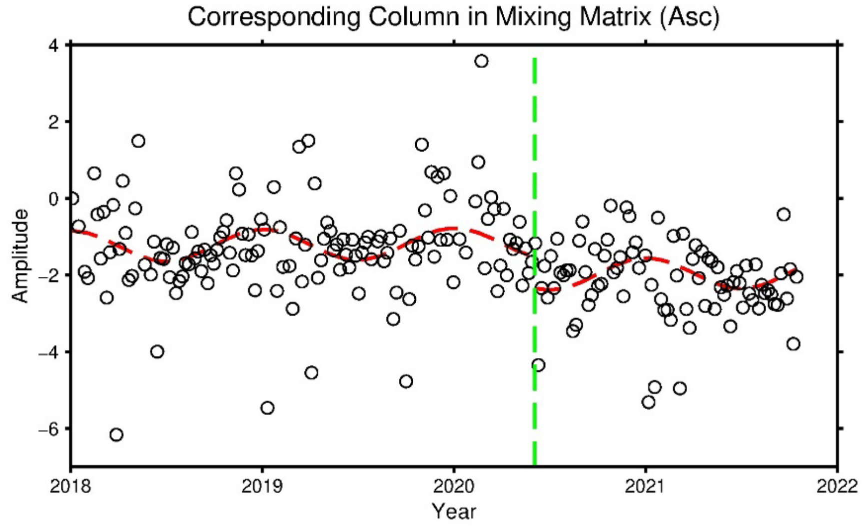
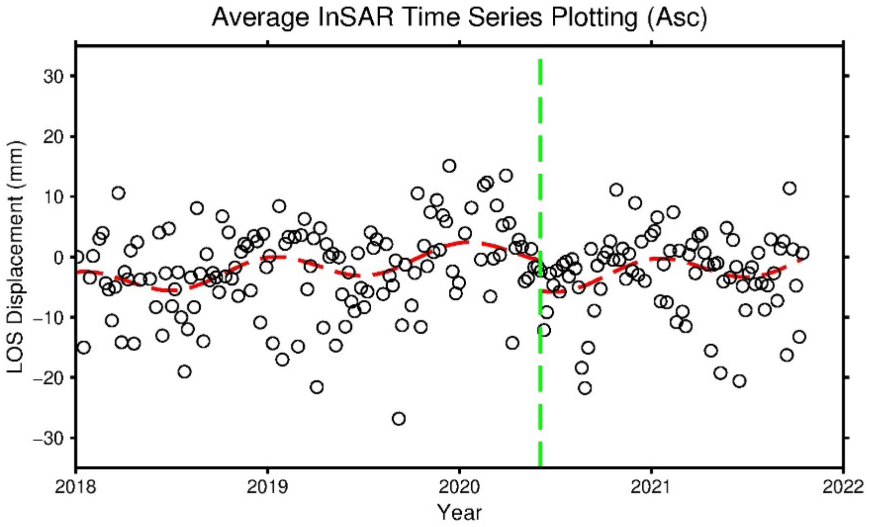
Parameterized Fitting & ICA











○ Observations — — Fitting — — Earthquake event time

Modelling: InSAR & GPS

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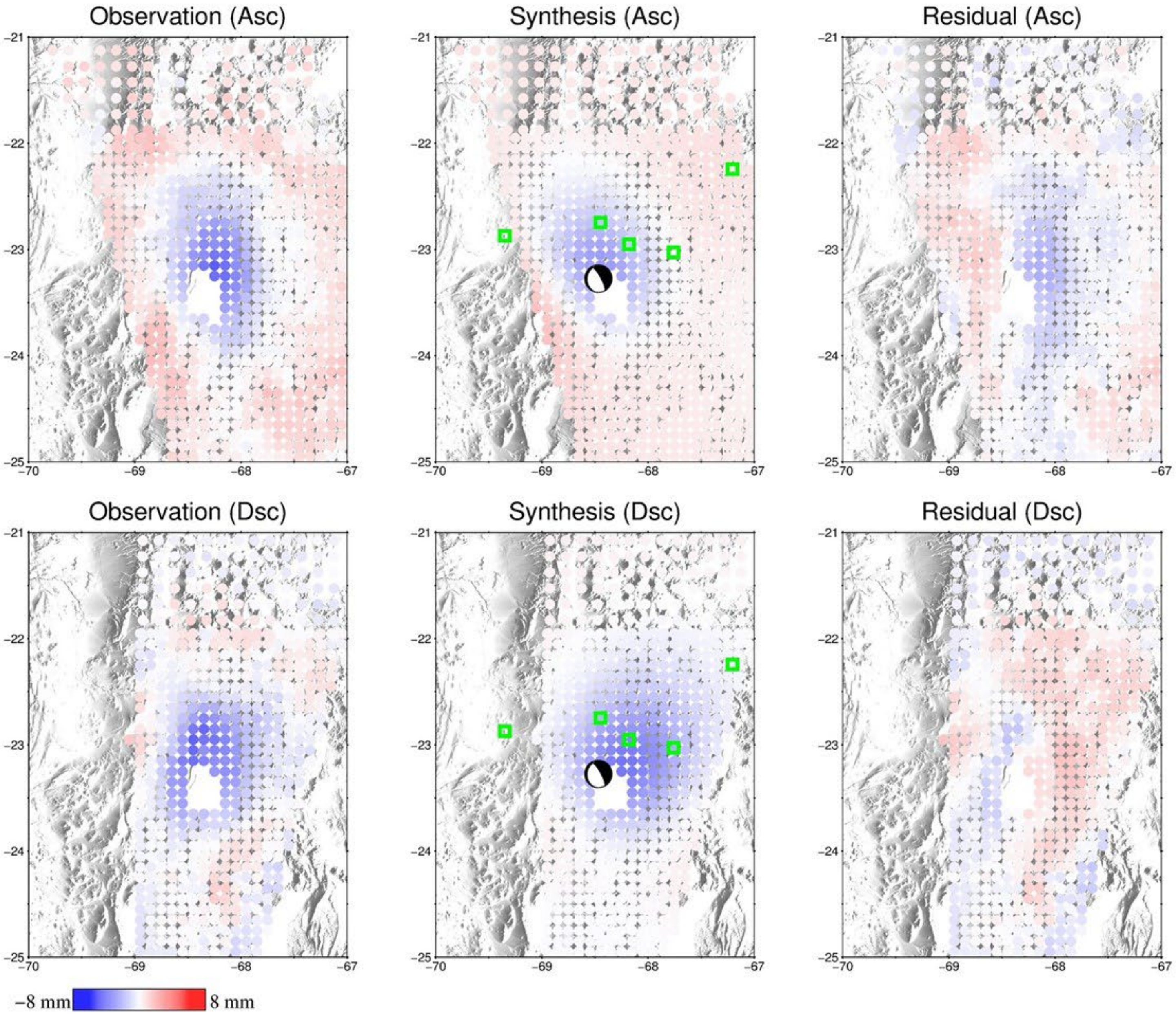

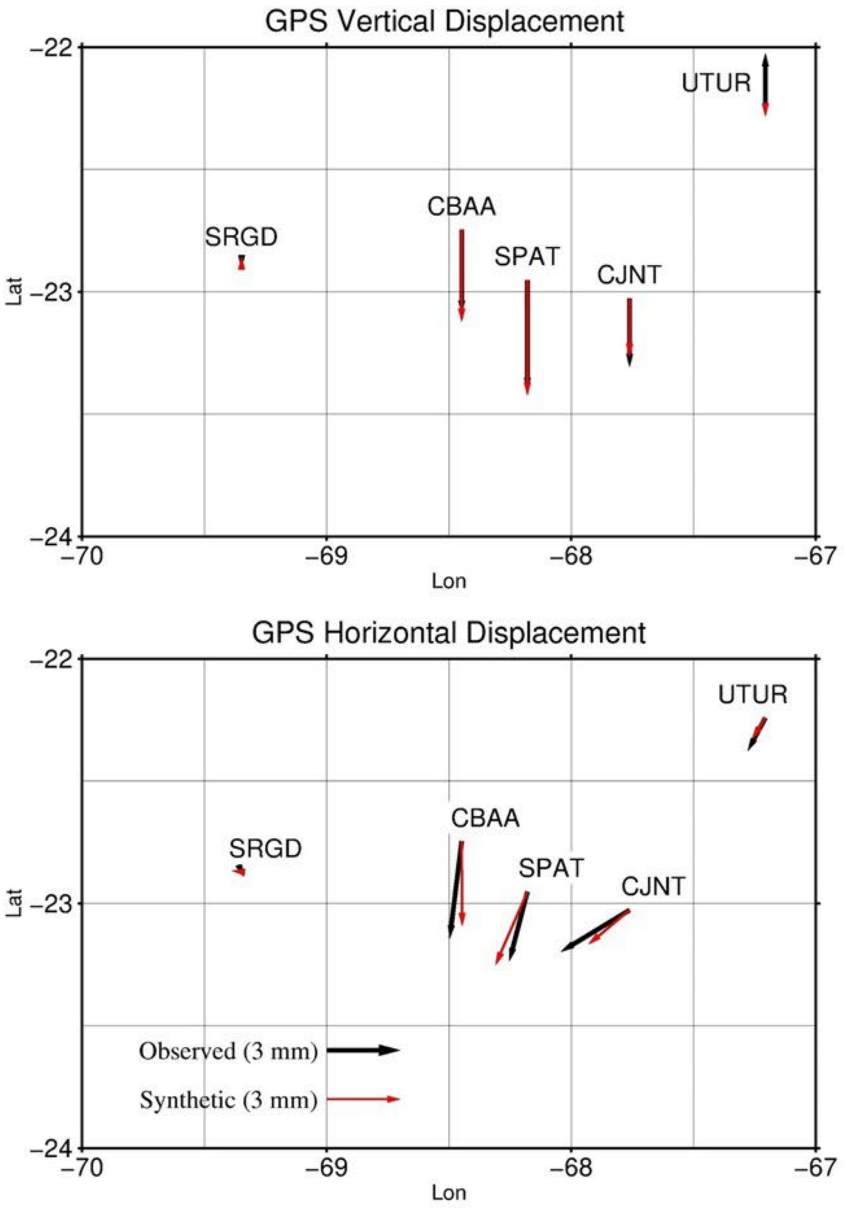

Modelling: Posterior Distribution

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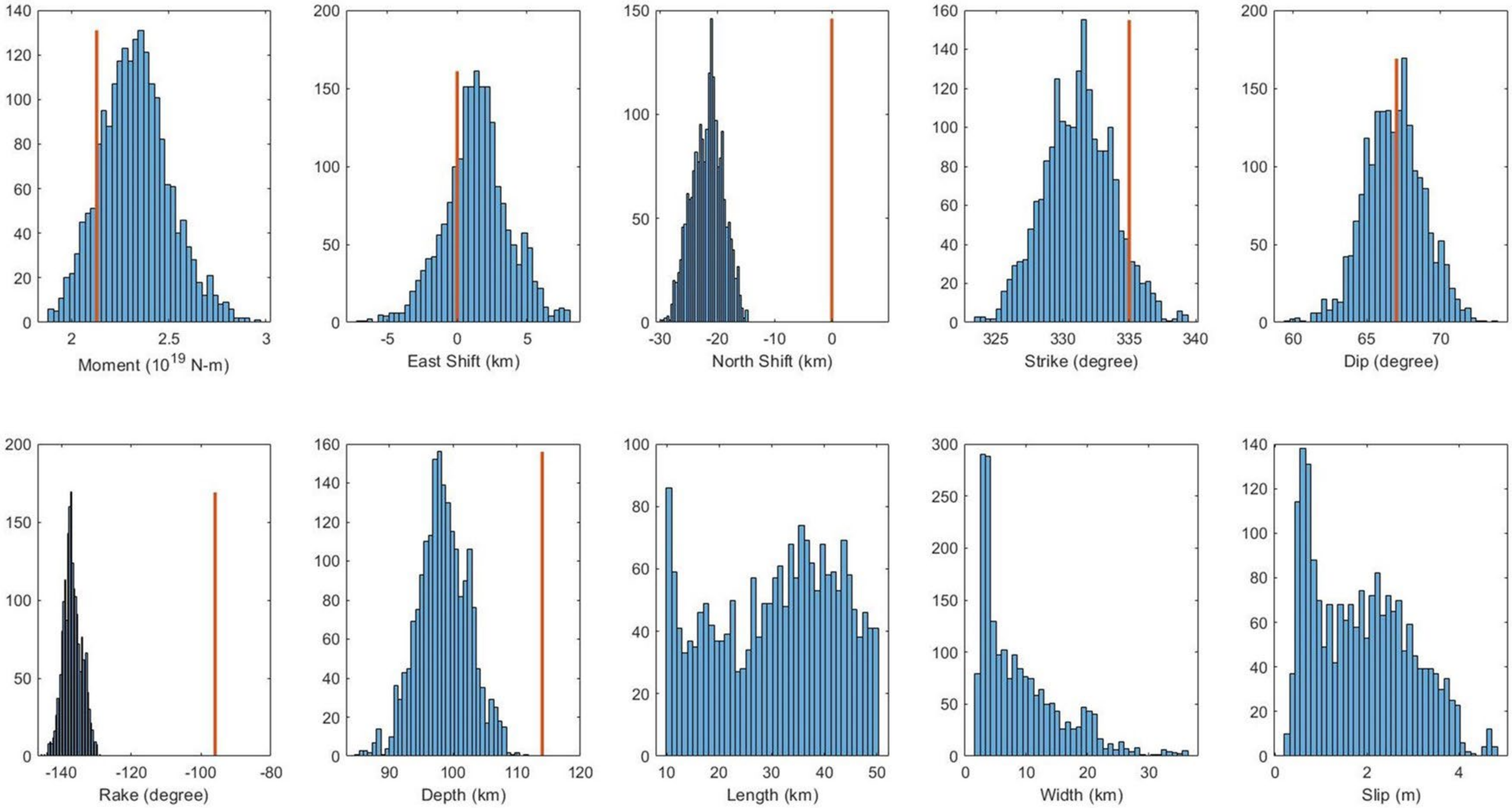

USGS solution

Forward Modelling & Velocity Structure

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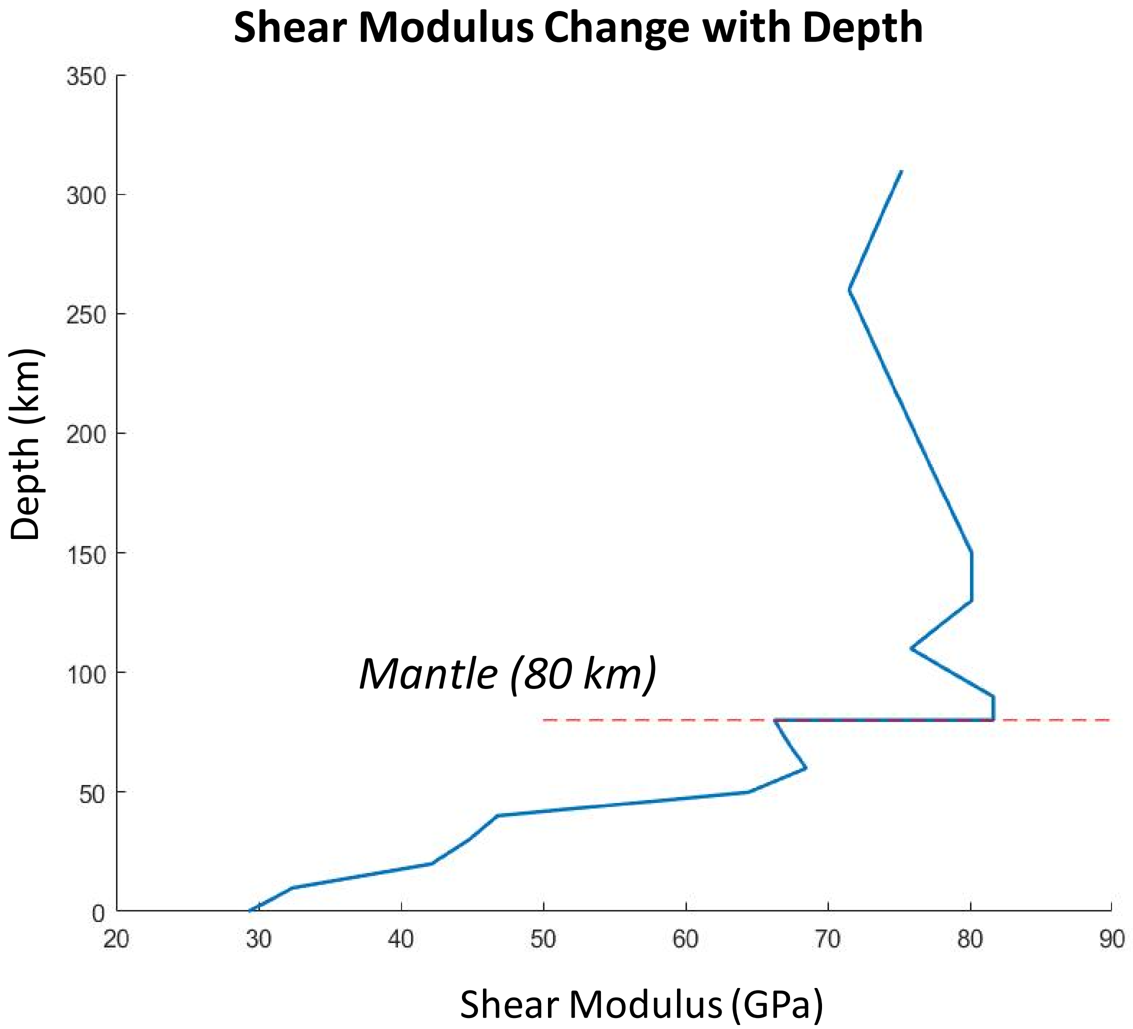
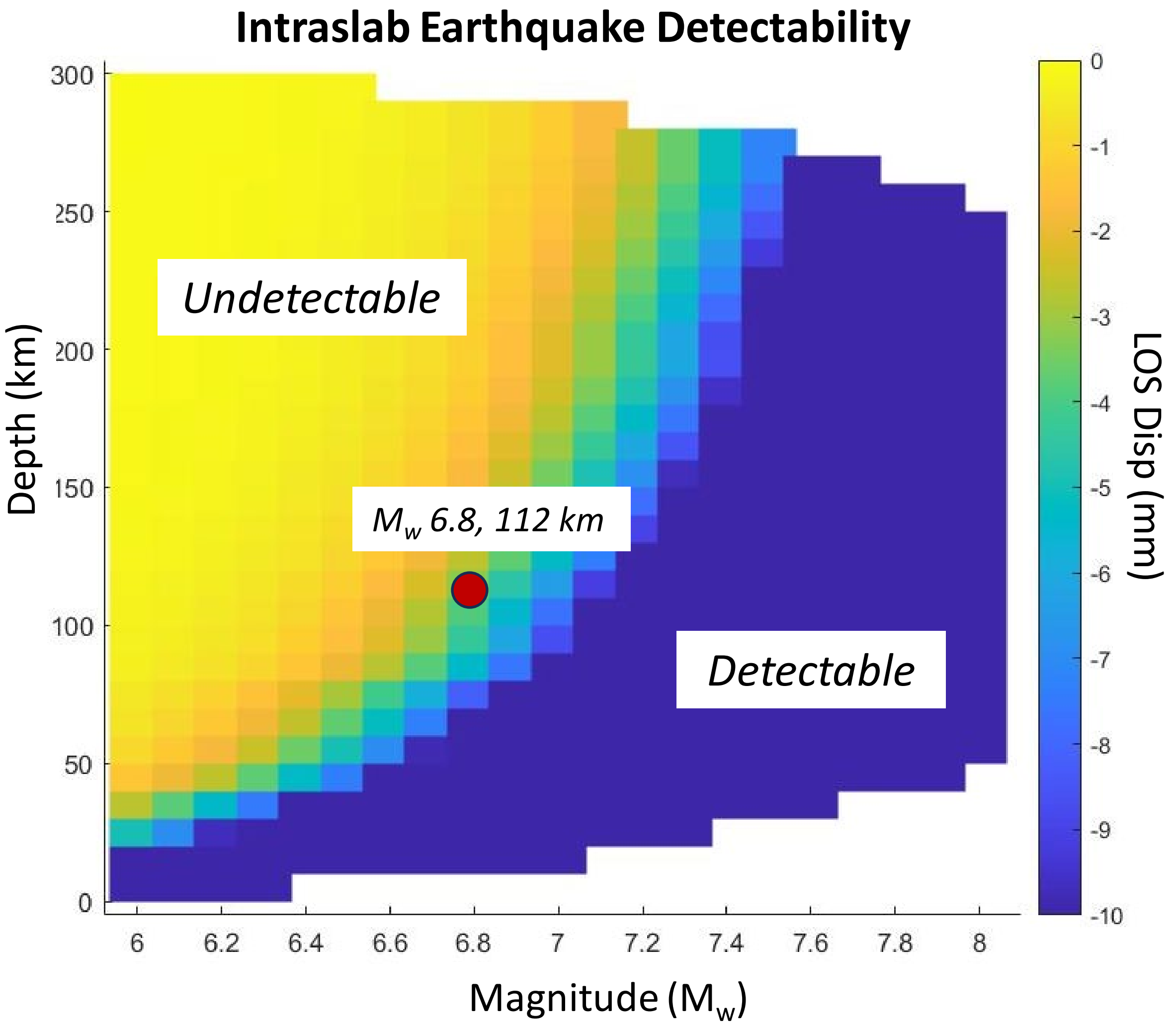
$$M_0 = \mu \cdot D \cdot A$$





Take Home Message

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- Ionospheric correction on Sentinel-1 ascending data can greatly improved the data quality in low latitude region, but is probably not worth doing on descending data.
- We retrieve coseismic deformation of an intraslab earthquake (M_w 6.8, 112 km depth), with peak displacement ~6 mm, using InSAR time series data.
- InSAR could help to constrain the fault geometry of intraslab earthquakes and compensate seismology for future study.

Supplementary: Ascending Time Series Example

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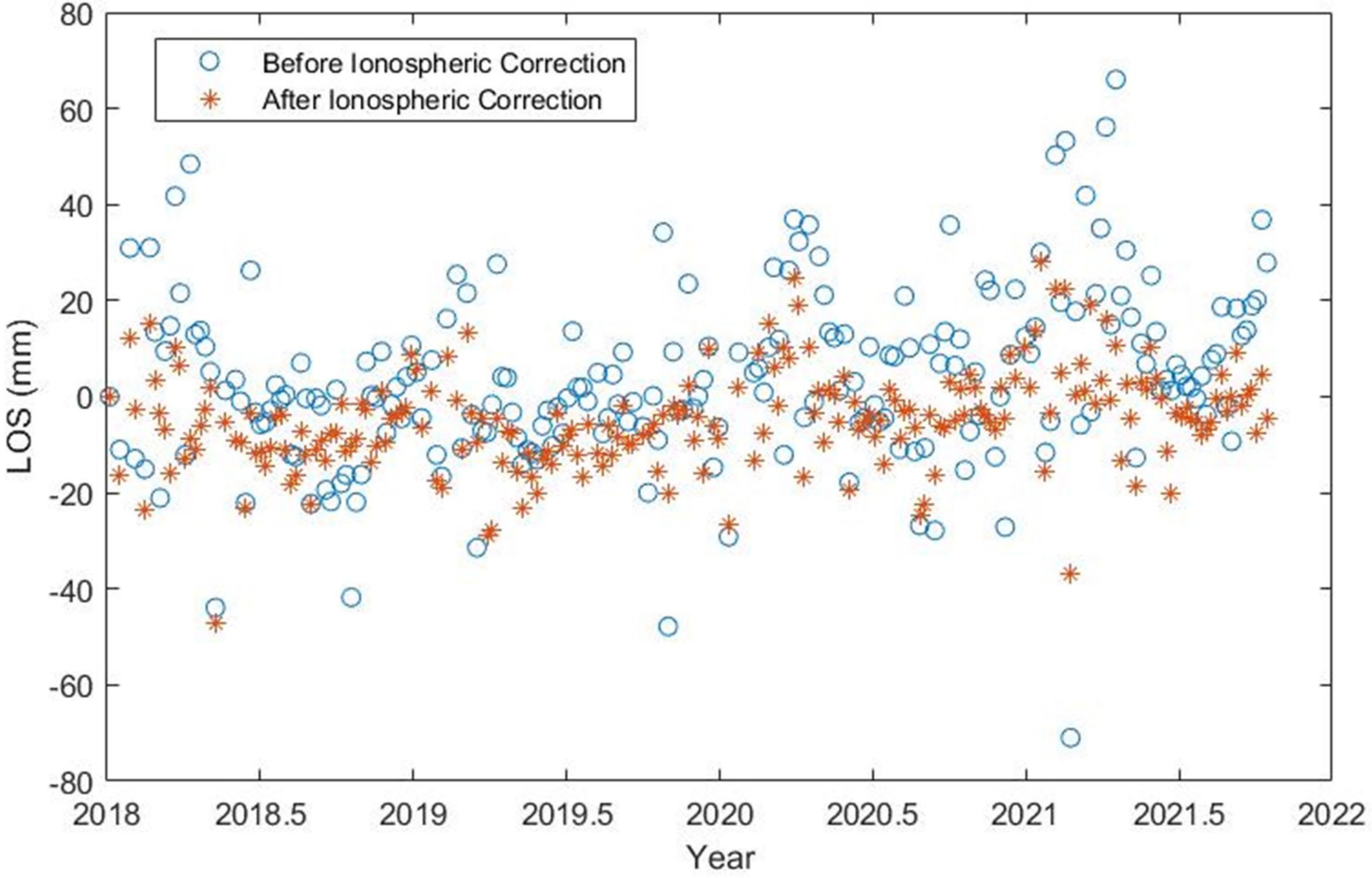

Supplementary: Descending Correction Example