Surface Displacement throughout the Earthquake Cycle over Haiti's Southern Peninsula

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FRINGE 2023
University of Leeds, UK | 11 - 15 September 2023

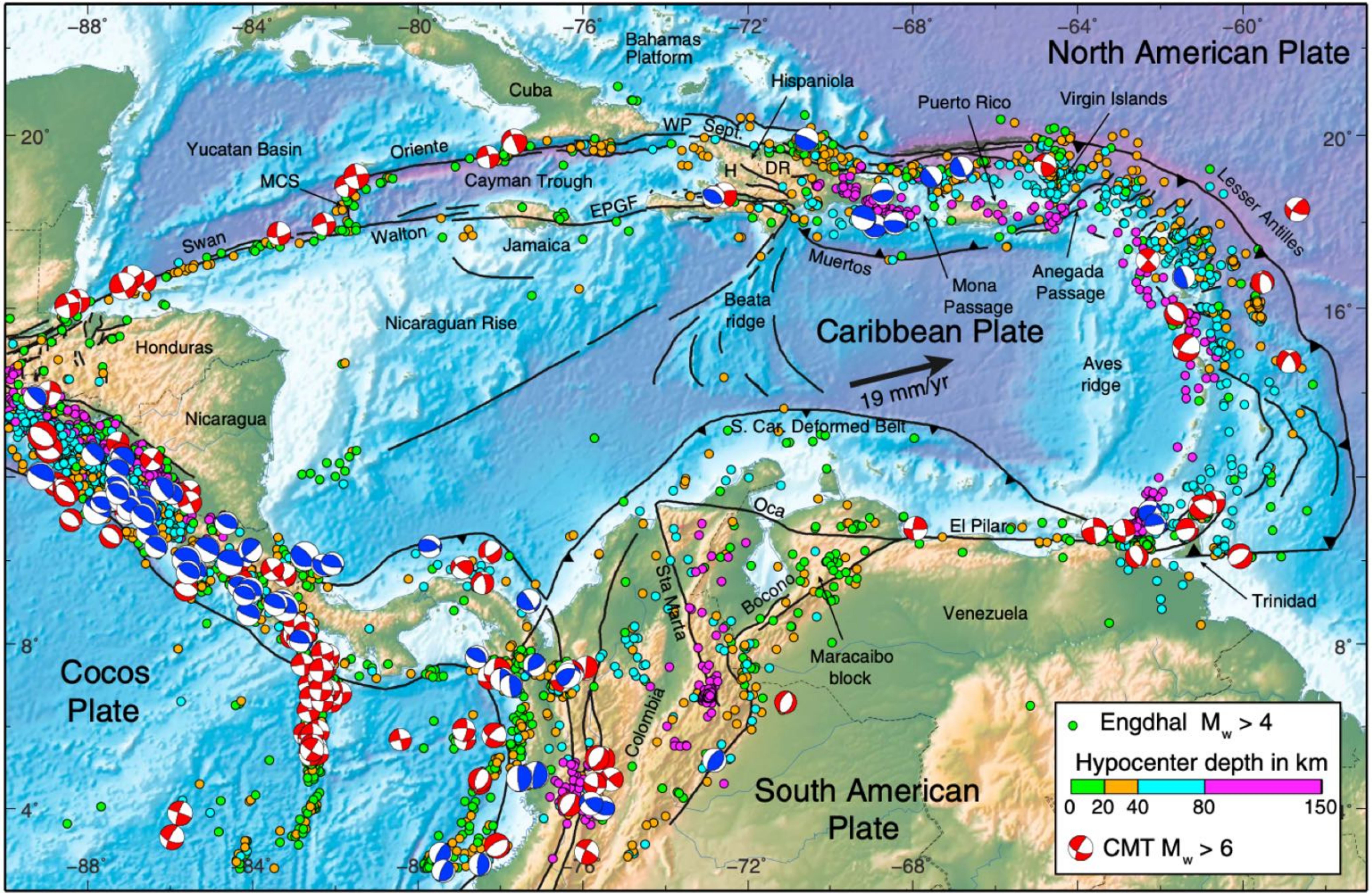
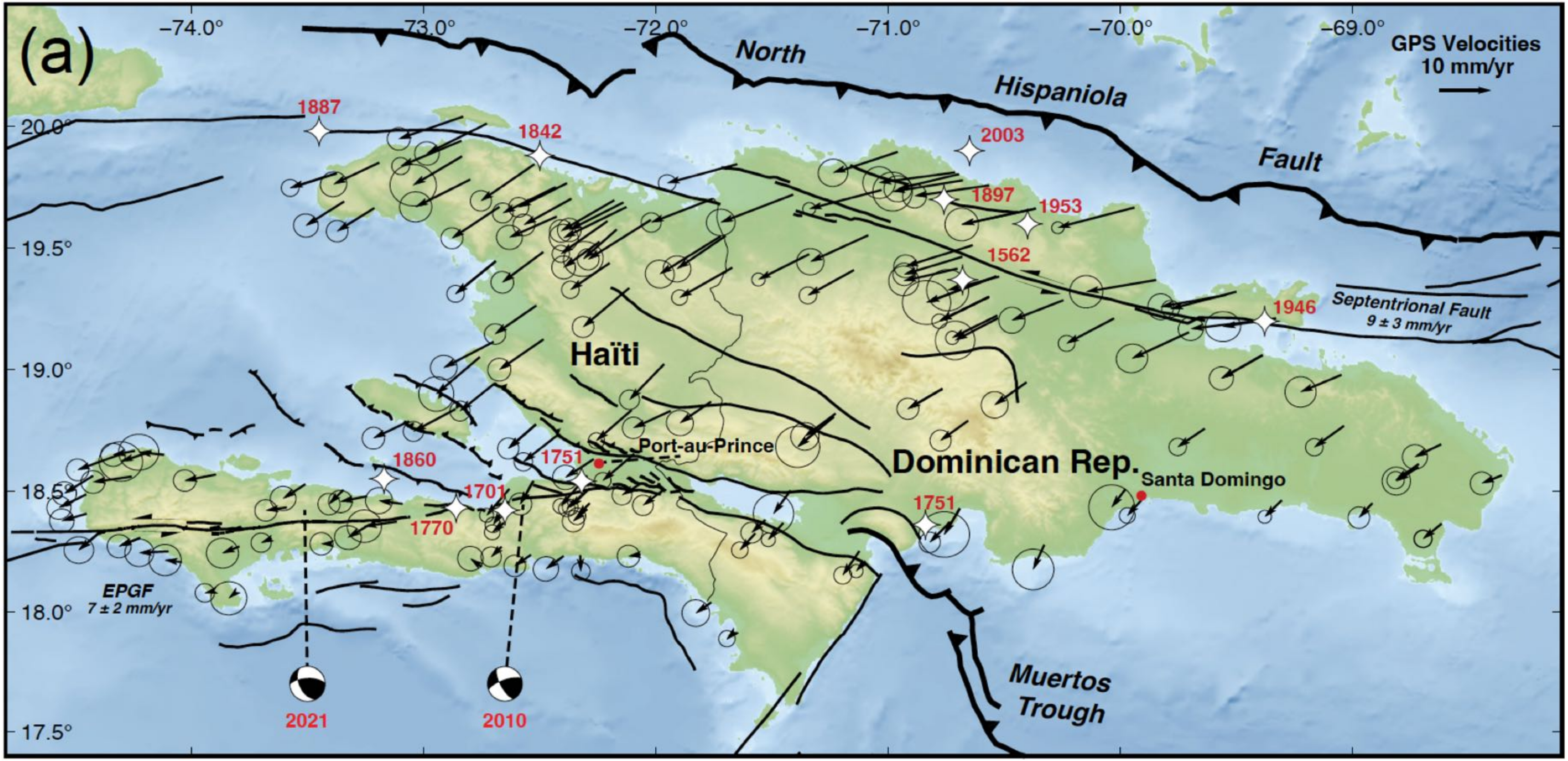


Figure from [Symithe et al., 2015]

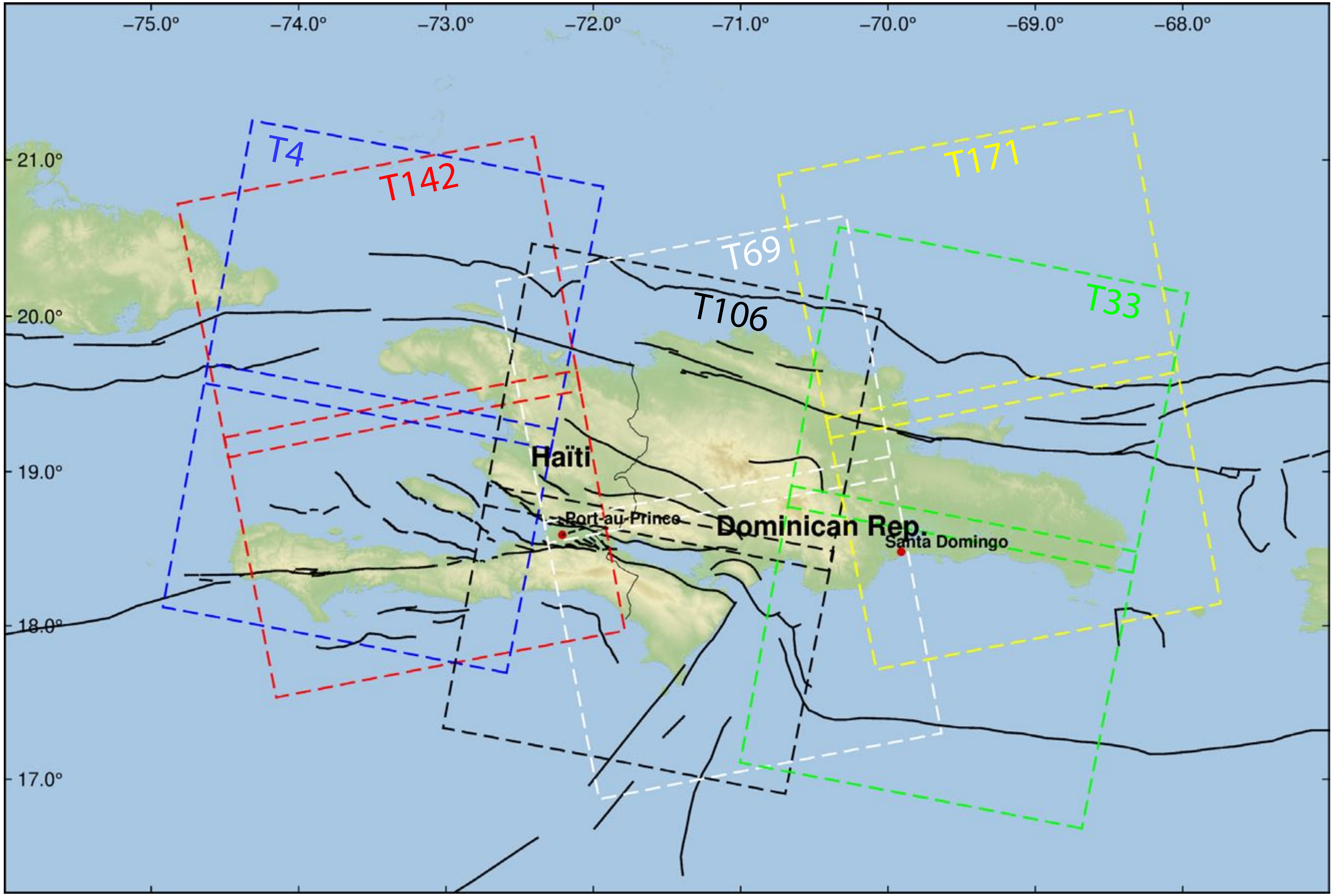
Hispaniola Island : a Transpressive context



How strain is partitionned along this transpressive system ?

Figure from [Raimbault et al., 2023]

SAR Geodetic Data



Sentinel - 1 A/B - 12 days before 2021 earthquake then 6 days

Interseismic :

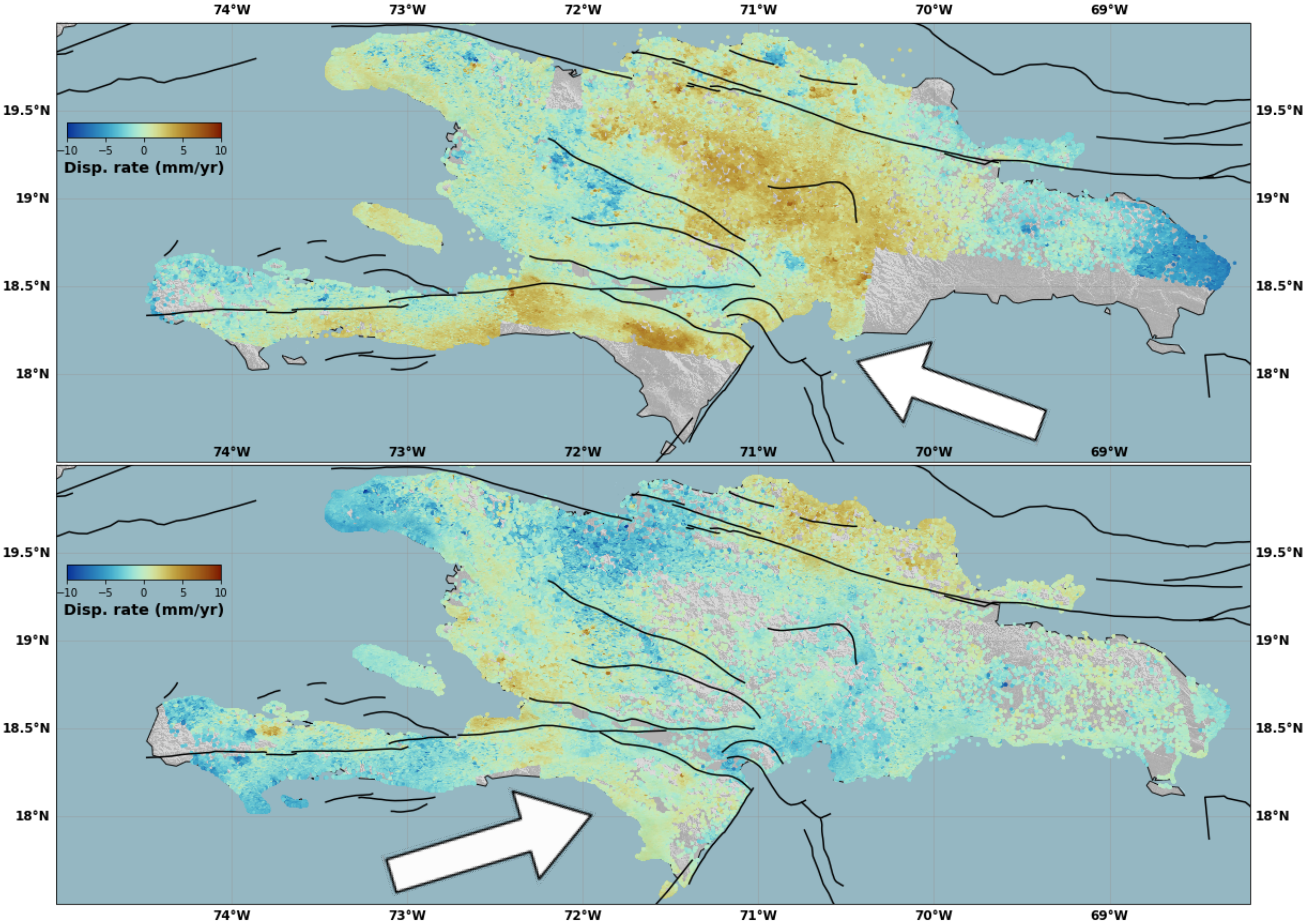
- T4/T142 --> 2014 to 08/2021
- T106/T69 --> 2014 to 03/2023
- T171/T33 --> 2014 to 03/2023

Postseismic

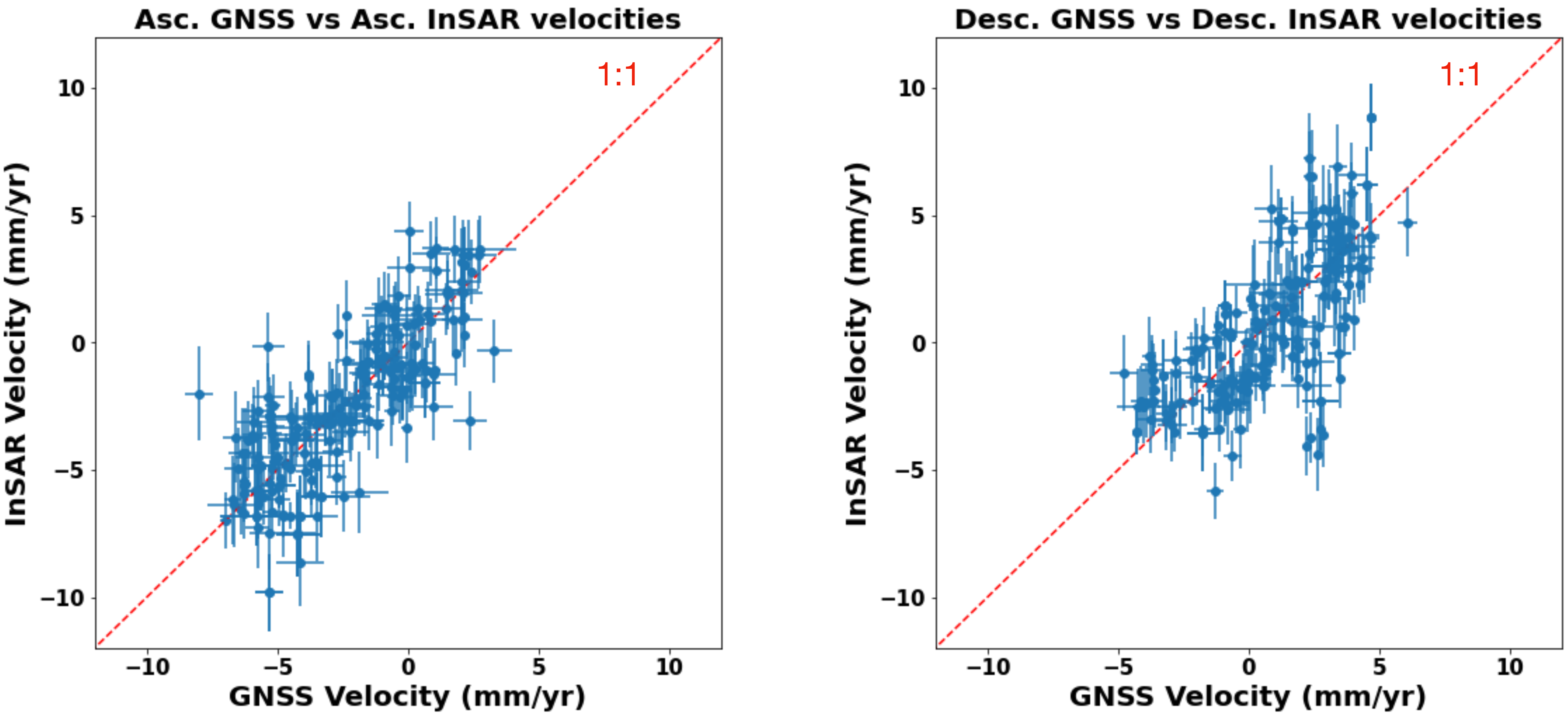
- T4/T142 --> 08/2021 to 04/2022

InSAR Processing and time series analysis

Desc. and Asc. Interseismic Velocities

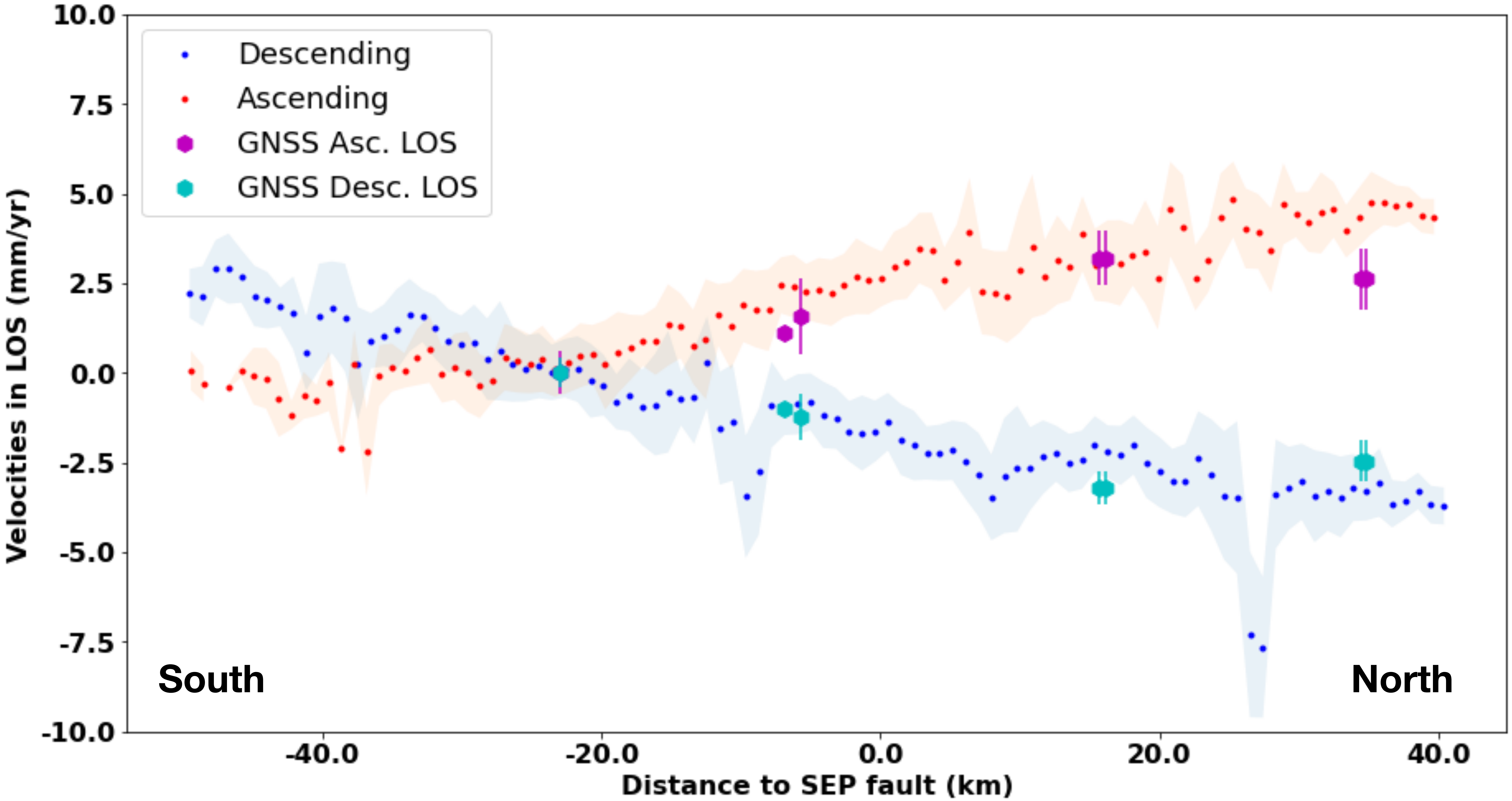


GNSS Projected in Asc. and Desc. LOS



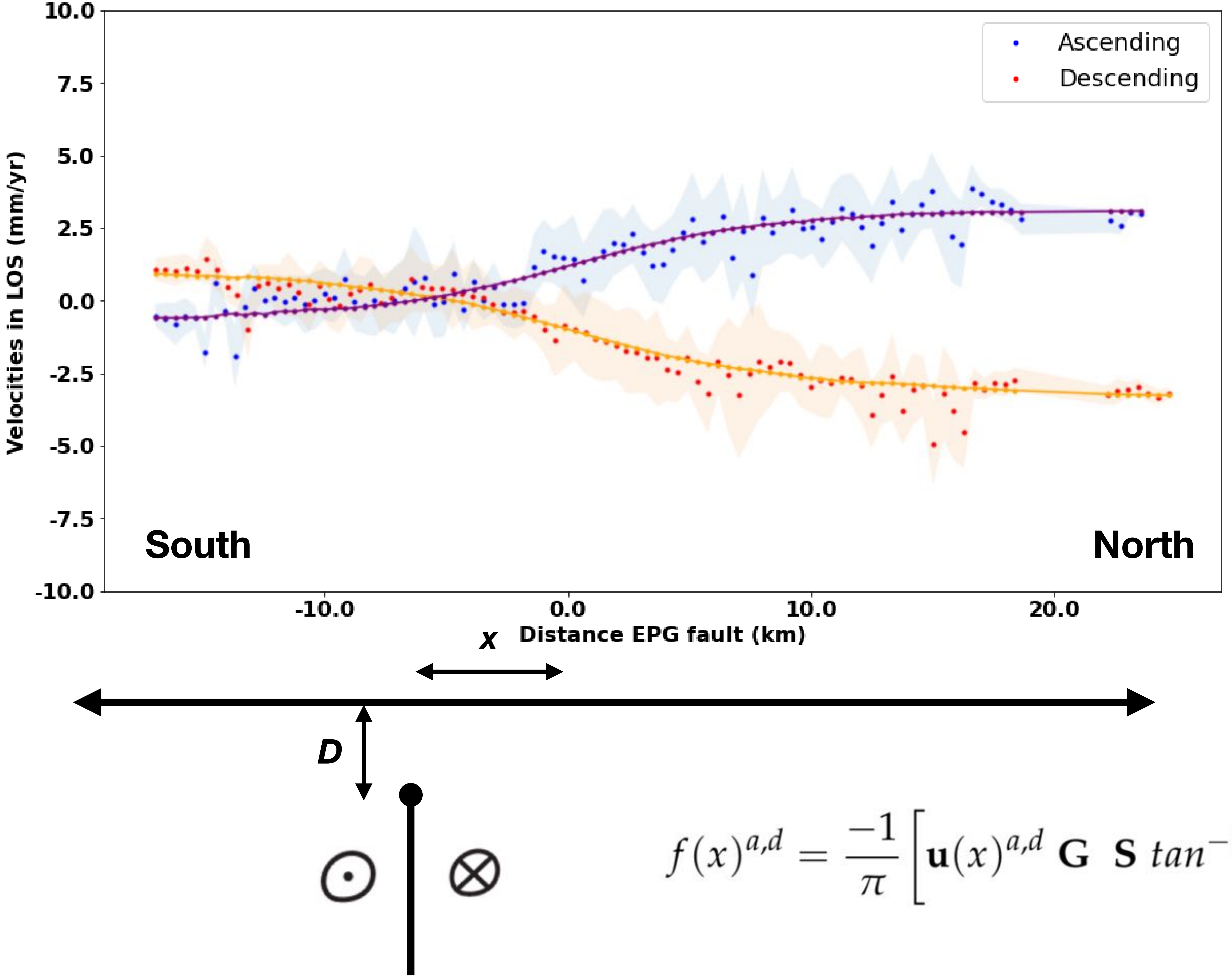
- **Reference Asc. and Desc. InSAR velocities to respective LOS projected GNSS**

Average Profile along the Septentrional fault



- Use the redondance of PS in large profiles to estimate gaussian KDE for uncertainties

EPG fault strike-slip screw dislocation



- **Bayesian estimation of the screw dislocation parameters using both LOS :**
- **EPG fault locking depth : 7.150 ± 3.135 km**
- **EPG fault slip rate : 10.063 ± 3.482 mm/yr**
- **Work in Progress**

$$f(x)^{a,d} = \frac{-1}{\pi}\left[\mathbf{u}(x)^{a,d}\ \mathbf{G}\ \ \mathbf{S}\ tan^{-1}\left(\frac{x-C}{D}\right)\right] + Y^{a,d} + V^{a,d}x$$

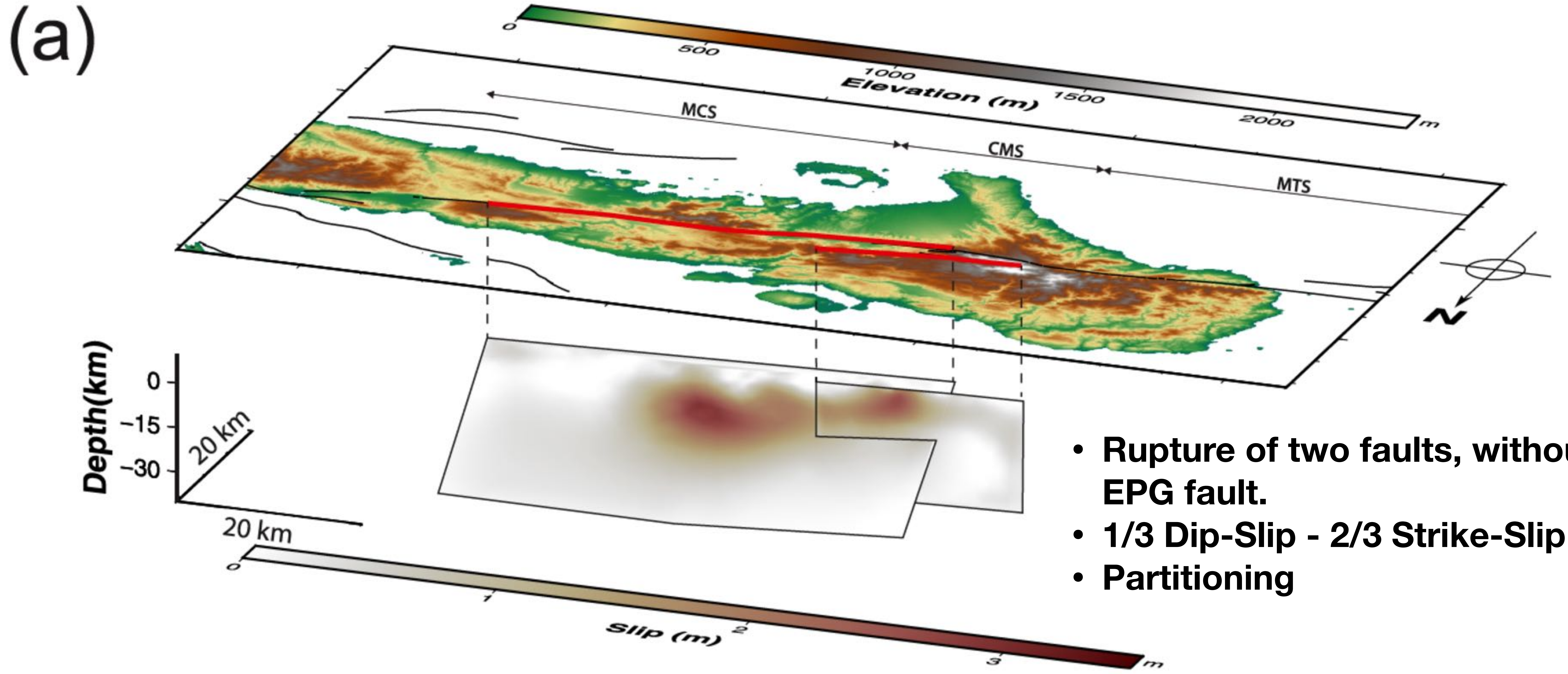
Partial Conclusions on the Interseismic Period

- **Interseismic PS study agrees with the GNSS campaign data**
- **Modeled with a strike-slip only dislocation --> What about the convergence across the transpressive system ?**
- **Asc. and Desc. LOS might be insensitive to possible N-S convergence, need to take the 3D GNSS**
- **Estimated rates in agreement with paleoseismology and model of Blocks.**

Road to Coseismic

Coseismic Displacement - 2021 EQ

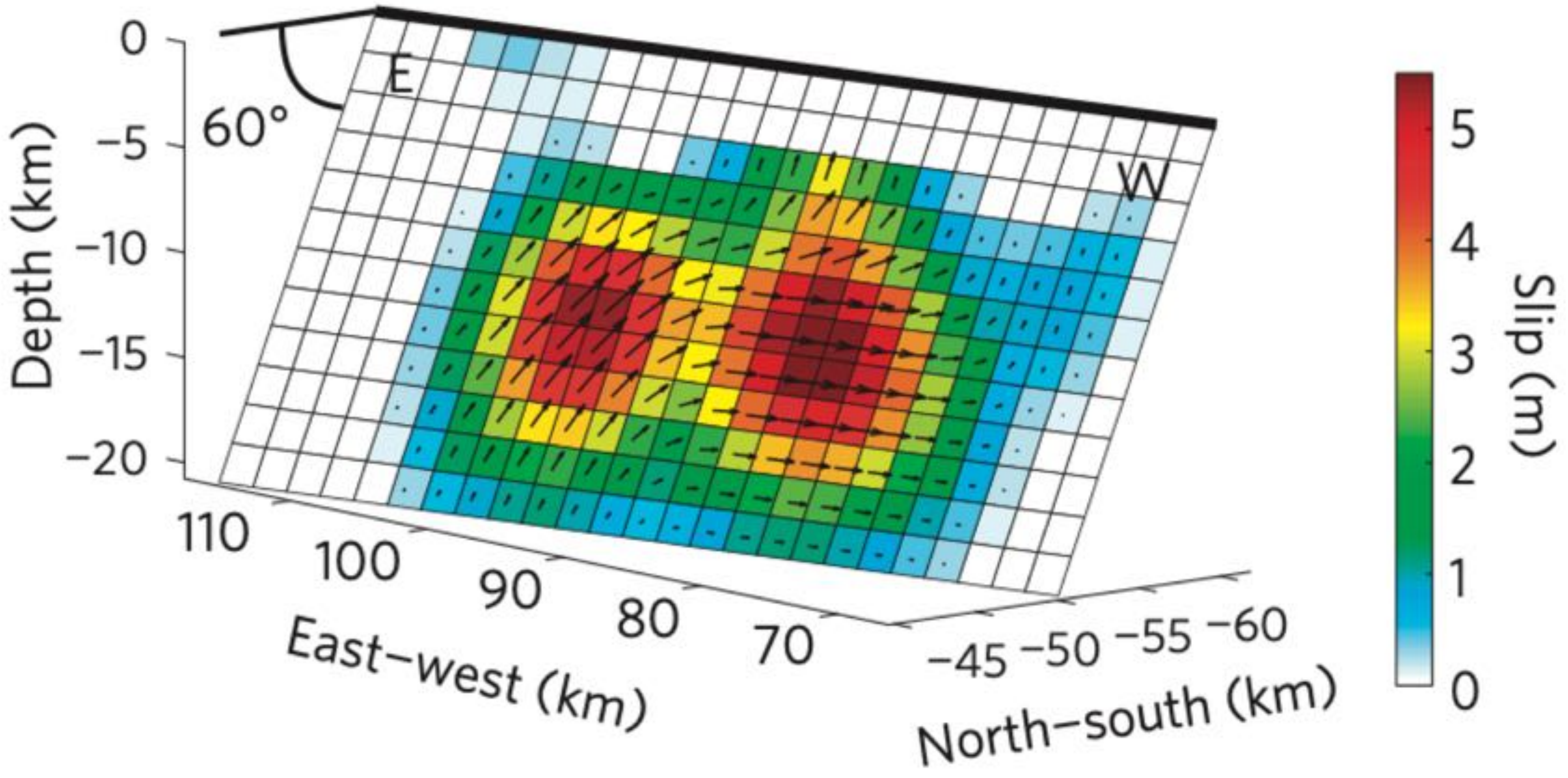
Coseismic Model of the 2021 Haiti Earthquake

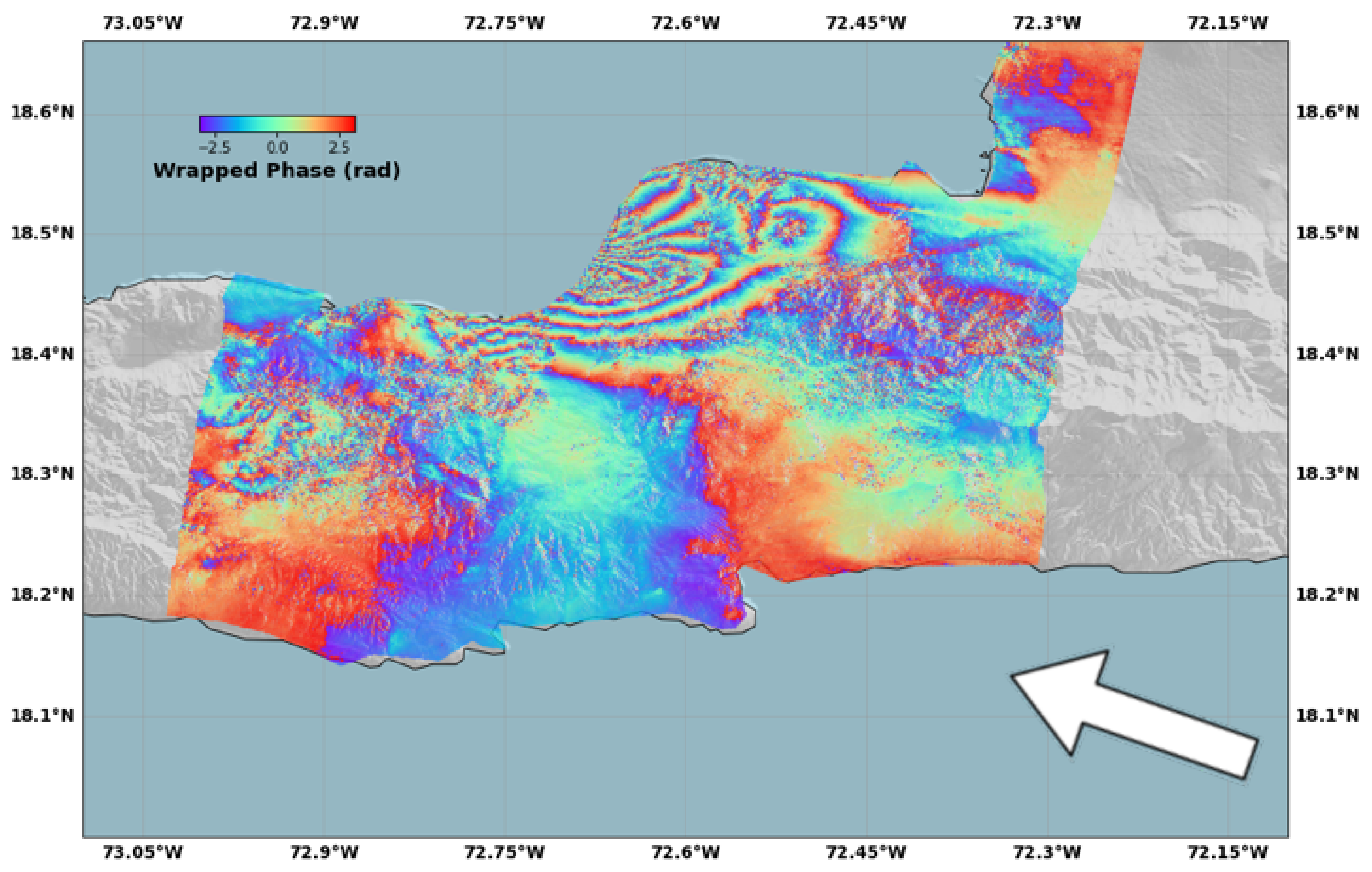


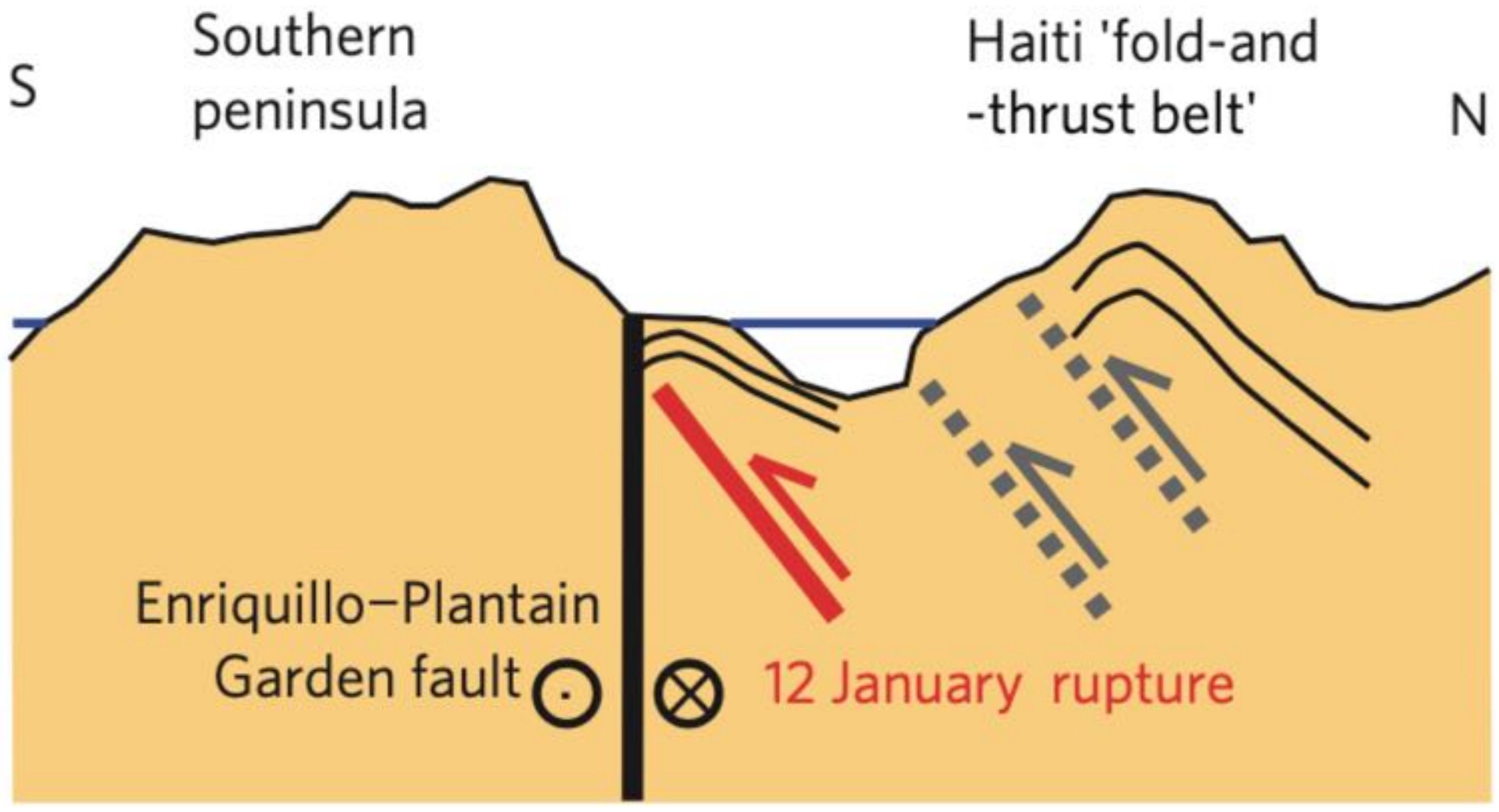
- Rupture of two faults, without EPG fault.
- 1/3 Dip-Slip - 2/3 Strike-Slip
- Partitioning

Figure from [Raimbault et al., 2023]

Coseismic Model - 2010 Haiti Earthquake







- **Rupture of a secondary thrust running parallel to the EPG fault.**
- **Initiate as a thrust and evolves as a mainly strike-slip event (1/3 Dip-slip and 2/3 Strike-slip).**

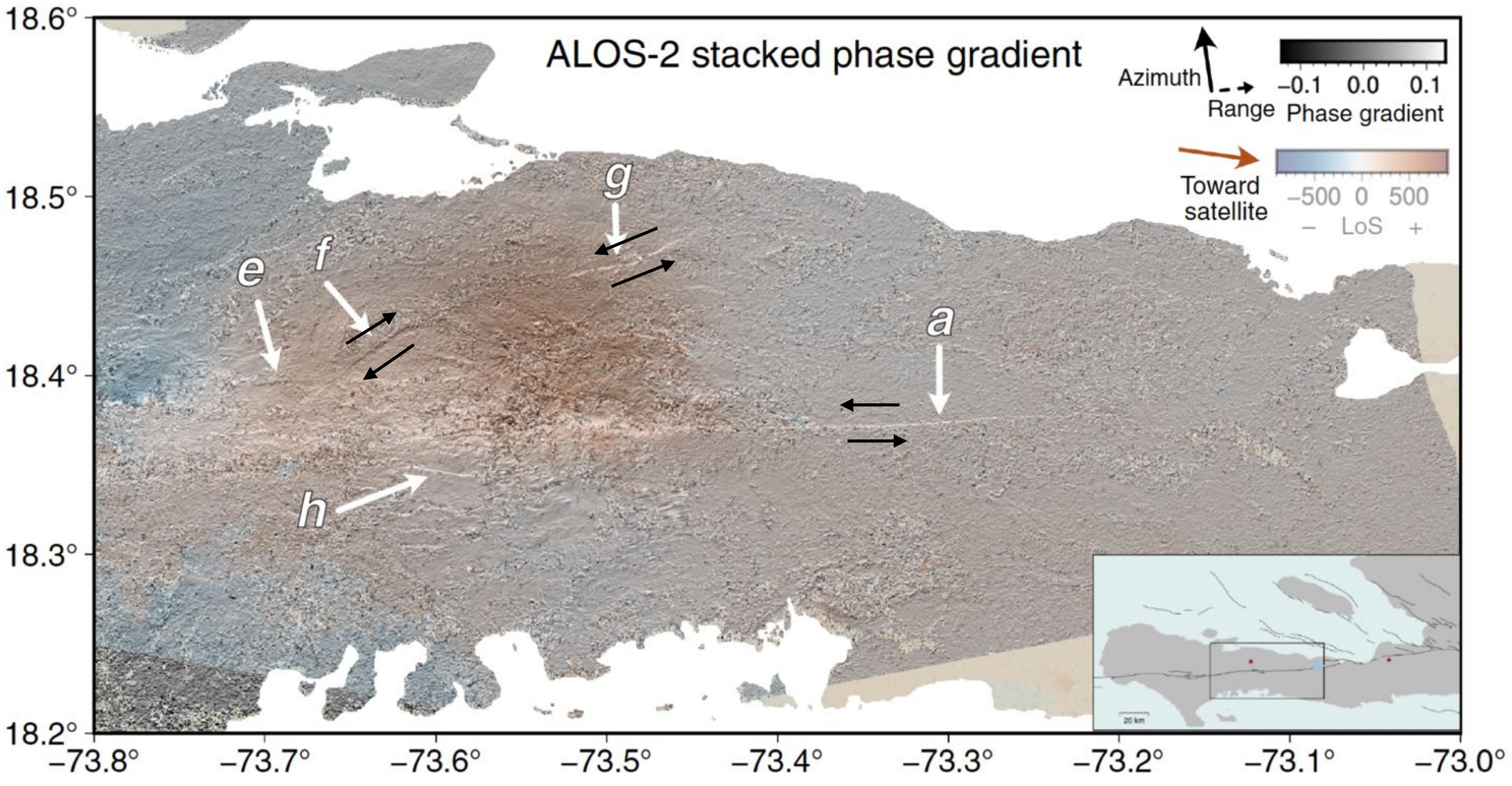
Figure from [Calais et al., 2010]

Partial Conclusion on the Coseismic Period

- Rupture of secondary thrust faults rather than EPG fault
- Comparable faulting event in 2010 and 2021.
- Partitioning of the transpressive system is visible during coseismic release.

→ **Road to Postseismic**

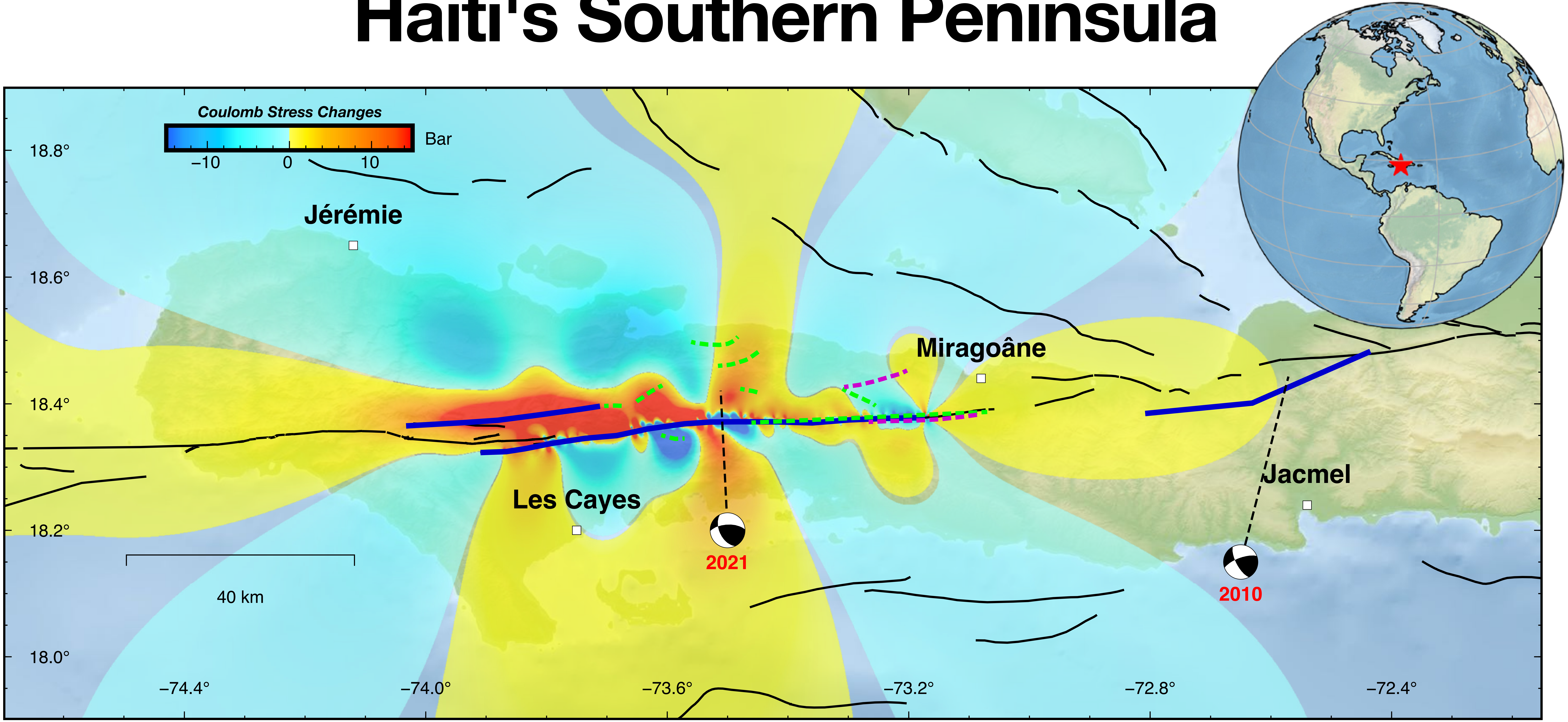
Active structure in the wake of the 2021 EQ



- **Coseismic Fractures and Postseismic Slip on Secondary Faults**
- **Both right-lateral and left-lateral faulting type**

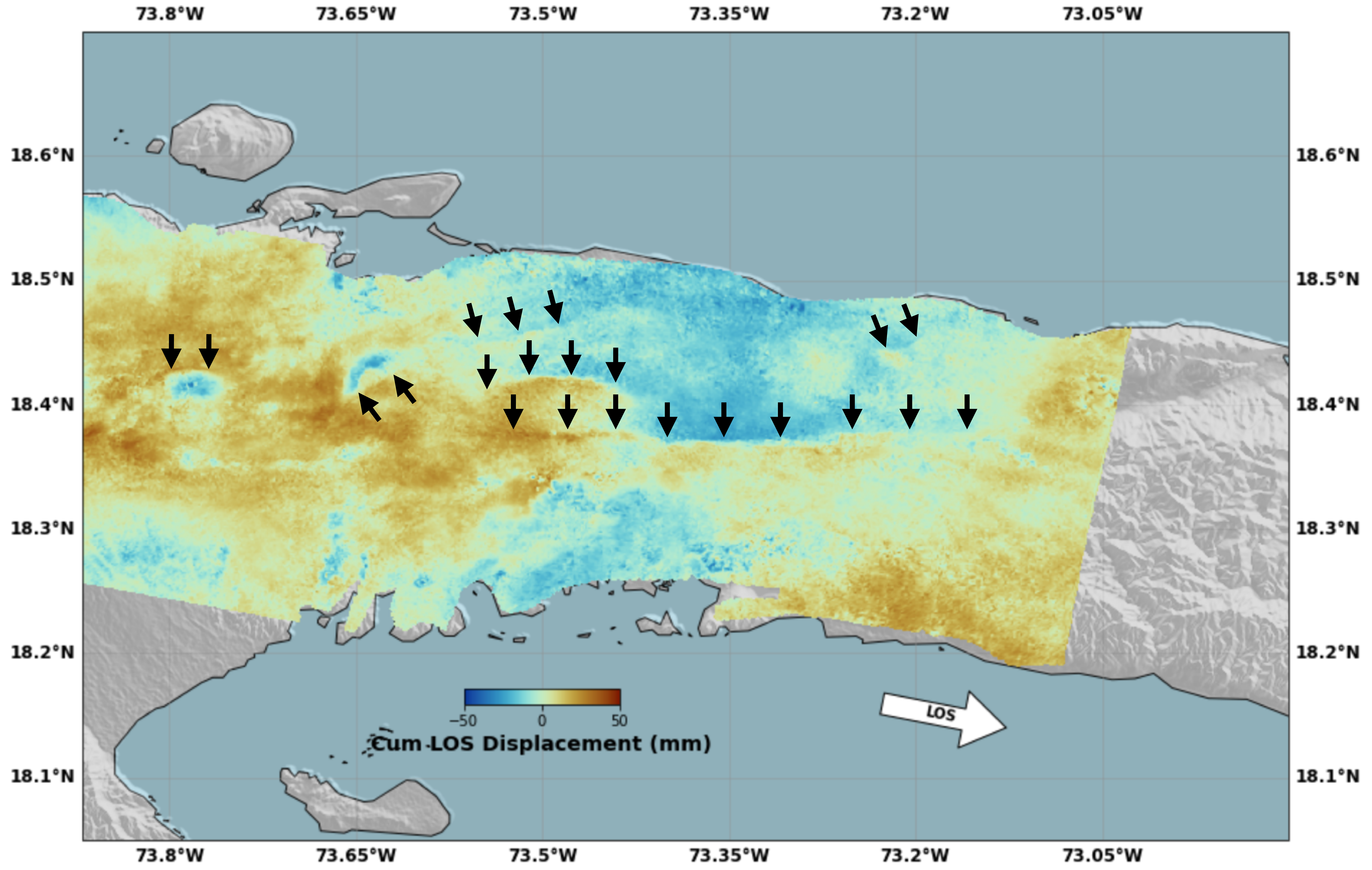
Figure from [Yin et al., 2022]

Haiti's Southern Peninsula

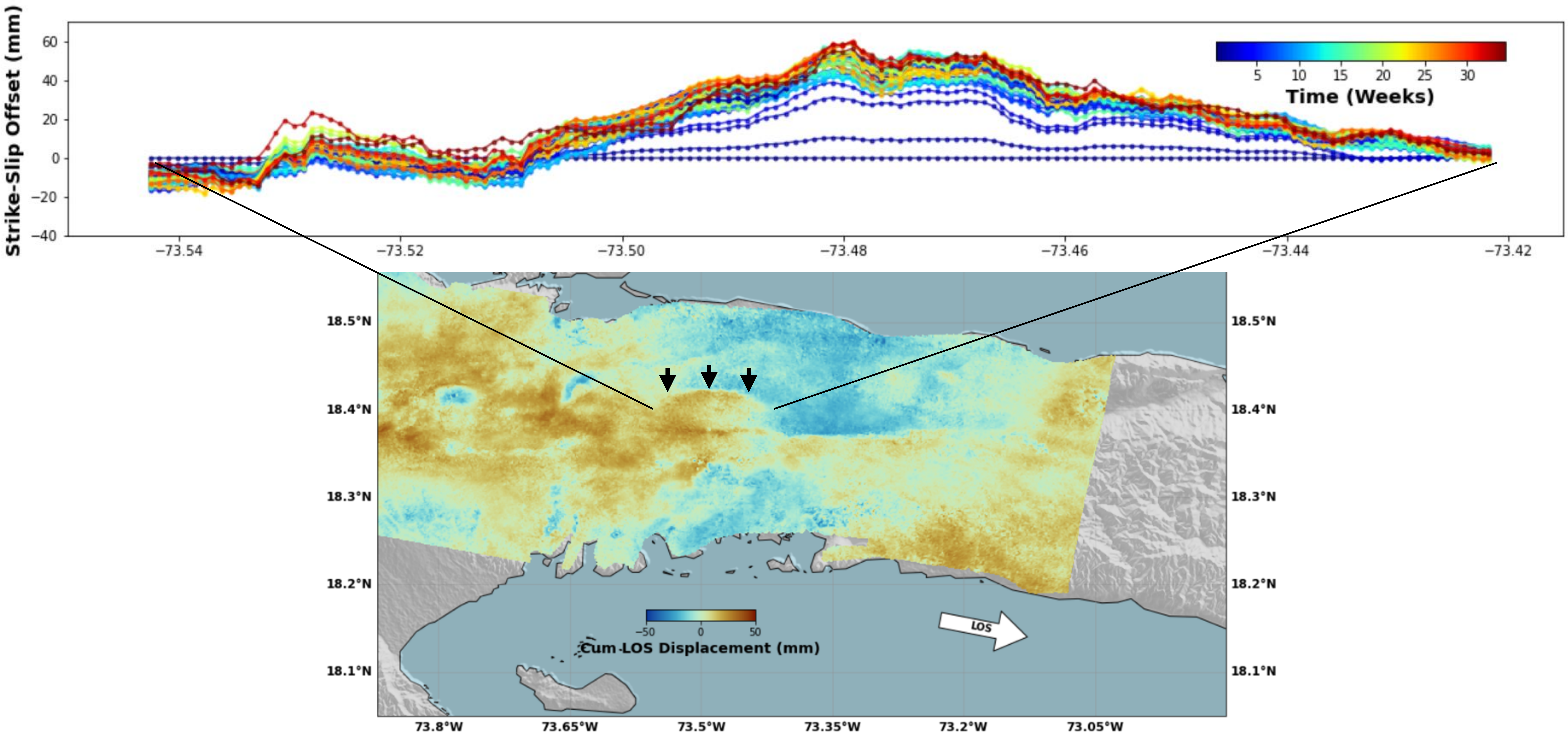


- Coulomb Stress Change caused by the 2021 earthquake for a vertical strike-slip E-W fault.
- To first order, areas of Coulomb stress increase match fault localization.

Multiple faults activated

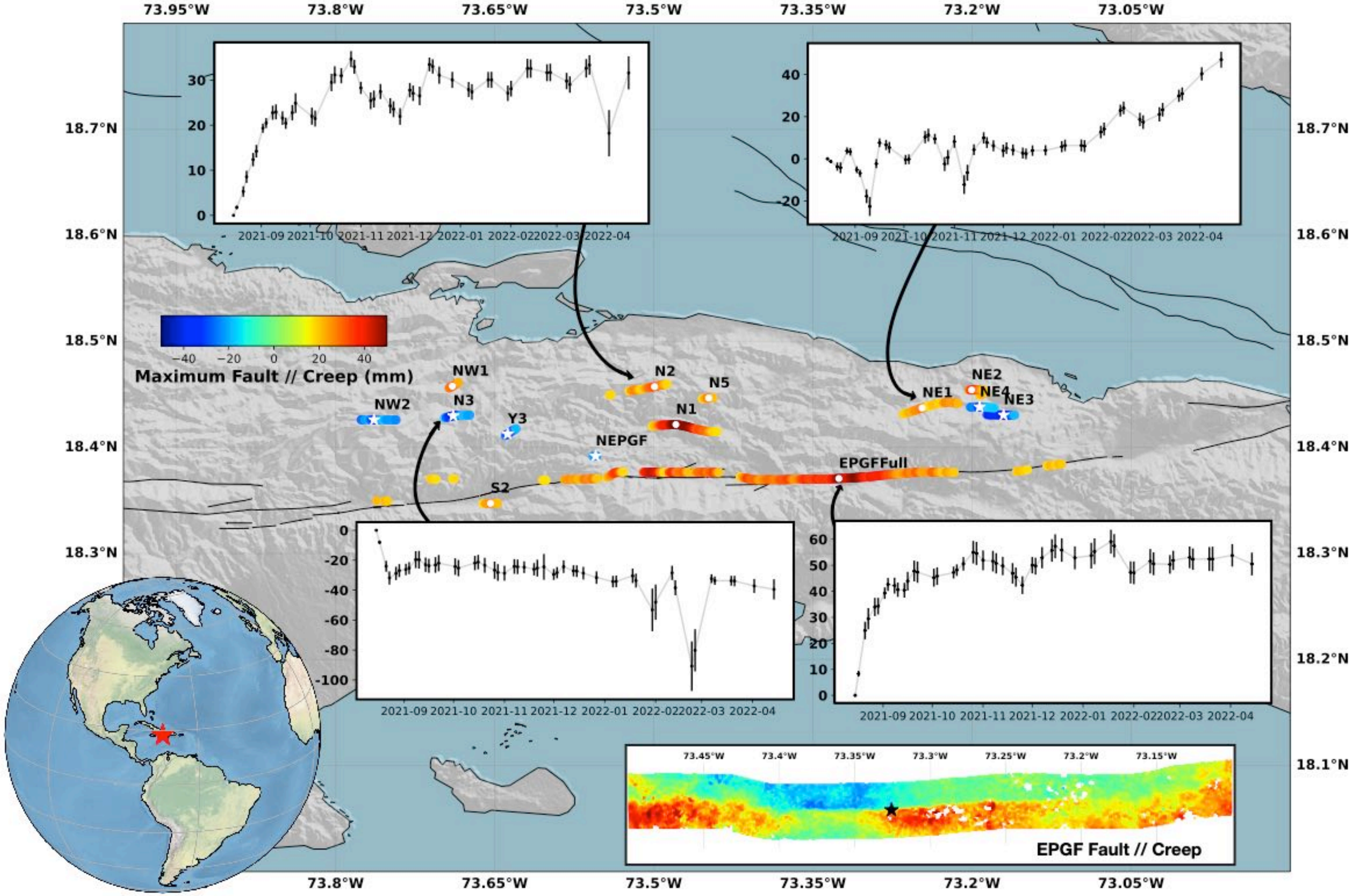


- Time series start right after the earthquake.
- Interpolation of Asc. and Desc. time series and projection to the EPG fault parallel and vertical displacement.
- Systematic along strike profile for each fault with fault parallel displacements projected along fault azimuth.



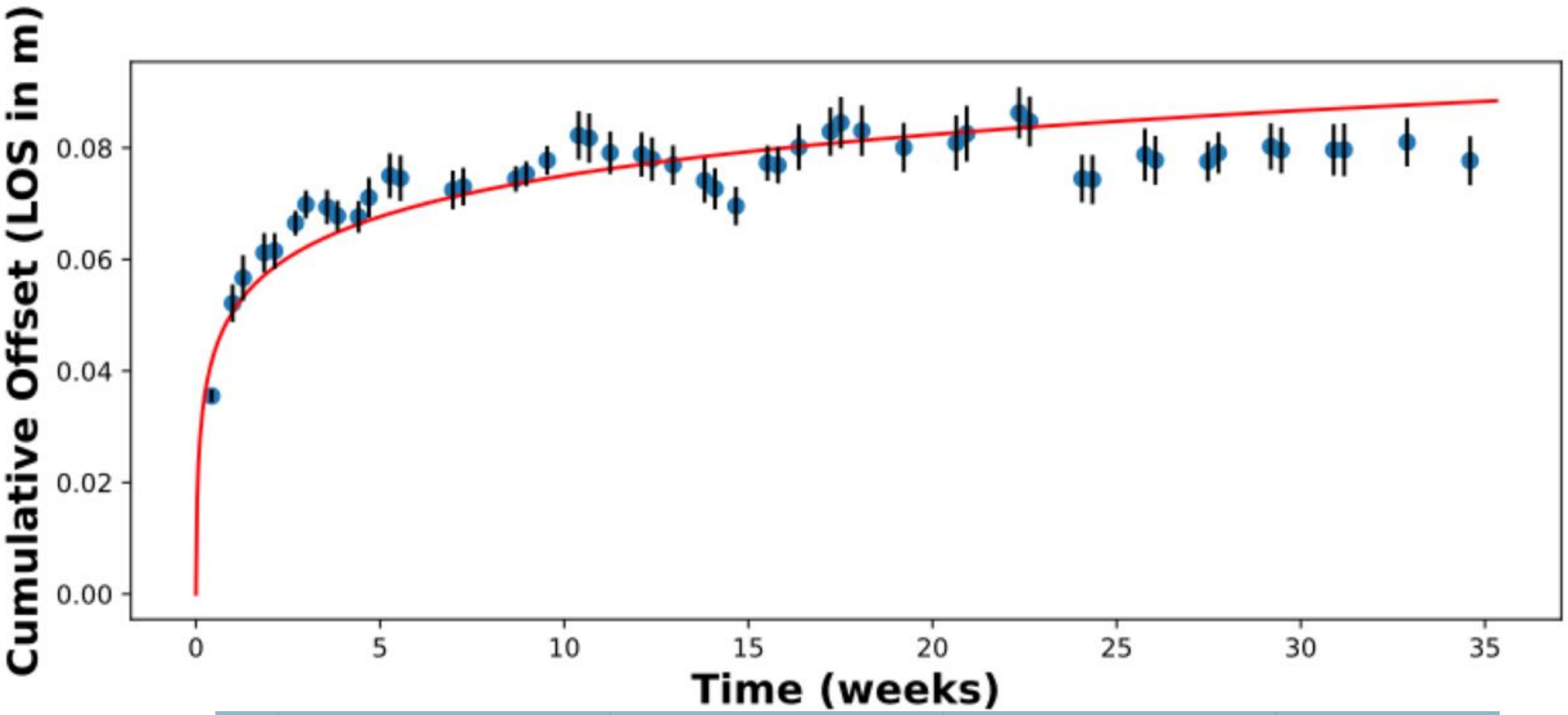
- Extraction of long strike fault offset displacement as a function of time
- We measure the step across the fault by subtracting the mean values within a given length of the fault trace on each side.

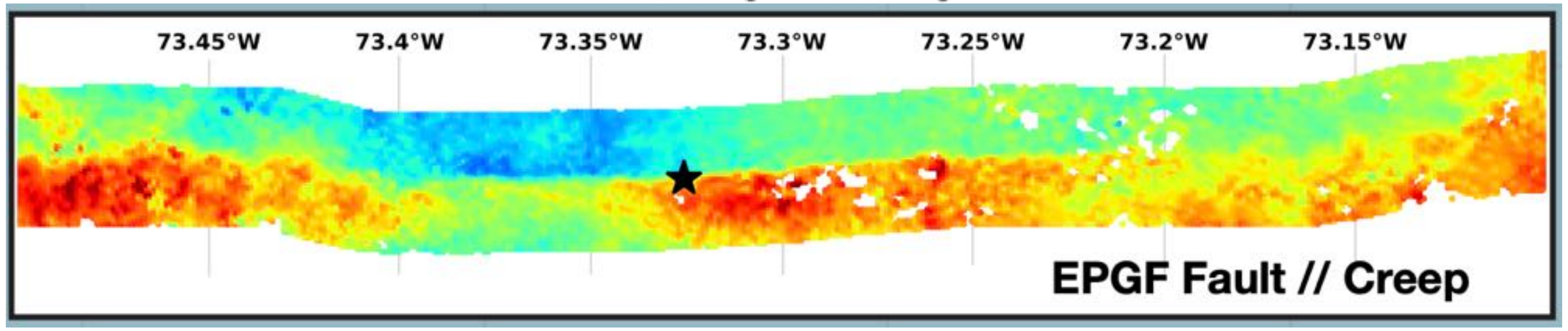
Afterslip on Passive Secondary Fault



- 14 fault segments holding left-lateral or right-lateral motion.
- Checked on raw Asc. and Desc. time series.
- Logarithmic decay characteristic of afterslip, but not on the fault rupture.

Afterslip on Passive Secondary Faults





- Rate-and-state friction law:

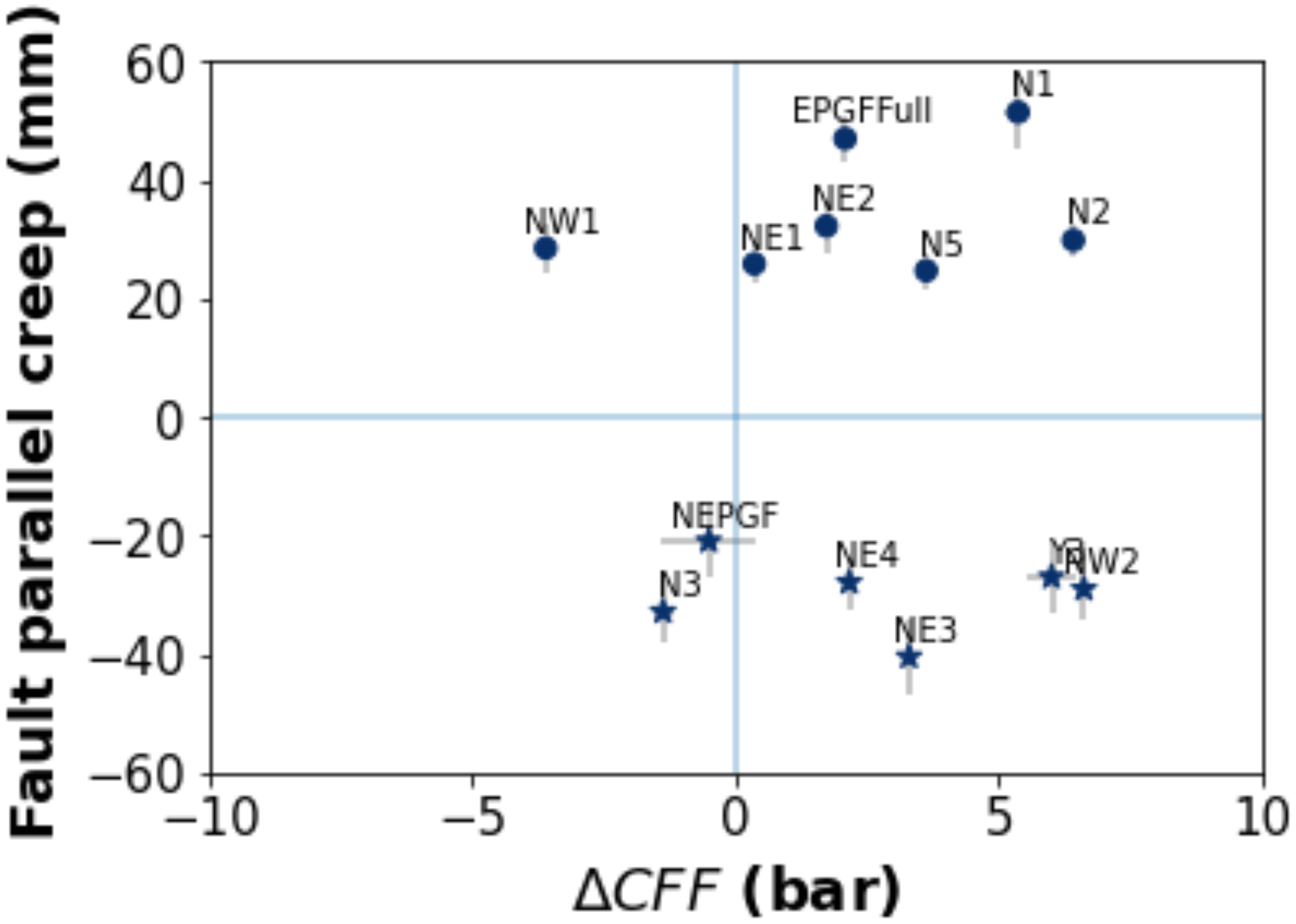
$$D(t) \approx V_{pl} t_r ln\left[1 + \frac{V+}{V_{pl} t_r} t\right],$$

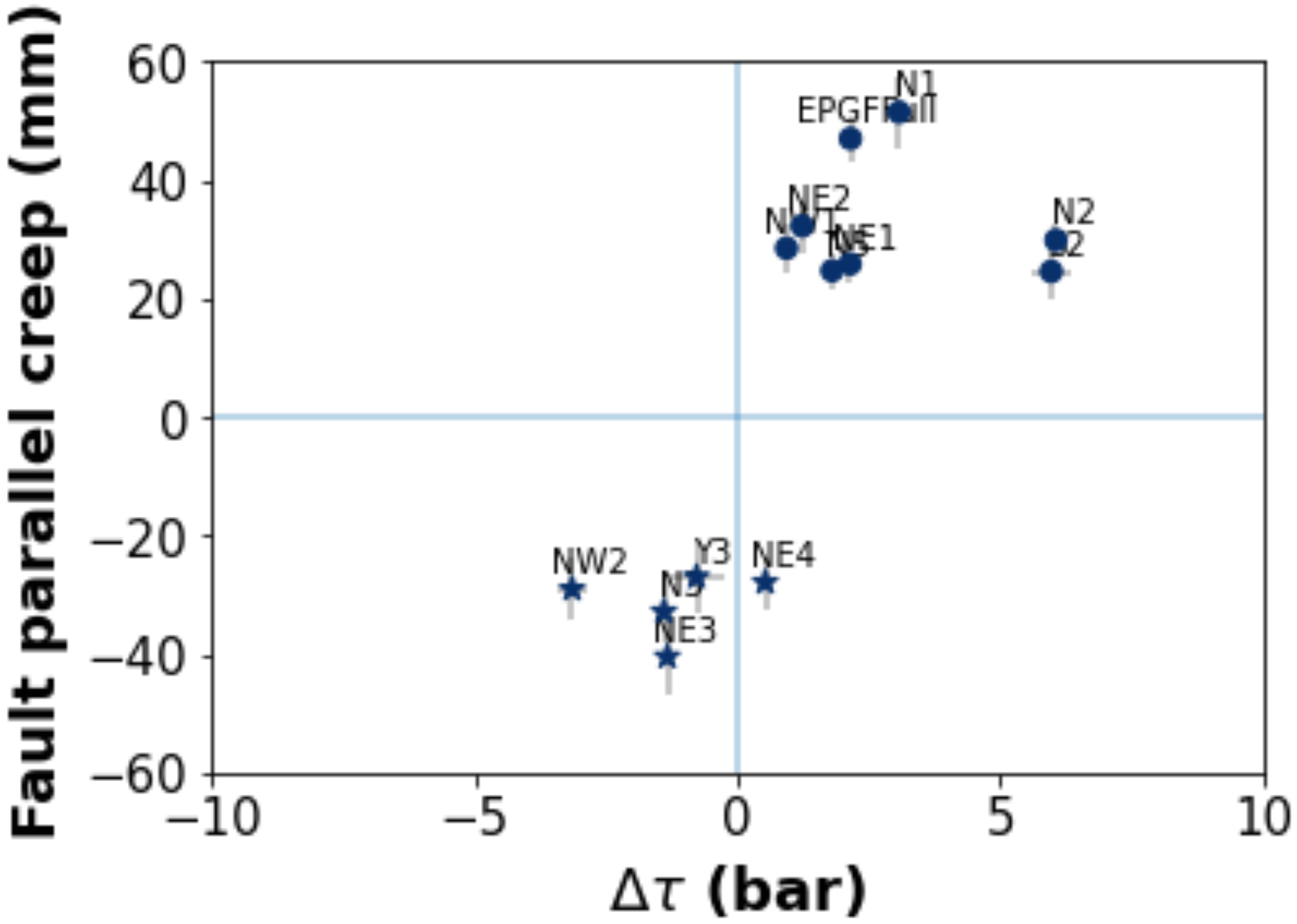
$$(a-b)\bar{\sigma_{eff}} = \frac{\Delta CFF}{ln\left(\frac{V+}{V_{pl}}\right)}$$

- Fault segments (a-b) ~10^{-2}
  Rate - Strengthening

- A compliant fault zone? --> Not purely elastic as characteristic time for slip
- Logarithmic decay of fault slip --> Viscous response?
- Drop of viscosity would be too high for a 5/10 week event --> Most likely frictional

Coulomb and Shear Stresses Redistribution





- Coulomb stress changes computed for each fault orientation.
- Fault creeping segments are in areas of Coulomb stress increase
- Faulting type depend on the shear stress variations.

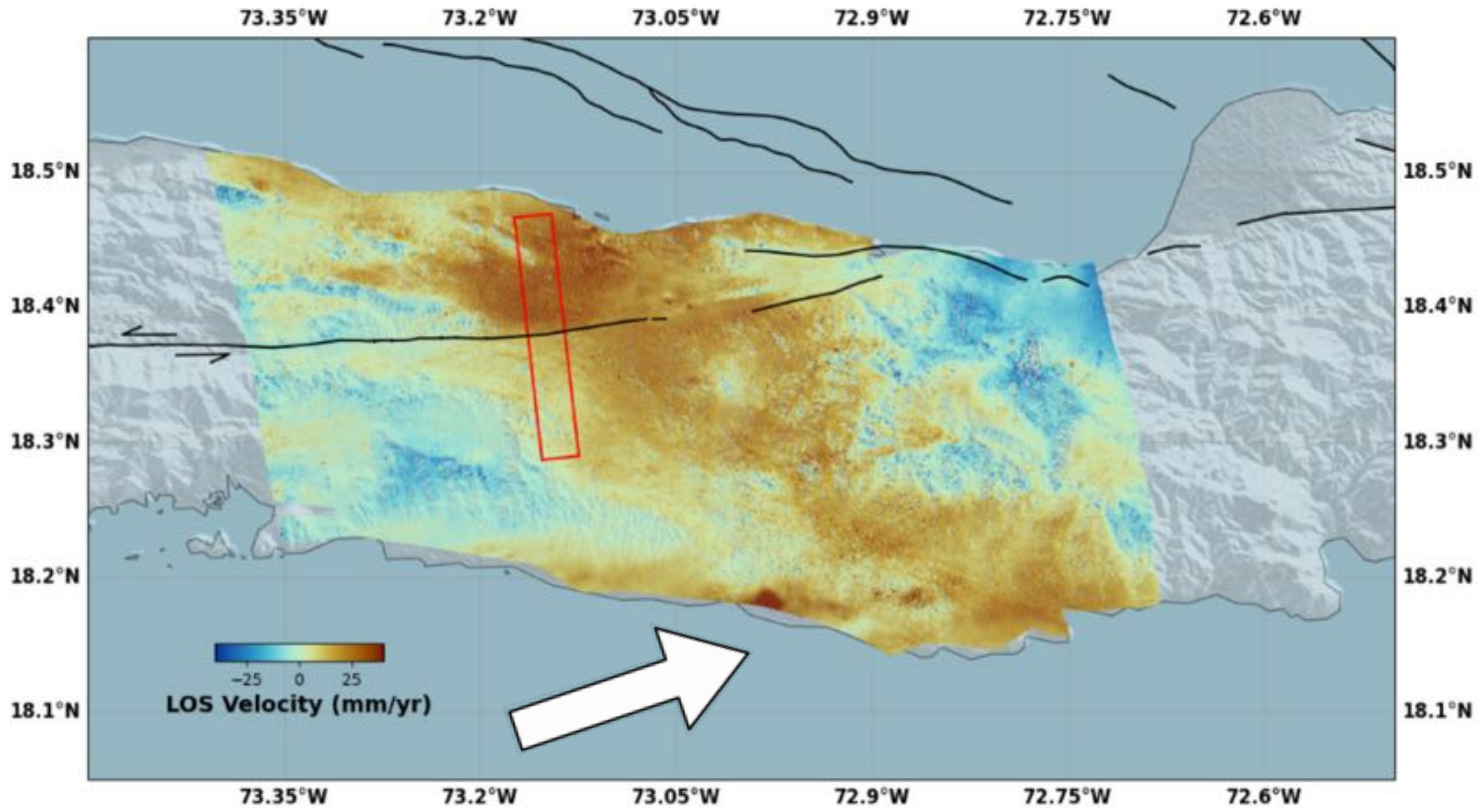
Partial Conclusion on the Postseismic Period

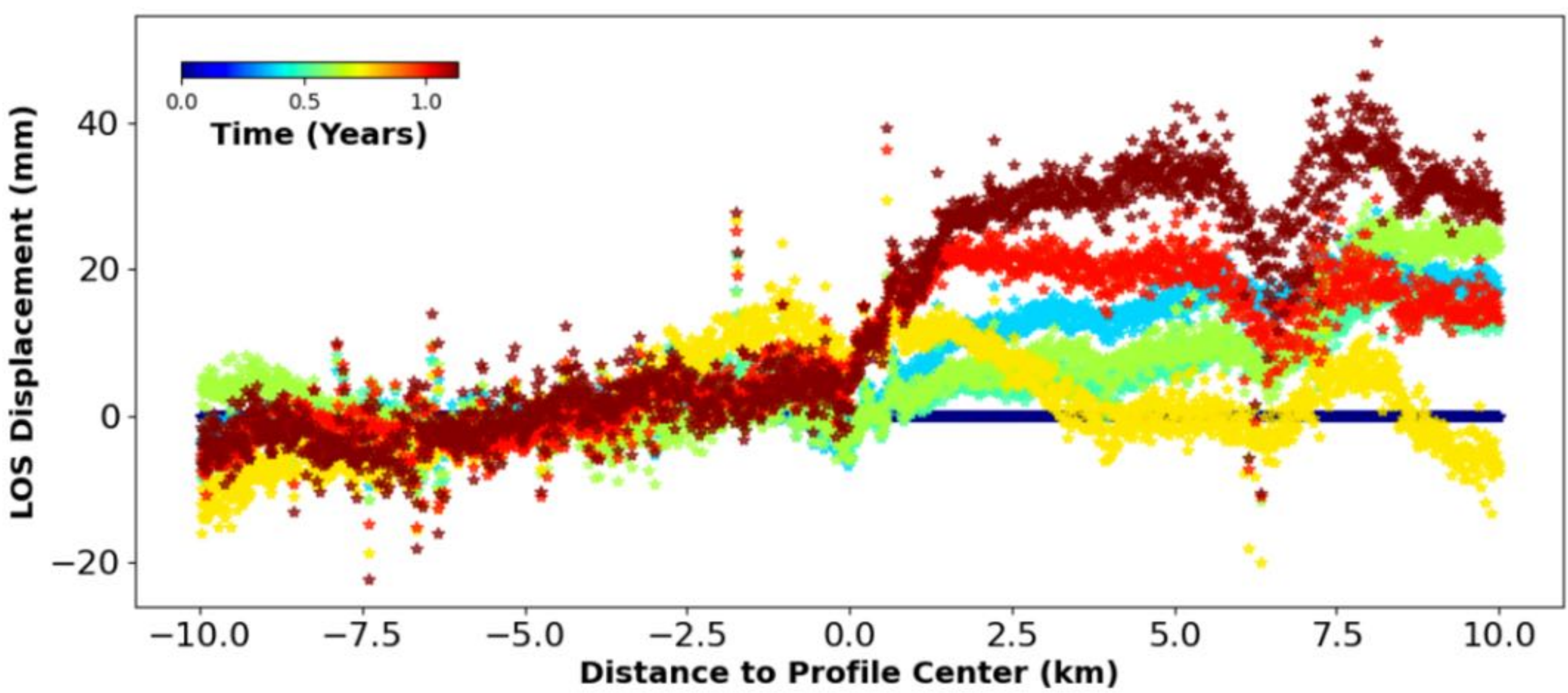
- **Multiple secondary faults activated.**
- **Frictional Rate-strengthening behaviour of all segments (a-b)~10^{-2}**
- **Strong link between the coseismic stress redistribution and Coulomb and Shear stress variations**
- **Secondary faults are passive markers responding to stress variation (shear)**

January 2022 - Mw 5.3 and 5.1 earthquakes

- **Same behavior after the 2022 earthquake sequence, with fault creep right after the coseimic event.**
- **We extract coseismic displacement from time series at earthquake date and estimate a rectangle earthquake source parameter.**
- **Fault location are also in Coulomb stress increase areas.**

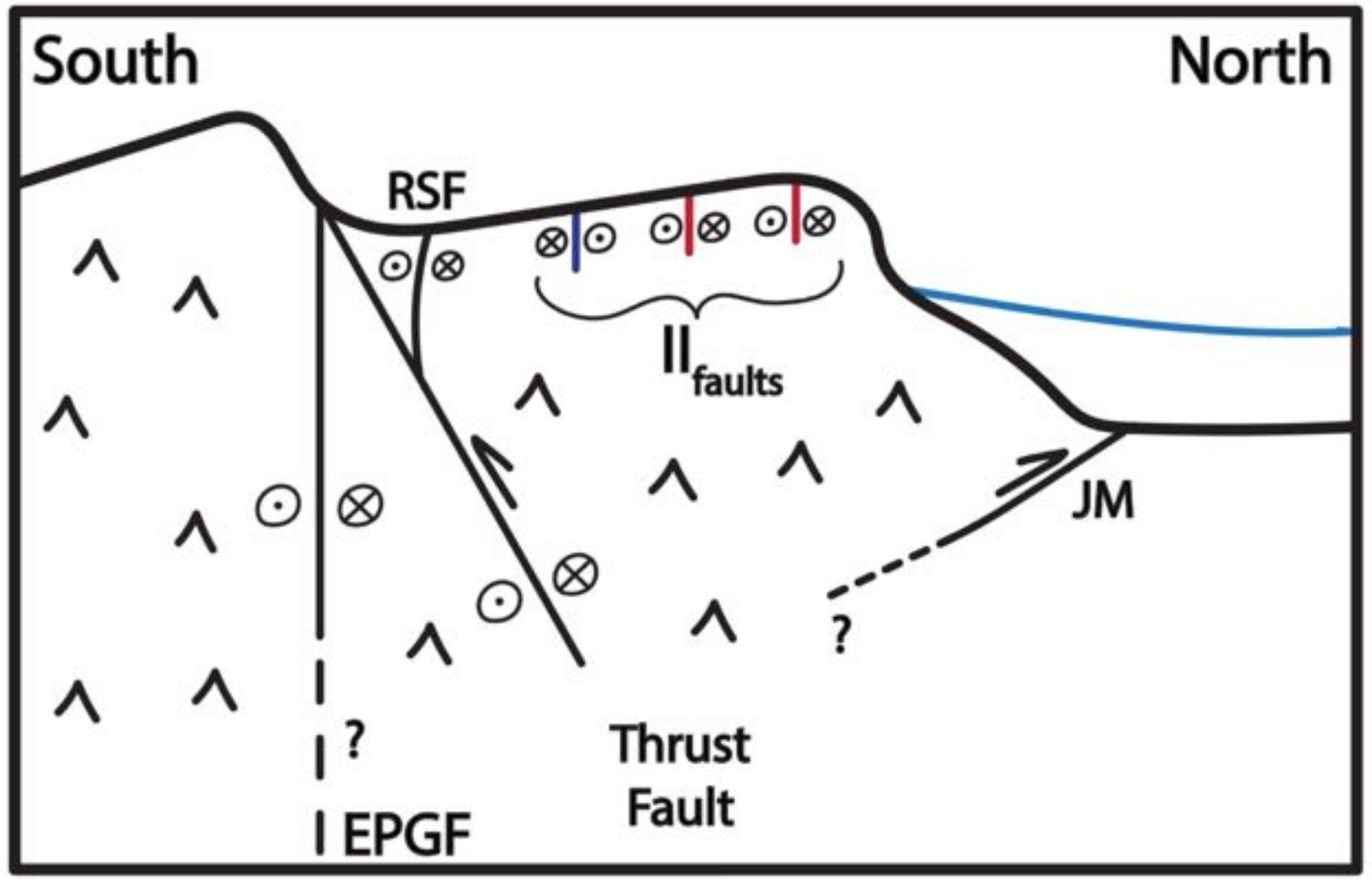
Fault creep following the 2010 Earthquake

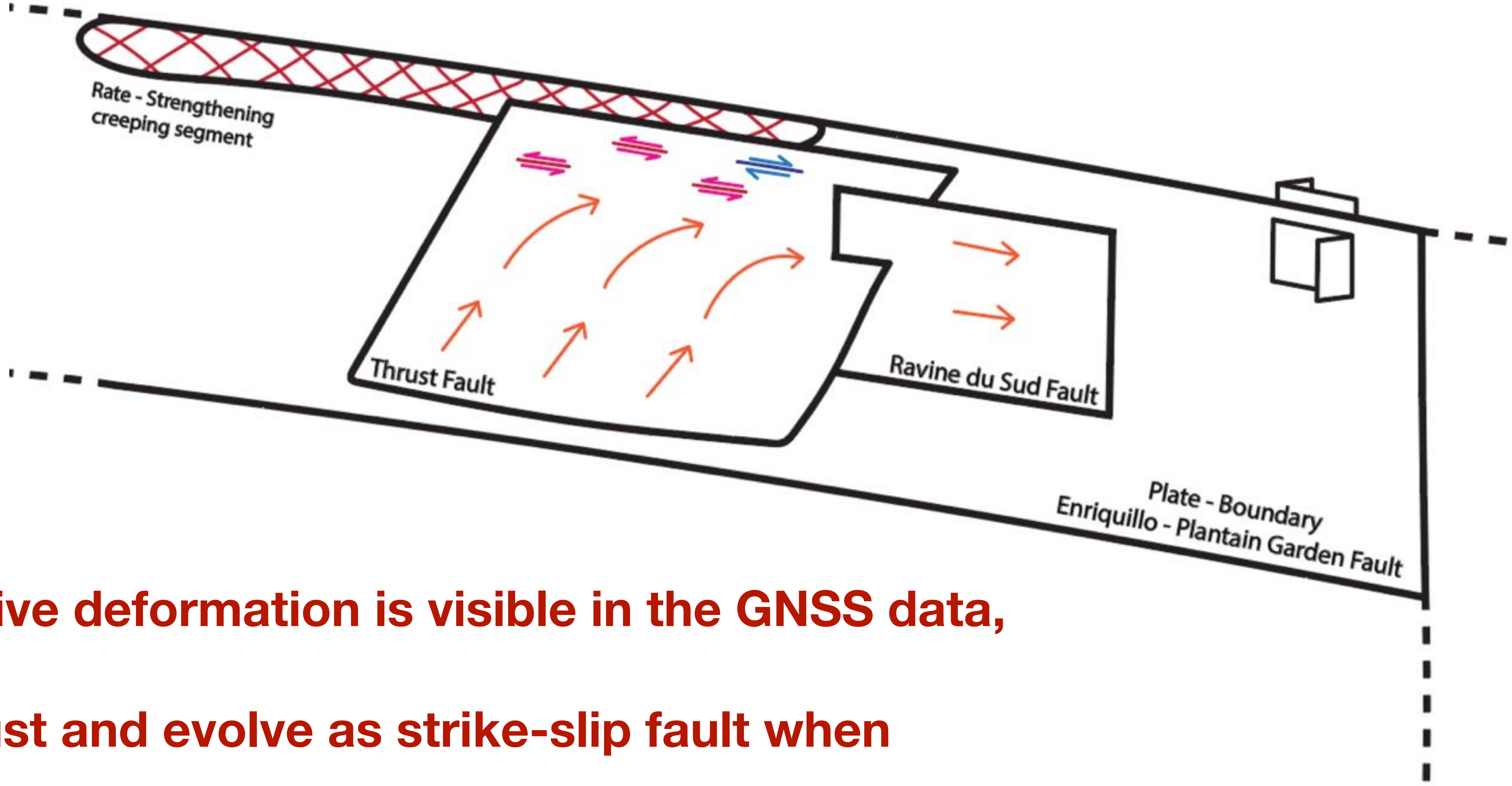




- **Post-earthquake ALOS - 1 ascending track 138 time series (5 images)**
- **Multiple secondary faults activated following the 2010 earthquake, with displacement rates up to 3/4 centimenters in the LOS.**

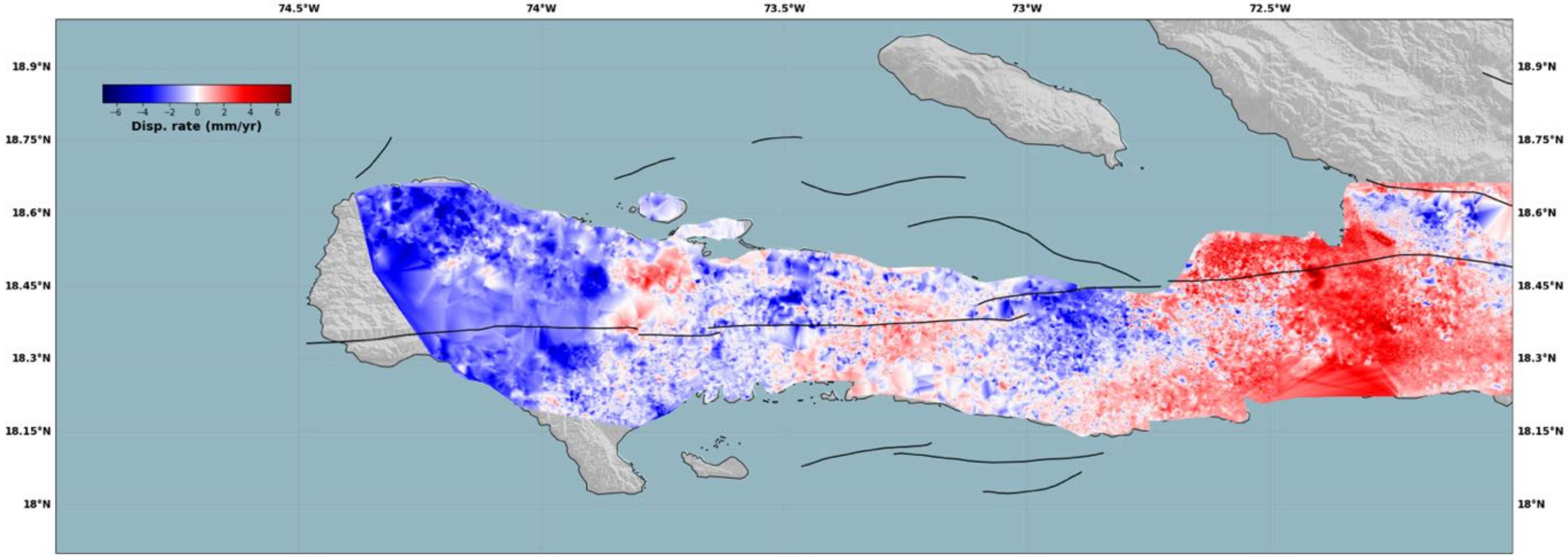
Summary and Conclusions

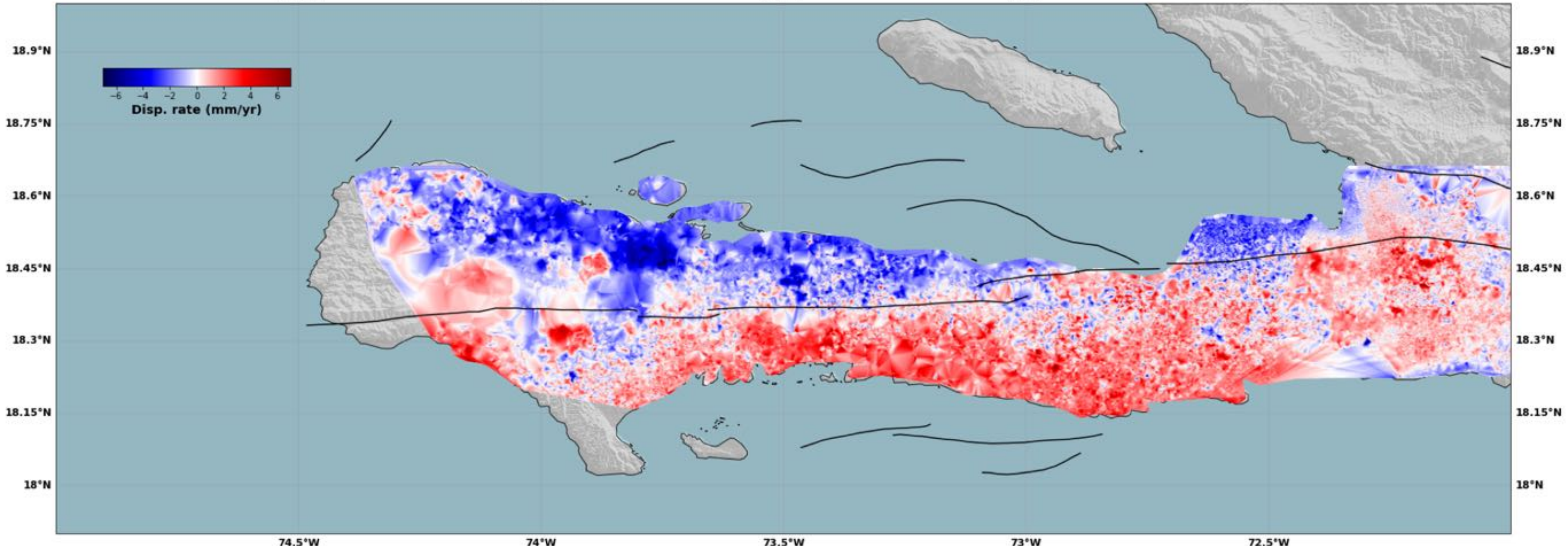




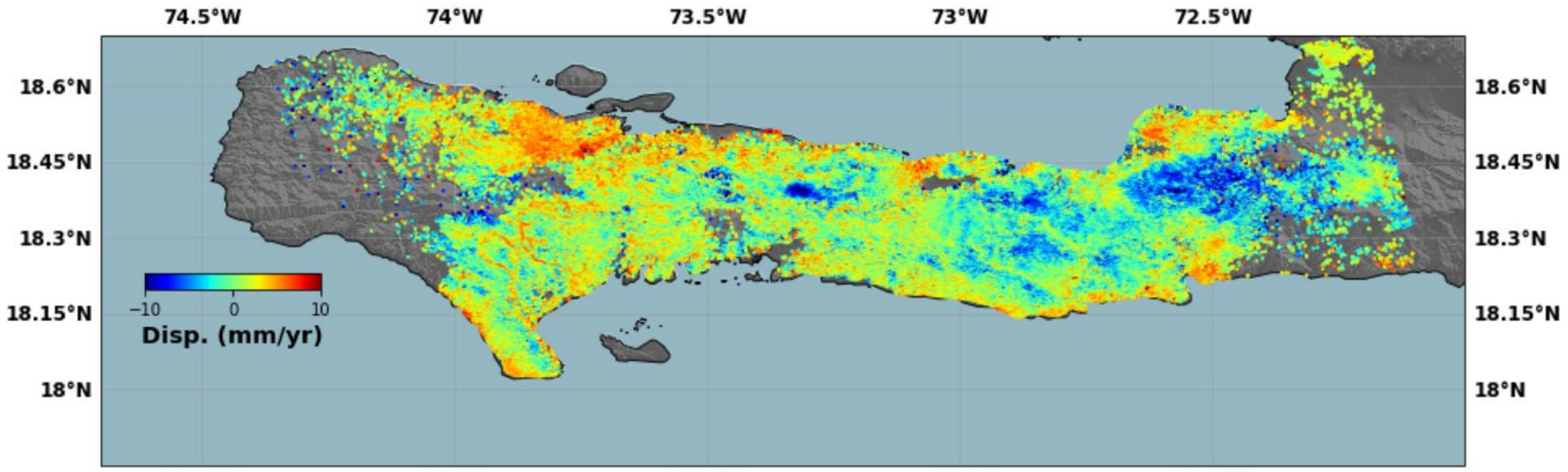
- Partitioning of the transpressive deformation is visible in the GNSS data, and in the Coseismic period.
- Large ruptures initiate as thrust and evolve as strike-slip fault when closer to the EPG fault.
- The EPG fault is locked at depth while presenting a RS behaviour in its shallowest part.
- Frictional response of multiple secondary faults to the Coulomb stress redistribution --> Passive markers reacting to stress

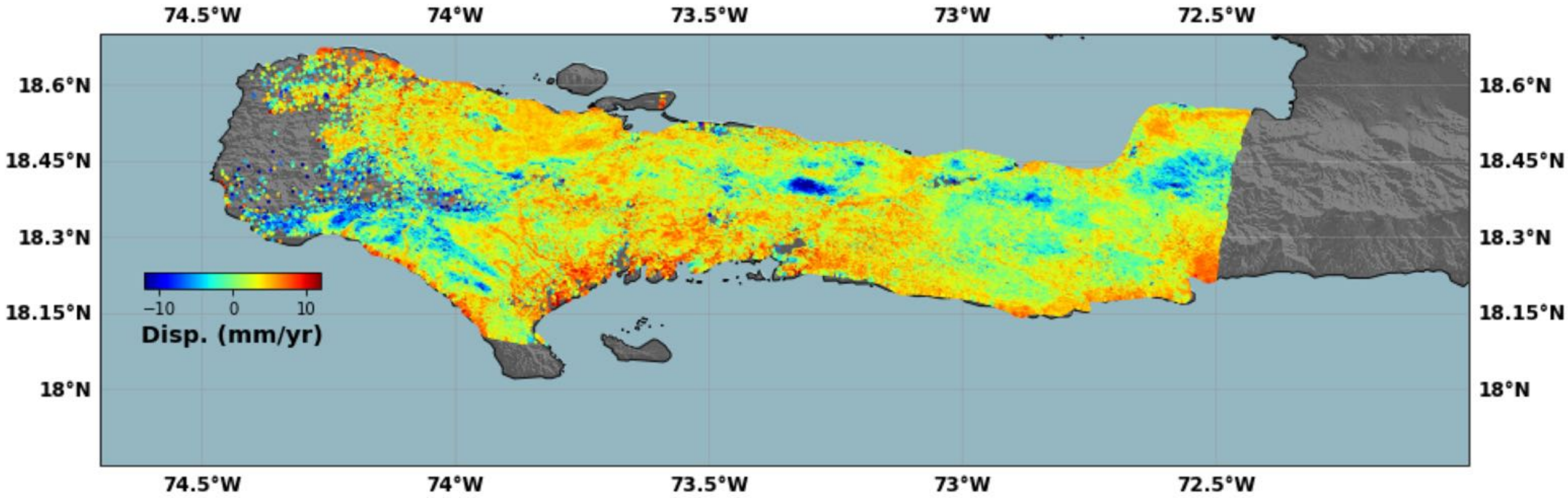
Preliminary Horizontal and Vertical Velocities

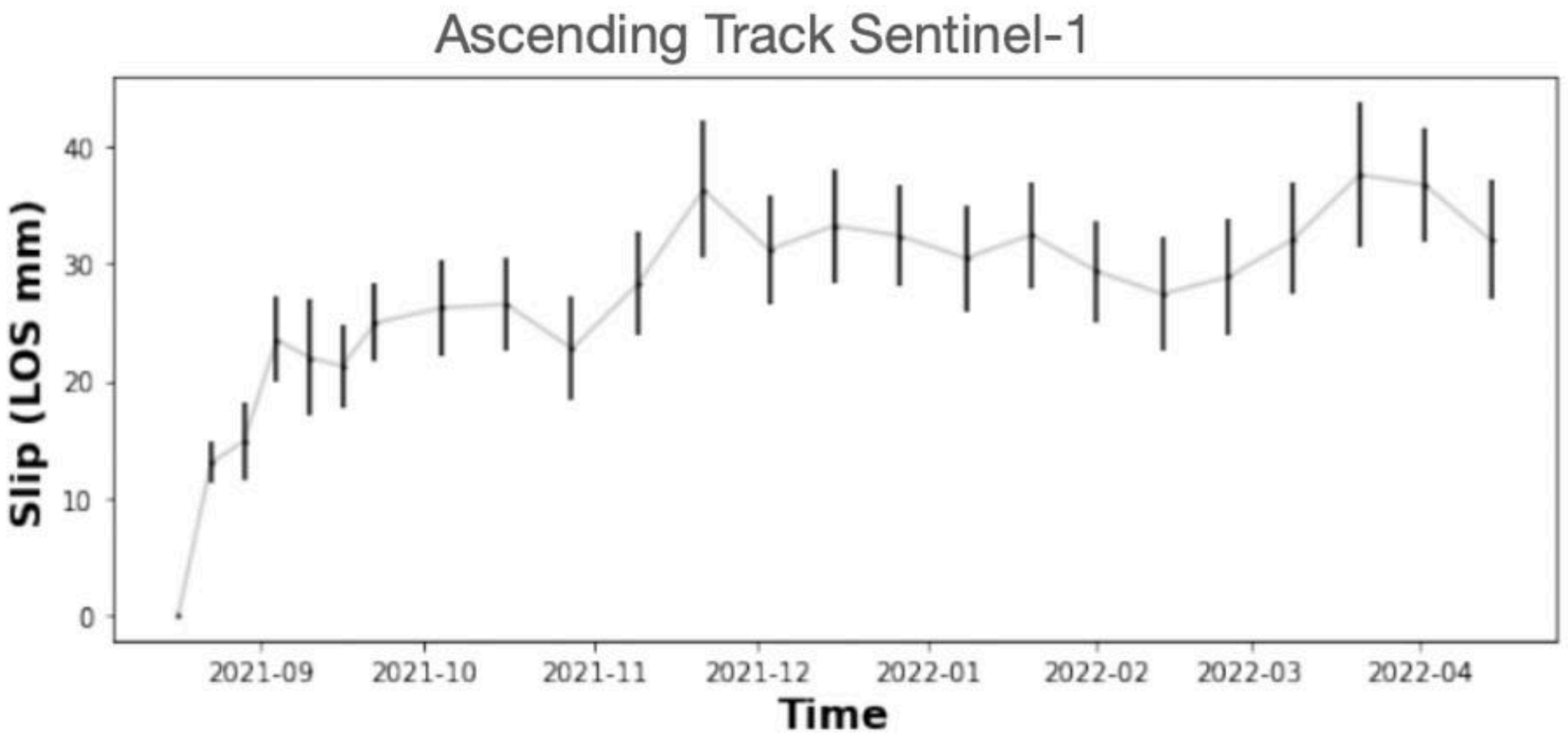


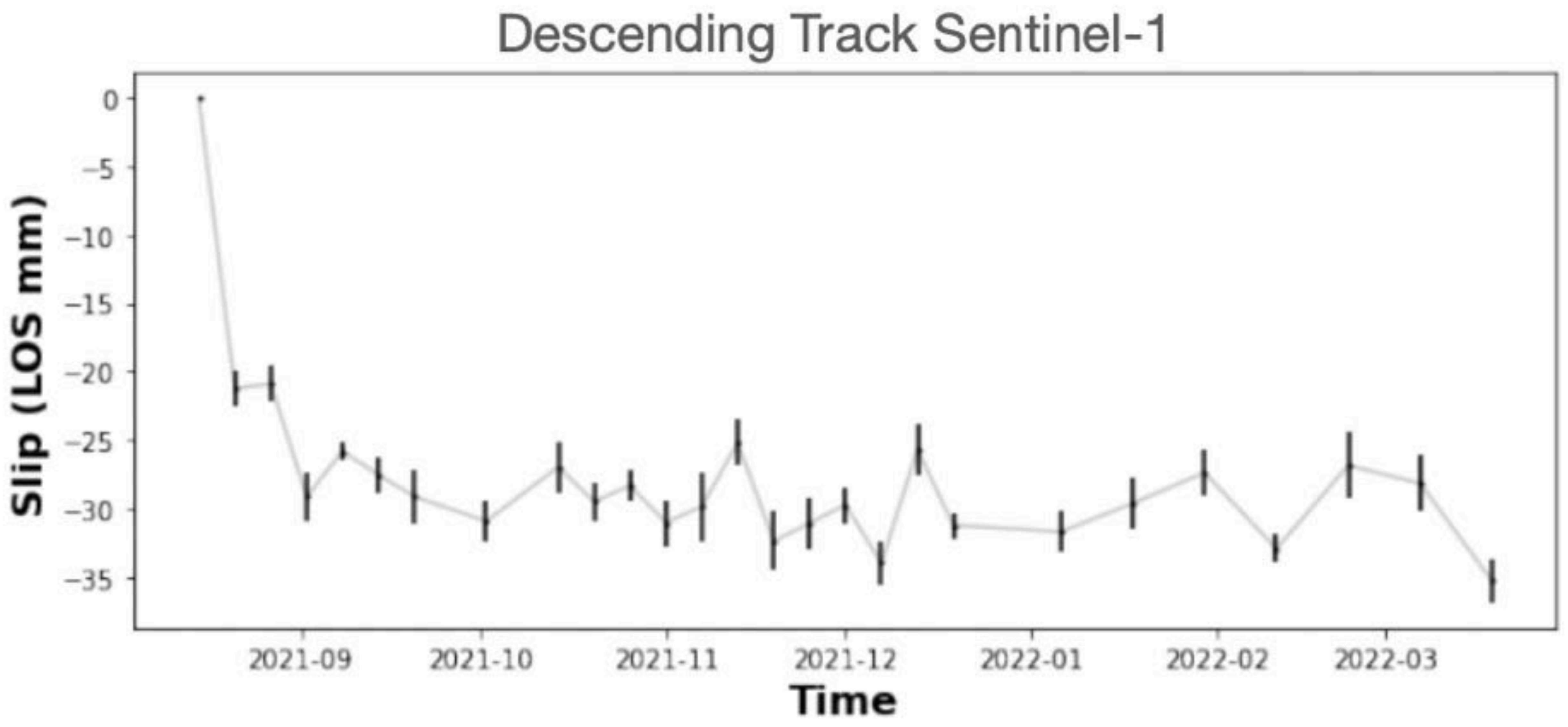


Distributed Scatterer Analysis

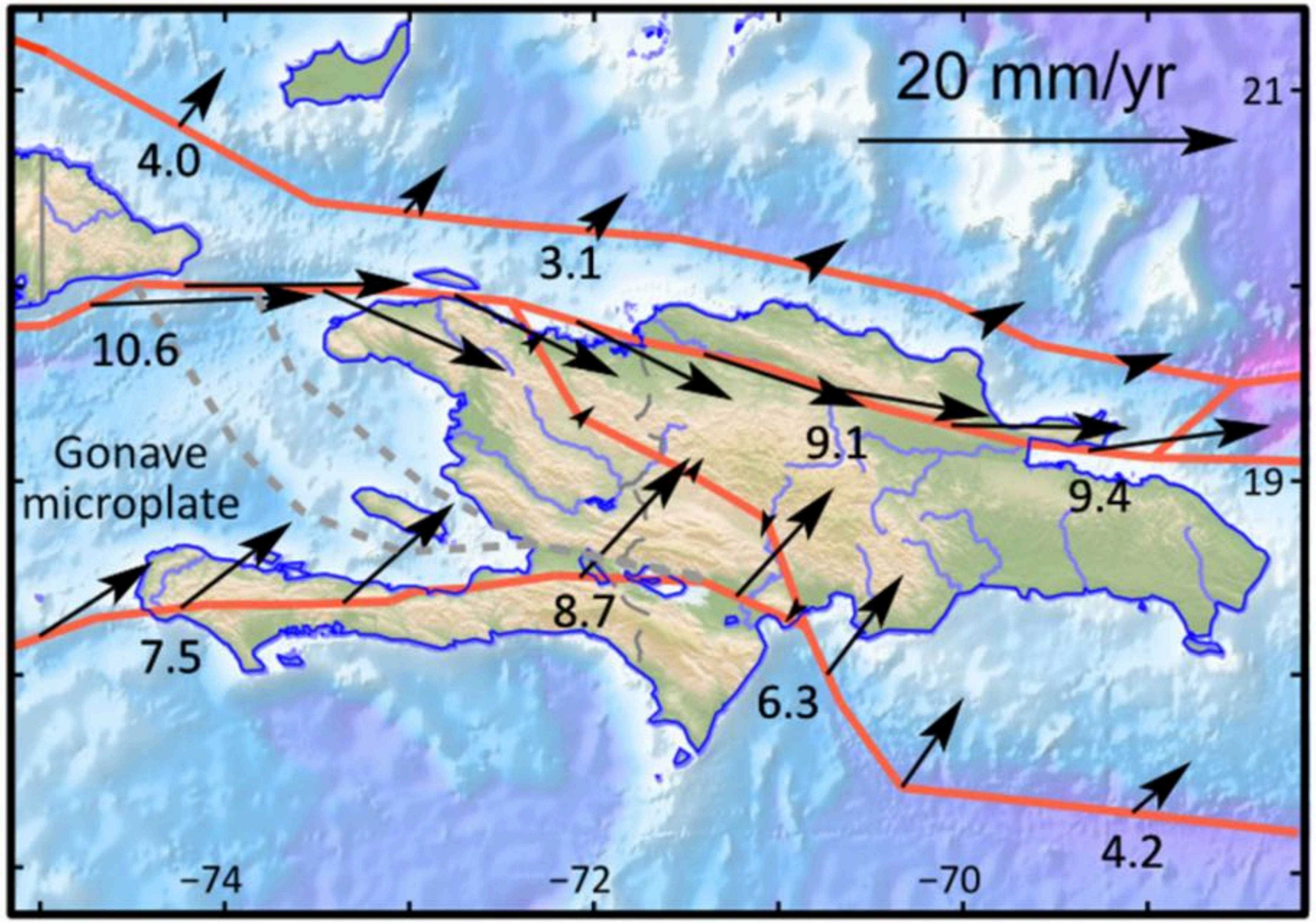




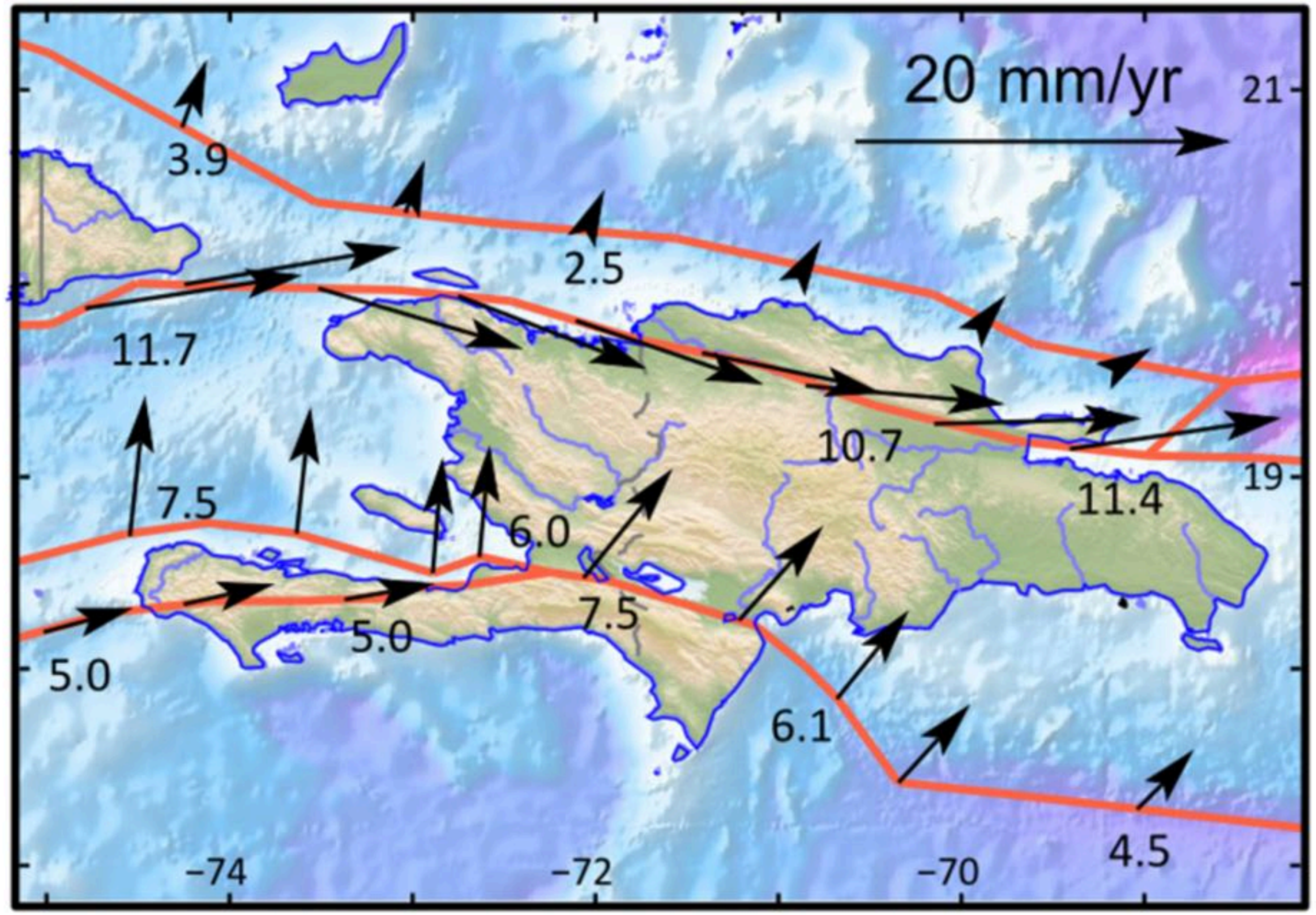

Ascending Track Sentinel-1
Slip (LOS mm)
Time
0
10
20
30
40
2021-09
2021-10
2021-11
2021-12
2022-01
2022-02
2022-03
2022-04


Descending Track Sentinel-1
Slip (LOS mm)
Time
0
−5
−10
−15
−20
−25
−30
−35
2021-09
2021-10
2021-11
2021-12
2022-01
2022-02
2022-03

Interseismic Model of "Blocks"



- Block Model with 2 strike-slip faults only (SEP and EPG fault)



- Block Model with 2 strike-slip faults and a thrust fault system running parallel to the northern Peninsula.

Figure from [Calais et al., 2023]