Integrating InSAR and GNSS for the Intra-Frame Deformation Model

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Intra-Frame Deformation Model

- Our main objective is to contribute to the development of this Intra-Frame Deformation Model-IFDM suitable for the significantly deforming regions of the U.S. (West Coast, Alaska, Hawaii, Caribbean) based on combined GNSS and InSAR data and methods.

- We are following the dynamic datum approach (Klein et al., 2019), which provide a time-dependent three-dimensional reference frame to allow users in deforming regions to tie into the National Spatial Reference System (NSRS).

- The project is funded by the NOAA National Geodetic Survey's Geospatial Modeling Program as a complement to the new National Spatial Reference System.

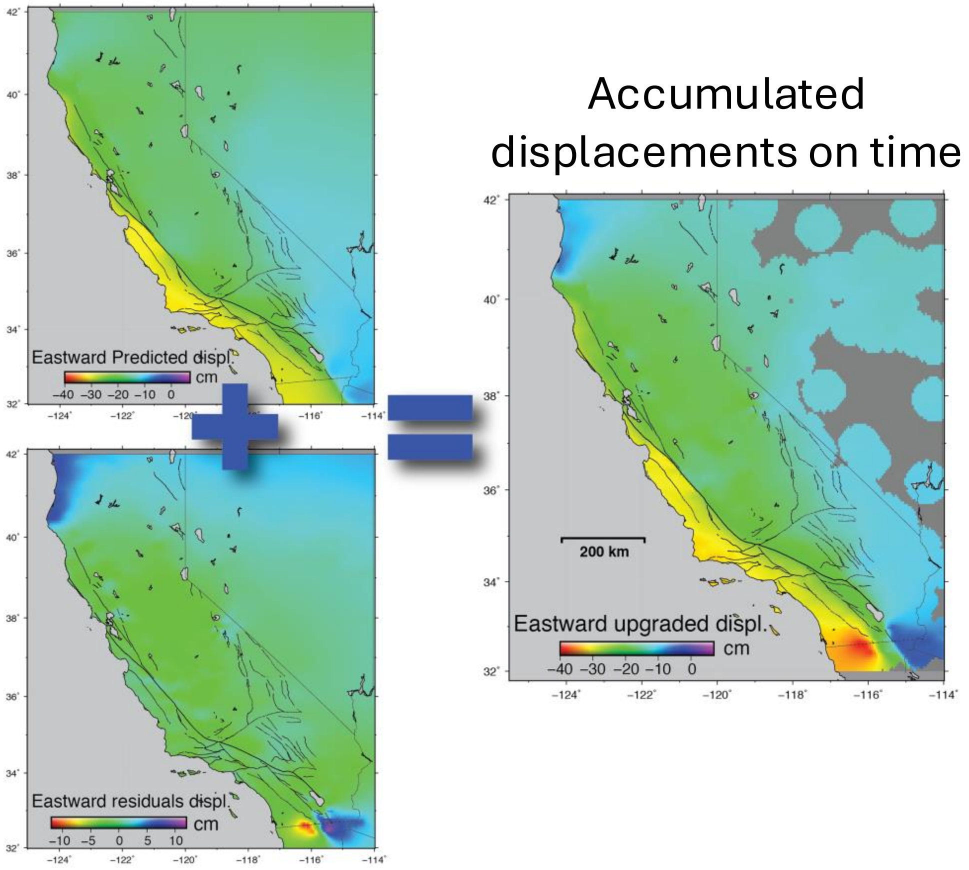
- We are integrating GNSS and InSAR displacement fields to achieve higher spatial resolution (< 1km) than available from GNSS alone (~20-40km), and to improve precision in areas of significant vertical land motion.

Dynamic Datum (Klein et al., 2019)

- Dynamic three-dimensional reference frame;
- Interseismic model and observed surface displacements provide changes in coordinates between different epochs of time for precise surveying applications (Bock and Klein, 2018);
- Interseismic model represents the secular motion, and it is used to predict the linear displacement at any point inside the region covered by the reference network;
- Observed surface displacements by GNSS stations are used to parametrically model their transient motion, defined as a station’s non-secular physical motions;
- Parametric model includes coseismic and postseismic displacements;
- Transients include vertical motions with natural causes, such as hydrological surface loading, water aquifer recharge, and magmatic processes or anthropogenic, such as water and mineral extraction, and hydrothermal power plant generation (Bock and Klein, 2018).

Interseismic Model

Accumulated displacements on time

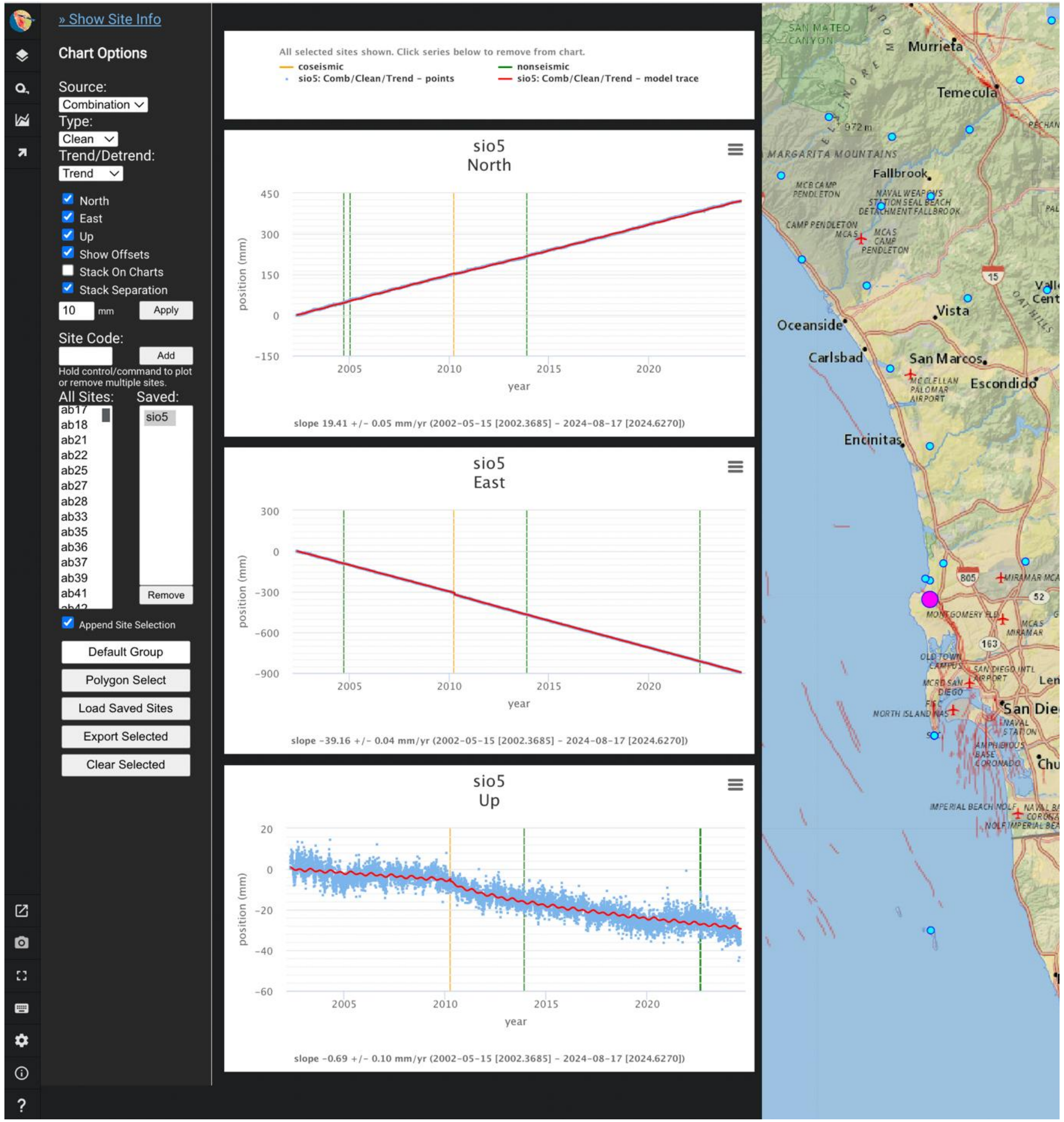


Transients

Source: Klein et al., 2019

JPL and SOPAC combinations

http://mgviz.ucsd.edu/

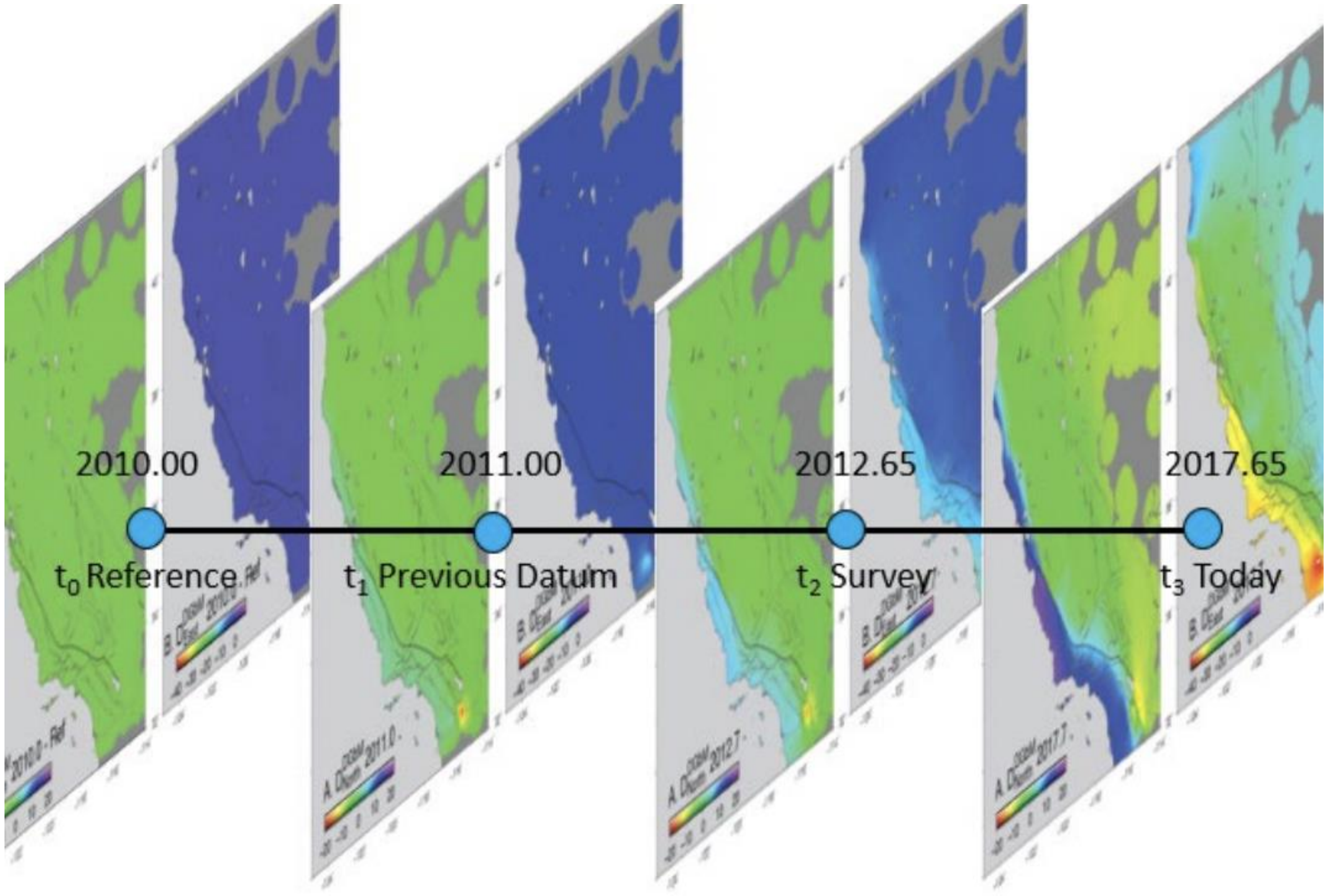


- Non-linear motions (transients) are reflected in the daily GNSS displacement time series, a combination of JPL and SOPAC solutions obtained through a NASA -funded project (http://sopac-csrc.ucsd.edu/index.php/measures-2/).

- This time series is parametrically modeled for velocity, coseismic offsets and postseismic motions, annual and semi-annual terms, and offset artifacts. The secular motions from the interseismic model plus the residual daily displacements from the GNSS time series are combined and gridded to define the dynamic datum with respect to an arbitrary reference epoch (Klein et al., 2019).

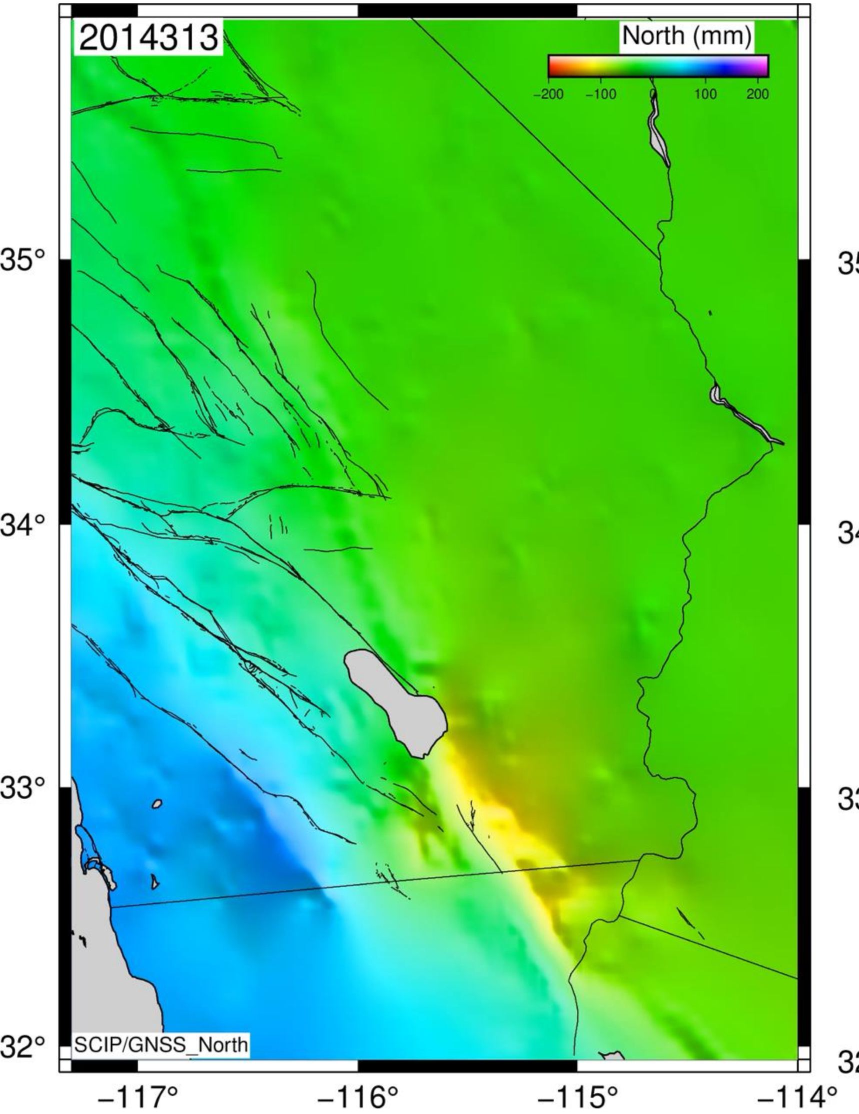
SCIP Utility

- The SCIP web application for the Western U.S. (http://sopac-adj.ucsd.edu/scip/)
- Provides the expected 3-D displacements between any two epochs with respect to several reference frames (e.g., NAD83(2011) and ITRF2020)

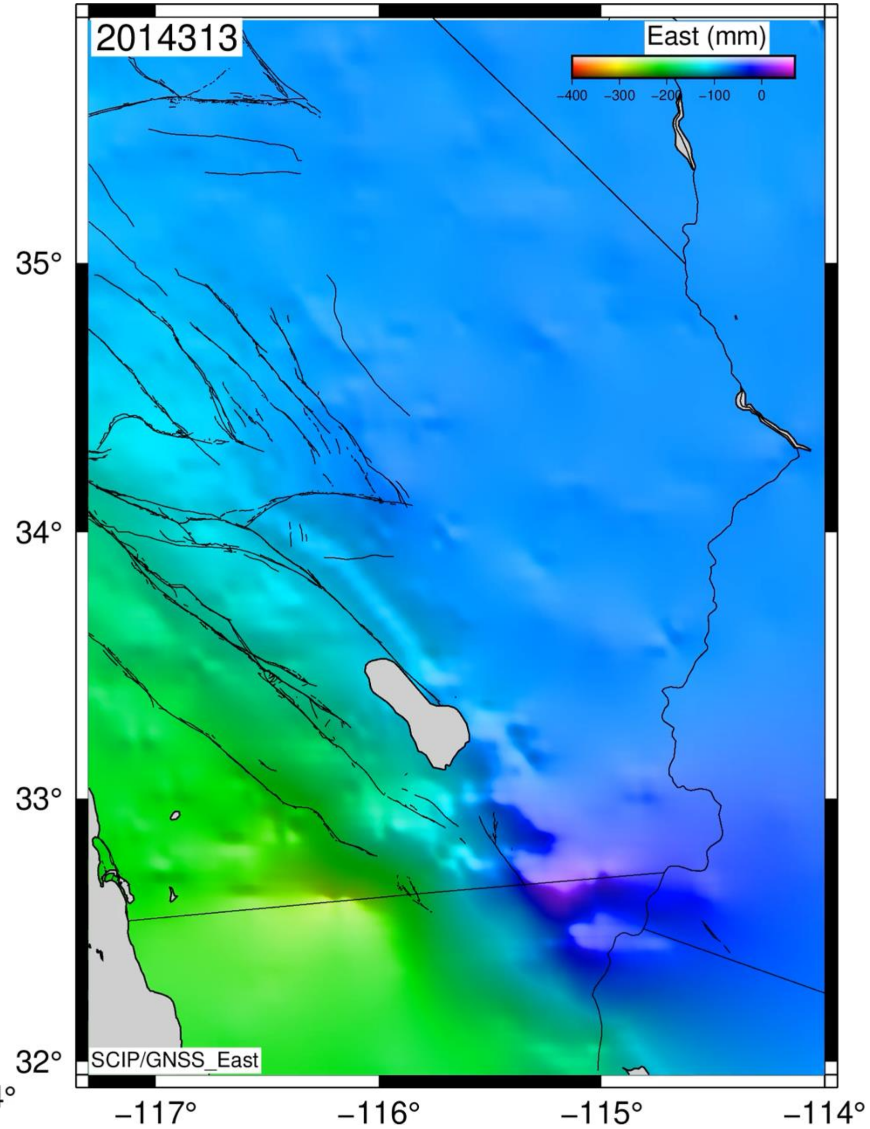


SCIP Utility

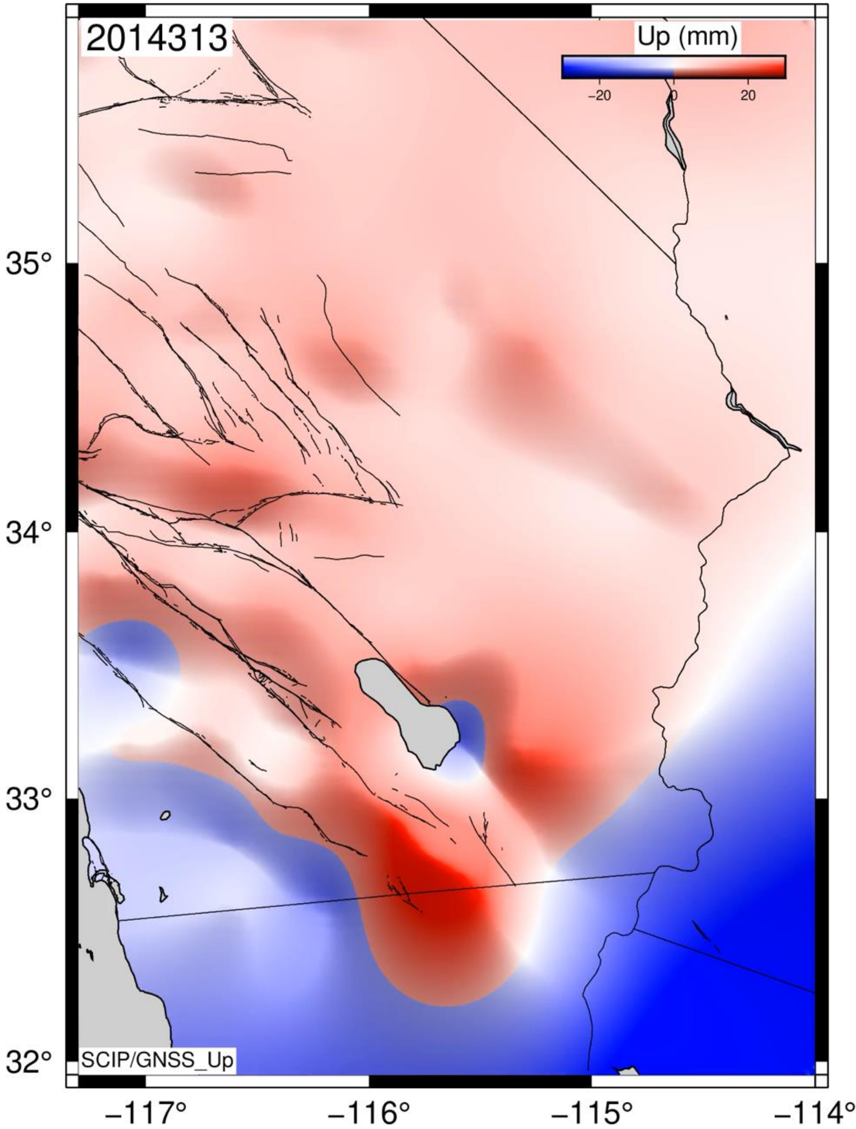
North



East

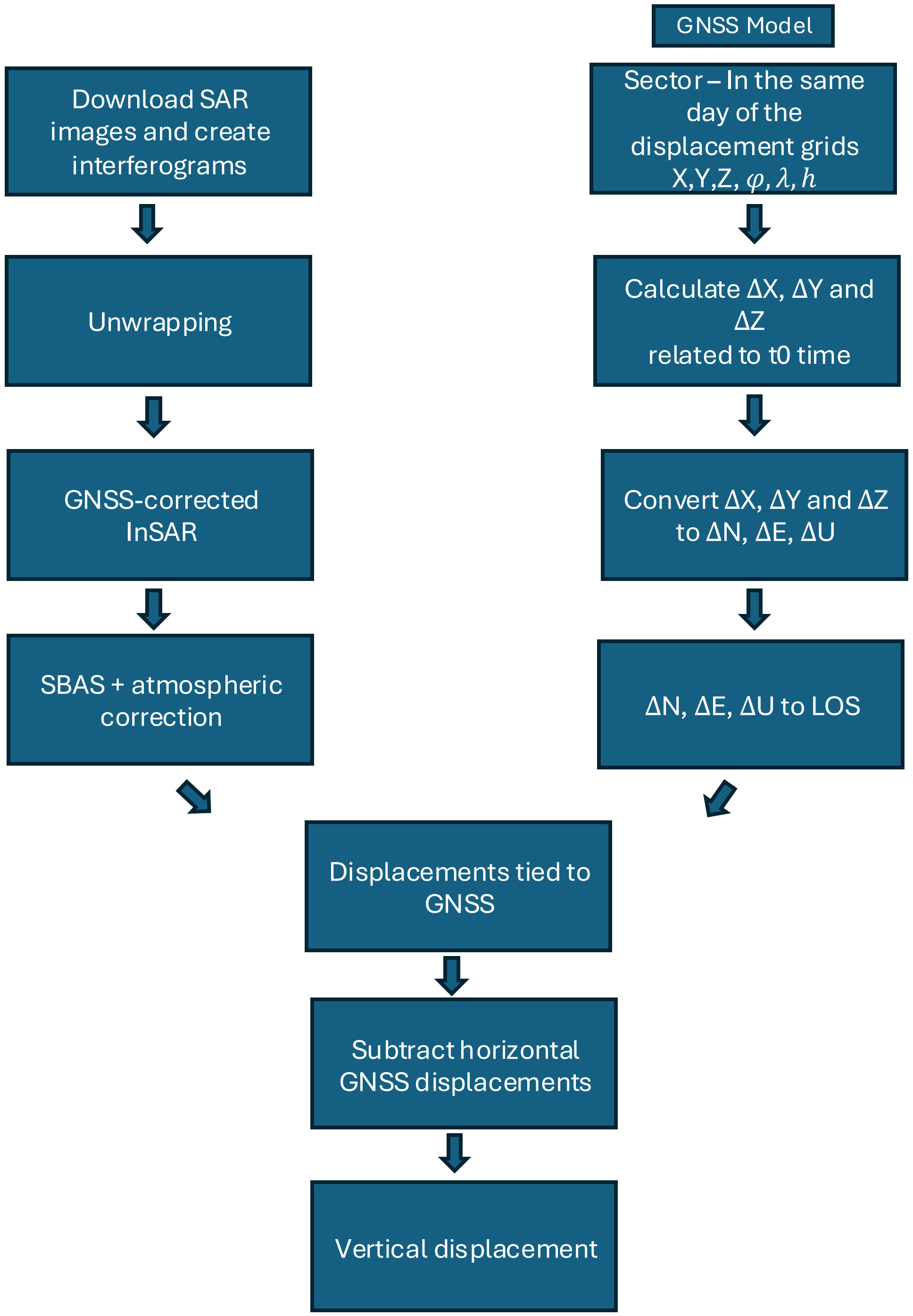


Up

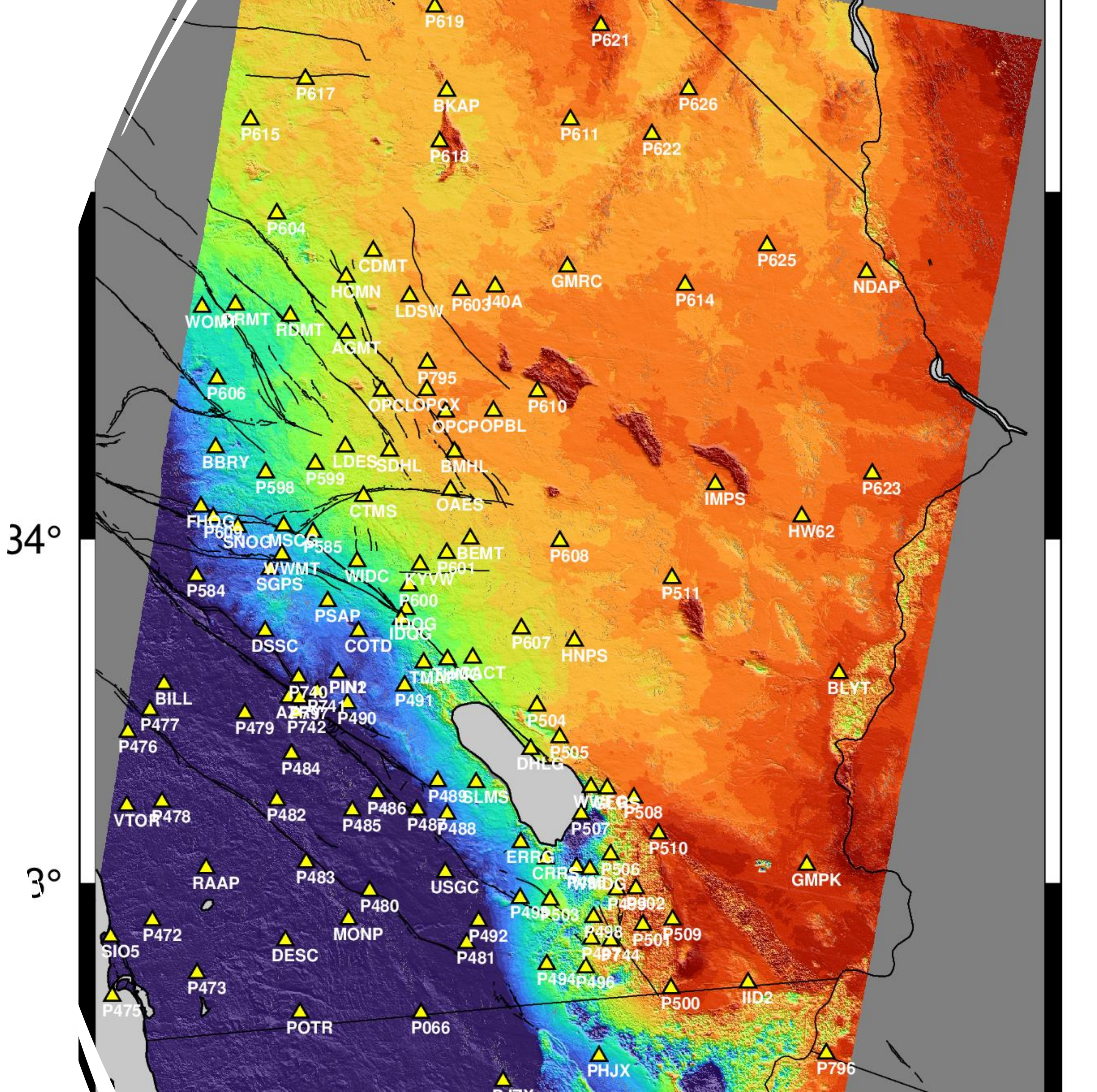


Integrating InSAR and GNSS

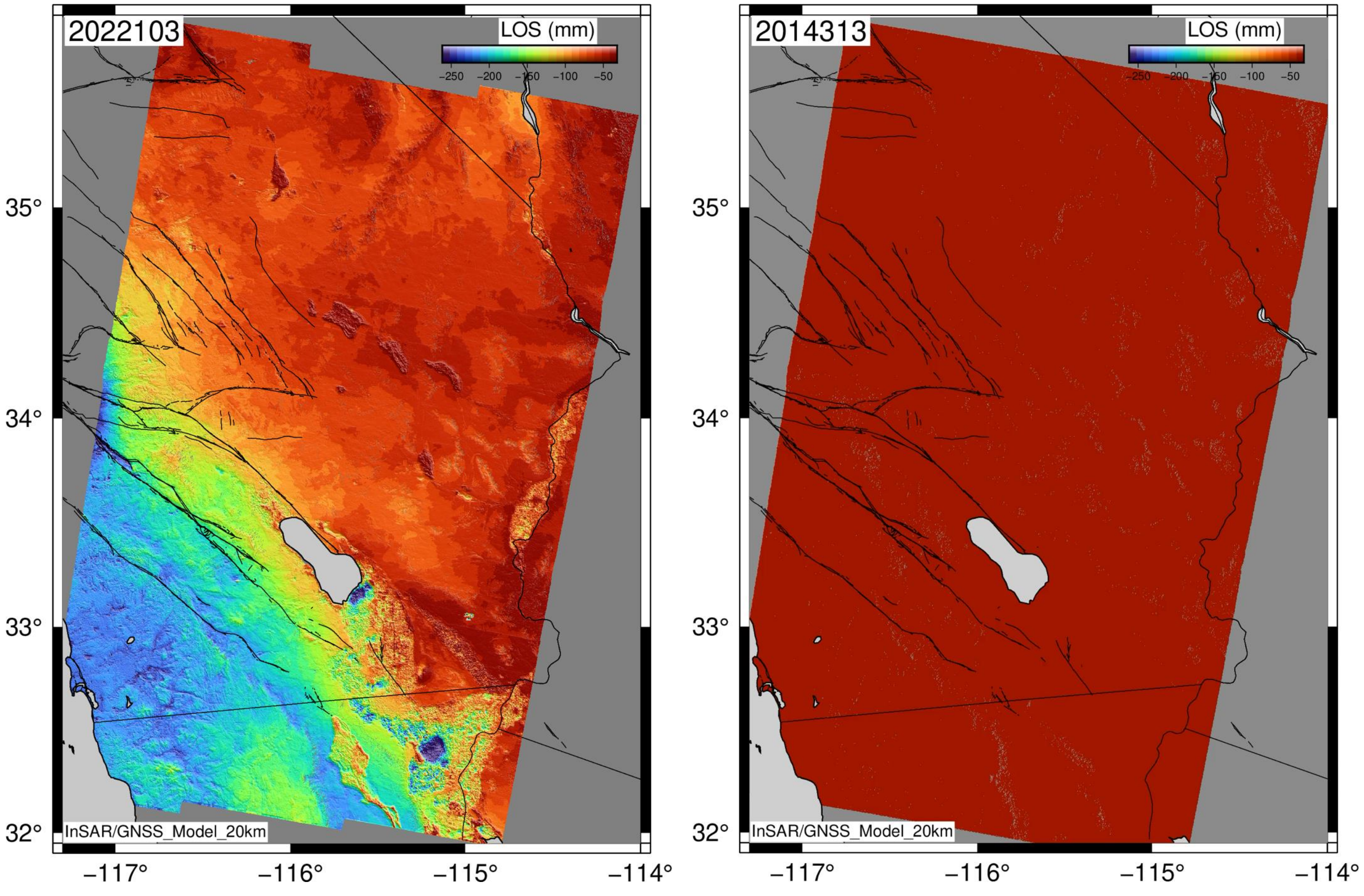
- Acquire SAR images and create interferograms pairs (perpendicular baseline < 150 m and temporal separation < 90 days)
- Perform Phase Unwrapping - SNAPHU (Chen & Zebker, 2002)
- Compute GNSS-corrected InSAR imagery with weekly solutions (Klein et al., 2019)
- Create displacement grids using a coherence-based SBAS approach integrated with atmospheric phase correction using common-scene stacking (Tymofyeyeva and Fialco, 2015)
- Tie the displacement grids to the GNSS model displacement related to the reference epoch using SOPAC's Sector utility (http://sopac-old.ucsd.edu/sector.shtml)
- Remove the horizontal GNSS displacements
- Separate the vertical component



Descending Track 173



Displacement Grids tied to GNSS stations

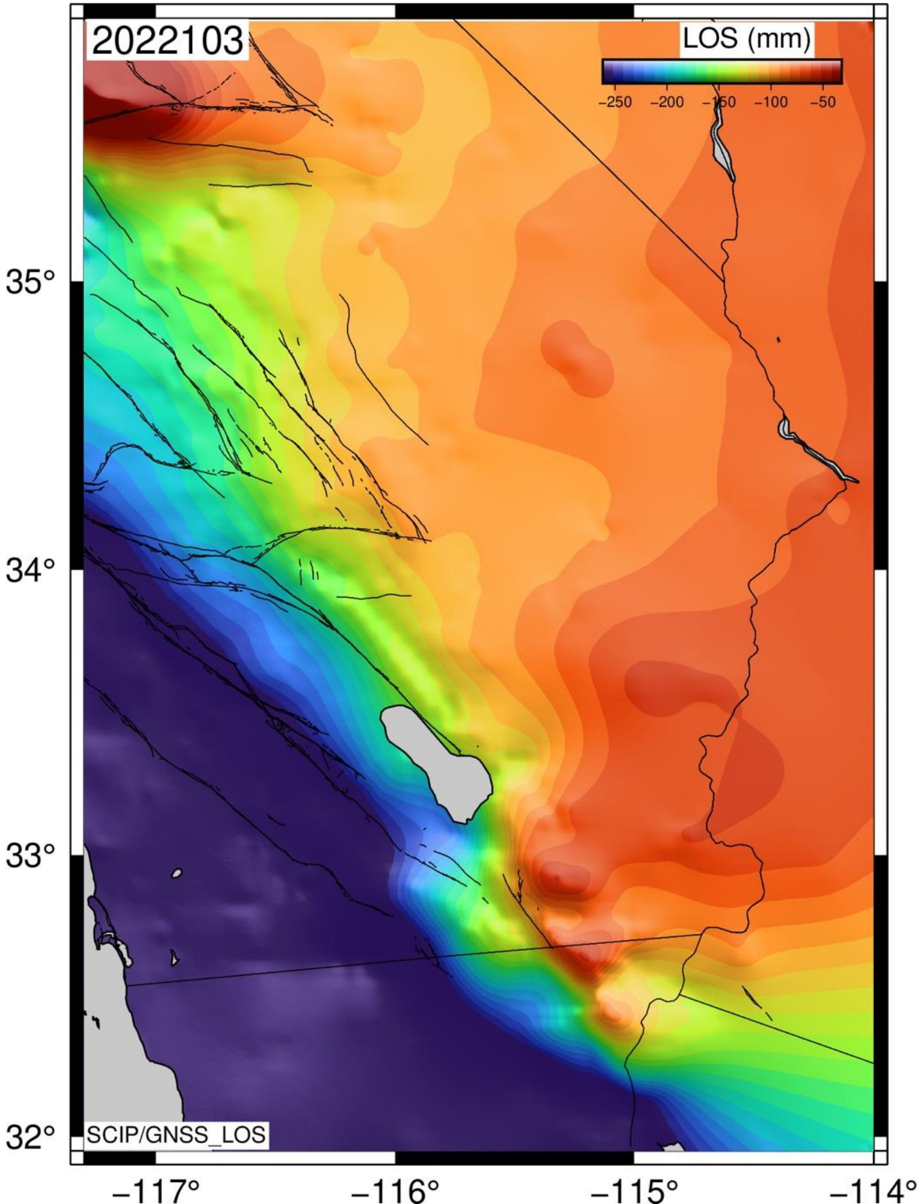


InSAR/GNSS Model 20 km

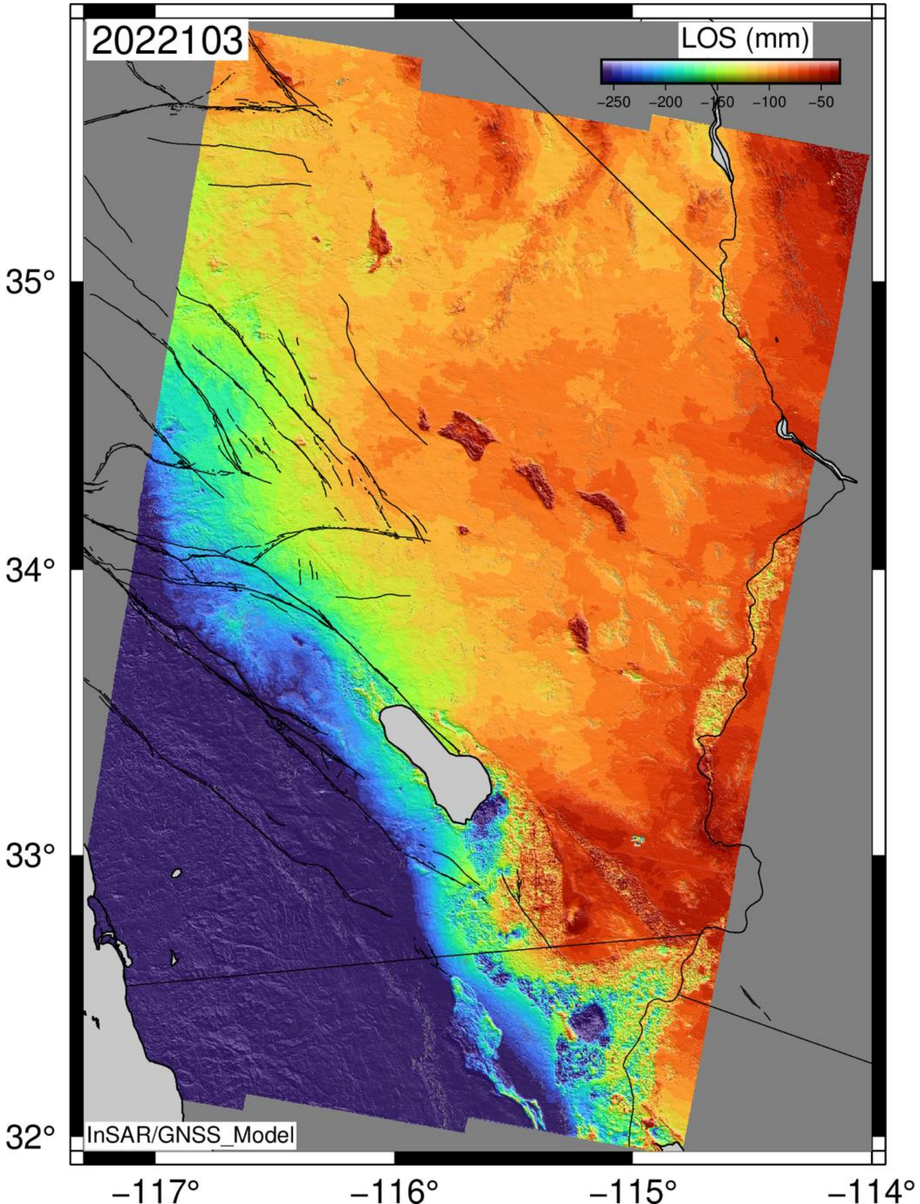
GNSS_LOS x InSAR_LOS

Referenced to 2010

SCIP GNSS

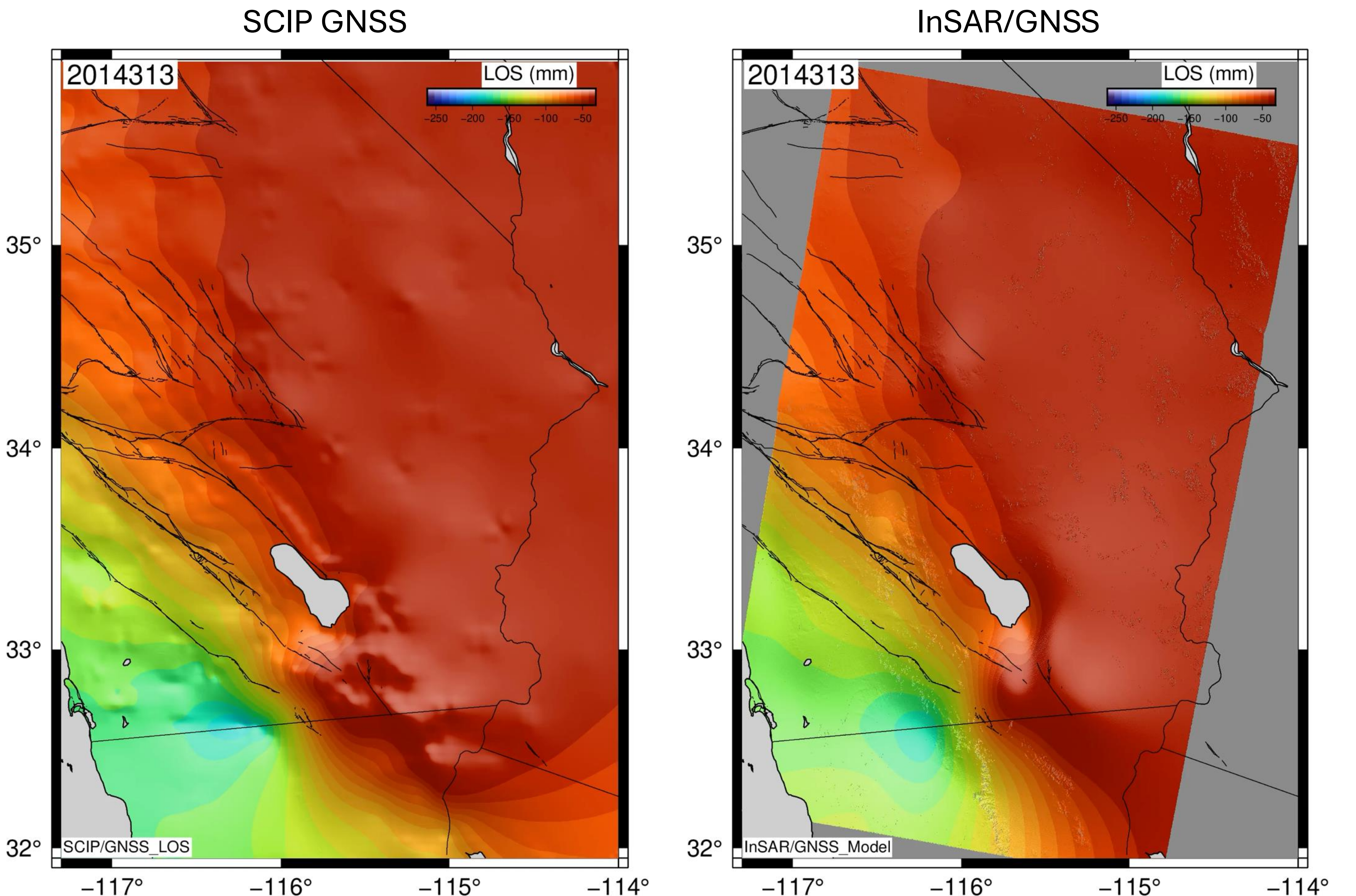


InSAR/GNSS



GNSS_LOS x InSAR_LOS

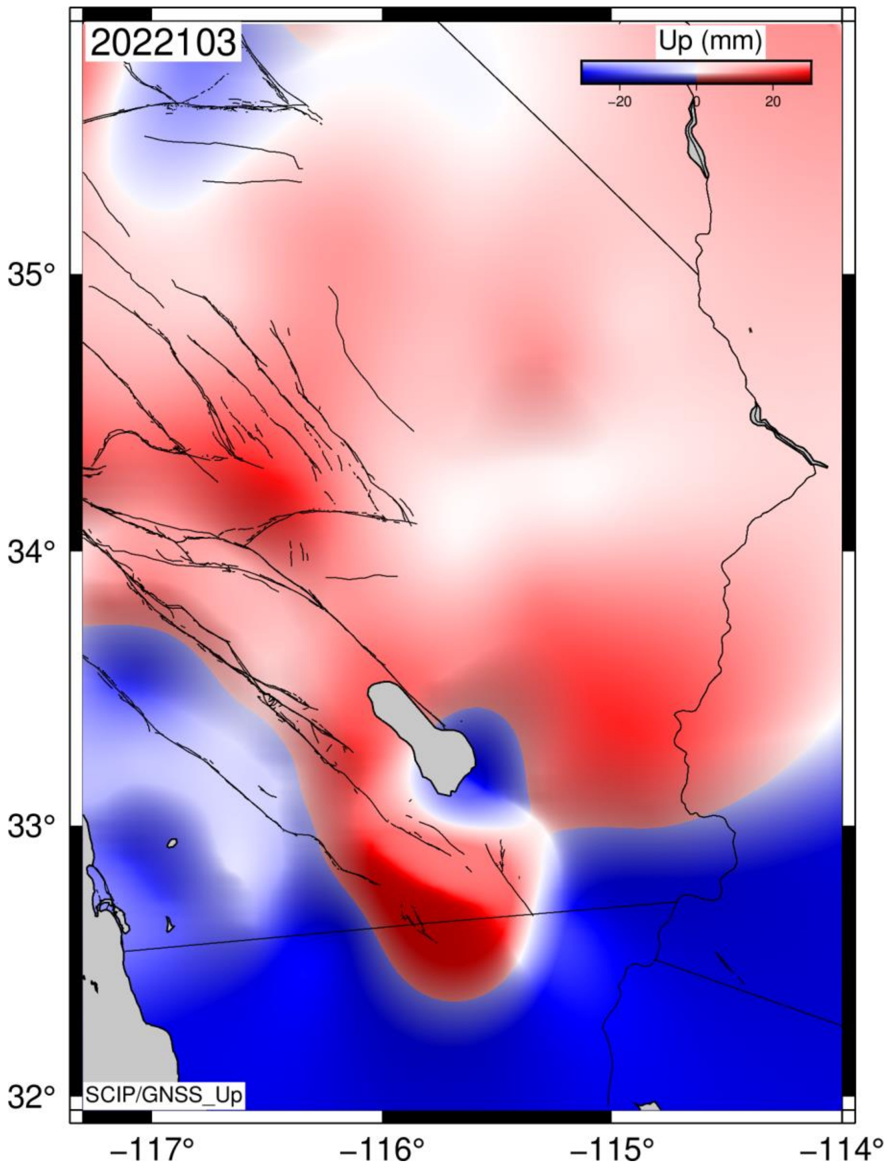
Referenced to 2010



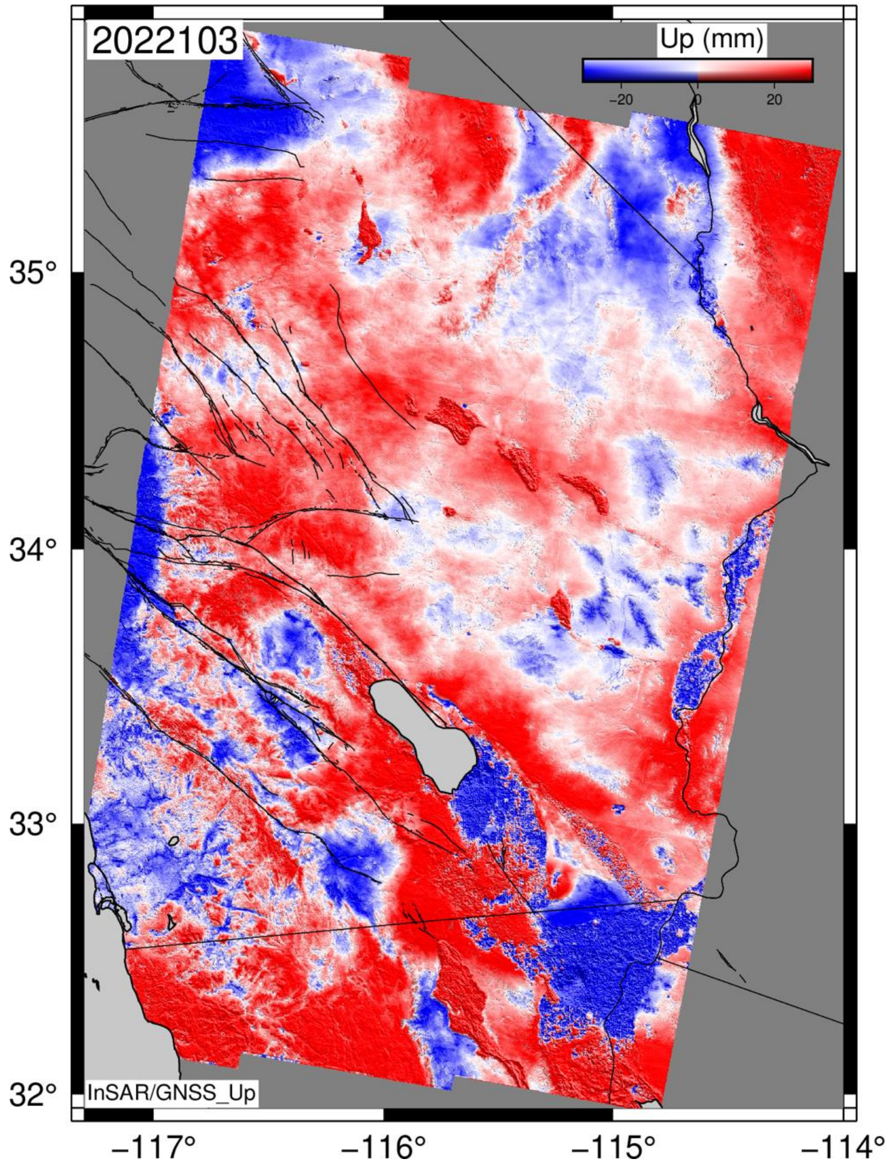
Vertical Displacements

Referenced to 2010

SCIP GNSS



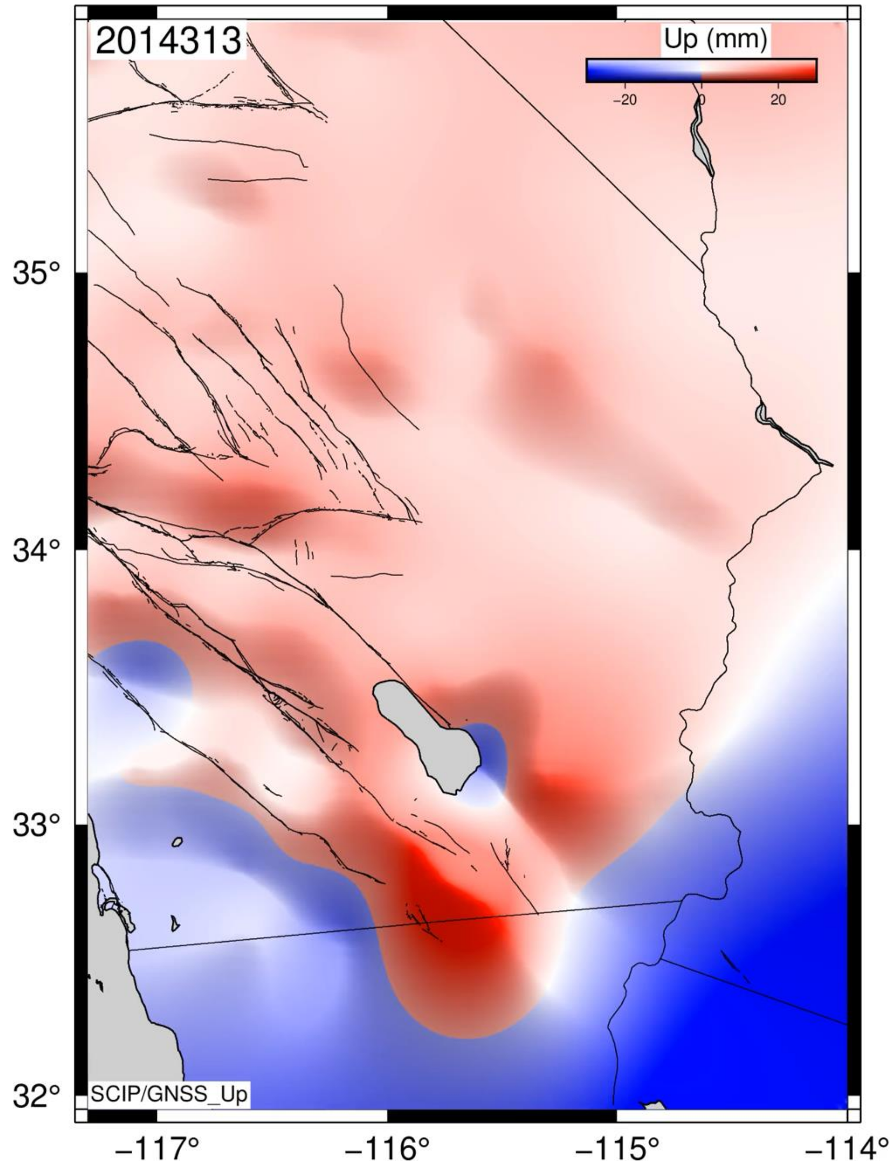
Up InSAR/GNSS



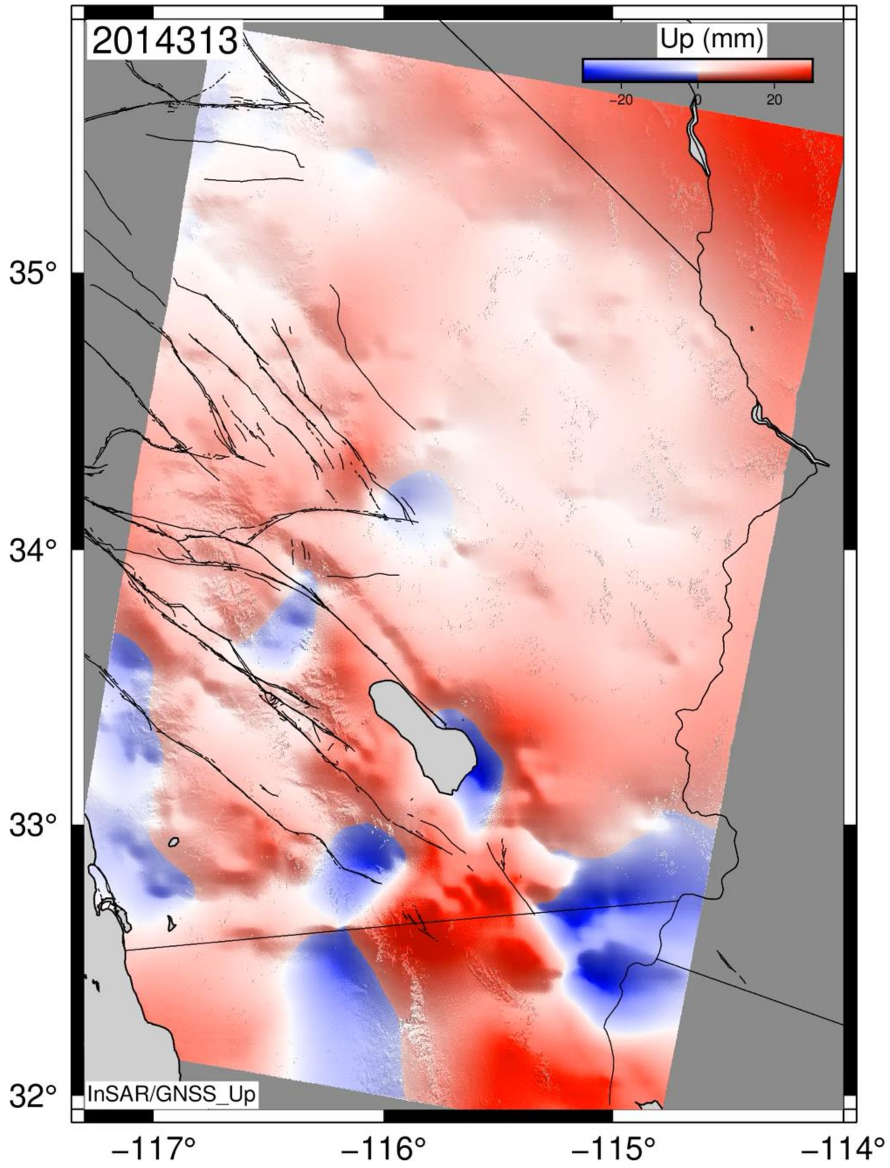
Vertical Displacements

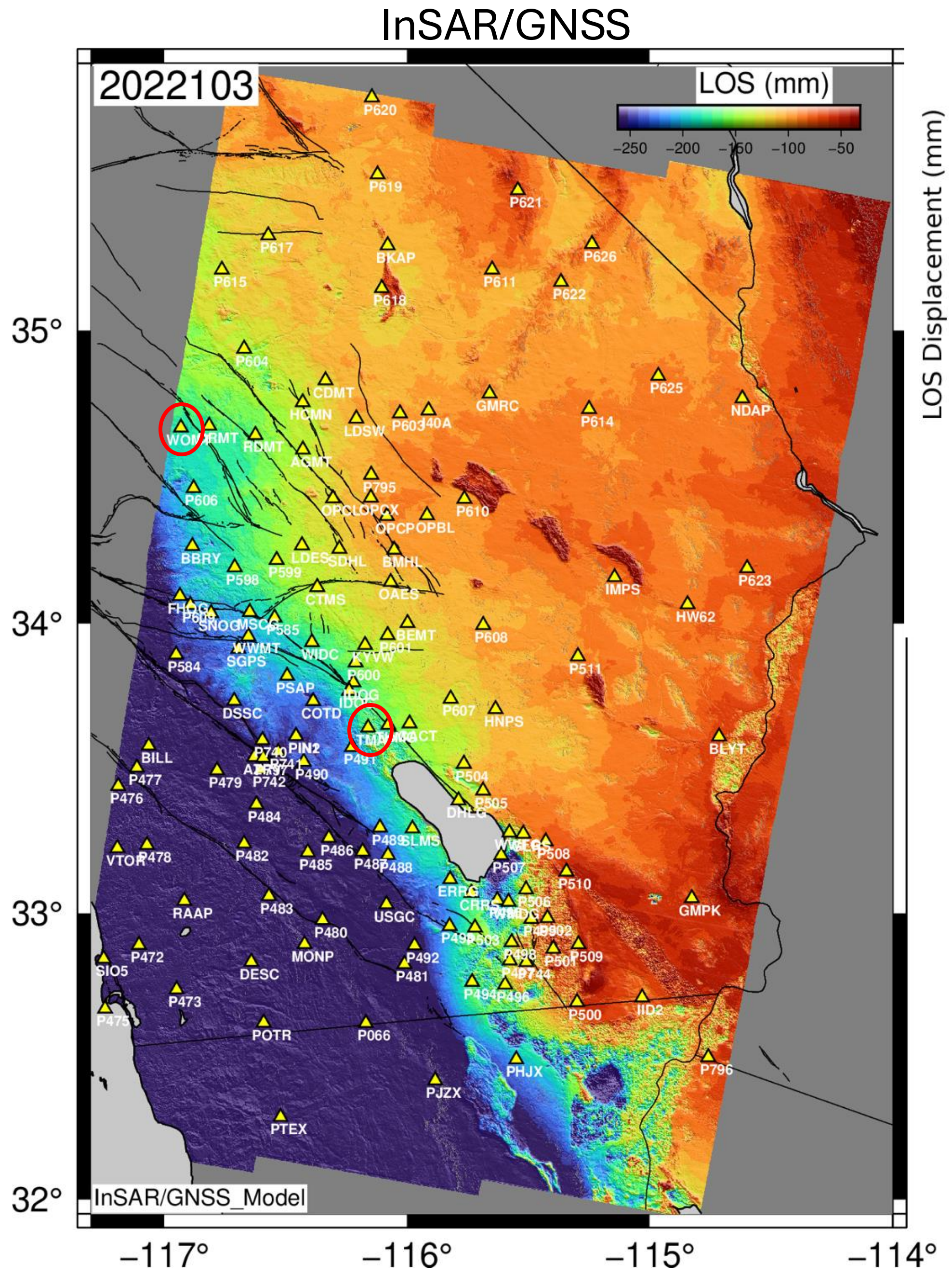
Referenced to 2010

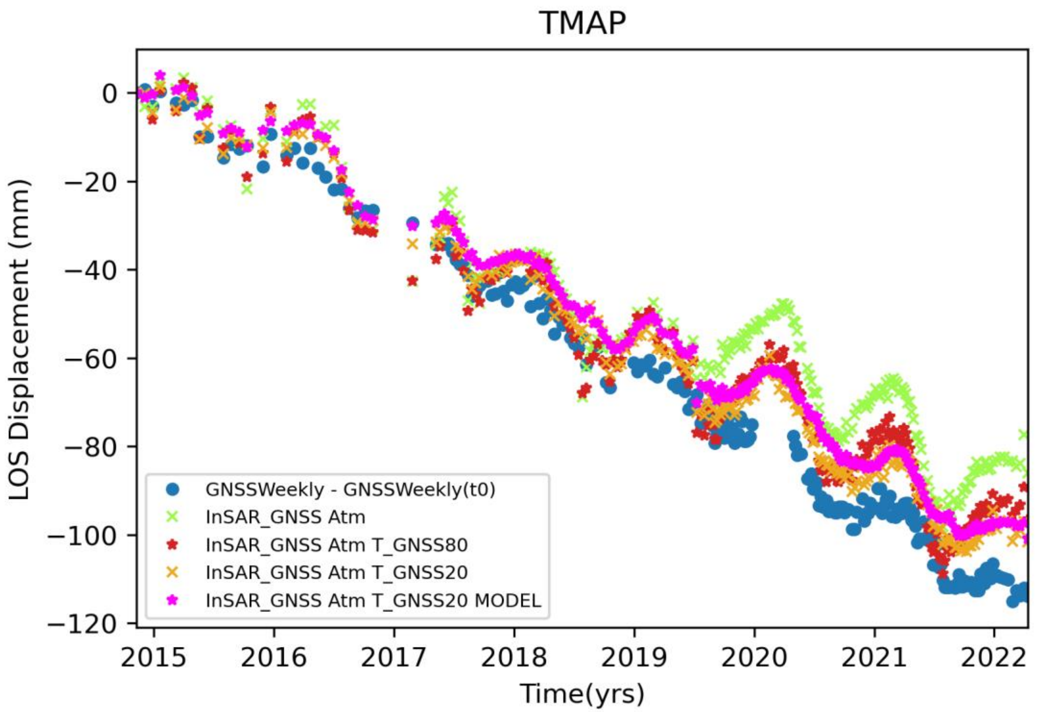
SCIP GNSS

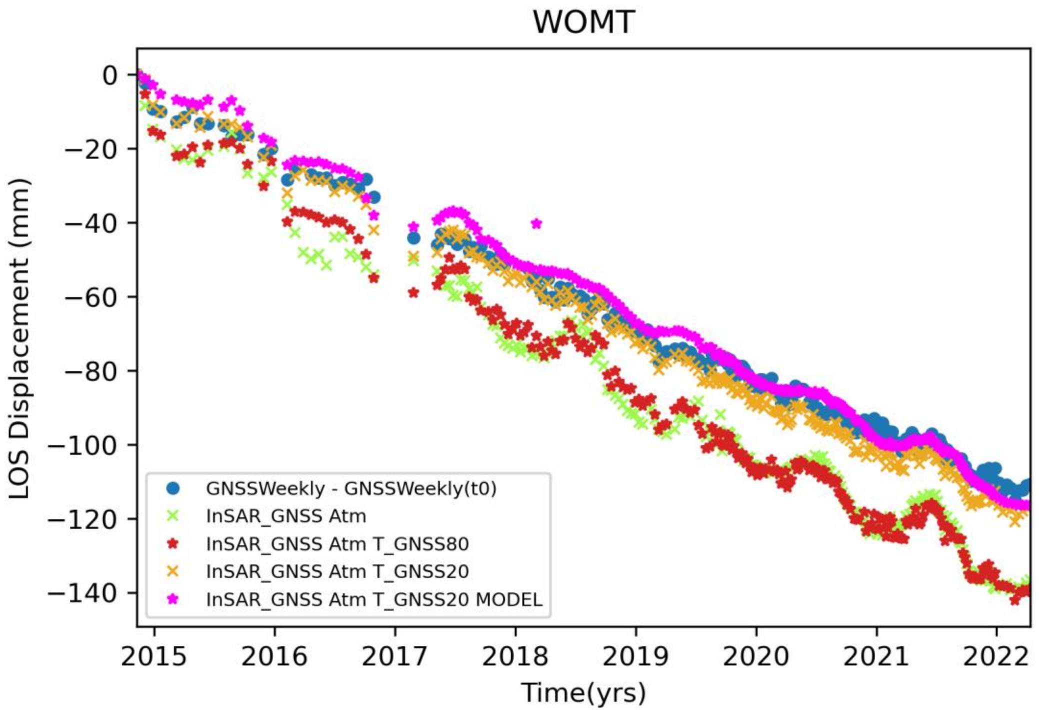


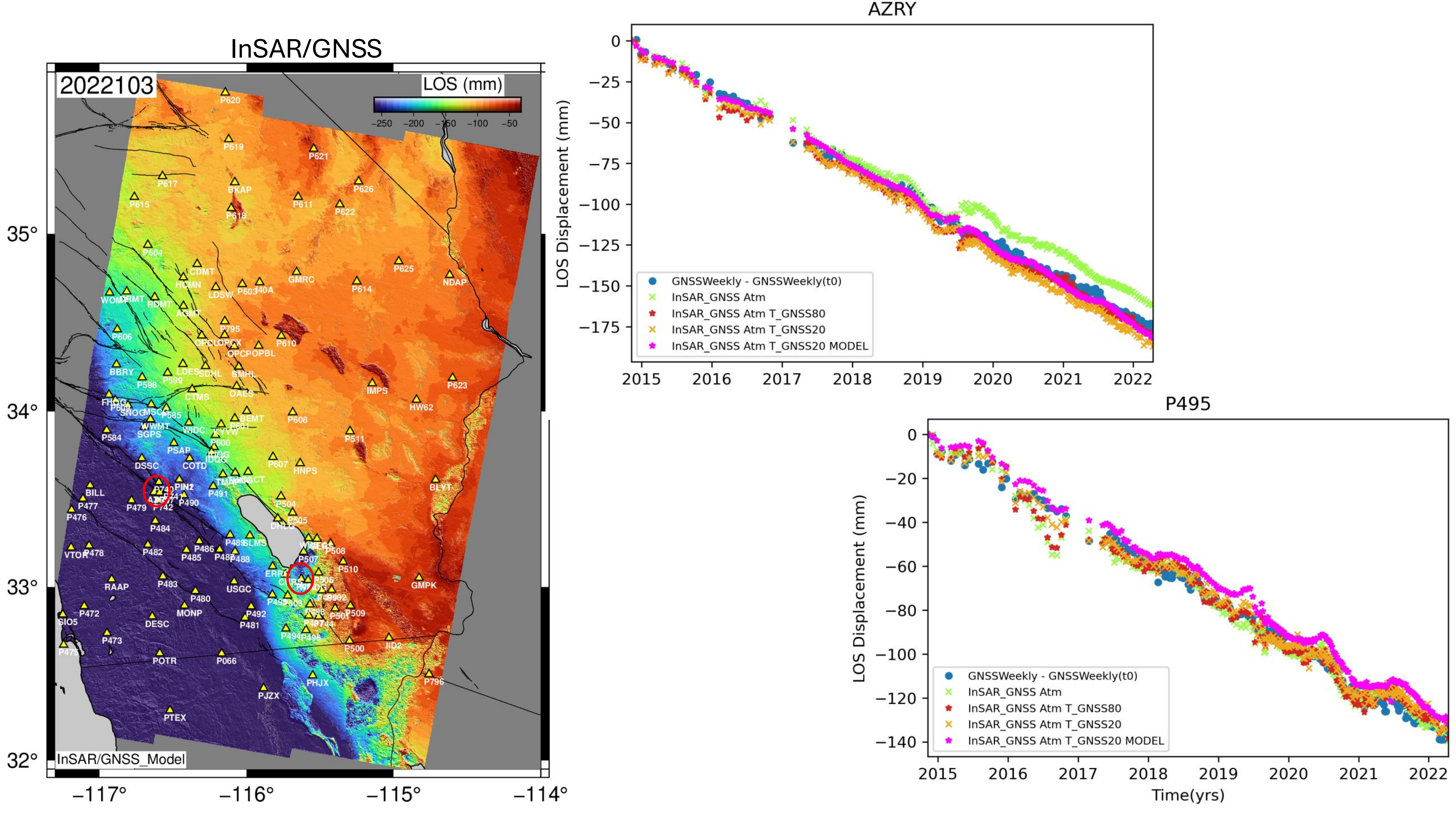
Up InSAR/GNSS




InSAR/GNSS
2022103
LOS (mm)
−250 −200 −150 −100 −50
InSAR/GNSS_Model
35°
34°
33°
32°
−117°
−116°
−115°
−114°


TMAP
LOS Displacement (mm)
Time(yrs)
0
−20
−40
−60
−80
−100
−120
2015 2016 2017 2018 2019 2020 2021 2022
GNSSWeekly - GNSSWeekly(t0)
InSAR_GNSS Atm
InSAR_GNSS Atm T_GNSS80
InSAR_GNSS Atm T_GNSS20
InSAR_GNSS Atm T_GNSS20 MODEL


WOMT
LOS Displacement (mm)
Time(yrs)
0
−20
−40
−60
−80
−100
−120
−140
2015 2016 2017 2018 2019 2020 2021 2022
GNSSWeekly - GNSSWeekly(t0)
InSAR_GNSS Atm
InSAR_GNSS Atm T_GNSS80
InSAR_GNSS Atm T_GNSS20
InSAR_GNSS Atm T_GNSS20 MODEL



InSAR/GNSS
2022103
LOS (mm)
−250 −200 −150 −100 −50
InSAR/GNSS_Model
35°
34°
33°
32°
−117° −116° −115° −114°
AZRY
P495
GNSSWeekly - GNSSWeekly(t0)
InSAR_GNSS Atm
InSAR_GNSS Atm T_GNSS80
InSAR_GNSS Atm T_GNSS20
InSAR_GNSS Atm T_GNSS20 MODEL
LOS Displacement (mm)
Time(yrs)
2015 2016 2017 2018 2019 2020 2021 2022

Next tasks

- Analyze the different results in each station
- Merge displacement in different tracks
- Test different approach for troposphere corrections
- Improve the vertical displacement
- Incorporate NISAR data
- Connect to the NSRS

Thank you!!

Acknowledgments:

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