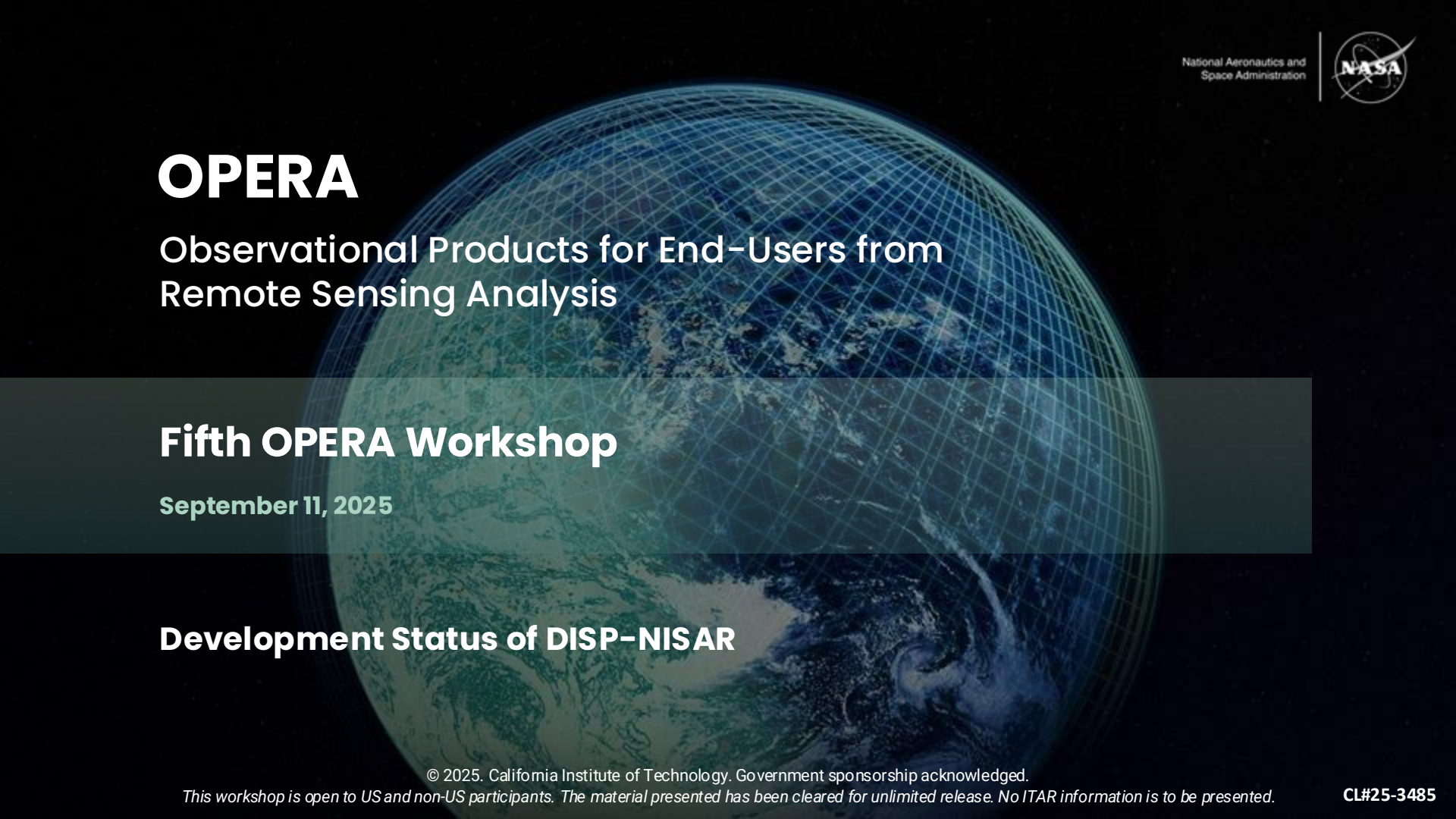


National Aeronautics and Space Administration

OPERA

Observational Products for End-Users from Remote Sensing Analysis

Fifth OPERA Workshop

September 11, 2025

Development Status of DISP-NISAR

This workshop is open to US and non-US participants. The material presented has been cleared for unlimited release. No ITAR information is to be presented.

CL#25-3485

Development Status of DISP-NISAR

Scott Staniewicz
Jet Propulsion Laboratory, California Institute of Technology

- Review of DISP-S1
- Requirements and differences of DISP-NISAR
- Example usage of DISP products

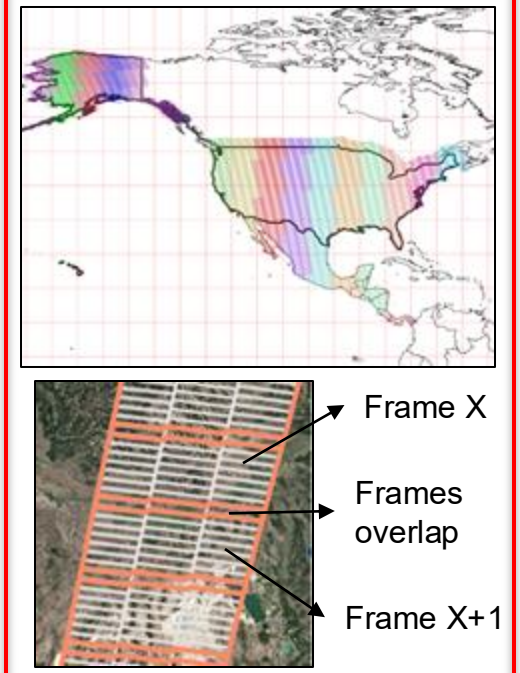
DISP-S1 and NISAR Product Overviews

National Aeronautics and Space Administration

The OPERA Surface Displacement products have a North American geographical scope

Description	Maps surface displacement from InSAR time series in radar line-of-sight (LOS) direction	**Sensor Temporal Sampling****	6-12 days for Sentinel-1 12 days for NISAR
		Pixel Resolution (Northings x Eastings)	30 m or better
Distribution	Alaska Satellite Facility Distributed Active Archive Center (ASF DAAC)	**File Format**	Hierarchical Data Format version 5 (HDF5)
Sensor	Sentinel-1 & NISAR	**Validated Release Date**	**Dec. 2024 (DISP-S1)** Feb. 2027 (DISP-NI)

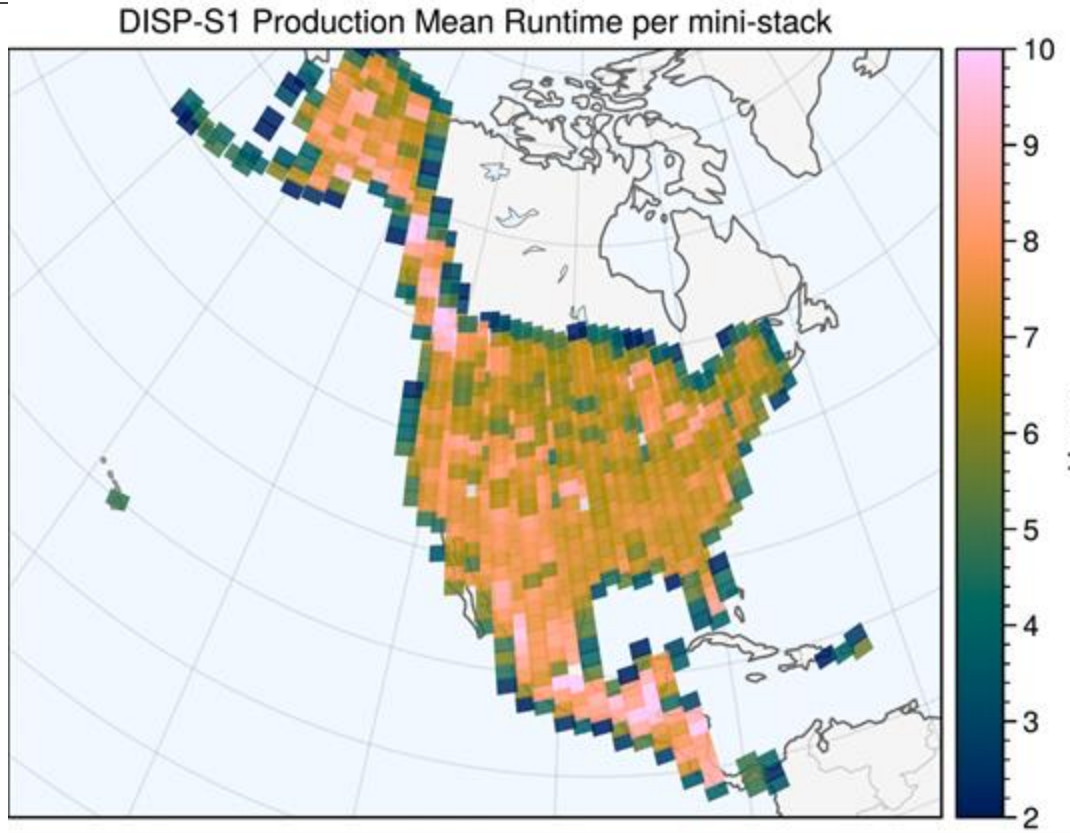
* USA and US Territories within 200 km from US border, Canada, and all mainland countries from the southern US border up to and including Panama.
***Based on Sensor input data availability*



Example of DISP-S1 frame.

DISP-S1 Production Status

- Historical production nearing completion
- Backfilling through end of 2025 in “batch mode”
- Forward mode to start next month

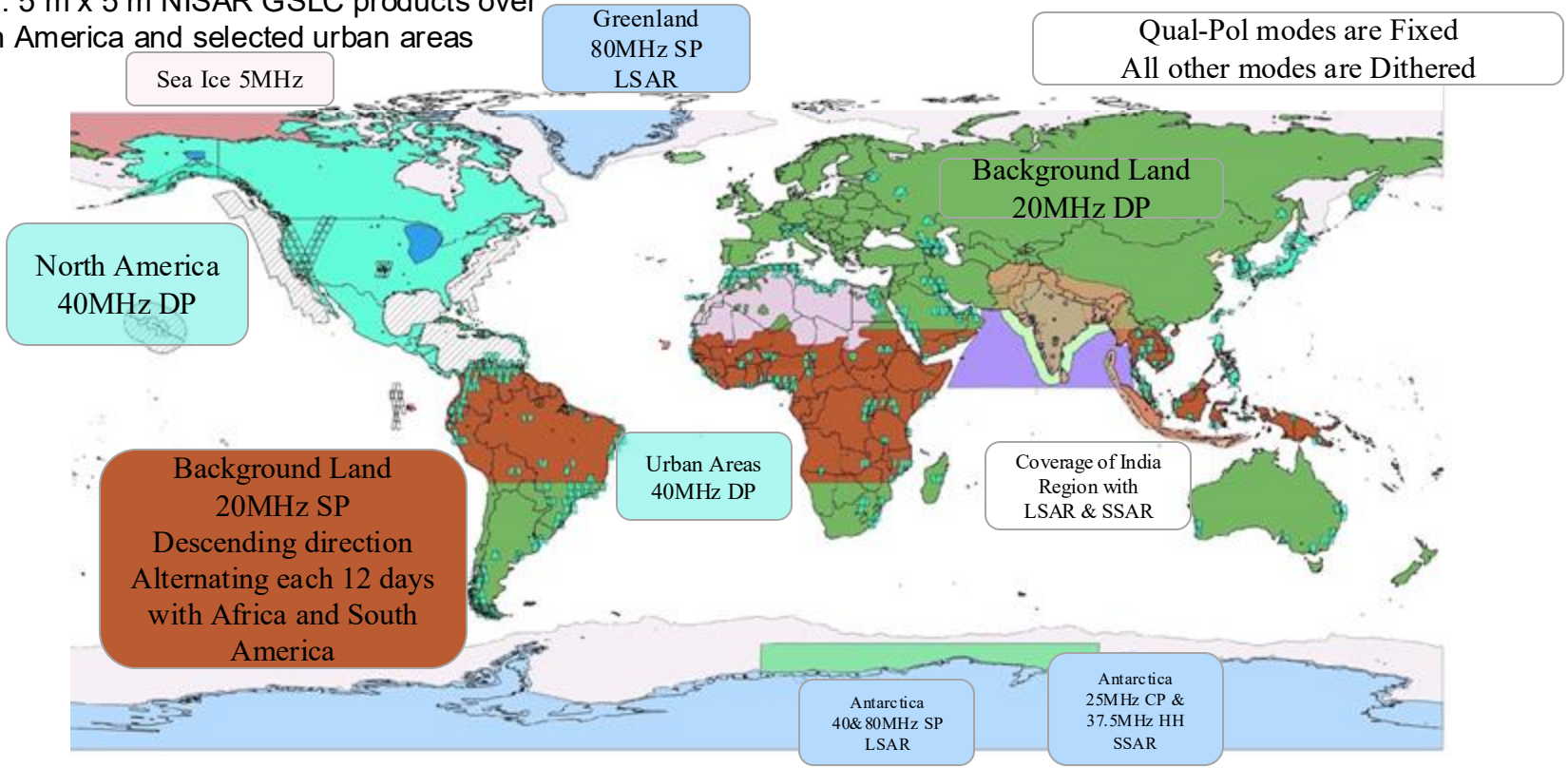


Mean runtime (in hours) of ascending frames for each batch of 15 products (one “mini-stack”)

NISAR observation plan

National Aeronautics and Space Administration

Cyan: 5 m x 5 m NISAR GSLC products over North America and selected urban areas



Driving requirements for Surface Displacement

National Aeronautics and Space Administration

Key specifications:

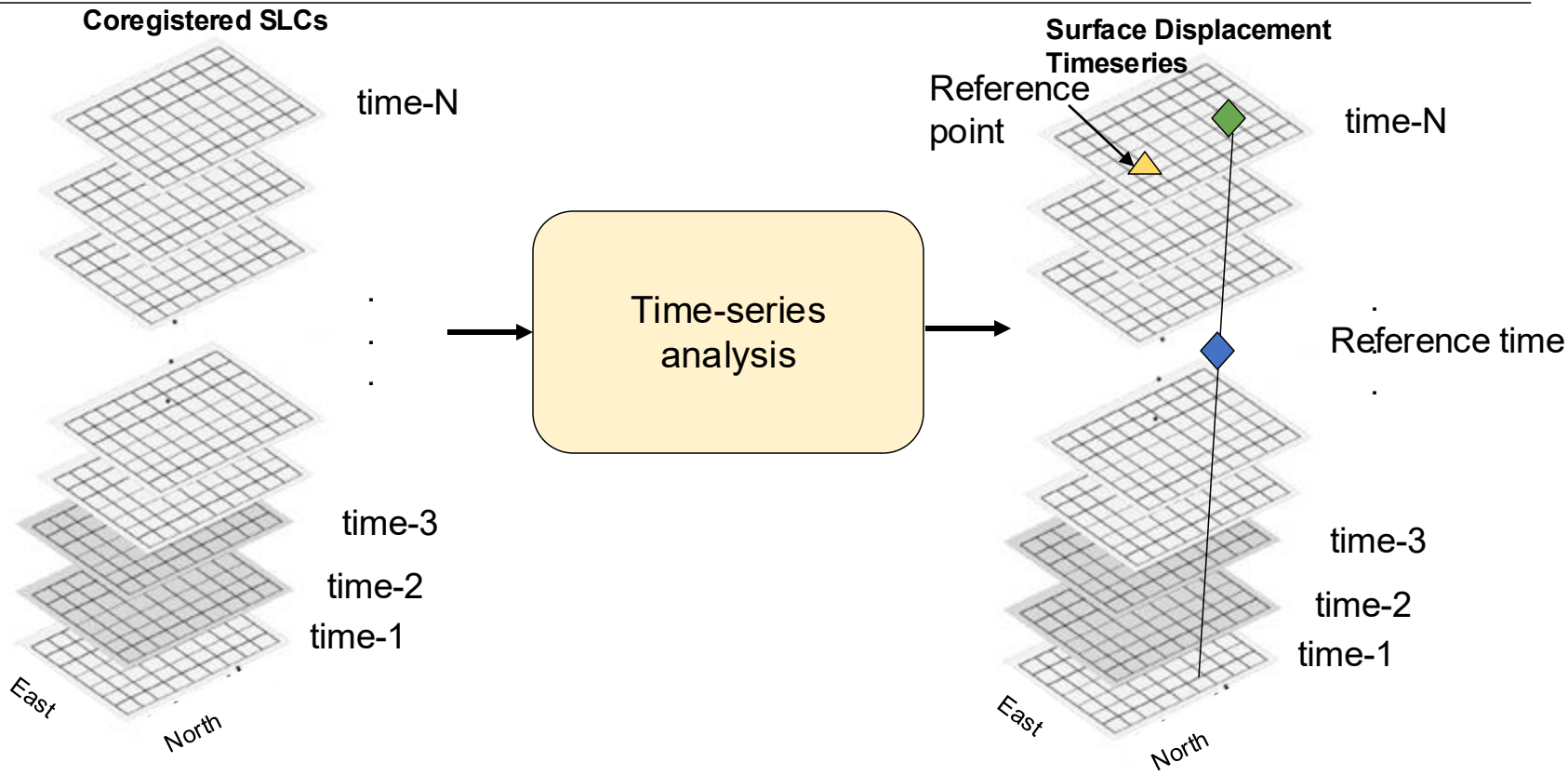
- Surface displacement time-series in radar Line Of Sight (LOS) direction
- 30 m spacing
- **Geocoded**, Frame-based displacement products
  - (DISP-S1 only) Frames consist of ~27 stitched bursts (~200 x 250 km frames)
  - (DISP-NISAR) We will use the NISAR-produced Track/Frame database

- The displacement product at a given epoch is relative to a reference date
- The displacement product is relative to a reference coherent pixel

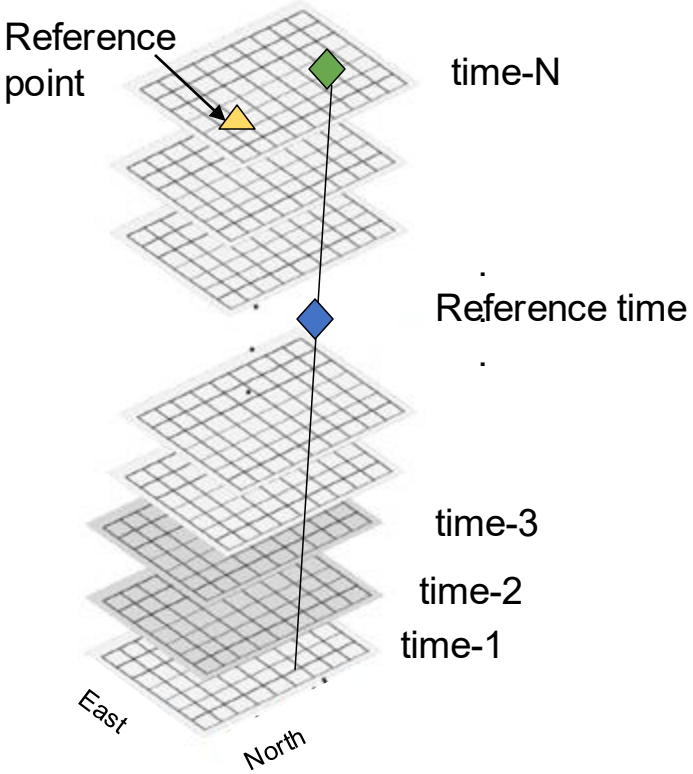
- 72 hours latency (after all inputs are available)

- Coverage: North America (USA 50 states plus all official 14 US Territories, all mainland countries between US CONUS south to and including Panama, and Canada within 200 km from US border)

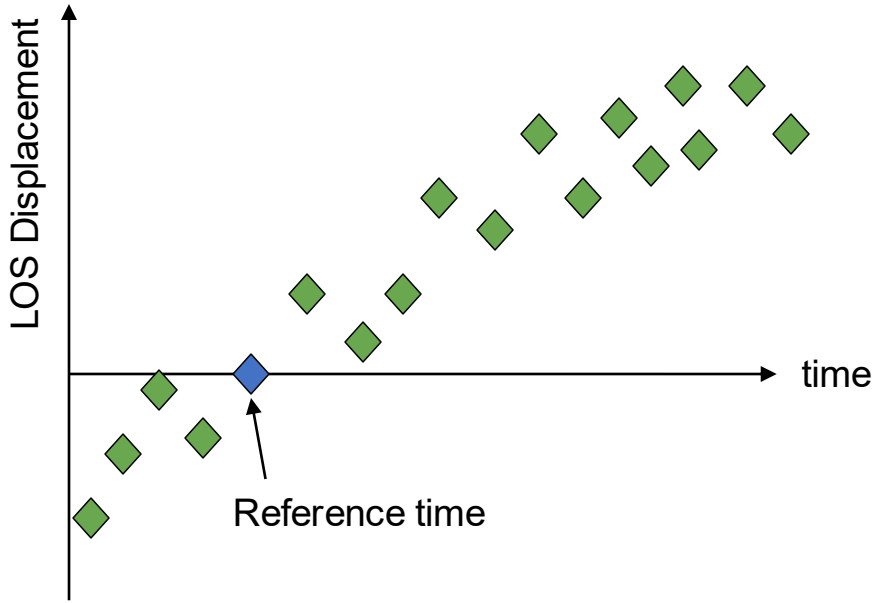
InSAR Displacement Time-series analysis



Surface Displacement Time-series Specification

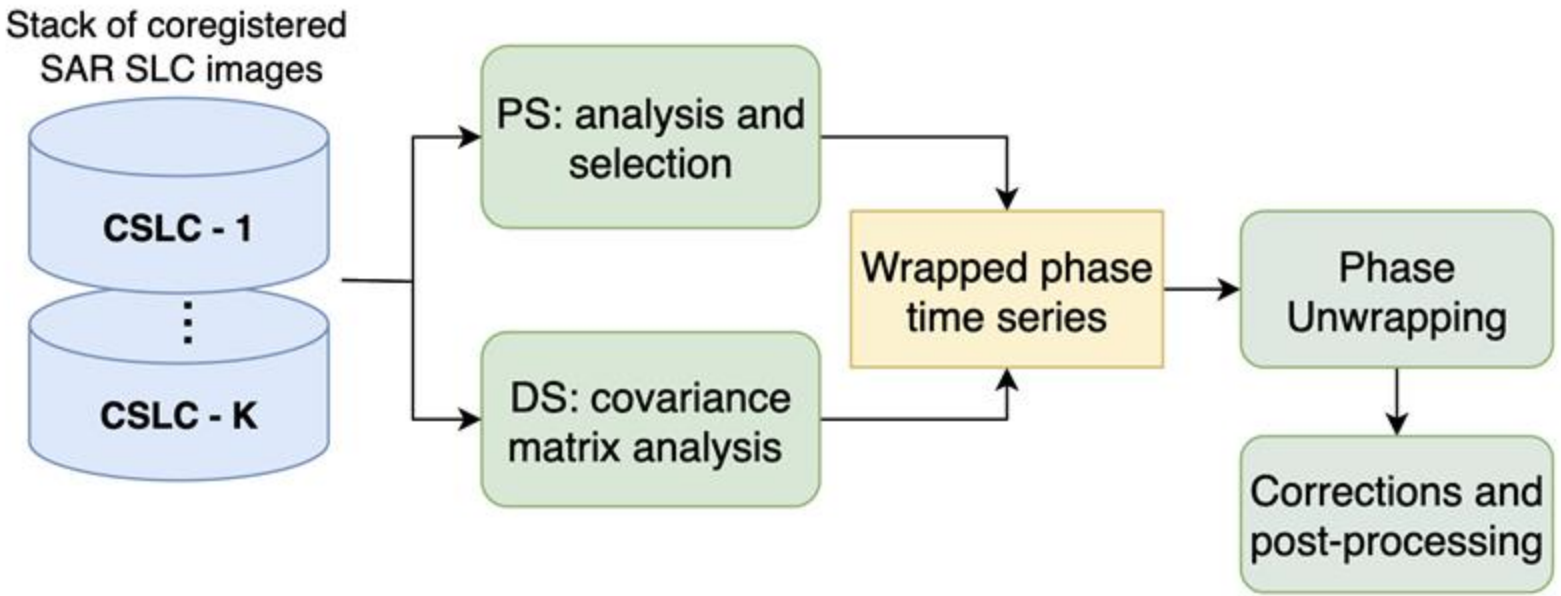


Each product represents displacement relative to a reference date and a reference pixel



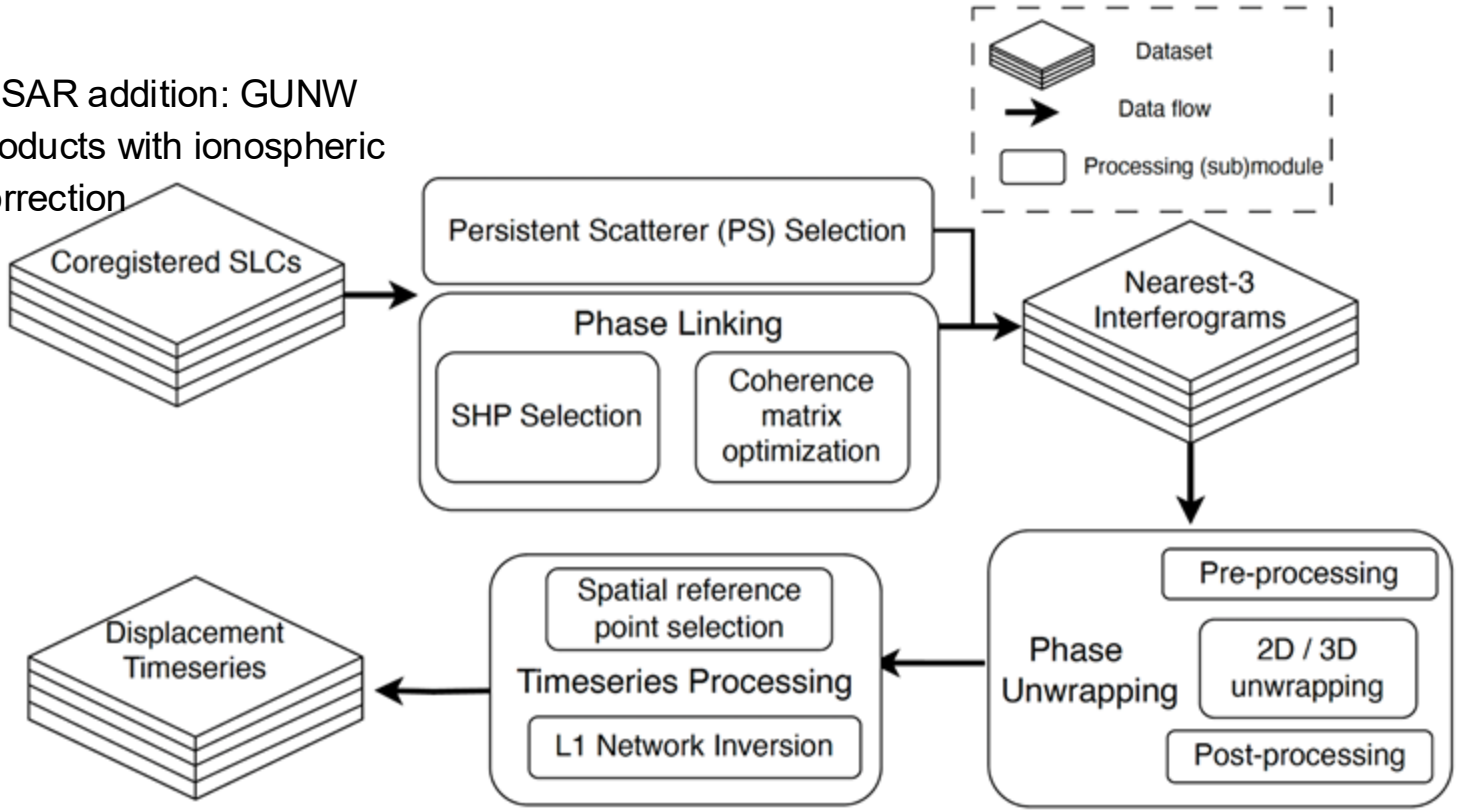
DISP algorithm (high level)

- The algorithm for estimating the displacement product from NISAR data will be similar to the algorithm used for the displacement product from Sentinel-1



DISP algorithm

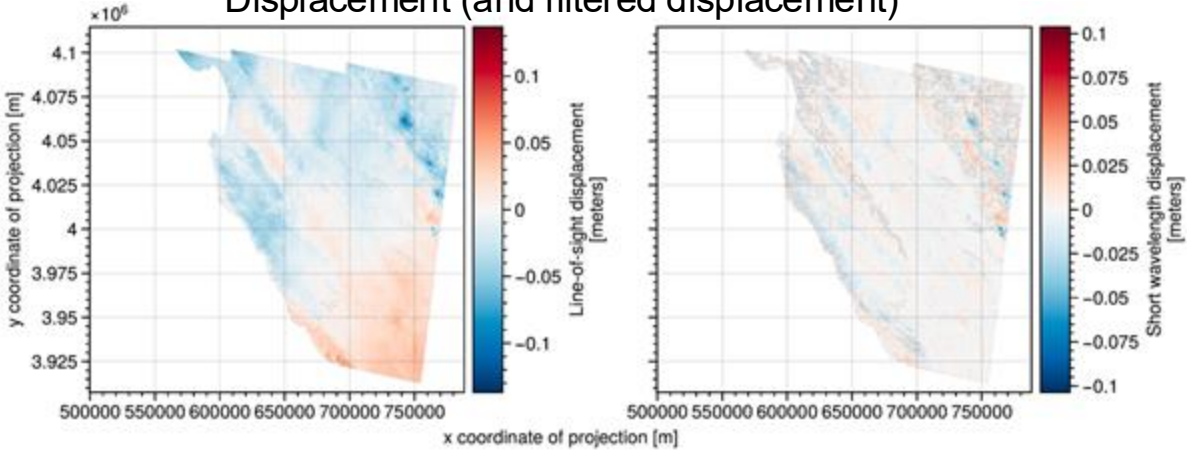
- NISAR addition: GUNW products with ionospheric correction



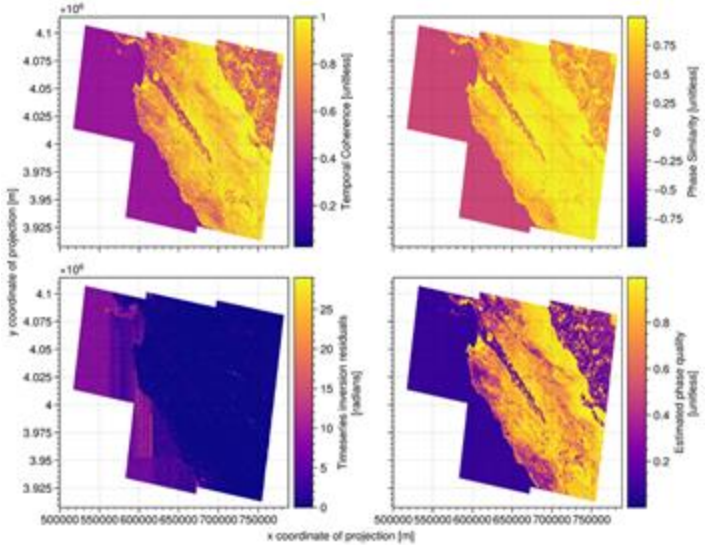
DISP Product Usage

DISP products can contain multiple quality layers and corrections, in addition to displacement rasters

Displacement (and filtered displacement)



Quality rasters



Corrections:

- Solid Earth Tide
- Ionospheric range delay
- **(external)** ECMWF-based tropospheric correction

Surface Displacement Example: West Texas

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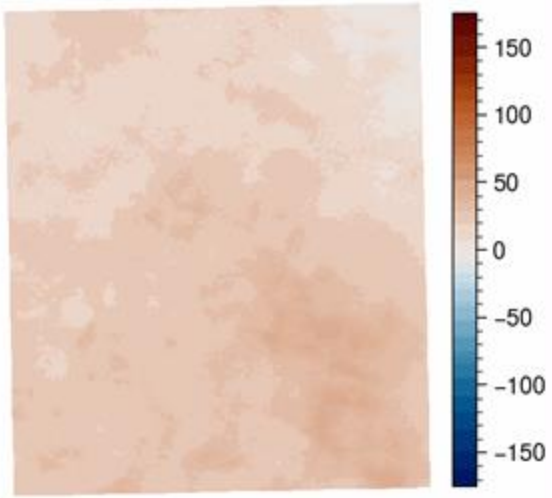
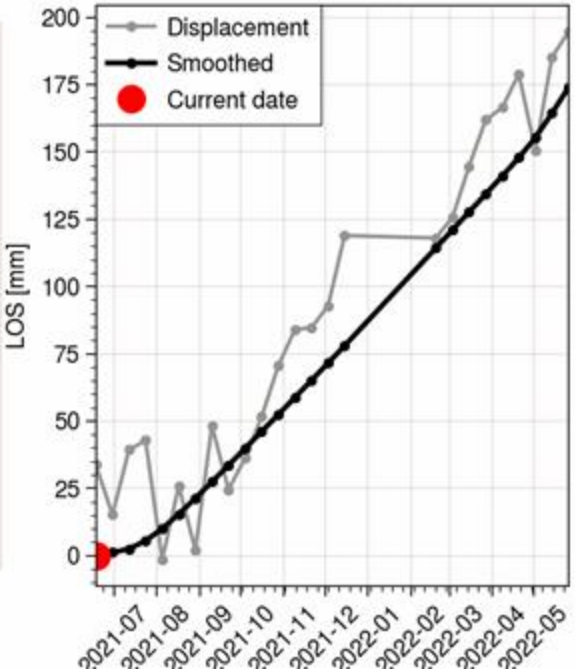


Subset of displacement product (includes atmospheric noise)

Temporally filtered (to reduce the atmospheric noise)



Application Examples: Houston, Palos Verdes

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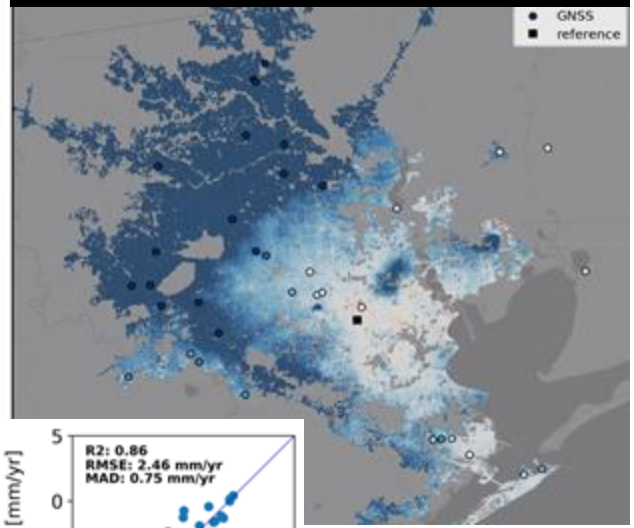
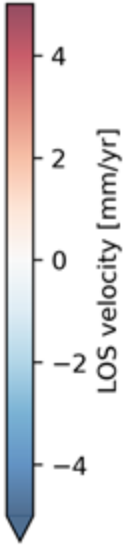
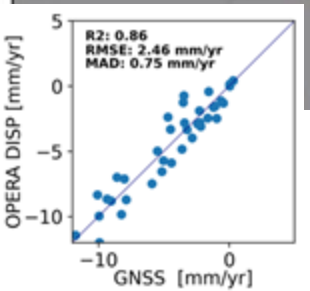
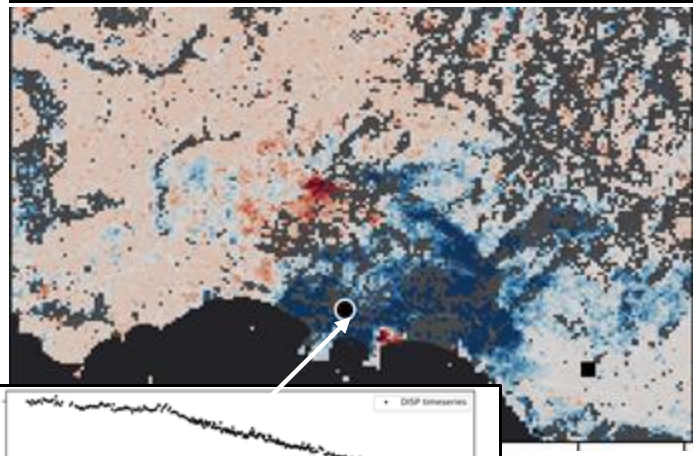
Average Velocity – Houston, TX

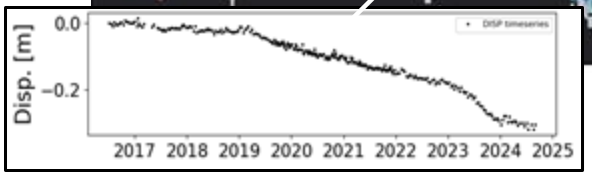


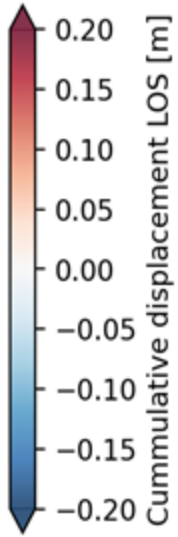




Palos Verdes, CA





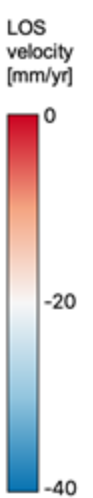


Comparing DISP-S1 Against Handcrafted Dataset: California

National Aeronautics and Space Administration

OPERA product performance at statewide scale similar (magnitude and pixel sampling) compared to other community efforts.

OPERA DISP-S1*

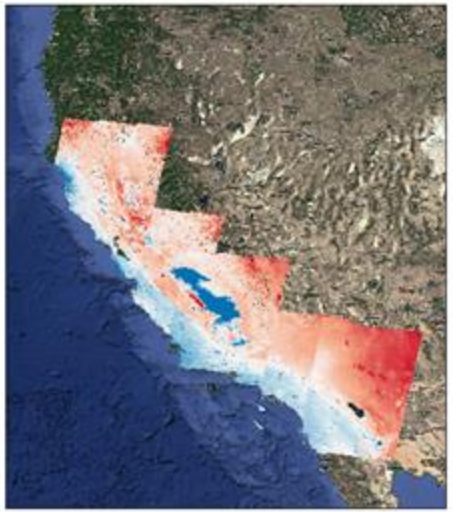


ARIA research group

Govorcin, M., Bekaert, D., Hamlington, B., Sangha, S., and Sweet, W. (*2025*)). Variable vertical land motion for sea level rise projections. Science Advances

San Diego Group

(Govorcin et al., 2025)



Xu, X., Sandwell, D. T., Klein, E., & Bock, Y. (2021). Integrated Sentinel-1 InSAR and GNSS time-series along the San Andreas fault system. *Journal of Geophysical Research: Solid Earth*, 126, e2021JB022579. https://doi.org/10.1029/2021JB022579

What will NISAR add

Advantages of NISAR L-band acquisitions for DISP product:

- **Regular acquisitions** over US from **both ascending and descending** orbits will improve the accuracy of vertical land motion estimation
- Longer wavelength at L-band will lead to **higher interferometric coherence**, fewer unwrapping errors, and **better spatial coverage** of displacement products compared to C-band
- **Higher resolution acquisitions** (40 MHz) will potentially lead to denser PS density
- L-band will lead to slower fringe rates for large displacement signals and therefore easier to unwrap

Risks and mitigation:

- Risk: L-band is ~18 times more sensitive to ionospheric delay compared to C-band.
  - Mitigation: We will use the **ionospheric phase estimates** from NISAR GUNW products to **correct the displacement products**

Looking Forward

Operational OPERA DISP-NISAR products are expected to become available in early 2027

Summary

- The OPERA project will generate DISP products from NISAR over North America
- The OPERA team will use the NISAR GSLC products as an input, as well as the ionospheric correction layers contained in the standard GUNW
- We expect OPERA DISP-NISAR products to have greater coverage and quality over Sentinel-1 data for the vegetated regions of North America

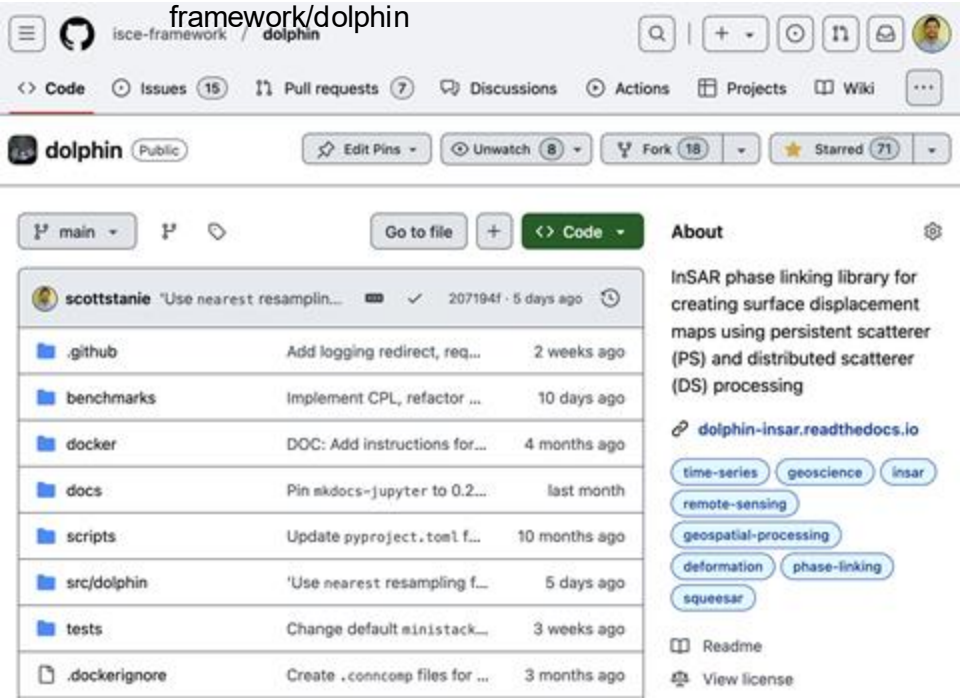
Next Steps

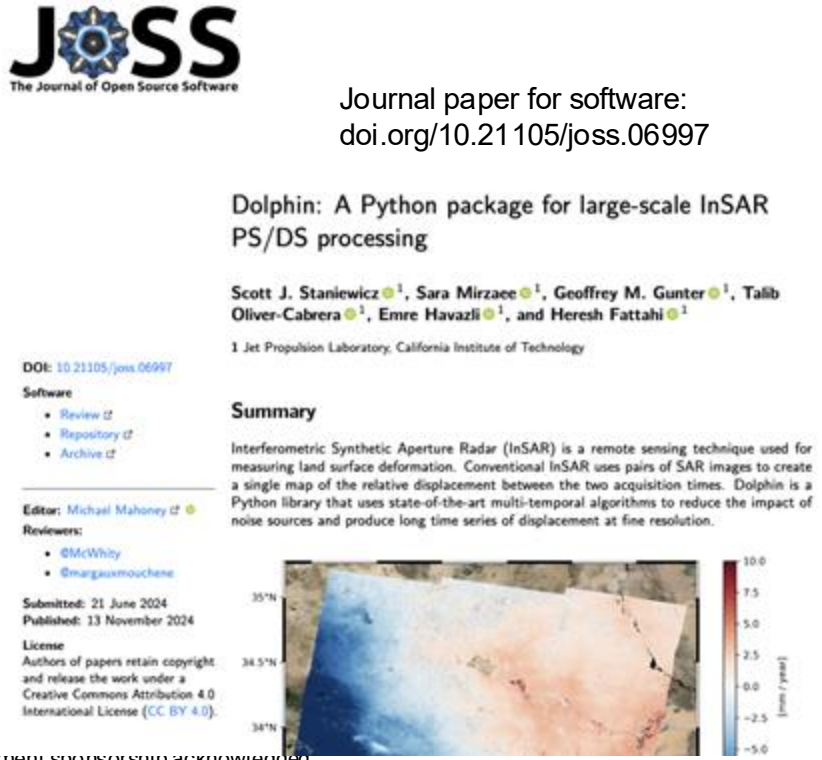
- OPERA team is currently adapting workflows using in DISP-S1 production to work with NISAR sample products
- Testing on real data will begin with first science-ready NISAR products

Backup

Using our open-source code

https://github.com/isce-framework/dolphin





Journal paper for software: doi.org/10.21105/joss.06997