# Marco Bagnardi, PhD

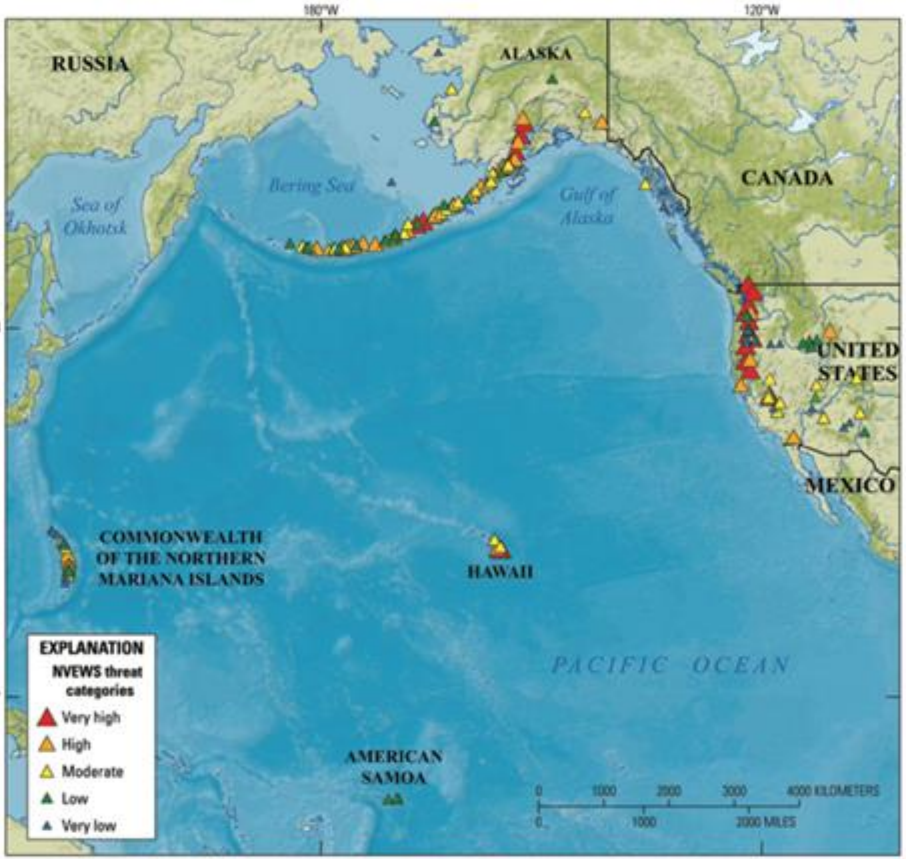
*Data Scientist*

Photo of recent eruption at Kīlauea, Hawai'i.
USGS image taken by M. Bagnardi on August 6, 2025.

## USGS – Volcano Science Center

(based at Cascades Volcano Observatory, Vancouver, WA)

- *SAR/InSAR monitoring of U.S. volcanoes*
- *National Volcano Information Service (NVIS, part of National Volcano Early Warning System–NVEWS)*
- *SAR/InSAR support to the Volcano Disaster Assistance Program (VDAP)*
- *Coordinator of international CEOS-WGD volcano project G-VEWERS (Global Volcano Early Warning and Eruption Response from Space)*




Base from Esri © 2018 and its licensors,
1984 WGS Mercator PCD projection

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# Volcano Science Center (VSC)

# 5 volcano observatories:

Alaska Volcano Observatory (AVO)
California Volcano Observatory (CalVO)
Cascades Volcano Observatory (CVO)
Hawaiian Volcano Observatory (HVO)
Yellowstone Volcano Observatory (YVO)

> 160 U.S. volcanoes: 18 very high threat

*From Ewert et al., 2018*



high threat

# Supporting the Volcano Disaster Assistance Program

Data processing and help with analyses of SAR and InSAR products from multiple platforms.


World map with locations of volcanoes (red triangles) at which the Volcano Disaster Assistance Program (VDAP) has responded during the nearly 40 years since the program's inception. From volcanoes.usgs.gov.

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# OPERA products for volcano monitoring

## Coregistered Single-Look Complex (CSLC) Product (Level 2)

- *Rapid generation of geocoded Sentinel-1 interferograms and coherence maps using selected bursts*

## Land Surface Displacement (DISP) Product (Level 3)

- *Hybrid persistent scatterer (PS) and distributed scatterers (DS) time series for long-term monitoring of volcanoes (may need in-house tweaking of algorithms)*

## Radiometric Terrain-Corrected (RTC) Product (Level 2)

- *Track morphological changes associated with volcanic activity (e.g., lava flow emplacement, ash/tephra deposits)*

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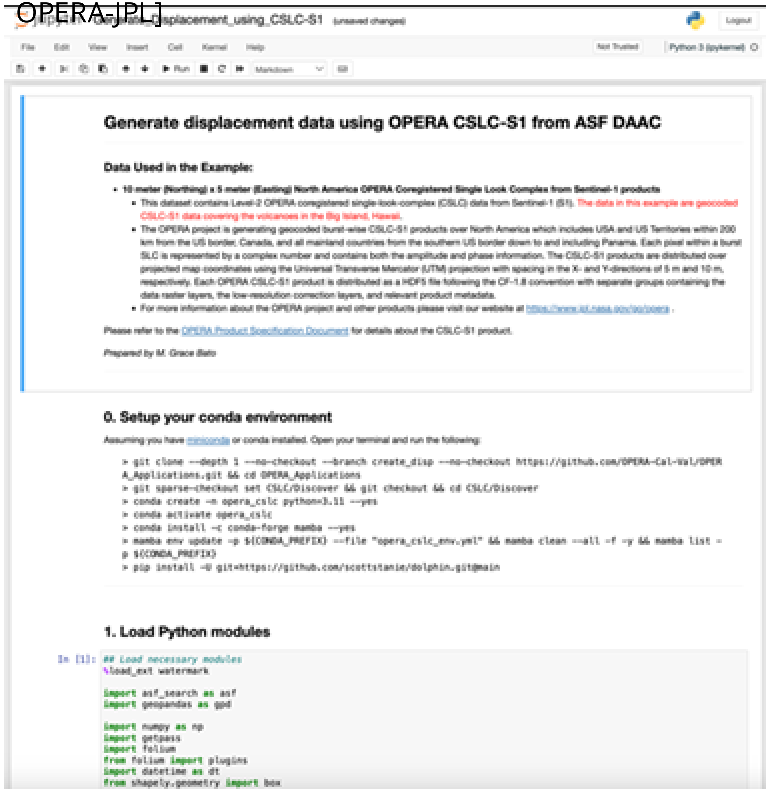
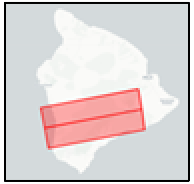
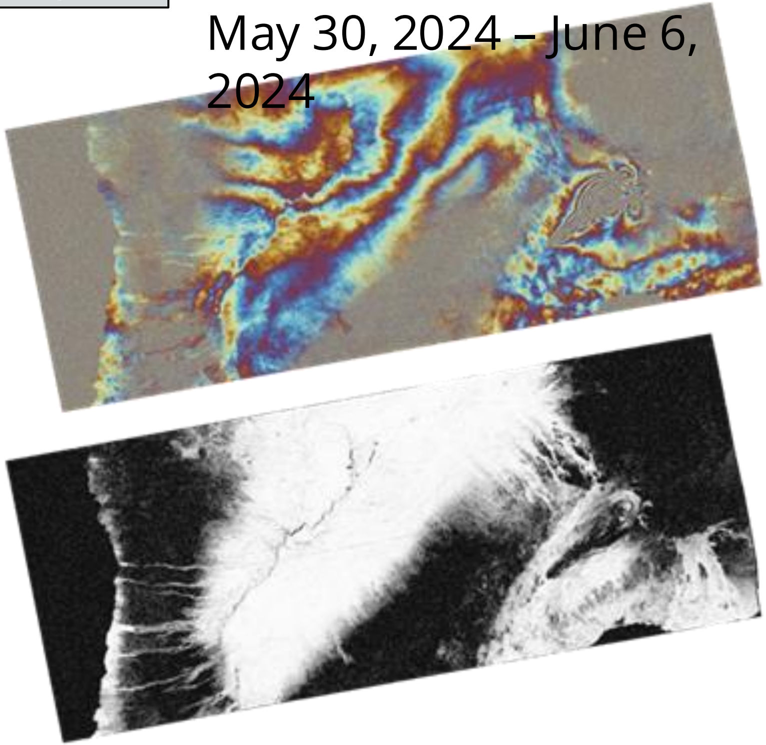
# Coregistered Single-Look Complex (CSLC)

Jupyter notebook [courtesy of M. Grace Bato, OPERA-JPL]



Example:
Sentinel-1 Ascending (T124)
May 30, 2024 – June 6, 2024



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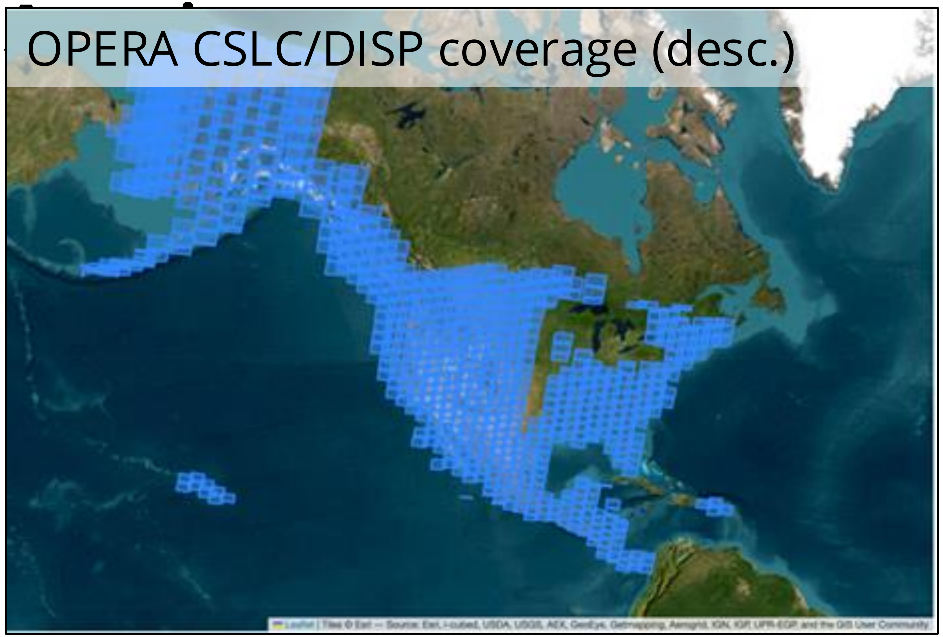
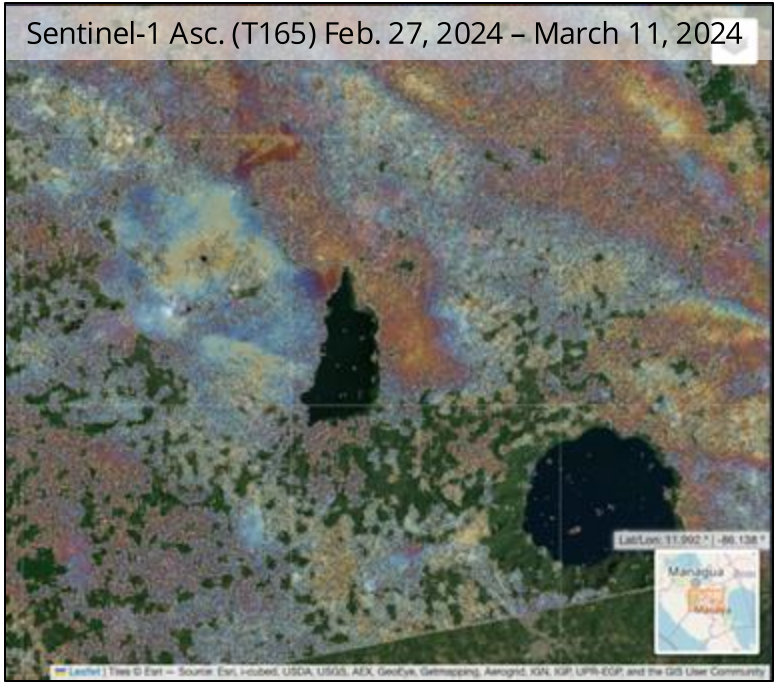
*Preliminary Information-Subject to Revision. Not for Citation or Distribution*

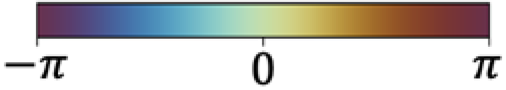
# VDAP responses to unrest in Central



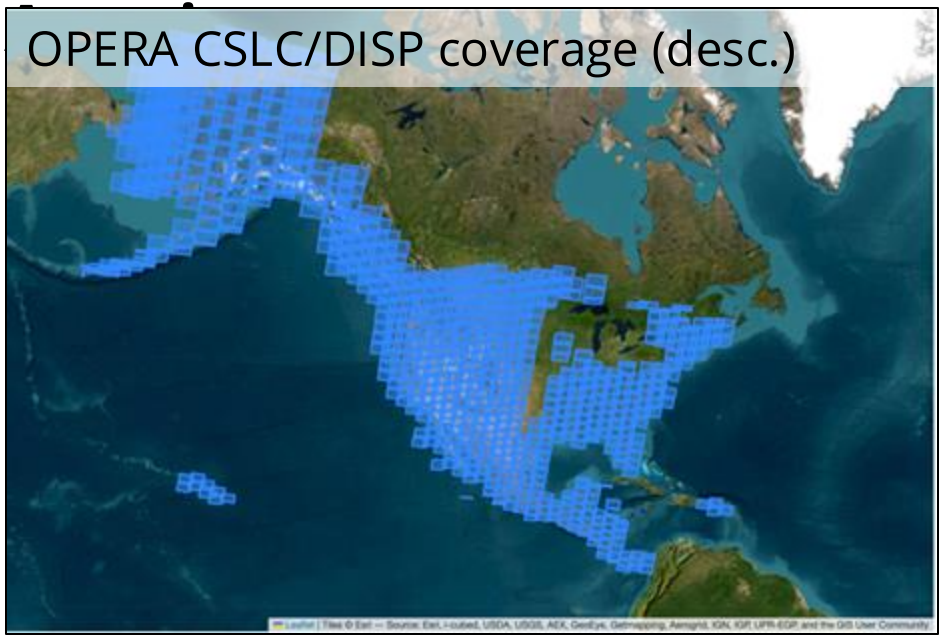

Map generated using OPERA-Cal-Val *view_disp-s1_frames.ipynb*
Jupyter Notebook




Volcán Masaya (Nicaragua) – VDAP response to support INETER
Interferograms formed using OPERA CSLC data and Jupyter Notebook.



# VDAP responses to unrest in Central

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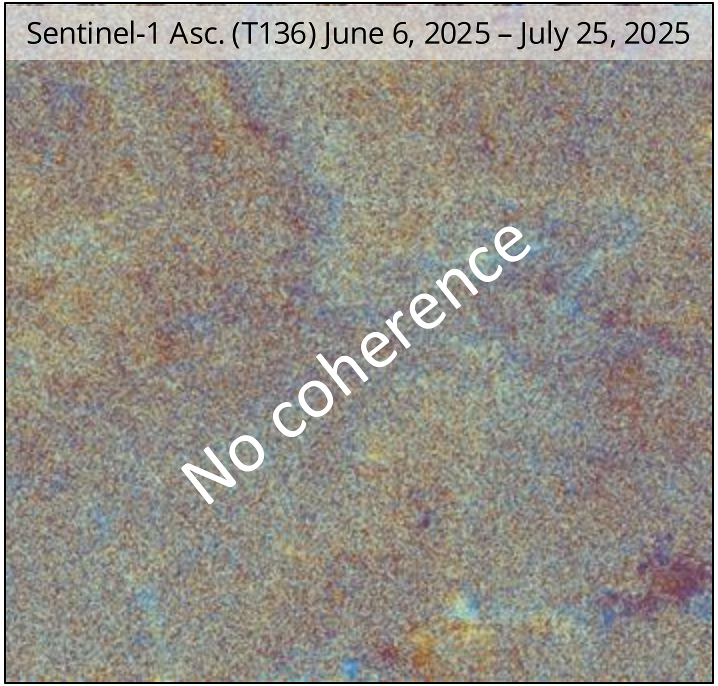
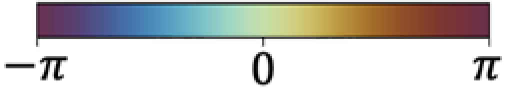



Volcán Chingo (El Salvador/Guatemala)
Interferograms formed using OPERA CSLC data and Jupyter Notebook.

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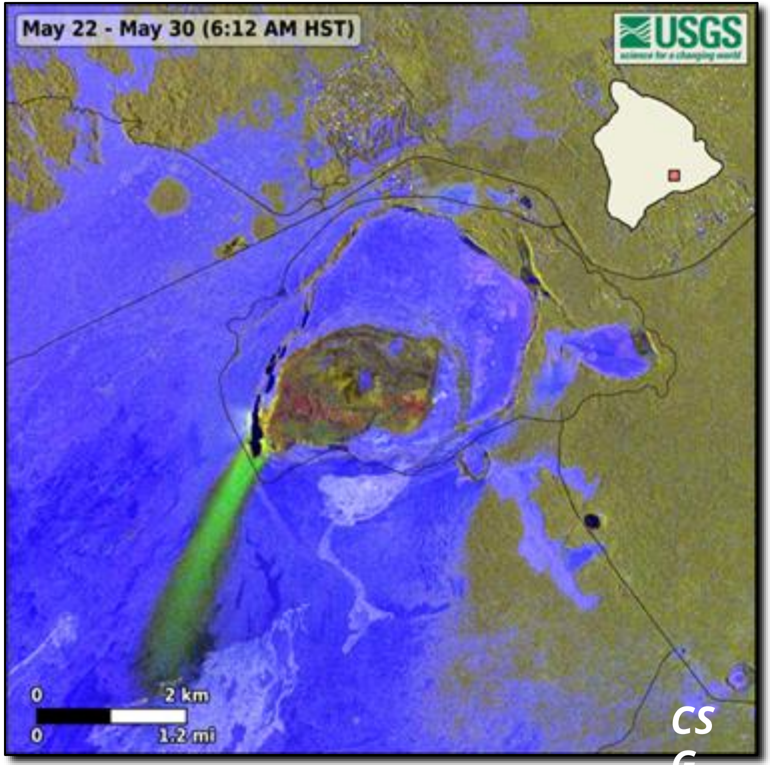
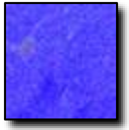
# Volcanic Flow Maps (RTC + interferometric coherence)



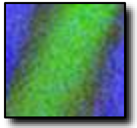

*Data collected by the COSMO-SkyMed Second Generation Constellation and provided by the Agenzia Spaziale Italiana (ASI)*




**Technique explained in Poland, 2022 (Bull. Vol.):** *Synthetic aperture radar volcanic flow maps (SAR VFMs): a simple method for rapid identification and mapping of volcanic mass flows*



Barren terrain, no change



Barren terrain, change

Vegetated terrain, no change

Vegetated terrain, change (not present in image to the left)

Recent lava flows, change

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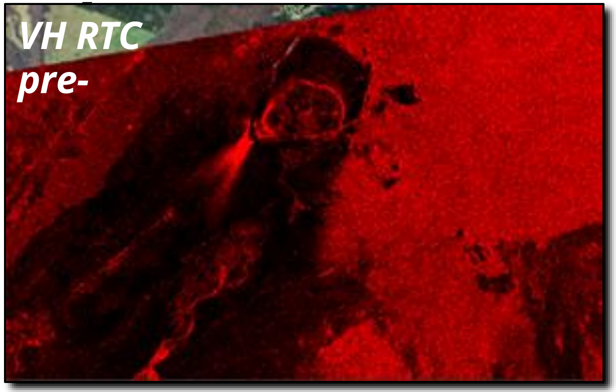
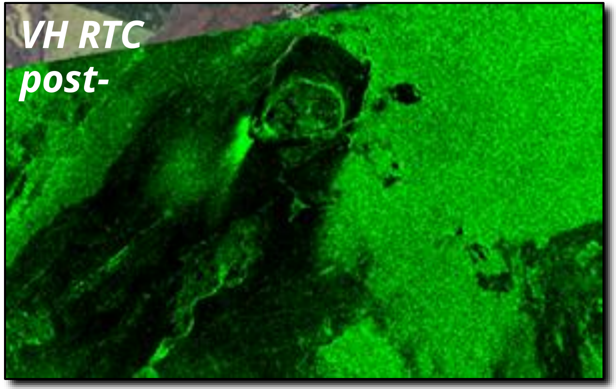
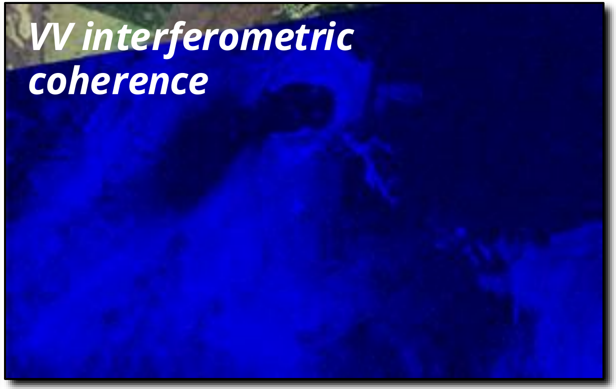
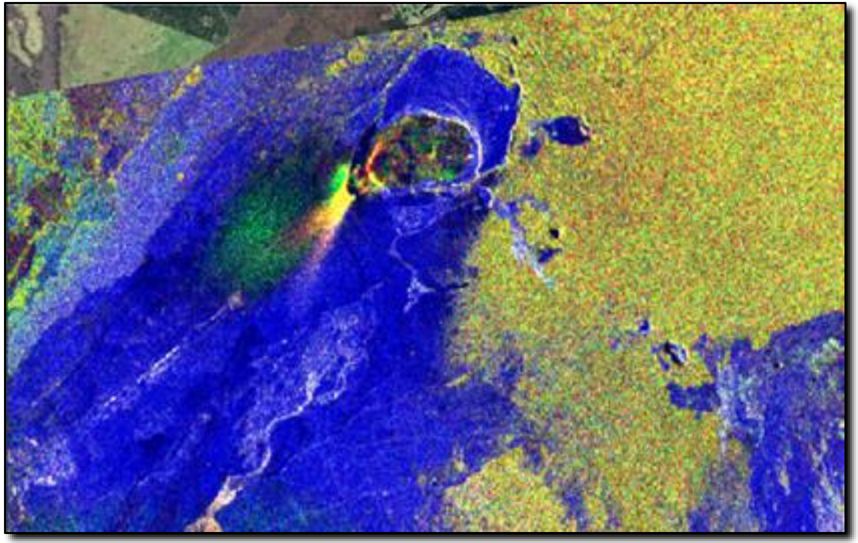
# Radiometric Terrain Corrected (RTC) + CSLC-derived



Volcanic flow map (VFM) derived from OPERA RTC and CSLC Sentinel-1 data (30m resolution).

June 18, 2025 – June 30, 2025

Interferometric coherence derived using OPERA Jupyter Notebook: *Map_Deformation_LavaFlow_using_CSLC-S1.ipynb*

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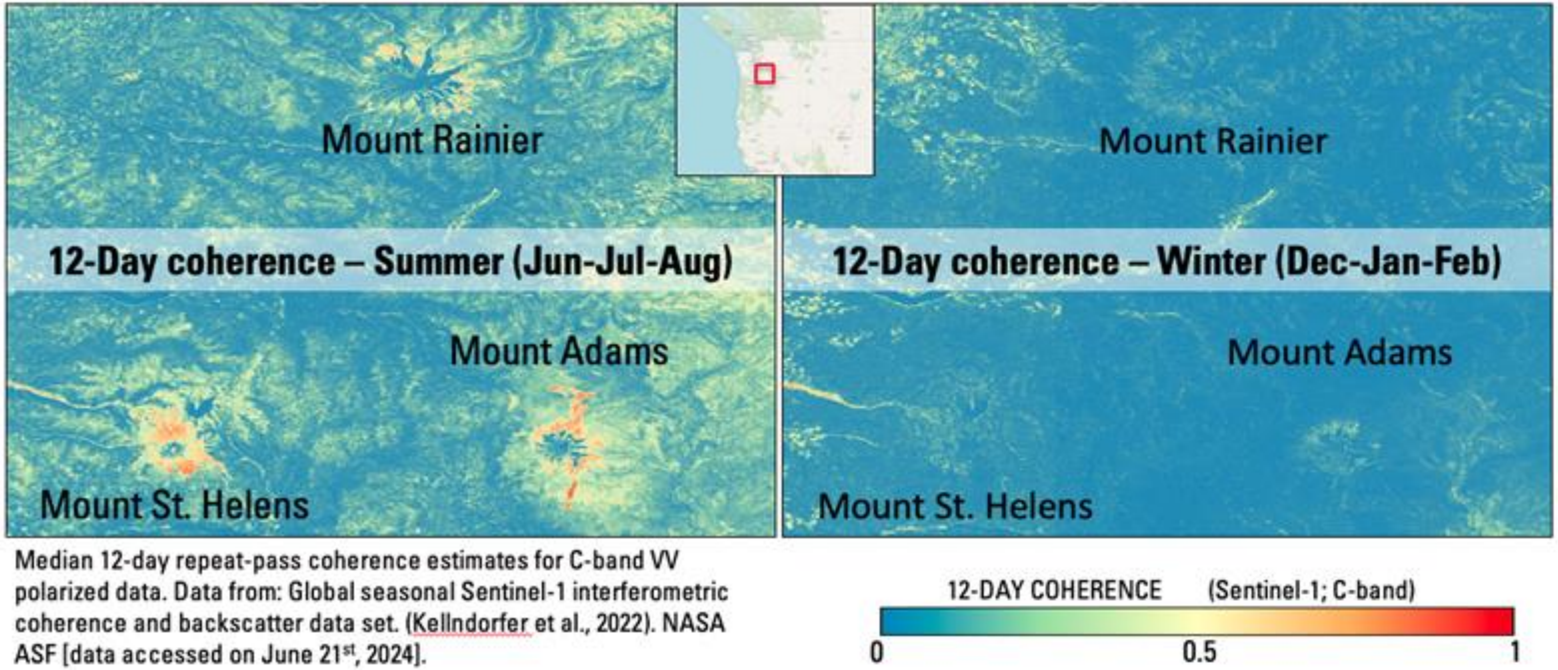
# In person training for CSLC/DISP-S1 products (May 21-23, 2025)

- Help with system setup on USGS server (for OPERA CSLC/DISP products)
- Practical tutorials on CSLC and DISP products
- Introduction to *Dolphin* (hybrid PS/DS time series software)
- Introduction to *Bowser* (viewer for DISP products)
- Discussions with OPERA-DISP team

# Future steps

- Collaborative work to adapt DISP workflow to volcano monitoring applications (e.g., seasonal snow cover at U.S. volcanoes)




Median 12-day repeat-pass coherence estimates for C-band VV polarized data. Data from: Global seasonal Sentinel-1 interferometric coherence and backscatter data set. (Kellndorfer et al., 2022). NASA ASF [data accessed on June 21st, 2024].

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# Future steps

- Collaborative work to adapt DISP workflow to volcano monitoring applications (e.g., seasonal snow cover at U.S. volcanoes)
- Assessment of NISAR-based OPERA products
- Integration of OPERA CSLC/DISP products and tools into

***VolcSARvatory: InSAR Geodesy for Volcano Monitoring***

  - NASA Disaster Program–funded project (*Research Opportunities in Space and Earth Sciences "Disaster Risk Reduction, Recovery, and Resilience" solicitation*)
  - Collaboration between University of Alaska, Fairbanks and USGS Volcano Science Center

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# USGS-VSC wishlist

- Further reduce data latency
- Prioritize in-person/virtual software training and support
- Assure long-term data availability
- Provide support for integration of new NISAR DISP products