# NISAR L-band Product Status: From Raw echoes to Analysis Ready Science data Products

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# Global mosaic of NISAR LSAR backscatter – cycle 15

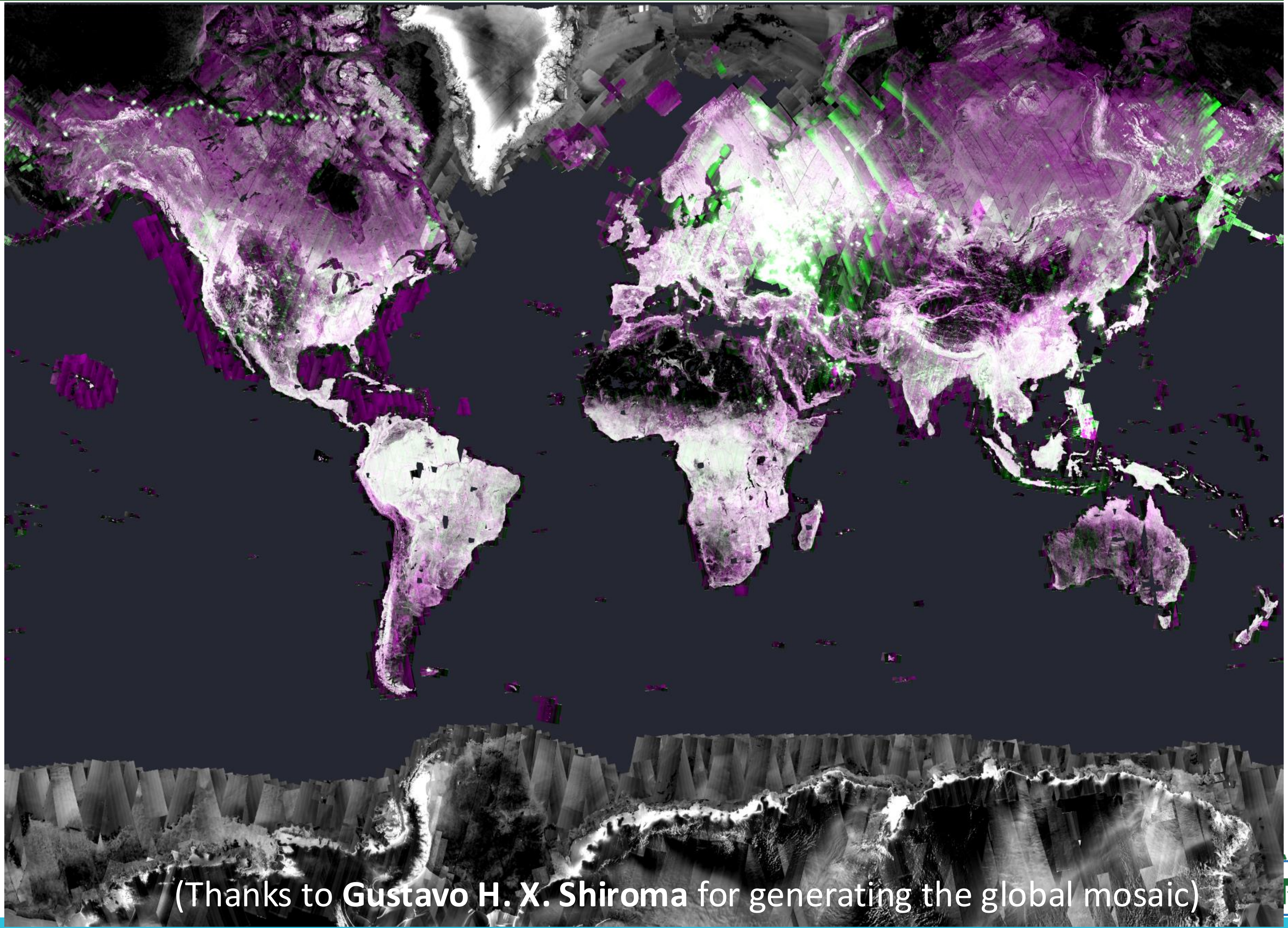
Global mosaic of NISAR backscatter, radiometric terrain corrected, derived from GCOV products produced by the automated Science Data System (SDS)

The ISCE3 software has been successfully scaled to the globe since LSAR turned ON. Science Data System is stable and has generated more than 1 million products.

**Daily inputs**: ~35 Tbits/day
**Daily production**: ~38 Tbytes/day

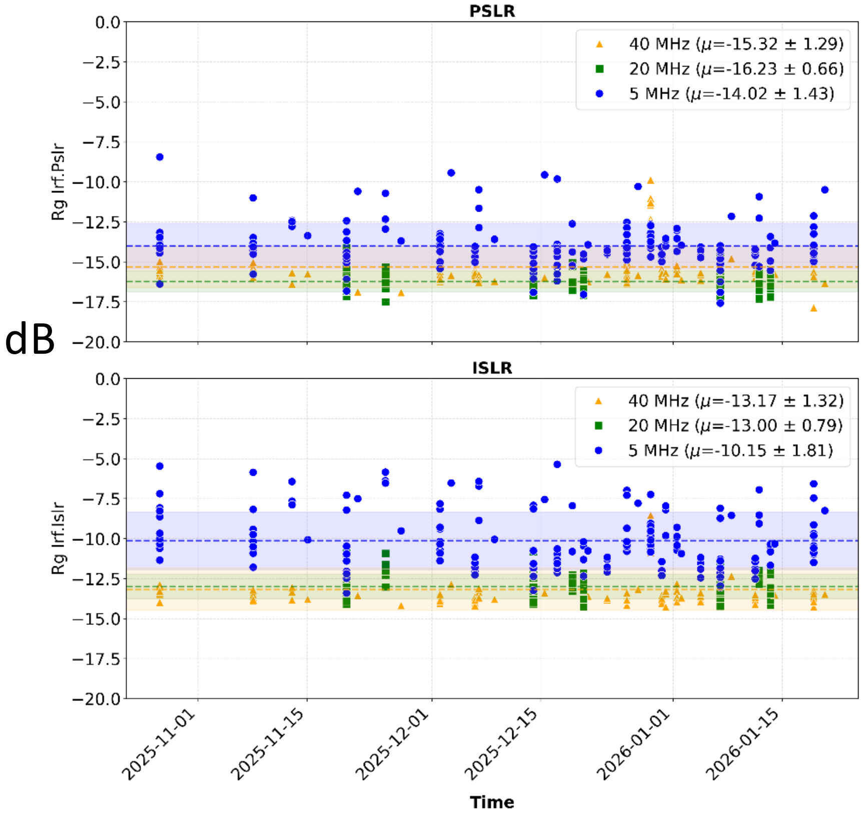
**Color overlay:**

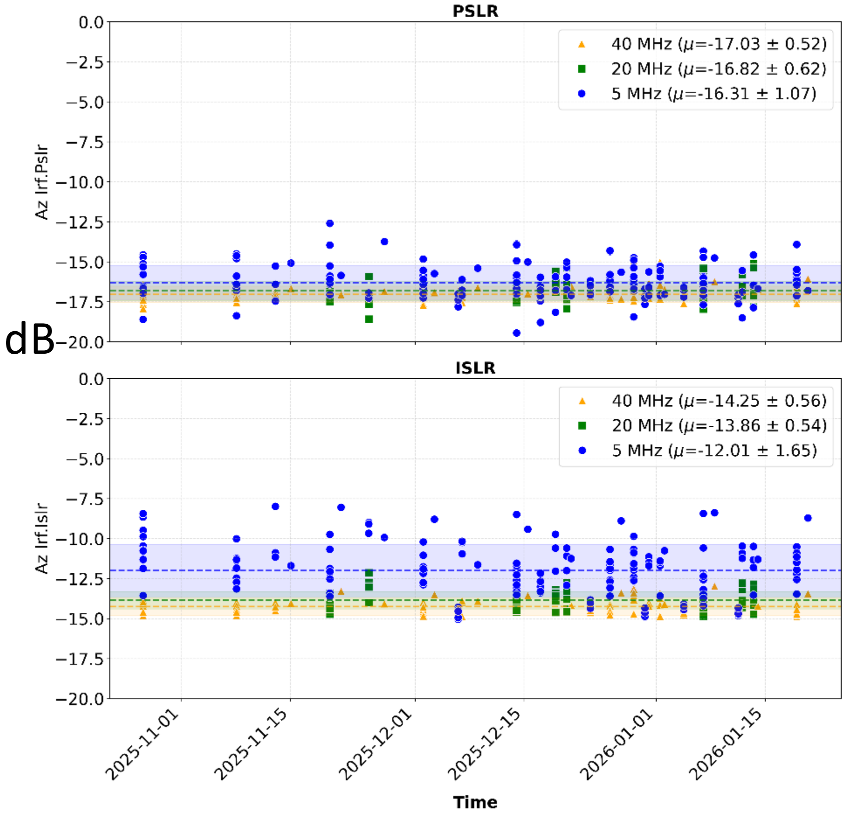
- Red: DP co-Pol (HH or VV)
- Green: DP cross-pol (HV or VH)
- Blue: DP co-Pol (HH or VV)
- Gray: SP (HH or VV only)
- Values in dB
- Thresholds were set at the 5th and 95th percentiles of the backscatter values.

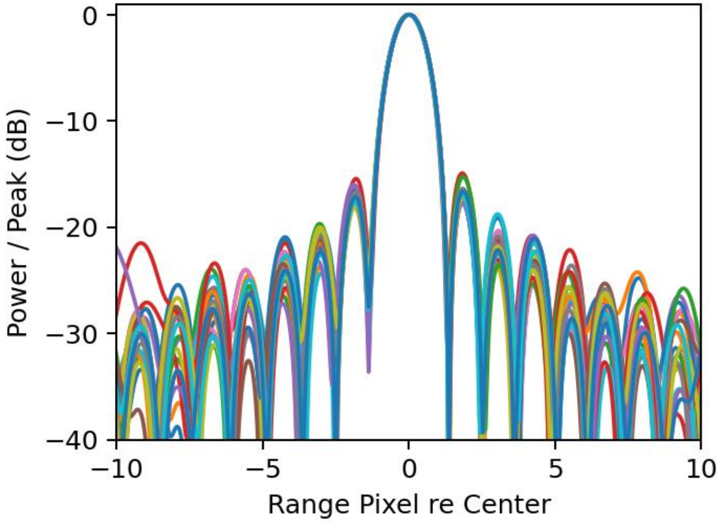


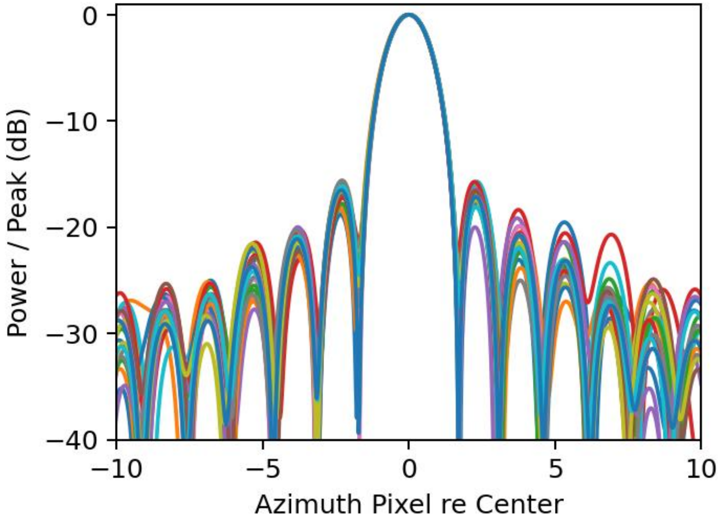
# Image quality (focusing quality over corner reflectors)

- **The ISLR and PSLR metrics show satisfactory quality of the focusing**
- Data over Oklahoma and Rosamond CRs are consistently well focused.
- Acquisitions over Alaska CRs show larger azimuth side lobes due to ionospheric TEC variations.

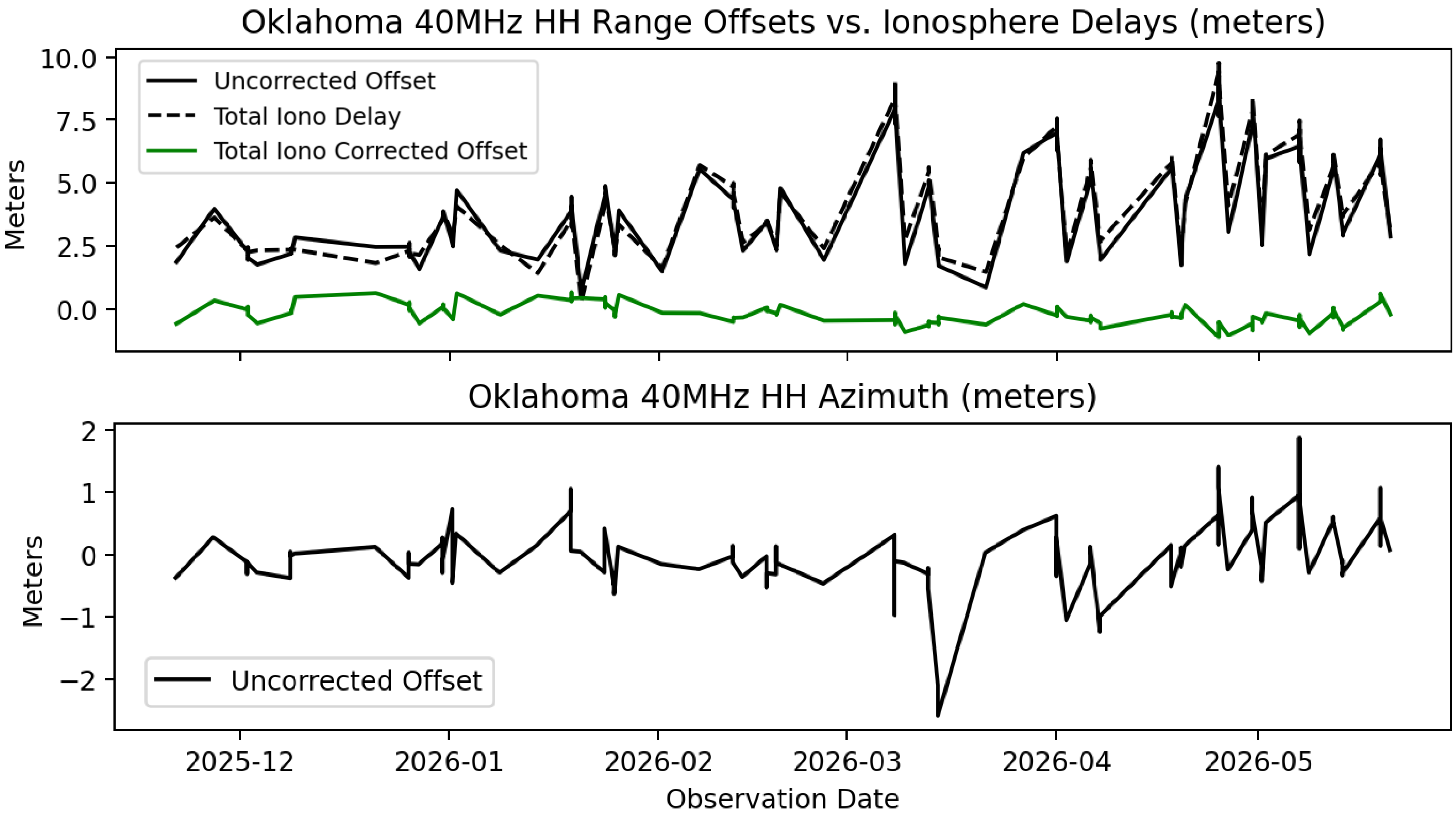


# Geometric calibration

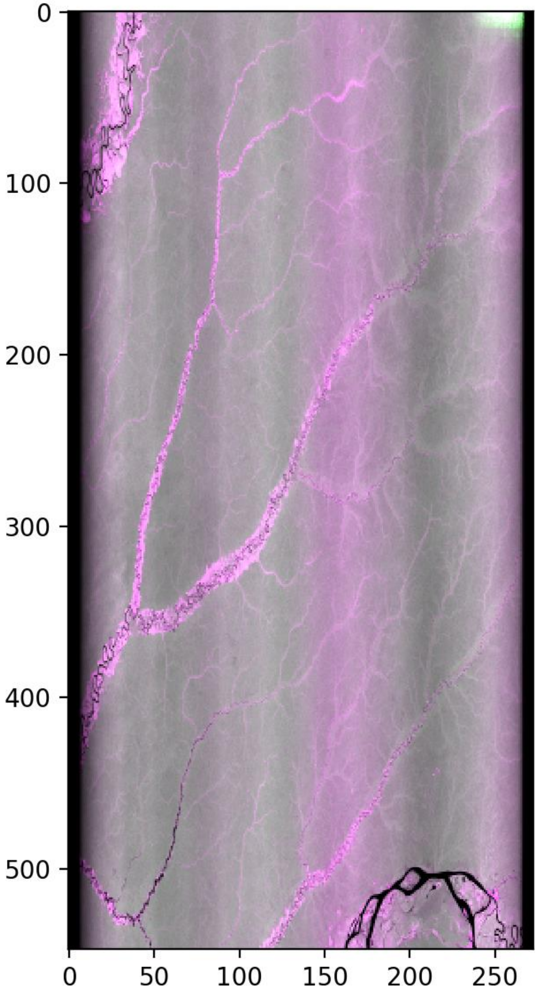



RSLC Geolocation Error (40 MHz, HH) over Oklahoma Corner reflectors, reaches an **average of ~20 cm in range direction** after ionospheric TEC correction

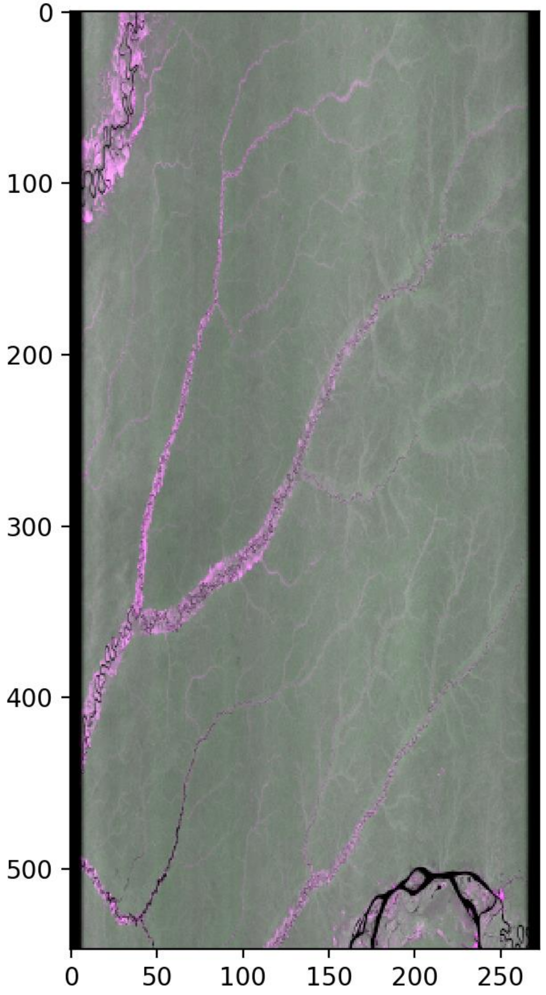
RSLCs corrected for Tropospheric Delay using TSX static tropospheric model

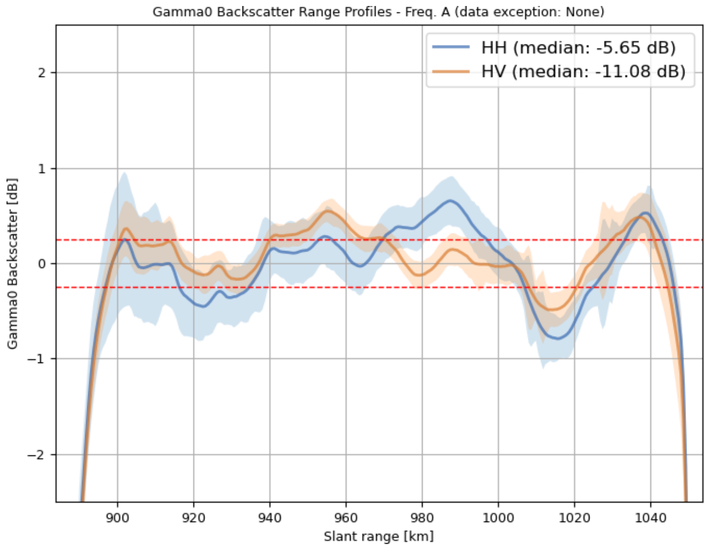
# Radiometric calibration (Elevation Antenna Pattern)

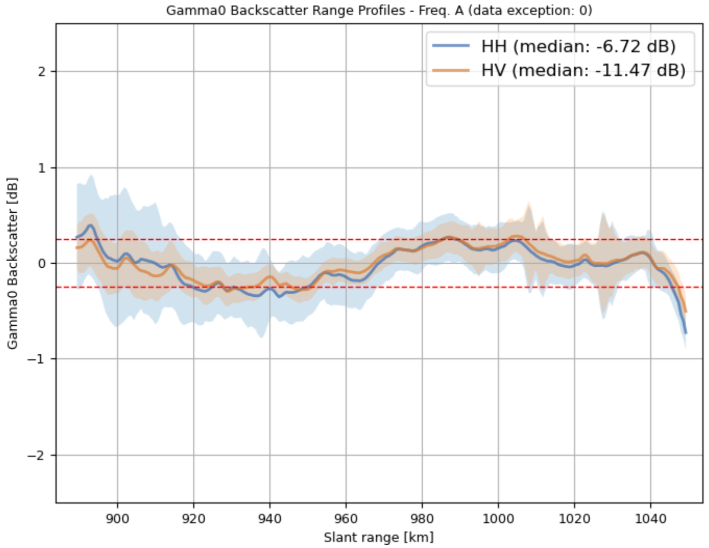
Gamma0 (EAP OFF)
Before calibration




Gamma0 (EAP ON)
After Calibration



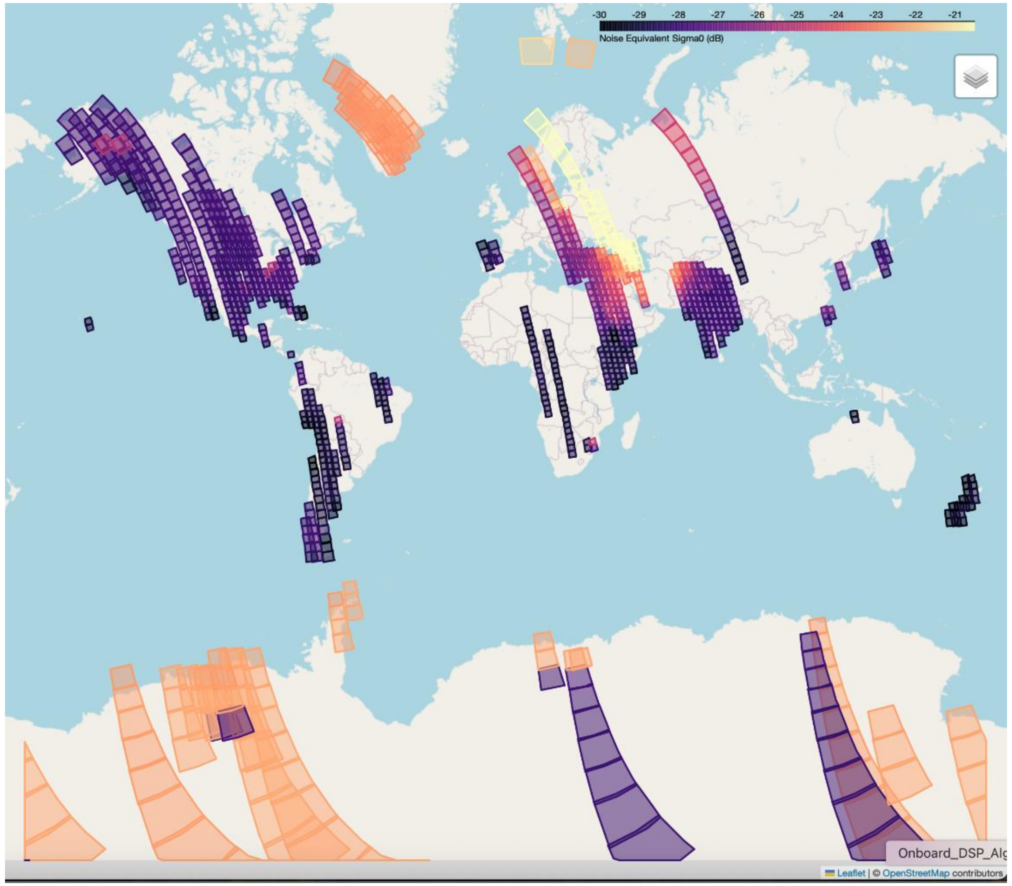



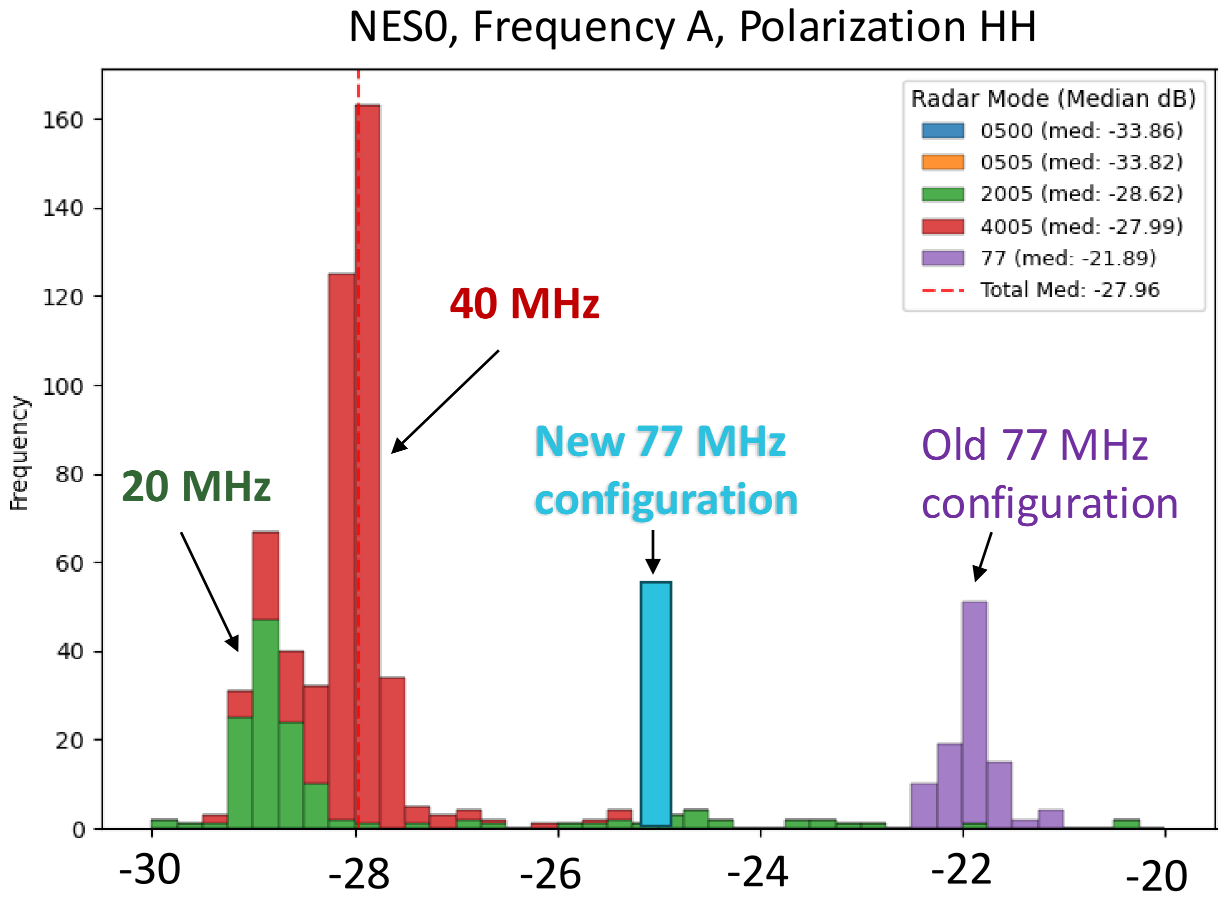




Radiometric calibration successfully reduces the backscatter variation in range direction caused by 2-way antenna pattern.

The residual for this frame over Amazon homogeneous target shows a small variation within **+/- 0.25 dB** and meets the radiometric accuracy requirement of ~ 1dB.

# RSLC (Noise Equivalent Sigma-0)

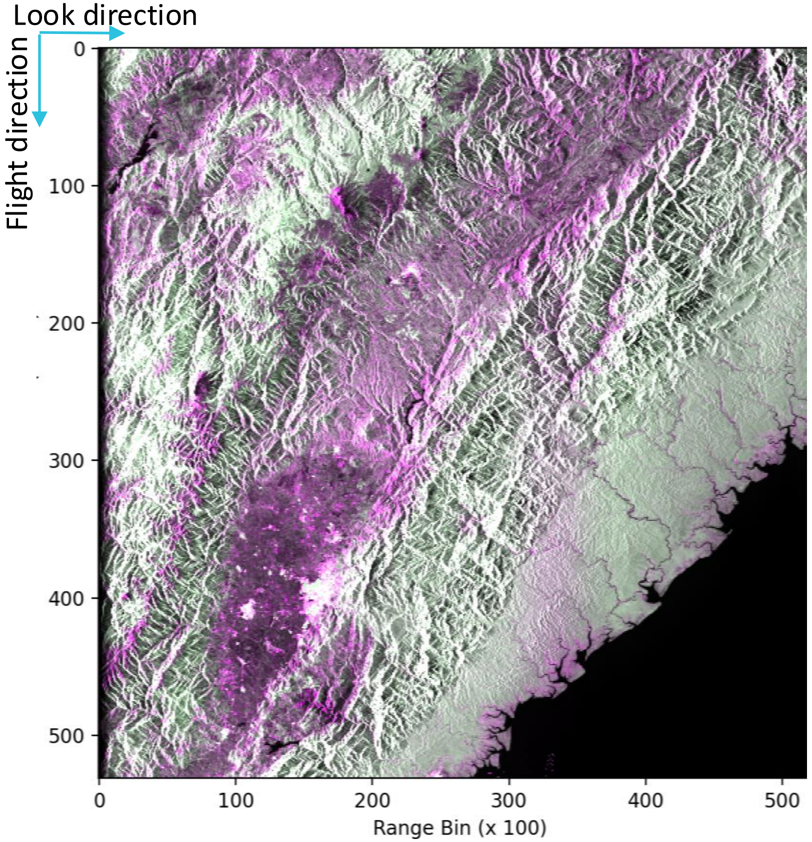


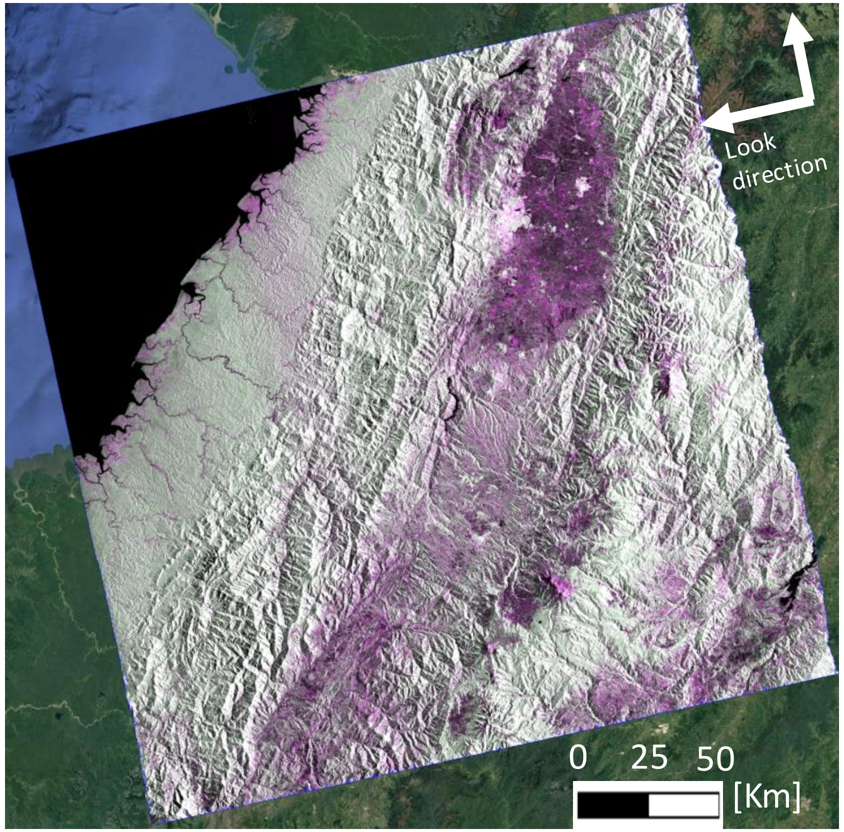

- Estimated noise power based on receive only pulses show satisfactory performance meeting NISAR requirement of ~ -23 dB.
- The performance for new configuration of 77 MHz data improves by 3-4 dB

# RSLC, GSLC, and GCOV acquired over Colombia

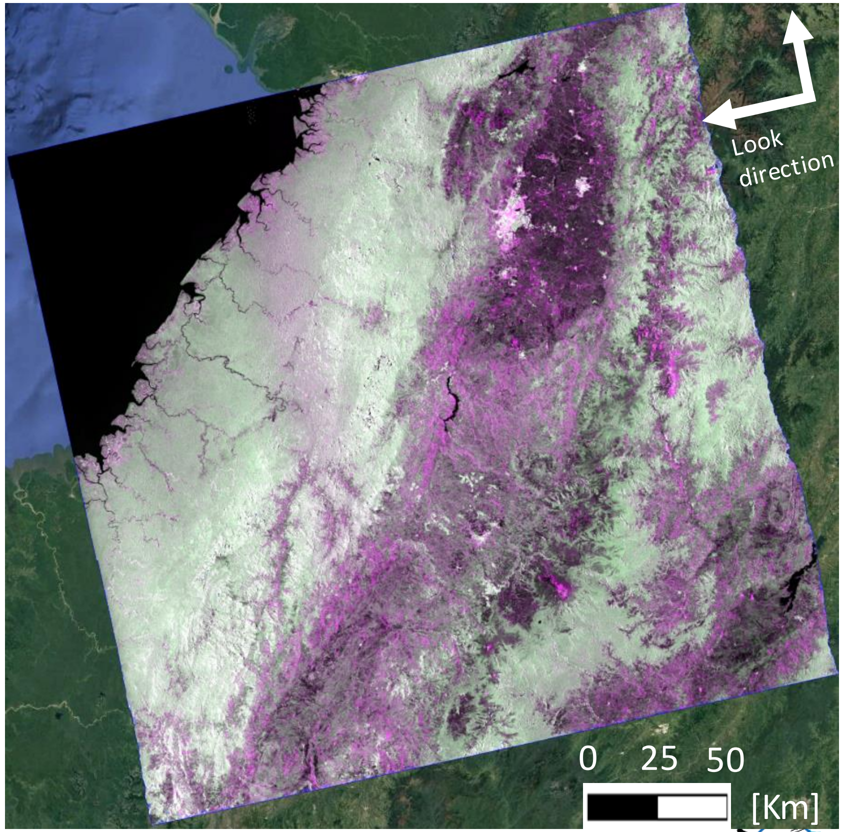
**RSLC** (Range-Doppler SLC)
~1.56 x 5 m for 77 MHz data
~ 3.12 x 5 m for 40 MHz data
~6.25 x 5 m for 20 MHz data
~25 x 5 m for 5 MHz data




**GSLC** (Geocoded SLC)
2.5 x 5 m for 77 MHz data
5 x 5 m for 40 MHz data
10 x 5 m for 20 MHz data
40 x 5 m for 5 MHz data

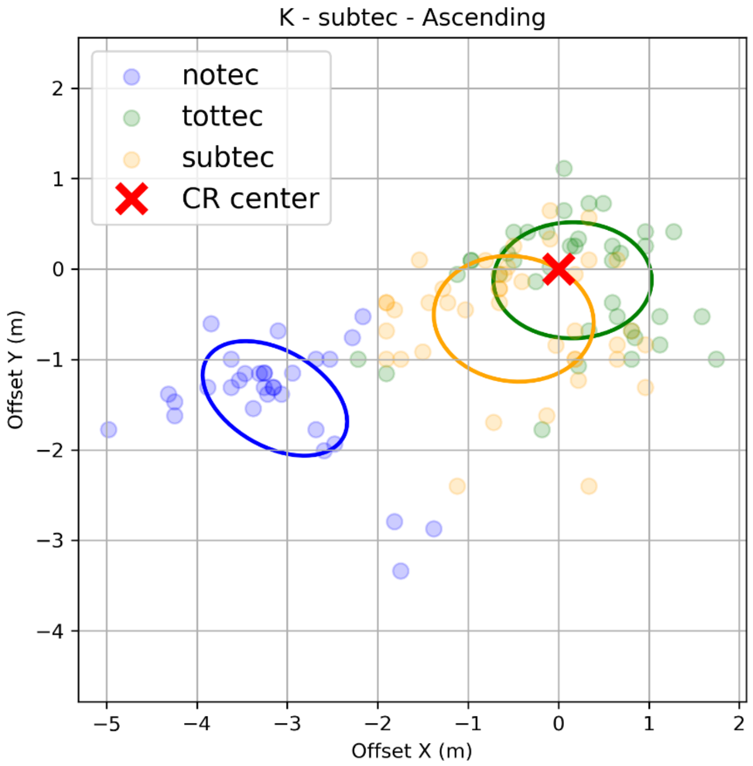


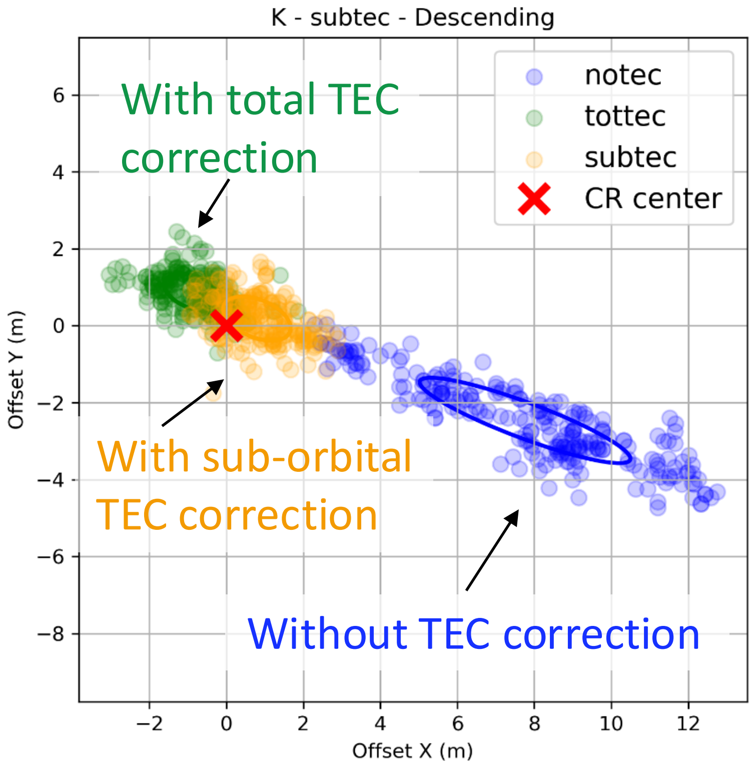

**GCOV** (Geocoded Covariance)
**Radiometric Terrain Corrected**
10 x 10 m for 40 MHz data
20 x 20 m for 20 and 77 MHz data
80 x 80 m for 5 MHz data



# Geocoded SLC, geolocation accuracy (Oklahoma Corner Reflectors)

| | | Median (m) | MAD (m) |
|---|---|---|---|
| Asc | X | -3.22 (notec)<br>0.22 (total tec)<br>-0.56 (sub tec) | 0.53 (notec)<br>0.57 (total tec)<br>0.74 (sub tec) |
| | Y | -1.31 (notec)<br>0.10 (total tec)<br>-0.37 (sub tec) | 0.23 (notec)<br>0.31 (total tec)<br>0.47 (sub tec) |
| Des | X | 8.19 (notec)<br>-0.82 (total tec)<br>0.72 (sub tec) | 2.12(notec)<br>0.59 (total tec)<br>0.63 (sub tec) |
| | Y | -2.45 (notec)<br>0.85 (total tec)<br>0.14 (sub tec) | 0.80 (notec)<br>0.38 (total tec)<br>0.40 (sub tec) |

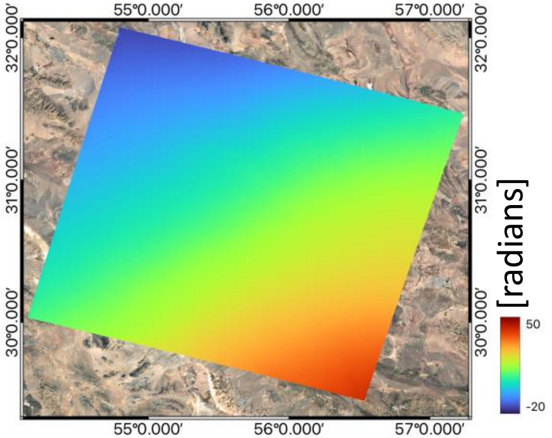


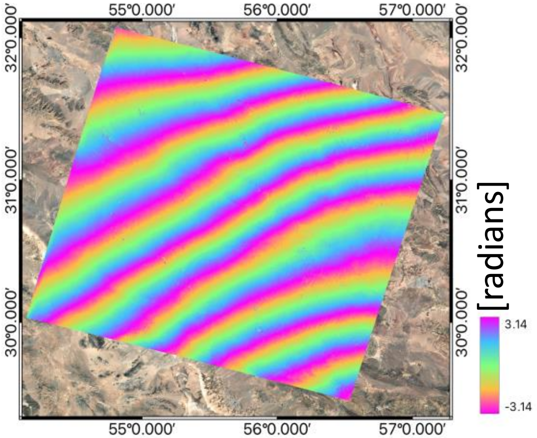

The geolocation accuracy of GSLC data over Oklahoma Corner reflectors has improved from 8.19 m +/- 2.12 m and -2.45 m +/- 0.8 m before TEC correction to **0.72 +/- 0.63** m and **0.14 +/- 0.40 m** after sub-orbital TEC correction in X and Y directions

# Geocoded wrapped and unwrapped interferogram (GUNW)

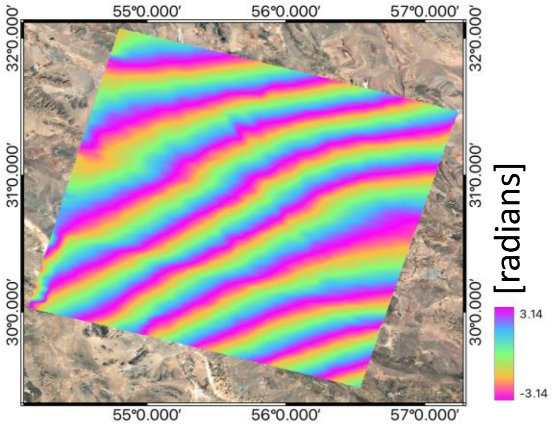
Unwrapped phase (80 m)



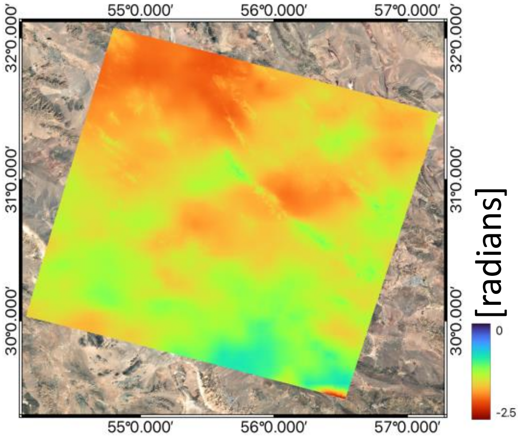

Wrapped phase (20 m)



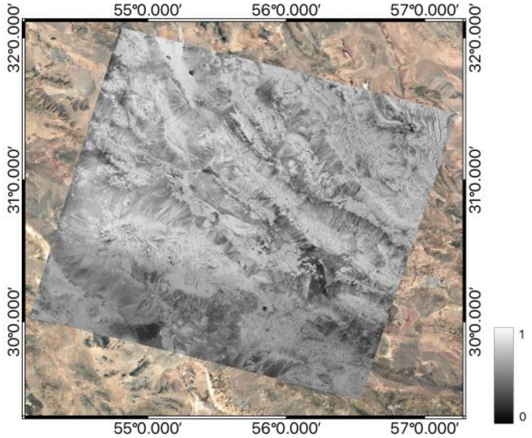

Ionospheric phase



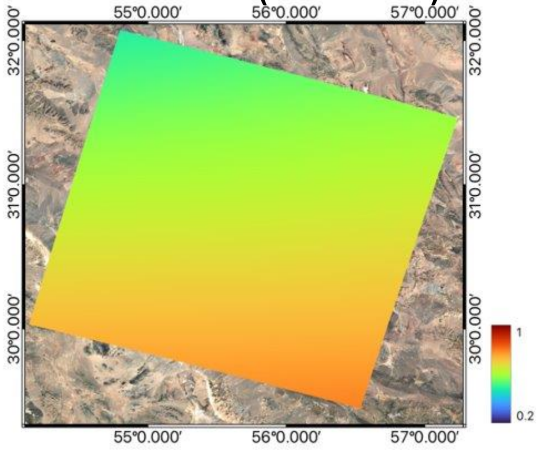

Tropospheric delay (3D cube)




Coherence (80 m)



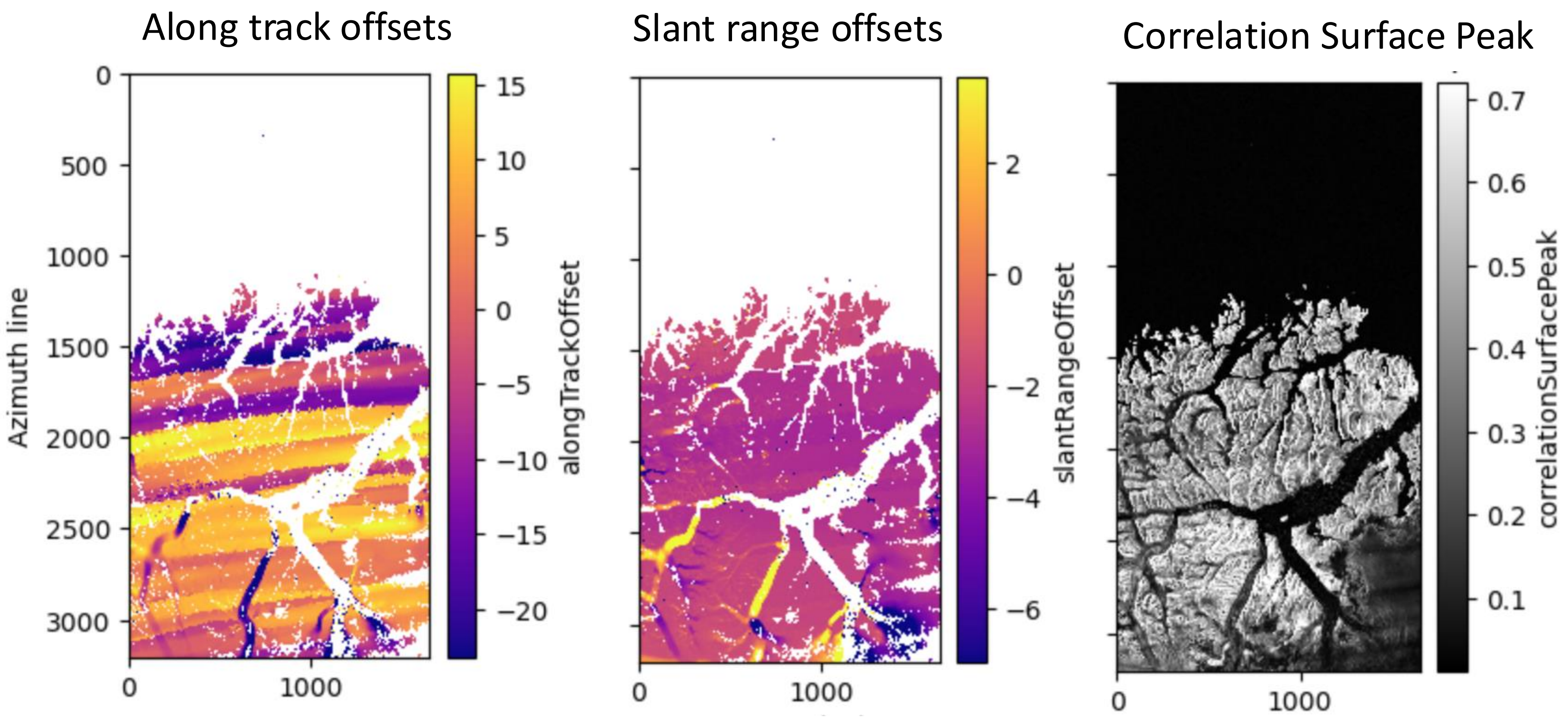

Solid earth tide (3D cube)




- **GUNW** (Geocoded Unwrapped and Wrapped phase) is produced globally over solid earth and cryosphere regions
- 80 x 80 m for unwrapped phase and its coherence layer
- 80 x 80 m for ionospheric
- Water and sub-swath masks at 80 m
- 20 x 20 m Wrapped phase and its coherence
- Tropospheric delay and Solid Earth Tide as 3D cubes
- Range Doppler Wrapped and Unwrapped products (RIFG and RUNW) are produced over Cryosphere regions

# Pixel Offsets products over Cryosphere regions

- **Range-Doppler Pixel Offsets (ROFF) and Geocoded Pixel Offsets (GOFF)** are produced over Cryosphere regions
- Nearest neighbor pairs in time (12 days)
- Each product contains 3 layers of offsets produced at 3 different resolution from coarse to fine resolutions to measure the movements of ice sheets with different speeds

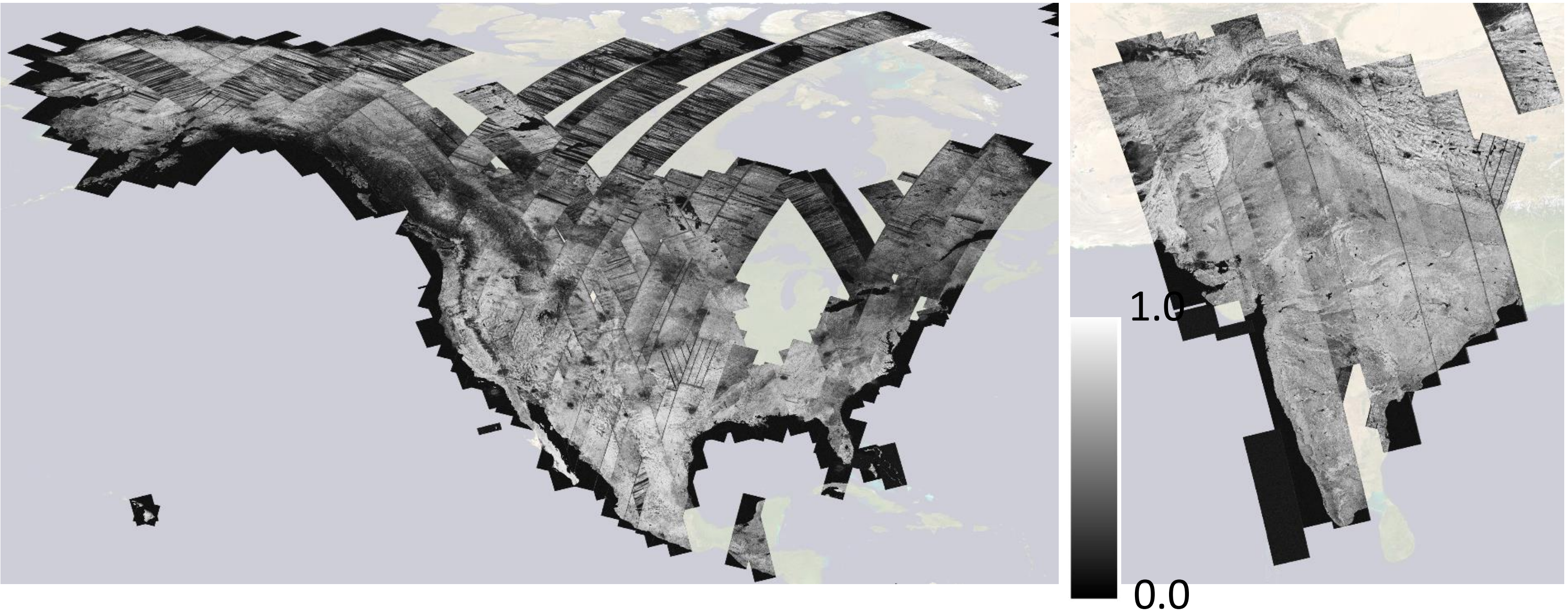


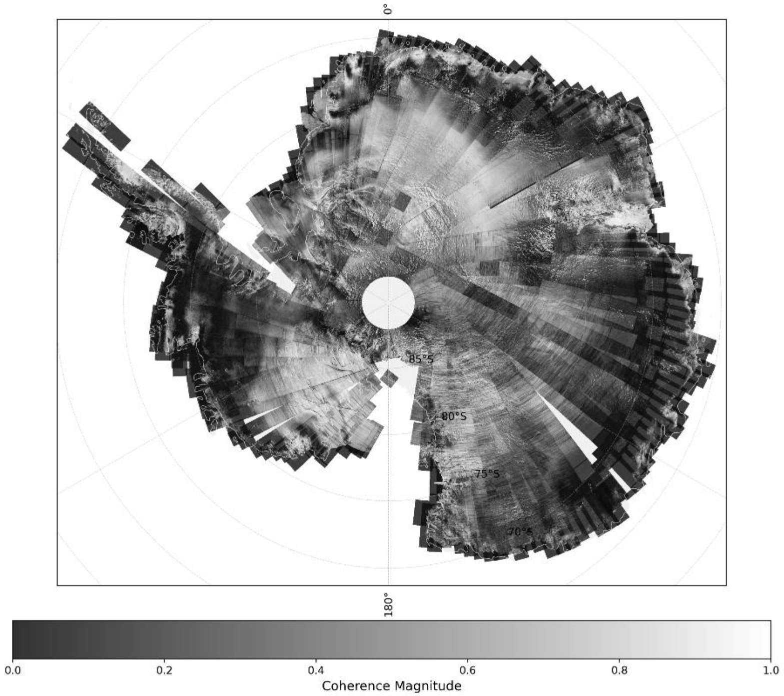

| Offset Layer | Slant Range Spacing (pixels) | Along-Track Spacing (pixels) | Template Size in Slant Range (pixels) | Template Size in Along-Track (pixels) | Search Radius in Slant Range (pixels) | Search Radius in Along-Track (pixels) | Maximum Observable Speed (km/year) |
|---|---|---|---|---|---|---|---|
| Layer 1 | 30 | 15 | 64 | 32 | 64 | 33 | 6 |
| Layer 2 | 30 | 15 | 96 | 64 | 64 | 33 | 6 |
| Layer 3 | 30 | 15 | 196 | 128 | 8 | 8 | 1.4 |

80 MHz configuration

# Interferometric coherence

Mosaic of interferometric coherence maps over US and India from **uncalibrated** images




- Overall, the interferometric coherence largely represents the physical properties and scattering characteristics of targets on ground.
- Coherence is higher in mid latitudes (e.g., 0.85 in Texas) and lower in polar regions mainly due to significant ionospheric variations
- Strong ionospheric variabilities at high latitudes and precipitation degrades coherence.
- Dark spots at the southern border of US, around Texas, Nevada Oklahoma and at the borders of India are caused by RFI

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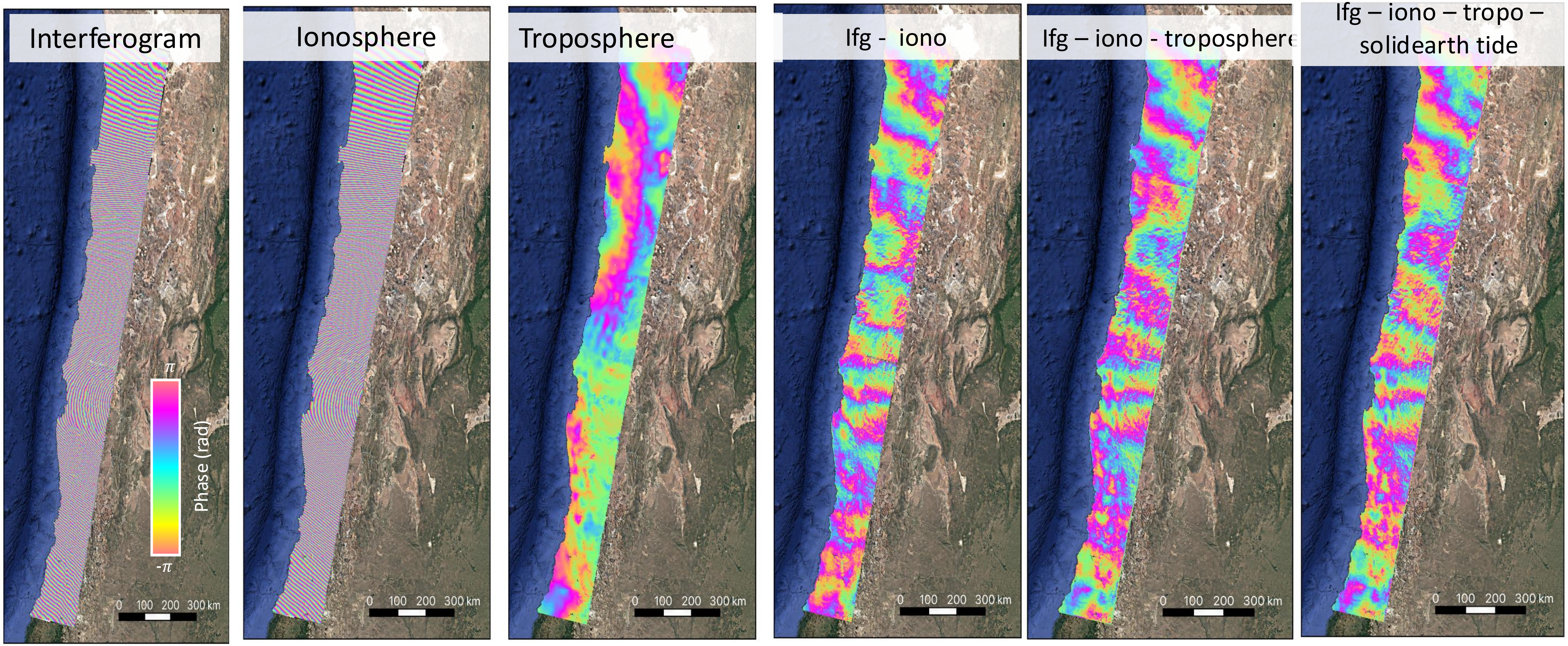
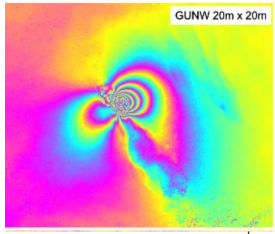
# Interferometric phase corrections with the correction layers included in the GUNW product




On average the standard deviation of interferometric phase across NISAR frames have largely reduced from ~225 cm before any correction to ~ 8 cm after corrections

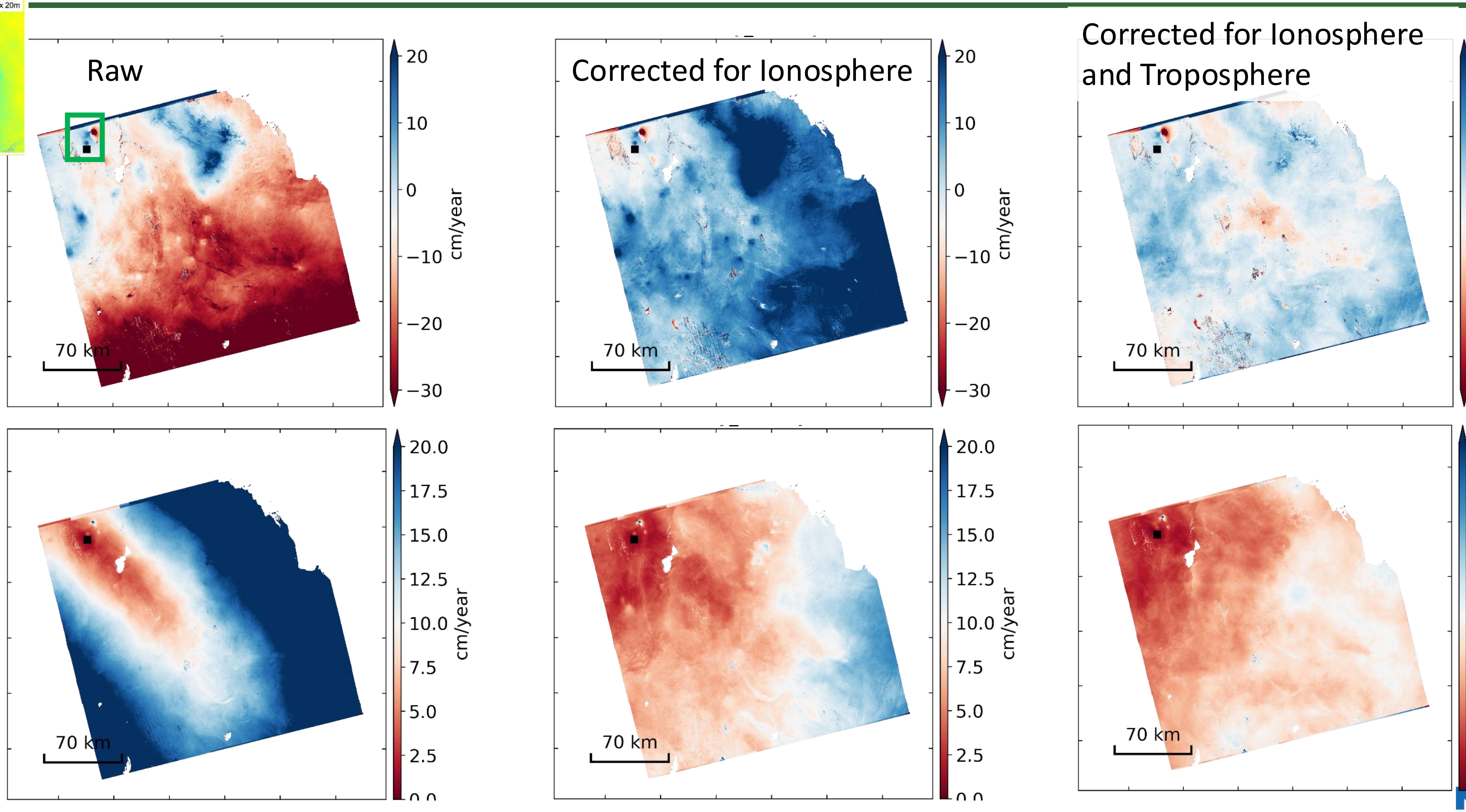

Reviewed and approved for public distribution via the URS

# Interferometric phase corrections with the correction layers included in the GUNW product

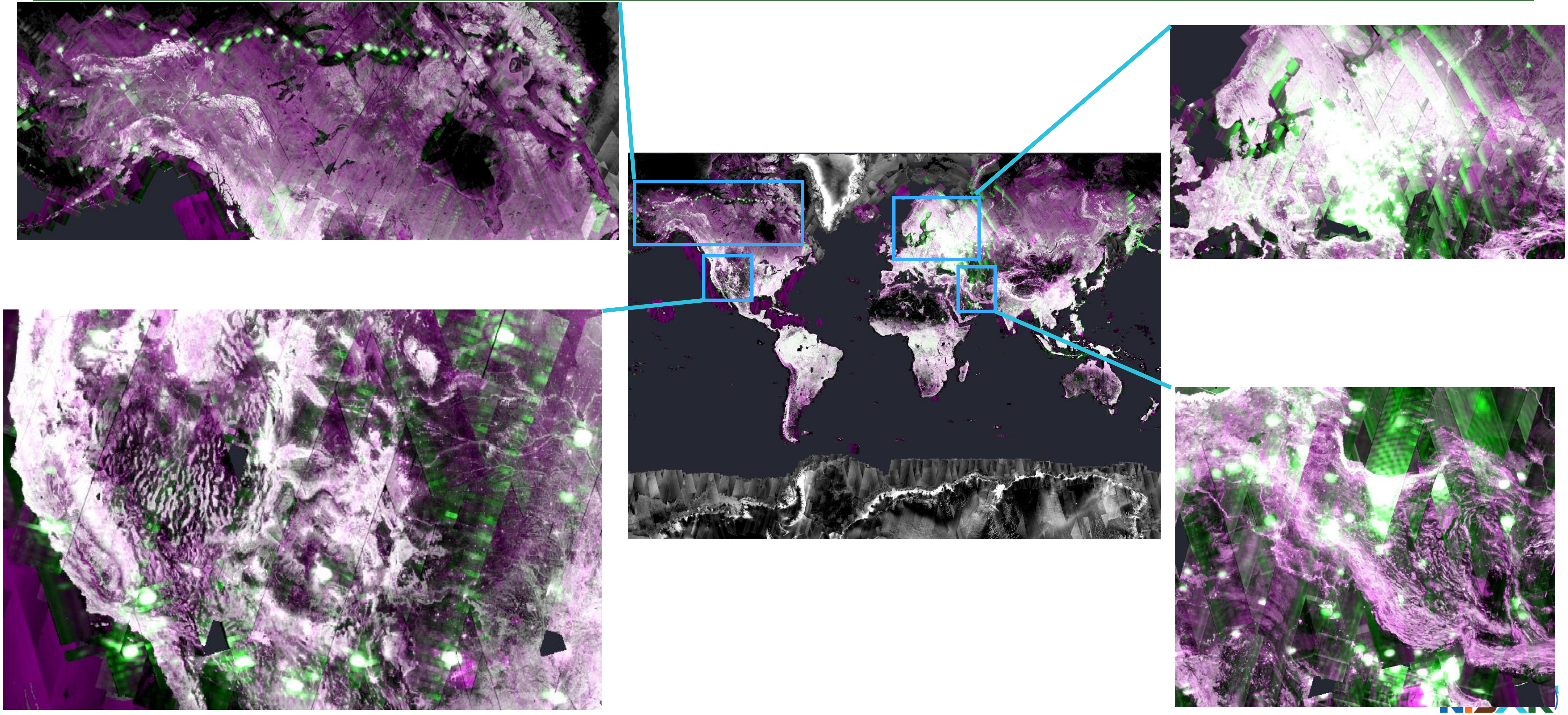


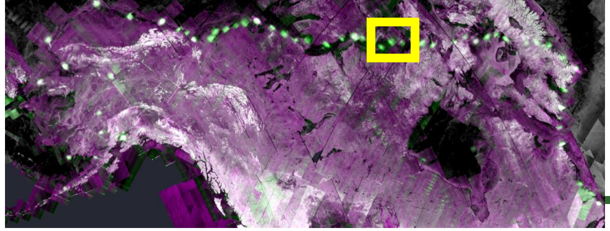

Velocity

Standard deviation of velocity



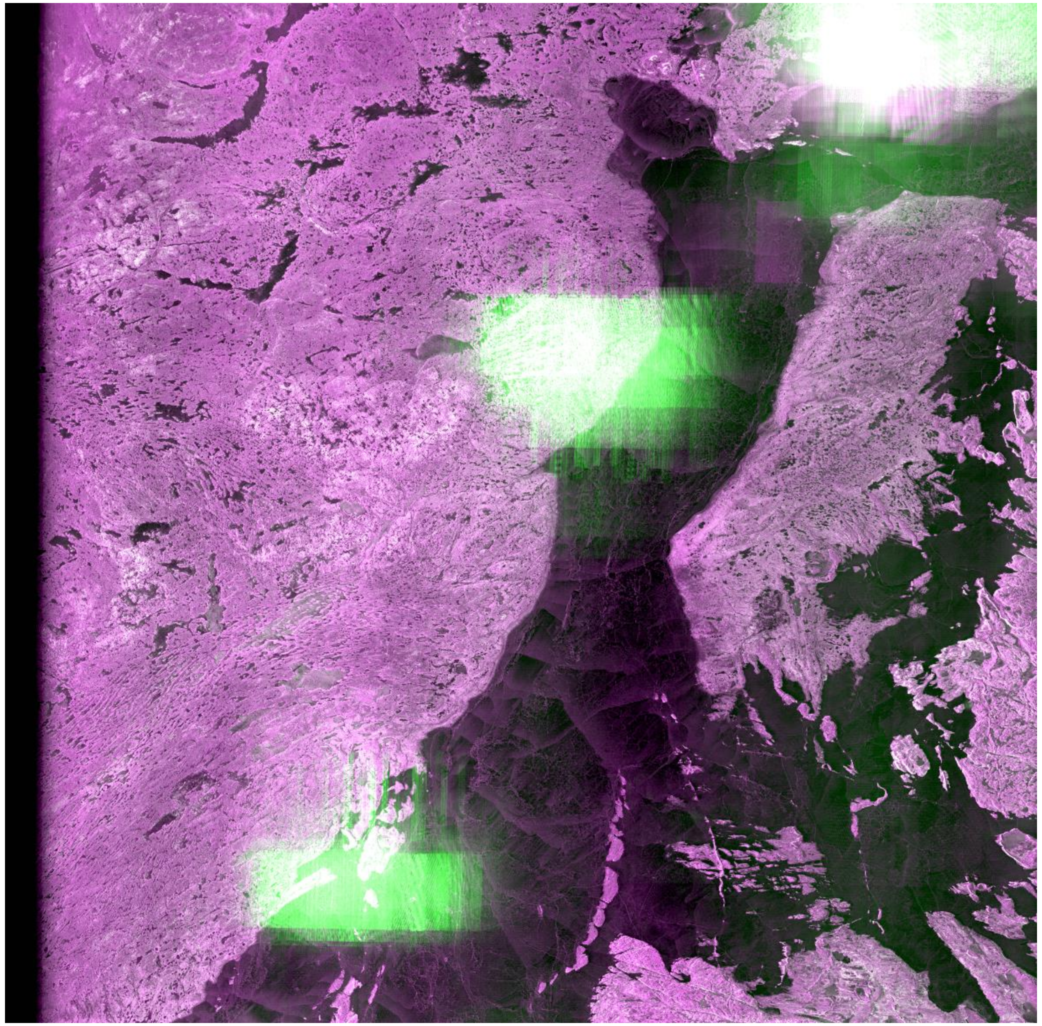
# Radio Frequency Interference (RFI)



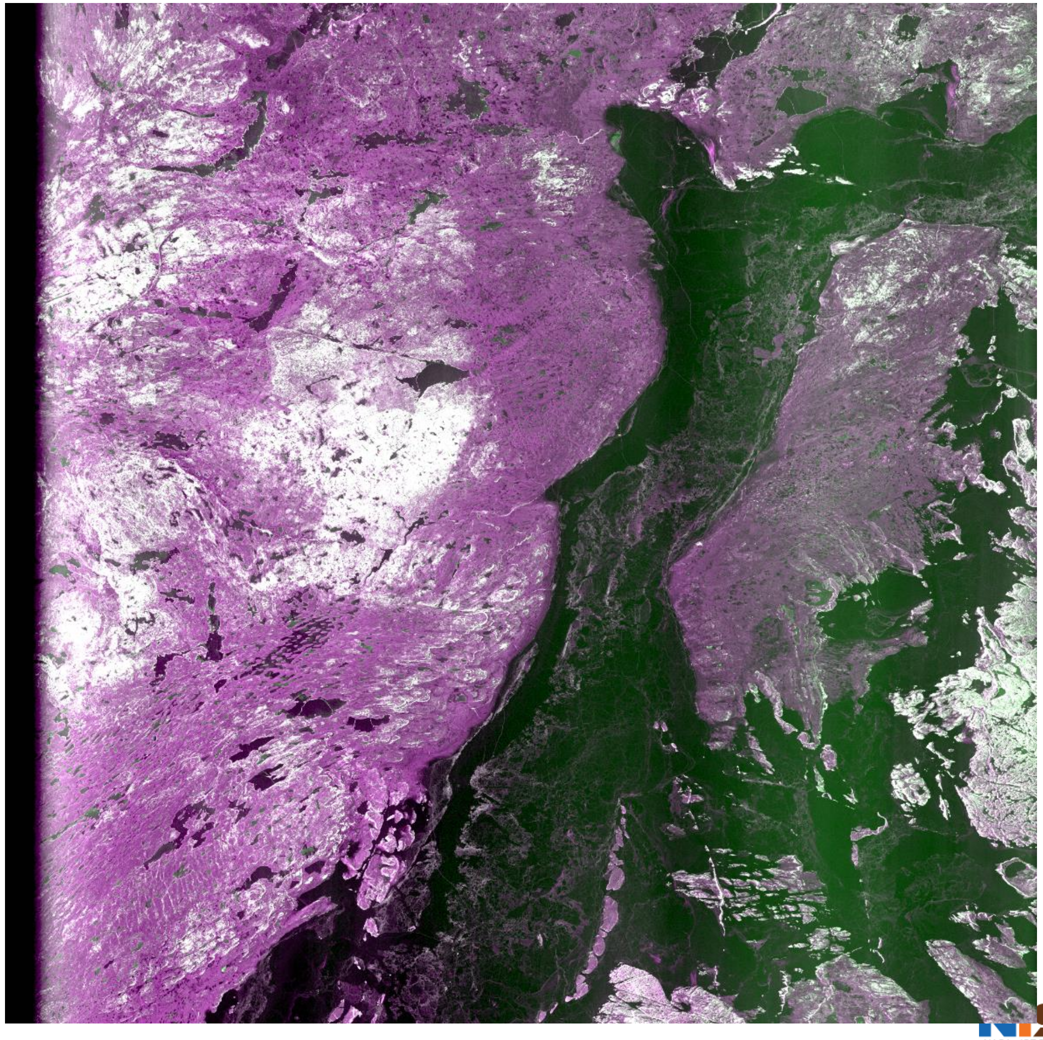


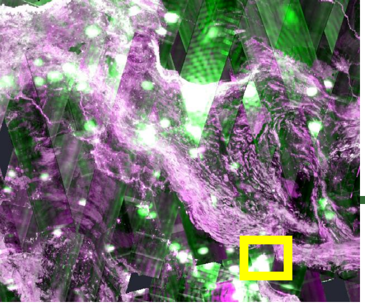
# Radio Frequency Interference (RFI)

Before RFI mitigation



After RFI mitigation





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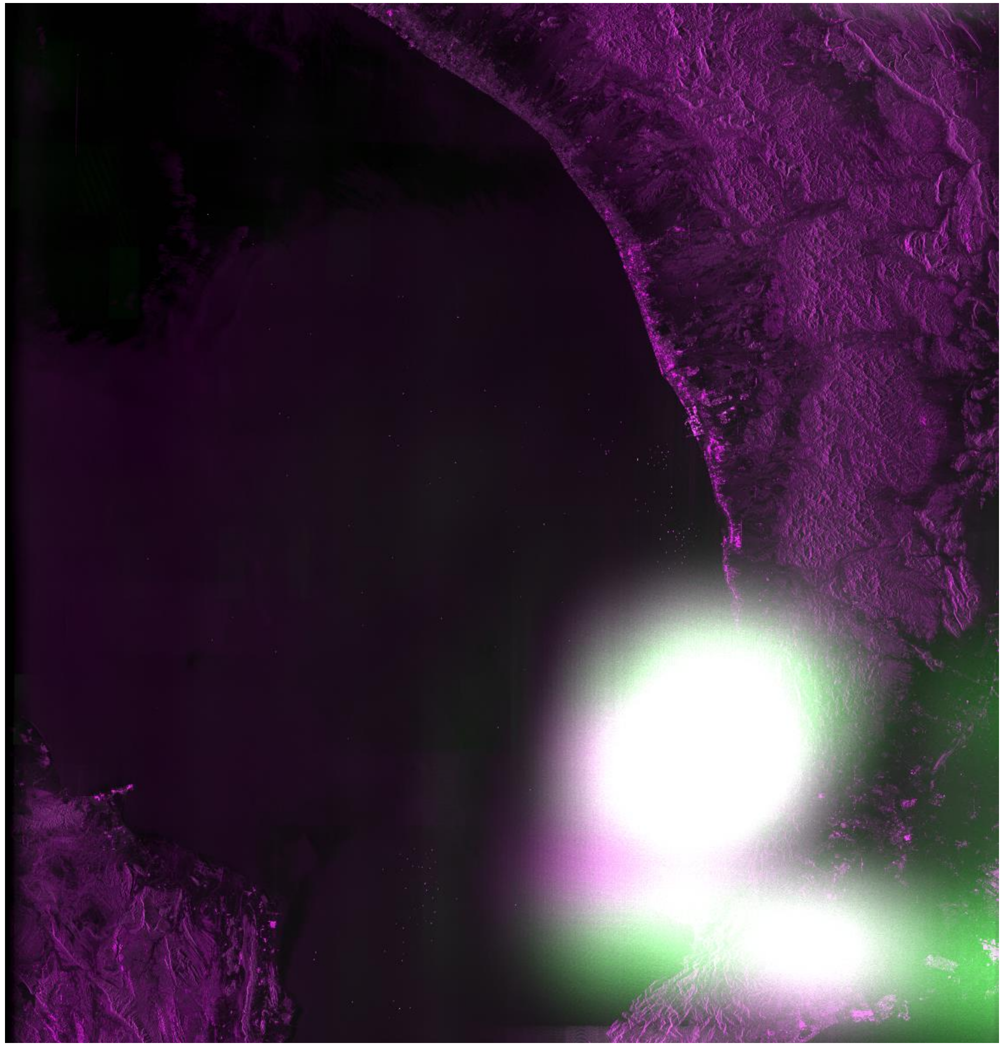
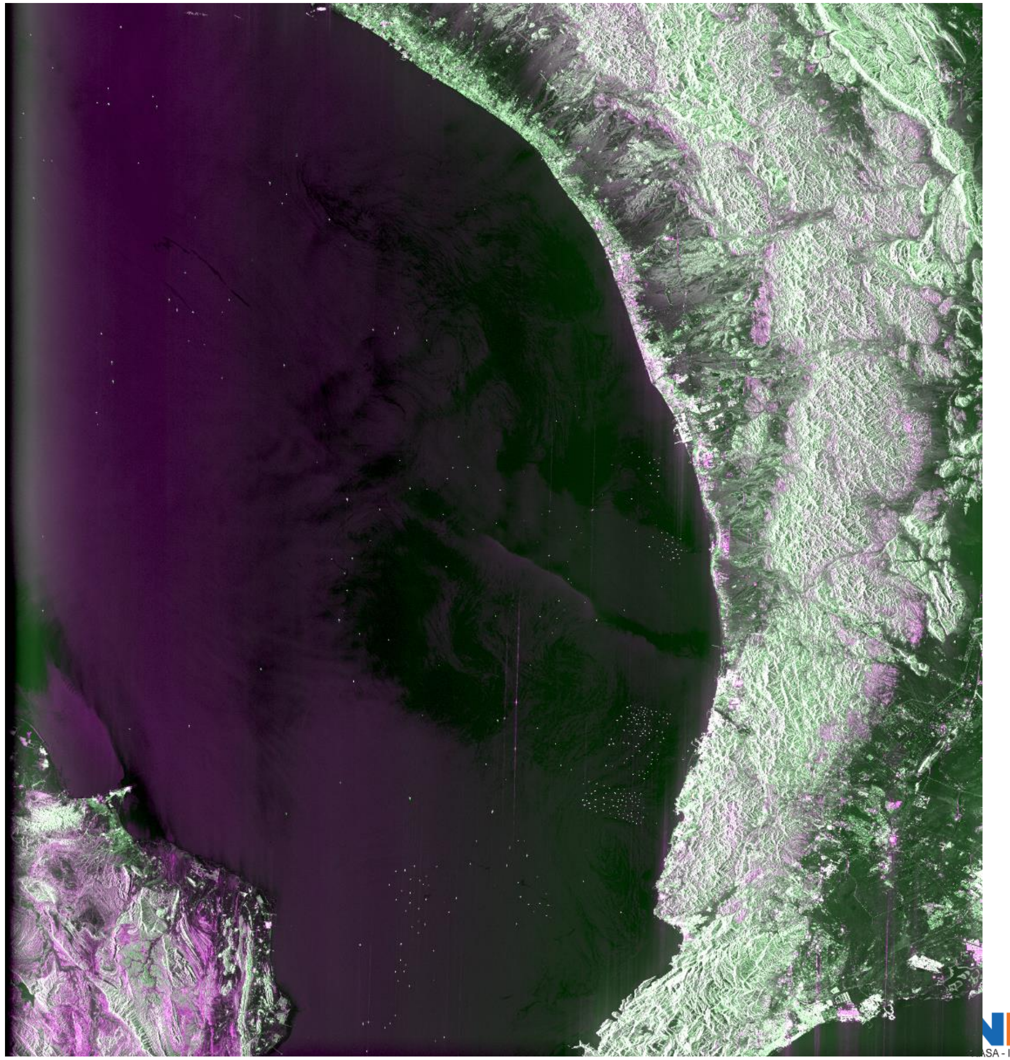
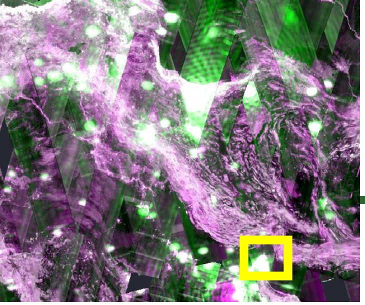
Before RFI mitigation



After RFI mitigation





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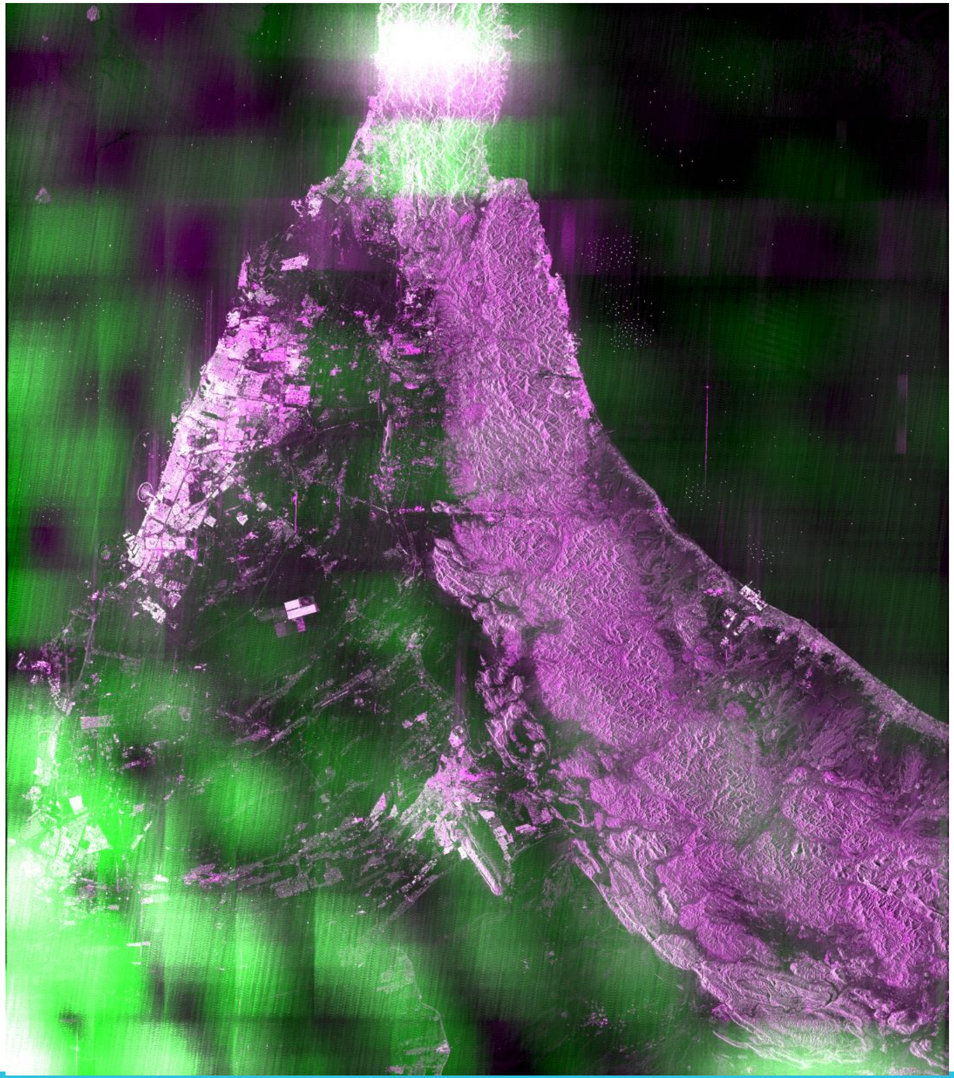
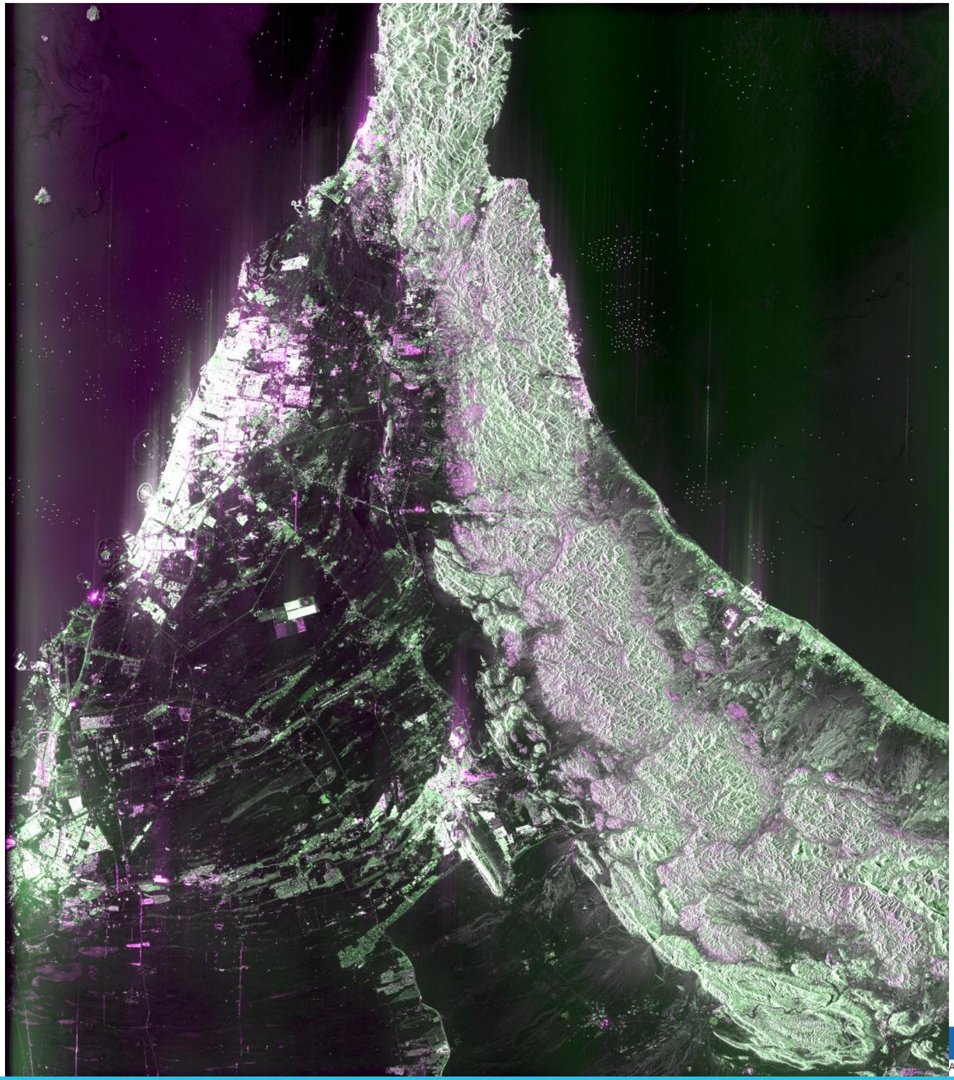
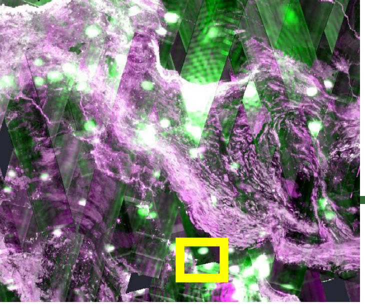
Before RFI mitigation



After RFI mitigation





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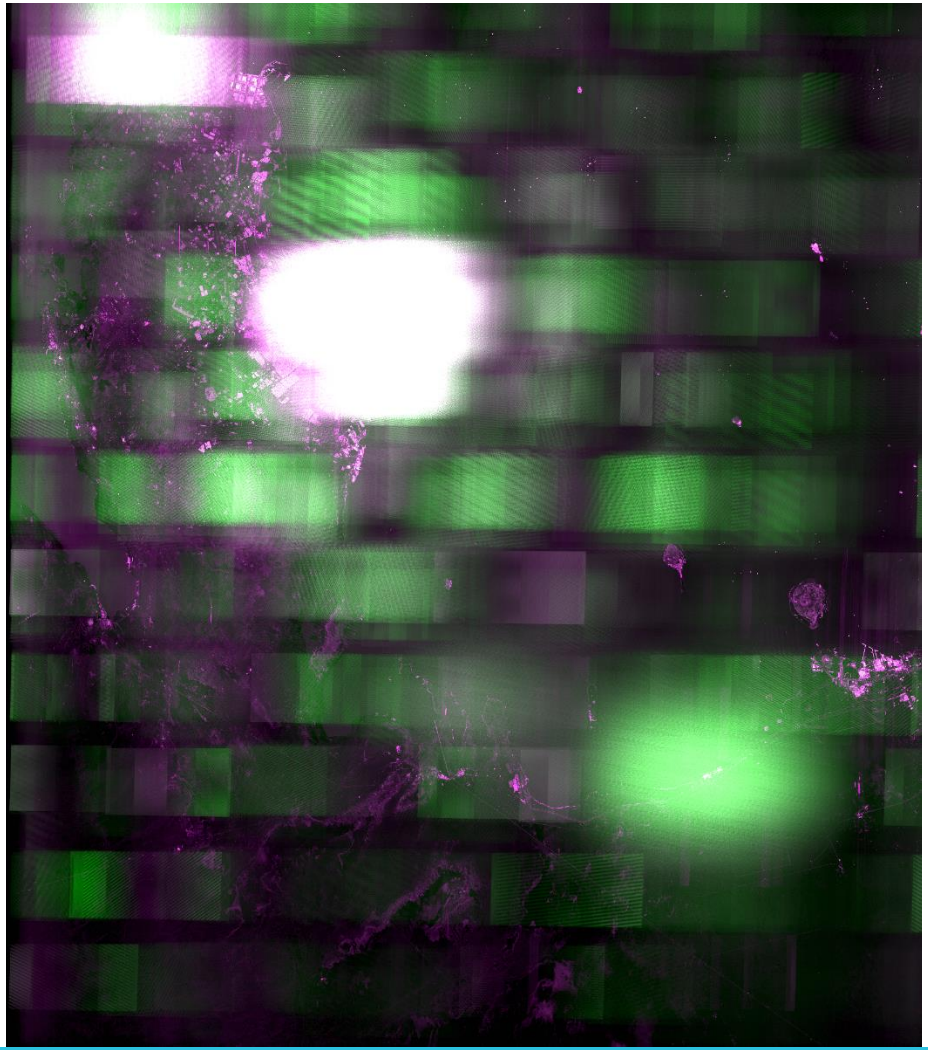
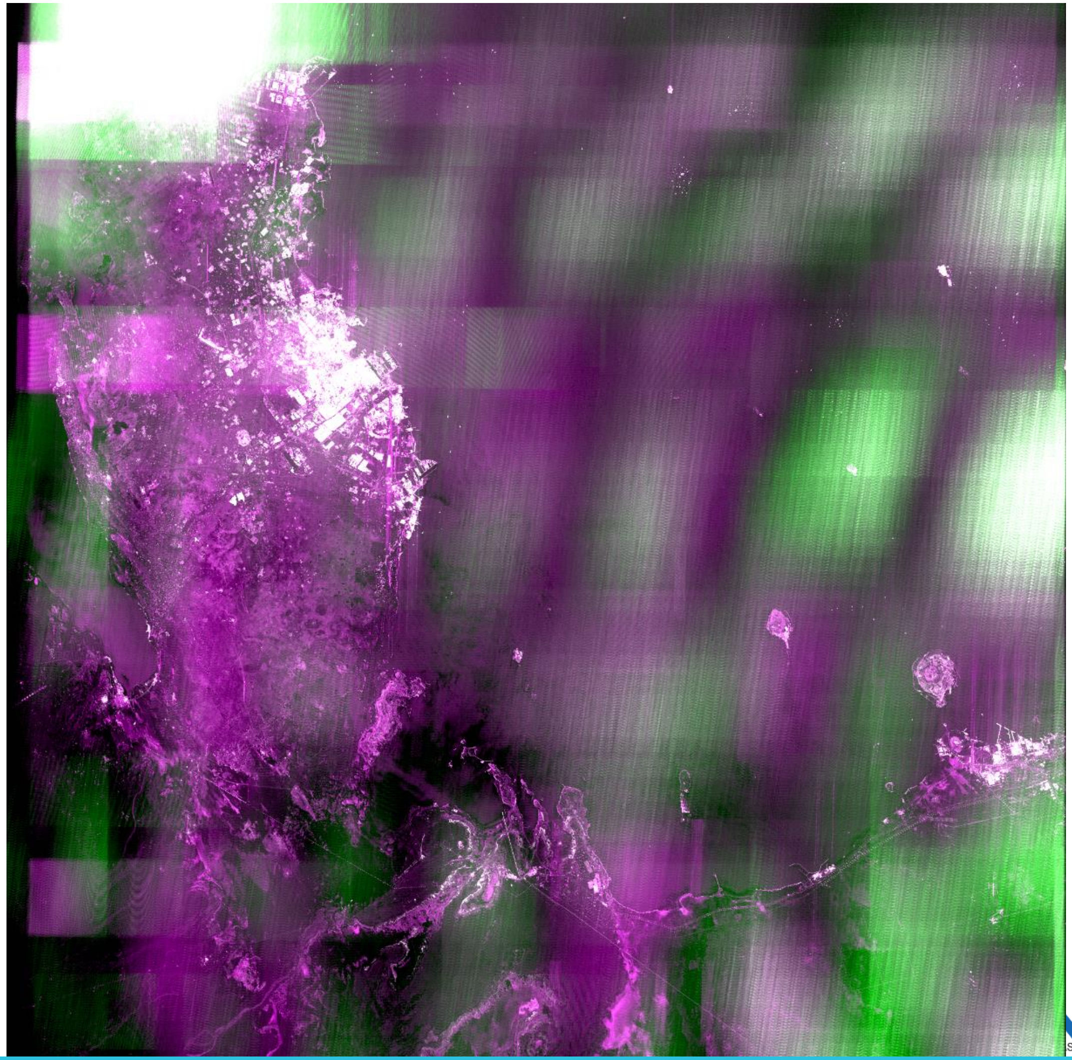
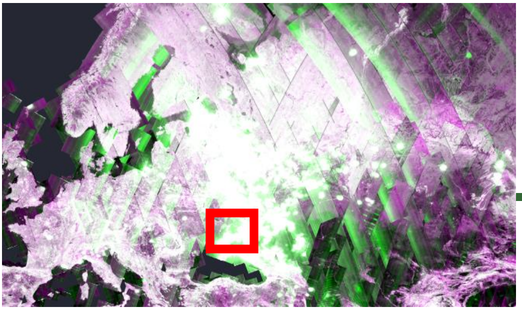
Before RFI mitigation



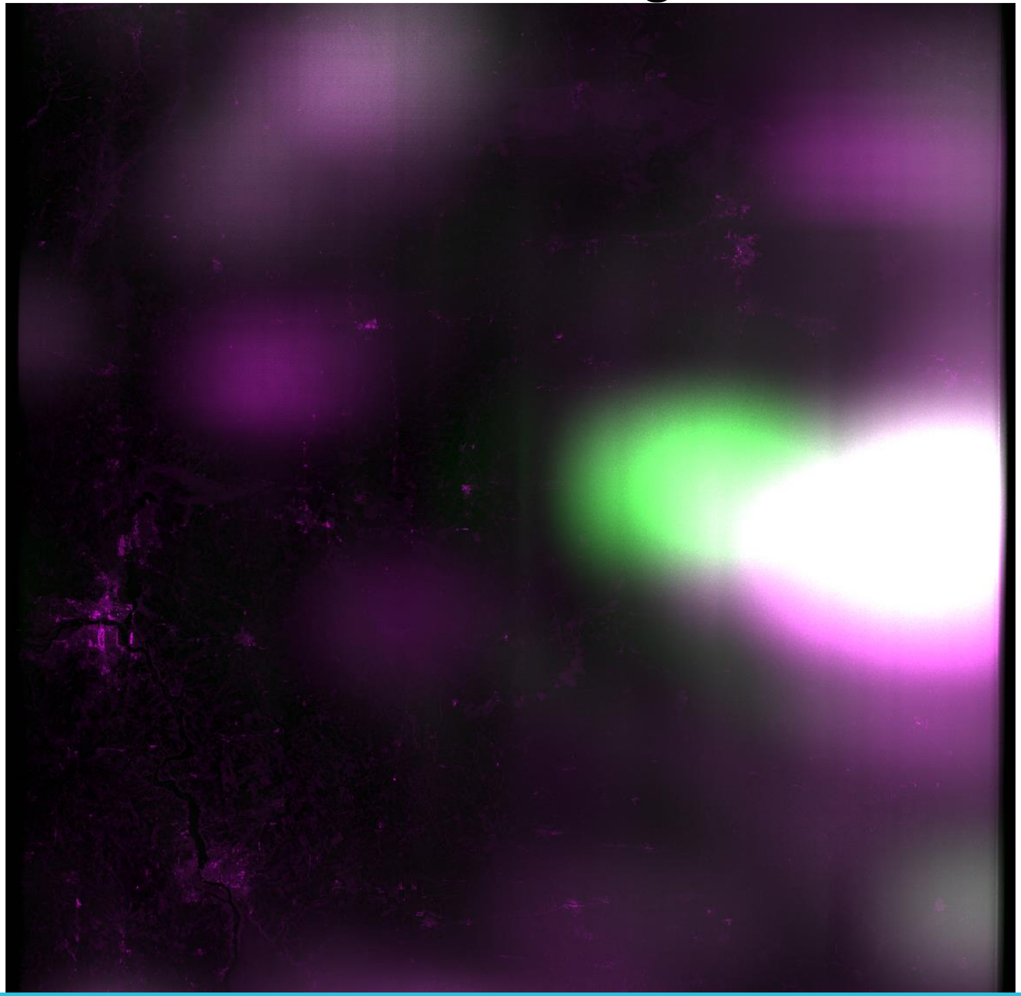
After RFI mitigation



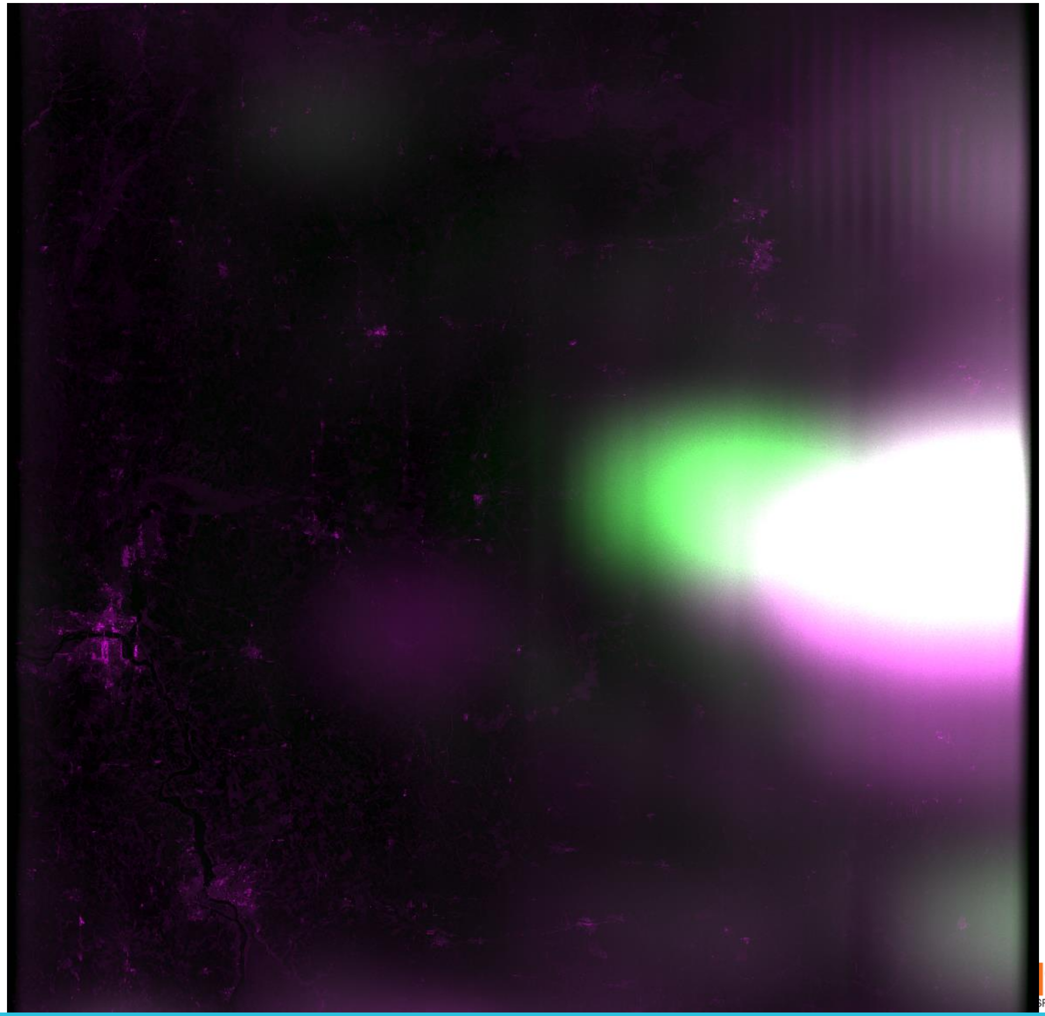


# Radio Frequency Interference (RFI)

Before RFI mitigation



After RFI mitigation



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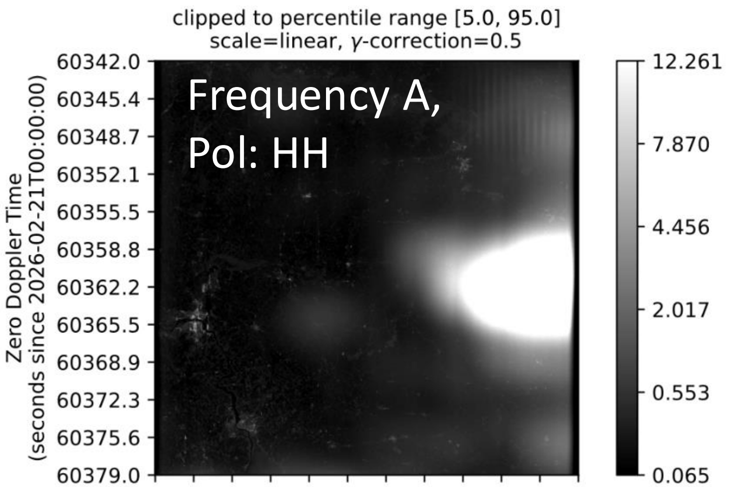
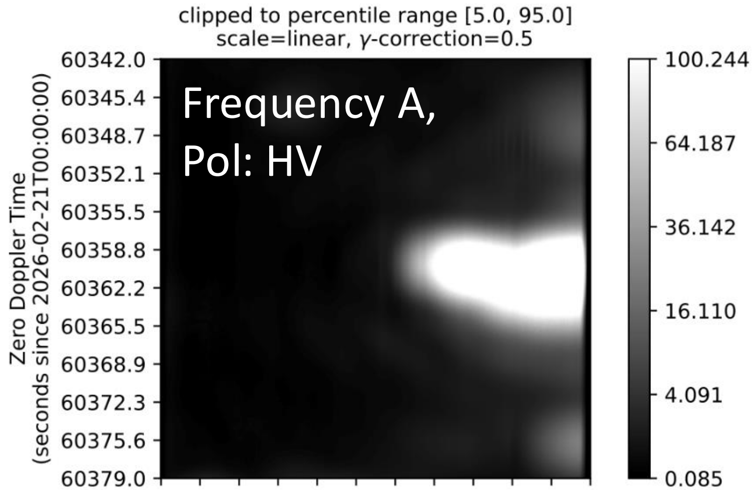
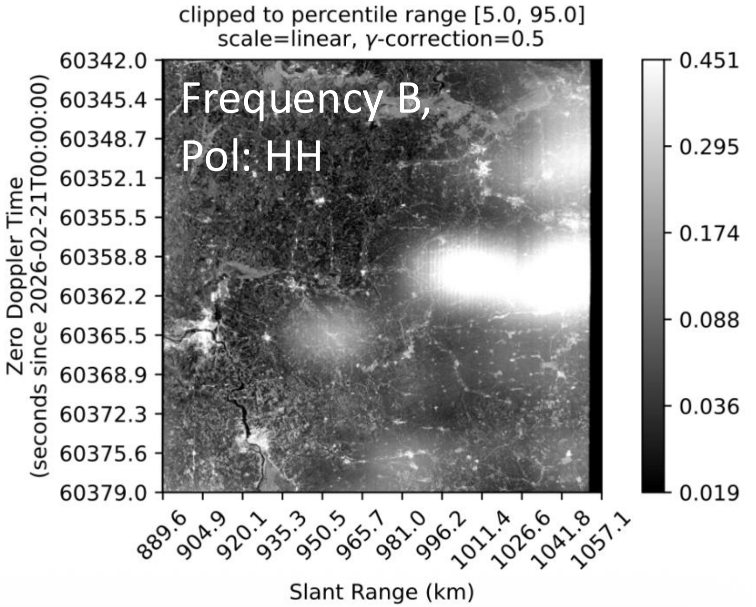
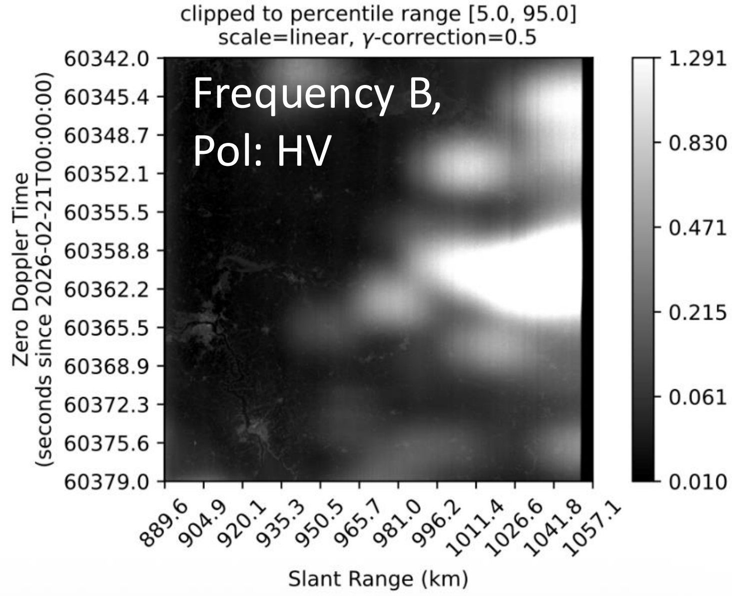
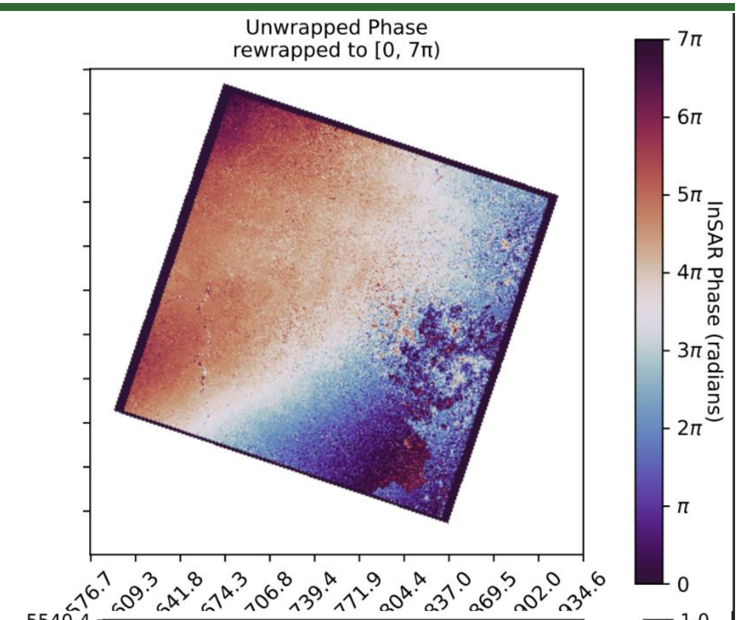
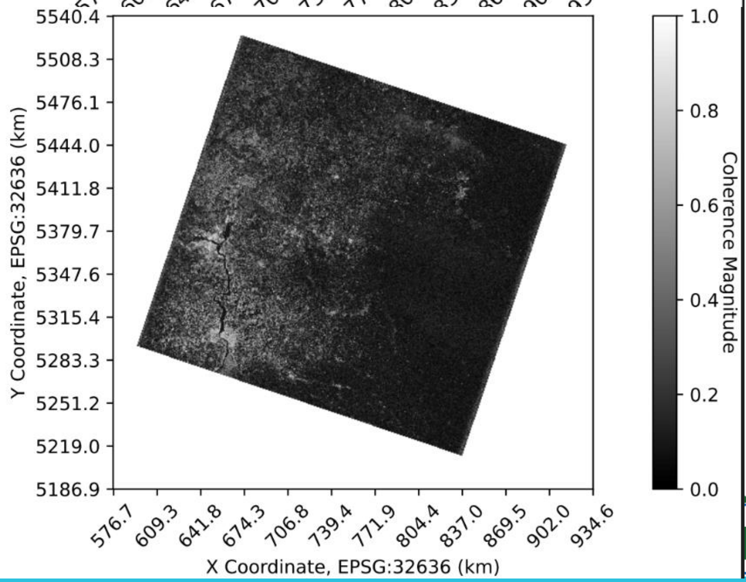


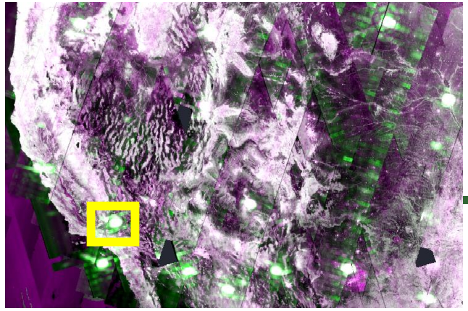



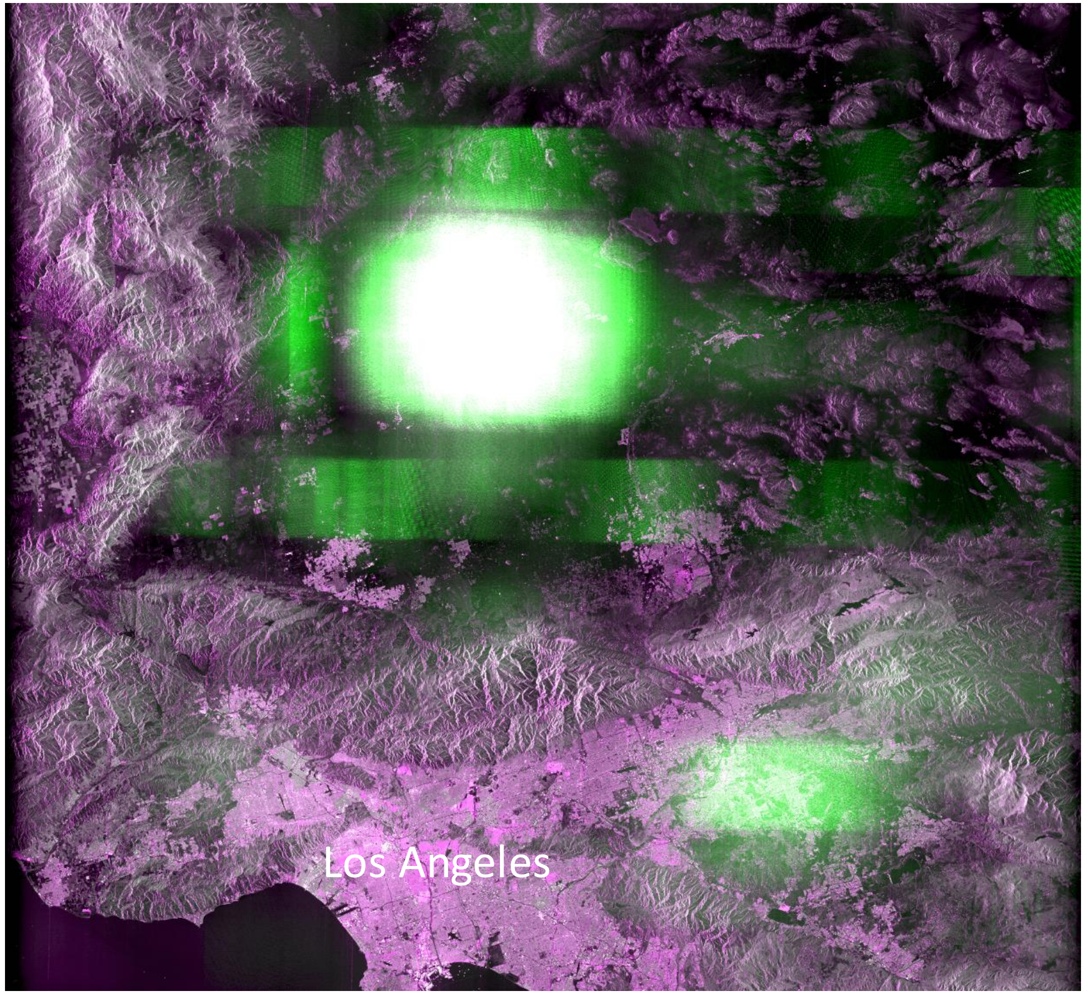



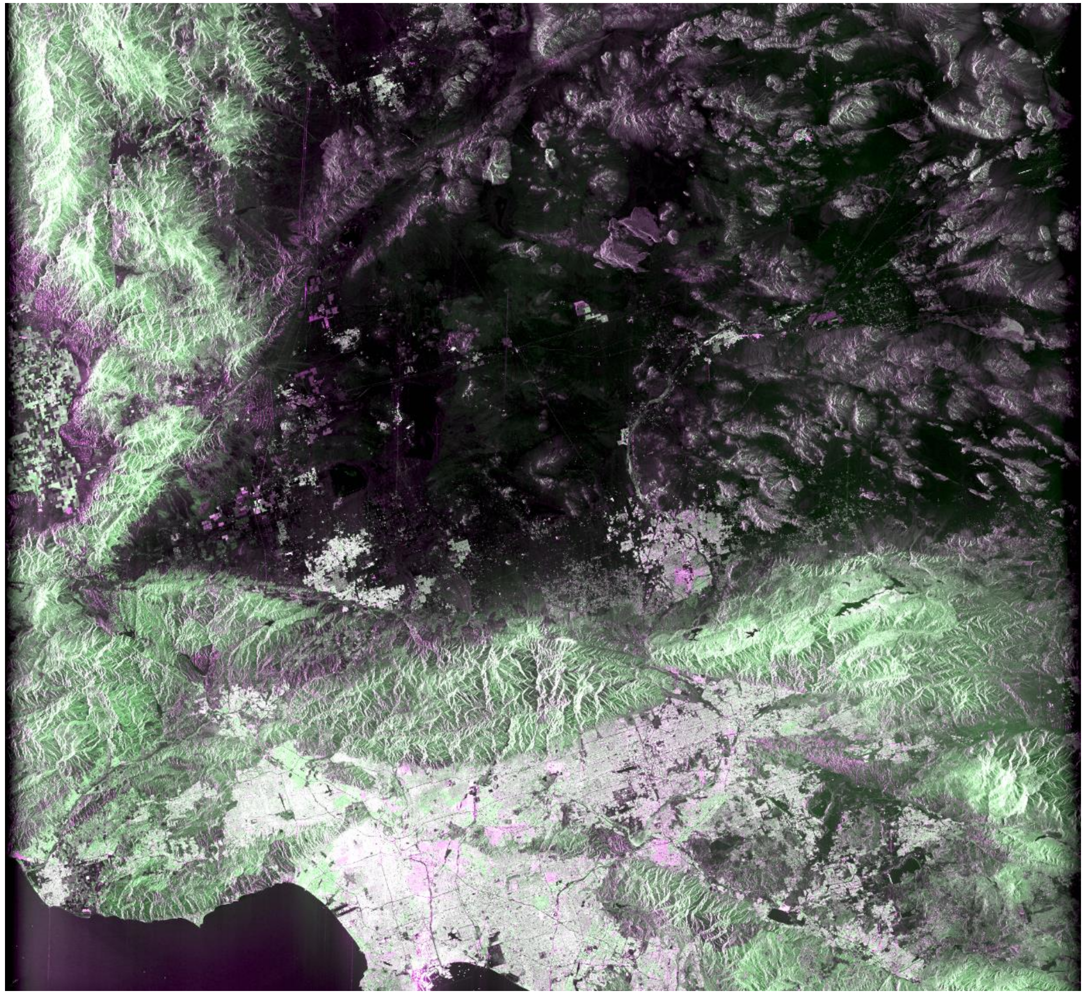


# Radio Frequency Interference (RFI)

Before RFI mitigation




After RFI mitigation



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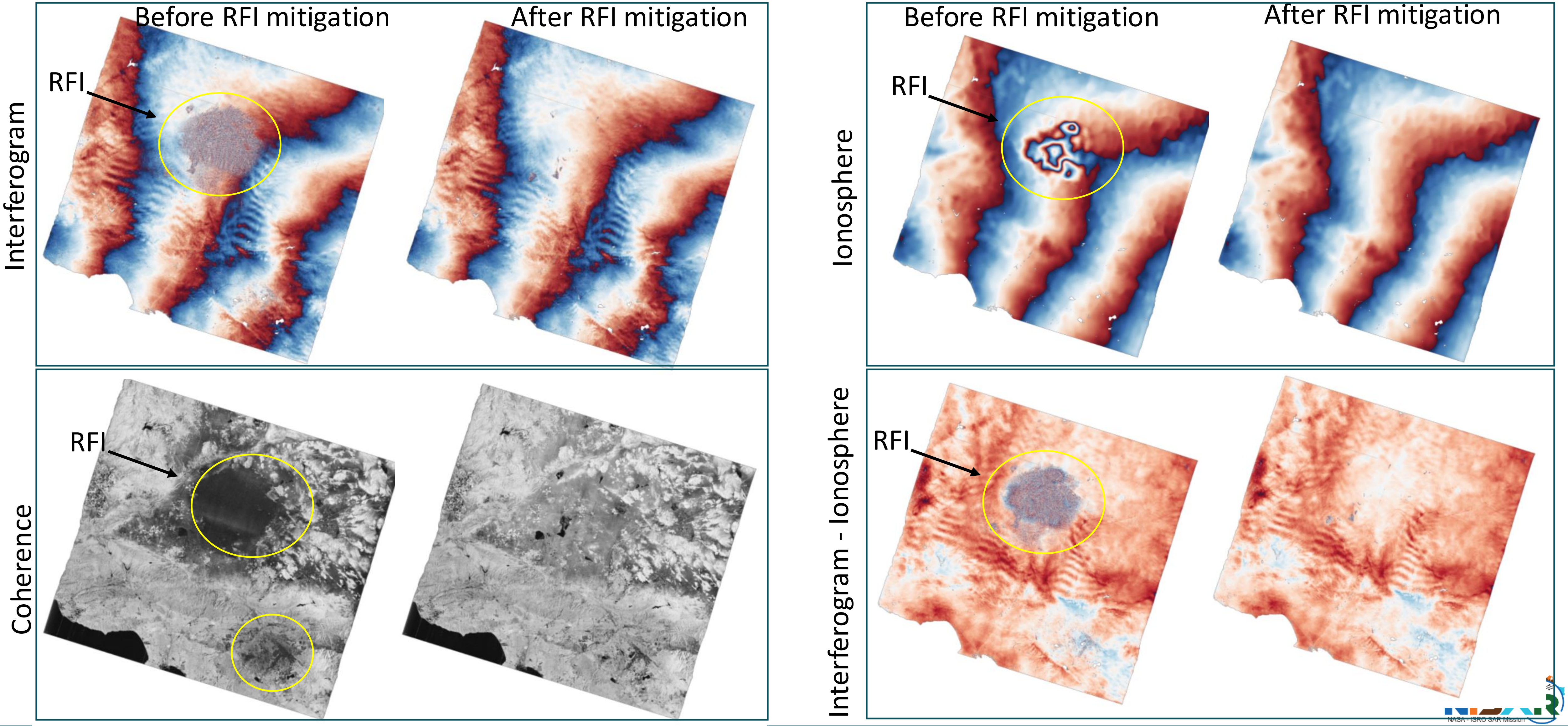
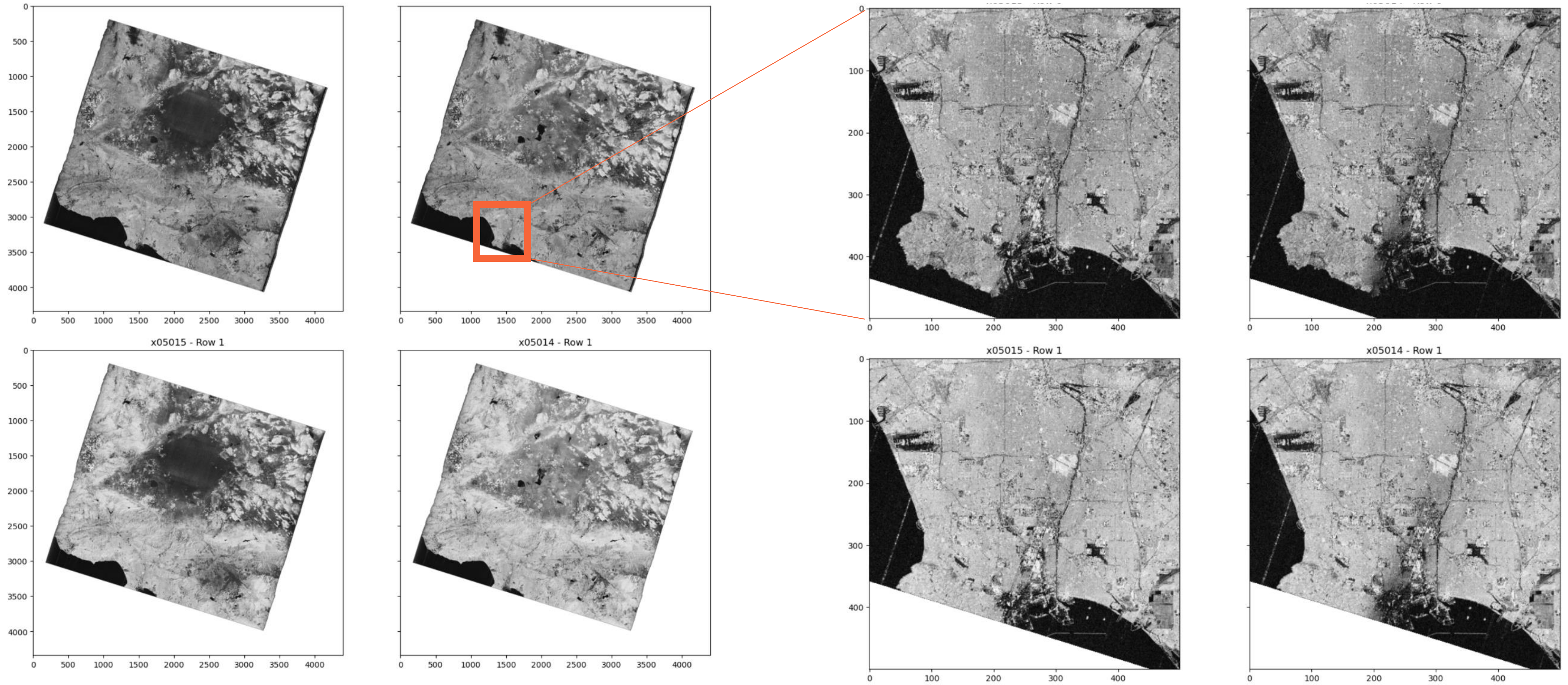
# Radio Frequency Interference (RFI) mitigation impact on InSAR



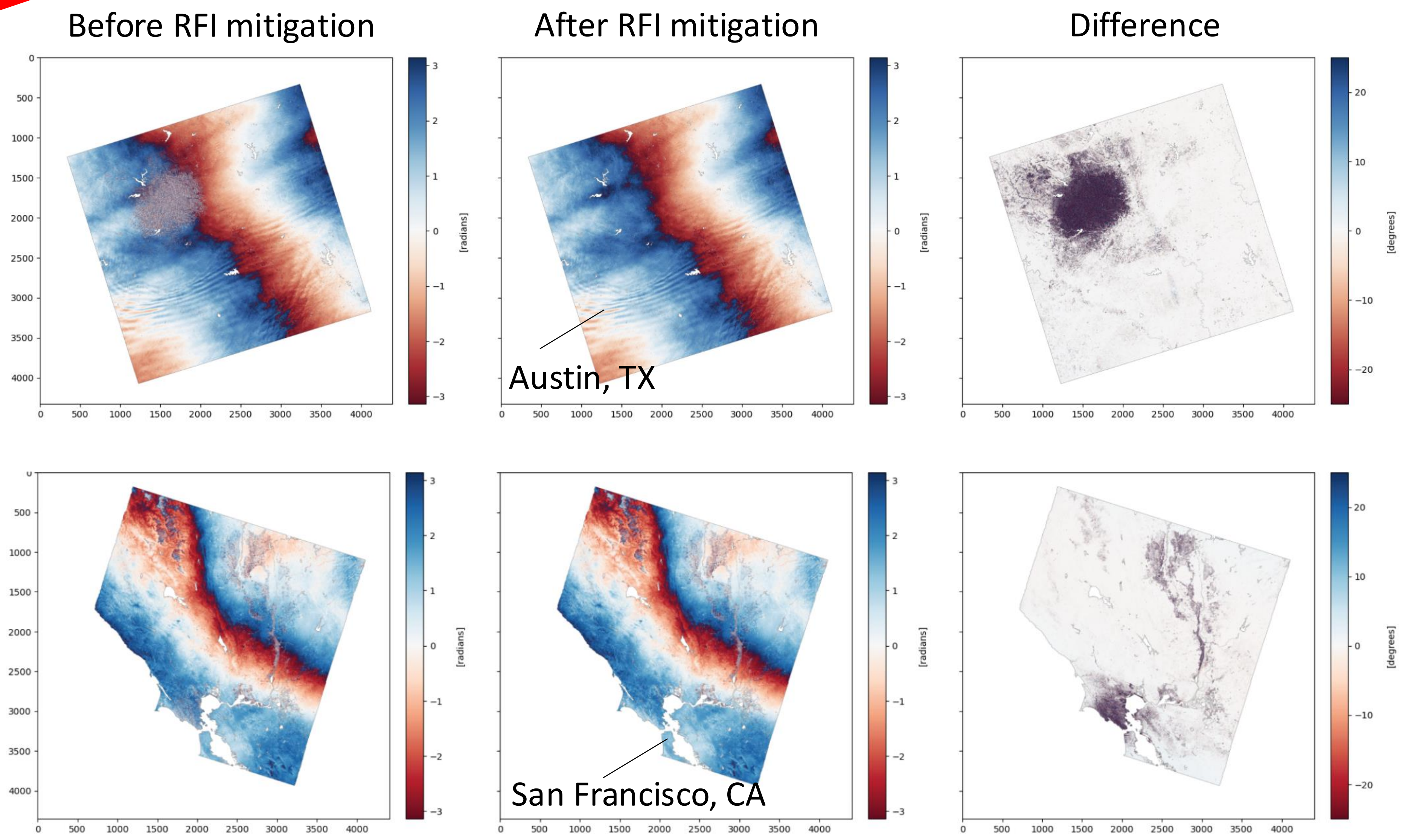
# Radio Frequency Interference (RFI) mitigation impact on InSAR

Before RFI mitigation | After RFI mitigation | Before RFI mitigation | After RFI mitigation



# Radio Frequency Interference (RFI) mitigation impact on InSAR

Candidate to remove

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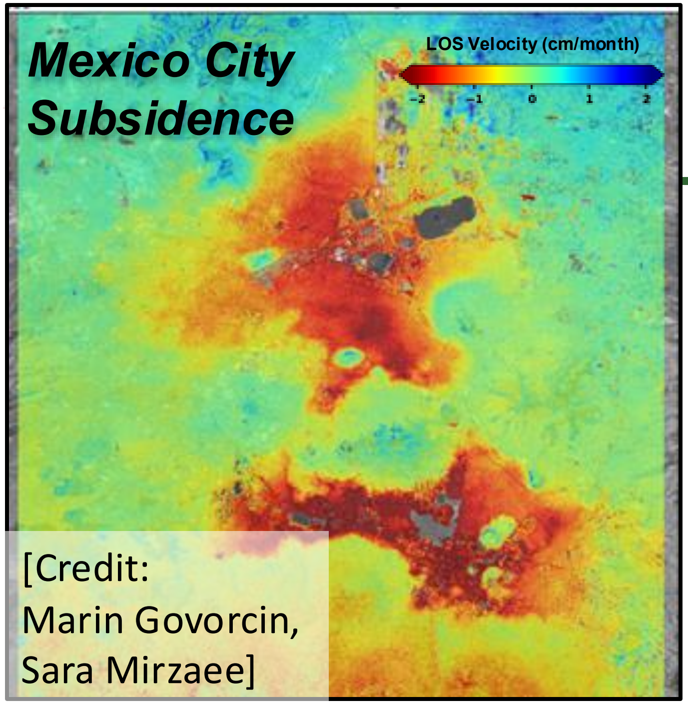
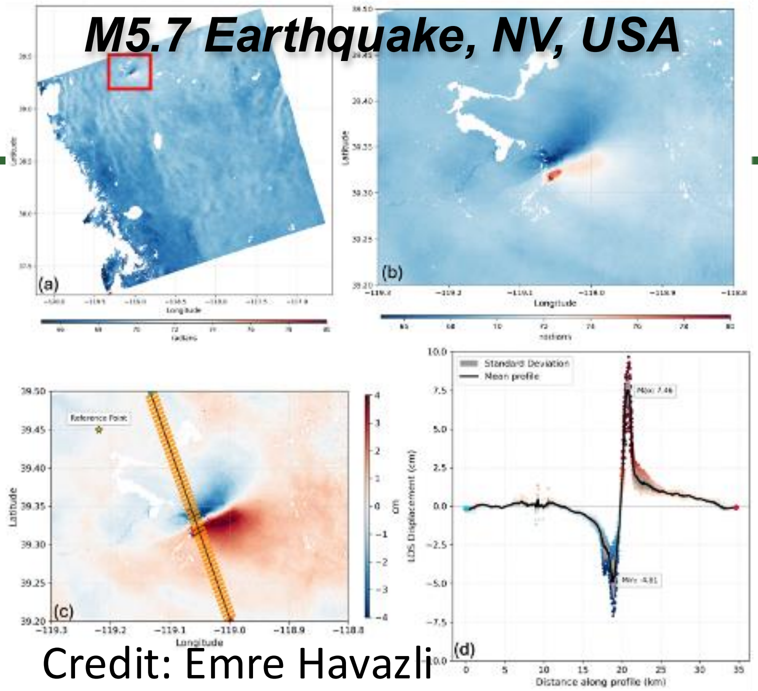
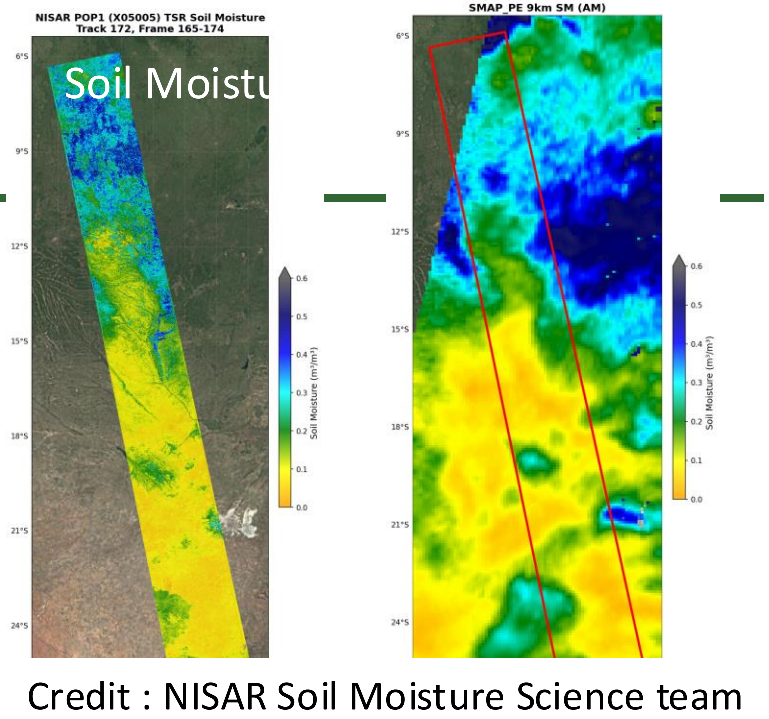
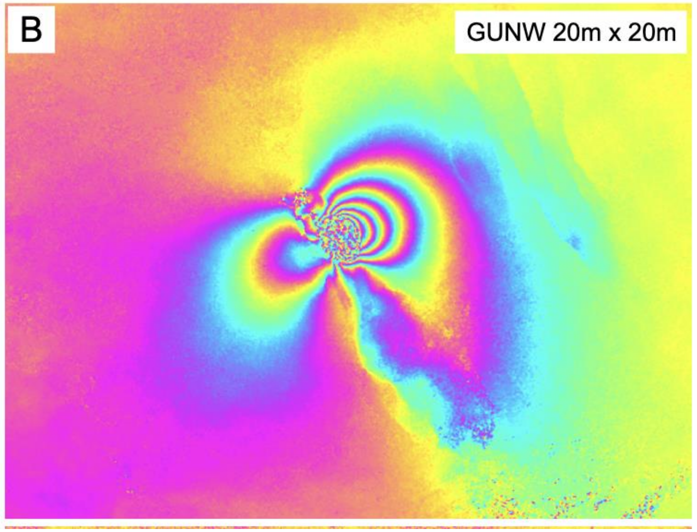
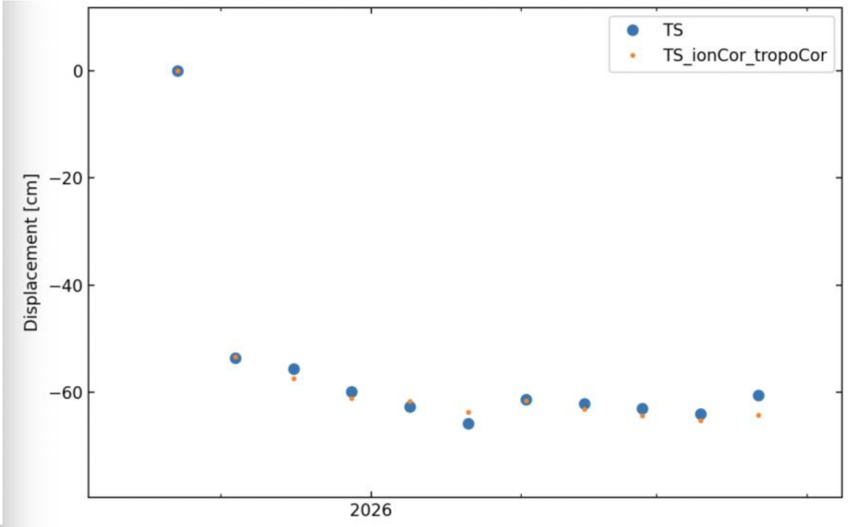
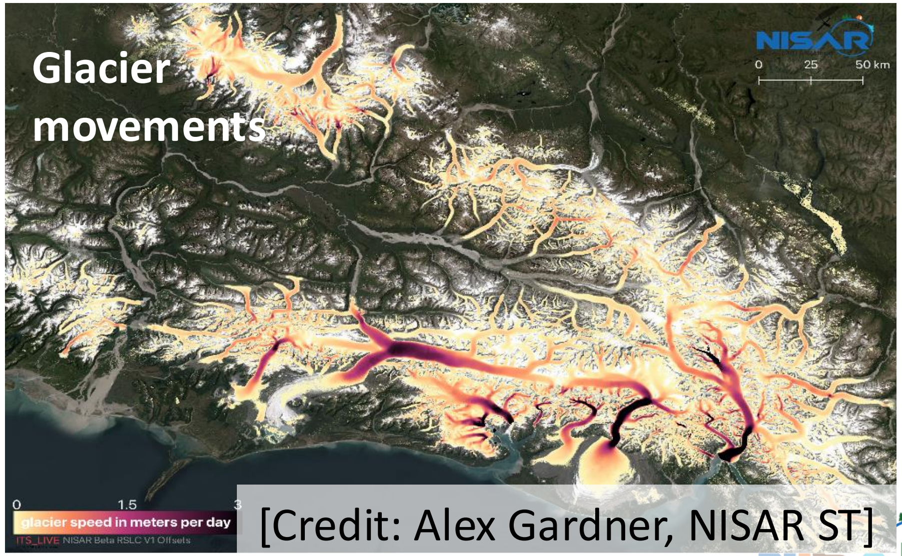

Mexico City Subsidence
LOS Velocity (cm/month)
-2 -1 0 1 2
[Credit: Marin Govorcin, Sara Mirzaee]


M5.7 Earthquake, NV, USA
(a)
(b)
(c)
(d)
Longitude
Latitude
Distance along profile (km)
Credit: Emre Havazli


NISAR POP1 (X05005) TSR Soil Moisture
Track 172, Frame 165-174
Soil Moistu
SMAP_PE 9km SM (AM)
Credit : NISAR Soil Moisture Science team


B
GUNW 20m x 20m


TS
TS_ionCor_tropoCor
Displacement [cm]
0
−20
−40
−60
2026


Glacier movements
NISAR
0 25 50 km
0 1.5 3
glacier speed in meters per day
[Credit: Alex Gardner, NISAR ST]

# Summary

- NISAR L1/L2 processor is stable within the NISAR science data system and have been successfully deployed to process hundreds of thousands of products at a global scale.

- Edge cases have been identified during commissioning and cal/val and fixes have been delivered when applicable.

- Geometric calibration, interferometric phase calibration, radiometric and polarimetric calibration have been performed and the calibrated products are under validation activities

- Algorithms to mitigate Radio Frequency Interference and to estimate ionospheric phase have been verified and deployed in the production system.

**NISAR Data User Guide**

https://nisar-docs.asf.alaska.edu/

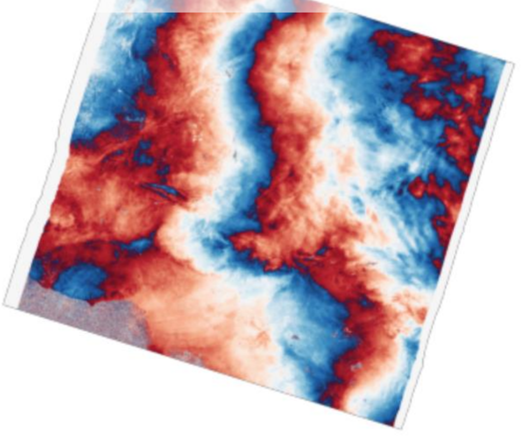
NISAR
NASA - ISRO SAR Mission

# Backup slides

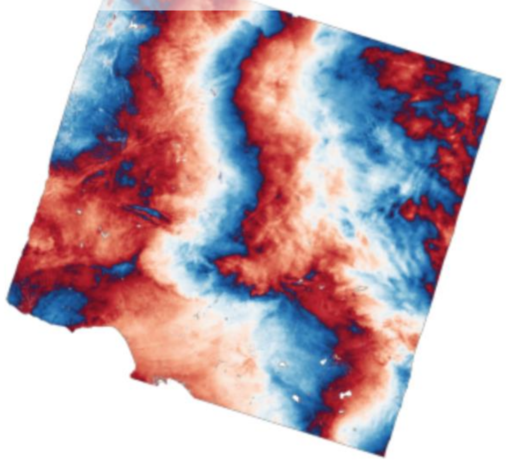
# Comprehensive metadata and masks in analysis ready products

Candidate to remove

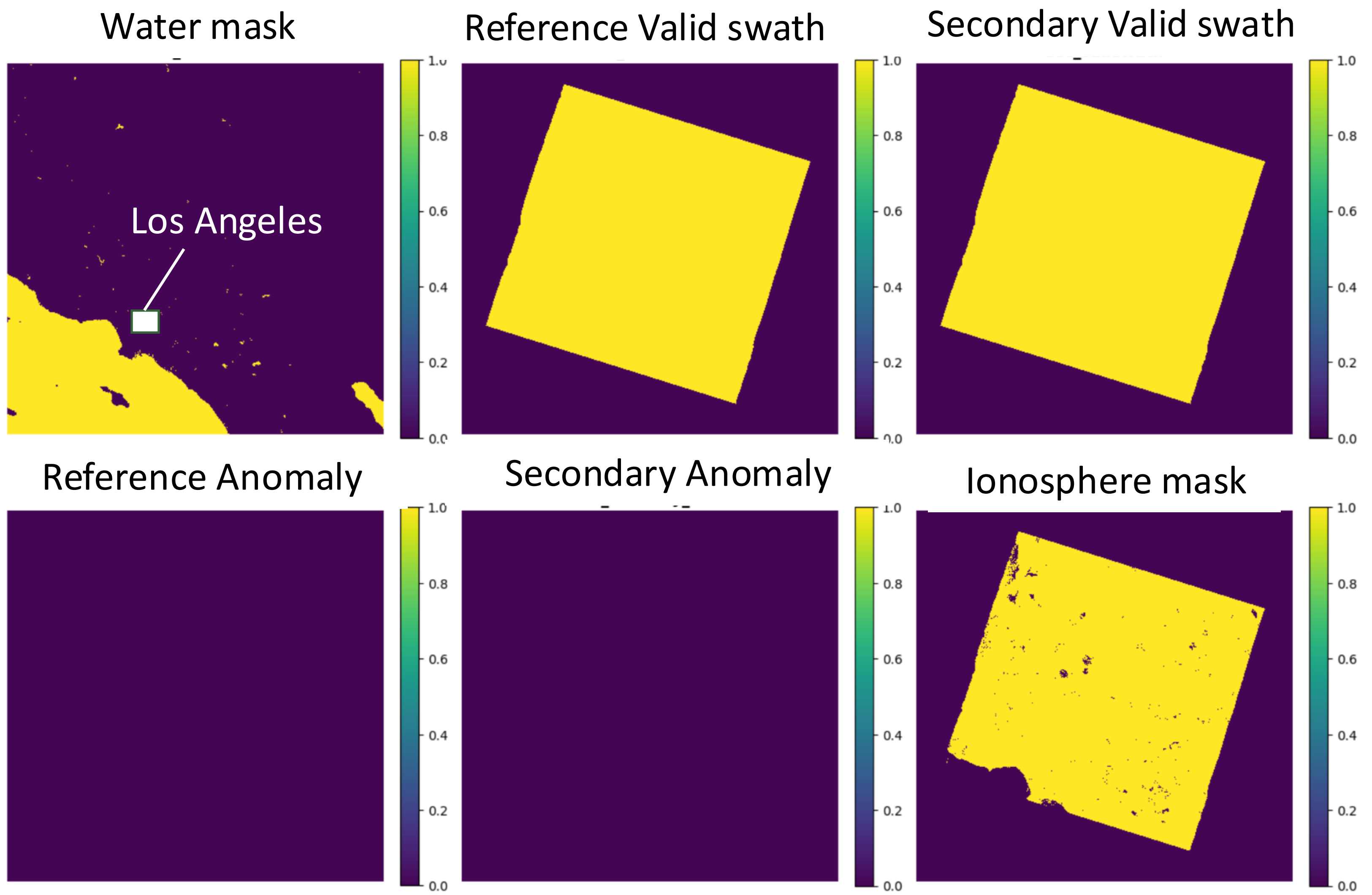
Unmasked interferogram



masked interferogram

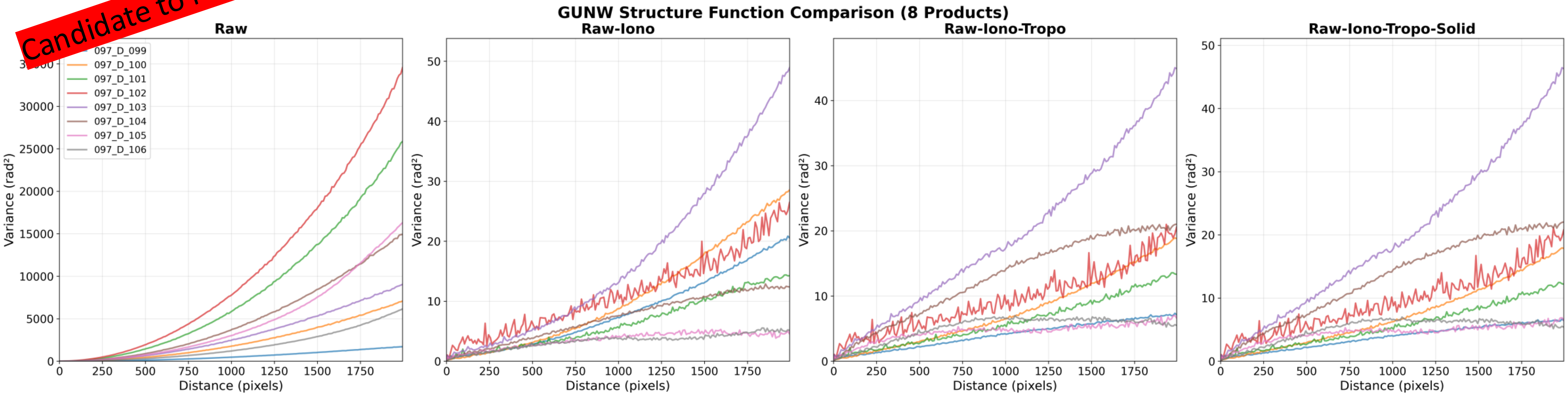


Mask datasets in the GUNW product



# Interferometric phase corrections with the correction layers included in the GUNW product

Candidate to remove




- On average the standard deviation of interferometric phase across NISAR frames have largely reduced from ~225 cm before any correction to ~ 8 cm after ionospheric, tropospheric and solid earth tide corrections.

- Ionosphere contributed to more than 95% of the observed interferometric phase in this example.

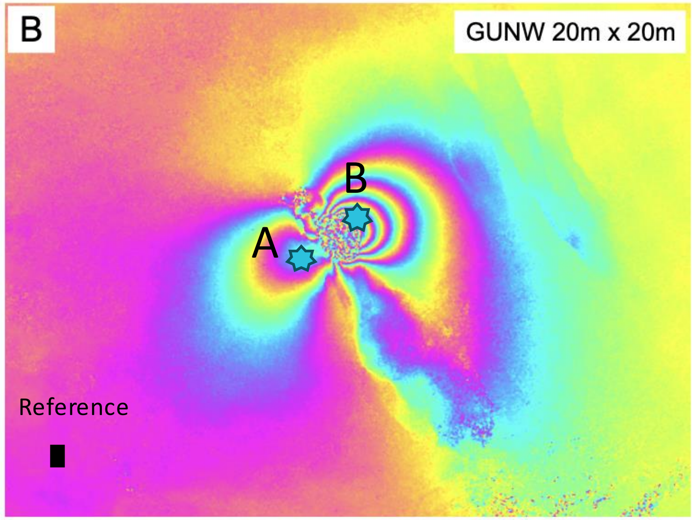
# NISAR Interferogram captures ground deformation

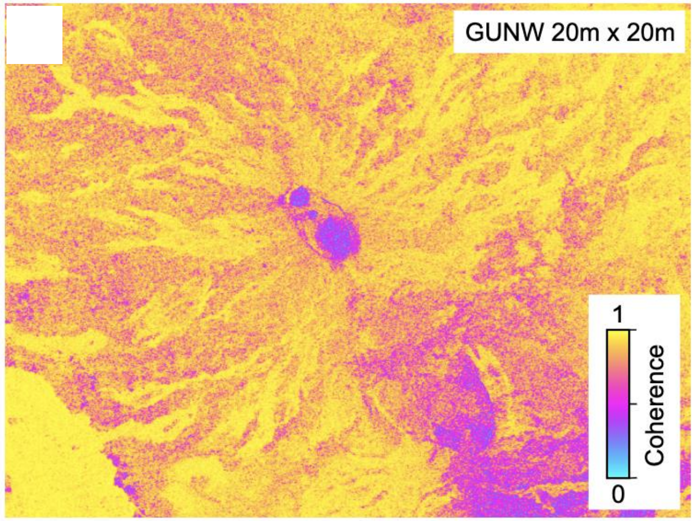
Candidate to remove

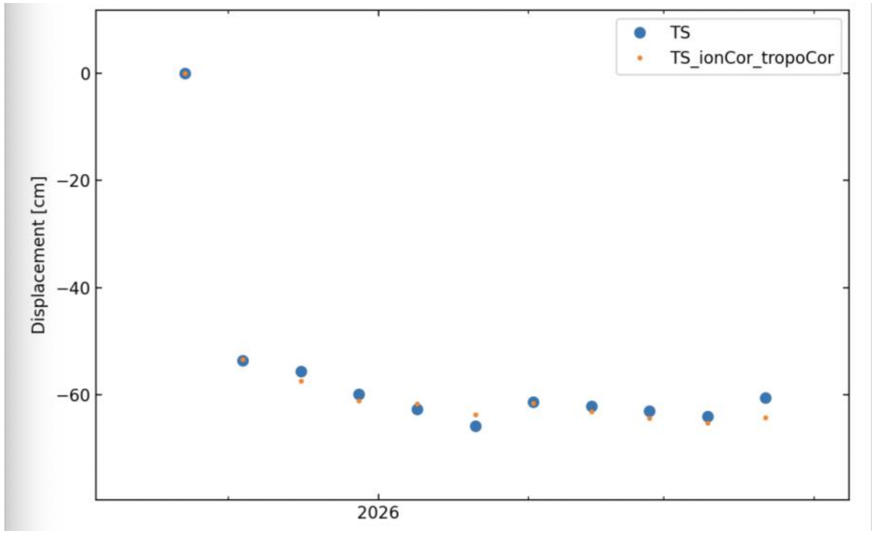
- On November 23, 2025, the Hayli Gubbi volcano in northern Ethiopia erupted

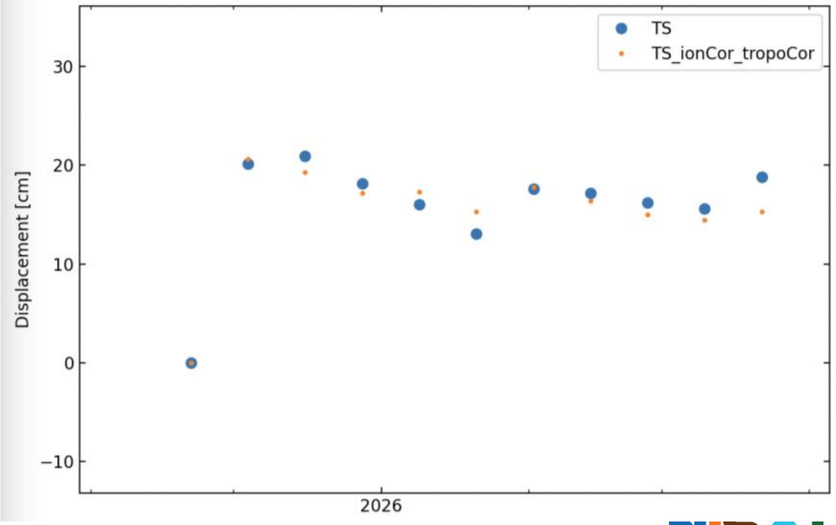
- In this remote area of East Africa, tectonic plates are moving away from each other, which allows magma to rise to the surface and feed several active volcanoes

- NISAR has captured the ground displacement due to this volcanic activity



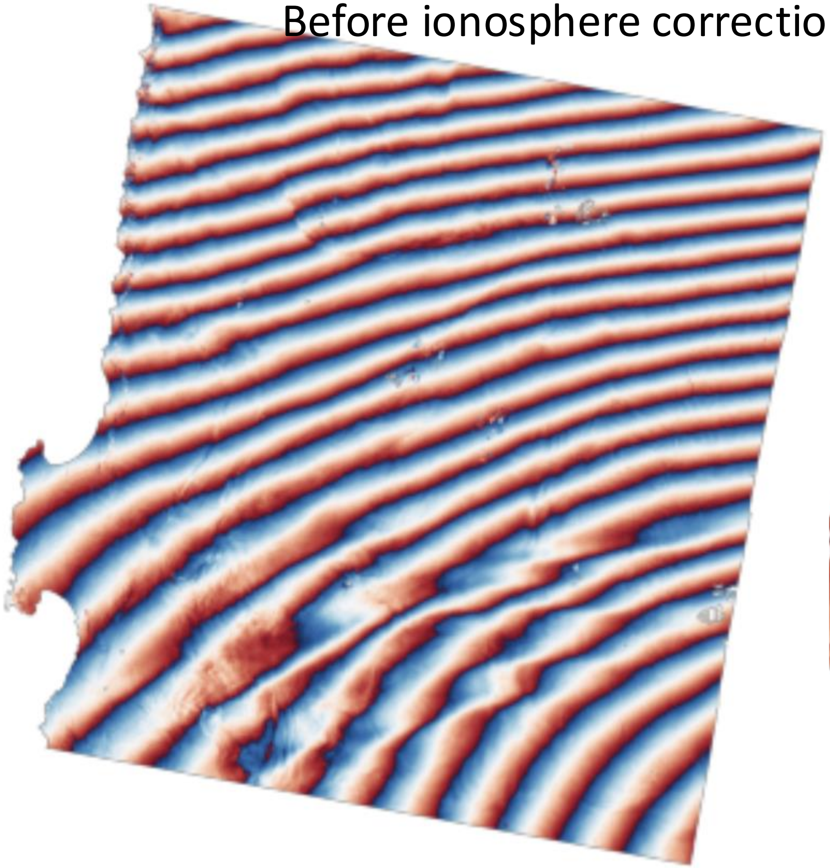



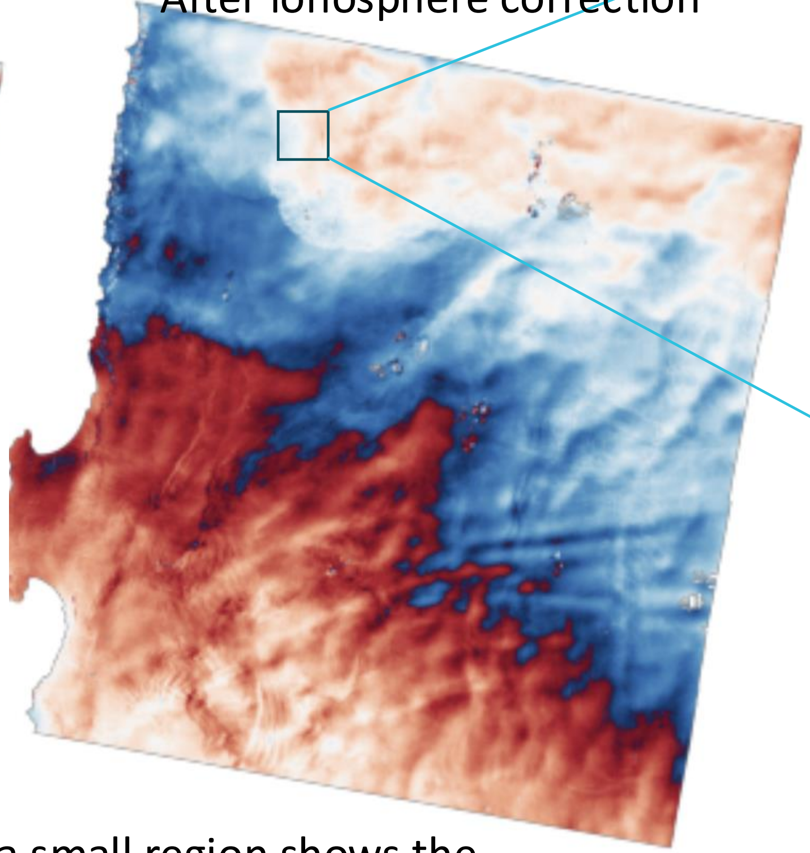



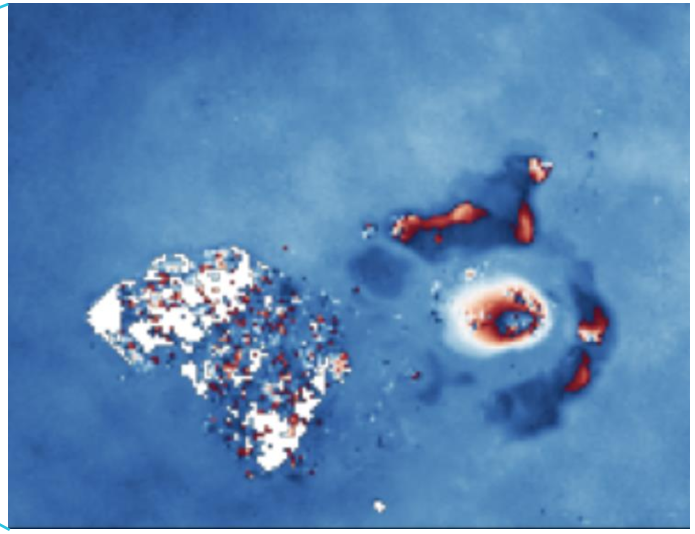
# Topography changes

GUNW interferogram
Before ionosphere correction



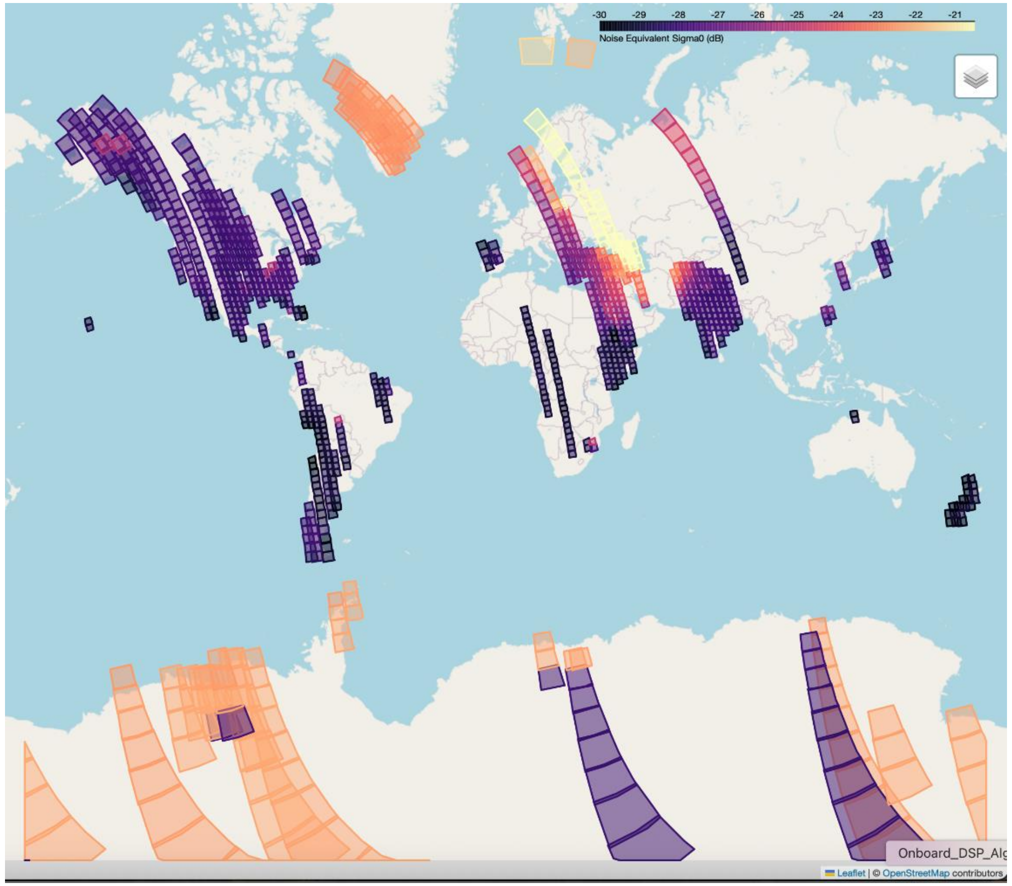
GUNW interferogram
After ionosphere correction

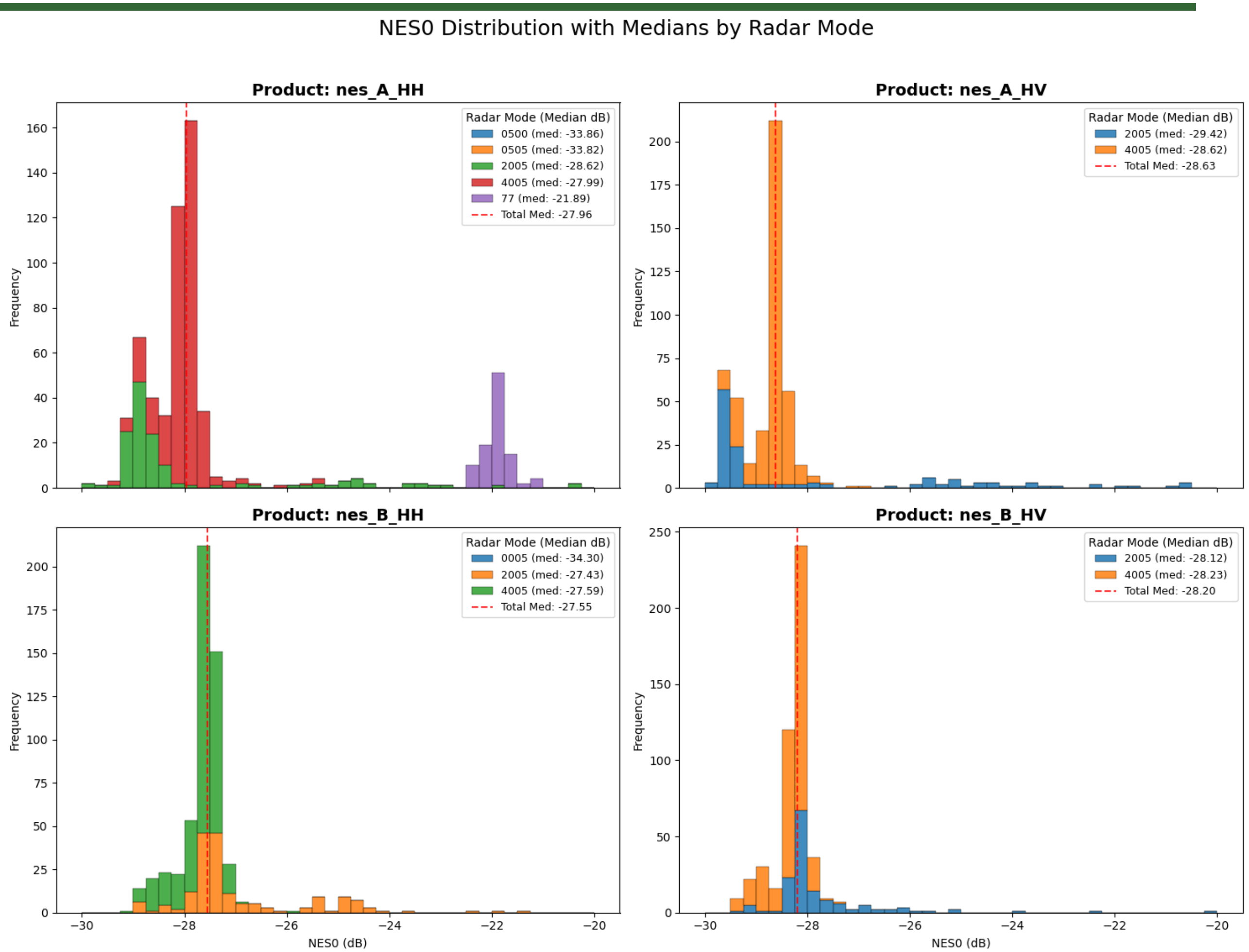





After ionosphere correction a zoom in to a small region shows the interferometric phase caused by topography changes over Chuquicamata Mine in Sierra Gorda, Chille.

# RSLC (Noise Equivalent Sigma-0)




Estimated noise power based on receive only pulses show satisfactory performance meeting NISAR requirement of ~ -23 dB. The performance for 77 MHz data is worse than 20 and 40 MHz due to loud Caltone overwhelming the recorded signal