EXPLOITATION OF 2-LOOK SCANSAR WITH ROSE-L FOR ALONG-TRACK SURFACE DEFORMATION MEASUREMENTS

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DLR

Motivation

Why along-track deformation measurements?

- Quasi-polar orbit
- Reduced N-S sensitivity of DInSAR phase
- Enable 3-D deformation measurements

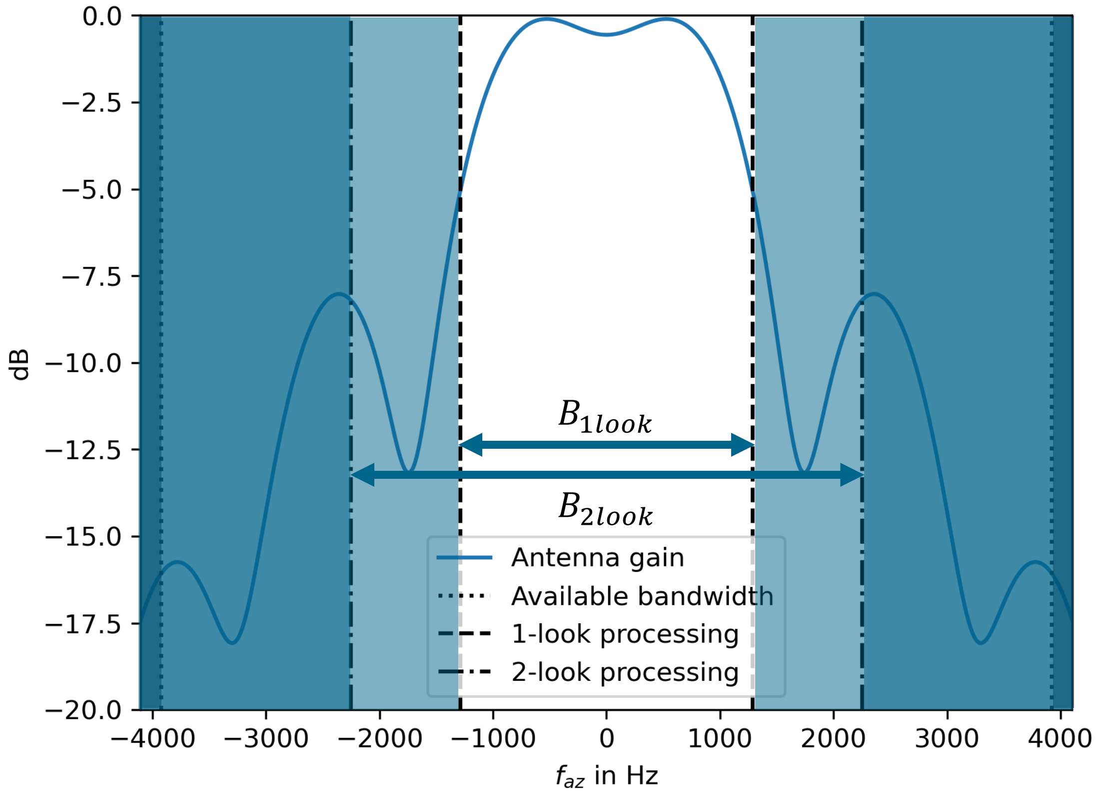
Why ROSE-L?

- Upcoming SAR mission
- Large available bandwidth
- ScanSAR

How?

- Processing more bandwidth
- Increase angular diversity

→ 2-look ScanSAR

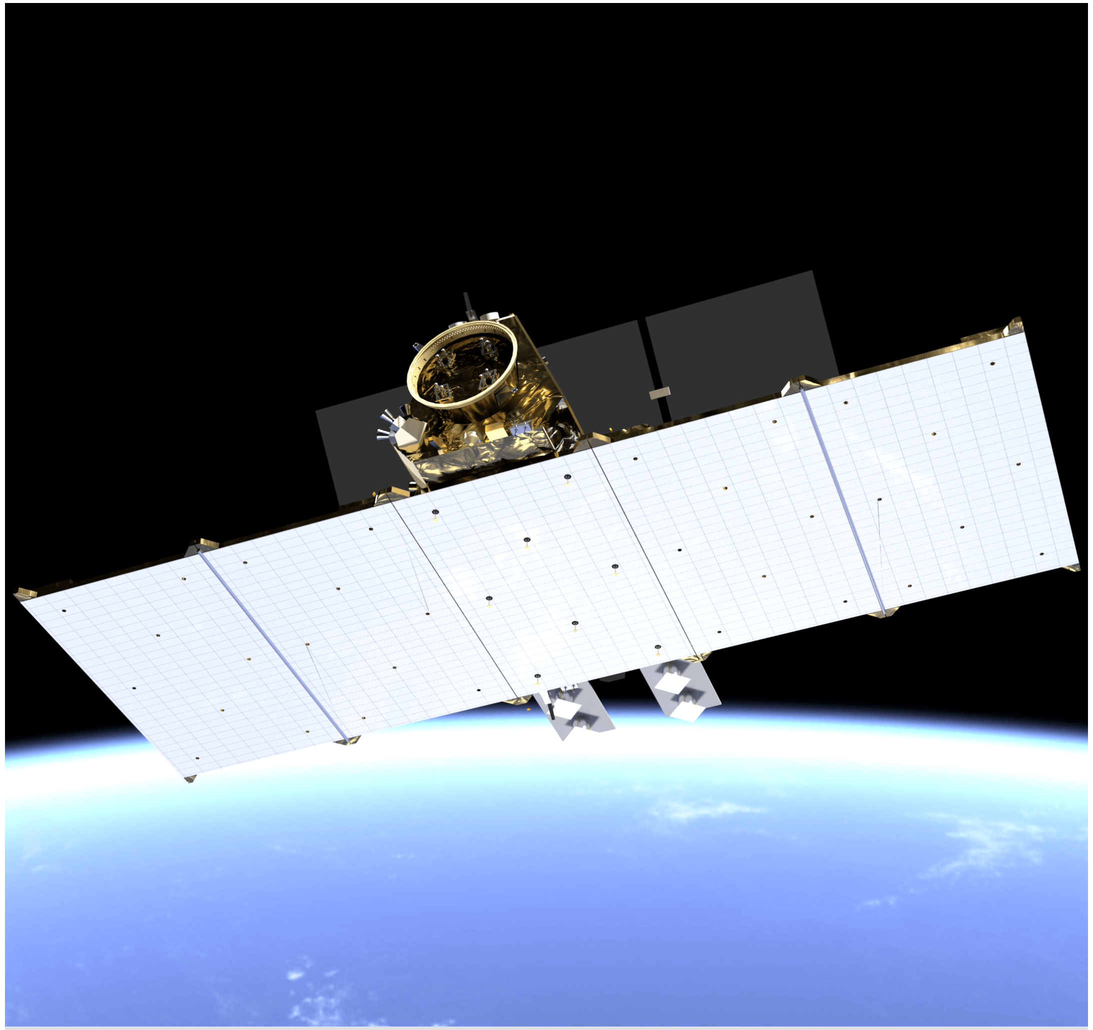


ROSE-L

- Part of Copernicus programme
  - Copernicus Sentinel Expansion mission

- L-band SAR
- Antenna: $11m \times 3.6m$ (five channels)
- Spatial resolution (az x rg):
  $\sim 10m \times 5m$ (dual pol)

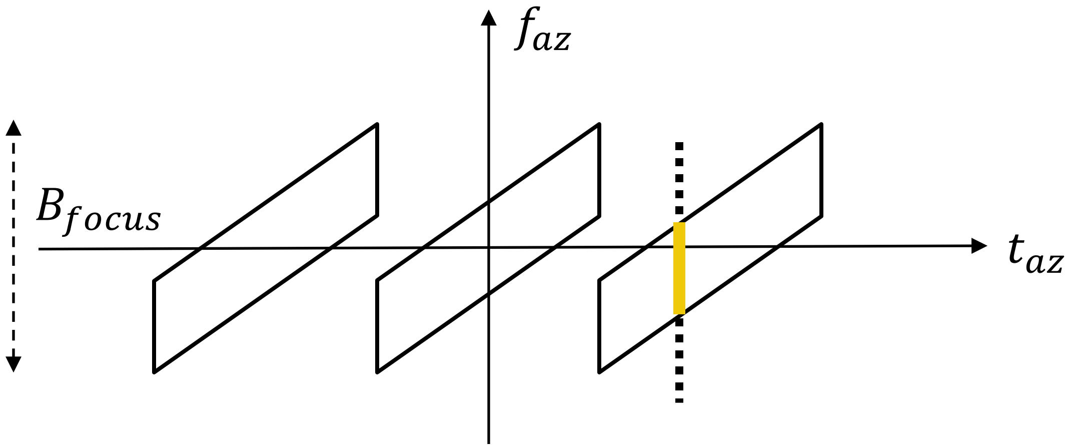
- Launch end of the decade



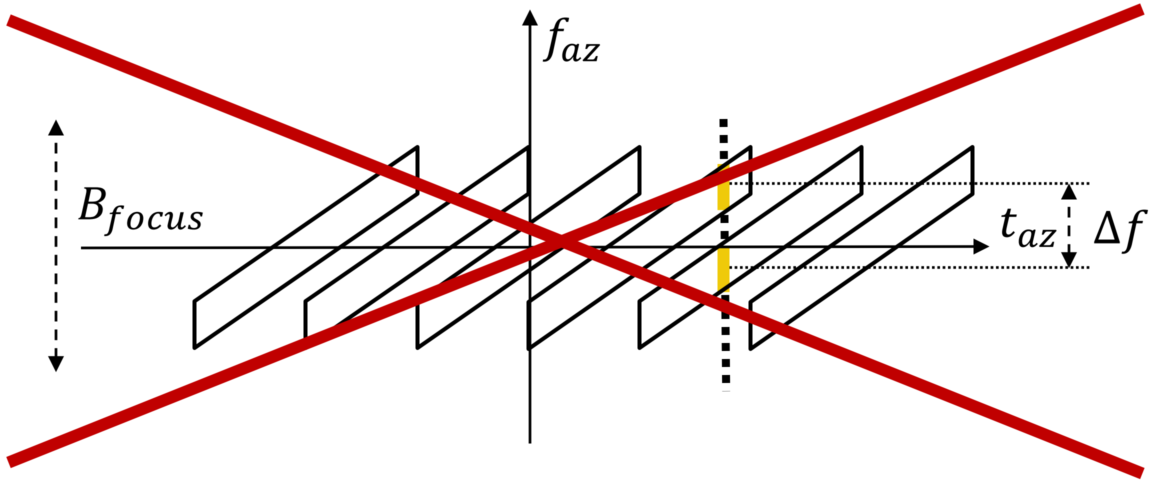
Source: https://www.esa.int/ESA_Multimedia/Images/2020/11/ROSE-L

Concept

1-look ScanSAR



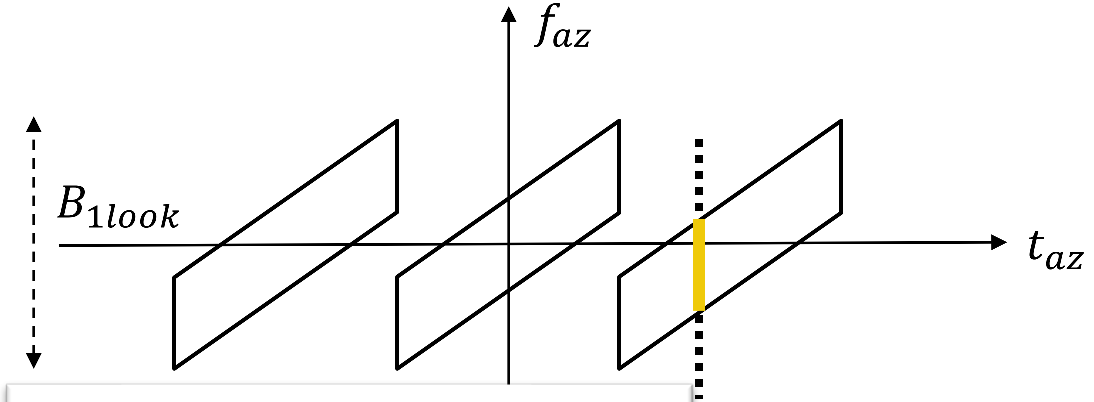
2-look ScanSAR (modified timeline)

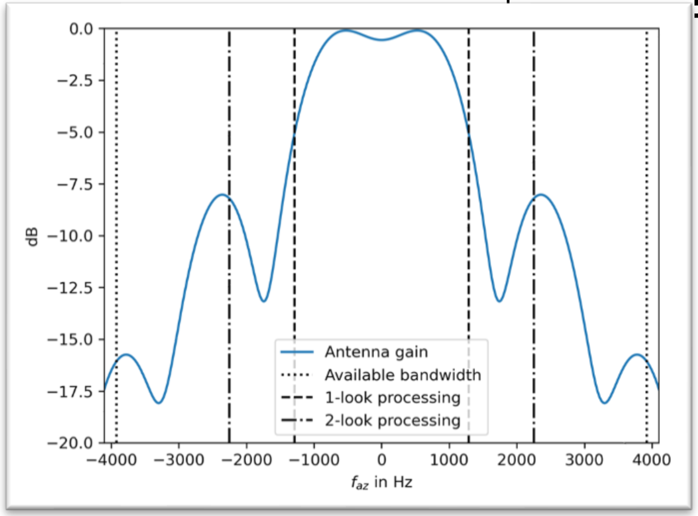


2-look ScanSAR so far: **Modified ScanSAR timeline**
- Half target bandwidth: Half azimuth resolution

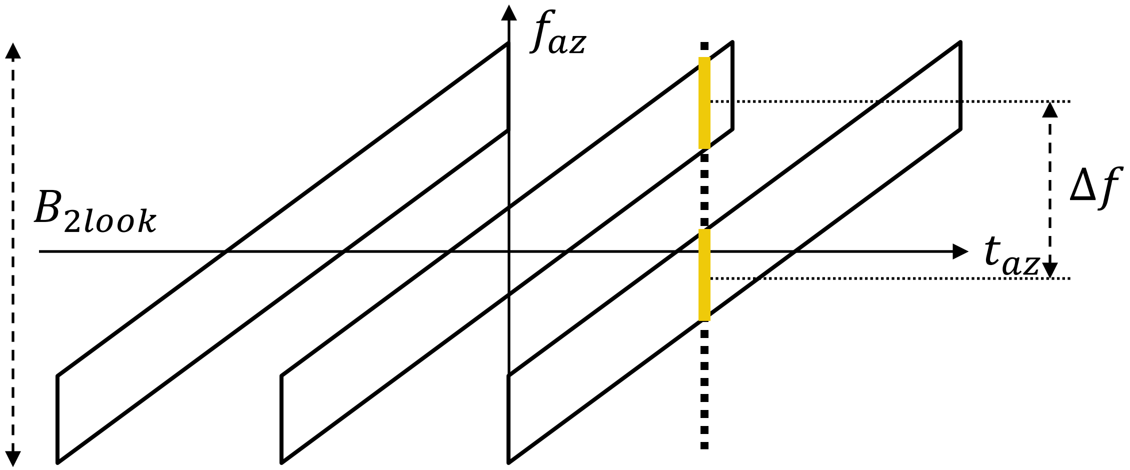
Concept

1-look ScanSAR





2-look ScanSAR (same timeline)



New 2-look ScanSAR approach:
Larger azimuth bandwidth available

- Same azimuth resolution
- But: Lower signal quality in extended burst areas
- Use of **spectral diversity** (aka MAI)

Assumptions for ROSE-L:

$$B_{rec} = 7840\ Hz$$
$$B_{1look} = 2570\ Hz$$
$$B_{2look} = 4500\ Hz$$
$$\Delta f = 1930\ Hz$$

Along-track motion estimation performance

1-look ScanSAR (Cross-correlation, reference)

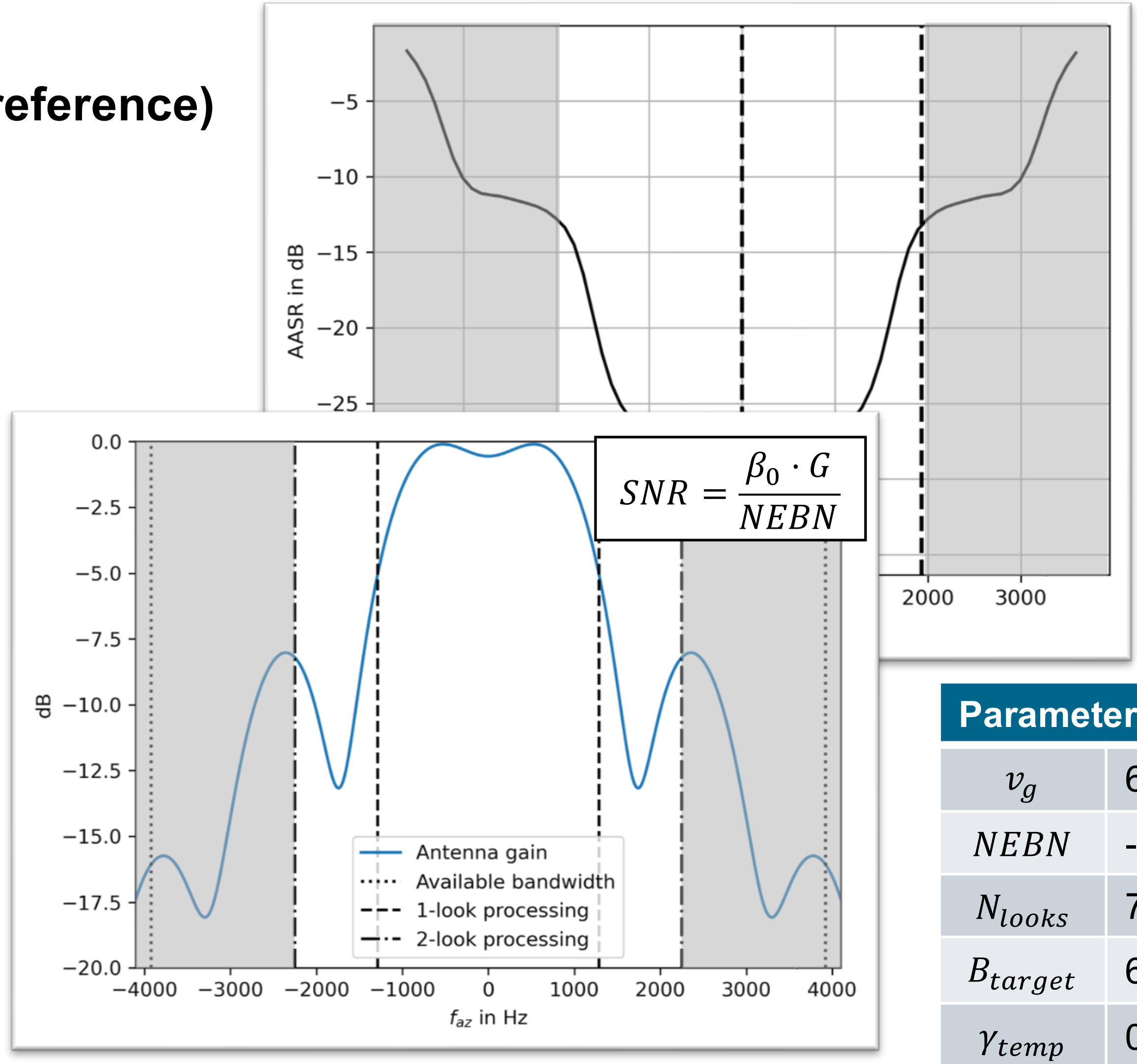
$$\sigma_{CC,CR} = \sqrt{\frac{3}{2 \cdot N_{looks}}} \frac{\sqrt{1-\gamma^2}}{\pi\gamma} \frac{v_g}{B_{target}} \text{ [1]}$$

2-look ScanSAR

$$\sigma_{2LSC} = \frac{1}{\sqrt{N_{looks}}} \frac{\sqrt{1-\gamma_{2LSC}^2}}{\gamma_{2LSC}} \frac{v_g}{2\pi\Delta f} \text{ [1]}$$

$$\gamma_{2LSC} = \sqrt{\gamma_{L1} \cdot \gamma_{L2}}$$

$$\gamma_{L\{1,2\}} = \gamma_{temp} \cdot \gamma_{SNR\{1,2\}} \cdot \gamma_{AASR\{1,2\}}$$



Parameters	
v_g	6811.34 m/s
$NEBN$	-26.2 dB
N_{looks}	70 (~50m x 70m)
B_{target}	640 Hz
γ_{temp}	0.7

[1] R. Bamler and M. Eineder, "Accuracy of differential shift estimation by correlation and split-bandwidth interferometry for wideband and delta-k SAR systems," in *IEEE Geoscience and Remote Sensing Letters*, vol. 2, no. 2, pp. 151-155, April 2005.

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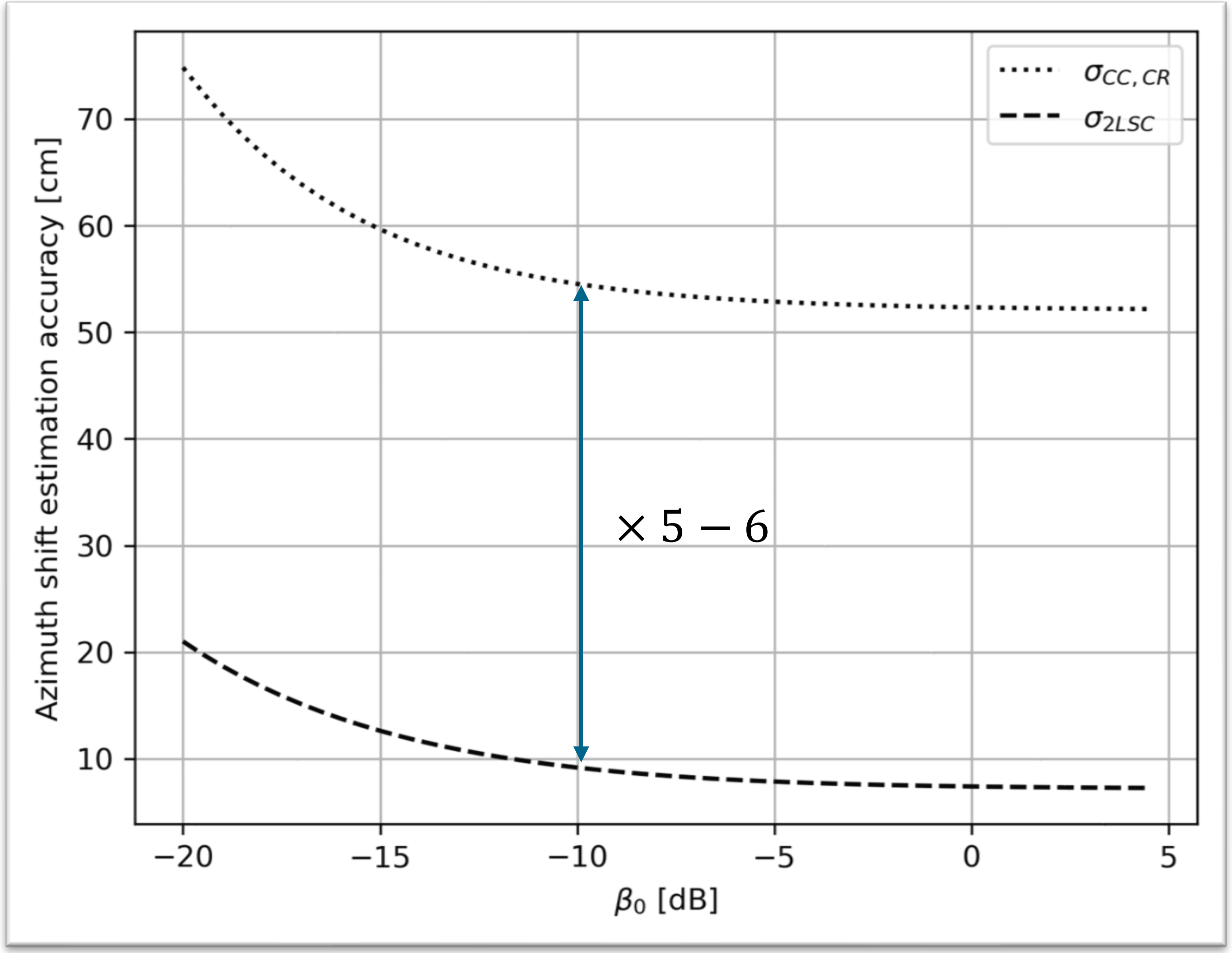

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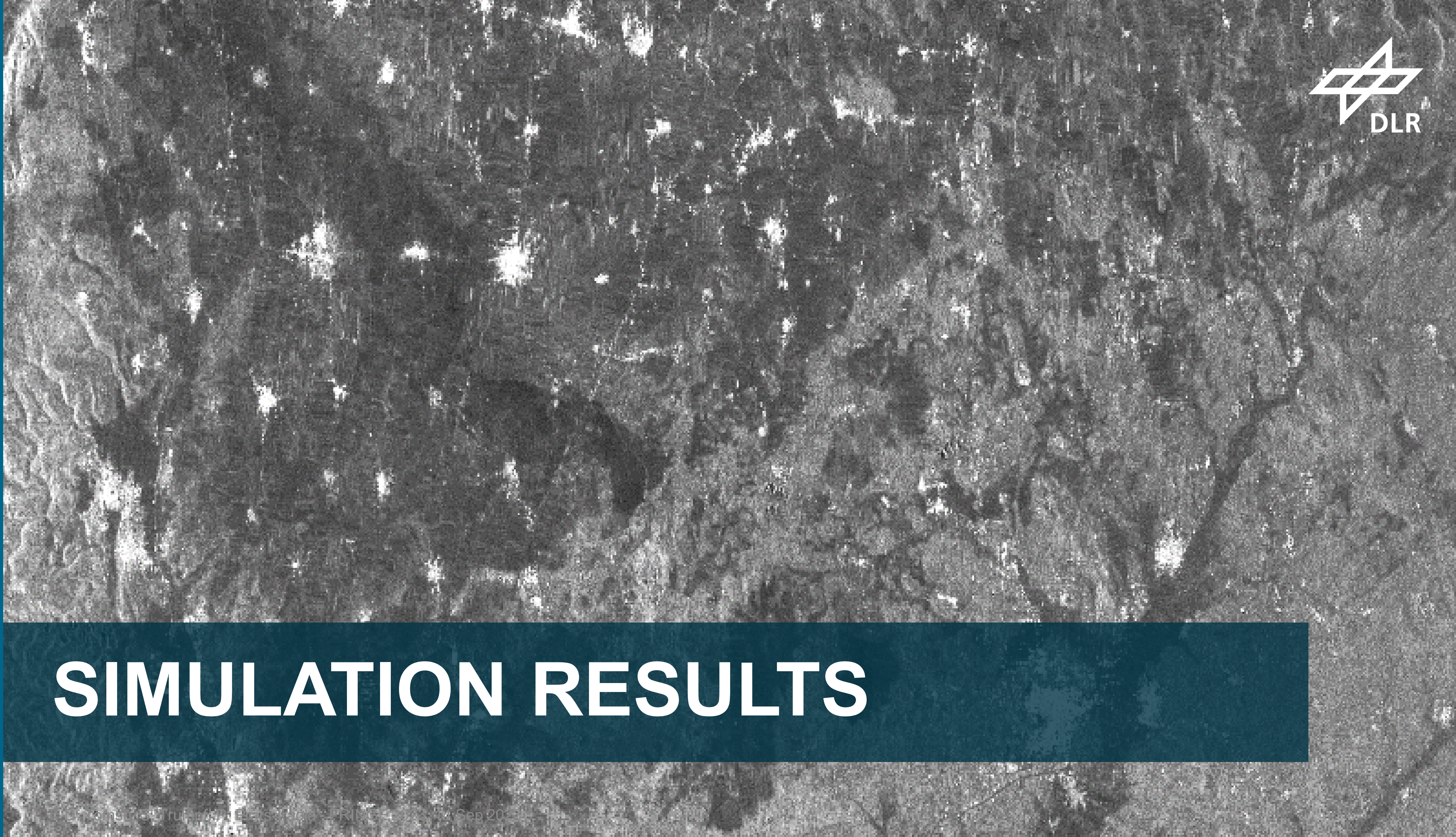


SIMULATION RESULTS

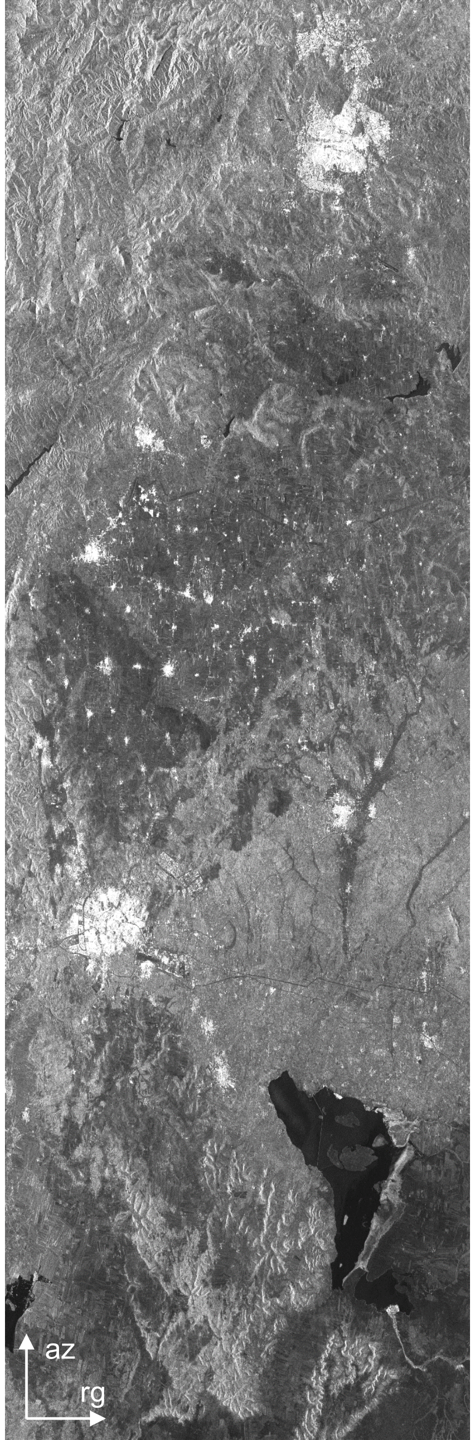
Input data

Input reflectivity

- Reflectivity of Sentinel-1 acquisition over Turkey-Syria border region (East Anatolian fault)

- Scene size (az x rg):
  $$150km \times 45km$$
- Spatial resolution (az x rg):
  $$50m \times 30m$$

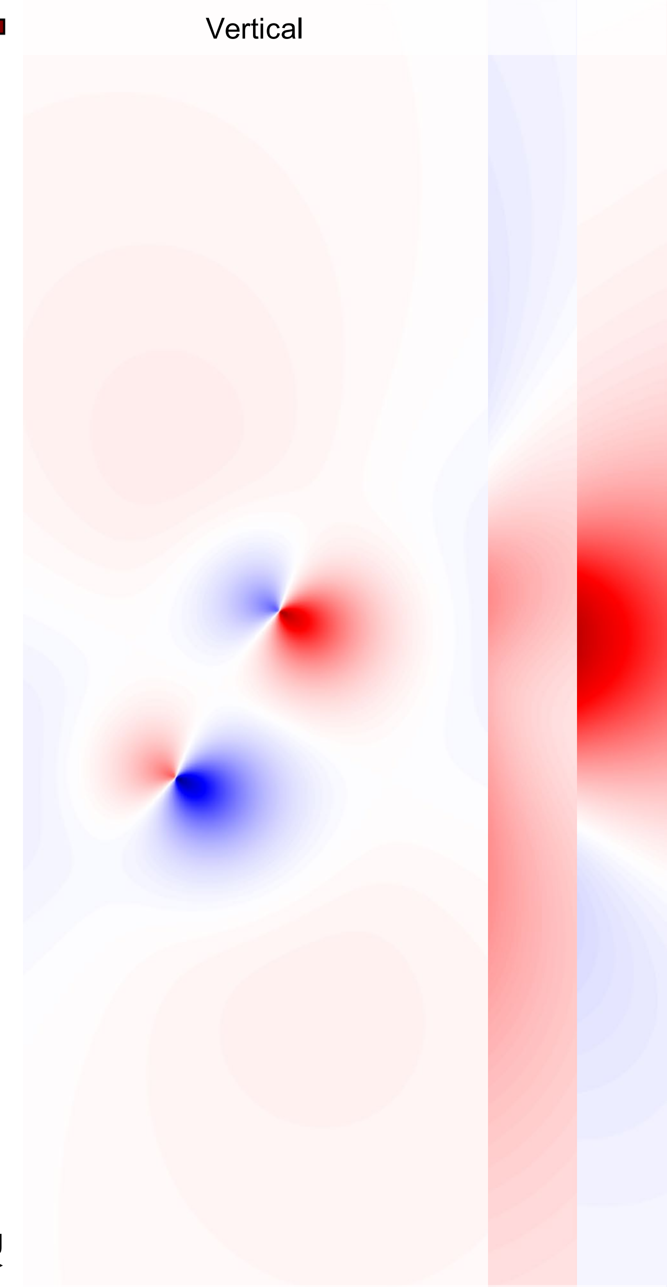
- Sinc-interpolation to match temporal sampling of
  $$\frac{1}{15}\mathrm{PRI}_{\mathrm{ch}}$$
  for <u>introduction of azimuth ambiguities</u>



Deformation

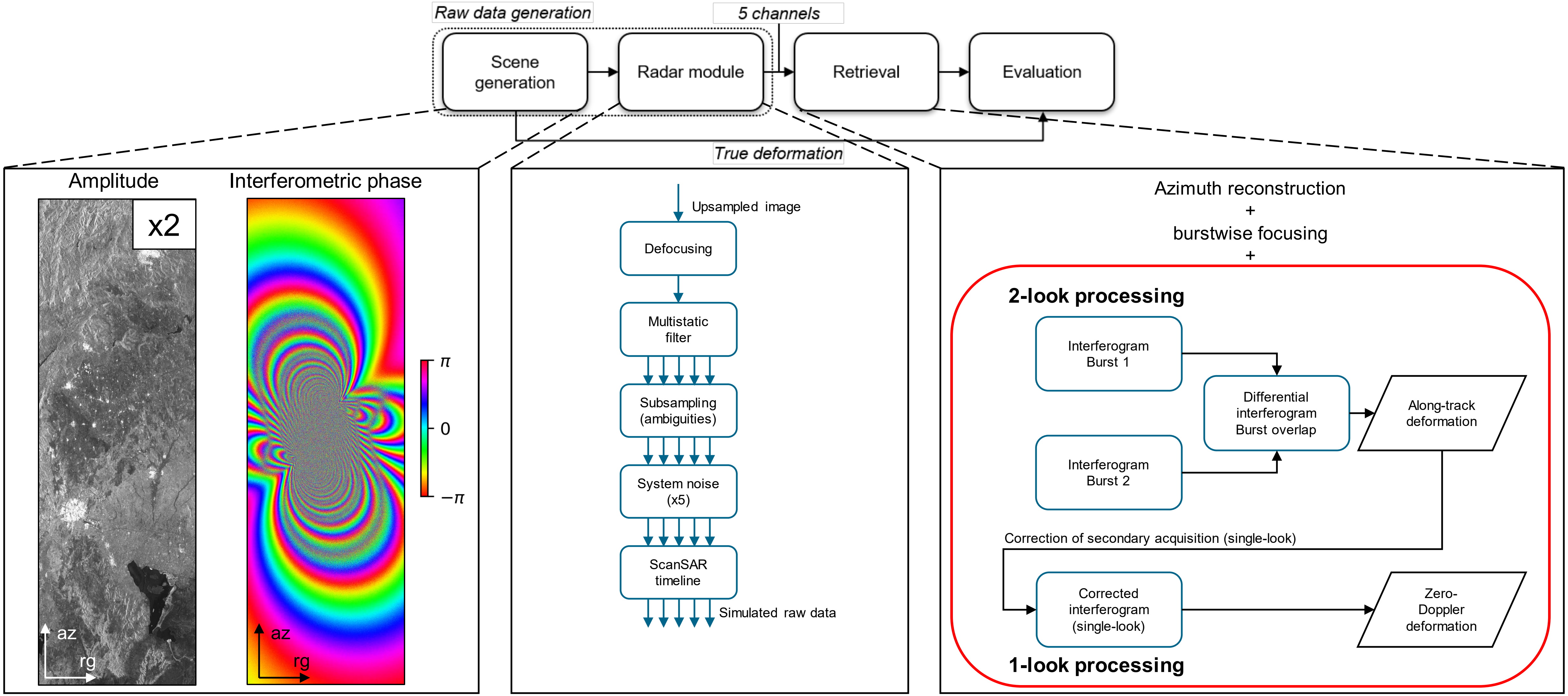
- Artificial deformation using Okada model [3]
- Finite rectangular source
- Strike-slip fault deformation

- Strong along-track component



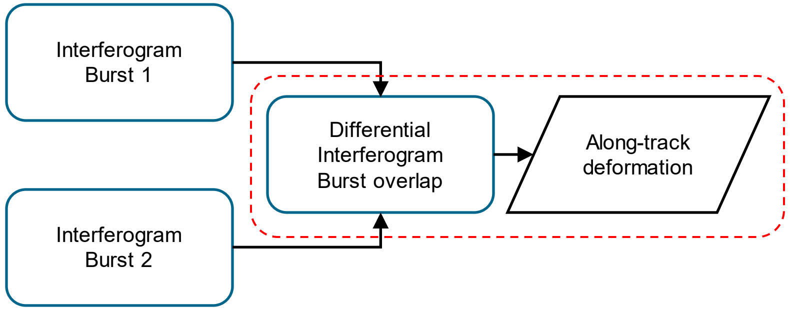
[3] Okada, Yoshimitsu. "Internal deformation due to shear and tensile faults in a half-space." *Bulletin of the seismological society of America* 82.2 (1992): 1018-1040.

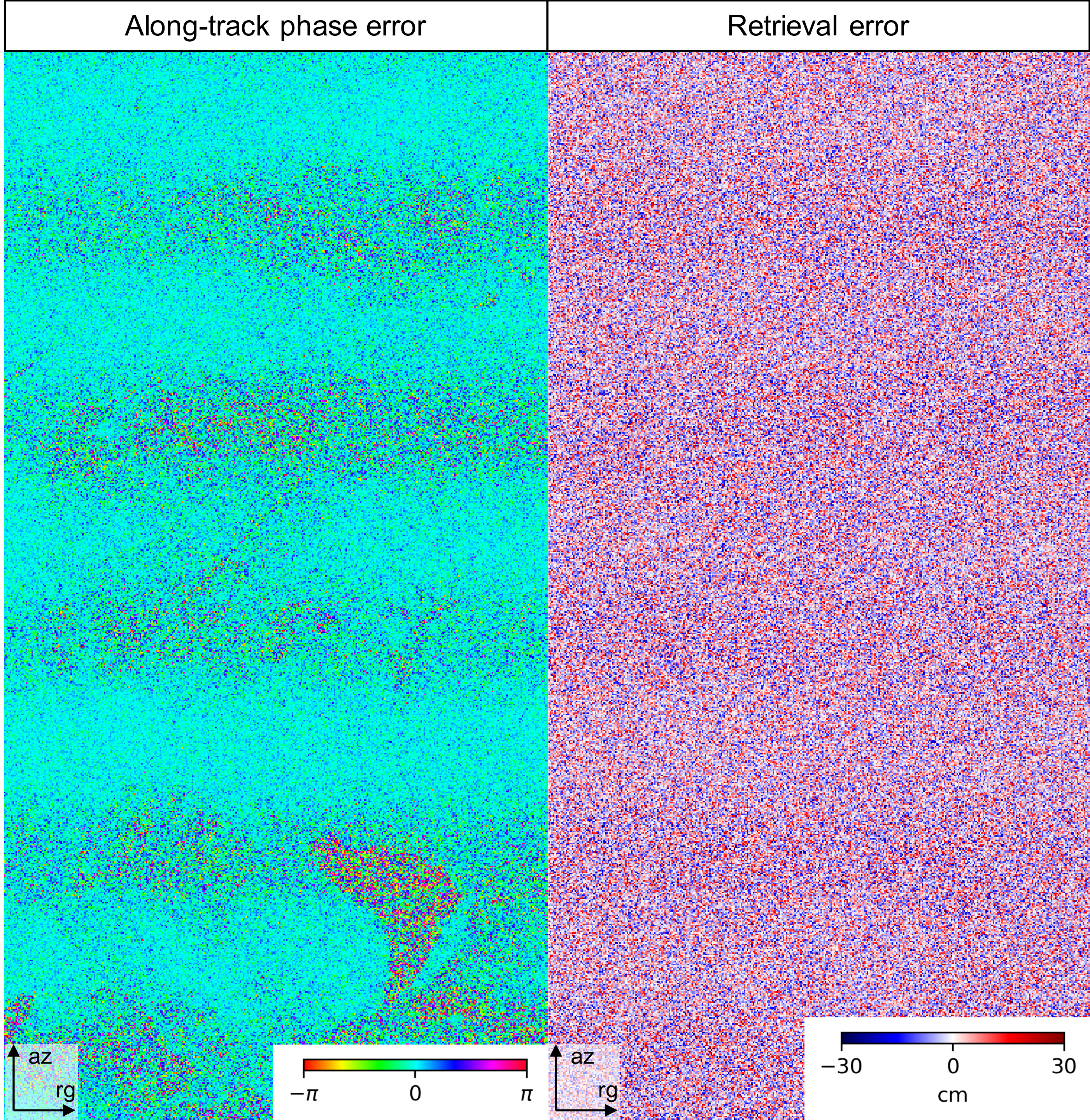
Simulation structure



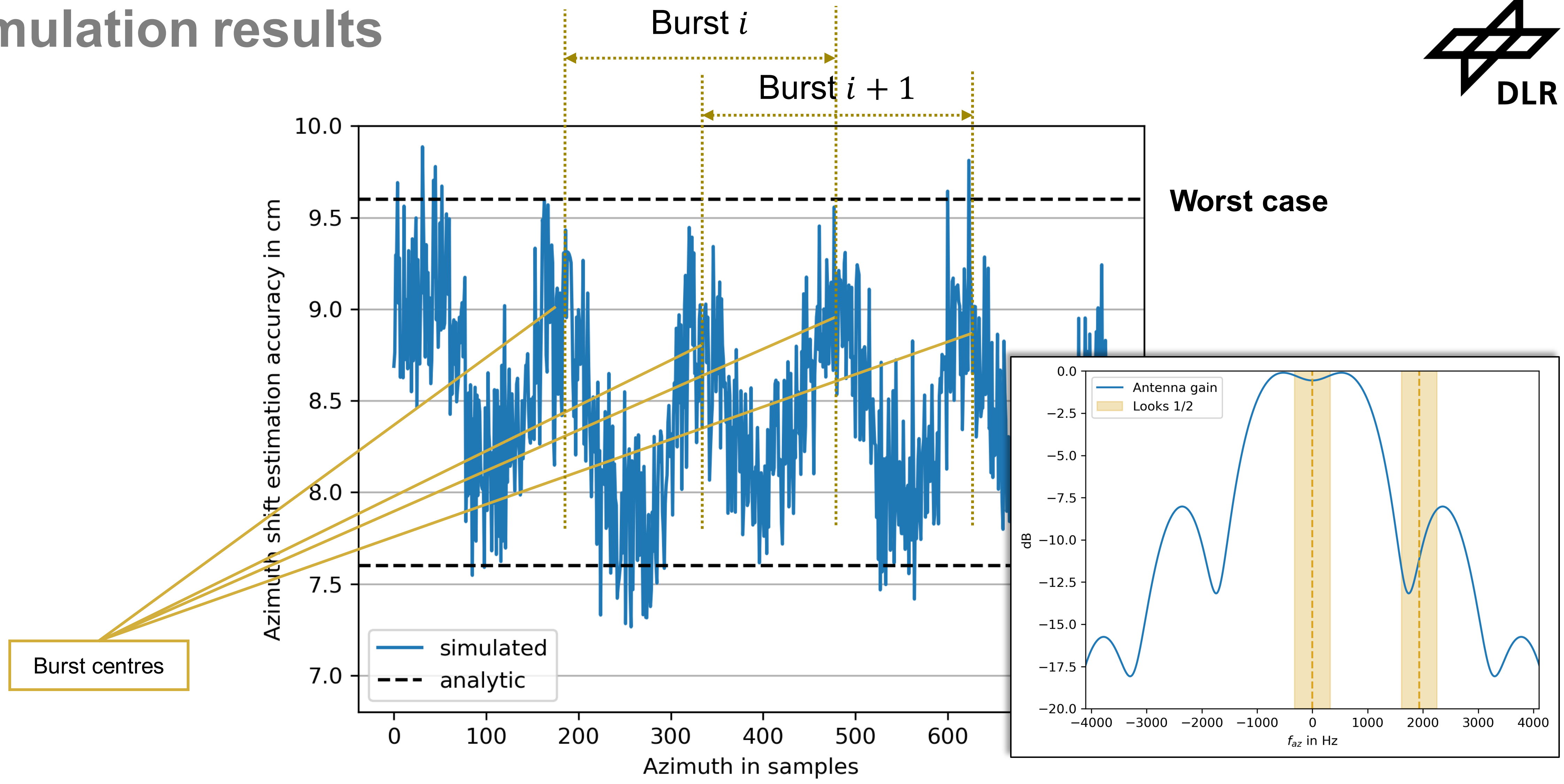
Simulation results

2-look processing





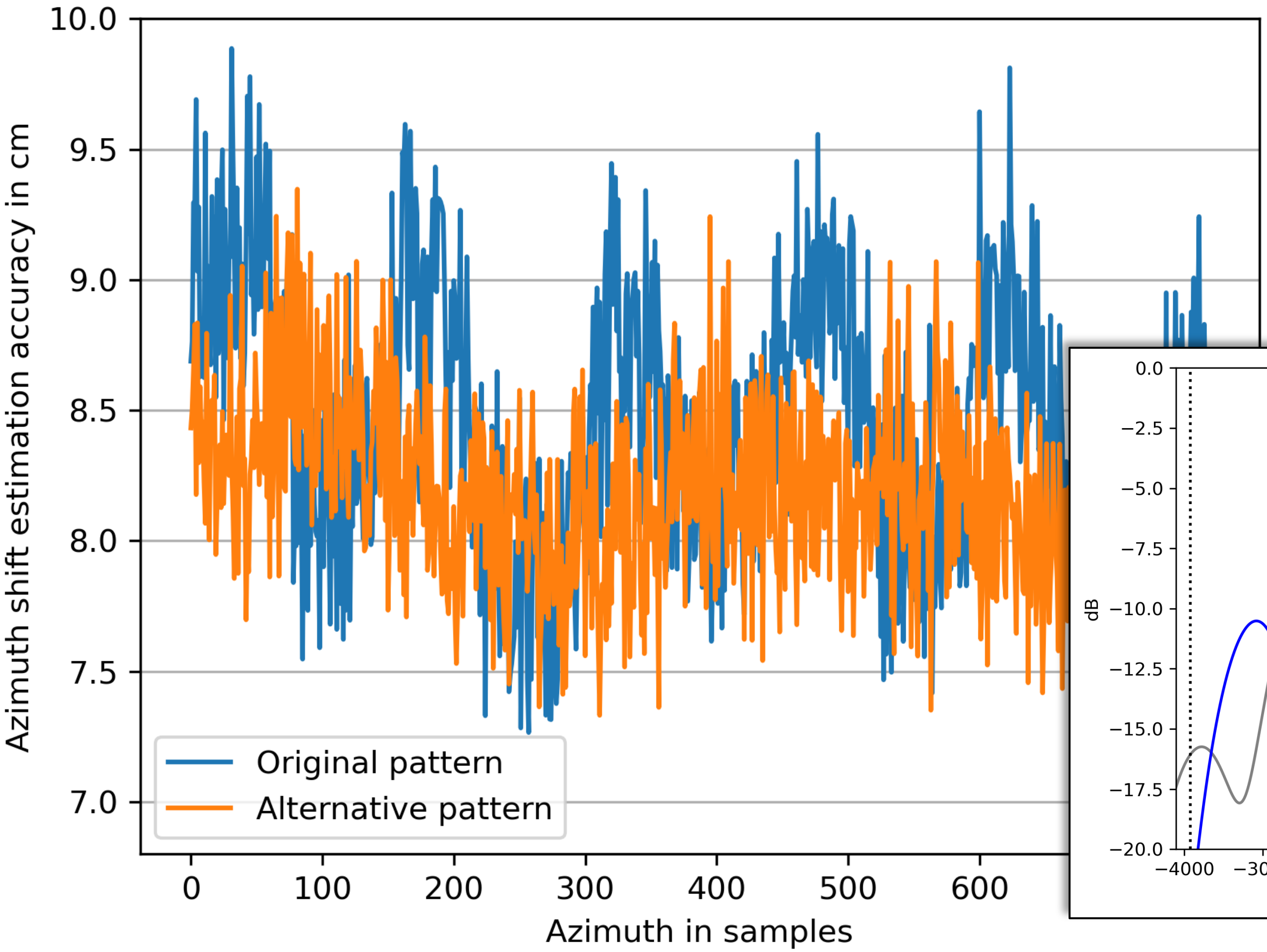
Simulation results

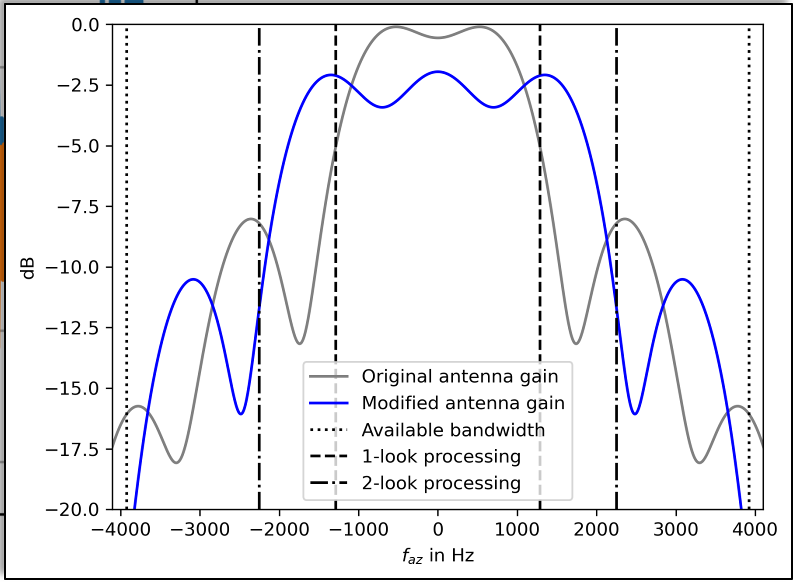


Simulation results

Influence of the antenna pattern

Idea: Adapting the **transmit antenna pattern phase spoiling** to widen the main antenna lobe [4]

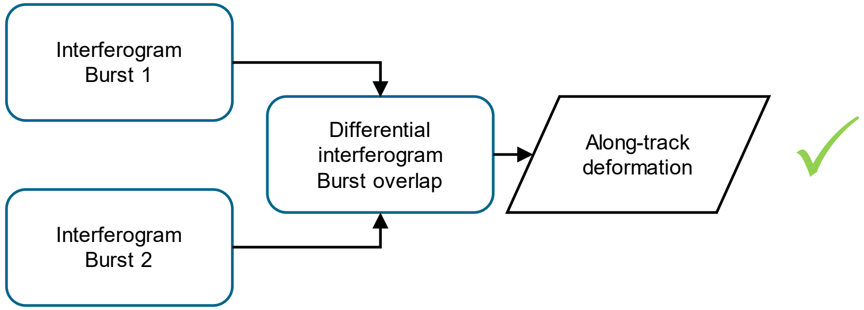


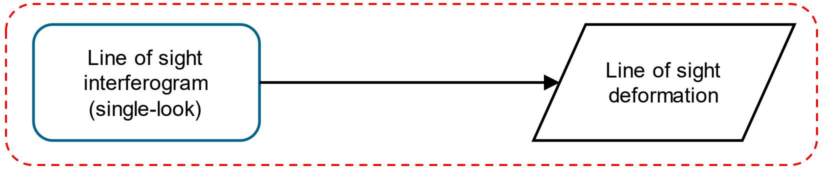


[4] S. Perna, F. Longo, S. Zoffoli, M. Davidson, L. Lannini and R. Lanari, "Advanced ScanSAR Capabilities Enabled by Optimized Antenna Array Azimuth Radiation Patterns: the ROSE-L Case Study," *IGARSS 2022 - 2022 IEEE International Geoscience and Remote Sensing Symposium*, Kuala Lumpur, Malaysia, 2022.

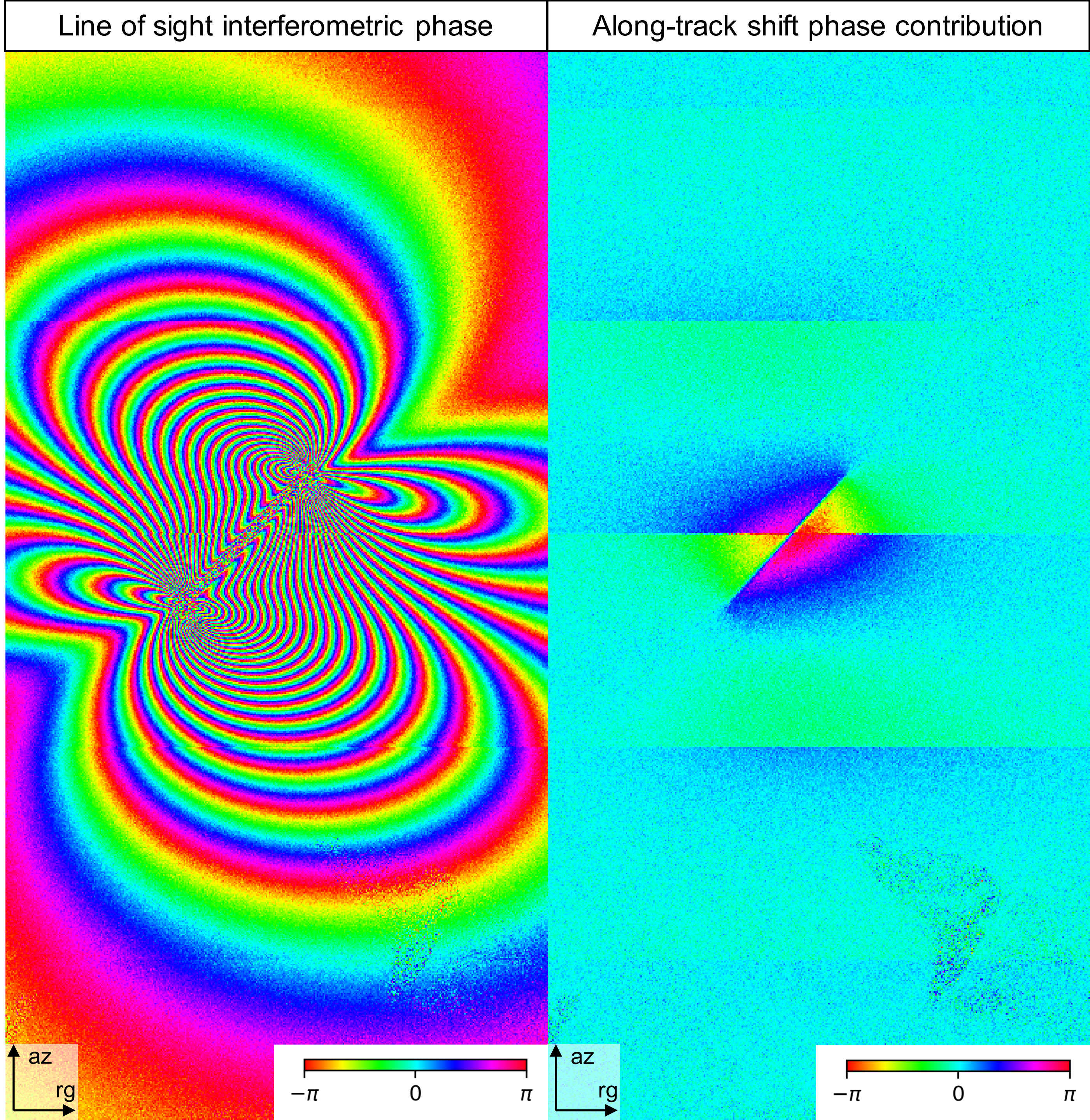
Simulation results

2-look processing



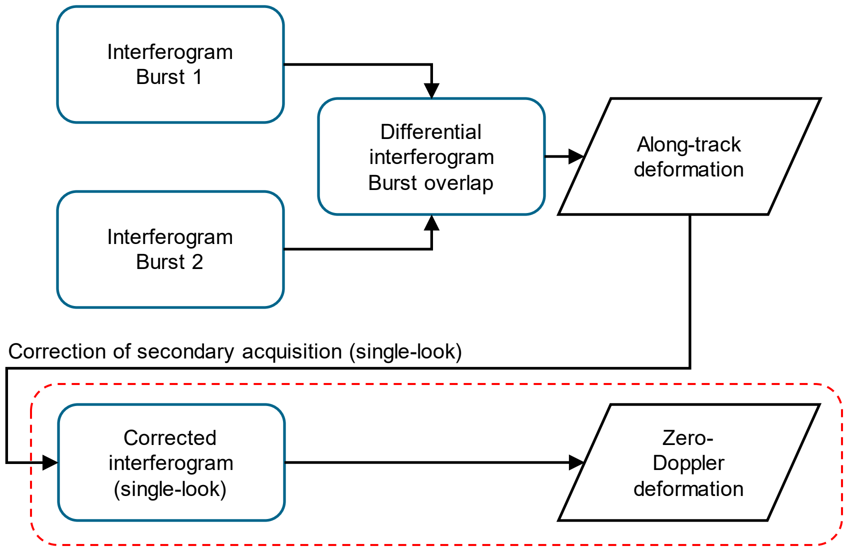


1-look processing



Simulation results

2-look processing



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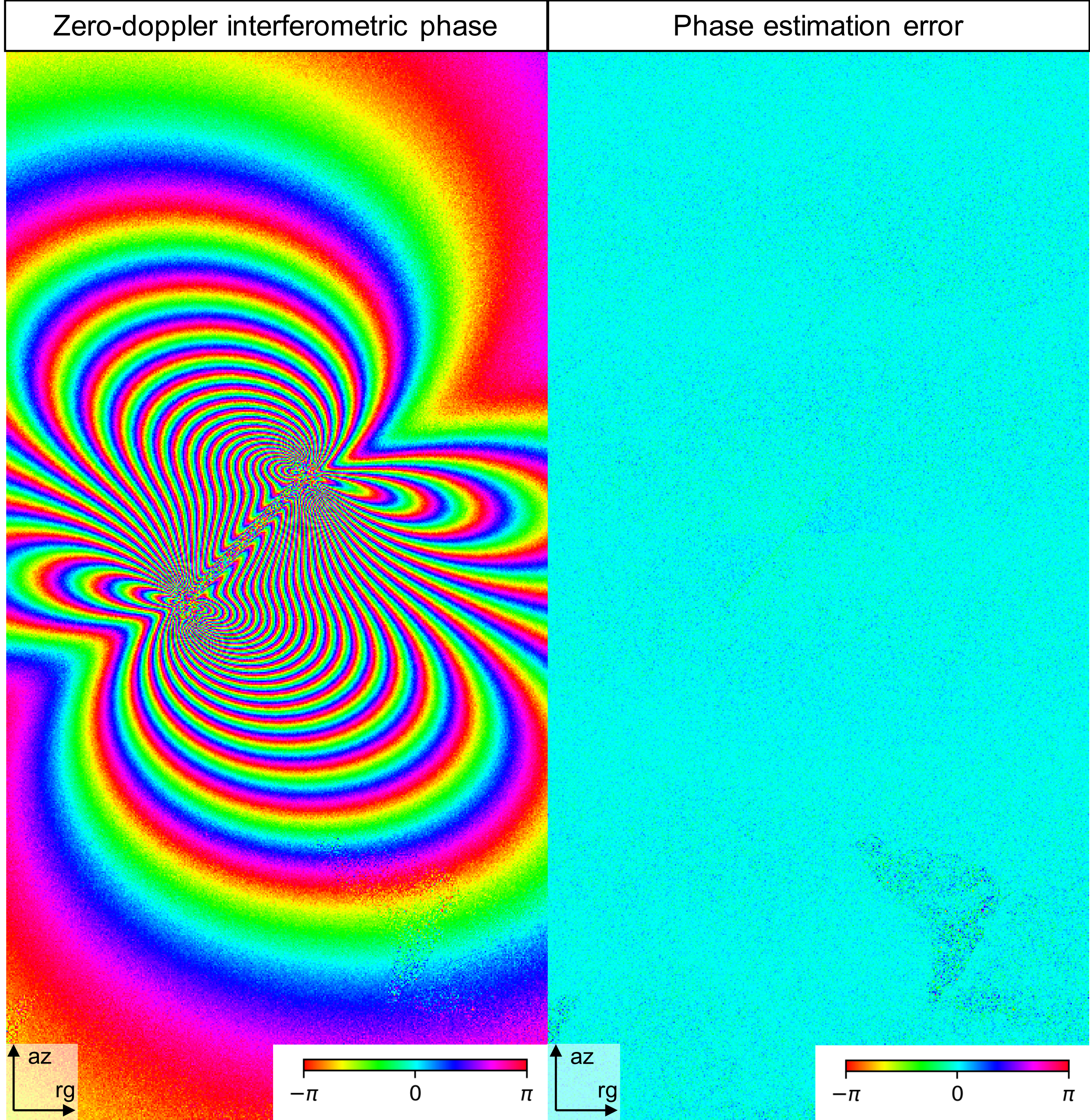

Conclusion

- Azimuth shift retrieval with 2-look ScanSAR in ROSE-L is possible without modifying the ScanSAR timeline nor the transmit antenna pattern

- Azimuth shift retrieval accuracy: $8 - 9\ cm$ @ spatial resolution $50 \times 70m$
  - But: depends on number of looks N_{looks}, can be improved by increasing N_{looks}

- Correction of 1-look interferograms feasible
  - Potential to correct jumps due to the ionosphere by exploiting the 2-look processing at ionospheric height

THANK YOU!

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