COHERENT AZIMUTH AMBIGUITY REMOVAL FOR ROSE-L TWO-LOOK SCANSAR ALONG-TRACK DEFORMATION MEASUREMENTS

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DLR

ROSE-L

- Part of Copernicus programme
  - Copernicus Sentinel Expansion mission
- L-band SAR
- Antenna: $11m \times 3.6m$
  - five azimuth channels with digital beamforming
- Spatial resolution (az x rg):
  $\sim 10m \times 5m$ (dual pol)
- ScanSAR

- Launch: end of the decade

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

Motivation

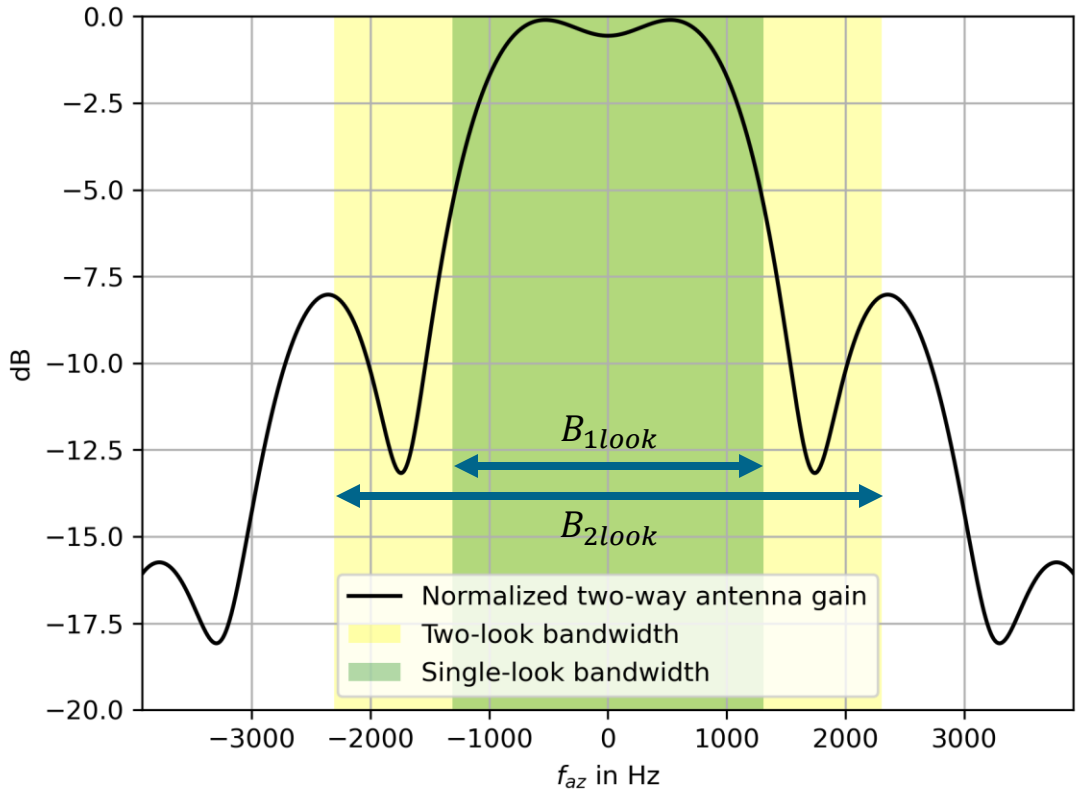
New opportunities with ROSE-L:

- Large available bandwidth in azimuth
- Possibility to process large overlaps between ScanSAR bursts

→ 2-look ScanSAR approach

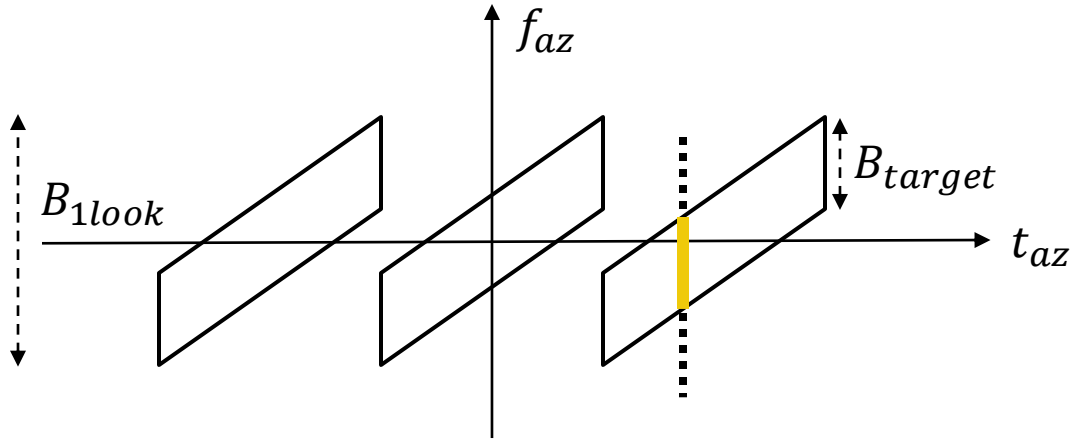
Along-track deformation measurements

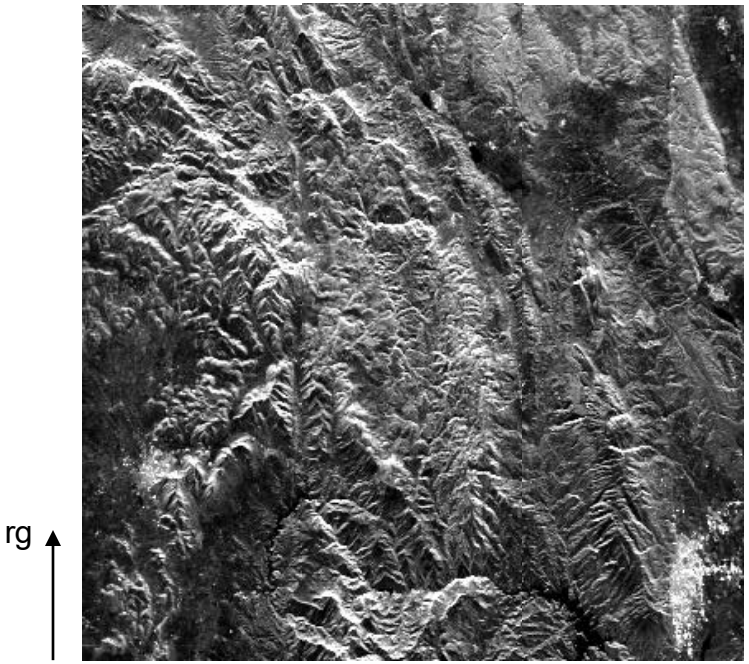
- Overcome reduced North-South sensitivity of DInSAR phase
- Enable 3-D deformation measurements



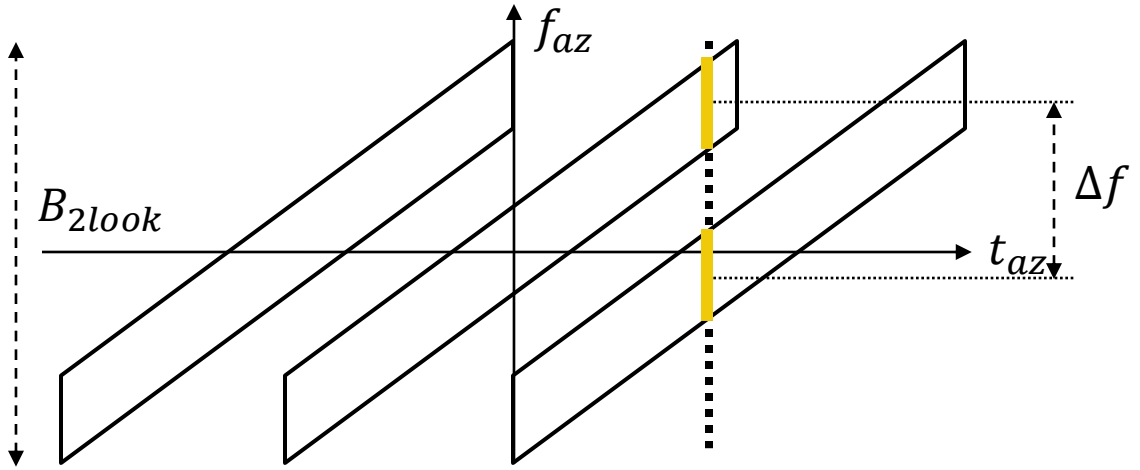
Retrieval concept

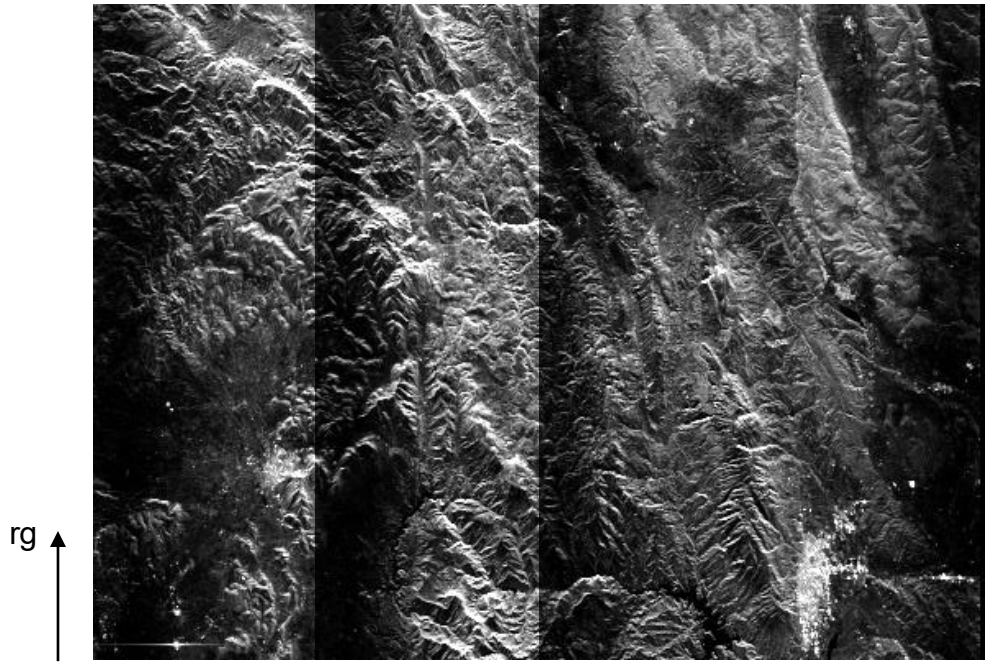
1-look ScanSAR



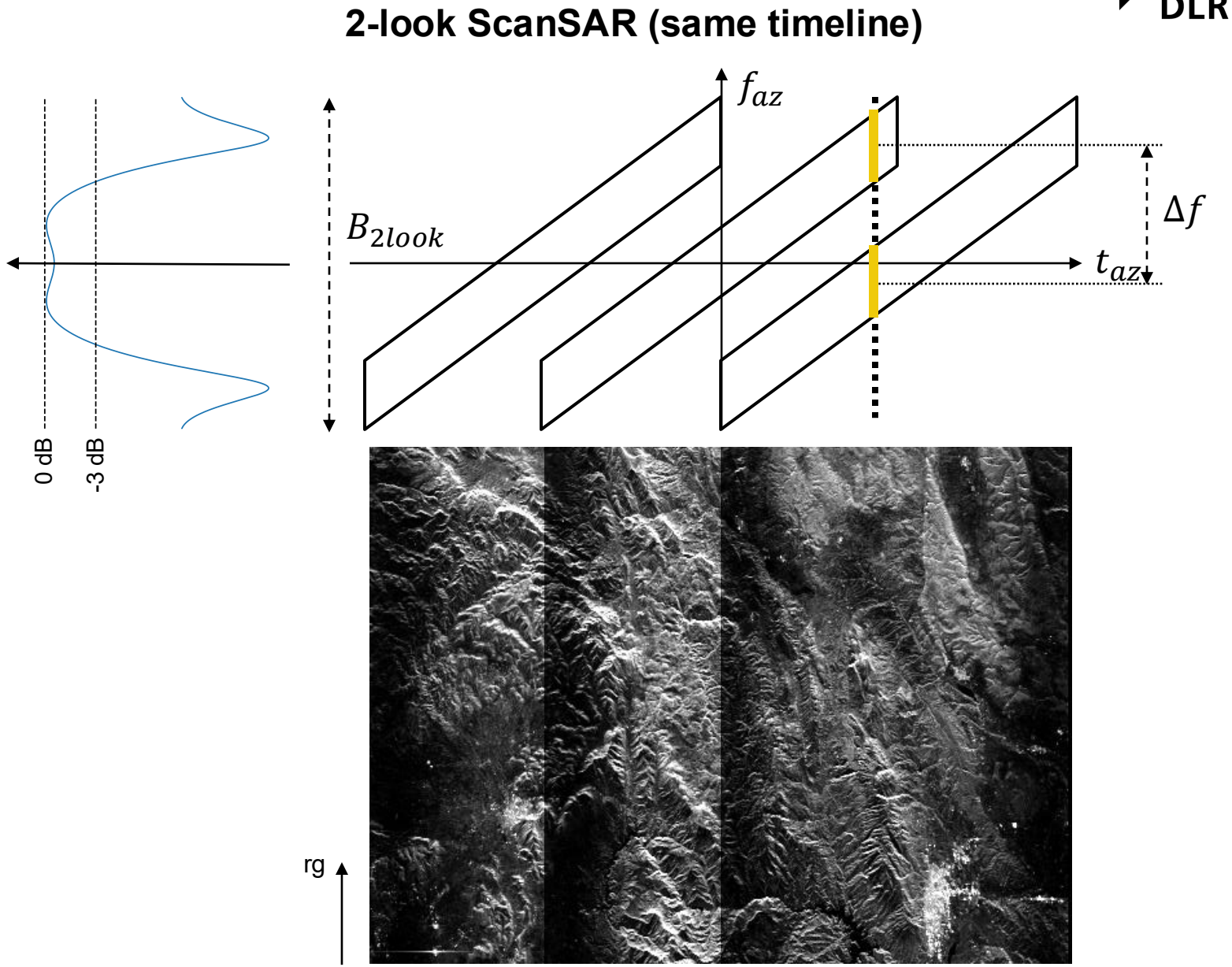


2-look ScanSAR (same timeline)

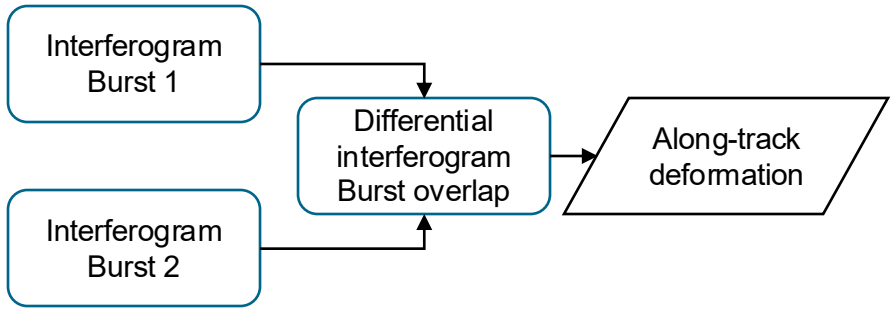




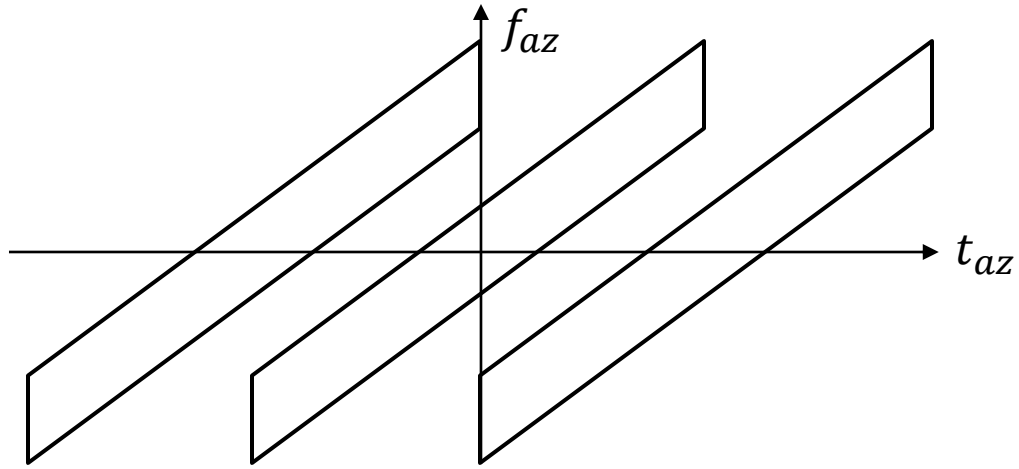
Retrieval concept

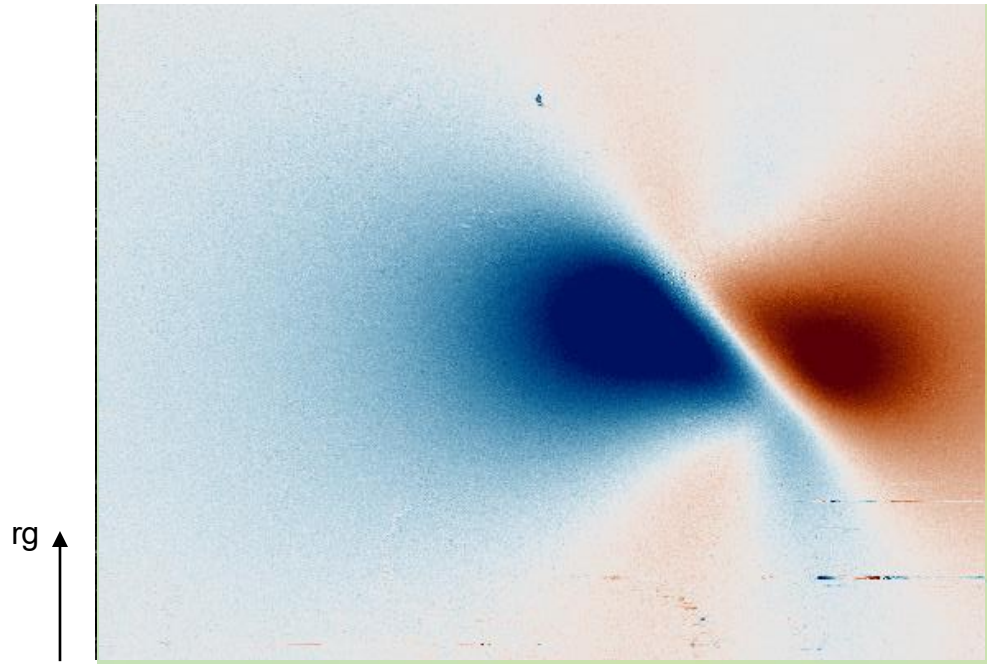


Retrieval concept



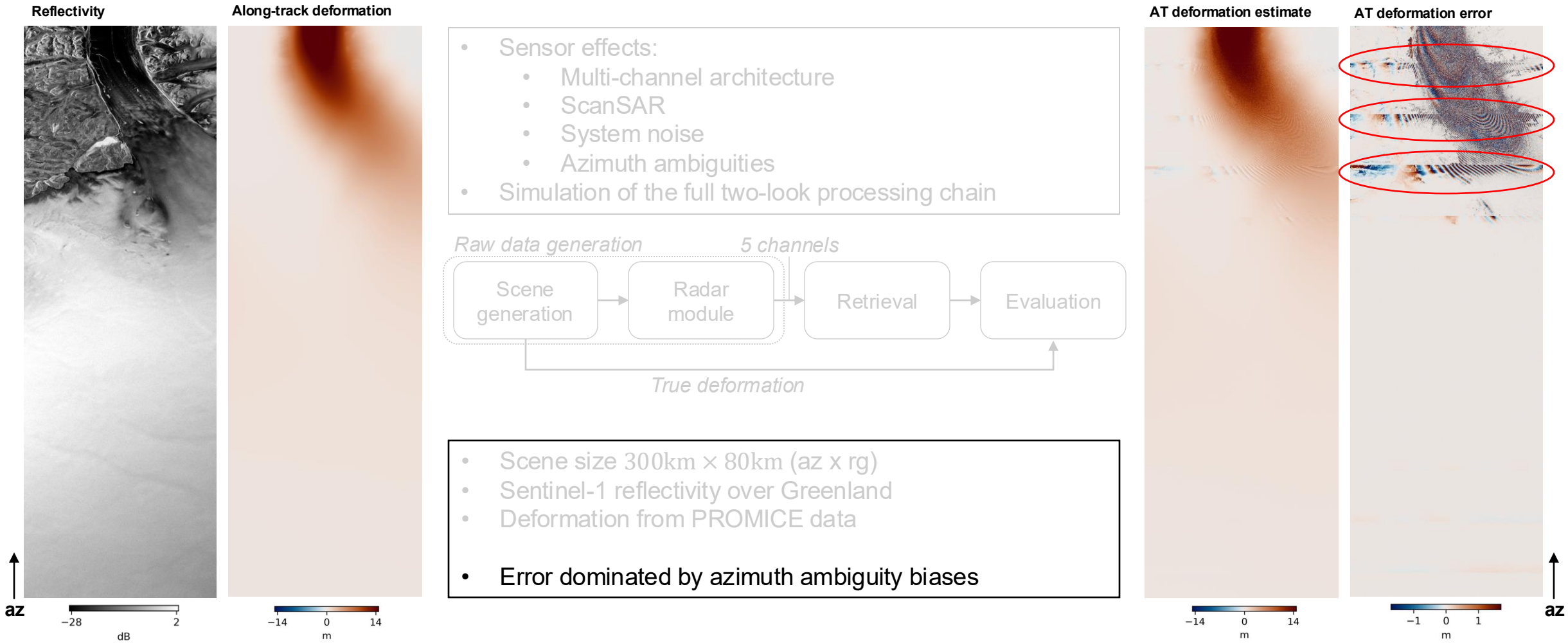
2-look ScanSAR





Performance analysis

…with simulations [1]



- Sensor effects:
  - Multi-channel architecture
  - ScanSAR
  - System noise
  - Azimuth ambiguities
- Simulation of the full two-look processing chain

Raw data generation *5 channels*

Scene generation → Radar module → Retrieval → Evaluation

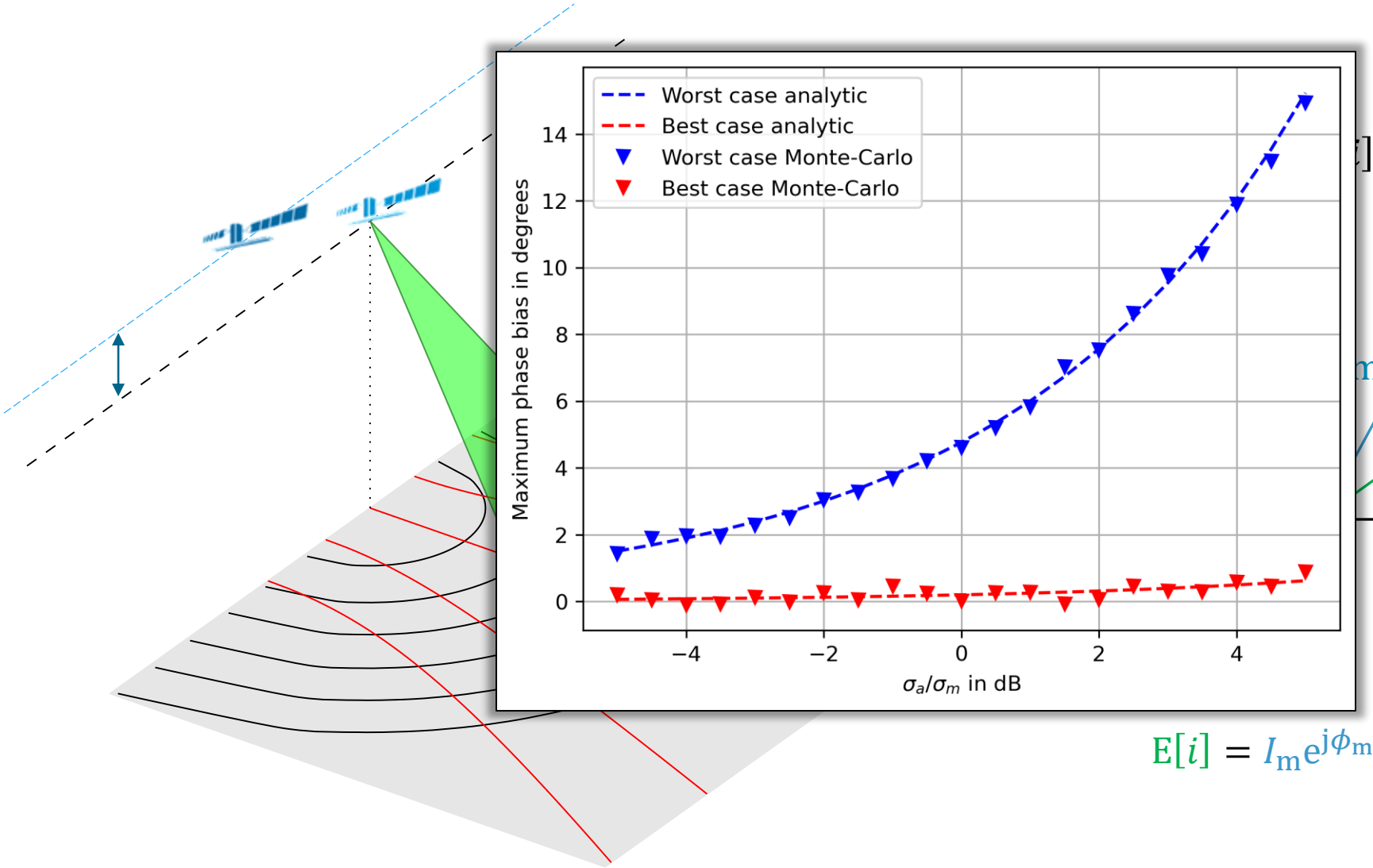
True deformation

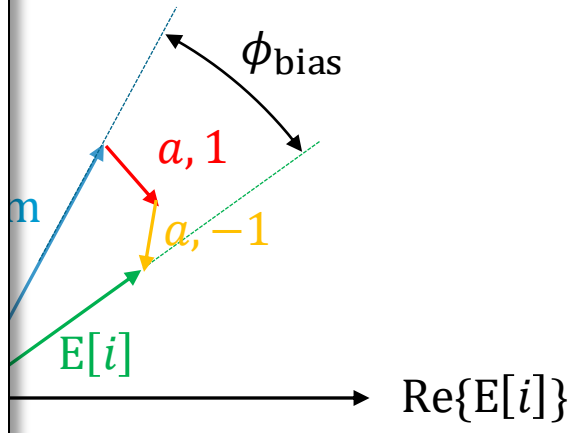
- Scene size $300\text{km} \times 80\text{km}$ (az x rg)
- Sentinel-1 reflectivity over Greenland
- Deformation from PROMICE data

- Error dominated by azimuth ambiguity biases

[1] S. Trumpf, P. Prats-Iraola, and A. Moreira, “Along-track deformation retrieval performance with the ROSE-L multichannel SAR system using two-look ScanSAR,” *IEEE Trans. Geosci. Remote Sens.*, vol. 63, pp. 1–15, 2025, doi: 10.1109/tgrs.2025.3557542.

Coherent azimuth ambiguities

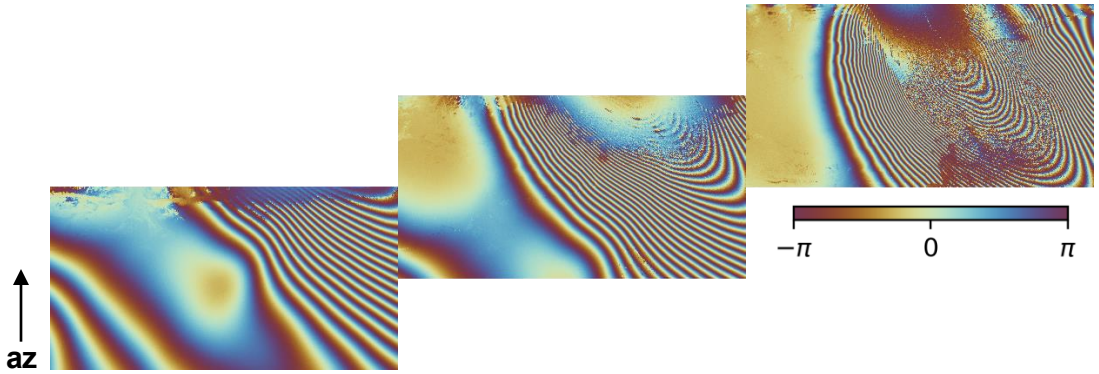




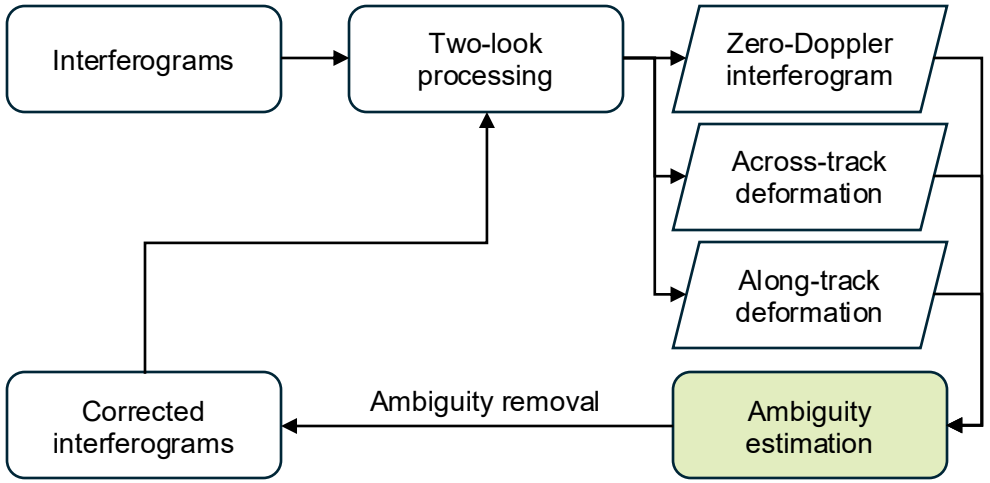
$$\mathrm{E}[i] = I_{\mathrm{m}} e^{\mathrm{j}\phi_{\mathrm{m}}} + I_{\mathrm{a},1} e^{\mathrm{j}\phi_{\mathrm{a},1}} + I_{\mathrm{a},-1} e^{\mathrm{j}\phi_{\mathrm{a},-1}} + \cdots$$

Removal strategy

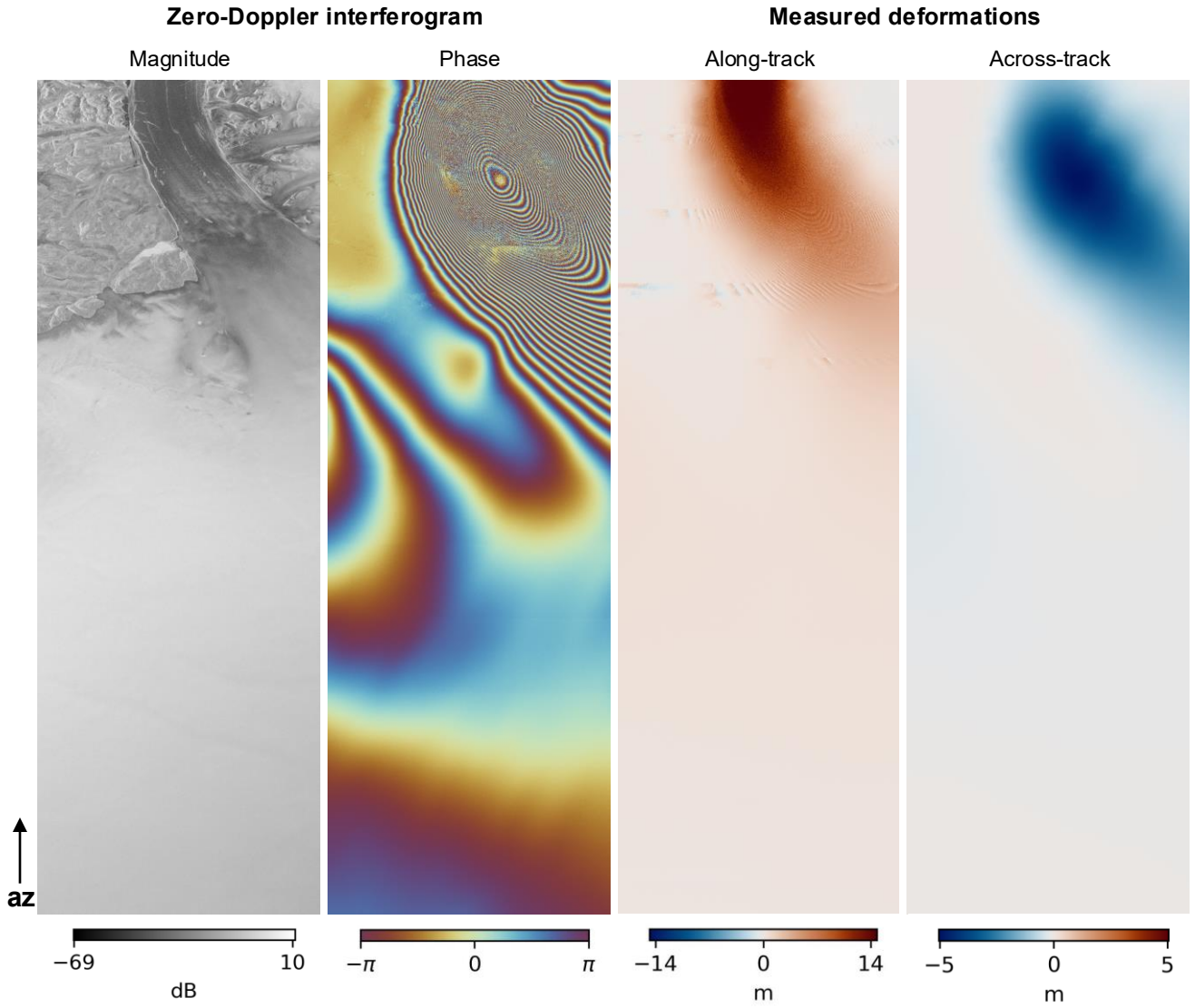
Goal: Remove biases in interferometric phase



Suggested estimation and removal algorithm



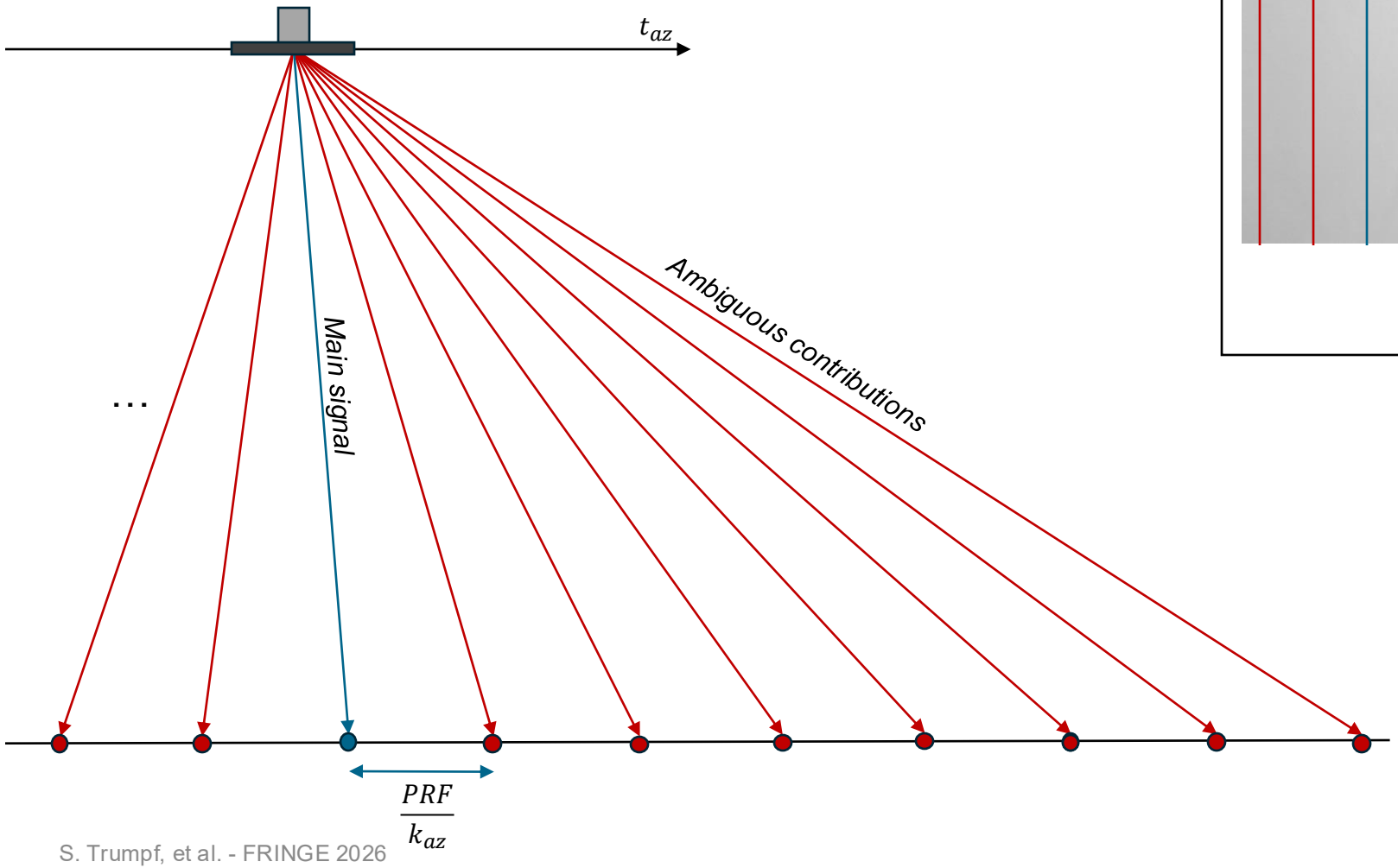
Ambiguity estimation based on two-look processing output

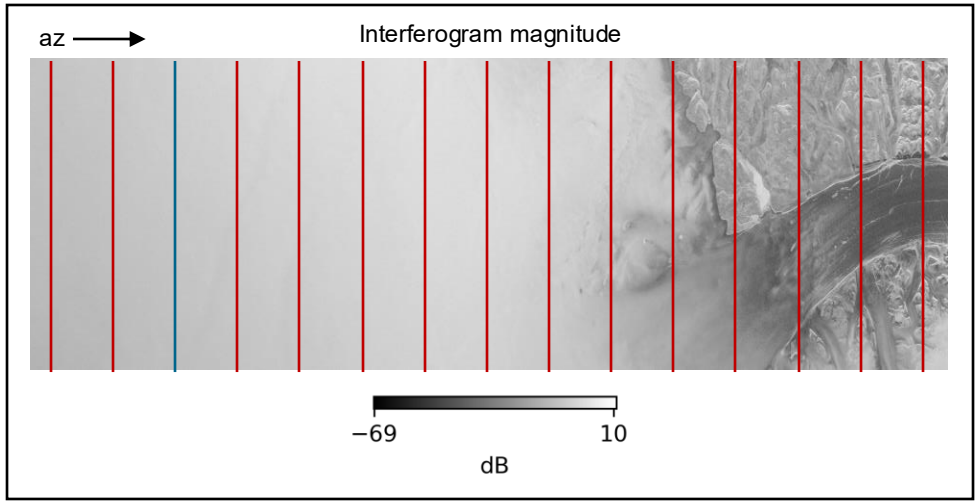


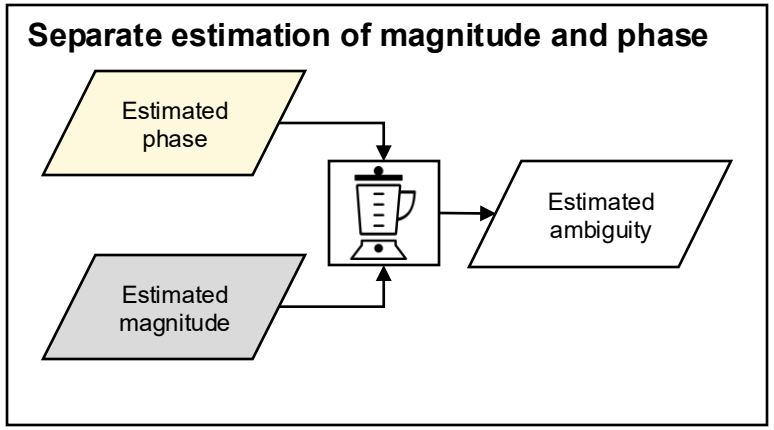
Removal algorithm

Ambiguity estimation

Where do the ambiguities come from?

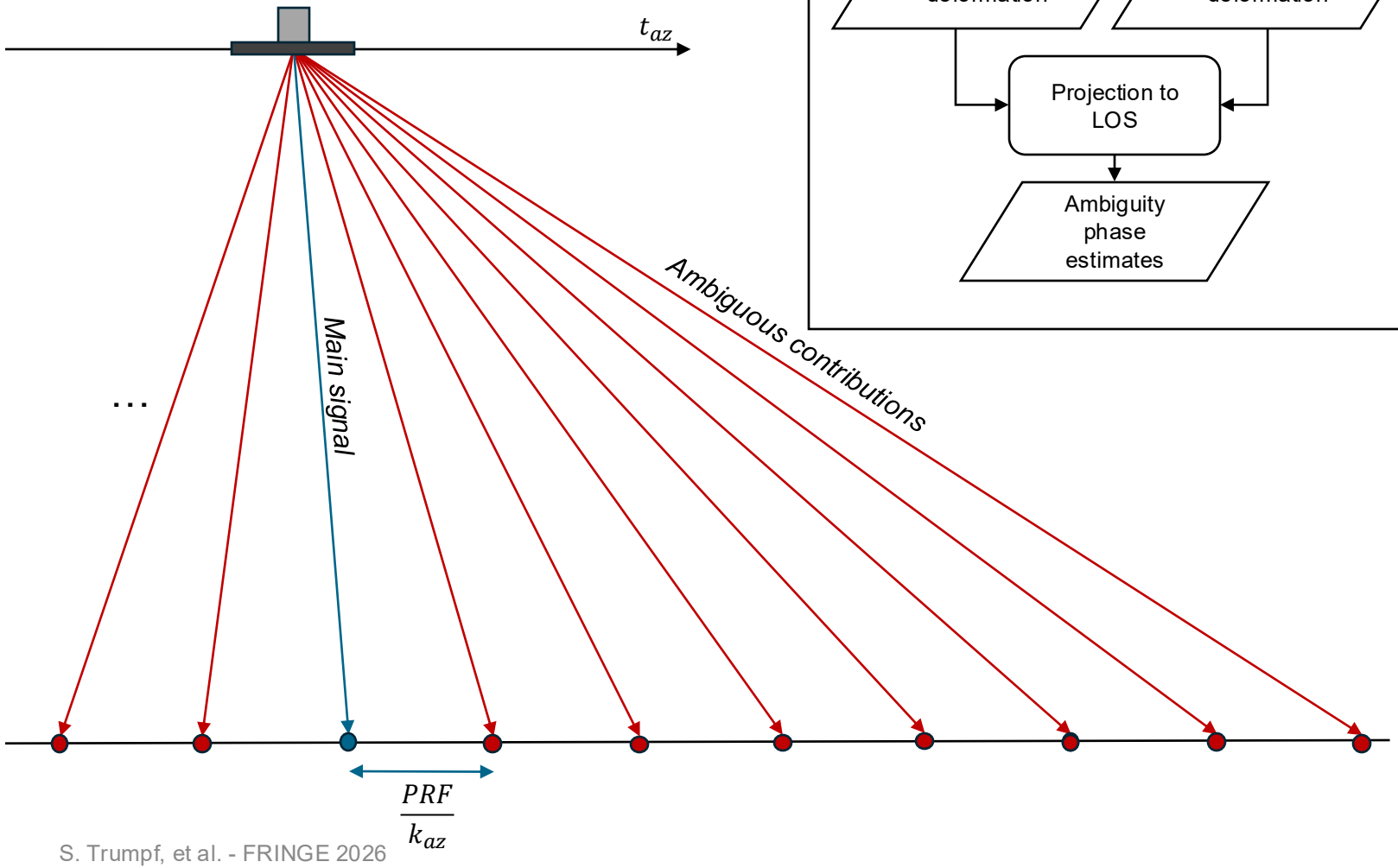




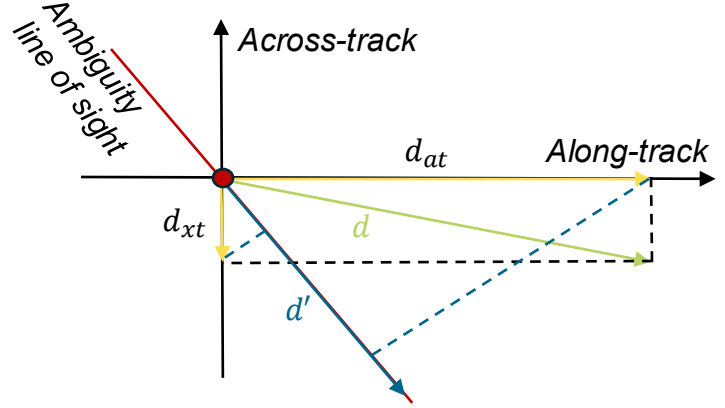


Removal algorithm

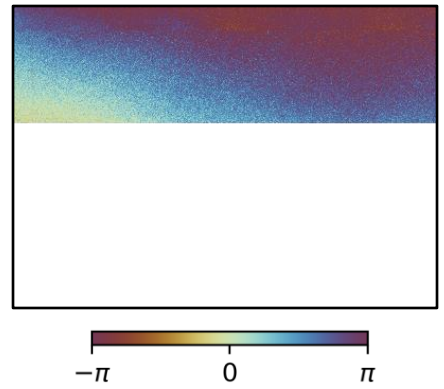
Estimated phase



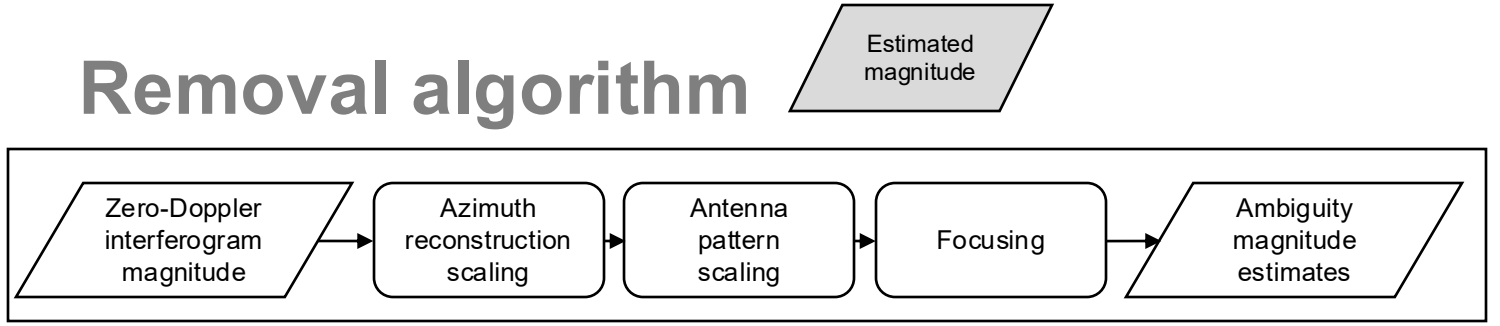
Deformation projection

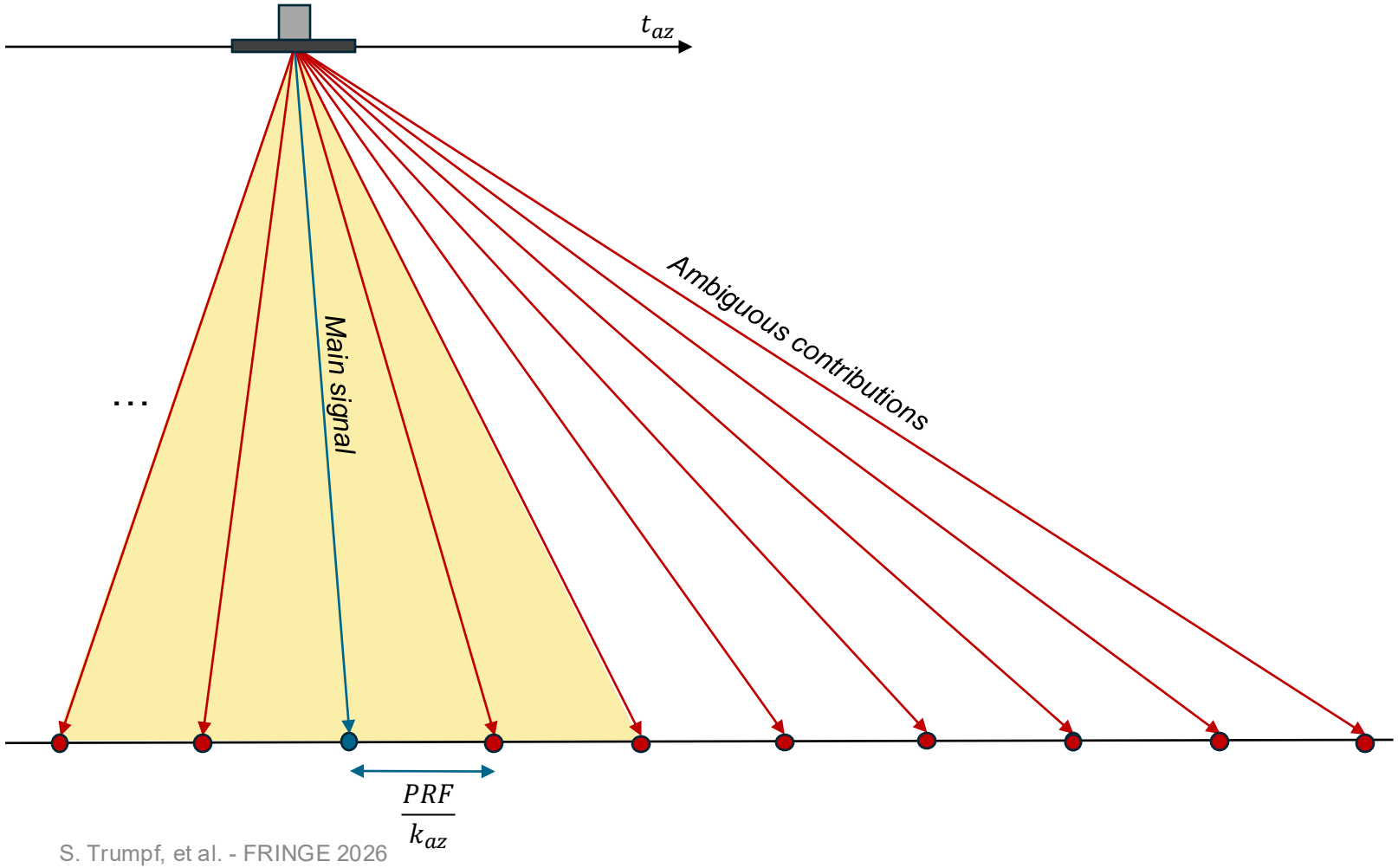


Synthetic ambiguity phases (single burst)

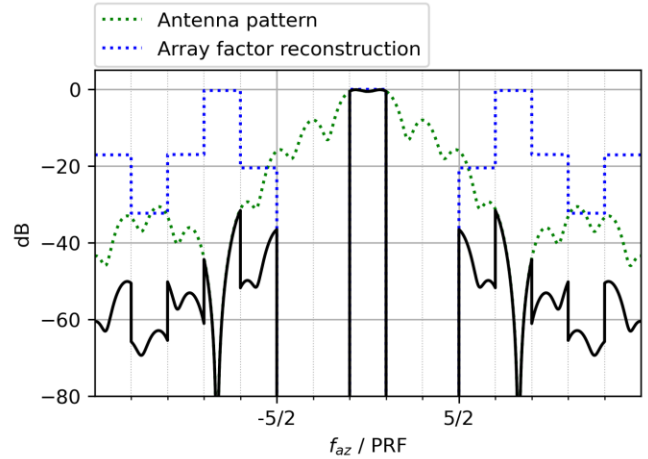


Removal algorithm

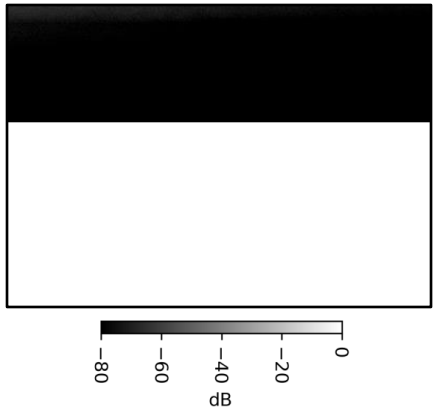




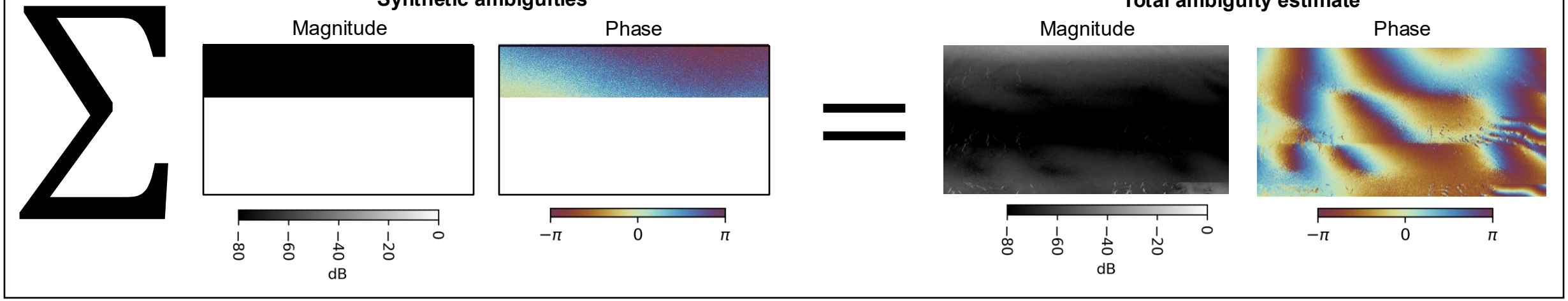
Scaling due to reconstruction



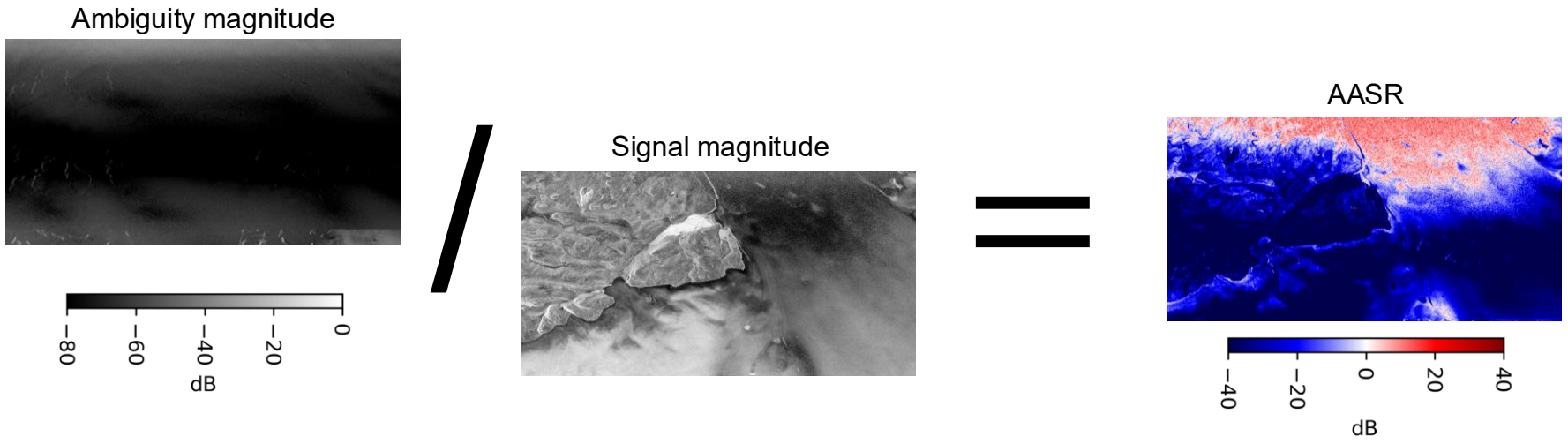
Synthetic ambiguity magnitudes (single burst)



Removal algorithm

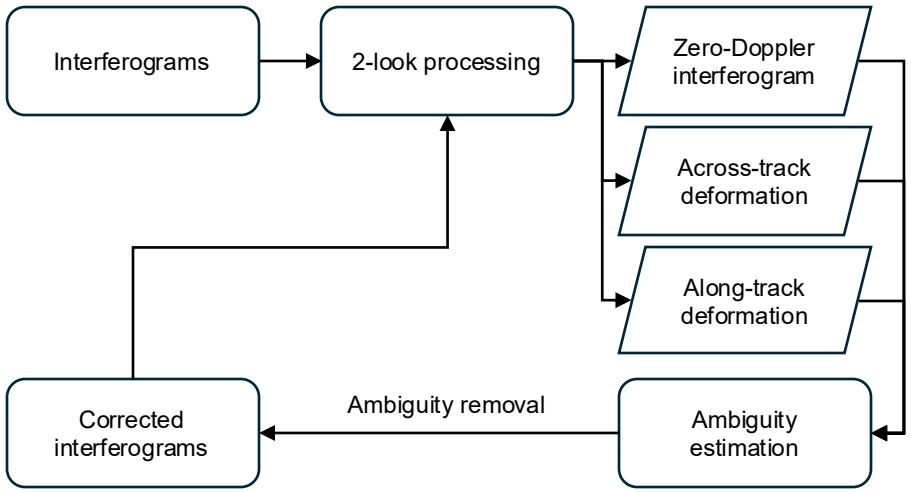


How large are the ambiguities w.r.t. the signal?

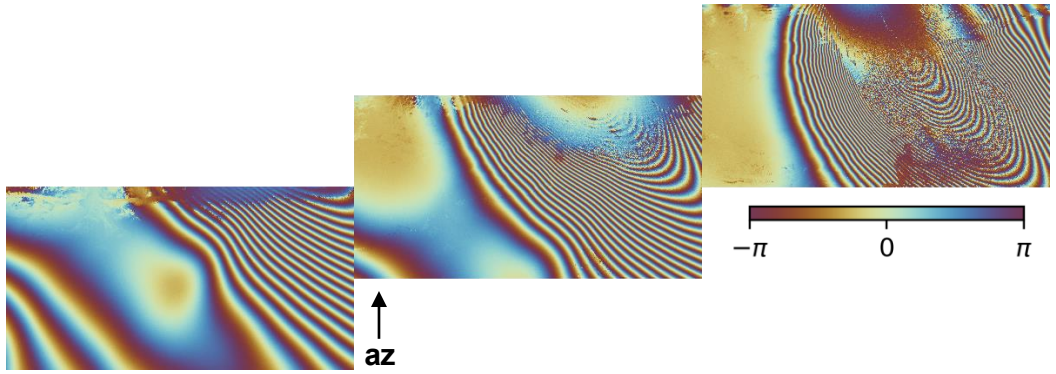


Coherent azimuth ambiguity removal

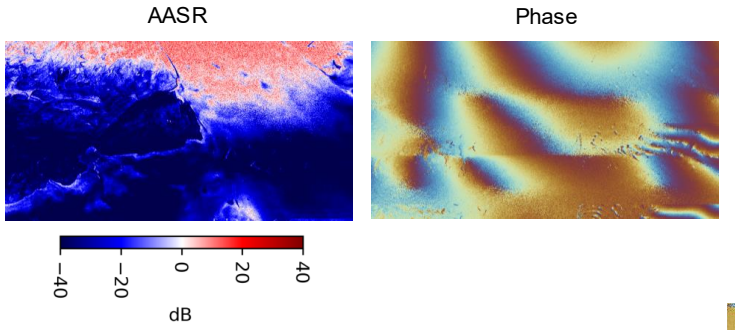
Ambiguity bias removal algorithm



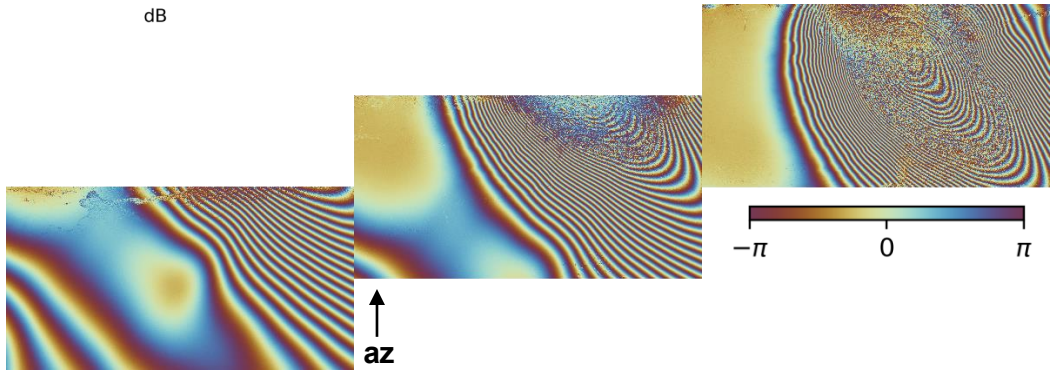
Biased interferometric phase



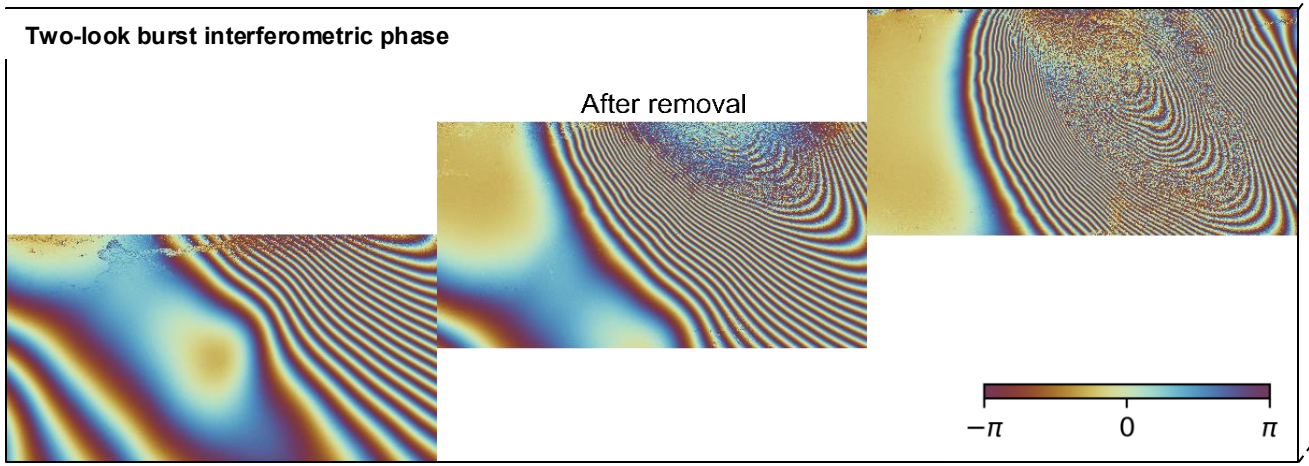
Ambiguity estimate



Corrected interferometric phase



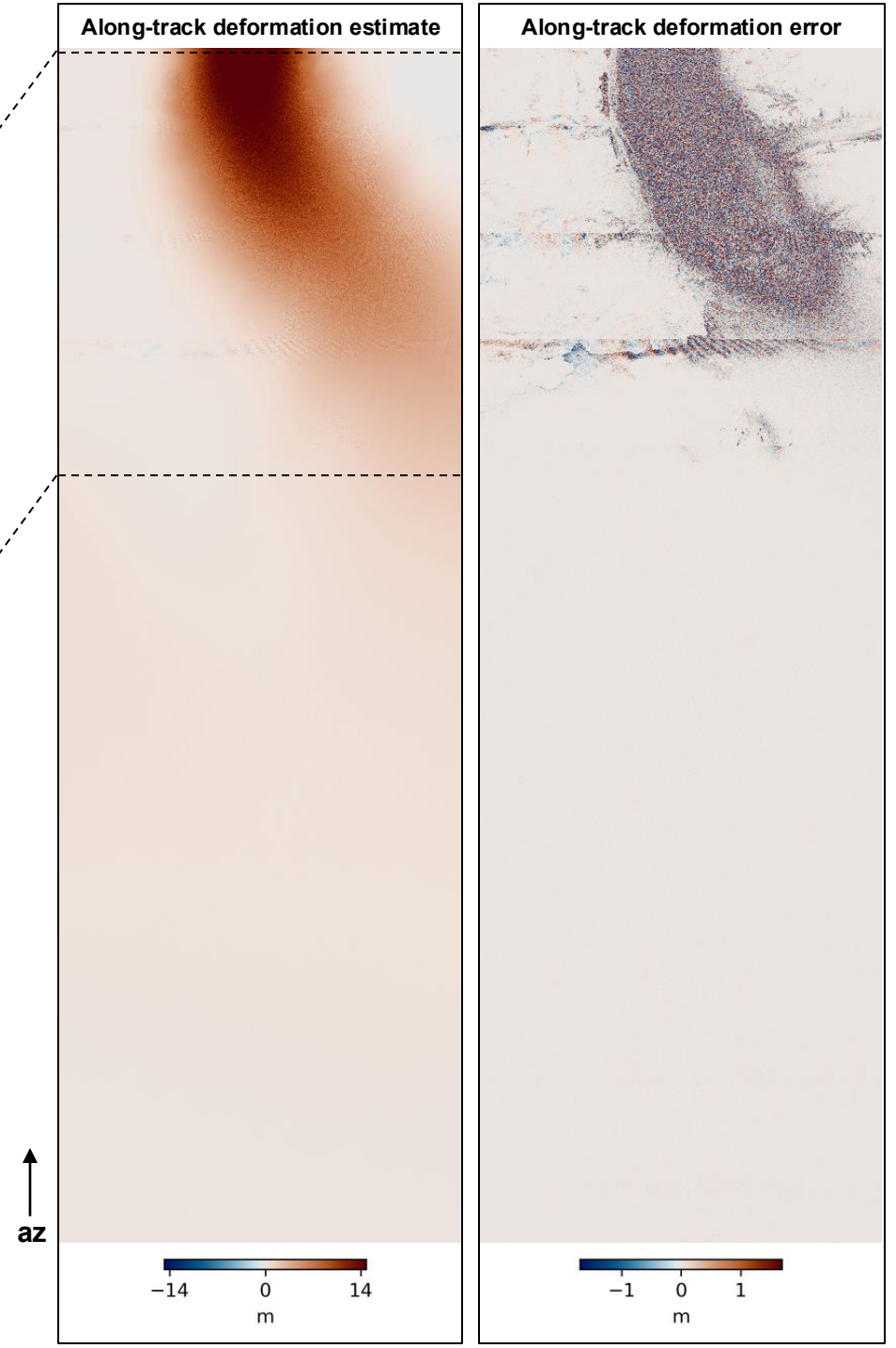
Coherent azimuth ambiguity removal



Significant reduction of azimuth ambiguity biases

Remaining biases due to:
- Inaccuracies in the estimation
- Ambiguity biases in the estimation (iterative application might compensate those)

Increased noise in areas with low signal-to-ambiguity ratios



Conclusions and outlook

Conclusions

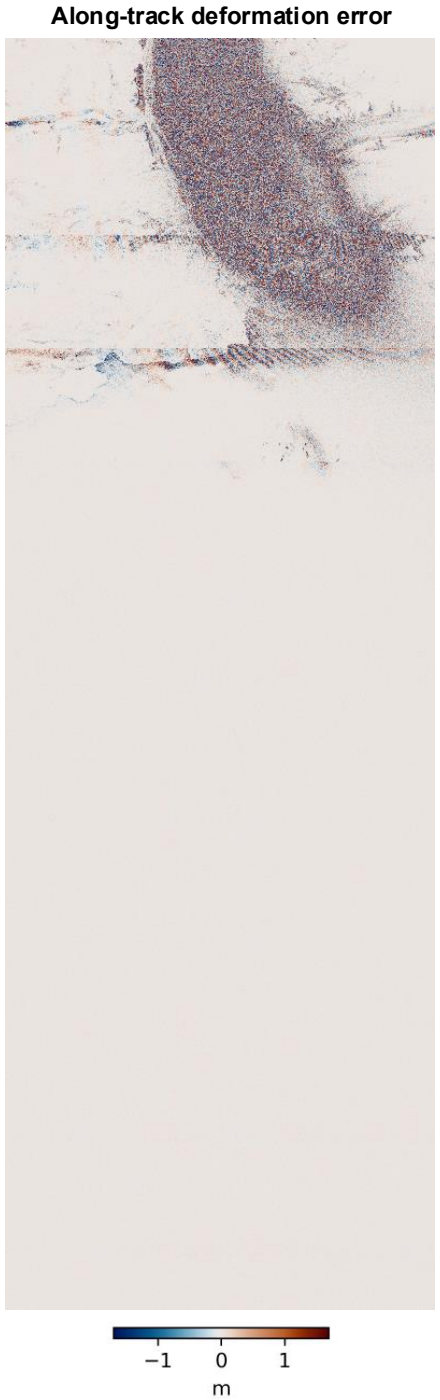
- **Significant mitigation** of coherent-azimuth-ambiguity biases
- Improved two-look ScanSAR deformation estimate **without modifying the system**
- Useful application on scenes with strong ambiguity biases

Drawback

- Increased noise in areas with low signal-to-ambiguity ratio

Further prospects

- Investigations on iterative application of the algorithm
- Advanced approaches to mitigation [2]



[2] D. Richter, M. Rodriguez-Cassola, M. Zonno, and P. Prats-Iraola, “Coherent azimuth ambiguity suppression based on linear optimum filtering of short along-track baseline SAR interferograms,” in *Proc. 14th Eur. Conf. Synth. Aperture Radar (EUSAR)*, Jul. 2022, pp. 1–5.

THANK YOU!

✉ simon.trumpf@dlr.de

Imprint

Topic:	**Improved along-track deformation retrieval with ROSE-L using two-look ScanSAR**
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Institute:	Microwaves and Radar Institute
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