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Sentinel-1 Azimuth Subbanding for Multiple Aperture Interferometry – Test Case over The Roi Baudouin Ice Shelf

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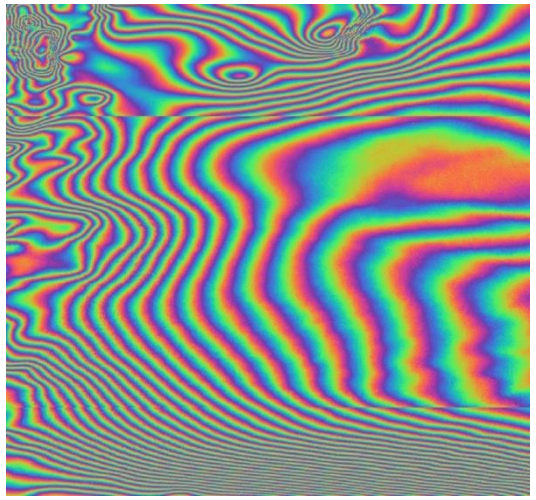
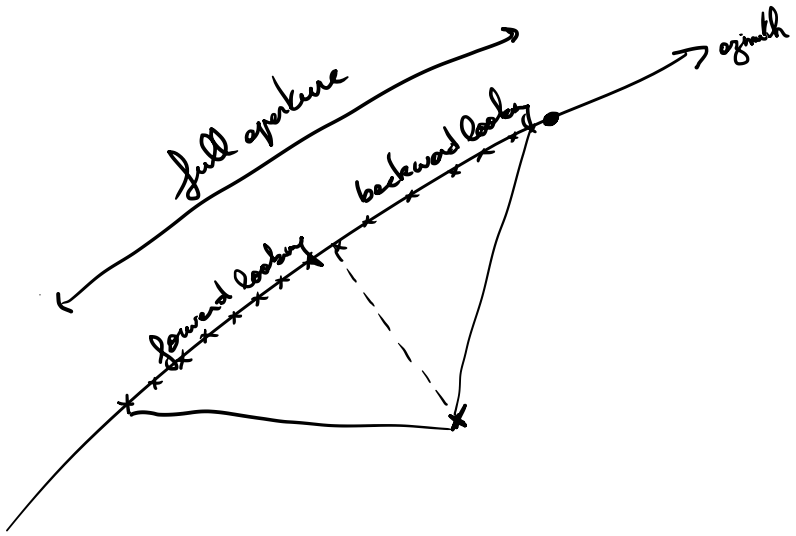
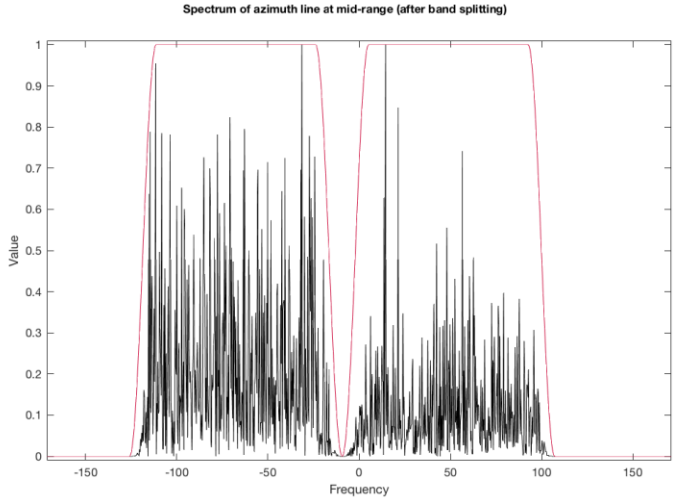
Displacements from InSAR



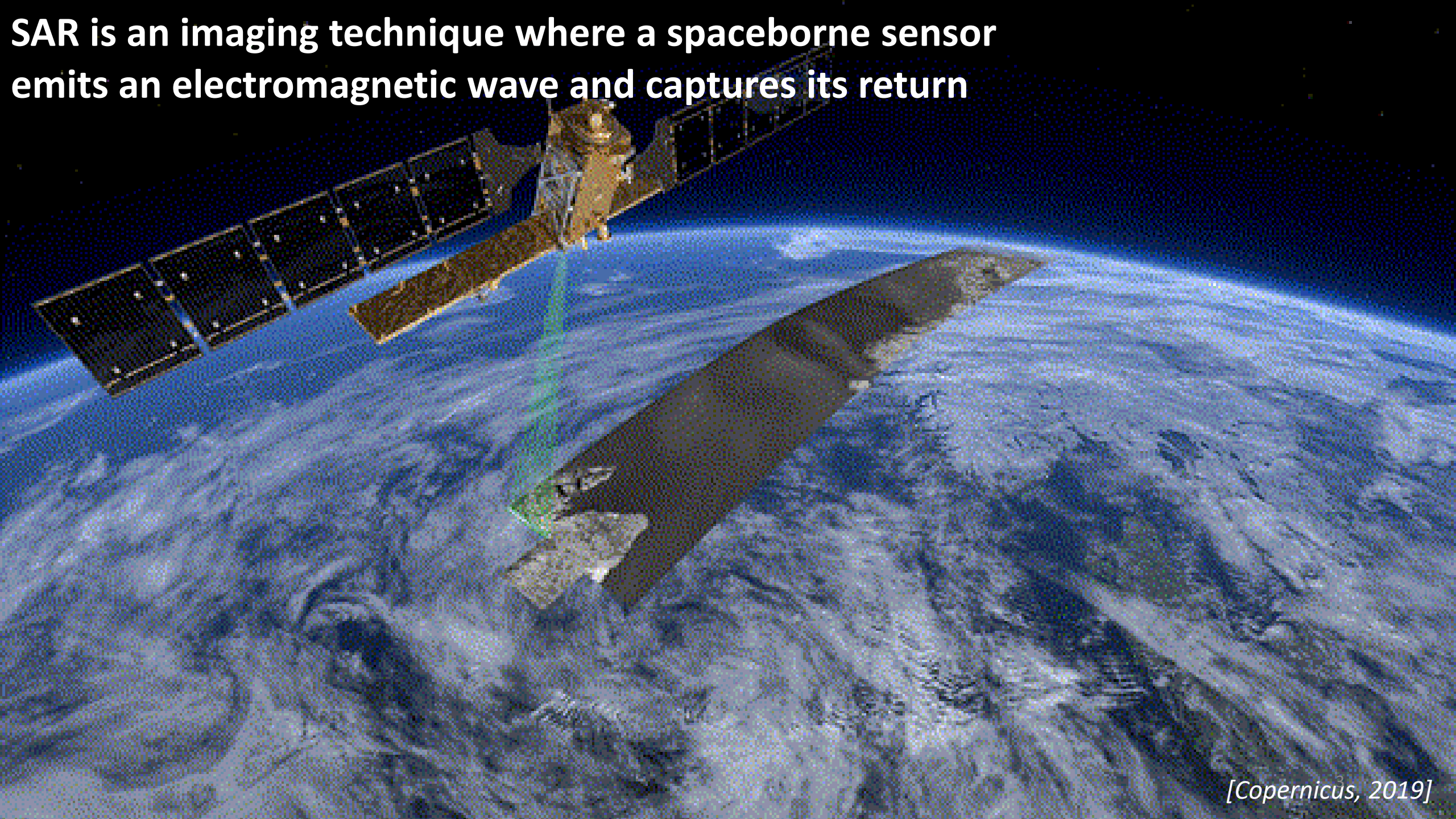
Multiple Aperture Interferometry



Spectral Results

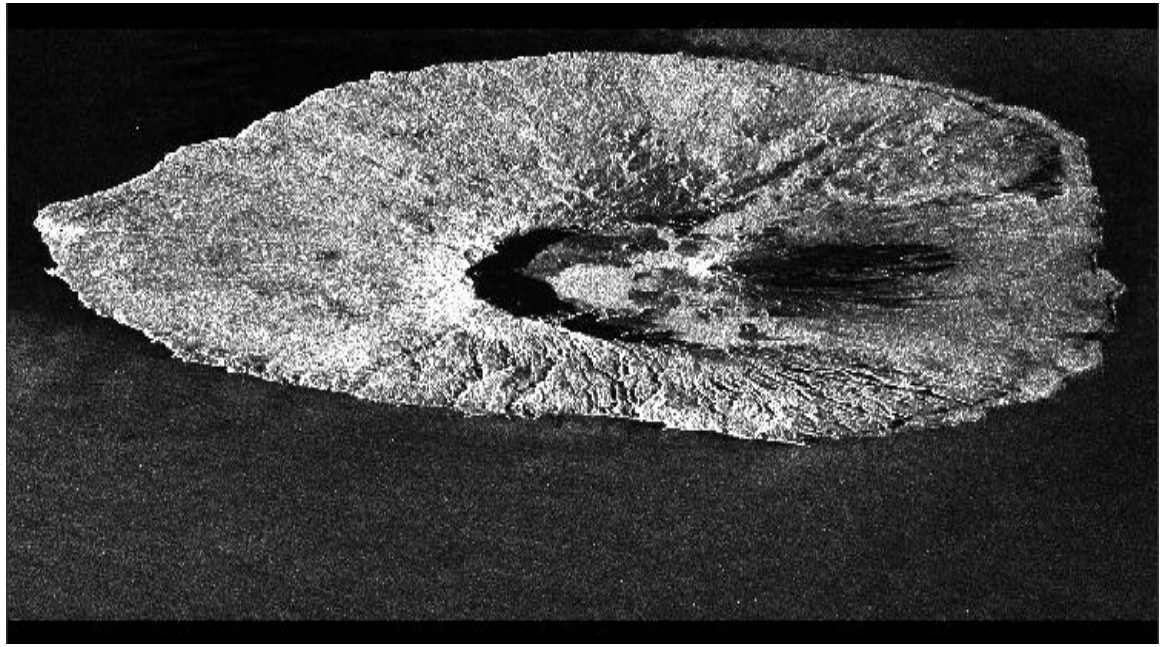


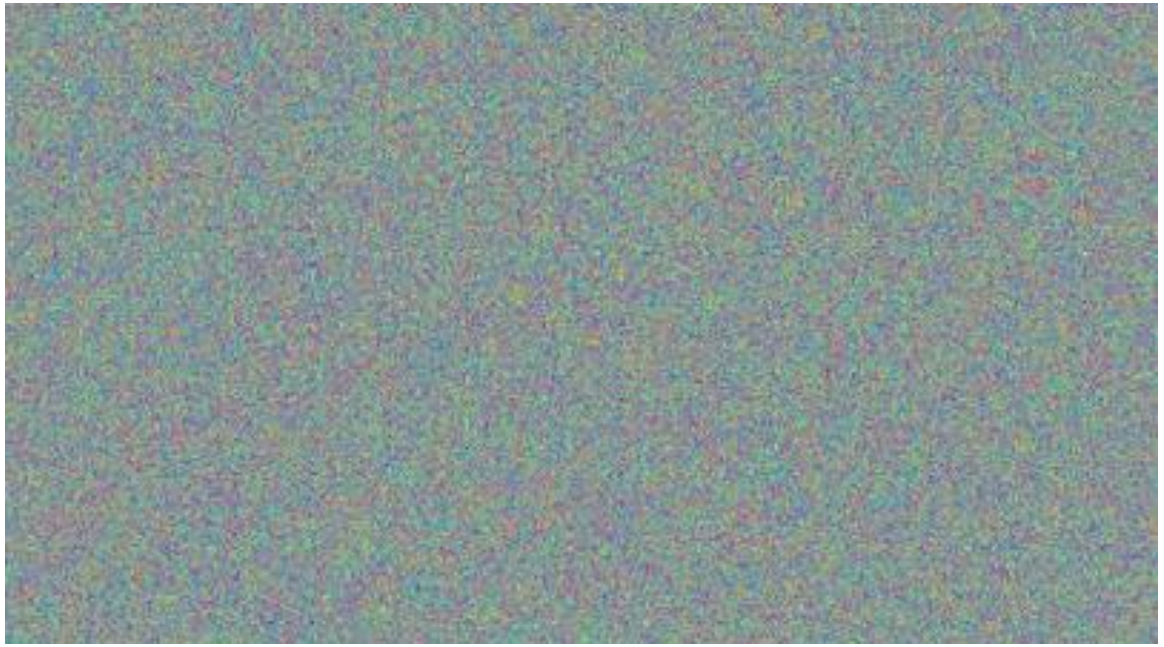
SAR is an imaging technique where a spaceborne sensor emits an electromagnetic wave and captures its return



[Copernicus, 2019]

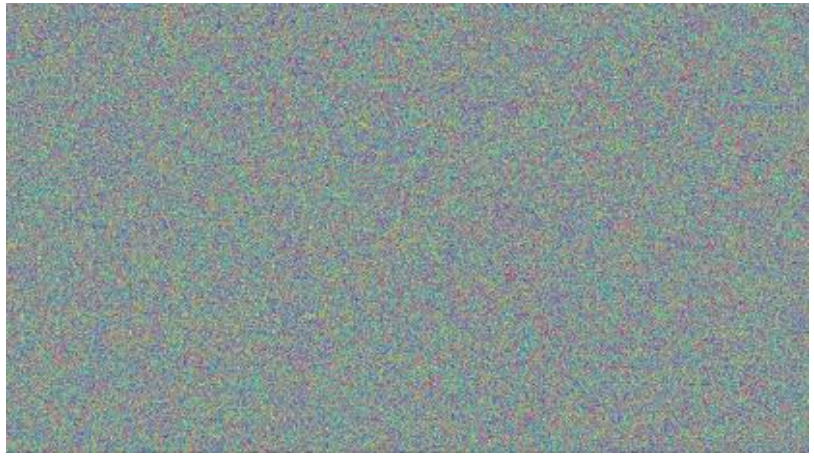
The image is composed of amplitude information (characteristics of the ground) and phase information (depends on the distance to the satellite)

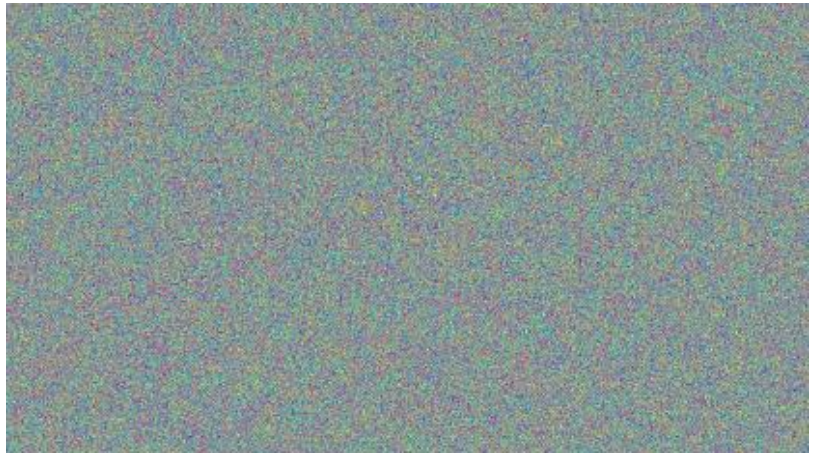


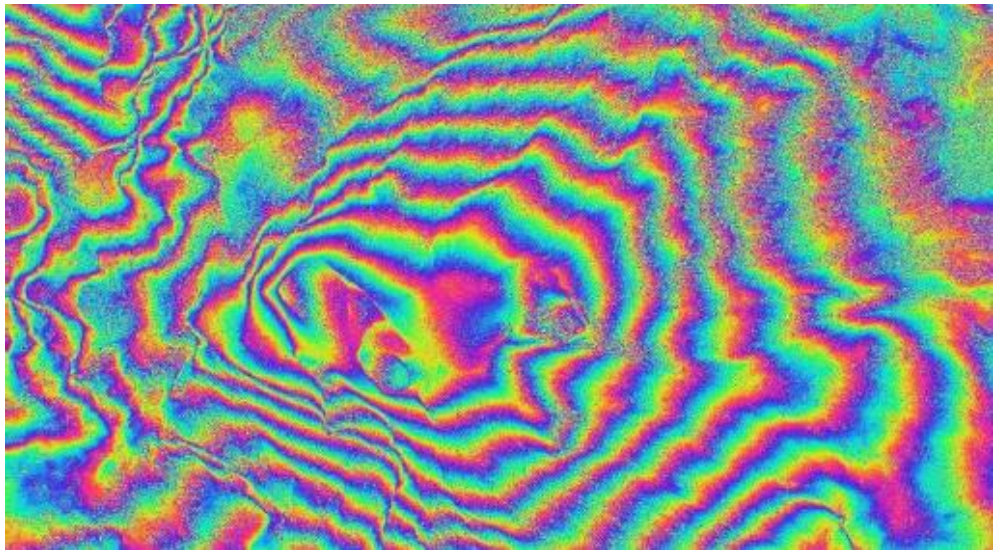


Amplitude Phase

By subtracting the phase of 2 SAR images taken from different dates and slightly different points of view, we make an interferogram





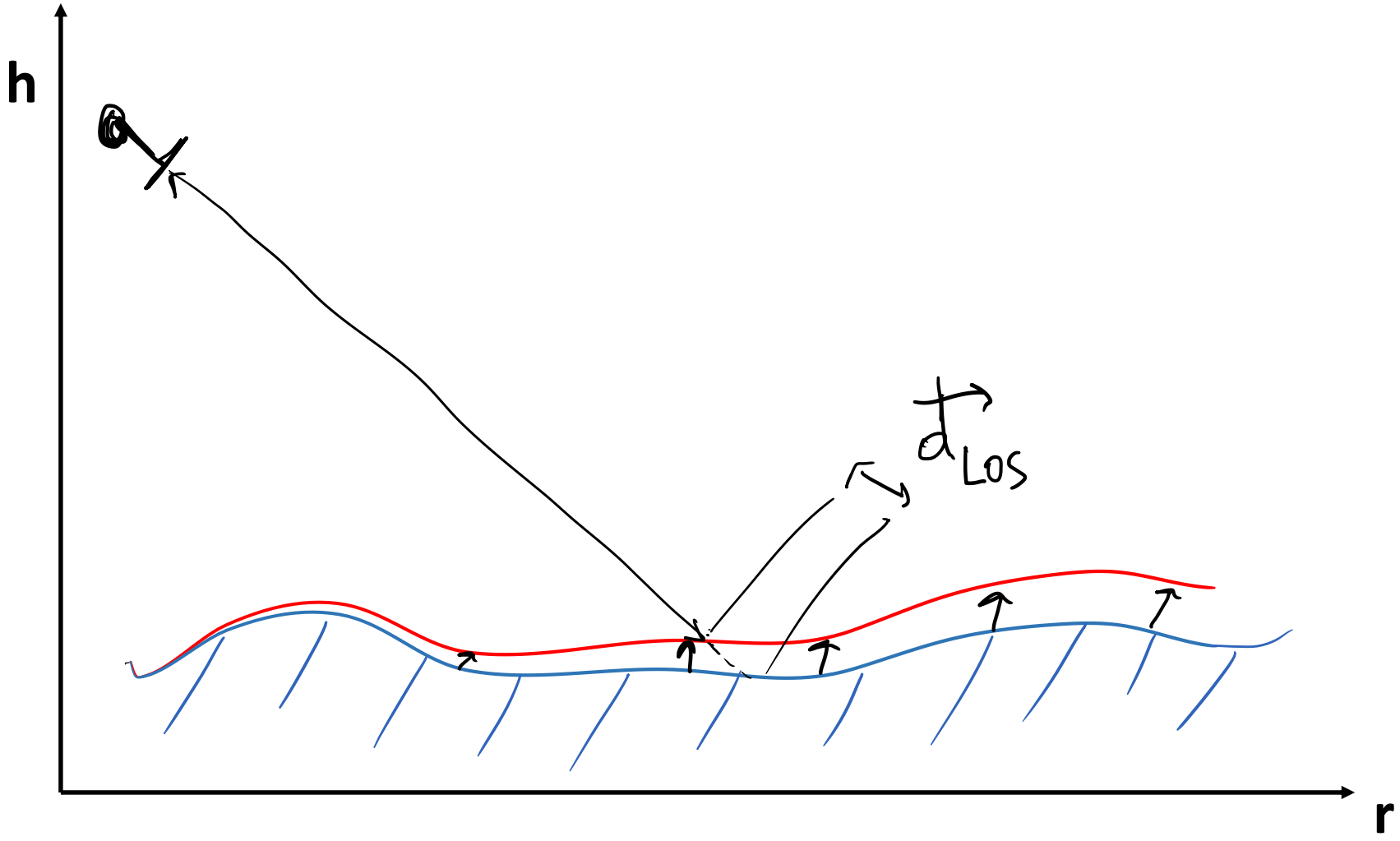


[TanDEM-X – Copahue volcano, i.e.]

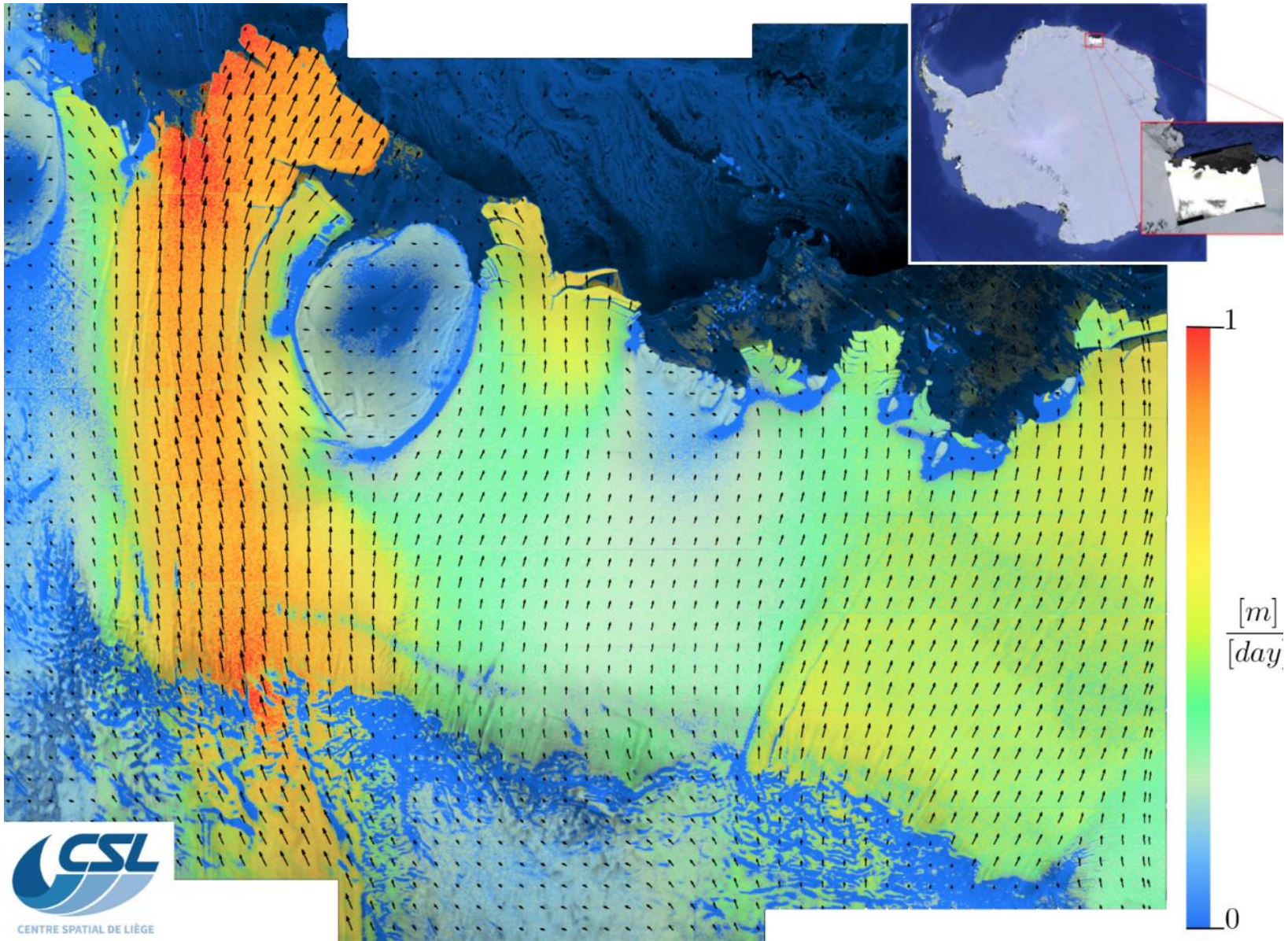
Many components are influencing the interferogram ;
DInSAR consists in retrieving the phase term related to displacement

$$\varphi_{intf} = \varphi_{orb} + \varphi_{topo} + \varphi_{atm} + \underline{\varphi_{mvt}}$$

The limits of SAR Interferometry is that it computes only a one-dimensional displacements, along the line-of-sight

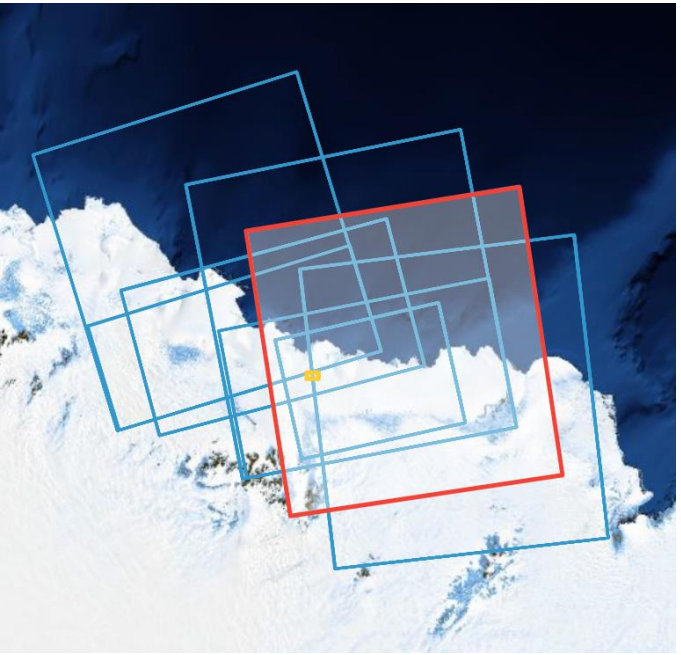


In polar regions, the ice follows a Northward direction, difficult to measure using classical SAR Interferometry



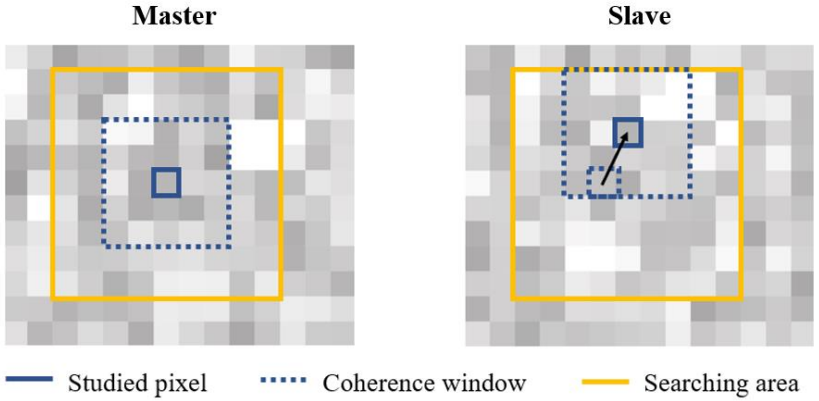
Different techniques exist, but all have important drawbacks: Orbits Combinations (1), Pixel Offset Tracking (2), Burst Overlapping Interferometry (3)

1



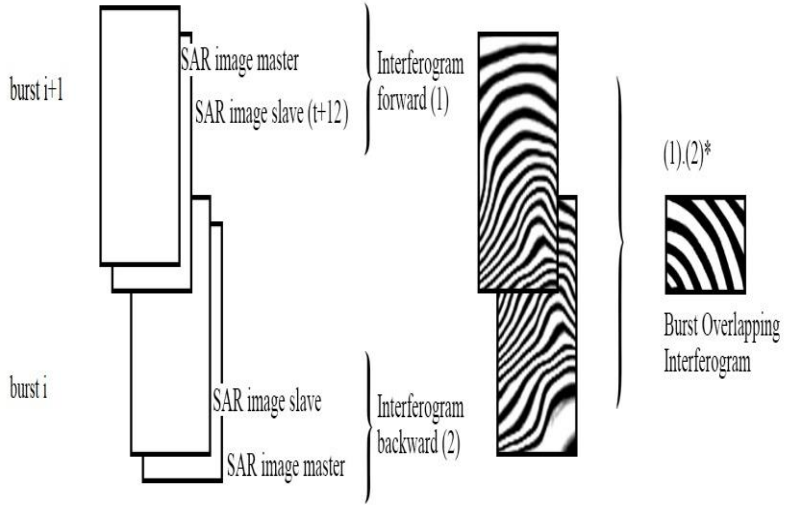
→ Limited available orbits

2



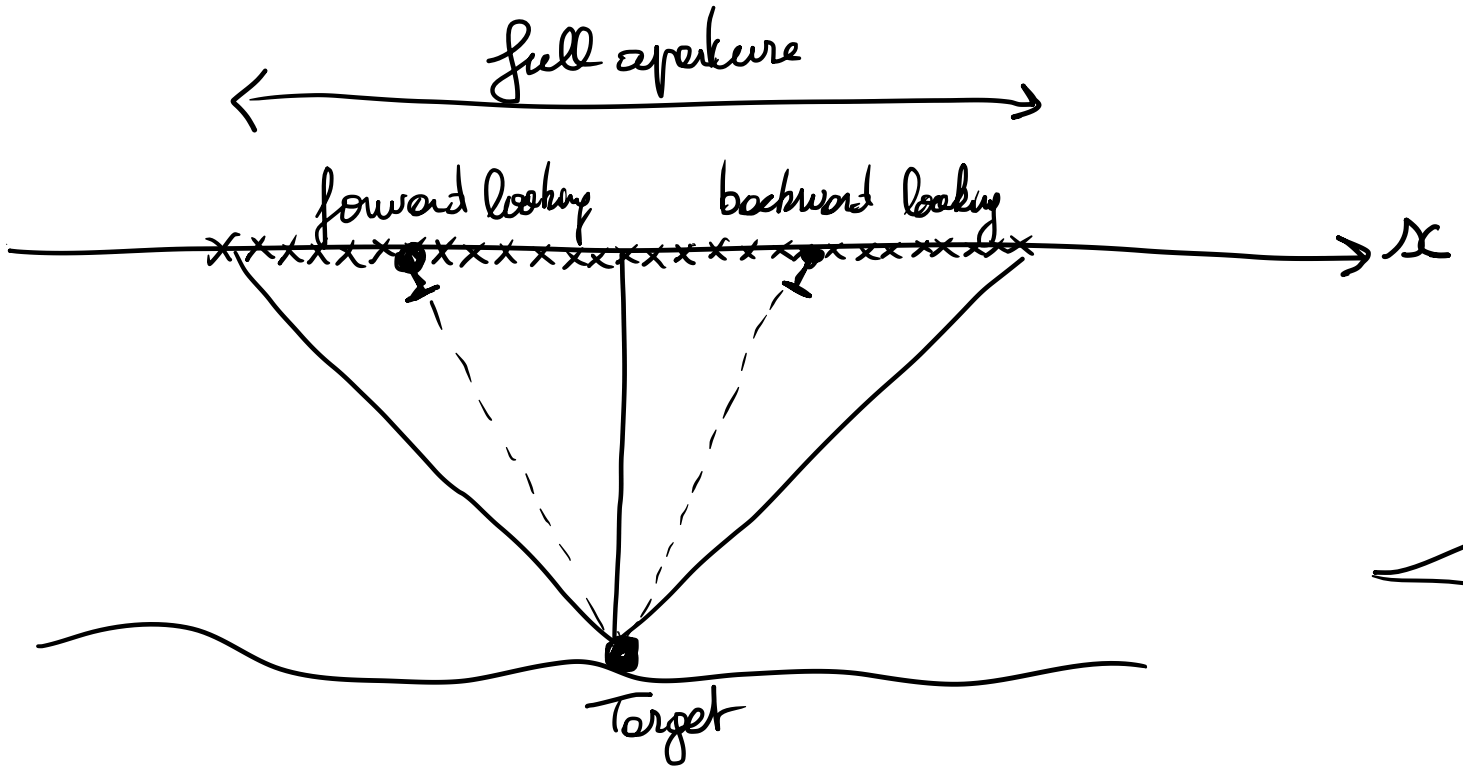
→ Limited accuracy

3



→ Limited spatial coverage

Multiple Aperture Radar (MAI) is a spectral diversity technique that allows the determination of azimuth displacements from phase shift differences



forward Intf
backward Intf
} φ_{MAI}

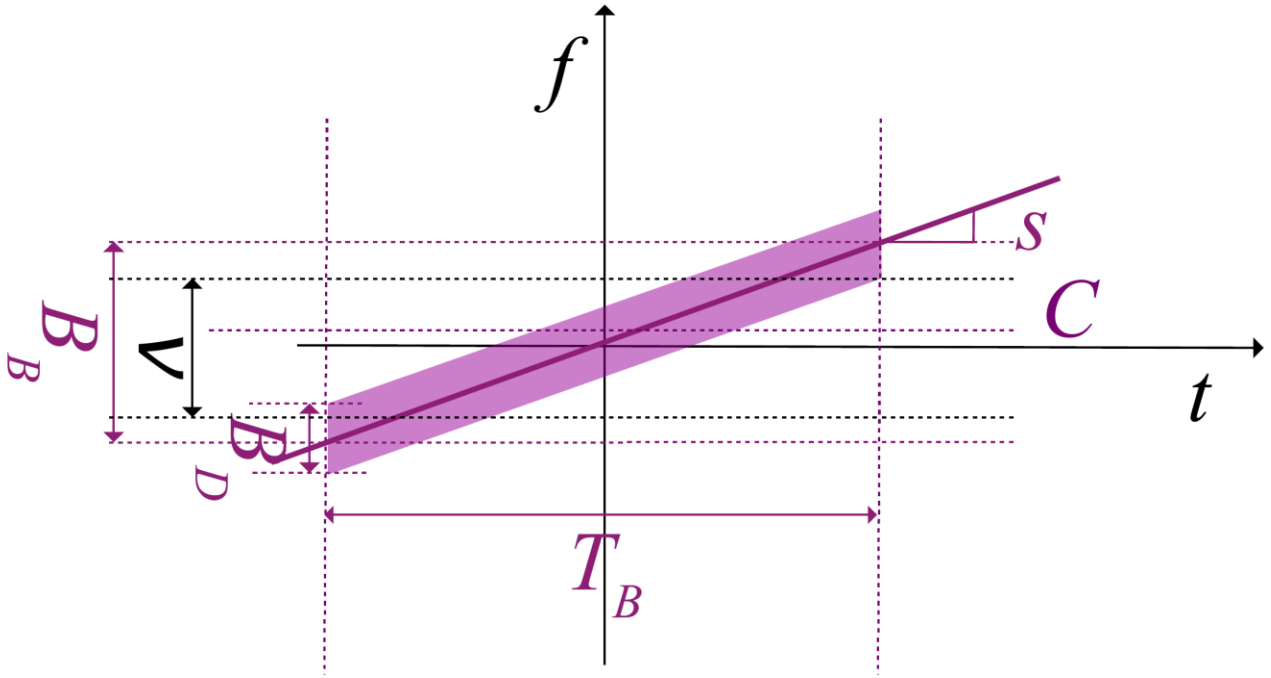
$$\varphi_{MAI} = \frac{2\pi \cdot \Delta f \cdot \Delta x}{}$$

Using SLC data, MAI requires a proper azimuth splitband operator, rarely described in the MAI literature

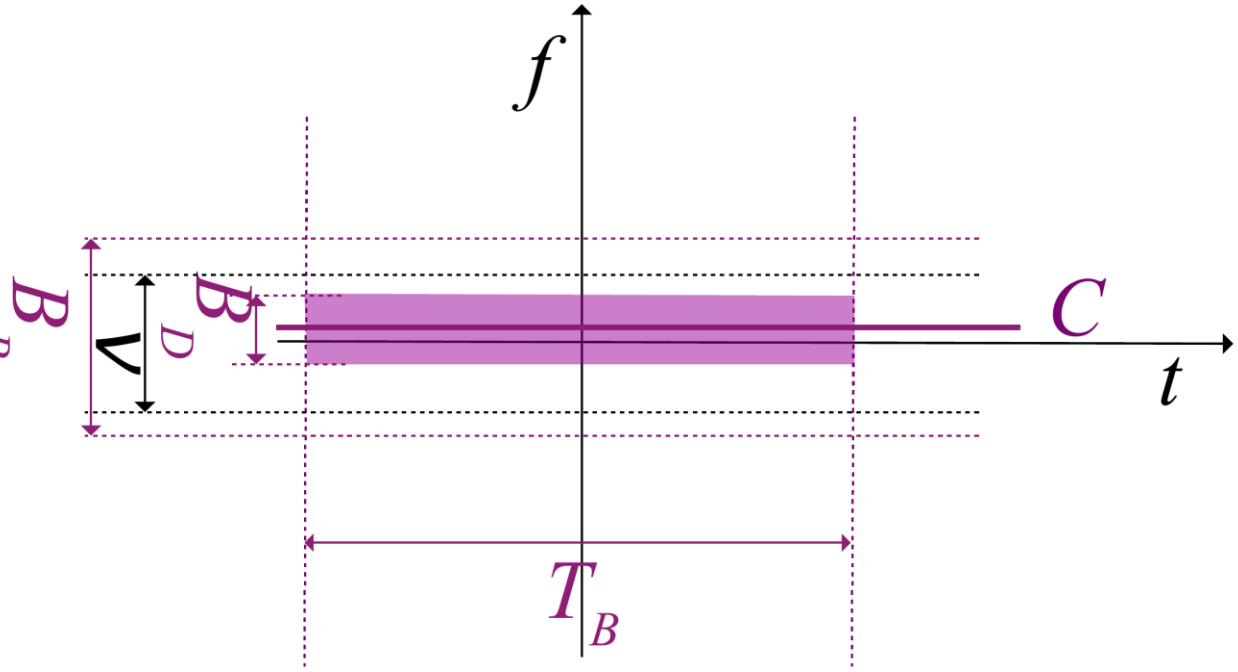
"Meanwhile, the azimuth spectrum of the coregistered SLC images are filtered into two non-overlapping bands with a spectral separation of two thirds of the azimuthal bandwidth, resulting in two passes of sublook images for MAI." HJ Jiang, 2017.

In this study, we develop and describe one splitband operator, and its adaptation to Sentinel-1 TOPSAR acquisition mode

To circumvent the azimuth aliasing problem, we apply azimuth band splitting on data obtained after deramping, aka removing the slope of the DC frequencies

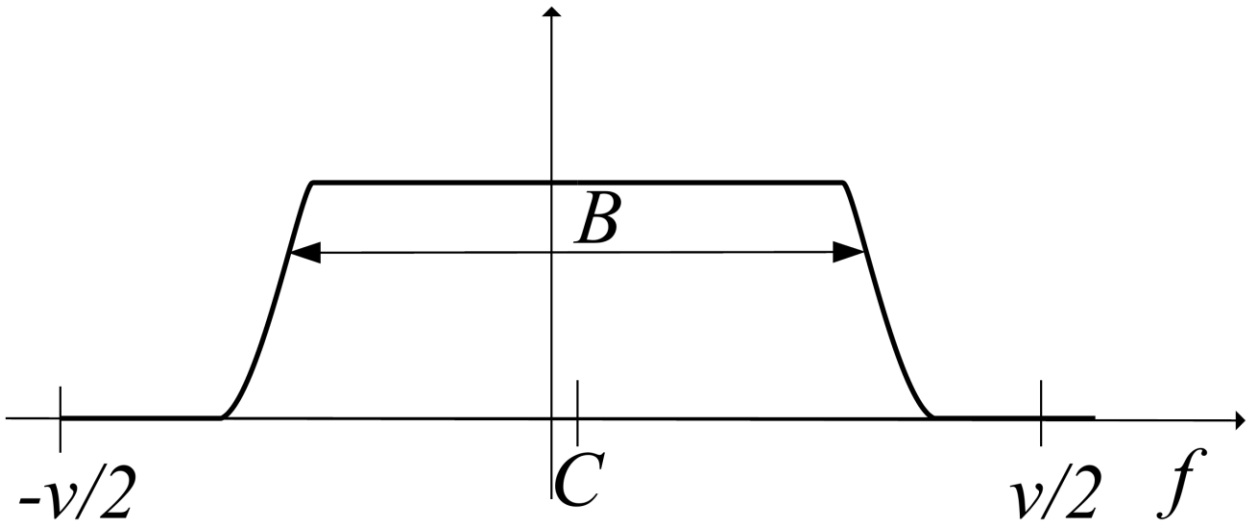


(a)

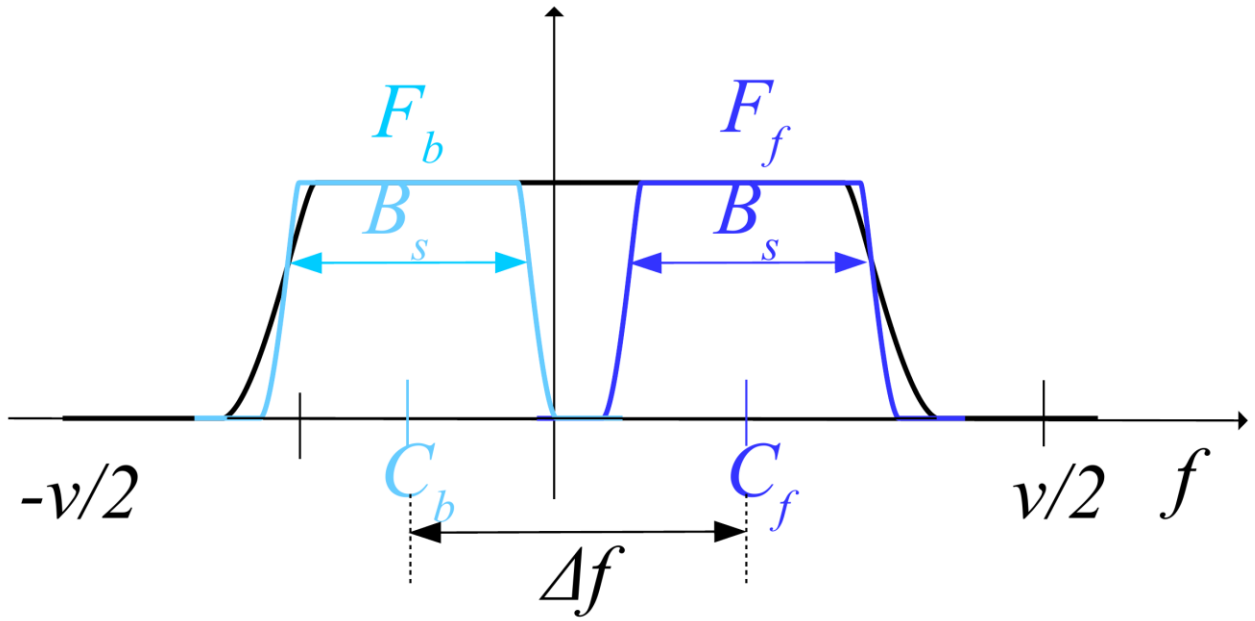


(b)

We choose to split the Doppler band into two separated subbands with their bandwidth as large as possible, maximizing sensitivity and azimuthal resolution

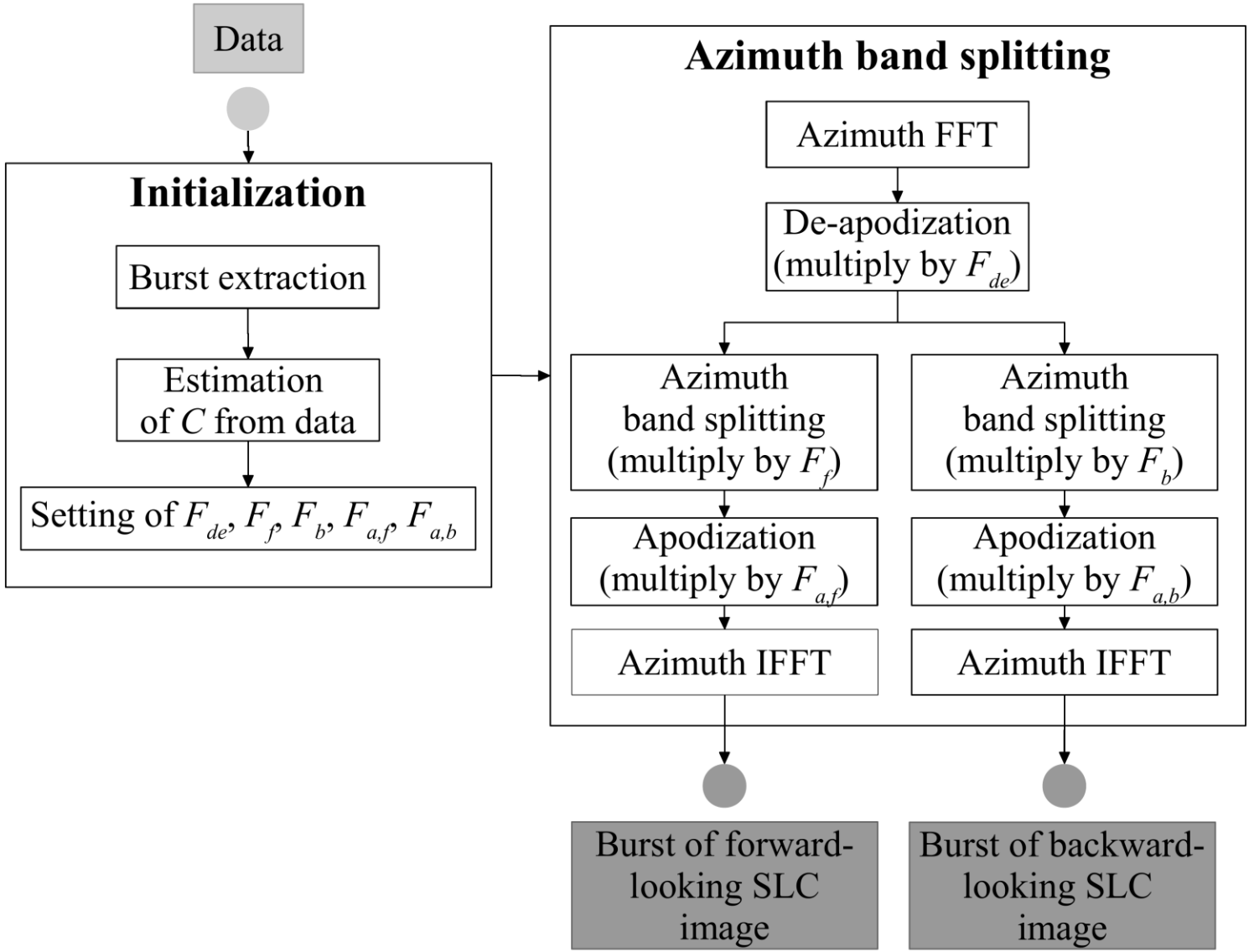


(a)

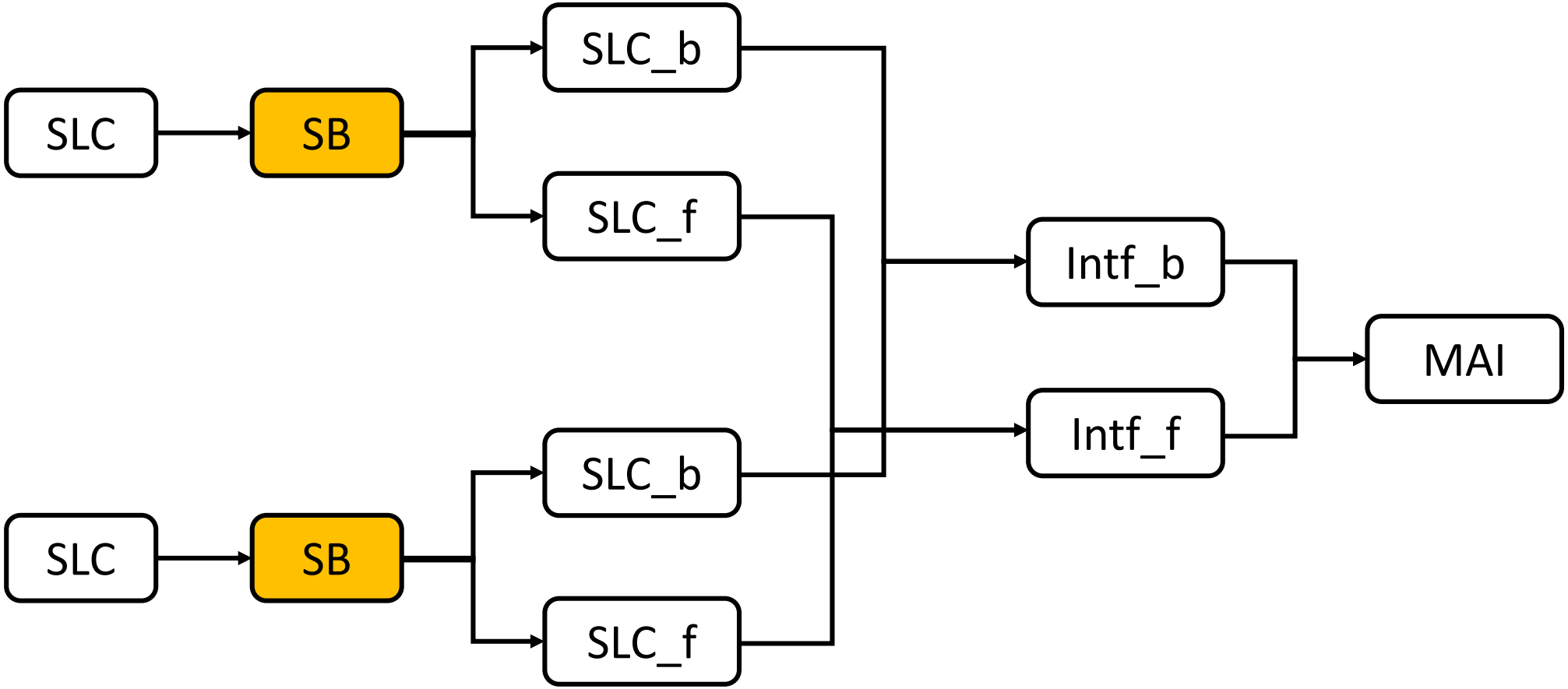


(b)

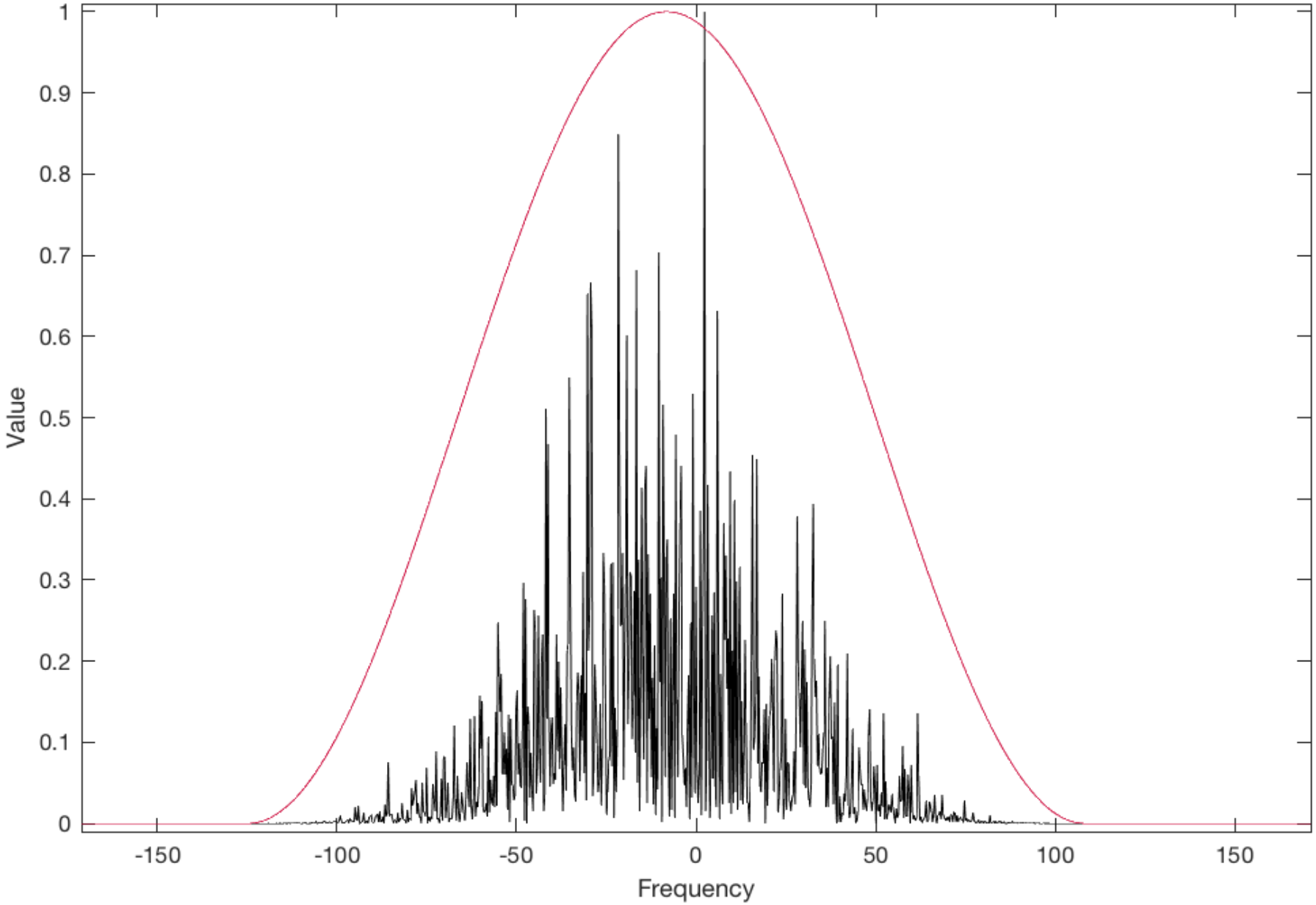
To reconstruct the separated echoes prior the focusing operation, de-apodization is performed before the band-splitting, re-apodization is applied after



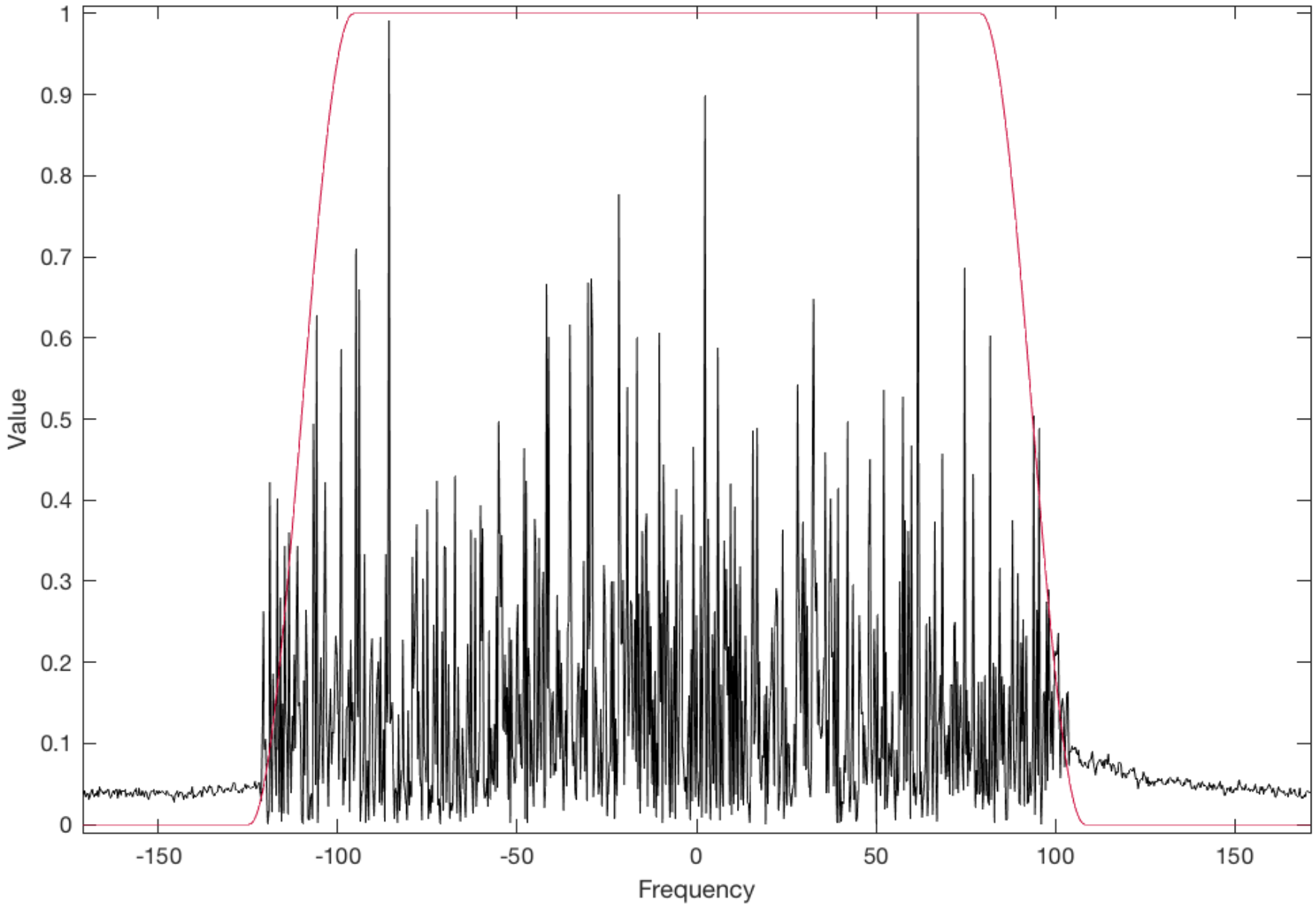
Then, based on subbanded images, we can perform Multiple Aperture Interferometry



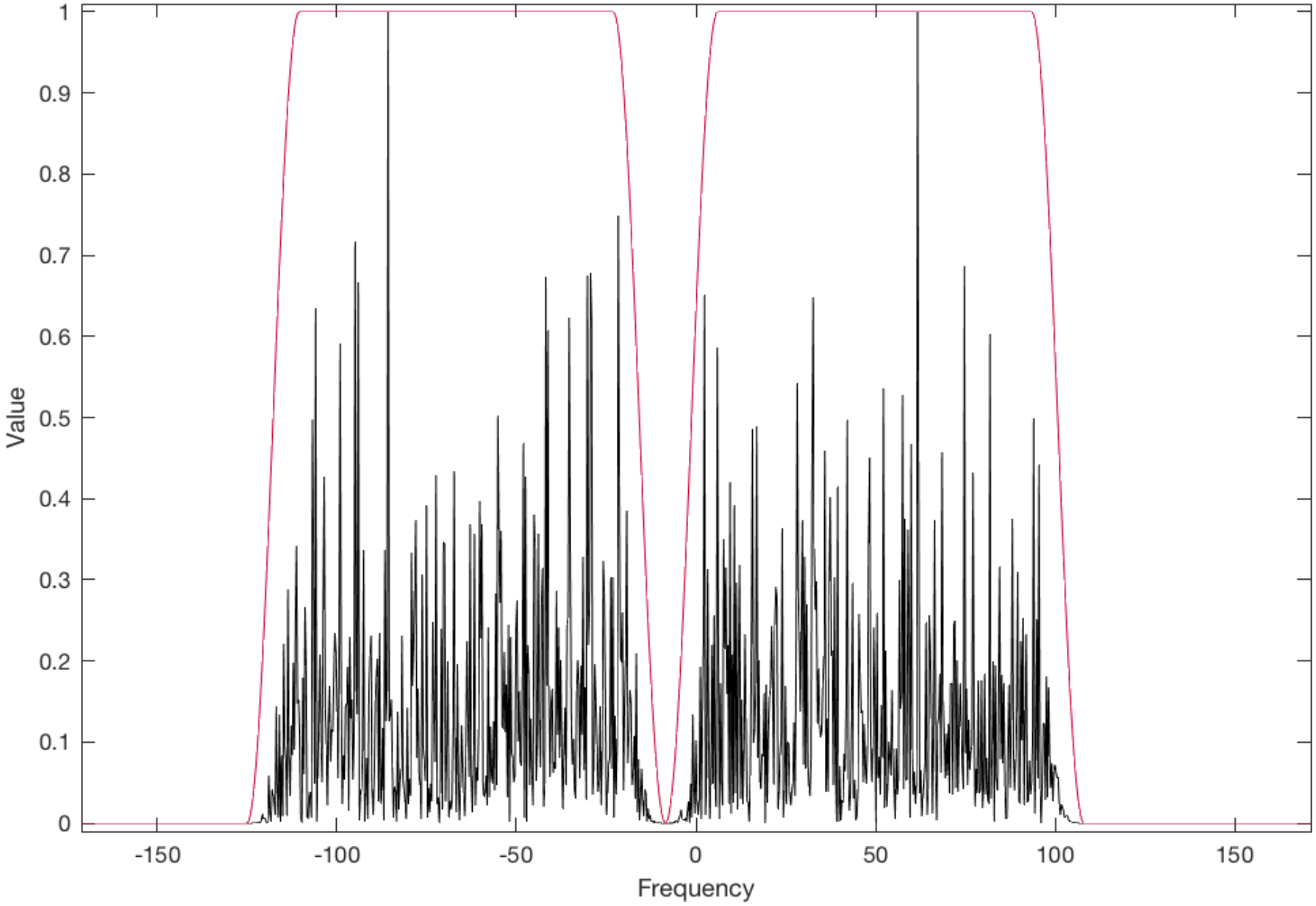
The initial spectrum of azimuth line at mid range



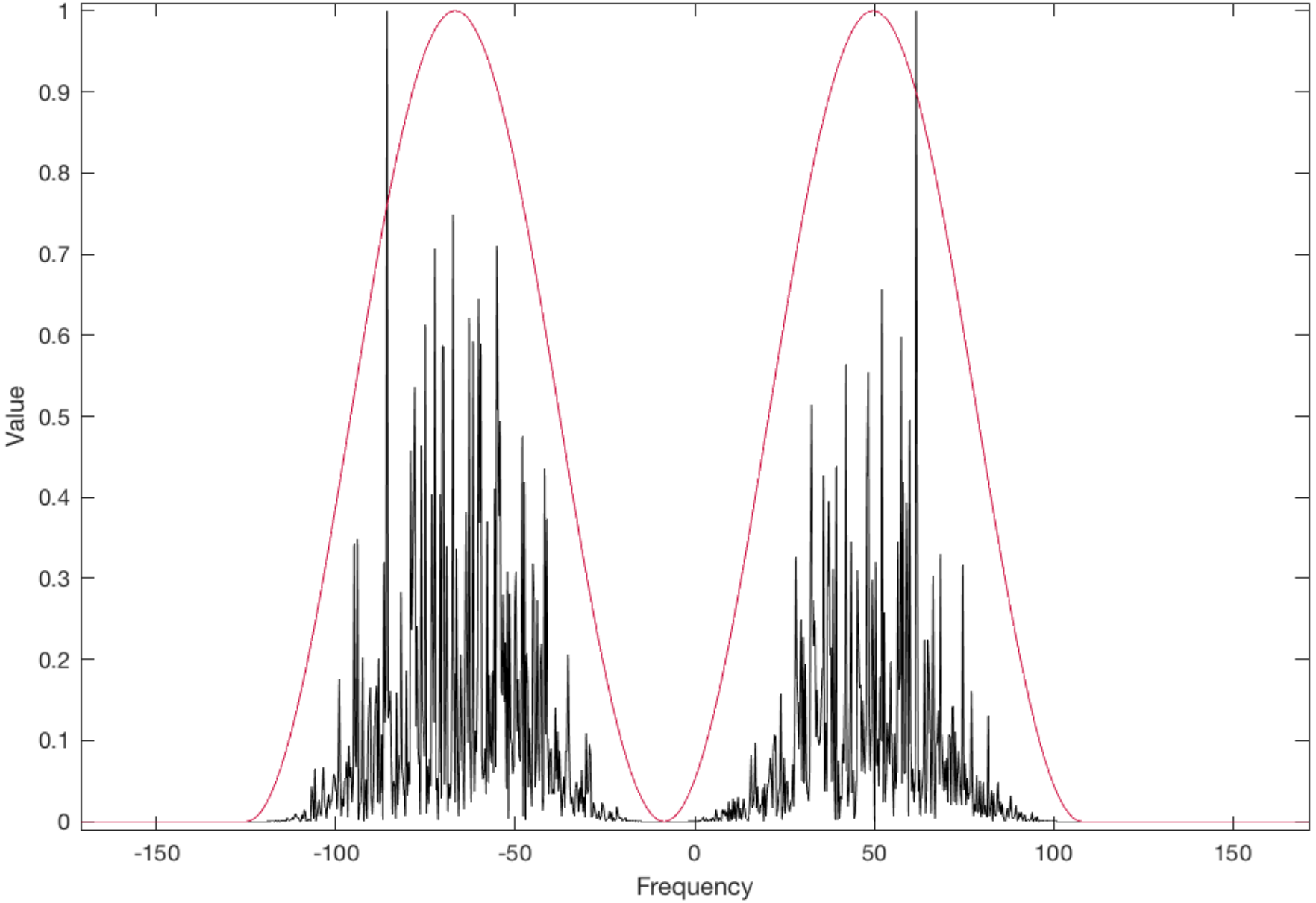
The spectrum of azimuth line at mid range after de-apodization



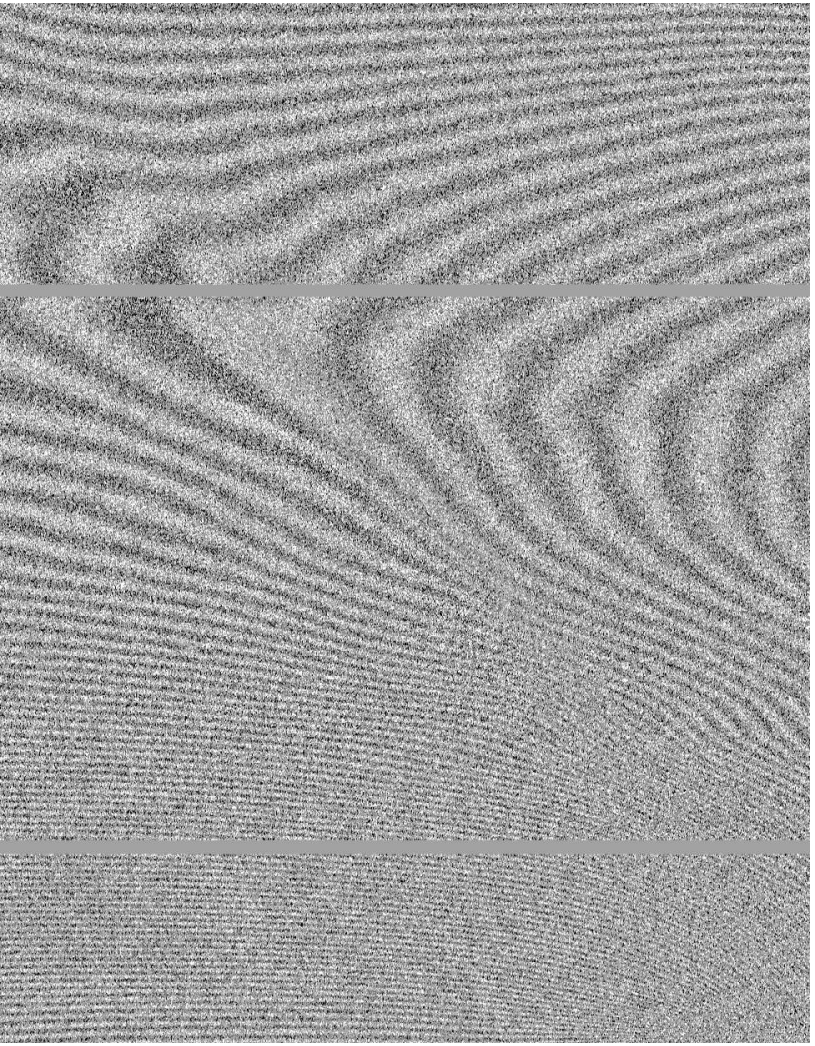
The spectrum of azimuth line after azimuth band splitting (both signals are displayed)



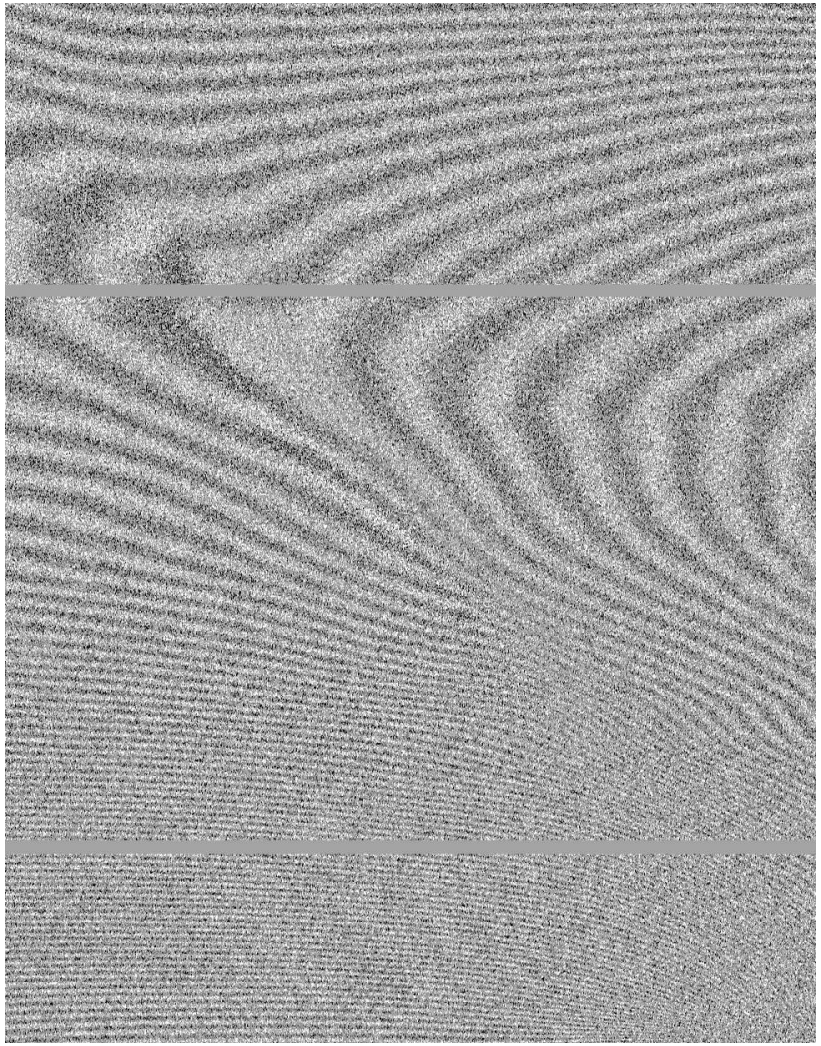
The spectrum of azimuth line after azimuth band splitting and re-apodization (both signals are displayed)



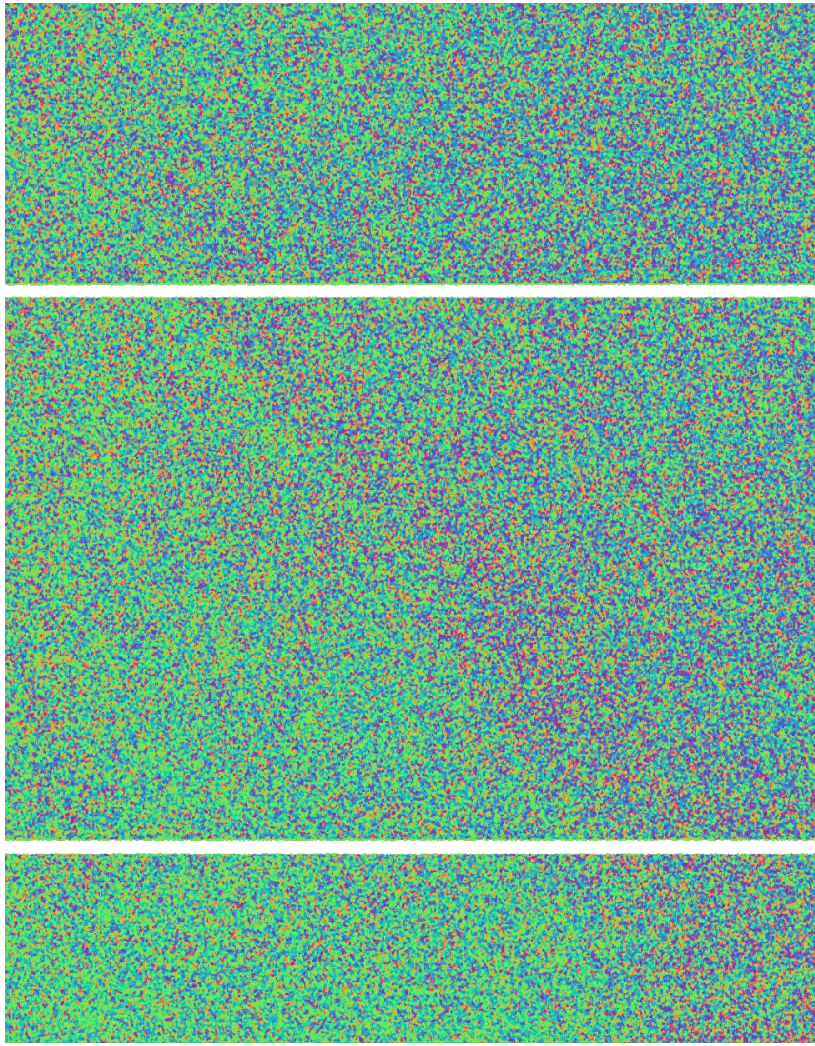
Forward and Backward looking interferogra look similar, but their subtraction lets appear the azimuthal displacement



Forward Looking

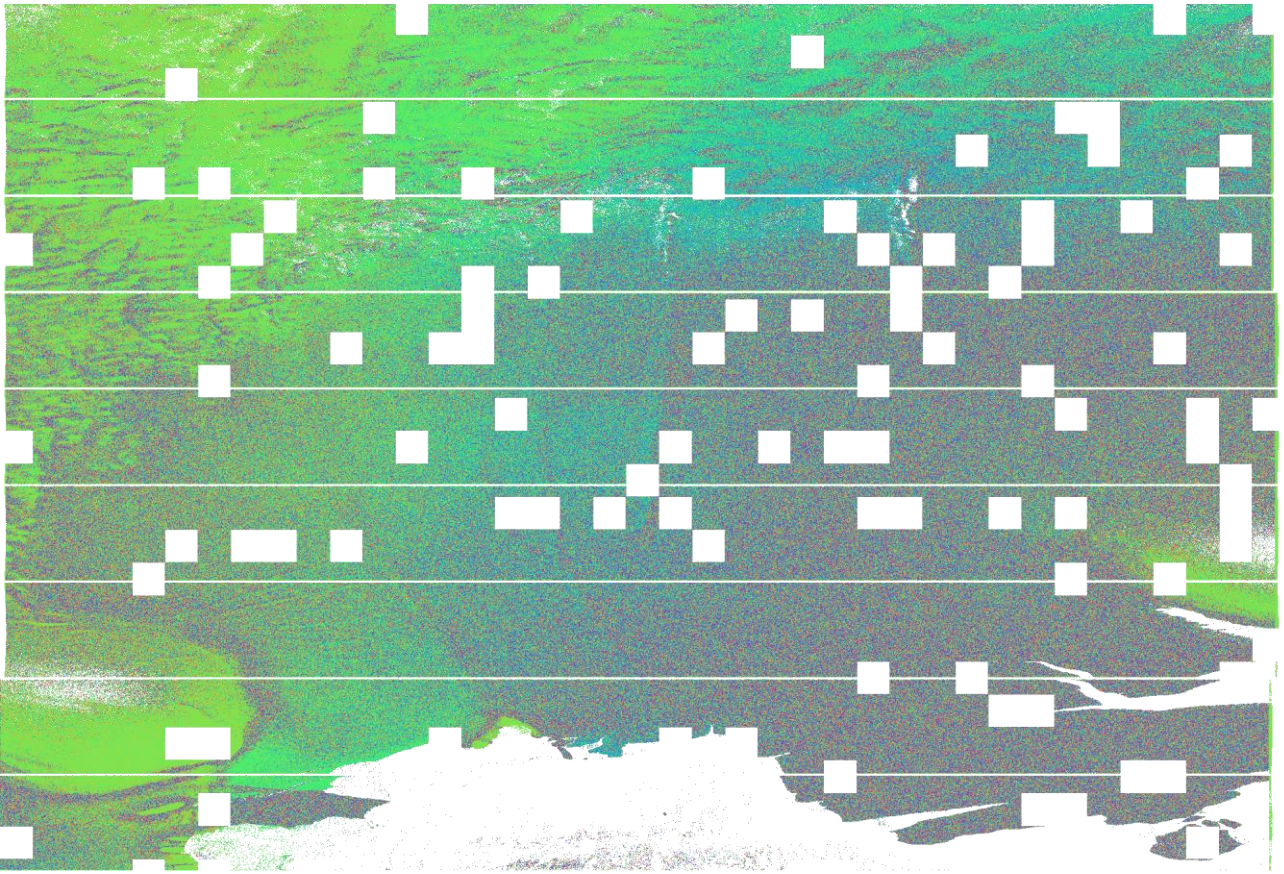


Backward Looking

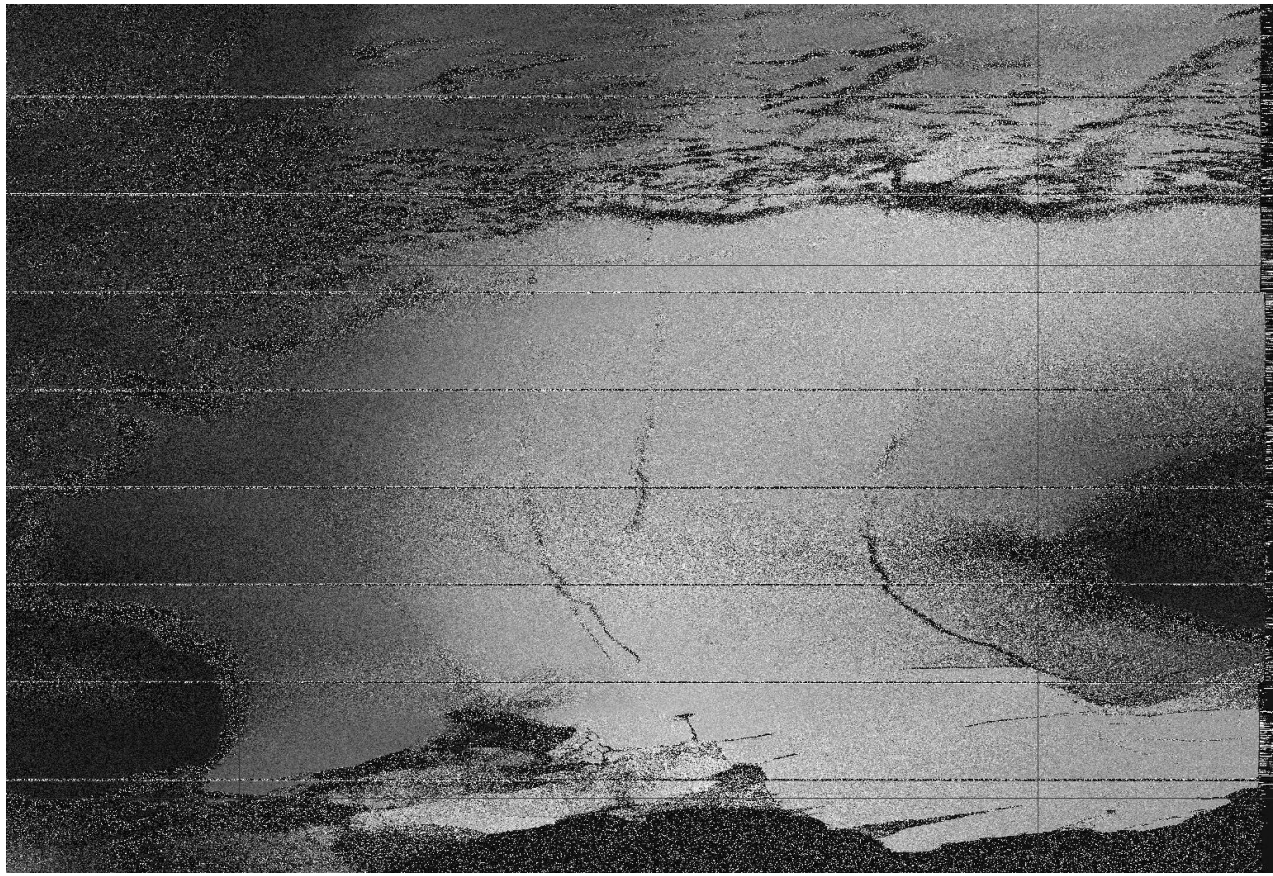


MAI phase

Results show a good correspondence with pixel offset tracking results, but low SNR strongly influence the expected accuracy



MAI



Offset Tracking

To conclude, MAI is a beautiful technique to infer azimuthal displacements, but its application to Sentinel-1 data show its limitations

Additional work is needed, and your comments are welcome in this regard.
Thanks for attending this session!

Murielle Kirkove and Quentin Glaude

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