Performance of Passive ROSE-L and NISAR Co-Fliers with a Large Baseline

Eric Loria, Ilgin Seker, Shashank Joshil, Charles Le, Richard Hodges, Marco Lavalle

Jet Propulsion Laboratory, California Institute of Technology

Multistatic Radar Workshop 2025– Milan, Italy

June 19-20, 2025

Jet Propulsion Laboratory
California Institute of Technology

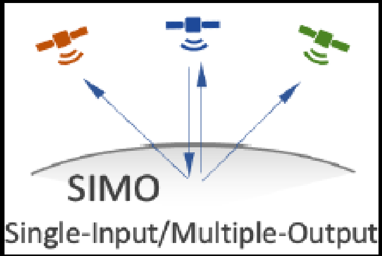
Long-Along Track Baseline Geometry for Co-Fliers

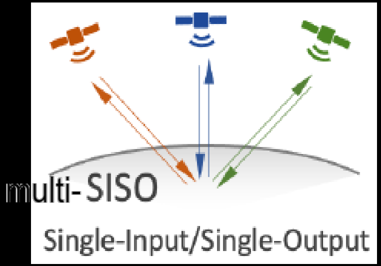
- The US National Academies of Sciences, Engineering and Medicine (NASEM) 2017 Earth Science Decadal Survey identified the designated and target observable Surface Deformation and Change (SDC)
- Large baselines (~200 – 300km) in the along track direction enable 3D deformation retrieval and atmospheric delay correction
- A potential cost-effective architecture is to utilize existing/future SAR satellites as illuminators in a bistatic formation. Two potential transmitters in L-band that can be used for SDC are ESA's **ROSE-L** and NASA-ISRO's **NISAR**.
- Each platform has its own advantages and challenges as a transmitter source for co-fliers
- In this presentation, we will briefly introduce:
  - MuTANT, our radar performance simulation tool
  - Trade spaces considered
  - and some preliminary radar performance results of potential co-fliers for each ROSE-L and NISAR

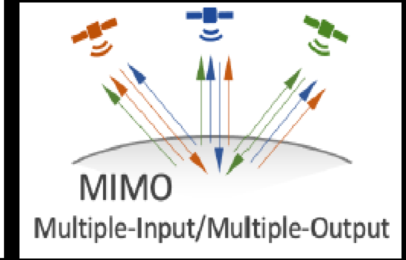
Multistatic Timing & Ambiguity & NESZ Tool (MuTANT)

Performance Metrics

- Timing
- Range Ambiguity (RASR)
- Azimuth Ambiguity (AASR)
- NESZ & SNR



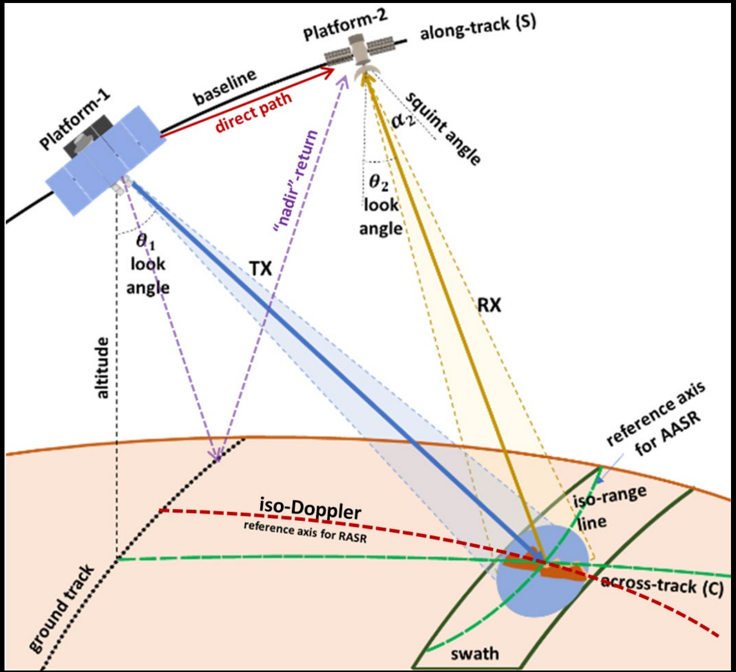




Current Features

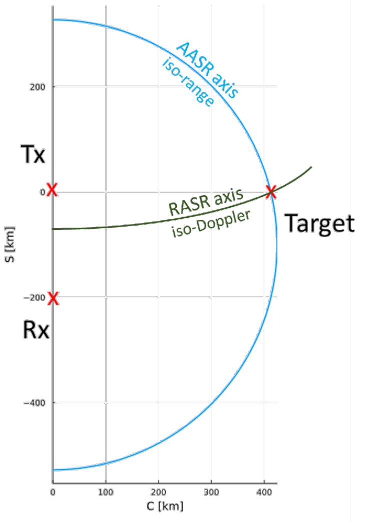
written in julia

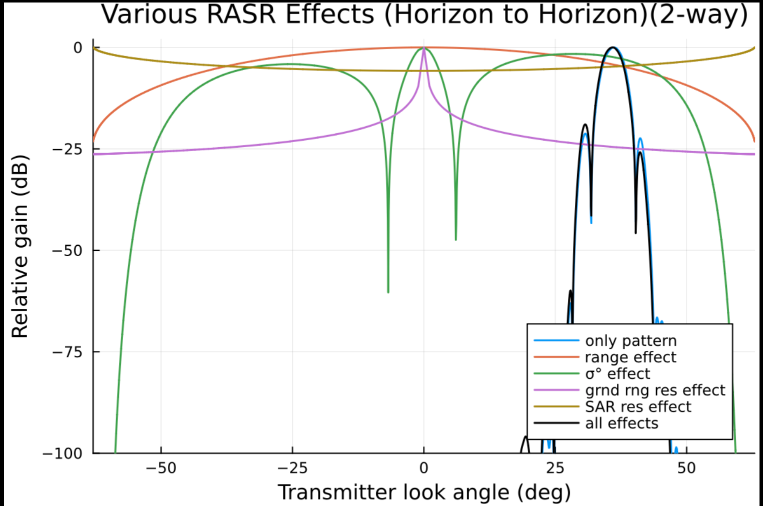
- Stripmap SAR
- multi-SISO/SIMO/MIMO multistatic modes
- Arbitrary multistatic platform formations
- Rectangular/elliptical antennas (or external pattern file)
- Timing diagrams for the 3 multistatic modes
- Timing coincidence checks (Tx-Rx eclipsing, etc.)
- 3 bistatic scattering coefficient models (GO, SPM, specular)
- Bistatic RASR analysis (horizon-to-horizon, iso-Doppler)
- Bistatic AASR analysis (-90˚ to 90˚ azimuth, iso-range)
- Direct path leakages among platforms
- Bistatic "nadir"-return (forward scattering)
- Ground resolution effect
- Processing gain effect
- Bistatic NESZ & SNR

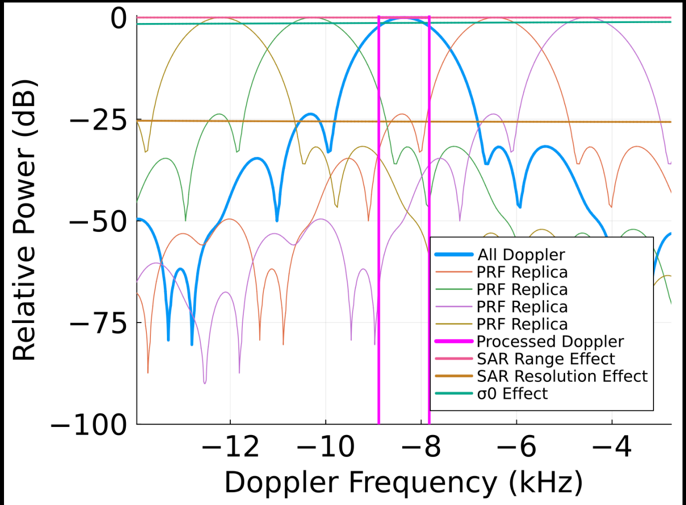


Ambiguity NESZ, and SNR Analysis in MuTANT

- Range ambiguities are calculated along the iso-Doppler axis between transmitter and receiver
- Azimuth ambiguities are calculated along the iso-range lines
- Numerous effects are folded into the ambiguity calculation:
    - Two-way antenna patterns
    - Bistatic sigma0 profiles
    - Two-way ranges
    - Range and azimuth resolutions (both calculated analytically and numerically)







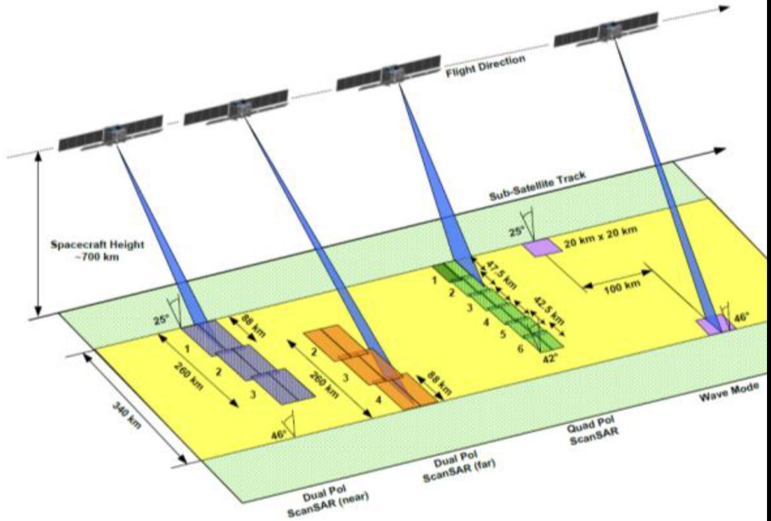
Co-flying with ROSE-L

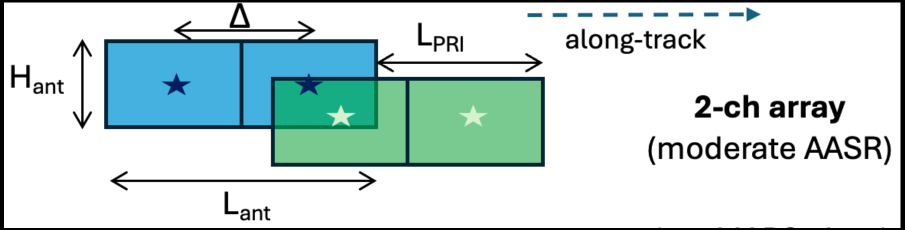
MAIN CHALLENGES

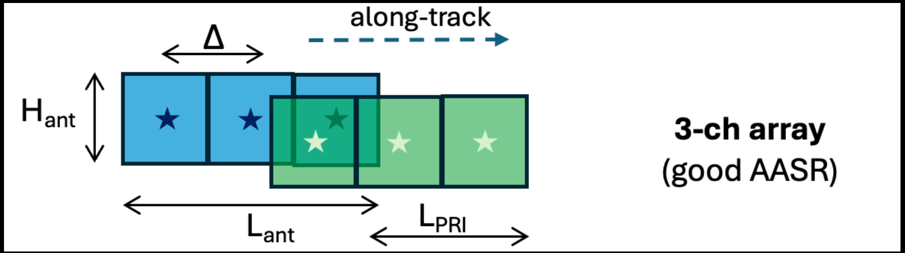
- ROSE-L on transmit illuminates 3 subswaths in sequence
- This requires a large illuminated Doppler band alongside the low PRF, which drives a large azimuth ambiguity

APPROACH

- Multiple sampling channels in azimuth can be used to suppress ambiguities through equal sample spacing
- Rectangular passive array antenna with several phase centers appears to be the most promising approach
- Signal reconstruction methods (MAPS) can also be used to suppress ambiguities
- Current reconstruction methods work well for monostatic geometries but are limited in performance with large baselines.
- We are currently developing reconstruction algorithms for large baselines







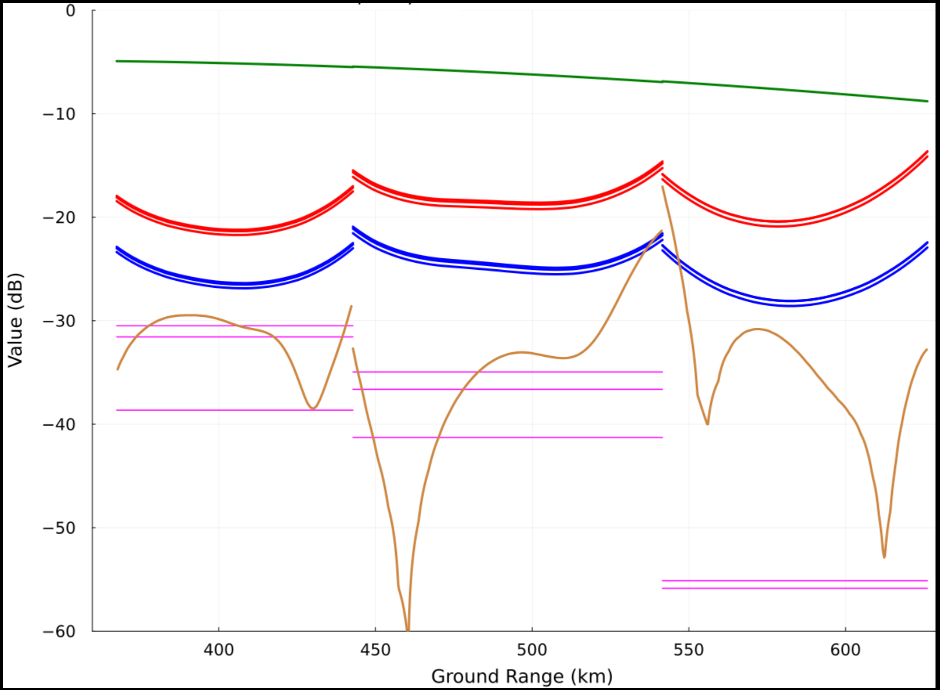
ROSE-L Co-Flier Performance (for ROSE-L dual-pol mode)

250 km baseline

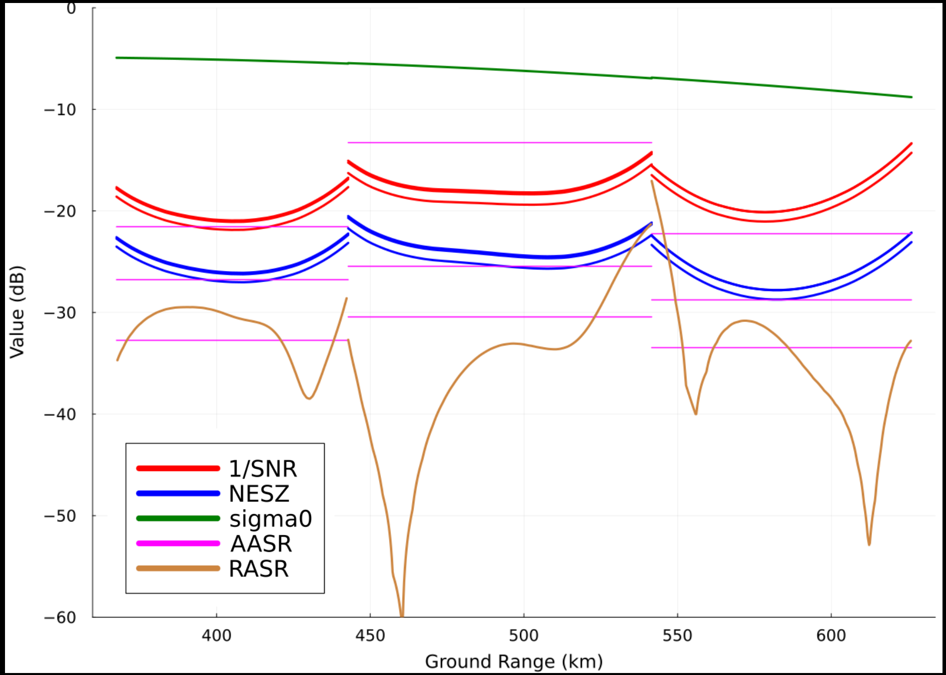
- Figures show radar performance for 2 and 3 azimuth channel arrays
- Different curves with the same color are for different azimuth targets within the ScanSAR Doppler band

ROSE-L Dual-Pol Mode	Sub-swath - 2	Sub-swaths – 1 & 3
Effective Antenna Size	10.5 x 2.5 m	8.9 x 2.5 m

3 Channel Array Antenna



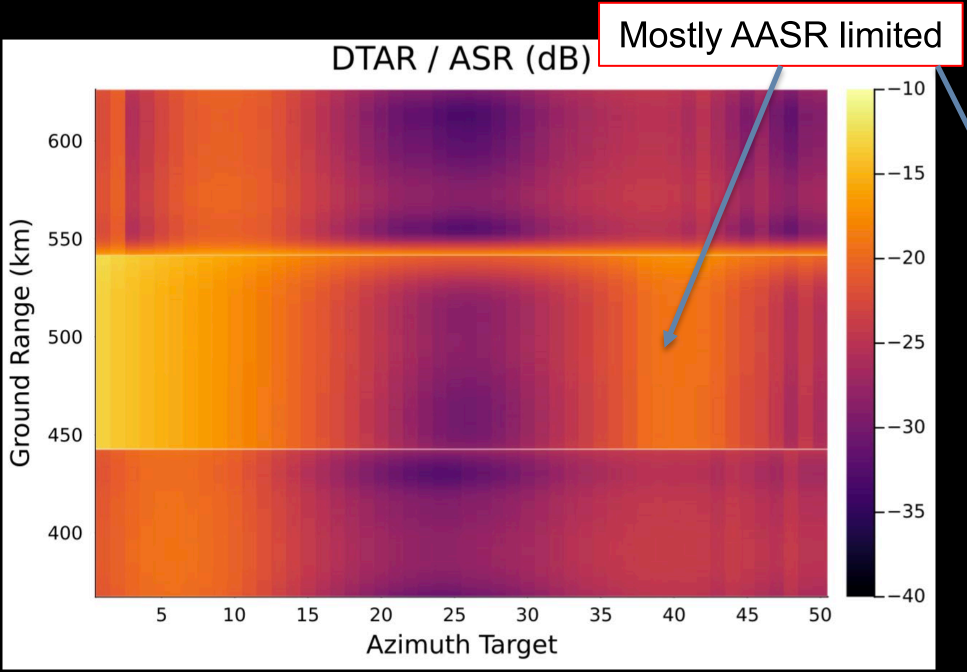
2 Channel Array Antenna



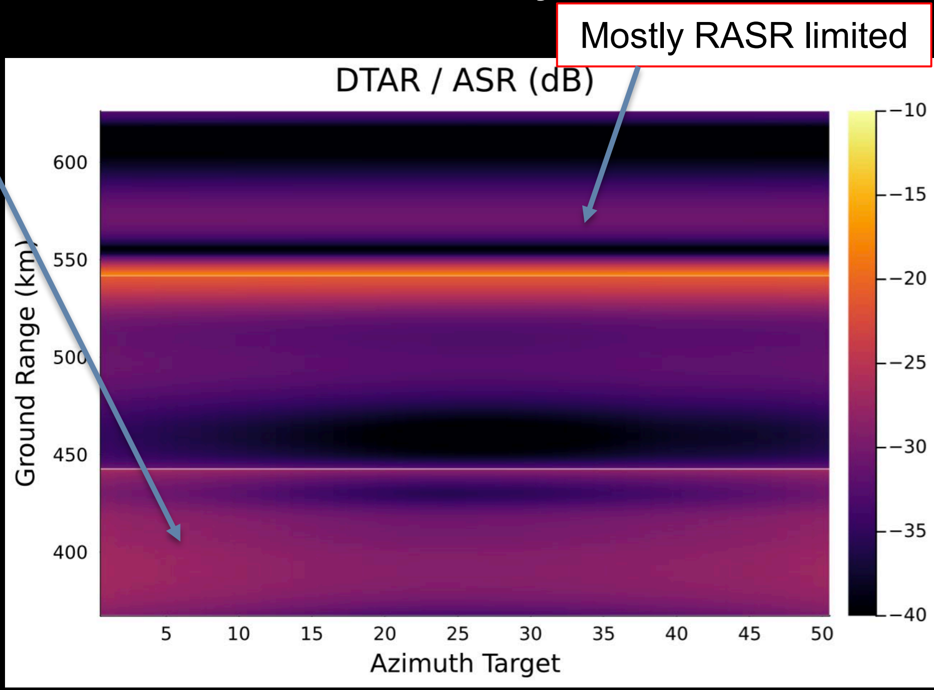
ROSE-L Co-Flier Performance (for ROSE-L dual-pol mode)

ROSE-L Dual-Pol Mode	Sub-swath - 2	Sub-swaths – 1 & 3
Effective Antenna Size	10.5 x 2.5 m	8.9 x 2.5 m

2 Channel Array Antenna



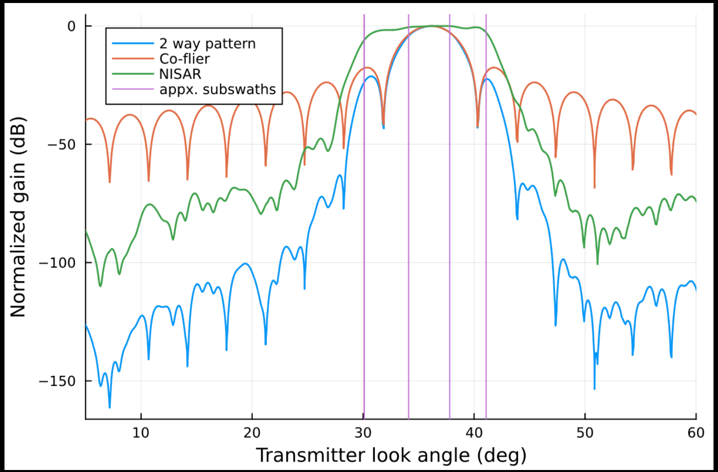
3 Channel Array Antenna



Co-flying with NISAR

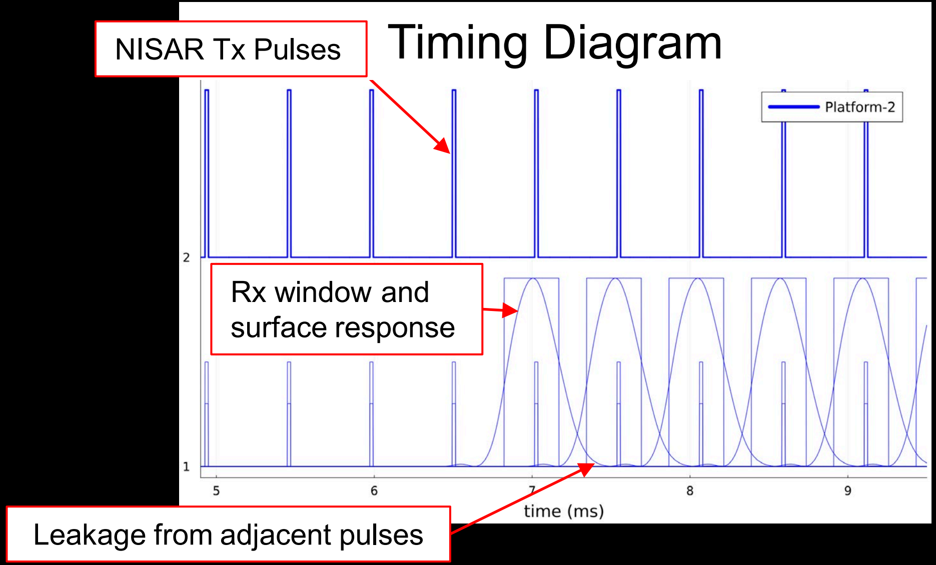
MAIN CHALLENGES

- NISAR illuminates a large (240km) swath all at once, then uses scanSAR on receive
- For simple receive antennas, we cannot image this size swath at once, so we divide in subswaths
- The large illuminated swath leads to large range ambiguities



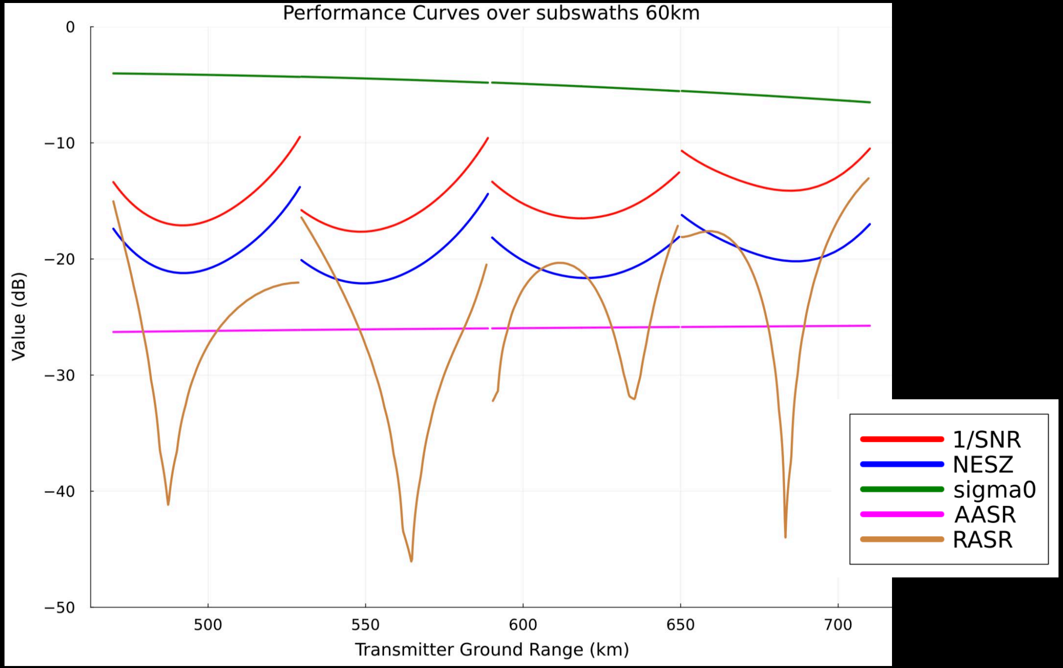
APPROACH

- Evaluated subswaths of 2 x 120km, 3 x 80km, 4 x 60km, etc.
- Receive antenna can be shorter in azimuth given the much smaller illuminated Doppler band (approximately > 3m necessary)
- Elevation size must be greater in order to reduce the effects of the large illuminated area from NISAR
- Subswathing combined with circular reflector antennas offer promising results
- Adjusting Rx antenna boresight pointing can also be used to reduce ambiguities



NISAR Co-Flier Performance (for NISAR dual-pol mode)

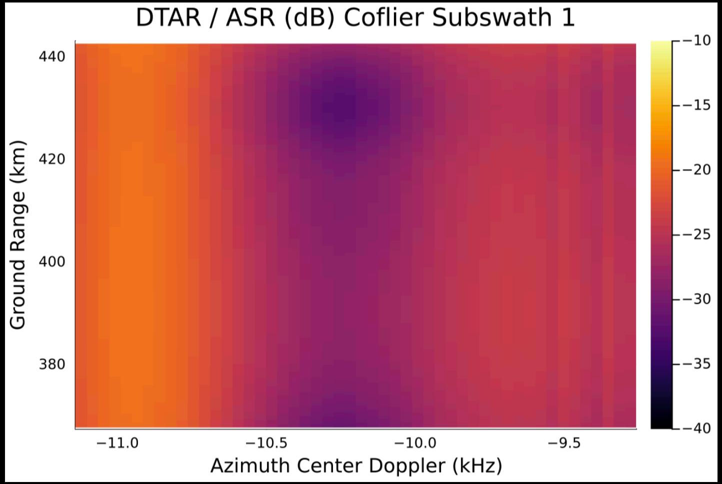
- Current approach segments the 240 km NISAR swath into 4 x 60 km wide swaths
- Co-flier uses a 6-meter circular reflector antenna (a mini-NISAR) which covers one subswath per orbit
- The co-flier antenna boresight pointing is optimized within each subswath to minimize RASR while maintaining NESZ performance
- Adjusting the edges between subswaths was also examined (extent or reduce adjacent subswaths to minimize the ambiguities at the edges)

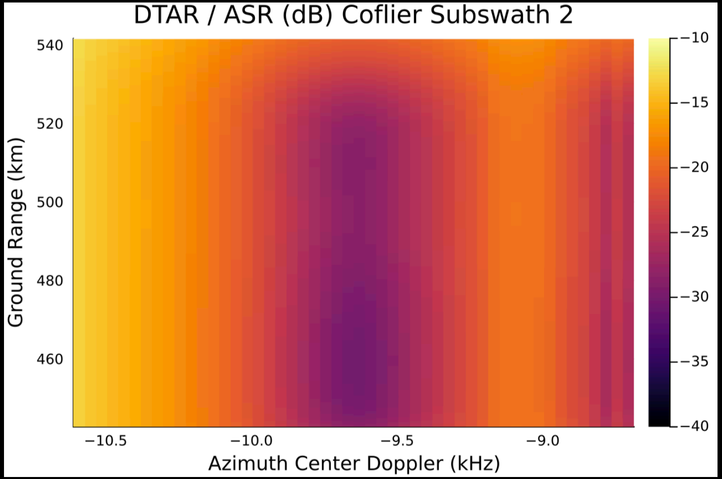


Jet Propulsion Laboratory
California Institute of Technology

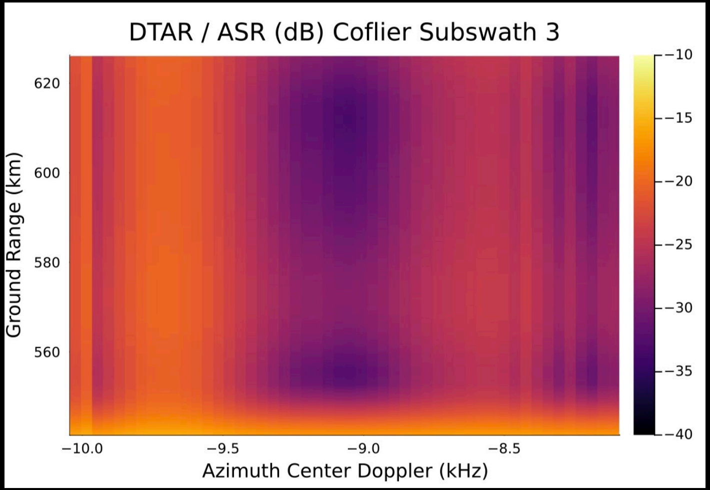
jpl.nasa.gov

ROSE-L Co-Flier Performance (for ROSE-L dual-pol mode)

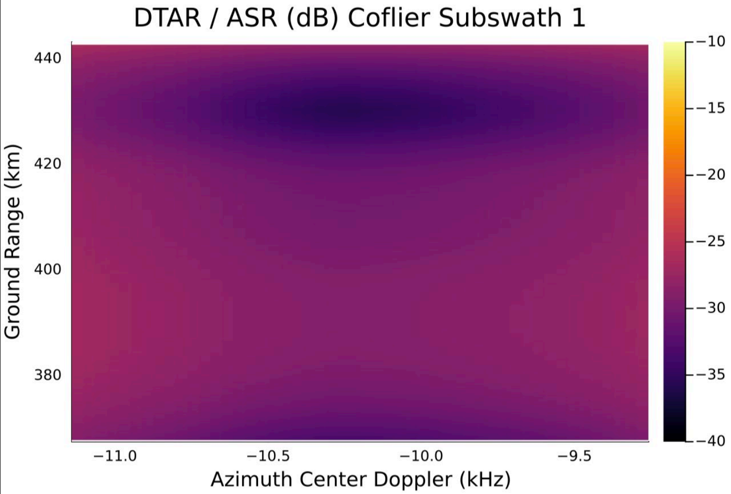


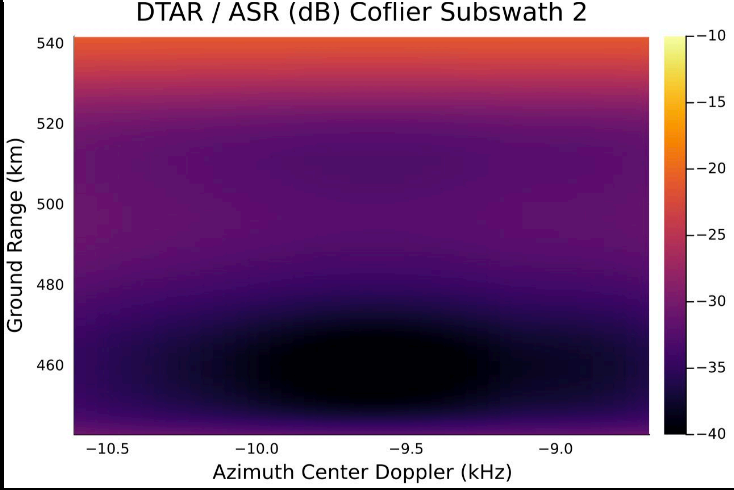


2 Azimuth Channels



ROSE-L Co-Flier Performance (for ROSE-L dual-pol mode)





3 Azimuth Channels