The MDA CHORUS™ SAR constellation

A unique perspective for improved slope stability monitoring and geotechnical risk assessment

Dylan Hickson, PhD[1*], Roger Morin[1], and Rodney Podmore[2]

[1]MDA Space, 13800 Commerce Parkway, Richmond, BC, Canada

[2]Leica Geosystems, 400 16th Road, Randjespark, Midrand, 1685, South Africa

[*]dylan.hickson@mda.space

RESTRICTION ON USE, PUBLICATION DISCLOSURE OF PROPRIETARY INFORMATION AND IMAGES

AGENDA

01

SAR for motion monitoring

02

MDA CHORUS™

03

Venetia mine case study

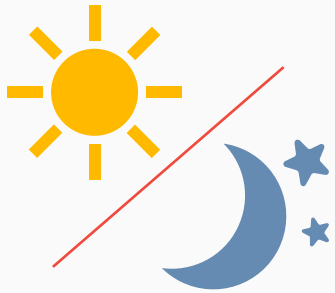
04

Future outlook

Synthetic Aperture Radar (SAR)

High resolution (1-20 m) satellite based radar observations of wide areas (100s of km) for consistent monitoring of critical assets

Active sensing: image day or night

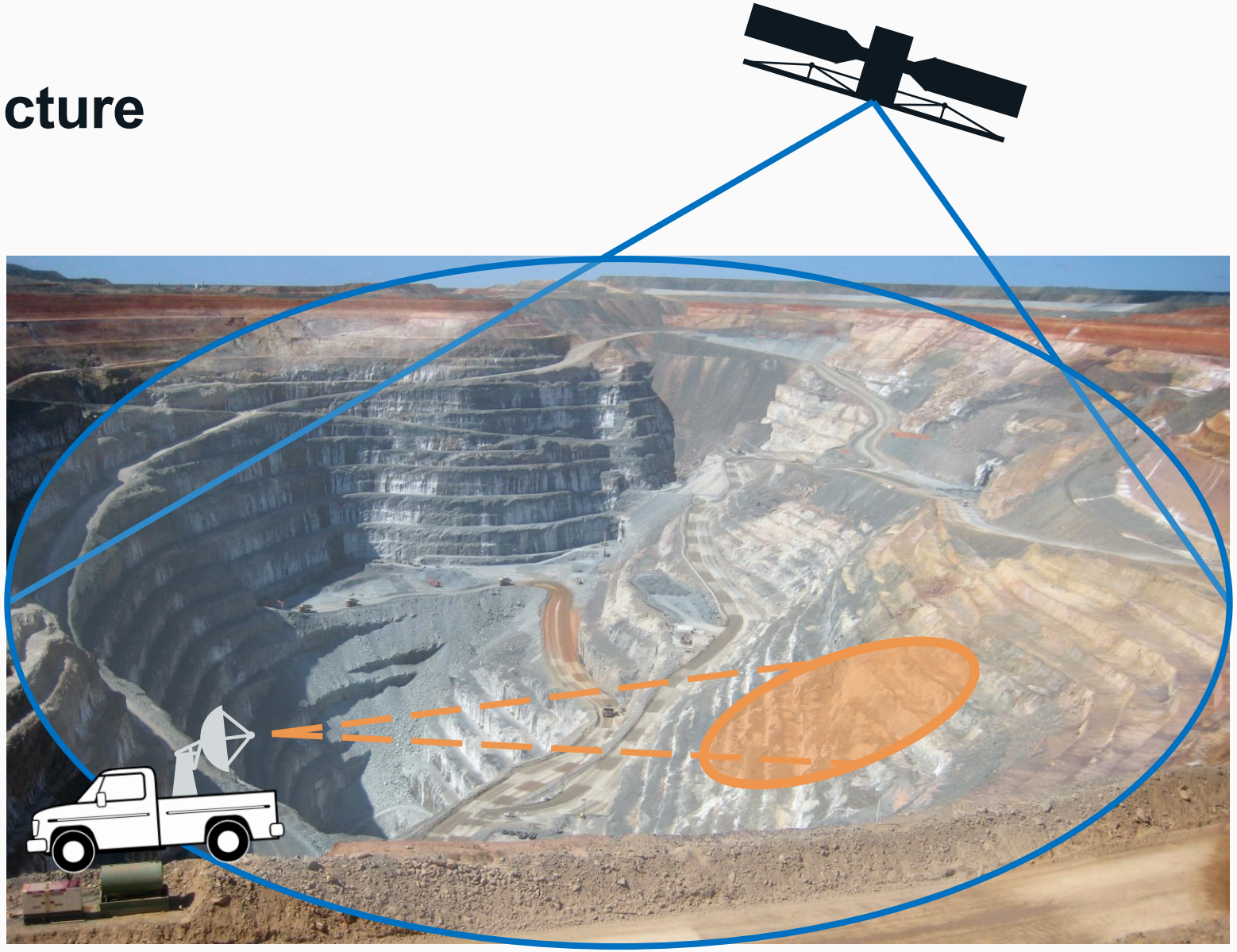


Microwave signal penetrates clouds

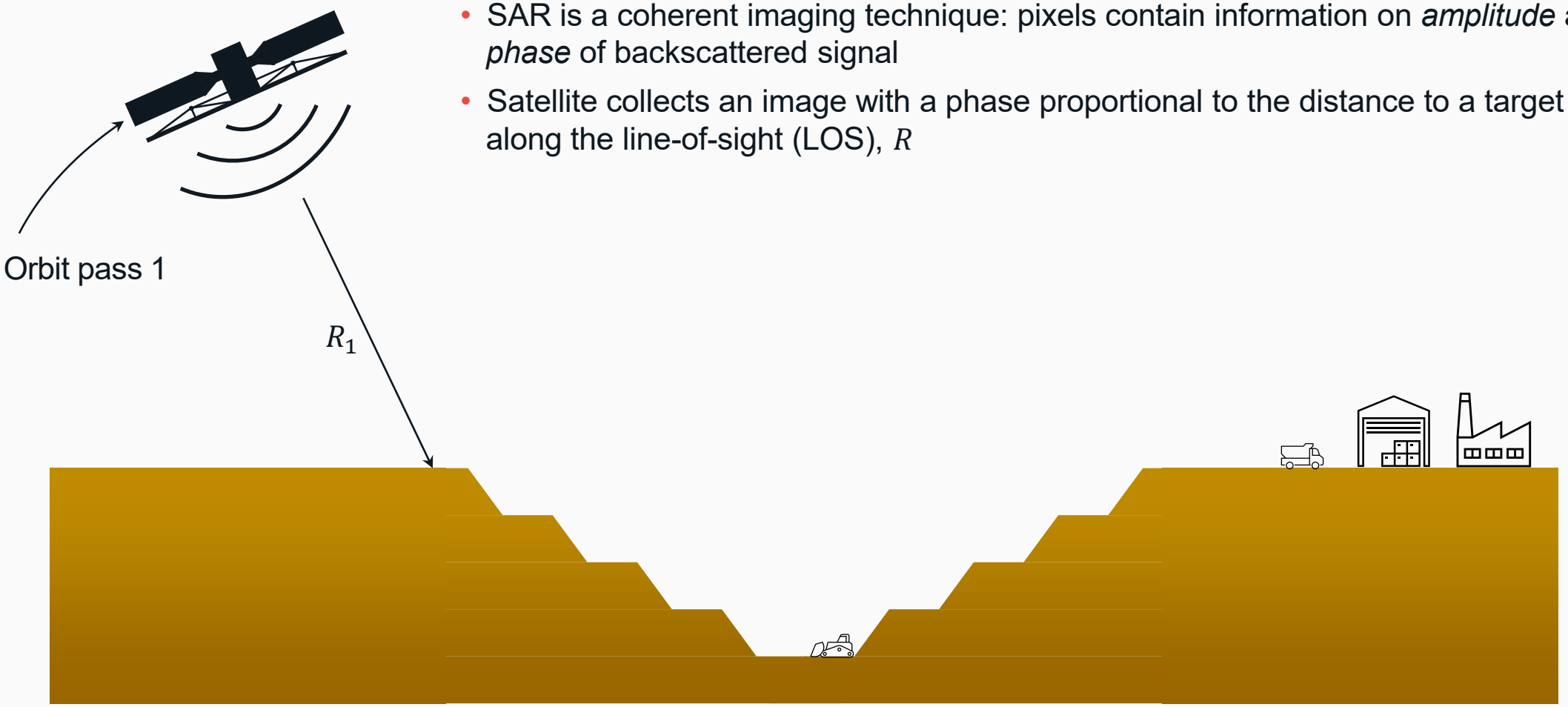
Satellite can image every orbit cycle for building reliable time series observations

Satellite SAR – the big picture

- **Ground-based radar:** a radar system deployed on the ground on-site
  - Limited area can be observed at one time
  - Requires on-site installation, logistics, and maintenance
  - High resolution with fast measurements
  - Detailed information for high risk areas
- **Satellite InSAR:** a radar system deployed on an orbital satellite
  - Monitor wide areas
  - No ground infrastructure required
  - Lower resolution and slower measurements
  - Early warning to identify movement
- Approaches can be combined for complementary monitoring program

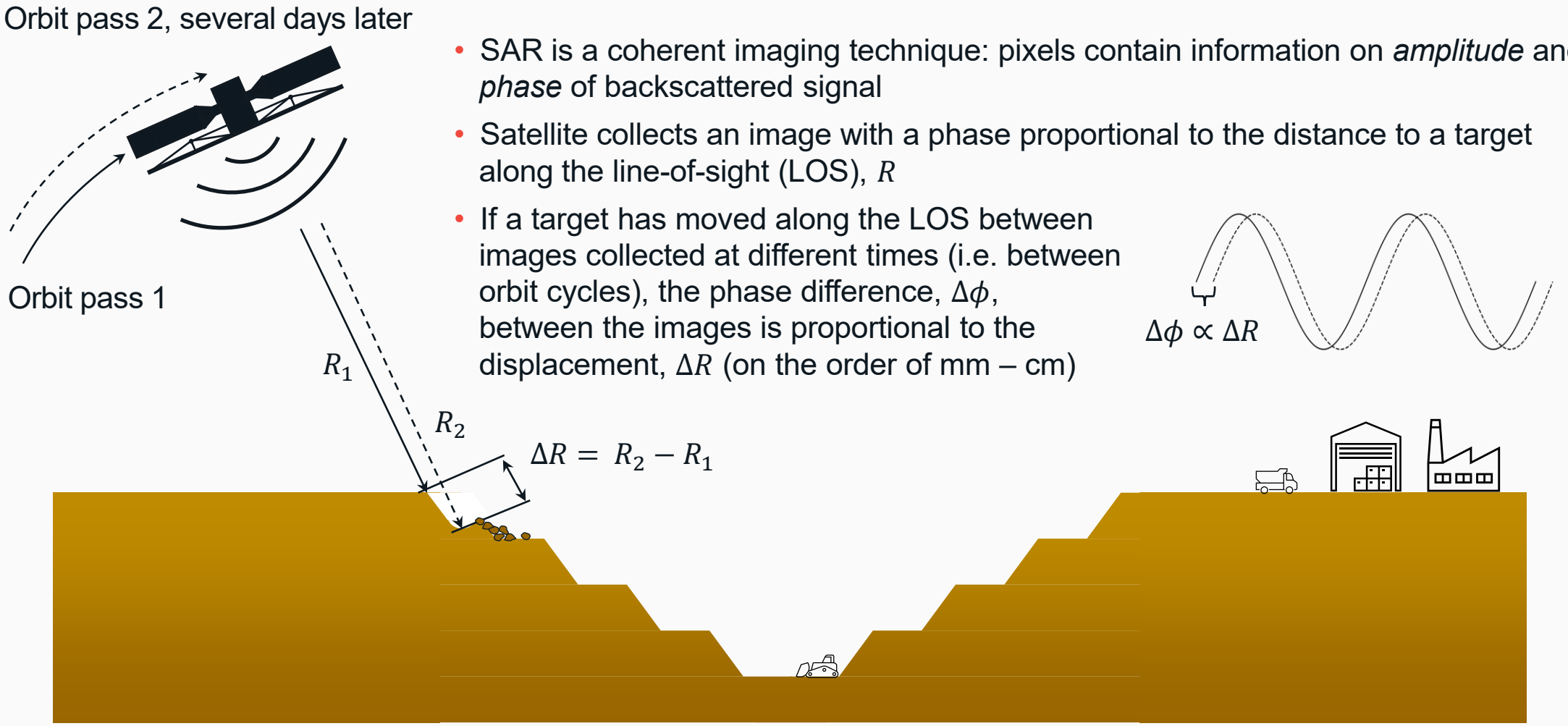


Interferometric SAR (InSAR)



- SAR is a coherent imaging technique: pixels contain information on *amplitude* and *phase* of backscattered signal
- Satellite collects an image with a phase proportional to the distance to a target along the line-of-sight (LOS), R

Interferometric SAR (InSAR)



- SAR is a coherent imaging technique: pixels contain information on *amplitude* and *phase* of backscattered signal
- Satellite collects an image with a phase proportional to the distance to a target along the line-of-sight (LOS), R
- If a target has moved along the LOS between images collected at different times (i.e. between orbit cycles), the phase difference, $\Delta\phi$, between the images is proportional to the displacement, ΔR (on the order of mm – cm)

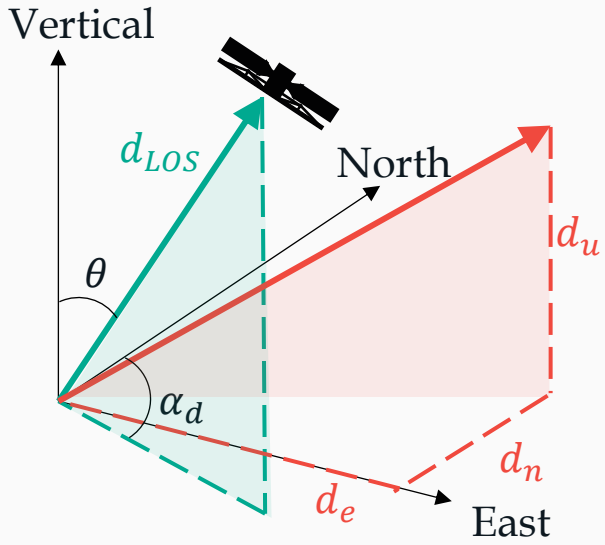
InSAR measures deformation along the line-of-sight (LOS)

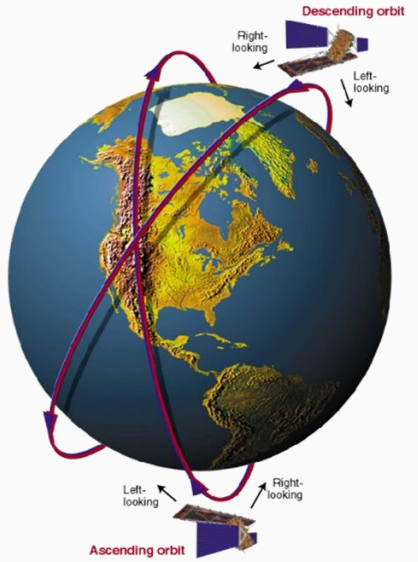
- A **single InSAR analysis** measures a projection of the surface movement along the **LOS direction only (1D)**

- Surface movement is actually a 3D vector quantity
  - If the LOS is not aligned with the true motion vector, the movement is underestimated!

- **2D InSAR** is possible by combining measurements **from SAR satellites in sun-synchronous orbits (SSO)**
  - Satellite orbital planes closely aligned with North-South -> LOS are East-West
  - Provides sensitivity to Vertical and East-West motion, but **cannot reliably measure North-South movement**

- **Limited solution:**
  - Challenging interpretation of results
  - Ambiguous modelling processes
  - Insufficient information for full 3D displacement of interest to stakeholders



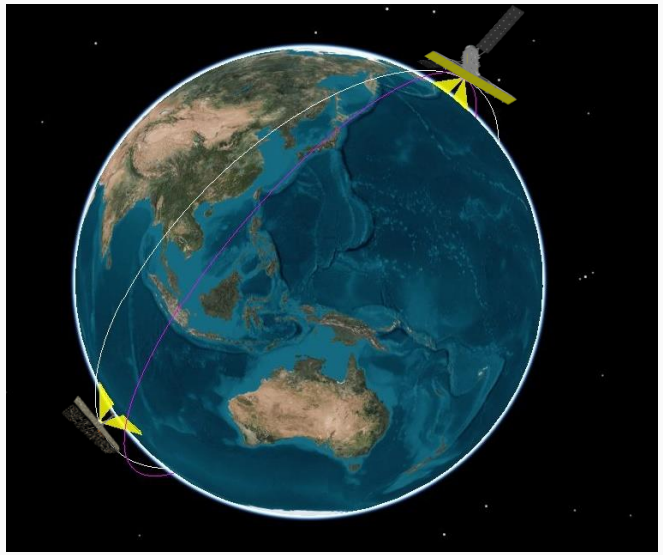


MDA CHORUS

- MDA CHORUS™ is being developed as a next generation SAR mission
- Dual-frequency mission including both C-band and X-band SAR satellite
- Broad area coverage, up to 700 km swath
- Novel mid-inclination orbit providing extensive coverage between ±62.5° latitude
- High resolution (as fine as 50 cm), flexible tasking (right/left looking), **controlled orbit supporting consistent InSAR**
- Currently targeted for launch in mid-2026

CHORUS Enables 3D InSAR Monitoring

- Medium inclined (53.5°) non-sun-synchronous orbit
  - ***Increased angular diversity***
- Reliable repeat coverage
  - ***Fixed orbit***
- Short repeat cycle (9.85 days)
  - ***Improved coherence***
- Wide area monitoring
  - ***Multiple beam modes at different resolutions***



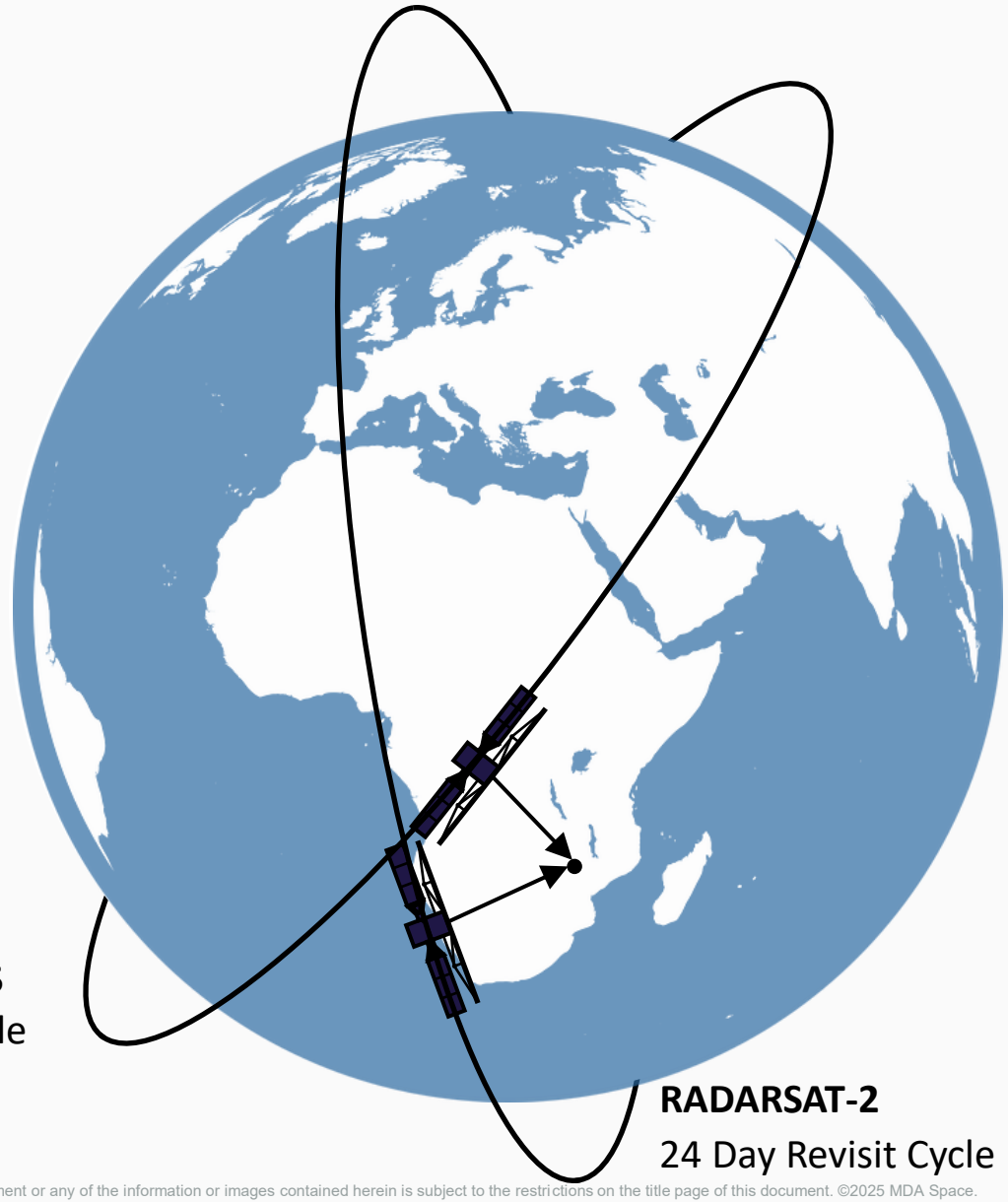
CHORUS-C InSAR Supported Modes

Beam Mode		Swath width	Swath positions	Resolution	Looks (Rg x Az)	Incidence angle range	Sensitivity (max NESZ)	Polarization
Spotlight		10 km x 7 km	128	3 m x 1 m	1	24.5° to 63.9°	-17.5 dB	SP/DP/CP
Stripmap	**3 m**	50 km	26	3 m	1	24.5° to 63.9°	-20 dB	SP/DP/CP
	5 m	100 km – 180 km	20	5 m	1		-21 dB	
	8 m	120 km – 180 km	6	8 m	1		-23 dB	

CHORUS performance numbers are preliminary and subject to change

SP - Single polarization, DP - Dual polarization, CP - Compact Polarization

MDA CHORUS



CHORUS
9.85 Day Revisit Cycle

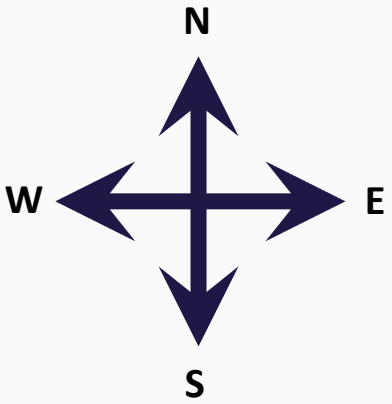
RADARSAT-2
24 Day Revisit Cycle

- InSAR deformation measurements are orthogonal to the satellite orbit
- For SSO orbits, this gives sensitivity to vertical deformation and E-W displacement
- CHORUS' inclined orbit provides exclusive N-S sensitivity
- Combined with RADARSAT-2*, this enables measurement of 3D deformation

*or another polar orbiting SAR

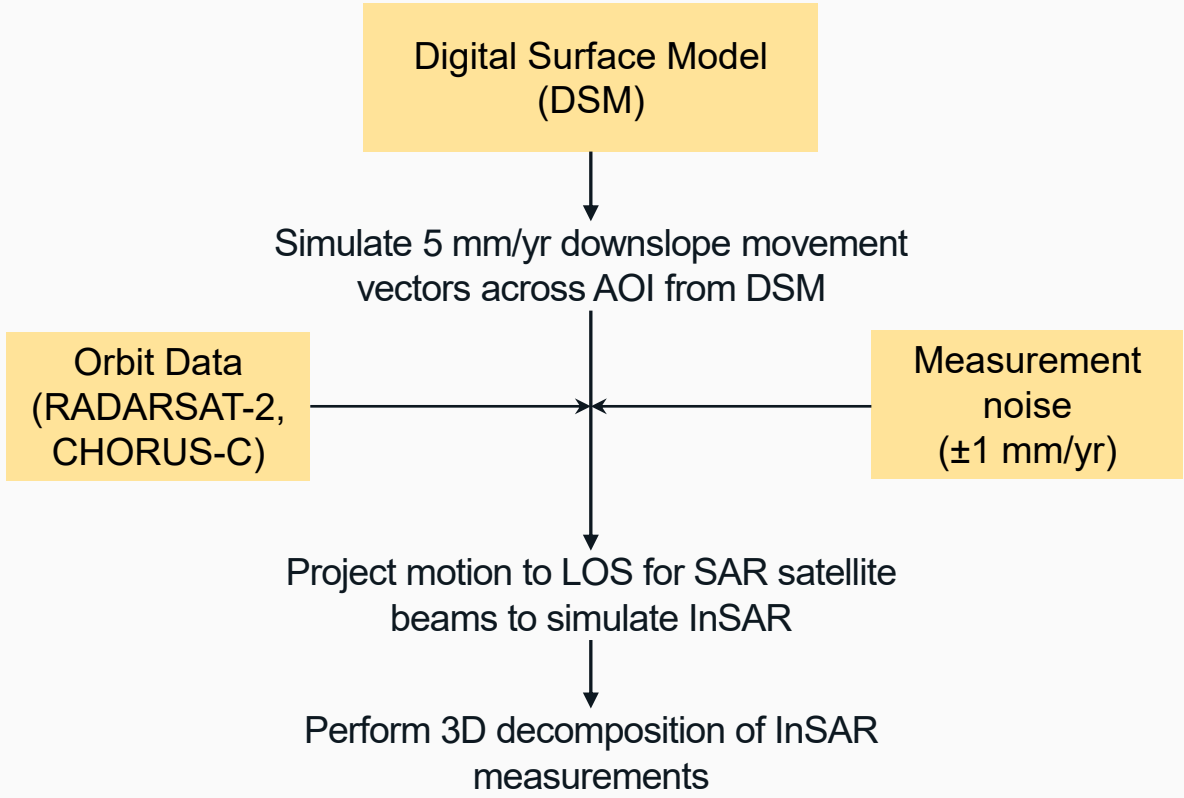
RADARSAT-2
InSAR sensitivity

RADARSAT-2 + CHORUS
InSAR sensitivity



Simulating 3D InSAR

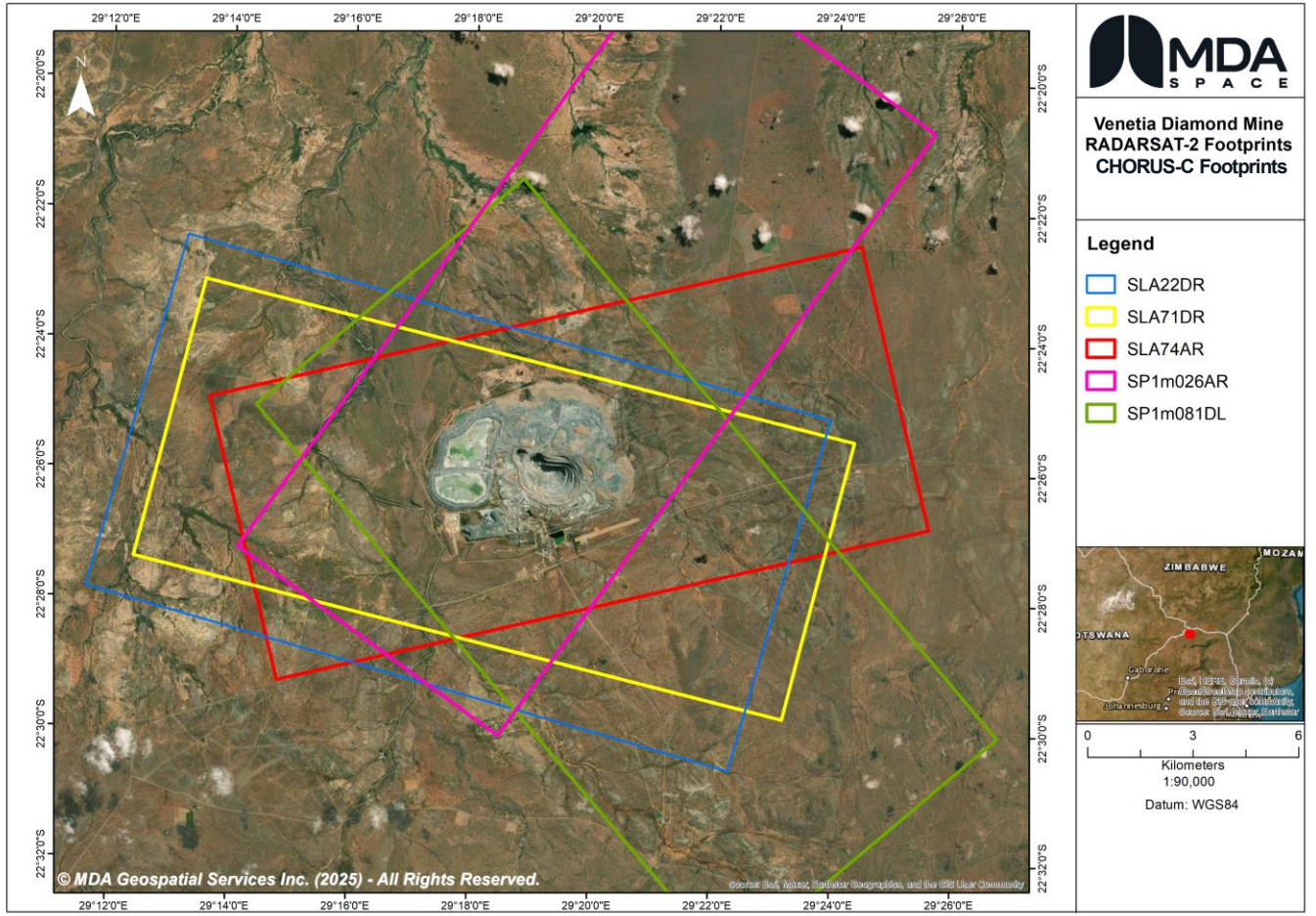
- Mining infrastructure (i.e. Tailings Storage Facilities, Open Pit) introduces complex topography and a wide variety of potential ground failure mechanisms
- We simulate downslope movement for all slopes across the AOI to illustrate the diverse displacement vectors possible
- Assess the ability to measure ground movement using satellite InSAR from SSO geometries and from mid-inclination orbits
  - **Case 1:** only SSO InSAR (RADARSAT-2 beams only)
  - **Case 2:** SSO and mid-inclination InSAR (RADARSAT-2 + CHORUS-C)
- Compare the 3D reconstruction from InSAR with our simulated deformation

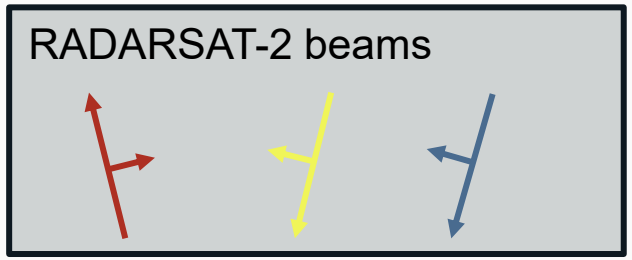


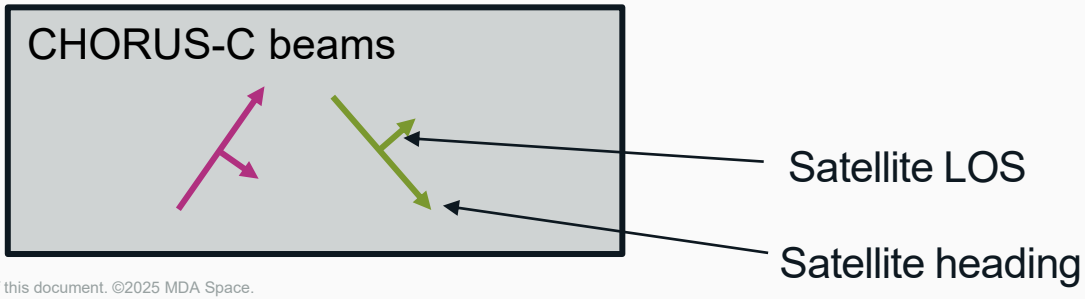
The Venetia Diamond Mine

RADARSAT-2 and CHORUS-C

- 3D inversion of InSAR measurements is very sensitive to the geometries from which the InSAR measurements were collected
- Flexible SAR sensors can image from many different beam positions with corresponding image footprints and LOS vectors
- Developed an optimization procedure to identify specific beam combinations that produce highest precision 3D inversion from orbit data
  - **Case 1**: RADARSAT-2
  - **Case 2**: RADARSAT-2 + CHORUS-C

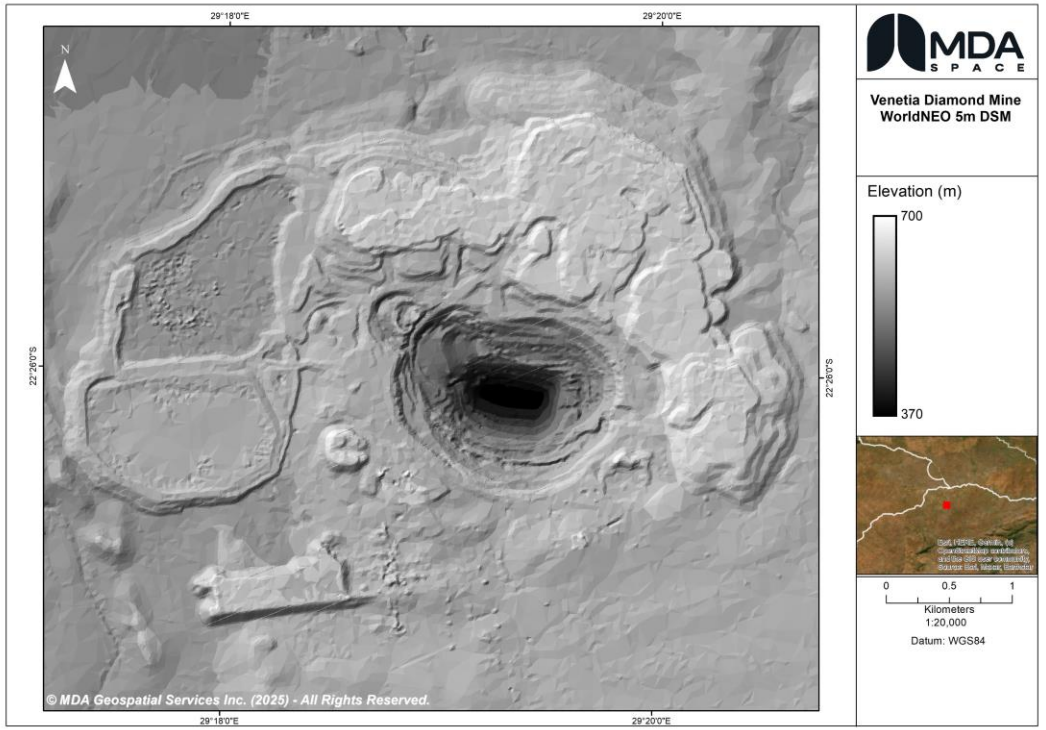


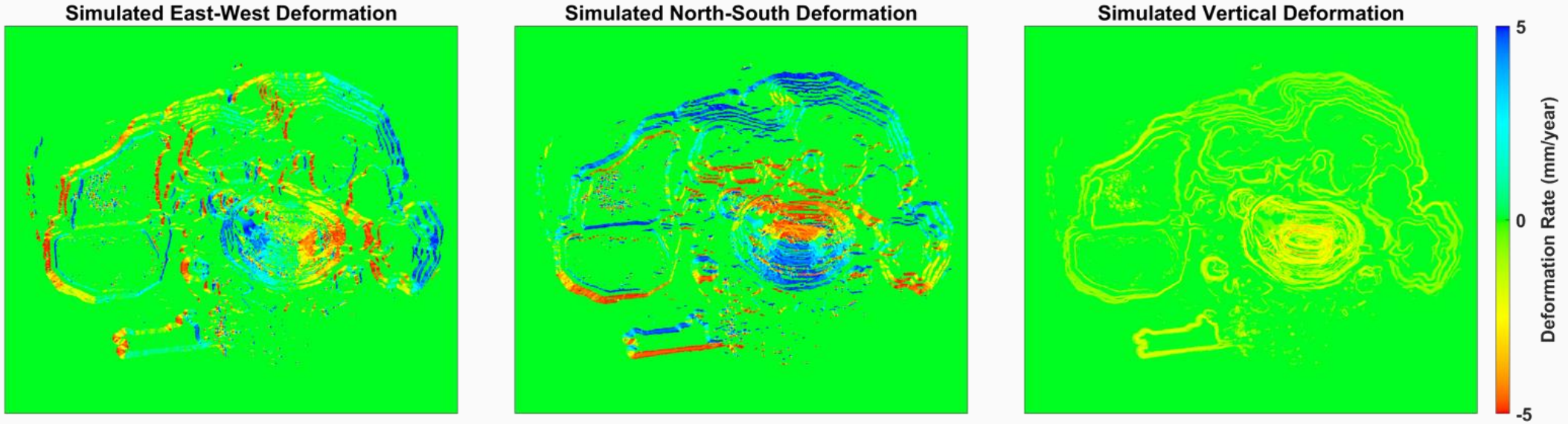




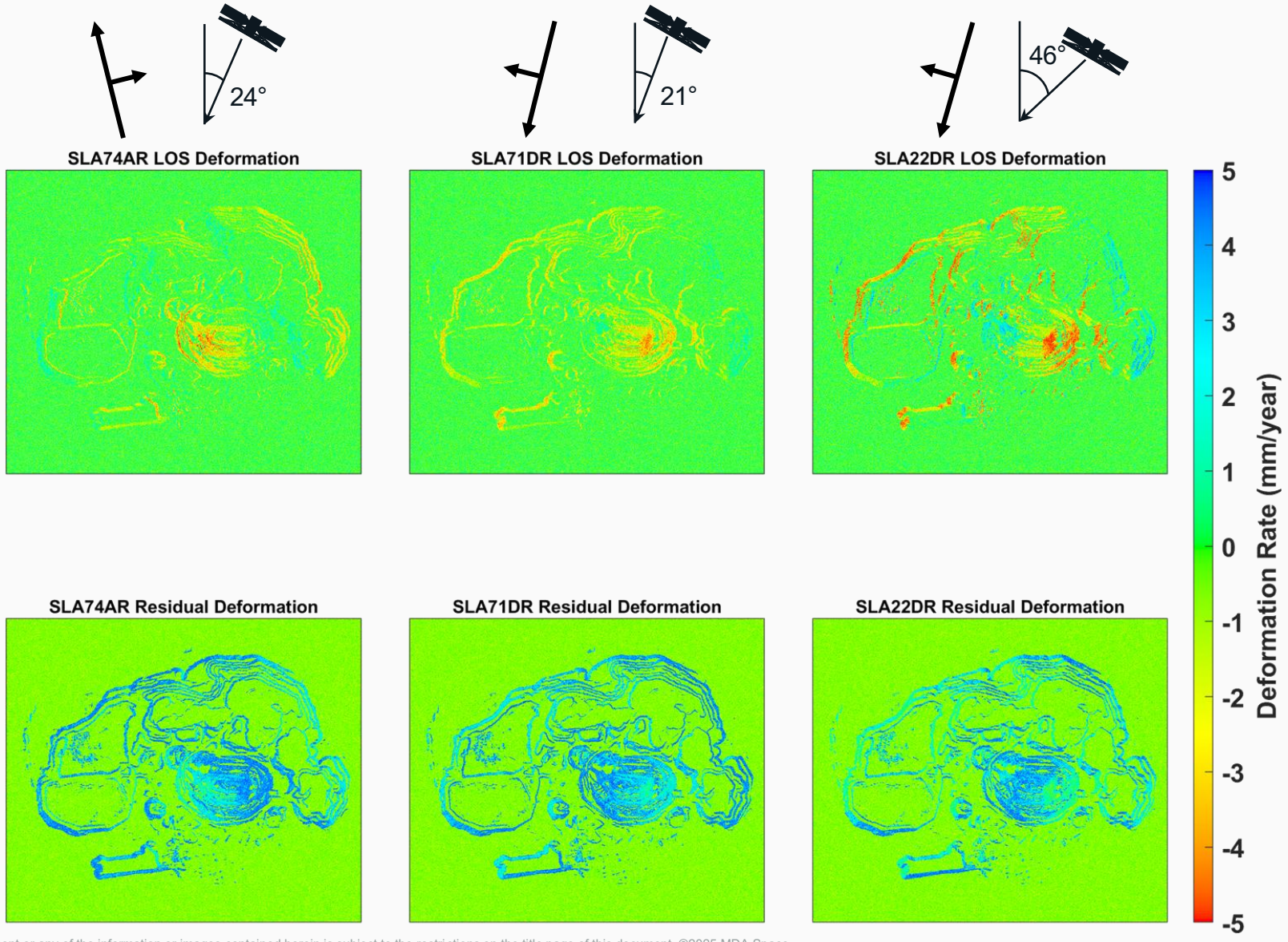
Simulating downslope deformation

- The 5 m resolution WorldDEM Neo Digital Surface Model (DSM) was used to compute the downslope vector for each slope across the mine
- A displacement of 5 mm/year was simulated for each vector
- The 3D components are separately displayed below:
  - East-West
  - North-South
  - Vertical



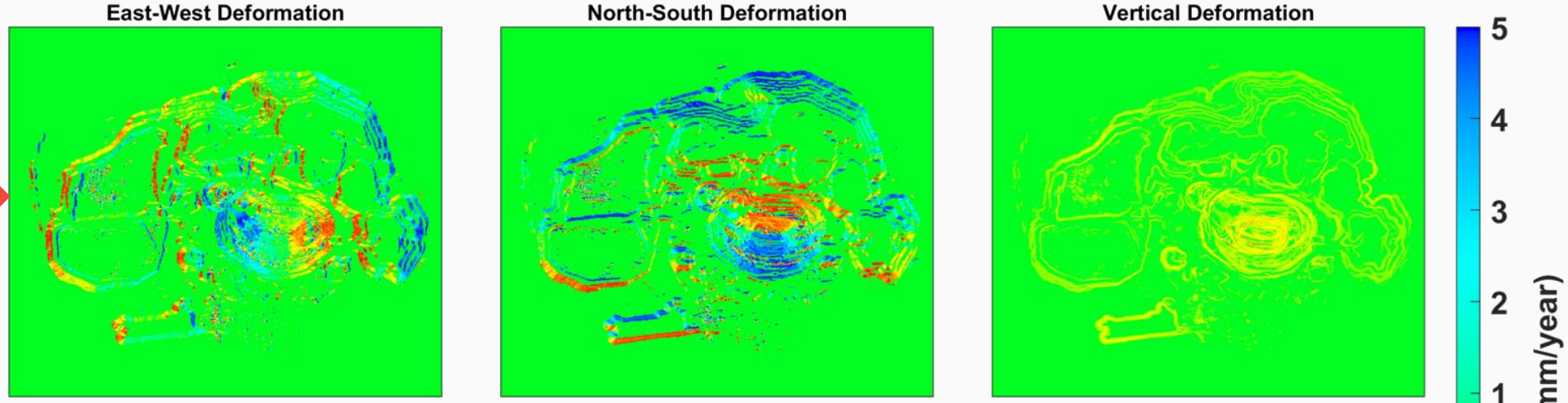


LOS deformation for SSO only (Case 1: RADARSAT-2)

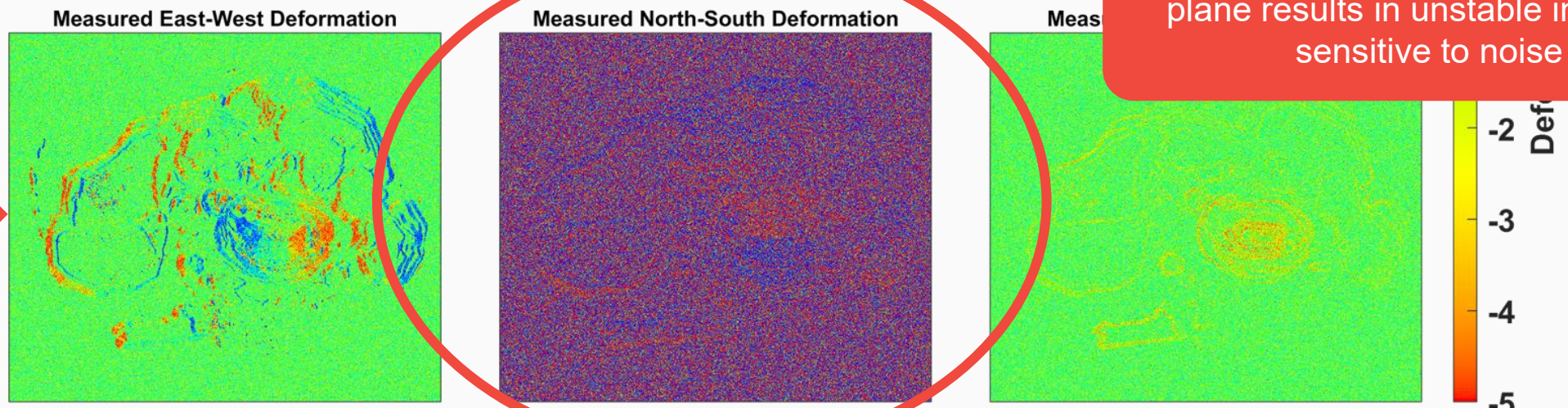


3D inversion of LOS measurements for SSO only (Case 1)

What we're trying to recover

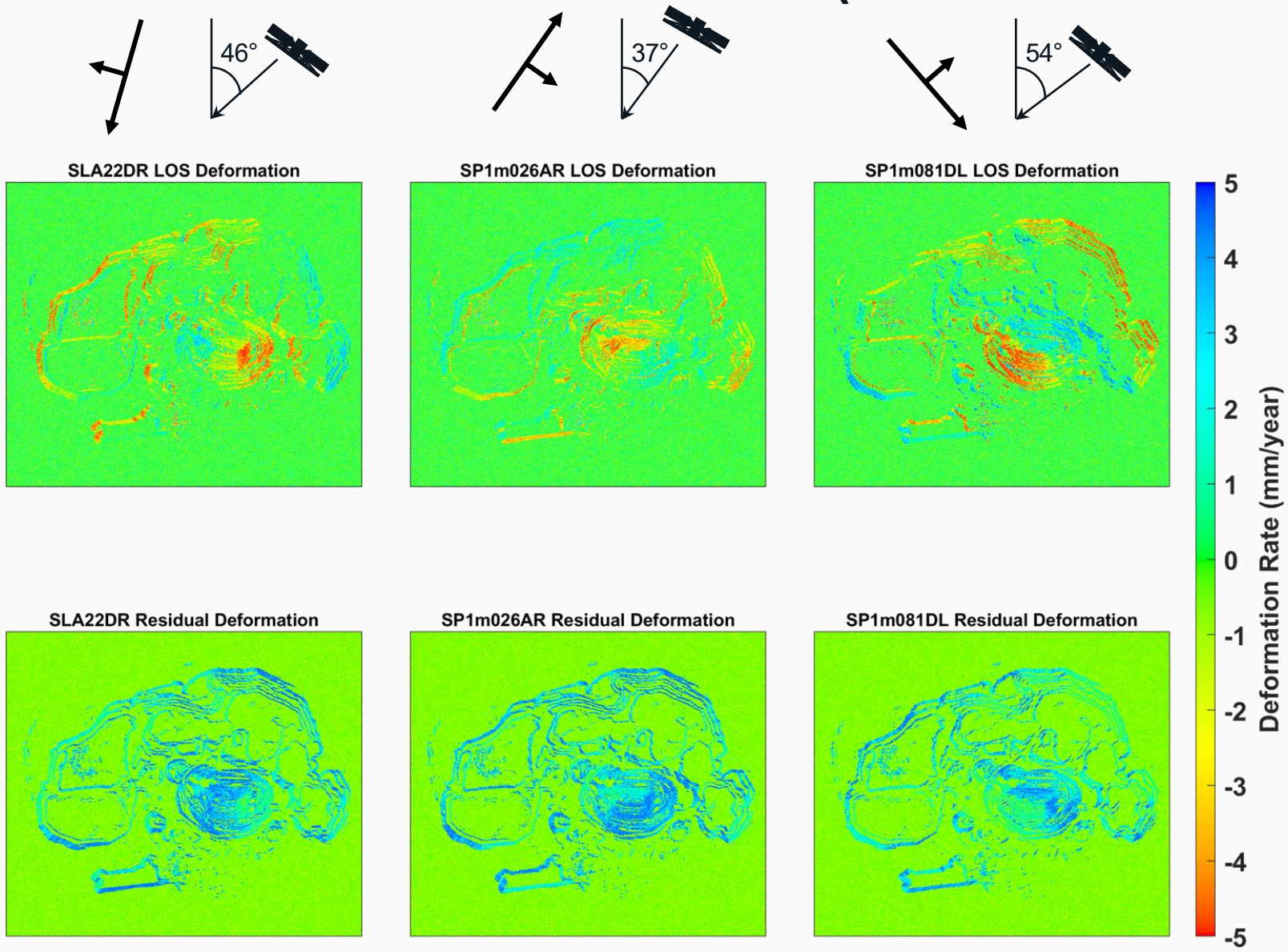


What we can reconstruct from InSAR

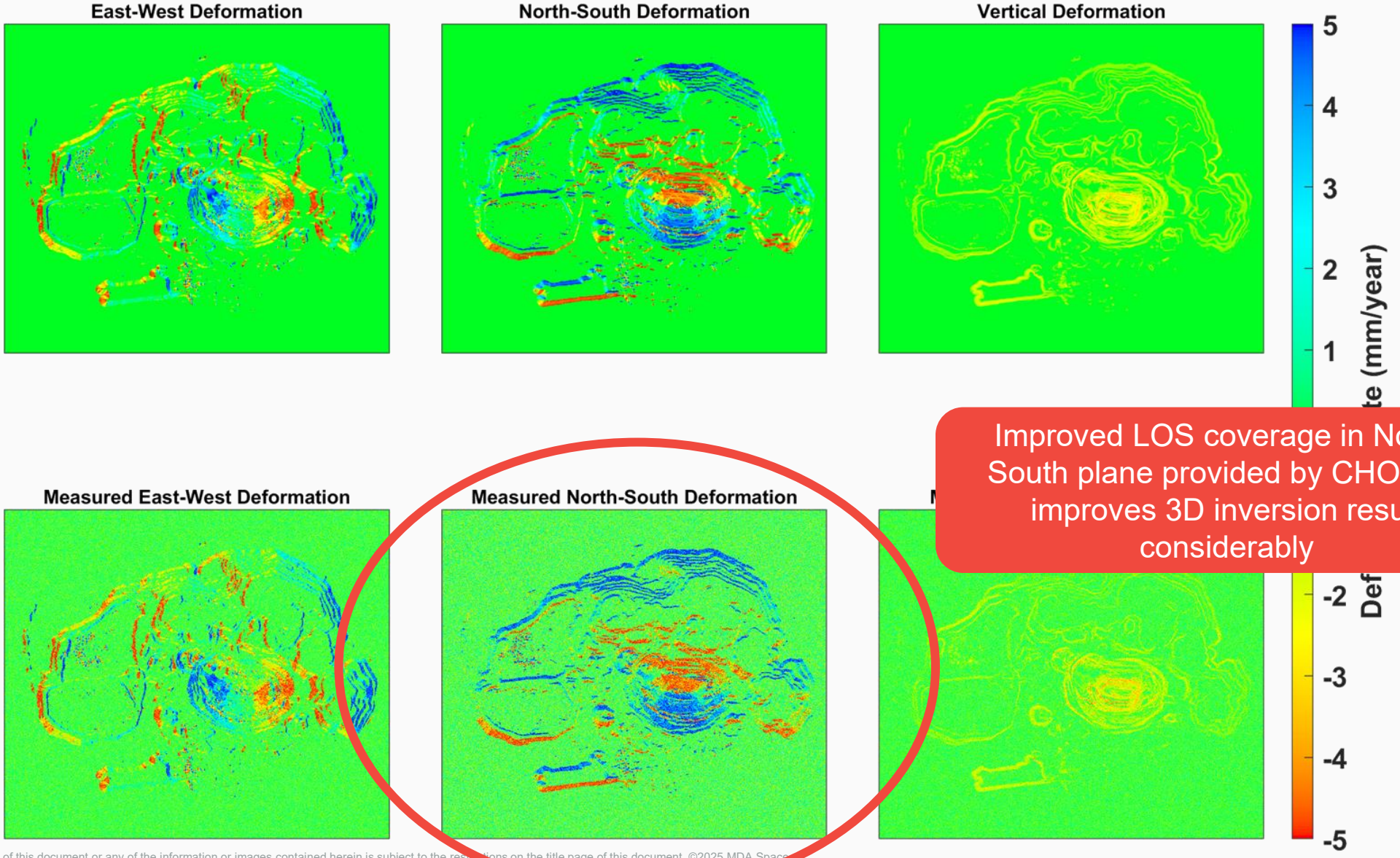


Lack of LOS coverage in North-South plane results in unstable inversion sensitive to noise

LOS deformation for SSO + mid-inclined (Case 2: RS2 + CHORUS)



3D inversion of LOS measurements for CHORUS + SSO (Case 2)



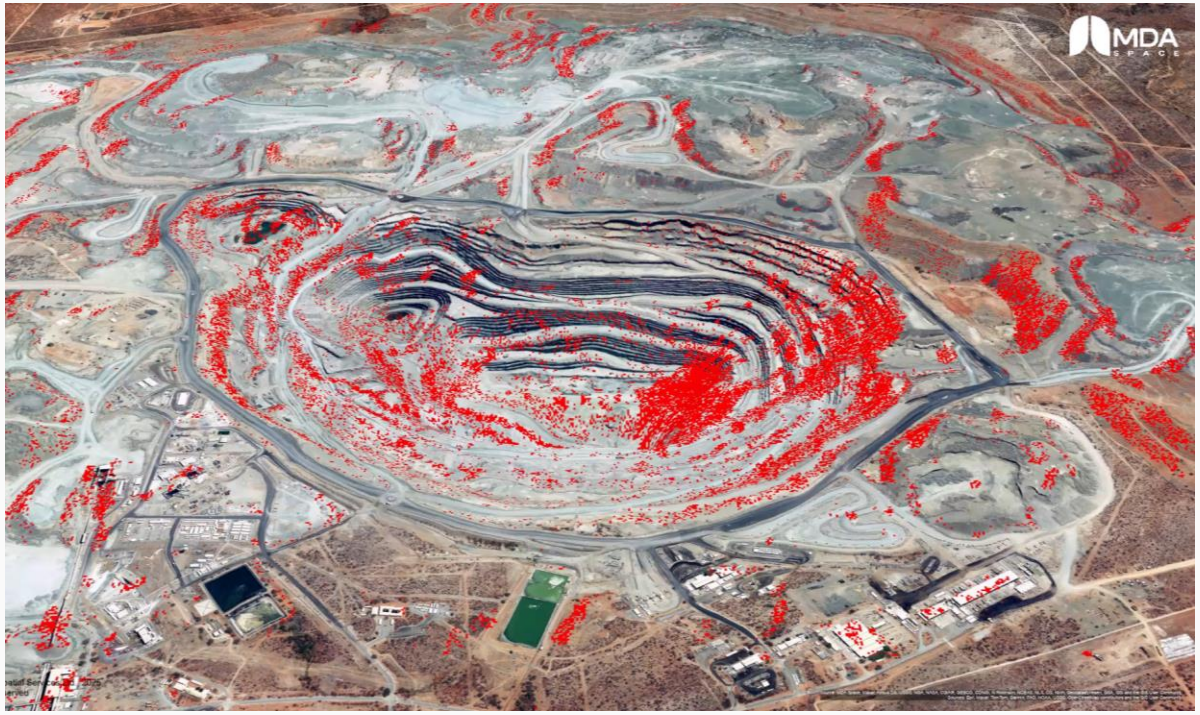
How does CHORUS improve InSAR monitoring?

- Enables significantly improved 3D recovery of surface movement vectors critical to geotechnical decision-making

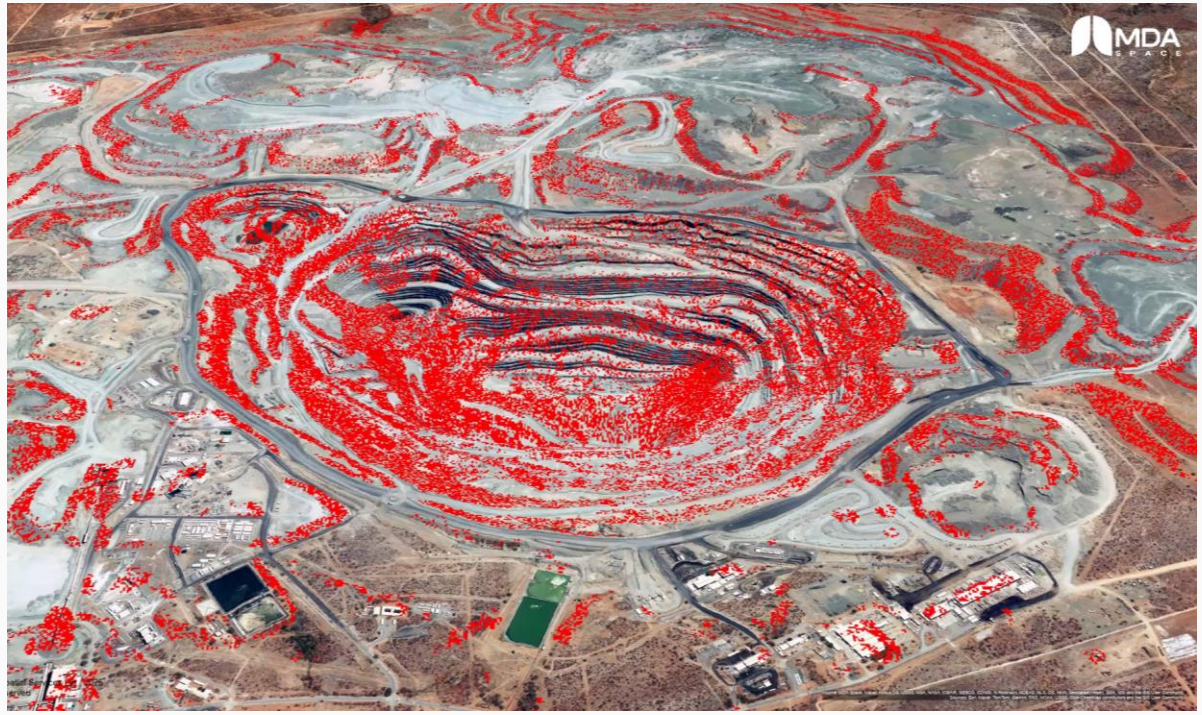
- Increase density of InSAR measurements by improving sensitivity to smaller displacements

InSAR measurement targets at the Venetia mine open pit

3 sun-synchronous orbits



2 mid-inclined + 1 sun-synchronous orbits



Summary

- MDA CHORUS™ is an upcoming dual-frequency SAR constellation mission introducing unique sensor capabilities
- The mid-inclined orbit planned for CHORUS will provide new LOS perspectives for InSAR deformation monitoring
- These new perspectives can be leveraged to *routinely* derive 3D displacement components from InSAR monitoring for the first time
- We present simulations of expected 3D InSAR sensitivity at the Venetia diamond mine illustrating the significant improvement in resolving North-South components of surface movement
- 3D inversion of InSAR measurements requires careful planning and implementation to avoid an unstable solution

Thank You

We’re excited to share the incredible capabilities of MDA CHORUS™ with you.

If you’d like to dive deeper into this groundbreaking mission, explore its technical capabilities or discuss potential collaboration, our team of experts is ready to provide you with all the information you need.

Dylan Hickson, PhD

Senior Member of Technical Staff – Systems

dylan.hickson@mda.space | geointelligence@mda.space | mda_geospatial_service@mda.space