

Capella Space Repeat-Pass InSAR Demonstration: current status

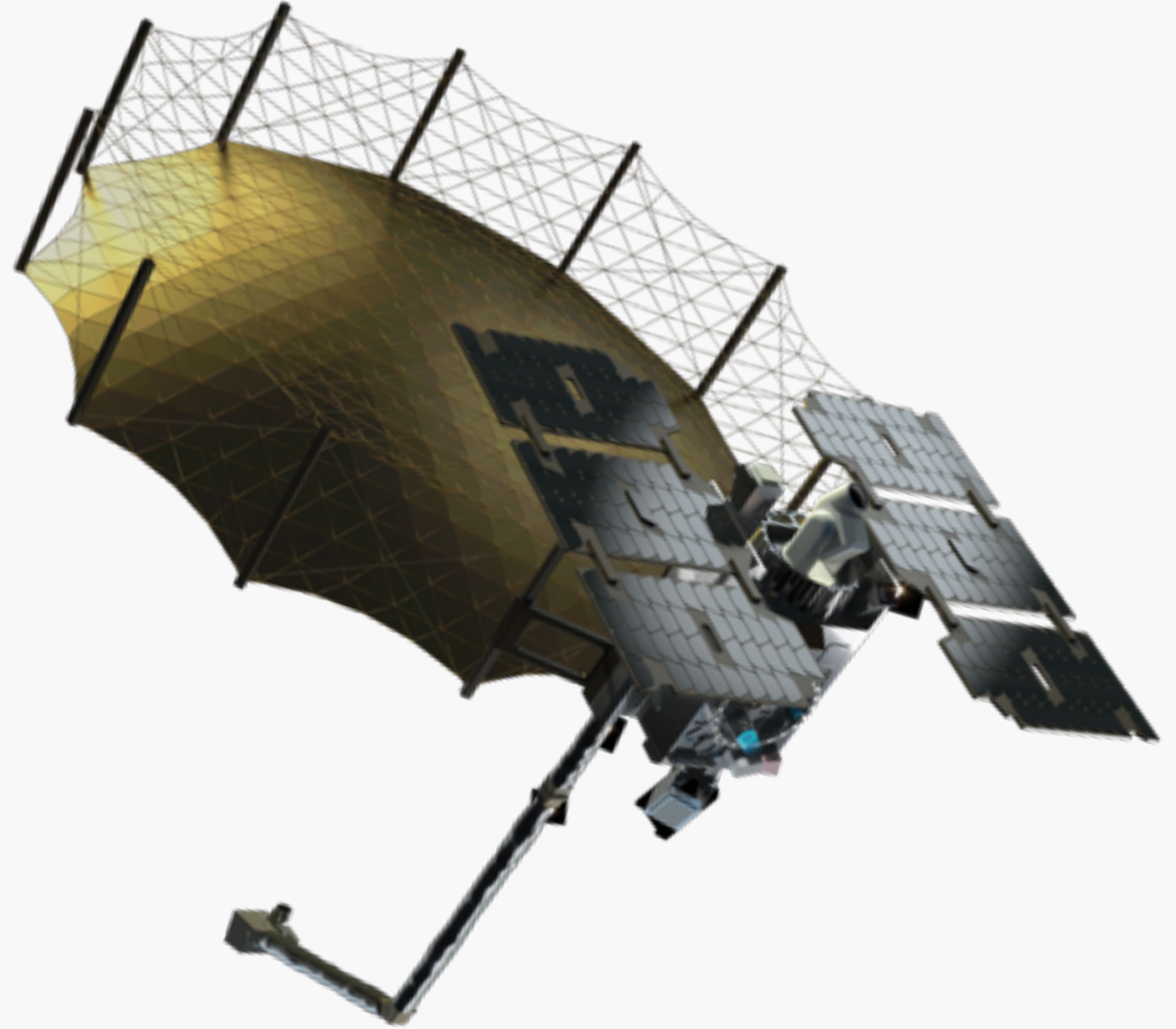
Nestor Yague-Martinez, Davide Castelletti, Martin Kamme, Victor Cazcarra Bes,
Michael Duersch, Scott Baker, Shaunak De, Gordon Farquharson, Craig Stringham

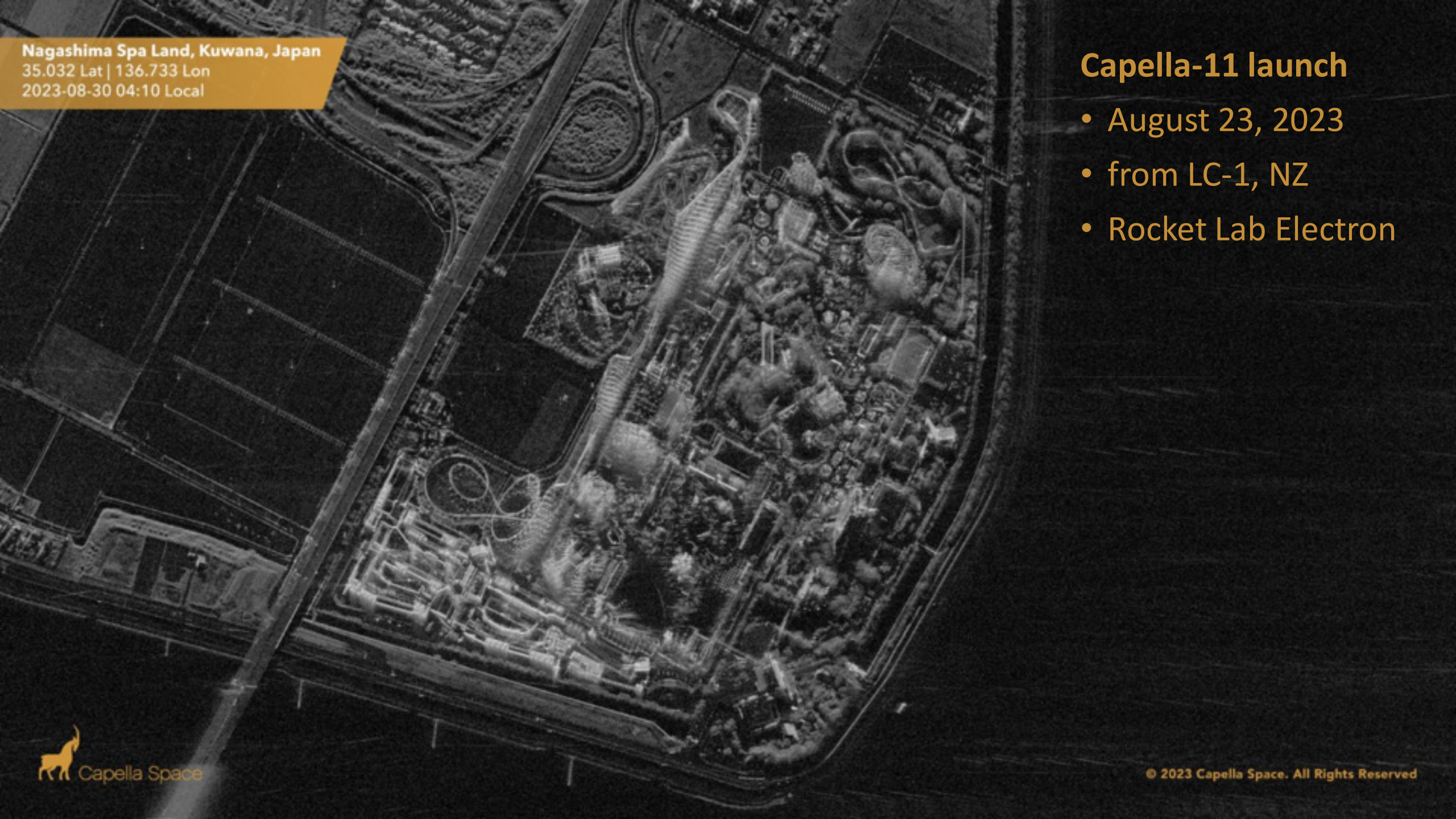


FRINGE 2023. University of Leeds, UK

Capella Space Introduction

- Founded in 2016 (started engineering work in 2017)
- Launched 11 satellites (Capella-1 through Capella-11)
- 100-160 kg class small satellites
- X band (9.65 GHz)
- Started delivering SAR imagery and data to customers commercially in 2021
- Satellites launched into inclined (MIO) and sun-synchronous (SSO) orbits
- Multiple Acadia satellites launching this year with Rocket Lab





Nagashima Spa Land, Kuwana, Japan

35.032 Lat | 136.733 Lon

2023-08-30 04:10 Local

Capella-11 launch

- August 23, 2023
- from LC-1, NZ
- Rocket Lab Electron

New Capella system generation: Acadia

Radar Specifications

Carrier frequency	9.3 GHz – 10.0 GHz
Antenna design	8 m ² parabolic reflector
Antenna gain	48 dB
Peak radiated power	840 W (minimum)
Bandwidth	10 MHz to 700 MHz
PRF	5 kHz to 16 kHz
Polarization	HH or VV
Look angle range	15° to 50°
Ground range resolution	0.76 m to 0.26 m
NESZ (with 700MHz)	-21.5 dB to -10.6 dB
RGIQE (for a 0 dB NRCS target, 9-look 50 cm az res.)	162.0 bits/m ² to 254.1 bits/m ² (275.3 bits/m ² at 43 deg. look angle)
Look direction	Left and right
Orbit directions	Ascending and Descending
SAR payload duty cycle	Up to 10 minutes per orbit
Spotlight dwell time	Up to 60 seconds

Spacecraft Capability

Mass	174 kg
Orbit average power	700 W
Agility	Upgraded ion thrusters, reaction wheels, torque rods, star trackers, magnetometers
Tasking uplink	L-Band via GEO @ 200 kbps or ground network
TT&C uplink/downlink	S/X-Band
Payload downlink	X-Band @ 1.2 Gbps
Optical communications terminal	Mynaric CONDOR Mk3
Direct downlink	Yes
Orbital inclinations	97° SSO, 44° MIO, 53° MIO
Nominal altitude	600 km
Design life	3 years



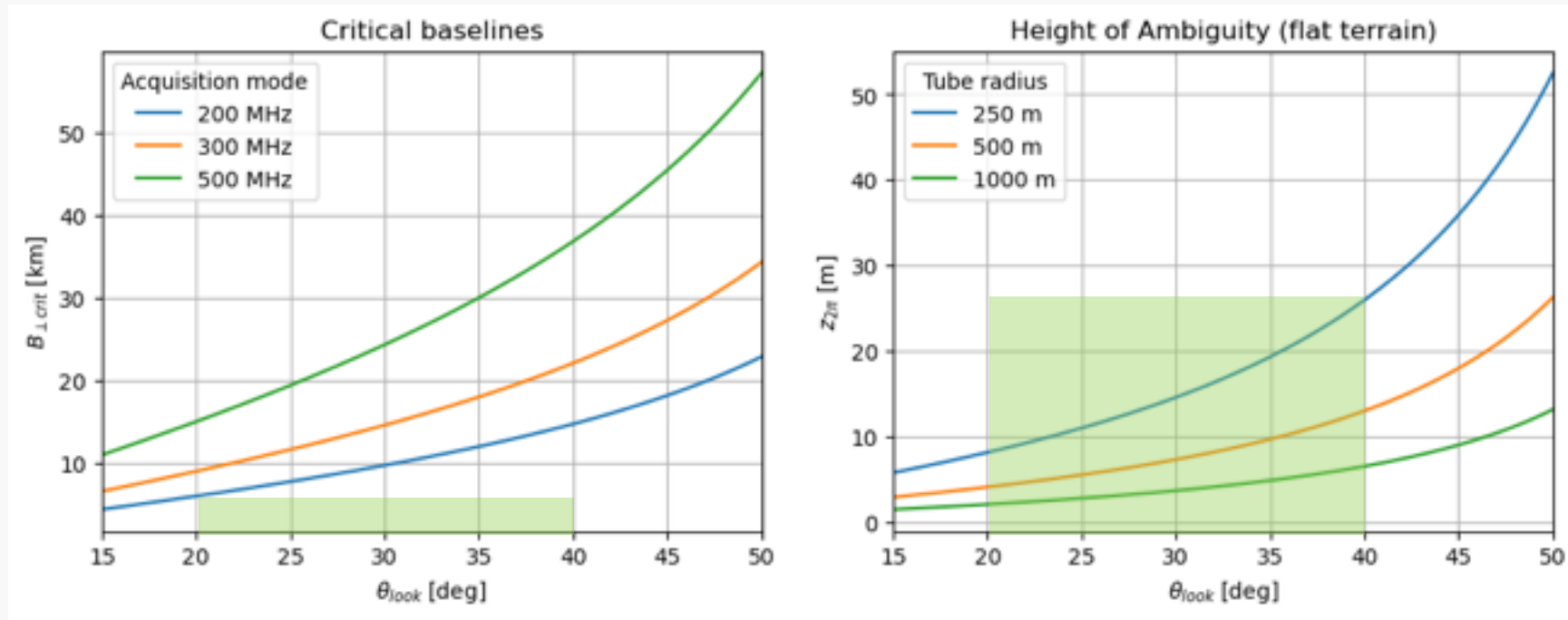
InSAR Demonstration Overview

	InSAR Performance	Orbit control	InSAR processing and verification
Main Goal	Quantify decorrelation sources and coverage for different InSAR orbital configurations. <ul style="list-style-type: none"> • Signal to Noise Ratio • Baseline decorrelation • Temporal decorrelation 	Achieve InSAR orbital tube of 250 m radius Upcoming launches: <ul style="list-style-type: none"> • Mid-inclined orbits • Repeat cycle: 3-5 days 	InSAR performance verification Evaluate: <ul style="list-style-type: none"> - repeatability consistency (pointing, overlap, baselines, etc.) - coherence modeling - etc
Elements	<ul style="list-style-type: none"> - Mission analysis Tool - InSAR Performance Tool 	<ul style="list-style-type: none"> - Reference Orbit generation - Acquisition - Maintenance 	<ul style="list-style-type: none"> - In-house developed InSAR processor: insarcapella - Opportunistic InSAR pairs finder (InSAR Pairs data base)

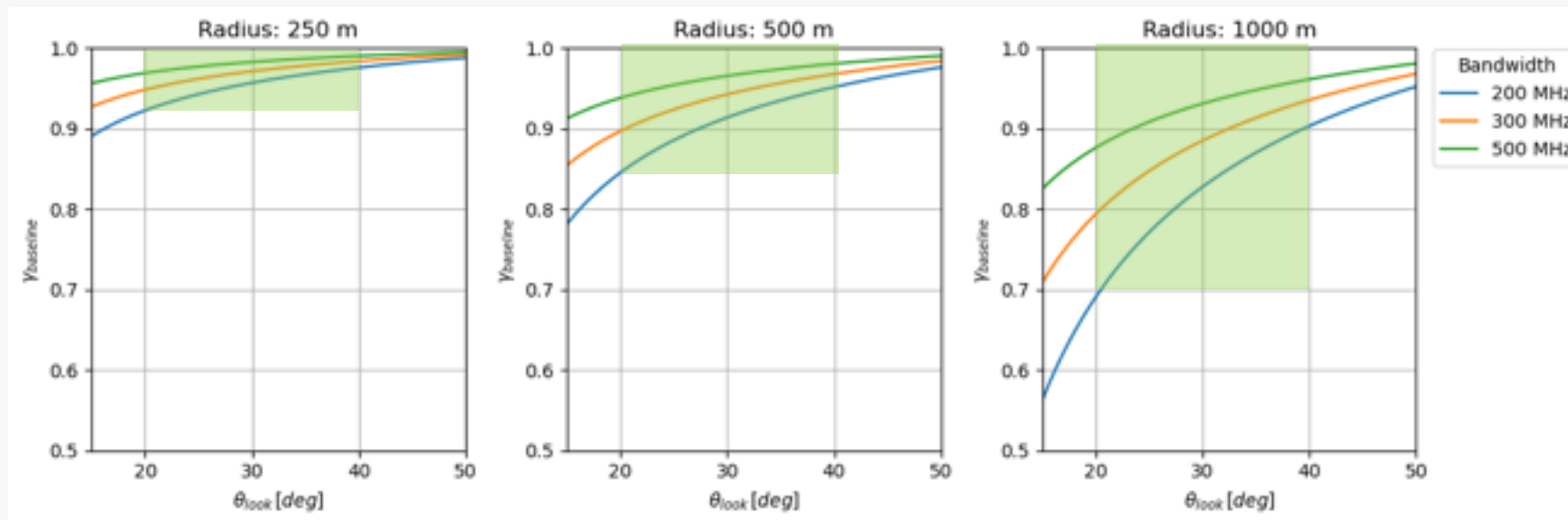
Duration: 3-5 months (acquire 30 collects over pre-defined sites)



Baseline decorrelation



Orbital tube requirement set to 250 m radius

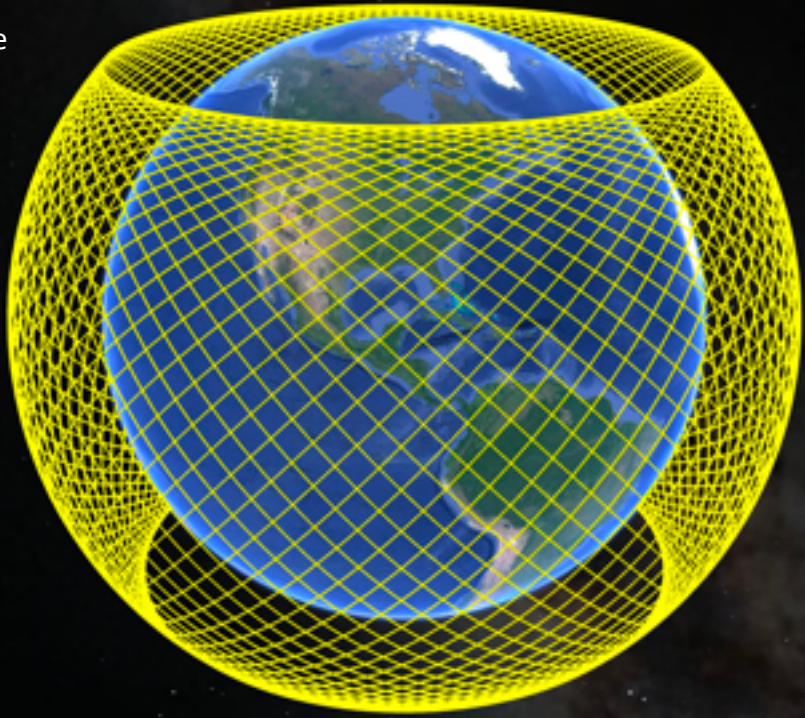


Development of a Mission Analysis Tool

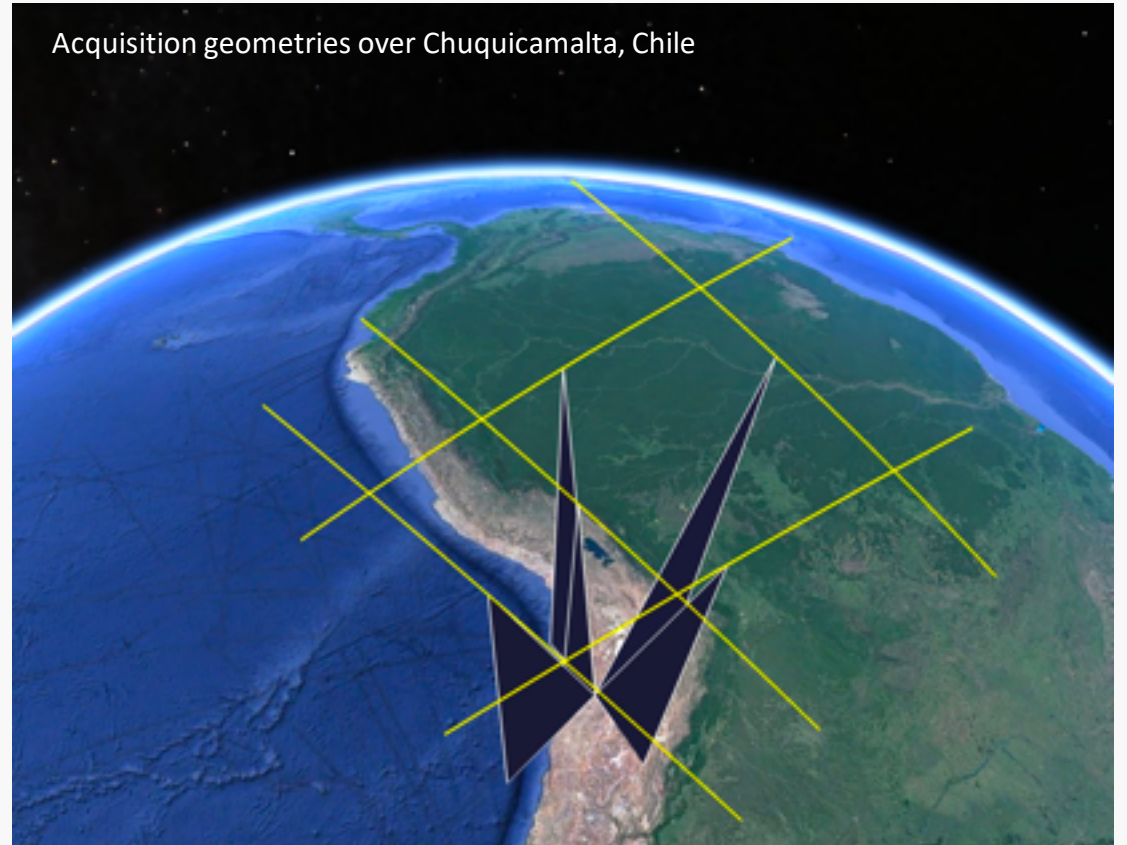
- Built tools to perform orbital modeling
- Developing algorithms for reference orbit generation, automated orbit acquisition and keeping

Orbital passes visualization of an RGT orbit with:

- Altitude: 620 km
- Inclination: 44 degree
- Repeat cycle: 5 days
- 73 orbits/cycle



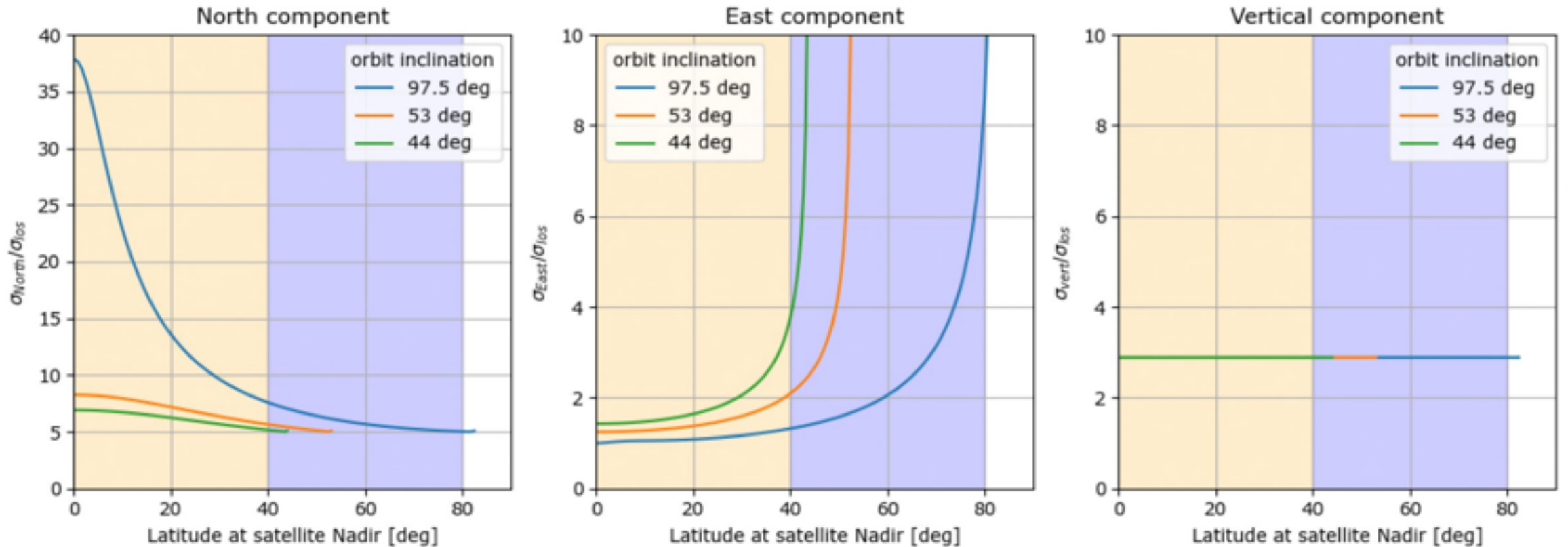
Acquisition geometries over Chuquicamalta, Chile



Orbit inclination / 3D deformation sensitivity analysis

3D deformation relative errors
3 geometries: Asc (35 deg), Asc (25 deg) and, Desc (35 deg)
(Right looking geometry)

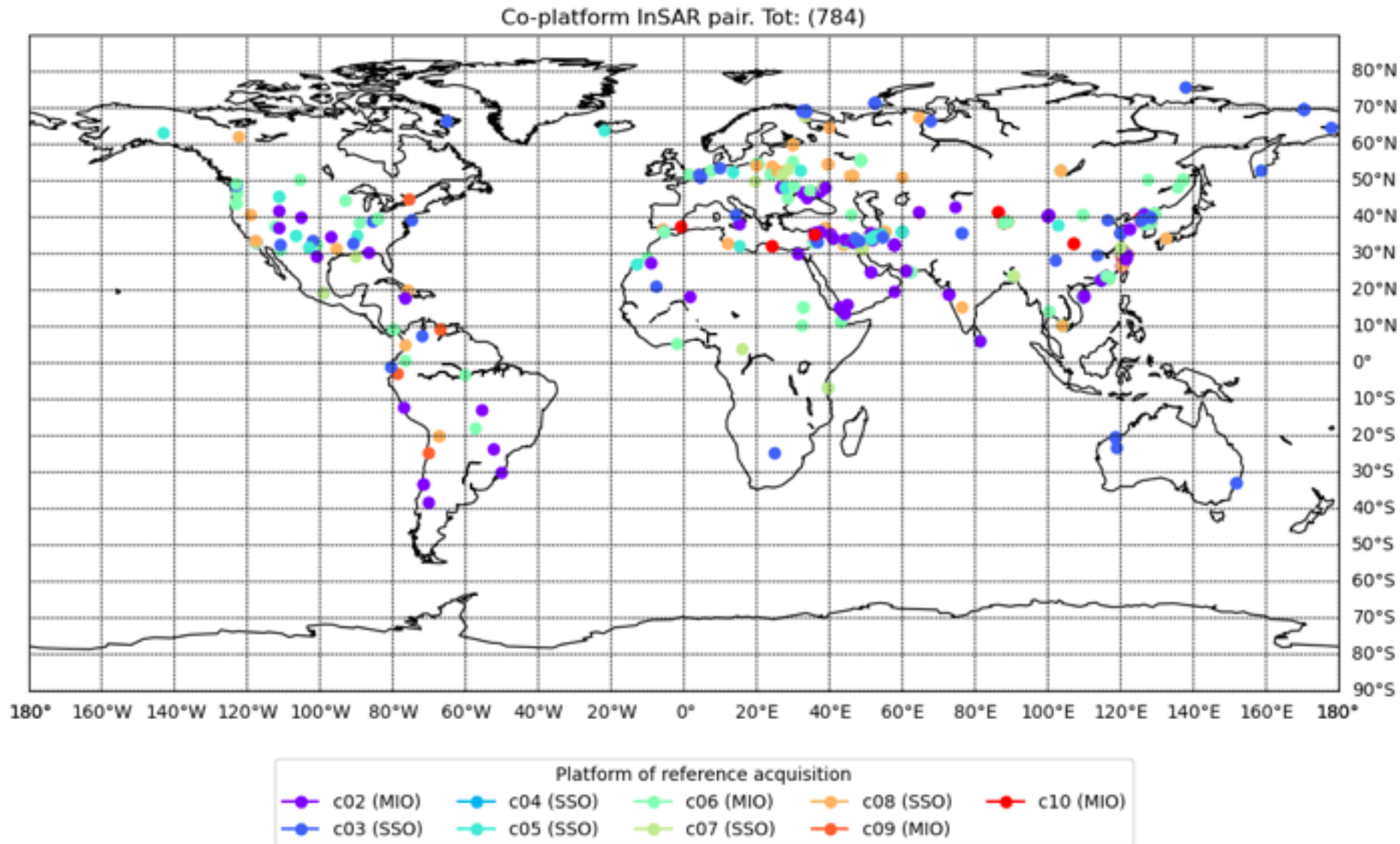
Capella Space



Wright et al. 2004; Ansari et al. 2016



Opportunistic InSAR-compatible pairs (co-platform)

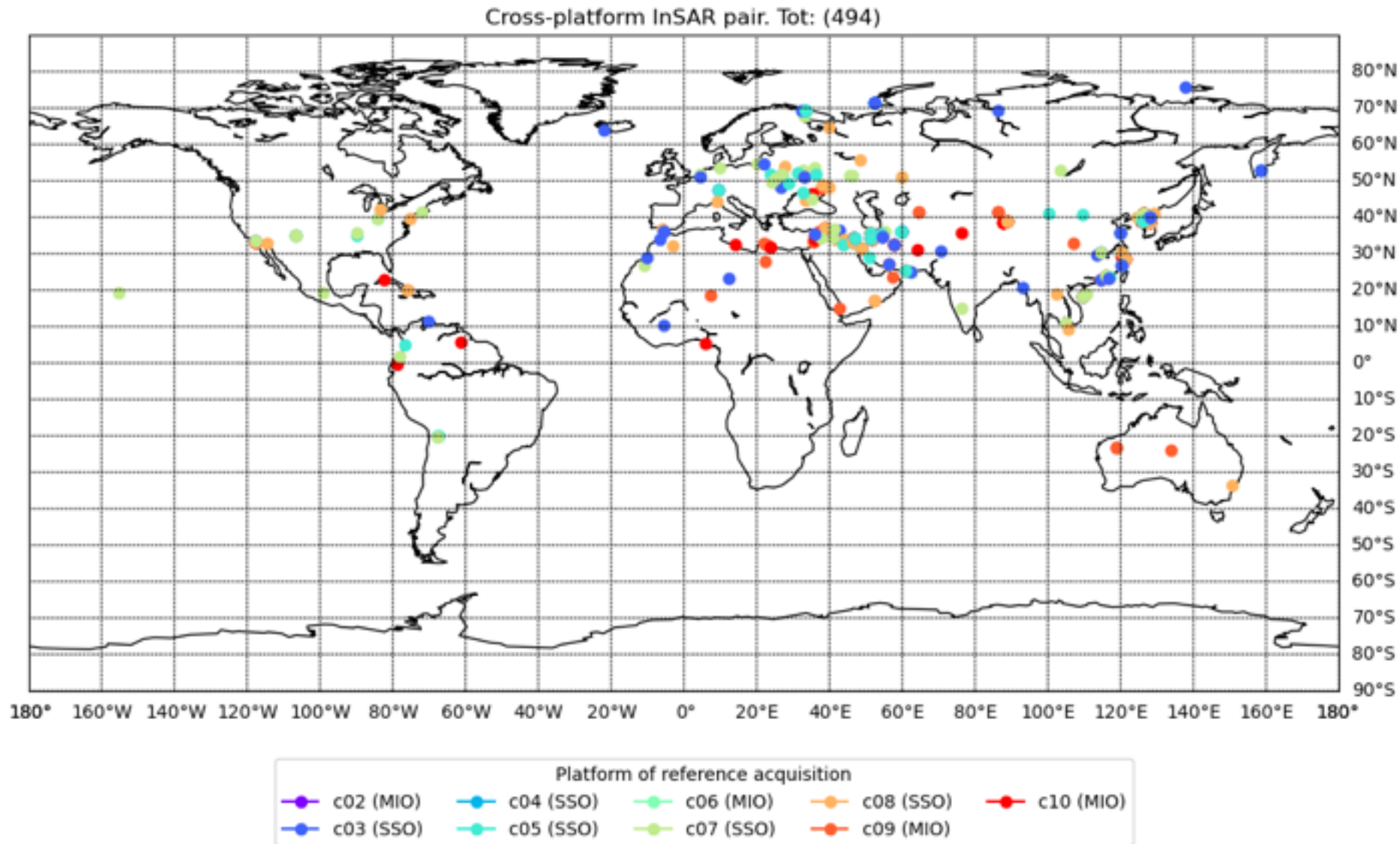


Co-platform

Time frame	01/2021 – 08/2023
Geom. Decorrelation	< 20%
Inc. angle	< 40 deg
Temporal baseline	< 60 days
#pairs	784



Opportunistic InSAR-compatible pairs (cross-platform)



Cross-platform

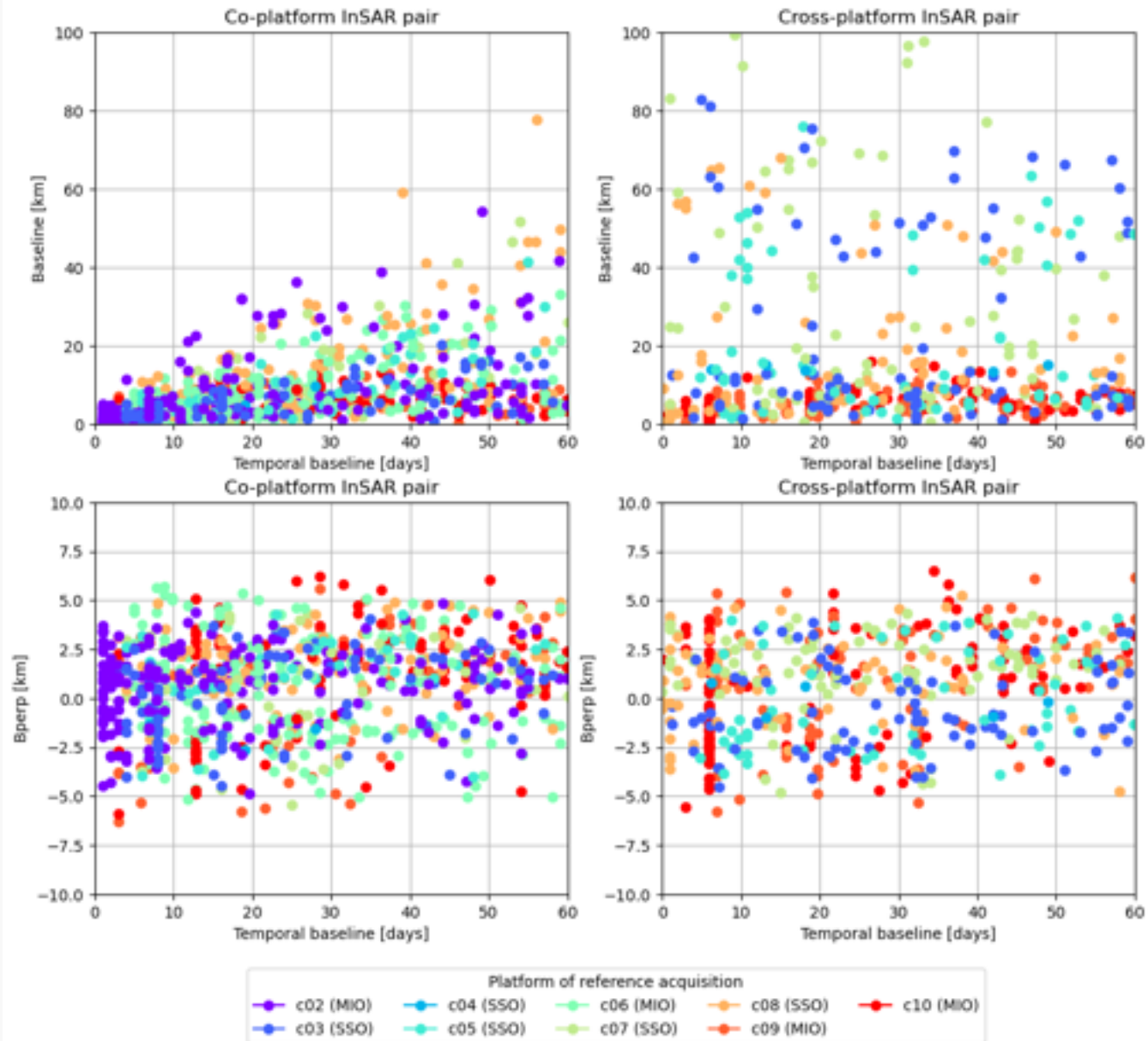
Time frame	01/2021 – 08/2023
Geom. Decorrelation	< 20%
Inc. angle	< 40 deg
Temporal baseline	< 60 days
#pairs	494



Baselines vs temporal baseline

Co-platform

Time frame	01/2021 – 08/2023
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Inc. angle	< 40 deg
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Cross-platform

Time frame	01/2021 – 08/2023
Geom. Decorrelation	< 20%
Inc. angle	< 40 deg
Temporal baseline	< 60 days
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West Angelas Mine, Australia
-23.173 Lat | 118.764 Lon
2021-07-01 | 2021-08-10



Bi-temporal composite

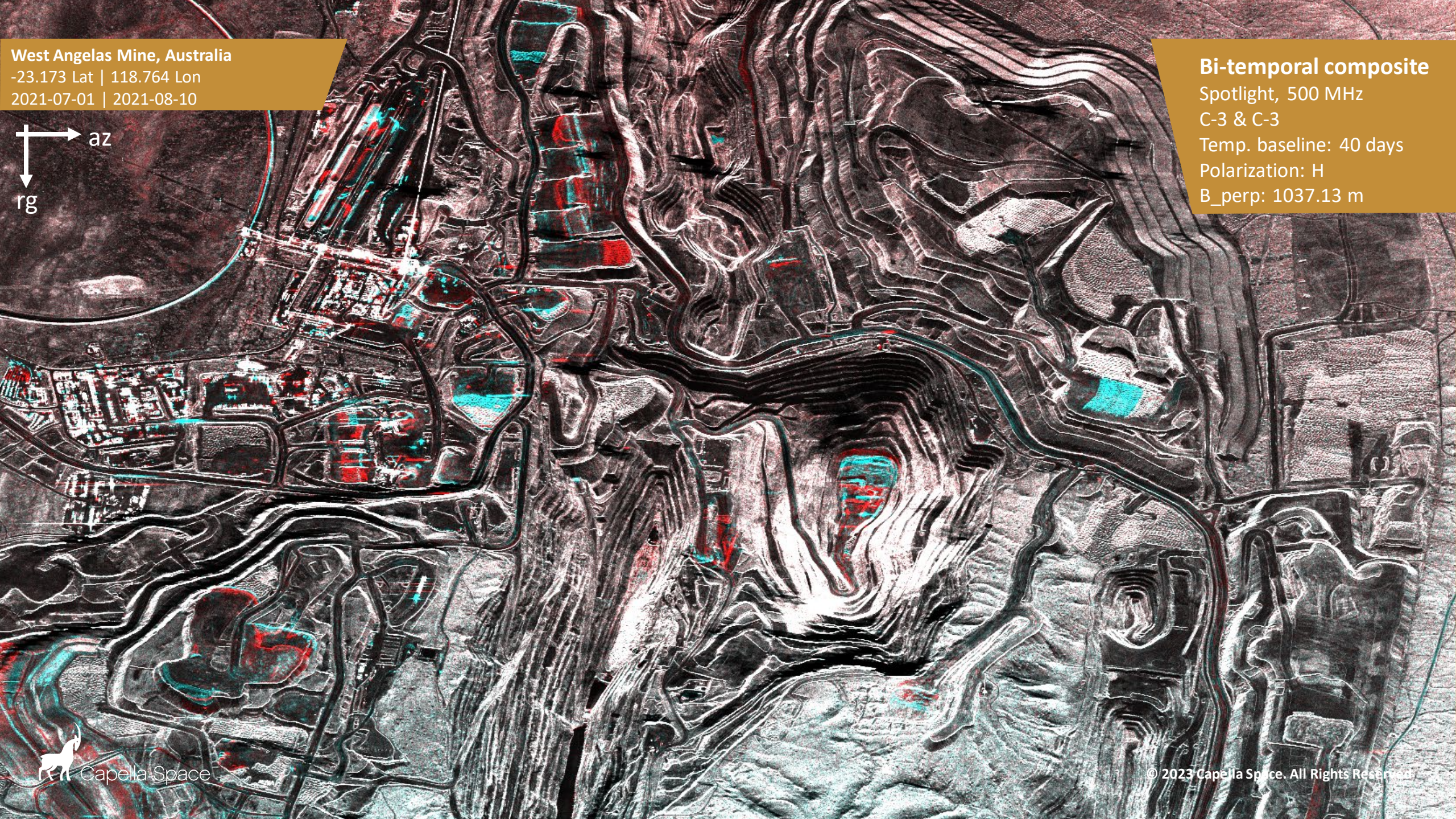
Spotlight, 500 MHz

C-3 & C-3

Temp. baseline: 40 days

Polarization: H

B_perp: 1037.13 m



West Angelas Mine, Australia
-23.173 Lat | 118.764 Lon
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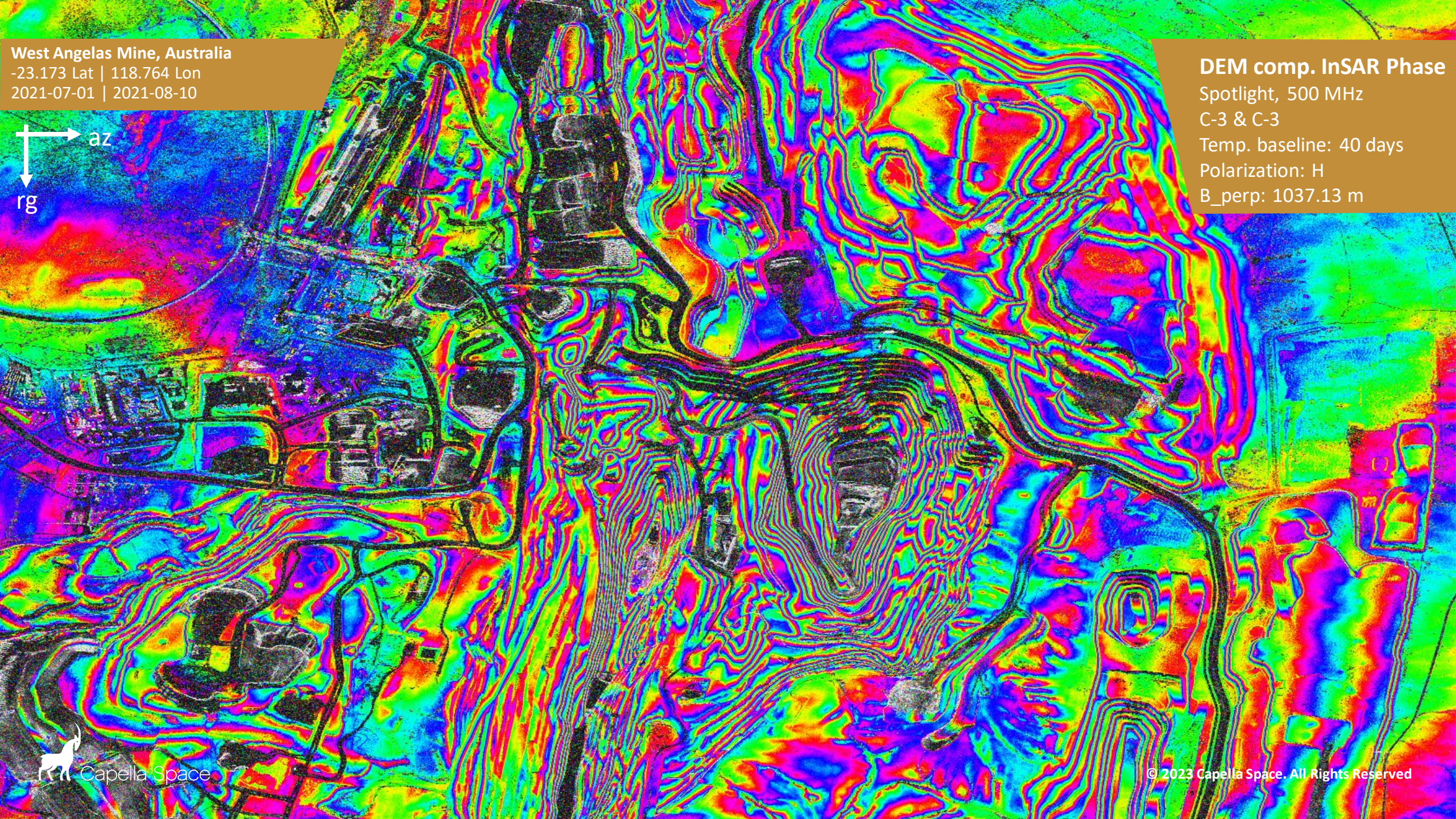
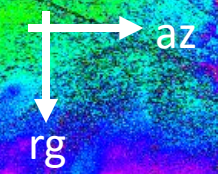


Coherence
Spotlight, 500 MHz
C-3 & C-3
Temp. baseline: 40 days
Polarization: H
B_perp: 1037.13 m



West Angelas Mine, Australia
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DEM comp. InSAR Phase
Spotlight, 500 MHz
C-3 & C-3
Temp. baseline: 40 days
Polarization: H
B_perp: 1037.13 m



Lebrija, Spain
36.899 Lat | -6.047 Lon
2023-01-06 | 2023-01-12

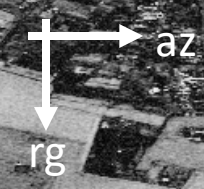


Bi-temporal composite

- Spotlight, 500 MHz
- C-8 & C-8
- Temp. baseline: 6 days
- Polarization: V
- B_perp: 1667.6 m



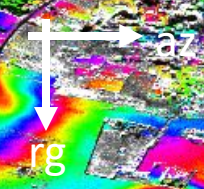
Lebrija, Spain
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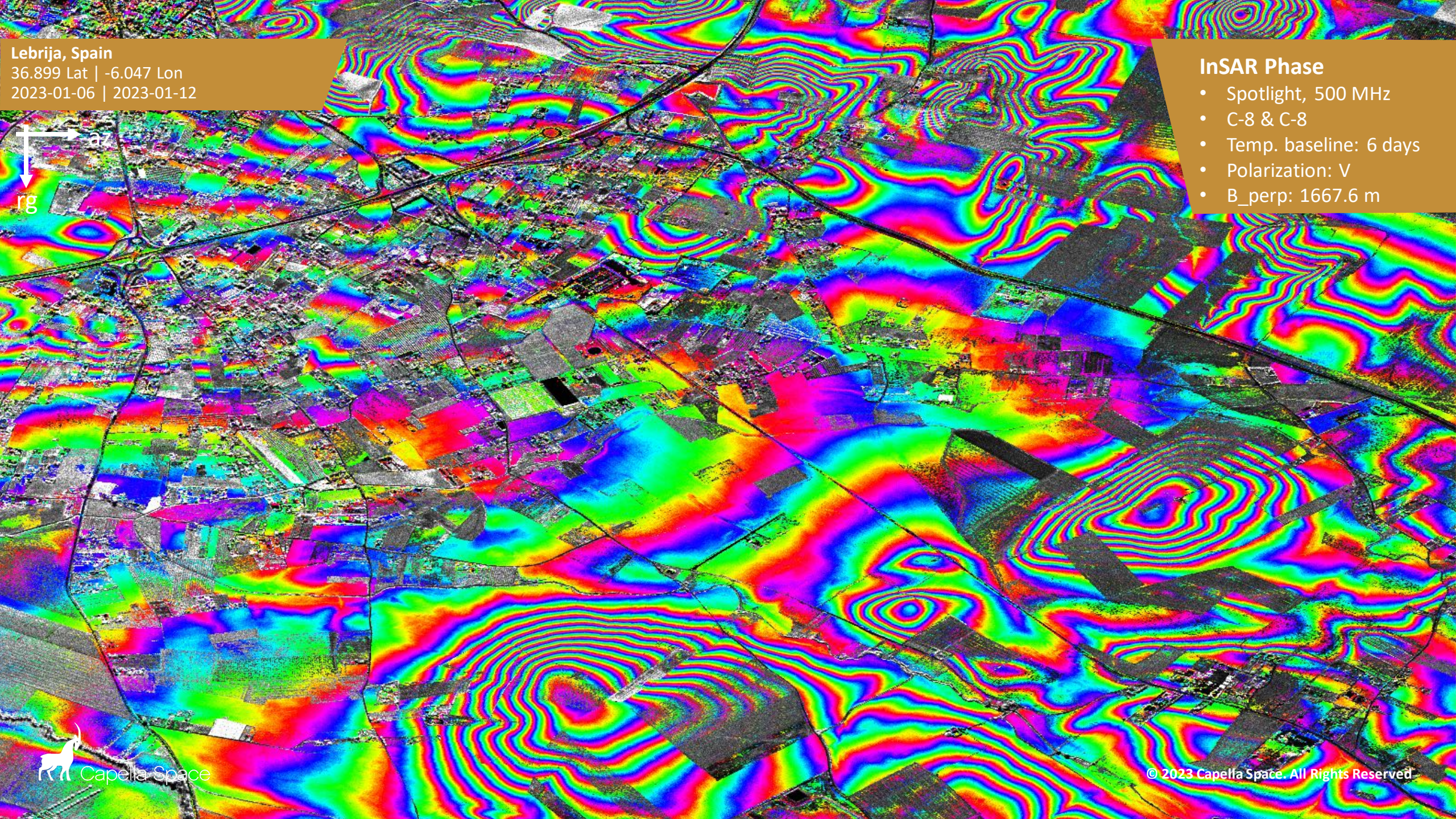
- Coherence**
- Spotlight, 500 MHz
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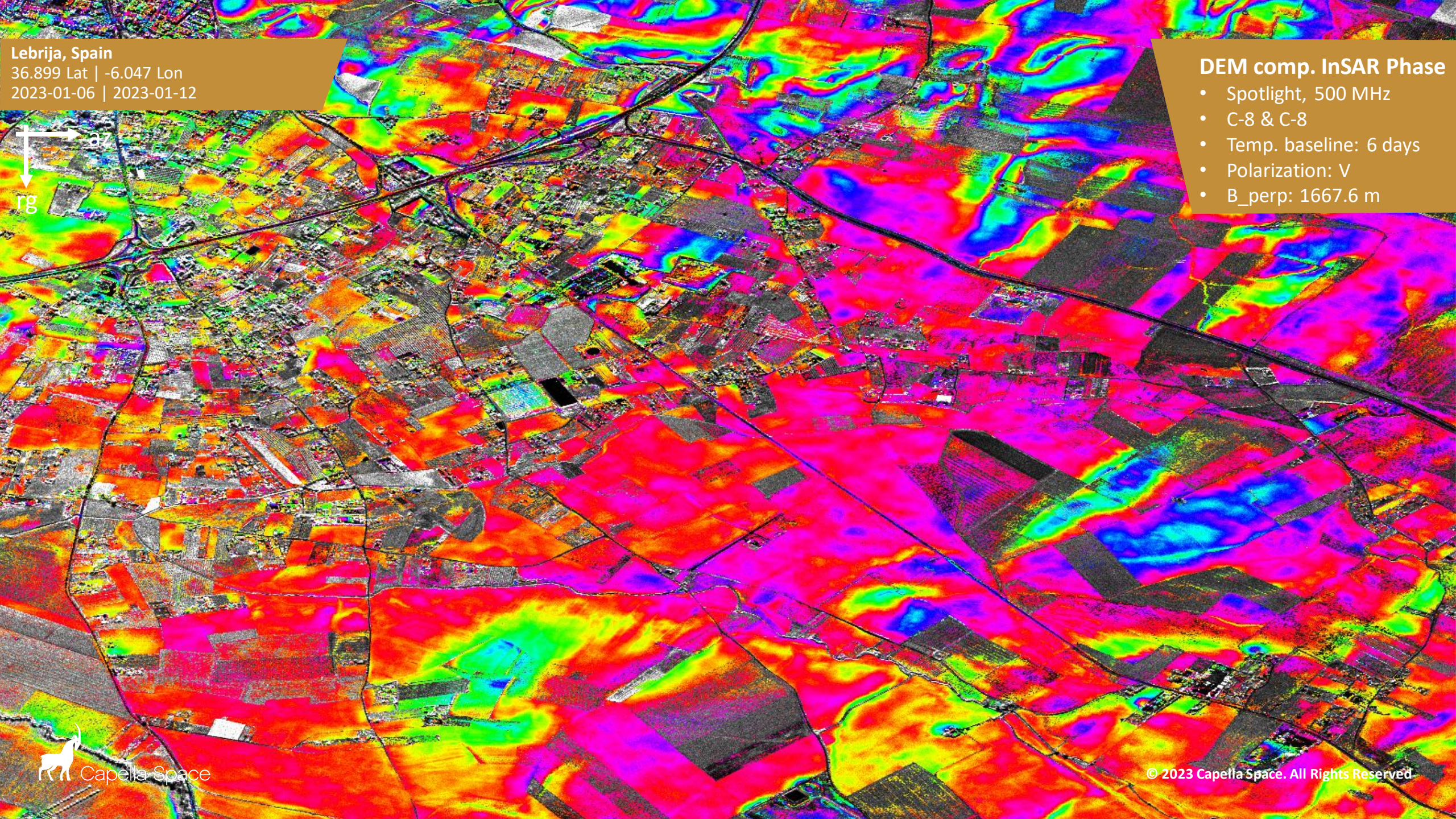
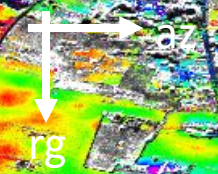
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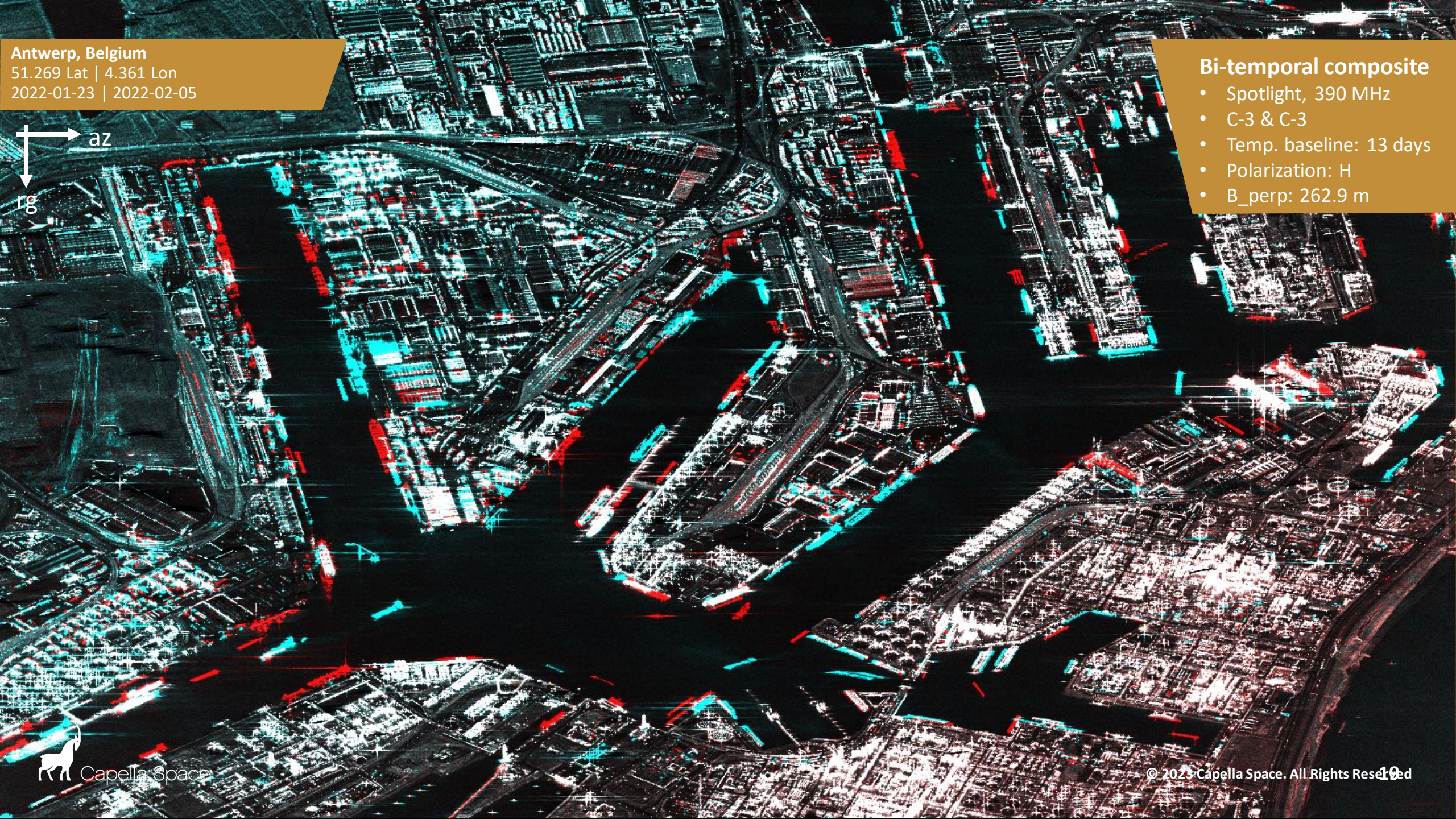


Antwerp, Belgium
51.269 Lat | 4.361 Lon
2022-01-23 | 2022-02-05

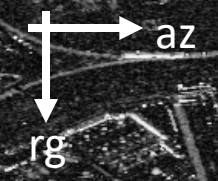


Bi-temporal composite

- Spotlight, 390 MHz
- C-3 & C-3
- Temp. baseline: 13 days
- Polarization: H
- B_perp: 262.9 m



Antwerp, Belgium
51.269 Lat | 4.361 Lon
2022-01-23 | 2022-02-05

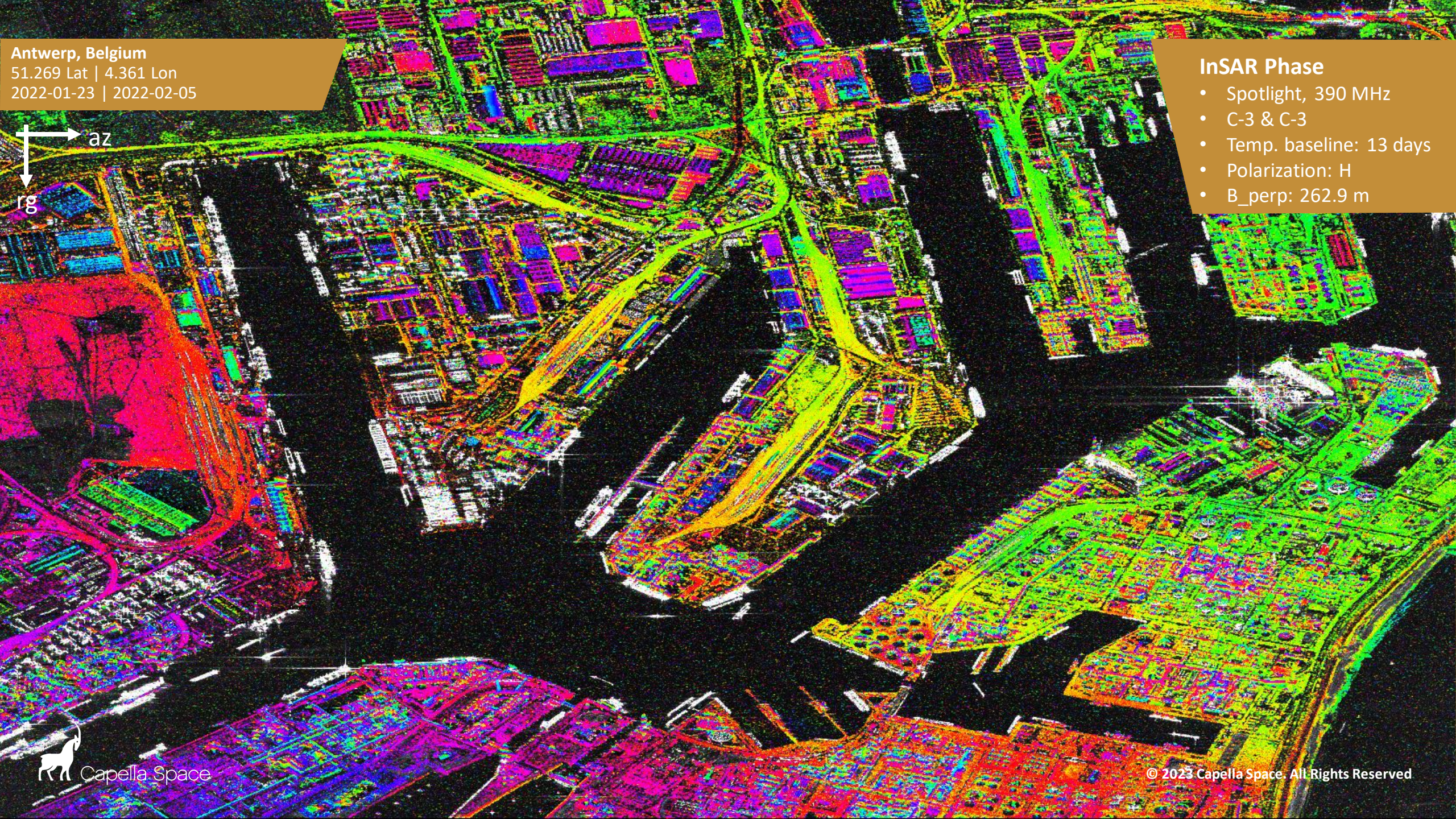
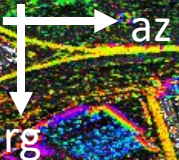


Coherence

- Spotlight, 390 MHz
- C-3 & C-3
- Temp. baseline: 13 days
- Polarization: H
- B_perp: 262.9 m

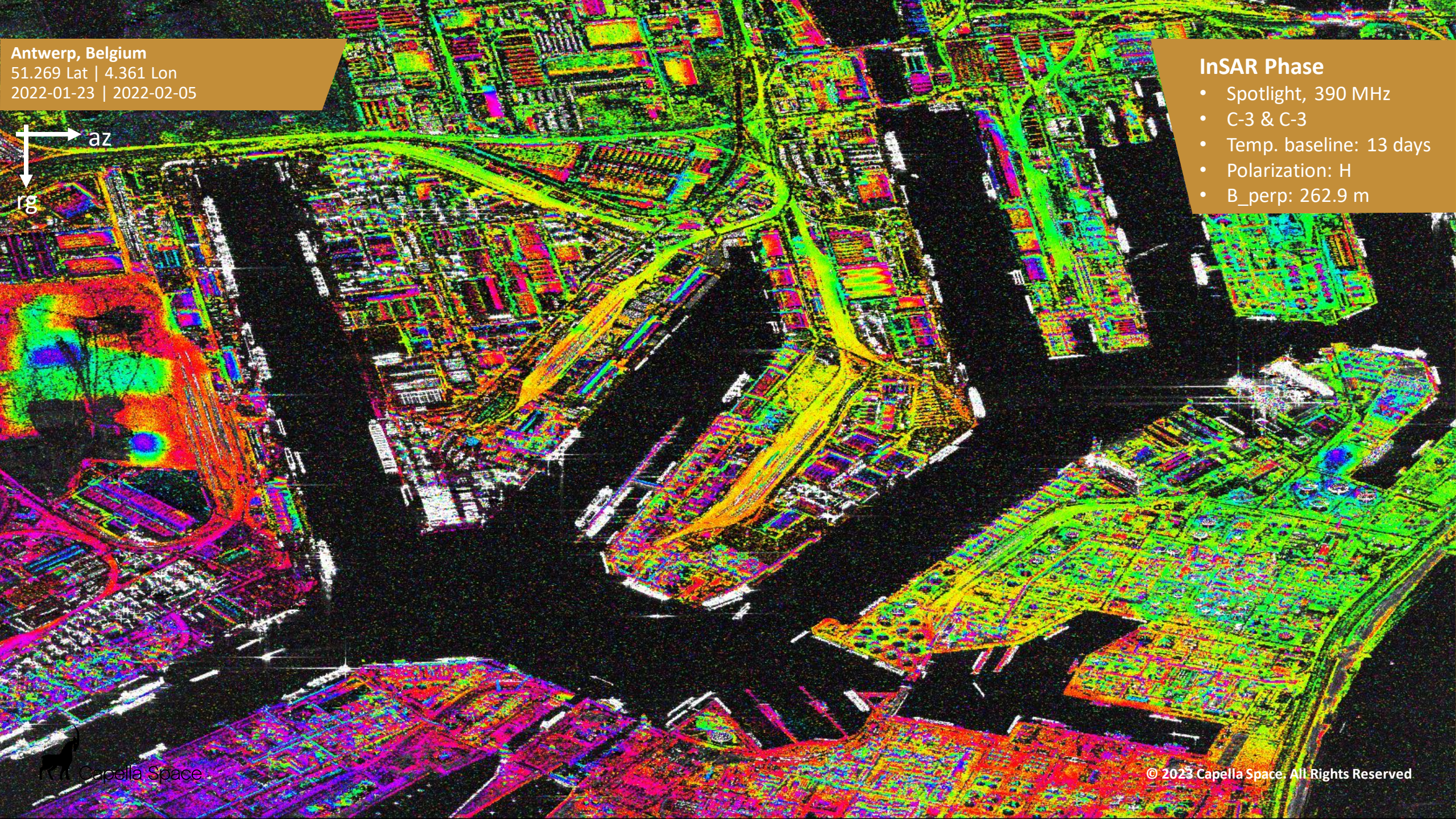
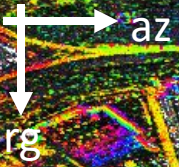
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Conclusions and Future Work

- Capella satellites are able to produce coherent imagery for favourable orbital passes (perp. baseline < critical).
- Acquired more than 1200 coherent pairs up to date in an opportunistic way.
- InSAR phase and Coherent Change Detection results demonstrated.
- The levels of coherence of the analysed dataset are as expected. Analyses on going.
- Mid-inclination orbits will provide enhanced sensitivity to North-South deformation when combining different geometries
- Working towards an InSAR orbit (250 m tube radius) for an upcoming Capella satellite (Acadia generation).



Q & A

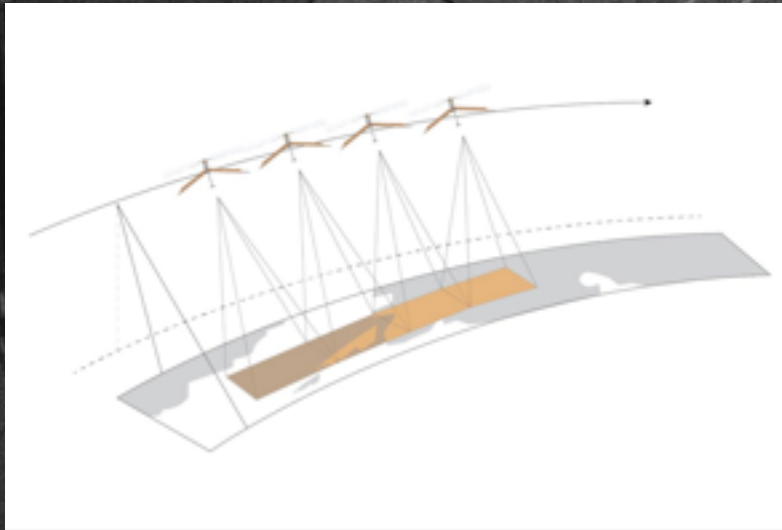
Interested in Capella InSAR sample data?

<https://www.capellaspace.com/contact/>

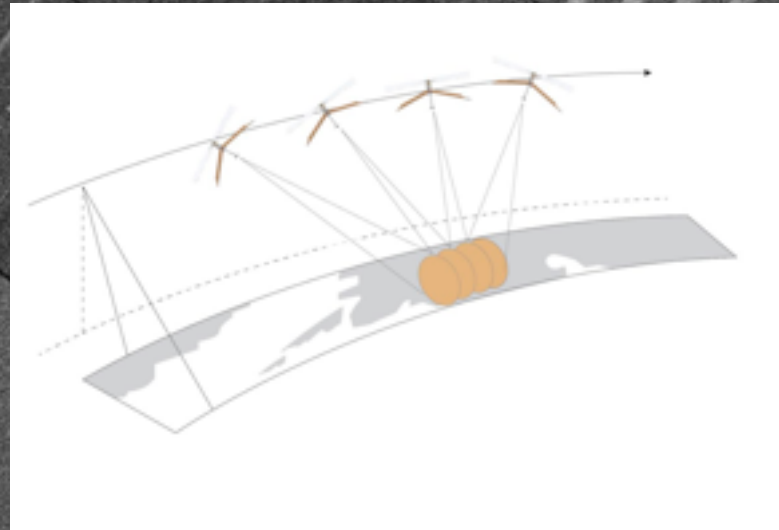


Acquisition modes / Standard products

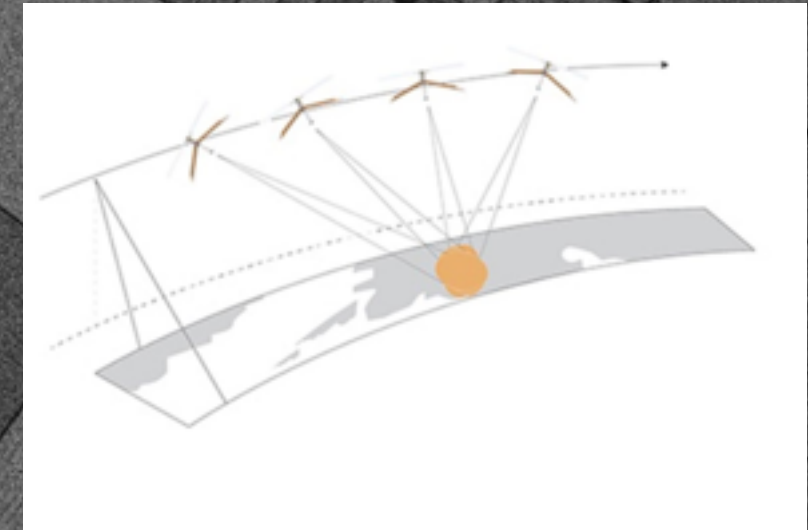
Stripmap



Sliding Spotlight



Spotlight

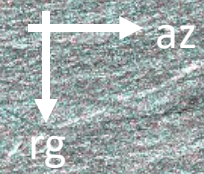


Bandwidth	200 MHz
Resolution [rg x az]	0.75 m x 1.2 m
Coverage	5 km x 20 km
	10 km x 100 km (custom)

Bandwidth	300 MHz
Resolution [rg x az]	0.5 m x 1.0 m
Coverage	5 km x 10 km

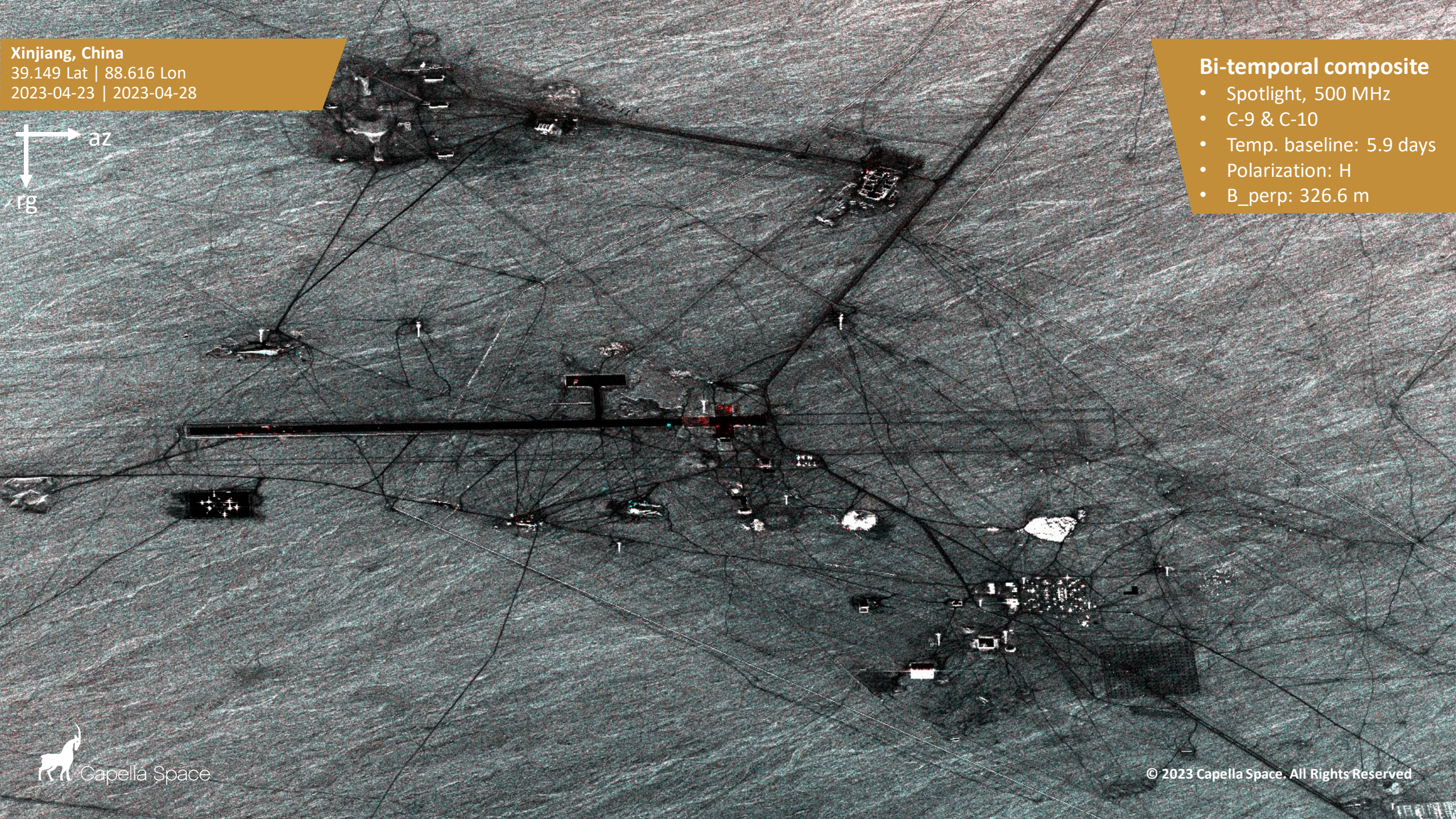
Bandwidth	500 MHz / 700 MHz
Resolution [rg x az]	0.3 / 0.21 x 0.5 m
	0.3 / 0.21 m x 0.25 m
Coverage	5 km x 5 km

Xinjiang, China
39.149 Lat | 88.616 Lon
2023-04-23 | 2023-04-28



Bi-temporal composite

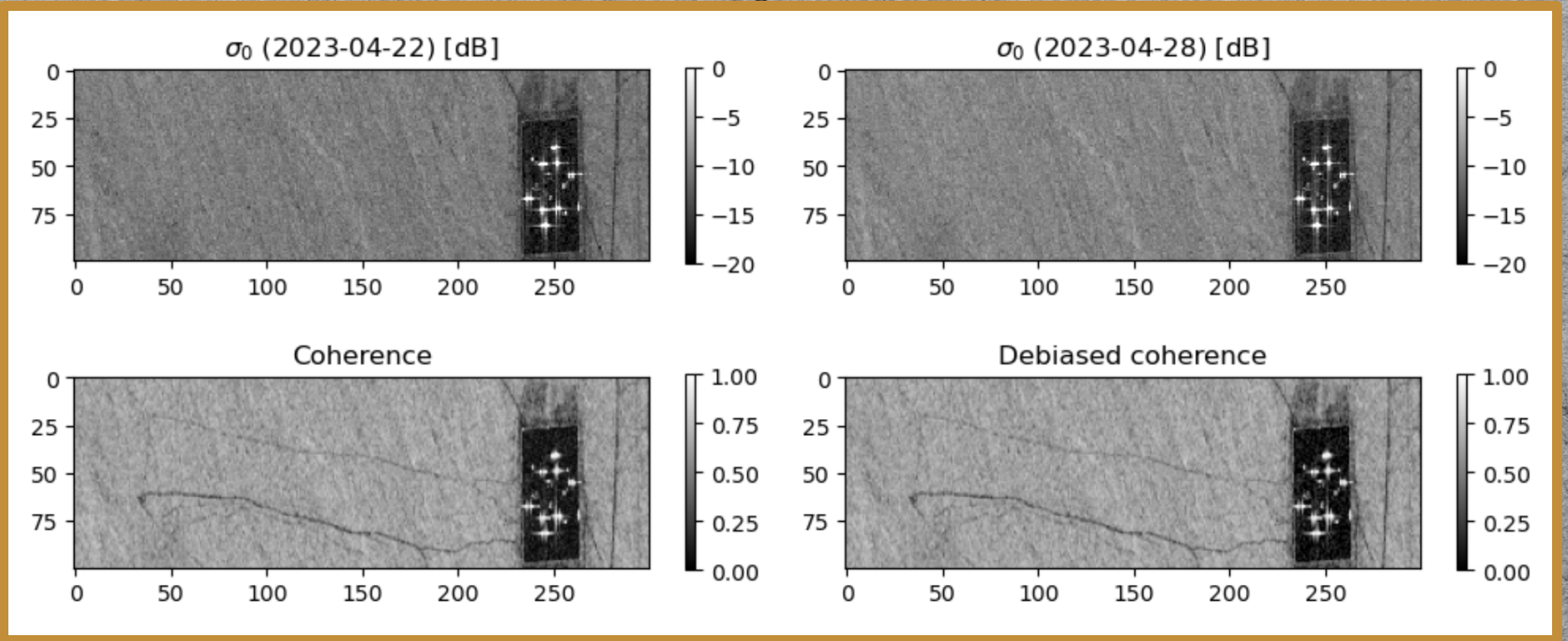
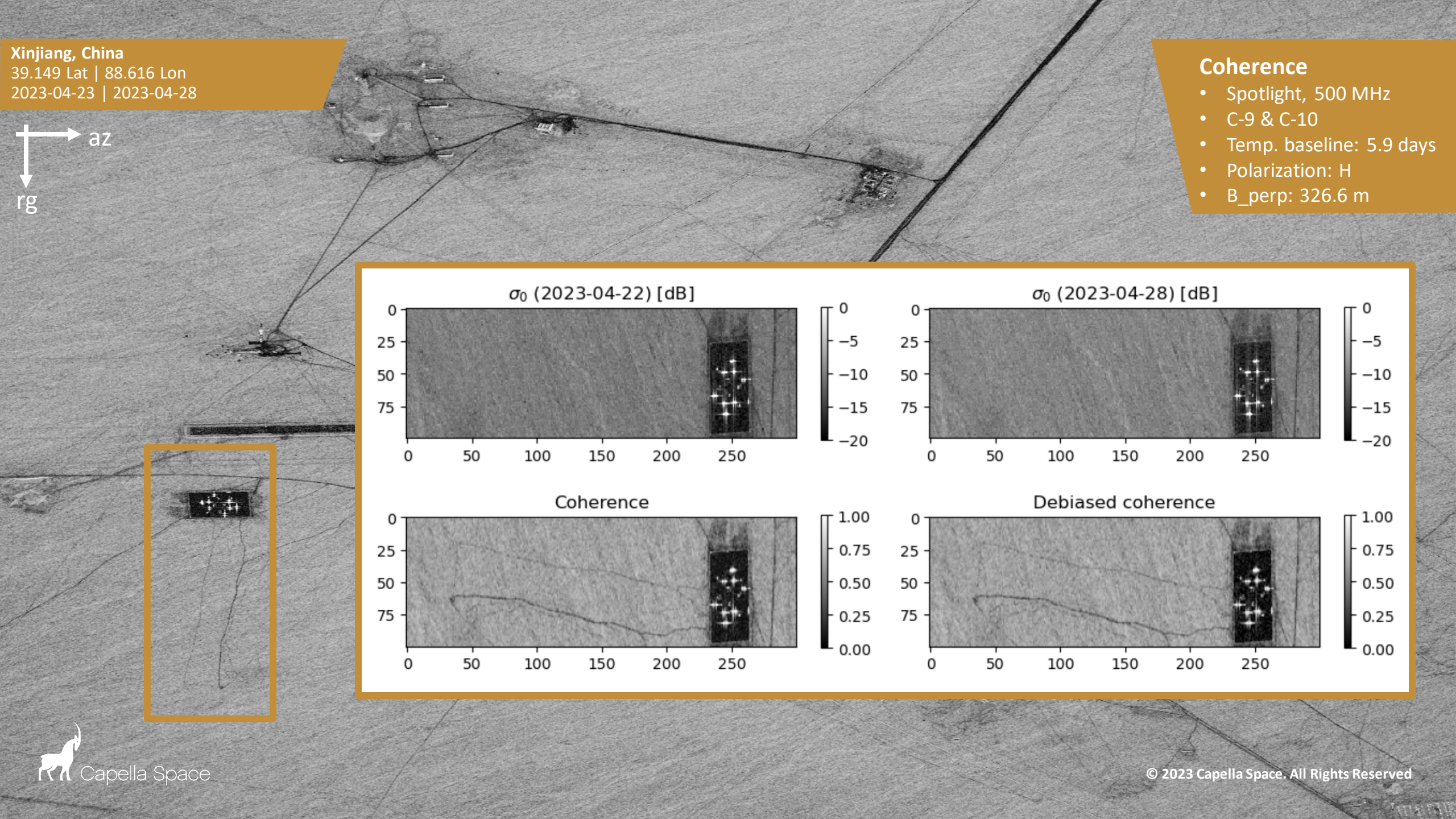
- Spotlight, 500 MHz
- C-9 & C-10
- Temp. baseline: 5.9 days
- Polarization: H
- B_perp: 326.6 m



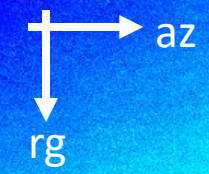
Xinjiang, China
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Coherence

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DEM comp. InSAR Phase

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