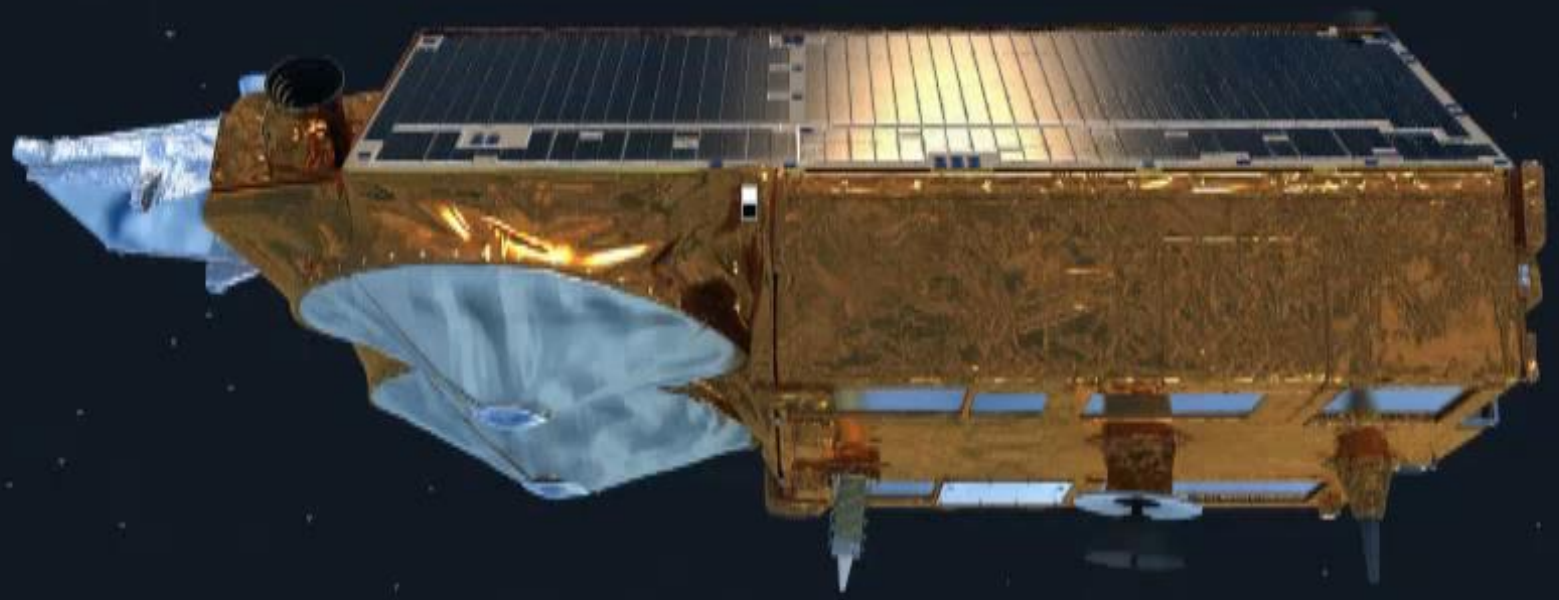
DUAL-CRYO | Land Ice

State of the Art & Scientific Readiness of Dual Band Measurements



Mal McMillan

Alan Muir, Jeremie Aublanc, Pierre Thibaut, Alejandro Egido, Robert Escola, Monica Roca, Andrew Shepherd, Jerome Benveniste, Craig Donlon, Michael Kern

- (A taster of…) current knowledge.
- Scientific Readiness for a future dual band mission.
- Knowledge gaps & unanswered questions (… in my opinion).

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spice esa

Sentinel-3 Tandem for Climate

POLAR MONITORING MISSION, ASSESSMENT AND CONSOLIDATION OF REQUIREMENTS AND ANALYSIS OF CAMPAIGN DATA

- Focus on Ku / Ka / laser.

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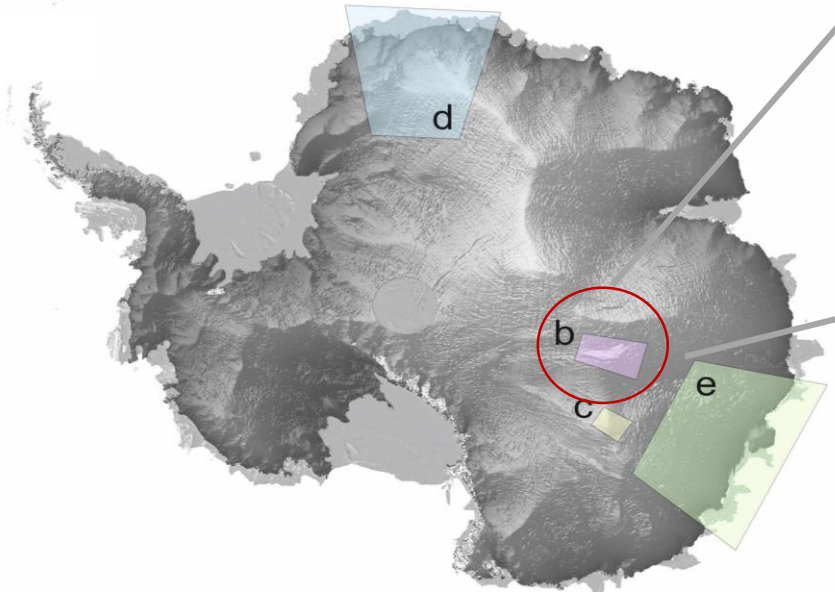
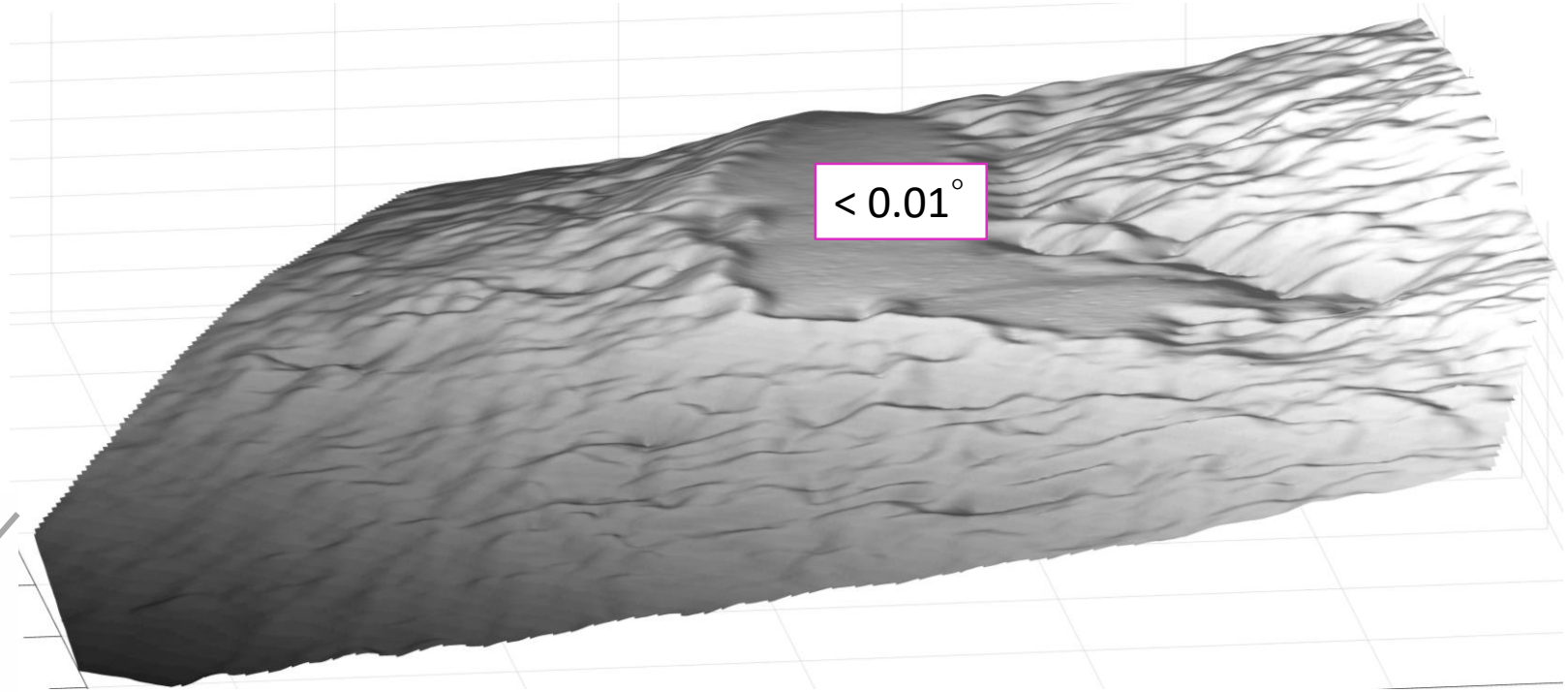
spice esa

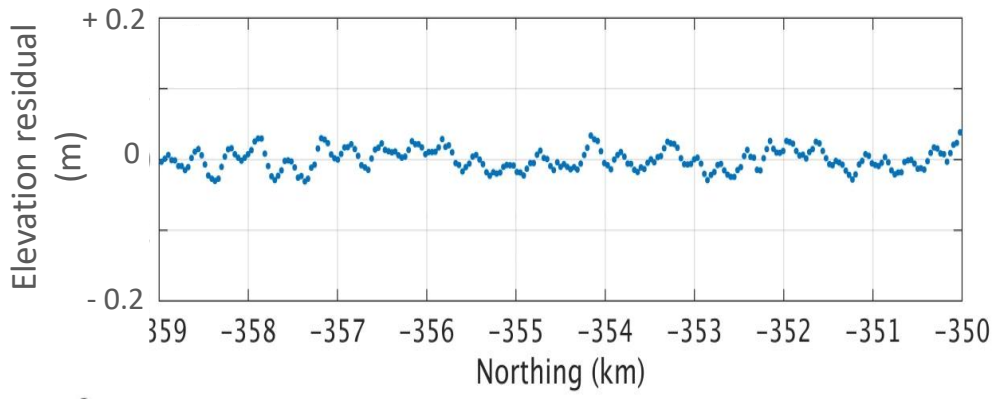
Sentinel-3 Tandem for Climate

POLAR MONITORING MISSION, ASSESSMENT AND CONSOLIDATION OF REQUIREMENTS AND ANALYSIS OF CAMPAIGN DATA

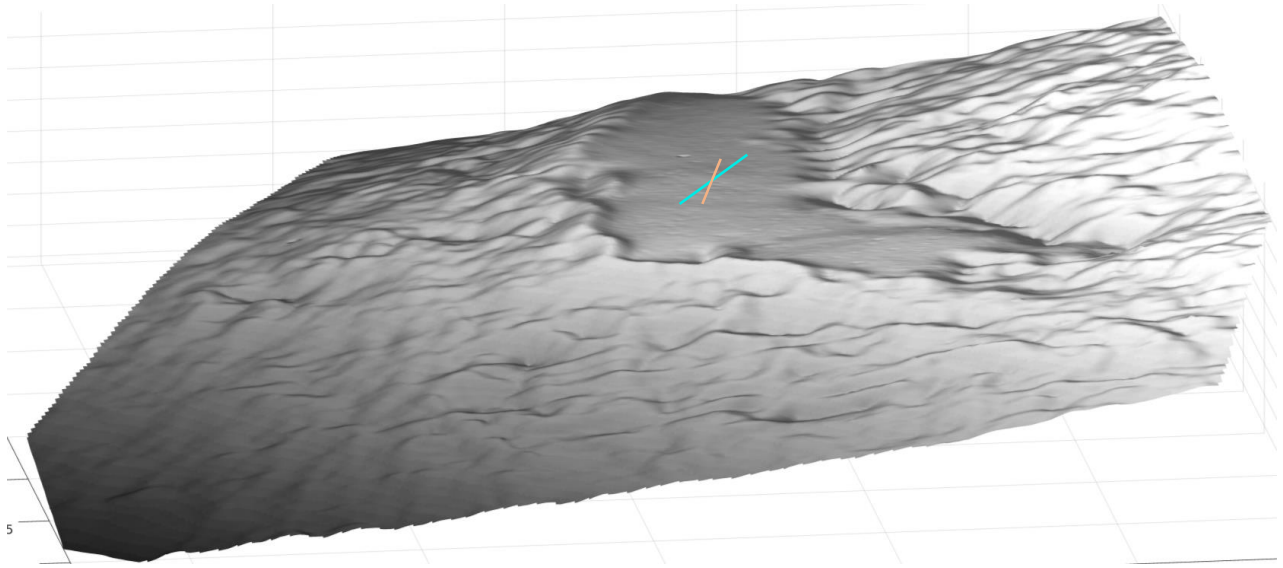
Radar backscatter from an ideal ice sheet surface



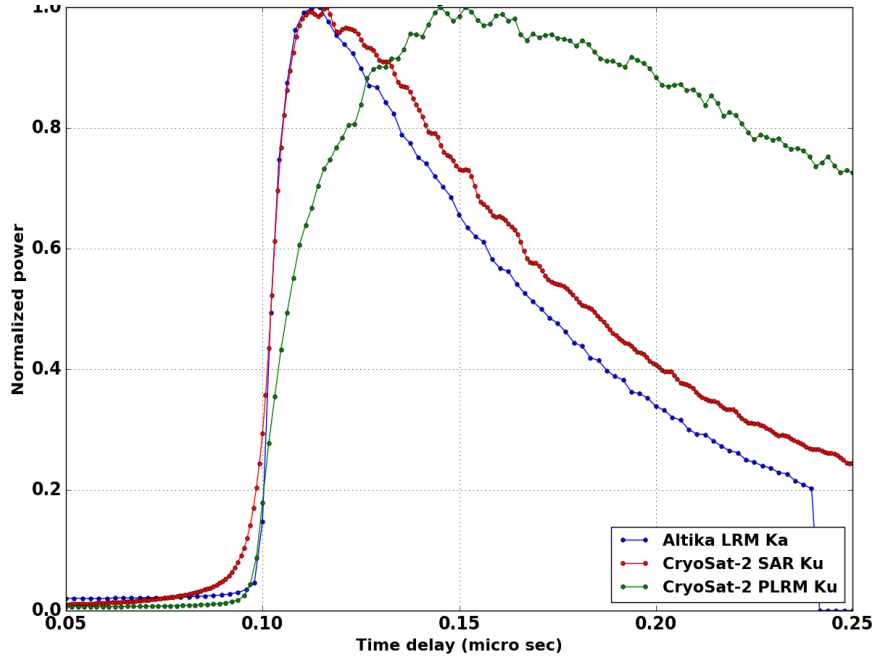




Radar backscatter from an ideal ice sheet surface



Mean waveforms (4s of aggregation) | 28-29 Nov. 2014

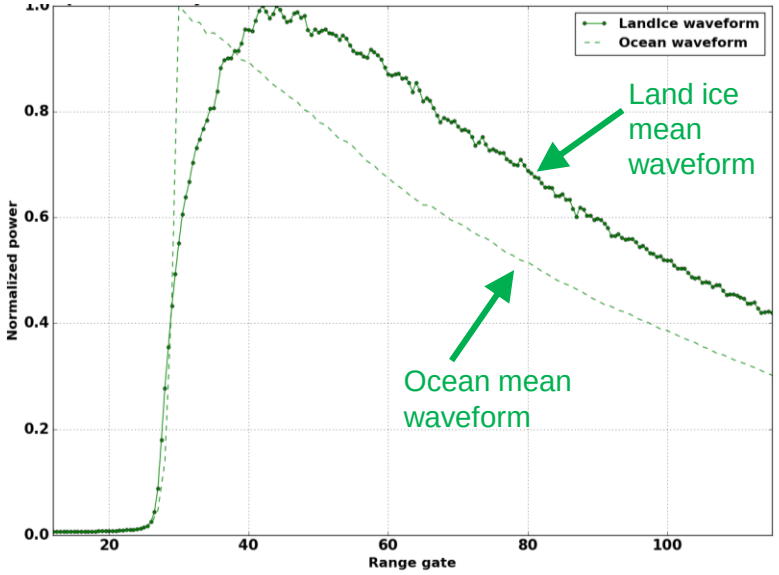


AltiKa **Cryosat-2 SAR** **Cryosat-2 pLRM**

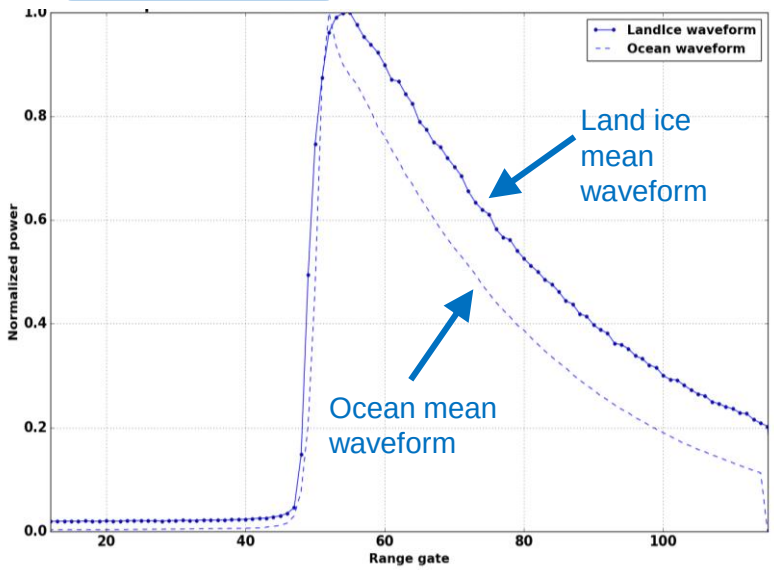
[*Credit J. Aublanc & P. Thibaut*]

Radar backscatter from an ideal ice sheet surface

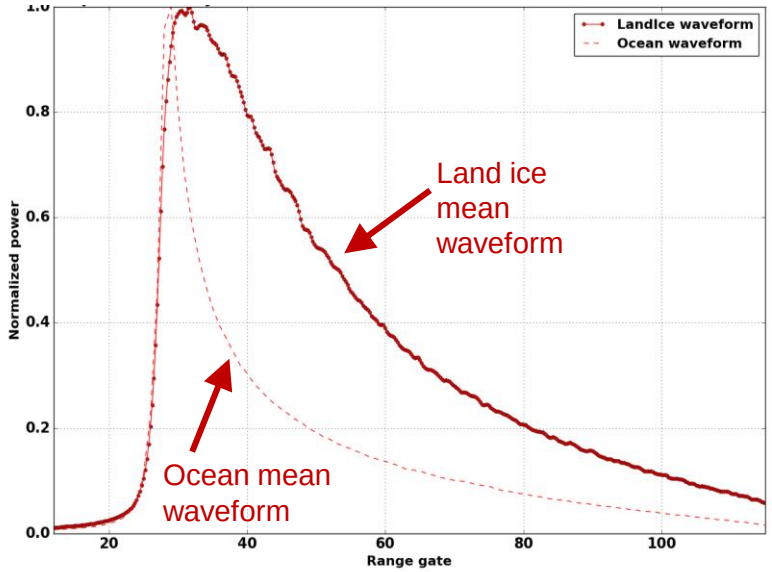
CryoSat-2 pLRM



AltiKa LRM



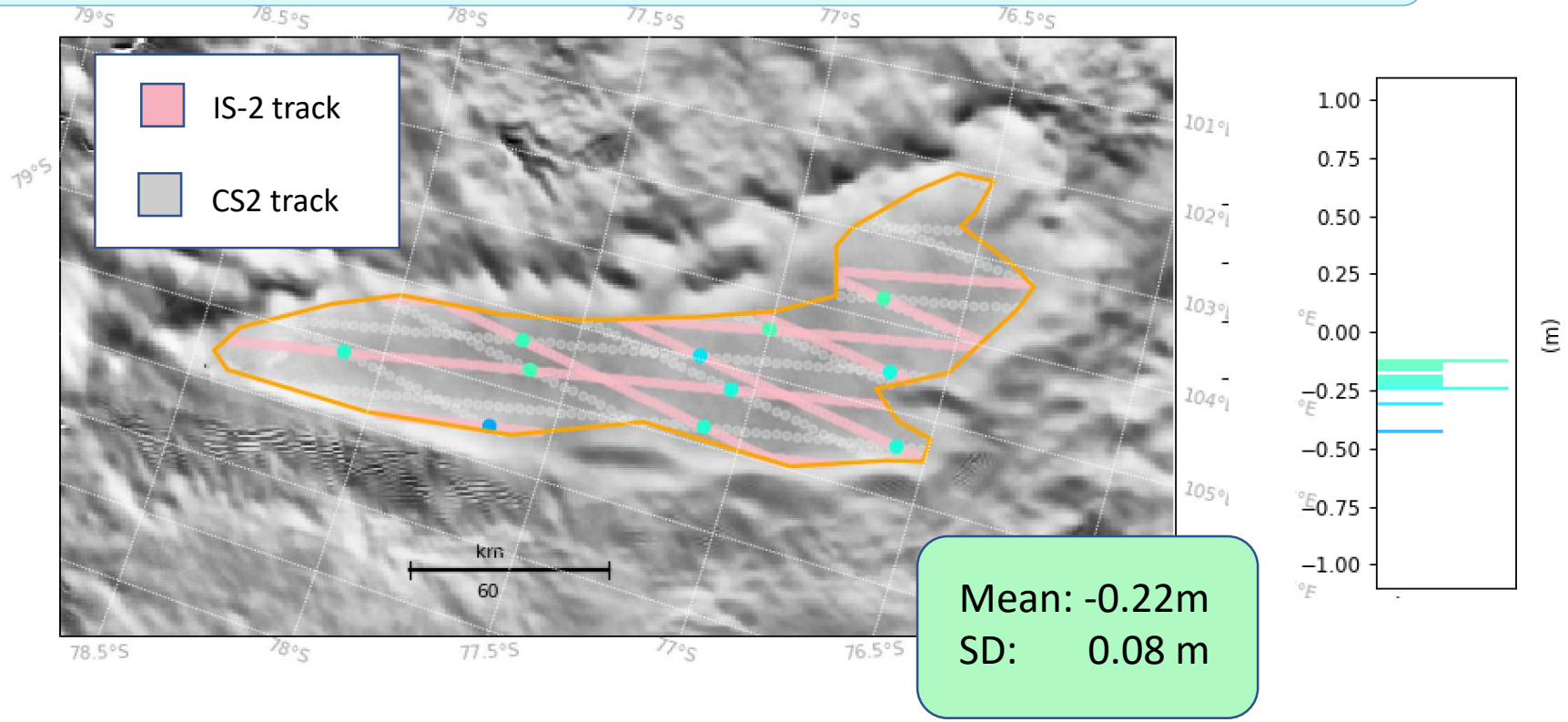
CryoSat-2 SAR



[*Credit J. Aublanc & P. Thibaut*]

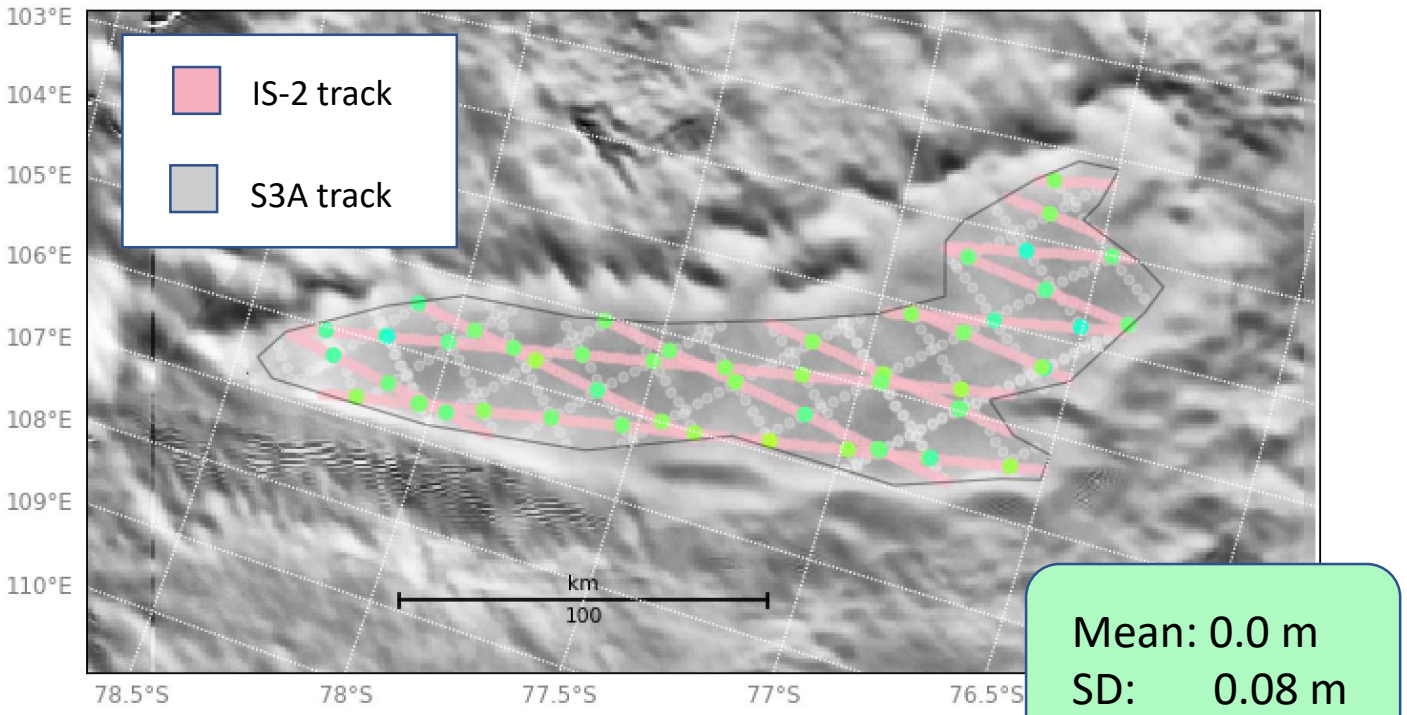
Evidence of Penetration – LRM

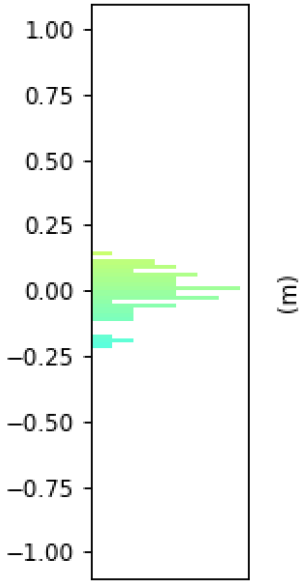
CryoSat-2 LRM – ICESat-2 elevation differences | Spring 2019 | Lake Vostok



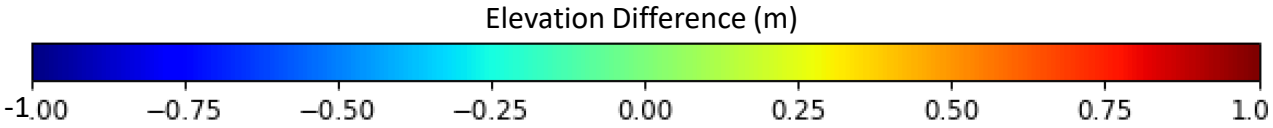
Evidence of Penetration – SAR

Sentinel-3A SAR – ICESat-2 elevation differences | Spring 2019 | Lake Vostok





Mean: 0.0 m
SD: 0.08 m



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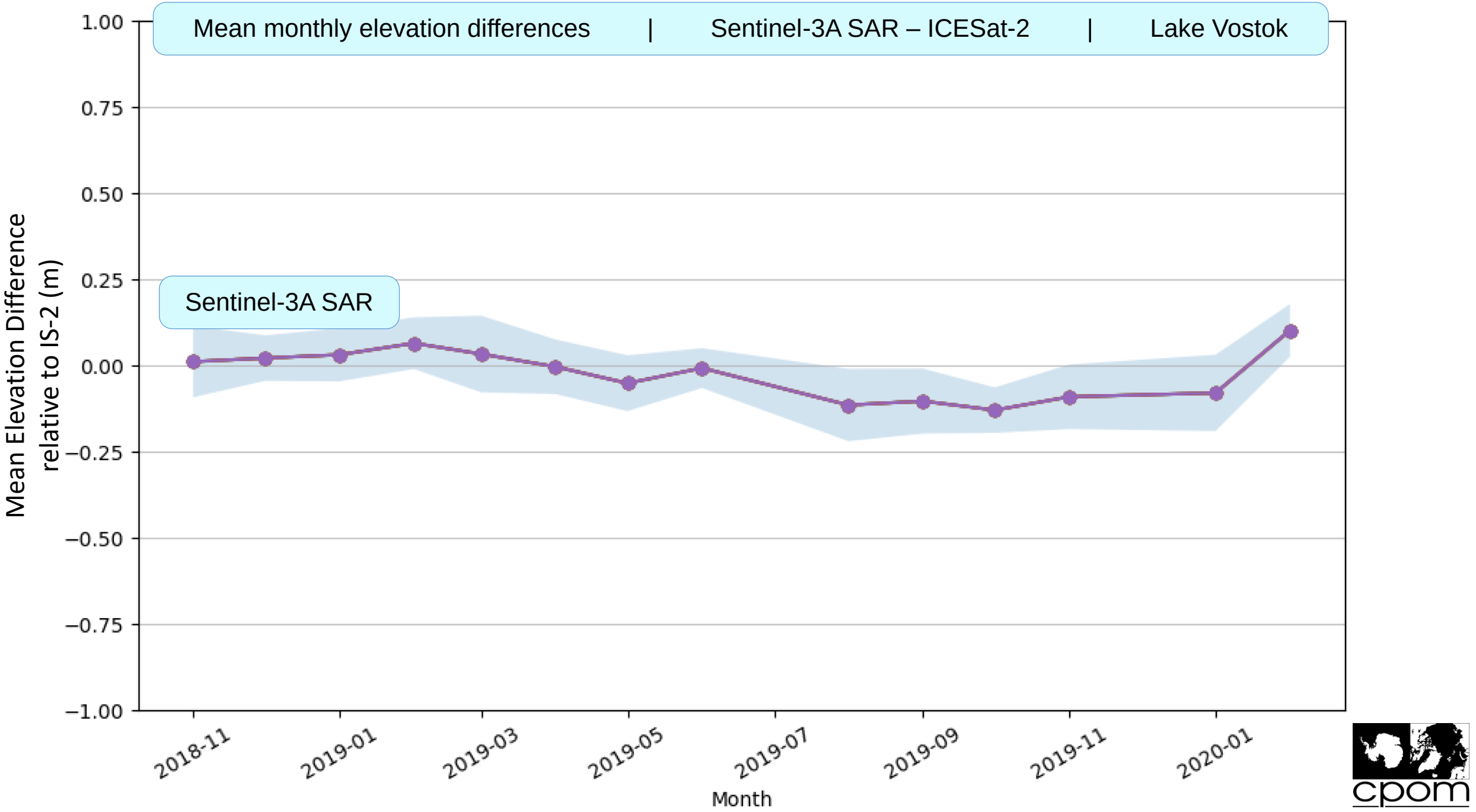
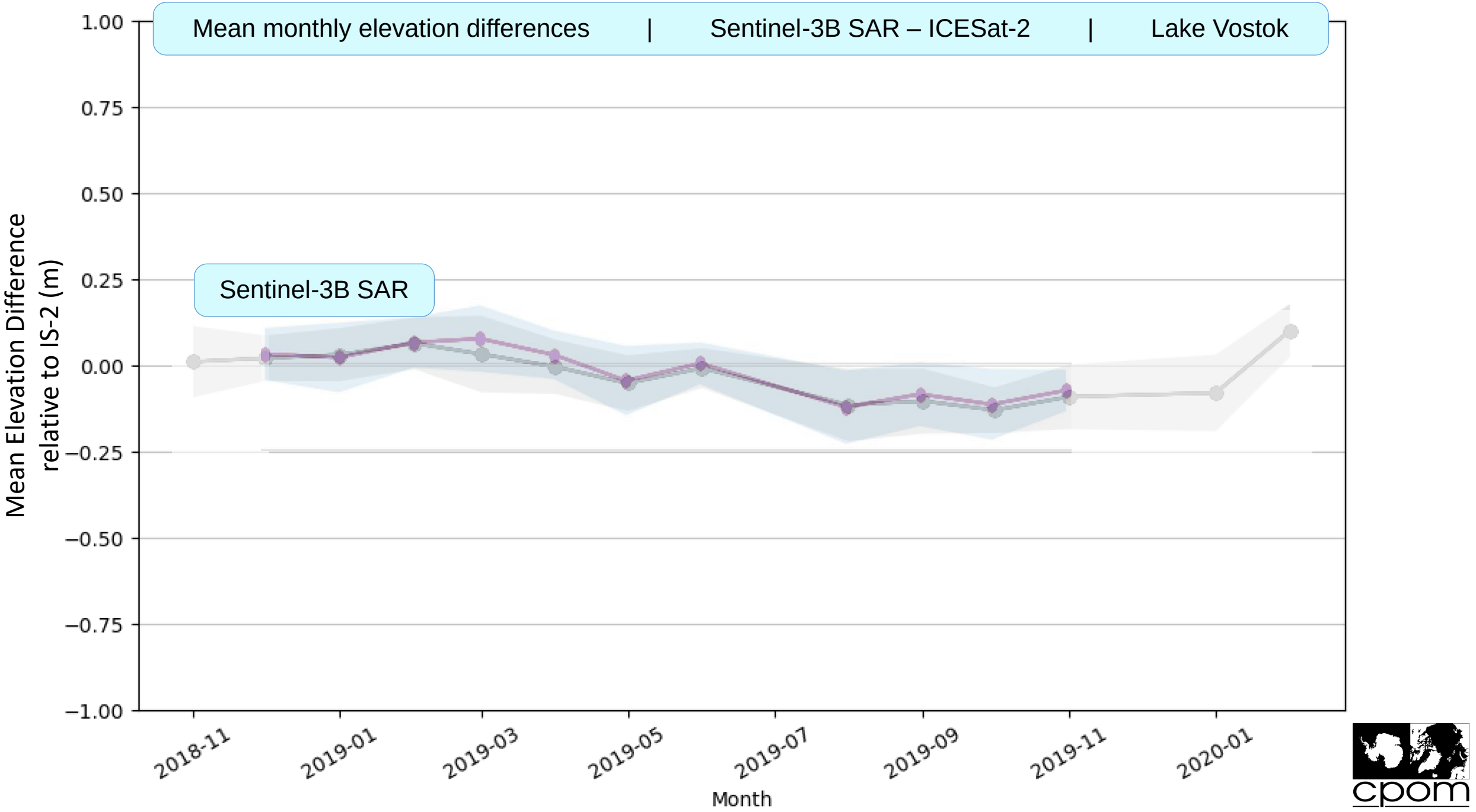

Mean monthly elevation differences | Sentinel-3A SAR – ICESat-2 | Lake Vostok
Sentinel-3A SAR
Mean Elevation Difference relative to IS-2 (m)
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
2018-11
2019-01
2019-03
2019-05
2019-07
2019-09
2019-11
2020-01
Month


Mean monthly elevation differences | Sentinel-3B SAR – ICESat-2 | Lake Vostok
Sentinel-3B SAR
Mean Elevation Difference relative to IS-2 (m)
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
2018-11
2019-01
2019-03
2019-05
2019-07
2019-09
2019-11
2020-01
Month

Mean monthly elevation differences | CryoSat-2 LRM – ICESat-2 | Lake Vostok

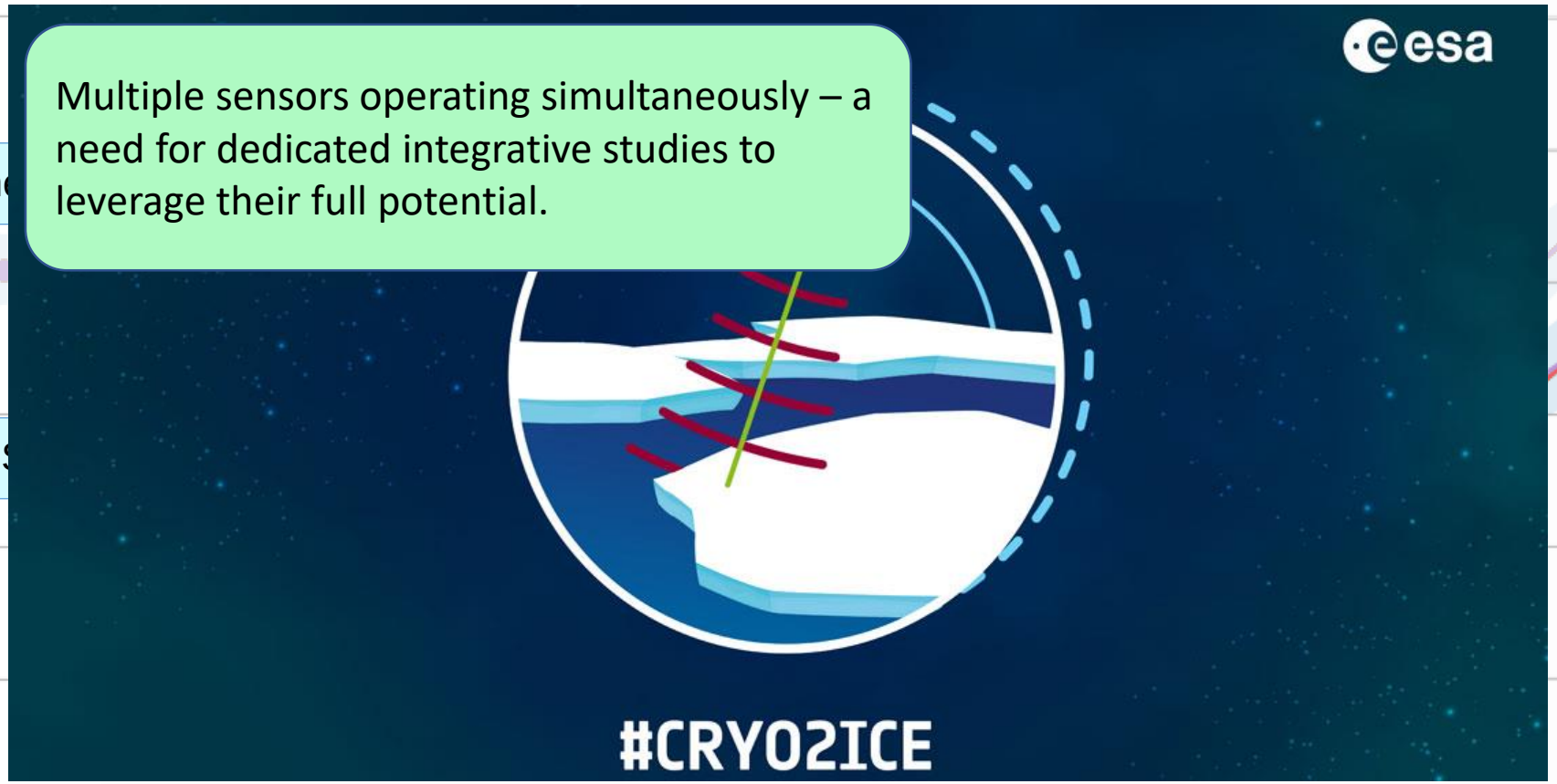
Mean Elevation Difference relative to IS-2 (m)

1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00

Sentin

Cryo

Multiple sensors operating simultaneously – a need for dedicated integrative studies to leverage their full potential.



2018-11
2019-01
2019-03
2019-05
2019-07
2019-09
2019-11
2020-01

Month

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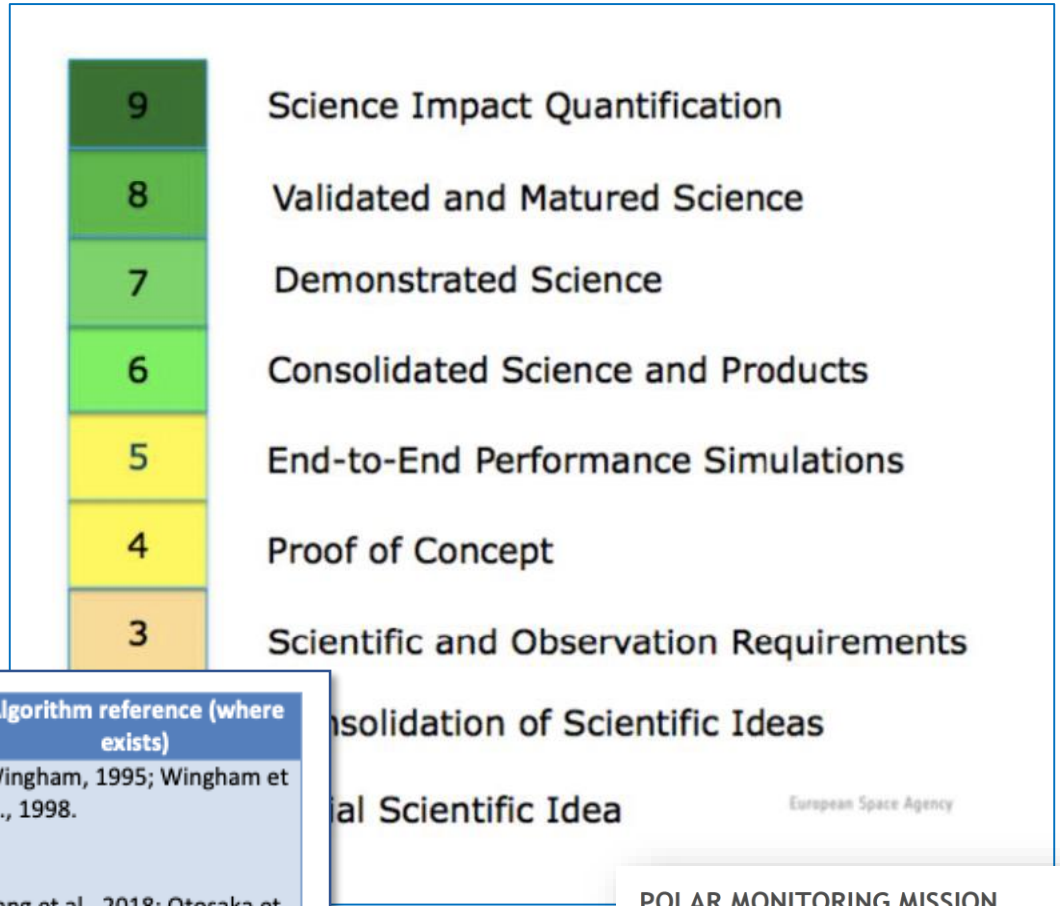
Dual Band Altimtery over Ice Sheets – Knowledge Gaps

Scientific Readiness Level of a Ku-Ka band mission

The purpose of this task was to:

1. Identify the algorithms that currently exist.
2. Make an assessment of their maturity (both current maturity, and expected maturity at 2025) & their SRL.
3. Ensure full traceability via references to supporting literature.
4. Highlight needs for future algorithm development activities.



Processing Step	Algorithm	Description	Maturity (expected maturity at 2025)	Existing SRL	Algorithm reference (where exists)
Retracking	Threshold Centre of Gravity	'ICE-1' retracker, as applied in ERS-1, ERS-2, Envisat, CryoSat-2 (LRM; baseline-c onwards), AltiKa and Sentinel-3 ground segments; retracks based on a threshold of the Offset Centre of Gravity amplitude.	**Ku**: Mature (mature)	9	Wingham, 1995; Wingham et al., 1998.
			Ka: Mature (mature)	8	Yang et al., 2018; Otosaka et al. (*in review*)

POLAR MONITORING MISSION, ASSESSMENT AND CONSOLIDATION OF REQUIREMENTS AND ANALYSIS OF CAMPAIGN DATA

Dual Band Altimetry over Ice Sheets – Knowledge Gaps

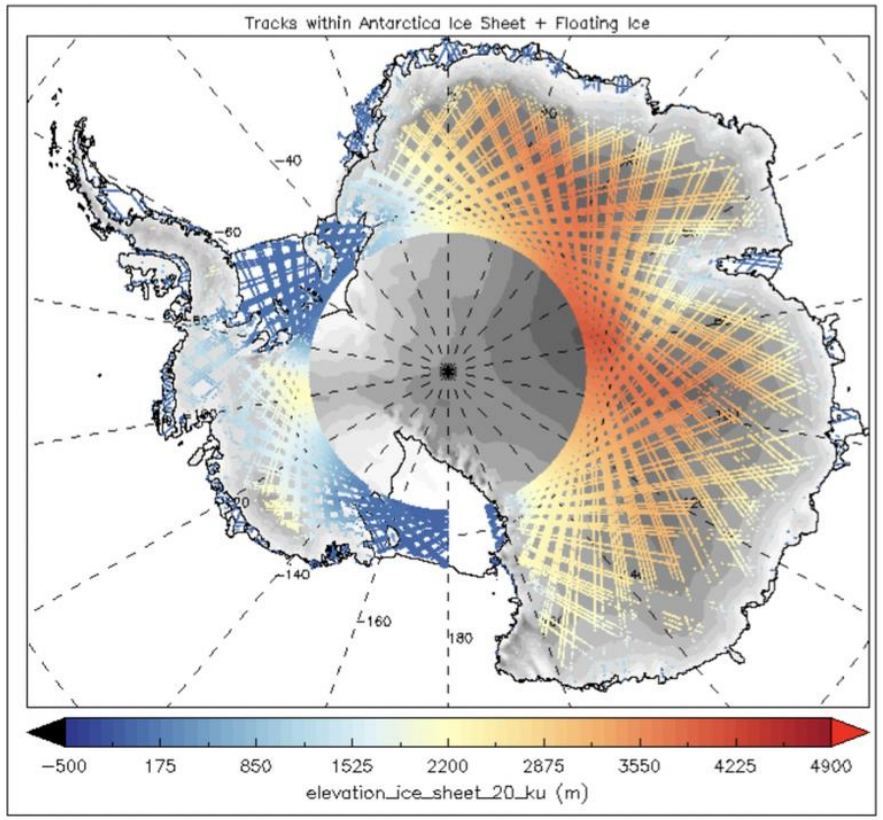
1. Immaturity of Open Loop tracking.

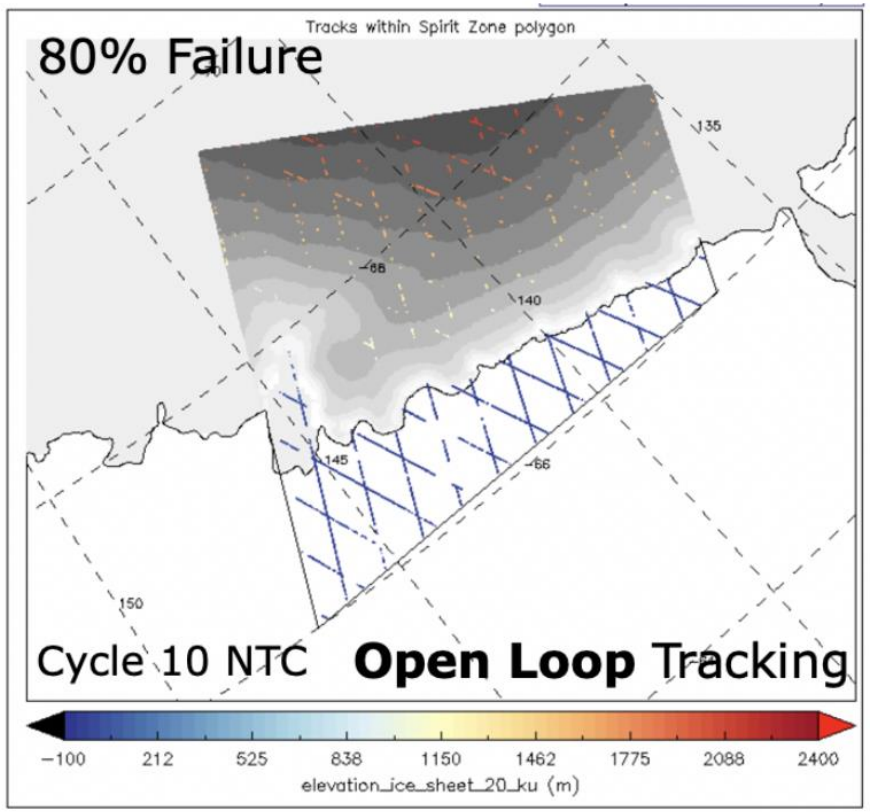
2. SAR processing:
   - Ka Unfocussed and Full-Focussed (closed burst).
   - Ku Fully-Focussed (closed burst).

3. Consistency of Ku & Ka acquisitions over complex terrain.

4. Estimation of penetration depth:
   - Divergent POCA's over complex terrain.
   - Impact of topography on the surface response.

1. Immaturity of Open Loop tracking => Not proven in orbit





Sentinel-3 – loss of coverage in experimental Open Loop tracking during commissioning phase.

- High priority to assess performance of Open Loop tracking:
  - Is it sufficiently agile to capture the surface response over complex terrain?
  - Capability to capture Ku and Ka responses.

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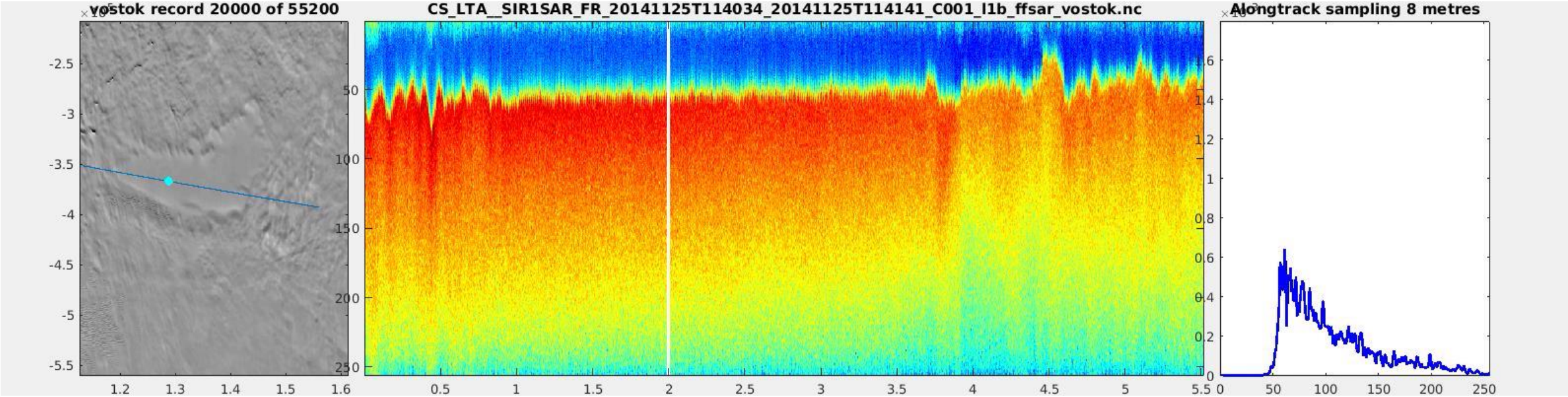
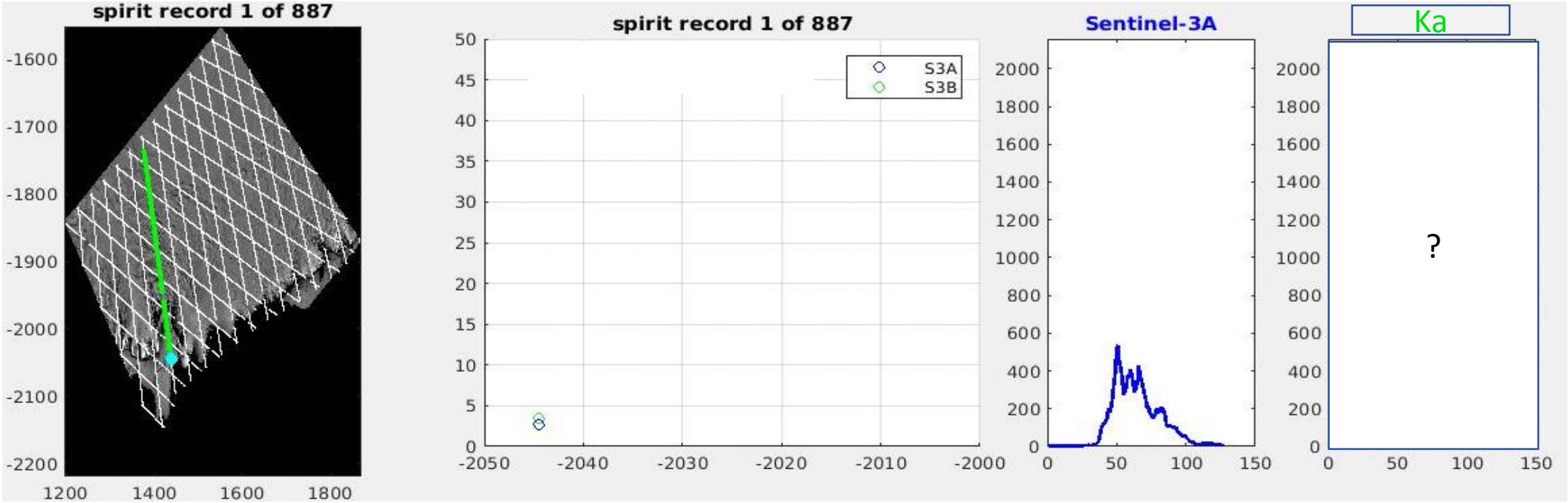
2. SAR Processing

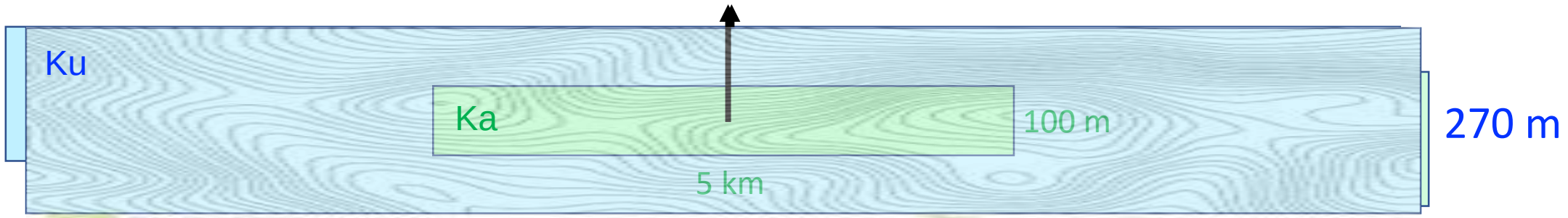
- Ka SAR (Unfocused & Fully-Focussed) processing has a low SRL.
- Ku FF-SAR (closed burst) over ice sheets is immature.



3. Consistency of Ku and Ka SAR acquisitions over complex terrain

Sentinel-3 Tandem for Climate

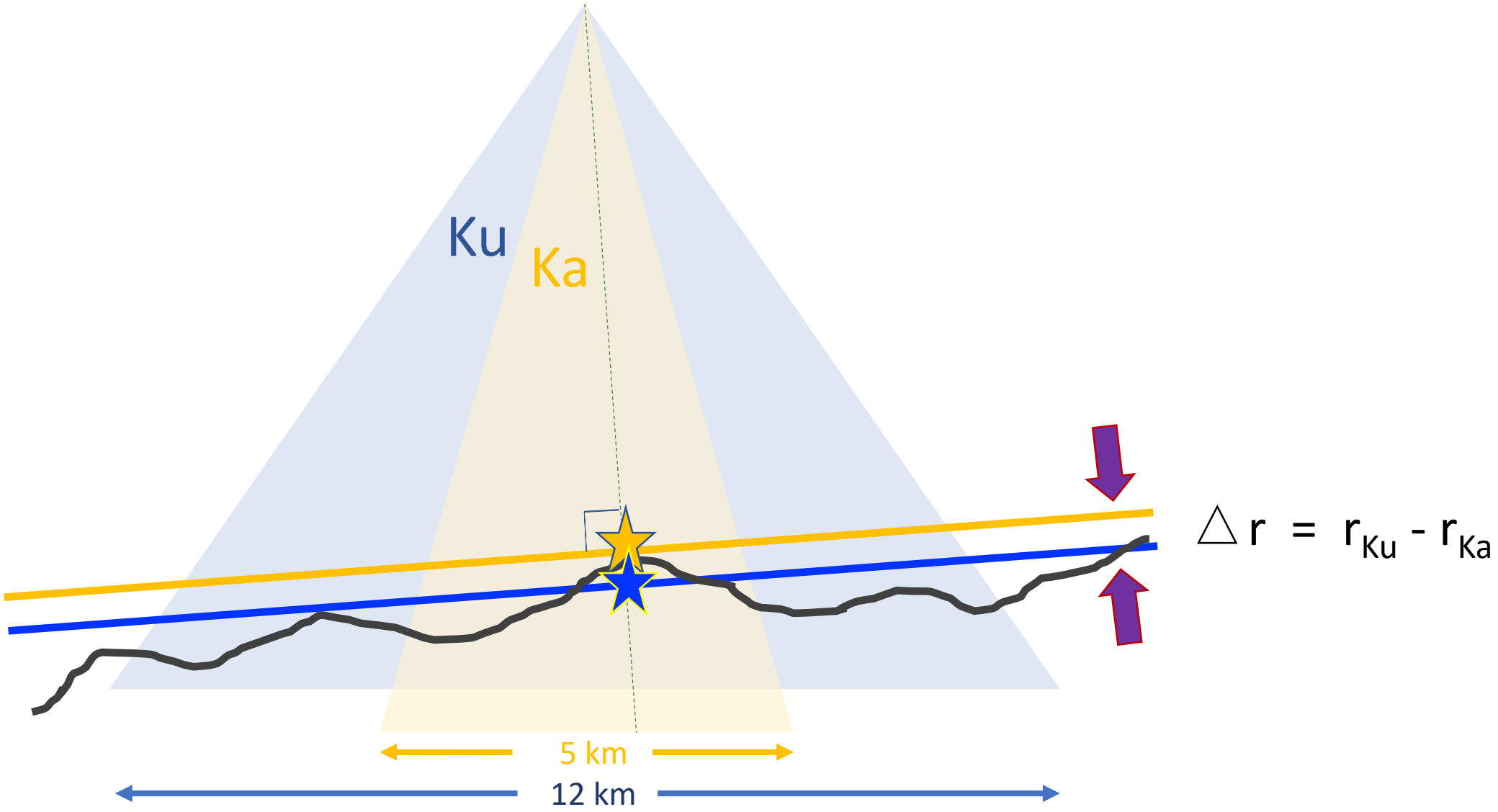




12 km

Based on -3dB beamwidth of 1.04° for Ku band and 0.43° for Ka band.

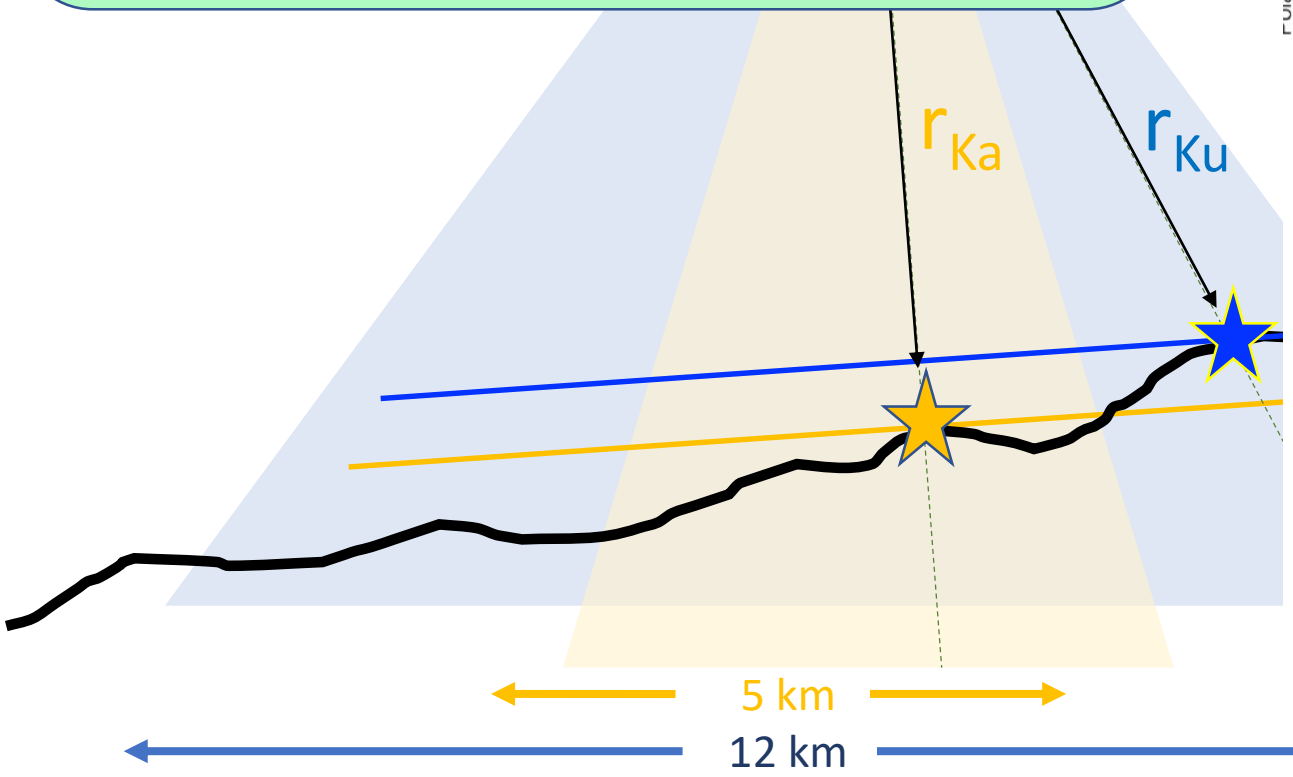
4. Estimation of penetration depth over complex terrain.

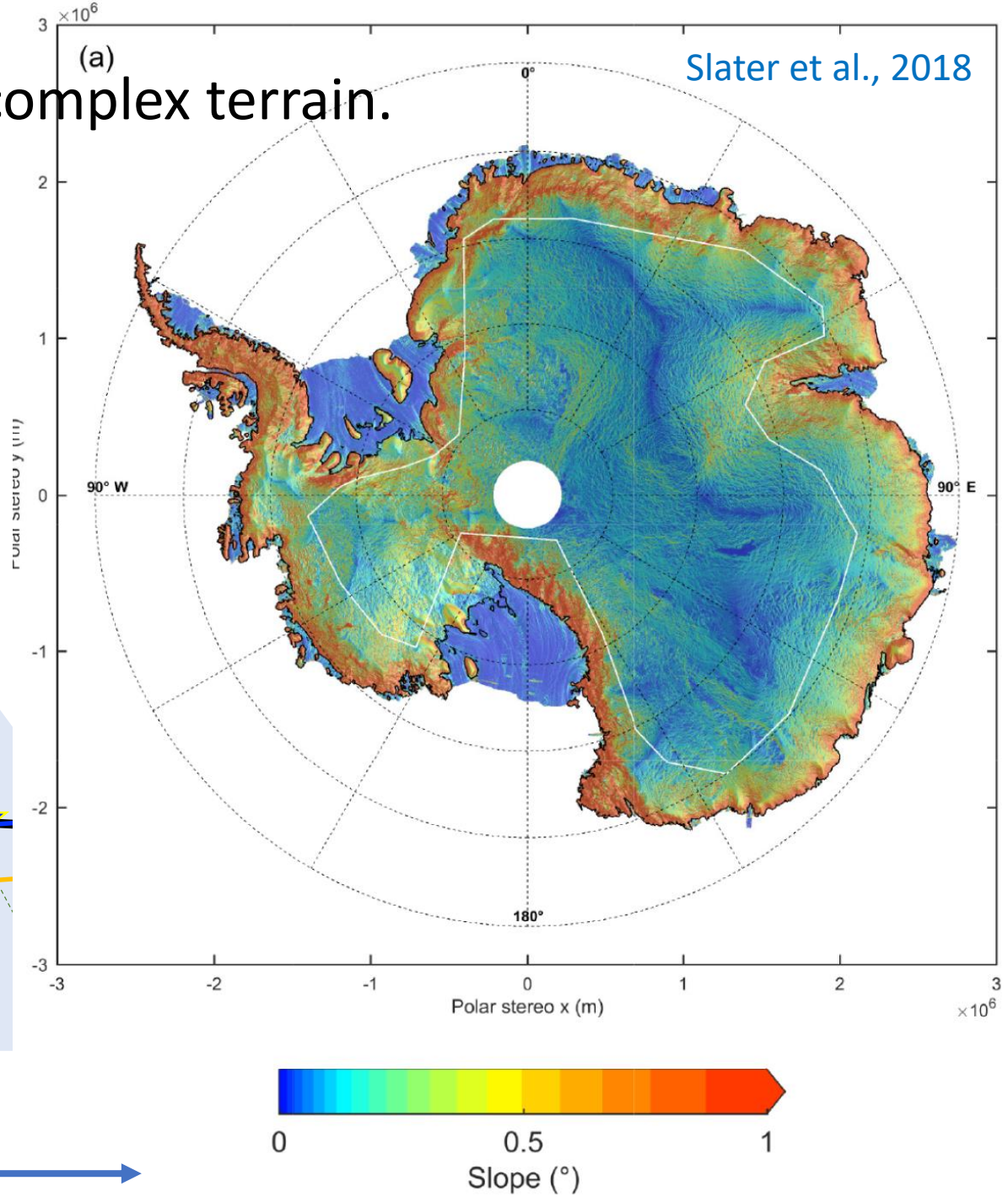


$$\triangle r = r_{Ku} - r_{Ka}$$

4. Estimation of penetration depth over complex terrain.

- To what extent is power returned from beyond the -3dB beamwidth?
- How does the coherency of Ku and Ka waveforms degrade with slope?
- Can the Ku interferometer be used to mitigate this effect?





Discussions Session

- What do we know, and already have solutions for? i.e. scientific readiness is good
- What do we know, but do not yet have solutions for (i.e. more work needed)? i.e. scientific readiness is not adequate
- What is not known? i.e. scientific readiness is unknown

Discussions Session

- What do we know, and already have solutions for? i.e. scientific readiness is good

- What do we know, but do not yet have solutions for (i.e. more work needed)? i.e. scientific readiness is not adequate
  - What is needed to solve this issue?
    - Further analysis of existing data?
    - New acquisition of satellite data (e.g. Cryo2Ice)?
    - New ground or airborne campaigns (e.g. Cryovex)?
    - New ground or airborne instrumentation?

- What is not known? i.e. scientific readiness is unknown
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    - New ground or airborne instrumentation?

Summary – and look ahead to discussions

- What do we know, and already have solutions for? i.e. scientific readiness is good

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