Glacial and Peri-glacial monitoring with Remote Sensing

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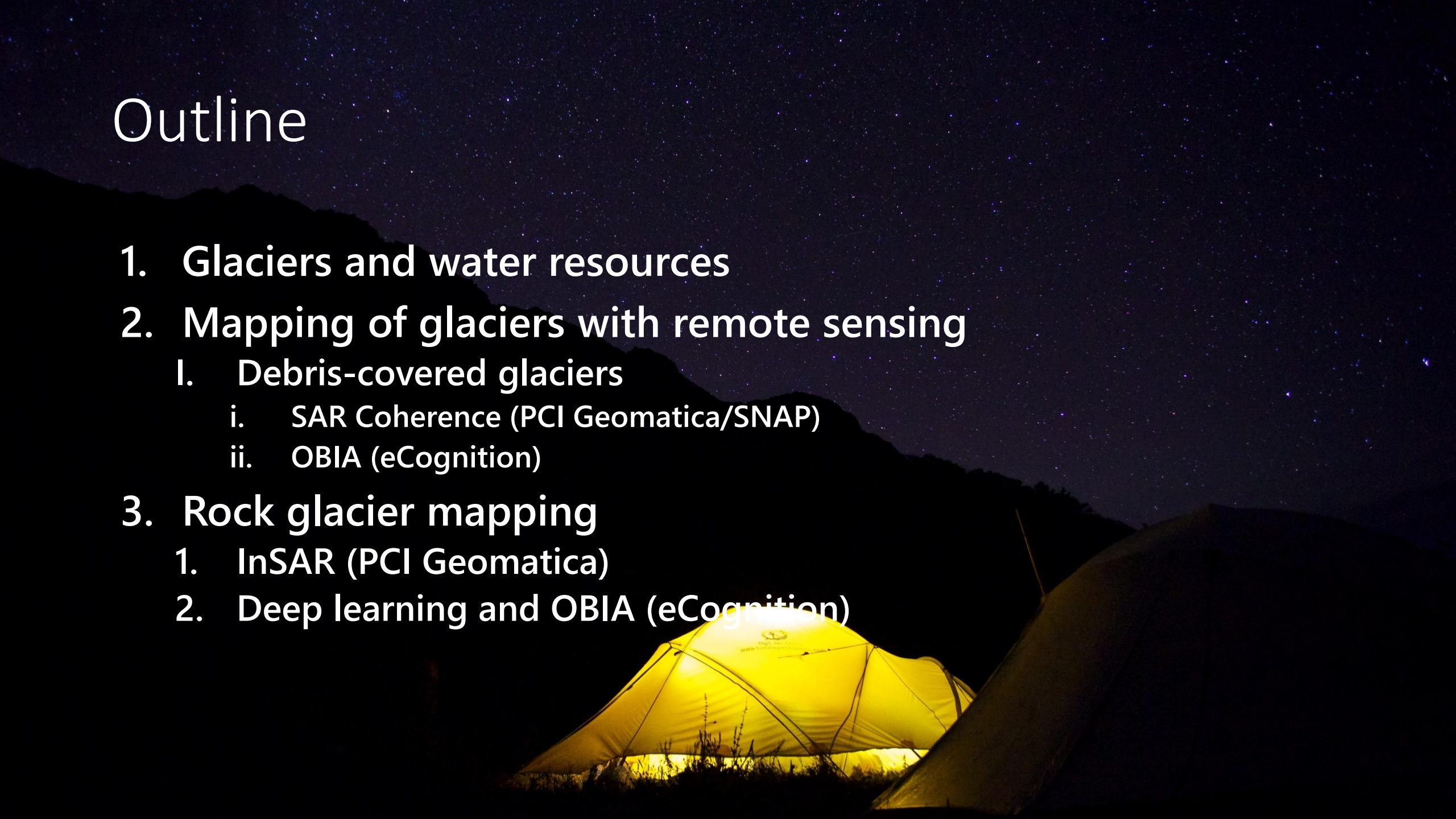
UNIVERSITY OF BERGEN

12 February 2020

TerraNor User Meeting 2020

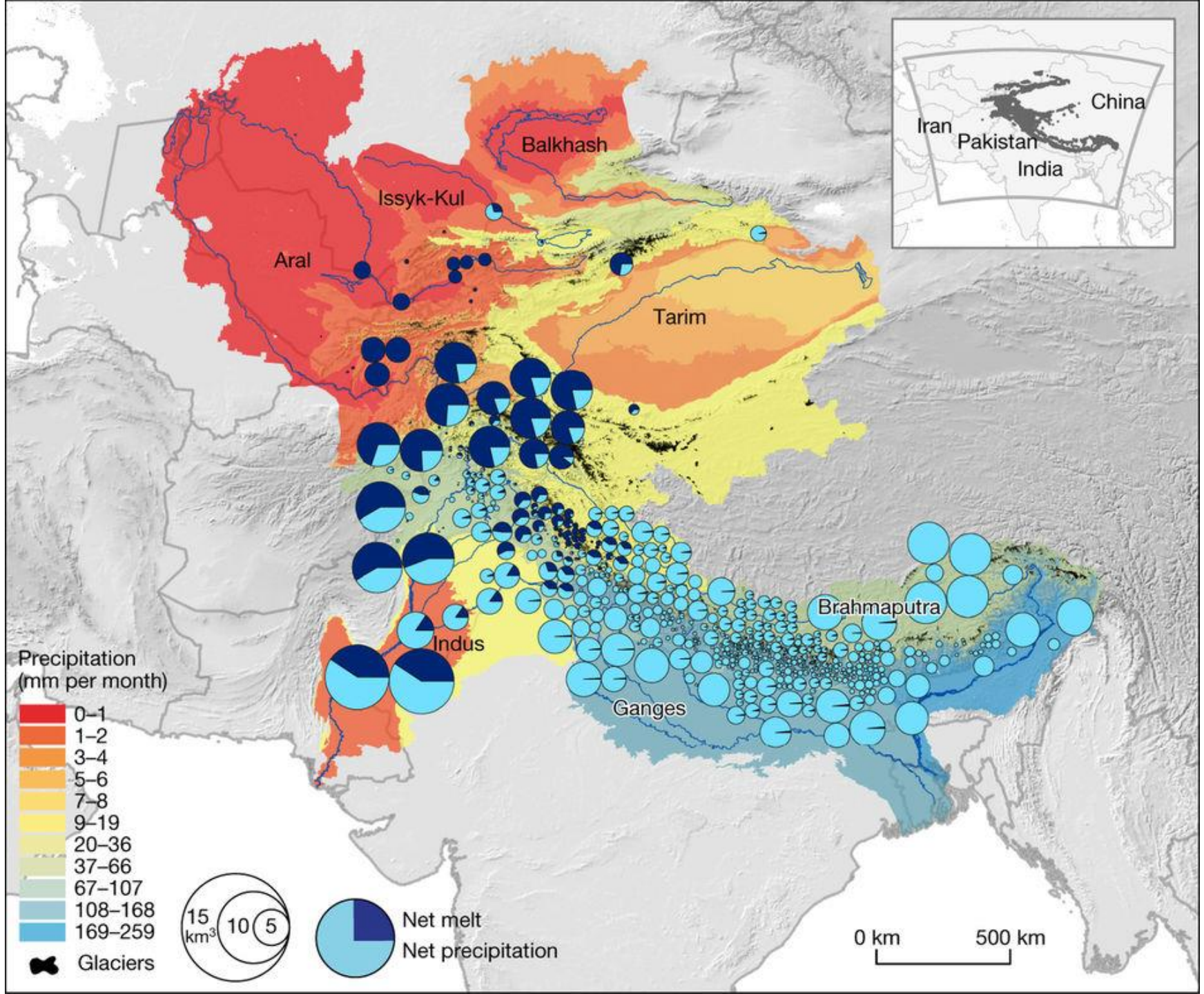
Outline

1. Glaciers and water resources
2. Mapping of glaciers with remote sensing
    I. Debris-covered glaciers
        i. SAR Coherence (PCI Geomatica/SNAP)
        ii. OBIA (eCognition)
3. Rock glacier mapping
    1. InSAR (PCI Geomatica)
    2. Deep learning and OBIA (eCognition)



What’s so interesting about glaciers anyway?

(Nils Erik Jørgensen , 5/2/2020., remarks at crowbar)



Pritchard, 2017

IPCC officials admit mistake over melting Himalayan glaciers

Senior members of the UN's climate science body admit a claim that Himalayan glaciers could melt away by 2035 was unfounded

5 GMT

The Himalayas. The row centres on the IPCC's 2007 report, which said 'glaciers in the Himalayas are receding faster than in any other part of the world.' Photograph: Getty

The UN's climate science body has admitted that a claim made in its 2007 report - that Himalayan glaciers could melt away by 2035 - was unfounded.

Most popular

In Australia: giant spider carrying a mouse is horrifying and impressive

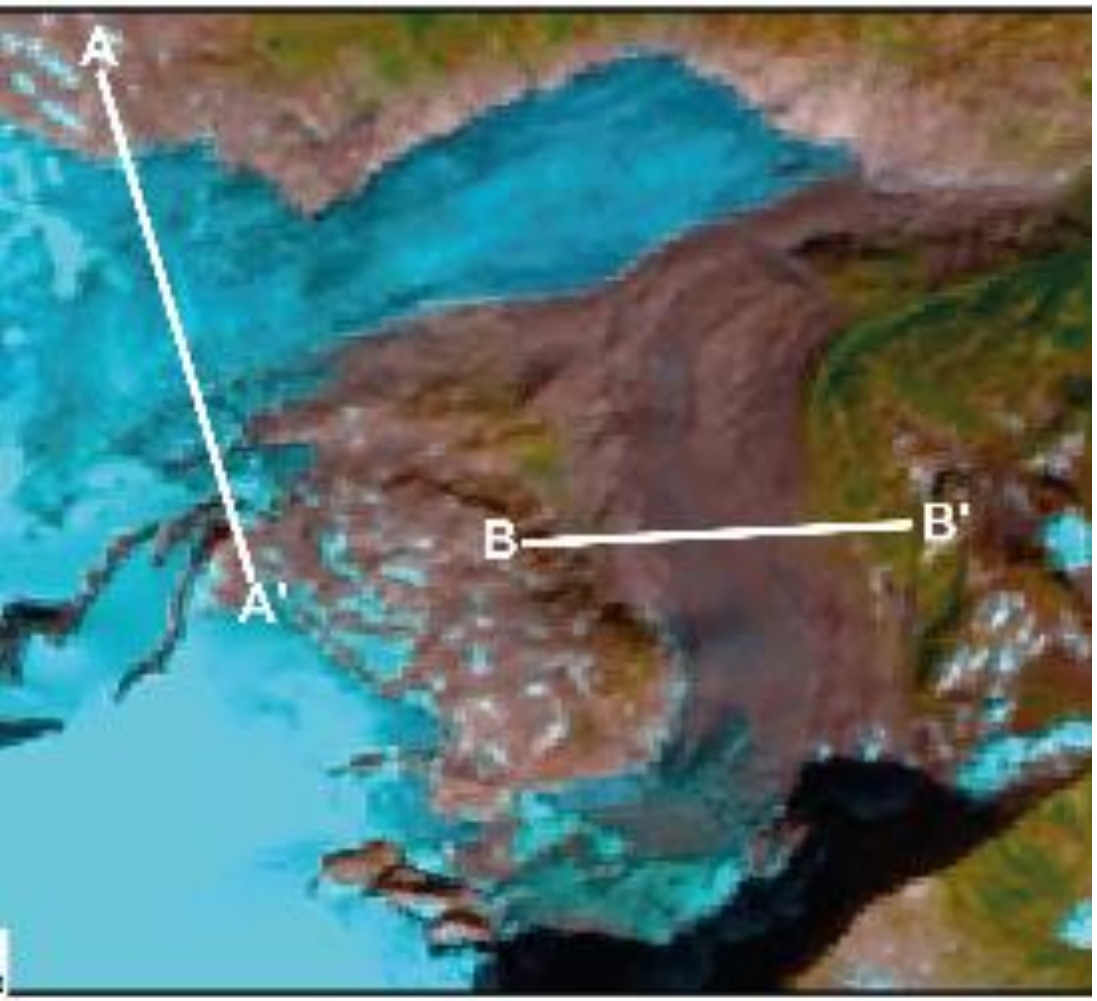
Premier League: 10 talking points from the weekend's action

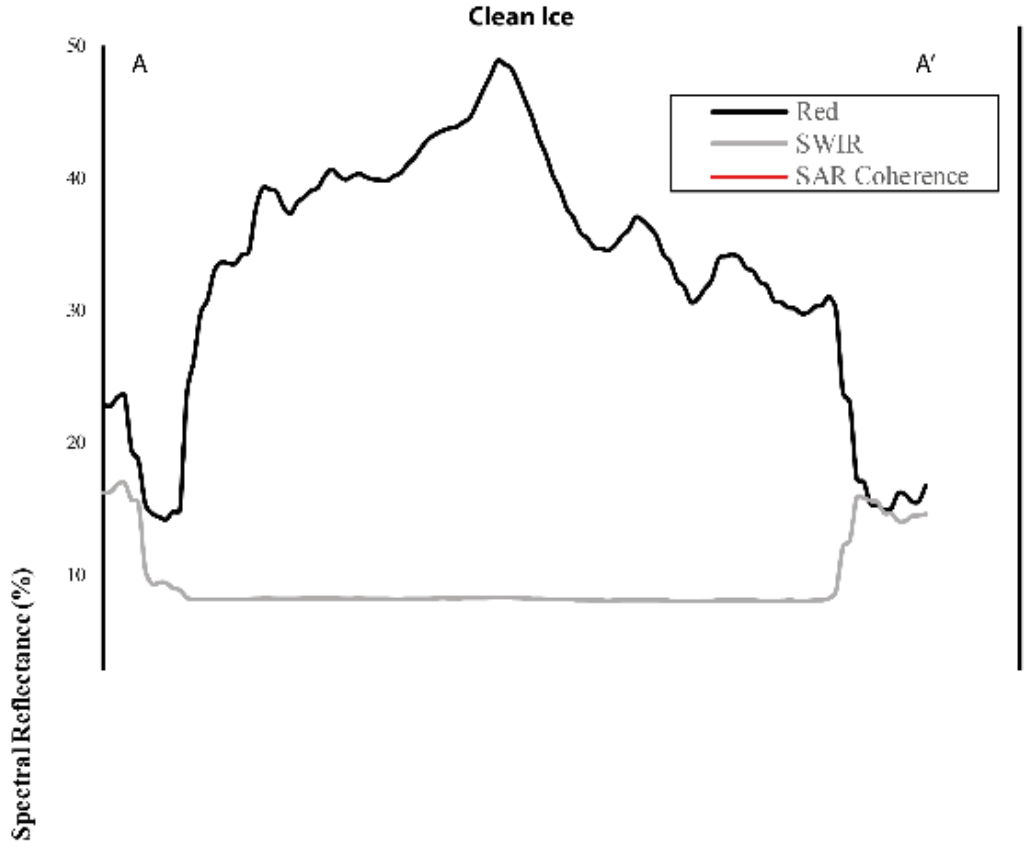
José Mourinho accuses Antonio Conte of humiliating him after Chelsea defeat

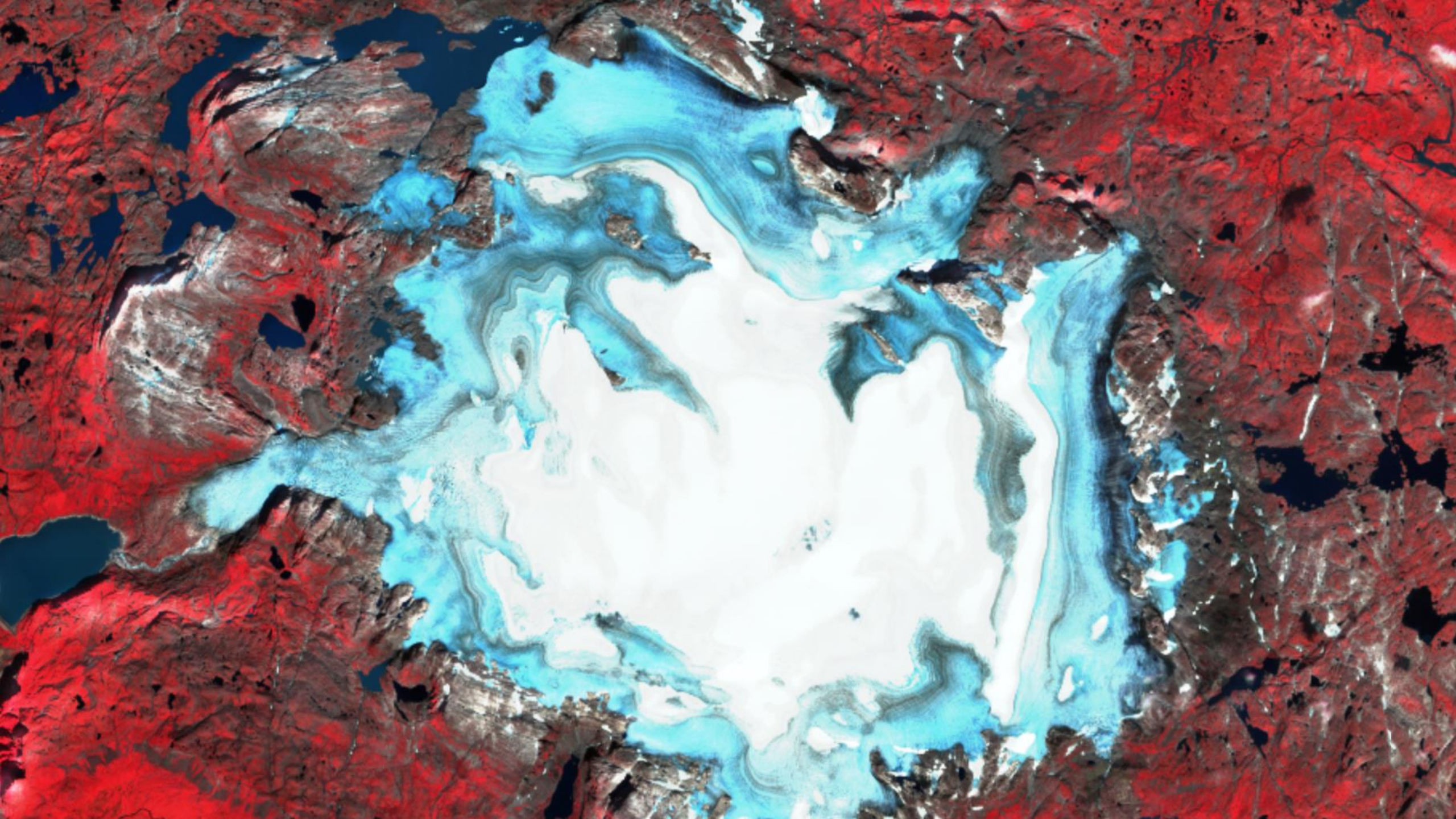
'Blasting and breathless': fears over India's fledgling 24-hour news media's march to war


Debris-covered ice

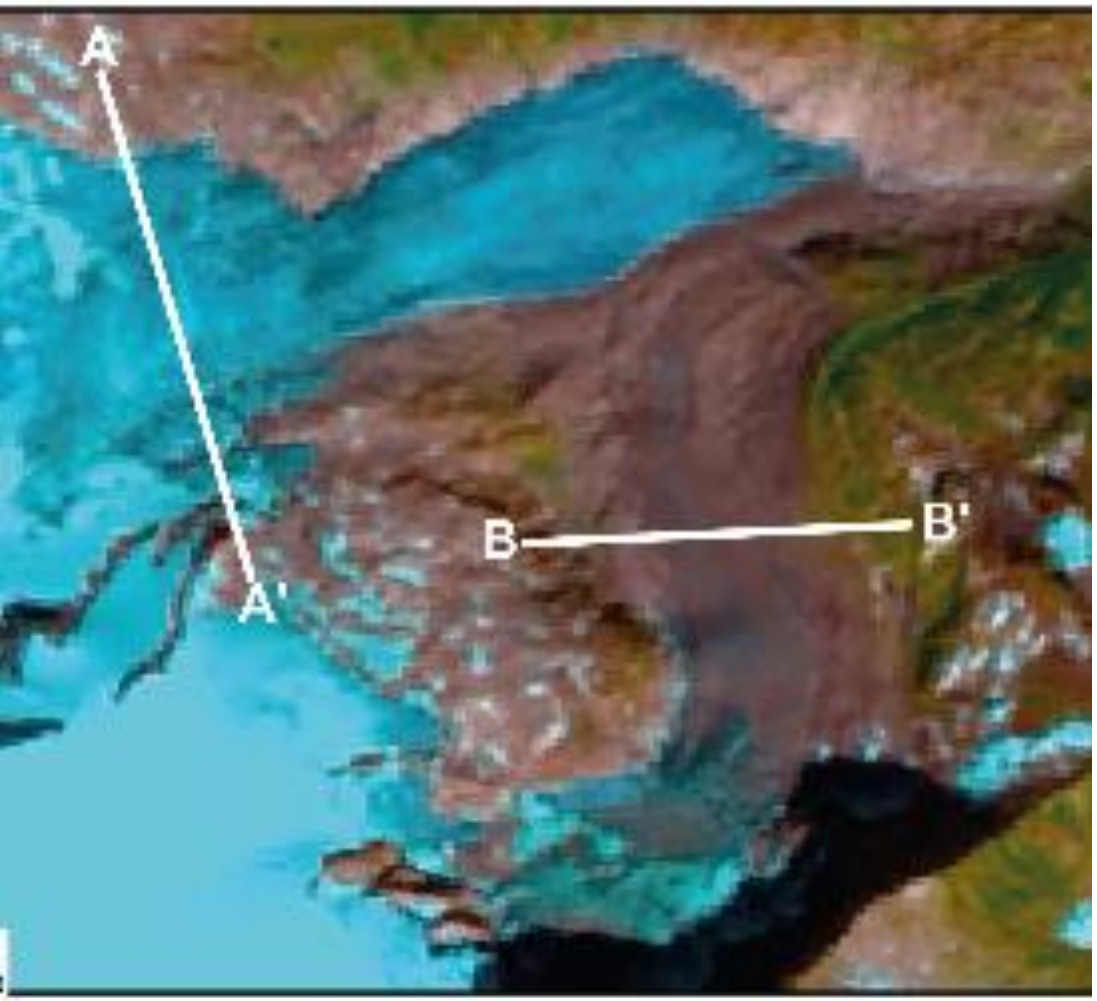

Clean ice

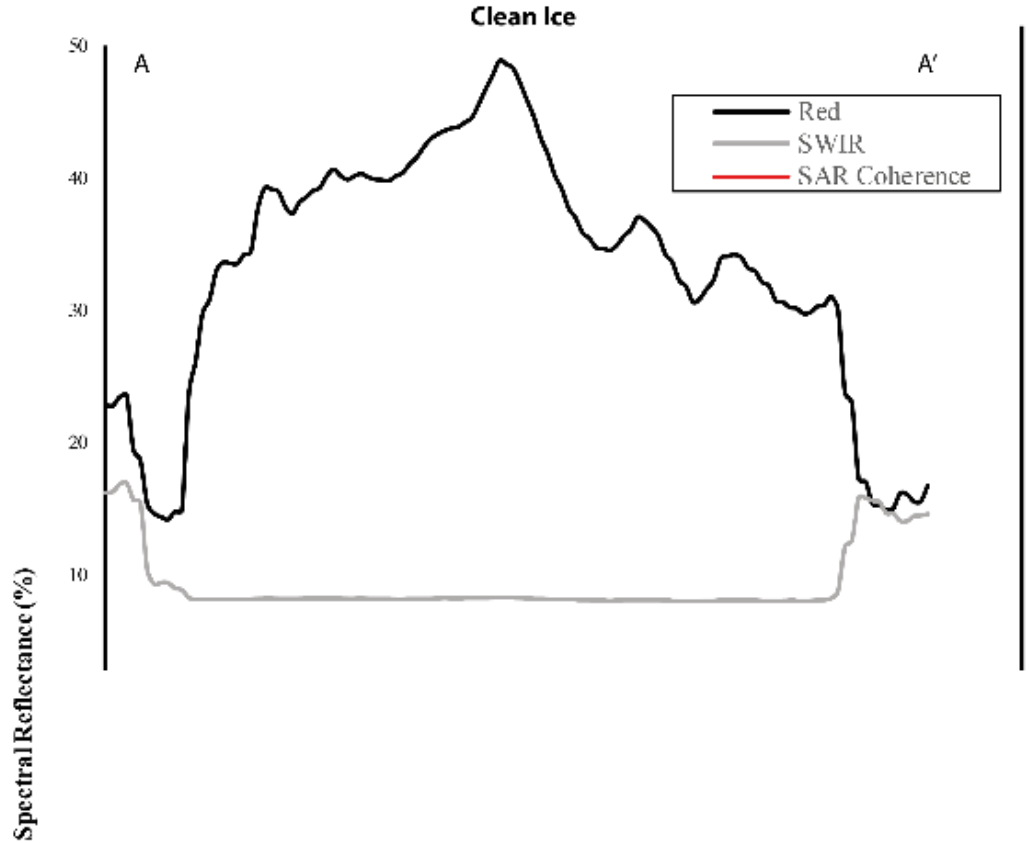

A
A'
B
B'


Clean Ice
A
A'
Red
SWIR
SAR Coherence
50
40
30
20
10
Spectral Reflectance (%)



How to monitor debris-covered glaciers?


A
A'
B
B'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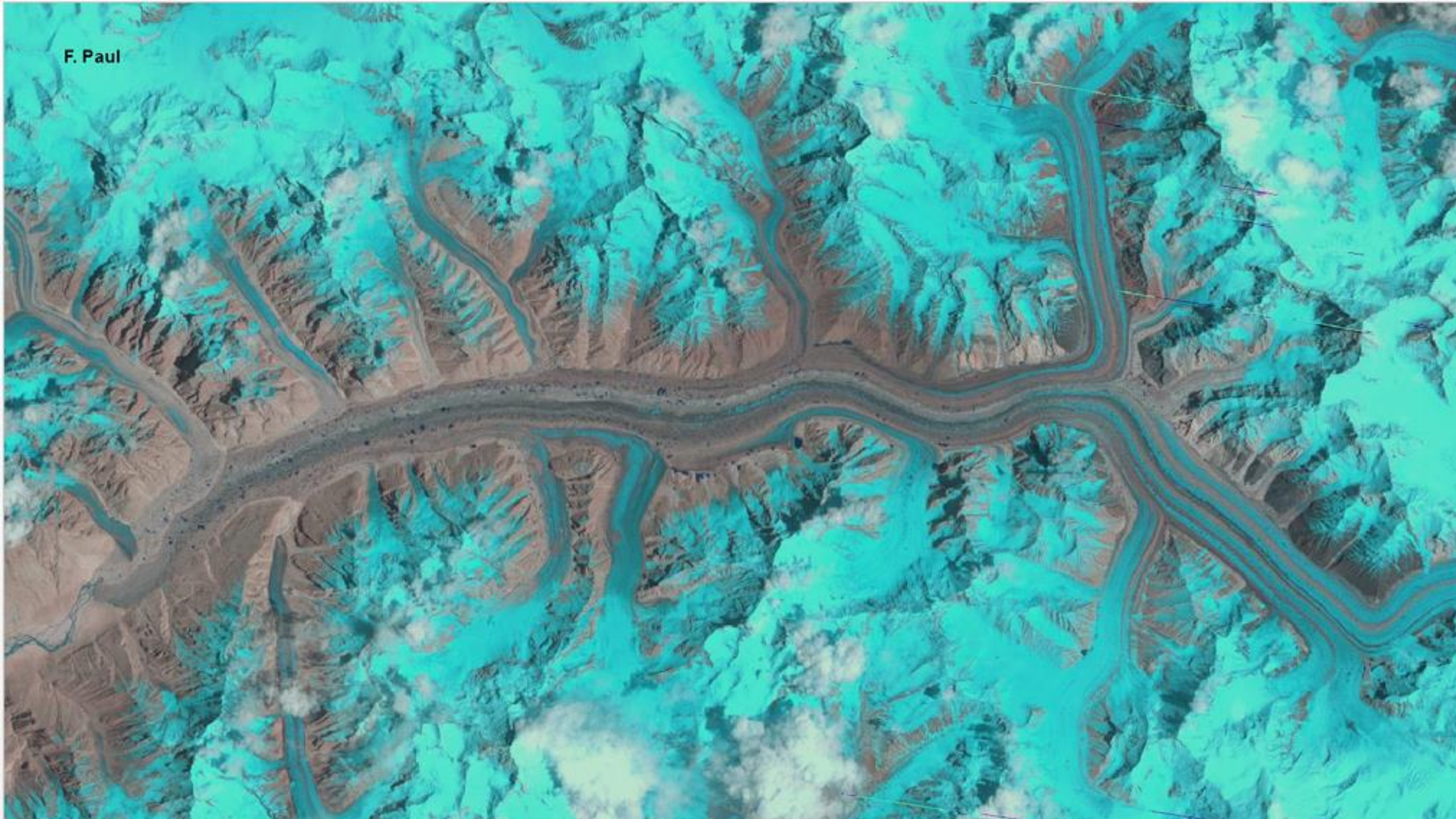
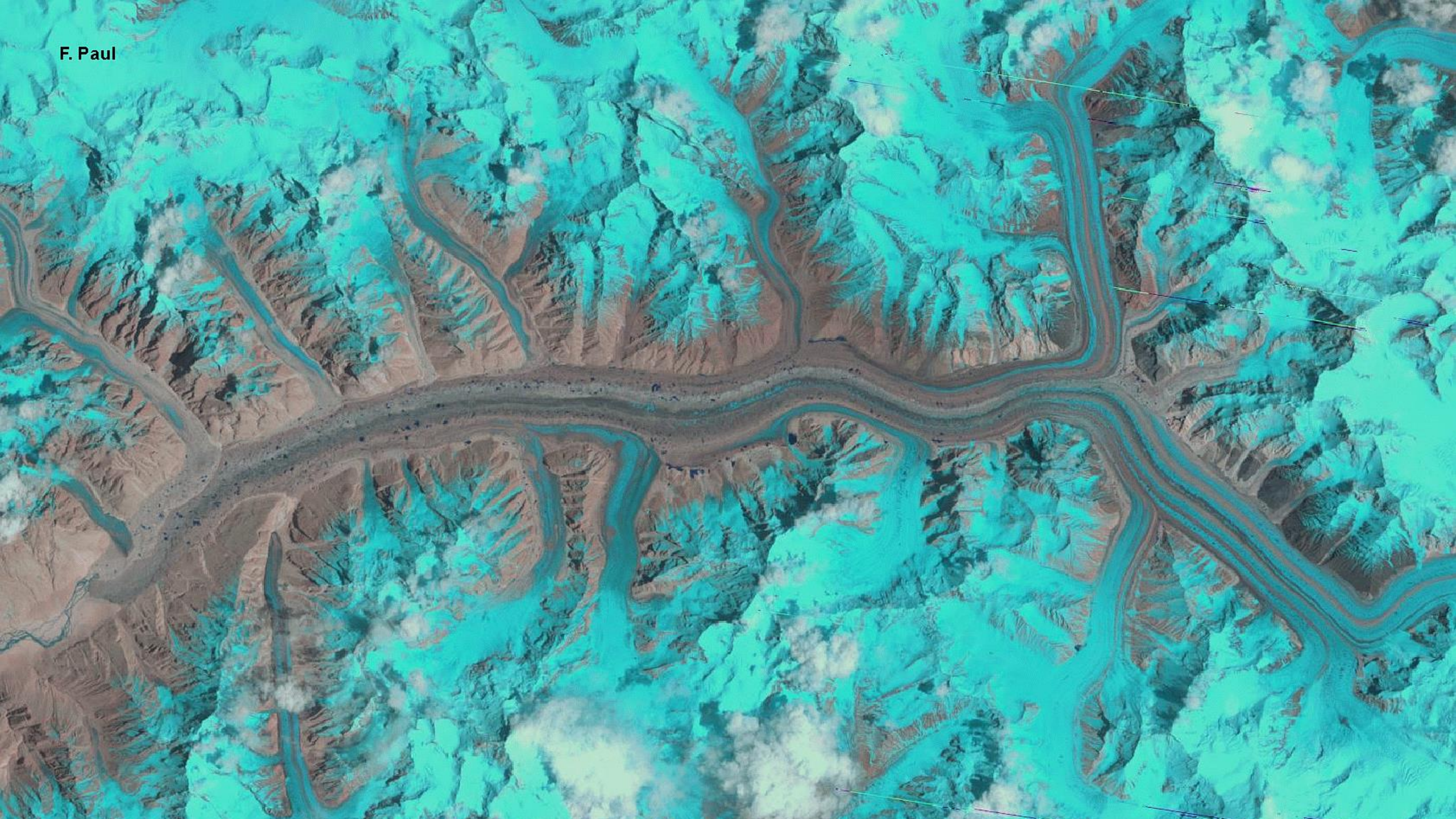
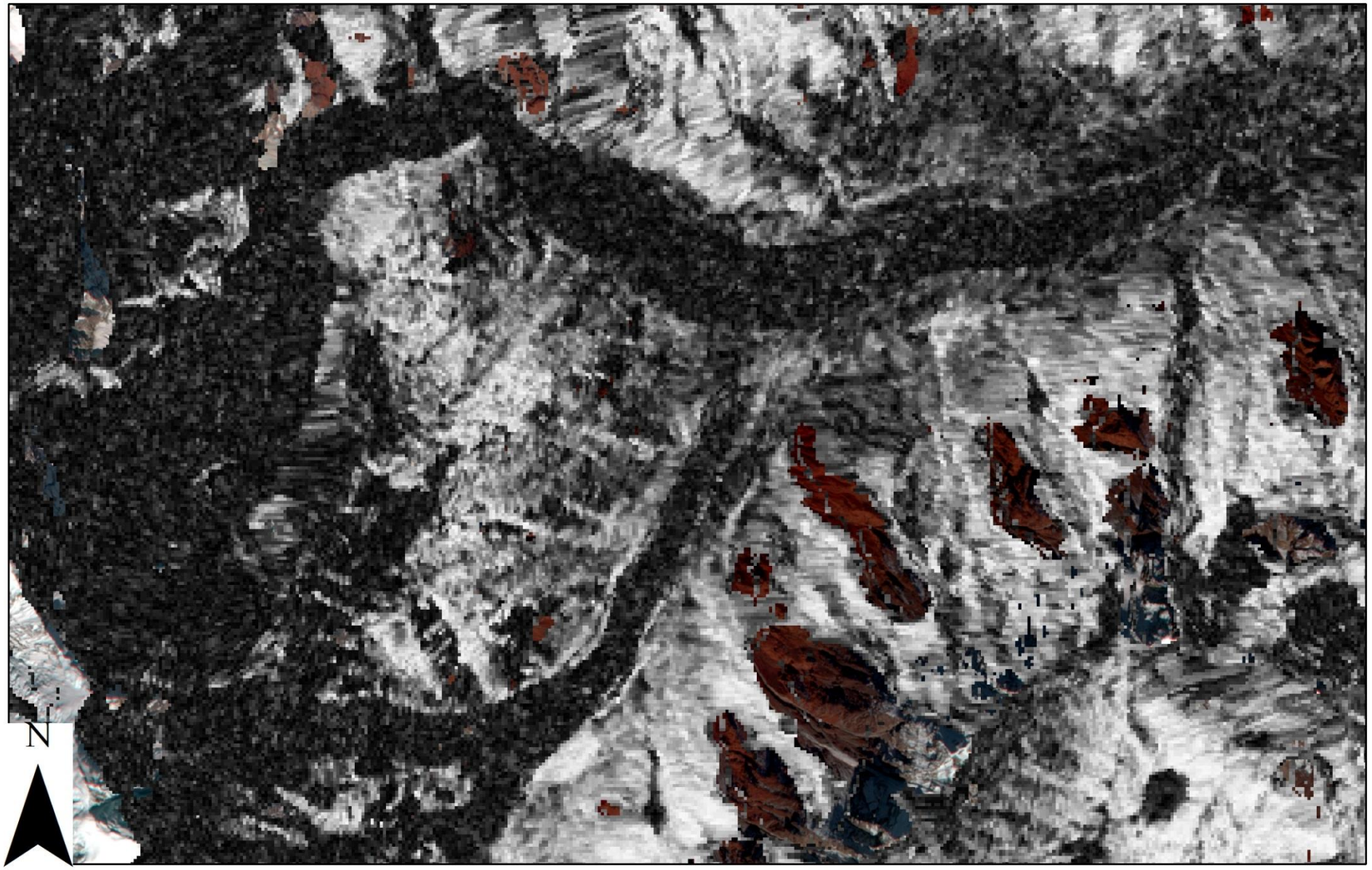

F. Paul


F. Paul



ALOS PALSAR SAR Coherence

Object Based Image Analysis

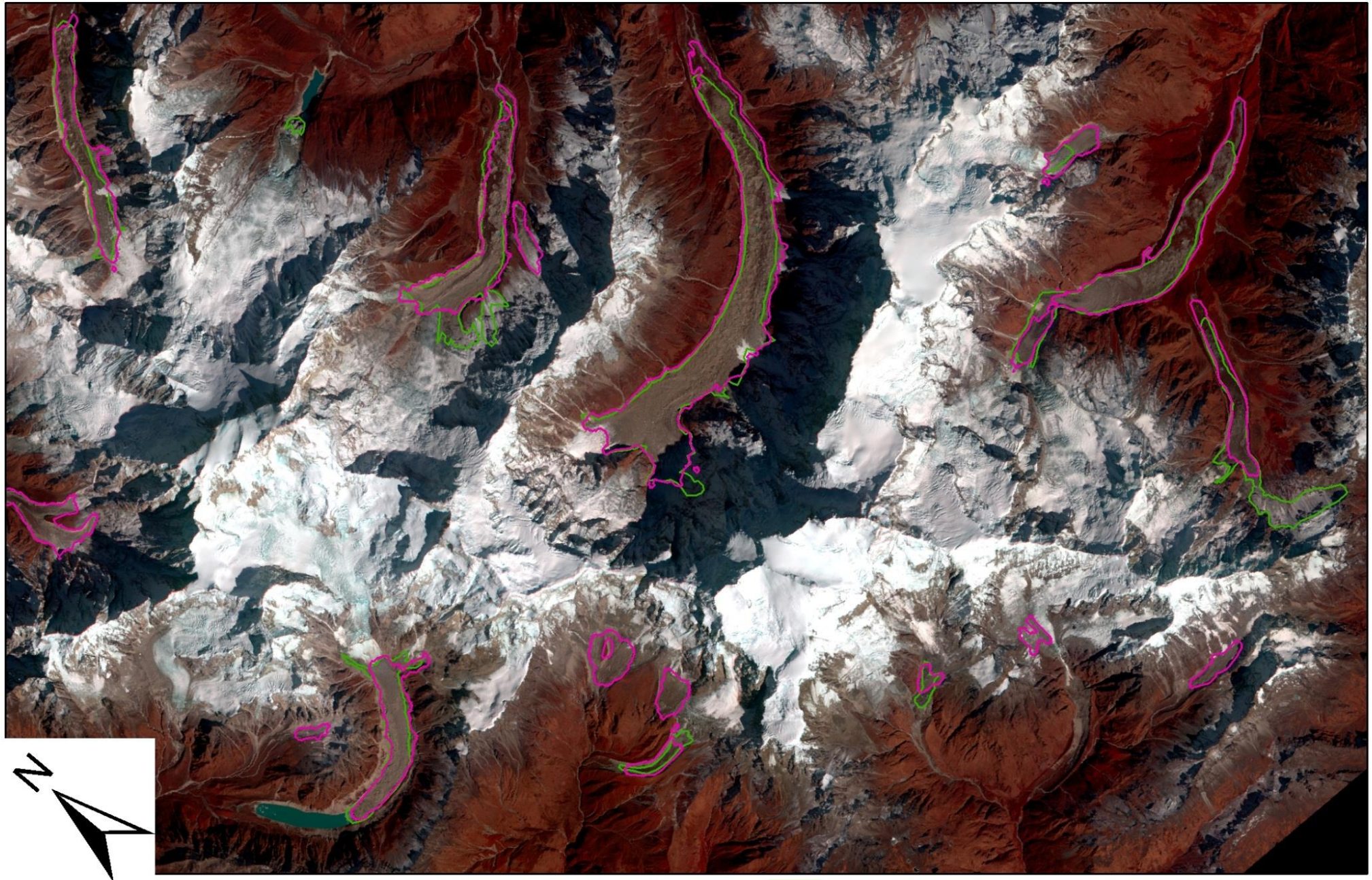
Data Sources
- Pixel-based

Segmentation
- Algorithm selection
- Scale determination

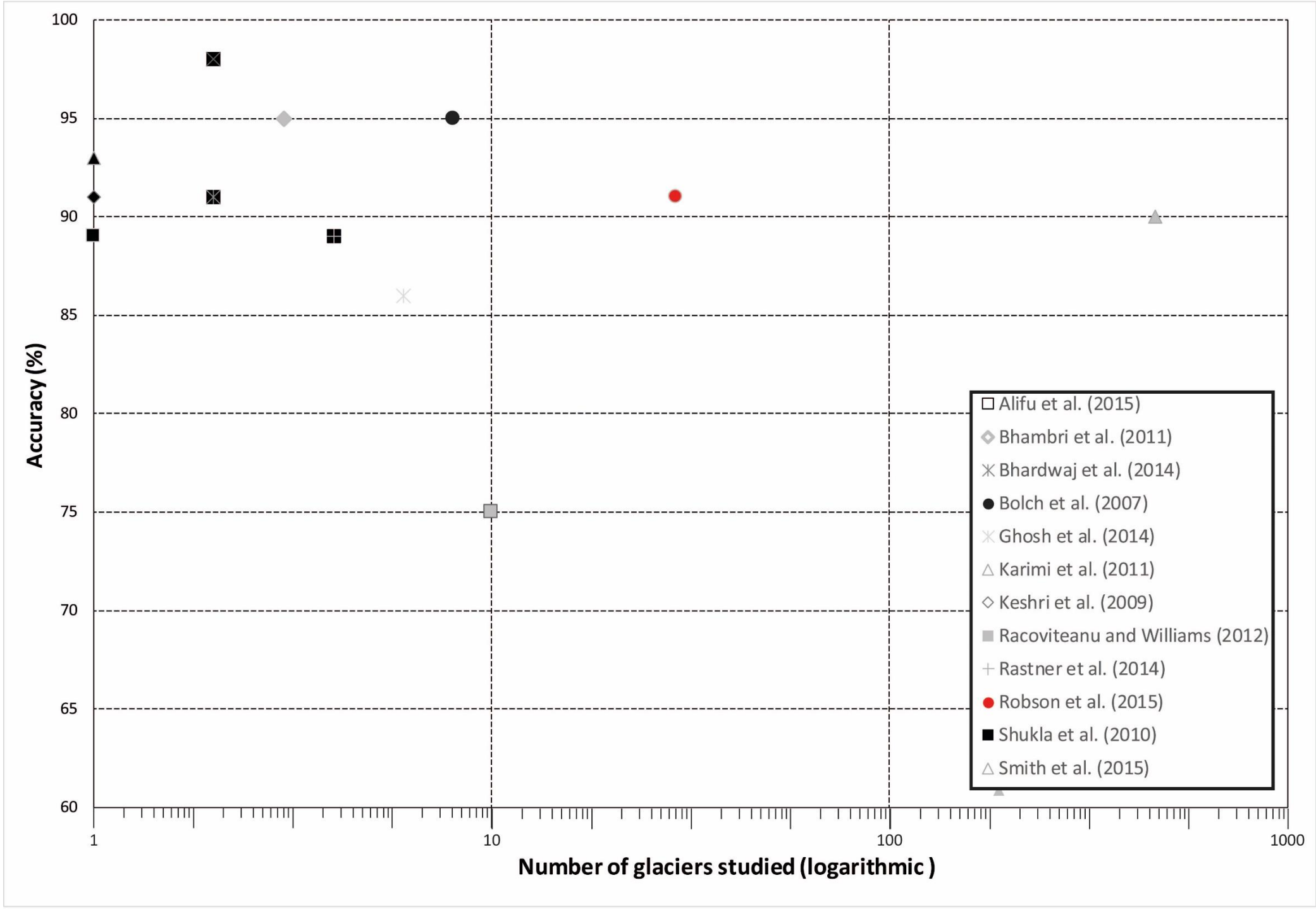
Feature Extraction
- Spectral, shape, texture, and contextual measures

Classification
- Parametric models
- Non-parametric models

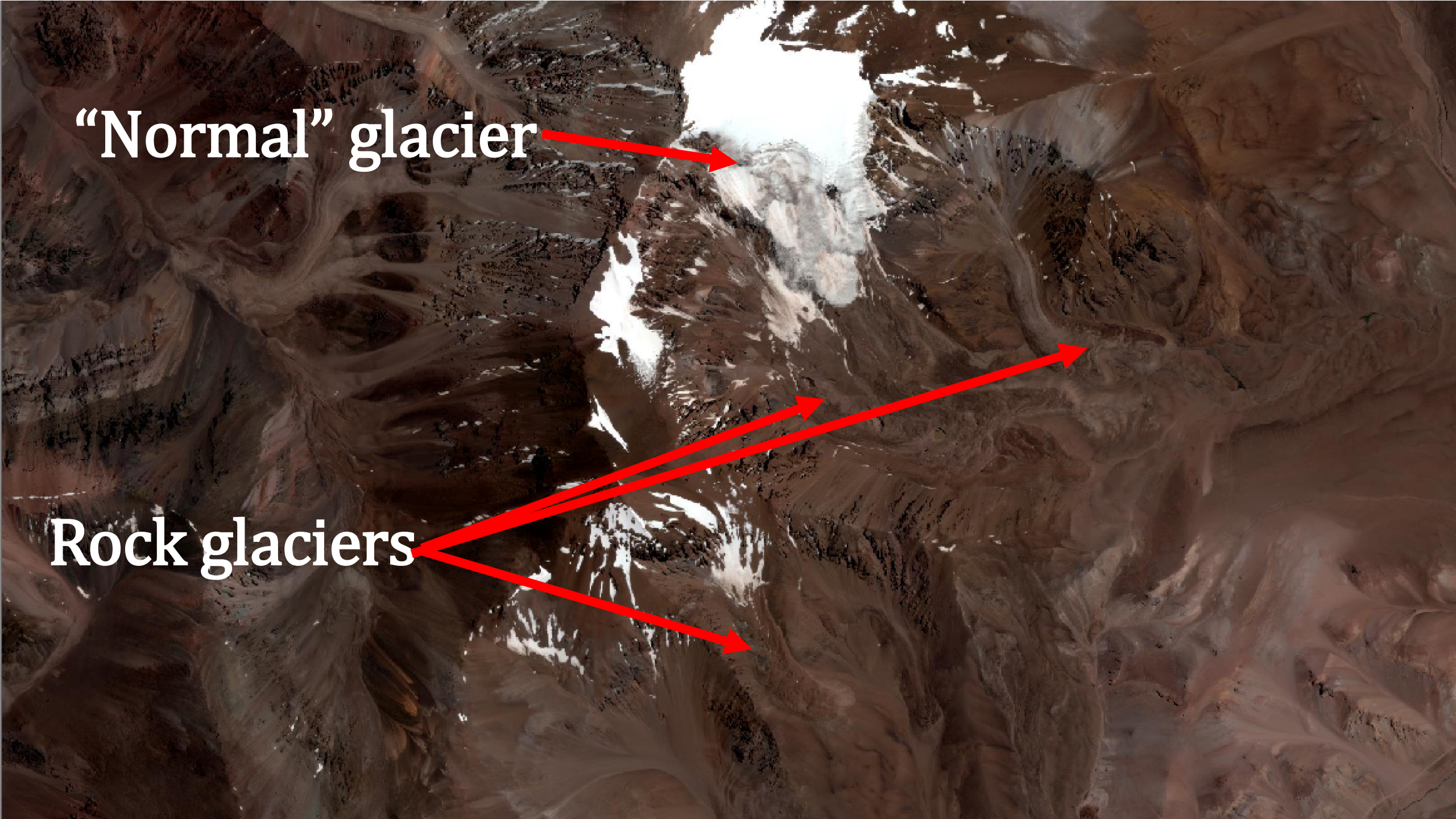
Chen et al., 2018

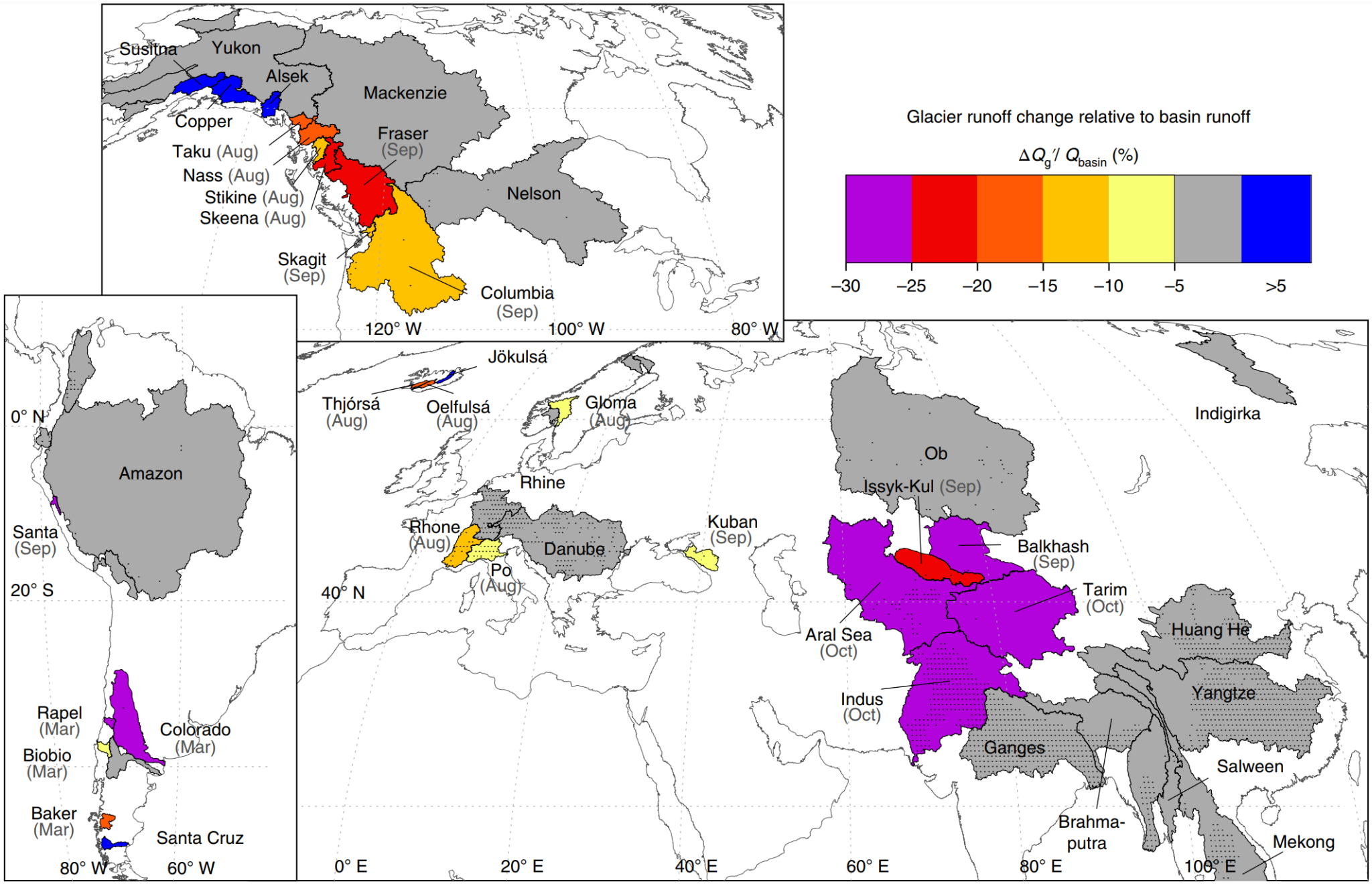


Background Image: Rapideye Image, 20th November 2012


100
95
90
85
80
75
70
65
60
Accuracy (%)
1
10
100
1000
Number of glaciers studied (logarithmic)
Alifu et al. (2015)
Bhambri et al. (2011)
Bhardwaj et al. (2014)
Bolch et al. (2007)
Ghosh et al. (2014)
Karimi et al. (2011)
Keshri et al. (2009)
Racoviteanu and Williams (2012)
Rastner et al. (2014)
Robson et al. (2015)
Shukla et al. (2010)
Smith et al. (2015)

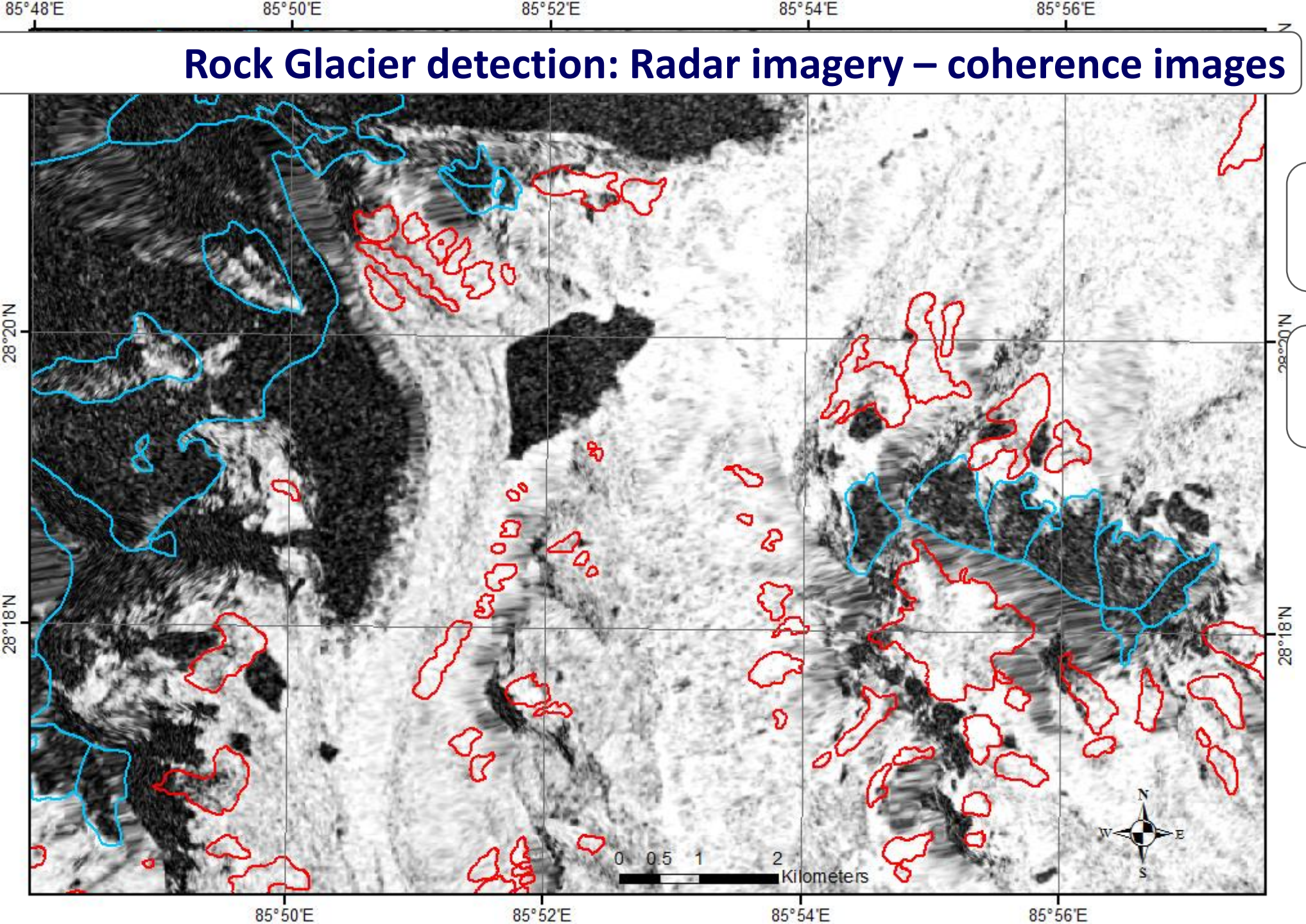
What about rock glaciers?


“Normal” glacier
Rock glaciers



Huss and Hock, 2018

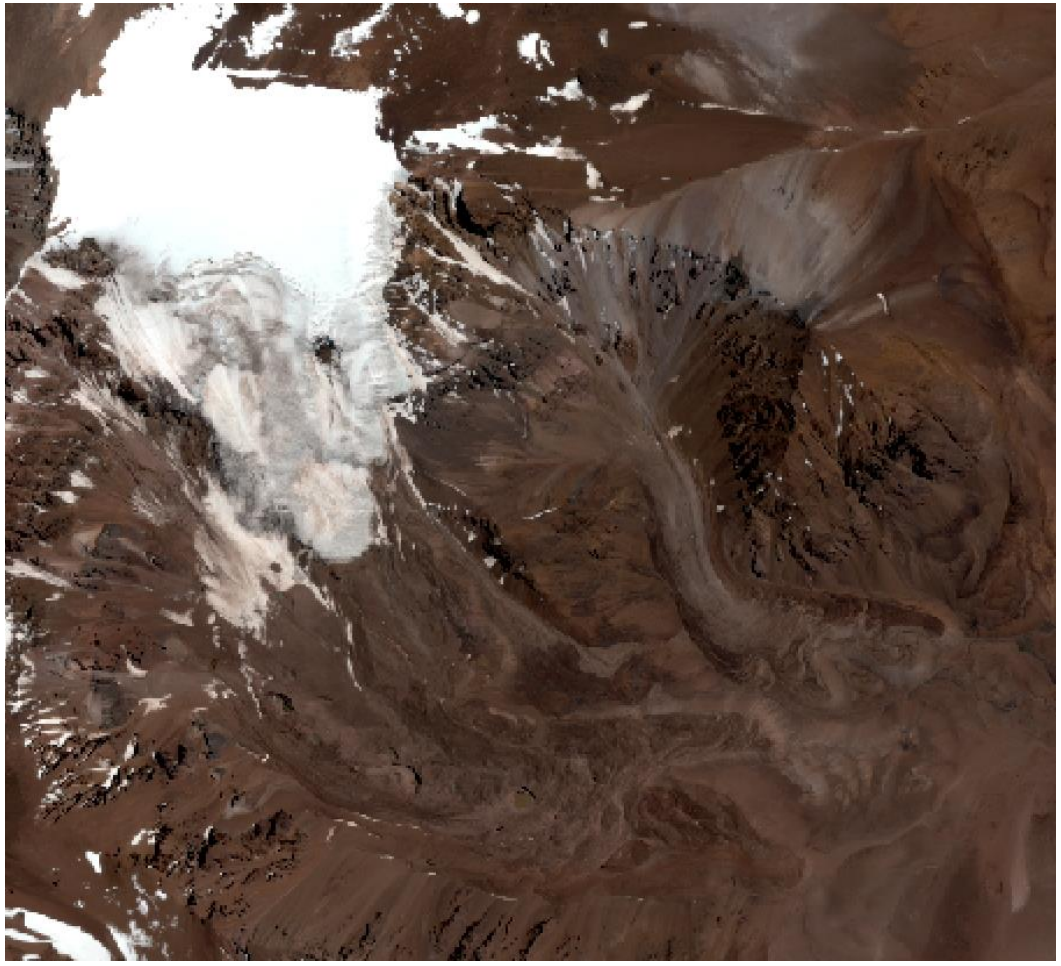
Rock Glacier detection: Radar imagery – coherence images

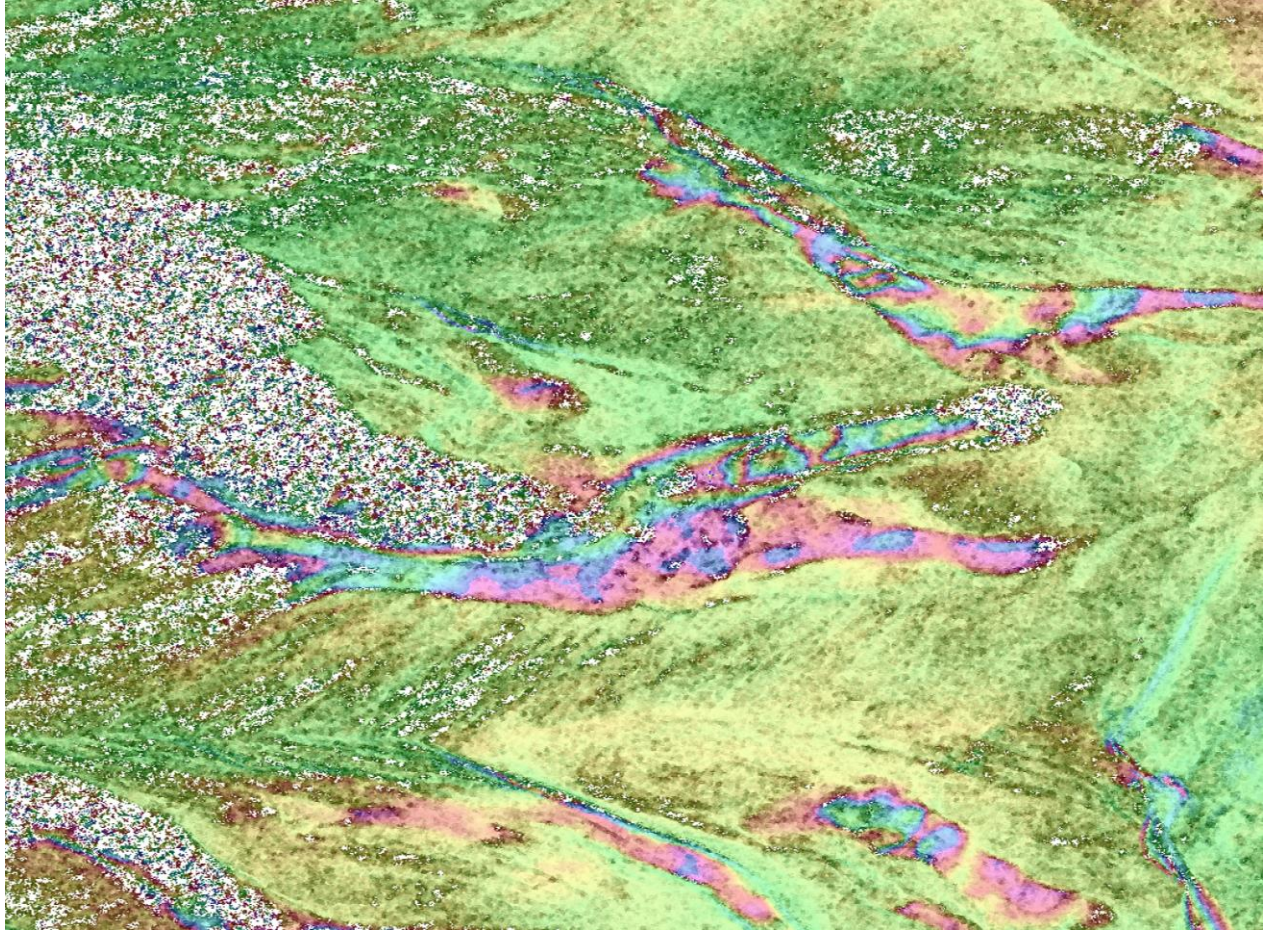


Glaciers and lakes -> no coherence

Rock Glaciers: Sometimes no co-herence

Rastner et al., in prep

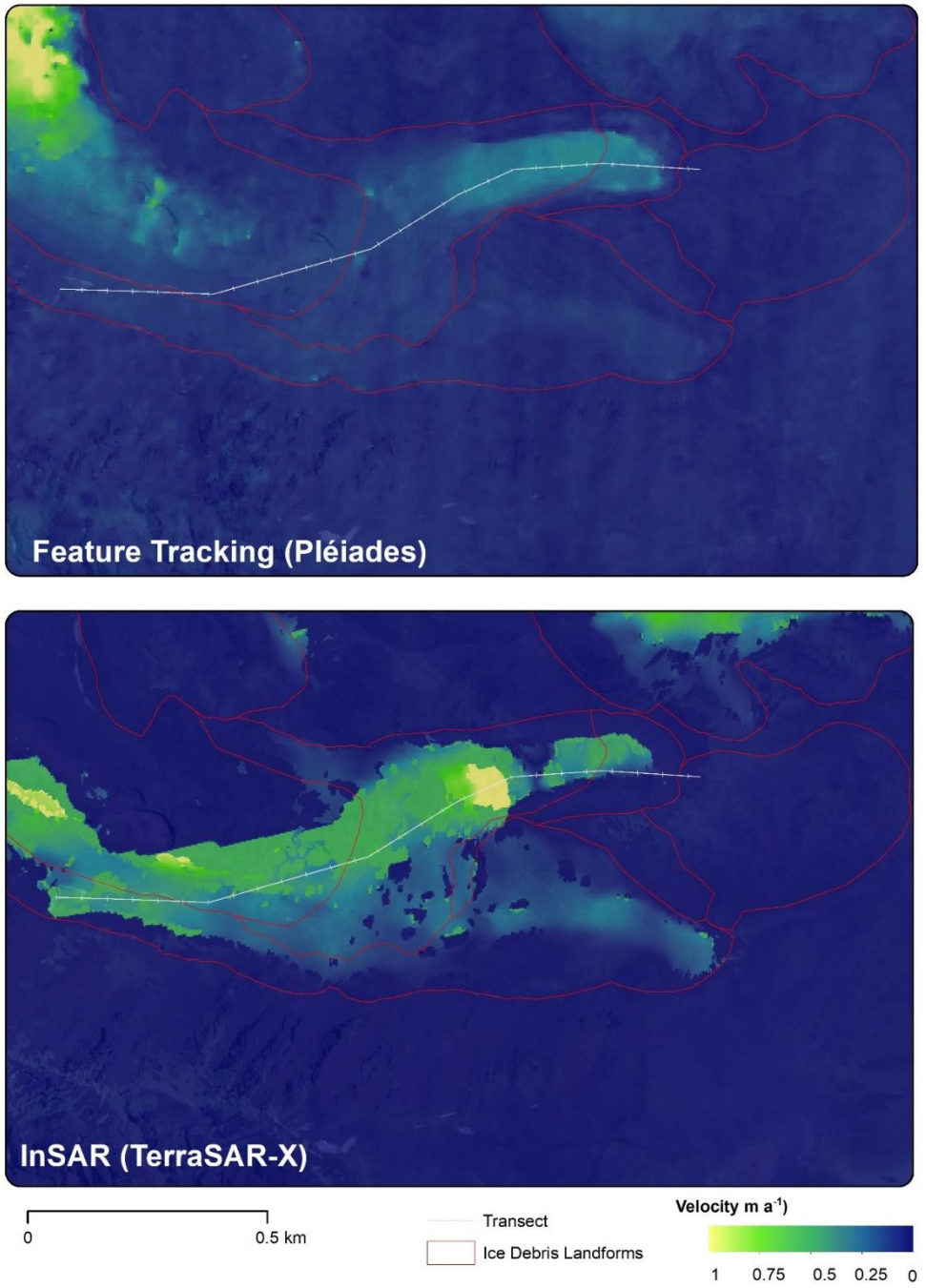




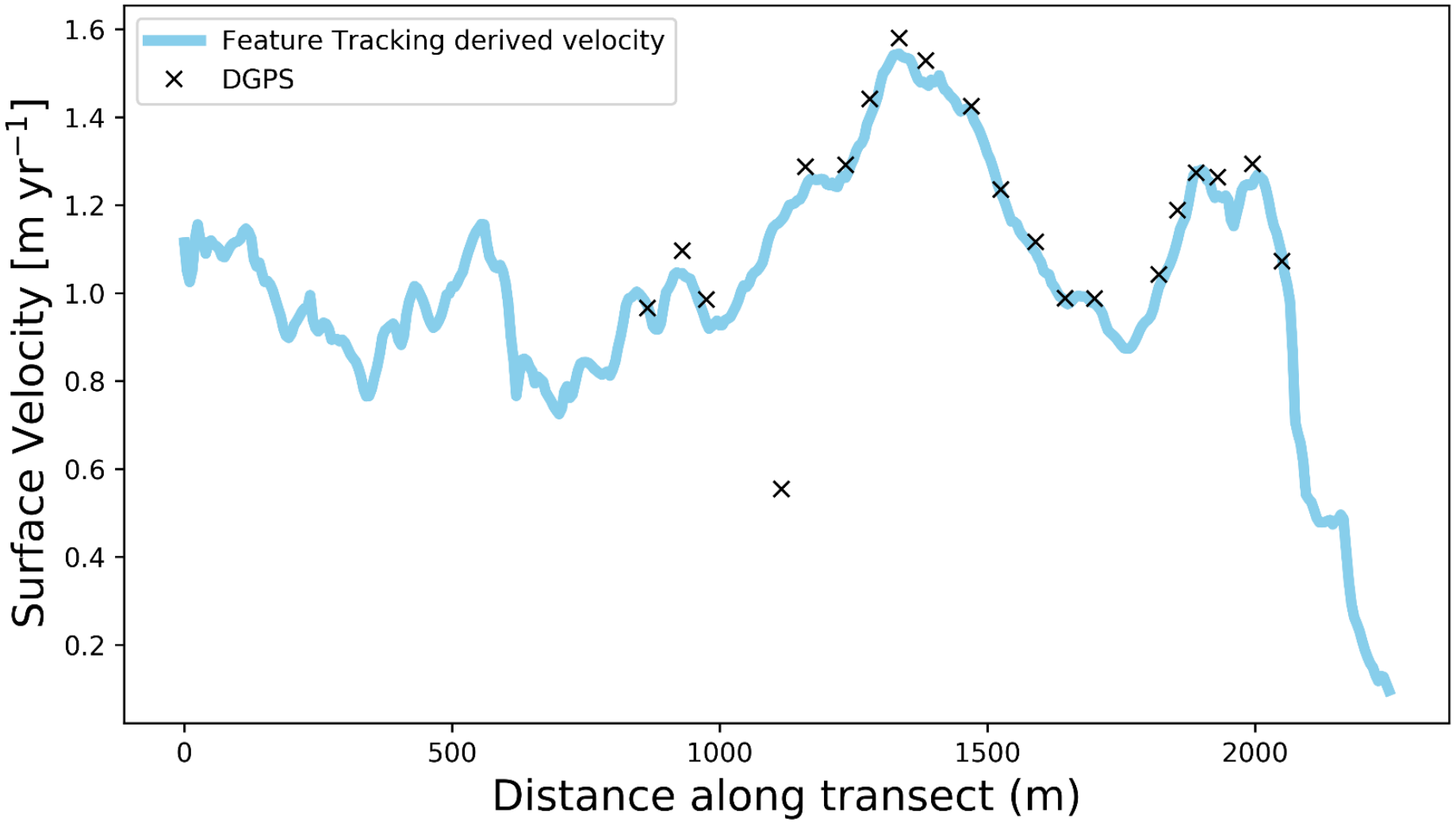
Using InSAR to identify active rock glaciers

InSAR vs Feature Tracking

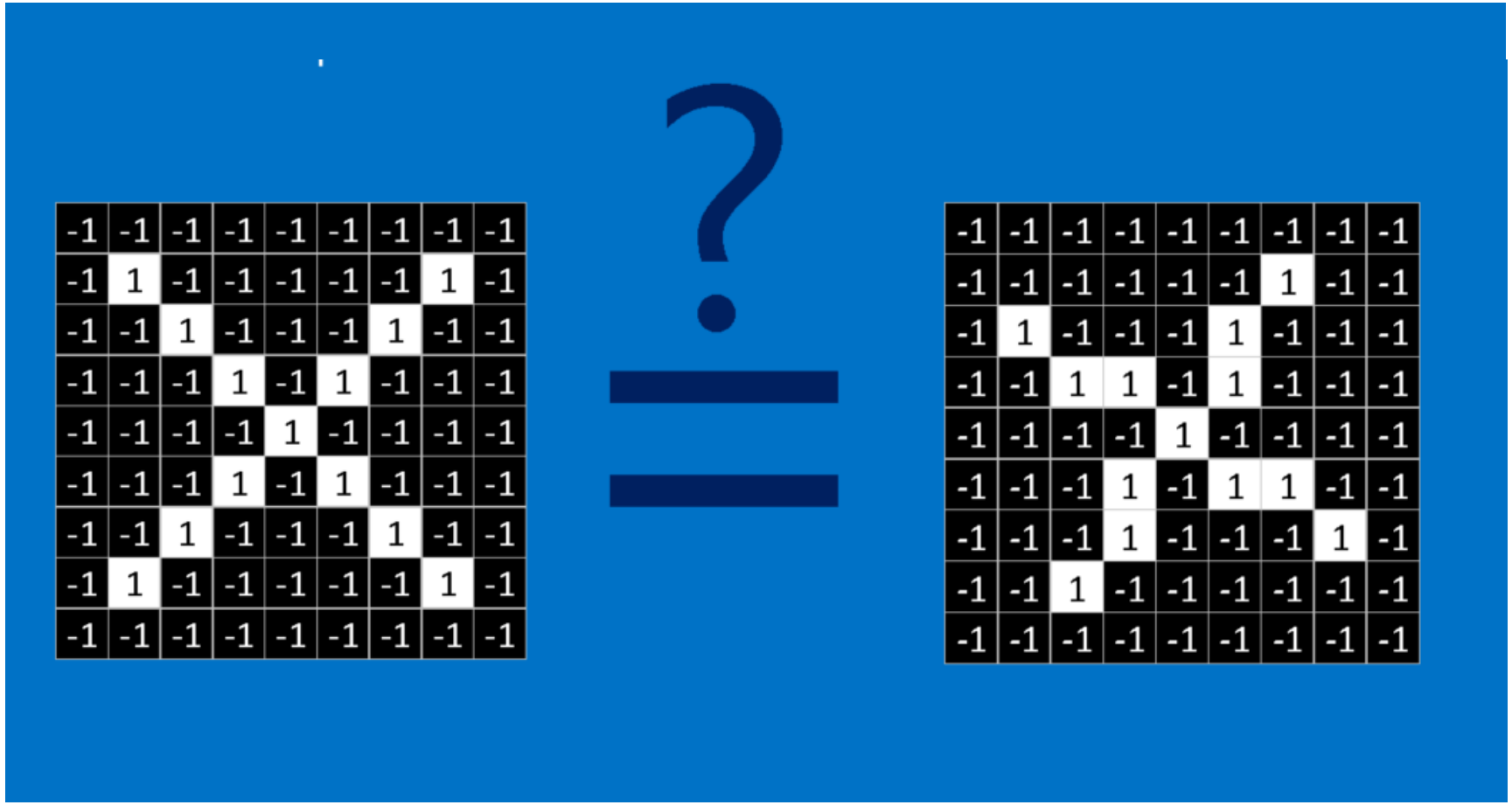
- **Both can distinguish active, deforming ice**
- **But disadvantes to both methods**
  - **InSAR – only line of sight movement, needs coherence**
  - **FT – a lot of filtering, need a large interval (data availability)**
- **What about inactive rock glaciers?**



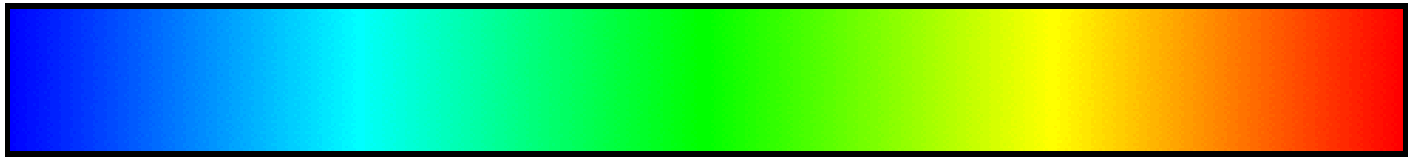
How accurate are these velocity measurements?



Deep Learning (convolutional neural networks)

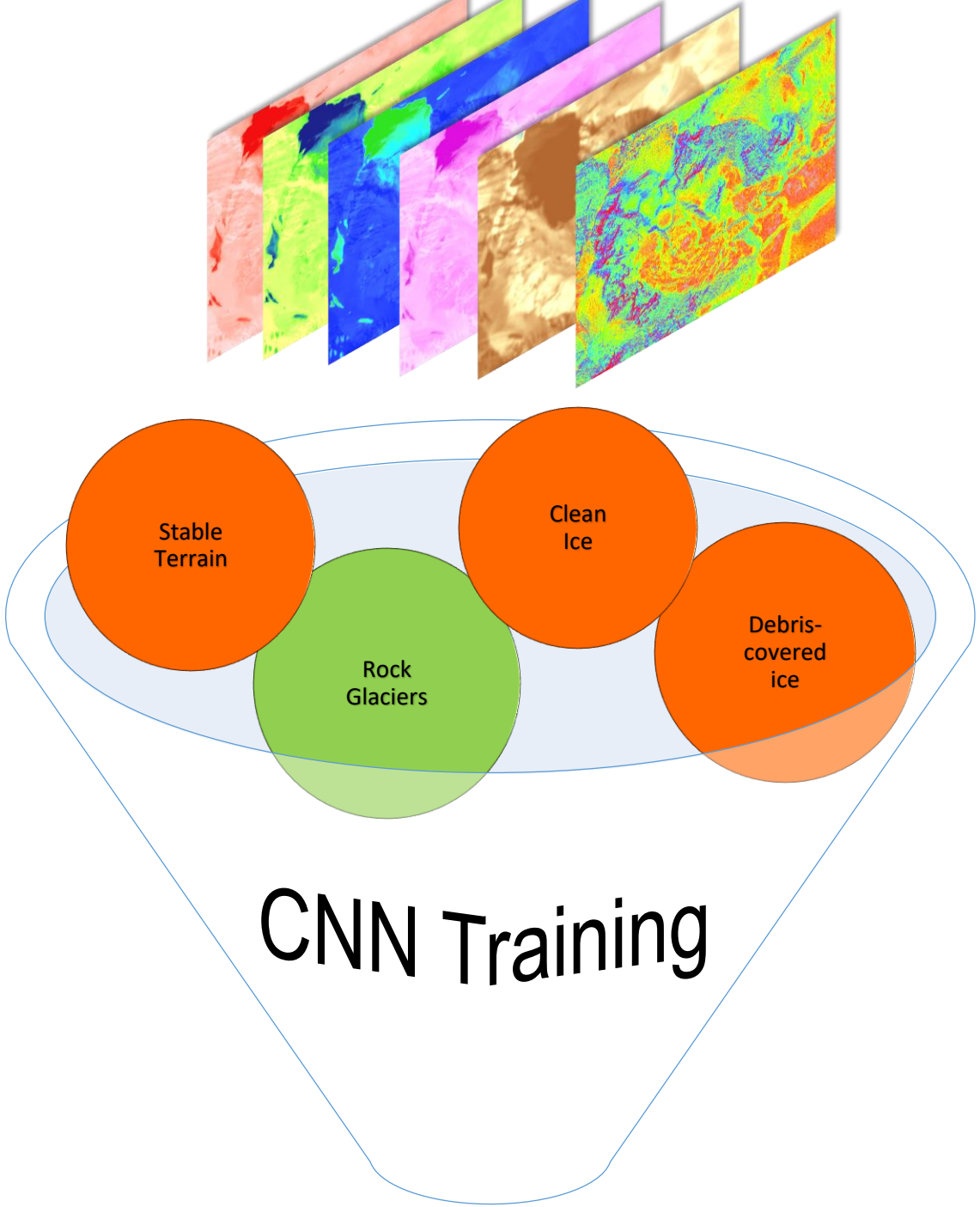


Most definitely not an X!



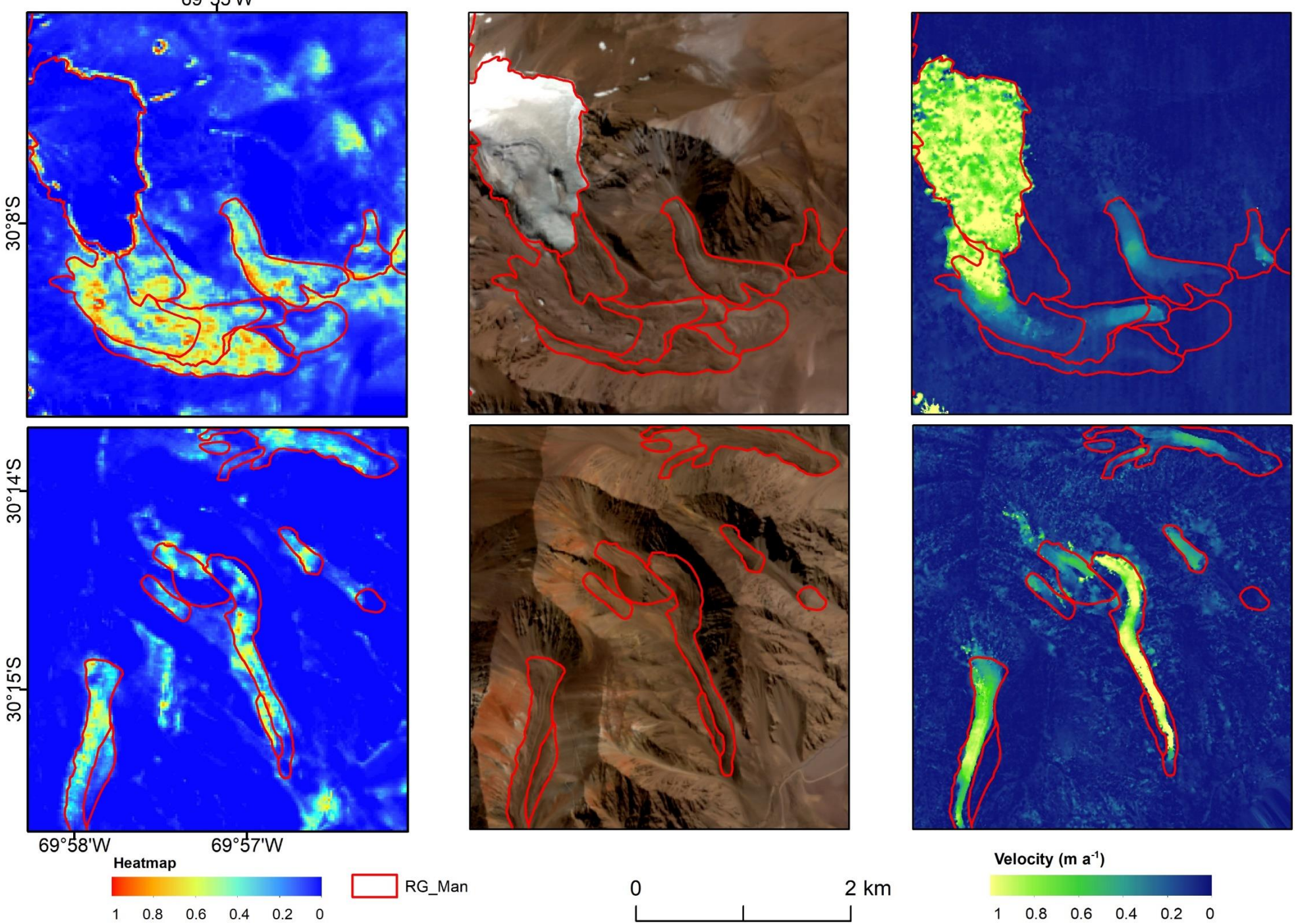
100% an X!

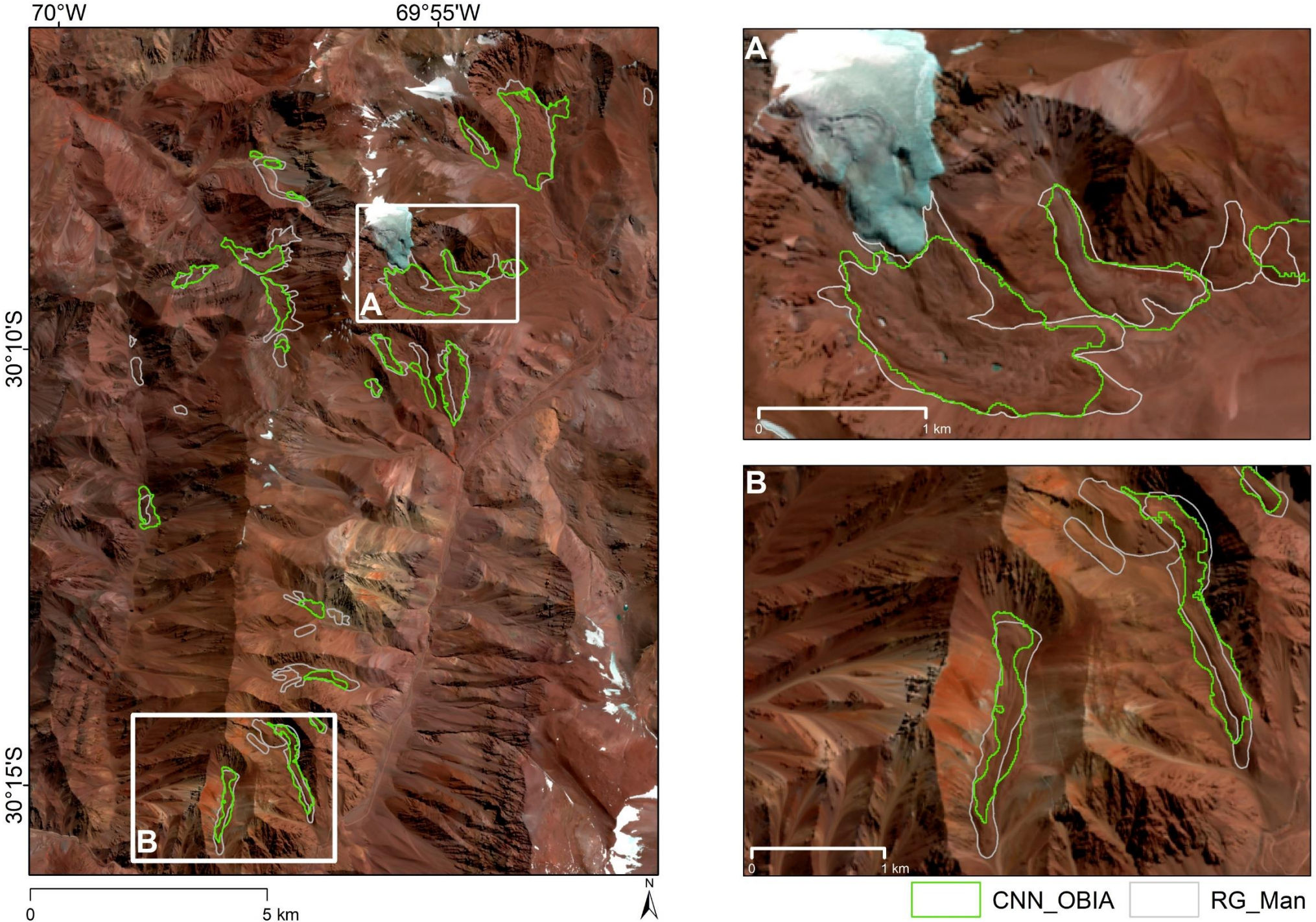
Could this be an X?

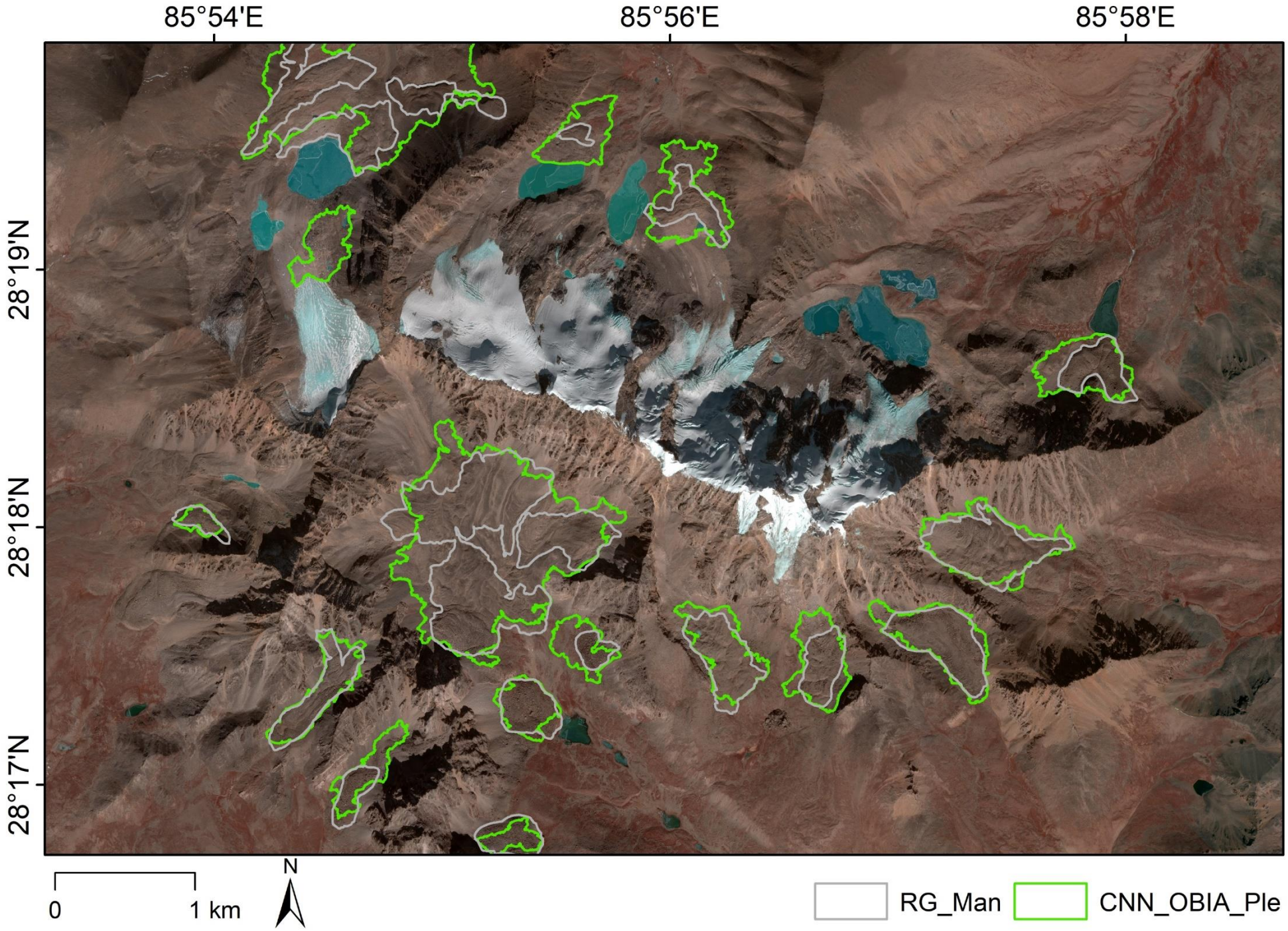


Rock Glacier Heatmap

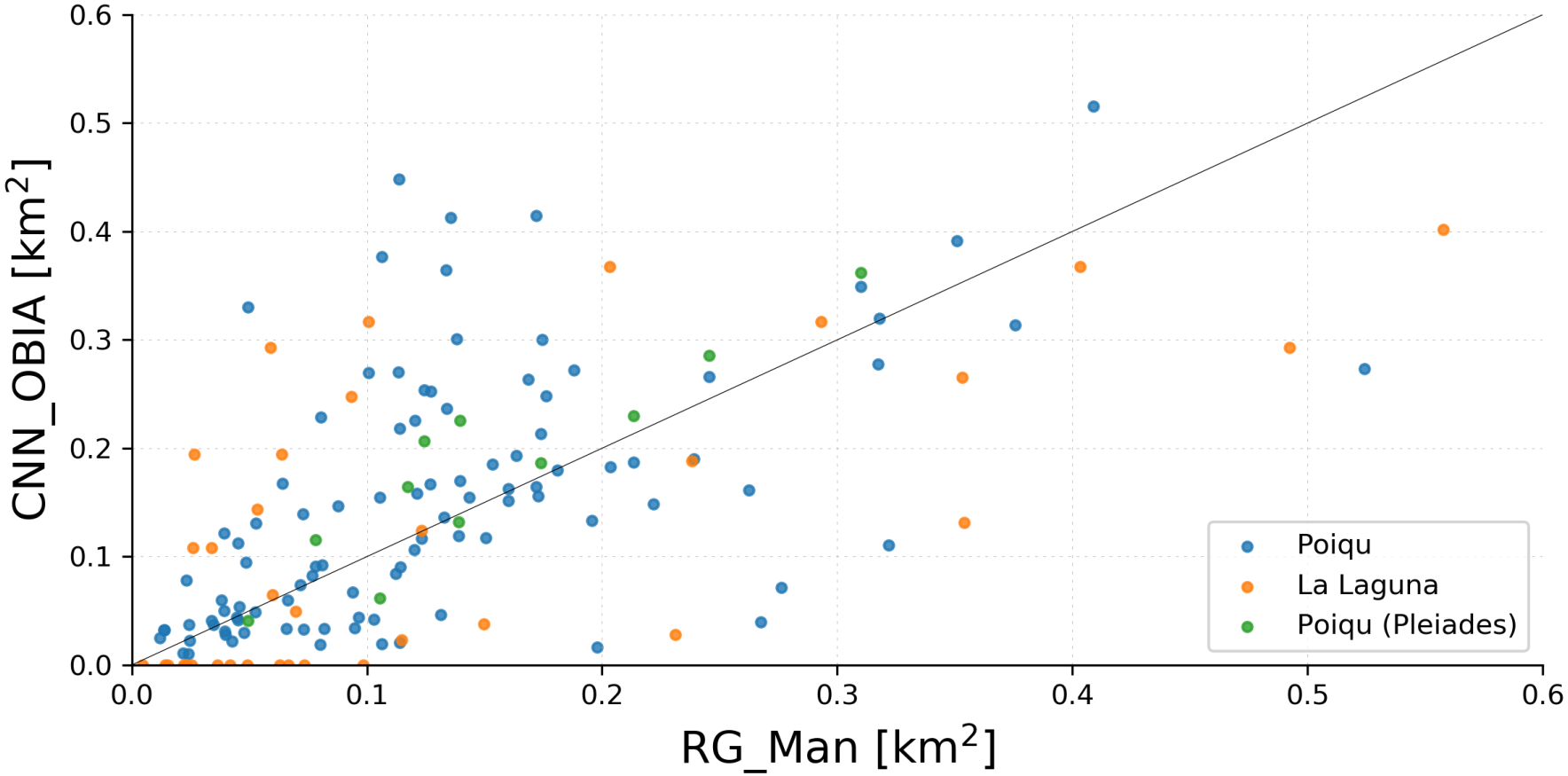
Sentinel 2 imagery
Sentinel 1 Coherence
Pleideas DEM


69°59'W
30°8'S
30°14'S
30°15'S
69°58'W
69°57'W
Heatmap
1 0.8 0.6 0.4 0.2 0
RG_Man
0
2 km
Velocity (m a-1)
1 0.8 0.6 0.4 0.2 0

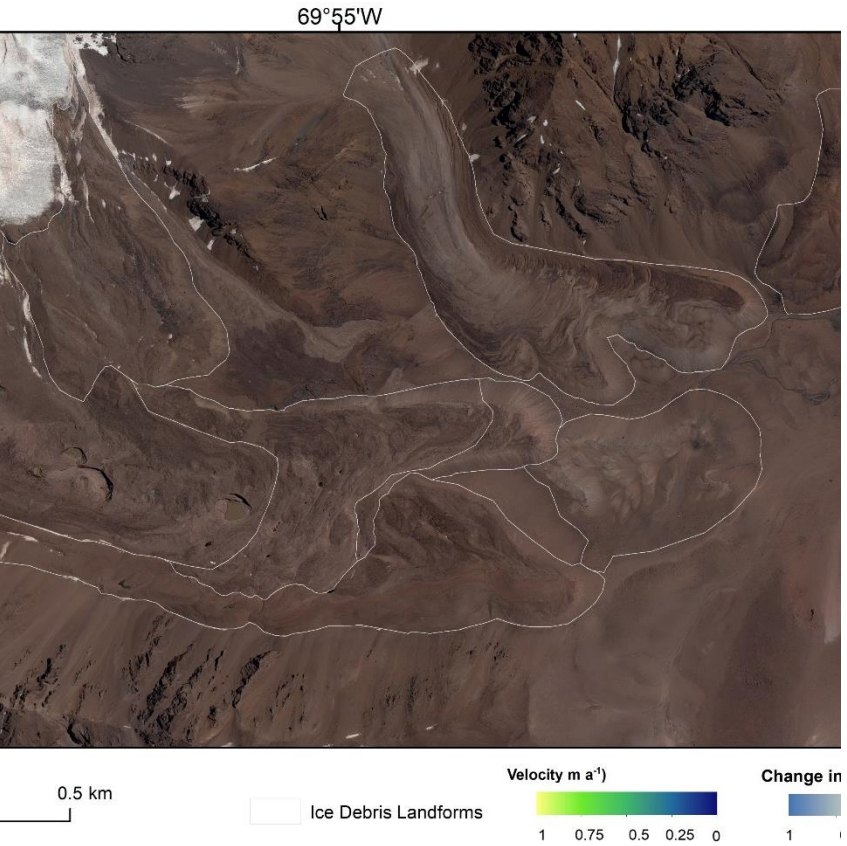

70°W
69°55'W
30°10'S
30°15'S
A
B
0
5 km
N
A
0
1 km
B
0
1 km
CNN_OBIA
RG_Man

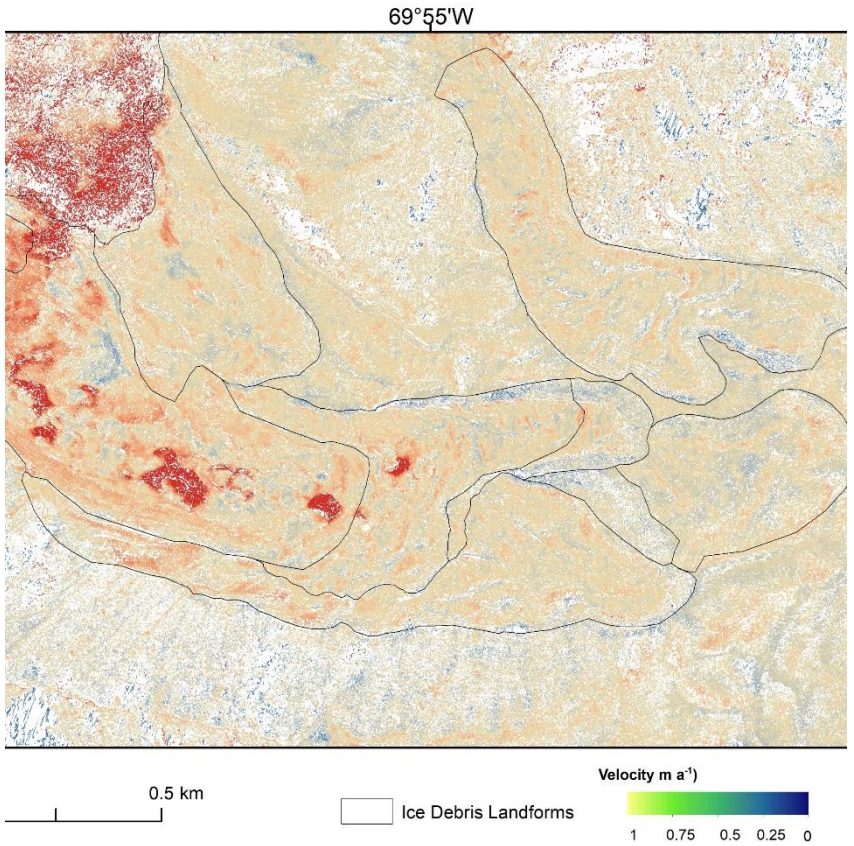

85°54'E
85°56'E
85°58'E
28°19'N
28°18'N
28°17'N
0
1 km
N
RG_Man
CNN_OBIA_Ple

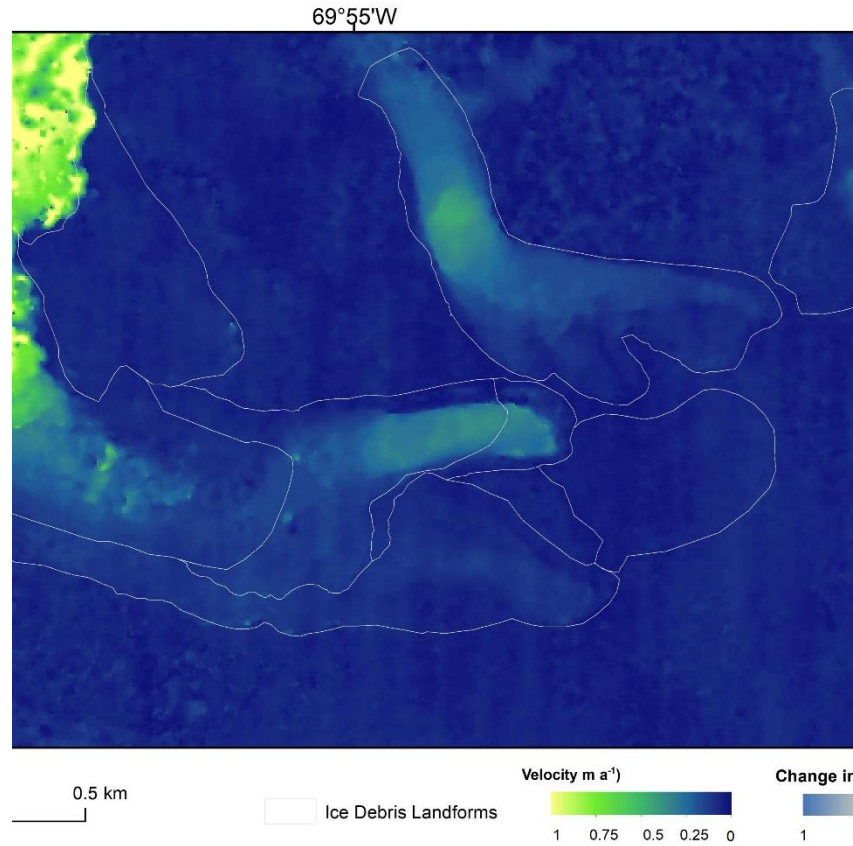
Accuracy



Classification	User Accuracy (%)	Producer Accuracy (%)	Total Accuracy (%)	Kappa
La Laguna	64	75	97.1	0.67
Poiqu	69	75	56.4	0.72
Total (Sentinel)	66	71	72.0	0.68
Poiqu (Pléiades)	72	88	76.8	0.76


69°55'W
0.5 km
Ice Debris Landforms
Velocity m a-1)
1 0.75 0.5 0.25 0
Change in
1


69°55'W
0.5 km
Ice Debris Landforms
Velocity m a-1)
1 0.75 0.5 0.25 0


69°55'W
0.5 km
Ice Debris Landforms
Velocity m a-1)
1 0.75 0.5 0.25 0
Change ir
1

Next Steps


Further investigation with Terrestrial Photogrammetry/UAVs

Thank you for your attention

Questions?