The view from afar:

Space observation of glaciers and related hazards

Andreas KÄÄB

Department of Geosciences, University of Oslo

European Geosciences Union – GIFT 2009

5 …

4 …

6 …

5 good reasons to monitor glaciers

4 …

6 …

5 good reasons to monitor glaciers

4 good reasons to do that *from space*

6 …

5 good reasons to monitor glaciers

4 good reasons to do that *from space*

6 methods for glacier monitoring from space

5 good reasons to monitor glaciers

4 …

6 …

1: Global sea level rise

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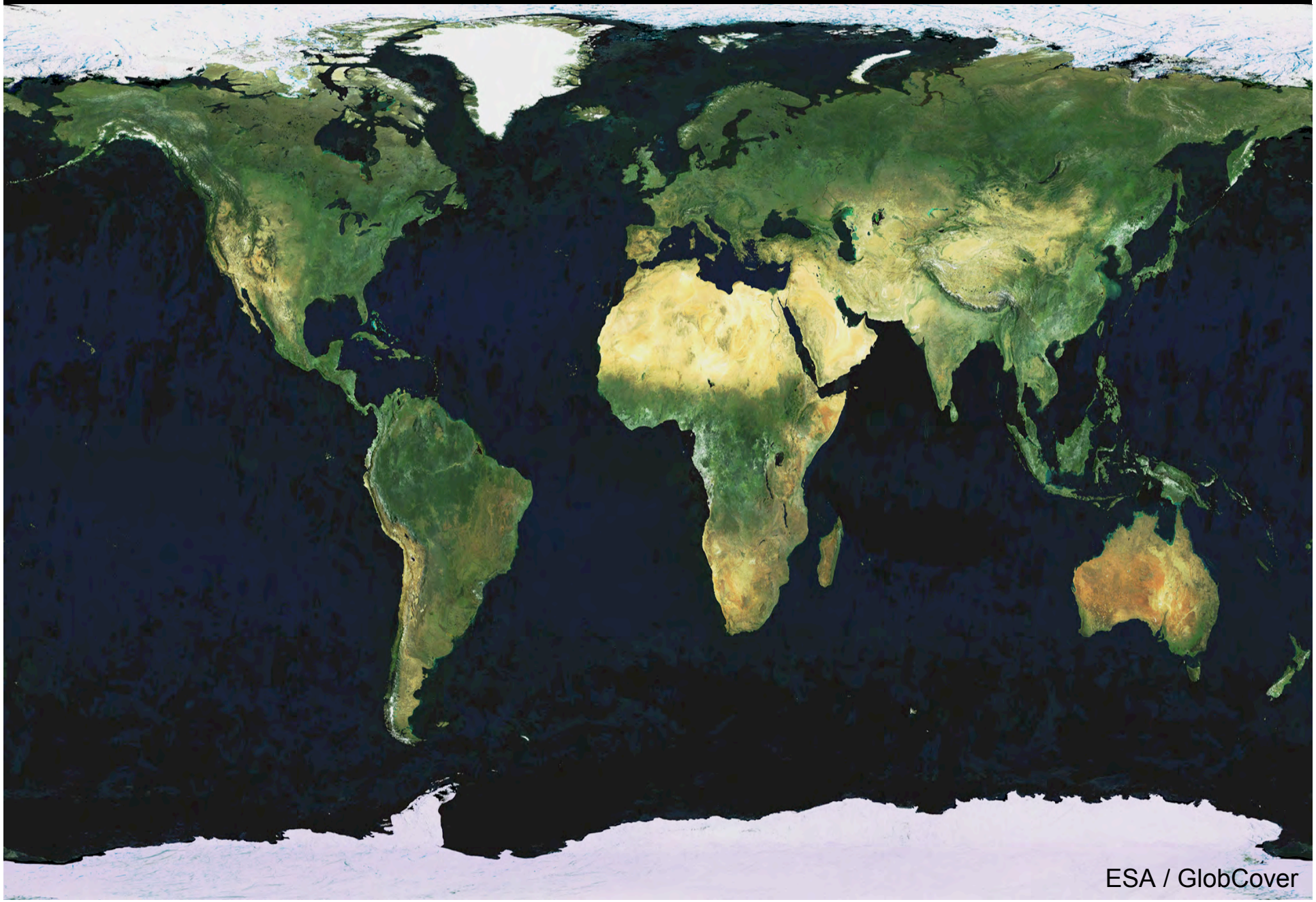

2: Glaciers are an important water resource

3: Glaciers are excellent climate indicators

1972 - 2007

3: Glaciers are excellent climate indicators

4: Glaciers can be dangerous

1996

4: Glaciers can be dangerous

5: Glaciers are beautiful and fascinating

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5 good reasons to monitor glaciers

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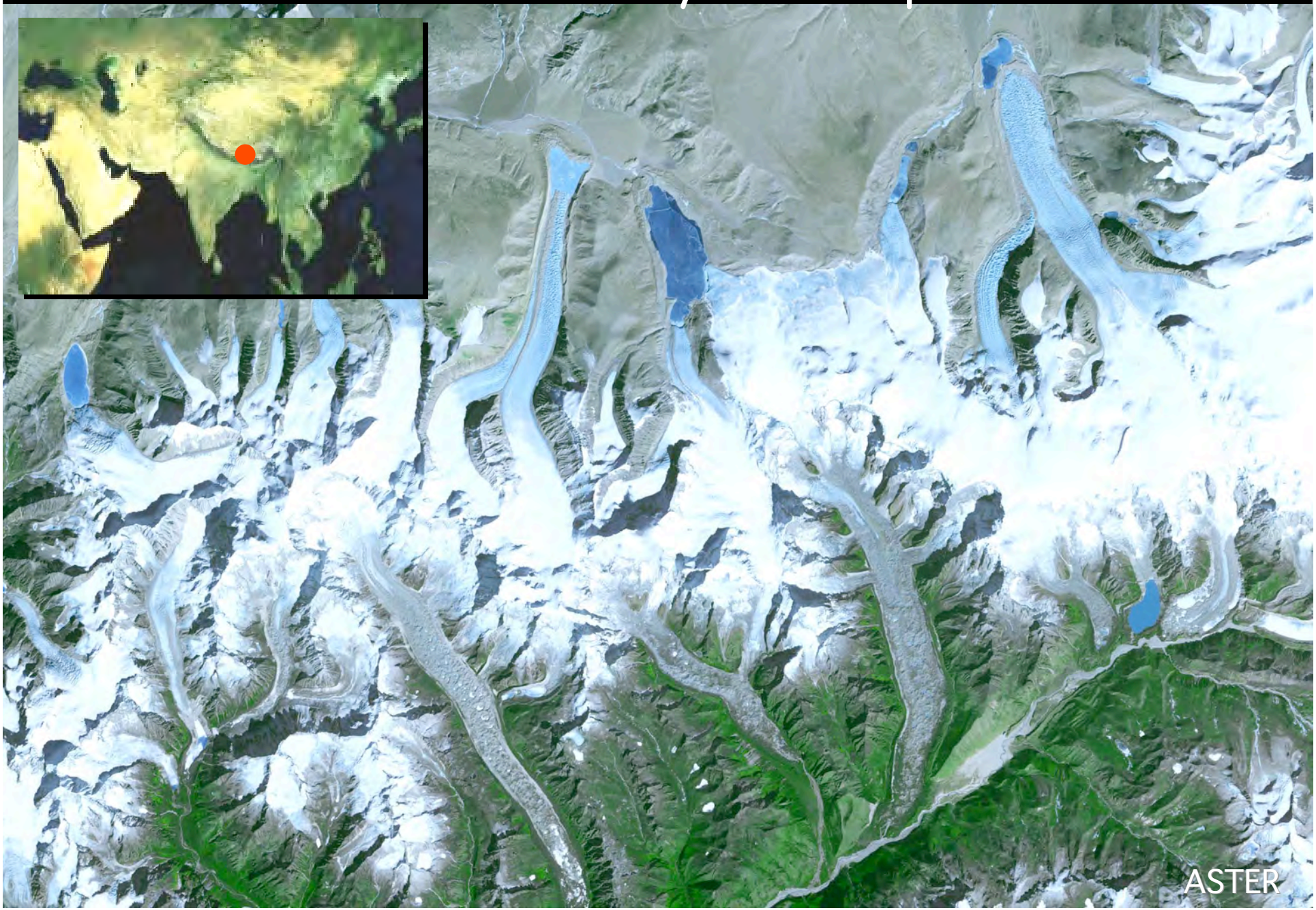
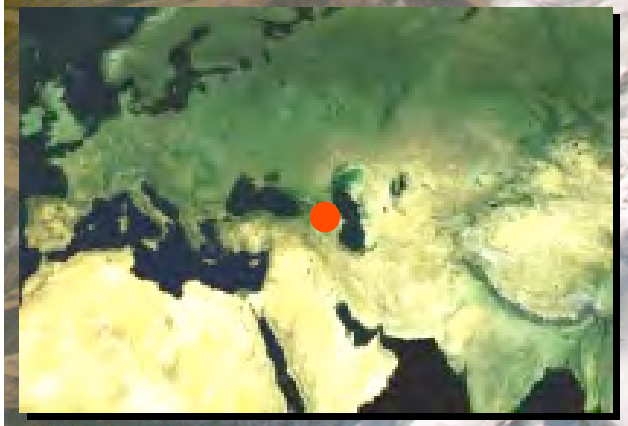
6 …

1: Glaciers are often at very remote places



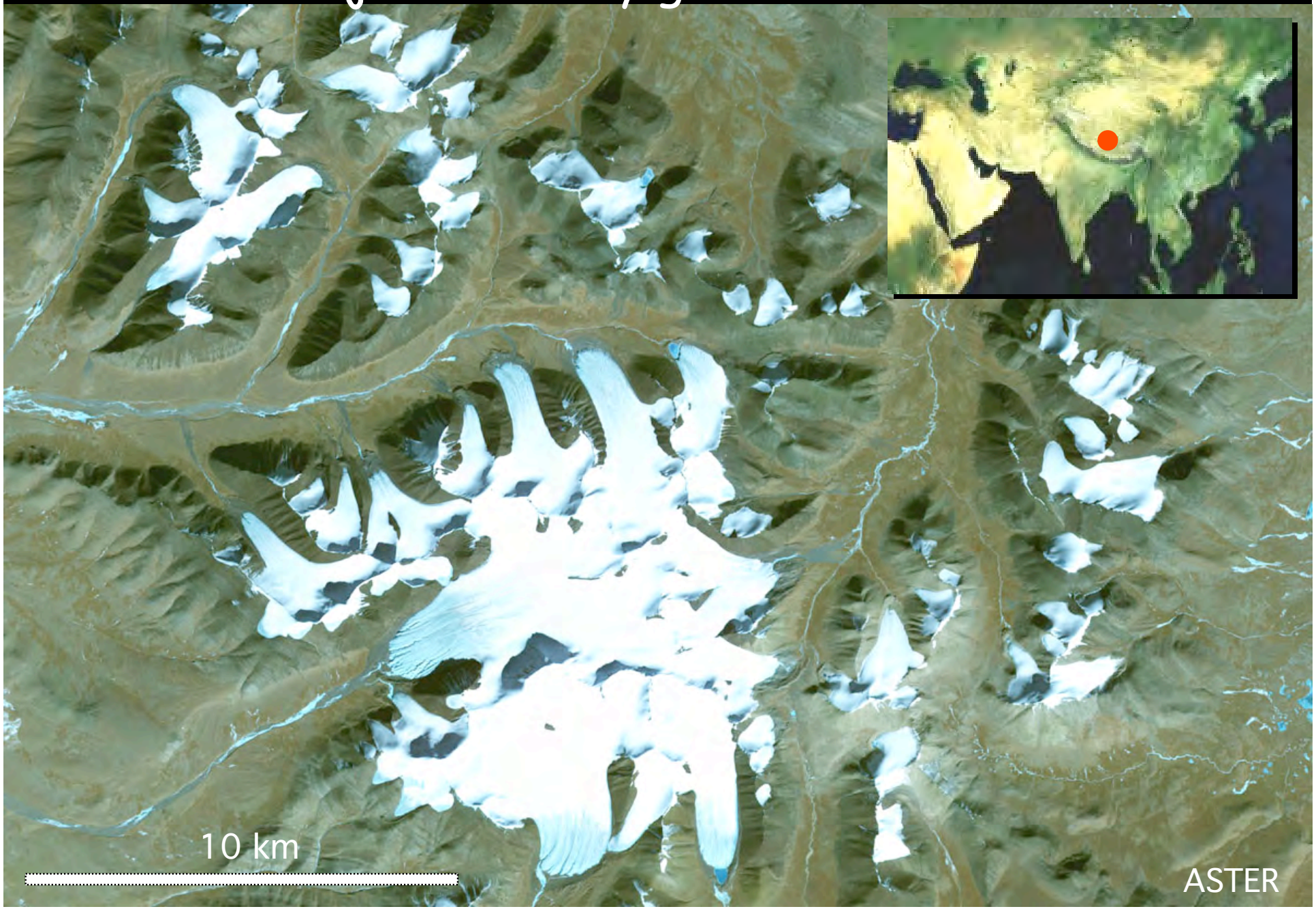
2: Glaciers are sometimes at very insecure places



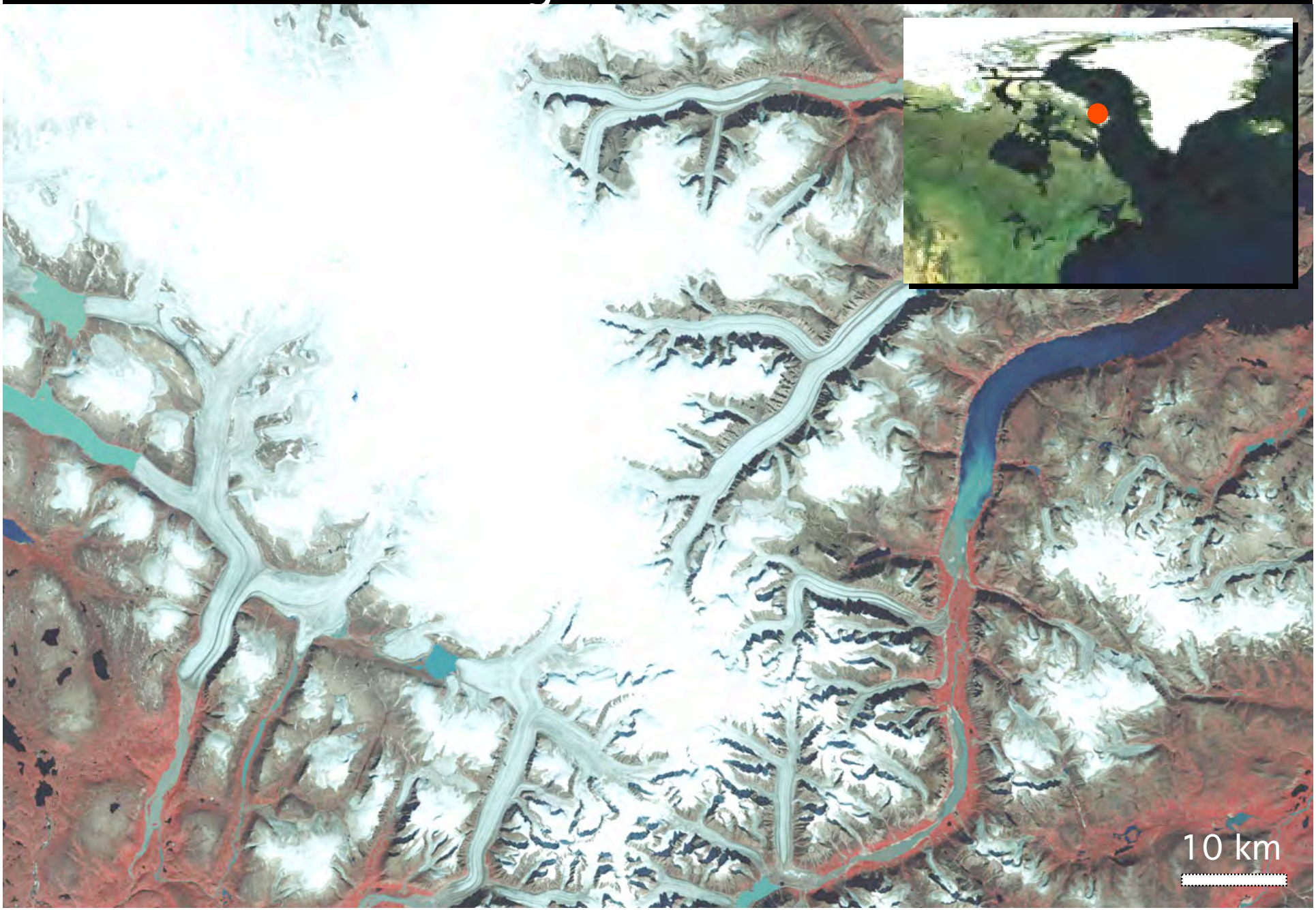
Int. Space

2: Glaciers are sometimes at very insecure places

3: There are just so many glaciers



3: ... and some are huge



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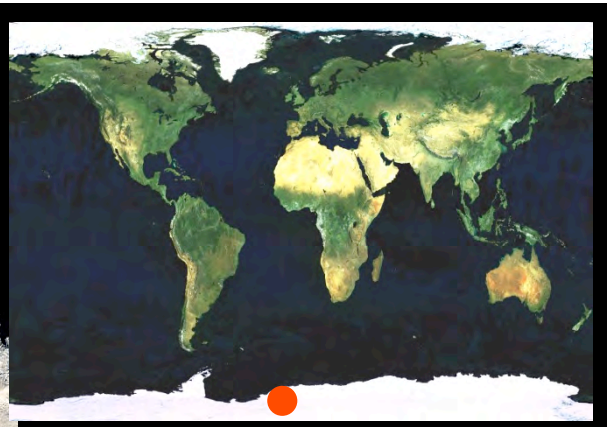

4500 km

AVHRR / USGS

4: Political and resource problems

- *Lack of funding for glacier monitoring*
- *Instable political or administrative situations*
- *Lack of expertise*
- *Research focus*
- *Problems in maintaining time series*
- *…*

5 good reasons to monitor glaciers

4 good reasons to do that *from space*

6 …

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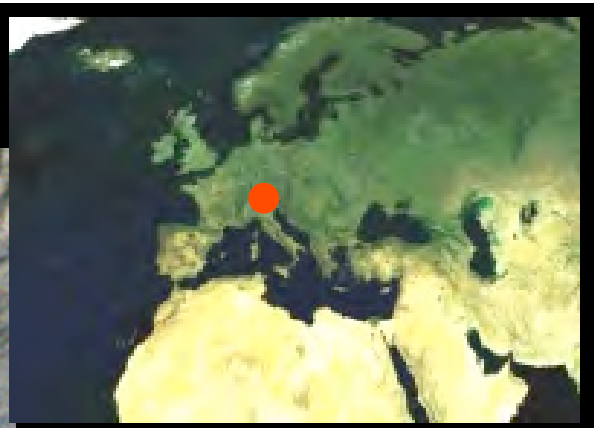
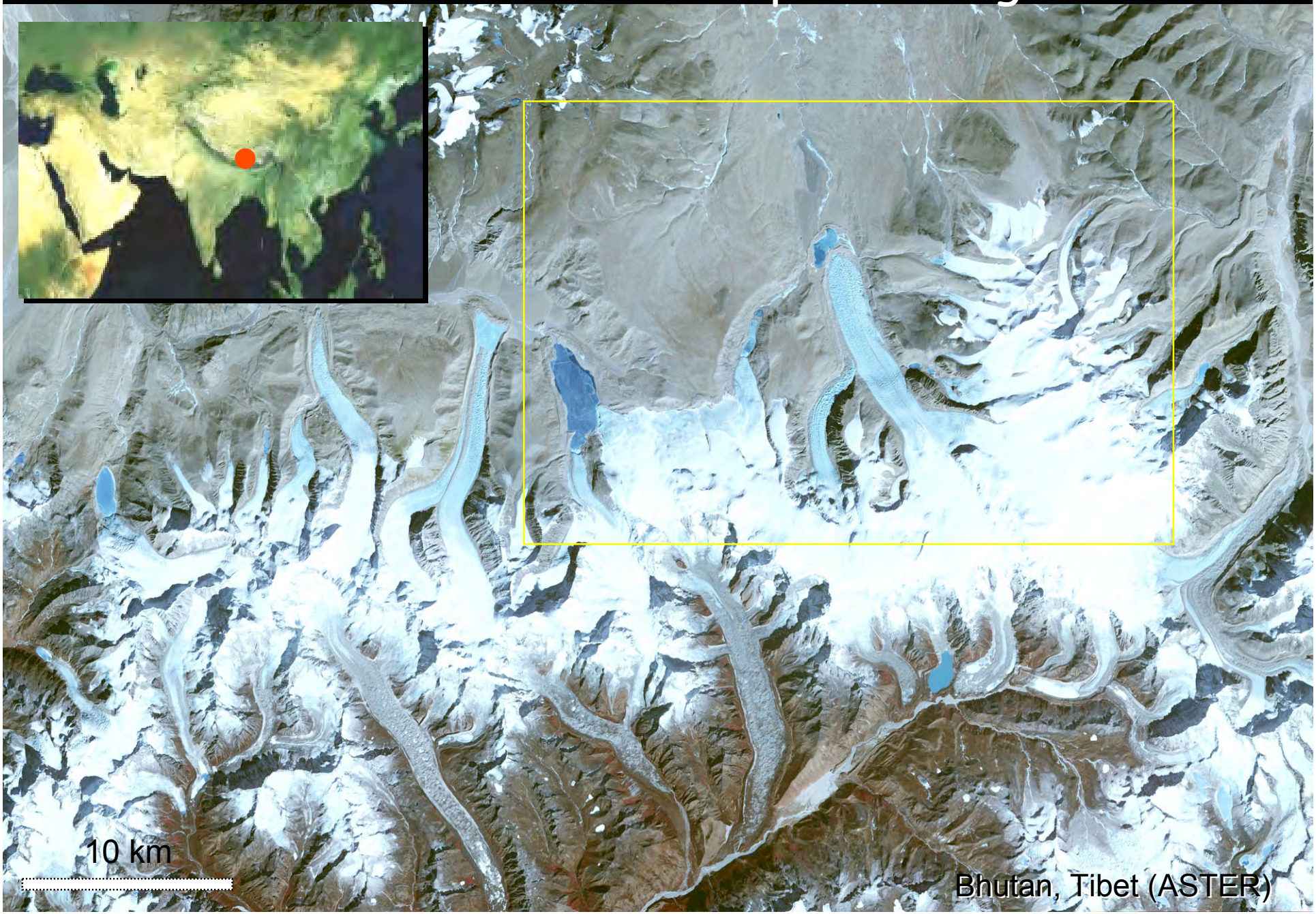
6 methods for glacier monitoring from space

1: Repeat optical images

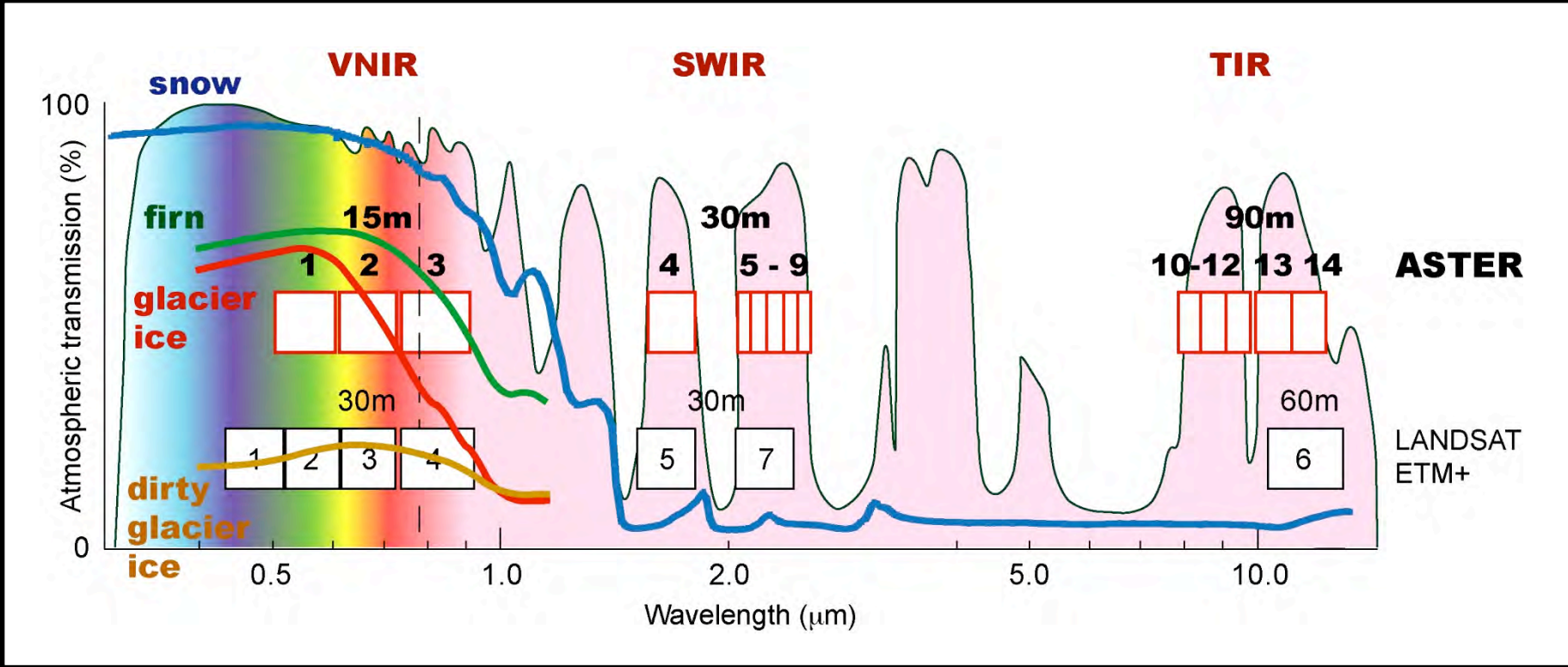


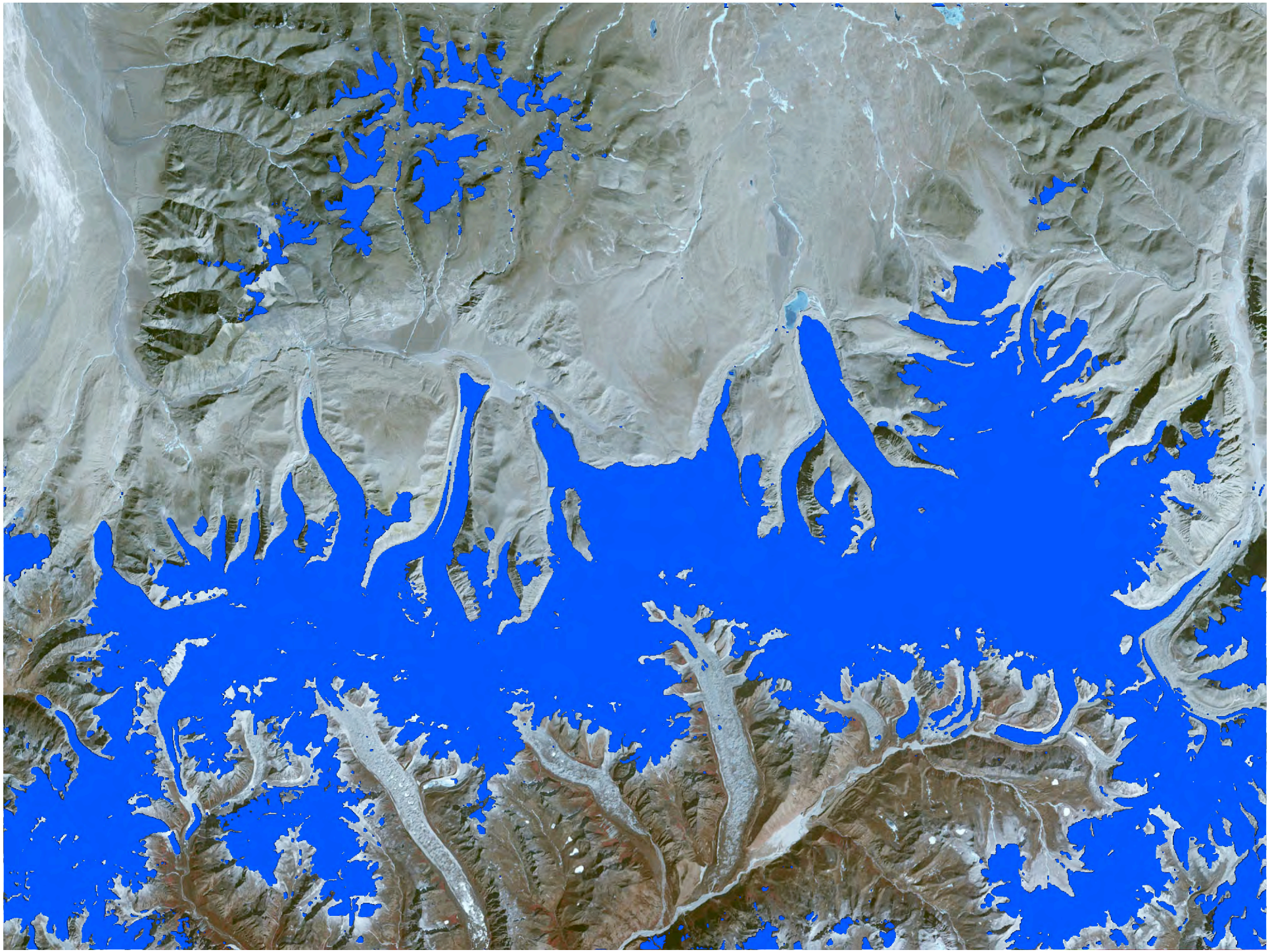
1: Automatic classification of optical images

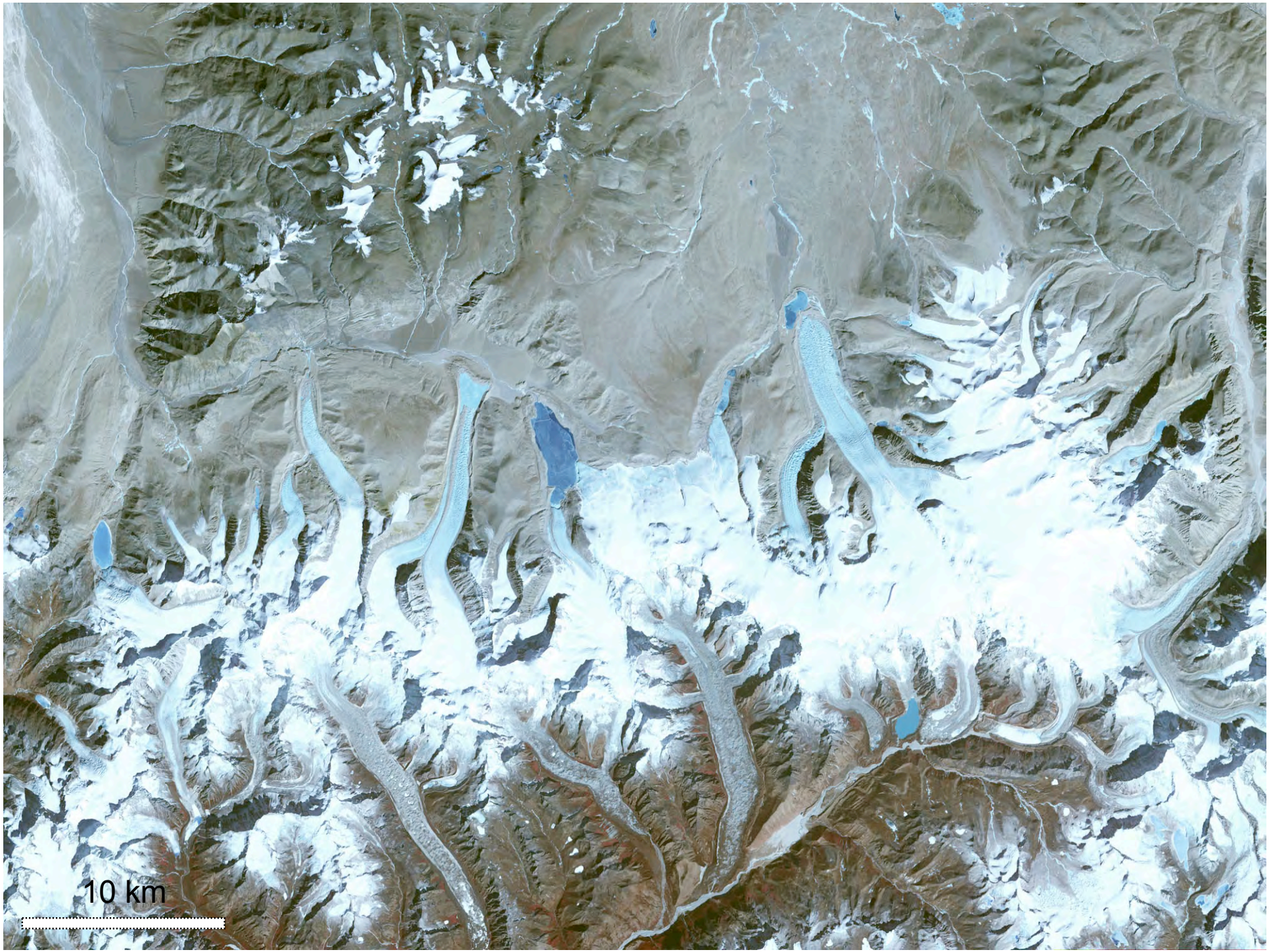



10 km

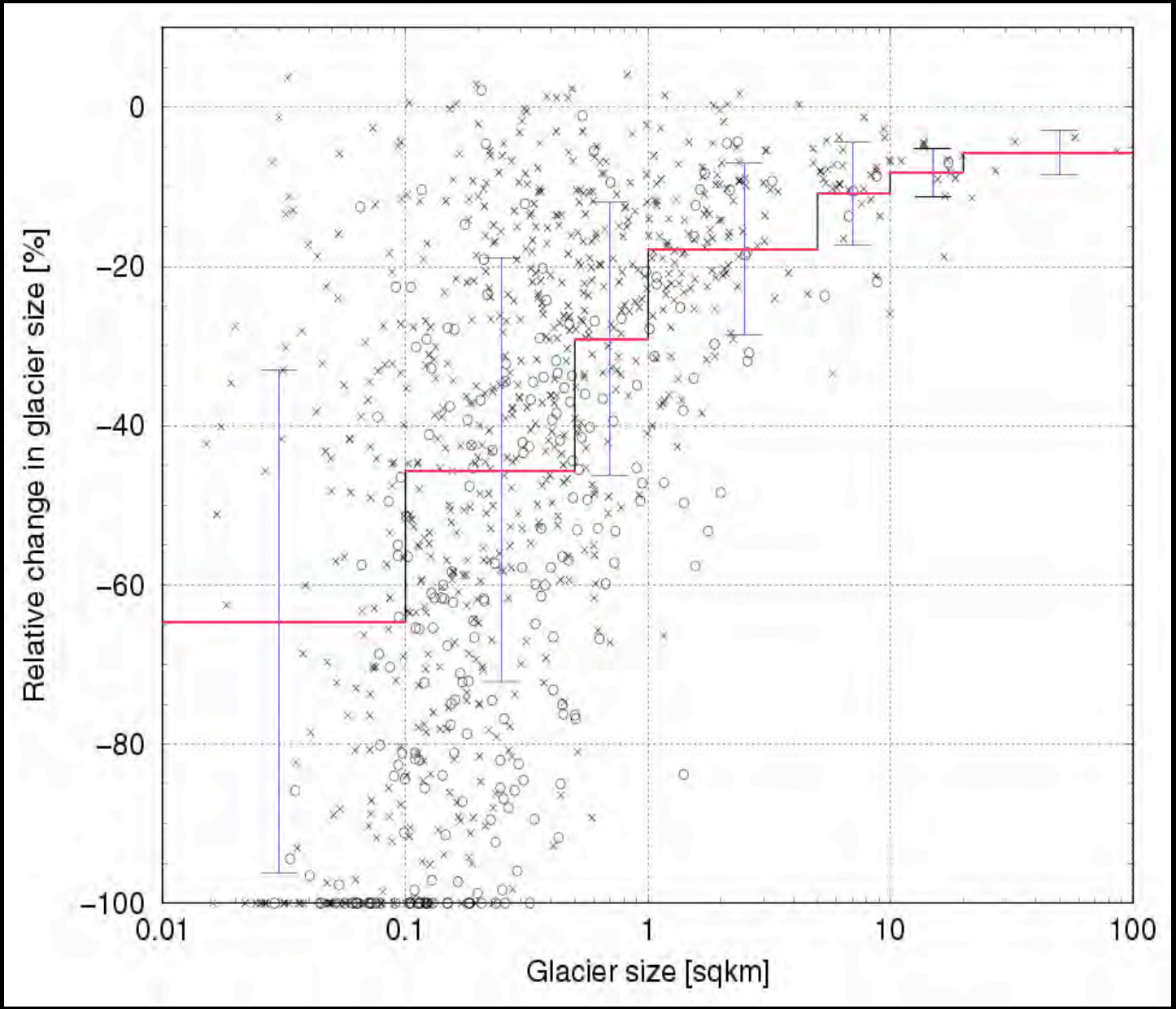
1: Reflectivity of snow and ice





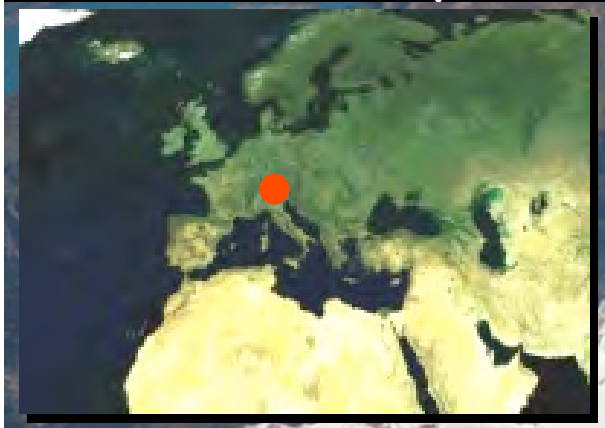

10 km

1: Swiss Alps 1973-2000



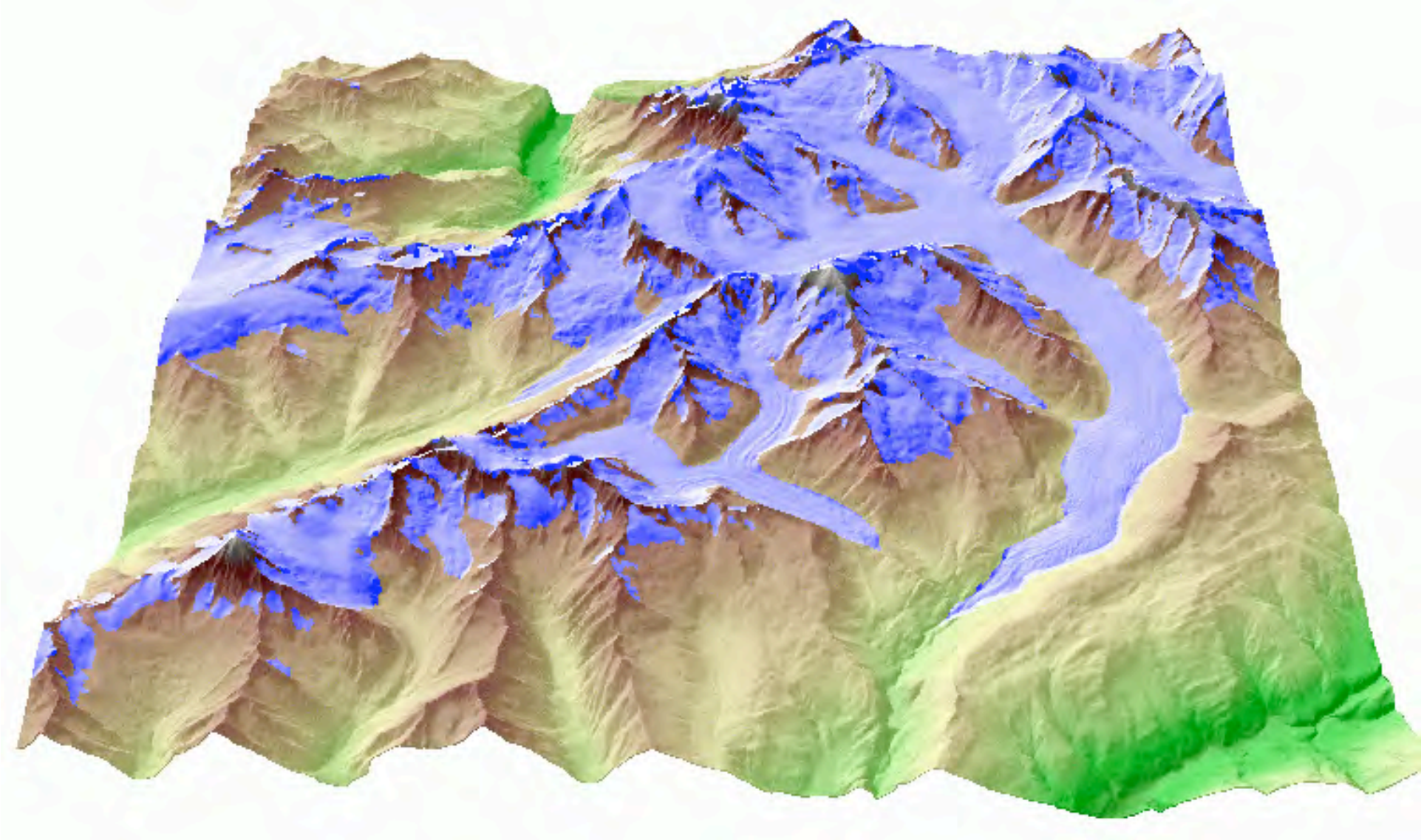
Paul et al.

2: Swiss Alps



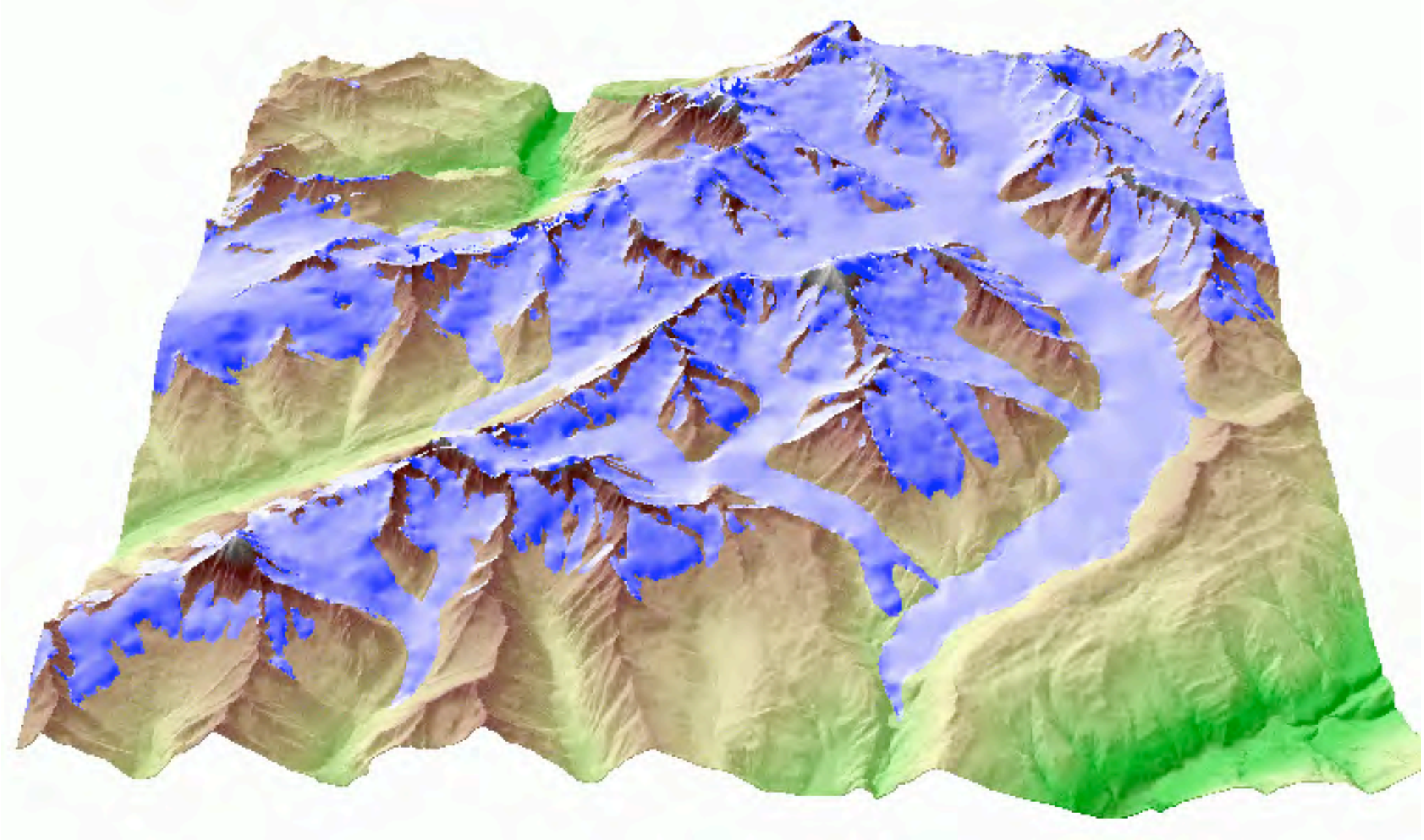
Int. Space Station

2: Swiss Alps 1995



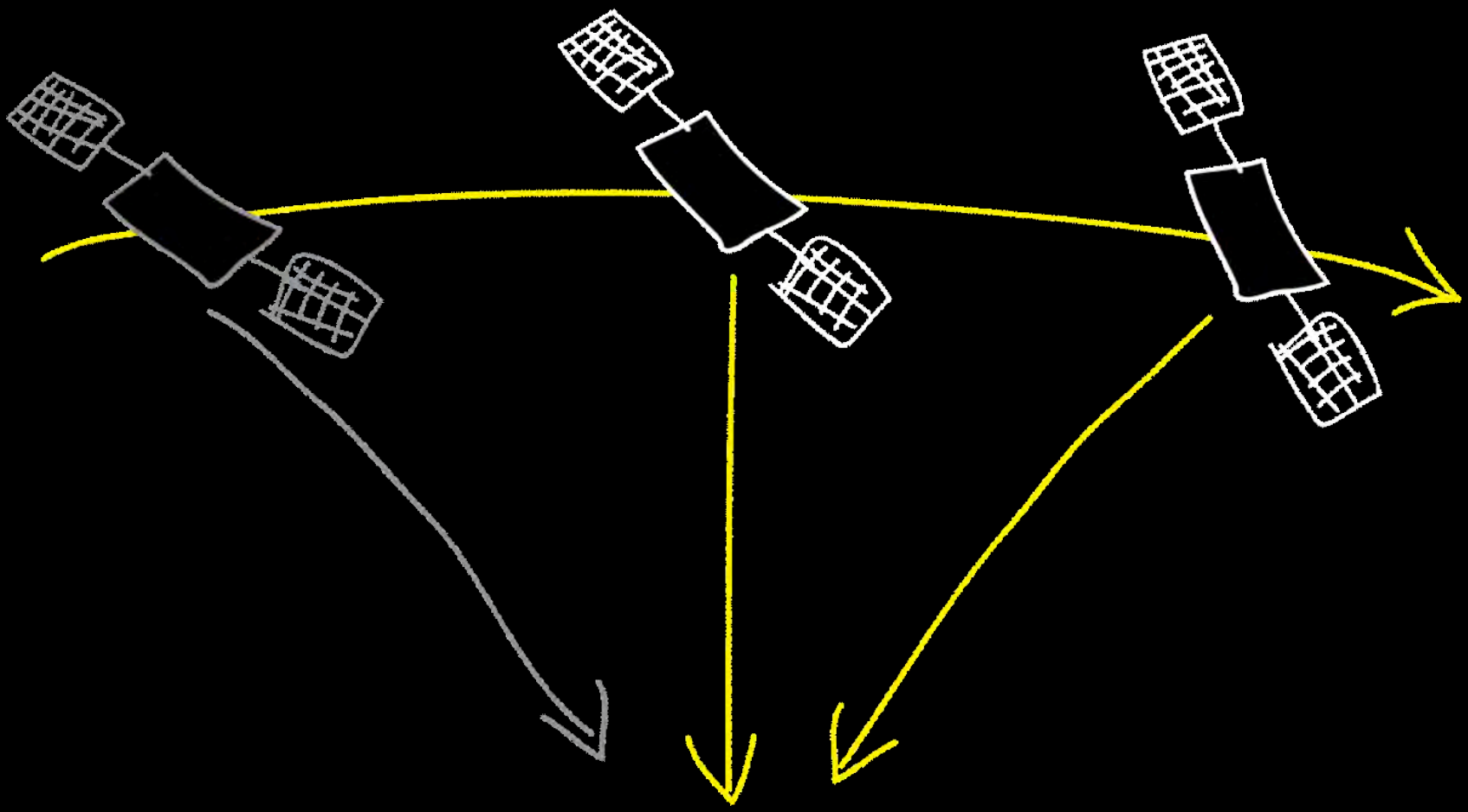
F. Paul

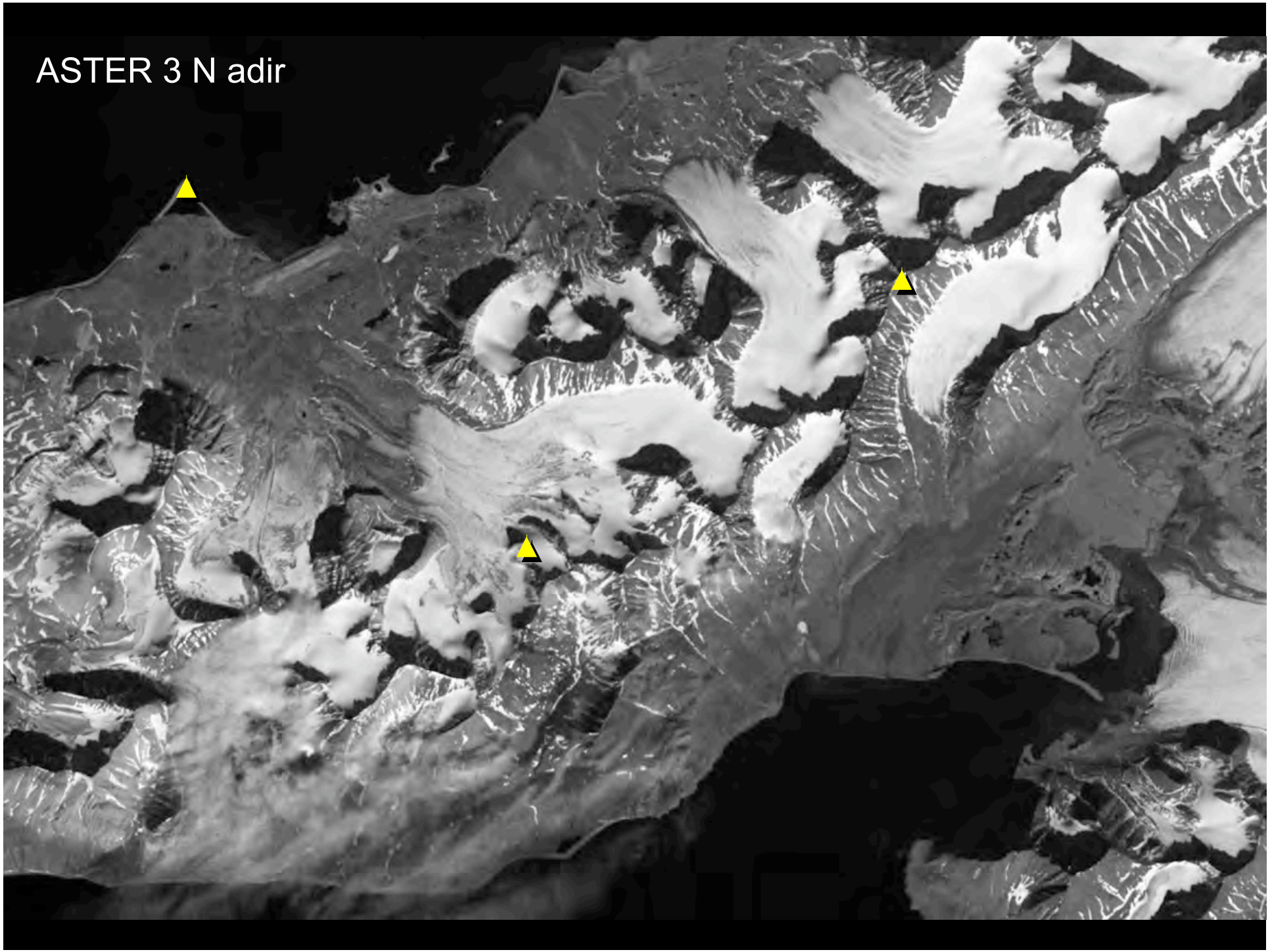
2: Swiss Alps 1850

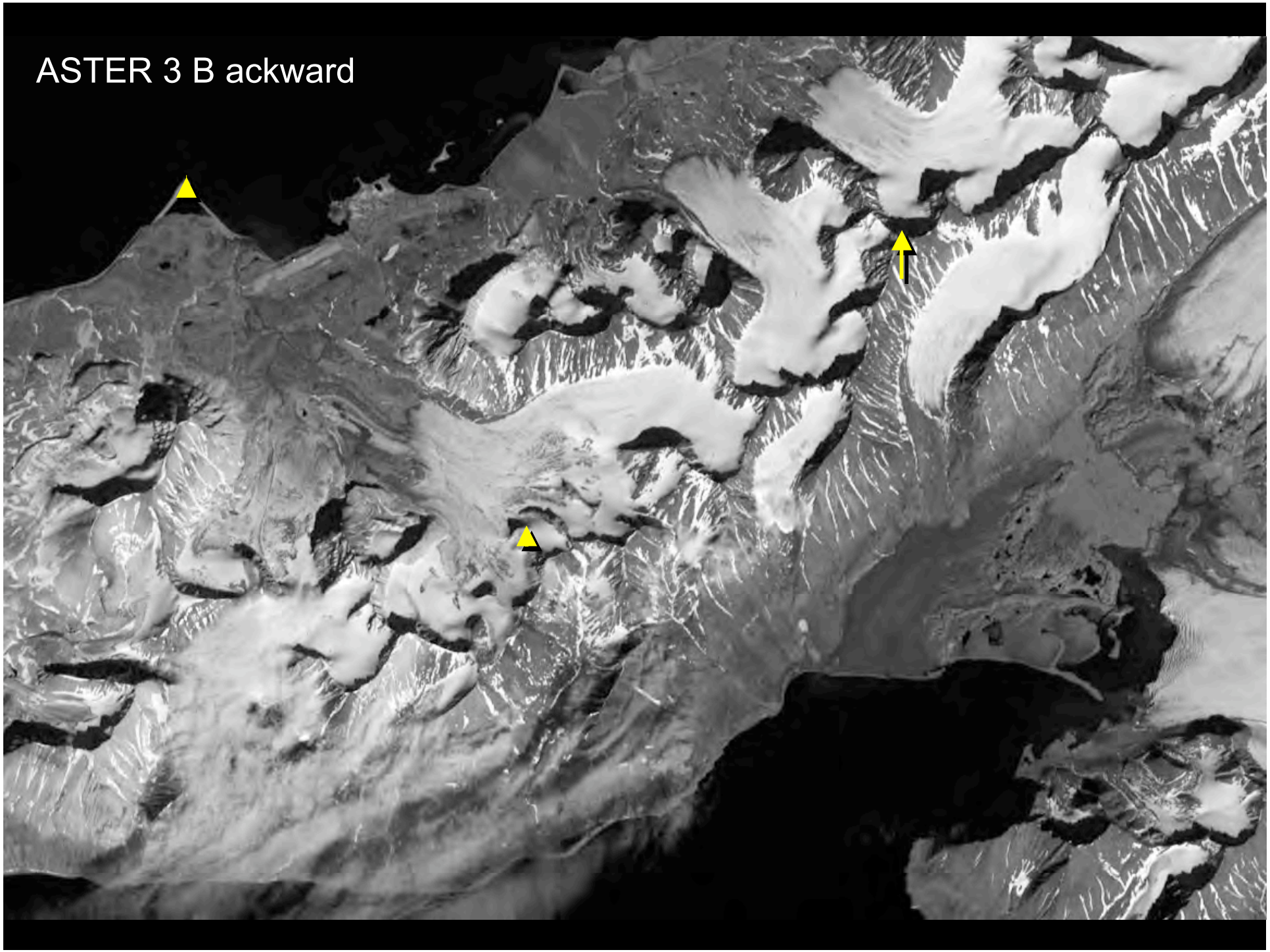


F. Paul

2: Satellite stereo / Glacier geometry and volume

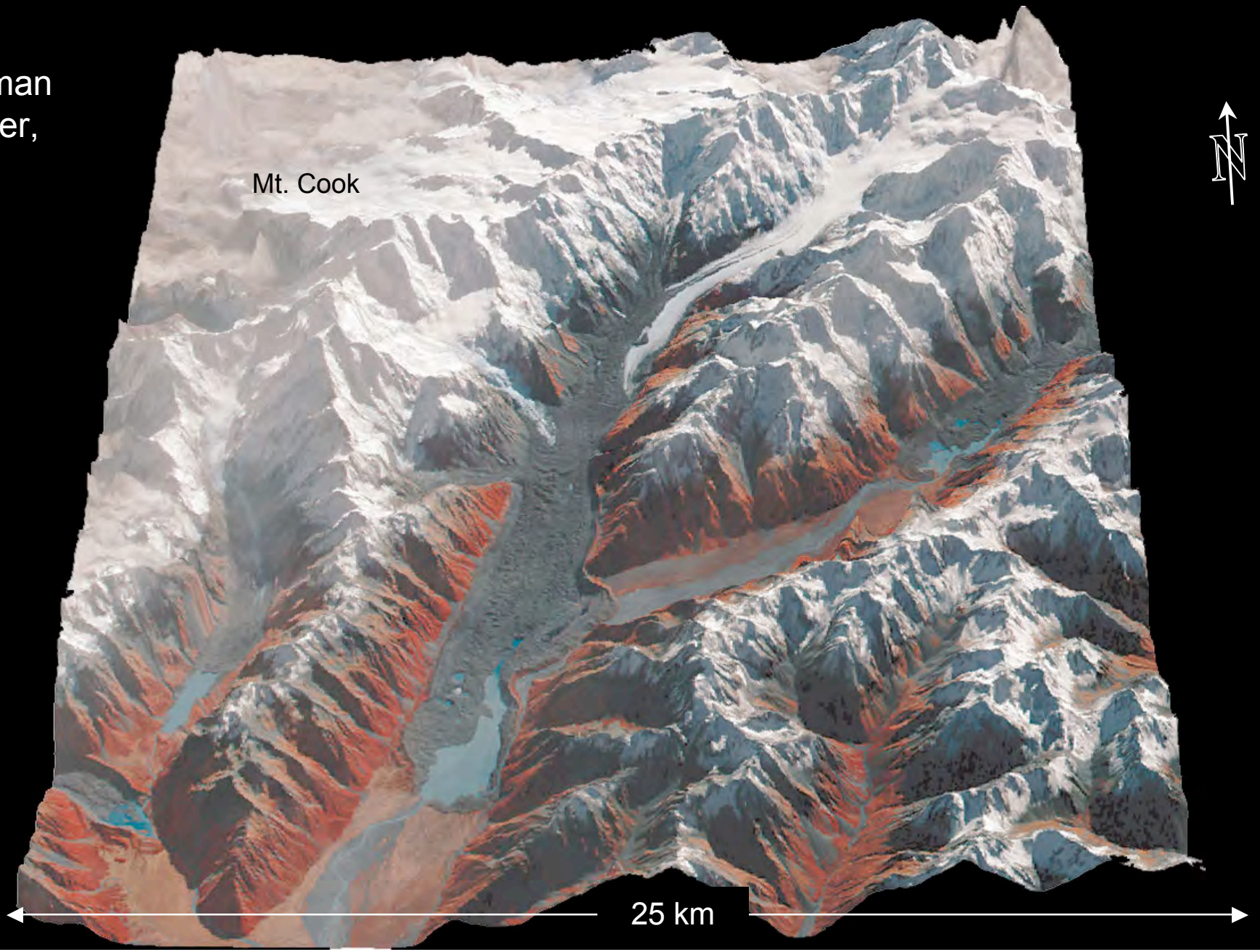



ASTER 3 N adir


ASTER 3 B ackward

2: Satellite stereo / Glacier geometry and volume

Tasman glacier, NZ



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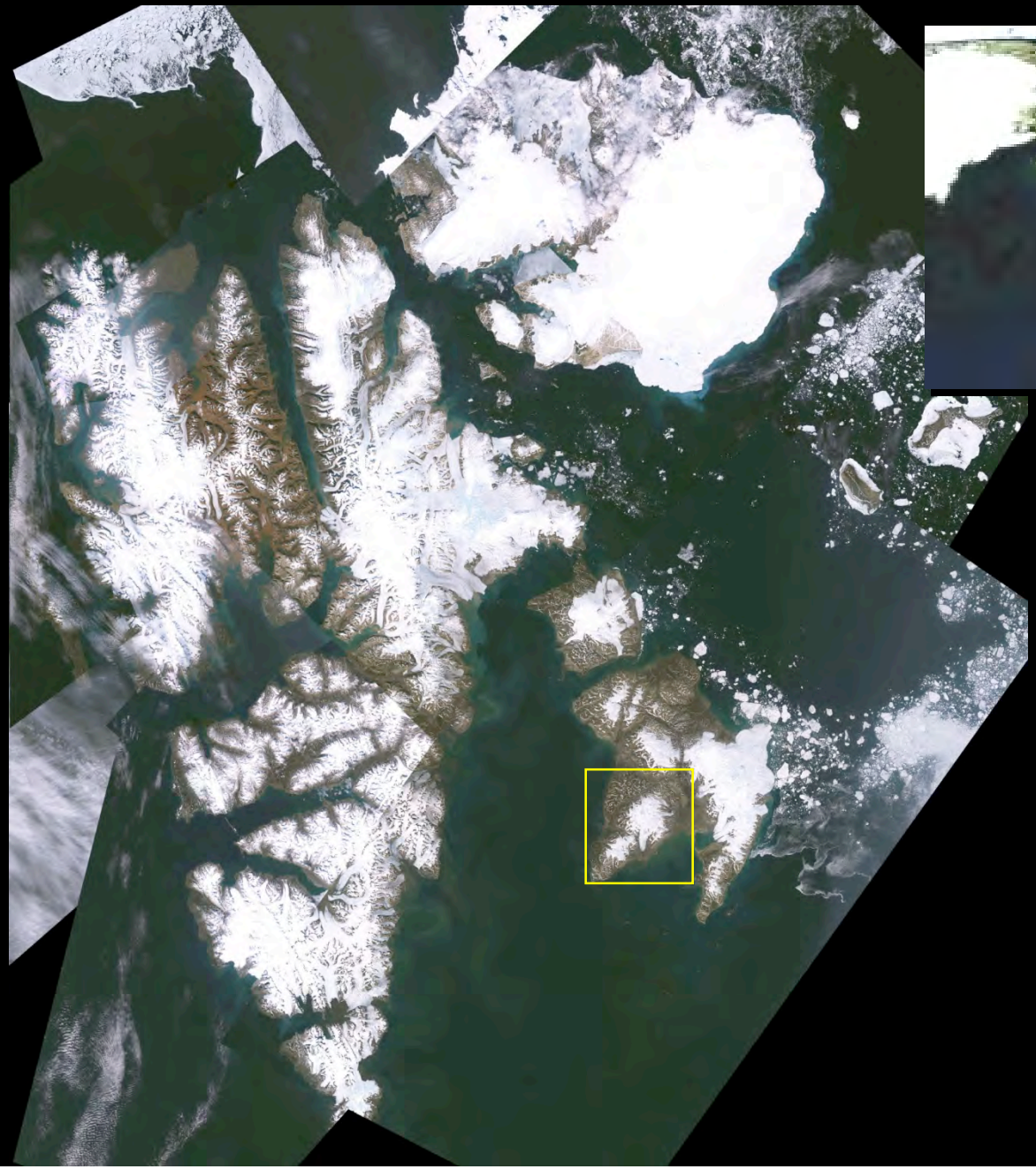

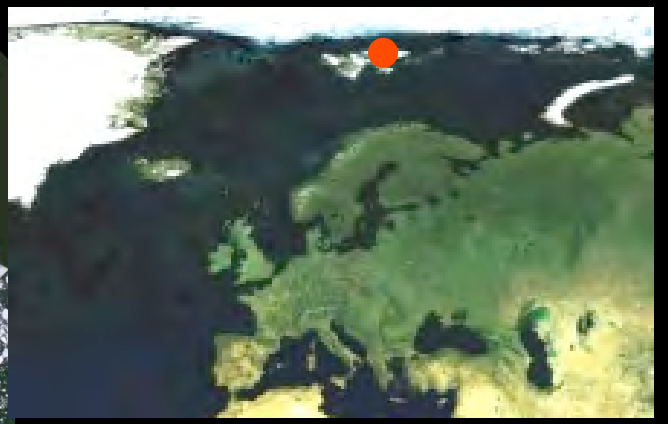

2: Satellite stereo / Glacier geometry and volume

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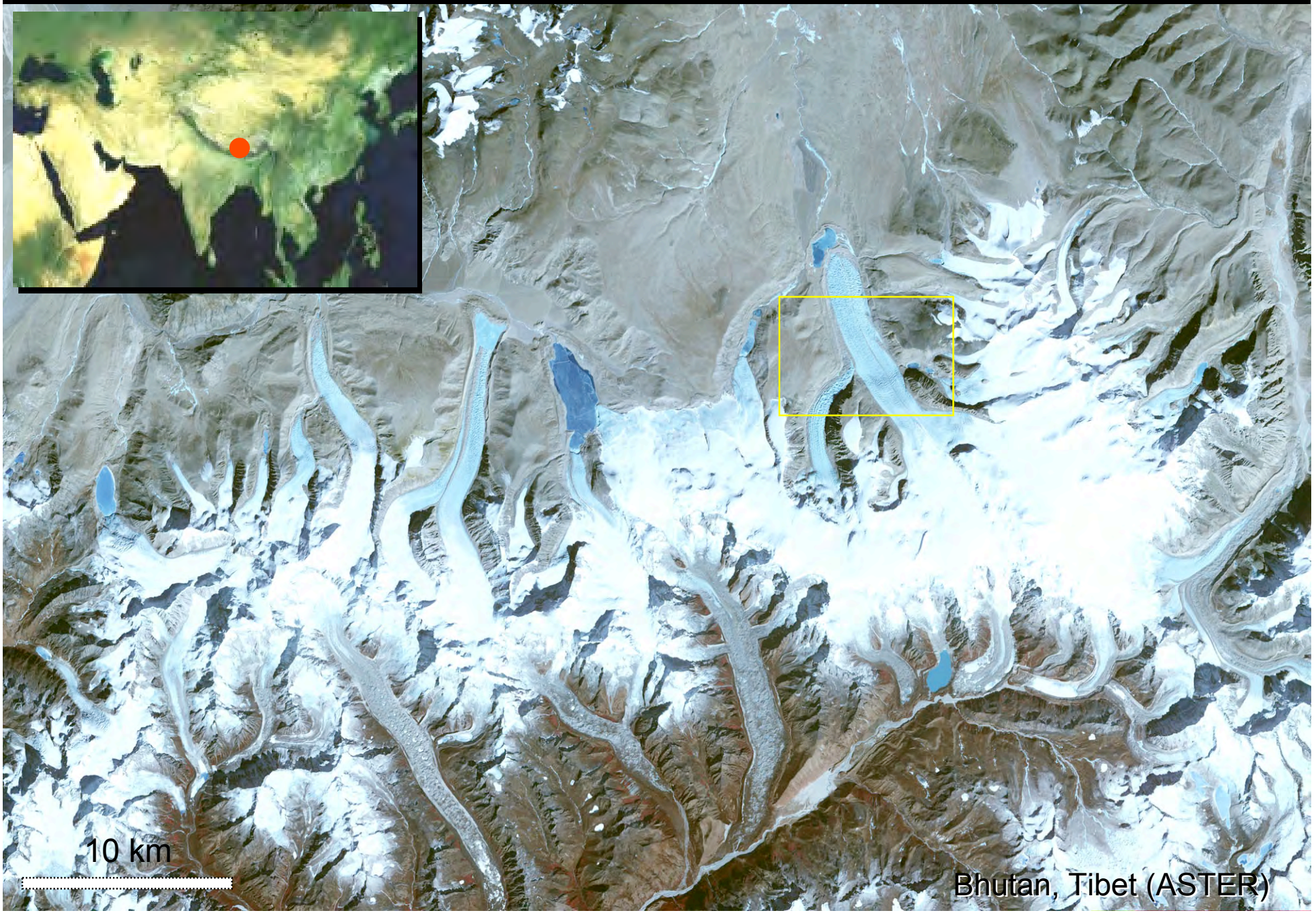
3: Glacier flow



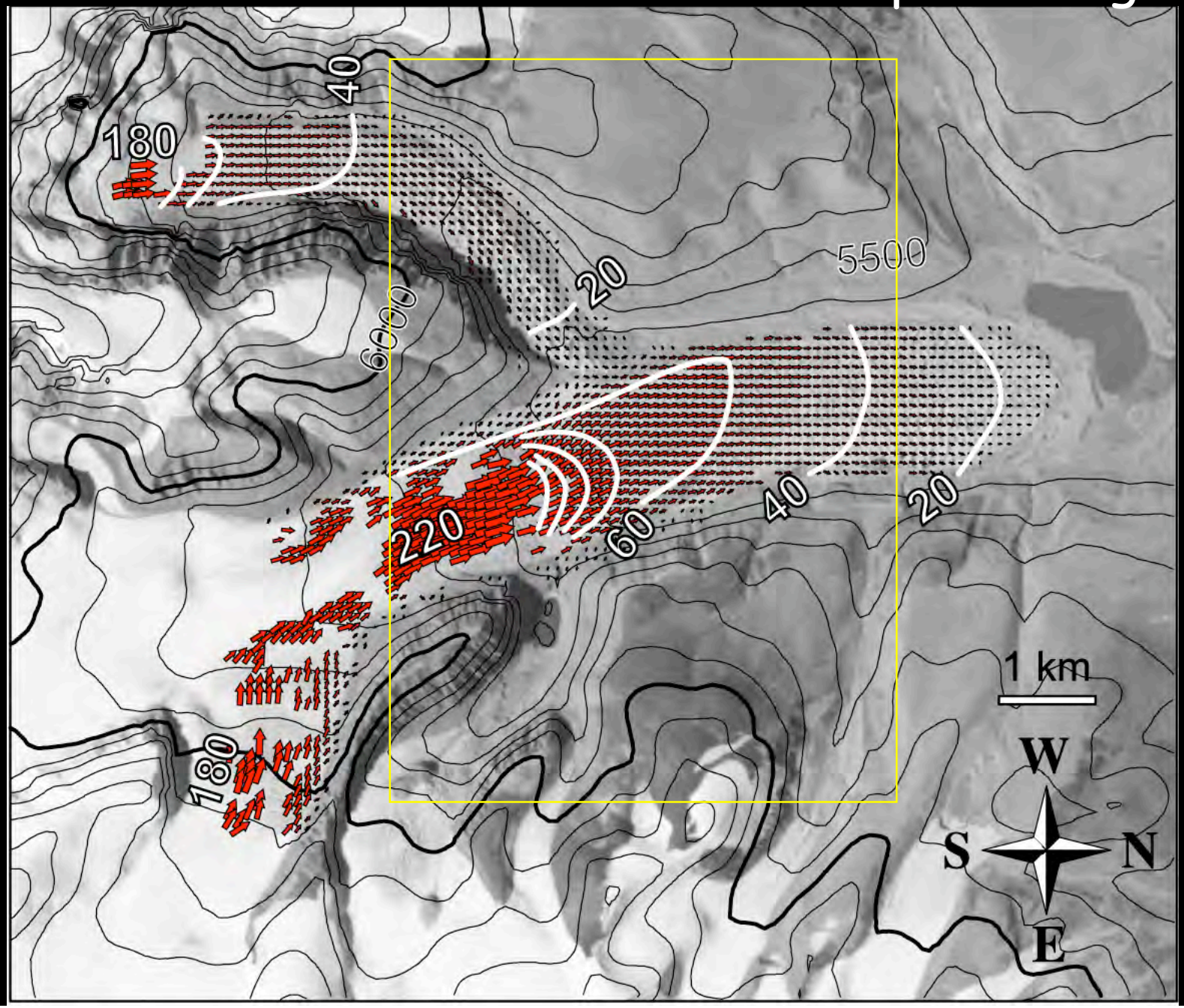
3: Glacier flow

Jan 2001

3: Glacier flow

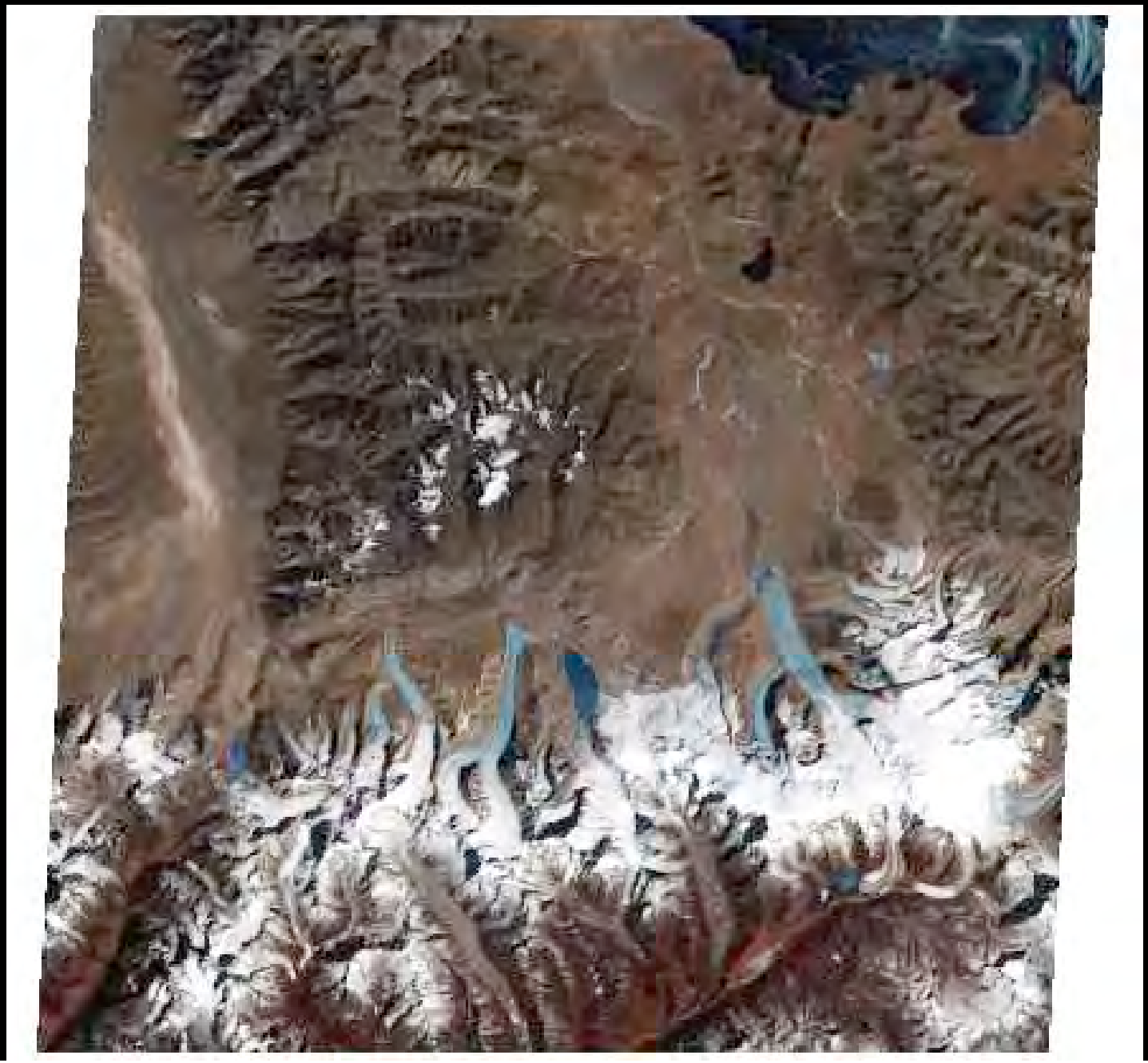
Nov 2001

3: Glacier flow / Correlation of repeat images



Great !

But ...



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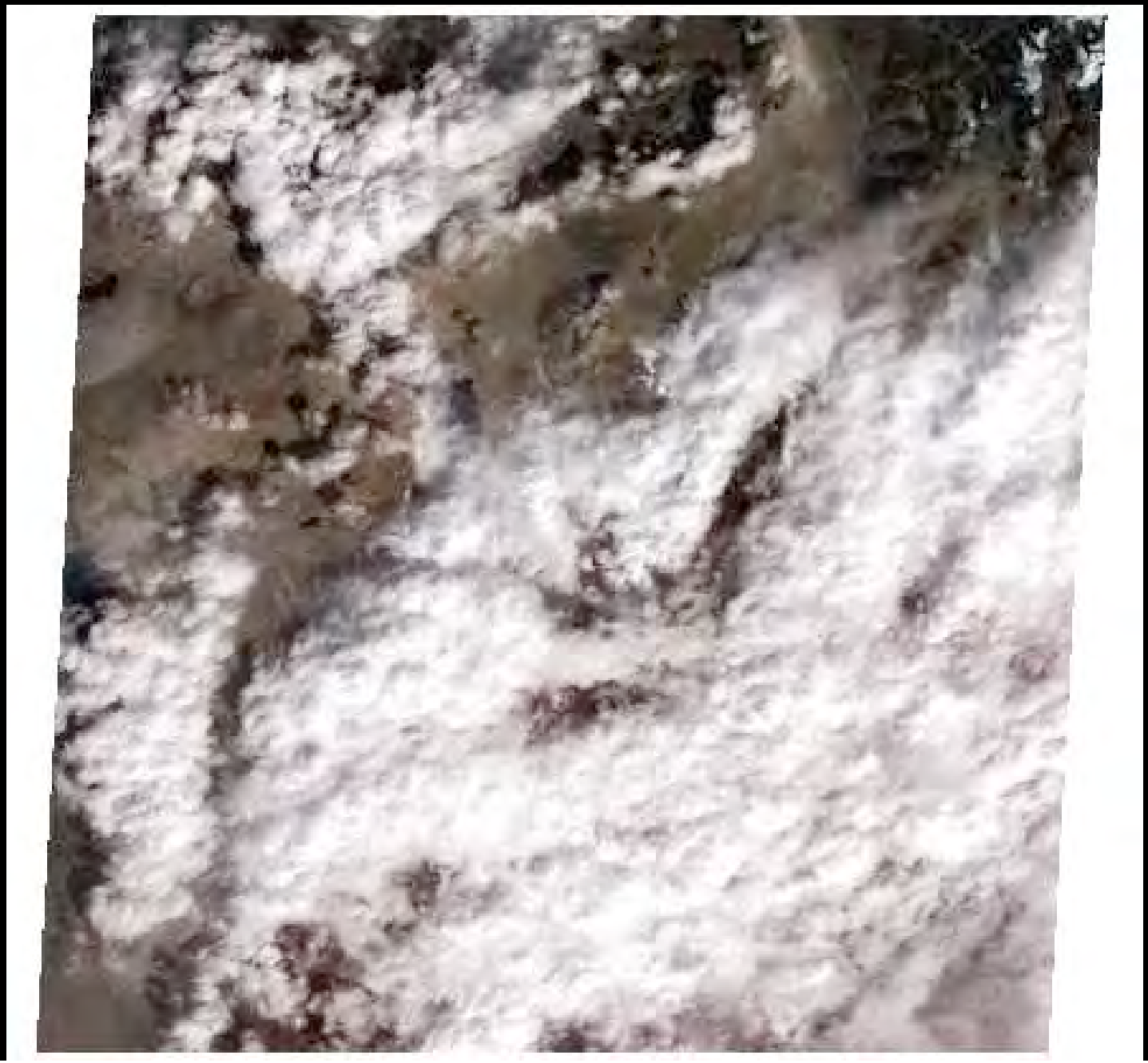
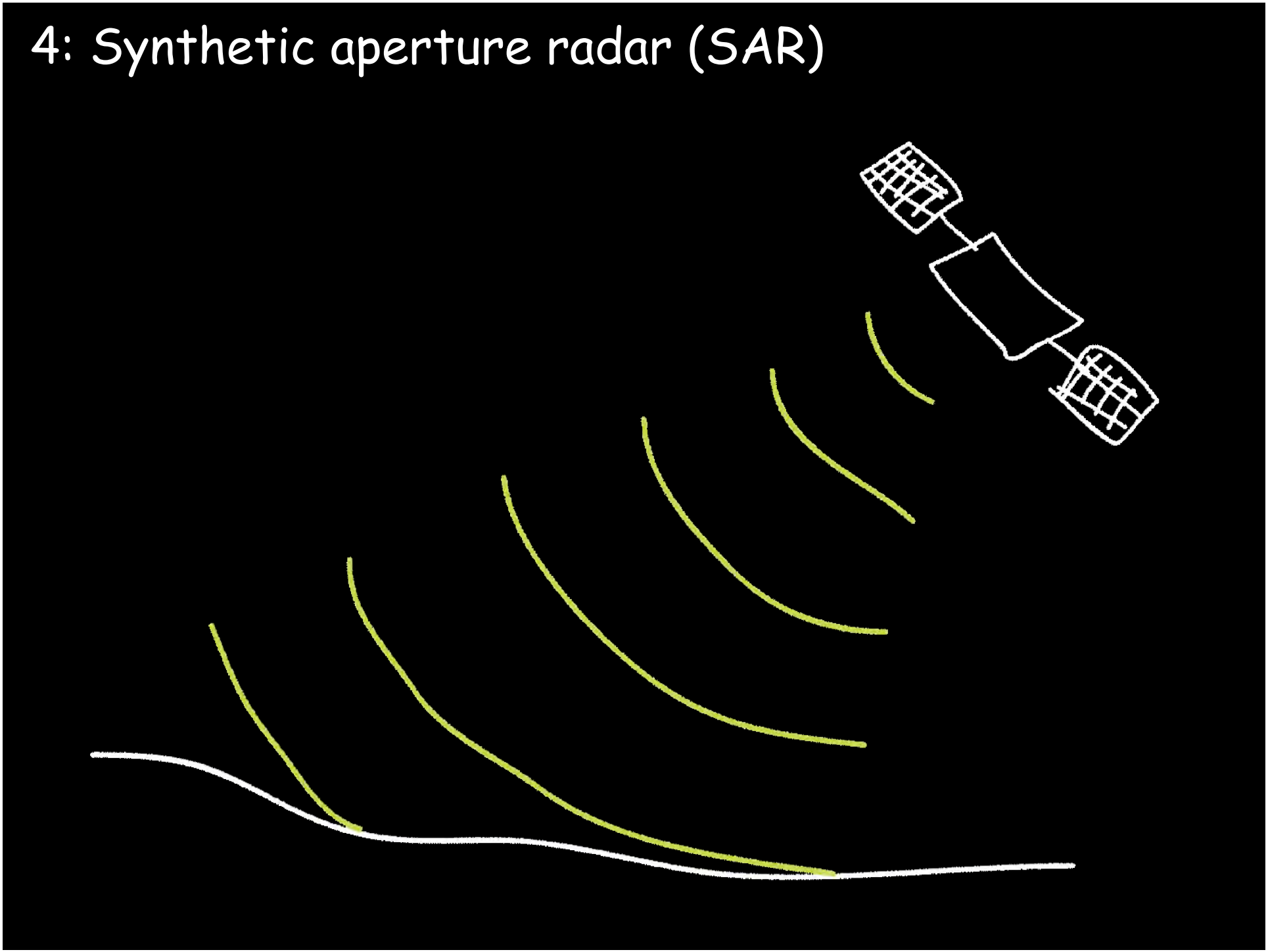


But ...

4: Synthetic aperture radar (SAR)



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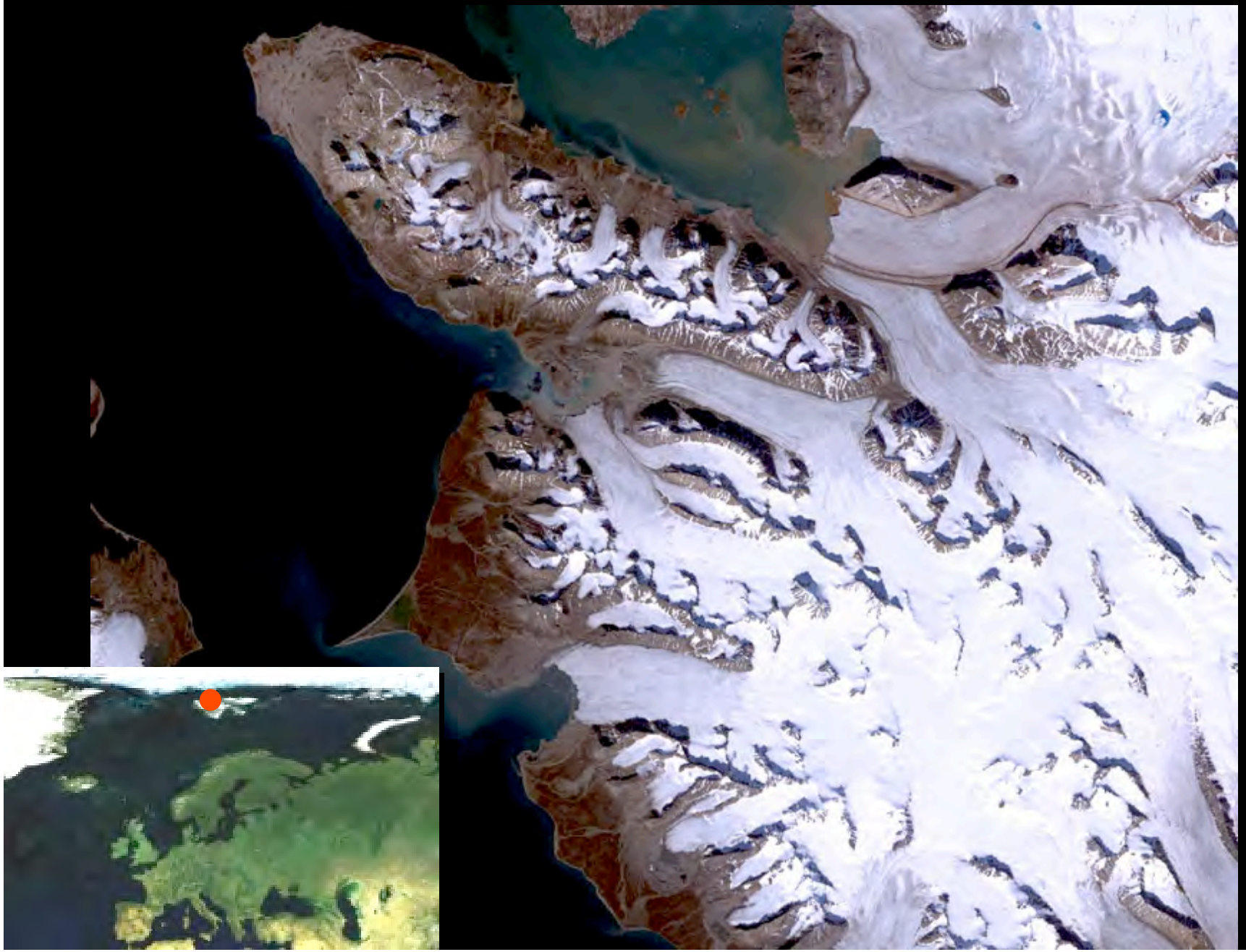

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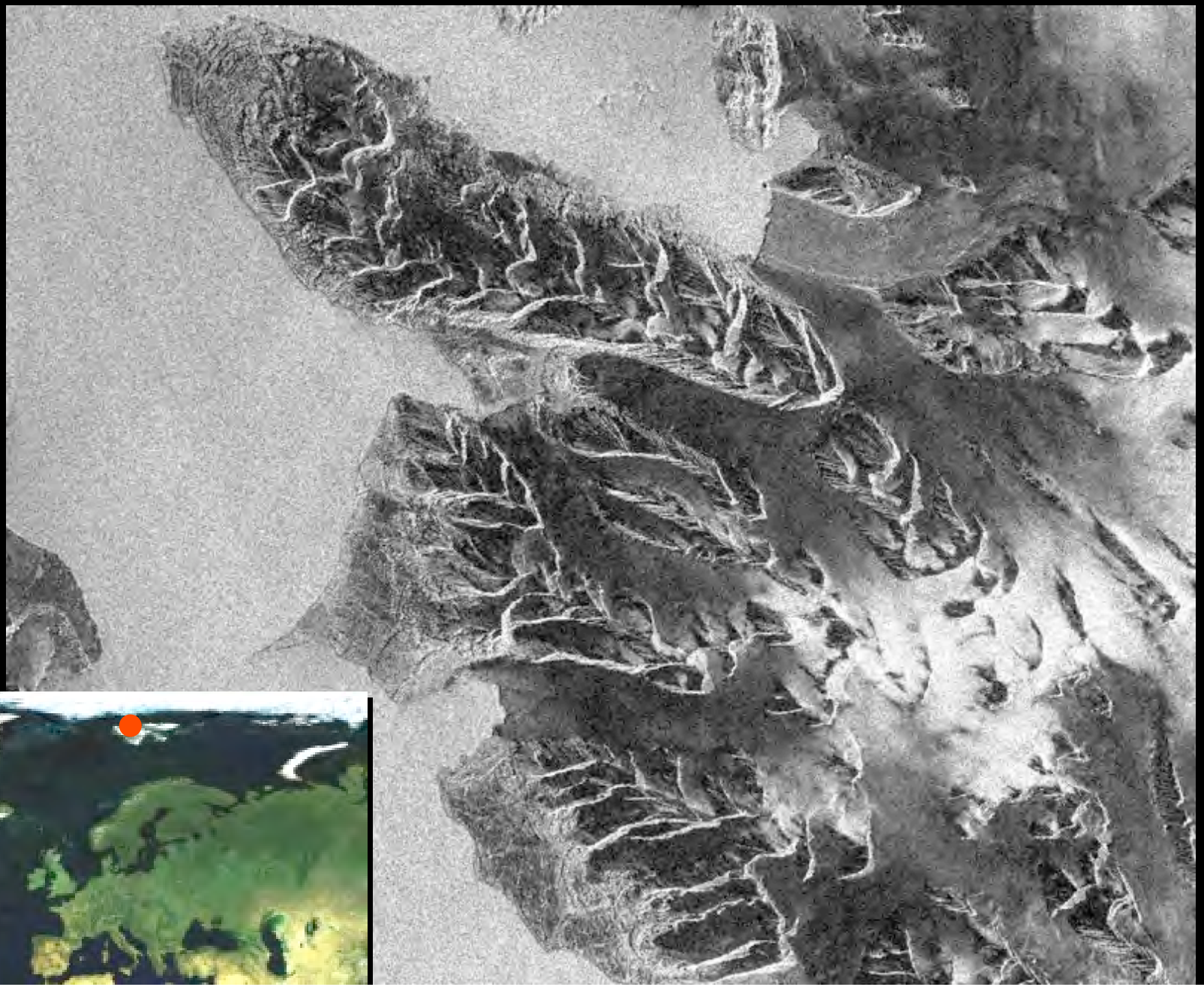

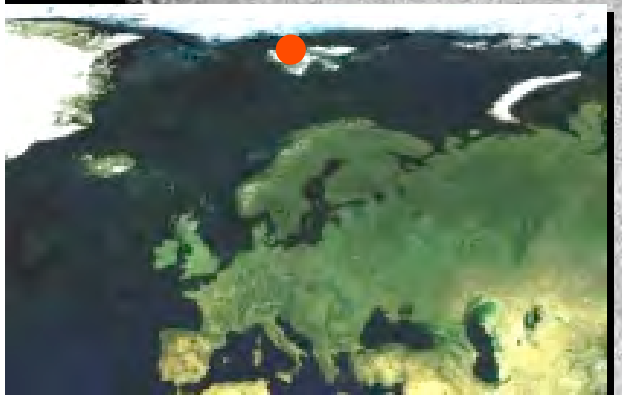

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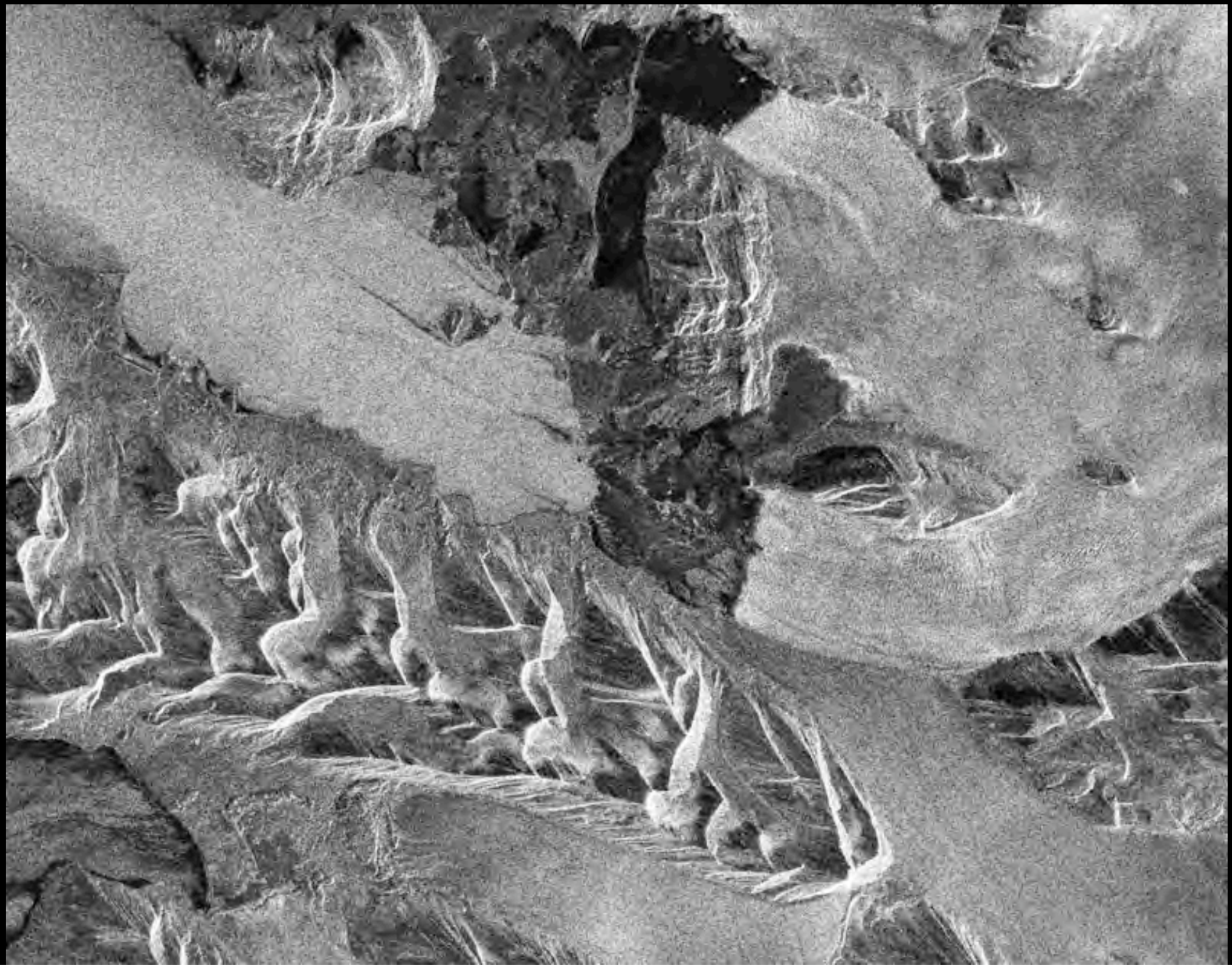

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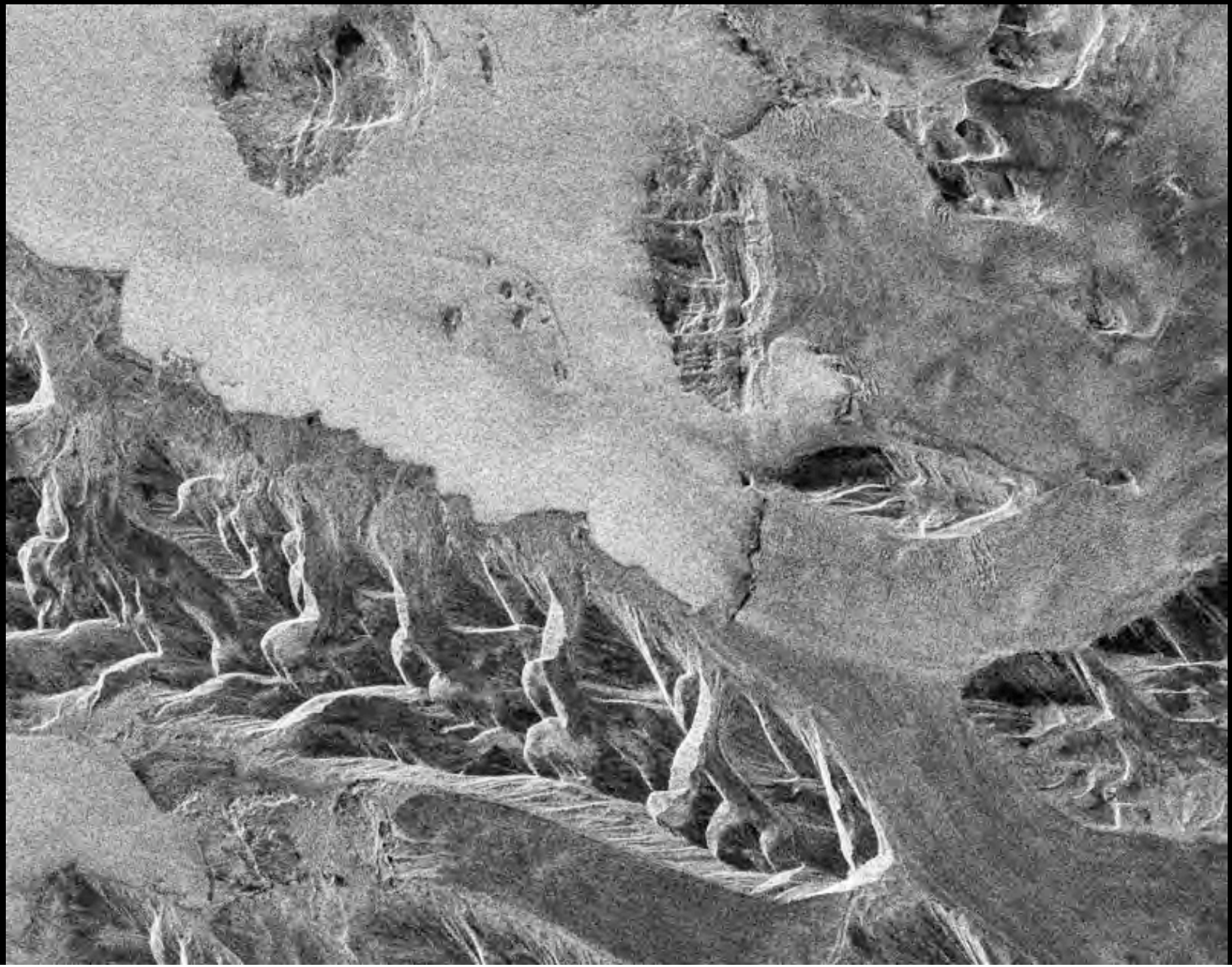

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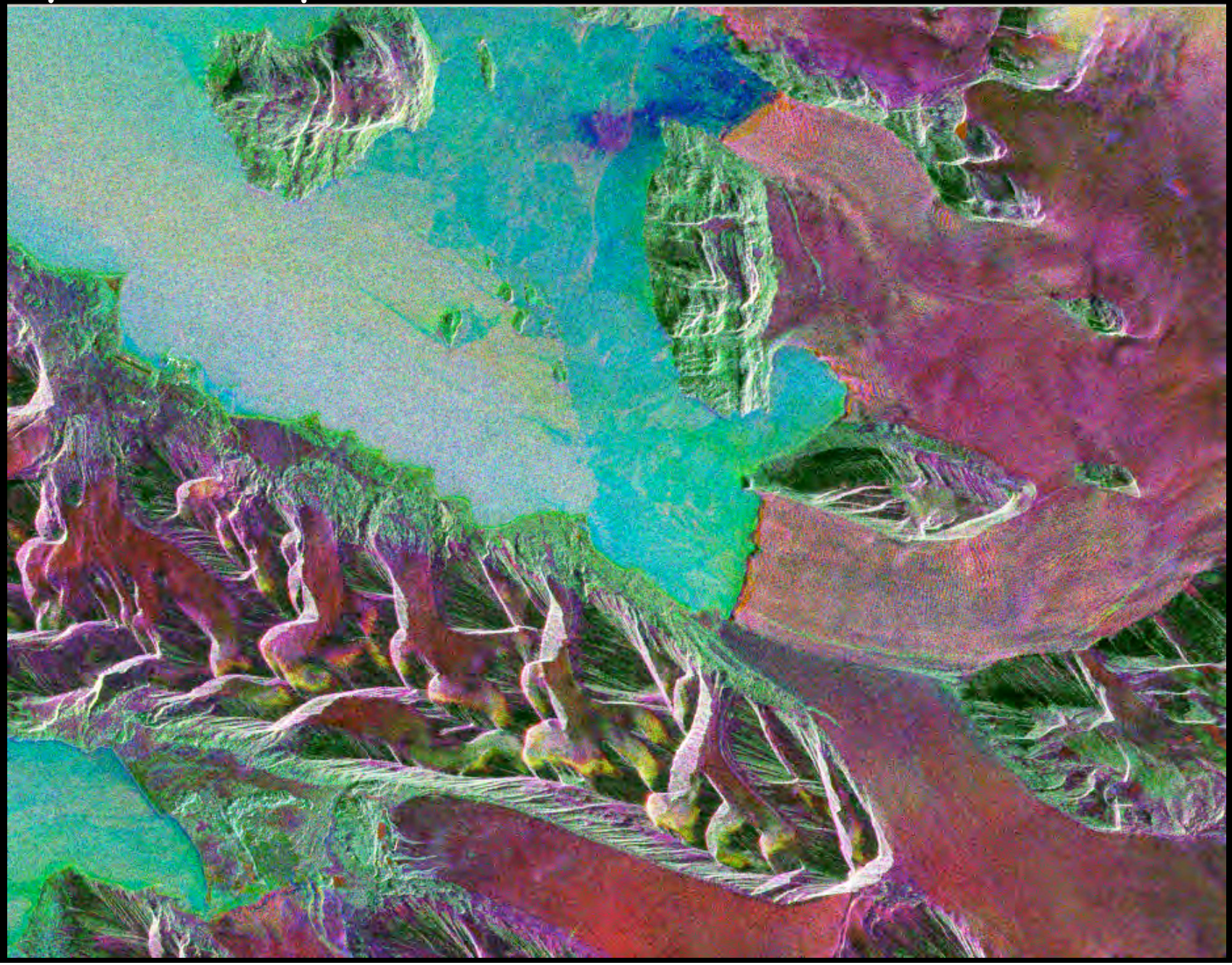
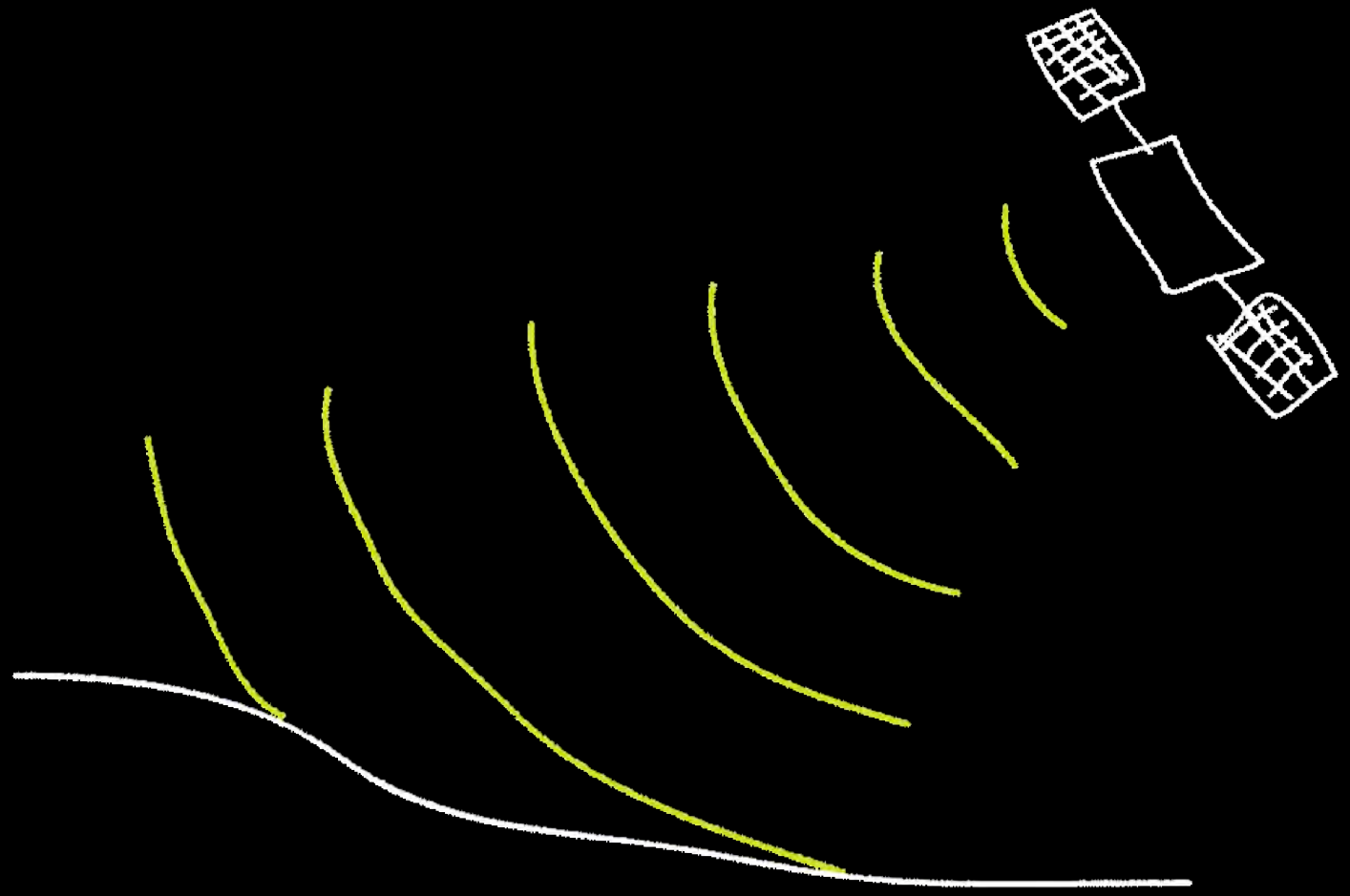


5: SAR interferometry



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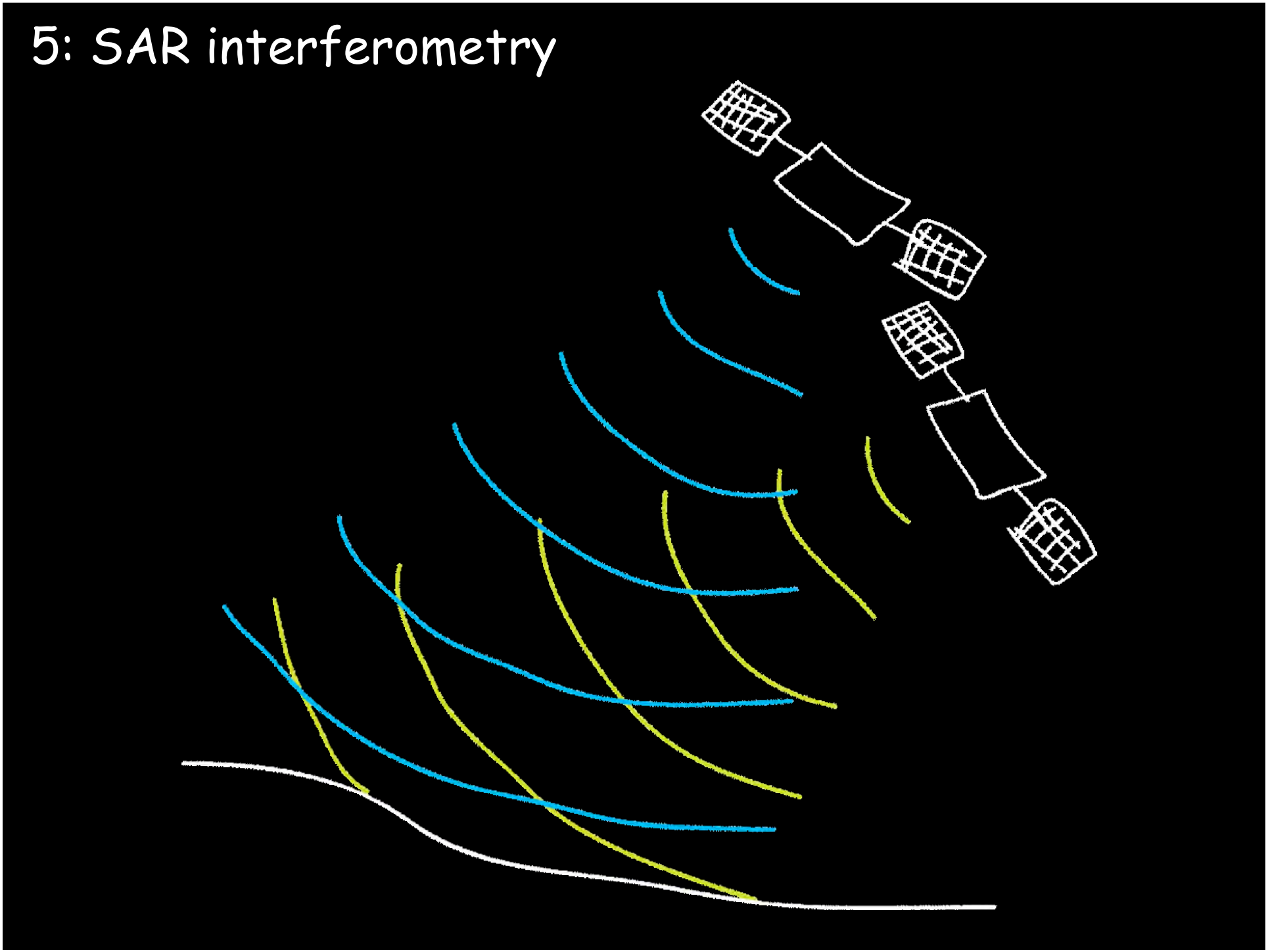

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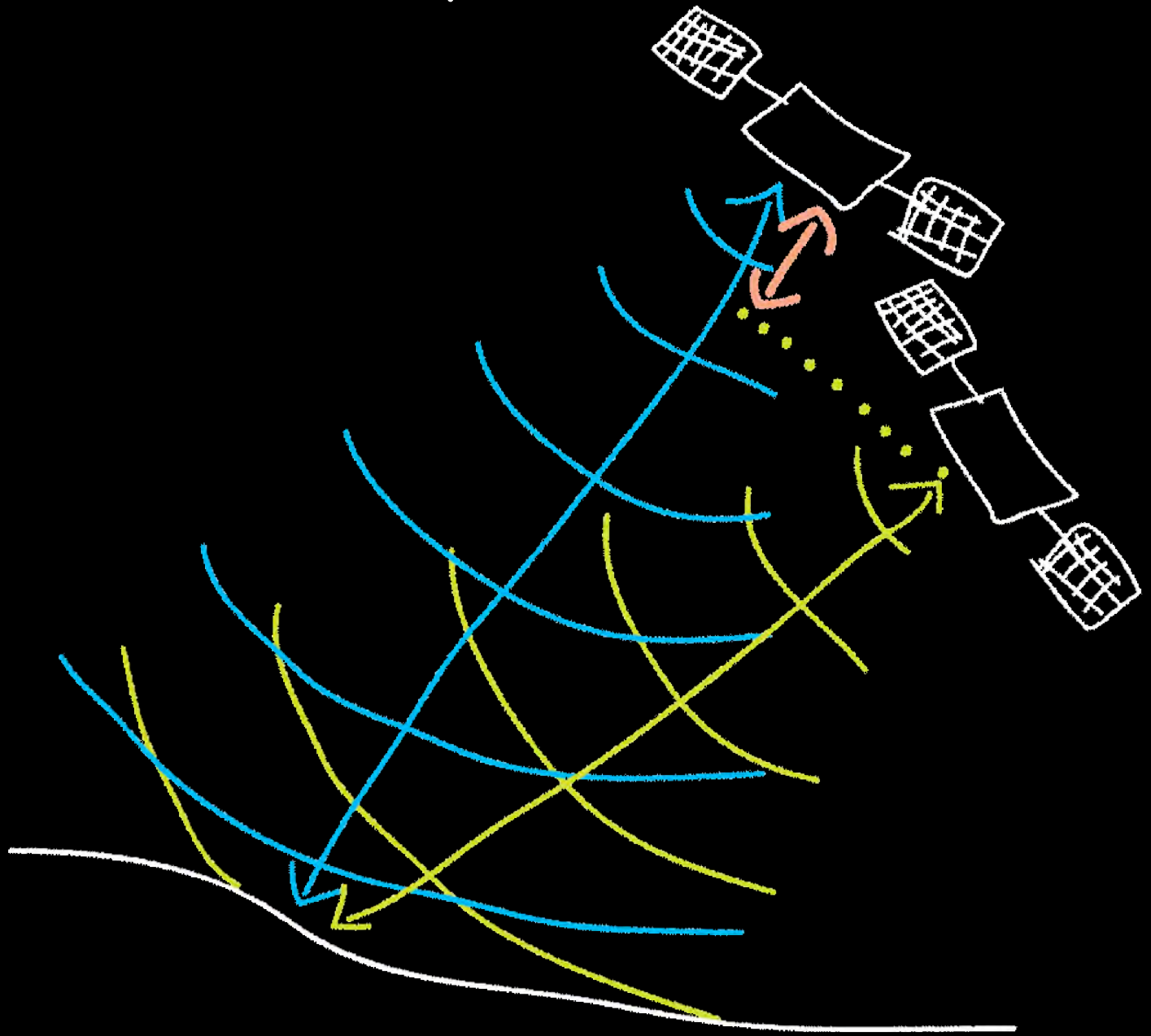

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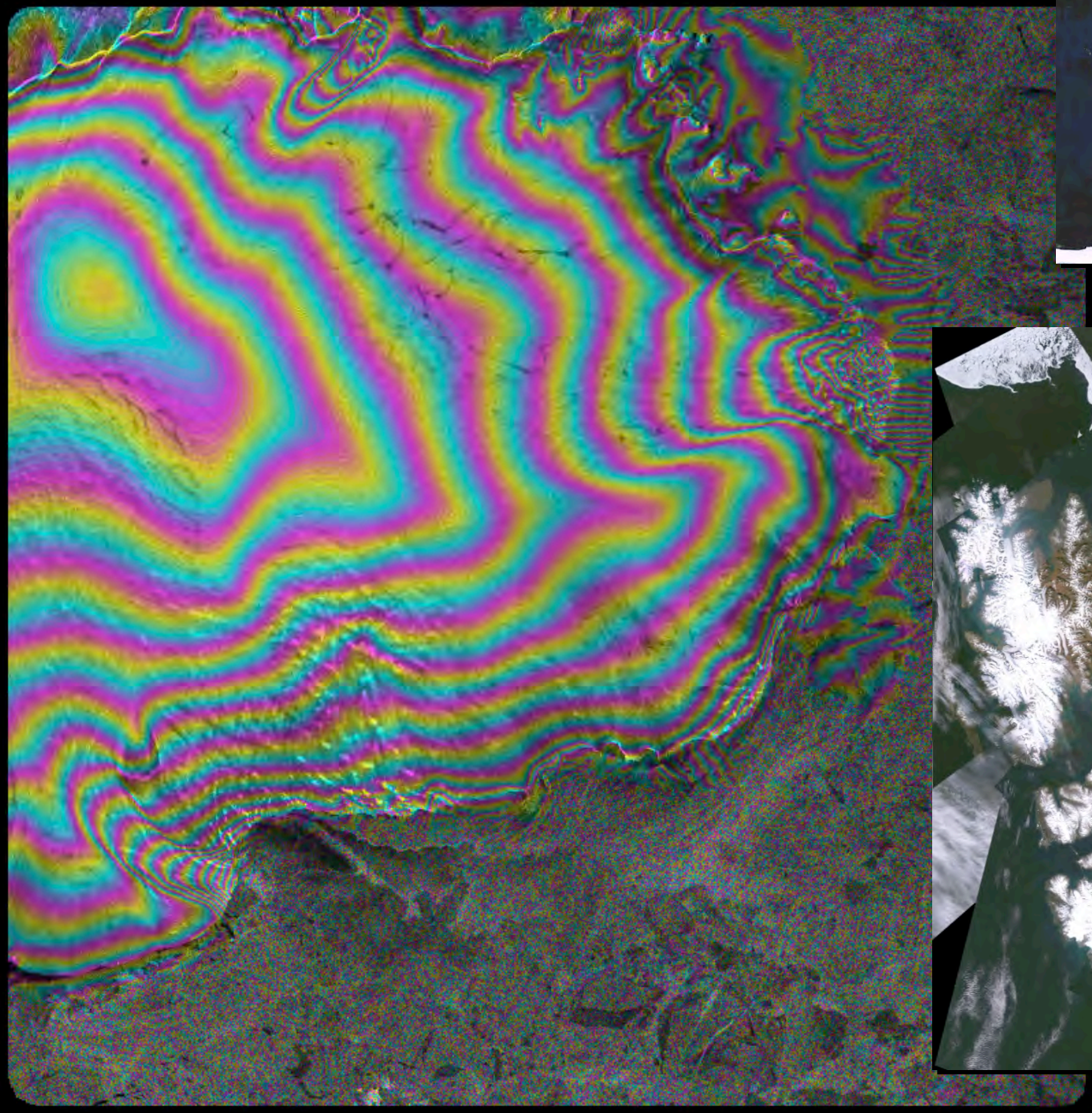

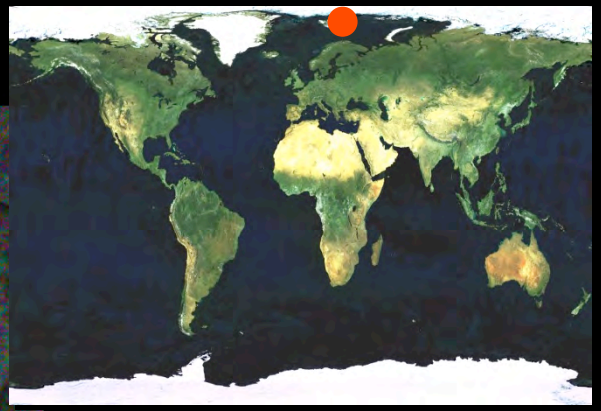

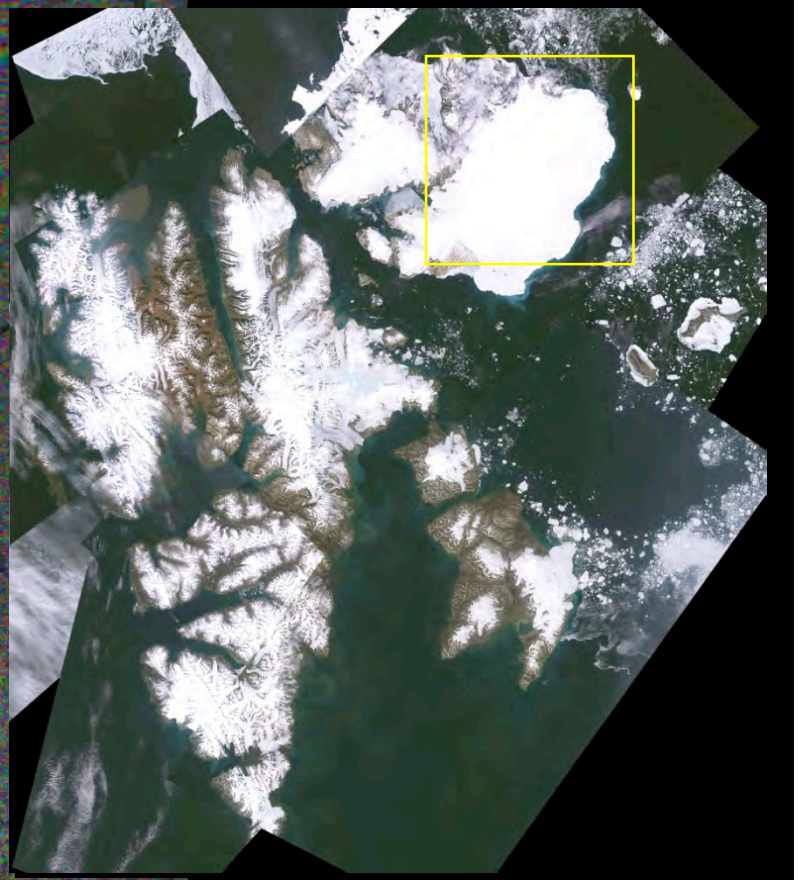

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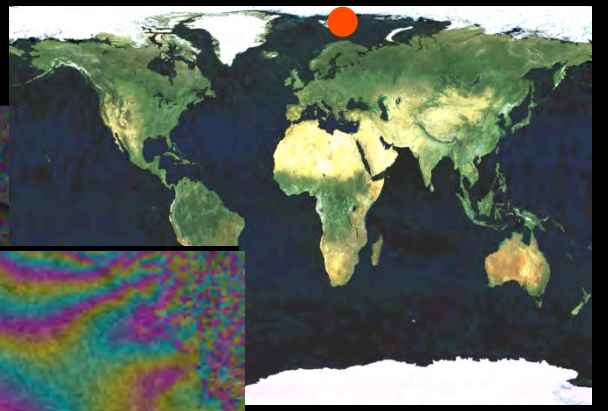
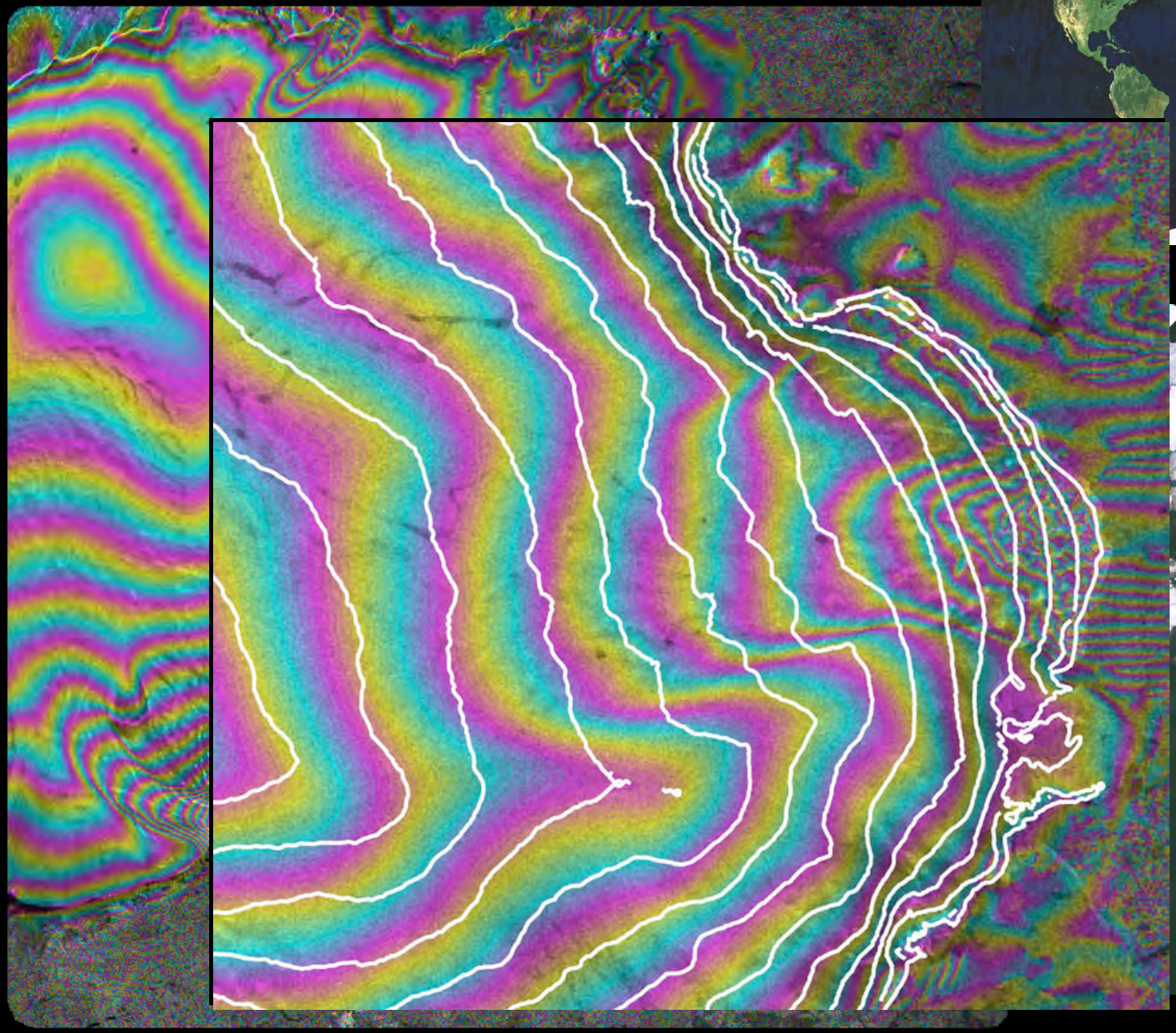
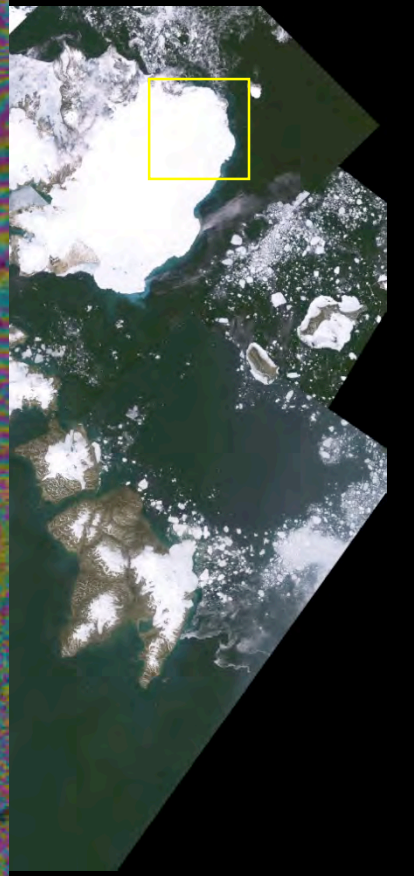
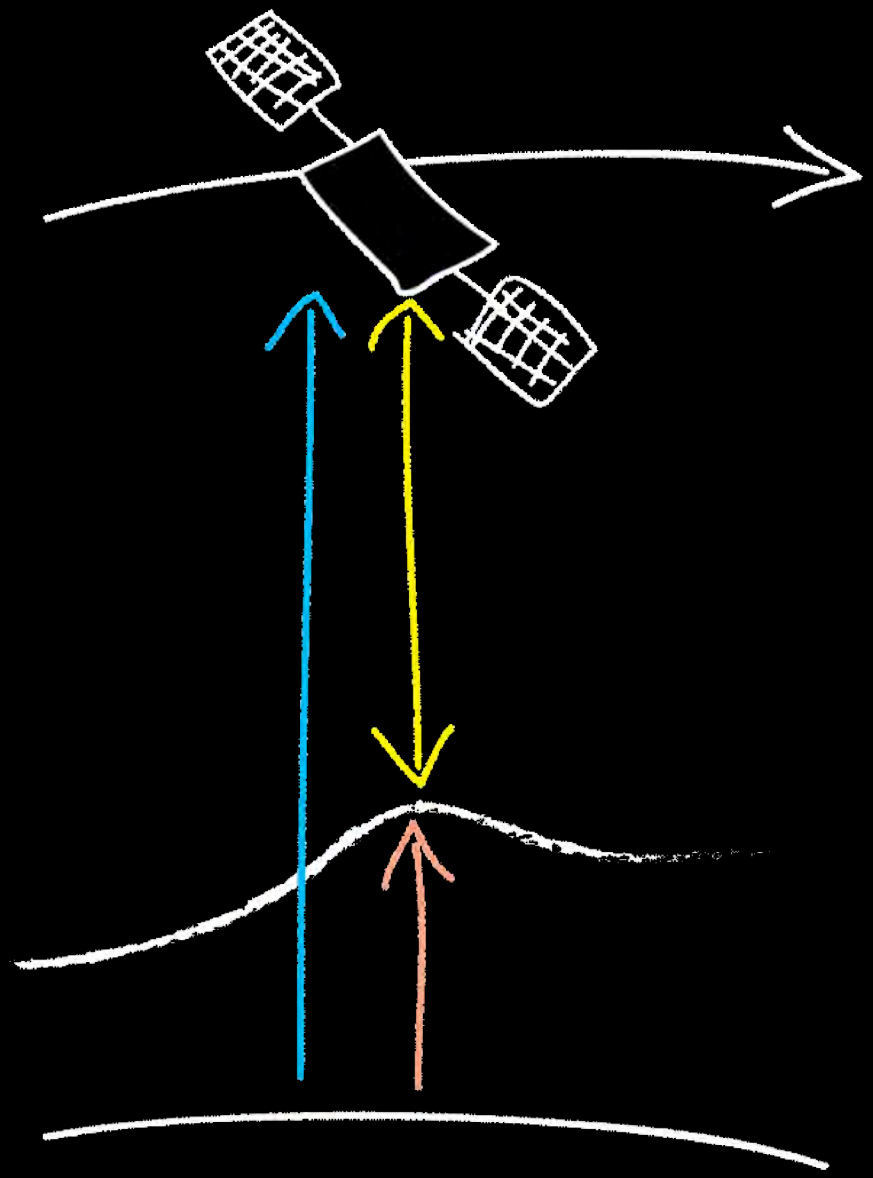


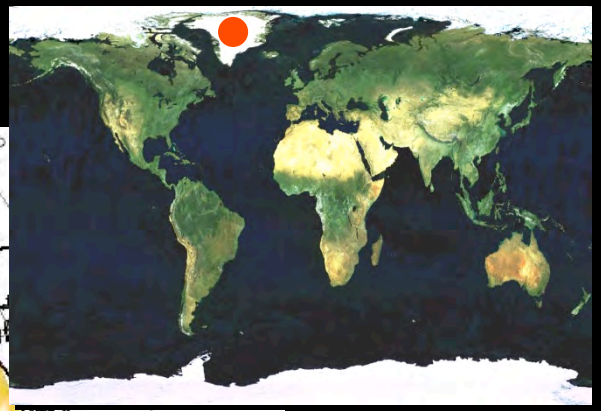


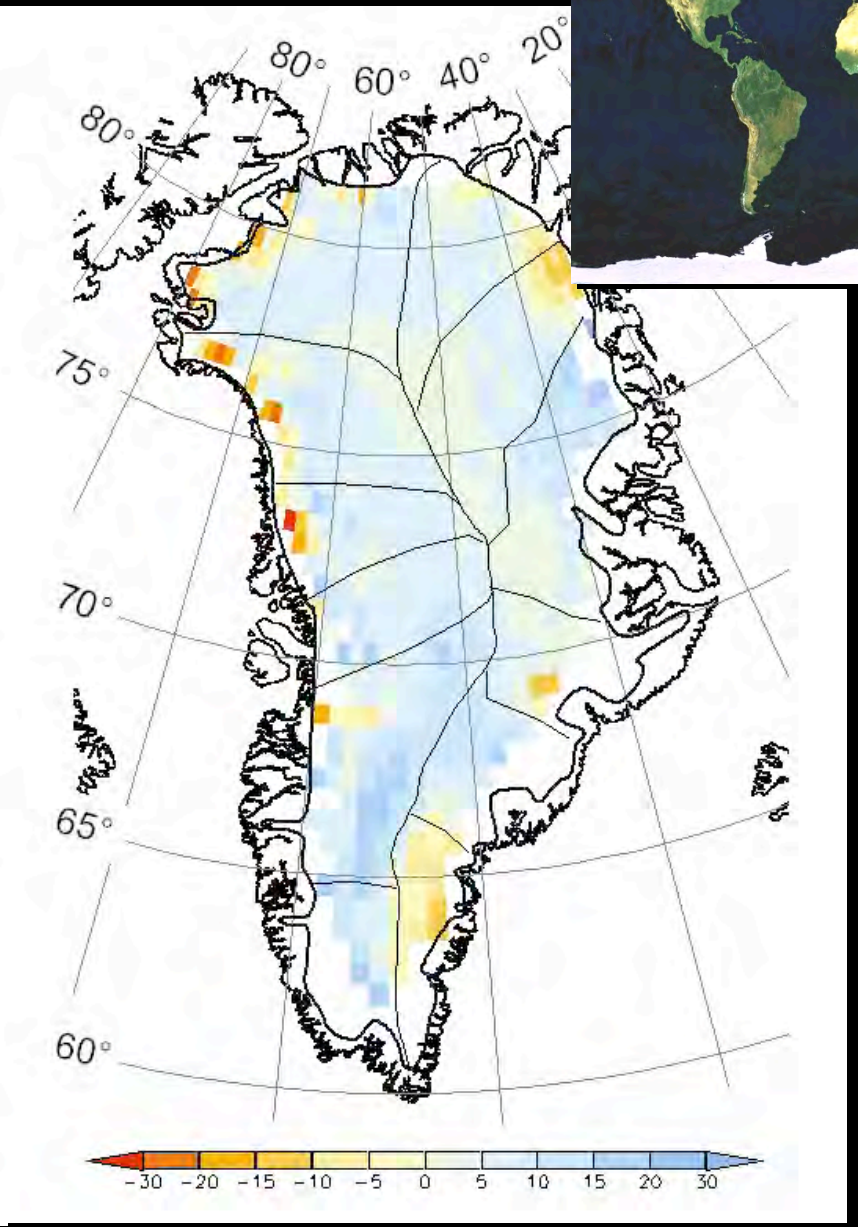


6: Satellite altimetry



6: Satellite altimetry (radar)

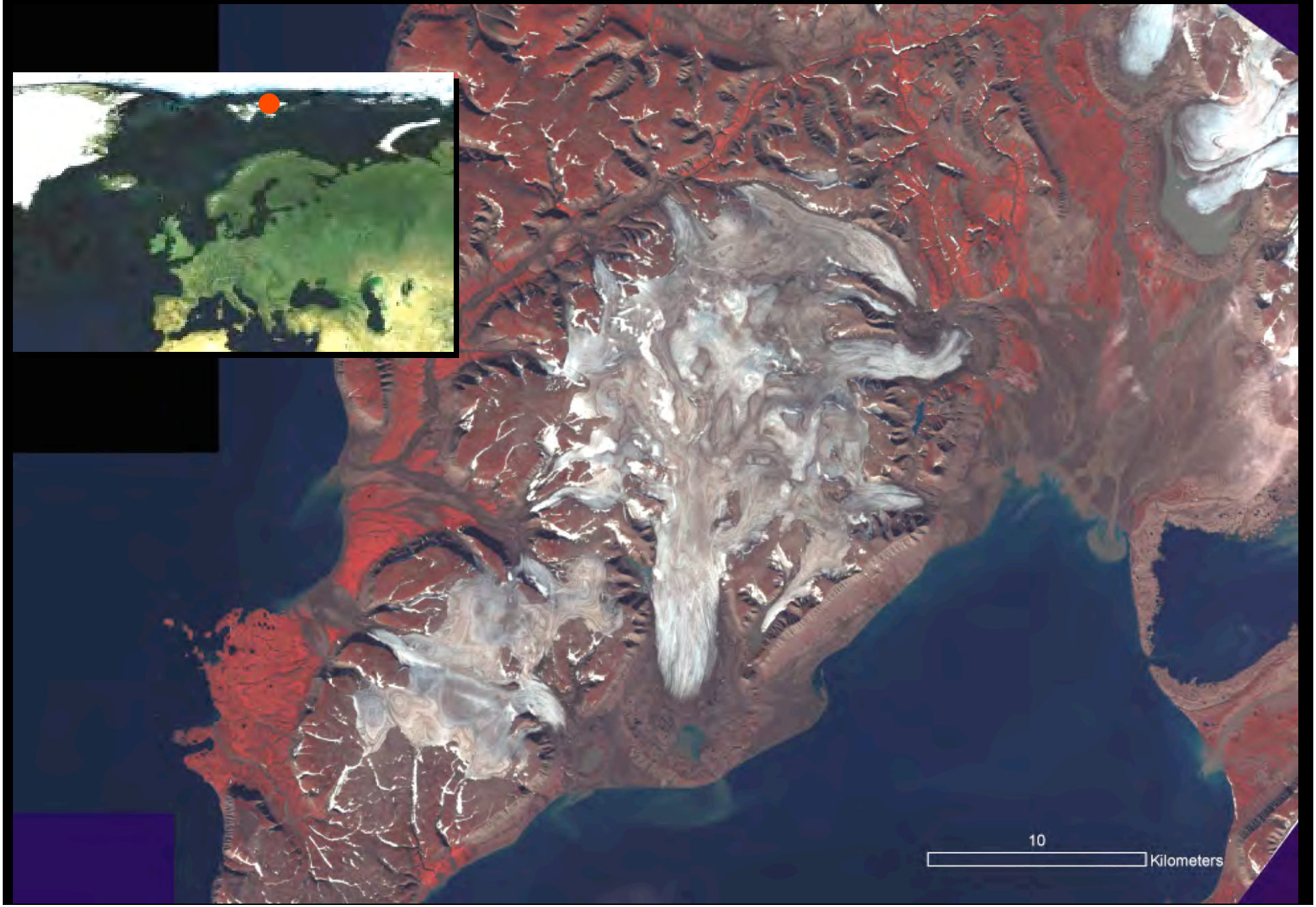




J. Bamber

1992 – 2003 (Johannessen et al.)

6: Satellite altimetry (laser)



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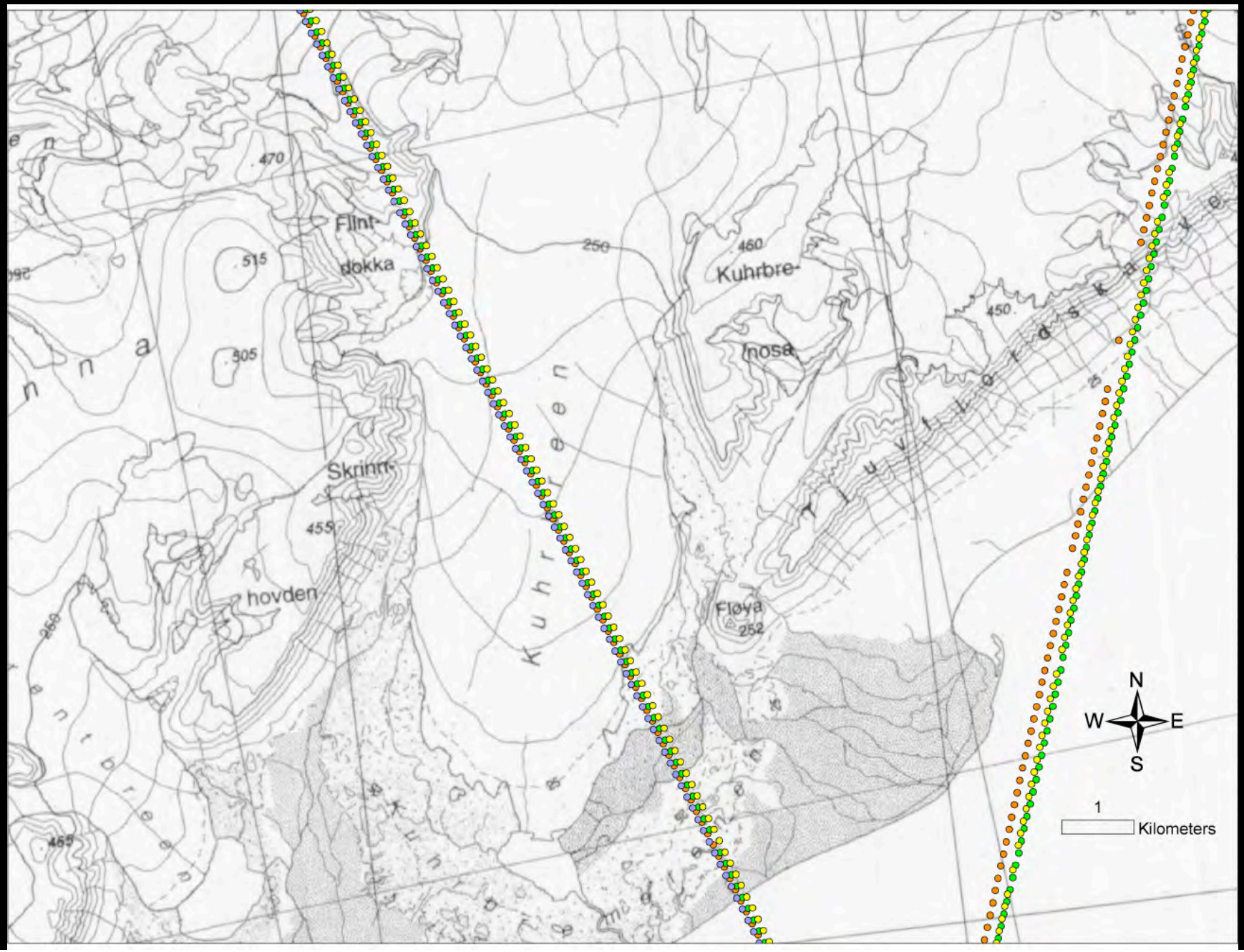

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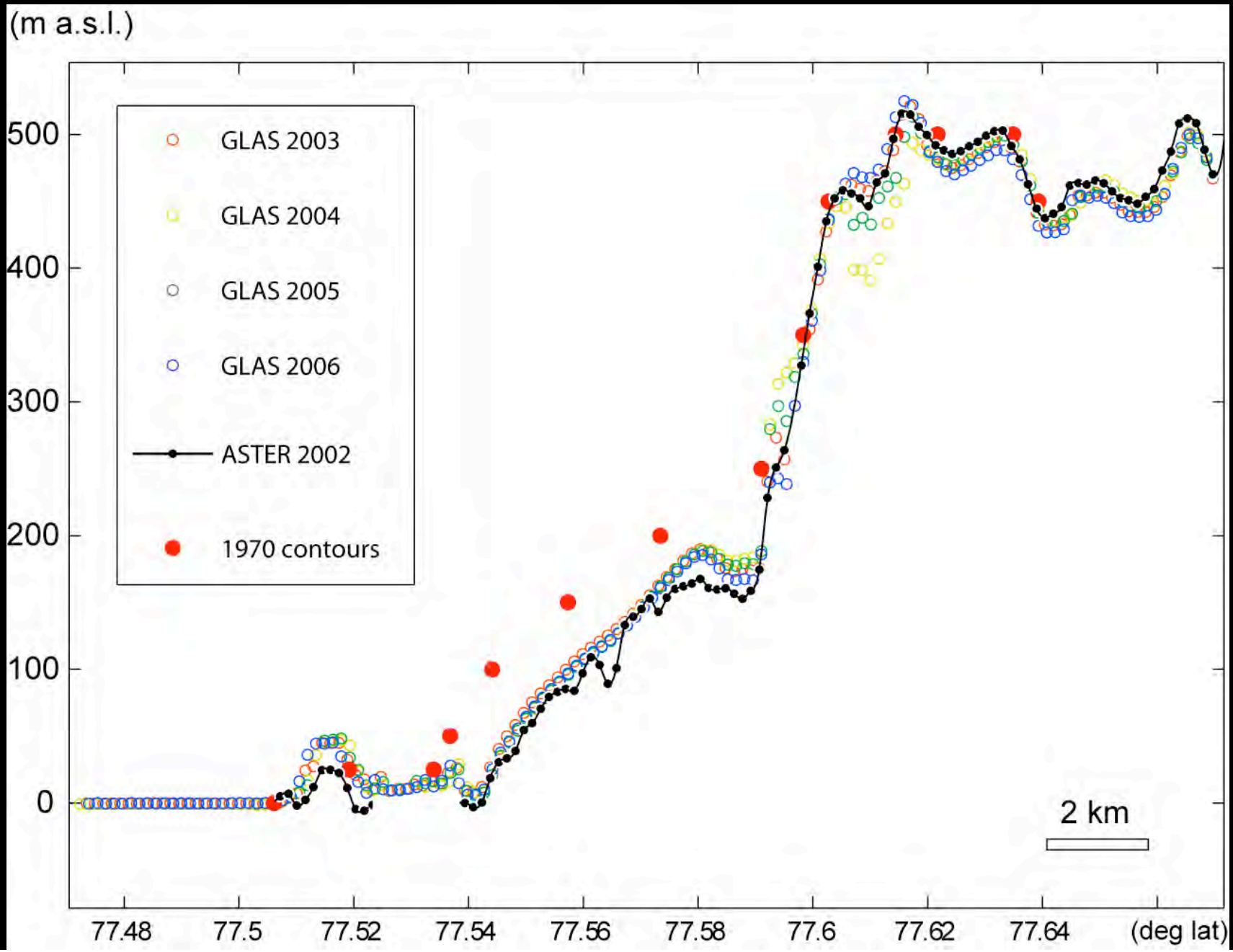

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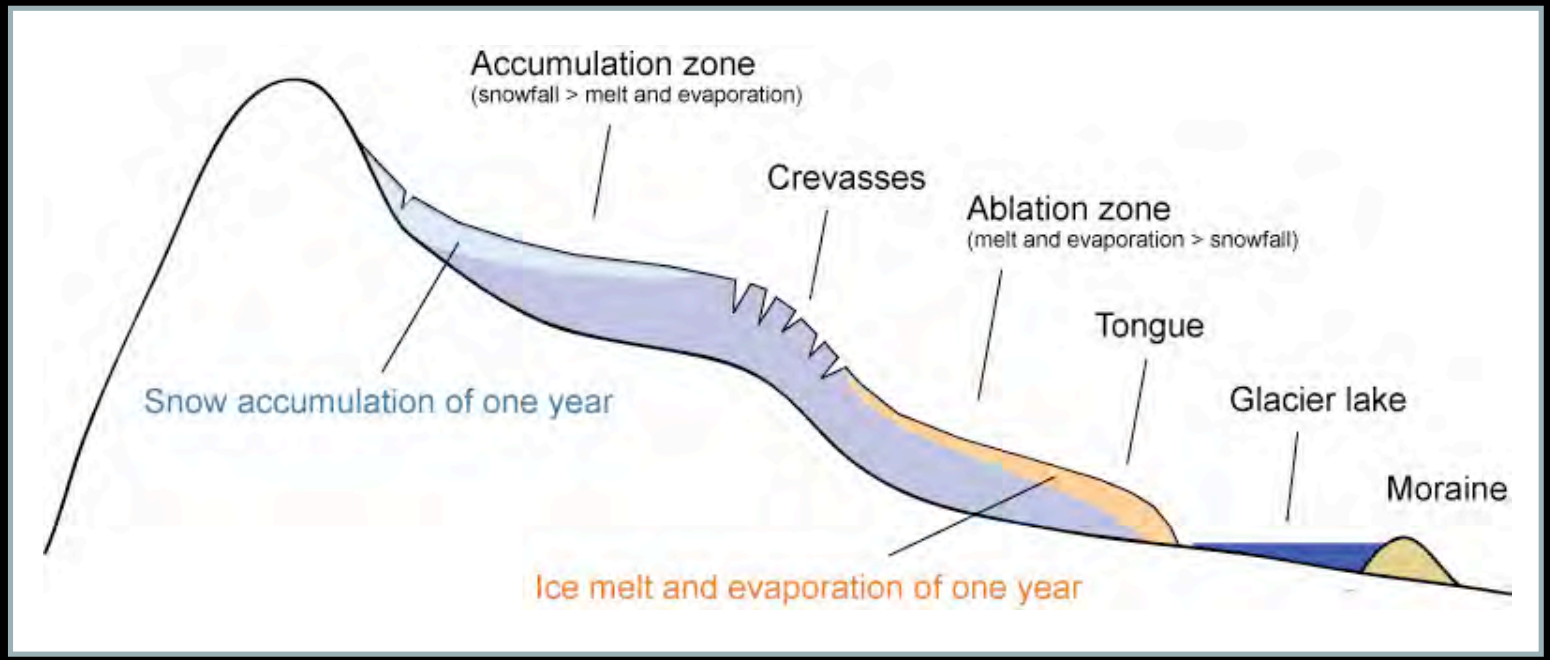
ESA Eduspace Glacier Module:

- Introduction to glaciers



ESA Eduspace Glacier Module:

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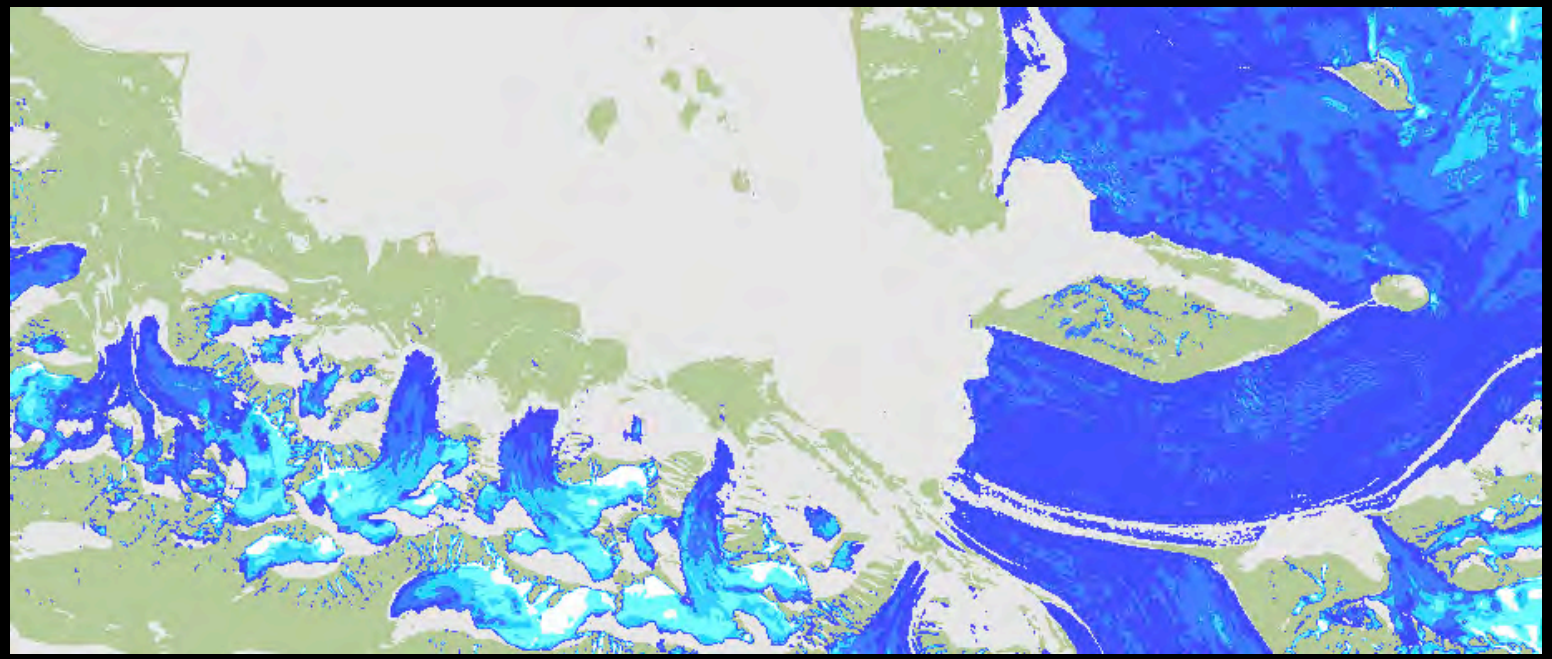
- Remote sensing of glaciers



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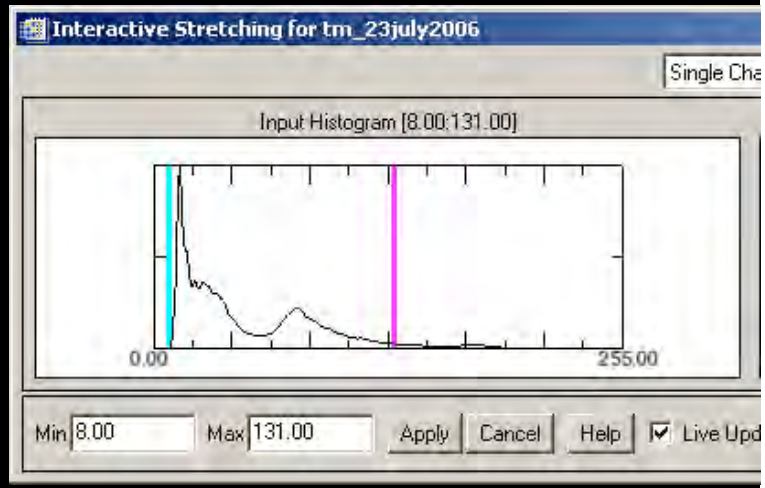
- Exercises



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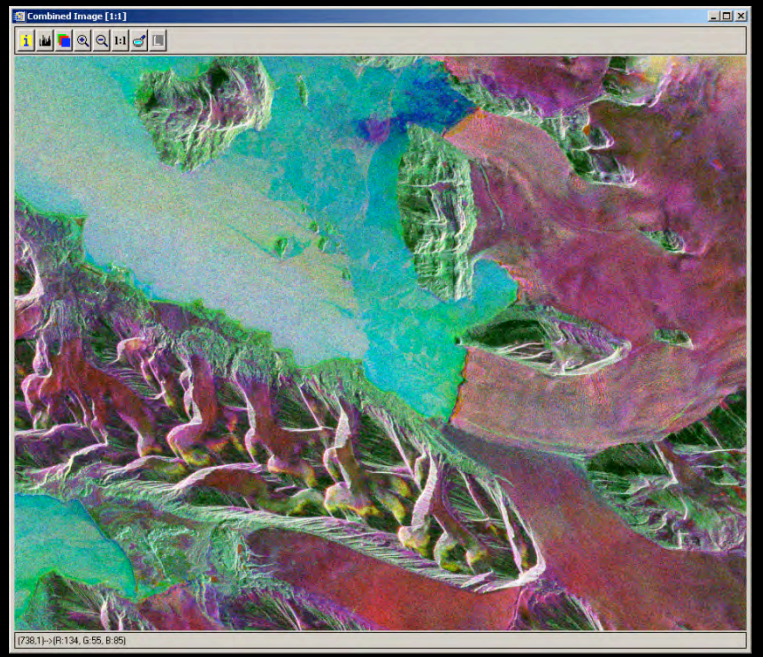

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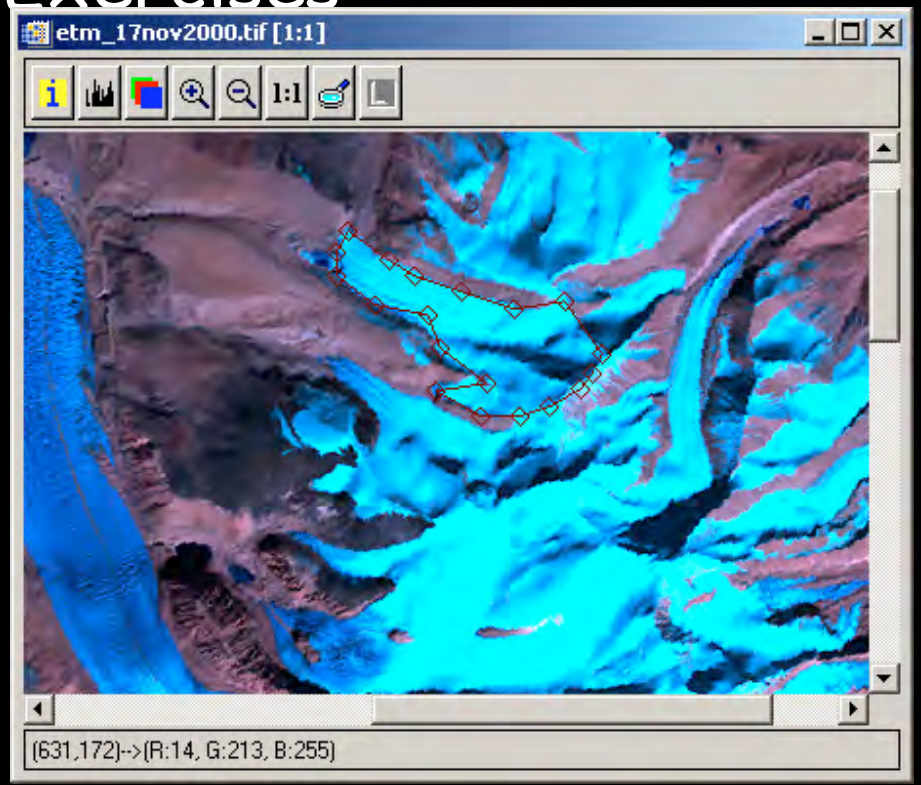

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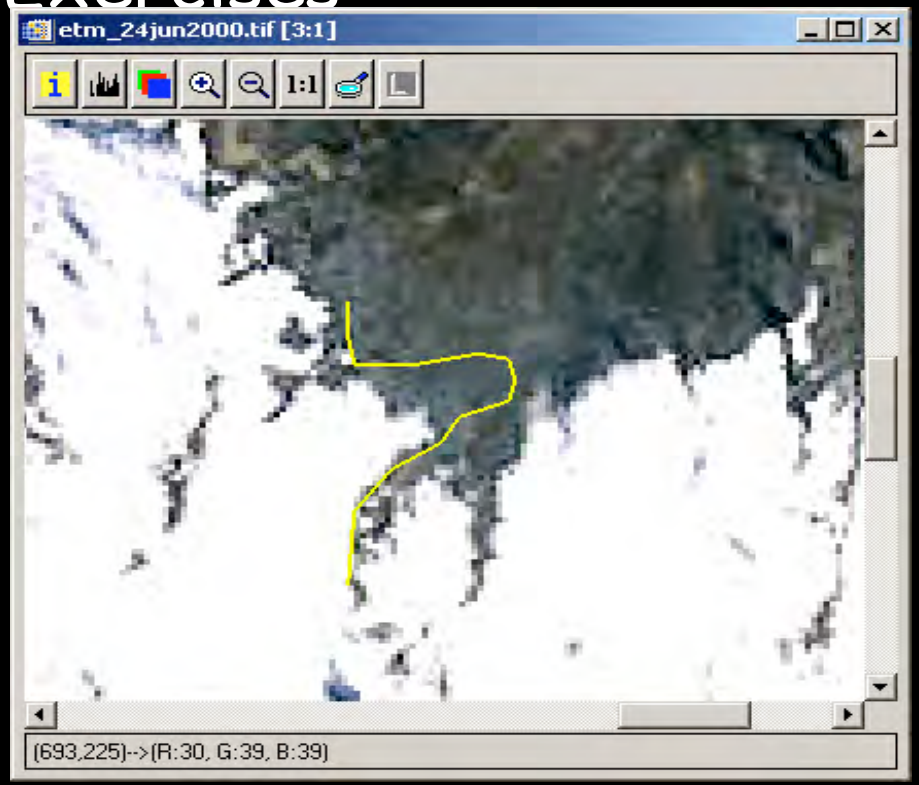

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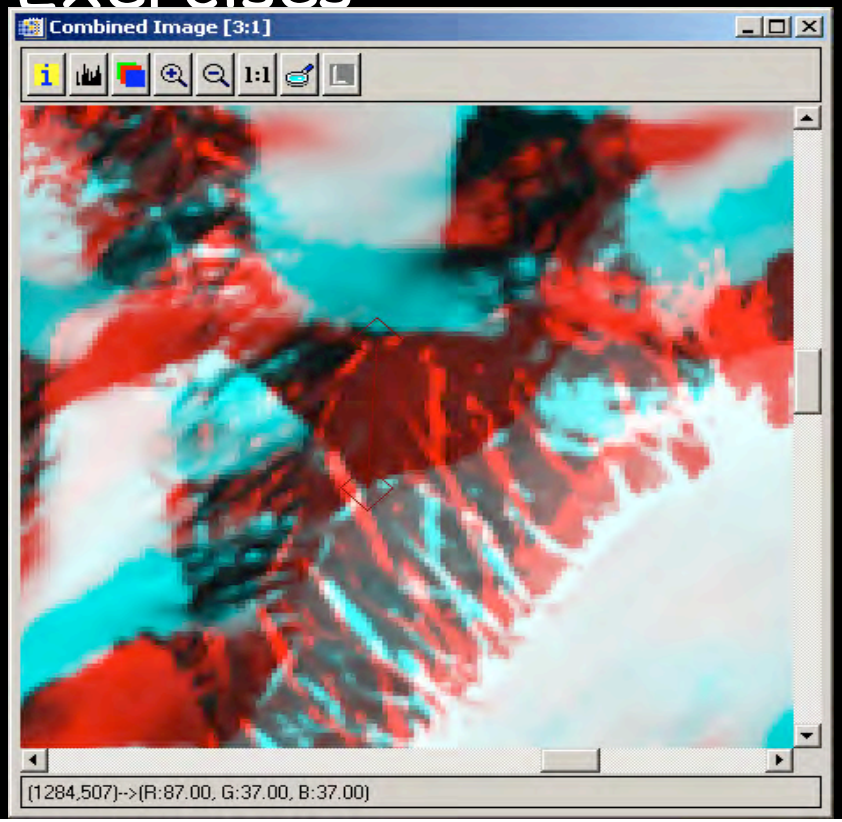

ESA Eduspace Glacier Module:

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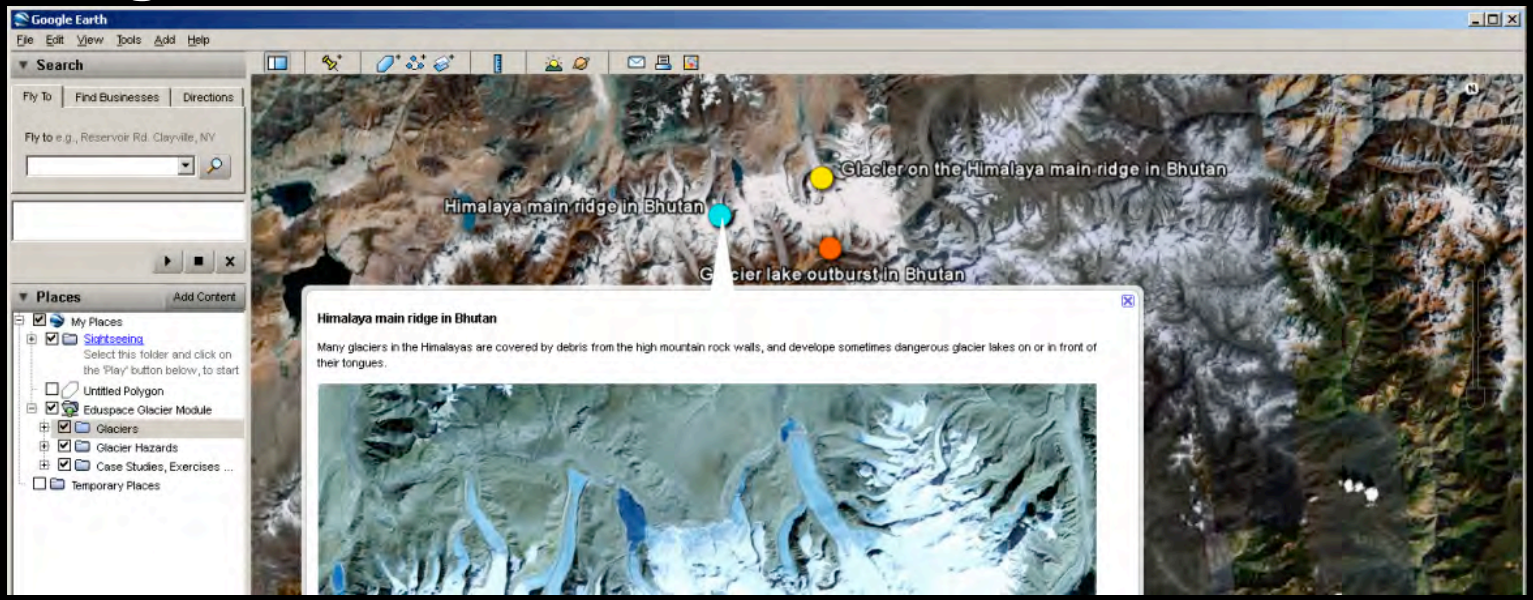
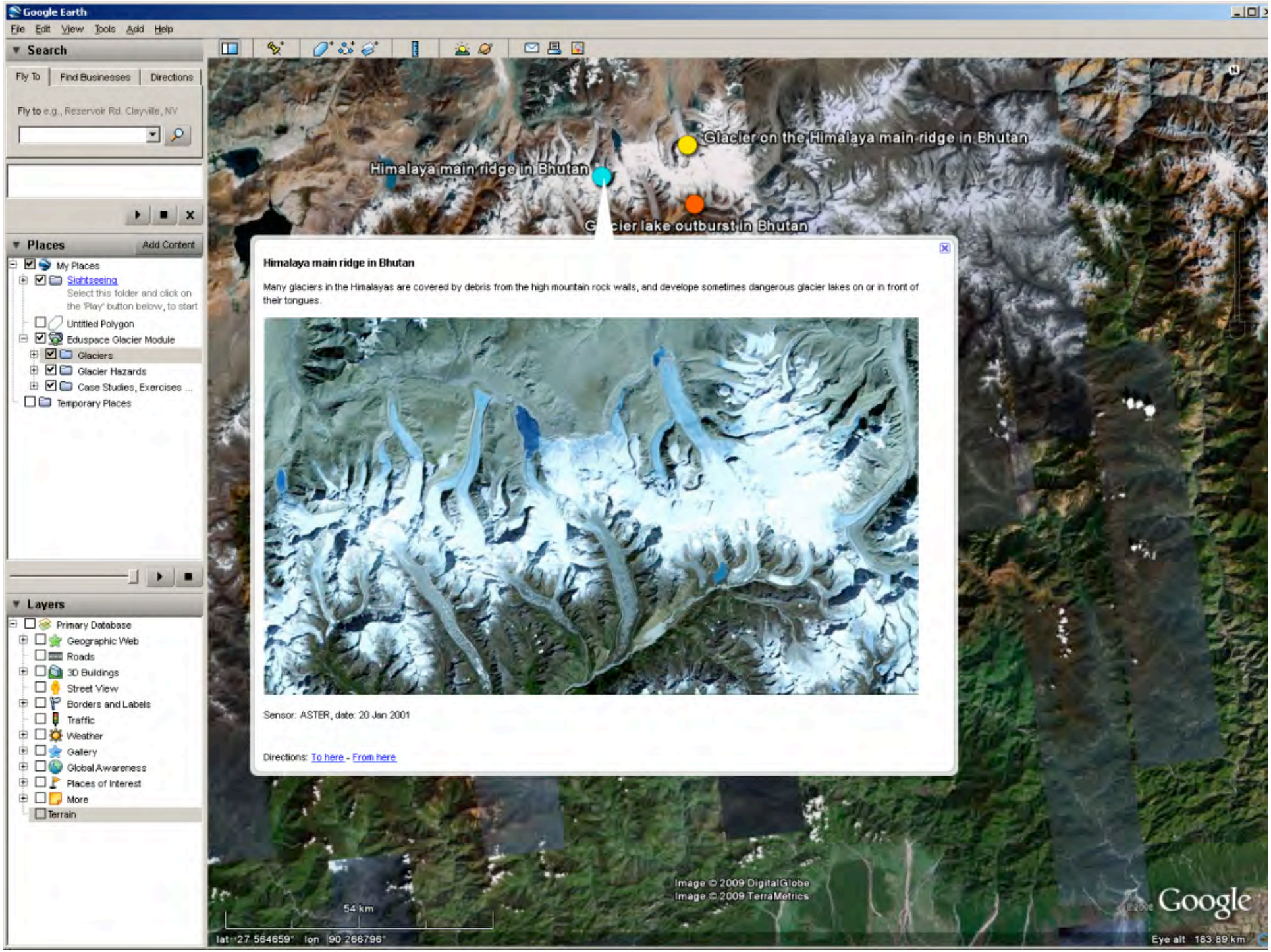
ESA Eduspace Glacier Module:

- Introduction to glaciers
- Remote sensing of glaciers
- Exercises
- GoogleEarth file

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Glacier on the Himalaya main ridge in Bhutan
Himalaya main ridge in Bhutan
cier lake outburst in Bhutan
Himalaya main ridge in Bhutan
Many glaciers in the Himalayas are covered by debris from the high mountain rock walls, and develope sometimes dangerous glacier lakes on or in front of their tongues.
Sensor: ASTER, date: 20 Jan 2001
Directions: To here - From here
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Image © 2009 TerraMetrics
54 km
lat 27.564659° lon 90.266796°
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Glacier on the Himalaya main ridge in Bhutan

Himalaya main ridge in Bhutan

Glacier lake outburst in Bhutan

Glacier lake outburst in Bhutan

Retreating valley glaciers often leave behind glacier lakes in front of or within their melting tongues. Nearly all glaciers in this image of the Bhutan Himalayas show lakes at their tongues. Once such a lake has formed, melting and retreat of the glacier front accelerates because water transports heat much more efficiently to the ice front than air can. The Bhutan Himalayas currently host more than 2,500 glacier lakes. On October 7, 1994, the greenish lake to the right in this image, Lugge Tsho, partially burst out. Though the impact in this lightly populated area was minimal (2 houses were damaged, five water mills washed away, and about 3 km2 of land damaged), traces of the subsequent debris flow down the valley remain visible seven years later in this 2001 image. The glacier tongue seen in the middle of the image, between the blue and green lakes, shows clearly how small ponds forming on a melting glacier tongue can rapidly grow and connect with one another to form large, potentially hazardous lakes.

Sensor: ASTER, date: 20 Jan 2001

Directions: To here - From here

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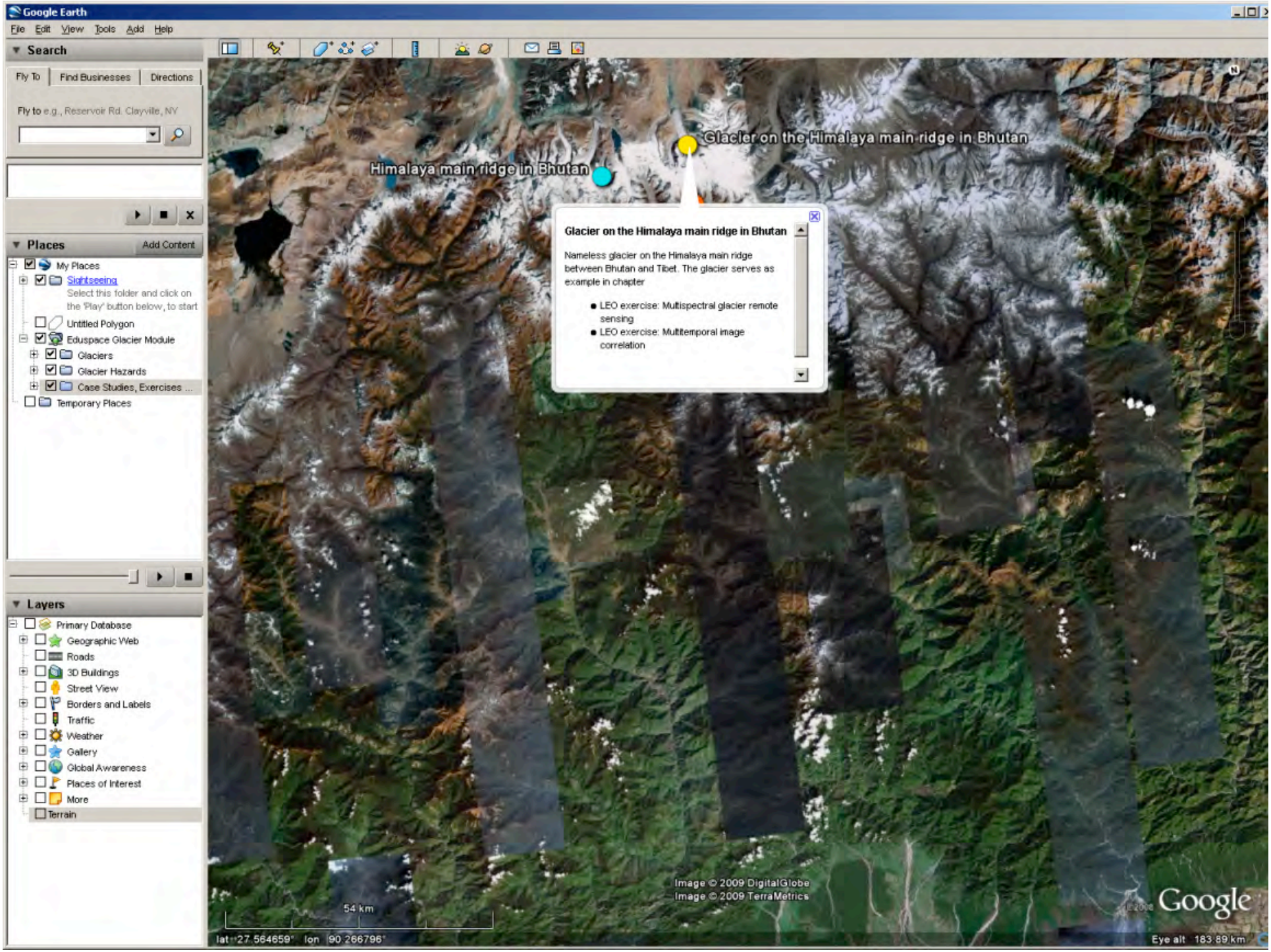
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Himalaya main ridge in Bhutan
Glacier on the Himalaya main ridge in Bhutan
Glacier on the Himalaya main ridge in Bhutan
Nameless glacier on the Himalaya main ridge between Bhutan and Tibet. The glacier serves as example in chapter
LEO exercise: Multispectral glacier remote sensing
LEO exercise: Multitemporal image correlation
Image © 2009 DigitalGlobe
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lat 27.564659° lon 90.266796°
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Thank you !

Andreas KÄÄB

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