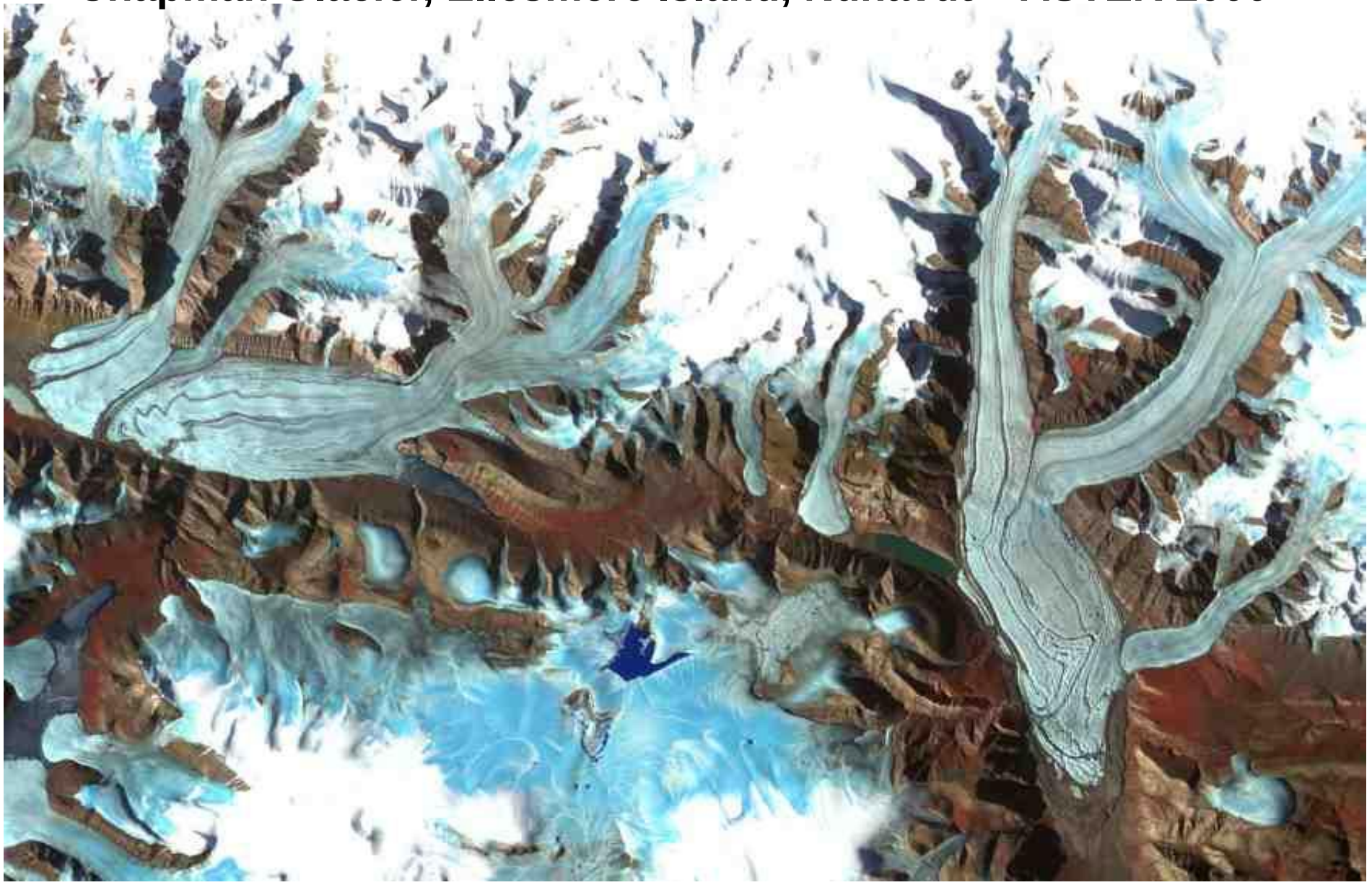
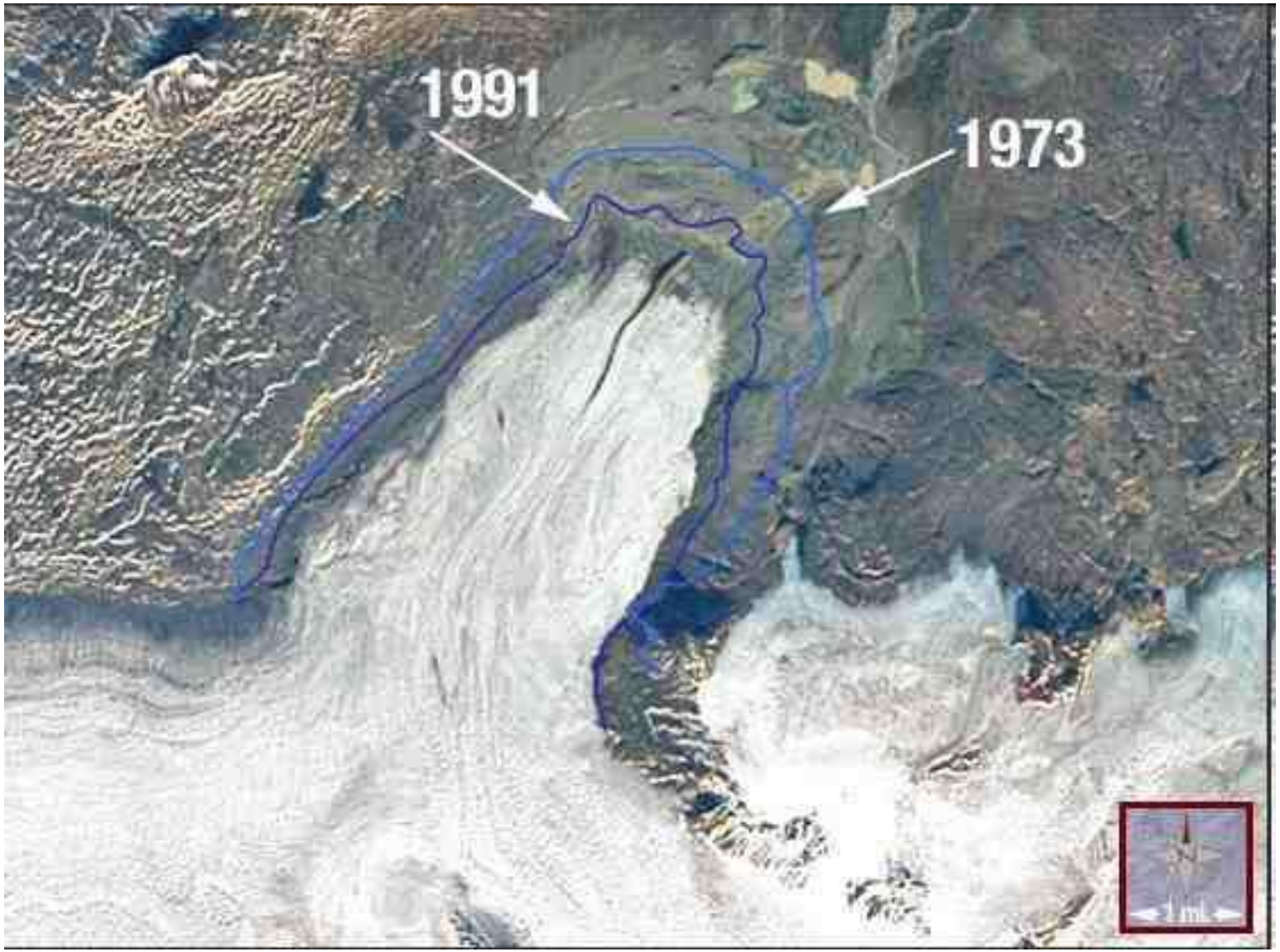
Remote Sensing of Glaciers

Chapman Glacier, Ellesmere Island, Nunavut – ASTER 2000



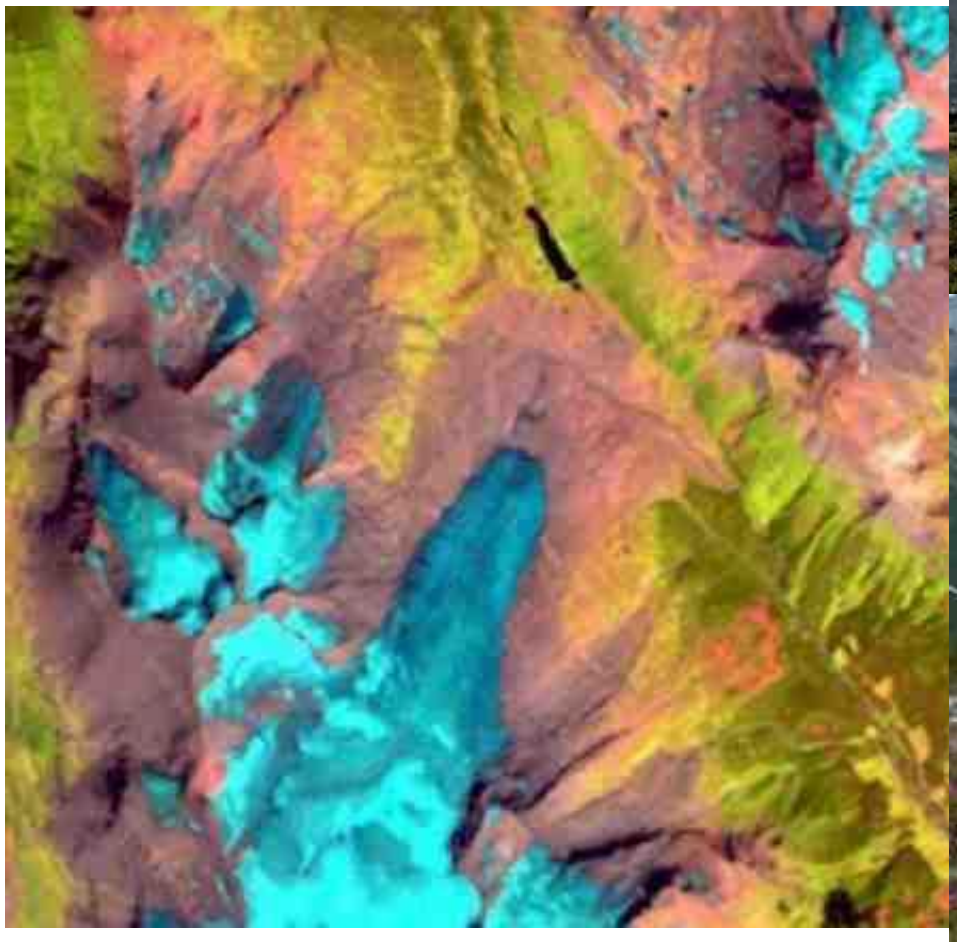
Digitised features: Eyjabakkajökull glacier, Iceland



Generated from maps, digital vectors, or image processing – all initially remote sensing

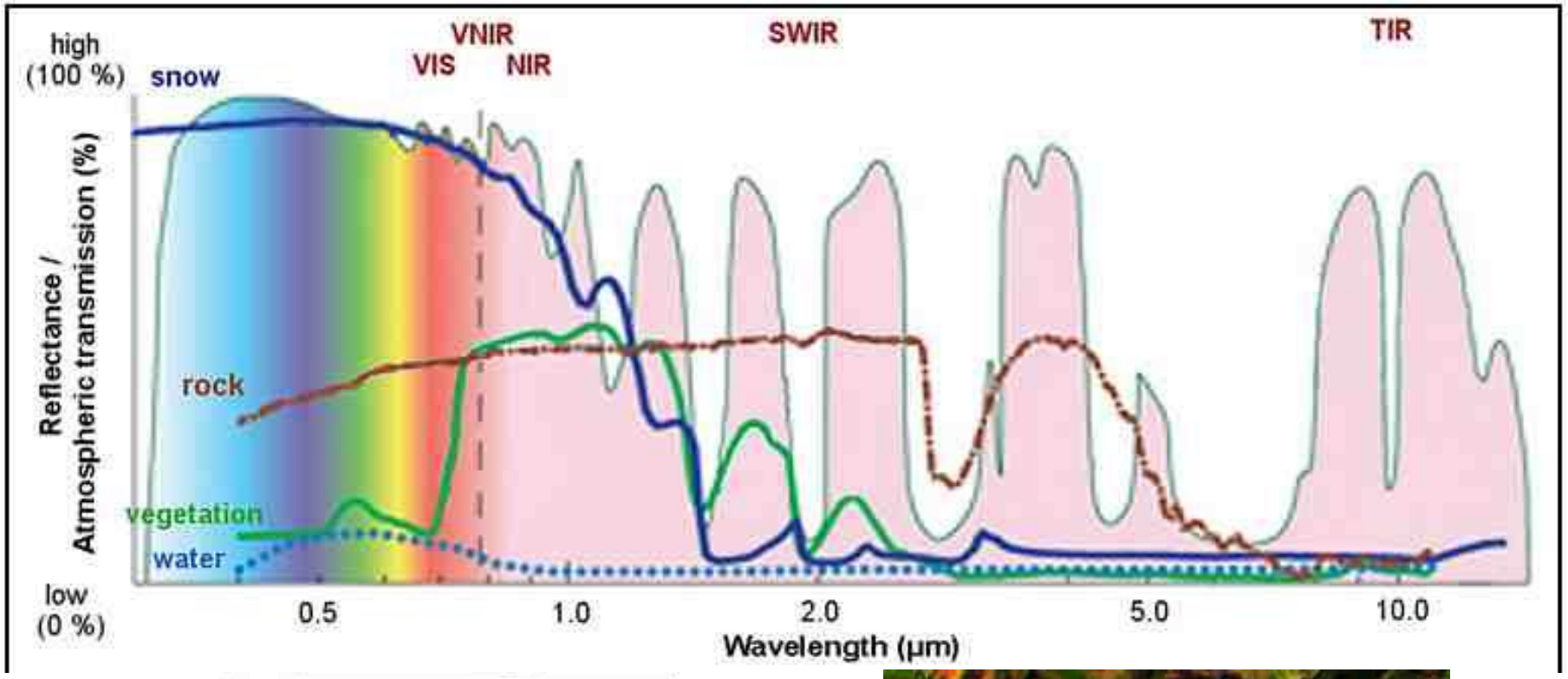
Landsat Images (since 1972 / 1984)
Most glaciers are remote ….

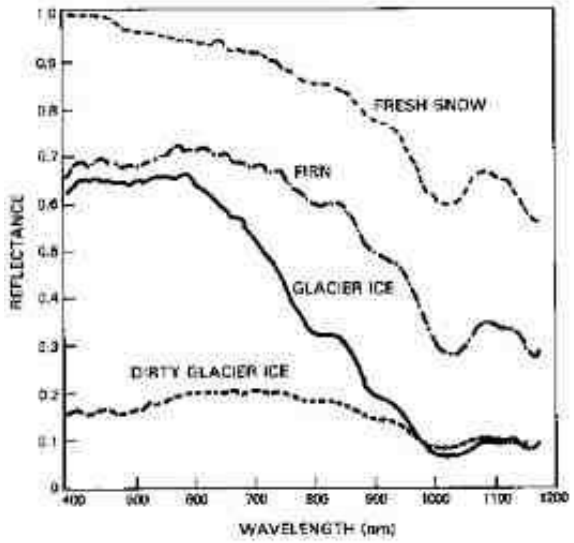
Note mark of Little Ice Age ~ 1850

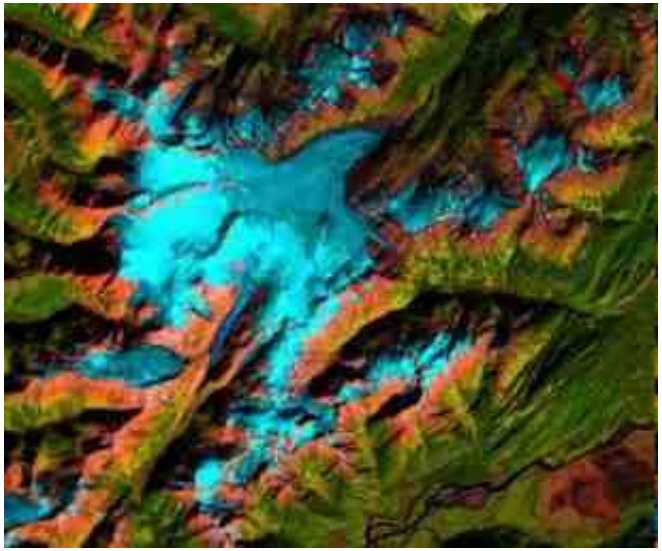


Note late lying snow cover

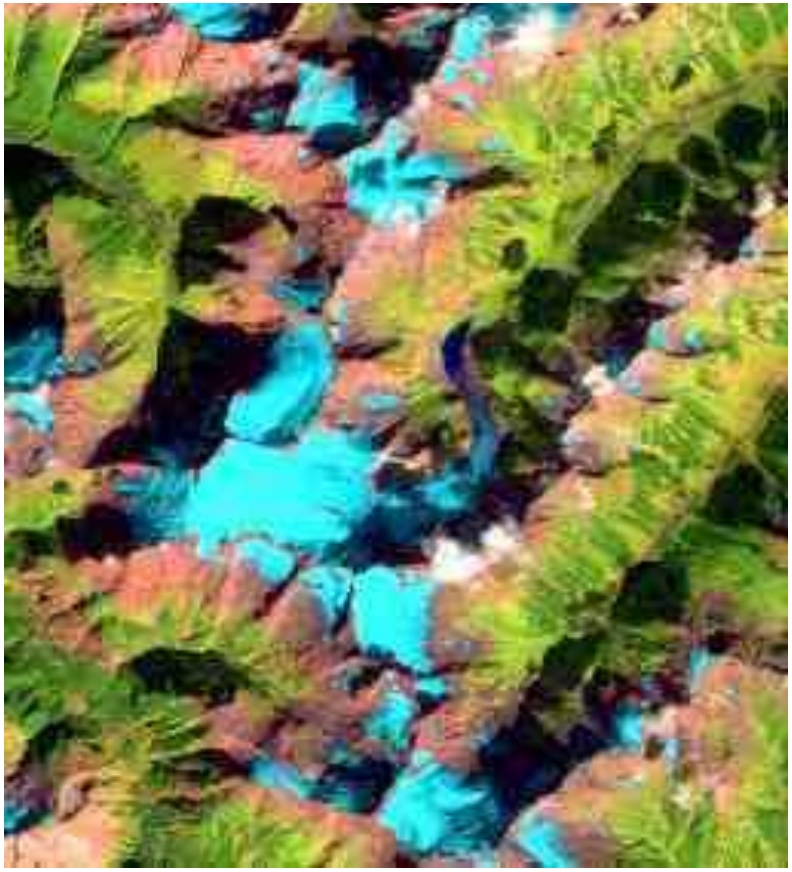
Spectral characteristics of snow and ice







The spectral curve explains why glaciers look blue-green on a 5-4-3 composite (why?) .. and enables distinguishing snow/ice from clouds compared to a normal composite.. (why?)



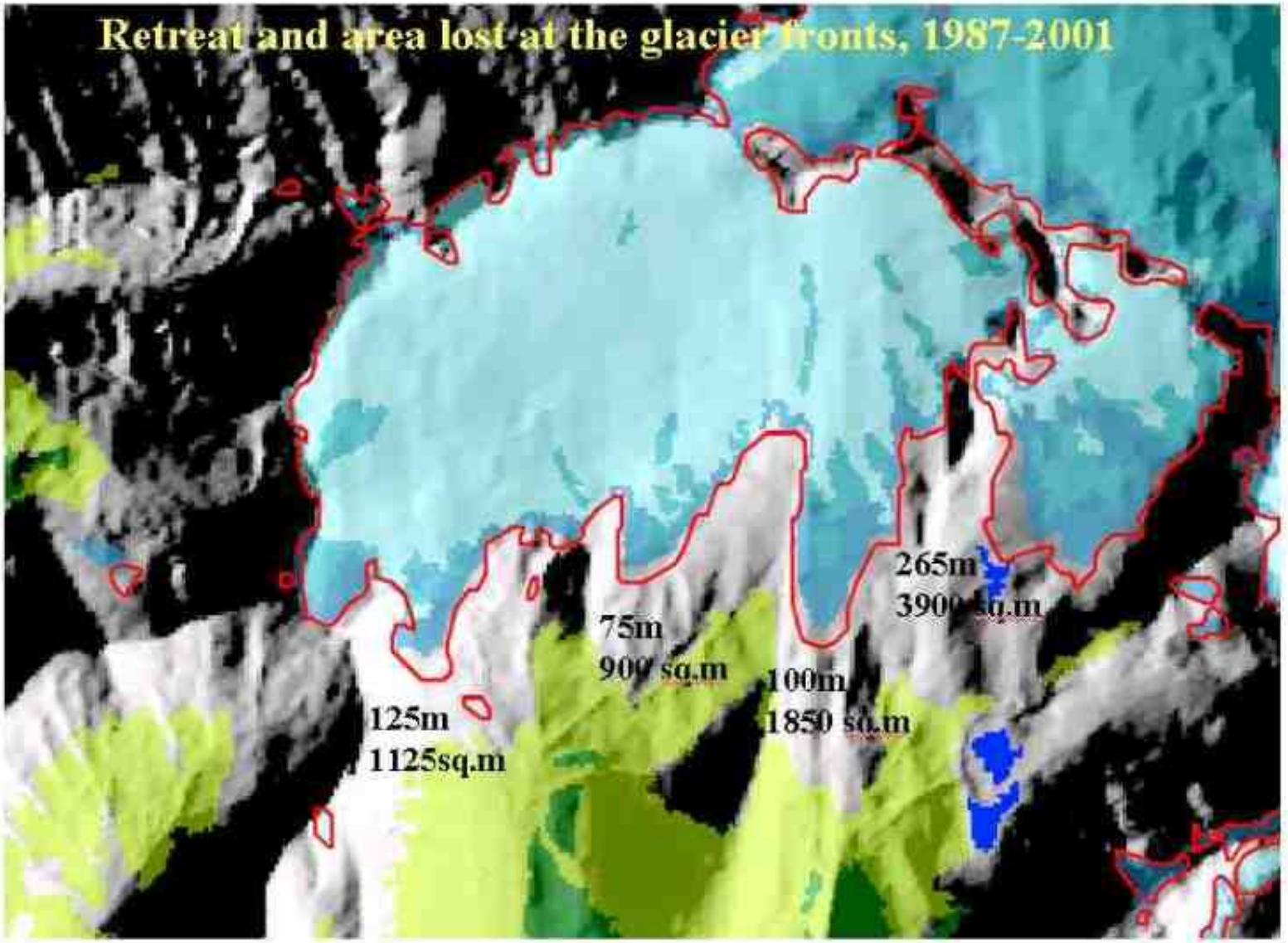
Mid-IR/Near-IR-Red

Red-Green-Blue

http://asterweb.jpl.nasa.gov/gallery-detail.asp?name=Aletsch

1. Image classification - supervised

Accumulation area (snow); Ablation (ice) ... and firn (wet snow)



Unsupervised classification: McBride OLI image including Kristi Glacier (SW corner)

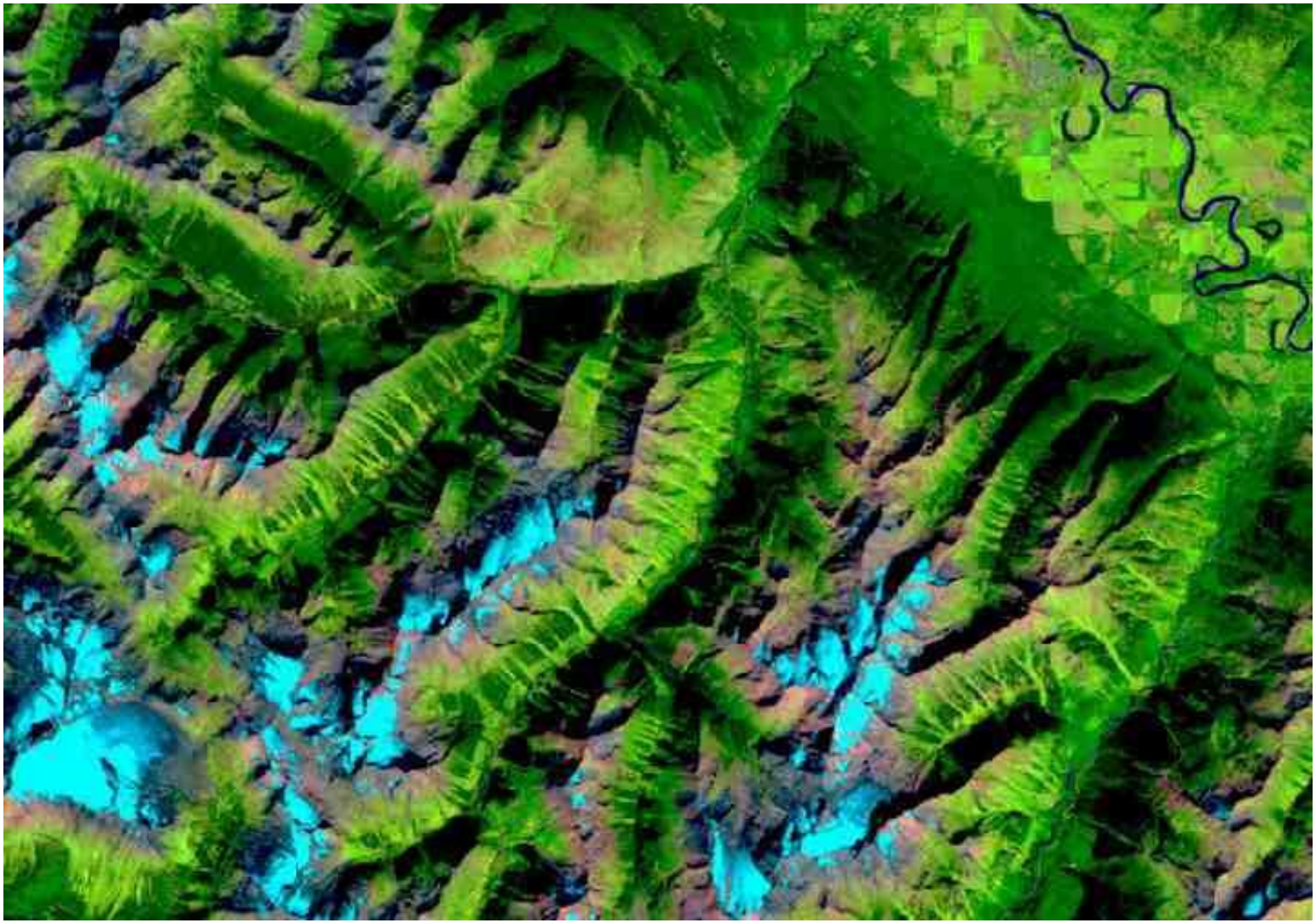
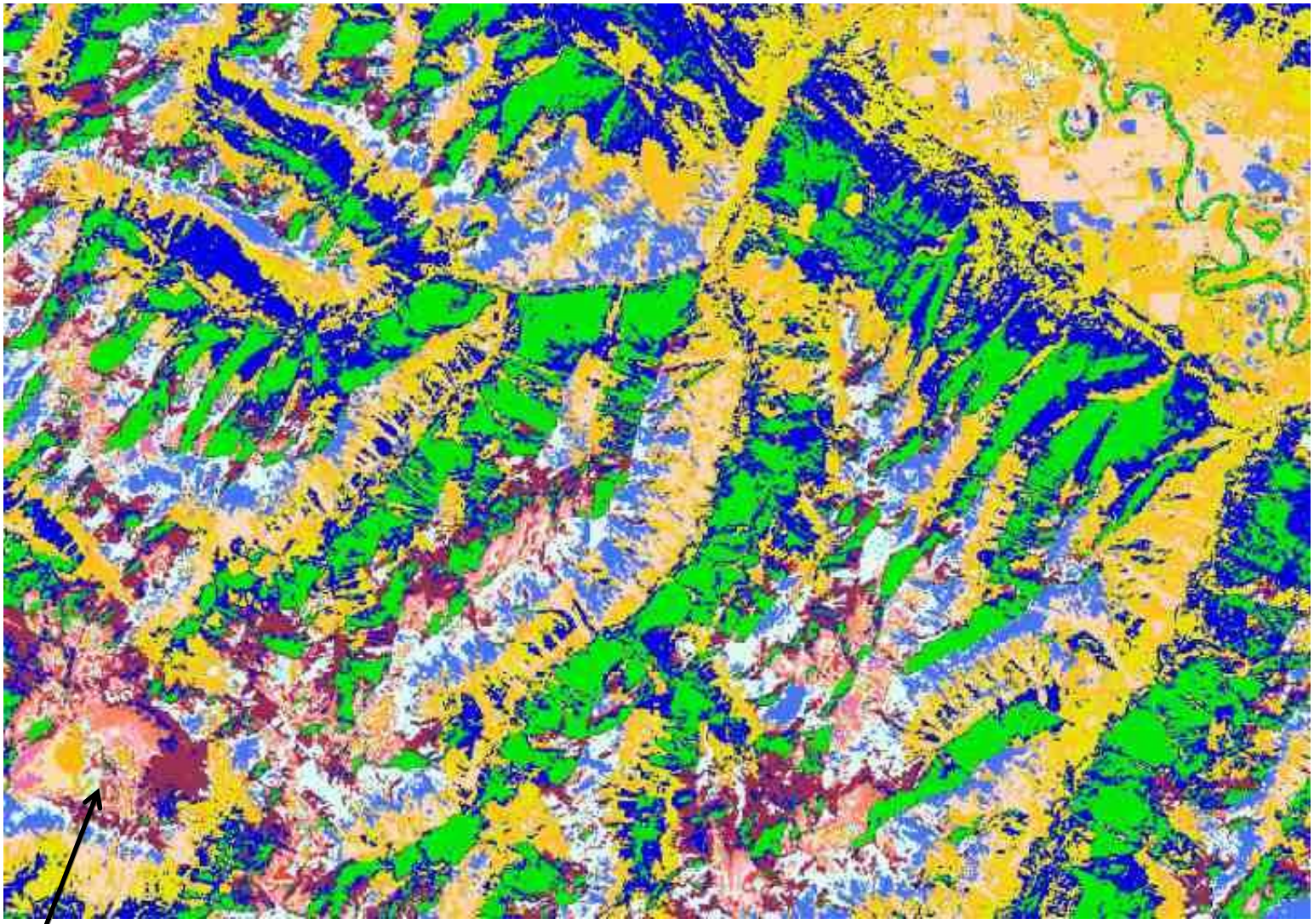


Image classification - Unsupervised



These orange-pink ones, not the brown one (forefield) – why so many 6?

2. Normalised Difference Snow Index (NDSI)

NDSI (TM) = (2-5)/(2+5)

NDSI (OLI) = (3-6)/(3+6)

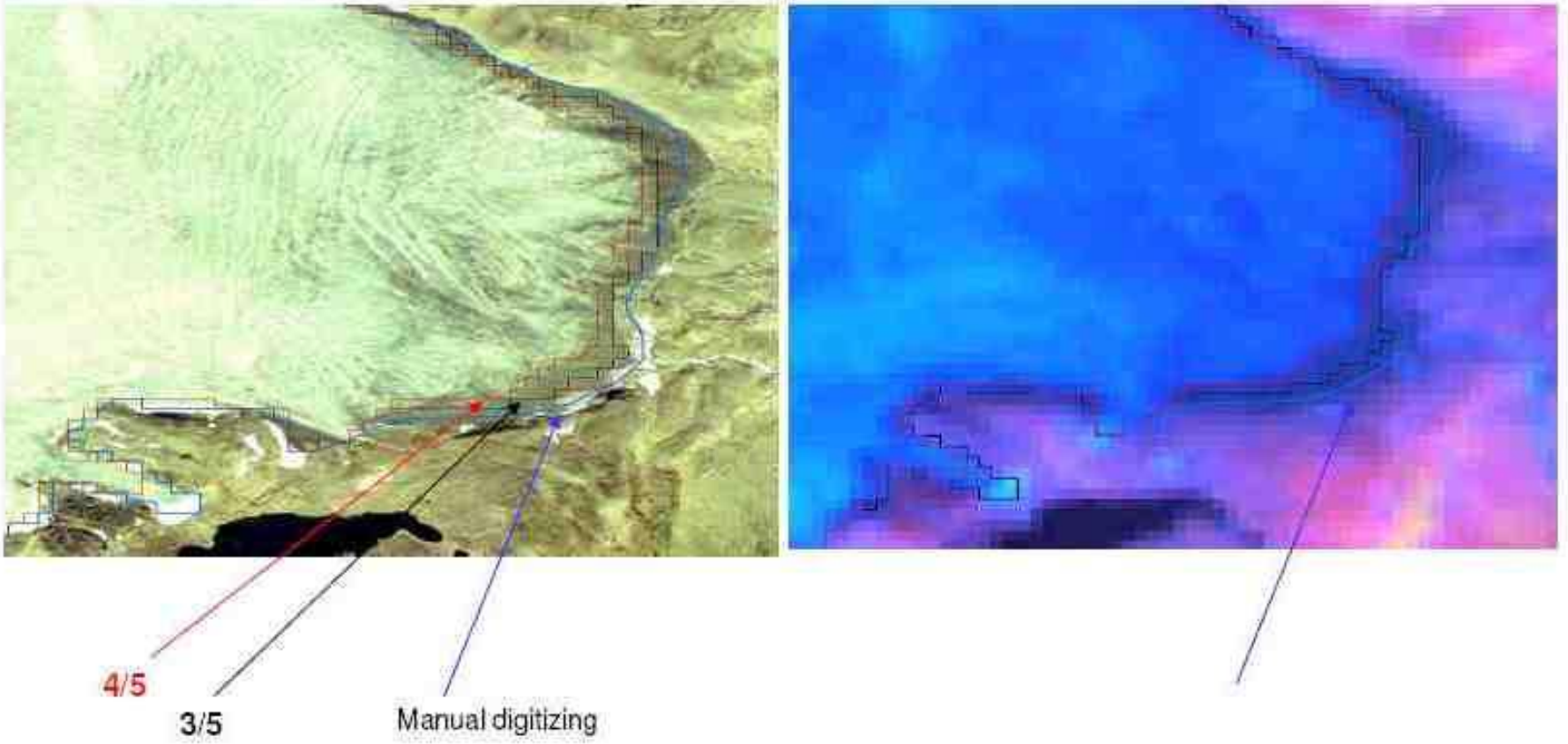
Method: use as threshold or input in classification

Note: its impossible to distinguish between snow covering glaciers and late lying snow on land except by size (sieve) and perhaps modelling from location

3. Ratio image - thresholding

…. NIR/MIR band ratio TM 4 / 5 (snow/ice >1.0)

Red/MIR TM 3/5 (snow/ice > 2.0) … 'better' for shadow areas



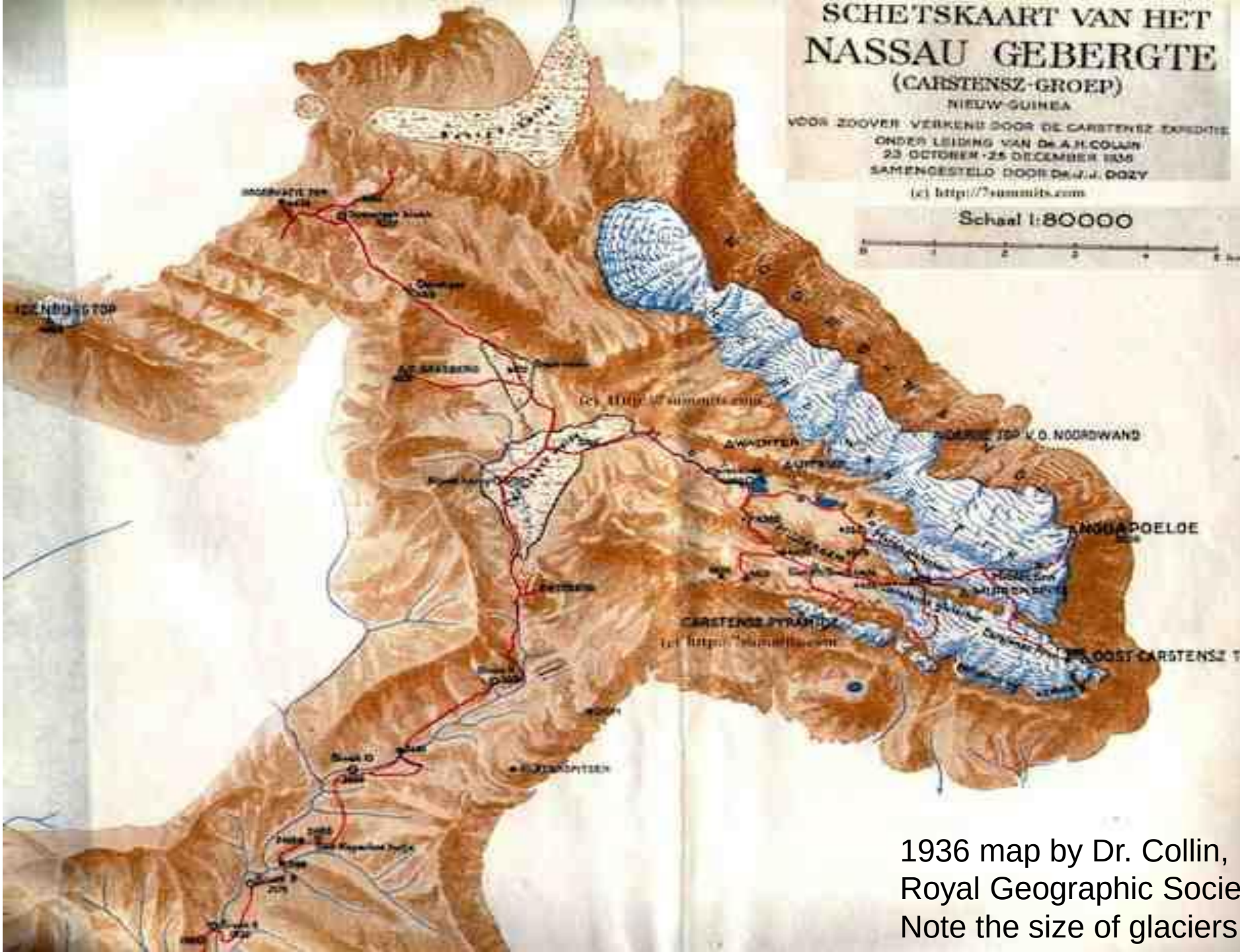
Snow and ice: very high in visible, very low in Mid-Infrared ('SWIR')

Ratio - Visible (Red) to SWIR captures snow/ice almost exclusively

- Some issues with silt-laden water, shadowed glaciers and debris cover

Puncak Jaya, Indonesia 4°S, 137°E elevation m. asl: 4884m

This is the highest peak in Asia, using distance from the centre of the Earth .



1936 map by Dr. Collin,
Royal Geographic Socie
Note the size of glaciers

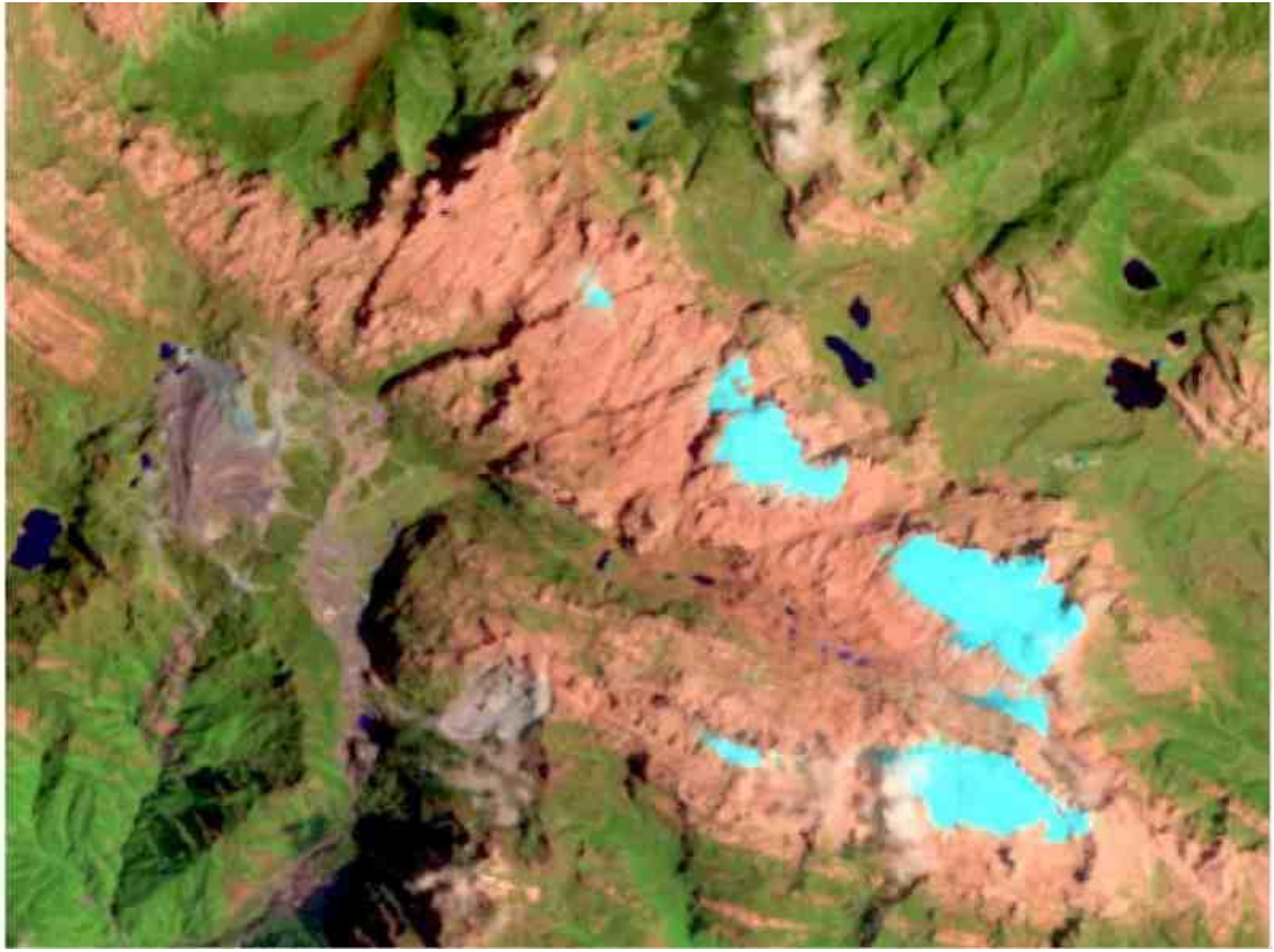
Landsat 5, 1988

Landsat 8, 2017

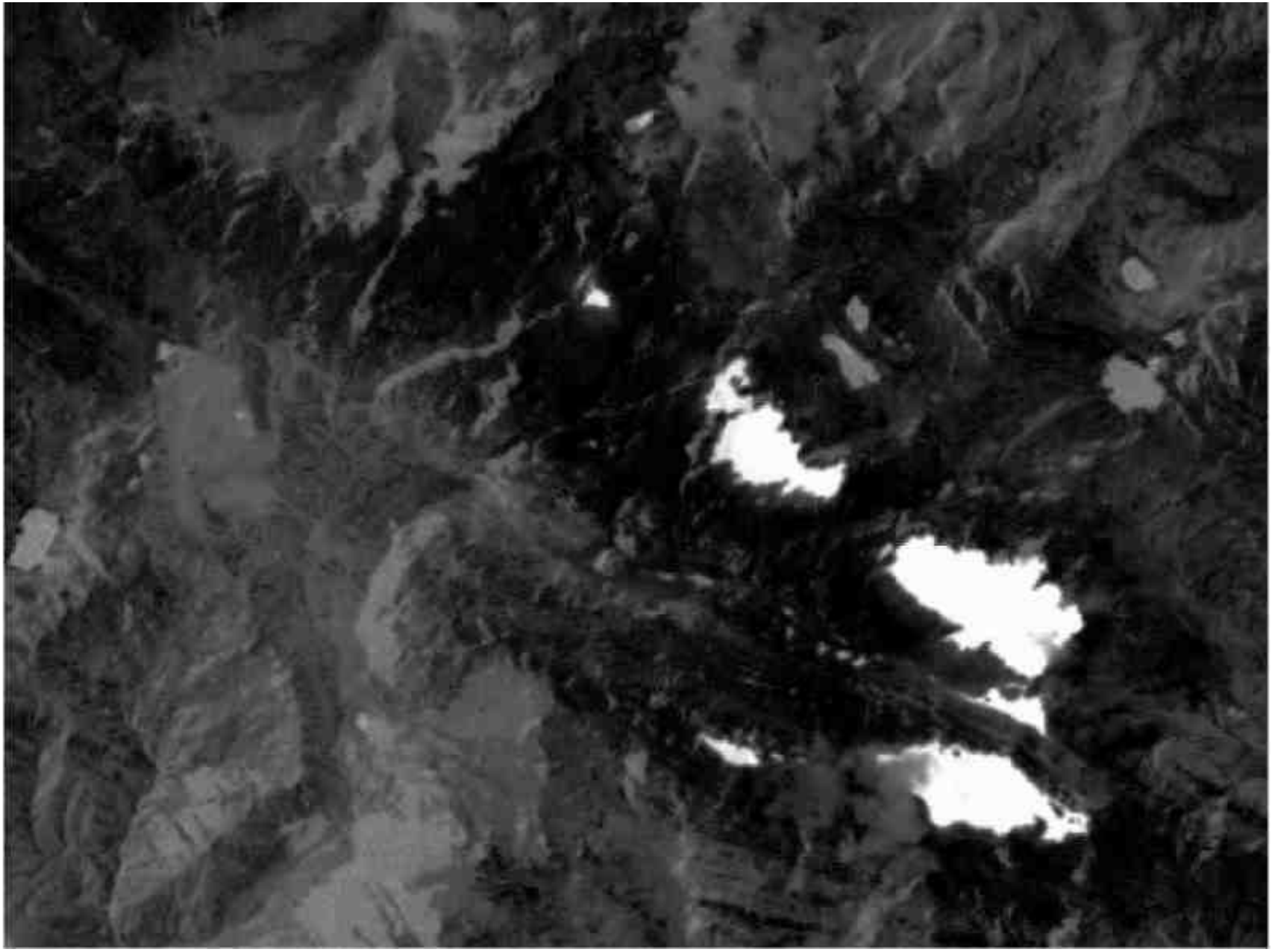
Grasberg gold Mine – largest in the world, diameter 2.3 km

Landsat 1992

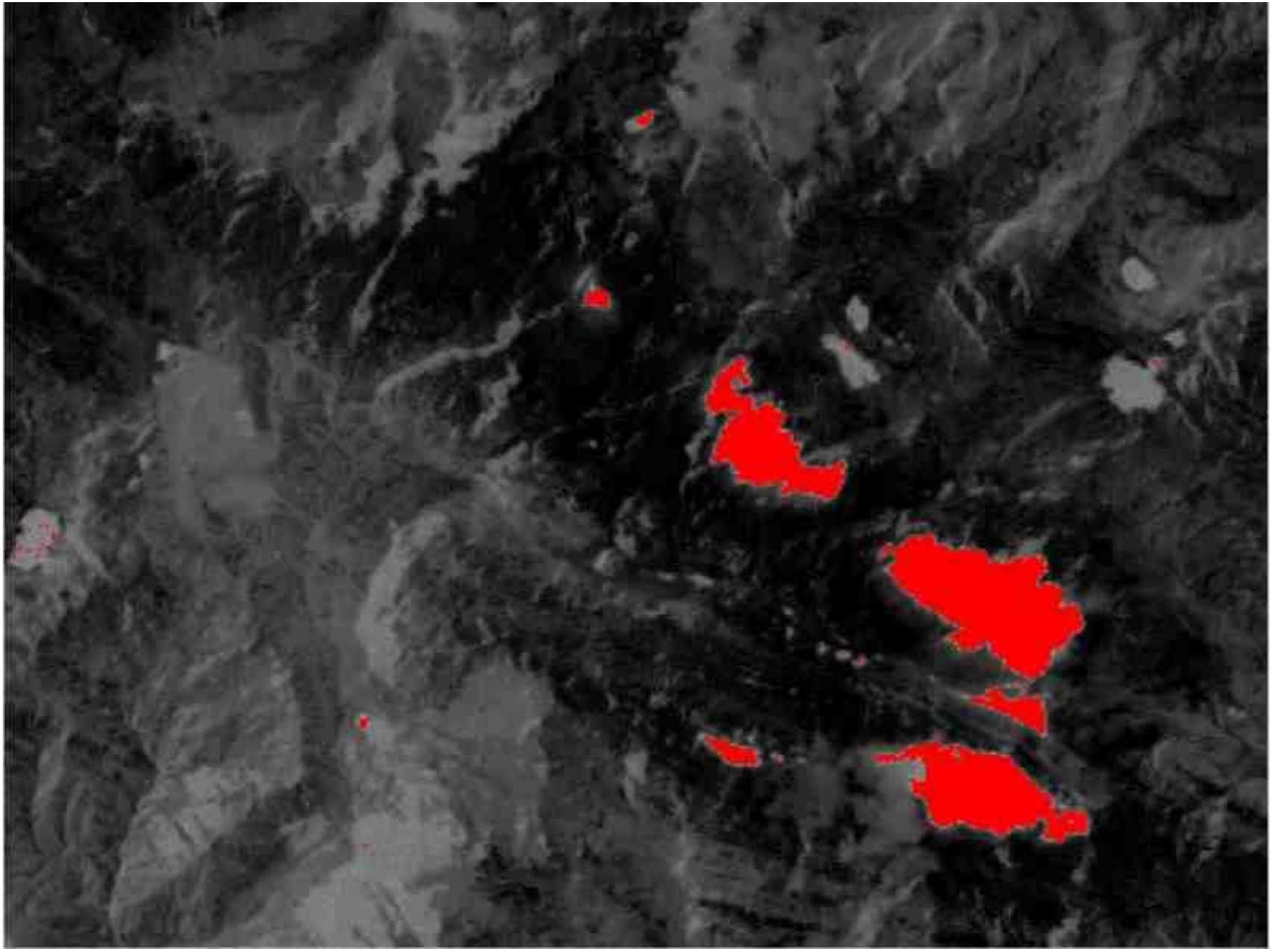
2 km



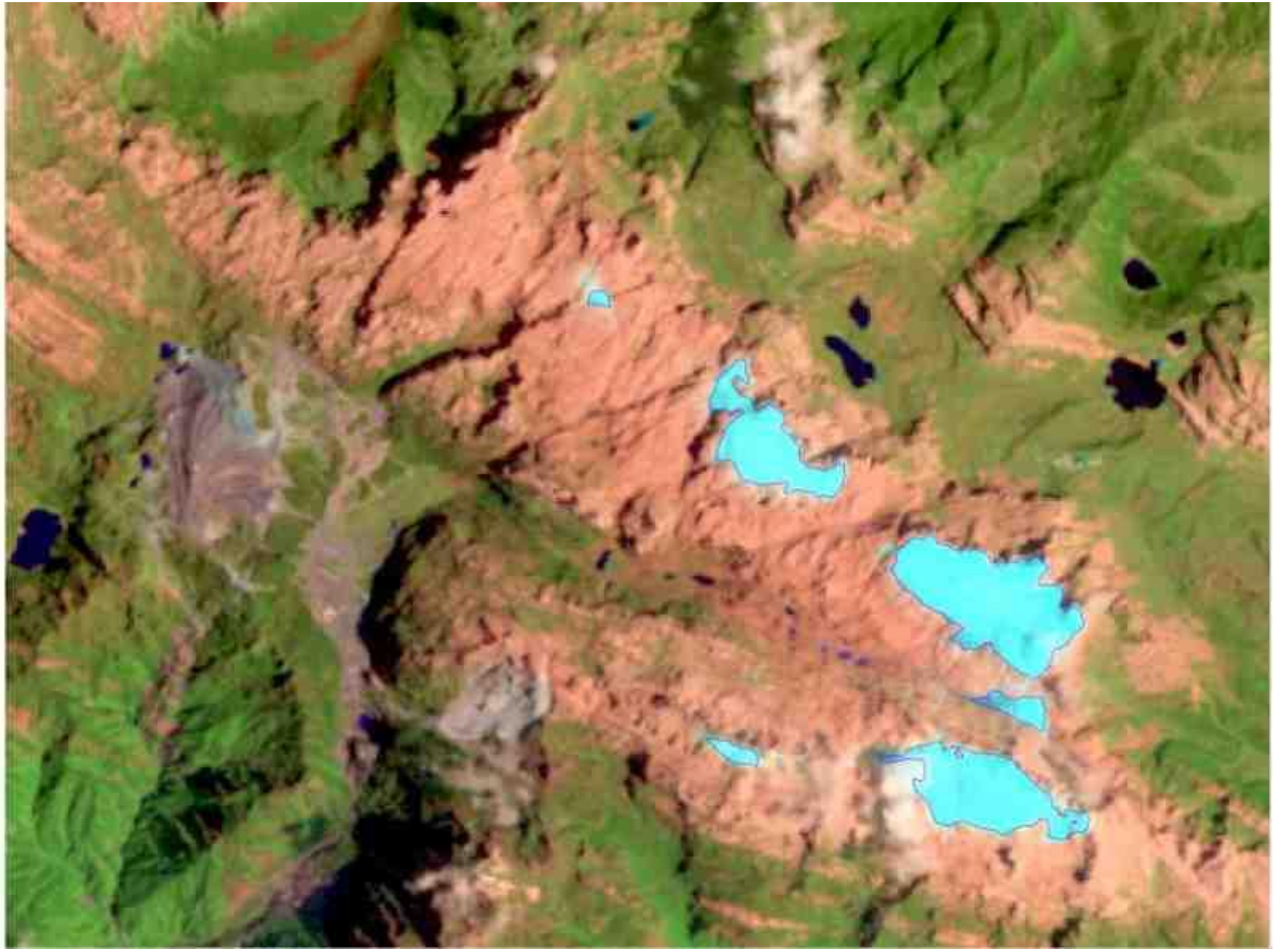
Red/Mid-IR ratio



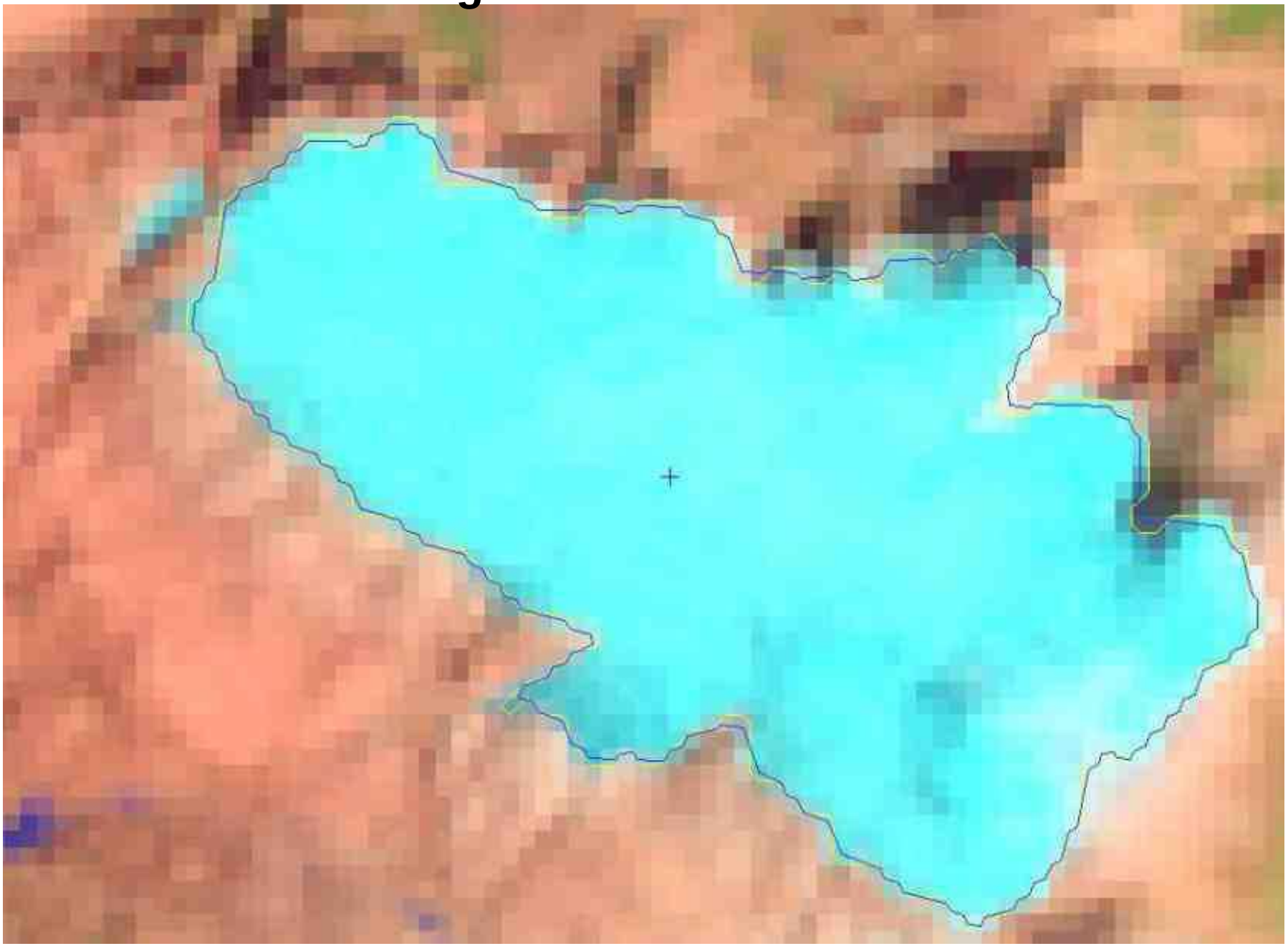
Threshold value 2.0



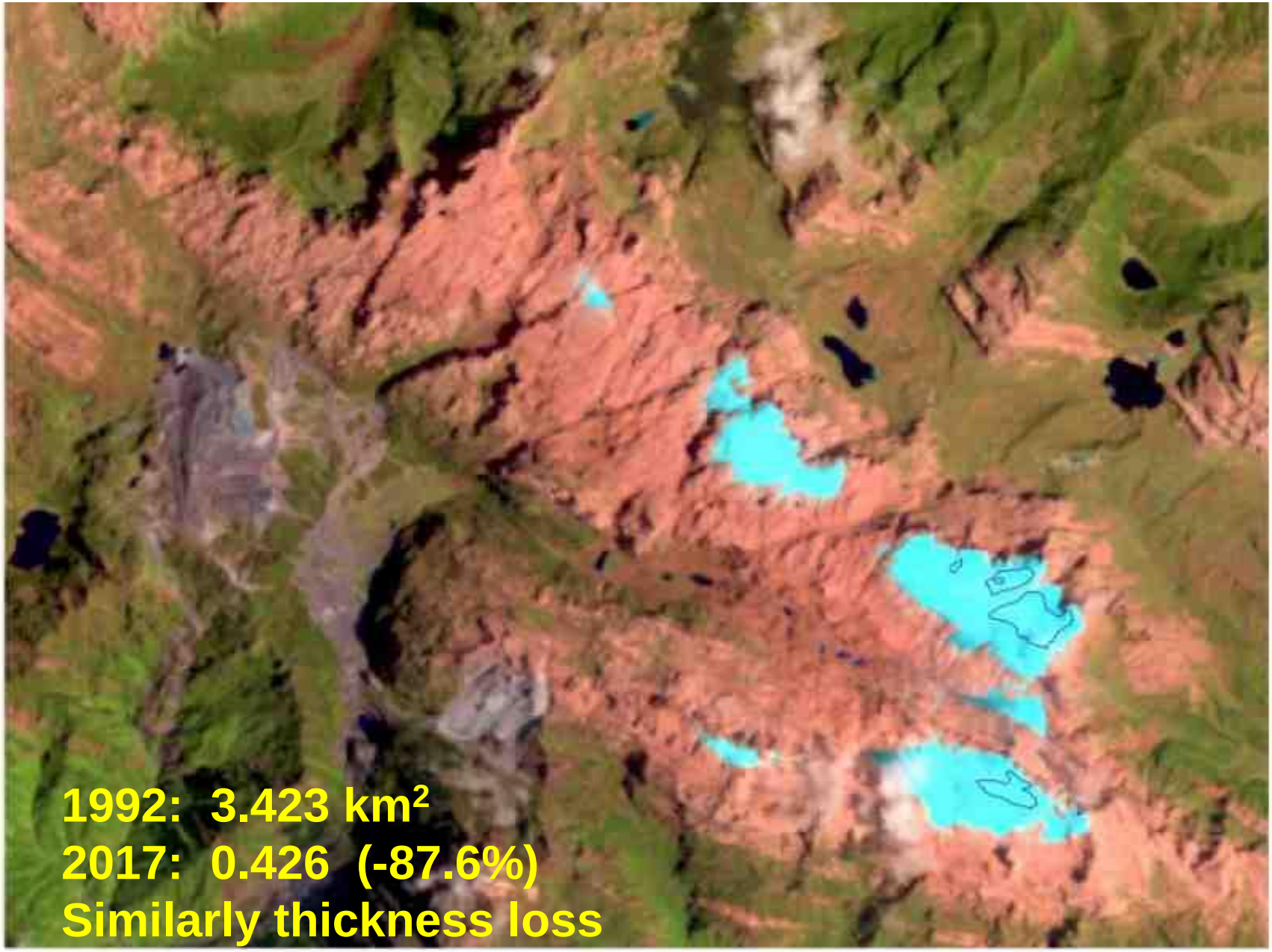
Convert bitmap to polygon



Vector smoothing

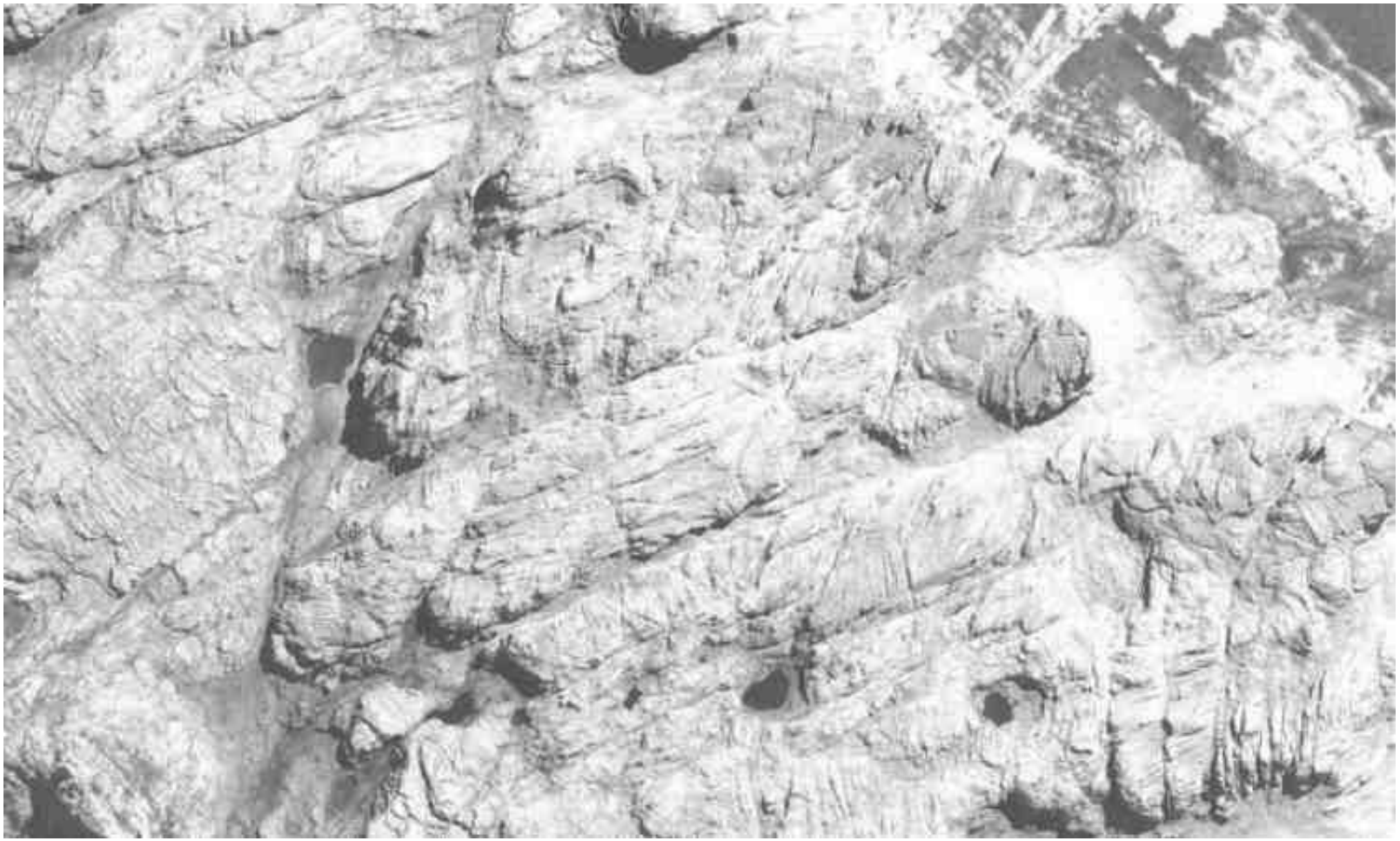


Overlay of 2017 polygons on 1992 image showing ice loss

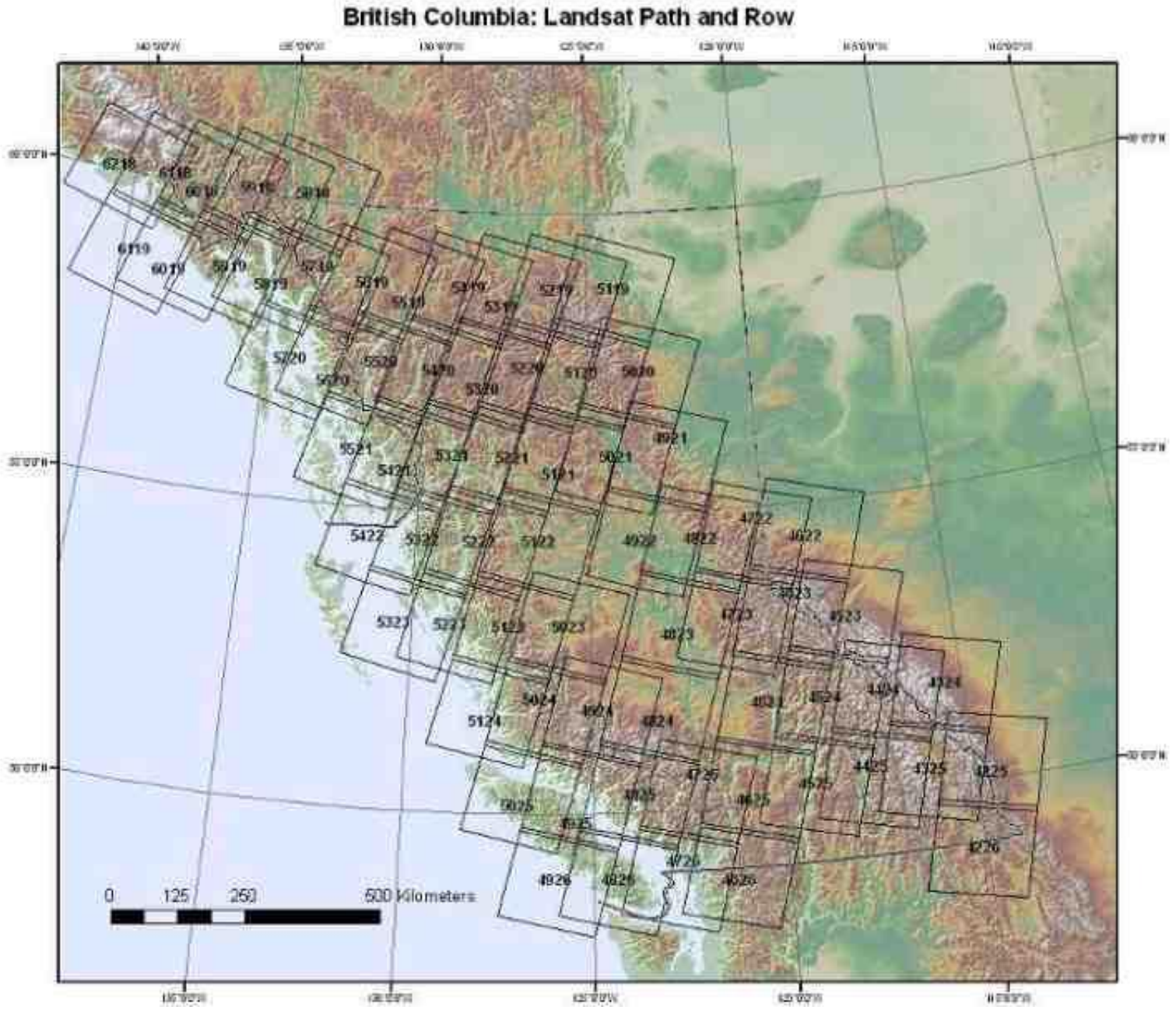


Carstenz Glacier sample, 2002 High resolution 1m Digital Globe

Carstenz Glacier, 2015 Pleiades

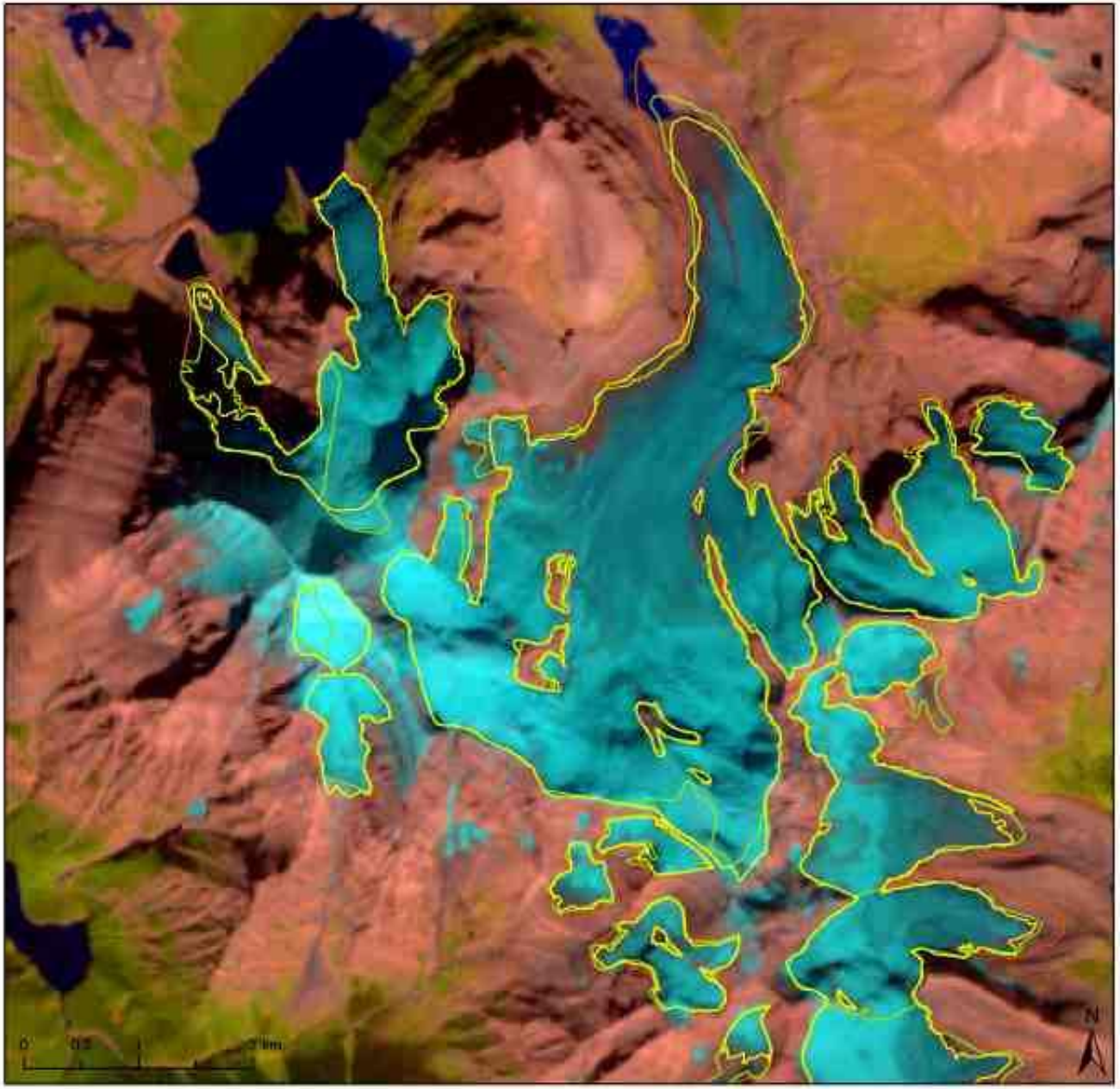


The cordilleran glaciers of western Canada



2007-08: We used 50 Landsat scenes and applied the 3/5 ratio, with threshold >2.0
~15,000 glaciers covering ~ 25,000 km²

Glacier retreat 1985 - 2015 at Mount Robson



Glacier outlines

- 2015
- 2005
- 1985

Image data: Landsat 8 (NASA)
Outline data: T. Bolch (2005)
and TRIM (BC Govt.) (1985)
Projection: WGS 84 UTM Zone 10N
Cartography: Sophie Goertz
Date: 10.09.2016

Robson Glacier
1911-2011

Challenges

1. mixed pixels → lower threshold

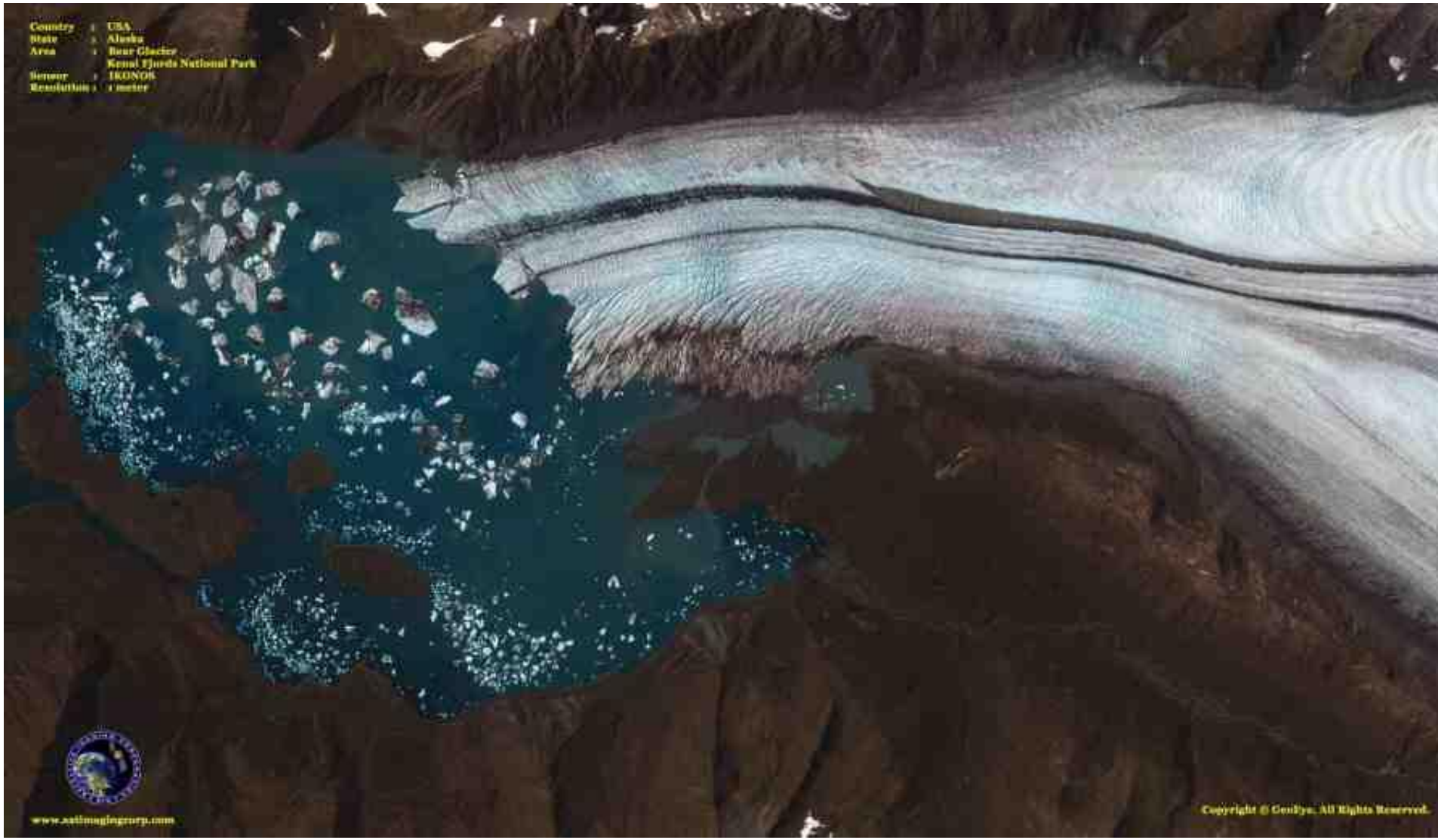
1. shadows → lower threshold

1. Misclassified lakes → higher threshold

1. Debris Cover

   DEM? Thermal?

Bear Glacier, Kenai Fjords, Alaska Ikonos



RGBNIR + Pan … no mid-IR

Selected New millennium High resolution sensors

Launched by corporations, not always countries

Date	Sensor	Bands*	Pixel (m)	Swath (km)	Orbit (km)	Data
1999	Ikonos	RGBN	1 / 4	11.3	681	11 bit
2001	Quickbird	RGBN	0.6/2.4	16.5	450	11
2003	Orbview 3	RGBN	1 / 4	8	470	11
2007	Worldview 1	RGBN	0.5 / 2	17.6	496	11
2008	GeoEye 1	RGBN	.41 / 1.65	15	681	11
2009	Worldview 2	8 bands	.46 / 1.85	16.4	770	11
2014	Worldview 3	Vis-MIR	.31 / 1.24	13.1	617	11
2016	Worldview 4 = GeoEye2 = same as Worldview 3				617	11

* and higher resolution Panchromatic band

https://www.satimagingcorp.com/satellite-sensors/other-satellite-sensors/

Other New millennium High resolution sensors - selected by geog357 – this class

Date	Sensor	Bands	Pixel (m)	Swath (km)	Orbit (km)		Country
2009	Deimos 1	GRN	22	600	625	8-10 bit	Spain/UK
2011	Pleiades	RGBN	0.5/2.0			?	France
2012	Kompsat	RGBN	0.7/2.8			14 bit	S.Korea
2017	Formosat	RGBN	0.5/2.0			14 bit	Taiwan

Also: Gokturk, DubaiSat, KoreaSat, KazeoSat , CartoSat, Gaofen …..

https://www.satimagingcorp.com/satellite-sensors/other-satellite-sensors/