Glacier mapping with Sentinel-2 in Svalbard: Challenges when creating a new glacier inventory in the Artic

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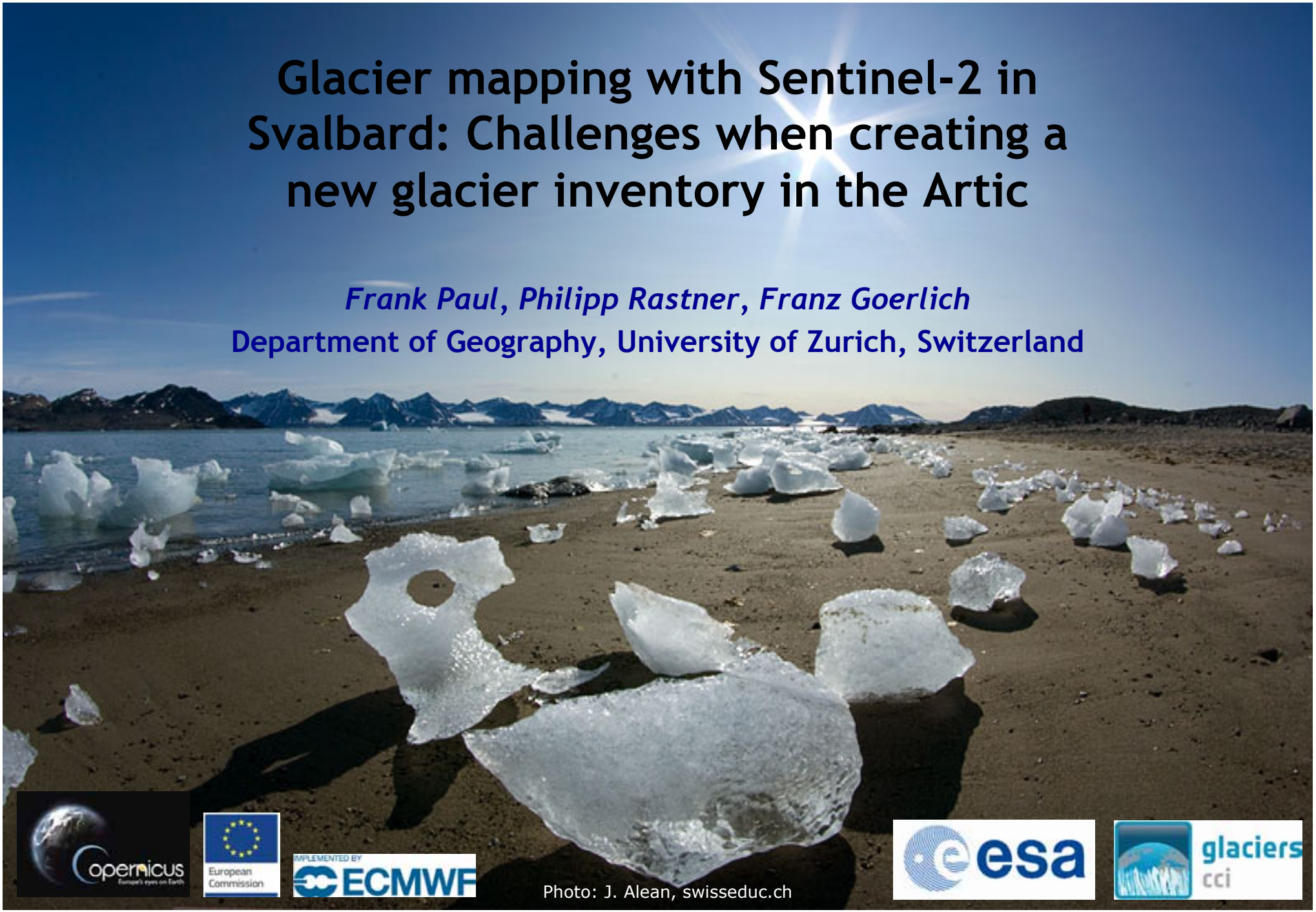


Photo: J. Alean, swisseduc.ch

Contents

The following slides provide:

a) an overview on the methods applied to map glaciers and

b) a presentation of various regions with challenges for manual correction (e.g. debris cover, seasonal/perennial snow fields)

We are particularly interested in feedback on how these unclear (and in RGI6 often excluded) regions should be handled.

We are aware that there is likely no right or wrong, but different purposes (e.g. climate change, water resources, modelling) require different parts of a glacier to be considered.

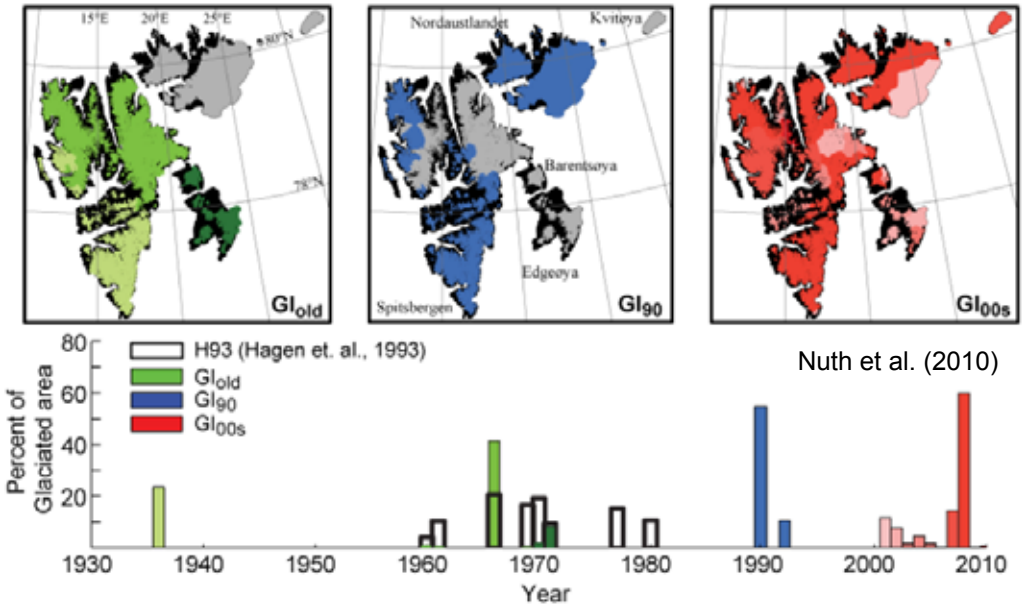
Please let us know what your needs are in this regard.

Thank you!

Location and previous inventory

Location of Svalbard in the eastern Arctic

Temporal overview of the 3 Svalbard glacier inventories



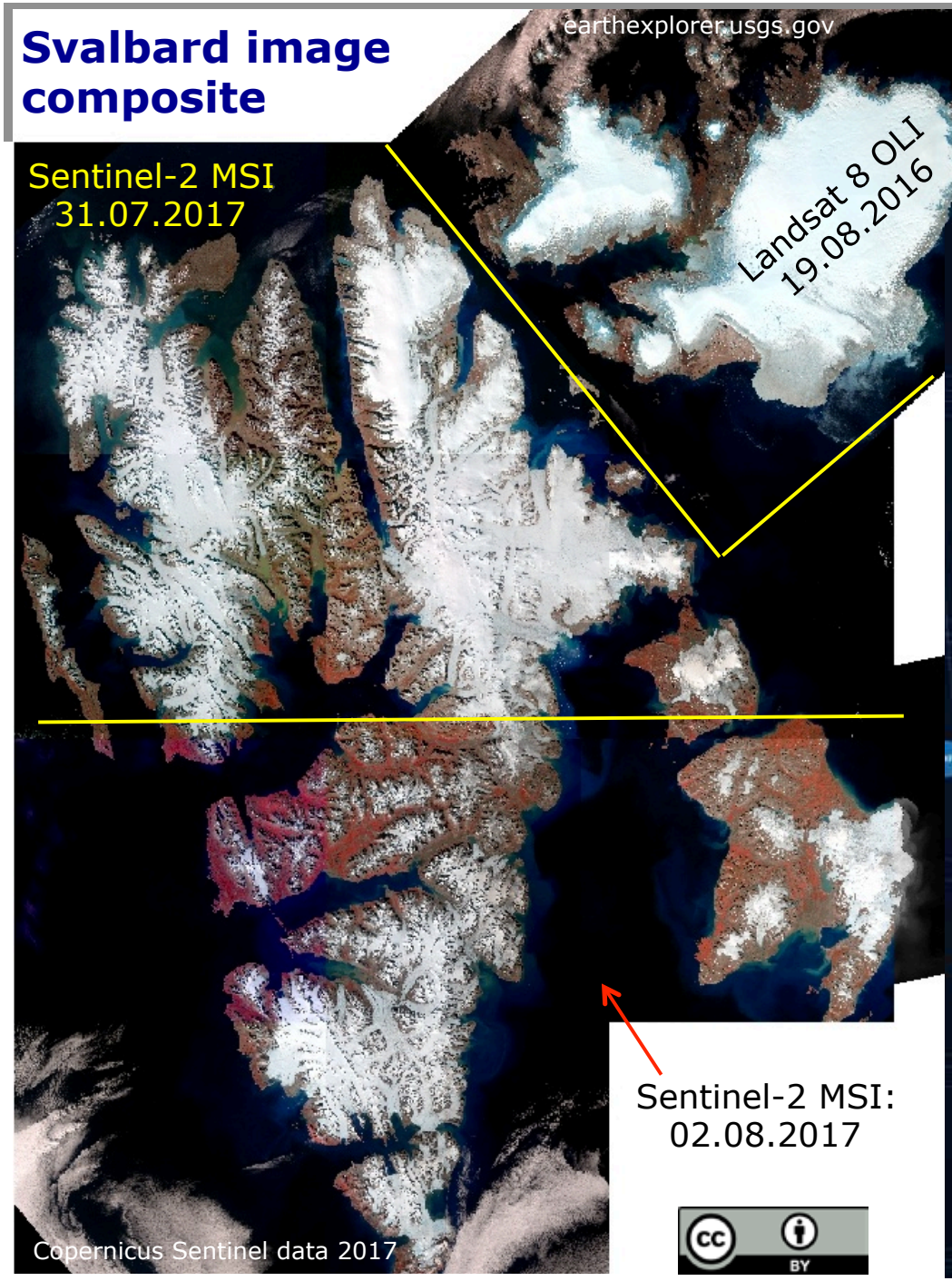
Nuth et al. (2010)

According to Nuth et al. (2013), Svalbard had 1668 glaciers in 1993 covering a comparable area of 36161 km^2, that decreased to 33608 km^2 (-7%) until 2010 (top right).
The larger glaciers in Svalbard are mostly very flat and from time to time they surge :)

Motivation and Methods

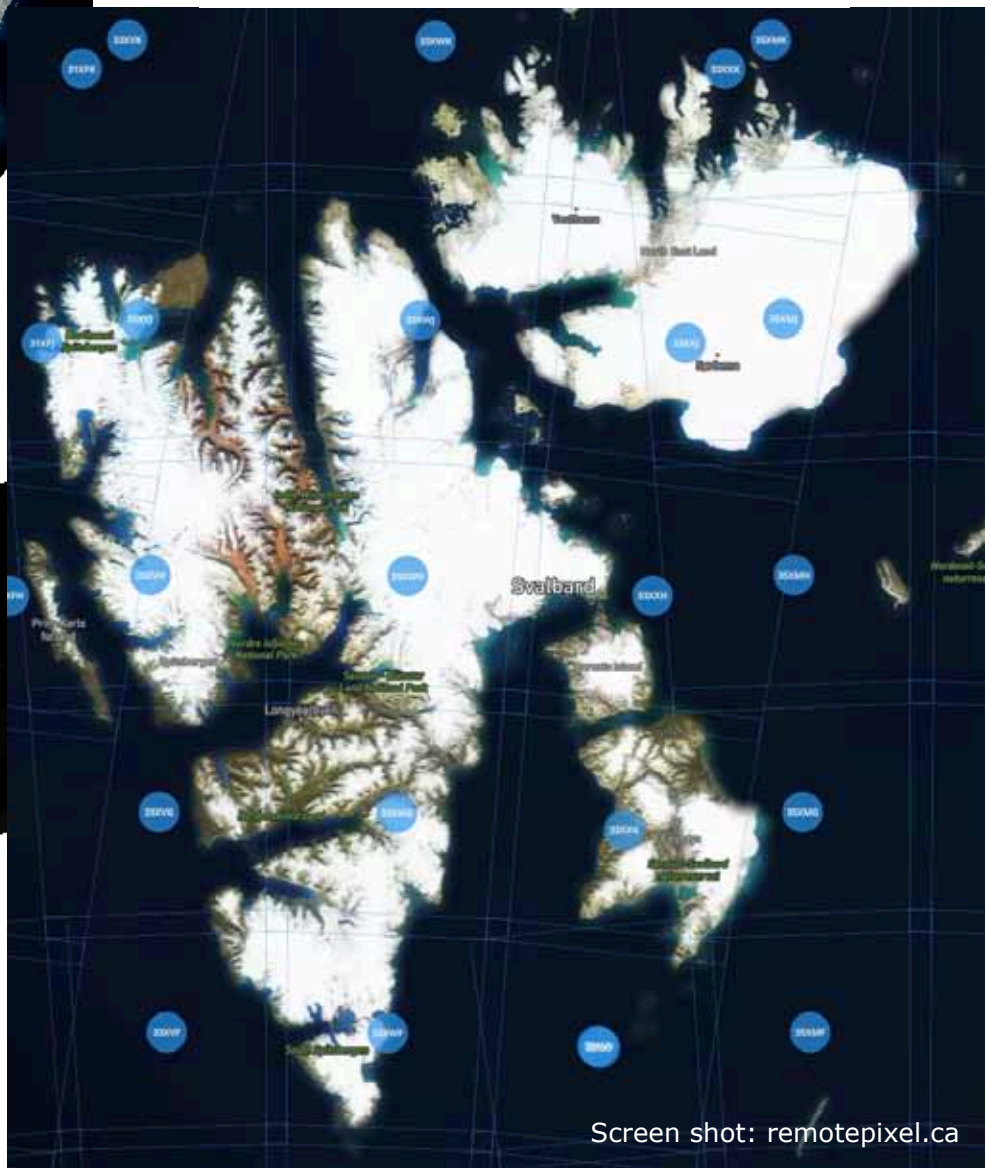
- Three glacier inventories are available for Svalbard, but they are partly incomplete and mix datasets from different years
- The last inventory by Nuth et al. (2013) is composed from satellite imagery spanning 10 years (from 2001 to 2010)
- It has a size threshold of 1 km^2 to remove perennial snow
- Major glacier mapping challenges exist (frequent cloud cover, long-lasting seasonal snow, debris cover, rock glaciers, ...)
- We basically used 2 Sentinel-2 scenes and 1 Landsat 8 scene to map all glaciers >0.02 km^2, compliant with other inventories
- Clean ice was mapped automatically with a band ratio and manually corrected (e.g. dirt/debris/clouds/water/ice bergs)
- Outlines from the previous inventory are used as a guide, but in many cases a clear delineation was very difficult

Svalbard image composite

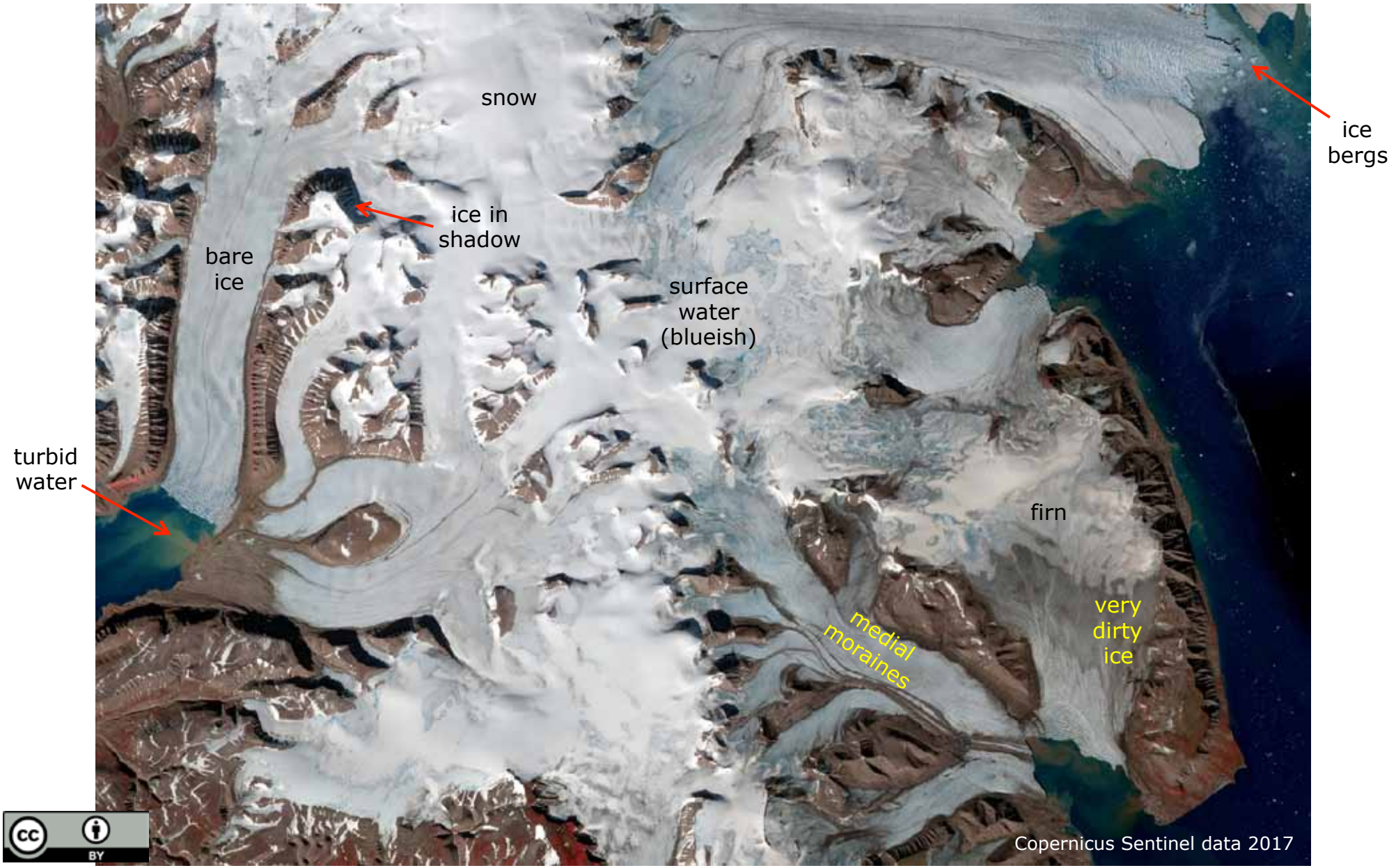


Svalbard overview

Sentinel-2 tile overview

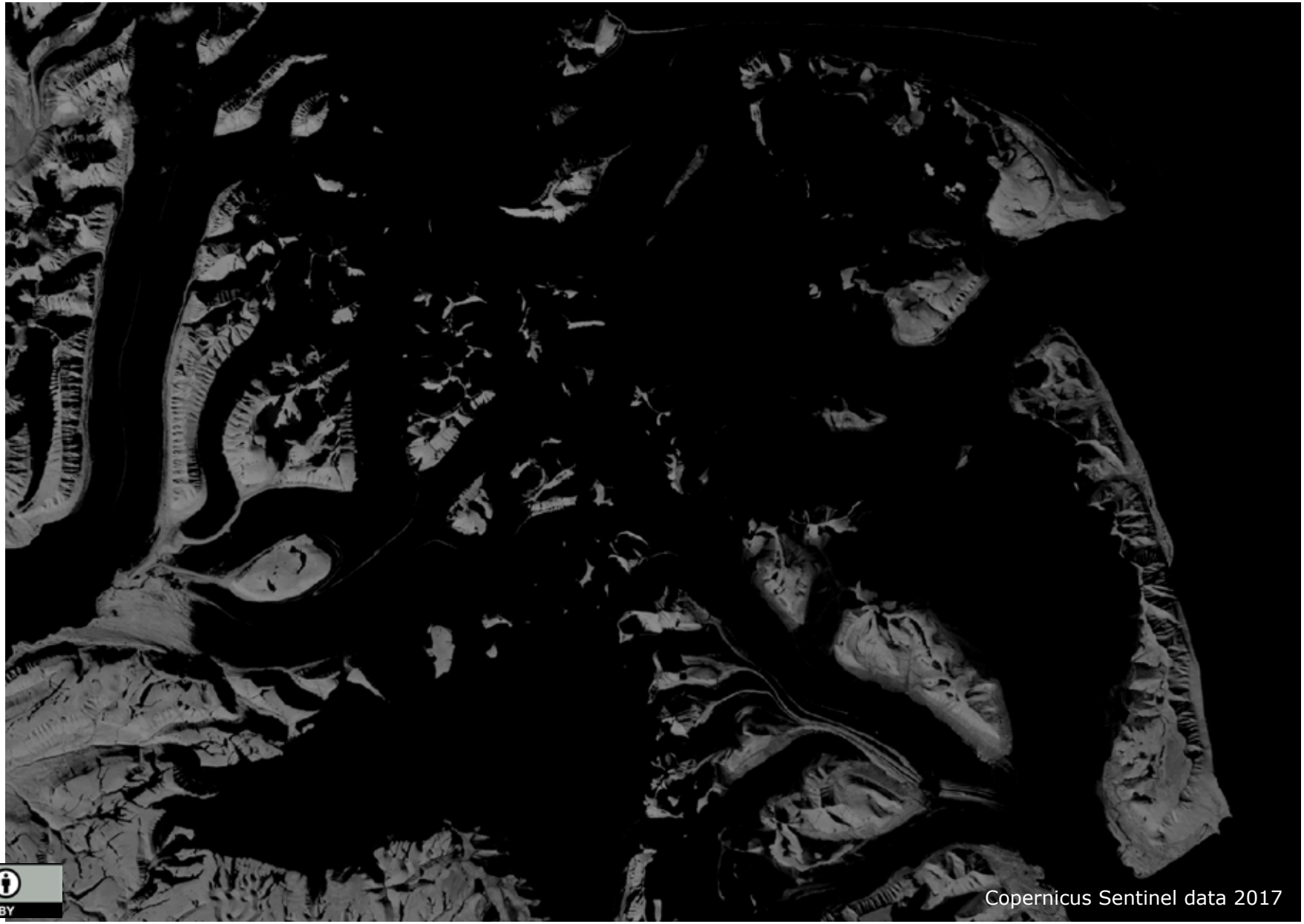


Svalbard subset overview (FCC w/ bands 8 4 3)

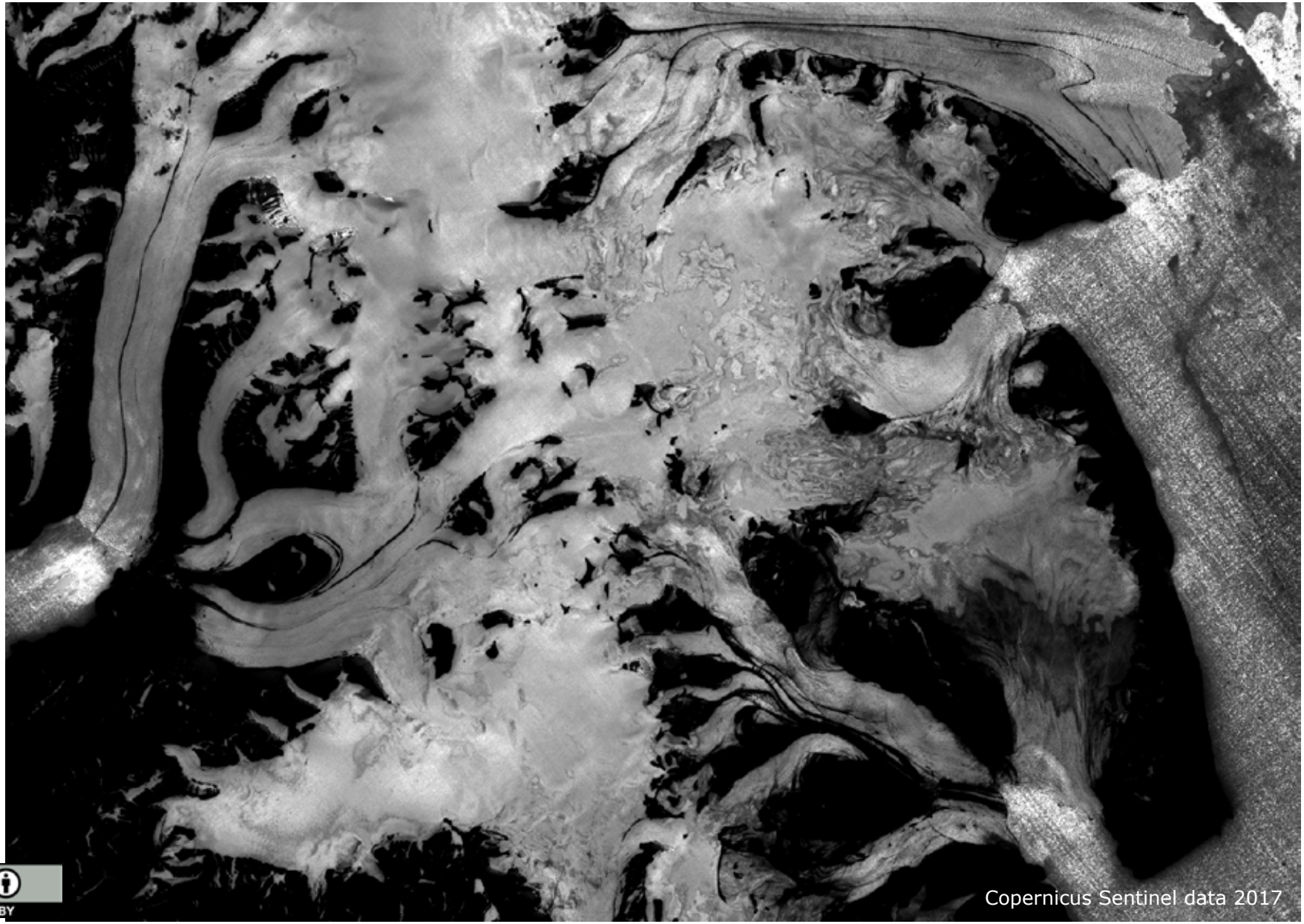


Subset in band 4 (red)

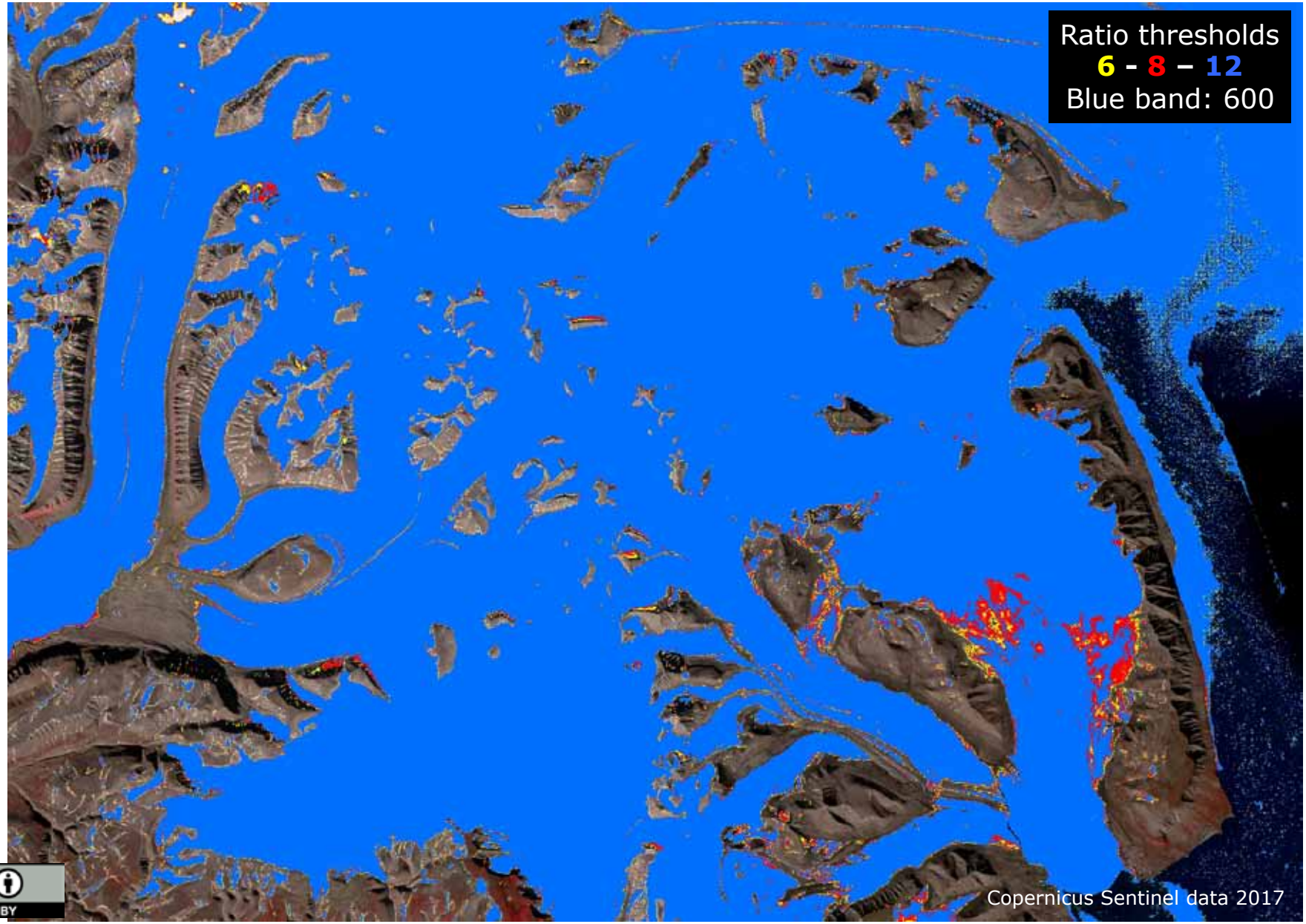
Subset in band 11 (SWIR)



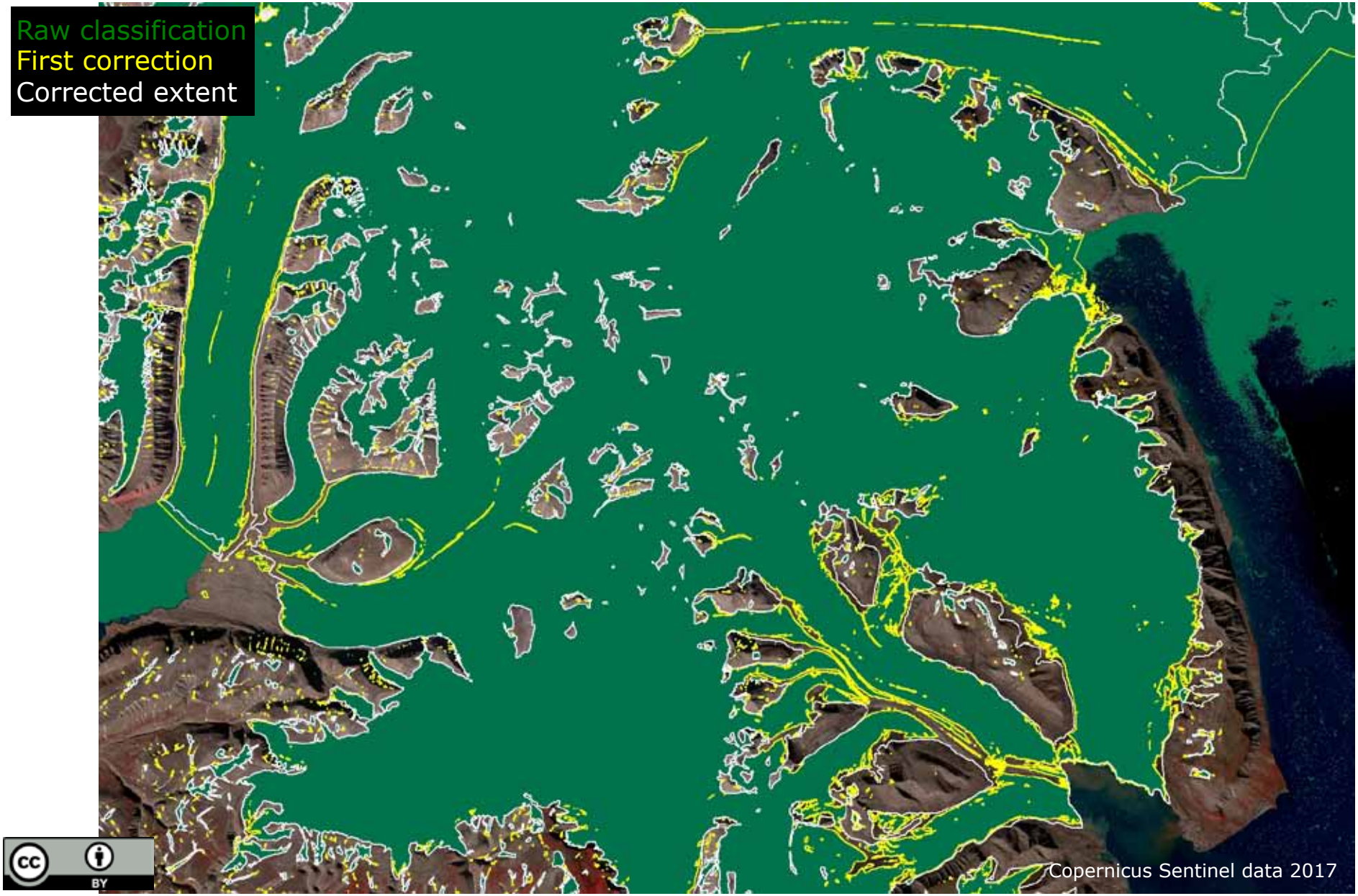
Band ratio 4/11



Resulting glacier masks after thresholding



Raw classification and after editing



Resulting corrected outlines

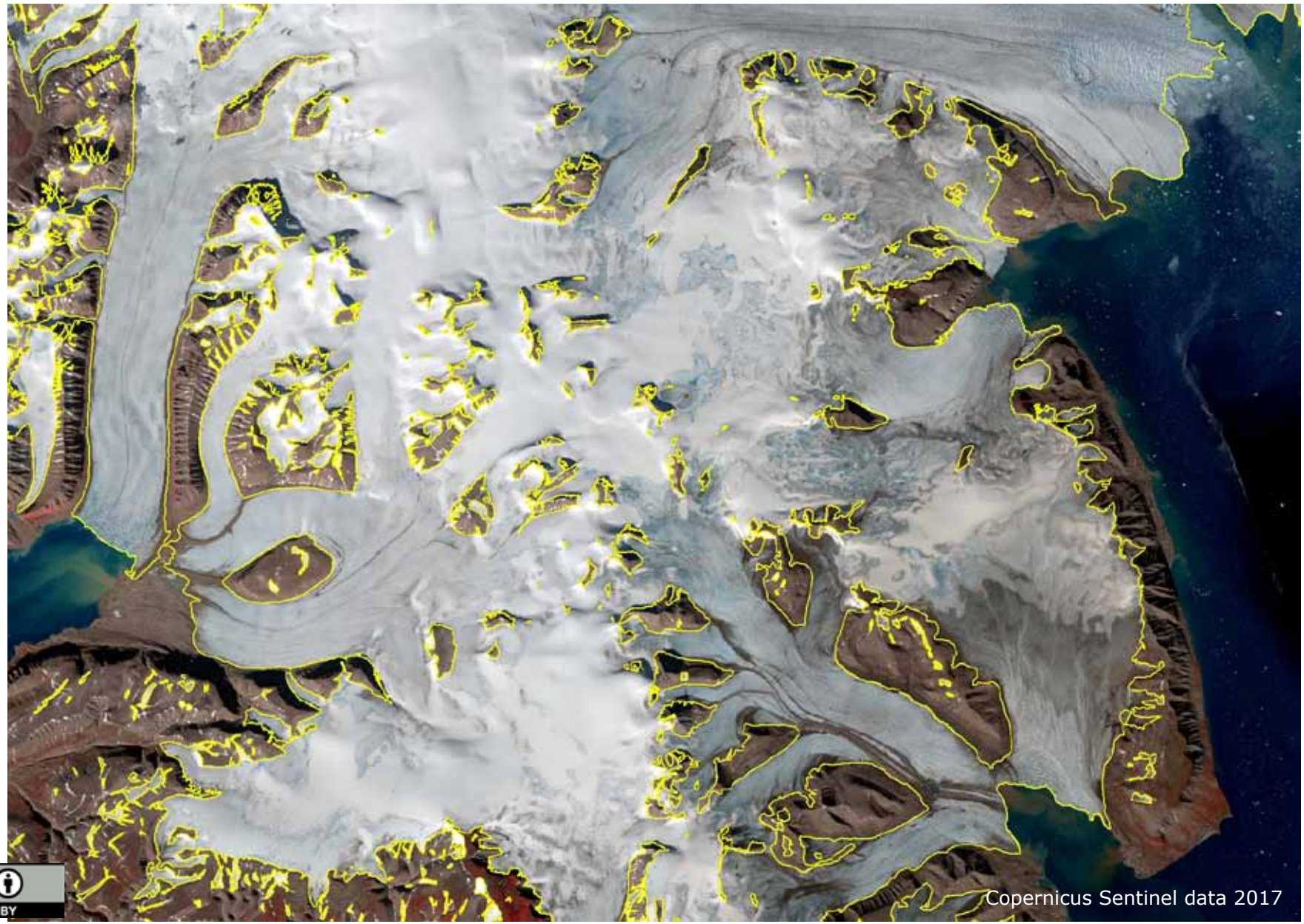
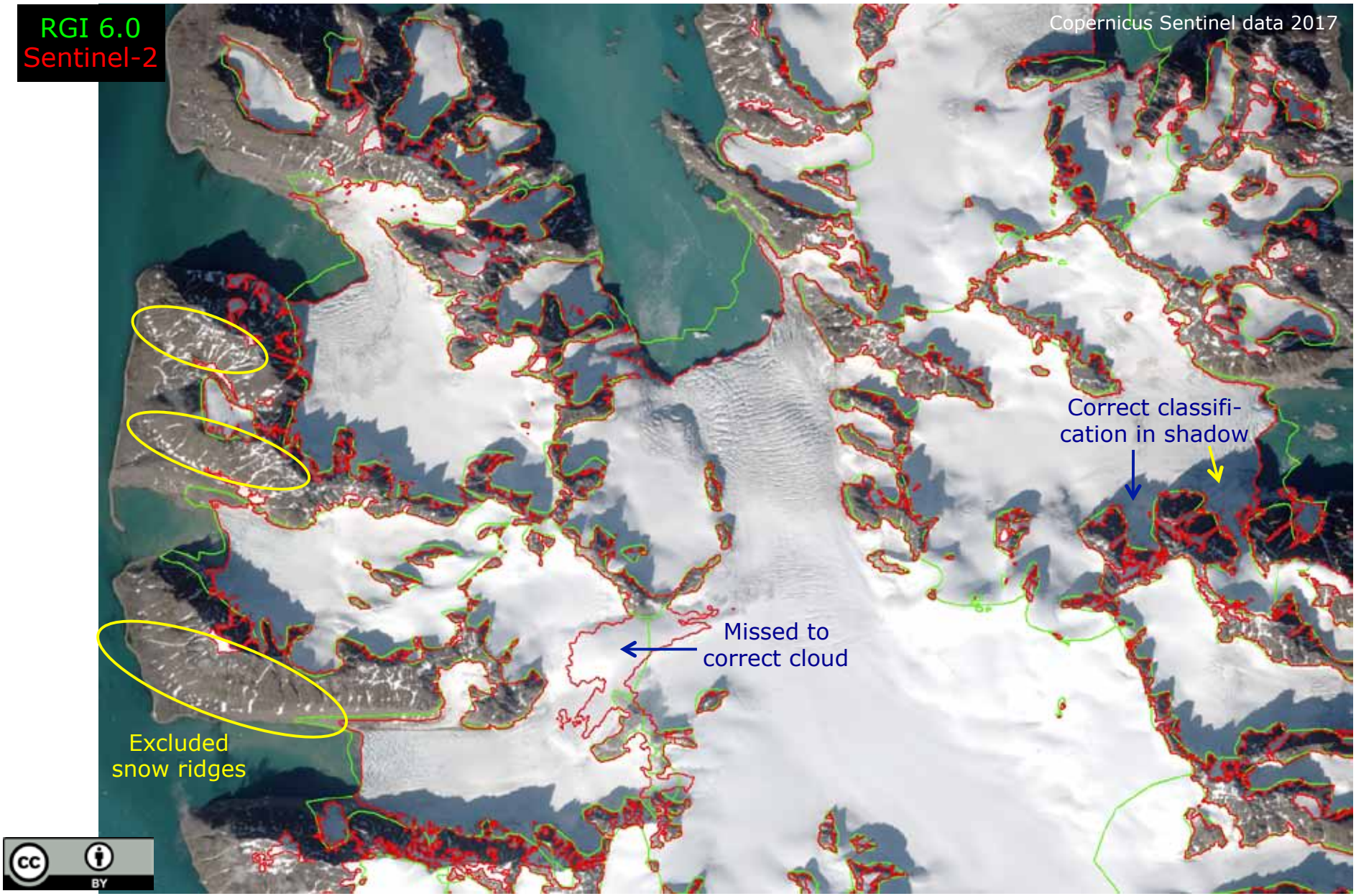
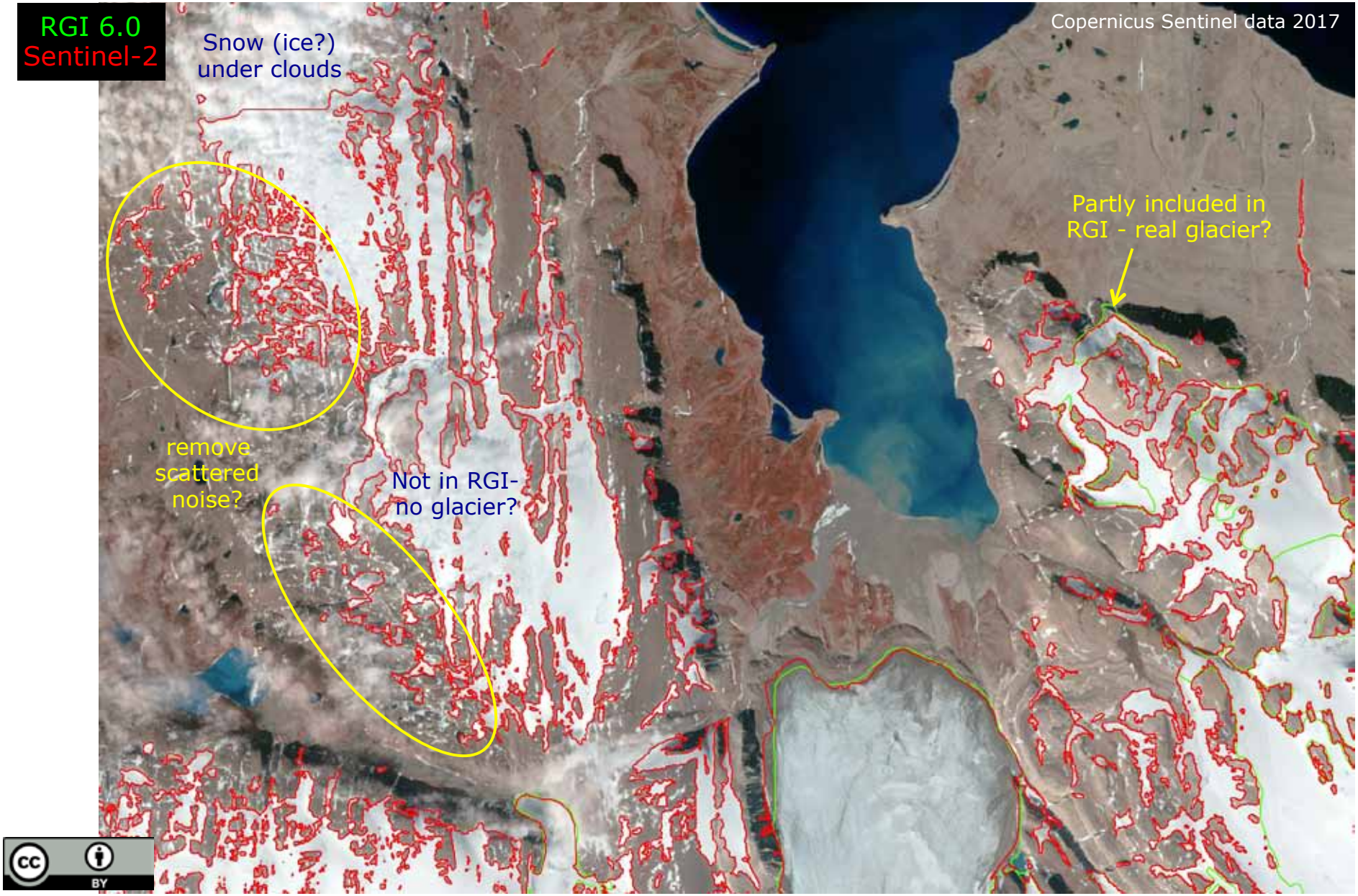


Image interpretation: All fine here

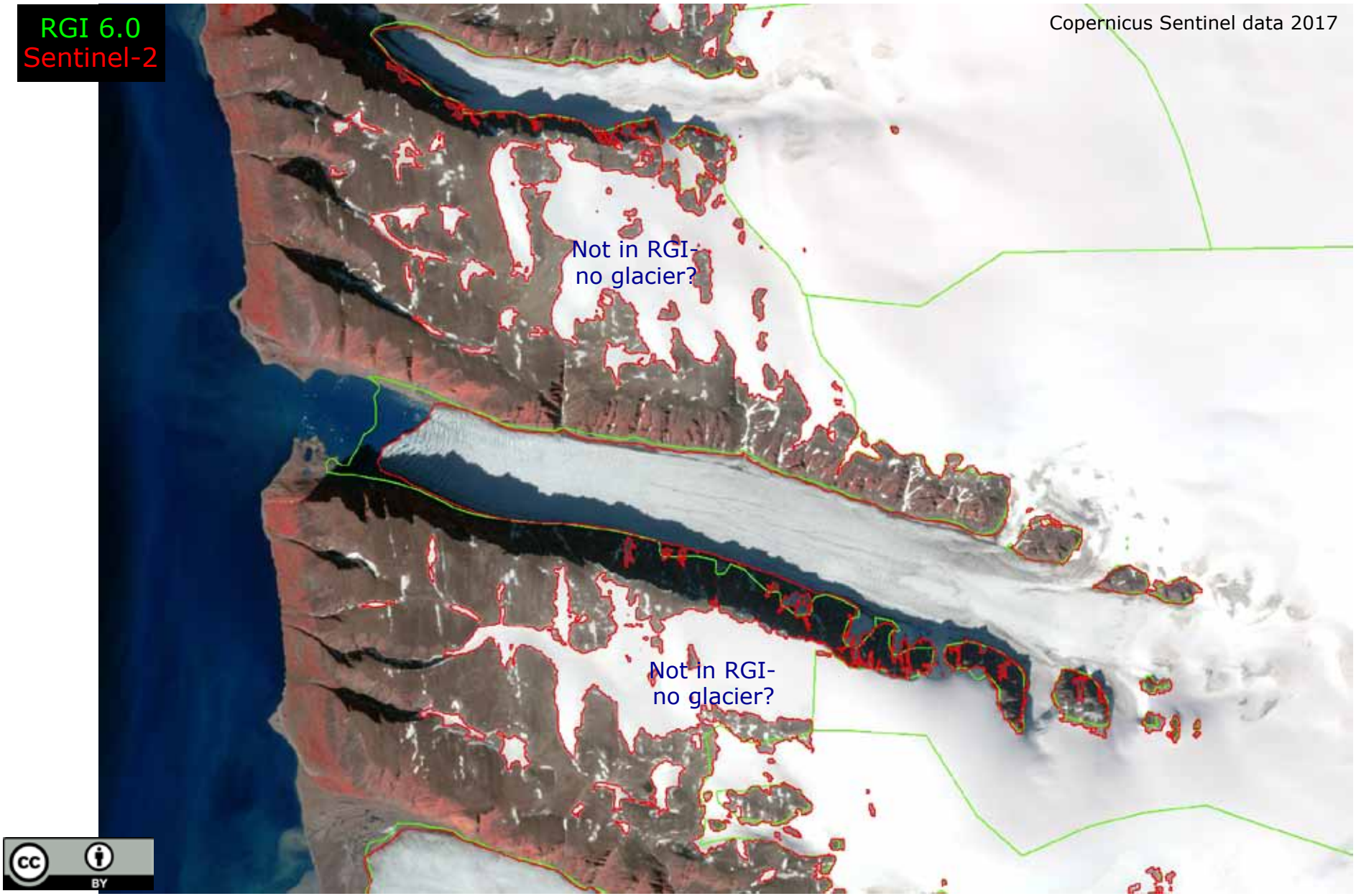
Challenges: Snow ridges, shadow & clouds



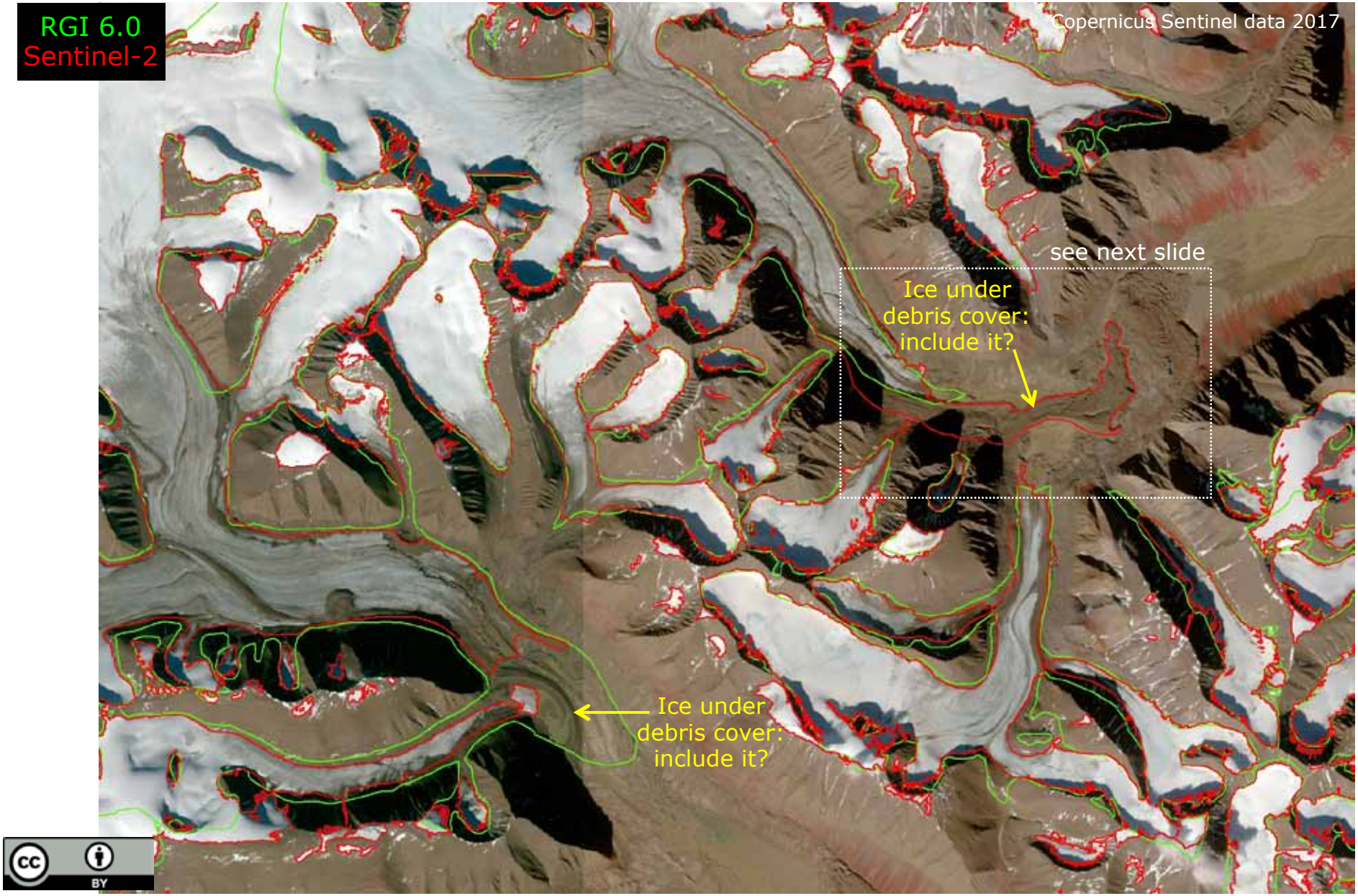
Challenges: Perennial snow fields & clouds



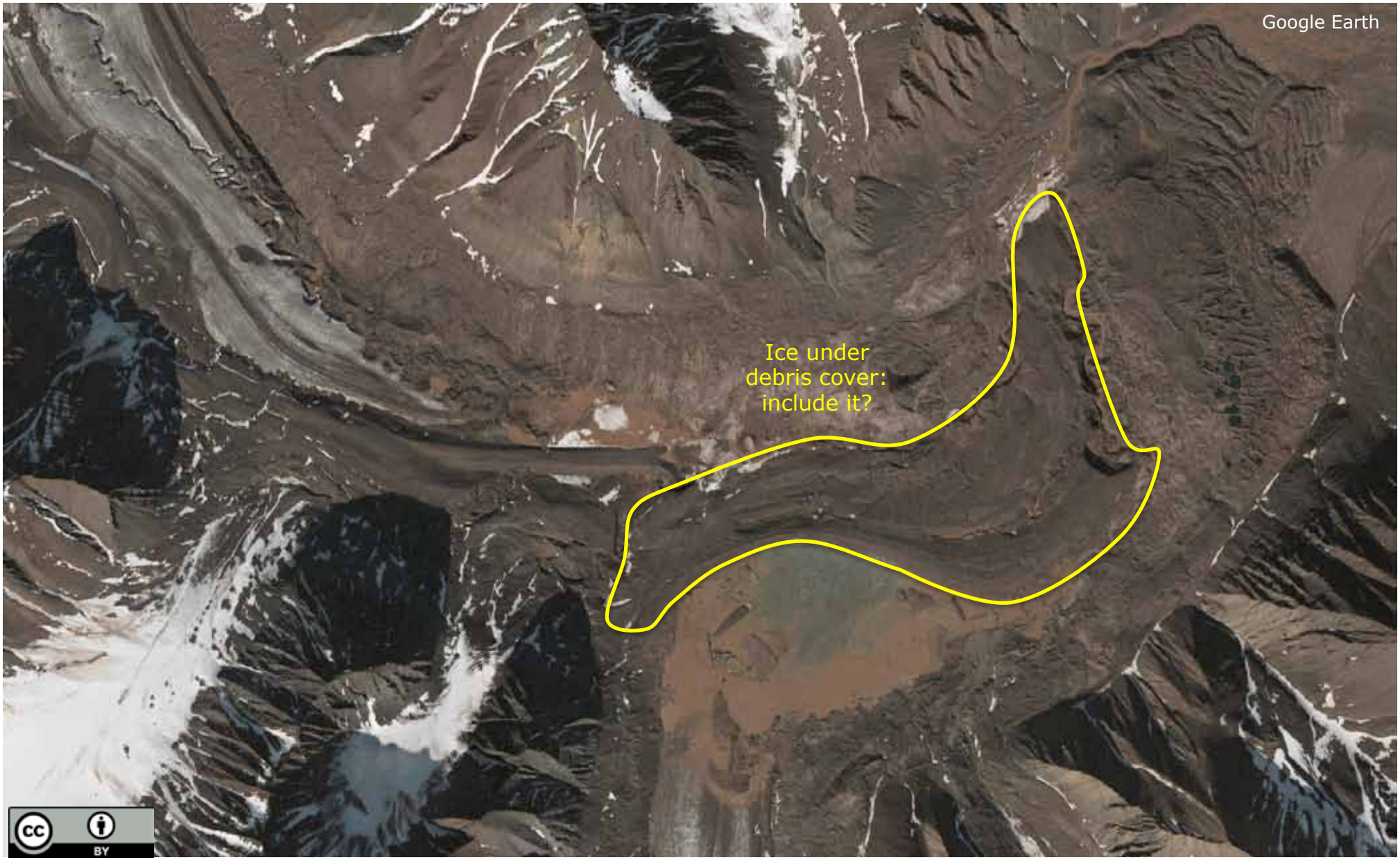
In- or exclude large perennial snow fields?



Post-surge down-wasting: Exclude dead ice?



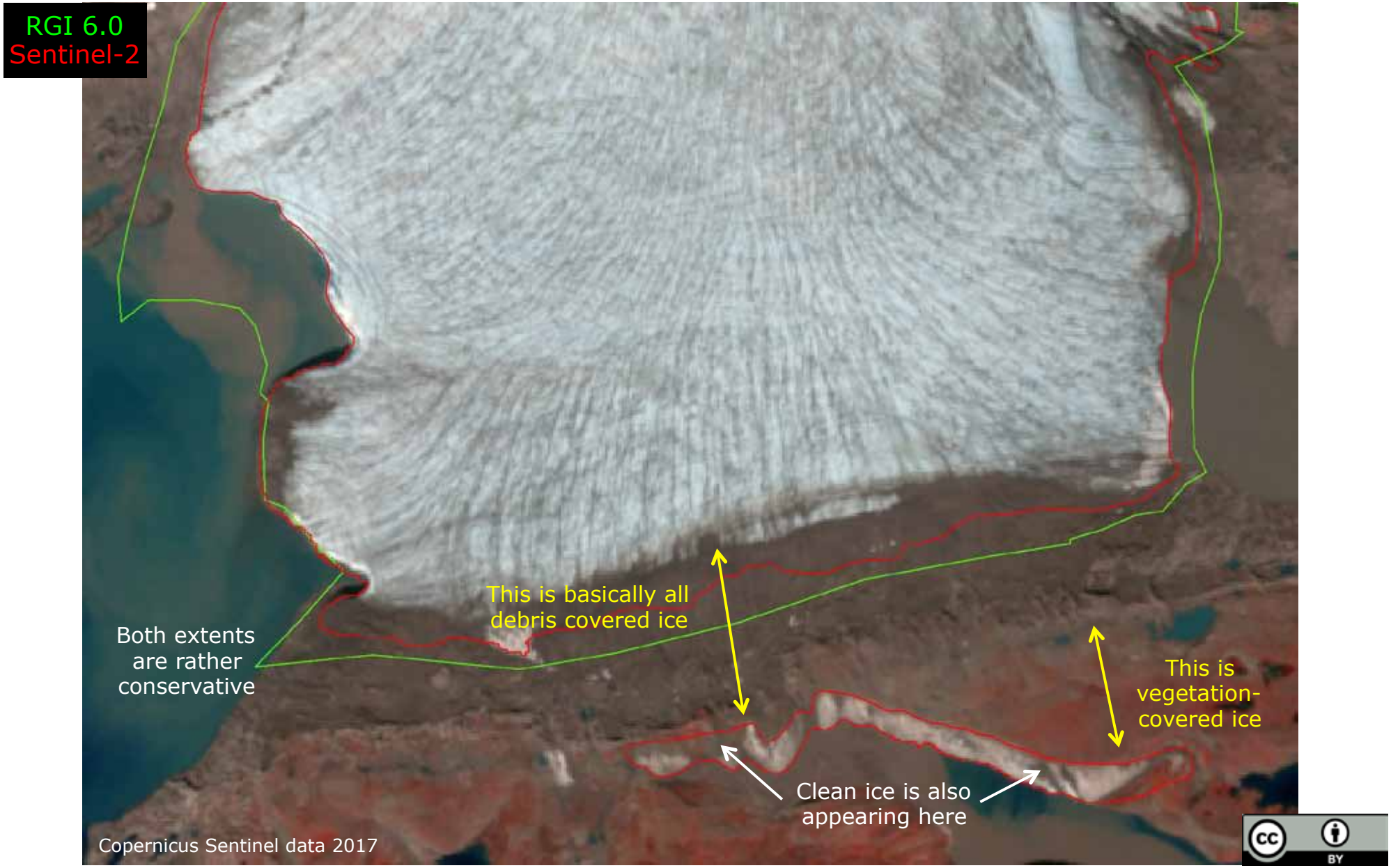
Post-surge down-wasting: Where is the boundary?



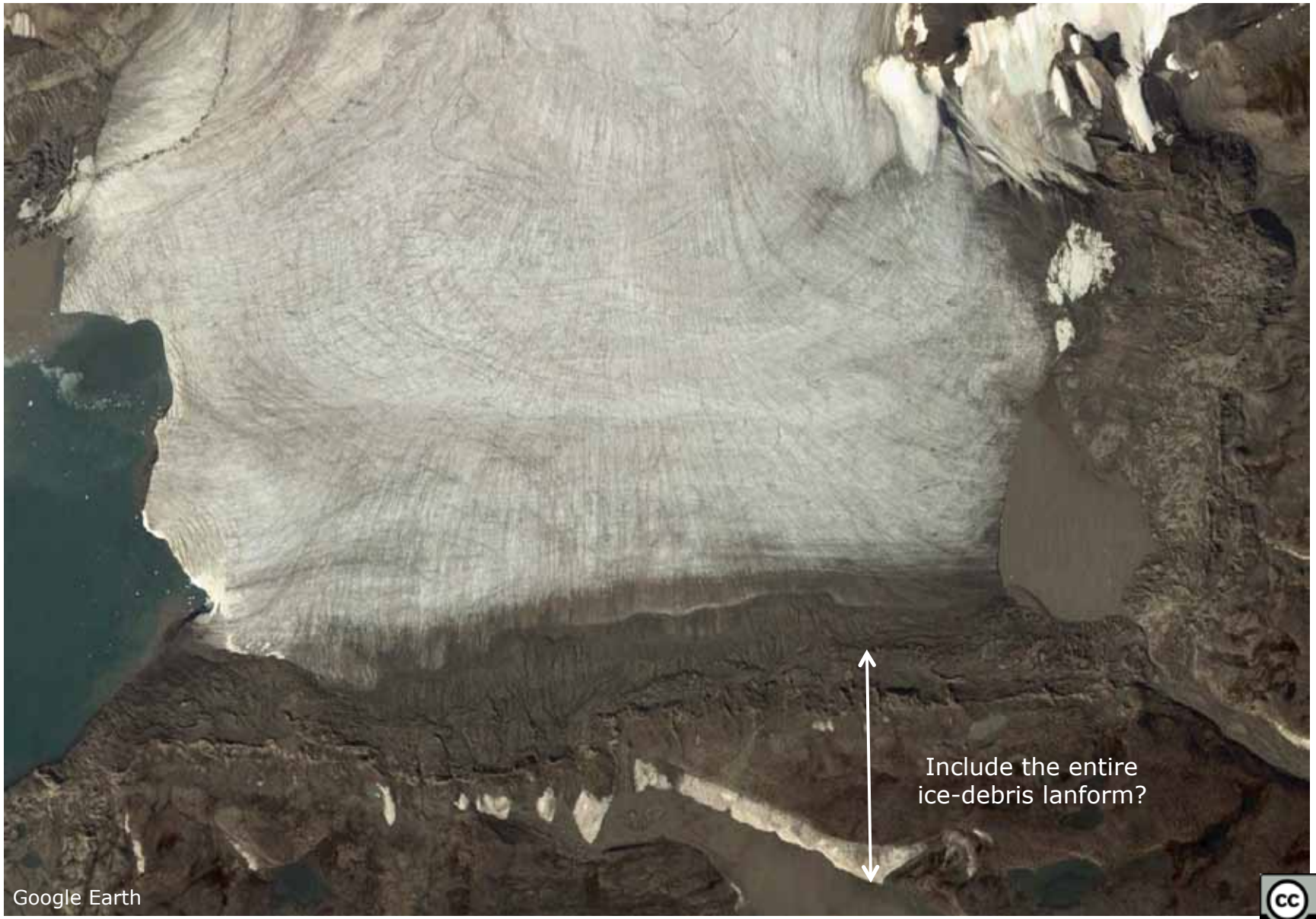
Another exampleof ice-cored moraines: Boundary?

Snow fields and ice under debris

Where is the ‘correct’ boundary?



Very-high resolution image from GE



Our suggestions

- Large perennial snow fields: include, but mark them in the attribute table (item ‘form’ in the RGI, code 2), maybe cut and remove elongated extensions?
- Small, ‘noisy’ snow fields: remove, they are likely seasonal
- Down-wasting dead ice: include, disconnect from main glacier, add code to item ‘form’ (e.g. code 4: ‘disconnected dead ice’)
- Connected ice-debris landform or rock glacier with unclear separation: include it and add new code to item ‘form’ (e.g. code 5: ‘connected to ice-debris landform’)
- Ice under clouds: use multi-temporal imagery for identification
- Calving terminus: assign code 1 or 2 for item ‘terminus type’

THANK YOU!