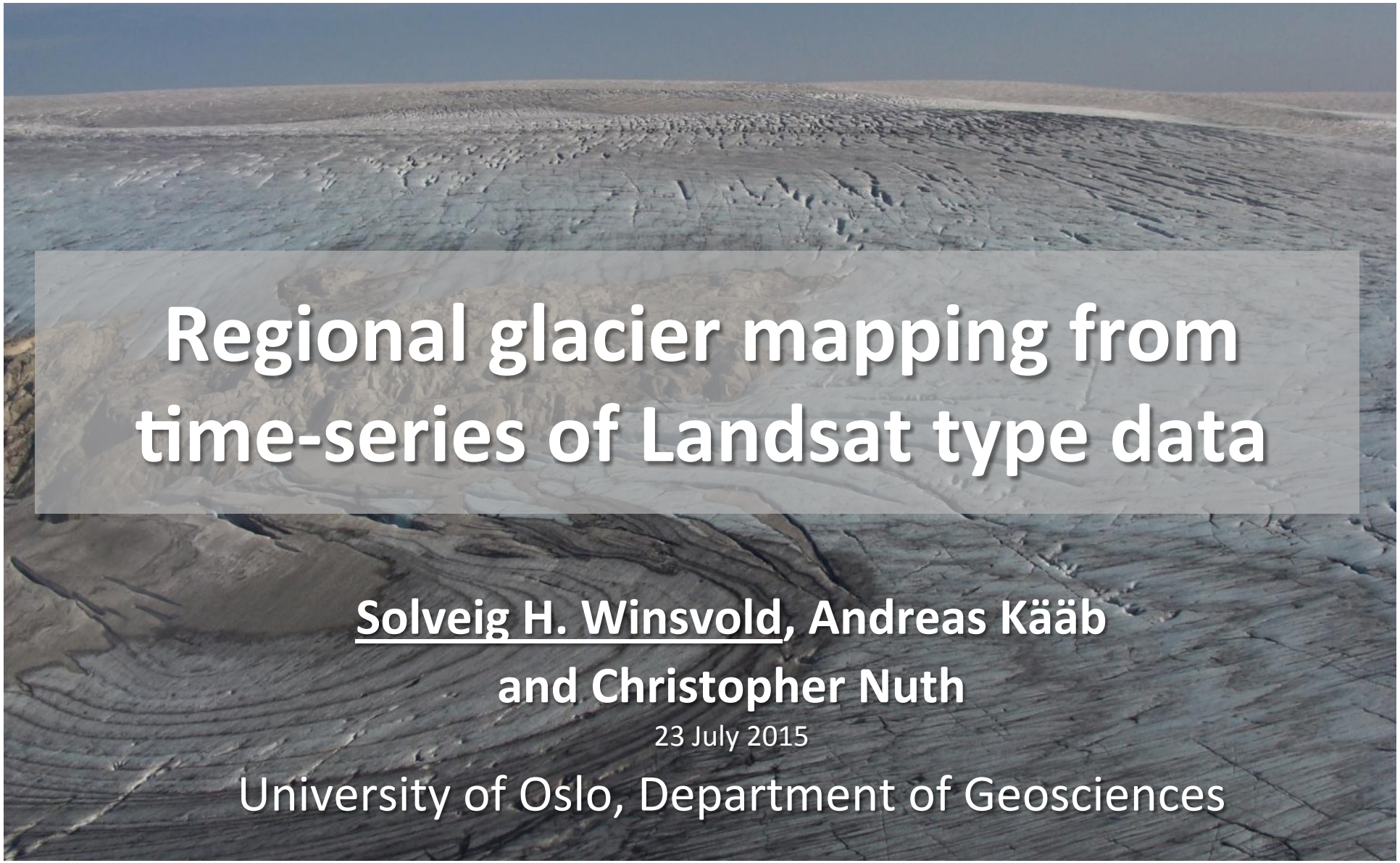


Regional glacier mapping from time-series of Landsat type data

Solveig H. Winsvold, Andreas Kääb and Christopher Nuth

23 July 2015

University of Oslo, Department of Geosciences

Why do we map glaciers?

Climate change:

- Essential climate variable – ECV (GCOS)
- Sea level change
- Natural hazards

Hydrological cycle:

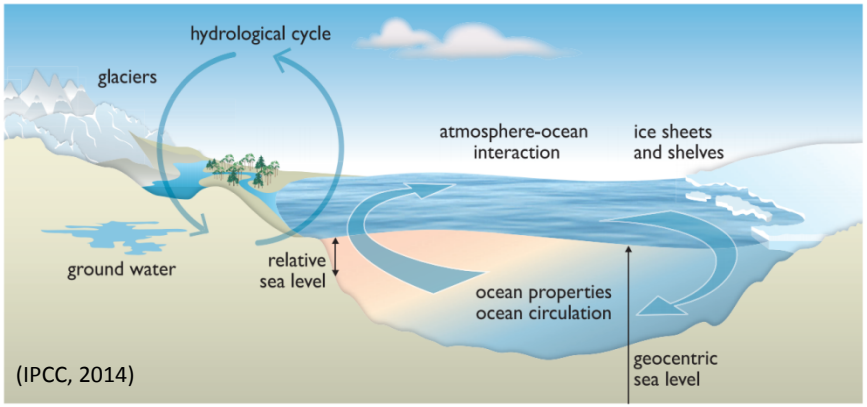
- Water resources
- Hydro power

Tourism

Modelling

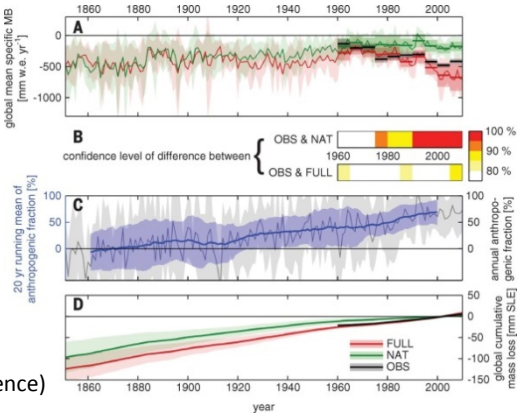
- Glacier inventories are important in glaciological and hydrological modelling assessments

(Hellstugubreen (Norway). Photo: NVE)

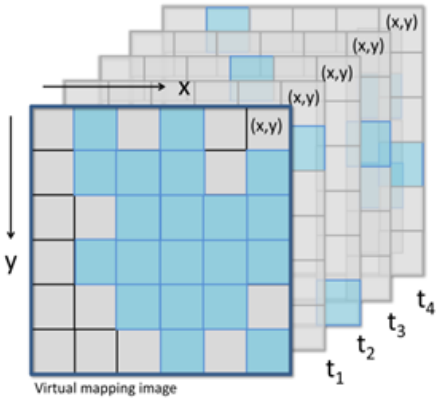


(IPCC, 2014)

(Ilulissat, Greenland.
Photo: Liss M. Andreassen)



(Marzeion, 2014, Science)

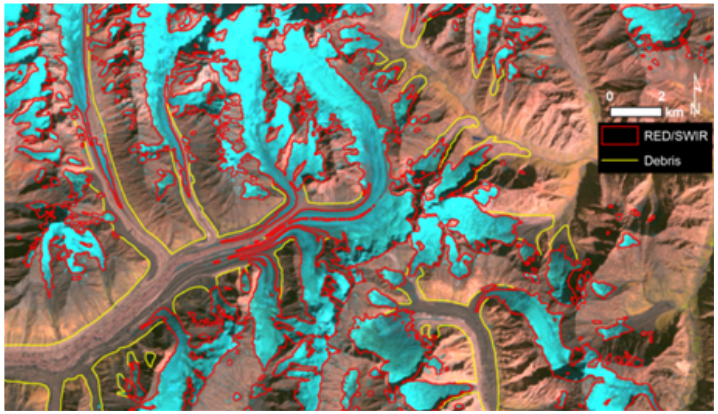


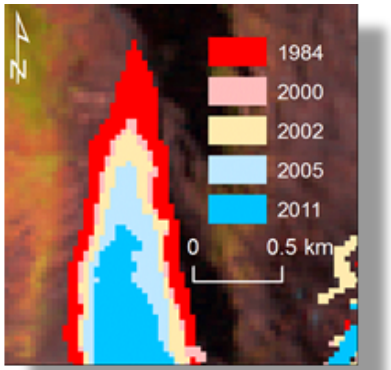
Synthesizing optimal mapping scene

- How and why do we want to improve the current glacier mapping method?

Improved glacier mapping

- How can this be done fully automatically?





Glacier change analysis

- Can changes be automatically extracted?

Background and Motivation

- **Higher temporal resolution of optical satellites in the future**
- Landsat archive
  - One of few remote sensing sources that represent a full climate record (~30 years)

Optical satellite mission	Lansat TM/ETM+	Landsat-8 OLI	Sentinel-2 MSI
Launch	1982 (TM4), 1984(TM5), 1999(ETM7)	**2013**	**2015**
Swath width	185 km	185 km	290 km
Revisit time	16-days	16-days	5-days (or better)

GOAL: Explore possibilities of future glacier mapping

- Robust methods

Background and Motivation

- Higher temporal resolution of optical satellites in the future
- **Landsat archive**
  - **One of few remote sensing sources that represent a full climate record (~30 years)**

Optical satellite mission	Lansat TM/ETM+	Landsat-8 OLI	Sentinel-2 MSI
Launch	1982 (TM4), 1984(TM5), 1999(ETM7)	**2013**	**2015**
Swath width	185 km	185 km	290 km
Revisit time	16-days	16-days	5-days (or better)

GOAL: Explore possibilities of future glacier mapping

- Robust methods

Background and Motivation

- Higher temporal resolution of optical satellites in the future
- Landsat archive
  - One of few remote sensing sources that represent a full climate record (~30 years)

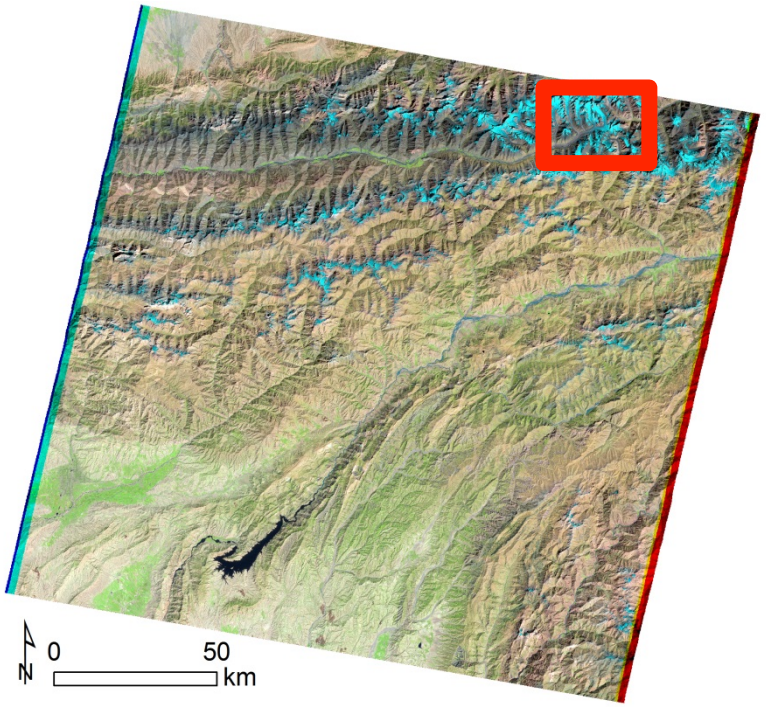
Optical satellite mission	Lansat TM/ETM+	Landsat-8 OLI	Sentinel-2 MSI
Launch	1982 (TM4), 1984(TM5), 1999(ETM7)	**2013**	**2015**
Swath width	185 km	185 km	290 km
Revisit time	16-days	16-days	5-days (or better)

GOAL: Explore possibilities of future glacier mapping

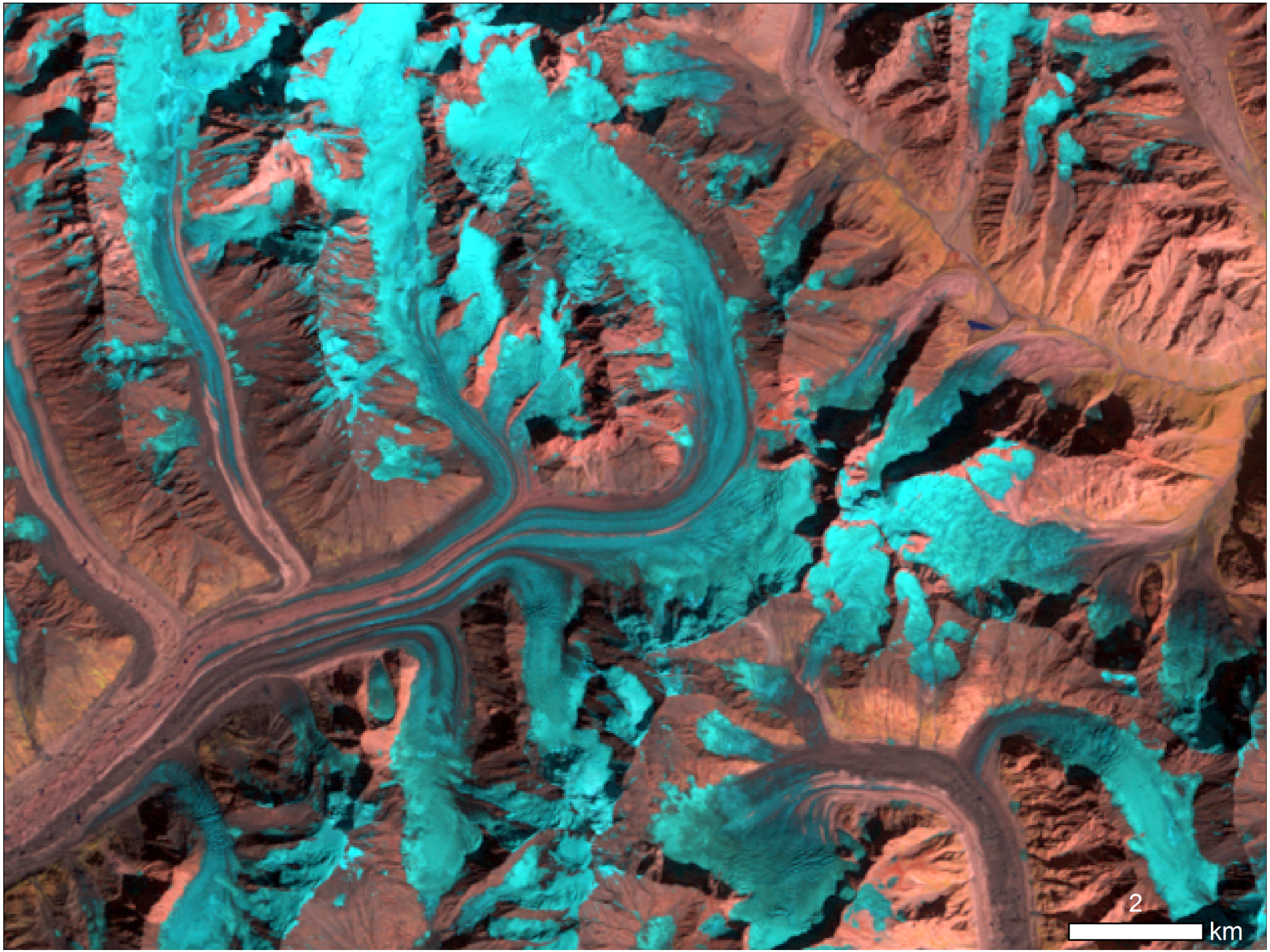
- **Robust methods**

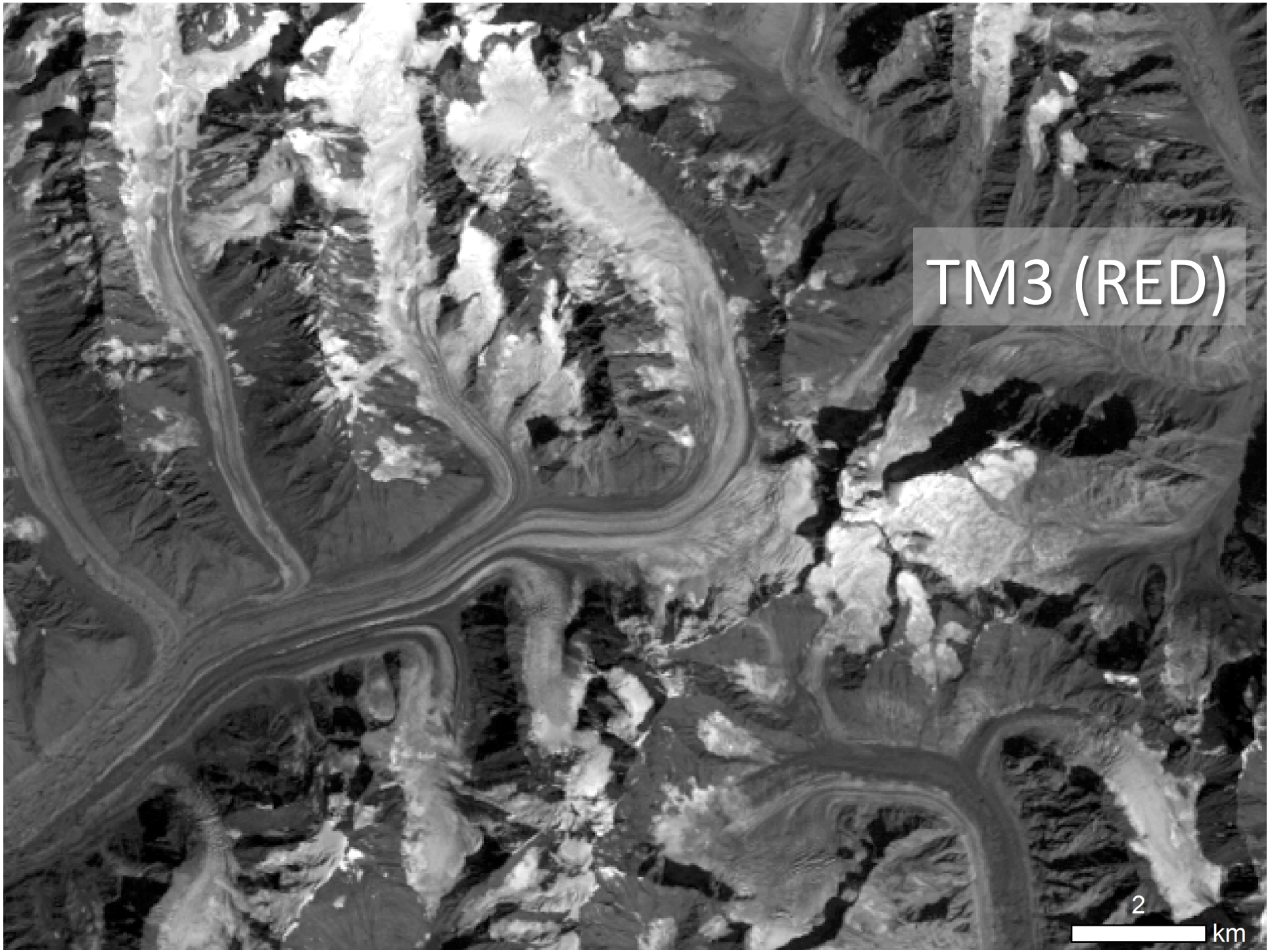
Current glacier mapping

$$Ratio\ image = \frac{RED}{SWIR}$$

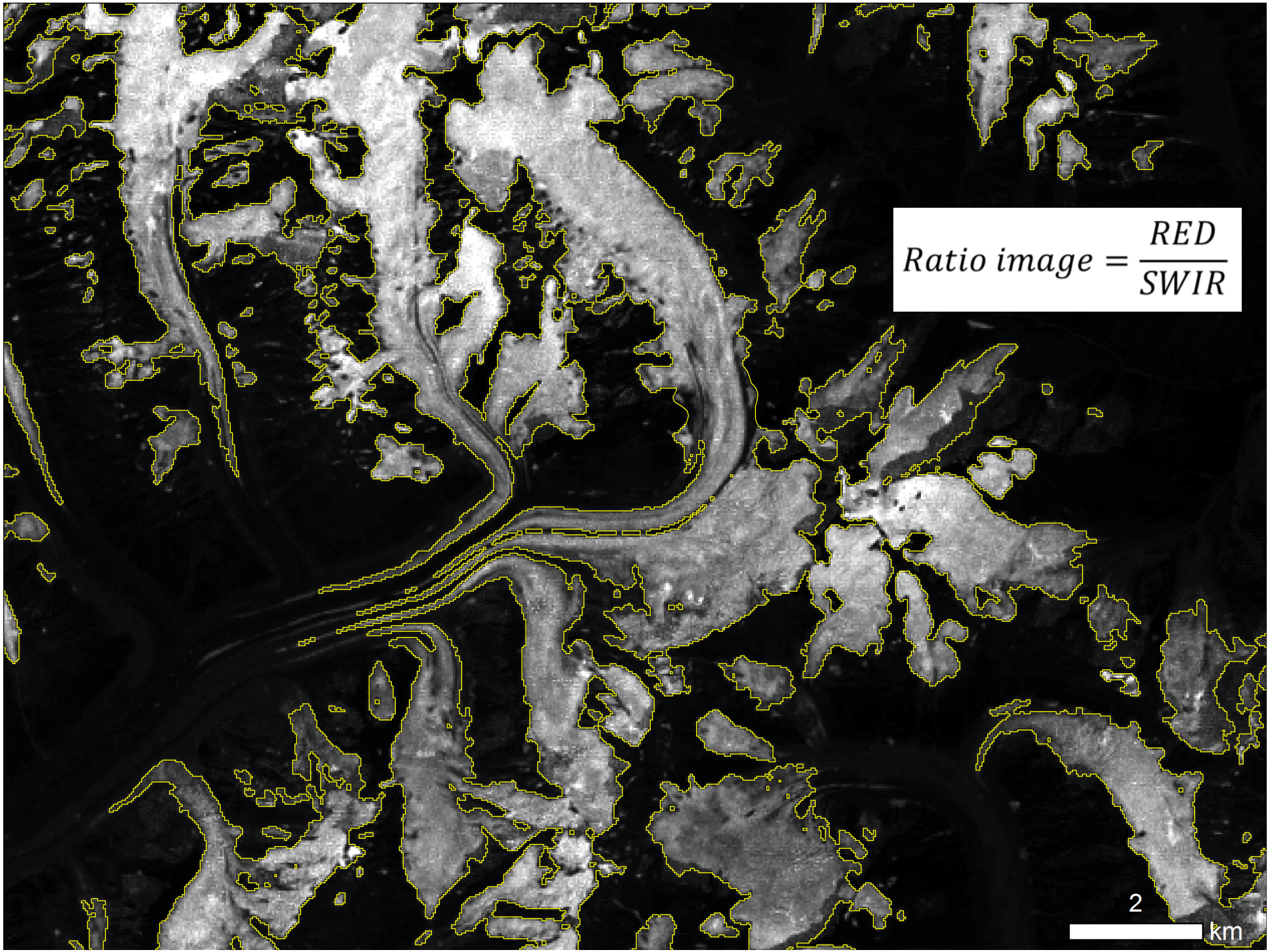


Future glacier mapping **builds** on this robust method for extracting snow and ice from optical satellite images

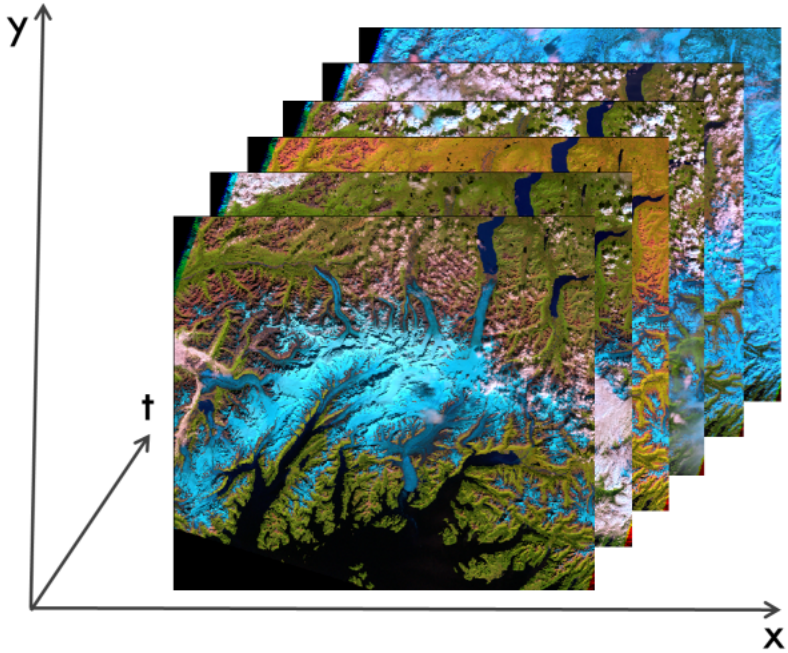

2
km


TM3 (RED)
2
km

TM5 (SWIR)
2
km


$Ratio\ image = \frac{RED}{SWIR}$
2
km

Interpretation methods

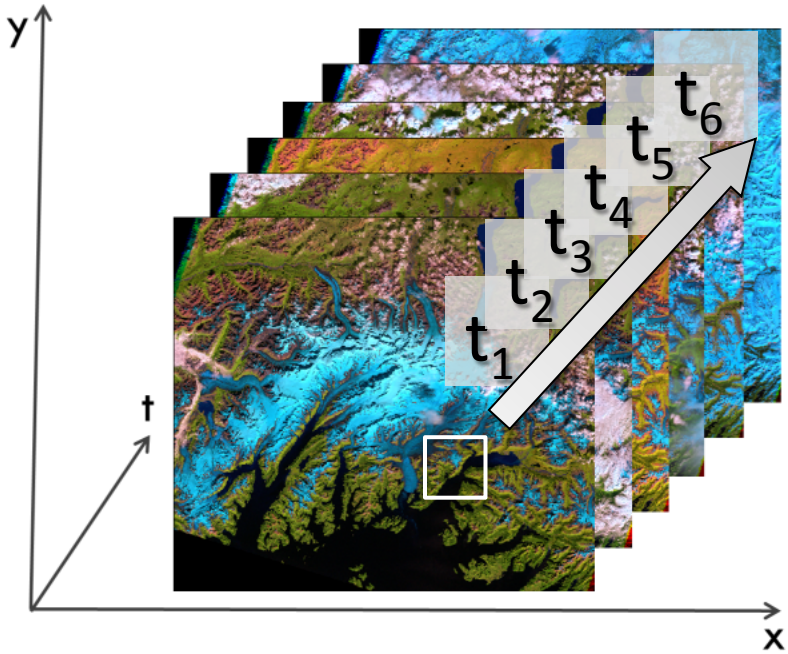


Time scales

Multi-annual

Intraseasonal

Interpretation methods

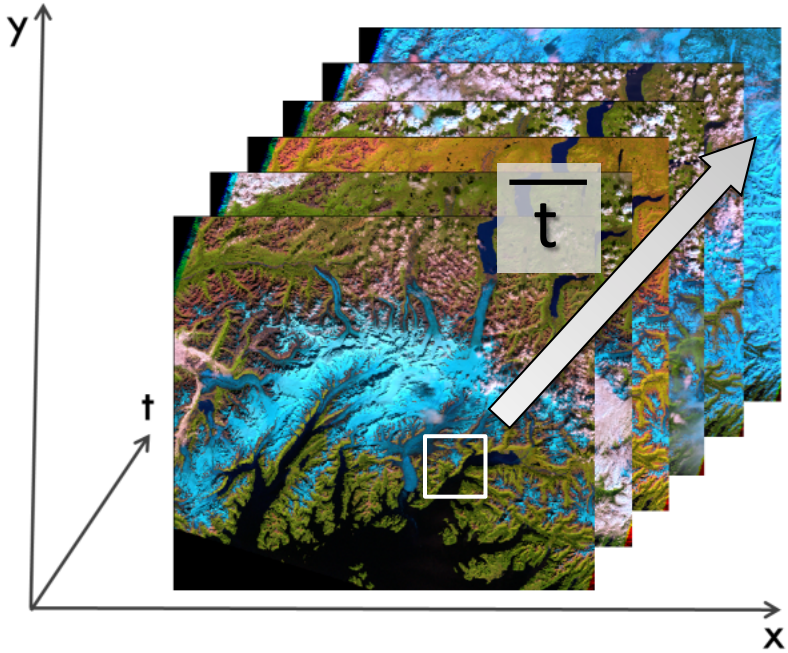


Time scales **Methods**

Multi-annual → **Chronologically**

Intraseasonal → **Chronologically**

Interpretation methods



Time scales

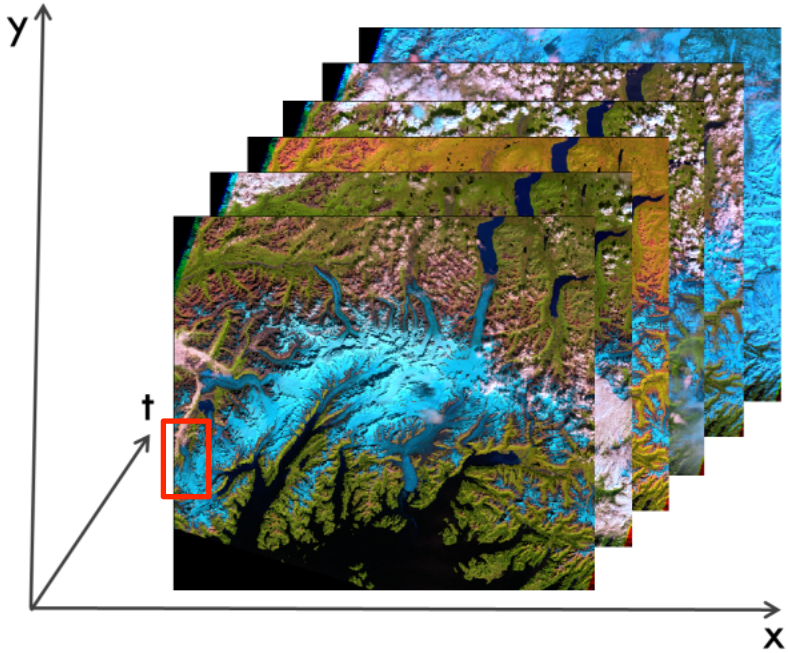
Methods

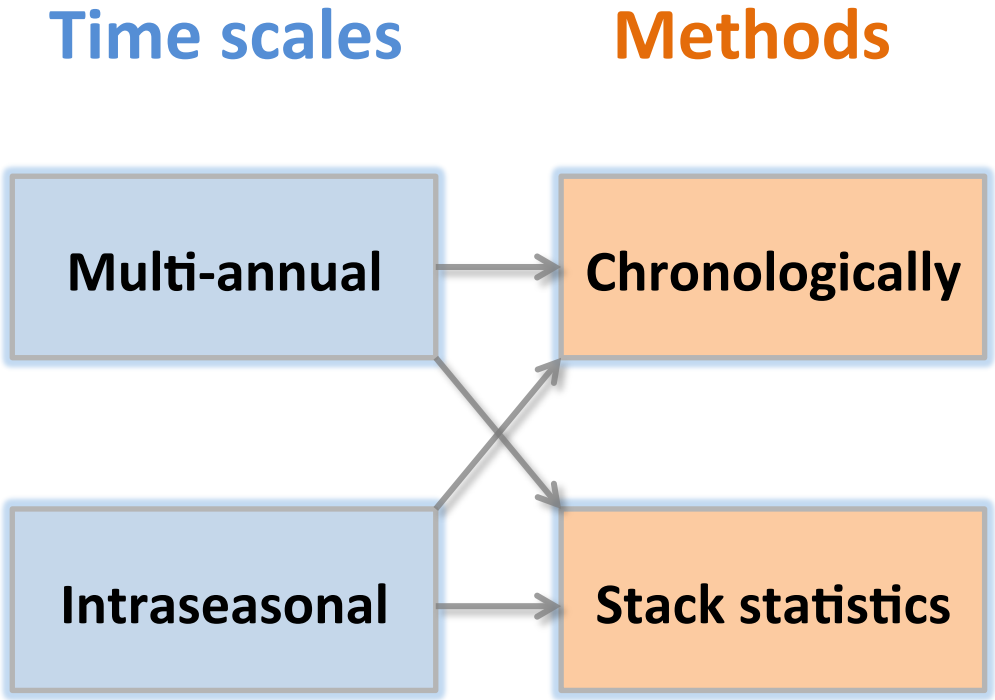
Multi-annual

Intraseasonal

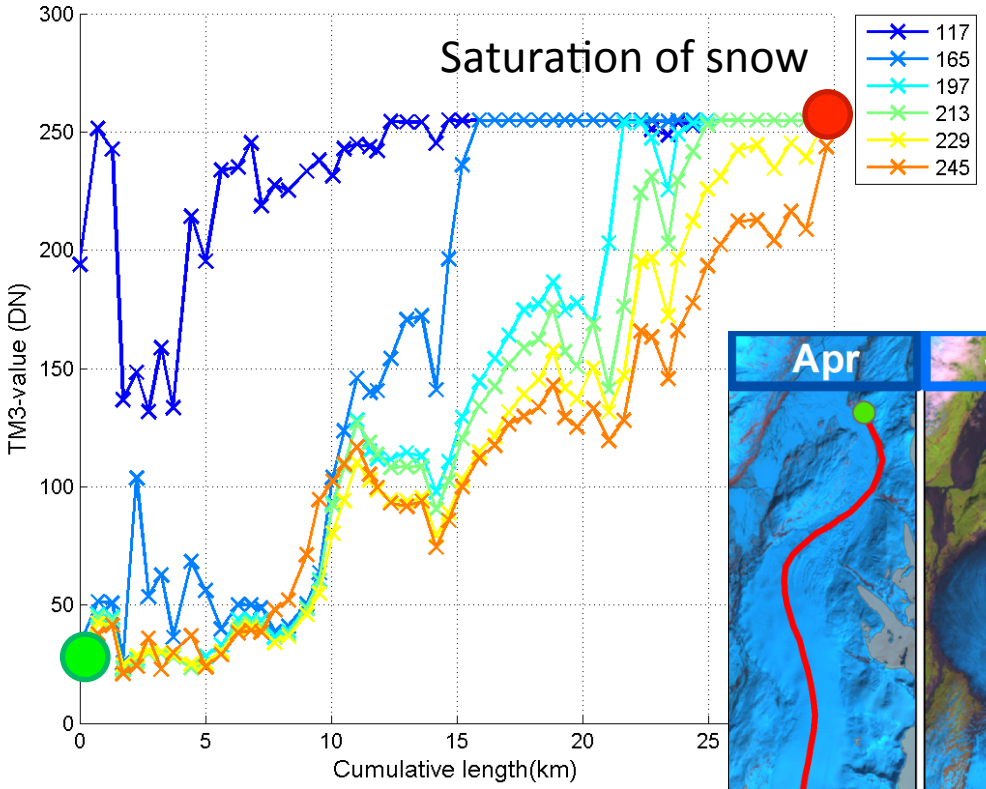
Stack statistics

Interpretation methods

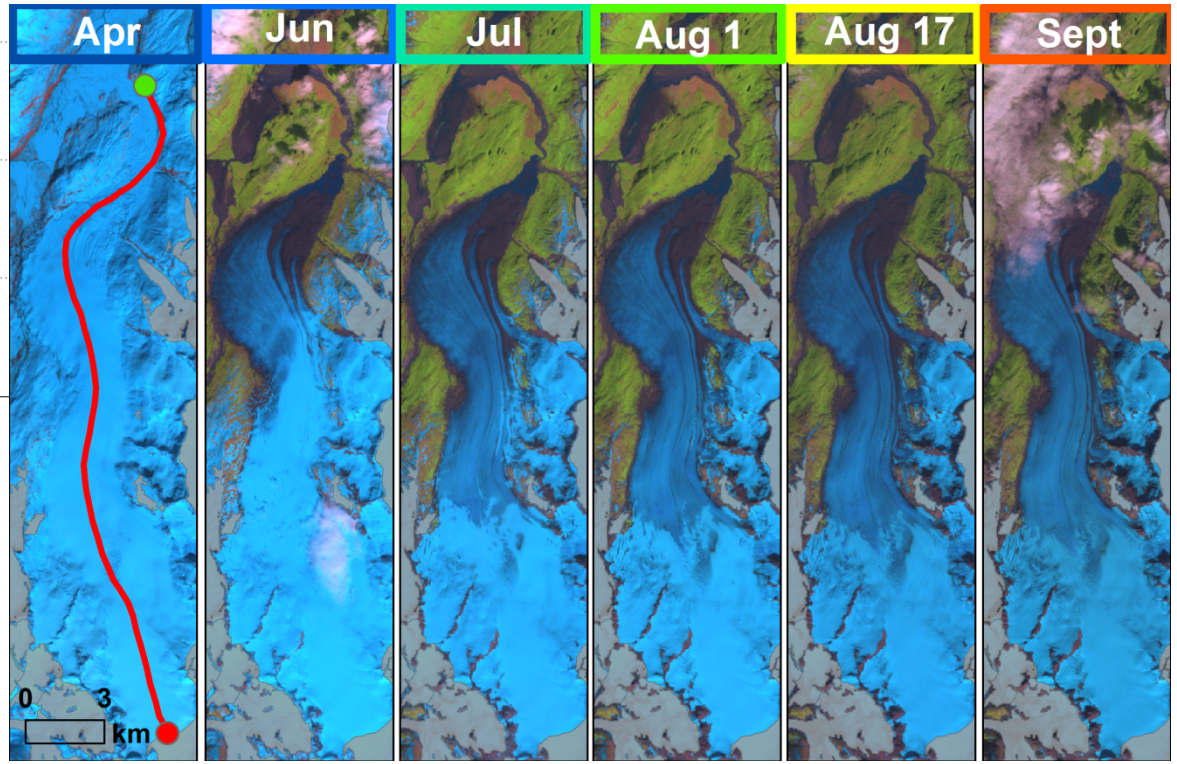


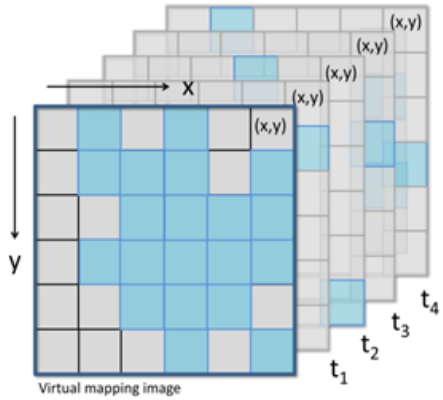


Time-series



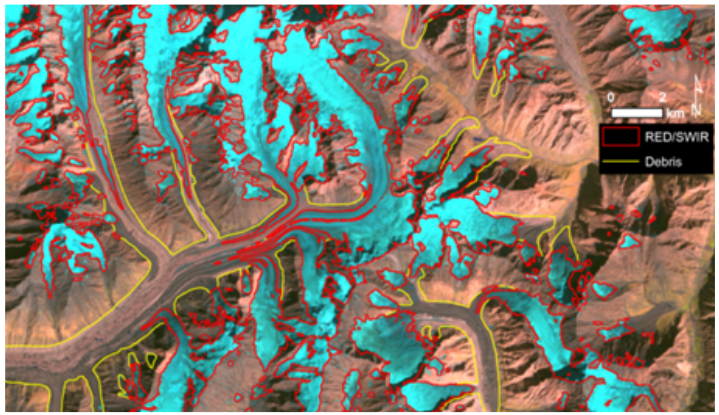
Chugach Mountains, Alaska

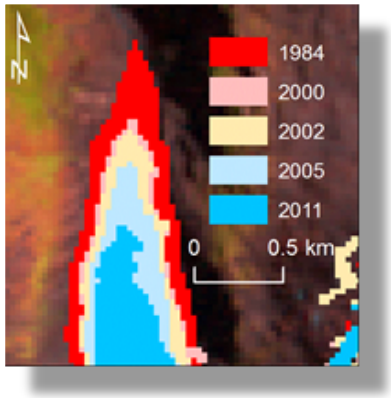




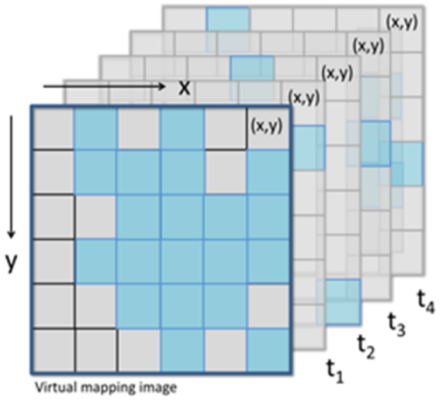
Synthesizing optimal mapping scene

Improved glacier mapping





Glacier change analysis

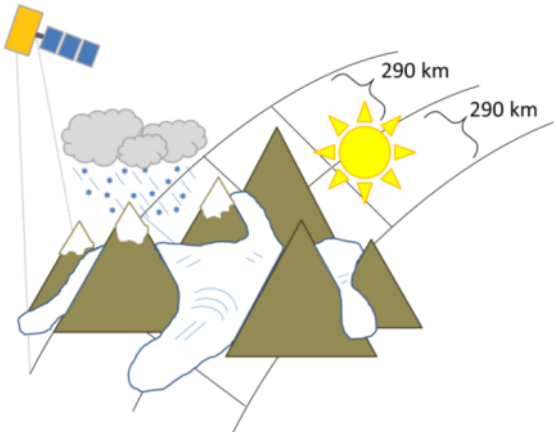


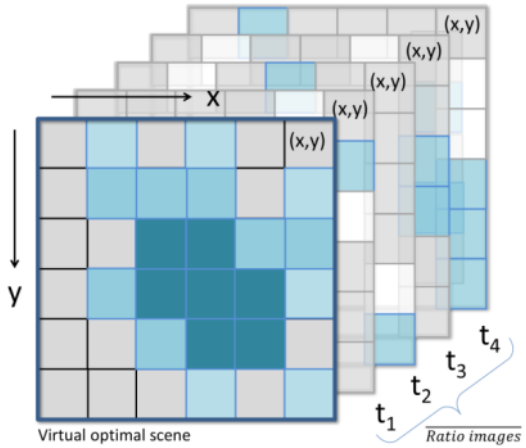
Synthesizing optimal mapping scene

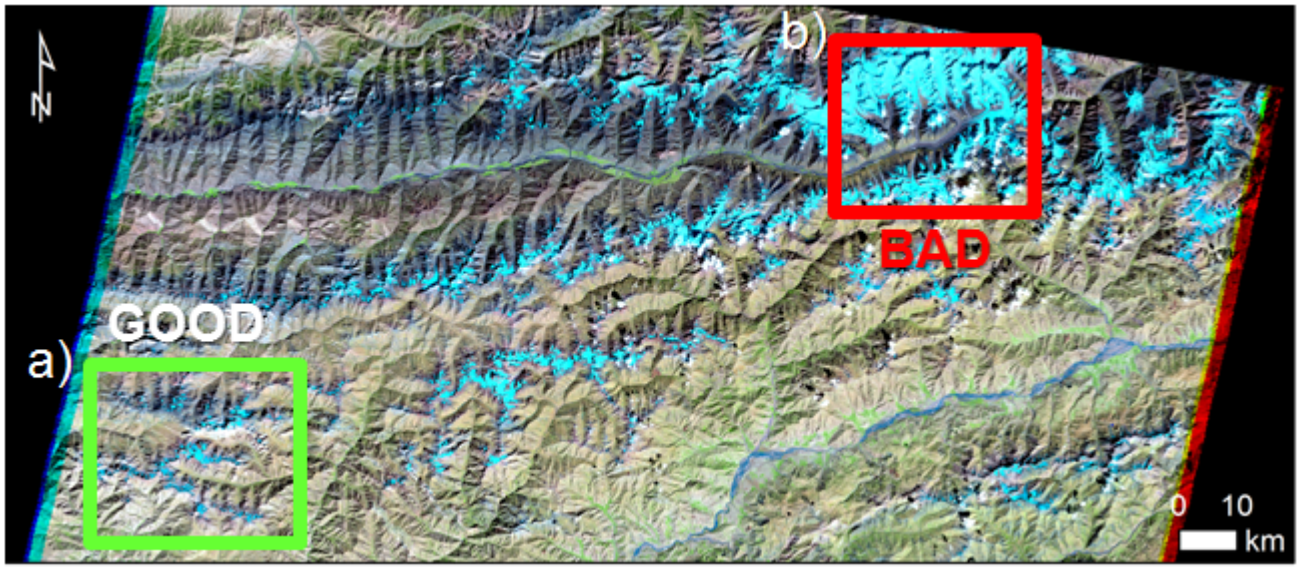
Synthesizing optimal scene

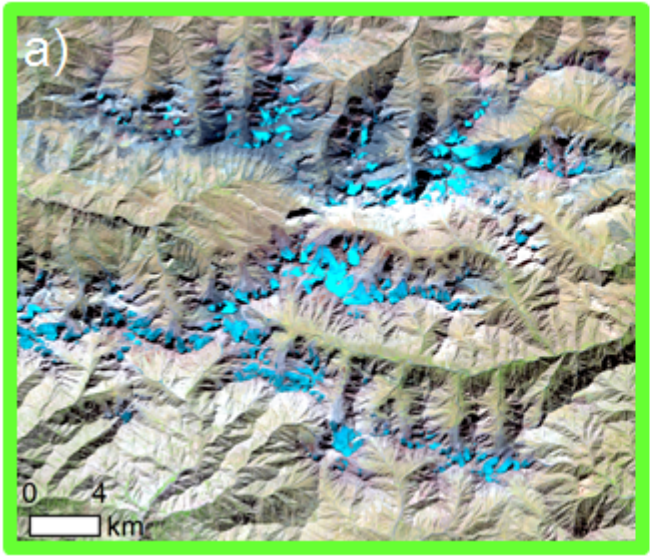
Regional glacier mapping

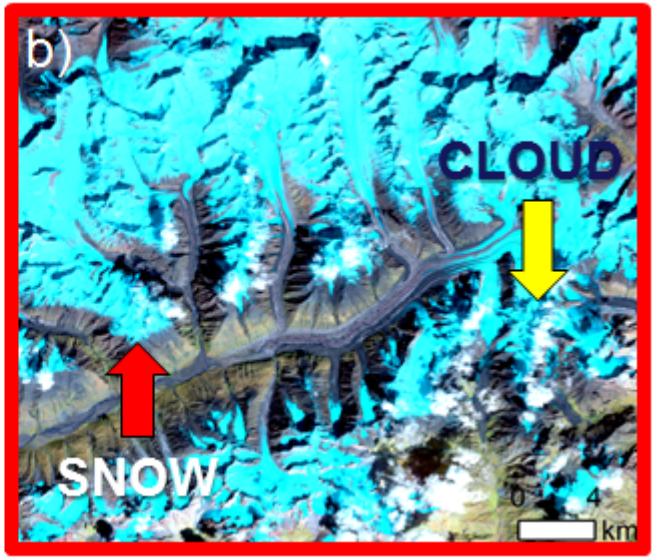
- Minimum snow cover



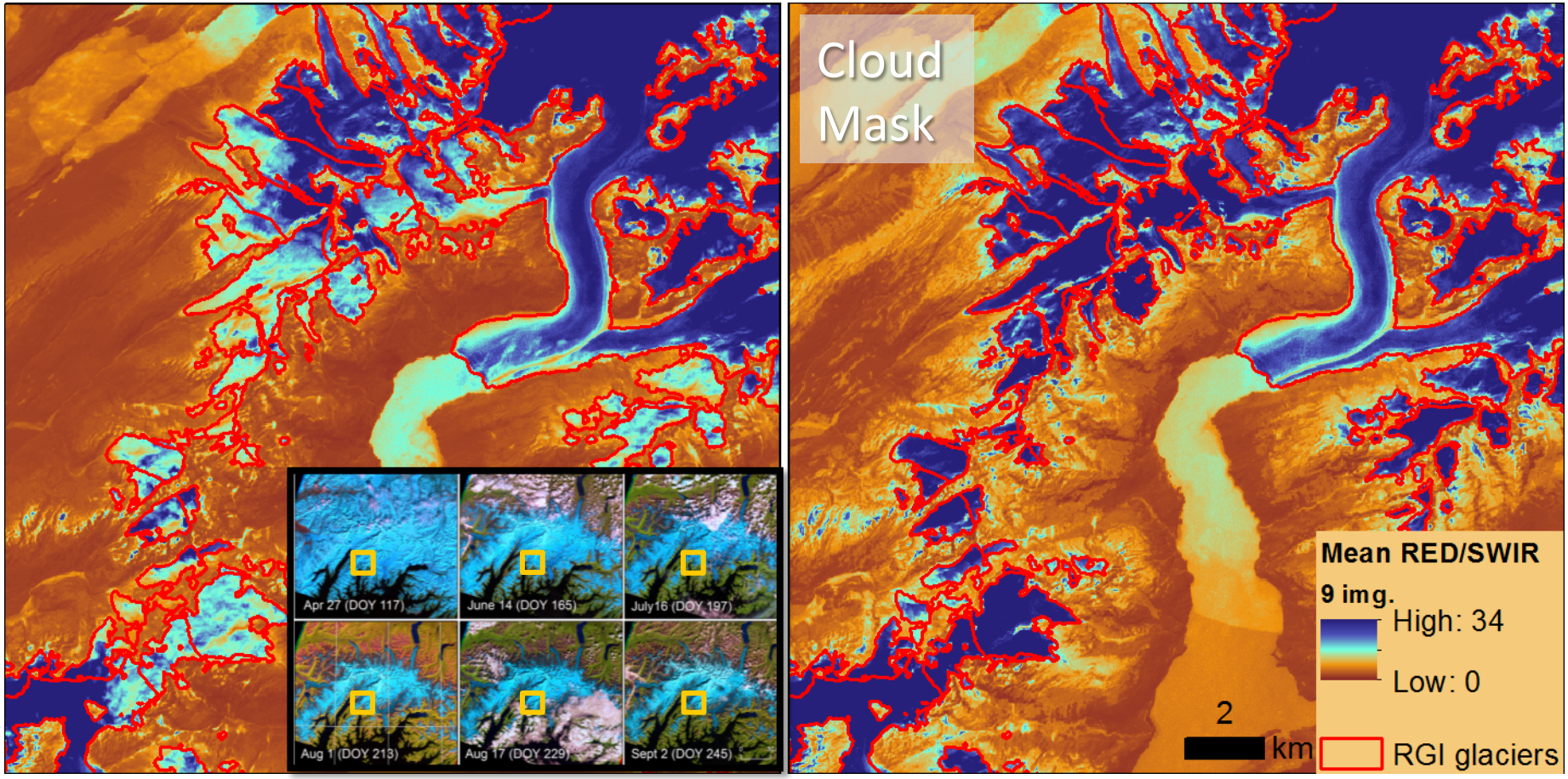








Synthesizing optimal scene

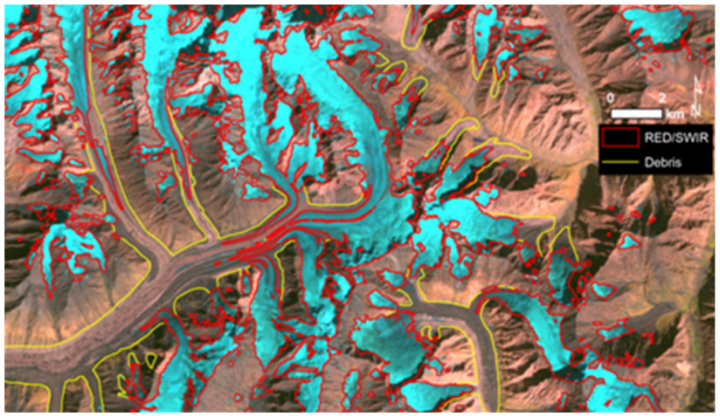


Cloud mask (Fmask): Zhu and Woodcock, 2012

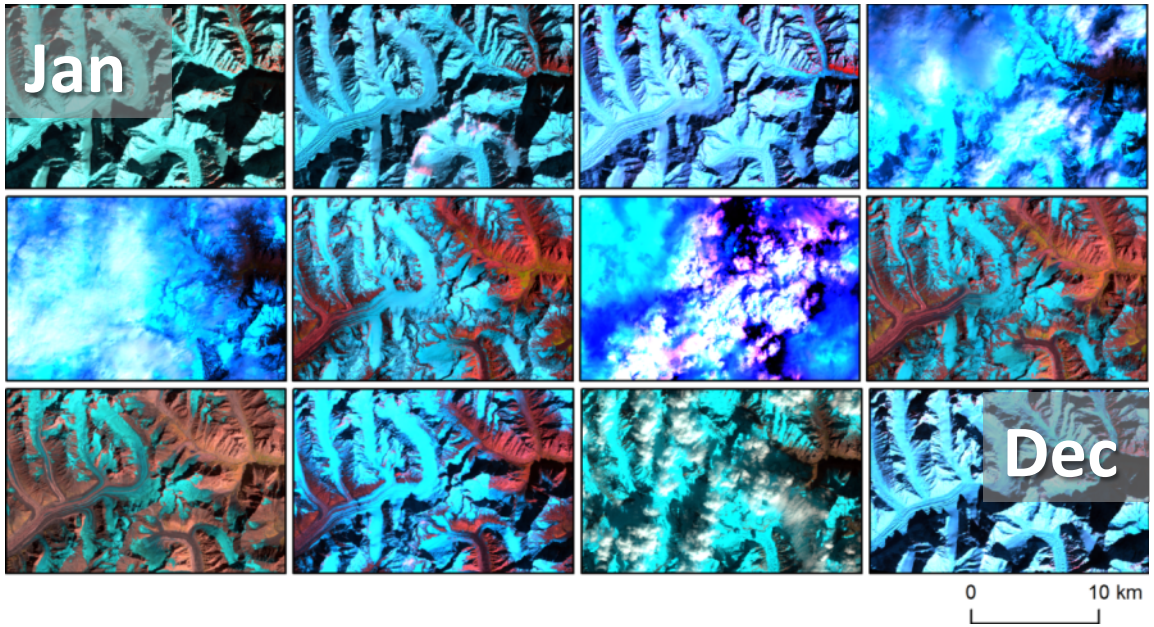
Chugach Mountains, Alaska

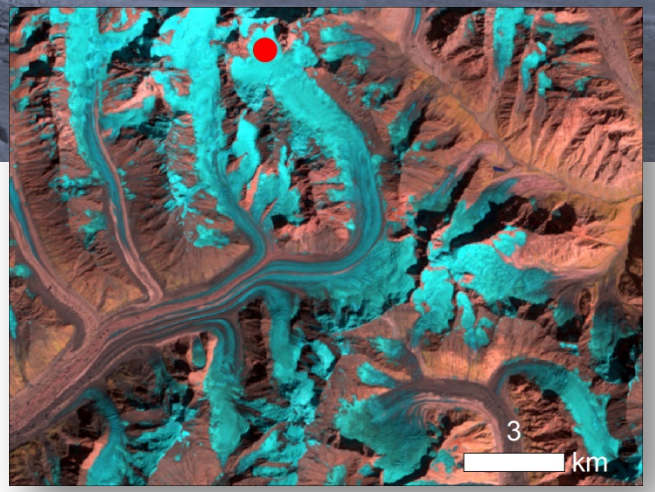
Mean RED/SWIR of 9 Landsat images

Improved glacier mapping

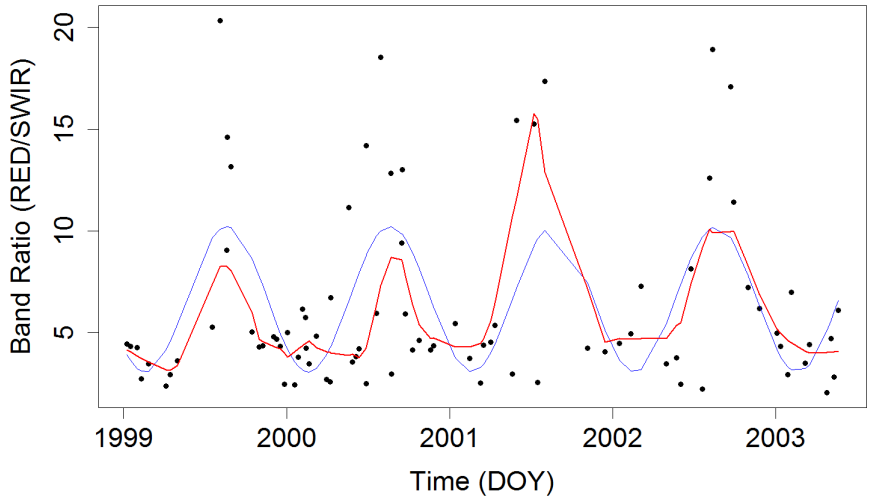


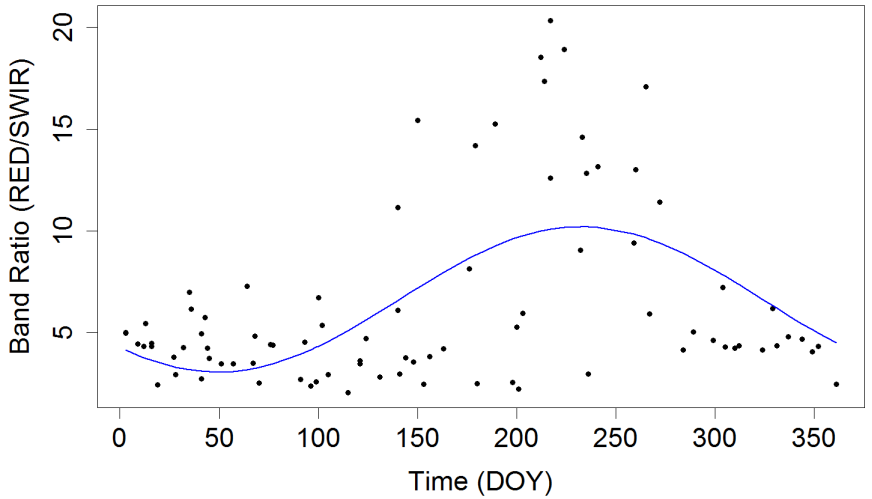
Glacier mapping



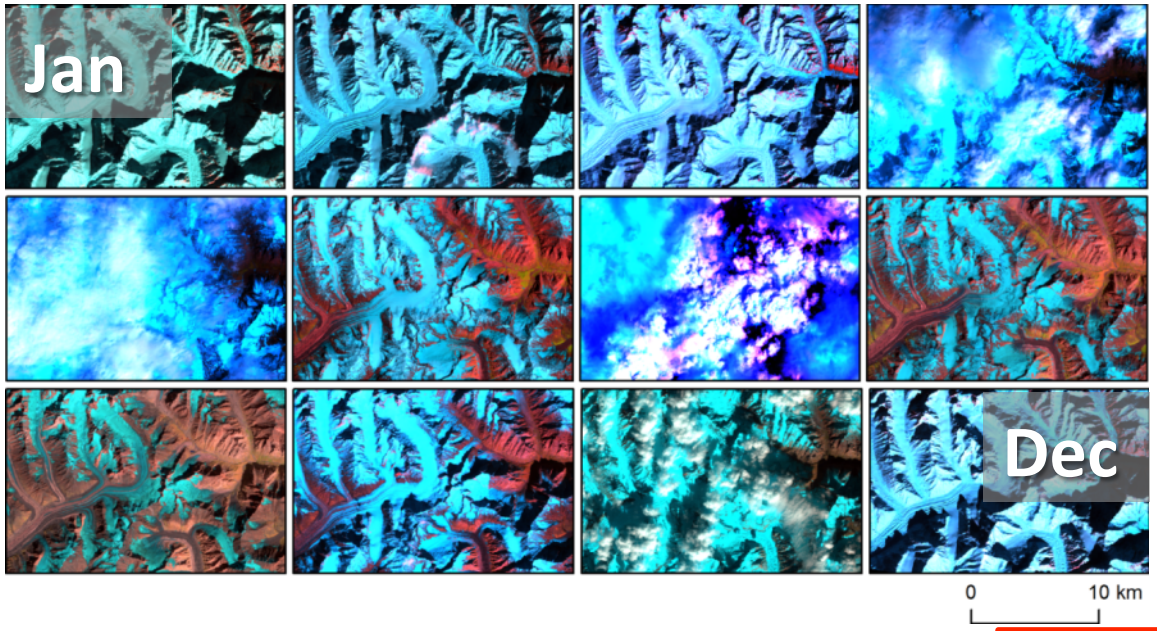


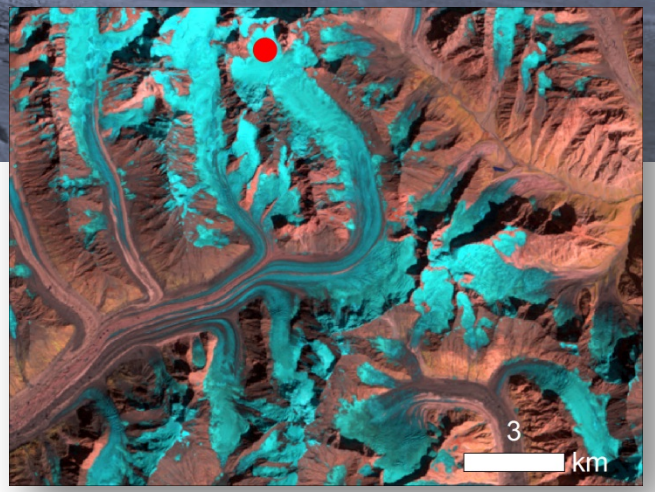
- Pamir (Tajikistan)
- 104 sat. Images
  - TM5 and ETM7+
- 1999 - 2003



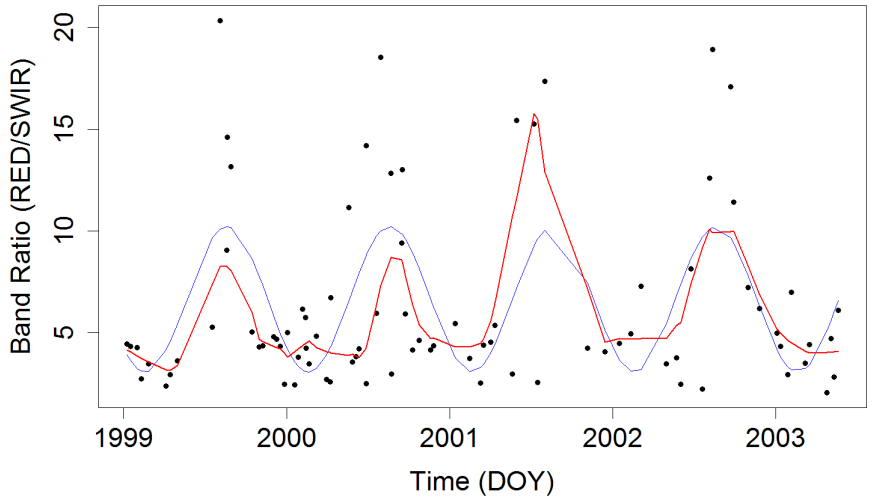


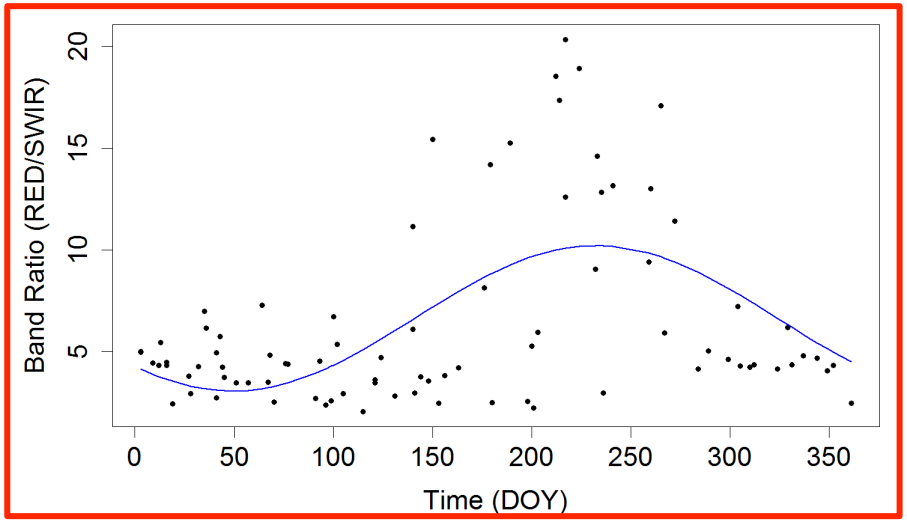
Glacier mapping



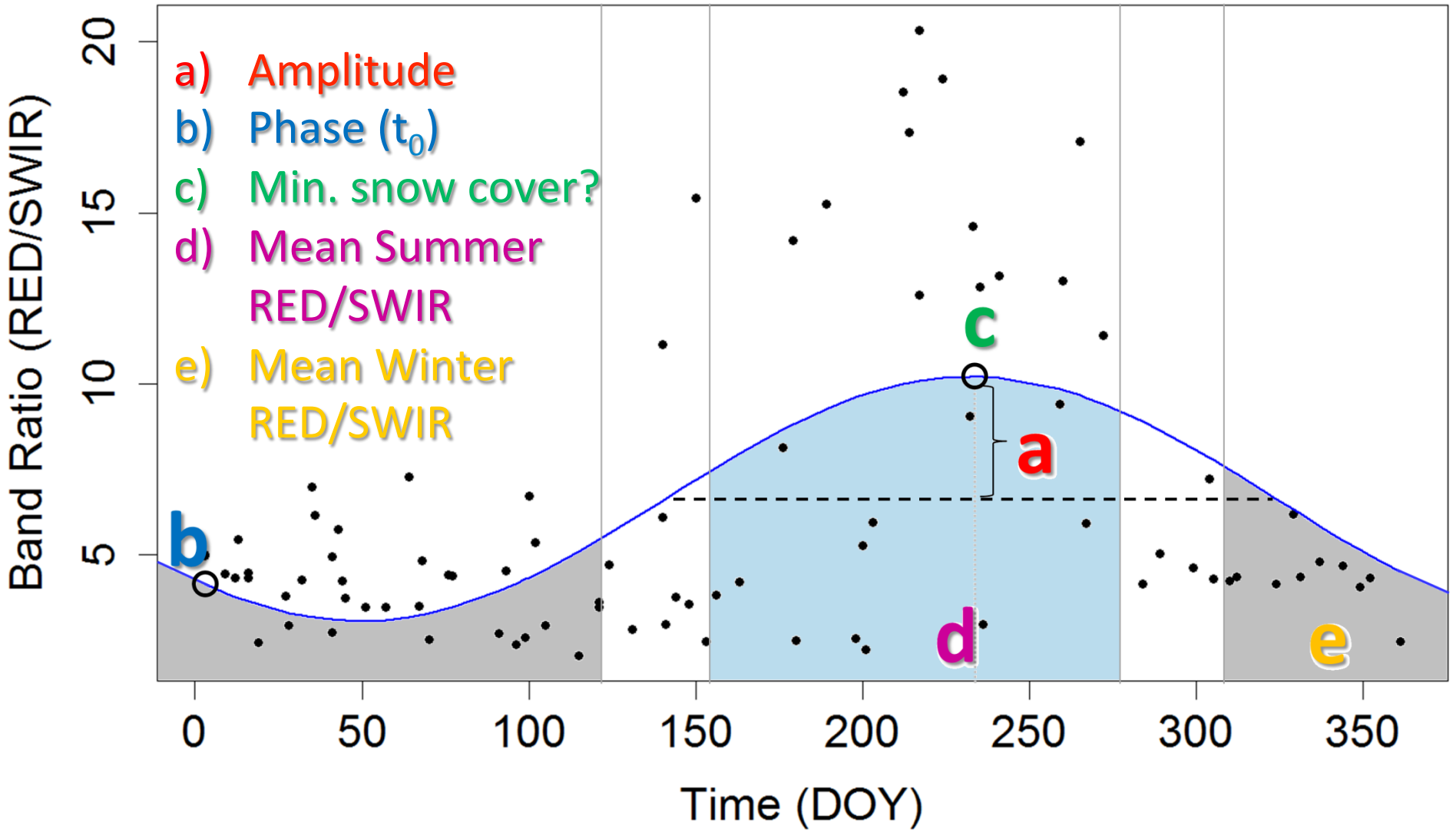


- Pamir (Tajikistan)
- 104 sat. Images
  - TM5 and ETM7+
- 1999 - 2003

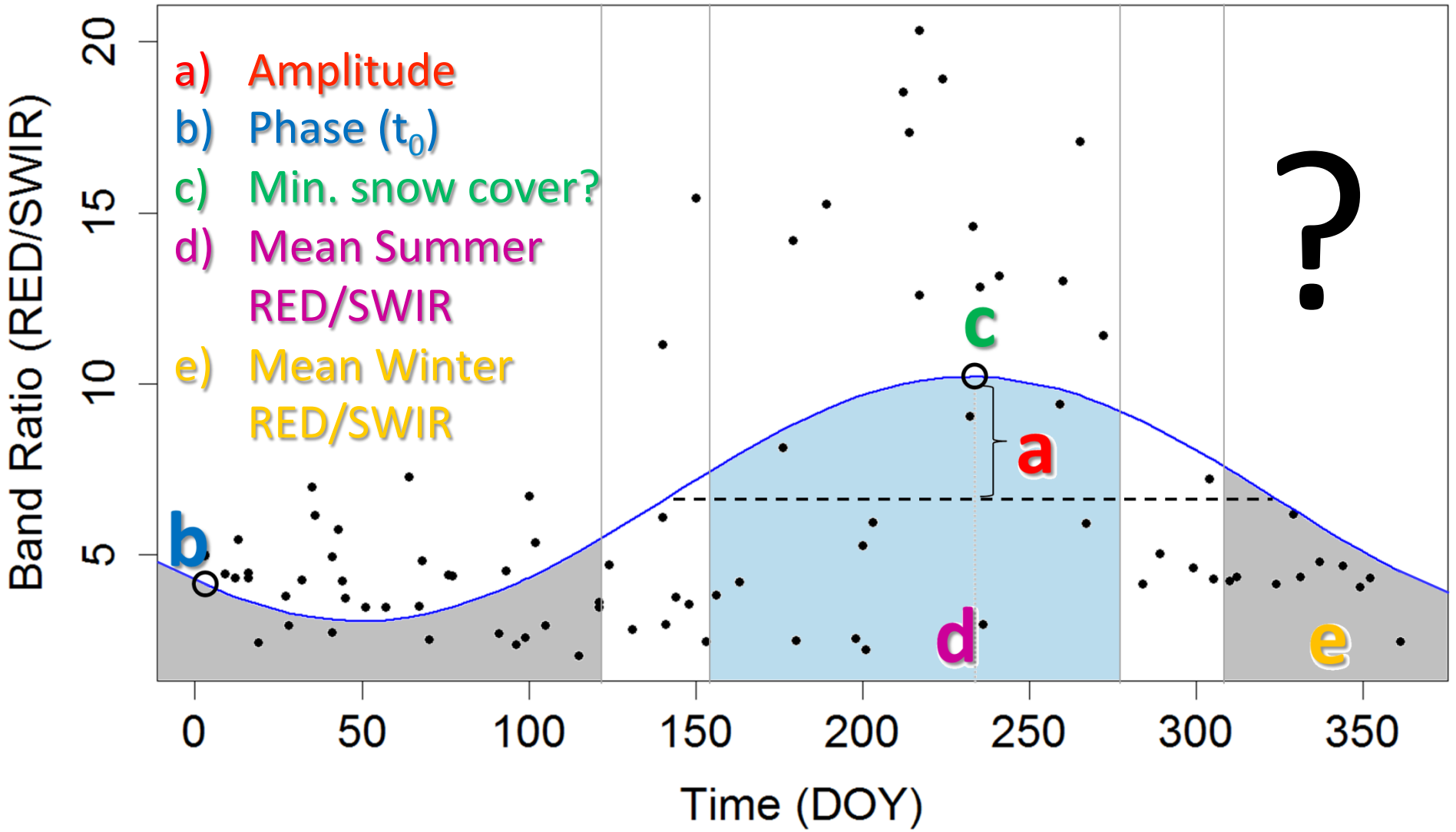




Temporal signal on and off glacier

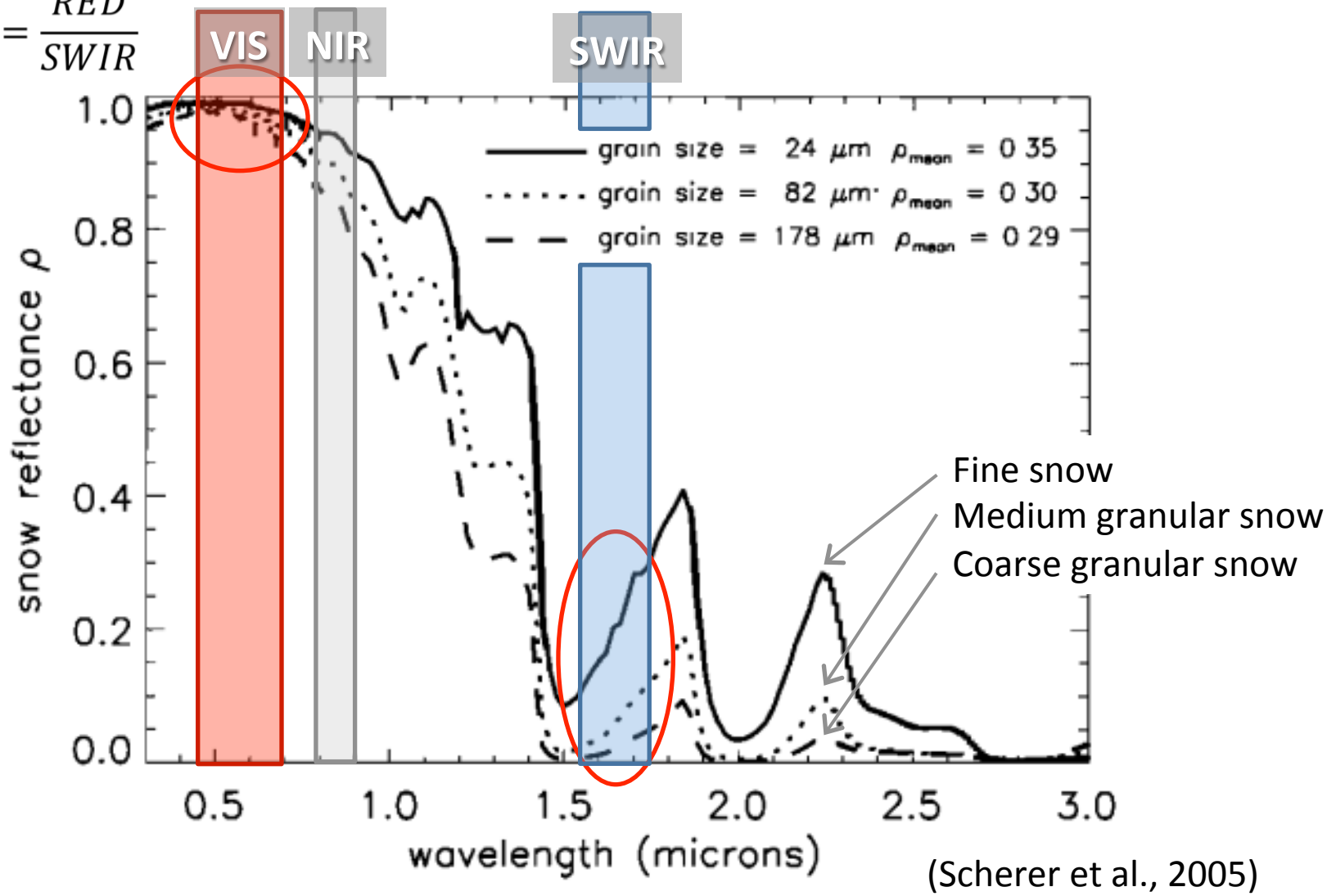


Temporal signal on and off glacier



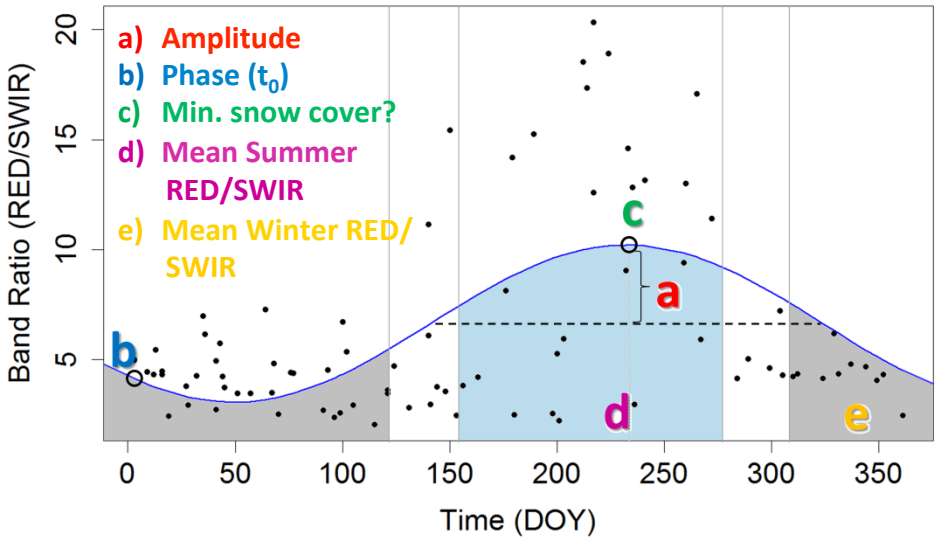
Temporal signal on and off glacier

$$Ratio\ image = \frac{RED}{SWIR}$$



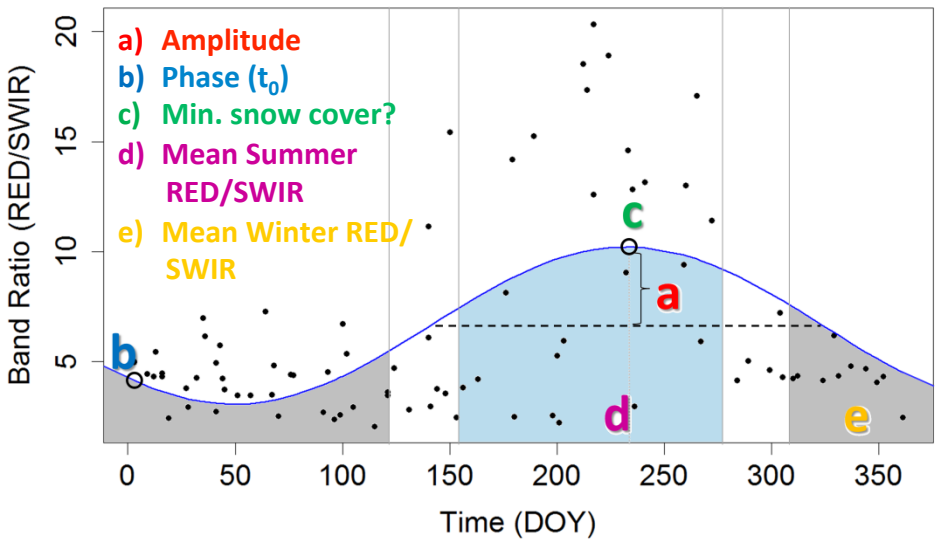
(Scherer et al., 2005)

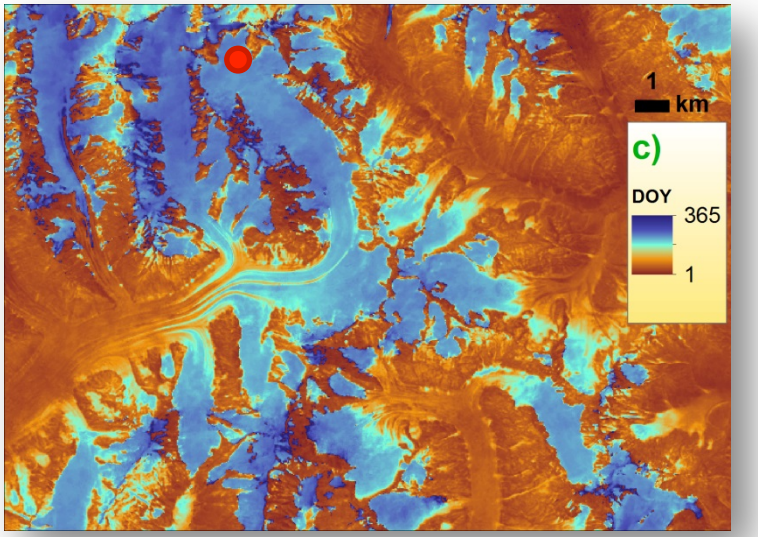
Temporal signal on and off glacier



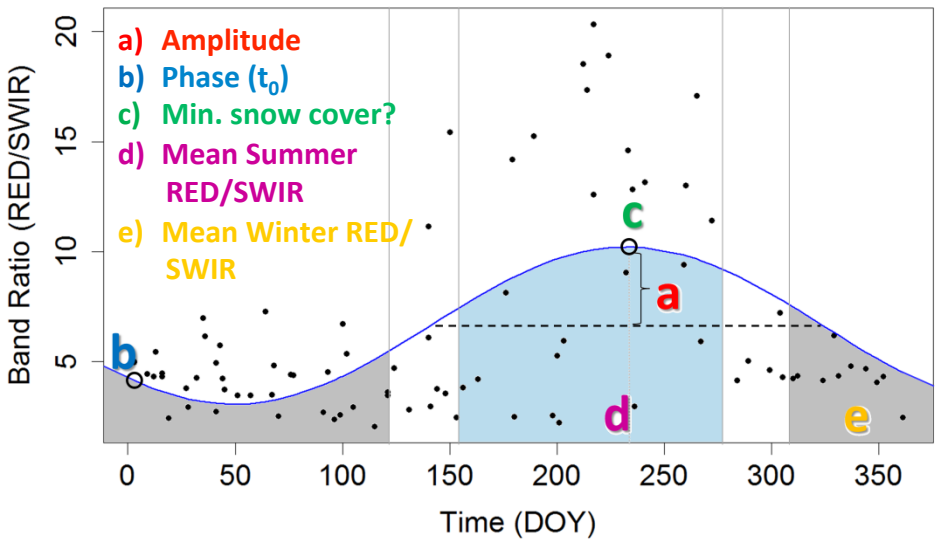
= one pixel

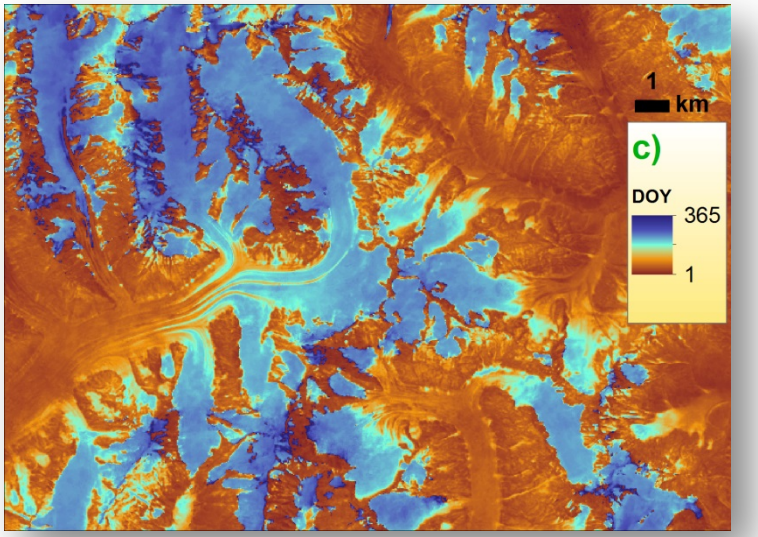
Temporal signal on and off glacier

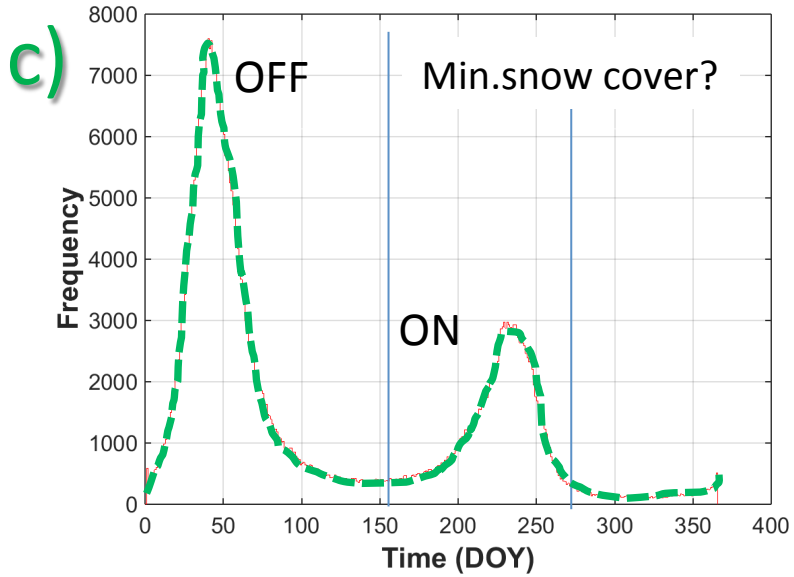




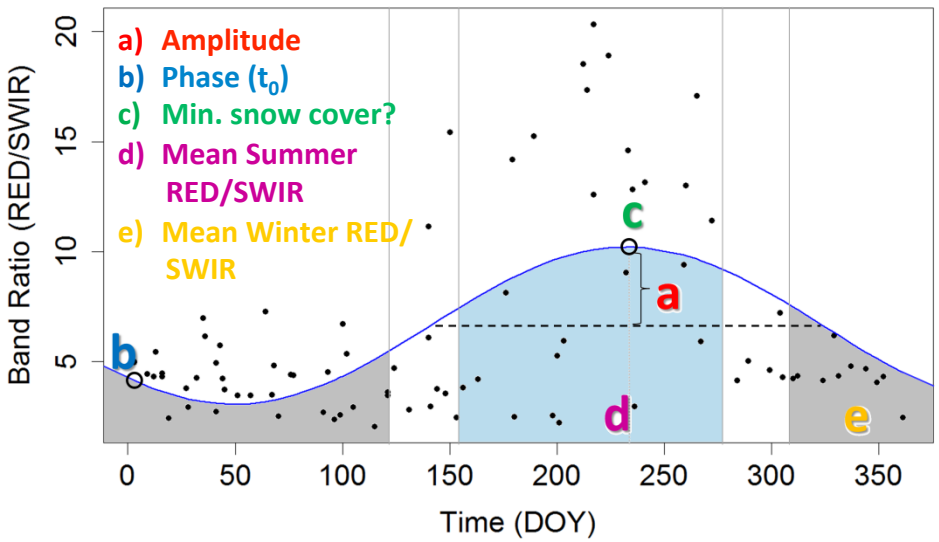
Temporal signal on and off glacier

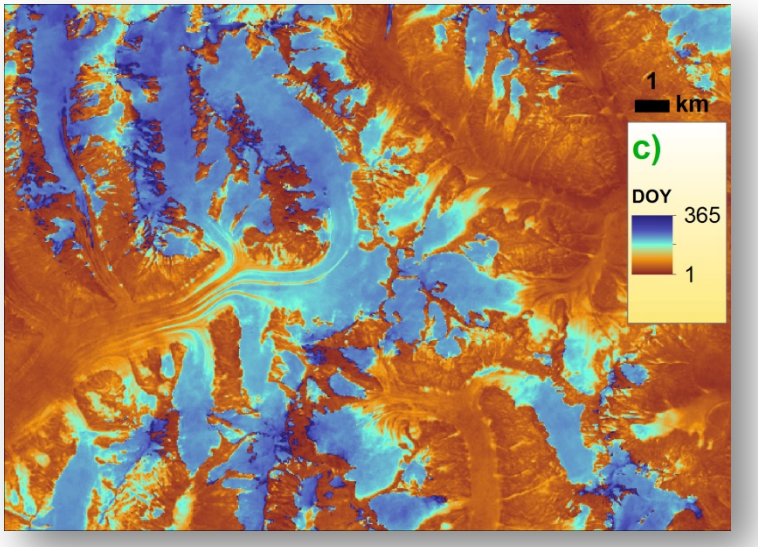


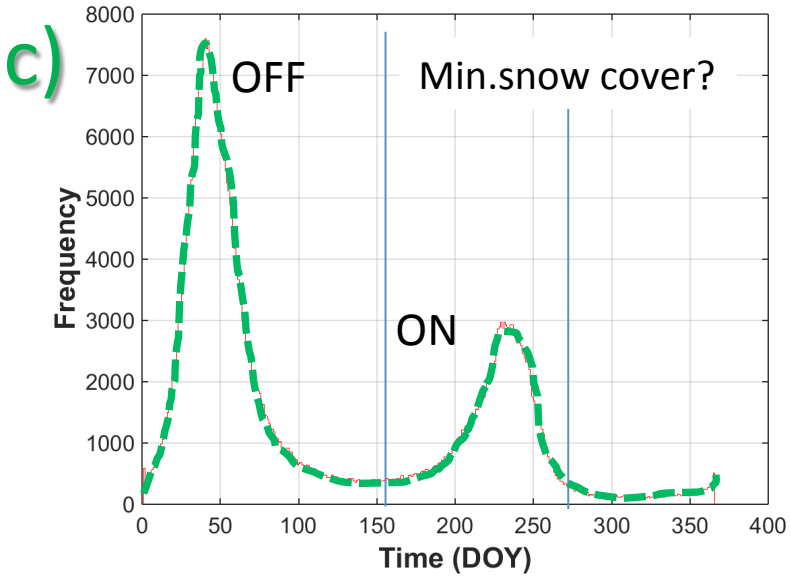


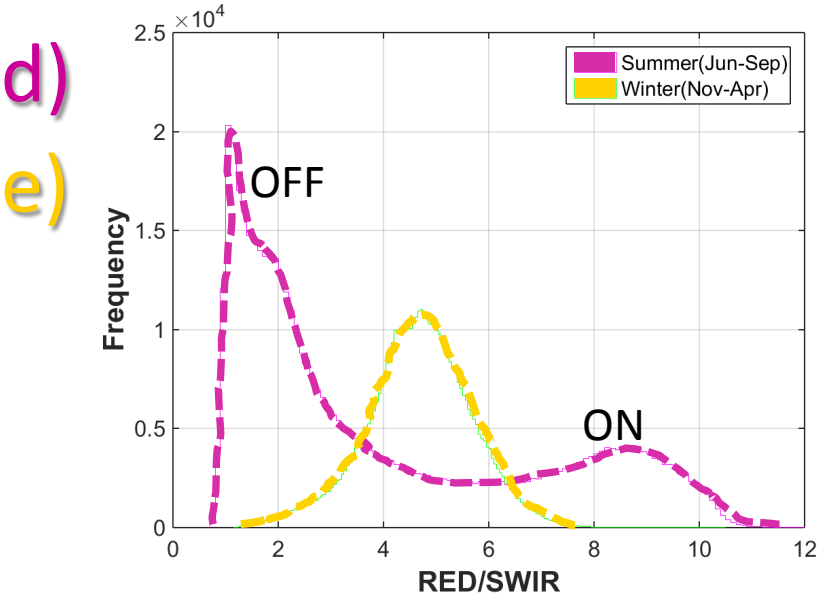


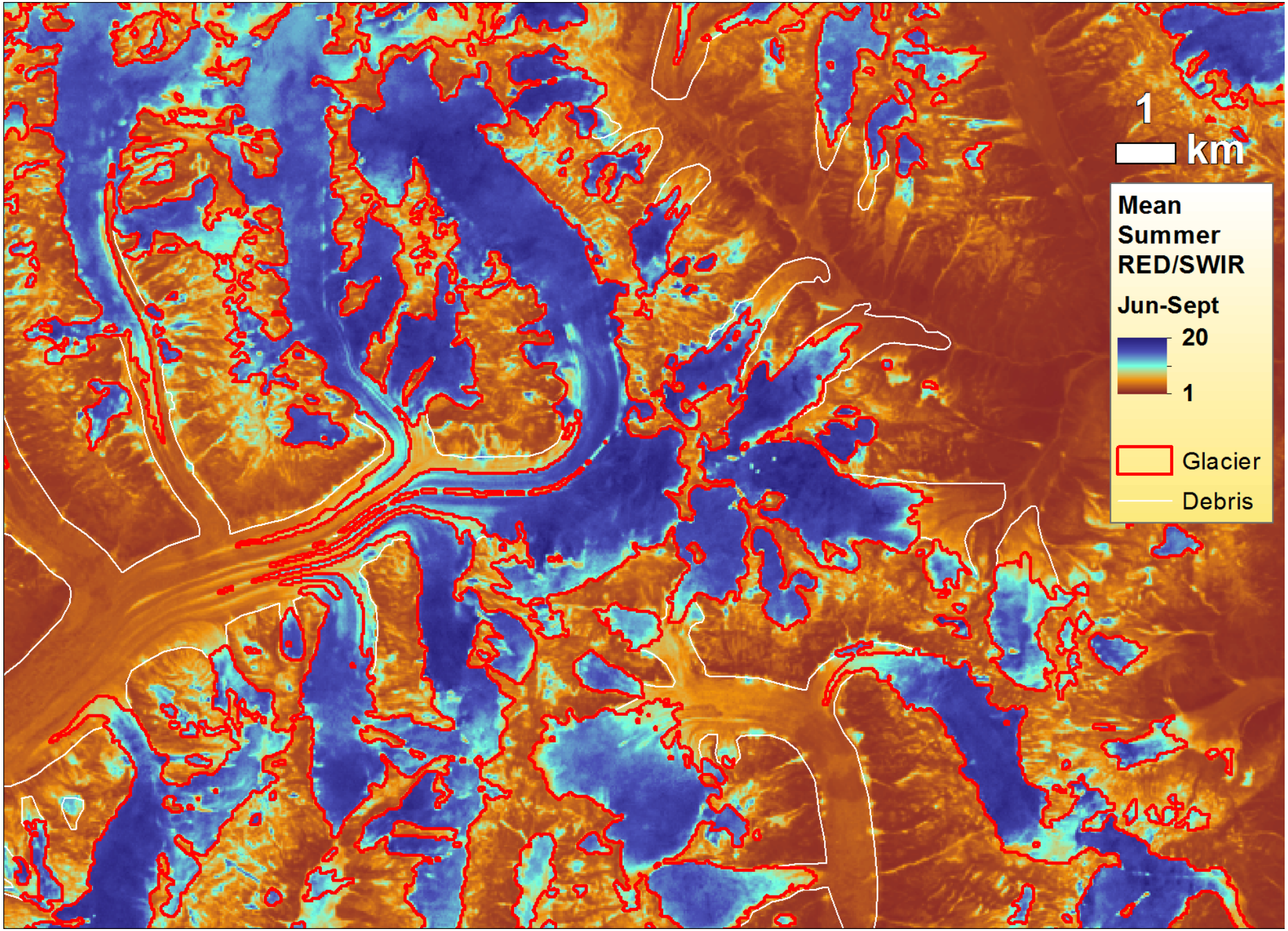
Temporal signal on and off glacier

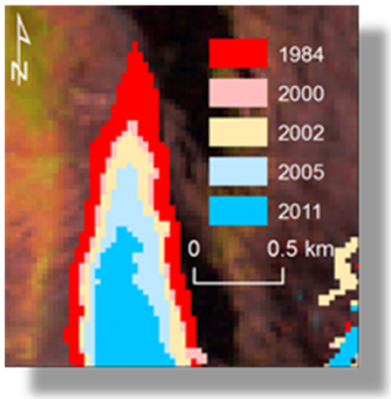






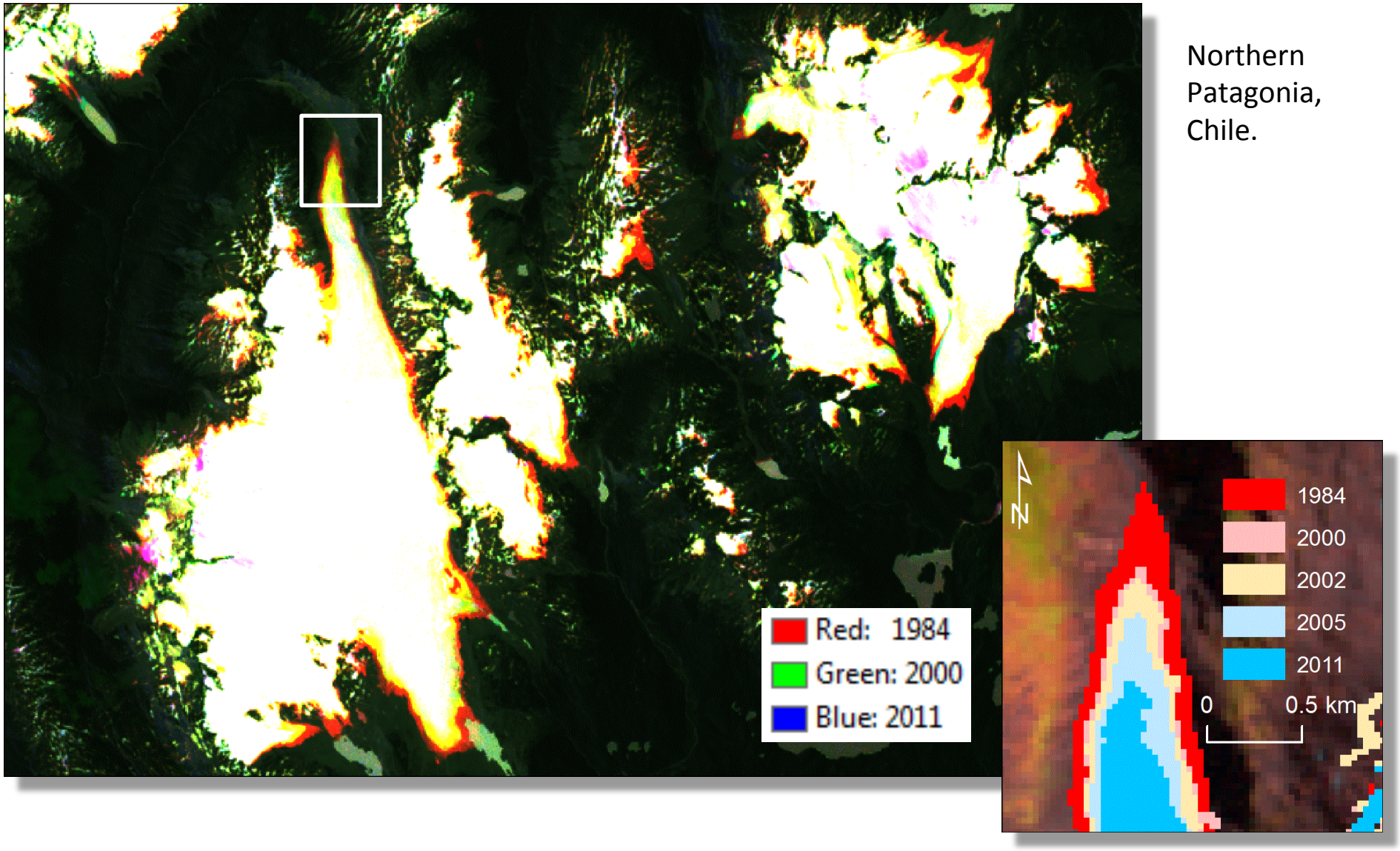



1
km
Mean
Summer
RED/SWIR
Jun-Sept
20
1
Glacier
Debris



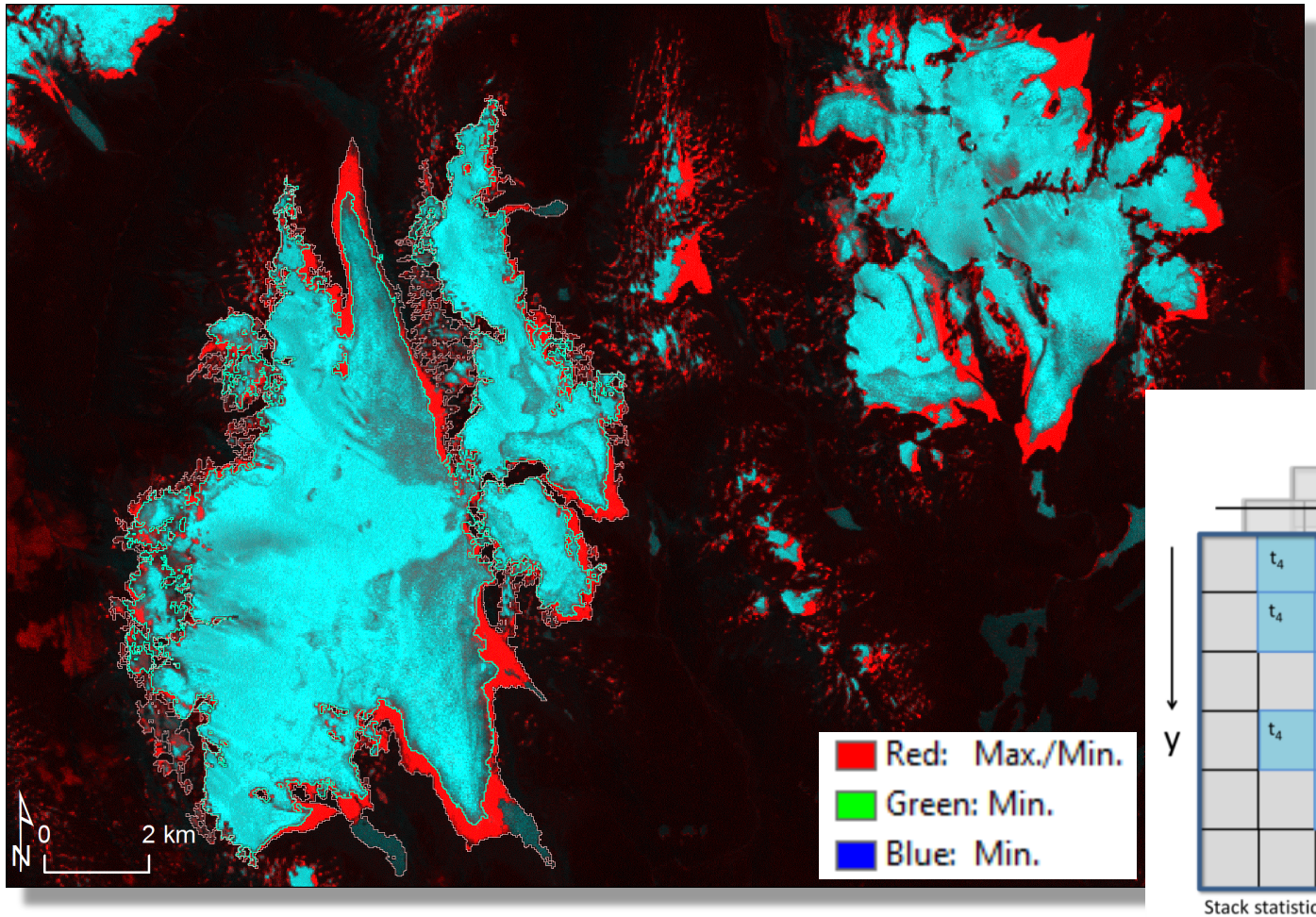
Glacier change analysis

Glacier change detection



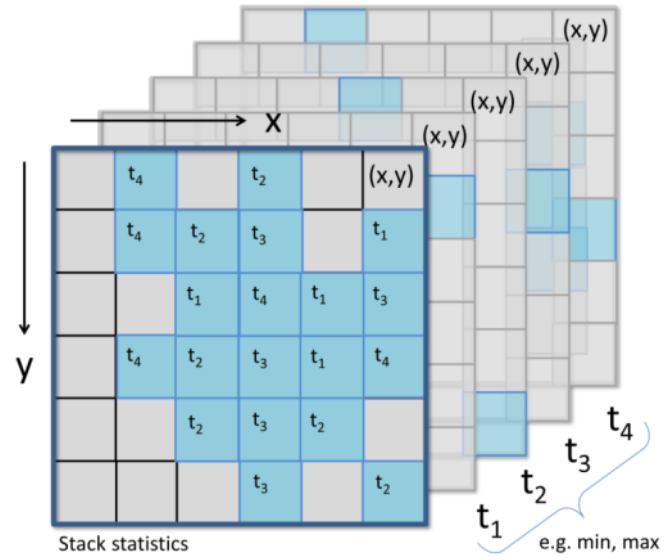
Northern Patagonia, Chile.

Glacier change detection



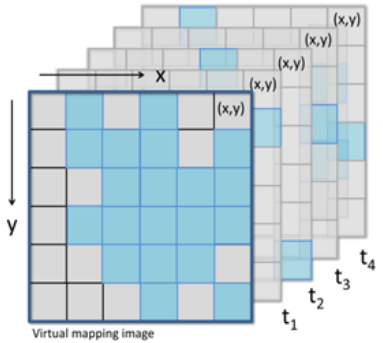
Years:

- 1984
- 2000
- 2002
- 2005
- 2011



Future: Possible to perform fully automated change analysis using for instance synthesized optimal mapping images

Conclusions

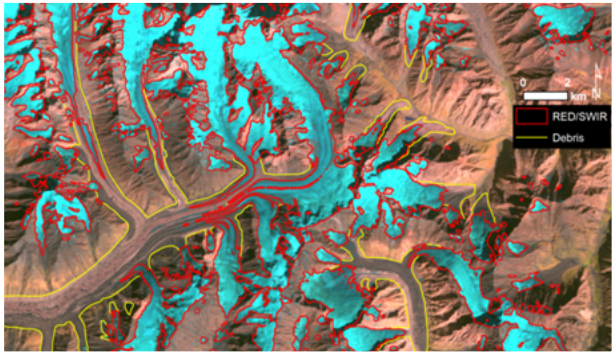


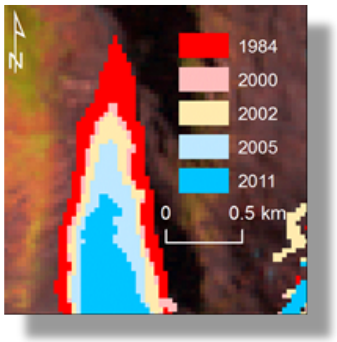
Synthesizing optimal mapping scene

- Why? Takes regional differences of snow and cloud conditions into account
- How? Mean of ratio images (with or without cloud mask)

Improved glacier mapping

- Potential automatic mapping of minimum snow cover using time-series solution of the summer ratio images





Glacier change analysis

- In the future, it could be possible to perform fully automated change analysis using for instance synthesized optimal mapping images

SVALI

erc

UiO : University of Oslo