Glacier mapping and monitoring with Sentinel 2 and Landsat 8

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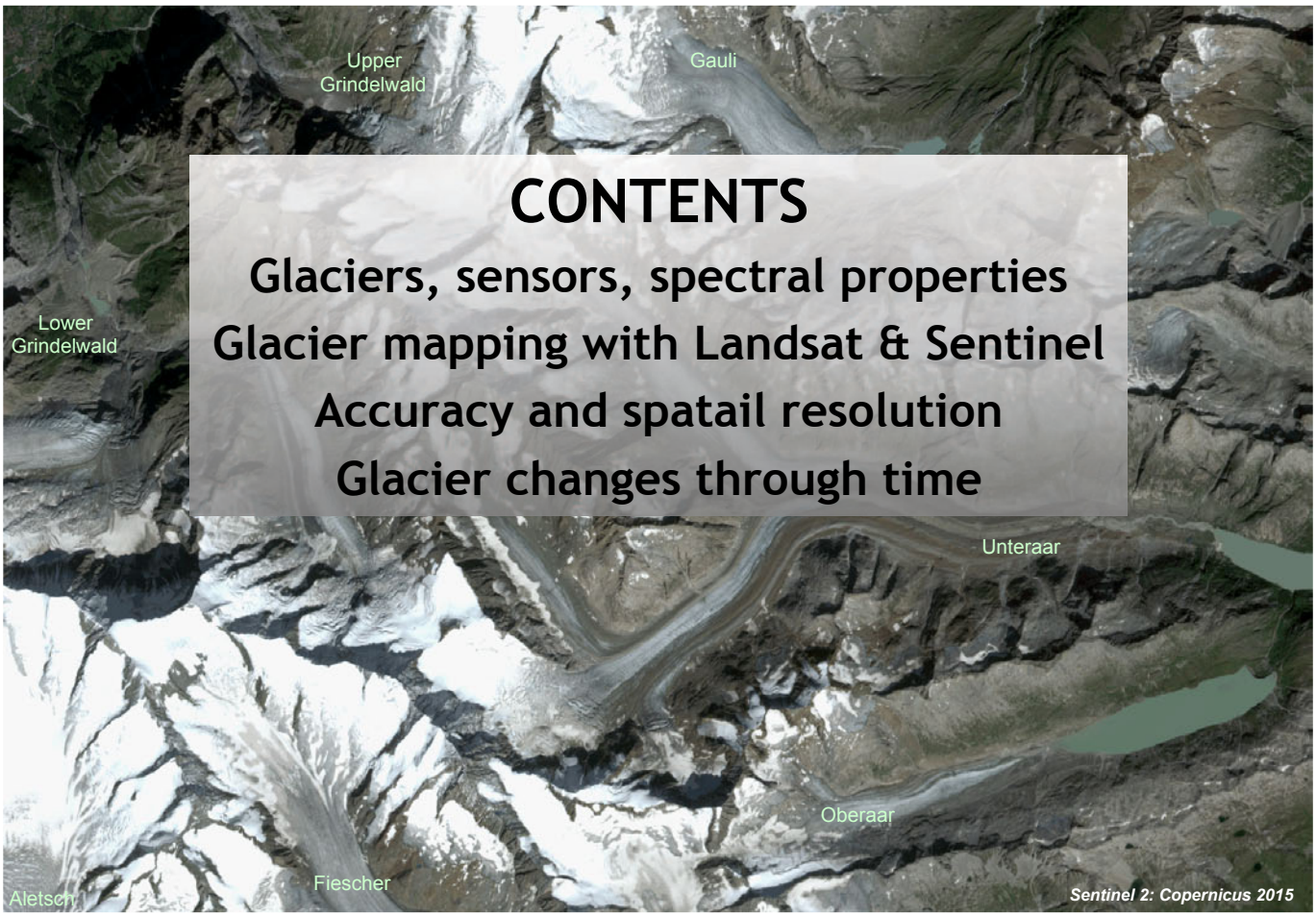
University of Zurich

x
Mt. Blanc

Sentinel 2: Copernicus 2015



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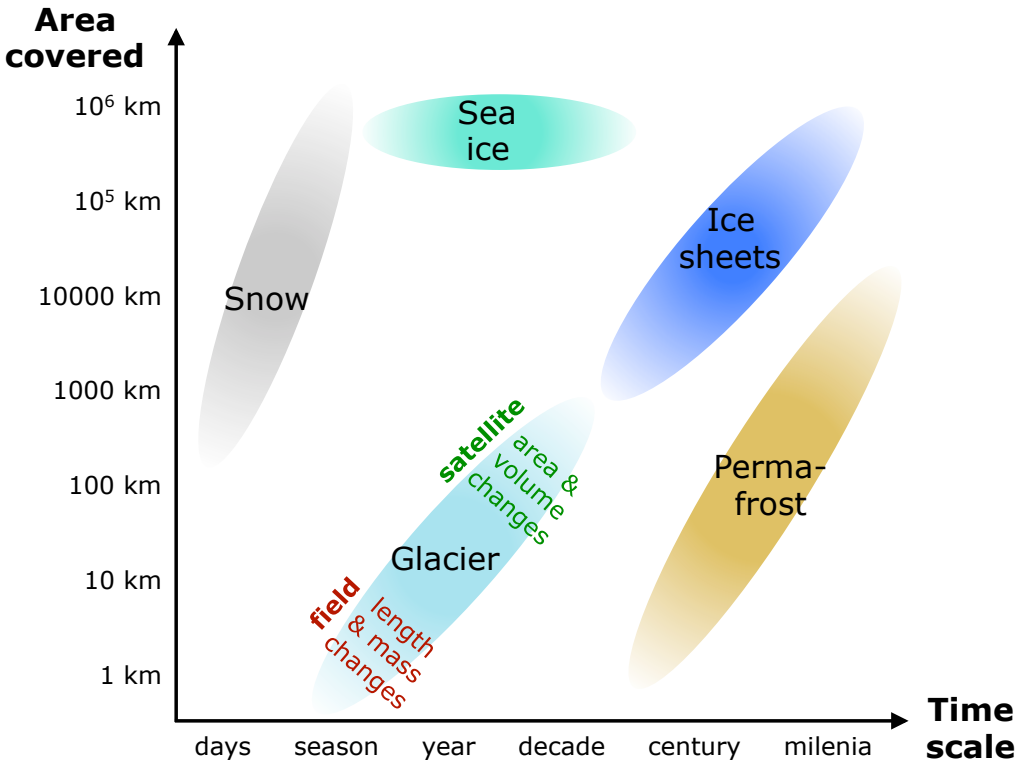
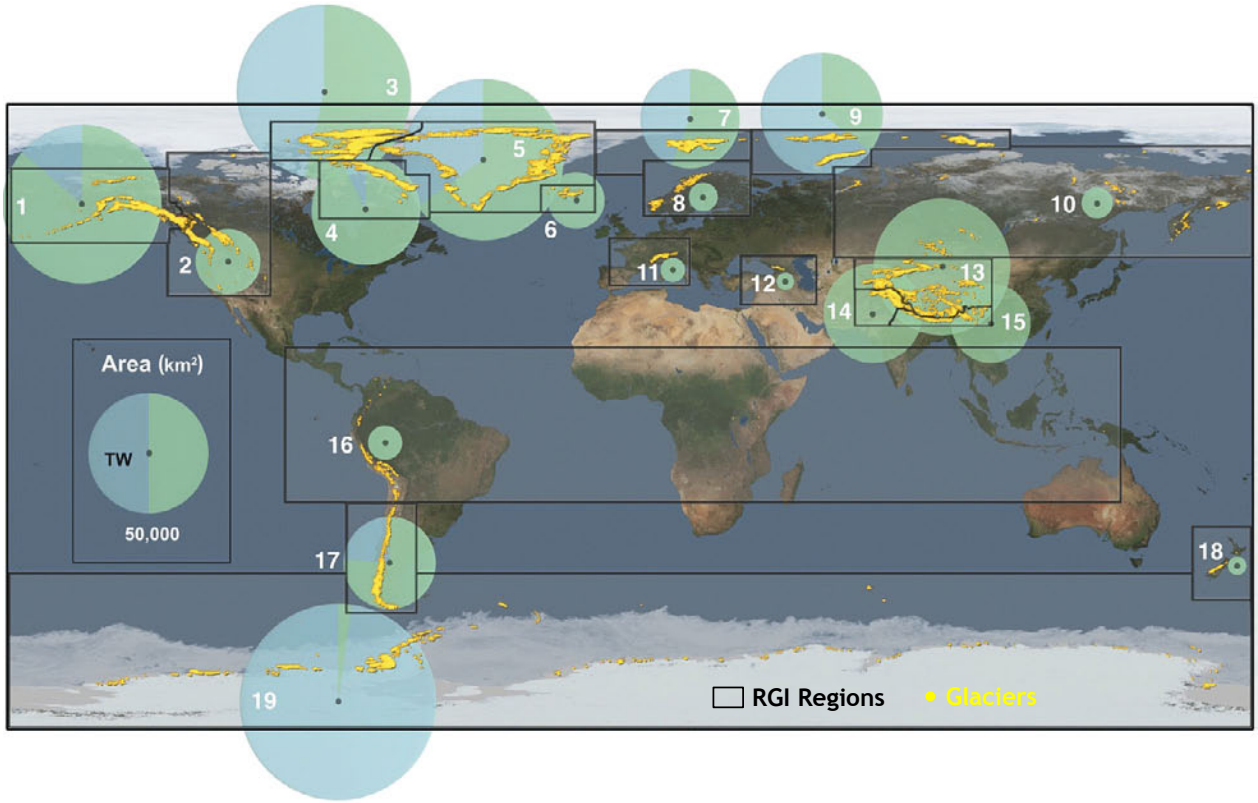
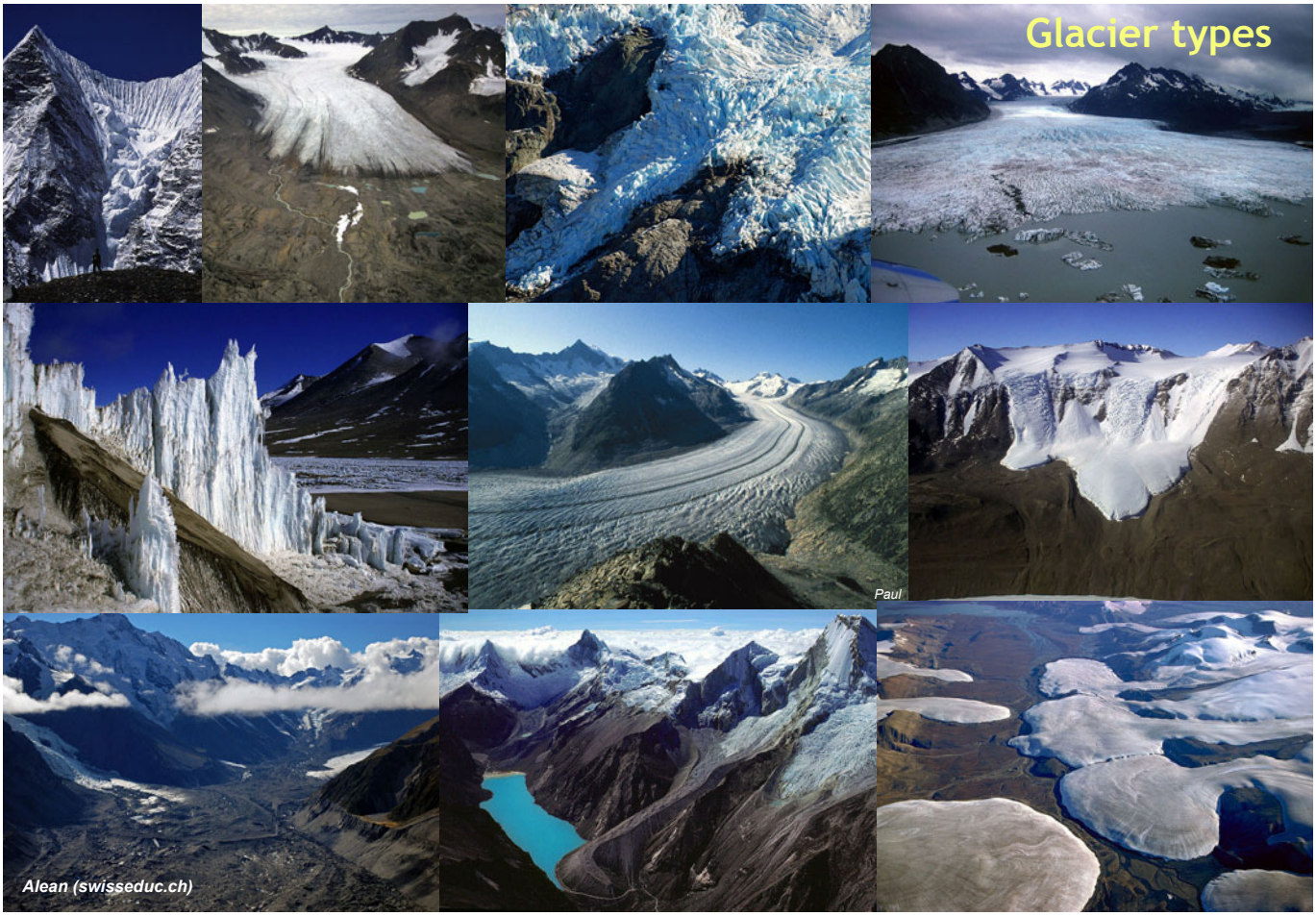


Global distribution of glaciers (200 000)




Glacier types
Paul
Alean (swisseduc.ch)

Advanced Spaceborne Thermal Emission and Reflection Radiometer
Satellites
LANDSAT
Image source: Internet

Sensors: timelines and applications

Sensor	60	65	70	75	80	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Corona																																					
Hexagon																																					
MSS																																					
TM																																					
ETM+																																					
OLI																																					
ASTER																																					
MSI																																					
SRTM																																					
GDEM																																					
ASTER																																					
SPIRIT																																					
RA-2																																					
ICESat																																					
Cryosat2																																					
Sentinel 3																																					
ERS1																																					
ERS2																																					
Envisat																																					
PALSAR																																					
PALSAR2																																					
TerraSAR-X																																					
TanDEM-X																																					
Sentinel 1																																					
C-Skymed																																					

Optical outlines velocity (DEMs)

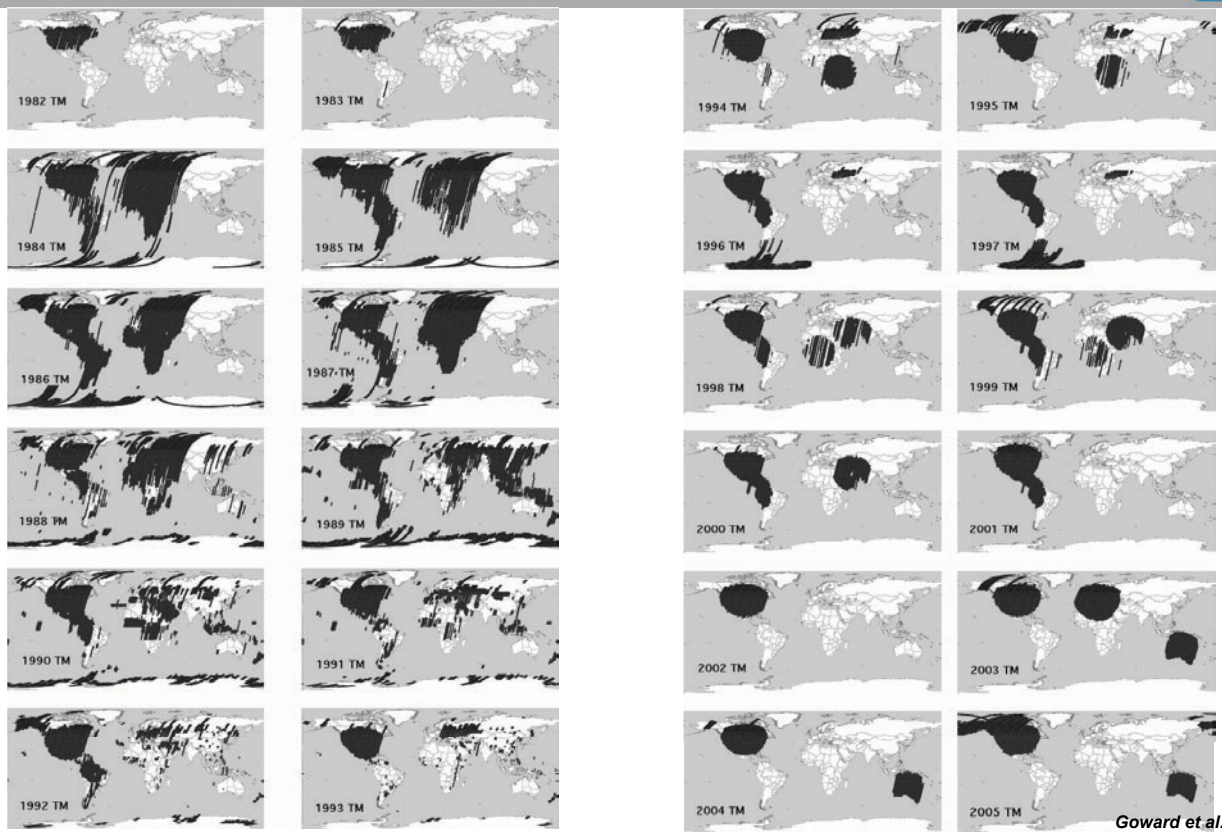
DEMs elev. change (inventories)

Altimeters elev. change

Microwave velocity (DEMs)

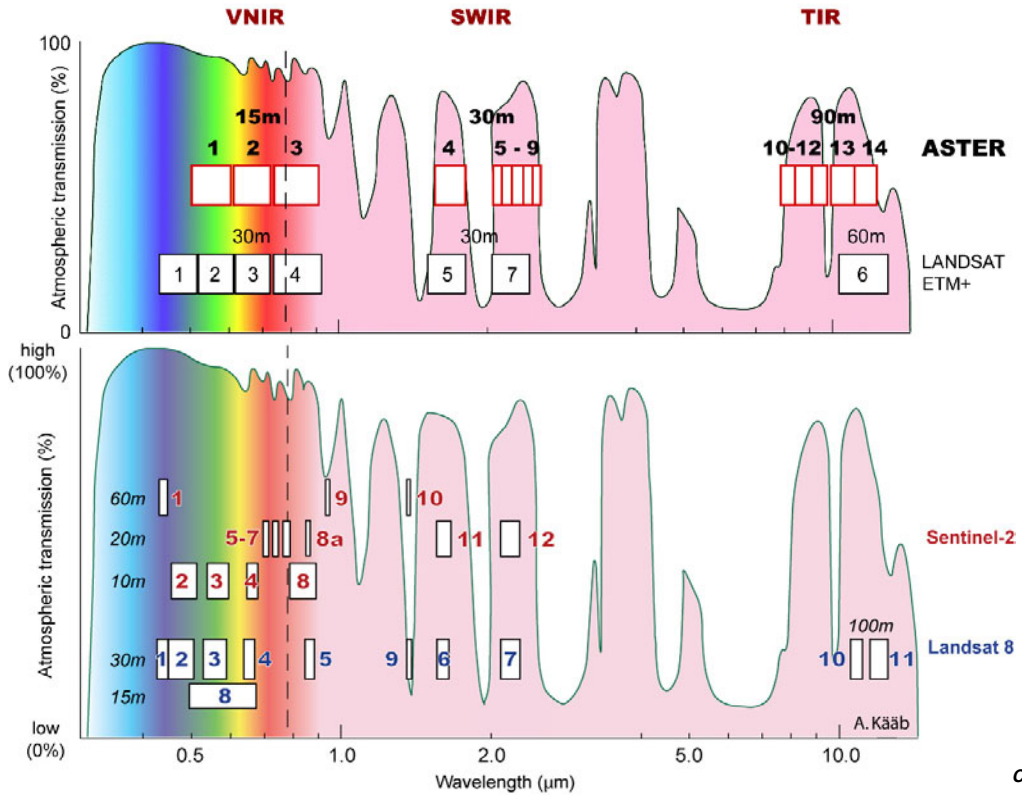
Paul (Glaciers_cci)

Spatio-temporal coverage (TM) at USGS



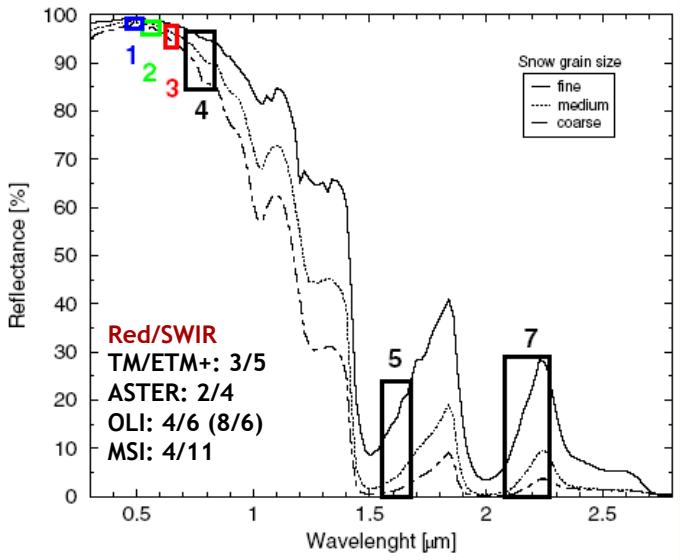
Goward et al. (2006)

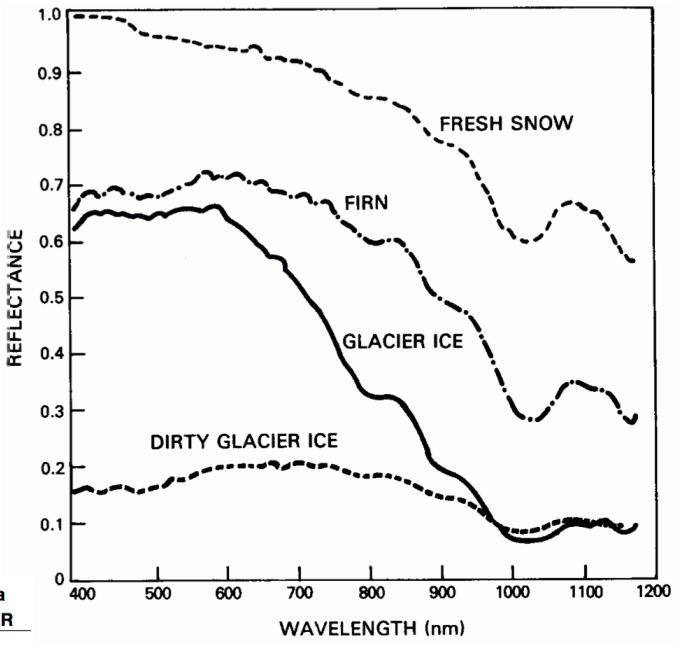
Spectral bands and atmospheric transmission



Courtesy: A. Kääb

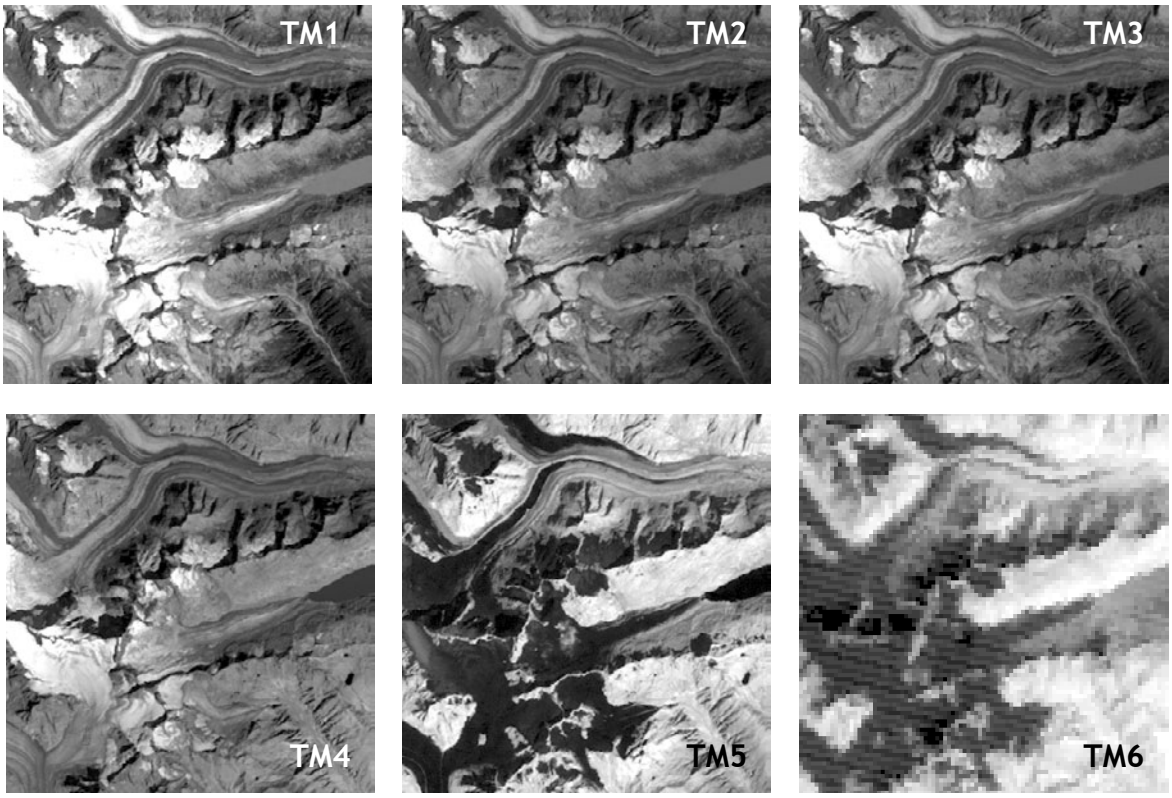
Spectral properties of ice and snow



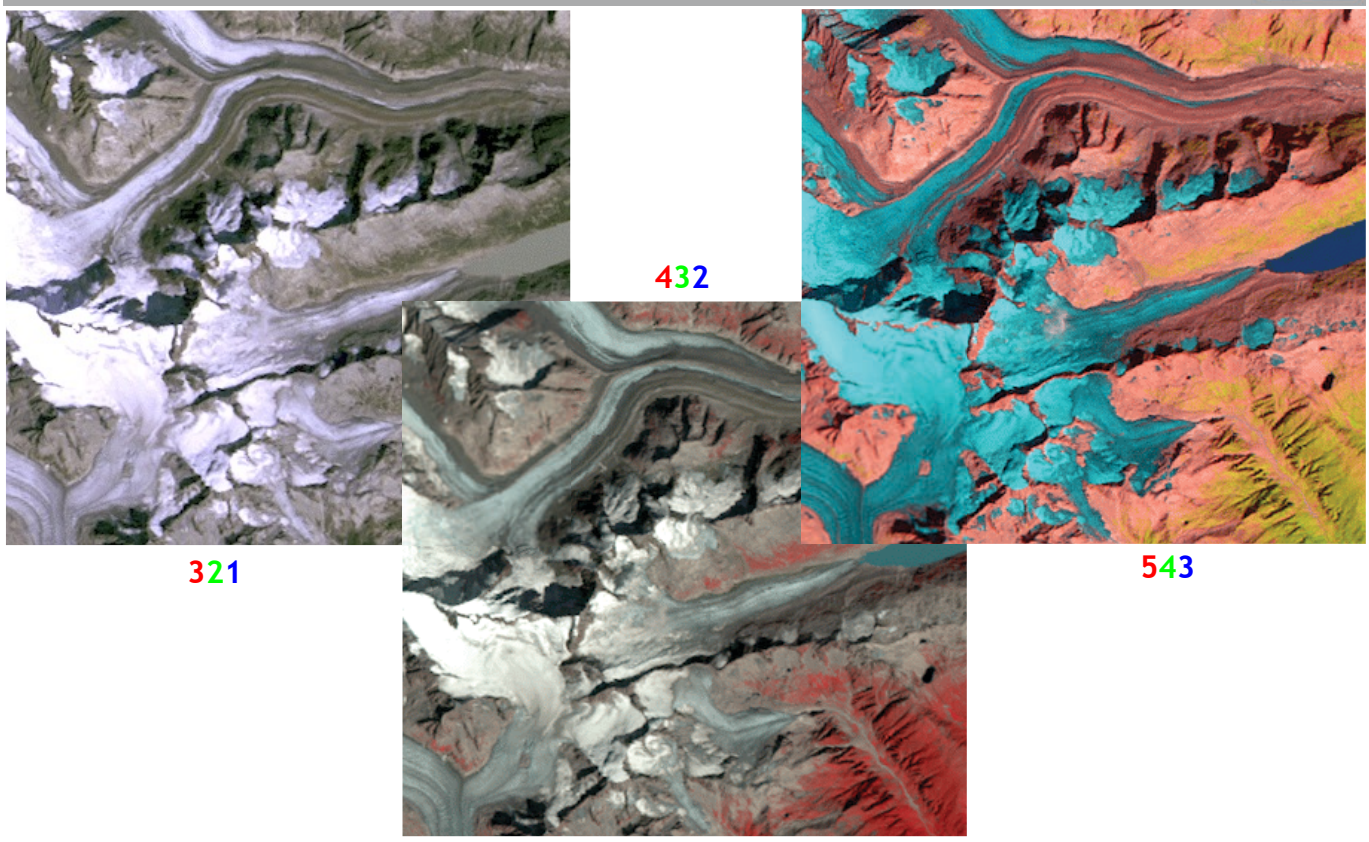


Band colour	Band number TM	OLI	MSI	AST	Landsat TM	Landsat ETM+	Landsat OLI	Sentinel2 MSI	Terra ASTER
Blue	1	2	2	-	0.45-0.52	0.45-0.52	0.45-0.51	0.46-0.52	-
Green	2	3	3	1	0.52-0.60	0.53-0.61	0.53-0.60	0.54-0.58	0.52-0.60
Red	3	4	4	2	0.63-0.69	0.63-0.69	0.63-0.68	0.65-0.68	0.63-0.69
NIR	4	5	8	3	0.76-0.90	0.76-0.90	0.85-0.89	0.78-0.90	0.76-0.86
SWIR	5	6	11	4	1.55-1.75	1.55-1.75	1.56-1.66	1.57-1.66	1.60-1.70
SWIR	7	7	12	5-9	2.08-2.35	2.09-2.35	2.10-2.30	2.10-2.28	2.15-2.43[1]
Pan	8	8	-	-	-	0.52-0.90	0.50-0.68	-	-

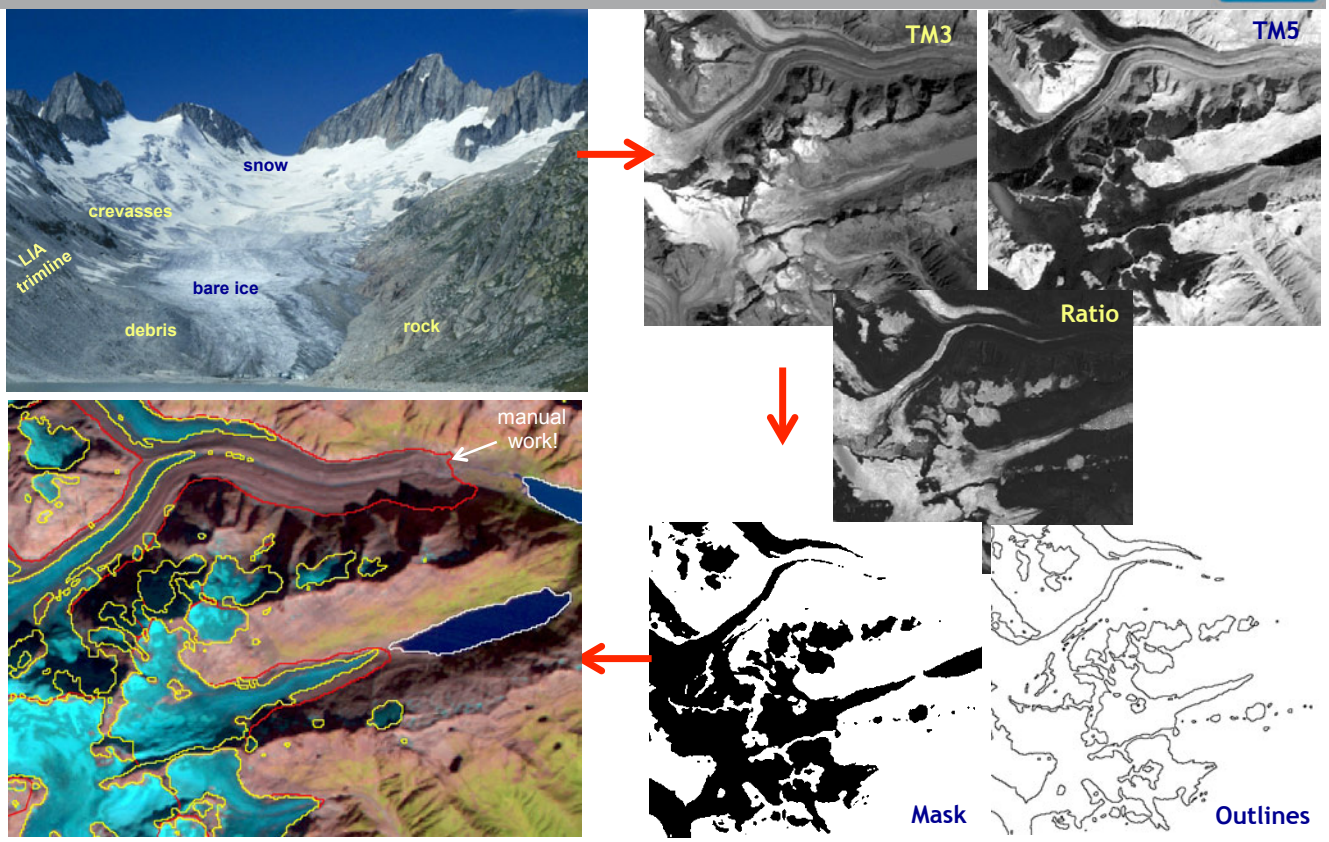
Glaciers as seen with Landsat Thematic Mapper TM



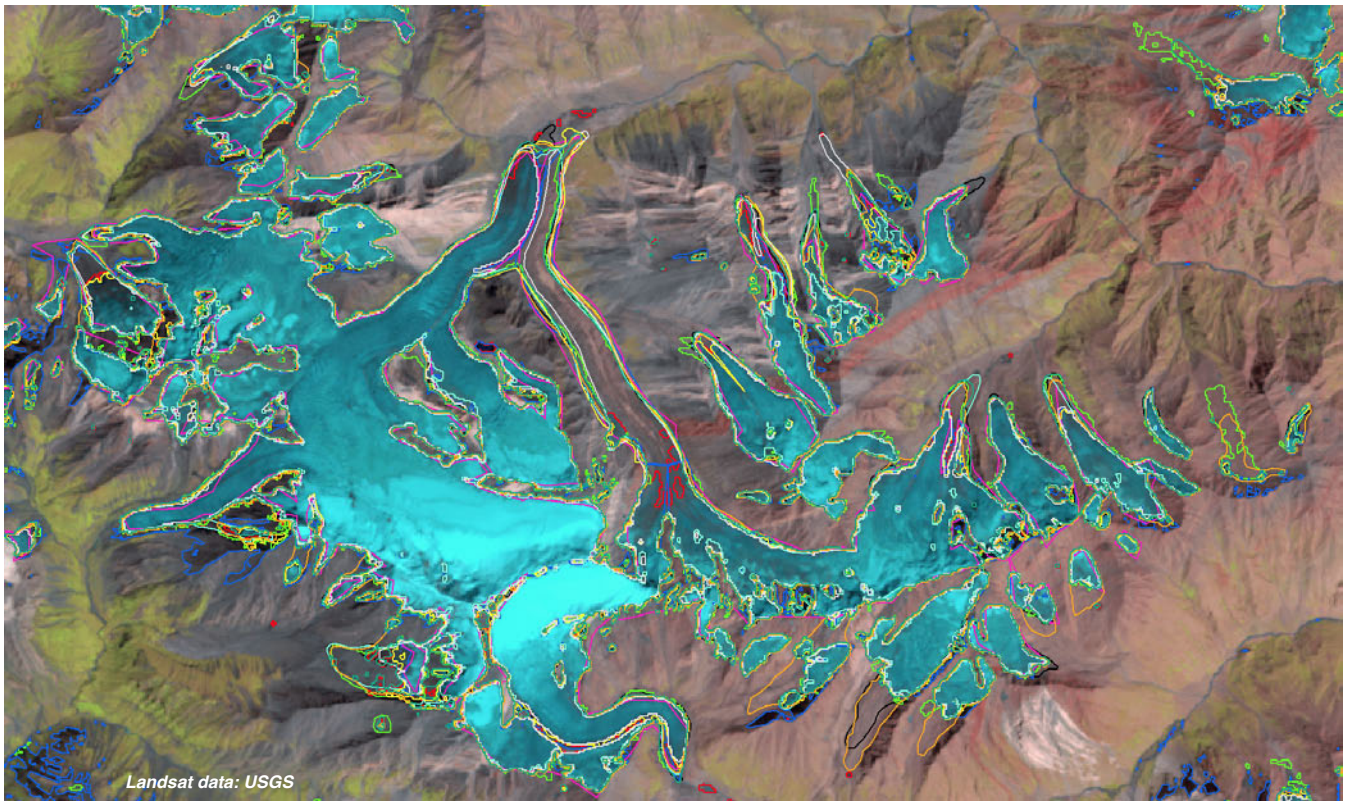
Three band false colour composites



Glacier mapping and corrections

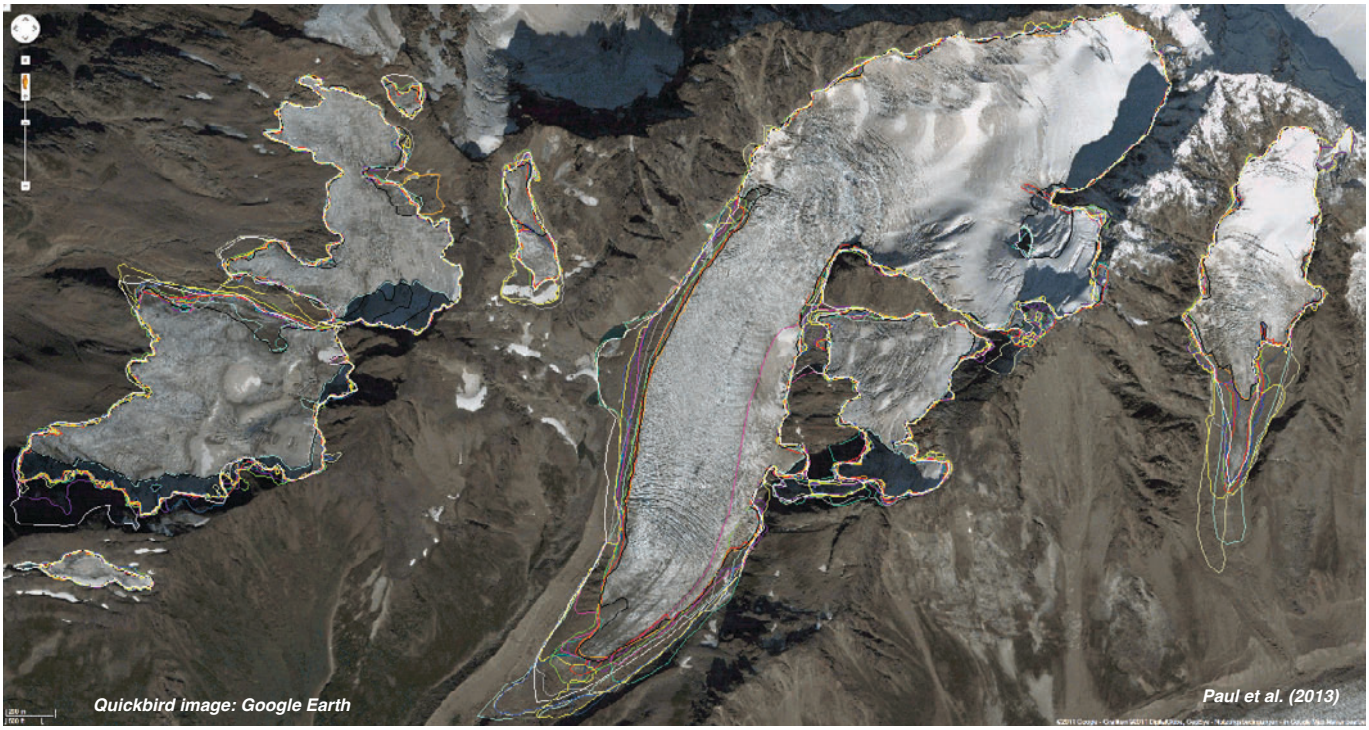


Accuracy: manual glacier delineation (Landsat)

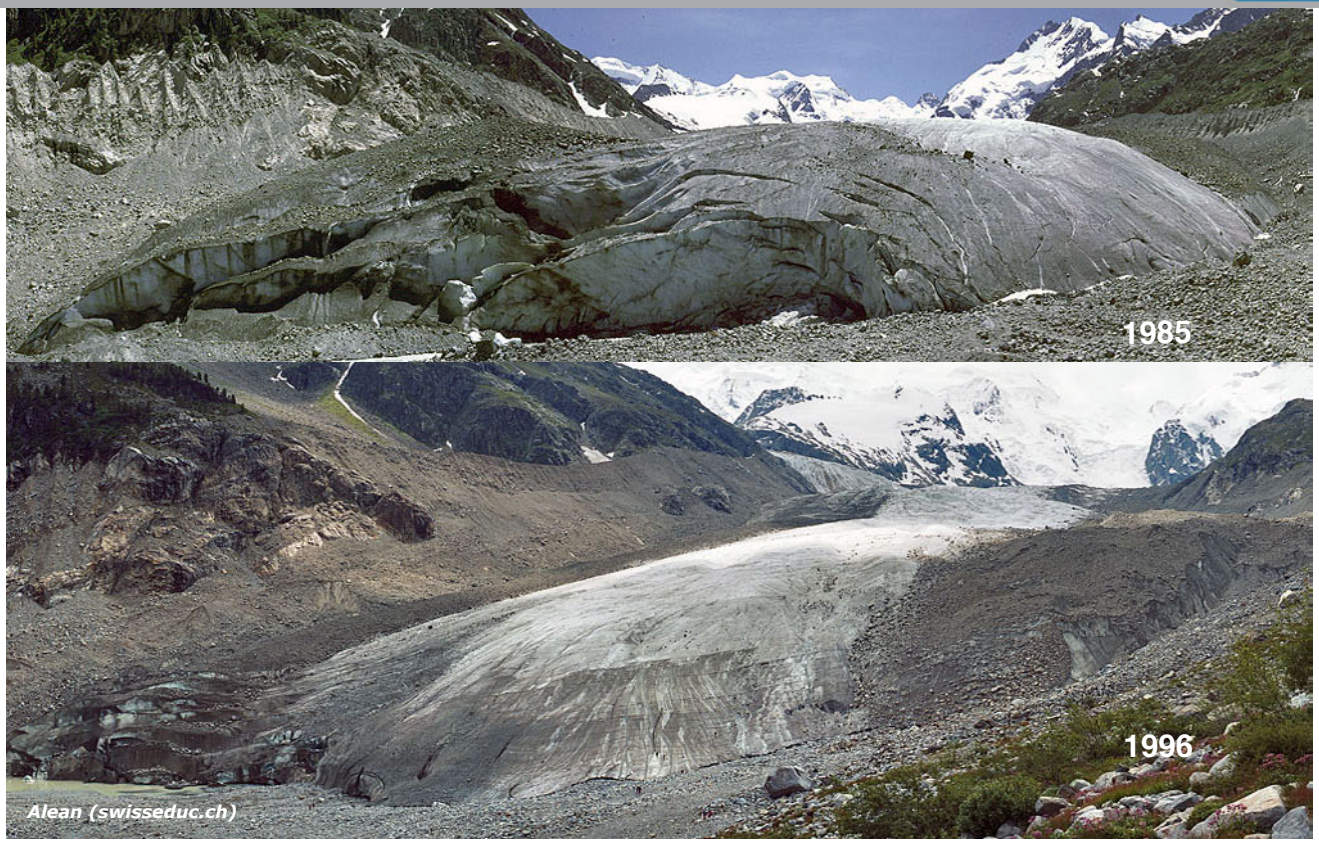


Paul et al. (2015)

Accuracy: manual glacier delineation (Quickbird)

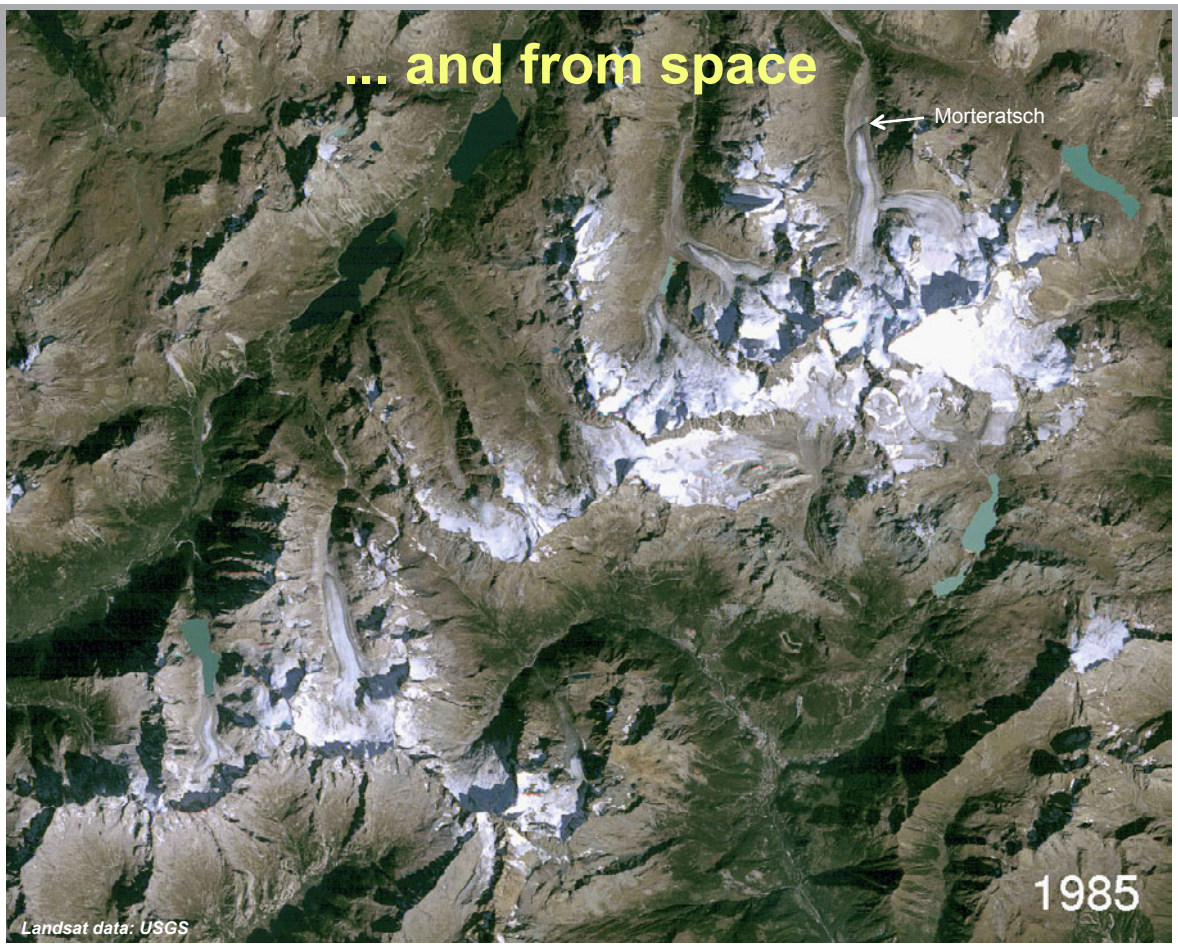


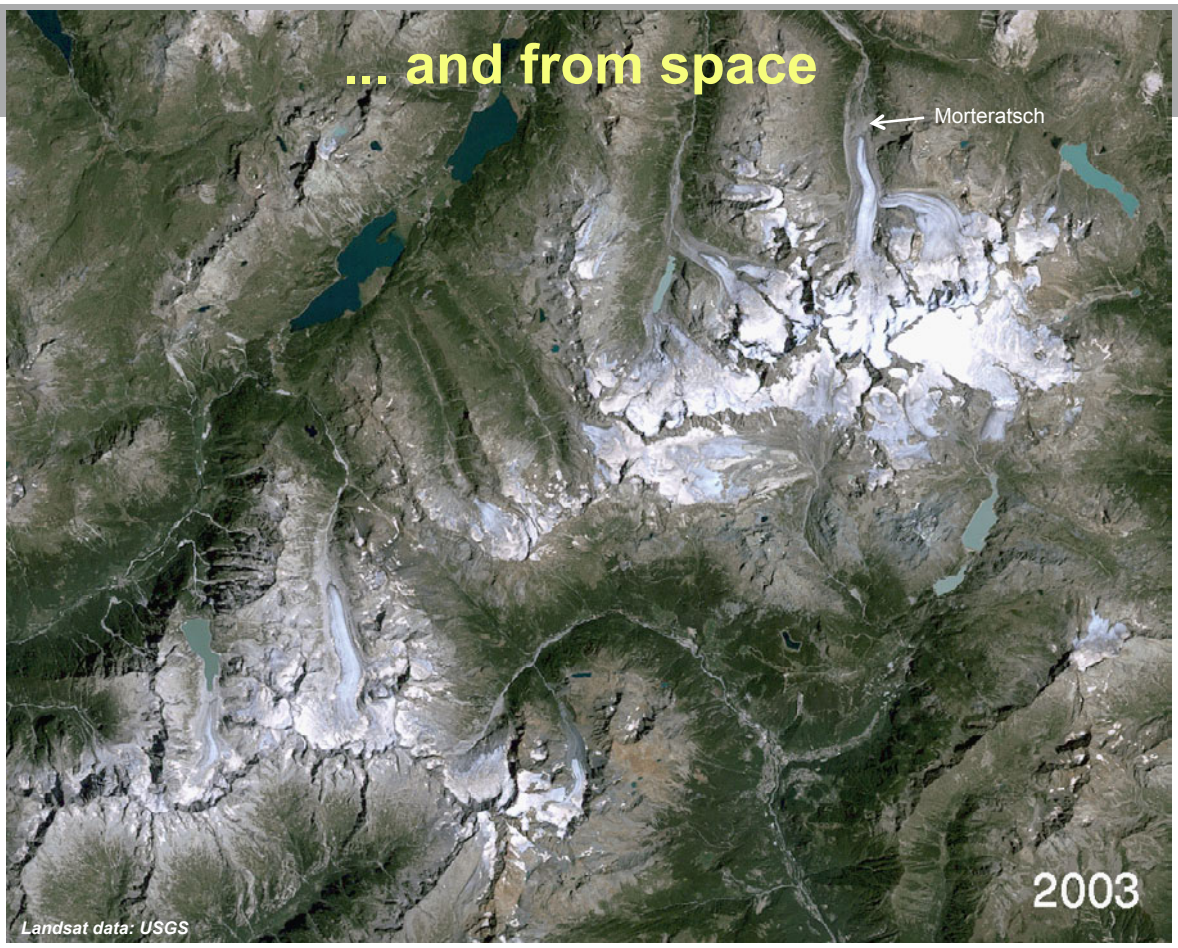
Glacier change from the ground: Morteratsch



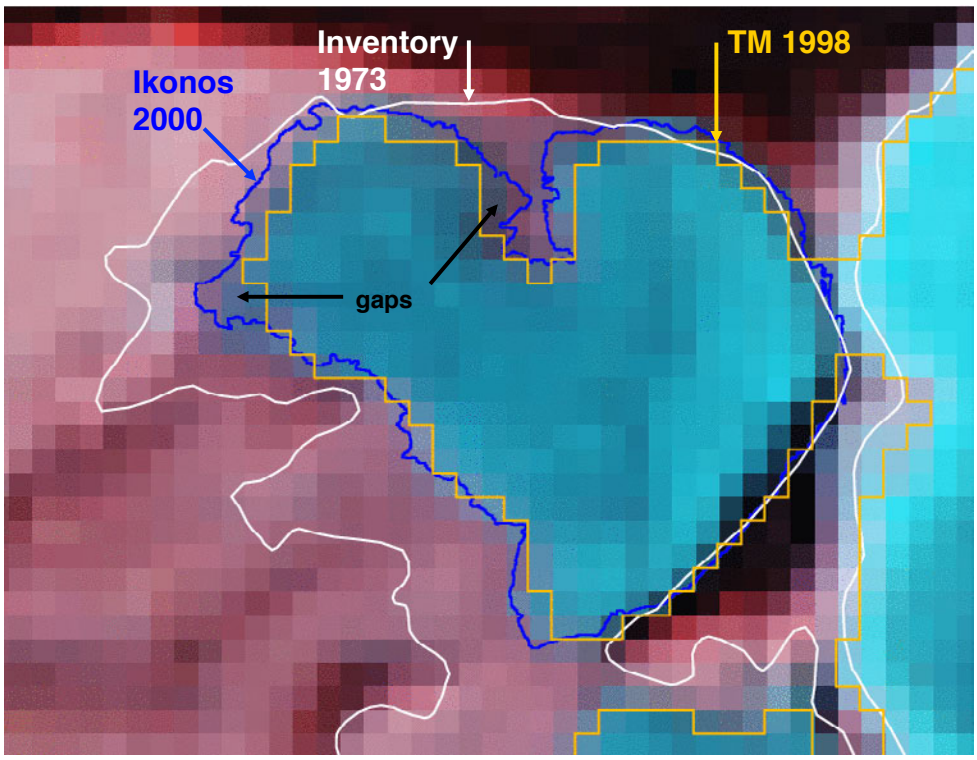
Glacier change from the ground: Morteratsch

... and from space

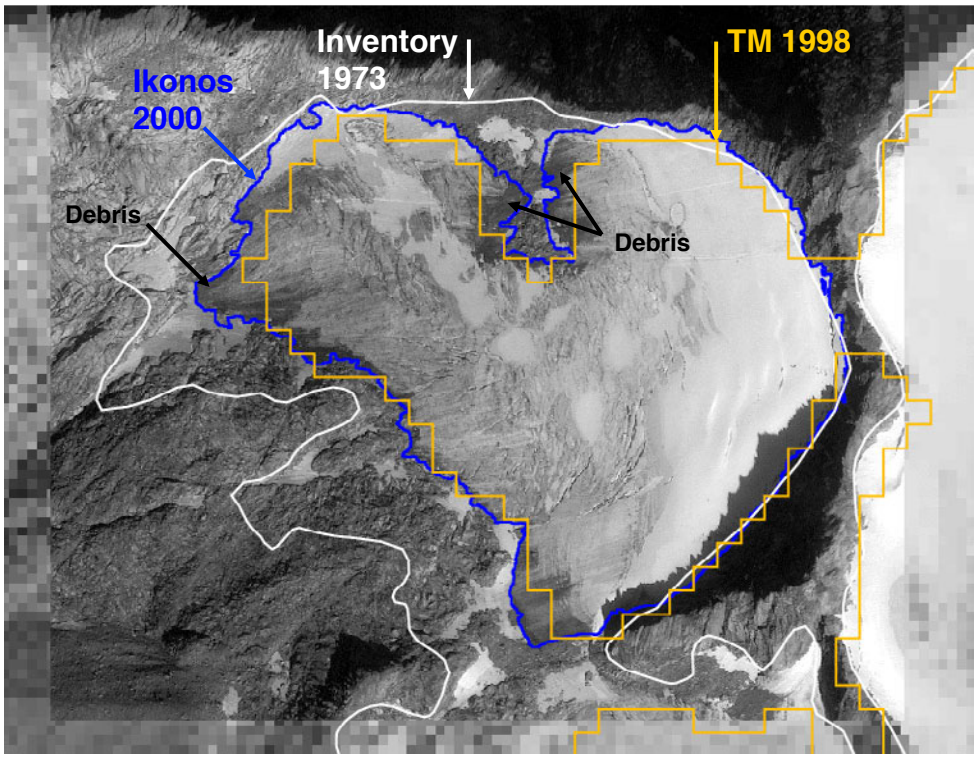




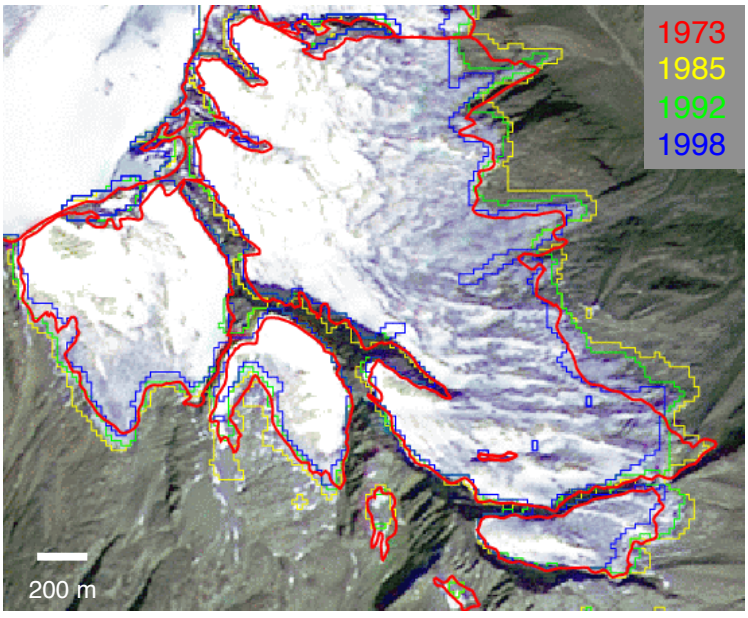
Accuracy: Comparison with TM543

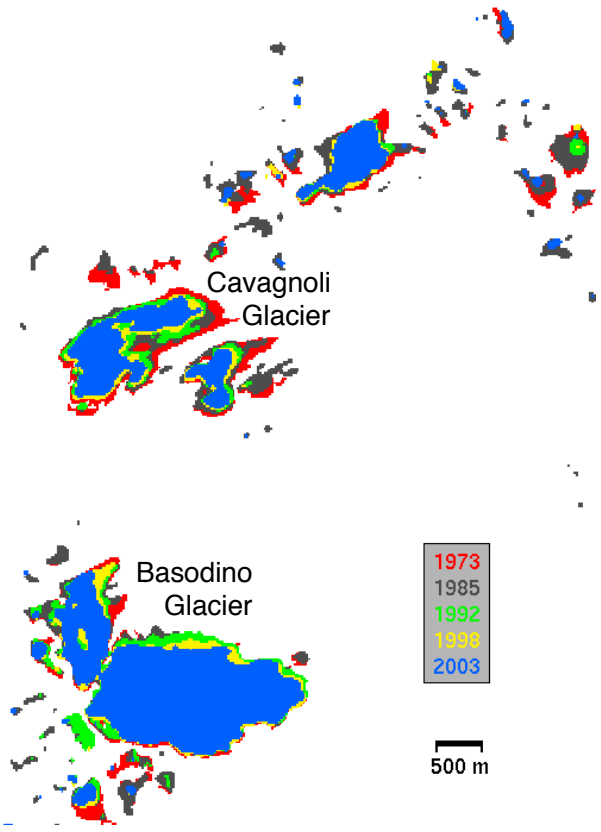


Accuracy: Comparison with HR Ikonos

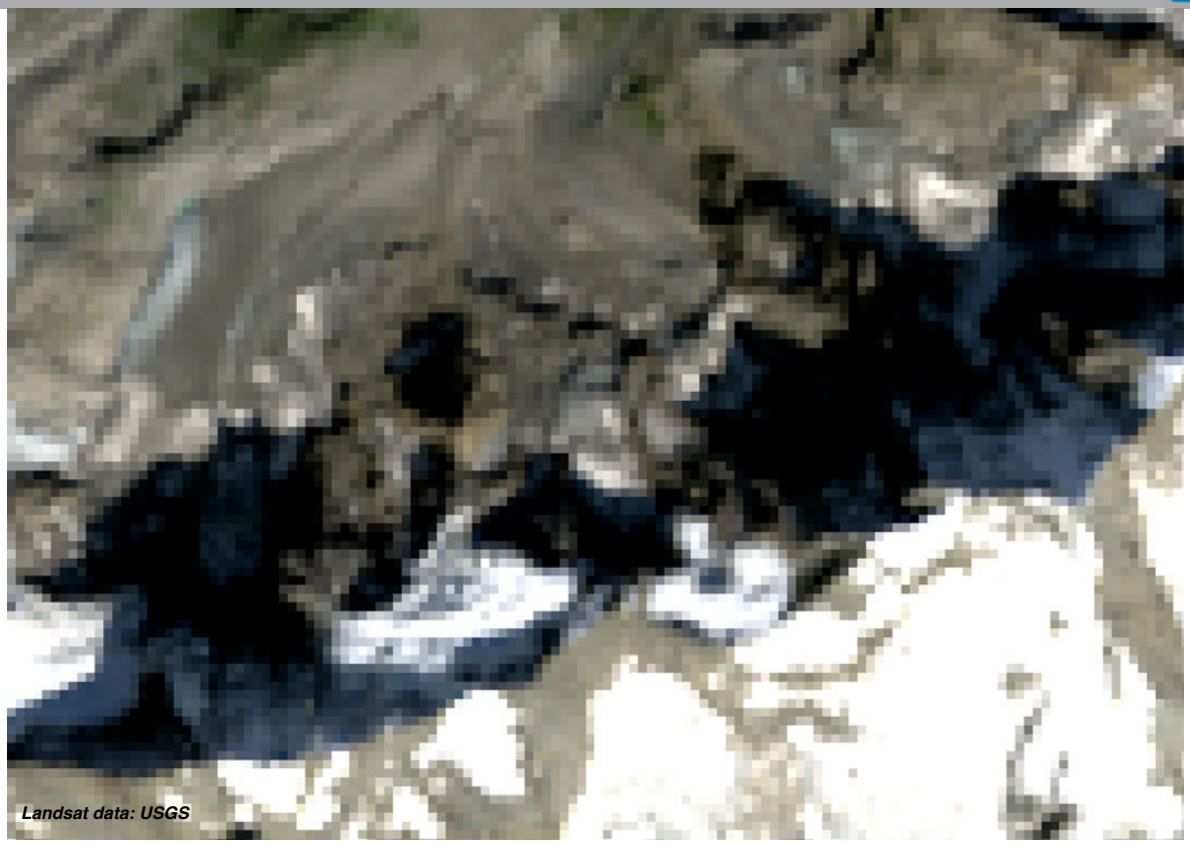


Accuracy: small scale change assessment



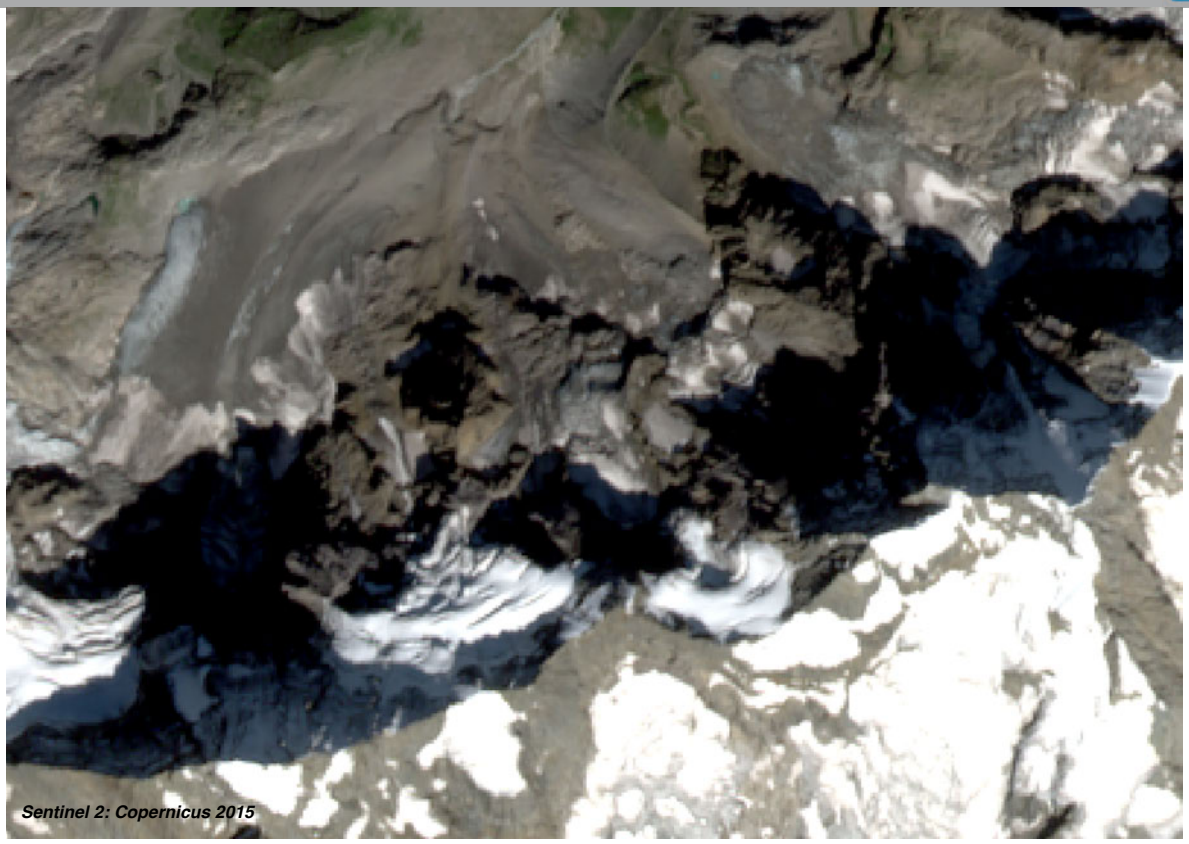


Spatial resolution: Landsat 8 OLI (30 m)



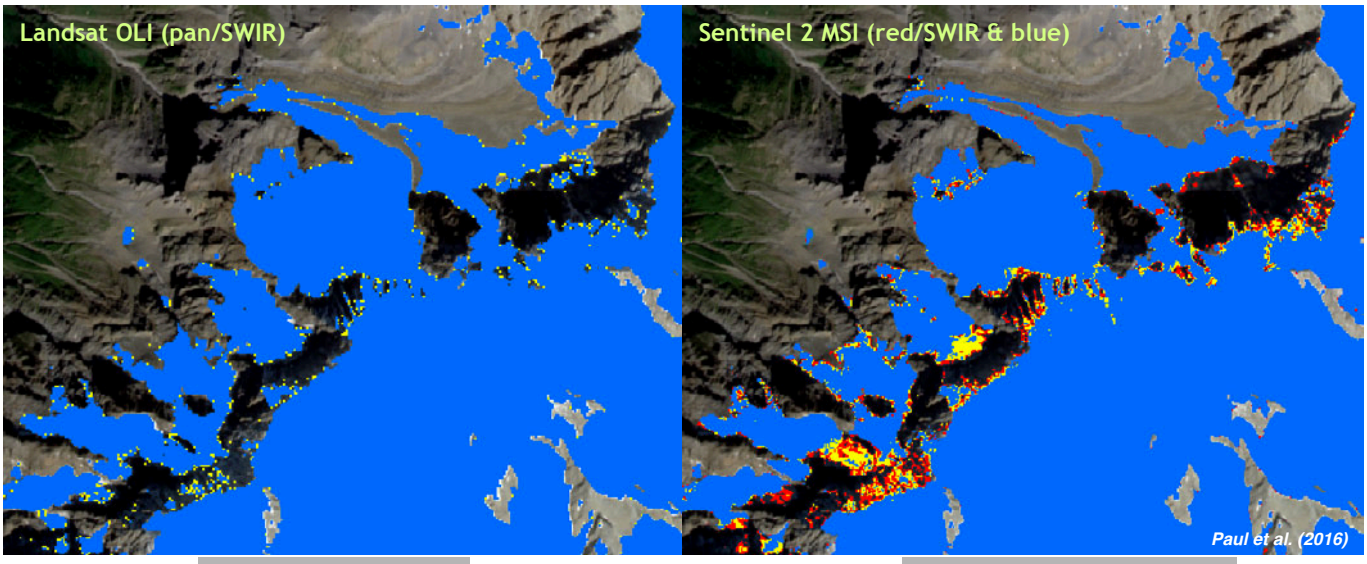
Landsat data: USGS

Spatial resolution: Sentinel 2 MSI (10 m)



Sentinel 2: Copernicus 2015

Glacier mapping with Landsat 8 OLI & Sentinel 2 MSI

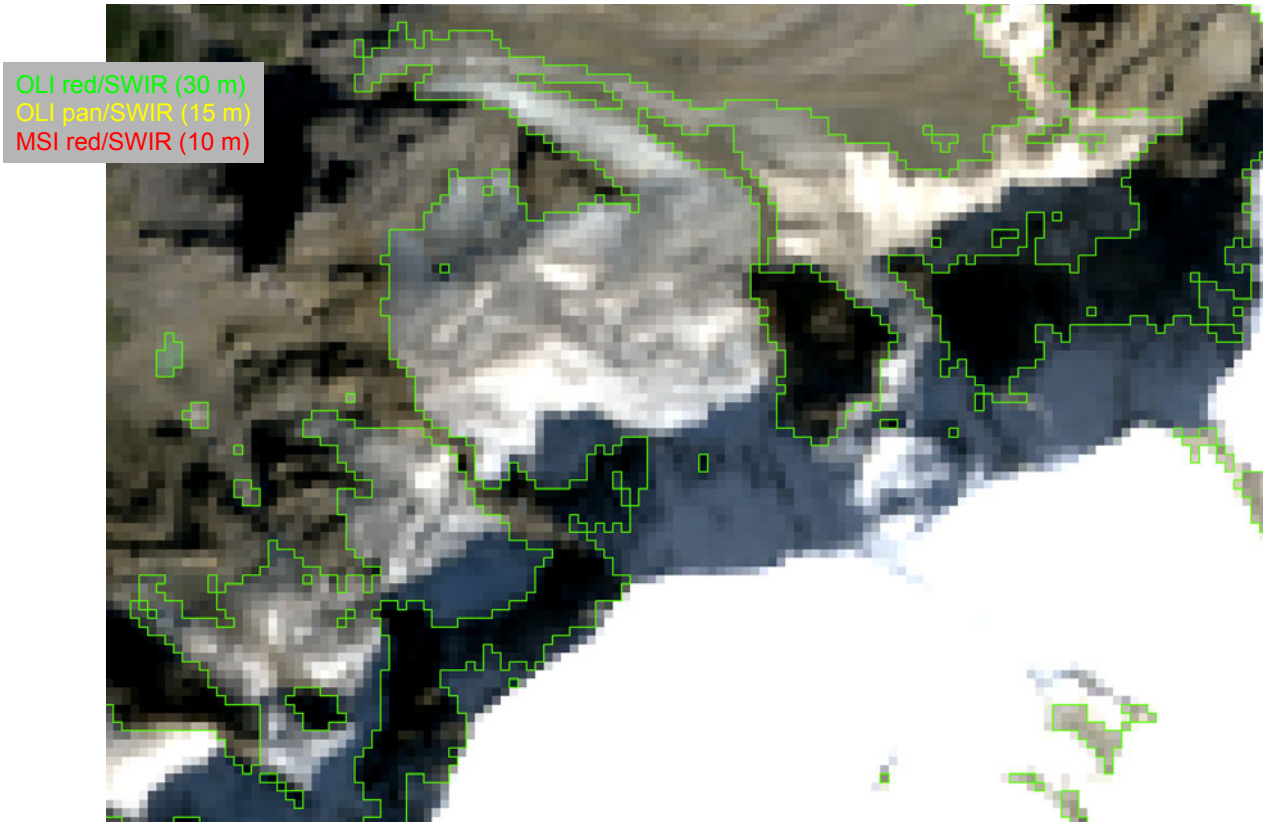


all colours 1.40
removed by 1.38

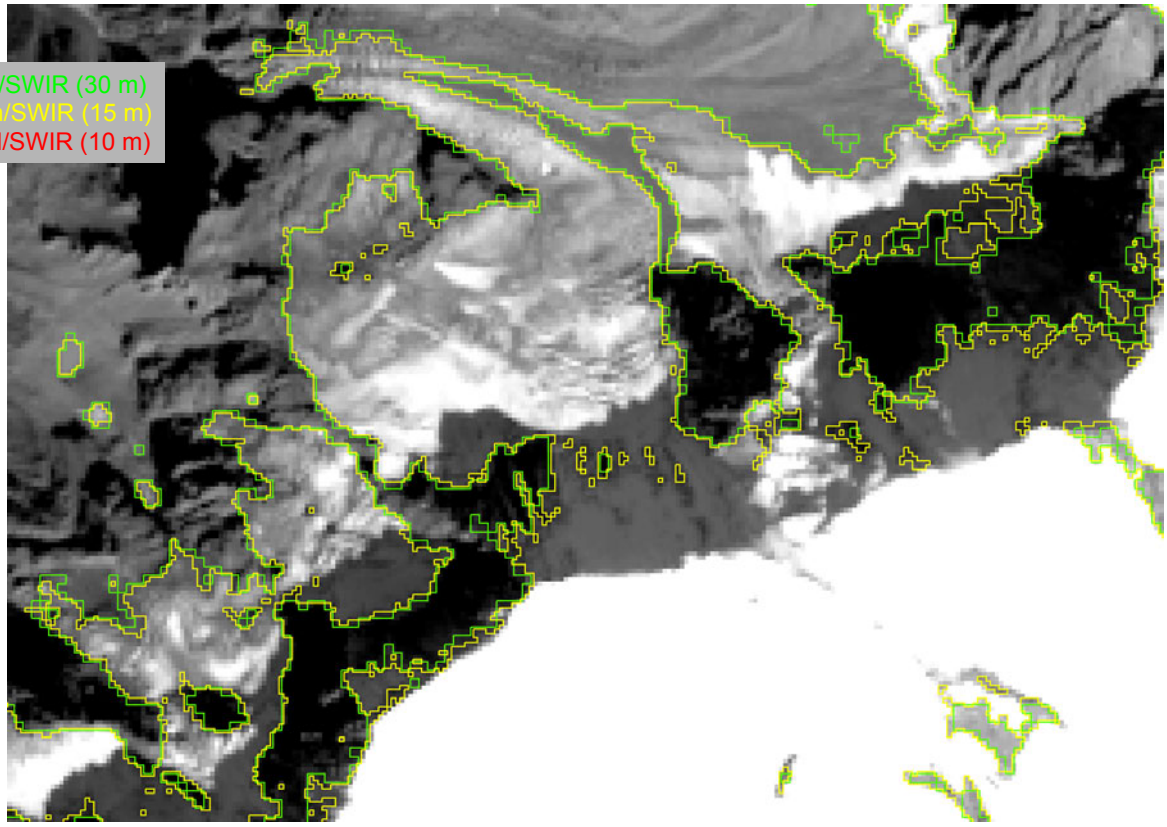
all colours 2.7 - 95
removed by 2.8 - 105
removed by 2.8 - 115

MSI requires an additional threshold in the blue band
to achieve the same performance in cast shadow as OLI

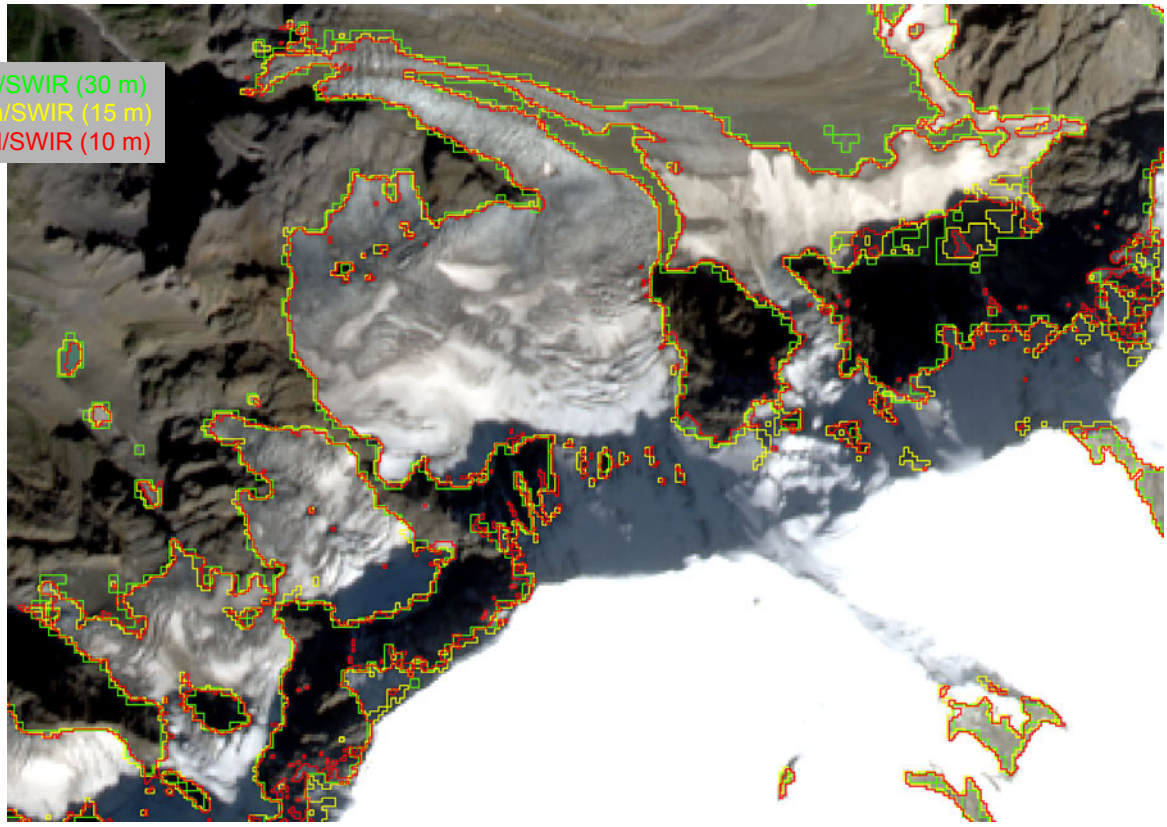
Outlines from OLI red/SWIR (30 m)



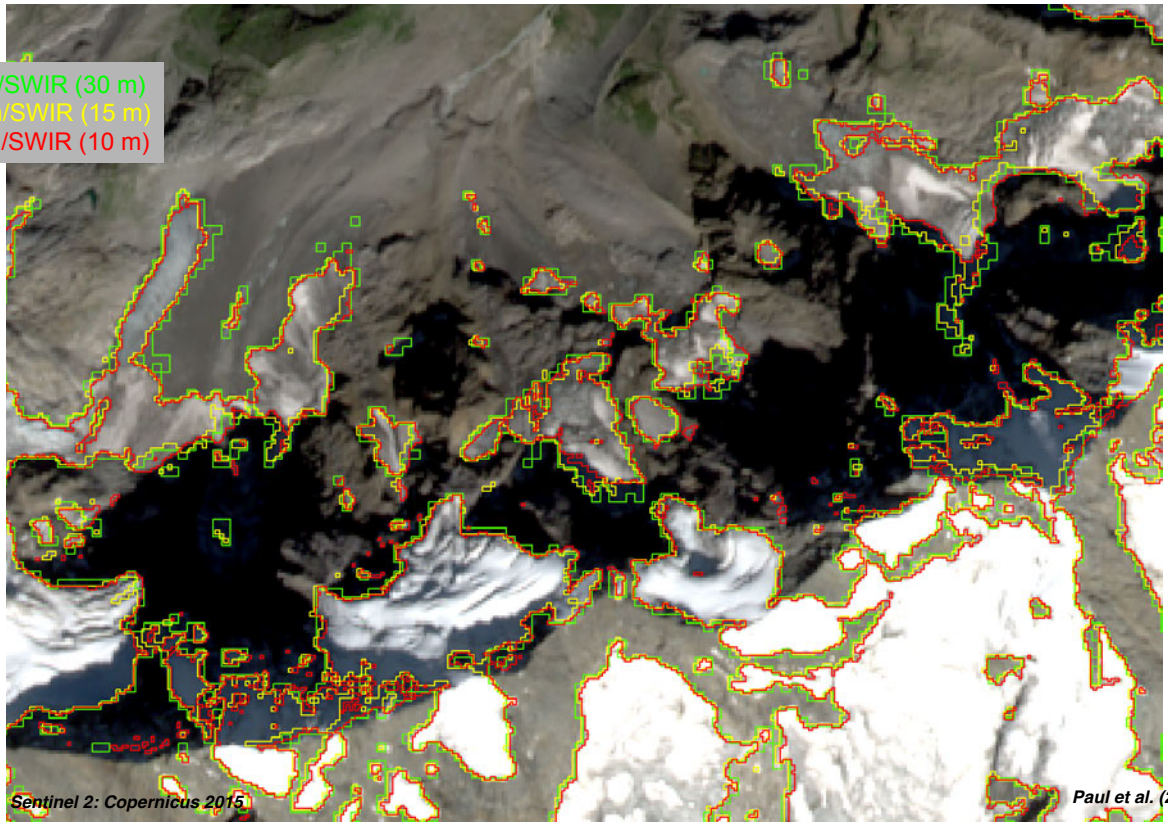
Outlines from OLI pan/SWIR (15 m)



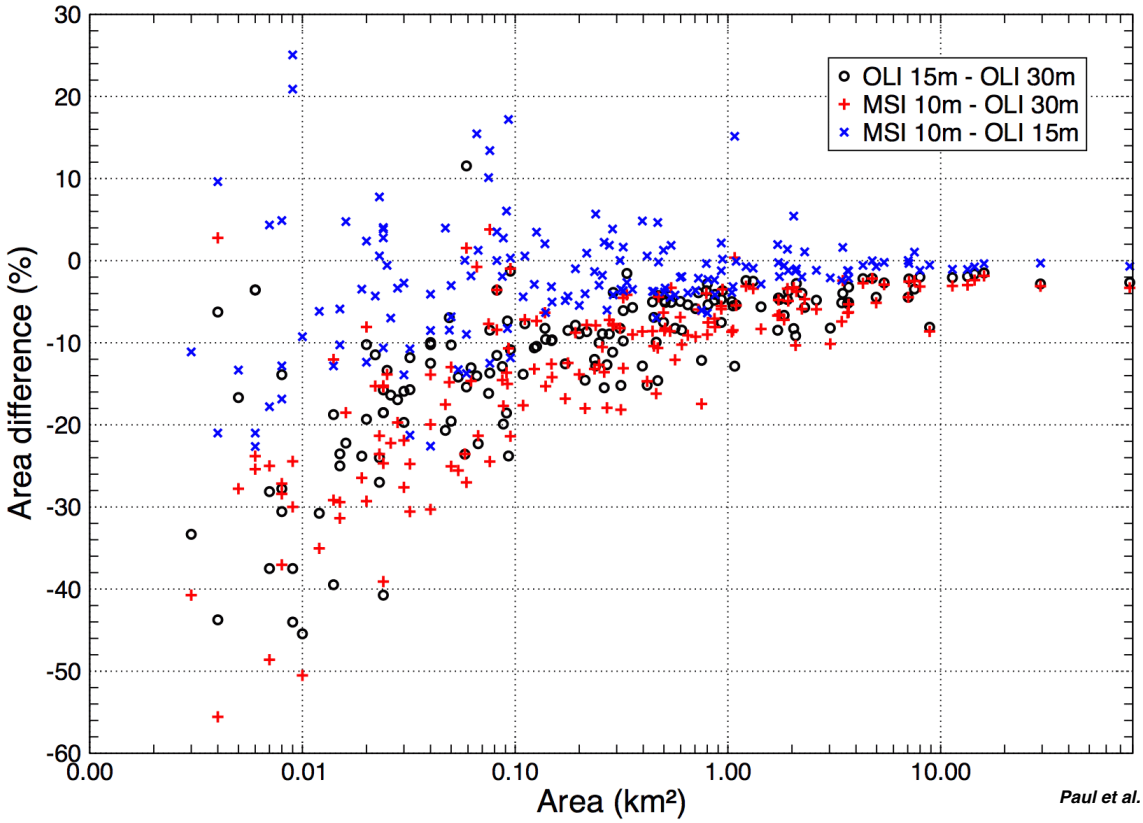
Outlines from MSI red/SWIR (10 m)



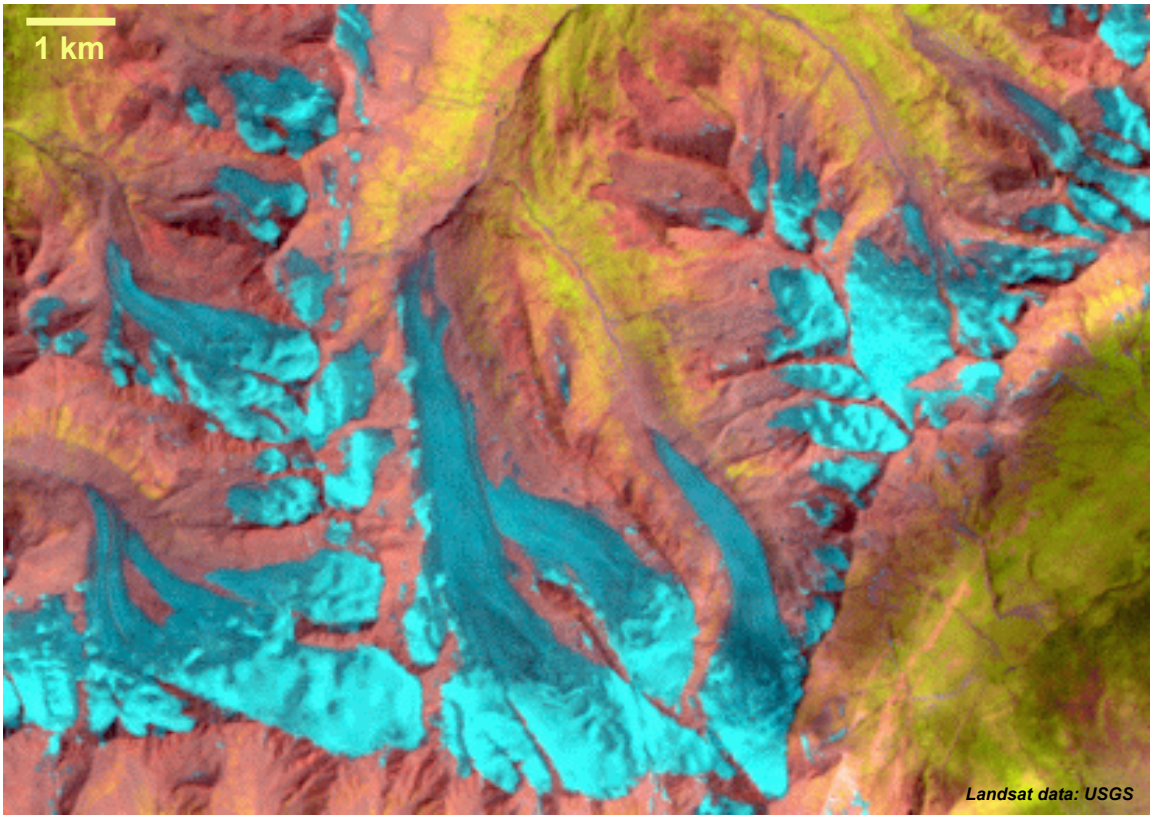
Glacier mapping with Landsat 8 OLI & Sentinel 2 MSI



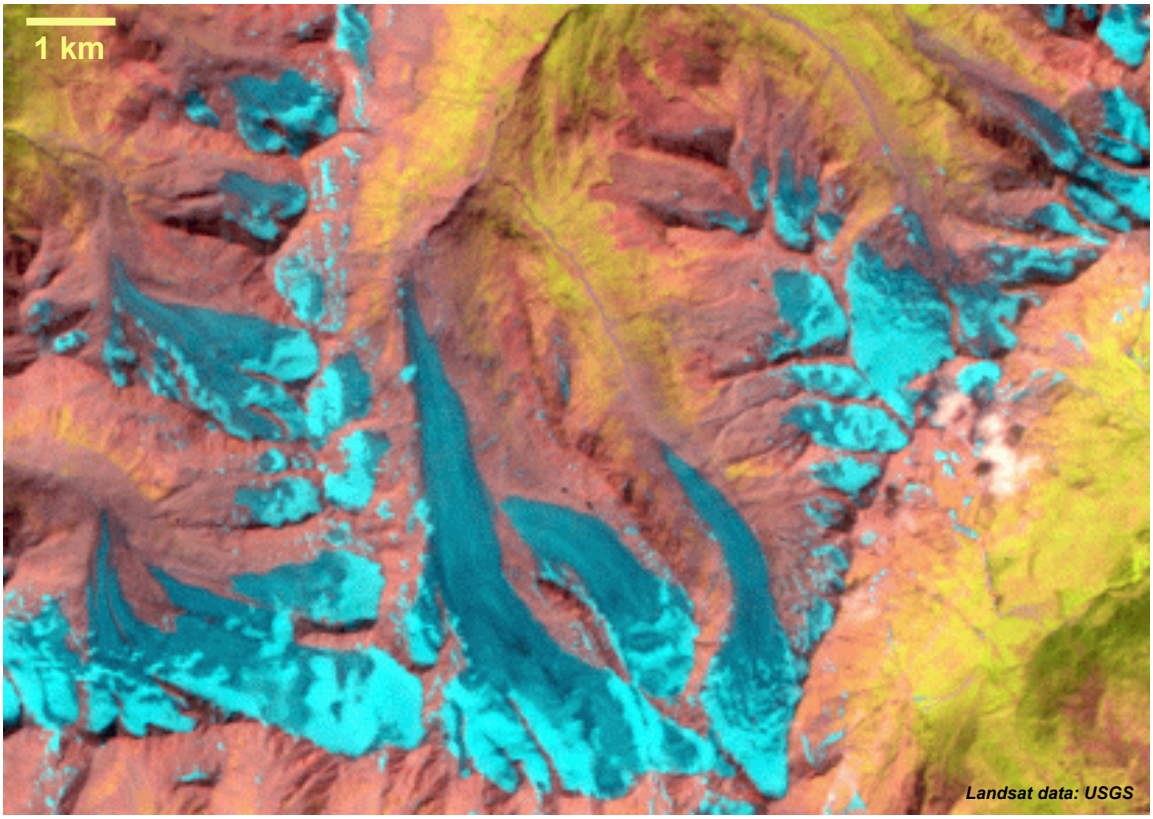
Relative area difference MSI/OLI pan/OLI red



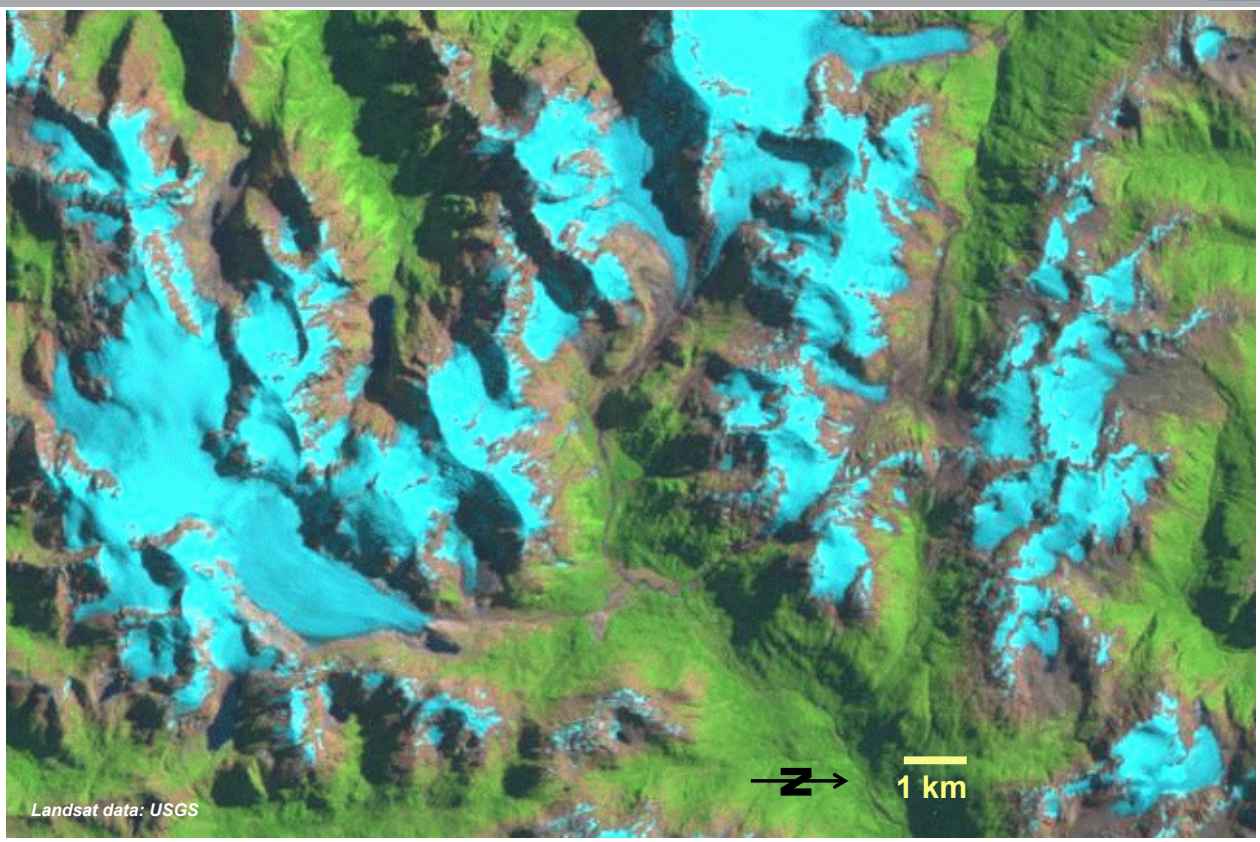
Glacier shrinkage Austria: 2003



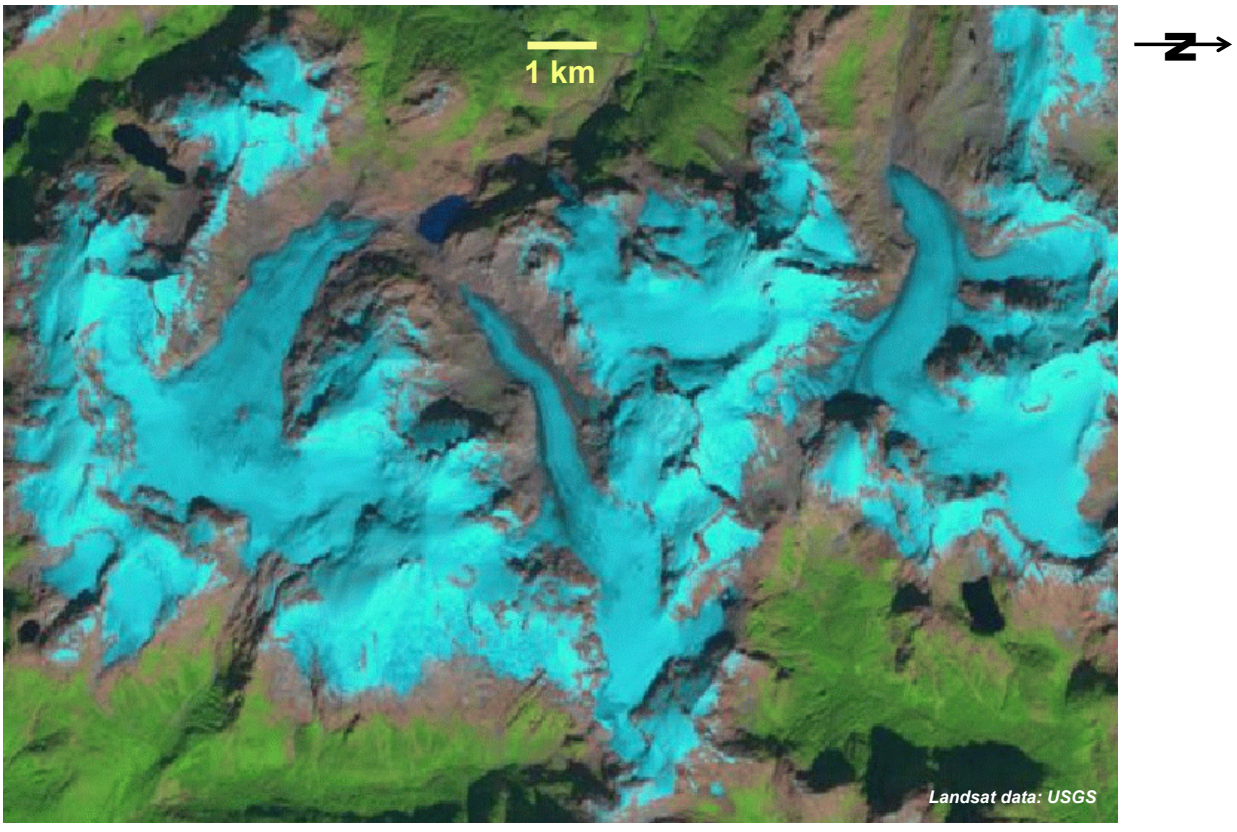
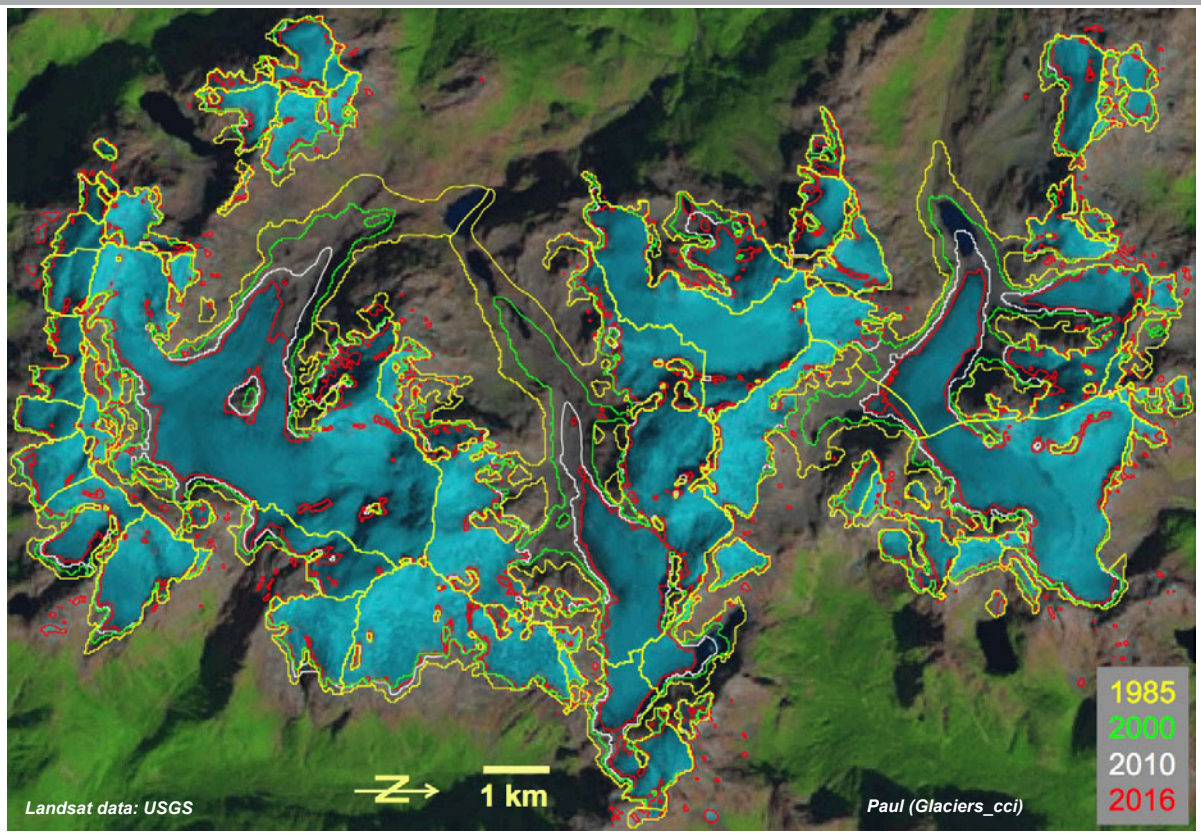
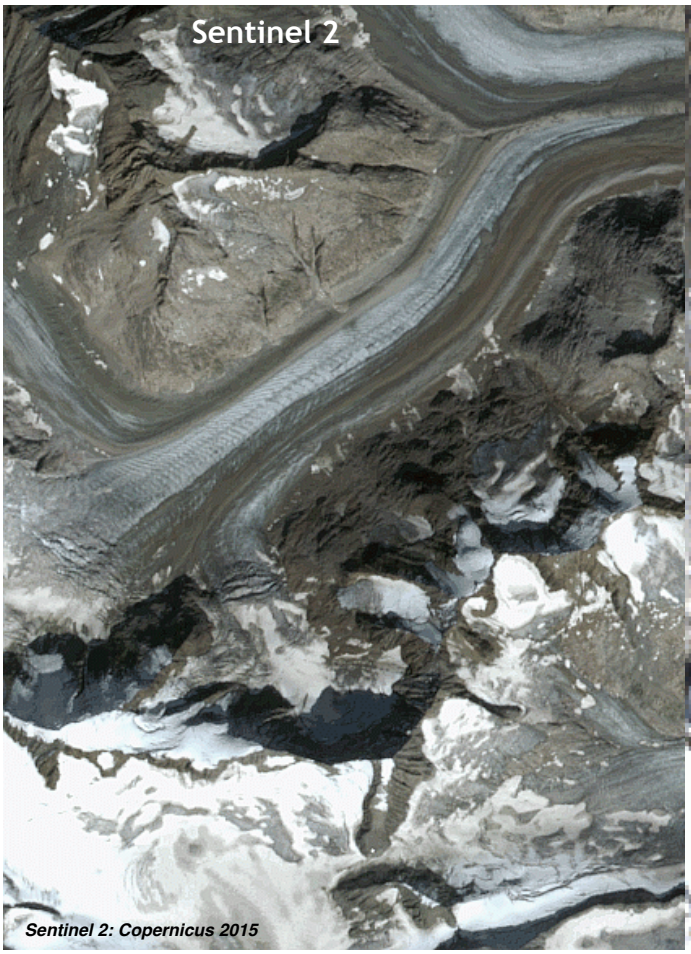
Glacier shrinkage Austria: 2009



Glacier shrinkage Patagonia: 1985-2000-2014



Glacier shrinkage in Patagonia: 1998-2014



Time series of area changes