

The use of UAVs for monitoring rock glaciers

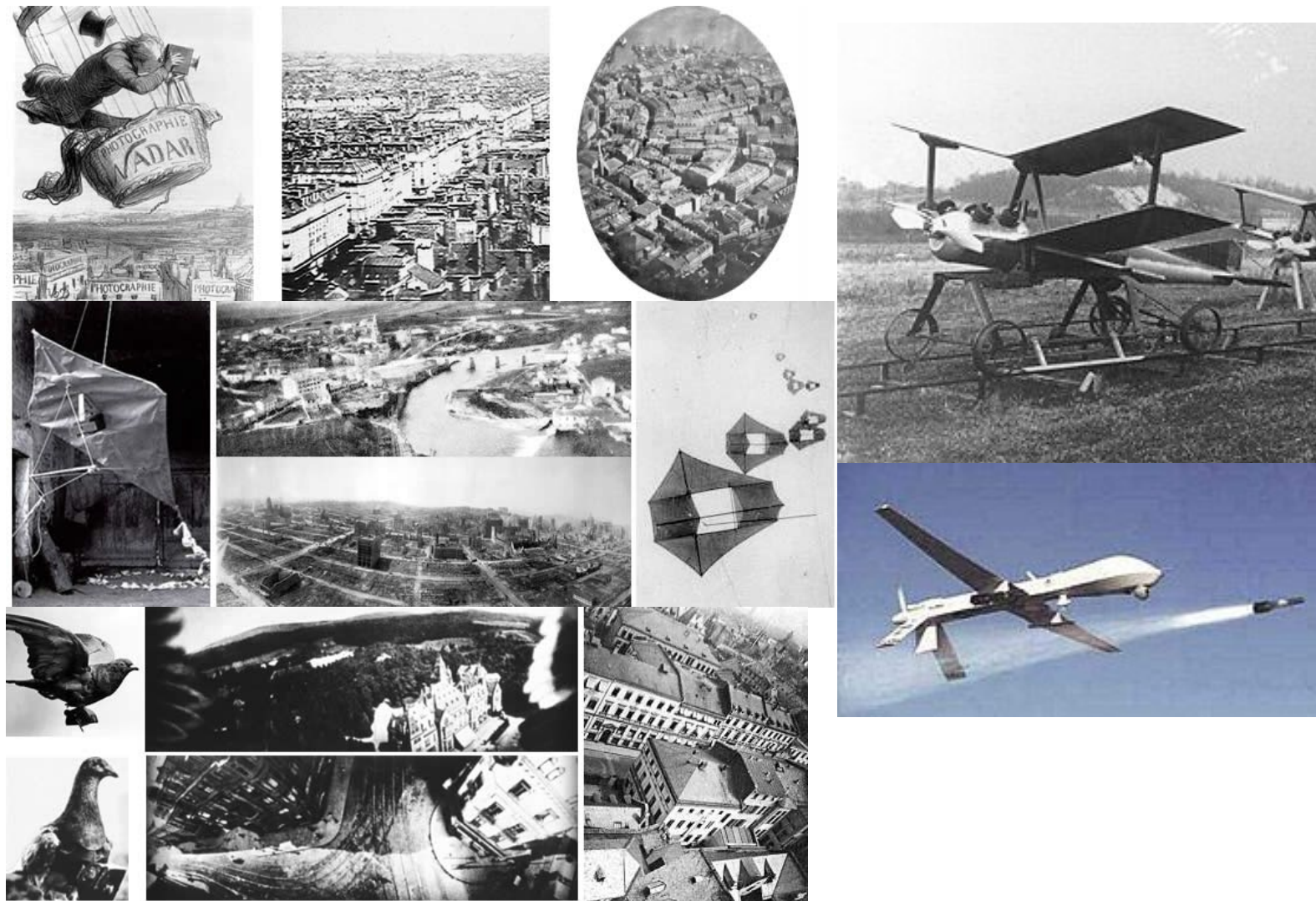


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Sebastián Vivero & János Mészáros



UAV origins



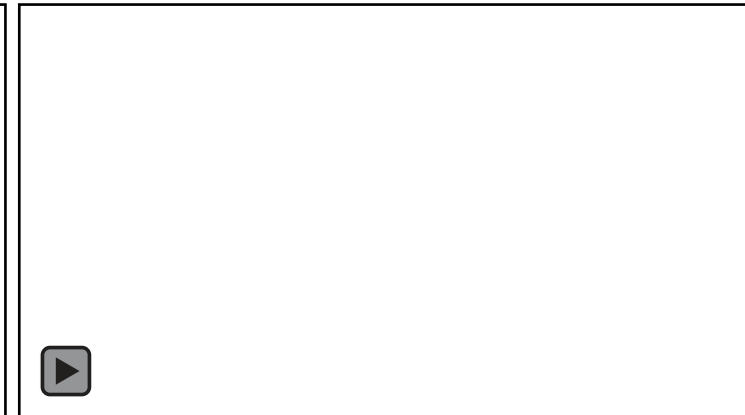
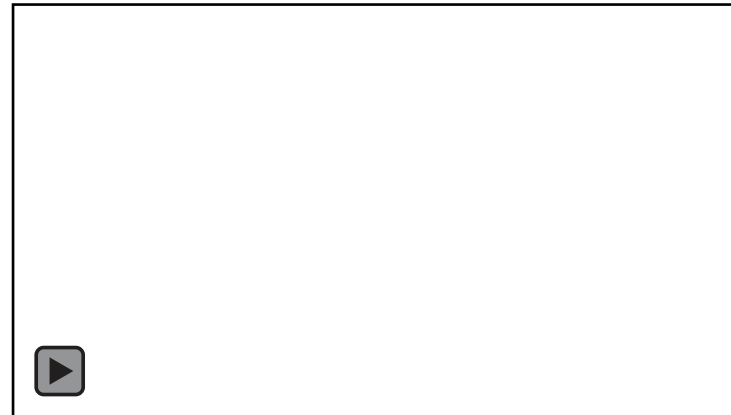
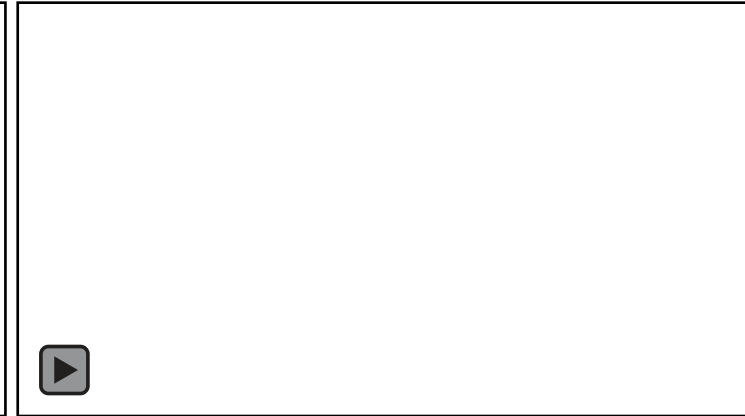
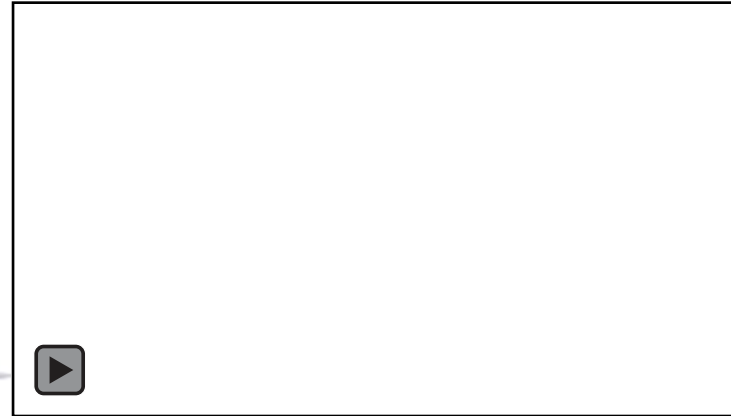
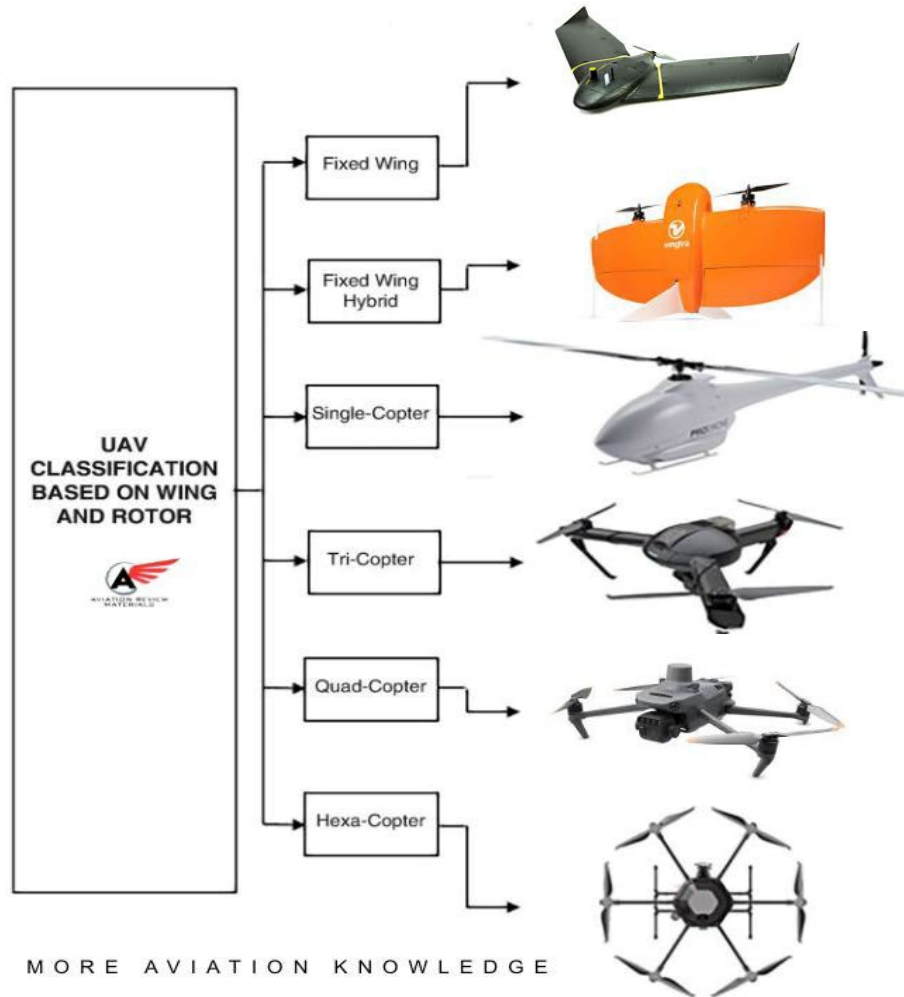
Drone: Popular and general term
→ Military contexts

UAV: Uncrewed/Unpiloted/Unmanned
Aerial Vehicle → Scientific term

UAS: Uncrewed Aerial System (Aircraft +
Ground Control Station +
Communication Link)

RPAS: Remotely Piloted Aircraft System
→ Another technical term

UAV types



European drone regulations overview

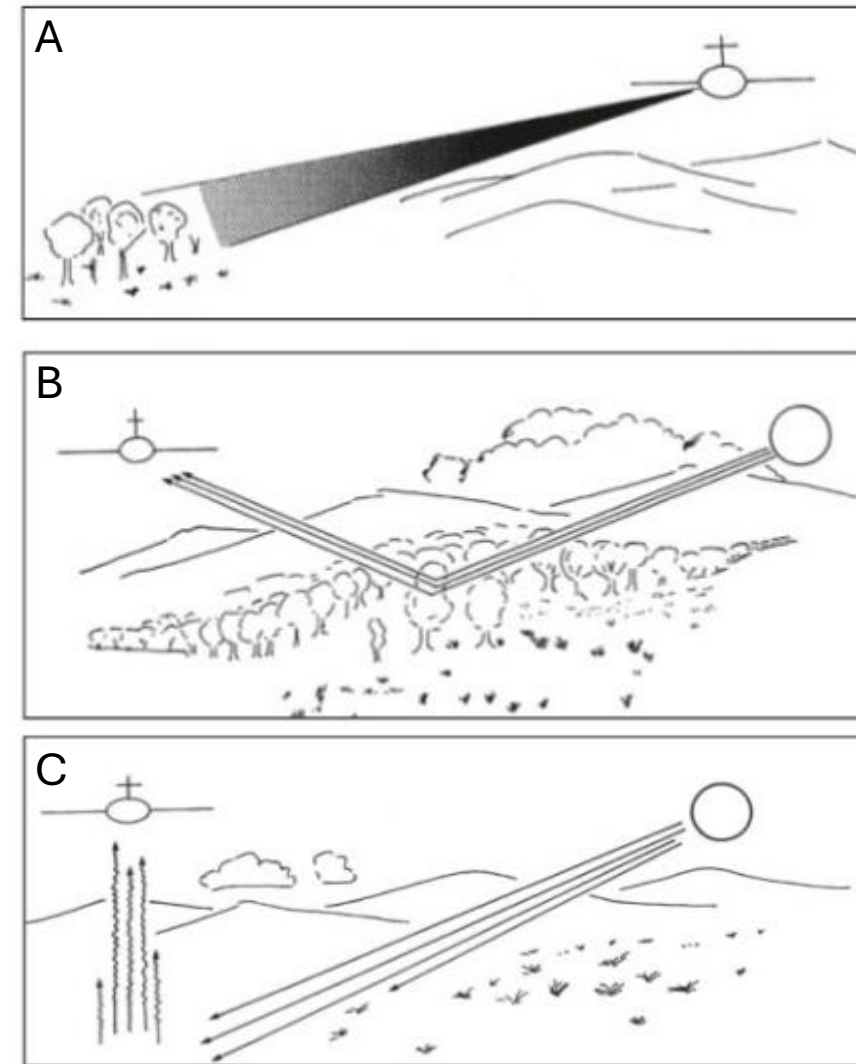


Certified Category Delivery of dangerous goods and transport of people	Operational authorization from the National Aviation Authority required 					
Specific Category BVLOS Beyond Visual Line Of Sight OOP Operations Over People	Operational authorization from the National Aviation Authority required 					
Open Category Low-risk operations Operational limitations < 120 m Altitude < 25 kg Weight VLOS Flight	Subcategory	Drone	Class identification	MTOM	Horizontal distance	Fly over people
	A3			< 25 kg	150 m from urban areas	May fly over uninvolved people but should be avoided when possible
	A3			< 25 kg	150 m from urban areas	No flight near people
	A2			< 4 kg	30 m from uninvolved people	No flight over uninvolved people
	A1			< 900 g	No flight over assemblies of people	No flight over uninvolved people, if it happens, overflight should be minimised
	A1			< 250 g	No flight over assemblies of people	May fly over uninvolved people, should be avoided when possible
	A3			N/A	150 m from residential, commercial or industrial areas	No flight near or over people
	A2			N/A	50 m from uninvolved people	No flight over uninvolved people
	A1			N/A	No flight over assemblies of people	No flight over uninvolved people, if it happens, overflight should be minimised
	www.AgEagle.com					
Jan 1st 2021 Start of transitional period		Limited Open Category TRANSITION PERIOD			Dec 31st 2023 End of transitional period	

Active RS: Using the sensors own transmitted and reflected radiation [A]

e.g. laser scanning (lidar) or microwave RS

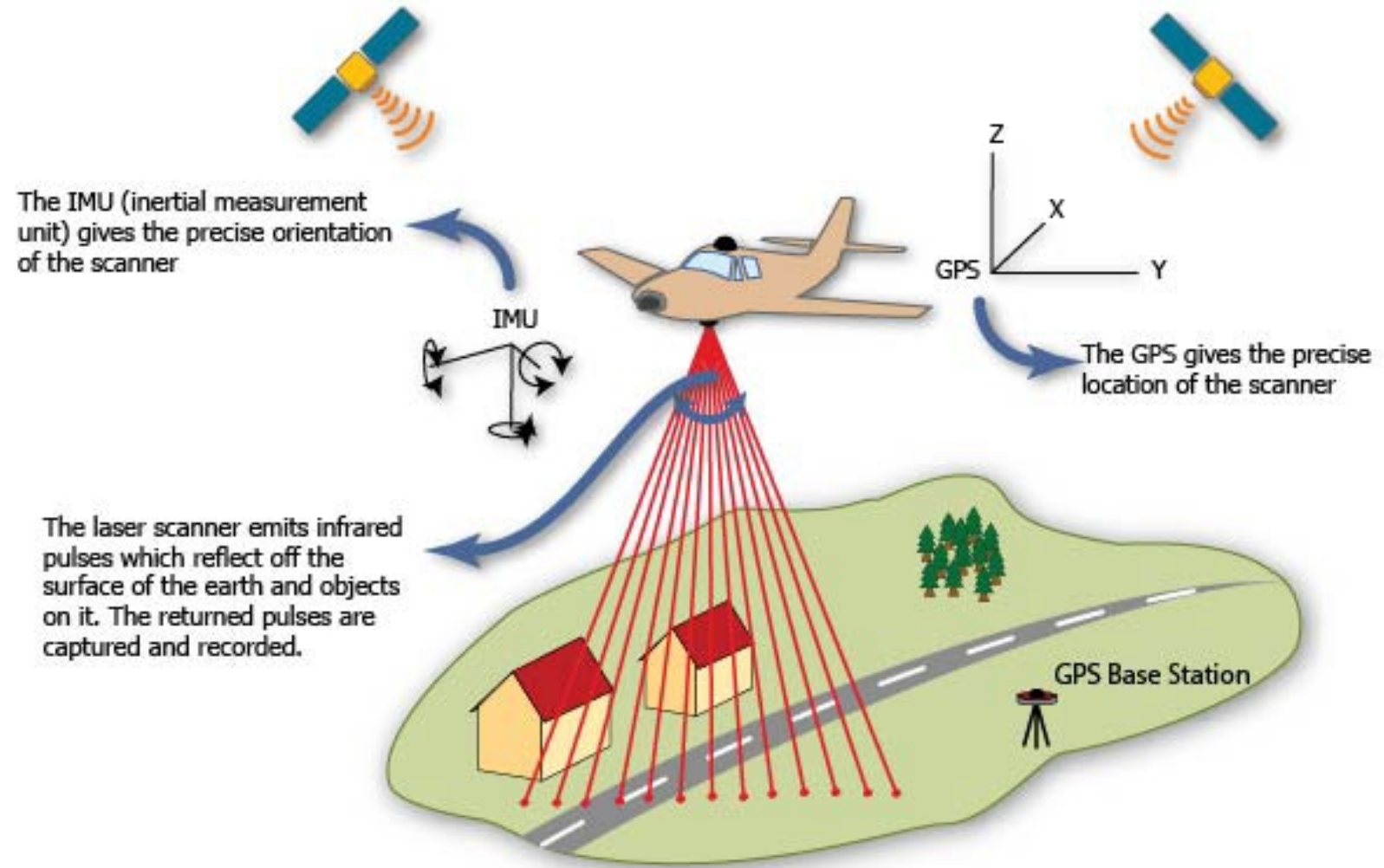
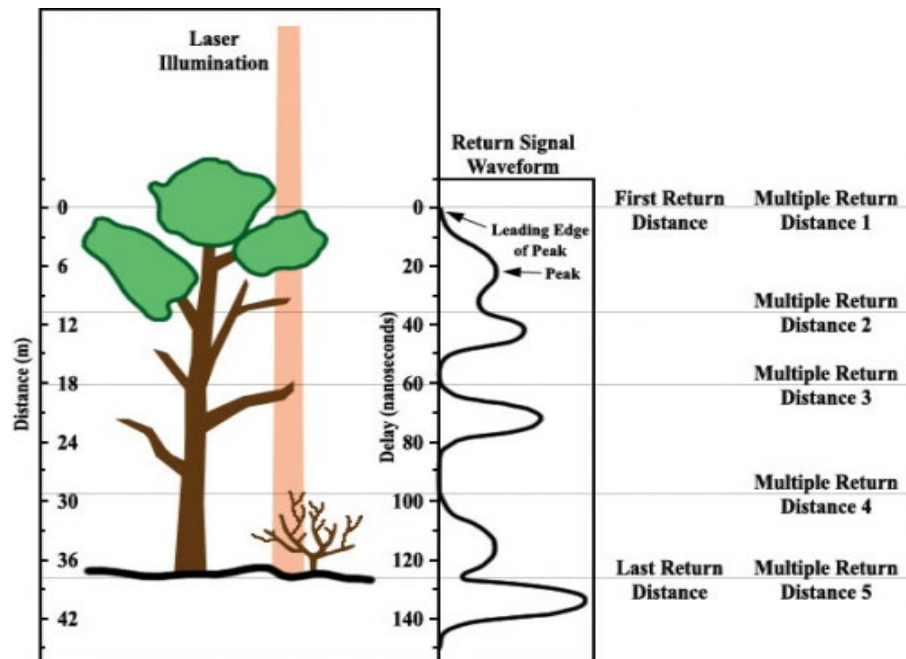
Passive RS: Using mainly the reflected solar radiation (RGB, multi- and hyperspectral RS) [B] or emitted terrestrial radiation (thermal RS) [C]



Laser scanning

Laser scanning → the measurement of 3D point coordinates and the recording of their back-scattered laser signal to characterize object geometry and surface properties

ULS: UAV-borne laser scanning

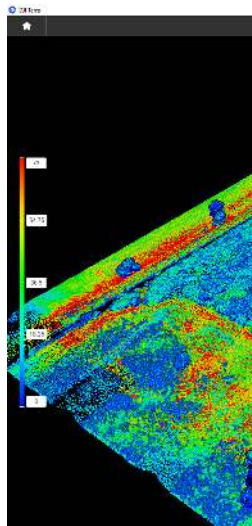


Laser scanning

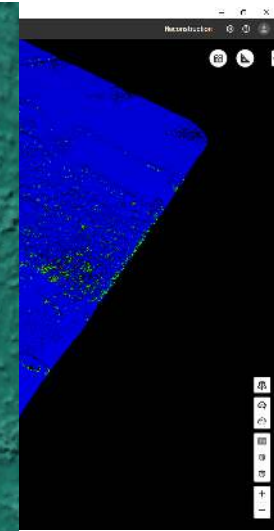
True
Colour
Point
Cloud



Reflectivity

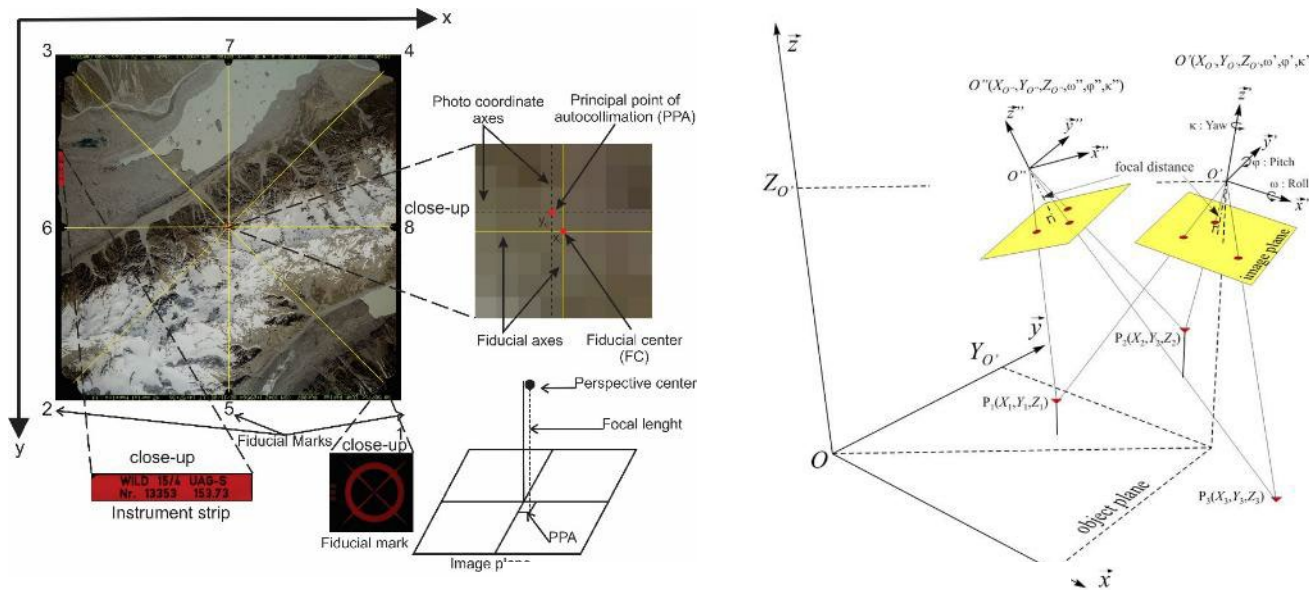


Returns



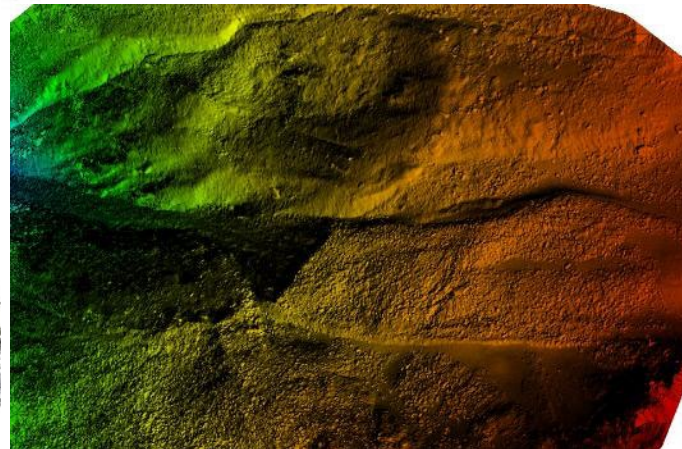
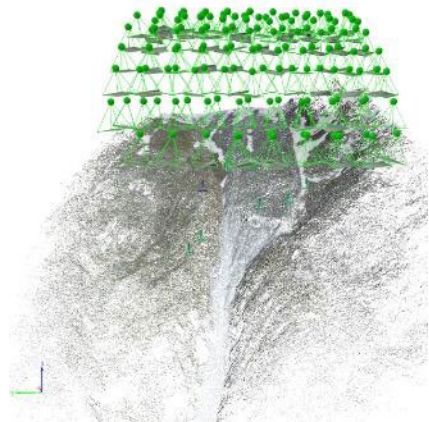
Profile



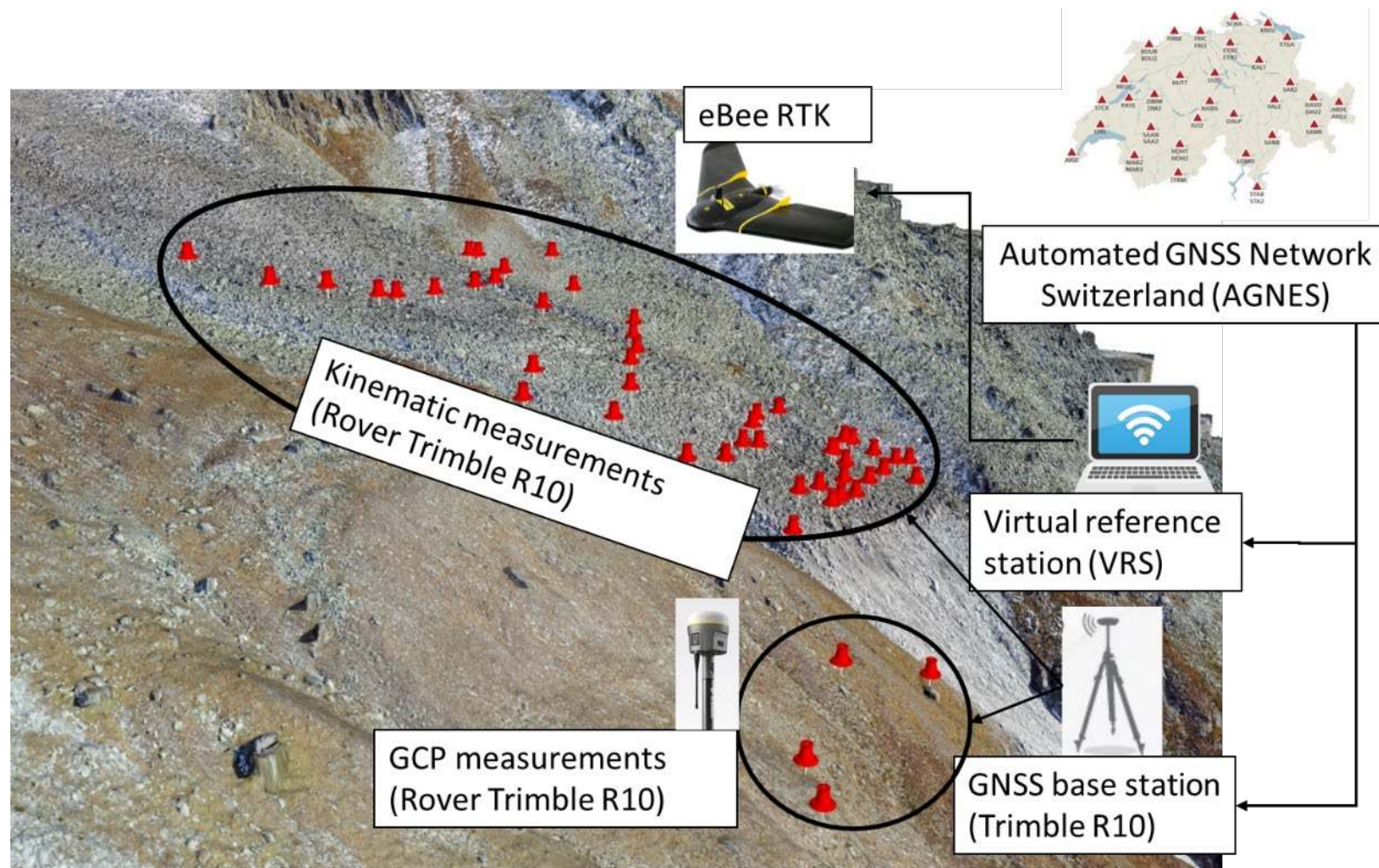


Photogrammetry → measuring and interpreting objects by photos

SfM: Structure from Motion → A computer vision and photogrammetry technique which estimates 2D and 3D shapes, as well as the internal and external orientations of a camera, from a sequence of overlapping two-dimensional images captured from different viewpoints.



UAV and GNSS surveys



GNSS: Global Navigation Satellite System → Includes GPS, GLONASS, Galileo and other constellations.

CORS: Continuously Operating Reference Station → Permanent, static GNSS base station providing corrections

Base station: Local, temporary GNSS receiver used as a reference

VRS: Virtual Reference Station → Virtual GNSS base station

RTK: Real-Time Kinematic → Broadcast corrections from base station or VRS.

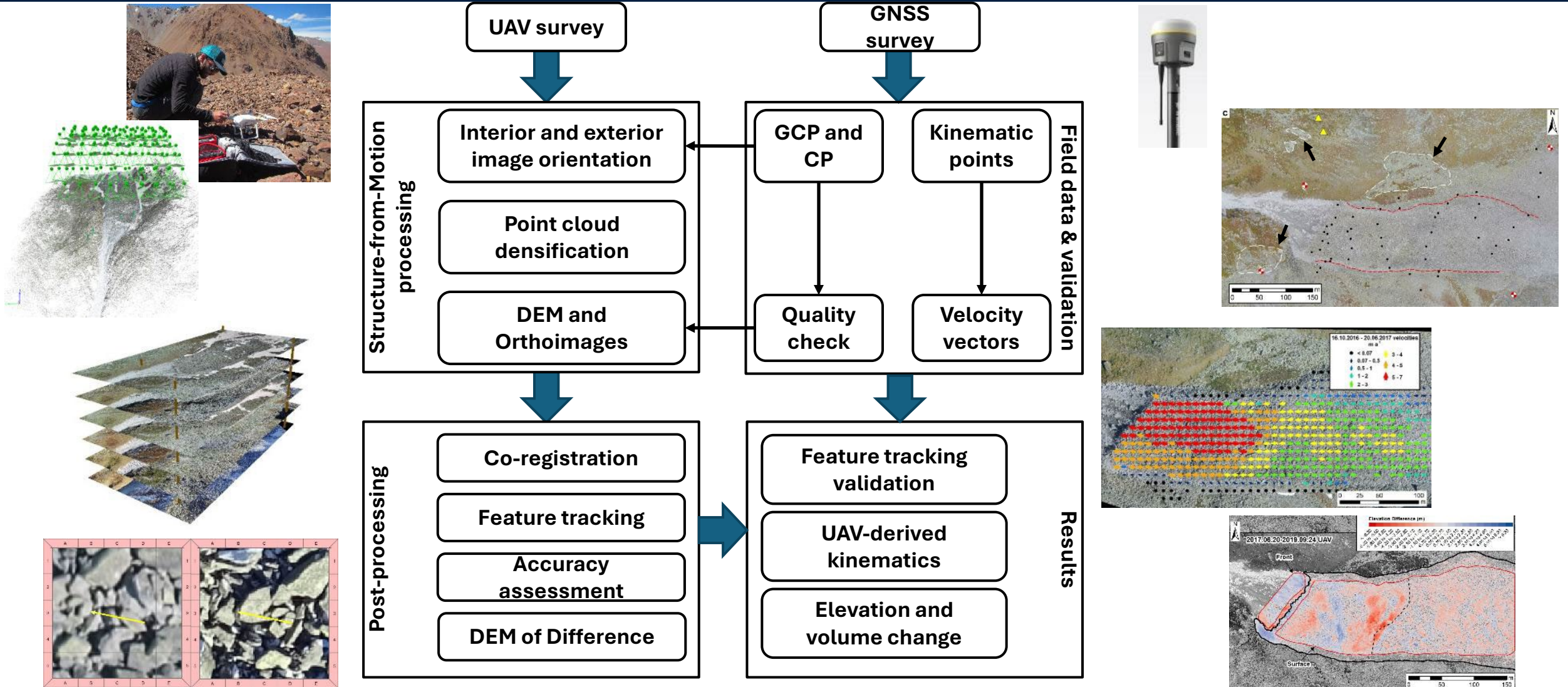
PPK: Post-Processed Kinematic → Corrections are applied after work

PPP: Precise Point Positioning → High accuracy without a local base

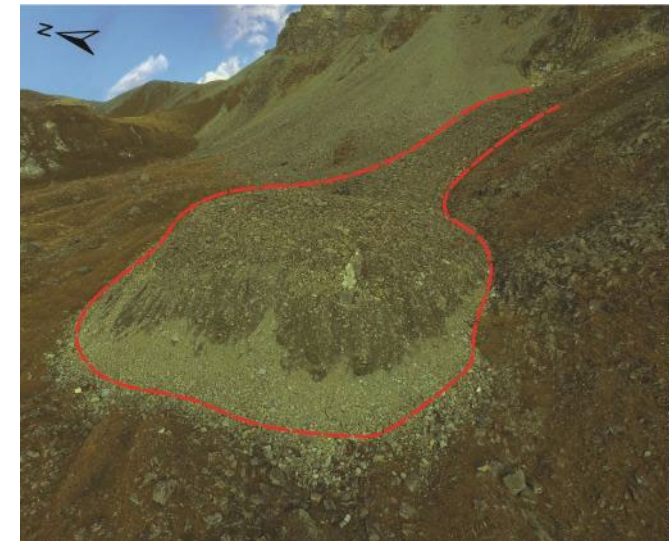
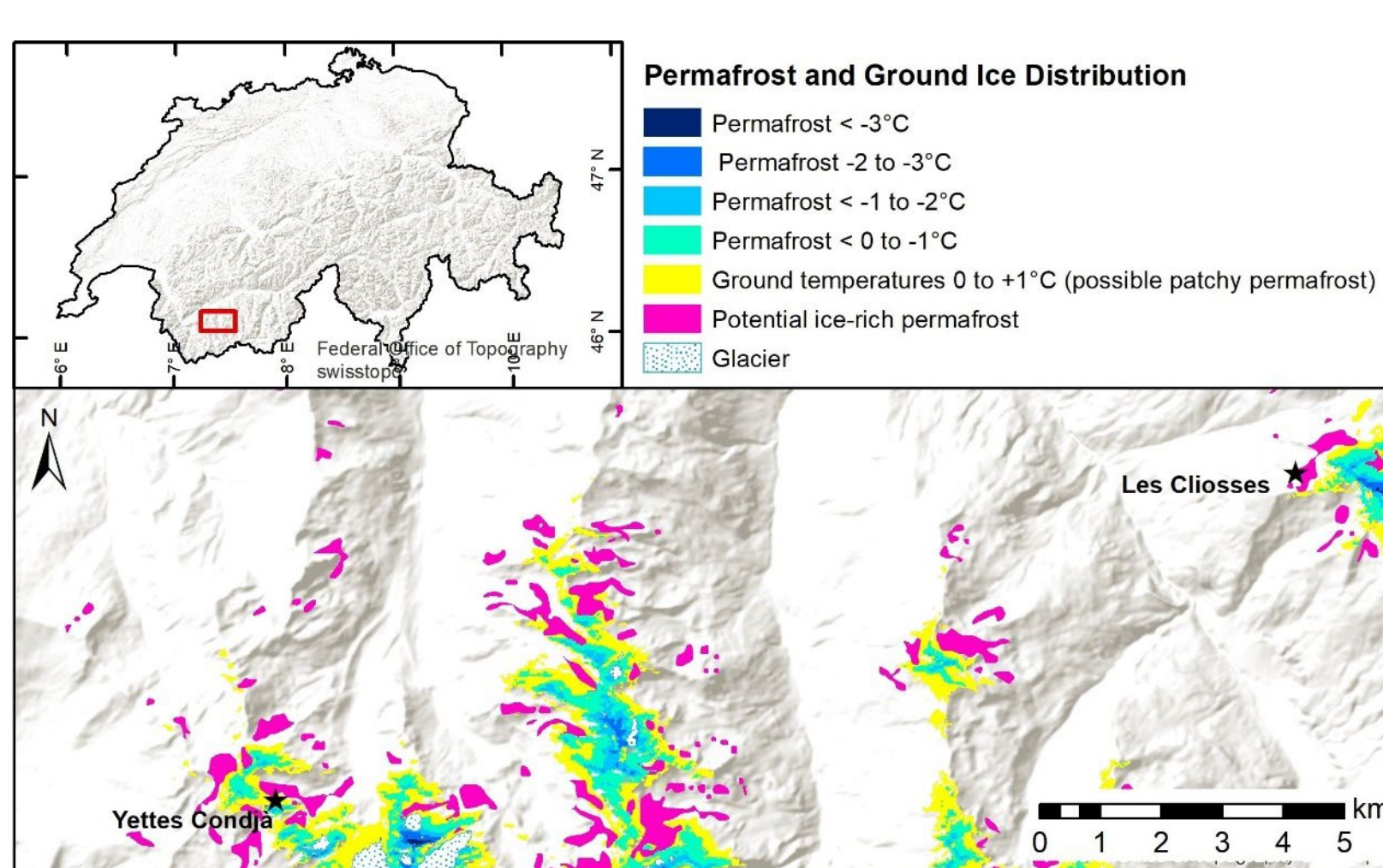
GCP: Ground Control Point → For quality

CP: Check Point → For validation

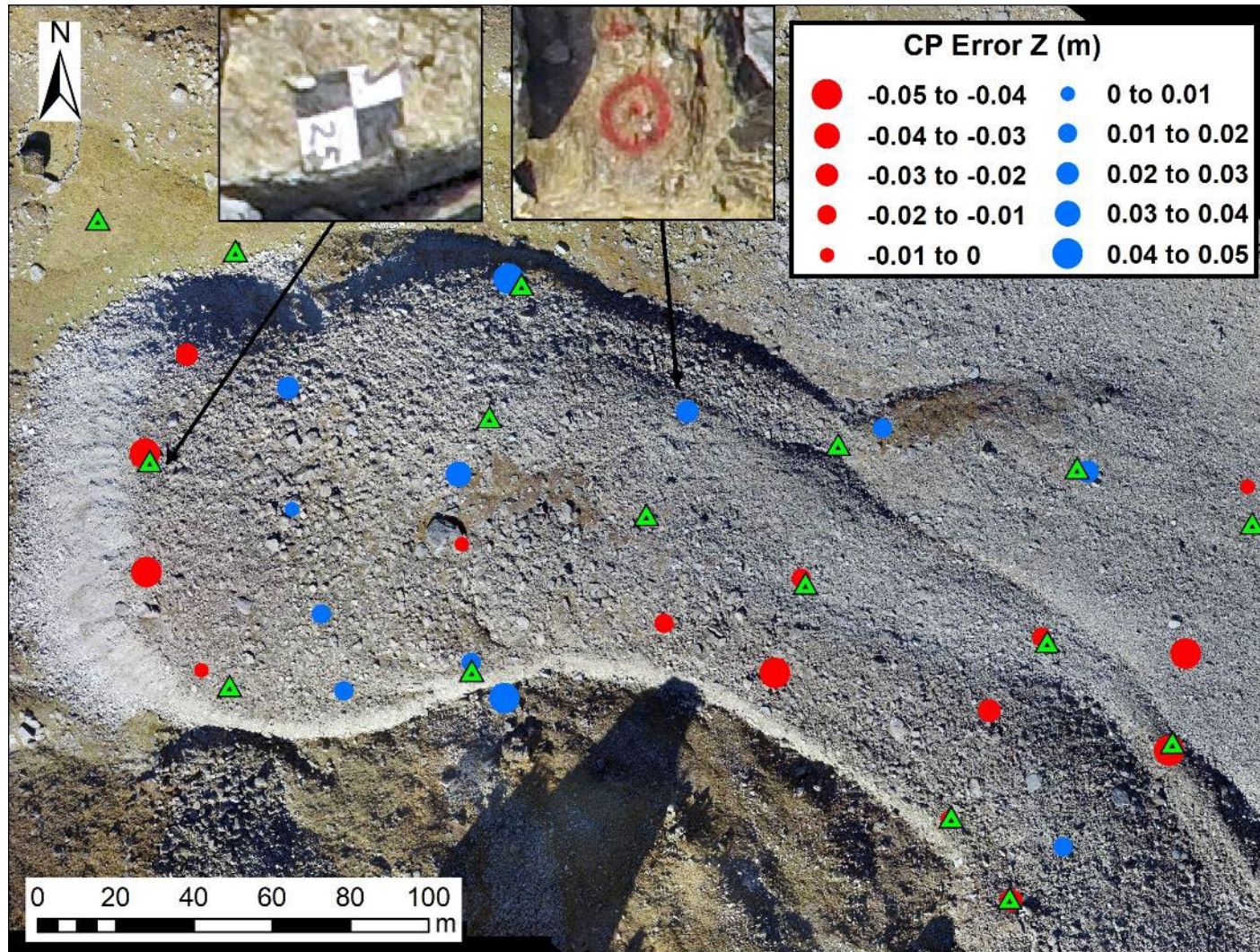
General workflow



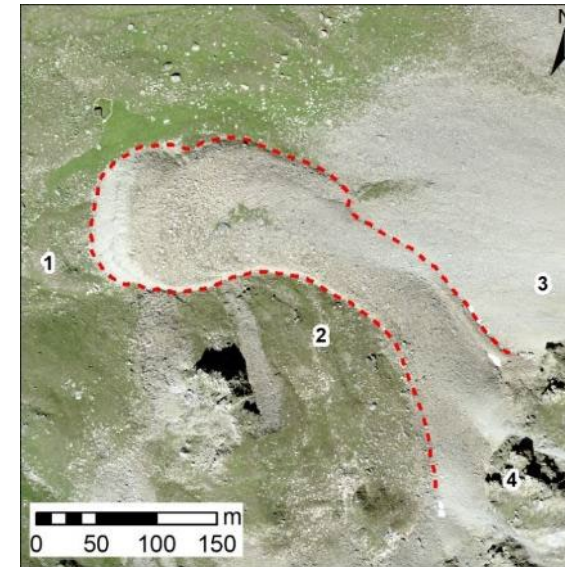
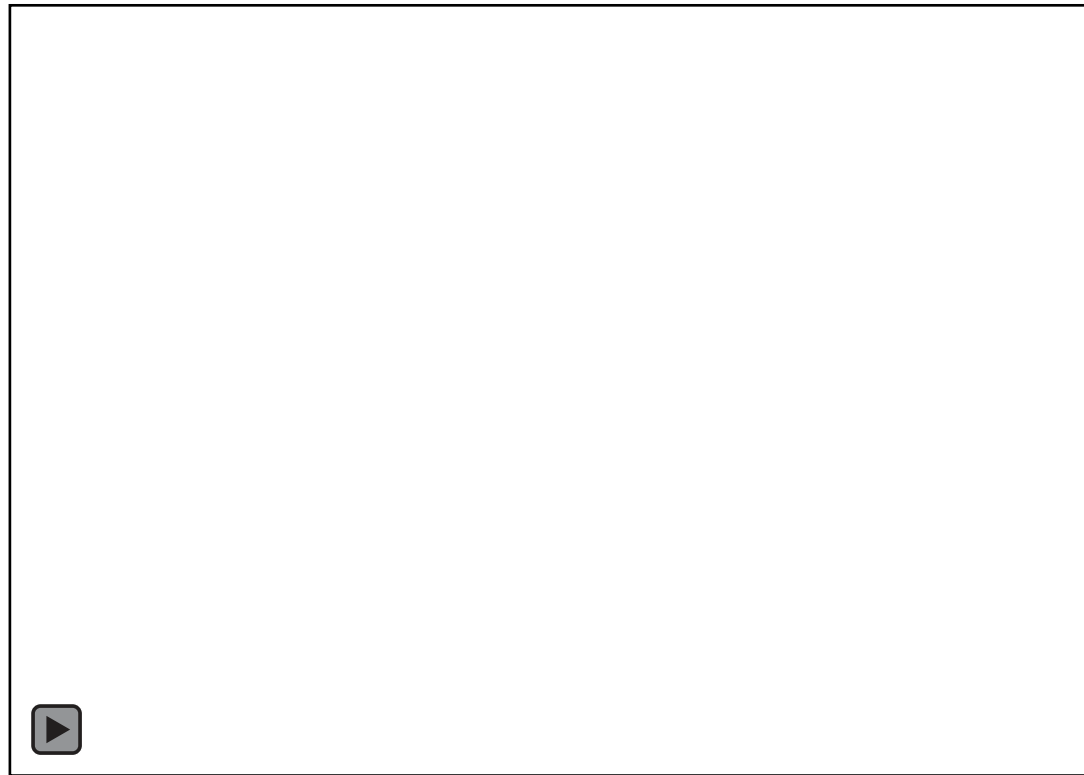
Les Cliosses & Yettes Condjà



GCP and CP distribution



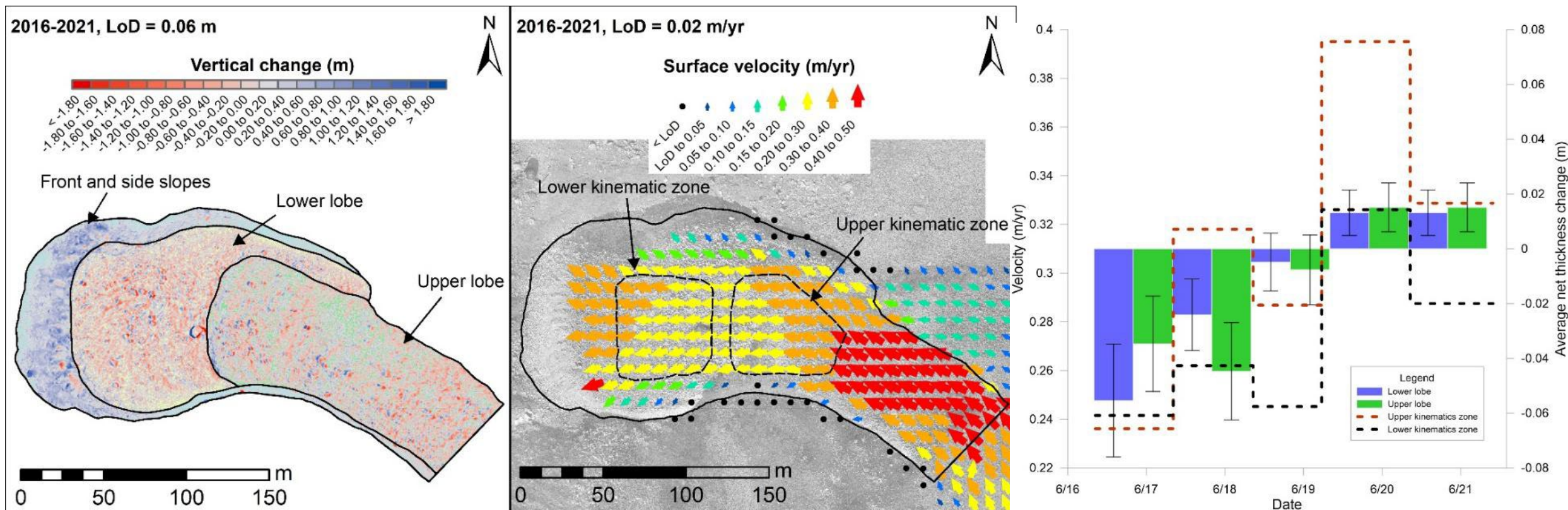
Hillshades & 3D models

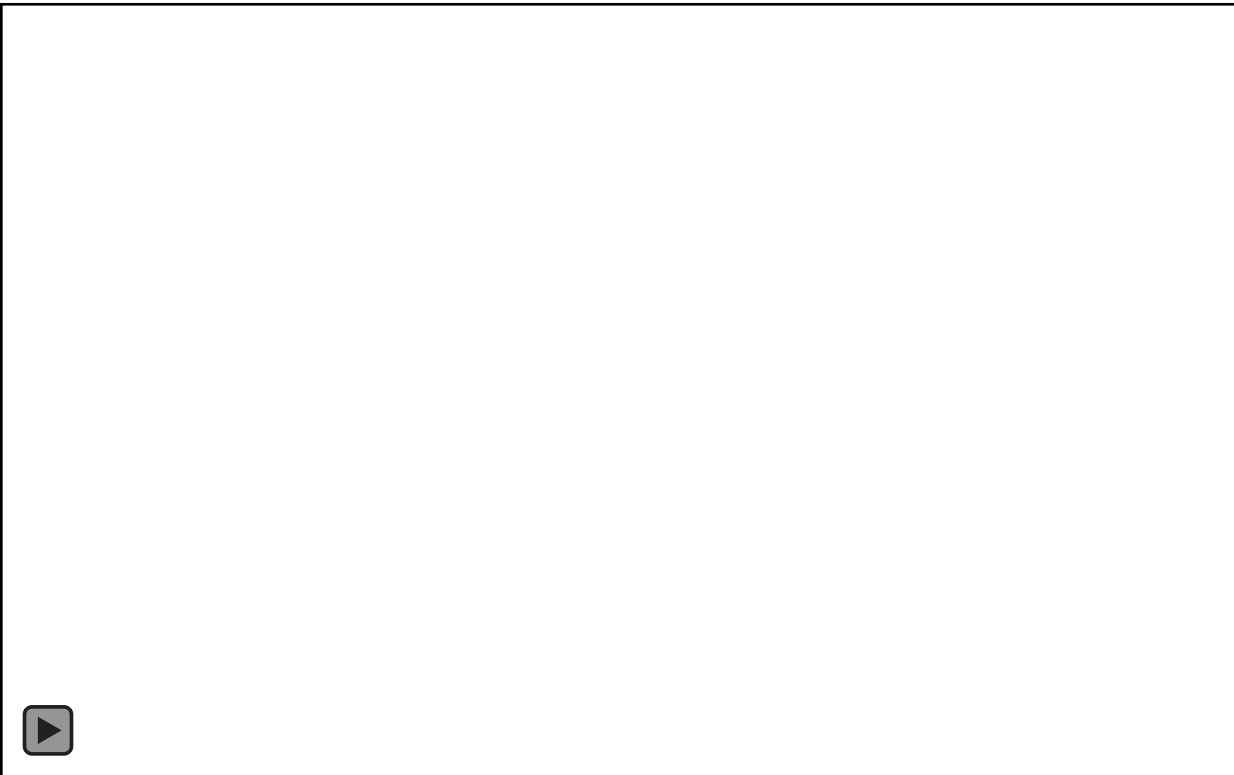


Lateral shearing
margin

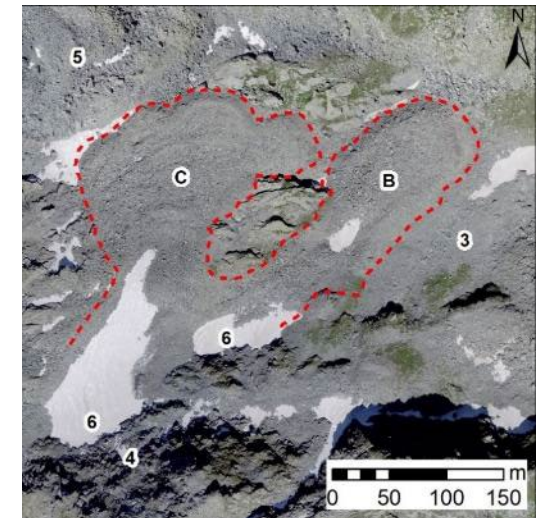
Steep front

DoD and surface velocity





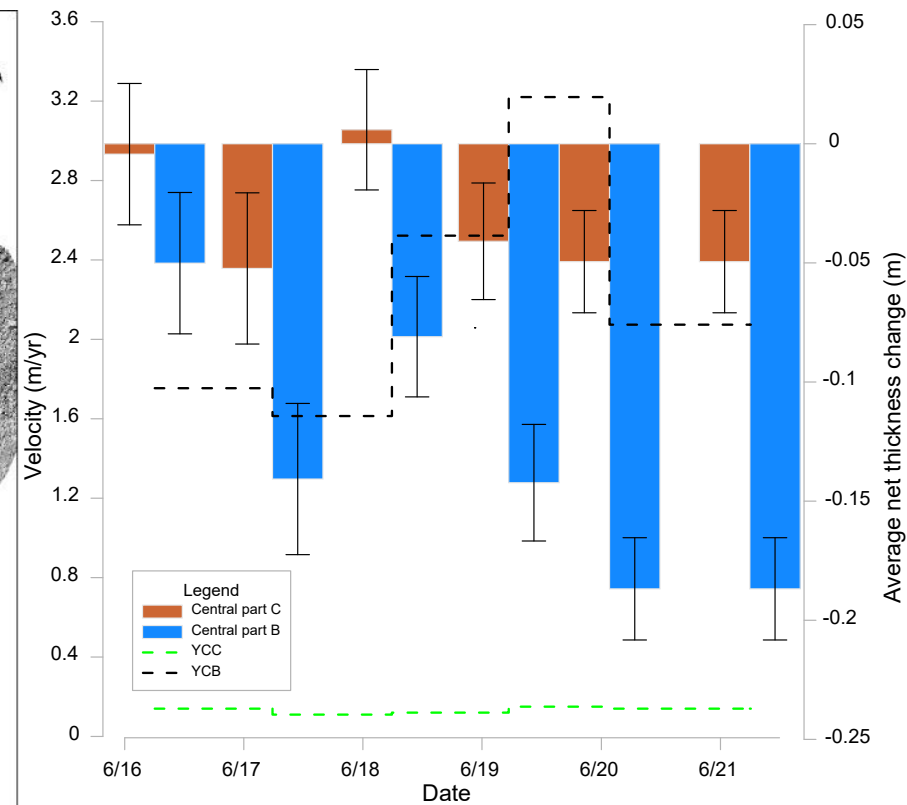
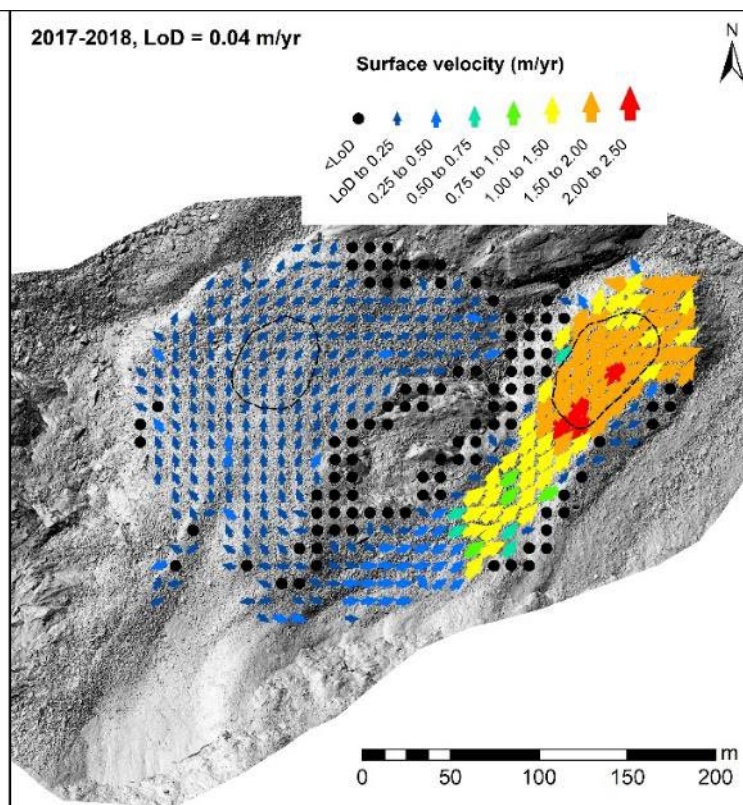
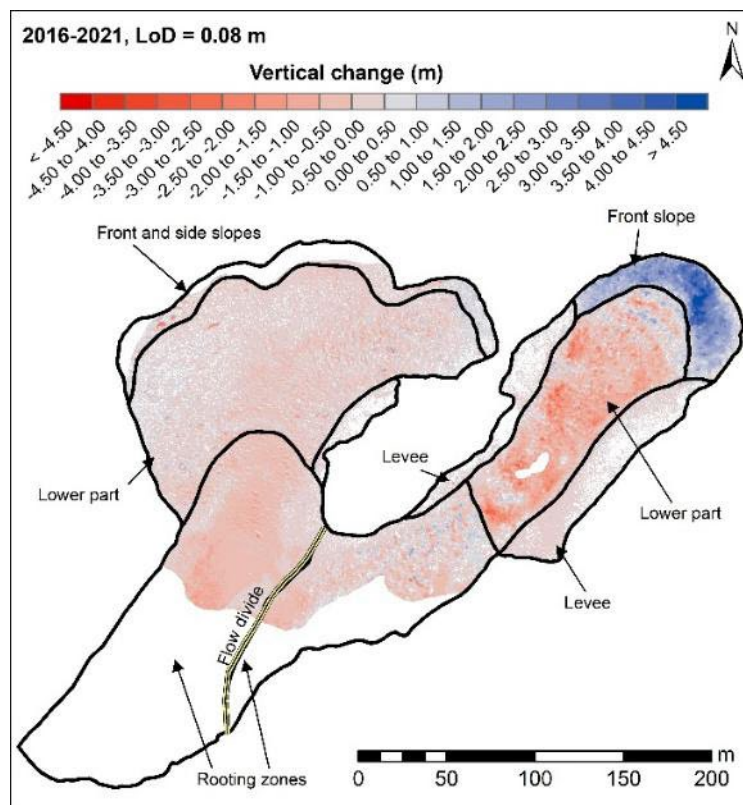
Seasonal firn
patch



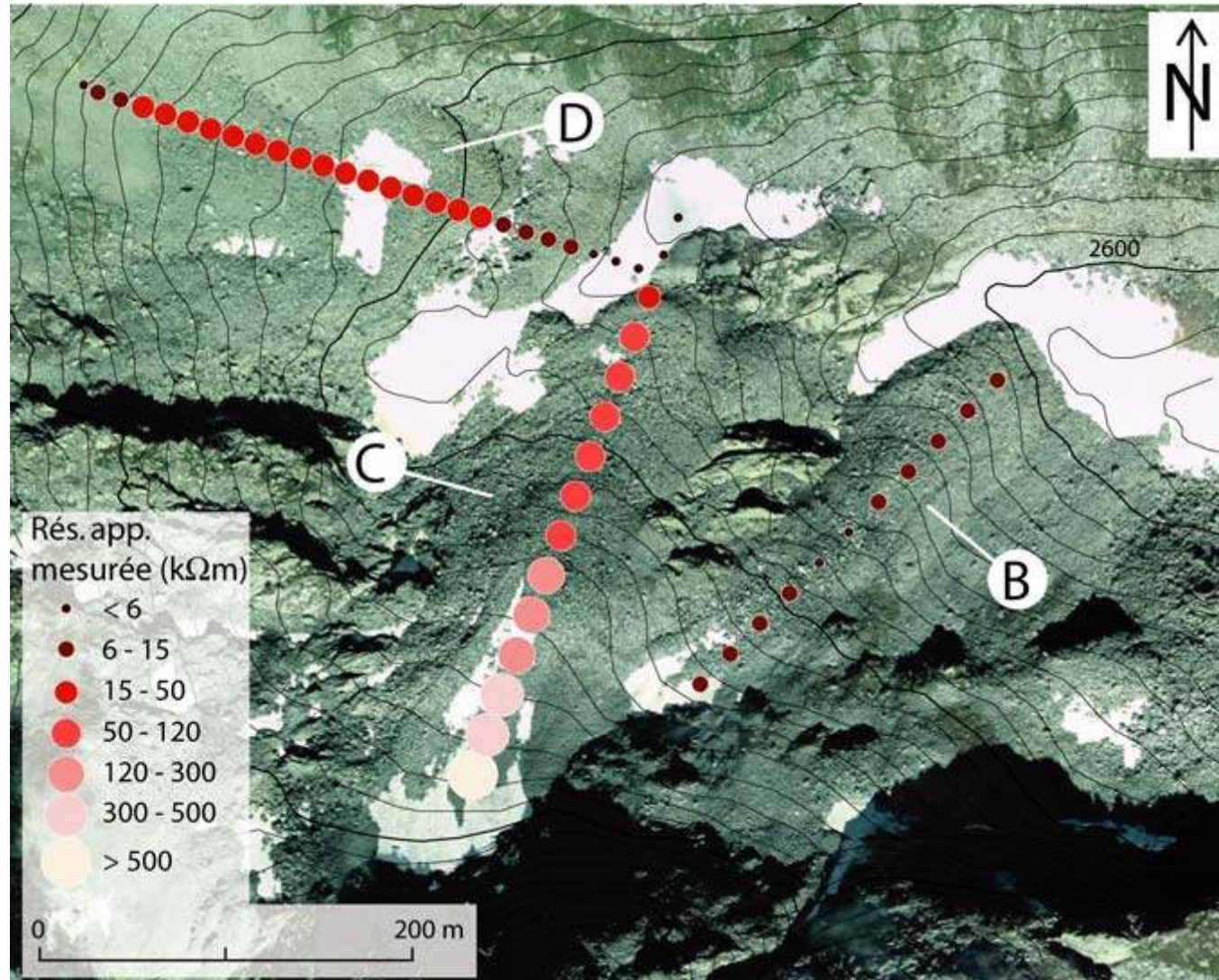
Lateral levee

latero-frontal
rampart
construction

DoD and surface velocity



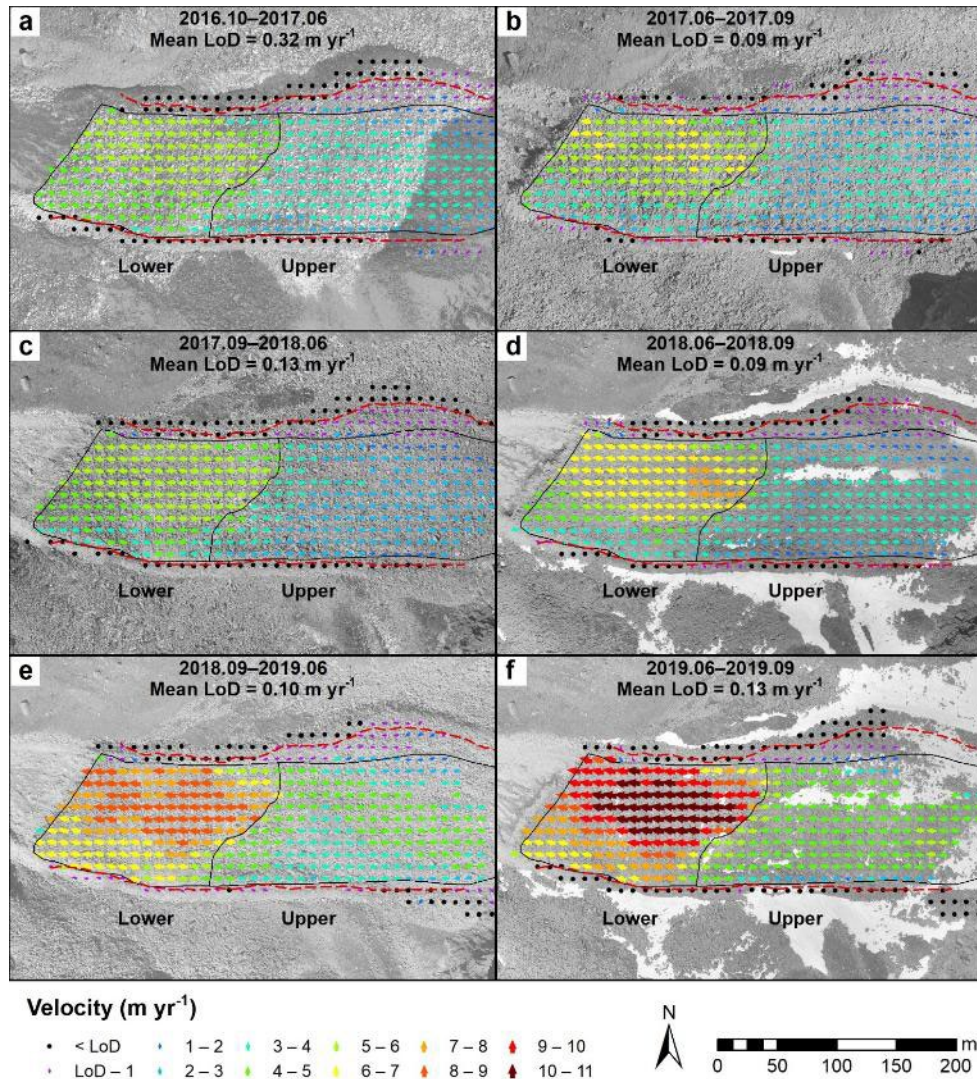
Yettes Condjà subsurface



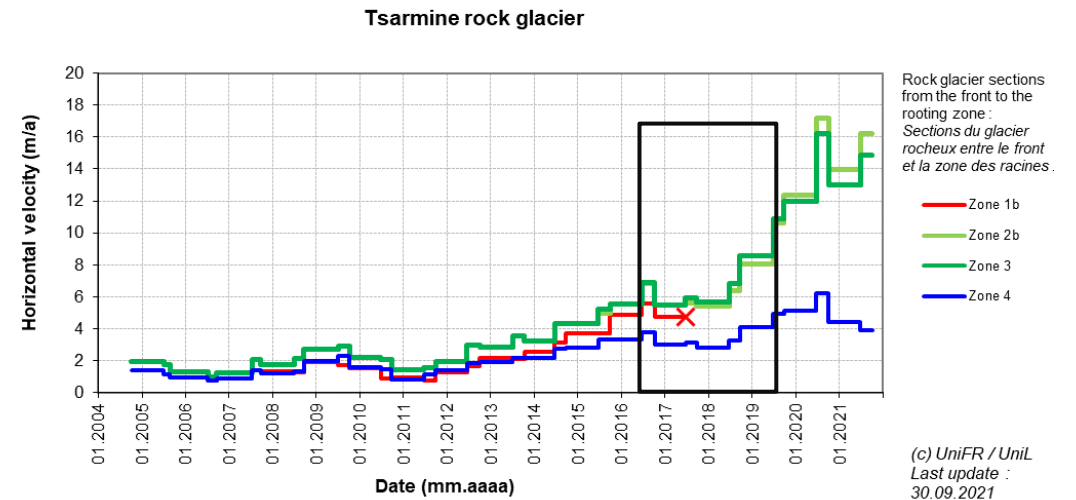
Destabilized Tsarmine rock glacier



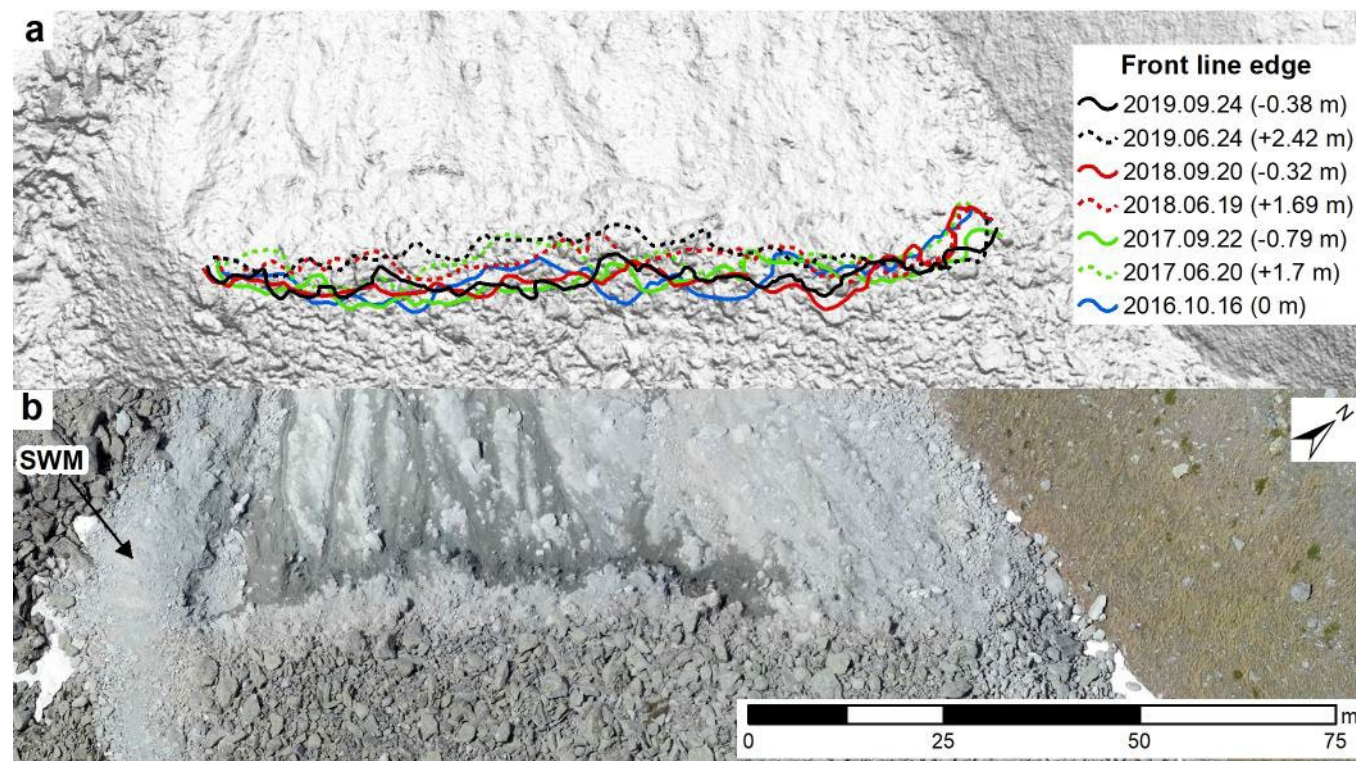
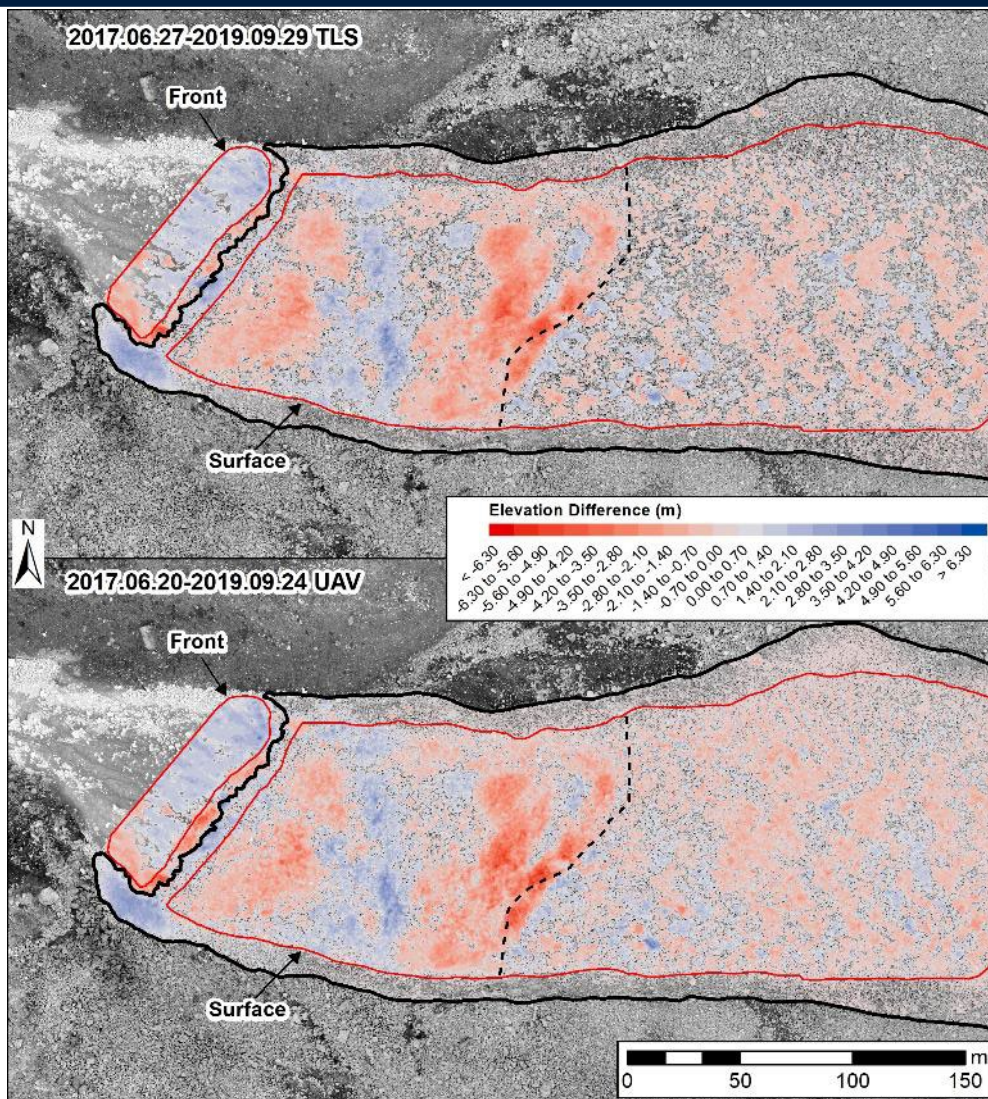
Seasonal analysis



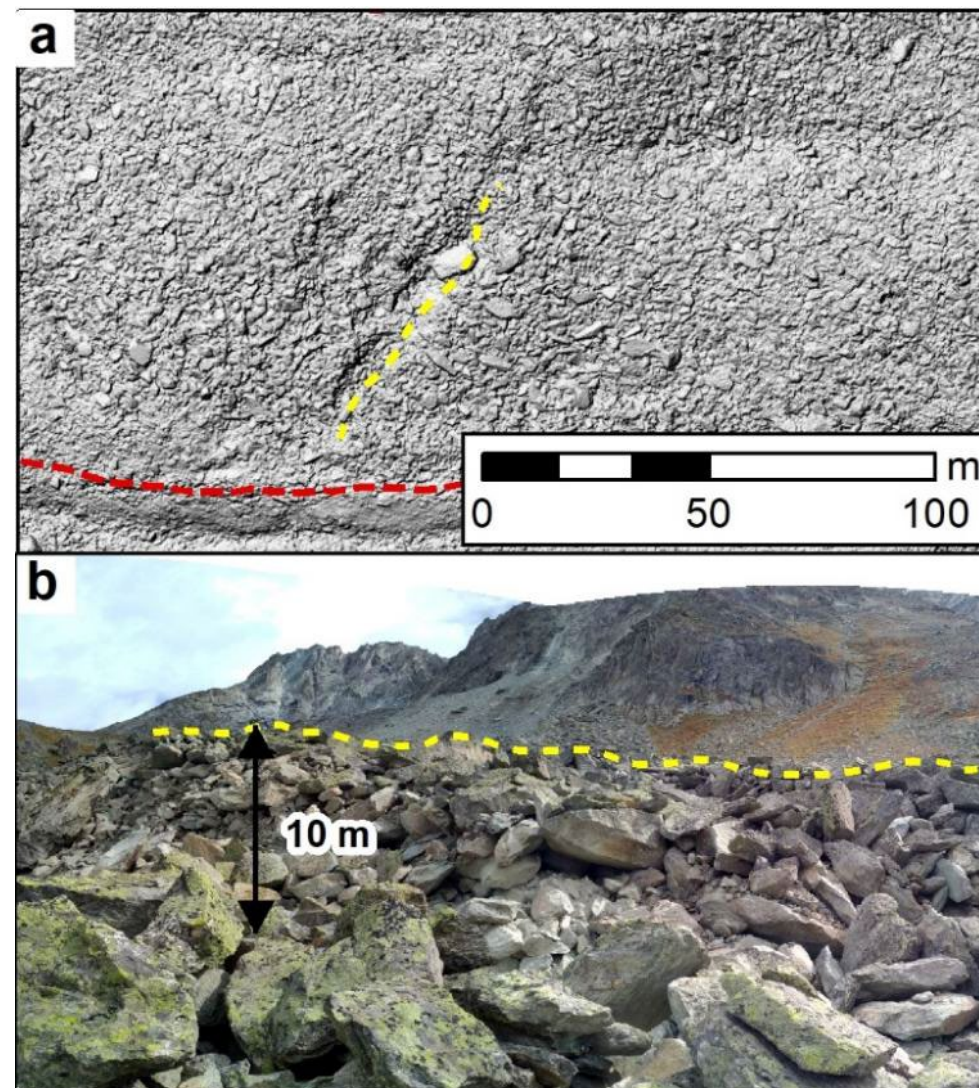
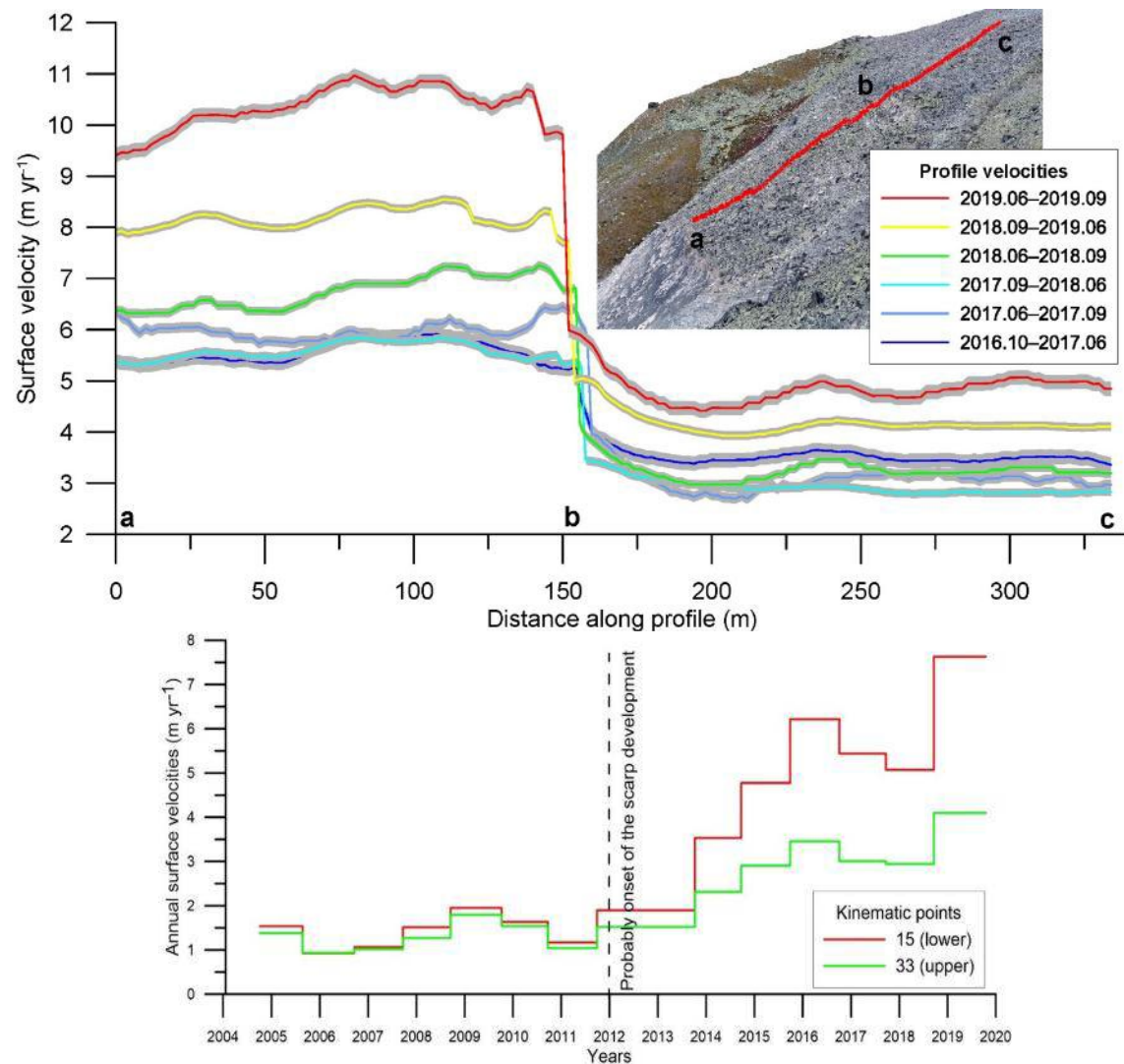
Periods	Rock glacier kinematics zones				
	Lower		Upper		Upper/Lower
	$\bar{d}$ (m)	$\bar{v}$ (m yr ⁻¹)	$\bar{d}$ (m)	$\bar{v}$ (m yr ⁻¹)	Ratio
a	3.40	5.02	2.26	3.34	0.67
b	1.27	4.93	0.77	2.99	0.61
c	3.64	4.92	2.09	2.83	0.58
d	1.40	5.50	0.77	3.02	0.55
e	5.54	7.30	3.14	4.13	0.56
f	2.20	8.74	1.12	4.43	0.51



DoD and frontal changes



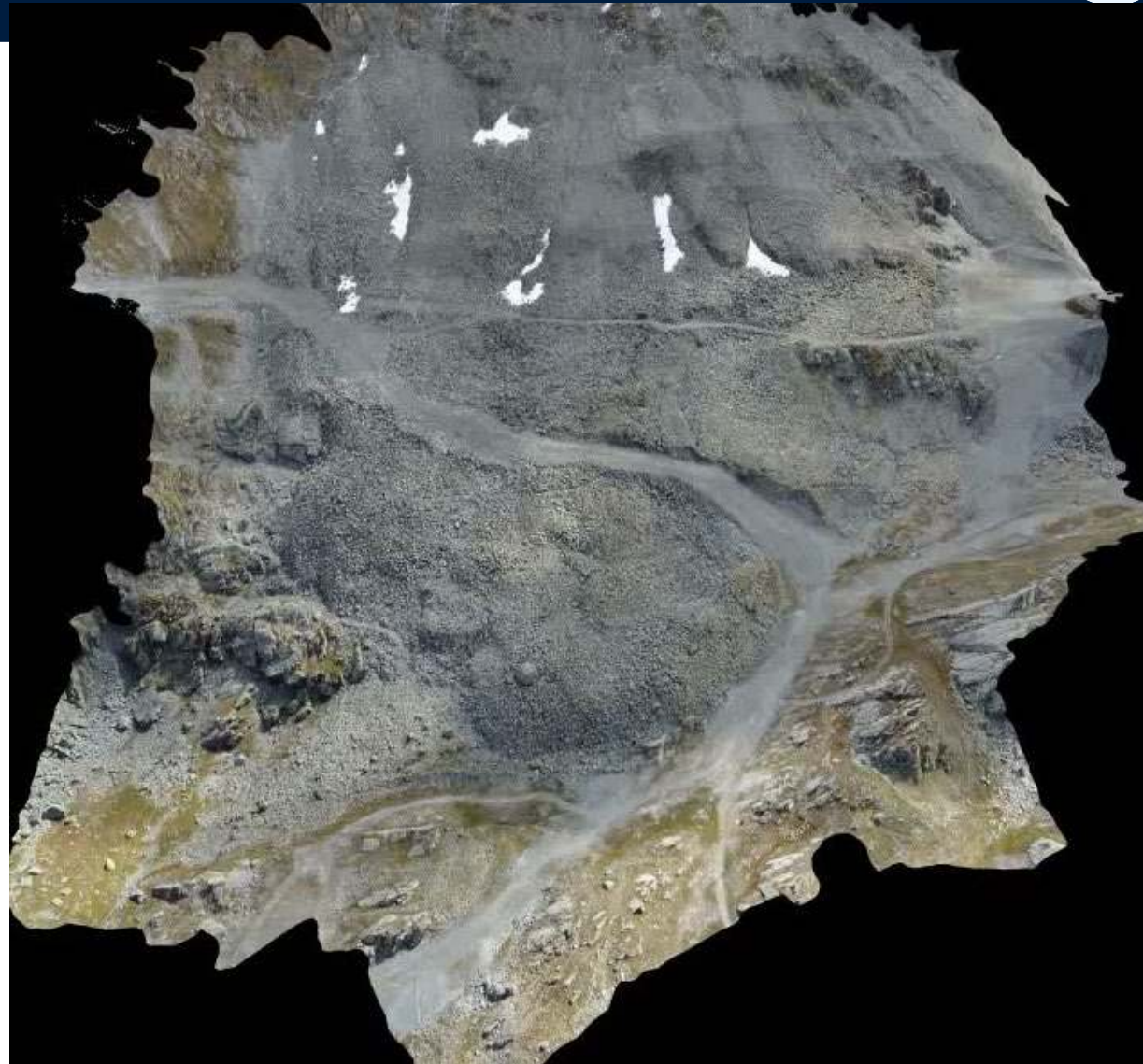
Velocity profiles

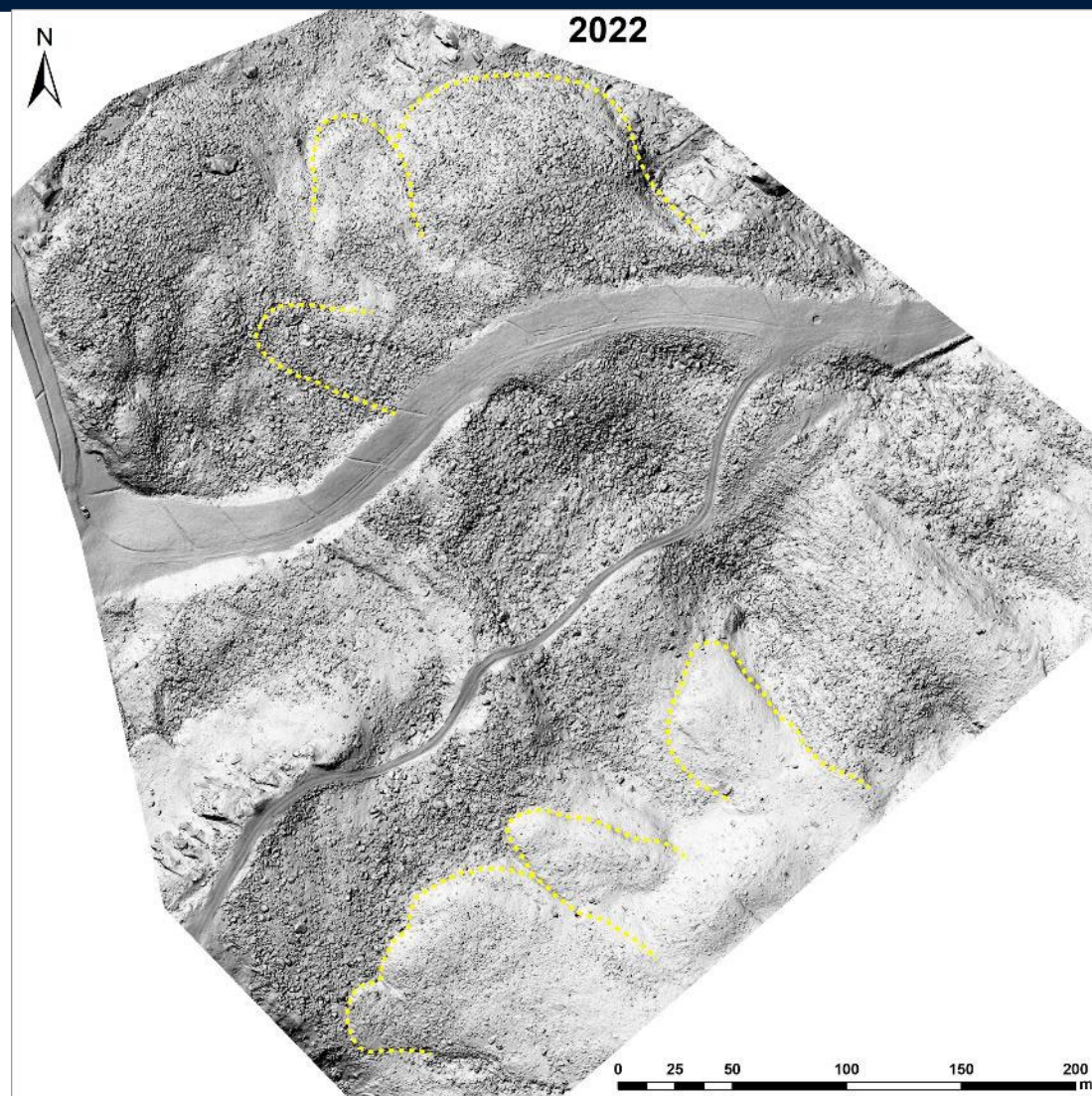


Lac des Vaux 3D

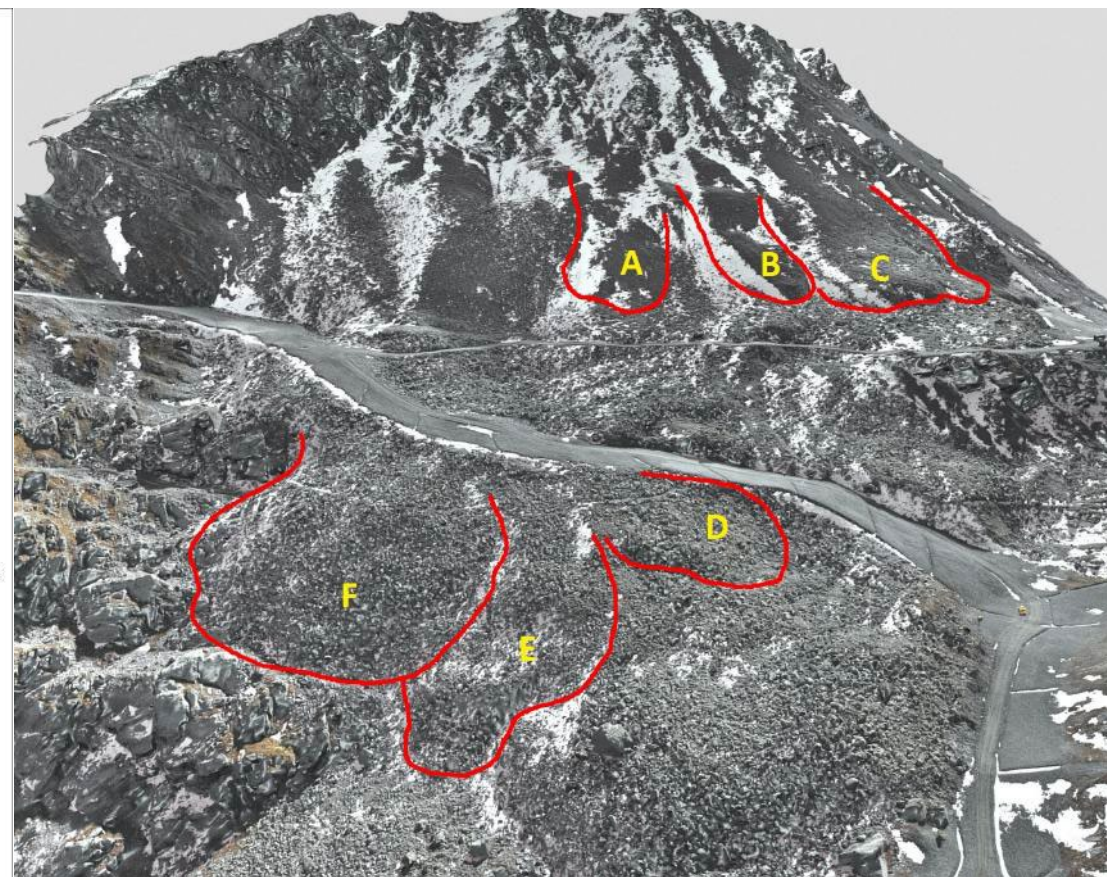
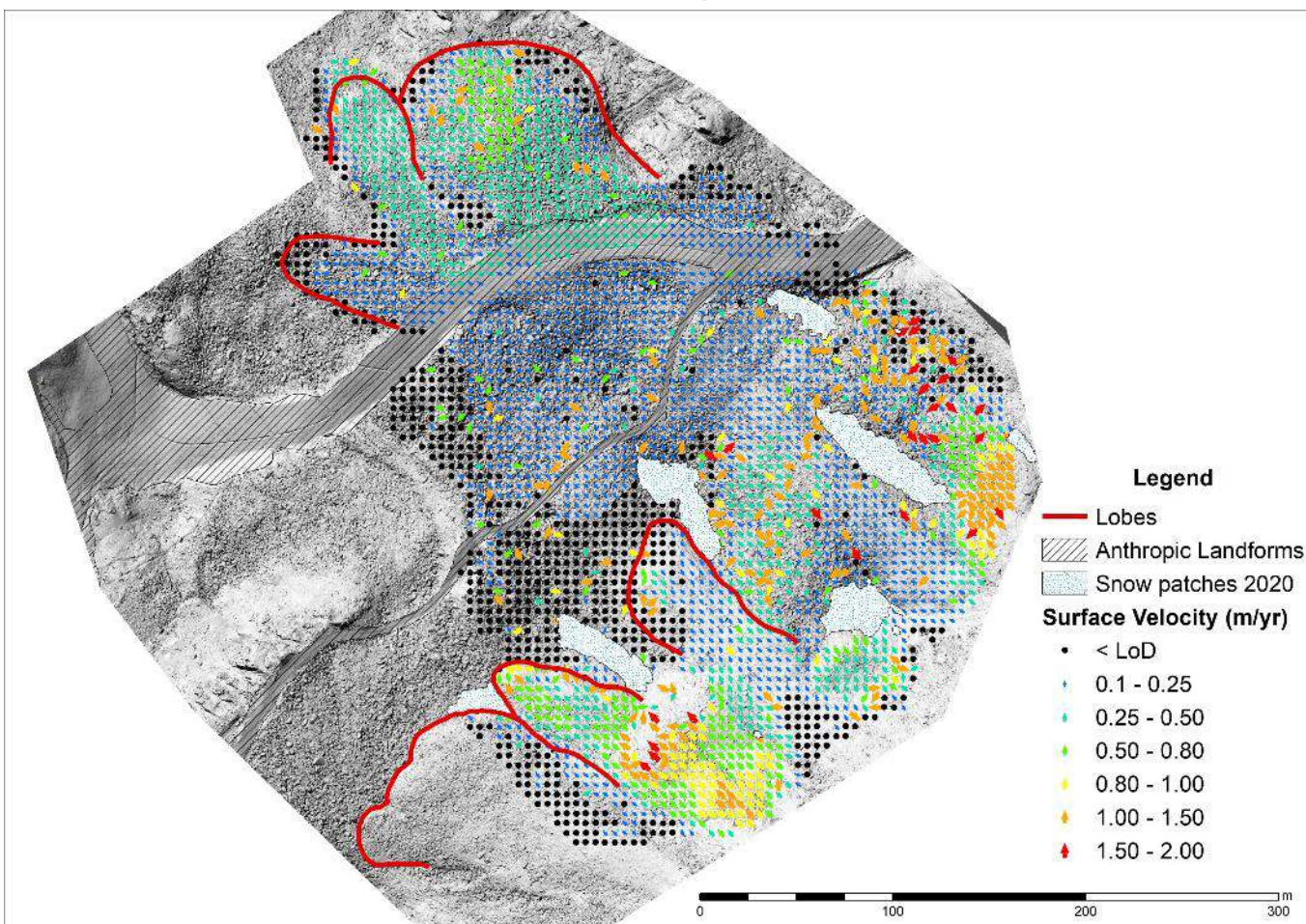


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Surface Velocity 2019-2020



Elevation Changes 2016-2021

