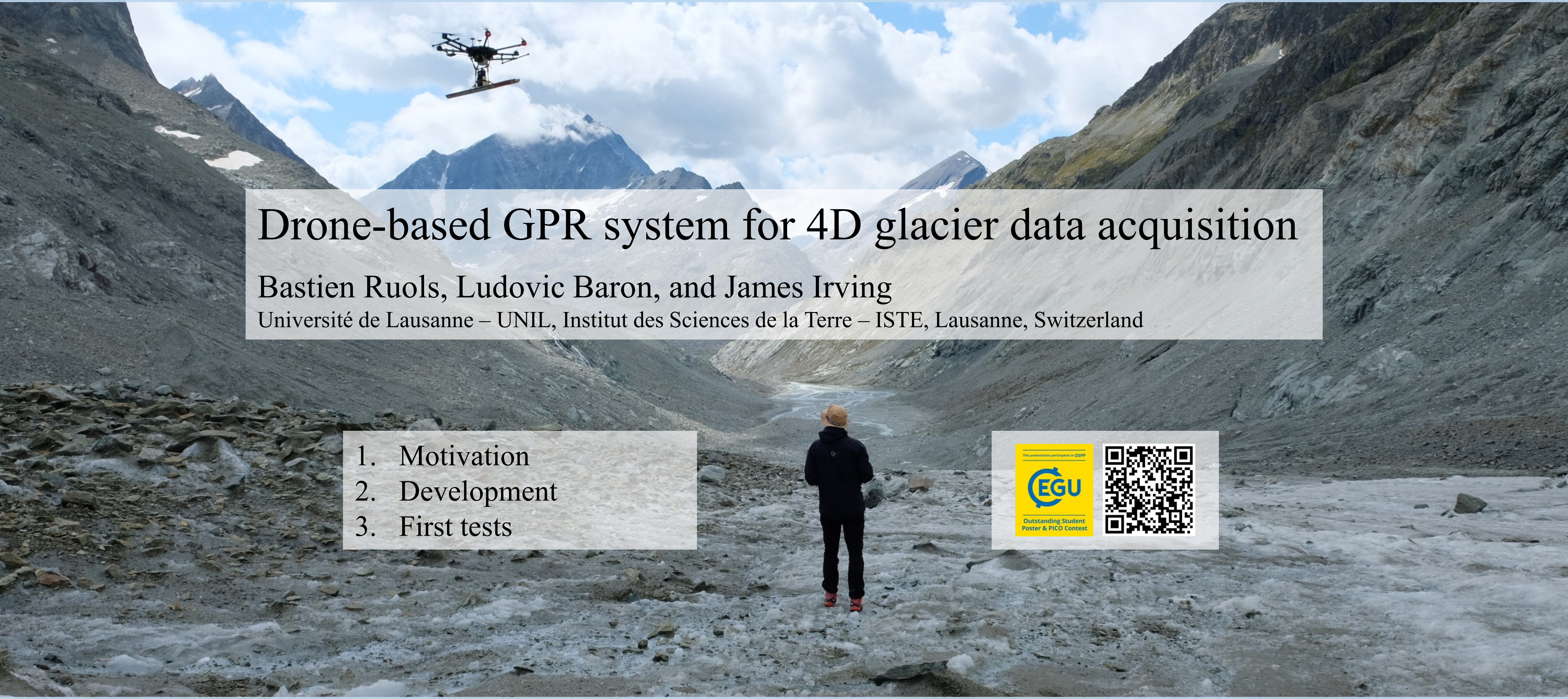

Drone-based GPR system for 4D glacier data acquisition

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1. Motivation
2. Development
3. First tests

This presentation participates in OSPP

EGU Outstanding Student Poster & PICO Contest

UNIL | Université de Lausanne

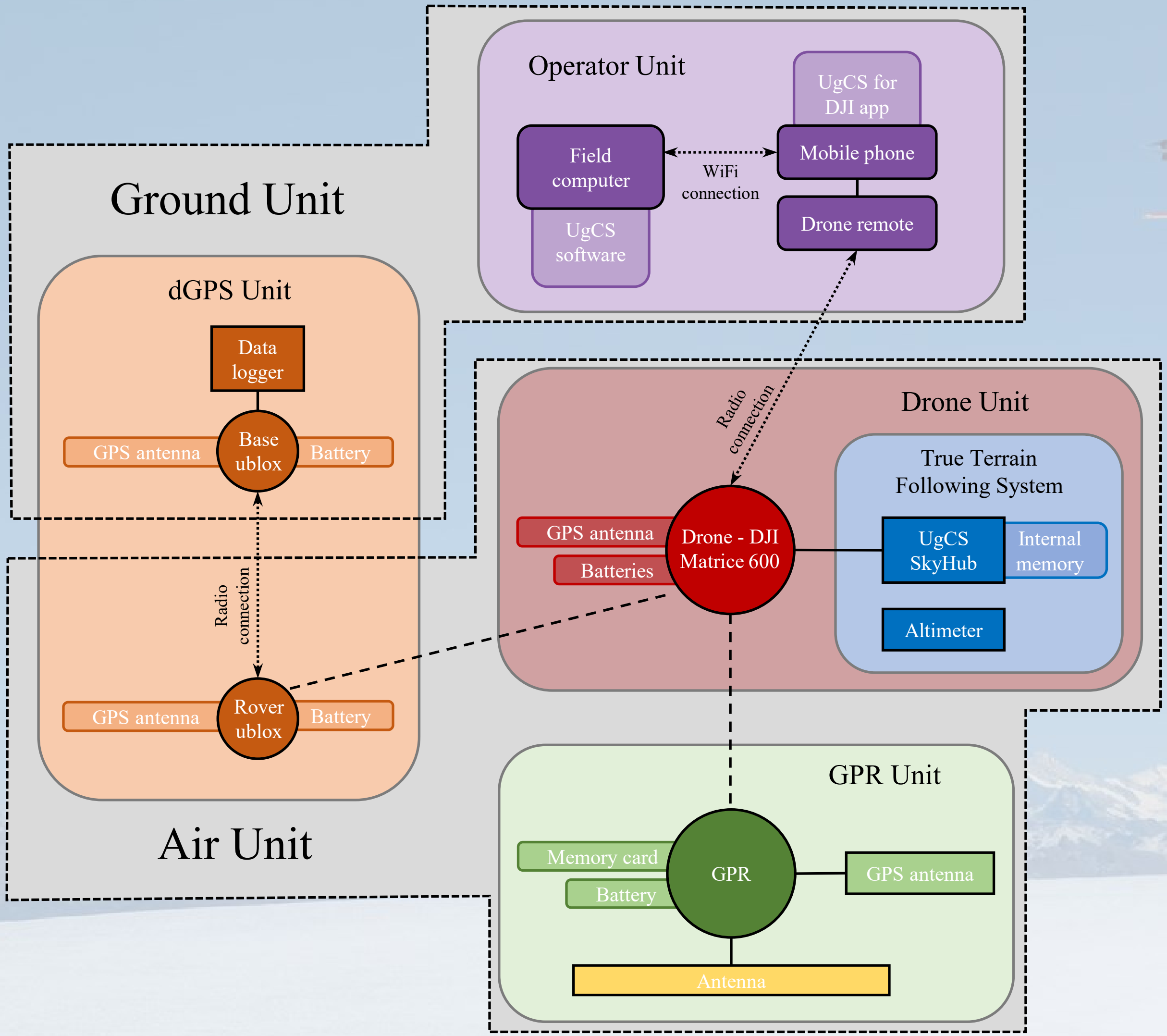
FNSNF Swiss National Science Foundation

EGU European Geosciences Union

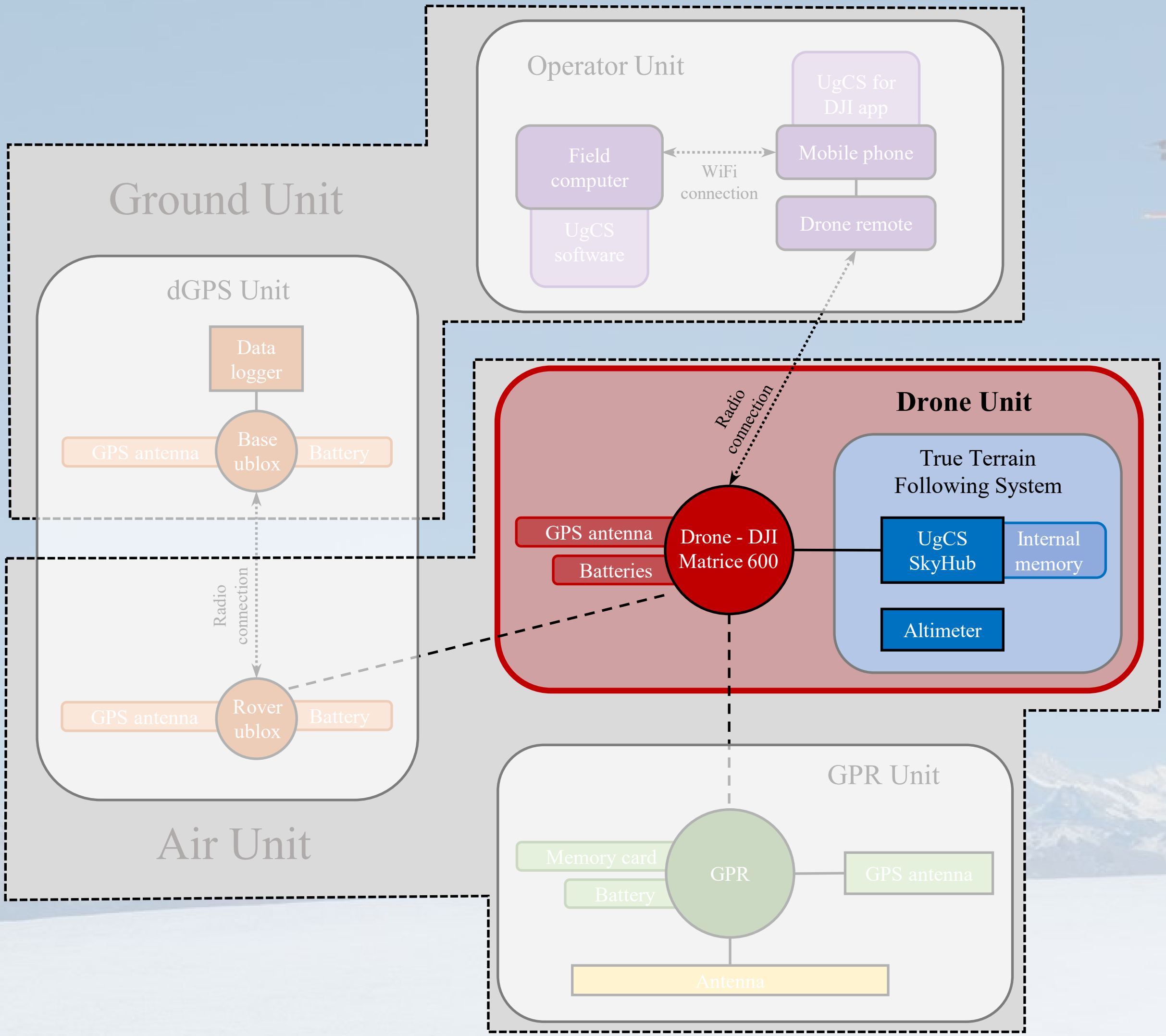
Part 1 : Motivation

1. High-density 3D GPR data ⟶ **Labour intensive**
2. 4D GPR data ⟶ **Low spatial density**
3. How can we repeat high-resolution 3D GPR data acquisitions over time?
4. Drone-based GPR system

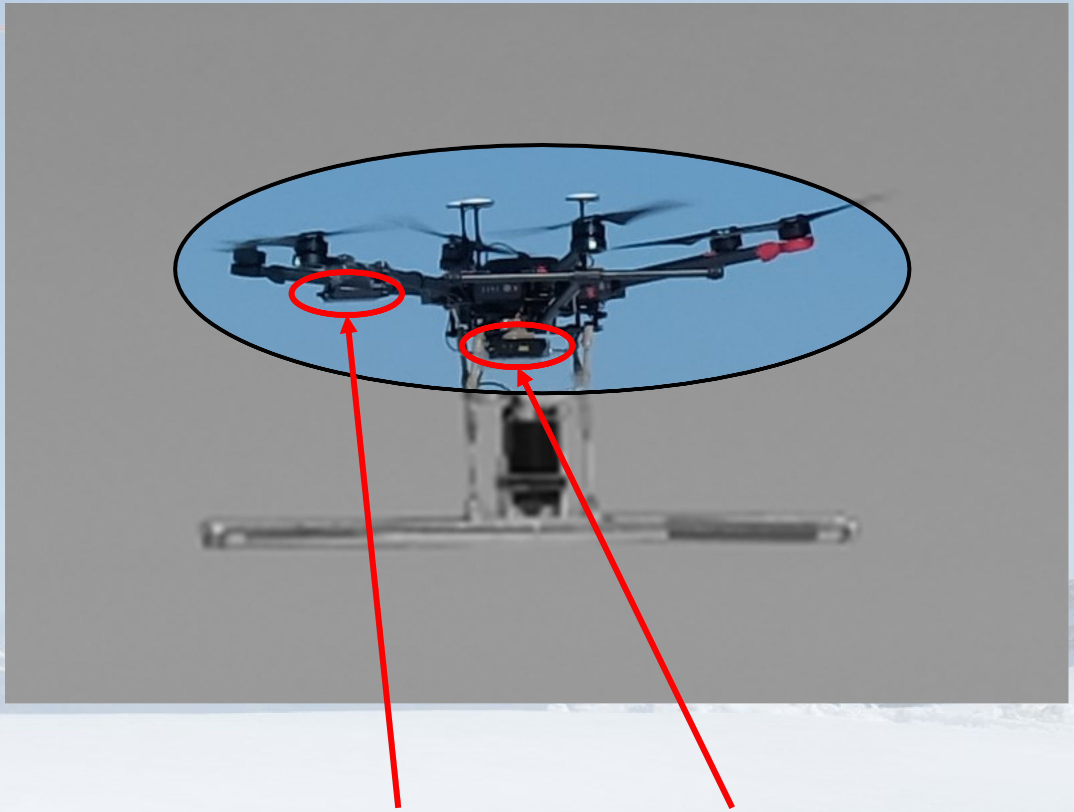
Part 2 : Development of the drone-based GPR system



Drone Unit

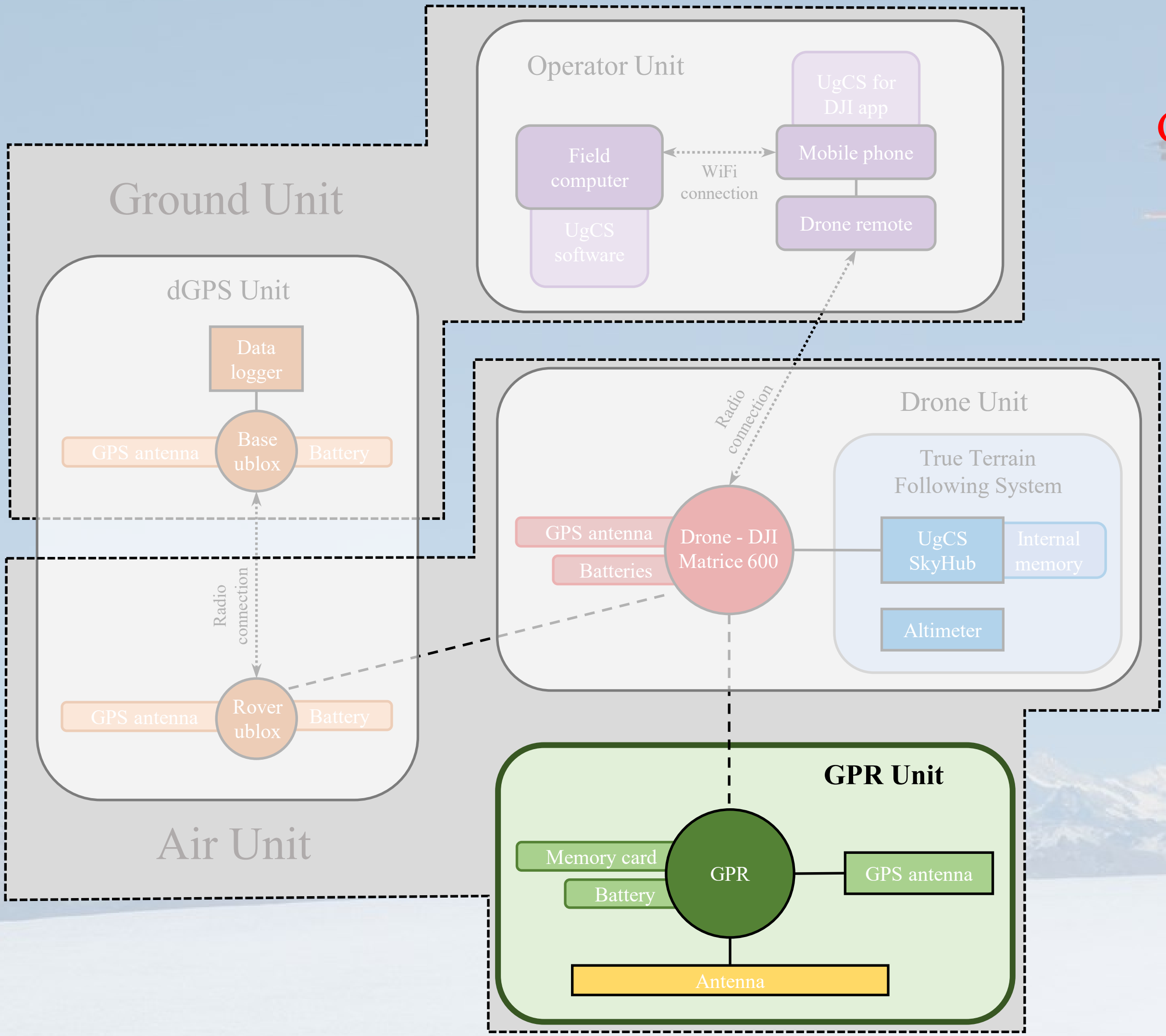


Ground Unit
Operator Unit
UgCS for DJI app
Field computer
Mobile phone
WiFi connection
UgCS software
Drone remote
dGPS Unit
Data logger
GPS antenna
Base ublox
Battery
Radio connection
Drone Unit
True Terrain Following System
GPS antenna
Batteries
Drone - DJI Matrice 600
UgCS SkyHub
Internal memory
Altimeter
Radio connection
GPS antenna
Rover ublox
Battery
Air Unit
GPR Unit
Memory card
Battery
GPR
GPS antenna
Antenna

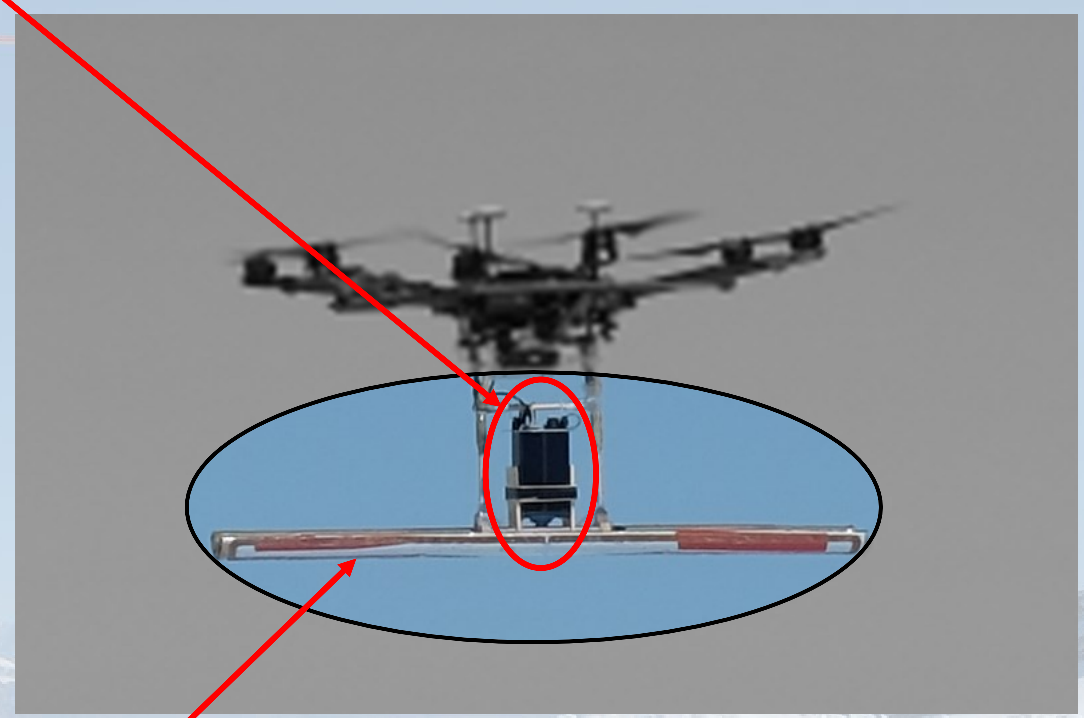


Radar Altimeter
Datalogger

GPR Unit

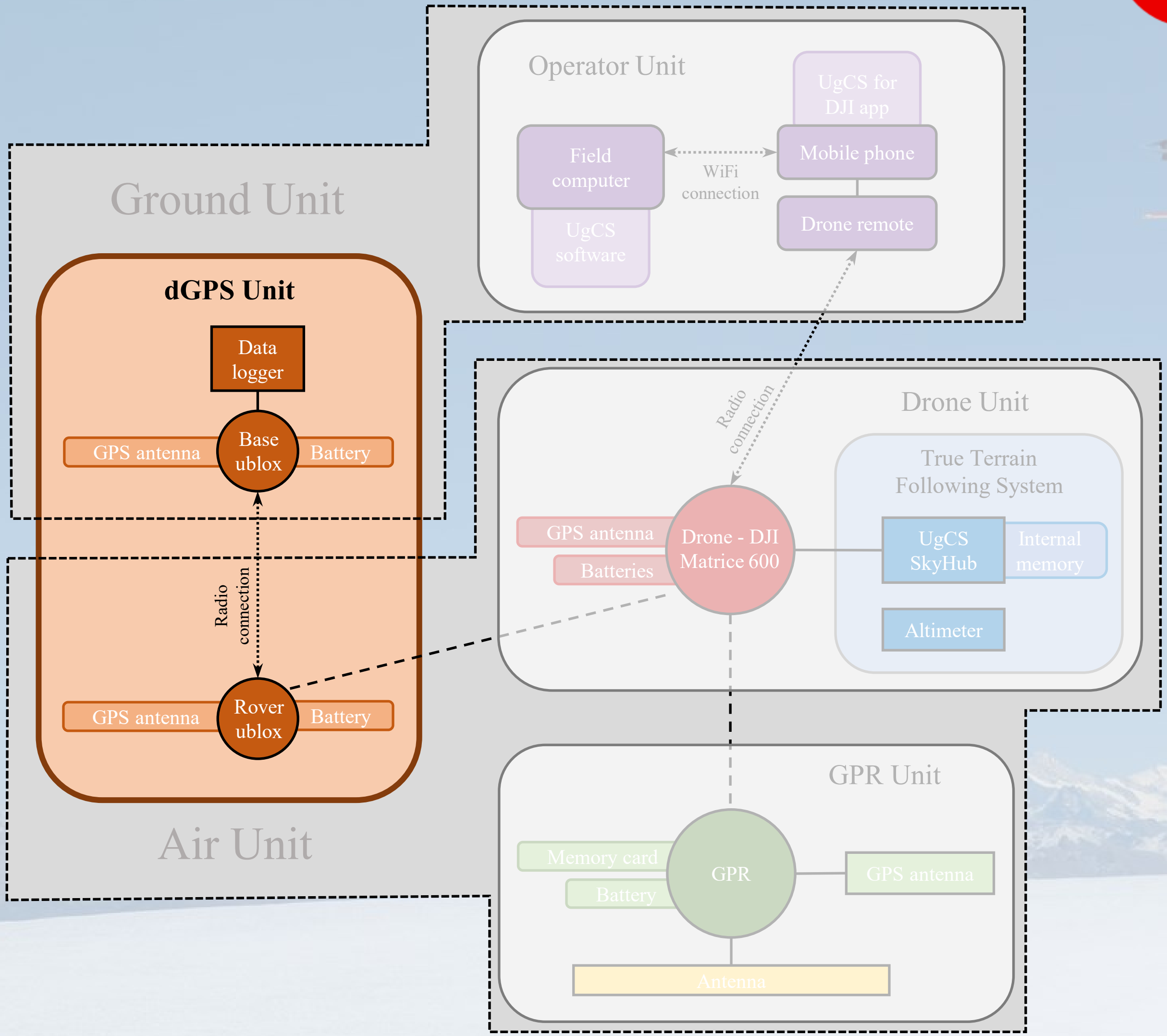


Trace length	2800 ns
Sampling frequency	320 MHz
Number of stacks	5000
Traces acquisition rate	14 Hz



Center-frequency	70 MHz

dGPS Unit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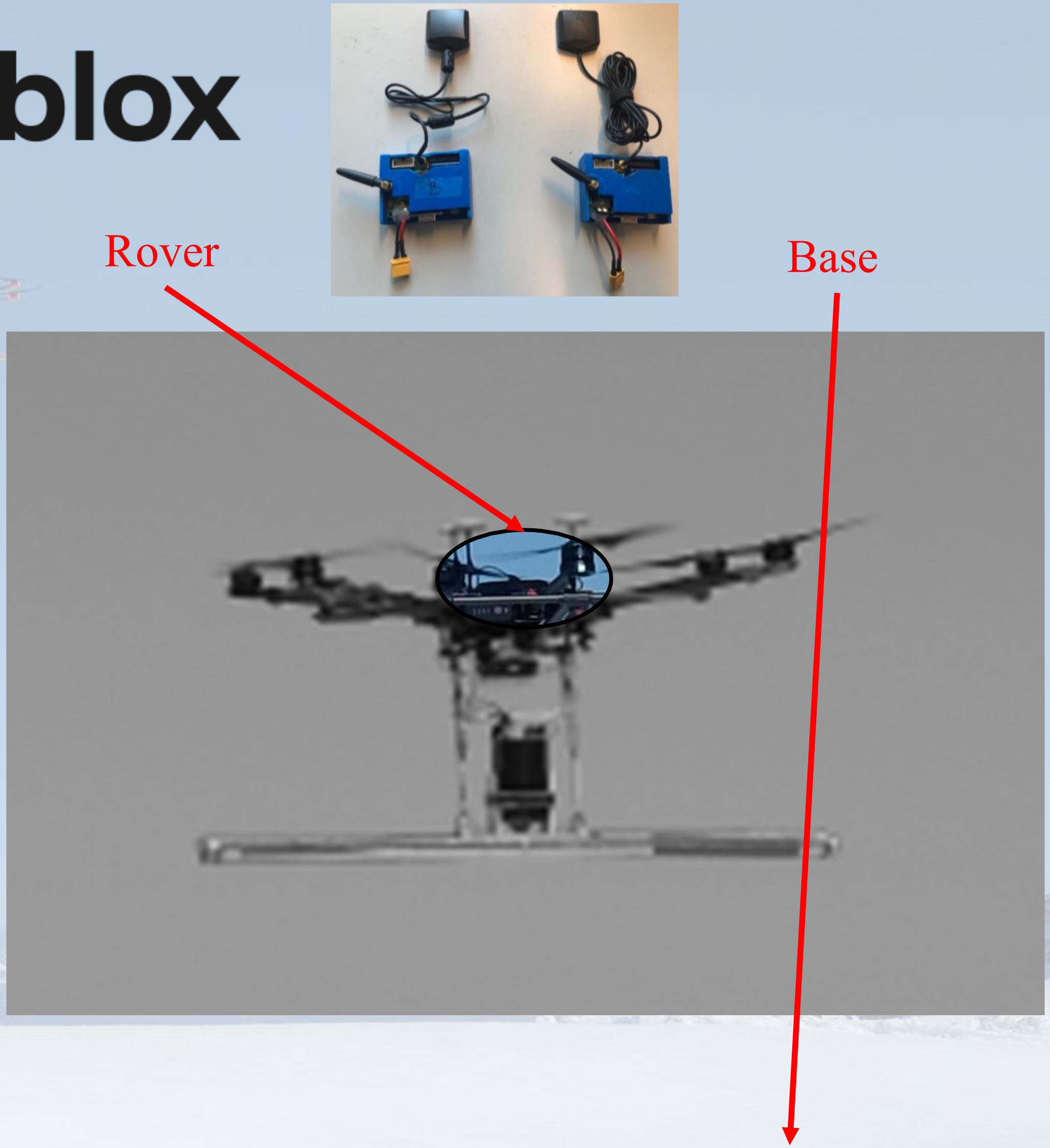
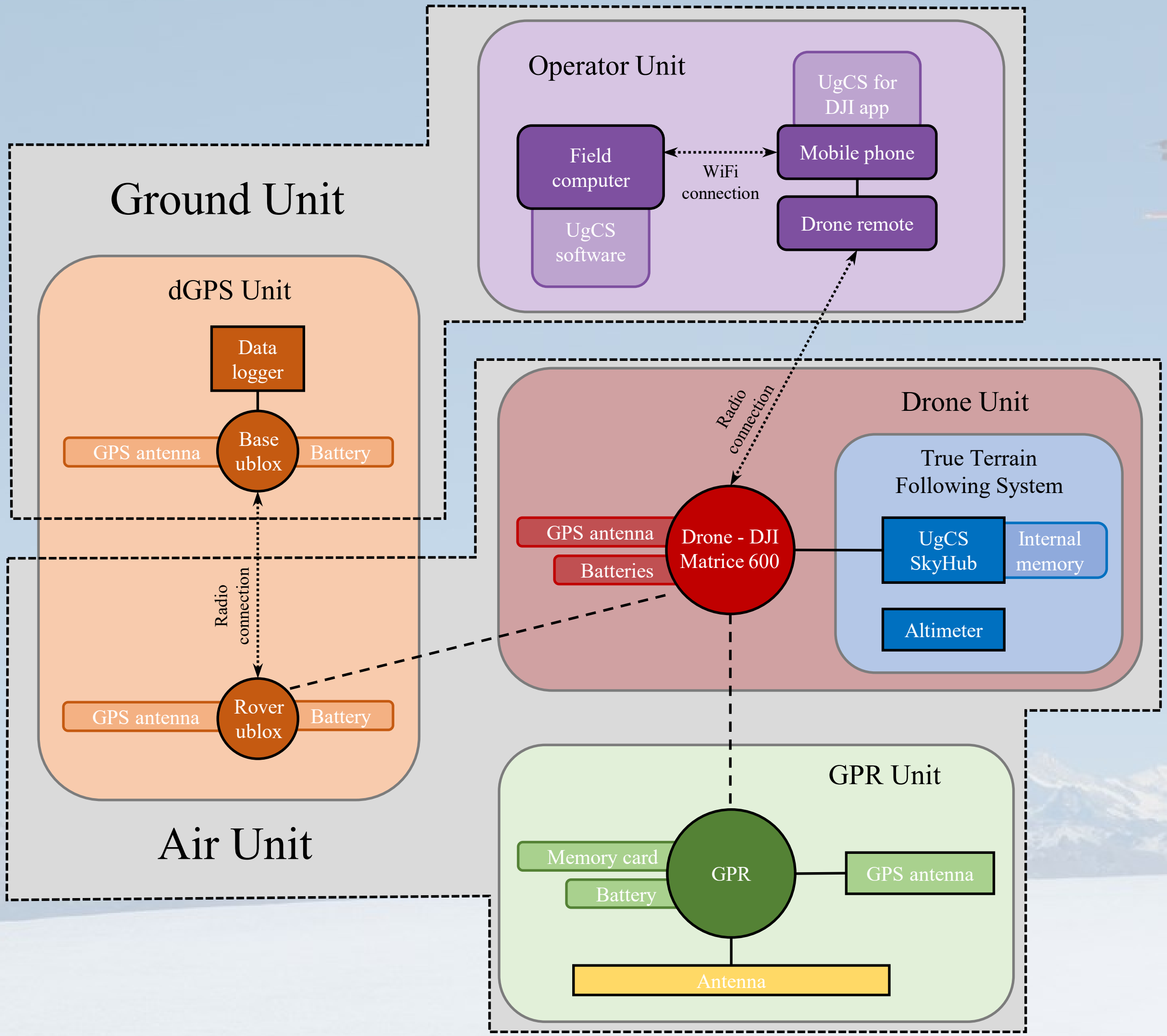
Antenna


Rover
Base

Whole system

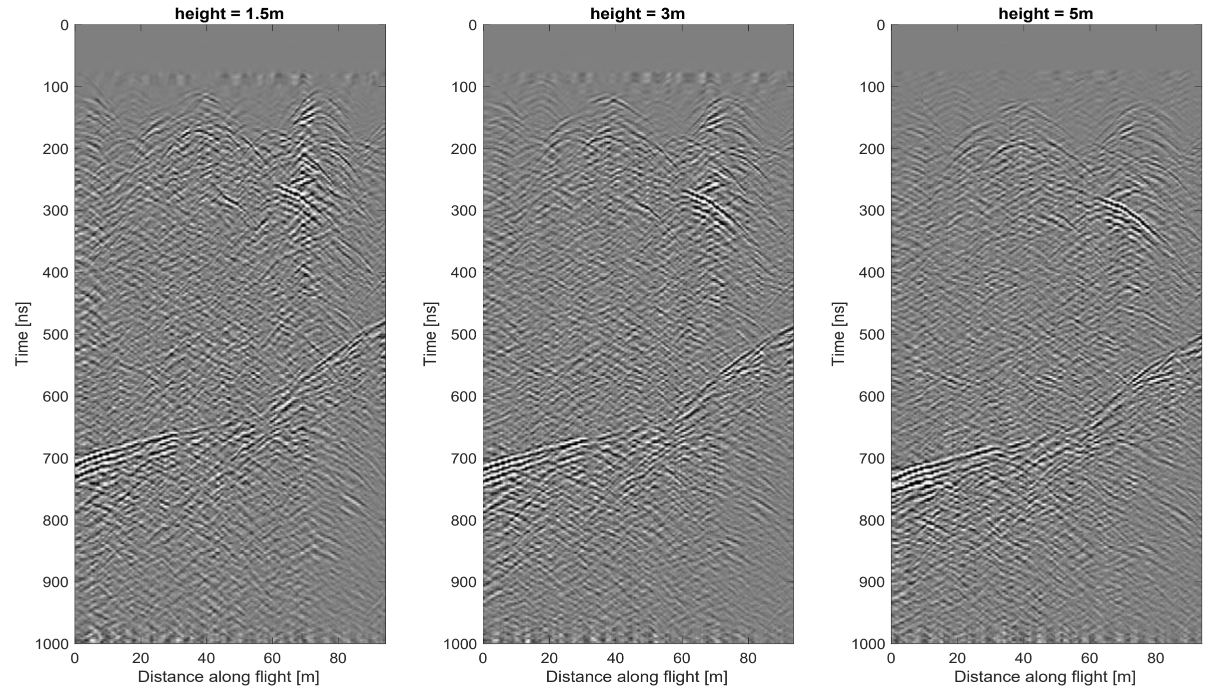


Payload Weight		
Drone Unit – True Terrain Following system		359 g
GPR Unit	GPR box	1496 g
	GPS	388 g
dGPS Unit		326 g
Total		**~2569 g**

Part 3 : First tests

OTEMMA GLACIER

Surveying the same profile at same speed (3m/s) but at different height above the surface:



Conclusions:

- Ice/bedrock interface and internal features clearly visible even when flying at 5m above the glacier surface.
- System able to fly faster if height of 5m considered.
- Migration needed to take into account this air layer.

Drone-based system recording one profile across glacier flow. Observations:

- Terrain Following System working, the drone is adapting its altitude to roughly follow the glacier surface topography.
- Antenna orientation set up perpendicular to trajectory / aligned with glacier flow, but other orientations are easily programmable.

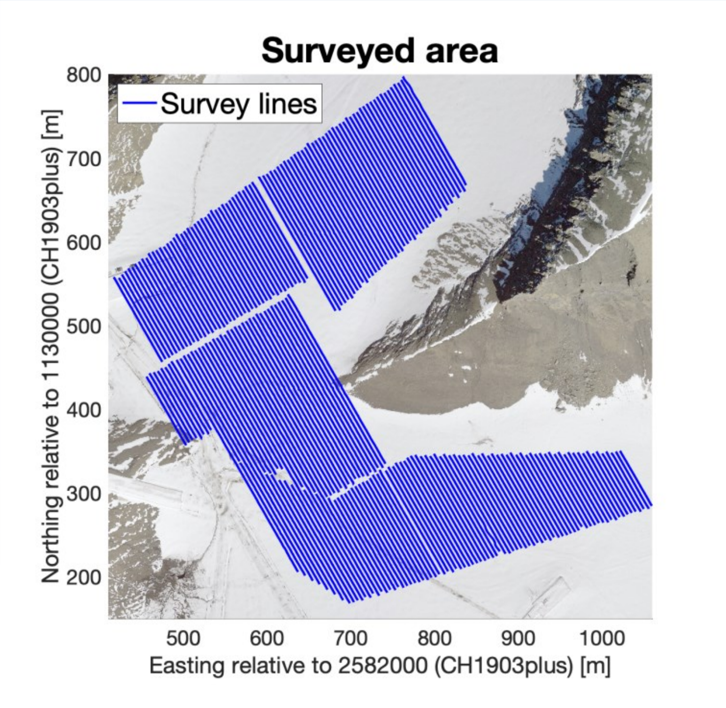
Trajectory recorded from above. Observations:

- Succession of profiles after each other.
- System able to fly between 3.5 and 4km per set of batteries. With our 4 sets of batteries, we can survey around 100 profiles of 150m long.

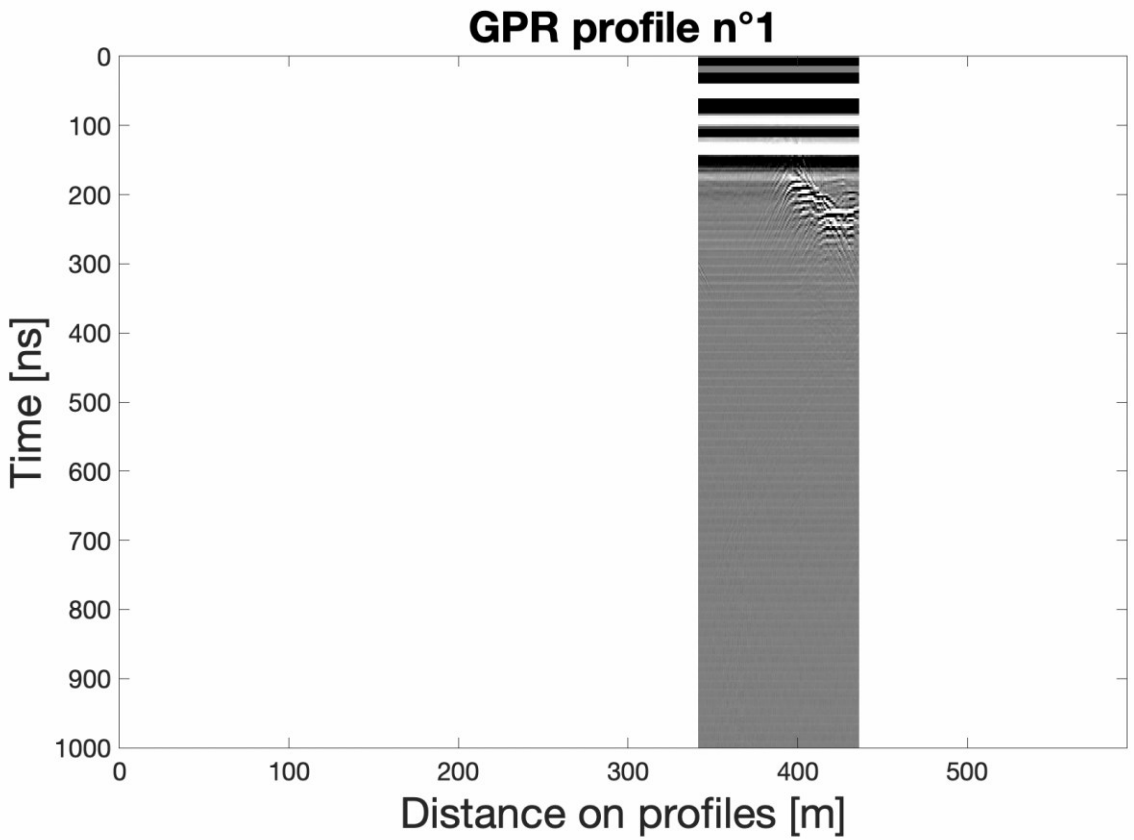
TSANFLEURON / SEX-ROUGE GLACIERS

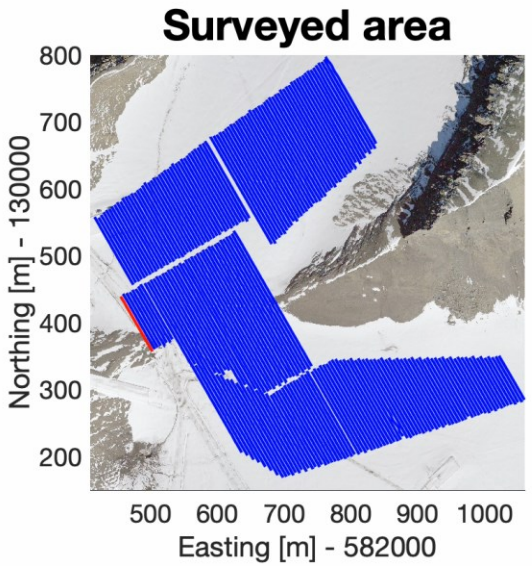
Recording a first 3D GPR data-sets over the Tsanfleuron pass where the ice is known to be very shallow.

Number of profiles	206
Spacing	5m
Total length	~ 30km
Time spent	3 half days



- Only basic processing applied: dewow, gain. Large antenna ringing phenomenon due to GPR box and interaction between the antenna and the drone. System not suitable to study internal structures which are less than 10 to 12m deep in ice.
- Left: profiles depicted in a row to check continuity between them.
- Right: showing in red which profile is depicted on the left side.





- Drone-based GPR system ✔
- High-resolution 3D GPR data acquisitions ✔

- Moving to 4D
  - starting this summer!
  - glaciers' internal hydrology and dynamics…

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