Design Project n°33: Evaluation of forestry damage caused by a large snow avalanche using drone technology

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Context

Context


Rosex
Ormont-Dessus
Mazots
Creux de Champ
Rasse
Google Earth
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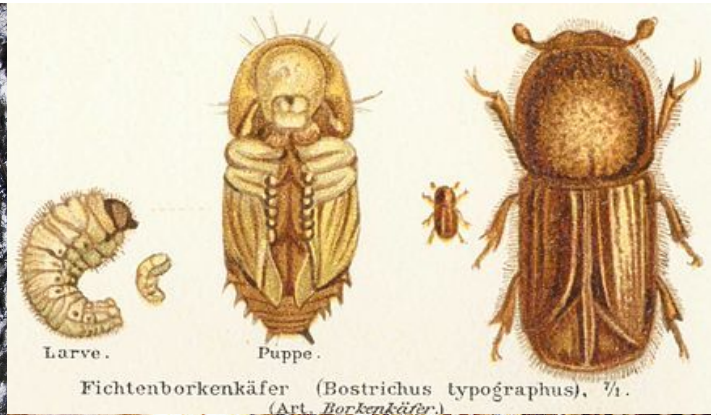
Image © 2021 Maxar Technologies
3 km
N

Context

European spruces

Bark beetles



Fichtenborkenkäfer (Bostrichus typographus), 7/1.

Objectives

1) Using drone technologies, create a detailed orthomosaic (2D map) and 3D model of the area of interest.

2) Compare Real Time Kinematics (RTK) and Post Processing Kinematics (PPK) georeferencing techniques.

3) Estimate the volume of wood to be removed in order to prevent a spruce bark beetle outbreak in the forest.

4) Estimate the volume of displaced snow due to the avalanche

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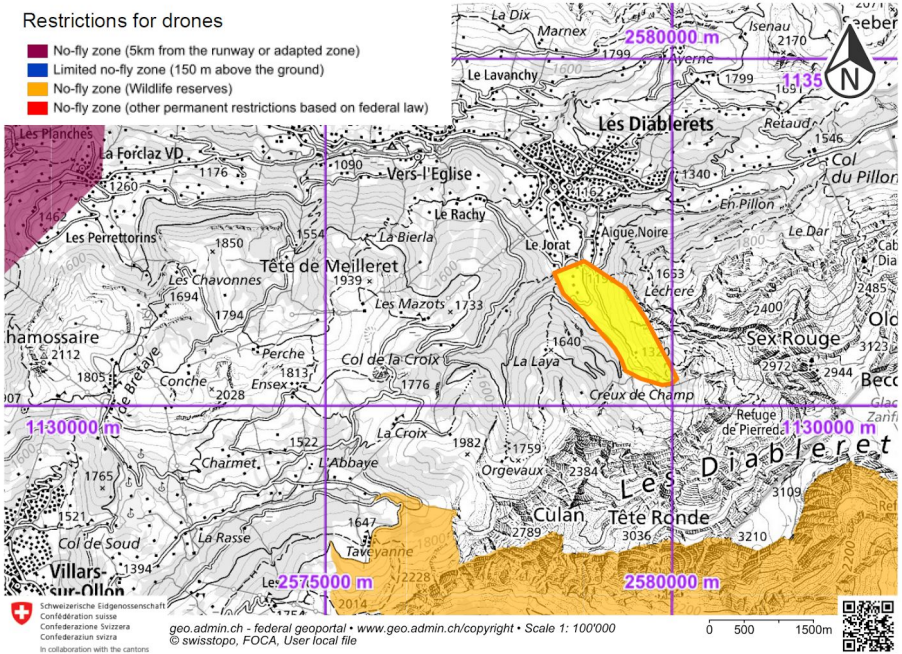
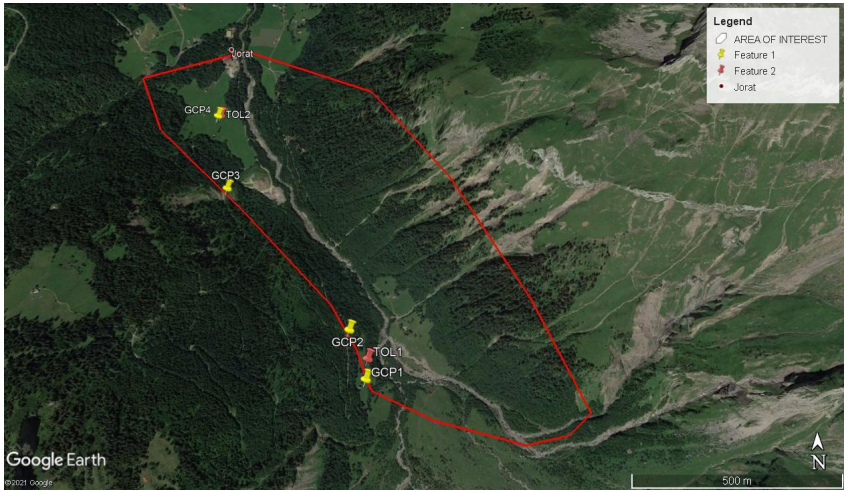
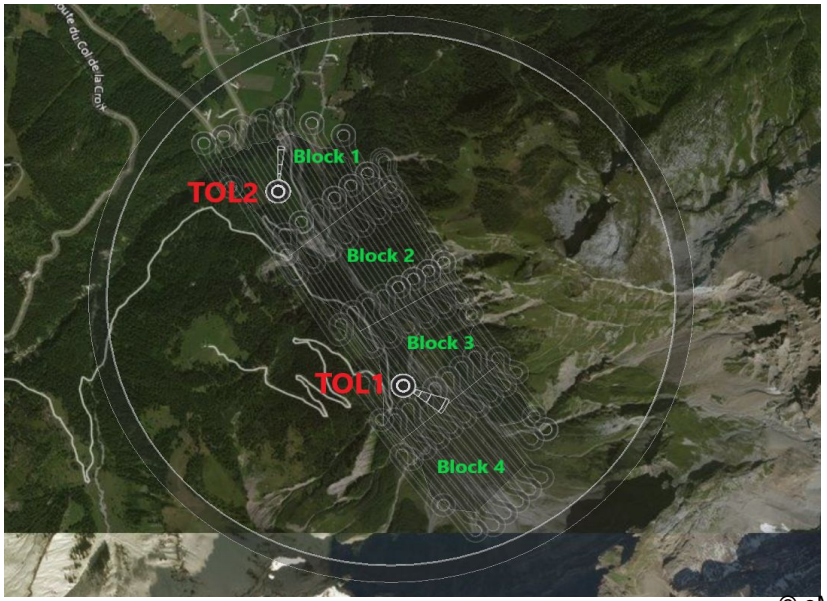
I. Drone flight: Preparation

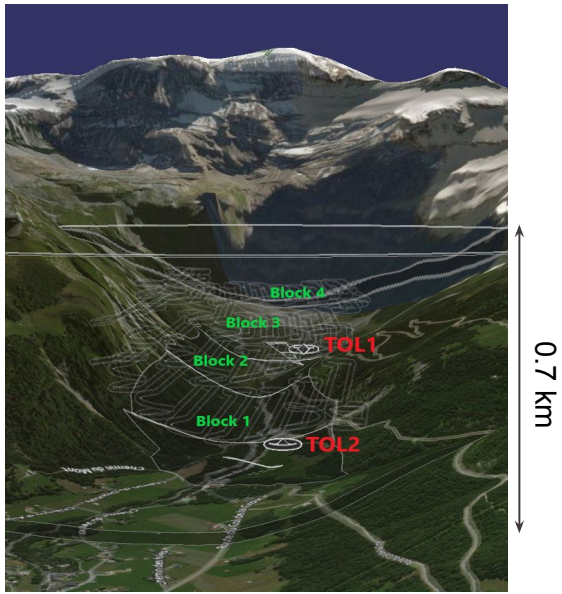
- Check the restrictions
- Delineate the area of interest (1.2km²)
- Set take-off and landing locations as well as Ground Control Points (GCPs)
- Create flight plans (eMotion)





I. Drone flight: Preparation





© eMotion

- 4 blocks of ~30 ha
- Each flight duration <30 min
- Lateral and longitudinal overlap: 70% and 85% respectively
- Planned Ground Sampling Distance: 3.5 cm/pixel (processing 5.61cm/pixel)

I. Drone flight: Execution

Equipment Used

2 eBee X Drones with S.O.D.A. cameras and 6 fully charged batteries

4 GCP targets

2 Triumph LS GNSS receivers

- 2 fully charged laptops
- Snow shoes

Speaker

I. Drone flight: Execution

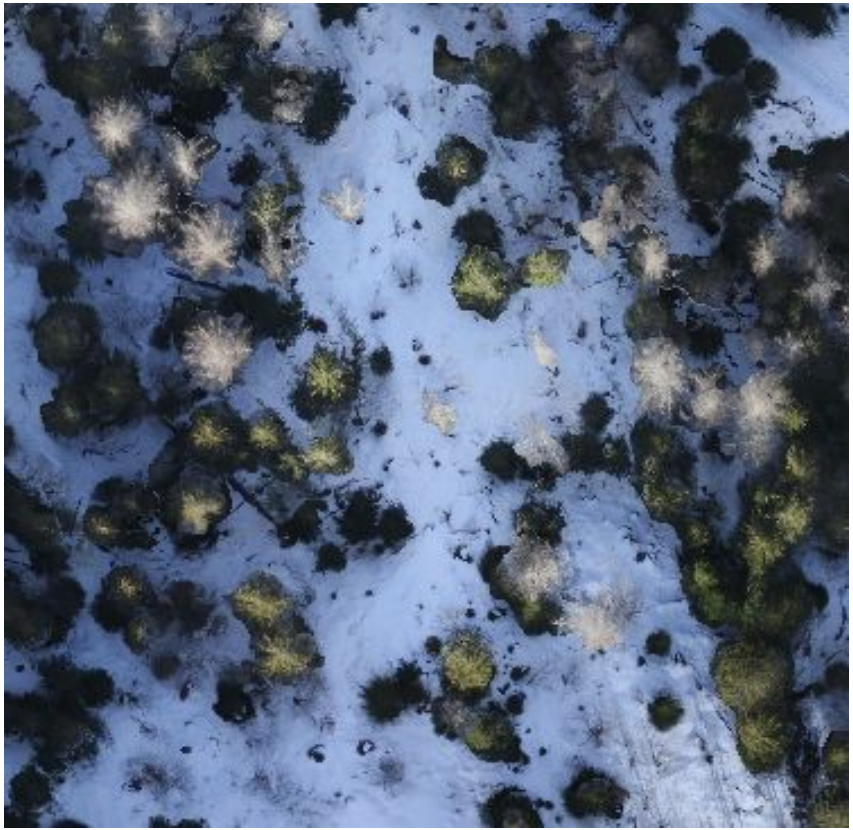
Weather Conditions

Ideal Conditions:

- Max. wind speed: 12.8 m/s
- No precipitation
- Cloud cover throughout the flight

Site Conditions:

- Wind speed: 3 m/s
- No precipitation
- Cloud cover for the first part of the flight only



I. Drone flight: Execution

Problems Faced

- Placing only 4 GCPs due to rough terrain
- Changing the location of takeoff and landing locations due to wind direction
- Broken drone wing when landing after the second flight
- Payload not detected before the third flight

Missing Data

- Coordinates and camera orientations not saved in the EXIF files for flights 3 and 4
- Corrupted log file → PPK not possible through eMotion software
- Event logs of flight 2 corrupted → PPK not possible for flight 2

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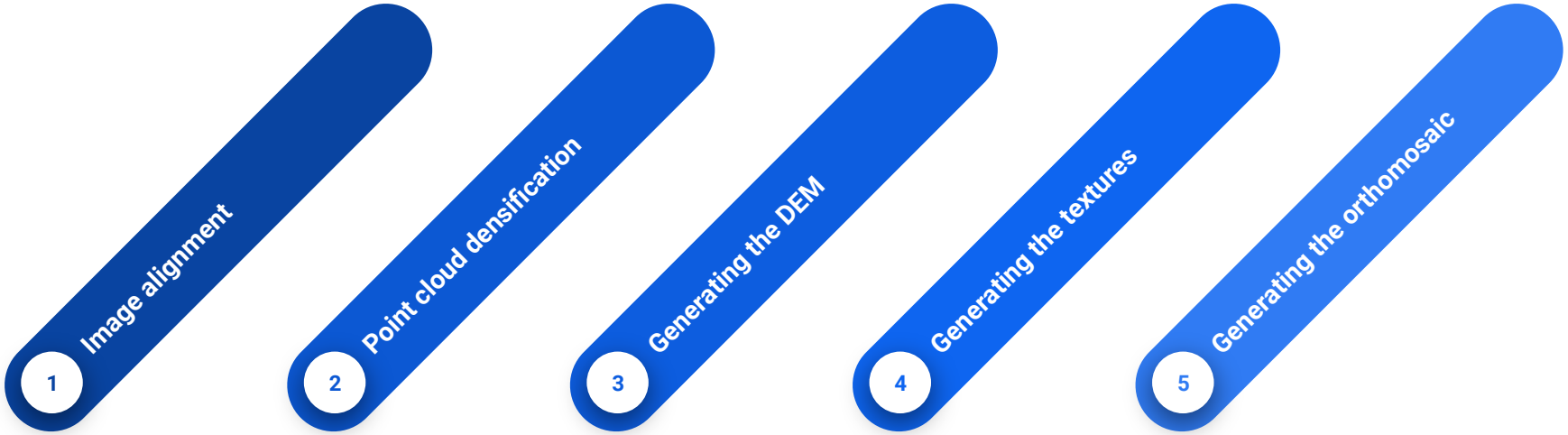
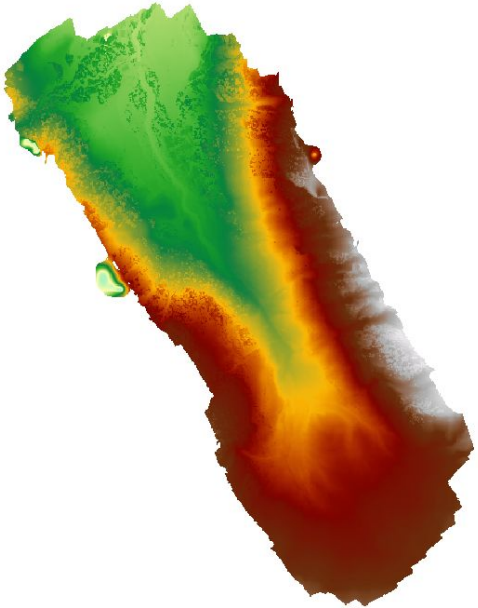
II. Photogrammetric results: model creation

Methodology



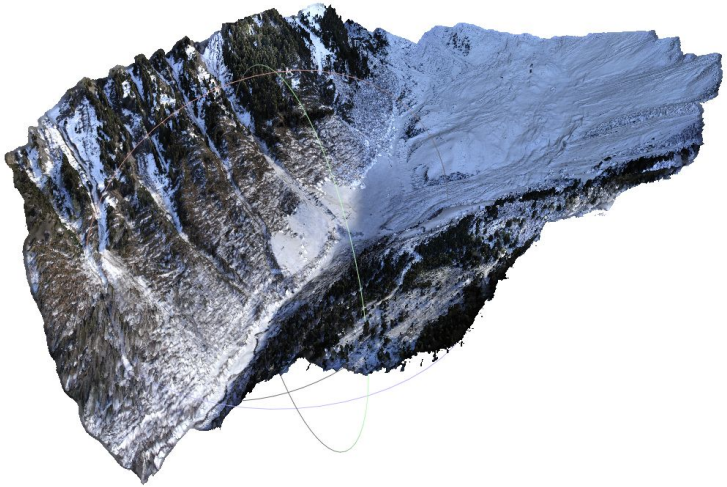
II. Photogrammetric results: model creation

Outputs



DEM

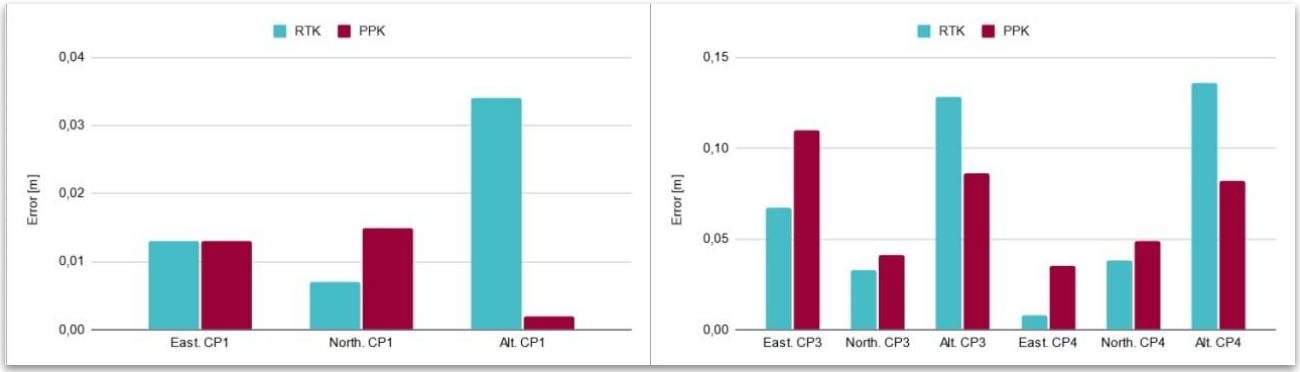
Orthomosaic



3D Model

II. Photogrammetric results: quality analysis

A. Checkpoints (RTK/PPK)



Error on checkpoints for image geolocation in RTK and PPK for Flight 1 (left) and Flight 3 and 4 (right)

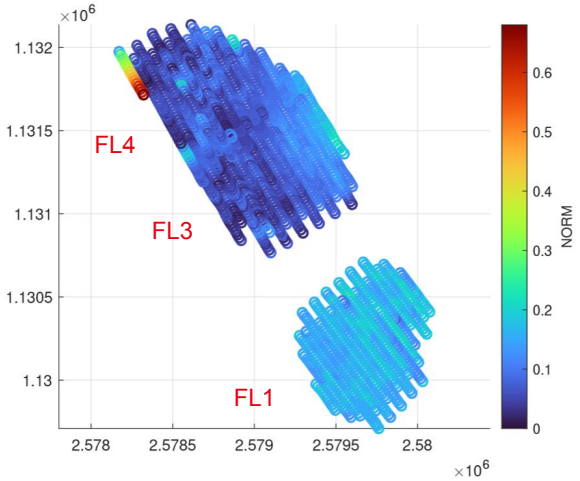
	Norme	
CP	**RTK**	**PPK**
CP1	0,037	0,020
CP3	0,148	0,146
CP4	0,141	0,102

Limitations:

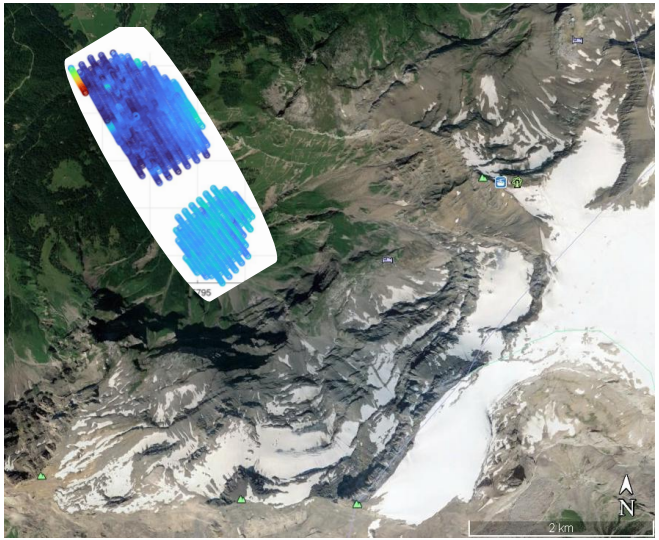
- number of checkpoints
- checkpoints location on images
- geometry leads to strong averaging: depends on image position in mapped area

II. Photogrammetric results: quality analysis

B. Image coordinates in RTK and PPK



Distance between RTK and PPK image location



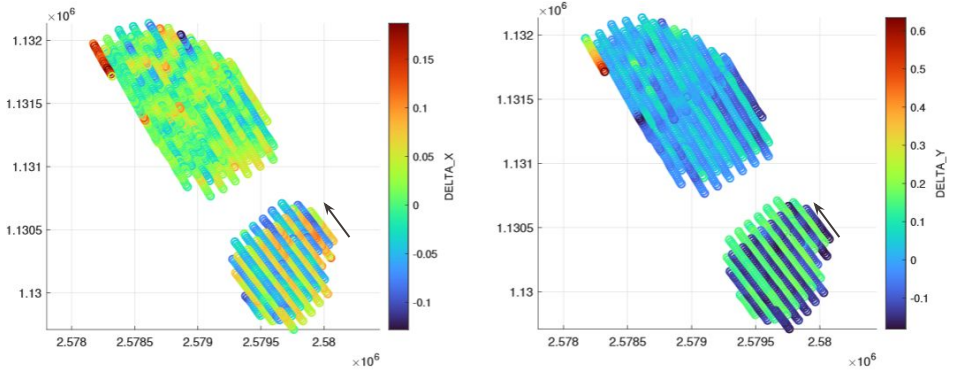
© Google Earth

- Flight 1, 3 and 4 in RTK and PPK
- Use of GCPs when processing (with coordinates obtained in PPK)
- Compute distances between RTK and PPK:
  $\Delta d_{RTK/PPK} = \sqrt{[(X_{RTK} - X_{PPK})^2 + (Y_{RTK} - Y_{PPK})^2 + (Z_{RTK} - Z_{PPK})^2]}$

=> overall, differences are larger for flight 1 than for flight 3 and 4 due to the topology of the terrain

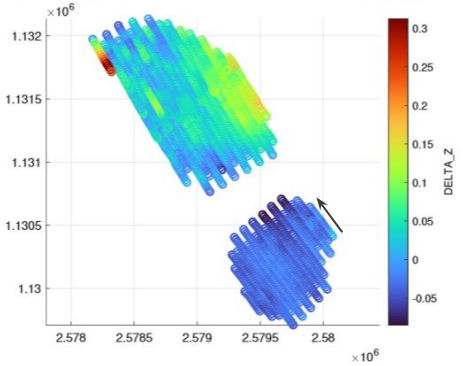
II. Photogrammetric results: quality analysis

B. Image coordinates in RTK and PPK



(a) Difference in the X coordinate

(b) Difference in the Y coordinate

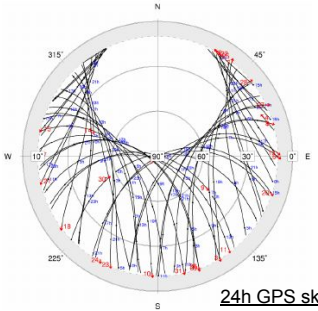


(c) Difference in the Z coordinate

(a) $\Delta X_{RTK/PPK} = X_{RTK} - X_{PPK}$

(b) $\Delta Y_{RTK/PPK} = Y_{RTK} - Y_{PPK}$

(c) $\Delta Z_{RTK/PPK} = Z_{RTK} - Z_{PPK}$

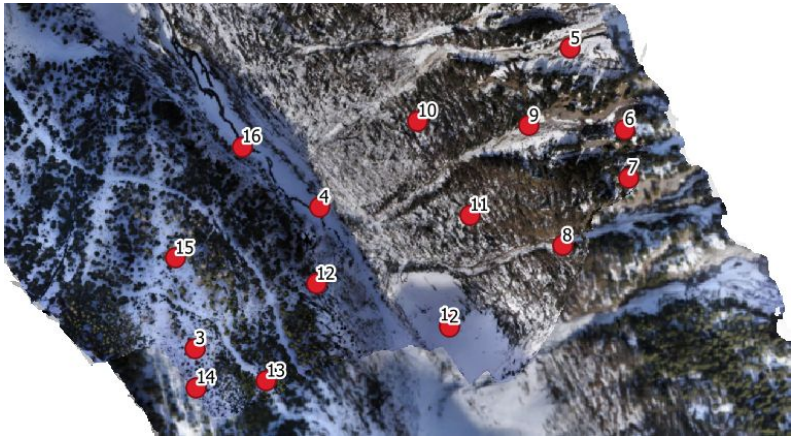


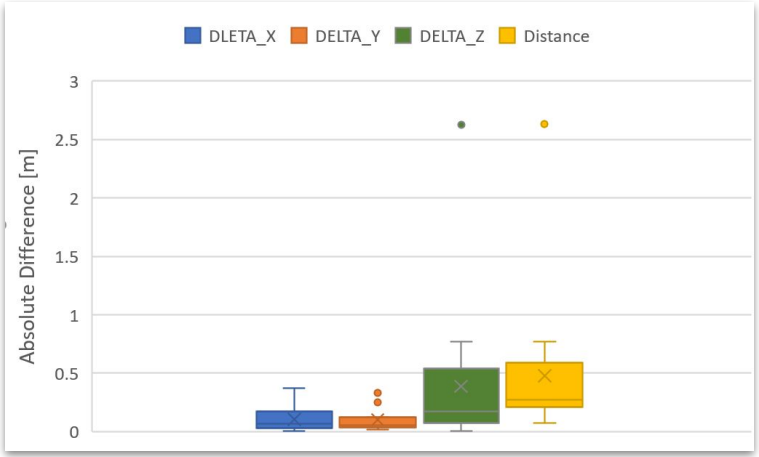
24h GPS sky plot [10]

When the drone turns right from South East to North West, it tilts, the antenna faces North where satellite visibility is limited. Carrier-phase ambiguities can be fixed only once the turn is completed and accumulated to increase the precision.

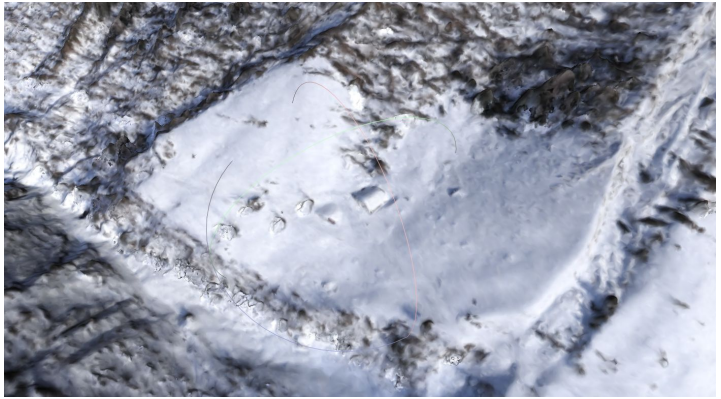
II. Photogrammetric results: quality analysis

C. Overlap between flights 2 and 3





- Differences in the X and Y directions are in the order of 10 cm
- Higher differences in the Z direction.



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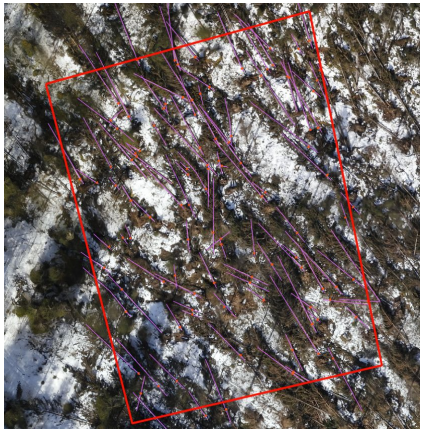
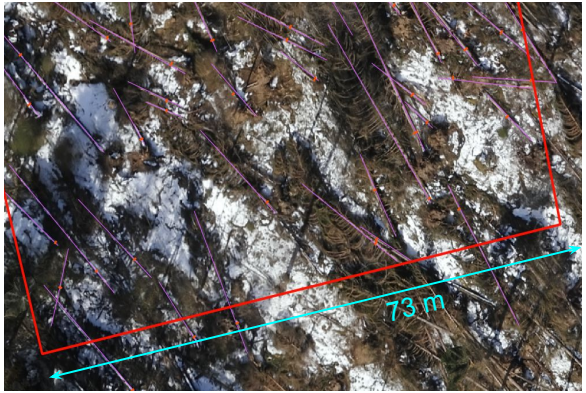
IV. Wood volume estimation

Orthomosaic with the zones where the counting of trees was done





- Pin isolated trees and define larger impacted zones
- 2 samples and 1 plot
  - length
  - diameter
  - approximation by a cone

	Plot [m^3]	Total area [m^3]
Foresters estimation	259 (2015)	6000-8000
Orthomosaic	39	2200
Extracted	?	5000

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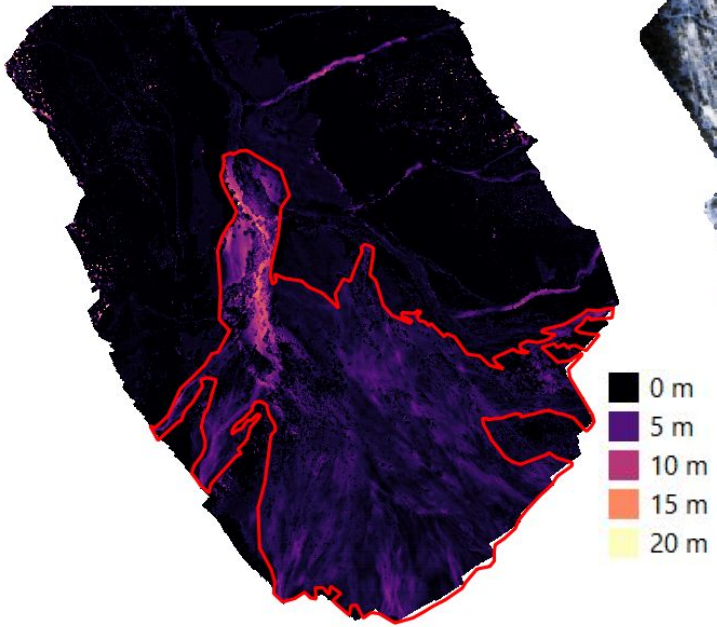
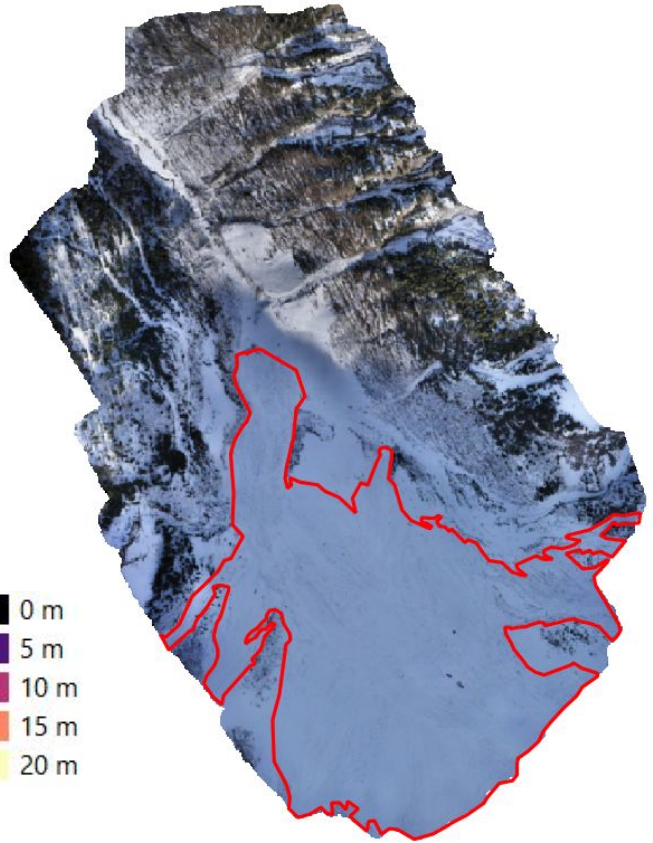
IV. Snow volume estimation

- Draw the limits of the avalanche
- Subtract the generated DEM from the SwissTopo DEM
- Multiply by the area of a pixel
- Sum the values within the avalanche limits





Volume = 941 280 m^3.

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V. Recommendations and Conclusion

Recommendations

- The use of PPK instead of RTK especially in mountainous terrain
- The calculation of a correction factor for the volume of wood estimated from the DEM
- Performing a second flight to make sure that all the trees were extracted
- The use of LIDAR coupled with automating the process of counting the trees

Conclusion

- The orthomosaic is a fast and accurate tool to spot the fallen trees, but not for volume estimations
- The DEM coupled with the orthomosaic can help estimate the volume of displaced snow and quantify the destructive impact on the forest.

Thank you for your attention,

questions?

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