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Monitoring of a landslide through the use of UAV survey

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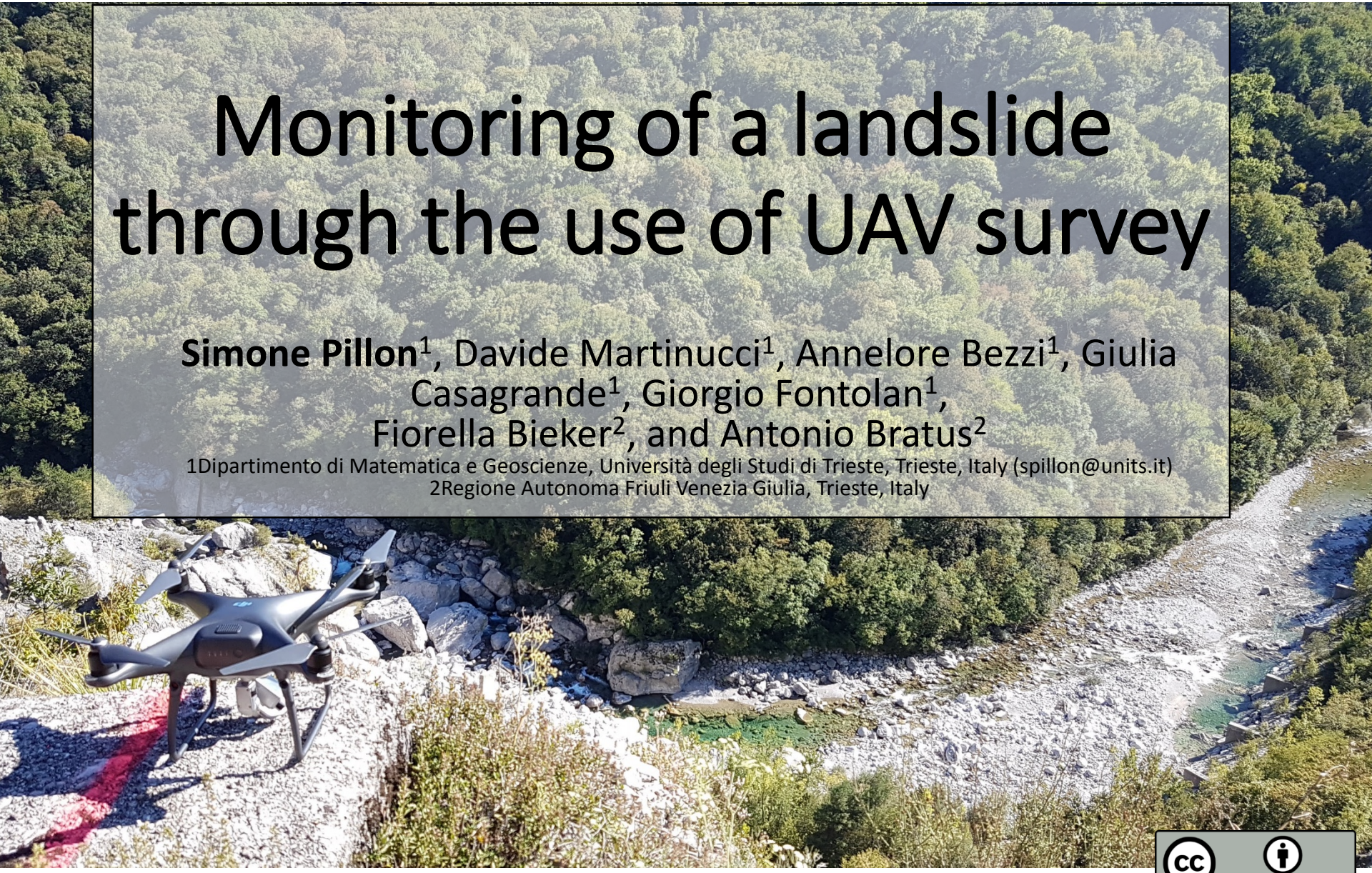

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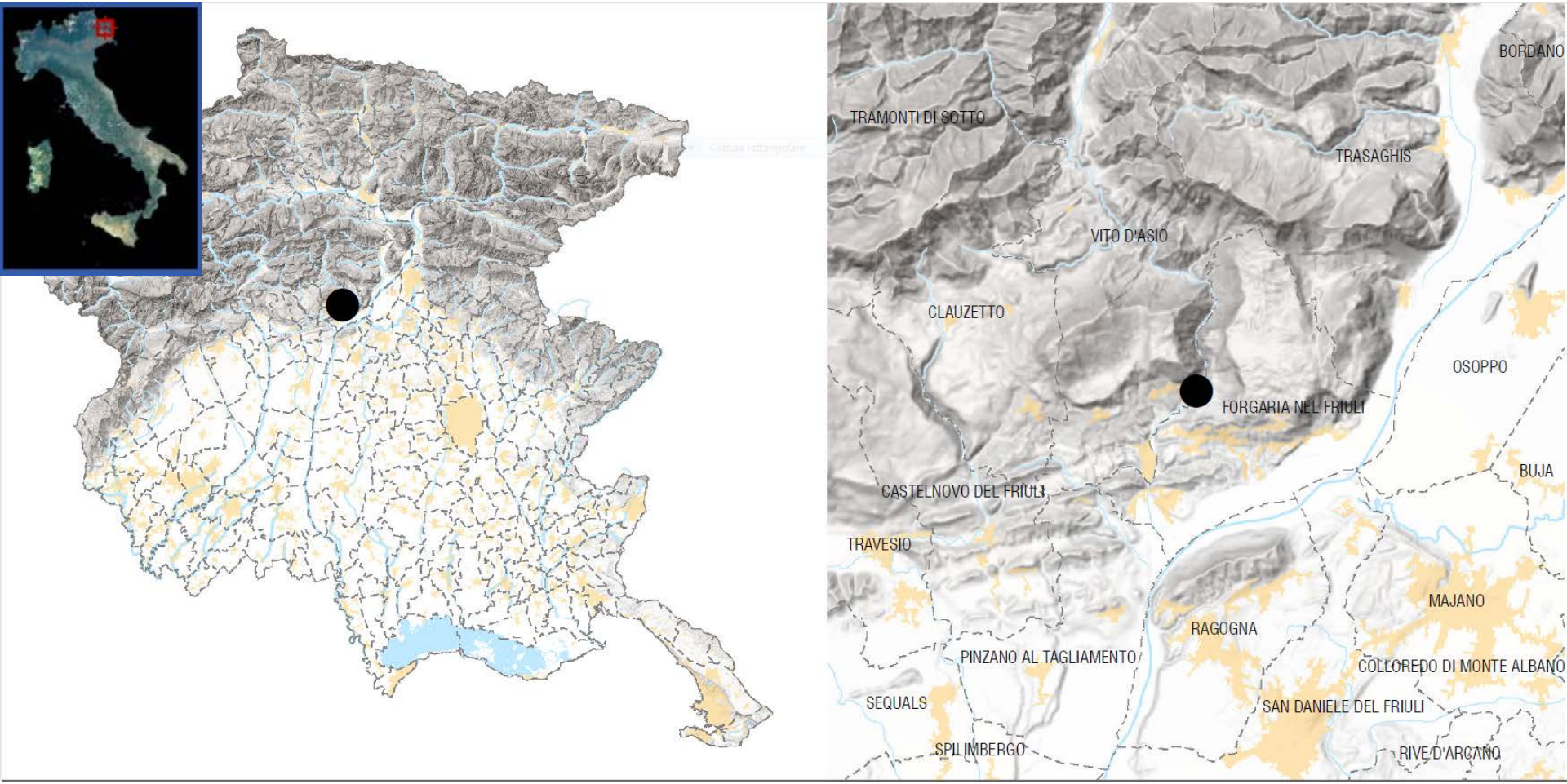
Abstract

The monitoring of landslides using UAVs is particularly convenient as these are dangerous areas that present access difficulties. This study aims to integrate monitoring carried out via traditional techniques (GNSS and total station surveys of benchmarks) with UAV photogrammetric survey, as the latter allows for a precise assessment of the volumes affected by movement. The Masarach landslide, located in Friuli Venezia Giulia (north east Italy), covers an area of approximately 20 ha.

Two surveys were carried out two years apart in order to measure displacements of much greater magnitude than instrumental errors. In the first survey, restricted to the most active area, a six rotor UAV was used, with a maximum take-off mass of 4 kg, which carried a 24 Mpixel APS-C camera. 243 high resolution images were captured and 27 GCPs (Ground Control Point) were surveyed with a GNSS RTK reciever. In the second survey a DJI Phantom 4 Pro UAV was used, carrying a 20 Mpixel 1“ sensor camera. 978 high resolution images were captured and 40 GCPs (Ground Control Point) were surveyed with a GNSS RTK reciever. Data were analyzed using Agisoft Metashape Professional to produce an orthophoto and a DSM (Digital Surface Model) with a ground resolution of 0.02 m and 0.04 m respectively. The DSMs were compared in ArcGIS to calculate the moving masses and highlight the areas of greatest instability. It emerged that approximately 10,000 cubic meters of landslide material were transported to the Arzino stream below, with verified displacements on the control point ranging from meters to centimeters. This work made it possible to accurately define the most active portion of the landslide.



Masarach landslide located in Friuli Venezia Giulia, North East Italy

Area: 20 ha Movement: Translational/Rotational

Active since 2005, as a part of a paleo landslide reactivated in 1976 during an earthquake

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The Masarach landslide discharges its material into the Arzino stream. Due to the risk of a dam formation, the Regional Geological Survey monitors the area since 2005.

Our research group cooperates with the Regional Geological Survey since 2015, applying UAV surveys to different environments, such as quarries, landslides, coasts, etc.

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First survey: April 2016
UAV: Airvision NT4C multicopter, 4kg
Camera: Sony Nex7 24 Mp with 30mm lens

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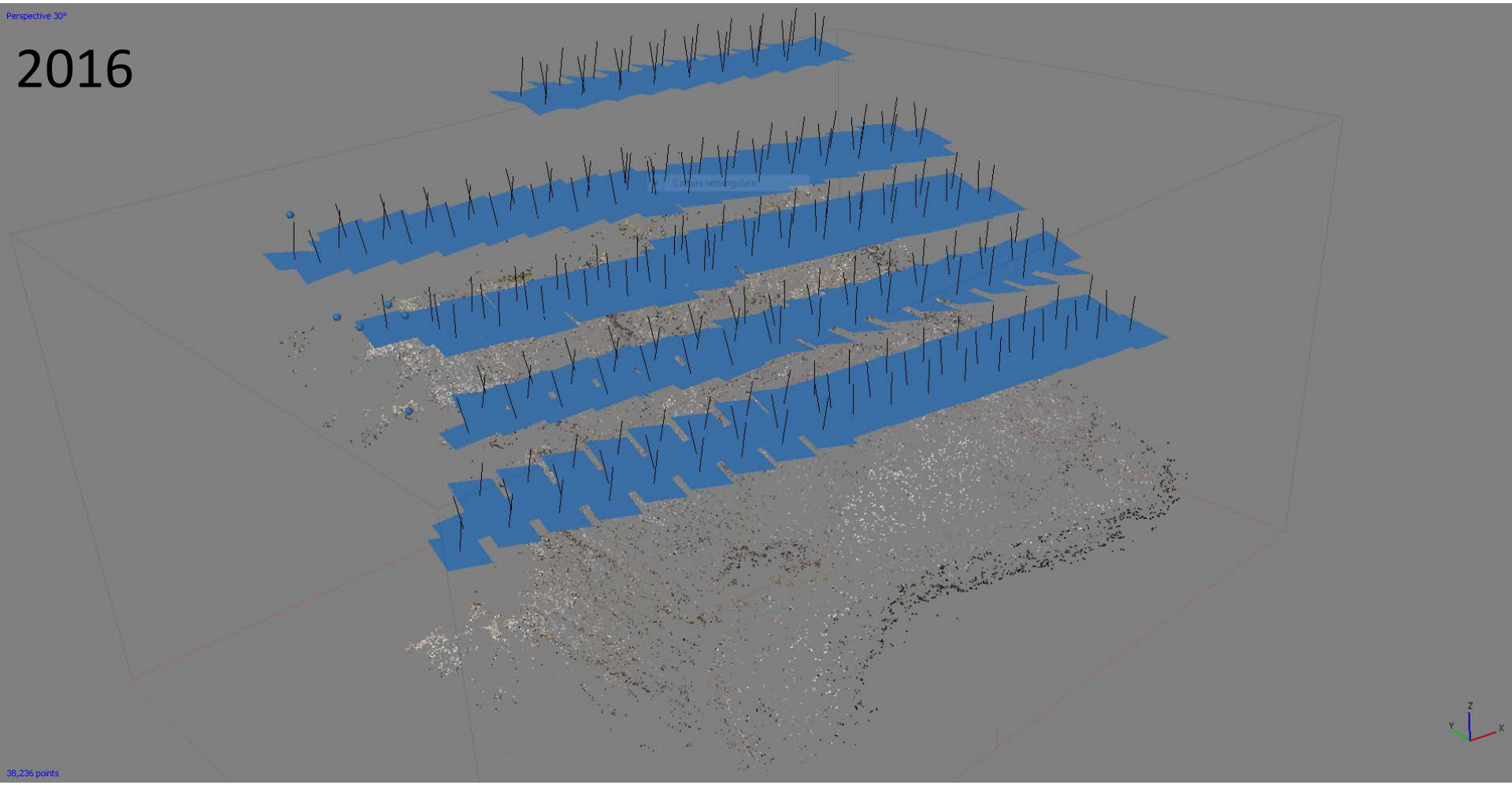
Photogrammetric models were computed using Agisoft Photoscan Professional



Surveyed area: 12 ha, due to short flight range (7 minutes per mission)
9 missions were flown at 5 different altitudes. 243 images captured.

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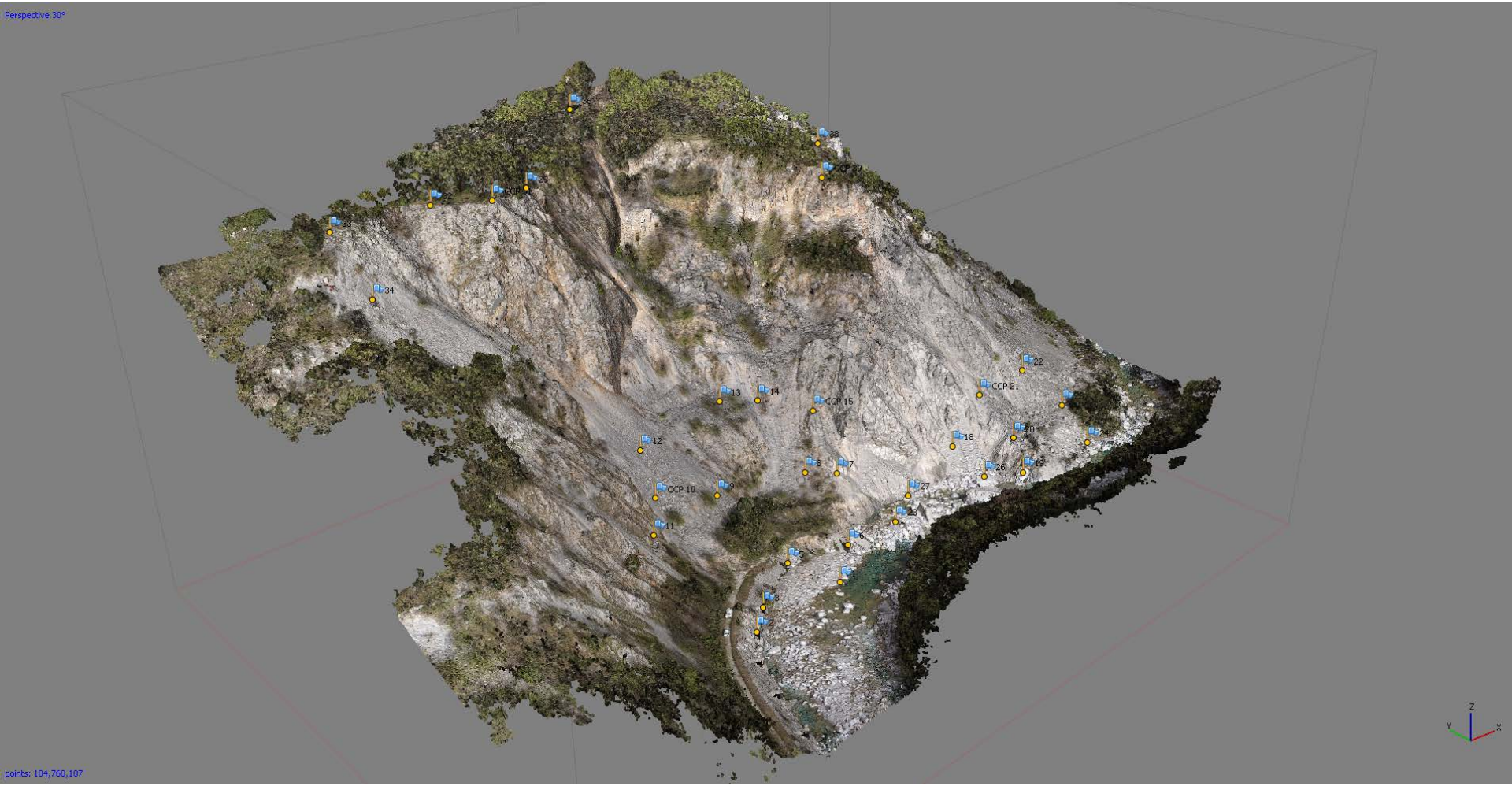
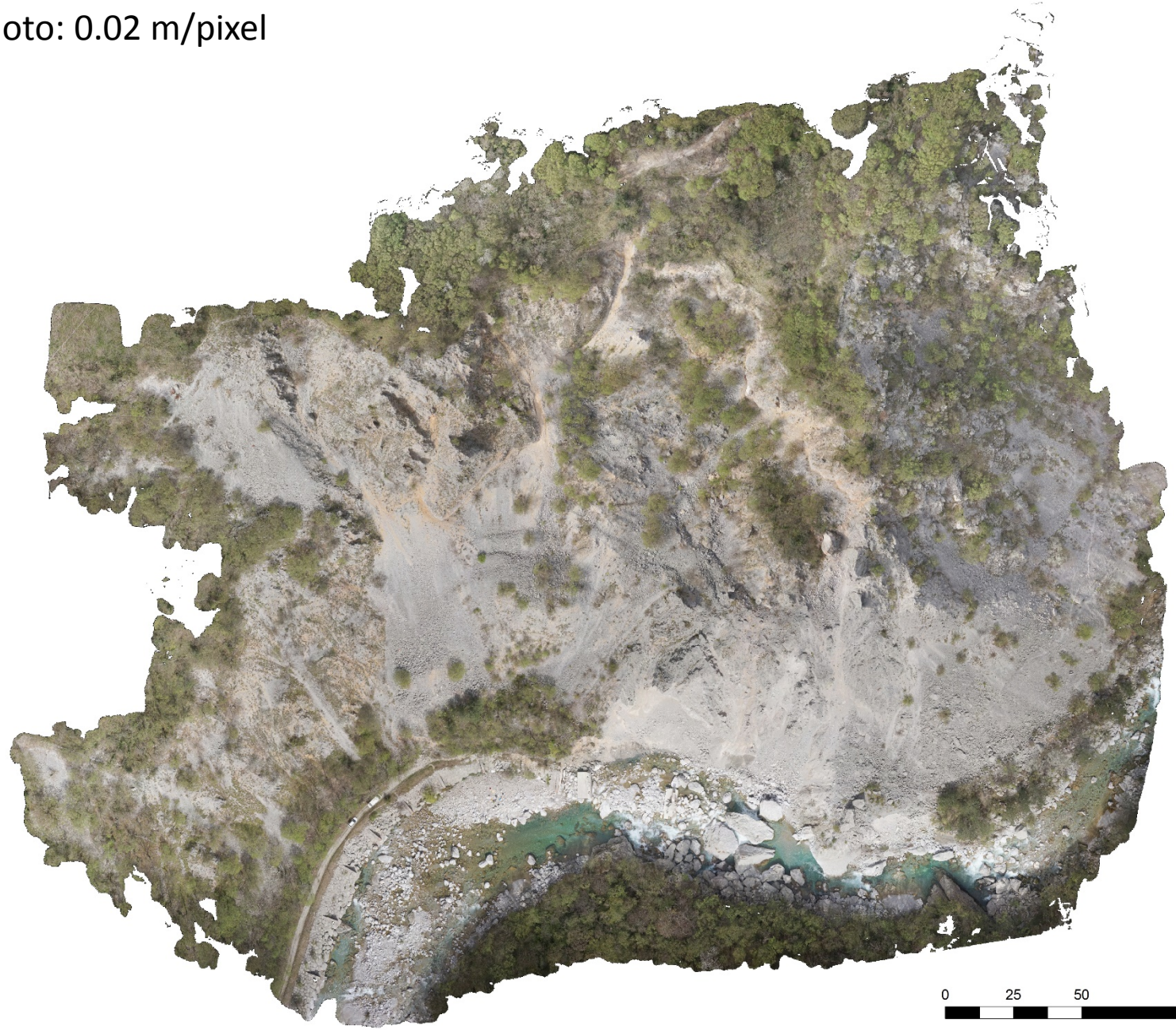
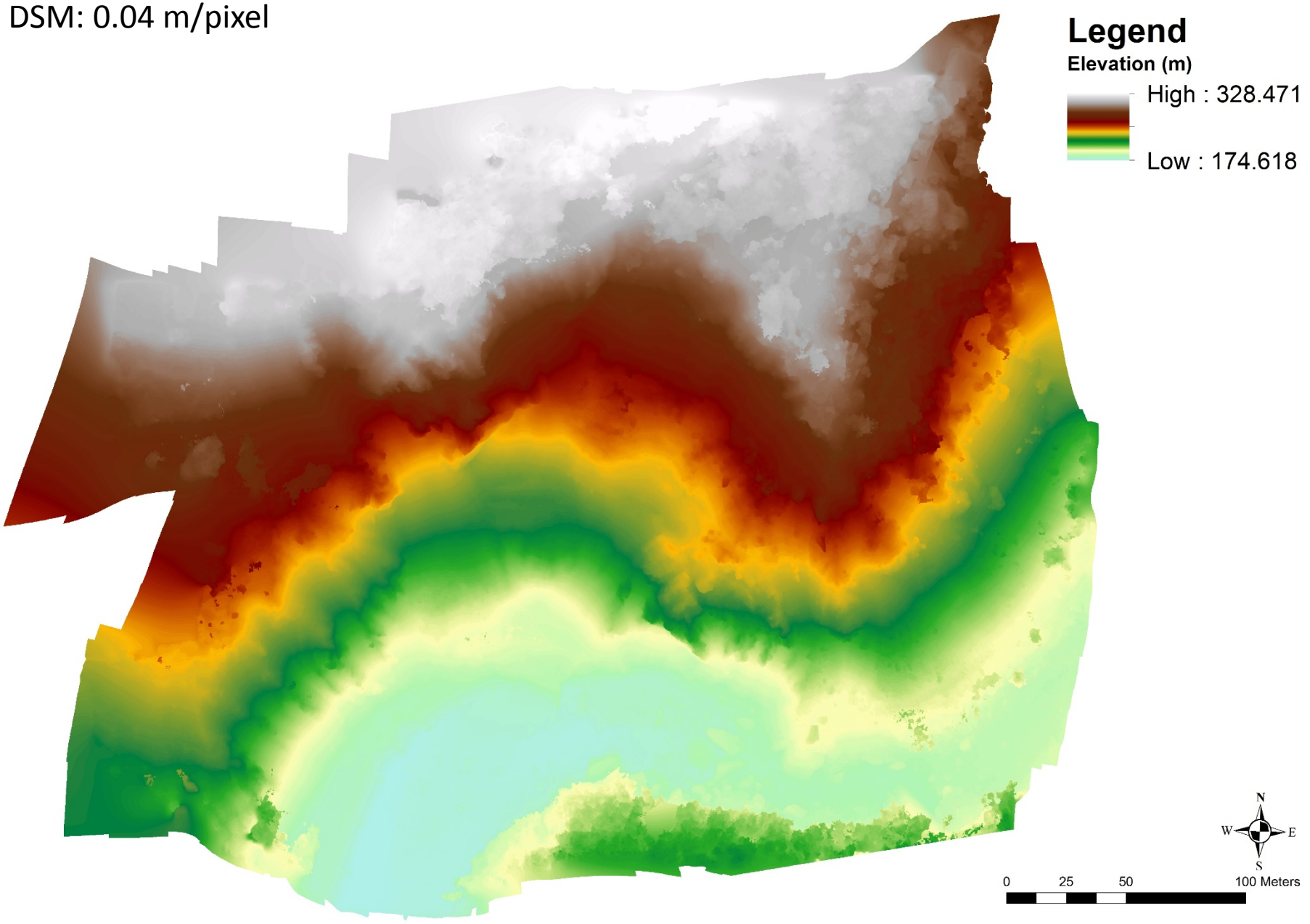


Dense cloud: 104 760 107 points
27 GCPs (2.52 cm total RMSE) and 5 CCPs (7.75 cm total RMSE).

Orthophoto: 0.02 m/pixel



DSM: 0.04 m/pixel



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Second survey: September 2018
UAV: DJI Phantom 4 Pro, 1.6kg
Camera: Sony 1'' sensor, 20Mp, 24mm lens

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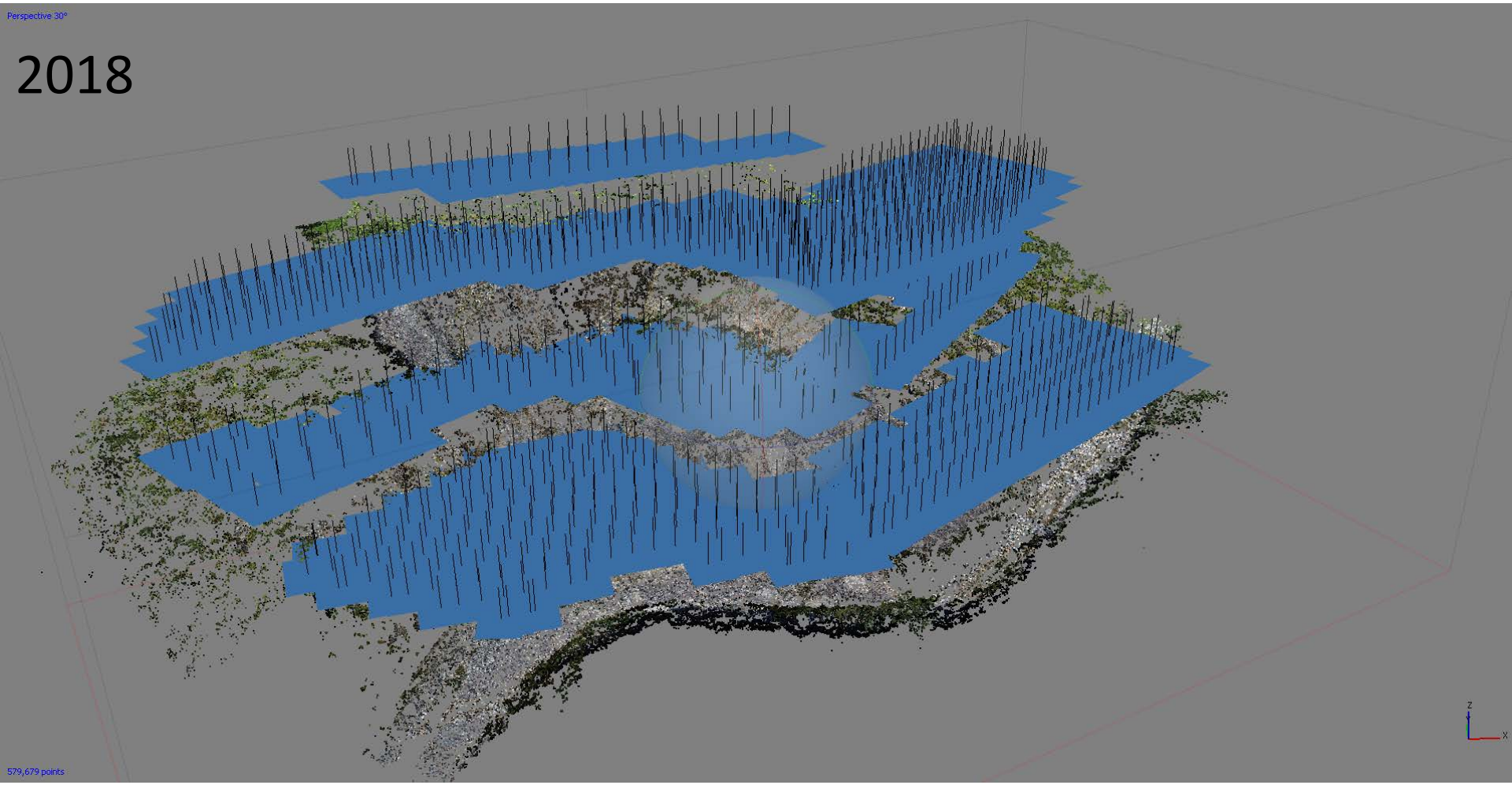

Surveyed area: 20 ha
8 missions were flown at 4 different altitudes. 978 images captured.

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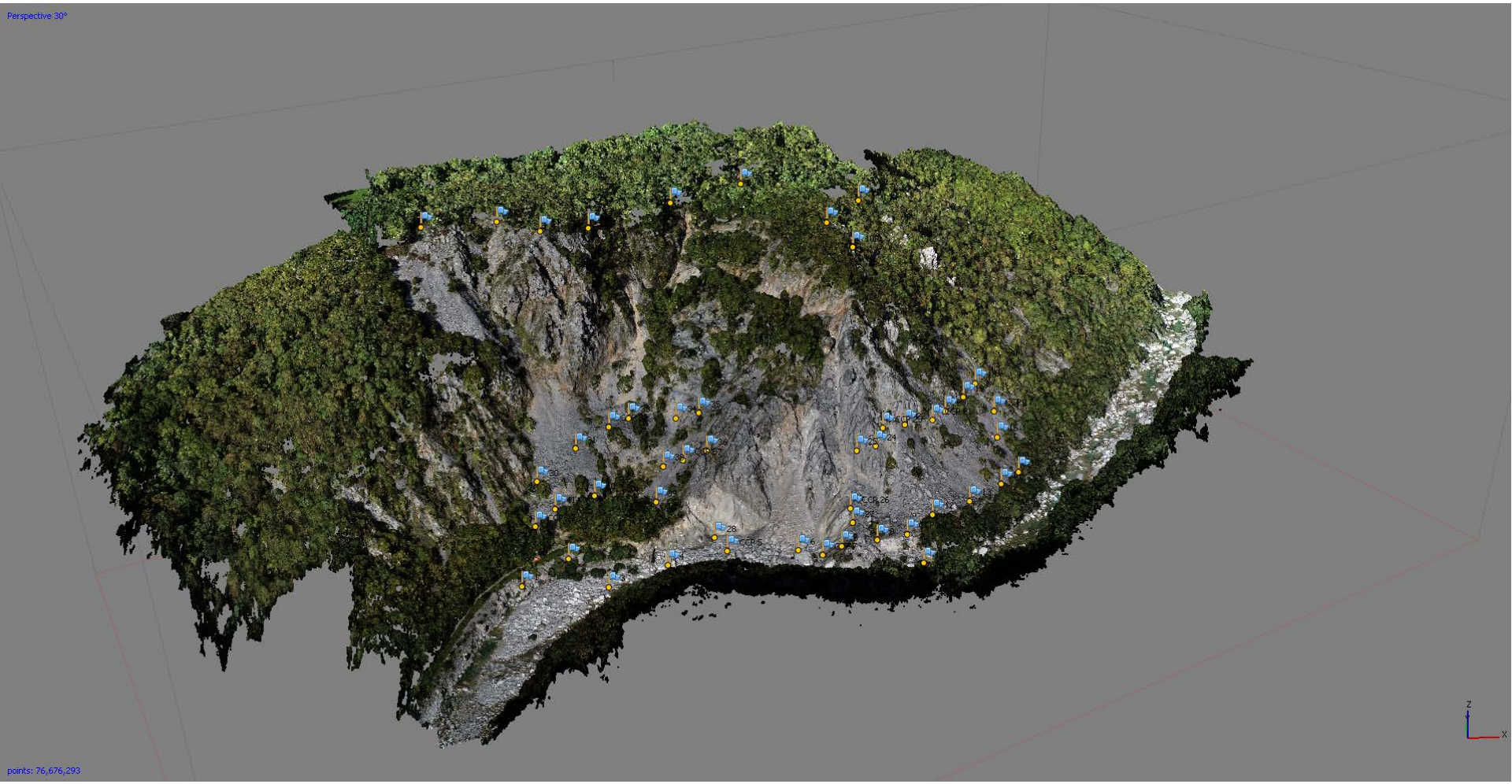

Dense cloud: 76 676 293 points
40 GCPs (6.96 cm total RMSE) and 10 CCPs (10.7 cm total RMSE).

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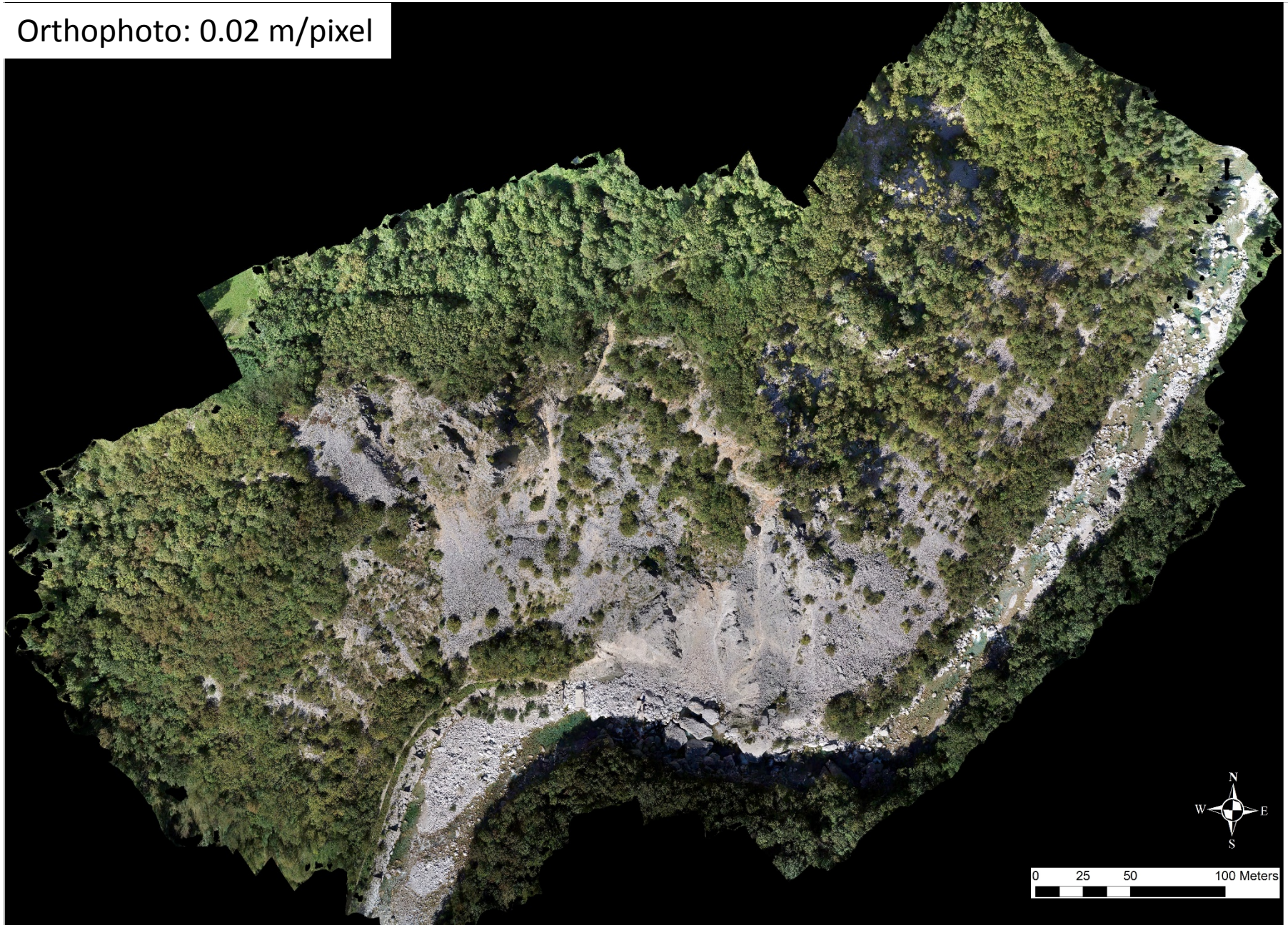
Orthophoto: 0.02 m/pixel



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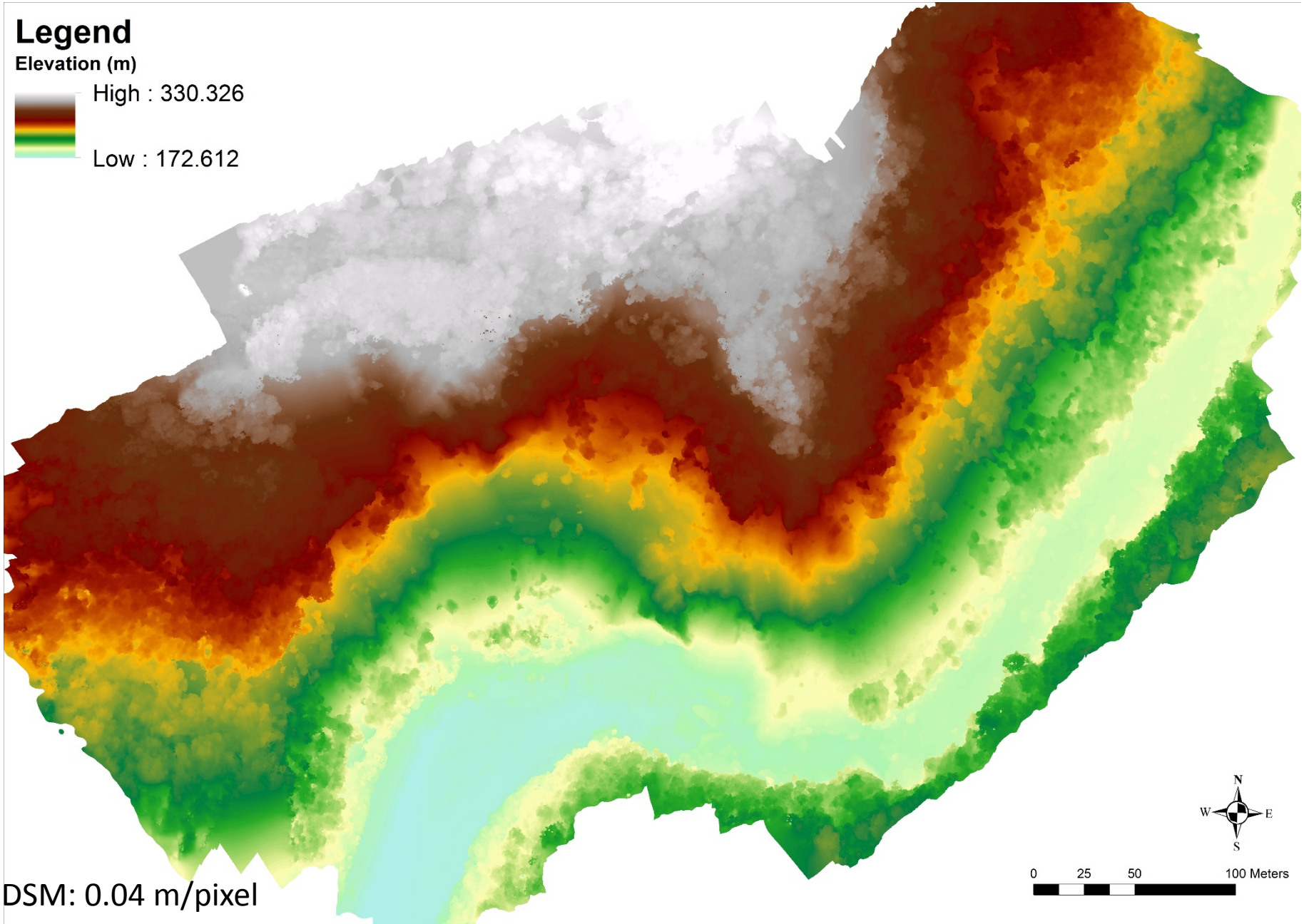

DSM: 0.04 m/pixel

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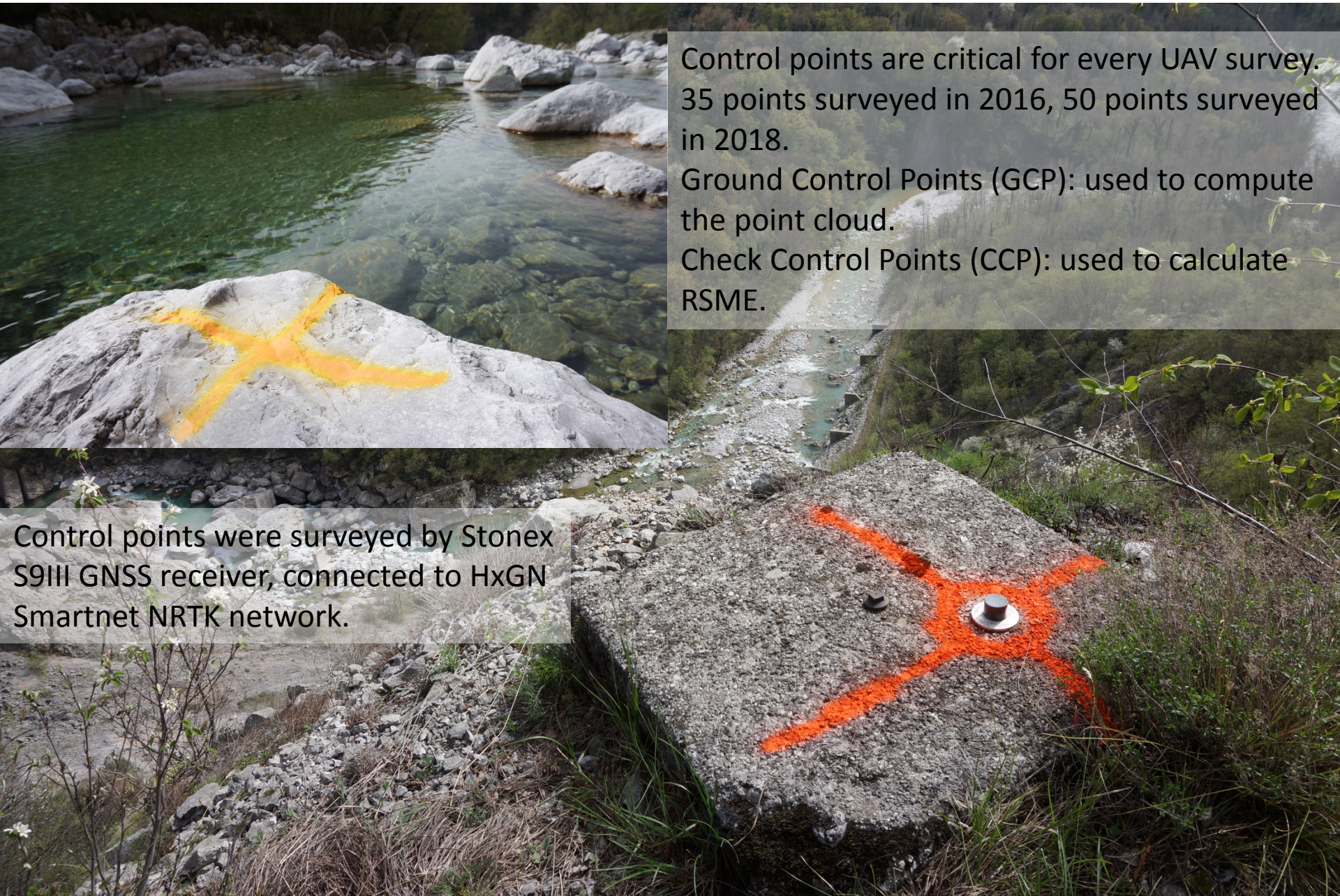

Control points are critical for every UAV survey. 35 points surveyed in 2016, 50 points surveyed in 2018.
Ground Control Points (GCP): used to compute the point cloud.
Check Control Points (CCP): used to calculate RSME.

Control points were surveyed by Stonex S9III GNSS receiver, connected to HxGN Smartnet NRTK network.

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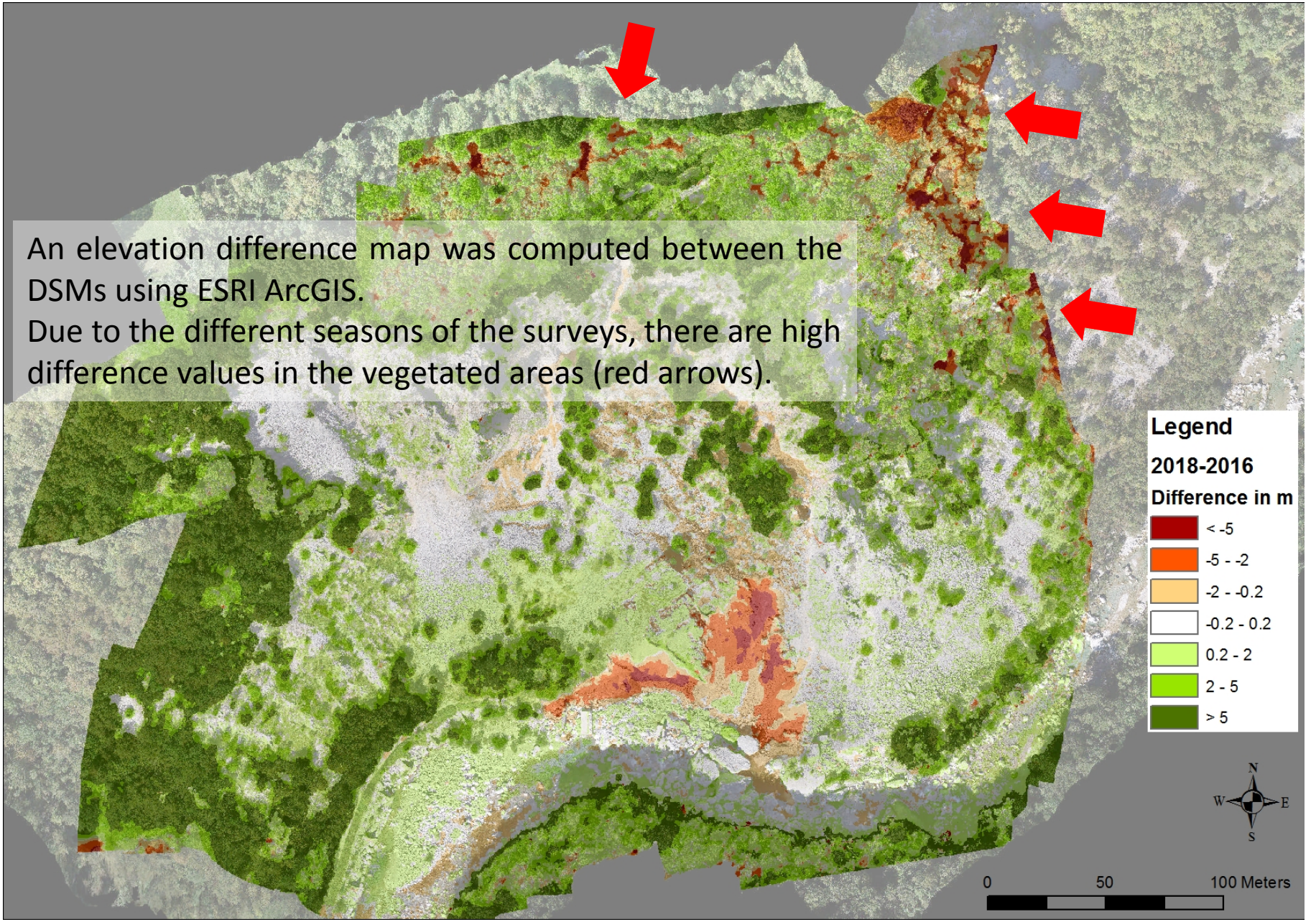

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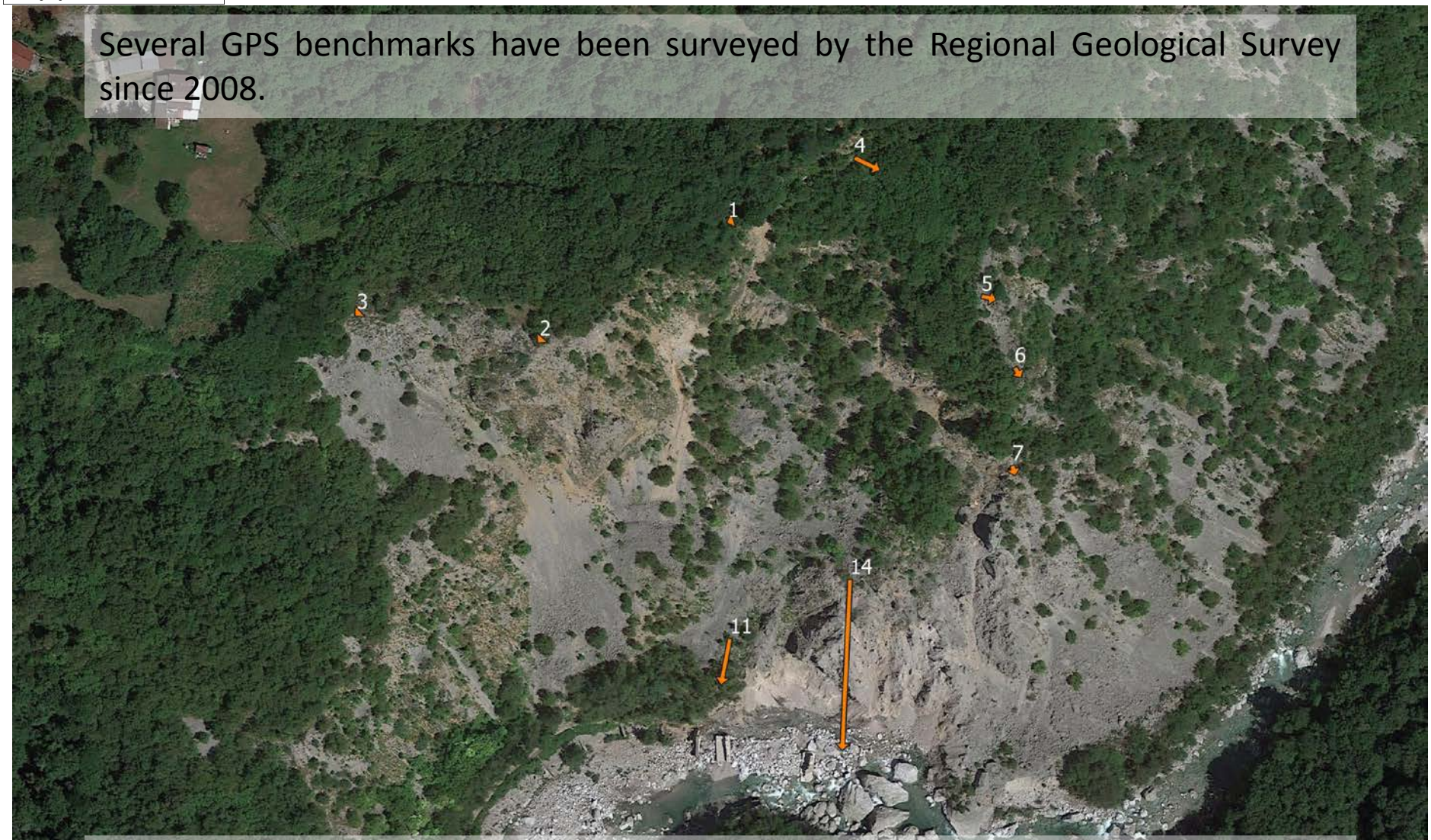
Several GPS benchmarks have been surveyed by the Regional Geological Survey since 2008.



Movements computed in the 2008-2019 interval show the most active part of the landslide (point 11: -0.97 m, point 14: -1.57 m vertical displacement). The yellow arrows represent the rate of vertical displacement and the direction of movement.

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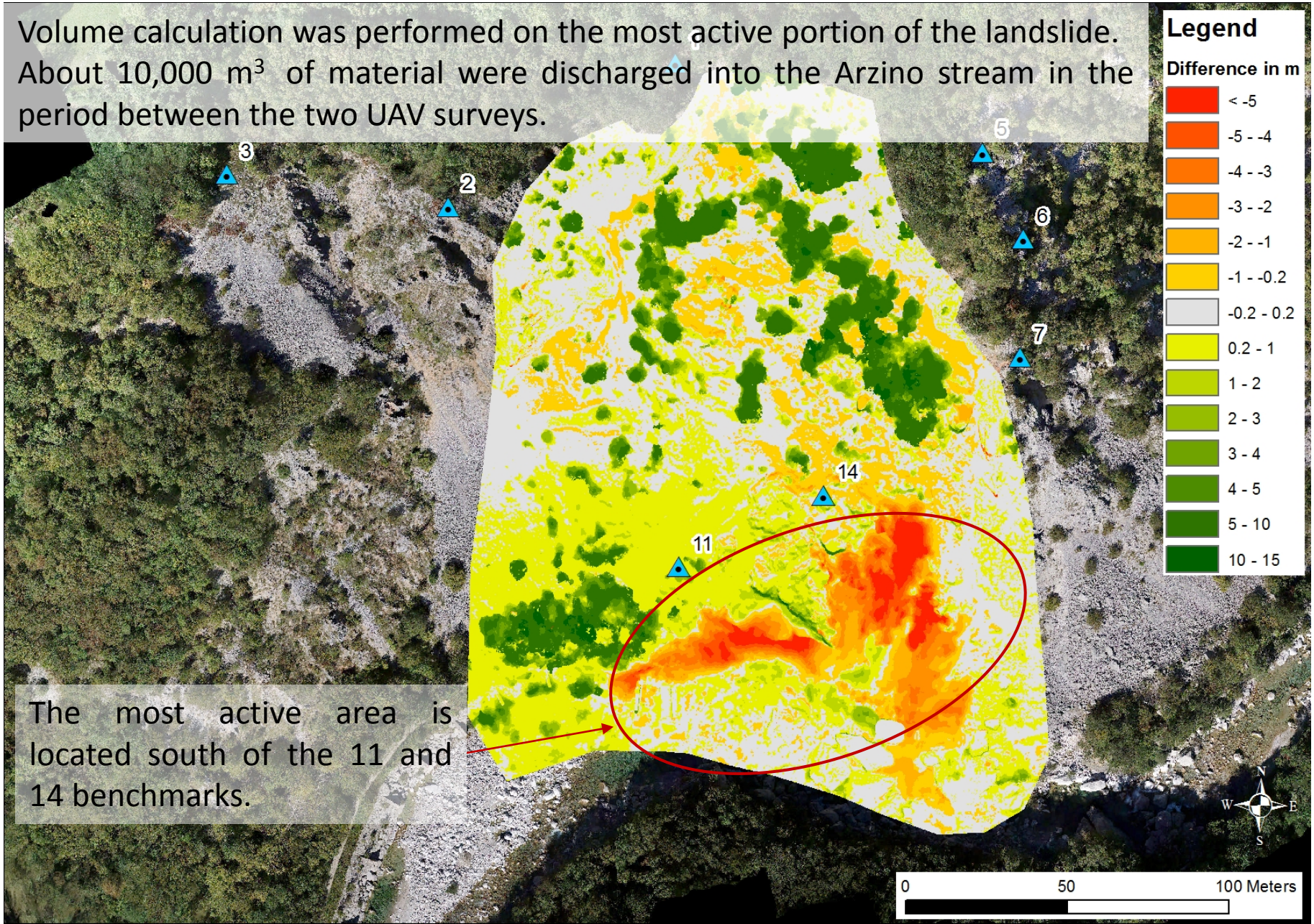
Volume calculation was performed on the most active portion of the landslide. About 10,000 m^3 of material were discharged into the Arzino stream in the period between the two UAV surveys.



The most active area is located south of the 11 and 14 benchmarks.

Conclusion

- Landslides areas are often difficult to access, therefore UAV surveys are useful and relatively easy to deploy.

- Two surveys were carried out two years apart. Considering the difficult terrain, the highest possible number of control points was measured, to obtain reliable photogrammetric models.

- Photogrammetric DSMs are often problematic in highly vegetated areas. Integration of UAV surveys with traditional benchmarks measurements helps to validate the results.

- The information provided by DSMs comparison greatly expands the single point data provided by benchmarks measurements, highlighting the most active areas.

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