ANALYSIS OF MIAGE GLACIER LAKE OUTBURST FLOODS (Courmayeur - AOSTA VALLEY)

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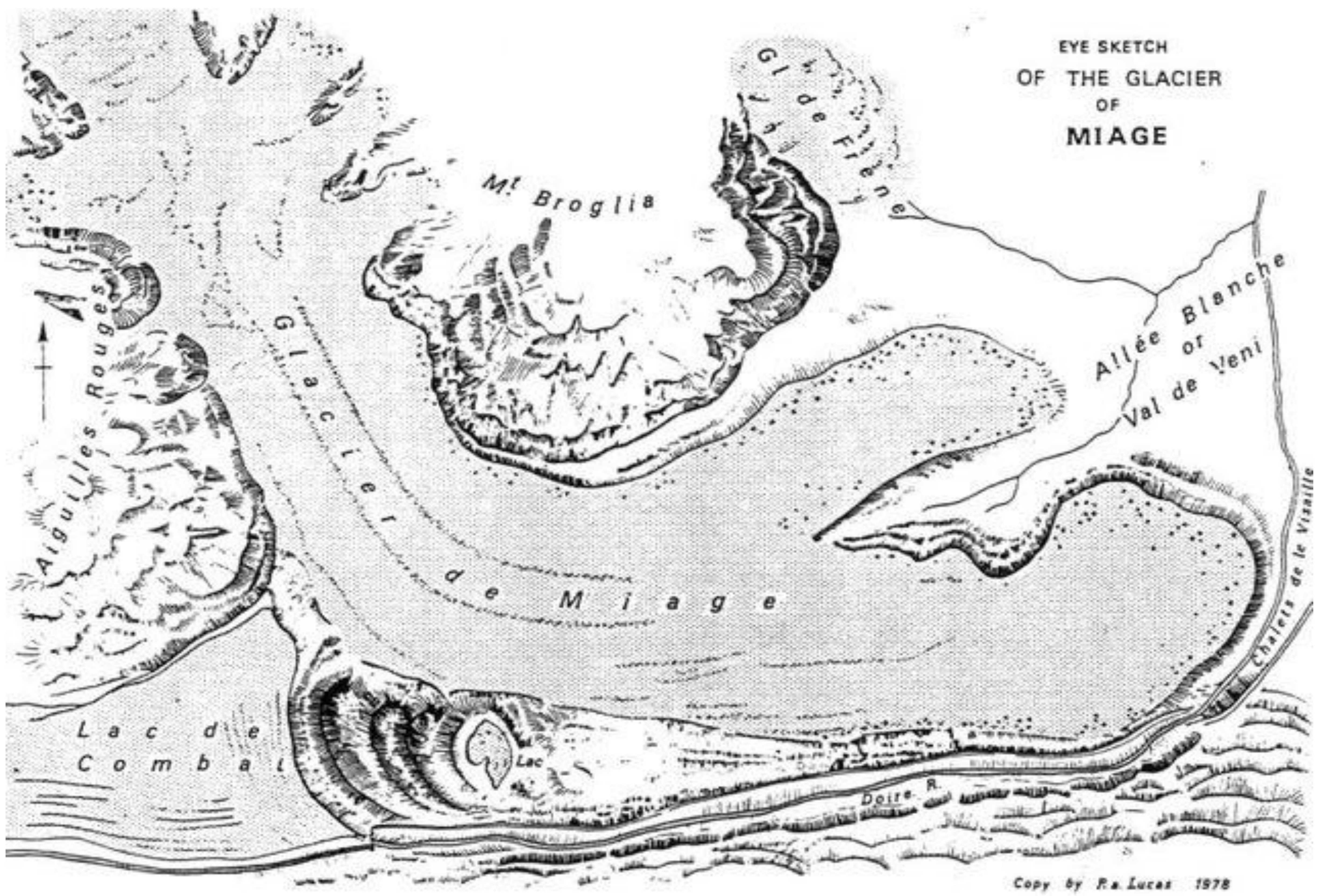
INTRODUCTION



A **GLOF event** on the 26_08_2014 was documented at Miage Lake to have had high debits causing flooding and damages to river embankments downstream. Such water discharges are considerably different from slower historical **drainages events** such as the one well documented by Deline et Al. (2006) happened on the 3rd September 2004 having had an estimated avarage discharge of 1.5 / 2 m^3/s .

MATERIALS

As a first step to better understand the actual evolutional trend of the entire Miage Glacier, data from two **topoghraphical surveys** have been **processed**. Both surveys have been commissioned by the Aosta Valley Autonomous region (RAVA); the first one is an aerophotogrammetrical survey from 1991; the digital output has a resolution of 10m raster cells, while the second one is a airborne Lidar survey from 2008 and has a resolution of 2m raster cells. Therefore the 2008 survey has been resampled to 10m resolution for data processing.

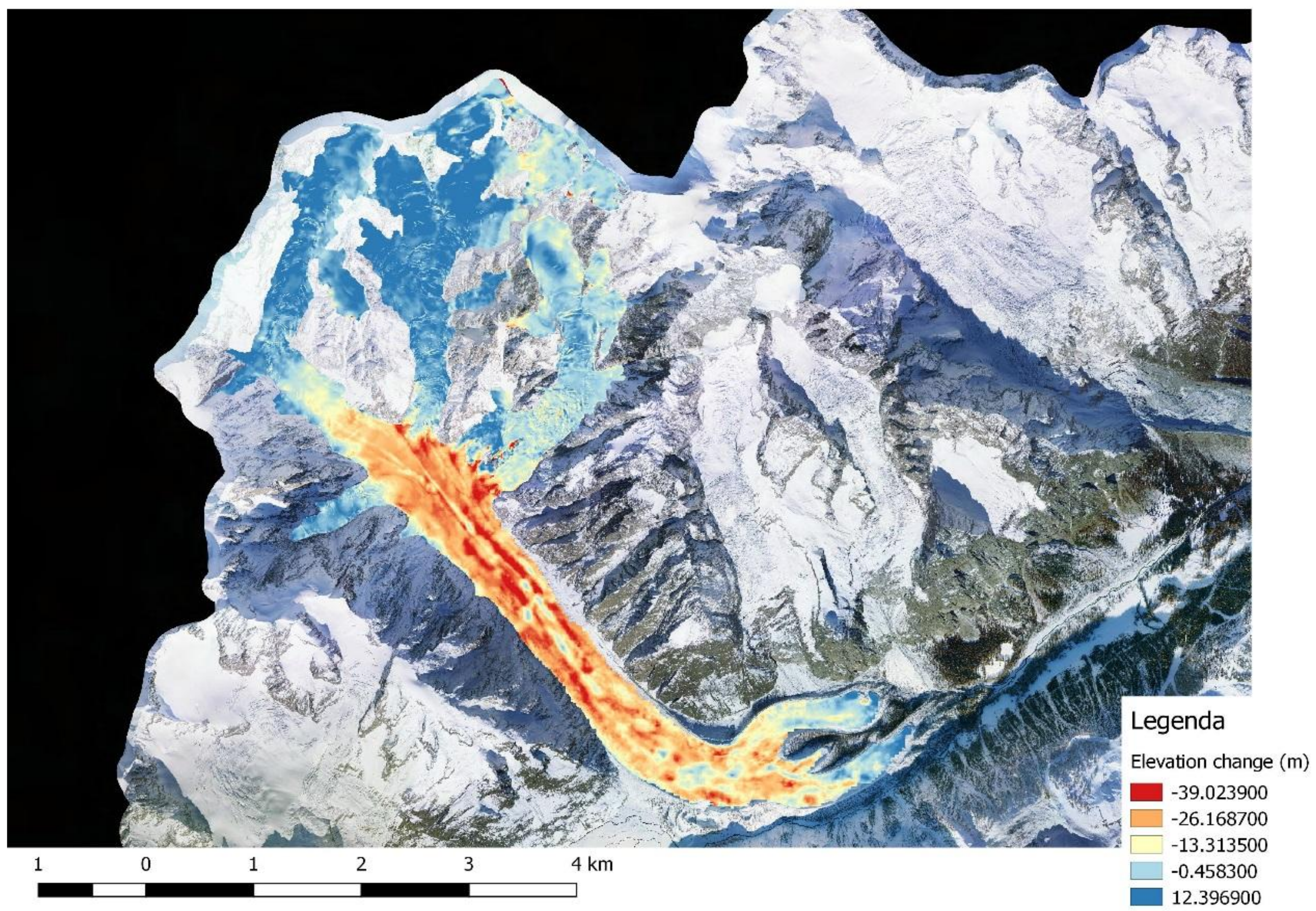
Evolution of Lake Miage area has been carried out by analysis of ESA **Sentinel 2B satellite** optical Images for the years 2015-2018, while former extention have been mapped by analysis of classic orthophotographs of 1988 and 1994 from the National Environment Ministry, and 2000-2008-2012 from images property of RAVA.
Airbus **Spot7** Satellite hi resolution imagery has been analysed to reconstruct surface velocities of 2016-2017.

Actual lake topography has been mapped in detail by means of aerophotogrammetrical **UAV flights** coupled with **RTK GPS** ground survey and the materialization of 16 Ground control points using a Geomax Zenith 25 pro GNSS Antenna coupled with a local virtual base station form the RAVA GNSS correction network.

UAV missions and RTK GPS measurement of fixed GCP's were carried out in July and August 2019.

METHODS

Dem differencing of Lidar and aerophotogrammetrical surveys has been performed on Qgis software making it possible to infer a geodetic cumulated mass balance of Miage Glacier. Processing of the UAV datasets has been performed using SfM algorithms on Agisoft Photoscan software. Sentinel-2 satellite images were processed on Esa-Snap software before importing them on Qgis software.



Elevation changes from Airborne Lidar and photogrammetric surveys of 2008 and 1991 obtained by means of DEM differencing

Survey Data

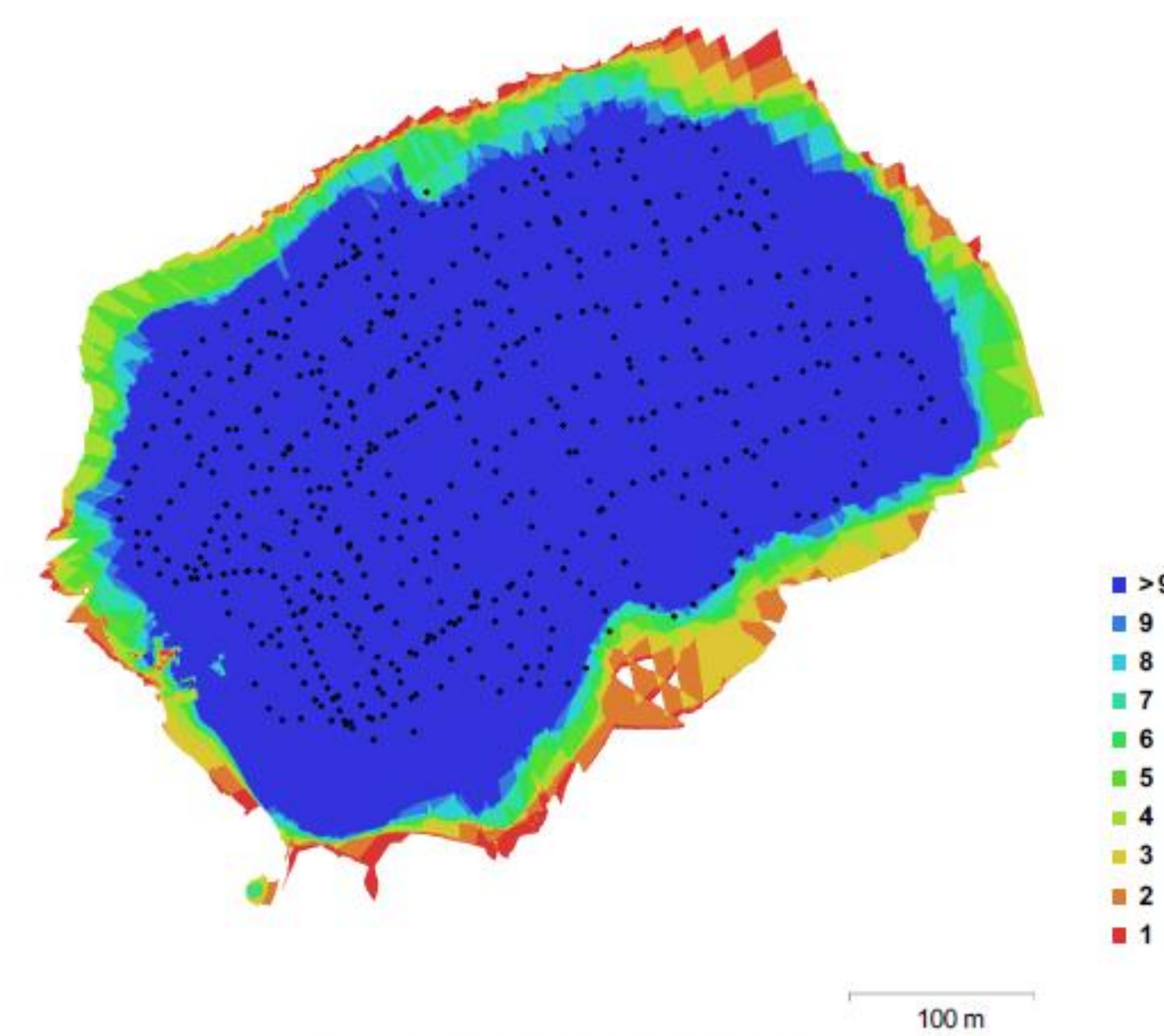
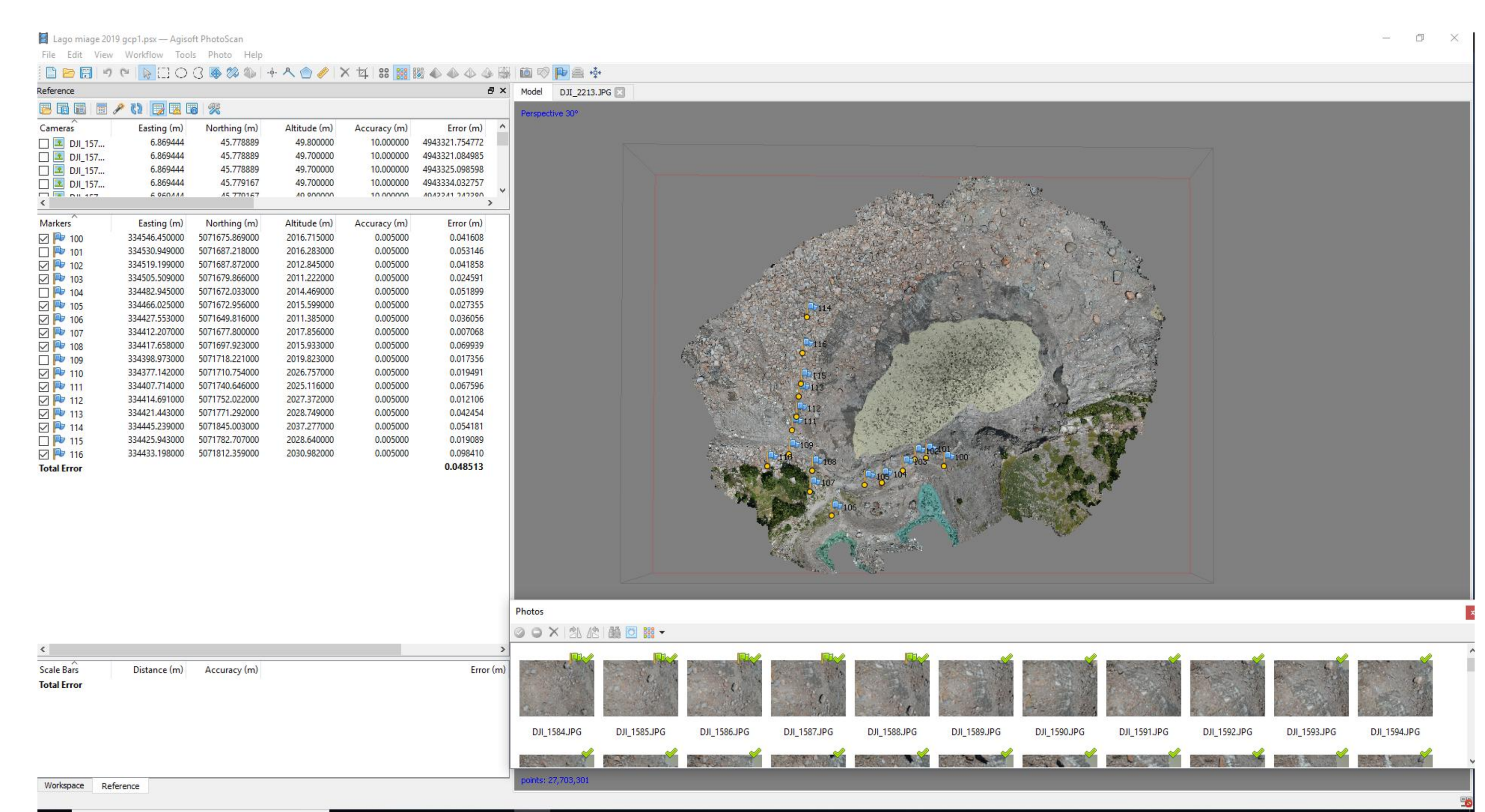


Fig. 1. Camera locations and image overlap.

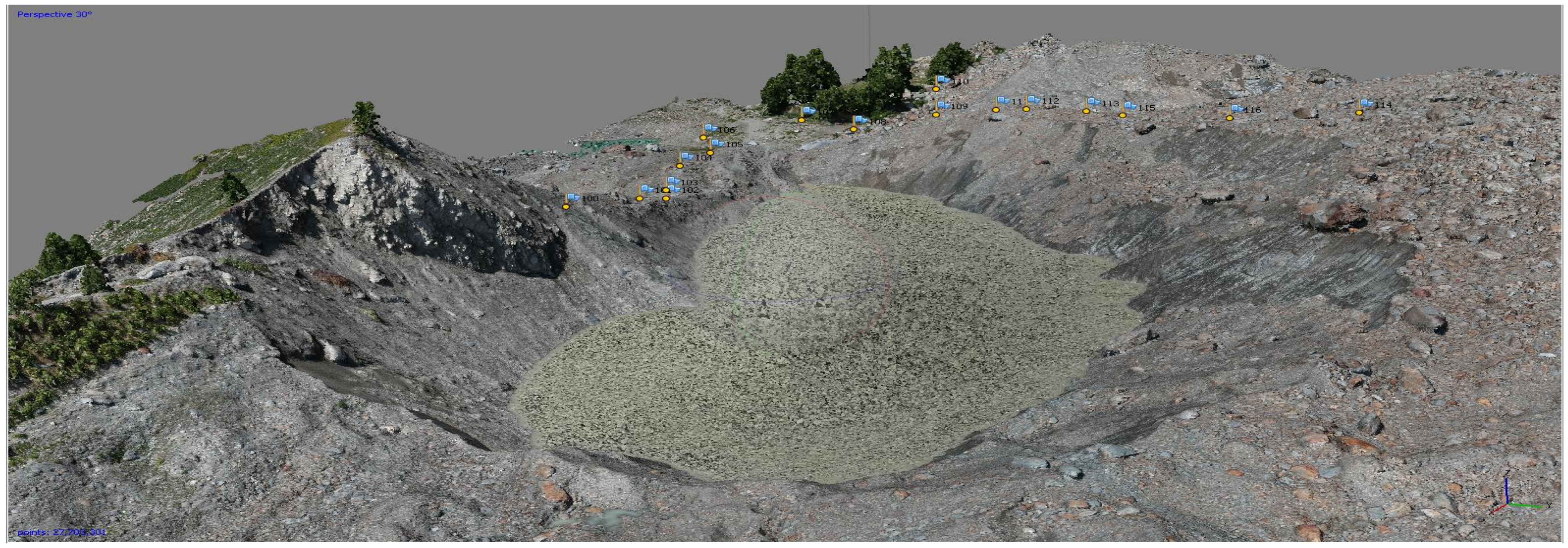
Number of images:	501	Camera stations:	498
Flying altitude:	84.9 m	Tie points:	140,842
Ground resolution:	2.78 cm/pix	Projections:	902,407
Coverage area:	0.154 km²	Reprojection error:	2.04 pix

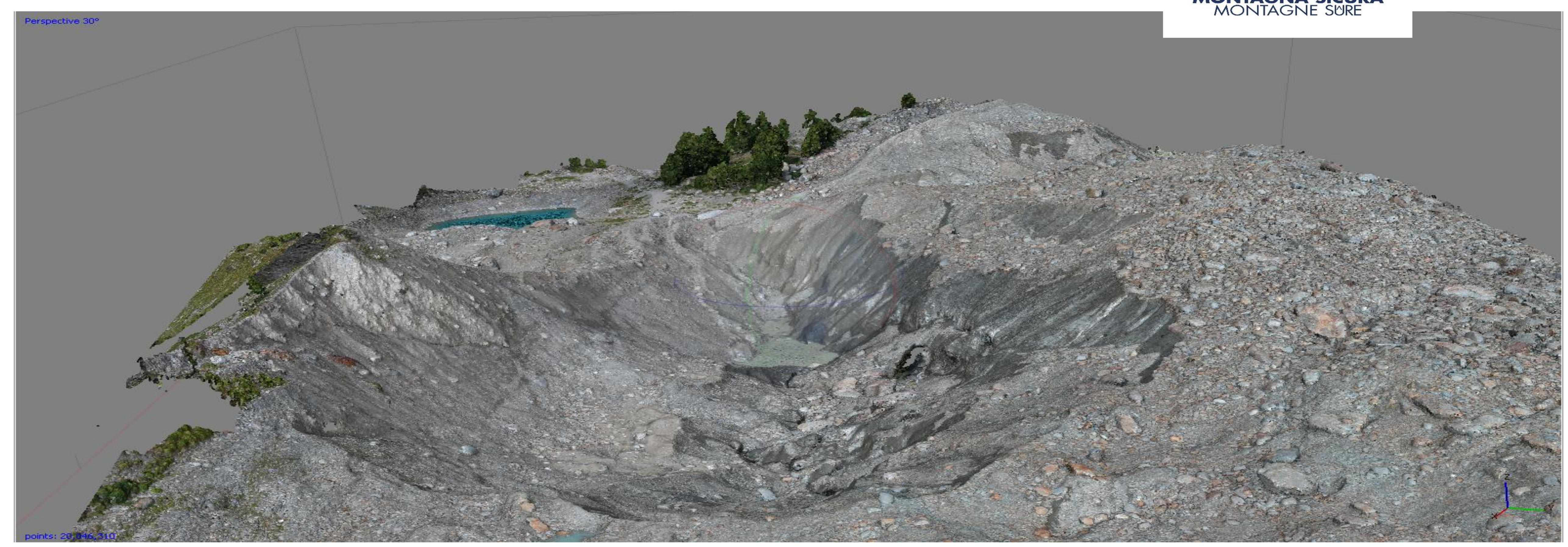
Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
FC1102 (4.49 mm)	3968 x 2976	4.49 mm	1.57 x 1.57 um	No

Table 1. Cameras.

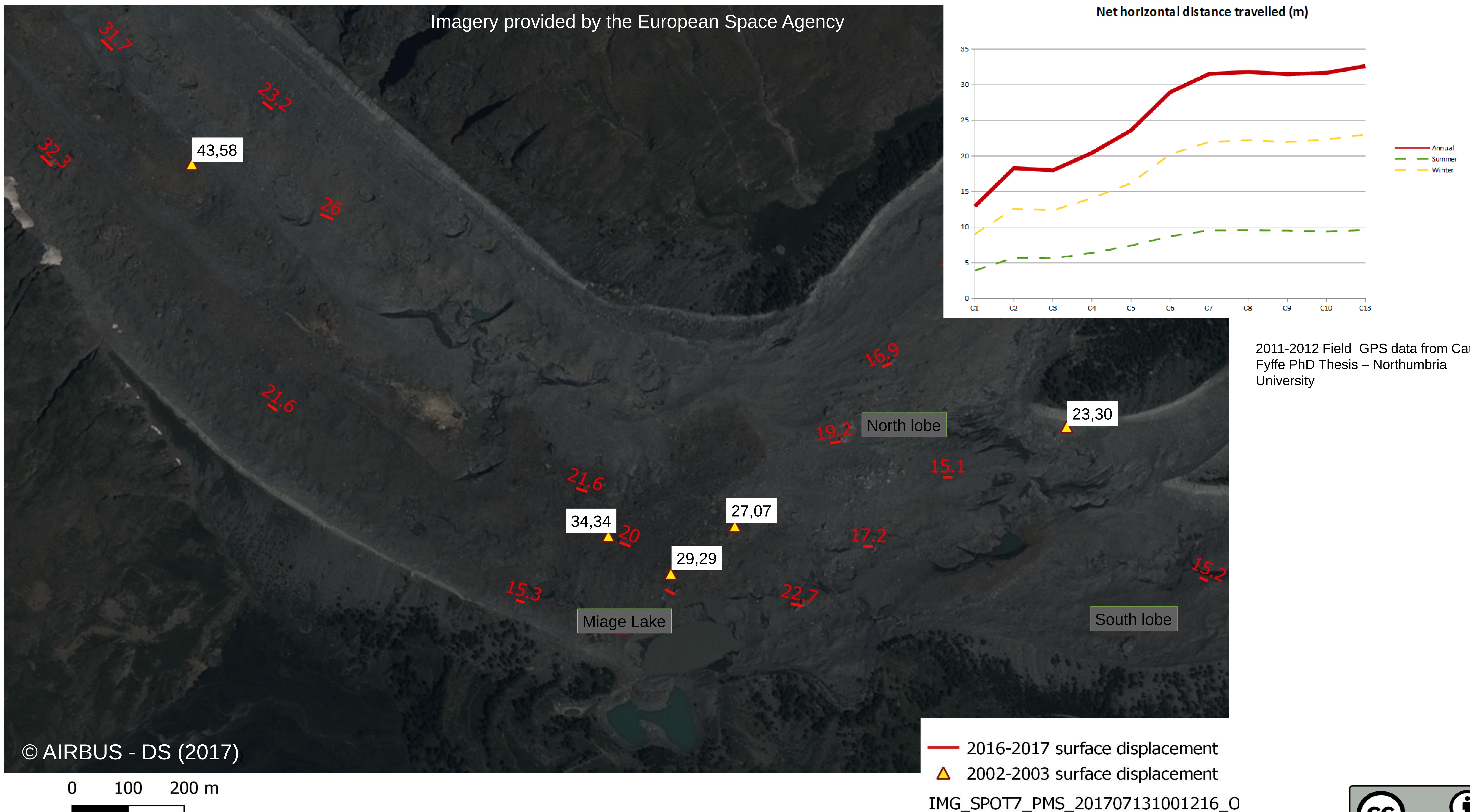


RESULTS





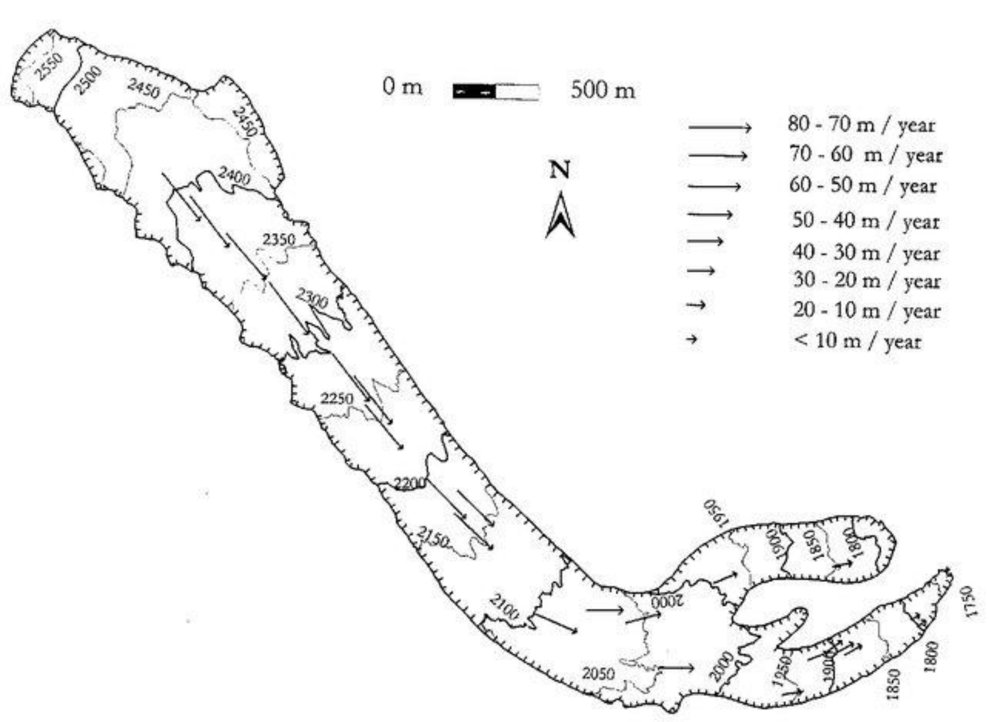
Dense clouds of Miage Glacier lake and surroundings acquired on 02_07_2019 and 28_08_2019 used for water volume estimation.



2011-2012 Field GPS data from Catriona Fyffe PhD Thesis – Northumbria University

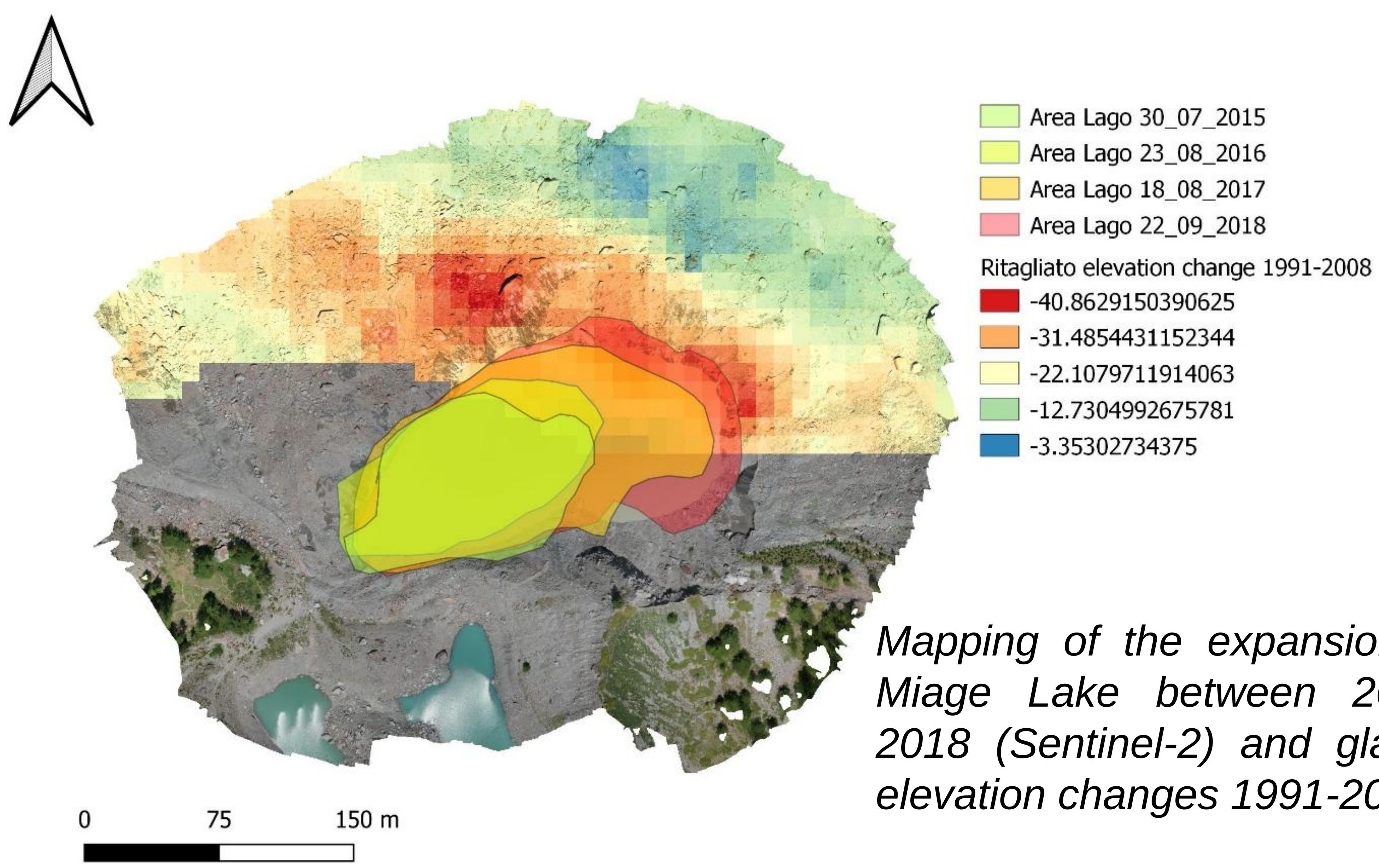
2002-2003 Field GPS data from Diolaiuti et Al. (2006)

1975-1991 data From Smiraglia et Al. (2000)



RESULTS

Dem differencing of topoghraphic surveys of 1991 and 2008 resulted in a **cumulated geodetic mass balance** for the Miage Glacier between **1991 and 2008 of -0,56 m Weq/yr**. The result is in good agreement (accounting for major negative trend after year 2000) with remote sensed data (2003 SPOT 5 – 2012 Pleiades) performed by means of DEM differencing obtained by stereo satellite imagery by Berthier et Al. in 2014 which infer a cumulated mass balance of **-0,84 (+/- 0,22) m Weq/yr.** The Lake area measurements from 2015 to 2019 document a fast and **unusual expansion** considering that the supraglacial/marginal part of the lake had been almost unchanged since almost a century. High resolution DEM's could be produced by coupling of UAV and GNSS surveys; by means of differencing a filled lake (07_02_2019) and an emptied lake (29_08_2019) DEM, **water volume of 2019** Miage Glacier Lake resulted in an estimation of **196.000 +/- 1000 m3.**
The measure of total water volume could make it possible to estimate an actual maximum GLOF debit of **25,17m3/s** (Clague 1973). Considering an average discharge of the main Val Veny stream during summer of about **15 m3/s**, such an additional GLOF discharge could already cause **problems on the stream pathway.**



Mapping of the expansion of Miage Lake between 2015-2018 (Sentinel-2) and glacier elevation changes 1991-2008.

CONCLUSIONS

We suggest the possibility of **2 different mechanism** of emptying: slower drainages by **intersection** of crevasses and subglacial drainage system, and faster drainages (GLOF's) possibly by means of **ice dam uplift.** Further investigation is needed to confirm this hypothesis
Topoghraphy monitoring in the years to come will give informations on the potential risk coming from the lake GLOF's. Moreover multitemporal **GNSS field surveys** could give important informations on the dynamics of the lake drainings, and possibly individuate a method of predictability of sudden GLOF's by monitoring of the Ice dam uplift. The installation of an **hydrographic station** on the glacial stream coming out of the Miage Glacier would give a better understanding of water discharges involved in the Lake drainages in the years to come.

Région Autonome Vallée d'Aoste Regione Autonoma Valle d'Aosta

EGU General Assembly 2020

FONDAZIONE MONTAGNA SICURA MONTAGNE SÛRE

Miage Glacier research Meeting – Courmayeur November 2020?

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Thank you!