Politecnico di Milano - Courses on Photogrammetry
Laboratory report

First Name:	Gaia	Person code:	10505043
Last Name:	Vallarino	Matriculation:	996164
CFU group:	10	Date:	04/01/23
Lab Topic:	05 - Satellite Photogrammetry		

Description of the performed activity *(max 50 lines)*

The aim of this laboratory is the monitoring of the Belvedere glacier on Monte Rosa, from two sets of satellite images taken in different year (2009 and 2017). The final goal was to check the temporal volume variation of ice of the glacier.

The satellite images, or stereo photos, are quite expensive and set one of the main differences with drone photogrammetry, for which you would only have to pay for the instrumentation. Another important difference between the two methods is, for example, the GSD (0.5 m for a panchromatic sensor satellite, some centimeters for a drone). Obviously, this also means that there is a big difference in the number of photos that the two different types of survey deal with.

For each epoch we have 2 satellite images, two multispectral (MS) and two panchromatic (P) ones. The P ones don't have the color information, because they have a very wide scale of greyscale acquisition. It is possible to upscale the hue and saturation of the MS (lower resolution, but colored image) to the P resolution and interpolate by means of a cubic spline resampling technique the color information. This technique is called pan-sharpening as is performed in QGIS. We also rescaled the color interpolation to go from the interval [0, 4095] to the interval [0, 65535]. To have smoother movement while zooming in and out the image, we built the image pyramids, which diminishes the level of detail as we zoom out, in order to speed up the image rendering on screen.

Afterwards, we added 5 additional markers to the GCP set, which had to be points available in both epochs, but not inside the glacier. Indeed, since we are considering the variation of the amount of ice in the glacier, we are supposing that the shape of it has changed in the 8 years. Using the point sampling tool, the Z information was estimated by interpolation of the horizontal coordinates; afterwards, the information was exported in a .csv file and imported as a reference in Metashape. After a first low quality BBA, we collimated all the GCP. As per usual, a percentage of the points were used as Check Points (2, 18, 10, 35) and then we ran another higher quality BBA. The accuracy is deemed acceptable since it is comparable to the GSD, and given the resolution of the DTM, we were expecting something along the lines of 50 cm, which is what comes out from our analysis (fig. 1). This also means the accuracy of 1 pixel will be around 50 cm – and anything lower or higher than that value will be a corresponding fraction of pixel. The dense cloud was computed with high and moderate deep filtering setting, calculating the colors and confidence values. We then came back to QGIS where we built the DEM by considering the dense cloud and not the depth map as parameter. We use the boundaries retrieved from the QGIS project (413800, 5086600; 418000, 5093200) to compute the orthophoto in Metashape.

Finally, having both the orthophoto and the DEM for the two epochs, we could go on to compute the volume loss. First, we had to clip our layers over a mask covering all the points and only the points of the glacier, because we wanted to compute just the volume difference there, not in other points. The mask was created over the 2009 orthophoto as a new shapefile and used to then clip both DEM images. By using the raster calculator, we computed the height difference between the two clipped DEM's as a subtraction (fig. 2) and then computed the volume loss via the raster surface volume tool (fig. 3-4-5)

Several methods of calculation are available in this tool, which control which values are considered (e.g., only above base level, only below base level, whether volumes below base level should be added or subtracted to the overall volume). In our case, we chose "*subtract volumes below base level*". As one could realistically expect, the total glacier volume decreased in the 8 years, by about $21.5 * 10^6$ m^3 of ice. We can also see a total loss of $22*10^6$ m^3 of ice using the "*count only below*" method, and a gain of about $1.8 *10^6$ m^3 with the "*count only above*".

We finally computed the displacement of the GCP (fig. 6), firstly identifying the points on the orthophoto and creating a new layer. We added the E, N coordinates to the attribute table, and with the "*sample raster values*" toolbox, we extracted the DEM value of each point. Finally, we joined the coordinates of the points for different years and computed the displacement through the field calculator tool in the attribute table. As it is possible to see in the exported layout and in fig. X, the points don't have a high displacement value, except for two, which are closer to the glacier. These two points caused problems during the collimation procedure too, as it was obvious that the terrain did change quite a bit during the decade, and it was not as easy to collimate them.

Final Line Count: 50

Attachments

Count	X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total (cm)
17	46.9288	29.8805	12.6158	55.6341	57.0466

Table 4. Control points RMSE.
X - Easting, Y - Northing, Z - Altitude.

Count	X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total (cm)
4	46.8553	23.9181	54.1555	52.607	75.5004

Table 5. Check points RMSE.
X - Easting, Y - Northing, Z - Altitude.

Fig. 1 – GCP & CP residuals

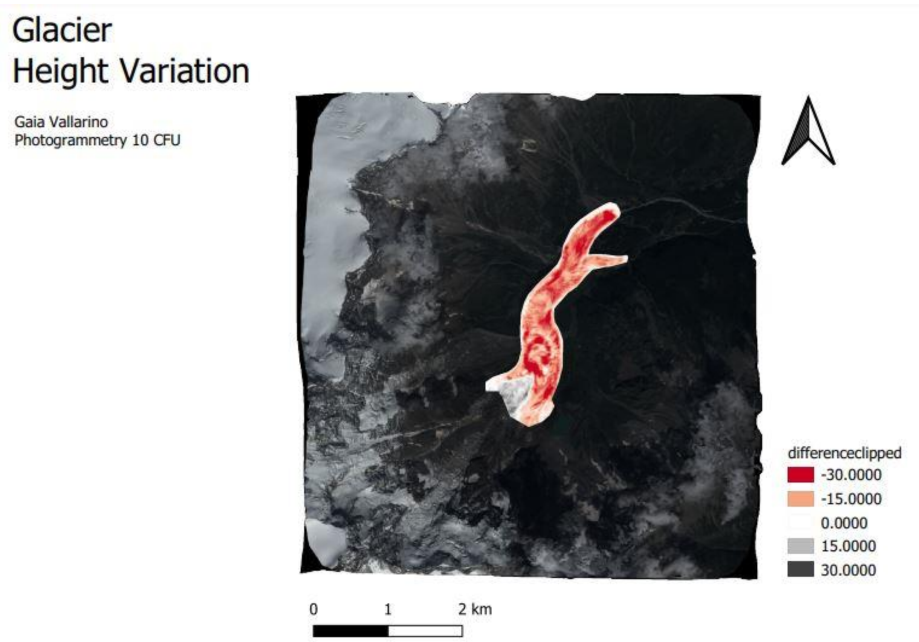
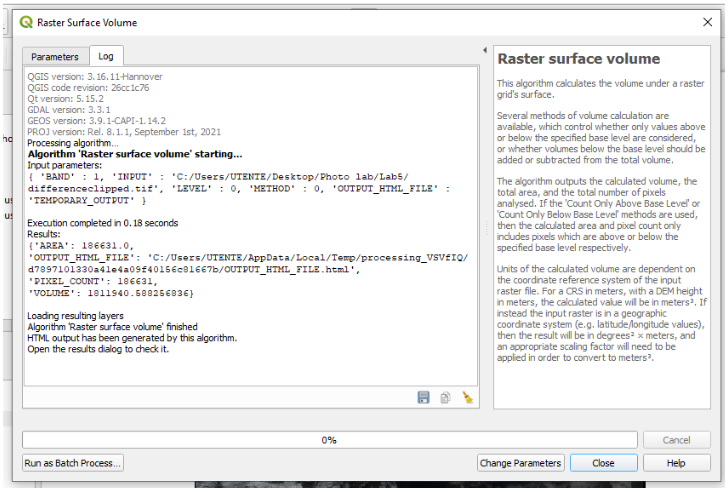
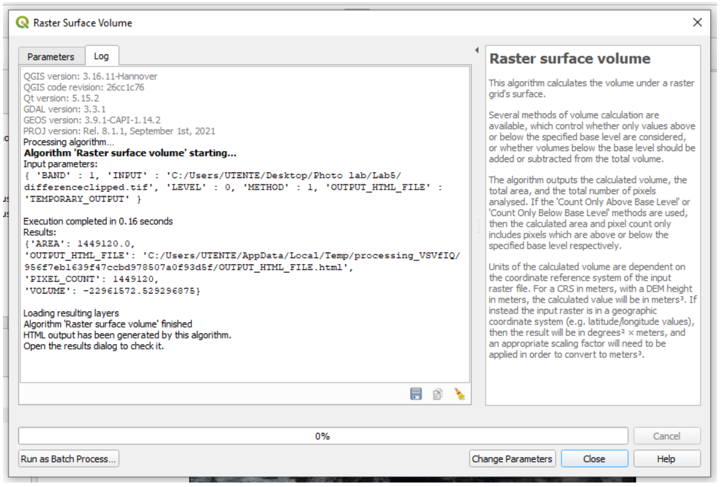


Fig. 2 – Height Variation





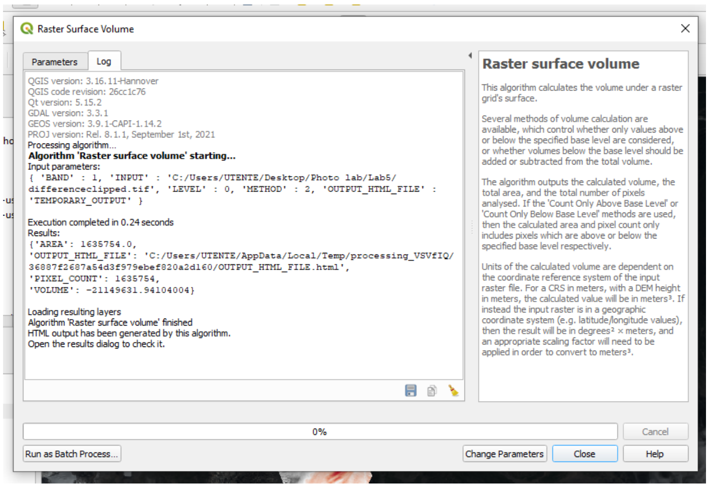


Fig. 3-4-5 – Volume Variation

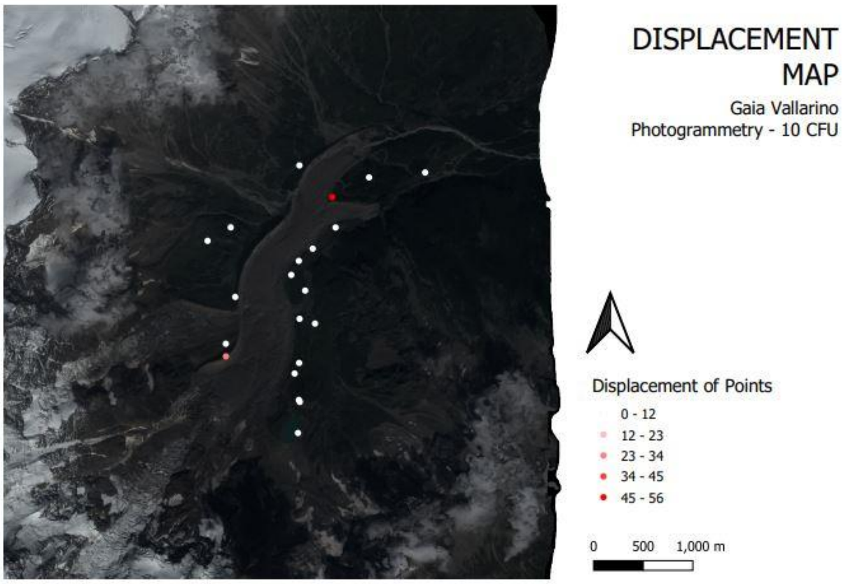


Fig. 6 – Displacement Map