Contents

1 Study site

Fig. 1) shows the land cover map of Bassies catchment.

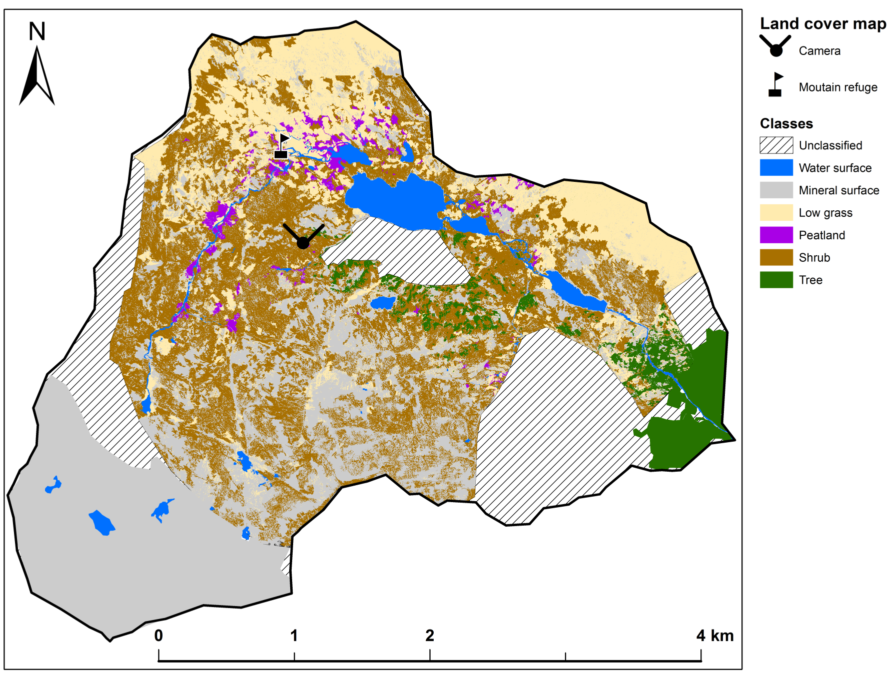

Figure 1: Land cover map of Bassies catchment.

2 Photogrammetric processing

2.1 ASP's parameters used to generate the DEMs from the Pleiades images.

We present in the following table the parameter set used to treat the flow of data through the Stereo Pipeline.

Stage	Parameter set	Selected parameter
Registration	ISIS adjust	No bundle adjustment
Stereo pre-processing	Pre-alignment options	Affine epipolar
	Intensity Normalization	Use entire input range
	Preprocessing filter	Laplacian of Gaussian
	Kernel size	prefilter-kernel-width 1.4
	Correlation Seed Mode	from disparity map
	Correlation number of pyramids	corr-max-levels 3
	Correlation sub seed value	corr-sub-seed-percent 0.25
Disparity map initialization	cost function	normalized cross correlation
	correlation kernel size	corr-kernel 25 25
	correlation window size	corr-search -80 -2 20 2
	Correlation time out	corr-timeout 600
Sub-pixel refienement	subpixel modes	affine window
	correlation kernel size	kernel 35 35
Outlier rejection / Hole filling	Fill in holes with an inpainting method	disable-fill-holes
	Automatic "erode" low confidence pixels	filter mode 1
		rm-half-kernel 5 5
		max-mean-diff 3
		rm-min-matches 60
		rm-threshold 3
Stereo triangulation	near-universe-radius	0.0
	far-universe-radius	0.0

2.2 Raw cloud from the snow-free Pleiades triplet

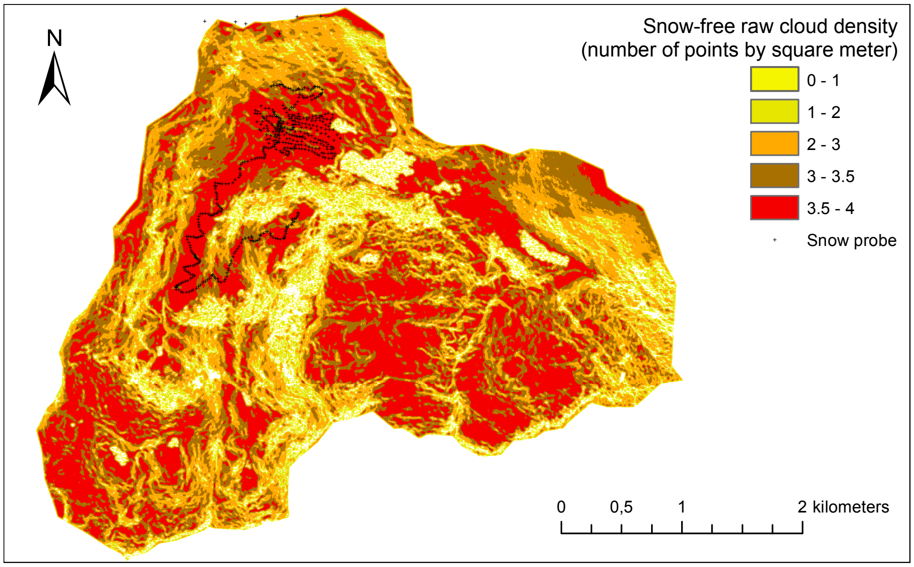

Figure 2: Density of the point cloud generated from the snow-free Pleiades triplet image (number of points per square meter).

2.3 Raw cloud from the winter Pleiades triplet

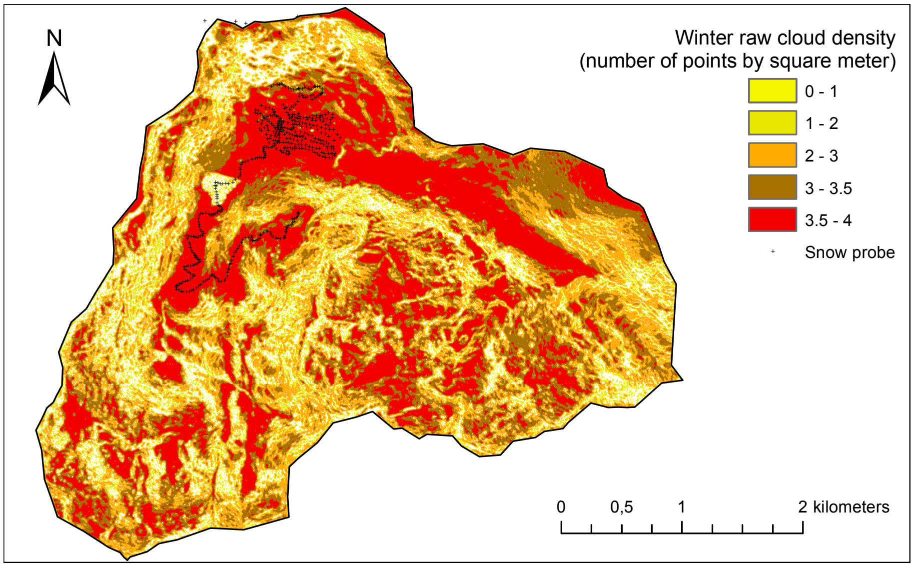

Figure 3: Density of the point cloud generated from the winter Pleiades triplet image (number of points per square meter).

3 Error assessments

The error on the DGPS measurements were provided during the post-treatment step by the GPS Pathfinder office software (V. 5.4). Such estimations are based on the GDOP associated to the positions (Geometrical Dilution of Precision, a measure of accuracy in 3-D position and time) and the distance to the correction base (21 km in our study). The error associated to the probe measurements are mainly due to penetration of the probe tip into the snow substrate, the reading between two probe spacing, and the verticality of the snow probe. According to the error propagation law, the errors terms due to the DGPS and the snow-probe measurements were estimated as follows:

- error term due to the DGPS measurements: $\sigma_{DGPS} = 0.1\ m$
- error term due to the probe measurements: $\sigma_{probe} = 0.15\ m$
- error term due to the DGPS and the snow-probe measurements:

$$\sigma_{DGPS+probe} = \sqrt{\sigma^2_{DGPS} + \sigma^2_{probe}} = \sqrt{0.1^2 + 0.15^2} = 0.18\ m. \tag{1}$$

We estimated the random error in the 2m-DEMs and the 2m-dDEMS based on the SD of the residuals terms (equation (1), (3) and (4) from section 4.1) as follows:

- 2m-Pléiades Winter DEM:

$$\sigma_{Zwinter} = \sqrt{SD^2_{R_{Z_w}} - \sigma^2_{DGPS}} = \sqrt{0.32^2 - 0.1^2} = 0.31\ m. \tag{2}$$

- 2m-Pléiades Snow-free DEM:

$$\sigma_{Zsnow-free} = \sqrt{SD^2_{R_{Z_s}} - \sigma^2_{DGPS} - \sigma^2_{probe}} = \sqrt{0.66^2 - 0.1^2 - 0.15^2} = 0.63\ m. \tag{3}$$

- 2m-Pléiades dDEM:

$$\sigma_{2m-dDEMPlei} = \sqrt{SD^2_{2m-\Delta Z\ Plei} - \sigma^2_{probe}} = \sqrt{0.58^2 - 0.15^2} = 0.56\ m \tag{4}$$

- 2m-UAS dDEM:

$$\sigma_{2m-dDEMUAS} = \sqrt{SD^2_{2m-\Delta Z\ UAS} - \sigma^2_{probe}} = \sqrt{0.62^2 - 0.15^2} = 0.60\ m \tag{5}$$

- 2m-Pléiades and UAS dDEMS differencing:

$$\sigma_{2m-\Delta(\Delta Z)} = \sqrt{\sigma^2_{2m-\Delta Z\ Plei} + \sigma^2_{2m-\Delta Z\ UAS}} = \sqrt{0.56^2 + 0.60^2} = 0.82\ m \tag{6}$$

4 Supplementary table

In the case where the Pléiades dDEM pixel values were higher than the maximum snow-probe value, $HS_{\max}$ (50 occurrences), the dDEM values are 40 to 50% of the cases also above this threshold. Even if the true HS is unknown, the mean of $|\Delta Z - HS_{\max}|_{HS_{\max}<\Delta Z}$ may be taken as an indication that the dDEM values are not inconsistent at this locations. The mean difference to the threshold value when the dDEM is below is 0.64 m.

In the case where the UAV dDEM pixel values were higher than the maximum snow-probe value, $HS_{\max}$ (32 occurrences), 81% of the UAV dDEM values are also above this threshold. The mean of $|\Delta Z - HS_{max}|_{HS_{max}<\Delta Z}$ varies from 0.57 to 0.69 m, according to the drone dDEM pixel resolution.

Table 1: Percentage of dDEM pixel values which exceed the maximum snow-probe value ($HS_{\max}$, 2.2 m and 3.2 m respectively, according to the type of the snow-probe). We also calculated the mean of the absolute difference between the dDEM value and $HS_{\max}$, in the cases where the pixel values were higher than $HS_{\max}$

Data source	Pléiades dDEM pixel size	Number of snow probe	Percentage of $\Delta Z > HS_{\max}$	Mean of $\lvert\Delta Z - HS_{\max}\rvert_{HS_{\max}<dDEM}$
Pléiades tri-stereo	1 m	50	50%	0.66 m
	2 m		40%	0.68 m
	4 m		40%	0.59 m
UAV	0.1 m	32	81%	0.69 m
	1 m		81%	0.57 m
	2 m		81%	0.66 m