Digital Surface Model of the eruption deposit at Cumbre Vieja volcano (La Palma, Spain) on 26-27 September 2021

Riccardo Civico[1], Tullio Ricci[1], Piergiorgio Scarlato[1], Jacopo Taddeucci[1], Daniele Andronico[1], Elisabetta Del Bello[1], Luca D'Auria[2,3], Pedro A. Hernández[2,3], Nemesio M. Pérez[2,3], María Asensio-Ramos[2], José Barrancos[2,3], David Calvo[2], David Martínez van Dorth[2,3], Eleazar Padrón[2,3], Antonio Álvarez[2], Carlo Doglioni[1]

1 Istituto Nazionale di Geofisica e Vulcanologia, Italy
2 Instituto Volcanológico de Canarias - INVOLCAN, 38320 San Cristóbal de La Laguna, Tenerife, Canary Islands
3 Instituto Tecnológico y de Energías Renovables - ITER, 38600 Granadilla de Abona, Tenerife, Canary Islands

Digital surface model of the Cumbre Vieja new volcano edifice and lava flows (La Palma, Spain) as of 27 September 2021, produced from 915 UAS derived aerial photographs using the Structure-from-Motion method.

The 2021 eruption of Cumbre Vieja volcano is the largest eruptive event in recorded history for La Palma Island (Canary Island, Spain). Over almost 3 months (September 19 - December 13, 2021), the volcano produced profound morphological changes in the landscape affecting both the natural and the anthropic environment over an area of tens of km^2.

Model shows numerous volcanic features including the new main edifice, lava flows, rafted material on lava flows, and tephra deposits.

Project Name: September 2021 Cumbre Vieja volcano eruption (La Palma, Spain) SfM DSM

Personnel
- PIs: Riccardo Civico, Tullio Ricci
- Contributors: Piergiorgio Scarlato, Jacopo Taddeucci, Daniele Andronico, Elisabetta Del Bello, Luca D'Auria, Pedro A. Hernández, Nemesio M. Pérez, María Asensio-Ramos, José Barrancos, David Calvo, David Martínez van Dorth, Eleazar Padrón, Antonio Álvarez, Carlo Doglioni

Dates of Collection: September 26-September 27, 2021

Site Information: Cumbre Vieja Volcano is part of a north-south trending rift zone located in the island of La Palma, Canarias, Spain. The area affected by the 2021 eruption is centered at 17.8972579°W, 28.6195191°N.

Site Conditions: Survey conditions varied during the fieldwork. The light varied between sunny and cloudy. The wind varied between light to strong breeze. In addition, viewing conditions were limited by the presence of vapour/gas plumes, and, at times, by atmospheric haze.

UAS Equipment and Data Collection Methods: We used a DJI Mavic 2 Pro to collect aerial photographs. We flew manually the UAS 100-400 m above ground level with both nadir and oblique camera angles. We collected aerial photographs on two days with varying light conditions.

Processing: We processed the photographs collected by the UAS into point cloud and DSM using Agisoft Metashape®. We set the processing parameters in Agisoft Metashape® to high for photo alignment accuracy and high quality and aggressive depth filtering for dense point cloud generation. We processed the Digital Surface Model (DSM) using the suggested resolution.

Georeferencing: The data on camera position were collected using GNSS information embedded in the image metadata. In addition, 17 ground control points (GCPs) were distributed along the outer boundary of the surveyed area to

establish survey control. GCPs coordinates were extracted from a pre-eruption 2m-pixel lidar-derived DTM (acquired in 2015 for the Spanish PNOA-LiDAR project) in areas not affected by the eruption.

Products: We generated a 0.5 m/pixel DSM covering an area of about 3.7 km^2. The dataset was processed and exported in the REGCAN95/UTM zone 28N [EPSG:4083] Coordinate System. According to the Agisoft Metashape® survey report the ground control points (GCPs) and check points error estimates are as follows: the total GCPs RMSE is 1.62 m and the total Check points RMSE is 0.59 m.

2021 Cumbre Vieja volcano eruption (La Palma, Spain) SfM DSM

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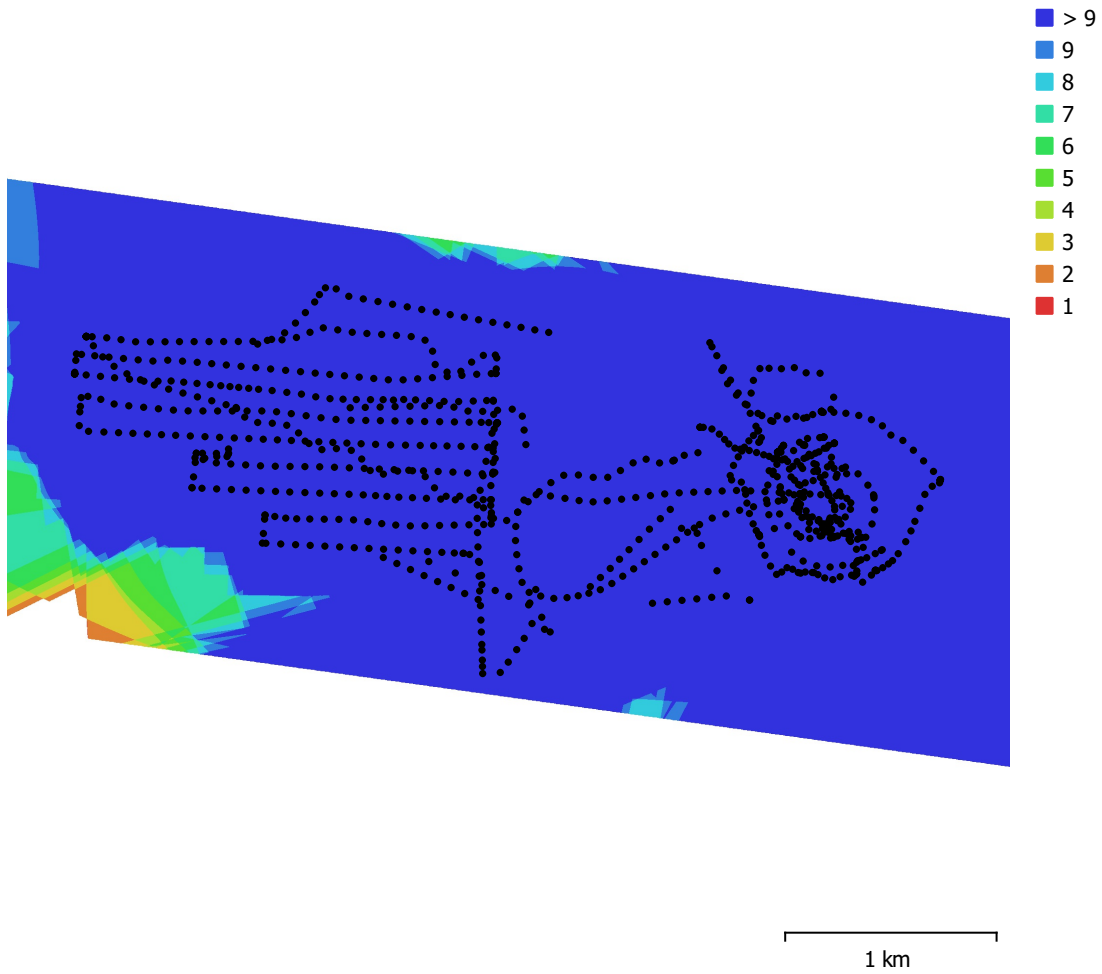
31 May 2022
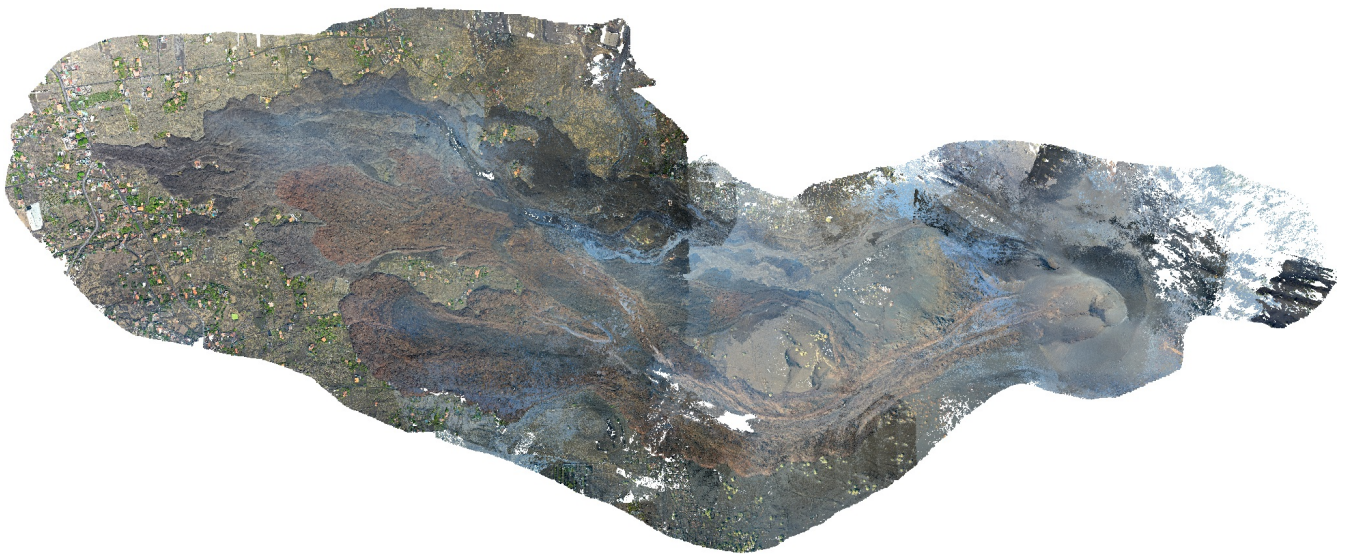
Survey Data

Fig. 1. Camera locations and image overlap.

Number of images:	915	Camera stations:	835
Flying altitude:	359 m	Tie points:	487,976
Ground resolution:	8.26 cm/pix	Projections:	1,692,493
Coverage area:	10 km²	Reprojection error:	0.597 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
L1D-20c (10.26mm)	5472 x 3648	10.26 mm	2.41 x 2.41 μm	No

Table 1. Cameras.

Camera Calibration
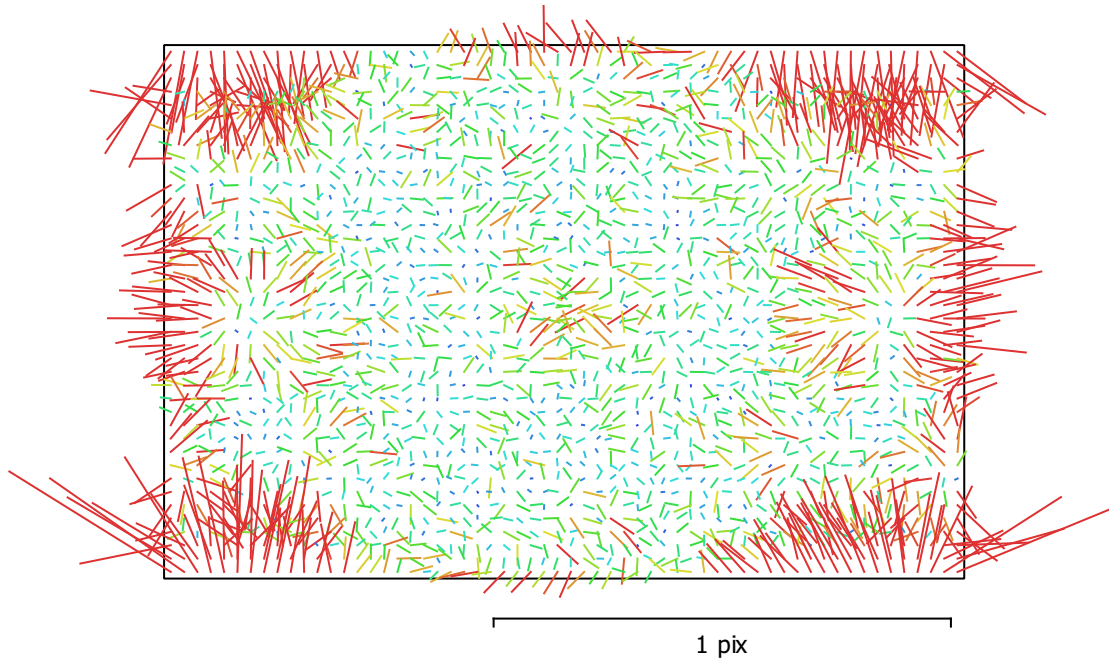
Fig. 2. Image residuals for L1D-20c (10.26mm).

L1D-20c (10.26mm)

915 images

Type	Resolution	Focal Length	Pixel Size
Frame	**5472 x 3648**	**10.26 mm**	**2.41 x 2.41 μm**

F:	4294.33		
Cx:	-5.77809	B1:	-1.37093
Cy:	9.27711	B2:	0.280416
K1:	-0.00314091	P1:	-0.000185248
K2:	-0.019791	P2:	0.000951649
K3:	0.0224969	P3:	0
K4:	0	P4:	0

Ground Control Points

Fig. 3. GCP locations and error estimates.

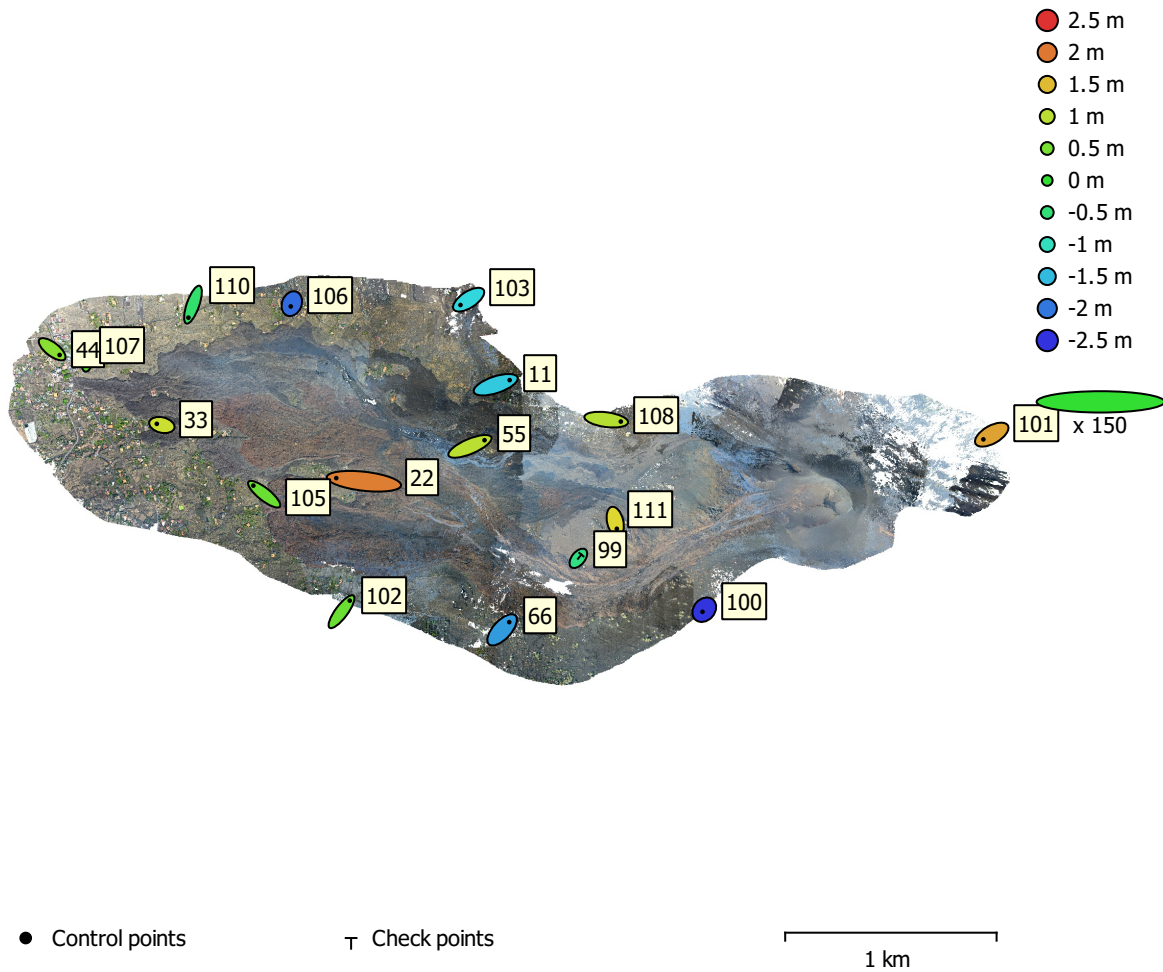Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.

Estimated GCP locations are marked with a dot or crossing.

Count	X error (m)	Y error (m)	Z error (m)	XY error (m)	Total (m)
15	0.703556	0.413316	1.40331	0.815979	1.6233

Table 2. Control points RMSE.

X - Easting, Y - Northing, Z - Altitude.

Count	X error (m)	Y error (m)	Z error (m)	XY error (m)	Total (m)
2	0.141474	0.364608	0.448565	0.391094	0.595118

Table 3. Check points RMSE.

X - Easting, Y - Northing, Z - Altitude.

Label	X error (m)	Y error (m)	Z error (m)	Total (m)	Image (pix)
11	0.879332	0.291545	-1.40399	1.68209	2.716 (10)
22	-1.74675	0.198549	1.94999	2.62546	0.600 (11)
33	-0.317949	0.0749629	1.11498	1.16184	0.944 (11)
44	0.470855	-0.361082	0.63025	0.865621	0.538 (9)
55	0.919885	0.389845	0.986205	1.40384	2.553 (12)
66	0.447536	0.488504	-1.73956	1.86145	1.189 (5)
100	-0.112085	-0.128659	-2.4787	2.48456	0.558 (4)
101	-0.527556	-0.29827	1.68537	1.79102	1.615 (6)
102	0.520269	0.697548	0.406433	0.960438	1.201 (4)
103	-0.514946	-0.33673	-1.29826	1.43667	0.944 (4)
105	-0.681111	0.541155	0.404192	0.959235	4.238 (14)
106	-0.0694497	-0.173776	-2.08962	2.09798	1.362 (11)
108	0.917248	-0.120995	0.954386	1.32922	1.550 (7)
110	-0.289189	-0.819915	-0.416833	0.964179	1.335 (16)
111	0.103894	-0.442704	1.29491	1.37243	1.285 (11)
Total	**0.703556**	**0.413316**	**1.40331**	**1.6233**	**1.994**

Table 4. Control points.

X - Easting, Y - Northing, Z - Altitude.

Label	X error (m)	Y error (m)	Z error (m)	Total (m)	Image (pix)
99	0.191636	0.2316	-0.58561	0.658257	1.010 (11)
107	-0.0574946	-0.460695	0.24389	0.524431	0.514 (12)
Total	**0.141474**	**0.364608**	**0.448565**	**0.595118**	**0.791**

Table 5. Check points.

X - Easting, Y - Northing, Z - Altitude.

Digital Elevation Model
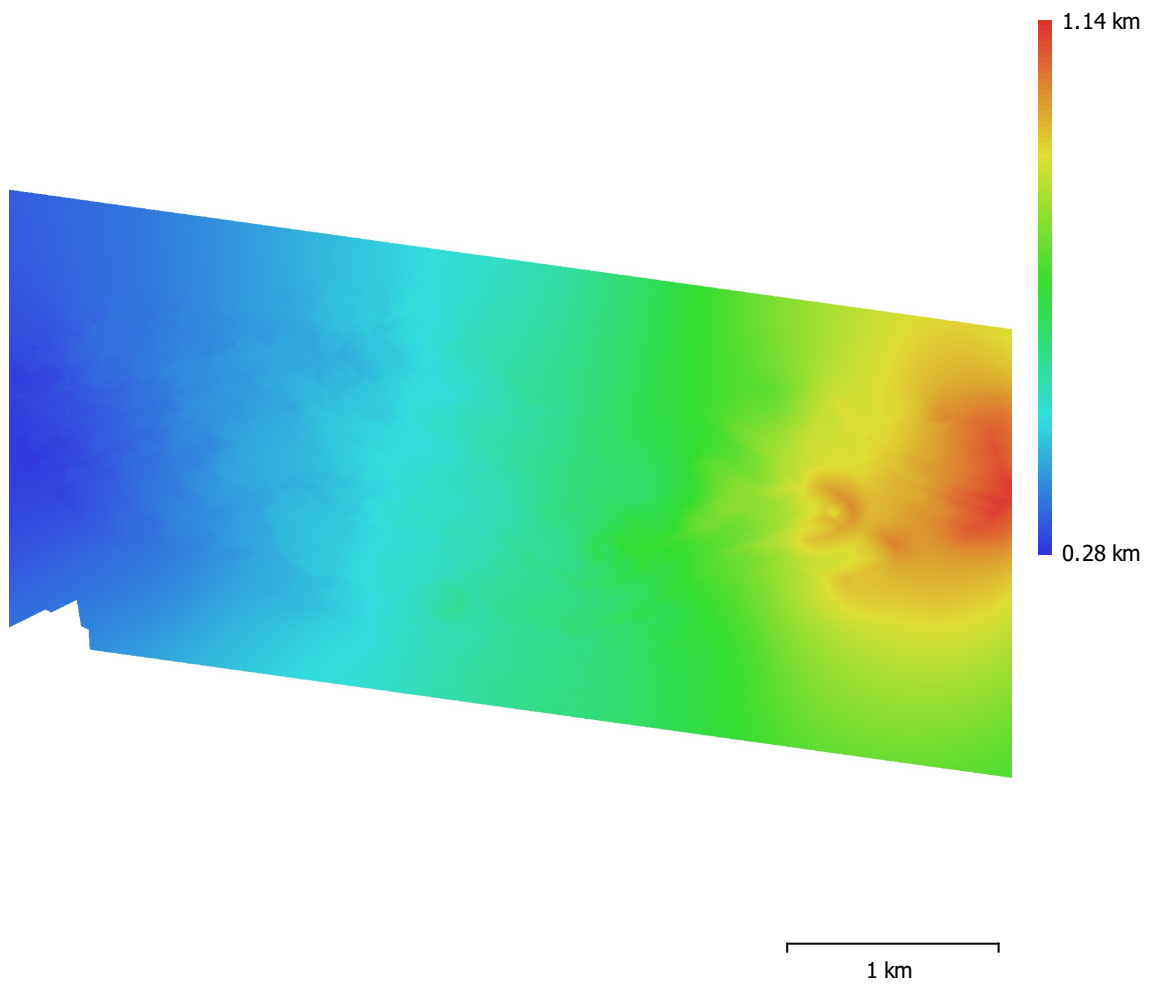

Fig. 4. Reconstructed digital elevation model.

Resolution: 16.5 cm/pix
Point density: 36.6 points/m²

Processing Parameters

General

Cameras	915
Aligned cameras	835
Markers	17
Coordinate system	REGCAN95 / UTM zone 28N (EPSG::4083)
Rotation angles	Yaw, Pitch, Roll

Point Cloud

Points	487,976 of 863,931
RMS reprojection error	0.195444 (0.597062 pix)
Max reprojection error	1.35612 (7.66412 pix)
Mean key point size	2.95992 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	3.79421

Alignment parameters

Accuracy	High
Generic preselection	Yes
Reference preselection	Source
Key point limit	40,000
Tie point limit	4,000
Filter points by mask	Yes
Mask tie points	No
Guided image matching	No
Adaptive camera model fitting	No
Matching time	7 minutes 21 seconds
Matching memory usage	618.37 MB
Alignment time	11 minutes 11 seconds
Alignment memory usage	900.02 MB

Optimization parameters

Parameters	f, cx, cy, k1-k3, p1, p2
Fit additional corrections	Yes
Adaptive camera model fitting	Yes
Optimization time	19 seconds
Software version	1.6.3.10732

Depth Maps

Count	829

Depth maps generation parameters

Quality	High
Filtering mode	Aggressive
Processing time	2 hours 9 minutes
Software version	1.6.3.10732

Dense Point Cloud

Points	191,708,941
Point colors	3 bands, uint8

Depth maps generation parameters

Quality	High
Filtering mode	Aggressive
Processing time	2 hours 9 minutes

Dense cloud generation parameters

Processing time	4 hours 16 minutes
Software version	1.6.3.10732

DEM

    Size   34,099 x 17,097

    Coordinate system   REGCAN95 / UTM zone 28N (EPSG::4083)

    Reconstruction parameters

        Source data   Dense cloud

        Interpolation   Enabled

        Processing time   9 minutes 47 seconds

    Software version   1.6.3.10732

System

    Software name   Agisoft Metashape Professional

    Software version   1.6.3 build 10732

    OS   Windows 64 bit

    RAM   63.83 GB

    CPU   Intel(R) Core(TM) i9-9900K CPU @ 3.60GHz

    GPU(s)   NVIDIA GeForce RTX 2080 SUPER