Bezymianny volcano 1967-2017 photogrammetric dataset (http://doi.org/10.5880/GFZ.2.1.2020.002)

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1. Licence

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3. Data Description

Decades of photogrammetric records at Bezymianny, one of the most active volcanoes on Earth, allow unveiling morphological changes, eruption and intrusion dynamics, erosion, lava and tephra deposition processes. This data publication releases an almost 7-decade long record, retrieved from airborne, satellite, and UAV platforms. The Kamchatkan Institute of Volcanology and Seismology released archives of high-resolution aerial images acquired in 1967-2013. We complemented the aerial datasets with 2017 Pleiades tri-stereo satellite and UAV images. The images were processed using ERDAS IMAGINE and PHOTOMOD software. Here we publish nine quality-controlled point clouds in LAS format referenced to the WGS84 (UTM zone 57N). By comparing the point clouds, we were able to describe topographic changes and calculate volumetric differences, details of which were further analyzed in Shevchenko et al. (2020, https://doi.org/...).

3.1. Sampling method and analytical procedure

The c. 5-decade-long photogrammetric record was achieved by 8 aerial and 1 satellite-UAV datasets. The 8 sets of near nadir aerial photographs acquired in 1967, 1968, 1976, 1977, 1982, 1994, 2006, and 2013 were taken with various photogrammetry cameras dedicated for topographic analysis, specifically the AFA 41-10 camera (1967, 1968, 1976, and 1977; focal length = 99.086 mm), the TAFA 10 camera (1982 and 1994; focal length = 99.120 mm), and the AFA TE-140 camera (2006 and 2013; focal length = 139.536 mm). These analog cameras have all an 18×18 cm frame size. The acquisition flight altitude above the mean surface of Bezymianny varied from 1,500-2,500 m above mean surface elevation, translating up to >5,000 m above sea level. For photogrammetric processing, we used 3-4 consecutive shots that provided a 60-70% forward overlap. The analog photo negatives were digitized by scanning with Epson Perfection V750 Pro scanner in a resolution of 2,400 pixels/inch (approx. pixel (px) size = 0.01 mm). The mean scale within a single photograph depends on the distance to the surface and corresponds on average to 1:10,000-1:20,000. Thus, each px in the scanned image represents about 10-20 cm resolution on the ground. The coordinates of 12 ground control points were derived from a Theo 010B theodolite dataset collected at geodetic benchmarks during a 1977 fieldwork. These benchmarks were established on the slopes of Bezymianny before the 1977 aerial survey and then captured with the AFA 41-10 aerial camera.

The most recent was a satellite dataset acquired on 2017-09-09 by the PHR 1B sensor aboard the Pleiades satellite (AIRBUS Defence & Space) operated by the French space agency (CNES). The forward, nadir and backward camera configuration allows revisiting any point on earth and was tasked for the acquisition of Bezymianny to provide a 0.5 m resolution panchromatic imagery dataset. In order to improve the Pleiades data, we complemented them with UAV data collected on 2017-07-29 with DJI Mavic Pro during fieldwork at Bezymianny.

3.2. Data processing

The software packages ERDAS IMAGINE 2015 v15.1 (Nelson & Khorram, 2018) and PHOTOMOD 5 (Adrov et al., 1995) were used for processing, allowing to perform interior and relative orientation of the aerial photographs, exterior orientation of the stereo models, triangulation, and DEM extraction (Granshaw, 2016). For the interior orientation, the analog cameras' focal length, frame size, lens distortion, and the position of the main point and fiducial marks were included. The relative orientation of adjacent photographs was performed automatically based on 25 tie points (Root Mean Square Errors (RMSE) = 0.1 pixels). The oriented stereo models were used to automatically extract points in the ERDAS Enhanced Automatic Terrain Extraction (eATE) module, which applies a normalized cross-

correlation algorithm with a window size set to 11×11 px, and with a correlation range of 0.2-0.7 for the highest pyramid level and the last pyramid, respectively. The obtained point clouds in LAS format were filtered in CloudCompare v2.9.1 (https://www.danielgm.net/cc/), with the noise filter tool, which resulted in an average number of points per point cloud of c. 300,000 for 5 km² (c. 0.06 points/m²). The resolution of final point clouds varies from 2 m to 30 m depending on the complexity of the surface. The average resolution of each point cloud varies from 4 m to 7 m.

We used ERDAS IMAGINE to process the three overlapping Pleiades images. We identified 45 automatically and manually tracked tie-points and used them for the relative orientation of the images (RMSE = 0.1 pixels). The exterior orientation was calculated automatically by employing the provided Rational Polynomial Coefficient data. Eventually, we extracted the DEM with the Erdas eATE module and subsequently filtered it with the CloudCompare noise filter. The final LAS point cloud has c. 10 million points for 60 km² (0.16 points/m²). Yet, the Pleiades images captured strong degassing and shadows, which caused a large gap in the point cloud along the western flank. But as we were fortunate to gather optical images of this area with UAV, we managed to fill the gap and improve the Pleiades dataset. We processed the UAV data set with Agisoft Photoscan 2018 (https://www.agisoft.com/downloads/installer), which is carried out by using the default settings for photo alignment (high quality with a 40,000 key-point and 1,000 tie-point limit), and dense cloud generation (high quality, aggressive depth filtering) in WGS84. Eventually, we merged both the Pléiades and the UAV derived point clouds with CloudCompare (RMSE = 0.8 points) and subsampled it to a spatial resolution of 2 m.

This data publication includes a description of the data (in pdf format) and the nine processed and controlled three-dimensional point clouds (in LAS format). The point clouds can be easily interpolated and imported into most open and commercially available geographic information system (GIS) software. Further details on data and data handling are provided in Shevchenko et al. (2020).

4. File description

4.1. File inventory

The ZIP file contains folder with individual point cloud data in LAS format from each date of aerial survey and satellite acquisitions, and description of these data in PDF format.

File name	File format	File size	Content
2020-002_Shevchenko-et-al_Bezymianny-volcano_1967-2017_data-description	PDF	864 KB	Description of data and methods
2020-002_Shevchenko-et-al_Bezymianny-volcano_1967_point-cloud	LAS	3.79 MB	Point cloud
2020-002_Shevchenko-et-al_Bezymianny-volcano_1968_point-cloud	LAS	3.82 MB	Point cloud
2020-002_Shevchenko-et-al_Bezymianny-volcano_1976_point-cloud	LAS	5.48 MB	Point cloud
2020-002_Shevchenko-et-al_Bezymianny-volcano_1977_point-cloud	LAS	5.80 MB	Point cloud

2020-002_Shevchenko-et-al_Bezymianny-volcano_1982_point-cloud	LAS	6.60 MB	Point cloud
2020-002_Shevchenko-et-al_Bezymianny-volcano_1994_point-cloud	LAS	5.70 MB	Point cloud
2020-002_Shevchenko-et-al_Bezymianny-volcano_2006_point-cloud	LAS	4.95 MB	Point cloud
2020-002_Shevchenko-et-al_Bezymianny-volcano_2013_point-cloud	LAS	5.04 MB	Point cloud
2020-002_Shevchenko-et-al_Bezymianny-volcano_2017_point-cloud	LAS	34.4 MB	Point cloud

4.2. Description of data tables

All LAS files contain the results of aerial data photogrammetric processing.

2020-002_Shevchenko-et-al_Bezymianny-volcano_1967_point-cloud.las

Column header	Unit		Description
Edge of boundary	North-east	55.9803, 160.6217	Latitude and longitude in WGS84 in decimal degrees
	South-east	55.9614, 160.6208	
	North-west	55.9808, 160.5800	
	South-west	55.9619, 160.5794	
Measurement XY	2,585x2,125		Value of XY in meters
Resolution	6		Average distance between points in meters
Acquisition date	1967-10-24		Date of aerial survey (yyyy-mm-dd)
Sensor	AFA 41-10		Analogue aerial camera

2020-002_Shevchenko-et-al_Bezymianny-volcano_1968_point-cloud.las

Column header	Unit		Description
Edge of boundary	North-east	55.9803, 160.6217	Latitude and longitude in WGS84 in decimal degrees
	South-east	55.9614, 160.6208	
	North-west	55.9808, 160.5800	
	South-west	55.9619, 160.5794	
Measurement XY	2,585x2,125		Value of XY in meters
Resolution	6		Average distance between points in meters
Acquisition date	1968-09-09		Date of aerial survey (yyyy-mm-dd)
Sensor	AFA 41-10		Analogue aerial camera

2020-002_Shevchenko-et-al_Bezymianny-volcano_1976_point-cloud.las

Column header	Unit		Description
Edge of boundary	North-east	55.9803, 160.6217	Latitude and longitude in WGS84 in decimal degrees
	South-east	55.9614, 160.6208	
	North-west	55.9808, 160.5800	
	South-west	55.9619, 160.5794	
Measurement XY	2,585x2,125		Value of XY in meters
Resolution	4		Average distance between points in meters
Acquisition date	1976-09-06		Date of aerial survey (yyyy-mm-dd)
Sensor	AFA 41-10		Analogue aerial camera

2020-002_Shevchenko-et-al_Bezymianny-volcano_1977_point-cloud.las

Column header	Unit		Description
Edge of boundary	North-east	55.9803, 160.6217	Latitude and longitude in WGS84 in decimal degrees
	South-east	55.9614, 160.6208	
	North-west	55.9808, 160.5800	
	South-west	55.9619, 160.5794	
Measurement XY	2,585x2,125		Value of XY in meters
Resolution	7		Average distance between points in meters
Acquisition date	1977-09-06		Date of aerial survey (yyyy-mm-dd)
Sensor	AFA 41-10		Analogue aerial camera

2020-002_Shevchenko-et-al_Bezymianny-volcano_1982_point-cloud.las

Column header	Unit		Description
Edge of boundary	North-east	55.9803, 160.6217	Latitude and longitude in WGS84 in decimal degrees
	South-east	55.9614, 160.6208	
	North-west	55.9808, 160.5800	
	South-west	55.9619, 160.5794	
Measurement XY	2,585x2,125		Value of XY in meters
Resolution	4		Average distance between points in meters
Acquisition date	1982-10-19		Date of aerial survey (yyyy-mm-dd)
Sensor	TAFA 10		Analogue aerial camera

2020-002_Shevchenko-et-al_Bezymianny-volcano_1994_point-cloud.las

Column header	Unit		Description
Edge of boundary	North-east	55.9803, 160.6217	Latitude and longitude in WGS84 in decimal degrees
	South-east	55.9614, 160.6208	
	North-west	55.9808, 160.5800	
	South-west	55.9619, 160.5794	
Measurement XY	2,585x2,125		Value of XY in meters
Resolution	6		Average distance between points in meters
Acquisition date	1994-10-01		Date of aerial survey (yyyy-mm-dd)
Sensor	TAFA 10		Analogue aerial camera

2020-002_Shevchenko-et-al_Bezymianny-volcano_2006_point-cloud.las

Column header	Unit		Description
Edge of boundary	North-east	55.9803, 160.6217	Latitude and longitude in WGS84 in decimal degrees
	South-east	55.9614, 160.6208	
	North-west	55.9808, 160.5800	
	South-west	55.9619, 160.5794	
Measurement XY	2,585x2,125		Value of XY in meters
Resolution	7		Average distance between points in meters
Acquisition date	2006-07-31		Date of aerial survey (yyyy-mm-dd)
Sensor	AFA TE-140		Analogue aerial camera

2020-002_Shevchenko-et-al_Bezymianny-volcano_2013_point-cloud.las

Column header	Unit		Description
Edge of boundary	North-east	55.9803, 160.6217	Latitude and longitude in WGS84 in decimal degrees
	South-east	55.9614, 160.6208	
	North-west	55.9808, 160.5800	
	South-west	55.9619, 160.5794	
Measurement XY	2,585x2,125		Value of XY in meters
Resolution	6		Average distance between points in meters
Acquisition date	2013-06-05		Date of aerial survey (yyyy-mm-dd)
Sensor	AFA TE-140		Analogue aerial camera

2020-002_Shevchenko-et-al_Bezymianny-volcano_2017_point-cloud.las

Column header	Unit		Description
Edge of boundary	North-east	55.9803, 160.6217	Latitude and longitude in WGS84 in decimal degrees
	South-east	55.9614, 160.6208	
	North-west	55.9808, 160.5800	
	South-west	55.9619, 160.5794	
Measurement XY	2,585x2,125		Value of XY in meters
Resolution	2		Distance between points in meters
Acquisition date	2017-09-09 and 2017-07-29		Dates of survey (yyyy-mm-dd)
Sensors	Pleiades-1B and DJI Mavic Pro		Satellite and UAV

5. Acknowledgements

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