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Structure-from-Motion applied to historical aerial photographs: parameter variability and application on landslide cyclonic evolution on France's La Réunion Island, Indian Ocean

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Geographical Surveys now distribute online their historical aerial photographs. The batches of digital images, holding the appearance and relief of the forever gone landscape, can be processed with automated Structure-from-Motion (SFM) photogrammetric pipelines. Are the results trustworthy? In this communication, we report the results of exploratory tests performed with Agisoft Metashape on sets of 1978, ~1/27.000, vertical aerial photographs from IGN-France over la Réunion volcanic island in the Indian Ocean. Georeferencing deliberately used ground control points and check points collected on IGN's web mapping portal. Validation was obtained from lidar and photogrammetric acquisition of 2015.

First, our results show that scanned photographs do not strictly map camera coordinates to image coordinates from one file to the next. Photos are slightly shifted and rotated on each scan. The photogrammetric assumption of a single camera per batch of images is thus violated. A preprocessing step, automated with Python, locates fiducials, computes camera principal point, rotates and crops the image file to a unique image reference frame. This feature is absent from Agisoft Metashape when fiducial coordinates are unknown.

Second, in the photogrammetric pipeline, camera calibration parameters are deduced from matched sparse points. The sensitivity of the "align" function was explored. The smallest RMS errors were ±7.03m for 11 ground-control points and ±5.45m for 9 independent check points when setting Align quality to "high" and a 4-parameters camera model using focal length (f), eccentricity (cx, cy), one radial distortion parameter (K1). A higher number of parameters delivered no accuracy improvement and correlated parameters. Intensive random sampling of sparse points subsets conducted to stable estimates of focal length and eccentricity. Improving the robustness of focal length determination would require additional, oblique photographs, which was not the spirit of historical survey design and were never acquired in past surveys.

Third, collecting ground control points on https://geoportail.gouv.fr resulted in digital surface model elevation accuracy within +/- 3.34m (Median Absolute Deviation). Validation was computed on a 2015 lidar digital terrain model at 5m resolution on stable grounds. Scanning artefacts, probably due to variable scanning velocity of the digitizing head, introduced elevation variation

stripes in Difference of DEM (DoD), parallel to the scanner direction. This pattern limits the detection of geomorphologically meaningful differences.

Fourth, a DoD between 2015-1978 for the Cirque de Salazie, in the north-east of La Réunion Island, highlighted landsliding masses active some time during the last 37 years and 13 cyclones. Beyond this proof of concept, archive aerial photographs in La Réunion go back until 1949 and covered the island twenty times. This time scale offers a welcome hindsight when producing landslide risk mitigation maps.

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