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# Use of full-frame sensors for height estimation of volcanic clouds

Klemen Zakšek (1,2), Klaus Schilling (1,3), Tristan Tzschichholz (1), and Matthias Hort (2)

(1) Zentrum für Telematik, Würzburg, Germany (klemenz@telematik-zentrum.de), (2) Uni. Hamburg, Inst. of Geophysics, Hamburg, Germany, (3) Uni. Würzburg, Informatik VII, Würzburg, Germany

The quality of ash dispersion prediction is limited by the lack of high-quality information on eruption source parameters. One of the most important ones is the Volcanic Cloud Top Height (VCTH). Because of well-known uncertainties of currently operational methods, photogrammetric methods can be used to improve VCTH estimates. But even photogrammetric methods have difficulties because appropriate data are lacking. Here we propose an application of full-frame sensors that are available on the new generation of small satellites. A full-frame sensor makes a 2D image in a fraction of a second and it does not require a satellite to move, as a typical push-broom sensor does. In addition, full-frame sensors usually provide a better spatial resolution than most operational satellite instruments, resulting in a shorter minimal distance between satellites to produce a suitable parallax. From such images, it is possible to reconstruct a volcanic plume in 3D using methodology Structure from Motion (SfM) using the following workflow.

1) Convert images to grayscale and use local adaptive Wallis filter to enhance texture in images. 2) Use SfM software for sparse 3D reconstruction, which includes pose estimation of the cameras, features detection, and features matching. 3) Densify 3D reconstruction, create a mesh and optionally cover it with texture. 4) Use a 7-parameters similarity transformation (based on the satellite's orbit) to geolocate the results.

The procedure has been tested with photos of 2009 Sarychev Peak eruption made by astronauts on the International Space Station (ISS), as a part of the NASA program Crew Earth observations. The estimated VCTH values are a bit larger than already published estimates. The presented work is just a pre-study of the forthcoming NetSat (planned launch at the end of 2017) and TOM mission (planned launch in 2019). These missions will provide VCTH based on simultaneous observations of clouds from different satellites – 4 (NetSat) and 3 (TOM) CubeSats will be flying in a pearl of strings or cartwheel formation. Both missions will fly on the height of 600 km with a distance of 100 km between two of them.