Geophysical Research Abstracts
Vol. 21, EGU2019-15649, 2019
EGU General Assembly 2019

Layer orientation measurements on virtual outcrops build from drone: techniques, accuracy and precision

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Measurements of the layer orientation is a key in geological mapping. With the development of 3D geological mapping the acquisition of numerous layer orientations is even more crucial. However, in many circumstances (i.e. roughed or remote terrain, other planet) outcrops can be difficult or impossible to reach. In such cases remote techniques may be used to produce "virtual" outcrops on which such measurements can be performed. The most straightforward technique is to measure the dip of a layer visible on an image draped on a DEM. This has been performed for example in the Andes (Riesner et al., 2017) and on Mars (Kneissl et al., 2011). However, the accuracy of the measurements highly depends both on the DEM and image resolution, and precision, and on the technique used (Quinn and Ehlmann, 2018). With the development of easy-to-use drones it is tempting to use such techniques not only from high resolution satellite imagery, but based on orthoimages and DEM computed from aerial photographs acquired with a Phantom 4 drone.
In this contribution we compare 16 bedding measurements performed on a large monoclinal limestone outcrop with a conventional technique (magnetic compass) with respect to measurements performed in three different ways from virtual images of the same outcrop acquired with a drone. The three different techniques used to calculate the layer surface attitude are: 1) from the x,y,z locations of three different points of the surface on the DEM; 2) from the x,y,z locations of three different points of the surface on the points cloud; 3) from the average plane fitting the points cloud of the surface (compass tool in the CloudCompare software). The results are also compared with the global attitude that can be calculated at the outcrop scale by fitting the intersection of a layer with the DEM to a single plane (LayerTools extension in ArcGIS). The comparisons are performed on two different outcrop virtual images: one constrained with differential GPS, in which case the precision is high but the measurements are superfluous, and another without GPS constraints that would corresponds to a remote outcrop.
This allow us to discuss which technique(s) is the more accurate and what precision can be expected from such measurements.

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