Monitoring 3D Surface Deformation of Physical Analogue Models using LiDAR Scanning

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Monitoring the surface evolution on physical analogue models is important for quantification of the model deformation. We present the application of LiDAR (Light Detection and Ranging) 3D scanning for monitoring the surface evolution of physical analogue models, complemented with digital imagery acquired during scanning.

Our previous work tested this approach for the first time on sandbox analogue models of geological systems with two model configurations, and sizes, representing specific tectonic settings: a convergent tectonic setting and a strike-slip tectonic setting.

Perspex parallelepiped boxes were used with four fixed walls (one basal and three laterals) and one mobile that worked as a vertical piston on the first model, or with two parallel basal plates with a step contact, where one remained fixed and the other was mobile attached to the back vertical wall, creating a strike-slip displacement with a restraining bend (second model). Initial sizes of model surfaces were 50 $\times$ 10 cm to 70 $\times$ 50 cm (length $\times$ width), respectively. On both models, the mobile walls were pushed by a computer controlled stepping motor at steady velocity, so deforming the models. Fine dry natural quartz sand from Fontainebleau was used as the analogue of brittle rocks. Sequential scanning of the models surface was performed during the models deformation and complemented with digital time-lapse image acquisition synchronized with LiDAR scanning, using an 18 MP camera orthogonally positioned to the models surface (top view), in order to monitor in-plane displacements and timing of the structures development. The previous work highlighted the results obtained for the smaller surface model, whereas here we highlight the results obtained for the large surface model (strike-slip model).

For each scanning, 3D point clouds were obtained and processed into 3D digital surface models (DSM) with high surface accuracy and resolution. With this set of DSMs, a time series of digital elevation models (DEM) was obtained for each analogue model allowing the quantification of the topography with high resolution and to analyse its evolution. Also, in-plane deformation quantification was obtained from the top view digital images and through the correlation of both sets of data, the timing of geomorphological expression and evolution during model deformation.

This work confirm that the LiDAR 3D scanning technique can be applied in laboratory to measure surface topography of physical analogue models with very good results regardless of their sizes.
and to monitor the topography evolution during deformation.

It also confirm that this combined monitoring method, the synchronized LiDAR 3D scanning and time-step digital image acquisition, can be used to measure the surface deformation of analogue models both vertical (topography) and horizontal (in-plane displacements).

Finally, this work shows new indoor employment possibilities for this technical equipment (LiDAR terrain 3D laser scanners), often available on Earth research institutions, which are generally used for outdoor measurements.

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