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LiDAR Scanning Application to Monitoring Surface Deformation of Physical Analogue Models

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Monitoring the surface evolution on physical analogue models is essential for quantification of the model deformation. We present the application of LiDAR (Light Detection and Ranging) 3D scanning to monitor surface evolution of physical analogue models.
This approach was tested on sandbox analogue models of geological systems with two different model configurations representing specific tectonic settings: a convergent tectonic setting and a strike-slip tectonic setting.
We used a Perspex parallelepiped box with four (one basal and three laterals) fixed walls and one mobile that worked as a vertical piston. On the strike-slip model, two basal plates with a step contact were used instead although only one was mobile together with the back vertical wall, creating a strike-slip displacement with a restraining bend. 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.
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 shows first of all, that the LiDAR 3D scanning technique can be applied in laboratory to measure surface topography of physical analogue models with very good results and monitor its topography evolution during deformation.
Secondly, it shows 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) or horizontal (in-plane displacements).
Finally, this may contribute to a new employment of technical equipment (LiDAR terrain 3D laser scanner) resources, often available on Earth research institutions, which are generally used for outdoor measurements.