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Geoscience Field: Geomorphology and Earth Surface Dynamics

Computing innovations with impact in our field

In the field of geomorphology, we are constantly trying to quantify rates and processes of Earth-shaping events (e.g. mass transport in floods, landslides, erosion) on the Earth's surface, but with limited measurements and study areas. We always want more - more frequency, synthesis, and trustworthiness - of measurements. I think the following two innovations allow us to acquire, reuse, and analyze more data, and ultimately to better support our hypotheses.

1) Tools like Google Earth Engine for (quickly) finding and analyzing patterns globally through time

Global Analysis of River Planform Change using the Google Earth Engine: A Bryk, W E Dietrich, N Gorelick, R Sargent, C A Braudrick https://agu.confex.com/agu/fm14/meetingapp.cgi#Paper/28715
"Geomorphologists have historically tracked river dynamics using a combination of maps, aerial photographs, and the stratigraphic record. Although stratigraphic records can extend into deep time, maps and aerial photographs often confine our record of change to sparse measurements over the last ~80 years and in some cases much less time. For the first time Google's Earth Engine (GEE) cloud based platform allows researchers the means to analyze quantitatively the pattern and pace of river channel change over the last 30 years with high temporal resolution across the entire planet."

(2) Tools for quickly obtaining 3D topography like Structure from Motion

Fonstad, M. A., Dietrich, J. T., Courville, B. C., Jensen, J. L. and Carbonneau, P. E. (2013), Topographic structure from motion: a new development in photogrammetric measurement. Earth Surf. Process. Landforms, 38: 421–430. doi: 10.1002/esp.3366
"Despite the range of available methods, the production of high resolution, high quality digital elevation models (DEMs) requires a significant investment in personnel time, hardware and/or software. However, image-based methods such as digital photogrammetry have been decreasing in costs. This test shows that SfM and low-altitude platforms can produce point clouds with point densities comparable with airborne LiDAR, with horizontal and vertical precision in the centimeter range, and with very low capital and labor costs and low expertise levels."

Science challenges that could benefit from innovations in IIS research

Challenges identified by our Research Coordination Network, Sediment Experimentalist Network (SEN)

(1) **Relating Experimental to Natural Systems: Scale Effects**

Laboratory experimental studies of sedimentary processes offer the great advantage of being able to control boundary conditions, precisely measure system evolution, and reduce process length and time scales. However, there is a danger that experiments do not faithfully reproduce natural systems which are at a much larger scale. Testing of scaling relations and comparison of large volumes of data from different experiments and natural systems would make progress on this challenge.

(2) **Autogenic vs. Allogenic Controls on Landscape and Stratigraphic Products**

A major challenge in Earth-surface research is decoupling the preserved signal of environmental (allogenic) forcing in landscape and stratigraphic records from those of internally-generated (autogenic) processes. A major stumbling block for distinguishing allogenic versus autogenic signatures in the morphologic and stratigraphic record is a lack of quantitative understanding of autogenic processes and their interactions with allogenic forcing. Example:

(3) **Reproducibility of experiments**

Even if boundary conditions are repeated to the best ability, natural variability may cause differences in the final outcome of experiments. Analysis and comparison of large volumes of data from different experiments would make progress on this challenge of defining the bounds of reproducibility.