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A network-based flow routing algorithm for point clouds: Facet-Flow Networks (FFN)

Aljoscha Rheinwalt (1), Bedartha Goswami (2), and Bodo Bookhagen (1)

(1) Institute of Earth and Environmental Science, University of Potsdam, Potsdam, Germany, (2) Potsdam Institute for Climate Impact Research, Potsdam, Germany

Flow routing algorithms estimate the flow on real or modeled topographic surfaces and are crucial for hydrologic and geomorphologic assessments, including delineation of river networks, drainage basins and sediment transport processes. Typical flow routing algorithms are designed to compute flows on regular grids and are therefore not directly applicable to arbitrarily sampled data. Existing algorithms have been evaluated against analytical flows on simple surfaces, but only for very high sampling densities. Despite these favorable conditions, grid effects are inevitable. In this study we propose a random sampling scheme to generate homogeneous point densities in combination with a novel flow routing algorithm that estimates the flow on triangulated surfaces. This minimizes biases due to spatial sampling and allows for direct flow estimation from point clouds. We first validate our algorithm on a Gaussian hill surface and study the convergence of its specific catchment area (SCA) compared to the analytical solution. Here, our algorithm performs better than the Multiple Flow Direction (MFD) algorithm, which is tuned to divergent surfaces. Second, we compute the SCA of a 6 km^2 steep and vegetated catchment on the Santa Cruz Island, California, based on airborne-lidar point cloud data. Catchment areas estimated by our method based on point clouds compare well with those estimated by the D_∞ or MFD algorithm on gridded data. The advantage of computing flow from point clouds becomes especially apparent on divergent topography and for small drainage areas: these are depicted with much more detail due to the higher sampling density of point clouds.