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What if the Earth is Not Flat?
Cross-Scale Analysis of Sub-Pixel Variations in Digital Elevation Models

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Digital terrain models guide scientists and planners in multiple ways and have fundamental impacts on society, safety and resource management. Terrain is currently modeled in a grid of pixels, assuming that elevation values are constant within any single pixel of a Digital Elevation Model (DEM) ('rigid pixel' paradigm). The assumption of rigid pixels generates basic spatial measurements that are in fact imprecise. In truth, terrain can bend, twist and undulate within each pixel, more similar to a continuous and flexible fabric. For localized areas or for very small pixel sizes, the amount of imprecision is insignificant, but can increase with larger pixel size and/or across regional or global expanses, as in the case with models of climate change, sea level rise, and other modeling applications, where pixels can span dozens to hundreds of kilometers. This research examines the sensitivity of surface adjustment to a progression of spatial resolutions (10, 30, 100, and 1000 meter DEMs), validating sub-pixel variations that can be directly measured from finer resolution LiDAR data. Tests will interpolate the elevation of 1,000 georeferenced random points using different methods (weighted average, as well as bi-linear, bi-quadratic, and bi-cubic polynomial fitting) and different contiguity configurations (incorporating first and second order neighbors), and conflate each resolution against a finer resolution LiDAR data benchmark. Additional tests will compute Root Mean Square Error (RMSE) between DEM and LiDAR to assess differences in various methods and resolutions. The paper will present results of the benchmark comparison for a number of study areas characterized by varying degrees of terrain roughness, along with guidelines for determining what terrain conditions and spatial resolutions dramatically modify elevation estimates, and which elevation estimation method(s) are more reliable for particular terrain conditions and particular pixel sizes.