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Comparison of different DTM resolutions for surface change calculations in a high mountain environment

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Working with high-resolution digital terrain models (DTMs) has become common practice for many geomorphologic and geomorphometric applications. Nowadays, with the up-come of Airborne Laser Scanning (ALS) and high resolution aerial photography, high resolution (1 m cell size or smaller) DTMs are available even for relatively large areas.
With those high-resolution DTMs, the terrain is represented in a high level of detail, which means that small objects can be recognized. But while an adequate description of the terrain is positive at first glance, a high-resolution DTM may result in a representation of the terrain surface which offers more detail than relevant for a specific research application. Therefore, the objective of this work is to identify an appropriate cell size, which allows to retrieve enough information while using a minimum of data, i.e. a cell size as large as possible.
The optimal cell size mainly depends on source point density, terrain complexity, and the scale of the intended application.
An extensive set of ALS data (19 flight campaigns) covering the Hintereisferner Region in the Ötztal Alps (Tyrol, Austria) is used to calculate differences in surface elevation for several geomorphological processes of different frequencies and magnitudes such as fluvial erosion, melting of dead ice or a rock fall. These calculations were done using DTMs with different cell sizes (from 0.25 m to 2.00 m with a step size of 0.25 m and from 2.00 m to 10.00 m with a step size of 1.00 m) and a point to point calculation as reference data set. The point to point differences are assumed to represent the actual changes of the terrain caused by the geomorphologic processes in the most accurate way. However, access to point data is not obligatory and if available, point data computing is not trivial and time consuming. In this study, a standard point to raster conversion method is used for the calculation of the DTM with different cell-sizes, which show the smallest differences between the raster and the ALS point data in three specific test areas (flat and plane, inclined and coarse, steep and coarse) . Hence, these DTMs are compared to the reference values, achieved from point to point computations. The calculations based on DTMs with smaller cell sizes show values closer to this reference. Furthermore the residuals and the standard deviation of the residuals increase with increasing cell size. It is also observed that – due to their dependency on particular topographies (inclination) and substrates – specific geomorphologic processes yield specific residuals and standard deviations.
On the one hand the results help to gain a better understanding of the influence of DTM resolution on calculations for surface changes in mountainous environments with a special regard to the effect of slope angle and surface roughness. On the other hand this work helps to evaluate the quality (in terms of surface accuracy) of freely available DTMs in various resolutions, which are often provided by public authorities.