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Potential of Airborne LiDAR in Geomorphology - A Technological Perspective

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Airborne LiDAR, also referred to as Airborne Laser Scanning, is widely used for high-resolution topographic data acquisition, offering a planimetric (<50cm) and vertical accuracy (<20cm) suited for many applications (e.g. in natural hazard management, forestry). Due to the direct determination of elevation and the penetration capabilities of the laser beam through gaps in vegetation, the LiDAR technology exceeds other methods such as stereo-photogrammetry or interferometric SAR particularly in vegetated areas. This contribution gives a review of recent developments of LiDAR systems but also advances in data processing, resulting in a higher data density and quality for geomorphological applications. Besides the elevation information most systems additionally record the strength of the received backscatter or even the full temporal distribution of the received energy (i.e. full-waveform). This radiometric information is a valuable parameter for further classification of the scanned areas, in particular for objects being not distinguishable by their geometry. In geomorphology airborne LiDAR data can either be used directly in the form of digital elevation data (e.g. digital terrain and surface model, original point cloud) and therein detected surface discontinuities (e.g. breaklines, lineaments) and forms (e.g. fans, rock glaciers), or indirectly by classification of surface features (e.g. vegetation and water) relevant for geomorphological processes. Furthermore, these datasets can be used for visual interpretation and mapping by experts or for automatic derivation of land-surface parameters by means of geomorphometry. With the availability of multitemporal datasets the investigation and quantification of dynamic processes becomes possible. Recent studies show the advantages by using full-waveform LiDAR system, which enable an improved echo detection and radiometric calibration of the received backscatter. The availability of additional echo attributes (e.g. backscatter cross section, echo width) makes sophisticated surface classification possible improving the quality of digital terrain models. On the processing side algorithms working directly on the three-dimensional point cloud including full-waveform information open up a new scale of investigation, even below the laser shot footprint diameter (e.g. <0.5m). Example applications that benefit from the state-of-the-art sensors and processing techniques are shown. Finally, the potential of future system developments for geomorphological applications are discussed, such as multispectral LiDAR systems, and their limitations from a practical point of view are highlighted.