Geophysical Research Abstracts
Vol. 20, EGU2018-7474, 2018
EGU General Assembly 2018

The role of micromorphology in snow cover accumulation: a comparison of terrain characteristics and UAV-acquired snow depth data

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In mid-mountain areas, where terrain varies moderately, wind characteristics and land cover are the dominating factors which determine snow accumulation and its distribution. It is also known that large- and medium-size terrain forms intrinsically control changes in snow depth, i.e. in concave forms snow tends to accumulate and, conversely, snow depths are often smaller within convex terrain features. However, in order to fully understand the impact of topography on snow accumulation it is necessary to consider the influence of terrain micromorphology. Namely, it is important to check if small terrain features – such as shallow depressions, small elevations, anthropogenic elements (e.g. draining ditch, roads) – control snow depths. This study aims to verify the research hypothesis that snow depth, mapped in detail in large cartographic scale, is driven not only by large- and medium-size terrain forms but also by small landforms. Novelty of our investigation lies in the use of unmanned aerial vehicles (UAVs) which became standard tools to reconstruct detailed terrain topography, with spatial resolution reaching a few centimetres. The high-resolution snow depth map can now be produced as a difference between the UAV-based digital surface model (DSM) of snow-covered terrain and the snow-free DSM. In addition, light detection and ranging (LIDAR) data are widely available in many countries, providing high-resolution (a few decimetres) elevation data. Combing the UAV-based snow reconstructions with LIDAR-based terrain derivatives enables to carry out new comparisons between snow depth and the underlying terrain features.

The research was conducted in southwestern Poland in the Izerskie Mountains which are a part of the Sudetes, the highest and extended mountain range northwards from Alpino-Carpathian chain in Central Europe, stretching along Polish-Czech border. The field experiment was carried out in Polana Izerska, an isolated meadow of approximate dimensions 250 x 170 m. The meadow is surrounded by coniferous forests. Elevations within Polana Izerska range between approximately 951 and 976 m a.s.l. We carried a series of UAV flights over Polana Izerska when snow cover occurred. We used the eBee UAV, manufactured by senseFly, equipped with Canon S110 RGB and Canon S110 NIR cameras. We used the novel, automated approach to reconstruct snow depth variability, which utilizes UAV-acquired oblique aerial images and processes them with the structure-from-motion (SfM) without the need for measuring ground control points (GCPs).

The research procedure is based on the comparison of the numerical snow depth maps with selected geomorphological and climatological parameters (TPI with modifications, land cover parameters, terrain roughness, wind effects, slope, aspect etc.).

The research is supported by the National Centre for Research and Development, Poland, through the project no. LIDER/012/223/L-5/13/NCBR/2014.