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Classification of Glacial Cirques in Slovenia

Klemen Cof[1], **Uroš Stepišnik**[1], Manja Žebre[2], and Matej Lipar[3]
[1]University of Ljubljana, Faculty of Arts, Department of Geography, Slovenia
[2]Geological Survey of Slovenia, Slovenia
[3]Anton Melik Geographical Institute, Slovenia

Slovenia is situated at the border of the European Alps, the Pannonian Basin and the Dinaric Alps. Over 90 % of its surface is covered by sedimentary rocks, of which nearly half are carbonate rocks such as limestone and dolomite. During the Quaternary extensive glaciations occurred here which reshaped the surface and formed typical glacial landforms such as moraines, glacial troughs and circular hollows called glacial cirques. Glacial cirques typically form at higher elevations underneath mountain ridges. They are often characterized by an arcuate planform and concave profile. The morphogenesis of glacial cirques is tied to the subglacial erosion of a rotational glacial flow which involves the plucking of underlying bedrock and abrasion of the cirque floor with the entrained sediment. The analysis of morphometric and morphogenetic properties of glacial cirques allows for the interpretation of the type, duration and intensity of glaciation as well as the paleoclimate during the time of the formation of glacial cirques.

Glacial cirques in Slovenia have yet to be systematically studied. The first step towards this is the identification and classification of glacial cirques. The identification was performed manually using key morphographic (arcuate planform, location near ridges) and morphometric (slope, curvature) parameters of glacial cirques and using the LIDAR surface data with a spatial resolution of 1x1 m from the Slovenian Environment Agency. In the first stage 129 potential glacial cirques were identified in the three Slovenian mountain ranges (the Julian Alps, the Kamnik-Savinja Alps and the Karavanke Mountains). Relevant morphometric data (slopes, curvature, dimensions, aspect, size, circularity…) were then calculated for the identified landforms. Using hierarchical clustering methods (Ward, Gower, minimum linkage, complete linkage…) and morphometric data multiple quantitative classifications of glacial cirques were made.

The obtained classification of glacial cirques in Slovenia was objective, statistically supported and founded on quantitative data and as such is potentially applicable to populations of glacial cirques elsewhere. There is still an unsolved dilemma regarding the objectivity and reliability of the manual identification of potential glacial cirques, which could possibly be solved by implementing machine learning. This could lead to a completely automated and impartial identification of glacial cirques.