CONNECTING GEODETIC MEASUREMENTS AND NON-METRIC IMAGERY FOR GLACIER MEASUREMENTS

Measuring Small Glaciers in Slovenia

Small glaciers in the Alps and elsewhere are important indicators of short-term local, and even global, climatic changes. Monitoring them usually involves measurements of the terminus retreat, the reduction of area and volume, and the velocity of glacier movements. Measurements of glaciers began in the Eastern Alps as early as 1878, when the first measurements were conducted on the Pasterze glacier (Austria) using a meter band. Regular tachymetric measurements were introduced on the same glacier as early as in 1928. Long-term glacier measurements show not only glacier changes over time but also how geodetic measuring techniques have evolved from classical to remote sensing technologies. While the new technologies enable more accurate measurements, they cannot cover the past glacier changes. This raises the important question of how to bring the old images into a common reference frame of new measurements. This article examines past and emerging approaches for glacial monitoring. The aim is to understand how these techniques and data might be integrated to support both historical and contemporary understanding of glacier changes.

Slovenia is home to two very small glaciers, and these are the most south-eastern glaciers in the Alps. Regular monitoring has been conducted on them for more than 60 years. Both glaciers, the Triglav glacier (Figure 1) and the Skuta glacier (Figure 2), are located at relatively low altitudes; their lowest points lie at the altitudes of 2,400m and 2,020m respectively. The Skuta glacier is an example of a small cirque glacier conserved in a very deep cirque, which protects the glacier by providing shade almost all year around. The Triglav glacier can be characterised as a small mountain glacier in the form of ice apron. Today, these two glaciers no longer display typical glacier characteristics such as glacier crevasses which result from the glacier's movement on uneven ground. Therefore, they can be regarded as glacier remnants. Crevasses were last observed on the Triglav glacier in 1955 and on the Skuta glacier in 1973. Then, the Triglav glacier measured over 10ha and the Skuta glacier a little less than 3ha. In comparison, at the end of September 2012, the Triglav glacier measured 0.6ha and the Skuta glacier 1.4ha (Figure 3).

Manual measurements and imaging

Systematic annual measurements of the Triglav and Skuta glaciers started in 1946. The measurements were conducted manually using meter band, rope and a compass to measure each glacier terminus's distances from and directions towards permanent points marked on the rocks around the glaciers (Figure 4a). From some permanent points, it was also possible to measure the vertical thinning of the glaciers.

During these expeditions, some non-metric images were also made from various standpoints using different cameras. Over the years, these standpoints became fixed and are still used today for annual imaging of the glaciers at the end of the melting season.

An additional regular monthly imaging of the Triglav glacier started in 1976 using a fixed panoramic Horizont camera from two fixed standpoints. A panoramic camera was chosen as it enabled the whole glacier to be covered in one single photograph. Unfortunately, classical photogrammetric stereovision cannot be applied since the views of the glacier from these standpoints are convergent.

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