DOCUMENTATION OF THE CREEP PROCESS OF WEISSENKAR ROCK GLACIER (CENTRAL ALPS, AUSTRIA)

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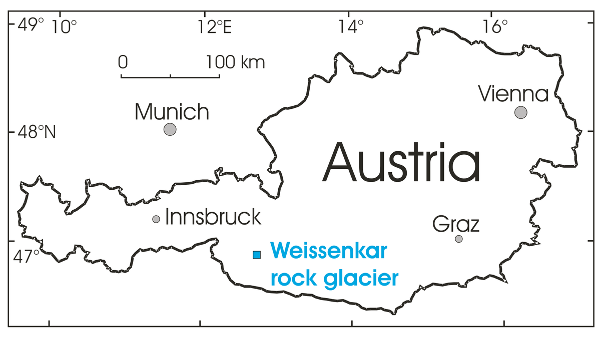
Abstract: Weissenkar rock glacier (46°57.5' N, 12°45' E) is situated in a glacially shaped cirque in the Schober Mountains of the Eastern Alps, Austria. The rock glacier creeps downslope at a comparatively low velocity of up to 11 cm/a. The creeping permafrost body has now reached a flat plateau-like area where its motion is retarded due to low inclination resulting in a very pronounced surface topography.
This poster is focused on the documentation of the kinematic state of Weissenkar rock glacier. Geodetic (1997-2001, 2003, 2004) and photogrammetric measurements (1974, 1998, 2002) were carried out in order to obtain quantitative information on surface deformation in general, and creep velocity and surface height change in particular. Results obtained are presented both numerically and graphically. An orthophoto map of the area of interest was compiled to provide a sound basis for cartographic work.
Finally, the kinetics of Weissenkar rock glacier will be discussed in respect to its morphology and its specific topographic situation.

Key words: Landslide monitoring, aerial photogrammetry, deformation measurement.

1. Introduction

Weissenkar rock glacier is situated in a west-exposed cirque nourished from active scree slopes beyond a steep, glacially shaped peak formed of crystalline rocks (Western Klammerkopf, 3126 m). The rock glacier mass creeps from the cirque (in which the existence of a Little Ice Age glacier is probable) to a quite flat plateau-like area composed of roches moutonees. These are remnants of transfluent ice transport from NE to SW across Goessnitzscharte (2732 m) during the periods of maximum ice extent in the Pleistocene. The lower limit of the rock glacier has an elevation of 2615 m, which is slightly above the mean value of this exposure in the Schober Mountains. Its dimensions (length some 500 m, maximum width 300 m) make it one of the larger rock glaciers of the Central Alps.

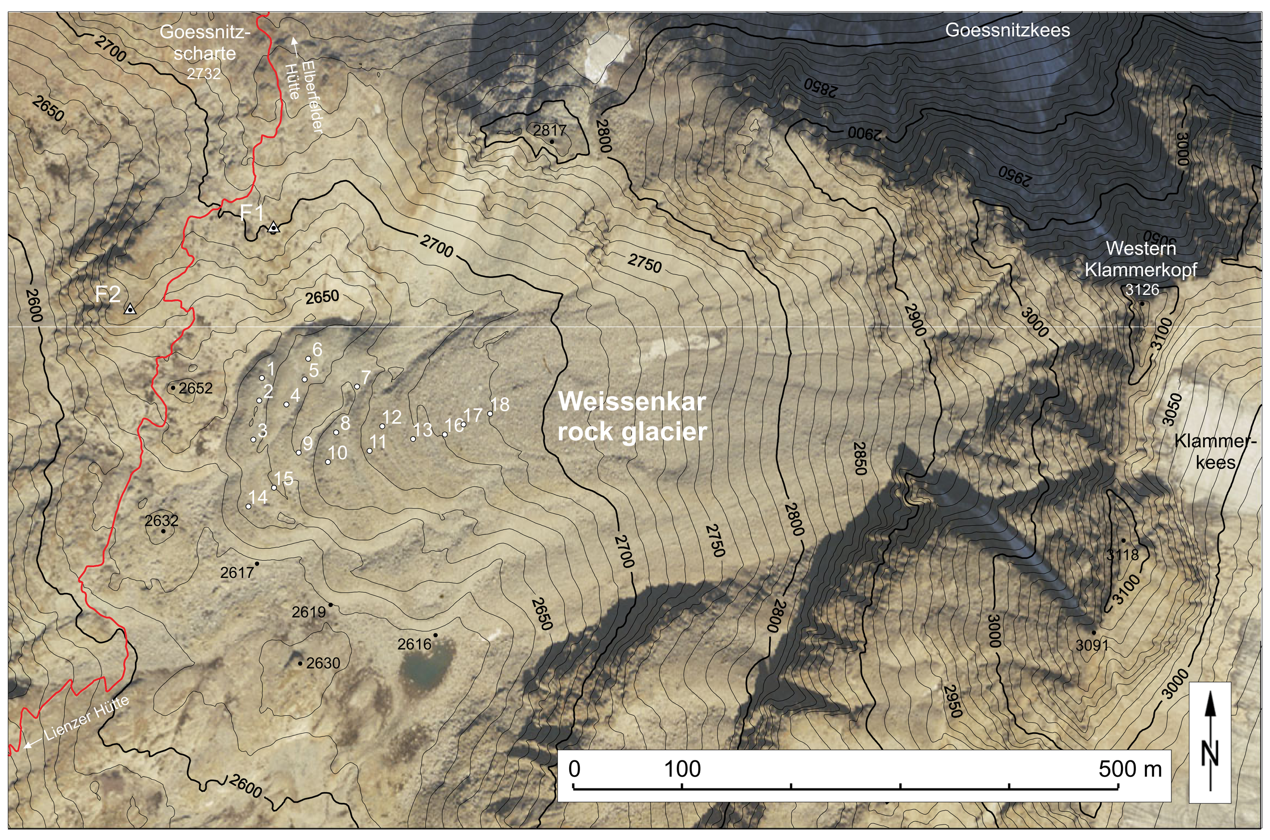


Panoramic view of Weissenkar rock glacier. Photograph taken in August 2004.

The viewing direction is from the geodetic refernce point F1 in a southerly direction.

2. Geodetic surveys 1997-2004

Two stable reference points, F1 and F2, were selected on bedrock northwest of the rock glacier. These points can be reached easily from the nearby hiking trail. All points were fixed with brass bolts driven into solid rock in 1998. This enabled the reflector to be placed directly on the bolt by means of an adapter. A total station (electronic theodolite) is used for the geodetic measurements, which are carried out from both positions, F1 and F2. GPS measurements were carried out in 1998 for better absolute positioning of the reference points. The geodetic measurements have been repeated every year since 1997, with one interruption in 2002. Point accuracies are in the order of 0.5-1 cm in planimetry and height. The annual measurements provide the basis for computing three-dimensional (3D) point displacement vectors. A cumulative vector plot of the moving surface points of the rock glacier is shown below.

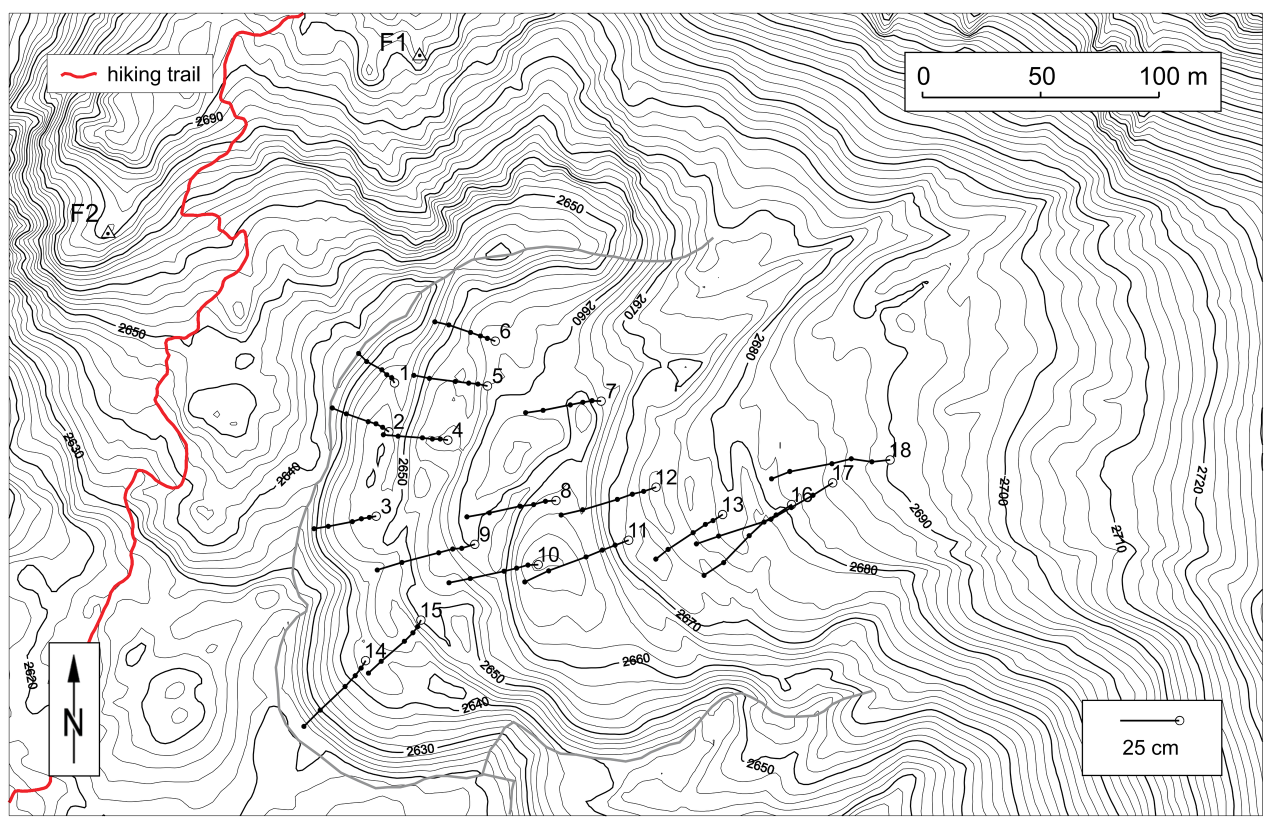


Orthophoto map showing Weissenkar rock glacier. F1 and F2 are geodetic reference points.

Points 1-18 are object points fixed by brass bolts on large boulders of the rock glacier surface.

The aerial photograph was taken on 18 September 2002.

Photograph (c) Amt der Tiroler Landesregierung, 2004.



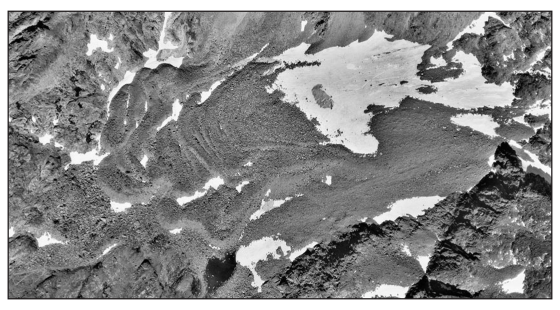
Horizontal movement of Weissenkar rock glacier for the time period 1998-2004.

The black dots of the horizontal flow/creep trajectory represent the positions of the object points at the time of measurements.

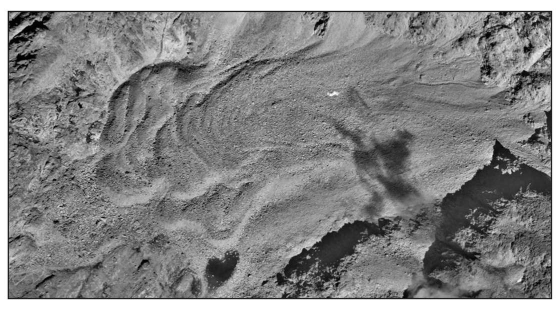
Note that the depicted displacements are exaggerated by a factor of 100.

3. Aerial surveys 1974, 1998, 2002

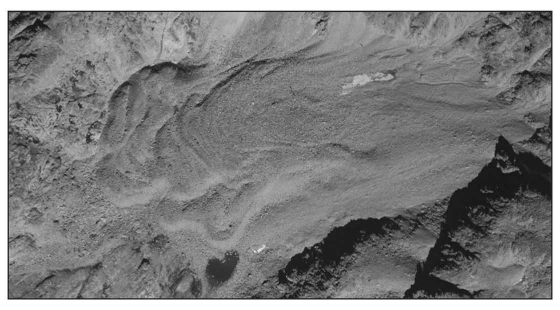
Large-scale photographs only were selected for further digital photogrammetric processing. The main task of the photogrammetric work was to derive a dense field of 3D displacement vectors for the time intervals 1974-1998 and 1998-2002 using our in-house developed software package ADVM (Automatic Displacement Vector Measurement). Furthermore, high-resolution DTMs for all three epochs were computed, and stereo orthophotos were prepared at 1:5,000 scale for visual interpretation.



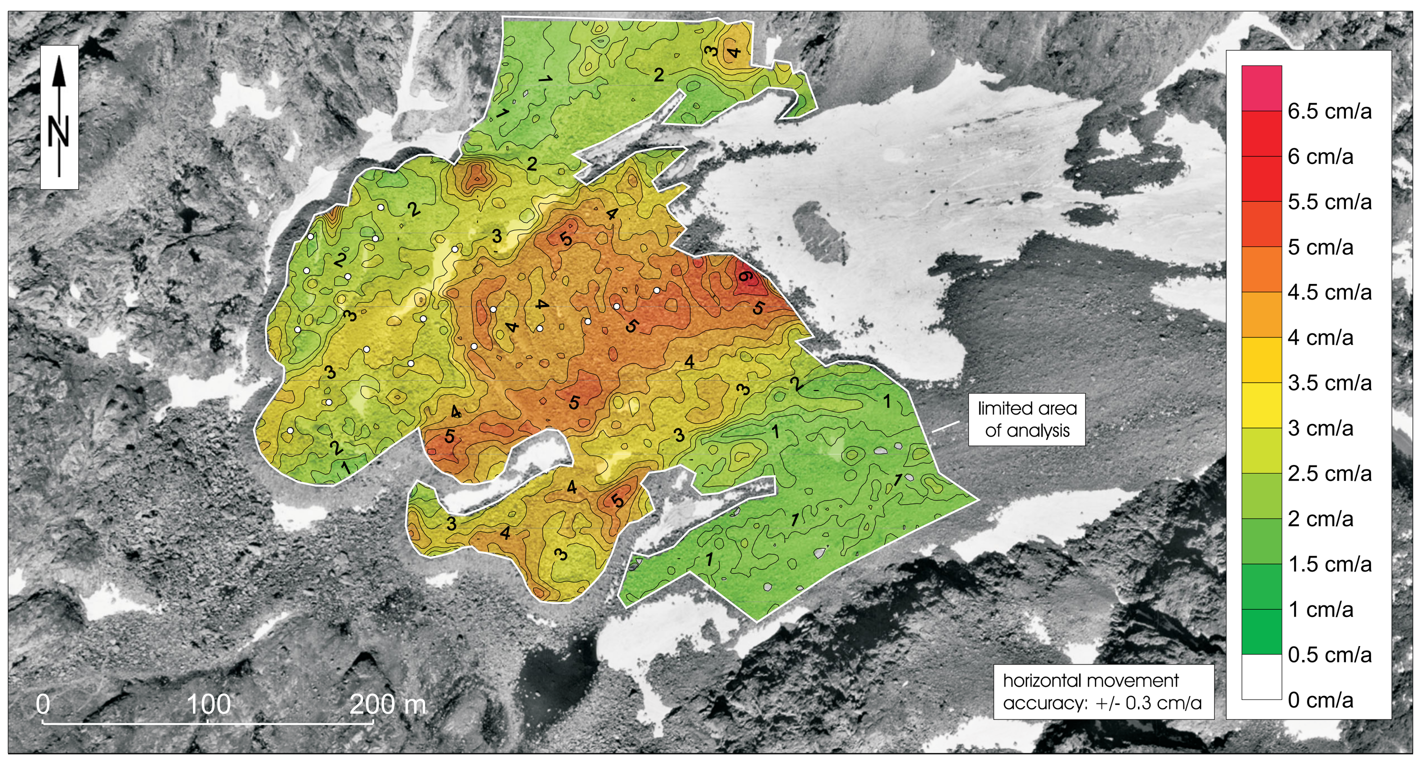
1974



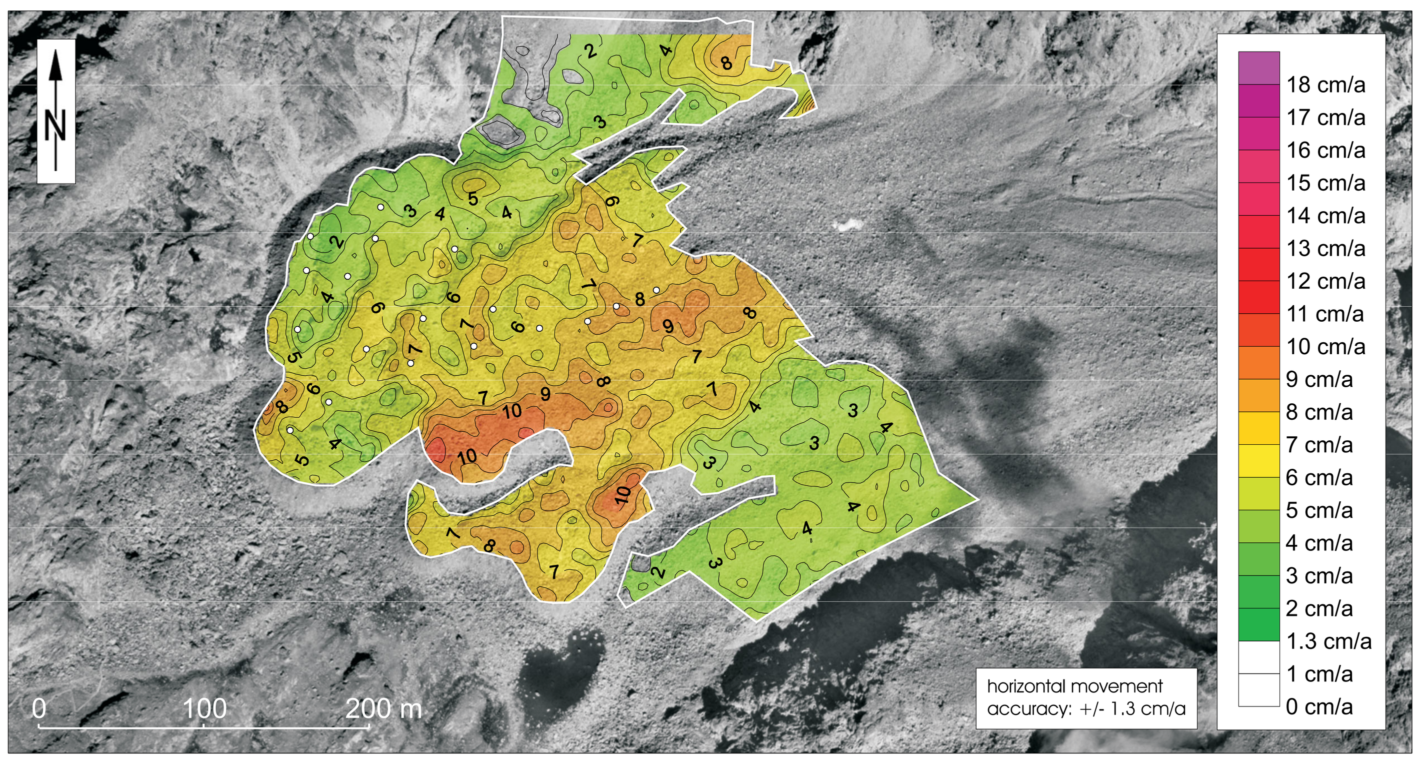
1998



2002

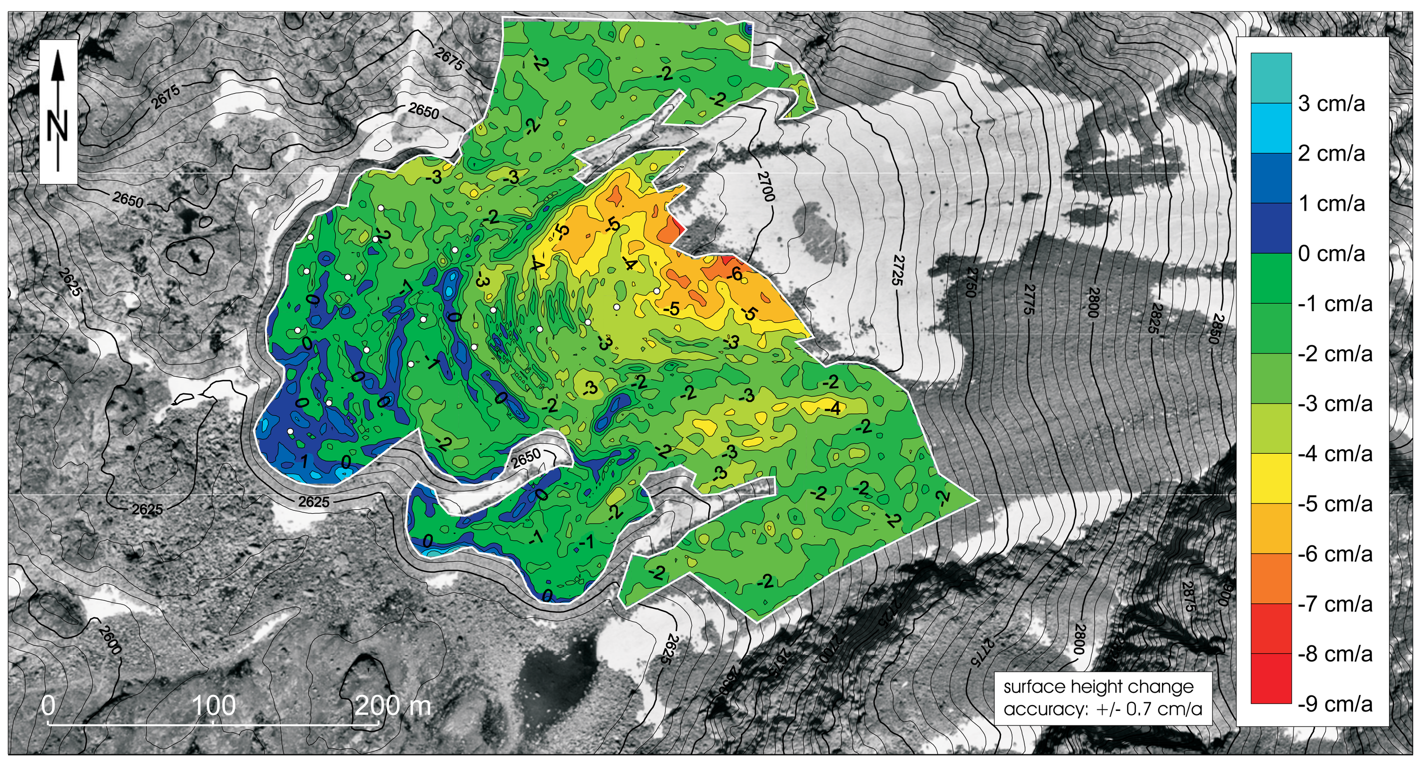


Mean annual horizontal flow/creep velocity for the time interval 1974-1998.



Mean annual horizontal flow/creep velocity for the time interval 1998-2002.

Notice that the color scales of the figures are different.



Mean annual surface height change for the time interval 1974-1998.

Surface height change has been derived from 3D displacement vectors and surface slope data assuming surface parallel flow.

4. Analysis

Geodetic measurements: The mean annual flow velocity (= average over 18 measurements) of Weissenkar rock glacier has increased significantly starting from 1999-2000. The 2003-2004 flow velocity is about 176 % of the value measured 4 years earlier. Photogrammetric measurements: Based on averaged values, a significant increase in flow velocity of about 93 % can also be deduced from the photogrammetric data. The change amounts to +2.6 cm/a.

5. Conclusions

It can be concluded that the flow velocity of Weissenkar rock glacier has increased significantly throughout all time periods for which measurements are available, i.e., from 3.2 cm/a (1974-1998) to 8.2 cm/a (2003-2004) based on averaged mean annual flow velocities observed at the 18 object points. The results of geodetic and photogrammetric measurements shown in this poster thus correspond very well with the morphological and periglacial observations. The horizontal creep velocities of the western lobe of the rock glacier are smaller (well pronounced in the period 1974-1998) than in the central and southern part. The overall pattern of horizontal flow velocities as well as the vertical changes shown corroborate the assumption of compressive flow.

Marked surface lowering was observed within the limits of the upper-most, younger lobe and especially at the location of a former perennial snow field. Overall surface lowering suggests permafrost degradation of -2 cm/a for the time period 1974-1998. Recent geodetic measurements (1998-2004) confirm the continuation of permafrost degradation. This statement is rather speculative, however, and is currently a matter of general discussion. The recent increase in surface velocity also remains to be explained.

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