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The functioning of Scott Glacier in conditions of climate global changes

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Introduction

North-western part of Wedel Larlsberg Land has become the site of comprehensive natural studies since 1986. They were connected with polar expeditions of scientists from Maria Curie-Skłodowska University in Lublin. At the study area, there have been systematic meteorological and topoclimatical measurements made and a review of hydrographical cartography during which the identification of way of alimentations of rivers were made, the extend of current glaciers and waterlogged areas and some patrol checks of water flow. Cartographical results were the basis of the choice of the drainage basin for further stationary studies. Among the group of glacial drainage basins as the basic object for studies the Scott Glaciers was chosen (Fig. 1).

A special attention in hydroclimatical research was paid to conditions of outflow, including the size and spatial diversity of ablation of the Scott Glacier (Bartoszewski et al. 2003). Possibilities of making those studies were seriously limited by their expeditionary character. It was impossible to observe some phenomena and processes systematically in full year periods. However the extensive material of measurement from ten-year period was collected. The length of the series was related to time-limits of beginning and finishing the expeditions. The range of time when the studies were conducted before the first decade of June and October. The basic material was consisted of hydrological data (water level in watercourse, flows in water-gauges and patrol measurements of flow) and meteorological (like temperature and air humidity, cloudiness, speed and direction of wind, fall and ground temperature at different depths).

Characteristics of study area

The drainage basin of Scott Glacier comprises of the area of 10.1 km^2 with the part of maritime plain (Calypsostranda) and partly glaciated mountain valley. The glacier covered 4.5 km^2 in 2006 which was 44.4% of the whole area. That type of valley glaciers is alpine and it fills almost the whole mountain valley surrounded by Bohlinryggen i Wijkanderberget (Fig. 1). The highest parts of the glacier reach 600 m a.s.l., and the front meets the height of 90 m a.s.l. The length of the glacier is 4 km, width of 1.1–1.8 km, and the mean decrease of the longer axe is 8°.

The Scott Glacier has well developed drainage system which brings water flowing down the surface, inside and under it. The system of drainage of the Scott Glacier is made by subglacial, inglacial and supraglacial streams of different size. In some exam-

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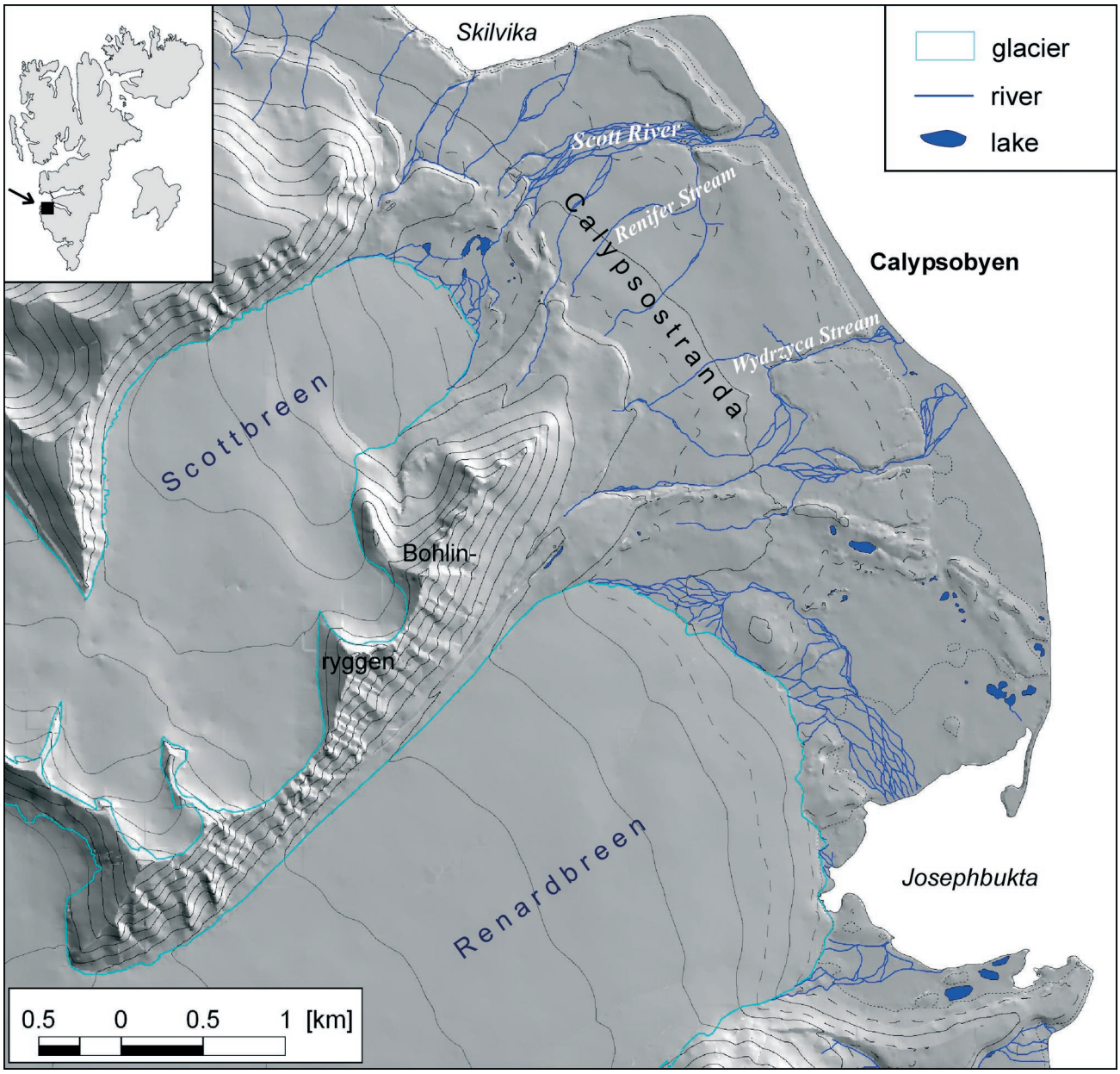

Fig. 1. Localisation of the study area (Zagórski 2002). The shadow relief map made on the basis of digital terrain model from the aerial photos of 1990 (Zagórski 2002)

ples the streams that cut the surface of the glacier vanish in glacial wells. Most of them group at the height of about 300 m a.s.l. in the zone of strong deformation of the bottom of the glacier. There is the rocky step linking two neighbouring mountain massives: Bohlinryggen and Wijkanderberget. A similar situation was also found in neighbouring valleys covered by Blomli i Tjørn Glaciers (Bartoszewski 1998). The system of drainage of the Scott Glacier can be considered as stabile and easy according to temporary studies.

The Scott Glacier, like most of Spitsbergen glaciers is at the stage of recession because of the removal of the fronts and changes of their longitudinal sections.

Being based on archival materials and GPS measurements, the recession of the Scott Glacier was characterised. It was stated that the intensivity of those processes is diverse in time. The information gathered during the analysis of changes of the range and geometry of that glacier confirm the negative balance of mass. In 1987–2002 the glacier was removed with the speed of 30 m a year, and its surface was being gradually lowered (Zagórski, Bartoszewski 2004). In the summer season of 2006 (3rd July – 31st August) the lowering of the glacier surface at the front was almost 2.5 m, and 1.0 m in the firn field. It was closely related to meteorological conditions.

Lowland part of the basin is built by lifted sea terraces of diverse height (Zagórski 2002). At the foreground, they were cut by erosion and aggradated with sandurs. The Scott River starts from a marginal lake that was created in an end depression between the

present front of the glacier and the front moraine, the waters from the side cracks, supraglacial outflow and numerous subglacial streams flow right into that depression. The Scott Glacier has one subglacial channel located in the central part of the glacier. A structure of the outflow, understood as a proportion of components in total outflow is a changeable phenomenon depending on time. In the first half of the polar summer the outflow of the origin of in-glacier component was much lower than the mean what was the result of intensive ablation of superficial snow cover in the lower and middle part of the glacier.

Through the gorge of the moraine ridge, glacier water flows onto sandur where the river makes wide braided system. That system means considerable stability at least during some years. Easter part of the drainage basin is drained by little streams of snow-permafrost origin of supply. The biggest of them is The Renifer Stream (Fig. 1). A water-gauge in the Scott River is located 200 m above the mouth to a fiord, in the middle part of the gorge. The length of the river to that place is 2.56 km and the mean decline is 35‰.

Results and discussion

Hydrographical studies in the Bellsund regions allow us to state that so called active hydrological period, with the phenomenon of river outflow, last for about four months. It begins in June with spring freshet caused by melting out of snow cover on maritime plains, and finishes at the beginning of October with the end of melt-out of glaciers and permafrost. Processes of polar drainage basins show clear seasonal differentiation thanks to which it is possible to distinguish some periods of special hydrological features. The detailed characteristic of that phenomenon has been presented in publications of Paulina's team (Pulina et al. 1984, Pulina 1986).

It is characteristic for glacial rivers during polar summer, that they have huge dynamic of outflow. It can be one supporting example – presence of violent freshet of ablation-rain origin. The single outflows during the freshet cumulation of the Scott River exceed 1200 $dm^3\ s^{-1}\ km^{-1}$. Specific feature of glacier rivers during rainless periods is twenty-four hours rhythm of flow as the effect of thermal and ablation cycle (Bartoszewski et al. 2006).

Hydrographical and climatological studies were conducted in 2006, between 1st July and 31st August. During that period of studies, the mean twenty-four hours air temperature was 4.9°C. The highest mean temperature was +7.8°C on 23rd July, the lowest was 2.8°C on 31st August. Absolute maximum air temperature at the height of 200 cm was 10.1°C on 23rd July, while the absolute minimum was 0.0°C on 31st August. Total of meteorological fall for the whole measurement period was 41.7 mm. The number of days with the fall was 29 (it is 47% of all days) with 11 days with the fall ≥1.0 mm. The highest fall was 8.6 mm on 25th August (Fig. 2).

The volume of outflow in summer season (6.4 mln m^3) was similar to one recorded in previous years (Bartoszewski et al. 2006). The mean flow was 1201 $dm^3\ s^{-1}$, what is correspondent to specific runoff index of 118,6 $dm^3\ s^{-1}\ km^2$. That time the runoff was 636 mm. The studied period was characteristic of no major freshets. Flows range was between 574 and 2719 $dm^3\ s^{-1}$ (Fig. 2).

The biggest freshet was on 26th August – the day after the highest fall. All rainfalls of twenty-four hours totals over 1.0 mm influenced the rise of flows.

The lowest flow of the Scott River on 31st August was connected with the fall of air temperature. The previous day and the day of the minimum flow, the temperature below zero (-1,5°C) was measured near the surface of the ground.

Twenty-four hours rhythm of discharge shows the influence of twenty-four hours run of air temperature at the height of 200 cm a.g.s. (Fig. 3). The maximum flow of the Scott River is about four hours after the thermal maximum.

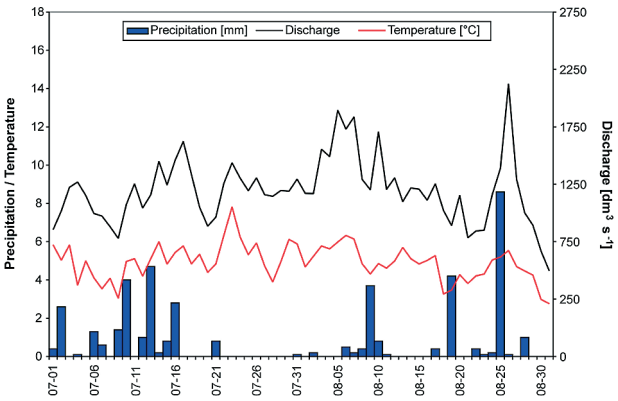

Fig. 2. The discharge of the Scott River, the precipitation and the temperature in Calypsobyen in 2006 summer season

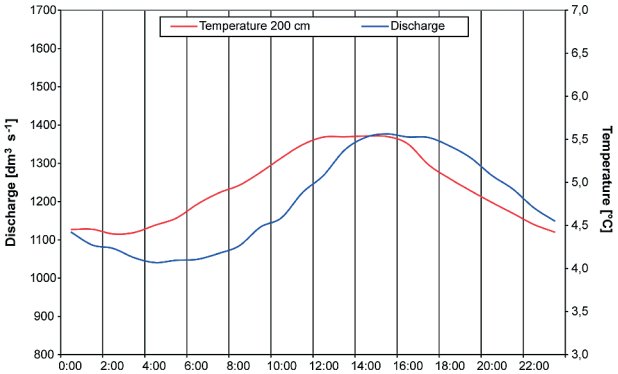

Fig. 3. Twenty-four hours rhythm of the discharge of the Scott River and air temperatures (200 cm above ground level)

Summary

Expeditionary character of hydrographical studies makes difficult the evaluation of the magnitude of the mean outflow from the analysed drainage basin. The registration of the outflow contained only part of the active hydrological period and the length of measurement series at certain years was diverse. On the basis of a series of ten summer seasons the factor of the outflow can be evaluated at about 900 mm.

The regime of the outflow of the Scott River is conditioned by the set of factors of which the most important is meteorological conditions, especially of an course of air temperature and precipitation in accumulation and ablation seasons. The analysis of meteorological conditions results that all freshets of the Scott River in the season of 2006 were of rain-ablation character.

The character of collected data makes difficult to do the equation of the water balance for the Scott drainage basin. Analysing the changes of geometry of the glacier it can be supposed that the size of the outflow exceeds the fall and the total is negative for years.

Acknowledgment

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