MONITORING OF DYNAMIC MOVEMENTS OF HANS GLACIER CONTROL POINTS USING SMARTSTATION

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1. ABSTRACT

The paper presents the results of investigations on the Hans glacier on Svalbard. The Artic conditions required the application of a very specific surveying technology to make surveys of displacements of an extensive and fast changing object. The technology that was implemented should combine observations made on extended areas (GPS) with classical observations of high precision. The SmartStation equipment which has been used to conduct the experiment of monitoring dynamic movements of a group of points situated on the Hans glacier fulfills this requirement. The surveys (quasi-continuous) were conducted in a period of three days. The paper contains the results of surveys as well.

2. SVALBARD

Svalbard (Cold Land) Archipelago with Spitsbergen as its biggest island is situated between 80°28' and 76°28' latitude north and 10°28' and 28°50' longitude east. It is one of the northernmost lands.
Spitsbergen is characterized by extremely changeable atmospheric conditions. They exert a considerable influence on measurement results, that is why measuring techniques have to be adjusted accordingly. The decisions in this respect are supported by our knowledge of polar conditions and experience gained during the field research. Climatic conditions favour massive ice accumulation in the form of glaciers flowing down from mountainous areas, often directly into fiords.

3. HISTORY OF GEODETIC RESEARCH ON THE HANS GLACIER

The history of geodetic research on the Hans glacier is several dozen years old. It is one of the few Arctic glaciers under continuous observation. The measurement techniques used, to a large extent, depend on currently available technologies. The basic measurements concern surface motion, front range and changes in the glacier density. Only a few years ago dominated classical techniques of measurement based on theodolites and electronic distance meter. Photogrammetric methods also proved to be very functional. Their main merit is supplying surface rather than point information. Owing to this technology we are still able to define the height of the glacier front and its range. All the research has a common purpose - to define the characteristics of ice movement over different seasons of the year and under different atmospheric conditions. Typical geodetic techniques were supplemented by digital photogrammetric methods including movement animation. However, they are less precise techniques but

rather more interpretative in character. At present, geodetic space measurement techniques are being introduced. The most recent ones combine GPS and EDM observations.

Fig. 1. Bird's eye view on Hans glacier

4. HYBRID TECHNOLOGY

Combining observations from different measurement techniques, e.g. satellite and classical, and supplementing them with data from other sensors, e.g. inclinometers, weather stations, etc. as well as great progress in information technology allowed to build hybrid monitoring systems. The systems are based on modern technologies which change or are equipped with new possibilities, supplemented by observations of different objects and phenomena both physical and natural. The observation set SmartStation TCRP 1202 by Leica GeoSystems is a good example of hybrid technology (fig.2).

Fig. 2. SmartStaion on the reference point

5. PROJECTING AND PERFORMING THE RESEARCH

In most research, by planning and performing experiments we either prove or disprove the thesis proposed for theoretical deliberations.
Research of many years shows that a glacier attains its greatest speed in its main stream. The movement of range poles evenly placed all over the glacier surface is constantly monitored. The purpose of our experiment was to define the movement of selected points on the glacier using hybrid technology. The instrument position was chosen so as to enable simultaneous observation of (control) points on the glacier and points situated on the slope of the Fugleberget mountain (stable points 107 and 108).

The equipment used had a long measurement range coinciding with highly precise observations. GPS measurements were carried out at the stand as well as observations with reference to resistance points. It enabled to determine the real position of the instrument and its orientation. This concept allowed to obtain information about the station movement from two independent sources. Due to continuous observations and incredibly difficult atmospheric conditions it became necessary to use an appropriate technique. The SmartStation seems to fulfill these requirements.

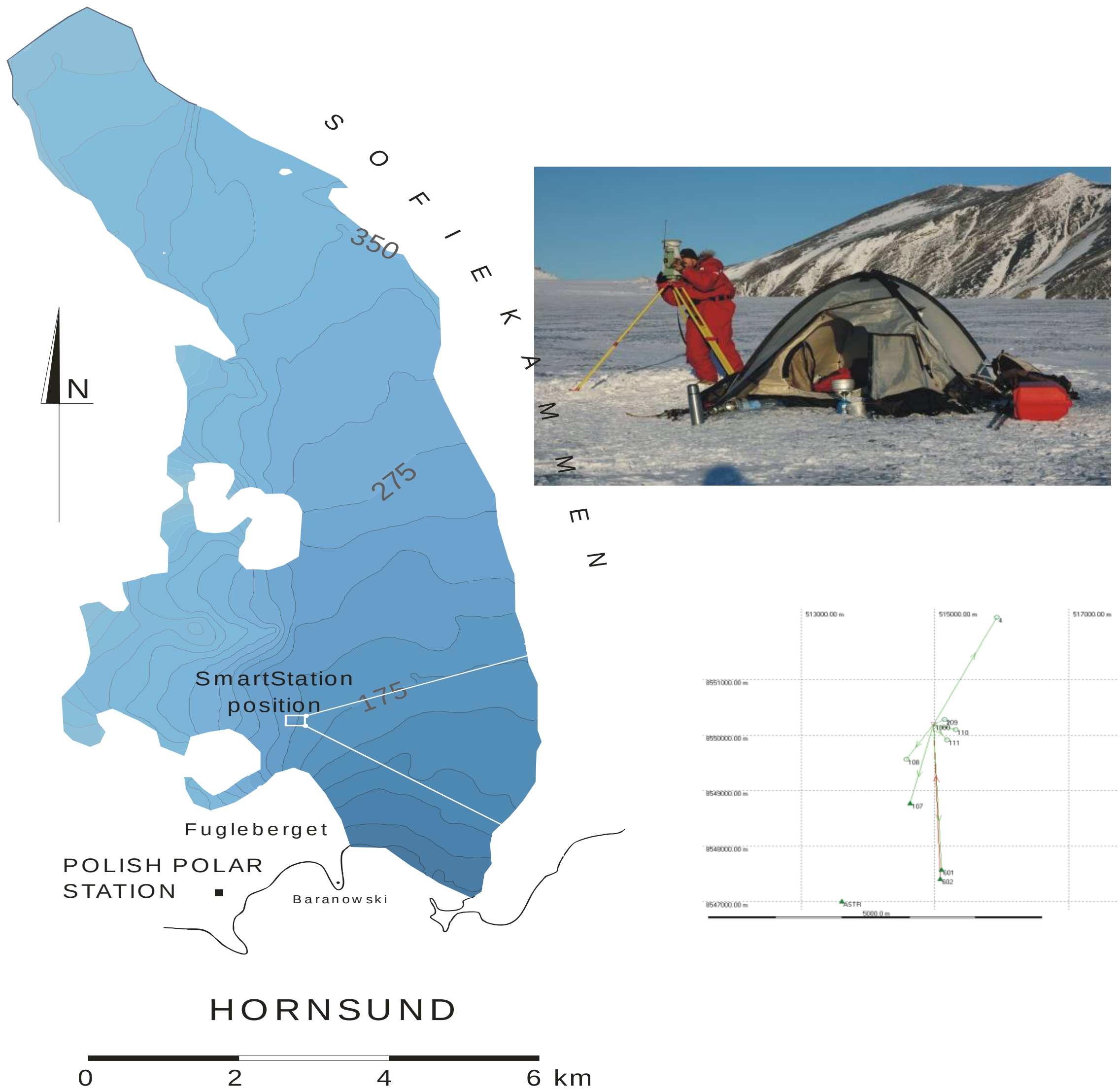


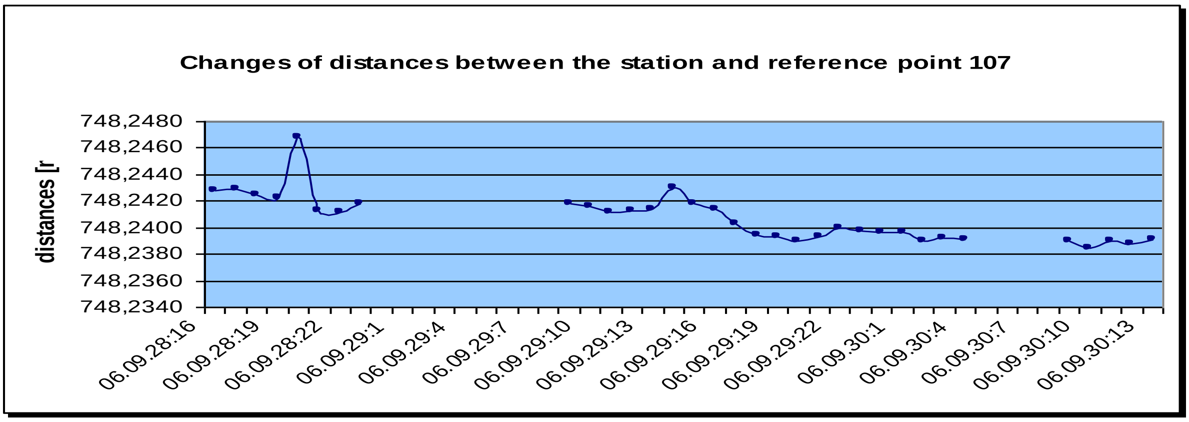
Fig. 3. Sketch of the network

Under these conditions, the used technology required adequate logistic support. The GPS reference station was positioned at one of the points of the photogrammetric base, pt.602, at Cape Baranowski. Point 601 of the base acted as a control point of reference. The reference stations sends an adjustment to the Smart system working in the RTK mode. The poles were fitted with prism reflectors for classical measurements with a TCRP 1202 instrument included in the SmartStation set. The Automatic Target Recognition (ATR) function possessed by the instrument was very helpful during night observations. Mainly due to this option, quasi-continuous monitoring was carried out over three days at one-hour intervals. At that time 34 observation series were carried out including 5 independent position measurements of the station (GPS-RTK).
Difficult ground conditions, i.e. high air vibration , strong sun ray reflection from the glacier surface and very low temperatures at night had a direct effect on the accuracy of measurements and their course.

6. MOVEMENTS

To avoid great instability of the station due to:

- **sinking of the tripod stand into the ice resulting in instrument levelling and orientation change,**
- **station movement (the glacier “flows”) disrupting the results of a singular observation cycle,**
- **locating the station to observe control points in the area of strong glacier movement.**



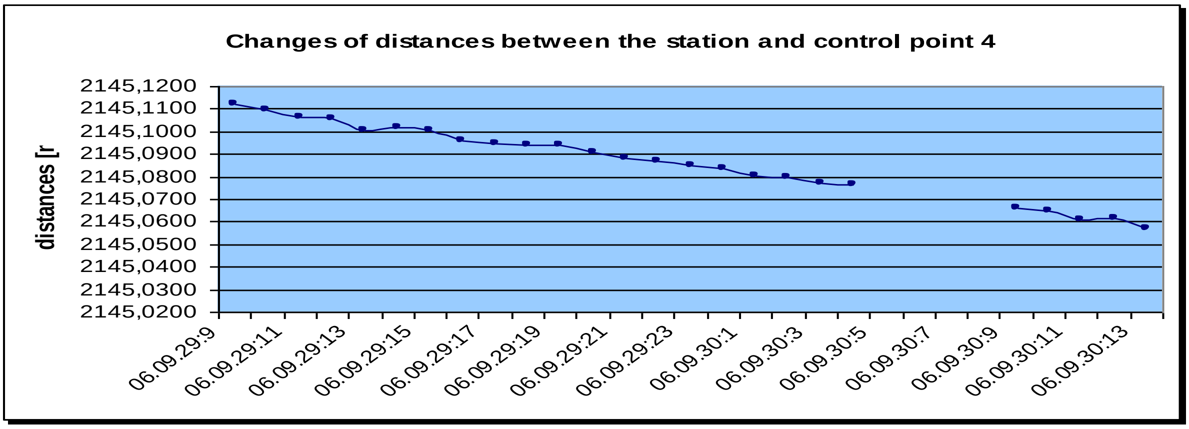


Fig. 4 . Changes of distances to control points

The instrument was placed in the area of good reference and slight surface movements of the glacier. The carried out GPS and TCRP observations allowed us to independently determine the station position and that of control points. The obtained movement values can be divided into two groups: station movement and control point movement. These values were diagrammatically presented. Analyzed observations led to the following results:

- mean error of defining the station position SmartStation (from TCRP intersection) ±0.6 cm,
- mean error of defining the station position SmartStation (from GPS-RTK) ±3-4 cm,
- error of defining point displacement by hybrid technology ±4-5 cm.

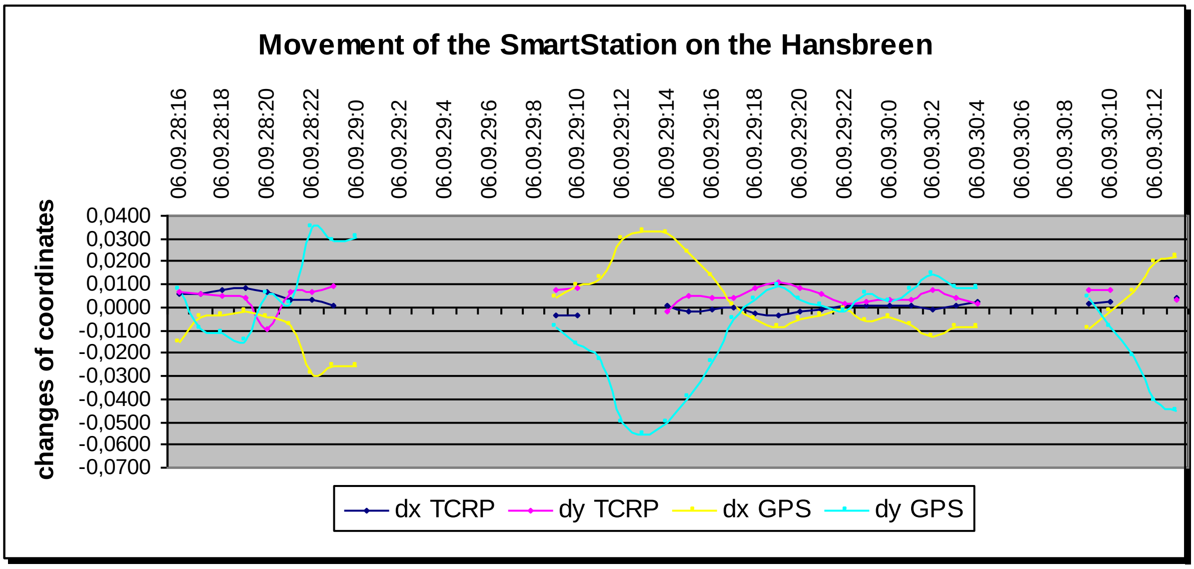


Fig. 5. Changes of the coordinates of station during the experiment

7. SUMMARY

The following results can be drawn from the above experiments:

1. The hybrid system is perfect for monitoring displacements within the 4-5 cm accuracy range,
2. Monitoring unquestionably requires a system aiding target recognition ATR,
3. Due to possible station instability it may be essential to raise the accuracy of movement definition by way of additional orientating observations and post-processing procedures. The set is dedicated to measurements carried out at stable stations,
4. The defect of the SmartStation system is its functional split with regards to GPS and TCRP observations,
5. Another defect is the GPS signal limitation to the RTK function,
6. Another SmartStation defect in monitoring is in its inability to update automatically weather data. In the case of precise measurements it is a disqualifying defect.