POLISH POLAR RESEARCH	11	3-4	411-417	1990

Jan CISAK and Stanisław DĄBROWSKI

Institute of Geodesy and Cartography
Jasna 2/4
00-950 Warszawa, POLAND

Polish geodetic and cartographic studies in the Arctic and Antarctic regions

ABSTRACT: Permanent renewal of measurements of phenomena occuring on Earth sufrace — the main task of geodesy and cartography — is the important element of geodynamic studies of the Arctic and Antarctic regions. Insitute of Geodesy and Cartography participates in the program of research led by Polish Academy of Sciences for over 10 years, using conventional geodetic methods, as well as new types of data, acquired from satellite observations and through remote sensing techniques. This activity is evidenced by setting-up astronomical main points close to *Hornsund* Station in 1958, as well as at *Arctowski* Station in 1976, where cyclic astronomical and satellite measurements were performed on these points. Geodynamic test site was organized in the Hornsund Region. As a result of these works numerous topographic and thematic maps were produced and many scientific publications were prepared by Institute specialists.

Key words: Arctic, Antarctic, geodesy, cartography.

Introduction

Institute of Geodesy and Cartography has carried out geodetic, photogrammetric and carthographic works within polar research coordinated by the Polish Academy of Sciences (CPBP 03.03 Program) for over 10 years. Geodesy has attained high position in these works; Insitute's specialists are involved in the works of the Committee of Polar Research, as well as in the works of the Scientific Committee on Antarctic Research (SCAR). Many specialists from the Institute participated in polar expeditions; four of them were the leaders of these expeditions. As a result of this deep involvement several publications were prepared (or will be printed soon); encluding maps of Hornsund region and King George Island.

Geodetic works

One of the main tasks of geodesy is to study shape of the Earth and geodynamic processes existing in the Earth crust. Significant progress has been done lately in the methods used for measuring and recording these processes. Several new methods utilizing satellite techniques have been lately prepared. It is now possible to measure positions of points on the Earch with decimetres accuracy (Transit), as well as with centimeters and even milimeters accuracy (GPS); so information on phenomena occuring on the Earch surface can be remotely acquired.

These new trends are evidenced by change of the name of SCAR Working Group — Geodesy and Cartography to the Working Group of Geodesy and Geographic Informations.

Undoubtedly, the most interesting for the discussed studies is to acquire data from the regions with sparse measurements and informations. This fact was perfectly understood by Prof. Jerzy Jasnorzewski, who established main points at the *Hornsund* Station in 1958 and at the *Arctowski* Station in 1976 and tried to determine latitude, longitude and azimuth of direction from astrometric measurements. At *Hornsund* Station the measurements were done with very high accuracy (Jasnorzewski 1964), but at the *Arctowski* Station unfavourable atmospheric conditions made proper measurements impossible. Astrometric measurements at the *Hornsund* Station were repeated by Dr Jan Cisak in 1983/84, using the same Wild T4 instrument and the same way of measurements (Kawrajski method).

Comparison of the results of these measurements was presented in the publication (Cisak and Jasnorzewski 1988). Two measurements, performed with similar accuracy at 25 year's interval, revealed difference in position of point in the form of vector of length of 25.6 m. So slight difference derived from two measurements only, can be hardly recognized as real movement of this point, because its value is within the maximum errors of both measurements. So third measurement is needed to solve this problem.

The measurements of position with the use of Doppler method were also done for the point at *Hornsund* Station. First measurement was performed by Norwegian group in 1985 using JMR receiver and the second by Polish team from IGiK with the use of Polish DOG3 receiver.

The results of astrometric and satellite measurements are presented (Table 1).

The results of Doppler measurements are significantly different from astrometric measurements. It is caused by difference in reference systems. Astrometric measurements are related to the inertial system, to the local vertical line, while Doppler measurements to geocentric system WGS 72. This difference must be known and remembered, when maps based on different systems are compared.

Table 1

Method Person responsible for measurements Date	φ	λ
astrometry Jasnorzewski 1959	77° 00′ 03″.57	15° 33′ 36″.32
astrometry Cisak 1984	77° 00′ 04″.25	15° 33′ 33″.21
Doppler JMR Norvegian Group 1985	77° 00′ 05″.63	15° 32′ 30″.67
Doppler DOG 3 IGiK 1988	77° 00′ 06″.13	15° 32′ 31″.52

This great difference between astrometric and Doppler measurements should be explained it the course of future research works, specially, when gravimetric measurements around the point will be done. Program of these measurements is currently being prepared.

Great contribution to the geodynamic studies was introduced given in 1988 by expedition, led by Dr. Andrzej Pachuta from the Technical University of Warsaw. This group, cooperating with the main expedition of Geophysics Institute, led by Dr. Stanisław Dąbrowski, set up in the Hornsund region geodynamic test net, consisting of some very well firmly stabilized points. Angles and distances in this net were measured with high accuracy. Repetition of these measurements should enable to determine the mutual movement of the test points.

In January 1988 the team of IGiK, participating in the 12 th Expedition to the *Arctowski* Station, measured the position of Jasnorzewski point, using Doppler DOG 3 receiver (Batke, Cisak and Dobrzycka 1989). The measurement at the *Arctowski* Station was the part of the international Intercosmos Doppler campaign. Among the station participating in this campaign were: Potsdam, Penc, Zwenigorod, Ondrzejow, Ulan Bator, Borowiec and the *George Forster* (GDR) — the second Antarctic station.

Observations were sent to the Penc-Station coordinating the whole compaign. Using GEODOP 5 software computations of position of point were done. From 311 satellite passes-utilizing „single point" method — the following results were obtained: $\varphi = -62° 09' 41''$ and $\lambda = 301° 31' 49''.99$. These data and the astronomical azimuth are currently used for orientation of new maps of this region.

Photogrammetric works

Photogrammetric methods are of special importance among the surveying methods. As it is known, field measurements are then done indirectly, through photographing terrain with the use of special cameras; afterwards restitution of spatial location and measurements of terrain features are performed, using photogrammetric instruments. Number of field measurements needed for such elaboration is small, comparing to the amount of terrain features, which can be mapped using photogrammetric photographs.

It is also important for many phenomena, that these photographs are the document, permitting temporal comparison of the state of studied object, *i. e.* monitoring its changes, their interpretation and measurement. However, it's worth mentioning, that direct comparison of photographs, although proper for observing and interpreting changes of object, can sometimes lead to the incorrect, erroneous conclusion, as photogrammetric measurement should always be referred to the same coordinate system, in which the measured magnitudes are defined. So there is need to adjust photogrammetric measurements to the points of geodetical network, which form framework for photogrammetric works and define their reference system. So, for these measurements geodetical framework should be first set; it must be also checked, if it is constant and up-to-date.

In Polish polar research works aerial photographs have been not taken permanently. However, a few works were performed on the basis of such photographs. In 1979, during the Polish Expedition to the *Dobrowolski* Station photogrammetric photographs of Bunger Oasis were taken at a scale of 1:5 500, than using these photographs a map at a scale of 1:5 000 was prepared. Network of points, stabilized and measured during this expedition, was the geodetical framework for these works.

In 1978, during the Expedition to the *Arctowski* Station, aerial photographs were taken from helicopter, mainly for photointerpretation. These photographs were used for various thematic studies, among others for mapping of coastline of Admirality Bay on the 1:25 000 map, for geomorphological studies of the land around the Bay, as well as for preparing topographic map at a scale of 1:50 000.

Photogrammetric aerial photographs of Spitsbergen were taken by Norwegian Polar Institute, courtesy of this Institute they were accessible to the Polish specialists, being a basis for many thematic elaborations.

Aerial photographs taken in 1960/61 were used for elaborating geomorphological map of the Hornsund region at a scale of 1:75 000, prepared by Institute of Geophysics of the Polish Academy of Sciences and Silesian University.

In 1987 the topographic map of Hornsund region, consisting of 10 sheets at a scale of 1:25 000 was prepared and printed on the basis of Norwegian aerial

photographs, taken in 1960, 1961 and 1970, and Polish supplementary field measurements. As a geodetic framework for this map triangulation points of Norwegian network were used; they were partly updated through measurements performed in the course of activities of Polish expeditions.

Aerial photographs, considering their range and possibility to record all terrain details, are particulary useful for topographic works and for the works covering large areas.

Photogrametric photographs taken from ground stations have their own particular feature. In polar regions, characterized by very diversified terrain relief, it must be taken into account, that visibility of some terrain features on the ground photographs will be limited. So these photographs must be taken from many stations, which must be properly planned, distributed and located in the common reference system, adjusted to the terrain framework.

On the basis of ground photographs several maps were prepared, *e. g.* map of Werenskiold Glacier (Lipert 1987) and map of vicinity of the *Hornsund* Station (Dąbrowski 1985).

Ground photogrammetry can be particulary effectively used for measurements of changes occuring at the front zones of glaciers (Dąbrowski and Lipert 1984). Owing to multiyear photogrammetric measurements large amount of data, charakterizing changes of front zones of Hornsund glaciers, was collected. Results of these works, for instance presented on 1:75000 geomorphological map (Karczewski *et. al.* 1984) and on 1:25000 topographic map (Barna and Warchoł 1987).

Moreover, methods of ground photogrammetry were used for recording and analysing changes of many phenomena in time. The following studies can be mentioned here: study of water movements in Hornsund, study of sea currents at the region of King George Island, changes of slope forms at the region of *Hornsund* Station, changes and development of a coastiline at the Hornsund region, changes of snow cover at the Hornsund region.

As an example, results of studies of movement of Hans Glacier surface, conducted by Dąbrowski and Kurczyński during Spitsbergen Expedition in 1987/88, are presented below. Photogrammetric measurements were perfomed during the whole year for points distributed along the line, perpendicular to the main direction of glacier flow, located over 0.5 km away from the front of glacier. Specially prepared disks were the signals on the selected points. 8 cycles of measurements were performed from July 1987 till July 1988. The results are presented (Fig. 1, Table 2).

Photogrammetric measurements of the glacier front were performed, at the same cycles. In this way, unique documentation for the front zone of Hans Glacier, collected throughout the whole year, was obtained. The most important conclusion drawn from these measurements is, that velocity of movement of glacier front is quite different (much higher) from velocity of flow of its surface outside zone of large cracks and crevasses.

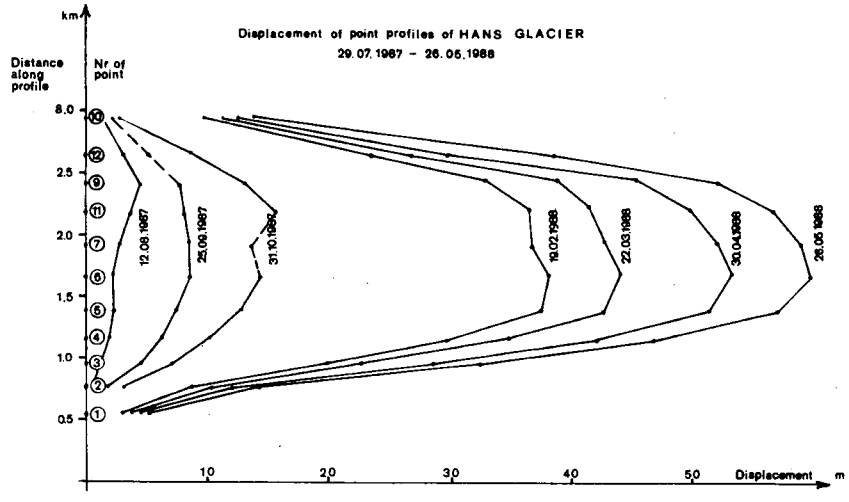

Fig. 1. Displacement of point profiles of Hans Glacier

Determination of the amount of ice, passing by glacier as a result of calving on a basis of range of its front line only can be incorrect, if volume of cracks and crevasses is not taken into account. A whole year's measurements of Hans Glacier prove that statement.

Discussed above geodetic, cartographic and photogrammetric studies, as well as examples of enclosed projects prove activity usefulness of these works for polar region explorations.

Table 2

Displacement of points of Hans Glacier surface along the selected profile between 29. 07. 1987 and 26. 05. 1988 (preliminary study)

No	Distance along profile	Displacement in m								Mean velocity m/day
		29 07 1987	12 08 1987	25 09 1987	31 10 1987	19 02 1988	22 03 1988	30 04 1988	26 05 1988	
1	310	0				3.1	3.6	4.2	4.9	0.016
2	519	0	0.5	1.9	2.9	8.6	10.2	12.0	13.9	0.046
3	706	0	1.1	4.4	6.9	19.7	22.9	28.4	32.1	0.107
4	906	0	1.9	6.1	9.8	29.9	34.6	42.0	46.7	0.155
5	1120	0	2.3	7.5	12.7	37.5	42.7	51.4	57.2	0.190
6	1392	0	2.2	8.6	14.4	38.0	43.8	53.1	59.6	0.198
7	1655	0	2.6	8.5	13.7	36.7	42.7	52.0	58.9	0.196
11	1921	0			15.8	36.6	41.6	49.5	56.5	0.188
9	2140	0	4.4	7.7	13.2	33.1	38.6	45.3	51.9	0.172
12	2377	0			8.6	22.1	25.7	27.0	36.8	0.122
10	2655	0	1.4		2.7	9.6	12.3	12.3	13.7	0.046

References

Barna S. and Warchoł Z. 1978. Spitsbergen, Hornsund. Topographic map 1:25,000.

Batke Z., Cisak J. and Dobrzycka M. 1989. Geodetic works carried out during the 12th Expedition to the Arctowski Station at Antarctic region. — Prace IGiK, 36: 111–122.

Cisak J. and Jasnorzewski J. 1989. Approaches to measurements of dynamics of Spitsbergen in the region of Hornsund Fiord. — Biul. Inf. BOINTE Geodezji i Kartografii, 33: 18–22 (in Polish).

Dąbrowski S. and Lipert C. 1984. Dynamics of the Hans Glacier Western Spitsbergen on the basis of photogrammetric measurements 1963–1980. — Prace IGiK, 31: 71–81.

Jasnorzewski J. 1964. Measurement of astronomical main point at the Isbjornhamna Bay at Spitsbergen's Hornsund Fiord. — Biul. Inf., 2: 6–58, Komitet Międzynarodowej Współpracy Geofizycznej przy PAN.

Karczewski A. *et. al.* 1984. Hornsund, Spitsbergen, geomorphology 1:75,000 (map) — Silesian Univ., Katowice.

Lipert C. 1987. Photogrammetric works in the Werenskiold Glacier area, Spitsbergen. — Pol. Polar Res., 8: 47–55.

Received July 10, 1990
Revised and accepted July 11, 1990

Streszczenie

Permanentne powtarzanie rejestracji chwilowych stanów zjawisk zachodzących na powierzchni Ziemi -- jako podstawowe zadanie geodezji i kartografii — jest istotnym elementem badań geodynamicznych Arktyki i Antarktyki. Instytut Geodezji i Kartografii uczestniczy w programie badań polarnych — prowadzonych przez PAN już ponad 10 lat, wykorzystując tradycyjne metody geodezji, jak również nowoczesne pozyskiwanie danych z obserwacji satelitarnych i przy użyciu metod teledetekcyjnych (por. fig. 1, tab 1–2). Rezultatem tej działalności jest założenie astronomicznych punktów wiekowych w pobliżu Stacji *Hornsund* na Spitsbergenie (Arktyka) w 1958 r. i Stacji *Arctowskiego* na Wyspie Króla Jerzego (Antarktyka) w 1976 r., a także wykonywanie na nich cyklicznych pomiarów astronomicznych i satelitarnych. W rejonie Fiordu Hornsund założono ponadto poligon geodynamiczny. W wyniku powstało szereg opracowań map topograficznych i specjalistycznych oraz publikacji naukowych.