

# POLISH RESEARCH IN HIGH ARCTIC

## POLSKÝ VÝZKUM V ARKTICKÉ OBLASTI

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### **Abstract**

*Poland has a long and rich tradition of a research and an exploration of High Arctic. The Polish research was hold especially in Svalbard where Poland has had its own Polar Station since 1957. A year-round scientific research in the Station is focused on: meteorology, seismology, Earth magnetism, an ionospheric research, a glaciology, an atmospheric physics and optics and an environmental research since 1978. The data are carried out in a strict compliance with the international standards and then are transmitted to the Polish Academy of Science where they are processed and published in the form of annuals or special issues and are used in national and international journals. Except of the whole year research there are many groups of scientists who introduce their own scientific projects in spring and summer. These researches deal with many different scientific disciplines – including biology, geophysics, geology, geodesy, geomorphology, glaciology and oceanology. Nowadays, a large part of the Polish activities in the Arctic is coordinated by the Centre for Polar Studies and the Polish Polar Consortium which stimulate and coordinate the activities of Polish scientists.*

### **Abstrakt**

*Polsko má dlouhou a bohatou tradici výzkumu a průzkumu arktické oblasti (High Arctic). Polský výzkum byl prováděn na Špicberkách, kde má Polsko od roku 1957 vlastní polární stanici. Celoroční vědecký výzkum ve stanici je zaměřený na meteorologii, seismologii, zemský magnetismus, výzkum ionosféry, studium ledovců, atmosférickou fyziku, optiku a výzkum životního prostředí od roku 1978. Data jsou zpracovávána za přísného dodržování mezinárodních standardů a odesílána do polské Akademie věd, kde jsou dále zpracovávána a publikována ve formě ročních nebo speciálních vydáních a jsou používána v národních a mezinárodních magazínech. Kromě celoročního výzkumu se zde nachází mnoho skupin vědců, kteří představují své vlastní vědecké projekty na jaře a v létě. Tyto výzkumy se týkají mnoha rozdílných vědeckých disciplín, které zahrnují biologii, geofyziku, geologii, geodézii, geomorfologii, glaciologii a oceánologii. V současnosti je velká část polských aktivit v polární oblasti řízena Centrem pro polární studie a polským Polárním konsorciem, které povzbuzují a řídí aktivity polských vědců.*

### **Keywords**

*Polish Polar Station, glaciology, glaciers, climate change, Spitsbergen*

### **Klíčová slova**

*Polská Polární Stanice, studium ledovců, ledovce, klimatické změny, Špicberky*

# 1 Introduction

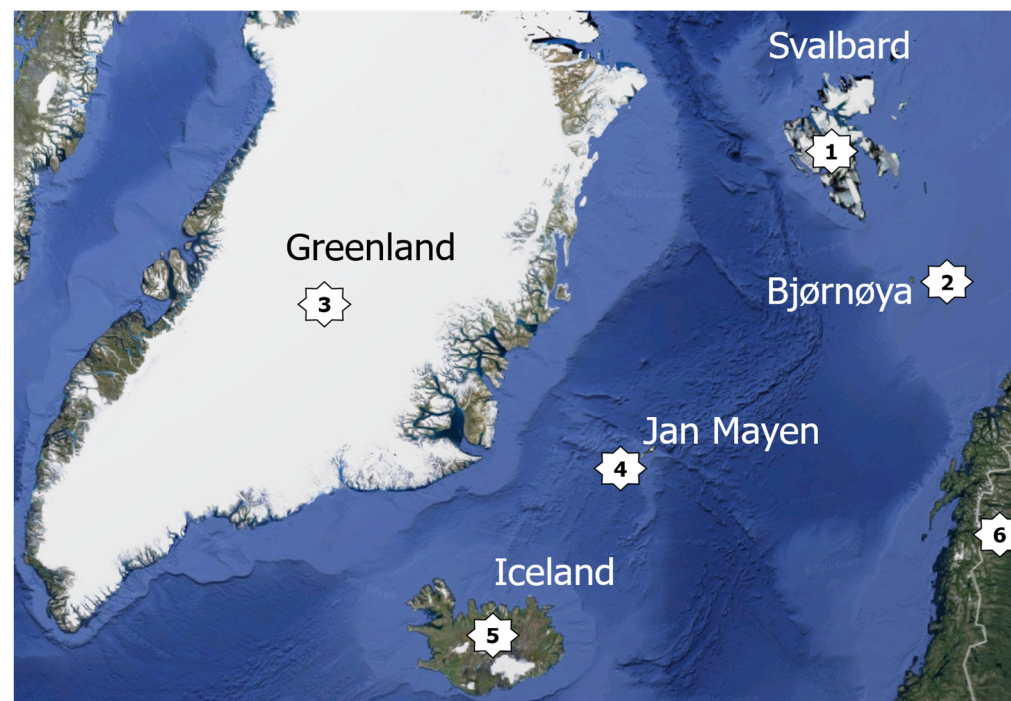
Studies of the Earth are essential for understanding the evolution of the environment for life and human activity. Polar areas play a particularly important role for the entire planet; they can be treated as stabilizers or amplifiers of global environmental changes. The unique cryosphere in these regions, and its interrelations with the atmosphere and ocean, cause an intensive exchange of both energy and mass within globally important atmospheric and marine systems. Water phase changes have a significant thermal impact on climate and hence, the Polar Regions play a crucial role in the process of global climatic change.

Aim of this articles is to present the outline of the history of Polish research in Arctic, on example of Svalbard, their development and plans for future studies on this area.

## 2 History of Polish research in Arctic

Poland has long and rich tradition of research and exploration of High Arctic (Glowacki, 2007). The main areas of Polish research in Arctic are presented on Fig.1. The research in the Polar Regions under the Polish national flag is more than 80 years old. However, the Polish polar activity dates back to a second half of the 19th century when several generations of Polish scientists – due to their patriotic activities were exiled to Russian Arctic. Most famous Earth scientists were Aleksander Czekanowski (1833–1876), Jan Czerski (1845–1892) and Benedykt Dybowski (1833–1930). They brought great contribution into the geographical and geological discoveries in the Siberian Arctic and Subarctic (Birkenmajer, 2015).

Since then, the Poles actively participated in the International Polar Years (1882–1883; 1932–1933; 1957–1958; 2007–2009) which were major periods of intense multidisciplinary polar research (Florindo et. al., 2015). One of the crucial moment in Polish research was year-long expedition passed the winter in the Arctic on Bjørnøya organized by – Jean Lugeon director of the State Meteorological Institute in Warsaw in the connection with II<sup>nd</sup> International Polar Year in 1932–1933. The expedition brought advances in understanding of magnetism, atmospheric science, and radio science and technology (Köhler, 2014).



**Fig. 1 Main areas of Polish scientific research in the Arctic. 1, 2 (Bjørnøya – Bear Island) – Svalbard; 3 – Greenland, 4 – Jan Mayen; 5 – Iceland, 6 – Abisko (Sweden) (base Google Earth Map, on the basis - Birkenmajer, 2015)**

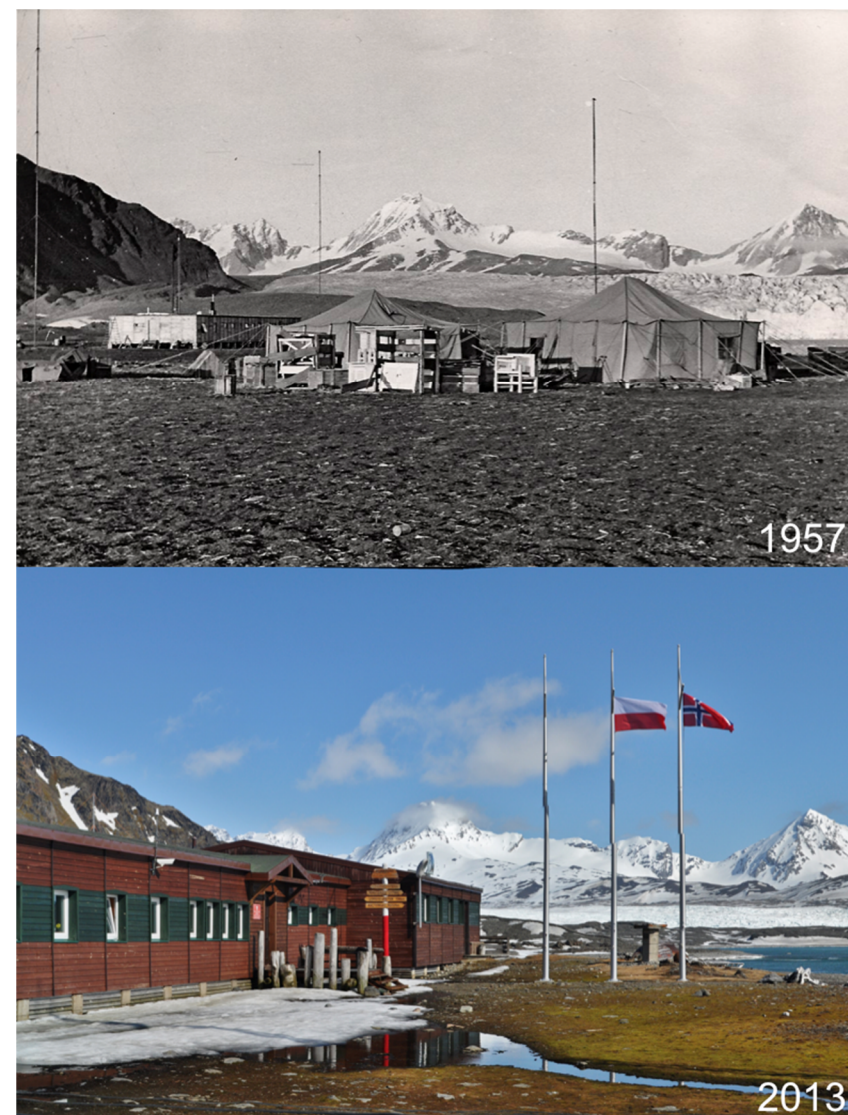
In years 1932–1938, four expeditions on Svalbard were organized, which main tasks was: trigonometric and photogrammetric surveys, geological studies, botanic and ornithological observations. Some of the major effects of this expeditions were: detailed topographic map, 1:50 000 created by Zagrajski and Zawadzki, monograph of geological and periglacial studies of Svalbard – written by Rozycki in 1959, geomorphological monograph of the area NW Spitsbergen written by Klimaszewski in 1960 (Birkenmajer, 2015). Numerous mountains were climbed for the first time and some of them were named after Polish scientist inter alia: Copernicus, Curie-Skodowska, Staszic or Pilsudski Mountain, there is also Poles' Glacier (Czarny et. al., 2015).

The Polish expeditions were resumed in 1956 with the reconnaissance expedition (leader Stanislaw Siedlecki) on which preliminary geological surveys where contacted to determine exact location of Polish Polar Station. During the III<sup>rd</sup> International Polar Year (1957–1958) the Polish Polar Station was founded in Hornsund Fjord on Svalbard, which provides a permanent base for Polish expeditions to this day.

In years 1956 – 1970 Polish scientific investigations, some of them organized with the Norwegian Polar Institute, were carried out on south and central Spitsbergen (between Sörkapp Land and Van Keulenfjorden) and Bear Island and they included among others: meteorology, geomagnetism, ionospheric studies, radioactivity of atmospheric fall-out, astronomic observations, oceanography, biology, glaciology, geomorphology, geology (geological mapping South Spitsbergen Wedel Jarlsberg Land, Torell Land and Sörkapp Land), paleontology and periglacial studies (Birkenmajer, 2015).

### 3 Polish Polar Station

Polish Polar Station (PPS) is situated in the Isbjörnhamna Bay in the Hornsund Fiord (77°00'N 15°33'E) in South Spitsbergen National Park. Station (Fig. 2) have all year round crew in year 1957/1958 and from 1978 until now. Crew (7-11 persons) is combine with scientists (geophysicist, meteorologists, chemists, geodesist) and technical specialists (mechanist, IT, administration). In years 1958–1978 several summer scientific expeditions were organized by Polish scientists.



**Fig. 2 Polish Polar Station in 1957 (photo from IGF PAS archive) and 2013**

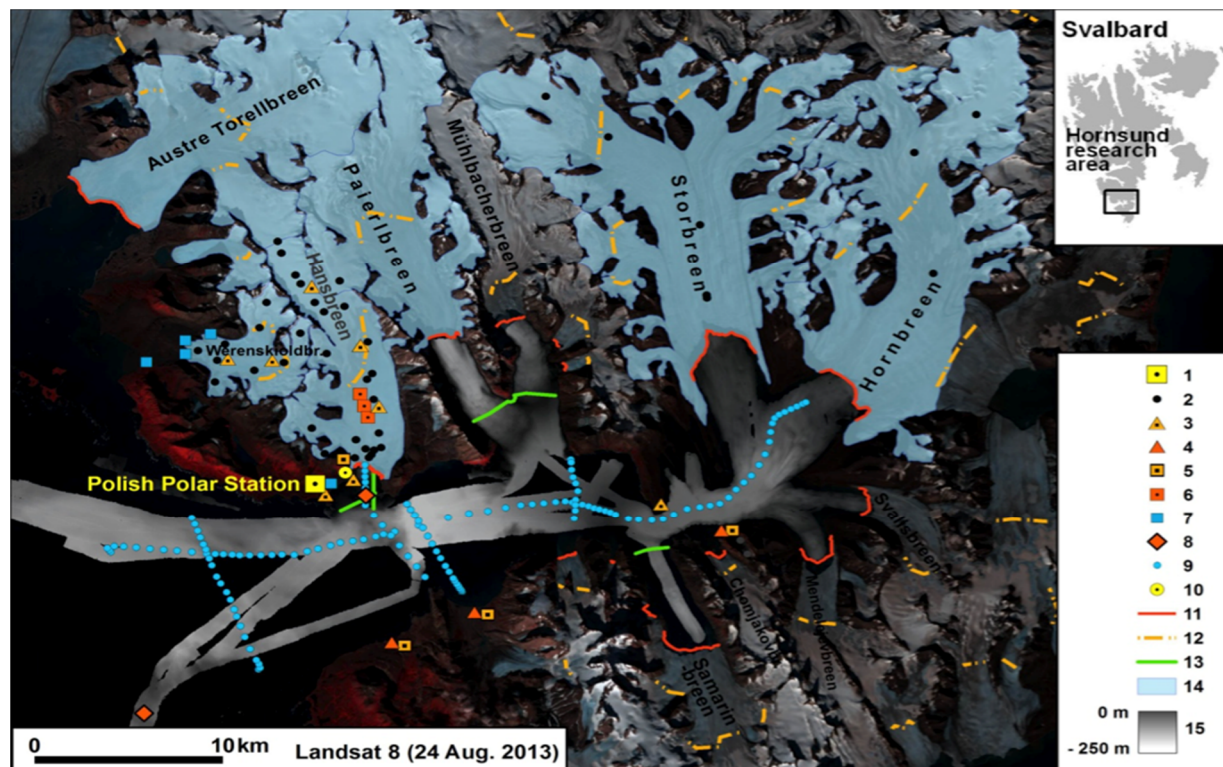


In years 1967–1971 the Station was used as a hunting station by the Norwegian trappers: Frederik Rubach and Odd Ivar Ruud (Puczko, 2007).

In 1978 the Station was refurbished and prepared for wintering house electricity generators and workshops, fuel tanks. In next years Station were renovated and extend (summer base). The largest changes took place in last 16 years when Station got modern look and new infrastructure.

The main topic of PPS the research at Hornsund is continuous observations of geophysical fields at high geomagnetic and geographical latitudes, glacier and periglacial response to climate change. Localization of the Station in Isbjørnhamna Bay gave the opportunity to study the glaciers located near the Station (mainly Hansbreen – Fig. 4), Werenskioldbreen) but nowadays, when the possibility of transport are easier and advanced automatic equipment allow monitoring of the glaciers inside the Hornsund fiord (Fig. 3). Collected data provides information about glacier geometry changes, glacier dynamics (tidewater glaciers), hydro-thermal structure of glaciers and contribution to sea level rise.

The Station provides also unique data on seismic events in South Spitsbergen connected glacial events and world earthquakes, which are important for study the Arctic seismicity. Measurements of geomagnetic field components together with those of atmospheric electricity elements, ionospheric absorption, and auroral observations provide information on the processes that occur in the magnetosphere and ionosphere under the influence of solar wind. Another important problem



**Fig. 3 Main components of the Arctic field laboratory ‘Hornsund’:** 1 – PPS; 2 – measuring points for glacier characteristics (stakes for monitoring mass balance, ice motion and snow cover properties), on Hansbreen since 1989; 3 – automatic weather stations (AWS) and 4 – simple AWSs (Hobo); 5 – year-long time-lapse cameras; 6 subglacial water pressure, basal sliding and thermal state of the glacier; 7 – rivers and subglacial outflows; 8 – constant temperature and dissolved solute monitoring in a vertical sea water profile; 9 – annually repeated CTD profiling; 10 – short-term fluctuations of cliff extent monitoring station; 11 – tidewater glacier fronts in a satellite monitoring scheme (since 2000); 12 – mean interannual ELA; 13 – salinity and flow measurements acoustic soundings; 14 – glaciers with bed topography and internal structure surveyed with GPR. The map is based on the satellite image of Landsat 8 and fiord bathymetry mapping. Maps by M. Blaszczyk ([www.polarknow.us.edu.pl](http://www.polarknow.us.edu.pl))



studied there is the determination of factors that affect the solar radiation inflow to the Earth's surface in the Arctic. Since 2002, Hornsund is also one of the six points designated by the European Union as the European Marine Biodiversity Flagship Site in the European Arctic what gives the opportunity to study marine and terrestrial ecology. Furthermore, many programs performed at the Station concern the physical parameters investigated in the framework of the International Program Global Change (Glowacki and Zwolinski, 2007). The station conducted also the geophysical measurements on terrestrial cryosphere, permafrost that provides the information about active layer thickness, physical and chemical processes occurring in the terrain.

During the whole year snow cover on glaciers/land, snow chemistry, and snow thickness distribution is determined.

The Station conducts year-round scientific research in: meteorology, seismology, Earth magnetism, ionospheric research, glaciology, atmospheric physics and optics and environmental research continuously since 1978. The data are always carried out in strict compliance with the international standards and then are transmitted to the Polish Academy of Science where they are processed and published in the form of annuals or special issues and are used in national and international journals. Parts of the data are transmitted to the international data centers (Table 1) or are available through the websites: [www.glacio-topoclim.org](http://www.glacio-topoclim.org) (Sikora et. al., 2012).

Apart from the research conducted during whole year, in the spring (March–April) and summer (June–September) various groups of scientists from all over the world are pursuing their own scientific projects. These researches concern many different scientific disciplines – including biology, geophysics, geology, geodesy, geomorphology, glaciology and oceanology.



***Fig. 4 Hansbreen retreat in 1957-2003 (photo from IGF PAS archive)***

**Table 1. Research fields (on the basis on Debski and Glowacki, 2008)**

<b>Discipline</b>	<b>Study</b>	<b>International cooperation/organizations</b>
Geomagnetism	magnetic field changes	<b>IAGA</b> – Intern, Asscation of Geomagnetism and Aeronomy; <b>IMAGE</b> – Inter. Monitoring for Auroral Geomagnetic Effects; <b>INTERMAGNET</b> – International Real-time Magnetic Observatory Network; <b>WDC-1</b> World Data Center for Geomagnetism
Electricity and optics of the atmosphere	<ul style="list-style-type: none"> <li>• electric field changes in the “polar cusp”;</li> <li>• separation of global effect and determination of factors affecting the UV radiation influx the Earth’s surface</li> </ul>	<b>AURNET</b> (Aerosol Robotic Network)
Ionosphere	soundings of ionosphere to determine the structure of the ionosphere	
Seismology	<ul style="list-style-type: none"> <li>• regional seismicity of the Arctic Sea Basin;</li> <li>• glacial seismic events (local network);</li> <li>• contribution to global seismology</li> </ul>	<b>FDSN</b> – Federation of Digital Seismograph Networks; <b>NORSAR</b> ; <b>VEBSN</b> – Virtual European Broadband Seismograph Network,
Glaciology	dynamics and mass balance of glaciers as indicator of global climate changes	<b>MAGICS</b> – Mass Balance of Arctic Ice Sheets and Glaciers in Relation to the Climate and Sea Level Changes (IASC); <b>WGMS</b> – World Glacier Monitoring Service (UNEP, IHP)
Meteorology	meteorological observation	<b>WDC</b> – World Data Centers
Biology	biodiversity of Arctic ecosystems	<b>ATBI</b> – All Taxa Biodiversity Inventory; <b>BIODAFF II</b> – Biodiversity and Fluxes in Arctic Glaciated Fjords; <b>BIOMARE</b> – Long Term Marine Biodiversity Research Sites <b>MARBENA</b> – Long term Infrastructure for Marine Biodiversity Research in Europe
Natural environment	<ul style="list-style-type: none"> <li>• long range transportation of air pollutants to the Arctic;</li> <li>• evolution of the polar environment as result of climate change and anthropogenic impact;</li> <li>• water circulation in the polar environment</li> </ul>	Terrestrial Ecosystem Monitoring Sites (UNEP, WMO)



## 4 Beyond the Polish Polar Station

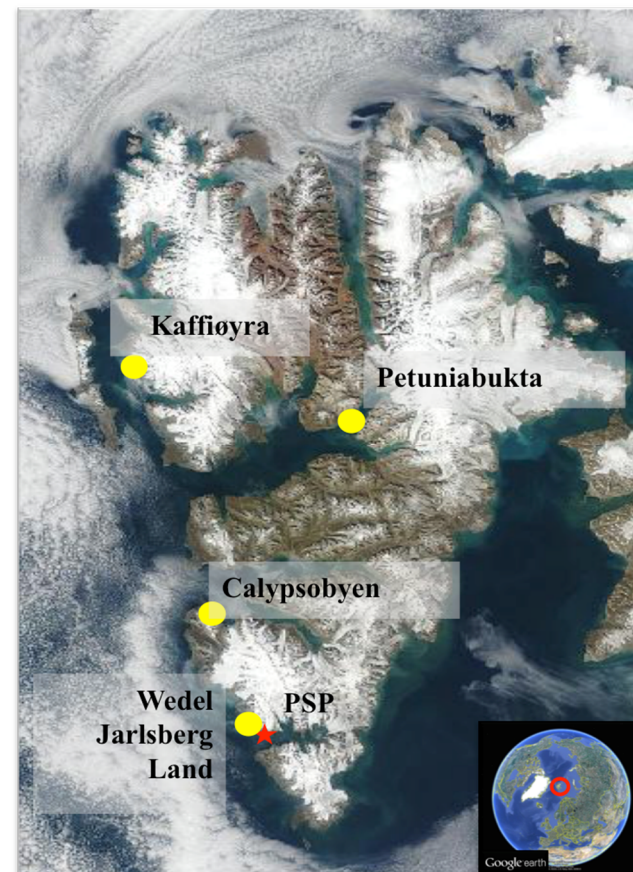
Apart from year-round opened Polish Polar Station Hornsund operated by the Polish Academy of Sciences there are four seasonal bases of Polish Universities located along the west coast and in the central part of Spitsbergen.

The researchers are conducted there during the summer time (from around June to September). The seasonal base are located in the Kaffiøyra operated by the Nicolaus Copernicus University, Calypsobyen (Bellsund) – Maria Curie-Sklodowska University, Petuniabukta – Adam Mickiewicz University and fore field of the Werenskioldbreen – University of Wroclaw (Fig. 5). The researches on the stations are focus mainly on glaciology (especially determining the process and causes of glacier extent), geomorphology, permafrost and periglacial processes, hydrology, climatology and botanical studies. Detailed results of these investigations can be followed on World Glaciological Monitoring Service (WGMS-IAHS) and Circumpolar Active Layer Monitoring (CALM-IPA) or <http://www.stacja.arktyka.com>, <http://geografia.umcs.lublin.pl/>, <http://www.staff.amu.edu.pl>, <http://polar.geom.uni.wroc.pl>.

Systematic annual research, since 1987, are also conducted in the Norwegian, Greenland and Barents Sea, as well as in the Hornsund fiord and other fiords on the western coast of Spitsbergen by the Institute of Oceanology of the Polish Academy of Sciences (IO PAN) using the research vessel (R/V) Oceania. This research vessel is adapt to performing oceanographic measurements in wide range of facilities: hydrography, optics, aerosols, acoustics, chemistry and biology. The newest equipment allow conducting physical measurements in situ (vertical profiling of basic properties of seawater and marine environment like temperature and salinity, water currents, light attenuation at selected wavelengths, photosynthetic active radiation, light transmission in the sea at selected wavelengths, chlorophyll fluorescence, sound scattering by the concentrations of fish and plankton), post processing of hydrophysical datasets, collection of samples (atmospheric aerosols, water bottle measurements, phyto and zoo-plankton, sample fish trawls, near-bottom sediment cores, bird watching) and their processing.

## 5 Projects and international cooperation

Nowadays, a large part of the Polish activities in the Arctic is coordinated by the Centre for Polar Studies (cooperation of: University of Silesia, Institute of Geophysics and Institute of Oceanology Polish Academy of Sciences) and the Polish Polar Consortium (18 scientific institutions: 15 higher education institutions and 5 research institute), which stimulate and coordinate the activities of Polish scientists.



**Fig. 3 Localization of Polish Polar Bases (PSP – Polish Polar Station) on satellite image (source terra/MODIS NASA 08-09-2002)**

The first result of their activity is a Polish Snow Research Program on Svalbard, which is a proposal to exploit the research potential by integrating Polish research activities and coordinating snow studies on Svalbard.

The Committee on Polar Research of the Polish Academy of Sciences is providing stimulation and an umbrella for cooperation within country and internationally. The Committee represents Poland in worldwide scientific organizations as International Arctic Science Committee (IASC), Scientific Committee on Antarctic Research (SCAR), International Permafrost Association (IPA), Forum of Arctic Research Operators (FARO) and others. Poland is one of twelve observers in the Arctic Council (since 1996) and a member of the International Arctic Science Committee (IASC) and the European Polar Board.

The polar research conducted in the Polish units was based mostly on funding from international and domestic grants. The biggest and most important are listed below:

- AWAKE 2 (Arctic Climate System Study of Ocean, Sea Ice and Glaciers Interactions in Svalbard Area) – funds awarded until 2016 from the Polish-Norwegian Research Fund;
- AWAKE – Arctic Climate and Environment of the Nordic Seas and the Svalbard – Greenland Area, The Polish-Norwegian Fund, project No. PNRF-22-A I-1/07;
- CLISED (Climate Change Impact on Ecosystem Health - Marine Sediment Indicators);
- ice2sea – Estimating the future contribution of continental ice to sea-level rise. EC Large-scale integrating project No. 226375, FP 7. UE;
- SvalGlac – Sensitivity of Svalbard glaciers to climate change, European Science. Foundation, PolarCLIMATE, ERANET EUROPOLAR;
- CDOM-HEAT (Source and transformation of Chromophoric Dissolved Organic Matter and its role in surface ocean heating and carbon cycling in Nordic Seas and European Arctic);
- PAVE (Atlantic Water Pathways to the Arctic: Variability and Effects on Climate and Ecosystems);
- GLAERE (Glaciers as Arctic Ecosystem Refugia);
- DWARF (Declining size - a general response to climate warming in Arctic fauna);
- POL-NOR (The Changing Ocean of the Polar North);
- iAREA (Impact of absorbing aerosols on radiative forcing in the European Arctic);
- QUAL (Quantifying climate variability since Late-glacial in Southern Svalbard), in which the participation of Polish scientists is funded by Finland until 2016.

Poland actively participates in the work of international organizations dealing with the Arctic region. The most important areas of cooperation is role of the Observer in the Arctic Council and participation in working groups AC. In the last two years Poland cooperates in Arctic Contaminants Action Program, the Arctic Monitoring and Assessment Programme Protection of the Arctic Marine Environment, Emergency Prevention Preparedness and Response Poland represents also at the level of the Observer or a member of such organizations as the Euro-Arctic Council Barents or the Northern Dimension (Luszczuk et al., 2015).



## 6 Conclusions

The Station cooperates with 25 scientific institutions in Poland and 35 institutions from other countries. In 2008 – 2015, the list of published papers, related to research on Svalbard (discipline: geology, glaciology, biology, oceanography, geophysics, environmental science, social science), with contribution Polish authors exceeds 807 (414 publication with JCI), 248 – grants and 866 – conference presentation, 11 – tenures, 30 – PhD dissertations and 73 – thesis (SSF, 2015). The Station is open for scientists and students from various universities, to collect materials for master's and PhD dissertations and professional training.

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