INSTITUTE OF METEOROLOGY AND WATER MANAGEMENT

Poland's National Report on activities related to the Global Climate Observing System (GCOS)

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Institute of Meteorology and Water Management
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Content

INTRODUCTION

Global Climate Observing System (GCOS) was called into being in 1992 by World Meteorological Organization (WMO), International Oceanographic Commission (IOC/UNESCO), United Nations Environmental Protection (UNEP) and International Council for Science (ICSU). The idea behind its creation was the management of the stream of observational and instrumental data essential for the monitoring of the Earth's climate, detection and attribution of changes, assessment of their influence on the socio-economic life as well as the preparation of the databases for the scientific research. Among forty four variables defined as Essential Climate Variables (ECVs) not only the meteorological but also hydrological, geochemical and biological were taken into account.

The decisions of the assistant bodies of UNFCCC: SBSTA/2005/10 no. 95 and SBSTA/2007/10 no.36 obliged UN members to prepare and provide the reports on the level of national implementation of GCOS to the Secretariat of Convention. Following report was prepared in accordance with the guidelines incorporated in the decision FCCC/SBSTA/2007/L.14/Add.1 on the subject of the manner of reporting in the domain of the global climate observing systems and the implementation of the agreement contained in the accepted Regional Project on GCOS Activities in the Central and Eastern Europe.

The aim of the report is the description of the activities which have been already undertaken or are planned in Poland. The aim of which is the initiation or the increase of effectiveness of the programme coordination as well as the overview of the national system of the atmosphere, land and oceanic observation and establishment of the scheme of the information circulation and national contribution to international observing systems.

GENERAL GEOGRAPHICAL CHARACTERISTIC OF POLAND

Poland is located in the Central Europe in the basin of Baltic Sea. Northern and mid part of the country is covered by South Baltic coasts and lowlands, with the number of lake districts. Polish Baltic Coast is predominantly flat and builds of sands. Occasional cliffs do not exceed 55m a.s.l. Total length of the coastline (bays included) is 770 km. On the lake districts areas there are rare moraine hills with the height exceeding 300m a.s.l. In the southern part of the country there are two mountain ranges. Sudety (in the south-western part) with the maximum height reaches 1603 m a.s.l. (Śnieżka) and Carpathian (in the southern and eastern part) with the highest range of Tatra Mountains with the peak of Rysy (2499m a.s.l.) indicating the maximum height above sea level in Polish territory. Between the belt of lowlands and Carpathians in the south-east there are highland areas with the heights between 400 and 600m a.s.l. The longest river of Poland is Vistula (1046 km) originating from the Babia Góra placed in Western Carpathian. It flows into the Baltic Sea in the vicinity of Gdańsk. Its drainage basins covers the area of nearly 195.5 $10^3 km^2$ of which nearly 169 $10^3 km^2$ is located on the territory of Poland and it comprises 54% of the area of the country. Second longest river in Poland is Oder (length - 854 km) which originate in Czech Republic and flows into Baltic Sea through the Szczecin Lagoon. Total area of its drainage basin is over 118 $10^3 km^2$ of which 106 $10^3 km^2$ is located on the territory of Poland which

comprises 34% of the country area. Forestation of Poland is nearly 29% and the total are of the country is 312 685 km^2, population is 38 110 000 and average population density is 122 p/km^2. Over 61% of Poland's population lives in cities. The largest cities are: Warsaw (the capital of Poland), Kraków, Łódź, Poznań, Wrocław and Gdańsk.

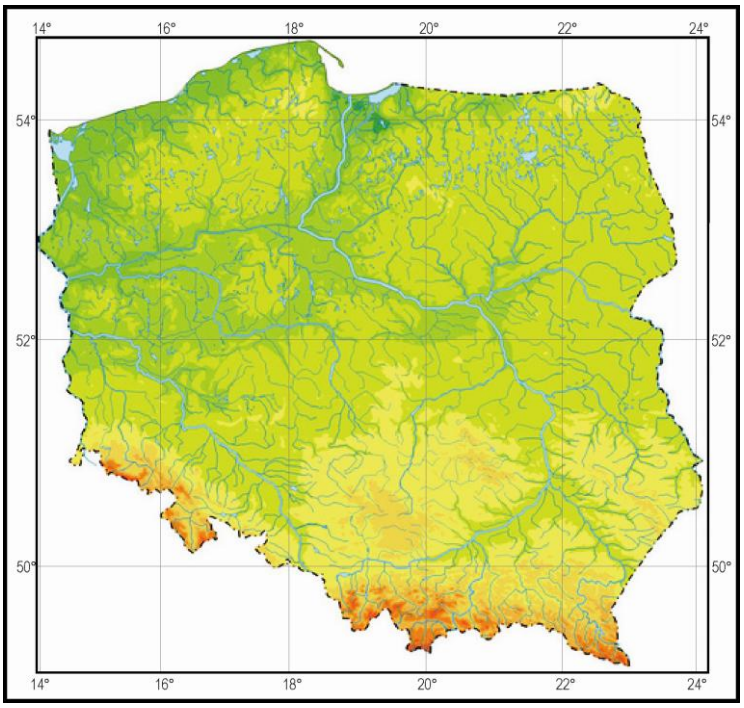

Fig.1 Poland – physical map

Chapter 1
GENERAL REMARKS

Tasks resulting from the GCOS programme in Poland are realized by couple of institutions. IMGW (Institute of Meteorology and Water Management) is in the highest degree involved in the process of the observations and measurements of ECVs. The history of the IMGW reaches the year 1919. The statutory subject of the IMGW's actions is the monitoring of the physical processes occurring in the atmosphere and hydrosphere especially for the purpose of effective hydro and meteorological cover which comprises forecasting and early warning about the phenomena posing a threat for the public safety, health and life of the citizens and their property together with the permanent and complex research conducted in the area of meteorology, hydrology, water management and oceanography which aim at steady improvement of the complex system of forecasting of potential results of the phenomena taking place in atmosphere and hydrosphere. IMGW also runs the monitoring of the climate of Poland. Under the Water Law Act (18 July 2001) this institution provides National Meteorological & Hydrological Service (PSHM). As a result it maintains the national observational-measurement network, system of the data exchange and archiving and meteorological & hydrological forecast offices. Meteorological and hydrological phenomena monitoring is financed in major part from the state budget.

Water Law Act also states that the observation-measurement data acquired in the

process of the PSHM statutory activities are a property of the state and IMGW only administers the historic database of measurements and observations and provides those data to other units on the principles derived from the due executive regulations for the aforementioned Water Law Act. Those regulations introduce different categories of users and products as well as rules on the payment for the data.

Moreover, monitoring of the ECVs in Poland is partly carried out by the Inspection of Environmental Protection or managed by the General Inspectorate of Environmental Protection and is led by following institutions:
Institute of Geophysics of Polish Academy of Sciences (IGf PAN)
Institute of Oceanology of Polish Academy of Sciences (IO PAN)
Institute of Environment Protection (IOŚ)
Universities: Adam Mickiewicz University in Poznań (UAM), Gdańsk University in Gdańsk (UG), Jagiellonian University in Kraków (UJ) University of Marie Curie-Sklodowska in Lublin (UMCS), University of Mikołaj Kopernik in Toruń (UMK), Silesia University in Sosnowiec (UŚ), Warsaw University in Warsaw (UW) Wrocław University in Wroclaw (UWr) and Humanistic-Earth Science University of Jan Kochanowski in Kielce (UJK)
National Parks: Wirgy National Park (WPN) and Kampinos National Park (KPN)

1.1. National Scheme of the Climate observation – implementation and coordination of the scheme and the strategy of implementation and acceptation of the observation, archiving and analyzing plans of national contribution to ECVs observation

There was no implementation of climate observing system at state level in Poland and thus no one was appointed a state coordinator for GCOS. Country contact spot was only introduced in IMGW appointing a person responsible for the communications between the GCOS Secretary and various institutions making measurements and research in accordance with the GCOS program. There is a lack of analyses investigating the effectiveness of the whole system at the state level, its consistence with all the guidelines and its entirety. In the moment of appointment GCOS combined the suite of existing but functioning separately programs which are still functioning independently from GCOS hence there is a possibility of the preparation of this government report and the analysis of the existing infrastructure in Poland in the view of GCOS requirements. Simultaneously it should be marked that IMGW providing national hydro-meteorological service actively participates in the GCOS activities according to its technical and financial capabilities. Representative of IMGW also took part in the preparation of Regional Activities Program of GCOS in the Central and Eastern Europe. Thus IMGW performed the analysis of the coherence of its observing and measurement schemes with the GCOS guidelines and its regional needs. On the basis of this analysis Poland undertook research in the field of data-rescue and development of the downscaling tools that would aim at study of regional climate scenarios and possible preparation of seasonal meteorological forecasts. In the data-rescue project as the result of signed

agreement between the IMGW in Warsaw and Deutsche Wetterdients (DWD) German side granted access for unspecified time to the archives of meteorological observation and measurements meteorological carried out on the territory of Poland by the German meteorological services in the years 1860-1945. After the transportation of the archives to Poland the cataloguing was made in the scope of meteorological, actinometrical and precipitation (only for the period 1933-1945) reports. Cataloguing of the of the precipitation charts for the period 1860-1935 are still in progress. Until today 7.5 million of elements' values were digitized. Those comprise over 211 000 data records from 60 meteorological stations located in 47 sites, 172 500 data records from 65 rain gauges, nearly 3000 data record from 7 actinometrical stations and over 1600 data records from 2 anemometric stations. Digitized data span from the period 1860-1950. With some delay in comparison with the digitizing scanning of the archive materials commenced. Analysis of the archives that was carried on proved high very level of completeness of data in the case of basic meteorological variables such as air temperature, atmospheric pressure or daily totals of precipitation. For selected measuring points there was a possibility of digitizing of hourly values of sunshine duration and wind speed and direction.

Simultaneously with the digitizing of the observation-measurement data the work is carried out on the meta base, which shall allow the homogenization of the series of digitized data. Additionally two Polish institutions (IMGW & UG) take part in the special task COST (ES0601) which is devoted to the homogenization of the meteorological data series.

In the first place the digitalization was performed for the data from the stations that are still functional. Thanks to that the reconstruction of the climatic conditions from some tens of stations in Poland was possible even for the period longer than 100 years. This programme will continue for the next few years.

Analysis of gathered material (including the completeness of the series and metadata) allowed appointing more than ten meteorological stations as potential candidates for the climatological reference stations. The aim of the reference stations program is the climate change monitoring. It is thus advised to include the stations being operational for many years in the same location and carrying out synchronic measurements of basic meteorological parameters with two set of instruments and sensors. One of the sets should be in accordance with currently used by all meteorological stations in the country. Second should be a traditional set using among others mercury thermometers for air temperature measurements. In the nearest time it is to be expected that some of those stations will be included in the global network of reference stations.

Moreover in several places in Poland the search for historic weather information commenced. This comprises library search, state archives and church records. Those activities allowed in the last few years the reconstruction the changes in variability of meteorological conditions among others in Kraków and its vicinity (since 1792, UJ), in Warsaw (since 1772, IMGW) and in Gdańsk (since 1739, IMGW, UG).

Comprehensive modernization of the observational-measurement network which was carried on after the catastrophic flood in 1997 resulted in the installation of the new

generation of meteorological equipment and sensors and the change in the location of several stations which aimed at the refinement of their representativeness. Taking the need to keep the continuity of the data series into consideration in most of those cases synchronic comparative measurements were carried on (at the old and new location of the station or with the usage of old and new equipment). At present extensive comparative analyses are being carried out aim of which is to establish quantitative and qualitative changes resulting from the modernization of measurement-observation network. Those operations are led as part of the methodical analyses (for PSHM) financed by the National Fund of Environment Protection and Water Management (NFOŚiGW).

1.2. Aid for the least developed countries, developing island countries and countries during the economic transition

Every year IMGW is visited by many delegations from friendly national hydro-meteorological services which get acquainted with the potential of the Institute, its structure and other details of its functioning. During such meetings there is also an experience exchange in the range of modernization of observational network and systems of data archiving and historical data storage. In some cases visits are in the form of short time training allowing the recognition of matters in more detail. Institute intends to continue this form of cooperation in the future.

Every year IMGW alone or in cooperation with the Polish Geophysical Society (PTGf) organizes national scientific-technological conferences devoted to widely acknowledged issues connected with the activities of the Institute. Since 2001 at least 5 national-level conferences referred to climate monitoring at state level and formulated the guidelines in the domain of observational-measurement schemes currently ongoing in the Institute and outside it as well as national research projects in the domain of climate change.

In May 2008 IMGW together with Gdańsk University, NOAA and NOC UK organized 4-day workshops “Advances in Marine Climatology – CLIMAR III”. It took place in Gdynia and the discussions on the most important issues of contemporary marine climatology were led during the event including the suitability of the currently operative observational-measurement schemes, data quality from the marine areas and prospect of changes in the ongoing schemes. Experts from all continents (more and less economically developed countries) took part in the workshop.

In October 2008 information workshops of IPCC took place in IMGW under the auspices of the Minister of Environment. During two sessions (one for press and nongovernmental ecological organizations, second for the higher civil servants and local-authorities) representatives of IPCC discussed the most important results of the AR4 and scientists from Poland presented issues concerning the climate change in the respective IPCC WGs from the Polish perspective.

IMGW presented in WMO agenda the problem of the shortages in the education of specialists in public communication in the domain of functioning of national hydro-meteorological services, informing on occurring dangers connected with extreme hydro-

meteorological events and climate change in general. IMGW proposed realization of the cycle of workshops in this domain for the representatives of meteorological services. First workshop took place in May 2008. Poland intends to organize the workshops for specialist on public communication from WMO member states coming from developing countries. Those would be devoted to marketing and effective communication with the representatives of governments and business cooperates and would take place in Warsaw in 2009.

1.3. International Projects and organizations conducting the climate observations (including satellite remote sensing agencies)

Despite the fact that no international agencies engaged in the observation of Earth from the Space operate in Poland the state is actively involved in the international satellite research projects. In 1999 Poland signed the agreement with EUMETSAT under which since 1 January 2000 Poland is one of the nine countries associated with this organization. Thus it benefits in the same laws and access to the acquired data and products as the member countries. The contribution of Polish membership fee to the total budget of EUMETSAT is 1.88%. Director of the IMGW dr. eng. Mieczysław Ostojski is (since 2007) vice-president of the EUMETSAT Advisory Committee on Cooperating States.

Since April 2007 Poland is also associated with the European Space Agency (ESA) and actively participates in the preparation of missions for many years now.

1.4. Paleoclimate research

IMGW and PAN take part in the EU Millennium project the objective of which the reconstruction of the climate variability in Europe during the last millennia on the basis of observational data and proxy data (dendrochronology and lake sediments). At few universities research is being carried on that aim at reconstruction of local climate conditions. Those reconstructions reach back to the beginning of the XIV century. Moreover on the basis of the paleo-oceanologic data the reconstruction of environmental conditions in Baltic Sea are performed. UG scientists also take part in the research projects which are the part of PAGES project.

In the Department of Environmental Physics of AGH in Krakow (http://www.ftj.agh.edu.pl/zfs/index2.php?site=profil) three direction of paleoclimatological research are being developed. Those are: research on the isotope composition of lake sediments, research on the isotope composition of cave dripstones, research on the isotope composition of organic matter. Sine 10 years comprehensive research of the Gościąż Lake sediments are carried out which is located near Toruń. This lake was created in the late glacial period (approx. 13 000 years BP) and until now there deposited over 16 meters of sediments of unique qualities. Continued research on the isotope composition of carbonates and diatoms shells will allow the reconstruction of climate variability and environmental conditions in the lake vicinity during last 13000 years. In the Institute of Geography of University of Gdańsk dating of laminate sediments from northern Poland lakes are carried out in the cooperation with Brema University.

Investment process is often proceeded by the archeological research of the investment location. In some cases archeological research was supported by paleoclimatic research. A number of universities carry out the research of lake bed sediments of selected lakes. In most of the cases they are undertaken with the intention of the assessment of local anthropogenic factors.

Those researches are extended with paleoclimatology only when the cores are taken and their initial analysis is performed. Dept. of Biology of Antarctic of PAN (http://www.arctowski.home.pl/?act=k2) for a couple of years carries out the research on the climate change occurring in the vicinity at the H. Arctowski Station (King Salomon Island, South Shetlands, Western Antarctic, ϕ=62^{o} 09' 41'' S, λ=58^{o} 28' 10'' W) during Holocene on the basis of cores taken from local lakes and analysis of sediments from the Admiralty Bay.

Chapter 2
ATMOSPHERIC ESSENTIAL CLIMATE VARIABLES
2.1. General Information

The measurements of climatological variables in Poland have long tradition and reach back (in the case of many locations) to XVIII century and in rare cases to XVII. Complex history of the country (no state during the period 1795-1918, multiple wars I&II WW) resulted in the repeated destruction of the measurements network and thus large part of the archive material was irretrievably lost. Multidirectional activities undertaken in the second half of the 20th century has led to the creation of a modern system of data retrieval, archiving, processing and exchange. After the disastrous flood in 1997 complex state system of hydro-meteorological monitoring was founded. It comprises vast network of automatic, telemetric gauging stations which acts parallel with the state basic meteorological measurements network which is incorporated into five level hierarchical structure.

2.2. Contribution to GCOS system from the international reference measurement-observation stations
2.2.1. GCOS Global Surface Network (GCOS GSN)

Two of the Polish stations were incorporated into the GCOS Global Surface Network. Both are the part of the IMGW observational-measurements network.

Łeba (WMO station number 12120)

Siedlce (WMO station number 12385)

Presently there are no plans for including additional stations to GSN.

Fig. 2. Location of the Polish stations being the part of GSN

Łeba

Meteorological observations in Łeba commenced probably in twenties of the 20-th century. After the break connected with the warfare activities the observations recommenced in Łeba on 1st January 1947 initially as a rain gauge and since 1st June 1947 as a climatological station. The observations were carried out at 6, 12, 20 hours of official time. Since 1st June 1961 the station functions as a synoptic stations carrying out 24/7 observations and measurements in the synoptic hours. 1st July 1972 the station was moved by 2 km.

Hydro-meteorological Station in Leba is located in the central part of the Polish Baltic Sea Coast and is located 2.5 km from the sea and 200m from the coastline of the large shallow lake. The surrounding of the station (excluding coastal dunes with the maximum height of 60m a.s.l.) is flat and partly boggy. Coordinates of the station are ϕ=54°45'13"N; λ=17°32'05"E. The altitude is 2m a.s.l.

Solar radiation components measurements are carried out in Łeba since November 1985. Program covers the measurements and archiving of: total shortwave radiation, direct solar radiation in the full range of the spectrum (and four additional narrowed spectra), diffused radiation, reflected radiation and radiation balance. Sunshine duration recordings are carried out in Łeba since 1 October 1989 and since 17 June 1993 UVB (280-320μm) also solar radiation measurements.

Since 1971 the station runs aeorological service twice a day (00 & 12 UTC) using Vaisalla radiosonde RS90.

Since nineties of the 20th century equipment for automatic measurement is gradually introduced (1992 – barometer, 1999 – rain gauge). In 2002 automatic meteorological station Vaisalla MAWS 301 was installed with the usage of which the measurements of atmospheric pressure, air temperature (at 2m and 5cm a.g.l), air humidity, precipitation, speed and direction of wind, visibility and the detection of precipitation type are performed. Despite the fact that the station maintains the 24/7 supervision of the observer since 2008 values received from automatic measurement systems are recognized as basic.

Archived in the digital format data cover the period since 1951. Earlier data are available in the hardcopy format (paper observation sheets).

Siedlce

The station was founded in 1881. Its activities were suspended a couple of times due to warfare activities during the 1st and the 2nd WWW. Since 1945 it runs without disturbances carrying out round-the-clock observations at the synoptic hours. Since December 1982 the station resides in the new location.

Hydro-meteorological station in Siedlce is located in the eastern part of Poland in the area of vast Podlaska Lowland. Terrain in the surroundings of the station is flat and open. Coordinates of the station are $\phi=52^{o}10'52"N$; $\lambda=22^{o}14'41"E$. The altitude is 152m a.s.l.

In 1983 sunshine duration measurements were commenced in Siedlce. During nineties the introduction of automatic measurement systems commenced (1992 – barometer, 1999 – rain gauge). In 2002 the automatic station Vaisalla MAWS 301 was installed and thus the measurements of atmospheric pressure, air temperature (at 2m and 5cm a.g.l), air humidity, precipitation, speed and direction of wind, visibility and the detection of precipitation type are performed. Despite the fact that the station maintains the 24/7 supervision of the observer since 2008 values received from automatic measurement systems are recognized as basic.

2.2.2. GCOS Global Upper Atmosphere Network (GUAN)

None of operational aeorological stations in Poland is a part of the programme of the climate variables in upper atmosphere measurements.

2.2.3. GCOS Global Atmosphere Watch (GAW)

Six from among Polish stations running measurements and observations is a part of the GAW which was created in 1989. The objective of the GAW project is the monitoring of the selected features of chemical composition of the atmosphere which are helpful in the recognition of the role of environmental changes as the result of changes of climatic conditions. Researches being the part of this project are led by order of the General Inspectorate of Environmental Protection. Four stations are run by IMGW. Moreover the measurements are carried out at IGf PAN and IOŚ stations. The stations are:

Jarczew (IMGW station code GAW PL4500101Q08, index WDGCC JCZ651N00),

Legionowo (IMGW)

Łeba (IMGW, station code GAW PL4000101Q08, index WDGCC LEB54N00)

Śnieżka (IMGW, station code GAW PL5000101Q08, index WDGCC SNZ650N00)

Belsk (IGf PAN)

Diabla Góra/Puszcza Borecka (IOŚ, station code GAW PL5500101Q08, index WDGCCDIG654N00)

Fig. 3. Location of the Polish GAW stations

All mentioned stations carry out the measurements along with the guidelines of the program for the GAW regional stations with the extended scope of the measurements.
Four of the mentioned stations additionally run the monitoring of the atmospheric pollution according to the EMEP programme. Those are: Jarczew, Śnieżka, Diabla Góra/Puszcza Borecka and Łeba. All Polish stations realise the basic measurement scope (so called level 1) and station Puszcza Borecka some elements of the extended level

Jarczew

The station is located in the east of the country in the southern part of the Podlaska Lowland. The programme of the research of the pollution of the atmosphere is operational since 1984. Station measures following variables: atmospheric ozone (O3), chemistry of the precipitation, physical and chemical properties of aerosols, reactive gases (SO2 and NO2). Coordinates of the station are ϕ=51^{o}49'N; λ=21^{o}59'E. The altitude is 180m a.s.l.

Legionowo

The station is located in the centre of the country on the Mazowiecka Lowland. Since the beginning of its existence (1928) the station was serving as the aerological station. Since 1979 measurements of ozone profiles are carried out with the usage of radiosonde method. Coordinates of the station are ϕ=52^{o}49'N; λ=21^{o}97'E. The altitude is 96m a.s.l.

Łeba

The location of the station was described in paragraph 2.2.1. The station measures such elements as: tropospheric ozone (O3), chemistry of the precipitation, chemical and physical properties of aerosols, reactive gases (SO_2 and NO_2) as well as the UV radiation.

Śnieżka

Mountain observatory is located at the highest peak of Karkonosze Mountain Range in Sudety Mountains in the south-western part of Poland. Meteorological measurements started in 1880 and the measurements as the part of GAW are carried out from 1991. Station covers the measurements of such elements as: tropospheric ozone (O3), chemistry

of the precipitation, chemical and physical properties of aerosols, reactive gases (SO_2 and NO_2). Station's coordinates are ϕ=50°44'N; λ=15°44'E. The altitude is 1603m a.s.l.

Diabla Góra/Puszcza Borecka

The station is located in the north-eastern part of Poland, in the region of Suwalskie Lake District. Since 1992 the station carries out the measurements of following elements: green house gases (CO2), tropospheric ozone (O3), chemistry of the precipitation, chemical and physical properties of aerosols, reactive gases (SO_2 and NO_2). Station's coordinates are ϕ=54°08'N; λ=22°03'E. The altitude is 158m a.s.l.

Belsk:

Station located in the centre of Poland on the Mazowiecka Lowland. It was founded in 1964 and apart from the meteorological measurements it carries out the measurements of the total solar radiation together with UVA and UVB, albedo of surfaces, chemical and physical properties of aerosols, optical thickness and the distribution of the quantities of aerosols in the column of the atmosphere (according to _AERONET guidelines), vertical distribution of coefficient of backward scattering (according to EARLINET guidelines), gaseous pollutions and total amount of ozone in the column of the atmosphere and its vertical profile. Station's coordinates are ϕ=51°84'N; λ=20°79'E. The altitude is 180m a.s.l.

The results of the GAW are delivered to:

- GAW/WMO/WDCSO – World Data Centre on Surface Ozone as part of the Norwegian Institute of the Air Protection (NILU) in Kjeller , Norway
- GAW/WMO/WDCA – World Data Center for Aerosols in Ispra, Italy
- GAW/WMO/WDCPC – World Data Center for Precipitation Chemistry in Albany, USA
- GAW/WMO/WDCGG – World Data Center for greenhouse gases in Tokyo, Japan
- Additionally data from Łeba are passed down to BMP/HELCOM

Research on the state of ozone layer over Poland and measurement of the UV radiation comprise:

- Measurements of the total amount of ozone in atmosphere and vertical distribution of ozone – station Belsk
- Measurements of ozone profiles with the radiosonding – station Legionowo
- Determination of the total ozone content over Europe with the satellite observations – IMGW Kraków office
- Measurements of the UV radiation intensity – stations: Belsk (IGf PAN) and Łeba, Legionowo and Zakopane (IMGW)

  Measurements results are transferred to:

  - GAW/WMO/WOUDC – World Ozone and Ultraviolet Radiation Data Center
  - GAW/WMO/WDCSO – World Data Centre on Surface Ozone as part of the Norwegian Institute of the Air Protection (NILU) in Kjeller , Norway

- Atmospheric Physics Laboratory – University of Saloniki

General Inspectorate of Environmental Protection published annual reports "Atmospheric Pollution Background Monitoring in Poland for the use of EMEP & GAW/WMO" and presents them at the internet site: http://www.gios.gov.pl

2.3. Measurements in other meteorological and atmospheric pollution networks

2.3.1. Observation-measurement service of the State Hydro-meteorological Service of IMGW

Measurement stations included into the measurement networks GSN or GAW are most often the component of the observation-measurements network of IMGW and on some rare occasions are subjects of other institution.

Despite the fact that major part of currently operational measurement stations and posts of IMGW were active in the first decades of the 20th century and sometimes even in the XIX century due to aforementioned historical conditions it was not until the second half of the 20th century that real regulation of the meteorological measurement network after huge war losses. During the years 1945-1949 40 large hydro-meteorological (synoptic) stations were rebuilt and activated with the permanent staff. Polish zone of Baltic Sea has also become the object of research. In 1949 meteorological coverage for civil aviation was also taken over by IMGW. Simultaneously there was a dynamic development of the communication and data transfer systems.

Organization of the observing-measurements IMGW Network

- Synoptic stations with the round-the-clock observer surveillance, automatic,
- Synoptic stations with the narrowed measurement range (shorter time of the observer surveillance) or only automatic,
- Climatological stations, sometimes with permanent post and sometimes automatic,
- Climatological posts with the narrowed range of measurements, sometimes automatic,
- Precipitation gauge stations,

Quantitative state of the IMGW observation – measurement network (as for 30 June 2008)

Meteorological stations and posts (total)	1314
Synoptic stations	54
Including:	
High Mountain Observatories – 2	
Regional hydro-meteorological stations – 9	
Hydro-meteorological stations – synoptic – 43	
Synoptic stations with limited programme	8
Including:	
Hydro meteorological stations with narrowed range of measurements – 2	
Automatic synoptic stations – 6	

Climagtological stations	66
Climatological stations with limited programme	156
Precipitation stations	1030
Aerological Stations	3

Fig. 4. Distribution of meteorological stations (synoptic) in Poland

Fig. 5. Distribution of climatological stations in Poland

Fig. 6. Distribution of the precipitation stations – precipitation gauge stations

Qualitative state of the IMGW observing-measurement network (as for 30 June 2008)

Points of the air temperature measurements [a]	284
Points of the water vapour pressure measurements [b]	128
Points of atmospheric pressure measurements [c]	62
Points of precipitation measurements [d]	1314
Points of the wind speed and direction measurements [b]	25

[a] synoptic and climatological stations, [b] synoptic and higher climatological stations, [c] synoptic stations, [d] all stations

Actinometric network (radiation measurements) of IMGW was founded in the beginning of the sixties and presently comprises 25 stations. Sunshine duration and total radiation measuring equipment is installed on all the stations. 10 of them carry out the measurements of all the components of the radiation balance and at twelve total, scattered, and reflected solar radiation are measured and on the next five only total and scattered radiation. Data from three IMGW actinometric stations (Kołobrzeg – coast station, Warszawa-Bielany – central Poland and Zakopane – mountain foot station – in the Tatras in the south of the country) and from one station of the IGf PAN (Belsk) are quarterly sent to WRDC (World Radiation Data Center) in Sankt Petersburg, Russia.

To meet the needs of archiving and processing of the data retrieved from the observation-measurement network IMGW Central Database of Historic Data was created in IMGW Databases Center in Warsaw. It comprises among others Central Climatological Database which in turn is divided into data: from meteorological stations, from meteorological posts and rainfall gauges. Central Climatological Database covers following data:

- From 65 synoptic stations – observational hours data and daily data (among others from 1961 for ten stations and since 1966 for 49 stations)
- From 245 meteorological stations and posts – readings of instruments and daily data (since 1951 for 39 posts, since 1954 for 21 posts, since 1961 for 69 posts and shorter series for the rest of the stations
- From 1680 rain gauges – daily data (since 1951 for 333 stations, from the sixties for 81 posts and shorter series for the remaining posts)

Enormous effort was put into the restoration of destroyed systems caused substantial delays in the domain of data archiving. Number of data series from before the beginning of the sixties is only now being digitized. Thanks to before mentioned agreement between the IMGW and DWD the Polish side successively gains access to historical materials of observational-measurement nature from the stations located once on German territory and presently being the domain of Poland. As the result of digitalization of those data carried out as part of the grand research project “Climate of Poland during the instrumental observation period” it is expected to widen the temporal coverage of data at some Polish measuring stations reaching back to XIX century.

2.3.2. IGf PAN posts

Institute of Geophysics PAN except the already described Belsk station runs another meteorological station – Hornsund on Spitsbergen in the Svalbard Archipelago (Norway).

Hornsund (WMO number 01003)

Synoptic station is located on the north-western coast of Hornsund Fiord near the mountains. The measurements are carried out since 1978 and aside standard meteorological

elements also radiation balance components, sunshine duration, albedo and mass balance of the glaciers and ice caps, sea surface temperature and river runoff measurements are also done. Station's coordinates are ϕ=77°00'N; λ=15°30'E. The altitude is 10 m a.s.l.

2.3.3. Natural Environment's Integrated Monitoring (ZMŚP)

One of the components of the National Environment Monitoring in Poland is Integrated Monitoring of the Natural Environment. Its objective is the conduct of observations of the greatest possible elements of natural environment on the basis of the field stationary research. Base stations of ZMŚP are located on the area characterizing basic types of Polish landscape. Integral parts of the research program of those stations are the measurements of basic meteorological elements. Those comprise: air temperature (at 2m and 5cm a.g.l.), ground temperature at several standard levels, water vapor pressure, wind speed and direction, atmospheric precipitation, characteristics of snow cover, sunshine duration and components of the solar radiation balance. As a part of the project of atmosphere's chemistry measurements research on the content of selected greenhouse gases and chemical properties of some aerosols are carried out. The results of the meteorological measurements are not subject of international data exchange but are used in the interpretation of the results of the natural environment monitoring.

Seven base stations of ZMŚP have been so far founded where the measurements are carried out according to aforementioned scheme. The network is coordinated by the Adam Mickiewicz University in Poznań.

Operational ZMŚP base stations comprise:

- Geo-ecologic Station of UAM in Storkowo (in north-western Poland)
- Diabla Góra/Puszcza Borecka, IOŚ
- WNP station in Krzywe near Suwałki
- Research Center of UMK in Koniczynka near Toruń
- KPN station in Kampinos (near Warsaw)
- Świetokrzyska Geoecological Station of UJKin Święty Krzyż near Kielce
- Station of Institute of Geography and Spatial Management PAN (IGPZ PAN) in Szymbark (southern Poland).

Activities described in this chapter are carried out under the long-term Programmes of the National Environment Monitoring (PMŚ) accepted by the Ministry of Environment and coordinated by the General Inspectorate of Environmental Protection.

2.4. National Meteorological Observations

2.4.1. ECVs – surface atmospheric components

GCOS Surface Network (GSN)

As it was stated in paragraph 2.2.1 there are two stations: Łeba and Siedlce. Monthly data averages of atmospheric pressure, air temperature, water vapor pressure, precipitation totals, sunshine duration totals are sent every month do DWD in Offenbach. Monthly totals

of precipitation are sent once in a year to GPCC. ClimatTemp reports are sent once a month to World National Weather Records Center, Asheville, USA.

Full World Weather Watch/Global Observing System (WWW/GOS) surface network

As was stated in paragraph 2.3.1. observation-measurement network in Poland consists of:

- 62 synoptic stations, all automated, 54 of which have all-around-clock observer surveillance and at 8 of them the surveillance lasts from 8 to 12 hours a day or there is none,
- 222 climatological stations and posts, 130 of which are automated with the telemetric function,
- 1030 rain gauges, 250 of which are automated with telemetric function

Baseline Surface Radiation Network (BSRN)

None of the Polish station has been incorporated into BSRN

Radiation Balance Measurements Network

As it was mentioned in paragraph 2.3.1. Polish actinometric network comprises:

25 stations measuring total radiation and sunshine duration including:

17 stations measuring total radiation and scattered radiation including:

12 station for total, scattered and reflected radiation including:

10 stations measuring all components of the radiation balance

and 2 station being a property of IGf PAN (Belsk & Hornsund)

Oceanic Drifting Buoys

Poland doesn't possess its own system of oceanic drifting buoys

Anchored Buoys

Poland doesn't possess its own system of anchored buoys

Vessels of Voluntary Observing Ship Climate Project (VOSClim)

Poland participated in the introductory phase of the VOSClim Project however doesn't possess its own vessels participating in the VOSClim Project.

Oceanic Network of Reference Buoys and stations at small isolated islands

Poland does not participate in the Oceanic Network of Reference Buoys and does not run any stations on small isolated islands.

Table 1a. Poland's national contributions to the surface-based atmospheric essential climate variables

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS Surface Network (GSN)	Air temperature	IMGW - 2	IMGW - 2	IMGW - 2	IMGW - 2	IMGW - 2
	Precipitation	IMGW - 2	IMGW - 2	IMGW - 2	IMGW - 2	IMGW - 2

Full World Weather Watch/Global Observing System (WWW/GOS) surface network	Air temperature, air pressure, wind speed and direction, water vapour	IGf PAN - 1 IMGW - 288 (including: 128 - water vapour and wind, 62 - air pressure)	IGf PAN - 1 IMGW - 288	IGf PAN - 1 IMGW - 288	IGf PAN - 1 IMGW - 6	IGf PAN - 1 IMGW - 6
	Precipitation	IGf PAN - 1 IMGW - 1314	IGf PAN - 1 IMGW - 1314	IGf PAN - 1 IMGW - 1314	IGf PAN - 1 IMGW - 140	IGf PAN - 1 IMGW - 140
Baseline Surface Radiation Network (BSRN)	Surface radiation	-	-	-	-	-
Solar radiation and radiation balance data	Surface radiation	IMGW - 25 IGf PAN - 2	IMGW - 25 IGf PAN - 2	IMGW - 25 IGf PAN - 2	IMGW - 3 IGf PAN - 1	IMGW - 3 IGf PAN - 1
Ocean drifting buoys	Air temperature, air pressure	-	-	-	-	-
Moored buoys	Air temperature, air pressure	-	-	-	-	-
Voluntary Observing Ship Climate Project (VOSClim)	Air temperature, air pressure, wind speed and direction, water vapour	-	-	-	-	-
Ocean Reference Mooring Network and sites on small isolated islands	Air temperature, air pressure, wind speed and direction, water vapour	-	-	-	-	-
	Precipitation	-	-	-	-	-

2.4.2. Atmospheric components of higher atmosphere strata ECVs

GCOS Upper Air Network (GUAN)

As stated in paragraph 2.2.2. – Polish aerological stations do not participate in GUAN

Full WWW/GOS Upper Air Network

Currently there are three operational aeorological stations in Poland:

- Hydro-Meteorological Station Łeba (WMO code: 12120)
- Aeorlogical Observatory Legionowo (WMO code 12347)
- Hydro-Meteorological Station Wrocław (WMO code 12424)

  In the nineties fourth aerological station was closed in Poznań. Presently at all aerological stations in Poland the measurements are performed twice a day (on the brake of 20th and 21st century due to economic reasons soundings in Łeba were carried out once a day). Data from those stations in the CLIMAT-TEMP format are sent to World National Weather Records Center in Asheville, USA.

Table 1b. Poland's national contributions to the upper-air atmospheric essential climate variables

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international
GCOS Upper Air Network (GUAN)	Upper-air-temperature, upper-air wind speed and direction, upper-air water vapour	-	-	-	-	-
Full WWW/GOS Upper Air Network	Upper-air-temperature, upper-air wind speed and direction, upper-air water vapour	IMGW - 3	IMGW - 3	IMGW - 3	IMGW - 3	IMGW - 3

2.4.3. Atmospheric Components of the chemical composition of ECVs
World Meteorological Organization/ Global Atmosphere Watch (WMO/GAW) Global Atmospheric CO_2 & CH_4 - Monitoring Network

Greenhouse gases monitoring is carried out in limited scope according to national law regulations.

As it was stated in paragraph 2.2.3. only two stations running according to the GAW network standards lead the measurements of CO_2: IOŚ station in Diabla Góra/Puszcza Borecka and IGf PAN station in Belsk.

In 2008 CO_2 measurements were commenced at the station of Institute of Oceanography of University of Gdańsk (Baltic Sea coast)

Since 1994 systematic measurements of CO_2 and CH_4 concentrations are carried out at Kasprowy Wierch (Tatra Mountains, 1987 m a.s.l.) by the Laboratory of Environmental Physics, Dept. of Physics and Applied Informatics of AGH University of Science & Technology in Kraków (http://www.ftj.agh.edu.pl/zfs/index.php). Moreover, the same station runs monitoring of N_2O and SF_6. Additionally, measurements of the isotope composition of CO_2 are carried out. Since 1982 the same team runs air quality monitoring in Kraków where the scope of the research covers the CO_2 and its isotope composition. In 2005 measurements on Śnieżka (Karkonosze, 1603 m a.s.l.) commenced. Access to the data from measurements run by AGH is restricted – data owner permission is required.

Since 2008 CO_2 measurements were started at the station of Oceanography of University of Gdańsk in Gdynia (Baltic Sea coast).

Compilation of the national emission and absorption of the greenhouse gases for the needs United Nations Framework Convention on Climate Change (UNFCCC) is the task of National Emission Center (KCIE) at Institute of Environmental Protection in Warsaw. Since 2006 KCIE carries out its tasks as a part of The National Administration of the Emissions Trading Scheme (KASHUE) also created at the Institute of Environmental Protection by the decree of the Minister of Environment (16 September 2005 in the case of the appointment of the National Administrator of the Emissions Trading Scheme.

WMO/GAW ozone sonde network

As it was stated in paragraph 2.2.3. the measurements of ozone content in atmosphere with the usage of ozone sondes are led by the IMGW station in Legionowo.

WMO/GAW column ozone network

As it was stated in paragraph 2.2.3. – measurements of the total amount of ozone in the atmosphere and its vertical distribution (*Umkehr observations*) are led by IGf PAN station in Belsk.

WMO/GAW Aerosol Network

Optical mass of aerosols is measured by two Polish stations within GAW network – PAN station in Belsk and PAN Institute of Oceanology in Sopot at the coast of Baltic Sea. As far as the first of them as it was stated in paragraph 2.2.3. carries out the measurements and recording of chemical and physical properties of aerosols, optical mass and distribution of the quantity of aerosols for the column of the atmosphere (AERONET project) and vertical coefficient of the back scattering (EARLINET project) the second one covers only the marine aerosols issues.

Table 1c. Poland's national contributions to the "atmospheric composition of ECVs" domain

Contributing networks specified in the GCOS implementation plan	**ECVs**	**Number of stations or platforms currently operating**	**Number of stations or platforms operating in accordance with the GCMPs**	**Number of stations or platforms expected to be operating in 2010**	**Number of stations or platforms providing data to the international data centres**	**Number of stations or platforms with complete historical record available in international data centres**
World Meteorological Organization/ Global Atmosphere Watch (WMO/GAW) Global Atmospheric CO_2 & CH_4 Monitoring Network	Carbon dioxide	IGf PAN - 1 IOŚ – 1 UG - 1	IGf PAN - 1 IOŚ - 1 UG - 1	IGf PAN - 1 IOŚ - 1 UG - 1	IGf PAN - 1 IOŚ - 1	IGf PAN – 1 IOŚ - 1
	Methane	-	-	-	-	-
	Other greenhouse gases	IOŚ - 1 IMGW - 3 (tropospheric O_3,reactive gases) AGH – 3 (CO_2) AGH - 1 (CH_4, N_2O, SF_6)	OŚ - 1 IMGW - 3 (tropospheric O_3,reactive gases) AGH – 3 (CO_2) AGH - 1 (CH_4, N_2O, SF_6)	OŚ - 1 IMGW - 3 (tropospheric O_3,reactive gases) AGH – 3 (CO_2) AGH - 1 (CH_4, N_2O, SF_6)	IOŚ - 1 IMGW - 3 (tropospheric O_3,reactive gases)	IOŚ - 1 IMGW - 3 (tropospheric O_3,reactive gases)
WMO/GAW ozone sonde network[a]	Ozone	IMGW - 1	IMGW - 1	IMGW - 1	IMGW - 1	IMGW – 1

WMO/GAW column ozone network[b]	Ozone	IGf PAN - 1	IGf PAN - 1	IGf PAN - 1	IGf PAN - 1	IGf PAN – 1
WMO/GAW Aerosol network[c]	Aerosol optical depth	IGf PAN - 1 IO - 1	IGf PAN - 1 IO - 1	IGf PAN - 1 IO - 1	IGf PAN - 1 IO - 1	IGf PAN – 1 IO - 1
	Other aerosol properties	IGf PAN - 1 IMGW - 3 UG - 1	IGf PAN - 1 IMGW - 3 UG - 1	IGf PAN - 1 IMGW - 3 UG - 1	IGf PAN - 1 IMGW - 3	IGf PAN - 1 IMGW - 3

a. Including SHADOZ, NDACC, remote sensing and ozone sondes.
b. Including filter, Dobson and Brewer stations.
c. Including AERONET, SKYNET, BSRN and GAWPFR.

As a part of National Environment Monitoring (PMŚ) 90 stations, 75 of which is controlled by the Inspectorates of Environmental Protection run ongoing monitoring of O_3 contents in the near ground strata of the atmosphere. The monitoring of SO_2 close to the ground surface is running on 1022 measuring stations (805 stations are controlled by the Inspectorates of Environmental Protection). Annual reports on this issue are published by the General Inspectorate of Environmental Protection and are available at WWW site www.gios.gov.pl and Voivodeship Inspectorates

Aerosols measurements are also carried out at one sea coast localization – in the Institute of Oceanography at University of Gdańsk in Gdynia. Since 2000 concentrations of ions in aerosols and precipitations (NO_3^-, Cl^-, NH_4^+, Na^+ and SO_4^{2-}, Hg^{2+}) as well as gaseous components in the air (Hg(0), HNO_3, NH_3 and H_2SO_4 are measured. Complementary measurements comprised Fe III & II, H_2O_2, total (TC) elementary (EC), organic (OC) carbon as well as metals (Zn, Cd, Pb) in aerosols, PM10.

2.5. Satellite observations

The most important center in Poland which carries out the research in the area of usage of satellite image sensing products in meteorology and indirectly in climatology is the IMGW Center of Satellite Teledetection (OTS), which is located in Kraków. The beginning of the activity of the Center occurred in sixties and since 1967 satellite products are generated operationally.

Currently, OTS runs the activity in the scope of hydro-meteorological service as well as research-implementation. It has the satellite receiving and processing station which allows the usage of over ten geostationary and circumpolar satellites: Meteosat, Meteosat-Rapid Scan, NOAA, MSG, METOP, GOES and Feng Yun.

OTS governs the archive of the satellite images in the form of photo pictures from the photo registering device from METEOSAT and NOAA satellites since sixties. Since 1987 raw satellite data are archived in the digital format which allows the reprocessing with a method of choice and creation of subsequent products.

Due to the fact that Poland is a member of international consortium EUMETSAT OTS actively participates in the projects developed during its activities. Thus information presented in Table 4 regard to the products received within EUMETSAT.

OTS, except the activities connected with the implementation of the current EUMETSAT products, carries out the activities leading to the implementation of the results of the projected schemes such as MTG (Third Generation Meteosat) since 2015.

Apart from IMGW the reception and processing of the satellite data is also carried out at couple of universities (UG, UŚ) and scientific institutions (IOPAN). However those are done in a restricted scope and selected aspects (clouds properties, wind field)

Table 2. Poland's activity in the domain of Global products requiring satellite observations - atmospheric essential climate variables

ECVs/Global products requiring satellite observations	**Fundamental climate data records required for product generation (from past, current and future missions)**
Surface wind speed and direction Surface vector winds analyses, particularly from reanalysis *For the sea surface on the basis of the data from scatterometer ASCAT, QuickScat*	**Passive microwave radiances and scatterometry** *Data from microwave equipment ASCAT from METOP satellite processed under EUMETSAT OSI-SAF also available from QuickSCAT satellite data*
Upper-air temperature Homogenized upper-air temperature analyses: extended MSU-equivalent temperature record, new record for upper-troposphere and lower-stratosphere temperature using data from radio occultation, temperature analyses obtained from reanalyses *air temperature for levels: 0.1, 0.2, 0.5, 1, 1.5, 2, 3, 4, 5, 7, 10, 15, 20, 25, 30, 50, 60, 70, 85, 100, 115, 135, 150, 200, 250, 300, 350, 400, 430, 475, 500, 570, 620, 670, 700, 780, 850, 920, 950, 1000, 1025, 1050 hPa*	Passive microwave radiances, high-spectral resolution IR radiances for use in reanalysis *TOVS/NOAA data: HIRS (High Resolution Inrfrared sounder) and AMSU (Advanced Microwave Sounding Unit)*
Water vapour Total column water vapour over the ocean and over land, tropospheric and lower stratospheric profiles of water vapour *Distribution of dew point temperature for levels: 0.1 0.2 0.5 1 1.5 2 3 4 5 7 10 15 20 25 30 50 60 70 85 100 115 135 150 200 250 300 350 400 430 475 500 570 620 670 700 780 850 920 950 1000 1025 1050 hPa* *Total content of water vapour in the column of atmosphere from TOVS/NOAA data* *Total content of water vapour in the atmosphere column from METEOSAT data*	Passive microwave radiances, UV/VIS radiances, IR imagery and soundings in the 6.7um band, microwave soundings in the 183 GHz band *1). TOVS/NOAA data equipment: HIRS (High Resolution Infrared Sounder) and AMSU (Advanced Microwave Sounding Unit)* *2). TOVS/NOAA data* *3). METEOSAT (MSG) data as well as data from global modem a so called "first guest"*
Cloud properties Cloud radiative properties (initially key ISCCP products) *Overcast mask, Cloud types, colour composites characterizing type of overcast and allowing the water phase for the cloud tops*	VIS/IR imagery, IR and microwave soundings *METEOSAT/SEVIRI and NOAA/AVHRR data*
Precipitation Improved estimates of precipitation, both as derived from specific satellite instruments and as provided by composite products 1). Precipitation intensity on the basis of the microwave sensors AMSU/NOAA and DSMP, precipitation intensity on the basis of METEOSAT/IR sensors calibrated with microwave data 2). Multisensor Precipitation Estimates. 3). Convective Rainfall Rate, Probability of Precipitation,	Passive microwave radiances, high-frequency geostationary IR measurements, active radar (for calibration) 1). Products developed and tested by IMGW as part of the EUMETSAT activities – H-SAF from the satellite data NOAA, DSMP, METEOSAT (MSG) 2). EUMETSAT MPEF products transmitted via EUMETCast system 3). Products generated in OTS from METEOSAT (MSG) data with the utilization of EUMETSAT MWC-SAT software

Earth radiation budget Top-of-atmosphere Earth radiation budget on a continuous basis *Shortwave and long wave radiation reaching the surface of the Earth*	Broadband radiances, spectrally-resolved solar irradiances, geostationary multi spectral imagery *EUMETSAT Land-SAF and OSI-SAF products registered by the EUMETCast system*
Ozone Profiles and total column of ozone *Total amount of ozone from TOVS/NOAA data*	UV/VIS and IR microwave radiances *TOVS/NOAA data received in OTS*
Aerosol properties Aerosol optical depth and other aerosol properties *Developed in the IO PAN*	VIS/NIR/SWIR radiances -
Carbon dioxide, methane and other long-lived greenhouse gases Distribution of greenhouse gases, such as $C0_2$ and CH_4, of sufficient quality to estimate regional sources and sinks -	NIR/IR radiances -
Upper-air wind Upper-air wind analyses, particularly from reanalysis *Geostrophic wind field derived from the geopotential height field from satellite TOVS/NOAA sounding* *Atmospheric Motion Winds – global product of EUMETSAT and local one generated in OTS with the utilization of NWC-SAF software*	VIS/IR imagery, Doppler wind lidar *TOVS/NOAA data registered in OTS* *METEOSAT/SEVIRI data - autocorrelation between the images in time series*
Atmospheric reanalyses -	Key FCDRs and products identified in this report, and other data of value to the analyses -

2.6. Commentary on the recommendations of Implementation Plan (GCOS IP)

(a) accordance of activities with the Rules of Climate Monitoring (GCMPs, A3)

On the every implementation of the new system one year comparison period is run together with the old system. Routine quality checks are performed. IMGW bought license for the meteorological data quality control system QualiMet and works on its implementation. Homogeneity check of data is not run routinely. It is only done for the need of the research projects with the methods agreed by the projects' contributors. Metadata (information on the manners of data acquisition – details and the history of the local conditions, equipment, measurement procedures and ways of data processing) are archived in every possible detail. In CBDH there is a dataset describing stations and beside that the is an implementation going on of the Comprehensive System of Network Management which, by assumption, is to become a reference source of complete metadata about the measurements stations.

(b) Adding the air pressure sensors to the drifting buoy program (A5)

Poland does not own a system of drifting buoys and does not participate in any of the international programs in this domain

(c) Assurance of the 3-hourly data of atmospheric pressure at sea level and the wind speed from the GSN stations (A10)

Data are available in the PSHM operation system

(d) Implementation of the high quality high altitude radiosonde reference networks

Poland is not engaged in the creation of such networks

(e) Agreement of the radiosonde system with the GCMP and coding requirements (A17)

All Polish radiosonde stations act according to one of state-of-the-art world system, in agreement with the GCMP coding requirements

(f) Providing of metadata and comparison results in the area of radiosondes to international data centers

Results of comparisons of different types of sondes exists as a database in the IMGW Center of Aerology, there was an active participation in COST 725 action on homogenization of radiosonde data.

(g) Development of the terrestrial GPS receivers of water vapour pressure data (A21)

Such network does not exist in Poland, its actuation is planned

(h) establishment of the measurements of chemical components of the atmosphere as addition to presented in Table 1c.

As presented in paragraph 2.4.3. – such monitoring is led in Poland under PMŚ by couple of hundreds of WIOŚ stations, cataloguing of the gases emission in Poland is done by KCIE

Chapter 3
OCEANIC EVCs
3.1. National oceanographic observations

The research on the marine environment of the Polish zone of Baltic Sea is realized by the series of institutions. Dominating role is played by the IMGW Center for Oceanography and Baltic Sea Monitoring in Gdynia. The research covers the monitoring of deepwater zone. This activity is carried out as a part of the National Environment Monitoring (PMŚ) coordinating by the General Inspectorate of Environmental Protection (GIOŚ). In the case of coastal zone, gulfs and lagoons of Baltic Sea monitoring is carried out since 2007 by WIOŚ. Apart from the meteorological observations measurements of physical and chemical parameters of sea water are done. Those comprise: sea water temperature, salinity, ocean currents (physical) as well as oxygen concentration, content biogenes, heavy metals, organic compounds (chemical), biological parameters and radionuclide's content. Data from the monitoring of the Baltic Sea are transferred to the European Environment Agency (EEA), HELCOM and International Council for the Exploration of the Sea (ICES).

Apart from IMGW the research of the marine environment of the Polish zone of the Baltic Sea are carried out by Sea Fisheries Institute (MIR) in Gdynia, IO PAN, UG and Marine Institute (MI) in Gdańsk.

Poland runs very limited oceanographic research outside the area of the Baltic Sea. The exceptions are the research vessel of IO PAN in Sopot "Oceania" performing regular cruises on the waters of Northern Atlantic and Arctic (Norwegian). The parameters measured during the cruises comprise: sea water temperature, salinity, ocean currents and state of the sea and the content of carbon in sea water, biogens and phytoplankton. The samples of marine aerosols are also gathered.

Poland does not participate in programs of support of oceanic buoys and drifter systems such as Argo.

Main contribution of Poland into the global ocean observing system comes from the VOS and SOOP programs. Major part of the Polish shipping (82 ships) takes part in the meteorological observations at sea, large part of which transmits data au courant to the centers of their acquisition (ca. 60 vessels). There exists however the problem of the communication with the part of the ships due to the fact that they operate on faraway waters of Pacific not visiting the country for many years. That is because of it that the Port Meteorological Officer – PMO keeps contact with analogous institutions in American countries which keep surveillance over the Polish ships on his behalf. Two vessels take part in the SOOP Program, both cruising at Baltic Sea. Until the end of 2008 Poland intends to install the automatic meteorological station at one of the oilrig platforms of the natural gas exploitation enterprise Petrobaltic, which is located on the Baltic Sea near Rozewie Cape.

IMGW network of near sea stations comprises 36 stations. 13 of them are located near the river mouths, 5 on the coasts of Bays (Szczeciński & Wiślany) the rest in the zone of the coast open to sea. 30 stations are equipped, in addition to traditional staff gauges and analogue instruments for the sea level registration (mareographs), with the automatic telemetric sensors which transmit the data au courant to the offices of Hydrological Forecasts of IMGW. Routinely, except from the measurements of sea level there are ice extent observations and, at selected stations additional measurements of temperature and salinity of sea water.

From remaining stations some are operational only during the winter season because of the ice extent observations carried out there.

None of the Polish stations takes part in the activities of the GLOSS system. There is a group of stations taking part in PSMSL but with the beginning of the Xxi century the data transfer was aborted. Presently, Poland transmits operational data about the seal level from the Władysławowo station (coordinates ϕ= 54°48’ N; λ= 18°25’ E) as a part of activities in the ESEAS network project.

The activities in the area of the reception and interpretation of satellite images regarding oceanic ECVs are run in Poland by already mentioned IMGW OTS, UG, UŚ and IO PAN. Those however concern only chosen aspects (wind field over the sea area, SST, ice extent, sea color).

Table 3a. Poland’s national contributions to the oceanic essential climate variables – surface

Contributing Networks specified in the GCOS implementation plan	**ECVs**	**Number of stations or platforms currently operating**	**Number of stations or platforms operating in accordance with the GCMPs**	**Number of stations or platforms expected to be operating in 2010**	**Number of stations or platforms providing data to the international data centres**	**Number of stations or platforms with complete historical record available in international data centres**

Global surface drifting buoy array on 5x5 degree resolution	Sea surface temperature, sea level pressure, position-change-based current	-	-	-	-	-
GLOSS Core Sea-level Network	Sea level	-	-	-	-	-
Voluntary observing ships (VOS)	All feasible surface ECVs	82	82	82	82	82
Ship of Opportunity Programme	All feasible surface ECVs	2	2	2	2	2

Table 3b. Poland's national contributions to the oceanic essential climate variables – water column

Contributing Networks specified in the GCOS implementation plan	**ECVs**	**Number of stations or platforms currently operating**	**Number of stations or platforms operating in accordance with the GCMPs**	**Number of stations or platforms expected to be operating in 2010**	**Number of stations or platforms providing data to the international data centres**	**Number of stations or platforms with complete historical record available in international data centres**
Global reference mooring network	All feasible surface and subsurface ECVs	-	-	-	-	-
Global tropical moored buoy network	All feasible surface and subsurface ECVs	-	-	-	-	-
Argo network	Temperature, salinity, current	-	-	-	-	-
Carbon inventory survey lines	Temperature, salinity, ocean tracers, biogeochemistry variables	-	-	-	-	-

Table 4. Poland's activities in the domain of "Oceanic ECVs requiring satellite observations"

ECVs/Global products requiring satellite observations	**Fundamental climate data records required for product generation (from past, current and future missions)**
Sea Ice Sea ice concentration -	Microwave and visible imaginary -
Sea Level Sea level and variability of its global mean -	Altimetry -
Sea Surface Temperature Sea surface temperature *X*	Single and multi-view IR and microwave imagery *Satellite IR data*

Ocean Colour Ocean colour and oceanic chlorophyll-a concentration derived from ocean colour -	Multi-spectral VIS imaginary -
Sea State Wave height and other measures of sea state (wave direction, wavelength, time period) *Direction and wind speed on the sea surface*	Altimetry *EUMETSAT OSI-SAF products available via EUMETCast transmission Generated on the basis of ASCAT/METOP data and QuickSCAT*
Ocean Salinity Research towards the measurement of changes in sea surface salinity -	Microwave radian ces -
Ocean Reanalyses Altimeter and ocean surface satellite measurements -	Key FCDRs and products identified in this report, and other data of value to the analyses -

Satellite products acquired by OST regard the sea surface temperature and sea state. Significant role in the satellite research of marine environment is played also by the scientific institutions especially IO PAN in Sopot. Researches carried out there regard the analysis of the satellite images of such elements as sea ice, SST, sea state and ocean color.

3.2. Commentary on the recommendation to GCOS Implementation Plan (GCOS IP)

(a) Amendment in the meta data acquisition and the data management techniques within VOSClim (06)

Poland does not participate in VOSClim program

(b) Assurance of the availability of high frequency data of sea level adjusted to atmospheric pressure and its transmission to world data centers (O13)

Poland transfers the sea level data with the 10 minute frequency within ESEAS project; moreover on the WWW site there are current data available from the stations Darłowo and Gdańsk.

(c) Sea level change subject share in the projects and increasing of the potential within GOOS, JCOMM, WMO and other institutions (O14)

No actions undertaken

(d) Development of effective schemes of the salinity measurements including VOS, research vessels and buoy systems (O15)

IMGW develops the SOOP program among others on the "Viking" ferry of the Stena Line ship's operator. The ferry cruises between Gdynia and Karlskrona and is equipped with the automated measurement system FerryBox

(e) Implementation of the measurements of surface partial CO_2 (O17)

No actions undertaken

(f) Implementation of the wave measurements as a component of the Anchored Buoys Reference Network program

Poland does not participate in the program. During last 10 years a few wave registering buoys were operational in various research projects. Those data are property of institutions which participated in the research.

(g) Amendment of the in-situ observations of sea ice quality with the usage of buoys, visual observations (SOOP, aircrafts) in the area of Arctic and Antarctic (O23)

No actions

(h) Utilization of systematic soundings of the full ocean profile along 30 transects every 10 years (O25)

No actions

(i) Realization of transects 41 SOOP XBT/XCTD (O26)

No actions

(j) Development of possibilities of biogeochemical and ecological ECVs measurements (O30)

Only selected biogeochemical and ecological elements enter in the range of programs of scientific institutions which have vessels at their disposal (i.e. IMGW and IO PAN)

(k) Engagement in data rescue projects and regional or global organizations or specialized data centers and data analysis (O36 & O37)

Marine Branch of IMGW in Gdynia carries out the projects on the reconstruction of chosen aspects of oceanographic conditions (ice extent and sea level change) in the region of Polish coast during the last couple of hundreds of years.

Chapter 4
TERRESTRIAL ECVs
4.1. Global Terrestrial Network – Hydrology (GTN-H)

Water level at inland posts is measured at 893 IMGW stations. Observations and measurements at those stations are carried out at 6UTC. Basic measurement range comprises: observation of water level, ice phenomena, thickness of the ice cover, overgrowing of the river channel with vegetation and sometimes registration of daily water level course (limnograph) and water temperature (at over 210 stations).

At some stations water level measurements are made also at 12 and 18 UTC. In the case of exceeding of warning level extra measurements are done every 6 hours and on the exceeding of alarm level every 3 hours.

Water level gauges are connected with the national nivelation network with the accuracy of 1mm. There are three altitude reference points controlled once a year and after each high water conditions. Geodesic transects are carried out at water gauging stations helping in the construction of the runoff intensity curve: water level gauging transect and three transects in the profiles which control the runoff intensity curve. During the hydrometric measurement the measurement of the water surface slope along the channel axis is also carried out.

Density of the hydrological measurements network is dependent on the level of flood threat at given area. Due to this fact it is grater in the south of the country.

Depth of snow cover is identified at 1314 stations in Poland and at one station located in the SW Spitsbergen - Hornsund (IGf PAN). At a couple of stations except everyday measurement of the snow cover depth the snow cover density is also determined in the form of water equivalent (mm H_2O/1cm of snow cover)

4.2. Global Terrestrial Network for River Discharge (GTN-R)

Permanent hydrometric (discharge volume) measurements are carried out at water gauging stations for the establishment of the relationship water level – discharge. In normal conditions there should be 7 to 10 measurements at each profile every year at differing water level states. It is extremely important that measurements are carried out at low water times as well as during high water (floods). Measurements are done with the usage of propeller-type current meter, electromagnetic current meter and Acoustic Doppler Current Profilers (ADCPs). Discharges are registered at all 693 measurement stations. Discharge registration network comprises all the river basins in Poland.

4.3. Global Terrestrial Network - Lakes (GTN-L)

Network of hydrological inland measurements is completed by the limnological measurements at 15 lakes located in the northern and western part of the country (Fig. 6). Those measurements regard the water balance of the monitored lakes. At all lakes included into the limnological network measurements of inflow and outflow are carried out. Additionally, at three of them measurement of evaporation from the lake surface are done. For some lakes the components of the water balance are calculated systematically since sixties of the 20th century. Moreover, at some lakes water temperature measurements both at surface and in the vertical profile are carried out. The transparency of water is also established as well as the water quality.

Fig 7. Distribution of limnological monitoring stations in Poland

IMGW processes and publishes the Hydrological Yearbooks on CD.

4.4. Global Terrestrial Network - Glaciers (GTN-G)

In high latitudes glaciers' monitoring is carried out. In the case of the Norwegian Arctic (South-western Spitsbergen) glaciers monitoring programme is run for many years and

comprises many parameters. It is carried out by UŚ and IGf PAN. In the case of Arctic the research of glaciers are run periodically and in the limited scope in the vicinity of Arctowski Station (ZBA PAN). This research allows the establishment of the pace of the glaciers retreat (since fifties of 20th century) and the intensity of summer discharge.

4.5. Global Terrestrial Network for Permafrost (GTN-P)

Regular measurements of the summer's thaw depth and systematic measurements of ground temperature (to 1,0m) are carried out in the area of Hornsund station (SW Svalbard) by IGf PAN. Those measurements are done since 1977.

4.6. Phenological monitoring Network

Tradition of phenological observations in Poland reaches the end of 19 century. They were recommenced by IMGW after WWII then subsequently stopped in 1992 and recommenced in 2005. Phenological observation network led under the scrutiny of IMGW comprises 70 stations. Apart from IMGW some universities and Farmers Advisory Centers.

Table 5. Poland's national contributions to the terrestrial domain essential climate variables

Contributing Networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS baseline river discharge network (GTN-R)	River discharge	-	-	IMGW-693	IMGW-51 data until 1999	IMGW-51 data until 1999
GCOS Baseline Lake Level/ Area/Temperature Network (GTN-L)	Lake level/ area/temperature	-	-	IMGW - 15	-	-
WWW/GOS synoptic network	Snow cover	IGf PAN - 1 IMGW - 6	IGf PAN - 1 IMGW - 6	IGf PAN - 1 IMGW - 6	IGf PAN - 1 IMGW - 6	IGf PAN - 1 IMGW - 6
GCOS glacier monitoring network (GTN-G)	Glaciers mass balance and length, also ice sheet mass balance	IGf PAN – 1 ZBA PAN – 1	IGf PAN - 1	-	IGf PAN - 1	IGf PAN - 1
GCOS permafrost Monitoring network (GTN-P)	Permafrost borehole-temperatures and active-layer thickness	IGf PAN - 1	IGf PAN - 1	IGf PAN - 1	-	-

4.7. Satellite Observations

Table 6. Poland's activity in the domain of global products requiring satellite observations - terrestrial

ECVs/Global products requiring satellite observations	**Fundamental climate data records required for product generation (from past, current and future missions)**
Lakes Maps of lakes, lake levels, surface temperatures of lakes in the Global Terrestrial Network for Lakes -	VIS/NIR imagery and radar imagery, altimetry, high-resolution IR imagery -
Glaciers and ice caps Maps of the areas covered by glaciers other than ice sheets, ice sheet elevation changes for mass balance determination -	High-resolution VIS/NIR/SWIR optical imagery, altimetry -
Snow cover Snow areal extent *Extent of snow cover, water content in snow, snow cover state (wet/dry)*	Moderate-resolution VIS/NIR/IR and passive microwave imagery *Products developed and tested by IMGW within EUMETSAT H-SAF on the basis of the METEOSAT VIS/HRV, NOAA and METOP (microwave), MODIS (Terra/Aqua) data*
Albedo Directional hemispherical (black sky) albedo -	Multispectral and broadband imagery -
Land cover Moderate-resolution maps of land-cover type, high-resolution maps of land-cover type, for the detection of land-cover change -	Moderate-resolution multispectral VIS/NIR imagery, high-resolution multispectral VIS/NIR imagery -
fAPAR Maps of fAPAR -	VIS/NIR imag ery -
LAI Maps of LAI -	VIS/NIR imagery -
Biomass Research towards global, above-ground forest biomass and forest biomass change -	L band/P band SAR, Laser altimetry -
Fire disturbance Burnt area, supplemented by active fire maps and fire radiated power *EUMETSAT Land-SAF product available in the EUMETCast transmission (presently used in IMGW)*	VIS/NIR/SWIR/TIR moderate-resolution multispectral imagery *EUMETCast transmission*
Soil moisture[a] Research towards global near-surface soil moisture map (up to 10 cm soil depth) *Product worked out as global (EUMETSAT MPEF) and local within H-SAF: humidity of surface stratum, root stratum for 3 layers. Product Is being tested.*	Active and passive microwave *ASCAT data from METOP satellite.*

[a.] Soil moisture is not listed as an ECV, but has been recognized in the GCOS implementation plan as an emerging ECV.

4.8. Response on recommendations of GCOS IP

(a) Development of the global network of biomass monitoring for the purpose of satellite data validation and calibration (T3)

Actions have not been undertaken; however the state level initiatives are taken up (eg. ZMŚP – paragraph 2.3.3.)

(b) Sustaining and development of ground water and aquifers monitoring programs

The state's assignments in the scope of recognition, balancing and protection of ground waters for the purpose of their rational utilization by the society and economy (National Hydrogeological Service – PSH) are carried out by the Polish Geological Institute (PIG). It maintains the network of stationary observations of ground waters and task forces for the assessment and hydrological forecasts. Observation network of ground waters comprises: hydrogeologic stations, ground water level observation points, quality of groundwater monitoring points, observational piezometers and encased springs. PSH supervises the functioning of the national monitoring of ground water quality and the network of regional monitoring.

IMGW is responsible for the network of 100 stations of ground water measurements located at the whole country area. 54 of them are the signaling posts and 41 stations are equipped in the telemetric function. Measurements and observations are carried out at 6UTC or just before the water intake if the measurements are taken in the farm well. Basic scope of measurements comprises: water level measurements whereas extended one additional measurements of water temperature. Measurements are carried out in farm wells or piezometers and measuring posts are set in a way to assess the level of the first acquifier water table, which is used for the estimation of the retention (water storage) capabilities of the drainage basin. Ground water stations are connected with the state nivelation system with the accuracy of 1mm. Measurements are carried out by the direct pressure sensors which perform the measurement of the pressure of water column over the sensor.

(c) Archiving and distribution of information on the state of water resources (T9)

Information on the Water resources is published every month by the IMGW. Until 2004 those were "Water Resources of the State" and since 2005 suite of detailed information about hydrology, economy water engineering is presented in"Monthly Hydro-Meteorological Bulletin"

(d) development of the snow cover measurements network and submission of historic data to specialized world centers

As it was mentioned in paragraph 4.1. snow cover depth is measured daily at over 1300 IMGW stations at the area of Poland. At 1200 posts depth of fresh snow is also measured once a day and at 205 localization twice a day water equivalent of snow is established.

There are no measurements along typical snow routes in Poland. Only in the area of the highest mountain range – Tatra Mountains – there is a network outside standard IMGW station. Network of the special measurements. (4 sites) where apart from typical measurements of snow depth and density of snow cover once a day additional physical and chemical characteristics of snow are checked. The network functions within the special avalanche warning system.

(e) Maintenance and development of the glaciers' observation network in the high latitudes as well as in Africa, Himalaya, New Zealand and South America (T13)

As presented in paragraph 4.4. – at IGf PAN and ZBA PAN stations monitoring of glaciers of Norwegian Arctic is carried out.

(f) Contribution to the development of global permafrost monitoring network (T16)

As stated in paragraph 4.5. – activities regard to Norwegian Arctic (IGf PAN).

(g) Reanalysis of historical data regarding individual ECVs

No actions

5. Conclusions

Analysis of the existing system of climate observations in the country allows the formulation of several conclusions.

Level of development of specific components of the system differs. It is definitely the highest in the terrestrial systems of measurements of ECVs in meteorology (on lands and oceans and higher strata of the atmosphere) and hydrology (snow cover as well as rivers and lakes monitoring) carried out basically within PSHM by IMGW.

There is also very high level of utilization of satellite systems in the scope of meteorological and oceanographic variables, and somehow lesser in the hydrological variables and other land characteristics. Also in this case dominating role is played by IMGW, however activities of other institutions such as IO PAN in Sopot and the Oceanography Institute of University of Gdańsk mainly in the range of optical characteristics of the atmosphere and sea surface observations substantially enrich this area.

The contribution of Polish institutions mainly Geophysics Institute of PAN and Earth Sciences Division of Śląsk University to climate observation program in high latitudes is also very important. The contribution of those institutions into glaciological and permafrost research is unique.

It is valuable to continue regular meteorological observations at sea areas as well as the transfer of data to Global Data Gathering Centers (GCC) in Hamburg and Edinburgh. This program functions thanks to the engagement of IMGW and deck officers understanding the meaning of the meteorological information.

Data acquired within the observation-measurement programs realized by the Polish units within GCOS are stored in dozen or so global data centers. Those are used in very important projects and initiatives of global importance such as global meteorological and oceanographical reanalyses or validation of satellite products. Data from marine areas are used by WMO to elaborate on the climatological characteristics of seas and oceans in accordance with Marine Meteorological Summary Scheme WMO, MCSS. Moreover they are part of such global bases as I-COADS (International Comprehensive Oceanic-Atmosopheric Data Set) being the basis of nearly all studies on seas and oceans climate variability. This is why those activities may be regarded as important for Poland.

List of Abbreviations

The names of the Polish institutions were translated into English but their abbreviations remind without translation.

AGH – AGH University of Science and Technology in Kraków (*www.agh.edu.pl/)*
DWD – Deutsche Wetterdienst
ECVs – Essential Climate Variables
ESA – European Space Agency
EUMETSAT – European Organization for the Exploitation of Meteorological Satellites
GCOS – Global Climate Observing System
I-COADS - International Comprehensive Oceanic-Atmospheric Data Set
ICSU – International Council for Science
IMGW – Institute of Meteorology and Water Management (*www.imgw.pl/*)
IGf PAN – Institute of Geophysics, Polish Academy of Sciences (*www.igf.edu.pl/)*
IGiPZ PAN – Institute of Geography and Spatial Organization, Polish Academy of Sciences (*www.igipz.pan.pl/)*
IM – Marine Institute (*www.im.gda.pl/)*
IOC – Intergovernmental Oceanographic Commission
IO PAN – Institute of Oceanology, Polish Academy of Sciences (*www.iopan.gda.pl/)*
IOŚ – Institute for Environmental Protection (*www.ios.edu.pl/*)
IPCC – Intergovernmental Panel on Climate Change
KASHUE – The National Administration of the Emissions Trading Scheme (*www.kashue.pl/)*
KCIE – National Emission Center (*emissions.ios.edu.pl/kcie/)*
KPN – Kampinos National Park (www.kampinoski-pn.gov.pl/)
MCSS - Marine Meteorological Summary Scheme WMO
MIR – Sea Fisheries Institute (*www.mir.gdynia.pl/)*
MTG – Third Generation Meteosat
NOAA – National Oceanic and Atmospheric Administration
NOC UK – National Oceanography Centre in Southampton
NFOŚiGW – The National Fund for Environmental Protection and Water Management
OTS – Satellite Teledetection Center IMGW (*www.imgw.pl/*)
PIG – Polish Geological Institute (*www.pig.gov.pl/)*
PMO – Port Meteorological Officer
PMŚ – National Environment Monitoring
PSH – National Hydrogeological Service
PSHM – Natioal Hydro-Meteorological Service
PTGf – Polish Geophysical Society
SBSTA – Subsidiary Body For Scientific And Technological Advice
UAM – Adam Mickiewicz University in Poznań (*www.amu.edu.pl/)*
UG – Gdańsk University (*www.ug.edu.pl/*)
UJ – Jagiellonian University in Kraków (*www.uj.edu.pl/)*
UJK – Jan Kochanowski Humanistic-Earth Sciences University in Kielce (*www.ujk.kielce.pl/)*

UMSC –Maria Curie-Skłodowska University in Lublin (*www.umcs.lublin.pl/)*
UMK – Mikołaj Kopernik University in Toruń (*www.umk.pl/)*
UNEP – United Nations Environment Programme
UNFCCC – United Nations Framework Convention on Climate Change
UŚ – Śląsk University In Sosnowiec (*www.us.edu.pl/)*
UW – Warsaw University in Warsaw(*www.uw.edu.pl/)*
UWr – Wrocław University in Wrocław (*www.uni.wroc.pl/)*
WIOŚ – Voivodeship Inspectorate for Environmental Protection
WMO – World Meteorological Organisation
WPN – Wigry National Park (*www.wigry.win.pl/)*
ZBA PAN – Dept. of Antarctic Reaserach of Polish Academy of Sciences (*www.arctowski.home.pl/)*