Examples of GIS Use in National Hydro-Meteorological Service in Poland

Introduction

Institute of Meteorology and Water Management (IMGW) manages the national hydro-meteorological service, the task of which is to maintain the network of stations, process data, as well as issues warnings, reports and announcements. There are 5 regional divisions of IMGW located all over Poland. Each division includes numerous stations and the scientific-research departments.

Information collected through the IMGW measurement network is related to specific observation points; hence one of natural methods of its presentation (directly or in processed form) is a map. Meteorological and hydrological data analyses are also connected with maps. Moreover, all kinds of models tend to be more frequently integrated with geographical information systems, used as pre- and post-processors of these models. As a result, individual teams in IMGW take more interest in spatial analysis tools, as well as in participation in projects aiming at development of digital map resources. GIS use in IMGW, together with its possible future application, constituted the subject of works of the authors of the present article. It resulted in proposals concerning the content of shared resources of geometrical data and connections with attribute data, as well as in proposals and examples of GIS use in routine works.

The concept of GIS implementation in IMGW

Within the framework of IMGW statutory works, a study of geographical information systems (GIS) use in the Institute was prepared (conf Madej P., Barszczynska M., Kubacka D., 1998-1999). The work was based on the analysis of the experience of individual organisational units and included declared respective needs and possibilities to finance the prepared project. The main postulation adopted in the study was the following: easy access to spatial data and GIS tools within the Institute, as well as widespread use of this technology in the outside activity (analyses, commissioned works, information and promotion). The postulation was adopted that the effects will be achieved in stages, as well as that in future, constant costs for the maintenance and up dating of the system will have to be allowed for.

In the project, GIS was indicated to be a tool of automation (partial) of repeating map work (bulletins, publications etc.). It especially concerns drawing isolines, and other tasks performed during measurement data processing.
A separate class of application is the visualisation of the results of models exploited in IMGW (e.g. meteorological or hydrological), or preparation of data for them, with the use of GIS technology. The use of GIS as a tool for disseminating information, especially via the Internet and Intranet, was also considered (conf. Madej P., 2002).

It was assumed that the Institute spatial information system would be based on the common map resource that shall operate on at least two level of detail. The general level corresponds to a scale of 1: 1 000 000 - 1: 500 000 and the detailed one to the scale of at least 1: 50 000. The scale of 1: 50 000 was suggested due to the fact that new hydrographic division of Poland is in that scale.

Proper layers of digital map shall be purchased or created, and connected with already existing attribute databases. Integration of geometrical data with IMGW historical and operational databases is one of the basic problems in customising GIS for the Institute.

It shall be noted that a number of specific issues requires specific data, e.g. flood protection problems, where great preciseness is needed for the area along the watercourses, or satellite pictures presented against the territory of Europe. Therefore, except for common map resources, additional layers will be indispensable. They shall conform to the basic resource, and the information about them shall be easily accessible.

The creation of a geographical information system for a large institution (such as IMGW) requires various tool solutions and their adaptation to users’ needs. In IMGW, the data and products of which, are of geospatial character, the need for data and tool access will be widespread. At the same time, various units will use GIS tools and software to a various degree. It influenced the concept as regards software. A traditional solution was suggested that be based on professional GIS, desktop GIS, as well as on simple tools for data presentation. Professional GIS shall be useful for research units and units dealing with data processing and completing and servicing map resources. It shall be useful for advanced spatial analyses using the existing data resource; at the same time new synthetic information created on output can enrich the map resources. Desktop GIS, intended for less advanced users, will suffice for numerous analyses and visualisations. Simple tools and ready-made applications will provide passive access for limited scope of information. These will be particularly helpful for other users, including IMGW customers. For some units, the software shall be supplemented with professional tools (e.g. for satellite data analysis and processing).

1 Based on the topographic map at a scale of 1: 50 000, on the commission of the Ministry of Environment, IMGW created a Hydrographic Division Map of Poland (MPHP). Its content is based on river network, with the courses and names of watercourses verified by IMGW, as well as country division into individual basins.
Examples of GIS Use in National Hydro-Meteorological Service in Poland

The above-mentioned requirements concerning GIS refer also to the tasks performed by the Institute’s organisational units. Presented below is an attempt of such systematisation as an introductory task proposal for geographical information system in IMGW. It only includes part of the requirements, mainly connected with the hydrology and water management units. Suggested tasks shall be treated as ones that initiate GIS technology application. They were classified according to the type of works carried out in IMGW and the needs of respective units.

Organisational units responsible for hydrological forecasting
1. Access to the general map showing water network, administrative boundaries, division boundaries, stations location, including basic information about them.
2. Weekly bulletin, available for the press, radio and TV, showing the present water levels on watercourses, ice phenomena, snow cover, precipitation (internet).
3. Monthly bulletin (available for money), including detailed data e.g. on the level of water resources in a basin.
4. Flood risk maps.

Units providing technical-organisational service of measurement network
1. Access to the general map showing water network, administrative boundaries, division boundaries, stations location, including basic information about them.
2. Map showing detailed location of stations with the possibility to obtain more information (coordinates, equipment, location description, history of a station, possibly a sketch-map and a sketch of equipment position in the meteorological yard).
3. Flood risk maps.

Units preparing expertises for outside customers
1. Interpolation of meteorological elements in the place where there in no station.
2. Selecting a station of defined location features.
3. Flood risk maps.

Units carrying out research works
1. Determining isolines, as regards various measurement elements.
2. Spatialization of point data
3. Preparing input data and presenting models results.
4. Carrying out area analyses.
5. Flood risk maps.

Furthermore, it is assumed that all user groups will exploit digital maps and GIS as access tools for attribute databases.

Current map resources

The creation of common map resource was started from small-scale maps (1: 500 000). They suffice for various applications, including data visualisation on the Internet and the Institute publications, as well as access tool for measurement and historic data. They also suffice for general visualisation of hydrological situation, both on the national and regional level. According to the adopted
principle, the first stage of creating GIS for IMGW consists of collecting map resources on hydrography, water management and environmental protection for the area of Poland. These were obtained by means of information exchange and purchase of basic layers that were later completed with thematic layers created independently.

Currently the map resources include:

1. Hydrography (rivers and canal axes, lakes and water reservoirs; the layer includes all water-courses, on which IMGW had or has river gauge stations)
2. Transport (roads and railways)
3. Localities being the seat of municipality, county, voivodeships, bigger villages etc.
4. Urban built-up areas
5. Forest areas
6. Observation-measurement stations of IMGW
7. IMGW divisions boundaries
8. Watersheds
9. Polish administrative division (municipalities area including the subdivision on smaller territory units, counties, old and new voivodeships).
10. Digital elevation model for Poland (in the form of grid at a resolution of 250 m)
11. Raster maps of Poland at a scale of 1 : 500 000 (from the Hydrological Atlas of Poland)

Examples of GIS use

The collection of maps is widely used in the activity of the Institute. Included below are examples of such use, which is the result of the authors’ experience. These have been selected so as to present various aspects of GIS technology application – beginning with visualisation, through detailed analysis integrating geometrical and attribute data and creating internet service to end with.

Map compositions for diversified use

One of the basic functional possibilities provided by GIS systems is the preparation of various map compositions intended for a range of purposes. The illustration below shows a map of the area encompassed by the boundaries of the IMGW Cracow branch, created on the basis of the collected and updated numerical layers. It shows division boundaries, river network and currently active meteorological and river gauge stations. This material constitutes basis for creating a large-size wall map.

Another use for the digital layers at a scale of 1:500 000 is a map prepared for monthly Bulletin of the National Hydrological and Meteorological Service (conf. Fig. 2). Headquarters, IMGW field branches, forecasting offices and stations
Examples of GIS Use in National Hydro-Meteorological Service in Poland

were selected from the full network of the measurement stations. These points were shown against the map depicting the borders of Poland, boundaries of voivodeships, IMGW divisions and selected important rivers and reservoirs.

This map has been created primarily to acquaint IMGW customers with its structure and location of the major units of the firm.

Creating this kind of composition requires careful consideration of what and how to visualise. Obtaining the desired effects may depend not only on the available geometric data, but also on the available attribute data. Attribute data allow highlighting graphically certain characteristics of the objects on the map, e.g. observation network stations of specific kind. Occasionally, special sets of graphic symbols need to be prepared, which are not normally available in tool products. Colours, style and size of the names are very important as well. It is essential, whether the projected composition is to be printed (if so, in what format) or only displayed on the screen.

Analysis of the possibility to reduce flood losses

It is an example of GIS use in the works outside the Institute’s statutory activity. ArcInfo Software Packet was used to analyse potential flood loss reduction in the Wisłoka valley as a result of the Krempna reservoir creation. The work included scanning maps of flood areas at a scale of 1:10 000, as well as its transformation to the appropriate projection and digitalisation of the range of potential inundation for the flow, when the probability of accidence amounts to 1%, 5%, 10% and 20%. Further, digitalised inundation lines were brought on numeric layers of land development map which allowed selecting objects at risk for food. Subsequently, after the adoption of unit loss indexes for respective categories of objects at risk for flood, potential flood losses for mentioned above probable flows were estimated. This work also effected in creating tables showing the summary of area, length or number of respective elements of land development for areas marked out by cross-section of watercourses and all inundation lines. Quantitative analysis is supplemented with map compositions visualising areas at risk for flood. (conf. Fig. 3).

Internet website

The above-mentioned resources of digital layers at a scale of 1:500 000 were also used for preparing information web pages about IMGW measurement network (Conf. Barszczyńska M., Madej P., 2000). This website is an interactive vector map, rendering the possibility to choose active layers, the possibility of continuous scaling and scrolling of a map, and providing access to attribute data related to the map objects. Objects on the map react to cursor movement and mouse click, which is how a user may obtain information about a selected measurement station (attribute data). From the technical point of view, this solution is based on the

2 Digital maps of flood areas development for the main flood rivers in Poland were made within the framework of works commissioned by RZGW (Regional Board for Water Management) and sponsored from the World Bank loan.
combination of HTML, JavaScript and SVG\(^3\), while the website code was mainly created automatically, on the basis of the data from information layers of GIS database, gathered in the form of ArcView project.

The information in this form can be accessible through www server; users need an Internet browser (Internet Explorer preferably) with Adobe SVG Viewer\(^4\). It is currently available at IMGW Intranet.

The above-presented examples show some of the possible uses of GIS tools and map resources gathered by IMGW. Numerous products prepared by the Institute require presenting results on the basis of maps. Further examples can be found in IMGW Internet service [www.imgw.pl](http://www.imgw.pl), especially in the Customer Service System (SOK).

Of great interest is the use of GIS technology in the research works of IMGW, e.g. for creating thermal maps (Conf. Ustrnul Z., Czekierda D., 2003). Soon the results of hydrologic and hydraulic models will be presented operationally, owing to the use of embedded GIS.

**Conclusions**

A few years ago, teams working in IMGW started using GIS tools and attempted to customise them on their own. The works were not co-ordinated, and often involved a range of diversified issues that required various tools and a very different preciseness of spatial data. Similar products were created, based on the same, but non-corresponding layers of numerical maps. The concept discussed in the article is an attempt at systematisation of works on GIS implementation in IMGW that is based on common resources of numerical layers, for potentially wide use in the activity of the Institute, as well on exchange of experience between organisational units taking advantage of GIS technology.

The postulations adopted in the presented concept are accomplished gradually. It also applies to collecting common map resources, exchange of products, service and information between the teams that accomplish various statutory tasks and carry out research works.

The resources of digital layers are constantly enriched, with special attention to their correspondence. Software toolkit is also developed, which increases the possibility to create maps and perform analyses. The collected map and tool resources are available to employees via local networks of IMGW divisions. More and more employees gain working knowledge of available software packages application. Various IMGW organisational units develop co-operation in this area. Current modernisation of the Hydrological and Meteorological Monitoring Forecasting and Protection System will soon effect in wider use of GIS in

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3 Scalable Vector Graphics ([www.w3.org/Graphics/SVG](http://www.w3.org/Graphics/SVG)), XML dialect designed for presenting two-dimensional graphics on www, recommended by W3 Consortium.

Examples of GIS Use in National Hydro-Meteorological Service in Poland

operational works. As a result of this, the level of integration and range of GIS application in IMGW matches the respective level in similar institutions in other European countries.5

Fig. 1 IMGW measurement network for the upper Vistula basin within the Cracow division boundaries

Fig. 2 Map for Bulletin of the National Hydrological and Meteorological Service

5 IMGW takes part in COST 719 „The use of Geographical Information Systems in Climatology and Meteorology” program (www.knmi.nl/samenw/cost719), within the frameworks of which the analysis was made of GIS use, in 15 institutions from 13 countries participating in the project.
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Fig. 3 Fragment of a land development map, with inundation lines
Examples of GIS Use in National Hydro-Meteorological Service in Poland

Fig.4 Detailed information about water gauge stations and about the contents of the Main Data Base, on the right there is a fragment of attribute data

Bibliography


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Examples of GIS Use in National Hydro-Meteorological Service in Poland

Summary

Majority of data measured, processed and prepared in Institute of Meteorology and Water Management (IMGW) is space-related, therefore GIS use is indispensable for its visualisation and processing. A proposal has been put forward, as regards the contents of the common resources of geometrical data and its integration with attribute data, as well as suggestions concerning GIS application in research and routine works of IMGW. A model of employing various types of GIS software, depending on needs, has been prepared. The examples provided in the article present various aspects of GIS use.

Keywords: geographical information systems, GIS, applications, proposal, national hydro-meteorological service

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Streszczenie

Większość danych mierzonych, przetwarzanych i opracowywanych w Instytucie Meteorologii i Gospodarki Wodnej (IMGW) ma odniesienie w przestrzeni, dlatego niezbędne jest użycie GIS do ich obróbki i wizualizacji. Przygotowano propozycje zawartości wspólnego zasobu danych geometrycznych i połączenia ich z posiadanymi danymi atrybutowymi oraz propozycje zastosowań GIS w rutynowych i naukowo badawczych pracach IMGW. Opracowano koncepcję użytkowania różnych rodzajów oprogramowania GIS w zależności od potrzeb. W opisanych w artykule przykładach przedstawiono różne aspekty zastosowania technologii GIS.

Słowa kluczowe: systemy informacji przestrzennej, GIS, zastosowania, koncepcja, narodowa służba hydrologiczno-meteorologiczna