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Remote sensing as the information source for thematic cartography

Abstract. Types of maps elaborated at the Polish Remote Sensing Centre (OPOLiS) on the base of remote sensing data, are presented in this paper. Information obtained from airborne thermal imageries, colour infrared photographs taken from aeroplanes and satellites, airborne multispectral photographs as well as photographs and scanner imageries taken from the Salyut 6 and Landsat satellites, were applied for elaboration of these maps.

The development of techniques and devices for collecting data on geographical environment has also been considered at the Institute of Geodesy and Cartography, where in 1971 a special laboratory on remote sensing applications for elaboration of different types of thematic maps was created. Panchromatic photographs were the preliminary source of information; they were taken for topographic purposes, and also, more frequently for the needs of particular thematic elaborations. In this period, also archival photographs were applied; their contents compared with the contents of new photographs, enabled to determine temporal changes within geographical environment.

One of the first thematic elaborations, based only on aerial photographs, was the map showing indirect results of development of mining industry, at the highly industrialized Upper Silesian District. This map showed: damps, embankments, excavations, tailing ponds, devastated land and waste land. The comparison of photographs taken in the period of 1955—1970 enabled to determine the changes in this region. The changes have expressed first of all: in increasing of the area of open pits and excavations, development of roads, and decreasing of rural and forested areas.

1. Thematic maps based on airborne thermal images

Two years later, the Institute was equipped with devices for taking thermal imageries. These were: the thermal camera Thermovision 680 and the thermal scanner Thermoprofile THP-1. Both devices were made by the Swedish AGA company. The elaboration of thematic maps showing thermal conditions of different objects and areas was started then, after the completion of research works, concerning methods of collecting and interpreting thermal imageries.

During the first period of utilization of this technique on collecting information, a series of maps presenting temperature distribution on the surface of rivers and lakes, into which heated water was discharged from open cooling systems of large power plants, was elaborated.

The map usually elaborated at the scale of 1 : 25 000 and printed in many colours generally presented with a black-and-white thermogram, and sometimes even with scores of thermal profiles, showed temperature distribution of water surface with the accuracy of 0,5°C.

Thermal images and panchromatic photographs were commonly applied for investigations and cartographic presentation of ice phenomena occurring in rivers into which water was discharged by industrial plants. Such maps covered the part of the Vistula River, where the influence of heated water could be noticed. On the maps, the range of this influence and the part of the river covered with ice and slush ice, rare, dense and partially melting due to warm water, were presented.

Microclimatic investigations were the following branch of application of thermal imageries. The results of these investigations were also shown in the form of maps. Till the present moment, thermal maps of the ground of three large cities: Warsaw, Cracow and Przemyśl and of two industrial plants and their vicinities have been elaborated at the Institute of Geodesy and Cartography. The method of real ranges presentation and the method of basic fields, with an average temperature value, were utilized for the cartographic elaboration. The maps were elaborated at the scale of 1 : 25 000.

Thermal images acquired from low altitudes, from the board of a helicopter, were applied as the information source concerning damages of the city heating network. The information concerning bad insulation of pipes or outflow of hot water, enriched the contents of the maps of the city heating network. Such maps were utilized for protection or localization of the place of damage.

Another branch of the application of airborne thermal imageries was the detection and mapping of subsurface fires of shallow coal deposits or subsurface fires of damps. Cartographic elaboration of the place of fire usually consisted of a black-and-white thermogram, a colour map of temperature distribution on the surface of the damp or of the area round the burning coal deposit and one or several profiles, presenting ground temperature along the determined line, with accuracy of 0,5°C.

Airborne thermal images were also applied for determining the range of the influence of the sulphur mine at Grzybów on the geographical environment. The sulphur at the investigated mine is exploited by the method of underground melting. Overheated water is forced deep under the Earth's surface; it dilutes sulphur deposits and the melted sulphur is pumped out to the surface. During the technological process not all water is pumped out. Part of it runs away before contacting the deposit

and another part — after diluting some amount of sulphur. The phenomenon of running away of warm, polluted water takes place both in deeper geological layers as well as in subsurface ones. This water extracts over the impermeable layers and occures several or over a dozen meters under the terrain surface. The water temperature is considerably higher than the temperature of surrounding layers, and due to the conductivity effect the water heats overlay layers.

Airborne thermal images can present, in particular conditions, usually subtle differences in temperatures of areas heated by warm and chemically polluted water and of surrounding areas. The results of the interpretation of thermal imageries were presented in the form of a map showing the range of influence of sulphur exploitation by means of the underground melting method on the pollution of the ground water.

2. Mapping of flood areas

The simplest remote sensing technique — panchromatic photography was applied in elaborating maps of the flood range. Three maps of this kind were drafted in the period of 1977—1979: two of them were based on airborne photographs and the third one was elaborated on the basis of the Landsat imageries. The flood, which occurred in spring of 1979, in North-East Poland, was taken on several successive satellite images. They enabled to analyse the development of the flood as well as its economic results. The map elaborated on the basis of satellite images presents the maximum range of the flood. Diagrams showing the height of the flood water, stating the time when the satellite images were taken, are also appended to this map. It is proper to add, that the map showing the first stage of the development of the flood, i.e., the maximum range of water in the upper courses of the rivers of North-East Poland, was elaborated and presented to the Flood Control Committee, 4 days after the satellite passed over the flooded areas.

3. Thematic maps based on false-colour aerial and satelite photographs

Almost since the beginning of its activities in the field of remote sensing application for thematic cartography the Institute of Geodesy and Cartography has applied the colour infrared photographs. They were utilized almost exclusively for the investigation of vegetation cover. The investigations in this field were directed on detection of pine damages, caused by the influence of industry, as well as by biotic factors, namely by the influence of pest insects. The investigations carried out at the Institute of Geodesy and Cartography allowed to find the relationship between the degree of tree damages, estimated by ground methods and its image on airborne photographs. It made possible to extrapolate

the results of destructive ground investigations onto large areas; this extrapolation was not only mechanical, but it was possible on photographs to determine in details the line separating areas characterized with various level of tree damages.

Further research works carried out in this field enabled to increase the number of details on maps of pine tree stand damages, which had been elaborated by the utilization of ground observations.

Traditionally, according to existing principles, four zones of damages were distinguished on the maps of stand damages: the zone free from damages, the zone of slight damages, the zone of strong damages and the zone of mortal damages of trees.

As far as the determination of zones I and IV did not create research problem, the classification of trees into zones II or III was somehow difficult to perform. Colour infrared photographs allowed not only to eliminate doubts, but also improved accuracy of determinating zones, introducing additionally 4 subzones for each of these two zones. Therefore, maps elaborated on the basis of the results of interpretating colour infrared photographs are much more accurate than the maps elaborated by conventional methods.

The method of interpretating colour infrared photographs was used for mapping forested areas being under the influence of gases and dusts emitted by industrial plants, for tree stands suffering from lowering of ground water level caused by activities of strip mines, and for tree stands invaded by a large gradation of pest insects.

Colour infrared photographs considerably accelerated the process of elaborating maps which were used for planning recultivative activities.

False colour photographs taken from the board of the Soviet space craft Soyuz-6 were applied in order to elaborate a map presenting the level of tree stand damages, of the Upper Silesian District. The scale of the satellite photographs enabled to elaborate a map at the scale of 1 : 100 000. Thus, it is a considerably smaller scale than in the case of maps elaborated on the basis of airborne photographs. Nevertheless, satellite photographs turned to be a good enough source of information for the purpose of a general map, which provided some description of the state of the pine tree stand in this highly industrialized region. On the basis of these photographs it was possible to distinguish only two zones of damages within pine forests; namely the zones of null and mortal damages. The resolution of satellite photographs and masking influence of the Earth's atmosphere did not allow to observe the subtle differences in the colour of the tree crowns of different damage levels.

4. Mapping of water pollution using multiband photography

The possibility of mapping water pollution occurred with the beginning of taking multispectral airborne photographs. As the result of the research works carried out at the Institute of Geodesy and Cartography, the correlation between optical density of multispectral photographs and water transparency has been stated. The relation has also been found between water transparency and the contents of general suspension, the amount of chlorophyll and some chemical substances which after dissolution in water cause the change within the contents of reflected sun rays.

These relations were utilized for investigating and mapping out of pollution distribution within coastal and inland lakes. The elaborated maps show in fact, only the temporary state of pollution distribution within the water reservoir, but they give sufficient information on the dimension and intensity of this phenomenon at a given moment.

Multispectral satellite imageries were applied in investigations of pollution occurring within larger water reservoirs, for example, the Szczecin Bay. Also in this case, the relation between the intensity of reflected electromagnetic radiation and water transparency, was determined. Since the satellite photographs are taken continuously, and the flight of a satellite over the Szczecin Bay is not always synchronized with contact investigations, at the Institute of Geodesy and Cartography was elaborated a method for correlating results of ground measurements with the value of reflected radiation, that is registered by a scanner located on board of the Landsat, in case when these ground investigations are carried out only once at the moment of the flight of the satellite. Then, the images are taken independently on the in-situ investigations, or when such investigations are not carried out at all.

This method was utilized for elaborating many satellite images covering the Szczecin Bay, the results of which are shown in the form of several thematic maps presenting the pollution of this reservoir. The comparison of maps allows to draw some conclusions concerning the dynamics of the expansion of the pollution within the closed basin, into which the Odra River and several smaller, strongly polluted rivers flow.

5. Mapping of air pollution by means of satellite imageries

Satellite imageries, permanently delivered to the Institute of Geodesy and Cartography, were utilized for elaborating maps of atmospheric pollution in Poland. Smokes emitted by industrial plants are clearly visible both on Landsat imageries as well as on the satellite photographs which are taken from Soviet spaceships. The utilized digital data processnig of photographs allows to enhance the contrast of photographed

objects, which makes interpretation of plumes of smokes easier. The knowledge of external orientation of the Landsat scanner and the shadow of the smoke, which is usually visible on the photograph, enable to calculate the altitude to which smokes and dusts emitted by industrial plants are raised.

Soviet satellite photographs are taken, in turn, according to the principles of stereophotogrammetry. Thus they enable to create the 3-dimensional model of the photographed area with very well visible plume of smoke hanging over it. The measurement of the parallax allows to determine the „z" coordinate at any given place within the smoke plume.

Satellite photographs of Poland, obtained from both sources, enabled to elaborate a map depicting directions and ranges of smokes emitted by industrial plants, at various wind directions, but generally, at high pressure areas with the inversion layer frequently occurring up to the altitude of 600 metres. Such a situation causes that in certain cases the emitted smokes reach the distance of 150 kms.

In spite of the fortuitous choice of the satellite photographs, the elaborated map depicts the distribution of smokes and the influence of the terrain relief on its directions. It is worthwhile considering, that the axis of the plumes of smokes which were interpreted on the basis of satellite photographs, frequently run differently than the axis calculated on the basis of the models of dispersion processes of gases and dusts, applied in meteorology.

For the South-West part of Poland a map presenting the range of industrial and municipal dust imission was also elaborated. Winter satellite photographs were utilized as the source of information for this purpose. These photographs taken within six days after the last fall of snow, exceptionally clearly presented the vicinities of cities and larger industrial plants which were under the influence of fall of dust. The microphotometric analysis even allowed to distinguish areas with various intensity of dust cover.

Until now, the elaboration of such a map for the entire territory of Poland turned out to be impossible. Meteorological conditions in this case, are exceptionally important, both at the moment of taking photographs, as well as during the peroid prior to it.

6. Land use maps

Airborne and satellite photographs were also applied in elaborating land use maps, both at large scales and general maps.

For elaborating large scale maps, airborne photographs are utilized, taken by means of different techniques and at different periods of time. Such maps usually show changes within the land use occurring due

to large investments, both industrial and municipal, connected with the design of new housing districts in large cities.

Satellite photographs were, in turn, applied in elaborating a general map of land use in Poland, as well as in elaborating land use maps for particular administrative districts of the first level (voivodships). In the first case, analog interpretation methods were applied, and in the second case — the digital method.

In order to elaborate a land use map for the whole country the Landsat imageries at the scale of 1 : 250 000 and the Soviet satellite photographs taken in spring and autumn of 1978 were applied. On the basis of this data ten main land use categories were distinguished, namely: arable land, green fields, coniferous forests, deciduous forests, mixed forests, urban areas, industrial-storage areas, waste land, rivers and water reservoirs.

After the generalization of contents and changing the cartographic projection, this map was published as the second in the history of the Polish cartography, land use map covering the whole country. It should be noticed, that while the first map was elaborated by a several-person group within four years, the second map was elaborated by a four-person group only within four months.

The works carried out in the field of digital processing of satellite photographs are discussed in detail by Krystyna Lady Drużycka and Jacek Domański in the present Proceedings of the Institute of Geodesy and Cartography.

Translation: Jacek Domański

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LA TÉLÉDÉTECTION COMME SOURCE D'INFORMATION POUR LA CARTOGRAPHIE THÉMATIQUE

Résumé

Les données de la télédétection pour les besoins de la cartographie thématique sont utilisées dans l'Institut de Géodésie et de Cartographie depuis plus de 10 ans. Au début ce n'étaient que des photos aériennes en blanc et noir, puis on a adopté d'autres techniques d'acquisition des données. L'une des premières c'était la technique de réalisation de photos en infrarouge thermal. A l'aide de cette technique on a réalise à l'Institut plusieurs cartes montrant la répartition de la température des eaux des fleuves et dans les réservoirs recevant des rejets d'eau chaude provenant de centrales électriques et on a élaboré des cartes des conditions microclimatiques dans de grandes villes et dans des usines importantes. La même technique a été utilisée pour acquérir des informations sur les défauts du réseau de chauffage urbain. Ces informations ont enrichi le contenu des cartes illustrant la disposition du réseau de ce chauffage. Les photos aériennes thermales ont été également utilisées pour détecter et rapporter sur les cartes des incendies souterrains ainsi que pour déterminer le rayon d'action de la dénaturation des eaux souterraines par les composés soufrés dans les mines utilisant la méthode de la fusion souterraine.

Une autre technique largement appliquée dans la cartographie thématique par l'Institut était celle des photos en infrarouge en fausses couleurs. Ces photos étaient utilisés uniquement pour rapporter sur les cartes des endommagements biotiques et abiotiques dans les forêts de pins ainsi que pour déterminer des surfaces forestières aux différents états de risque industriel.

Les photos aériennes macrospectrales étaient utilisés de leur tour pour l'élaboration des cartes illustrant la pollution des réservoirs d'eau.

Dans la cartographie thématique on a également utilisé les photos de satellite, aussi bien americaines que russes, pour l'élaboration des cartes d'exploitation de la terre aux échelles 1 : 500.000 et 1 : 100.000 ainsi que de la carte illustrant l'état de la pollution de l'air en Pologne.

Traduit par: M. Bohdan Jakubowski

АНДЖЕЙ ЦИОЛКОШ

ДИСТАНЦИОННОЕ ЗОНДИРОВАНИЕ КАК ИСТОЧНИК ИНФОРМАЦИИ ДЛЯ ТЕМАТИЧЕСКОЙ КАРТЫ

Резюме

Данные дистанционного зондирования для нужд тематического картирования используются в Институте Геодезии и Картографии свыше 10 лет. Первоначально были это почти исключительно черно-белые аэроснимки, позже были введены другие техники получения данных. Одной из первых была техника проведения съемки в тепловой инфракрасной части спектра. С помощью этой техники изготовлено в Институте много карт, изображающих распределение температуры воды в реках и водохранилищах, обремененных сбросами теплой воды из теплоэлектростанций, составлено карты микроклиматических условий в больших городах и крупных промышленных предприятиях. Эта техника применялась также для получения информации о повреждениях городской теплосети, которой дополнено содержание карт, изображающих распределение городской сети центрального отопления. Наконец, тепловые аэроснимки применялись для обнаружения и картирования подповерхностных пожаров, а также для установления предела загрязнения грунтовой воды соединениями серы в шахтах, работающих по методу подземной выплавки.

Другой техников широко применяемой в тематическом картировании в IGiK, были снимки в инфракрасной области спектра с недействительными цветами. Использовались они почти исключительно для картирования биотических и абиотических повреждений в сосновых лесах, а также для обозначения лесных пространств, находящихся в разных состояниях промышленной угрозы.

В свою очередь многоспектральные аэроснимки используются для составления карт, изображающих загрязнение водохранилищ.

В тематической картографии были использованы также космические снимки, как американские, так и советские, для составления карты землепользования в масштабе 1 : 500 000 и 1 : 1 000 000, а также для составления карты, представляющей состояние загрязнения атмосферного воздуха в Польше.

Перевод: Róża Tołstikowa

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TELEDETEKCJA JAKO ŹRÓDŁO INFORMACJI DLA KARTOGRAFII TEMATYCZNEJ

Streszczenie

Dane teledetekcyjne do potrzeb kartowania tematycznego są wykorzystywane w Instytucie Geodezji i Kartografii od ponad 10 lat. Początkowo były to niemal wyłącznie czarno-białe zdjęcia lotnicze, później zostały wprowadzone inne techniki pozyskiwania danych. Jedną z pierwszych była technika wykonywania zdjęć w podczerwieni termalnej. Za jej pomocą wykonano w Instytucie wiele map obrazujących rozkład temperatury wód w rzekach i zbiornikach obarczonych zrzutami ciepłej wody z elektrowni cieplnych, opracowano mapy warunków mikroklimatycznych w dużych miastach i wielkich zakładach przemysłowych. Tę technikę stosowano także do zdobywania informacji o uszkodzeniach miejskiej sieci ciepłowniczej, którymi wzbogacono treść map obrazujących przebieg miejskiej sieci ogrzewczej. Wreszcie lotnicze obrazy termalne stosowano do wykrywania i kartowania pożarów podpowierzchniowych, oraz do ustalenia zasięgu skażenia wód podpowierzchniowych związkami siarki w kopalniach pracujących metodą podziemnego wytapiania.

Inną techniką stosowaną szeroko w kartowaniu tematycznym w IGiK były zdjęcia w podczerwieni o barwach nierzeczywistych. Wykorzystano je niemal wyłącznie do kartowania uszkodzeń biotycznych i abiotycznych w lasach sosnowych, a także do wyznaczenia obszarów leśnych znajdujących się w różnych stanach zagrożenia przemysłowego.

Z kolei wielospektralne zdjęcia lotnicze wykorzystano do opracowania map obrazujących zanieczyszczenie zbiorników wodnych.

W kartografii tematycznej wykorzystano również zdjęcia satelitarne, zarówno amerykańskie, jak i radzieckie. Wykorzystano je do opracowania map użytkowania ziemi w skali 1 : 500 000 i 1 : 100 000, a także do opracowania mapy obrazującej stan zanieczyszczenia powietrza atmosferycznego w Polsce.