

Remote Sensing Education at Bulgarian Universities and High Schools – State of the Art, Perspectives and Significance

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Abstract. In the second half of the last century, remote sensing methods became increasingly influential in the civil sector of the economy. Their various applications such as monitoring and analysis of the atmosphere, terrestrial and aquatic features of the environment, made them widely applicable in numerous scientific and economic fields. The purpose of present work is to describe the past, current status, future perspectives and significance of remote sensing education at Bulgarian universities and high schools. The methods used are review of the available literature, questionnaires with students and academic staff and internet survey. The beginning of the remote sensing education for civil purposes in Bulgaria started in the early 1940's with the establishment of the High School of Technics in Sofia. From the 1970's remote sensing methods were developed, studied and applied in the institutes of the Bulgarian Academy of Sciences. Some of the pioneers in the development of specialized applications and education in remote sensing of Ph.D. students in Bulgaria are Space Research Institute, National Institute of Meteorology and Hydrology, Institute of Geography, Central Laboratory of Geodesy and Institute of Oceanology. Nowadays, remote sensing courses are included in the curriculum of several universities such as Sofia University, The University of Architecture, Civil Engineering and Geodesy, University of Mining and Geology, Technical University of Sofia, University of Forestry, New Bulgarian University. At high-school education remote sensing introductory courses have been taught since the middle of 1990's at the National High School of Mathematics and Science. At present, the principles and methods of remote sensing have their applications in geodesy, civil engineering, geology, geography, landscape science, ecology, geomorphology, archaeology and preserving the natural and cultural heritage. The perspectives for remote sensing education in Bulgaria are connected with better understanding of the essence and effectiveness of remote sensing at solving or mitigating of the global issues of 21st century.

Keywords: Remote sensing, geo-information, education, history, perspectives

Introduction

The beginning of remote sensing (RS) education at Bulgarian high schools and universities can be traced back to the 1920s of 20th century, when photogrammetry courses have been introduced in the State Geography School (SGS). In 1930 SGS have founded first photogrammetry school. Simultaneously, a photogrammetric division and instructions and regulations for these measurements were prepared. In 1942 the Department of Photogrammetry, Topography and Cadaster was established. Initially, it was affiliated to the Civil Engineering Division at High School of Technics. In 1945, following the changes in the curriculum and structure of the department its name was changed to Photogrammetry and Topography. In 1948 the department further narrowed its subject of study by transferring its name to Photogrammetry. From the beginning of 1950s to the beginning of 1970s photogrammetry and RS had been changing rapidly. The emergence of space era in remote

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sensing methods by the launching of the first earth's satellite in 1957, through the digital era in photogrammetry, remote sensing and image processing made subsequent changes in teaching remote sensing and photogrammetry inevitable. In 1974, Department of Remote Sensing of the Earth, formerly named as Scientific Direction *Remote Sensing Methods*, was formed at the Central Laboratory of Space Research at Bulgarian Academy of Sciences (BAS) [1]. This can be also accepted as the start year of civilian Ph.D. education in remote sensing in Bulgaria. In 1979, Department of Applied Geophysics at University of Mining and Geology (UMG) adopted two courses particularly oriented to the application of RS methods in geophysics. These courses, i.e. Remote Sensing Methods in Geophysics and Digital Image Processing (DIP), are read by to-day in the masters and baccalaureate programs Applied Geophysics. In the late 1980s of 20th century the university education in remote sensing was enriched by introduced courses of remote sensing read in specialization Photogrammetry and Cartography at University of Architecture, Civil Engineering and Geodesy (UACEG).

1. Materials and methods

Present study is based on questionnaires, literature review and internet survey. Textbooks, internet materials, study guides etc. were used as a source of reference for the historic outline for the development of remote sensing education in Bulgaria. The results from questionnaires were summarized in following sections of present work.

2. State of the art

University education in RS was the first available RS education in Bulgaria. This is due to the fact that university education is the one which prepares RS specialists and scientists for their future research. Sofia University *St. Kliment Ohridski* (SU) is the leading university in Bulgaria [2]. The RS lectures are taught at the MSc programs in Geography and Geographic Information Systems (GIS) and Cartography since 1998. From that time the RS lectures have been further deployed in three disciplines read for the Geomorphology, Physical Geography and Landscape Ecology, Climatology and Hydrology, Planning and Managing of the Territorial Systems and Applied Geochemistry MSc programs. Baccalaureate programs in Geography, Regional Development and Politics and Geology there are optional courses to the students such as: Satellite Climatology and Meteorology, Introduction to the Aerospace Research, Remote Sensing and Aerospace Cartography. The courses are mandatory for those students who are enrolled in MSc program in GIS and RS. The main application fields of RS education are in agriculture, forestry (deforestation), wildfires detection and monitoring. At the time of completion of present work there were 10 MSc students and 3 Ph.D. students pursuing their theses in RS or by using the means of geo-information. Recently, at Sofia University has been established *University Centre for Aerospace Observation*. The Centre is aimed at serving scientific-educational projects and application infrastructure of the university. At Biology Faculty at SU on MSc level students may attend an advanced course in "Information technologies for environment preservation". The course is aimed to acknowledge students with fundamentals of contemporary aerospace information technologies used in natural resources preservation. Within the course students are using modern means of geo-information software systems and GPS data to complete their projects. The *University Centre for Space Research and Technologies* at SU was established at Faculty of Physics, due to the closest relation of meteorology to the satellite observations for preparing meteorological forecasts. The courses: Remote Sensing in Meteorology, Remote Sensing in Geophysics and Satellite Data in Synoptic Analysis are taught in BSc and MSc programs in mete-

orology and geophysics. There are also 3 textbooks and study guides issued for studying purposes [3, 4].

The University of Architecture, Civil Engineering and Geodesy (UACEG) offers courses related to remote sensing curriculum, such as, Topographic Geomorphology, Photogrammetry, Cartography, Cartography Methods in Economy and Ecology, Automated Cartography, Engineer Photogrammetry, Remote Sensing Methods and DIP, GIS. In 2006, a new education plan adopted DIP as a part of the core curriculum. By this time, each year at Photogrammetry and Cartography master's program had been accepted 17 to 20 students approximately. The UACEG offers also Ph.D. education in photogrammetry and RS. There is also one project completed within a contract between the National Science Fund at Ministry of Education, Youth and Science: *Using Satellite Imagery for Evaluation of the Ecological Condition of Soils*.

Forestry applications of RS are taught at University of Forestry (UF). The first course starts in the beginning of 1990s as Geodesy and Remote Sensing course. Since 1992 the course name is Photogrammetry and Remote Sensing. The course is read in three of the BSc programs at UF, such as: Forestry, Ecology and Environment Protection and Landscape architecture. Along with RS methods taught in the abovementioned programs there is a GIS course, which is read to MSc programs such as Landscape Architecture. Courses are supplied by a textbook, which second updated edition is expected to be released by 2011. The University was also one of the first educational institutions in Bulgaria and Balkan region to accomplish forest mapping using the means of RS in 1994 within a PHARE-MERA project.

Presently, each year by average of 18 students attend the courses of RS methods taught at Department of Applied Geophysics, University of Mining and Geology *St. Ivan Rilski* (UMG). The courses are covered by one textbook: *Remote Sensing Methods in Geophysics and Geology* [5]. Since introducing the two courses in Applied Geophysics, there have been about 30 students who did defend their masters by using RS and DIP methods. Two Ph.D.'s from Department of Applied Geophysics at UMG had defended their dissertations at Institute of Solar-Terrestrial Influences, i.e. formerly Central Laboratory of Solar-Terrestrial Influences. There has been one project implemented for the thermo-physical capacity of rocks in the Rhodopi Mountains by using RS methods successfully completed in 2007. Remote sensing methods are part of the core curriculum of the students in Department of Geology and Minerals Exploration. Since 1998 a GIS course has started in the MSc and BSc programs in Economical Geology, Oil and Gas Geology and Hydrogeology. The BSc program in Geology and Geo-Informatics has been made available to the graduates in earth systems sciences in 2003. Presently, the course of Remote Sensing in Geology is taught to 10 students accepted to the master's program Economical Geology and 10 students in the baccalaureate in Geology and Geo-informatics. There are also, two employees of the department staff who pursue their Ph.D. in remote sensing. The satellite data available to students and Ph.D. students is from Landsat 7 – ETM+ and ASTER, whereas the data from ASTER spectroradiometer is used mainly by Ph.D. students. There is also one textbook issued in 2007 supplemented with laboratory practical exercises [6, 7]. According to the university officials' statistics successfully completing students are employed in geology, mining, ecology and natural resource protection and all other sectors of the national economy.

The education in Bulgaria on an academic level is regulated by the Superior Academic Council (SAC). All academic levels and applications fields are accredited by the National Evaluation and Accreditation Agency (NEAA). The latest accreditation of the scientific institutes, divisions and departments are according to the directions and regulation No 114-111 from 5 March 1990 according to which the Ph.D. education in RS of the Earth and planets has a reference number – 01.04.12. At present, remote sensing Ph.D. education is provided by several institutes affiliated to BAS. The foremost one, which provide RS education for Ph.D. students since the mid of 1970s of 20th century, is Department of Remote sensing of the Earth, Space Research Institute (SRI). There have

been awarded more than 30 Ph.D. diplomas to Ph.D.'s from Bulgaria, FYR of Macedonia, Egypt, Mongolia and Vietnam, one of which was awarded to first Bulgarian cosmonaut. The Ph.D. topics in RS can be grouped in two groups:

- Developing of spectrometry, videospectrometry and radiometric systems (ground-based or proximal, aerial and satellite) and [8];
- Improving of methods for processing and interpretation of data from laboratory, terrestrial observations and satellite images.

The Ph.D. theses have been completed within the research programmes of the missions of both Bulgarian astronauts, such as: *Thrace, Moesia, Les, Balkan*, as well as the global project ZEMIA, and the development and implementation of the research programmes of the BULGARIA-1300 – METEOR-PRIRODA Project; the International project PHOBOS for observation of Mars' satellite Phobos, the international space-targeted project— Nature (*Priroda*) for remote sensing of the Earth from the onboard instruments of the *Mir* Space station. SRI has been also planning, organizing and conducting various complex sub-satellite experiments carried out on test sites as well as processing of data for territories of the member-states of the *Intercosmos* Programme, carried out during flights of the international space crews working on projects *Studying of Dynamics of Geosystems with Remote Sensing Methods* and *Inland Water Objects* [9]. Nowadays, within the Centre for Education of Ph.D. Students at BAS are organized two courses aimed at improving the abilities of early stage researchers in their Ph.D. thesis writing [10]. These courses are “Remote sensing and aerospace research of extreme nature disasters” given by Prof. G. Mardirossian and “Environmental monitoring by using nano- and micro-satellites” read by Sen. Res. Fell. II rank Dipl. Eng. R. Nedkov, Ph.D. The courses are aimed at real time and near real time ecological and environmental monitoring of terrestrial and aquatic environments, observations of floods, wildfires, air pollution. The Ph.D. students are trained in the newest nano- and micro-satellites' platforms, sensors, parameters and characteristics of data acquired. The courses are organized within the framework of the contract BG051PO001/07/3.3-02/63/170608 between Bulgarian Ministry of Education, Youth and Science and SRI-BAS – the OP “Human Resources Development” funded by European Social Fund (ESF). Recently formed Institute within the system of BAS – Institute of Solar-Terrestrial Influences, formerly Central Laboratory for Solar-Terrestrial Influences, educates Ph.D. in RS as well. There are more than 7 Ph.D.'s who defended their theses in the application fields of imaging spectroscopy, geo-informatics and RS. The National Institute of Meteorology and Hydrology (NIMH) at BAS also educates Ph.D. Students in RS. There have been defended 3 Ph.D. theses in the application field of agricultural meteorology. The Institute of Oceanology (IO) at BAS educates Ph.D. Students in the RS. At the time of completion of present work there are 2 Ph.D. Students who pursue their theses within the framework of the project contract No BG051PO001/07/3.3-02/63/170608.

At Agricultural Academy RS and geo-information methods are used mainly in the fields of applied soil science and agriculture, investigation of status of the agricultural system soil-vegetation-atmosphere and Evaluation of status of soil and vegetation. At present, there are 2 Ph.D. students which are pursuing their Ph.D.'s by using RS methods and one Ph.D. student with dissertation.

During the last decade private university education in Bulgaria has thrived. The leading private university in Bulgaria is the New Bulgarian University (NBU), founded in 1992. Courses in remote sensing applications for monitoring of ecological disasters are taught since 1997 in master programs. Nowadays, the set of courses consists of: Ecology Disasters, Remote Sensing of the Earth, Universal Mechanics and Cosmology, Remote Sensing for Geophysical Surveys. More than 30 students have defended their master degrees in Ecology and Environment. As textbooks are used some monographs written by renowned scientists from SRI-BAS who also give lectures at NBU [11, 12, 13].

3. Perspectives and significance

As it was concluded from the questionnaires the lecturers and professors in RS at Sofia University envisaged the development of RS education and research at Faculty of Geography mainly in development of methods and techniques for RS based on Unmanned Aerial Systems. They foresee, also, that RS will become one of the main sources of geospatial information in near future. The vision for the future development of RS and geo-informatics education in Bulgaria as expressed by the lecturers from the UMG is oriented towards utilization of simpler software applications with rigorously developed application modules oriented for the specialized needs of RS methods. This opinion is mainly supported by the great deal of specific and un-specific material, which should be covered on specialized lectures, such as working with GIS and RS software packages. The optimization of the workload on the university lectures, professors and staff could be achieved by better defined objectives, developing of supporting or introductory courses which will free some more space for the applications part covered in specific courses. At present, there is also a growing imbalance between the newly developed software and hardware means, education plans and curricula. This needs to be better reflected by developing better structure of educational curricula and optimizing the adoption of new techniques and means of education by universities. As such example can be given the lectures in ecoinformatics and GIS, which are provided at no charge to everyone who wants to get an insight to the courses [14].

Professors and lecturers from private higher and universities express their opinion regarding the future of RS education, which are focused mainly on using the means of multimedia for education. They foresee that RS and geo-informatics are about to be more widely adopted in agriculture, natural resource and environmental protection.

With the rising importance of geo-informatics in a world scale for solving various global problems the role of remote sensing education has greatly increased its significance. The importance of such education is rising also from the paradigm of Earth Observation (EO), which is based on modern geo-information methods and technologies. The Global Monitoring for Environment and Security (GMES) initiative of European Commission (EC) realize that paradigm on a European scale. Therefore, in order to provide the platform for EO, more and better qualified RS and GIS technicians and specialists will be needed.

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