TRANS-BOUNDARY WATER MANAGEMENT USING INTEGRATED REMOTE SENSING AND GIS TECHNIQUES

M. Stefouli [1], E. Charou [2], A. Kouraev [3], A. Stamos [1]

[1] Institute of Geology and Mineral Exploration, 3rd Entrance Olympic Village Axarnai 13677 Attiki, Greece
[2] N.C.S.R. "Demokritos", Inst. of Informatics & Telecommunications 153 10 Agia Paraskevi, Attiki, Greece
[3]LEGOS-OMP, Avenue Edouard Belin 14, 31400 Toulouse France

E-mail: stefouli@igme.gr

Various conventions have been established for the Protection and Use of Trans-boundary Watercourses and International Lakes which aim to strengthen national measures for the protection and ecologically sound management of trans-boundary surface waters and groundwater and establish concrete procedural obligations of cooperation between littoral states. They also include provisions for monitoring, research and development, consultations, warning and alarm systems, mutual assistance, institutional arrangements, and exchange and protection of information, as well as public access to information.

The entire Prespa basin has been declared a trans-boundary protected area, with the establishment of the "Prespa Park" by the Prime Ministers of Albania, Greece and the FYR of Macedonia on 2 February 2000. According to the Strategic Action Plan for the Sustainable Development of the Prespa Park, which lays down the jointly agreed targets of trilateral cooperation in Prespa, gaps in knowledge of the system's main features and governing processes need to be filled as a matter of priority, while major and environmentally adverse past interventions or current practices need to be restored to the extent possible or changed [1].

Up to date information for the Prespa region is lacking or it is difficult to access. There are recommendations for priority data collection (meteorological data on higher elevations, snowfall data, flow gauges, sediment load, ground water level and water quality [1]). Remote sensing techniques are a valuable tool to fill the existed lack of information. In order to achieve the purpose of the analysis various types of satellite data have been used that includes images from optical sensors in various resolutions as well radar satellite systems. Main objective of this study is the assessment of the use of an integrated methodology, which includes remote sensing and GIS techniques for appraising the state of trans-national lake ecosystems. The methodology includes mapping and scientific processing and analysis of various data, and application of satellite image processing as well as radar altimetry techniques.

The application of GIS techniques includes the formulation of a data inventory after the acquisition of topographic maps, compilation of geological and hydrogeological maps based on analysis of relevant data, compilation of digital elevation model for the area of interest based on satellite data and available maps. It also includes the acquisition of various hydro-meteorological data when available. On the basis of available maps and satellite data, digital elevation models are used in order to delineate the basic sub-catchments of the Prespa basin as well as the irrigation network in the area. The characteristics of the basin as well as the statistical quantities of its hydrographic network have also been estimated. Finally a land cover map for the basin has been included in the inventory. All data can be made available to Internet for easy access by the public.

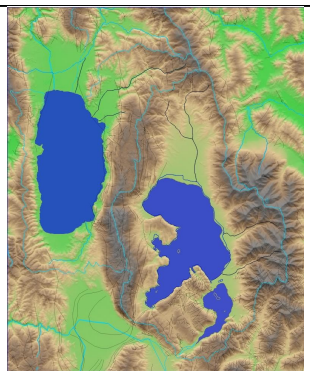
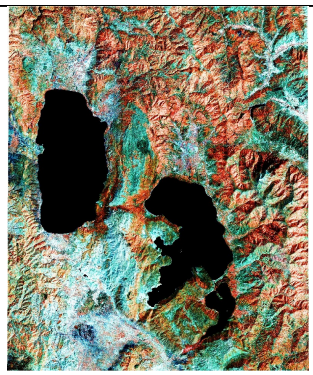
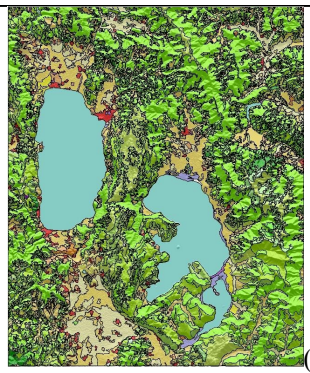

(a)

(b)

(c)

Figure 1 Selected map data for Prespa region: (a) Digital Elevation (b) satellite images (c) land cover.

The optical satellite data are used for mapping land cover / use and the assessment of Land cover changes as well as monitoring water quality parameters. Up to date information of land use, land cover, vegetation status and their changes over time (e.g. seasonally) is important for the understanding and modeling of hydrological processes such as infiltration, water needs etc. Space borne sensors can provide such information, at different levels of spatial and thematic details-resolution, Giri et. all 2005, [3]. A land use/cover classification for the broader area of the Macro Prespa lake is performed using ENVISAT MERIS Full Resolution data. Land cover changes are detected due to forest fires and change of land use. Lake surface changes have also been assessed using multi-temporal Landsat images. The Macro Prespa lake has lost nearly 10 Km^2 of its surface due to a drop of the water level during the last 20 years as it is shown in Table 1.

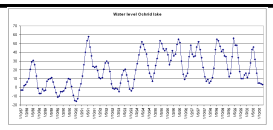
Acquisition dates satellite imagery	SurfaceArea km^2 Macro Prespa (satellite data)	Water Level (m) Macro Prespa	Surface Area km^2 Micro Prespa	Water Level Micro Prespa	SurfaceArea km^2 (satellite data) Ochris lake	Water level Fluctuation Ochrid lake:1987 to 2000
1978 (Landsat MSS image)	~276	849.32	-		Ochrid lake 0 = 693.17 a.s.l.	
1988 (Landsat TM image)	273.70	849.48	40.13	850.67	355 .65	
2000 (Landsat ETM image)	265.26	845.78	40.13	851.46	355 .58	

Table 1. Macro Prespa Average Monthly Water Levels - Macro Prespa - PUSTEC (Liqenas) – Albania: Time series 1952 – 2005 (from [3]) Ochrid lake: Time series 1967-2000.

Lake water level data appears to be the only parameter with ample availability of measurements in the specific case study area and it should be kept as consistent as possible. However, almost constant differences are noted when Greek and Albanian records were compared, indicating disparities in the associated datum [2]. An experiment has been done to done to complement in situ water level time series by satellite radar altimetry observations. Water level variability of 1-1.5 m, sometimes up to 3 m has been interpreted for Ochrid lake. No in situ data are available for this period, but previous observations indicate variability of up to 1 m for this lake. This suggests that some geophysical corrections for altimetric measures should be checked and corrected in order to obtain more accurate estimates of water level.

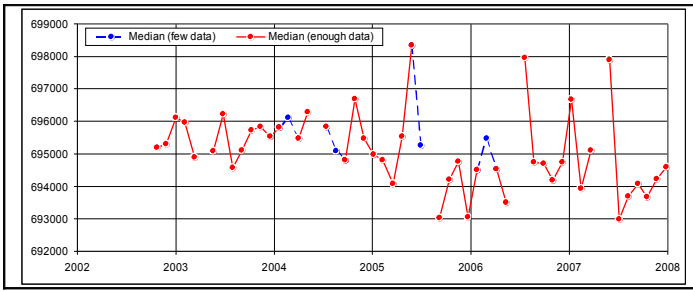


Figure 2. Median values of Ochrid lake level from ENVISAT data. The size of the lake and orientation of Envisat track make it possible to select sufficient number of altimetric observations for calculating Ochrid lake water level.

Traditional monitoring of water quality as well as other environmental parameters involves specialized personnel and both on site and laboratory analysis. Such procedures impose considerable implementation budget and data are not always accessible by the public. Water quality parameters of the lakes can be retrieved from remote sensing. In this work MERIS Data area have been used for the assessment of spatio-temporal variability of selected water quality parameters like turbidity, suspended solids and algae or chlorophyll concentration. Cloud cover has limited the application of monitoring the water quality parameters while another limiting factor is the coarse sensor resolution.

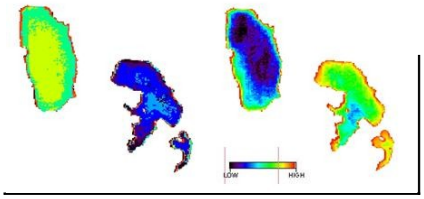
Field Data point	Secchi depth(m)	Turbidity (FNU)	Spatial variations of Secchi depth / Turbidity from MERIS data	Chl α (mg/l)	TSS (mg/l)
	3.2 Reference value 2000			4	4
Macro Prespa	2.84 August 2007				
	2.08 September 2007	5			
	1.91 August 2007				
Micro Prespa	1.8 September 2007	6		10.43	4

Table 2. Field measurements of Secchi depth, Turbidity, Chl α, TSS used for assessing MERIS data.

All data provided by the satellite observations have been used to update information stored in the GIS data base. Remote sensing provides valuable information concerning different hydrological parameters of interest to a transnational water basin assessment project. The observations from space have the potential to significantly improve the understanding of hydrological processes affecting lakes. Monitoring is supported due to the multi-temporal character of the data and water quality assessments can be performed. The methodology proved to be cost effective and could be used in conjunction with in situ observations and hydrological modelling. The combination of data from different sources linked by the powerful prospects of new Earth Observation techniques will result in the development of new knowledge that can be used for supporting policies like the EU 2000/60 Water Framework Directive which, as agreed by the three countries, the integrated water management in the Prespa Park area as a whole, has to be built on its principles.

REFERENCES

[1] Study on the interaction between lake Micro Prespa and river Devolli (Albania -Greece) Contr. No: ANAP-88-2004, Hellenic Ministry of Foreign Affairs , Society for the Protection of Prespa.

[2]] Stamos, A., et all, Study of Prespa Lake Using Nuclear and Related Techniques, IAEA Regional project RER/8/008, Final Report, June 2003.

[3] Giri, C., Zhu, Z. and Reed, B., 2005. A Comparative Analysis of the Global Land Cover 2000 and MODIS Land Cover Data Sets. Remote Sensing of Environment, Vol. 94, No. 1, pp. 123-132.

ACKNOWLEDGEMENTS

This work is part of ESA Cat.-1 project no. 4864 entitled “Monitoring and assessing internal waters (lakes) using operational space born data and field measurements.” ESA is acknowledged for providing the MERIS data. The Society for the Protection of Prespa, Greece is acknowledged for providing lake measurements. This study has been supported and data have been provided by the working team of the “Sustainable management of the International waters: Prespa lake NATO SfP Project No. 98116”: Prof. Todor Anovski, Prof. Viktor Popov , Prof. M Kolaneci. Dr S. Amataj, Dr A Stamos, D Mattheopoulos, Coordinator: Dr K. Shawse.