Neki FRASHËRI[*], Betim ÇIÇO[*], Akli FUNDO[**]

ANALYSIS OF ENVIRONMENTAL CHANGES IN SHKODRA LAKE AREA USING REMOTE SENSING

Përmbledhje: Vrojtimi në distancë është përdorur për të analizuar evolucionin e parametrave mjedisore – vijën e bregut dhe indeksin e normuar të bimësisë në zonën e Liqenit të Shkodrës. Ndryshimet e vijës së bregut janë dalluar duke krahasuar imazhet e Landsat. NDVI është vlerësuar duke përdorur imazhet e MODIS, duke llogaritur trendin e rendit të parë dhe të dytë per çdo piksel për dallimin e trendit dhe tendencave të përmbysjes së tij. Ndryshimet e vijës së bregut tregojnë rritjen e sedimentimit në bregun verior të Liqenit. Analiza e trendit e NDVI jep nje paraqitje të zonave ku bimësia është ne zhvillim ose pakësim, duke vlerësuar dhe mundësinë e përmbysjes të trendit.

Fjalë kyçe: *vrojtimi në distancë, analiza e trendit, parametrat mjedisore*

Abstract: Remote sensing is used to analyze the evolution of environmental parameters – the shore line and normalized vegetation index in the Shkodra Lake area. Variations of shore lines are identified comparing Landsat images. NDVI is evaluated using MODIS images, calc ulating the trend of first and second order for each pixel used for identification of trend and reversal tendencies. Variations of shore line indicate the increase of sedimentation in northern shore of the Lake. Trend analysis of NDVI gives a presentation of areas where vegetation trend is increasing or decreasing, with some evaluation of the possibility of reversal of the trend.

Key words: *remote sensing, trend analysis, environmental parameters*

INTRODUCTION

Remote sensing technologies offer a wide range of images with different layers of visible and infra- red bands, which combination allows remote determination of many environmental parameters for the atmosphere, ground surface and water areas. The list includes vegetation, moisture, chemical composition, ground and water

[*] Neki Frashëri, Betim Çiço, Polytechnic University of Tirana, Faculty of Information Technology

[**] Akli Fundo, Faculty of Mathematical Engineering and Physical Engineering

temperatures, status of suspended matter in water (sediments, algae etc.), aerosols and air parameters, etc.

In our past works for the analysis of environmental situations in critical areas, as in Ohrid -Prespa system (Pano *et al.,* 2001) and in Adriatic Sea coastline (Pano *et al*., 2006), we have used satellite images to evaluate changes in time of environmental conditions. In both cases there are serious damages created by humans to nature and nature to humans. If Prespa Lakes were damaged as result of human activity, in Adriatic coast considerable sections of the beach and buildings are lost a s result of sea transgression (Photo 1).

Photo 1. View of Semani beach (left). Satellite view of Semani beach (center), and Micro Prespa Lake (right)

Comparison of satellite images made visible the evolution of shore lines in regional scale (Fig. 1). These results motivated further work for processing of satellite images in time-space domains. The work was done in framework of projects WETSYS-B and SEE-GRID-SCI.

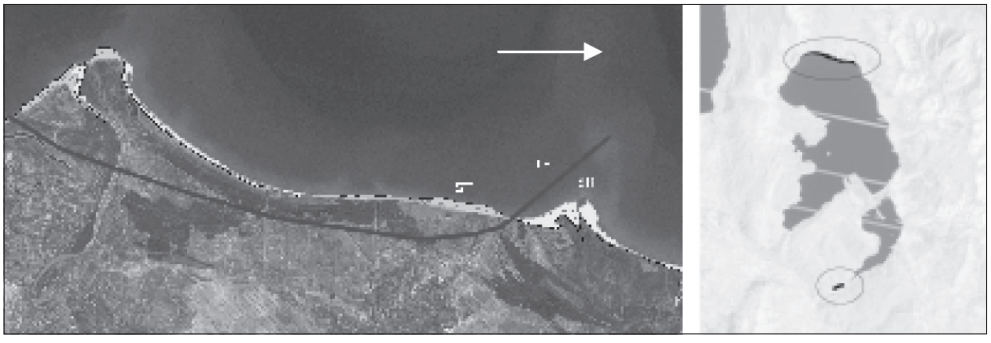

Figure 1. Semani beach (left) ST ~ Sea Transgression, SR ~ Sea Regression, TL ~ Tectonic Fault; Prespa Lakes complex (right) with water regression areas in black

MATERIAL AND METHODS

Two methodologies were developed for processing of satellite images in time domain. The first solution was developed in framework of WETSYS-B project; and

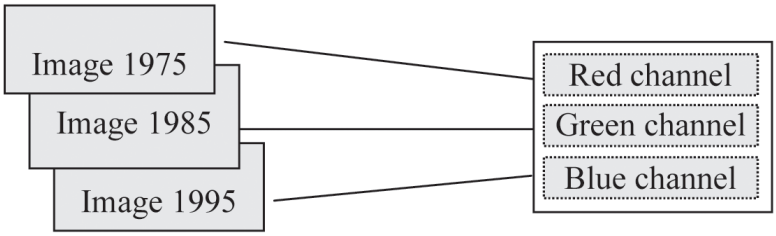

Figure 2. Schema of combination of different images in time as RGB channels

consisted in combination as Blue, Green and Red channels of grayscale images of the same satellite band combination for the same area (Fig. 2).

Combination of satellite bands is selected in order to characterize some environmental parameter in study, as combination of Red and NIR bands for calculation of vegetation index NDVI, and NIR bands for evaluation of water covered areas.

Areas where the environmental parameter does not change in time give the same value for all three colors Blue, Green and Red, the result is a gray color for that area. Otherwise, when the environmental parameter has changed in time, the resulting RBG image has non-gray color in respective areas. First application of the method was for identification of the evolution of shore lines. The combination of colors is presented in figure 3, customized for this case.

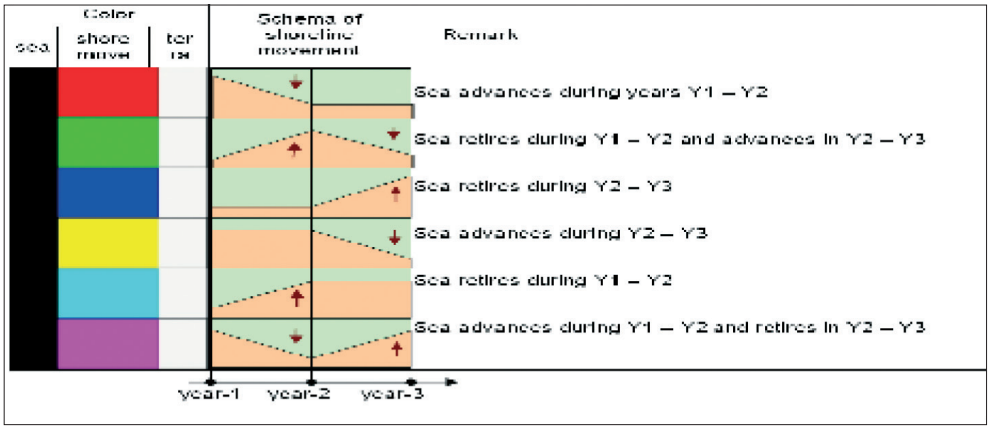

Figure 3. Schema of combination of RGB channels where shore line changes in time

The method was used with Landsat images, which can be downloaded freely and cover a long time span of 25 years. The resolution of first Landsat images is 60 m for bands Green, Red, NIR 1, NIR 2, reduced in 30 m in recent satellites for bands Blue, Green, Red, and four NIR bands, completed with a panchromatic image of resolution 15 m. This resolution is sufficient for some regional studies. The method may give wrong results if environmental parameters that have strong seasonal variations are

considered. Another problem is experienced with Landsat–7 images because of black strips due to equipment fault. In order to eliminate somehow these strips we calculated averag es for each valuable pixel using the CHERS application framework developed in SEE-GRID-SCI project (http: //www. see-grid-sci. eu/).

CHERS application framework (Change of Environment with Remote Sensing) was devel oped in SEE-GRID-SCI as one of applications to be executed in the grid environment (Frasheri *et al*., 2009). Considering the huge quantity of data from multiple high resolution images and the volume of data processing in complicated calculation schemes, high performance computing platforms may be used for fast processing of images (Muresan *et al*., 2009).

The idea of CHERS is processing of values in time for each pixel. We experimented the trend analysis as one of data processing schemes that permits the evaluation of the trend of environment evolution (Fig. 4).

We used trend analysis of first order (linear) and of second order. While the first order analysis gives the trend of evolution of environmental parameters, second order analysis (curvature) may give hints of tendencies in the future (Fig. 5).

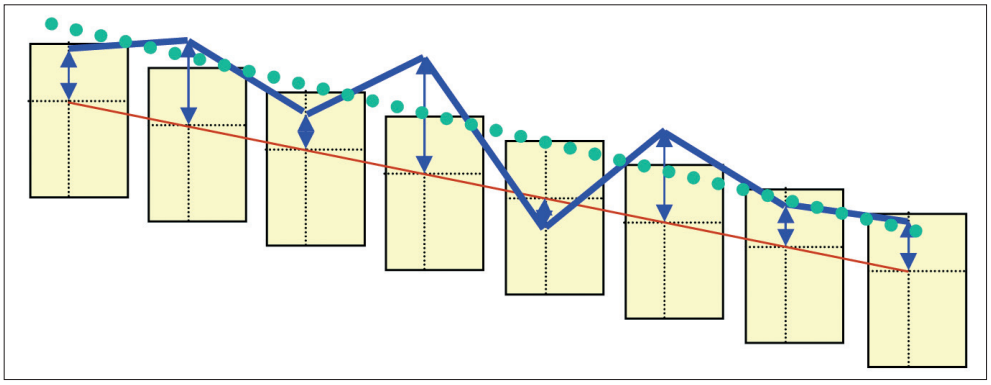

Figure 4. Schema of trend analysis in time for individual pixels.

Parallelization of calculation processes in CHERS is done through dividing image suites in parallel sub-suites, which may be processed independently from each other.

Arrays with trend coefficients for each pixel are combined as false color images using average values as Red, coefficients of first order as Green and those of second order as Blue. For any pixel of resulting image, dominance of red indicates high average but negative trend, dominance of green indicates low average but positive trend, and dominance of blue indicates low average and negative trend but positive curvature.

We used CHERS for processing of freely downloaded MODIS images, covering the period after 2000, with medium resolution of max 250 m. MODIS images are available on daily basis, with condition that the studied area would not be covered by clouds. MODIS offers a wide range of NIR bands suitable for evaluation of most environmental parameters in aqua, terra and atmosphere. We calculated the nor-

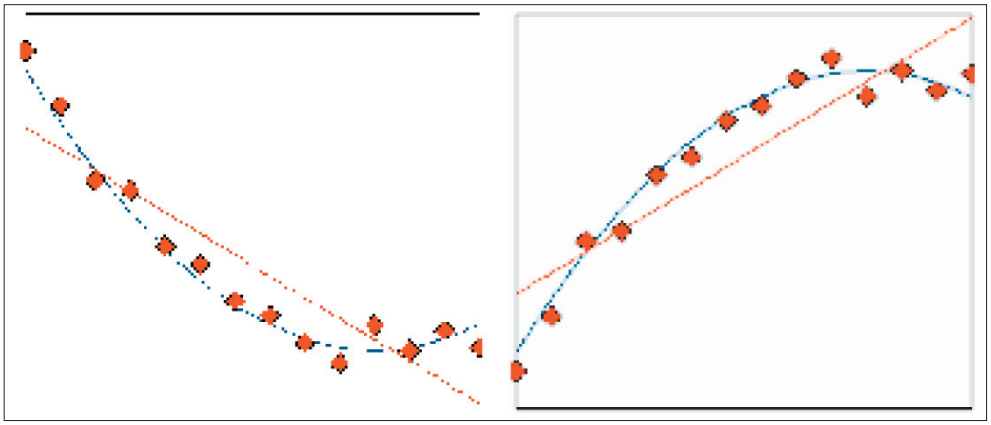

Figure 5. Comparing trends of first and second order; second order trend gives hints of reversals

med vegetation index NDVI from Red and NIR MODIS bands for the Shkodra Lake area, selecting representative images for each season for the period 2001–2009.

RESULTS AND DISCUSSION

Combination in false colors of Landsat NIR images from 1975, 2000 and 2009 shows clearly the advance of reeds in north-western shore of Shkodra Lake, and little regression of water line south- eastern corner near Shkodra. The same results are evident in the combination of NDVI images from the same years (Fig. 6). NDVI combination indicates also areas where vegetation is increased or decreased.

Evolution of environmental situation is identified in a combination of panchromatic Landsat images of resolution 15 m from 2000 and 2009 (Fig. 7).

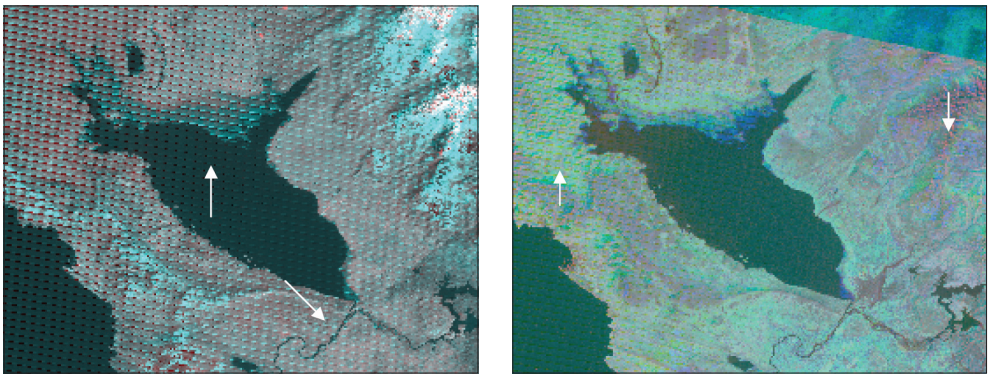

Figure 6. False color combination from Landsat 1975, 2000 and 2009. Left – NIR (arrows show areas with shore line regression); right – NDVI (up arrow – area with vegetation increase, down arrow – area with vegetation decrease).

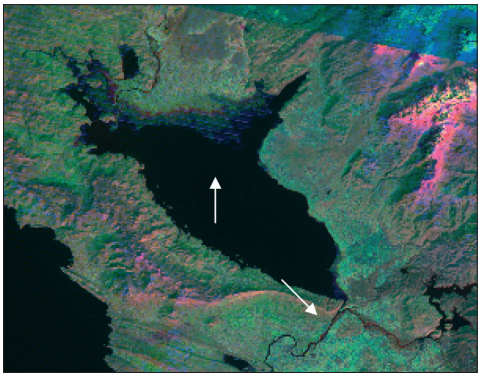

Figure 7. False color combination of panchromatic Landsat from2000 and 2009. Areas with shoreline regression are visible as blue-green areas in north-western shore and south-eastern corner.

The trend of vegetation is presented in false color images produced with trend coefficients from MODIS images of the period 2001–2009 (Fig. 8), blue – green – yellow areas indicate increase of vegetation and reddish areas high average but negative trend.

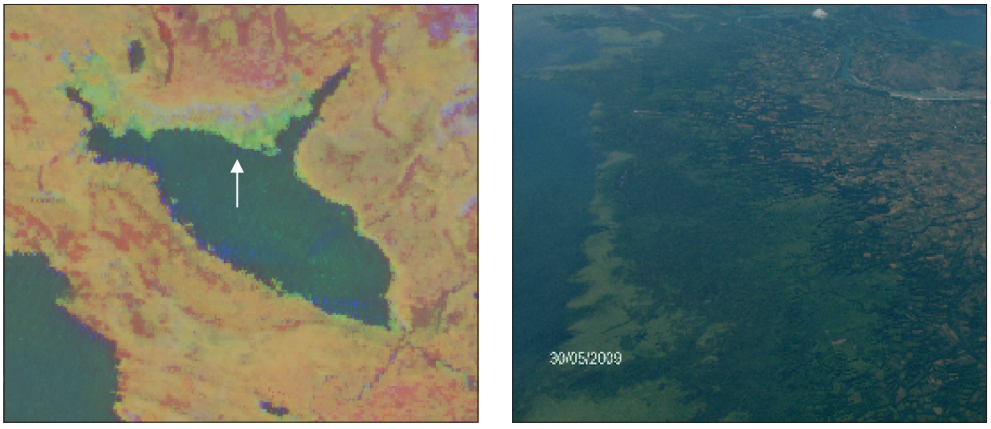

Figure 8. False color combination of trend coefficients of NDVI from MODIS images from 2001–2009 (arrow shows highest increase of vegetation, right – aerial view of this area).

CONCLUSIONS

Combination of satellite image bands makes possible a good and fast evaluation of variations in time of environmental parameters. Results may be interpreted quantitatively if properly calibrated with data from field observations.

The methodology requires processing of numerous images in order to avoid eventual errors originates from seasonal variations of environmental situation. High resolution images are necessary for engineering purposes.

Volume of calculations may be supported by grid platforms available in the region integrated in framework of EGI InSPIRE project funded by European Commission (http://www.egi.eu/).

Considerable sedimentation and fast development of vegetation is visible in the north-western shore of the Shkodra Lake. Minor changes are identified in the south-eastern corner of the Lake, where originates Buna River. Variations of vegetation are visible in specific areas around the Lake.

REFERENCES

[1] Frashëri, N., Çiço, B. & Paçi, H., 2009. *Processing of Satellite Images for Evaluation of Environmental Changes in Time with CHERS*. SEE-GRID-SCI User Forum 2009, Bogazici University, Istanbul, Turkey, December 9–10, 2009

[2] Muresan, O., Pop, F., Gorgan, D. & Cristea, V. 2009. *Satellite Image Processing Applications in MedioGRID.* Proceedings of the Fifth International Symposium on Parallel and Distributed Computing (ISPDC'06) Timisoara, Romania, July 06-July 09

[3] Pano, N., Frashëri, A., Simeoni, U. & Frashëri, N. 2006. *Outlook on seawater dynamics and geological setting factors for the Albanian Adriatic coastline development*, Academy of Sciences, Albanian Journal of Natural and Technical Sciences no. 1–2: 152–166.

[4] Pano, N., Frashëri, A., Beqiraj, G. & Frashëri, N. 2001. *Outlook on Uncontrolled Anthropogenic Impact for Damages to the Micro Prespa Lake*. European Geophysical Society (EGS) General Assembly, Nice, France, 25–30 March 2001