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CIVILIZATIONS, ECONOMIES, AND ENVIRONMENT IMPACT EVALUATION VIA REMOTE SENSING

Abstract: Satellite based remote sensing data exist from early seventies (LANDSAT etc.), with multiband images freely available in repositories of USGS and ESA; their volume multiplied last decades with images from satellites as MODIS, ERS, ENVISAT, SENTINEL and new generations of LANDSAT. These data over multiband information on environmental situation, making possible utilization of physical properties of vegetation and soils for identification of environmental changes. Data processing is possible even using of general purpose image processing software in conditions of "citizen-science", also using professional software both commercial and open source. In particular specific home-developed software is used for specific processing as trend analysis in time domain. In our presentation we give a synthesis of our works demonstrating the use of LANDSAT and SENTINEL images for identification of environmental changes as water bodies shorelines changes and vegetation variations, changes created from both human and natural factors but with strong impact in human activity; and use of trend analysis for evaluation of time dependent environmental phenomena with eventual prognosis for the future. Studied areas include Buna River delta and Shkodra Lake, Adriatic Sea beaches in Semani and Patoku region, and Ohrid-Prespa Lakes. The latter case represent a typical negative and economically not effective hydrotechnic intervention that has seriously damaged the Micro-Prespa Lake part of Albania, while former cases show how wrong evaluation of geomorphological environmental conditions has led in human activities in wrong sites and destroyed by natural phenomena. A review of the work done in this area by Academy of Sciences of Albania in collaboration with Polytechnic University of Tirana is presented in this paper.

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INTRODUCTION

Got interested on remote sensing over fifteen years ago while trying to understand the "interfacing" between human activities and environment, and their reciprocal impacts. In a time span of three decades Albania lost its share of Micro Prespa Lake, and two popular beaches in Adriatic Sea shores of Semani and Patoku disappeared under waves of the sea. What remained is shocking.

Fig. 1 — Micro Prespa Lake (Albanian part) in 2001 and 2006

In seventies a project was done for Micro Prespa Lake, diverging during winters the turbulent water of Devolli River into the lake, in order to use it during summers for agriculture. It never worked, because extra waters of Micro Prespa flew in Macro Prespa Lake, with the only impact of filling the lake with sediments.

The area of Adriatic Sea Semani beach was used for many purposes — oil and gas prospecting, agricultural activities, and a range of buildings used for vacancies in summer. Now there is no trace of buildings, except some "exotic" remains. What happened there — sea transgression due to abrasion or subsidence?

Fig. 2 — Semani beach, a caffe-bar improvised over concrete basements of an old borehole, and a water tower, both were well far from sea one upon a time.

Fig. 3 — Patoku lagoon, central part was sandy belt with buildings, now submerged.

Patoku lagoon central area was one of sandy beaches of Adriatic Sea, with buildings used for summer vacancies, now submerged. External sandy belt is newly created by sediments of Mati River (seen in far right of Fig. 3b). Central belt of lagoon is composed by old submerged buildings and new roads built afterwards (the area is used for fishing).

Because of missing historical data, we turned the attention towards multiband LANDSAT images dating from 1972, latter on multiband MODIS, radar ENVISAT and SENTINEL images were used as well. Not only remote sensing made possible to understand better evolution in time of water body shorelines, but identified also significant environmental changes in time and space.

METHODOLOGY

We have used three different methodologies to process satellite imagery.

The simplest one consists in combining, as a false RGB image, two or three bands from satellite images of the same area but taken from different days. Bands can be basic ones directly from satellite images, we have used Near Infra Red Band (NIR) for water bodies shorelines, which has black color for water surfaces; or combined bands as Normalized Differential Index of Vegetation (NDVI) obtained from the difference of NIR and Red bands, considering the fact that vegetation absorbs Red and radiates in NIR bands. Images can be from the same season in different years for long term changes, or from different seasons of the same year for seasonal variations. Band combinations were done using a general purpose image processing software (GIMP).

In case of water bodies shorelines, false color images from NIR band show black color for permanent water surfaces and gray scale for permanent ground surfaces; while single or two combinations of Red, Green or

Blue colors show surfaces where water bodies changed in time. A similar logic can be used to interpret other RGB combinations of satellite bands.

A more complicated methodology was developed during the FP7 EC project SEE-GRID-SCI. Software package (CHERS — Changes of Environment from Remote Sensing) was developed for calculation of temporal trend polynomials for each of pixel positions from a suite of a single band images of the same area taken from different days.

The third methodology is the standard Differential Interferometry of Synthetic Aperture Radar (SAR) images, which permits evaluation of ground movements in millimeter scale, and is sensible from vegetation and other environment parameters. We have used ESA software NEST and Sentinel Tools for image processing, running at home and in the cloud infrastructure offered by ESA.

Satellite images were obtained from free Internet repositories of NASA & USGS and of ESA.

HISTORY OF MICRO PRESPA LAKE

The water complex of Ohrid — Makro Prespa — Micro Prespa Lakes is shared between Albania, FYROM/Makedonia and Greece. Micro Prespa Lake is shared between Albania and Greece, its water flows to Macro Prespa Lake via karst and one artificial surface channel, while Macro Prespa waters flow into Ohrid Lake through karts. Waters from Ohrid Lake flow into Adriatic Sea through one of main rivers in Balkans — Black Drini River; Lakes are important environmental site and populated by fish and birds.

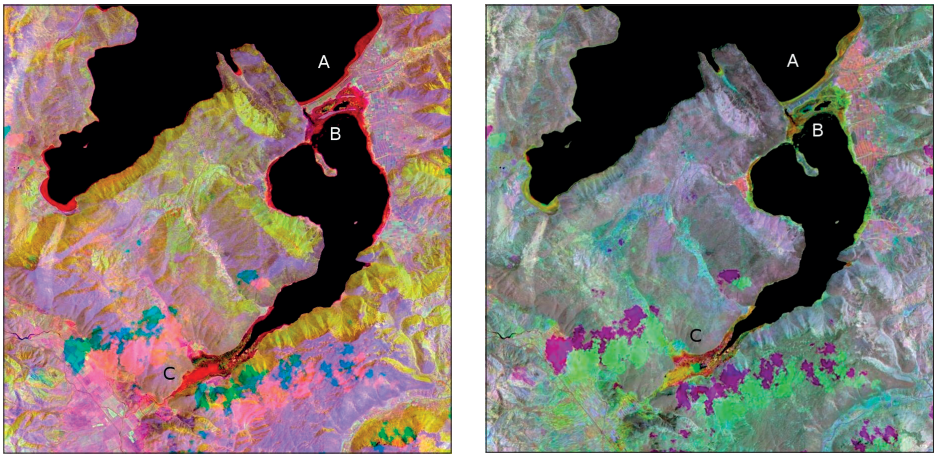

Fig. 4 — Micro Prespa Lake NIR bands combined as RGB from years 2002–1987–1973 and 2010–2002–1987, red areas show loss of free water surfaces.

In early seventies a channel was dug to pour River Devolli turbulent winter waters into the Micro Prespa Lake, with the idea of storing it and using during the summer. Normally the extra water flew into Macro Prespa lake and very little remained for use in summer, nevertheless the project continued for decades with the only significant impact — filling of lake with sediments and damaging the terrain and biology of the area.

In 2001 it was possible to begin with the field study of the Lake, resulting in termination of that stupid project. But for better understanding of evolution of situation in years we were forced to use Landsat images.

HISTORY OF ADRIATIC SEA SHORELINE

We used RGB combinations of Landsat NIR bands to analyze four decades of history of Adriatic Sea shore, and of deltas of rivers Vjosa, Semani

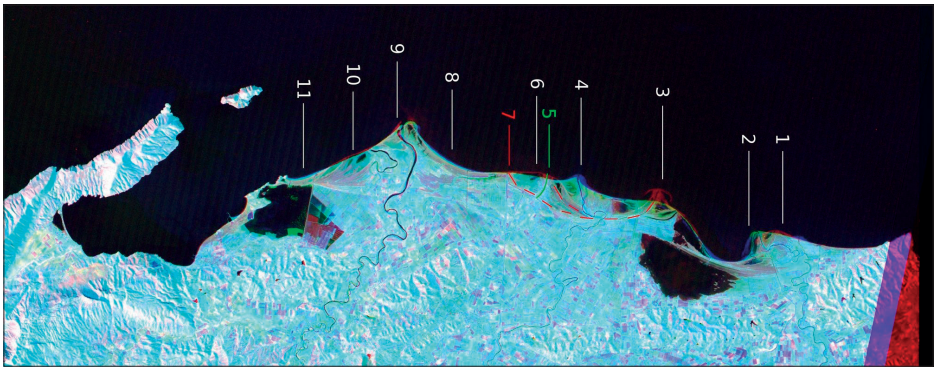

Fig. 5 — 90° right rotated RGB combination of NIR bands of southern Adriatic Sea shores for years 1973–1987–2002, destruction of old deltas and creation of new deltas is visible.

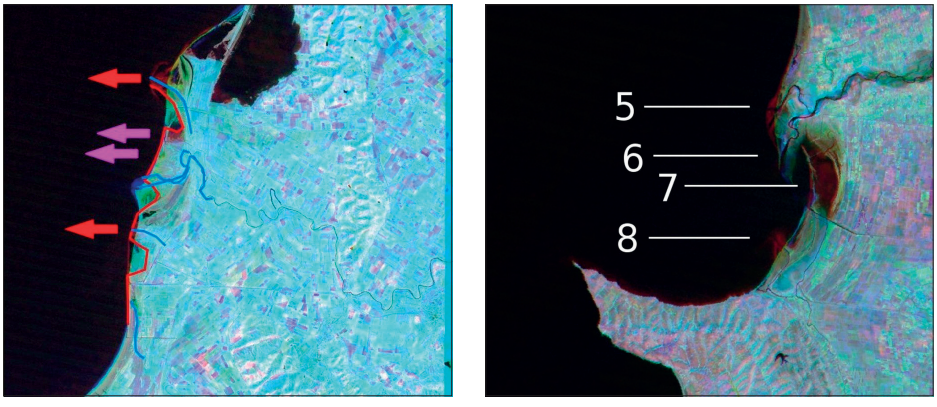

Fig. 6 — Evolution of Semani beaches of Adriatic Sea, and of Patoku Lagoon.

and Shkumbini. A detailed analysis of delta area of Semani River showed three stages of the shore (Fig. 6a), presence of an open bay, creation of a delta, and filling of the bay with sandy sediments.

For Patoku Lagoon in northern Adriatic Sea shore (Fig. 6b) the reddish color of eastern half indicates the presence of sandy ground there where today is free water surface. Destruction of deltas of Ishmi and Mati Rivers are visible.

PROBLEMS AROUND SHKODRA LAKE

While processing Landsat images for Shkodra area we identified changes in the delta of River Buna. The left tip of delta with its small islands is disappearing while sand accumulated in east of delta (Fig. 7).

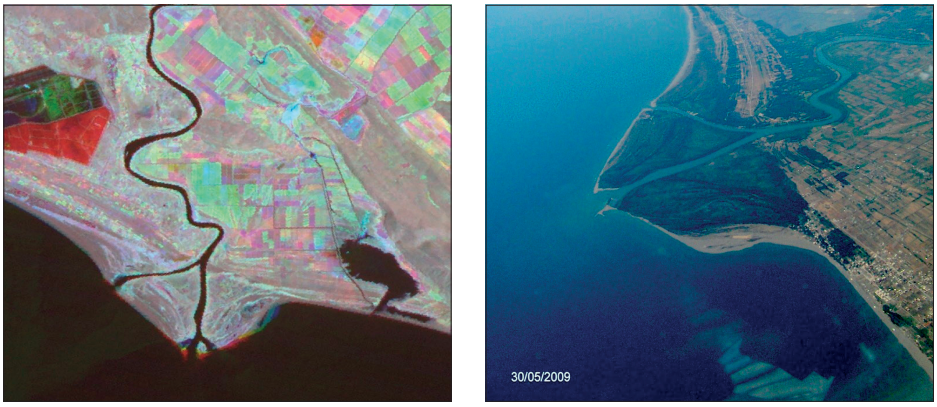

Fig. 7 — RGB combination of Landsat NIR bands from years 1977–1987–1999, and aerial view from year 2009.

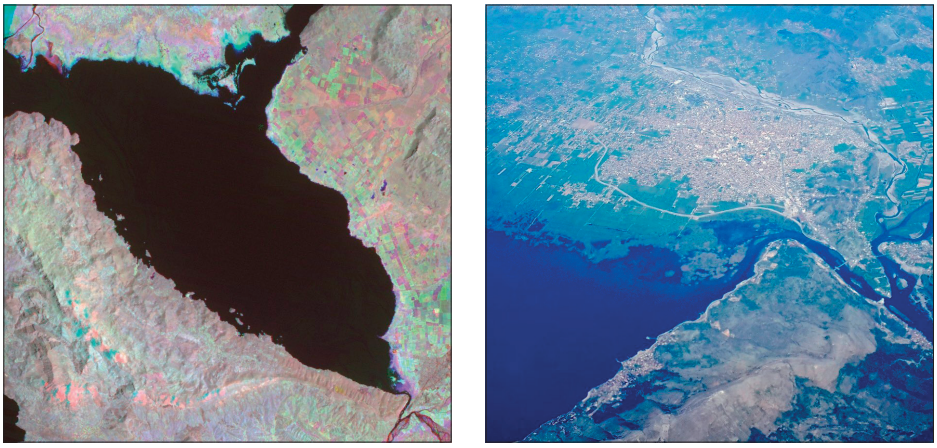

Fig. 8 — RGB combination of Shkodra Lake NIR bands for years 1977–1987–1999, and aerial view of sediments in sources of Buna River.

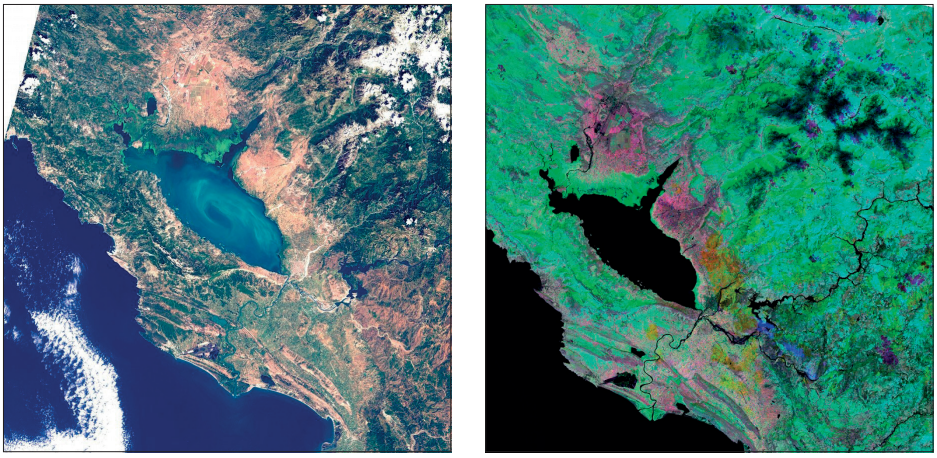

Fig. 9 — RGB and NirGB Landsat band combinations for Shkodra Lake.

Changes of shores of Shkodra Lake are identified as well, with accumulation at the source of Buna River (Fig. 8).

Natural colors image and respective false color image replacing Red with NIR bands is shown in Fig. 9. Areas without vegetation cover are clearly visible.

In Fig. 10 a false color RGB combination of NDVI images from Landsat8 for spring-summer-autumn of year 2014 is presented, presenting seasonal variations of vegetation.

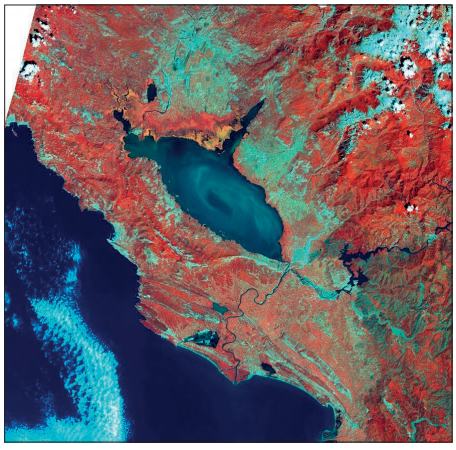

Fig. 10 — RGB combination of 2014 spring-summer-autumn NDVIs.

Low resolution images from multiband satellite MODIS were used to identify flown areas from rivers Buna and Vjosa as result of extreme precipitations, combining as RGB image NIR bands from two dates before and after flows (Fig. 11).

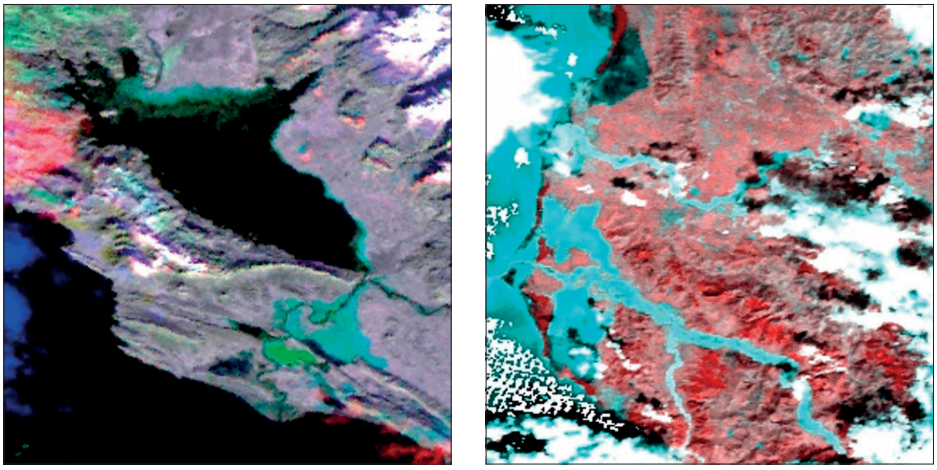

Fig. 11 — Flowed areas from Buna (winter 2010) and Vjosa (winter 2015) Rivers.

Preprocessed MODIS images of aerosols (atmospheric optical depth) were used for trend analysis and evaluation of correlations between ground measurements and satellite data (Fig. 12).

Processing of radar images from Envisat and Sentinel satellites produced differential interferograms (Fig. 13), which fringes located in hilly ranges of northern PreAdriatic Depression indicate significant environmental changes with not yet identified causes (subsidence? erosion? vegetation changes).

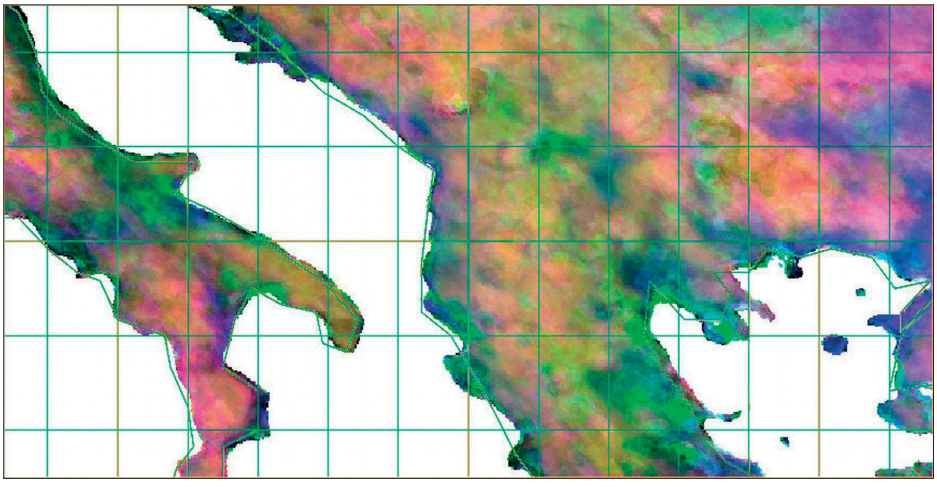

Fig. 12 — RGB combination of second order polynomial trend coefficients (average, slope, curvature) of MODIS aerosols images suite from 2000–2010.

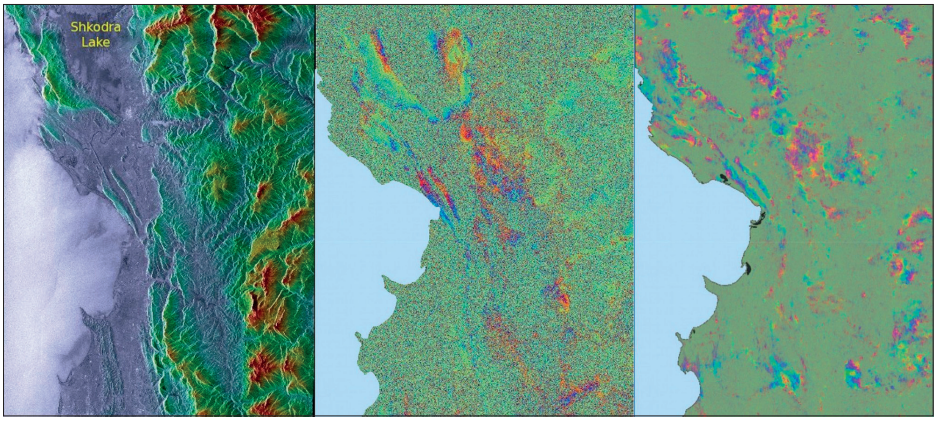

Fig. 13 — Radar intensity and two interferograms from Envisat (21 Mar 2003 — 05 Nov 2004) and Sentinel (20 Jul 2015 — 09 Jul 2017) for northern PreAdriatic Depression.

CONCLUSIONS

— Studied areas include Buna River delta and Shkodra Lake, Adriatic Sea beaches in Semani and Patoku region, and Ohrid-Prespa Lakes demonstrated that LANDSAT and SENTINEL images for identification of environmental changes as water bodies shorelines changes and vegetation variations, changes created from both human and natural factors but with strong impact in human activity; and use of trend analysis for evaluation of time dependent environmental phenomena with eventual prognosis for the future.

— The case in the area Ohrid-Prespa Lakes represents a typical negative and economically not effective hydrotechnic intervention that has seriously damaged the Micro-Prespa Lake part of Albania.

— The former cases show how wrong evaluation of geomorphological environmental conditions has led in human activities in wrong sites and destroyed by natural phenomena.

— Based on multiband LANDSAT images dating from 1972, latter on multiband MODIS, radar ENVISAT and SENTINEL images used we can conclude that remote sensing made possible to understand better evolution in time of water body shorelines, but identified also significant environmental changes in time and space.

— A detailed analysis of delta area of Semani River showed three stages of the shore, presence of a open bay, creation of a delta, and filling of the bay with sandy sediments.

— In the Patoku Lagoon (in northern Adriatic Sea shore) the reddish color of eastern half indicates the presence of sandy ground there where today is free water surface. Destruction of deltas of Ishmi and Mati Rivers are visible.

— Processing of the Landsat images for Shkodra area identified changes in the delta of River Buna. The left tip of delta with its small islands is disappearing while sand accumulated in east of delta.

— Changes of shores of Shkodra Lake are identified as well, with accumulation at the source of Buna River.

— Natural colors image and respective false color image replacing Red with NIR bands is shown in Skadar Lake where the areas without vegetation cover are clearly visible. A false color RGB combination of NDVI images from Landsat8 (spring-summer-autumn of year 2014) presenting seasonal variations of vegetation.

— The combining as RGB image NIR bands from two dates before and after flows (Buna and Vjosa Rivers) with a Low resolution images from multiband satellite MODIS, can use to identify flown areas as result of extreme precipitations.

— RGB combination of second order polynomial trend coefficients (average, slope, curvature) of MODIS aerosols images (atmospheric optical depth suite from 2000–2010) demonstrated that we can apply trend analysis and evaluation of correlations between ground measurements and satellite data.

— By the Processing of radar images from Envisat and Sentinel satellites produced differential interferograms, fringes located in hilly ranges of northern PreAdriatic Depression indicate significant environmental changes, but it was difficult to identify causes: subsidence, erosion, or vegetation changes.

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REFERENCES

[1] Pano N, Frasheri A, Beqiraj G, Frasheri N. Outlook on Uncontrolled Anthropogenic Impact for Damages to the Mikro Prespa Lake. European Geophysical Society General Assembly, Nice, France, 25–30 March 2001.

[2] Pano N, Frasheri A, Beqiraj G, Frasheri N, Haska H. 2004. Outlook on damages caused from anthropogeneous impact on Micro Prespa Lake. Bulletin of Geological Sciences, Nr. 1, pp. 83–93, Geological Survey of Albania.

[3] Pano N, Frasheri A, Simeoni U, and Frasheri N, "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, Tirana 2006, p. 152–166.
[4] Bushati J, M. Florian and Frasheri N. ICT application for monitoring air pollution in the area of Shkodra Lake. BALWOIS'2010, Ohrid 25–29 May 2010.
[5] Frasheri N, Cico B, Paci H, Processing of Satellite Images in Space-Time Domain. Springerlink Earth Science Informatics Volume 3 Number 4, 2010.
[6] Frasheri N, Cico B, Fundo A. Analysis of Environmental Changes in Shkodra Lake Area Using Remote Sensing. Academy of Sciences of Albania & Academy of Sciences and Arts of Montenegro, International Conference on Shkodra Lake — Status and Perspectives, Podgorica — Shkodra 19–21 qershor 2010.
[7] Frasheri N, Frasheri A, Pano N, and Bushati S. Outlook on seawaters dynamics and geological factors of development of Albanian Adriatic coastline. European Geosciences Union General Assembly 2011, Vienna 03–08 April 2011.
[8] Frasheri N, Pano N, Frasheri A, Beqiraj G, Bushati S, and Taska E. A review on anthropogenic impact to the Micro Prespa lake and its damages. European Geosciences Union General Assembly 2012, Vienna Austria, 22–27 April 2012.
[9] Frasheri N, Beqiraj G, Bushati S. Analysis of aerosols variations using MODIS images. BALWOIS 2012 — Ohrid, Republic of Macedonia — 28 May, 2 June 2012.
[10] Pano N, Bushati S, Frasheri N. Climate Change Impact on Buna. IAEG XII Congress, Torino 15–19 September 2014.
[11] Frasheri N, Beqiraj G, Bushati S, Frasheri A, Taushani E. Remote Sensing Analysis of the Adriatic Shoreline Movements. International Scientific Conference Integrated Coastal Zone Management In The Adriatic Sea, Institute Of Marine Biology, Kotor, Montenegro 29 September — 1 October 2014.
[12] Frasheri N, Beqiraj G, Bushati S. Recent environmental changes in Albania through remote sensing. Earth Observation Open Science 2.0 Conference, 12–14 October 2015, ESA/ESRIN, Frascati, Italy.
[13] Frasheri N, Beqiraj G, Bushati S, Frasheri A. Application of Remote Sensing for the Analysis of Environmental Changes in Albania. ESA Living Planet Symposium 2016, 9–13 May 2016, Prague Czech Republi.
[14] Vila F, Frasheri N, Mandia F. Vleresimi satelitor dhe lokal i aerosoleve ne zonen e Shkodres. Konferenca Vjetore "Java e Shkencës" 2016, Prishtinë 10–12 maj 2016.
[15] Frashëri N, Bushati S, Beqiraj G, Lamaj M. Application of differential inteferometry for analysis of ground movements in Albania. IJNTS 2016.
[16] Frasheri N, Beqiraj G, Bushati S. SAR Interferometry for Identification of Environmental Phenomena — Case of Albania. ESA FRINGE 2017 Workshop, Aalto University of Helsinki (Finland), 05–09 June 2017.