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Thermal Remote Sensing for Water Outflows Detection and Determination of the Role of Lineaments in Underground Hydrodynamics of Evia Island/Central Greece

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Abstract

The coastal karst system of Evia Island, which is developed due to the extended presence of carbonate formations, discharges into the sea in many different locations having a direct relation to the tectonic system of the area. Thermal infrared remote sensing has been proved its capability in monitoring thermal differentiations of coastal water plumes. The aim of this work is to locate the fresh water outflows through remote sensing and specific with the use of Landsat's 8 thermal images and how this karstification process is controlled by the lineaments of the area.

Introduction

The study area is the island of Evia, which extends along the South-Eastern mainland of Sterea Hellas in Central Greece; covers an area of 3684 Km^2. Part of the Evia Island's is covered by carbonate formations creating a coastal karst base level which is a consequence of Alpine Orogeny's tectonic movements and of the vertical eustatic movements in the Quaternary period. Coastal aquifers have the tendency to discharge their subsurface flow into the sea through coastal or submarines springs, which appear in tectonic discontinuities.

Having as a goal to detect and map this significant groundwater discharge Landsat-8 (L8) thermal infrared (TIR) data have been used for monitoring of the cold-water plume patterns in the coastal areas (Gibbons *et al*., 1989). The thermal infrared bands of L8 provide temperature measurements at a spatial resolution of 30 m and permit the study of surface temperature characteristics (Parcharidis *et al.,* 1998). It is known that various surface objects reflect the radiation in different ways depending on surface properties. The use of thermal bands is based on the fact that all physical surfaces absorb the electromagnetic radiation according to their texture, their orientation and their heat capacity and they emit it accordingly to the environment (Parcharidis *et al.,* 1998; Migiros *et al*., 2005).

Geological setting of the study area

The tectonic evolution of the Evia region and its surroundings has formed the geomorphology of the island. The intense tectonic movements during the Quaternary period as well as the consequence of Alpine orogenic activities were leaded to strongly karst development. Coastal and submarines karst springs were revealed in many areas of Evia (Katsikatsos *et. al.,* 1976b). From geological point view, Evia consists of the following units (Katsikatsos, 1992): (a) The unit of Central and Northern Evia and Skyros belong to Pelagonian zone which overthrust on the unit of Southern Evia and is composed of: 1) Paleozoic crystallized formations, 2) Neo-Paleozoic semi-metamorphosed clastic formations, 3) Formations of Lower-Middle Triassic (clastic formations, volcanic rocks and limestones), 4) Limestones of Middle – Upper Jurassic, 5) Masses of ophiolites that are overthrusted on the Upper Cretaceous limestones and 6) Flysch sediments, (b) The unit of Almyropotamos consists of Mesozoic to Middle-Eocene coarse-grained marbles of great thickness, passing upwards into metaflysch and schists intercalate in the entire thickness of these marbles, (c) The unit of Southern Evia which is metamorphosed and overthrust on the flysch of Almyropotamos unit and Comprise: 1) Tsakaioi unit consisting of schist and amphibolite including large bodies of serpentine, 2) Styra unit consisting of thin plate marble, sipoline, quartizite and amphibolitic schist and 3) Ochi unit is consists of glaucophane schist, large bodies of amphibolite and manganese microquartzite. Moreover, ophiolitic rocks were developed at the base of the Styra – blueschist nappe on top of the Mesozoic – Eocene unit of Almyropotamos (Papanikolaou, 2009) and (d) The Post alpine sediments which include Alluvial and Neogene sediments.

Materials and Methodology

The geospatial data that were used for the research was: 1) 18 topographic maps at 1:50.000 scale of the Hellenic Geographic Service, 2) 12 geologic maps at 1:50.000 of Institute of Geology and Mineral Exploration, 3) satellite images of Landsat 8 with various dates from 2013 to 2018, and 4) image analysis software's (ENVI v.5.5 - Harris Geospatial Solutions, USA and European Space Agency and ArcGIS v.10.5.1, Environmental Systems Research Institute, Redlands, CA, USA). Thermal images were processed using ENVI program for conversion DN to temperature (Celsius degrees), following the steps outlined in the handbook of USGS (2016). L8 contains two thermal bands (Band 10, high gain and Band 11, low gain) with resolution 30m which record the scattering of infrared radiation from the sea surface. Band 10 was selected, because acquisition in high gain was provided greater radiometric resolution (sensitivity). Brightness temperatures (in Kelvin) are computed as follows (Where: $K1$ and $K2$ = Calibration constants, in Kelvin. ENVI reads these values from the Landsat metadata):

$$T = \frac{K2}{\ln\left(\frac{K1}{L_\lambda} + 1\right)}$$

Then, the new images were imported to ArcMap 10.5.1. Bilinear interpolation, density slicing and temperature supervised classification were used. With the same program, topographic and geologic maps were edited. Finally, combing thermal images with geological maps and tectonic lineaments, sea surface temperature (SST) maps had been created.

Results

The fresh water outflows are more diluted and cooler in relation to sea water, and spread upwards to the sea-surface, creating characteristic water plumes (Astaras, 2001). At thermal images, the darkest tones correlate with the lowest temperatures which are related to the fresh cold water outflows. In many coastal areas of Evia Island (Metoxi, Xalkida, Marmari, Limni, Vlaxia, Vathiremma, Aliveri) the phenomenon was clearly detected. More specifically, at Limnionas-Xalatzas area the appearance and quantity of outflows' is more clear and higher (figure 1).

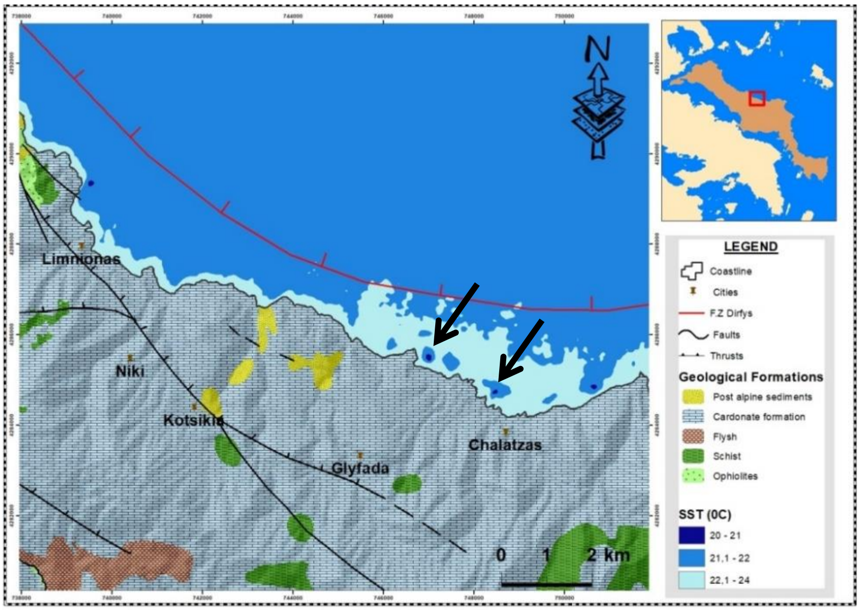

Figure 1. Water outflows mapped on July image of L8 (03/07/2013 – dry period). The outflows are appeared clearly (black arrows show the fresh water outflows).

Conclusion

Remote Sensing is possible to identify fresh water outflows based on thermal anomalies in sea surface. In this research Landsat 8 TIRS (high gain) images were used (from 2013 to 2018) to detect the fresh water plumes into the sea. G.I.S was utilized to combine geologic and topographic maps with thermal images having as a purpose of creating classified sea surface temperature maps (SST) and investigate the relation of water outflows with the tectonic lineaments of the study area.

References

Astaras, T., 2001. The present state remote sensing applications to multitemporal monitoring of the environment, with emphasis to delineation of coastal plain areas suffering from salt water encroachment (intrusion) and to detection of water discharge in coastal rocky (mainly carstic) environment. Future prospects. A keynote lecture presented at the 9th MCM of COST 621 Meeting in Venice, Italy, March 22-24, 2001

Gibbons, D.E., Wukelic, G.E., Leighton, J.P., Doyle, M.J. 1989. Application of Landsat Thematic Mapper data for coastal thermal plume analysis at Diablo Canyon. Photogrammetric Engineering and Remote Sensing 55: 903-909.

IGME - Institute of Geology and Mineral Exploration, Department of Geological Maps, 12 Maps Sheets, 1:50.000 Scales.

HAGS - Hellenic Army Geographic Service, 18 Map Sheets, 1:50.000 Scales.

Katsikatsos, G., Mercier, Vergely, J. P., 1976b. La fenetre d Attique. Cyclades et des fenetres metamorphiques des Hellenides internes (Grece). C.R Acad. Sc. Paris, 283, D., 1614 -1616, Paris

Katsikatsos, G., 1992. Geology of Greece, Study and Teaching, University of Patras.

Migiros, G., Psomiadis, E., Papanikolaou, I., Karamousalis, T., Stamatis, G., 2008. Groundwater coastal discharge of the karstic system of the Mani Peninsula, Southern Peloponnesus-Greece. Proceedings of the 8th International Congress of Hydrogeology, Vol. 1, p. 317-326.

Papanikolaou, D., 2009. Timing of tectonic emplacement of the ophiolites and terrane palegeography in the Hellenides, Lithos, 108, 262–280.

Parcharidis, I., Psomiadis, E., Stamatis, G., 1998. Using Landsat TM images to study karstic phenomenon. ITC Journal, 1998-2, p.118-123, Netherland.

USGS - U.S. Geological Survey, Department of the Interior (2016). Landsat 8 (L8) data users hand book, Version 2.0, EROS Sioux Falls, South Dakota.