13:15 – 13:30	The behavior of "green" consumers in Greece under financial crisis *H. Theodoropoulou, M. Zavali*
13:30 – 16:30	**LUNCH BREAK (Lunch offered for Conference participants at main hotel restaurant of Royal Mykonian Hotel)**
	GIS AND REMOTE SENSING **CHAIRS: C. Cartalis, K. Perakis**
16:30 – 16:45	Use of Earth Observation in assessing the impact of Major Sport Events *C. Cartalis, D. Asimakopoulos, M. Petrakis, N. Adaktylou, M. Stathopoulou and N. Chrysoulakis*
16:45 – 17:00	Wet and dry sand spectral signatures as a tool for the precise shoreline detection and extraction from remotely sensed images *P. G. Drakopoulos, G. Ghionis, K. Lazogiannis, S. E. Poulos*
17:00 – 17:15	The study of ice conditions of the Caspian Sea using satellite monitoring data (2008-2011) *S. Berdnikov, N. Yaitskaya, Y. Lychagina*
17:15 – 17:30	Assessment of the vulnerability of coastal areas to the application of pesticides using GIS and multiple criteria analysis *D. Kitsiou, M. Kostopoulou, V. Varnava and K. Koufa*
18:00 – 18:30	**COFFEE BREAK**

Wet and dry sand spectral signatures as a tool for the precise shoreline detection and extraction from remotely sensed images

P.G. Drakopoulos[1*], **G. Ghionis**[2], **K. Lazogiannis**[2], **S.E. Poulos**[2]

[1]Department of Optics and Optometry, Technological Educational Institute of Athens, Ag Spyridonos 12210, Athens, Greece

[2] Department of Geology and Geoenvironment, University of Athens, Zografou, 15784, Athens, Greece

*Corresponding author: E-mail: pdrak@teiath.gr, Tel +30 2105385747

Abstract

Shoreline displacements are due to physical, anthropogenic and environmental factors such climate change. Remote sensing has become an essential tool for monitoring shoreline changes and understanding the physical processes in the coastal environment. However, ground truthing is necessary in order to detect the limits of sea-level inundation and /or wave run up. Within the framework of the THALES-DAPHNE project, we have initiated an investigation regarding the reflectance properties and spectral signatures of various samples of dry and wet beach sands. To this end, spectral reflectance characteristics for a collection of sand samples from various Hellenic beaches have been measured in the laboratory under dry and wet conditions. In addition ongoing field measurements are in process along the beach face of the delta of the River Pinios, that debouches at the NW coast of the microtidal Aegean Sea.

Keywords: Environmental monitoring; Remote Sensing, shoreline position

1. INTRODUCTION

Deltaic coasts are amongst the most vulnerable coastal environments either because of human impact (e.g. the construction of dams) and/or because of climate change (e.g. sea level rise, changes in storminess [1]). The study of the seasonal and decadal changes of shoreline position is one of the key processes in understanding the morphodynamic evolution of such sedimentary environments. In particular, for the Pinios delta, recent observations (Thalis-DAPHNE research project) along the deltaic coast revealed seasonal changes in shoreline position in the order of few meters, with the exception of its mouth, where its southern part retreated by more than 10 m after the SE storm of January 2012.

Within this concept, high resolution remote sensing information from already operational satellite sensors (e.g. SPOT-5, IKONOS, Quickbird, Formosat, WorldView-2, Geoeye, TerraSAR-X, TanDEM-X), recently launched or future missions (e.g. SPOT-6/7, Pleiades, TerraSAR-X2, with accuracy down to 0.5 m) could be used in principle to extract information on the morphological characteristics of the beach (e.g. shoreline length/position, beach width and area) and to contribute in a better understanding of the medium-term beach zone dynamics. The procedure includes the collection of in-situ reflectance measurements, the creation of a local database of spectral signatures for the differentiation between the wet part of the lower beach face (swash zone) and the dry upper part, and finally the correlation with corresponding satellite data. This will be a vital step that will lead to an improved determination of the shoreline position through the assessment of the satellite information accuracy and a better image classification of the beach sediment nature.

The selection of the deltaic coast of Pinios river (Figure 1) as a study area, is based on the following facts: ***(i)*** Pinios is the largest Greek river having its drainage basin (some 10,000 km^2) within Greek geographical boundaries; ***(ii)*** it is the only river in Greece with very limited flow controls (in less than 10% of its catchment; ***(iii)*** the Pinios delta is recognized as an environmentally sensitive coastal zone and as such, it is protected by the NATURA 2000 network.

The Pinios River delta has a cuspate shape and is exposed to moderate wave activity (mean wave heights ~1 m); the highest (although rare) offshore waves approach from the SE and because of the long fetches, can locally exceed 4 m in height [2]. The deltaic coast is characterized by sandy beaches with low sand dunes, consisting (mostly) of medium – sized sand abundant in quartz and feldspars.

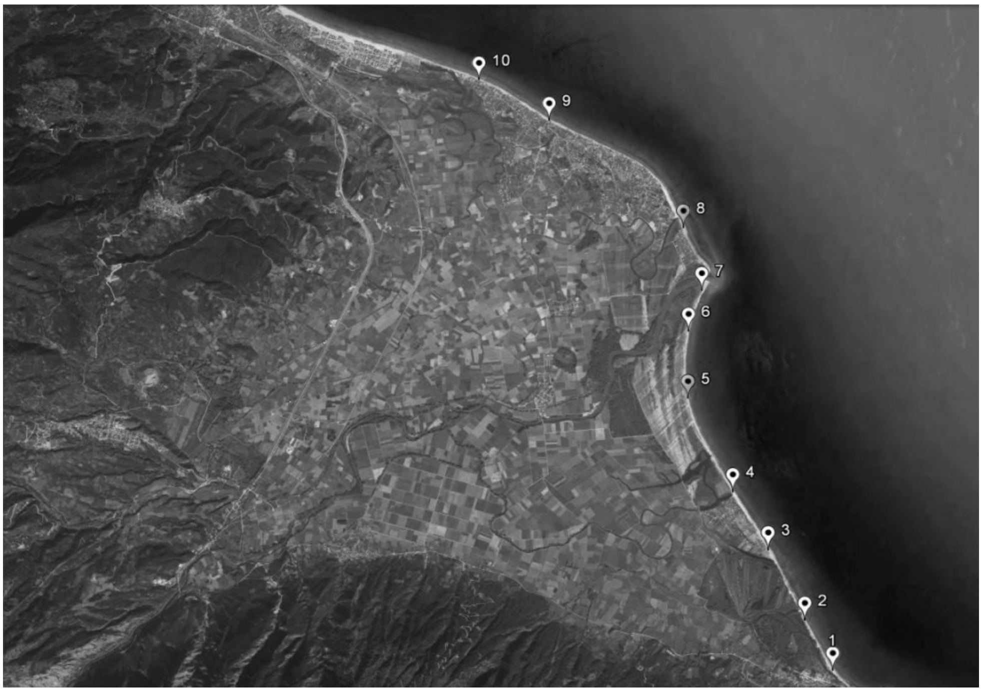

Figure 1. Map of the study area and sampling sites (image source: Google Earth).

The scope of this contribution is to develop a tool that will be used to identify the shoreline position with high accuracy. The results will be verified using satellite images calibrated through ground truthing on both the wet lower shoreface and the adjacent dry (beyond the wave reach) part of the upper beach face. This work also contributes to an effective coastal zone management facilitating a rapid and cost-effective assessment of shoreline retreat induced by changes in mean sea level and storm surges, in order to identify hot-spots of beach erosion.

2. MATERIALS AND METHODS

For the development of the procedure, reflectance measurements were initially performed in the laboratory. For this reason an HR4000 spectrometer, a fiber optic diffuse reflectance probe and tungsten-halogen light source at 3100 K (Ocean Optics) were employed. Reference reflectance was provided by a spectralon plate. For the field measurements, the various radiances were probed under daylight conditions through a 3^{o} FOV Gershun tube attached via an optical fiber to a Jaz (Ocean Optics) spectrometer.

The wavelength dependent reflectance measured is defined as:

$$R(\lambda) = R_g \frac{L_{\text{sand}}(\lambda) - L_{\text{dark}}(\lambda)}{L_{\text{spec}}(\lambda) - L_{\text{dark}}(\lambda)}$$

Where $L_{sand}(\lambda)$ is the radiance from the sand sample, $L_{spec}(\lambda)$ the radiance from the spectralon plate and R_g the known reflectance of the plate. The measurements were performed with a 45^o monitoring angle with the illuminant coming from the same direction thus avoiding possible specular components.

For classification purposes, the following indices were estimated [3,4]:

$$BI = \left[\frac{R^2 + G^2 + B^2}{3}\right]^{1/2}, \quad SI = \frac{(R-B)}{(R+B)}$$

where *BI*, the brightness index, is indicative of the average reflectance magnitude and *SI*, the saturation index, of the spectra slope. The indices were evaluated at the center of the corresponding band of the IKONOS satellite (*R*=664.8 nm, *G*=550.7 nm, *B*=480.3 nm).

The laboratory measurements were carried on samples from 11 beaches all around Greece. The samples were initially dry and gradually the moisture content was increased while the reflectance was monitored. Pinios beach in situ reflectance spectra were also collected at station 8 (Fig.1). In addition, beach sediment samples were analysed granulometrically by dry-sieving (for material coarser than 0.0625 mm) and characterised according to Folk's (1980) nomenclature [4].

3. RESULTS AND DISCUSSION

The measured reflectance spectra showed that different kinds of sand have dissimilar optical properties and spectral signatures, as expected. Whitish sands have high reflectance (~70% in the visible part of the spectrum), while dark grey sands low (~20%), with an overall ascending slope of the spectrum towards longer wavelengths. Colored sand samples generally have spectral curvatures associated to the dominant color (Figure 2). Grain size seems to contribute to the overall albedo which increases with decreasing grain size.

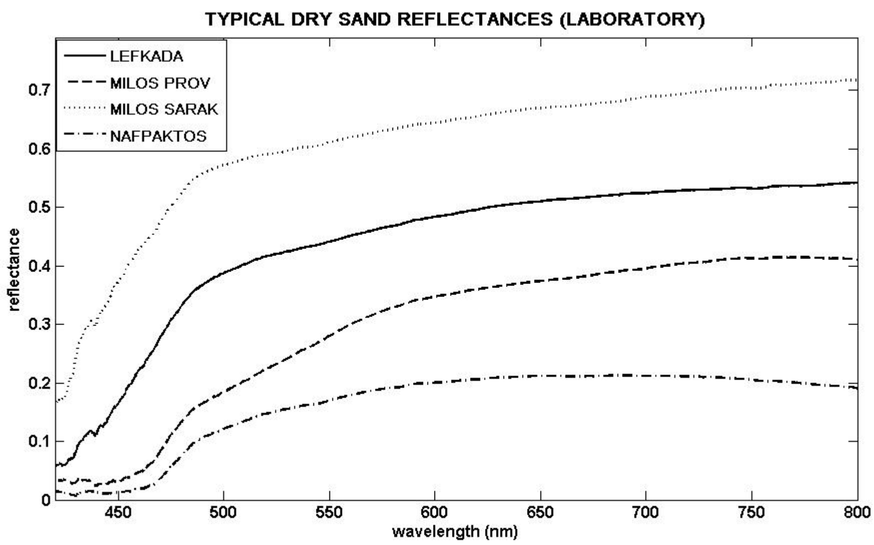

Figure 2. Reflectance spectra of different sand types as measured in the laboratory.

Experiments including dry and wet samples showed that increased wetness lowers, proportionally, the albedo of the samples across the whole spectrum (Figure 3a). Field measurements of the spectral reflectance of the wet and dry sediments of the foreshore zone along the deltaic coast of the River Pinios produced similar results (Figure 4a).

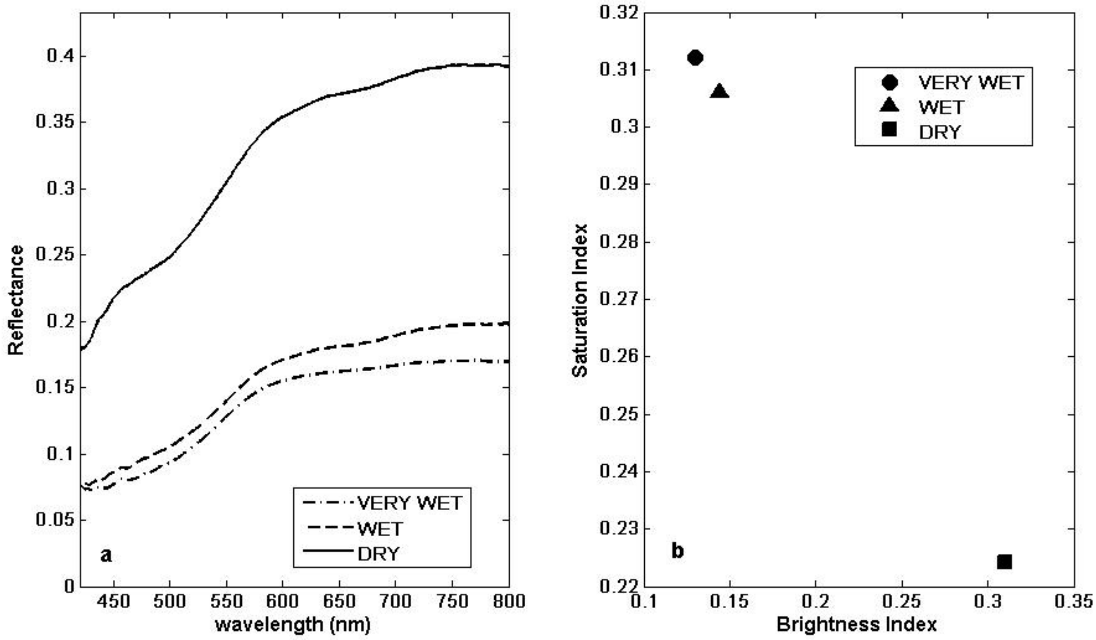

Figure 3. (a) Sand reflectance spectra in the visible for variable moisture content. (b) Variation of saturation index and brightness index with moisture content. The sample is from the Glyfada beach.

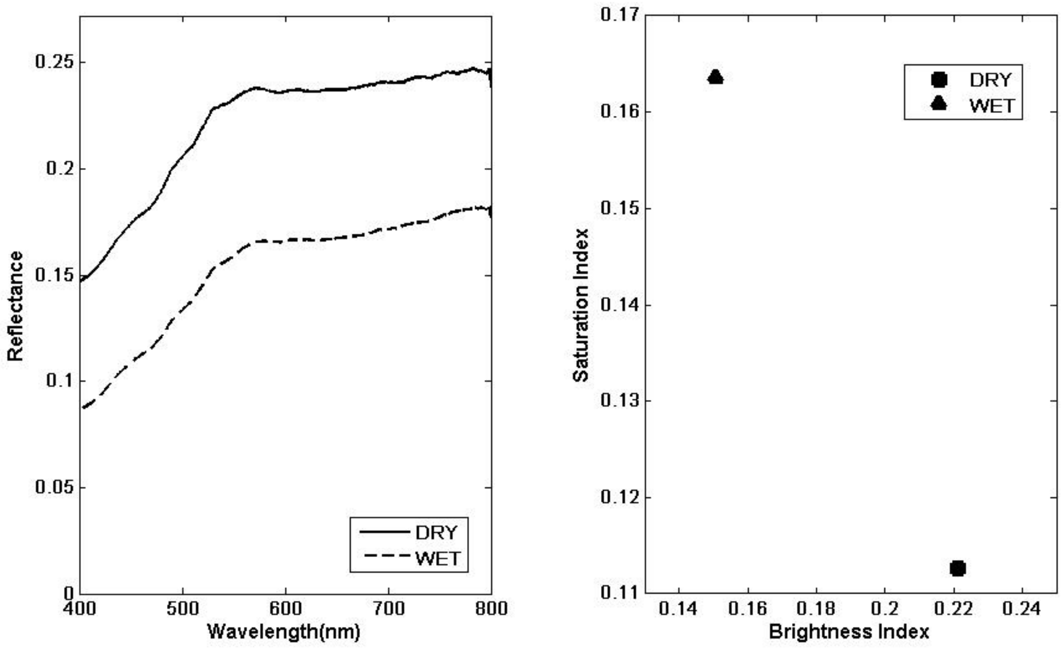

Figure 4. Similar to Figure 3 but for field measured spectral reflectance under daylight conditions

Two spectral indices were found to be highly efficient in differentiating between wet and dry spectra: dry samples have high Brightness Index (average reflectance magnitude) and low Saturation Index (Spectra Slope); increased water content in the samples results in proportionally lower Brightness Index and increased Saturation Index. Therefore, the magnitude of the ratio between these indices can be used to classify beach sand samples as dry or wet (Figure 3b and 4b). Evaluation of a similar set of classification indices proposed by Ouillion et al. [6] but for dry samples only, did not exhibit as high sensitivity for different moisture contents.

In Table 1 the granulometric results for the location where in-situ measurements were performed are shown. It is interesting to note that although the mean grain size increases significantly toward the upper beach face, and a decreased albedo is expected, the grouping of the two indices remains well defined.

Table 1. Granulometric results for the beach sediments at Station 8 (Pinios river delta).

Sample	**(Mean grain size)** Mz	**Characterization**
8S (Swash zone)	0.18	GRAVELLY SAND
8B (Beach face)	1.50	SLIGHTLY GRAVELLY SAND

4. CONCLUSIONS

This paper presents some of the preliminary results of an investigation on the reflectance properties and spectral signatures of various samples of dry and wet beach sand. Future work may include monitoring of the in-situ sediment moisture [7] as well as an identification of the mineralogical composition of each sample. Nevertheless, initial laboratory and field results seem encouraging enough that a database with distinct spectral signatures for various sand types and conditions of sand can be built. Having established typical ranges of spectral indices ratios for each condition of a particular beach from in-situ measurements, remotely sensed images can be potentially used for the automated identification and extraction of the shoreline position. The next major step to undertake will be the association and comparison of the above indices with indices estimated from satellite images acquired concurrently with the in-situ measurements.

Acknowledgements

This work is supported by the research program THALES - DAPHNE (MIS: 375908) that is funded by the Operational Programme "Education and lifelong learning, 2007-2013" of the Ministry of Education and Religious Affairs, Culture and Sports

References

1. Vörösmarty C.V., Meybeck M., Fekete B., Sharma K., Green P., Syvitski J., 2003. Anthropogenic sediment retention: major global impact from registered river impoundments, Global and Planetary Change, **(39)**, 169–190.
2. Soukissian, T., Hatzinaki, M., Korres, G., Papadopoulos, A., Kallos, G., Anadranistakis, E., 2007. "Wind and Wave Atlas of the Hellenic Seas", Hellenic Centre for Marine Research Publ., 300 pp., ISBN-987 960 86651 9-4.
3. Mathieu R., Pouget M., Cervelle B., Escadafal R., 1998. Relationships between Satellite-Based Radiometric Indices Simulated Using Laboratory Reflectance Data and Typic Soil Color of an Arid Environment, Remote Sens. Environ., **(66)**, 17-28.
4. Ray S.S., J.P. Singh, G. Das, S. Panigrahy, 2004. Use of High Resolution Remote Sensing Data for Generating Site-specific Soil Mangement Plan, in ISPRS Archives **Vol XXXV** (B7), 132-137.
5. Folk, R.L., 1974. The petrology of sedimentary rocks: Austin, Tex., Hemphill Publishing Co.
6. Ouillion S., Lucs Y., Gaggelli J., 2002 Hyperspectral Detection of Sand, Proceedings, 7th International Conference on Remote Sensing for Marine and Coastal Environments, Miami Florida
7. Kaya S., Seker D., Yasa N., Kabdasli S., Tanik A., 2007. Utility of Remote Sensing Technology for Determining Characteristics of Sandy Beaches, Clean 2007, **35(6)**, 654 – 659.