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EXTENDED ABSTRACT

Advanced remote sensing technology is an outcome of the increased capability in processing large data sets and the development of hyper-spectral sensors with contiguous narrow spectral bands and high ground resolution. Furthermore, the identification of fine spectral and spatial information of coastal properties allows for thematic mapping. As coastal regions are our most precious resource, the main objective of this presentation is to portray with some examples the spectral regions of the electromagnetic spectrum that are diagnostic for the measurements of coastal processes and inventories of environmental conditions with very particular characteristics of which a summary is shown in Table 1.

Table 1. Special characteristics of coastal regions

COASTAL CHARACTERISTICS
• COASTAL WATER vs OPEN OCEAN
COAST IS A BOUNDARY TO FLOW
BATHYMETRY OVER CONTINENTAL SHELF
• SALINITY FLUCTUATIONS
RIVER RUNOFF
PRECIPITATION
CONTINENTAL AIR MASSES
• GENERAL WATER PROPERRTIES AND MOTIONS
LARGER FLUCTUATIONS THAT IN THE OCEANS
• SHORE
BOUNDARY THAT LIMITS MOTION HORIZONTALLY AND VERTICALLY. CONSEQUENCE: EROSION, DEPOSITS, TIDES, RIVER RUNOFF, REDUCED SALINITY AND STABILIT, SEA LEVEL CHANGE
• CONCERN: POLLUTION AND EUTROPHICATION

Remote sensing of the coastal region takes into consideration spectral properties of the many surface manifestations and wavelengths that range from about 0.40 to 0.70µm. Those spectral regions can provide significant information on coastal surfaces and many water column characteristics including bathymetry, bottom topography, amounts of colored dissolved organic matter (CDOM), suspended sediments and marine photosynthetic pigments. For a quantitative interpretation of remote sensing data, the photon penetration of water has to be taken into account as summarized with Table 2 showing the absorption coefficient and penetration depth of light as a function of wavelength.

Table 2: Absorption coefficient a_w of pure water, and the absorption depth calculated for selected wavelengths

WAVELENGTH (μm)	a_w (m^{-1})	$d_a = a(\lambda)^{-1}$ (m)
0.443	0.0086	116
0.551	0.0661	15
0.667	0.4325	2
0.678	0.4470	2

Coastal vegetation and phytoplankton show the position of spectral bands where photosynthetic pigments absorb in the visible part of the EMS whereas an increase in reflectance in the near-infrared, the so-called red edge, is diagnostic for vegetation. These spectral characteristics allow the differentiation between bare soil, healthy and stressed vegetation and water-covered surfaces.

The number of spectral channels required for quantitative assessments ranges from a few to several hundreds. In Figure 1 an example is given where only two spectral bands were used and were positioned in specific absorption and reflectance bands of coastal vegetation whereas some remote sensing systems operate with more than two hundred channels.

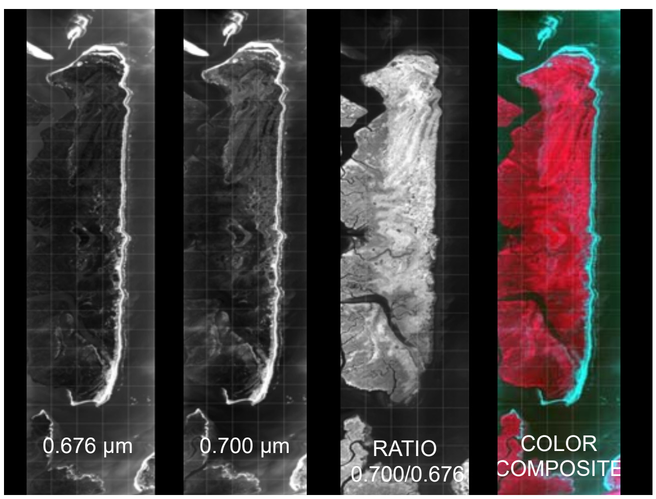

Figure 1. Remote sensing of a coastal environment that is based on two spectral bands.

Due to differences in spectral signatures, targets build apparent clusters in multi-spectral space that can be divided into distinct regions with interactive analysis. In the case of coastal regions, such analysis permits the identification of specific oceanic regimes. When clustering is present, two-dimensional scatter plots may assist to design pattern classifiers for further supervised classification. Examples of clusters that relate to different spectral responses of targets is shown in Figure 2 where clusters are recognized in spectral band ratios that can be further processed for spectral classification.

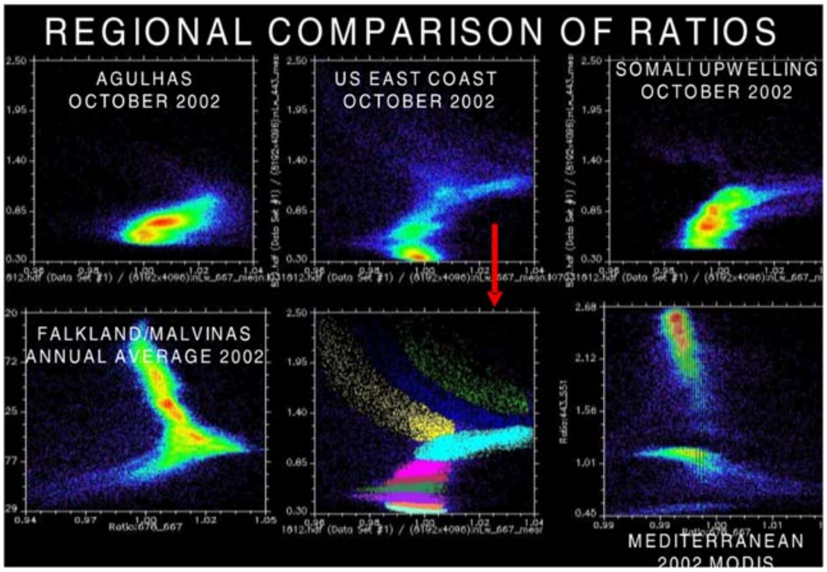

Figure 2. The diagram shows clusters in various coastal regions.

Multi-spectral remote sensing in oceanic and coastal waters is the basic tool to retrieve photosynthetic pigments. The procedure is based on analyzing the spectral regions that are characterized by strong absorption of chromophobic dissolved organic matter (CDOM), carotenoids and the various chlorophylls. However, the spectral location of absorption bands may differ according to the sensor specifications, spectral band positions and spatial resolution. Derivative analysis of spectra has also been introduced as one technique for extracting absorption features from complex reflectance spectra. For instance, high-resolution spectroscopy is being used for the detection of potentially harmful algae blooms.

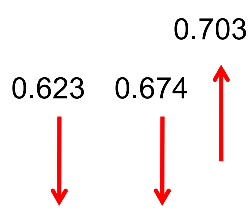

Figure 3. Spectrum based on a comparison of clean ocean water and a spectrum that was obtained over a cyanobacteria bloom showing the absorption bands of photosynthetic pigments and the red edge.

The use of hyper-spectral monitoring is of importance for marine pollution monitoring. This has been demonstrated, for instance, with observations of the 2010 oil spill in the Gulf of Mexico (Szekielda et al., 2014). Strong reflectance in the near infrared was observed over patches of oil and at wavelengths below 0.5μm no major absorption bands were present.

More refined methods for feature extraction from targets include spectral classification that can be applied to an image by separating spectral end members from spectrally pure pixels. Processing the data with the end members in spectra and measuring spectral similarity by calculating the angle between the spectra in the image pixels allows the generation of classified images. Such processing is documented with examples from a space-borne hyper-spectral sensor that was designed specifically for characterizing the coastal environment (Lucke et al., 2011).

Keywords: *Remote sensing, coastal, multi-spectral, environment*

References

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Dr. Karl Szekielda is member of the Doctoral Faculty of the Earth and Environmental Sciences of the Graduate School and Adjunct Professor at the City University of New York (CUNY). Dr. Szekielda is presently with University of The Bahamas as a U.S. Fulbright Scholar in research and teaching. Prior to his Fulbright award in The Bahamas, he was in 2012 and 2015 a U.S. Fulbright Specialist at the Ateneo de Manila, Philippines. He returned to the Philippines in 2016 under a USAID Science, Technology, Research and Innovation for Development Project.

Professor Szekielda has worked with various laboratories of excellence. He has worked at the U.S. Naval Research Laboratory, Washington, D.C, 2006-2010, as an ONR/ASEE Senior Faculty Fellow in the analysis and interpretation of hyper-spectral data obtained from aircraft and satellite altitudes over the oceans, monitoring spatial and temporal events over coastal regions with the coastal scanner HICO on the International Space Station. He also has worked at NOAA's Cooperative Remote Sensing Science and Technology Center (CUNY), 2000-2003, and at NASA Goddard Space Flight Center, Maryland, 1969-1971, where he received a National Academy of Science/NRC award and began his career as an oceanographer.

Professor Szekielda's main areas of teaching are in marine and coastal environment, issues related to small island developing states, sustainable development and environment and remote sensing and satellite monitoring of the Earth with emphasis on the oceans. He has held positions as Adjunct and Research Professor at New York University and Columbia University; was Visiting Professor at the University of Hamburg; and an honorary member of the Academia Sinica in Beijing. At the United Nations, 1974-1996, as chief of section in New York, he carried out technical assistance programs on remote sensing and outer space matters and later as head of branch of the Environment and Natural Resources Management Division of ESCAP in Bangkok, on environment and natural resources development in cooperation with various governments.

Professor Szekielda has written well over a hundred publications in scientific journals and has contributed to many books and proceedings. His book, *Satellite Monitoring of the Earth*, published by John Wiley and Sons, Inc. New York is widely used as a text at universities teaching remote sensing.