Monitoring estuarine salt crusts using hyperspectral data (River Odiel, SW Spain)

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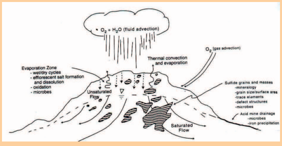
Abstract: Marshes are highly dynamic ecosystems based on the interaction between sea level, land elevation, vegetation cover and sediment accretion. In the current study case, the acid mine drainage-contaminated River Odiel water in the estuary, interact with marine salt water resulting in complex geochemical processes developing salt crusts in intratidal planes. The use of imaging spectroscopy techniques with Hyperion imagery and field and laboratory spectral data permits the monitoring of the spectral trends of the salt crusts and perform a temporal monitoring of these efflorescences. Climate variability, geomorphology and tidal regime have been established as key factors in the salt crusts development. The results evidence that the marshes of the River Odiel are a suitable testsite with the upcoming spaceborne sensors EnMAP (ESA) and HyspIRI (JPL). The good signal/noise ratio and the temporal resolution allow the acquisition of large sequences of images, adequate for real time data analysis.

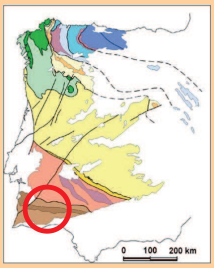
Keywords: Imaging spectroscopy, coastal marsh geology, mine waste contamination, real time Earth Observation.

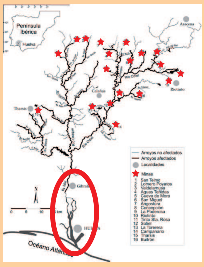
AREA OF STUDY: The Iberian Pyrite Belt

- Massive sulphide ore. It hosted the world's largest non-ferrous metallic metal stock.
- The metallic sulphides (pyrite) are being weathered.
- Acid Mine Drainage runoff towards the sea.



$FeS_2 + O_2 + H_2O \longrightarrow Fe(OH)_3 + H_2SO_4$

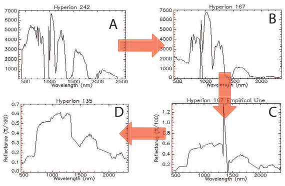




DATA AND IMAGE PROCESSING

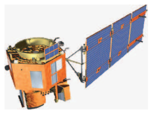
Hyperion pre-processing routine

- Cleaning of overlaping channels and faulty detectors.
- Conversion of DN to reflectance values.
- Atmospheric correction (Empirical Line)
- Cleaning of noisy channels (H_2O, O_2).
- Finaly: 135 from 220 useful channels.

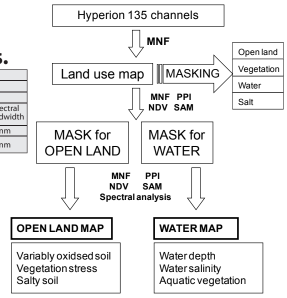


Hyperion specs.

Orbital height: 705 km			
Spatial resolution: 30 m			
Spectral resolution: 220 channels			
	Spectral range	Sampling interval	Spectral bandwidth
VIS	400-1000 nm	10 nm	15 nm
NIR-SWIR	900-2500 nm	10 nm	15 nm

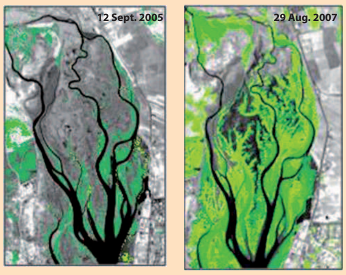


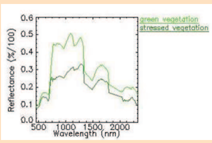
Hyperion processing routine

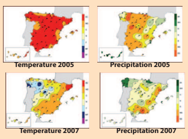


RESULTS

CHANGES IN VEGETATION



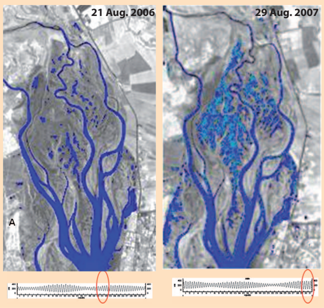




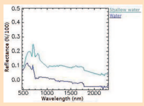
The hyperspectral capabilities of the Hyperion sensor allows the performance of highly detailed vegetation analysis. The analysis of temporal series of images reveals how the estuarine vegetation of marshes evolve thorough time.

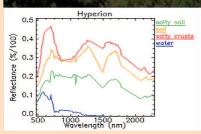
Hyperion data analysis shows that the development of healthy vegetation in the marshes corresponds with humid and moderately warm climatic conditions.

CHANGES RELATED TO TIDAL EFFECTS

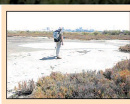


The analysis of hyperion data has permited to record the variations in water flooding, wet intertidal surfaces and salt development over soil in areas of water withdrawal.

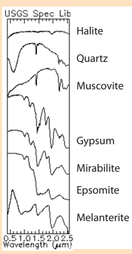




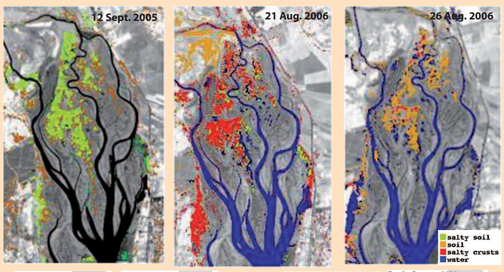
Hyperion endmembers used as reference to compile the salt crusts maps.

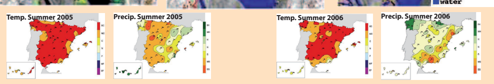


USGS Spectral Library	Flat 0.40 µm-0.92 µm	0.686 µm	1.450 µm	1.453 µm +1.507µm	2.208 µm	2.22 µm+ 2.27 µm
Halite NaCl						
Quartz SiO_2					*	
Muscovite $KAl_2(Si_3Al)O_{10}(OH,F)_2$					*	
Gypsum $SO_4Ca.2(H_2O)$	*		*	*	*	*
Mirabilite Na_2SO_4	*		*			
Epsomite $MgSO_4 \cdot 7(H_2O)$	*		*			
Melanterite $Fe^{2+}(SO_4) \cdot 7(H_2O)$			*			
VEGETATION		*				



SALT EFFLORESCENCES





The salty areas of 27 August 2005 are flooded on 21 August 2006 at high tide. A wide area is covered by previously wet land that subsequently developed a salty soil, with these regions ribboned by narrow belts of soil with no evidence of salt. This outer ribbon represents the last endmember of the drying process according to the maps of 2005. Five days later, on 26 August 2006, the salty soils exhibit spectral features devoid of salt, and the salty areas are sparse.

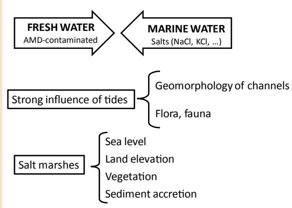
At the end of August during the comparatively wet year of 2007, salt development is restricted to small topographically elevated areas; the remaining topographically low areas are flooded, displaying a spectral response with a strong vegetation component. King tides are responsible for the wide flooding, since this Hyperion scene was recorded at low tide.

THE ESTUARINE ENVIRONMENT

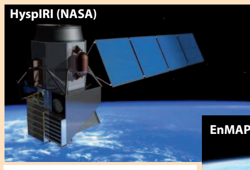
When the Odiel river reaches the Atlantic Ocean, it takes place a mixture of fresh acid water, coming from the drainage of the northern reliefs, with saline marine water.

Estuary environments are strongly influenced by tides, controling the geomorphology of channels, the development of vegetation and the fauna.

The evolution of salt marshes is controled by the variations of the sea level, the land vegetation and the sediment accretion.



NEW PERPECTIVES



HyspIRI

Hyperspectral: 210 bands (380 - 2500 nm)
Thermal multispectral: 8 bands (3-12 µm)
Spatial resolution: 45 m (hyper), 60 m (multi)
Temporal resolution: 30 days.

EnMAP

Hyperspectral: 232 bands (420 - 2450 nm)
Spatial resolution: 30 m (hyper)
Temporal resolution: 21 days.

One of the most promising trends in Earth Observation is the Real Time Monitoring.

Future hyperspectral sensors onboard NASA's HyspIRI and ESA's EnMAP will provide an adequate temporal coverage of the Earth surface, offering standarized products for science and industry, in all the different disciplines of environmental, agriculture and Earth sciences.

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