Semi-arid Wetlands: Assessment of their Degradation Status and Monitoring by Multi-Sensor Remote Sensing

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Presentation overview

- Objectives
- Project background
- Project team
- Study area
- Methodology
- Field work
- Available EO data
- Application of CHRIS data
**Objectives**

The aim is to apply a multi-sensor and multi-scale approach to study semi-arid wetlands in Spain using advanced Earth Observation Systems with the support of field spectroradiometry, and ancillary field and laboratory data.

In this case, data from the Compact High Resolution Imaging Spectrometer (CHRIS) aboard ESA's Proba will be used to obtain environmental information from target scenes within the different wetland areas in contrasting seasons (wet and dry) within the same year.

Specific objectives:

- Explore complex wetland characteristics -> shallow water bodies, hygrophytic vegetation, soil conditions (humidity) and characteristics (crusts, iron oxides).
- Identifying open water lamina and flooded vegetated areas.
- Determining wetland plant communities and invasive vegetation species.
- Detecting anthropogenic influences (agricultural management).
- Implementing CHRIS information to improve results obtained with multisensor data and to enhance monitoring studies.
Project background

- Wetlands in semi-arid regions are complex and fragile ecosystems and are especially important because of their role in maintaining and controlling the environmental quality and biodiversity and undergo extreme changes from the wet to the dry season.

- These wetlands are saline or non-saline and are very dynamic systems subject to natural (seasonal) as well as man-induced changes which produce alterations in wetland ecosystems.

- A reduction or disappearance of wetland areas are linked to the development of large irrigation systems in the regions with a significant reduction of the ground water resources, land use changes, water drainage, waste deposition and waste water effluence.

- The research presented for this project forms part of a greater ongoing investigation in wetlands that was initiated in 1995.

Combining traditional and well-established research methods with cutting-edge technology will:

1) Advance our knowledge in detecting, understanding and monitoring environmental changes occurring to these types of ecosystems.

2) Develop new methods for extracting indicators from multi-sensor data to determine their degradation status and trend in a timely and spatial manner.
**Project team**

This project is within the framework of the Spanish National project “Multidisciplinary analysis of geoindicators of degradation in protected wetlands (Las Tablas de Daimiel National Park)” (CGL22005-06458-C02-02/HID).

Coordinator: Dr. Jose Gumuzzio from the Autonomous University of Madrid.

Team: 12 members -> multi-disciplinary (geology, hydrology, geomorphology, pedology, biology, remote sensing, geo-thematic mapping).

National collaboration: • Geological Survey of Spain (IGME)
  • Centro de Estudios y Experimentación de Obras Públicas (CEDEX)
  • Research Centre for Energy, Environment and Technology (CIEMAT)

International collaboration: • Centre for Remote Sensing, Boston University (USA)
  • School of Geography, Nottingham University (UK)
These test sites exemplify a global problem affecting many wetland areas, namely that population growth and expansion of agricultural areas are the main reasons for these wetlands to disappear and with them a valuable natural resource supporting biodiversity and wildlife habitats.
• Karstic environment enclosing numerous saline lakes (playa lakes).
• Introduction of irrigation systems in an area characterized by a semi-arid climate, closed basin hydrology, and karstic geology of evaporitic sediments, is changing the water balance and soil properties of the playa lakes and surrounding areas.
• The results are increased rates of soil and water salinization.
Study area Las Tablas de Daimiel

- National Park (UNESCO Man and Biosphere Reserve and Ramsar Convention)
- The area is in a depressed basin filled with Tertiary sediments, mainly of limestone and calcareous clays.
- Water sources: (1) Guadiana River (freshwater) and Cigüela River (brackish)
  (2) Upwelling groundwater from underlying karstic aquifer.

Diminishing water level.
Areas with temporal flooding.
Crop cultivation with intensive irrigation surrounding wetlands.
Salt efflorescence.
Methodology

Data acquisition
- Hyperspectral and multispectral
  - Wet (spring) and dry (autumn) season

Calibration procedures
- System, atmospheric, radiometric and geometric
- Unsupervised and supervised classification
- Pool of endmembers
- Spectral unmixing

Data processing
- Field campaigns
- Surface sample analyses (sediment, soil, water)

Ground-truth data
- Selected surface covers
- Over a greater

Validation of results
- Hyperspectral (HyMap, CHRIS)
- Multispectral (ASTER, ETM+, TM)

Monitoring
- Georeferenced (field data, EO data)
- Thematic maps

Database management
Methodology

I

Field data

Field spectrometer campaign

Determination of vegetation

Sediment, soil, water studies

II

Hyperspectral data
CHRIS, HyMap

Image-derived endmembers

III

Spectral library

Identify endmember

Abundance maps

Spectral unmixing

Endmember pool

Detecting changes in wetland areas

Cartographic and ancillary data

Image-derived endmembers

Multispectral and multitemporal data TM, ETM+ y ASTER
Field work

Spectral sampling

Soil characterisation and sampling

Water sampling
Registration and location
Sample id: P8LS096T26E_Salt crust (H44)
Acquisition date: 07/07/2003  Acquisition time: 13:21:04
Location: La Lagunilla  Municipality: Villafranca de los Caballeros
UTM-East: 471423  UTM-North: 4365514  Elevation (m): 638

Abiotic and biotic characteristics
Geomorphic environment: Lacustrine
Landscape: Lake plain  Landform: Lake bed
Topography: Flat  Microtopography: Even
Slope class (%): 0 - 0.1  Slope form:  Hillslope position:  
Land use: Not used and not managed  Vegetation: None
Anthropogenic influence: No influence
Surface cover feature: Salt crust
Parent material: Marl and gypsum sediments

Soil properties
Carbonates (%): 7.2  pH (1:25 H2O): 8.6
Fe2O3 (%): 0.4  Organic matter (%): 2.4
Electric conductivity (dSm-1): 37.8  Munsell colour: Dry 10YR8/2 (very pale brown)  Wet 10YR6/2 (light brownish grey)

Mineralogical composition*
Bloedite:  Halite: +
Hexahydrate: Tr.  Pentahidrite: +
Starkeyite: +  Tridimite:  
Gypsum: ++  Calcite: +
Dolomite:  Quartz: Tr.
K-feldespar: +  Na-feldespar:
Phyllosilicates: + (illite)

*(Tr. - trace; + common; ++ abundant; +++ very abundant)

Spectral field library

Wetland soil.

Wetland vegetation.
Wetland status

- Natural area with Steppe vegetation
- Degraded area with invasive vegetation
- Invasive vegetation
- Land use change
### Available EO data

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<thead>
<tr>
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<th>Los Monegros</th>
<th>Las Tablas de Daimiel</th>
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<tbody>
<tr>
<td><strong>Hyperspectral</strong></td>
<td>1 CHRIS scene 2006</td>
<td>1 CHRIS scene 2006</td>
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<tr>
<td><strong>Multispectral</strong></td>
<td>2 TM 1984 - 1997</td>
<td>5 TM 1985 - 2003</td>
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<tr>
<td></td>
<td>2 ETM+ 2002 - 2003</td>
<td>5 ETM+ 2001 - 2003</td>
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</tbody>
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**Further CHRIS scenes**

- 4 HyMap Scenes 2004
IsoData Classification

Soil Classes - SAM classification

ASTER 16 June 2004
SAM Classification (saline soils)

La Mancha Spectral Library

Resampled spectra

ASTER 16 June 2004
CHRIS acquisition

Las Tablas de Daimiel (22 May 2006) → Cloudy

Los Monegros (Chris-LN-060607-6D92-41)

Further acquisition: Las Tablas de Daimiel 6 October 2006
Los Monegros 13 October 2006
Application of CHRIS data

- Spectral information to determine complex wetland characteristics.
- Angular information to obtain structure of vegetation and the water body.
- Detect wetland changes between the dry and wet seasons.
- Monitoring these ecosystems by integrating the CHRIS data to historical EO data.
Acknowledgements

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