Analysis of Protected Areas: The Use of Satellite Images for Data Mining within ECOPOTENTIAL

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Abstract

The EU-funded ECOPOTENTIAL project [1] shall demonstrate, among others, the application potential of satellite images for detailed ecological studies of environmental and ecological protected areas within pre-defined bio-geographical regions of Europe. These studies aim at the corroboration of essential variables for the monitoring of protected areas in Europe.

The innovative character of our project is a systematic assessment of how to exploit SAR satellite images in combination with multispectral optical satellite images and/or local in-situ measurements. The results of the project shall demonstrate the scientific gain when combining SAR image data with optical instrument data. While standard products of Sentinel-2 and WorldView-2 provide a sound basis for multispectral analysis and interpretation of vegetated areas, any additional information contained in SAR images (of TerraSAR-X and Sentinel-1) can improve the classification results and the analysis of time series data. We estimate that about 10 essential protected area variables (out of 93 envisaged variables) can be extracted from these images.

Datasets and Methodology

Sentinel-1 image time series

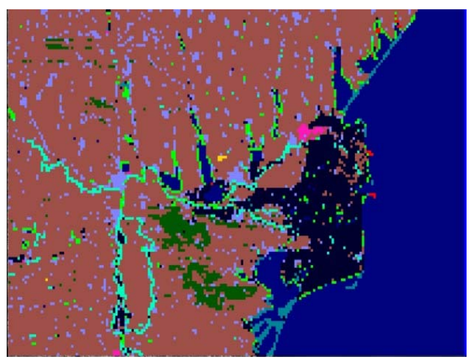
- Input data: Danube Delta, Romania (30 images from 01.03.2015 - 18.05.2016 within 12 day intervals) ; Wadden Sea and Dutch Delta, Netherlands (21 images from 22.12.2014 - 22.03.2016 within 12 day intervals)
- Image classification:
  - Feature extraction:
    - Gabor filtering
    - Weber descriptors
  - Classification using a Support Vector Machine
  - Semantic labelling based on a hierarchical annotation scheme [2]
  - Results are classification maps and data analytics [3]

Landsat-5 image time series

- Input data: Doñana National Park South of Spain (12 images from 10.2009 - 08.2010 with one month interval)
- Image classification:
  - Computation of three spectral indices:
    - Normalized Difference Vegetation Index (NDVI), a green vegetation indicator and two variations of Normalized Difference Water (NDWI), related to liquid water
  - Feature extraction:
    - Represent each image as three layers of spectral indices
    - Vectorise local neighborhoods of 3x3 pixels for each layer (nine-dimensional vectors)
    - Concatenate the corresponding feature vectors of the index layers (27-dimensional vectors)
  - Apply *k*-means to the feature vectors of all images
  - Consider the changes in the class assignment of every region over time as a change map [4]

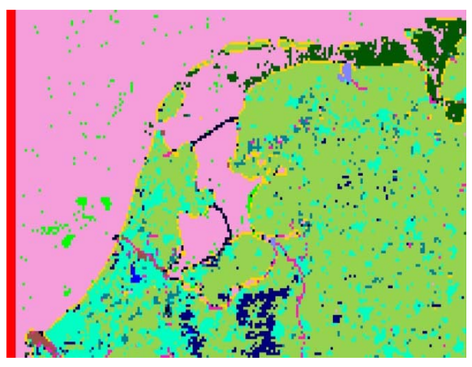
Results

Danube Delta, Romania



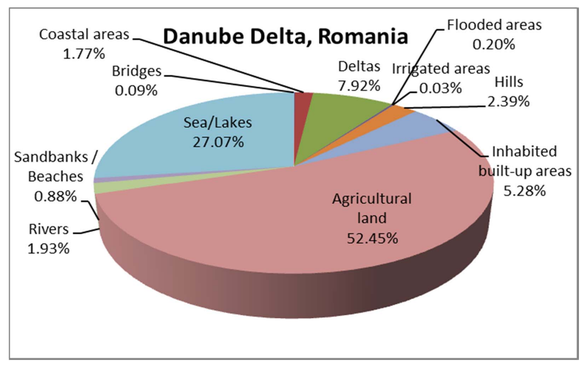
- *Black edge (image edge effect)*
- *Bridges*
- *Coastal areas*
- *Deltas*
- *Flooded areas*
- *Irrigated areas*
- *Hills*
- *Inhabited built-up areas*
- *Rivers*
- *Sandbanks / Beaches*
- *Agricultural land*
- *Sea / Lakes*

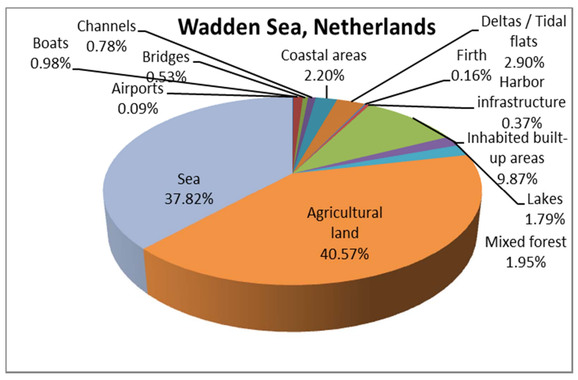
Wadden Sea, Netherlands

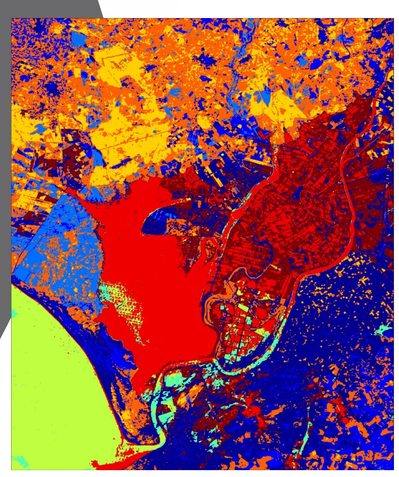


- *Airports*
- *Black edge (image edge effect)*
- *Boats*
- *Bridges*
- *Channels*
- *Coastal areas*
- *Deltas / Tidal flats*
- *Firth*
- *Inhabited built-up areas*
- *Lakes*
- *Harbour infrastructure*
- *Agricultural land*
- *Sea*
- *Natural vegetation*

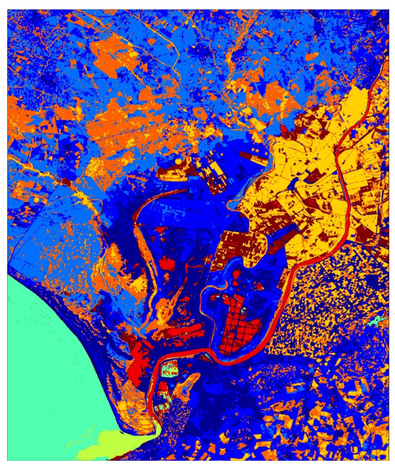
Classification maps and statistical analytics for Sentinel-1A



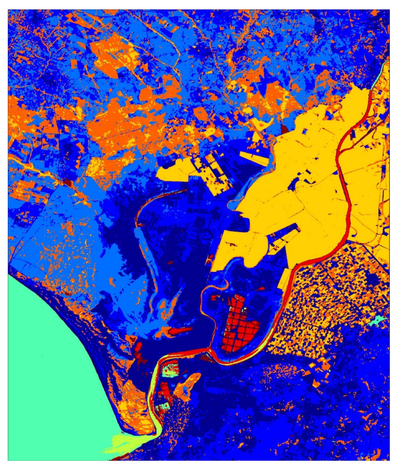




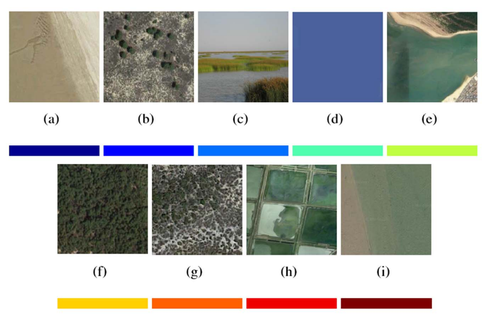
Doñana, February 2010



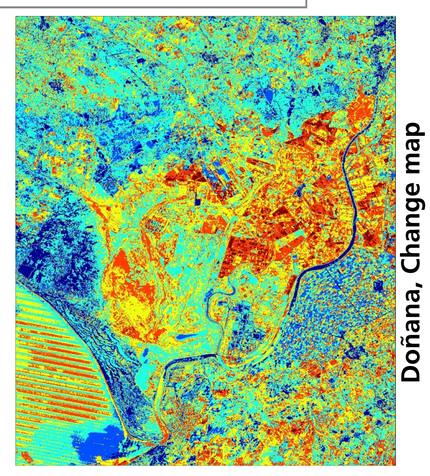
Doñana, June 2010



Doñana, August 2010



(a) Bare soil, (b) Very sparse vegetation, (c) Marshland, (d) Deep water such as Ocean, (e) Sediments, (f) Forest, (g) Bushes, (h) Mid-level water, (i) Shallow water.



Doñana, Change map

Conclusion and Future Work

For *Sentinel-1A* the results show reliable classification maps with more than 10 semantic categories, as well as the corresponding statistical analytics. In future, we plan to use these results for detailed validation and long-term cross-comparisons.

For *Landsat-5* the results show that the local descriptors from the index representation of the images help to discover more homogeneous land cover categories. These categories can be further used to assess the land cover dynamics over time and the affected parameters.

References

[1] ECOPOTENTIAL project. Available: http://www.ecopotential-project.eu/protected-areas

[2] O. Dumitru, G. Schwarz, and M. Datcu, *Land Cover Semantic Annotation Derived from High Resolution SAR Images*, JSTARS, vol. 9(6), pp. 2215-2232, 2016.

[3] O. Dumitru, G. Schwarz, and M. Datcu, *SAR Image Land Cover Datasets for Classification Benchmarking*, JSTARS, 2017, under review.

[4] D. Espinoza-Molina, R. Bahmanyar, R. Diaz-Delgado, J. Bustamante, and M. Datcu, *Land Cover Change Detection Using Local Feature Descriptors Extracted From Spectral Indices*, submitted to IGARSS 2017.

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