Coastline detection using high resolution multispectral satellite images

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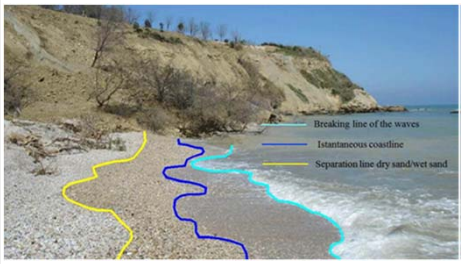
Study area



Limits identified in coastal environment

Ortona, Abruzzo (central Italy)

Introduction

In this work we want to test the ability to detect the coastline (or rather the instantaneous coastline) from a WorldView-2 acquisition representing a portion of the coast of Ortona (Chieti, Abruzzo). In particular, our research is directed at an identification of an algorithm that allows the coastline extraction in automatic or semi-automatic mode.

The coastline is a portion of land that contains the emerged and submerged areas and is subject to continental and marine geomorphologic processes. The shoreline determination and its restitution is a key element in the coastal environment's monitoring for emerged and submarine zone.

Remote sensing is a technique increasingly competitive in this kind of study, in fact it allows a very speed data acquisition and processing with high accuracies, with reference to high resolution satellites of last generations.

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Pan-sharpened image

Classified image

WorldView-2

WorldView-2 is the first high resolution commercial satellite with 8 multispectral bands; there are 4 new bands at 1.8 meter of spatial resolution in addition to the standard 4 band (blue, green, red and near infrared): coastal blue, yellow, near infrared 2, and red-edge. The panchromatic band have 0,5 m of spatial resolution.

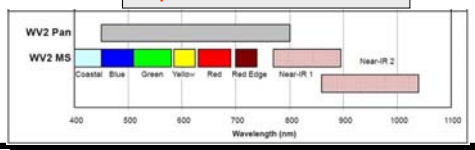
These bands offer several advantages to users in the identification of a greater number of ground cover classes (e.g. more variety of vegetation), in the extraction of a greater number of features, in monitoring changes in the use of the soil, ...

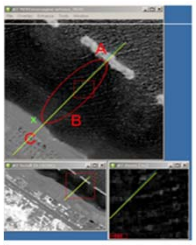
Multispectral classification

Pixel-based classification techniques have been applied on pansharpened image (obtained from Gran Smith algorithm), using Maximum Likelihood algorithm.

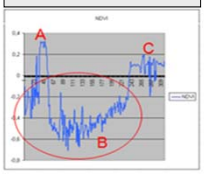
Several regions of interest (ROI) have been defined including 4 different types of buildings, dry sand, wet sand, roads, pools, sidewalks, shade, water and three classes of vegetation.

Spectral bands – WorldView 2



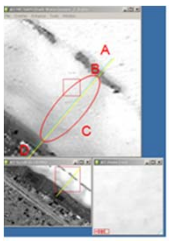


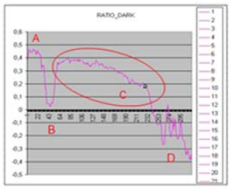
NDVI



Performing a cross-section to the coastline on the image obtained by the algorithm NDVI, a sharp change of slope of the curve at the points of separation "sand-sea" can be seen.

MF/SAM





The same trend can be observed on the graph representing the ratio from SAM (Spectral Angle Mapper) and MF (Matched Filtering) algorithms.

Vegetation and water automatic detection

Some algorithms useful for the vegetation and water study were used (such as the vegetation index NDVI and the normalized index NDWI) in order to better define the coastline location.

The Normalized Difference Vegetation Index (**NDVI**) is a simple algorithm to estimate the vegetation density and condition; it provides a dimensionless numerical value between -1 and +1. It can be also used to obtain useful information about the coastline, in fact it assumes values between -0.1 and -0.5 at the separation from sand / water.

$$NDVI = \frac{NIR - R}{NIR + R}$$

The Normalized Difference Water Index (**NDWI**) is used to study the areas covered from water. It is similar to NDVI but using the green band instead of the red one.

With this algorithm water assumes positive values, while terrain and vegetation have negative values; dry sand, due to its high reflectance in green band and in near infrared band, is characterized by positive values but near to 0.

$$NDWI = \frac{NIR - G}{NIR + G}$$

Similar algorithms allows to study the presence of water using the information contained in the green, blue, red and infrared bands through the algorithms MF (Matched Filtering), SAM (Spectral Angle Mapper) and their ratio that shows the best separation between the dry sand and the wet sand.

The analysis are made from area covered by muddy water and dark water.

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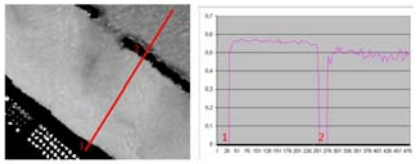
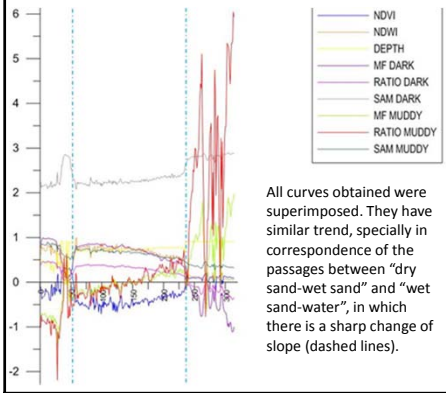
Relative Depth



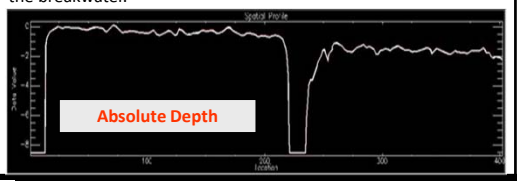


All curves obtained were superimposed. They have similar trend, specially in correspondence of the passages between "dry sand-wet sand" and "wet sand-water", in which there is a sharp change of slope (dashed lines).

Relative Depth

Another algorithm used in image processing and showing a clear separation between the sand and the sea is the *Relative Depth*. This tool uses a bathymetry algorithm developed by Stumpf and Holderied (2003), which correlates the various bands in the multispectral image, in particular the coastal and blue bands. The "Relative Depth" function allows an useful analysis of the seabed at depths up to 14 m (values range from zero to one).

If these results are integrated with bathymetric information, the absolute depth of the sea could be obtained, "scaling" the values of relative depth on the actual values of the absolute depths. In this study we have used absolute depth data detected by IGM maps and the relative depth was scaled by functions "raster math". The shape of the seabed obtained is very similar to the expected one, from a depth value equal to 0 on the coastline to a max of -2,20 m in accordance with the bathymetric contours reported on the IGM catography, with some peak value probably due to the proximity to the shore and the breakwater.



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THANK YOU FOR YOUR ATTENTION

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