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PolSAR observation of coastal areas

E. Ferrentino, F. Nunziata, M. Migliaccio

Università degli Studi di Napoli Parthenope,
Dipartimento di Ingegneria, Centro Direzionale, isola C4
Napoli, Italy

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Outline

- Motivations
- Methodology
- Experiments
- Conclusions

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Motivations

The study of coastal zone is of paramount importance due to both anthropomorphic activities (e.g. mining of seashore sand for building purposes) and natural phenomena (e.g. coastal erosion), which threaten the stability of land and safety

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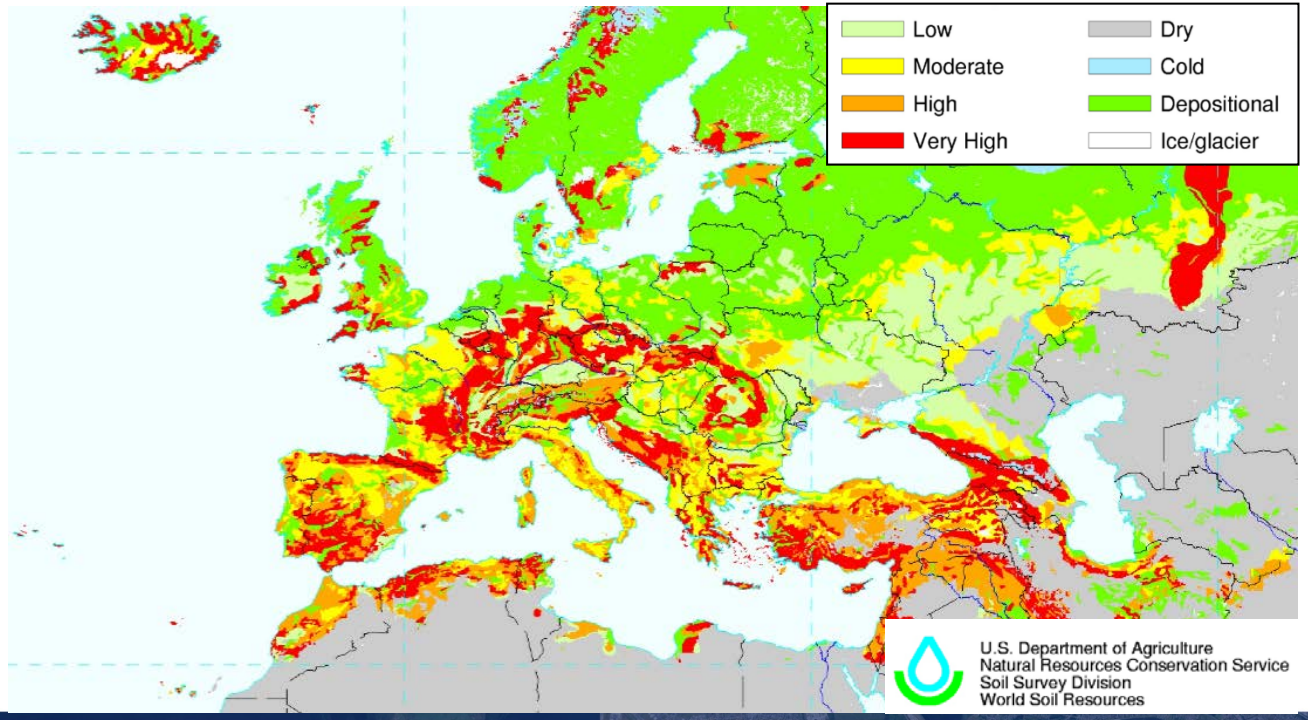
Vulnerability (Coastline Extraction)

Risk (Coastal Area Classification)

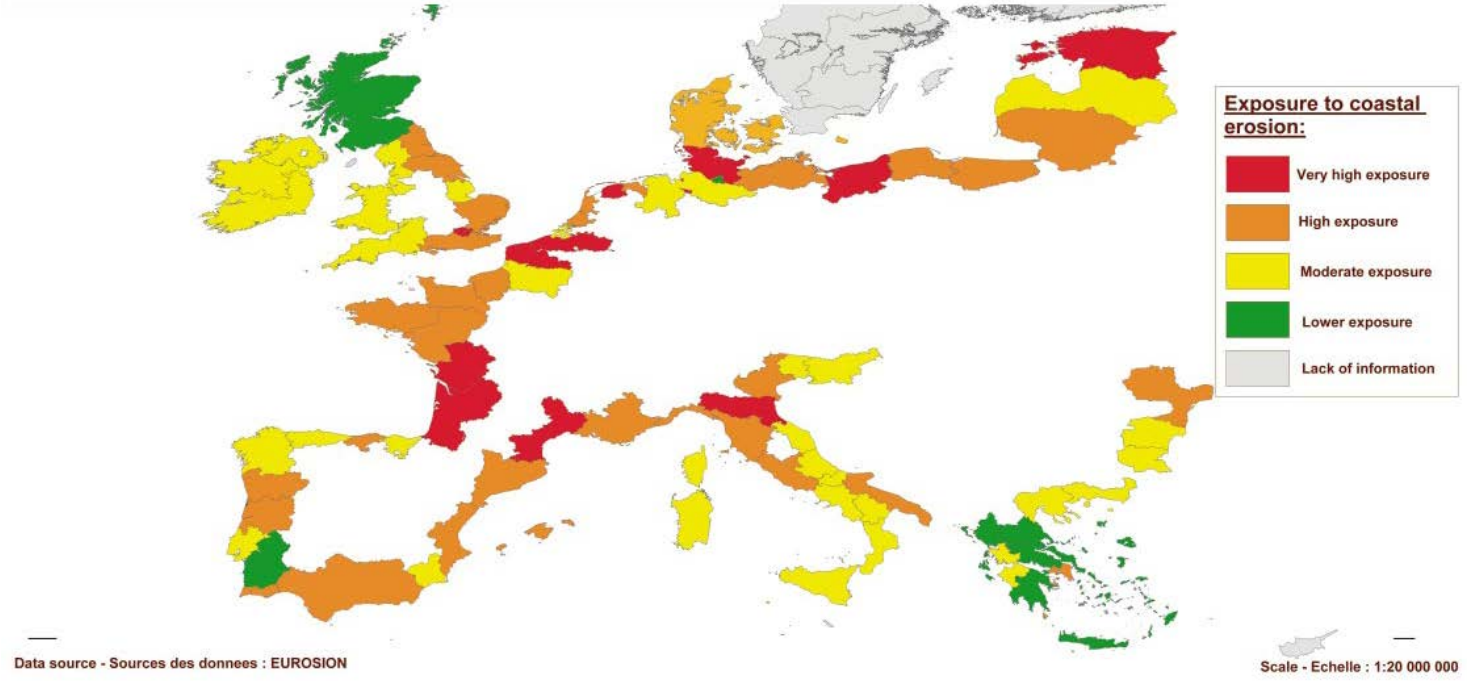
Motivations

Costal Erosion Vulnerability



Motivations

Risk Mapping



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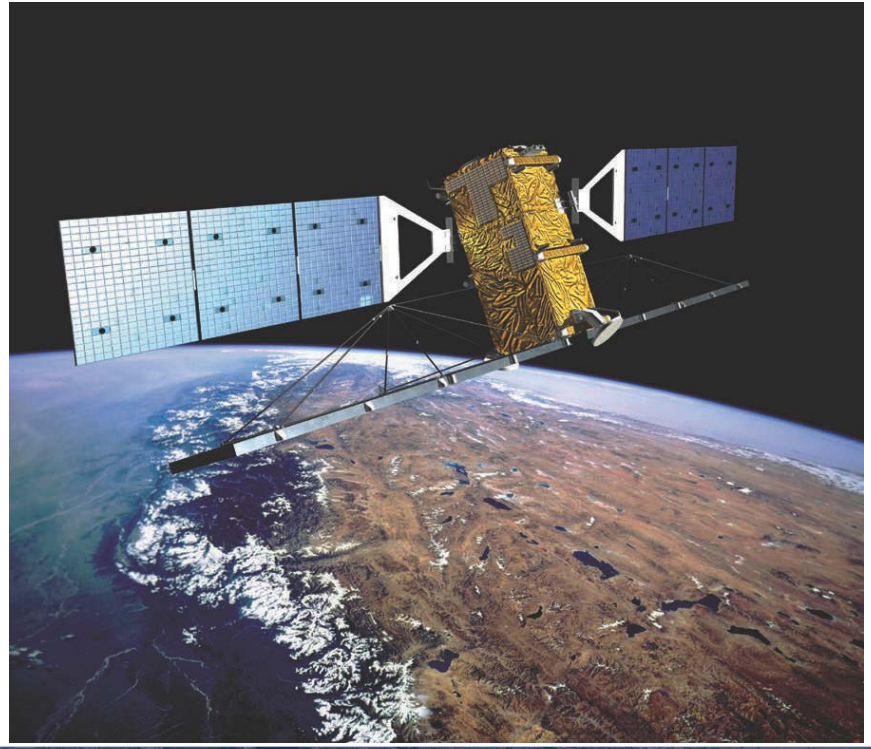
Synthetic Aperture Radar

- All-day acquisitions
- Almost all-weather acquisitions
- Fine spatial resolution



Coastline Extraction

Coastline extraction

1) Land / Sea discrimination

2) Edge Detection Algorithm

Coastline extraction

1) Land / Sea discrimination

2) Edge Detection Algorithm

Land / Sea Discrimination

a) Dual polarization (DP) → Based on the correlation between co- and cross-polarized channels

+

b) Full polarization (FP) → Based on scattering components obtained by the Freeman Durden Decomposition

Land / Sea Discrimination

a) Dual polarization (DP)

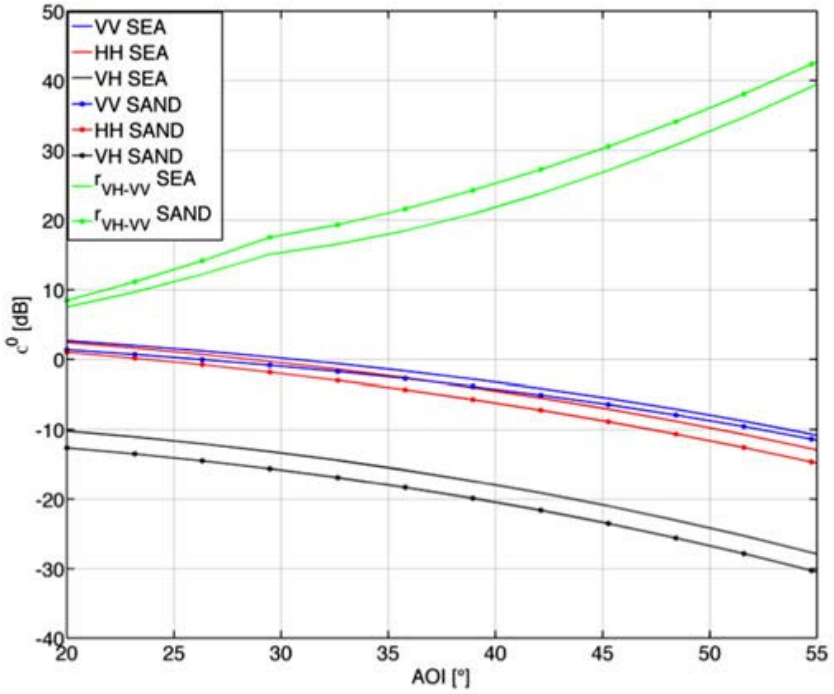
Based on the correlation between co- and cross-polarized channels

+

b) Full polarization (FP)

Based on scattering components obtained by the Freeman Durden Decomposition

DP Land / Sea Discrimination



The metric is based on the correlation between co- and cross-polarized amplitude channels:

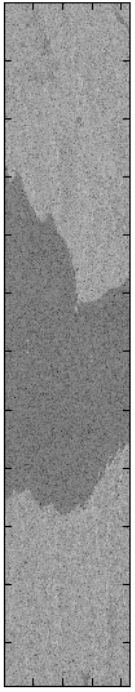
$$r = \langle |S_{xx}||S_{xy}| \rangle$$

	Sand	Sea
ε	67 + j31	27 + j4
T	20°	27°

DP Land / Sea Discrimination

VV

VH



r

Sensor	Feature	Normalized distance
RadarSAT-2	vv	0.97
	vh	1.00
	r	3.03

Land / Sea Discrimination

a) Dual polarization (DP)

Based on the correlation between co- and cross-polarized channels

+

b) Full polarization (FP)

Based on scattering components obtained by the Freeman Durden Decomposition

Polarimetric Decomposition

Polarimetric decompositions aim at decomposing the measured covariance matrix according to elementary scattering mechanisms.

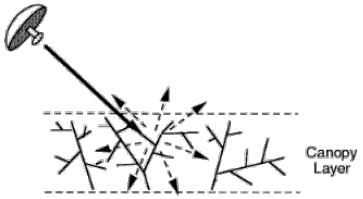
The Freeman-Durden Decomposition decomposes the measured covariance matrix $[C_3]$ as follows

$$[C_3] = f_v \langle [C_3] \rangle_v + f_d [C_3]_d + f_s [C_3]_s$$

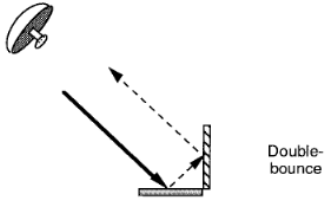
where f_s, f_d and f_v are the surface, double-bounce and volume scatter contributions.

Polarimetric Decomposition

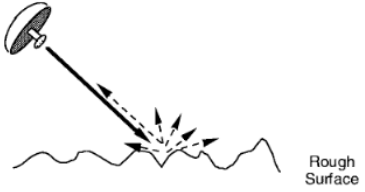
Volume Scattering where a canopy scatterer is modelled as a set of randomly oriented dipoles.



Double Bounce scattering modelled by a dihedral corner reflector (e.g. Build, Urban Area)



Surface or single-bounce scattering modelled by a first-order Bragg surface scatterer (e.g. Sea, Sand)



FP Land / Sea Discrimination

Coastline extraction purposes

$$[C_3] = f_v \langle [C_3] \rangle_v + f_d [C_3]_d + f_s [C_3]_s$$

Coastline extraction

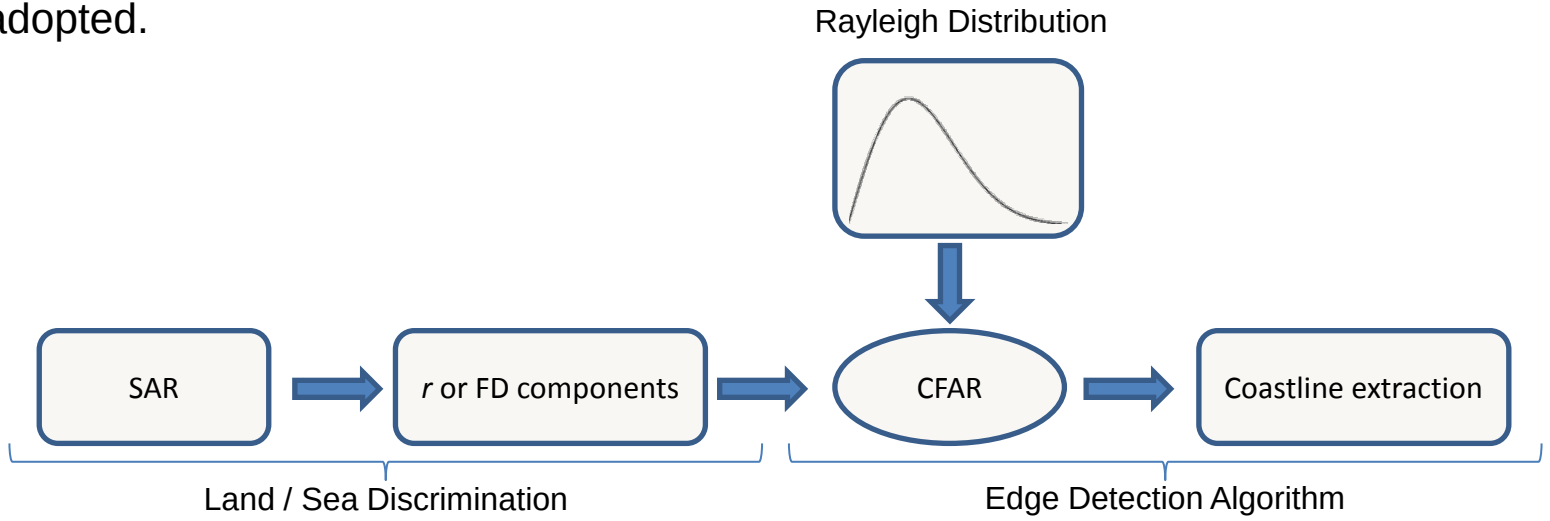
1) Land / Sea discrimination

2) Edge Detection Algorithm

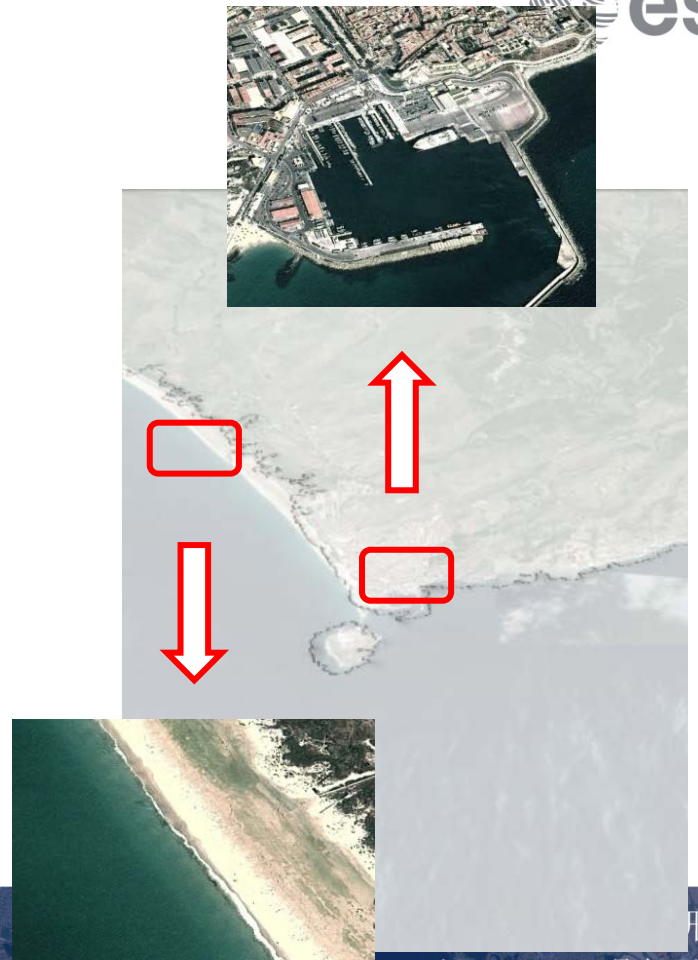
Coastline Extraction

- The metric is Rayleigh-distributed over sea surface, hence, a constant false alarm rate (CFAR) method is used to obtain a binary output where land and sea are clearly distinguished.

- To extract continuous coastline from the binary image the Sobel edge detector is adopted.



- Coastline Extraction
- Classification



Classification

Freeman Durden Decomposition

$$[C_3] = f_v \langle [C_3] \rangle_v + f_d [C_3]_d + f_s [C_3]_s$$

Outline

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- **Experiments**
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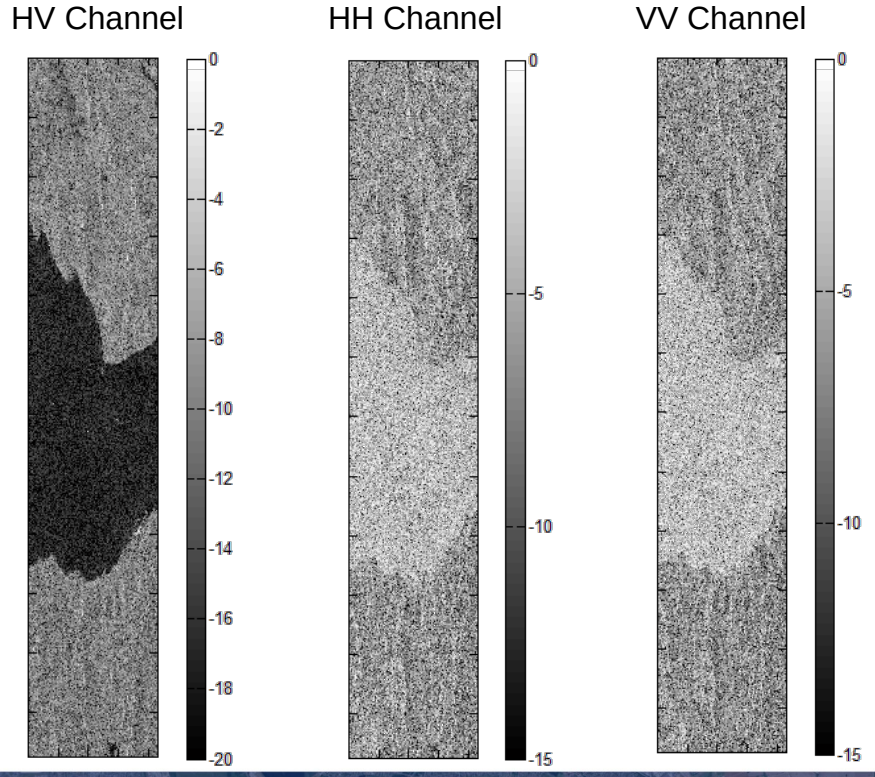
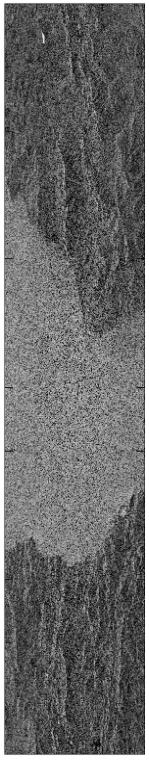
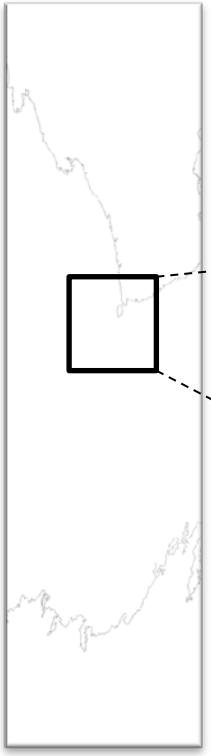
Experiments – First Case

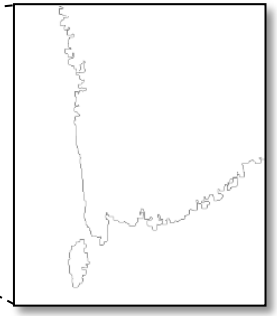
- Strait of Gibraltar
- Quad-Pol Data (HH, HV, VV, VH)
- Sensor: RADARSAT-2 SAR
- AOI = 20.8° NR, 22.8° FR
- Resolution: 9 m x 8 m
- Data acquisition: 03/31/2008
- Wind speed: ~ 7 m/s

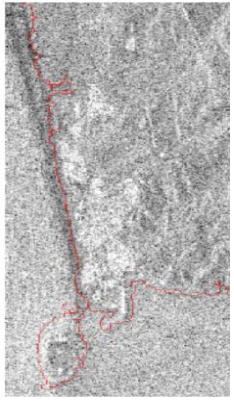


DP Coastline Extraction

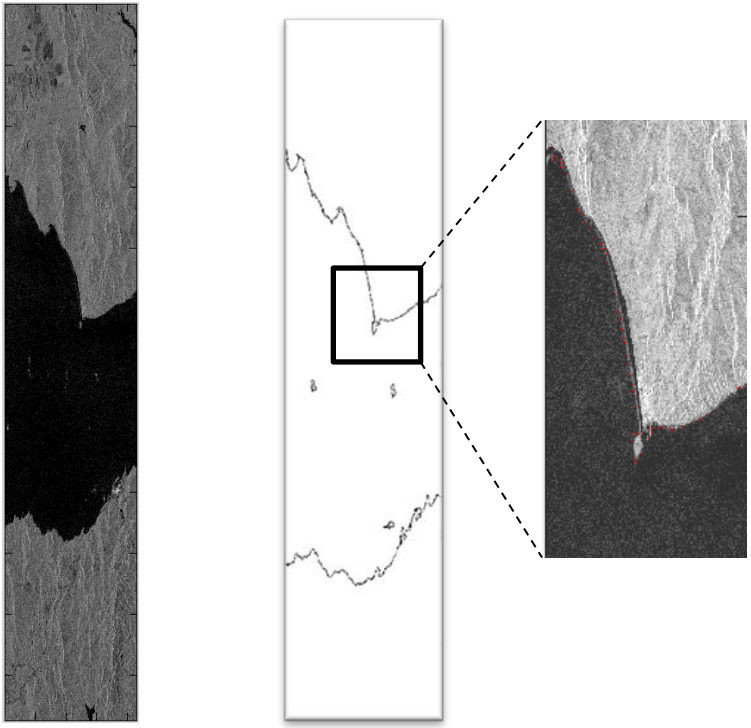




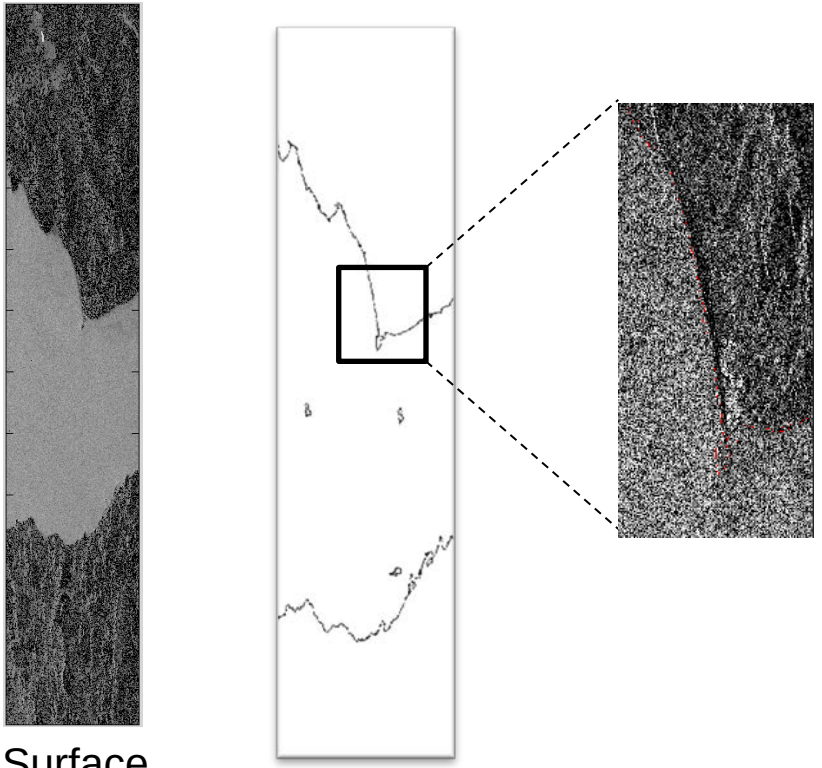




FP Coastline Extraction



Volume



Surface

Comparison

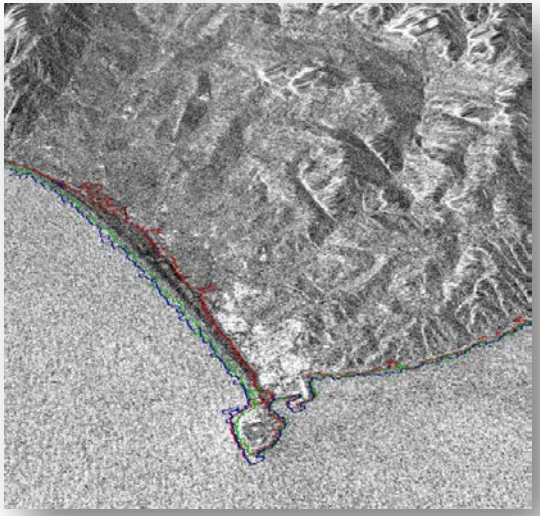


FIGURE LEGEND

--- *r*

--- *Surface*

--- *Volumetric*

Distance between the coastline extract and the coastal zone

r	Volumetric	Surface
-310 m	232 m	171 m

Comparison

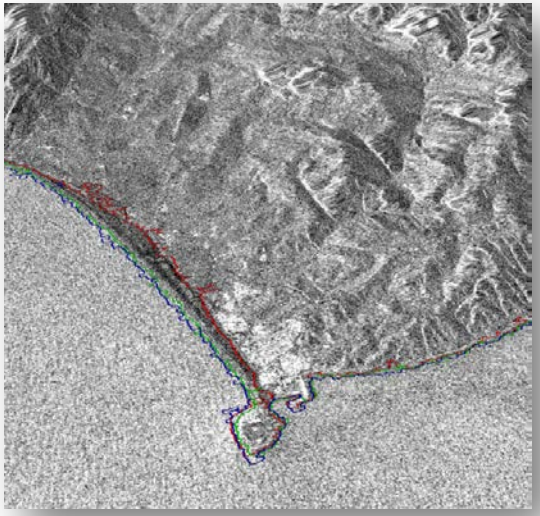


FIGURE LEGEND

--- *r*

--- *Surface*

--- *Volumetric*

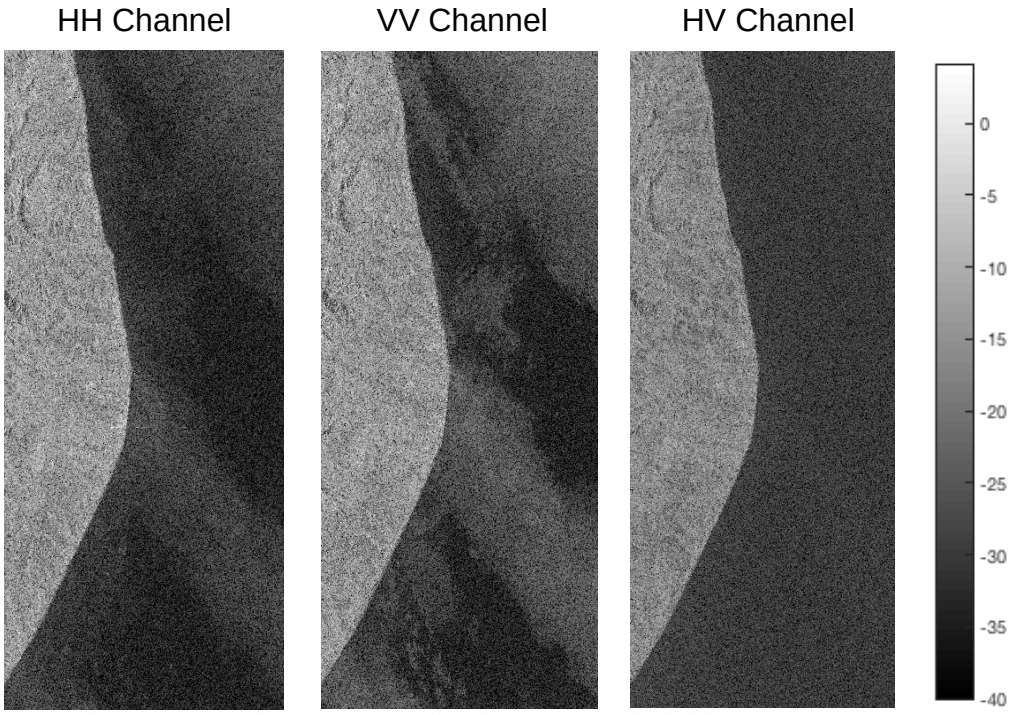
Distance between the coastline extract and the coastal zone

r	Volumetric	Surface
-310 m	232 m	171 m

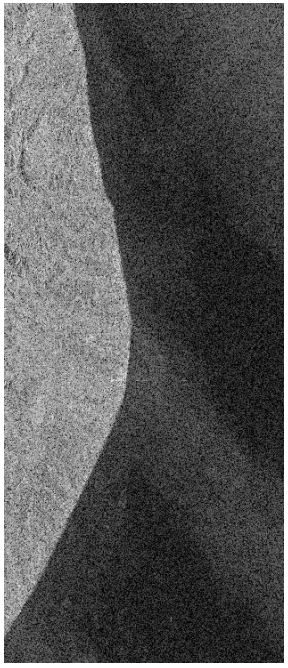
Surface allows to obtain an improvement of 139 m than *r*

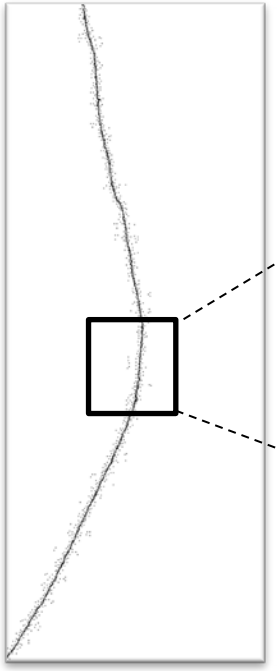
Experiments – Second Case

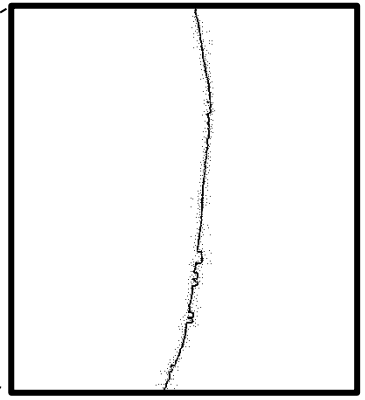
- Monasterace Marina
- Quad-Pol Data (HH, HV, VV, VH)
- Sensor: RADARSAT-2 SAR
- AOI: 45.2° NR – 46.5° FR
- Resolution: 4.7 m x 4.8 m
- Data acquisition: 16/07/2014
- Wind speed: ~ 5 m/s

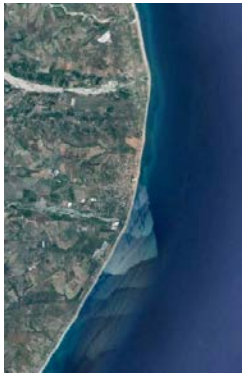


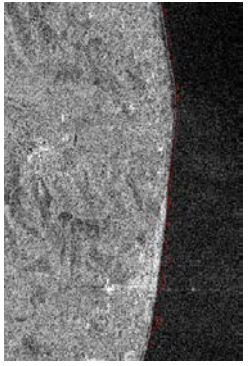
DP Coastline Extraction



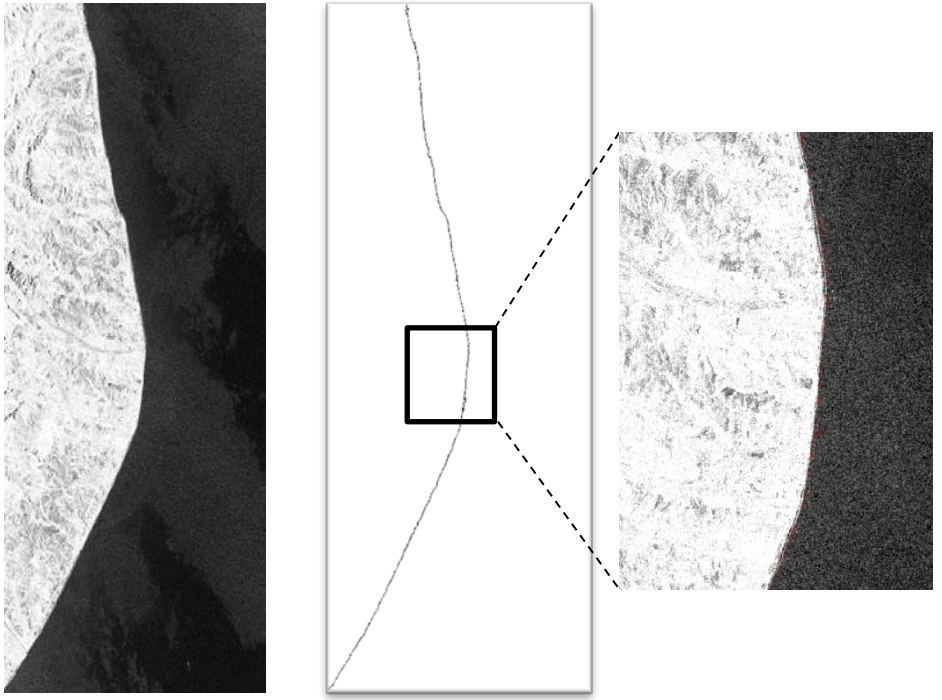




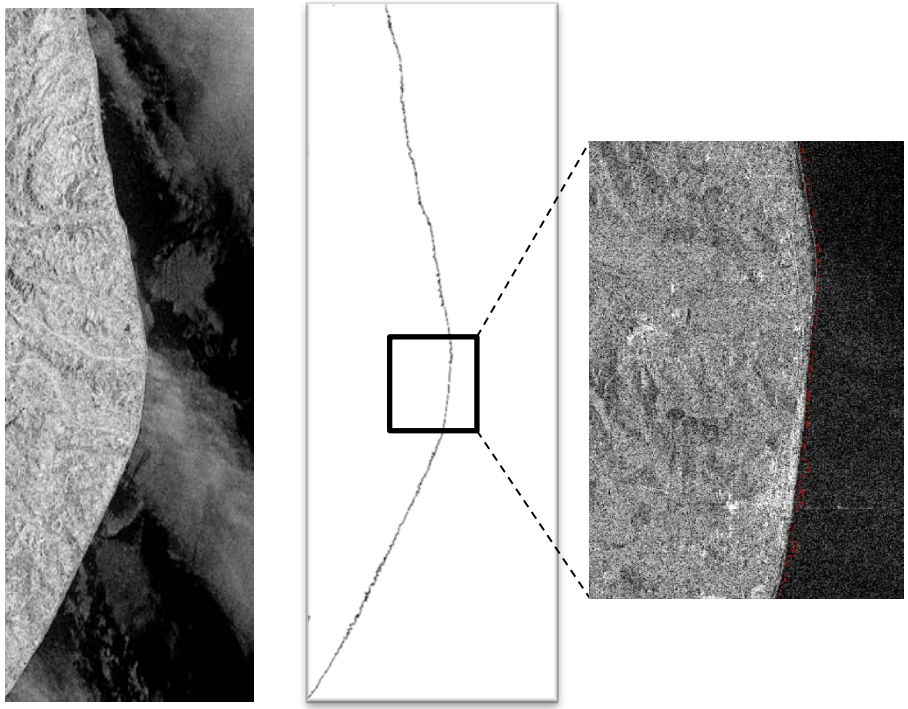




FP Coastline Extraction



Volume



Surface

Comparison

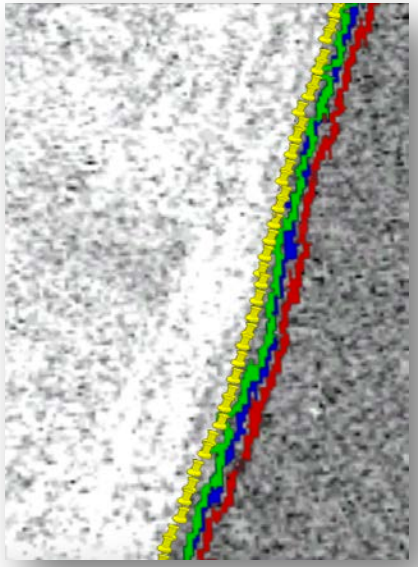


FIGURE LEGEND

--- *r*

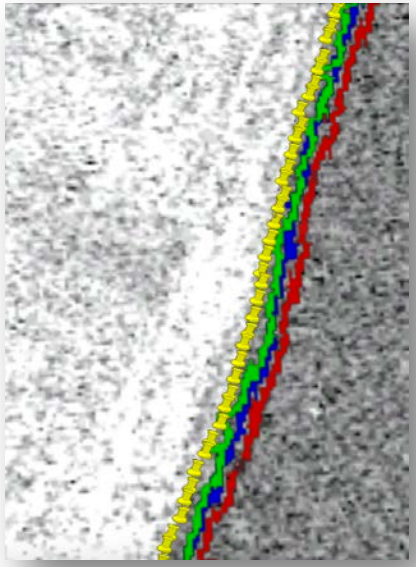
--- *Surface*

--- *Volumetric*

--- *GPS Ground Truth*

r	Volumetric	Surface
58.7 m	36.9 m	20.2 m

Comparison



r	Volumetric	Surface
58.7 m	36.9 m	20.2 m

FIGURE LEGEND

--- *r*

--- *Surface*

--- *Volumetric*

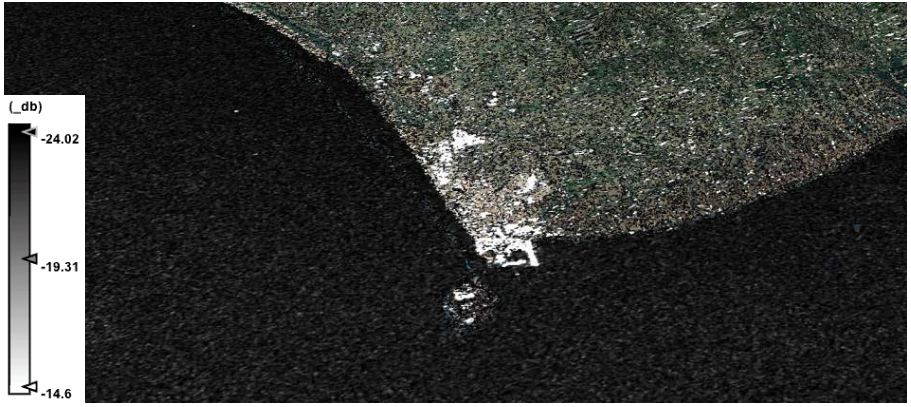
--- *GPS Ground Truth*

Surface allows to obtain an improvement of 38.5 m than *r*

Classification

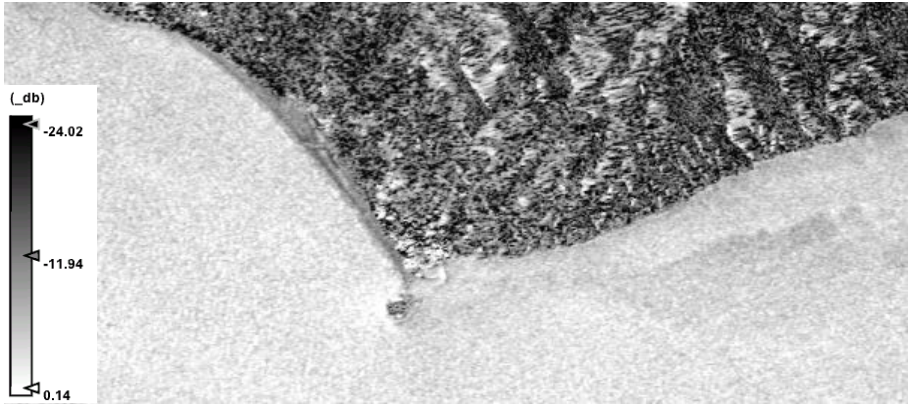
Classification

Double Bounce Component



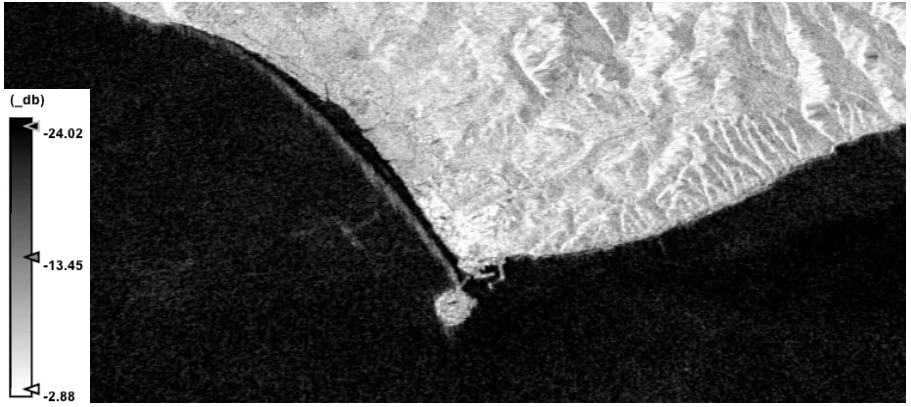
Classification

Surface Component

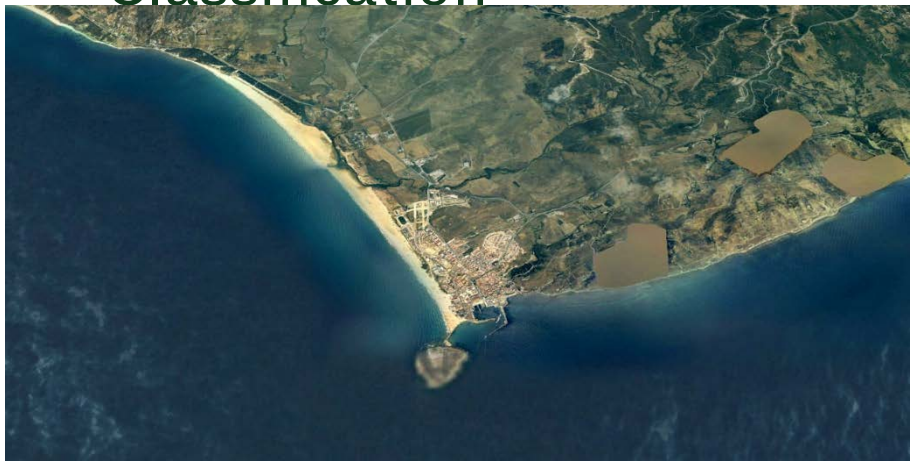


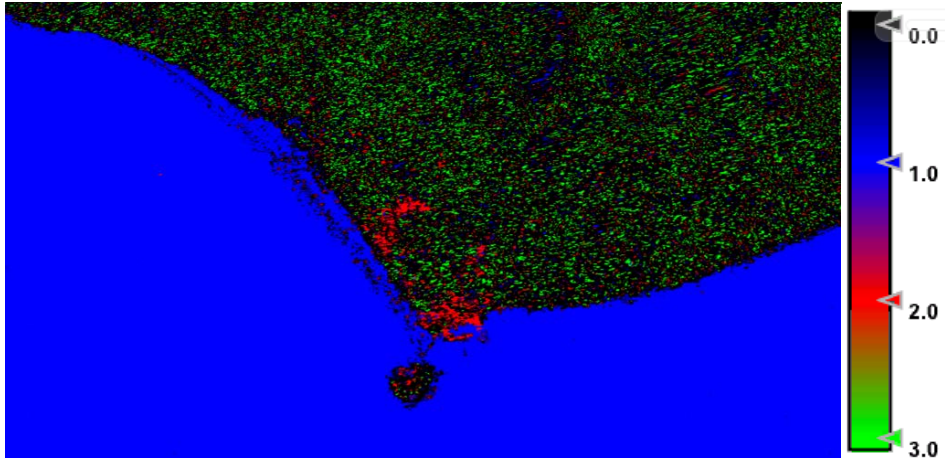
Classification

Volumetric Component



Classification





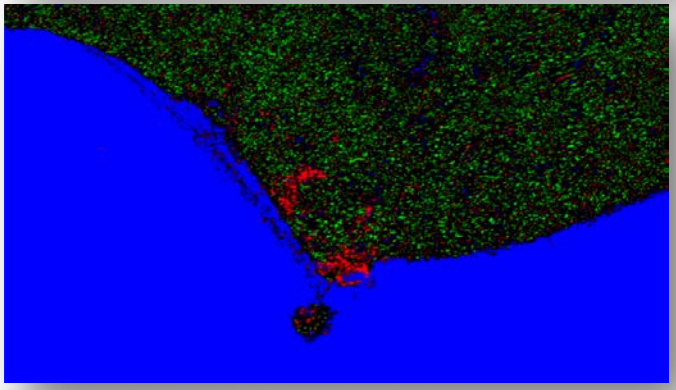
Blue – Sea and Sand

Red – Urban areas

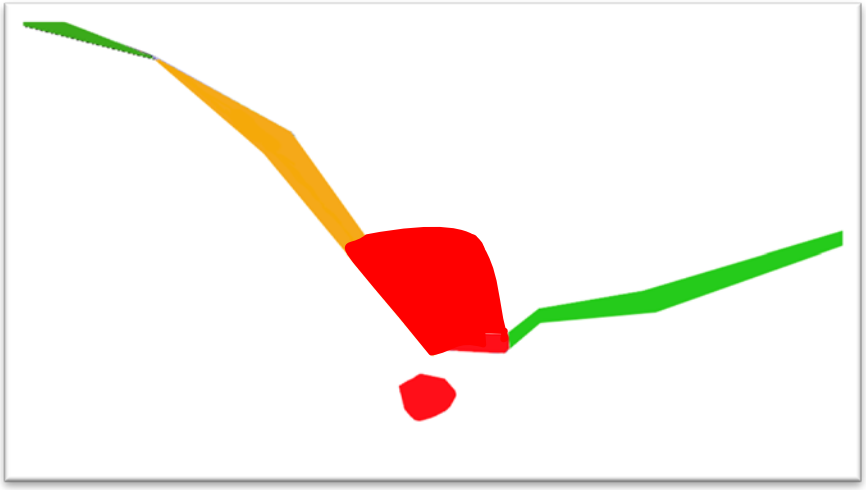
Green – Volumetric areas

Black – Unclassified

Classification



Risk Mapping



=== Low Risk

=== Medium Risk

=== High Risk

Conclusions

Polarimetric SAR data have been exploited to extract coastline and to classify coastal areas

Coastline extraction is based on:

- correlation between co- and cross-polarized amplitude channels.
  - The method is computer-time effective.
  - It enhances land/sea separation when compared to single-pol channels.
  - In the first experiment, Sandy Beach is not detected.
- FD decomposition.
  - Allows improving the accuracy of coastline extraction when surface/volumetric components are exploited.

Classification is based on:

- FD decomposition.
  - Elementary scattering mechanisms, i.e. surface, double-bouncing and volume, are identified. It allows a rough risk analysis.

Thank you for your kind attention

Emanuele Ferrentino
email: emanuele.ferrentino@uniparthenope.it
Dipartimento di Ingegneria
Università degli studi di Napoli "Parthenope"