Sentinel-1 and Sentinel-2 imaging for reference water extraction and monitoring

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Introduction

Monitoring the evolution of surface water extent may be crucial to prevent and promptly manage flood and drought events. This research proposes an operational semi-automatic methodology for surface water extraction at a synoptic scale, based on free satellite data.

The proposed methodology takes advantage of the availability of free and frequent microwave and multi-spectral information acquired by the recently operational **Sentinel-1 (S1)** and **Sentinel-2(S2)** ESA's missions. By integrating the two data sources the method aims to overtake some of the innate biases that can affect the single-source surface water extraction: geometric and radiometric radar effects, e.g. shadows and speckle, and optical lack of information due to cloud cover.

Two case studies were chosen: one in North Africa and one in Europe. In order to validate the proposed methodology, reference water bodies (ground truth) were derived by visual interpretation and manually extracted.

Case studies:

For the preliminary tests have been chosen two areas presenting specific topographic and morphological characteristics:

1_Tétouan Province (Marocco) - seacoast and mostly mountainous topography;

Imagery used for the analysis:

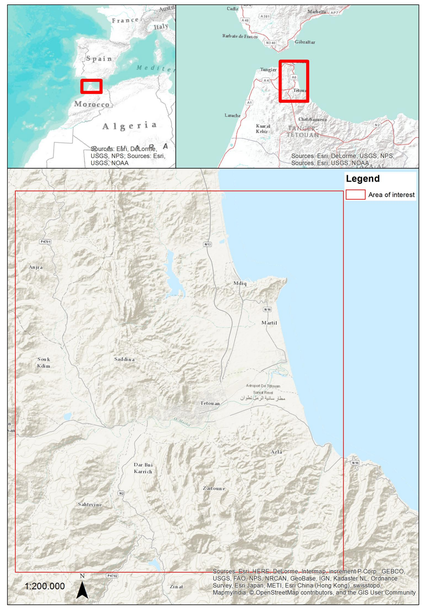
- S2A acquired on 2017-03-10 at 11:09 UTC (descending orbit)
- S1A acquired on 2017-03-10 at 8:43 UTC (descending orbit)

2_Enna Province (Sicily - Italy) - mainly mountainous topography;

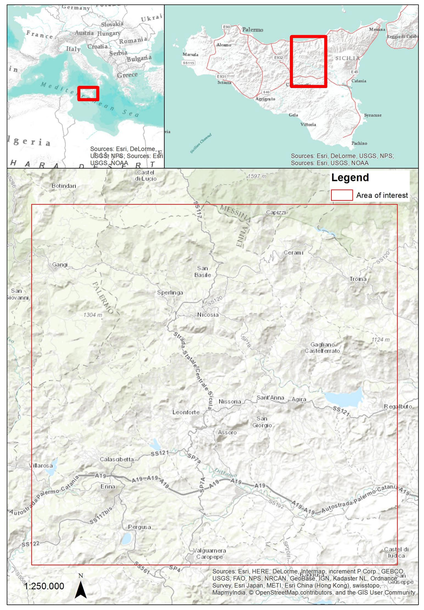
Imagery used for the analysis:

- S2A acquired on 2017-03-19 at 09:50 UTC (descending orbit)
- S1A acquired on 2017-03-19 at 19:35 UTC (ascending orbit)

Tétouan Province - Area of interest



Enna Province - Area of interest



Methodology

1_Water body classification using the S2 scenes:

1_Water body classification using the S2 optical scenes: The water extraction is performed by thresholding the Modified Normalized Difference Water Index (MNDWI) with a pixel spacing of 20m. This type of classification is performed because it minimises the errors due to the presence of shadows and has a higher reliability in urban areas. MNDWI > 0.4 is the threshold used to define water bodies.

S2 optical image → $MNDWI = \frac{Green - SWIR}{Green + SWIR}$ → MNDWI > 0.4

2_Water body classification using the S1 scenes:

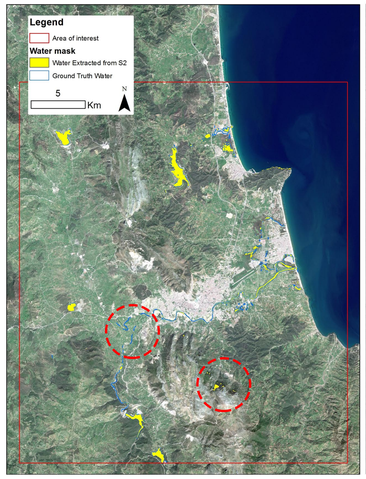
All data are multi-looked to 20m pixel space. The scene is orthorectified, a k-means classification is applied and the classes that better represent water bodies are manually selected. Afterwards a filtering is applied on those areas that have a slope higher than 4.5°. Holes and isolated pixels are automatically removed during the post processing procedure

S1 radar image → Orthorectification → K-means classification → Classes selection → Filtering on Slopes > 4.5° → Holes and isolated pixels removal

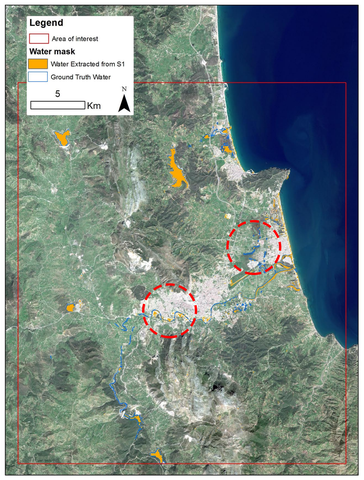
3_Validation

The validation is performed by comparison of the classification with the reference ground truth data. The ground truth data is derived by photointerpretation and manual extraction of the water bodies from the optical imagery (S2) used for the classification. Accuracy is evaluated by the calculation of the Confusion Matrixes.

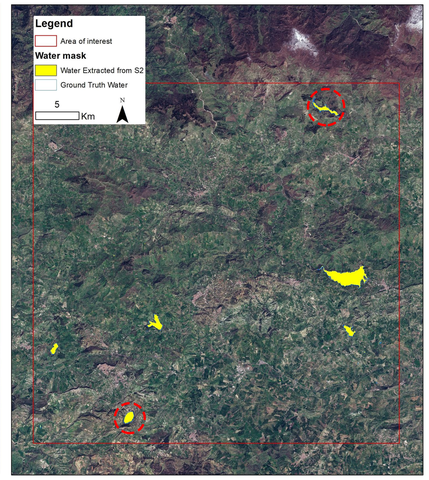
Tétouan Province - water from (S2)



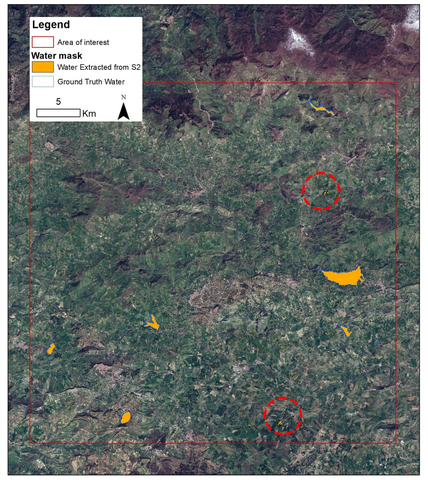
Tétouan Province - water from (S1)



Enna Province - water from (S2)



Enna Province - water from (S1)



Conclusions

1_Results

The methodology showed encouraging results with an accuracy greater than 75%. From the results of this work the classification derived with the S2 optical imagery has higher accuracies than the one obtained with the S1 radar imagery in both considered cases.

1_Tétouan Province Marocco

	Producer Accuracy %	Omission Error	User Accuracy %	Commission Error
S2(MNDWI)	77,31	22,69	87,98	12,02
S1(K-Mean+Filtering)	63,18	36,82	62,48	37,52

2_Enna Province - Sicily

	Producer Accuracy %	Omission Error	User Accuracy %	Commission Error
S2(MNDWI)	81,06	18,94	93,82	6,18
S1(K-Mean+Filtering)	70,38	29,62	81,13	18,87

2_Future work

The goal of this work is to study the feasibility to generate an automatic procedure that extracts the water on a given area around the world.

The tested methodology, can be integrated in a more general workflow which envisages:

1. Semi-automatic thresholding of the MNDWI on optical imagery (with thresholds that can be customized for the area to permit a better extraction of the water bodies).
2. Semi-automatic classification of the S1 images with automatic filtering on slopes.
3. Post-classification refinement with automatic removal of holes and isolated pixels.
4. Integration of the missing information in the optical classification (clouds/shadows) with radar information.

In order to achieve this aim, the methodology need to be tested on a more significant number of cases.