OIL SPILL DETECTION USING RADAR

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Abstract: *As we already know, oil spills/slicks are a major cause of water pollution. The complications deriving from detecting the oil spills are generated by the wind and the water surface conditions. Data processing and optimization should be done carefully, taking into account the fact that reflexions are very low in the oil spots/slicks areas. The paper presents an optimized method in order to detect and classify these oil slicks, by using radar data within the spots polluted areas. A case study is also presented.*

1. Introduction

Remote sensing images represent more than hust a picture of the Earth Surface. They are an important data source that captures a specific time and space situation, in a specific place in the world, so that we can observe the changes in time .Previous studies that used radar data (Envisat), done in the Mediterranean Sea have shown that more than a third part of the images contained various oils amounts from spills or incidental causes. (Pavlakis2001).

In the frame of oil spill pollution, the marine transport is a major factor, both by socially and economically point of view.

The disastrous consequences of marine pollution are various, let us just remind you of the global climateric changes and the aquatic ecosystems destruction. That is why the need to detect oil spots is crucial –by identifying their location and evaluating their moving, in order to protect the costal areas ecosystems. Oil spots monitoring, using radar data aims to detect the pollution factors an/or to anticipate the precautions to take for water and national and international costal zones protection.

2. Radar recordings

Satellite Radar data improve the possibilities to detect and monitor the oil spills , as they cover large areas regardless the meteo conditions and they provide a cheap and quick inspection method.

More specific, satellite monitoring, especially by using SAR (Sintetic Aperture Radar) observations, is another tool, besides optic sensors observations.

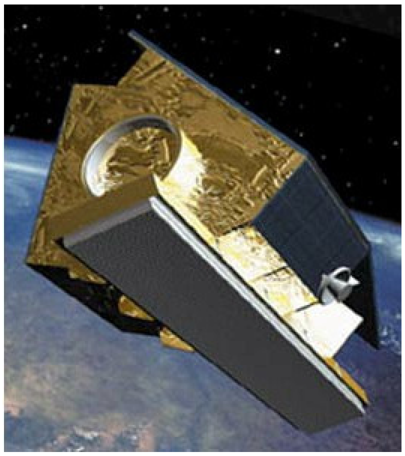
SAR capabilities/capacities in detecting oil spots is well known and proved by studies, such as: (Martinez si Moreno, 1996; Ziemke, 1996; Kubat et al,. 1998; Benelli si Garzelli, 1999; Lu et al., 1999; Solberg et al., 1999; Del Frate et al., 2000; Gade et al., 2000; Topouzelis et al., 2002; Topouzelis et al, 2007).

Most of them are based on dark areas detection. As for SAR images, any area presenting the feature of a higher contrast compared to adjacent zones must be investigated as a highly probable oil pollution.

Dark areas are treated as potential oil spots. These zones may contain sleecs derived from any oil product, coming from marine extraction platforms, oil distilleries , pipelines leaks or tanker ships ;they might also contain ice sleecs, they might be calm zones (where the wind speed is less than 3m/s) , wind protected zones, etc (Espedal, 1998). That is why a classification is needed. In most of the cases, detecting and monitoring oil spills are critical for a prompt intervention.

The four targets/ objectives are: prevention, warning, monitoring and damage cuantification (Bava, 2002). Regardless the source and the cause, oils spots represent a threat, and in order to reduce/diminish their effects, permanent monitoring is a first step in reacting to a possible undesirable incident

Records used for the case study were obtained by using TerraSAR-X.



X-band, 9.65 GHz (λ=3.1cm)
Pixel size: 1m
Distance: 515 km,
Orbit inclination (97.44°)
Incidence angle: 15° - 60°

Fig. 1. TerraSAR-X

Let me remind just some of the pro and cons (advantages and disadvantages) of Radar records .

Pros: active system - independent of solar light /sun light ?
- capable to record regardless the atmospheric conditions;
- cover large terestrial surfaces in a short period of time;

Cons: - their resolution can not be compared to those of the optic images
- problems in fragmented/ hilly relief/terrain, due to parasite reflexions

3. Software instruments

A set of software instruments (Nest si **Definiens**) that allows the extraction of data from radar images, was provided for the case study by European Space Agency (ESA) si German Space Commision (DLR).

In this paper, an area of oil pollution was investigated, more precisely the Timos Sea, Australia – since August/ September 2009, information being provided for study during **"ROSA/ESA/DLR Radar Remote Sensing Course 2009"**, event that took place in Bucharest.

The derived images from Radar data were visually analyzed, then digitally processed by filtering and texturing, in order to emphasise the oil spots .

4. Detecting the polluted areas by using Radar Images

The systems used to capture the radar images collect the information from the object space that corresponds to the spatial and spectral distribution of the energy issued and reflected by this surface.The automatic recognition of the forms involves identifying the categories these objects belong to (n.r the objects that are present in the informational content of the captured image) .

The recognition is done based on the *spectral signature of the objects in the image*.

Classifying the spectral signatures depends on the a priori knowledge , regarding the nature of the objects represented in the image. The classifying project has 3 stages, as follows:

1) *establish the categories of spectral signatures;*
2) *classifying each pixel based on the spectral response registered by the sensor;*
3) *verifying the results and establishing the precision of the classification. (Zavoianu F. – note de curs)*

The waves and the irregularities from the the water surface reflect the radar back to the sensor, that leads to a certain shine of the water surface.

But the oil products diminish the waves and the water irregularities, thus the energy reflected back to the sensor is lower .

The presence of an oil spot might be detected as a darker area than the surrounding water .

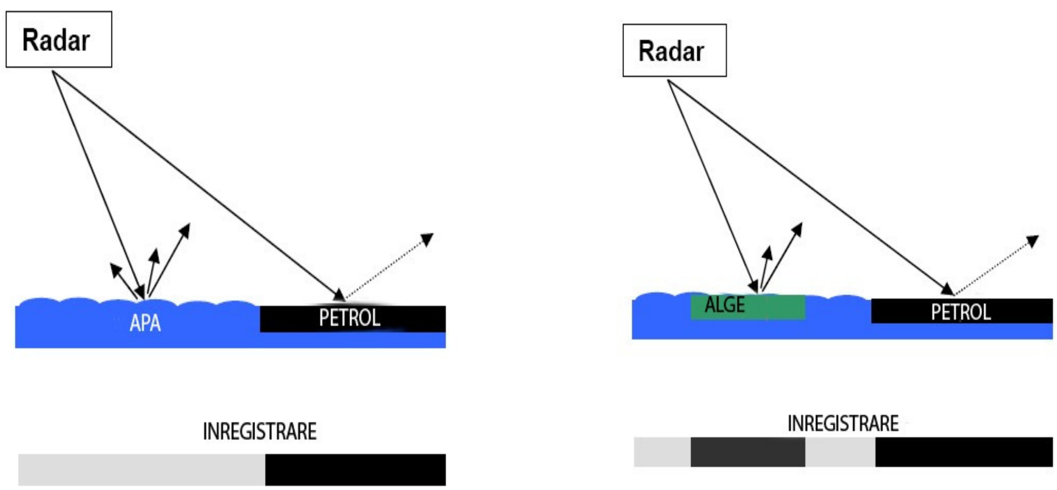


Fig. 2. Radar waves reflexion

5. Factors that influence the oil products detection

SAR related factors : wave lenght, polariztion, revisit interval, incidence angle.
Environment related factors : type of oil product, the presence of wind generated waves, the dimension and the dispersion of the sports, dark areas due to low intensity reflexion and that might be confusing.

Polarisation: The contrast between the oil spots and the surrounding water is usually higher in case of VV polarizare that HH ...

Wave lenght preferred for the detection of oil spots can be found *in* C and X bands.

The temporal resolution is not an issue taking into account that TerraSAR-X si Cosmo-SkyMed can provide daily records for the same area.

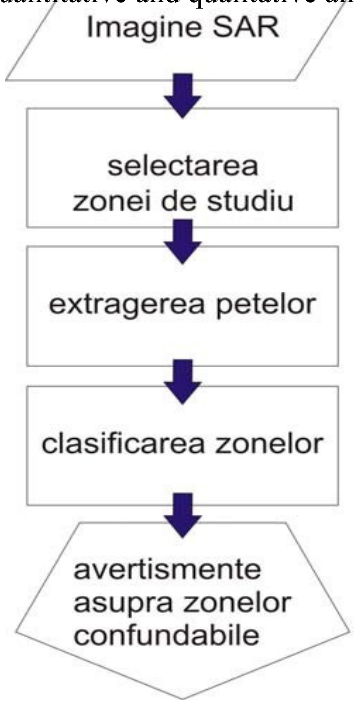
Spatial resolution. Spatial resolution is the minimum distance between two objects the sensor cand record individually, according to the geometric properties of the detectors /detecting system field of view.

The spectral signature registered by the sensor is unique for each object in the space, but is not constant. Based on it, we can differentiate the objects or the classes/categories. It depends, in case of the reflective sensors, to the time of the day, the season, the vegetative status of different marine cultures, the atmospheric conditions, solar radiation angle, terrain slope, orientation, etc. (Zavoianu F.)

Problem areas may appear in case of mild winds, of shorelines, plancton , sea weeds, ice etc. In these cases, further investigations are are required, such as the speed and the direction of the wind, the distance from the shire, the geometry and the texture of the spot.

6. The phases / steps of detecting and classifying the oils spots from Radar images

The processing of the records is complex and it depends on the type of image (conventional or dynamic) , the objective/scope, the preliminary processings and quantitative evaluations. We can distinguish the following processing types: geometrical, radiometrical, quantitative and qualitative analysis and extraction.



The selection of the restricted area that contains the dark zones.The hystogram modification, detection of the limits by wavelets analisys, sub-zones grouping, etc.

The analysis of the spot features: surface, geometry, texture, contrast from the surrounding area, the number of the adjoint sub-zones and the distance between them, etc.

The differentiation between polluted and confused areas using additional information.

Tha classifying statistics, probability models, etc.

Fig. 3 Principle scheme of working steps

7. Case study

An oil spill in the Timor Sea, on the west coast of Australia may represent an ecological /environmental disaster. It is important to establish the nature of the visible spots in the Radar recorded images.

Following the first investigations, we know the incident is caused by the marine drilling platforms, located 250 km north from Truscott city and 690 km west of Darwin. The incident was observed on the 21th of August, 2009. The images registered by TerraSAR-X show a spot of 25,000 sq kms, that moved towards the Indonezian waters, threatening the local species of flora and fauna.

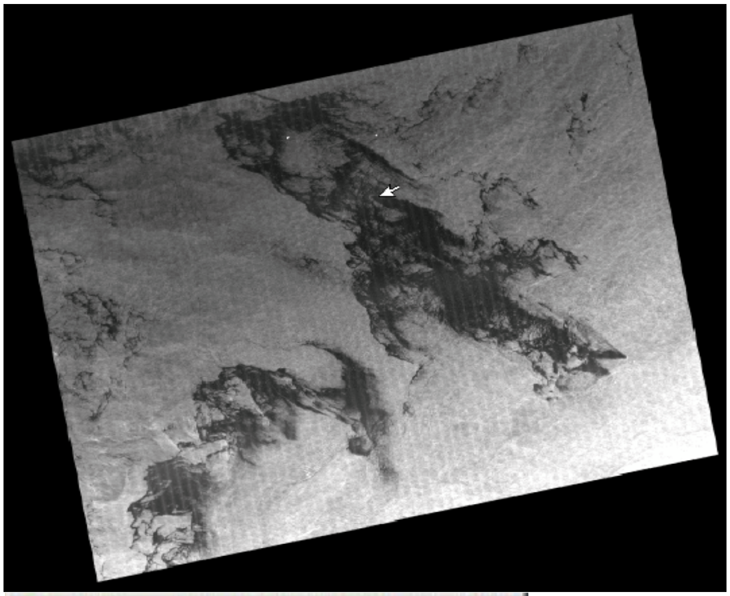


Fig. 4. Radar Image above the studied area

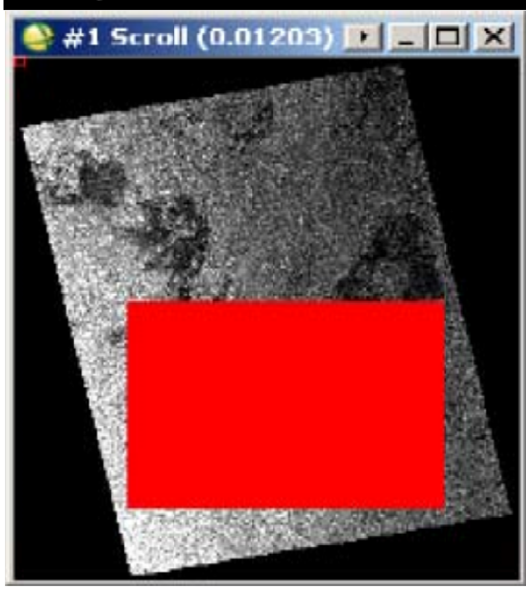


Fig. 5. The extraction of a sub-zone, to be investigated

We have used for investigation sub-zones extracted from the initial image, as working on small images considerably increases the calculating time. Noise filtering has as an effect the homogenization of the image features, which is useful in classifying the pixel level. For the study data we have used the "Enhanced LEE" filter.

The image segmentation in classes of objects with similar spectral answers.

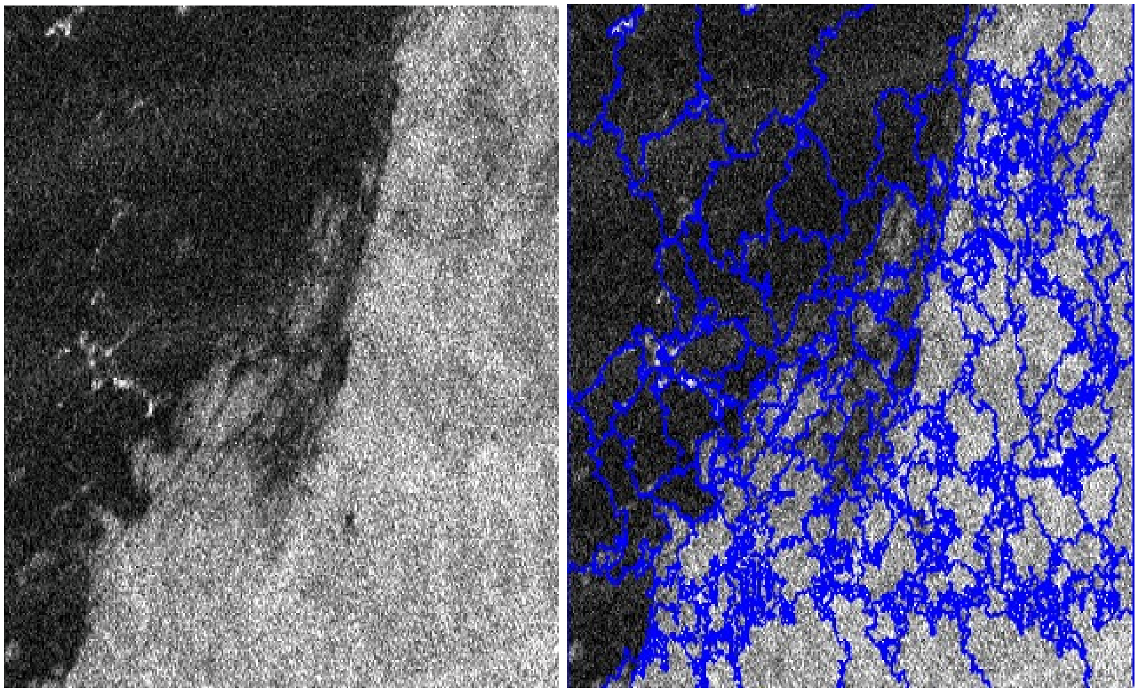


Fig. 6. The segmentation result

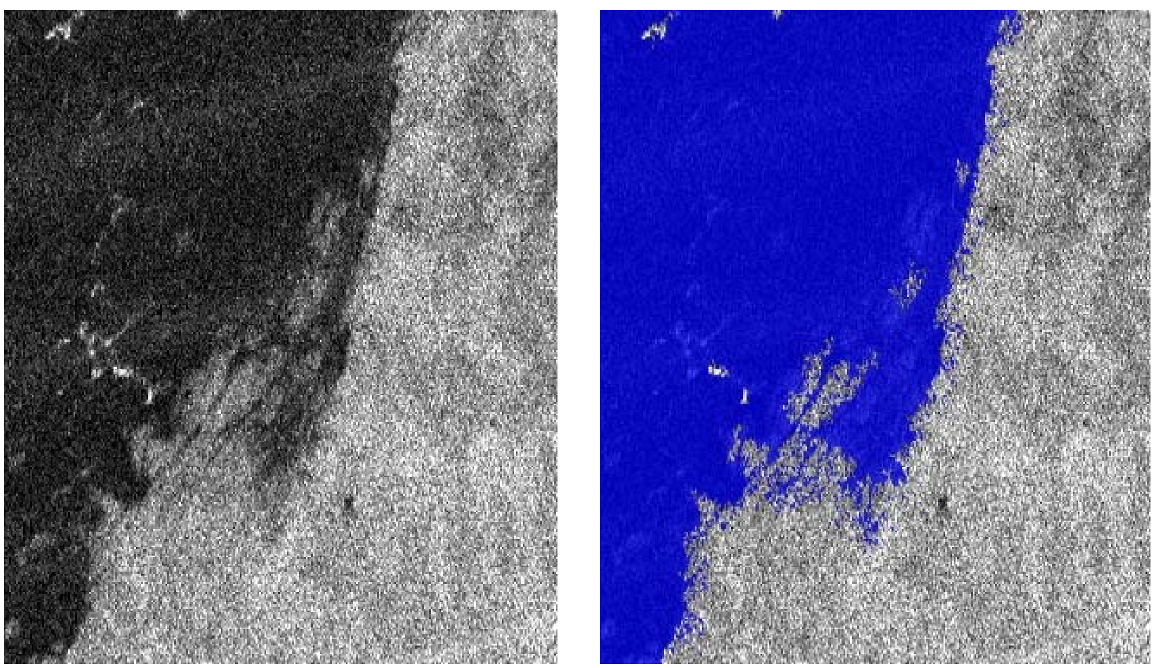


Fig. 7. The initial automatic classification

We have to mention that not in all cases the automatic classification has as an effect a complete result. In the presented image there are objects that might remain unclassified, objects that are placed in other classes, such as islands, due to parasite reflexions, fact that requires a manual intervention in this process. By defining some surface condition, derived from further investigations on the image, we can eliminate these islands from the automatic classification, the result being a solution quite close/similar to the real situation.

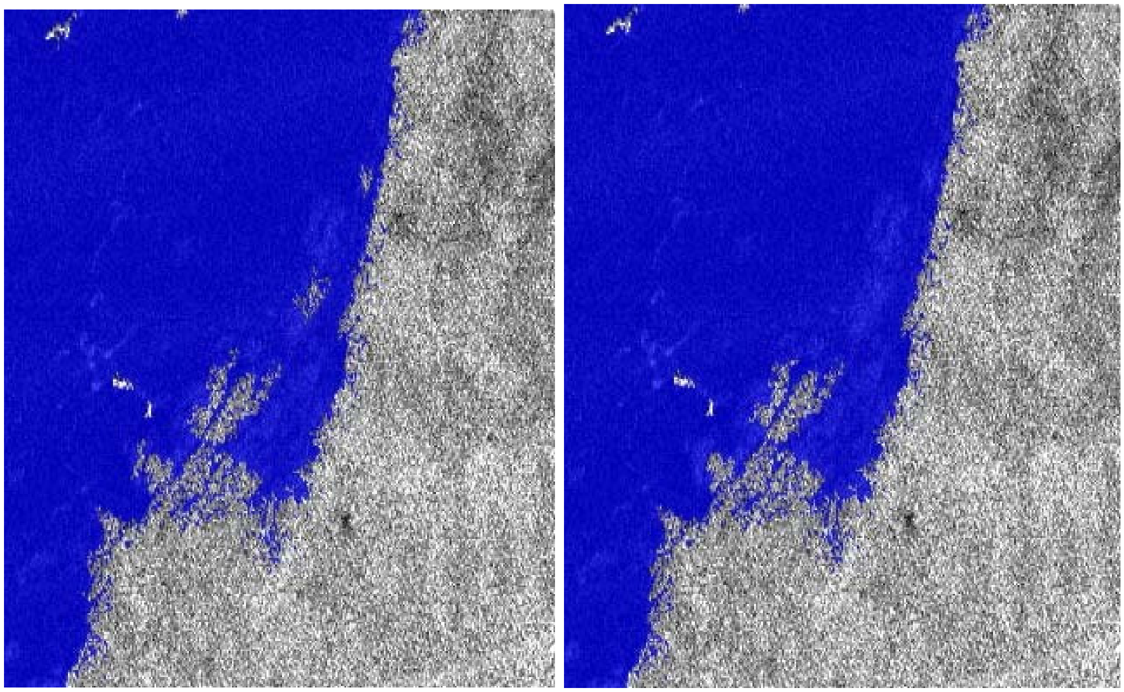


Fig. 8. The removing of other objects included in the oil spots

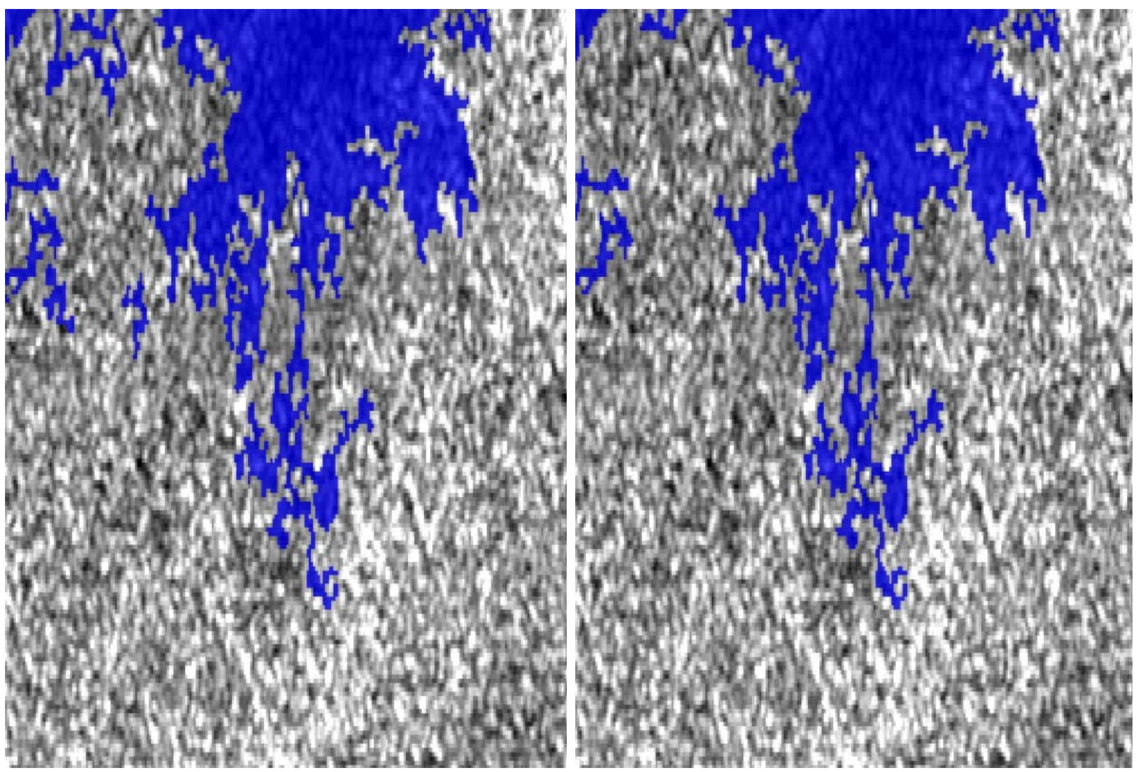


Fig. 9. The agglutination/ annexation of surrounding areas classified as independent oil spots.

The agglutination/ annexation of surrounding areas classified as independent oil spots, as the false classification are made after additional image investigations, in a process of manual classification.

The final result might be the exporting of the oil mask in Geo-Tiff format, which can be superposed/ overlapped on any other image, plan or map of the interest zone. Also, by investigating data that are different,one can make forecasts regarding the movements, the form modifications and the dimensions of the spots, thus facilitating the cleaning, interventions/measures.

8. Bibliography

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