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IMPROVED OIL SLICK IDENTIFICATION USING CMOD5 MODEL FOR WIND SPEED EVALUATION ON SAR IMAGES

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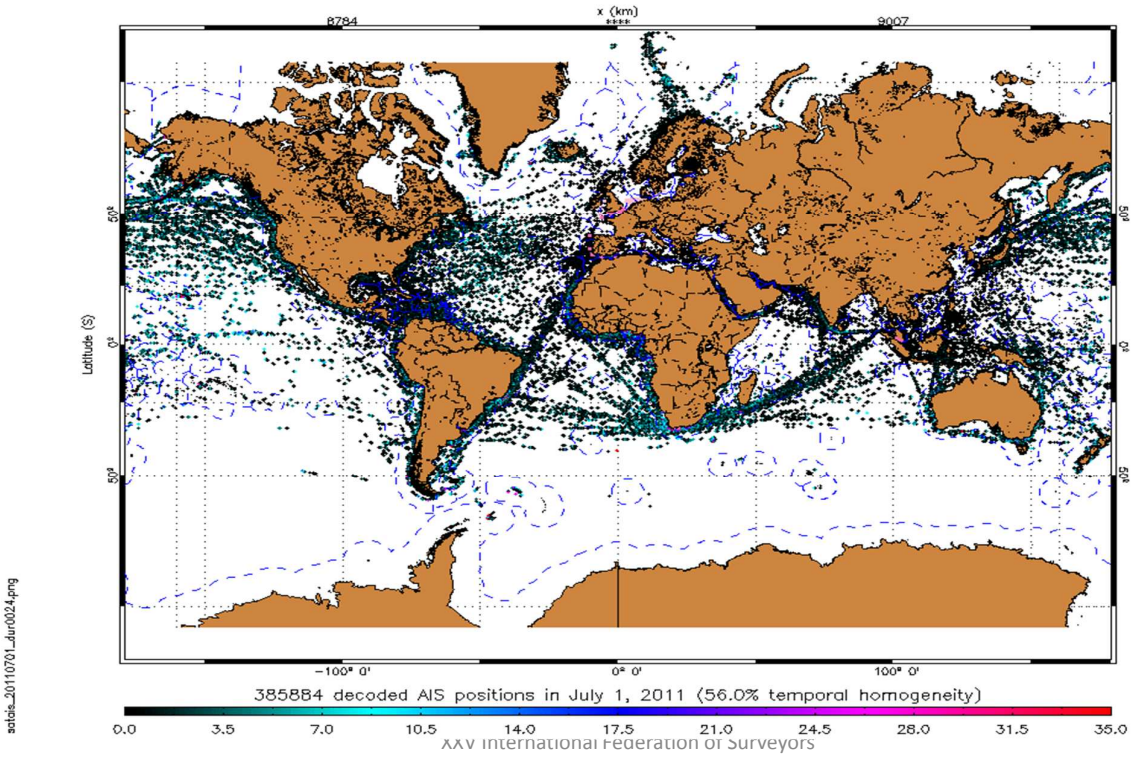
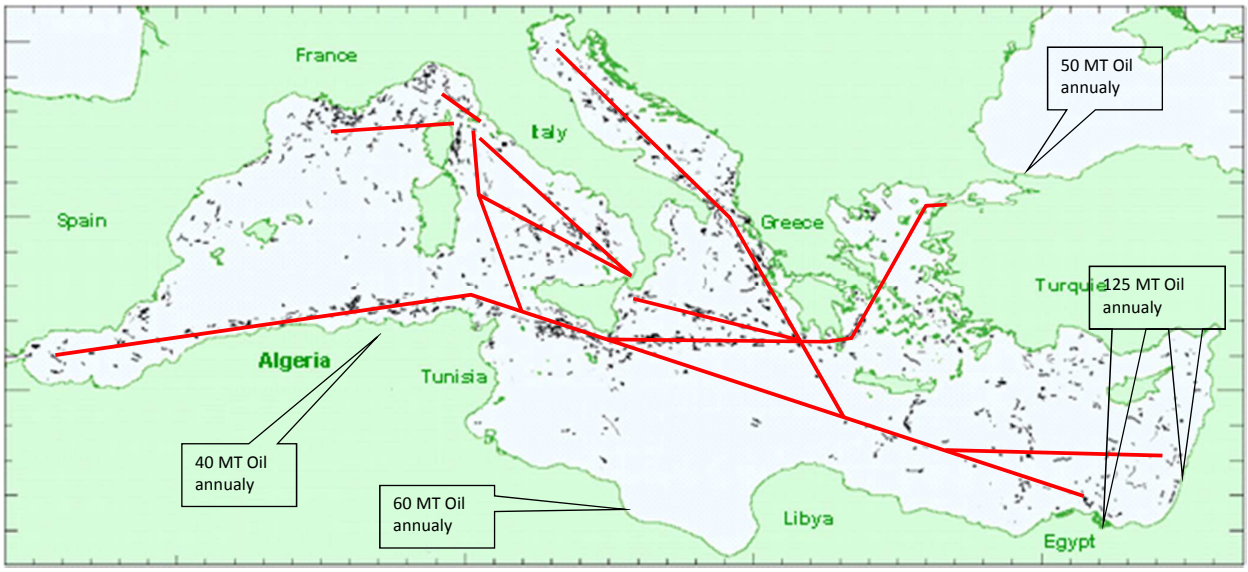
MAPPING ILLICIT DISCHARGES



DETECTED SPILLS ASSOCIATED WITH SHIP ROUTES



Introduction

To decrease the ominous effect due to this pollution, the surveillance of the inshore zones is necessary:

Coast guard

- Limited to small sectors.
- Don't cover the totality of the navy surface.

Satellite remote sensing

- An extended observation capacity.
- A fast detection and identification of the pollution.

The radar SAR is the useful tool in the control and surveillance of oil spill pollution on sea surfaces.

Problematic/Objective

Physical and geometric parameters alone are not always sufficient to provide enough information in order to identify the nature of the oil spill.

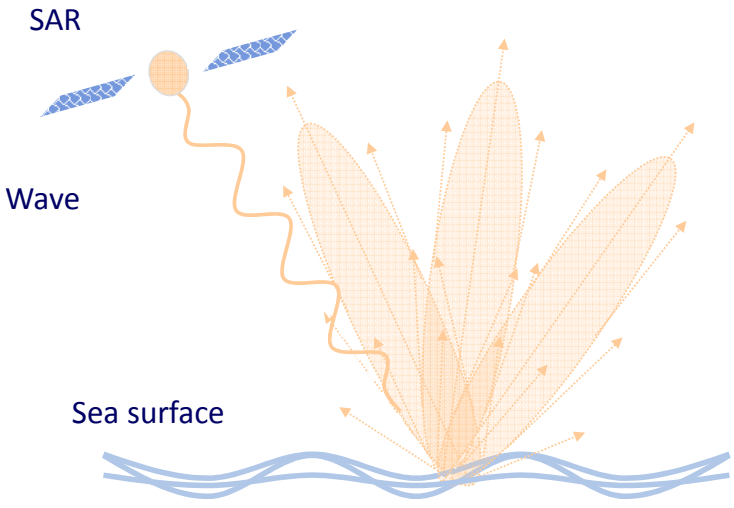
There are several natural phenomena that can have the same radar signature as an oil spill called look alikes. To help in the identification of the suspect objects, supplementary data, such as the wind speed that can be calculated from radar images, have proved themselves to be efficient.

The objective of this study is to estimate the wind vector from radar SAR images. This is to be done in order to include wind speed, in addition to parameters linked to the physics and the geometry of the oil spill, in the neural network as additional input (using 2 models CMOD4 and CMOD5 to estimate the wind speed).

Observation Of The Sea By The Radar SAR

The Radar is an instrument that has the following particularities:

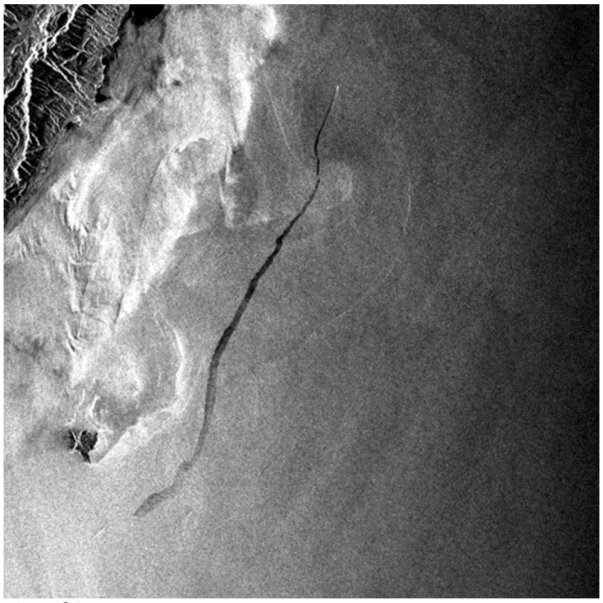
- ✓ The possibility to work night and day.
- ✓ The weak sensitivity to the atmospheric conditions.
- ✓ The power of detection of the roughness of the surface.



Braggscattering phenomenon

The SAR Image

- Once oil poured in sea, it remain to the surface of water
- Increase the viscosity of the surface that becomes smooth.
- Attenuation of the radar signal backscattering

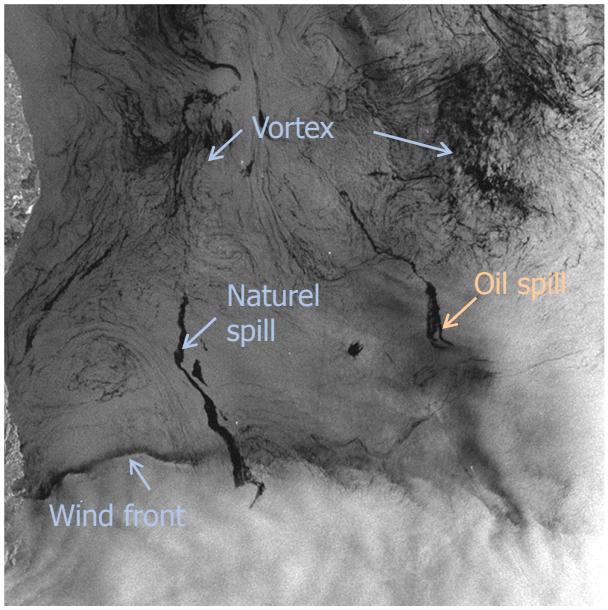


Characterization Of Oil Spill On The SAR Images

Several natural phenomena present a radar signature similar to the one of the oil spills.

Identification

- Oil Spill
- Look-alike

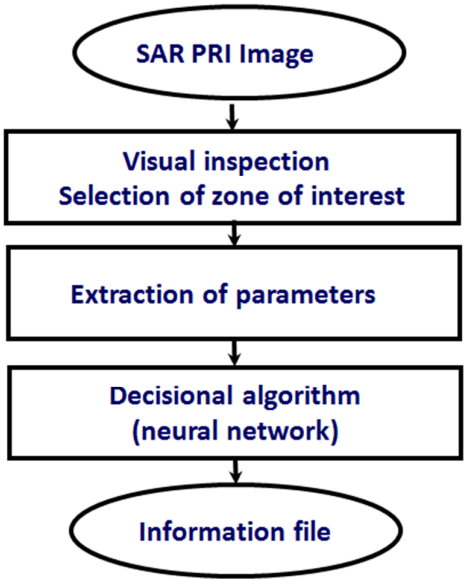


Look Alikes

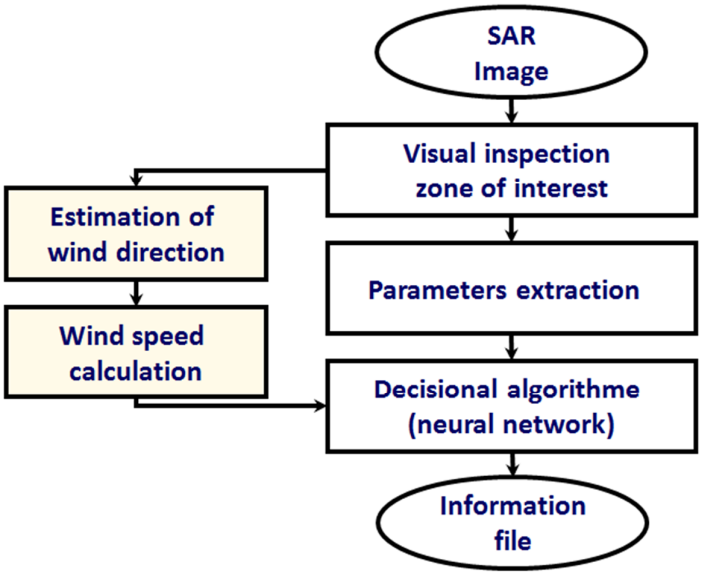
- SAR sensors detect all films that, like oil, smooth the sea surface:
- Look-alikes: Other man-made substances: fish or vegetable oil, chemical, sewage, other…
- Natural phenomena: low wind area, algae, current front …

Identification Methodology

First approach:



Second Approach:



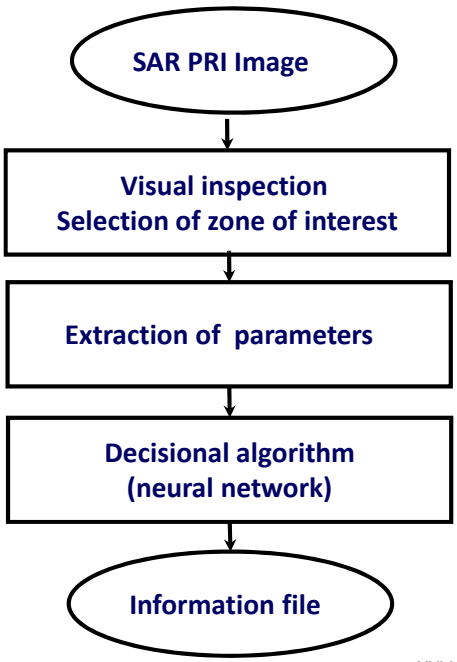
Data Set

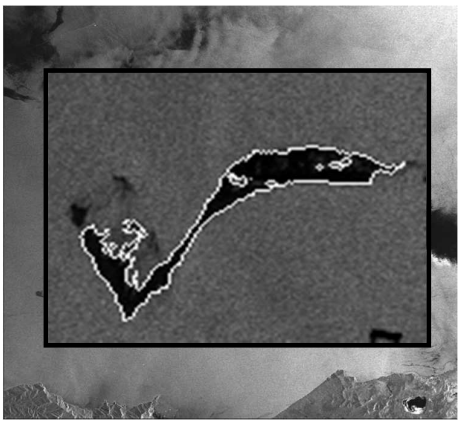
84 SAR PRI / ERS-2 images
149 examples of spill candidates:
76 oil spills
73 look-alike

Characteristics	Value
Frequencie	5.3 GHZ
Incidence angle	23 °
pixel	12.5 m x 12.5m
scene	100 x 100 Km

Characteristics of SAR PRI images

Identification Method (First Approach)





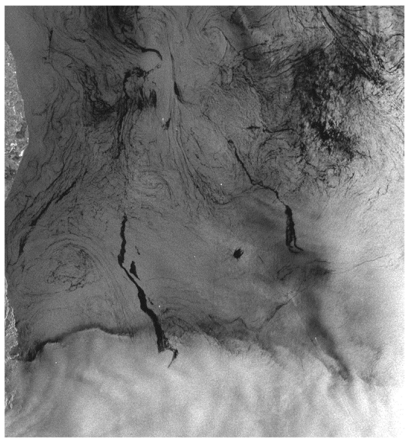
Geometric parameters

Statistical parameters

Characterization

Geometric parameters :

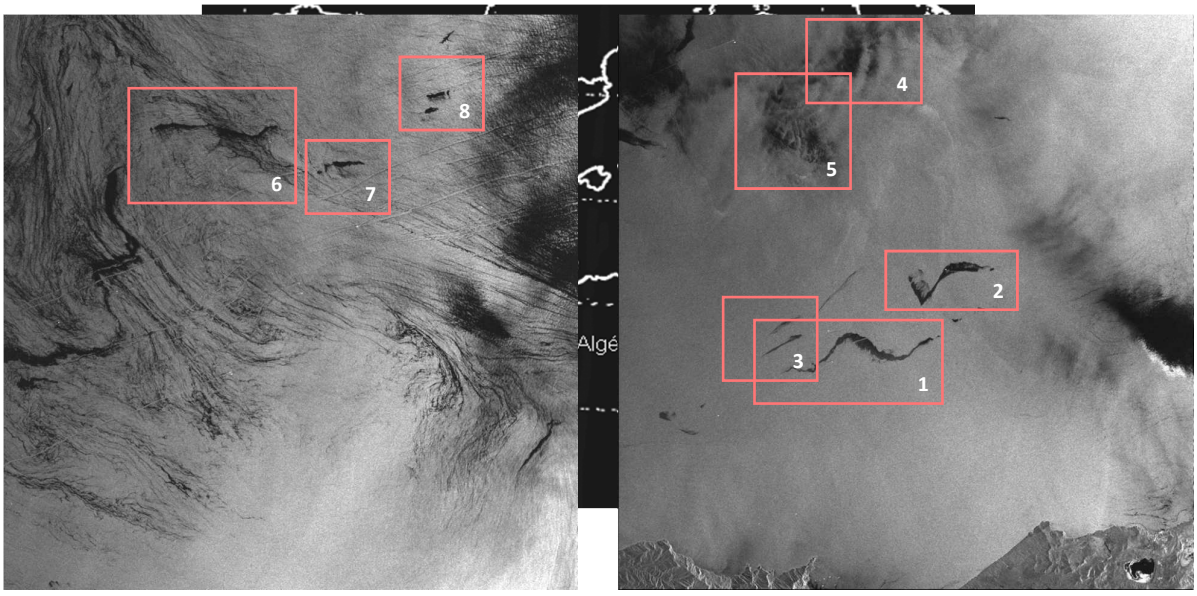
- Area (A)
- Perimeter (P)
- Complexity (C)
- Spreading (S)



Statistical Parameters :

- Object standard deviation (OSD)
- Background standard deviation (BSD)
- Contrast maximum (ConMax)
- Contrast mean (ConMe)
- Gradient maximum (GMax)
- Gradient mean (GMe)
- Gradient standard deviation (GSD)

Areas of Study



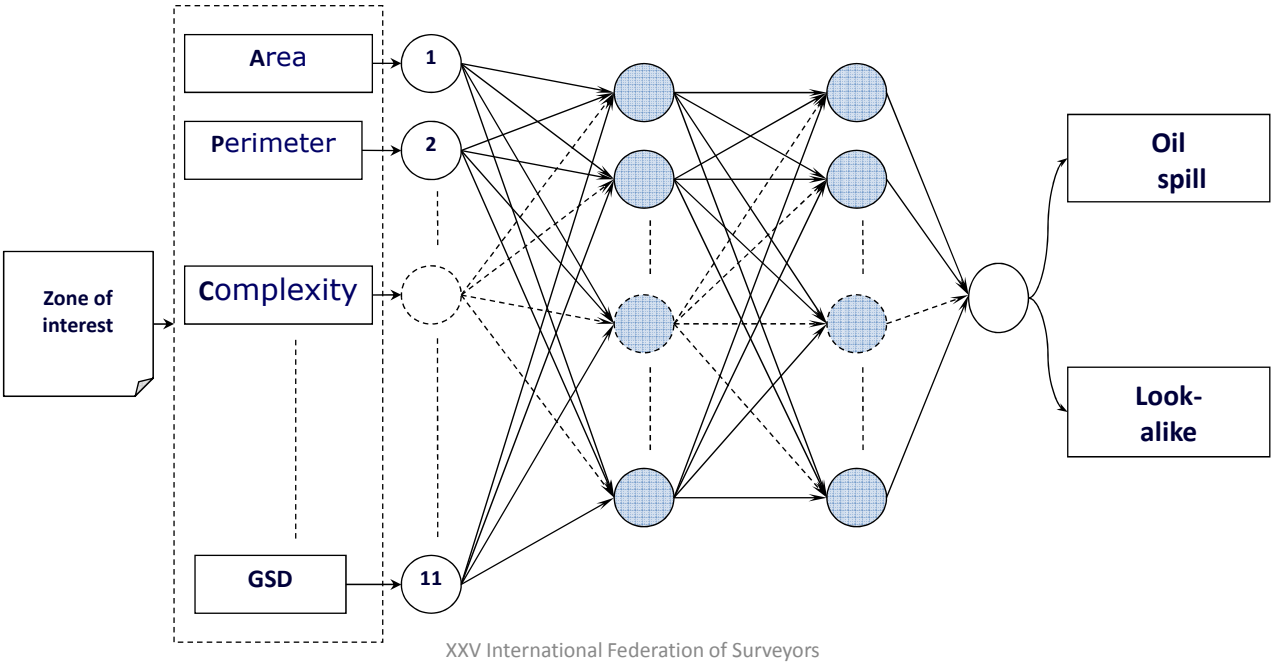
Arzew coastal zone (May 2000)

El-Kala coastal zone (September 2002)

Features

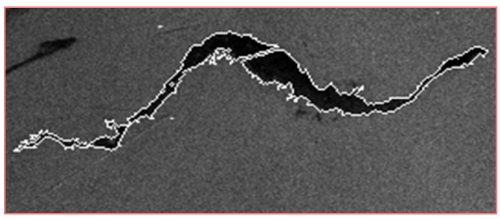
Parameter	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
A(Km²)	17.48	26.61	3.03	54.64	76.8	62.64	2.52	1.95
P(Km)	43.30	76.70	13.70	110.7	250.20	190.25	11.25	9.25
C	5.4	4.01	2.22	5.22	8.05	6.52	2.5	2.2
S	5.20	7.64	1.22	28.52	30.01	29.11	2.1	2.1
Osd	2.61	2.59	1.64	2.35	1.89	2.12	1.50	0.22
BSd	0.91	0.84	0.71	1.41	1.38	1.25	0.62	0.31
ConMax	15.38	13.85	8.59	13.58	10.33	12.55	8.62	7.54
ConMe	8.64	6.46	5.44	6.4	5.48	5.94	5.21	4.34
Gmax	15.16	9.05	6.94	7.01	6.59	6.7	5.83	6.47
GMe	7.2	2.99	3.18	3.2	2.64	3.0	2.54	3.22
GSd	1.42	1.31	1.39	1.53	0.94	1.23	1.28	1.21

Neural Network (11 Inputs)



Results (First approach)

Zone	Type	Identification
1	Oil spill	0.41
2	Oil spill	0.85
3	Oil spill	0.92
4	Look-alike	0.01
5	Look-alike	0.07
6	look-alike	0.08
7	Oil spill	0.72
8	Oil spill	0.92



149 examples:

76 Oil spills.
73 Look-alike.

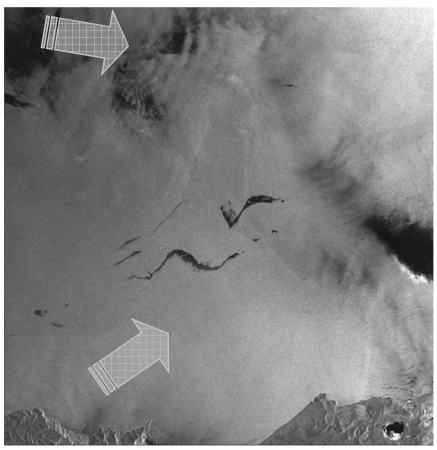
9 ambiguous results.
16 identification errors.

83% of good identification

Wind Direction Estimation

The evaluation of the wind direction is based on the interpretation of atmospheric and oceanic phenomena. The maximum of phenomena provoked by wind is collected in order to estimate the direction of wind.

Arzew costal zone



El-Kala costal zone

CMOD4 and CMOD 5 Models

CMOD4 is a model for evaluation of wind vector, initially developed for radar scatterometers, it gives the backscattering coefficient according to wind speed, wind direction and the incidence angle

$$\sigma^0 = b_0\,(1 + b_1.cos\varphi + b_3.Tanh\,(b_2\,).cos\,(2\varphi))$$

b0, b1, b2 and b3 are coefficients dependent on the incidence angle and the wind speed.

CMOD5 was derived to correct for some deficiencies of the currently widely used C-band GMF called CMOD4 with approximation of coefficients.

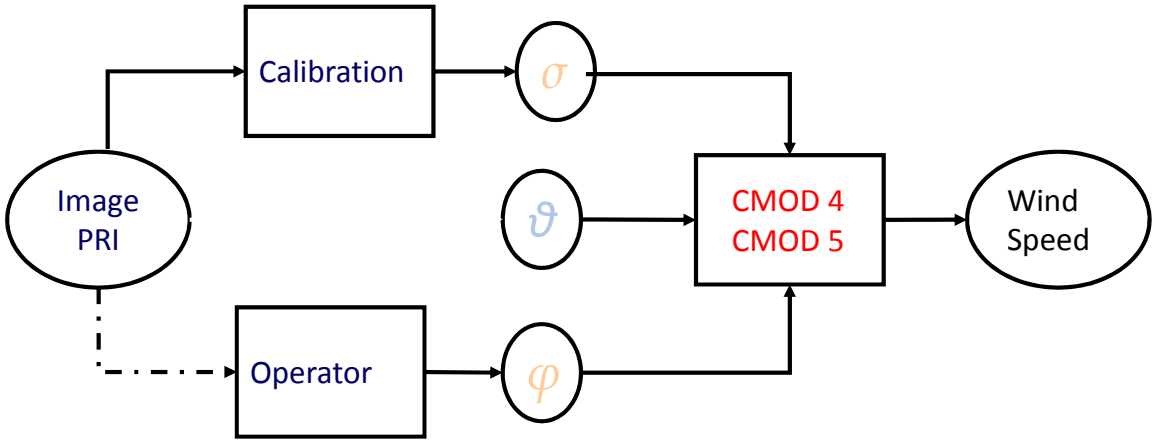
$$\sigma^0 = b_0(\,1 + b_1.cos\,\varphi + b_2.cos\,2\varphi\,)$$

where B0, B1 and B2 are functions of wind speed and incidence angle.

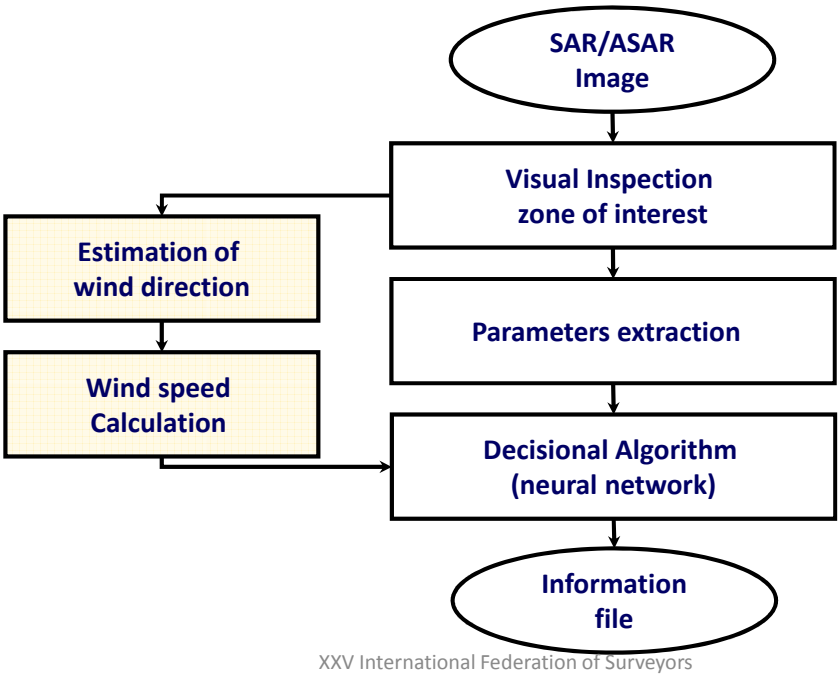
Wind Speed Estimation

The principle of the wind vector estimation is based on the inversion of the CMOD-4 and CMOD-5 models:

$\sigma = f\,(\,V, \theta, \varphi\,)$ ⇒ $V = g(\,\sigma\,, \theta, \varphi\,)$



Identification Method (Second approach)



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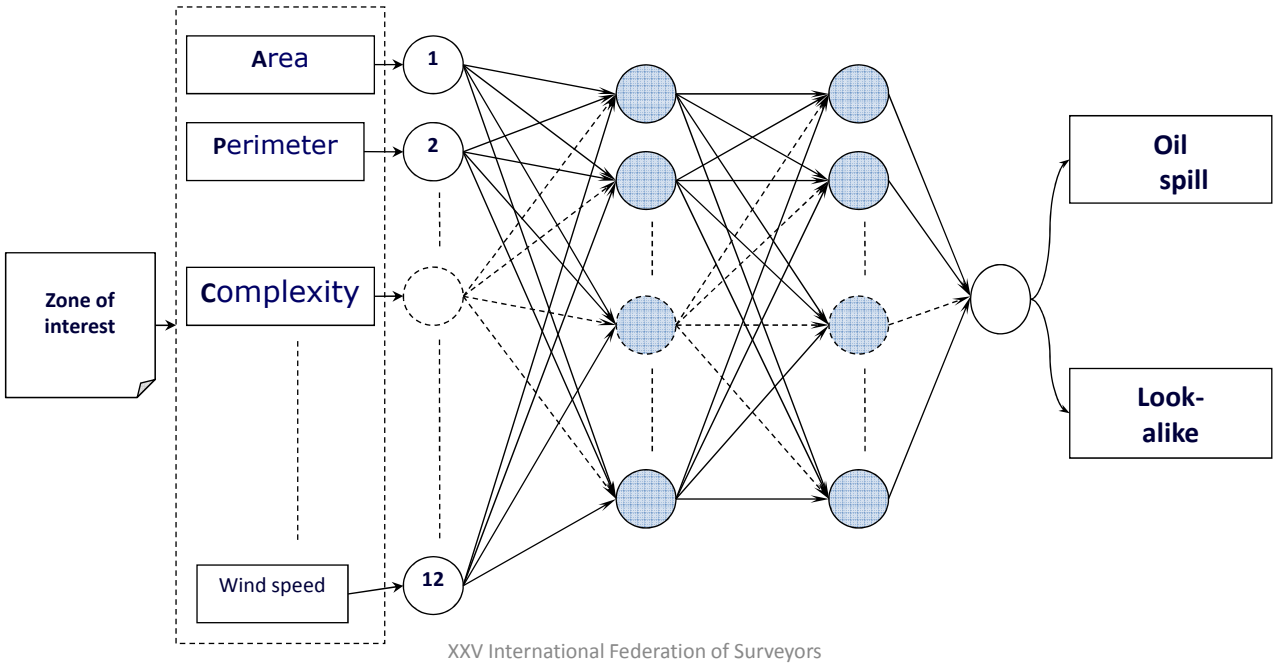
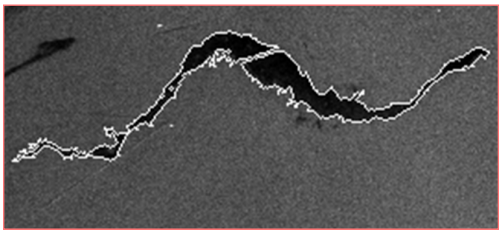
GMe	7.2	2.99	3.18	3.2	2.64	3.0	2.54	3.22
GSd	1.42	1.31	1.39	1.53	0.94	1.23	1.28	1.21
V(CMOD4)	**4.1**	**4.1**	**3.9**	**2.4**	**2.1**	**1.9**	**2.1**	**2.4**
V(CMOD5)	**5.4**	**5.4**	**5.2**	**3.7**	**3.4**	**3.2**	**3.4**	**3.7**

Neural Network (12 Inputs)



Results (Second approach)

	Type	(CMOD4)	(CMOD5)
1	Oil spill	89%	99%
2	Oil spill	92%	99%
3	Oil spill	95%	99%
4	Look-alike	2%	0.004%
5	Look-alike	6%	0.5%
6	Look-alike	3%	4%
7	Oil spill	81%	99%
8	Oil spill	96%	99%



149 exemples:

76 oil spills.

73 Look-alike.

CMOD4: 3 ambigous results.
13 identification error.

89% of good identification

CMOD5: 1 ambigous results.
10 identification error.

92% of good identification

Conclusion

In conclusion of our study:

- ✓ The two developed processes gave encouraging results.
- ✓ The evaluation of the wind direction from the SAR-PRI images can be done by visual interpretation.
- ✓ The adaptation of the CMOD4 model to the SAR-PRI images permits the evaluation of the wind speed.
- ✓ The wind speed brings an improvement to the process of identification.
- ✓ The CMOD5 improve the identification of oil spill on SAR images

Thank you for your attention

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