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A THALES Group Company

ADVANCED SATELLITE-BASED OIL SPILL DETECTION

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Maritime awareness

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- Ocean health is crucial for the Earth well being

- The ocean is a eco-system with major responsibility for climate, coastal erosion, etc

- Maritime pollution monitoring became an essential tool to monitor sea health and a very important challenge in terms of natural environmental preservation

Maritime Monitoring context

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- Sea pollution monitoring importance is stressed by several European (and not only) projects that aim on sea preservation
- The synergy between R&D and operational projects is crucial to implement global monitoring architectures in the near future
- EDISOFT works on the bigger European operational project of pollution monitoring: EMSA CleanSeaNet
- Other important R&D projects which EDISOFT have worked: EC FP7 Sea-U and ESA AOSD

AOSD context

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• The knowledge acquired during the aforementioned projects allowed EDISOFT to plan the implementation of a non-supervised automatic tool for oil spill detection

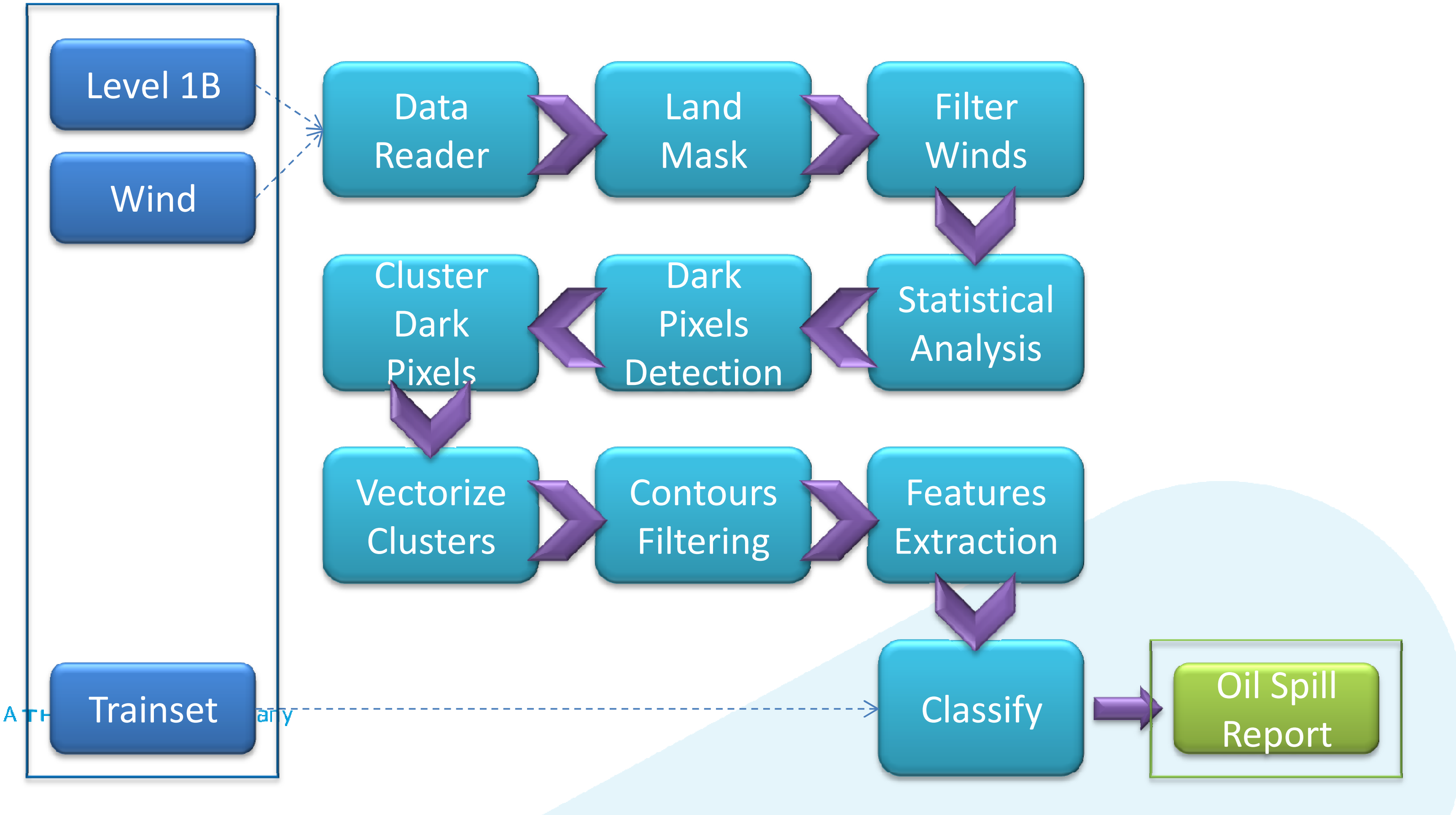
• The project involves strong R&D components to improve oil spill detection capabilities

AOSD objectives

- Convergence to an automatic algorithm
- Being closely related to the operational segment
- Focused on the oil spill detection processing chain automation (e.g. CleanSeaNet)
- Integration with an already tested and optimized software as NEST
- Integrating auxiliary data (like wind data), together with image and geometry analysis

Software architecture

The AOSD follows the processing model of NEST; its architecture is the following.



Data reader

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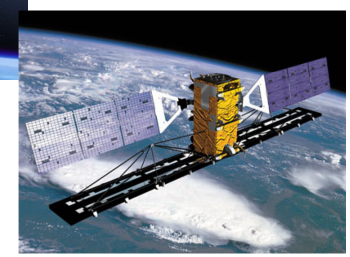
The current software version reads data acquired from the following satellites:

- Envisat
- Radarsat-1
- Radarsat-2





- Imagery data can be combined, if available, with winds ancillary data

Land mask

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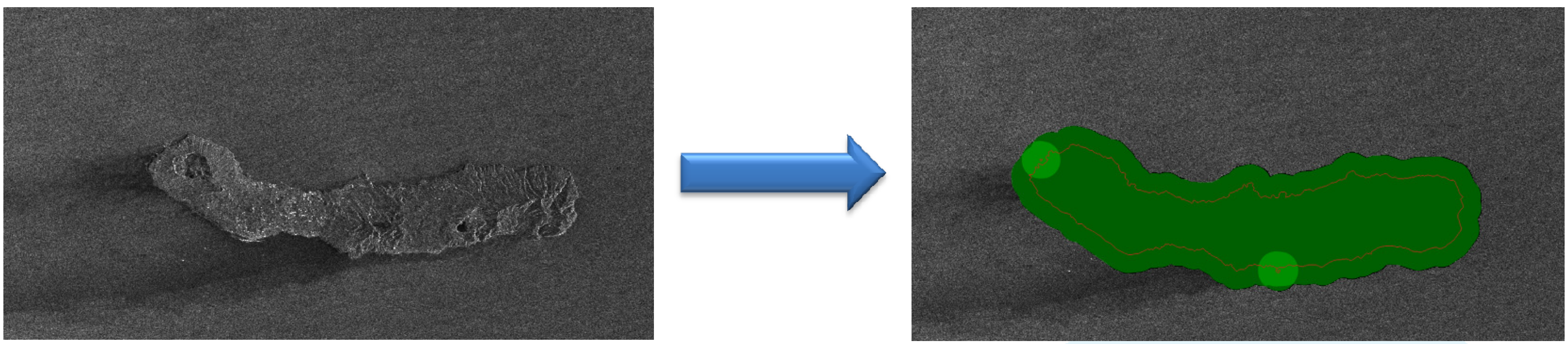
- Land areas are masked with no data value, to be excluded by the detection component
- A user defined buffer is added to exclude areas near the coast



Filter winds

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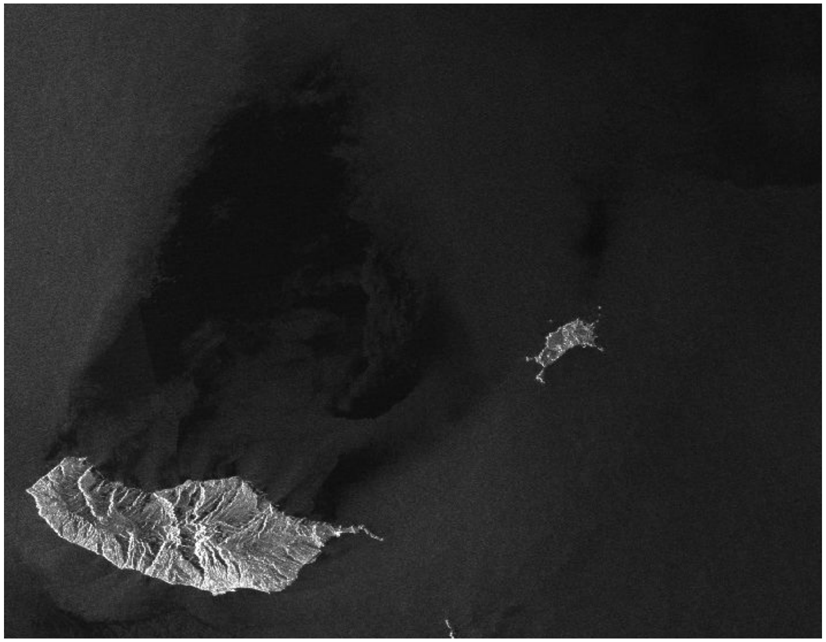
- Invalid wind areas are excluded from the analysis
- "Invalid" is defined according to the user input criteria



- Low winds – lower values are excluded
- High winds – higher values are excluded

Statistic analysis

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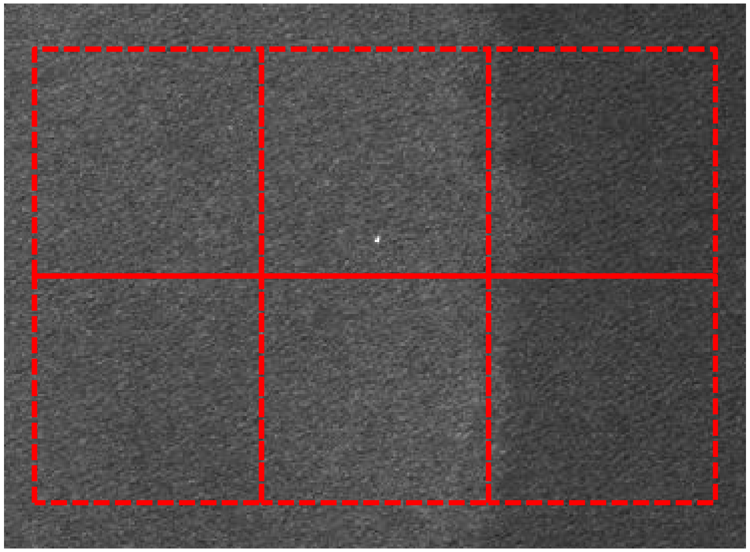
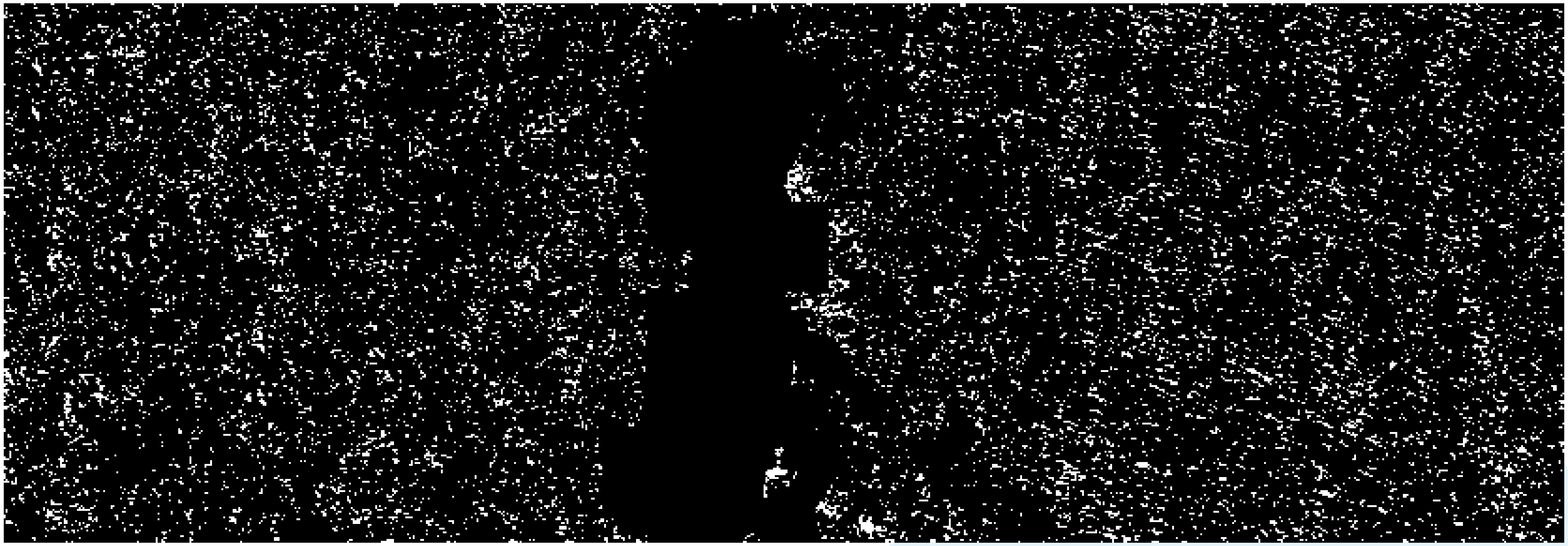
- Smaller window areas are analyzed to find individual threshold values
- Threshold values are automatically adapted to a sliding-window covering each analysed area



- Window size – defined by the user
- Statistic data extraction – in each sliding-window
- Threshold – combining statistical data

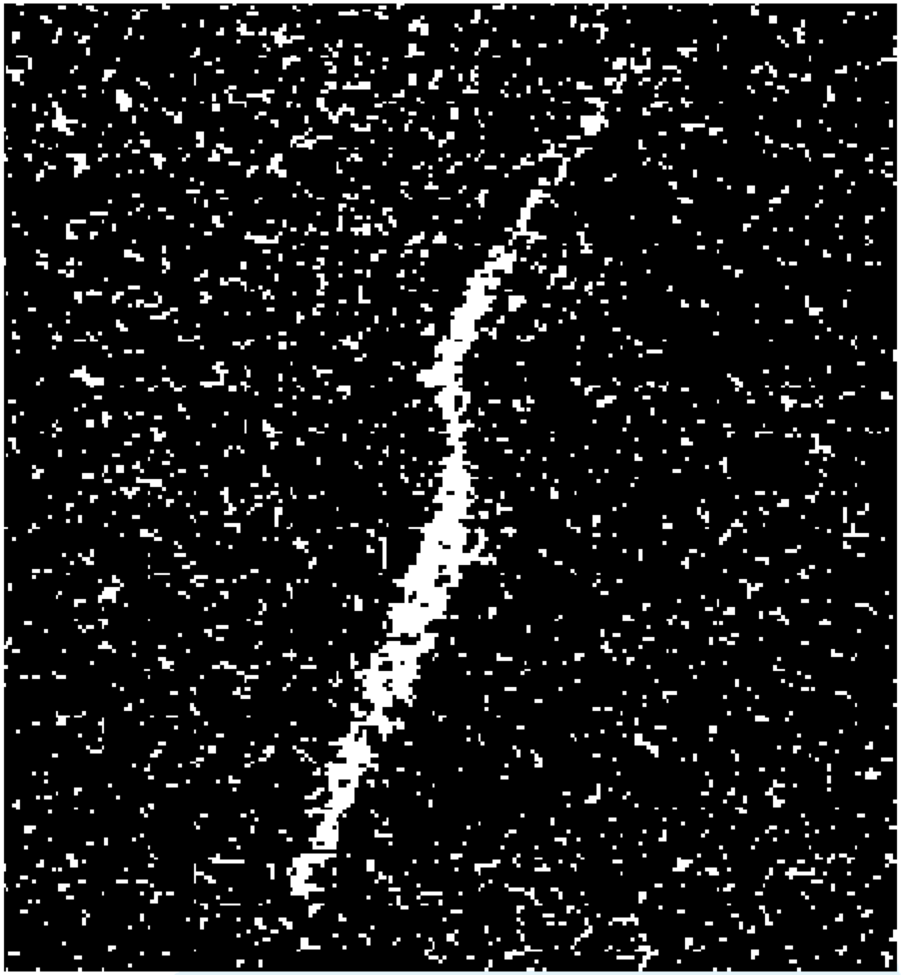
Dark pixels detection

- Each pixel is filtered according to the established window threshold
- Only lower amplitude values allow the analysed pixel to move on to the next phase



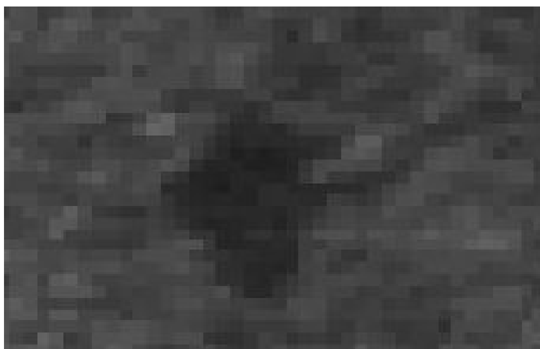
Cluster dark pixels

- Darker pixels are aggregated according to a user defined distance
- Each group of aggregated pixels form a cluster
- Non-clustered pixels are discarded

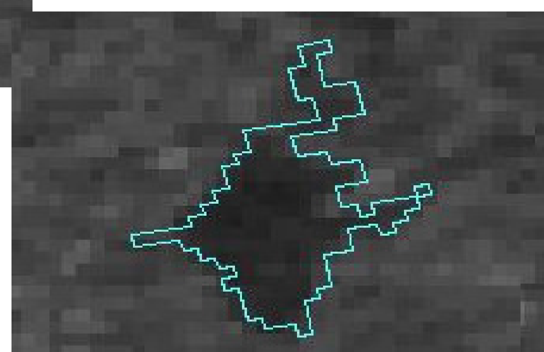


Vectorize clusters

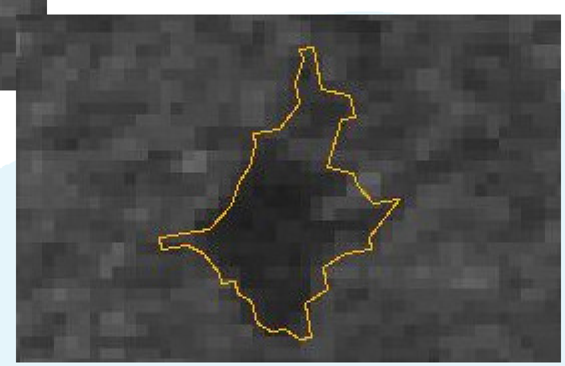
- The remaining dark clusters are converted from raster to the vectorial domain



- Clusters are vectorised to polygons

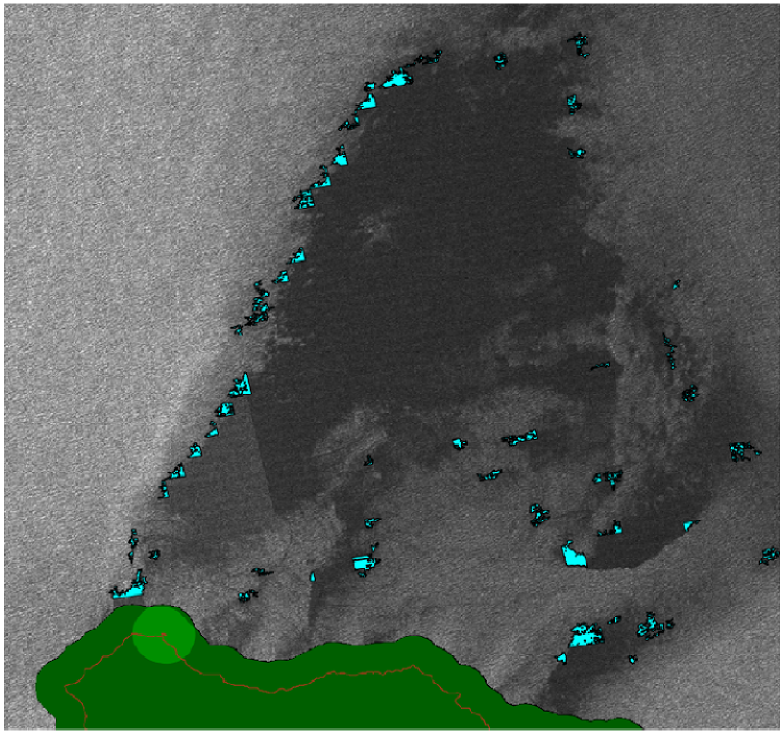


- Polygons are simplified to contours



Contours filtering

- Formed contours can be discarded if they do not comply with three exclusion criteria:



1. Being an invalid polygon
2. Dimension
3. Closeness to an invalid wind area

Features extraction

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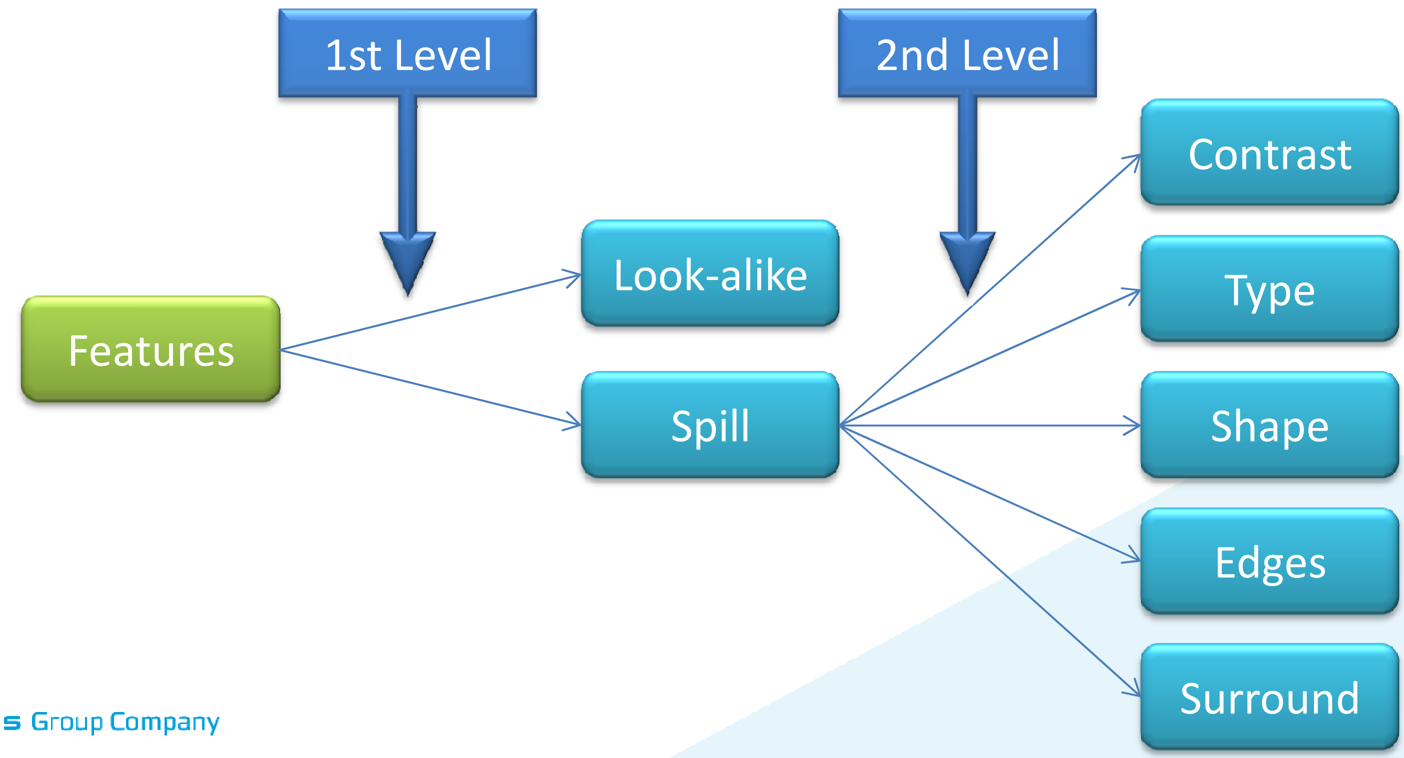
- Well defined features that can better characterise an oil spill were previously chosen
- Based on the definition, the individual features of each contour are extracted
- The individual feature values are delivered to the classifier

	C-AREA	C-PERIM	C-COMPLEX	C-DENSITY	C-CONTRAST	C-GRADIENT	C-SURMEAN	C-WIDTH	C-LENGTH	C-LINEAR	C-WIND
0	2053673.34416862	12266.0404829536	73.261772402448	0.627229741116614	0.894949757498382	4.59694938686272	0.156317936692128	633.302863202606	3888.19152019553	6.13954514674541	6.23188090374385
1	774095.51842652	8060.01427919646	83.9222403882415	0.828386141936914	0.808657686381 2	0.608117353575306	0.141565012976809	266.167924940337	2999.22767509399	11.2681784469946	5.06643352725289
2	1313716.46005226	6038.49658445741	27.7559443831991	0.702206319286965	0.825074369351552	0.297284514875 22	0.142506326320364	727.940686394968	1804.70261465707	2.47918909931333	2.25907407478153
3	1349075.98947229	9670.97043014475	69.3272060214479	0.721327047248578	0.828305588019 19	0.417040350579741	0.164647100678788	405.571647603053	3326.35675458428	8.20165012579946	8.77962250576056
4	829825.893312577	4824.74895535902	28.0519114549606	0.704967156019 61	0.897991217417608	0.236059497172147	0.136922354433247	419.228095441365	1979.41383780334	4.72156770819332	3.15919385402661
5	539890.01650289	4933.53190200138	45.0827692383066	0.843921884222435	0.887418053160 98	0.271743771825753	0.125806111885537	359.179036441084	1503.12229202566	4.18488313493824	2.78855267356049
6	3000031.92404144	14546.6934962438	70.5346799738713	0.742492098883821	0.831805939538005	0.337909178345755	0.158924628294606	753.431636036926	3981.82367257859	5.28491701453247	2.48531993881601
7	994939.171868004	4821.21388579633	23.3623361003612	0.593629255636903	0.881466509050831	0.246392341250764	0.127898542501826	589.103158938759	1688.90483232231	2.86690846364631	2.91797170478014
8	2137820.66542638	7955.70473443345	29.6064299709926	0.647271318113 12	0.920704263416 32	0.290604260170132	0.13923623908847	829.345845448059	2577.71914715677	3.10813535909635	4.28008545239767

Classify

- All detected and filtered remaining patterns are then classified based on their individual features
- Classification is done in two levels



Classify

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- The first classification level is based on the Support Vector Machines (SVM).
It has the purpose to classify the detected dark patch as oil spill or look-alike.

- The second level of classification is executed for the classification of the detected oil spills, with the purpose to characterize the oil spill according to its attributes

Oil Spill Report

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- Available in three different formats:

  1. Esri shapefile
  2. EMSA OSN
  3. Google Earth KMZ

Correlation analysis

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- Classification can only provide efficient predictions if the model is well balanced

- Development of a prediction model capable of classifying dark features as a spill or a look-alike

- It was essential to determine which variables are relevant to the model

- Understanding each variable relevance was performed through a correlation analysis

Oil spill characteristics

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- Type – linear, tail, angular, patch, droplet
- Contrast – strong, medium, weak
- Surround – homogeneous, inhomogeneous
- Shape – smooth, irregular
- Edges – Sharp, sharp and diffuse, diffuse
- Wind speed – low, moderate, high

Extracted variables

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- The variables are extracted according to the aforementioned oil spill characteristics
- Definition of each detection with the variables:
  - Area
  - Perimeter
  - Length
  - Width
  - Linearity
  - Complexity
  - Density
  - Gradient

Decision variable

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- Spill confidence level

- Divided in five sub-level types:
    - Ongoing spill
    - High confidence
    - Medium confidence
    - Low confidence
    - Lookalike

- The variable holding the prediction result

Results

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- Prepared dataset based on the available archive
- Total of 78 ENVISAT scenes randomly selected
- AOSD validation data set results:

AOSD	Lookalike	Low	Medium	High	Total
Success	18585	76	71	41	**18773**
Fails	3003	56	58	30	**3147**
Rating	86%	58%	55%	58%	
				Overall performance	**86%**

Detection example I

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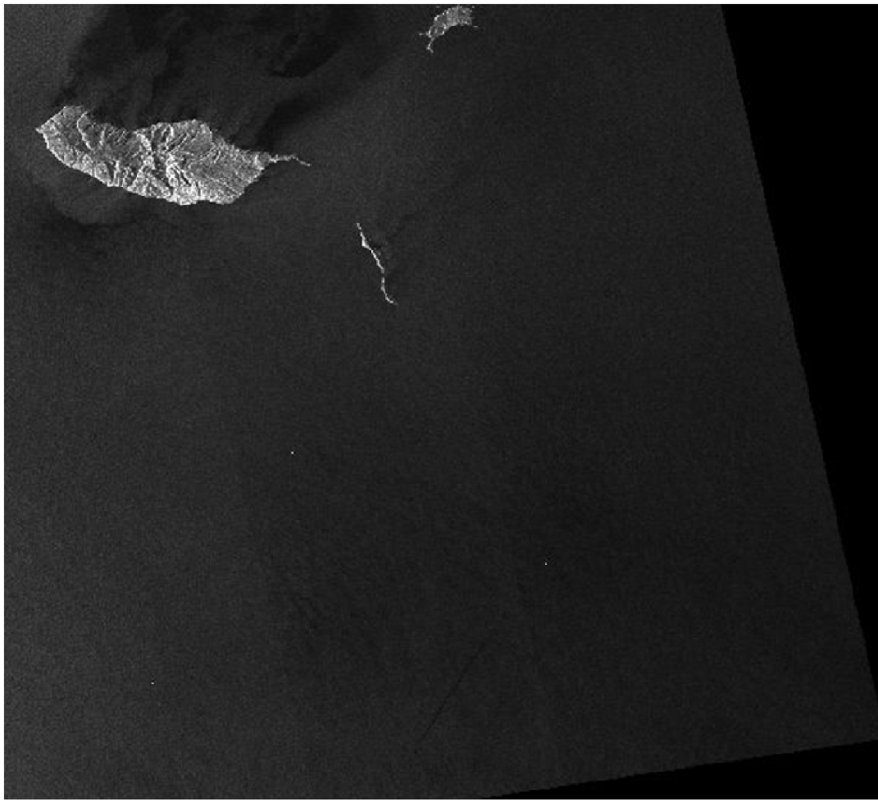

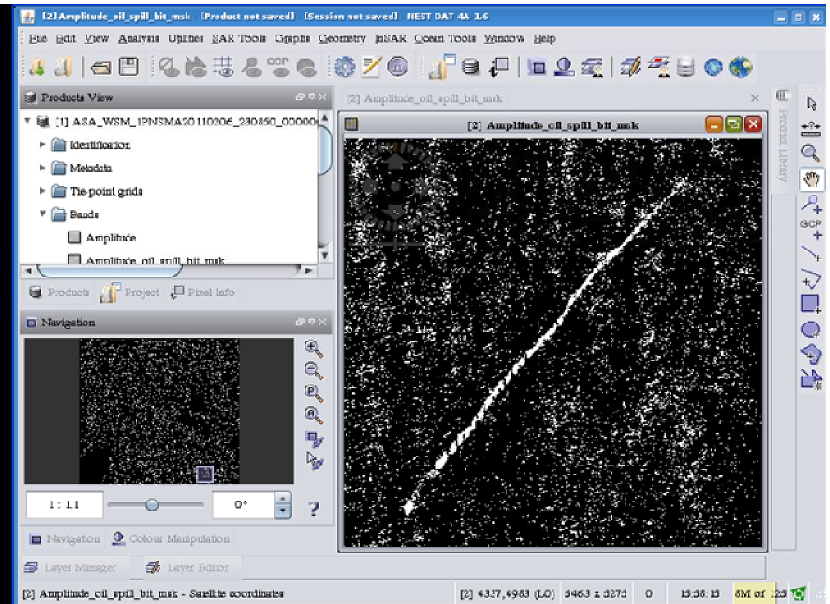

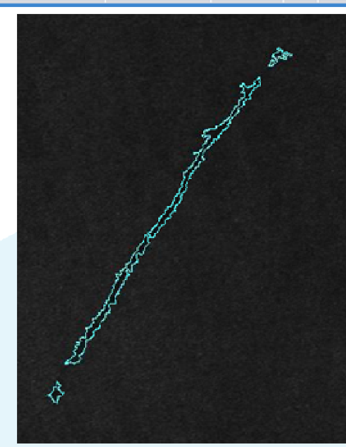

Detection example II

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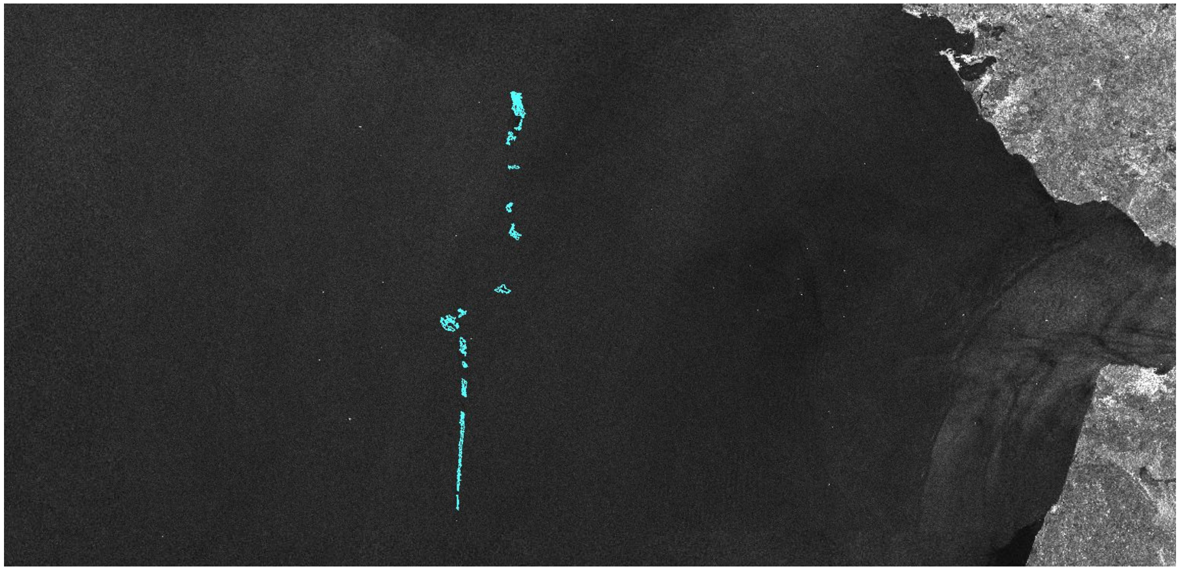

CSN results (2007-2011)

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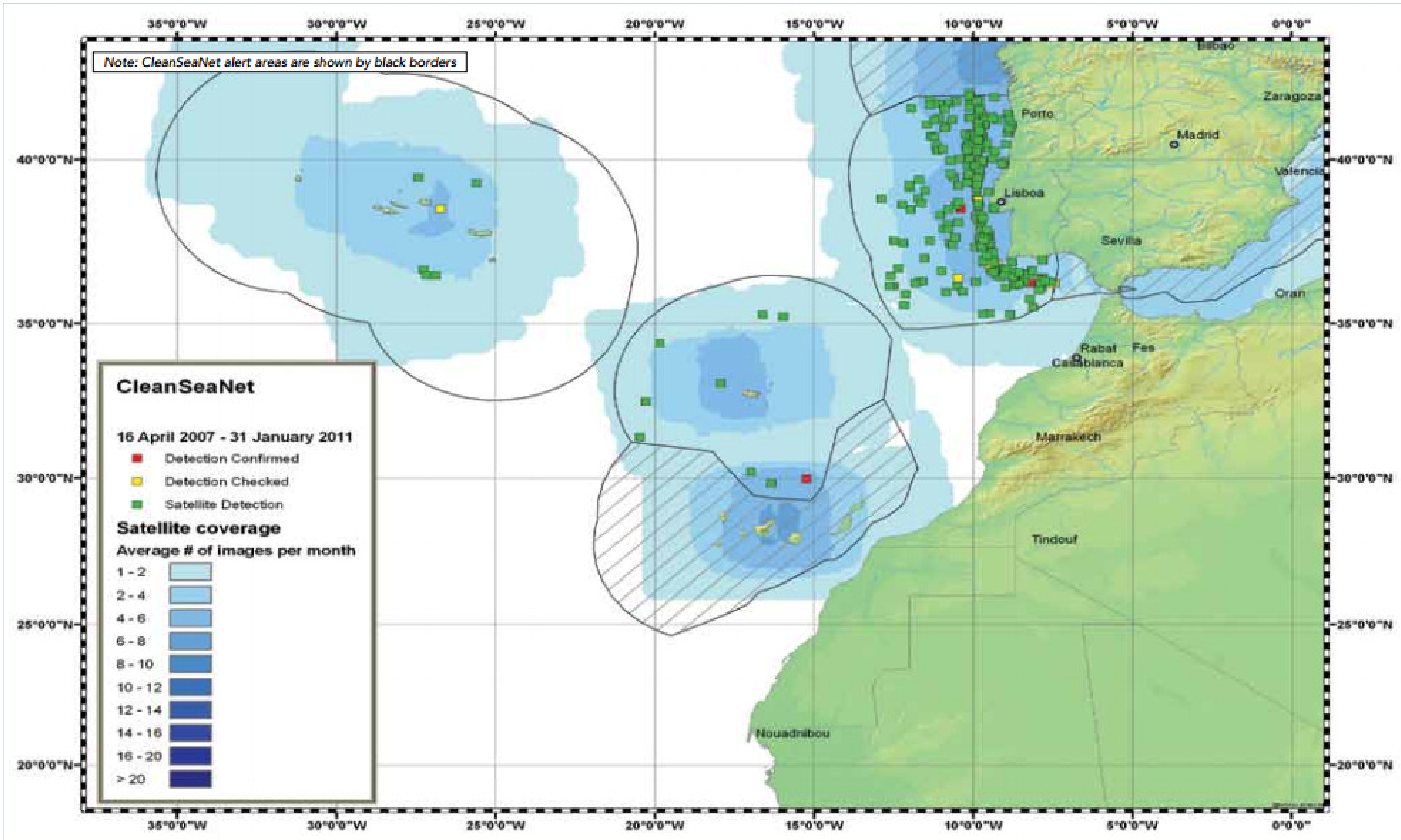

Future work

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- Upgrade to the latest available version of NEST
- Integration of AOSD within the EMSA CSN service
- Integration of other SAR systems – Sentinel-1, TerraSAR-X, COSMO-SkyMed
- Spill orientation – to detect possible responsible ships
- Integrate other ancillary data sources – to help preventing false positive detections
- Improve time efficiency – to be used operationally
- Incorporate additional layers of information – as detected vessels and AIS positions

THANK YOU

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