



European Maritime Safety Agency

CleanSeaNet – European Satellite Oil Spill Monitoring and Vessel Detection Service

SAR Image Analysis



CleanSeaNet SAFEMED Info Day – Lisbon – November 2013

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European Maritime Safety Agency

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- Introduction to SAR
- Detection principle in CSN
- SAR signatures
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Introduction to SAR



SAR stands for: **S**ynthetic **A**perture **R**adar

Radar stands for: **R**adio **D**etection and **R**anging

*"**Radar** was developed as a means of using radio waves to detect the **presence** of an object and to determine their **position**".*

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Introduction to SAR

Radar Systems

There are different radar types, with different characteristics, geometries and scopes:



CW Doppler Radar



Weather Radar



Side Looking Aerial Radar (SLAR)



Synthetic Aperture Radar



Navigation Radar

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Introduction to SAR

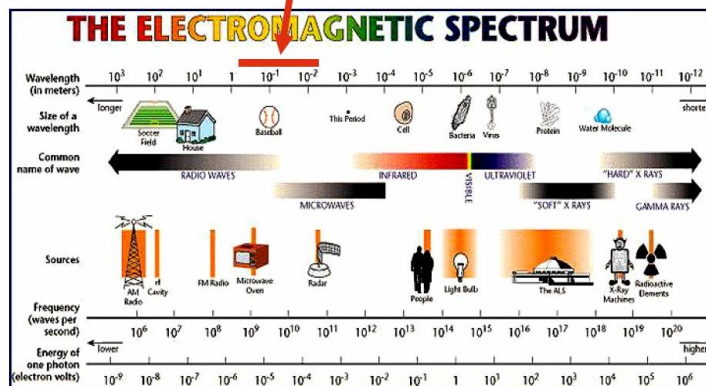
- Radars are active systems => they illuminate the Earth surface, then measure the reflected signal.
- Therefore, images can be acquired day and night, completely independent of solar illumination, what is particularly important in high latitudes (polar night).

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Introduction to SAR

Radar remote sensing

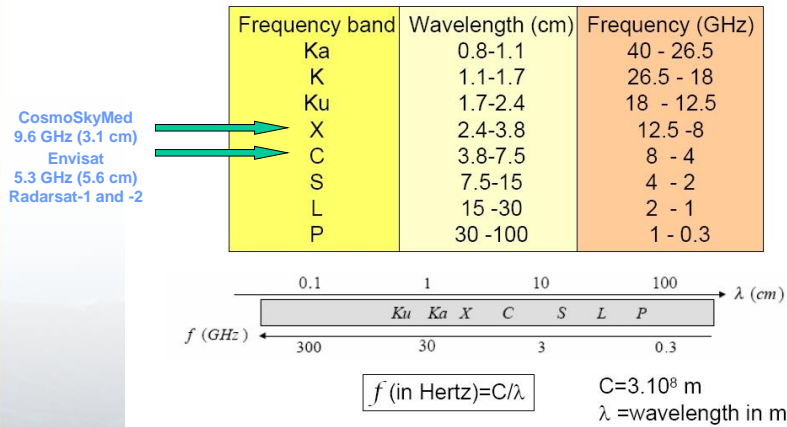


SAR emits and receives electromagnetic pulses in the **microwave portion** of the electromagnetic spectrum, ranging from ~ 1mm to 1 meter (300GHz to 300 MHz).

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Introduction to SAR

Radar frequency

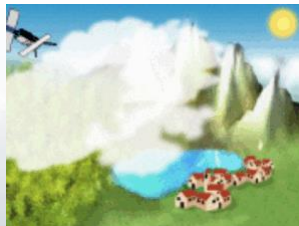


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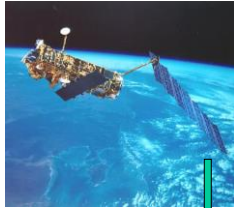
Introduction to SAR

- Because wavelengths of SAR sensors are much longer than optical or infra-red waves, they easily penetrate clouds, and images can be acquired independently of current weather conditions.
- This all-weather capability is one of the main advantages of imaging radars compared to optical sensors

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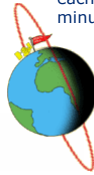
Introduction to SAR



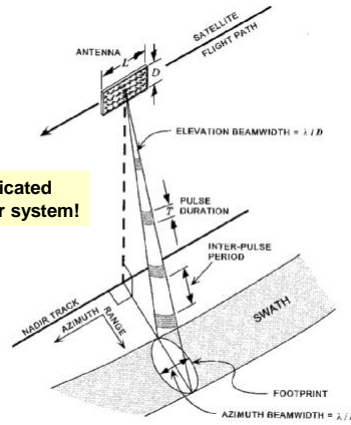
Envisat



SAR antenna: 1.3mx10m



SAR is a sophisticated Side Looking Radar system!



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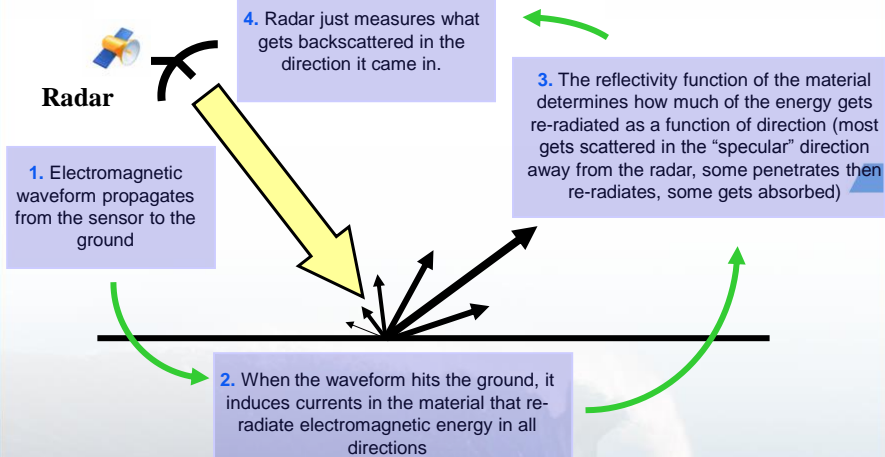
Introduction to SAR



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Introduction to SAR

What does a Radar Measures?

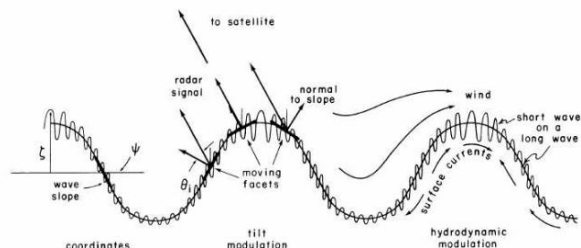


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Introduction to SAR

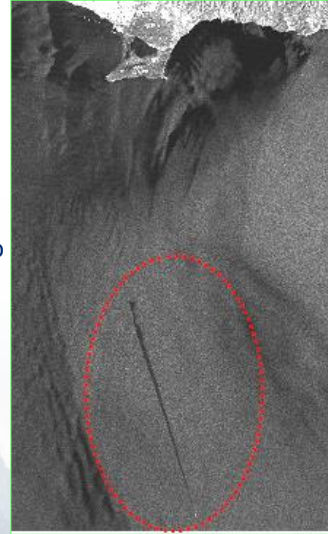
- In a SAR image, pixels represent a measure of the backscattered signal.
- The value depend on the physical interactions of the radiation with the targets. Many factors have an influence like: roughness, dielectric constant of the material, local incidence angle, the shape and orientation of objects.
- But for ocean main influence is the level of roughness of the sea surface on the order of the cms. These are the small ripples, which are mainly driven by the wind.

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Detection Principles in CSN

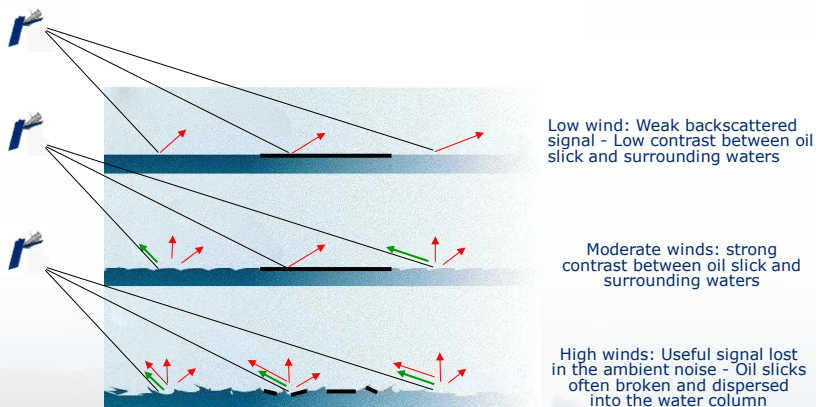
- Oily films
 - smooth the sea surface
 - reduce the backscattered signal
 - appear as darker areas
- Vessels are visible as bright spots, due to the metallic structure, which is a strong reflector



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Oil Spill Detection

Moderate winds favourable for oil slick detection



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2-3 m/s < **WIND** < 12-15 m/s

Oil Spill Detection

- However SAR sensors detect a high variety of other phenomena that result as well in damping out small waves generated by the wind.
- These phenomena (atmospheric, oceanographic) are denominated Look-alikes and give rise to false alarms, the so-called false positives.
- This is the reason why CSN detections are not "Oil Spills" but "Potential Oil Spills", having an associated confidence level.
- On the other hand, whenever an oil spill is visible in the SAR image but is not identified as such, this is denominated a false negative.
- A "good" oil spill detector should as well have a high detection rate as well as a low misdetection rate.

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Oil Spill Detection

- Note: Fish or vegetable oil cannot be discriminated in SAR from mineral oil and as such are not considered lookalikes. For validation, they are considered as true detections.
- Examples of Look-alikes are:
 - low wind area, algae, current front, upwelling area...

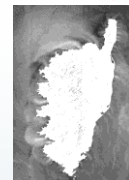
17



Current fronts

Low wind, rain cells
and oil seepage

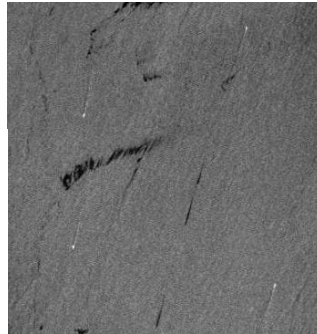
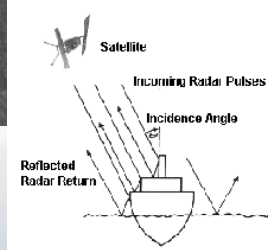
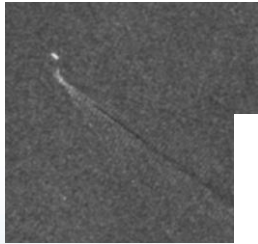
Algae



Land breeze

Vessel Detection

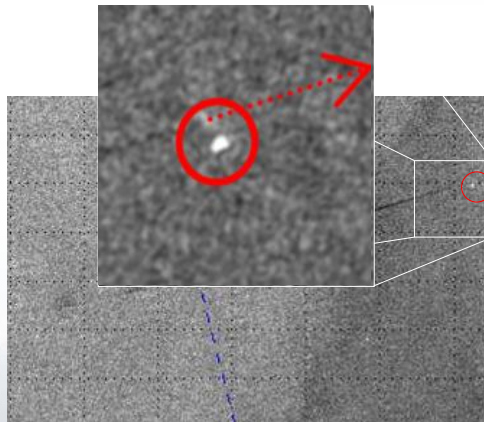
- Vessels have sometimes an associated wake and are often displaced due to "Doppler-effect".
- High Sea State can: generate false positives or negatives (mask vessels)



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SAR Signatures: oil slicks

Vessels may be sometimes slightly off-set from the wake due to the 'Doppler' effect



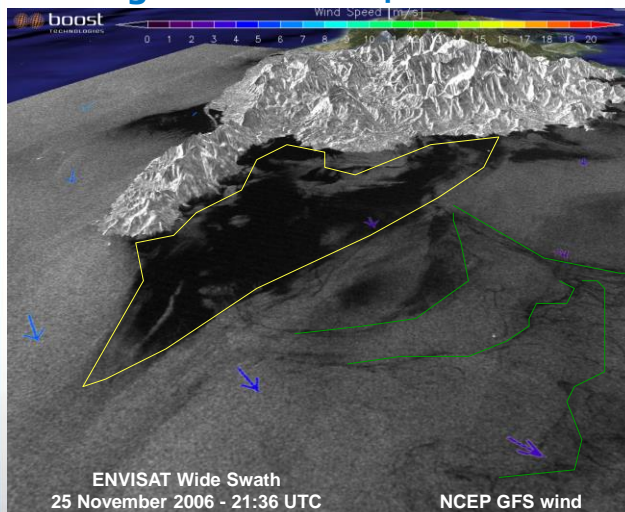
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Data sources used for discrimination

- Sea Surface Temperature
 - MultiSpectral/HyperSpectral
 - Wind (SAR/Meteo)
 - Ice charts
 - Nautical Charts
 - Vessel Traffic Information
- increase of data sources may increase the analysis duration!!**

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SAR Signatures: examples of Lookalikes



Low wind areas

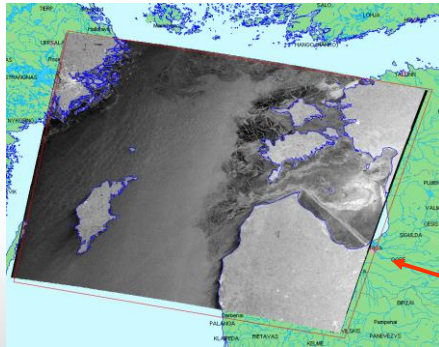
DEM (Digital Elevation Model) of Corsica with wind speed arrows.

Wind shadow areas and the presence of natural films on the sea surface are indicated.

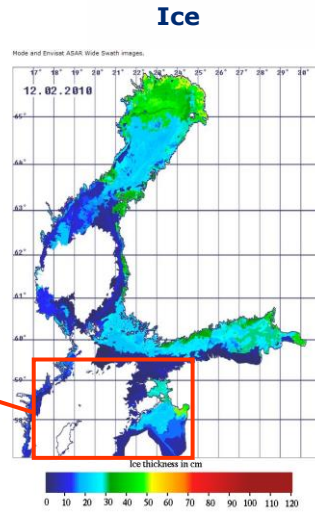
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SAR Signatures: examples of Lookalikes

Acquisition from 12/02/2010 at 09:02:24
over Latvia and Estonia



Ice Thickness Map product provided by The Finnish Meteorological Institute (FMI) under Polar View project, supported by ESA



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SAR Signatures: examples of Lookalikes

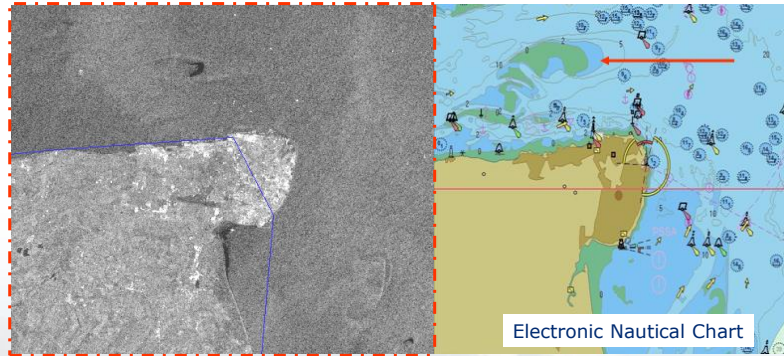


Sea Ice Crevasses

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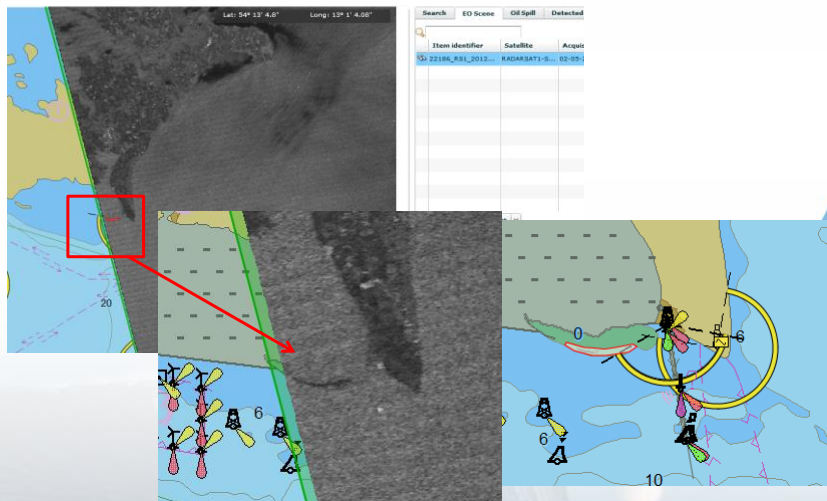
SAR Signatures: examples of Lookalikes

Sandbanks



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Example: sandbank confused with oil spills

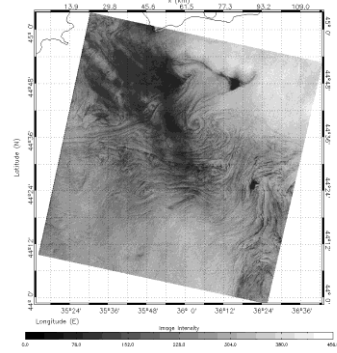


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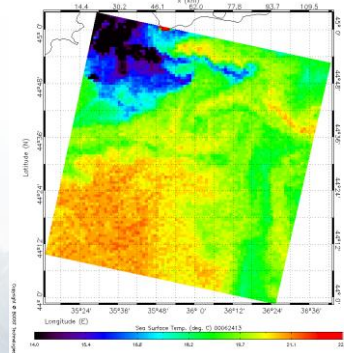
SAR Signatures: examples of Lookalikes

Natural films (organic materials, algae, fish oils) accumulate on sea surface. Patterns of sea surface currents are visible in the SAR images.

**Black Sea - ERS2 Precision Image
24-June-2000**

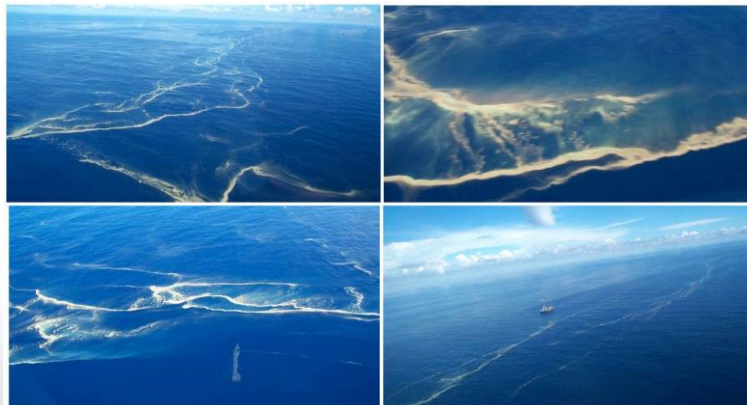


**AVHRR Sea Surface Temperature
24-June-2000**



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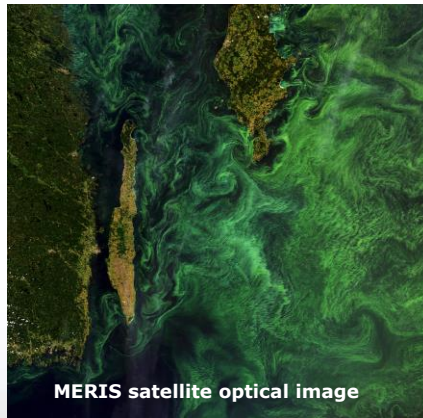
SAR Signatures: examples of Lookalikes Algae bloom



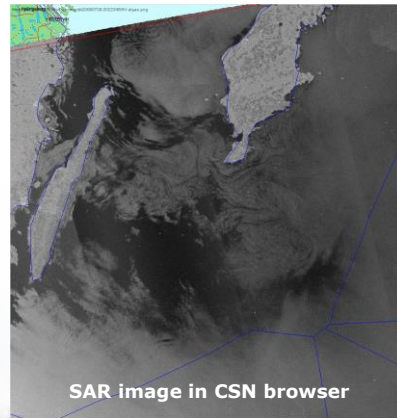
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Algae blooms are a frequent occurrence in the Baltic Sea in Spring and Summer.

SAR Signatures: examples of Lookalikes



MERIS satellite optical image



SAR image in CSN browser

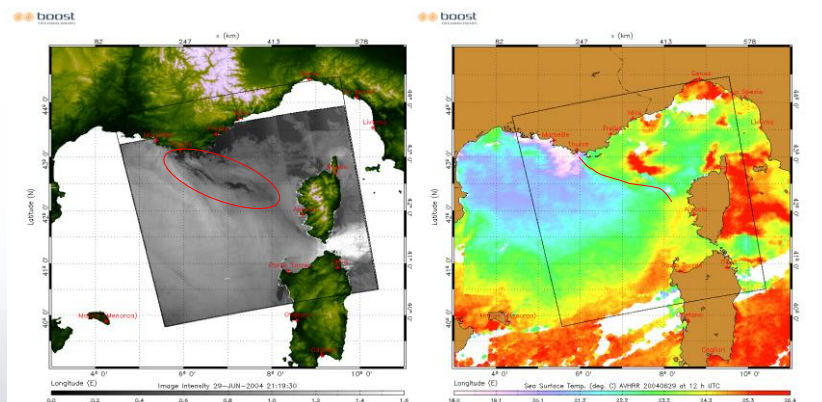
During a bloom, algae can cover extensive areas of the sea surface therefore interfering with the analysis of the image for oil spill detection.

CSN acquisition planning is modified to avoid areas with algae blooms

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SAR Signatures: examples of Lookalikes

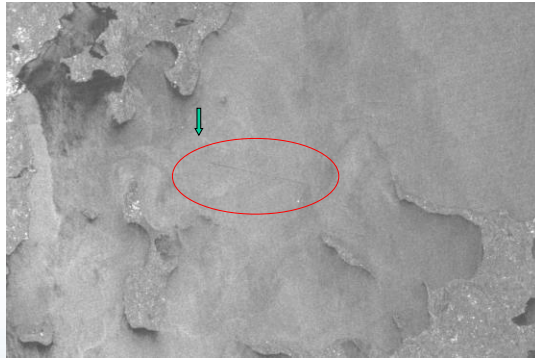
Boundaries of water masses - Areas of convergence or divergence modulate the sea surface roughness



ENVIAT 2004-06-29 21:19:30 UTC and AVHRR Sea Surface Temperature 2004-06-29 12:00 UTC

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SAR Signatures: examples of Lookalikes Vessel Wake

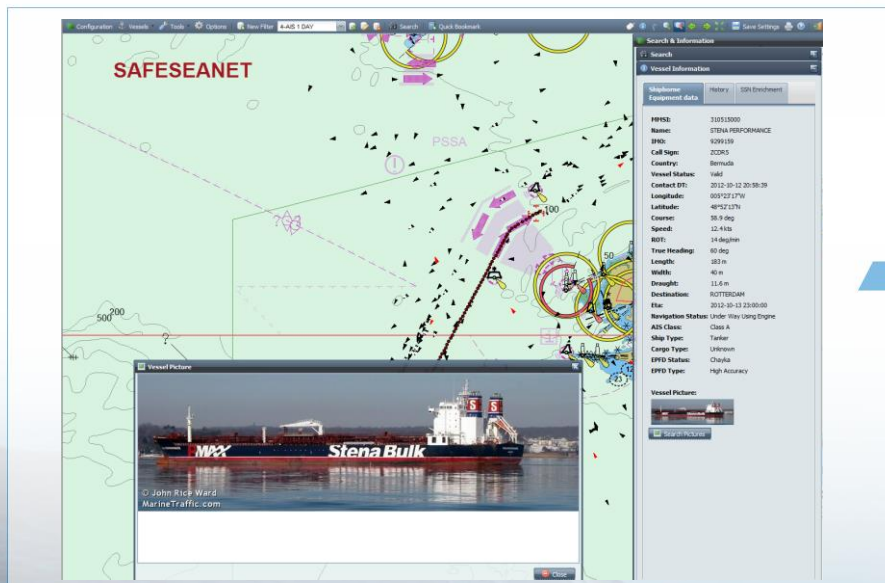


- Image from 2009/03/24
- Kattegat; Denmark
- Linear shaped slick.
- Homogeneous surroundings.
- Low wind 2-4 m/s.
- Source identified.



Propellers or turbines of ships generate intense turbulence in the trailing wake which can persist over several tens of kilometres at low winds (<5 m/s). Ex: High speed crafts

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SAFESSEANET

Stena Bulk

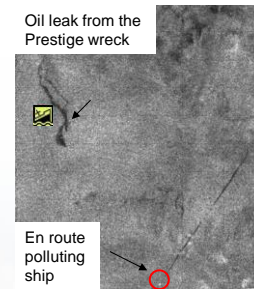
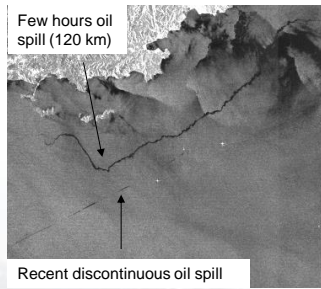
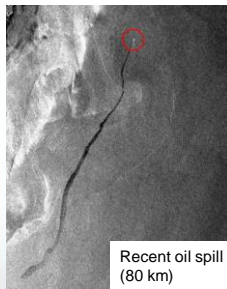
Vessel Information

IMO Number	310130000
Name	STENA PERFORMANCE
MMSI	6299159
Call Sign	Z2285
Country	Bermuda
Vessel Status	Under way
Contact ID	2012-10-12 20:59:39
Longitude	005°12'17W
Latitude	48°52'12N
Course	30.9 deg
Speed	12.4 kts
ROT	14 deg/hr
Tow Heading	60 deg
Length	82 m
Width	40 m
Draught	11.6 m
Destination	ROTTERDAM
ETA	2012-10-13 23:00:00
Navigation Status	Under way using engine
ABX Class	Class A
Ship Type	Tanker
Cargo Type	Unknown
EPFD Status	Onboard
EPFD Type	High Accuracy

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SAR Signatures: oil slicks

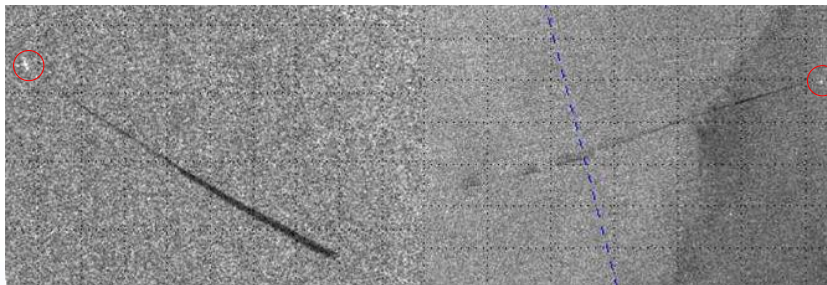
- What are typical signatures/patterns of oil slicks?
- Some examples:



Vessels and Oil Platforms appear in SAR images as bright spots, as they are strong radar 'reflectors'

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SAR Signatures: oil slicks



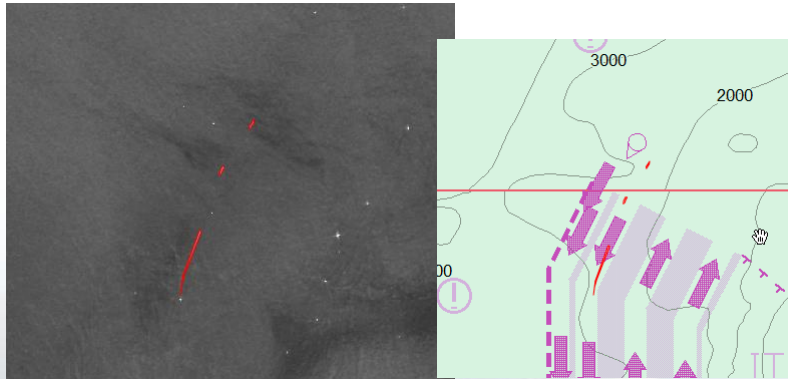
—Shape: linear, ongoing oil discharge, ship visible and attached to the slick.

—Recent spills are visible as linear features, with spreading tail (opening out away from polluting ship).

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SAR Signatures: oil slicks

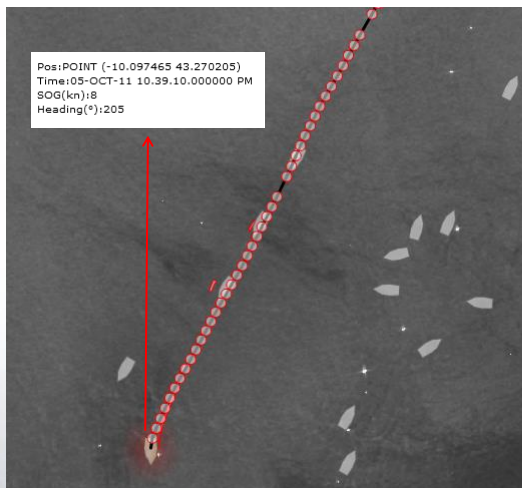
Operational Analysis – Combined Use of Satellite Image and of AIS information



ENVISAT 2011-10-05 22:38:33 UTC – Class A potential spill detected – Close to Galician Coast

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SAR Signatures: oil slicks



Search	EO Scene	Oil Spill	Detect
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

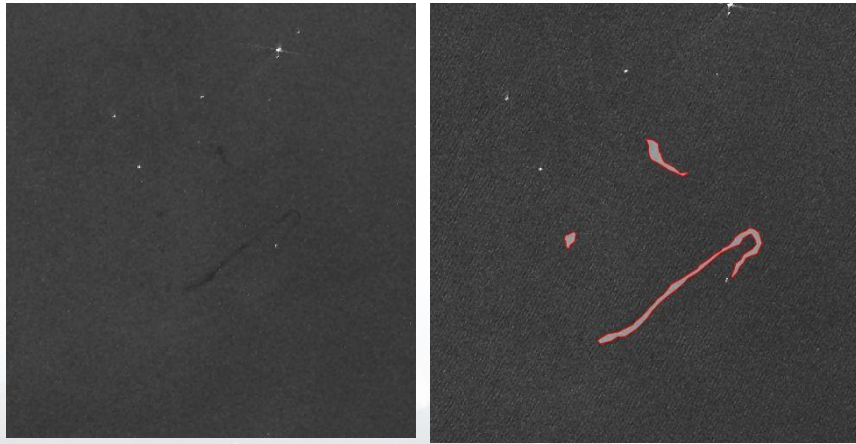
Operational Analysis –
Combined Use of Satellite
Image and of AIS
information

Search in selected scenes

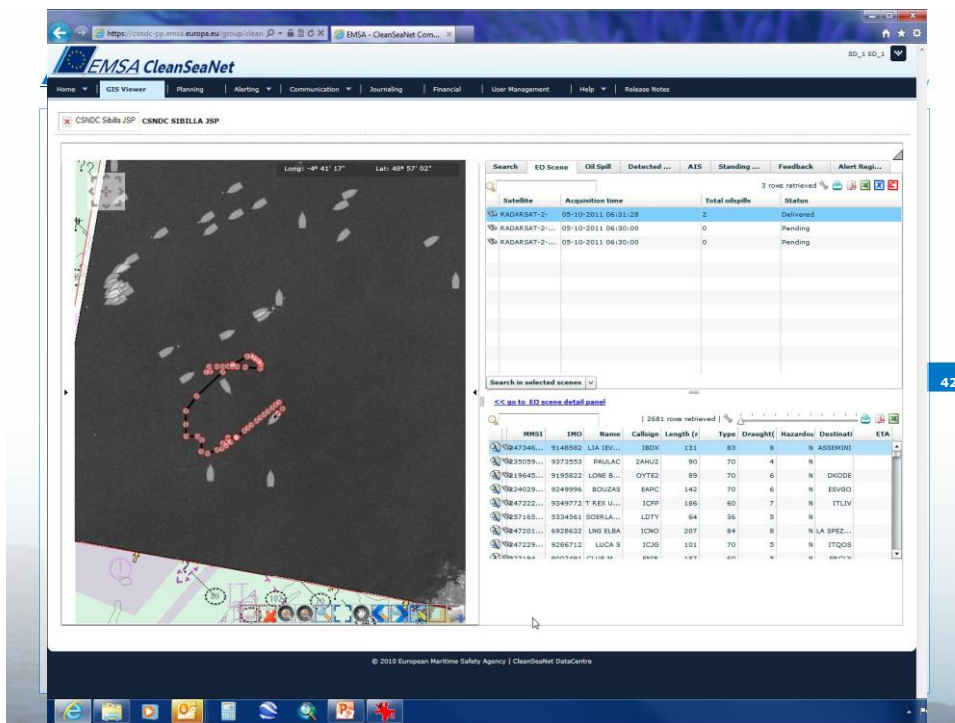
[<< go to EO scene detail panel](#)

MMSI	IMO	Name
305225000		unknown
250002264		
228854000		unknown
227439000		FV NEPTUNE1

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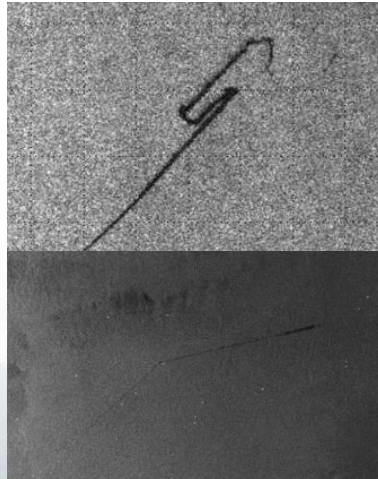
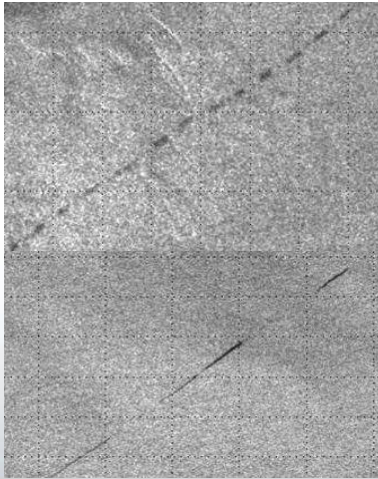
EMSA CLEANSEANET DETECTION: Oil spill and attached vessel visible



© 2010 European Maritime Safety Agency | CleanSeaNet DataCentre

SAR Signatures: oil slicks

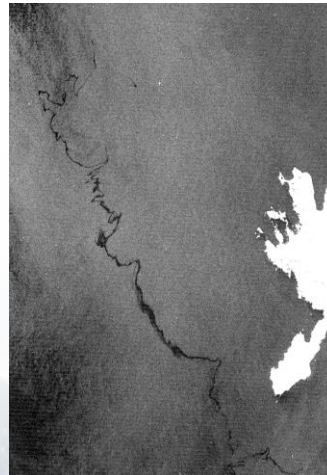
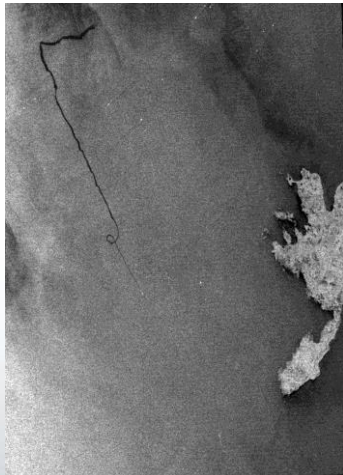
Shape: ship operations, discontinuous discharge, manoeuvres, traffic lanes



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SAR Signatures: oil slicks

Shape: older spill shows the influence of wind and sea surface currents



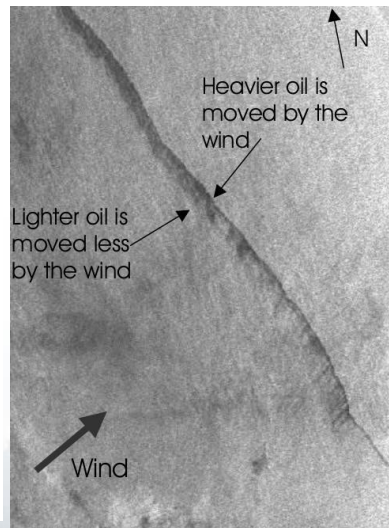
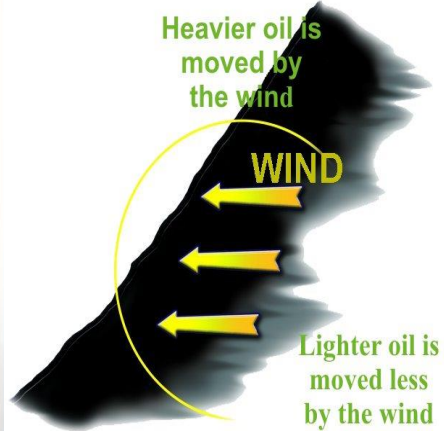
16 September 2003 20:03:35 UTC

17 September 2003 16:13:22 UTC

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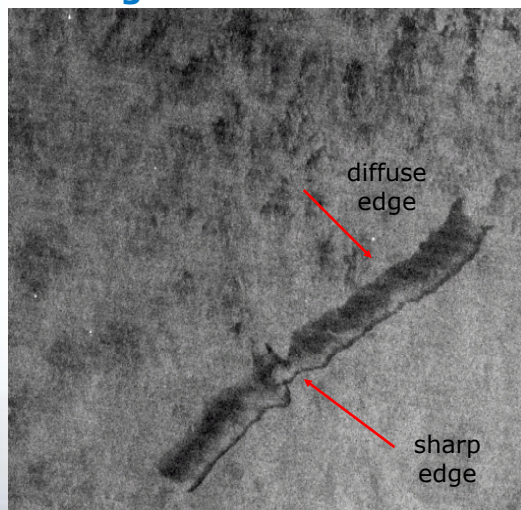
SAR Signatures: oil slicks

Edges: wind effect



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SAR Signatures: oil slicks

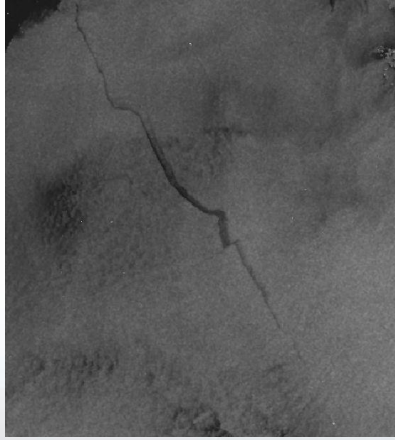


Edges – sharp, diffuse

The wind makes the oil accumulate downwind.

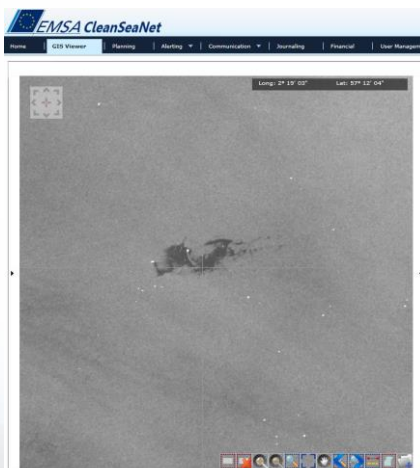
In this image from which direction is the wind blowing?

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EMSA CLEANSEANET DETECTION: Oil spill located within TSS lanes



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EMSA CLEANSEANET DETECTION: Oil spill linked to offshore platform

SAR Signatures

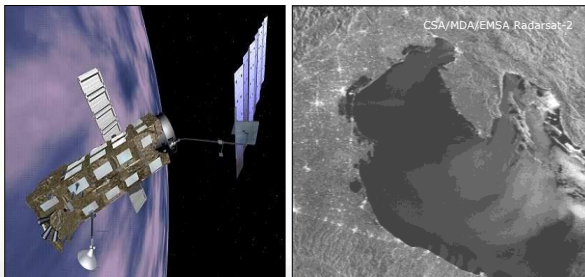
SAR image analysis – main points

- On receiving a CSN alert the duty officer should check the image on the CSN browser and perform an independent analysis
- Wind conditions in the area of the detection should always be consulted (SAR and Meteorological).
- Officers' knowledge of local sea conditions can improve the quality of image analysis - location of estuary outflow, surface current patterns, seasonal occurrence of algae blooms, upwelling, winds, maritime traffic patterns
- Workshops to improve SAR image analysis for oil spill detection are periodically held with overall conclusions reports. Also Harmonization workshops are held among Operators from different SPs

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CleanSeaNet web portal:

<http://cleanseanet.emsa.europa.eu>



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satellite coordinators@emsa.europa.eu