

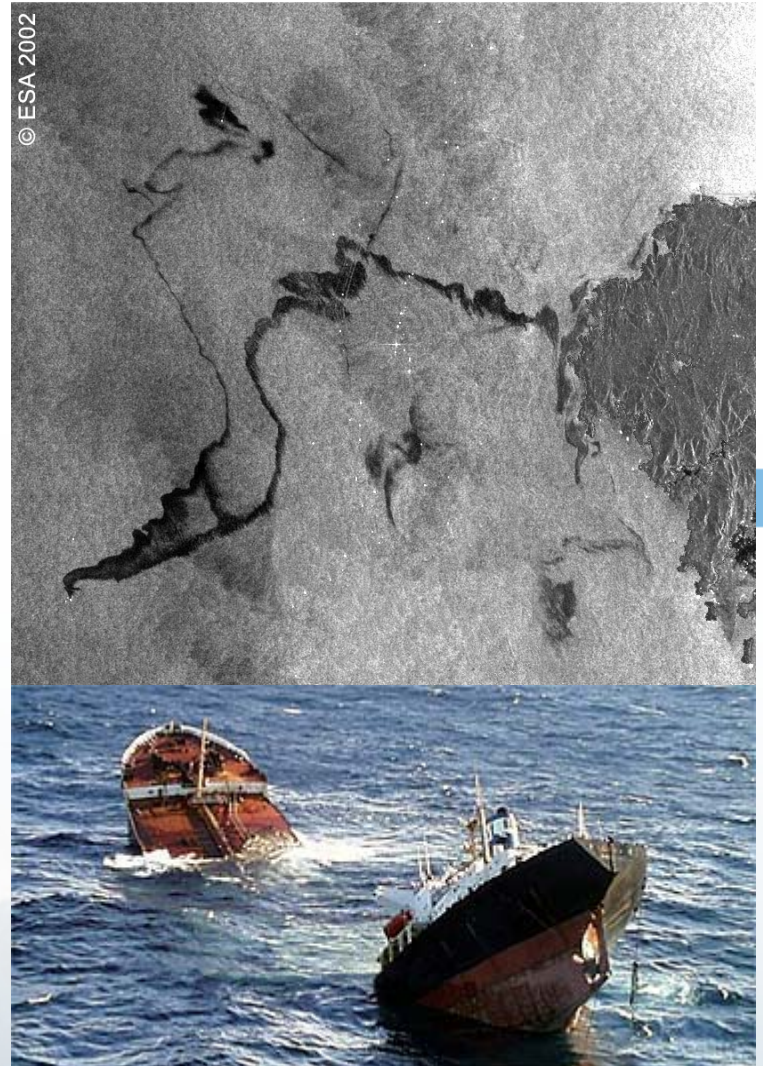
Identification of Oil Spills by Satellite

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EMSA

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Content

- Oil spill problem & behaviour
- Techniques & methodologies for surveillance and detection
- CleanSeaNet service
- Next steps - Modelling
- Outlook & Conclusions



EMSA in a nutshell

EMSA's mandate refers to "ensuring a high, uniform and effective level of maritime safety, maritime security [...], prevention of pollution and response to pollution by ships within the Community"

Set up of EMSA under Regulation (EC) N° 1406/2002 of 27.6.2002

Legal Basis for CleanSeaNet

Article 10 of Directive 2005/35/EC of 7 September 2005 on “Ship-source pollution and on the introduction of penalties for infringements” (entered into force on 1 March 2007):

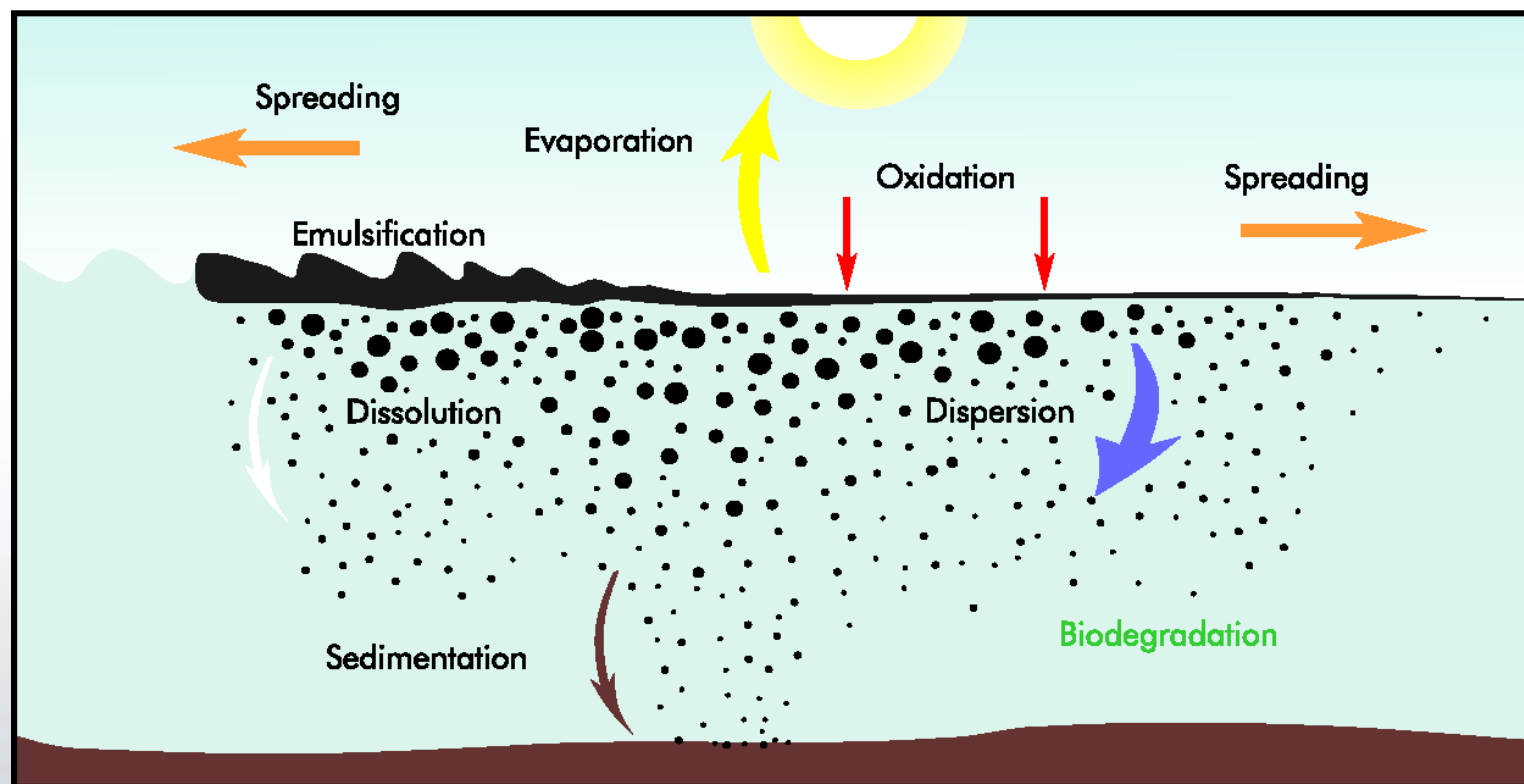
2. In accordance with its tasks as defined in Regulation (EC) No 1406/2002, the European Maritime Safety Agency shall:

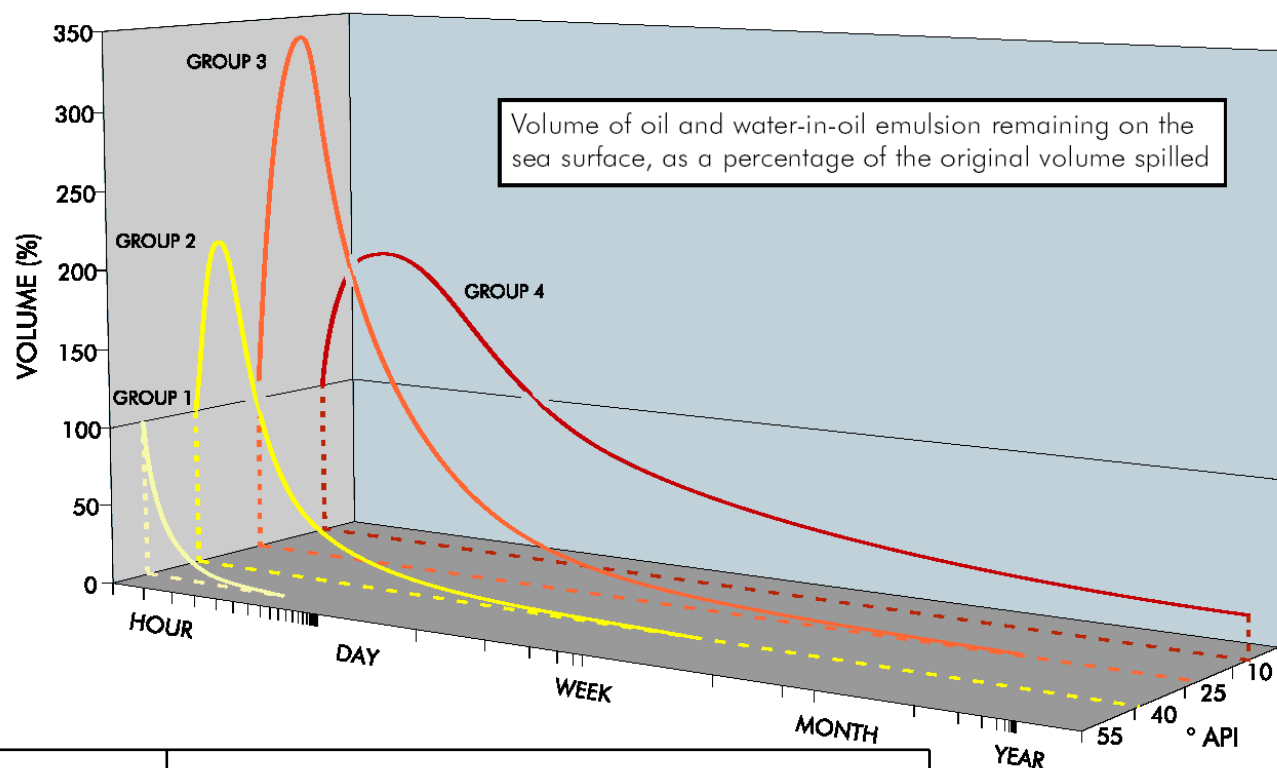
a) **work with the Member States** in developing technical solutions and providing technical assistance in relation to the implementation of this Directive, **in actions such as tracing discharges by satellite monitoring and surveillance;**

- Some 270,000 to 6.3 mio. tonnes of oil are released into the ocean every year.
- UN led “Group of Experts on Scientific Aspects of Marine Environmental Protection (GESAMP):
1.2 mio. tonnes/yr.
- PriceWaterhouseCooper has calculated the annual costs (2005 prices):
 - European spills estimated to 50,100 tonnes/yr
 - for clean-up around €120 million
 - for environmental degradation and all other economic and societal costs €149,600 per tonne;
Multiplied with the estimated volume of oil spillage in European waters: €7.5 billion per year.

Oil spill behaviour: Processes

Source: ITOPF





| Group | Density | Examples |
|-----------|-------------------|--|
| Group I | less than 0.8 | Gasoline, Kerosene |
| Group II | 0.8 - 0.85 | Gas Oil, Abu Dhabi Crude |
| Group III | 0.85-0.95 | Arabian Light Crude, North Sea Crude Oils (e.g. Forties) |
| Group IV | greater than 0.95 | Heavy Fuel Oil, Venezuelan Crude Oils |

Transition from R&D to operational services

Institutional demands

- Int. agreements (e.g. MARPOL)
- European Directives and Regulations

demands

R&D products

- National research (e.g. Universities)
- EU Framework Program
- Int. research co-operations

solutions

Operational services to serve inst. demands

EMSA

- **CleanSeaNet satellite surveillance**

Nat. Activities

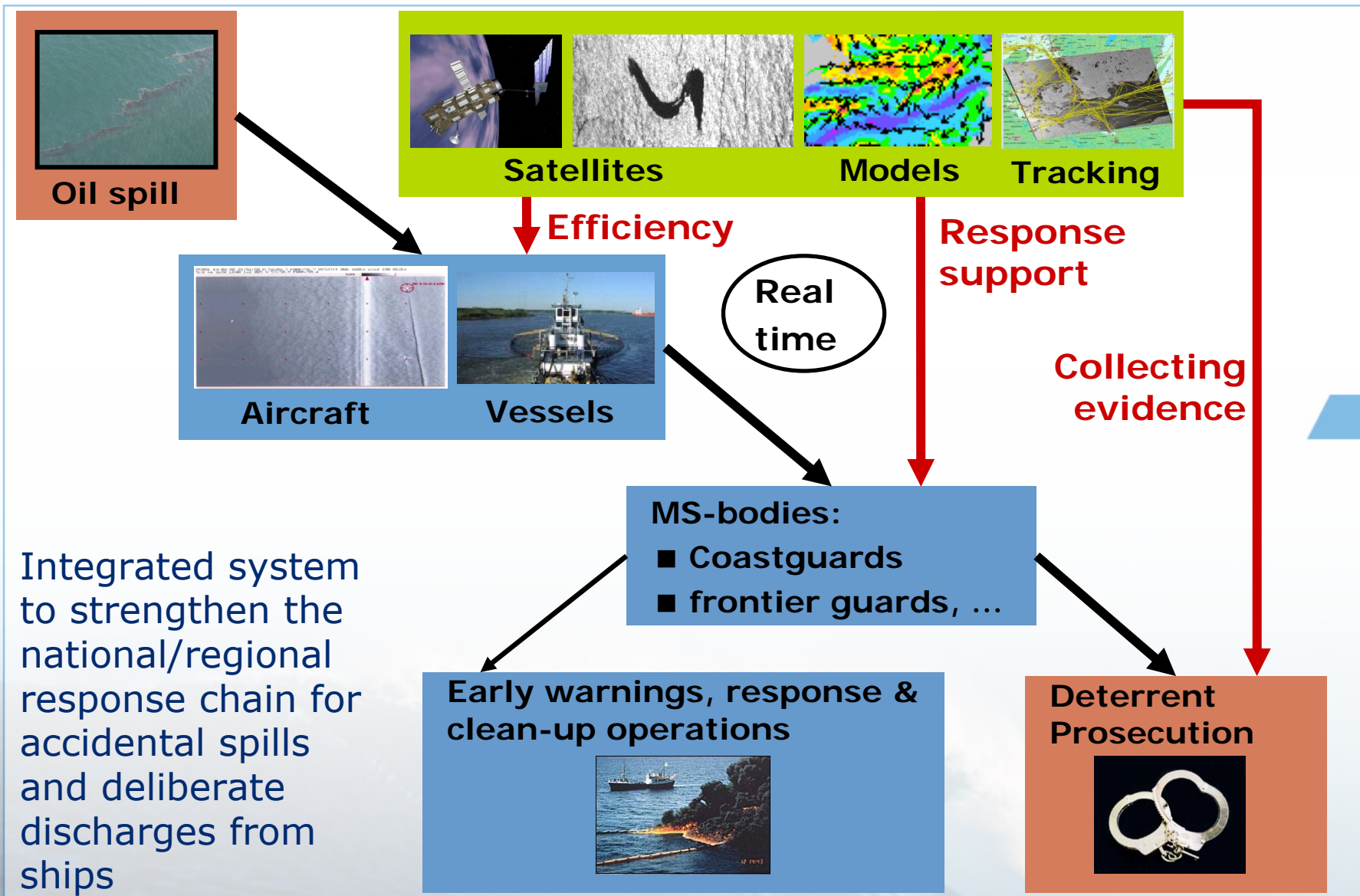
- Aerial surveillance, combating, enforcement

GMES

- Marine Core Services

Scope of the CleanSeaNet oil spill monitoring service

- **European system for detecting oil slicks** at sea using satellite surveillance on request of Coastal States (EU, EU candidate countries and EFTA) and of the Commission.
- To achieve a system that **links into the national/regional response** chain (aerial/naval surveillance) and strengthens routine, operational pollution surveillance of illicit discharges and response for accidental spills
- CleanSeaNet provides a **complete service chain** from the collection of coverage requirements to the provision of operational results.
- **Identification of potential polluters** by combining CleanSeaNet and vessel traffic information and models.



A thick green arrow pointing downwards, indicating the progression of time from 1980 to the future.

1980

Airborne systems

1990

– SLAR, IR/UV, vis. inspection, (MWR, LFS)

Satellite SAR

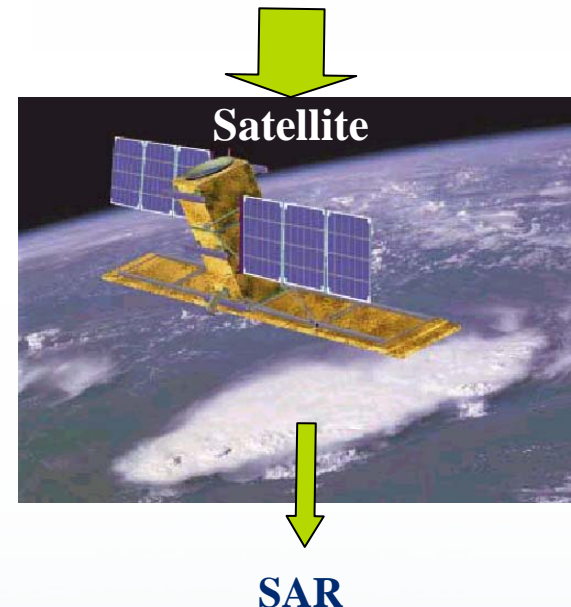
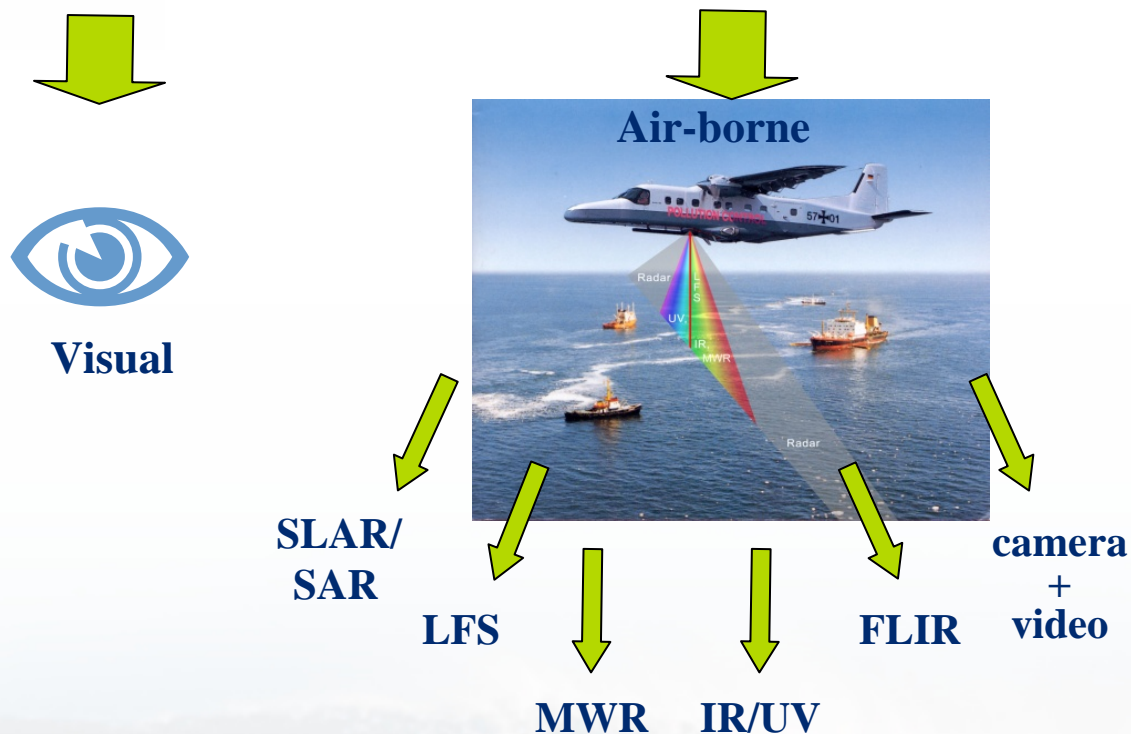
2000

Integration of the systems

future

Complementing with
vessel tracking data, models

Techniques & methodologies:



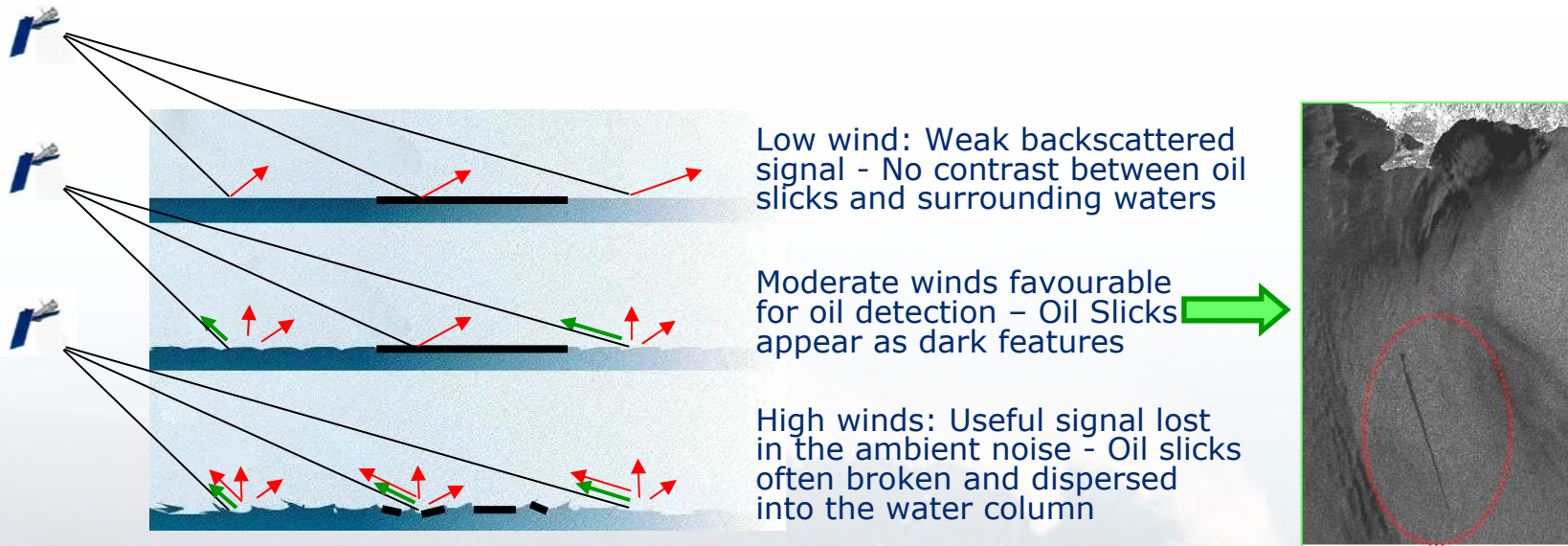
More than 16 of the 24 European and EFTA Coastal States operate aircraft

- aircraft are equipped differently
- flight hours per year vary strongly from CS to CS

EMSA CleanSeaNet service is operational since 04/2007
 EMSA-CSN is providing approx. 2000 satellite SAR images with a growing tendency:
 $2.6 \cdot 10^8 \text{ km}^2 = 728 \cdot \text{Area of Germany (357.000 km}^2\text{)}$

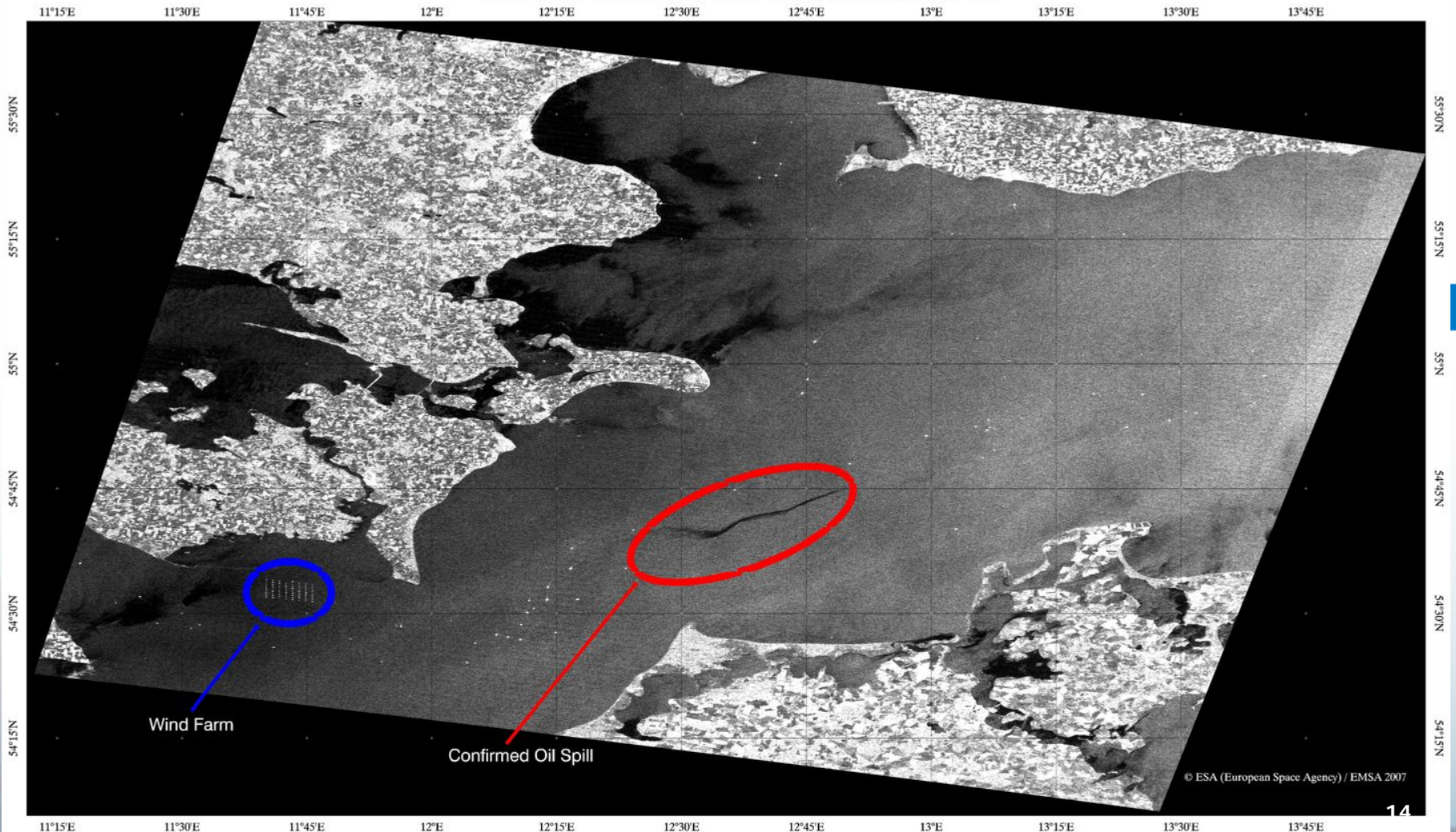
Oil Slick Detection in S(L)AR images

- S(L)AR emits electromagnetic pulses and measures the level of the backscattered signal. Doppler history along track is used for azimuth resolution and signal modulation for range resolution.
- S(L)AR sensors provide information on the **surface roughness** of the ocean. Ocean's roughness is **driven by the wind** which creates ripples at the sea surface.
- The presence of a **film on the sea surface damps out small waves** and **reduces the measured backscattered energy** which results in darker areas in the S(L)AR image



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

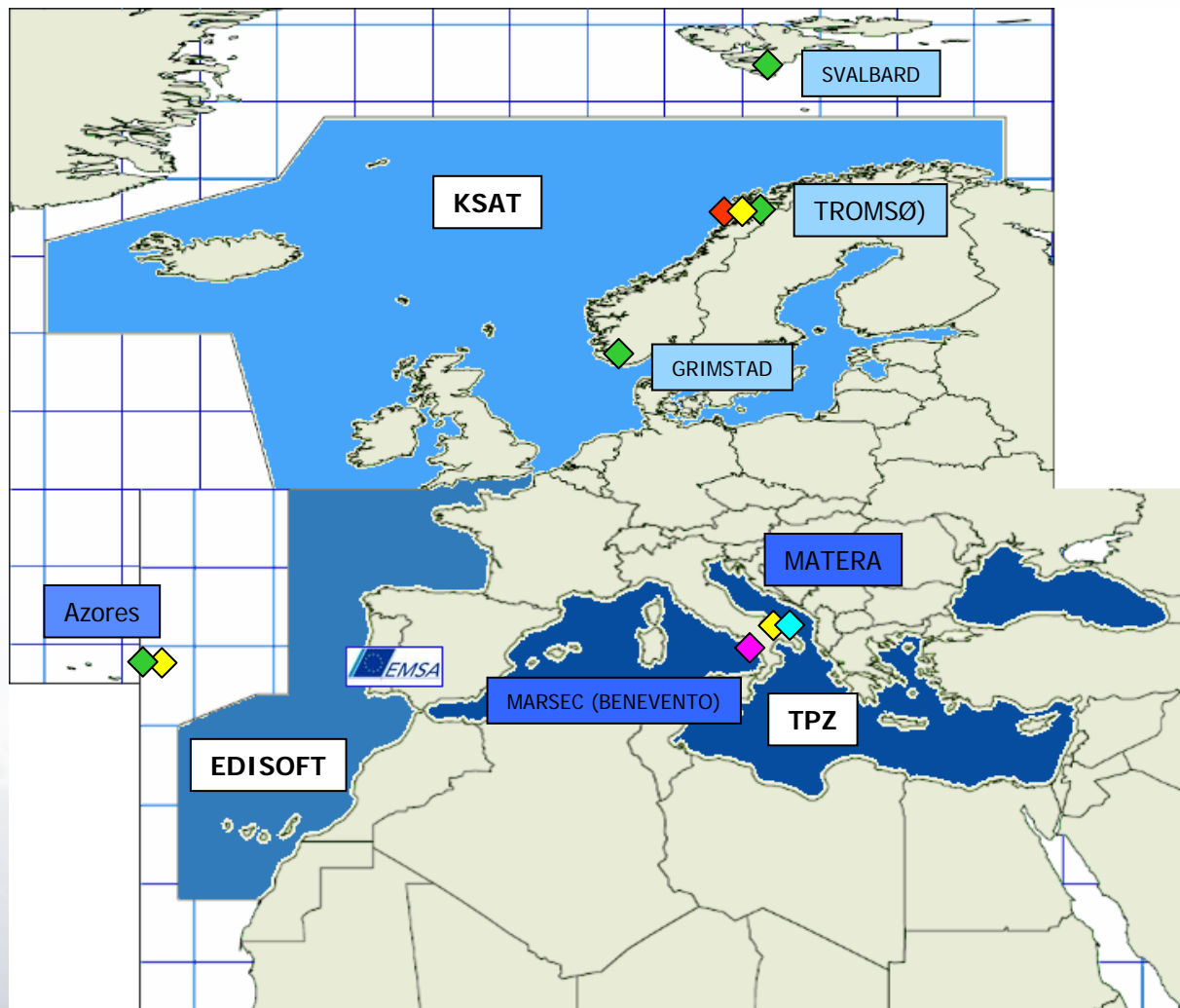
EMSA CleanSeaNet
ENVISAT-ASAR 2007-06-23 09:32:02 UTC, Baltic Sea

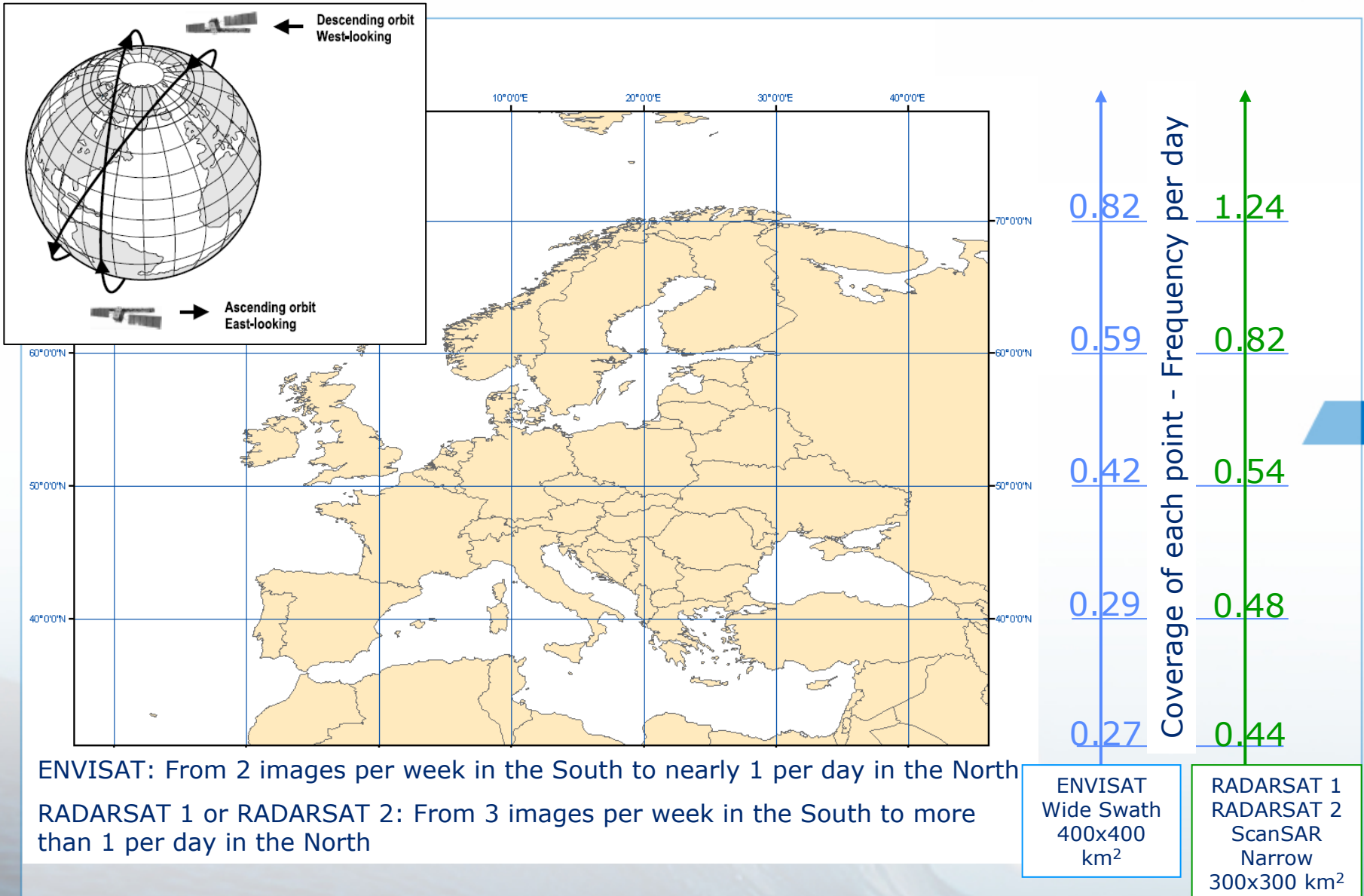


CleanSeaNet satellite Network

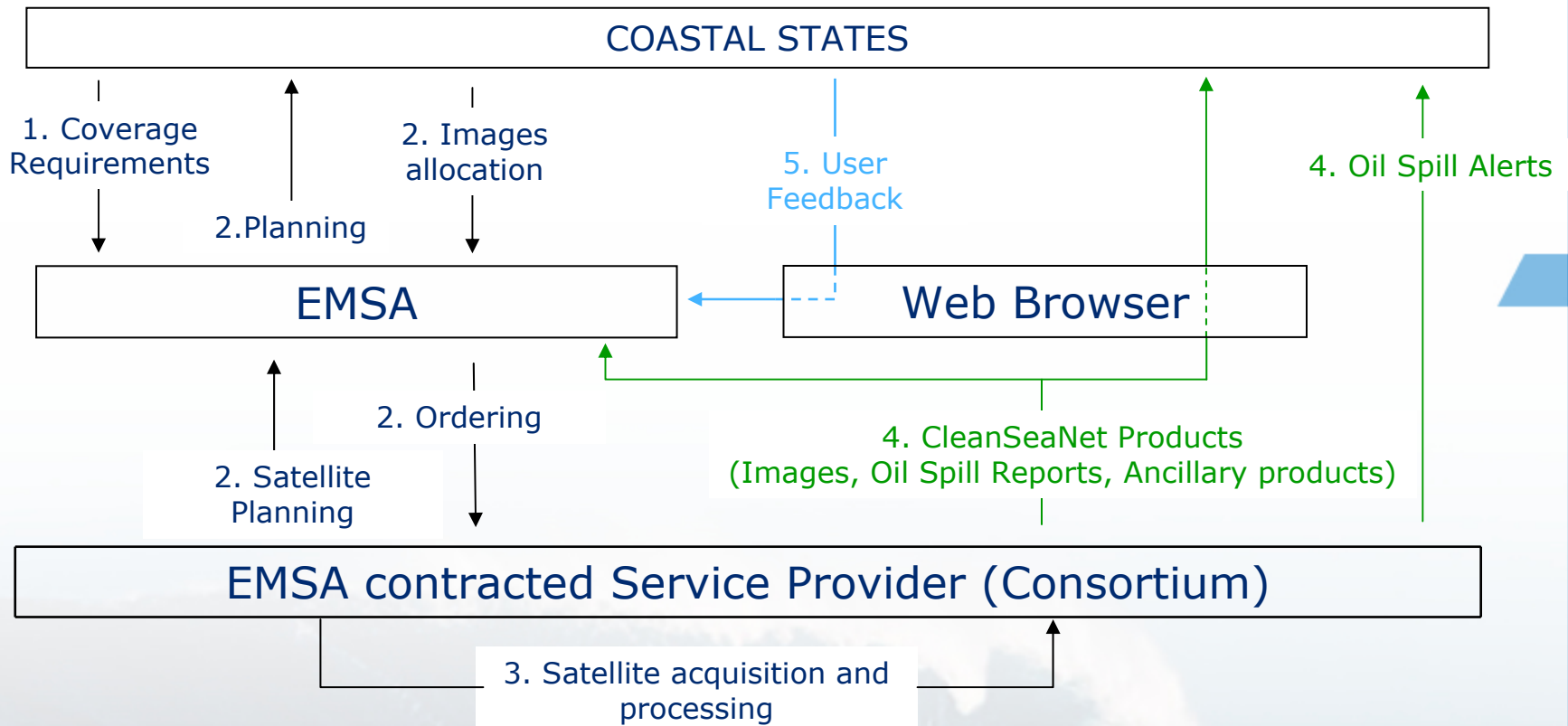
- ENVISAT
(01/03/2002*)
- RADARSAT 1
(04/11/1995*)
- RADARSAT 2
(14/12/2007*)
- Sentinel 1 a/b
(in 2013 ff.)

- Oil Service Desk
- Oil Detection Chain
- Ground Station (ENVISAT and RADARSAT)
- Ground Station (ENVISAT only)
- Ground Station (RADARSAT only)





CleanSeaNet Service Flowchart



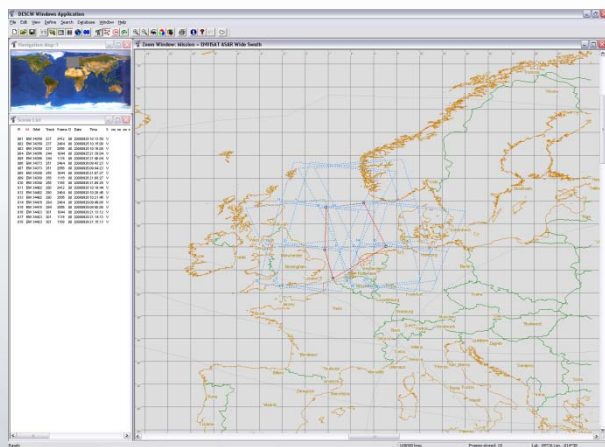
Planning and ordering (1 & 2)



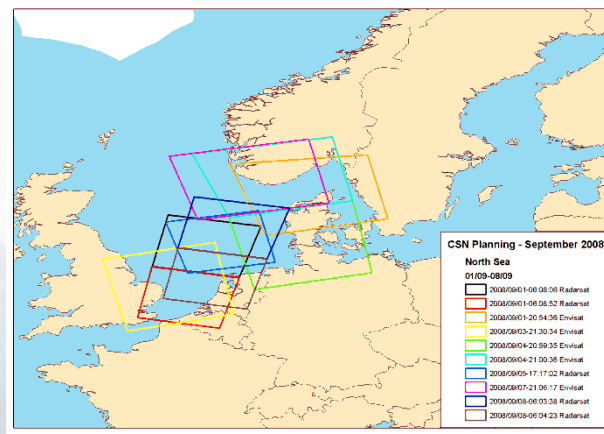
Areas of interest and coverage requirements for each area are defined by the Coastal States on a monthly basis

18

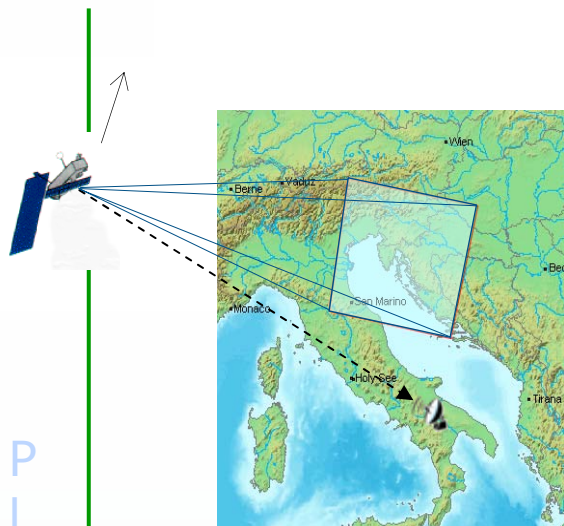
Planning the satellite scenes



Proposed acquisition schedule

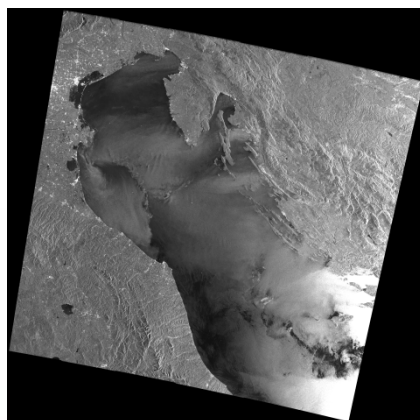


Near Real Time Service – 30 Minutes (3 & 4)



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Acquisition and
Processing



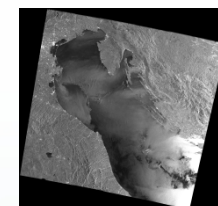
Oil Spill
Analysis

Phone and email alert

Oil Service
Report



Image
(LR, HR)



Ancillary data

Alert &
Product Delivery
(Web Browser, EMSA)

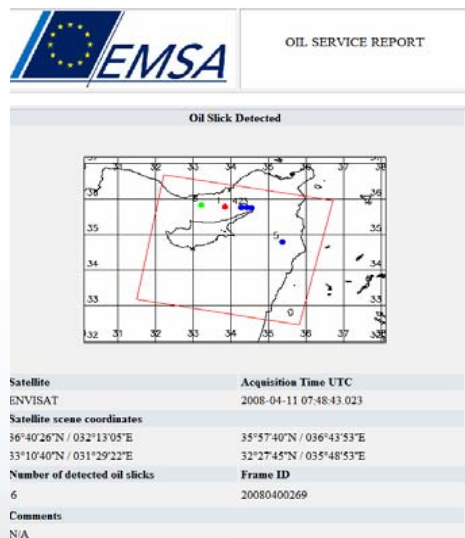
F
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e
d
b
a
c
k

T0 = End of scene acquisition

T = T0 + 30 min


Products delivered by CleanSeaNet

- Satellite images (both in full-resolution and in reduced-resolution) and image data such as acquisition date, geographic coordinates, etc...
- "Oil Spill Reports" or "Clean Sea Reports" containing the indication of the oil spill detected from that image. Reports are delivered in the email alert and are available via the web browser



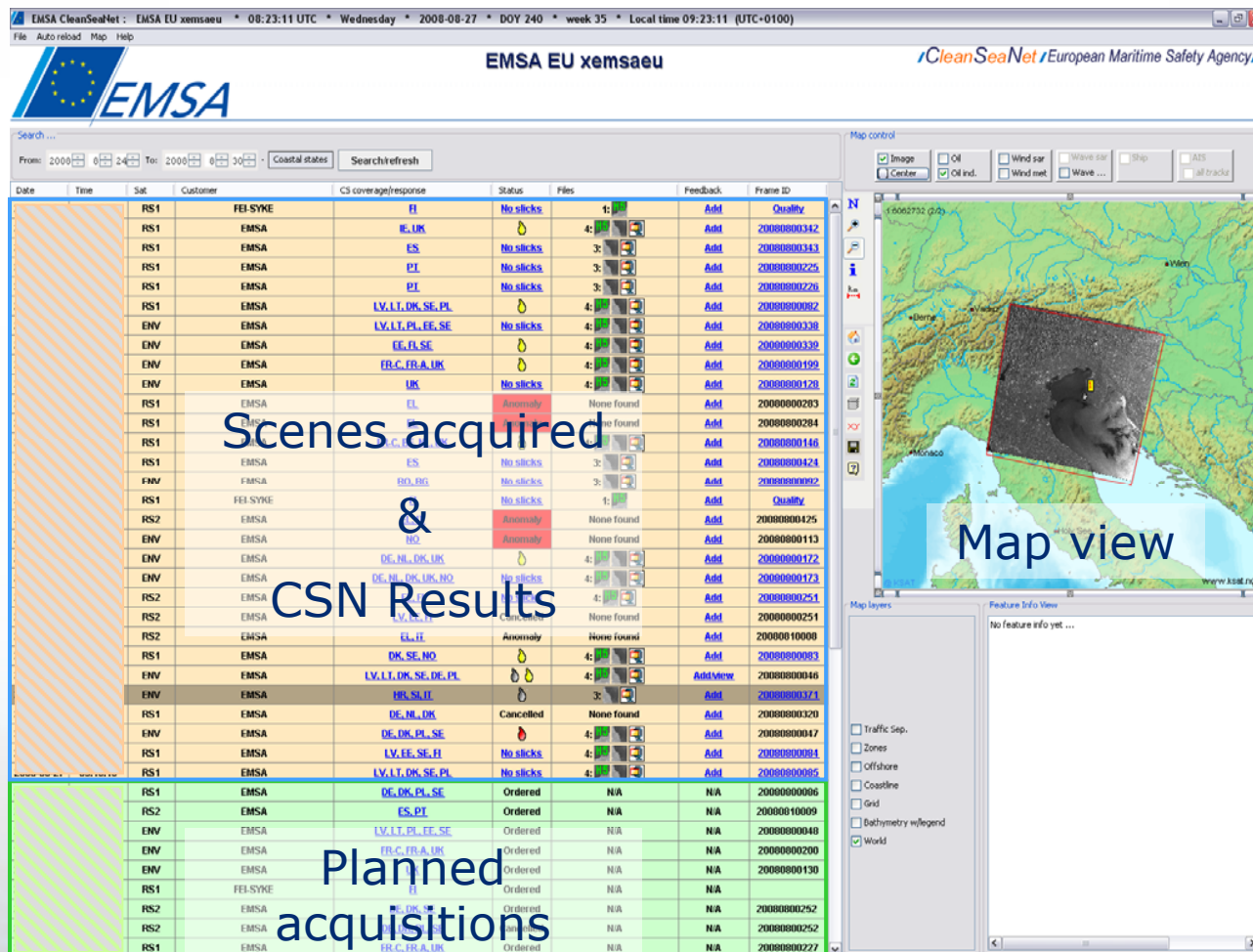
| Oil Slick number | Confidence | Possible sources | Country (EEZ) | |
|------------------|------------|------------------|---------------|-------------------------|
| 1 | HIGH | N/A | Cyprus | Details |
| 2 | MEDIUM | N/A | Cyprus | Details |
| 3 | MEDIUM | N/A | Cyprus | Details |
| 4 | MEDIUM | N/A | Cyprus | Details |
| 5 | MEDIUM | N/A | N/A | Details |
| 6 | LOW | N/A | Turkey | Details |

| Oil Slick number 1 | | Confidence: HIGH | |
|---|-----------------|--------------------|-------------------|
| Central Position: 35°47'03" N / 033°50'43"E | | | |
| Region affected | | Country associated | |
| N/A | | Cyprus | |
| Area | Width | Length | Slick orientation |
| 13.02 km² | 4.75 km | 32.41 km | E-W |
| Possible sources | | | |
| N/A | | | |
| Characteristics | | | |
| Type: | Angular | Skape: | Smooth |
| Contrast: | Medium | Edges: | Sharp |
| Surroundings: | Homogeneous | | |
| Met ocean data: | | | |
| Model Wind: | 4 m/s from 311° | Model Wave: | 0 m |
| SAR Wind: | 3 m/s from 281° | SAR Wave: | N/A |
| Sea Surface Temperature: | 18°C | Sea Current: | 0 m/s |
| Criteria for confidence level | | | |
| Medium contrast, sharp edges, smooth angular shaped slick, source: N/A, homogeneous surrounding | | | |
| Comments | | | |
| N/A | | | |

Potential oil spills with 3 Confidence levels (low, medium and high ) are reported as well as "Clean Sea" reports

- Associated ancillary data: meteorological wind and wave data, SAR wind and SAR swell data derived from the image
- Other ancillary data when available from external providers like AIS information

The EMSA CleanSeaNet Web Browser



EMSA CleanSeaNet : EMSA EU xemsaeu * 08:23:11 UTC * Wednesday * 2008-08-27 * DOY 240 * week 35 * Local time 09:23:11 (UTC+0100)

File Auto reload Map Help

EMSA EU xemsaeu

CleanSeaNet / European Maritime Safety Agency

Search ...

From: 2000 To: 2000 Coastal states Search refresh

| Date | Time | Sat | Customer | CS coverage/response | Status | Files | Feedback | Frame ID |
|------|------|----------|----------|------------------------|-----------|------------|----------|-------------|
| RS1 | | FEI-SYKE | | FI | No slicks | 1: | Add | Quality |
| RS1 | | EMSA | | IE, UK | No slicks | 4: | Add | 20080800342 |
| RS1 | | EMSA | | ES | No slicks | 3: | Add | 20080800343 |
| RS1 | | EMSA | | PT | No slicks | 3: | Add | 20080800225 |
| RS1 | | EMSA | | PT | No slicks | 3: | Add | 20080800226 |
| RS1 | | EMSA | | LV, LT, DK, SE, PL | No slicks | 4: | Add | 20080800092 |
| ENV | | EMSA | | LV, LT, PL, EE, SE | No slicks | 4: | Add | 20080800338 |
| ENV | | EMSA | | DE, PL, SE | No slicks | 4: | Add | 20080800339 |
| ENV | | EMSA | | FR, C, FRA, UK | No slicks | 4: | Add | 20080800199 |
| ENV | | EMSA | | UK | No slicks | 4: | Add | 20080800120 |
| RS1 | | EMSA | | EL | Anomaly | None found | Add | 20080800203 |
| RS1 | | EMSA | | ES | Anomaly | None found | Add | 20080800284 |
| RS1 | | EMSA | | ES | No slicks | 3: | Add | 20080800146 |
| RS1 | | EMSA | | ES | No slicks | 3: | Add | 20080800424 |
| ENV | | EMSA | | RO, BG | No slicks | 3: | Add | 20080800092 |
| RS1 | | FEI-SYKE | | | No slicks | 1: | Add | Quality |
| RS2 | | EMSA | | | Anomaly | None found | Add | 20080800425 |
| ENV | | EMSA | | NO | Anomaly | None found | Add | 20080800113 |
| ENV | | EMSA | | DE, NL, DK, UK | No slicks | 4: | Add | 20080800172 |
| ENV | | EMSA | | DE, NL, DK, UK, NO | No slicks | 4: | Add | 20080800173 |
| RS2 | | EMSA | | LV, LT, DK, SE, PL | No slicks | 4: | Add | 20080800251 |
| RS2 | | EMSA | | LV, LT, DK, SE, PL | No slicks | 4: | Add | 20080800251 |
| RS2 | | EMSA | | EL, IT | Anomaly | None found | Add | 20080810000 |
| RS1 | | EMSA | | DK, SE, NO | No slicks | 4: | Add | 20080800083 |
| ENV | | EMSA | | LV, LT, DK, SE, DE, PL | No slicks | 4: | Add | 20080800046 |
| ENV | | EMSA | | DE, NL, DK, UK | No slicks | 3: | Add | 20080800371 |
| RS1 | | EMSA | | DE, NL, DK | Cancelled | None found | Add | 20080800320 |
| ENV | | EMSA | | DK, DK, PL, SE | No slicks | 4: | Add | 20080800047 |
| RS1 | | EMSA | | LV, EE, SE, FI | No slicks | 4: | Add | 20080800084 |
| RS1 | | EMSA | | LV, LT, DK, SE, PL | No slicks | 4: | Add | 20080800095 |
| RS1 | | EMSA | | DK, DK, PL, SE | Ordered | N/A | | 20080800006 |
| RS2 | | EMSA | | ES, PT | Ordered | N/A | | 20080810009 |
| ENV | | EMSA | | LV, LT, PL, EE, SE | Ordered | N/A | | 20080800048 |
| ENV | | EMSA | | FR, C, FRA, UK | Ordered | N/A | | 20080800200 |
| ENV | | EMSA | | | Ordered | N/A | | 20080800130 |
| RS1 | | FEI-SYKE | | FI | Ordered | N/A | | N/A |
| RS2 | | EMSA | | DE, DK, UK | Ordered | N/A | | 20080800252 |
| RS2 | | EMSA | | | Ordered | N/A | | 20080800252 |
| RS1 | | EMSA | | FR, C, FRA, UK | Ordered | N/A | | 20080800227 |

Scenes acquired & CSN Results

Planned acquisitions

Map view

Map control

Image Center Oil Oil ind. Wind dir Wind met Wave ... Ship AIS All tracks

Map layers

Feature Info View

No feature info yet ...

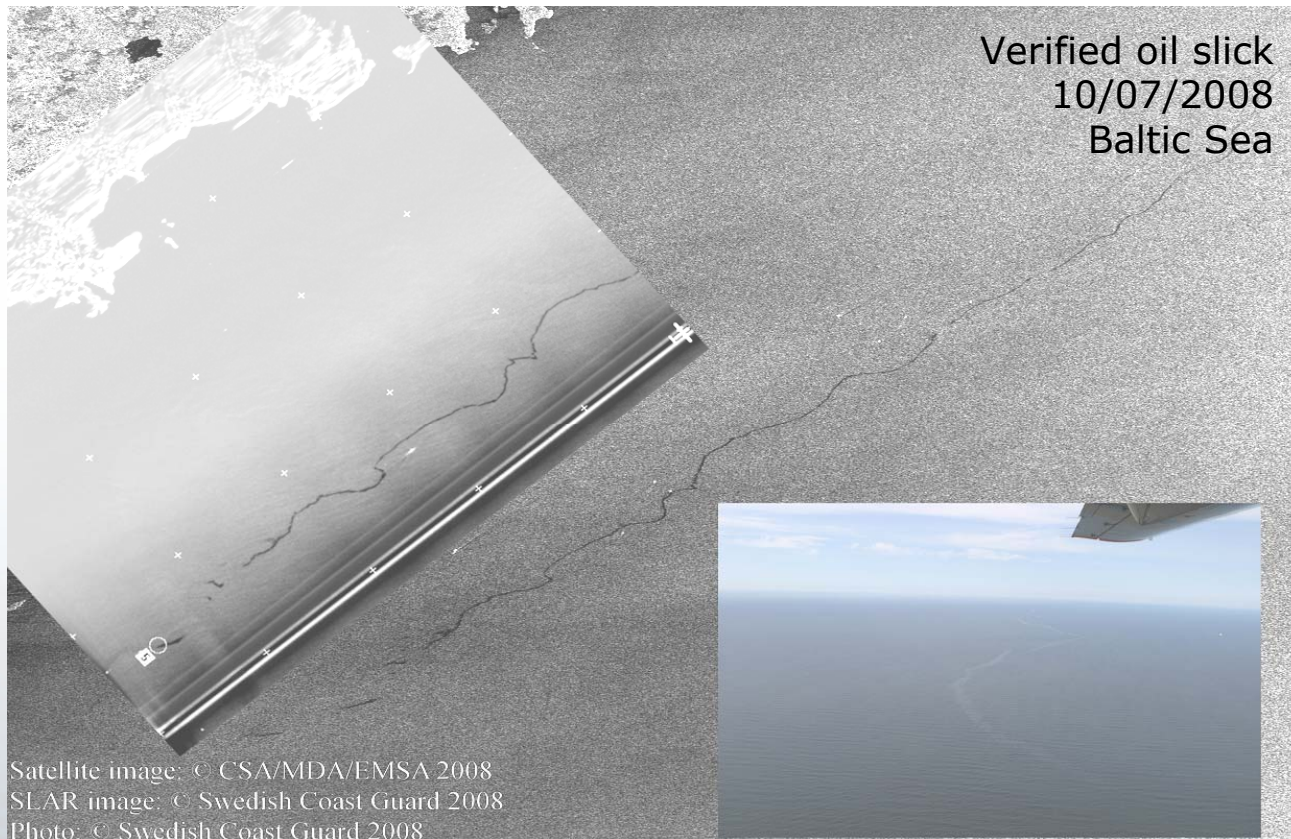
Traffic Sep. Zones Offshore Coastline Grid Bathymetry w/legend World

This centralised interface allows:

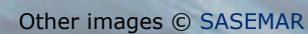
- Viewing the acquisition plan
- Viewing and downloading CSN products
- Providing Feedback

Follow-up and Feedback by Coastal States (5)

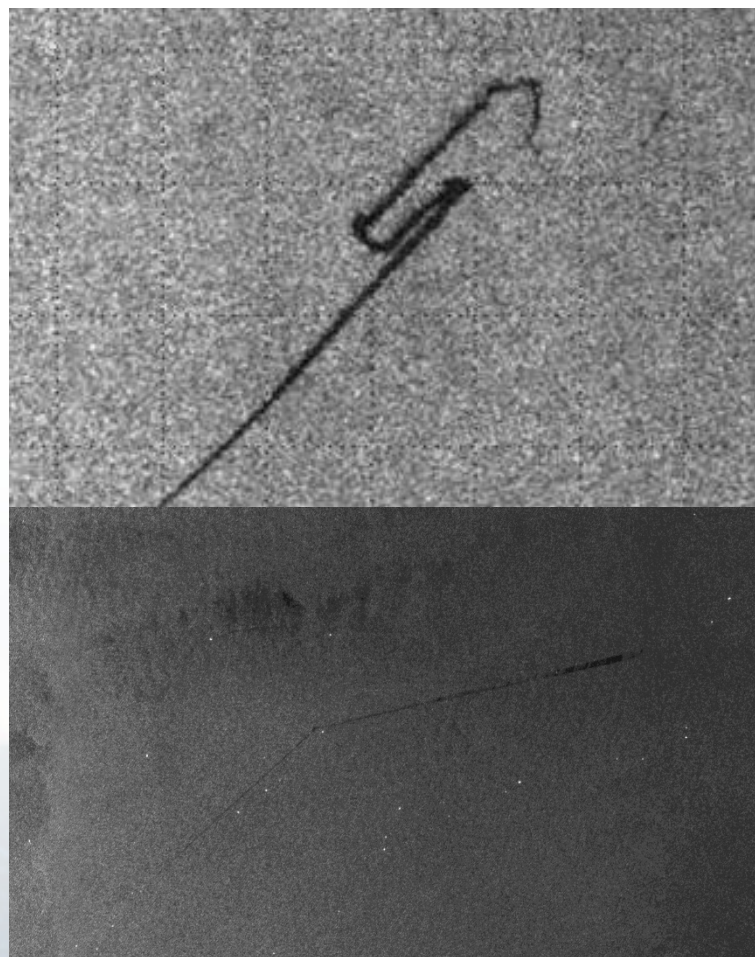
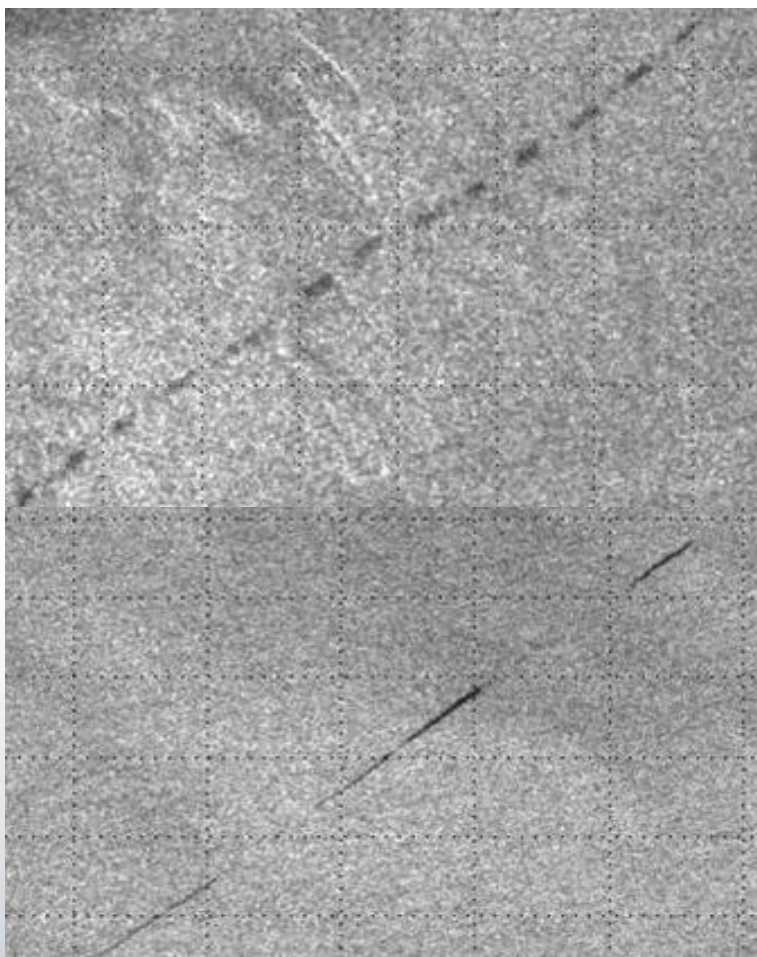
Coastal States are responsible for follow-up actions on oil spill indications. According to the CleanSeaNet conditions of use, they should verify spills as completely as possible and provide feedback to EMSA.



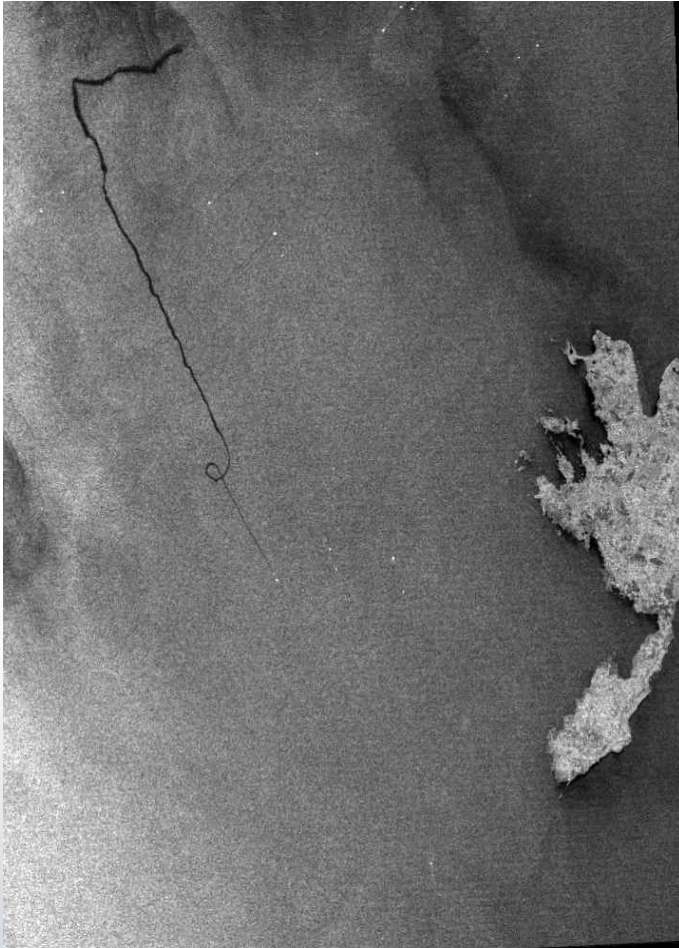
23



Pollution resulting from ship operations: discontinuous discharge from ship, manoeuvres, traffic lanes



Influence of wind and sea surface currents



16 September 2003 20:03:35 UTC



17 September 2003 16:13:22 UTC

Oil Slick Detection in SAR images – Look-alikes

SAR sensors detect all **films on the sea surface that damp out small waves generated by the wind.**

CleanSeaNet detections are **not “Oil Spills” but “Potential Oil Spills”**. Discrimination between Oil Spills and Look-alikes require more information and most often in-situ verification.

How to reduce the number of false alarms?: good knowledge of local conditions (Winds, currents, vessel traffic,...), improvement of the oil detection chain by a thorough analysis of feedback and by gathering experience

Look-alikes:

- Other man-made substances: fish or vegetable oil, chemical, sewage, other...
- Natural phenomena: low wind area, algae, current front, upwelling area...



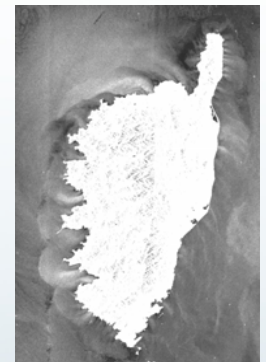
Current fronts



Low wind, rain cells
and oil seepage

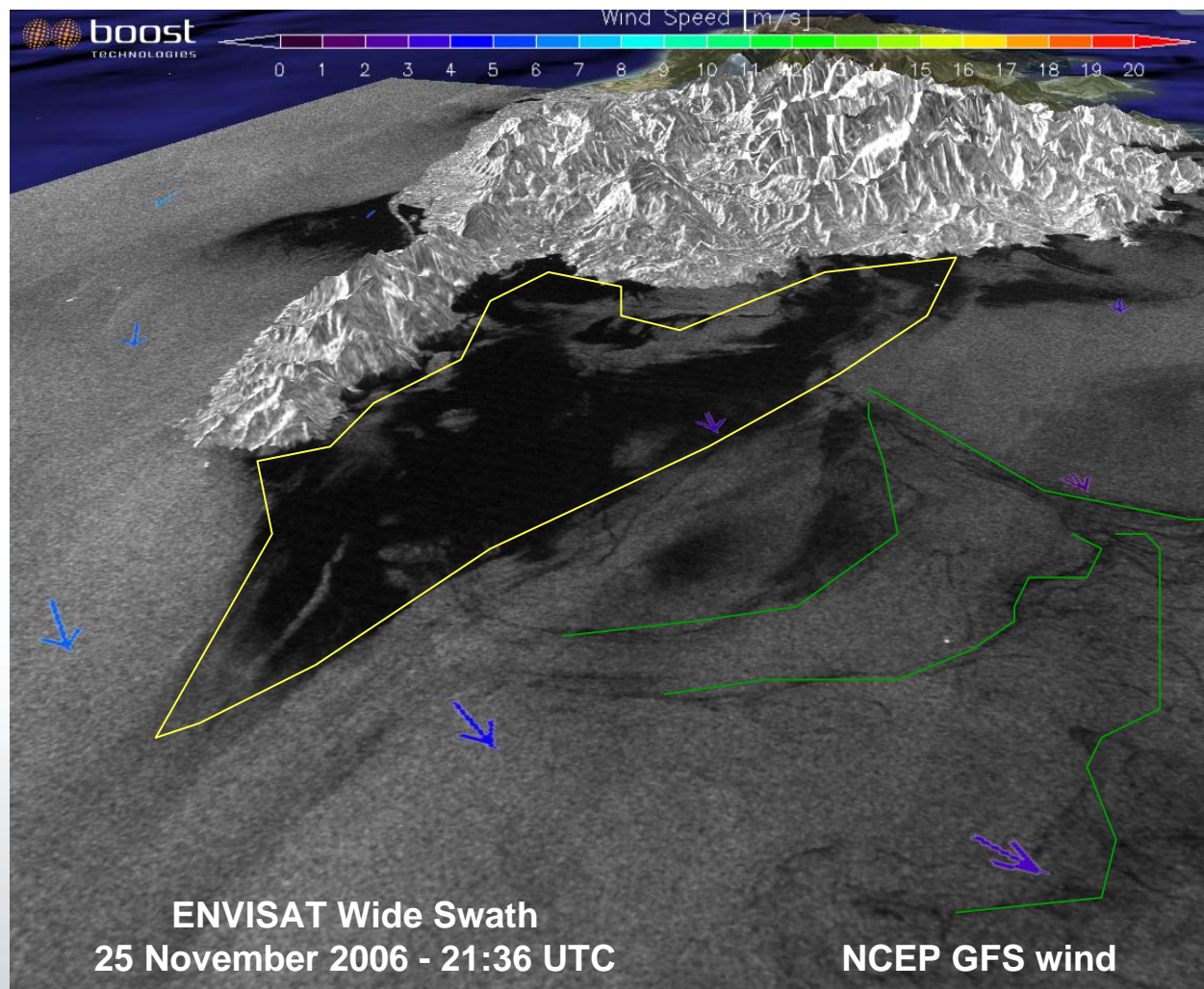


Algae



Land breeze

Low wind speed



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

27

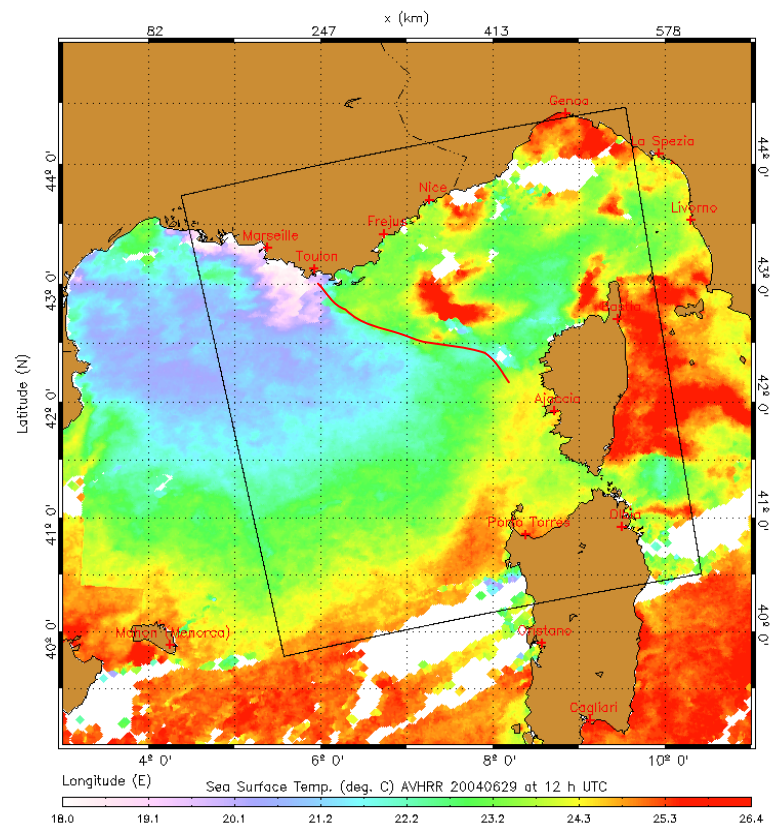
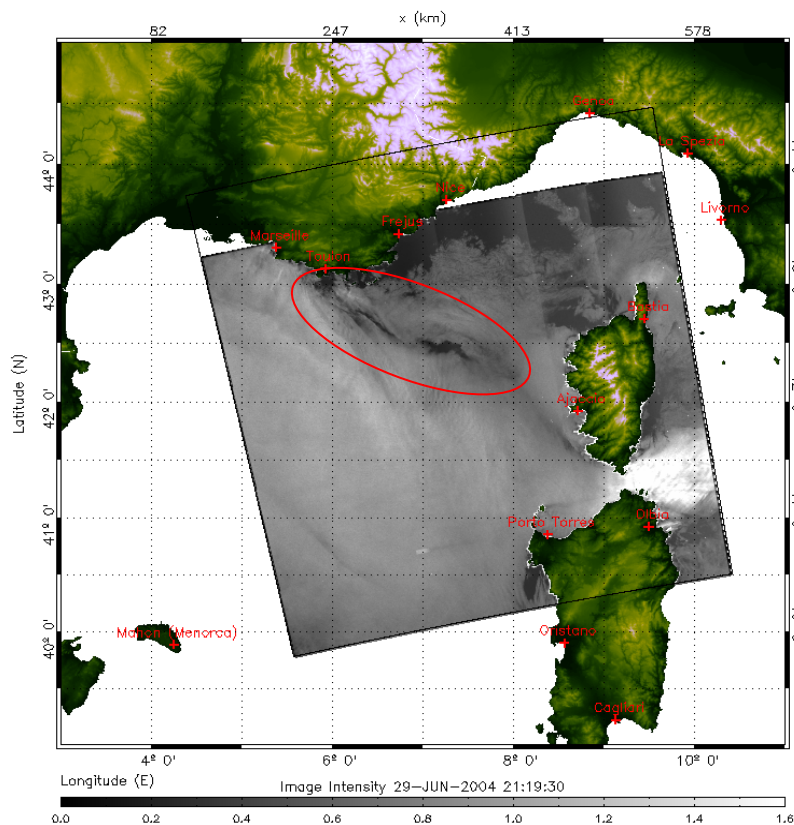
Wind shadow areas and the presence of natural films on the sea surface are indicated.

Boundaries of water masses

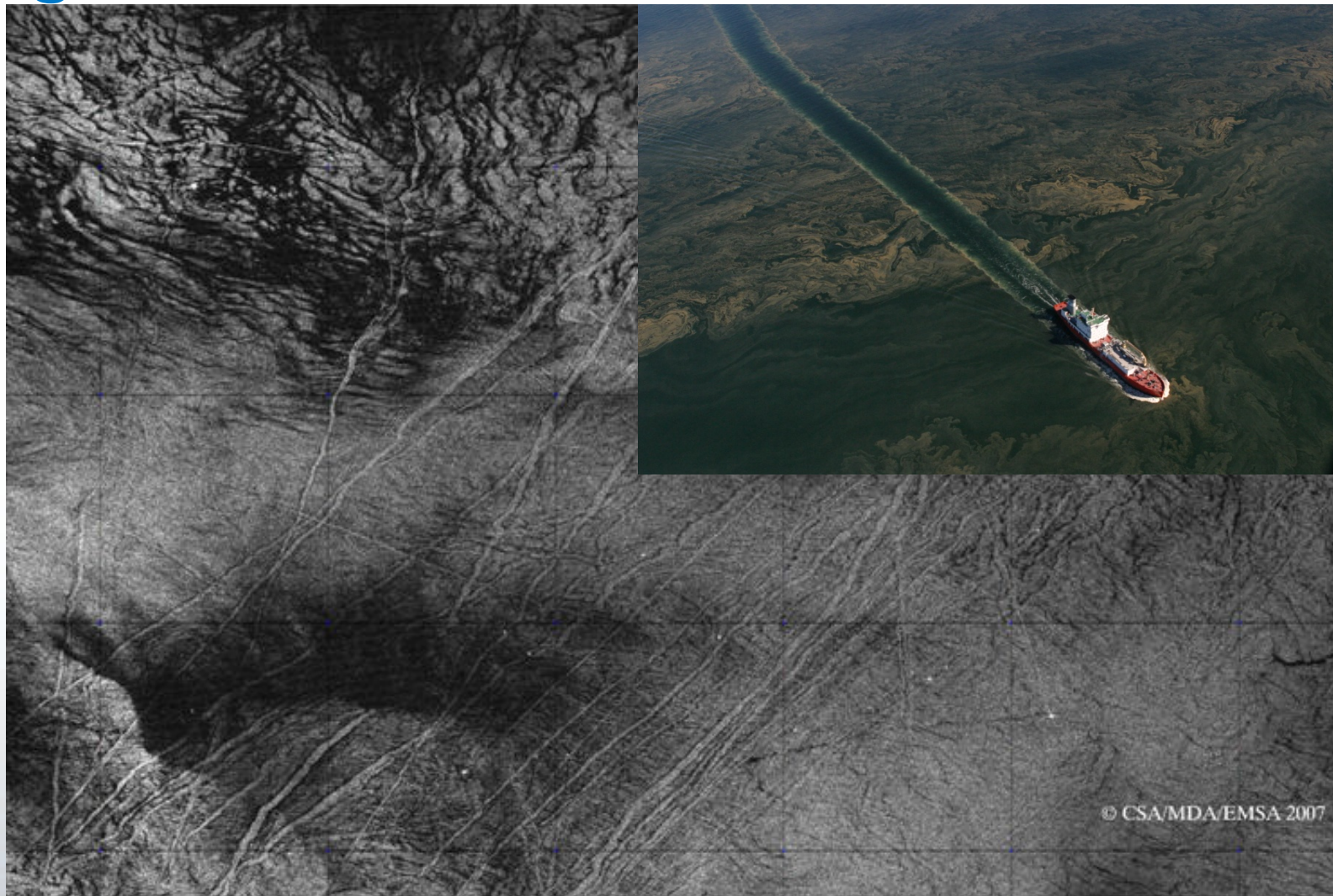
Areas of convergence or divergence modulate the sea surface roughness

boost
TECHNOLOGIES

boost
TECHNOLOGIES



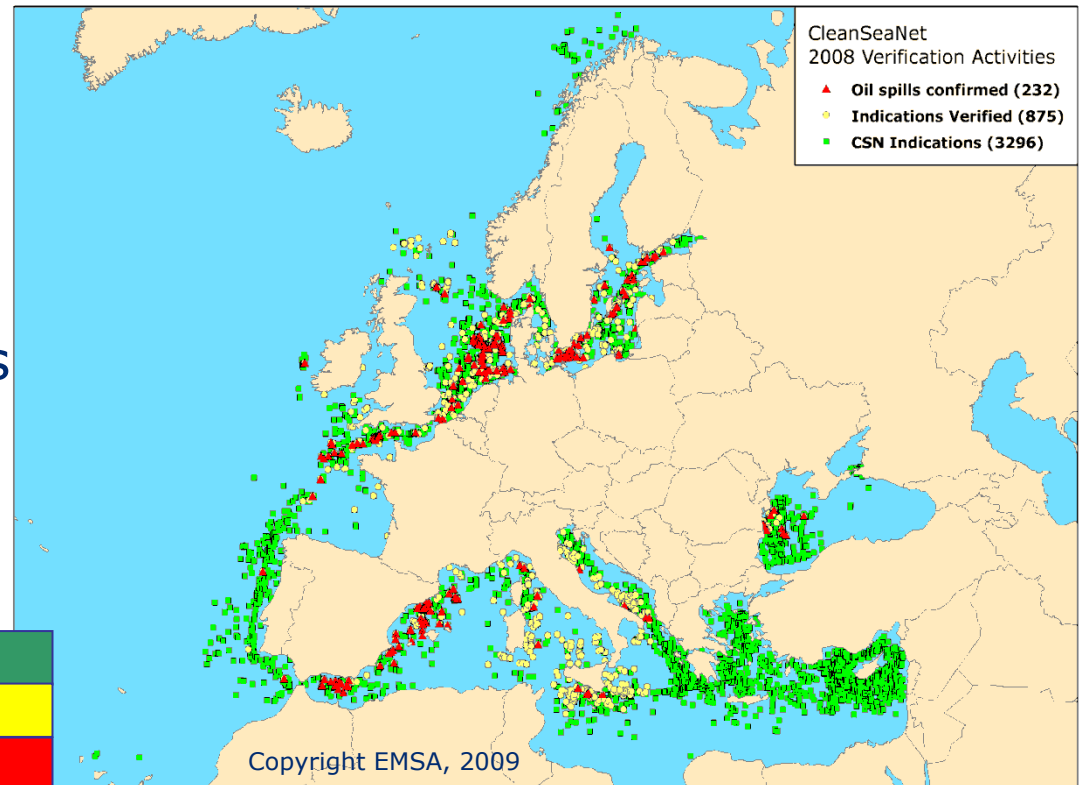
Algae bloom



EMSA-CSN results of the first operational year

- 3296 potential in the 2333 images
- 27% spills confirmed (875 checked)
- many of the detected potential spills could not be assessed correctly due to
 - evaporation and
 - physical degradation of oil

=> The time between the satellite overpass and the check via aircraft is crucial.



3296 Oil indications

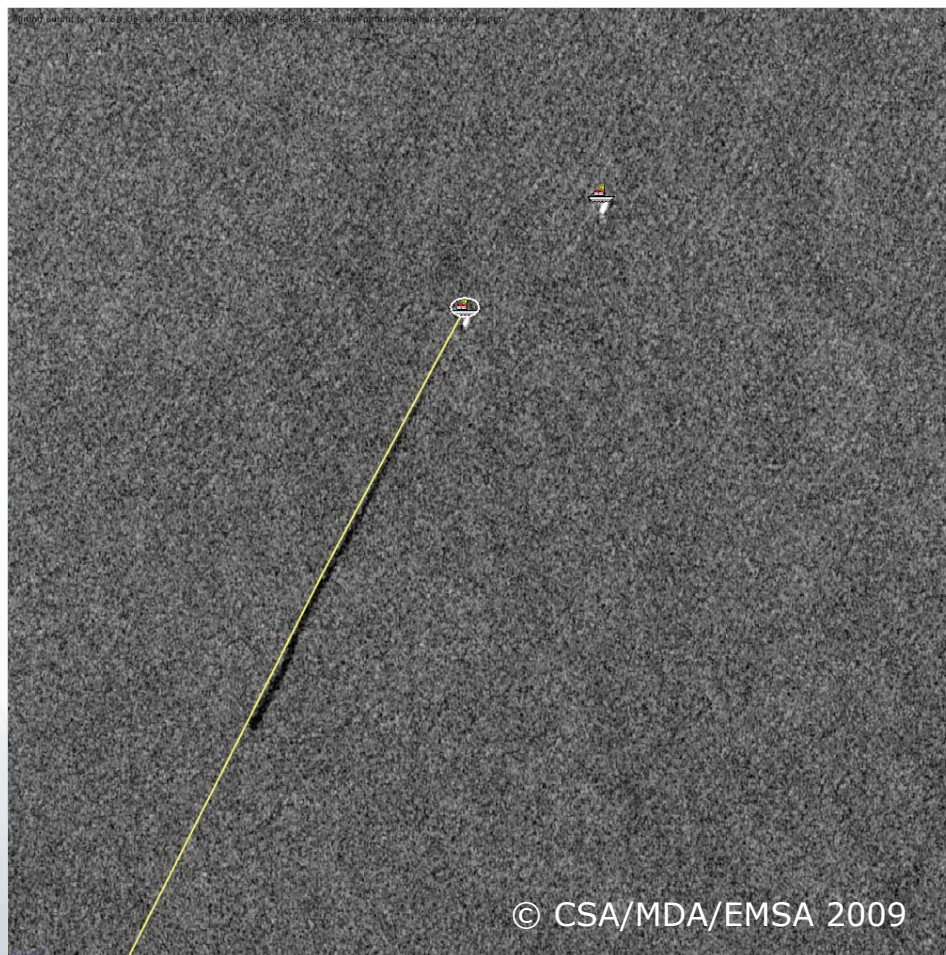
875 Indications Verified (27%)

232 Oil Spills Confirmed (27%)

08/01/2009, Canary Islands

Feedback and Port State Control request

- After the CSN alert Spanish authorities sent "Sasemar 103" aircraft to investigate the case
- The oil slick was verified and documented by SLAR, IR and MWR. The amount of discharged oil was at least 3.9 m³
- AIS data and oil drift model results were analysed by SASEMAR and the evidence confirmed that the potential source indicated in the CSN report was actually the polluter
- Spain sent a Port State Control request and a flag state report



Support in case of accidental spills

In case of accidental spills, EMSA has the capacity to support the affected Coastal State with additional satellite coverage:

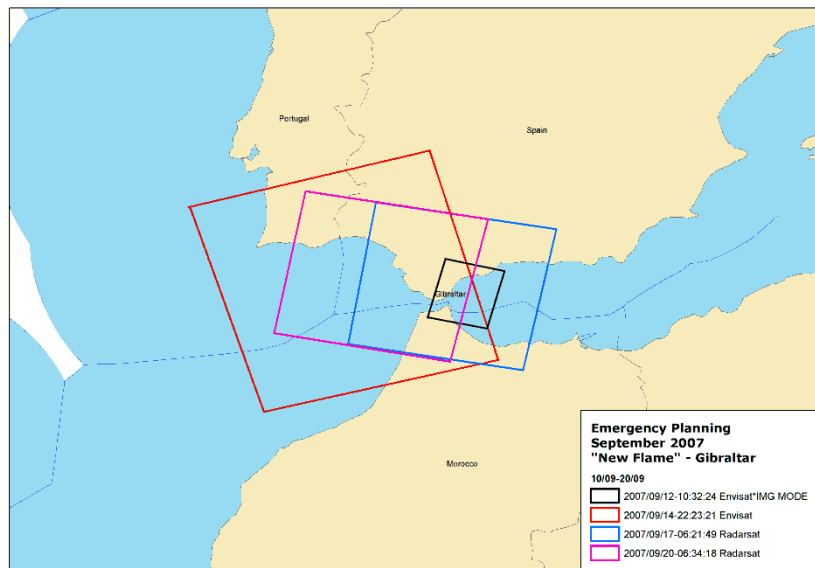
- Envisat and Radarsat 1 and 2 images: emergency planning and ordering via CleanSeaNet.
- Other SAR or optical data: in case of major disasters via the activation of the “**International Charter for Space and Major Disasters**”.

A close cooperation between the CleanSeaNet team and the affected Coastal State allows optimising satellite planning and ordering.

For each accidental situation, EMSA issues tailor-made products, briefings, reports... to better fulfil Coastal States authorities expectations.

Emergency support: examples

Grounding of the MS New Flame off Gibraltar in September 2007



European Maritime Safety Agency

CleanSeaNet Briefing 14/09/2007

CleanSeaNet Briefing: New Flame, Gibraltar

Introduction

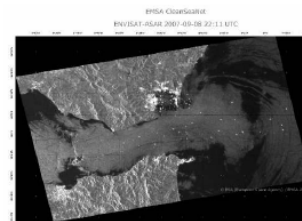
Following the head on collision between the double hulled oil products tanker *Torm Gertrud* (30058 gt, built 2002, IMO 9240885, DNV classified, Danish flagged, owned and managed) and the bulk carrier *New Flame* (26824 gt, built 1994, IMO 9077393, Panamanian flagged and owned, Greek managed) off Gibraltar on 12th August, and the subsequent weather damage to the partially submerged hull of the latter, Spanish authorities (SASEMAR) requested EMSA to acquire any available satellite image via the CleanSeaNet service for monitoring of a possible oil leakage from the damaged vessel. Following the first CleanSeaNet Briefing (07/09/2007) which included the analysis of two scenes acquired on the 5th and 6th of September, this report focuses on the next set of images acquired and delivered by EMSA.

Image Analysis

The following sequence of images was acquired between the 8th and 12th of September from the ENVISAT and RADARSAT-1 satellites. Both low and high resolution images were examined, no oil was detected in the vicinity of the *New Flame* and clean sea reports were dispatched to the Spanish authorities. All processed high resolution images are available via the CleanSeaNet DataBank.

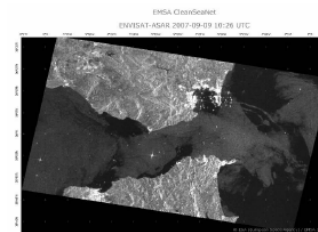
ENVISAT 08 September 2007 Image

The bright features on the sea surface are vessels which are strong point radar reflectors giving a very bright signal compared to the surrounding sea. Two medium confidence level slicks were detected 100km east of Gibraltar which are clearly unrelated to the New Flame accident.



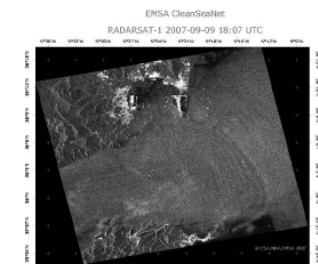
ENVISAT 09 September 2007 Image

In this ENVISAT scene the areas of very low wind are clearly visible (as darker patches), as are the internal wave patterns (described below).



RADARSAT-1 09 September 2007 Image

The pattern seen in this Radarsat-1 scene of alternating bands of rough and smooth sea represent internal waves generated by the interaction between tidal currents and topographic features.



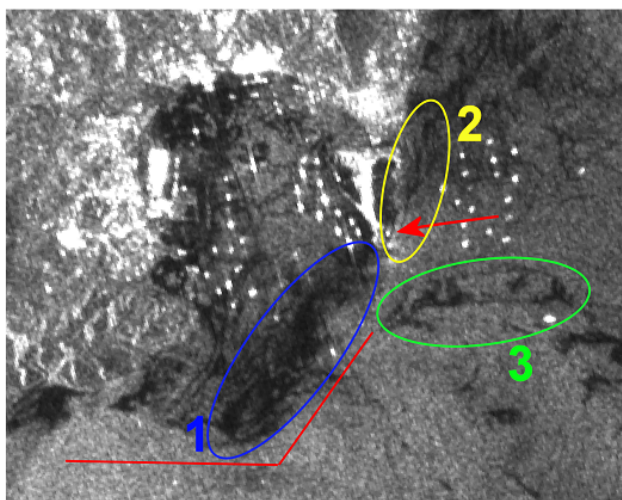
Emergency support examples

Grounding of the MS Fedra off Gibraltar in October 2008

CleanSeaNet Quick Look Report no. 1

EMSA CleanSeaNet satellite monitoring of the Bay of Gibraltar: Report no. 1 (14/10/2008)

Satellite: ESA ENVISAT
Sensor: Advanced Synthetic Aperture Radar (ASAR)
Mode: ScanSAR Wide
Date: 2008-10-13
Time: 22:09:06 UTC



EMSA CleanSeaNet
ENVISAT ASAR
© ESA European Space Agency / EMSA 2007

No major oil pollution could be identified.

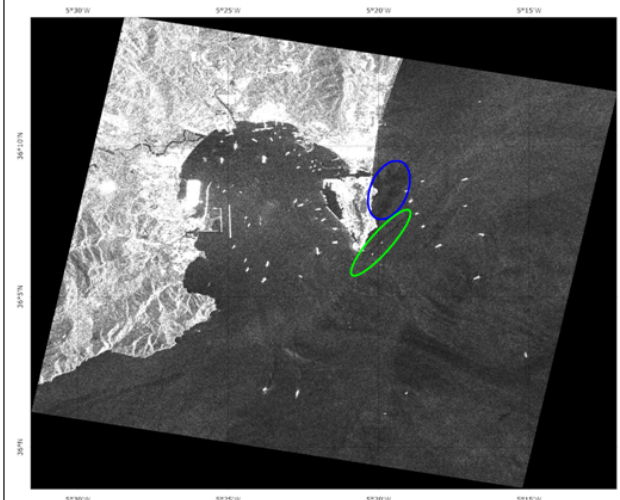
This Synthetic Aperture Radar image (ASAR, max. pixel resolution 150 m) shows several dark patches. With the easterly wind with a force of around 5m/s allows a good detection of possible oil spills:

- Blue (1): The lee effect of Gibraltar introduces reduced surface waves leading to the dark pattern. However in this area could be oil originated from the vessel, but there is no specific contrast, which allows the identification of oil.
- Yellow (2): This feature could be potentially been oil released from MV Fedra as the origin of this patch is linked to the Europa Point. However due to its vicinity to the shore line this information is of low confidence and has to be verified by local authorities.
- Green (3): According to the pattern structure, this feature could be oil, but due to the

CleanSeaNet Quick Look Report no. 6

EMSA CleanSeaNet satellite monitoring of the Bay of Gibraltar: Report no. 6 (22/10/2008)

Satellite: RADARSAT 1
Sensor: Synthetic Aperture radar
Mode: Standard Image S3
Date: 2008-10-22
Time: 06:23:17 UTC



EMSA CleanSeaNet
Radarsat 1 Standard Image Mode
2008-10-22 06:23:17 UTC
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No major oil pollution could be identified.

No major potential oil slicks are identified in this Synthetic Aperture Radar image (RADARSAT-1, max. pixel resolution 50 m). Wind conditions permit detection of possible oil slicks.

- Blue: This dark patch could be due to the window shadow originated by the elevation of the Europa Point.
- Green: According to the pattern structure, these features could be oil. However due to its vicinity to the shore line this information is of low confidence and has to be verified by local authorities.

The CleanSeaNet polluter identification activities

Directive 2005/35/EC on ship sourced pollution and on the introduction for penalties for infringements:

Article 10.1(b): establish common practices and guidelines on the basis of

those existing at international level, in particular for:

- the monitoring and early identification of ships discharging polluting substances in violation of this Directive, including, where appropriate, on-board monitoring equipment,
- reliable methods of tracing polluting substances in the sea to a particular ship, and
- the effective enforcement of this Directive.

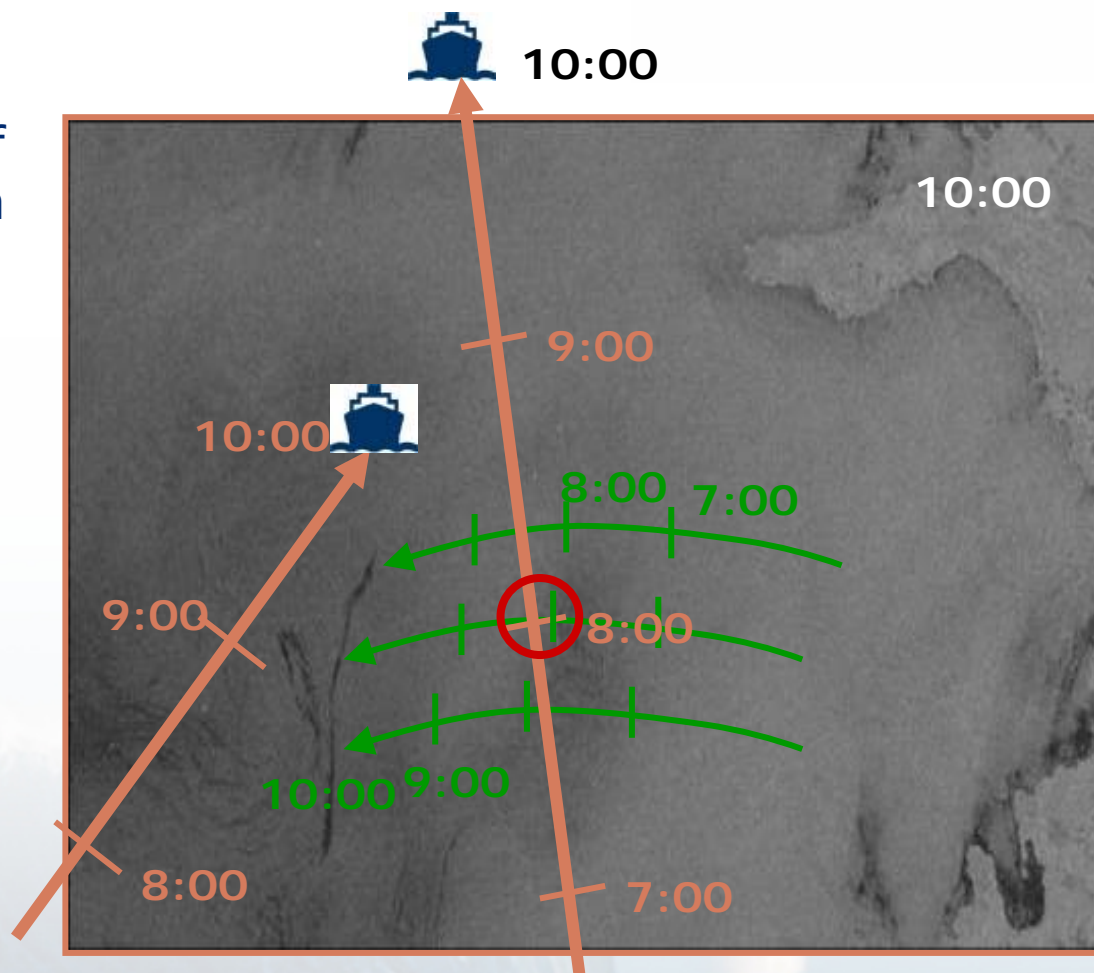
– Work programme 2009 (p.54):

In 2009, a new platform will be created for the second generation of CleanSeaNet. The service offered to Member States should be more flexible to include new satellite sources and new applications. A robust and modular Data Management and Data Dissemination System will be developed in 2009. One of the improvements should be that **vessel position data from the SafeSeaNet project (AIS and LRIT data) should be available on a structural basis in CleanSeaNet for all participating States** to help identify suspected polluters. Where possible, existing regional and local fore- and hind-cast models will be connected to CleanSeaNet. This will provide the capability to link an individual illegal discharge with individual ship tracks.

Linking a vessel to a slick

Theoretical example of the use in combination of:

- Satellite detection
- Oil drift modelling
- Vessel Monitoring



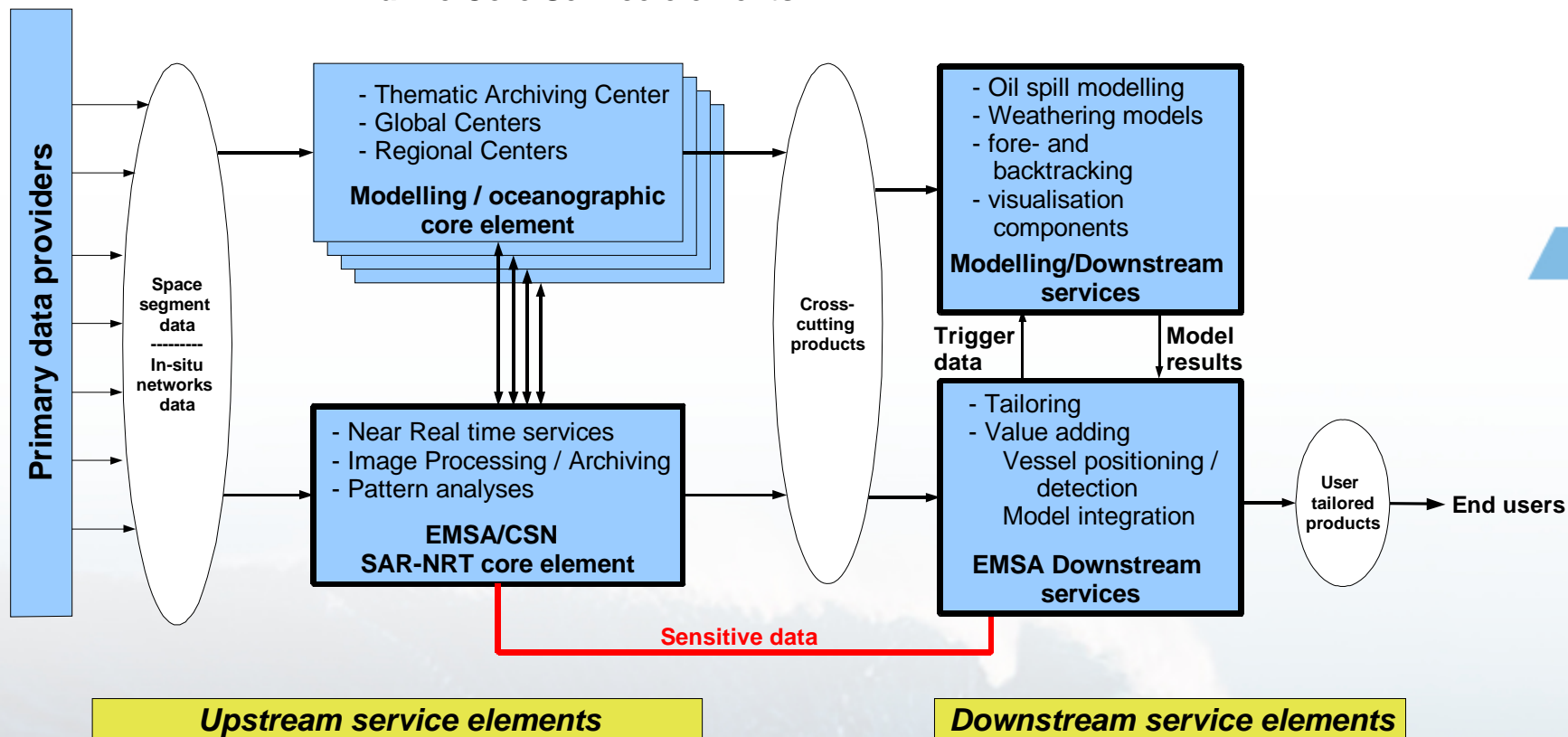
- CSN to **provide a 'first analysis'** of modelling results to CS users
- Backtracking for polluter identification (min. 24 hours)
- Forecasting for pollution response activities (min. 96 hours) incl. weathering
- Distributed architecture where **external models 'link'** to CSN
- MS oil spill models shall be used which are tailored and appropriate for individual sea basins
- Possibility to choose more than 1 model for a particular sea area (ensemble)
- The intention is to setup a **close co-operation** and **bi-directional data exchange** between EMSA and the MS models
- More Information:

***Non-paper:
EMSA's view on further development of oil spill modelling
21/11/2008***

CSN and GMES

CSN was the first fully operational maritime GMES at all!!

Marine Core Service elements

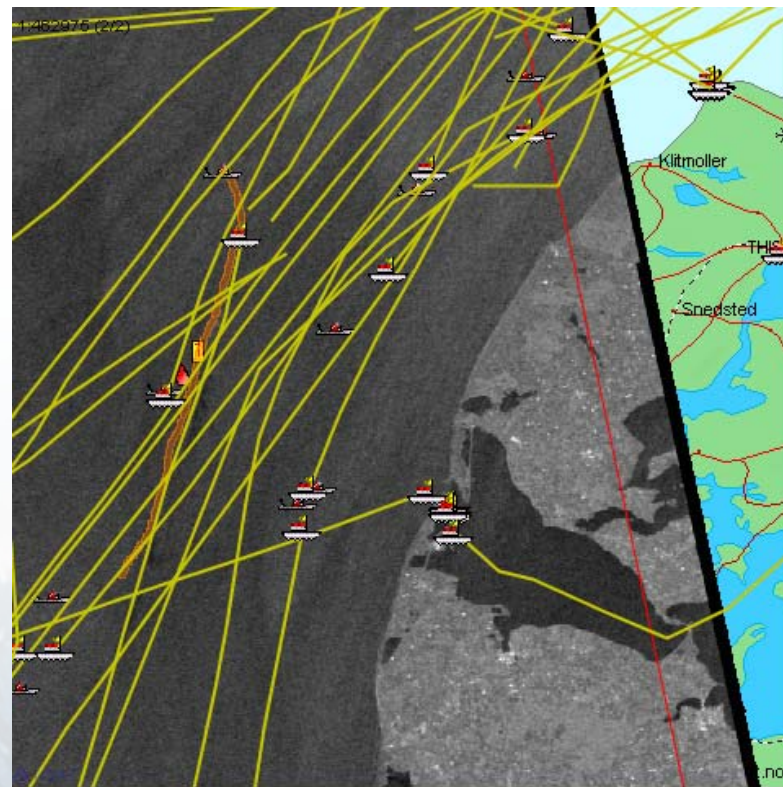


Model implementation guideline

- The models will be available only according to the distribution policy by model operators. A sophisticated user management is foreseen.
- Any investigation results will remain exclusively with the Coastal State
- EMSA wants to provide the operational entities with Near Real Time information (30 min.) to support
 - the decision making process on follow up activities
 - the Coastal States with immediate links between spill and potential polluters
- It is up to the CS/model operators to co-operate on this issue with EMSA to improve the CSN information content and to promote the model
- Pilot Projects
 - MEDSLICK
 - SeaTrackWeb

CSN 2nd generation: a complete approach

- An integrated maritime surveillance platform: comprehensive, flexible and advanced system; providing
 - meteorological and sea state information, SST, algae, ...
 - vessel traffic information (AIS, LRIT, STIRES)
 - Oil drift modelling: links to forecast and backtracking models tailored for specific sea areas
 - Static information (Nautical charts, bathymetry, borders, ...)
 - Optical, hyper-, multispectral images
 - Sat. vessel detection
- Fusion of data
 - Vessel tracking with backtracking data for polluter identification
 - wind and wave for improving the confidence



Conclusions – what we have achieved

- Sustainability
- Cost Sharing
 - Reduced price for a large amount of images
 - Satellite surveillance is an indispensable tool to achieve the basic European coverage.
- Co-Operation
 - “Oil spill surveillance is a cross border activity”
 - Mutual benefits for coastal states
 - Sharing of images and aerial surveillance
- European standardised service
 - All European waters
 - Comprehensive, quick and easy to access information
 - easy to compare



Conclusions – what's next

- Remote sensing provides a unique technology to identify potential (illicit) pollutions, but with
 - integration of modelling and vessel informationthe systems become tools
 - to determine potential polluters,
 - to provide elements for the chain of evidence,
 - to support clean-up operations
- Co-operation and co-ordination with law enforcement has to be intensified to improve prosecution and deterrence
- CleanSeaNet's 2nd generation service will provide a very extended and unique portfolio and as such could be an extremely relevant source of information for other EU Agencies and MS.

Thank you very much!

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

