The 3rd NOWPAP Joint Training Courses on Remote Sensing Data Analysis

Vladivostok, Russia, 11 October 2011

Monitoring of oil pollution with the use of satellite imagery

Leonid M. Mitnik

V.I. Il'ichev Pacific Oceanological Institute FEB RAS, Vladivostok, Russia

mitnik@poi.dvo.ru

Oil spill monitoring by remote sensing http://cearac.poi.dvo.ru msn 産経ニュース

ニュース検索 bing

トップ 速報 事件 政治 経済・IT 国際 スポーツ エンタメ ライフ 科学 地方 オピ

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[国際]ニュース

トピック：資源

ブログに書く 引用ブログ 49 メッセ 印刷

中国の海上油田で原油流出　隠蔽体質に非難集中

2011.7.6 00:02 (1/2ページ)

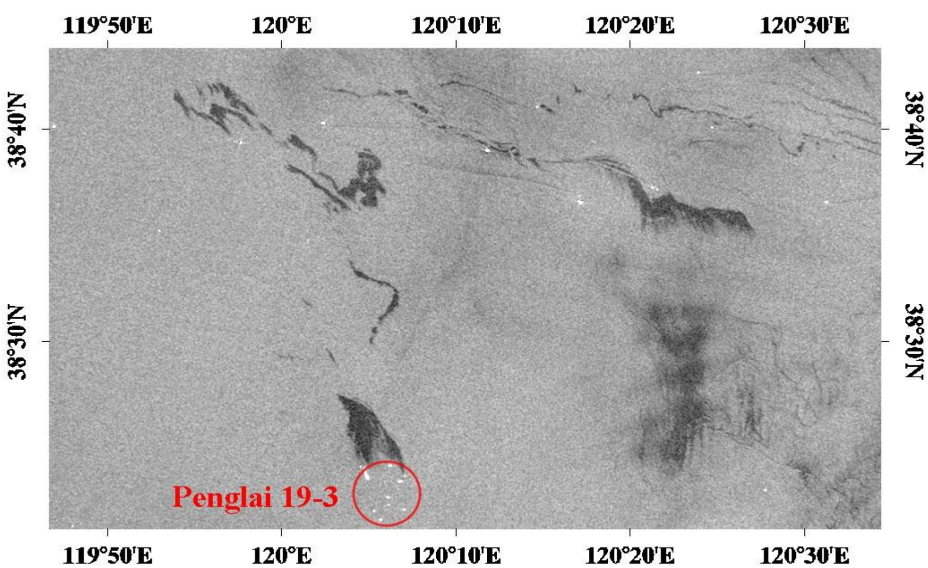
【北京＝川越一】中国山東省沖の渤海にある同国最大の海上油田で6月上旬に原油が流出していたことが発覚し、国家海洋局は5日、初めて事故を公表し、原油が広がった面積は840平方キロにわたったことを明らかにした。汚染拡大が懸念されているにもかかわらず、発生から約1カ月も事故を隠蔽した当局や企業の姿勢に、国民の不信感が高まるのは必至だ。

クリックして拡大する

同油田は、中国国有石油大手、中国海洋石油と米石油大手コノコフィリップスが共同開発した。原油が流出したのは6月4日。同月20日ごろ、インターネット上の書き込みで発覚した。中国海洋石油関係者による内部告発とみられている。

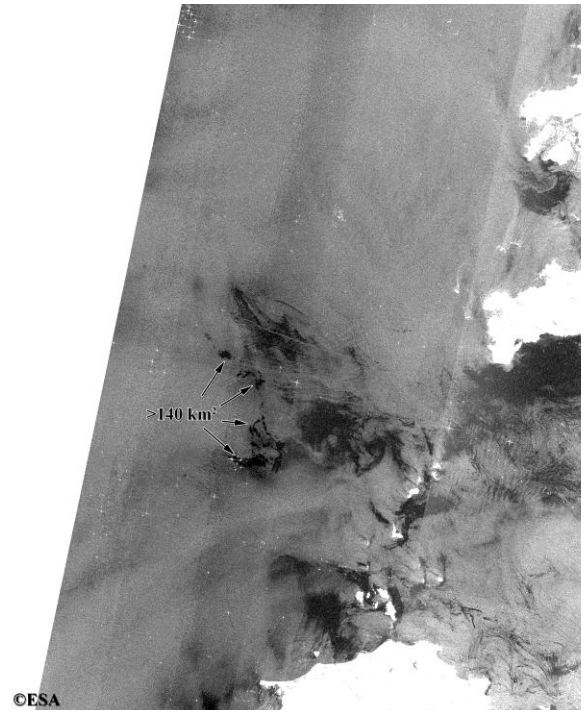
中国メディアからの問い合わせに沈黙を守っていた中国海洋石油は1日夕になって流出を認めた。3日には同社関係者が「油漏れの範囲はわずか200平方メートル程度だ。事故処理はすでに完了しており、現場海域の環境への影響は少ない」とコメントしたが、国家海洋局の発表によって、事態を著しく過小評価していたことも浮き彫りとなった。

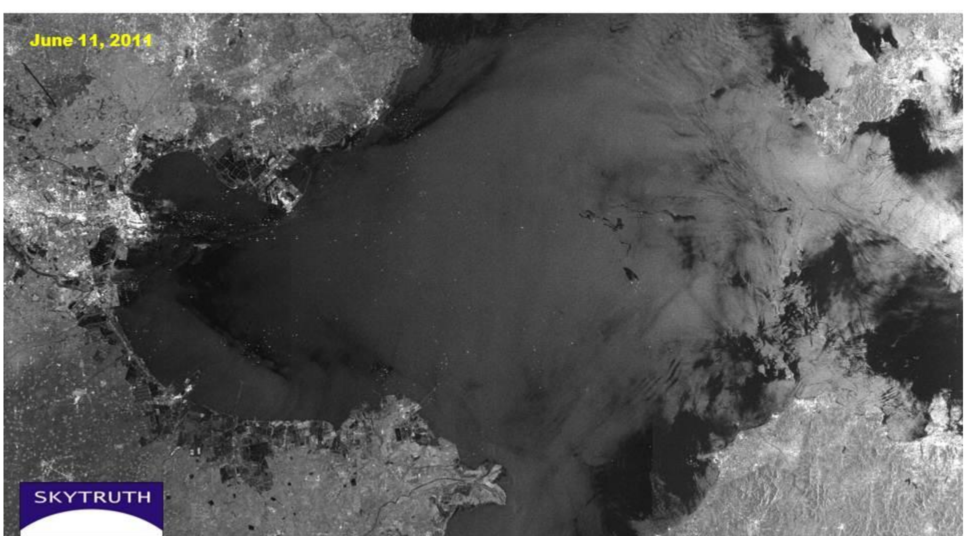
Bohai Bay. Yellow Sea. Penglai 19-3 offshore oil field



Envisat ASAR. 11 June 2011. Polluted area 65 km^2

Image courtesy of ESA - European Space Agency





Skytruth issued this information on 28 July 2011

Detail from Envisat ASAR image identifying cluster of platforms assumed to be in the Penglai 19-3 offshore oil field; and likely oil slicks.

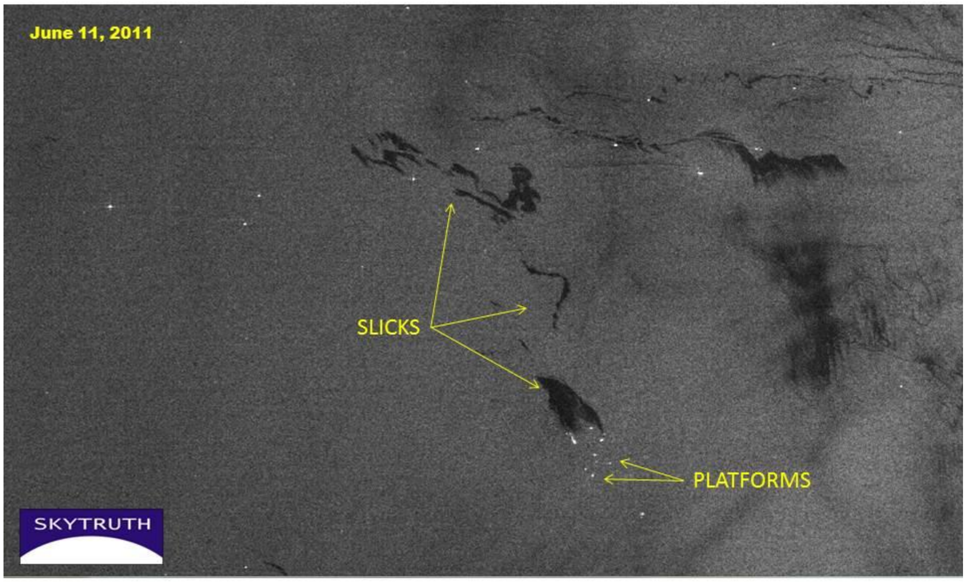
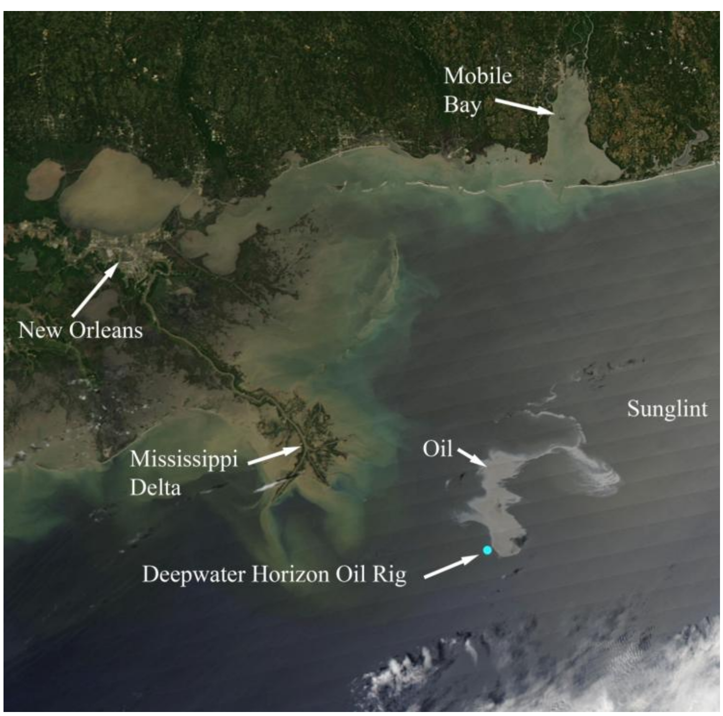


Image courtesy of ESA - European Space Agency



MODIS 250 m Image of spill 25 April 2010

International Space Station Sun Glint Image of Oil May 5, 2010

Picture taken by astronaut Soichi Noguchi – NASA Image

(AP Photo/Eric Gay)

(**Britannica.com)**

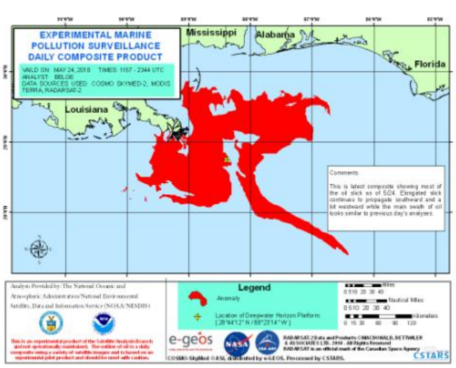
Oil was skimmed by boats and burned, boomed and vacuumed , and cleaned from beaches by hand.

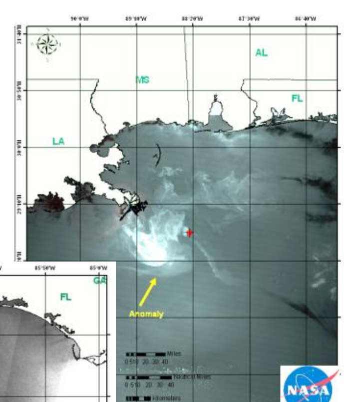
(Oceanleadership.org)

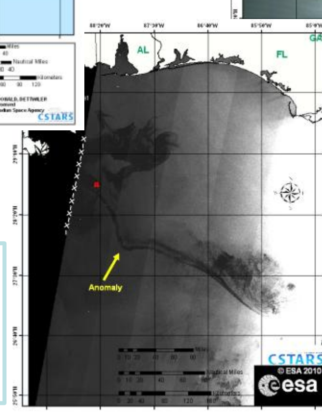
Oil in wetlands may be one of the longest lasting impacts from the Deepwater Horizon spill

In this June 8, 2010 photo, oil pools against the Louisiana coast along Barataria Bay. (AP Photo/Charlie Riedel)

Both SAR and Sun Glint Imagery were Valuable Imagery for Oil Mapping







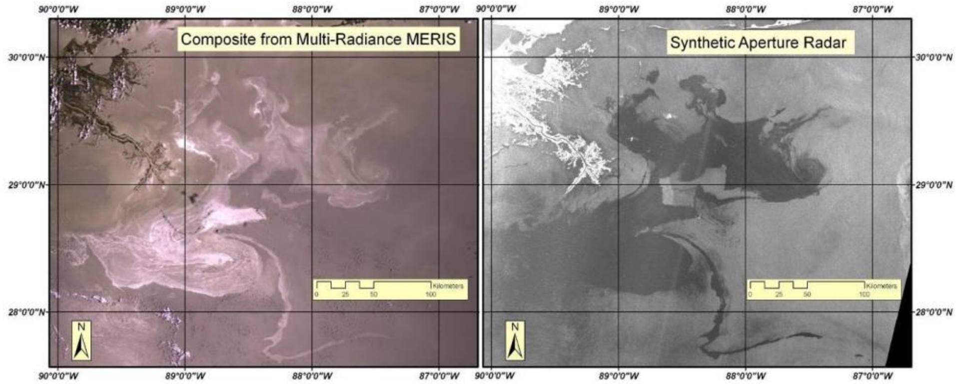
NESDIS Experimental Marine Pollution Surveillance Report Daily Composite for 05/24/10

NESDIS maps the surface oil extent in the Gulf of Mexico daily using high-resolution visible and synthetic aperture radar satellite data

NASA Terra MODIS Visible Image 05/24/10 1643Z

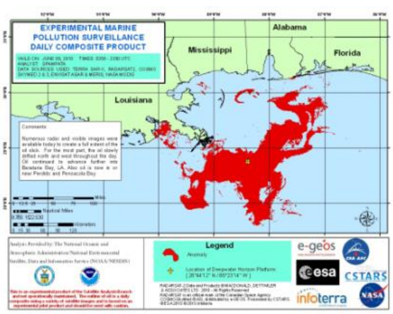
ESA ENVISAT Synthetic Aperture Radar Image 05/25/10 1910Z

Good Correspondence of SAR and Visible Sun Glint Imagery of Oil

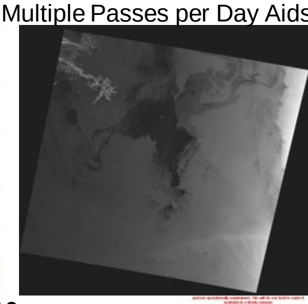


ENVISAT MERIS Visible Multi-spectral Image (left) and ENVISAT ASAR Image (right) for 5/27/10 © European Space Agency, 2010

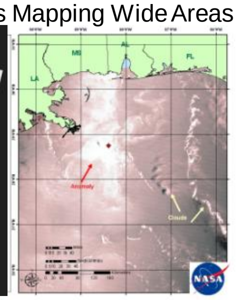
Multiple Passes per Day Aids Mapping Wide Areas



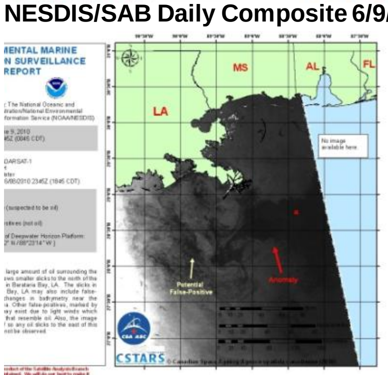
NESDIS/SAB Daily Composite 6/9/10



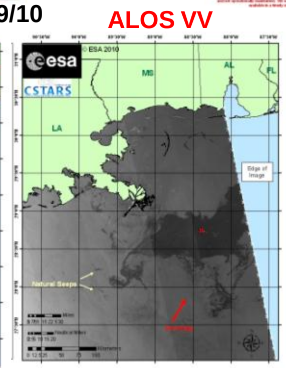
ALOS VV



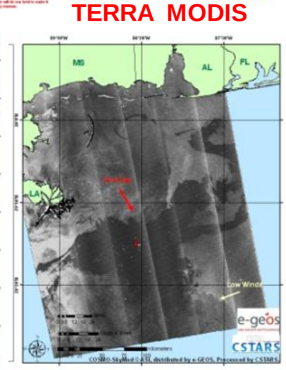
TERRA MODIS



RADARSAT-1 HH

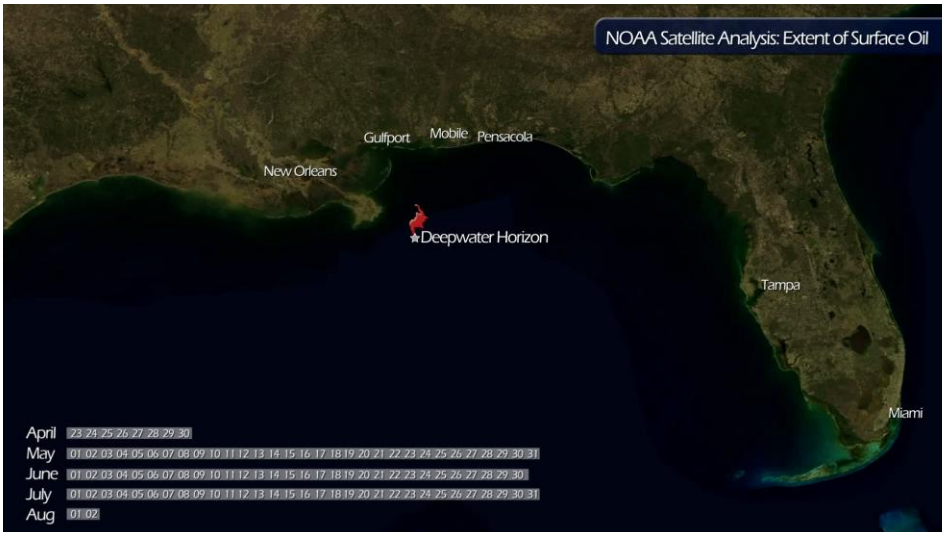


ENVISAT VV

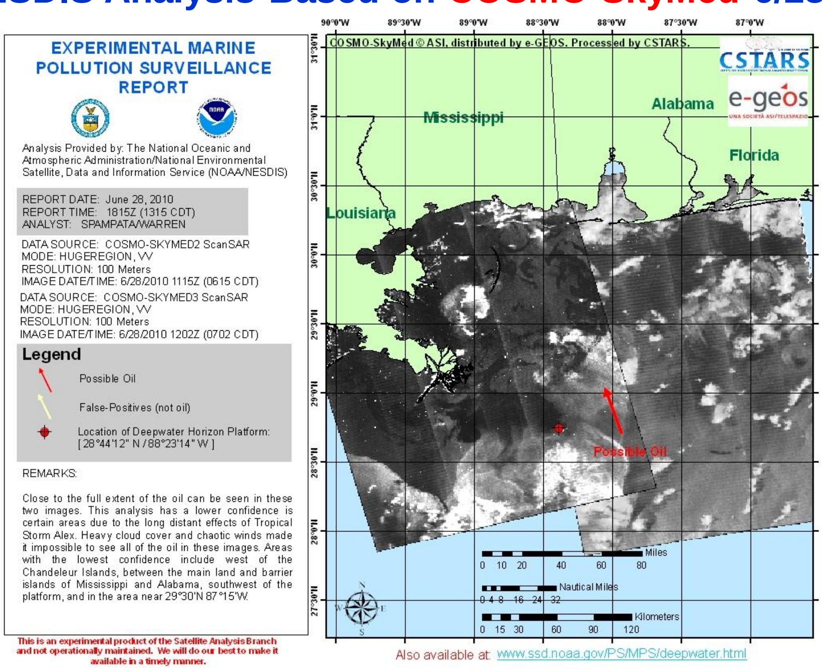


COSMO-SkyMed VV

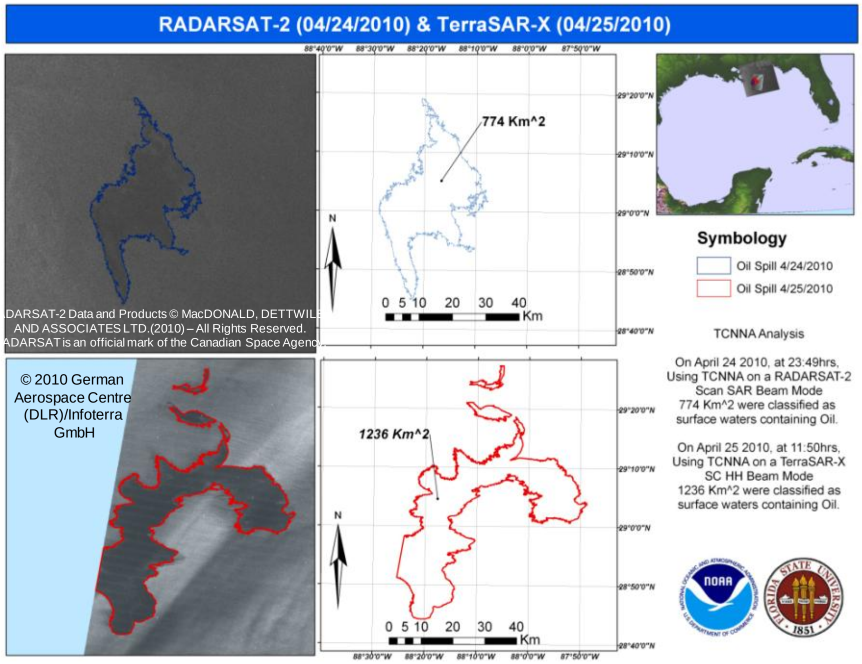
Deepwater Horizon Event Time Series of NESDIS SAB Daily Composite Analyses
Experimental Marine Pollution Surveillance Daily Composite Product

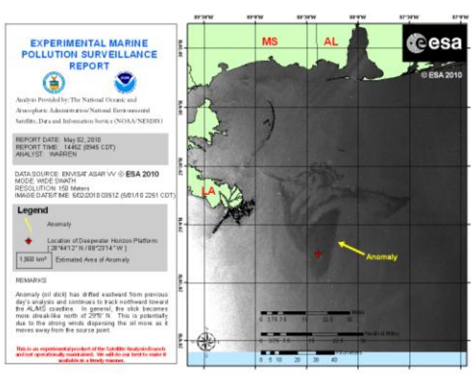


NESDIS Analysis Based on COSMO-SkyMed 6/28/10



Example of Oil Spill Mapping Algorithm Analysis of Deepwater Horizon Spill

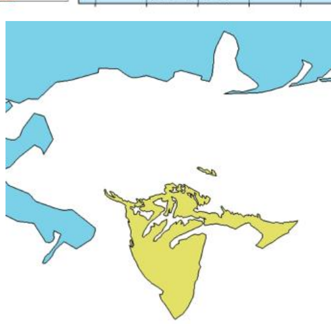


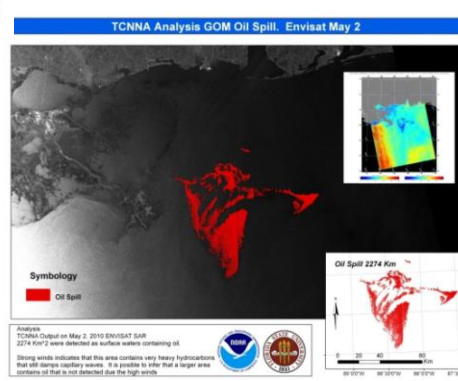


ENVISAT ASAR VV Image
2 May 2010

Manual Analysis – Imagery - *left top*
Shape File – *left bottom*

STAR Research Automated Analysis – *Texture*
Classifying Neural Network Algorithm - *right bottom*





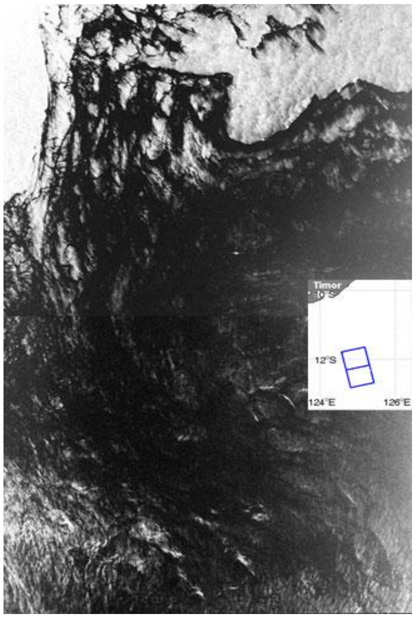
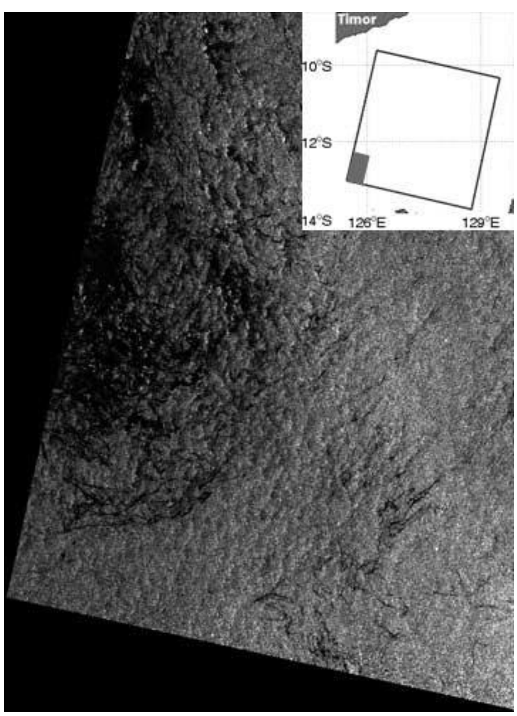


Fig. 2. Fragment of ALOS PALSAR image acquired on 2 September 2009 at 14:37 UTCwith HH-pol. The boundaries of two frames are given in an incertion.

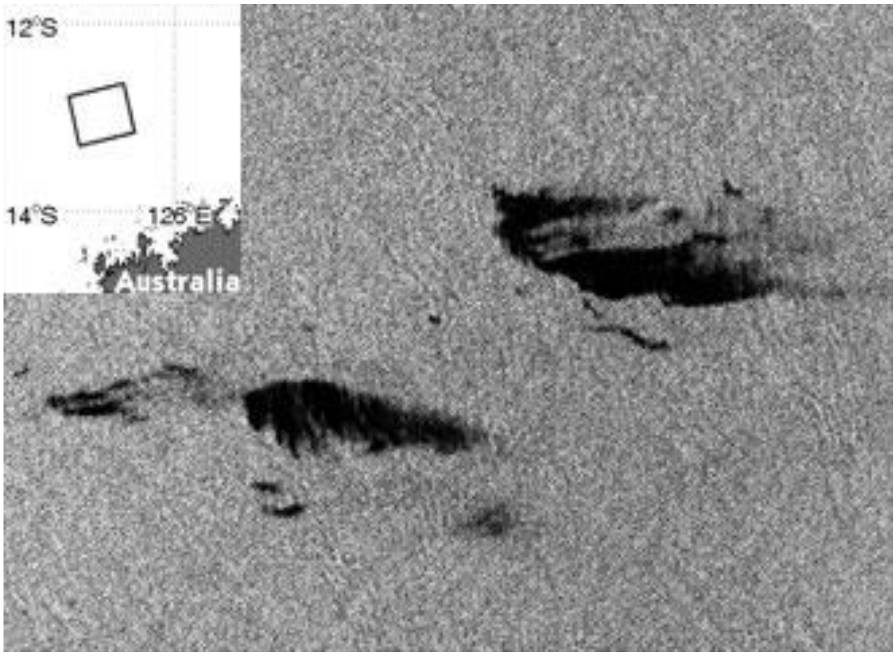
TIMOR SEA

On August 21, 2009, a well on the Montara oil platform in the Timor Sea off the northern coast of Western Australia blew out as a new well was being drilled on the platform by the West Atlas mobile drilling rig.

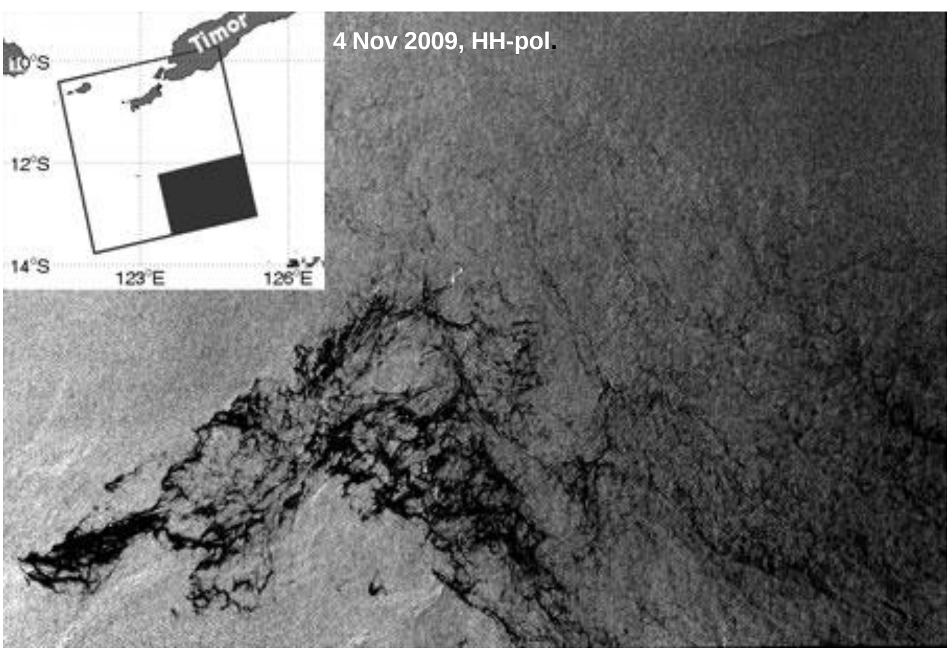
PALOS PALSAR images were acquired on 2 and 30 September, 18 October and 4 November 2009



Fragment of PALSAR image with HH-pol for 30 September 2009 at 01:40 UTC showing oil spill northeast of Montara platform. The square in an insertion marks the boundary of PALSAR frame and dark rectangle shows the location of the fragment.



Fragment of ALOS PALSAR image. 18 October 2009, 14:37 UTC, HH-pol.



Leonid M. Mitnik. OIL SPILL DETECTION AND MAPPING IN THE NORTHWEST PACIFIC OCEAN BY L-BAND ALOS PALSAR. PI 364

Outlines

1. Global and regional inputs of oil to marine environment.
2. Behavior of oil at sea (weathering)
3. Characteristics of sea slicks and crude oil spills.
4. Remote sensing techniques of oil pollution detection
   4.1. Physical grounds of oil detection on the sea water by remote techniques
      Ultraviolet and visible range. Hyperspectral visible-near infrared (VNIR) and fluorescence lidar sensors
      Infrared range. Infrared radiometer.
      Microwave range. Microwave radiometers, Side-looking real aperture radar (RAR) and synthetic aperture radar (SAR).
   4.2. Processes involved in SAR ocean imaging
5. Satellite SARs: ERS-1, ERS-2, Envisat, ALOS.
6. SAR signatures of biogenic slicks, oil spills, oceanic/atmospheric phenomena.
7. CEARAC-POI web site "Oil spill monitoring by remote sensing".
8. Examples of annotated SAR images of NOWPAP area.
9. Algorithms of oil spill detection on SAR images (preprocessing and masking, detection of dark patches and bands, dark patch feature extraction, discrimination of oil from the look-alikes).
10. Satellite monitoring of NOWPAP area
11. Conclusion.

How does oil affect marine life? (*Oceanus*, 2004)

From experiments and field measurements, we know that certain types and concentrations of petroleum chemicals can harm marine life. Long-term effects of oil exposure can alter the physiology and ecology of populations of marine organisms, especially those found in sensitive habitats.

Biological and physical processes can reduce the concentration of oil chemicals in an ecosystem, especially if the source of pollution is cut off. As concentrations decline and chemical compositions change, plant and animal communities usually rebound. But the recovery can range from months to decades depending on the chemistry, the conditions, and the organisms and ecosystems affected.

One of the significant advances in the 1970s and 1980s was the development of guides to the sensitivity of various types of coastal ecosystems to oil pollution. Maps of sensitive ecosystems are now used during responses to accidental oil spills, improving the ability of resource managers and engineers to assess where containment booms and other prevention and cleanup measures should be deployed.

There have been few studies, however, on the cumulative effect of chronic inputs of oil to the marine environment, including the many sources associated with oil consumption on land. Assessing these impacts is complicated because oil runoff is often accompanied by other polluting chemicals, making it difficult to tease out which ones have which deleterious effects. Limited experiments have taught us that the interactive effects among chemicals can either increase or decrease each chemical's long-term effects, depending on the organisms and chemicals.

Much of our knowledge about the effects of oil is still limited. It has focused on biochemical and physiological effects on a few individual organisms and on the degradation of a few particular habitats. But we need a better understanding of the large-scale effects of oil on entire communities and populations, rather than individual organisms. The complexity of how species interact within ecosystems—such as how damage to one species can affect the other species that feed on it—leads to contentious debate whenever regulators start to weigh long-term impacts on marine life.

UNESCO, 2003

Ocean observing systems are critical for advancing detection and prediction of diverse marine phenomena.

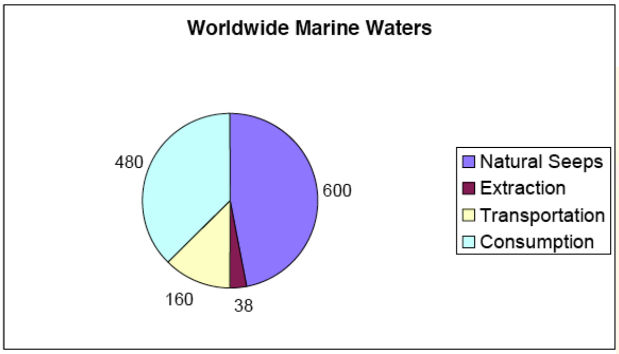
UNESCO. 2003. *The Integrated, Strategic Design Plan for the Coastal Oceans Observation Module of the Global Ocean Observing System. GOOS Report No. 125. IOC Information Documents Series No. 1183.* UNESCO, Paris, France, 190 pp.

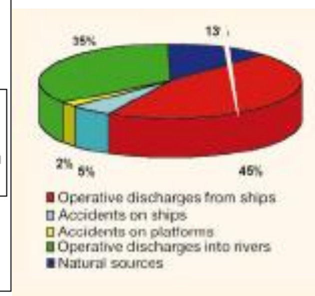
Global inputs of oil to marine environment

Types of Oil Pollution		Percentage of the World total
Offshore Drilling	50000	2.16
Large Oil Spills	120000	5.17
Natural Seeps	200000	8.62
Up in Smoke	300000	12.93
Routine Maintenance	450000	19.40
Down the Drain	1200000	51.72
Total World, tonnes	2320000	100.00

Offshore drilling - operation discharges and drilling accidents during oil exploration.
Large oil spills typically oil tanker accidents such as collisions and groundings.
Natural seeps comes from seepage off the ocean floor and eroding sedimentary rocks (has occurred for thousands if not millions of years.
Up in Smoke - from oil consumption in automobiles and industry (atmospheric fallout).
Routine maintenance occurs from ship bilge cleaning and so forth.
The worst oil pollution - **oil dumped into the drains and road runoff** - dumping oils and oil products down storm drains after oil changes, urban street runoff and so forth.

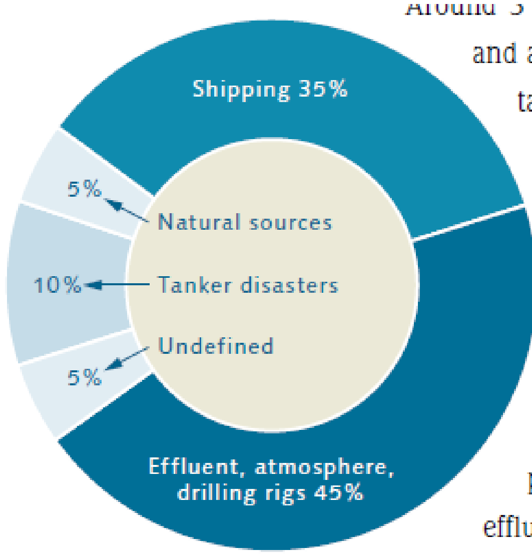
Global inputs of oil to marine environment

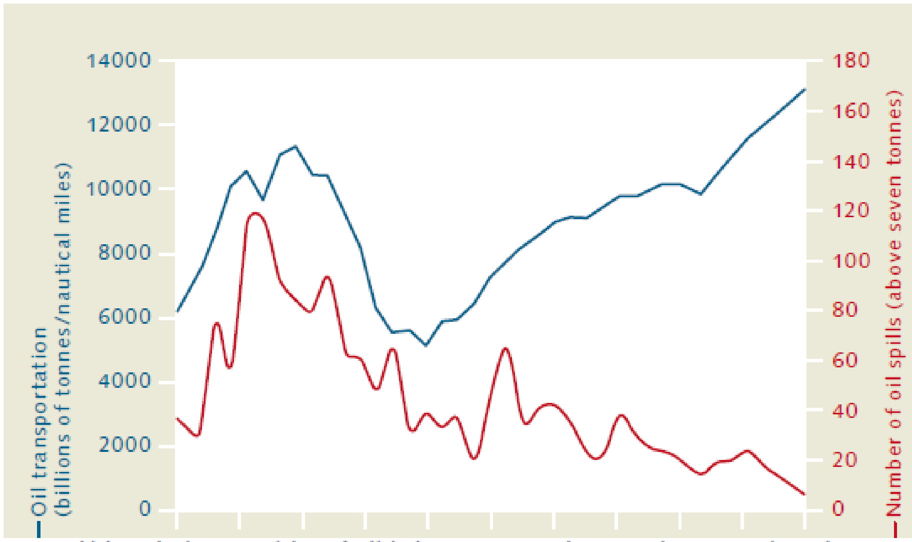




Average annual contribution to oil in the ocean (1990-1999) from major sources of petroleum in kilotonnes. (*Oil in the Sea III: Inputs, Fates, and Effects (2003*), National Academy of Sciences).

http://books.nap.edu/openbook.php?record_id=10388&page=29





Although the quantities of oil being transported across the oceans have decreased considerably since the 1970, the amount of marine oil pollution caused by oil tanker disasters, technical defects or negligence has fallen dramatically. The statistics cover oil spills above 7 tones: records of small spills are somewhat patchy.

Inputs of oil to marine environment in NOWPAP region

Types of Oil Pollution		**Percentage of the total**
Offshore Drilling	?	
Large Oil Spills	?	
Natural Seeps	?	
Up in Smoke	?	
Routine Maintenance	?	
Down the Drain	?	
Total, tonnes	?	

Evolution of oil

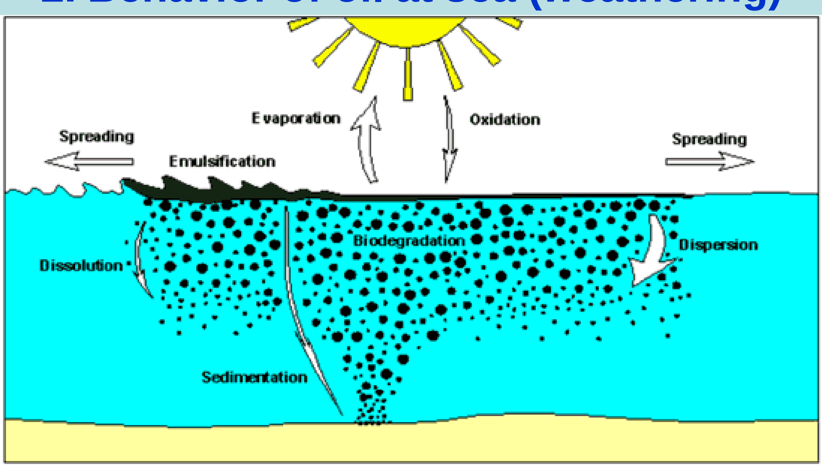
Spreading, Evaporation, Dispersion, Emulsification, Dissolution, Oxidization, Sedimentation and Biodegradation

The above processes combine to produce natural dissipation of oil into the marine environment.

Spreading, Evaporation, Dispersion, Emulsification and Dissolution **are most effective during early stages of a spill whilst** ***Oxidization, Sedimentation and Biodegradation*** **occur in the later stages.**

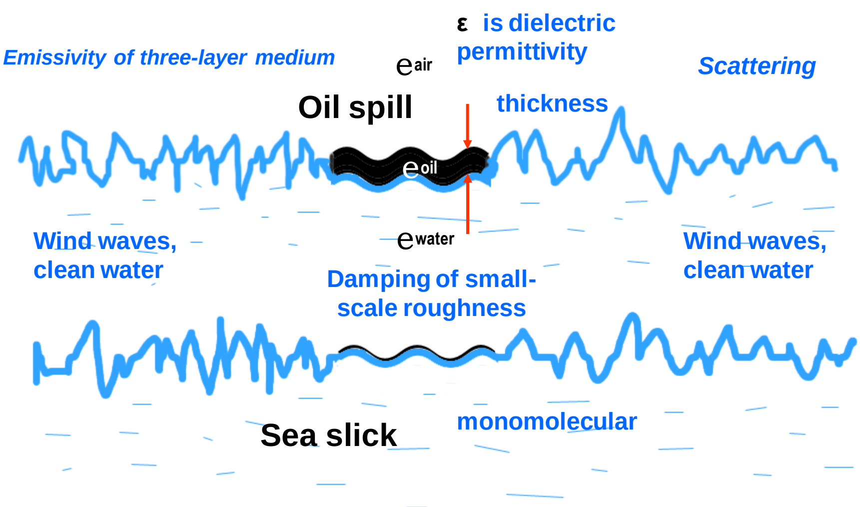
How long the process of natural dispersion takes is an almost unquantifiable figure as it is highly dependant on environmental conditions that are uncontrollable.

2. Behavior of oil at sea (weathering)



The rate at which oil dissipates is greatly dependant on the type of oil, weather/sea conditions and whether the oil remains water borne or becomes land-bound. The processes involved in its evolution, collectively known as weathering, are ***spreading, evaporation, dispersion, emulsification, dissolution, oxidation, sedimentation and biodegradation*****. The time scale however, of their relative importance, varies from few hours to months.**

Remote sensing of oil spill and sea slick



3. Summarizing characteristics and nomenclature for the sea slicks and crude oil spills

Marine Surface Films. Physico-Chemical Characteristics, Influence on Air-Sea Interactions, and Remote Sensing, M.Gade and H. Hühnerfuss, Eds. Universität Hamburg, Germany, Springer, 2006)

	Sea slicks	Crude oil spills
Chemical constituents	*surface-active substances* consisting of a *hydrophilic* head group and a *hydropholic* tail	alcanes, cycloalcanes and aromatics with *preferentially hydrophopbic* character, no hydrophilic head group
Distribution at the water surface	a) substances spread on the water surface; b) substances *are being spread* on the water surface; c) a sea slick *is generated (or produced)* at the surface	a) crude oil *is spilled* at the sea surface; b) a crude oil spill *is generated (or producing)* at the sea surface
Thickness	*monomolecular*, typically 2.4-2.7 nm	thicker layers, typically µm-range, if freshly spilled even cm-range (in connection with accidents)
Origin	both biogenic (secreted by plankton or fish) and man-made	nearly in all cases man-made, in few cases oil seeps
Water wave damping mechanisms	resonance-type wave damping in the short-gravity-wave region, (*Marangoni damping*)	damping by an interfacial layer of higher viscosity
Microbial or photochemical transformation of constituents	relatively fast: time scale hours or few days (→ soluble, highly polar substances that disappear in the bulk water)	very slow: several months (→ *weathered oil spills* → formation of surface active compounds → *slick* formation around thick spill centers)

Comparison of properties of different kind of airborne remote sensors

Feature name	SLAR	UV	Infrared	Microwave	Lidar (LFS)
Range	wide	narrow	narrow	narrow	narrow
Oil classification capabilities	no	no	no	no	yes
Sensitivity to oil film thicknesses	N.A.	> 0.1 µm	> 10 µm	50 µm to 2.5 mm	0.1 µm to 20 µm
Horizontal range from nadir @300m flight altitude	± 30 km	± 250 m	± 250 m	± 250m	± 75 m
Spatial resolution	10 m (along flight track), 75 m (across flight track)	3.5 m	3.5 m	> 5 m	10 m pixel-to-pixel distance
Detection of oil spills underneath the surface	no	no	no	no	yes
Operating at night	yes	no	yes	yes	yes
Film thickness determination	no	no	no	50 µm to 2.5 mm	0.1 µm to 20 µm
Measuring geometry	Line-by-line	Line-by-line, 160 Hz	Line-by-line, 160 Hz	Line-by-line, 20 Hz	Conical, 5 Hz (20 Hz max.)
Sensitivity	no	On clouds	On clouds	no	On clouds, flight altitude

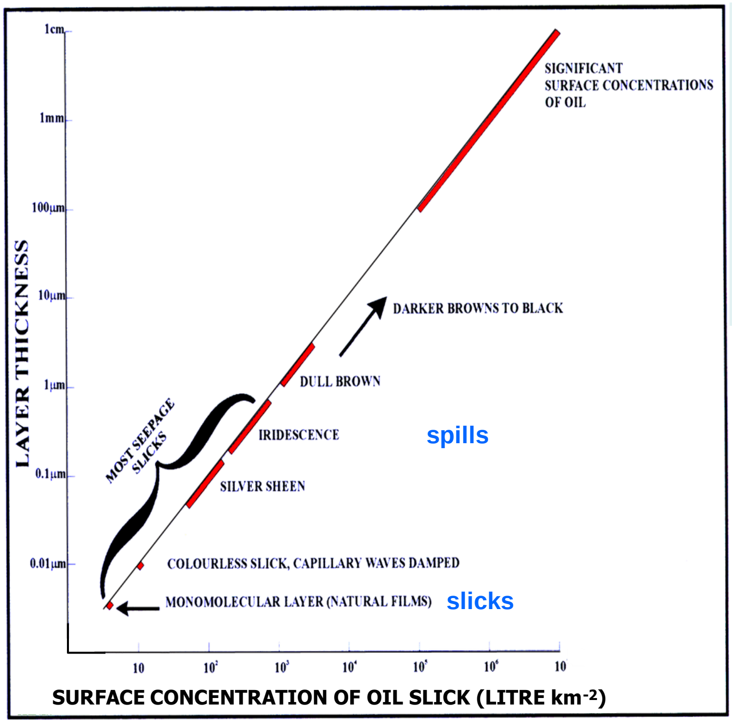
SLAR – Side Looking Airborne Radar, UV- ultraviolet

A.Samberg. Advanced oil pollution detection using airborne hyperspectral lidar technology.
The SPIE Annual Symp. on Defence and Security, 28 Mar – 1 Apr 2005, Orlando, FL, USA.

Bonn agreement oil appearance code

A correlation between the visual appearance of oil and the thickness of oil on the sea.
Used to estimate spilled oil volume

CODE	APPEARANCE	QUANTITY m^3 / km^2	THICKNESS µm
1	SHEEN (SILVERY / GREY)	0.04 - 0.3	0.04 – 0.3
2	RAINBOW	0.3 – 5.0	0.3 – 5.0
3	METALLIC	5.0 – 50	5 – 50
4	DISCONTINUOUS TRUE OIL COLOUR	50 – 200	50 – 200
5	TRUE COLOUR	200 - > 200	200 - > 200



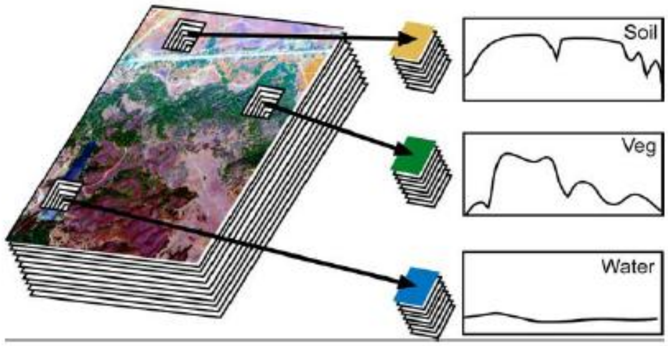
Spill thickness determines appearance at sea at given wind speed

Estimating the volume of a spill

	Film Thickness	Quantity Spread
Appearance	mm	l/ha
Barely visible	0.0000381	0.365
Silvery sheen	0.0000762	0.731
First trace of color	0.0001524	1.461
Bright bands of color	0.0003048	2.922
Colors begin to dull	0.0010160	9.731
Colors are much darker	0.0020320	19.463

One tonne of crude oil is roughly equal to 308 US gallons, or 7.33 barrels

Hyperspectral imagery



The concept of hyperspectral imagery, when image are made at many narrow contiguous wavelength bands, resulting in a complete spectrum for each pixel.

Single sensors are unlikely to provide adequate temporal and spatial coverage at adequate resolution for pollution monitoring. Systematic routine monitoring of marine environment requires inputs of microwave. IR and visible data in ways that take advantage of their respective strengths. Satellies provide global statistical information: oil spills are observed all over the world seas.
Study with 1600 ERS SAR images taken over the Mediterranean Sea showed that a half of the images present at least one slick. Similar estimates were obtained for the Baltic Sea and for the South East Asia area.

Hyperspectral imagery

In the visible spectrum, crude oil and heavy refined oils are distinguished thanks to three optical properties which vary from oil to oil, and which make them detectable at sea by optical sensors:

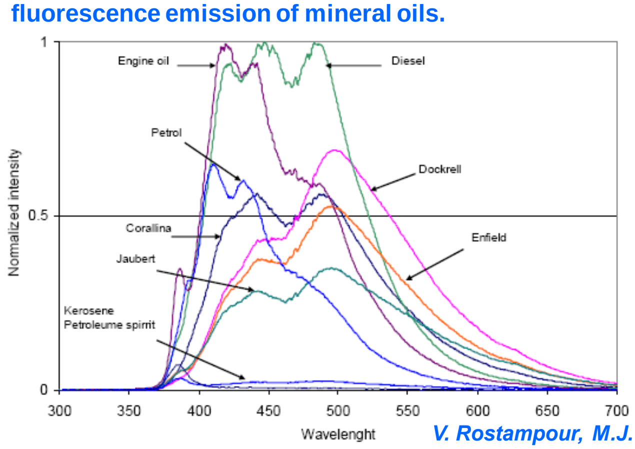
- Their refractive index is greater than that of seawater
- Their coefficient of light absorption is much stronger than that of water, particular at shorter wavelengths
- They fluoresce when subjected to bright natural light.

Hyperspectral imagery

Up-to-date, a laser fluorosensor is the most useful instrument in oil remote sensing, because of its capability to distinguish oil on backgrounds that include water, soil, weeds, ice and snow. It is the only sensor that can positively discriminate oil on most backgrounds. This type of active sensors takes advantage of the fact that certain compounds in petroleum oils absorb UV light and become electronically excited. This extinction is rapidly removed through the process fluorescence emission, primarily in the visible region of the spectrum. Since very few other compounds show this tendency, fluorescence is a strong indication of the presence of oil. Natural fluorescing substances, susch as chlorophyll, fluoresce at wavelengths that are different enough than oil to avoid confusion. As different types of oil yield slightly different fluorescent intensities and spectral signatures, it is possible to differentiate between classes of oil under ideal conditions.

Fluorescence behavior of the oil spills

Fluorescence-based monitoring systems are reliable and accurate means for quantifying and detecting a compound in all environments. Hydrocarbon oils indicate significant fluorescence response when they are exposed to UV radiation. The fluorescence emission measurement provides substantial information on the detection and monitoring of hydrocarbon oils. Chemical composition and aromatic compounds are mainly responsible for the fluorescence emission of mineral oils.



Fluorescence emission spectra of four Australian crude and five refined oils at 385 nm excitation wavelength..

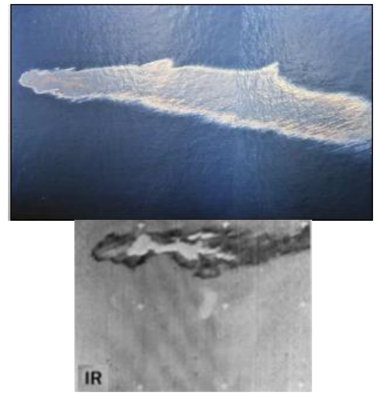
V. Rostampour, M.J. Lynch. Ocean Optics'06

Infrared sensor

The IR sensor is used to provide relative, not absolute, thickness information of oil slicks on the sea surface, not rain, mist or fog.

The sensor detect IR radiation in the 8-12 mkm emitted by oil.

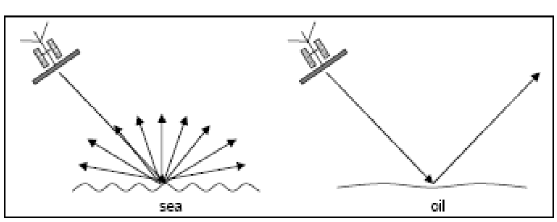
The oil layers are depicted as variations in gray level (or in defined colors).



Areas of relatively thin oil film are apparently cooler than the surrounding sea and areas of thicker oil films are actually warmer than the surrounding sea because they absorb the sunlight more rapidly. (*European Workshop Oil pollution Monitoring. Existing oil remote sensing means.* D. Mason. Aircraft and aerial sensors).

Why the SAR can detect an oil spill event?

- An oil spill may cover vast areas of the sea surface and damp some of these capillary waves.
- In this way, the water surface roughness is reduced and can be detected by the Normalized Radar Cross-Section (NRCS) on SAR images, since it appears as a dark area or an area in which there is an absence of sea clutter.



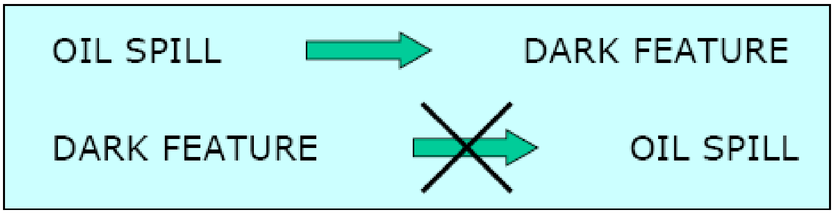
short gravity – capillary waves

Wind speed > 2m/sec…

http://serac.jrc.it/midiv

Signature of oil spills from ship discharges

Are all dark features oil spills?



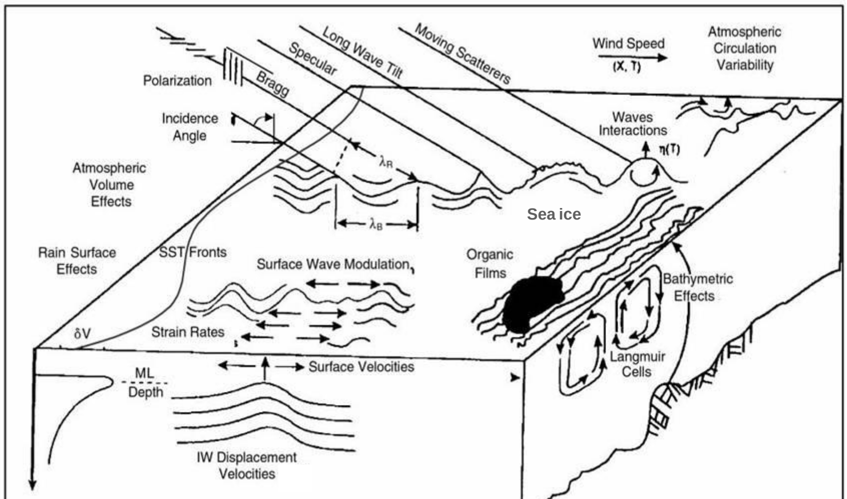
- Oil spills are not the only phenomena which can appear as a dark feature in a SAR image.
- Under certain air/sea boundary layer conditions, other sea surface manifestations of natural origin may result to SAR expressions or false targets, similar to those due to an oil spill.
- They are usually referred to as look-alikes objects.

Look-alike

Natural slicks	**Reflections of the bottom topography in shallow waters**
Threshold winds (fronts),	**Plumps of municipal sewage**
Wind shadows behind islands	**Wave shadows behind land**
Calm areas	**Weed beds that calm the water just above them**
Surface currents	**Grease ice**
Internal waves	**Biogenic oils**
Rain cells	**Whale and fish sperm, etc.**
Upwelling areas	

http://serac.jrc.it/midiv

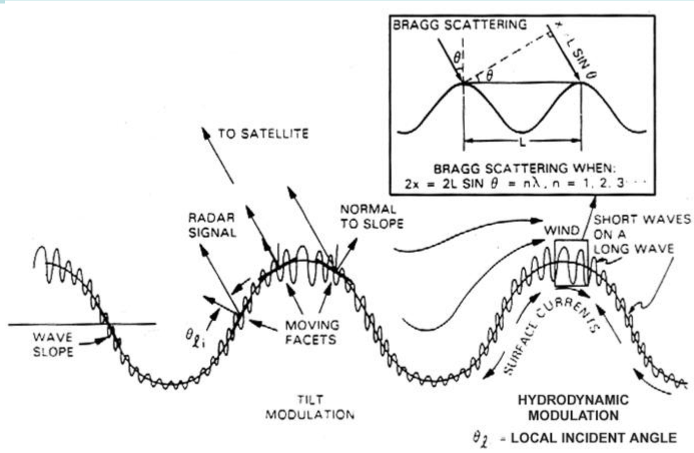
4.2. Processes involved in SAR ocean imaging



[adapted from Press et al., 1996]

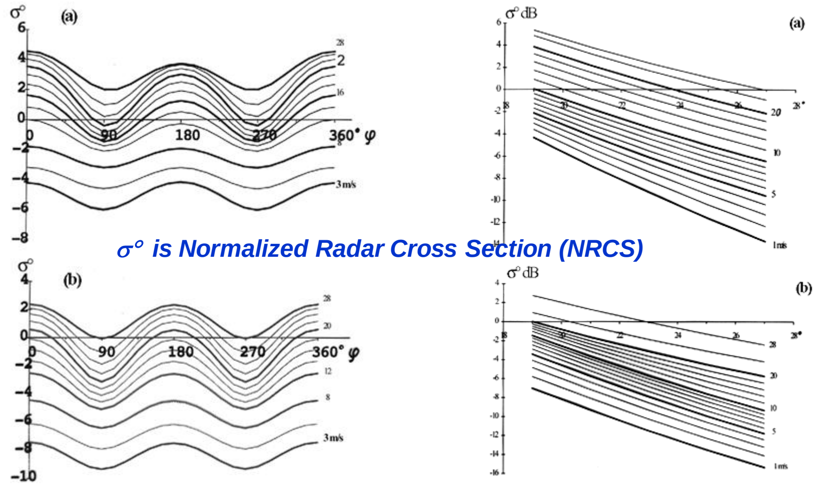
Main SAR response from the ocean is from resonance of the radar microwaves with capillary and small gravity surface waves (i.e. Bragg waves), as well as modulation by longer waves.

Scatter from composite surfaces



The scatter of radar signals can be calculated by assuming the ocean surface has two scales: (a) short wavelength ripples, riding on (b) longer, larger waves. The Bragg scatter from each small area is calculated using the local small wave field and the local orientation of the surface. The scatter is then integrated over the entire area, using the probability density function for surface slopes due to longer waves. The local cross section is (*Wright,* 1968; *Bass et al.,* 1968). Recent development in modeling of radar scattering from the sea surface can be found in (*Kudryavtsev et al., 2003,*).

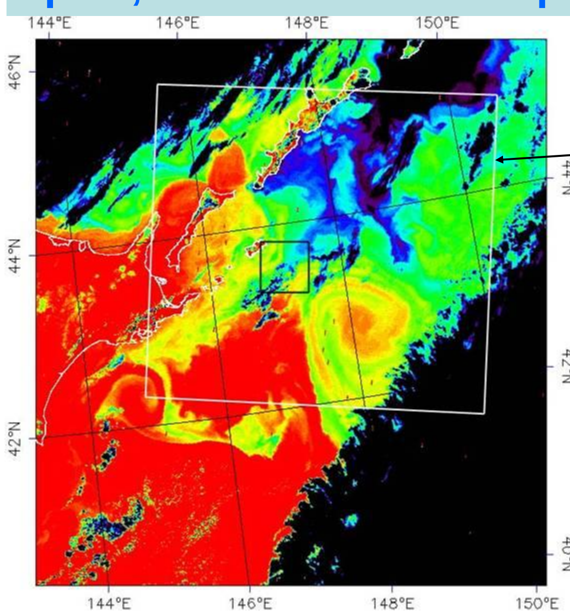
Geophysical model function CMOD4



σ° is Normalized Radar Cross Section (NRCS)

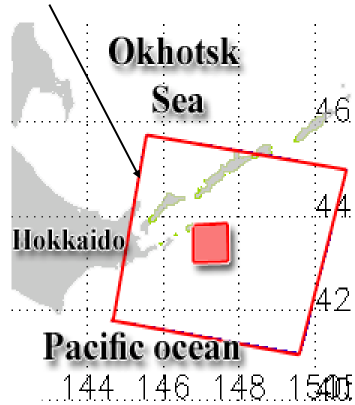
NRCS are plotted versus wind directions (left) and versus incidence angle (right) for VV polarization for wind speed between 3 and 28 m/s. These cross sections were computed using C-band model CMOD4 for a fixed incidence angle of 20° (a) and 23° (b) (left) and for wind direction upwind φ = 0° (a) and crosswind φ = 90° (b) (*Stoffelen and Anderson*, 1987).

6. SAR signatures of biogenic slicks, oil spills, oceanic and atmospheric phenomena

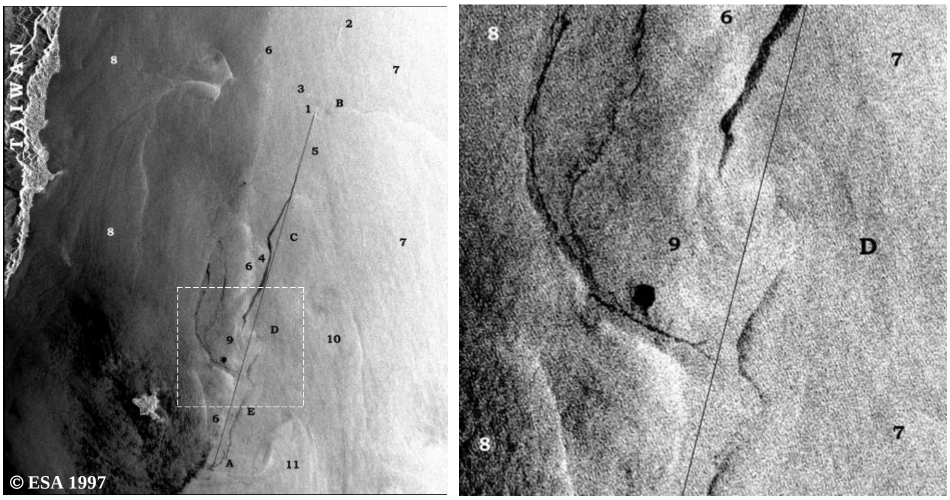


Terra MODIS infrared image. **24.9.06, 01:15 UTC**

Boundaries of Envisat ASAR image at 00:21 UTC



Oil pollution. Kuroshio east of Taiwan



ERS-1 SAR. 29 December 1997

Mitnik L., K.-S. Chen, C.-T. Wang Reconstruction of surface currents from ERS SAR images of oil-tank cleaning slicks. P. 315-336 in: *Marine Surface Films. Physico-Chemical Characteristics, Influence on Air-Sea Interactions, and Remote Sensing*, M.Gade and H. Hühnerfuss, Eds. Universität Hamburg, Germany, Springer, 2006.

Oil spill detection and characterization by satellite SAR and airborne SLAR, hyperspectral and lidar data

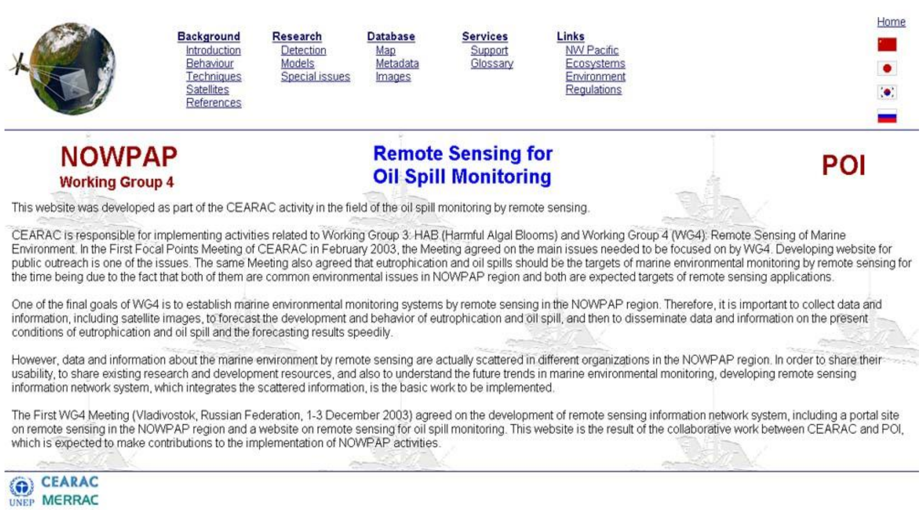
- **Satellite SAR and airborne SLAR systems are useful for regional-scale observation and detection. Airborne optical sensors are not convenient for that task because of their reduced swath.**
- **Microwave and fluorescence lidar sensors are complementary, regarding the different thickness ranges that can be estimated by both sensors.**
- **Hyperspectral and lidar sensors could be used in the same manner as IR/UV sensors for regional scale detection (compensation of the SLAR blind zone). Hyperspectral data would allow a better spatial resolution to be reached, but could not be used during night flights however.**
- **Thermal IR and hyperspectral VNIR sensors are complementary as far as their detection capabilities are concerned: thin oil slicks can not be detected by thermal IR sensor because of the sea surface thermal balance (they can be with an hyperspectral sensor) while thick oil slicks still influence the signal recorded by a thermal IR sensor (quick saturation of the signal as a function of oil thickness in the case of a n hyperspectral sensor).**
- **Joint use of hyperspectral and fluorescence lidar sensors allow high spatial resolution thickness distribution maps to be obtained, while SAR, SLAR, and IR/UV are only used for detection.**

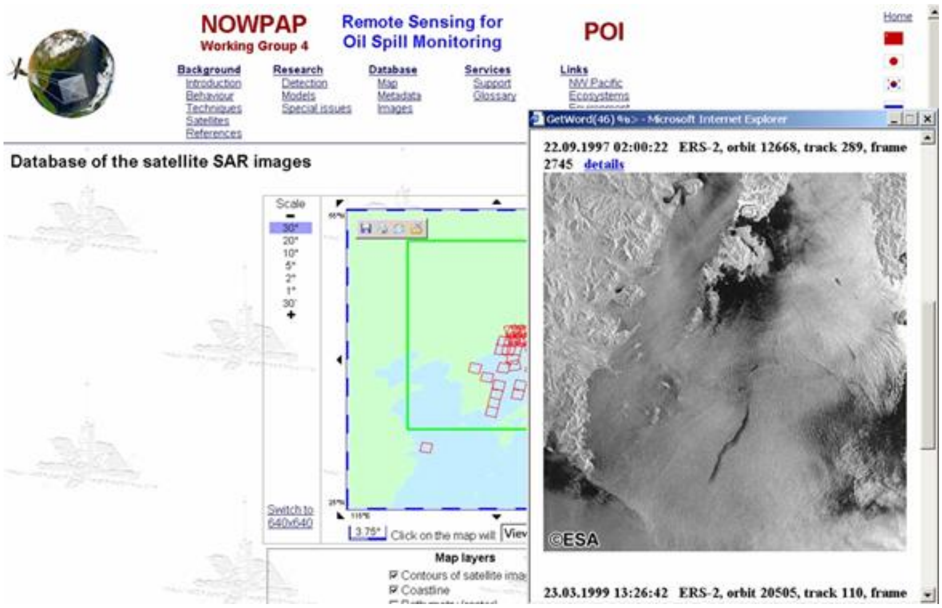
7. CEARAC-POI web site “Oil spill monitoring by remote sensing” http://cearac.poi.dvo.ru

The following sections are in the website:

1. Introduction
2. Behaviour of oil at sea
3. Remote sensing techniques of oil pollution detection
4. Marine satellite remote sensing data used for oil spills monitoring
5. Algorithms of interactive and automatic detection of oil spills
6. Database of the georeferenced satellite SAR images of the Northwest Pacific. Database of the annotated georeferenced satellite SAR images with revealed oil pollution.
7. Environmental information that is important for oil pollution monitoring/evolution (winds, currents, ice, weather forecast) - Links to the China, Japan, Korea and Russia.
7. References.
8. Links.

Web site on oil spill monitoring





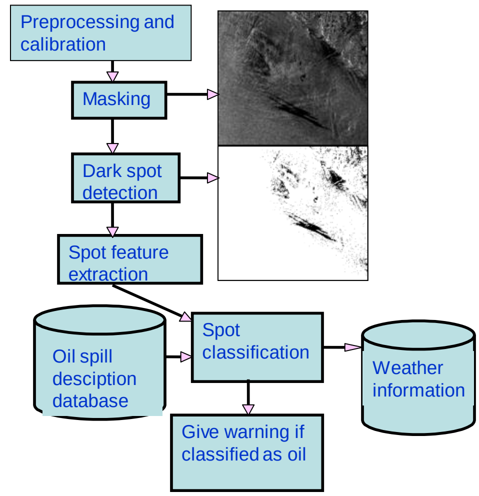
Summary by Month

Month	Daily Avg				Monthly Totals					
	Hits	Files	Pages	Visits	Sites	KBytes	Visits	Pages	Files	Hits
Oct 2011	289	89	160	56	226	35421	511	1443	803	2603
Sep 2011	350	127	171	74	759	275686	2221	5136	3821	10510
Aug 2011	355	121	195	71	649	278640	2219	6051	3773	11035
Jul 2011	457	157	266	85	717	546878	2656	8246	4885	14168
Jun 2011	357	101	226	82	699	106031	2469	6786	3048	10714
May 2011	373	124	231	77	748	140366	2396	7171	3854	11578
Apr 2011	335	106	196	79	686	102135	2397	5883	3193	10056
Mar 2011	477	173	305	92	700	156564	2867	9466	5393	14814
Feb 2011	478	137	298	102	812	120342	2856	8350	3844	13395
Jan 2011	452	148	273	89	768	96248	2774	8477	4589	14031
Dec 2010	433	174	253	90	752	102466	2792	7864	5405	13431
Nov 2010	523	248	324	80	801	137227	2419	9726	7447	15715
Oct 2010	542	251	317	101	1053	274053	3143	9844	7785	16816

9. Algorithms of oil spill detection on SAR images. Overview

Three main parts:

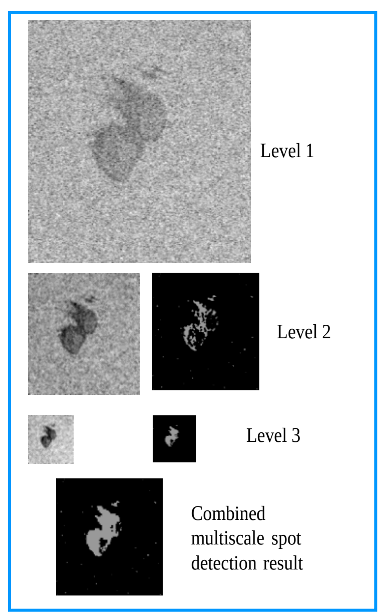
- **Spot detection**
- **Spot feature extraction**
- **Spot classification**
  - **Decide oil spill or look-alike based on a statistical model for oil in different wind conditions and of different shapes**



A. S. Solberg, University of Oslo

Dark spot detection

- Sensor-specific modules for ERS; Radarsat and Envisat ASAR.
- Dark spots are identified based on an adaptive thresholding algorithm.
- Wind information is used to compute the threshold.
- After initial thresholding, a clustering step is used to get better separation between the spot and the surrounding.
- A multiscale pyramid approach is used to refine the results. Each level in the pyramid is thresholded and the thresholded images combined.



Spot detection - Envisat

- Spot detection consists of the following steps:
  - Landmasking
  - Normalization of backscatter
  - Speckle filtering
  - Estimate homogeneity (indication of wind speed) if wind information is not available
  - Compute two-level image pyramid
  - Threshold each level in the pyramid
  - Combine the multiscale segmentations

A. S. Solberg, University of Oslo

Spot feature extraction

- Dark spot features:
  - Slick complexity
  - Slick power-to-mean ratio
  - Slick local contrast
  - Slick width
  - Slick local neighbors
  - Slick global neighbors
  - Border gradient
  - Slick area
  - Distance to detected ship
  - Slick planar moment
  - Number of regions in the image
  - Slick smoothness contrast

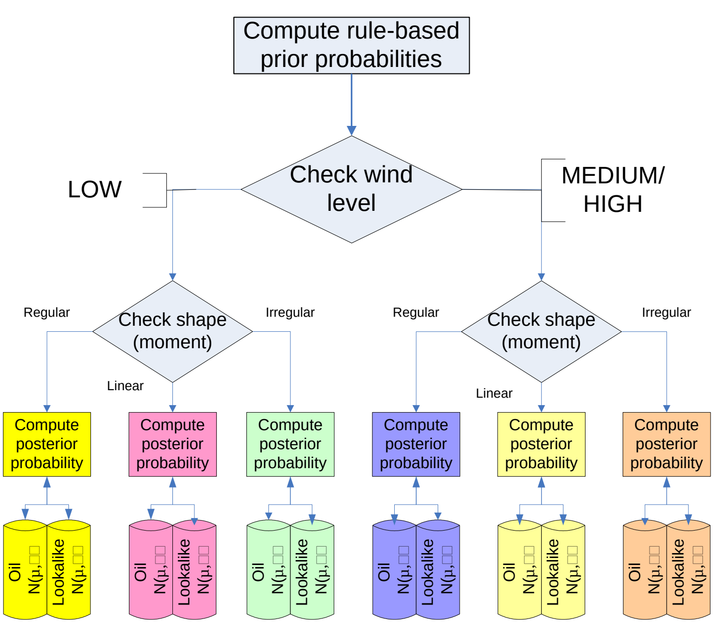
A. S. Solberg, University of Oslo

Spot classification

- **After spot detection and feature extraction, each spot is classified as either oil or look-alike.**
- **Combines a statistical model with prior knowledge about oil spills and look-alikes.**
- **The likelihood of observing both oil and look-alikes depends on the wind level and area-specific parameters.**
- **The presence of a ship or oil platform close to a slick increases the likelihood of being oil.**
- **Oil spills and look-alikes are divided into subclasses based on wind level and shape.**
- **Probabilities from the statistical model are combined with rule-based corrections.**

A. S. Solberg, University of Oslo

Subclasses based on wind and shape



Oil spills classification (Mediterranean Sea)

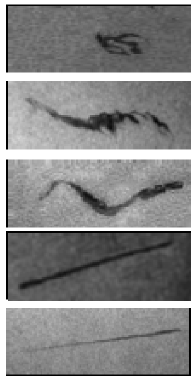
Amorphous spill

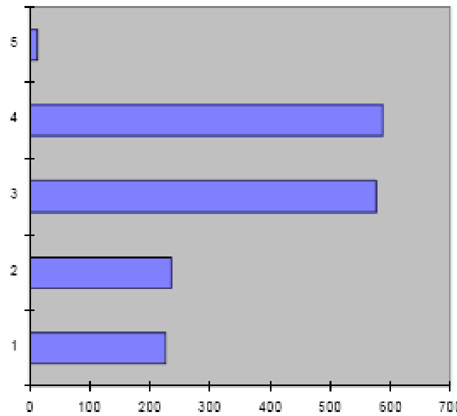
Old zig-zag spill

Fresh zig-zag spill

Old straight spill

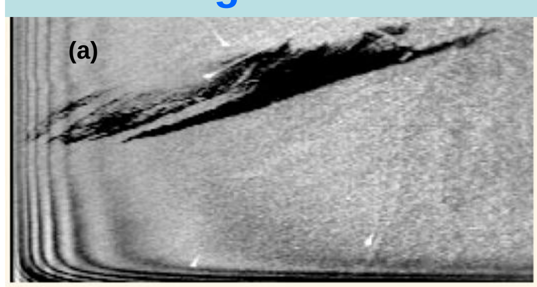
Fresh straight spill





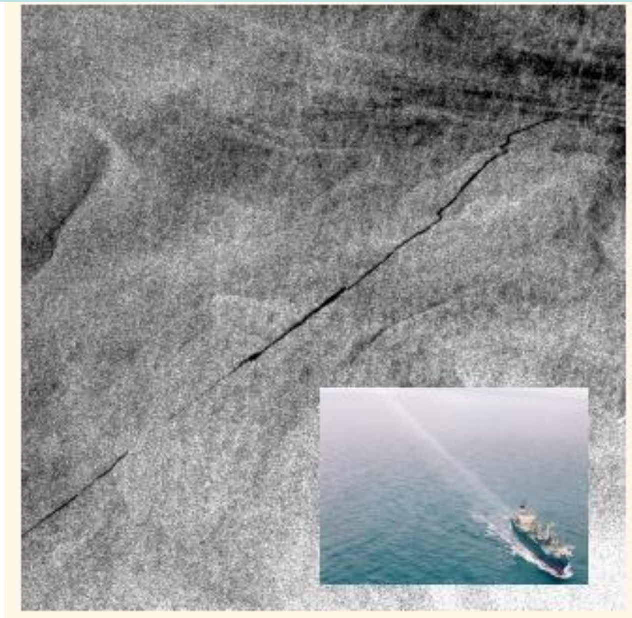
http://serac.jrc.it/midiv

Training and testing the algorithm

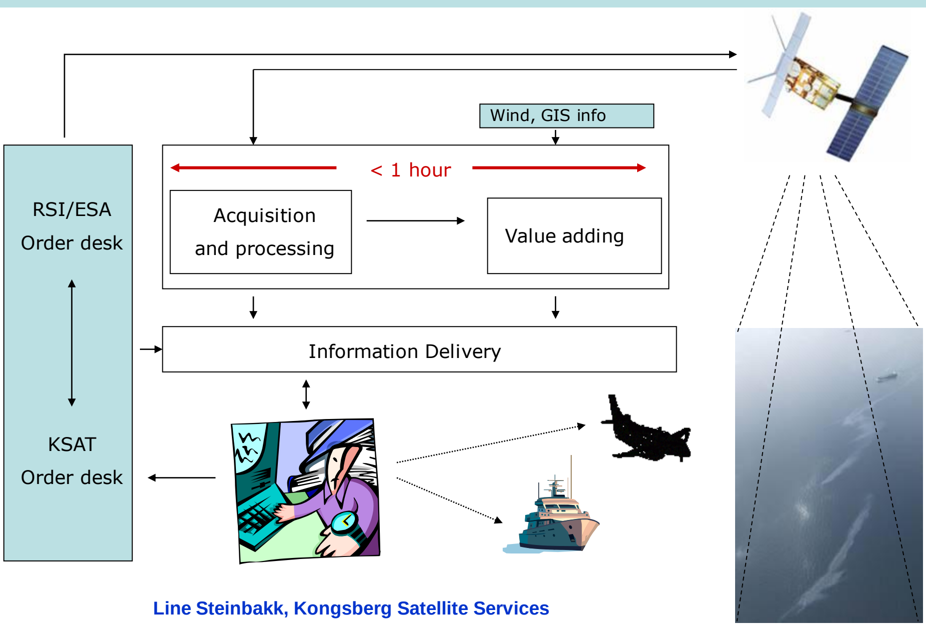


An oil slick off the Dutch coast as observed simultaneously by a surveillance aircraft equipped by Side-Looking Radar (a), and by ERS-1 SAR (b). The shape of the spill appears identical in the two images.

Training and testing the algorithm

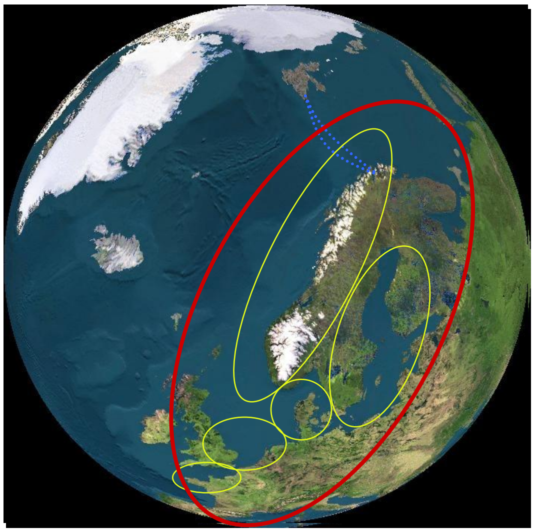


Satellite monitoring: European experience
Near real time service chain



Line Steinbakk, Kongsberg Satellite Services

North-European Service



Line Steinbakk, Kongsberg Satellite Services

- Today there are four separated services
- Customers requires one joint service
- KSAT is merging existing services into one North-European Oil spill service
- The joint service will be available for paying customers in the:
  - Barents Sea
  - Baltic
  - North Sea
  - English Channel

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***S. Anderson, U. Raudsepp.* OIL SPILL STATISTICS FROM SAR IMAGES IN THE NORTH EASTERN BALTIC SEA SHIP ROUTE IN 2007-2009. Proc. IGARSS 2010.**

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CleanSeaNet service of the European Maritime Safety Agency.
CleanSeaNet is a near-real-time satellite-based oil spill and vessel monitoring service. It entered into operation on 16 April 2007. The service is continually being expanded and improved and provides a range of different products to the Commission and to EU Member States, and to other governmental and institutional partners as appropriate
http://cleanseanet.emsa.europa.eu/ I
Information on this site is subject to a disclaimer and a copyright notice

International Charter: Space and Major Disaster. http://www.disasterscharter.org /

R. Santoleri1 and PRIMI Cruise Group. **The PRIMI project: August-September 2009 validation cruise on oil spill detection and fate. SEASAR 2010.**

Oil analysis and Remote Sensing.
Part III

"The National Academy of Sciences estimate that 1.7 to 8.8 million tons of oil are released into world's water every year, of which more than 70% is directly related to human activities. The effects of these spills are all too apparent: dead wildlife, oil covered marshlands and contaminated water chief among them. This reference will provide scientists, engineers and practitioners with the latest methods use for identify and eliminating spills before they occur and develop the best available techniques, equipment and materials for dealing with oil spills in every environment. Topics covered include: spill dynamics and behaviour, spill treating agents, and cleanup techniques such as: in situ burning, mechanical containment or recovery, chemical and biological methods and physical methods are used to clean up shorelines. Also included are the fate and effects of oil spills and means to assess damage"-- 2010

Conclusions (lessons for NOWPAP region)

- Today the satellite-based oil monitoring service is in operational use by most of the key end-users in North Europe
- The multinational concept trials have been successful and have reduced the main bottlenecks for further service development
- With such a concept established throughout Europe service costs and information can be shared among regional, national and international authorities.

Line Steinbakk, Kongsberg Satellite Services