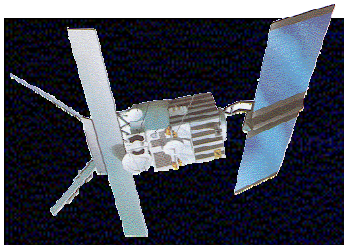

US/EU-Baltic International Symposium
May 23-25, 2006
Klaipeda, Lithuania

OPERATIONAL SATELLITE MONITORING OF OIL SPILL POLLUTION IN THE SOUTHEASTERN BALTIC SEA: 1.5 YEARS EXPERIENCE

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Dr. Sergey Stanichny *Marine Hydrophysical Institute, National Academy of Sciences of Ukraine, Sevastopol, Ukraine*

Dmitry Soloviev

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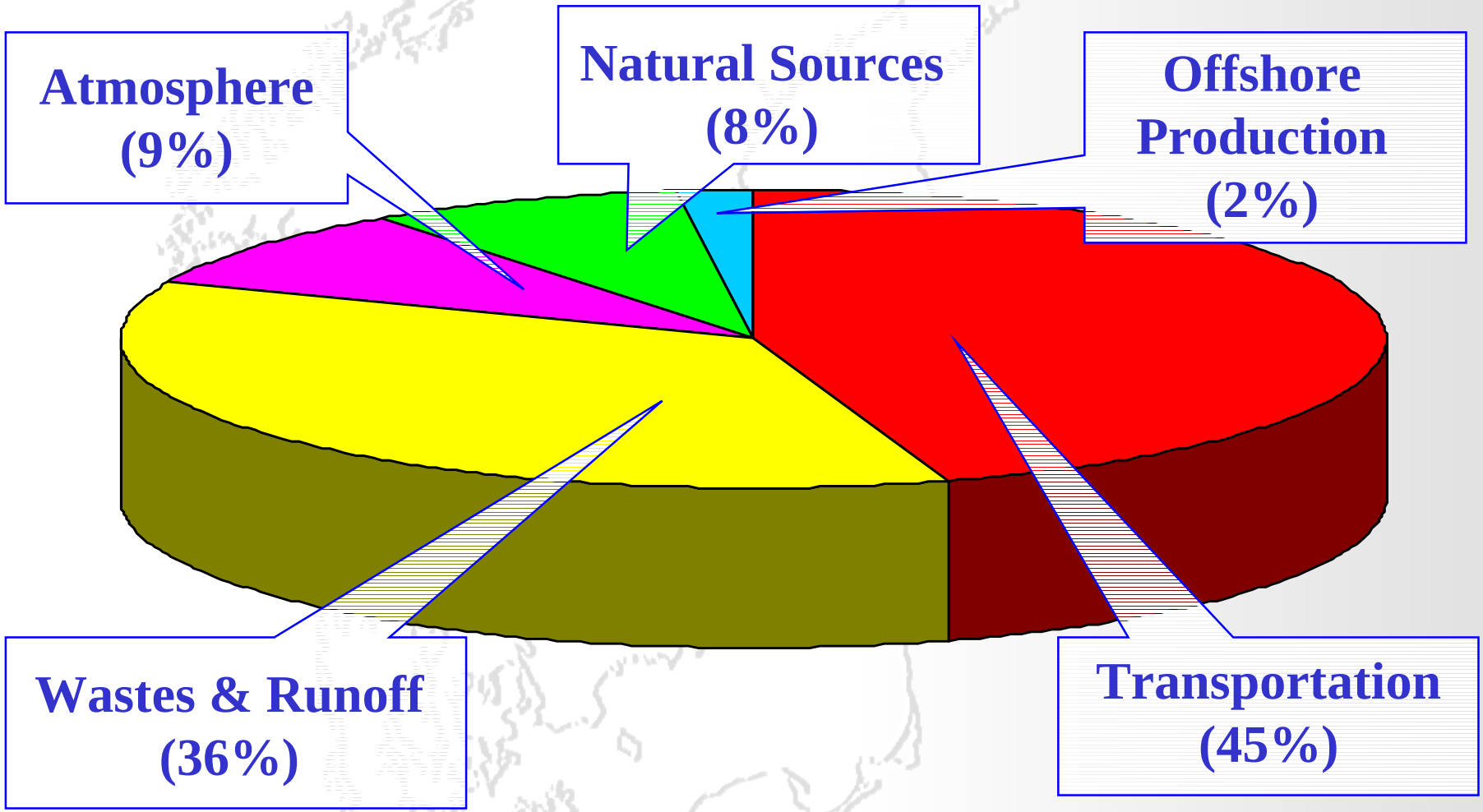
Olga Pichuzhkina *LUKOIL-Kaliningradmorneft, Kaliningrad, Russia*

Oil in the sea

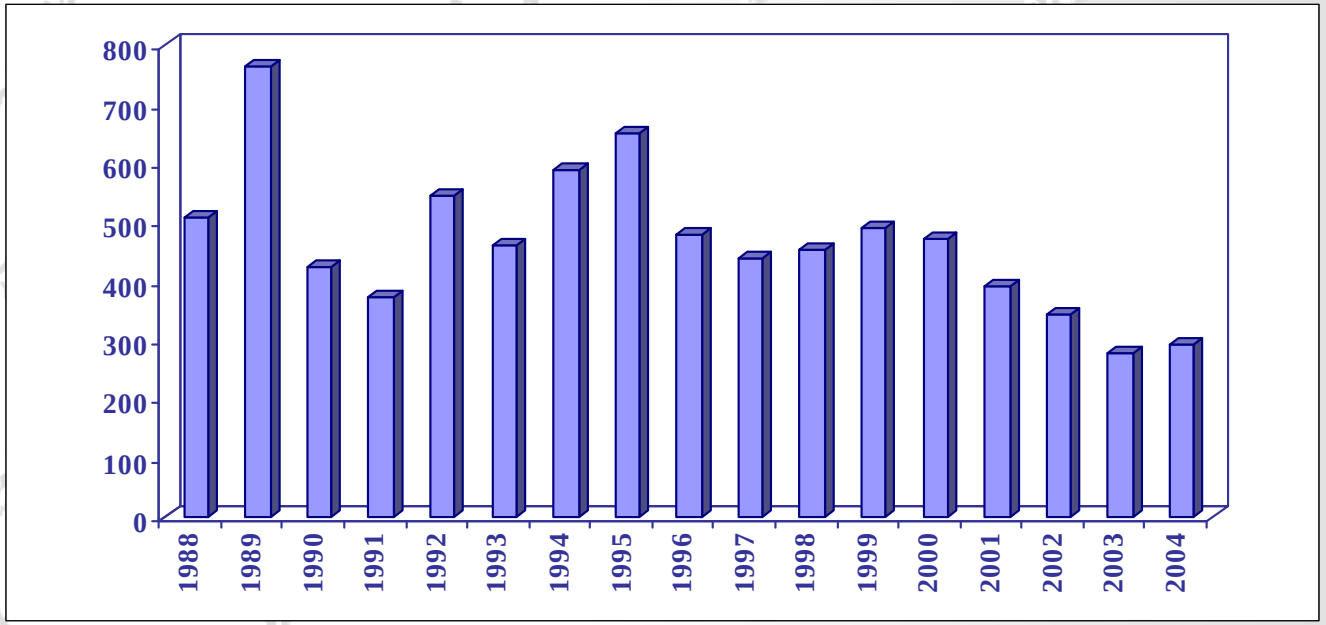


Ship accidents in the Baltic Sea

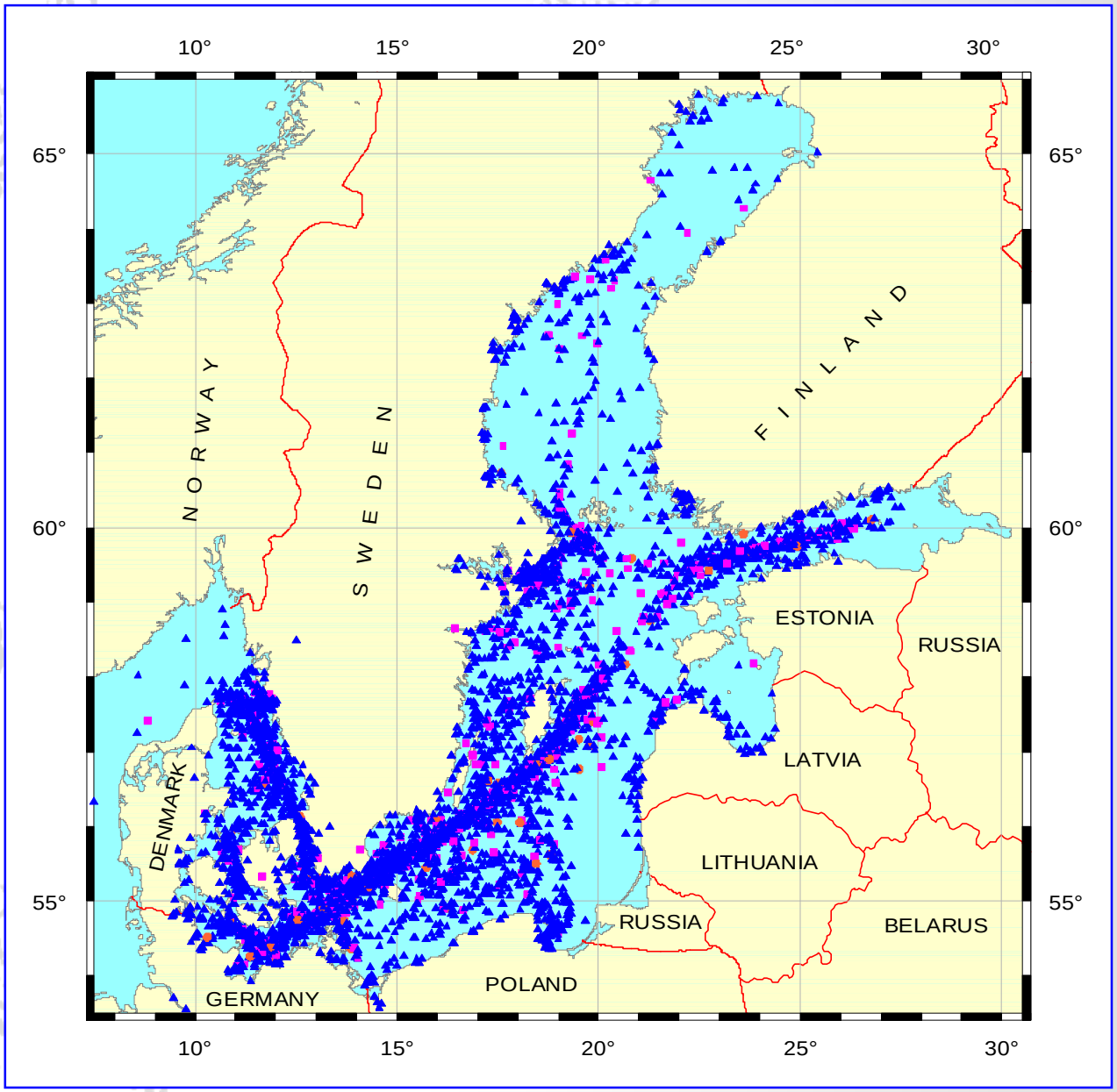
- ***Tsesis*** **(1977, off Nynäshamn, Sweden. Spill: 1,000 t)**
- ***Antonio Gramsci*** **(1979, off Ventspils, Latvia. Spill: 5,500 t. New incident in 1985, off Porvoo, Finland. Spill: 580 t)**
- ***Jose Marti*** **(1981, off Dalarö, Sweden. Spill: 1,000 t)**
- ***Globe Asimi*** **(1982, off Klaipeda, Lithuania. Spill: 16,000 t)**
- ***Sivona*** **(1984, in The Sound, Sweden. Spill: 800 t)**
- ***Volgoneft*** **(1990, off Karlskrona, Sweden. Spill: 1,000 t)**
- ***Baltic Carrier*** **(2001, international waters between Denmark and Germany. Spill: 2,700 t)**

Number of confirmed oil spills in the Baltic Sea in 1988- 2004

Country	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Denmark	129	159	34	46	18	17	30	48	36	38	53	87	68	93	54	37	30
Estonia	-	-	-	-	18	7	4	3	-	3	10	33	38	11	9	4	19
Finland	-	-	-	-	-	-	-	26	42	104	53	63	89	107	75	40	36
Germany	90	139	45	85	76	43	75	55	44	34	23	72	51	51	44	60	42
Lithuania	-	-		8	34	28	-	-	65	-	-	-	-	0	-	-	0
Latvia	-	-	73	20	15	6	-	-	-	-	33	18	17	6	21	14	13
Poland	40	69	88	14	92	110	104	72	50	25	33	18	51	24	25	39	10
Russia	82	184	-	3	13	-	-	-	-	-	-	-	-	-	-	-	-
Sweden	168	212	184	197	278	250	375	445	241	234	249	197	158	98	117	84	143
Total number	509	763	424	373	544	461	588	649	478	438	454	488	472	390	345	278	293



Map of oil spills detected in the Baltic Sea in 1989 - 2002



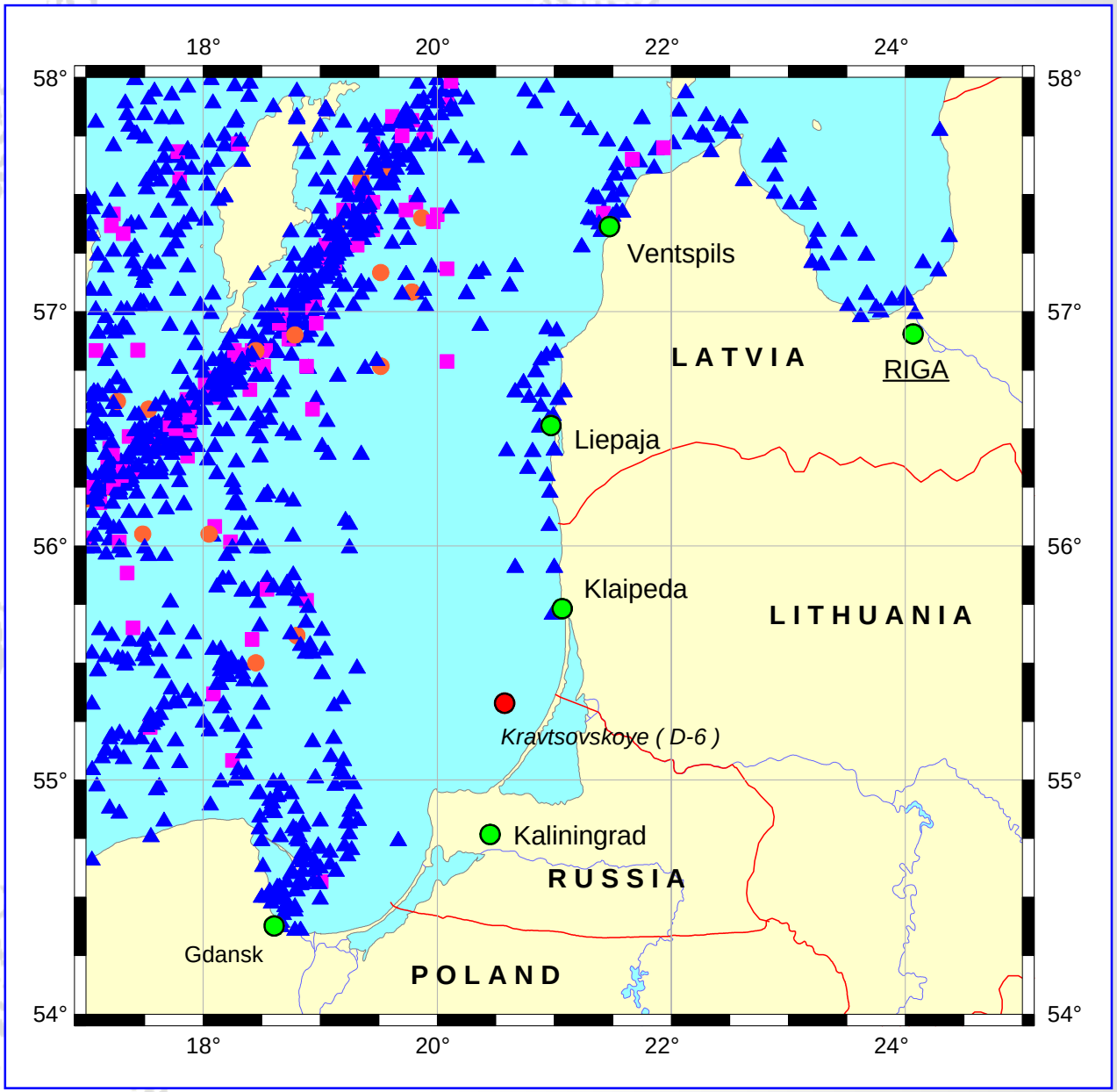
Category 1 – < 1 m³

Category 2 – 1 m³ < 10 m³

Category 3 – 10 m³ < 100 m³

Category 4 – > 100 m³

Map of oil spills detected in the southeastern Baltic Sea in 1989 - 2002



Category 1 – / < 1 m^3

Category 2 – * 1 m^3 < 10 m^3

Category 3 – 10 m^3 < 100 m^3

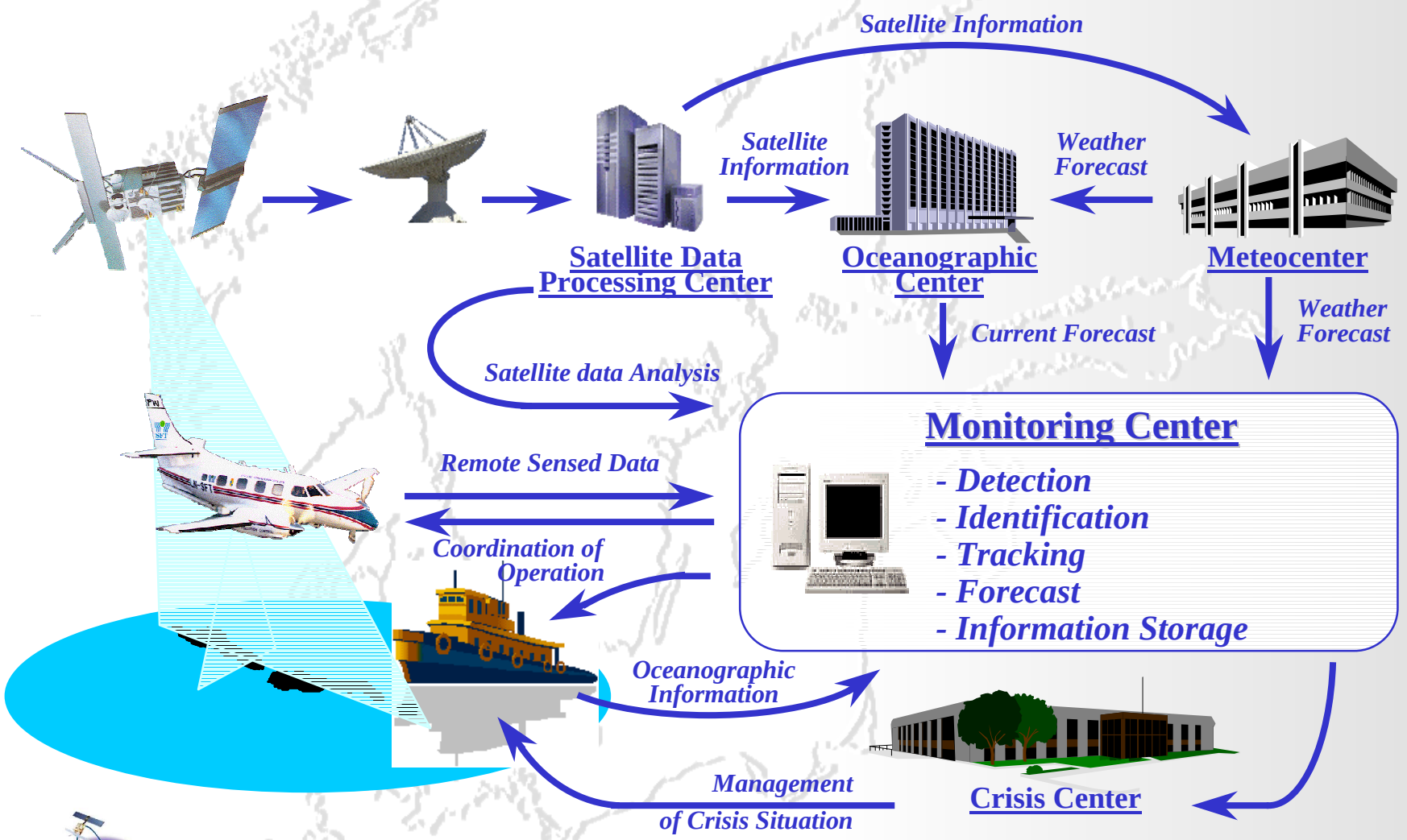
Category 4 – > 100 m^3

Oil transportation volumes of certain Baltic oil terminals in 1997, 2000 and 2015

Country / port (terminal)	1997	2000	2015
Estonia/Muuga	9.2	17.8	24.0
Finland/Hamina	1.2	1.3	1.5
Finland/Porvoo	13.3 (other 5)	13.6	15.0
Latvia/Riga	1.3	3.0	5.0
Latvia/Ventspils	19.05	26.7	30.0
Latvia/Liepaja	—	0.1	0.5
Lithuania/Klaipeda	1.7	5.2	8.0
Lithuania/Butinge	—	3.5	8.0
Russia/St. Petersburg	3.5	7.5	10.0
Russia/Primorsk	—	—	24.0
Russia/Batareinaya	—	—	6.0
Russia/Kaliningrad	0.3	1.1	2.0
Total (million tons)	54.5	79.8	134.0

© Rytkonen et al., 2002

Scheme of oil spill monitoring



Oil spill monitoring in the Mediterranean, North and Baltic Seas

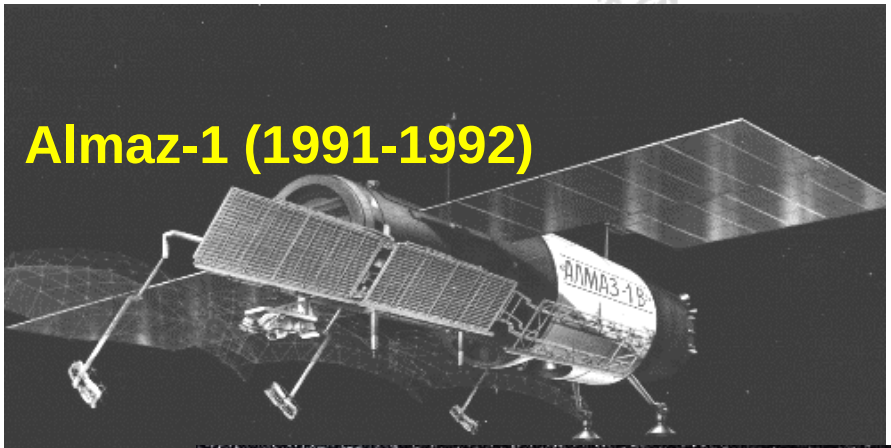
Each year ships and industries damage the delicate coastal ecosystem in many parts of the world by releasing oil or pollutants into rivers and coastal waters. Off-shore environments are also polluted by mineral oil mainly due to: tanker accidents, illegal oil discharges by ships, natural oil seepage.

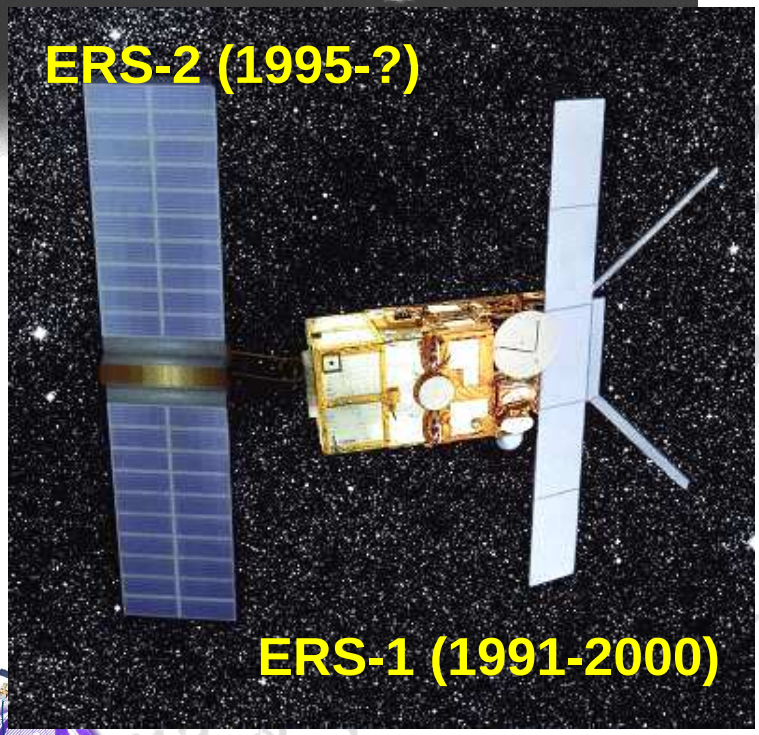
After a tanker accident the biggest problems is to obtain an overall view of the phenomenon, getting a clear idea of the extent of the slick and predicting the way it will move. For natural and man-made oil spills it is necessary to operate a regular monitoring. Oil pollution monitoring in the Mediterranean, North and Baltic Sea is normally carried out by aircraft or ships. This is expensive and is constrained by the limited availability of these resources. Aerial surveys over large areas of the seas to check for the presence of oil are limited to the daylight hours in good weather conditions.

National aircraft resources in the EU countries in 2000

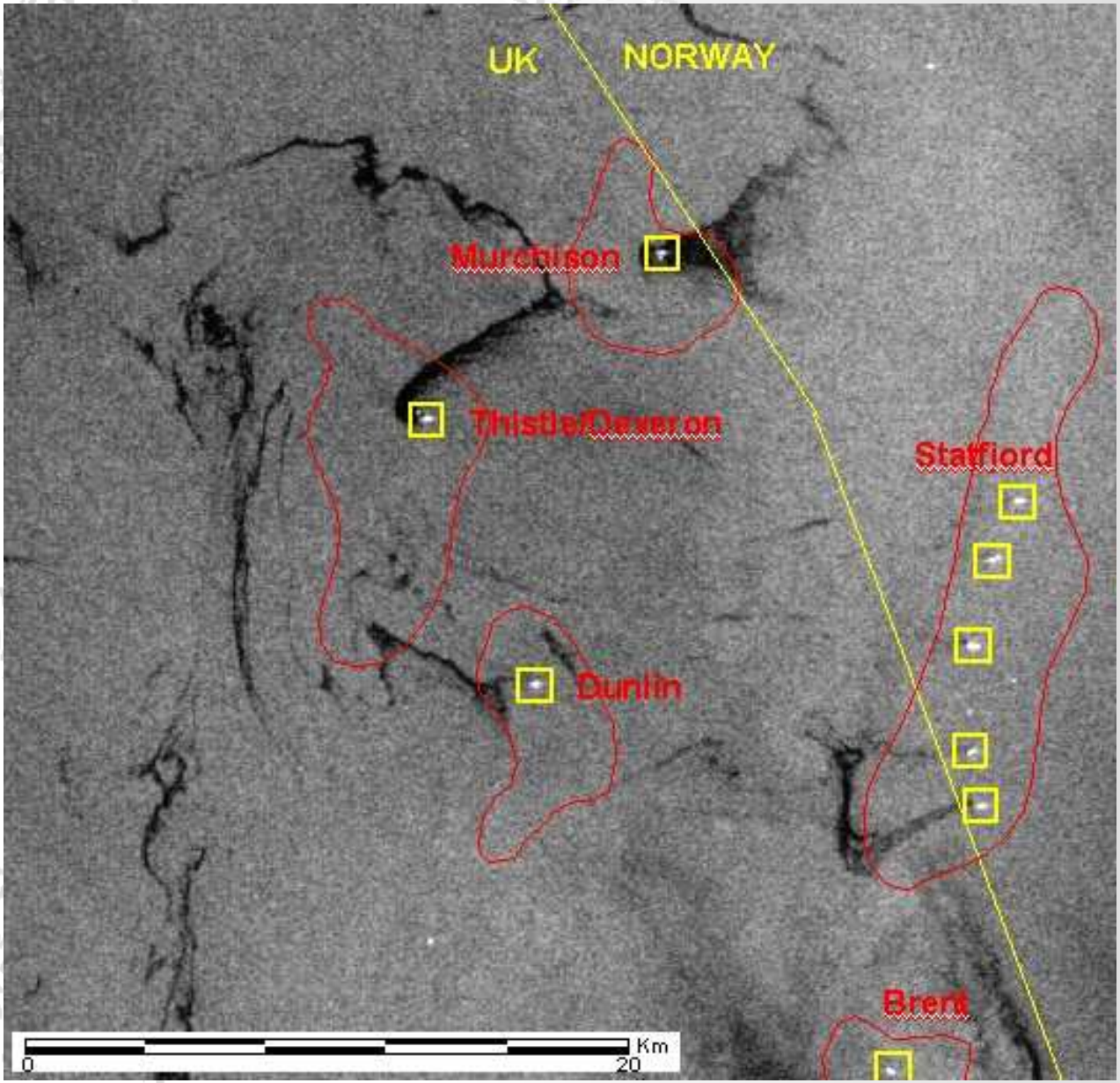
Country	Number and type of aircrafts	Sensors
Denmark	1 Gulfstream	SLAR
Finland	2 Do 228	SLAR, IR/UV
Germany	2 Do 228 LM	SLAR, IR/UV, MWR, LFS
Sweden	3 CASA 212	SLAR, IR/UV, MWR, video camera, FLIR
Greece	F406, M28	SLAR, IR/UV, MWR, video camera
Norway	Fairchild Merlin	SLAR, IR/UV, MWR, video camera
Portugal	5 CASA 212	SLAR, IR/UV, MWR, video camera
Netherlands	Cessna 404	SLAR, IR/UV, MWR, video camera
Great Britain	Cessna 402	SLAR, IR/UV, MWR, video camera
Italy		Visual and specific means for oil spill detection
France		
Spain		Visual oil spill detection
Ireland and Belgium		No info

SAR satellites





Oil platforms and oil spills in the North Sea 30 October 1994 ERS-1, © ESA



Materials and methods

Since 1993 there is no more regular aerial surveillance of the oil spills in the Russian sector of the southeastern Baltic Sea.

Lukoil-Kaliningradmorneft Project (since June 2004)

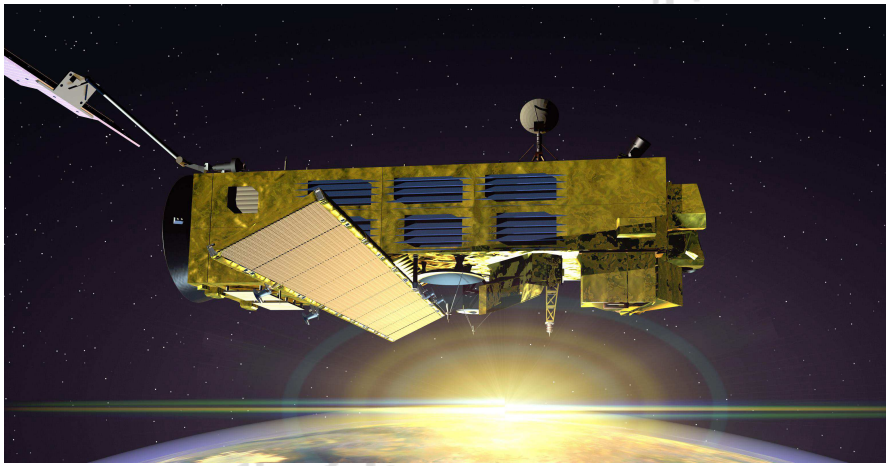
“Complex satellite monitoring in the southeastern Baltic Sea”

includes satellite monitoring of oil spills and other parameters of the sea state and mesoscale water dynamics.

It is performed on the base of satellite remote sensing of:

- ***Oil spills (ASAR imagery of ENVISAT and RADARSAT)***
- ***Wind speed, wave height (QuikSCAT, Jason-1)***
- ***IR (AVHRR NOAA, MODIS-Terra and -Aqua)***
- ***Visible (MODIS-Terra and -Aqua, AVHRR NOAA)***
- ***Chlorophyll (SeaWiFS)***

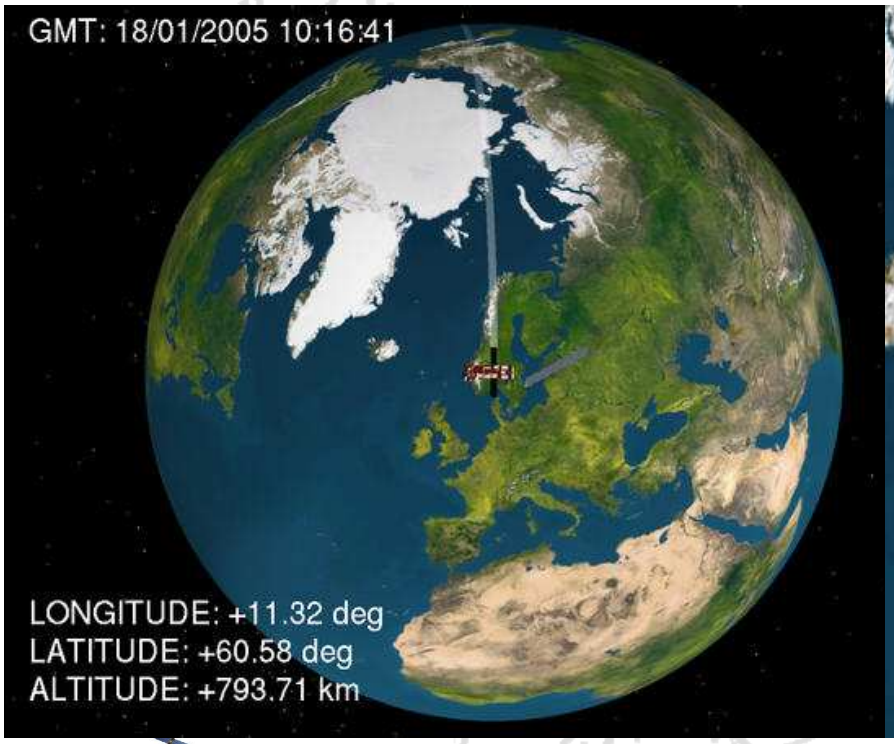
- ***Meteo***
- ***SMHI SeaTrack numerical model (oil spill drift)***

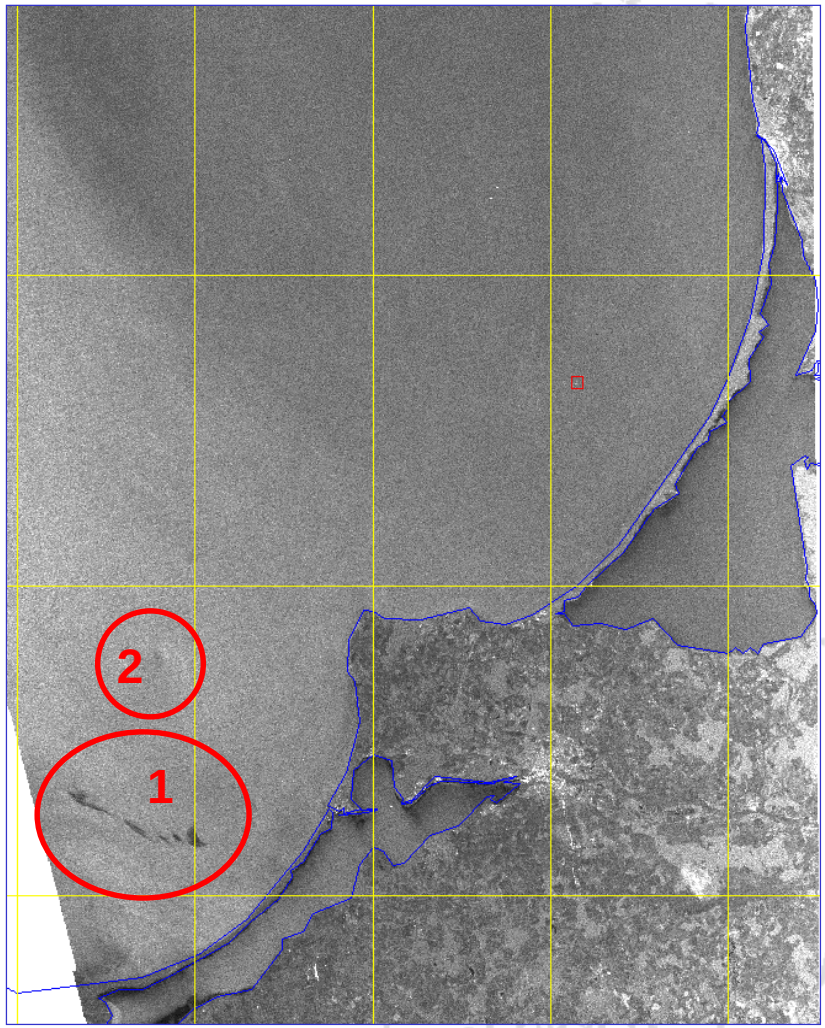


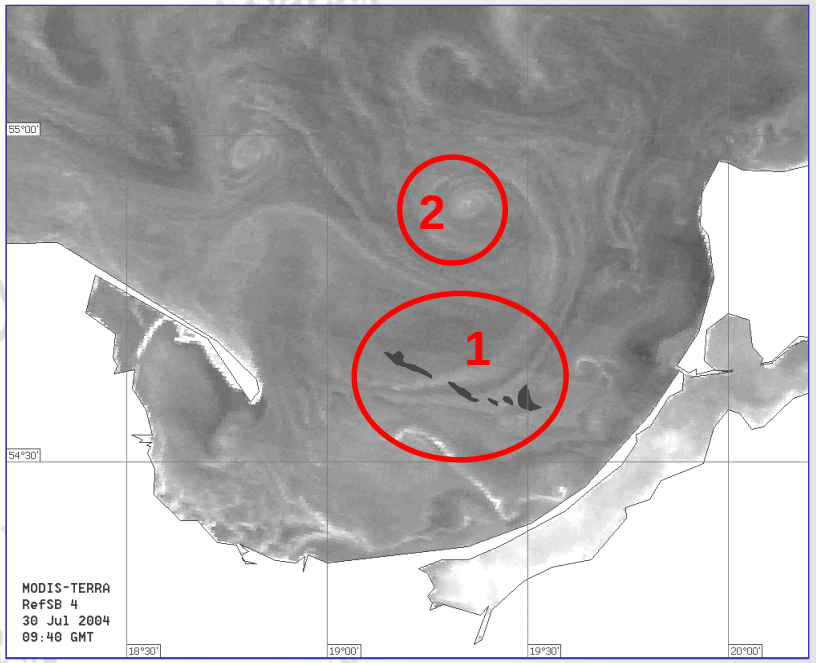
ENVISAT satellite
European Space Agency

Kongsberg Satellite Services
Tromsø, Norway

KONGSBERG



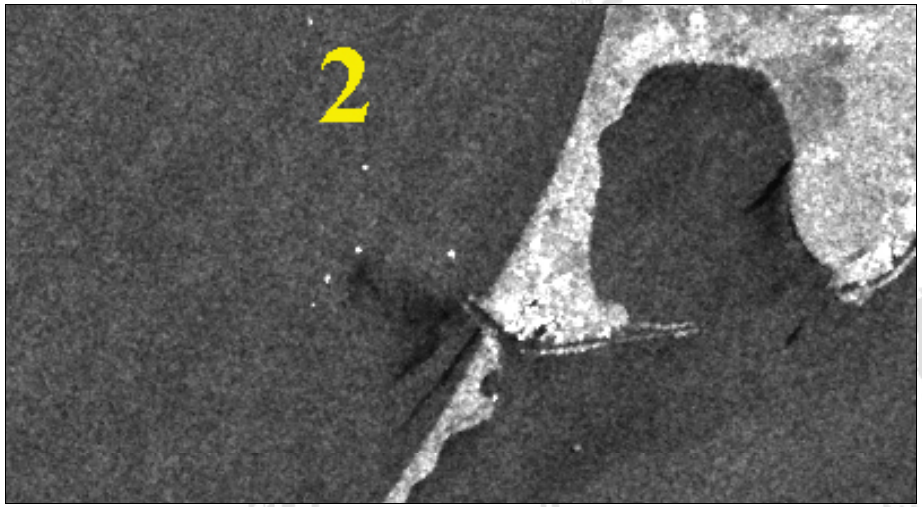




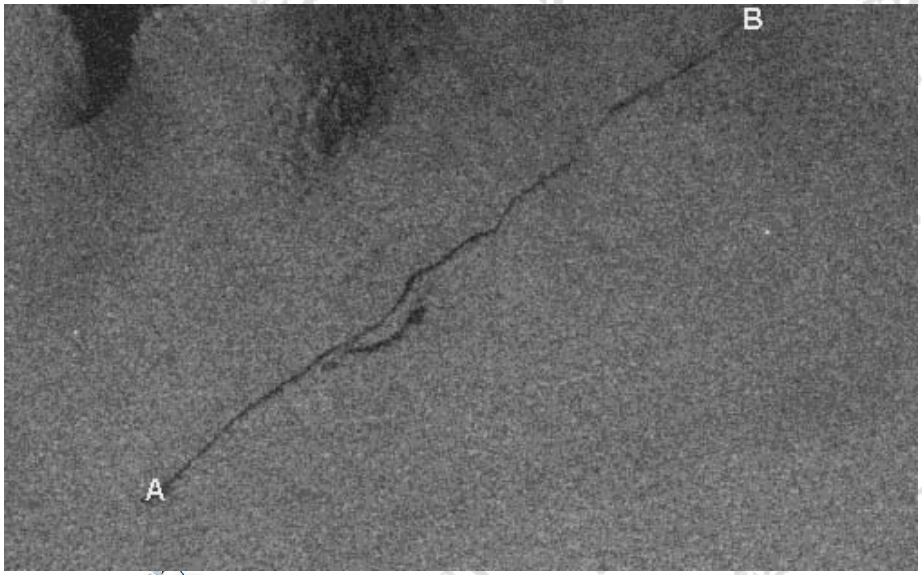
Mesoscale dynamics in the Gulf of Gdansk as revealed by MODIS-Terra (250 m) on 30 July 2004, 09:40 GMT. Black spots are locations of oil spills detected on ASAR image at 20:08 GMT.

ASAR ENVISAT image of the southeastern Baltic Sea on 30 July 2004, 20:08 GMT. (1) indicates a chain of oil spills in the Gulf of Gdansk; (2) is a spill in the cyclone.

SAR imagery of the southeastern Baltic Sea

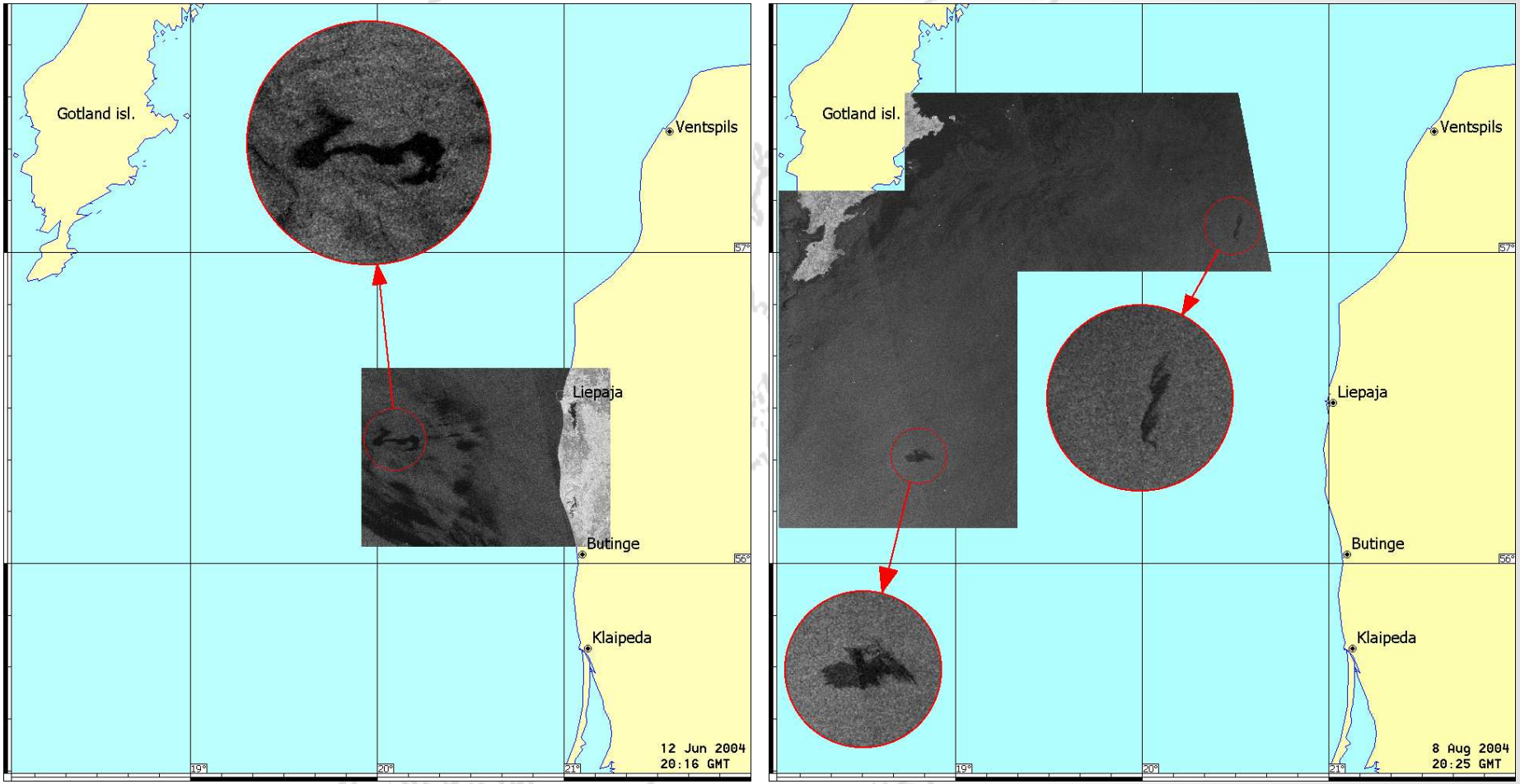


1 October 2004
Two oil spills in front of the Baltic Channel

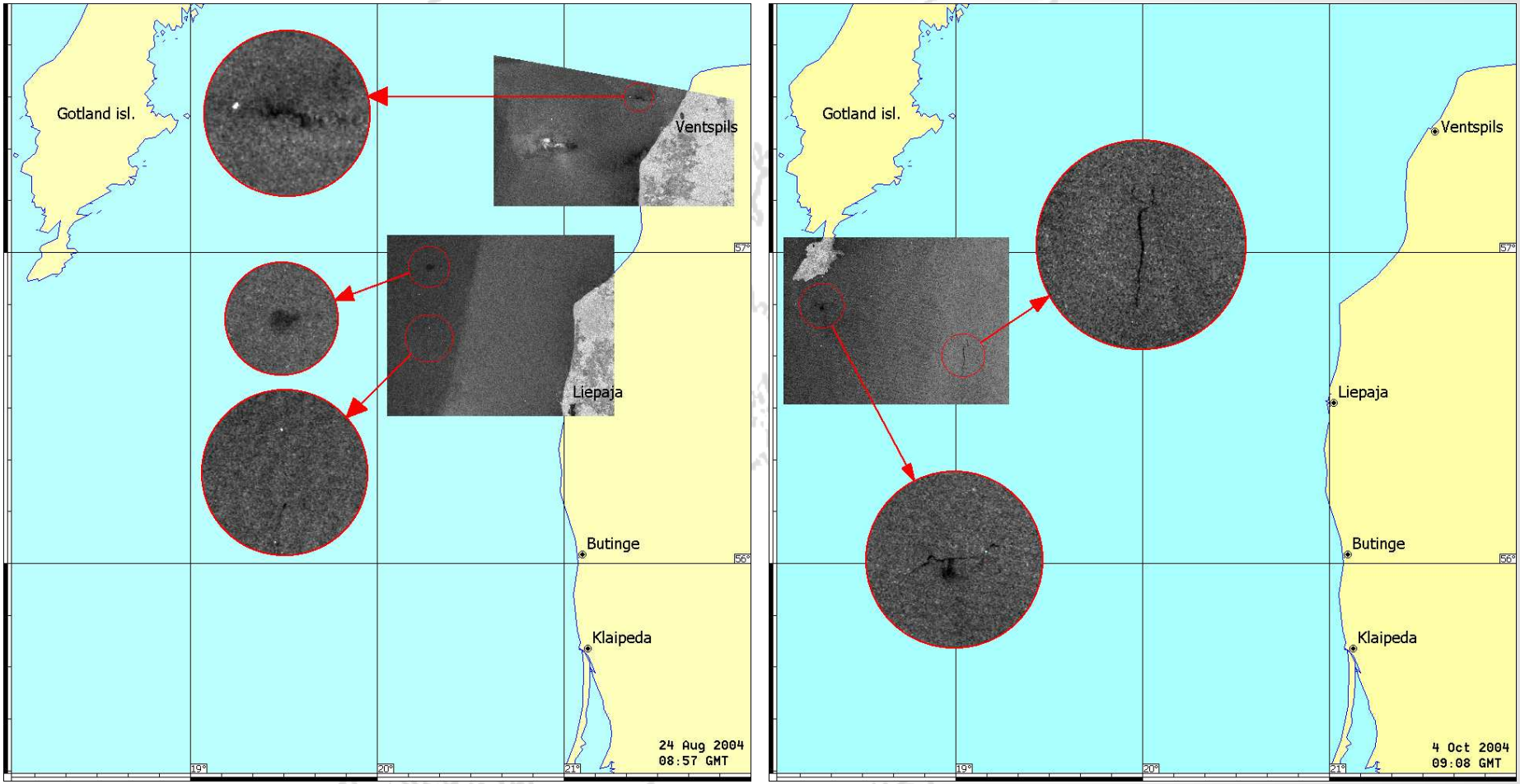


2 November 2004
Eastward of Oland Island, oil spill from the ship
A: 56°09′43″N, 17°05′30″E
B: 56°18′11″N, 17°24′24″E
Length AB = 32 km

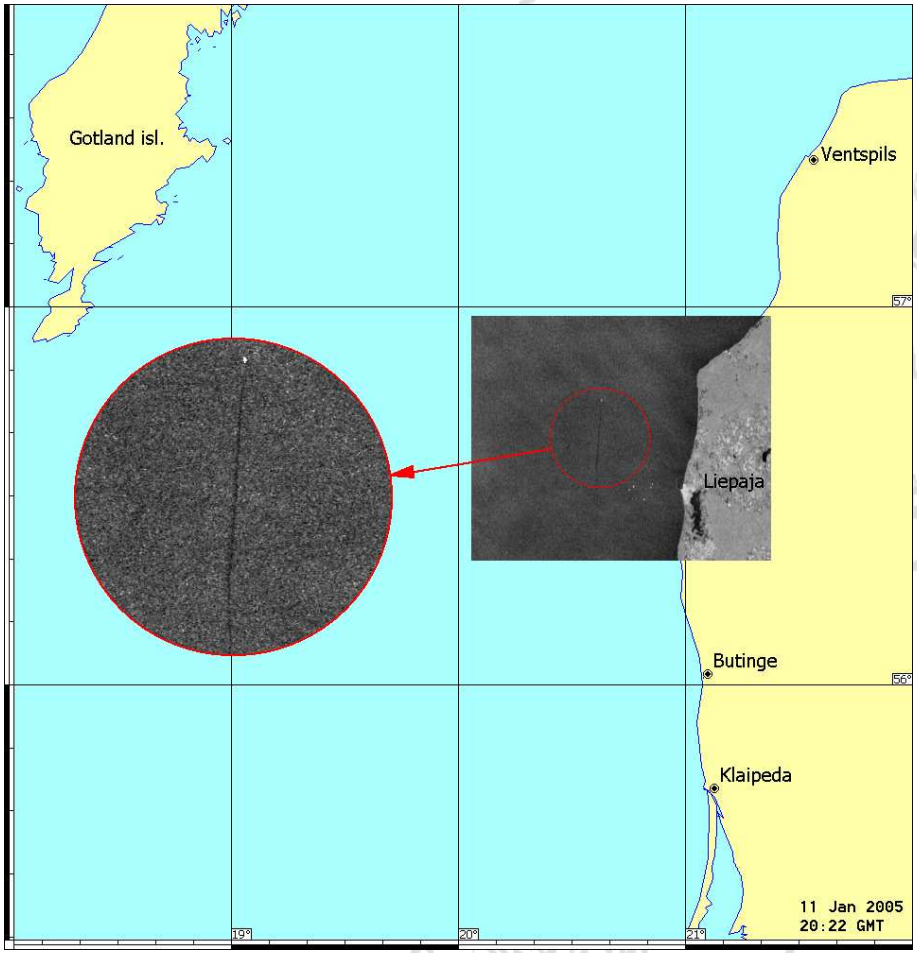
Oil spill gallery in the southeastern Baltic Sea

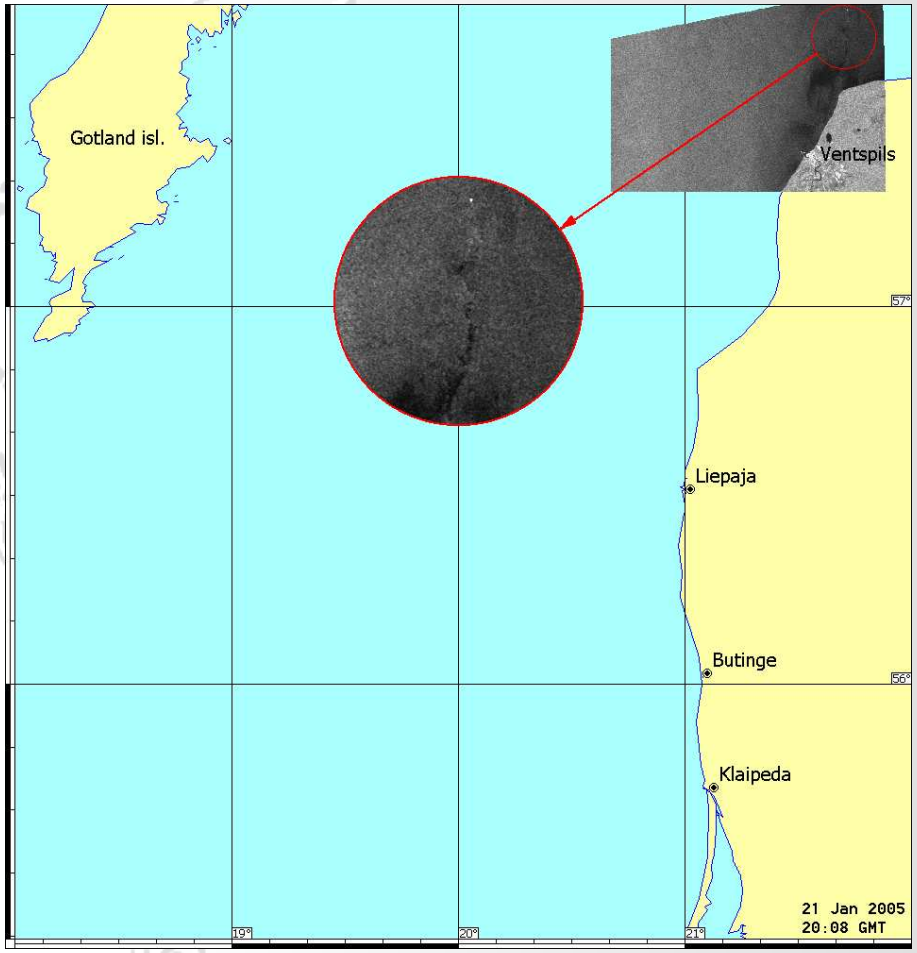


Oil spill gallery in the southeastern Baltic Sea

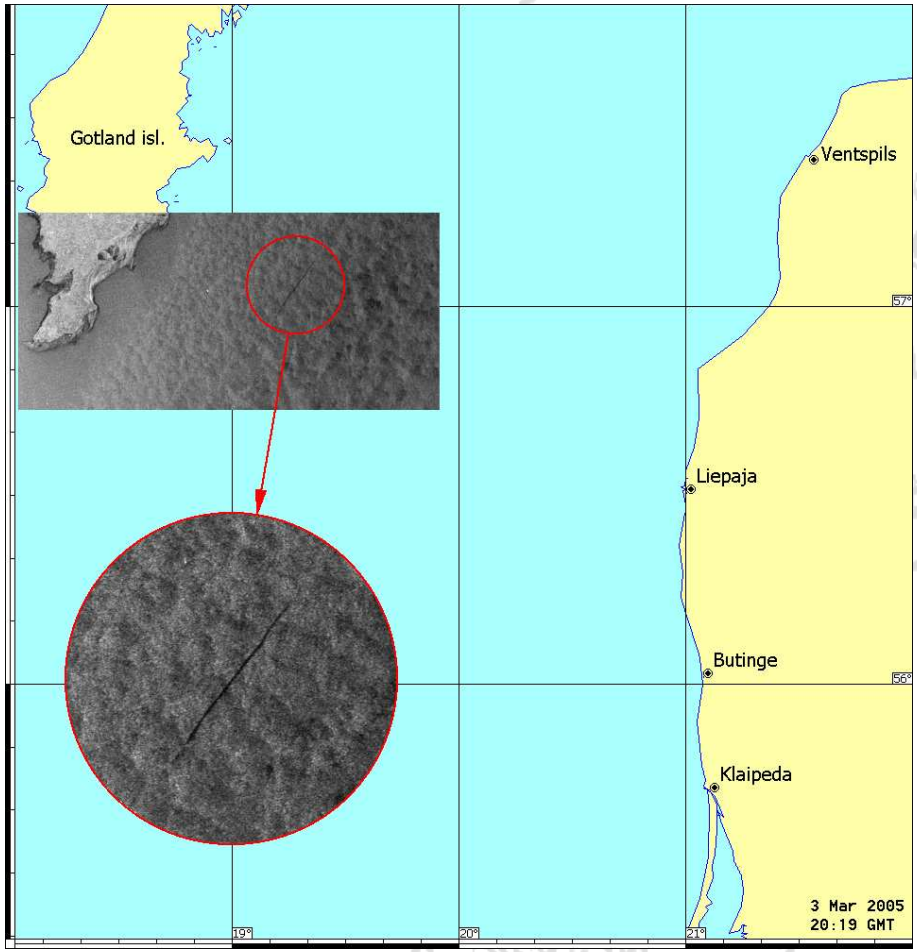


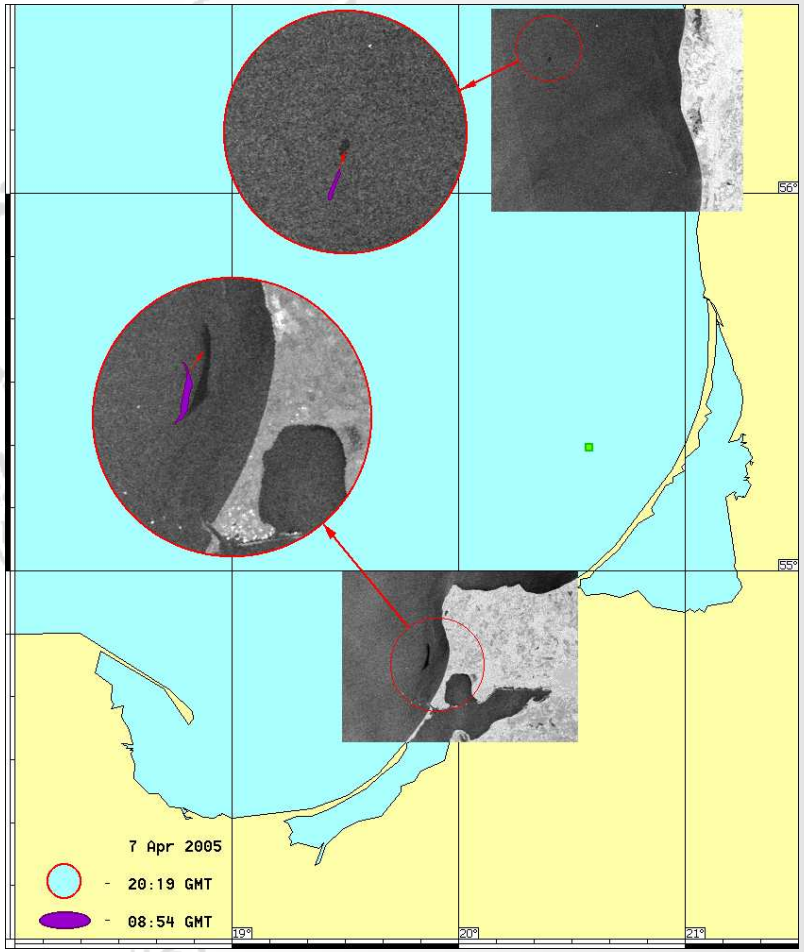
Oil spill gallery in the southeastern Baltic Sea



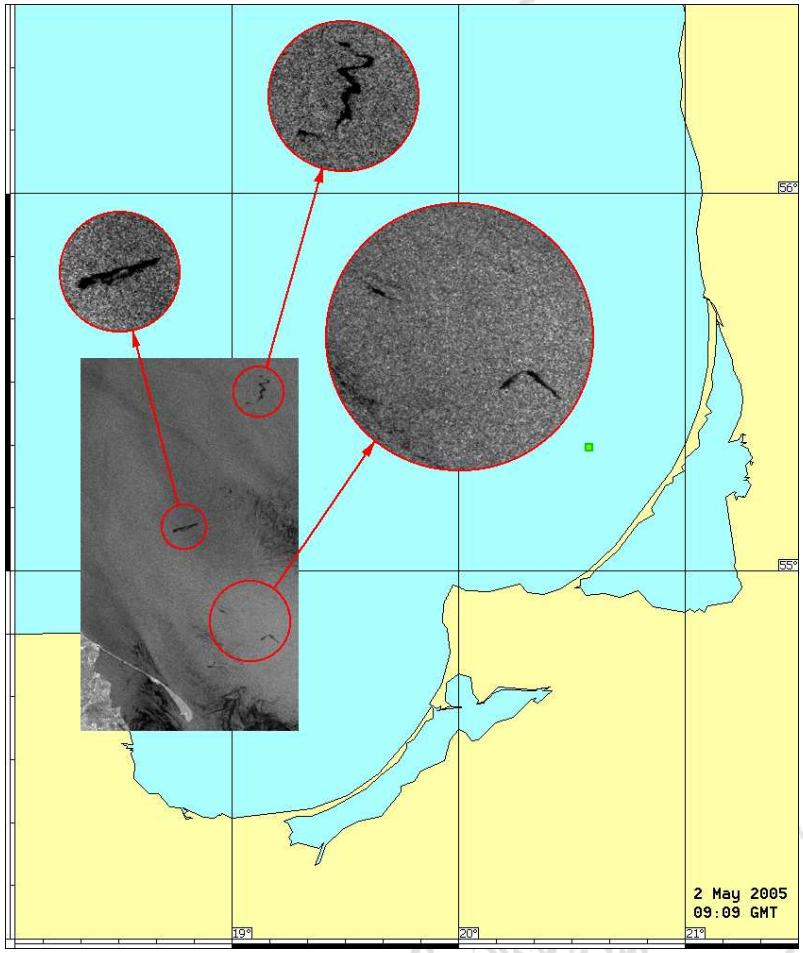


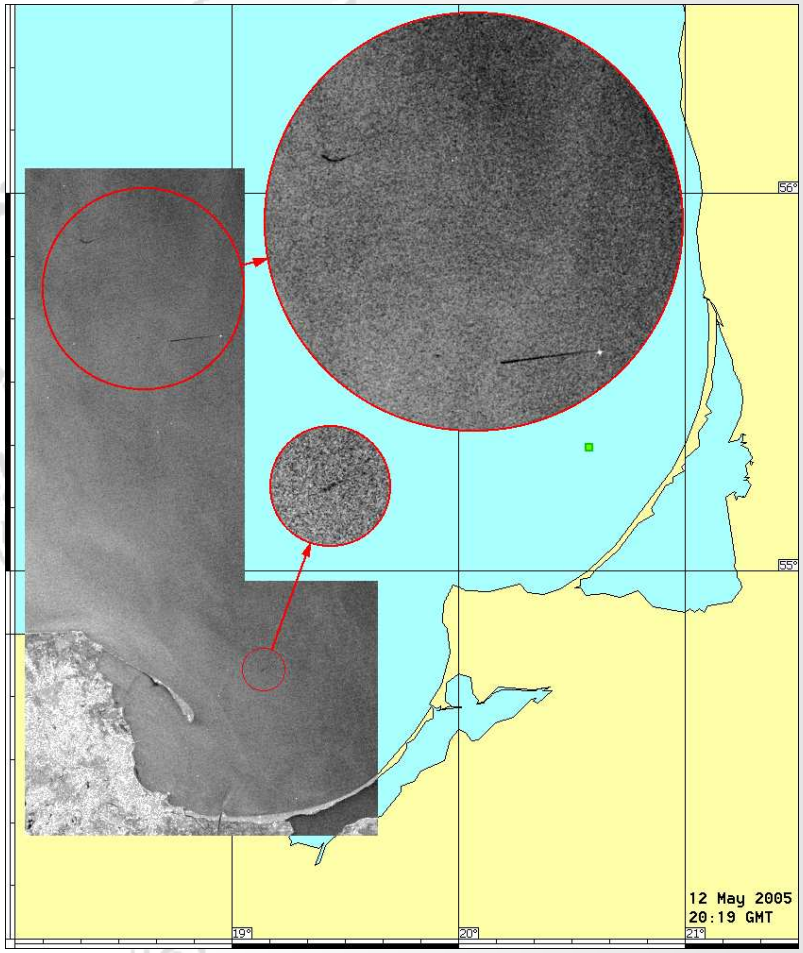
Oil spill gallery in the southeastern Baltic Sea



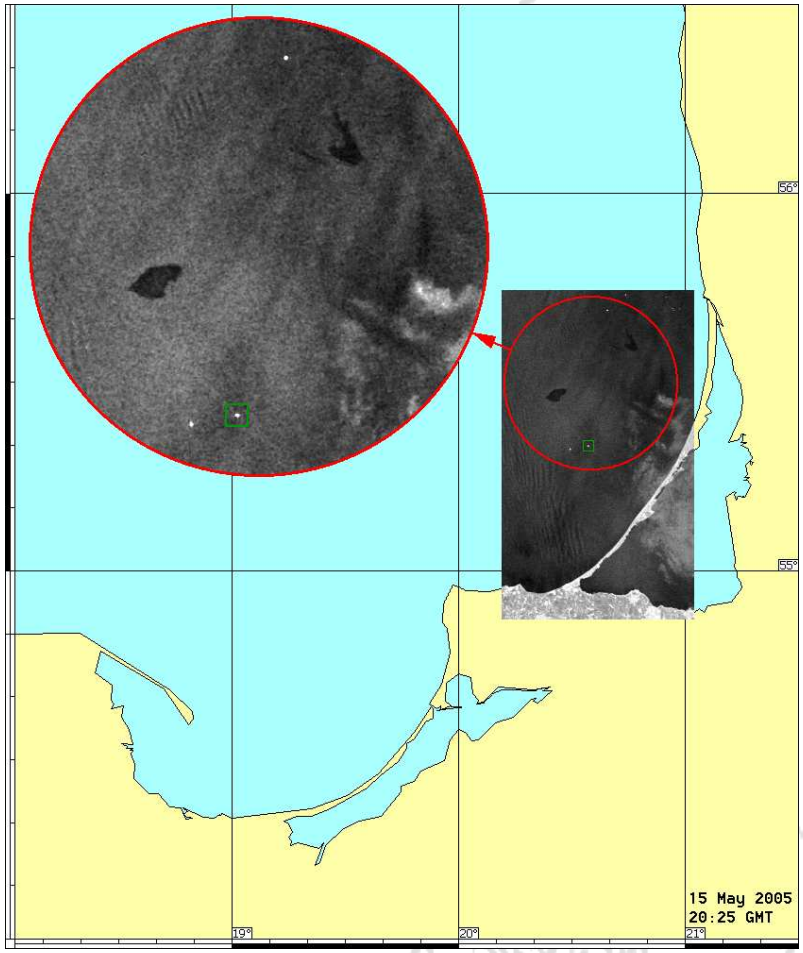


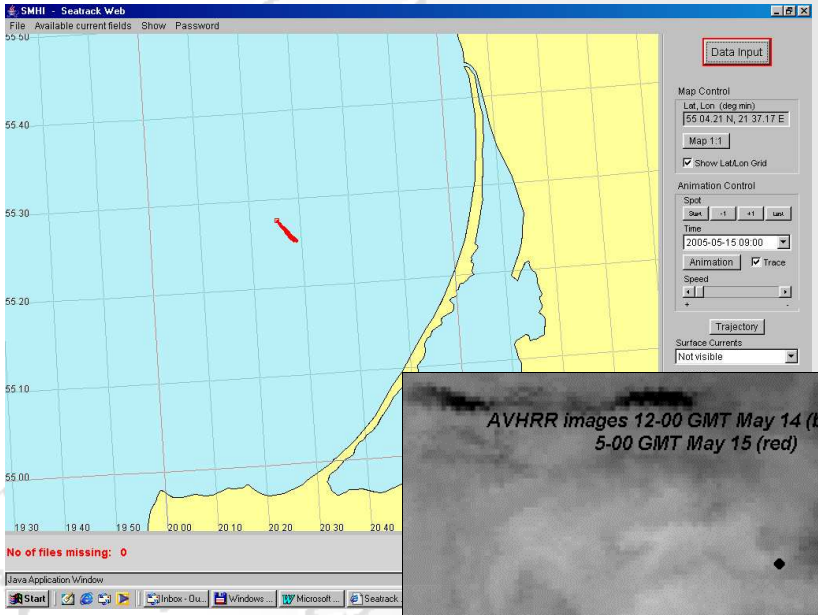
Oil spill gallery in the southeastern Baltic Sea

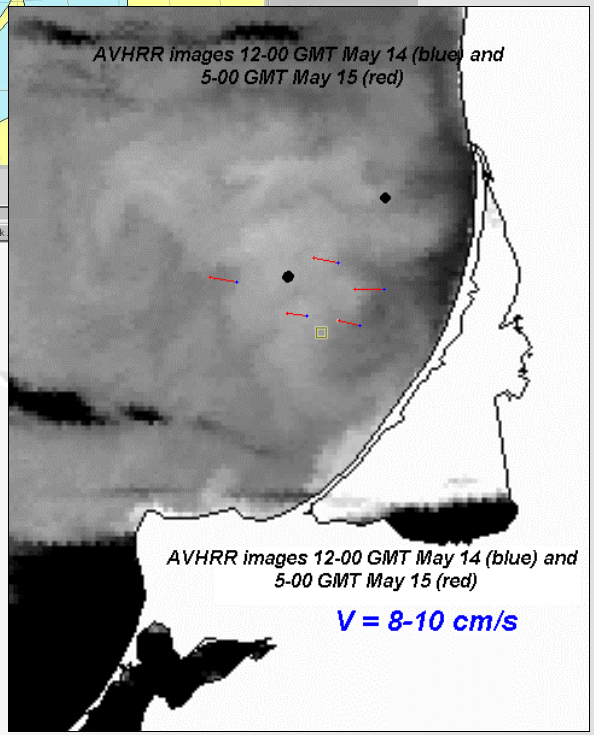




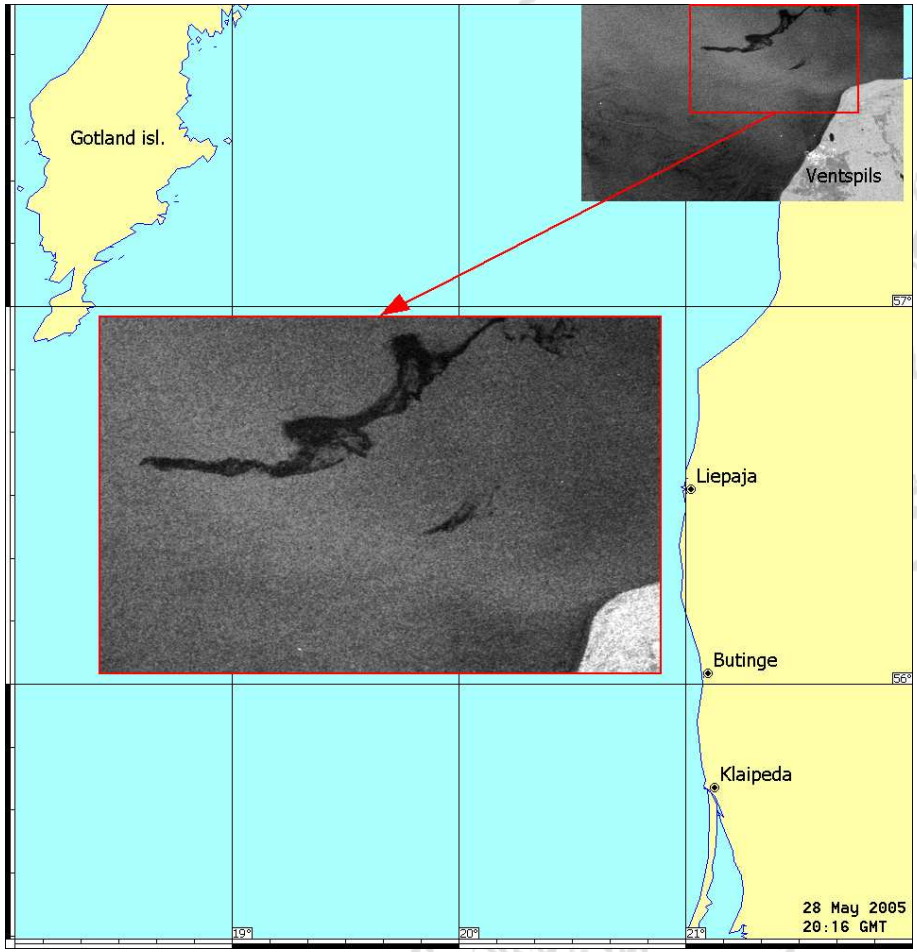
Oil spill gallery in the southeastern Baltic Sea

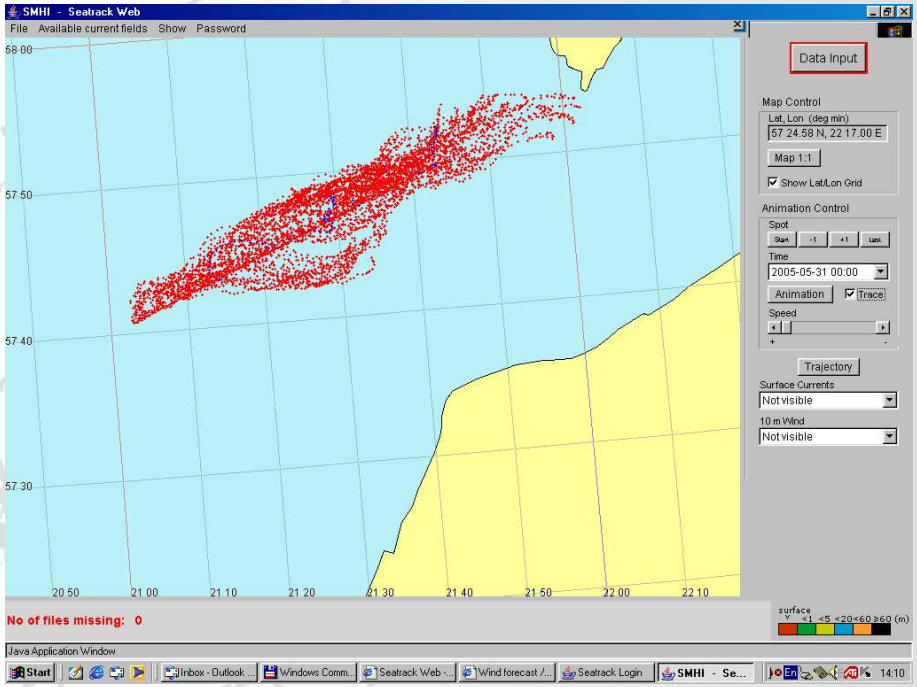






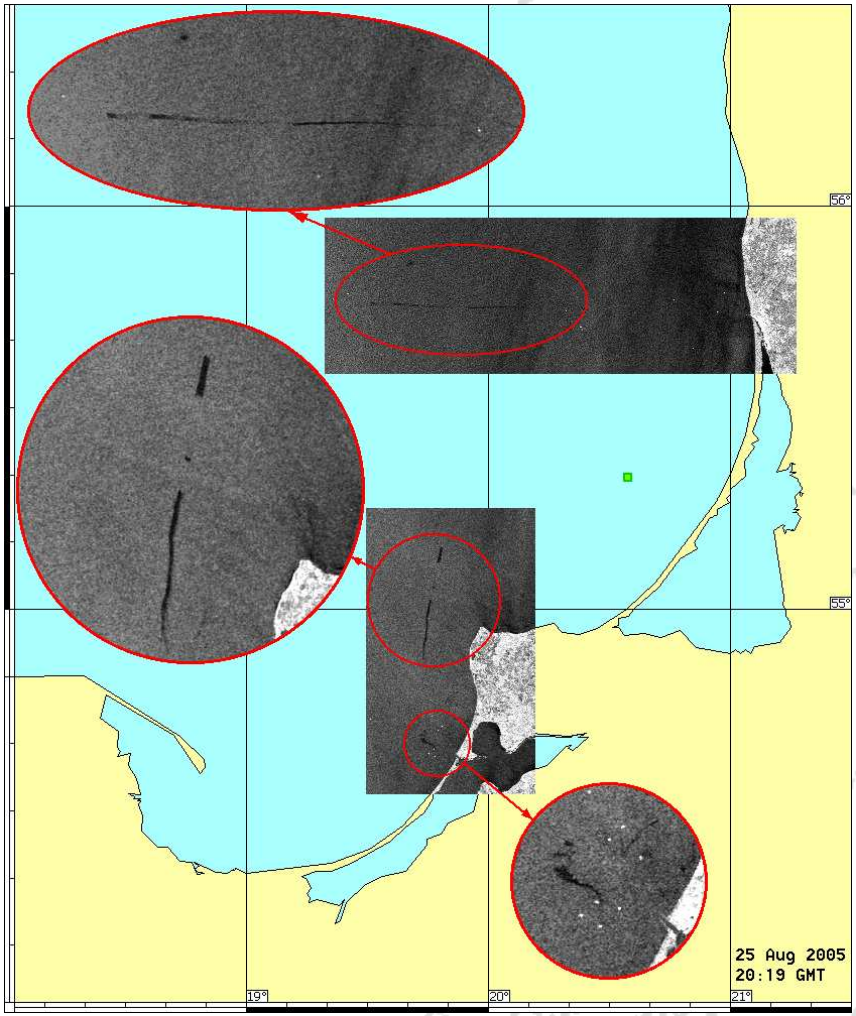
Oil spill gallery in the southeastern Baltic Sea

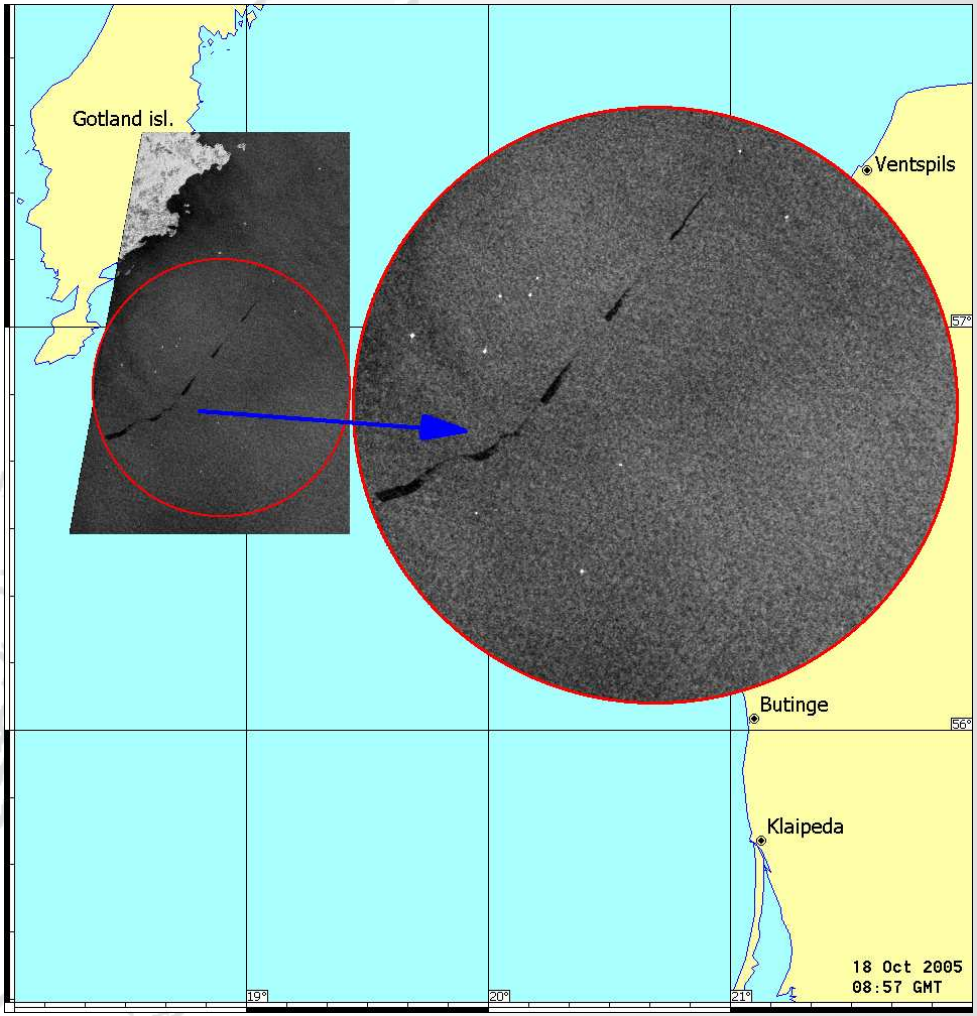




SMHI operational oil spill drift model Seatrack Web

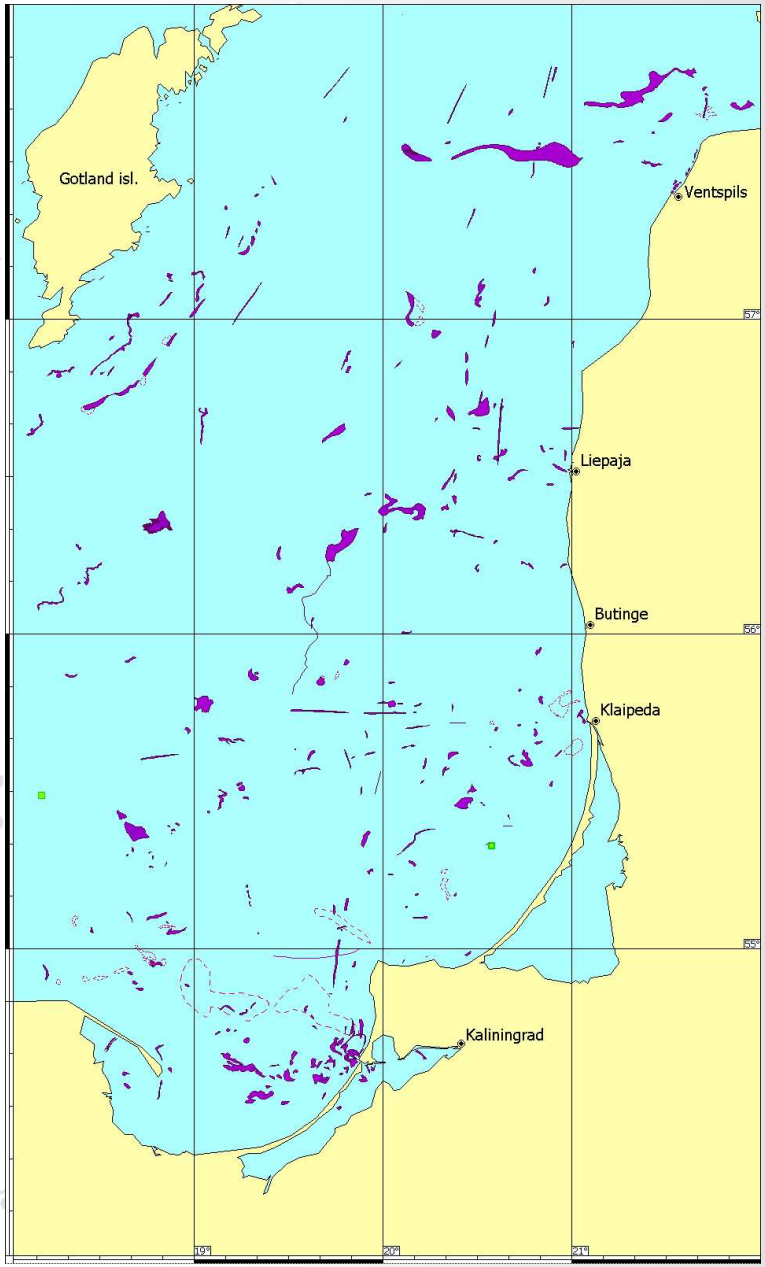
Oil spill gallery in the southeastern Baltic Sea



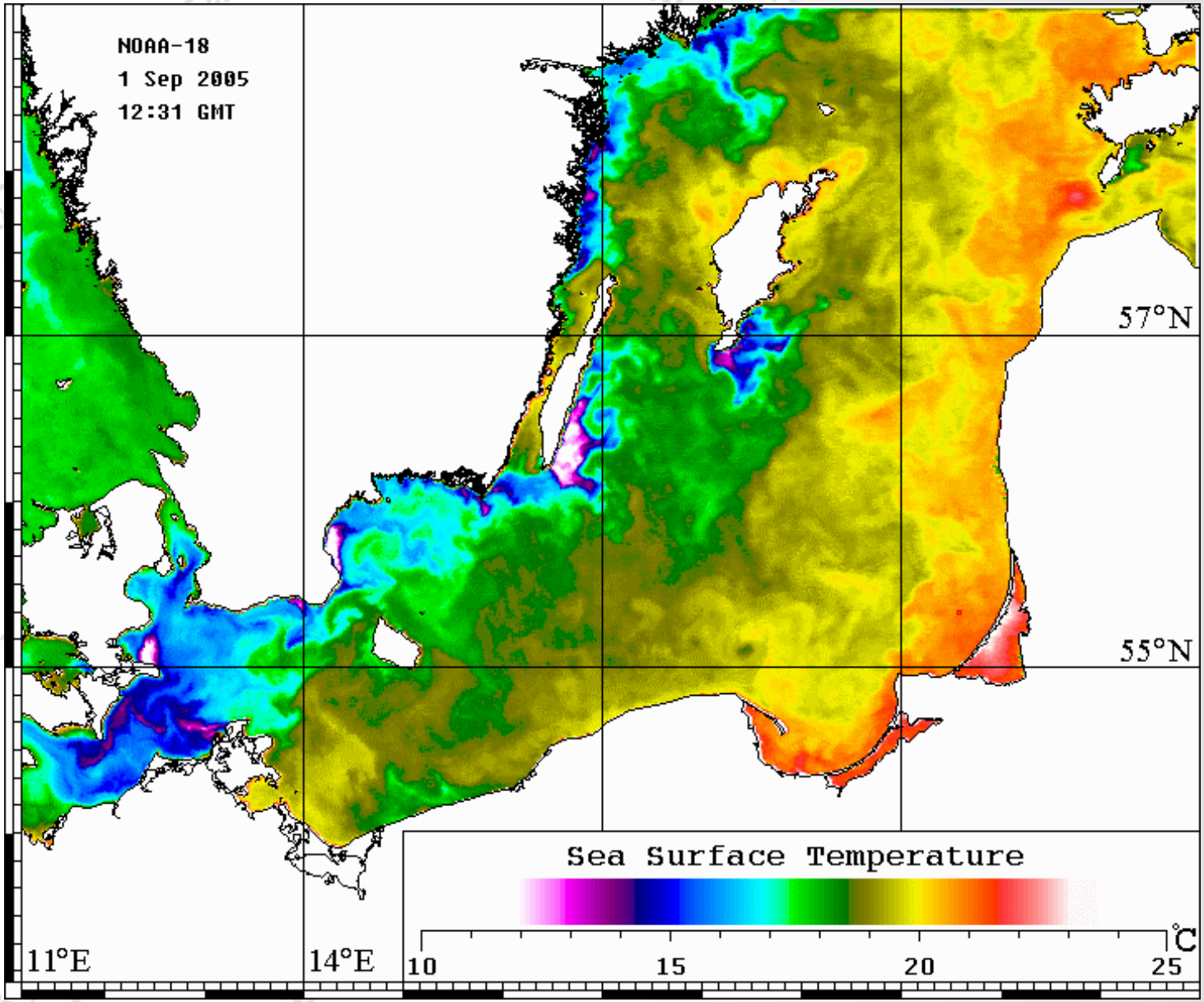


Map of oil spills detected by ASAR ENVISAT in the southeastern Baltic Sea in June 2004 – November 2005

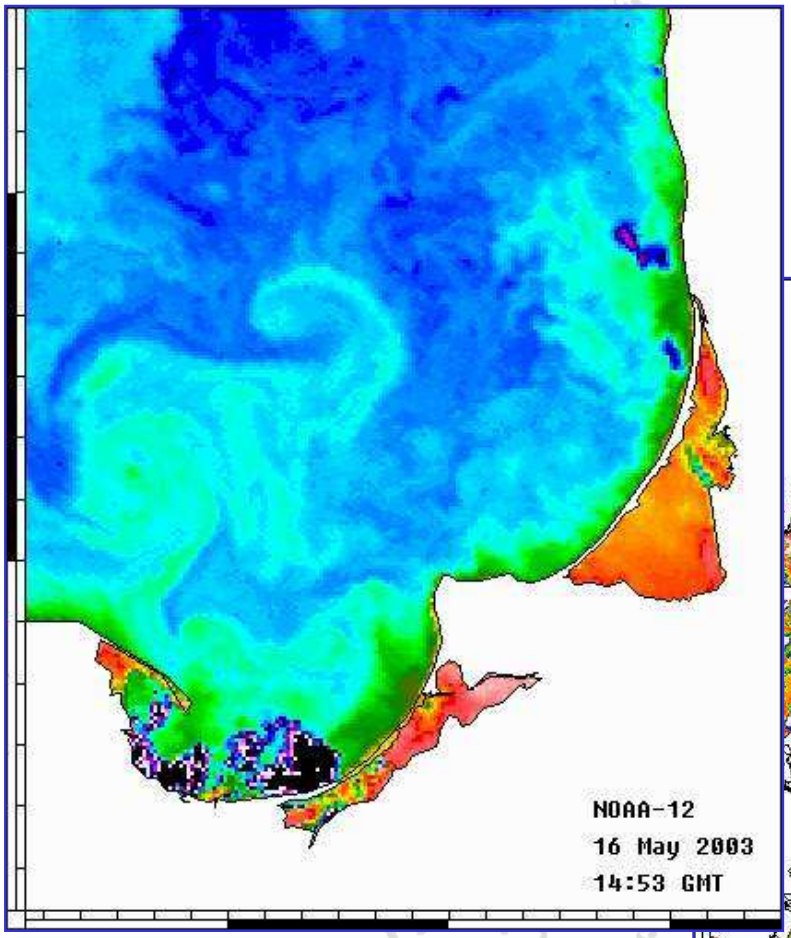
247 ASAR (Envisat + Radarsat)
274 oil spills

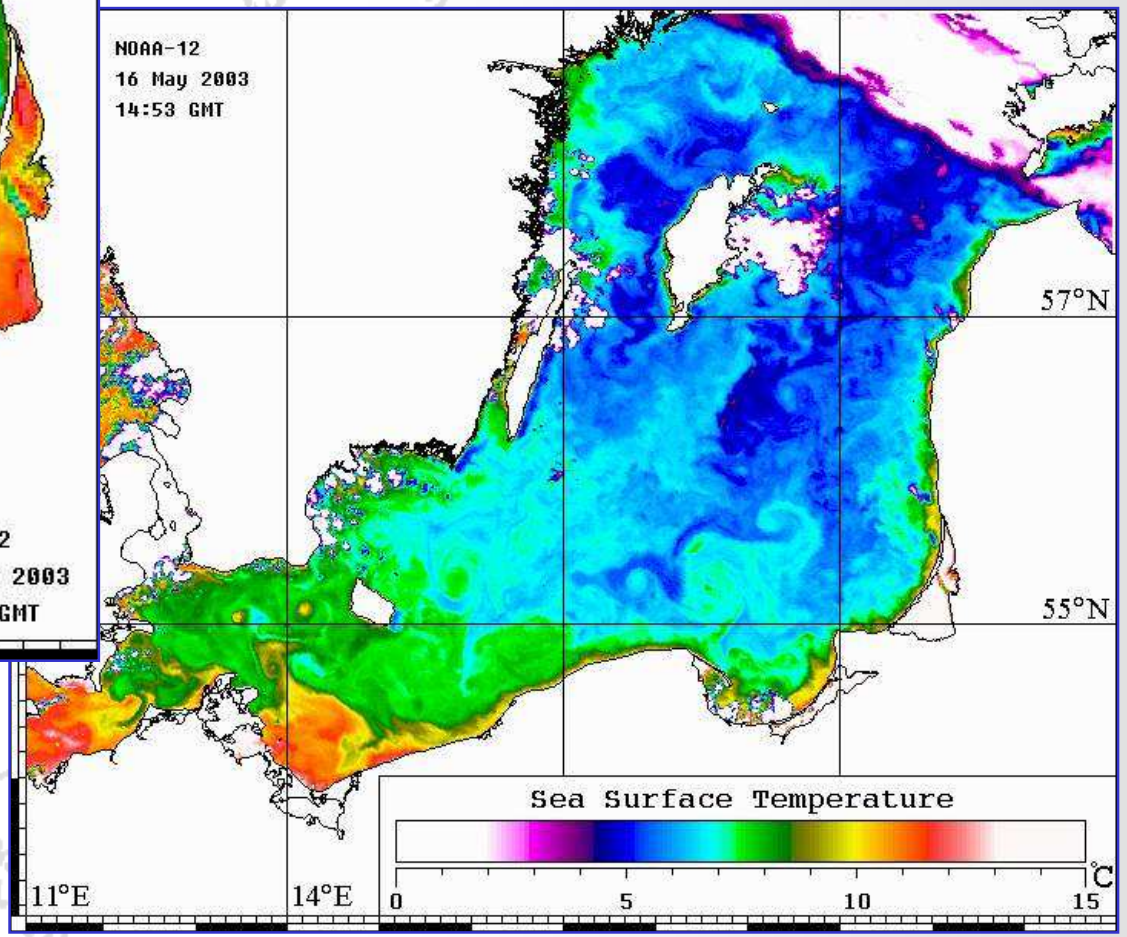


1600 IR+VIS images from AVHRR-NOAA and MODIS-Terra and Aqua



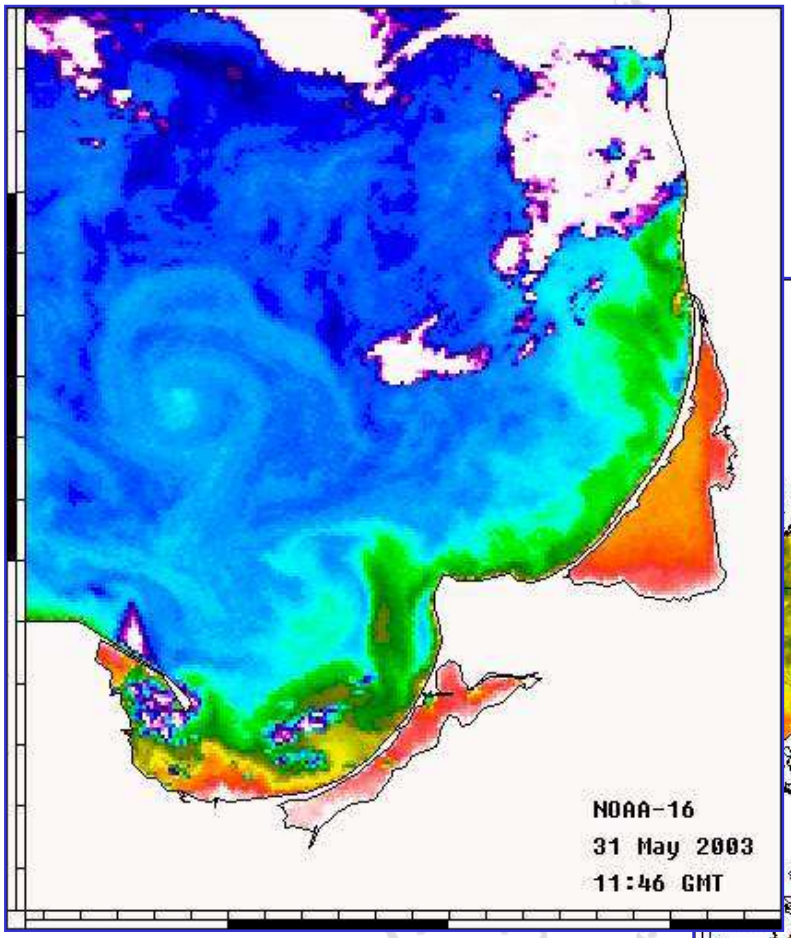
Sea Surface Temperature

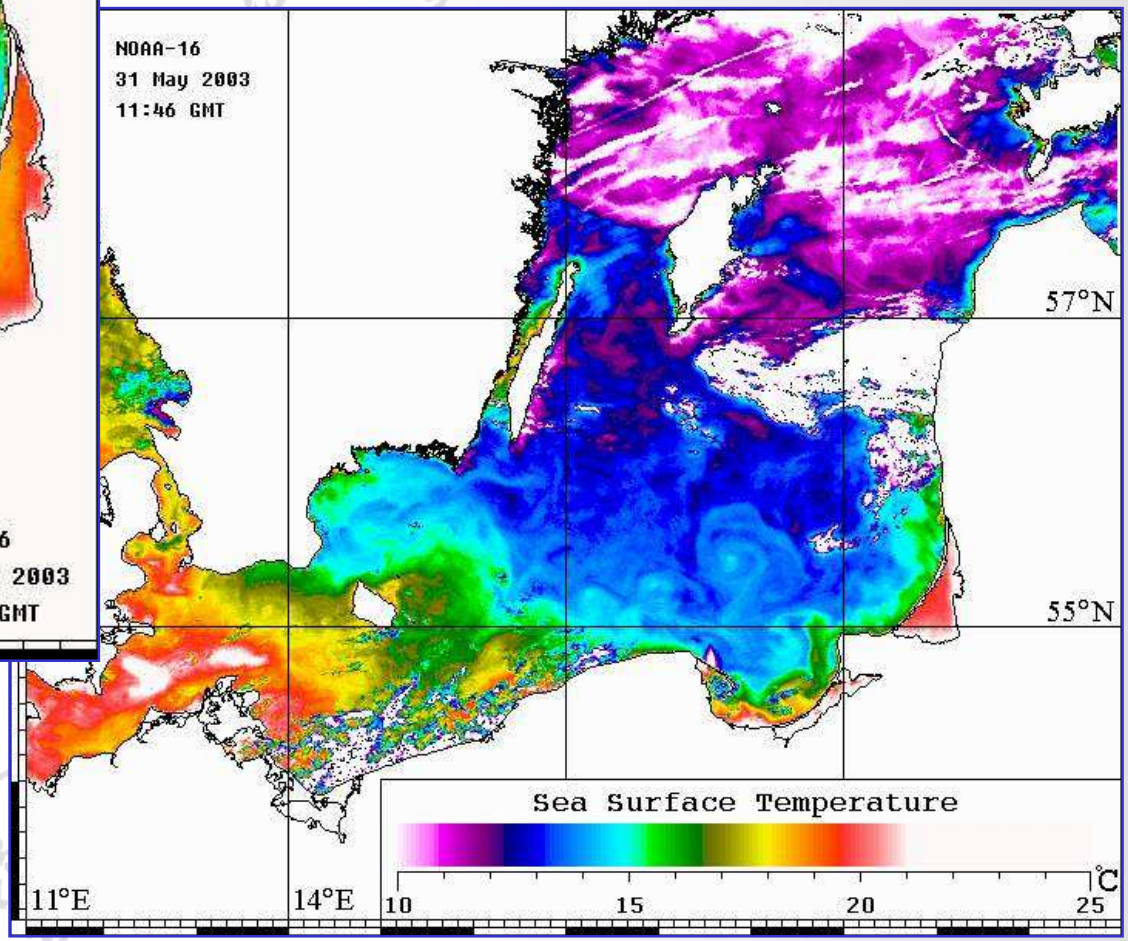




16 May 2003, 14:53 GMT
NOAA-12

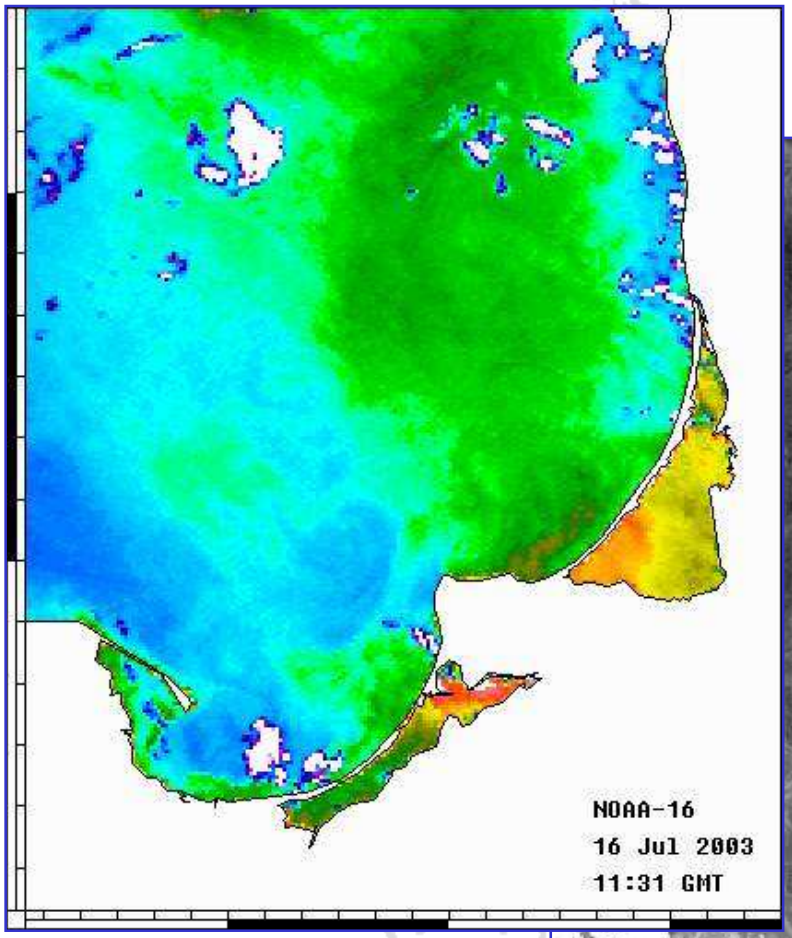
Sea Surface Temperature

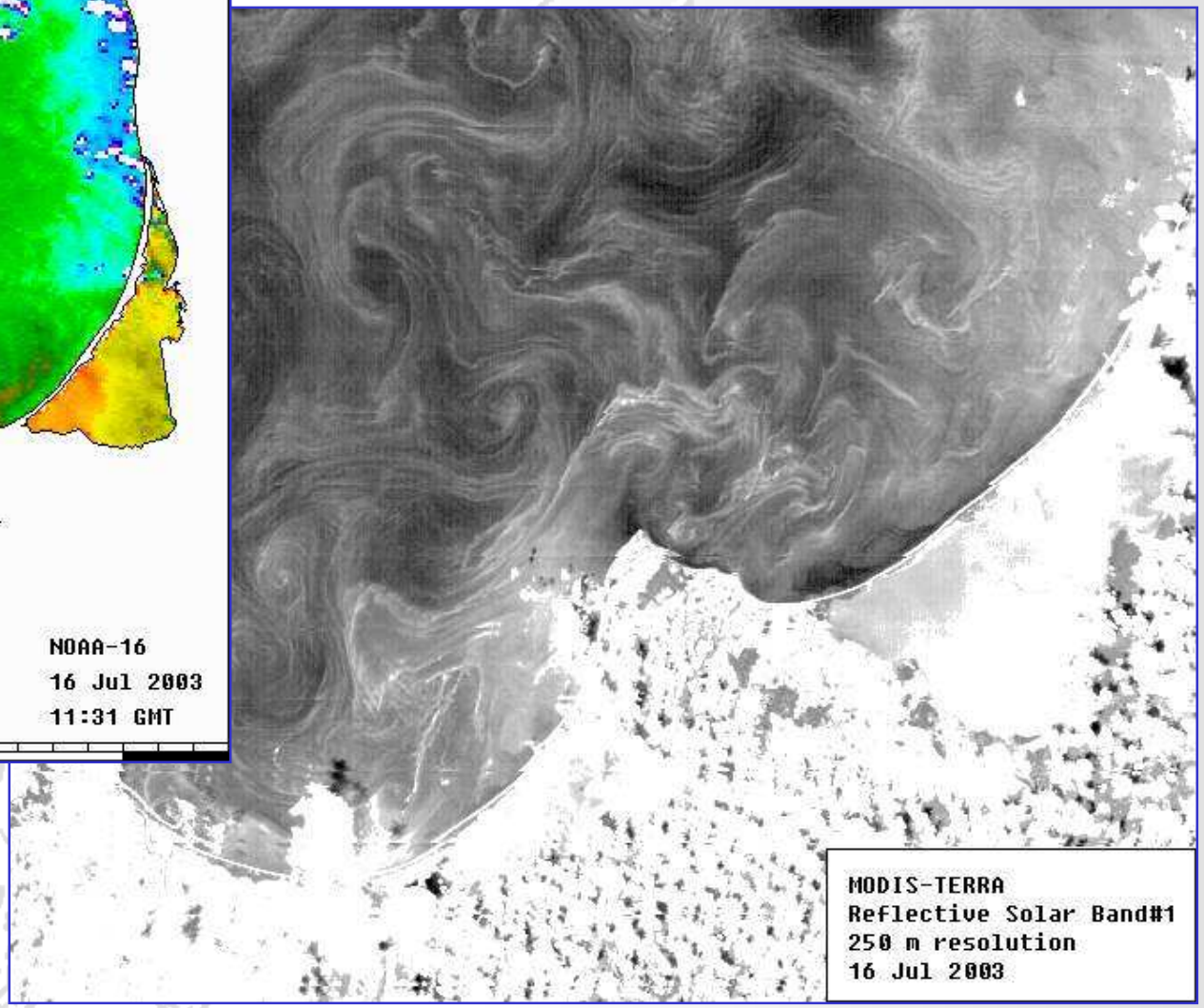




31 May 2003, 11:46 GMT
NOAA-16

MODIS-TERRA
Reflective Solar Band #1

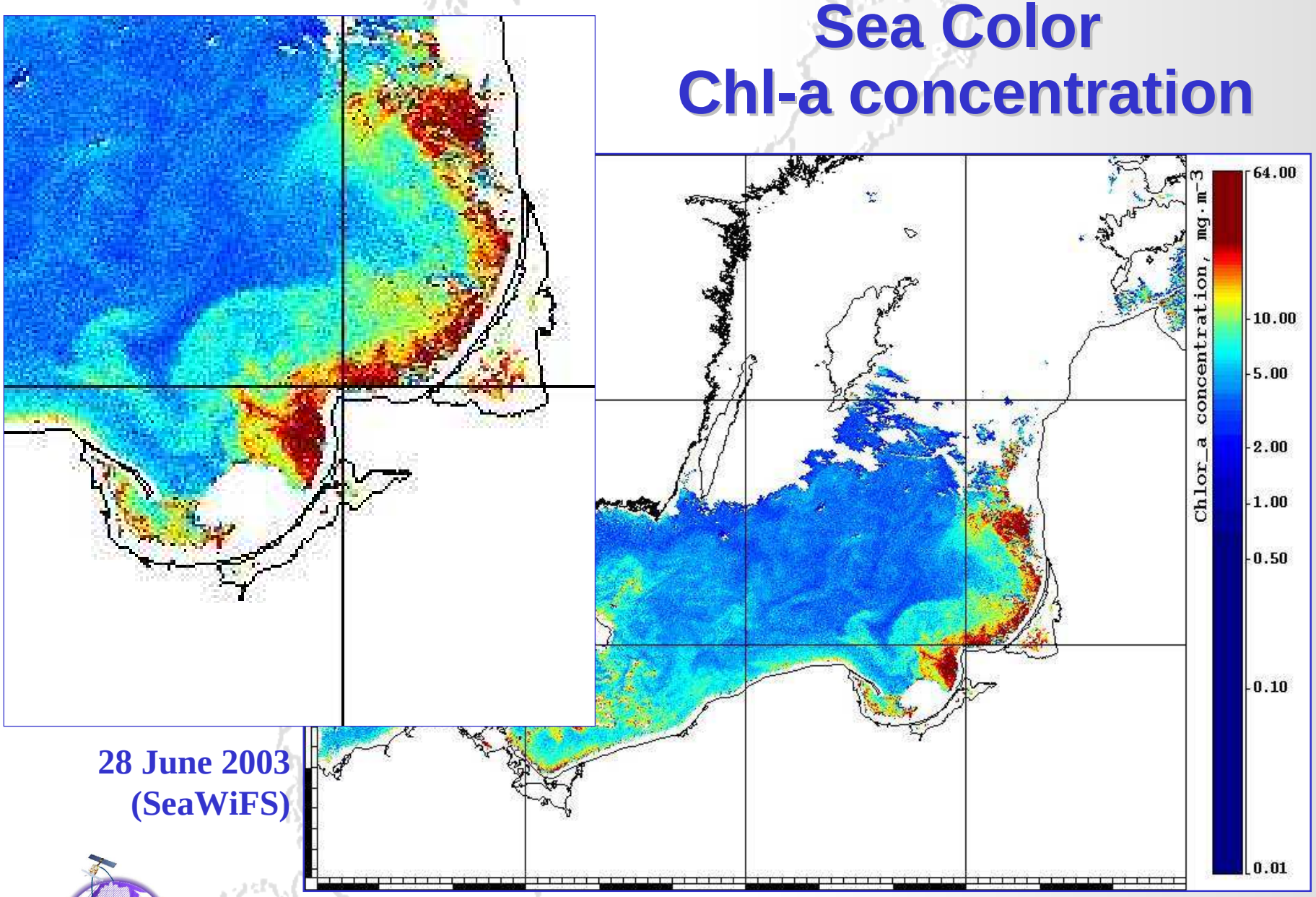




Sea Surface Temperature

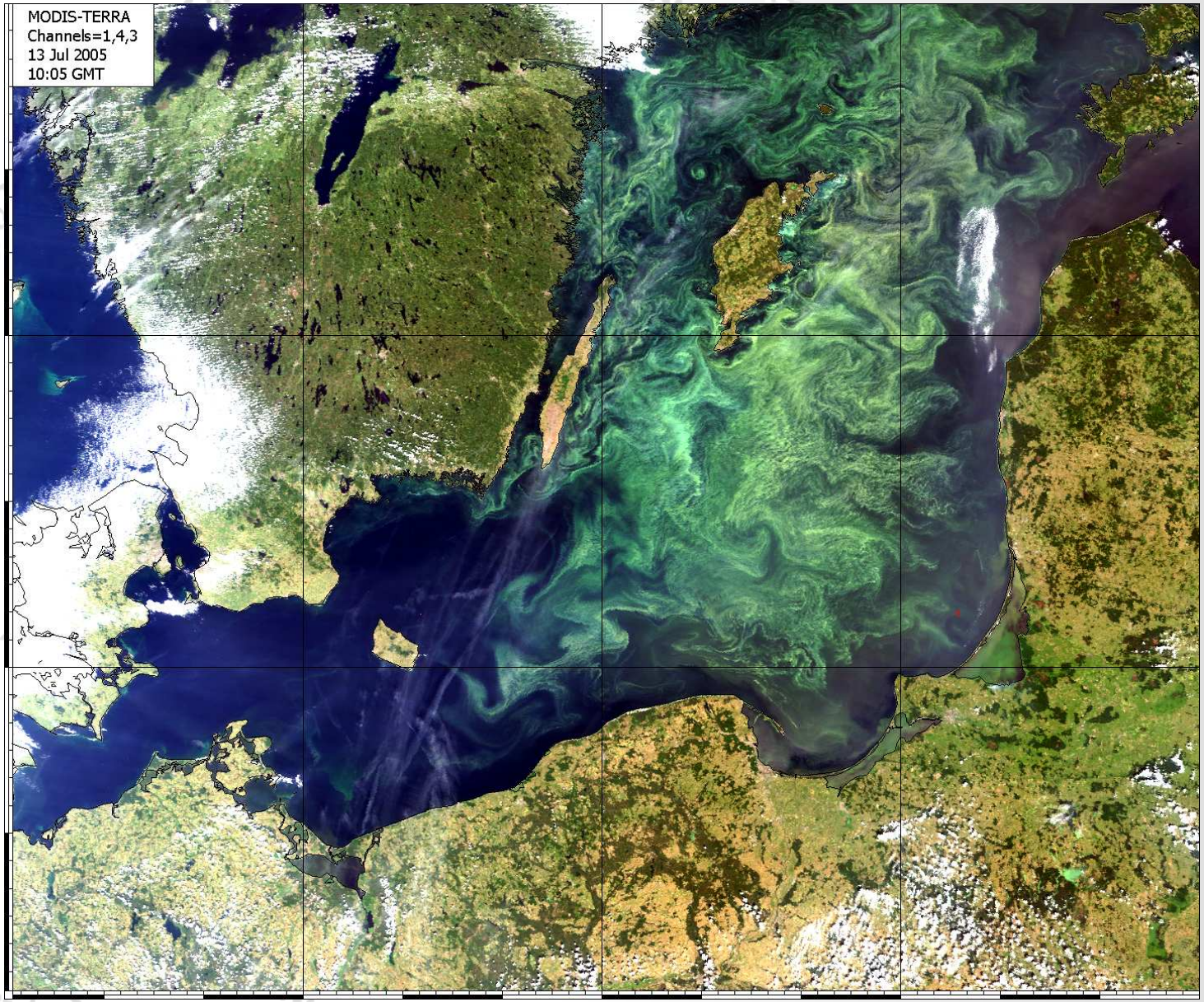
16 July 2003, 11:31 GMT
NOAA-16

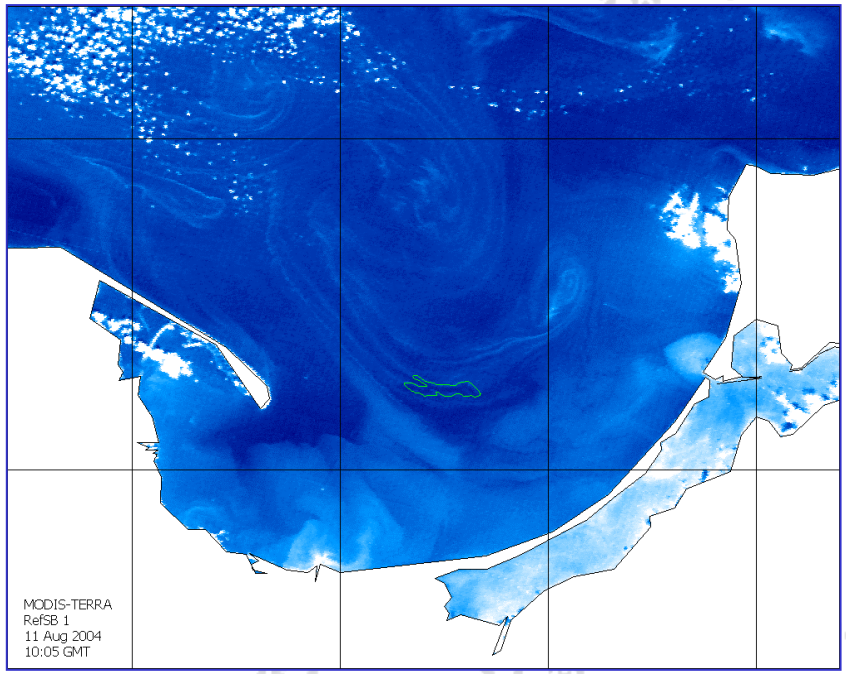
Sea Color
Chl-a concentration

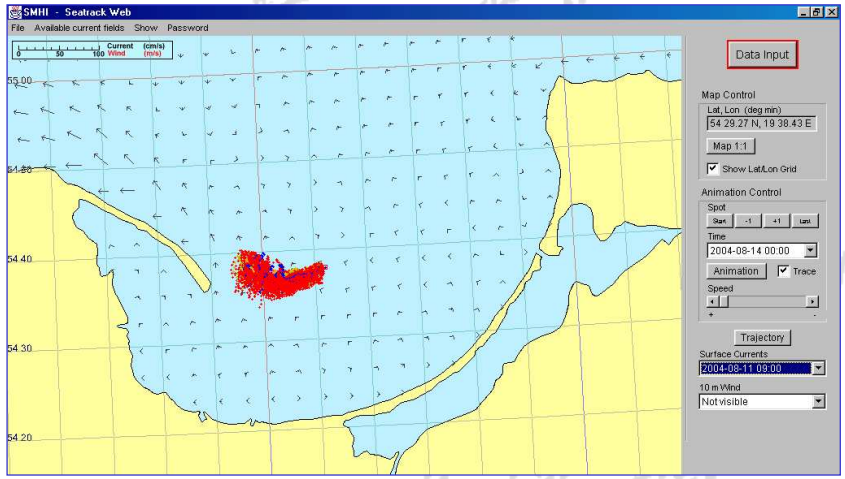


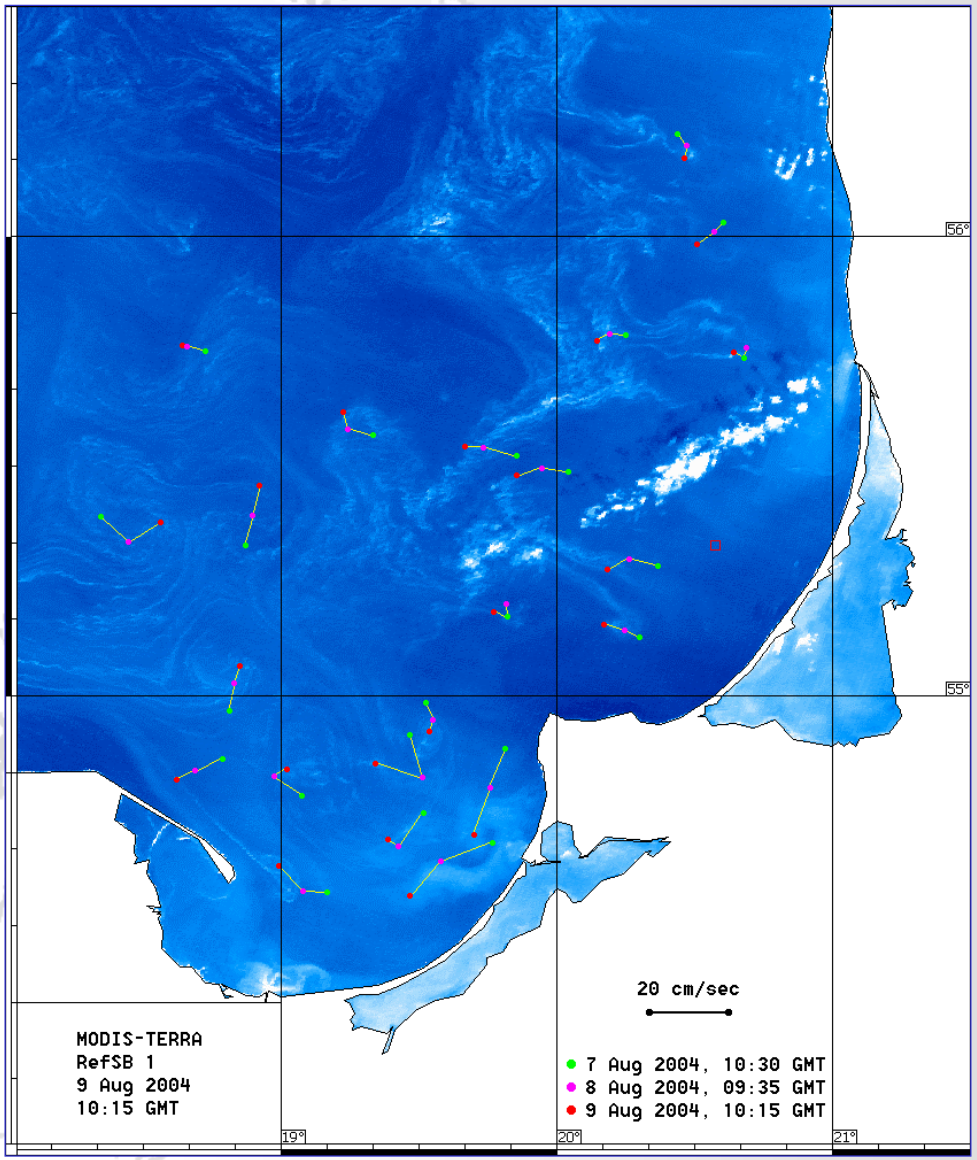
28 June 2003
(SeaWiFS)

Algae bloom
13 July 2005





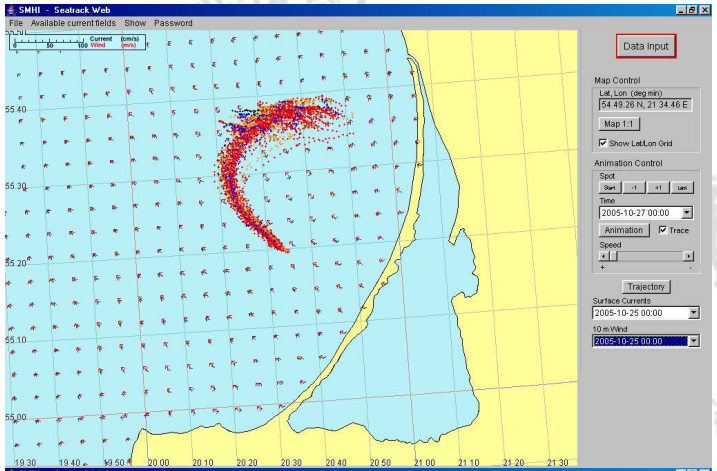




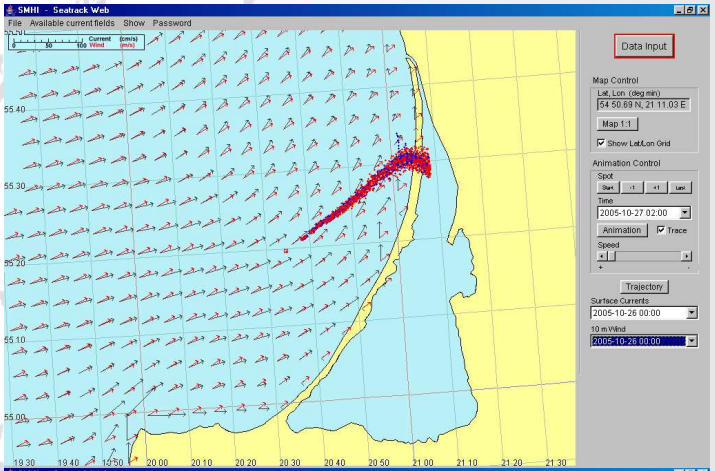
OIL SPILL MONITORING IN THE SOUTHEASTERN BALTIC SEA

Daily forecast of oil spill drift from D-6 for 48 hours basing on SMHI SeaTrack Web model

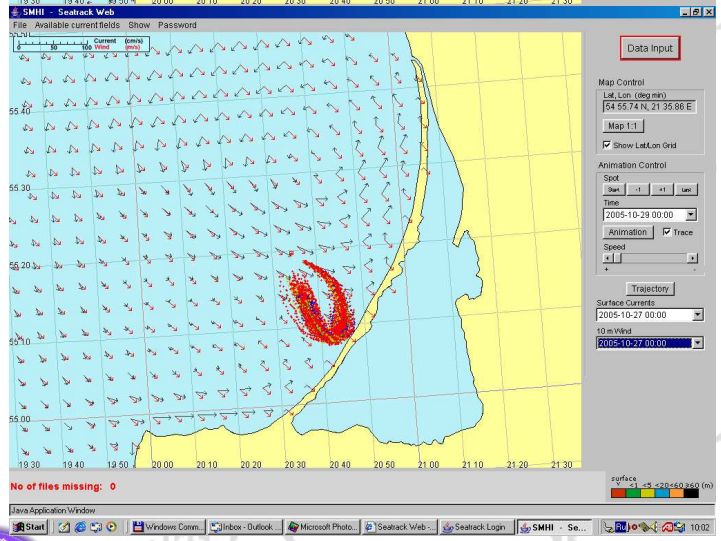
25.10.05



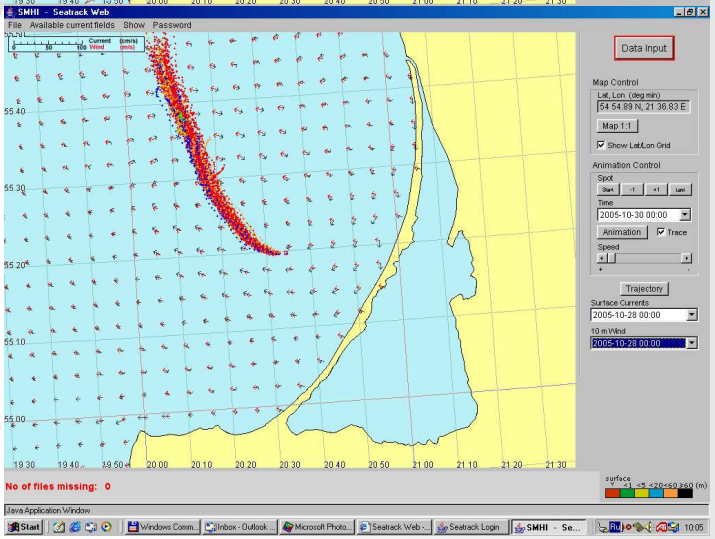
26.10.05



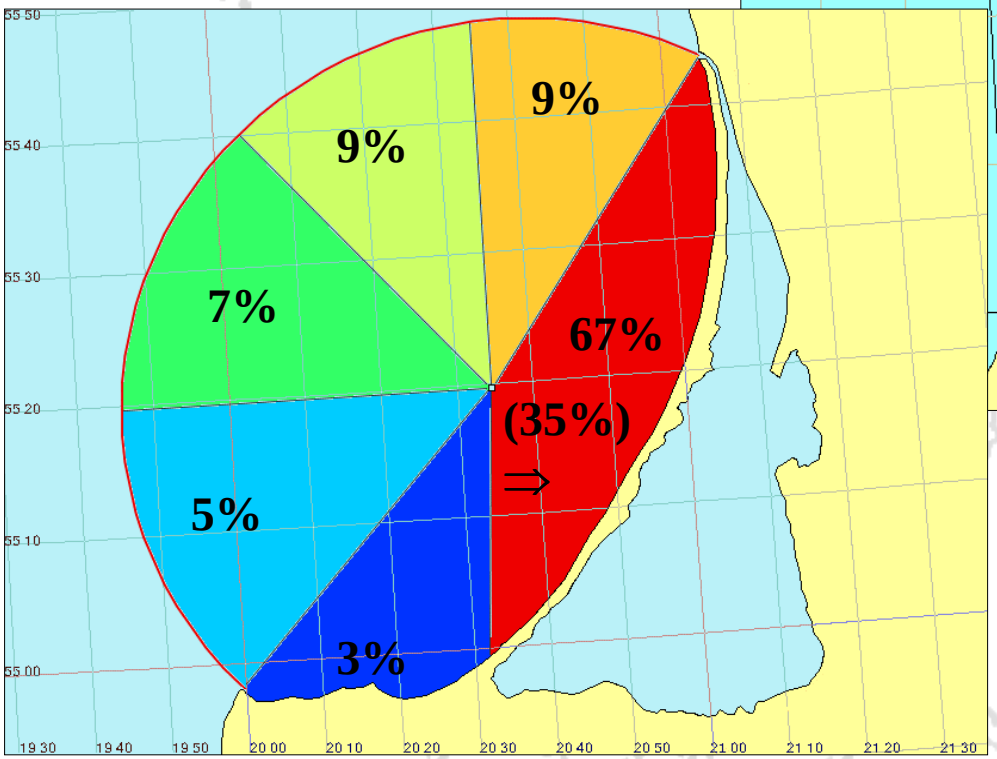
27.10.05

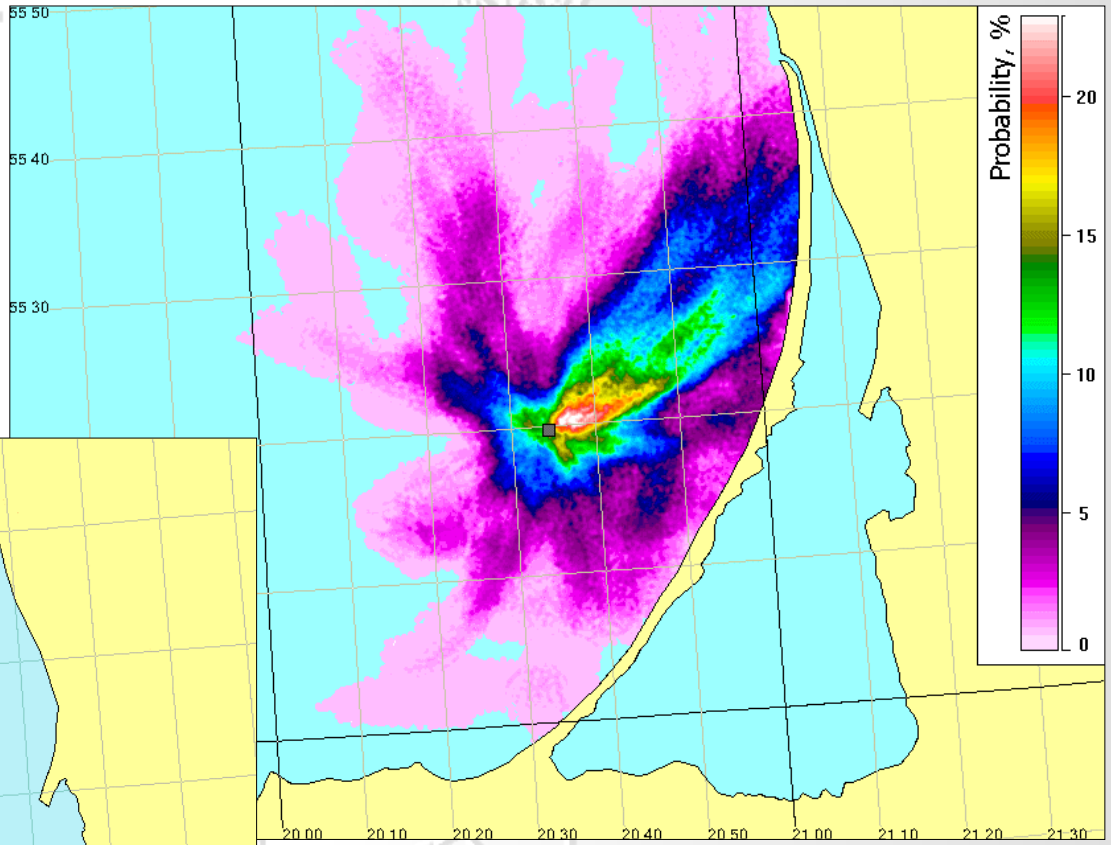


28.10.05

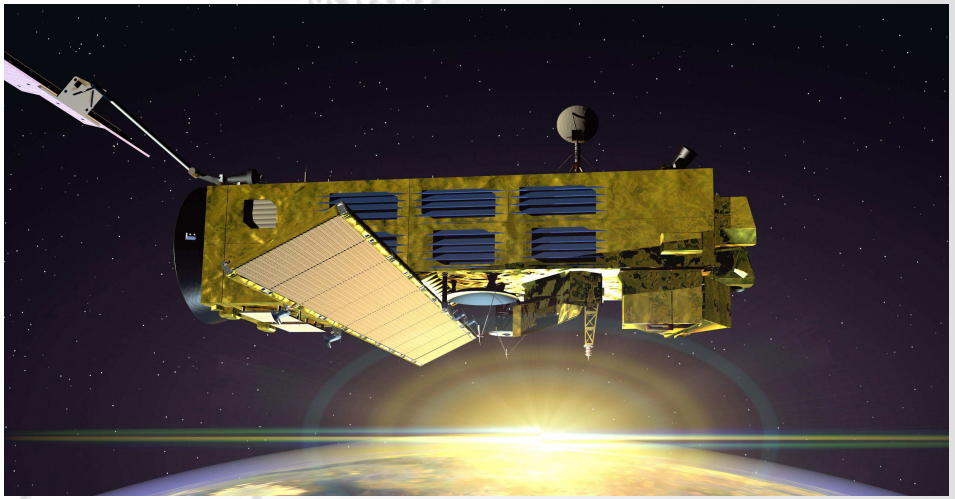


Potential probability of oil spill drift from D-6 oil platform





Conclusions



ENVISAT ASAR provides new capabilities to monitor oil spills, in particular, in the Baltic Sea. Combined with satellite remote sensing (AVHRR NOAA, SeaWiFS, MODIS, Jason-1, QuikSCAT) of SST, chlorophyll concentration, mesoscale dynamics, wind and waves, this observational system represents a powerful method for long-term monitoring of ecological state over global to regional scales, as well as smaller areas of particular interest, such as the southeastern Baltic Sea.

The growing availability of sea observation data should encourage interest, involvement and investment by the Baltic states authorities with responsibility for the environment, pollution control, meteorology, coastal protection, transport, fisheries and hazard management, and private companies operating in the sea and coastal zone.