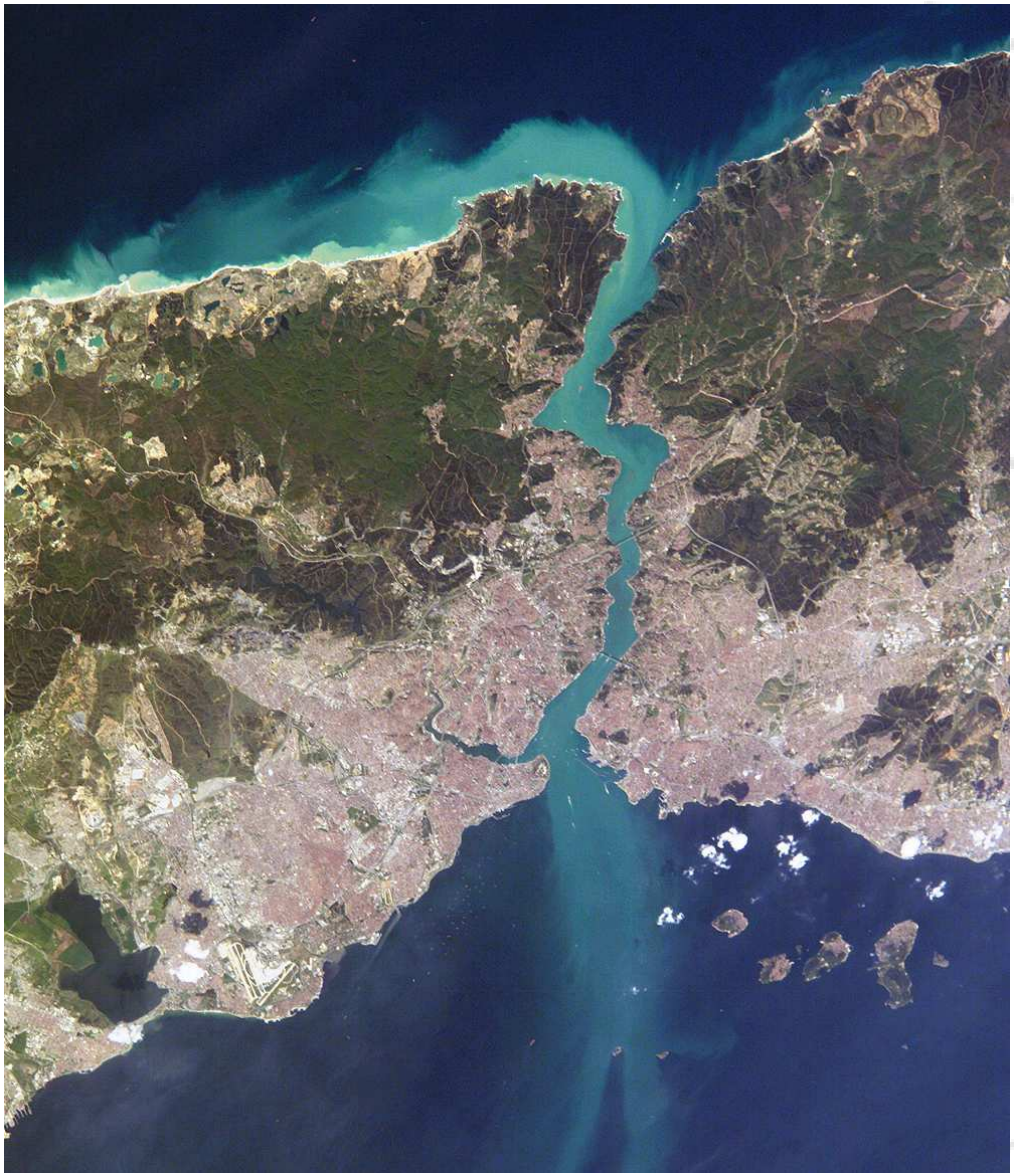


Image Courtesy: NASA Earth Observatory

SATELLITE MONITORING OF THE CASPIAN AND BLACK SEAS

Prof. Andrey G. Kostianoy
Elena V. Kostianaya
P.P. Shirshov Institute of Oceanology,
Russian Academy of Sciences,
Moscow, Russia

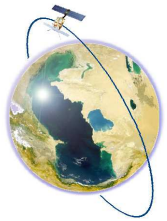
Black Sea National and International Projects (1995-2004)

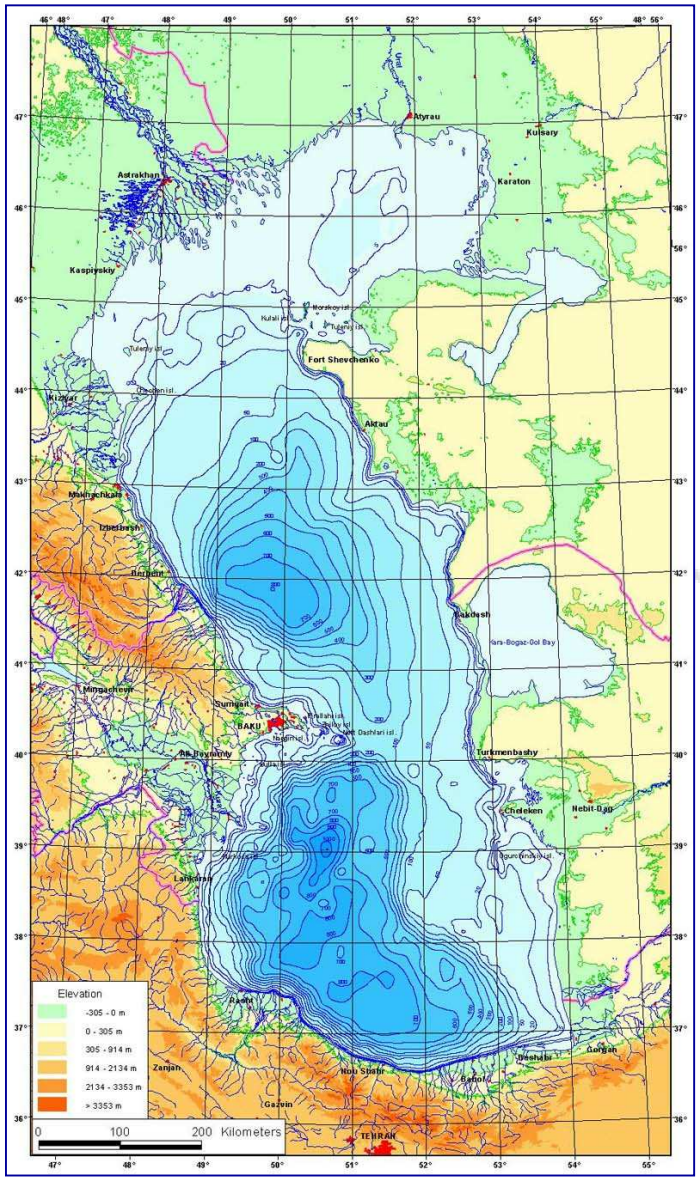
Russian Ministry of Industry, Science and Technologies Project "Estimation of Variation of Base Thermohydrodynamic Parameters of the Caspian Sea and its Impact on the Evolution of the Sea Ecological State" (2002-2004)

NATO Science for Peace Programme Project "Multi-disciplinary Analysis of the Caspian Sea Ecosystem" (2004-2006)

General goals of the projects are:

To monitor main hydrographic, dynamic and meteo parameters of the Caspian Sea.
To improve the regional capacity for analyzing the functioning of the Caspian Sea.
To understand its present state for predicting future changes with respect to natural and anthropogenic influences.



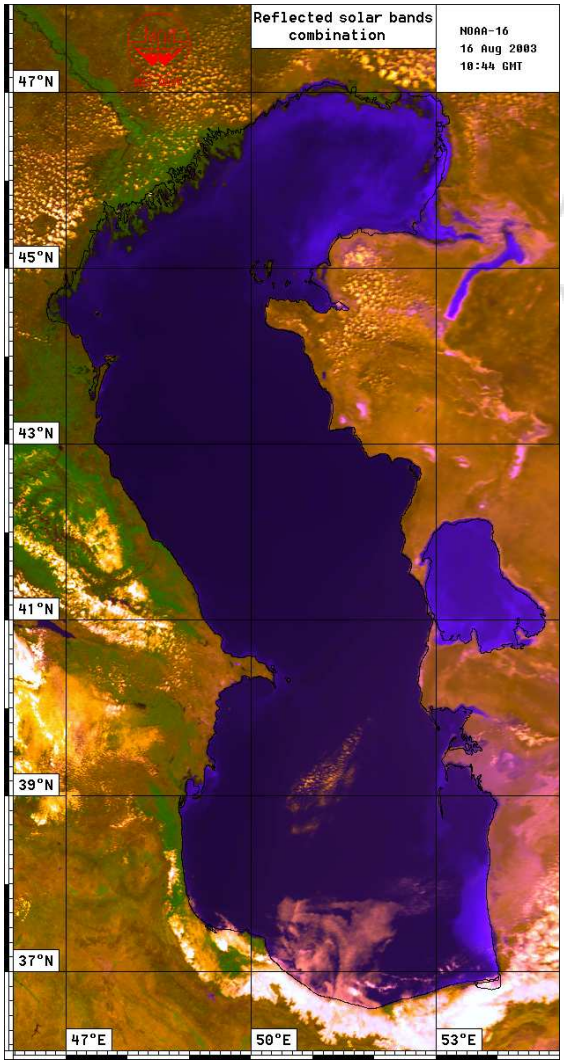


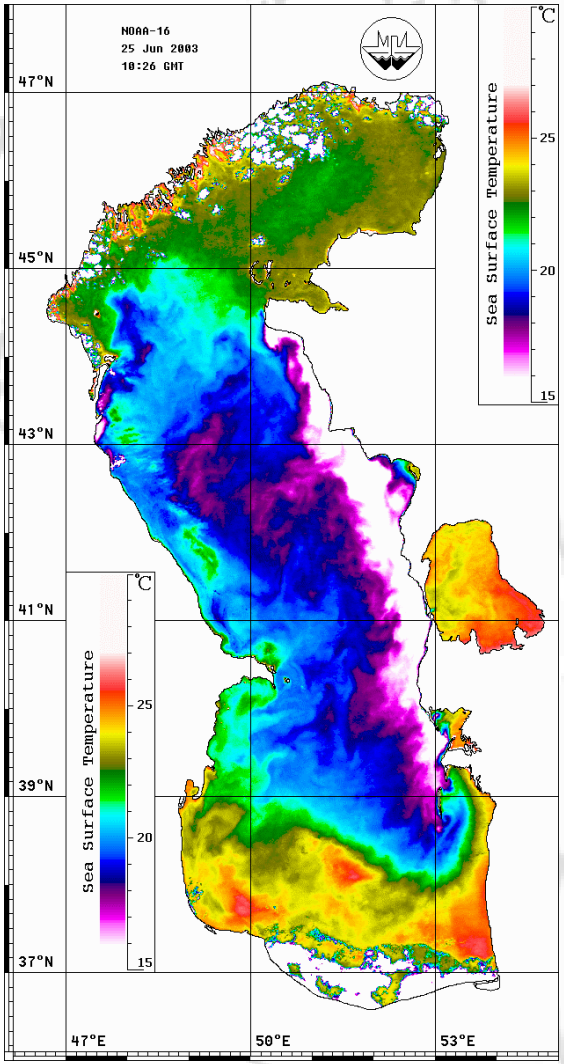
Motivation and Data:

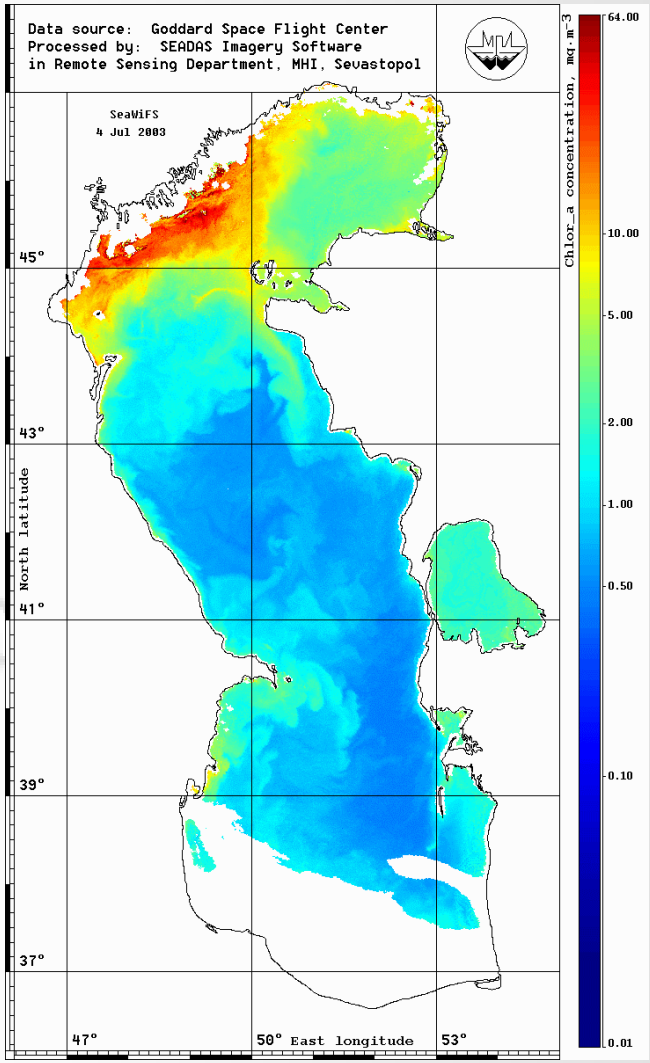
Since the early 1990s regular measurements of the Caspian Sea level and main thermohydrodynamic parameters are practically absent.

Lack of meteorological data.
Lack of oceanographic data.
Lack of regular data exchange between the Caspian countries.

Today, the monitoring of the Caspian sea surface temperature, sea level, chlorophyll concentration, mesoscale dynamics, wind and waves, and some of the meteo parameters is organized based on the satellite IR and VIS data (AVHRR NOAA, SeaWiFS, MODIS), altimetry data (TOPEX/Poseidon, Jason-1) and re-analysis data.



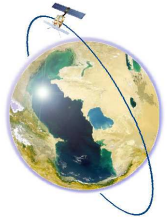


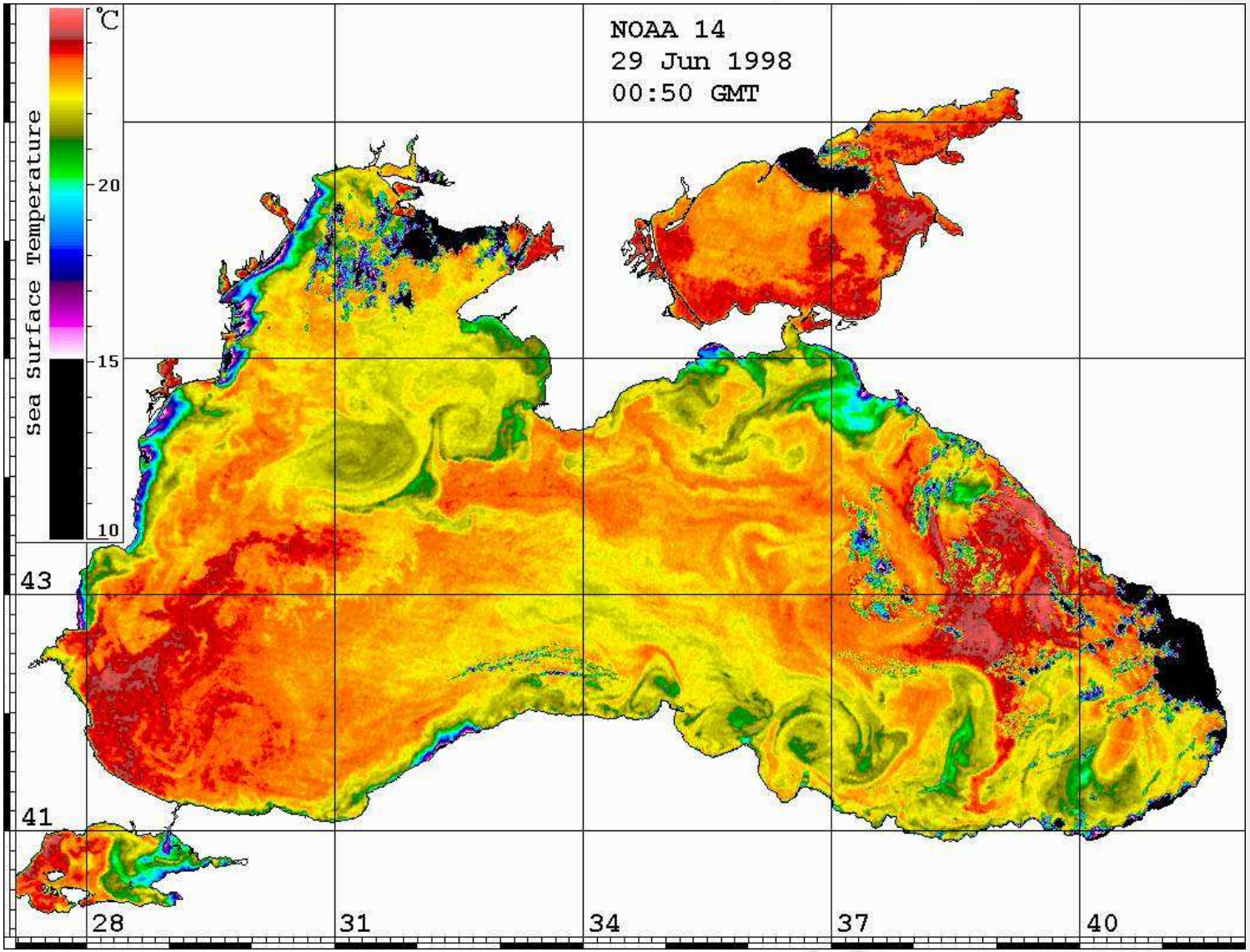


VIS (NOAA)

SST (NOAA)

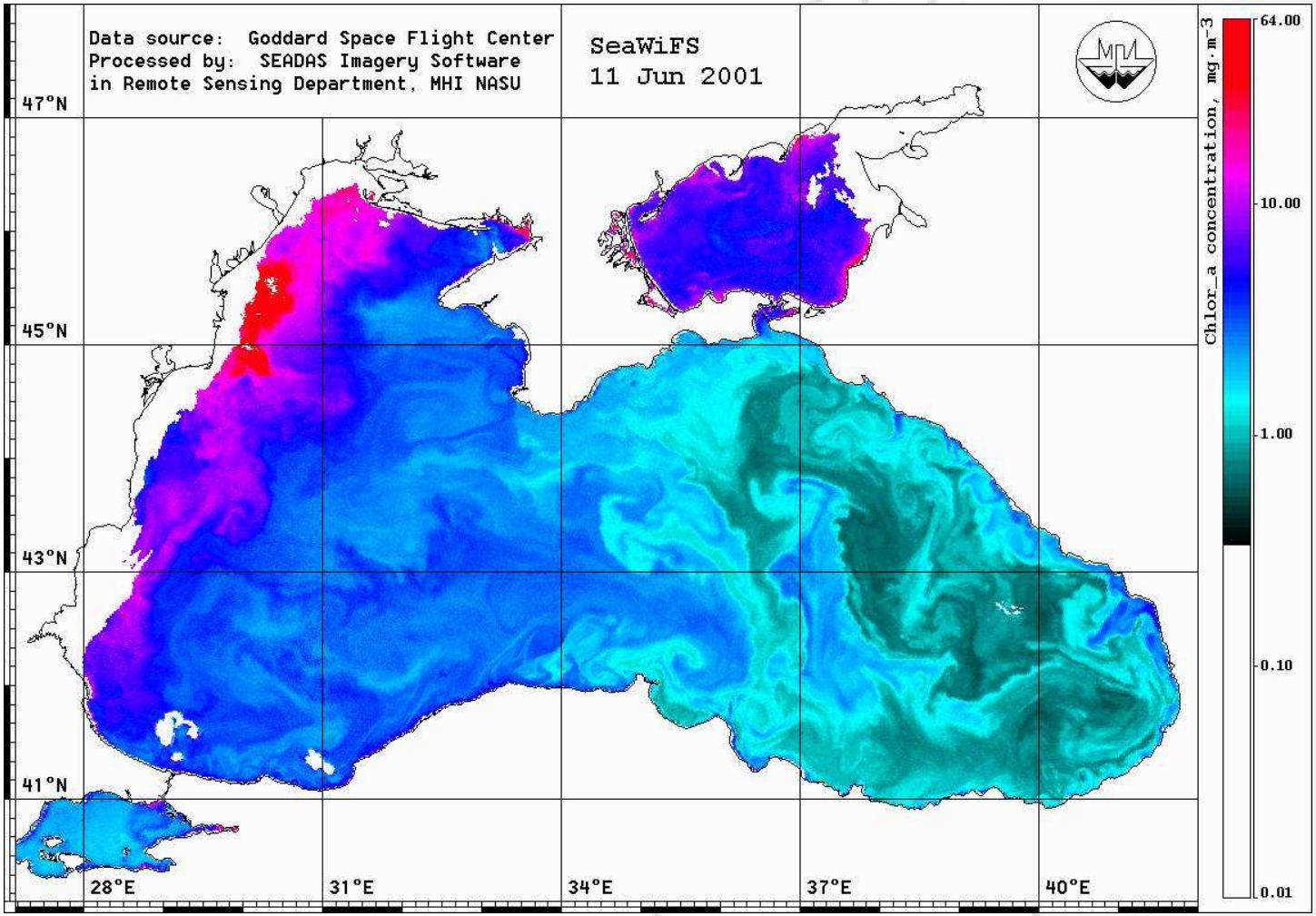
Chl (SeaWiFS)





Black Sea Surface Temperature

NOAA-14 29.06.1998



Black Sea Surface Chlorophyll Concentration

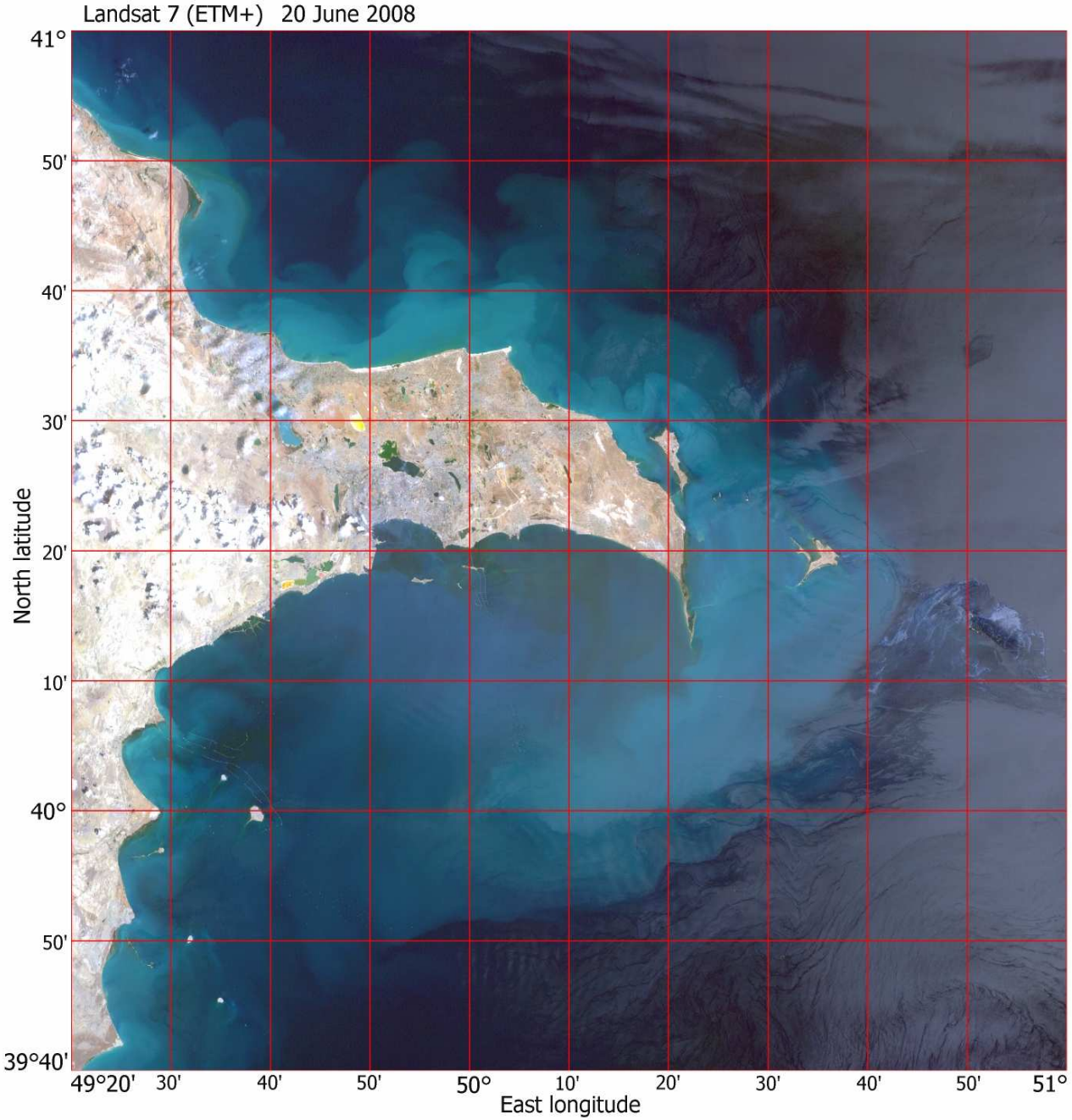
SeaWiFS 11.06.2001

ENVISAT Medium Resolution Imaging Spectrometer (MERIS), 300 m resolution, image acquired on 22 September 2003.

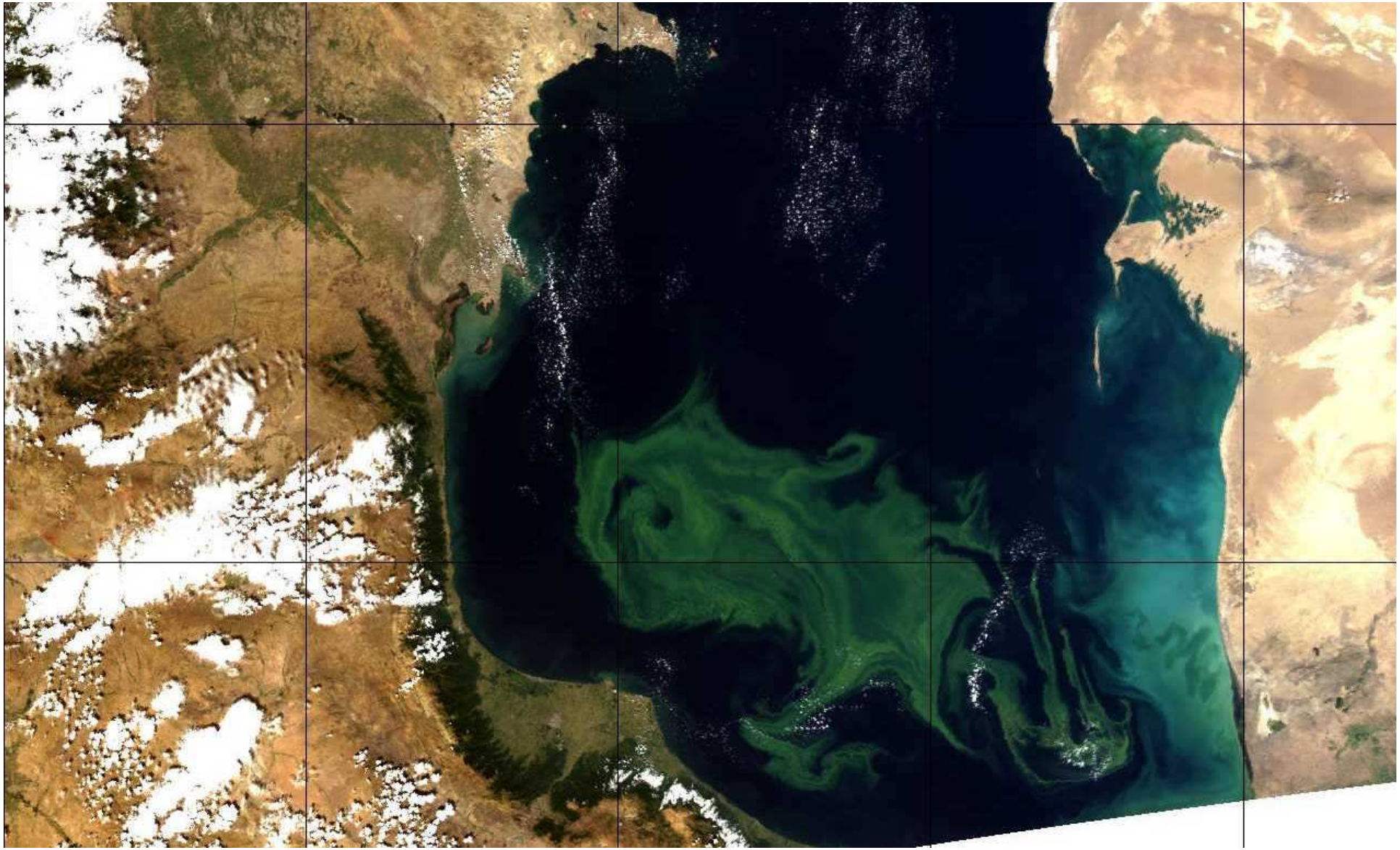
The Northern Caspian Sea suffers from a process called eutrophication, greatly increased by human activities like intensive and mechanized agriculture.
In this process, the sea gradually fills with organic and inorganic sediments, becoming a swamp or bog, and eventually a meadow.

The northeastern part of the Caspian Sea, the most shallow, is seen in the image in bright blue colour probably due to a mixture of plant life and sediments.

©ESA 2004

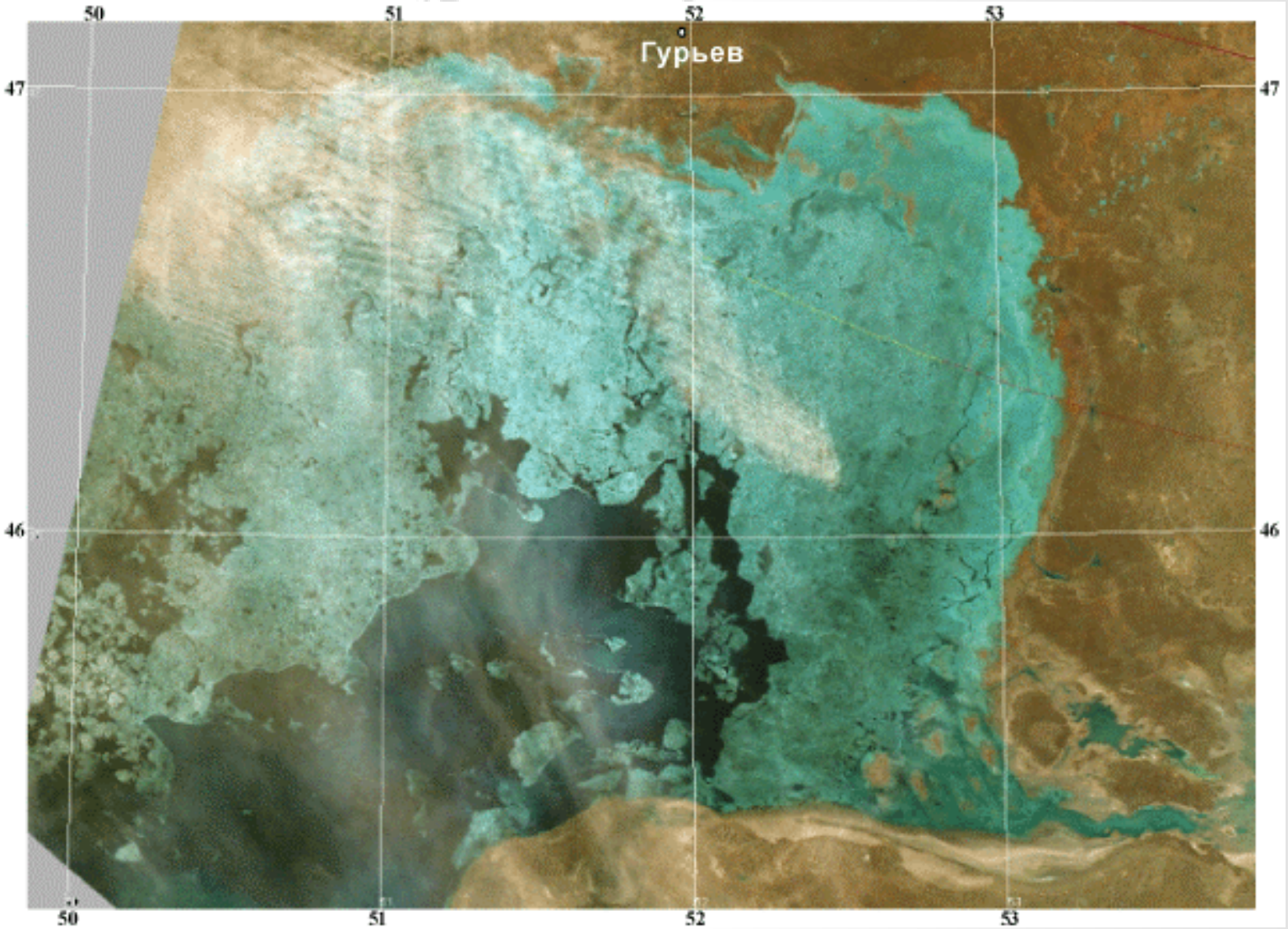


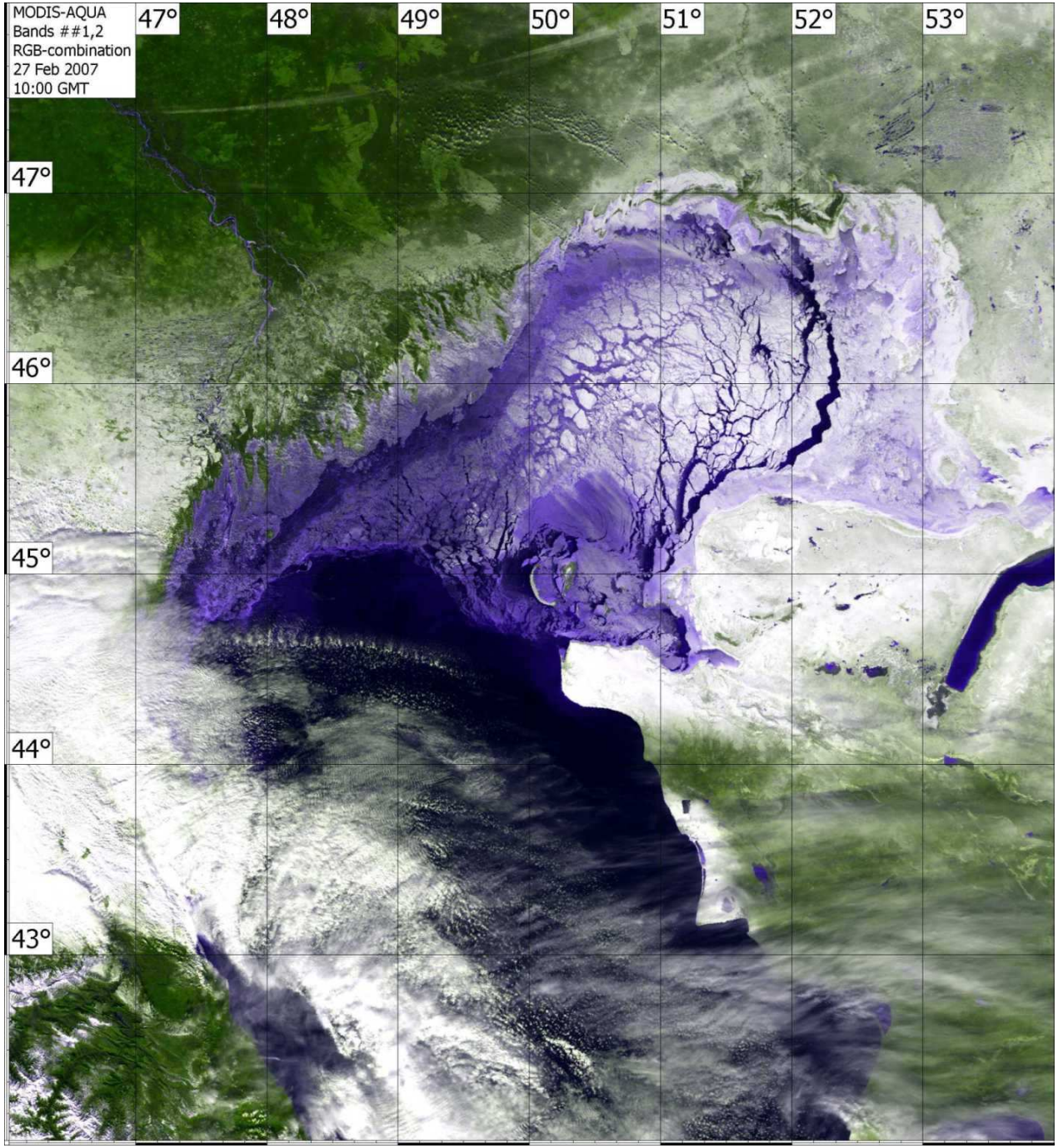
Изображение Апшеронского полуострова, полученное со спутника Landsat 7 (ETM+) 20 июня 2008 г. (разрешение 30 м). На снимке отчетливо проявляется вдольбереговое течение, огибающее полуостров (светлые тона), благодаря высокой концентрации взвешенного вещества.



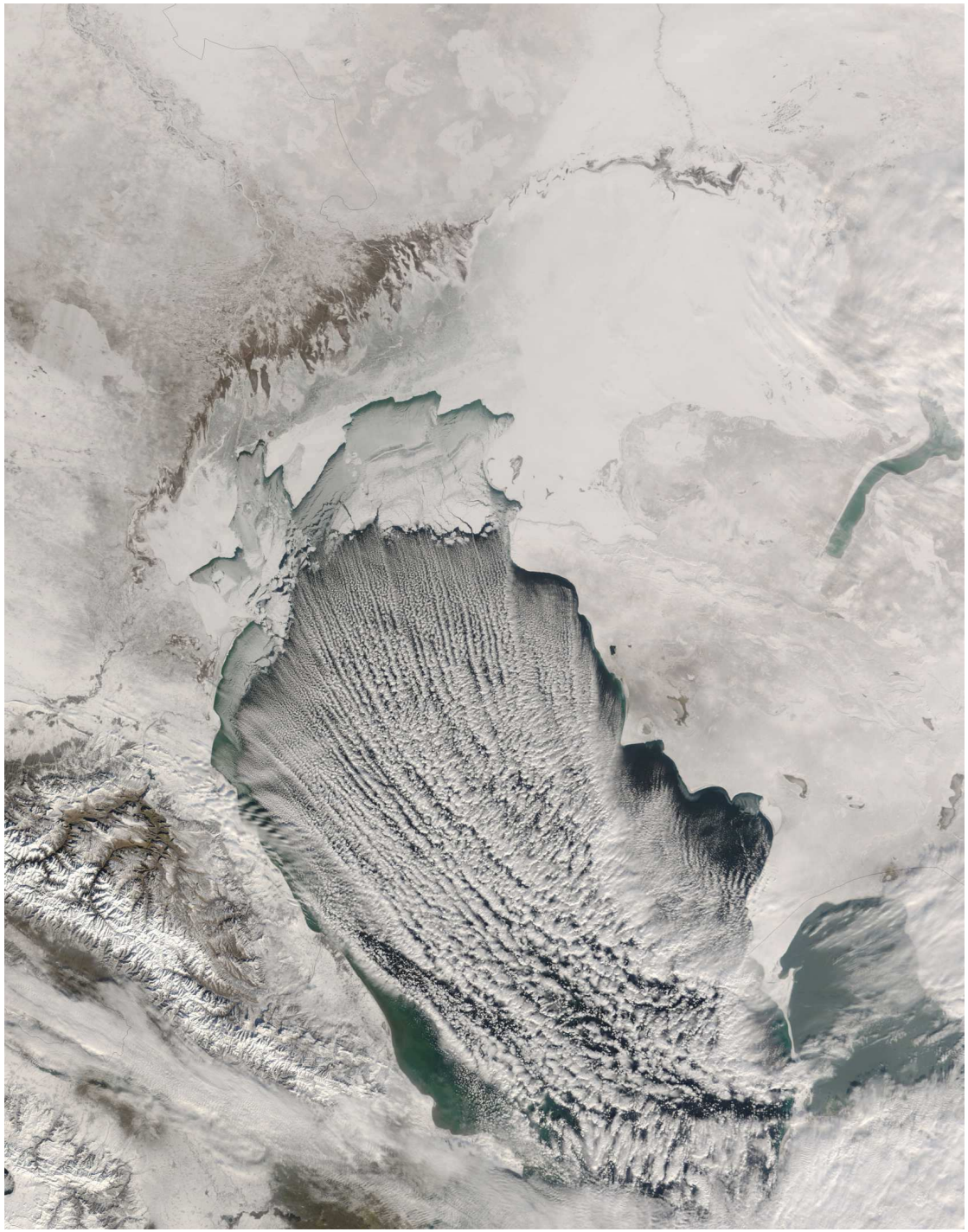
Аномально сильное цветение вод Южного Каспия (зеленый цвет) 1 сентября 2005 г. по данным спутника MODIS-Terra (разрешение 1 км).

The North-Eastern Caspian Sea, sea ice (Resourse-01, 16/02/1999)

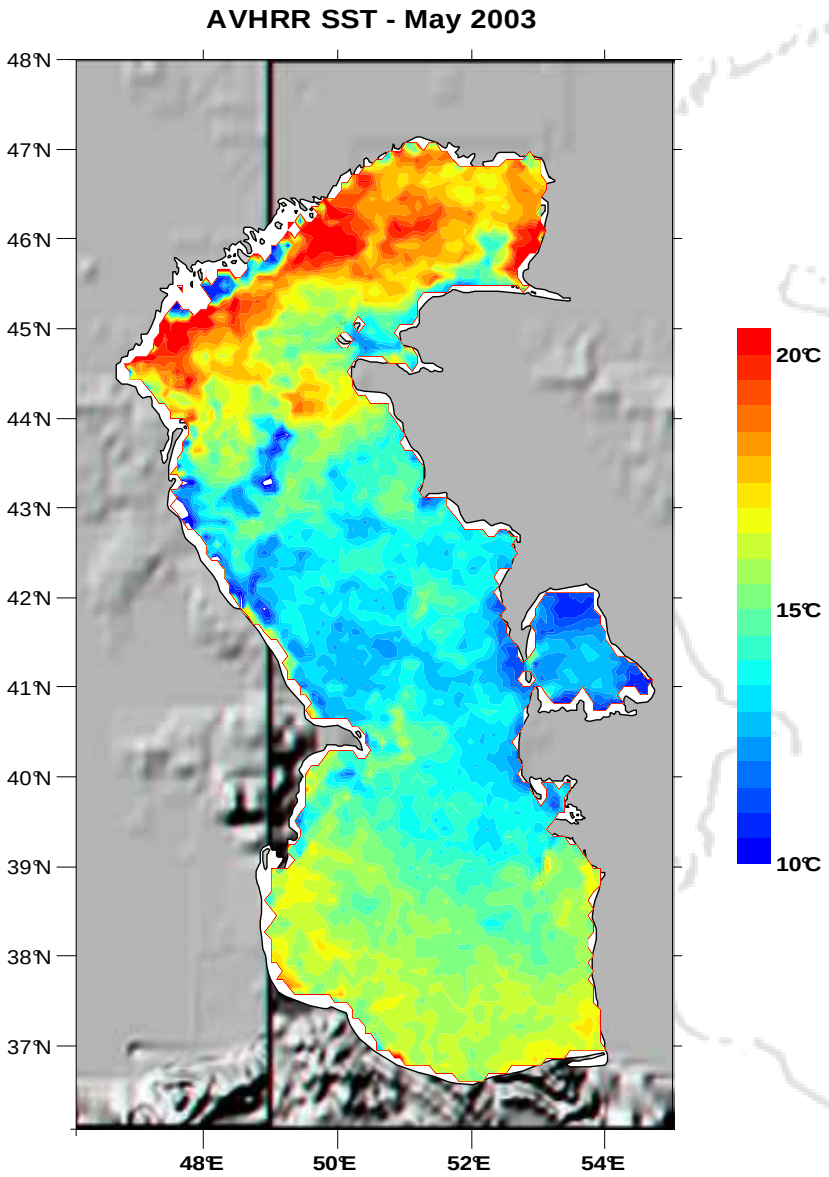




Ледовые условия, концентрация и кромка льда в Северном Каспии 27 февраля 2007 г. (MODIS-Aqua, разрешение 250 м).



Снег на суше, лед и конвективная облачность на акватории Каспийского моря 10 января 2008 г. (MODIS-Terra, разрешение 250 м).

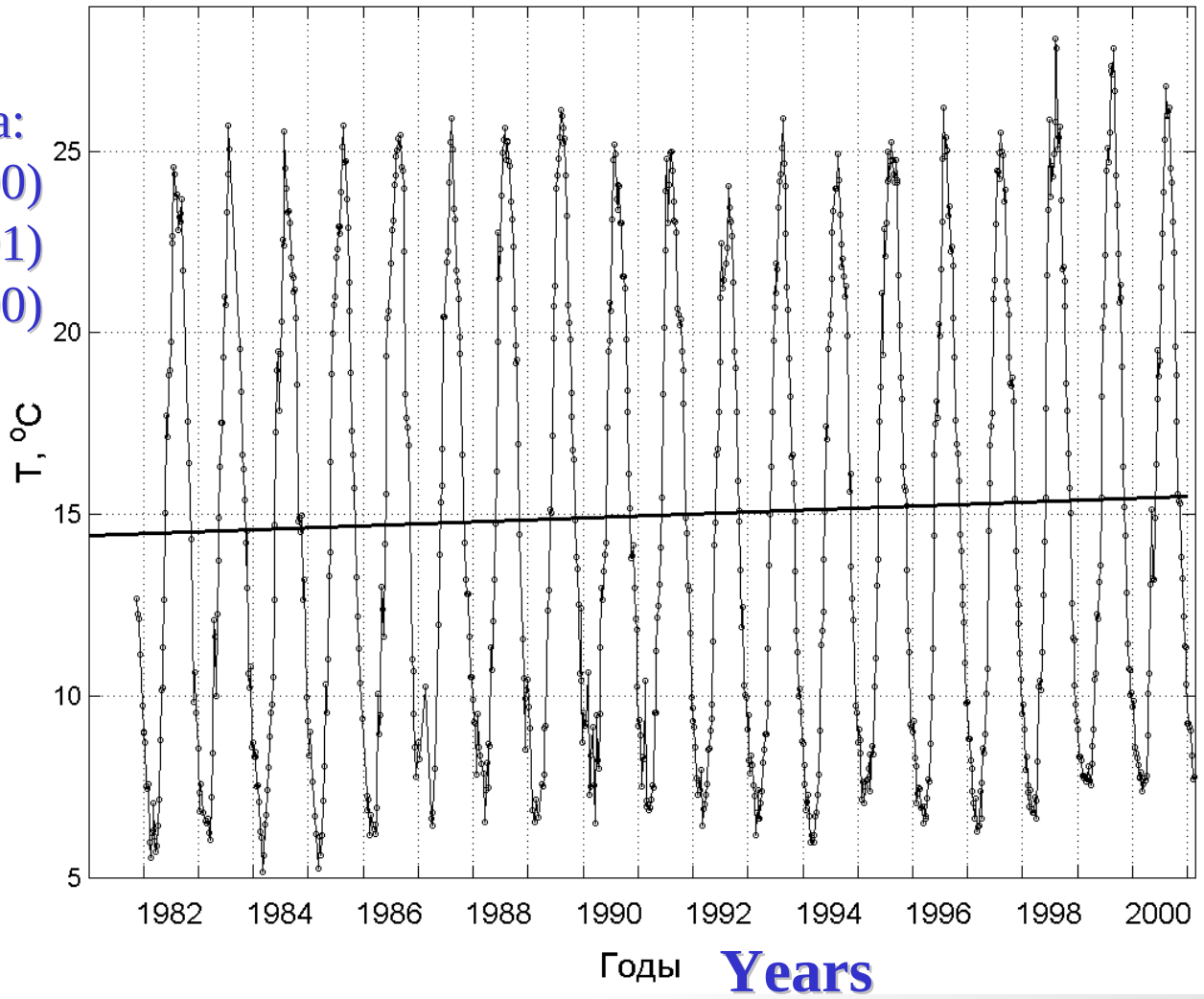


Archive of monthly re-analysis data (maps) on SST, chlorophyll concentration, atmospheric pressure, wind, precipitation, humidity for 1997-2004.

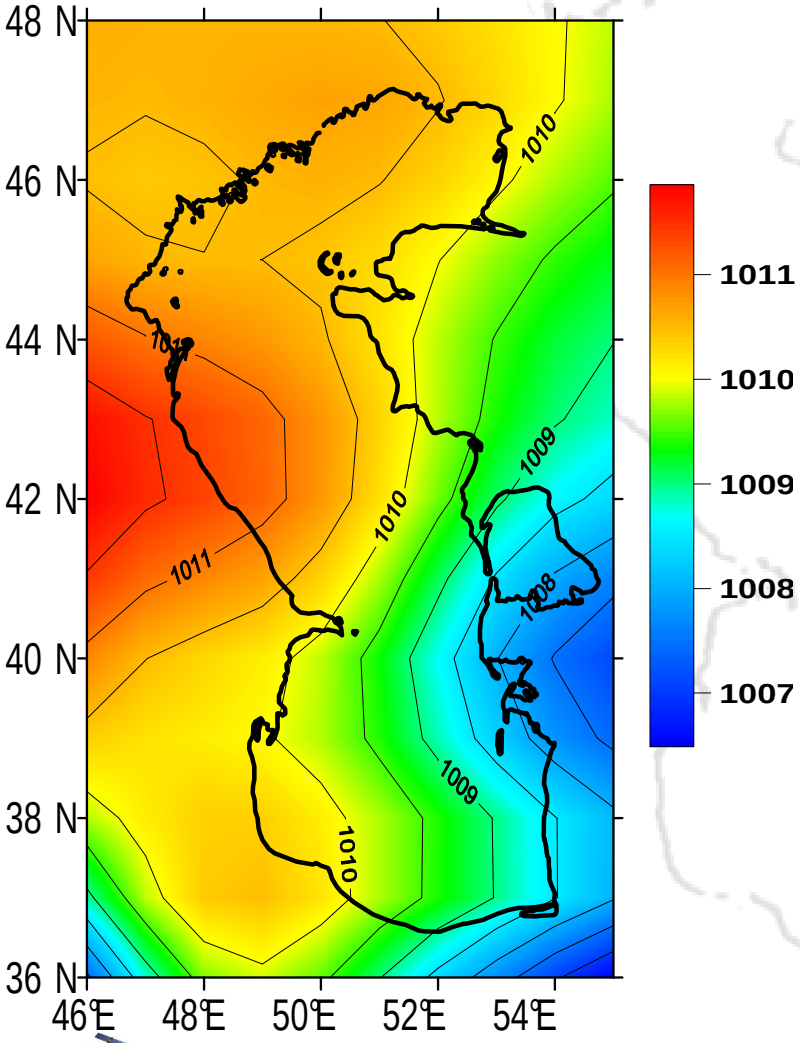
SST (AVHRR) May 2003

Interannual positive trends have been revealed in 1982-2000.

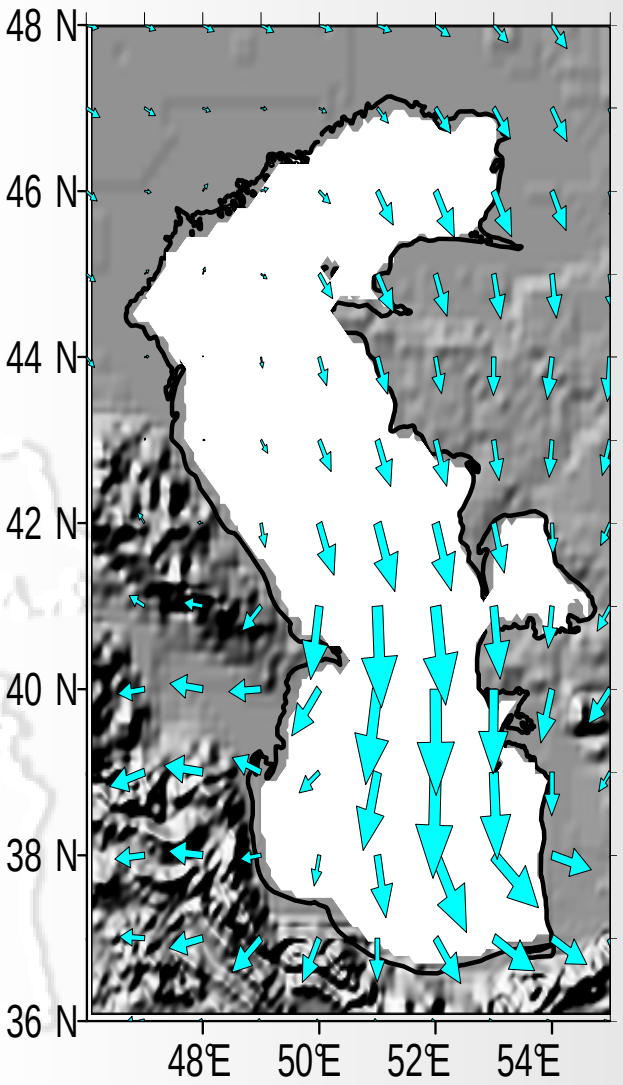
The Middle Caspian Sea:
+0.05 C/year (1982-2000)
+0.27 C/year (1982-1991)
+0.30 C/year (1992-2000)

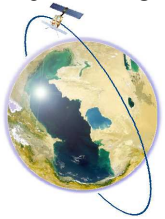


Atmospheric pressure (mbar) June 2001

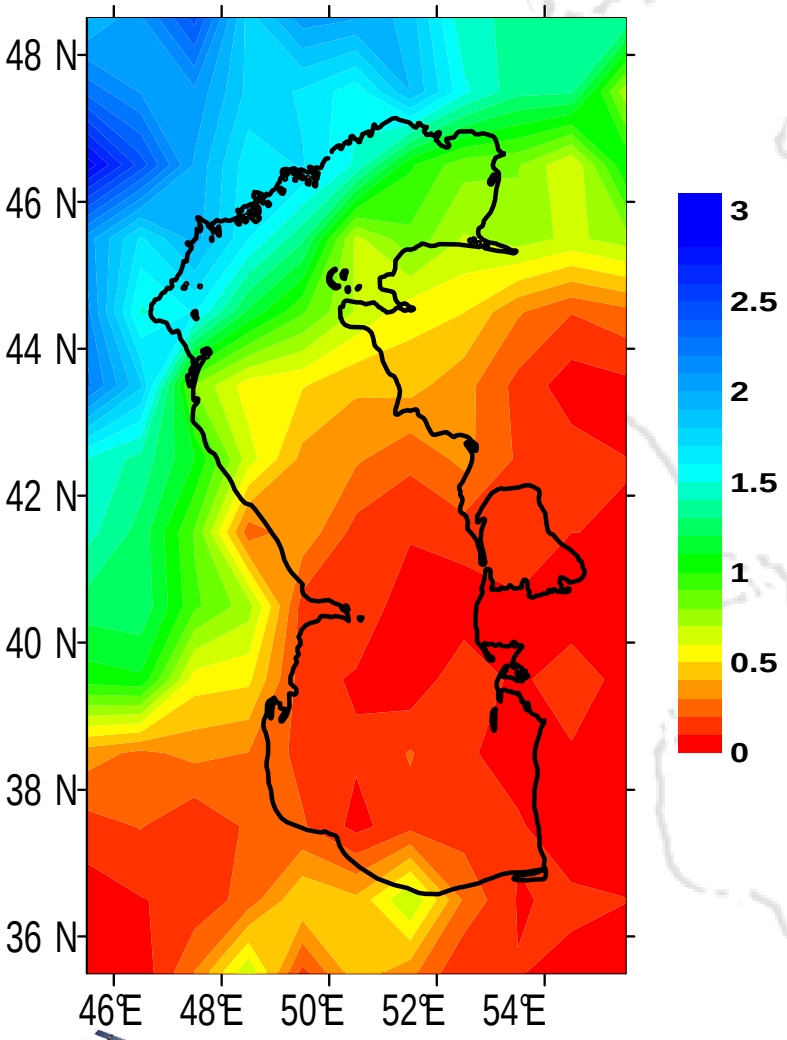


Wind at 10 m (m/s) in June 2001

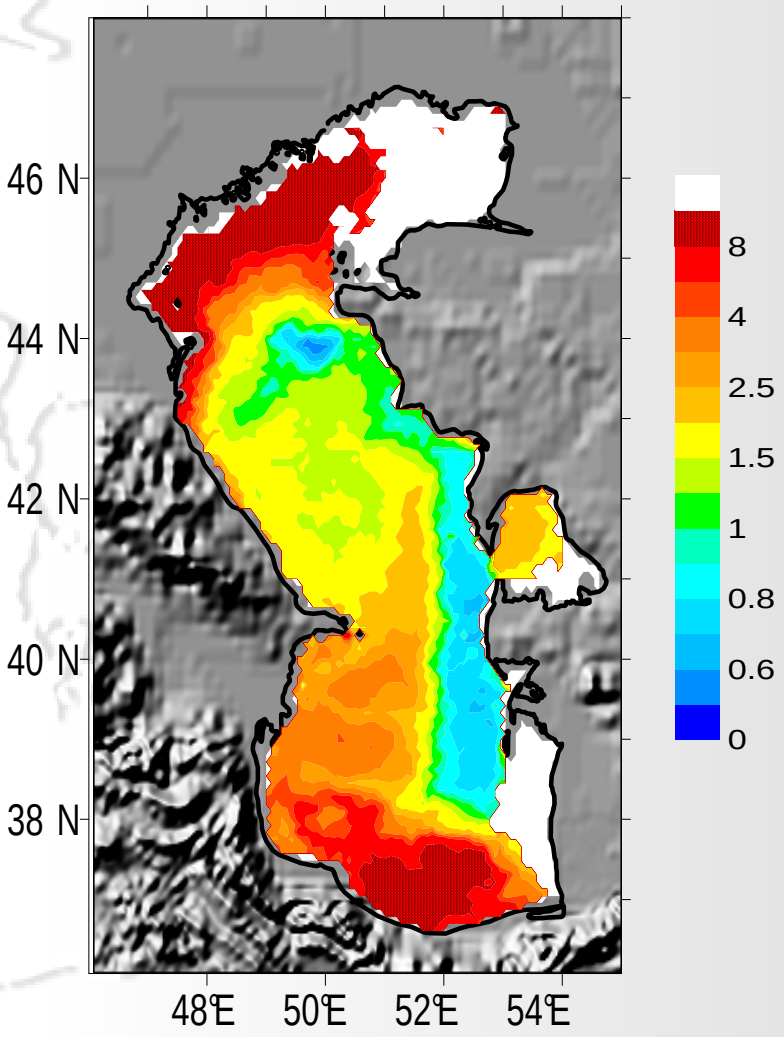


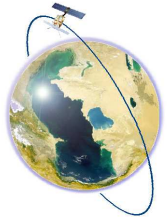


Atmospheric precipitation (mm/day)
June 2001



SeaWiFS chlorophyll (mg/m3)
June 2001





SATELLITE MONITORING OF THE CASPIAN AND BLACK SEAS

The Caspian Sea level gauge measurements

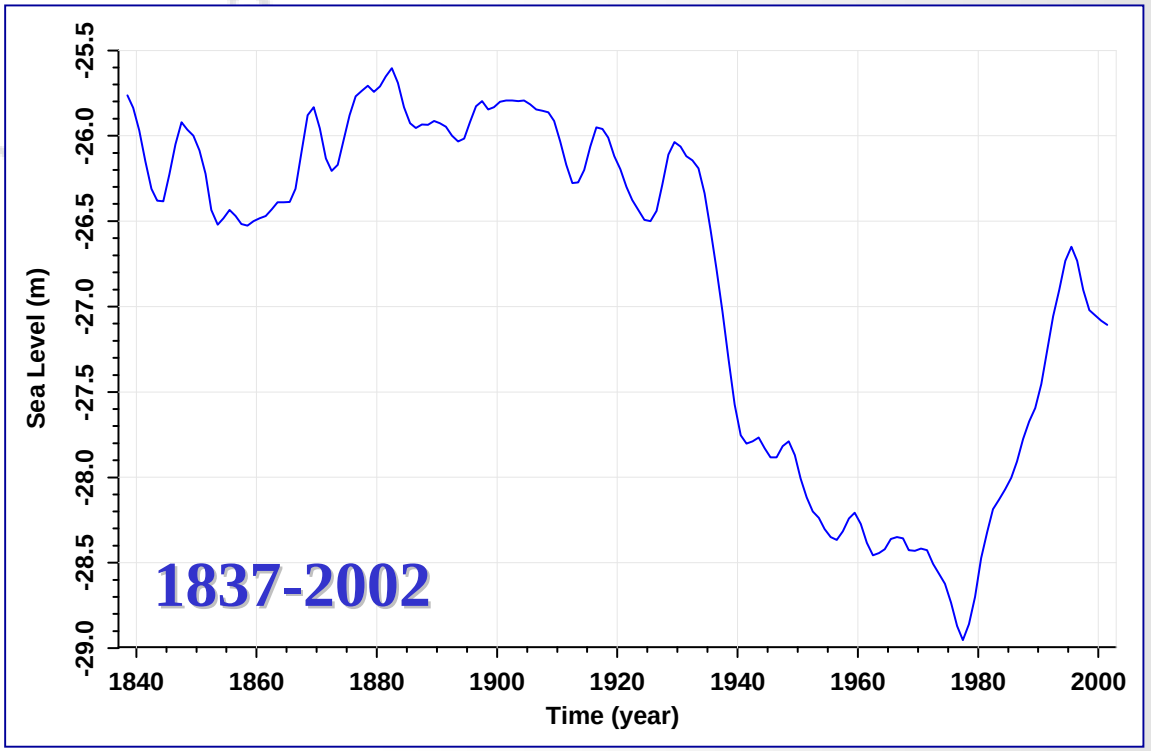
1960 - 79 gauge stations in FSU

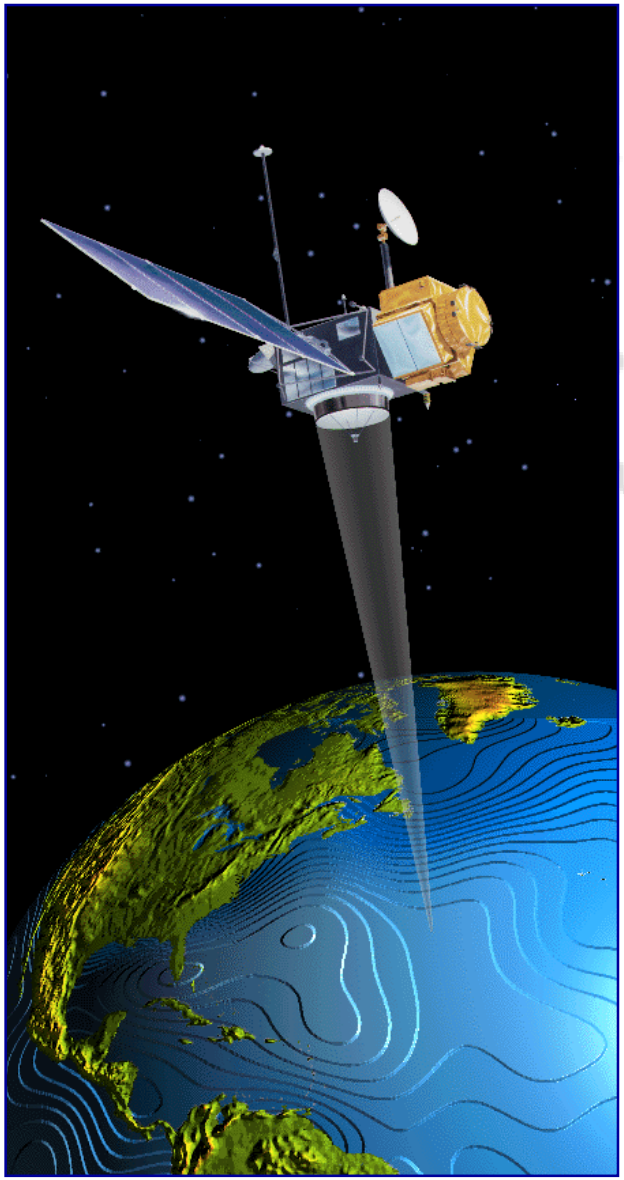
1972 - 51

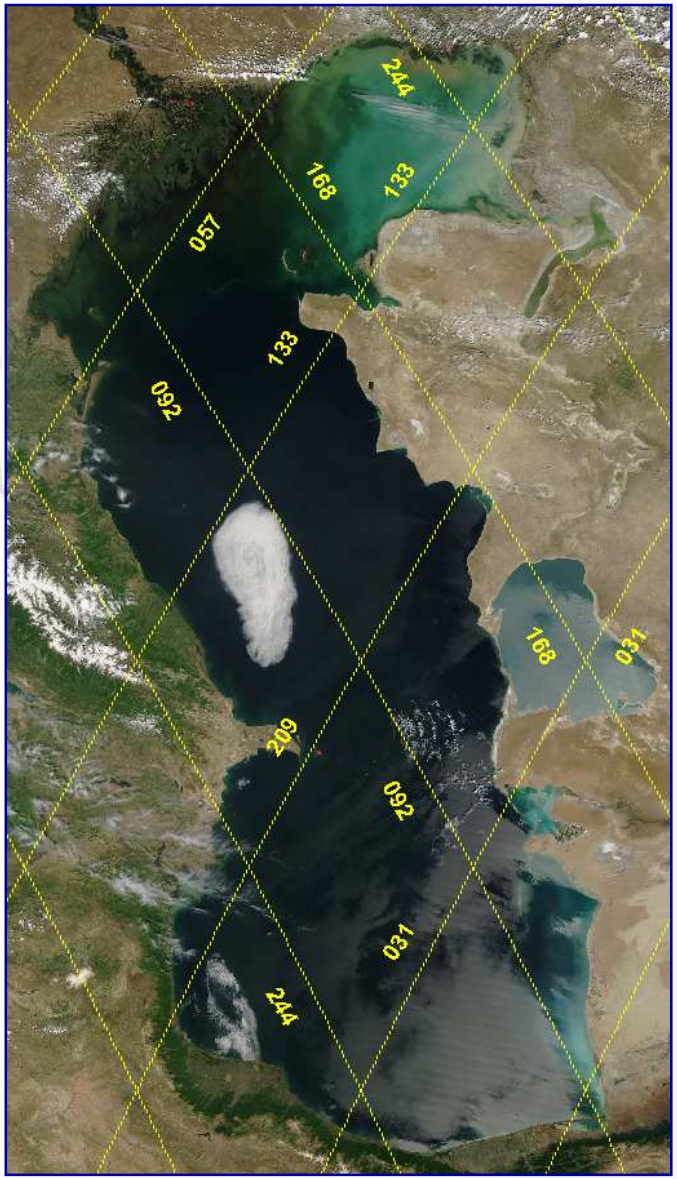
1992 - 36

2004 - 3 in Russia + 4-5 ?

What is alternative?

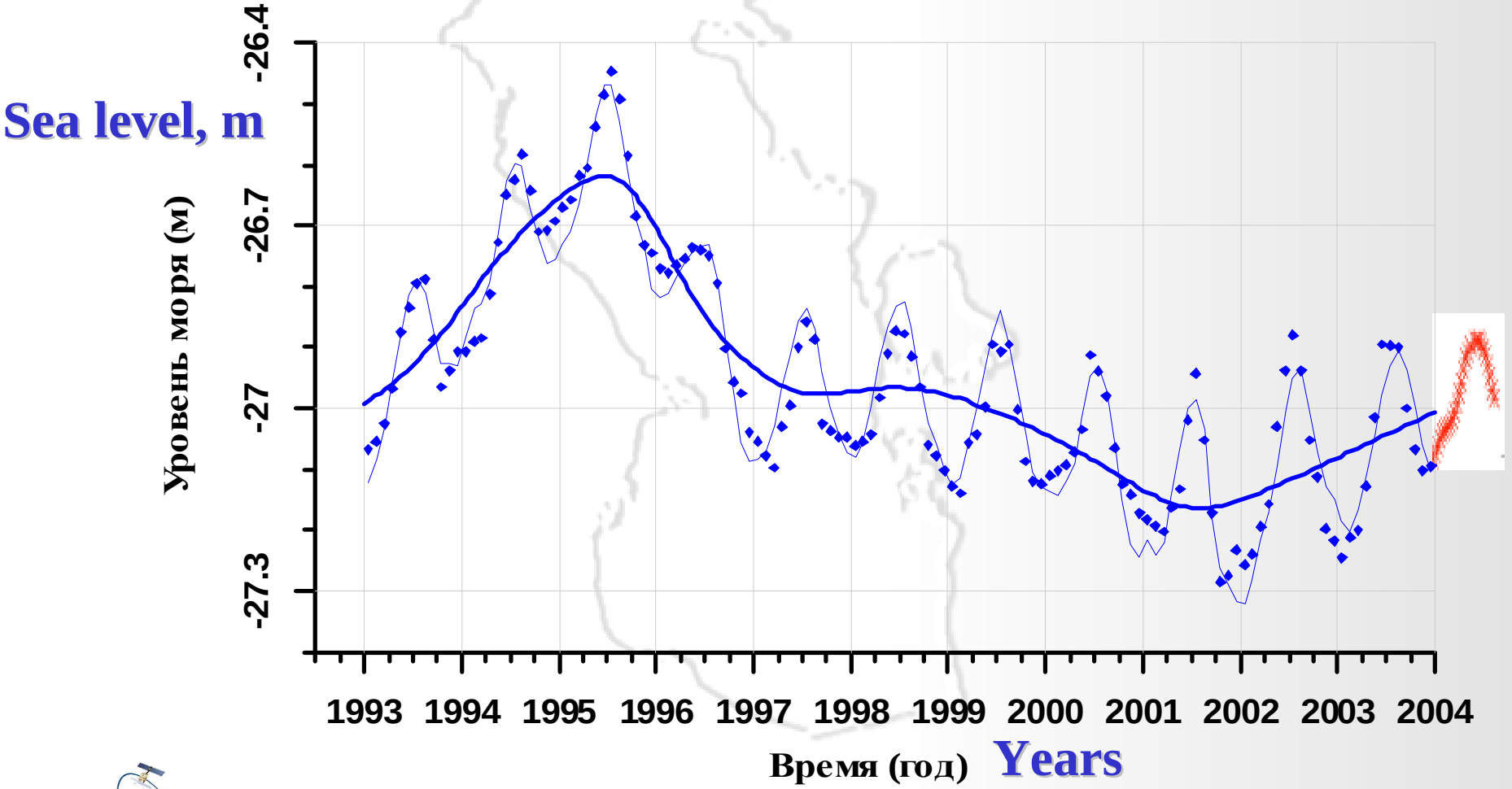






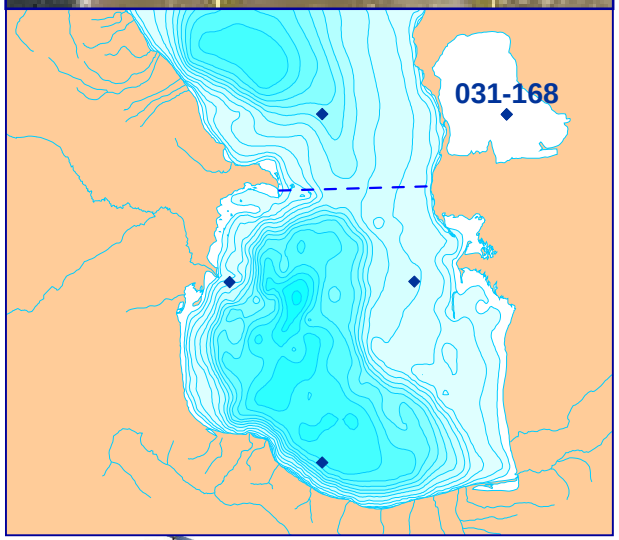
Analysis of seasonal and interannual variability of the sea level in the Caspian Sea and the Kara Bogaz Gol Bay by satellite altimetry data of TOPEX/Poseidon and Jason-1, 1992-2004, orbital period - 10 days (5 days in cross-over points)

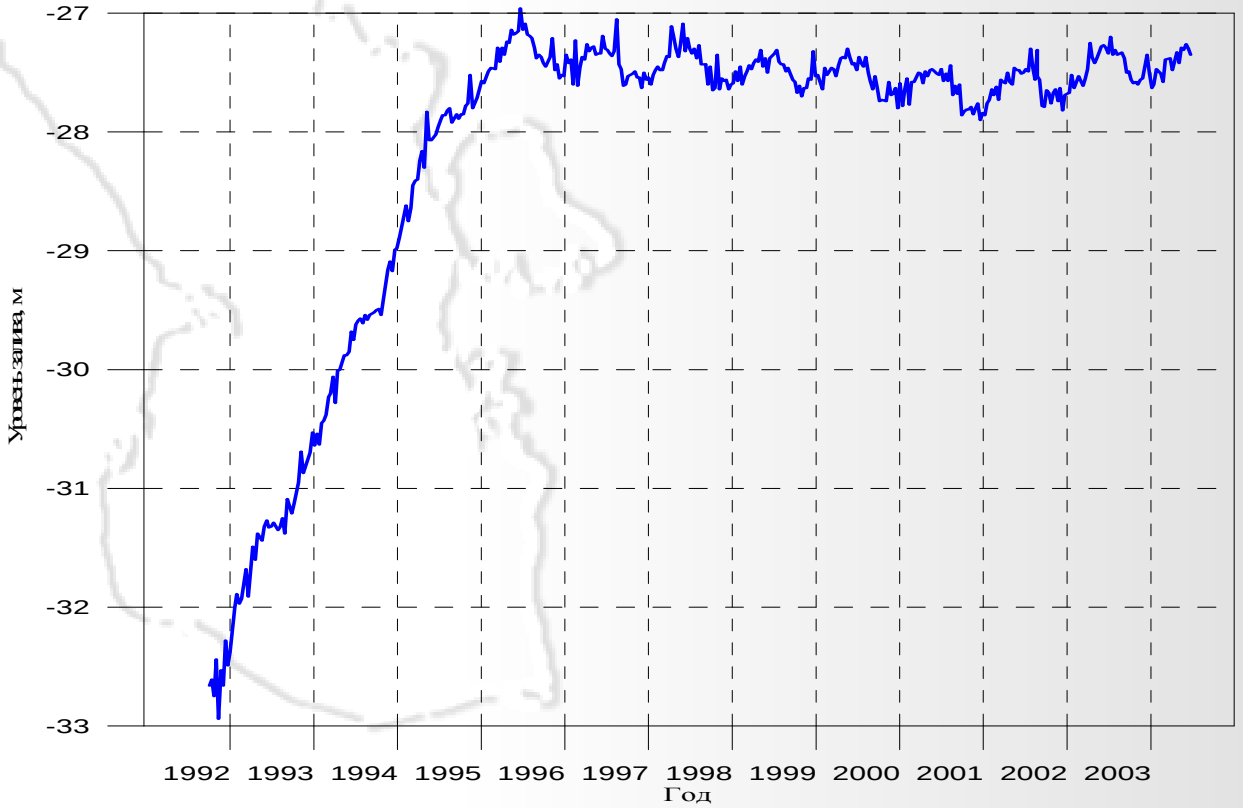
The Caspian Sea level interannual and seasonal variability (1992-2004) based on TOPEX/Poseidon and JASON-1 altimetry data. Markers are monthly gauge data.



The Kara-Bogaz-Gol Bay sea level variability (T/P altimetry, 1992-2004)

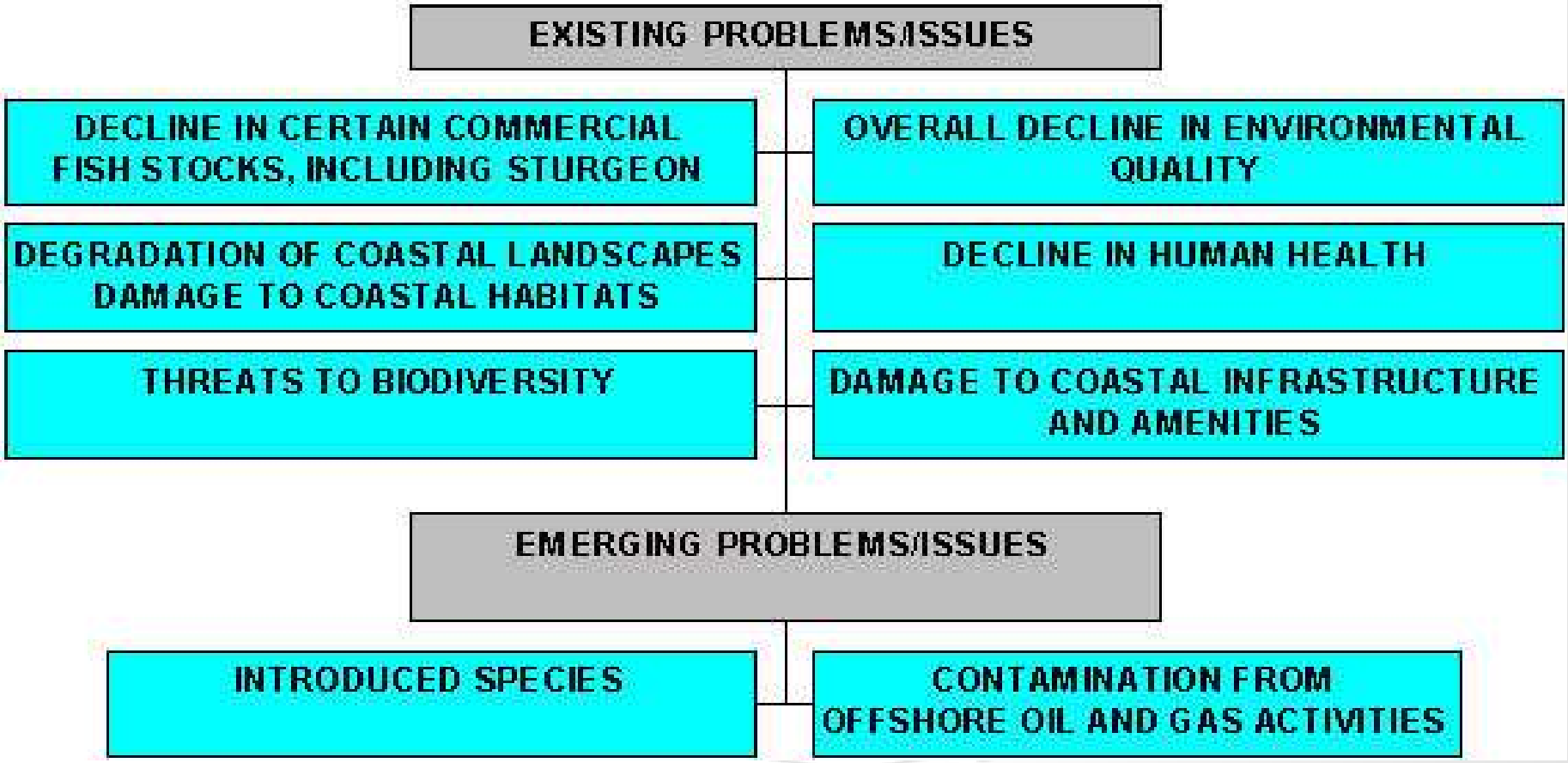
In March 1980 the Caspian-KBG strait was dammed. By November 1983 the KBG had already dried up entirely. In 1992 the dam was destroyed. KBG was filled up by the Caspian water with a rate of about 1.5 m/year in 1992-1996. Then the decreasing trend of 6 cm/year in 1997-2002 was similar to that of the Caspian Sea.





Caspian Environment Programme (CEP)

The Caspian Sea major environmental issues:



The Caspian Sea under pollution

Main sources of the pollution are:

River run-off

Industrial and municipal waste waters

Offshore and onshore oil production

Oil transportation

Flooded coastal zone due to sea level rise

Intensive oil and gas development in the Caspian region resulted in extensive water, land and air pollution, wildlife and plant degradation, exhaustion of natural resources, ecosystem disturbance, desertification and considerable losses in biological and landscape diversity.

Negative environmental changes cause growth of human morbidity and mortality. Life-rate in the Caspian littoral states is lower for 15-20 years than in developed countries.

Caspinfo

OIL

The Caspian Sea Region contains proven oil reserves estimated to be between 17 and 33 billion barrels, comparable to Qatar on the low end, and the United States on the high end.

Reserves

Country	Proven Oil Reserves		Potential	Total	
	Low	High		Low	High
Azerbaijan	7 BBL	12.5 BBL	32 BBL	39 BBL	44.5 BBL
Iran ‡	0.1 BBL		15 BBL	15.1 BBL	
Kazakhstan	9 BBL	17.6 BBL	92 BBL	101 BBL	109.6 BBL
Russia ‡	0.3 BBL		7 BBL	7.3 BBL	
Turkmenistan	0.5 BBL	1.7 BBL	38 BBL	38.5 BBL	39.7 BBL
Uzbekistan	0.3 BBL	0.6 BBL	2 BBL	2.3 BBL	2.6 BBL
Total	17.2 BBL	32.8 BBL	186 BBL	203.2 BBL	218.8 BBL

Production

In 2002, regional oil production reached roughly 1.6 million barrels per day, comparable to South America's second largest oil producer, Brazil. By 2010, production is forecast to reach between 3 and 5 million barrels per day, which exceeds annual production from South America's largest oil producer, Venezuela.

Caspian Sea Region Oil Production (Thousand Barrels per Day)

Country	1992	2002	2010	
			Low	High
Azerbaijan	222	318	789	1,140
Iran‡	N/A	N/A	N/A	
Kazakhstan	530	939	1,617	2,400
Russia‡	N/A	N/A	150	
Turkmenistan	110	184	374	964
Uzbekistan	66	152	205	240
Total	928	1,593	3,135	4,894

Turkish Straits

Increased oil exports from the Caspian Sea region to Russian and Georgian ports and across the Black Sea has led to increased oil tanker traffic (and risks of an accident) through the narrow, winding Turkish Straits (including the Dardanelles, Marmara Sea, and Bosporus Straits). According to Energy Information Administration (www.eia.doe.gov) around 50,000 vessels per year (nearly one every 10 min) now pass through them. Around one-tenth of these are oil or liquefied natural gas tankers. This increased congestion has led to a growing number of accidents; between 1988 and 1992, there were 155 collisions in the Straits, some of them resulting in spilling thousands tons of oil into the Straits.

Aerial oil spill monitoring in the Black Sea
7 August 2004, Novorossiisk

Oil spill from GEORGIOS III

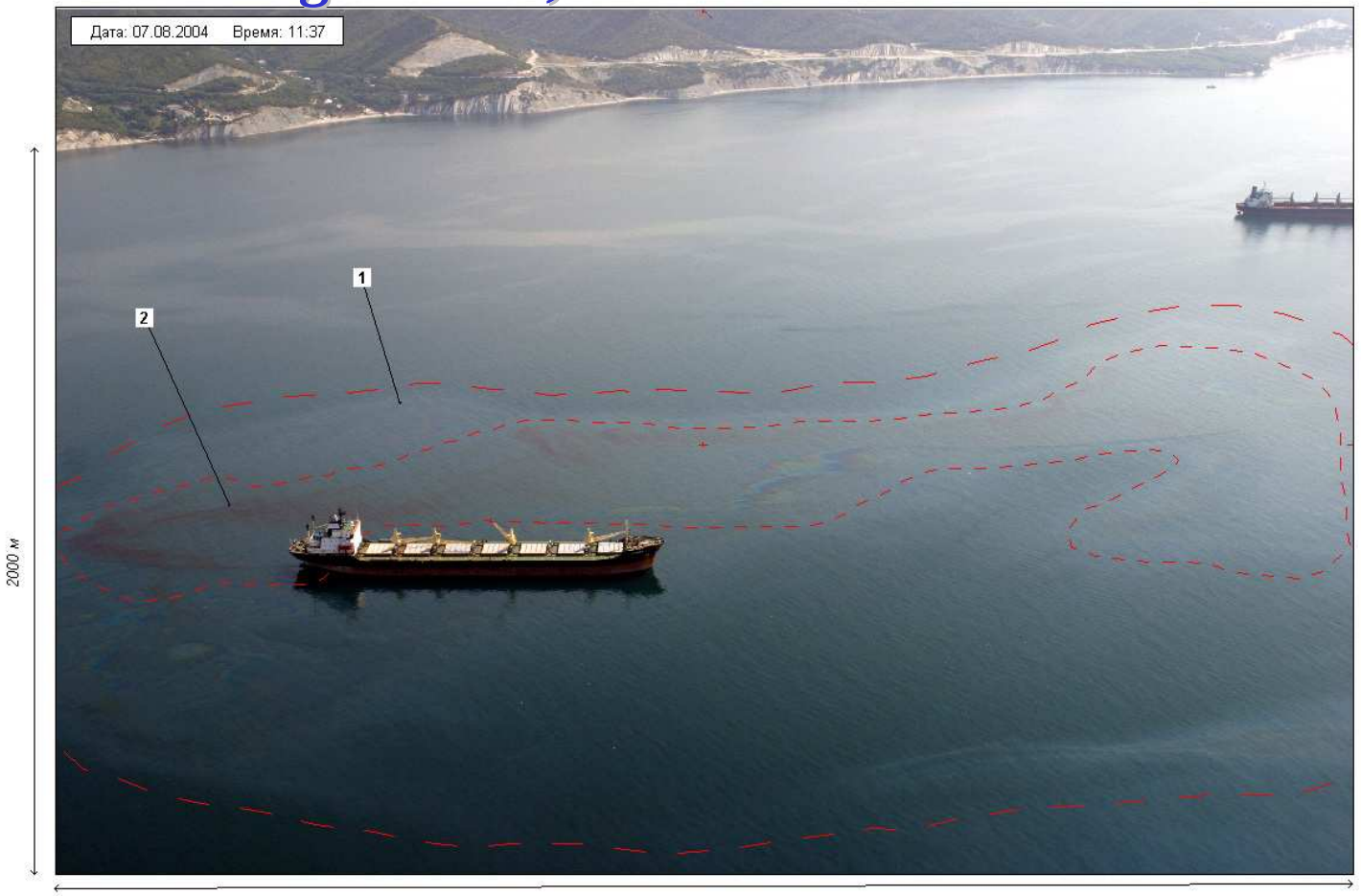


Рис. Шлейф нефтепродуктов у т/х GEORGIOS III

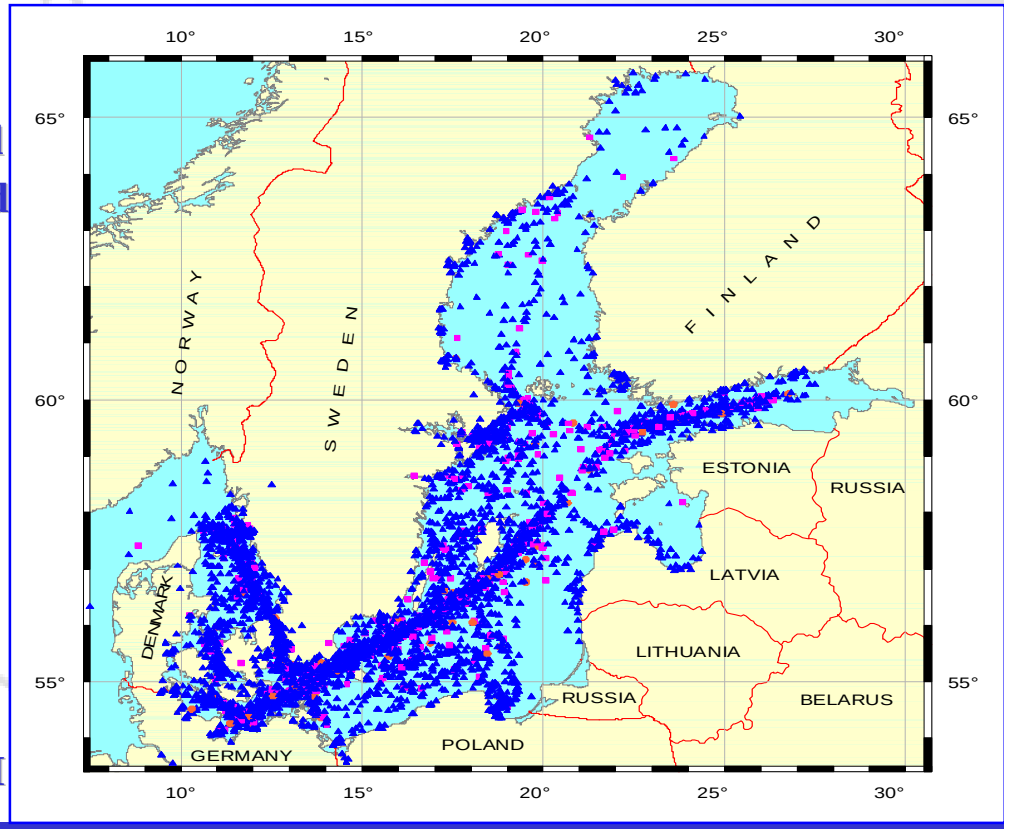
1 - Зона распространения пленок нефтепродуктов интенсивностью 3-4 балла
2 - Зона распространения пленок нефтепродуктов интенсивностью 5 баллов

Image Courtesy:
Yu.I. Yurenko,
Russian Hydrometeorological Service, Sochi

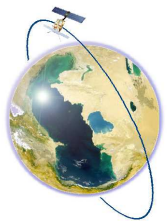
Oil spill monitoring in the Mediterranean, North and Baltic Seas

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 (ESA).

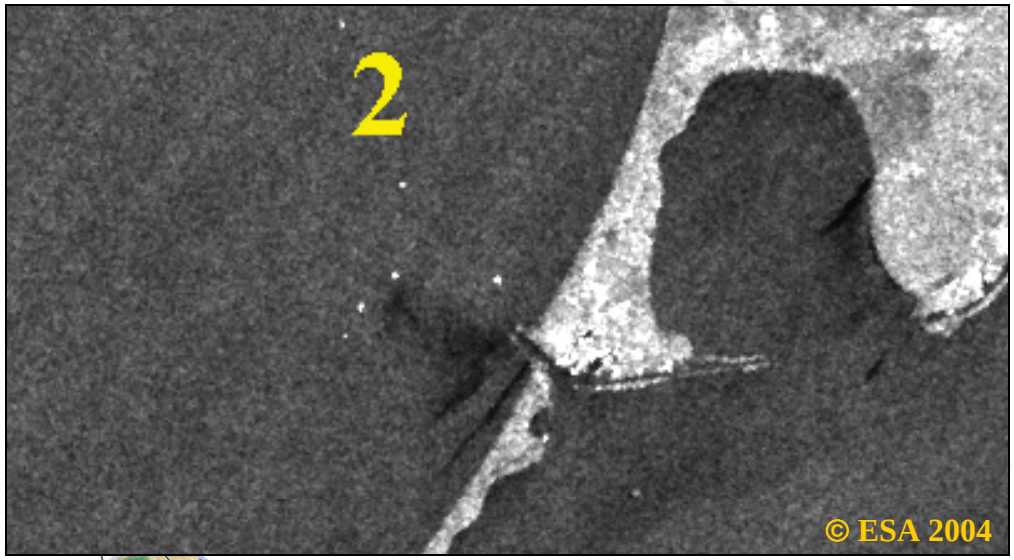


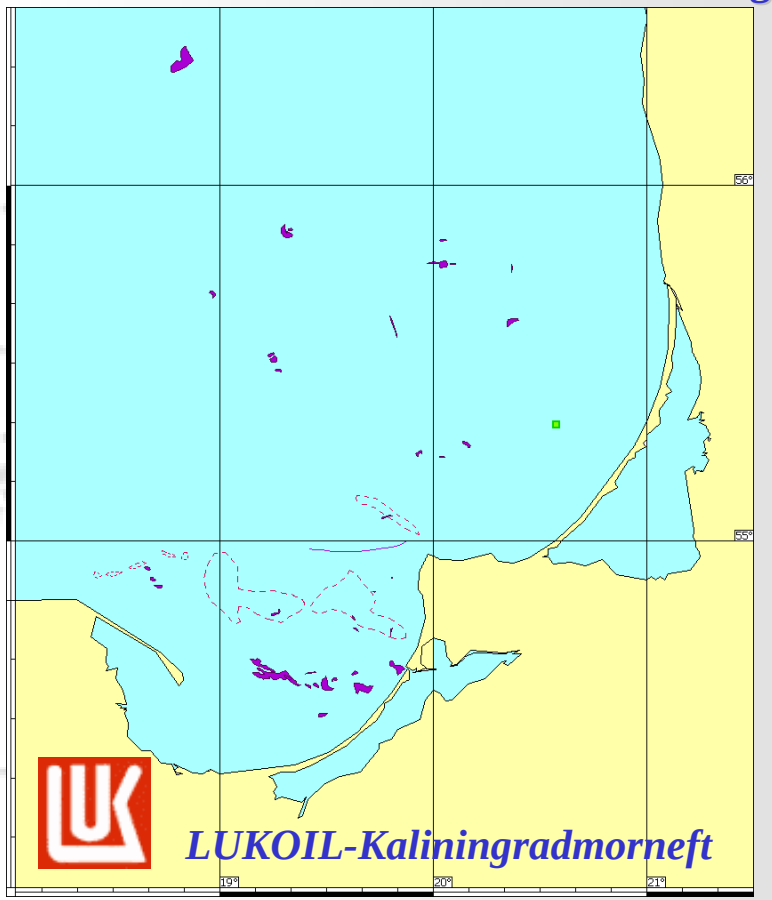
Oil spills 1989-2002, HELCOM



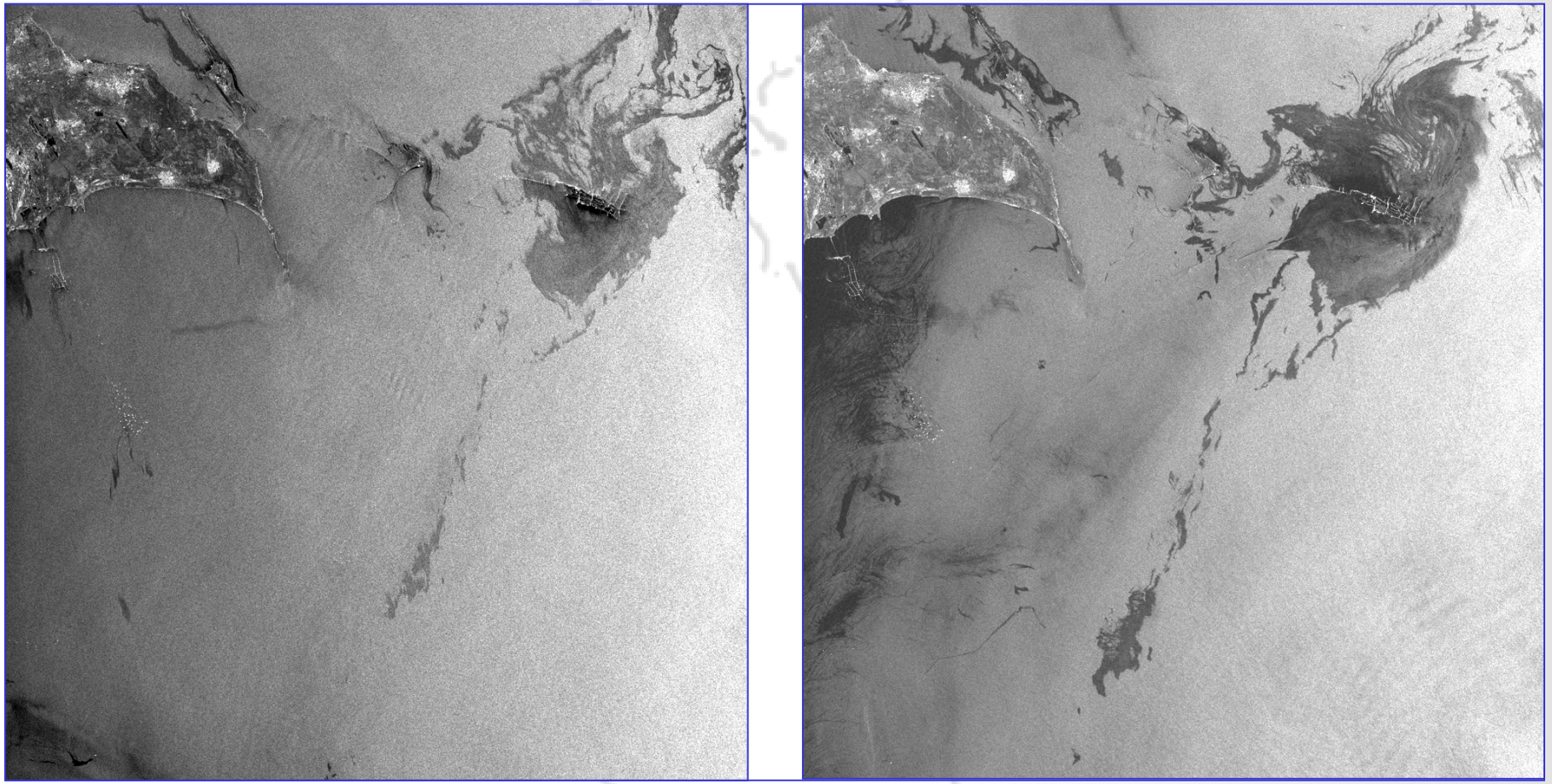
Satellite oil spill monitoring in the Baltic Sea

Satellite imagery can help greatly identifying probable spills over very large areas and then guiding aerial surveys for precise observation of specific locations. The Synthetic Aperture Radar (SAR) instrument, which can collect data independently of weather and light conditions, is an excellent tool to monitor and detect oil on water surfaces. This instrument offers the most effective means of monitoring oil pollution: oil slicks appear as dark patches on SAR images because of the damping effect of the oil on the backscattered signals from the radar instrument. This type of instrument is currently on board the European Space Agency's ENVISAT and ERS-2 satellites.





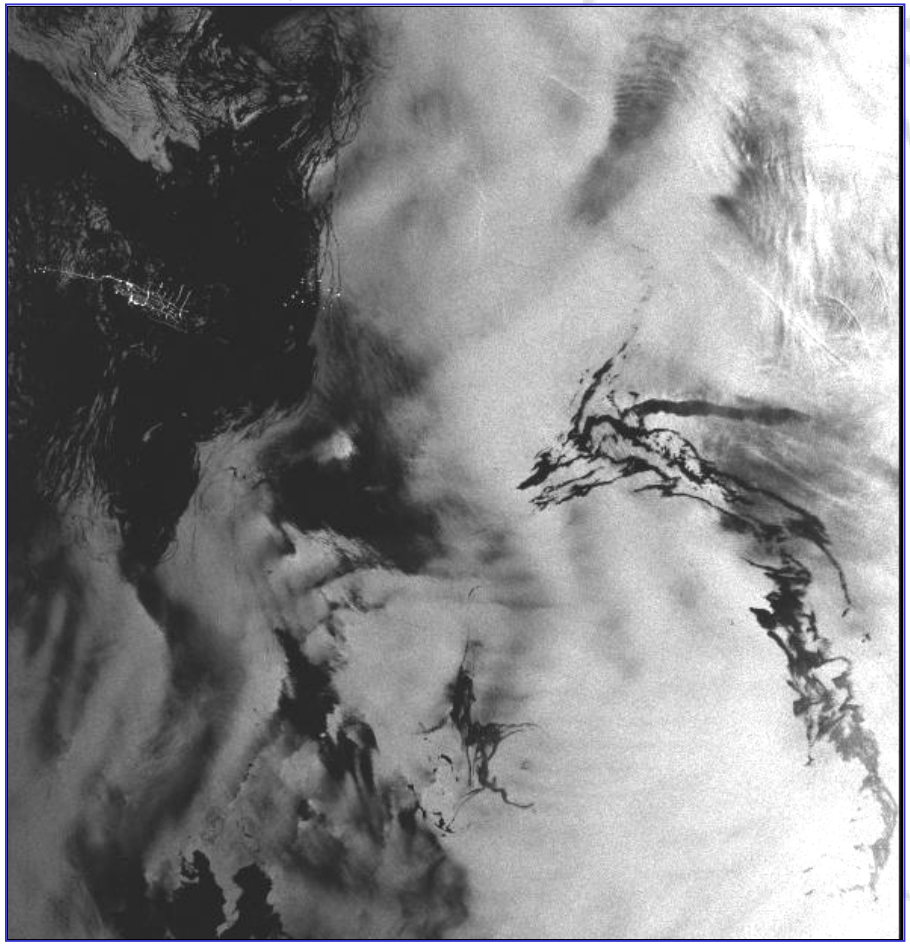
Oil spill monitoring in the Caspian Sea



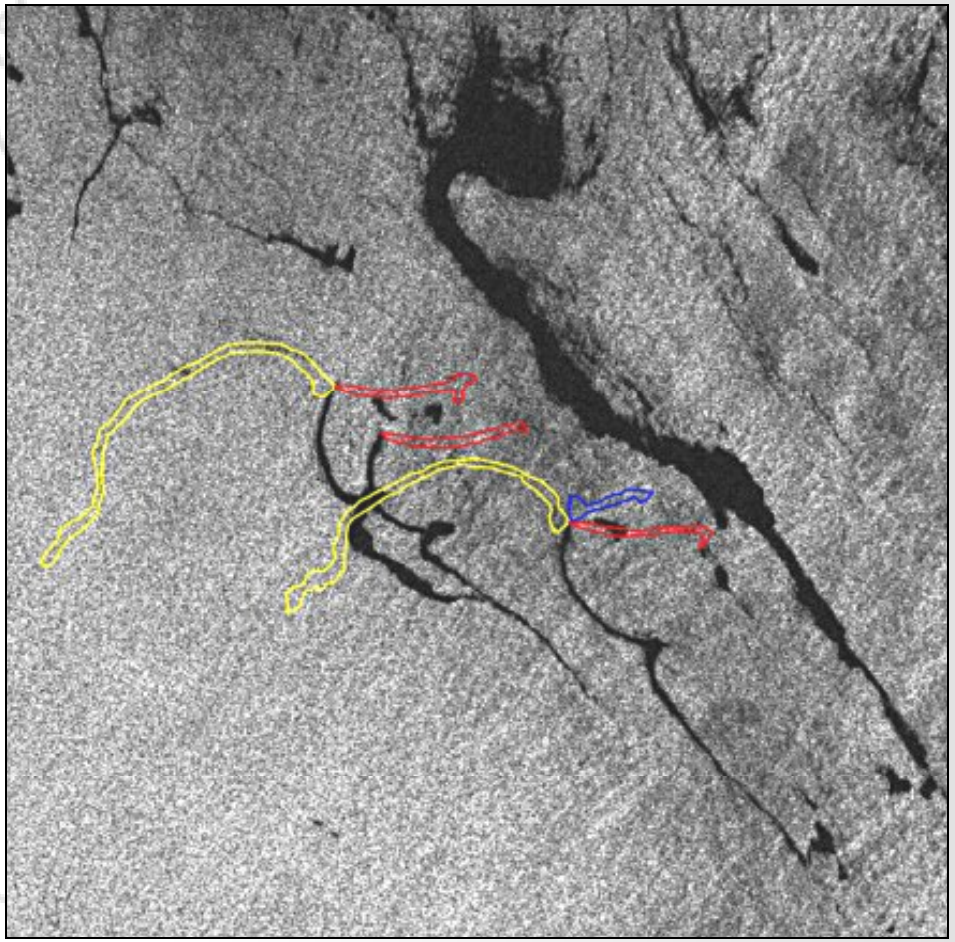
Dynamics of oil spills near Neftyanye Kamni. SAR imagery of ERS-1 on 12 May (left) and of ERS-2 on 13 May 1996 (right). Larger spill on 13 May is due to low wind speed. © ESA

Oil spill monitoring in the Caspian Sea

The Middle Caspian Sea
ERS-1, 28/05/1996 © ESA



The Southern Caspian Sea. Oil spill tracks show possible bottom sources of oil. © InfoTerra.



Oil spill monitoring in the Caspian Sea. Baku, 25 August 2004

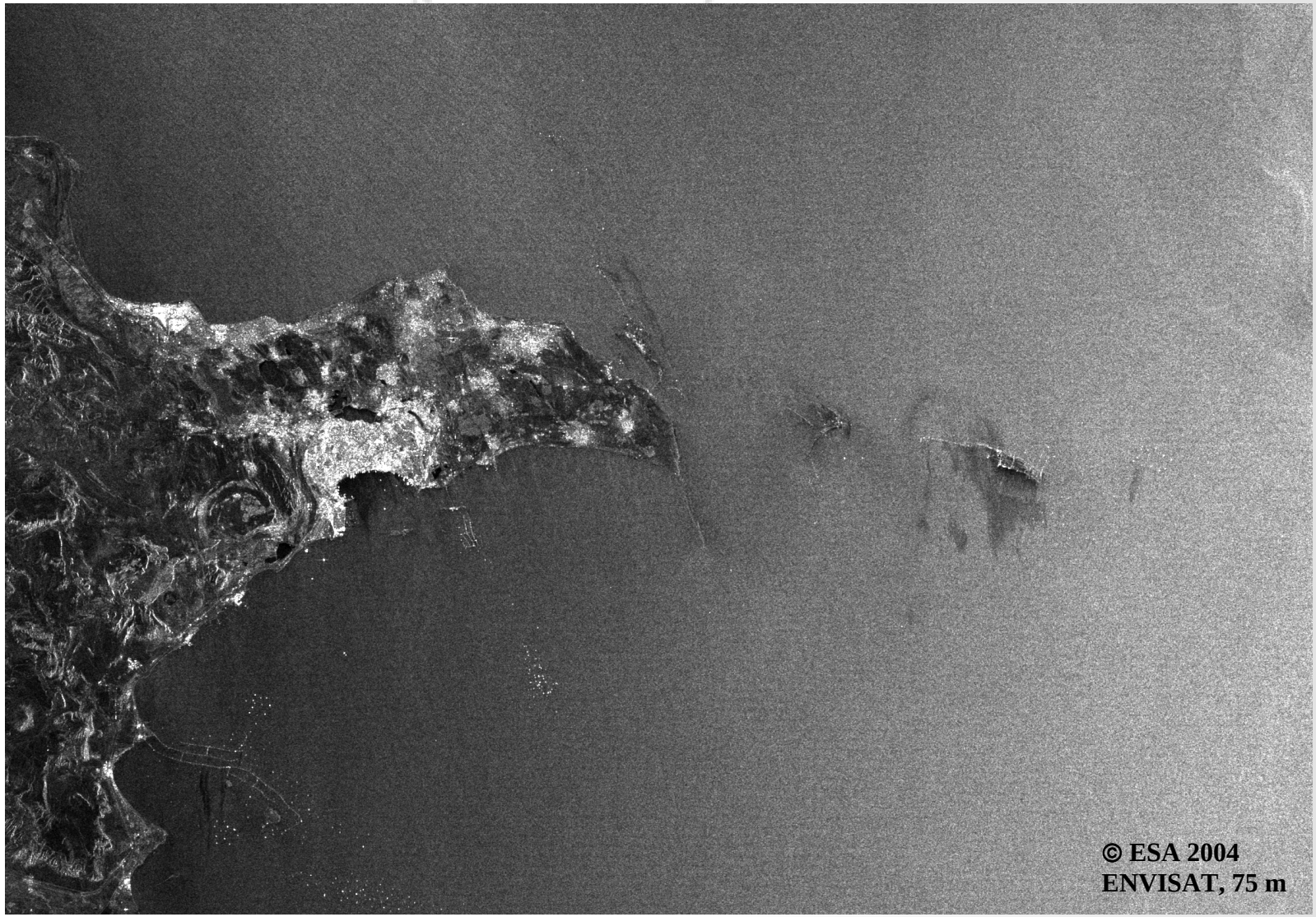


Image Courtesy: O.Yu.Lavrova, Russian Space Research Institute

Oil spill monitoring in the Caspian Sea. Baku, 10 September 2004

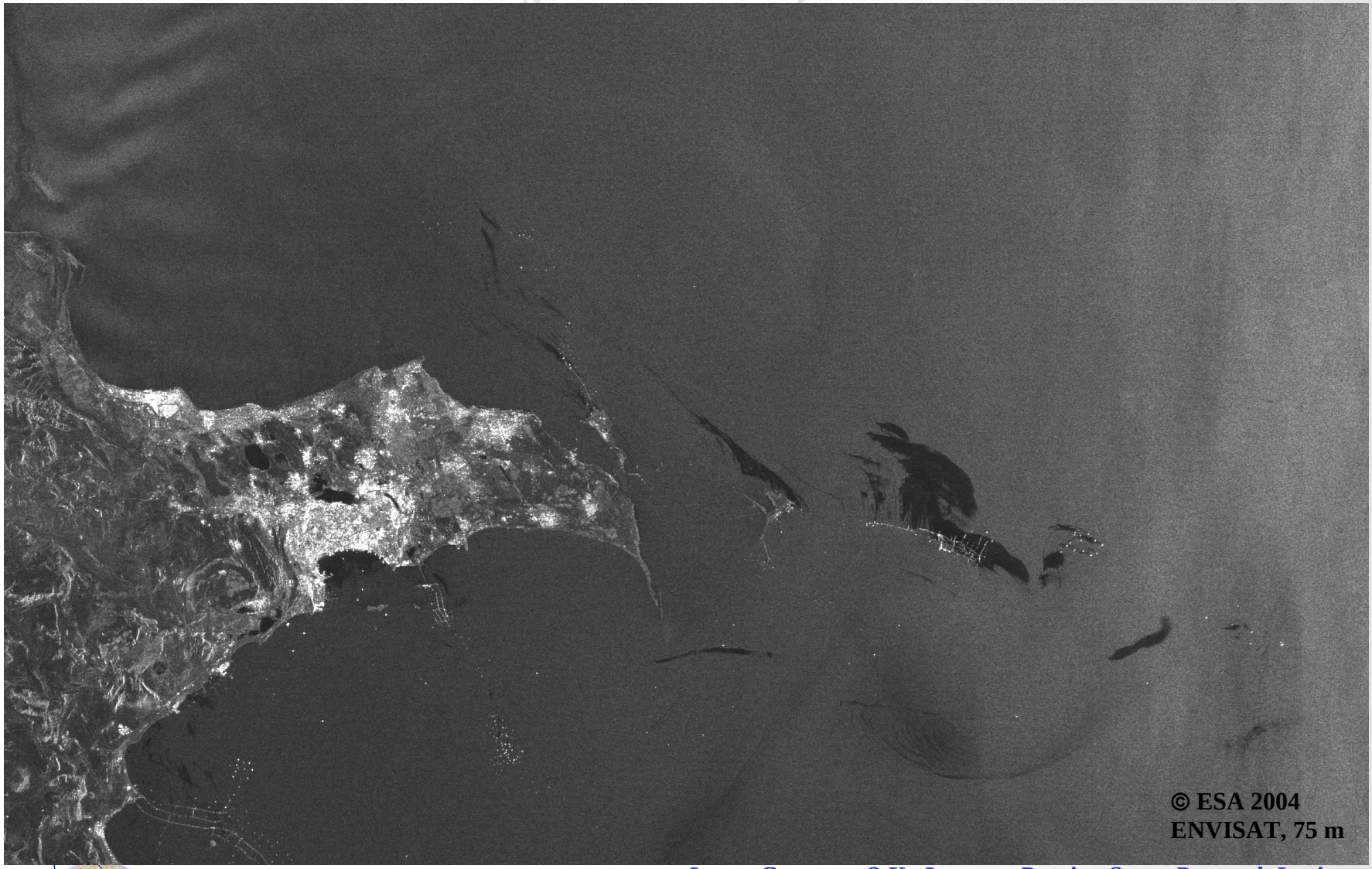


Image Courtesy: O.Yu.Lavrova, Russian Space Research Institute

Oil spill monitoring in the Black Sea. Novorossiisk, 26 July 1999

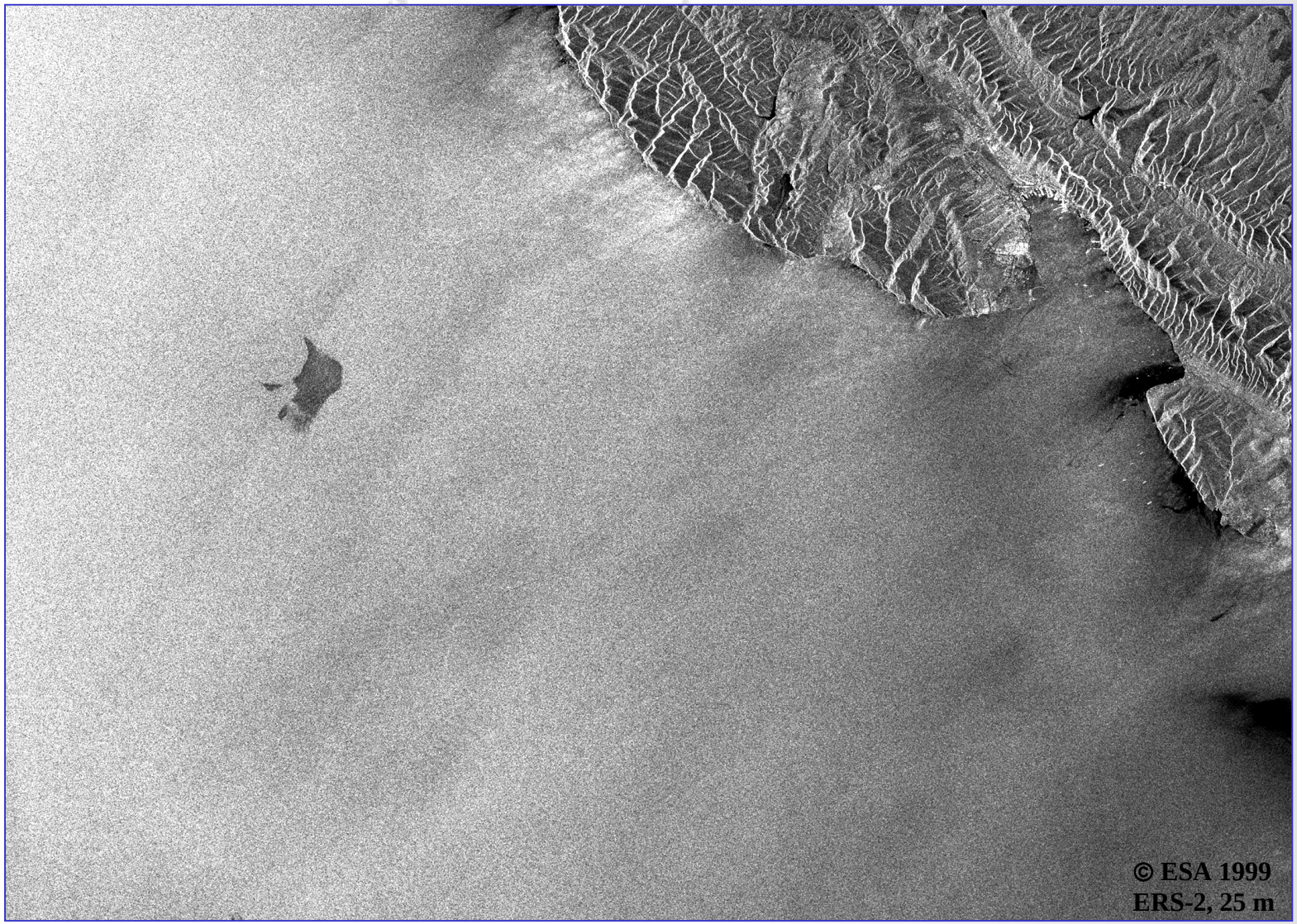


Image Courtesy: O.Yu.Lavrova, Russian Space Research Institute

Oil spill monitoring in the Black Sea. Novorossiisk, 11 August 1999

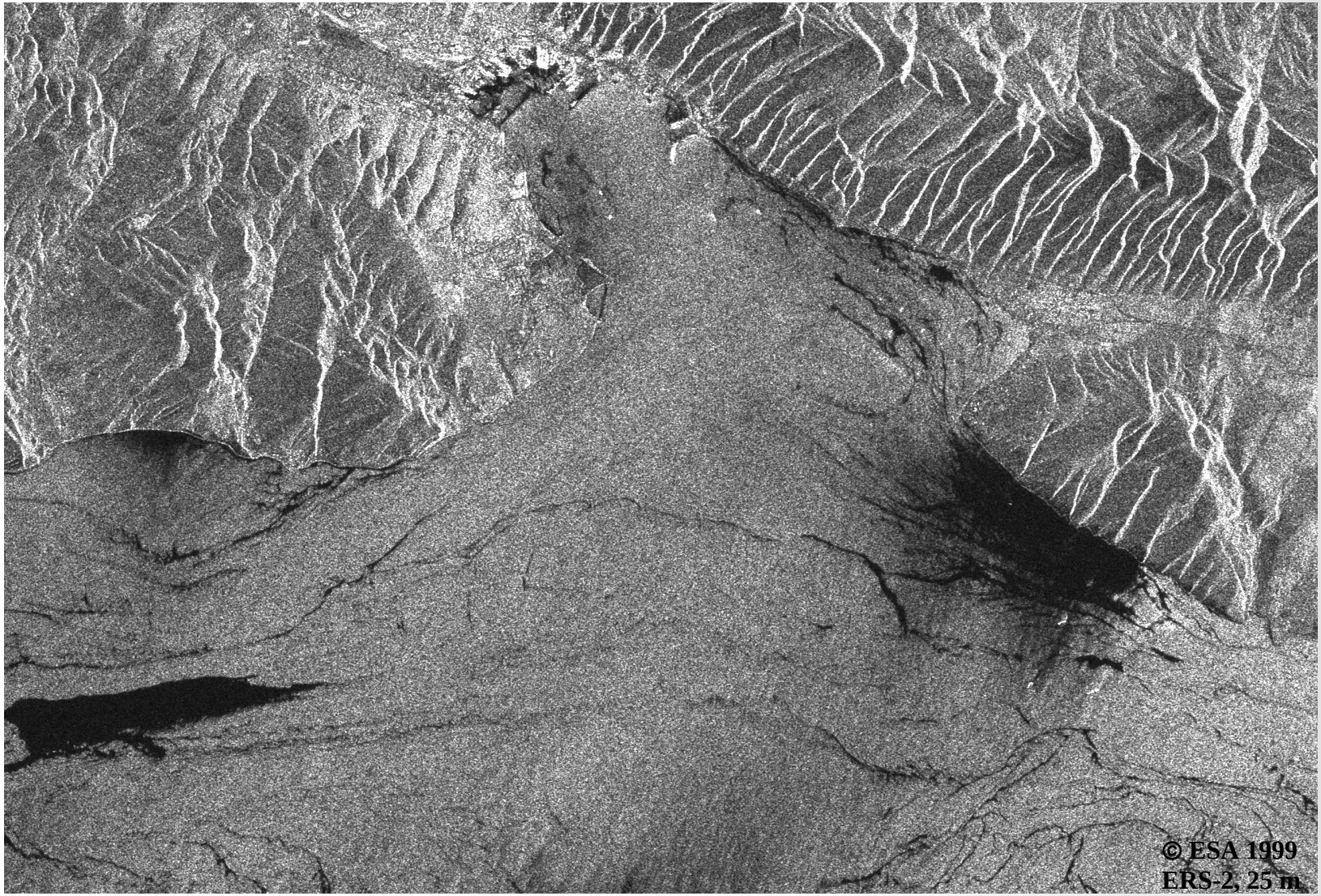


Image Courtesy: O.Yu.Lavrova, Russian Space Research Institute

Oil spill monitoring in the Black Sea. Novorossiisk, 31 July 2002

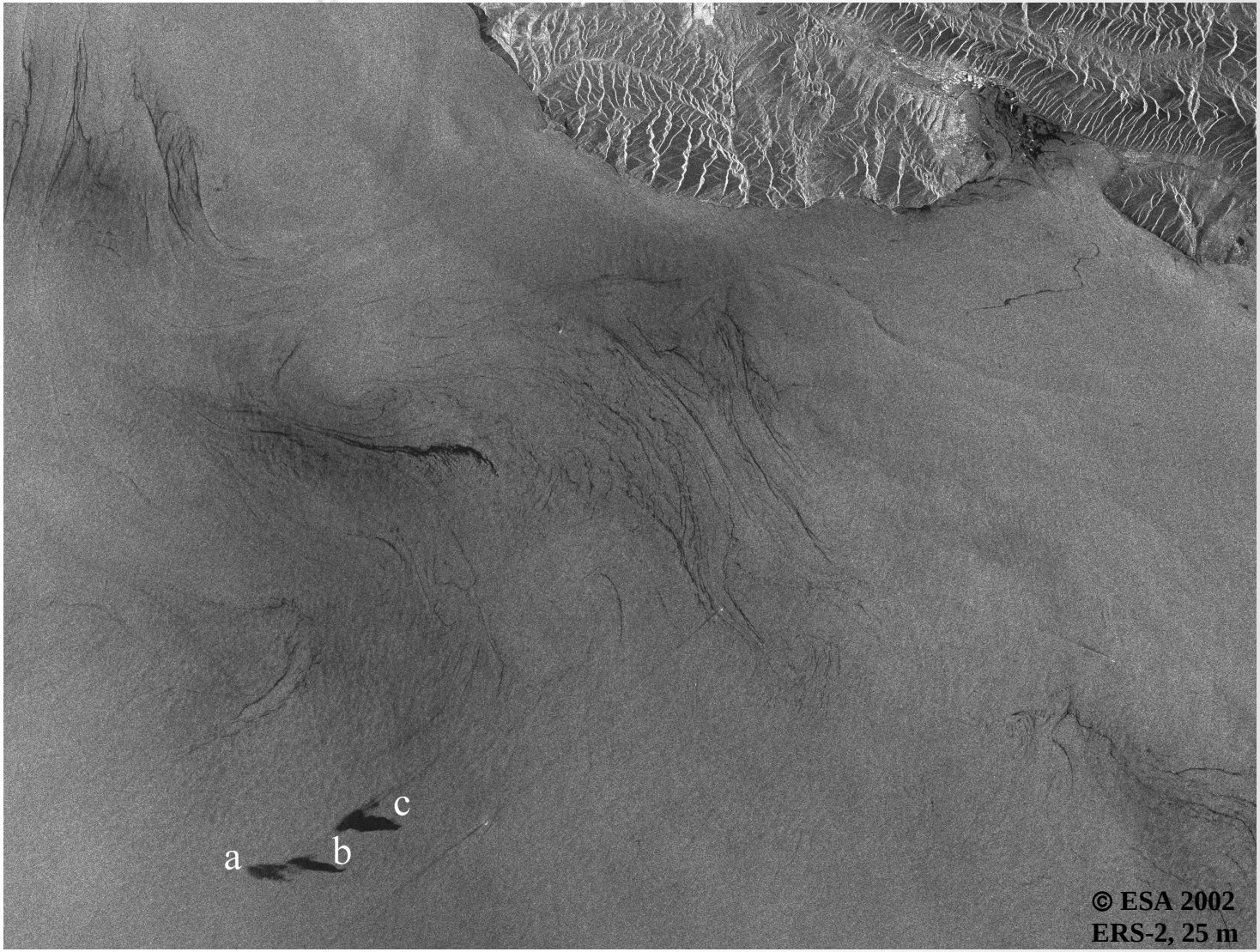
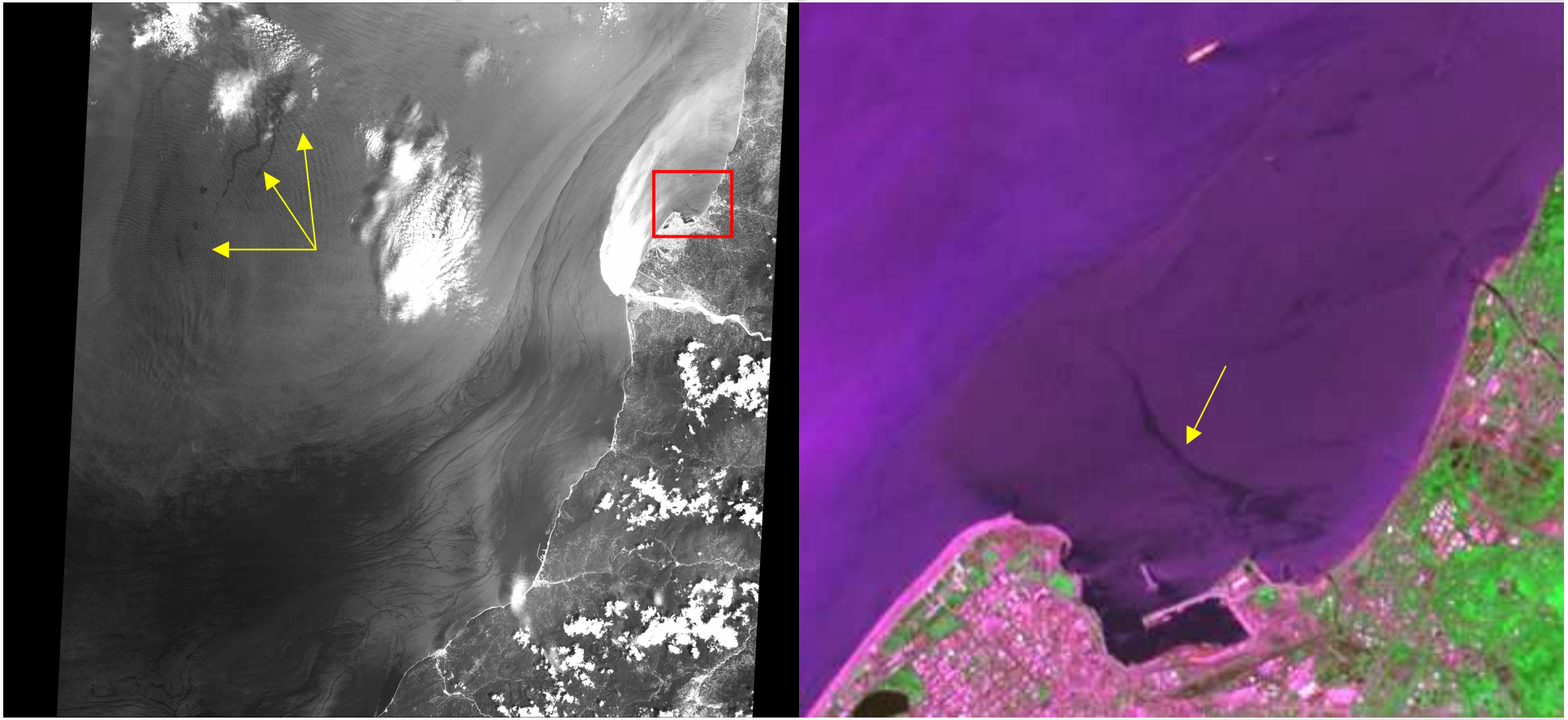
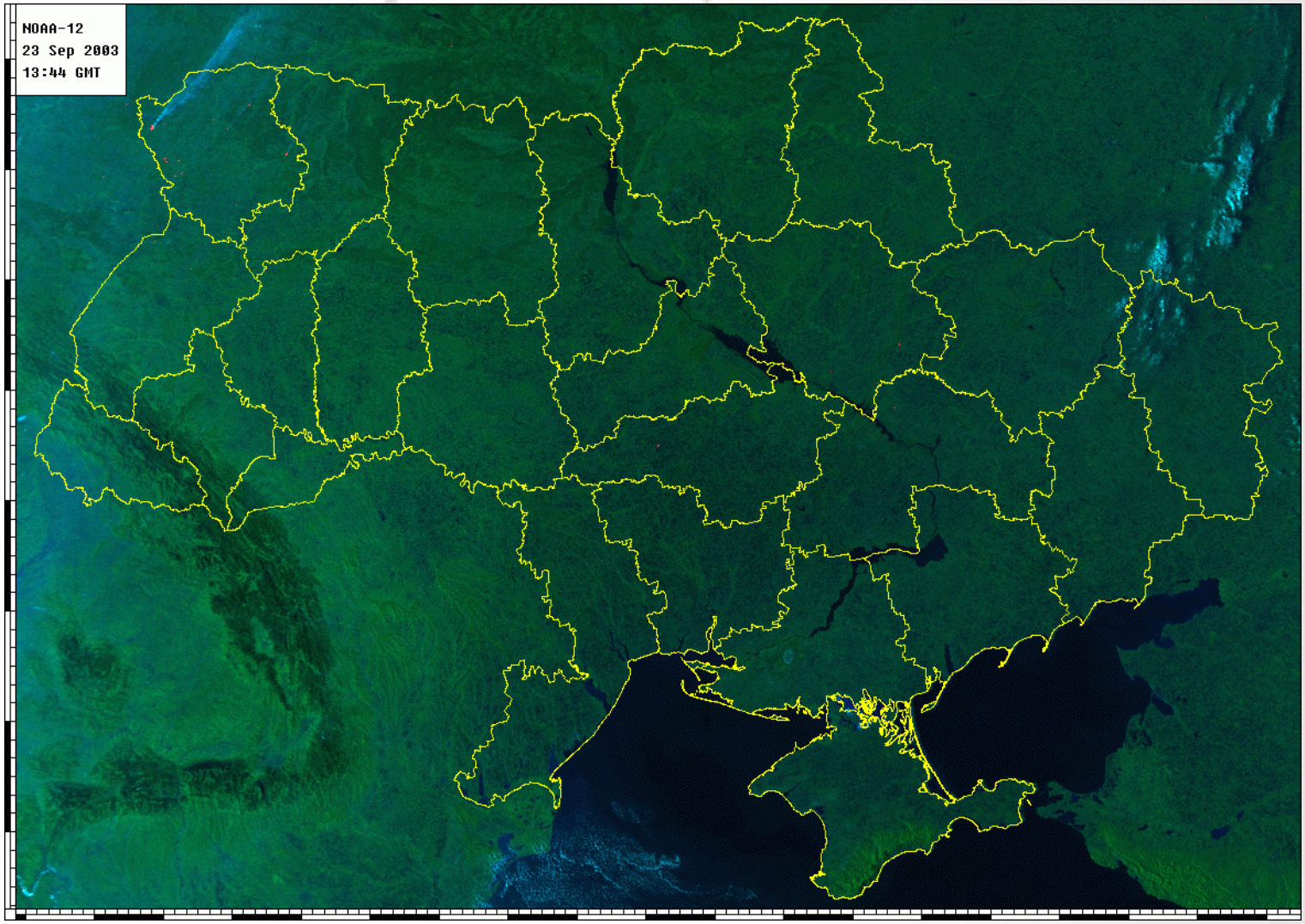


Image Courtesy: O.Yu.Lavrova, Russian Space Research Institute

Oil spills in the Black Sea
30 June 2002, Batumi
ASTER Terra, 15 m



Detection of forest fires. Ukraine, 23 September 2003, NOAA-12.



Detection of forest fires in Kazakhstan

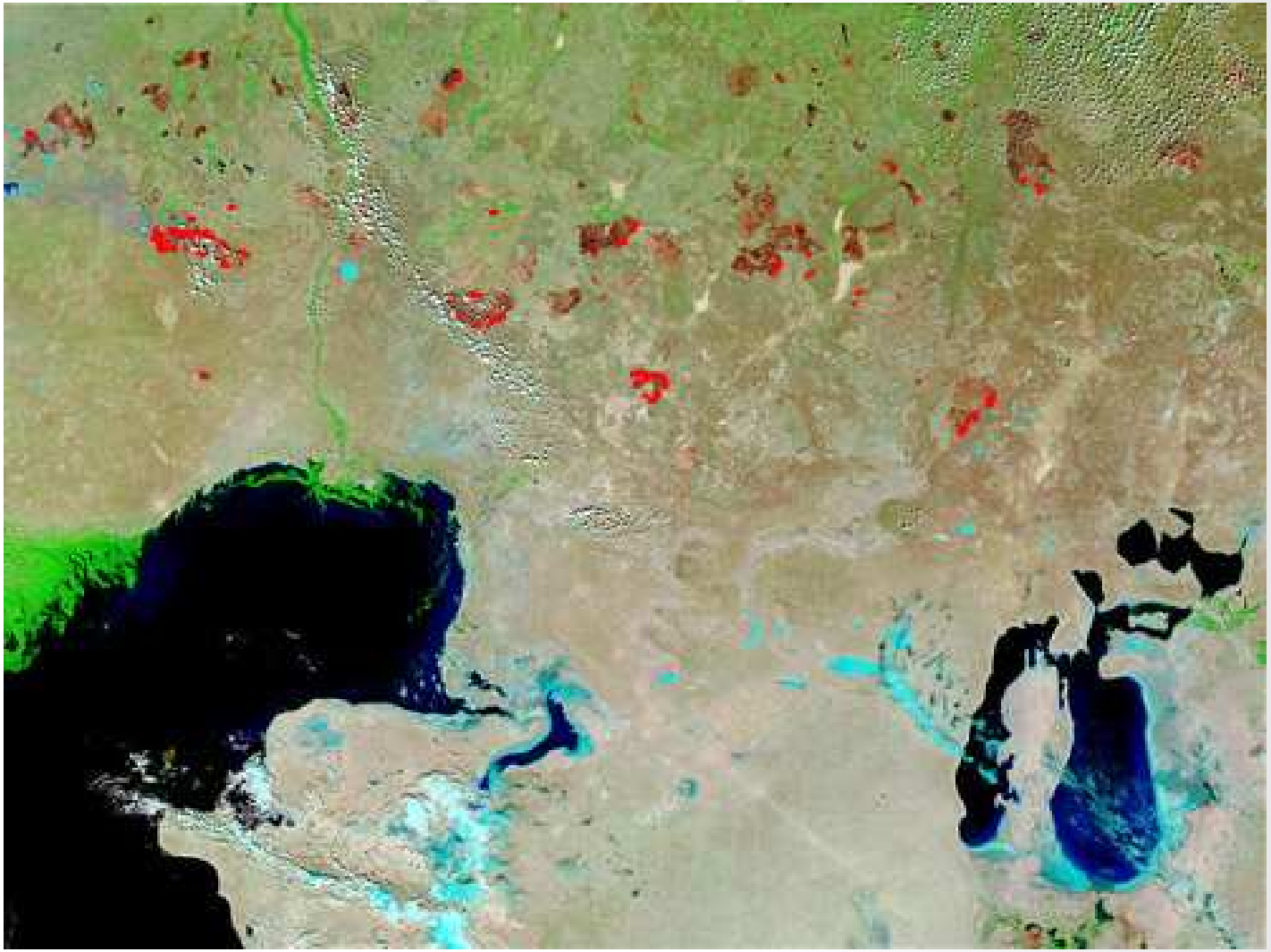
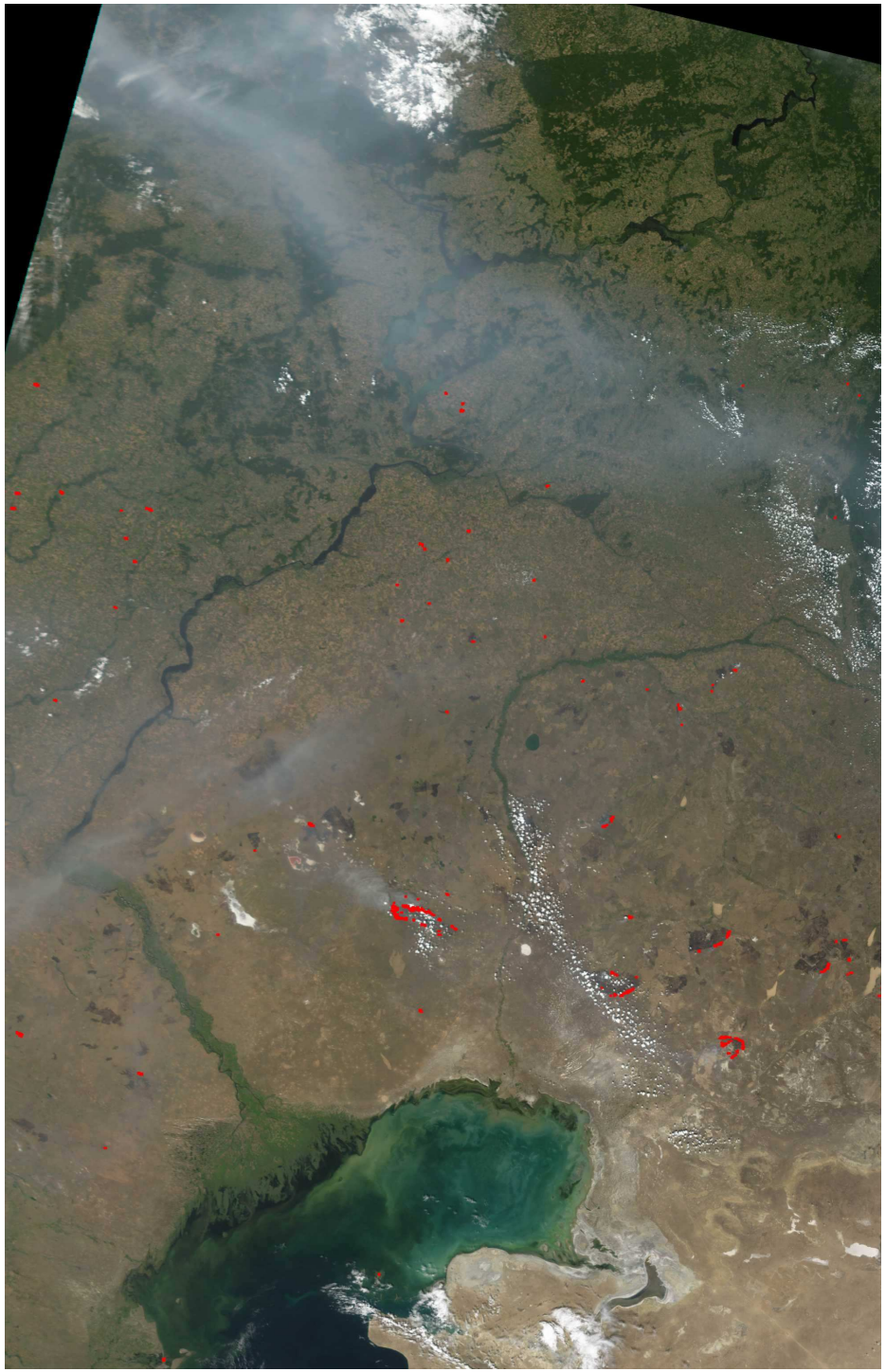


Image Courtesy: NASA Visible Earth



Пожары (красные точки) севернее Каспия 2 августа 2002 г. (MODIS-Terra, разрешение 250 м). В верхней части кадра шлейф дыма от пожаров в Московской области

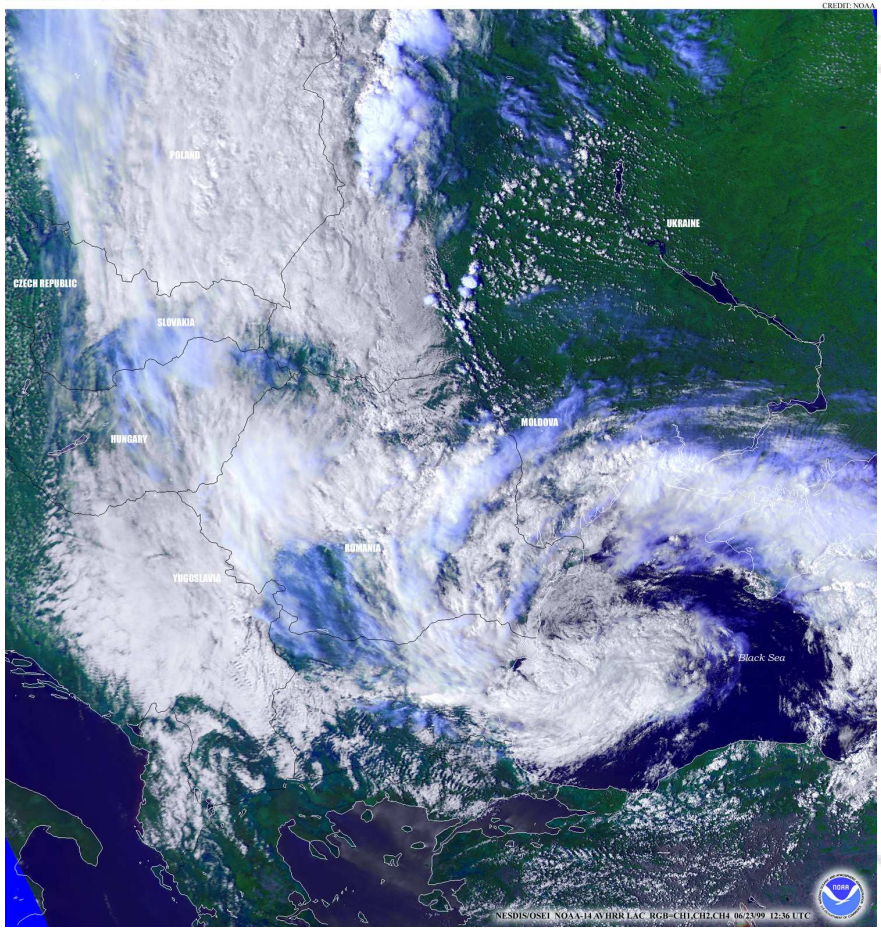
Detection of forest fires in Turkey

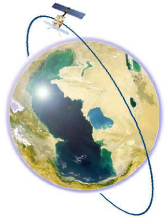
Image Courtesy: NASA Visible Earth

Severe weather conditions
Heavy rains flood Novorossiisk region on 8 August 2002

The most recent in a succession of storms to hit central and eastern Europe swirls over the Black Sea. Serious flooding is occurring in parts of Romania and the Czech Republic.

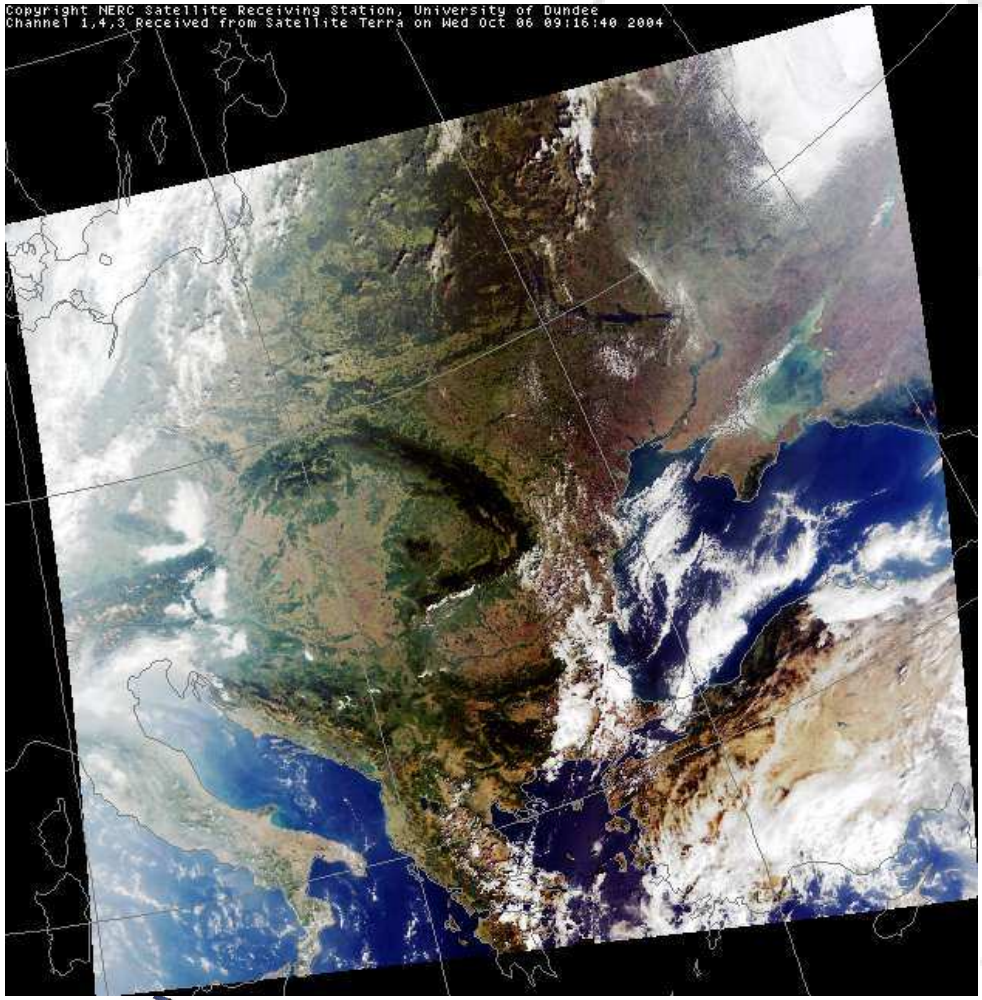
CREDIT: NOAA



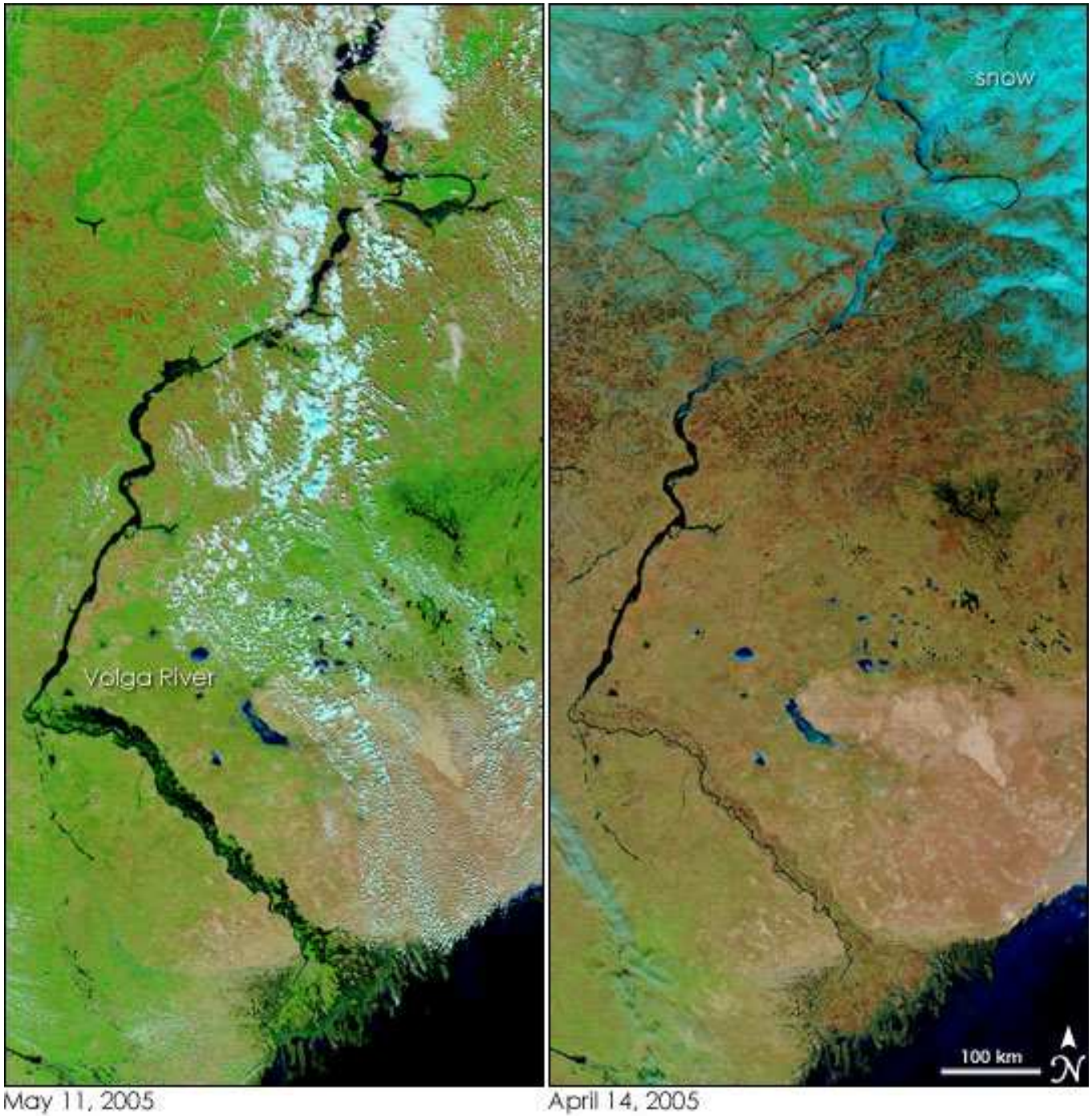


SATELLITE MONITORING OF THE CASPIAN AND BLACK SEAS

Severe weather conditions
Heavy rains flood Istanbul on 7 October 2004



17 August 2004
25 July 2002
3 December 2001



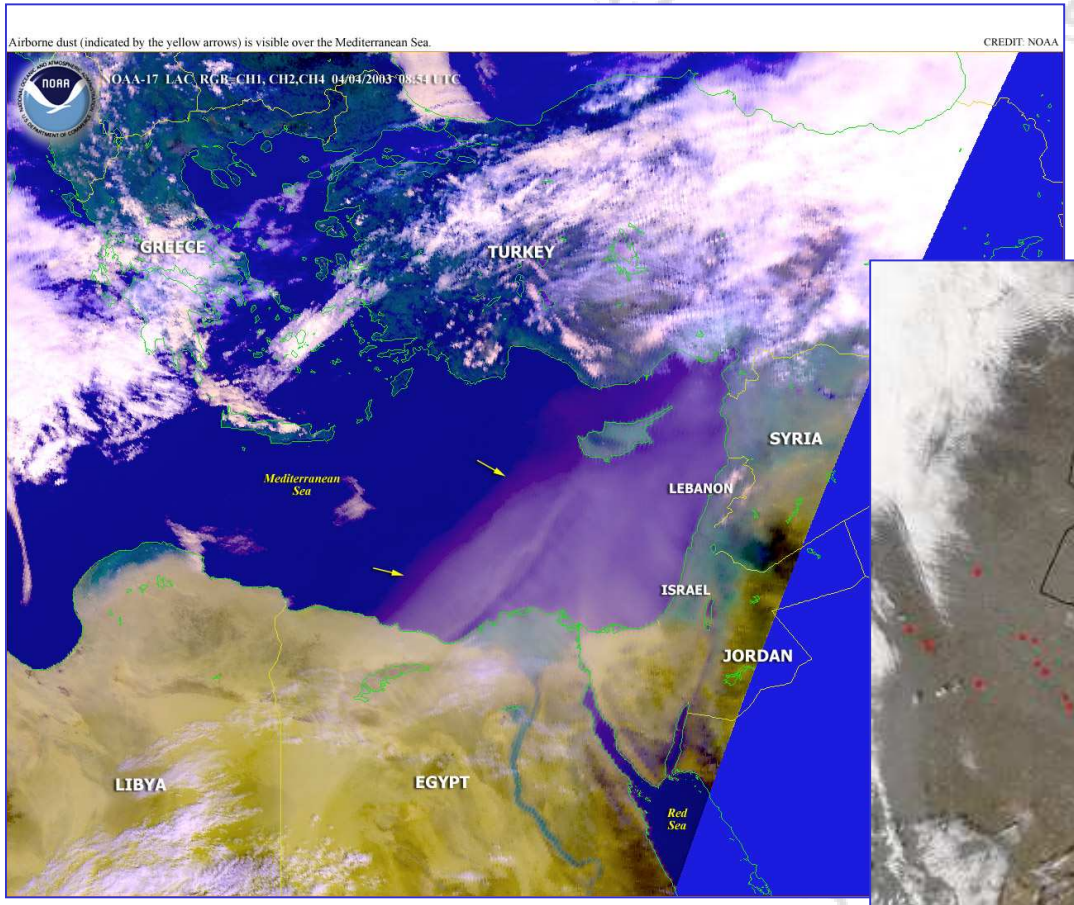
Затопление территорий в результате паводка в низовьях Волги 11 мая 2005 г. (а), которое произошло в результате таяния снегов (голубой цвет на правом кадре) выше по течению реки (б) – 14 апреля 2005 г. (MODIS-Terra, разрешение 250 м).

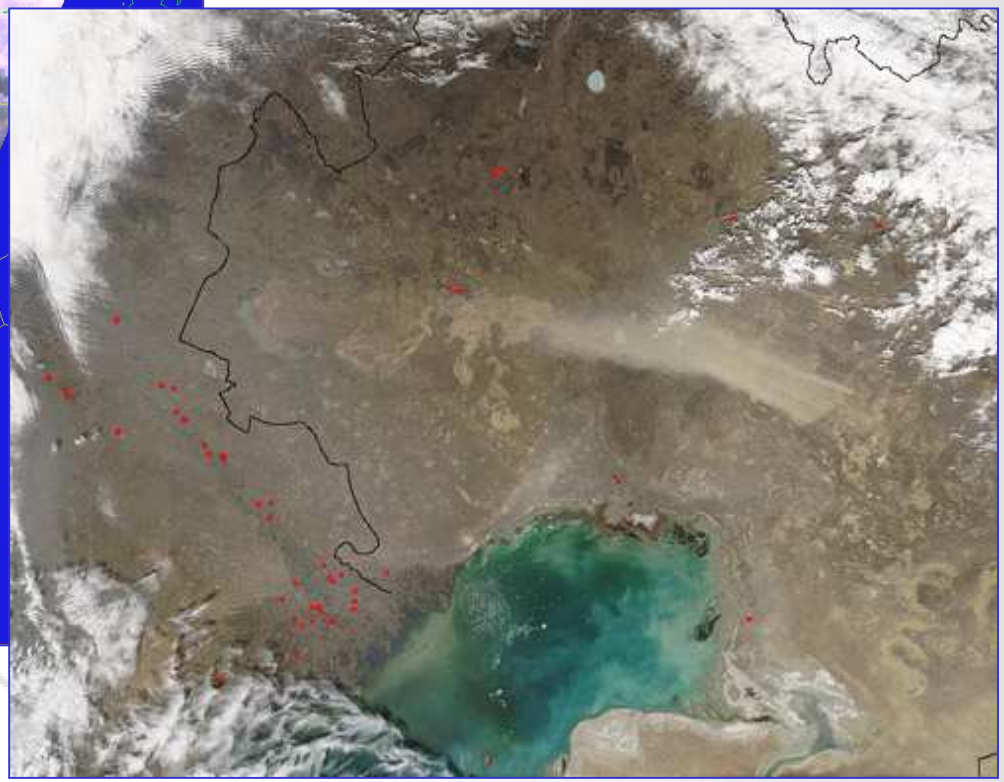
Severe weather conditions
Snow in Turkey and Kazakhstan

Image Courtesy: NASA Visible Earth

Image Courtesy: NASA Visible Earth

Severe weather conditions
Dust storms in Turkey and Kazakhstan





4 April 2003, NOAA

Image Courtesy: NASA Visible Earth