Satellite monitoring of sea surface state of Russia’s coastal zone of the Black and Azov Seas

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Satellite monitoring of Russian Seas

In Russia, no satellite monitoring of seas is conducted on a regular basis.

In 2005-2006, Lukoil Russian oil company ordered a monitoring of the region of its platform in the Baltic Sea. Space Radar Laboratory (Space Research Institute) was responsible for SAR data interpretation.

The only long-term quasi operational monitoring of a coastal zone is conducted in the Russian sectors of the Black and Azov Seas:

- since 2003, in April-October, under the contract of the Russian Hydrometeorological Center

- SAR data analysis: Space Radar Laboratory (Space Research Institute)
Main goals of monitoring

• operational mapping of water state and pollution (anthropogenic and biogenic)
• analysis of meteorological condition and its impact on weathering, drift and spread of pollutants
• understanding local circulation patterns and their impact on weathering, drift and spread of pollutants
• deducing typical local pollution evolution modes
Sensors used for operational monitoring of the environment

- Synthesized aperture radars Envisat ASAR, ERS-2 SAR, RADARSAT, resolution 12.5 - 75 m;
- IR radiometers NOAA AVHRR, spectral bands 10.3 - 11.3 µm, resolution 1 km;
- Imaging spectroradiometers Terra/Aqua MODIS; spectral bands: 0.622-0.672 µm, 0.546-0.556 µm and 0.438-0.448 µm; resolution 250 m
- Microwave scatterometer QuikSCAT
- ERS-2, JASON altimeters
The overall scheme of complex use of satellite data in the monitoring
Pollution of the Azov-Black Sea basin

- high level of pollution
- slow water exchange with the ocean
- in the Black Sea, vertical water exchange between the layers is very weak, especially in summer
- the Azov Sea is a vastly shallow-water sea
The main sources of pollution

• river outflows into the sea;
• damages of underwater sewage outlets;
• failures of oil terminal installations;
• wastewaters from human settlements and industrial plants;
• pollution from ships, both due to failures and illegal discharges;
• certainly, oil pollution as a result of tanker catastrophes
The Russian coast of the Black Sea stretches for about 350 km. There are 45 rivers flowing into the sea. Coastal outflows are composed mainly of industrial and household wastewaters from tourist facilities, ground rainwash and accidental runoffs from industrial plants situated near the river. The greatest river pollution is observed during spring floods and after heavy rain showers.

a) ASAR Envisat image of the northeastern part of the Black Sea acquired 11.07.2006, 19:19 UTC (1 marks areas of river outflows)
b) Map of water state and circulation superimposed on Aqua MODIS image obtained several hours before (river outflows are marked by light green color)
River outflows into the Black Sea (2)

LISS IRS

MSU METEOR-3M

Black Sea

Poti

22.09.2003

14.08.2003
Damages of underwater sewage outlets

**Wastewaters flowing near Ghelendjik Bay. Envisat ASAR, 09.09.05. Yellow oval shows the location of wastewaters coming up to the surface.**

**Optical image from a helicopter acquired several hours later. White band is the trace of propagating pollutants.**
Water pollution in the ports

Oil pollution in the port of Novorossiisk. Envisat ASAR, 07.08.04

Oil pollution in a helicopter optical image acquired several hours before.
Illegal discharges of wastewaters from ships

- SAR data are best suited for these purposes.

- All Envisat ASAR images, both Narrow and Wide Swaths, were ordered under ESA projects.

- Among Narrow Swath products, alternating polarization is preferred.

- Since no financing was allocated for NRT data, first the data in the EOliosa system were analyzed; estimates further adjusted when full resolution data arrived.

- Wide Swath SAR data are the most adequate for the purposes of detecting oil pollution. They almost completely cover the Russian sectors of the Azov and Black Seas, and have lower speckle noise.
Illegal discharge of wastewaters from ships (2)

Envisat ASAR image, 17.04.07
A large patch of 0.3 sq. km in size is located 2 km off the largest child resort of Anapa. The two bright white points are ships, the lower one is suspected to be responsible for the spilling.
Illegal discharge of wastewaters from ships (3)

ASAR Envisat image obtained 19.09.2006 at 19:19 GMT.
Area of the detected oil slicks (km²): 1 – 9.2; 2 – 1.6; 3 – 1.2; 4 – 0.5; 5 – 3.5
Illegal discharge of wastewaters from ships

Envisat ASAR image, 19.09.06
19:19 UTC. Length of the spill is 50 km, area 9.2 km²

Envisat ASAR image, 17.04.2006
07:32 UTC. Length of the spill chain is 31 km, area 2.5 km²
Ship detecting using alternating polarization images

Envisat ASAR. Swath IS1. 13.08.2007

VV – polarization
indistinct or no ship manifestations

VH – polarization
all atmospheric processes are masked, only ships are revealed
Wastewater discharge manifestations photographed from a helicopter

Optical imaging from helicopter coinciding with ASAR data provides a solid evidence of ship discharges, that could not be confused with ship wake manifestations
One of the main problems of oil monitoring of the sea in Russia – inadequate penalty practice for pollution of the sea.

There still exists no working legal mechanism admitting satellite data as an evidence of spillages from particular ships.

It is of interest to know how such system works in other countries.
Study of coastal circulation and its impact on the evolution and drift of pollutants

TERRA/AQUA MODIS

- biogenic slicks
- upwelling flows
- phytoplankton accumulation
- hypothetical route of the Rim Current
- alongshore current
- near-shore anti-cyclonic eddies
- cyclonic eddies
- near-shore turbid waters
- supposed outflows of turbid waters from the near-shore zone
- Strong persistent southern winds
- Stable Rim Current passing close to the coast
- Pollutants accumulate near the coast and are transported along it

- Subsiding wind or a change in its direction
- Unstable Rim Current passing far from the coast
- The Rim current may split into several branches, meander; anticyclonic eddies are very probable to occur near the coast
- The distribution of pollutants is irregular. Partly, they are transported across the Rim Current via its interaction with the eddies, partly, they accumulate inside the eddies

- Long-term calm
- Weak Rim Current and the absence of the near-shore branch of the Current
- Large near-shore anticyclonic eddies develop and interrupt the alongshore transport of pollutants
- Small cyclonic eddies occur and contribute to the cleaning of coastal waters
Catastrophe in the Kerch Strait  11.11.2007

Tanker Volgoneft-139 broke down into two parts

Before the catastrophe, strong south-western winds had persisted in the region for a long time. As a consequence, wind fetch grew from usual 5-10 km to 50-100 km, which caused a very strong surge. On November 11, wind speed reached 35 m/s, wave height - over 6 m.
Numerous oil patches are detected near Tuzla and Chushka Spits. Pollutants propagate into the Tamansky Bay.
Envisat ASAR image, 20.11.07
Strong wind signatures and no traces of pollution

Aqua MODIS image, 19.11.07
Pollution near Chushka Spit and in the Tamansky Bay
Envisat ASAR image, 23.11.07
No traces of pollution

Aqua MODIS image, 23.11.07
Less pollution near Chushka Spit and in the Tamansky Bay
Forecasts hold that pollutants will come to the surface again and again because the Strait is very shallow and the sunk oil can be easily perturbed.
Conclusions

• Multisensor complex monitoring conducted in the Russian sectors of the Black and Azov Seas makes it possible not only to reliably detect sea surface pollution but also to obtain information on the state of the surface.

• There is an urgent need in Russia to develop an efficient penalty mechanism against illegal oil spilling and wastewater discharges, that would admit satellite SAR data as an evidence.

• For the first time Russia faced a serious tanker catastrophe. It turned out that at the governmental level, there is no agreement with ESA on emergency SAR imaging of regions of catastrophe and immediate supply of the data to experts.

• How similar problems are solved in other countries?
THANK YOU!