Subchapter 6.4. Satellite monitoring of the oil spill in the Kerch Strait

Lavrova O., Bocharova T., Mityagina M.

6.4.1. Satellite monitoring of the oil spill in November 2007

Due to a complicated meteorological situation, helicopter survey of oil pollution and heavy fuel oil patch mapping became possible on November 14 only, i. e., three days after the catastrophe (Fashchuk D. Yu., 2009, Ivanov A. *et al.,* 2008a). As well, satellite visual imaging was not informative enough due to heavy cloudiness.

Since the synthetic aperture radar (SAR) on board of the *Almaz-1* satellite completed its work in 1992, no Russian radars have been in operation on board of the earth-orbiting satellites. At present, the most accessible and purposeful data are provided by the Envisat and ERS-2 European satellites. These data have spatial resolution most adequate for the purposes of environmental monitoring of the sea surface, i. e., 25×25m for the scene size of 100×100 km, and 150×150 m for the scene size of 400×400 km. SAR is able to work at two polarizations and their combinations, i. e., VV, HH, VH, HV. The sea surface oil pollution is best detected through using the VV polarization data (Brekke C., Solberg A. H. S., 2005). SAR data from the Canadian Radarsat-1/2 satellites are commercial and nearly inaccessible because of the high cost.

For technical reasons, the SAR ad-hoc emergency imaging of the Kerch catastrophe site was not conducted. The earliest SAR images publicly available were the Radarsat-1 data dated November 15 (15:34 UTC) and 16 (03:45 UTC) obtained and processed by the Scanex R&D Center (Ivanov A. and Zatyagalova V., 2008 a, b, c). A few minutes after the second image taking (Nov.16, 03:52 UTC), data from the frontline SAR on board of the TerraSAR-X satellite belonging to the German Space Agency (DLR) were received at vertical and horizontal polarizations with 3 m resolution. The TerraSAR-X images were obtained in the framework of the MOPED international project (Bocharova T. *et al.*, 2008). The data were of great importance due to their higher resolution in comparison to the Radarsat data posted on internet, thus enabling an accurate geo-referencing. Another SAR image of the catastrophe site was obtained from Envisat on November 16 at 19:39 UTC at vertical polarization of 12ю5 m pixel. Analysis of the above mentioned data combined with a helicopter survey data enabled assessment of pollution and its development. Fig. 4 presents the Radasat-1 fragments (Fig. 6.4.1a), and the TerraSAR-X (Fig. 6.4.1b) and Envisat ASAR (Fig. 6.4.1c) im-

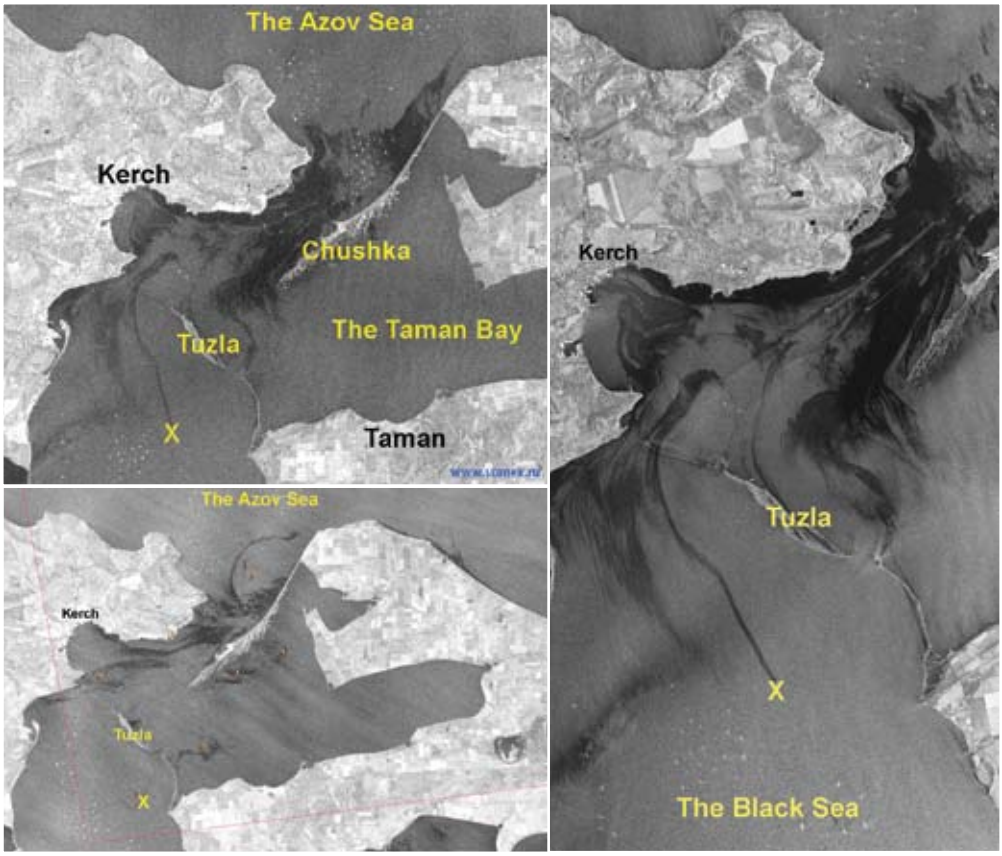

Fig. 6.4.1. Satellite SAR imaging of the Kerch Strait on 16.11.2007, i. e., five days after the catastrophe. Location of the *Volgoneft-139* tanker bow part is marked with a cross.

a) Fragment of the Radarsat-1 image acquired at 03:45 UTC (© CSA, R&DC «ScanEx», 2007); (top)
b) Fragment of the TerraSAR-X image acquired at 03:52 UTC, resolution 3 m (© InfoTerra 2007); (right)
c) Fragment of the Envisat ASAR image acquired at 19:39 UTC, resolution 12,5 m (© ESA 2007) (bottom)

ages. In all the images, a nearly single-point pollution source was clearly detected: It was the *Volgoneft-139* tanker bow part. No traces of pollution propagating from the tanker stern aground were seen anymore. Oil pollution stemming from the location of the tanker's stern part was observed during the November 14 helicopter survey. On November 15, the tanker stern was tugged to the port of Caucasus and it stopped being a source of pollution, being well surrounded by booms.

Also, all the three SAR images showed the second nearly single-point pollution source being the Western tip of the Tuzla dam. Evidently, during the previous days storm a large amount of heavy fuel oil got washed ashore by a strong northward current from the Black Sea. After that, heavy fuel oil kept being washed further away to the North in the direction of the Chushka Spit and into the Taman Bay (Lavrova O. *et al.*, 2008 a, b).

Particularly interesting were the low SAR signal dark regions occupying almost the whole Northern part of the Kerch Strait. They looked most impressive in the morning images (Fig. 6.4.1a, b). Although modeling performed by the experts of the State Oceanographic Institute (Ovsienko S. *et al.,* 2008) evidenced that pollution was expected to propagate all along the Chushka Spit, it did not seem probable that the whole low SAR signal dark region was an exclusive result of the oil spill accident of the *Volgoneft-139* tanker. A more reasonable assumption was that the huge slick area had been formed by a light oil film pollution emerging from other boats caught by the storm at the Azov side of the Kerch Strait. A large number of boats were easily visible at all three SAR images (bright specks).

In evidence of the fact that along with the heavy fuel oil from the *Volgoneft-139* tanker, a large amount of oil was spilled into the Northern part of the Kerch Strait by other vessels, a document entitled a «Note-Report Of the Situation at 18:00 in the Kerch Strait, Near the Port of Caucasus And the Novorossiysk Port In the Result Of a Strong Wind Under Unfavorable Weather Conditions Prevailing Over the Krasnodar Region Territory» was forwarded to the regional division of the Russian EMERCOM on November 11, 2007, i. e., 12 hours after the tanker catastrophe. In particular, the document said: «In the vicinity of the Ilyich settlement, a heavy fuel oil patch of 800 m long and 10 m wide was detected at the shore». Meanwhile, modeled estimations were predicting the tanker's heavy fuel oil propagation to the area not earlier than in 48 hours the earliest.

Estimations of the sea surface pollution area obtained during the aerial and satellite visual observations mentioned above did not confirm the assumption that oil was spilled as a result of the *Volgoneft-139* tanker accident only. According to the aerial data, the heavy fuel oil patches size was reaching 200-400 m^2 and the light oil films occupied a somewhat larger area. On the contrary, pollution area detected by the SAR data analyses later was much larger and was covering tens of square kilometers. Presence of such a huge difference could be explained by the following: by the time of the first SAR image taking (16 November), almost all the heavy fuel oil spilled had been washed ashore or had sunk. So, only those oil films remained on the sea surface that were hardly detectable from helicopter under the cloudy weather conditions without sunlight, though clearly visible at the SAR images.

6.4.2. Satellite monitoring of the Kerch Strait in summer 2008

Since many experts anticipated that heavy fuel oil sunk during the catastrophe in the Kerch Strait would rise up to the sea surface in the result of the water temperatures going up during a warmer time period, the area monitoring was carried out in spring-sum-

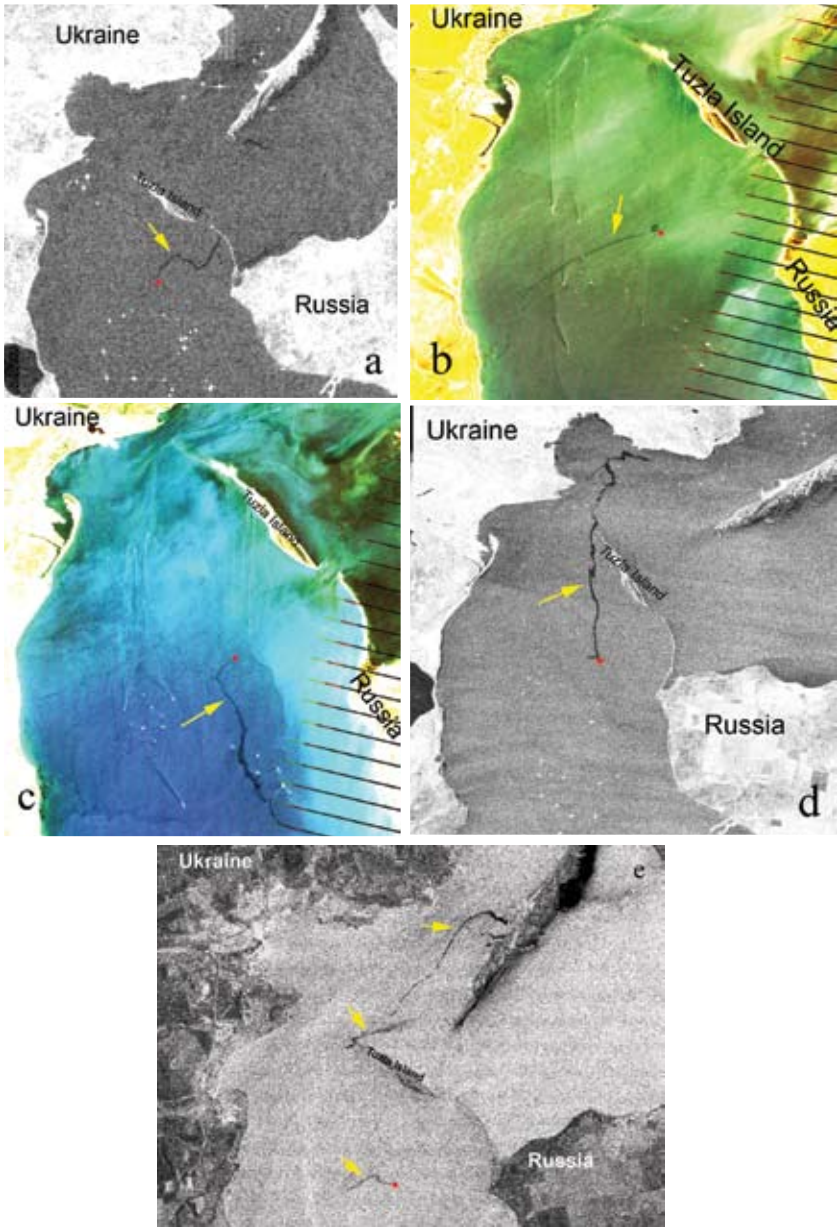

Figure 6.4.2. The Kerch Strait sea surface pollution with oil film in summer 2008.

The satellite data obtained in June-August 2008 showing evidences of petroleum products resurfacing in the Kerch Strait. Oil products emerging on the surface of the ship sinking area (marked by asterisk) and spread by the wind and current to form thin threadlike oil slicks of 5-20 km long.

a) Envisat ASAR (30×30 km), 17.06.08, 07:40 UTC (©ESA 2008), total slick length was 9 km.
b) Landsat ETM+ image (20×20 km), 26.06.2008, 08:09 UTC, total slick length was 8 km.
c) Landsat ETM+ image (20×20 km), 12.07.2008, 08:09 UTC, total slick length was 8 km.
d) Envisat ASAR (30×30 km), 18.07.08, 19:25 UTC (©ESA 2008), total slick length was 20km.
e) Envisat ASAR image (30×20 km), 16.08.08, 07:54 UTC (©ESA 2008), showing oil slicks along the route of transportation of the wrecked oil tanker bow part. Oil slick was stretching from the Tuzla Island to the port of Caucasus. Some residual oil films were detected at the accident site.

mer 2008. No broad-scale pollution of the area to indicate any significant heavy fuel oil rise to the sea surface was detected during the satellite observations over the period. However, beginning from the second decade of June 2008, all the SAR images revealed the slicks typical of oil films. i. e., narrow dark bands having the same source location and stretching for several kilometers along the wind and current predominated at the time of imaging. The source of the slicks directly coincided with the location of the *Volgoneft-139* tanker bow part (Fig. 6.4.2a). Those slicks were clearly seen as well on the visual images obtained in the cloudless conditions by Landsat ETM+ (Fig. 6.4.2b, c). That pollution remained intense till 16 August 2008 when pumping of heavy fuel oil left in the tanker's bow was completed and the vessel was lifted and tugged to the port of Caucasus (Fig. 6.4.2d). The most interesting SAR images and analysis results were presented at http://www.iki.rssi.ru/asp/dep_moni. htm. The synopsis map of the Kerch Strait pollution in June-August 2008 shows the arrows indicating the wind speed and direction at the time of SAR imaging. Obviously, forced by the wind and current, film slicks drifted for distances of up to several kilometers playing, in a way, a role of tracer usable for a study of circulation processes in the Kerch Strait (Lavrova O. *et al.*, 2009).

6.4.3. Satellite monitoring of oil pollution in the Kerch Strait region in 2009

Throughout the whole year 2009, monitoring of the Black Sea basin was conducted based on the synthetic aperture radar (SAR) data received from the European Space Agency rolling archive. The Kerch Strait region was a main point of focus in the course of that work. Although the archive contained the pre-ordered images of the region of interest only (that was not all the possible data received from all the satellites passes), the scope of available data was sufficient enough to draw certain conclusions.

During the year 2009, 107 SAR images (comprising 1-3 scenes each) featuring the Kerch Strait and its environs were analyzed. Out of them, 34 images were obtained

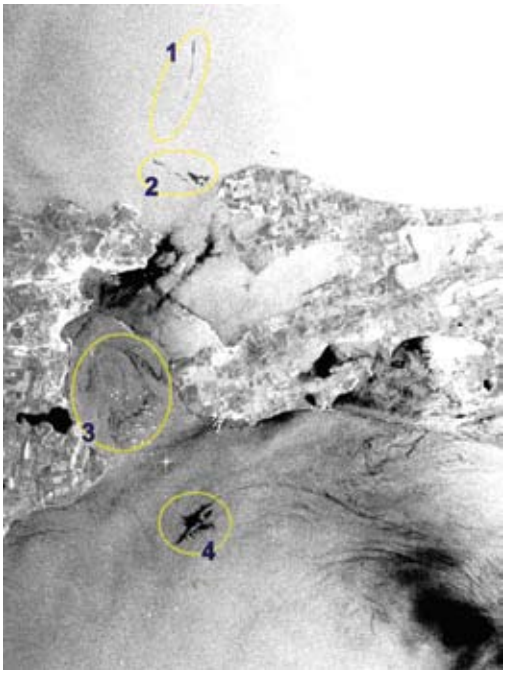

Fig. 6.4.3. Envisat ASAR acquired on 8 June 2009, at 07:50:44:

1 — oil/wastewater spill from a moving ship on ship route to the Kerch Strait;
2, 3 — oil/wastewater spills from ships at anchorage sites;
4 — algae bloom.

by ERS-2 and 73 images — by the Envisat instruments. Most of the images (79) were of narrow 100 km swath, while 28 images had a swath of 400 km. Ground resolution (pixel size) was 75 m. The SAR data was analyzed and interpreted in combination with other available satellite and contact measurement data in order to increase the results reliability.

Environmental situation in the Kerch Strait region has always generated certain concern in terms of contamination. Large ports and oil terminals, intense all-year-round tanker and cargo ship traffic, sea-based cargo re-loading practice were among the main potential negative factors. Oil pollution was constantly detected at the boat anchorage sites in the Northern and Southern sections of the Kerch Strait (Figure 6.4.3, circle 2 and 3), as well as along the ship routes in the Strait (Figure 6.4.3, circle 1). Those were largely deliberate discharges often performed illegally in the result of such routine tanker and ship operations discharges as oily ballast and tank water washing, fuel oil sludge, engine room wastes and foul bilge water. As to the core of the Kerch Strait, i. e., the area between the Tuzla Island and the Northern part of the Chushka Spit, it was often difficult there to differentiate oil from other anthropogenic pollution, and eutrophication (algal blooms) and wind-induced slicks.

6.4.4. Summary: Satellite monitoring on the Kerch Strait

Analysis of the available SAR data coupled with related auxiliary data has revealed that oil pollution in 2009 remained at the levels usual for the Kerch Strait region. There were no indications of either extreme pollution volumes or more intense pollution events having taken place during the year. Therefore, we may conclude, that the 2009 SAR observations brought no evidence of the 2007 severe storm aftereffects and the tanker catastrophe in the Kerch Strait.

Taking into account the complicated ecological situation in the Kerch Strait due to permanent anthropogenic pressure, in particular, extremely intense transportation of crude oil and oil products via the Strait, an urgent need should be mentioned to carry out a regular oil spill monitoring in the area complimented with remote sensing observations.