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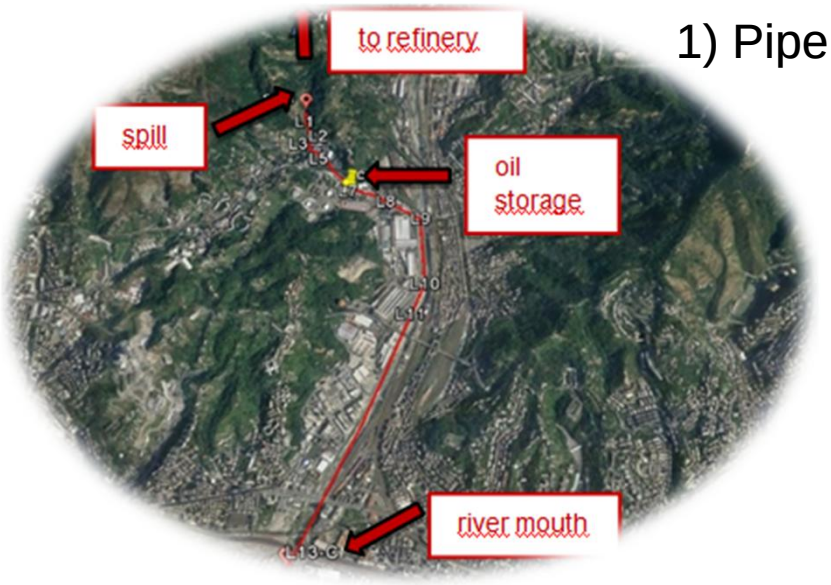
OIL SPILL CASE STUDIES IN THE LIGURIAN SEA

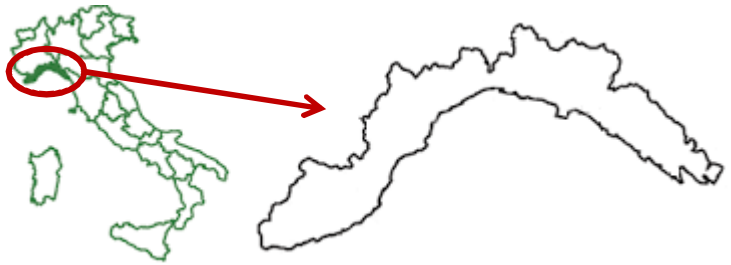
Mauro Quagliati, Stefania Magrì, Patrizia De Gaetano, Rosella Bertolotto

Agenzia Regionale per la Protezione dell'Ambiente Ligure (ARPAL) – UTCR Genova, Italy

Oil Spills in the Ligurian Sea

1) Pipeline failure





2) Waxy material release

3) Ship collision

Papers

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An Oil Pipeline Catastrophic Failure: Accident Scenario Modelling and Emergency Response Development

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Multicomponent Dispersion of Hydrocarbons at Sea: Source Term Evaluation and Hydrodynamic Simulation of the Spill

Tomaso Vairo[a*], Stefania Magrì[a], Patrizia De Gaetano[a], Mauro Quagliati [a], Bruno Fabiano[b]

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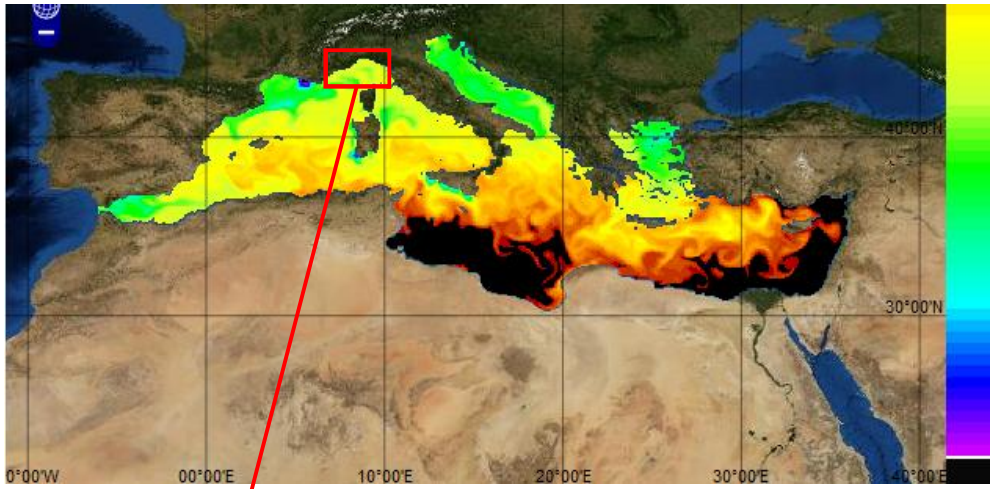
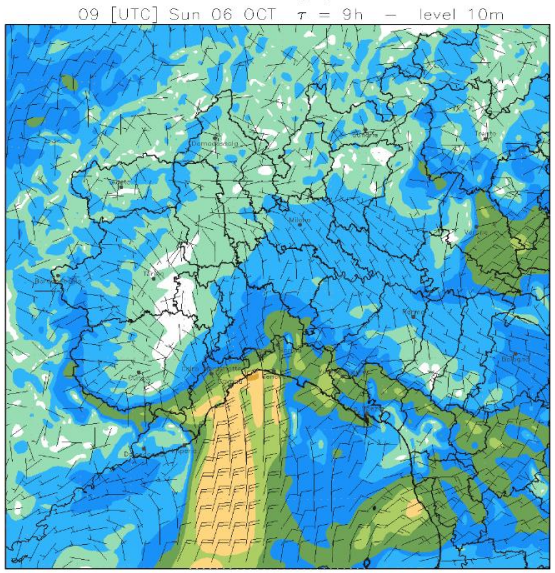
[b]DICCA Civil, Chemical and Environmental Eng. Dept. – University of Genoa, via Opera Pia 15 – 16145 Genoa, Italy

Operational forecast system: 3D hydrodynamic circulation model of the Ligurian Sea

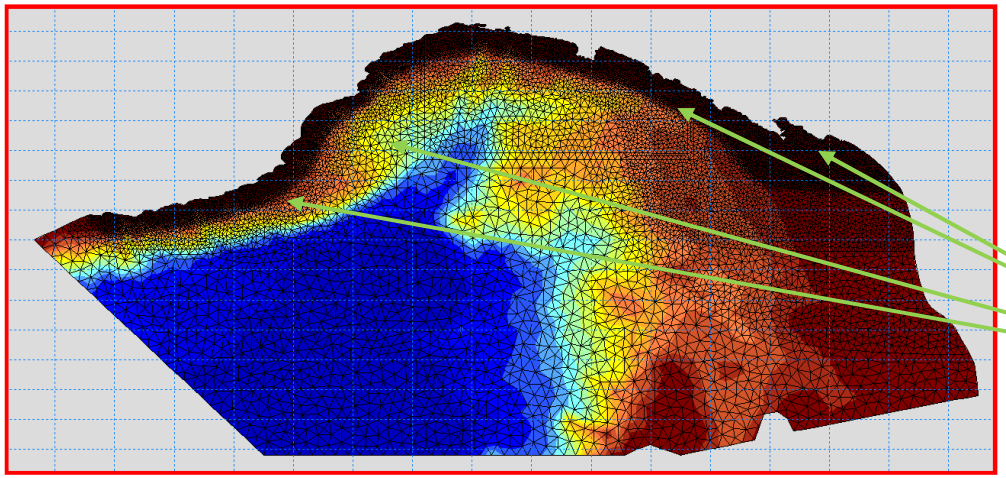
MFS Oceanografic model (6.5 km)



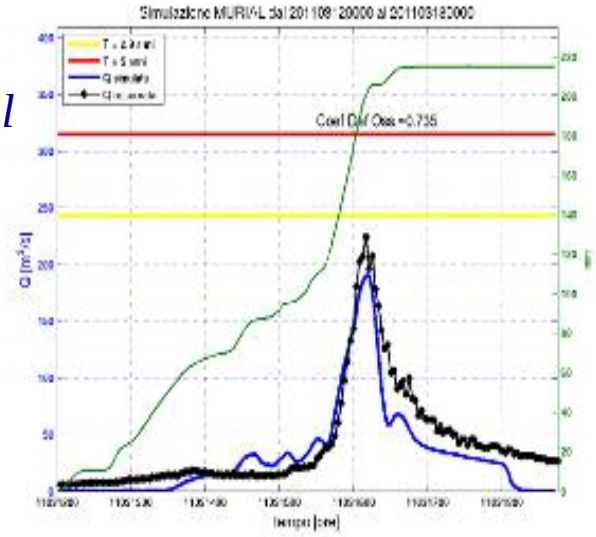
MOLOCH - LAM Atmosferic Model (3 km)



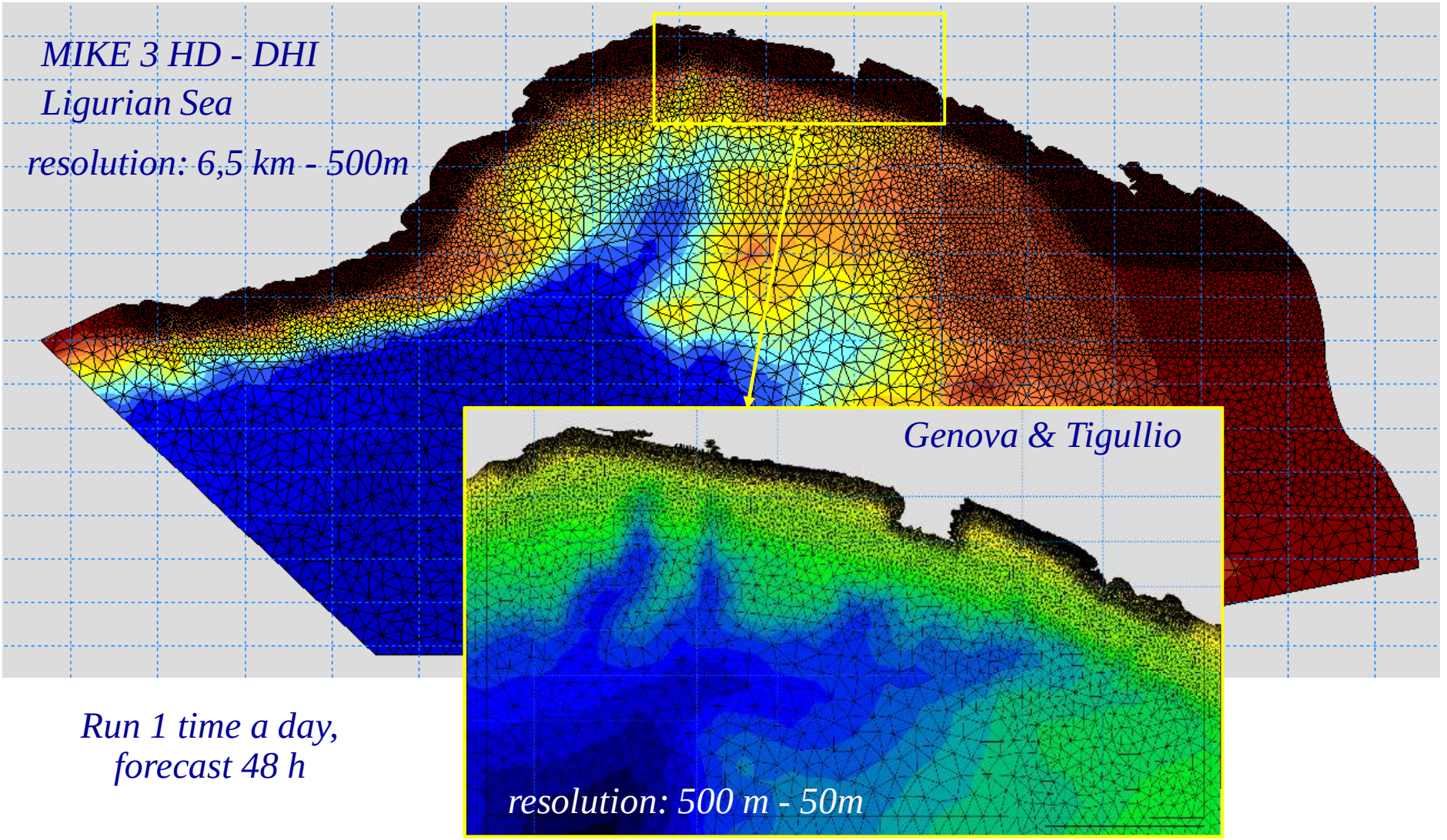
MIKE 3 HD Ligurian Sea (6.5 km -500 m)



DRiFt – hydrological model



Operational forecast system: 3D hydrodynamic circulation model of the Ligurian Sea



Run 1 time a day, forecast 48 h

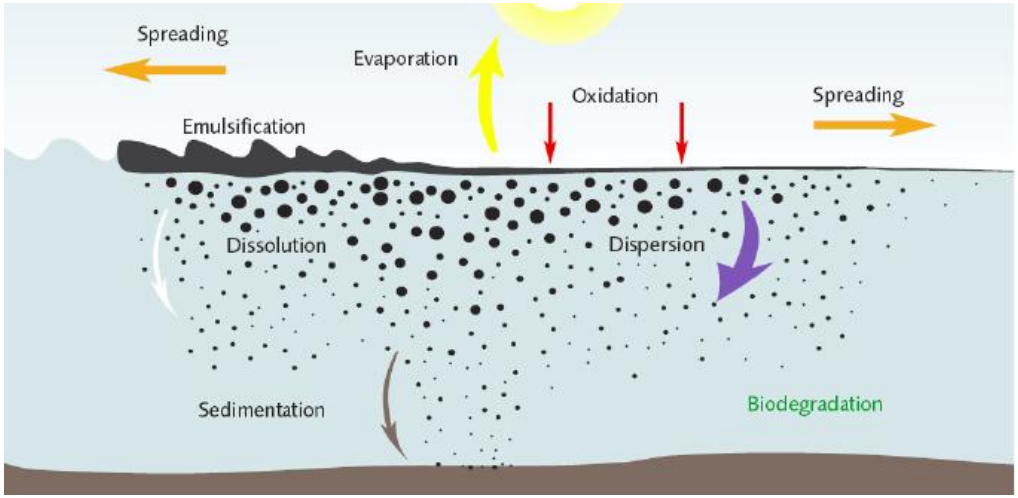
Oil Spill Modelling

A Lagrangian modelling approach (MIKE Oil SPill – DHI) is used both for oil spills and non-reactive floating material, allowing to simulate the trajectories of dragged and dispersed particles under the combined action of current and wind.

The particle tracking approach is to transport particles according to a drift regime and adding dispersion by introducing a “random walk term”

$$dX_t = a(t, X_t)dt + b(t, X_t)\xi_t dt$$

Langevin Equation

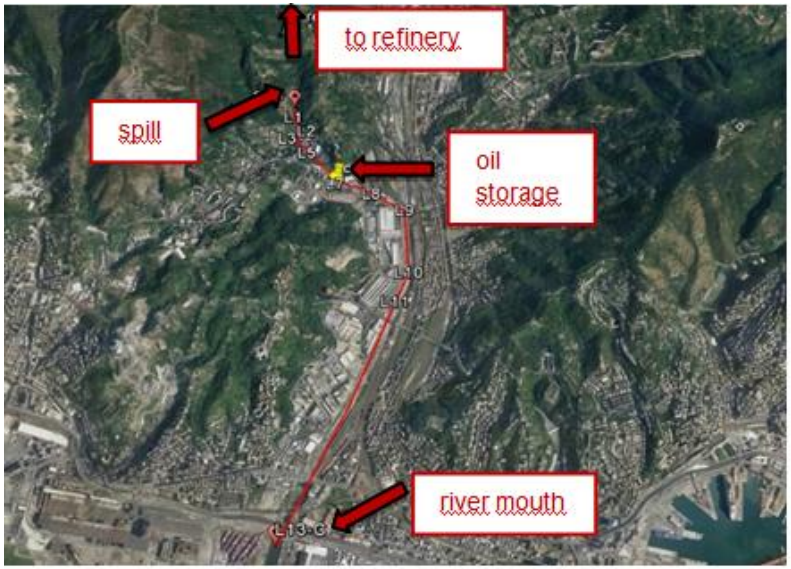


Processes acting on spilled oil (MIKE 2017 Oil Spill ECOlab Template)

An oil pipeline catastrophic failure: accident scenario modelling and emergency response development

On April 17th 2016, a 16” off-ground pipeline, crossing varied rural and urban terrain, ruptured and spilled approximately **600 m^3 of crude oil** firstly into the “Fegino rio” a small tributary river then in “Polcevera river”, for a length of about 4.5 km of waterway.

The pipeline connecting the port oil terminal of Genoa with a downstream oil refinery and an oil storage area, located in the inner part of Liguria, has an overall length of 22 km.



Modelling framework for emergency response

The framework needed for drawing-up contingency plans and laying down operative procedures is developed at two time scales:

- Short-time evolution of the cloud of hydrocarbon vapours, connected to potential toxic effects and flame development;

- Short/medium-time study of the evolution of the drift of oil spills under the influence of wind and tide estimation of the ‘characteristic spreading time.

The framework development was made according to two subsequent steps, based on different “key oil components” source modeling:

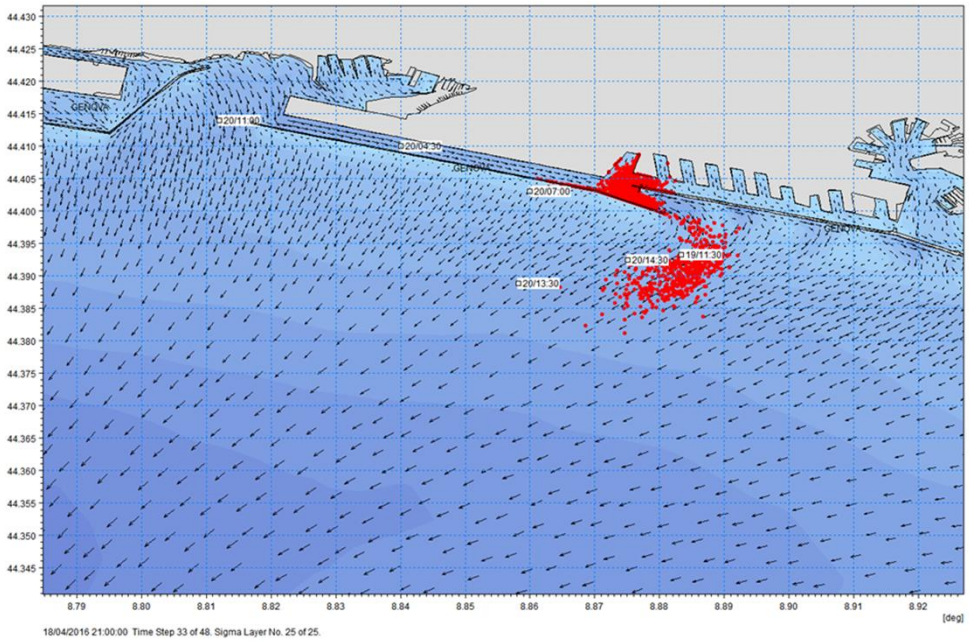
- atmospheric dispersion impact of the light HC fractions;

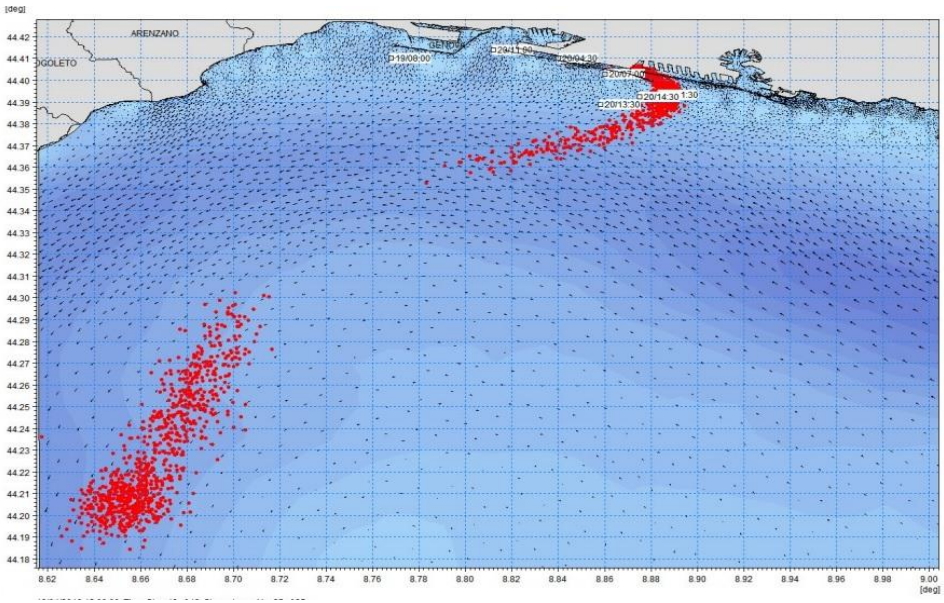
- hydrodynamic dispersion modelling, by a Lagrangian approach, of the of the spill, considering the scenario of downstream flow of the oil slick into the sea, due to emergency containment failure (worst case).

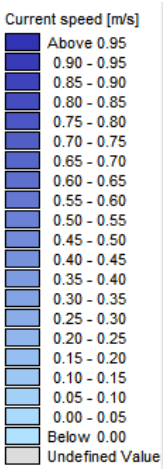
Following the accident, and the spill into the river, **a certain amount of oil reached the mouth of the stream**, creating a buffer zone, curbed by the containment barriers. In order to assess the potential impact of an eventual release into the sea, we performed several simulation runs of the oil spill spreading, according to the modeling framework described in Vairo et al., (2016).

Simulations were performed assuming the **cautious hypothesis of complete and continuous release from the barriers**, while on sea observations demonstrated that only slight occasional slicks occurred.

Results and discussion – Oil Spill





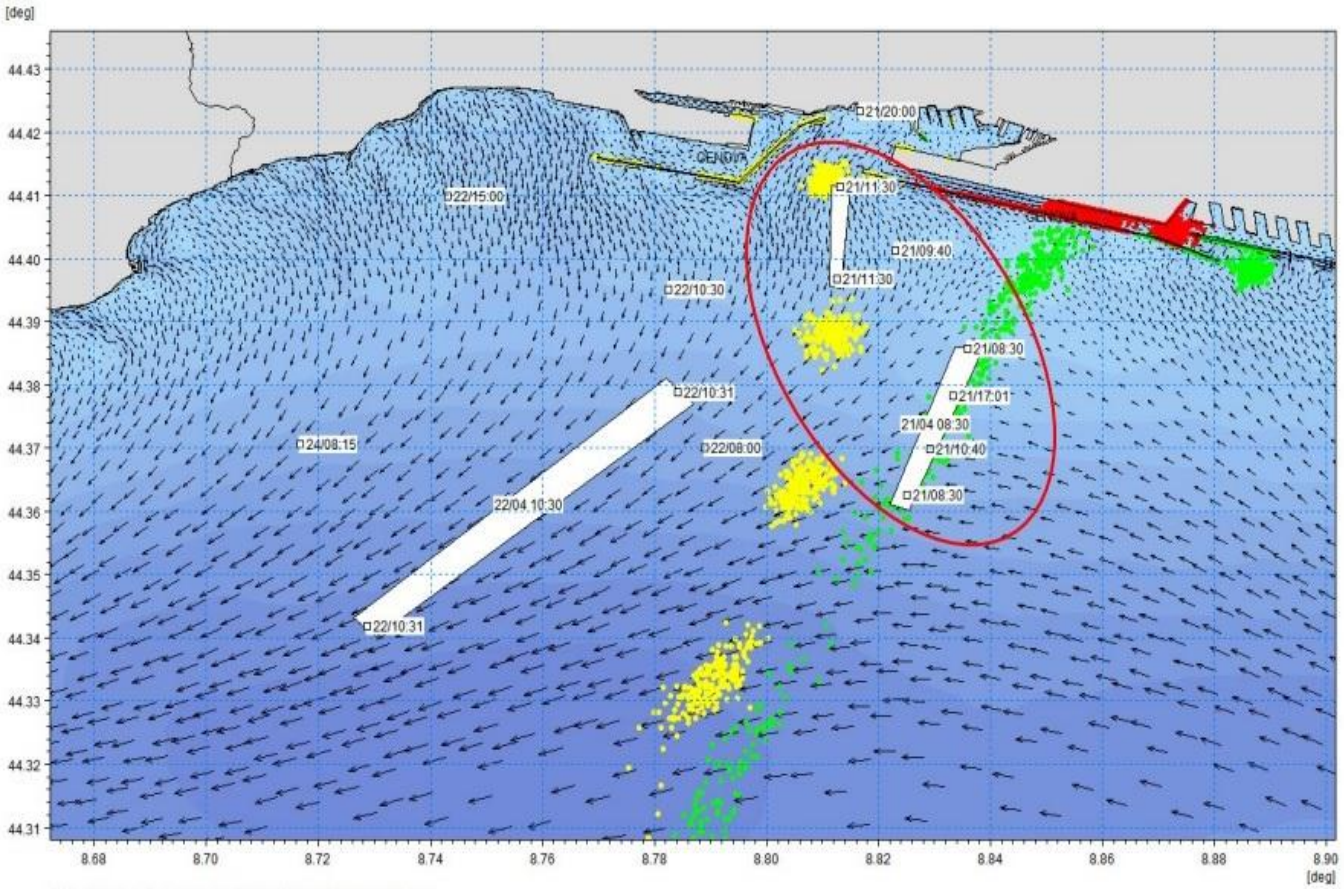


Oil spill trajectory and spreading obtained for the day 18th April 2016 in the worst case

Oil spill trajectory and spreading obtained for the day 19th April 2016 in the worst case

Results and discussion – Oil Spill

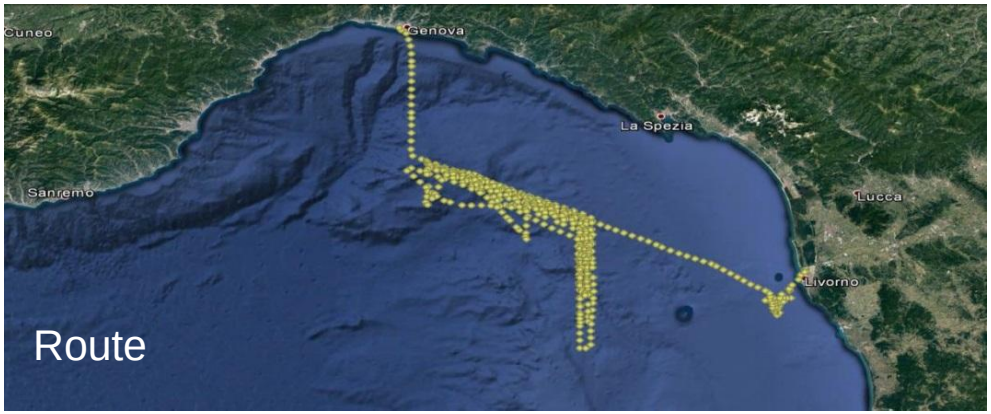
The following figure depicts the slick evolution for the day 21st April 2016 10 a.m. The particles coming from the western entrance (yellow) and that from eastern one (green) are pushed towards open sea and tend to spread out along the direction NE-SW, due to the combined effects of wind and dominant current.



The agreement with observations at sea in the morning of the same day (white areas) is rather remarkable.

Multicomponent dispersion of hydrocarbons at Sea: source term evaluation and hydrodynamic simulation of the spill

In the days from 15.6.2017 to 17.6.2017, solid waxes beached in some areas of Liguria (from west to east) and in Massa Carrara.
The region includes the sensible area represented by Portofino promontory, with 13 km of rough coastline, steep seabed and high indices of biodiversity, both in its terrestrial and marine ecosystems.
The paraffin waxes spillage was hypothesized by the Port Authority as issued by a ship in transit from Genoa to Livorno on the days between 4.6.2017 and 7.6.2017, due to the accordance between the findings along the coast and the material carried by ship and the route travelled. The ship's route, supplied by the Coast Guard, is compatible with the tank washing activities, as evidenced by the come-and-go on the route between Genoa and Livorno

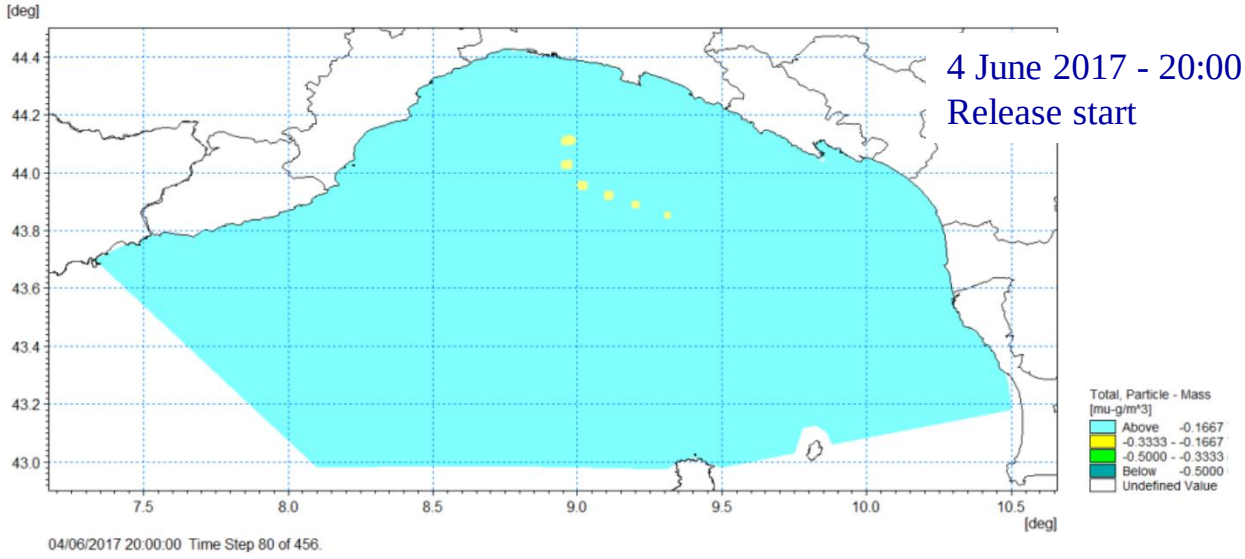


Route

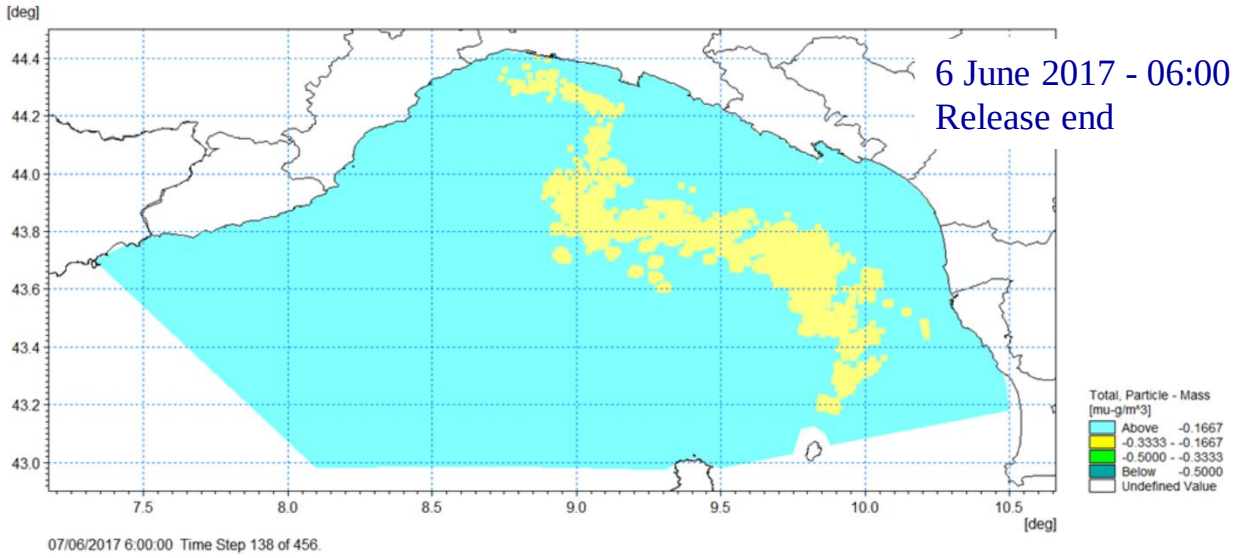
Findings

A Lagrangian modelling approach is used, allowing to simulate the trajectories of dragged and dispersed particles under the combined action of current and wind. The applicative phase includes continuous hydrodynamic simulation runs carried out over the time span from 1.6.2017 to 20.6.2017.

A multi source term simulation, based on the actual ship's route (decoupled from the hydrodynamic simulation) was performed

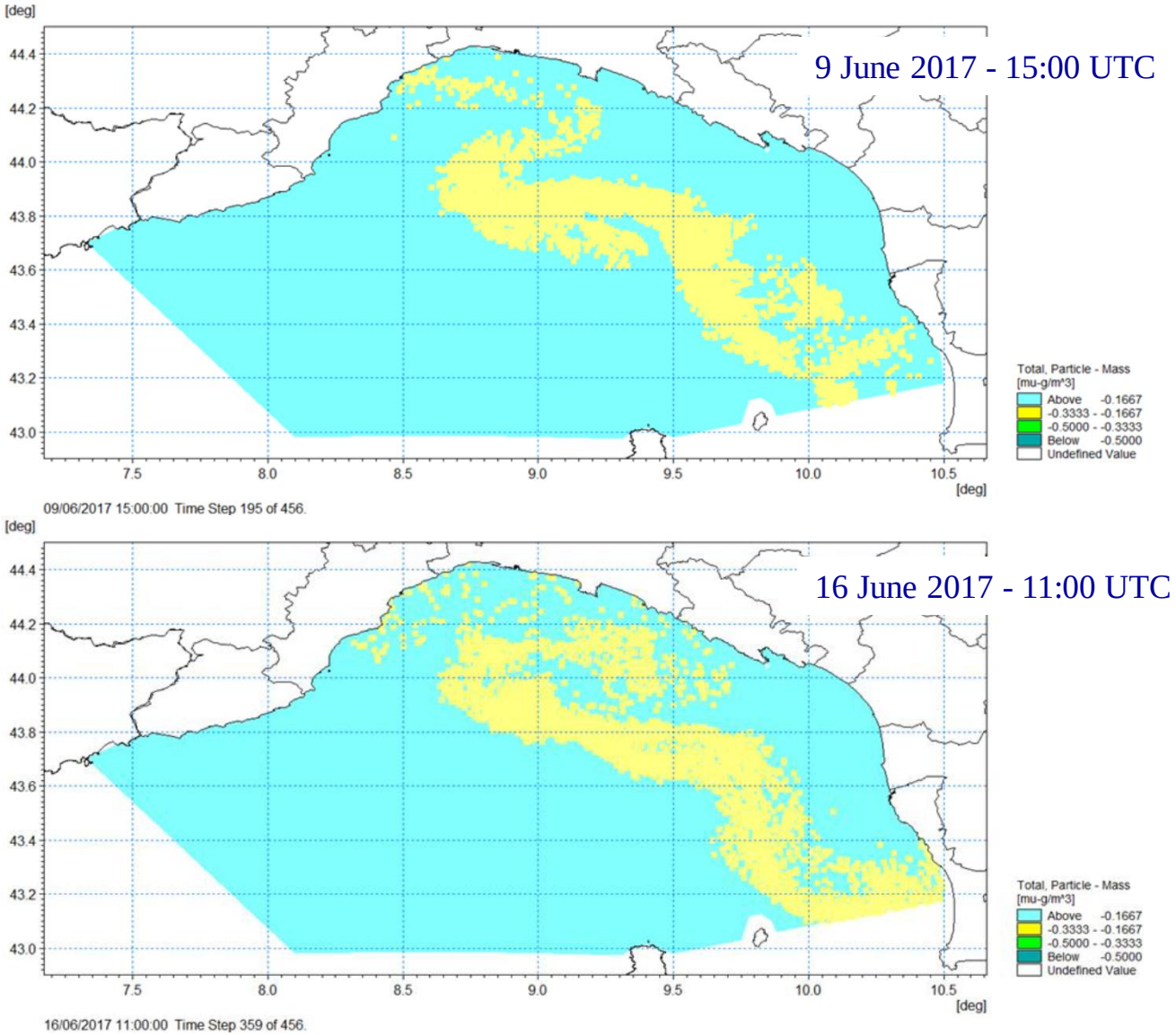


4 June 2017 - 20:00 UTC
Release start



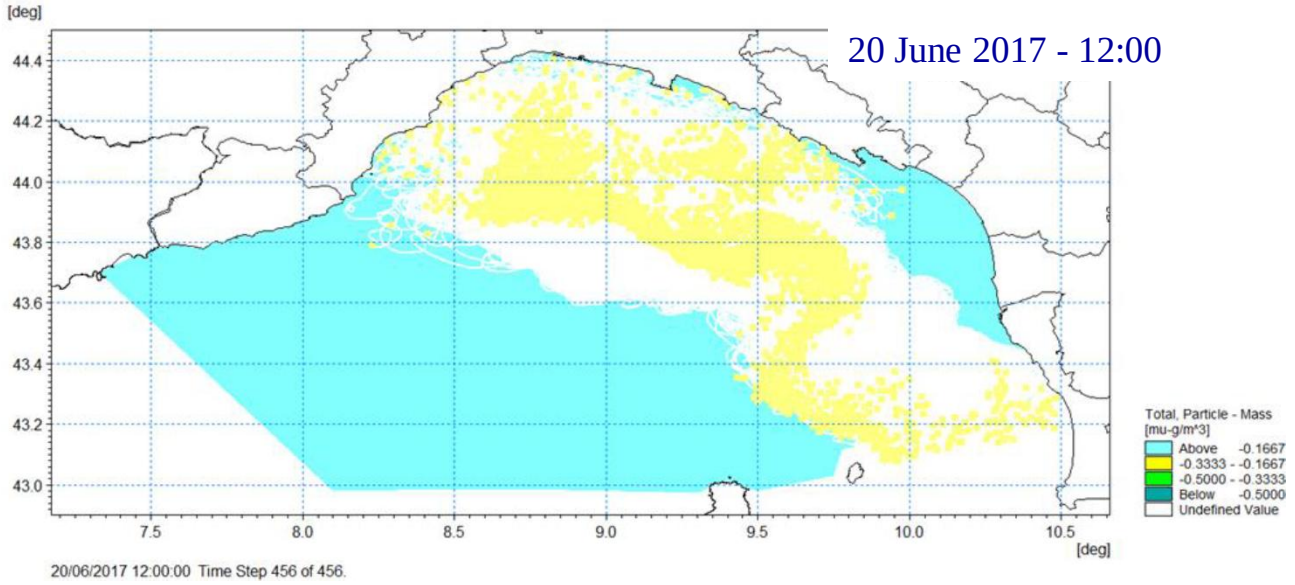
6 June 2017 - 06:00 UTC
Release end

Results and discussion



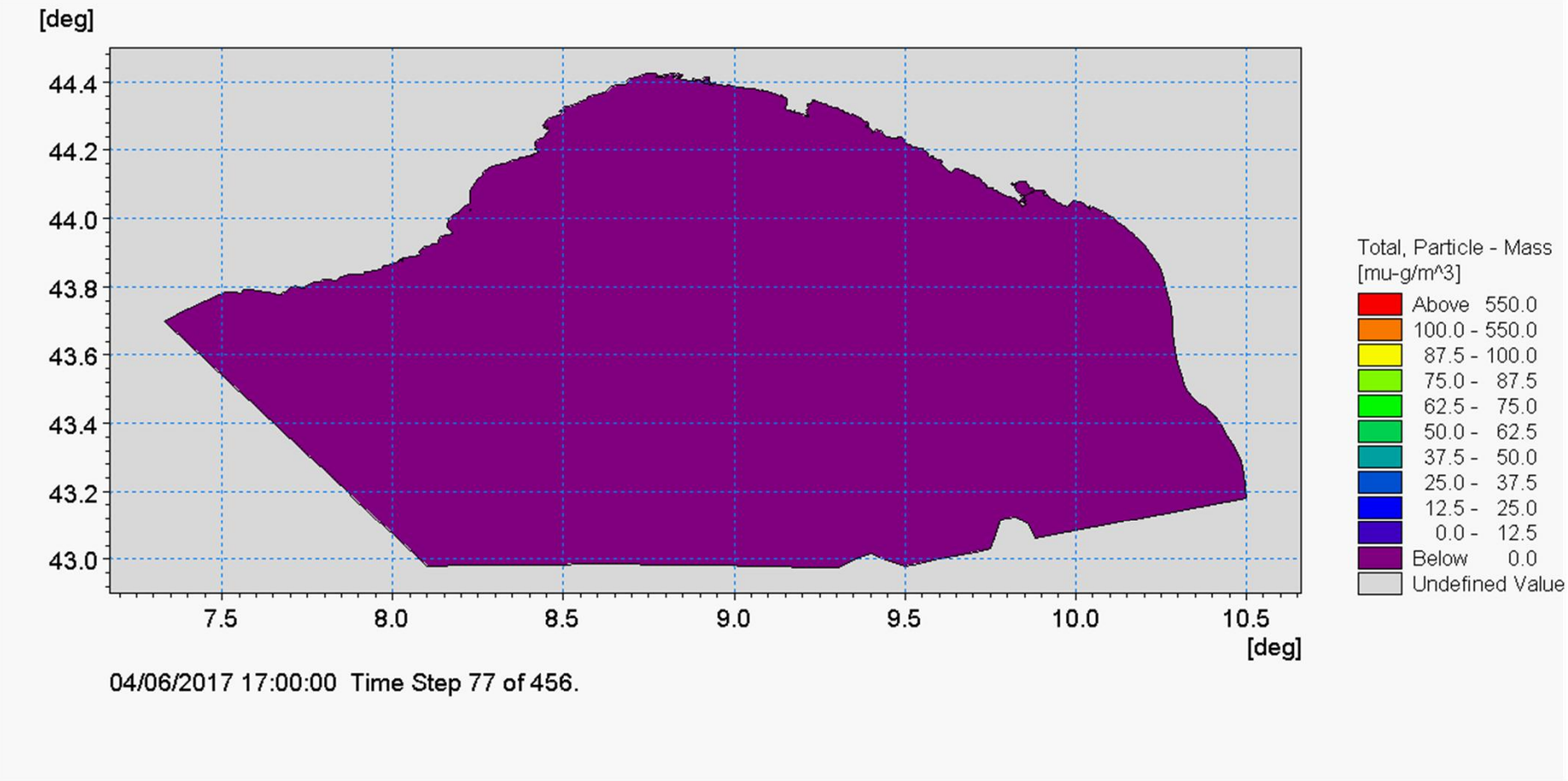
Results and discussion

The first material beachings are observed on the shores of Savona (West) on 9.6.2017 at 15:00, while the particles begin to spread also towards the East Ligurian and Tuscany coasts. As clearly evidenced on 16.6.2017, the material reaches the beaches of Tuscany and East Liguria, on the beaches of Sori, Recco, Chiavari, Moneglia and Marina di Pisa.



The figure depicts the final time of the simulation, with all the trajectories of the released floating particles colored in white, evidencing the overall extent of the coastline affected by the particle beaching.

Results and conclusion



Results and conclusion

Comparing the simulation results with the locations of material along the coast, a remarkable agreement was found, thus providing a validation of the proposed mechanism. It can be concluded that the hypothesis that the beached material comes from tank washing of the ship on the trajectory was found to be convincing.

The use of numerical modelling can provide important information to predict or reconstruct possible accident scenarios either in the operational emergency phase, or in forensic investigation, thus representing an effective tool to support Public Authorities.

The agreement between sightings of material and particle tracking simulation supports the coherence of the pollution hypothesis.
The proposed approach is simple as it considers the transport of passive components, but has the potential to be further developed to include weathering processes and consider the ageing of the particles released, so as to become a robust simulation model for better understanding hydrocarbons fate and its environmental effects.

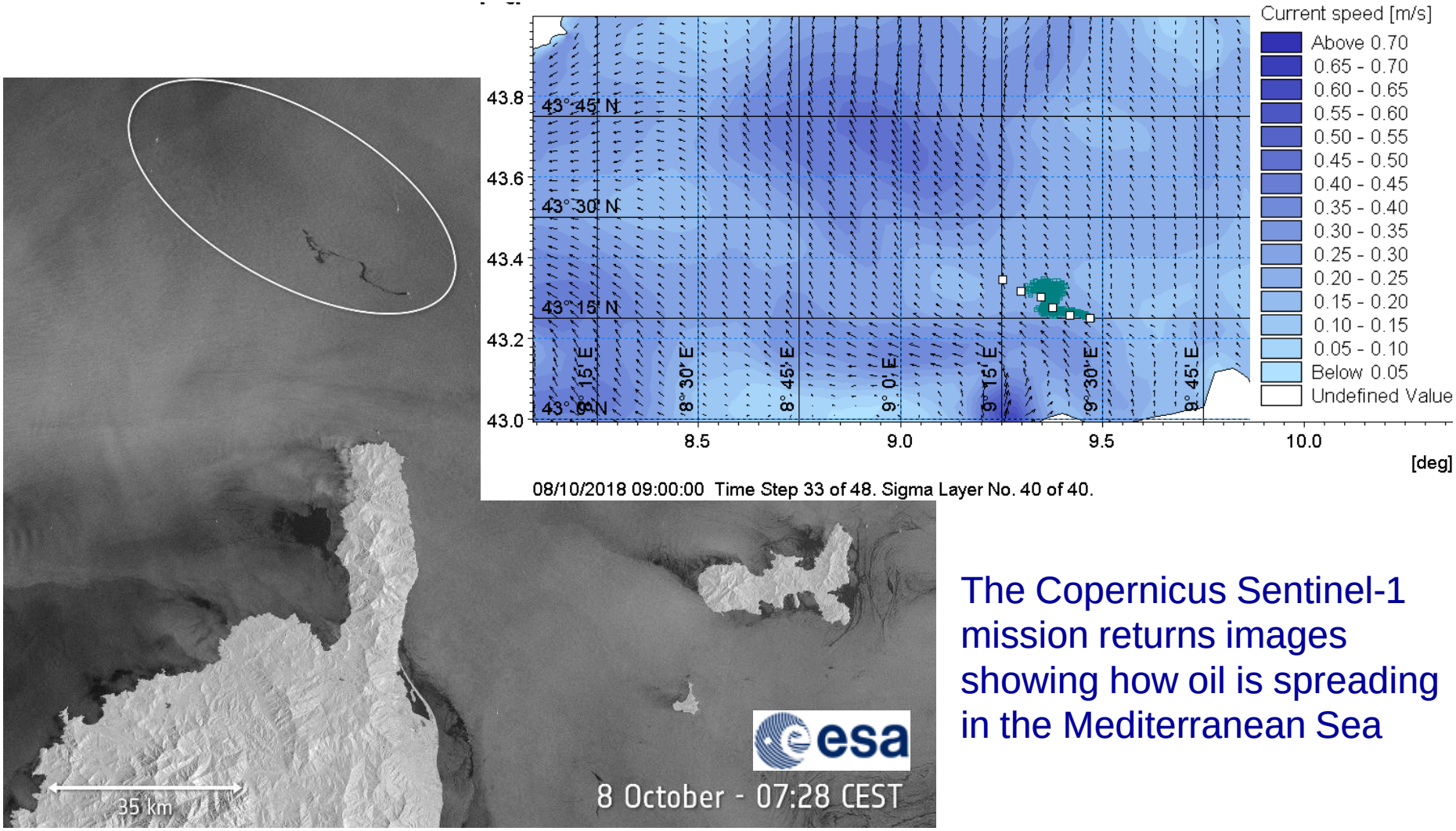
Fuel Spill after ships collide near Corsica

On October 7th 2018 morning, two merchant ships collided north of Corsica causing a **fuel spill** of about **600 m³**.
The collision occurred in French waters, but the emergency operations were conducted as part of a joint pact among France, Italy and Monaco (Ramogepol) to combat pollution accidents in the Mediterranean.

ARPAL supported Public Authorities with indications on the most likely trajectory of the spillage of fuel at sea.

Results and discussion – Oil Spill

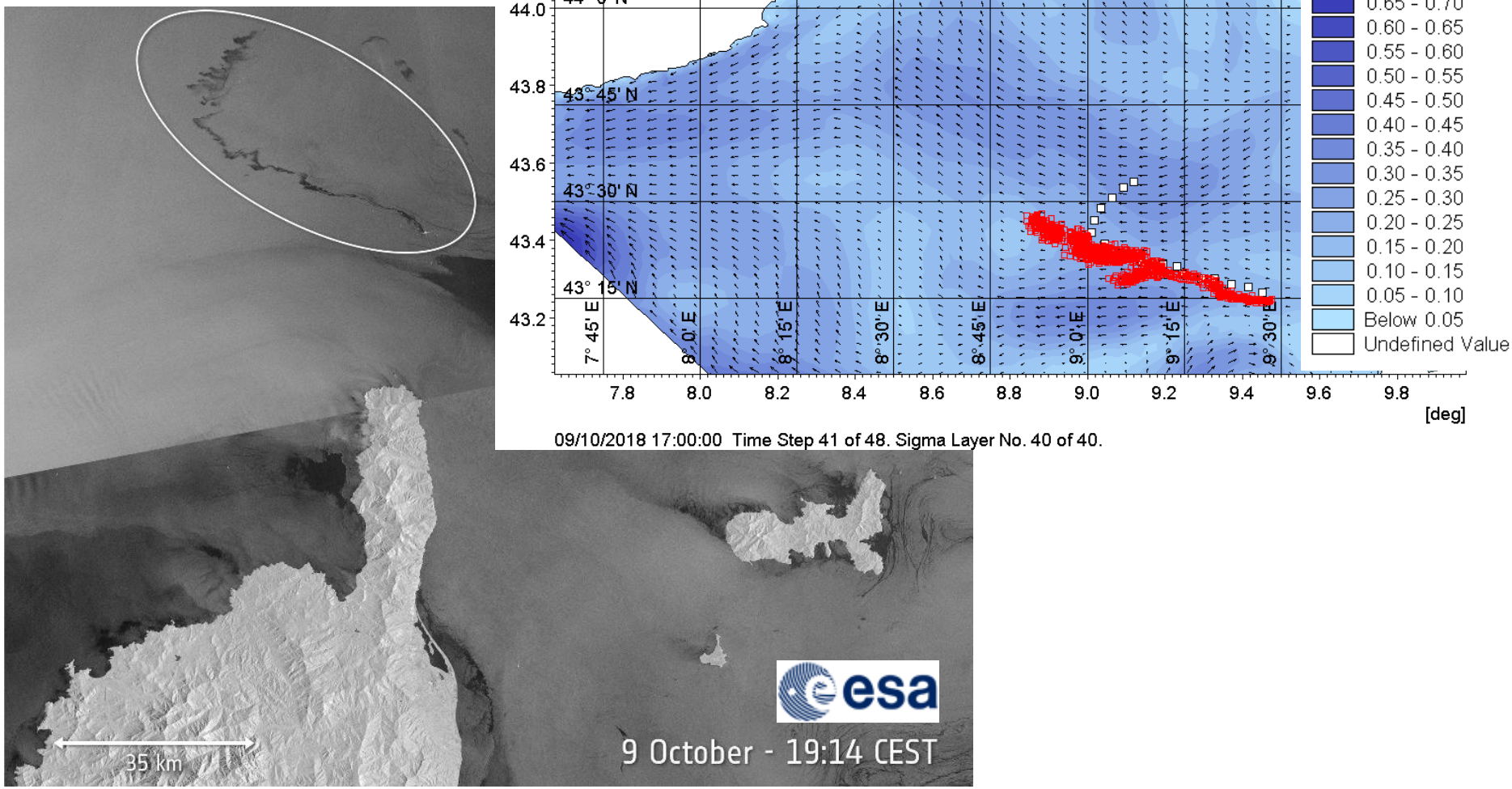
Simulations were performed assuming the hypothesis **of continuous release** from the ship since the collision occurred.
Results were compared with the image of the spill captured by Sentinel-1 satellites



The Copernicus Sentinel-1 mission returns images showing how oil is spreading in the Mediterranean Sea

Results and discussion – Oil Spill

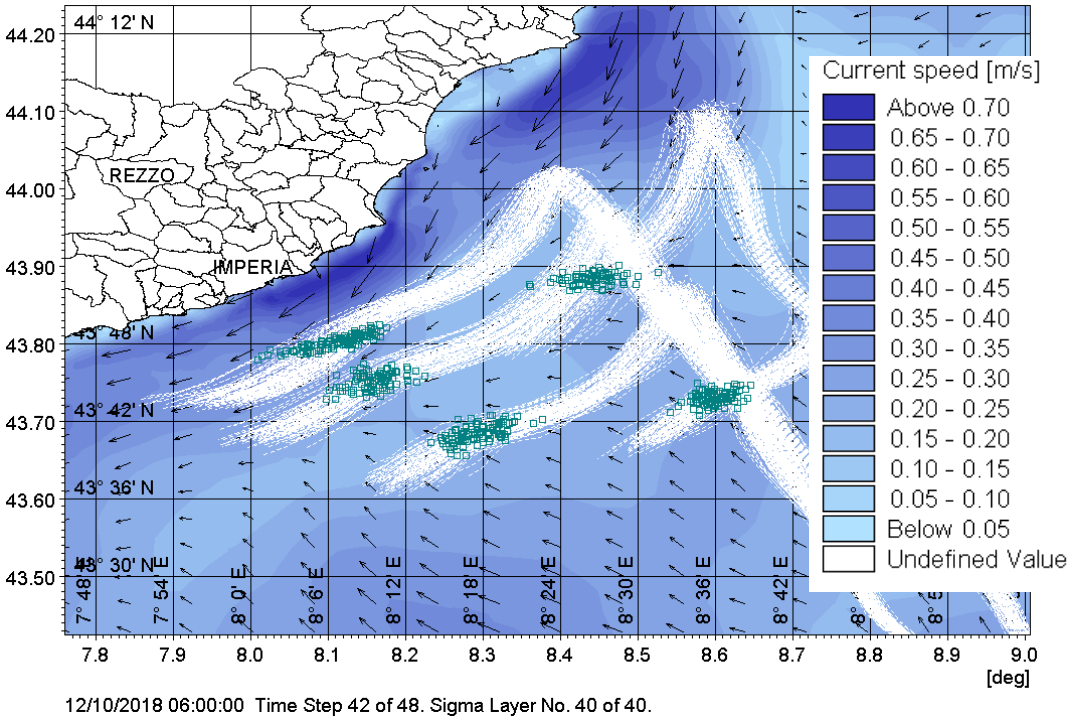
Further simulations were performed based on the Sentinel-1 images and updated meteo-oceanographic forecast produced on 08 October 2018.
During the first days, the prevailing direction of oil drift is to the North-West.



Results and discussion – Oil Spill

After 120 hr from the collision, the slick reaches western Ligurian coast, at a distance of about 15 NM.

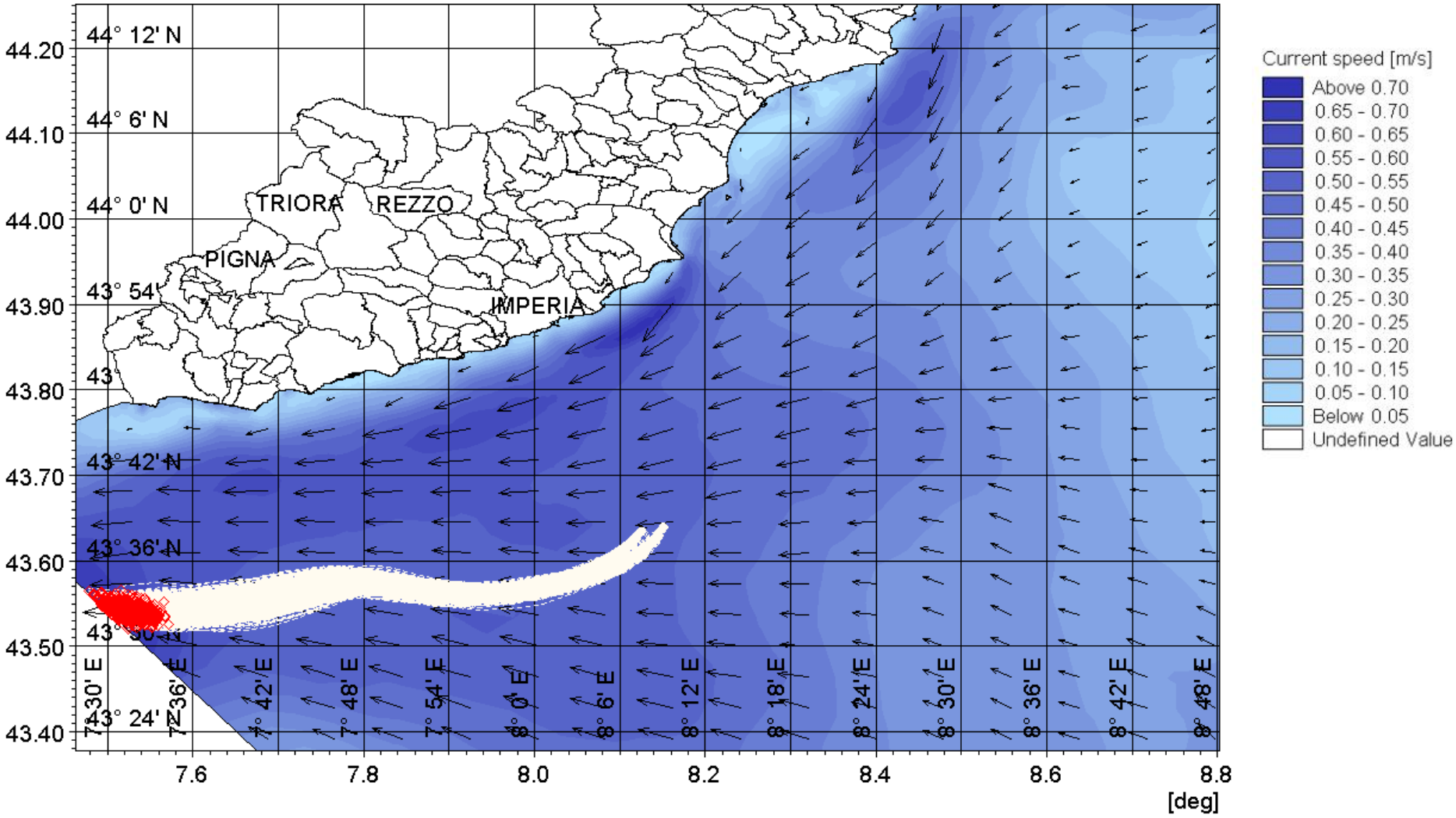
Simulation results support the sightings of material, reported by the public Authorities



12/10/2018 06:00:00 Time Step 42 of 48. Sigma Layer No. 40 of 40.

Results and discussion – Oil Spill

Currents and wind slowly push the slick to the coastlines of Monaco, France, and Italy.



Thanks for your attention

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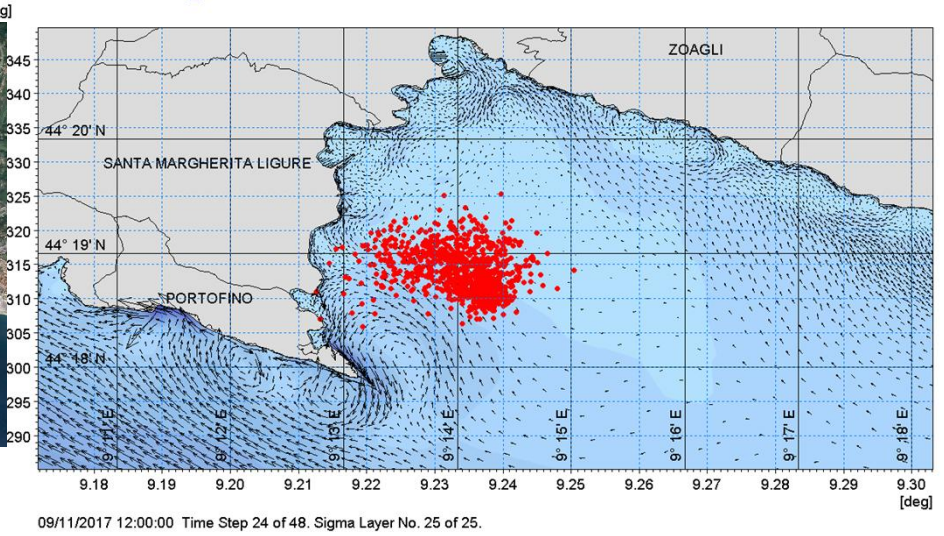
Esercitazione antinquinamento a Portofino



Modulo Oil Spill di Mike associato al campo di velocità della corrente (modello Genova e Tigullio).

Mappe di dispersione delle particelle di inquinante per la valutazione dello spiaggiamento:

- ✓ dopo 4 ore dall'inizio del rilascio, le prime particelle raggiungono la costa;
- ✓ in serata spiaggiamento su tutto il litorale tra Santa Margherita e la punta del Promontorio di Portofino