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Πρόγνωση διασποράς πετρελαιοκηλίδων στο θαλάσσιο περιβάλλον

“Forecasting of dispersion of oil spills in marine sea”

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Democritus University of Thrace

12 June 2026



ΔΗΜΟΚΡΙΤΕΙΟ ΠΑΝΕΠΙΣΤΗΜΙΟ
ΘΡΑΚΗΣ DEMOCRITUS
UNIVERSITY
OF THRACE

Permanent risk of major oil pollution

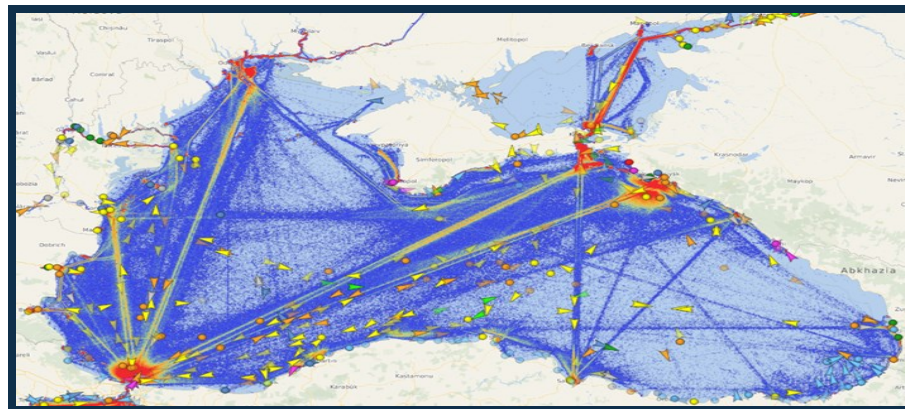
Why marine safety modelling matters now

01 Maritime transport

Tanker traffic and shipping density across enclosed seas creates a permanent baseline of accident risk.

02 Coastal & offshore oil-gas

Operations at coastal terminals and offshore installations introduce continuous structural and operational hazards.



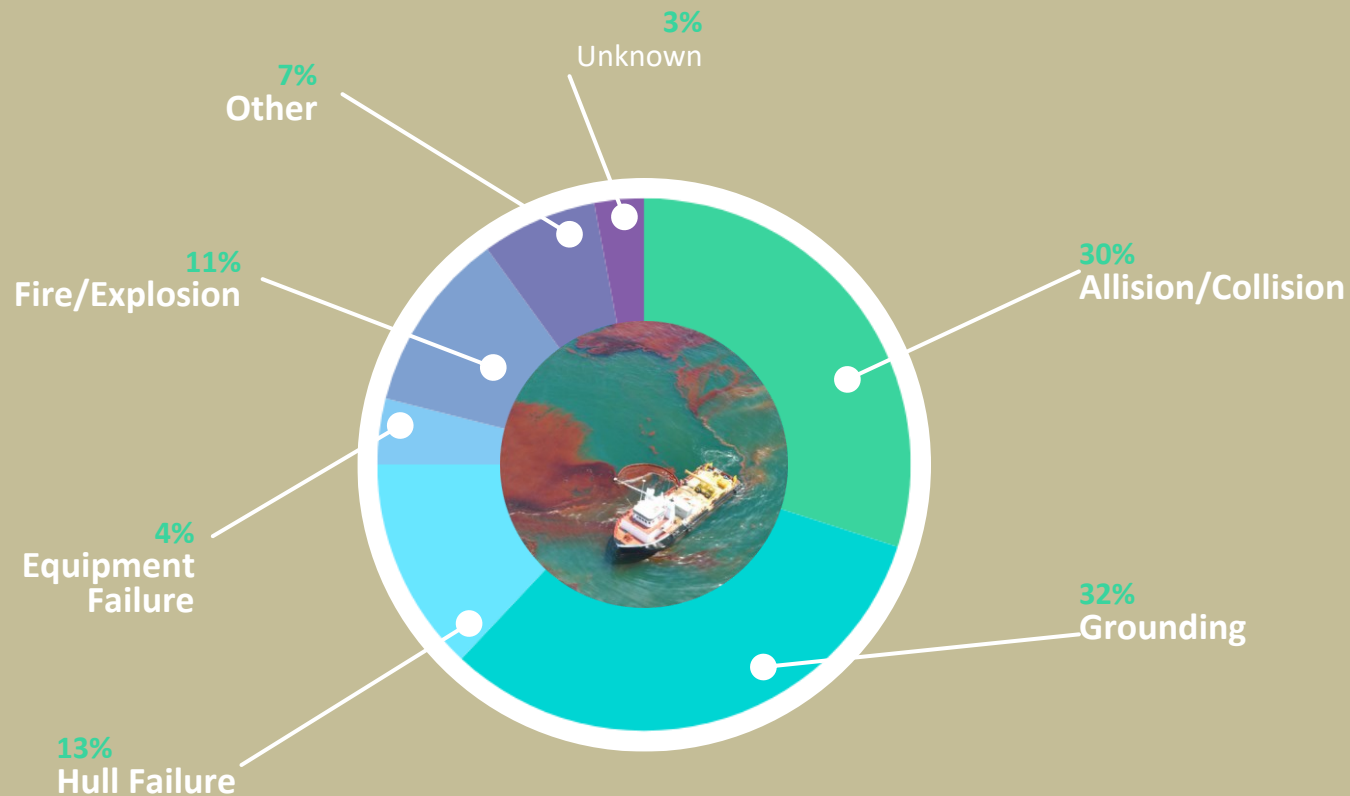
Black Sea ship-density routes · marinetraffic.com

REGULATORY FRAMEWORK

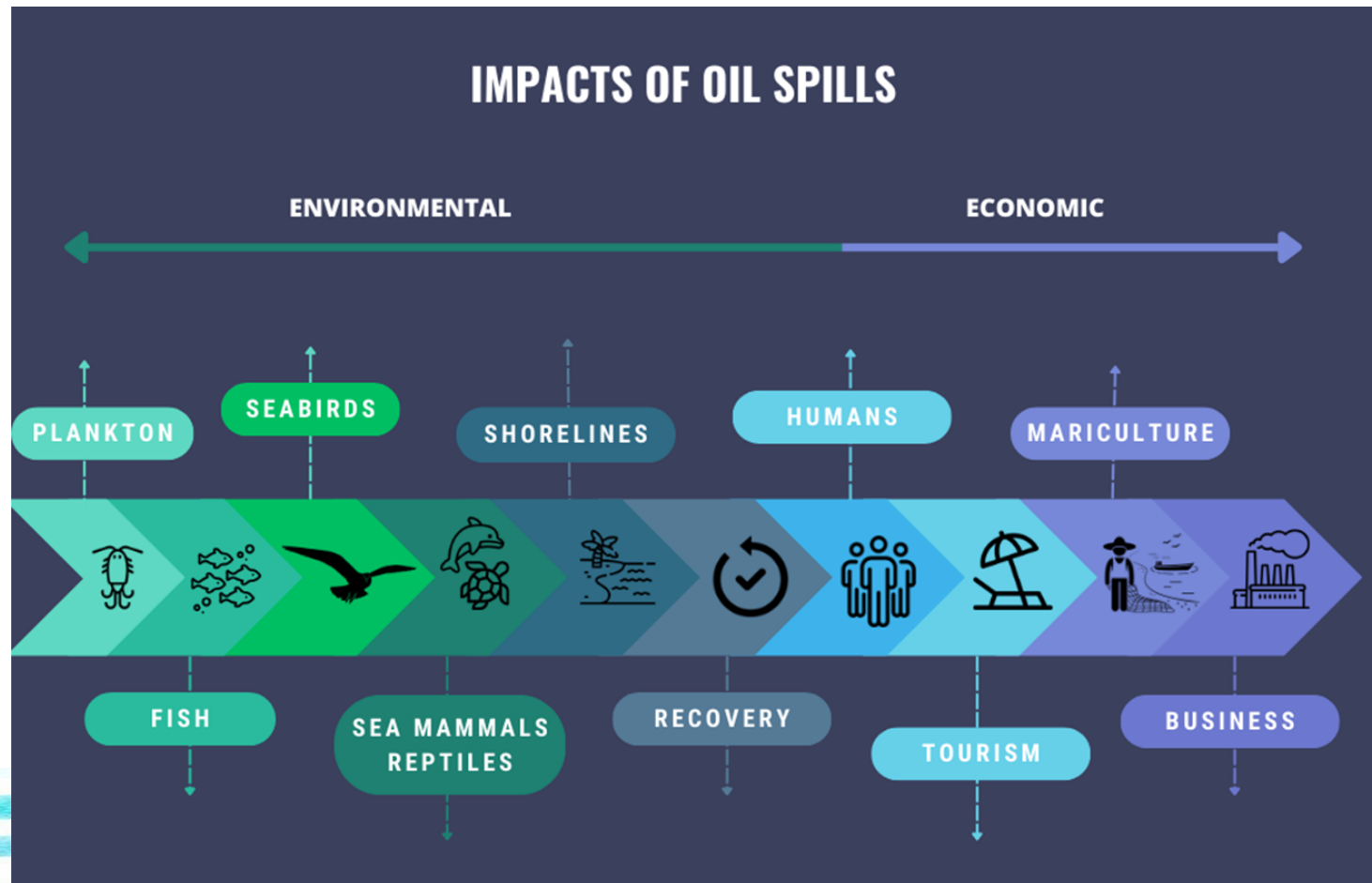
Barcelona Convention & EU Directives

Contingency plans require the application of dedicated oil spill models for response preparedness.

Causes of large tanker spills

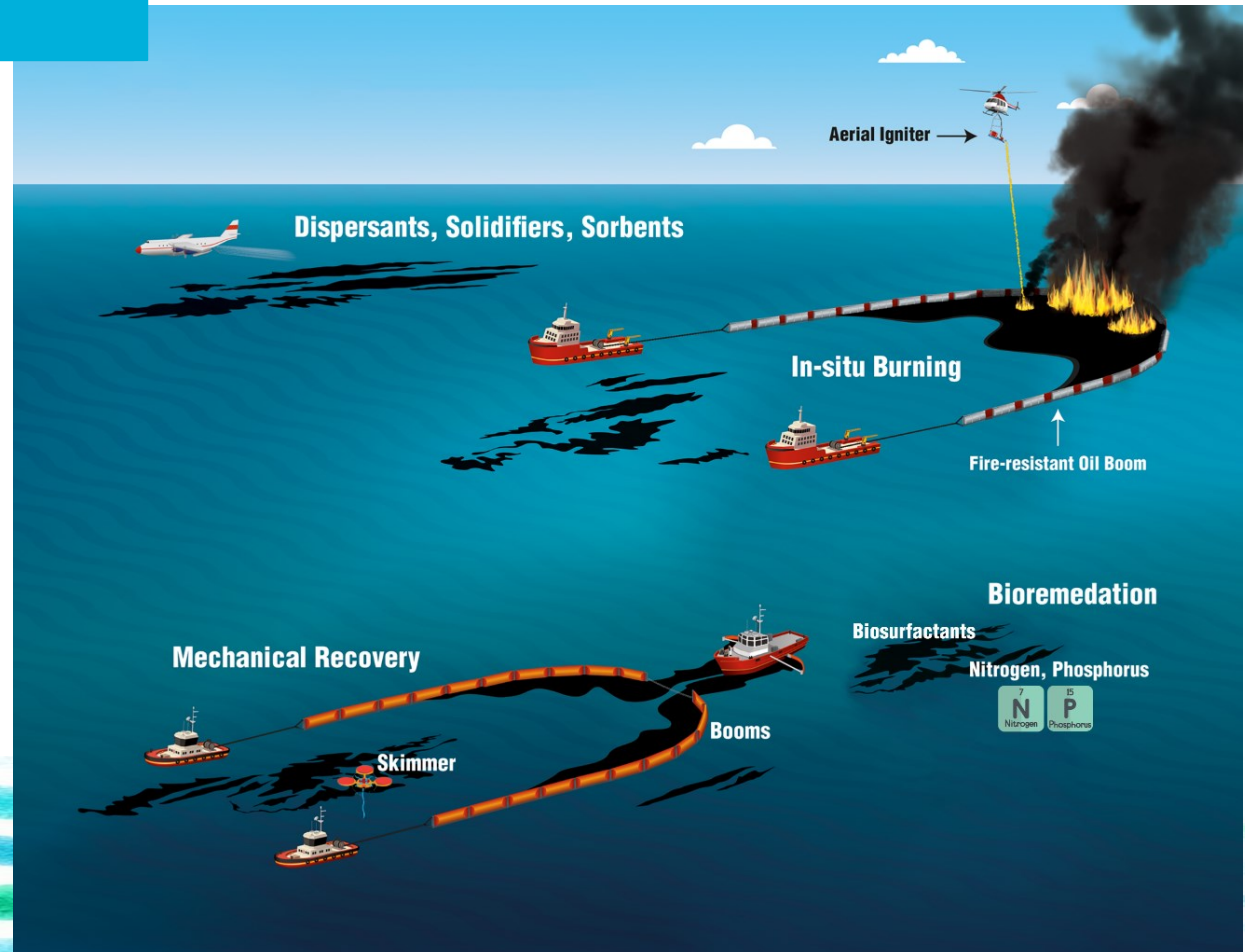


IMPACTS OF OIL SPILLS

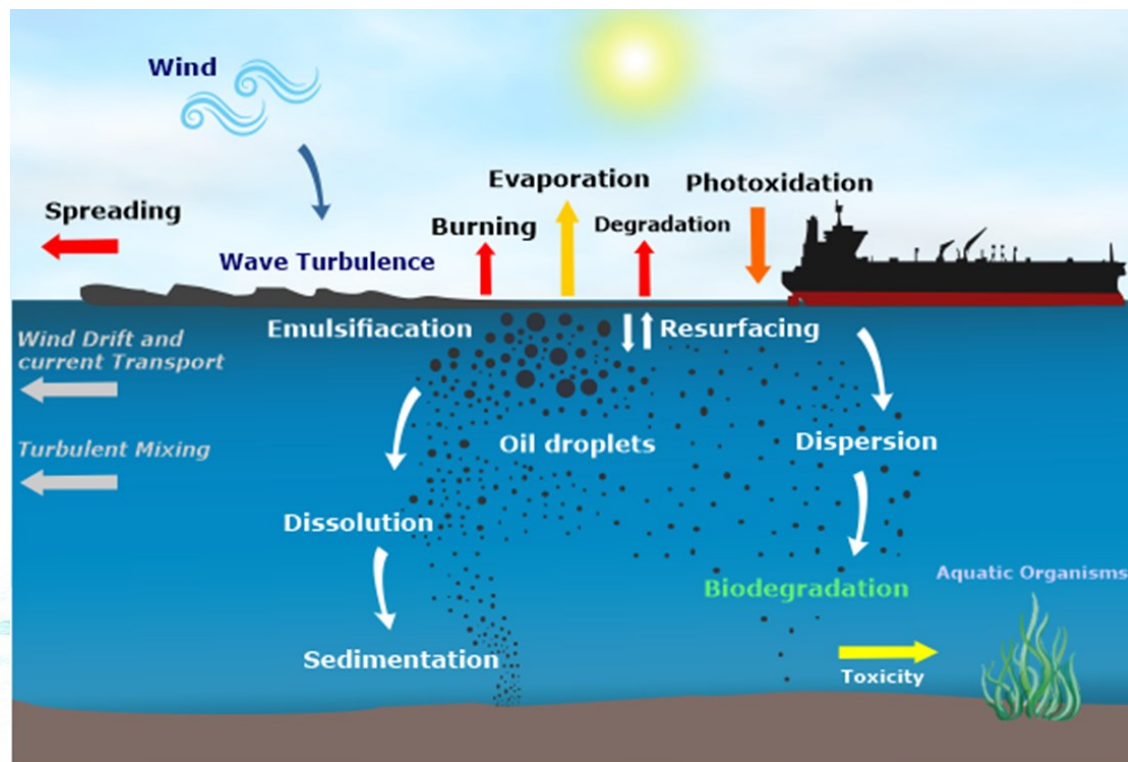


Clean-Up Methods

- ✓ Dispersants, Sorbents
- ✓ In-situ Burning
- ✓ Bioremediation
- ✓ Boomers, Skimmers



Oil Weathering and Transport Processes



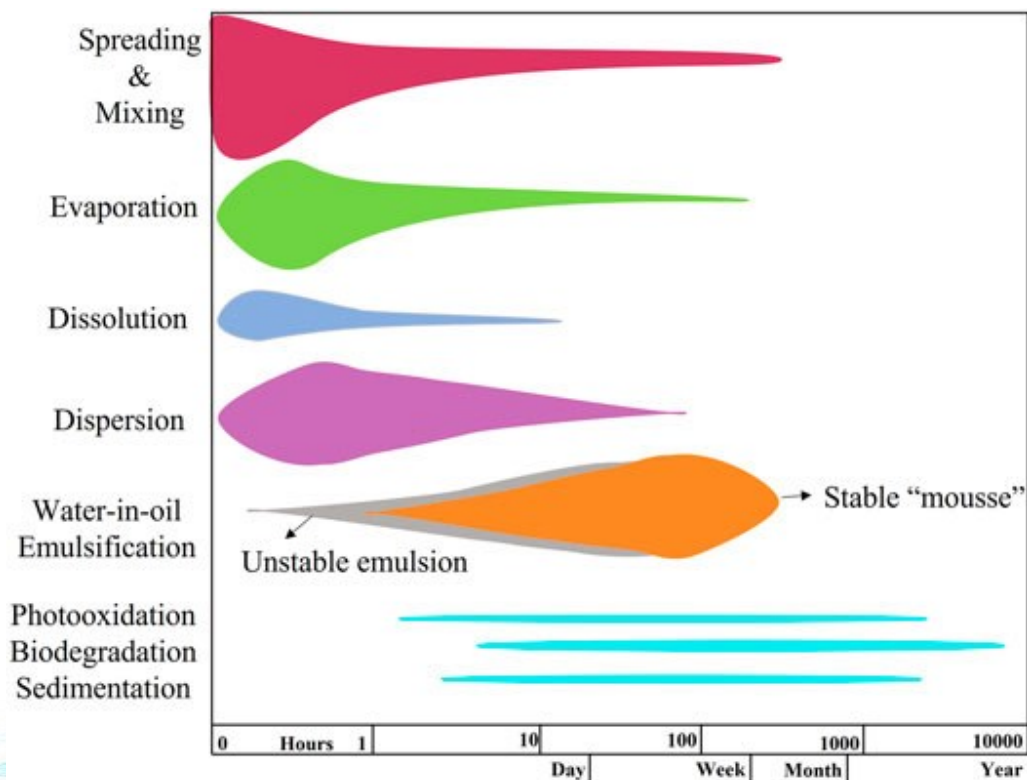
➤ *Meteorological Conditions*

Winds, Waves, Currents

➤ *Physico-Chemical Processes*

- ✓ Evaporation
- ✓ Spreading
- ✓ Emulsification
- ✓ Dispersion
- ✓ Dissolution
- ✓ Sedimentation
- ✓ Photooxidation
- ✓ Biodegradation

Temporal Evolution of Oil Weathering Processes



Source: Zhong et al., 2022

- The:
 - **spreading,**
 - **evaporation,**
 - **dispersion,**
 - **emulsification, and solubility**
 are the most critical OWP, which act in the **initial stages** of an oil spill.
- In a **second, more long-term stage,**
 - **photooxidation,**
 - **biodegradation, and**
 - **sedimentation**
 play a more significant role and determine the final fate of the spilled oil.

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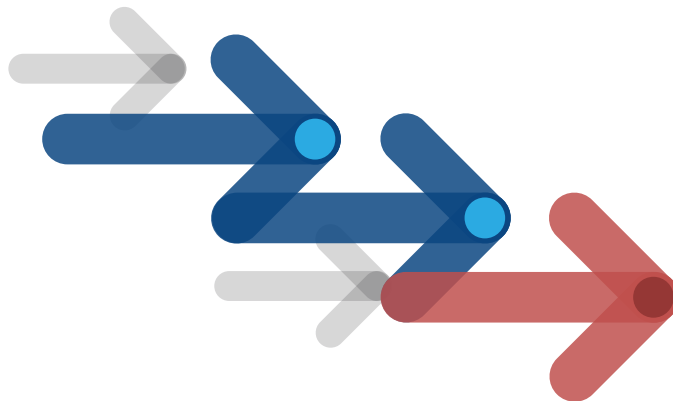


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Oil Spill Modeling



Oil Spill Models Preparedness



Background
of oil spills



Gather
information from
models



Evaluate the
information

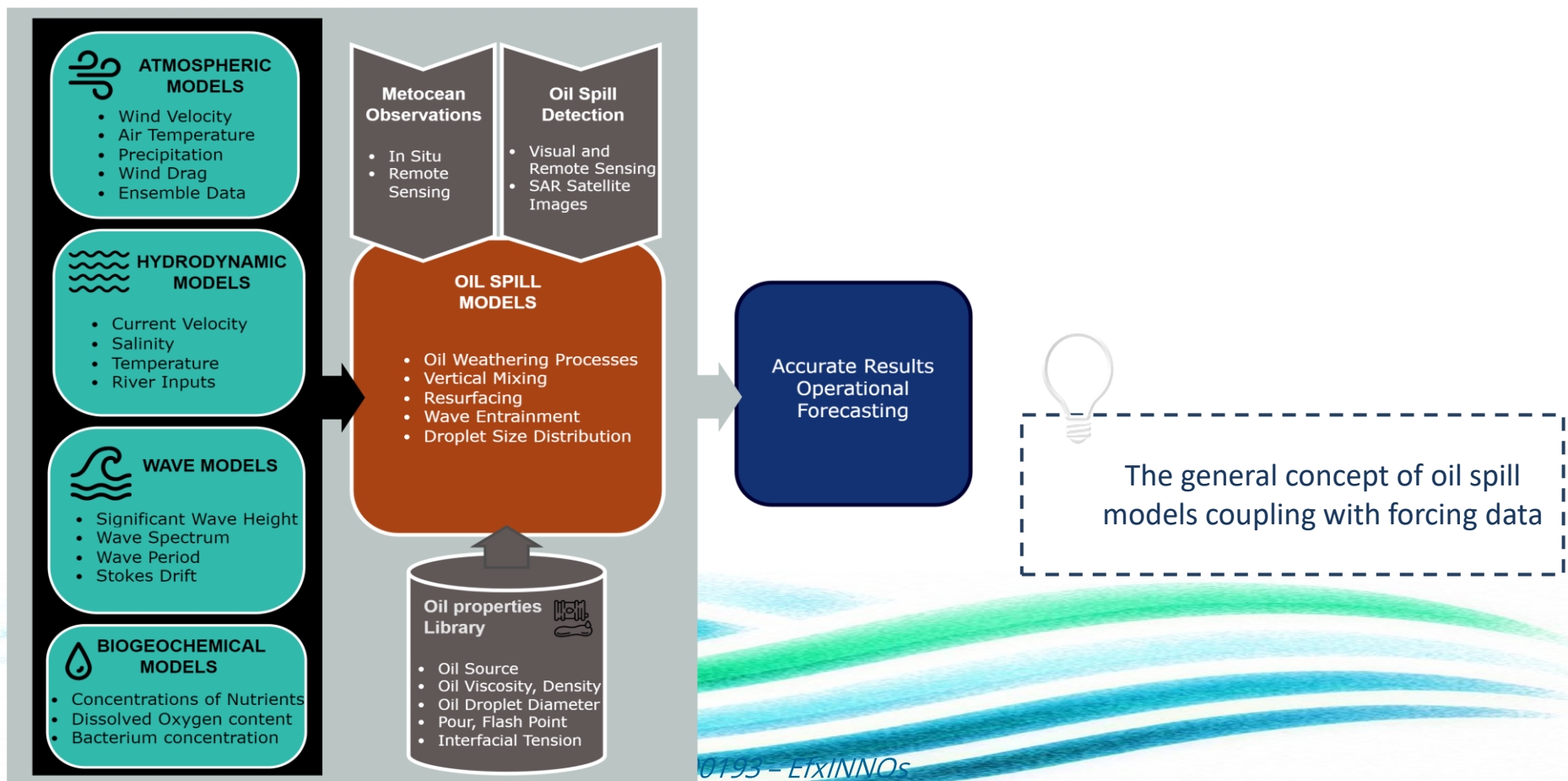


Prepare the oil
spill model



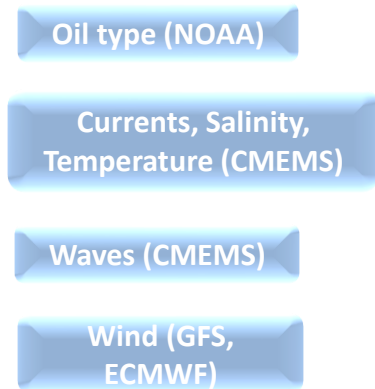
Run the model
and take results

Oil Spill Models and Forcing Data

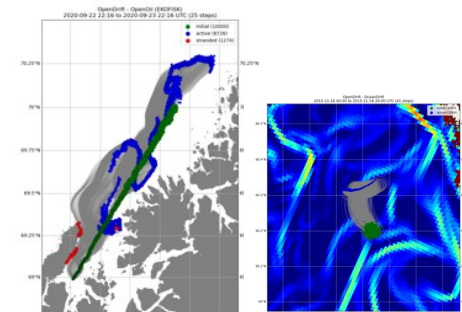


Methodology of OpenOil model

Input

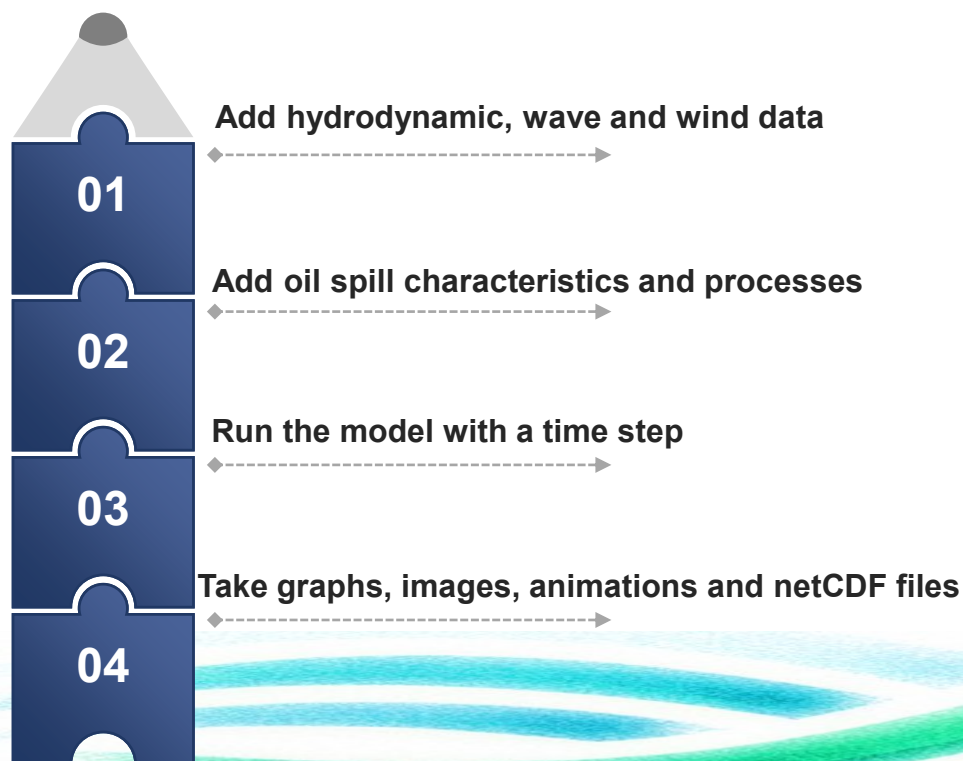


Output



Oil Mass Balance, oil viscosity, density, water fraction, z property, vertical mixing, oil thickness, oil droplet size distribution

Methodology of OpenOil models' set-up



You can download and install the *OpenDrift* model from :

<https://opendrift.github.io/install.html>

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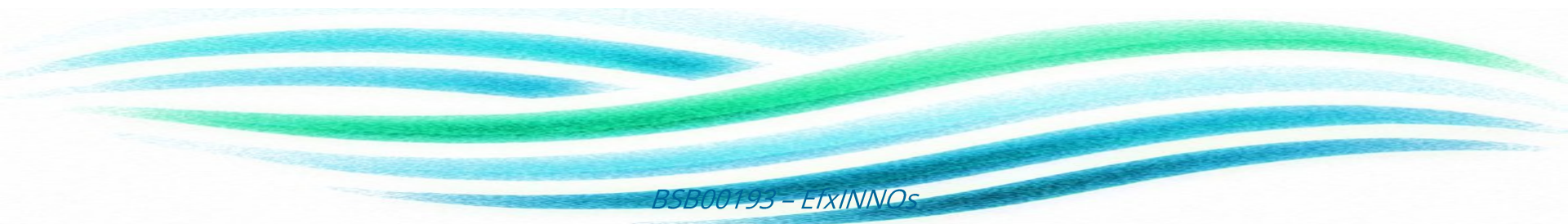
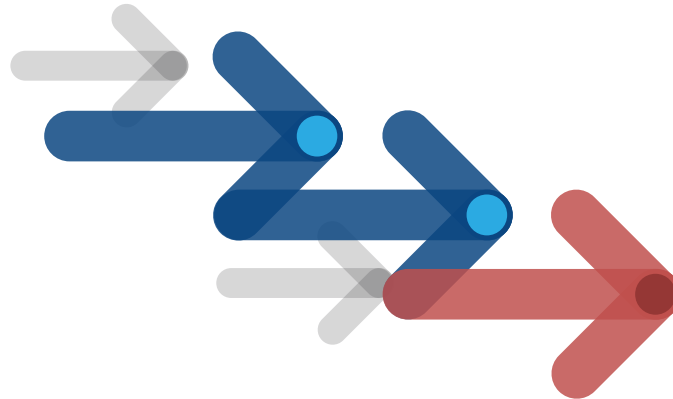


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Real-time oil spill predictions



Real-time Syrian oil spill 2021

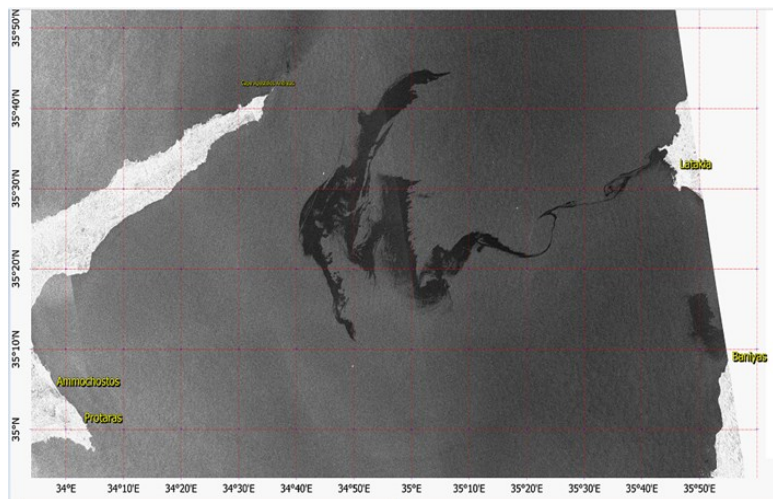


Fig: The SAR image obtained at 15:41 GMT on the 29 August 2021 shows the oil slick to spread offshore between Cyprus and Syria.

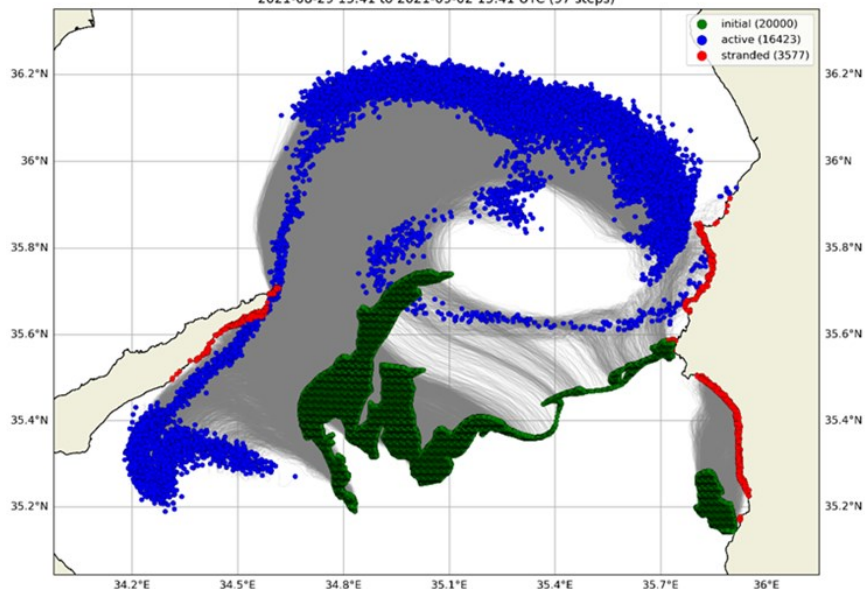
- ✓ Oil spill was not only widely spread westward in the **NE Levantine** between **Syria, Cyprus and Turkey**, but also was bifurcated to the north and to the south directions under the influence of the western peripheries of the **local anticyclonic and cyclonic** eddies dominated the area, threatening the cape of Apostle Andreas at the most eastern tip of Cyprus and later on the SE coast of Turkey.

Configurations	Run 1	Run 2	Run 3	Run 4
Spillages polygons	Determined by the Sentinel 1 SAR polygons provided by EMSA-CSN and ESA			
Number of particles	20,000 particles			
Start date of simulation	08/29/2021	08/31/2021	09/02/2021	09/04/2021
End time of simulation	09/01/2021	09/02/2021	09/05/2021	09/07/2021
Duration of simulation	4 days			
Oil type	Iranian Heavy oil (density: 878 kg/m ³ , viscosity: 0.109 kg/ms)			
Wind data	SKIRON (hourly, of 10km horizontal resolution)			
Hydrodynamic data (sea currents & SST)	CYCOFOS (6 hourly, of 2km horizontal resolution)			

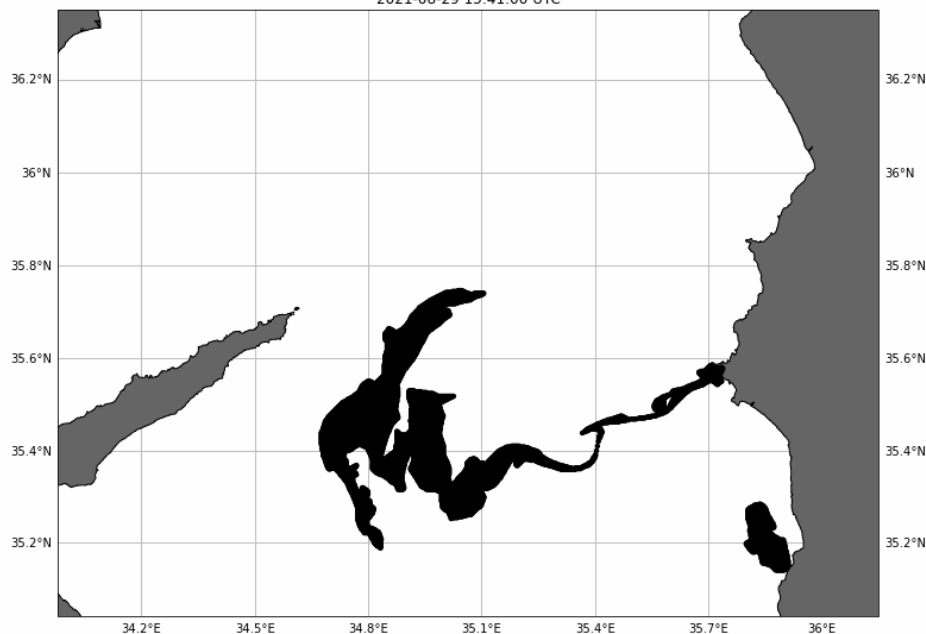
➤ Configuration for four MEDSLIK and OpenDrift Operational Runs

Syrian Oil Spill Scenarios

OpenDrift - OpenOil (SLEIPNER KONDESAT 2002)
2021-08-29 15:41 to 2021-09-02 15:41 UTC (97 steps)



OpenDrift - OpenOil (SLEIPNER KONDESAT 2002)
2021-08-29 15:41:00 UTC



- ✓ Oil spill simulation at the NE Levantine, between Cyprus and Syrian Gulf at the end of 4-day (from 29/08/2021 15:41 to 02/09/2021 15:41) simulation via OpenOil submodule.

- ✓ Green dots are the initial positions of the elements (life rafts),
- ✓ Grey lines are trajectories,
- ✓ Blue dots are positions at the end of the simulation,
- ✓ Red dots indicate elements which have hit land (stranded).

Volgoneft 212 — Kerch Strait, December 2024

06:00**GMT**

15 December 2024

≈4,000**tons**

of mazut fuel released

≈60**km**

of coastline impacted

Many**days**

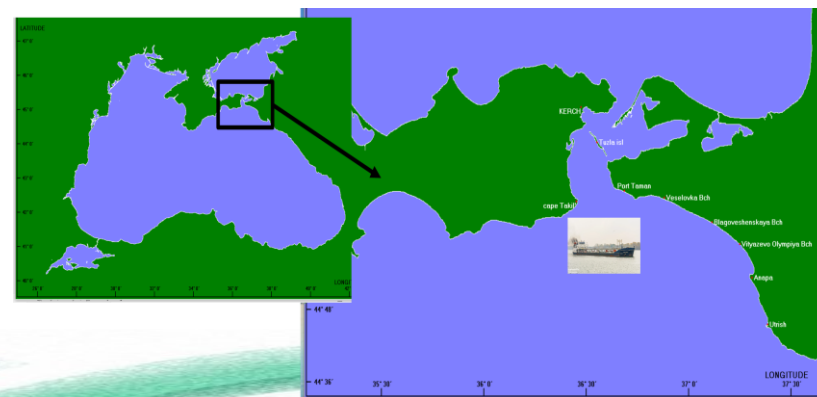
of unknown leak rate

WHAT HAPPENED

The hull of the tanker broke at the southern entrance of the strait

On-site reports show that within the first 72 hours the spill reached the northeast Black Sea coast, **extending up to 60 km** from Veselovka–Blagoveshenskaya to Anapa beaches.

- **Detection** of the slick from satellite SAR was **constrained** by very rough met-ocean conditions.
- Only a few useful images were obtained from RadarSat and ESA on 19 and 23 December 2024.



Medsluk model

01 Transport & diffusion

Oil particle advection driven by ocean currents and wind drag

02 Fate processes

Evaporation · emulsification · viscosity changes · dispersion

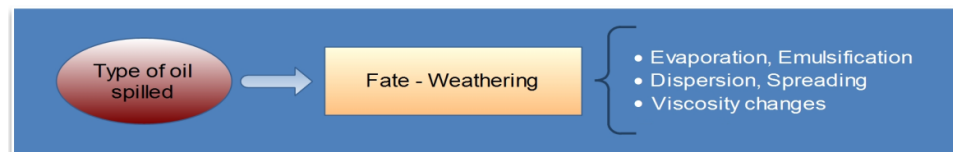
03 Vertical exchange

Dispersion in the water column and sedimentation pathways

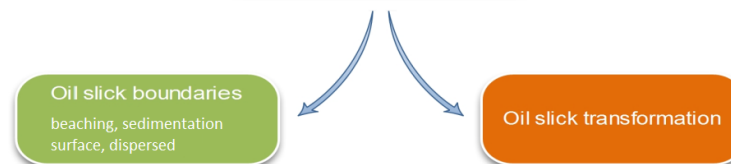
04 Coastal interaction

Coastal impact and adhesion to shoreline types

INITIAL CONDITIONS AND ENVIRONMENTAL VARIABLES



ADVECTION - DIFFUSION



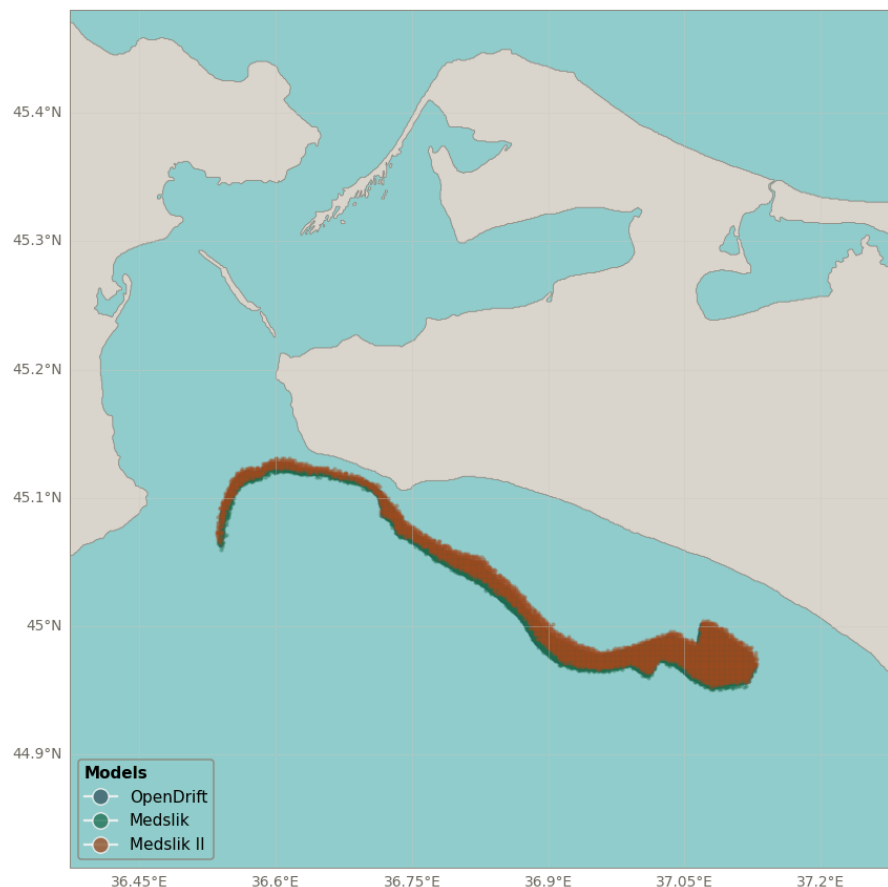
COUPLED DATA SOURCES

EMSA-CSN · ESA SAR imagery · Drones

Validated in Mediterranean and Black Sea oil spill incidents.

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Kerch Strait oil spill — 2024-12-19 15:30 UTC



Three models, one event

Inter-comparison of Lagrangian oil spill simulations

- ✓ OpenDrift results
- ✓ Medslik results
- ✓ Medslik-II results

OpenDrift

Hydrodynamics –
CMEMS
Waves - CMEMS
Winds – NOAA GFS

Medslik

Hydrodynamics –
CMEMS
Waves - CYCOFOS
Winds – SKIRON

Medslik-II

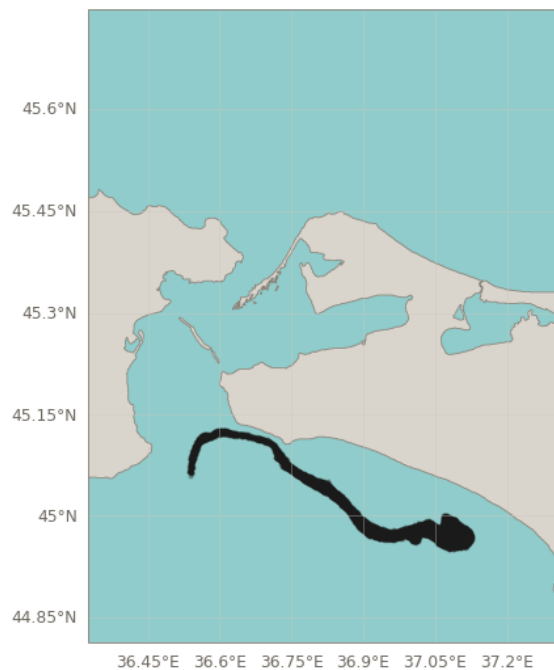
Hydrodynamics –
CMEMS
Waves - CMEMS
Winds – ECMWF

All simulations use the same SAR-derived initial conditions, and a 45-hour forecast window · 19–21 Dec 2024

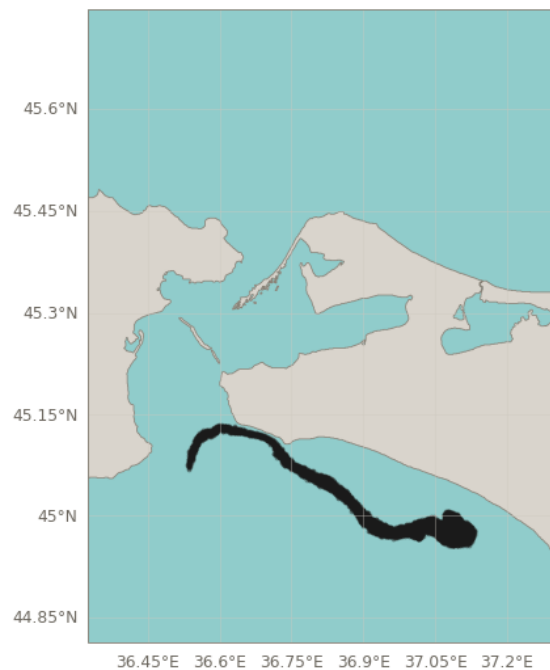
Models' comparison

Kerch Strait oil spill — 2024-12-19 15:30 UTC

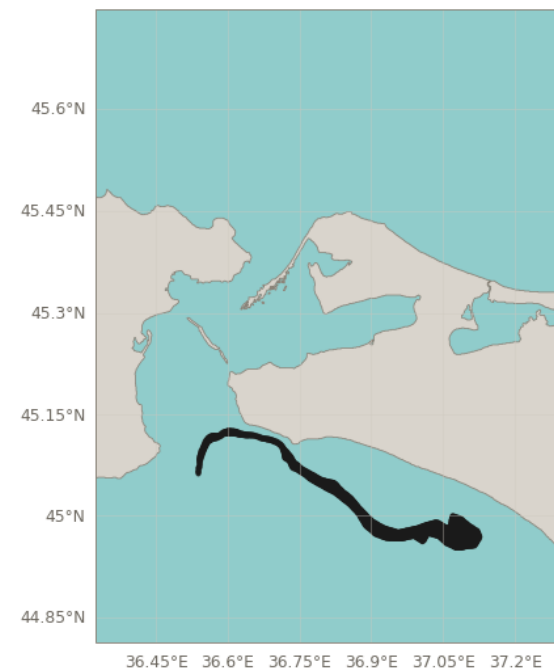
Medslik



Medslik II



OpenDrift



● active oil ● beached

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Thank you!

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