



# Coastal pollution

## Copernicus for Coastal Zone Management



1. **Copernicus Marine Environment Monitoring System (CMEMS) data in the Arctic**
2. **Microplastic transport and oil spill studies in the Arctic area**
3. **Examples of oil spill/plastics modeling using CMEMS data in the Med Sea**
  - Operational forecast of oil spill drift (e.g. MEDESS)
  - Hazard mapping for operational oil spills
  - Plastic debris modeling





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# OUTLINE

1. **Copernicus Marine Environment Monitoring System (CMEMS) data in the Arctic**
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# CMEMS Arctic Sea data

<http://marine.copernicus.eu/>

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**4TH GEO BLUE PLANET SYMPOSIUM IN TOULOUSE TO FOCUS ON THE OCEAN**  
Mercator Ocean, in the frame of the Copernicus Marine Service, has organized with GEO Blue Planet and the Université Fédérale Toulouse Midi-Pyrénées, the 4th GEO Blue Planet Symposium from July 4th-6th, 2018. It will be held in Toulouse, France, home to Mercator Ocean.  
READ MORE

**4TH GEO** JULY 4-6, 2018 TOULOUSE, FRANCE  
**BLUE PLANET SYMPOSIUM**  
Our Future is Blue: Linking Ocean and Coastal Information with Societal Needs

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# C M E M S Arctic Sea data

The screenshot displays the Copernicus Marine Environment Monitoring Service (CMEMS) website. The header includes the European Commission logo, the CMEMS logo, and the text "COPERNICUS MARINE ENVIRONMENT MONITORING SERVICE". Below the header is a navigation bar with links: ABOUT US, MARKETS & BENEFITS, NEWS, SCIENCE & MONITORING, TRAINING & EDUCATION, SERVICES PORTFOLIO, and a "SHORT-CUT TO SERVICES" dropdown. The main content area shows a search results page for "ARCTIC\_ANALYSIS\_FORECAST\_PHYS\_002\_001\_A". The search criteria include "REGIONAL DOMAIN" (Arctic Ocean), "PARAMETERS" (T bottomT S SSH UV MLD SIC SIT SIUV SNOW), "TEMPORAL COVERAGE" (From 1992-01-01 to 2018-09-13), and "PRODUCT WITH DEPTH LEVEL". The results show two products: "ARCTIC\_ANALYSIS\_FORECAST\_PHYS\_002\_001\_A" and "ARCTIC\_ANALYSIS\_FORECAST\_BIO\_002\_004". Each product entry includes a table with columns for MODEL, parameters, and a map of the Arctic region.

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Search by keyword

**REGIONAL DOMAIN** ▶  
Arctic Ocean

**PARAMETERS** ▶  
**TEMPORAL COVERAGE**  
From 1992-01-01 To 2018-09-13  
☐ If checked, the search results will only show products containing the whole selected time range

**PRODUCT WITH DEPTH LEVEL** ☐

Found 28 ocean products matching your criteria. [Export results](#)

**ARCTIC\_ANALYSIS\_FORECAST\_PHYS\_002\_001\_A**  
ARCTIC OCEAN PHYSICS ANALYSIS AND FORECAST

MODEL	Parameters	Map
T bottomT S SSH UV MLD SIC SIT SIUV SNOW SIAGE SIALB	12.5 km x 12.5 km (12 depth levels) From 2016-01-01 to Present daily-mean, hourly-instantaneous	ARC

MORE INFO ADD TO CART WMS Sub-setting

**ARCTIC\_ANALYSIS\_FORECAST\_BIO\_002\_004**  
ARCTIC OCEAN BIOGEOCHEMISTRY ANALYSIS AND FORECAST

MODEL	Parameters	Map
CHL PHYC ZOOC O2 NO3 PO4 SI PP KD	12.5 km x 12.5 km (12 depth levels) From 2016-01-01 to Present daily-mean	ARC

MORE INFO ADD TO CART WMS Sub-setting

## Some available products

- Physics and waves analysis and forecast
- Biogeochemistry analysis and forecast
- Physics reanalysis (1991-2016)
- Biogeochemistry reanalysis (2007-2010)
- In Situ Near Real Time observations
- Along-Track L3 sea surface heights NRT
- Surface Chlorophyll concentration from satellite observations: monthly and 8-days
- Surface Chlorophyll concentration from satellite observations
- Chlorophyll concentration from satellite observations (daily average) reprocessed l3 (esa-cci)
- Ocean optics products (daily average) reprocessed l3 (esa-cci)
- Sea and ice surface temperature
- Sea ice drift reprocessed (1999-ongoing)



- Sea ice can be coarsely characterised by its concentration, thickness and motions. For the last decades these characteristics have been monitored by satellites and assimilate in numerical models.
- The CMEMS catalogue offers an Arctic data assimilative regional reanalysis and forecast based on TOPAZ, and several global products including the Arctic (GLORYS, CGLORS, ORA, GloSea).
- Presently, sea ice concentration and drift are well monitored by satellites, but sea ice thickness measurements and simulations are still impaired by large uncertainties.
- For an adequate simulation of oil spills and microplastics, other sea ice properties (floe size, topography, age and snow coverage) ought to be known, as well as waves in ice.



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# MicroPlastics in the Arctic

Microplastics (MP) are recognized as a growing environmental hazard and have been identified as far as the remote Polar Regions, with particularly high concentrations of microplastics in sea ice.

Sea ice has been identified early on as a major means of transport for various pollutants, with north and east Greenland as well as the Laptev Sea, being especially prone to contamination from several sources.

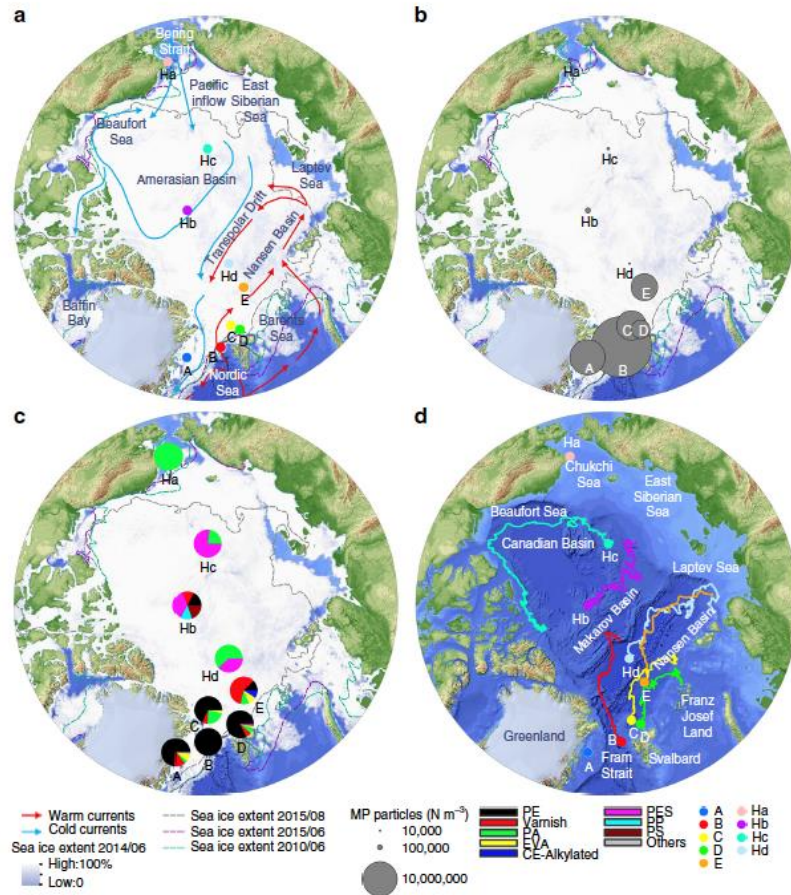
Arctic sea ice can be considered a temporary sink, a source and an important transport vector of MP, at least to the Fram Strait and North Atlantic MP may have been transported with the relatively highly MP-contaminated offshore North Atlantic waters into to the Arctic Ocean

I. Peeken, S. Primpke, B. Beyer, J. Gutermann, C. Katlein, T. Krumpfen, M. Bergmann, L. Hehermann and G. Gerdt. *Arctic sea ice is an important temporal sink and means of transport for microplastic*. Nature Communication 2018. 9:1505. DOI: 10.1038/s41467-018-03825-5



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# MicroPlastics in the Arctic



Pathway and microplastic content  
of sea ice cores in the Central Arctic

I. Peeken, S. Primpke, B. Beyer, J. Gutermann, C. Katlein, T. Krumpfen, M. Bergmann, L. Hehermann and G. Gerdts. *Arctic sea ice is an important temporal sink and means of transport for microplastic*. Nature Communication 2018. 9:1505. DOI: 10.1038/s41467-018-03825-5



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# MicroPlastics in the Arctic

Species	Location	Years	Incidence of plastic ingestion	Average mass plastic per individual	References
<b>Seabirds</b>					
Northern fulmar <i>Fulmarus glacialis</i>	Svalbard, Europe. 78.3°N, 16.1°E	1982-1984	29%		Mehlum and Gjertz 1984; Gjertz et al. 1985; Lydersen et al. 1985
		2013	87.5%	0.08g	Trevaill et al. 2015
	Bjørnøya, Svalbard, Europe 74°24'N, 19°0'E	1983	82%		Van Franeker 1985
	Jan Mayen, Europe, 71°0'N, 9°0'W	1983	79%		Van Franeker 1985
	East Canadian Arctic. 67-74°N, 62-90°W	2002-2008	Latest: 84%	Latest: 0.09g	Mallory et al. 2006; Mallory 2008; Provencher et al. 2009
Brünnich's guillemot/ Thick-billed murre <i>Uria lomvia</i>	Svalbard, Europe. 78.3°N, 16.1°E	1982-1984	20%		Mehlum and Gjertz 1984; Gjertz et al. 1985; Lydersen et al. 1985
		1988-1999	6%		Falk and Durinck 1993
	Prince Leopold Is. Canada. 74°0'N, 90°0'W	2008	8%	0.0017g	Provencher et al. 2010
	The Minarets, Canada. 67°0'N, 61°8'W	2007-2008	6%	0.0003g	Provencher et al. 2010
Little auk/dovekie <i>Alle alle</i>	Svalbard, Europe. 78.3°N, 16.1°E	1982-1984	11.6%		Mehlum and Gjertz 1984; Gjertz et al. 1985; Lydersen et al. 1985
	Hakluyt Island, Greenland, Europe 77°25'N 72°42'W	1997-1998	8.7%		Pedersen and Falk 2001
Kittiwake <i>Rissa tridactyla</i>	Svalbard, Europe. 78.3°N, 16.1°E	1982-1984	1.9%		Mehlum and Gjertz 1984; Gjertz et al. 1985; Lydersen et al. 1985

<b>Cetaceans</b>					
Bowhead whale, <i>Balaena mysticetus</i>	Baffin Bay, Canada				Finley 2001
	Beaufort Sea, Alaska, USA				Lowry 1993
Sperm whale, <i>Physeter macrocephalus</i>	Between Iceland and Greenland, Europe 62-67°N 24-30°W	1977-1981	<10%		Martin and Clarke 1986
<b>Fish</b>					
Greenland Shark, <i>Somniosus microcephalus</i>	South Greenland, Europe 59-76°N,	2012	8.3%		Nielsen et al. 2013

## Plastic ingestion by animals in the Arctic

A. Trevaill, S. Kuehn and G. W. Gabrielsen 2015. *The State of Marine Microplastic Pollution in the Arctic*. Kortrapport / Brief Report no. 033, pp.32





# MicroPlastics in the Arctic



All photographs: Bo Eide,  
Tromsø kommune

Marine litter collected in a small cove  
on Sessøya island, west of Tromsø.



Registration of collected marine litter in Rekvika.



Part of a trawl net, and other assorted fisheries related marine litter washed ashore on Kvaløya, west of Tromsø.



Collected marine litter on board the Coast Guard vessel KV Farn.

A. Trevaill, S. Kuehn and G. W. Gabrielsen 2015. *The State of Marine Microplastic Pollution in the Arctic*. Kortrapport / Brief Report no. 033, pp.32





# Oil spill modelling in ice-covered waters

- Comprehensive tracking and long-term monitoring of oil released in ice requires assimilating field data, plotting real-time observations, and integrating this information with forecasting tools such as weather models, ice drift algorithms, and oil spreading and weathering models.
- Oil spill trajectory models running at low and mid-latitudes use information about ocean currents, winds and waves to predict where the oil is likely to drift. The presence of sea ice and especially its percent coverage drastically changes how an oil spill spreads locally among the floes and how it moves regionally and in what proportion to the ice drift velocity.
- There is need to improve the resolution and accuracy of regional ice modelling, and also to focus on integrating these results with oil spill trajectory and fate and behaviour models considering sea ice



D. Dickins, 2017. *Arctic oil spill response technology. Joint industry programme. Synthesis report.* pp.120



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## C M E M S Med - M F C data


- Ocean currents (hourly forecasts, daily analyses) for calculation of the **oil spill** and **plastic transport**
- Sea surface temperature (hourly forecasts, daily analyses) for calculation of the oil weathering
- Mediterranean Sea physics as boundary conditions for nesting a high-resolution model  
(Adriatic Forecasting System AFS)



Online catalogue on <http://marine.copernicus.eu/services-portfolio/access-to-products/>

Select the area of interest and the parameter





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Search by keyword

**REGIONAL SCOPE**  
 Mediterranean Sea

**TEMPORAL COVERAGE**  
 From 2018-01-01 To 2018-09-13  
☐ If checked, the search results will only show products containing the whole selected time range

**PRODUCT WITH DEPTH LEVEL**

Found **29 ocean products** matching your criteria.
Export results

#### MEDSEA\_ANALYSIS\_FORECAST\_PHY\_006\_013

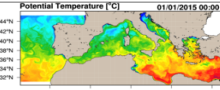
MEDITERRANEAN SEA PHYSICS ANALYSIS AND FORECAST

MODEL				X
Temperature				
Salinity				
Sea Surface Height				
Current Velocity				
Mixed Layer Thickness				
Sea Ice				
Wind				
Wave				
Plankton				
Oxygen				
Nutrients				
Primary Production				
Reflectance				
Turbidity				
Transparency				

#### MEDSEA\_ANALYSIS\_FORECAST\_PHY\_006\_013

MEDITERRANEAN SEA PHYSICS ANALYSIS AND FORECAST

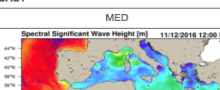
Potential Temperature [°C]
01/01/2015 09:00 UTC



#### MEDSEA\_ANALYSIS\_FORECAST\_WAV\_006\_017

MEDITERRANEAN SEA WAVE ANALYSIS AND FORECAST

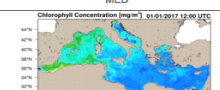
Spectral Significant Wave Height [m]
11/12/2016 12:00 UTC



#### MEDSEA\_ANALYSIS\_FORECAST\_BIO\_006\_014

MEDITERRANEAN SEA BIOGEOCHEMISTRY ANALYSIS AND FORECAST

Chlorophyll Concentration [mg/m³]
01/01/2017 12:00 UTC





# Data: how to download the product

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The screenshot shows the Copernicus Marine Environment Monitoring Service (MEMS) website. The header includes the European Commission logo and the service name. A navigation bar contains links for ABOUT US, MARKETS & BENEFITS, NEWS, SCIENCE & MONITORING, TRAINING & EDUCATION, SERVICES PORTFOLIO, and a dropdown for SHORT-CUT TO SERVICES. Below the navigation bar, there's a section for 'Home > Services portfolio > Access to products'. The main content area displays 'MEDITERRANEAN SEA PHYSICS ANALYSIS AND FORECAST' with a map of the Mediterranean Sea showing potential temperature. A red circle highlights the 'DOWNLOAD PRODUCT' button. Below the map, there's a 'PRODUCT IDENTIFIER' section with the identifier 'MEDSEA\_ANALYSIS\_FORECAST\_PHY\_006\_013'. The 'OVERVIEW' section provides a short description and detailed description of the product. The detailed description mentions the Mediterranean Forecasting System (MFS) and the NEMO model. The bottom of the page features logos for Copernicus and the European Commission.

Download the  
product with the user  
interface  
after creation of an  
account



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# Operational forecast of oil spill: methodology



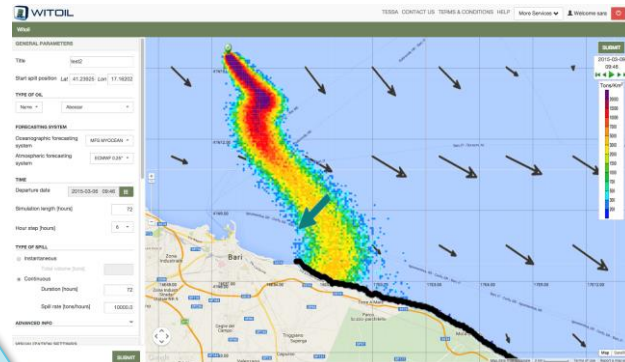
Cumulative  
hourly  
forecasts,  
daily analyses  
 $1/16^\circ \times 1/16^\circ$   
horizontal  
resolution

ECMWF

6 hr -  
12, 5 km

MEDSLIK-II

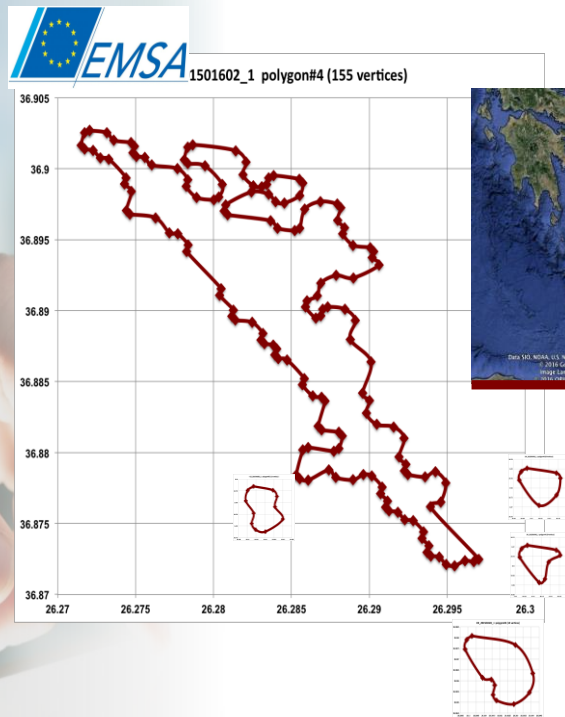
Oil  
Spill  
forecast



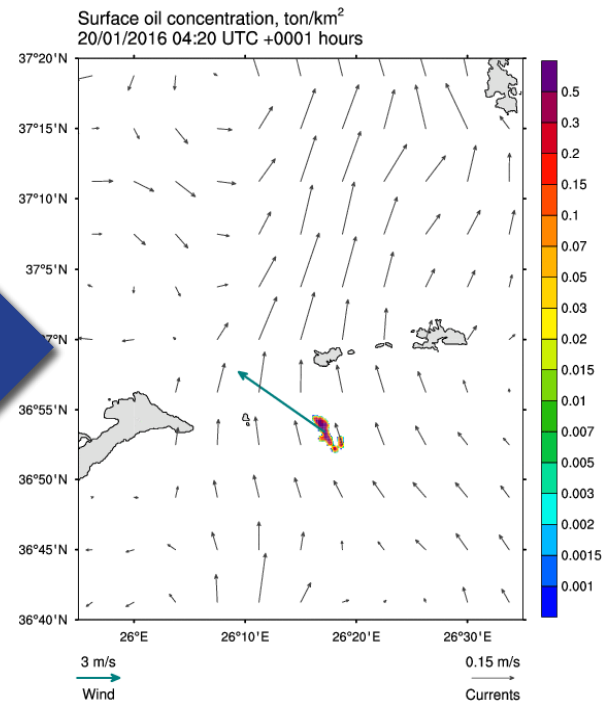


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# Operational forecast of oil spill drift: demonstration



Northward transport  
led to  
the oil  
contamina-  
tion of  
Kinaros  
Island  
and the  
(Greece)





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# Hazard mapping for operational oil spills: methodology

The oil hazard mapping methodology uses the following assumptions:

1. the traffic density distribution and the amount of oil operationally spilled
1. the oil spill simulations, performed using the past daily meteo- oceanographic conditions from 2009 to 2013

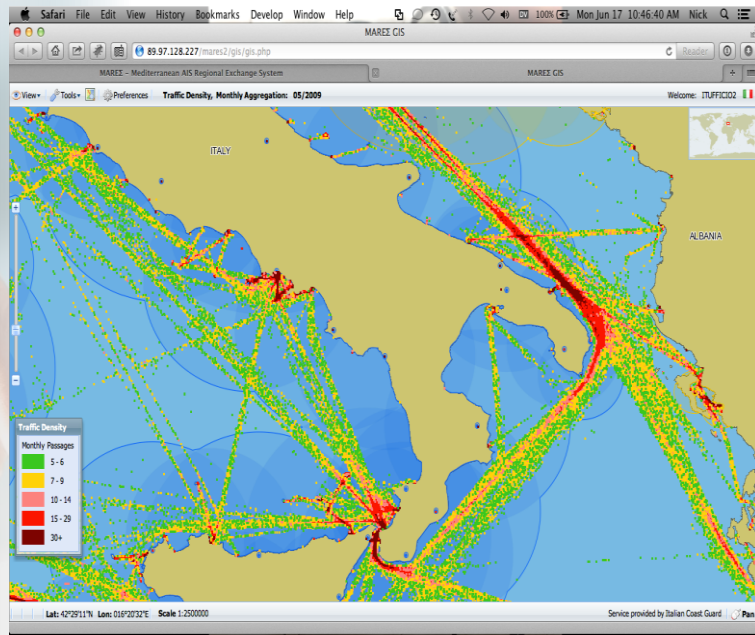




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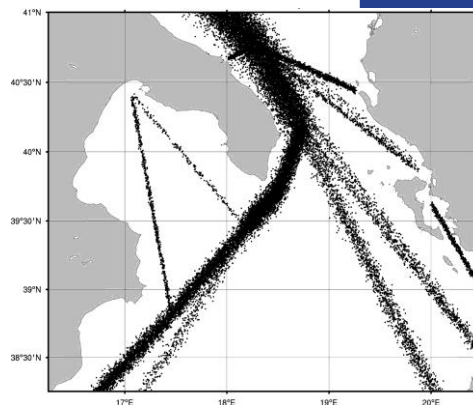
# Hazard mapping for operational oil spills: methodology - the traffic density distribution

*Digitizing the ship traffic maps provided by the Italian Coast Guard*



Monthly Ship Traffic Maps provided by ITCG

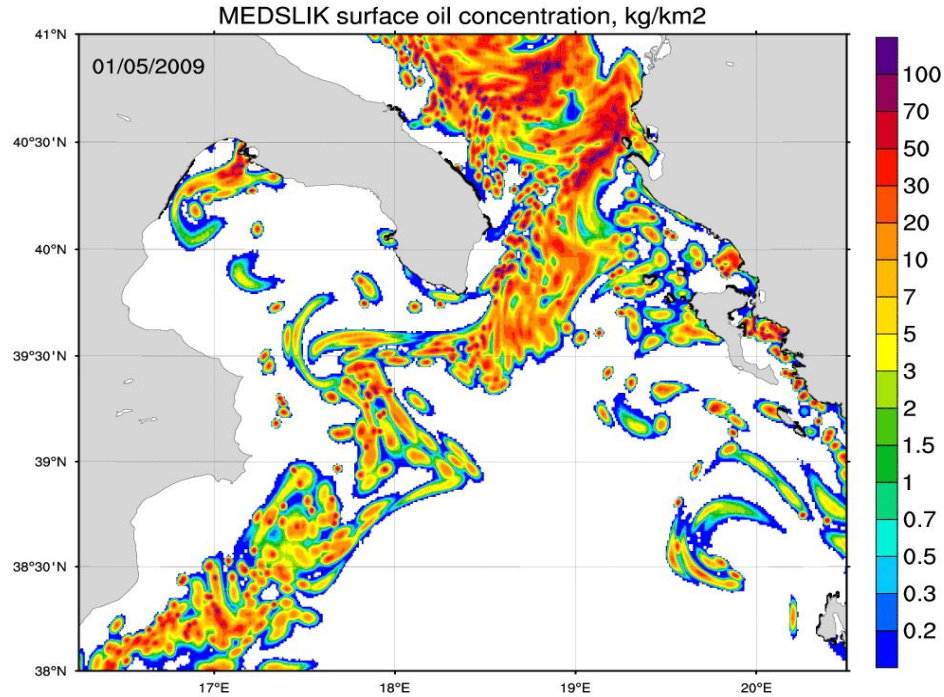
Spill list  
1.000.000  
spills/month





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# Hazard mapping for operational oil spills: methodology - the oil spill simulations



Hourly Surface Oil Concentration  $C_{\text{HOUR}}(x,y)$  Maps



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# Hazard maps for operational oil spills: demonstration

Marine Pollution Bulletin 90 (2015) 259–272

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: [www.elsevier.com/locate/marpolbul](http://www.elsevier.com/locate/marpolbul)

Oil spill hazard from dispersal of oil along shipping lanes in the Southern Adriatic and Northern Ionian Seas

S. Liubartseva<sup>a,\*</sup>, M. De Dominicis<sup>b</sup>, P. Oddo<sup>b</sup>, G. Coppini<sup>c</sup>, N. Pinardi<sup>d</sup>, N. Greggio<sup>e</sup>

<sup>a</sup> Centro EuroMediteraneo sul Cambiamento Climatico, Bologna, Italy  
<sup>b</sup> Istituto Nazionale di Geofisica e Vulcanologia, Bologna, Italy  
<sup>c</sup> Centro EuroMediteraneo sul Cambiamento Climatico, Lecce, Italy  
<sup>d</sup> Department of Physics and Astronomy, University of Bologna, Italy  
<sup>e</sup> Italian Coast Guard Headquarters, Ministry of Infrastructure and Transport, Rome, Italy

**ARTICLE INFO**

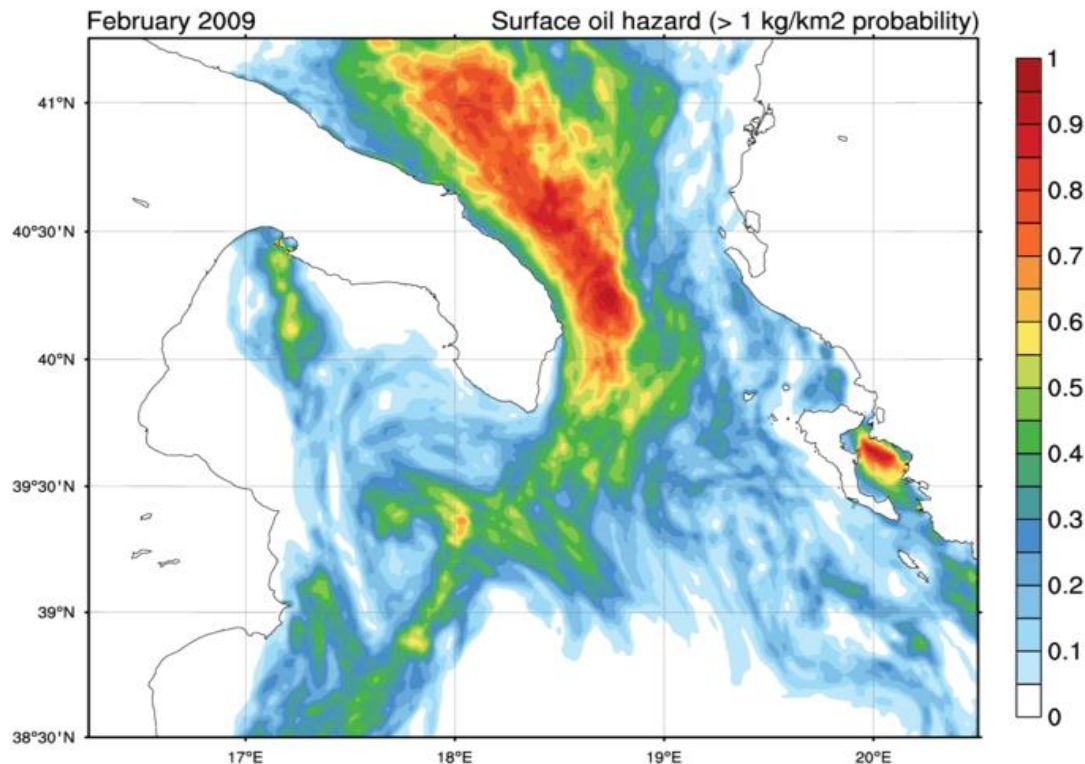
Article history:  
Available online 14 November 2014

**Keywords:**  
Oil spill modelling  
Hazard mapping  
Operational oil pollution  
Southern Adriatic and Northern Ionian Seas

**ABSTRACT**

An assessment of hazard stemming from operational oil ship discharges in the Southern Adriatic and Northern Ionian (SANI) Sea is presented. The methodology integrates ship traffic data, the fast and transport oil spill model MEDSLIK-II, coupled with the Mediterranean Forecasting System (MFS) ocean currents, sea surface temperature analyses and ECMWF surface winds. Monthly and climatological hazard maps were calculated for February 2009 through April 2013. Monthly hazard distributions of oil show that the zones of highest sea surface hazard are located in the southwestern Adriatic Sea and eastern Ionian Sea. Distinctive “hot spots” appear in front of the Taranto Port and the sea area between Corfu Island and the Greek coastlines. Beached oil hazard maps indicate the highest values in the Taranto Port area, on the eastern Greek coastline, as well as in the Bari Port area and near Brindisi Port area.

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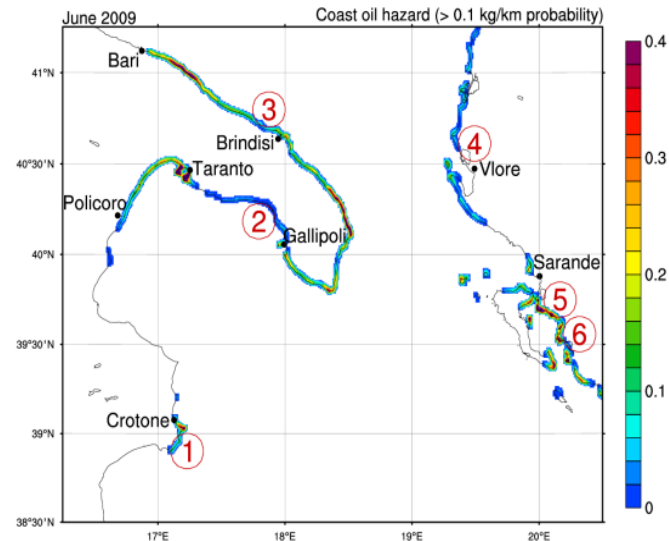
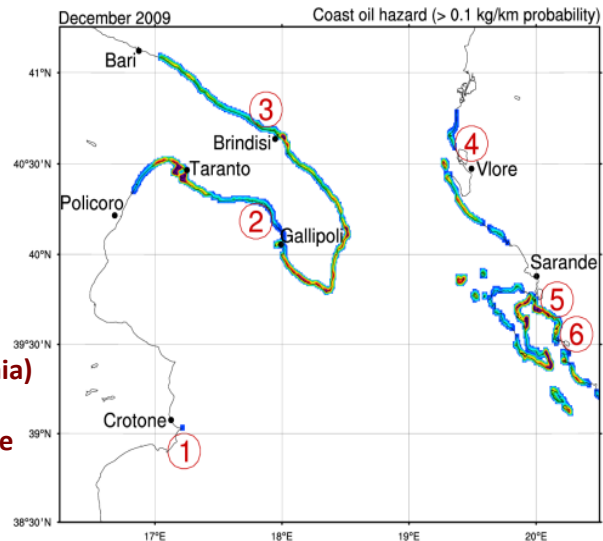




# Hazard maps for operational oil spills: demonstration

## *At risk of chronic oil pollution: Marine Protected Areas*

- (1) Capo Rizzuto MPA (Italy)
- (2) Porto Cesareo MPA (Italy)
- (3) Torre Guaceto MPA (Italy)
- (4) Vjose-Narte Landscape Protected Site (Albania)
- (5) Butrinti National Park (Albania)
- (6) Kalama Delta Natural Reserve (Greece)







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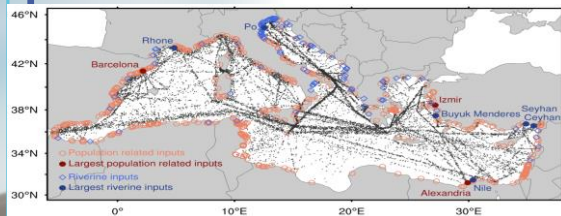




# Plastic debris modeling in the Med Sea

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## Sources

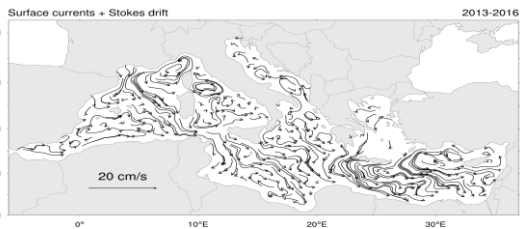


- Cities
- Rivers
- Shipping lanes

## Transport and interaction with the boundaries

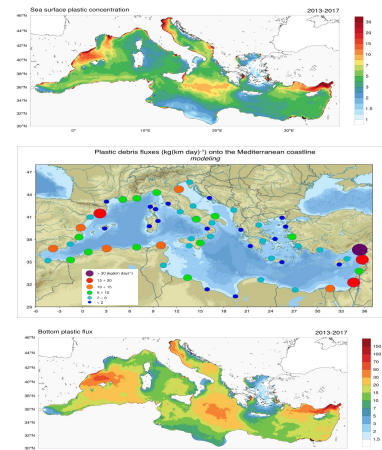
Sea surface drivers:

- Currents
- Waves (the Stokes drift)



Stochastic beaching and  
sedimentation

## Destination



- Sea surface
- Coastlines
- Bottom

Ensemble simulations

2D Stochastic  
Lagrangian module



# Plastic debris modeling in the Med Sea

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Inputs of plastics into  
the Mediterranean

Operational  
oceanography  
datasets

*Ensemble simulations*



*2D Stochastic  
Lagrangian module*

Sea surface plastics

Coastal plastics

Benthic plastics

## Coastal human population:

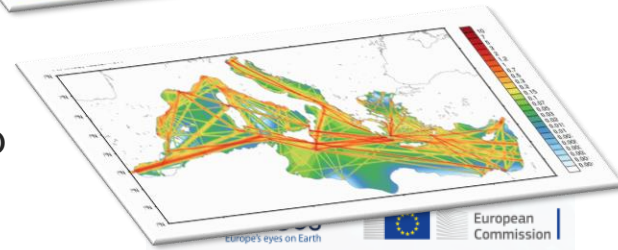
by Brinkhoff <http://www.citypopulation.de>

## River discharges:

by Verri et al. (2017), PERSEUS Atlas (2015),  
Ludwig et al., (2010, 2009), Tockner et al. (2009)

## PDFs of ship locations:

by an original methodology of AIS traffic map  
digitizing (Liubartseva et al., 2015)



Europe's eyes on Earth

European  
Commission

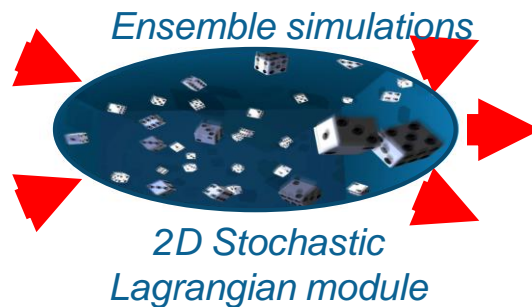


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# Plastic debris modeling in the Med Sea

Inputs of plastics into  
the Mediterranean

Operational  
oceanography  
datasets



Sea surface plastics

Coastal plastics

Benthic plastics

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**TEMPORAL COVERAGE**  
From 1992-01-01 To 2017-08-1

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Found 28 products matching your criteria.

**MEDSEA\_ANALYSIS\_FORECAST\_PHYS\_006\_001**  
MEDITERRANEAN SEA PHYSICS ANALYSIS AND FORECAST

MODEL: 3DUV S SSH T  
0.063 degree x 0.063 degree (72 depth levels)  
From 2013-01-01 to Present  
daily-mean, hourly-mean

MORE INFO | ADD TO CART | WMS | Sub-setting

Potential Temperature (°C) 01-03-2017 00:00 UTC

Daily analyses of ocean currents and waves (Clementi et al., 2017) provided by CMEMS at a  $1/16^\circ \times 1/16^\circ$  (~ 6.5 km) horizontal resolution

**Transport Mechanism = Sea surface currents + Waves**





# Plastic debris modeling in the Med Sea

User  
Uptake

Inputs of plastics into  
the Mediterranean

Operational  
oceanography  
datasets

*Ensemble simulations*



*2D Stochastic  
Lagrangian module*

Sea surface plastics

Coastal plastics

Benthic plastics

Floating at the  
sea surface

*This probability  
drops with  
trampling near  
the coast*

*This probability  
grows with  
particle age*

Stuck on the  
coastline

Anchored to the  
bottom

*3 states of particles and allowed transitions  
between the states*

**1 200 000 virtual particles per day are  
seeded into the Mediterranean and  
tracked 2013 – 2017**

- (1) Advection by the surface currents and Stokes drift
- (2) Random walk technique for subgrid turbulence
- (3) Stochastic algorithms for beaching and sedimentation

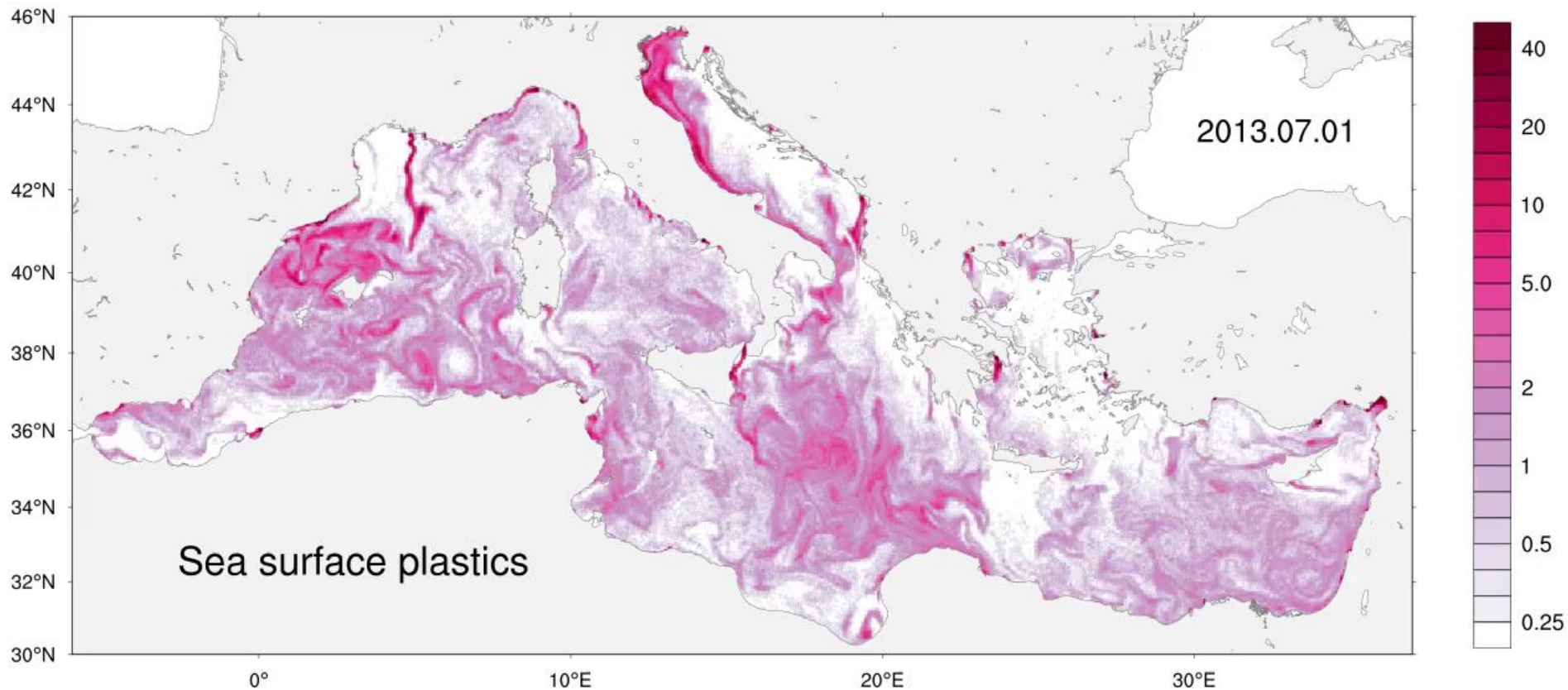
## Stochastic Lagrangian modeling





User

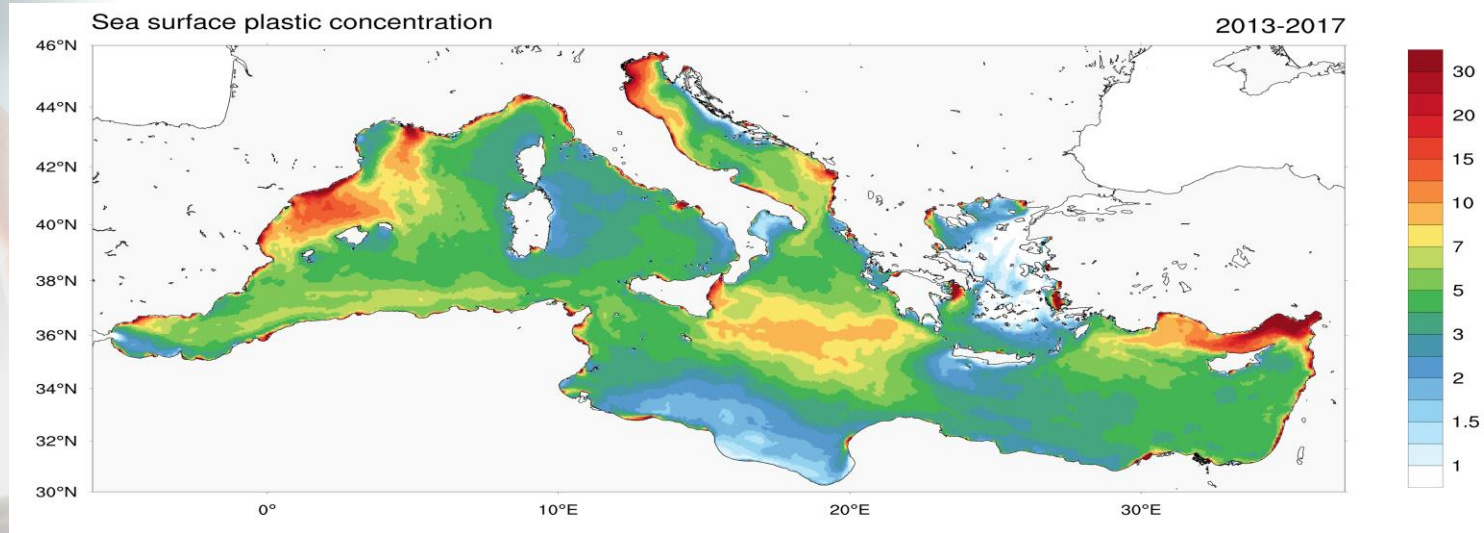
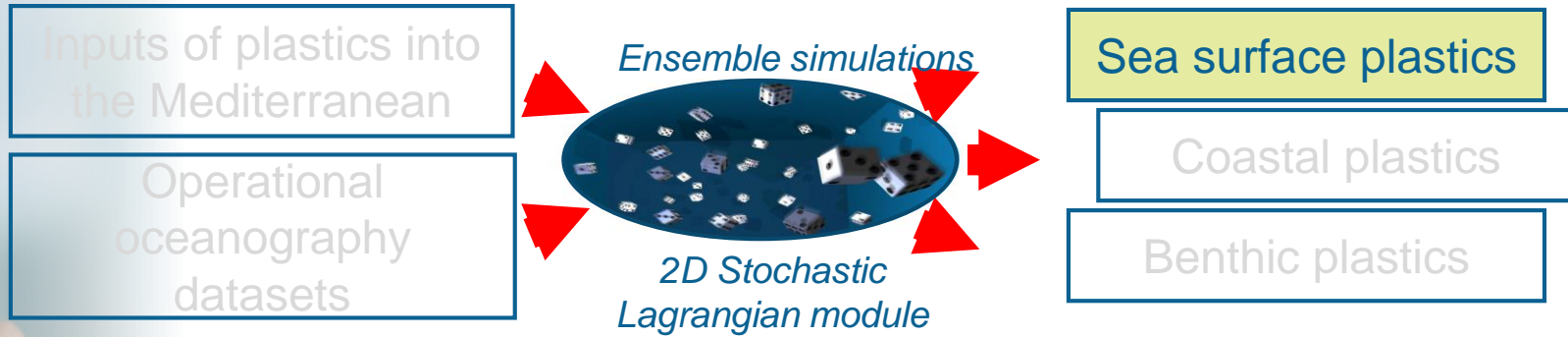
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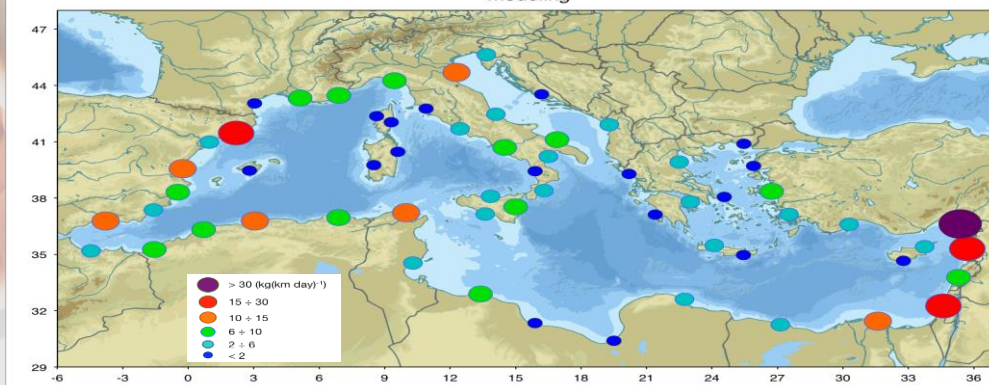
2D Stochastic  
Lagrangian module

Sea surface plastics

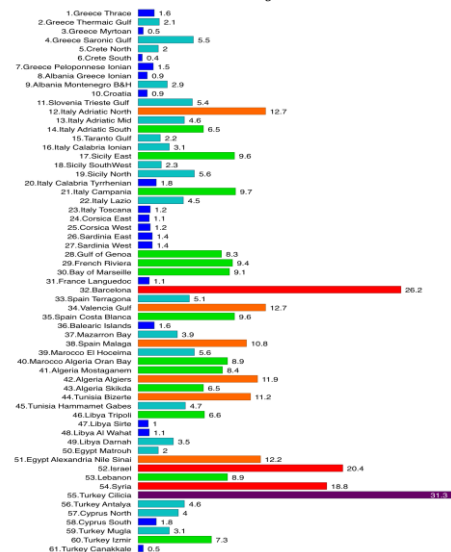
Coastal plastics

Benthic plastics

Plastic debris fluxes ( $\text{kg}(\text{km day})^{-1}$ ) onto the Mediterranean coastline  
modeling



Plastic debris fluxes ( $\text{kg}(\text{km day})^{-1}$ ) onto the Mediterranean coastline  
modeling



Relief Map of the Mediterranean Sea by Nzeemin,  
[https://commons.wikimedia.org/wiki/File:Relief\\_Map\\_of\\_Mediterranean\\_Sea.png](https://commons.wikimedia.org/wiki/File:Relief_Map_of_Mediterranean_Sea.png)

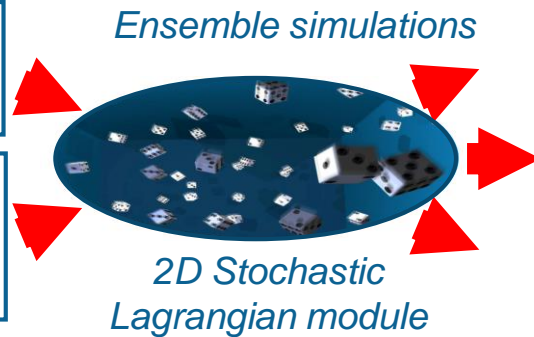


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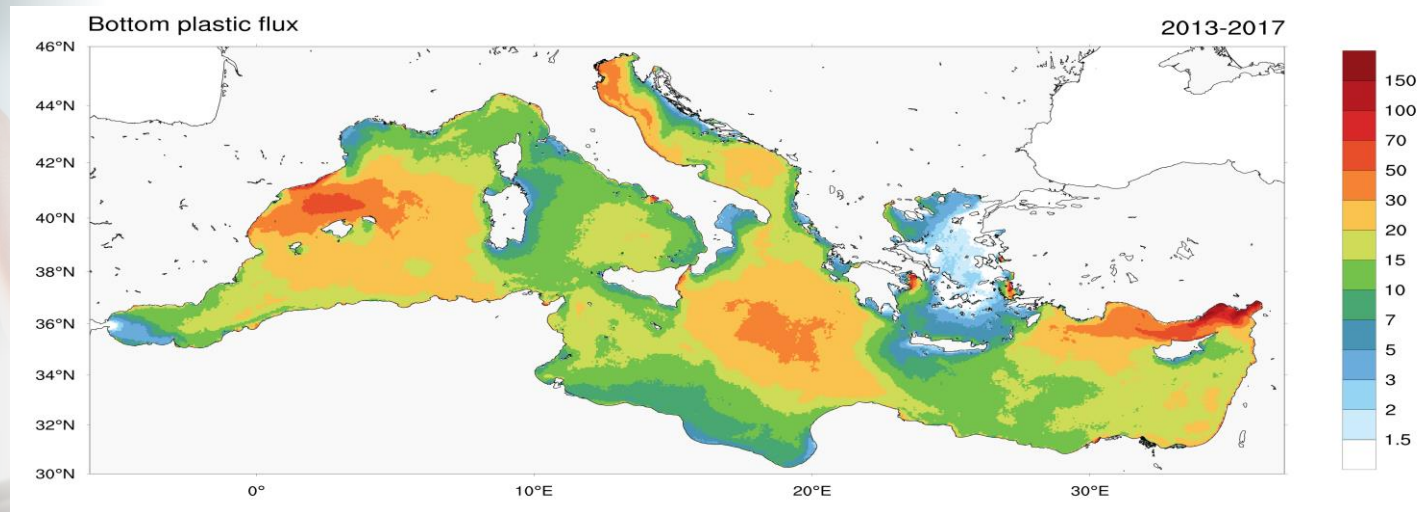
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Sea surface plastics

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Thank you!