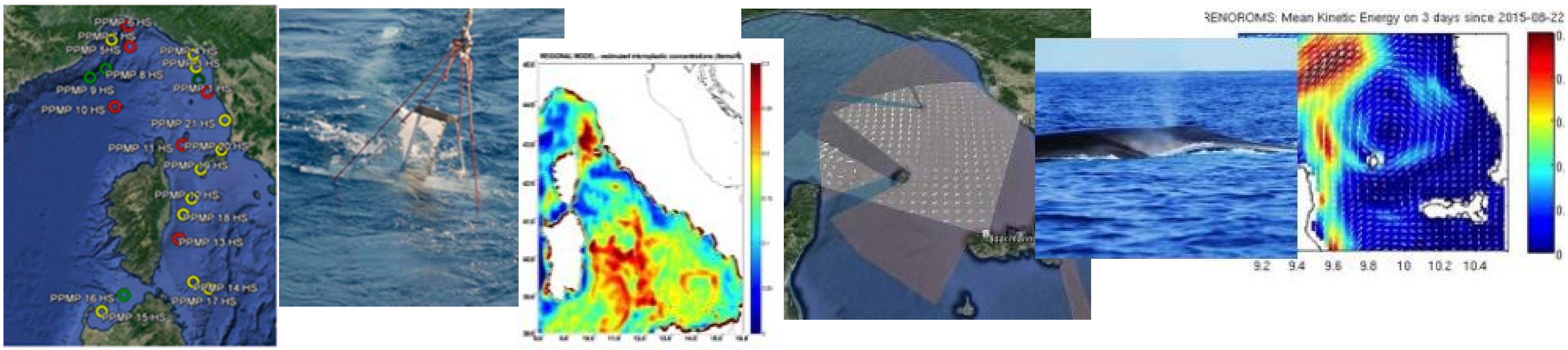
JONSMOD
Latest modeling techniques for shallow seas
Florence - October 17-19, 2018

Merging observations and numerical models to assess pollutants distribution in the North-Western Mediterranean Sea



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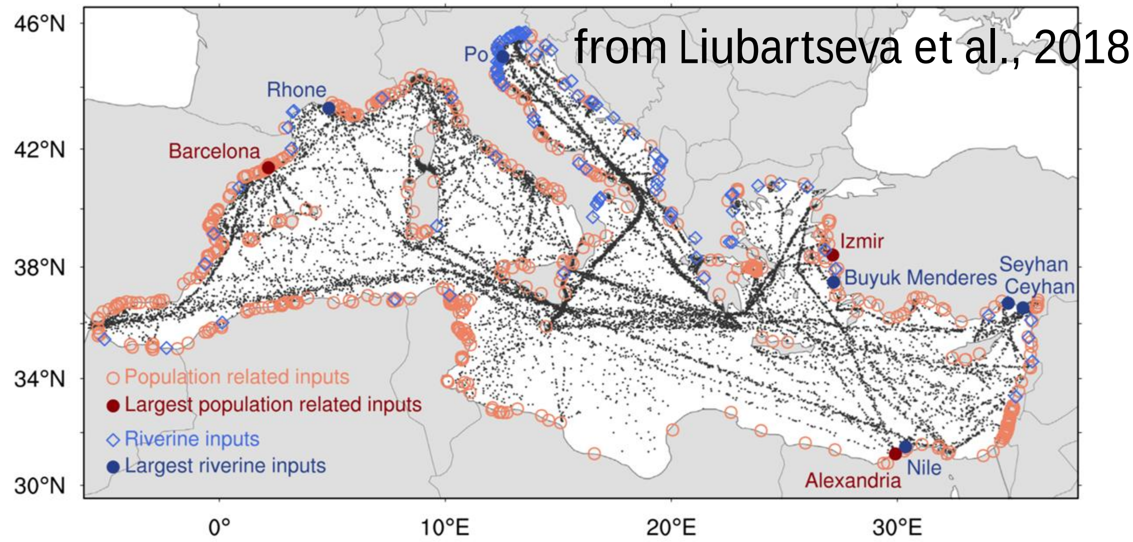
17/10/2018

Diffuse or point-source pollution ?

Numerical models aimed at forecasting pollution at sea normally are able to predict the evolution of active or passive tracers, from point to non-point sources.
Several codes are used for tracking pollutants and surface debris

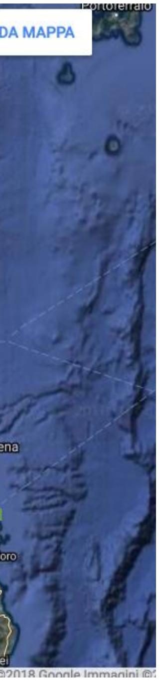


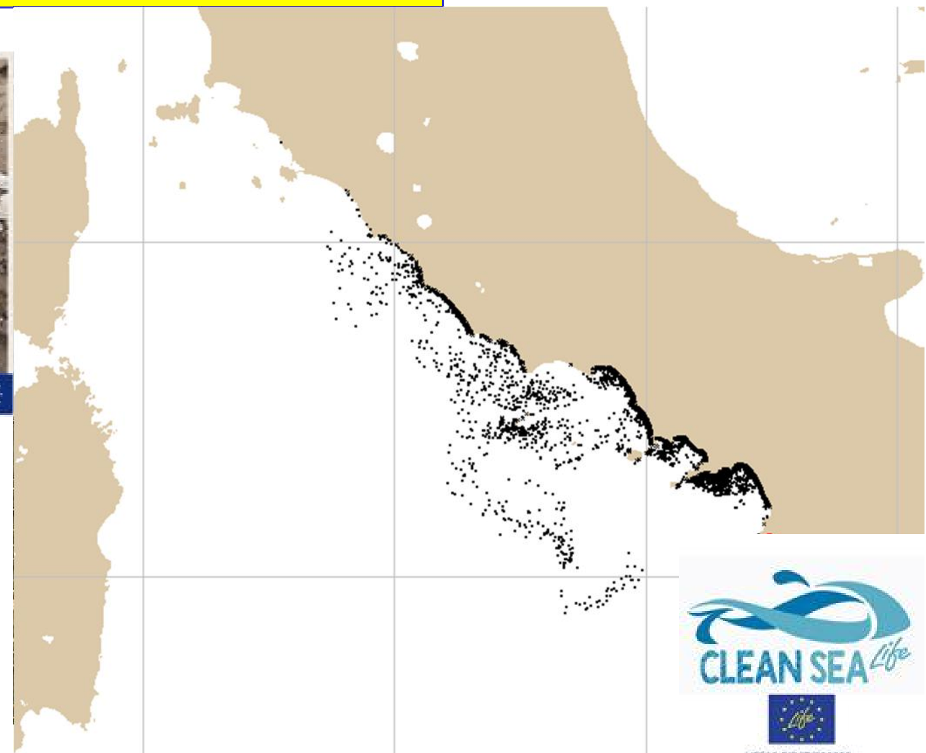
The reliability of such predictions is strongly dependent on the quality of the hydrodynamic data used to force transport/diffusion models.

- Model resolution (eddy resolving)
- Physical processes (ie. Wave-current interactions, tides)
- Model uncertainty
- Sources characterization

- Need for observations

A recent case study: PML from source to beaching

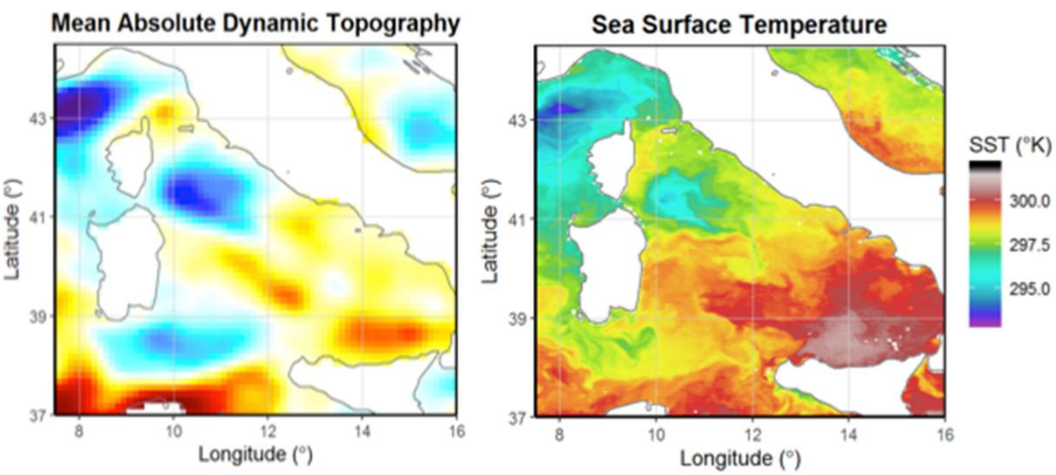




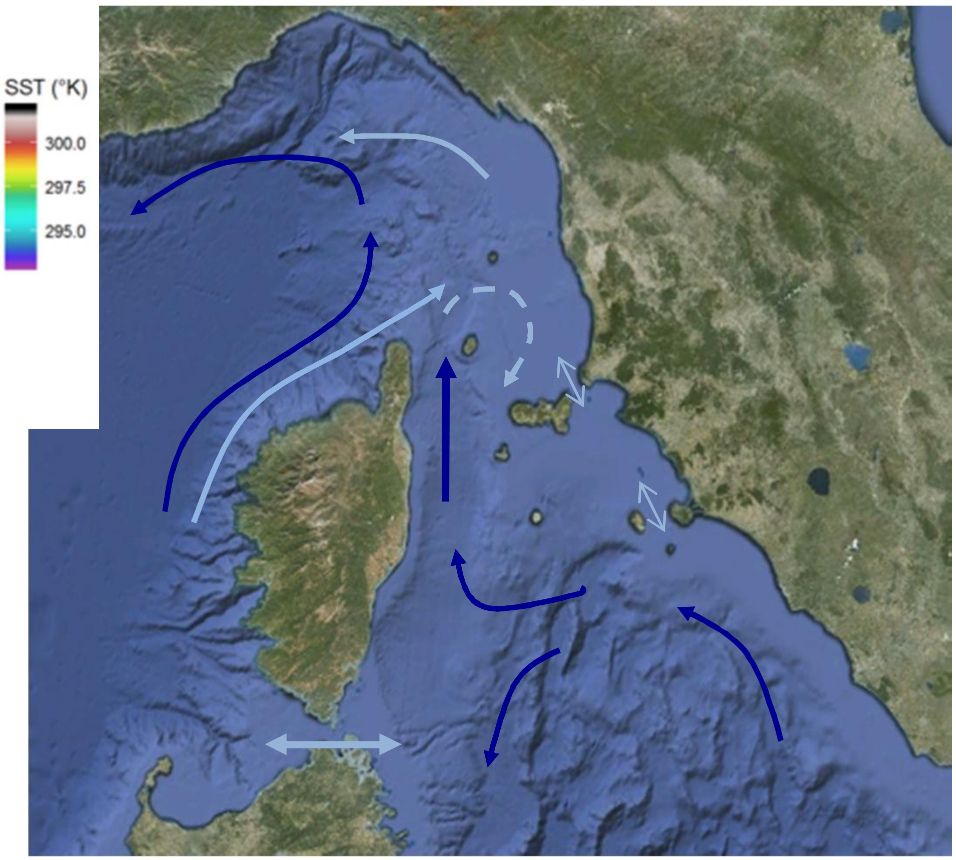
- On middle February 2018 a huge amount of filters used by water treatment plant were released at sea after following the breaking of a water purification tank.
- The pollutant source was identificated by back-tracking and then we were able to reconstruct the pathways of such filters and to simulate their impact on the Western Tyrrhenian beaches by forward tracking

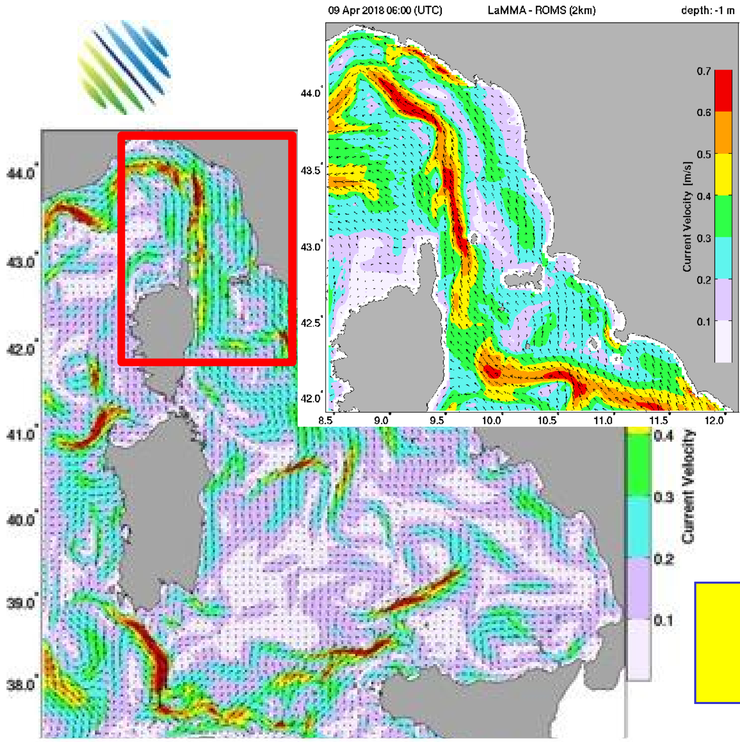
An overview of the Ligurian/North Tyrrhenian

- Ligurian and Tyrrhenian basin connected through a system of straits and channels on shelf areas.
- Seasonal circulation studied by Astraldi and Gasparini (1992), Vignudelli et al. (2003)



- Eastern and Western Corsica currents join to form the North Mediterranean Current.
- Prevailing northern currents along the Corsica channel
- Surface water circulation modulated by atmospheric forcing, recurrent anticyclonic circulation around the Capraia island





Model resolution: 1/48 ° → 1/72 °

Vertical levels: 32

Boundary/initial conditions: CMEMS

Bathymetry: EMODNET

Vertical turbulence: GLS

Horizontal mixing : none

Forecasting period: 120 h

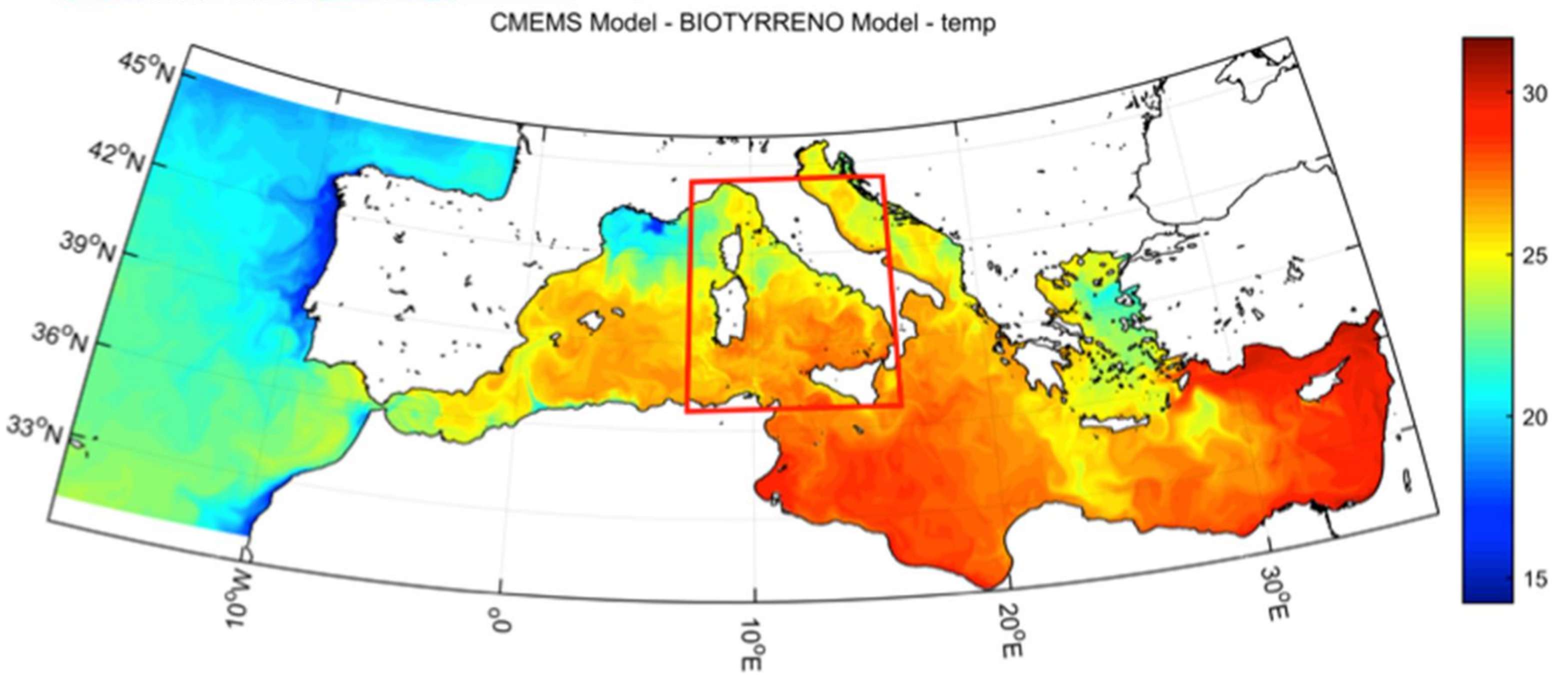
Analysis: 30 days run

River input: climatological flow

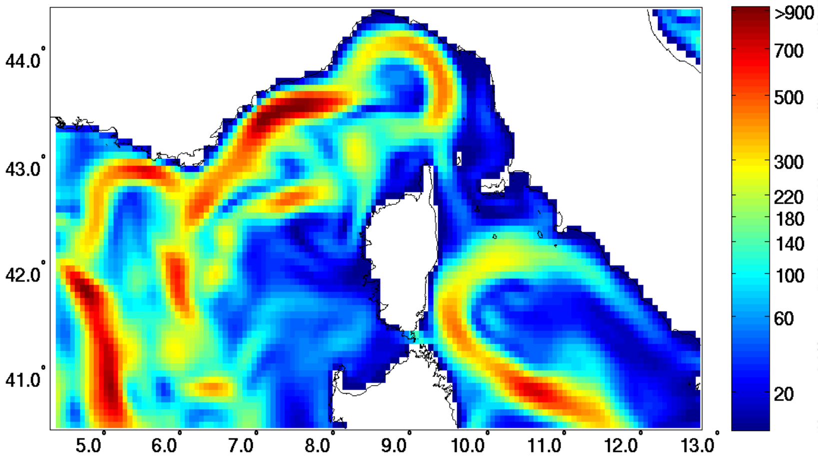
Atmospheric forcing parameterization: bulk flux formulation

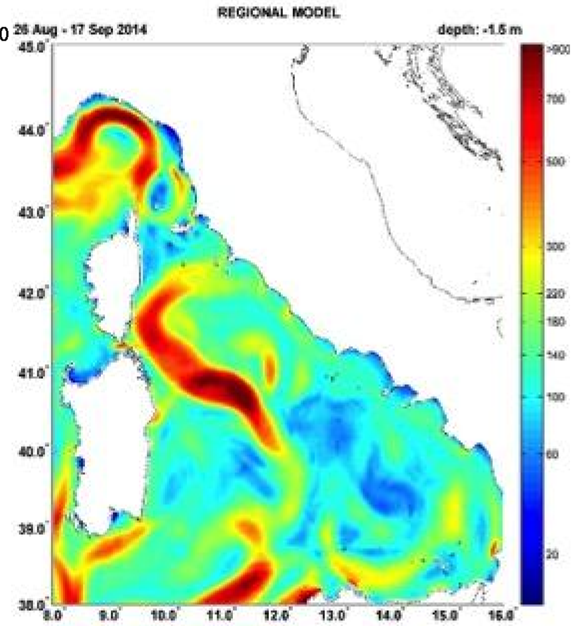
- WRF-ARW ECM 3Km (0-48 h)
- WRF-ARW ECM 12 Km (48-120 h)

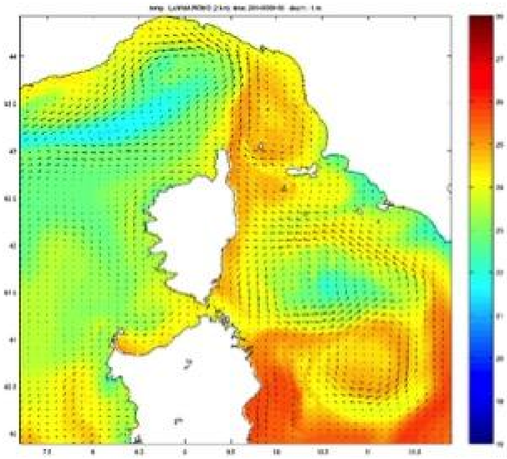
Models



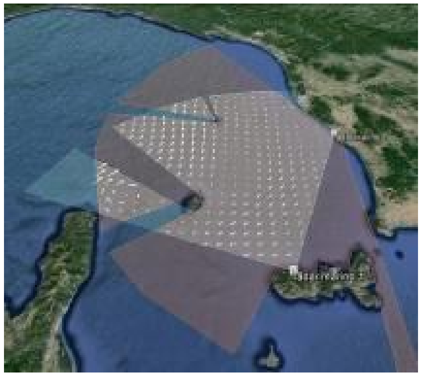
Resolution is critical

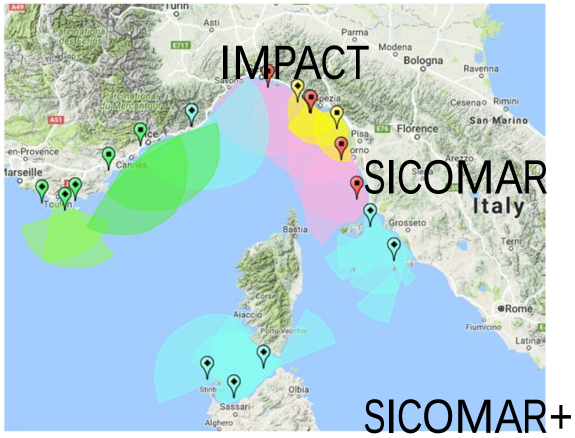




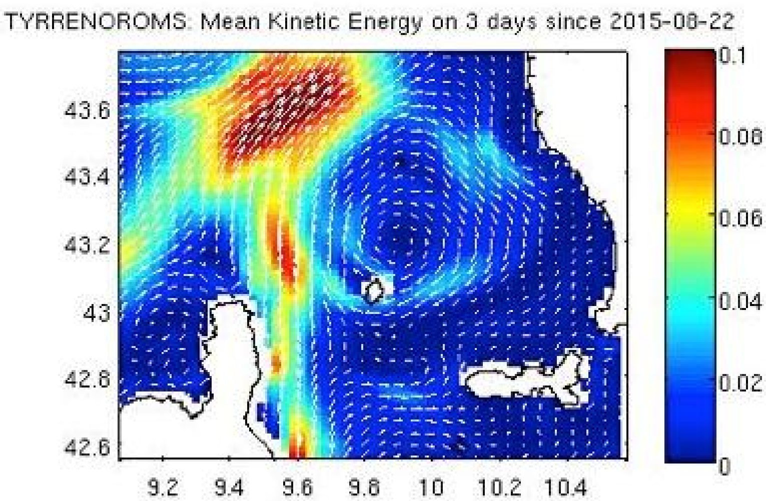


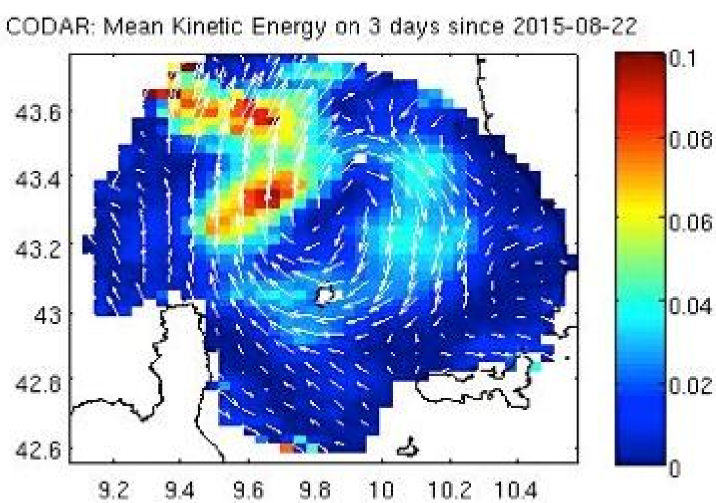
- Local scale features not always present in CMEMS products → need for downscaling
- Higher resolution models confirm the observed structure of surface circulation
  - Mesoscale circulation features also observed through HF radars along the Ligurian Sea (part of a wide initiative)

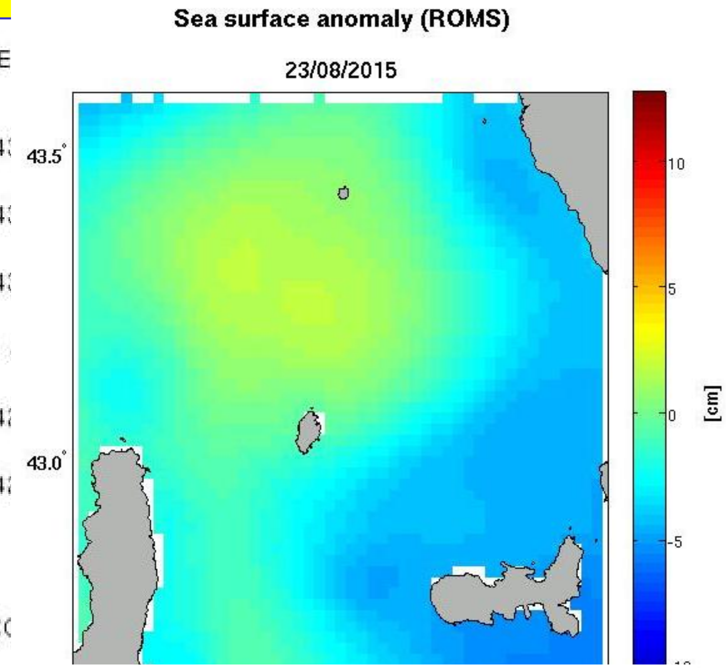


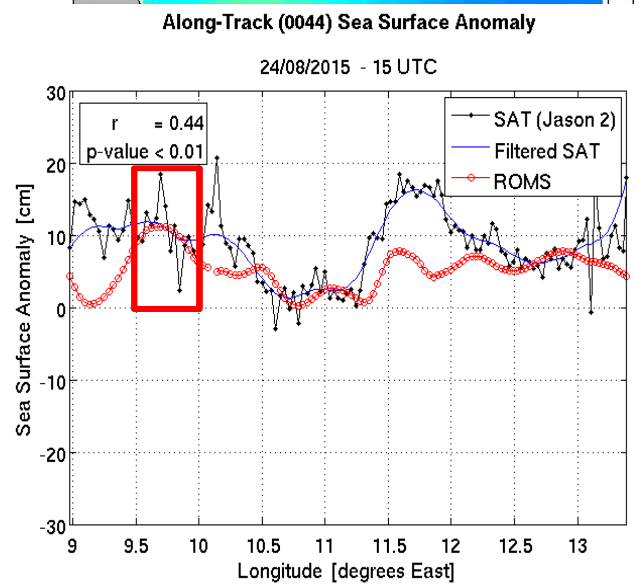


Comparing radar and model data





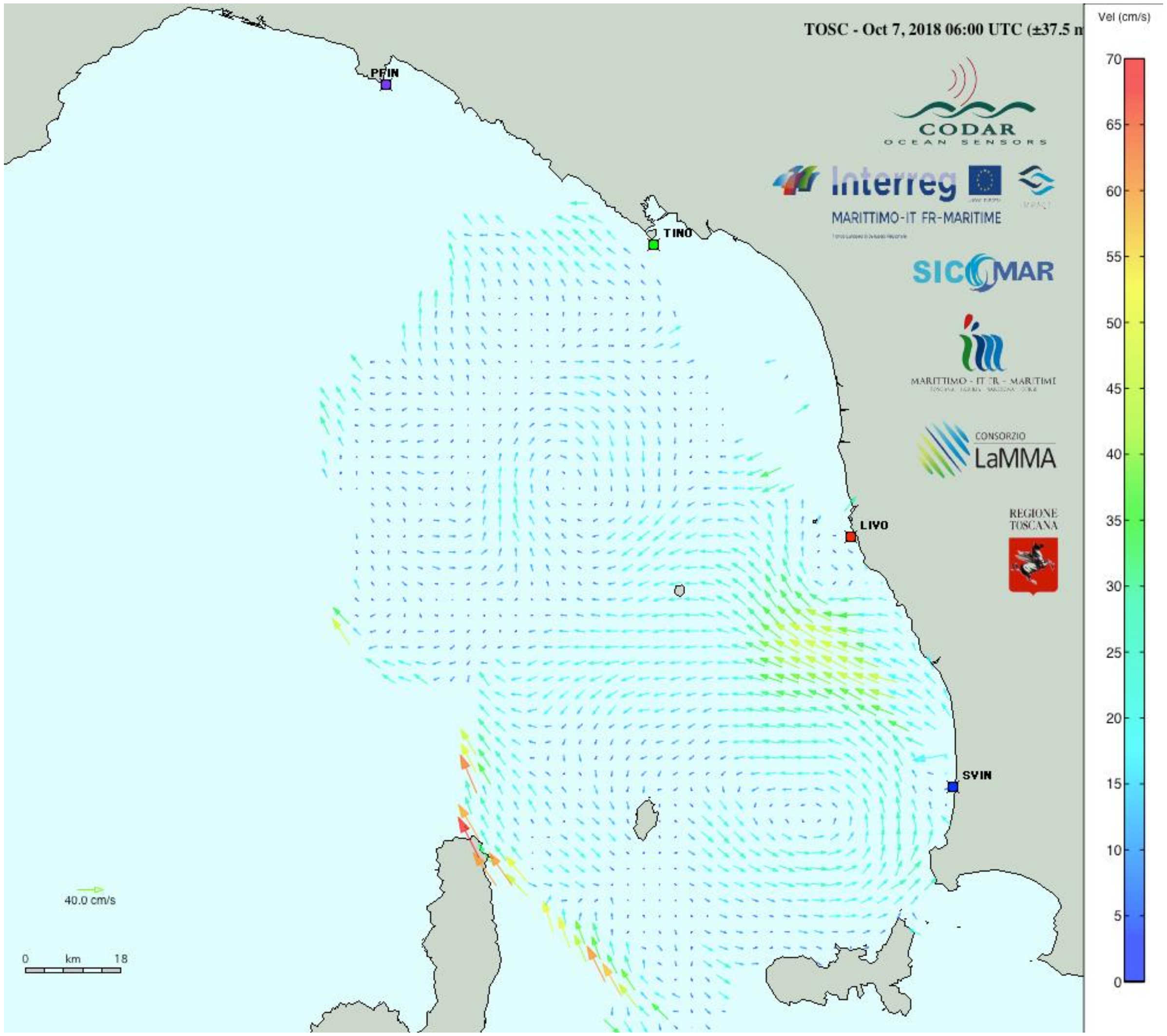




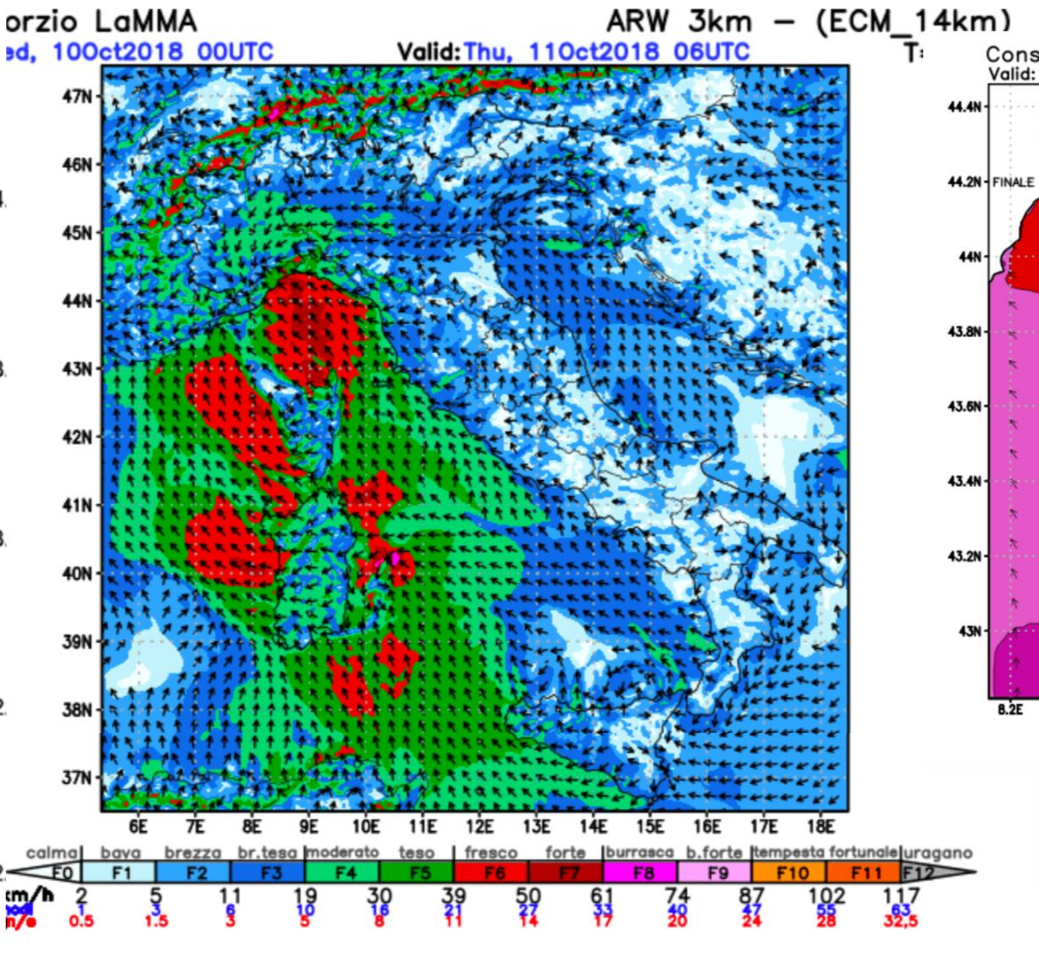
A case study of today → Predict the evolution and impacts of an oil spill

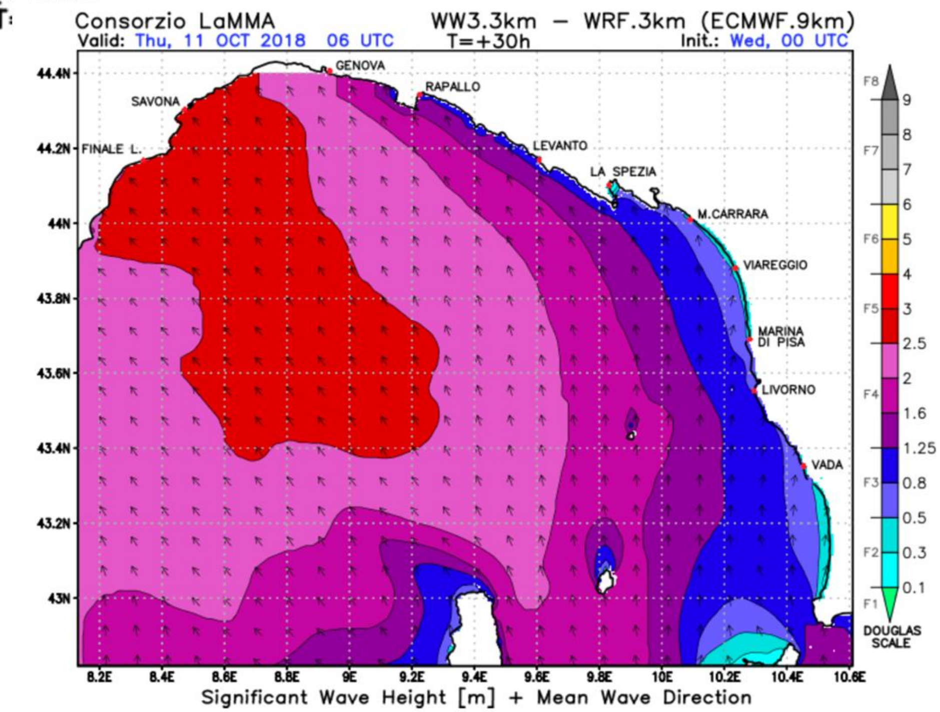
On Sunday October 7th two ships, Tunisian and Cypriot, both departed from the port of Genoa, clashed off the coast of Corsica. Such a spill created a trail of pollution several kilometers long and several hundreds of meters wide, heading away from Corsica to the Northwest.

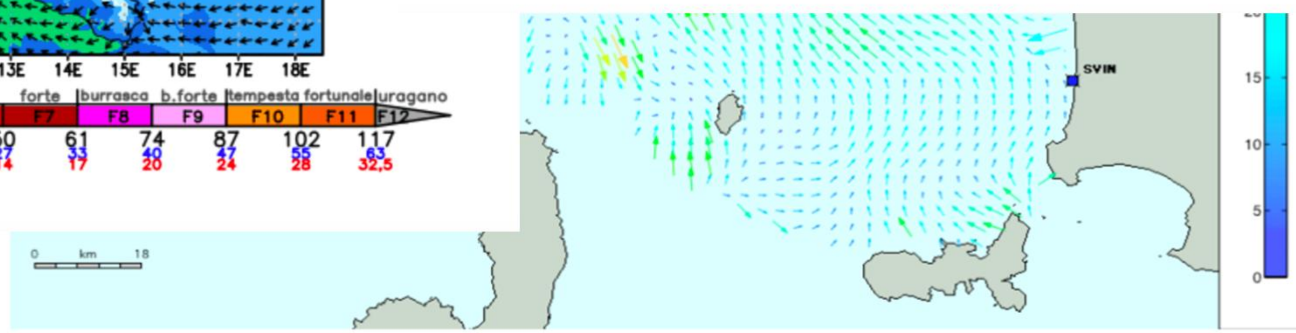
Radar vs model data



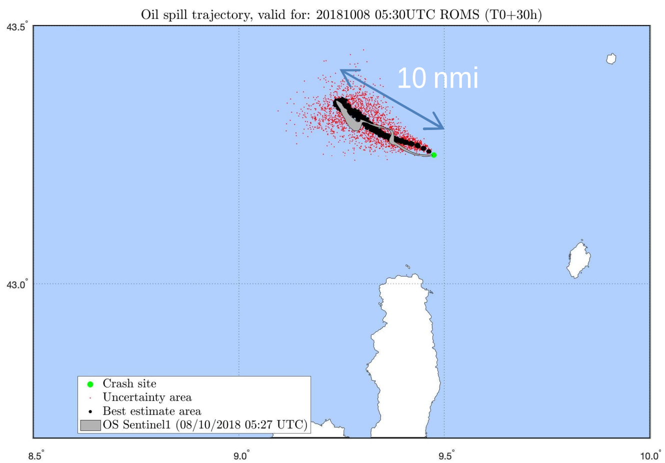
Radar vs model data

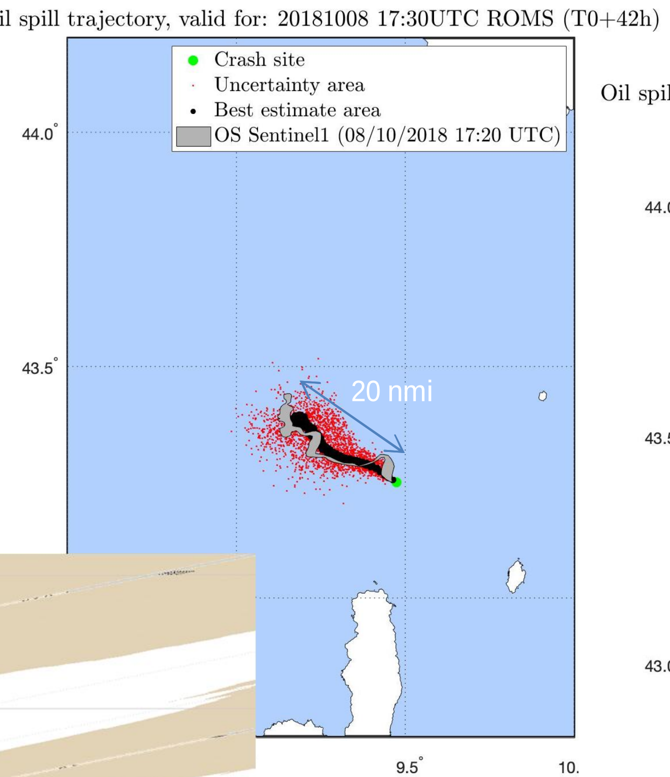


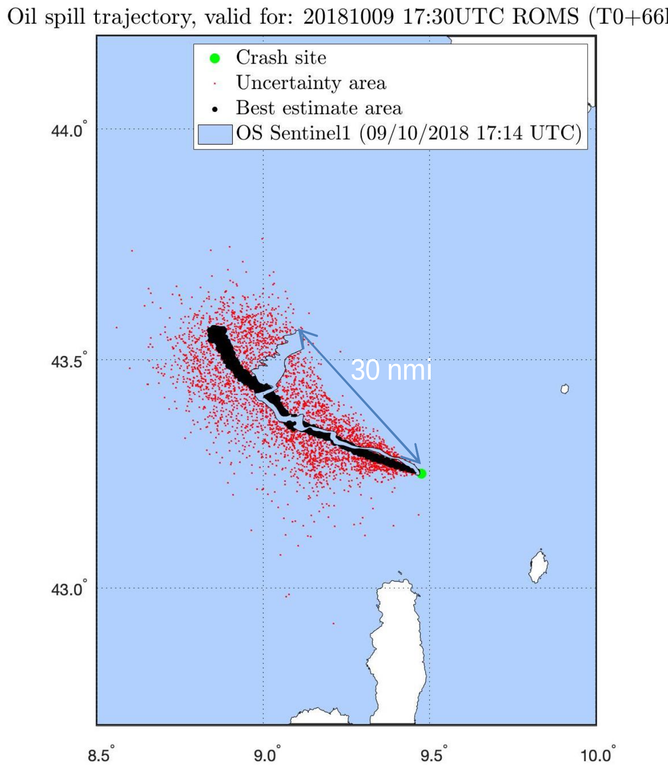


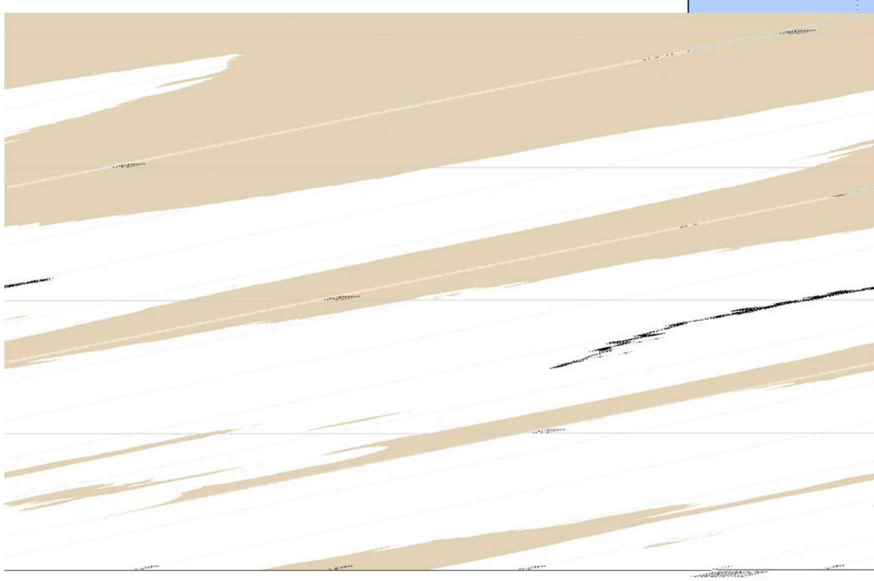


Model vs observations, few hours after the accident

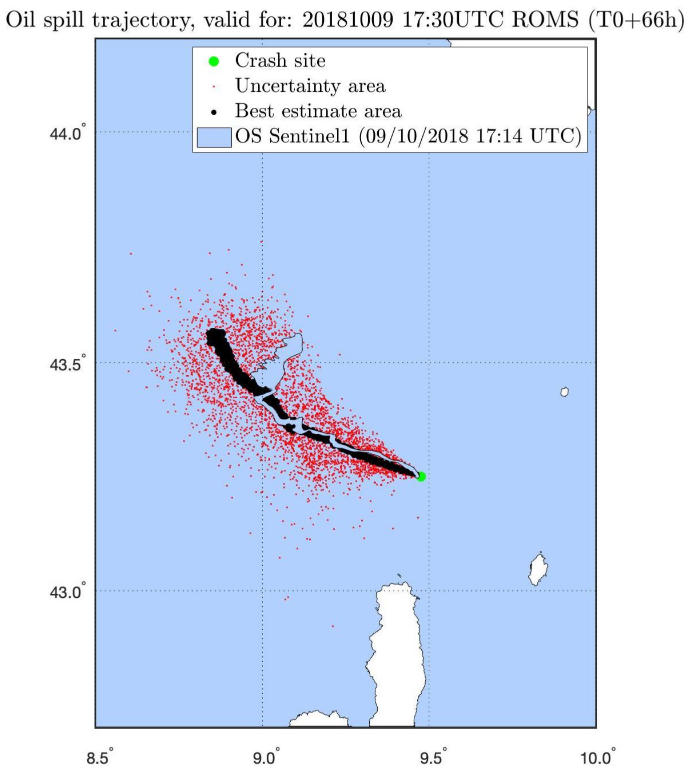


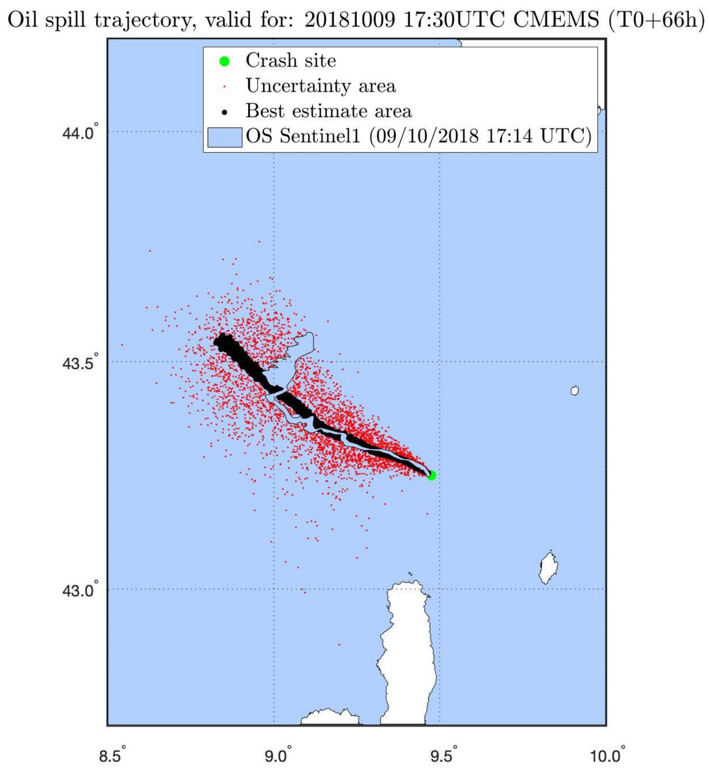




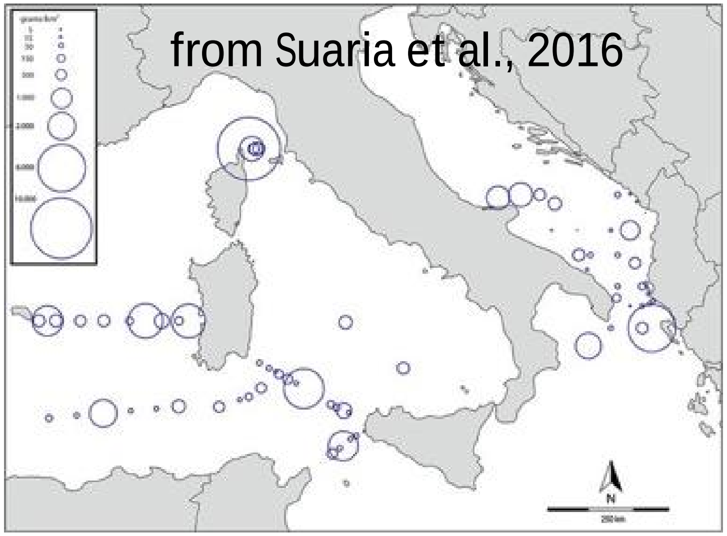


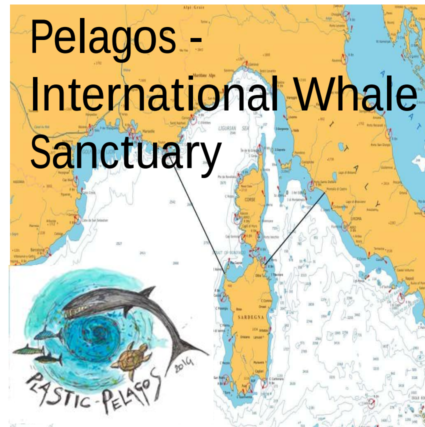
Effects of model resolution / forcings

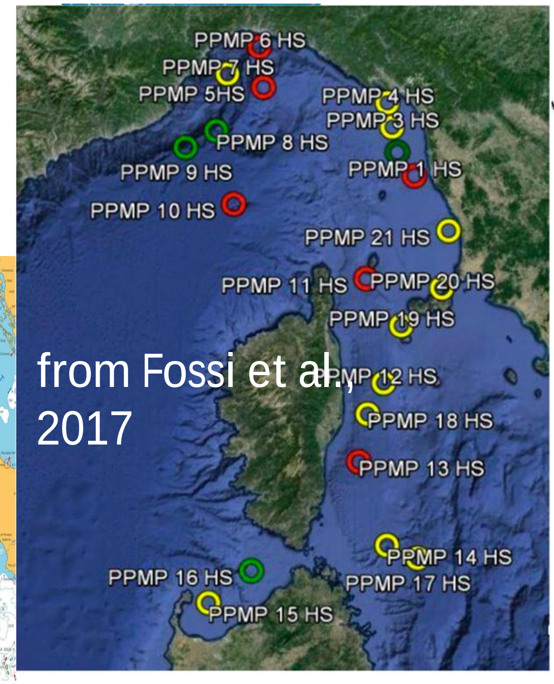




PML observations in the WMED







- High Plastic Marine Litter (PML) concentration found in the Med (Cózar et al. 2015)
- PML observations (number, weight and size), shows a wide variety of values (from a few grams to some kilograms per square kilometer) → do such concentrations depends on circulation?
- Lack of data; data spread over time

- Ob1: understand the interactions between the high PML concentrations and marine habitats (turtles, cetaceans, ...), dependant on the variability of ocean/biogeochemical conditions.
- Ob2: characterize "hot spot" areas for PML concentration to better address observation needs and designing future sampling campaigns

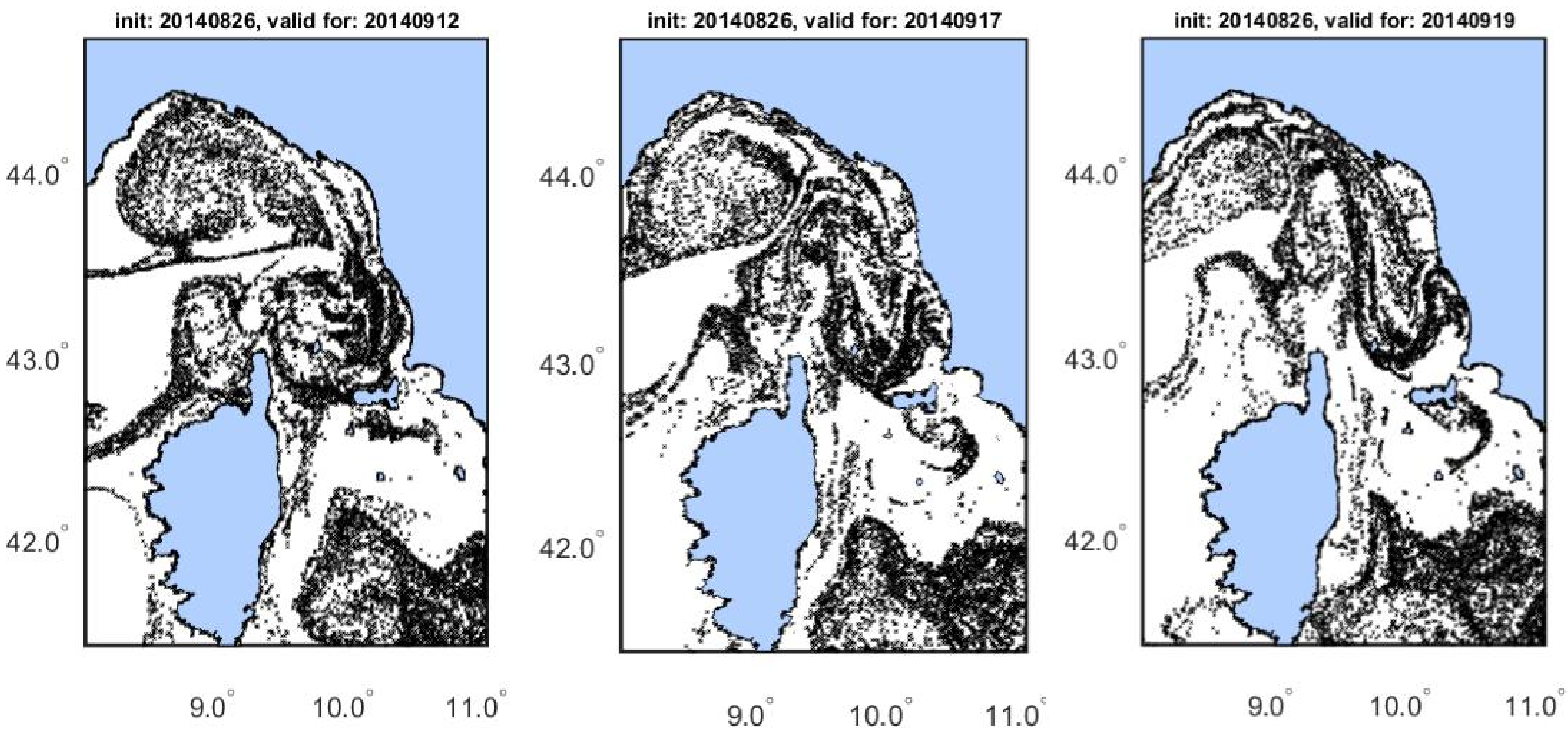
PML simulations, simplified assunptions

- PML simulation, a form of diffuse pollution → "standard" lagrangian particles simulation. But how to apply them? (No IC are known)
- Homogenous initial conditions → motivated by the lack of global information describing the distribution of floating debris
- Passive particles → no mass was considered (no differentiation between plastic types micro- meso- or macro-)
- No wind and no Stokes drift effects
- No diffusion effects
- Time scales considered ≤ 1 month
- No degradation processes taken into account for short time scales

- ❑ The concentration of a passive tracer (such as floating debris) at the mesoscale depends on previous hydrodynamic history, and too short of a simulation time does not allow particles to concentrate or to disperse on significant hydrodynamic structures
- ❑ Need to track particles for a sufficiently long period of time (15-30 days)

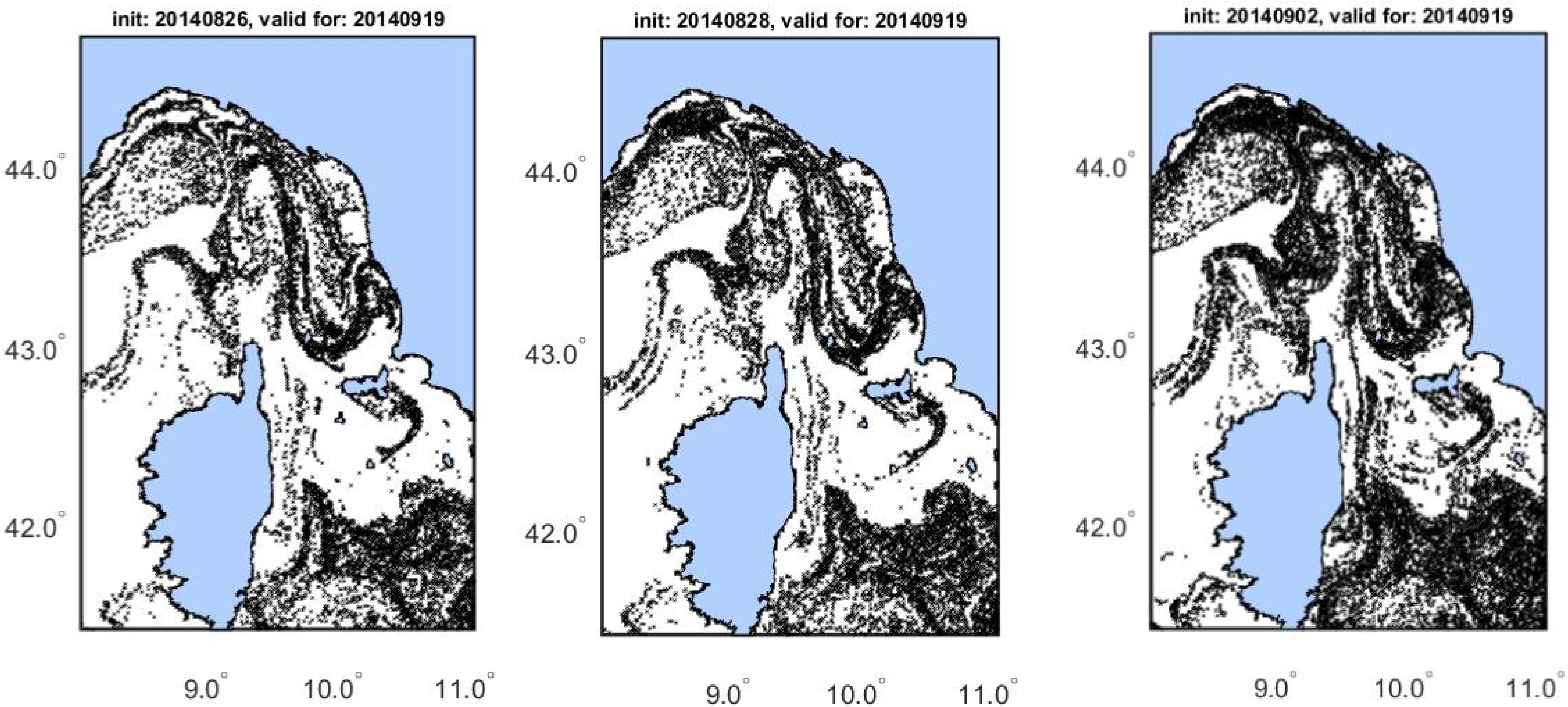
As a further approximation: no PML sources added to simulations

Persistency



- same initial conditions, different forecast times
- persistency of accumulation in specific areas for days

Effects of initial conditons on PML simulations



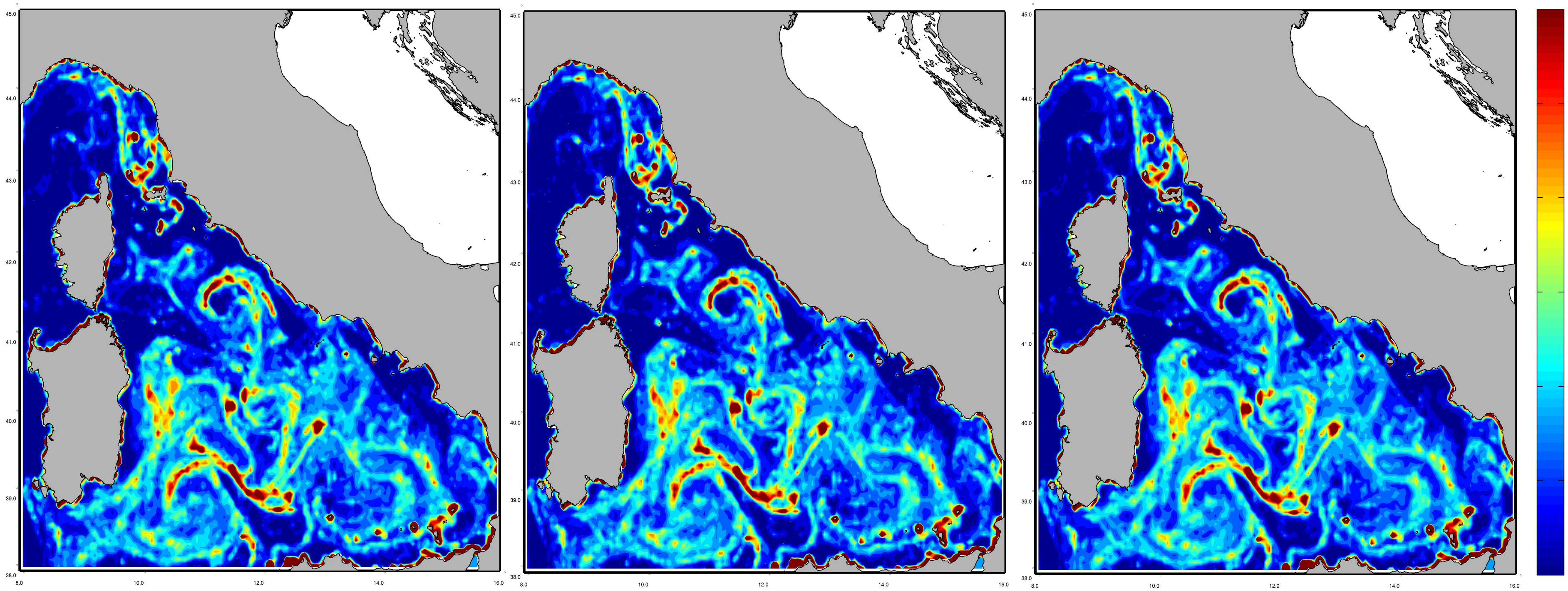
- Different initial times (IC), same forecast times;
- the system tends to lose memory of the homogeneous initial conditions after a few days, differences can be attributed to the uncertainties of the hydrodynamic prediction;

Calculation of concentrations

Initial splot density = 1 item/km^2
Histogram grid resolution = 5 km

Shifted splot grid
Initial splot density = 1 item/km^2
Histogram grid resolution = 5 km

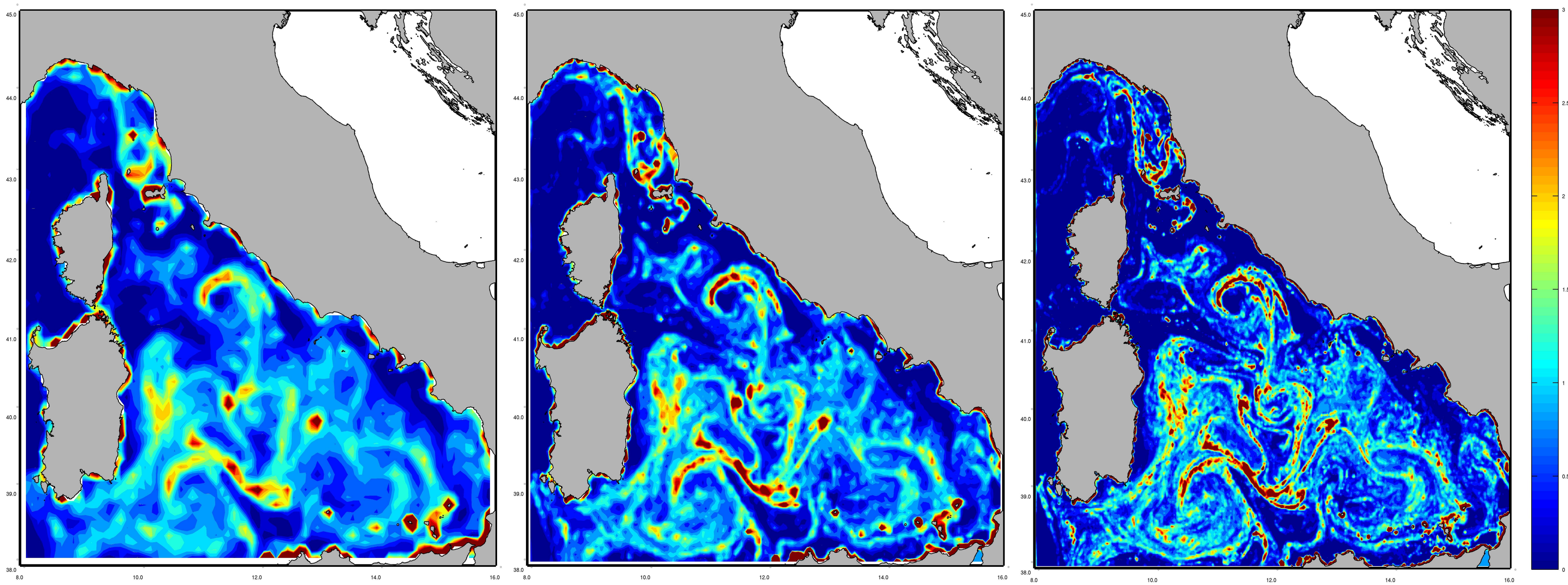
Higher splot density
Initial splot density = 8 item/km^2
Histogram grid resolution = 5 km



- not having diffusive effects in the model (or reduced to the minimum) the simulations do not seem particularly affected by the initial density

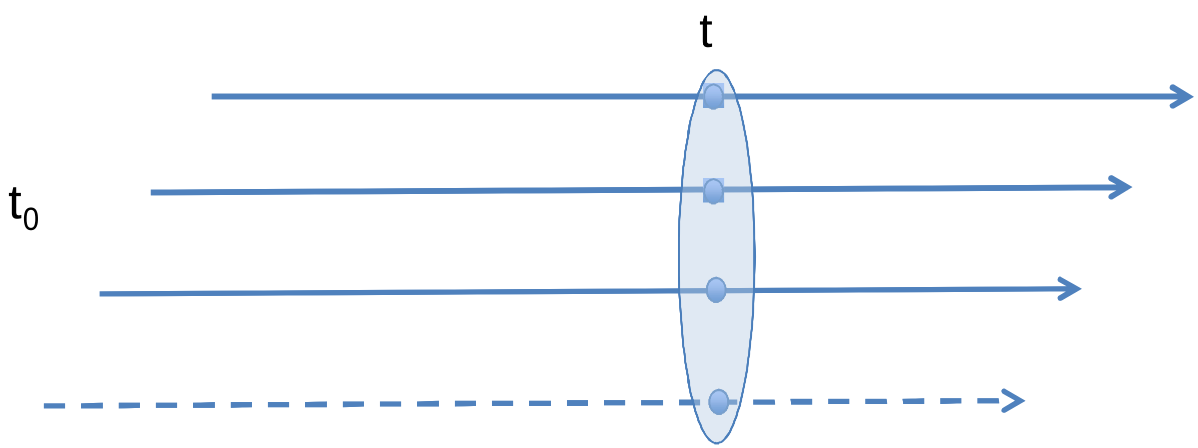
Concentration resolution

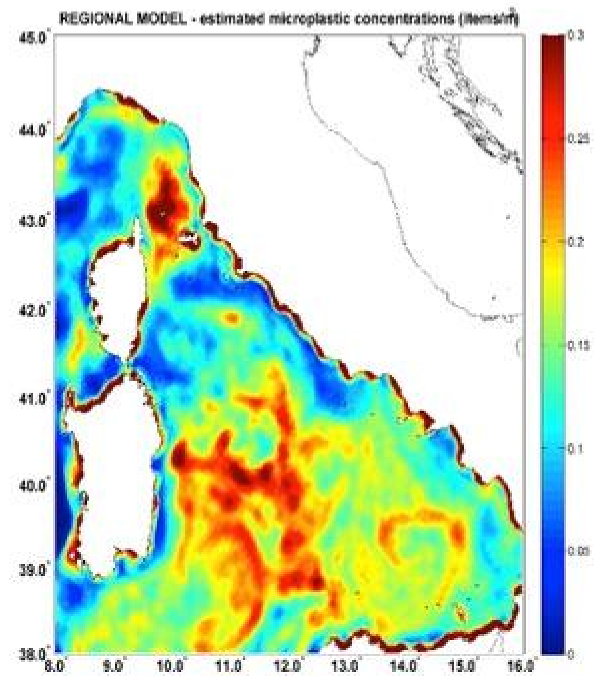
Initial splot density = 8 item/km^2 Histogram grid resolution = 10 km	Initial splot density = 8 item/km^2 Histogram grid resolution = 5 km	Initial splot density = 8 item/km^2 Histogram grid resolution = 2.5 km



- To improve statistical significance, we studied the effect of using different grids for calculating the concentration, close to the resolution of the model or with lower resolution

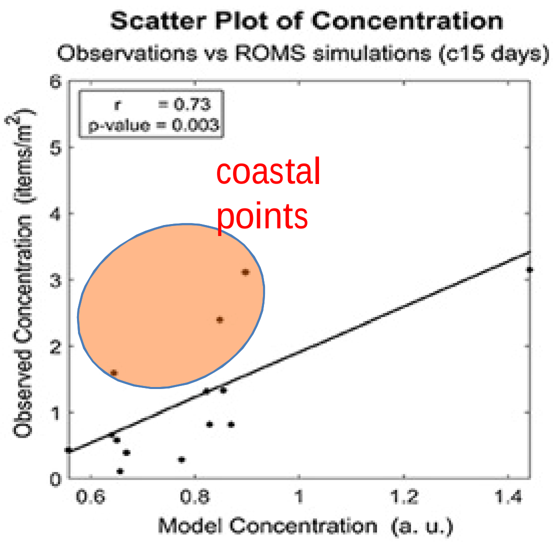
Model uncertainties

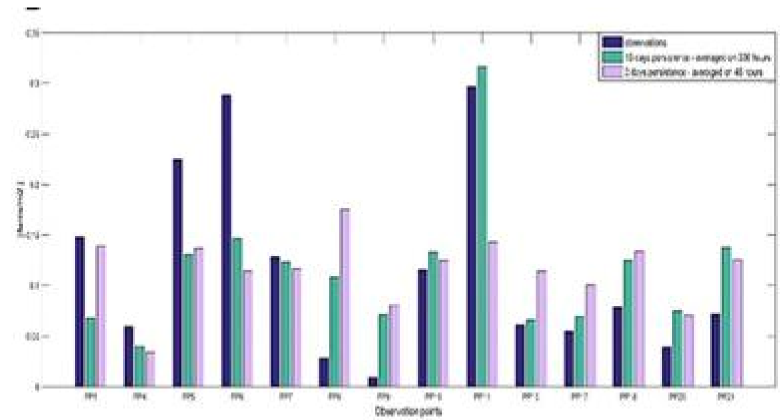




- We calculated the averages of the values obtained from different runs, and then compared the values obtained from the "virtual" concentrations obtained from the model with observations.
- The best results, in terms of correlation, were obtained by averaging runs lasting around two weeks $<C_{15}>$. The result also improves by increasing the number of simulations (up to 7-10) on which we calculate such an average.

Observations vs data





- Using our "best skill" metrics, good statistical correlation between the field data and the mean relative density, <Ct>, computed from the regional model → we can convert the dimensionless concentration or relative density <Ct>, into physical concentrations expressed in terms of standard units (e.g., items/m^2). A bias and a factor for unit conversion were estimated using a linear fit between the modeled and observed concentrations.
- Better fit found in areas characterized by more stable hydrodynamic features
- Worst fit found near coastal areas (e.g. port of Genoa, mouth of the Arno river) → need to include sources of PML in the model

Conclusions

- Need for PML distribution → understanding the presence of hot spot areas due to hydrodynamic structures <u>not persistent</u> but <u>recurrent</u>
- Too sparse observations. Need for more frequent and better designed observations for PML, alternative methods?
- Resolution is critical in resolving the mesoscale hydrodynamic processes at a regional scale that affect the concentration of PML
- Modelling sources for PML (from ports, major rivers, coastal cities, ship routes …) is crucial to understand the presence of PML expecially in coastal areas and even for short term predictions

Thanks!

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