Monitoring and prediction of marine coastal environments: the OGS regional operational system for the Northern Adriatic Sea

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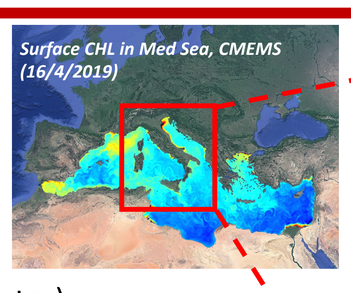
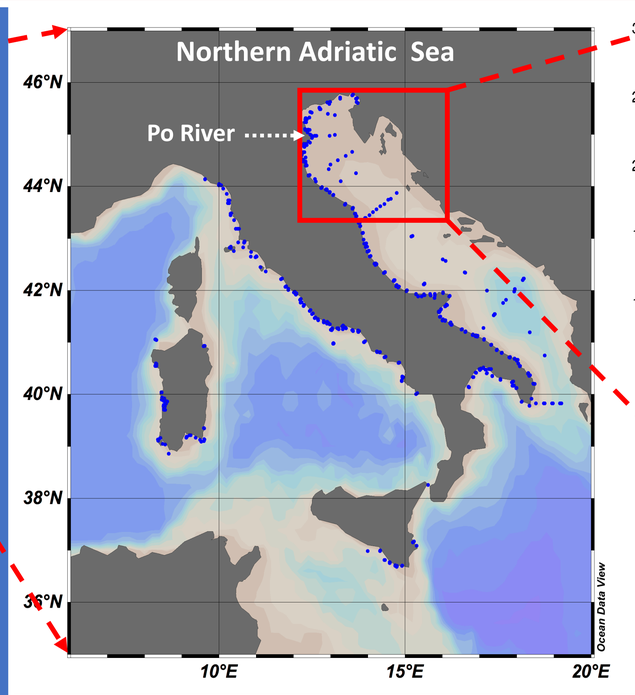
1. Context

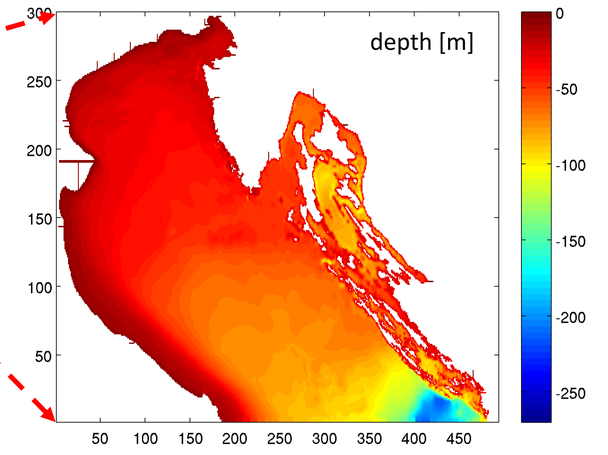
The **Northern Adriatic Sea** (NAd) is the northernmost part of the Mediterranean Sea.
NAd environmental conditions are characterized by:

- **shallow** bathymetry + extensive **freshwater** inputs
- **dense water** formation (strong cooling + evaporation in winter)
- ecosystem strongly linked to **nutrient loads** and **eutrophication** phenomena
- **tourism** + **marine resources exploitation**, depending on and influencing **seawater quality**
- coastal waters belonging to a **cross-border** region (Italy, Slovenia, Croatia)

The implementation of a **regional operational system** for NAd marine environment is a key asset to provide **services** for different users involved in **monitoring**, **management**, and **economic** activities.







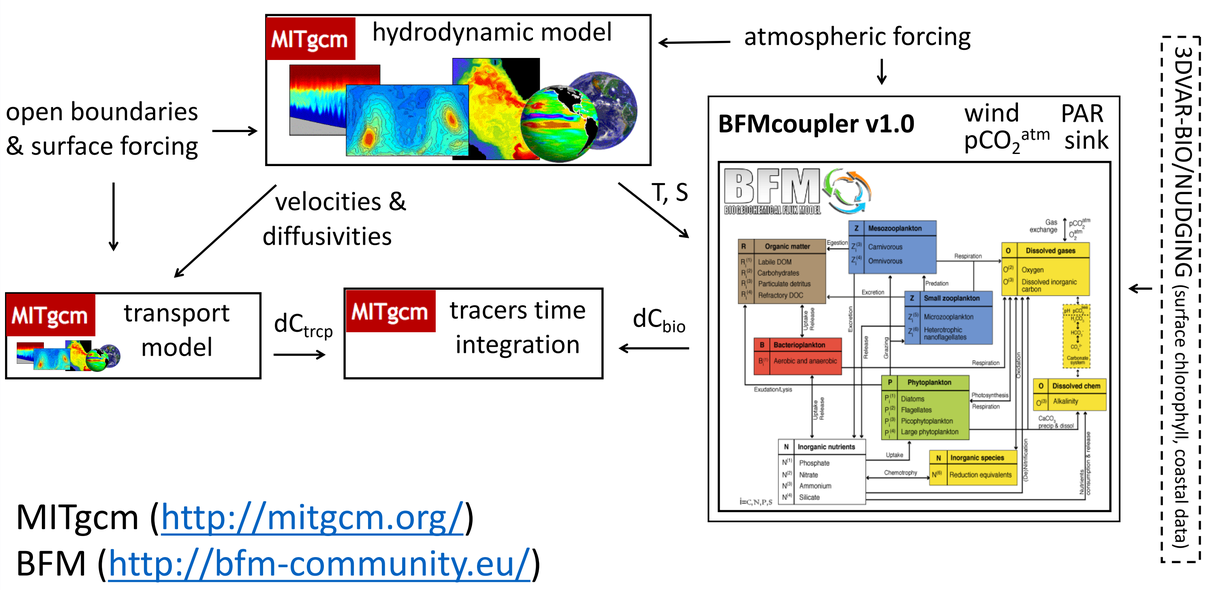
Study area (left) with in situ dataset (blue dots) and model domain and bathymetry (right). The model has an horizontal resolution of 1/128° (~850 × 600 m), with 27 vertical levels and 19 main freshwater sources (rivers).

model development

2. Proposed solution and model implementation

The system features a **high-resolution** (1/128°) **coupled MITgcm-BFM model** initialized and driven by the **downscaling** of the regional Mediterranean Copernicus Marine Environment Monitoring Service (**CMEMS**).
The model adopts a **nudging data assimilation** method integrating **in situ datasets** (**nitrate**, **phosphate**) managed by the Italian Institute for Environmental Protection and Research (**ISPRA**), **hydrological and meteorological data**, and **CMEMS satellite maps** of **sea surface temperature** and **chlorophyll**.

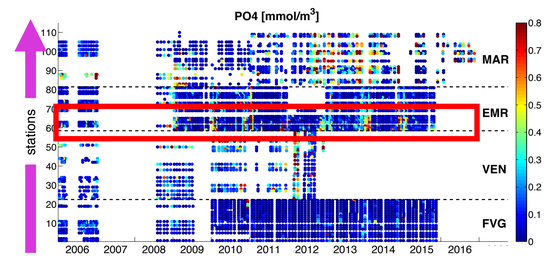
Adriatic Sea biogeochemical modeling: *Cossarini et al., 2015, Ecol. Model. 314, 118–134*
Adriatic Sea hydrodynamic modeling: *Querin et al., 2016, J. Geophys. Res. Oceans 121*
Coupled model: *Cossarini et al., 2017, Geosci. Model Dev. 10, 1423–1445*

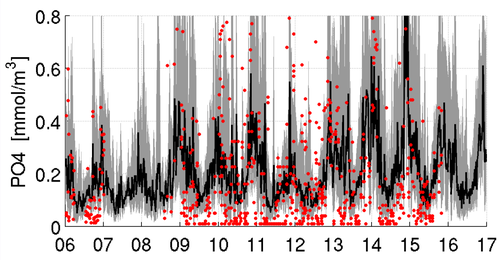


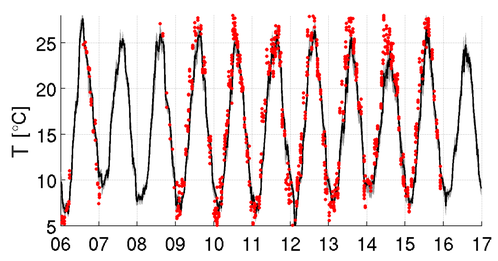
MITgcm (http://mitgcm.org/)
BFM (http://bfm-community.eu/)

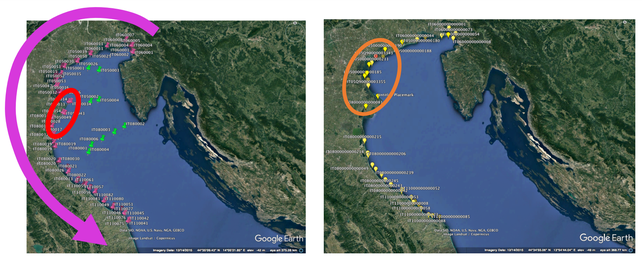
pre-operational phase

Fig. A - Comparison with the ISPRA dataset for PO4 and T (2006-2016) in the Po delta coastal area





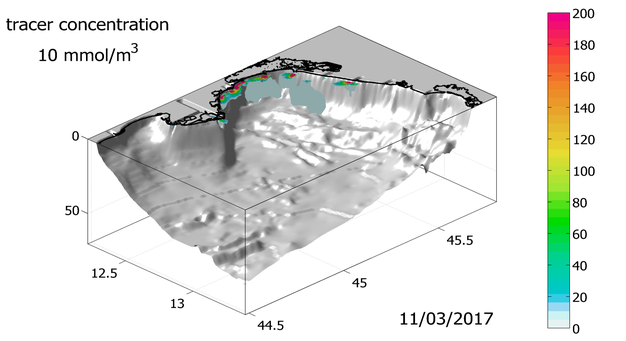




Assimilation and **comparison** with in situ data (ISPRA stations; **Fig. A**)

Coastal sewage discharges: bottom sources of **nutrients** and **pollutants** (ISPRA dataset; **Fig. B**)

Fig. B - Bathing waters case study: potential impact on coastal areas of 12 underwater sources of "E. Coli"



Contaminant evolution based on dispersion/transport first order decay law [*Chan et al., 2013*]:

$$k(z,t) = \left(k_b + k_s S(z,t)\right)\theta^{T-20} + k_I I(t) e^{-e_t z}$$

z (depth), t (time), k_b=0.8, k_s=0.017, k_I=0.086, e_t=0.5 (higher transparency), θ=1.07

3. Results

Model validation (reanalysis 2006-2017)

The model reproduces the **seasonal** and **interannual variability** of the main hydrodynamic and biogeochemical properties of NAd, **consistently** with the national observing system dataset (Fig. A), literature references and available climatologies [*Solidoro et al., 2009*].

Estimation of eutrophication and water quality

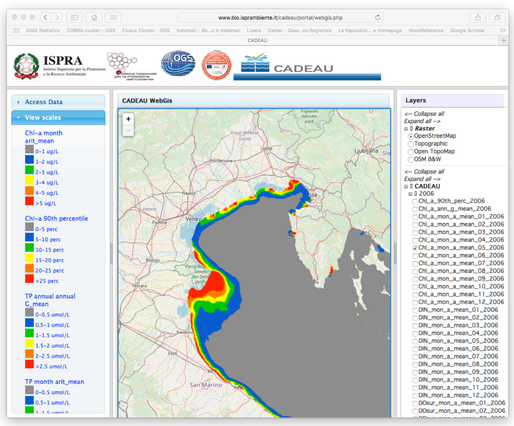
Current products (freely available) include:

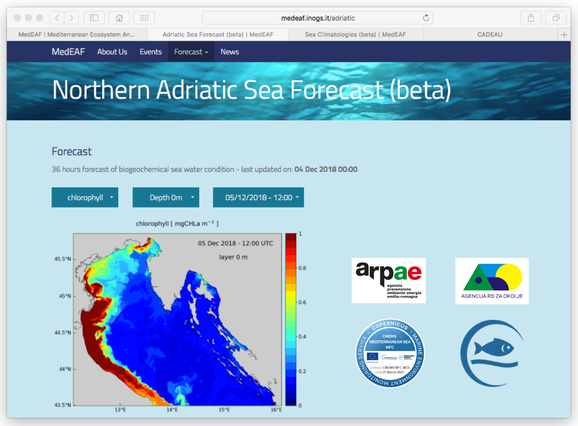
- quantitative assessments of the **current status** of the marine environment
- **short-term forecast** provided as hourly maps of environmental variables (e.g., temperature, nutrients, chlorophyll and oxygen)
- **specific products** and **indexes** designed to support the evaluation of the Good Environmental Status in NAd to meet the requirements of **EU Directives** (WFD/BWD/MSFD)

Potential impact of sewage discharges

The model can simulate the dispersion of underwater plumes of pollutants (e.g., Escherichia Coli, Fig. B).

operational phase





4. Towards the operational system

The system is now working in **pre-operational phase** with the aim to:

- **extend** the existing service implemented within the **Copernicus CADEAU** User Uptake demonstration project
- provide **detailed** and **up-to-date** information and forecasts of **physical** and **biogeochemical** seawater conditions for NAd

results are published on the webpage of the Mediterranean Ecosystem Analysis and Forecast (**MedEAF**) system (http://medeaf.inogs.it/adriatic)

Next steps in 2019/2020

Foreseen **system developments** include **assimilation** of **surface current velocity** from HF radar data and of **biogeochemical coastal data**, revised **optical component of the BFM model** to account coastal water characteristics.

Credits: ISPRA staff for leading the CADEAU project
work generated using E.U. Copernicus Marine Service Information

Summary

We developed a **service** mainly targeted to **policymakers**, **public authorities** and **private stakeholders** who need reliable and detailed **information** and **tools** to develop and comply with **specific legislation** and **policies** for environment and civil protection, urban areas management, fishery governance, human health, sustainable development and tourism.