ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale
Sistema Nazionale per la Protezione dell'Ambiente
JONSMOD
Latest modeling techniques for shallow seas
Florence - October 17-19, 2018
CONSORZIO LaMMA

HIGH RESOLUTION NUMERICAL ANALYSIS OF BATHING WATER HYDRODYNAMICS AROUND ADIGE RIVER MOUTH (NORTH ADRIATIC SEA)

CADEAU Project – Operational Service in support of the EU directives in the North Adriatic coastal areas

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COPERNICUS MARINE ENVIRONMENT MONITORING SERVICE
CMEMS DEMONSTRATION COASTAL - MED SEA
Contract 32-DEM2-L5
Until 4 October 2019

CADEAU

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

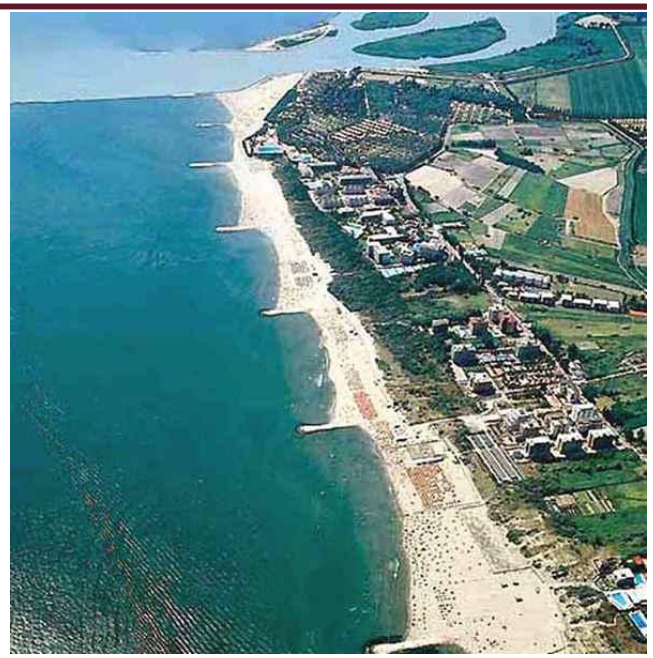
Sistema Nazionale per la Protezione dell'Ambiente

CADEAU

Cadeau project

CADEAU is a downstream coastal service devoted to operationally deliver products to quantify nutrient dynamics, eutrophication and bathing water quality in coastal areas in support of the application of the EU Directives relative to coastal and marine environment (WFD, UWWTD, BWD, MSFD) derived.

The forcing conditions are provided by the Copernicus Marine Service (CMEMS) and COSMO-LAMI model (ARPAE-SIMC, the HydroMeteorologicalService of the Emilia-Romagna Regional Agency for Environmental Protection), the model also assimilates in situ water quality data from the SoE EIONET network.



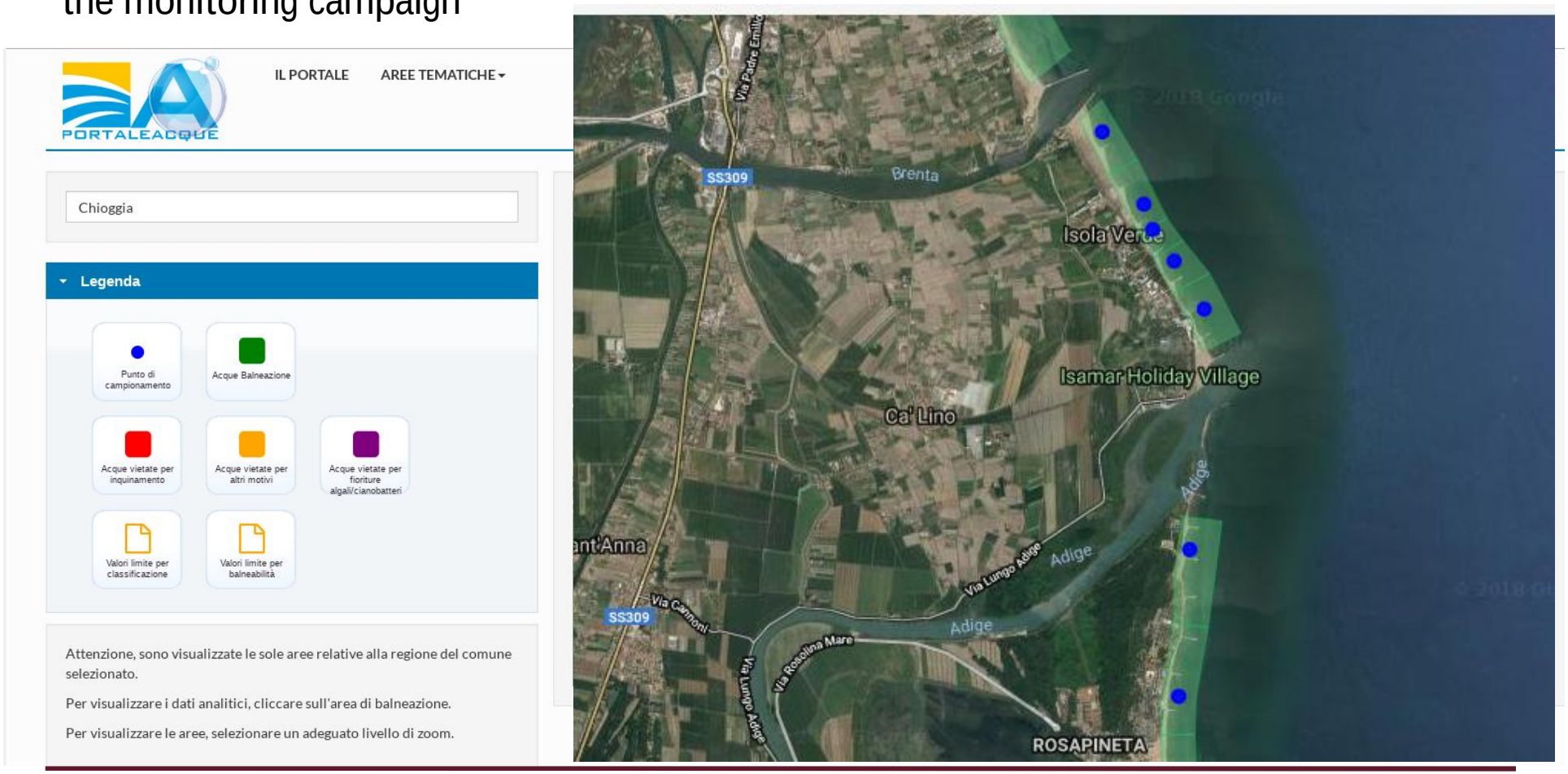
Give information on

- the level of impacts associated to urban waste water treatment plants (UWWTPs), with discharge points in or near the sea and rivers;
- on the space-time distribution of major parameters related to water quality for Noth Adriatic Sea (focus point Chioggia town)

NORTH ADRIATIC SEA ⟶ ADIGE RIVER MOUTH

North Adriatic coast is one fo the most sensitive area due to eutrophication and marine resources exploitation (acquaculture; overfishing, ...) affecting the sea water quality

''Portale Acque'' website deals with all the italian bathing water with real time data of the monitoring campaign



WAVE-CURRENT INTERACTION MODEL (ISPRA)

- Shallow water equations for coastal area study
- Finite difference scheme
- Wave-current fully coupling in the time domain

$$\frac{\partial \eta}{\partial t} + \frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = 0$$

$$\frac{\partial U}{\partial t} + \frac{\partial (U^2 / H)}{\partial x} + \frac{\partial (UV / H)}{\partial y} = -gH \frac{\partial \eta}{\partial x} + 2\frac{\partial}{\partial x}\left(\mu H \frac{\partial u}{\partial x}\right) + \frac{\partial}{\partial y}\left[\mu H \left(\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right)\right] - FU$$

$$\frac{\partial V}{\partial t} + \frac{\partial (UV / H)}{\partial x} + \frac{\partial (V^2 / H)}{\partial y} = -gH \frac{\partial \eta}{\partial y} + \frac{\partial}{\partial x}\left[\mu H \left(\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right)\right] + 2\frac{\partial}{\partial y}\left(\mu H \frac{\partial v}{\partial y}\right) - FV$$

$$U = Hu \qquad V = Hv \qquad H = h + \eta$$

$$F = \frac{g}{H^{7/3}} n^2 \sqrt{U^2 + V^2}$$

Eddy Viscosity $\mu = \mu_0 + \mu_T$

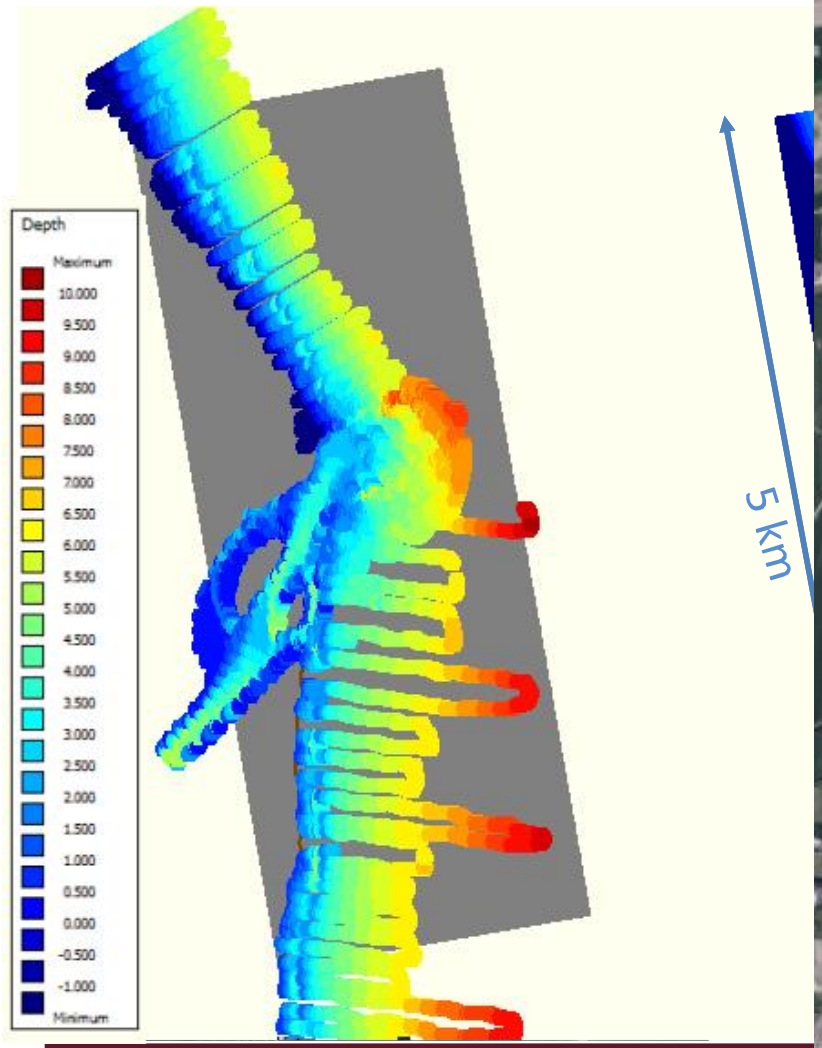
$\mu_T = C\, H\, u_\tau$

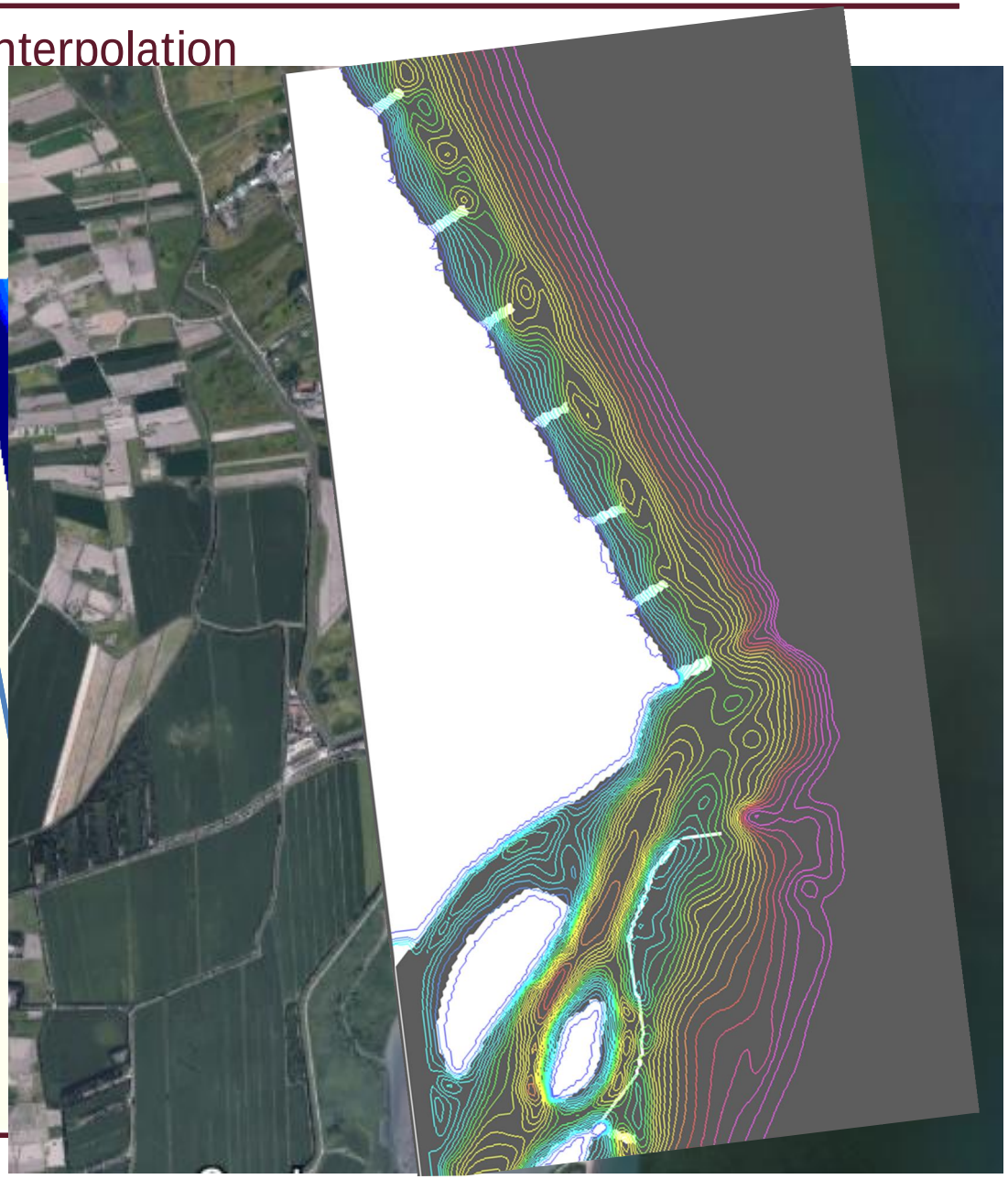
Coastal engineering scale
Spatial resolution: 1m → 100 m
Time scale: 1 hour → 1 day

F. Lalli et al., 2016. A numerical model for wave-current interaction at the scale of marine engineering, J OPER OCEANOGR

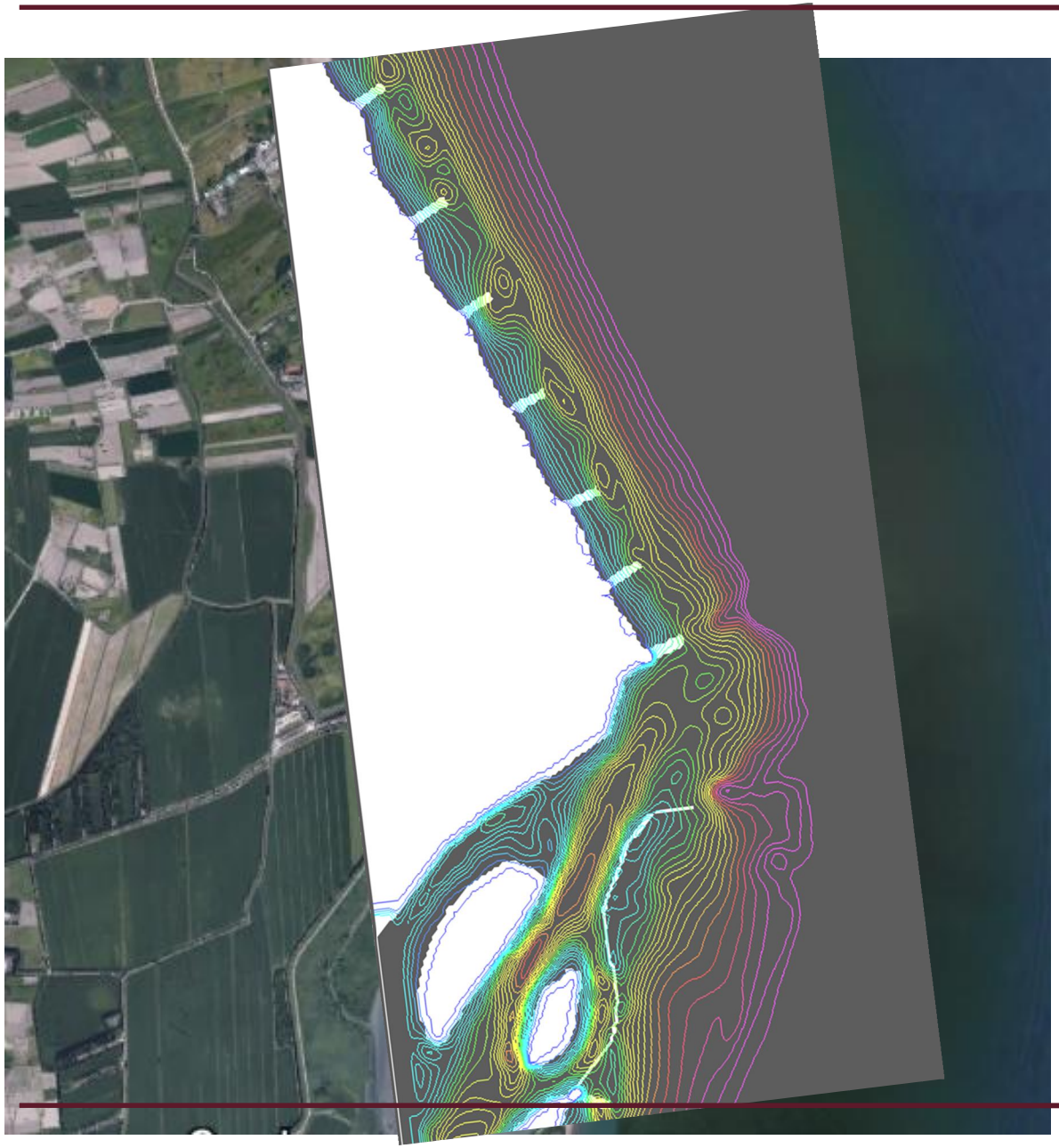
Adige mouth

From bathymetric data of the area, interpolation techniques, grid model generation





Adige mouth



Litorale a nord della foce: terra e isolinee batimetriche nel dominio di calcolo

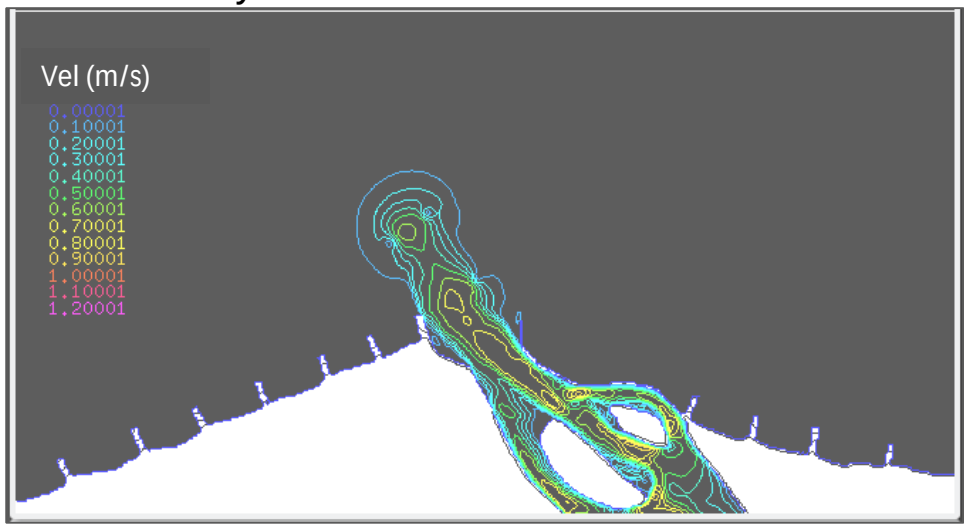
Valori batimetrici

CONTOUR LEVELS
0.20000
0.40000
0.60000
0.80000
1.00000
1.20000
1.40000
1.60000
1.80000
2.00000
2.20000
2.40000
2.60000
2.80000
3.00000
3.20000
3.40000
3.60000
3.80000
4.00000
4.20000
4.40000
4.60000
4.80000
5.00000

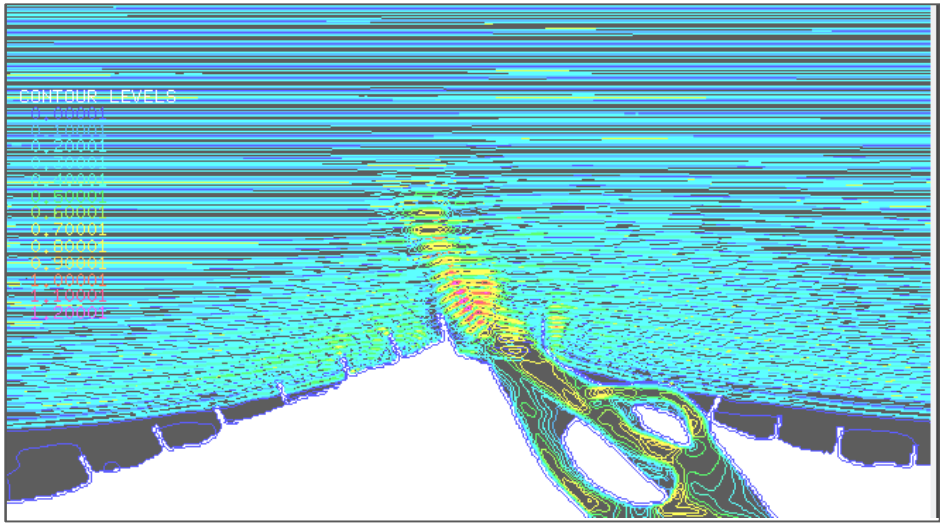
Artificial Marine structures

RIVER PLUME PROPAGATION: VELOCITY FIELD

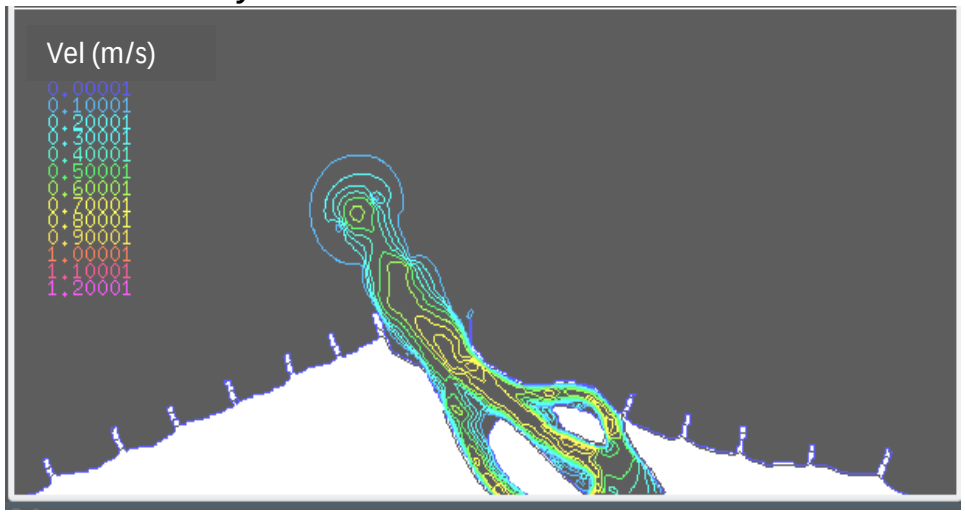
Time 1 only river flow



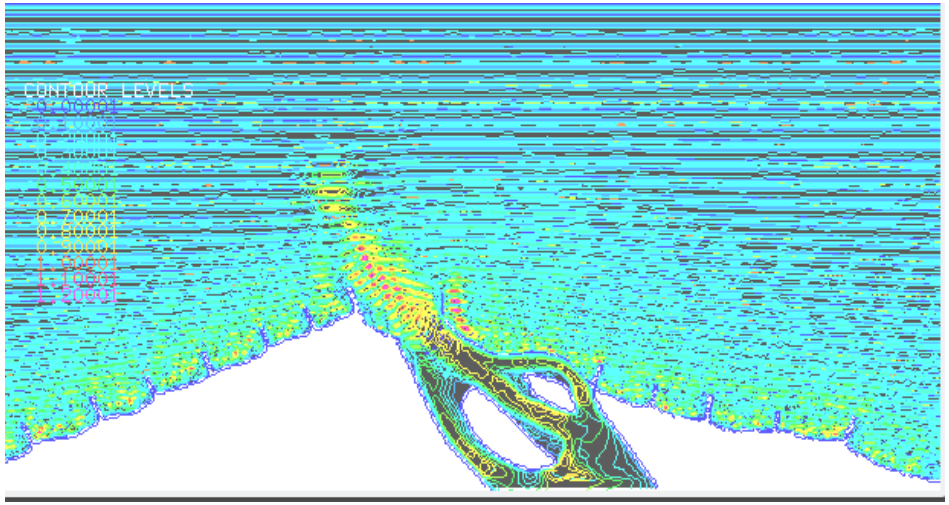
Time 1 river flow + wave action



Time 2 only river flow

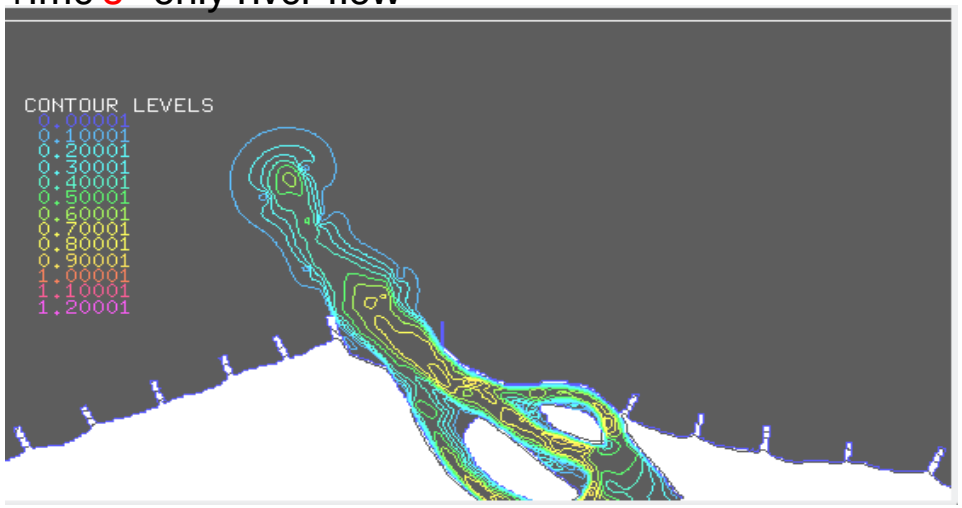


Time 2 river flow + wave action

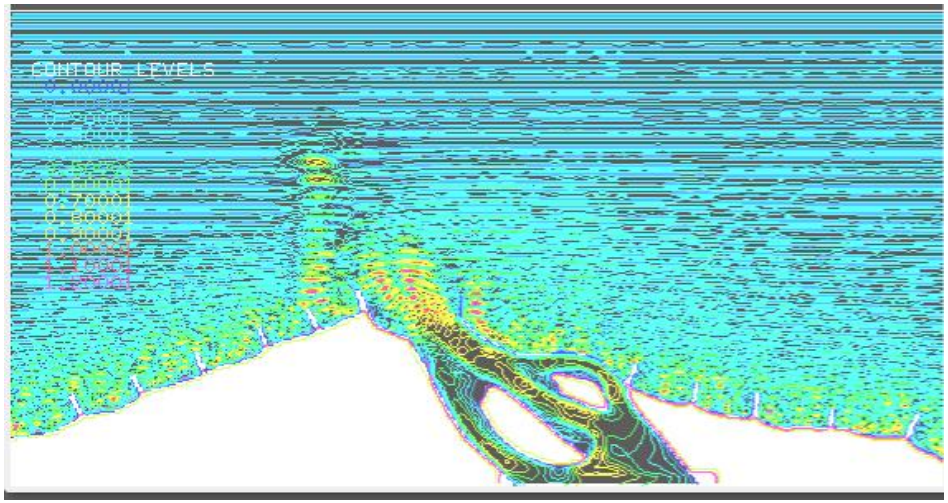


RIVER PLUME PROPAGATION: VELOCITY FIELD

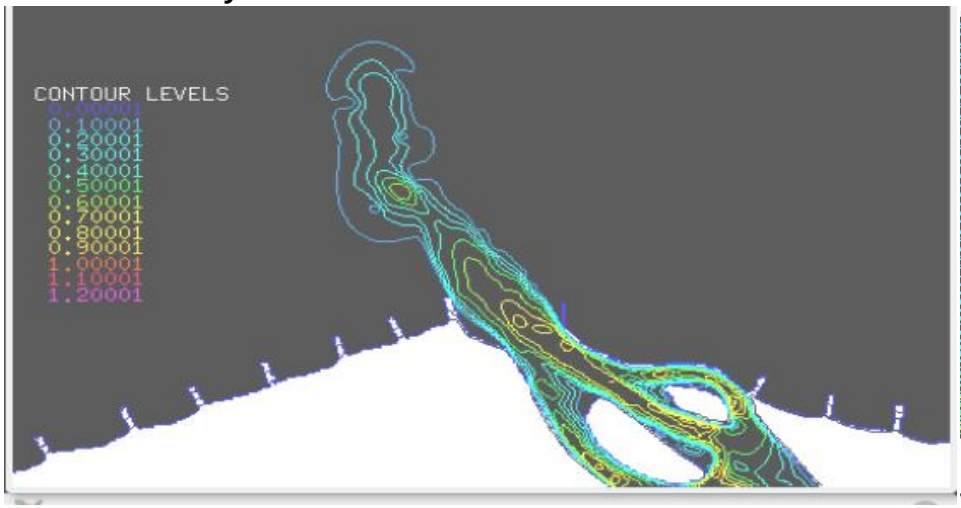
Time 3 only river flow



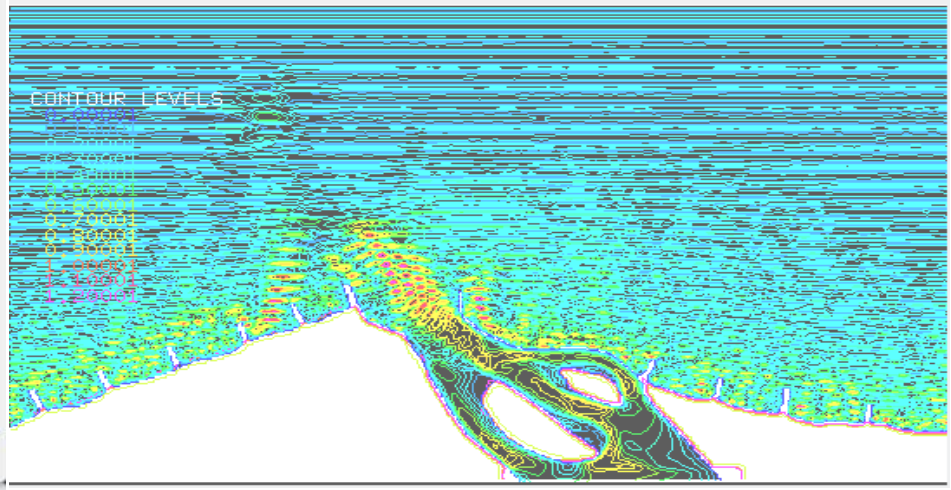
Time 3 river flow + wave action



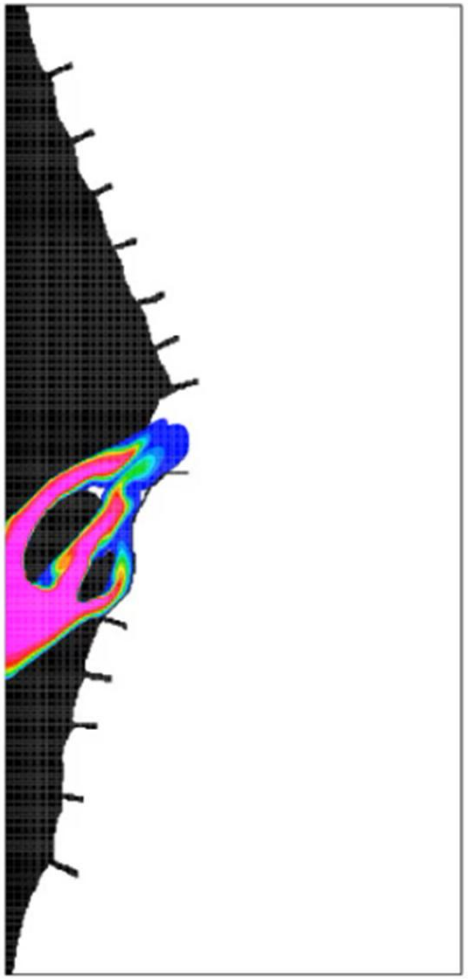
Time 4 only river flow



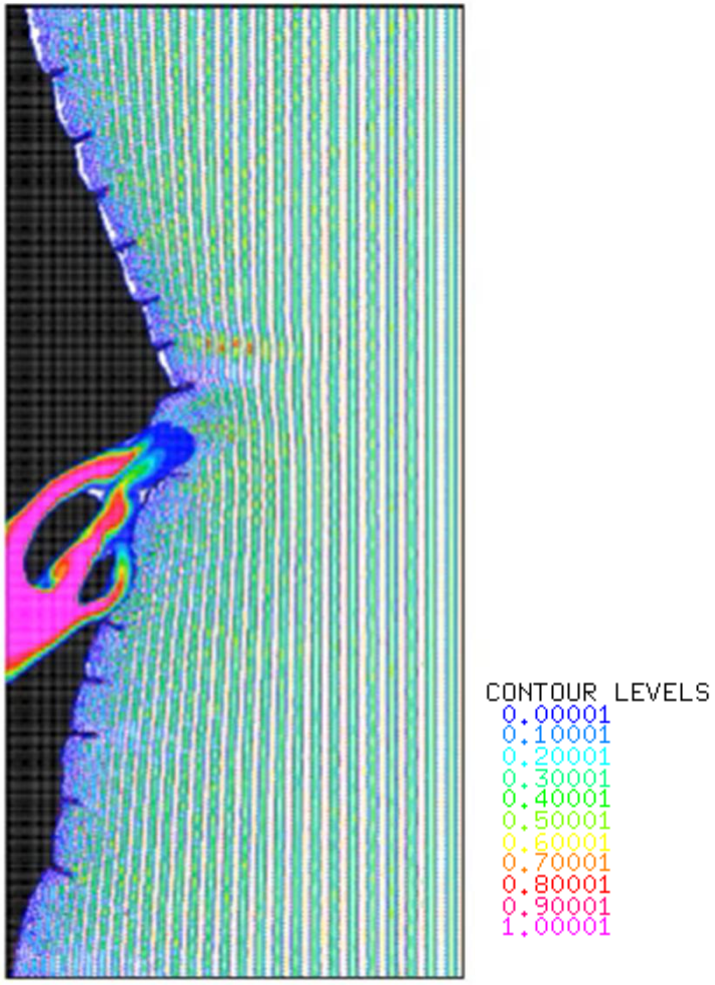
Time 4 river flow + wave action



PASSIVE TRANSPORT



NO WAVE ACTION



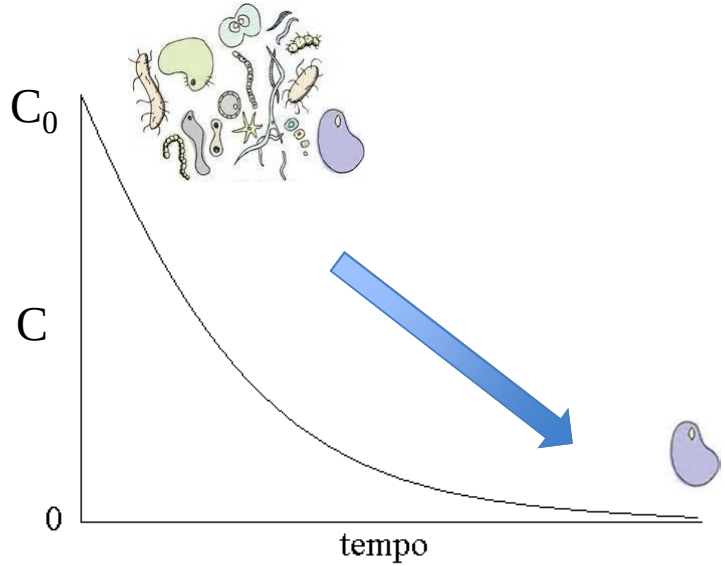
WAVE ACTION

BACTERIAL LOAD: DECAY EQUATION

$$\frac{\partial C}{\partial t} = -kC$$

$$C = C_0 e^{-kt}$$

SOLAR RADIATION
TEMPERATURE
SALINITY
TORBIDITY



$$k = \frac{-\ln(0.1)}{T_{90}}$$

T90 Values for Coliform bacteria (Wallis et al., 1977)

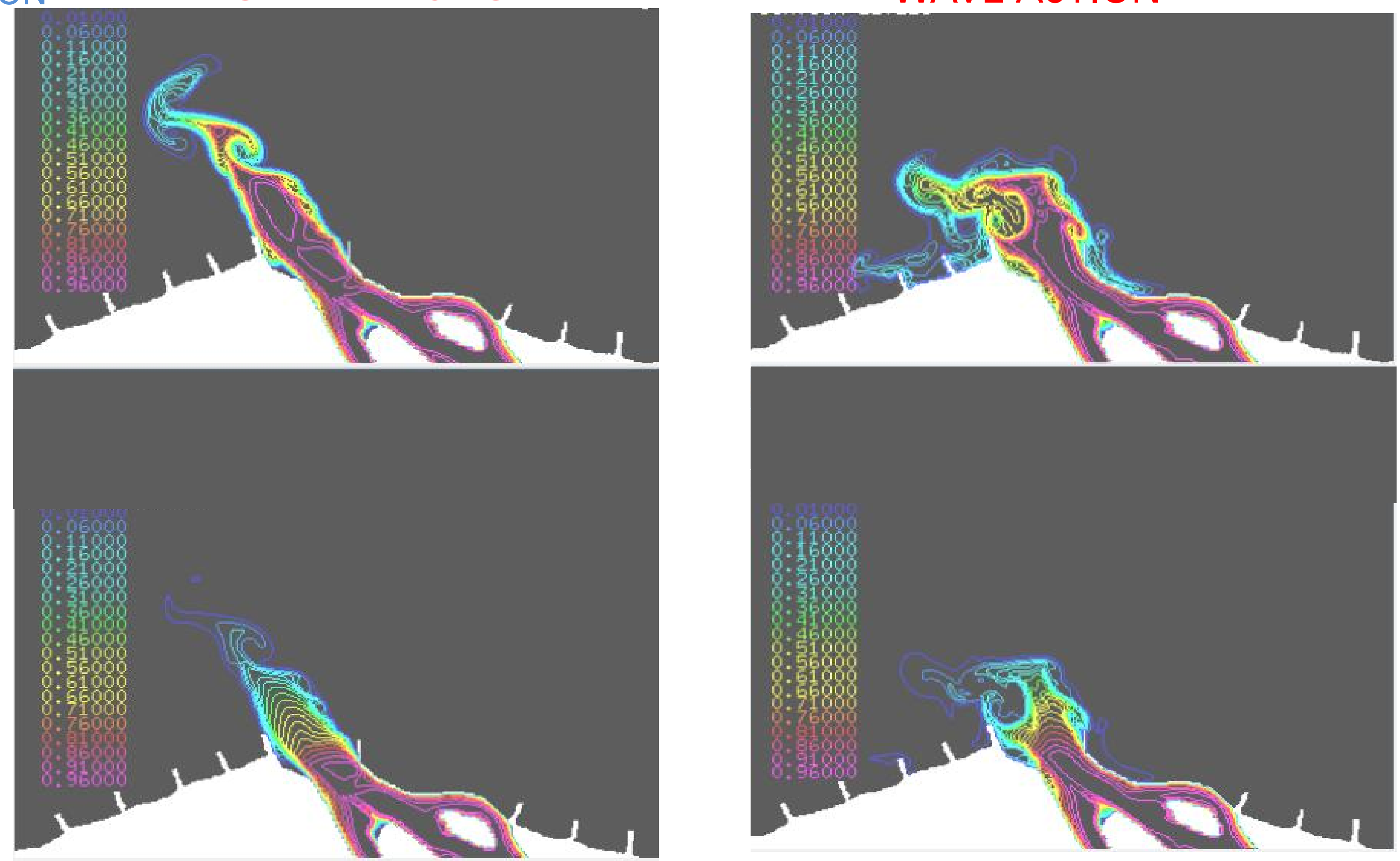
T_{90} = 34 hrs at 00:00
T_{90} = 19 hrs at 06:00 am
T_{90} = 2.5 hrs at 12:00 am
T_{90} = 6.7 hrs at 06:00 pm

DISPERSION AND DECAY OF BACTERIAL LOAD

NO WAVE ACTION | WAVE ACTION

DISPERSION

DECAY

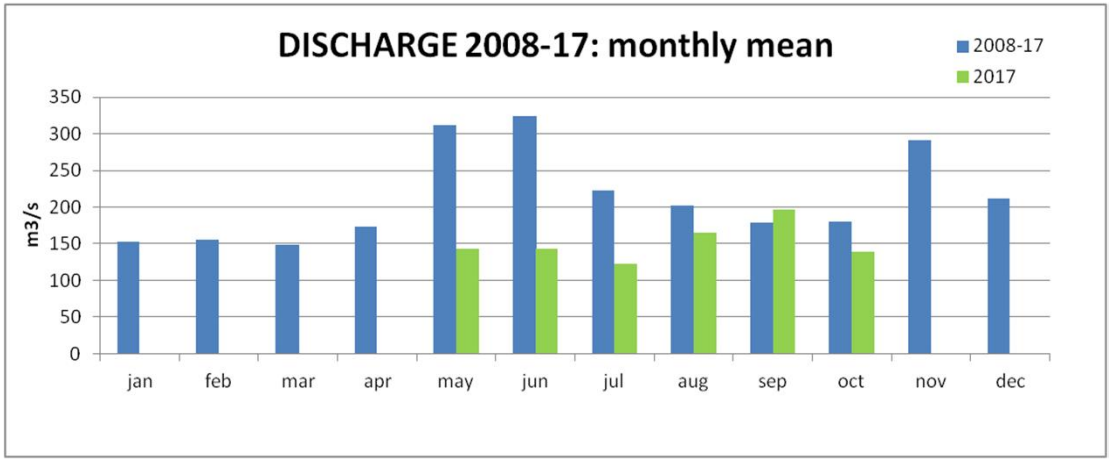


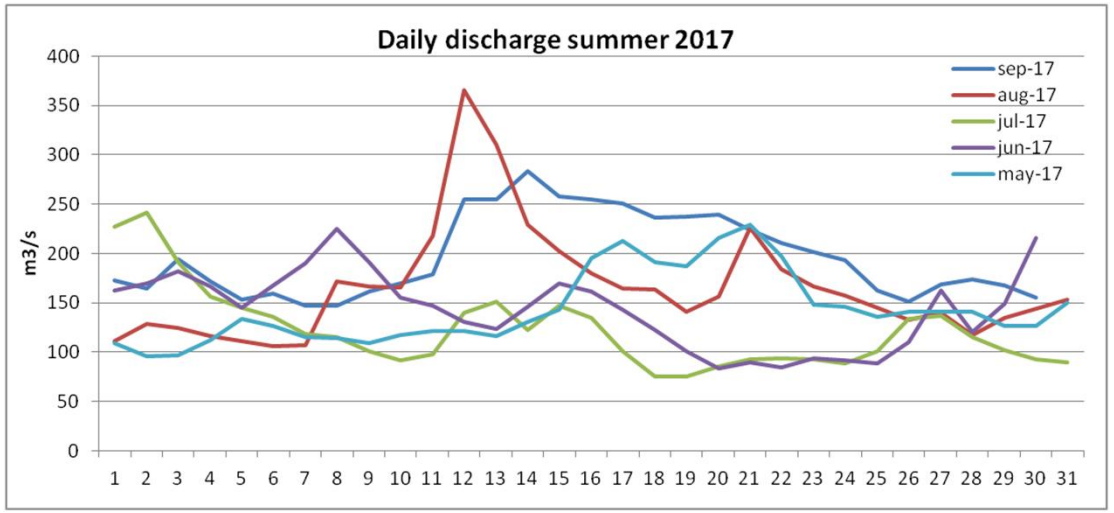
Summer scenario

REAL CASE AUGUST 2017

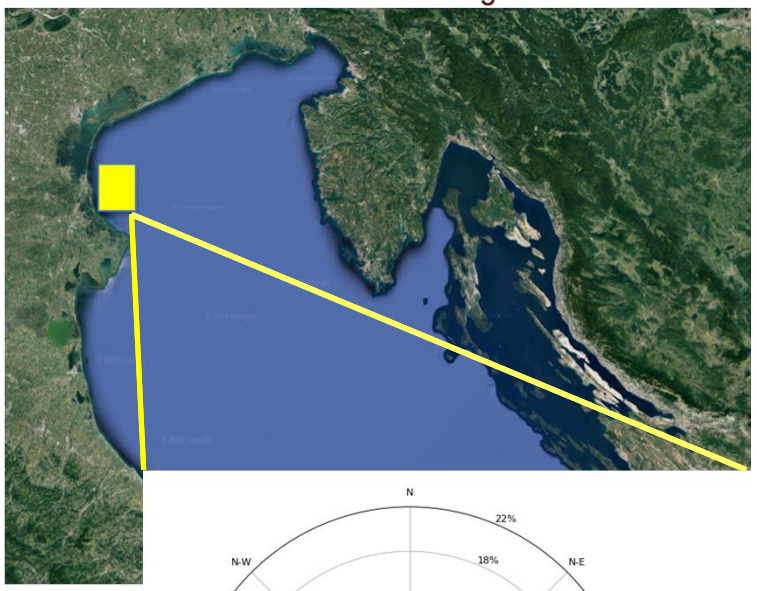
PRINCIPAL FORCINGS: ADIGE RUNOFF - WIND → LITTORAL CURRENT

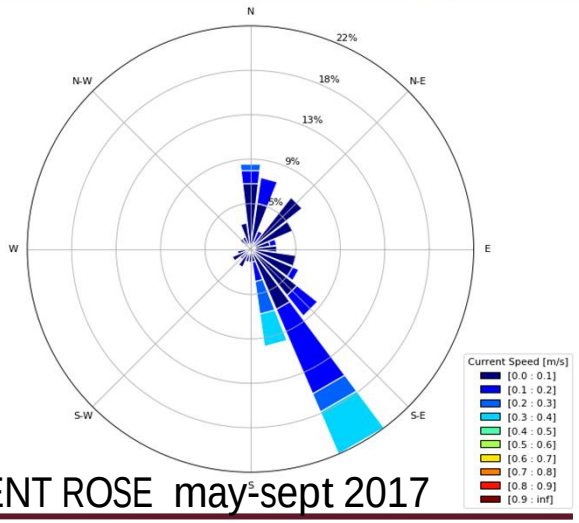
→ WAVE ACTION





MITgcm-BFM model

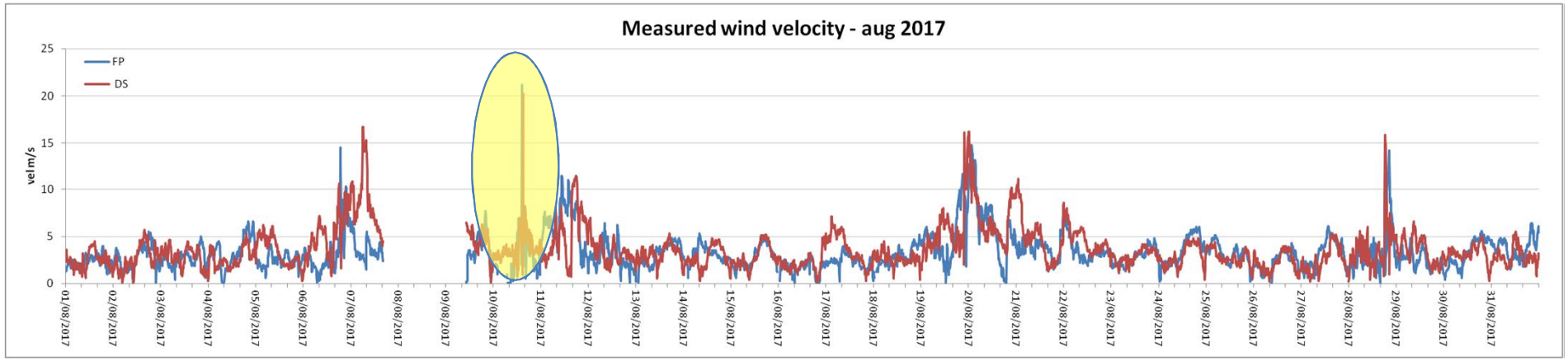


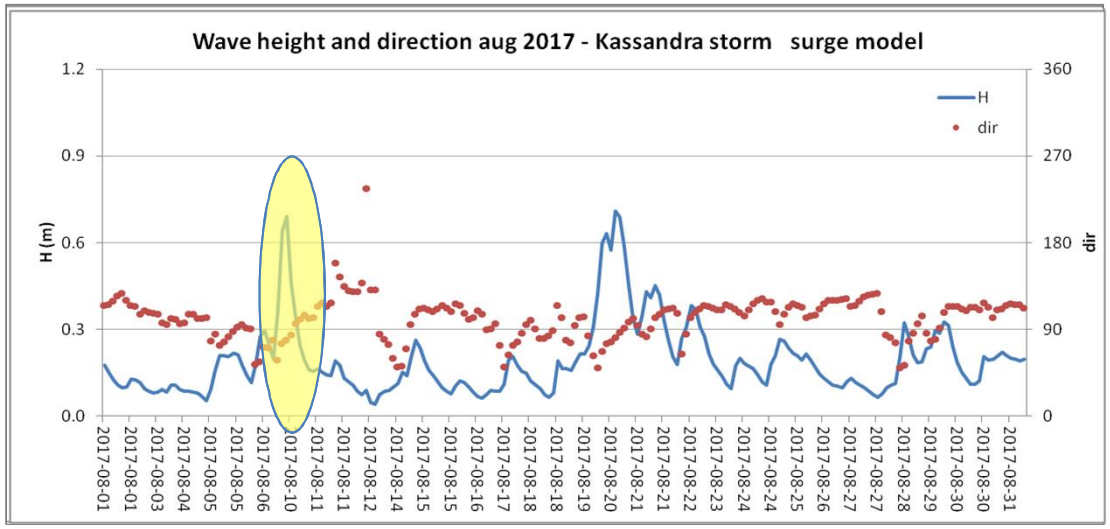


CURRENT ROSE may-sept 2017

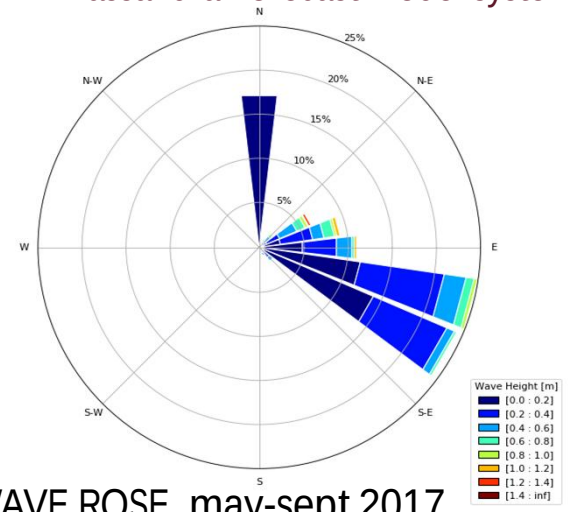
Summer scenario

WIND DATA from METEOMAREOGRAPHIC STATIONS (ISPRA)
LITTORAL CURRENT from coupled MITgcm-BFM MODEL Adriatic sea scale (OGS)
WAVE HEIGHT from KASSANDRA STORM SURGE MODEL SYSTEM (ISMAR)





Kassandra forecast model system

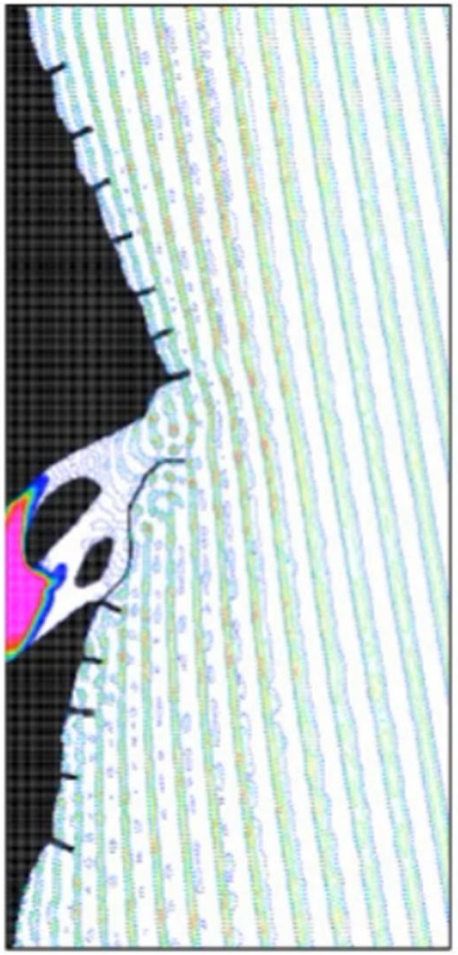


WAVE ROSE may-sept 2017

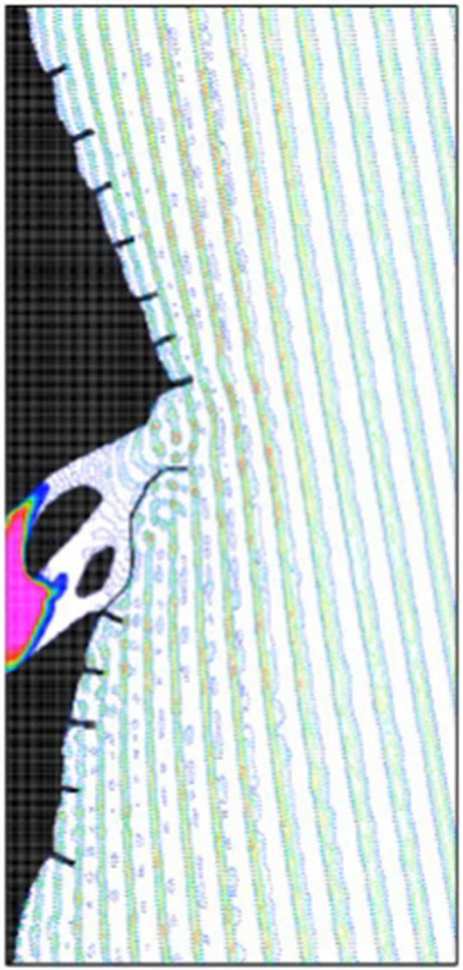
SIMULATION RESULTS

ADIGE DISCHARGE 220 m^3/s
LITTORAL CURRENT 10 cm/s
WAVE H 40 cm, Dir 80°N

DISPERSION



DISPERSION AND DECAY

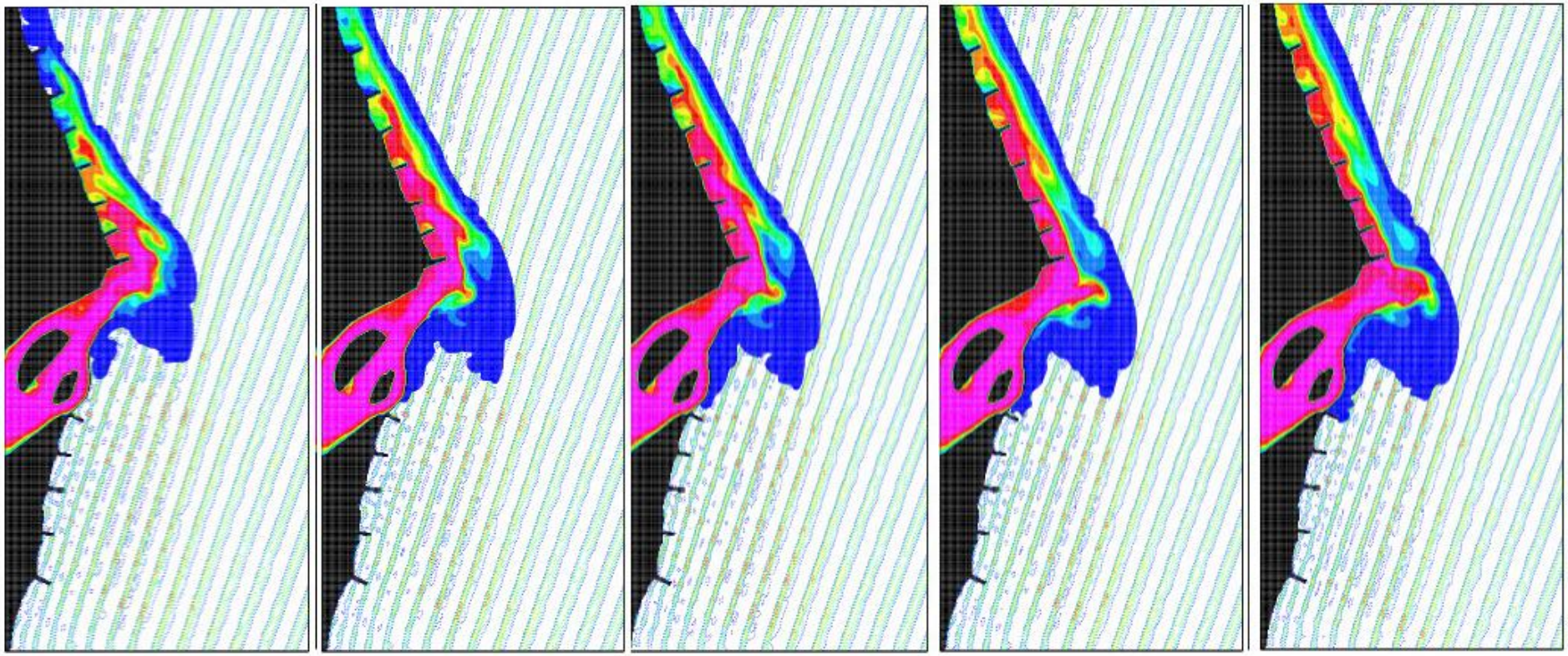


Summer scenario

SIMULATION RESULTS

ADIGE DISCHARGE 220 m^3/s LITTORAL CURRENT 10 cm/s
WAVE H 40 cm, Dir 120°N

TIME -> -> -> -> -> -> ->



Conclusion

- The high resolution wave-current model was used in the 2D shallow water version, the spatial domain was discretized by a staggered grid.

- The simulations were carried out by using different boundary conditions, concerning river flow discharge, littoral currents, waves.

- The current input was given by the coupled MITgcm-BFM model developed for the CADEAU project goals.

- The model allows to reproduce the bacterial dispersion and decay downstream the discharge points.

- Several scenarios can be simulated in order to evaluate the coastal hydrodynamic circulation due to the Adige river-Adriatic sea interaction; the model is an useful tool to estimate the impact of bacterial pollution on the coastal area and on the bathing waters.

HIGH RESOLUTION NUMERICAL ANALYSIS OF BATHING WATER HYDRODYNAMICS AROUND ADIGE RIVER MOUTH (NORTH ADRIATIC SEA)

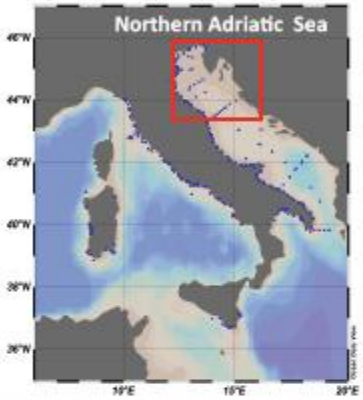
Progetto CADEAU – Prodotti e servizi derivati da COPERNICUS MARINE SERVICE a supporto delle Direttive Europee per l'ambiente costiero

GRAZIE

18 ottobre 2018

INTRODUCTION

EU countries are requested to comply with many **EU Directives** with respect to **coastal and marine environment** (e.g., WFD, UWWTD, BWD, MSFD).
Such Directives either prescribe **threshold values** to comply with, or define the process to make an **environmental assessment** and to specif **environmental targets** and **actions** to reach them.



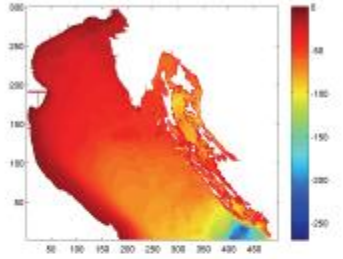


Fig. 1. Study area (left) and model domain and bathymetry (right). The model has a horizontal resolution of 1/128° (~850 × 600 m), with 27 vertical levels and 19 main freshwater sources (rivers).

CMEMS DOWNSTREAM SERVICE

CADEAU is a **downstream application** that aims to operationally produce an **annual bulleti** reporting the **marine environmental state** and the **water quality** in the Italian coastal are of the **Northern Adriatic Sea** (CMEMS Mediterranean Sea region, Fig. 1).
The service (Demonstration 32-DEM-L5) is applied to the Northern Adriatic, since it is one o the most sensitive areas along the **Italian coastline** where **eutrophication** and **marin resources exploitation** both influence and depend on the **quality** of the marine ecosystem.
CADEAU focuses on nutrient dynamics, eutrophication and bathing water quality in coast areas in **support** of the application of the EU Directives.

IMPLEMENTATION OF THE SERVICE

The system is based on the high-resolution, **coupled MITgcm-BFM model** (*Adcroft et al.*, 2017, *Cossarini et al.*, 2017, Fig. 2 and 3). The meteorological forcing is obtained from the **COSMO-LAMI** model. The coupled model is initialized and driven by the **downscaling** of the products (hydrodynamics and biogeochemistry) of the CMEMS Mediterranean Monitoring and Forecast Centre. The **MEDSEA_REANALYSIS_PHYS_006_004** and **MEDSEA_REANALYSIS_BIO_006_008** datasets are used to obtain the daily open boundary conditions on the southern side of the domain. Further, the model will **integrate** the Italian water quality monitoring system by means of **nudging** and **data assimilation** algorithms.
The **products** are designed to provide information on the **space-time distributions** of the major parameters related to **water quality** (nitrogen and phosphorus concentration, chlorophyll, dissolved oxygen) and they will be **publicly delivered** through a dedicated **web-portal**:
http://www.sintai.isprambiente.it/faces/public/CADEAU/index.xhtml

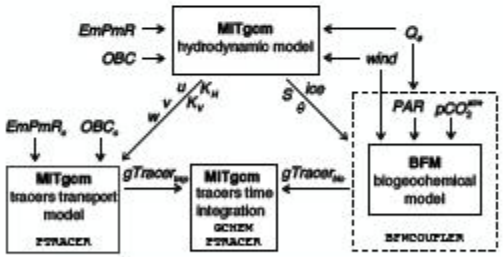


Fig. 2. Description of the MITgcm-BFM coupling and interfaces amon the different components. Q_s: heat fluxes; *EmPmR* (*EmPmR*$_c$): wate (matter) fluxes; *OBC* (*OBC*$_c$): open boundary condition for hydrodynami (biogeochemical) variables; *S*, θ, *u*, *v*, *w*, *ice*, K_h and K_v: hydrodynami variables; *PAR*, *wind* and pCO_2^{atm}: forcing variables for th biogeochemical model.