Copernicus Marine Environment Monitoring Service

Modélisation côtière

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Qu'est-ce qu'un modèle océanique ?

Marine Monitoring

- Modèle mathématique : équations primitive de la mécanique des fluides

$$\frac{\partial T}{\partial t} = -u \cdot \nabla T + D_T + F_T$$

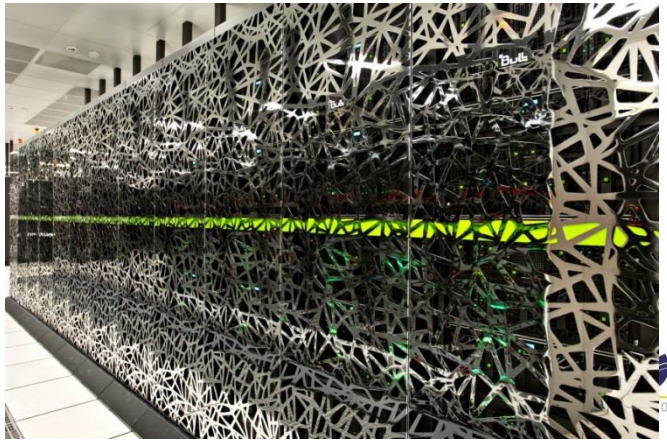
$$\frac{\partial S}{\partial t} = -u \cdot \nabla S + D_S + F_S$$

$$\frac{\partial u}{\partial t} = -u \cdot \nabla u + fv - \frac{1}{\rho_0}\frac{\partial P}{\partial x} + D_u + F_u$$

- Équations sont discrétisées (temps et espace)

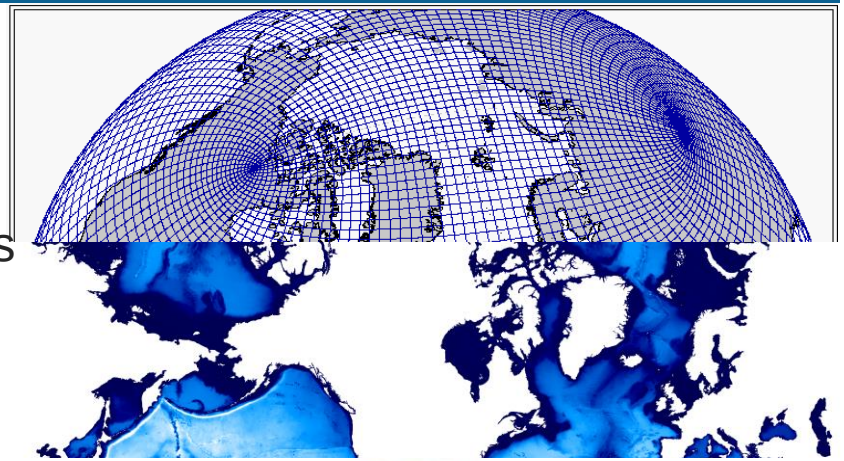
modèle numérique

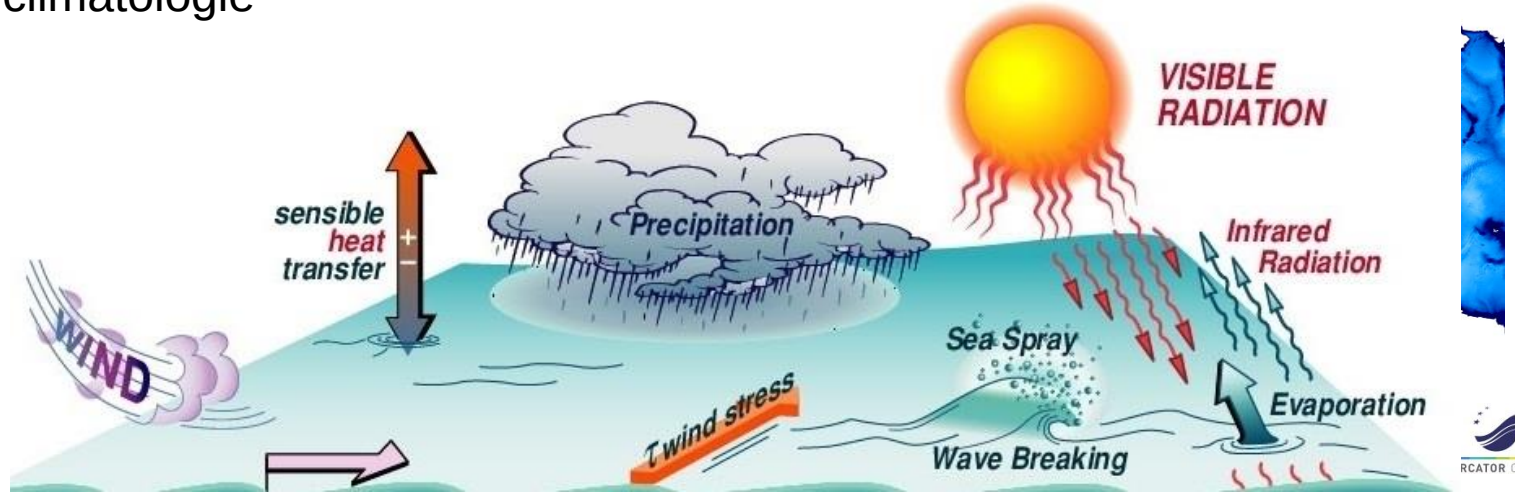
```
   .CTER*(*) pfilename
  .EGER,INTENT(IN) :: pim,pjm
 :EAL,DIMENSION(pim,pjm),INTENT(IN) :.
 NTEGER,INTENT(IN):: par_orix, par_sz
 NTEGER,INTENT(IN) :: pitau0
REAL,INTENT(IN) :: pdate0, pdeltat
 NTEGER,INTENT(OUT) :: pfileid, phorlc

 NCLUDE "netcdf.inc"

 'NTEGER :: ncid, iret
  'EGER :: lenq, lengf, lenga
    'CTER(LEN=120) :: file, tfil
     'ER*30 :: timenow
```



Que faut-il pour un modèle océanique ?

- Une grille
- Une bathymétrie
- Des forçages atmosphériques
- Des apports d'eau douce
- Des conditions initiales : climatologie





A quoi sert un modèle océanique ?

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Ocean Models simulate several properties from the **Surface to the Sea Floor**:

Physical parameters: temperature, salinity, currents, elevation or sea surface height (SSH), sea ice…

Biogeochemical parameters: Chl-a, Primary Production, Oxygen…

Wave parameters: Significant Wave Height…

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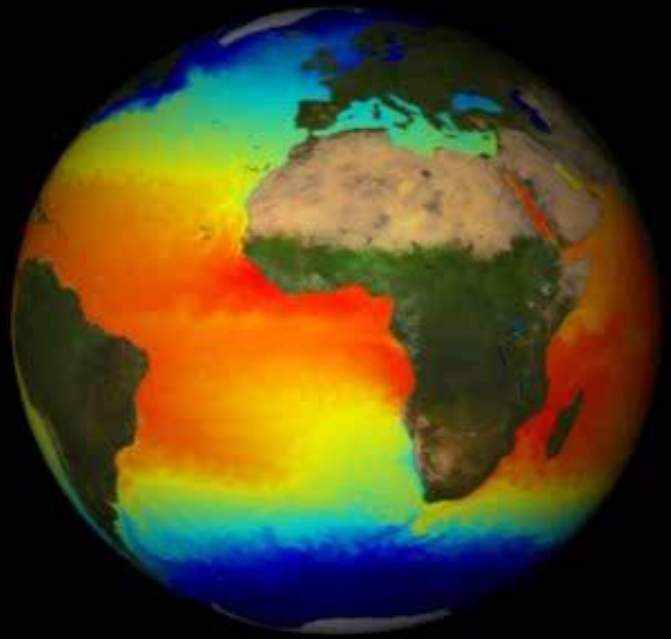
Monitoring

Température de surface



FROM GLOBAL TO REGIONAL/COASTAL SCALE

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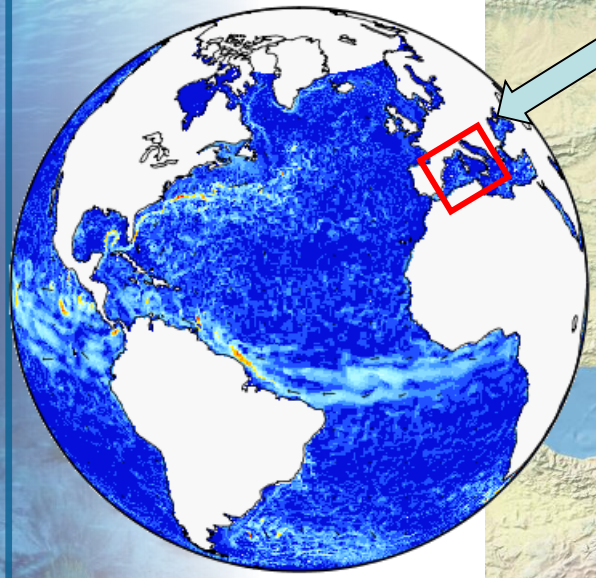

PARENT MODEL = CMEMS

Model n°2 = CHILD

Model n°1 = PARENT

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CHILD MODEL NEED TO BE FED BY PARENT

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Atmospheric forcing

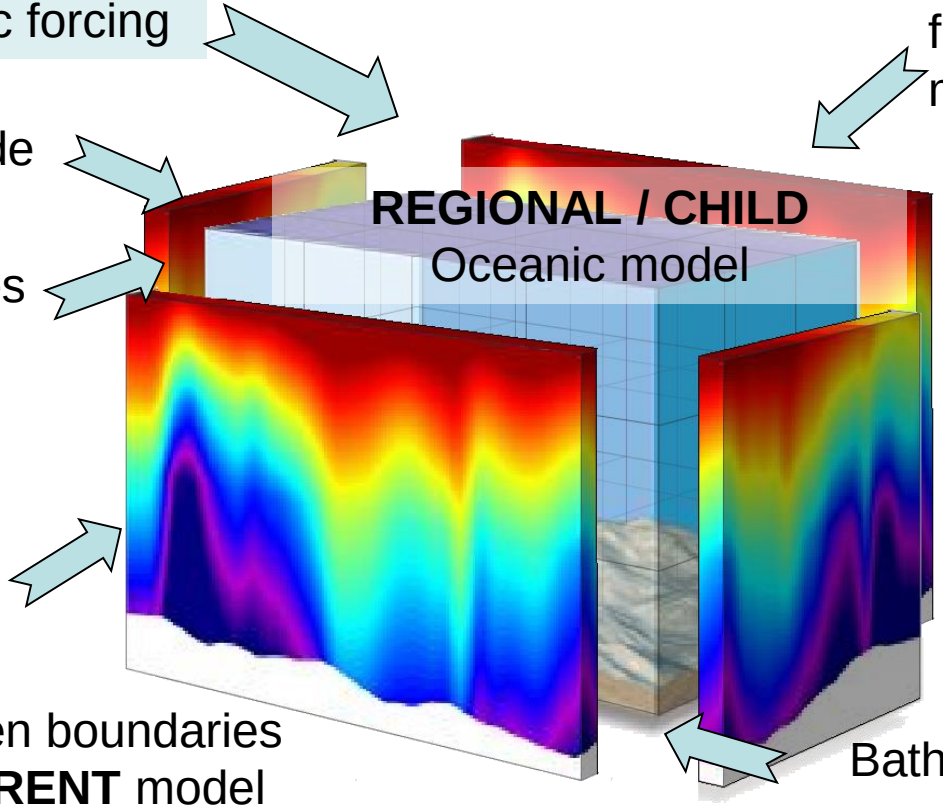
Oceanic initial conditions from **CMEMS/PARENT** model

Tide

Waves

REGIONAL / CHILD
Oceanic model

Rivers



Oceanic open boundaries **CMEMS/PARENT** model

Bathymetry and grid

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FROM PARENT TO CHILD MODEL

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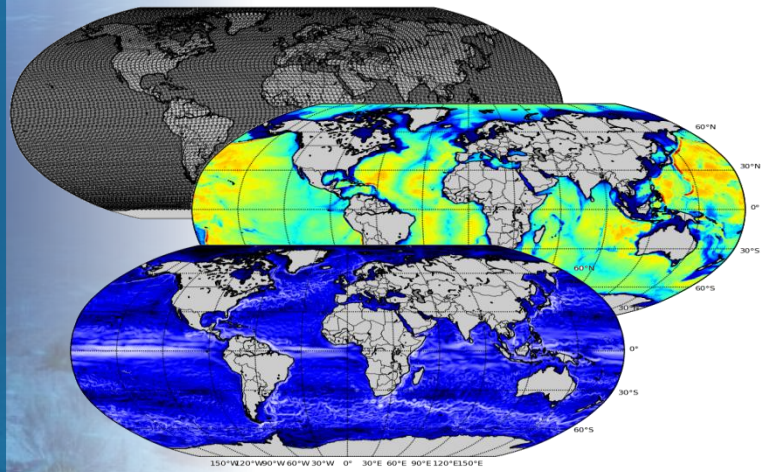
PARENT → **CHILD**

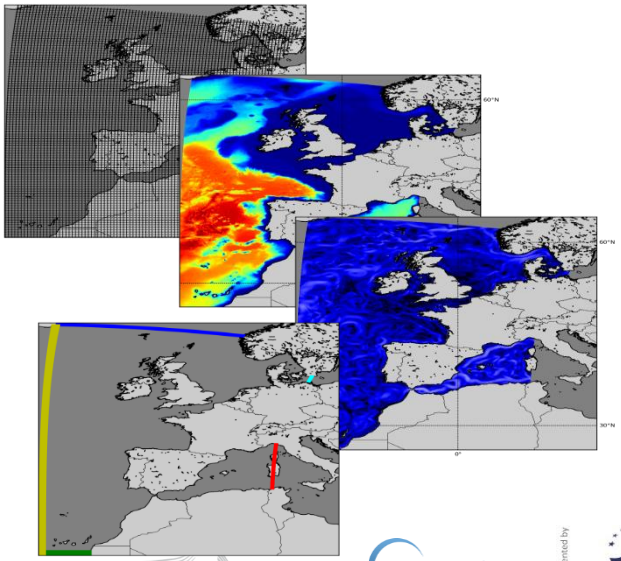


Grid

Bathymetry

Initial condition

Boundary condition



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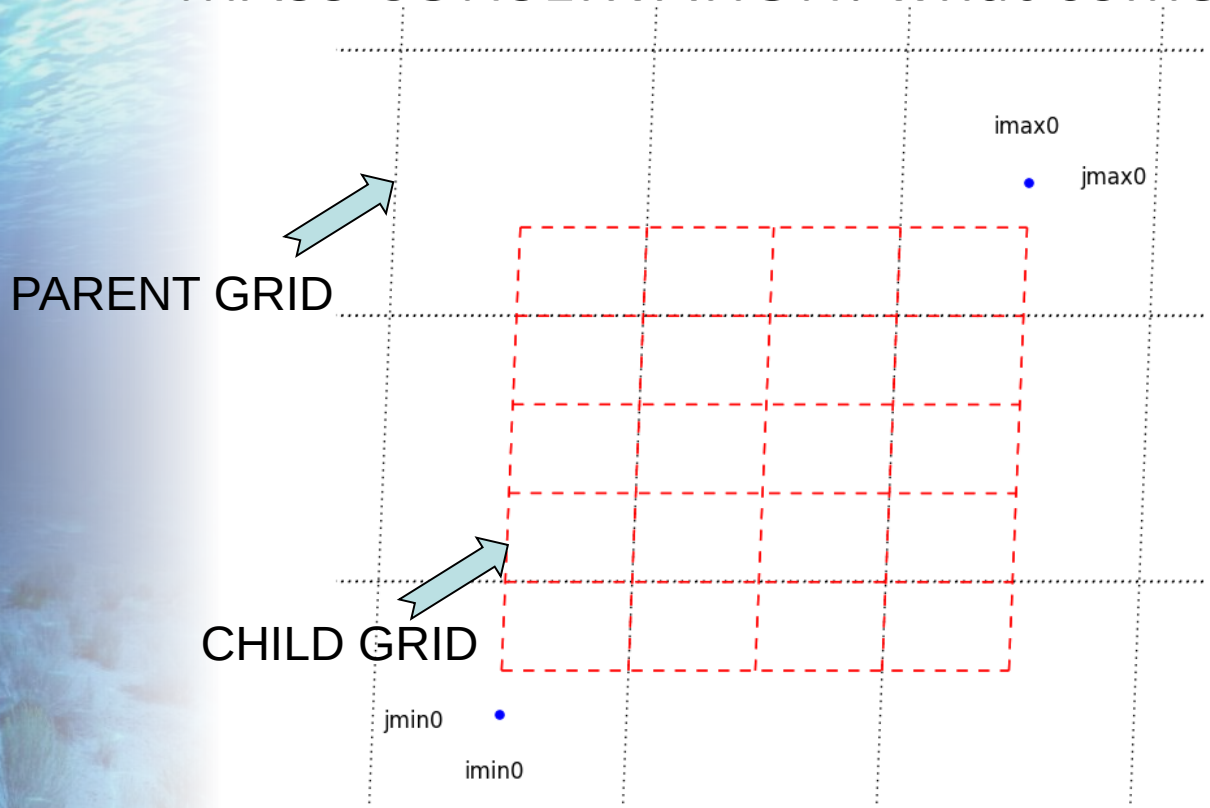
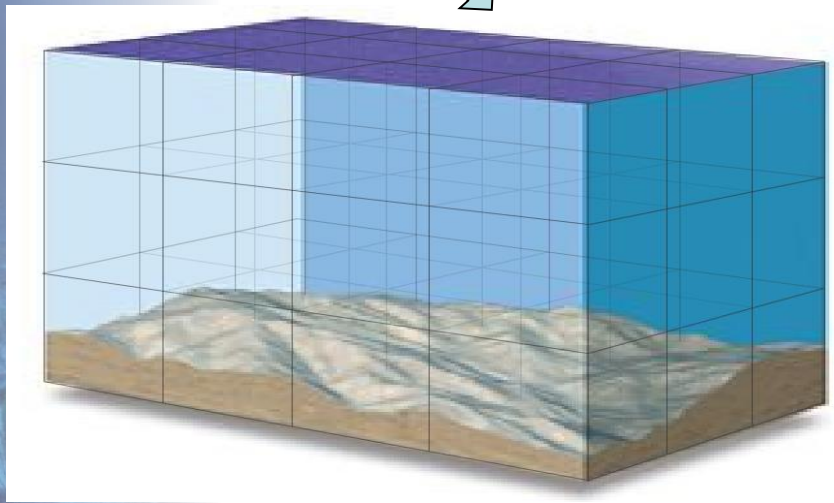
MASS CONSERVATION: what comes in gets out

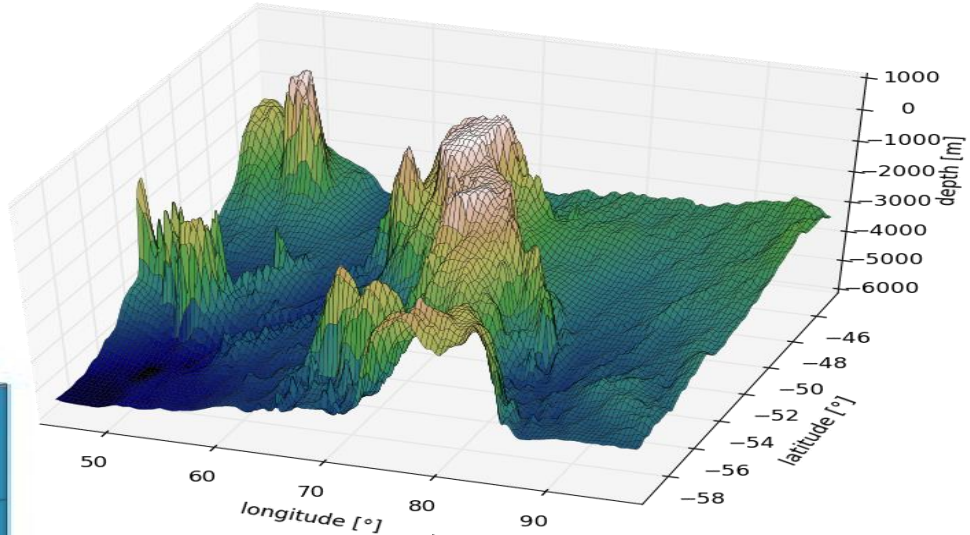


La bathymétrie

CHILD Bathymetry needs to fit PARENT Bathymetry at boundaries

PARENT bathymetry





CHILD bathymetry

Les conditions initiales

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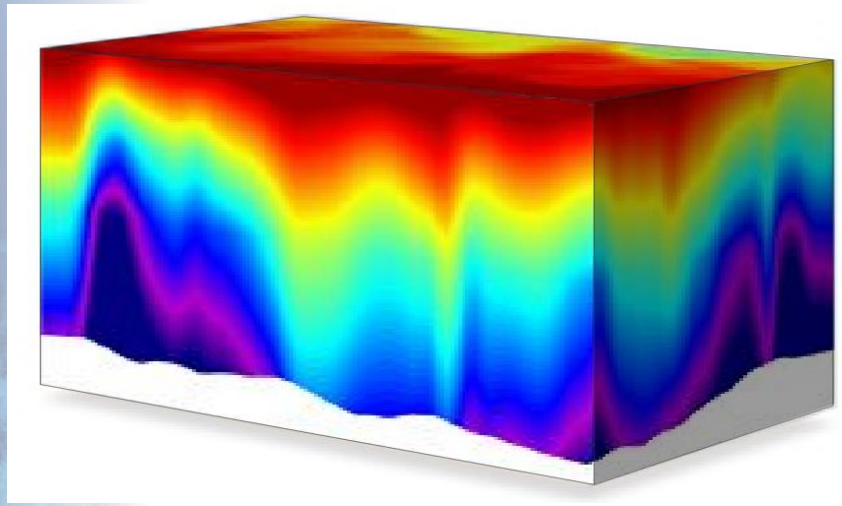

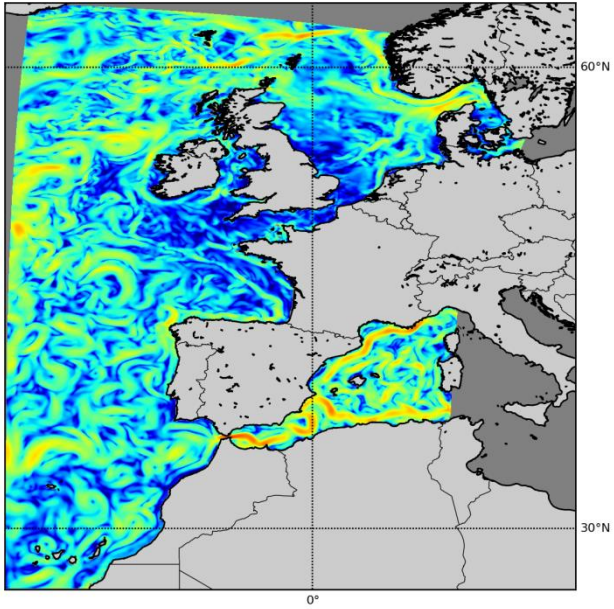

Les conditions aux frontières

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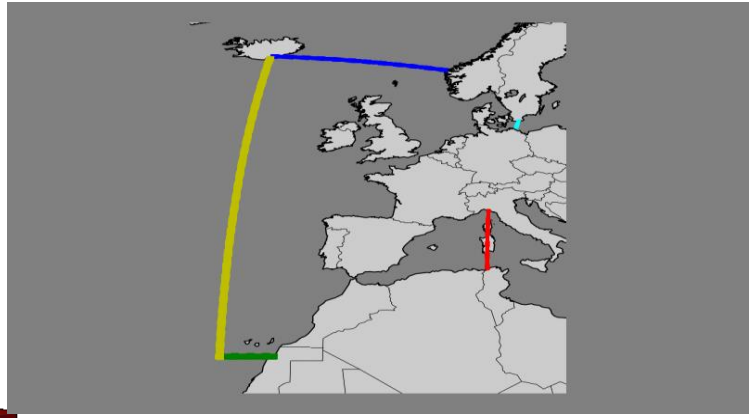

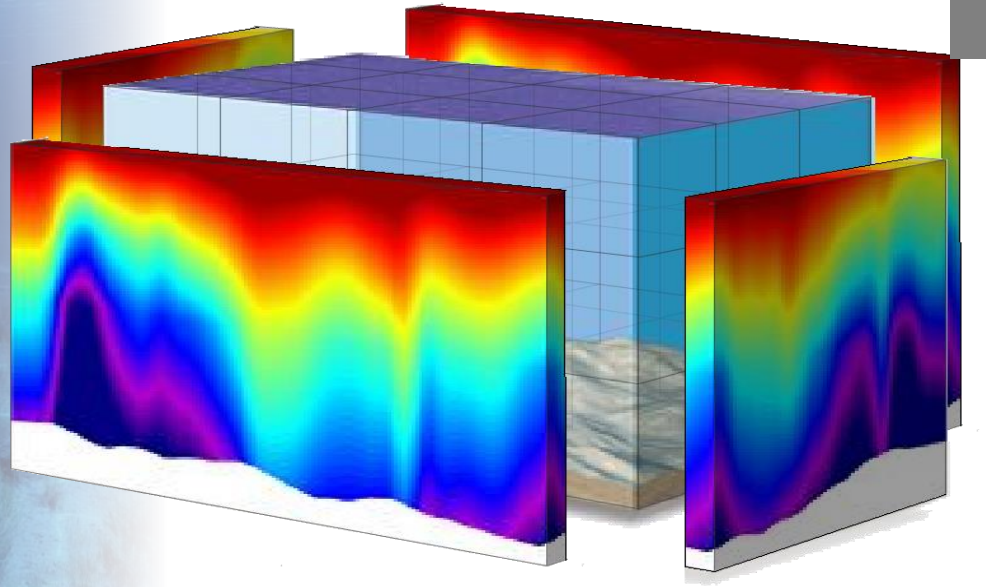

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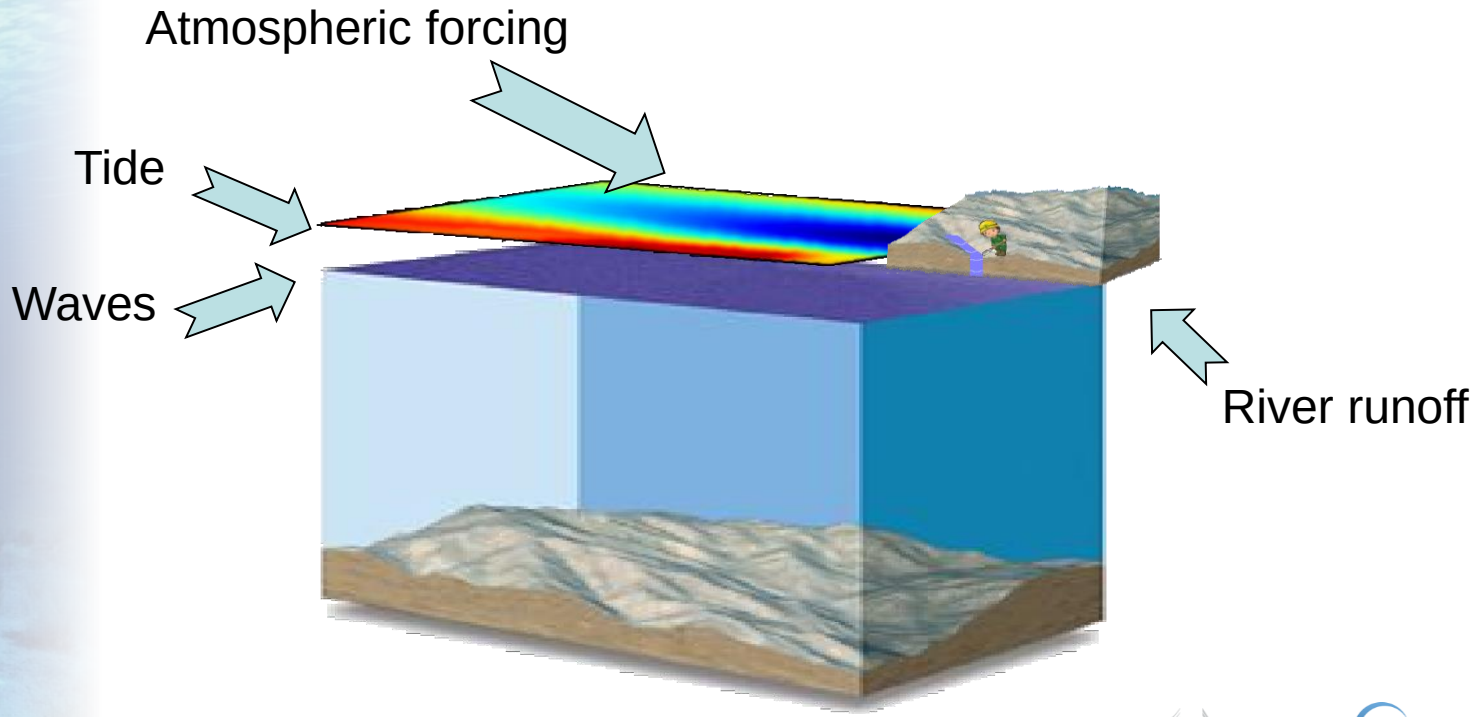
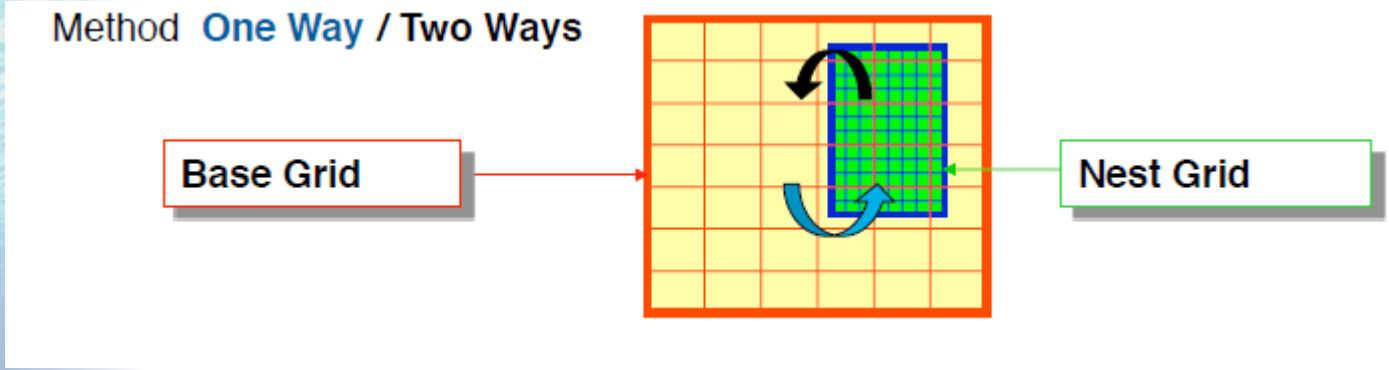
Les forçages

Marées, vagues, apport en eau douce des rivières, forçages atmosphériques



Les types de couplages



1 WAY NESTING

- The CHILD grid gets information from the PARENT grid at the boundary

2 WAYS NESTING

Both models are integrated simultaneously:

- The CHILD grid gets information from the PARENT grid at the boundary
- The CHILD grid updates the PARENT grid

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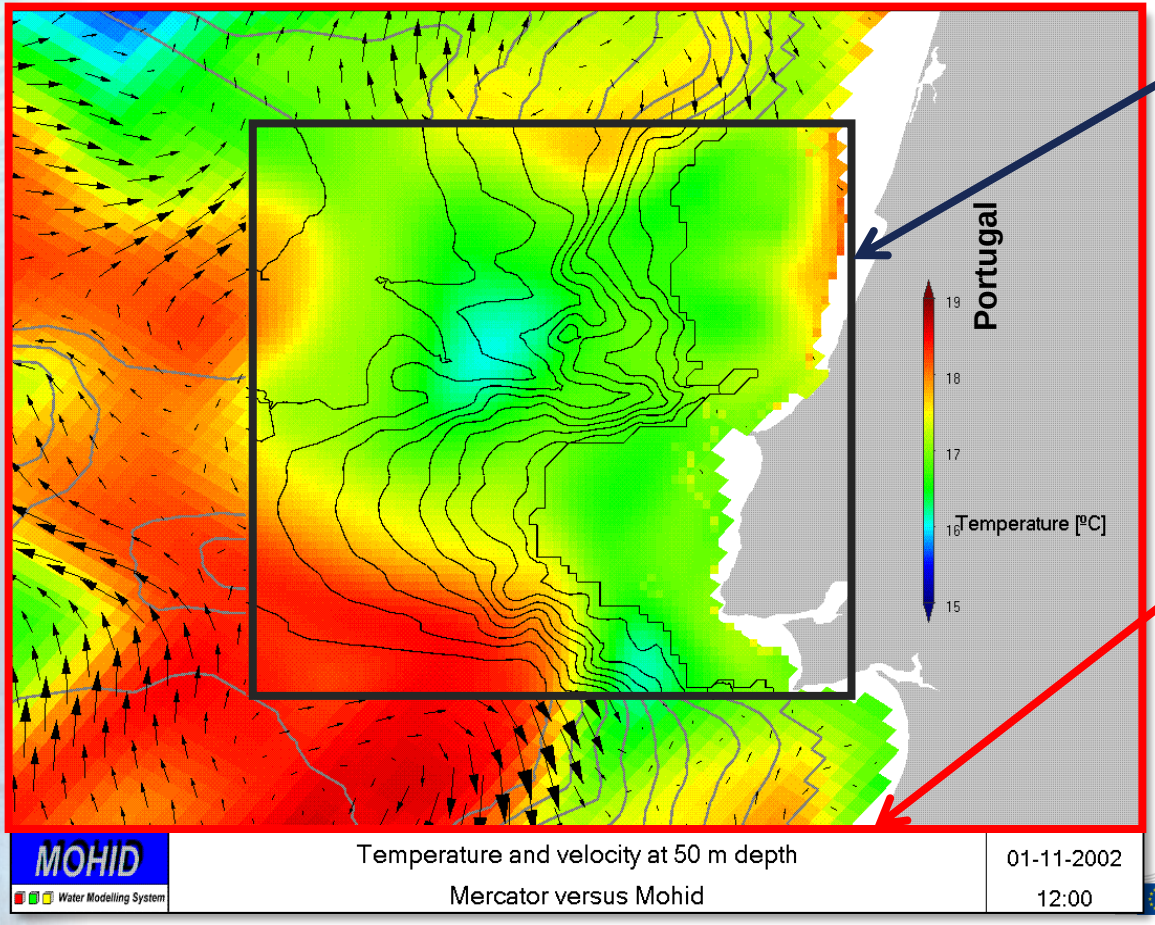
Exemple



IST/MARETEC

INSTITUTO SUPERIOR TÉCNICO

CMEMS

courtesy:
Luis Fernadez
Paulo Leitão

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Coastal dynamics: Downscaling in the Mediterranean Sea

Copernicus for Marine Environment Monitoring Service (CMEMS) and Coastal Zone Management

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User Uptake

Downscaling in the Mediterranean Sea

Copernicus products: systematic and high quality

- CMEMS provides **regular** and **systematic** reference information on the physical state, variability and dynamics of the ocean and marine ecosystems for the global ocean and **the European regional seas**.
- Ocean states: **Analysis**, **Forecasts** and **Re-analysis**
- **User needs**: (i) maritime safety, (ii) marine resources, (iii) **coastal and marine environment**, (iv) weather, seasonal forecast and climate.

- Implementation of an **Operational Forecasting System** at shelf-coastal-harbour scale
- **Physical studies for multi disciplinary research** needs from the oceanographic regional scale to the subregional-shelf scale to the coastal (harbour) engineering scale

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User Uptake

Downscaling in the Mediterranean Sea

Coastal downscaling
(higher resolution, increased accuracy of forecasts in coastal areas)

- ✓ Implementation of an **Operational Forecasting System** at shelf-coastal-harbour scale
- ✓ Physical studies for **multi disciplinary research needs** from the oceanographic regional scale to the subregional-shelf scale to the coastal (harbour) engineering scale

BENEFITS

For producing forecasts in a specific region or coast in order to support services for ports managing, transport, coastal planning, etc.

For emergencies (e.g. search and rescue) management or for modeling contaminants/plastics dispersion, but also to support marine rapid environmental assessment, monitoring surveys and data collection

For multi disciplinary studies at different scales

User Uptake

Downscaling in the Mediterranean Sea

From CMEMS

- **Temperature**
- **Salinity**
- **Currents**
- **Sea Surface Height**
- **Waves**

From ECMWF

- **Mean Sea Level Pressure**
- **Cloud Cover**
- **2m relative humidity**
- **2m air temperature**
- **10m zonal and meridional winds components**

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Let's see the example of the

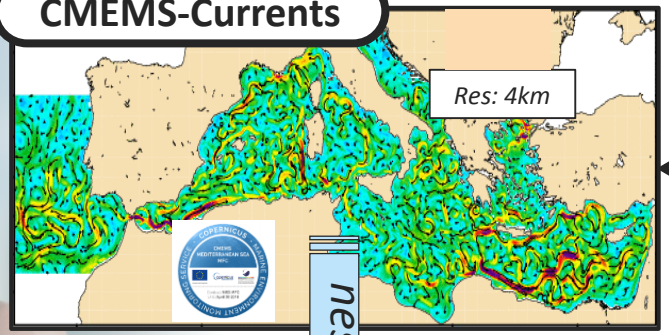
Operational Forecasting System at shelf-coastal-harbour scale in the Adriatic Sea, in which the main elements are:

- Hydro dynamics
- Waves

Downscaling in the Mediterranean Sea

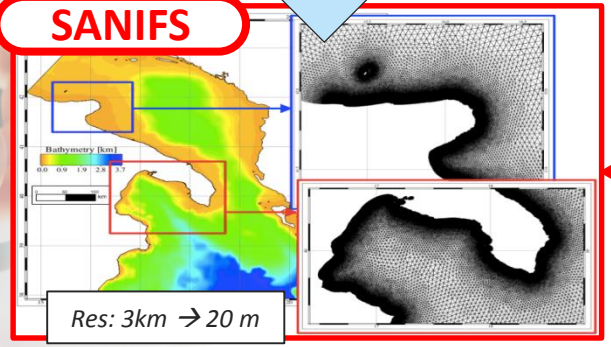
User Uptake

CMEMS-Currents



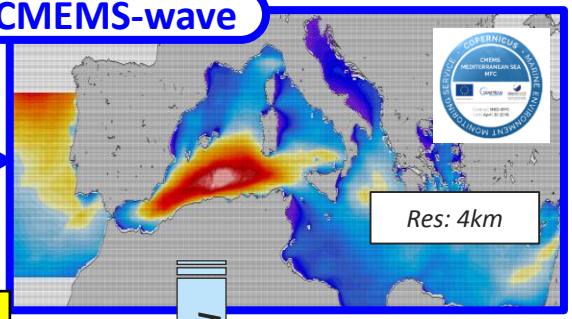
nesting

SANIFS



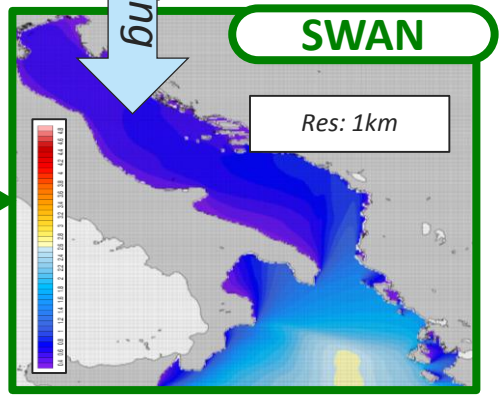
Spatial scale	Physics: Hydro dynamics	Physics: Waves
Regional (CMEMS)	NEMO Madec (2008)	WAM
Sub Regional	SHYFEM Umgiesser et al. (2004)	SWAN Booij et al. (1999)
Coastal		
Harbour		

CMEMS-wave



nesting

SWAN



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Downscaling in the Mediterranean Sea

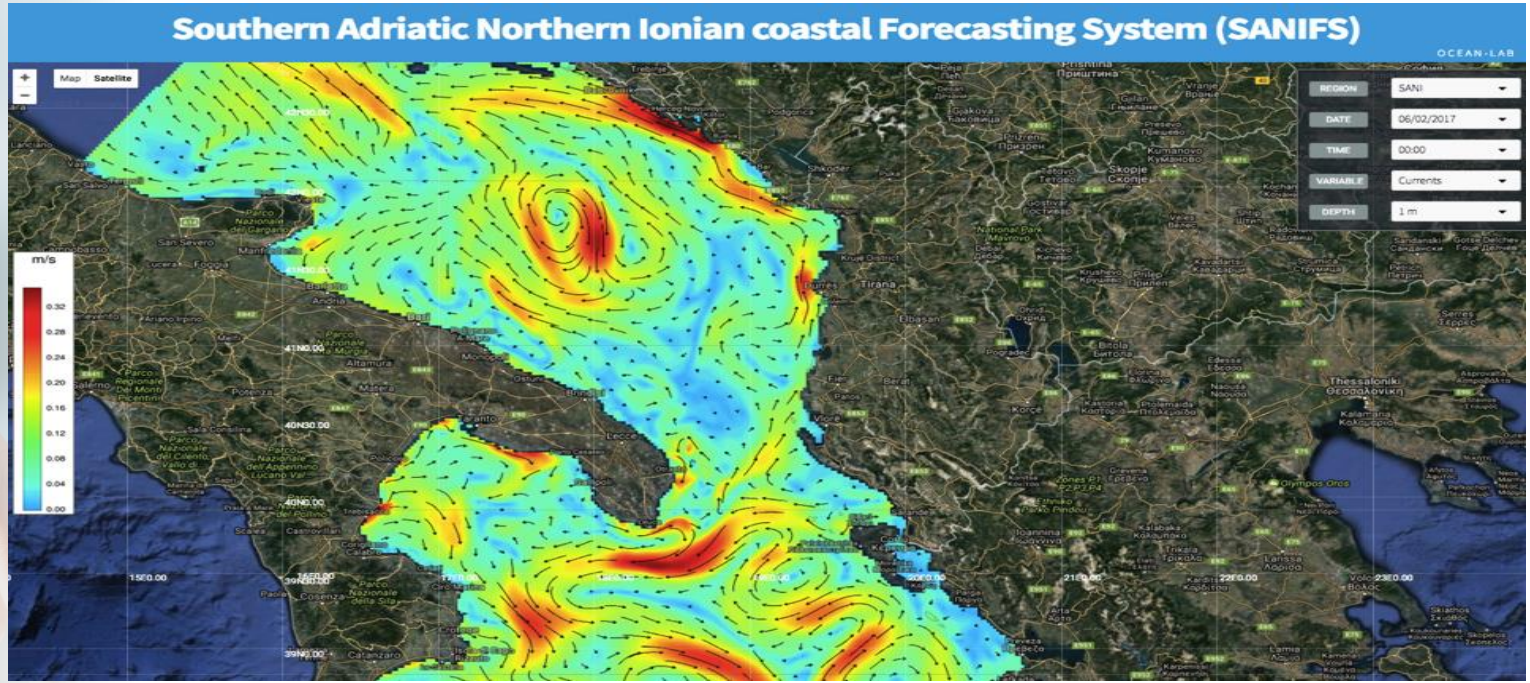
Let’s focus on the

- Hydro dynamics

of the **Operational Forecasting System** at shelf-coastal-harbour scale in the Southern Adriatic Sea and Ionian Sea

User Uptake

Downscaling in the Mediterranean Sea



- **System**: Operational Forecasting
- **Model**: SHYFEM (unstructured-grid model)

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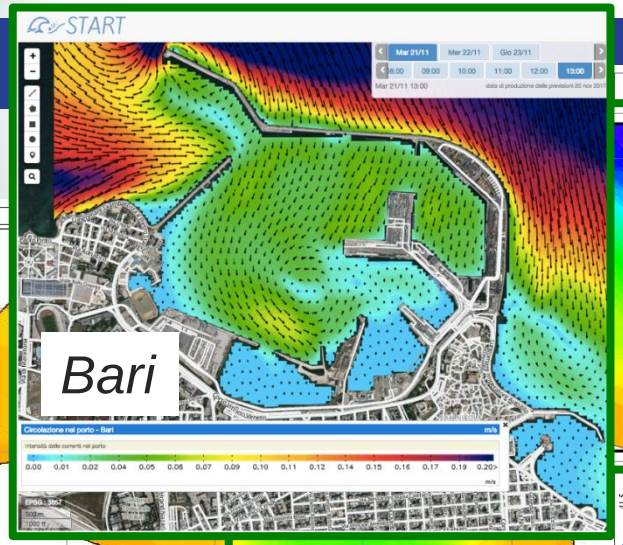
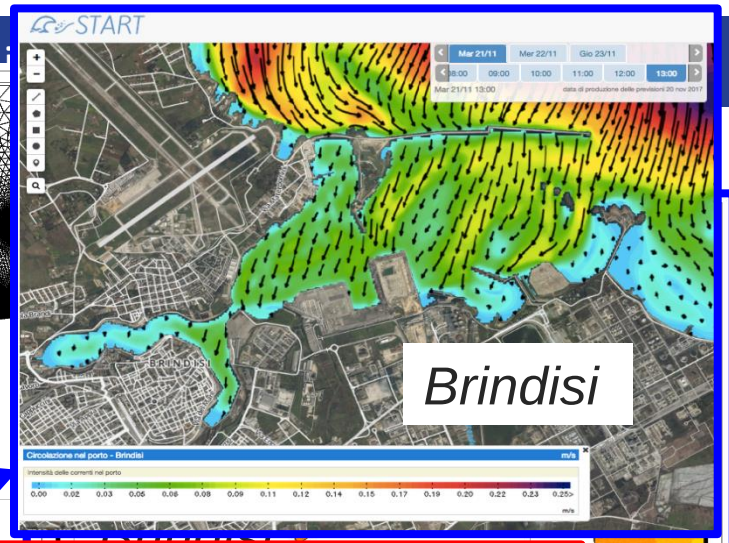
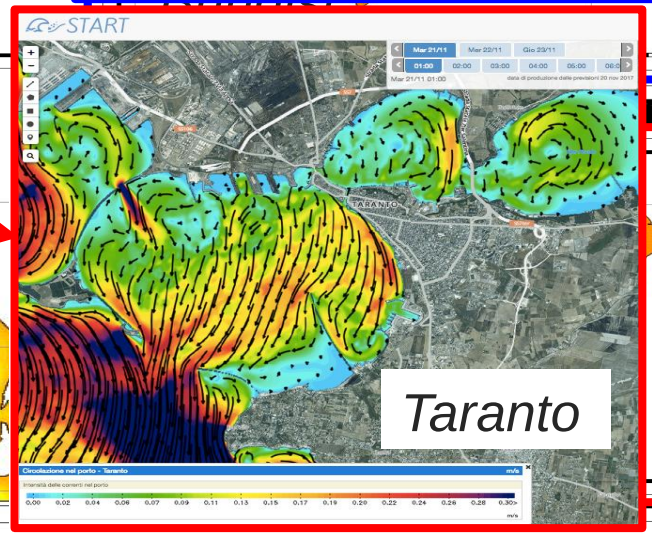
User Uptake







Bathymetry [km]
0.0 0.9 1.9 2.8 3.7

0 50 100 km

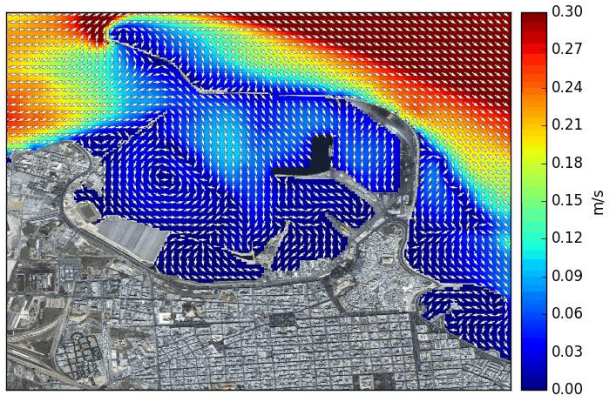
SHYFEM model

3D unstructured-grid finite-element model. Hydrodynamics and tracers fields

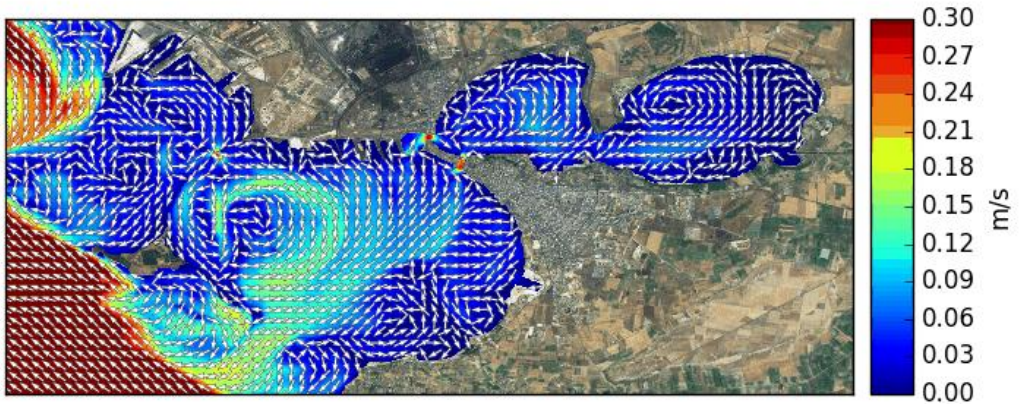
Downscaling in the Mediterranean Sea

User Uptake

Every day, 3-days hourly forecast up to 10 m horizontal resolution



Bari harbour

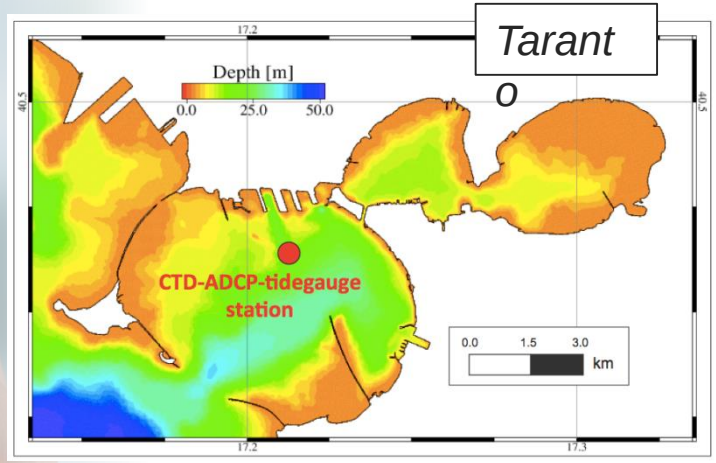


Taranto harbour

User Uptake

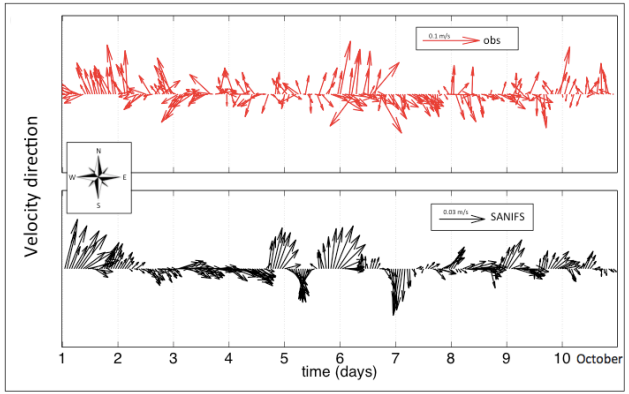
Downscaling in the Mediterranean Sea

Comparison with observations

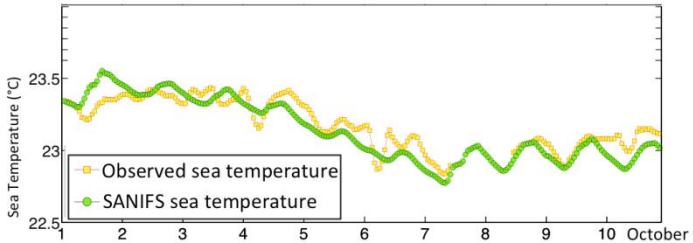


Tarant o

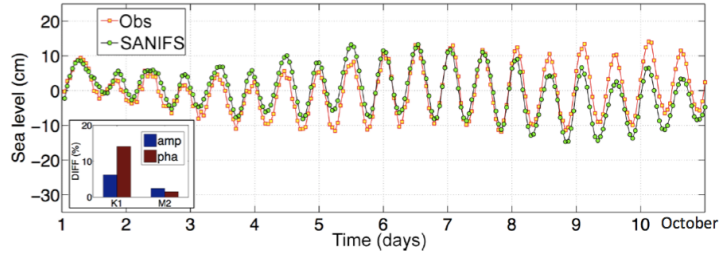
Comparison with **ADCP** data - *Velocity*



Comparison with **CTD** data - *Temperature*



Comparison with **tidegauge** data – *Sea level*



Downscaling in the Mediterranean Sea

CONCLUSIONS

- CMEMS provides **regular** and **systematic** reference information on the physical state, variability and dynamics of the ocean and marine ecosystems for the global ocean and **the European regional seas**.

- **Coastal environment:** increasing the accuracy of forecasts in coastal areas

- **Downscaling:** efficient nesting between CMEMS and coastal models (**unstructured grid approach**)

Operational Forecasting System from the sub-regional to the shelf-coastal-harbour scale - *Federico et al., 2016*, SANIFS (Southern Adriatic Northern Ionian Forecasting System)

Multiple nesting from CMEMS to SANIFS to coastal-harbour scale - *Gaeta et. al., 2016*, (A coupled wave–3-D hydrodynamics model of the Taranto Sea (Italy): a multiple-nesting approach)

Downscaling in the Mediterranean Sea

CONCLUSIONS

- The operational system is stable and robust
- Short-time simulations at three different scales, from large to shelf-coastal, to coastal and harbour
- Higher horizontal resolution at the coastal-harbour scale

The new CMEMS boundary conditions at 1/24° used in SANIFS are extremely important since they are more accurate and reduce the scales differences

Merci!

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