Coupling principles and implementation

for a coupling with an atmospheric or oceanic models

- WW3 courses -

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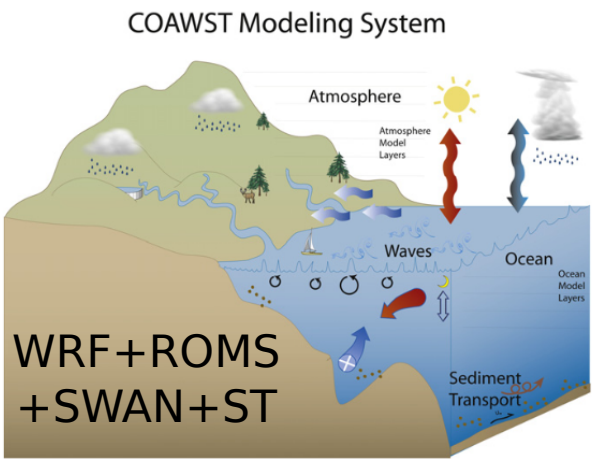
Ocean, waves and atmosphere interactions

- Atmospheric forcing from ocean not well-known (C_d under strong wind speed : hurricanes, storms, ...)
- Strong two-way ocean-atmosphere interactions at mesoscale (Chelton et al. 2004)
- ...
- $\rightarrow$ The talk of Fabrice at 9h "Coupling wave and atmospheric or oceanic models"

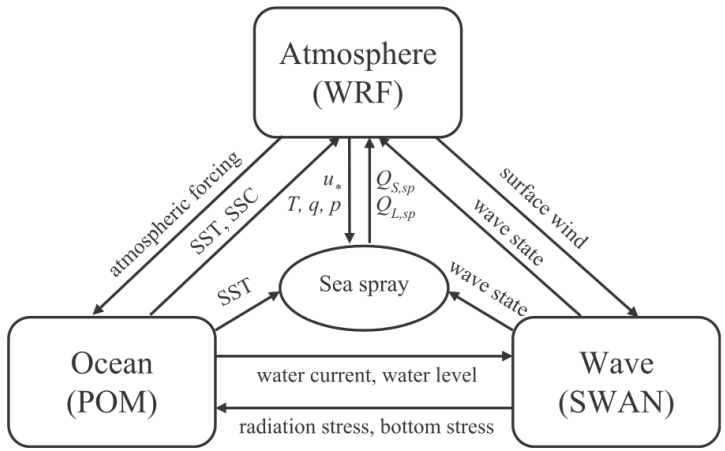
Need to have coupling ocean-waves-atmosphere simulations at every scales !

$\rightarrow$ Need to develop the coupling ...

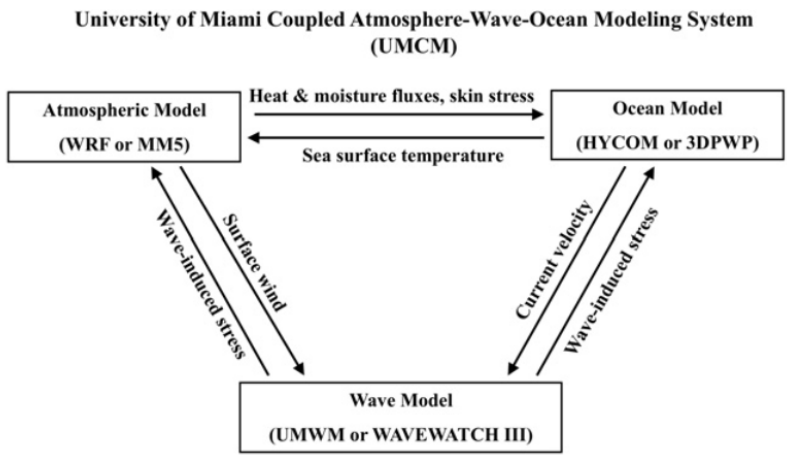
Different coupling systems



COAWST, Warner et al. 2010

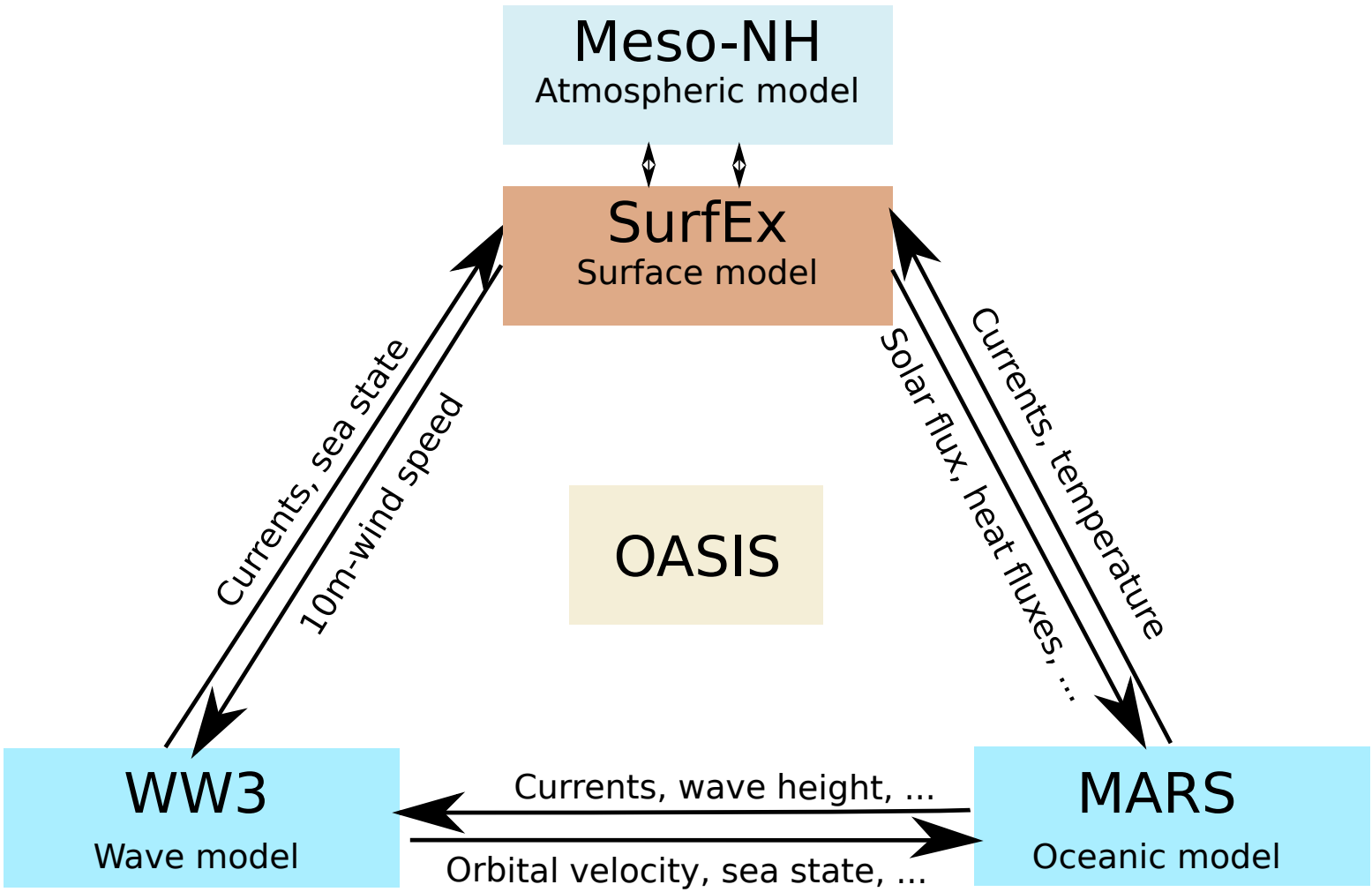


CAWOMS, Liu et al. 2011



UMCM, Chen et al. 2013

Our developements



What is OASIS ?

Choice of the coupler : OASIS

OASIS (Ocean-Atmosphere-Sea-Ice-Soil) : developed by the CERFACS (Toulouse) to coupled the different component of the climatic system

Using the last version of the coupler OASIS (OASIS3-MCT 2.0) :

- No exe for the coupling, using functions in the library "OASIS" (USE MOD_OASIS)
- Using the library MCT (Argonne National Laboratory) for parallel exchanges
- Using the library SCRIPR (Los Alamos National Laboratory) for the interpolations
- Using namelist to configure the exchanges (*namcouple*)
- ...

Implementation : call to specific functions contains in the library OASIS

To put in the models

Initialization:
--> oasis_init_comp
--> oasis_get_localcomm

Grid data definition:
--> oasis_write_grid
--> oasis_write_corner
--> oasis_write_area
--> oasis_write_mask
--> oasis_terminate_grids_writing

Partition definition:
--> oasis_def_partition

Coupling field declaration:
--> oasis_def_var

Terminate initialization:
--> oasis_enddef

Exchanges coupling fields:
--> oasis_get
--> oasis_put

End of coupling:
--> oasis_terminate

before the temporal loop:
grid data definition can be outside of the code!

functions in the new module **w3oacpmd.ftn**

in the temporal loop:
functions in the new module **w3agcmmd.ftn** ou **w3ogcmmd.ftn**

after the temporal loop:
function in the module **w3oacpmd.ftn**

Synchronus versus asynchronus coupling : get or send first ?

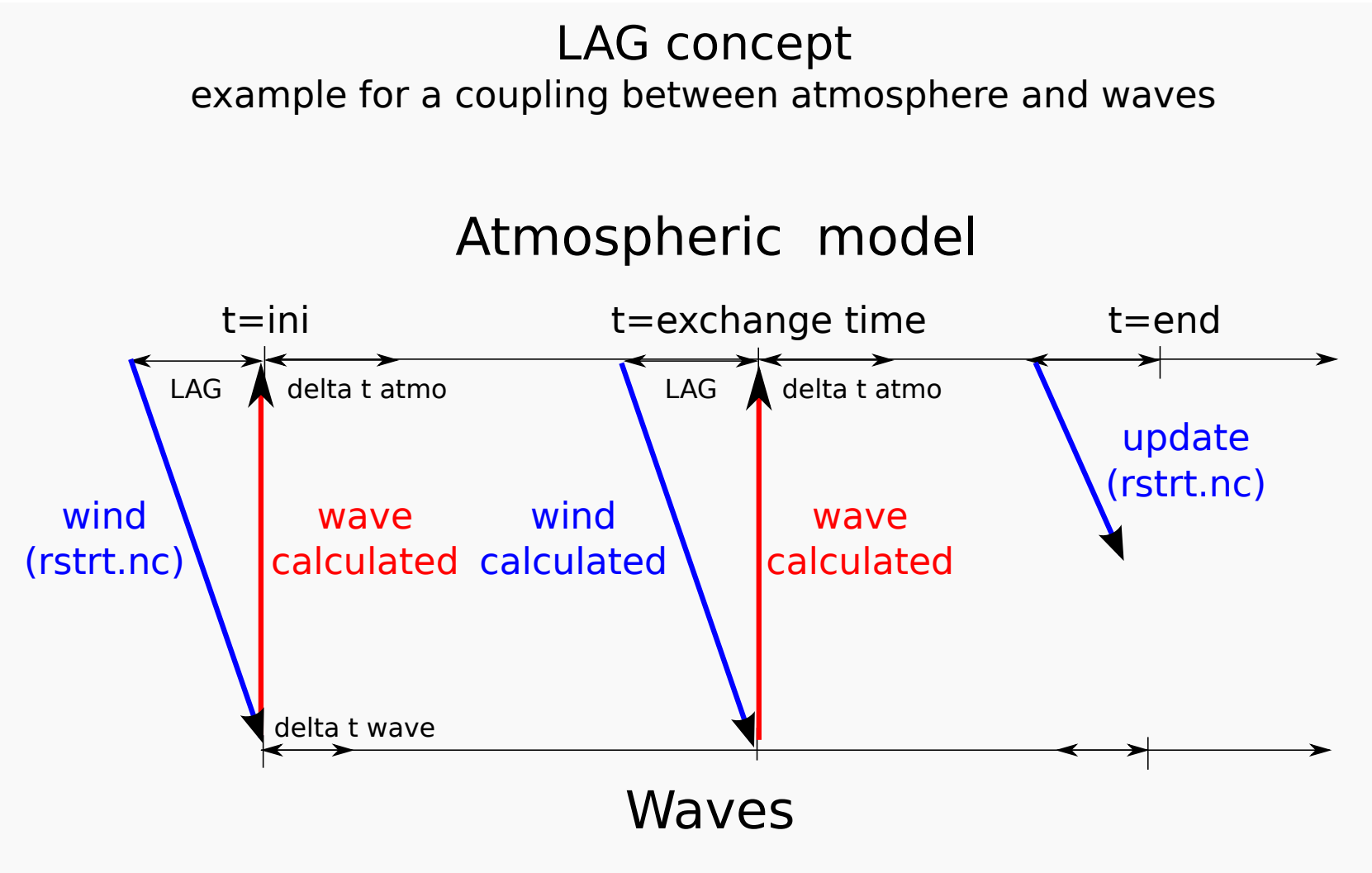
Asynchronus

- based on temporal windows : to calculate mean fluxes → good for bulk formulations
- causes a time offset which can be decreased by decreasing the size of the time window
- **Using the kind of coupling to respect bulk formulations**

Synchronus

- based on the time step : Instant exchange values
- relevance of instant values to the parameterization of turbulent flows ?

Definition of LAG for asynchronous coupling



How to launch asynchronus coupling simulation ?

- Load the environnement (library, ...)
- Create restart file *rstrt.nc* for the first model (asynchronus coupling)
- Define the namelist for OASIS : *namcouple*
  - Number of models used
  - Number of exchange fields
  - Type of exchange fields
  - Exchanges frequency
  - LAG
  - Type of interpolation (SCRIPR)
  - Type of operation on the fields (mean, conversion, ...)
  - ...
- Example of simulation on 8 cores :

  mpirun -np 6 exe_model1 : -np 2 exe_model2

Example of outputs produce by asynchronous coupling simulation

for a coupling between WW3 and Méso-NH

- Classical outputs for Méso-NH
- Classical outputs for WW3
- Outputs for OASIS :
  - grids.nc, areas.nc, masks.nc (x,y)
  - debug.01.000000, debug.02.000000
  - wwatch.timers_0000, mesonh.timers_0000
  - VARMNH01_mesonh_01.nc, VARWW301_wwatch_01.nc (x,y,t)
  - rmp_mnht_to_ww3t_DISTWGT.nc, rmp_ww3t_to_mnht_DISTWGT.nc
  - nout.000000
  - rstrt.nc update

Reminder : functions to implement in WW3

To put in the models

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Partition definition:
--> oasis_def_partition

Coupling field declaration:
--> oasis_def_var

Terminate initialization:
--> oasis_enddef

before the temporal loop:
grid data definition can be outside of the code!

functions in the new module **w3oacpmd.ftn**

Exchanges coupling fields:
--> oasis_get
--> oasis_put

in the temporal loop:
functions in the new module **w3agcmmd.ftn** ou **w3ogcmmd.ftn**

End of coupling:
--> oasis_terminate

after the temporal loop:
function in the module **w3oacpmd.ftn**

Initialization and Grid data file definition

cpl_oasis_init (w3oacpmd.ftn) used in ww3_shel.ftn

- Initialization of OASIS (**oasis_init_comp**)
- Initialization of the local communicator MPI_COMM (**oasis_get_localcomm**)

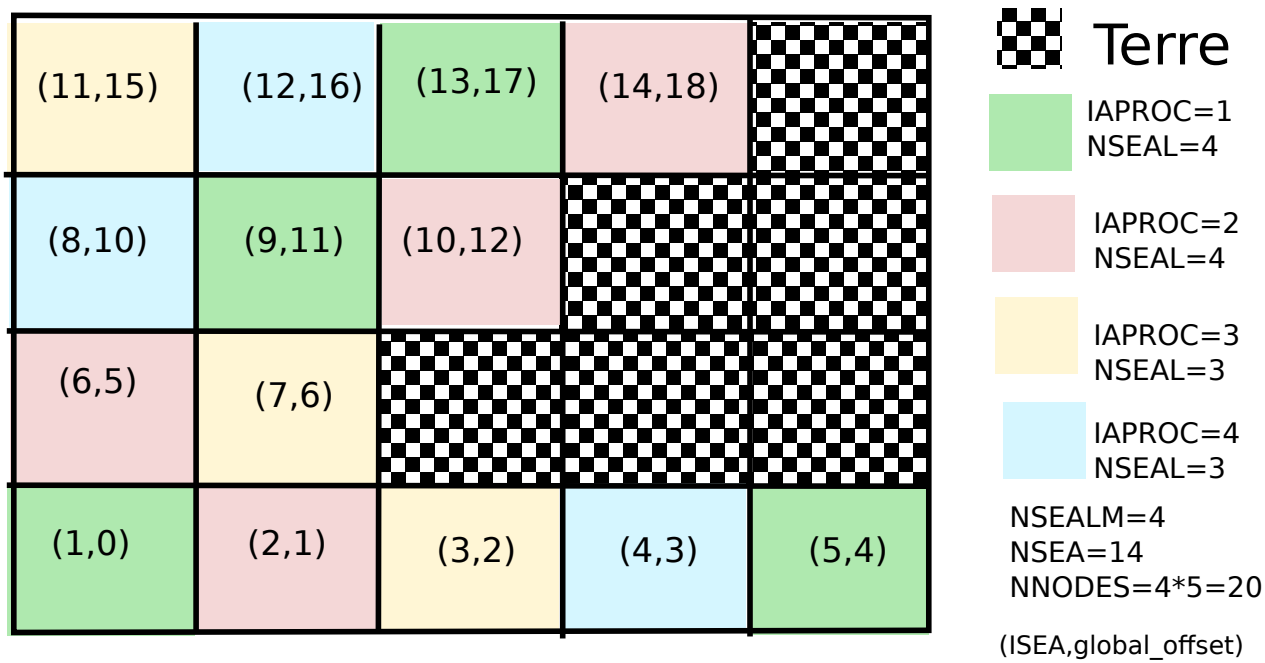
cpl_oasis_grid (w3oacpmd.ftn) used in ww3_shel.ftn

- Create grid files for remapping :
  - grids.nc : LAT/LON of each grids (**oasis_write_grid**)
  - grids.nc : corners of each cell (**oasis_write_corner**)
  - areas.nc : area of each cell (**oasis_write_area**)
  - masks.nc : sea/land mask for each grid (**oasis_write_mask**)
- Termiation of the grid data definition (**oasis_terminate_grids_writing**)

Partition definition

cpl_oasis_define (w3oacpmd.ftn) in ww3_shel.ftn

- This function informs to OASIS how WW3 is parallelized (as MPI) (**oasis_def_partition**)



Coupling field declaration

cpl_oasis_define (w3oacpmd.ftn) in ww3_shel.ftn

- Provide to OASIS the list of fields that will be exchanged between models (**oasis_def_var**)
- Creating the grids of files, weight for interpolations is performed at this stage (**oasis_enddef**)
- ...

Extra developements : chose the coupling fields in the input file ww3_shel.inp

```
$ Type 7 : Coupling
   20110902   110000  0020   20110903  000000
$
N
$
$   - Sent fields by ww3:
$       - Ocean model : T0M1 HS DIR BHD TWO UBR FOC TAW LM DRY
$       - Atmospheric model : CUR CHA HS FP
$
  CUR CHA HS FP
$
$   - Received fields by ww3:
$       - Ocean model : SSH CUR DRY
$       - Atmospheric model : WND
$
  WND
$
$ Homogeneous field data ------------------------------------------- $
```

Receiving and sending actions

Receiving fields : rcv_fields_from_ocean / atmos w3agcmmd.ftn or w3ogcmmd.ftn used in w3fldsmd.ftn

- Using the OASIS function : **oasis_get**
- Receiving coupling fields

Using fields

- as for forcing fields (switch ST3, ST4 or others to modify the use of the wind in WW3)

Sending fields : snd_fields_to_ocean / atmos w3agcmmd.ftn or w3ogcmmd.ftn used in w3wavemd.ftn

- Using the OASIS function : **oasis_put**
- Sending fields to OASIS

Termination

cpl_oasis_finalize (w3oacpmd.ftn) in ww3_shel.ftn

- Using the OASIS function **oasis_terminate**

Message in debug.01.00000 :

oasis_terminate : Calling MPI_Finalize
oasis_terminate SUCCESSFUL RUN
**** EXIT oasis_terminate

Installation/Compilation

- Installation and automatic compilation of OASIS in the regtest
- Add switch : COU, OASIS and OASACM/OASOCM

Summary of the modifications

WW3 routines (ftn folder)

Main program : ww3_shel.ftn

- call cpl_oasis_init (w3oacpmd.ftn)
- call cpl_oasis_grid (w3oacpmd.ftn)
- call cpl_oasis_define (w3oacpmd.ftn)

temporal loop

- call w3fldg (w3fldsmd.ftn)
  - call rcv_fields_from_atmos/ocean (w3a/ogcmmd.ftn)
- call w3wave (w3wavemd.ftn)
  - call snd_fields_to_atmos/ocean (w3a/ogcmmd.ftn)

end of temporal loop

- call cpl_oasis_finalize (w3oacpmd.ftn)

Programs: ww3_grid, ww3_prnc, ... not modify

Case study : Iroise sea

Config of Méso-NH

- $\Delta t = 2s$
- $\Delta x = \Delta y = 2.5km$
- $n_x = n_y = 80$

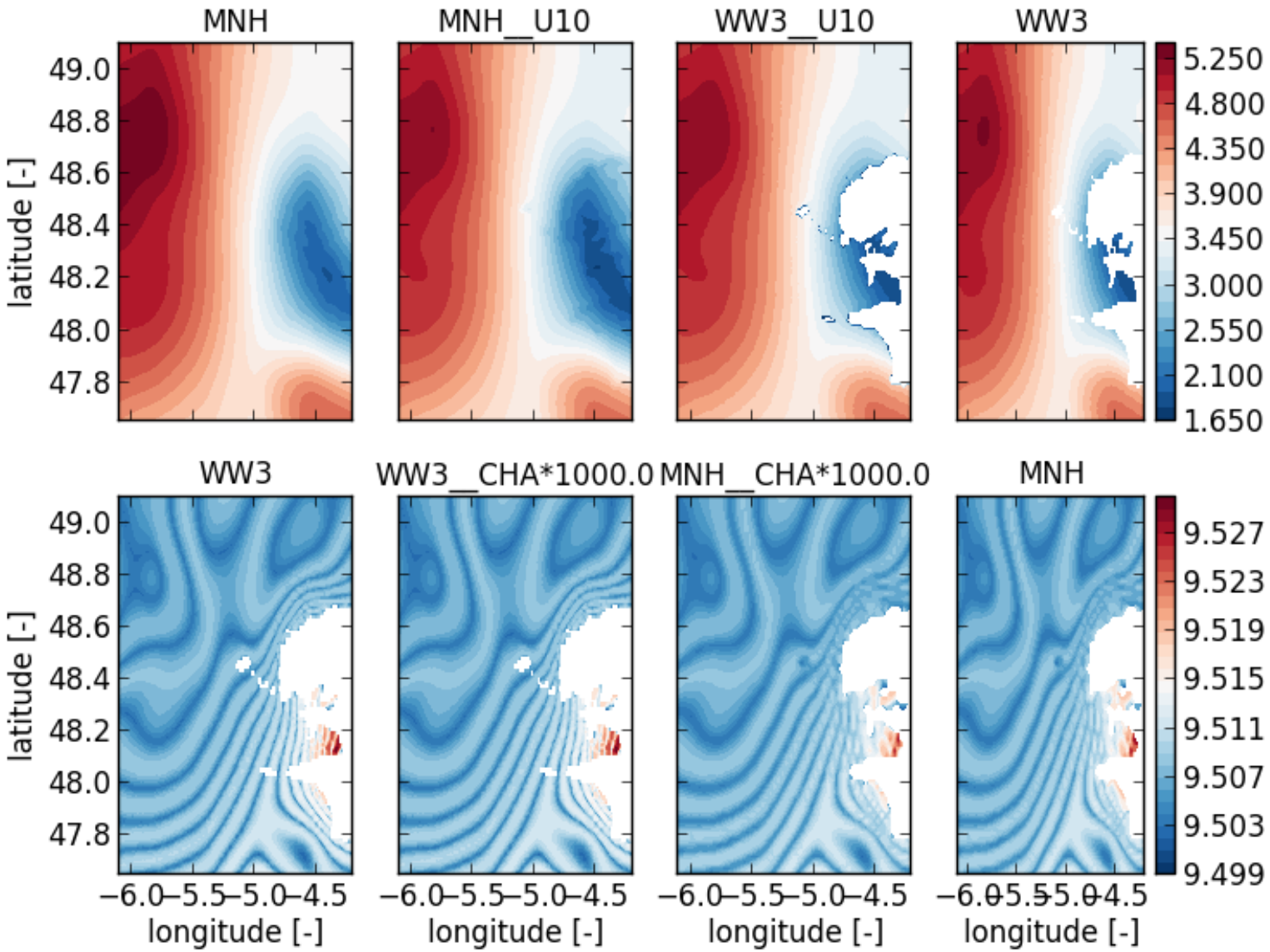
Config of WW3

- $\Delta t = 1s$
- $\Delta x = \Delta y = 1.5km$
- $n_x = 103, n_y = 119$

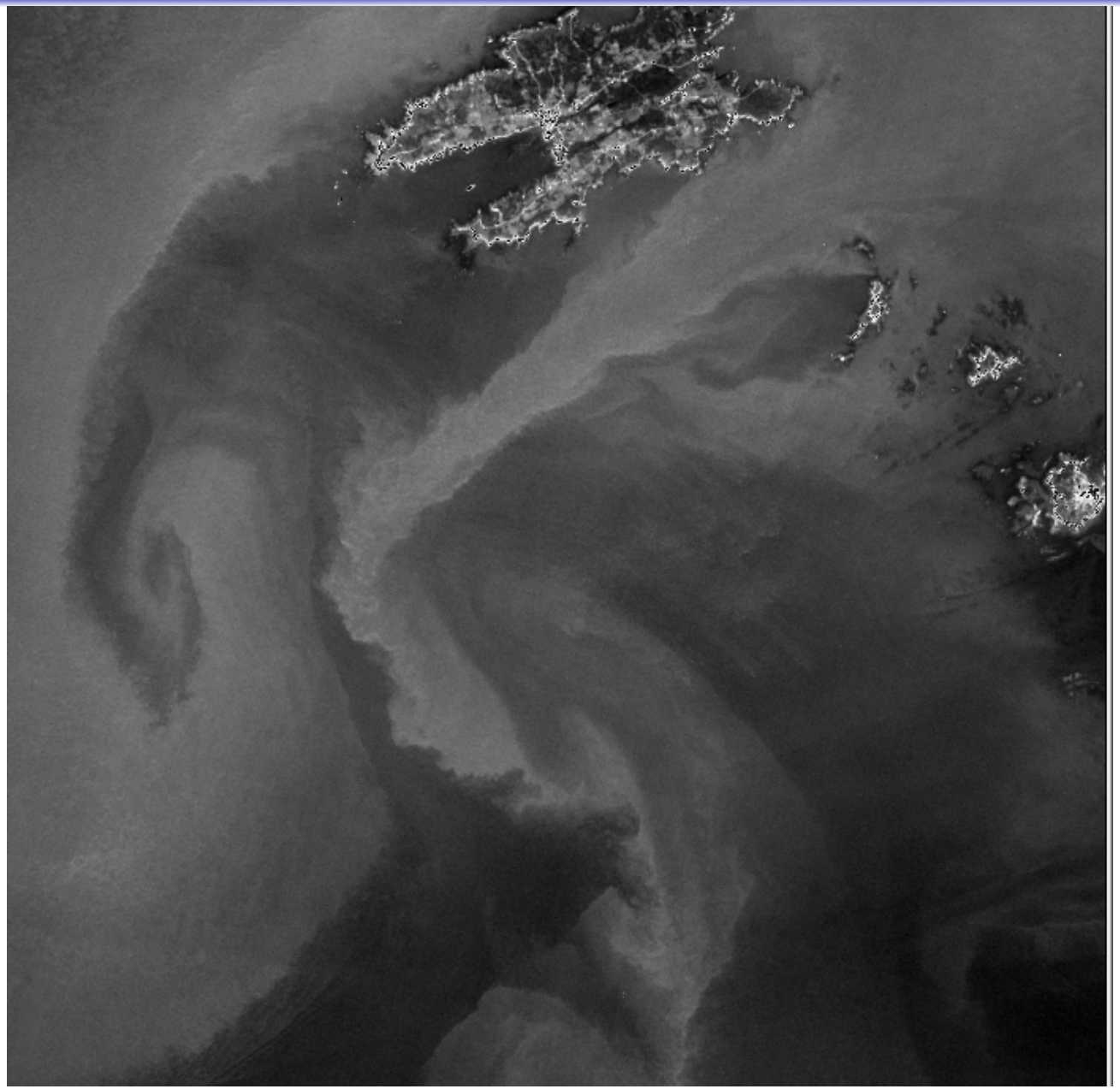
Coupling set-up

- Lenght of the simu : 30s
- Frequency of the exchanges : 10s
- Type of interpolation : SCRIPR/DISTWGT
- All the fields are exchange :
  - $U10$, $V10$ from Méso-NH to WW3
  - $UCUR$, $VCUR$, HS, TP, CHA from WW3 to Méso-NH

Checking exchanges for U10 and CHA



Real case study : close to Ushant (Ouessant) island



Summary

- WW3 can be coupled with MARS3D or Méso-NH and soon with the both
- Toy model developp to verify the algorithm, exercise this afternoon
- Working on regular grid
- Unstructured grids not tested
- Models can have different grids resolution and size
- Using only one domain (not yet coded for grid-nesting)
- ...

Thanks for your attention