Coupling CROCO with other models using OASIS

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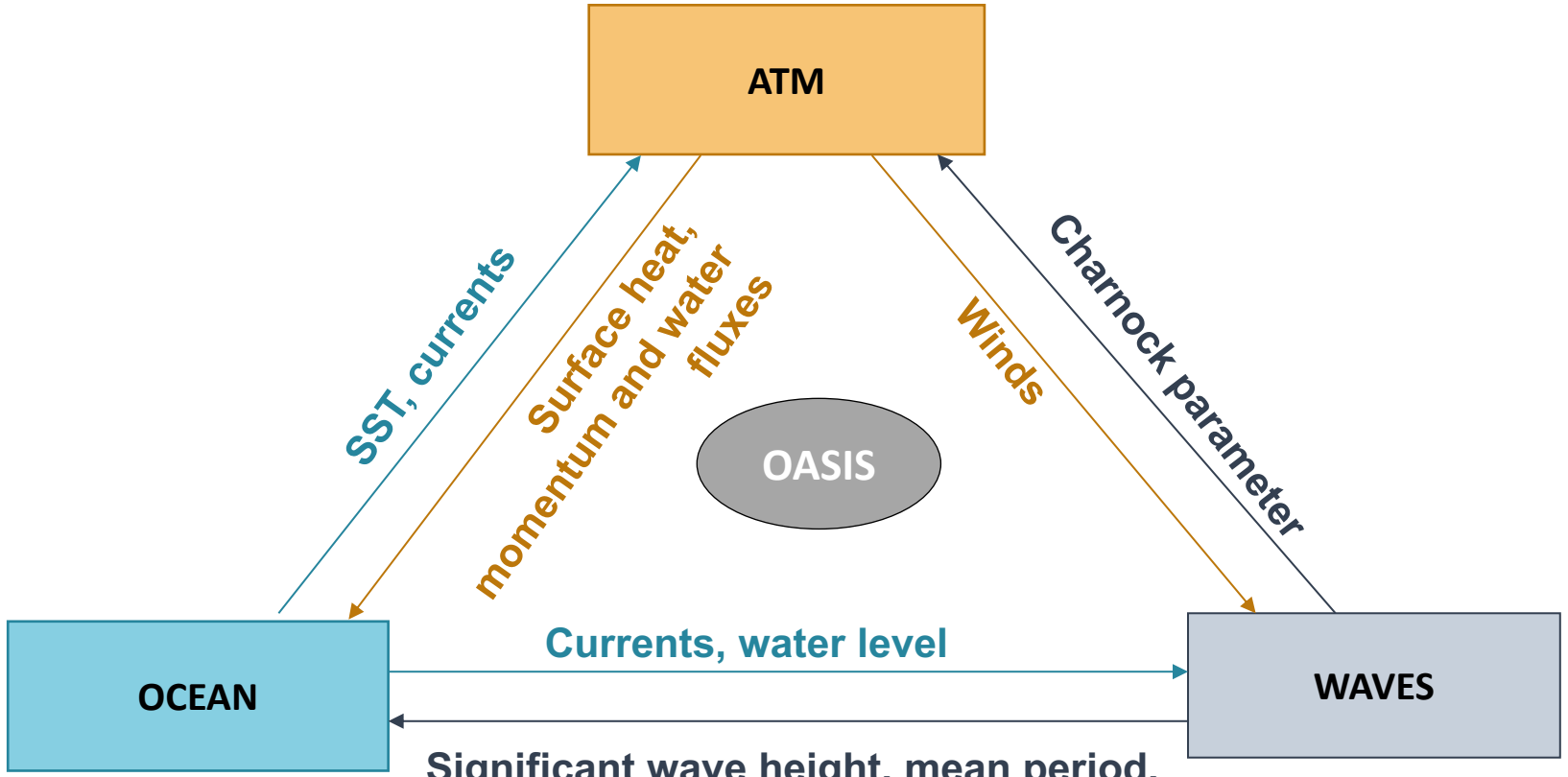
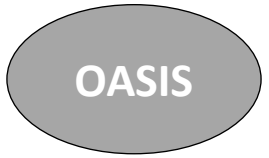
Coupling philosophy



Coupling philosophy

The OASIS-MCT coupler

OASIS-MCT (Ocean-Atmosphere-Sea-Ice-Soil, Model Coupling Toolkit) is a coupler developed at CERFACS, Toulouse, France.



It is a **set of libraries** (not an executable file) providing functions which are called in the models themselves:

- Exchange of variables and time interpolations (PSMILE library)
- Parallel exchanges (MCT library)
- Grid interpolations (SCRIPR library)

It has the **advantage** of being:

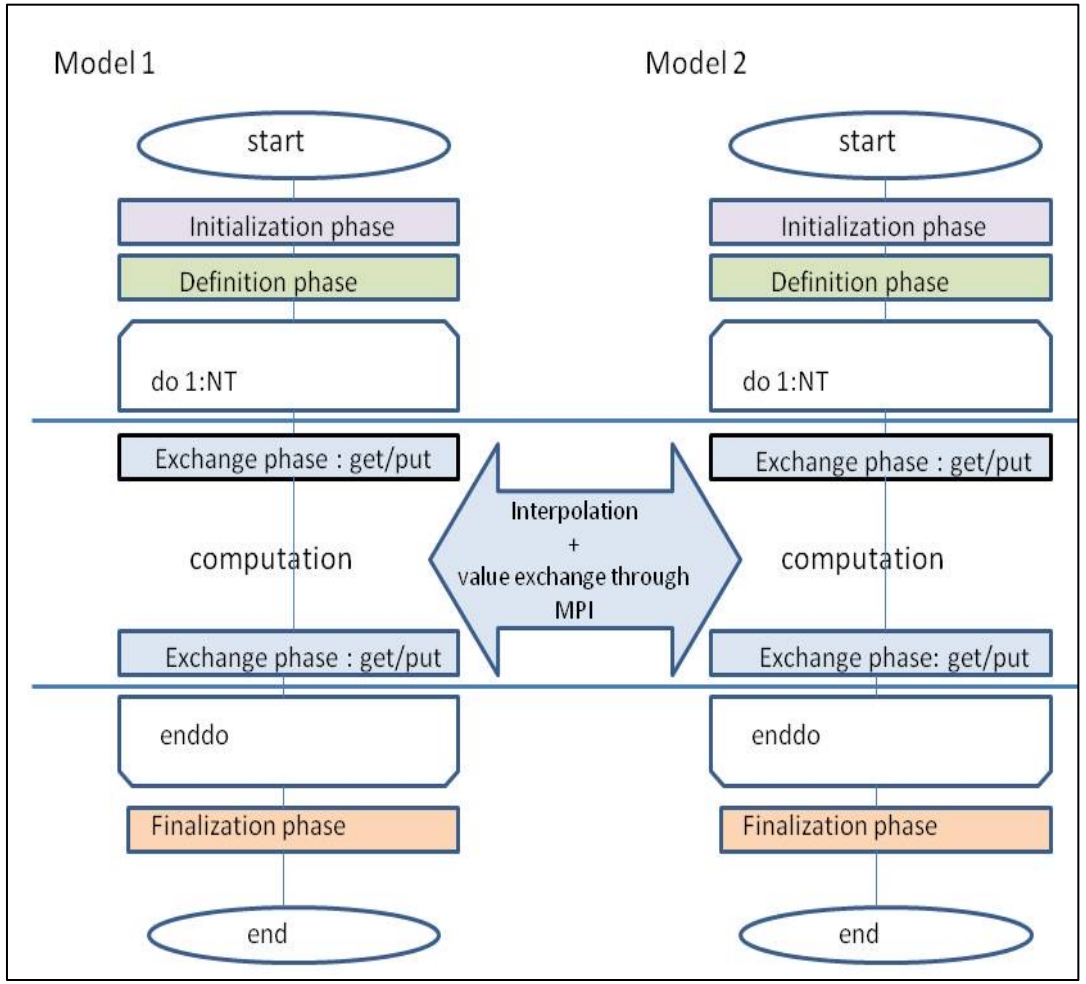
- non-intrusive, easy implementation: only a few calls in the model time stepping, and a few additional routines
- A common interface for a variety of models (e.g. CROCO, NEMO, SURFEX, WW3…)

Coupling philosophy

OASIS-MCT implementation in models

OASIS-MCT implementation calls:

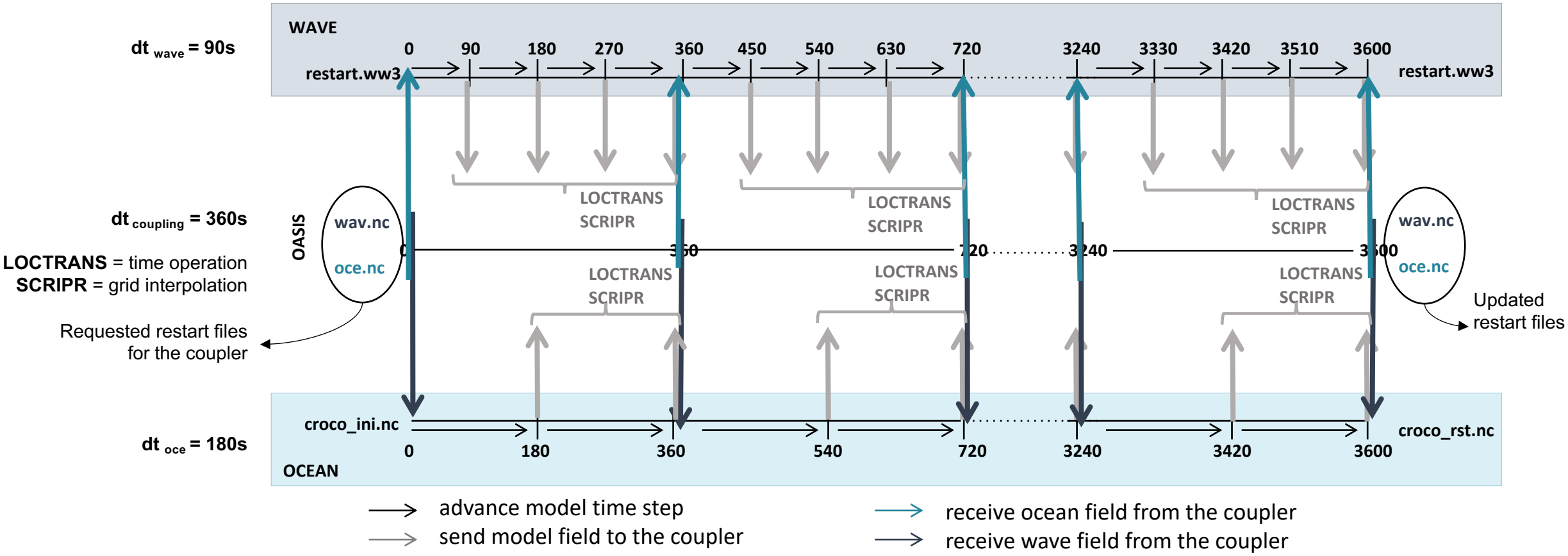
- **Initialization**
  - oasis_init_comp(…)
  - oasis_get_localcomm(..)
- **Definitions**
  - oasis_write_grid(…)
  - oasis_def_partitions(…)
  - oasis_def_var(…)
- **Exchange fields** (within time stepping)
  - oasis_put(…)
  - oasis_get(…)
- **Finalization**
  - oasis_terminate(…)



Coupling sequence

Example

Exchange phase is called every time step but the effective exchanges are only performed at the defined coupling frequency



Transformations performed by OASIS-MCT

The OASIS3-MCT coupler can process:

- time transformations (**LOCTRANS**):
  - INSTANT no time transformation, the instantaneous field is transferred
  - ACCUMUL the accumulated field over the coupling period is exchanged
  - AVERAGE the averaged field over the coupling period is transferred
  - T_MIN the minimum value of the field for each source grid point over the coupling period is transferred
  - T_MAX the maximum value of the field for each source grid point over the coupling period is transferred

- 2D spatial interpolations (**SCRIPR**):
  - BILINEAR interpolation based on a local bilinear approximation
  - BICUBIC interpolation based on a local bicubic approximation
  - CONSERV 1st or 2nd order conservative remapping
  - DISTWGT distance weighted nearest-neighbour interpolation (N neighbours)
  - GAUSWGT N nearest-neighbour interpolation weighted by their distance and a Gaussian function

See OASIS manual for more detailed information

OASIS-MCT namelist file

namcouple

The **namcouple** is the namelist file through which you will specify which fields will be coupled.

A first section gathers general settings:

```
# NFIELDS: total number of fields being exchanged
 $NFIELDS
 23
#############################################################
# NBMODEL: number of models and their names (6 characters)
 $NBMODEL
 3  wrfexe  wwatch  crocox
#############################################################
# RUNTIME: total simulated time for the actual run in seconds (<I8)
 $RUNTIME
 86400
#############################################################
# NLOGPRT: debug and time statistics informations printed in log file
$NLOGPRT
 1 1
```

OASIS-MCT namelist file

namcouple

The **namcouple** is the namelist file through which you will specify which fields will be coupled.

A second section provides the information on exchanged fields.
A typical sub-section for one exchanged field looks like:

```
CROCO_SSH WW3__SSH 1 360 1 oce.nc EXPORTED
318 248 318 248 ocnt ww3t LAG=180
R  0  R  0
SCRIPR
DISTWGT LR SCALAR LATLON 1 4
```

Line 1: OASIS name for field in sending model
OASIS name for field in sending model in target model
Unused digit
Coupling period
#of transformations (here 1 interpolation)
Restart file name
Keyword: EXPORTED = field written only at the end of the simulation
EXPOUT = field written at every coupling time step in restart file

Line 2: # of points of the sending and target grids, names of the sending and target grids, LAG=dt of sending model
Line 3: type of grid (**P**eriodical or **R**egional) and # of overlapping points for sending and target models
Line 4: keywords for transformations to perform
Line 5: Parameters for each transformation

⇒A basis of namcouple files can be found in the croco/SCRIPTS/SCRIPTS_COUPLING/OASIS_IN directory.

OASIS-MCT additional files

- Input files:
  - **Restart files**: they have to be build for initialization, and they will be automatically written at the end of the simulation for the next one: oce.nc, atm.nc, wav.nc
  - **Namelist** file: namcouple

- **Grid generated files**: these files are requested for interpolations, they are automatically built at the beginning of the simulation by all models: grids.nc, masks.nc, areas.nc
- **Grid interpolation generated files**: these files are built automatically by OASIS according to the previously cited grid files, and to SCRIPR settings in the namcouple: rmp_ww3t_to_ocnt_DISTWGT.nc, rmp_ocnt_to_ww3t_DISTWGT.nc …

- **Log files**: several log files are produced by OASIS, they should be checked at the end of the simulation or if something goes wrong during the simulation:
  - nout.000000 : OASIS log file
  - crocox.timers_0000, wwatch.timers_0000 : OASIS log file for time statistics
  - debug.root.01, debug.root.02 : log files for the master processor for each model
  - debug.notroot.01 : log files for other processors for each model

Steps to setup a coupled simulation

Summary

(1) Get the source codes

(2) Set-up your configuration architecture and environment. You can use: croco/create_config.bash (all-prod-cpl option)

(3) Compile:
- First compile OASIS
- Then, compile your models in coupled mode (with the same netcdf libraries and compilers)

NB: CROCO can alternatively be compiled automatically when launching the run within the **coupling toolbox**

(4) Perform pre-processing for your different models

(5) Define the namelists and input files:
- OASIS namcouple
- Models' namelists: croco.in, ww3_grid.inp, ww3_shel.inp, namelist.input
- Create restart files for the coupler

(6) Running: launch the models simultaneously, e.g.: mpirun -np 4 wwatch : -np 4 crocox

(7) Outputs: check log and ouptut files

Use can alternatively **use the coupling toolbox** to perform steps 5-6 more easily

⇒ If you have problems during your coupled run, check the dimensions of the grids in all grid files (models and OASIS grids and masks files)

Hands on

CROCO coupling with a toy atmospheric model

Detailed description are available here :
https://croco-ocean.gitlabpages.inria.fr/croco_doc/tutos/tutos.16.coupling.simple.html [not fully up-to-date]

- Coupling croco with a toy model that mimic an atmospheric model
  - Simpler
  - You will do the main steps for coupling croco using the generic coupler oasis

- **The atmopheric toy model : what is does ?**

  - Read a wrf output file (3 hourly output in our case)

  - Send atmospheric fields to CROCO :
    - Surface wind stress (zonal, meridional and module)
    - Surface heat fluxes (solar short wave and net non-solar heat fluxes)
    - Evaporation fluxes

  - Receive ocean fields from CROCO :
    - SST
    - Zonal & Meridional surface currents (Ucurr & Vcurr)

CROCO coupling with a toy atmospheric model

Deployment [see all instructions in NOTES_TP.txt]

```
# First create your work directory
mkdir -p /home/studentXX/lustre/AirSea/RUN_TOY_TEST
cp /home/student33/lustre/AirSea/Run_OA_toy/NOTES_TP.txt RUN_TOY_TEST

# Launch an interactive jobs
qsub -X -I -l select=1:ncpus=6:mpiprocs=6 -q serial -l walltime=02:00:00 -P WCHPC

# Go into your Run directory and copy
cd /home/studentXX/lustre/AirSea/RUN_TOY_TEST
cp -r /home/student33/lustre/AirSea/Run_OA_toy/* .
cp: overwrite ‘./NOTES_TP.txt’? N

##################
# Source the env files for compiler and netcdf
source myenv_mypath.sh
```

CROCO coupling with a toy atmospheric model

CROCO compilation for OA coupling with oasis

#1) Compile CROCO code in OA coupling mode with the OASIS3 coupler :

- check in cppdefs.h,: define MPI, OA_COUPLING and FRC_BRY and undef CLIMATOLOGY
- check in jobcomp :

FC=ifort

MPIF90=mpiifort

```
PRISM_ROOT_DIR=/home/apps/chpc/earth/OASIS3-MCT_3.0_branch/oasis3-mct/CHPC_oa3-mct_intel2020
```

```
./jobcomp
```

#2) Link the executable croco to crocox

```
ln -sf croco crocox
```

```
#3) Creation of the SCRATCH dir. for croco outputs
[ ! -d SCRATCH ] && mkdir SCRATCH
```

CROCO coupling with a toy atmospheric model

Get in put files for croco and for atm -toy

#1) Get the CROCO_FILES

```
cd CROCO_FILES
ln -sf /home/student33/lustre/Data/croco_grd.nc .
ln -sf /home/student33/lustre/Data/croco_ini.nc .
ln -sf /home/student33/lustre/Data/croco_bry.nc .
ln -sf /home/student33/lustre/Data/croco_blk.nc .
cd –
```

#2) Creation of the toy input files : from a wrf output file from 01-Janv-2005 to 31-Jan-2005, with output every 3 hours ; see ${SCRIPTDIR}/toy_getfile.sh

```
OASIS_SCRIPTS/create_oasis_toy_files.sh TOY_FILES/wrfout_d01_20050101_20050201_fortoya_NC4.nc
toy_atm.nc wrf '2,249'
```

CROCO coupling with a toy atmospheric model

Creation of the OASIS restart files

```
##################
#Creation of the OASIS restart files ; see ${SCRIPTDIR}/cpl_getrst.sh  & ${SCRIPTDIR}/cpl_getfile.sh
#
# 1) for toy_atm => atm.nc
export SCRIPTDIR=./
OASIS_SCRIPTS/create_oasis_restart_from_calm_conditions.sh TOY_FILES/wrfout_d01_20050101_20050201_fortoya_NC4.nc
atm.nc wrf "TOY_V_01 TOY_U_01 TOY_TAUX TOY_TAUY TOY_TAUM TOYSRFLX TOYSTFLX TOY__EMP TOY_UOCE TOY_VOCE TOY_PSFC
TOY__SST TOY__SSH TOY_TOM1 TOY___HS TOY__DIR TOY_TWOX TOY_TWOY TOY_TAWX TOY_TAWY TOY__CHA"


# 2) for croco => oce.nc
export SCRIPTDIR=./
OASIS_SCRIPTS/create_oasis_restart_from_calm_conditions.sh CROCO_FILES/croco_grd.nc oce.nc
croco "CROCO_SST CROCO_SSH CROCO_NOCE CROCO_EOCE"
```

CROCO coupling with a toy atmospheric model

3 days (1-3 janv 2005) coupled simulation

#Launching for 3 days with output for croco every days and exchange with toy_atm every 3 hours

```
mpirun -np 4 ./crocox croco.in : -np 2 ./toyexe
```

Outputs are in SCRATCH/

CROCO coupling with a toy atmospheric model

Namcouple

```
#############################################################
# This is a typical input file for OASIS3-MCT.
# Keywords used in previous versions of OASIS3
# but now obsolete are marked "Not used"
# Don't hesitate to ask precisions or make suggestions (oasishelp@cerfacs.fr).
#
# Any line beginning with # is ignored. Blank lines are not allowed.
#
#############################################################
# NFIELDS: total number of fields being exchanged
$NFIELDS
9
#############################################################
# NBMODEL : number of models and their names (6 characters)
$NBMODEL
2 toyexe crocox
#############################################################
# RUNTIME: total simulated time for the actual run in seconds (<I8)
$RUNTIME
259200
#############################################################
...
```

9 fields exchanged :

- 3 from Ocean => Atmosphere
- 6 from Atmosphere => Ocean

Name of the model [for oasis]

Run duration 3 days [in second]

CROCO coupling with a toy atmospheric model

Atmospheric toy model namelist

```
&NAM_OASIS NB_TIME_STEPS=24,
        DELTA_T=10800,
        GRID_FILENAME='grid_atm.nc' /

&NAM_FCT_SEND CTYPE_FCT='FILES',
           CNAME_FILE='toy_atm.nc',
           VALUE=10 /

&NAM_RECV_FIELDS NB_RECV_FIELDS=3,
              CRCVFIELDS(1)='TOY__SST',
              CRCVFIELDS(2)='TOY_UOCE',
              CRCVFIELDS(3)='TOY_VOCE' /

&NAM_SEND_FIELDS NB_SEND_FIELDS=6,
              CSNDFIELDS(1)='TOY_TAUX',
              CSNDFIELDS(2)='TOY_TAUY',
              CSNDFIELDS(3)='TOY_TAUM',
              CSNDFIELDS(4)='TOYSTFLX',
              CSNDFIELDS(5)='TOYSRFLX',
              CSNDFIELDS(6)='TOY__EMP' /
```

Number of time step of 3 hours read and send

"dt" of the atm toy model in second = 3h. It drives the coupling frequency

The wrf output file read by the atm toy model

The fields received from croco through oasis coupler

The fields send to croco through oasis coupler

CROCO coupling with a toy atmospheric model

Exercices

- What is the coupling frequency ?
- Change to run a simulation of 30 days
  - namcouple
  - TOYNAMELIST.nam
  - croco.in