

Mesh refinement in NEMO

Implementation of an agrif zoom in the Indonesian Throughflow

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in collaboration with
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Outline

Introduction

Preparing the child model

Running the model

Application

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Introduction

Preparing the child model

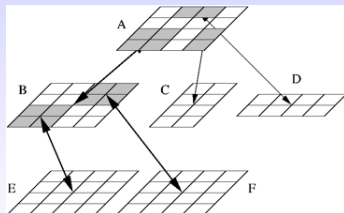
Running the model

Application

The AGRIF software

AGRIF : Adaptive Grid Refinement In Fortran

- ▶ deals with any number of grids
- ▶ includes necessary routines to code grid's interactions
- ▶ allows any space and time refinement coefficients



Principle : Run the same model on grids with different space/time resolutions

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AGRIF in NEMO

- ▶ Activated thanks to cpp key (key_agrif)
- ▶ grid's locations specified in AGRIF_FixedGrids.in

imin	imax	jmin	jmax	spacerefx	spacerefy	timeref
2						
40	70	2	30	3	3	3
110	130	50	80	5	5	3
1						
20	40	8	30	3	3	3
0						
0						

```

graph TD
  G0((G0)) --- G1((G1))
  G0 --- G2((G2))
  G1 --- G3((G3))
  
```

- ▶ each grid has its own input and output files
- ▶ works in MPI

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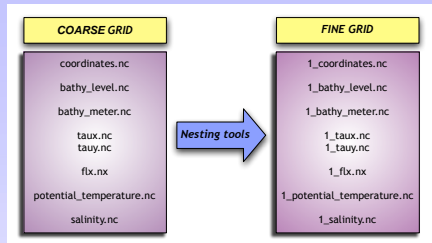
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forcings, initial conditions can be made through the « nesting tools »




Features

Goal : to simplify the design of NEMO-AGRIF configurations

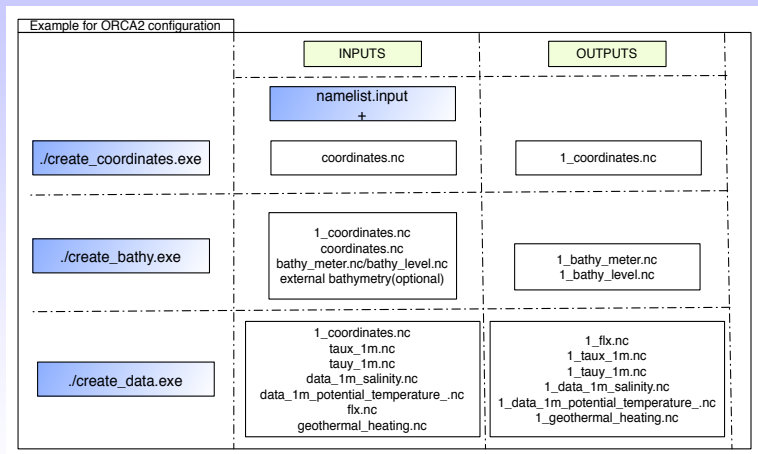
- ▶ set of fortran 95 tools especially designed for NEMO
- ▶ provides the necessary data sets to run an embedded model
- ▶ flexible in order to allow a wide range of external data
- ▶ based on a namelist file which contains various available options

Technical aspects

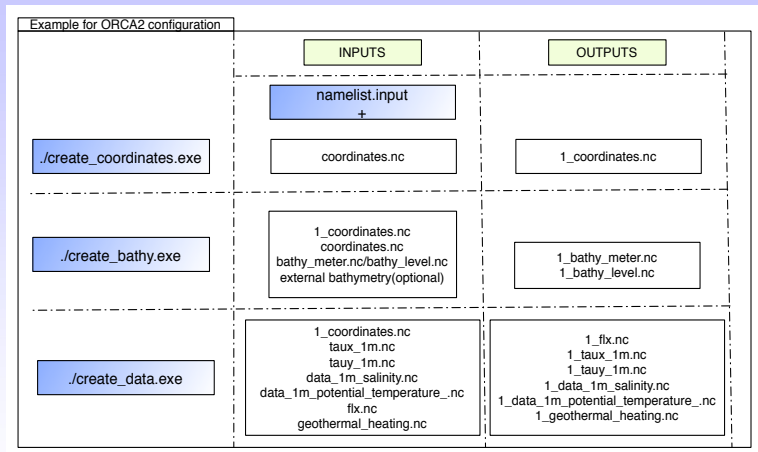
- ▶ Interpolation procedure based on SCRIP¹ with optimizations
 - ▶ bicubic or bilinear interpolation available for forcing files
 - ▶ bilinear, arithmetic or median average for bathymetry
- ▶ Smoothing algorithm on the bathymetry (optional)
- ▶ partial cells or full cells options
- ▶ allow the use of external high resolution database (etopo and OPA format)
- ▶ possibility to interpolate a restart file to add a child grid in a previous run

¹Spherical Coordinate Remapping Interpolation Package 

Global framework



Global framework



Summarize : Nesting tools might be useful as a first step before making more complex experiments

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Before running the code

Compiling procedure

- ▶ based on the usual NEMO installation and compilation environment.

Filling in the namelists

- ▶ NEMO Namelist variables are completely independant in each grid except for temporal management (rdt, nitend, ...)

⇒ Possibility to adapt namelist options to the resolution of the corresponding grid :

- ▶ Different diffusion terms
- ▶ Different advection schemes
- ▶ Different vertical coordinates

Run Directory

```

zephir NEMORUN_ORCA 98 % ls
1_bathy_level.nc          1_tauy_1m.nc           flx.nc
1_bathy_meter.nc         AGRIF_FixedGrids.in   geothermal_heating.nc
1_coordinates.nc         ahmcoef                namelist
1_data_1m_potential_temperature_nomask.nc bathy_level.nc         namelist_ice
1_data_1m_salinity_nomask.nc bathy_meter.nc         opa
1_flx.nc                 coordinates.nc         runoff_1m_nomask.nc
1_geothermal_heating.nc data_1m_potential_temperature_nomask.nc STRAIT.dat
1_namelist               data_1m_salinity_nomask.nc tauy_1m.nc
1_namelist_ice           EMPave.dat             tauy_1m.nc
1_taux_1m.nc             EMPave_old.dat
zephir NEMORUN_ORCA 99 %

```

Run Directory

```

zephir NEMORUN_ORCA 98 % ls
1_bathy_level.nc          1_tauy_1m.nc          flx.nc
1_bathy_meter.nc        AGRIF_FixedGrids.in  geothermal_heating.nc
1_coordinates.nc        ahmcoef               namelist
1_data_1m_potential_temperature_nomask.nc  bathy_level.nc       namelist_ice
1_data_1m_salinity_nomask.nc  bathy_meter.nc       opa
1_flx.nc                coordinates.nc        runoff_1m_nomask.nc
1_geothermal_heating.nc  data_1m_potential_temperature_nomask.nc  STRAIT.dat
1_namelist              data_1m_salinity_nomask.nc  taux_1m.nc
1_namelist_ice          EMPave.dat           tauy_1m.nc
1_taux_1m.nc            EMPave_old.dat
zephir NEMORUN_ORCA 99 % █

```

Run Directory

```

zephir NEMORUN_ORCA 122 % ls
1_bathy_level.nc                1_taux_1m.nc                ocean.output
1_bathy_meter.nc               1_tauy_1m.nc                opa
1_coordinates.nc              1_time.step                 ORCA_1d_00010101_00101231_diagap.nc
1_data_1m_potential_temperature_nomask.nc  AGRIF_FixedGrids.in        ORCA_2D_y0001m05d26.dimgproc
1_data_1m_salinity_nomask.nc   ahmcoef                     ORCA_KZ_y0001m05d26.dimgproc
1_flx.nc                       bathy_level.nc              ORCA_S_y0001m05d26.dimgproc
1_geothermal_heating.nc       bathy_meter.nc              ORCA_T_y0001m05d26.dimgproc
1_namelist                     coordinates.nc               ORCA_U_y0001m05d26.dimgproc
1_namelist_ice                 data_1m_potential_temperature_nomask.nc  ORCA_V_y0001m05d26.dimgproc
1_ocean.output                 data_1m_salinity_nomask.nc  ORCA_W_y0001m05d26.dimgproc
1_ORCA_2D_y0001m05d26.dimgproc  datrj.out                   runoff_1m_nomask.nc
1_ORCA_KZ_y0001m05d26.dimgproc  EMPave.dat                  solver.stat
1_ORCA_S_y0001m05d26.dimgproc  EMPave_old.dat              STRAIT.dat
1_ORCA_T_y0001m05d26.dimgproc  flx.nc                       taux_1m.nc
1_ORCA_U_y0001m05d26.dimgproc  geothermal_heating.nc       tauy_1m.nc
1_ORCA_V_y0001m05d26.dimgproc  ice.evolu                    time.step
1_ORCA_W_y0001m05d26.dimgproc  namelist
1_solver.stat                  namelist_ice
zephir NEMORUN_ORCA 123 % █

```


Outline

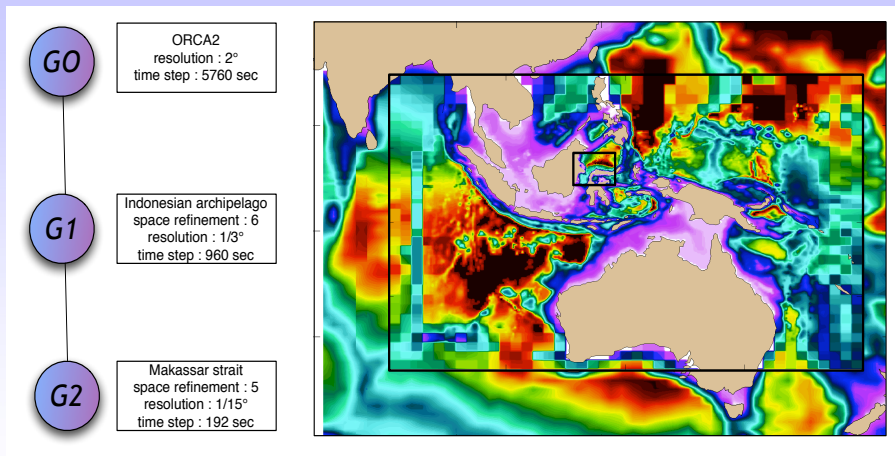
Introduction

Preparing the child model

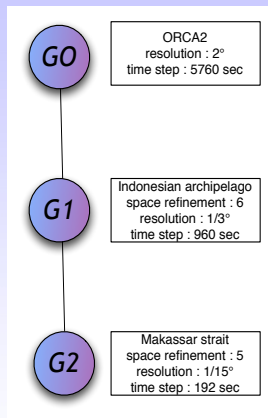
Running the model

Application

Configuration (1)



Configuration (2)



Computational cost




- ▶ ORCA2 : 182x149 points → 2%
- ▶ grid 1 : 262x274 points → 28%
- ▶ grid 2 : 119x304 points → 70%

Forcing files creation

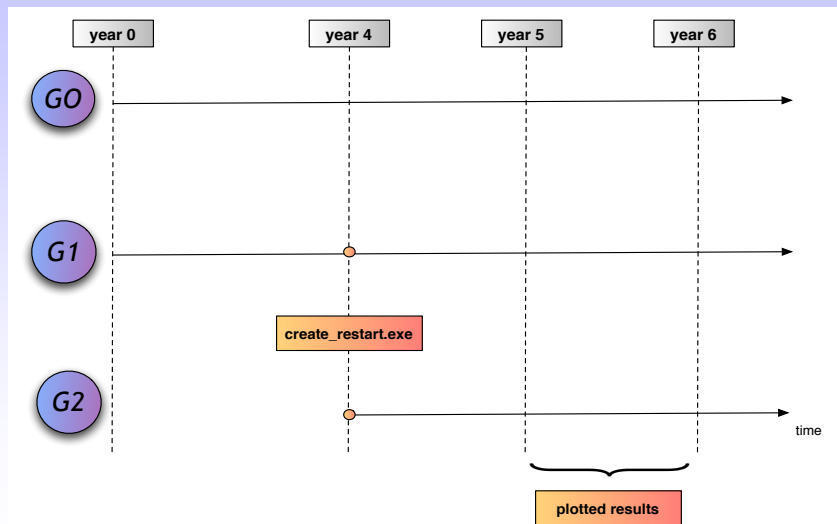
through « nesting tools »

- ▶ External bathymetry :
 - ▶ ORCA025 for G1 + bilinear interpolation
 - ▶ etopo2 for G2 + median average
- ▶ Climatological fields : interpolated from global ORCA2 forcings (bicubic interpolation)
- ▶ Vertical coordinate : partial cells
 - ▶ $e3zps_min = 40$.
 - ▶ $e3zps_rat = 0.25$

Configuration (3)

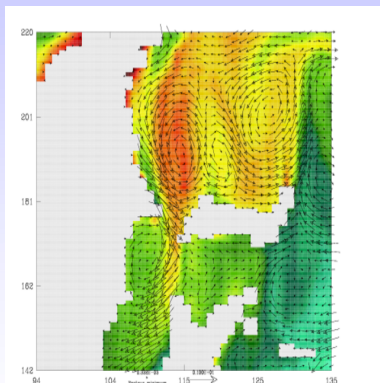
	advection scheme	advection for tracers	advection on momentum
	2nd order centered	laplacian iso-neutral	laplacian iso-neutral
	3rd order upwind	laplacian iso-neutral	bilaplacian horizontal
	3rd order upwind	laplacian iso-neutral	bilaplacian horizontal

Configuration (4)

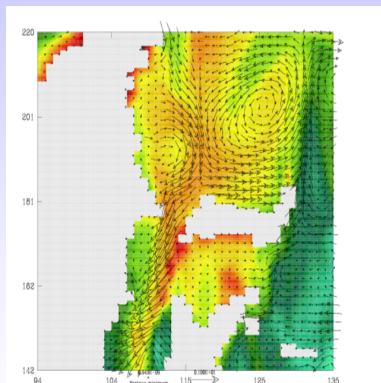


Influence of 2way nesting

- mean fields (September)



fine grid (level 1) only



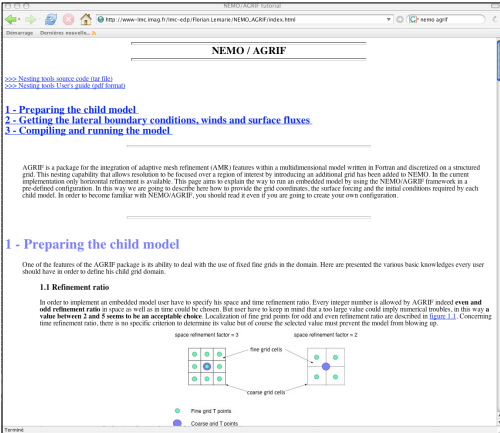
fine grid (level 1) + fine grid (level 2)

Movie

- ▶ From January 0006 up to January 0007
- ▶ G2 + 10 points of G1 surrounding G2
- ▶ surface temperature and currents

Website and documentation

http://www.lodyc.jussieu.fr/NEMO/ (Pre-Post processing packages part)



NEMO / AGRIF

[>>> Nesting tools source code \(tar file\)](#)
[>>> Nesting tools User's guide \(pdf format\)](#)

1 - Preparing the child model
2 - Getting the lateral boundary conditions, winds and surface fluxes
3 - Compiling and running the model

AGRIF is a package for the integration of adaptive mesh refinement (AMR) features within a multidimensional model written in Fortran and discretized on a structured grid. This nesting capability that allows resolution to be focused over a region of interest by introducing an additional grid has been added to NEMO. In the current implementation only horizontal refinement is available. This page aims to explain the way to run an embedded model by using the NEMO/AGRIF framework in a pre-defined configuration. In this way we are going to describe here how to provide the grid coordinates, the surface forcing and the initial conditions required by each child model. In order to become familiar with NEMO/AGRIF, you should read it even if you are going to create your own configuration.

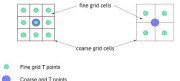
1 - Preparing the child model

One of the features of the AGRIF package is its ability to deal with the use of fixed fine grids in the domain. Here are presented the various basic knowledges every user should have in order to define his child grid domain.

1.1 Refinement ratio

In order to implement an embedded model user have to specify his space and time refinement ratio. Every integer number is allowed by AGRIF indeed **even and odd refinement ratio in space** as well as in time could be chosen. But user have to keep in mind that a too large value could imply numerical troubles, in this way a **value between 2 and 5 seems to be an acceptable choice**. Localization of fine grid points for odd and even refinement ratio are described in figure 1.1. Concerning time refinement ratio, there is no specific criterion to determine its value but of course the selected value must prevent the model from blowing up.

space refinement factor = 3 space refinement factor = 2



● Fine grid T points
● Coarse grid T points

