ROMS_AGRIF 2.0 User's Guide

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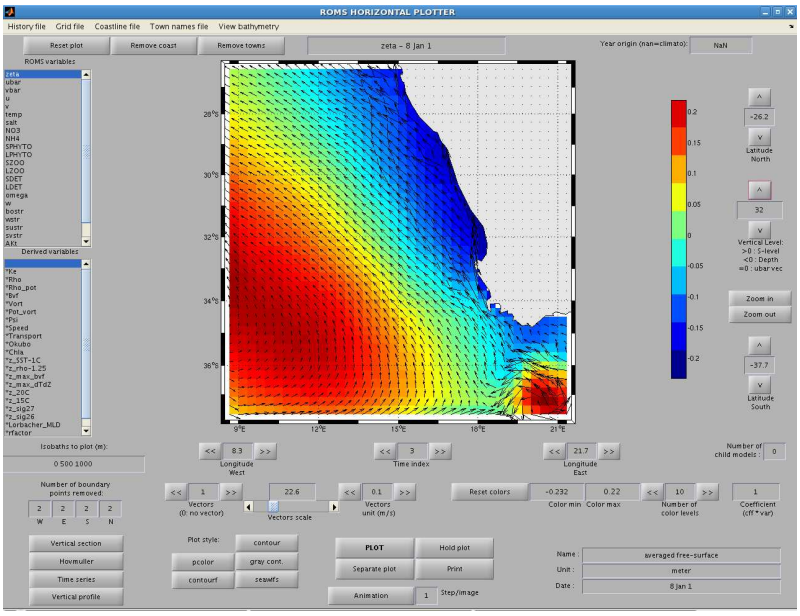

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Introduction

The Regional Ocean Modeling System (ROMS) is a new generation ocean circulation model (Shchepetkin and McWilliams, 2005) that has been specially designed for accurate simulations of regional oceanic systems. The reader is referred to Shchepetkin and McWilliams (2003) and to Shchepetkin and McWilliams (2005) for a complete description of the model. ROMS has been applied for the regional simulation of a variety of different regions of the world oceans (e.g. Blanke et al., 2002; Di Lorenzo et al., 2003; Haidvogel et al., 2000; MacCready et al., 2002; Marchesiello et al., 2003; Penven et al., 2001).

To perform a regional simulation using ROMS, the modeler needs to provide several data files in a specific format: horizontal grid, bottom topography, surface forcing, lateral boundary conditions... He also needs to analyze the model outputs. The tools which are described here have been designed to perform these tasks. The goal is to be able to build a standard regional model configuration in a minimum time.

In the first chapter, the system requirements and the installation process are exposed. A short note on ROMS model is presented in chapter 2. A tutorial on the use of ROMSTOOLS is shown in the third section. Tidal simulations, inter-annual simulations, nesting tools, biology and operational regional modeling are presented in section 4, 5, 6, 7 and 8.

In the second chapter, some details of the IRD version of ROMS new release, named roms_agrif 2.0, using the AGRIF nesting procedure are presented.
First, the new AGRIF 2-ways nesting procedure implemented in the code is described, then new numerical and physical schemes and parametrization are exposed. Then a changelog section since the last roms_agrif 1.0 offical version is presented. Finally, the cpp-keys, parameters and input files are described in details to correctly configure the model options.

Contents

Chapter 1

ROMSTOOLS matlab toolbox

1.1 Installation

1.1.1 System requirement

This toolbox has been designed for Matlab. It needs at least 2 Gbites of disk space. It has been tested on several Matlab versions ranging from Matlab6 to Matlab2006a. It has been mostly tested on Linux workstations, but it could be used on any platform if a NetCDF and a LoadDAP Matlab Mex files are provided. The NetCDF Matlab Mex file is needed to read and write into NetCDF files and it can be found at the web location: http://mexcdf.sourceforge.net/. The LoadDAP Matlab Mex file is used to download data from OpenDAP servers for inter-annual and forecast simulations. It can be found at the web location: http://www.opendap.org/download/ml-structs.html. The Matlab LoadDAP Mex file provides a way to read any OpenDAP-accessible data into Matlab. Note that the LibDAP library must be installed on your system before installing LoadDAP. Details can be found at the web location: http://www.opendap.org. MexCDF and LoadDAP mex files are provided for Linux (system FEDORA 32bits: mexcdf and Opendap_tools/FEDORA ; system CENTOS or FEDORA 64bits: mexnc and Opendap_tools/FEDORA_X64), but they are not working on all the plateforms.

All the other necessary Matlab toolboxes (i.e. air-sea, mask, netcdf or m_map...) are included in the ROMSTOOLS package. Global datasets, such as topography (Smith and Sandwell, 1997), hydrography (Conkright et al., 2002) or surface fluxes (Da Silva et al., 1994), are also included.

1.1.2 Getting the files

All the necessary compressed tar files (XXX.tar.gz) containing the Matlab programs, several datasets and other toolboxes and softwares needed by ROMSTOOLS are located at:

http://roms.mpl.ird.fr/Roms_tools/index.html

For the ROMS source code you should download ROMS_AGRIF version V1.1.

1.1.3 Extracting the files

Download all the compressed tar files. Uncompress and untar all the files (gunzip and tar -xvf). You should obtain the following directory tree :

```
Roms_tools
    |– Aforc_NCEP
    |– Aforc_QuikSCAT
    |– air_sea
    |– COADS05
    |– Compile
    |– Diagnostic_tools
    |– Documentation
    |    |– User_guide
    |– Forecast_tools
    |– mask
    |– mex60
    |– mexnc
    |    |– tests
    |– m_map
    |    |– private
    |– Nesting_tools
    |– netcdf_g77
    |– netcdf_ifc
    |– netcdf_matlab
    |    |– listpick
    |    |– ncatt
    |    |– ncbrowser
    |    |– ncdim
    |    |– ncfiles
    |    |– ncitem
    |    |– ncrec
    |    |– nctype
    |    |– ncutility
    |    |– ncvar
    |    |– netcdf
    |– netcdf_x86_64
    |– Oforc_OGCM
    |– Opendap_tools
    |    |– FEDORA
    |    |– FEDORA_X64
    |– Preprocessing_tools
    |– Roms_Agrif
    |    |– AGRIFZOOM
    |    |    |– AGRIF_FILES
    |    |    |– AGRIF_INC
    |    |    |– AGRIF_OBJS
    |    |    |– AGRIF_YOURFILES
```

```
|   |   |– LIB.clean
|– Run
|   |– DATA
|   |– FORECAST
|   |– ROMS_FILES
|   |– SCRATCH
|   |– TEST_CASES
|– SeaWifs
|– SST_pathfinder
|– Tides
|– Topo
|   |– Matlab
|– TPX06
|– TPX07
|– Visualization_tools
|– WOA2001
|– WOA2005
```

Definition of the different directories :

- Aforc_NCEP : Scripts for the recovery of surface forcing data (based on NCEP reanalysis) for inter-annual simulations.
- Aforc_QuikSCAT : Scripts for the recovery of wind stress from satellite scatterometer data (QuickSCAT).
- COADS05 : Directory of the surface fluxes global monthly climatology at 0.5° resolution (Da Silva et al., 1994).
- Compile : Empty scratch directory for ROMS compilation.
- Diagnostic_tools : A few Matlab scripts for animations and basic statistical analysis.
- Documentation : Location of the ROMSTOOLS user guide.
- Forecast_tools : Scripts for the generation of an operational modeling system
- mask : Land mask edition toolbox developed by A.Y. Shcherbina.
- mex60 : Matlab NetCDF interface for 32 bits Linux architectures.
- mexnc : Matlab NetCDF interface for 64 bits Linux architectures.
- m_map : The Matlab mapping toolbox (http://www2.ocgy.ubc.ca/∼rich/map.html).
- Nesting_tools : Preprocessing tools used to prepare nested models.
- netcdf_g77 : The NetCDF Fortran library for Linux, compiled using g77 (http://www.unidata.ucar.edu/packages/netcdf/index.html).
- netcdf_ifc : The NetCDF Fortran library for Linux, compiled with ifort. The Intel Fortran Compiler (ifort) is available at http://www.intel.com/software/products/compilers/flin/noncom.htm.

- netcdf_matlab : The Matlab NetCDF toolbox (http://woodshole.er.usgs.gov/staffpages/cdenham/public_html/MexCDF/nc4ml5.html).

- netcdf_x86_64 : The NetCDF Fortran library for Linux, compiled with ifort on a 64 bits architecture.

- Oforc_OGCM : Scripts for the recovery of initial and lateral boundary conditions from global OGCMs (SODA (Carton et al., 2005) or ECCO (Stammer et al., 1999)) for inter-annual simulations.

- Opendap_tools : LoadDAP mexcdf and several scripts to automatically download data over the Internet.

- Preprocessing_tools : Preprocessing Matlab scripts (make_grid.m, make_forcing, etc...).

- Roms_Agrif : ROMS Fortran sources.

- Run : Working directory. This is where the ROMS input files are generated and where the model is running.

- SeaWifs : surface chlorophyll-a climatology based on SeaWifs observations.

- SST_pathfinder : Directory of a higher resolution SST climatology (Reynolds and Smith, 1994) for the thermal correction term.

- Tides : Matlab routines to prepare ROMS tidal simulations. Tidal data are derived from the Oregon State University global models of ocean tides TPXO6 and TPXO7 (Egbert and Erofeeva, 2002): http://www.oce.orst.edu/research/po/research/tide/global.html.

- Topo : Location of the global topography dataset at $2'$ resolution (Smith and Sandwell, 1997). Original data can be found at: http://topex.ucsd.edu/cgi-bin/get_data.cgi

- TPX06 : Directory of the global model of ocean tides TPXO6 (Egbert and Erofeeva, 2002).

- TPX07 : Directory of the global model of ocean tides TPXO7 (Egbert and Erofeeva, 2002).

- Visualization_tools : Matlab scripts for the ROMS visualization graphic user interface.

- WOA2001 : World Ocean Atlas 2001 global dataset (monthly climatology at 1° resolution) (Conkright et al., 2002).

- WOA2005 : World Ocean Atlas 2005 global dataset

- WOAPISCES : World Ocean Atlas Global dataset for biogeochemical PISCES data

1.2 LibDAP and LoadDAP

It is sometimes difficult to compile LoadDAP. LibDAP must be installed before installing LoadDAP. You have to declare the LibDAP binary and library in tour /.bashrc with th command PATH and LD_LIBRARY_PATH. Once, compile and install LoadDAP.

Here are a few instructions for the installation of these libraries:

- Download libDAP and loadDAP tar.gz version at the web location http://www.opendap.org
- To build the libDAP library, follow these steps:
- log you as a root
- Uncompress and untar the file libdap.tar.gz (gunzip and tar -xvf)
- >: cd libdap_directory
- Type './configure' at the prompt. Some libraries must be installed on your system to successfully run configure and build libDAP library : libcurl (http://curl.haxx.se/) and libxml2 (http://xmlsoft.org/).
  Example:

```
checking for a BSD-compatible install... /usr/bin/install -c
checking whether build environment is sane... yes
checking whether make sets (MAKE)... yes
checking build system type... i686-pc-linux-gnu
checking host system type... i686-pc-linux-gnu
checking for gawk... (cached) mawk
checking for g++... g++
checking for C++ compiler default output file name... a.out
...
config.status: dods-datatypes.h is unchanged
config.status: executing depfiles commands
```

- Type 'make' to build the library.
  Example :

```
make[1]: Entering directory '/home/tropic/tan/soft/libdap-3.6.2'
Making all in gl
make[2]: Entering directory '/home/tropic/tan/soft/libdap-3.6.2/gl'
make all-am
make[3]: Entering directory '/home/tropic/tan/soft/libdap-3.6.2/gl'
...
```

- Type 'make check' to run the tests. To pass this step you must have DejaGNU framework (GNU FTP mirror list: http://www.gnu.org/prep/ftp.html).
  Example :

  ---

  make[1]: Entering directory '/home/tropic/tan/soft/libdap-3.6.2/gl'
  dejagnu_driver.sh
  ...
  Test Run By tan on Thu Jul 19 11:19:02 2007
  Native configuration is i686-pc-linux-gnu
  ===== das-test tests =====
  Running ...
  ===== das-test Summary =====
  ===== dds-test tests =====
  Running ...
  ===== dds-test Summary =====
  ===== expr-test tests =====
  Running ...
  ===== expr-test Summary =====
  PASS: dejagnu_driver.sh
  ==================
  All 1 tests passed
  ==================
  make[2]: Leaving directory '/home/tropic/tan/soft/libdap-3.6.2/tests'
  make[1]: Leaving directory '/home/tropic/tan/soft/libdap-3.6.2/tests'

- Type 'make install' to install the library. By default the files are installed under /usr/local/lib/. You can specify a different root directory using the following control : 'make install root_directory'.

- Go to the .bashrc and add
  EXPORT LD_LIBRARY_PATH=$LD_LIBRARY_PATH : root_directory.'

- The installation of the loadDAP library is done as for libDAP. By default the files are installed under /usr/local/share/.

- Go in the .dodsrc file, add the PROXY_SERVER configuration, if needed, for example PROXY_SERVER http,proxy.legos.obs-mip.fr:3128

1.3 Future plans

- A graphic user interface could be useful for the preprocessing tools.

- There is need for an improvement of the extrapolation and interpolation methods.

1.4 Warnings

- Since Geostrophy is used to obtain the horizontal currents for the lateral boundary conditions, this method should be applied with care close to the Equator. An extrapolation of the currents outside an equatorial band (2°S-2°N) is performed to get an approximation of the equatorial currents.
- On extended grids, the objective analysis used for data extrapolation can be relatively costly in memory and CPU time. The "nearest" Matlab function that is less costly can be used instead. If the computer starts to swap, you should think of reducing the dimension of your model's domain.

1.5 Tutorial : the Southern Benguela example

This section presents the essential steps for preparing and running a regional ROMS simulation. This is done following the example of a model of the Southern Benguela at low resolution and using climatological forcing at surface and boundaries.

1.5.1 Getting started : Processing input files

Once the installation has been successful, launch a Matlab session in the directory: ∼/Roms_tools/Run. Run the start.m script to set the Matlab paths for this session.

In this step of this installation, you have to know a few things concerning your matlab setup and tour computer environnmemnt:

- What is the architecture of my machine 32 or 64 bits ? For that do uname -a.
- What are the native matlab installation library that I have ?
- If I have already native netcdf routines and library with my Matlab version, I don't need to use the netcdf library provided by Roms_tools, so remove it from start.m file.
- If I have already native m_map routines with my Matlab version, I don't need to use the netcdf library provided by Roms_tools, so remove it from start.m file.
- For these questions, it can be useful to edit your matlab path with the matlab command **path** in a matlab session.

In the Roms_tools, some netCDF libraries for matlab are provided :

- mex60 : matlab12 (old) and 32 bits architecture
- mexnc : matlab7 and 64 bits architecture

In the Roms_tools, some "Opendap" bins and librarys are also provided :

- Opendap_tools/FEDORA : LibDAP and LoadDAP bin and library for Fedora Linux distribution, 32 bits architecture
- Opendap_tools/FEDORA_X64 : Same for 64 bits architecture.

However, if your Linux distribution differs from Fedora, the best is to compile and install by your own the LibDAP and LoadDAP (section 1.2)

You are now ready to create a new configuration. It is important to respect the order of the following preprocessing steps: make_grid, make_forcing, make_clim. For all the preprocessing steps, there is only one file to edit : ∼/Roms_tools/Run/romstools_param.m . This file contains the necessary parameters for the generation of the ROMS input NetCDF files. The first section in romstools_param.m defines the general parameters, such as title, working directories or file names:

%%%%%%%%%%%%%%%%%%%%%
%

```
% 1- General parameters
%
%%%%%%%%%%%%%%%%%%%%
%
% ROMS title names and directories
%
ROMS_title = 'Benguela Test Model';
ROMS_config = 'Benguela_LR';
%
ROMSTOOLS_dir = '../';
%
%
Run directory %
RUN_dir=[ROMSTOOLS_dir,'Run/'];
%
ROMS_files_dir=[RUN_dir,'ROMS_FILES/'];
%
% Global data directory (etopo, coads, datasets download from ftp, etc..)
%
DATADIR=ROMSTOOLS_dir; %
% Forcing data directory (ncep, quikscat, datasets download with opendap, etc..)
%
FORC_DATA_DIR = [RUN_dir,'DATA/'];
%
% ROMS file names (grid, forcing, bulk, climatology, initial)
%
eval(['!mkdir ',ROMS_files_dir])
%
bioname=[ROMS_files_dir,'roms_frcbio.nc']; %Iron Dust forcing file with PISCES
grdname=[ROMS_files_dir,'roms_grd.nc'];
frcname=[ROMS_files_dir,'roms_frc.nc'];
blkname=[ROMS_files_dir,'roms_blk.nc'];
clmname=[ROMS_files_dir,'roms_clm.nc'];
ininame=[ROMS_files_dir,'roms_ini.nc'];
oaname =[ROMS_files_dir,'roms_oa.nc']; % oa file : intermediate file not used
% in roms simulations
bryname=[ROMS_files_dir,'roms_bry.nc'];
Zbryname=[ROMS_files_dir,'roms_bry_Z.nc'];% Zbry file: intermediate file not used
% in roms simulations
%
frc_prefix=[ROMS_files_dir,'roms_frc']; % generic bulk forcing file name
% for inter-annual roms simulations (NCEP or GFS)
blk_prefix=[ROMS_files_dir,'roms_blk']; % generic forcing file name
% for inter-annual roms simulations (NCEP or GFS)
%
% Objective analysis decorrelation scale [m]
% (if Roa=0: simple extrapolation method; crude but much less costly)
%
```

%Roa=300e3;
Roa=0;
%
interp_method = 'linear'; % Interpolation method: 'linear' or 'cubic'
%
makeplot = 1; % 1: create a few graphics after each preprocessing step
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

Variables description:

- title='Benguela Test Model' : General title. You can give any name you want for your configuration.
- ROMS_config = 'Benguela_LR' : Name of the configuration. This is used for the storage of NCEP or OGCM data for a specific configuration.
- ROMSTOOLS_dir = '../' : "Roms_tools" directory.
- RUN_dir=[ROMSTOOLS_dir,'Run/'] : Roms_tools/Run directory. This is where all the work is done.
- ROMS_files_dir=[RUN_dir,'ROMS_FILES/'] : Roms_tools/Run/ROMS_FILES/ directory. This is where ROMS input NetCDF files are stored.
- ROMS_files_dir=[RUN_dir,'ROMS_FILES/'] :
- DATADIR=ROMSTOOLS_dir; : Global data directory (ETOPO, COADS, datasets download from ftp, etc..)
- FORC_DATA_DIR = [RUN_dir,'DATA/'] : Forcing data directory (NCEP, QUIKSCAT, datasets downloaded with opendap, etc..)
- bioname=[ROMS_files_dir,'roms_frcbio.nc'] : Name of the ROMS input NetCDF Iron dust forcing file for PISCES biogeochemical model.
- grdname=[ROMS_files_dir,'roms_grd.nc'] : Name of the ROMS input NetCDF grid file. This is where the horizontal grid parameters are stored. In general, we follow the style : XXX_grd.nc.
- frcname=[ROMS_files_dir,'roms_frc.nc'] : : Name of the ROMS input NetCDF forcing file. This is where the surface forcing variables (such as wind stress) are stored. In general, we follow the style : XXX_frc.nc.
- blkname=[ROMS_files_dir,'roms_blk.nc'] : Name of the ROMS input NetCDF bulk file. This is where the atmospheric variables used for the bulk parametrization (such as air temperature) are stored. In general, we follow the style : XXX_blk.nc.
- clmname=[ROMS_files_dir,'roms_clm.nc'] : Name of the ROMS input NetCDF climatology file. This is where ROMS prognostic variables (u,v, temp, salt, ubar, vbar, zeta) for lateral boundary and interior nudging are stored. This file can be large because variables are stored for all the ROMS grid interior points. It is called "a climatology file" because this was the file used in the past for the restoring of the

ROMS solution towards an in-situ climatology (such as Levitus for example). In general, we follow the style : XXX_clm.nc.

- ininame=[ROMS_files_dir,'roms_ini.nc'] : Name of the ROMS input NetCDF initial file. This is where ROMS prognostic variables (u,v, temp, salt, ubar, vbar, zeta) are stored for the initial conditions. In general, we follow the style : XXX_ini.nc.
- oaname =[ROMS_files_dir,'roms_oa.nc'] : Name of an intermediate file which is not used by ROMS. This is equivalent to the climatology file, but on a z vertical coordinate. Firstly, the variables are horizontally interpolated to create a roms_oa.nc file (a OA file). Then, they are vertically interpolated on the ROMS s-coordinate for the climatology file. In general, we follow the style : XXX_oa.nc.
- bryname=[ROMS_files_dir,'roms_bry.nc'] : Name of the ROMS input NetCDF boundary file. This is an alternative of the climatology file. In this case, variables are only stored for the lateral boundaries. In general, we follow the style : XXX_bry.nc.
- Zbryname=[ROMS_files_dir,'roms_bry_Z.nc'] : Intermediate file on a z coordinate for the boundary file. In general, we follow the style : XXX_bry_Z.nc.
- frc_prefix=[ROMS_files_dir,'roms_frc'] : First part of the forcing file names in the case of inter_annual simulations. In this case, a separate file is created for each month. For example, a forcing file based on NCEP for January 2000 is : roms_frc_NCEP_Y2000M1.nc
- blk_prefix=[ROMS_files_dir,'roms_blk'] : First part of the bulk file names in the case of inter_annual simulations. In this case, a separate file is created for each month. For example, a bulk file based on NCEP for January 2000 is : roms_blk_NCEP_Y2000M1.nc
- Roa=0 : Decorrelation length scale in meters for the objective analysis (300 km is a reasonable value for the employed datasets). If Roa=0, the "nearest" Matlab extrapolation method is used instead of an objective analysis. This is much less costly, but the results might be at a lower quality.
- interp_method = 'cubic' : Horizontal interpolation method used after the objective analysis. It can be linear or cubic.
- makeplot = 1 : Select to generate images after each step of the preprocessing.

1.5.2 Building the grid

The part of the file romstools_param.m that you should be edit is :

```
%%%%%%%%%%%%%%%%%%%%%%
%
% 2-Grid parameters
% used by make_grid.m (and others..)
%
%%%%%%%%%%%%%%%%%%%%%%
%
% Grid dimensions:
%
lonmin = 8; % Minimum longitude [degree east]
```

```
lonmax = 22; % Maximum longitude [degree east]
latmin = -38; % Minimum latitude [degree north]
latmax = -26; % Maximum latitude [degree north]
%
% Grid resolution [degree]
%
dl = 1/3;
%
% Number of vertical Levels (! should be the same in param.h !)
%
N = 32;
%
% Vertical grid parameters (! should be the same in roms.in !)
%
theta_s = 8.;
theta_b = 0.;
hc =10.;
%
% Minimum depth at the shore [m] (depends on the resolution,
% rule of thumb: dl=1, hmin=300, dl=1/4, hmin=150, ...)
% This affect the filtering since it works on grad(h)/h.
%
hmin = 75;
%
% Maximum depth at the shore [m] (to prevent the generation
% of too big walls along the coast)
%
hmax_coast = 500;
%
% Topography netcdf file name (ETOPO 2 or any other netcdf file
% in the same format)
%
topofile = [DATADIR,'Topo/etopo2.nc'];
%
% Slope parameter (r=grad(h)/h) maximum value for topography smoothing
%
rtarget = 0.25;
%
% Number of pass of a selective filter to reduce the isolated
% seamounts on the deep ocean.
%
n_filter_deep_topo=4;
%
% Number of pass of a single hanning filter at the end of the
% smoothing procedure to ensure that there is no 2DX noise in the
% topography.
%
n_filter_final=2;
```

```
%
% GSHSS user defined coastline (see m_map)
% XXX_f.mat Full resolution data
% XXX_h.mat High resolution data
% XXX_i.mat Intermediate resolution data
% XXX_l.mat Low resolution data
% XXX_c.mat Crude resolution data
%
coastfileplot = 'coastline_l.mat';
coastfilemask = 'coastline_l_mask.mat';
```

Variables description:

- lonmin = 8 : Western limit of the grid in longitude [-360°, 360°]. The grid is rectangular in latitude/longitude.
- lonmax = 22 : Eastern limit [-360°, 360°]. Should be superior to lonmin.
- latmin = -38 : Southern limit of the grid in latitude [-90°, 90°].
- latmax = -26 : Northern limit [-90°, 90°]. Should be superior to latmin.
- l = 1/3 : Grid longitude resolution in degrees. The latitude spacing is deduced to obtain an isotropic grid using the relation: $d\phi = dl\cos(\phi)$.
- N = 32 : Number of vertical levels. Warning! N has to be also defined in the file : ∼/Roms_tools/Run/param.h before compiling the model.
- theta_s = 6. : Vertical S-coordinate surface stretching parameter. When building the climatology and initial ROMS files, we have to define the vertical grid. Warning! The different vertical grid parameters should be identical in this file and in the ROMS input file (i.e. ∼/Roms_tools/Run/roms.in). This is a serious cause of bug. The effects of theta_s, theta_b, hc, and N can be tested using the Matlab script : ∼/Roms_tools/Preprocessing_tools/test_vgrid.m.
- theta_b = 0. : Vertical S-coordinate bottom stretching parameter.
- hc = 10. : Vertical S-coordinate H_c parameter. It gives approximately the transition depth between the horizontal surface levels and the bottom terrain following levels. It should be inferior to hmin.
- hmin = 75 : Minimum depth in meters. The model depth is cut a this level to prevent, for example, the occurrence of model grid cells without water. This does not influence the masking routines. At lower resolution, hmin should be quite large (for example 150m for dl=1/2). Otherwise, since topography smoothing is based on $\frac{\nabla h}{2h}$, the bottom slopes can be totally eroded.
- hmax_coast = 500 : Maximum depth under the mask. It prevents selected isobaths (here 500 m) to go under the mask. If this is the case, this could be a source of problems for western boundary currents (for example).
- topofile = [ROMSTOOLS_dir,'Topo/etopo2.nc'] : Default topography file. We are using here etopo2 (Smith and Sandwell, 1997).

- rtarget = 0.25 : This variable control the maximum value of the r-parameter that measures the slope of the sigma layers (Beckmann and Haidvogel, 1993):

$$r = \frac{\nabla h}{2h} = \frac{h_{+1/2} - h_{-1/2}}{h_{+1/2} + h_{-1/2}}$$

  To prevent horizontal pressure gradients errors, well known in terrain-following coordinate models (Haney, 1991), realistic topography requires some smoothing. Empirical results have shown that reliable model results are obtained if r does not exceed 0.2.

- n_filter_deep_topo=4 : Number of pass of a Hanning filter to prevent the occurrence of noise and isolated seamounts on deep regions.

- n_filter_final=2 : Number of pass of a Hanning filter at the end of the smoothing process to be sure that no noise is present in the topography.

- coastfileplot = 'coastline_l.mat' : Binary GSHSS coastal file used by m_map for graphical pruposes. The letter before ".mat" selects the coastline resolution. f: Full resolution, h: High resolution, i: Intermediate resolution, l: Low resolution c: Crude resolution.

- coastfilemask = 'coastline_l_mask.mat' : Binary file used for the coastline in the masking toolbox.

Save romstools_param.m and run make_grid in the Matlab session :

```
>>
>> make_grid
```

You should obtain in the Matlab session:

```
Making the grid: ../Run/ROMS_FILES/roms_grd.nc

Title: Benguela Test Model

Resolution: 1/3 deg

Create the grid file...
LLm = 41
MMm = 42

Fill the grid file...

Compute the metrics...

Min dx=29.1913 km - Max dx=33.3244 km
Min dy=29.2434 km - Max dy=33.1967 km

Fill the grid file...
```

```
Add topography...
ROMS resolution : 31.3 km
Topography data resolution : 3.42 km
Topography resolution halved 4 times
New topography resolution : 54.6 km
Processing coastline_l.mat ...
Do you want to use editmask ? y,[n]
Apply a filter on the Deep Ocean to remove the isolated seamounts :
4 pass of a selective filter.
Apply a selective filter on log(h) to reduce grad(h)/h :
13 iterations - rmax = 0.24381
Smooth the topography a last time to prevent 2DX noise:
2 pass of a hanning smoother.
Write it down...
Do a plot...
>>
```

You should keep the values of LLm and MMm during the process. They will be necessary for the ROMS parameter file ∼/Roms_tools/Run/param.h. In this test case, LLm0 = 23 and MMm0 = 31.

During the grid generation process, the question "Do you want to use editmask ? y,[n]" is asked. The default answer is n (for no). If the answer is y (for yes), editmask, the graphic interface developed by A.Y.Shcherbina, will be launched to manually edit the mask (Note that, for the moment, editmask is not working with matlab7 and mexnc). Otherwise the mask is generated from the unfiltered topography data. A procedure prevents the existence of isolated land (or sea) points.

Figure (1.1) presents the bottom topography obtained with make_grid.m for the Southern Benguela example. Note that at this low resolution (1/3°), the topography has been strongly smoothed.

1.5.3 Getting the wind and other surface fluxes

The next step is to create the file containing the different surface fluxes. The part of the file romstools_param.m that you should edit is :

```
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%
% 3-Surface forcing parameters
% used by make_forcing.m and by make_bulk.m
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%
% COADS directory (for climatology runs)
%
coads_dir=[ROMSTOOLS_dir,'COADS05/'];
%
% COADS time (for climatology runs)
```

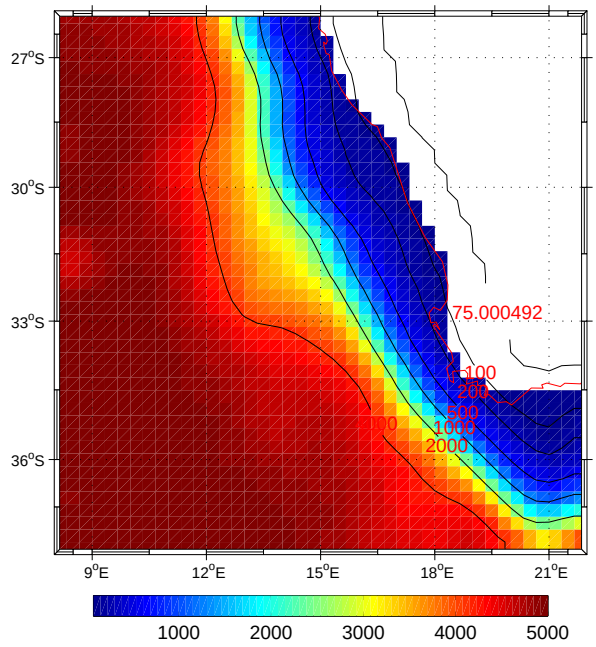


Figure 1.1: Result of make_grid.m for the Benguela example

```
%
coads_time=(15:30:345); % days: middle of each month
coads_cycle=360; % repetition of a typical year of 360 days
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
% 3.1 Surface forcing parameters
% used by pathfinder_sst.m
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
pathfinder_sst_name=[ROMSTOOLS_dir,...
'SST_pathfinder/climato_pathfinder.nc'];
```

Variables description:

- coads_dir=[ROMSTOOLS_dir,'COADS05/'] : Directory where the global atlas of surface marine data at 1/2° resolution (Da Silva et al., 1994) is located.

- coads_time=(15:30:345) : Time in days for the monthly climatology. It corresponds to the middle of each month. ROMS uses this time to interpolate linearly the forcing variables in time.

- coads_cycle=360 : Duration on which the forcing variables are cycled. Here, for the sake of simplicity, we are running the model on a repeating climatological year of 360 days.

- pathfinder_sst_name=[ROMSTOOLS_dir,SST_pathfinder/climato_pathfinder.nc'] : Directory of the monthly climatology of sea surface temperature from Pathfinder satellite observations (Casey and Cornillon, 1999). This can be used has an alternative of Da Silva et al. (1994) SST.

Save romstools_param.m and run make_forcing in the Matlab session :

```
>>
>> make_forcing
```

You should obtain :

```
Benguela Test Model

Read in the grid...

Create the forcing file...
Getting taux for time index 1
Getting tauy for time index 1
...
Make a few plots...
>>
```

This program can take a relatively long time to process all the forcing variables. Figure (1.2) presents the wind stress vectors and wind stress norm obtained from the global atlas of surface marine data at 1/2° resolution (Da Silva et al., 1994) at 4 different periods of the year. Da Silva et al. (1994) sea surface temperature (SST) is used for the restoring term (dQdSST) in the heat flux calculation. To improve the model solution it is possible to use a SST climatology at a finer resolution (9.28 km) (Casey and Cornillon, 1999). To do so, you can run pathfinder_sst.m in the Matlab session :

```
>>
>> pathfinder_sst
```

You should obtain :

```
... Month index: 1
... Month index: 2
...
>>
```

For the surface forcing, instead of directly prescribing the fluxes, it is possible to use a bulk formula to generate the surface fluxes from atmospheric variables during the model run. In this case, ROMS needs to be recompiled with the BULK_FLUX cpp key defined. To generate the bulk forcing file, you need to run make_bulk in the Matlab session :

>>
>> make_bulk

You should obtain :

Benguela Test Model

Read in the grid...

Create the bulk forcing file...
Getting sat for time index 1
Getting sat for time index 2
...
Make a few plots...
>>

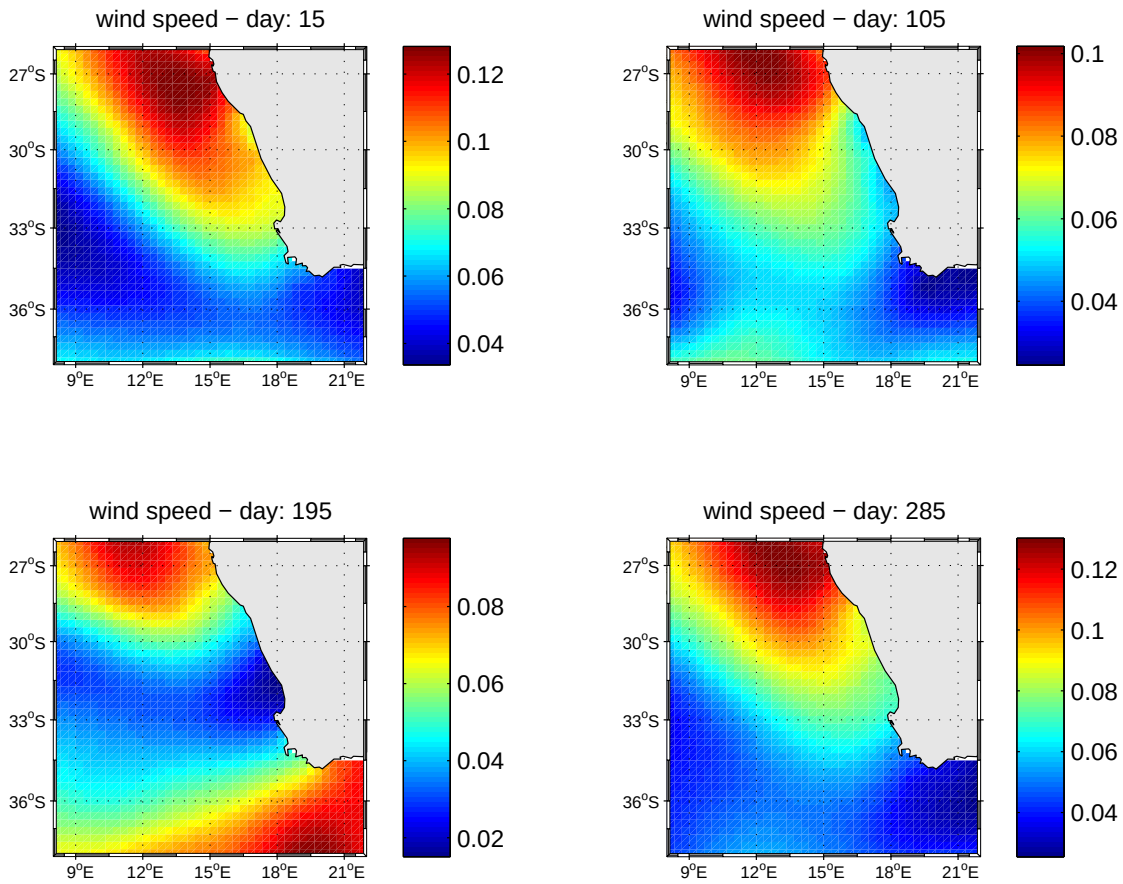


Figure 1.2: Wind stress[N.m^{-2}] obtained using make_forcing.m for the Benguela example.

1.5.4 Getting the initial and the lateral boundary conditions

The last preprocessing step consists in generating the files containing the necessary informations for the ROMS initial and lateral open boundaries conditions. This script generates two files : the climatology file (XXX_clm.nc) which gives the lateral boundary conditions, and the initial conditions file (XXX_ini.nc).
The part which should be edited by the user in the file romstools_param.m is. Note that you can you can add the variables for the NPZD or PISCES biogeochemical models. For that, define makebio or makepisces flags in the romstools_param.m.

The part which should be edited by the user in the file romstools_param.m is:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
% 4-Open boundaries and initial conditions parameters
% used by make_clim.m, make_biol.m, make_bry.m
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Open boundaries switches (! should be consistent with cppdefs.h !)
%
obc = [1 1 1 1]; % open boundaries (1=open , [S E N W])
%
% Level of reference for geostrophy calculation
%
zref = -1000;
%
% Switches for selecting what to process in make_clim (1=ON)
% (and also in make_OGCM.m and make_OGCM_frcst.m)
makeini=1; %1: process initial data
makeclim=1; %1: process lateral boundary data
makebry=0; %1: process boundary data
makebio=0; %1: process initial and boundary data for idealized NPZD type bio model
makepisces=0; %1: process initial and boundary data for PISCES biogeochemical model
%
makeoa=1; %1: process oa data (intermediate file)
makeZbry=0; %1: process data in Z coordinate
%
insitu2pot=1; %1: convert in-situ temperature into potential temperature
%
% Day of initialization for climatology experiments (=0 : 1st January 0h)
%
tini=0;
%
% World Ocean Atlas directory (WOA2001 or WOA2005)
%
woa_dir=[ROMSTOOLS_dir,'WOA2005/'];
%
```

```
% Surface chlorophyll seasonal climatology (WOA2001 or SeaWifs)
%
chla_dir=[ROMSTOOLS_dir,'SeaWifs/'];
%
% Set times and cycles for the boundary conditions:
% monthly climatology
%
woa_time=(15:30:345); % days: middle of each month
woa_cycle=360; % repetition of a typical year of 360 days
%
```

Variables description:

- obc=[1 1 1 1] : Switches to open (1=open) or close (0=wall) the lateral boundaries [South East North West]. This is used for the application of mass enforcement. Be aware, this should be compatible with the open boundary CPP-switches in the file ∼/Roms_tools/Run/cppdefs.h.
- zref=-1000 : Depth [meters] of the level of no motion for the geostrophic velocities calculation.
- makeini=1 : Switch to define if the initial file (roms_ini.nc) is generated. Should be 1.
- makeclim=1 : Switch to define if the climatology (lateral boundary conditions) file (roms_clm.nc) is generated. Should be 1.
- makeoa=1 : Switch to define if the OA (objective analysis; roms_oa.nc) file is generated. This should be 1. The OA files are intermediate files where hydrographic data are stored on a ROMS horizontal grid but on a z vertical grid. The transformation into S-coordinate is done later. This file is not used by ROMS.
- makebry=1 : Switch to define if the boundary file (roms_bry.nc) is generated. Used only with make_bry.
- makeZbry=1 : Switch to define if the boundary intermediate file on a z coordinate (roms_bry_Z.nc) is generated. Used only with make_bry.
- makebio=1; Switch to process initial and boundary data for idealized NPZD type bio model
- makepisces=1 : Switch to process initial and boundary data for PISCES biogeochemical model
- insitu2pot=1 : Switch defined if it is in-situ temperature that is provided. In this case, in-situ temperature is converted into potential temperature.
- tini=0 : Day of initialization in climatology experiments (15 = January 15).
- woa_dir=[ROMSTOOLS_dir,'WOA2005/'] : Directory where the World Ocean Atlas 2005 climatology (Conkright et al., 2002) is located. The World Ocean Atlas 2001 climatology can also be used.

- chla_dir=[ROMSTOOLS_dir,'SeaWifs/'] : Directory of the surface chlorophyll seasonal climatology.

- woa_time=(15:30:345) : Time in days for the WOA monthly climatology. It corresponds to the middle of each month. ROMS uses this variable to interpolate linearly the climatology variables in time.

- woa_cycle=360 : Duration on which the climatology variables are cycled. Here, for the sake of simplicity, we are running the model on a repeating climatological year of 360 days.

Save romstools_param.m and run make_clim in the Matlab session :

```
>>
>> make_clim
```

You should obtain :

```
Making the clim: ../Run/ROMS_FILES/roms_clm.nc

Title: Benguela Test Model

Read in the grid...
Create the climatology file...
Creating the file : ../Run/ROMS_FILES/roms_clm.nc
...
Make a few plots...
>>
```

This program can also take quite a long time to run. Figure (1.3) presents 4 different sections of temperature for the initial condition file for the Benguela example. The sections are in the X-direction (East-West), the first section is for the Southern part of the domain and the last one is for the Northern part of the domain.

An alternative of using a climatology file is to create a boundary file. In this case, only boundary values are stored. The cpp key FRC_BRY should be defined and ROMS recompiled. Run make_bry in the Matlab session :

```
>>
>> make_bry
```

You should obtain :

```
Making the file: ../Run/ROMS_FILES/roms_bry.nc

Title: Benguela Test Model

Read in the grid...
...
```

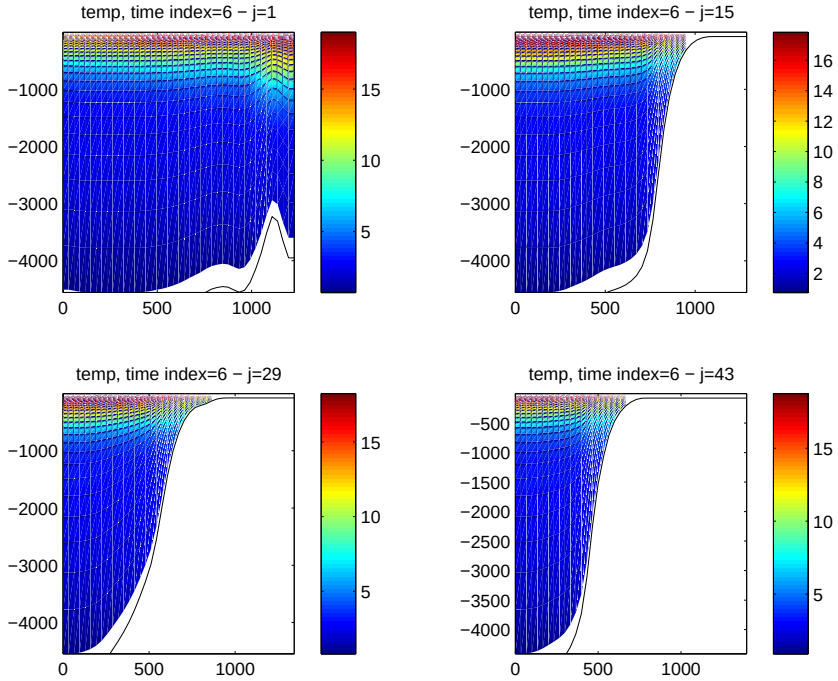


Figure 1.3: Result of make_clim.m for the Benguela example

1.5.5 Compiling the model

Once all the netcdf data files are ready (i.e. XXX_grd.nc, XXX_frc.nc, XXX_ini.nc, and XXX_clm.nc), we can prepare ROMS for compilation. All is done in the ∼/Roms_tools/Run/ directory.

Parameters of the configuration : param.h

Edit the file ∼/Roms_tools/Run/param.h. The line which needs to be changed is:

```
# elif defined BENGUELA_LR
    parameter (LLm0=41, MMm0=42, N=32) ! < −− Southern Benguela Test Case
# else
```

These are the values of the model grid size: LLm0 points in the X direction, MMm0 points in the Y direction and N vertical levels. LLm0 and MMm0 are given by running make_grid.m, and N is defined in romstools_param.m. The param.h parameters are described in detail in section 2.4

Numerical and physical options : cppdefs.h

The second file to edit is ∼/Roms_tools/Run/cppdefs.h. This file defines the CPP keys that are used by the the C-preprocessor when compiling ROMS. The C-preprocessor selects the different parts of the Fortran code which needs to be compiled depending on the

defined CPP options. These options are separated in two parts (the basic option keys and the advanced options keys) in cppdefs.h. All the keys and their organization are described in section 2.5.

Compilation script : jobcomp

ROMS can be compiled by running the UNIX tcsh script ~/Roms_tools/Run/jobcomp. Jobcomp should be able to recognize your system. It has been tested on Linux, IBM, Sun and Compaq systems. On Linux PCs, the default compiler is the GNU g77, but it is possible to uncomment specific lines in jobcomp to use g95 or ifort. The latter is mandatory when using AGRIF and/or OPEN_MP. When changing the compiler you should provide a corresponding NetCDF library. Once the compilation is done, you should obtain a new executable (roms) in the ~/Roms_tools/Run directory. ROMS should be recompiled each time param.h or cppdefs.h are changed.

1.5.6 Running the model

Edit the input parameter file: ~/Roms_tools/Run/roms.in. The vertical grid parameters (THETA_S, THETA_B, HC) should be identical to the ones in romstools_param.m. Otherwise, the other default values should not be changed. The definition of all the input variables is given at the start of each ROMS simulation. To run the model, type in directory ~/Roms_tools/Run/ : ./roms roms.in. The description of the namelist roms.in is descibed in details in section 2.6

On the screen, you should check the Cu_max parameter: if it is greater than 1 you are violating the CFL criterion. In this case, you should reduce the time step.
Example of model run:

> : ./roms roms.in

You should obtain :

Southern Benguela
480 ntimes Total number of timesteps for 3D equations.
5400.00 dt Timestep [sec] for 3D equations
60 ndtfast Number of 2D timesteps within each 3D step.
1 ninfo Number of timesteps between runtime diagnostics.

6.000E+00 theta_s S-coordinate surface control parameter.
0.000E+00 theta_b S-coordinate bottom control parameter.
1.000E+01 Tcline S-coordinate surface/bottom layer width used in
vertical coordinate stretching, meters.
Grid File: ROMS_FILES/roms_grd.nc
Forcing Data File: ROMS_FILES/roms_frc.nc
Bulk Data File: ROMS_FILES/roms_blk.nc
Climatology File: ROMS_FILES/roms_clm.nc
Initial State File: ROMS_FILES/roms_ini.nc Record: 1
Restart File: ROMS_FILES/roms_rst.nc nrst = 480 rec/file: -1
History File: ROMS_FILES/roms_his.nc Create new: T nwrt = 480 rec/file = 0

1 ntsavg Starting timestep for the accumulation of output
time-averaged data.
48 navg Number of timesteps between writing of time-averaged
data into averages file.
Averages File: ROMS_FILES/roms_avg.nc rec/file = 0

Fields to be saved in history file: (T/F)
T write zeta free-surface.
F write UBAR 2D U-momentum component.
F write VBAR 2D V-momentum component.
F write U 3D U-momentum component.
F write V 3D V-momentum component.
F write T(1) Tracer of index 1.
F write T(2) Tracer of index 2.

F write RHO Density anomaly.
F write Omega Omega vertical velocity.
F write W True vertical velocity.
F write Akv Vertical viscosity.
F write Akt Vertical diffusivity for temperature.
F write Aks Vertical diffusivity for salinity.
F write Hbl Depth of KPP-model boundary layer.
F write Bostr Bottom Stress.

Fields to be saved in averages file: (T/F)
T write zeta free-surface.
T write UBAR 2D U-momentum component.
T write VBAR 2D V-momentum component.
T write U 3D U-momentum component.
T write V 3D V-momentum component.
T write T(1) Tracer of index 1.
T write T(2) Tracer of index 2.

F write RHO Density anomaly
T write Omega Omega vertical velocity.
T write W True vertical velocity.
F write Akv Vertical viscosity
T write Akt Vertical diffusivity for temperature.
F write Aks Vertical diffusivity for salinity.
T write Hbl Depth of KPP-model boundary layer
T write Bostr Bottom Stress.
1025.0000 rho0 Boussinesq approximation mean density, kg/m3.
0.000E+00 visc2 Horizontal Laplacian mixing coefficient [m2/s]
for momentum.
0.000E+00 tnu2(1) Horizontal Laplacian mixing coefficient (m2/s)
for tracer 1.
0.000E+00 tnu2(2) Horizontal Laplacian mixing coefficient (m2/s)
for tracer 2.

0.000E+00 rdrg Linear bottom drag coefficient (m/si).
0.000E+00 rdrg2 Quadratic bottom drag coefficient.
1.000E-02 Zob Bottom roughness for logarithmic law (m).
1.000E-04 Cdb_min Minimum bottom drag coefficient.
1.000E-01 Cdb_max Maximum bottom drag coefficient.

1.00 gamma2 Slipperiness parameter: free-slip +1, or no-slip -1.
1.00E+05 x_sponge Thickness of sponge and/or nudging layer (m)
800.00 v_sponge Viscosity in sponge layer (m2/s)
1.157E-05 tauT_in Nudging coefficients [sec^1]
3.215E-08 tauT_out Nudging coefficients [sec^1]
1.157E-06 tauM_in Nudging coefficients [sec^1]
3.215E-08 tauM_out Nudging coefficients [sec^1]

Activated C-preprocessing Options:

REGIONAL
BENGUELA_LR
OBC_EAST
OBC_WEST
OBC_NORTH
OBC_SOUTH
SOLVE3D
UV_COR
UV_ADV
CURVGRID
SPHERICAL
MASKING
AVERAGES
AVERAGES_K
SALINITY
NONLIN_EOS
SPLIT_EOS
BULK_FLUX
BULK_EP
SPONGE
CLIMATOLOGY
ZCLIMATOLOGY
M2CLIMATOLOGY
M3CLIMATOLOGY
TCLIMATOLOGY
ZNUDGING
M2NUDGING
M3NUDGING
TNUDGING
ANA_BSFLUX
ANA_BTFLUX
UV_VIS2

MIX_GP_UV
TS_DIF2
MIX_GP_TS
CLIMAT_TS_MIXH
LMD_MIXING
LMD_SKPP
LMD_BKPP
LMD_RIMIX
LMD_CONVEC
OBC_M2FLATHER
OBC_M3ORLANSKI
OBC_TORLANSKI
M2FILTER_COSINE

Linux 2.6.9-42.0.3.ELsmp x86_64
NUMBER OF THREADS: 1 BLOCKING: 1 x 1.

Spherical grid detected.

hmin hmax grdmin grdmax Cu_min Cu_max
75.000000 4803.032721 .301836927E+05 .331215714E+05 0.12176008 0.91533005
volume=9.52398609326108750000E+14 open_cross=6.10483688831244468689E+09

Vertical S-coordinate System:

level S-coord Cs-curve at_hmin over_slope at_hmax

32 0.0000000 0.0000000 0.000 0.000 0.000
31 -0.0312500 -0.0009350 -0.373 -2.584 -4.794
30 -0.0625000 -0.0019030 -0.749 -5.247 -9.746
29 -0.0937500 -0.0029380 -1.128 -8.074 -15.019
28 -0.1250000 -0.0040767 -1.515 -11.152 -20.790
27 -0.1562500 -0.0053591 -1.911 -14.580 -27.249
26 -0.1875000 -0.0068304 -2.319 -18.466 -34.613
25 -0.2187500 -0.0085426 -2.743 -22.938 -43.132
24 -0.2500000 -0.0105560 -3.186 -28.141 -53.095
23 -0.2812500 -0.0129416 -3.654 -34.248 -64.842
22 -0.3125000 -0.0157835 -4.151 -41.463 -78.776
21 -0.3437500 -0.0191819 -4.684 -50.031 -95.377
20 -0.3750000 -0.0232566 -5.262 -60.241 -115.220
19 -0.4062500 -0.0281514 -5.892 -72.443 -138.993
18 -0.4375000 -0.0340388 -6.588 -87.056 -167.524
17 -0.4687500 -0.0411263 -7.361 -104.584 -201.807
16 -0.5000000 -0.0496640 -8.228 -125.635 -243.041
15 -0.5312500 -0.0599527 -9.209 -150.939 -292.668
14 -0.5625000 -0.0723554 -10.328 -181.377 -352.427
13 -0.5937500 -0.0873092 -11.613 -218.013 -424.414
12 -0.6250000 -0.1053416 -13.097 -262.126 -511.156

```
11 -0.6562500 -0.1270882 -14.823 -315.262 -615.700
10 -0.6875000 -0.1533158 -16.841 -379.282 -741.723
9 -0.7187500 -0.1849493 -19.209 -456.432 -893.656
8 -0.7500000 -0.2231040 -22.002 -549.423 -1076.845
7 -0.7812500 -0.2691252 -25.306 -661.522 -1297.738
6 -0.8125000 -0.3246355 -29.226 -796.670 -1564.114
5 -0.8437500 -0.3915923 -33.891 -959.622 -1885.352
4 -0.8750000 -0.4723564 -39.453 -1156.112 -2272.770
3 -0.9062500 -0.5697755 -46.098 -1393.057 -2740.015
2 -0.9375000 -0.6872846 -54.048 -1678.800 -3303.552
1 -0.9687500 -0.8290268 -63.574 -2023.407 -3983.240
0 -1.0000000 -1.0000000 -75.000 -2439.016 -4803.033

Time splitting: ndtfast = 60 nfast = 89
Maximum grid stiffness ratios: rx0 =0.2353349875 rx1 = 2.5672736953

GET_INITIAL – Processing data for time = 0.000 record = 1

GET_TCLIMA – Read climatology of tracer 1 for time = 345.0
GET_TCLIMA – Read climatology of tracer 1 for time = 15.00
GET_TCLIMA – Read climatology of tracer 2 for time = 345.0
GET_TCLIMA – Read climatology of tracer 2 for time = 15.00
GET_UCLIMA – Read momentum climatology for time = 345.0
GET_UCLIMA – Read momentum climatology for time = 15.00
GET_SSH - Read SSH climatology for time = 345.0
GET_SSH - Read SSH climatology for time = 15.00
GET_SMFLUX – Read surface momentum stresses for time = 345.0
GET_SMFLUX – Read surface momentum stresses for time = 15.00
GET_BULK – Read fields for bulk formula for time = 345.0
GET_BULK – Read fields for bulk formula for time = 15.00

DEF_HIS/AVG - Created new netCDF file 'ROMS_FILES/roms_his.nc'.
WRT_GRID – wrote grid data into file 'ROMS_FILES/roms_his.nc'.
WRT_HIS – wrote history fields into time record = 1 / 1

MAIN: started time-steping.

STEP time[DAYS] KINETIC_ENRG POTEN_ENRG TOTAL_ENRG NET_VOLUME trd
0 0.00000 0.000000000E+00 2.1475858E+01 2.1475858E+01 9.5239861E+14 0
1 0.06250 1.306369099E-04 2.1476230E+01 2.1476361E+01 9.5239208E+14 0
...
```

1.5.7 Long simulations

In many studies, there is a need for long simulations: to reach the spin-up of the solution and/or to obtain statistical equilibriums. For regional models, 10 years appears to be a

reasonable model simulation length. In this case, to prevent the generation of large output files, the strategy is to relaunch the model every simulated month. This is done by the UNIX csh script: run_roms.csh . Warning! the ROMS input file use for long simulations is roms_inter.in. It should be edited accordingly.

1. It gets the grid, the forcing, the initial and the boundary files.
2. It runs the model for 1 month.
3. It stores the output files in a specific form: roms_avg_Y4M3.nc (for the ROMS averaged output of March of year 4).
4. It replaces the initial file by the restart file (roms_rst.nc) which as been generated at the end of the month.
5. It relaunch the model for next month.

Part to edit in run_roms.csh:

```
set MODEL=roms
set SCRATCHDIR=‘pwd‘/SCRATCH
set INPUTDIR=‘pwd‘
set MSSDIR=‘pwd‘/ROMS_FILES
set MSSOUT=‘pwd‘/ROMS_FILES
set CODFILE=roms
set AGRIF_FILE=AGRIF_FixedGrids.in
#
# Model time step [seconds]
#
set DT=5400
#
# Number of days per month
#
set NDAYS = 30
#
# number total of grid levels
#
set NLEVEL=1
#
# Time Schedule - TIME_SCHED=0 –> yearly files
# TIME_SCHED=1 –> monthly files
#
set TIME_SCHED=1
#
set NY_START=1
set NY_END=10
set NM_START=1
set NM_END=12
```

Variables definitions:

- MODEL=roms : Name used for the input files. For example roms_grd.nc.
- SCRATCHDIR=‘pwd‘/SCRATCH : Scratch directory where the model is run
- INPUTDIR=‘pwd‘ : Input directory where the roms_inter.in input file is.
- MSSDIR=‘pwd‘/ROMS_FILES : Directory where the roms input NetCDF files (roms_grd.nc, roms_frc.nc, ...) are stored.
- MSSOUT=‘pwd‘/ROMS_FILES : Directory where the roms output NetCDF files (roms_his.nc, roms_avg.nc, ...) are stored.
- CODFILE=roms : ROMS executable.
- AGRIF_FILE=AGRIF_FixedGrids.in : AGRIF input file which defines the position of child grids when using embedding.
- DT=5400 : Model time step in seconds.
- NDAYS = 30 : Number of days in 1 month.
- NLEVEL=1 : Total number of model grids (no AGRIF: NLEVEL=1).
- NY_START=1 : Starting year.
- NY_END=10 : Ending Year.
- NM_START=1 : Starting month.
- NM_END=12 : Ending month.

To run a ROMS long simulation in batch mode on a Linux workstation:

> : nohup ./run_roms.csh > exp1.out &

To check the execution of your model, type in the directory ∼/Roms_Tools/Run :
>: more exp1.out

1.5.8 Getting the results

roms_gui

Once the model has run, or during the simulation, it is possible to visualize the model outputs using a Matlab graphic user interface : roms_gui. Launch roms_gui in the Matlab session (in the ∼/Roms_tools/Run/ directory):

>>
>> roms_gui

A window pops up, asking for a ROMS history NetCDF file (Figure 1.4). You should select roms_his.nc (history file) or roms_avg.nc (average file) and click ”open”.

The main window appears, variables can be selected to obtain an image such as Figure (1.5). On the left side, the upper box gives the available ROMS variable names and the lower box presents the variables derived from the ROMS model outputs :

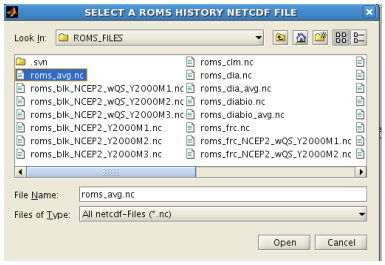


Figure 1.4: Entrance window of roms_gui

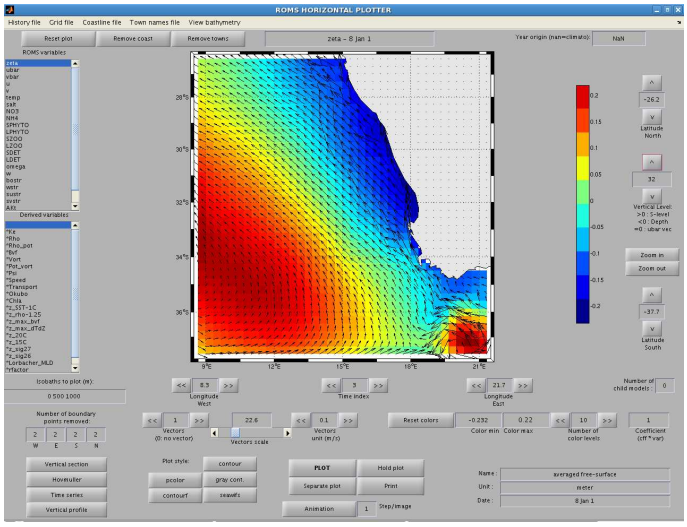


Figure 1.5: roms_gui

- Ke : Horizontal slice of kinetic energy: $0.5(u^2 + v^2)$.
- Rho : Horizontal slice of density using the non-linear equation of state for seawater of Jackett and McDougall (1995).
- Pot_Rho : Horizontal slice of the potential density.
- Bvf : Horizontal slice of the Brunt-Väisäla frequency: $N^2 = -\frac{g}{\rho}\frac{\partial \rho}{\partial z}$
- Vort : Horizontal slice of vorticity: $\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}$.
- Pot_vort : Horizontal slice of the vertical component of Ertel's potential vorticity: $\frac{\partial \lambda}{\partial z}\left[f + \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right)\right]$. In our case, $\lambda = \rho$.
- Psi : Horizontal slice of stream function: $\nabla^2 \psi = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}$. This routine might be costly since it inverses the Laplacian of the vorticity (using a successive over relaxation solver).
- Speed : Horizontal slice of the ocean currents velocity : $\sqrt{u^2 + v^2}$.
- Transport : Horizontal slice of the transport stream function : $\nabla^2 S_{vd} = \frac{\partial \bar{v}}{\partial x} - \frac{\partial \bar{u}}{\partial y}$.

- Okubo : Horizontal slice of the Okubo-Weiss parameter : $\Lambda^2 = \left(\frac{\partial u}{\partial x} - \frac{\partial v}{\partial y}\right)^2 + \left(\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right)^2 - \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right)^2$.
- Chla : Compute a chlorophyll-a from Large and Small phytoplankton concentrations.
- z_SST_1C : Depth of 1°C below SST.
- z_rho_1.25 : Depth of 1.25 kg.m^{-3} below surface density.
- z_max_bvf : Depth of the maximum of the Brunt-Väisäla frequency.
- z_max_dtdz : Depth of the maximum vertical temperature gradient.
- z_20C : Depth of the 20°C isotherm.
- z_15C : Depth of the 15°C isotherm.
- z_sig27 : Depth of the 1027 kg.m^{-3} density layer.
- r_factor : $r = \frac{\nabla h}{2h} = \frac{h_{+1/2} - h_{-1/2}}{h_{+1/2} + h_{-1/2}}$

It is possible to add arrows for the horizontal currents by increasing the "Current vectors spatial step". It is also possible to obtain vertical sections, time series, vertical profiles and Hovmüller diagrams by clicking on the corresponding targets in roms_gui.

Diagnostics

To analyze the long simulations, a few scripts have been added in the directory: ∼/Roms_tools/Diagnostic_tools:

- roms_diags.m : Get volume and surface averaged quantities from a ROMS simulation.
- plot_diags.m : Plot the averaged quantities computed by roms_diags.m.
- get_Mmean.m : Get the monthly mean climatology.
- get_Smean.m : Get the seasonal and annual mean climatology from the outputs of get_Mmean.m.
- get_Meddy.m : Get the monthly variance climatology (if the variable nonseannal = 1, the non-seasonal variance is computed; i.e., the seasonal variation are filtered). It needs that get_Mmean.m and get_Smean.m are run before.
- get_Seddy.m : Get the seasonal and annual RMS from the results of get_Meddy.m.
- roms_anim.m : Create an animation from the monthly history or average files.

Run these scripts in a Matlab session. The obtained mean or eddy files can be visualized with roms_gui.

If you need to create and play ".fli" animations, you should install ppm2fli and xanim on your system. If you have a Linux PC, you can follow these steps:

1. log in as root

2. go to the directory where the file is saved.
3. type : rpm -Uvh ppm2fli-2.1-1.i386.rpm
4. type : rpm -Uvh xanim-2.80.1-12.i386.rpm
5. log out

If you are not using a Linux PC, you should ask your system administrator to install these programs.

1.6 Tides

Using the method described by Flather (1976), ROMS is able to propagate the different tidal constituents from its lateral boundaries. To do so, define the cpp keys TIDES, SSH_TIDES and UV_TIDES and recompile the model using jobcomp. To work correctly, the model should use the Flather (1976) open boundary radiation scheme (cpp key OBC_M2FLATHER defined).
The tidal components are added to the forcing file (XXX_frc.nc) by the Matlab program make_tides.m. Edit the file : ∼/Roms_tools/Run/romstools_param.m. The part of the file that you should change is :

```
%%%%%%%%%%%%%%%%%%%%
%
% 5-Parameters for tidal forcing
%
%%%%%%%%%%%%%%%%%%%%
%
% TPXO file name (TPXO6 or TPXO7)
%
tidename=[ROMSTOOLS_dir,'TPXO6/TPXO6.nc'];
%
% Number of tides component to process
%
Ntides=10;
%
% Chose order from the rank in the TPXO file :
% "M2 S2 N2 K2 K1 O1 P1 Q1 Mf Mm"
% " 1 2 3 4 5 6 7 8 9 10"
%
tidalrank=[1 2 3 4 5 6 7 8 9 10];
%
% Compare with tidegauge observations
%
lon0=18.37;
lat0=-33.91; % Cape Town location
Z0=1; % Mean depth of the tidegauge in Cape Town
```

Variables definitions :

- tidename=[ROMSTOOLS_dir,'TPXO6/TPXO6.nc'] : Location of the netcdf tidal dataset. This file is derived from the Oregon State University global model of ocean tides TPXO.6 (Egbert and Erofeeva, 2002). Data sources can be found at http://www.oce.orst.edu/po/research/tide/global.html. It is also possible to use TPXO7.
- Ntides=10 : Number of tidal components to process. Warning! This value should be identical to the value of the parameter Ntides in param.h: "parameter (Ntides=10)".
- tidalrank=[1 2 3 4 5 6 7 8 9 10] : Order to select the different tidal components.
- lon0=18.37;lat0=-33.91;Z0=1 : Location of a tidal gauge to compare the interpolated values with observations.

An important aspect is the definition of time and especially the choice of a time origin. This is defined in ∼/Roms_tools/Run/romstools_param.m:

```
    %%%%%%%%%%%%%%%%%%%%%%%%%%
%
% 6-Temporal parameters (used for make_tides, make_NCEP, make_OGCM)
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
Yorig = 1900; % reference time for vector time
% in roms initial and forcing files
%
Ymin = 2000; % first forcing year
Ymax = 2000; % last forcing year
Mmin = 1; % first forcing month
Mmax = 3; % last forcing month
%
Dmin = 1; % Day of initialization
Hmin = 0; % Hour of initialization
Min_min = 0; % Minute of initialization
Smin = 0; % Second of initialization
%
SPIN_Long = 0; % SPIN-UP duration in Years
```

% The origin of time (Yorig: 1 january of year Yorig) should be kept the same for all the preprocessing and postprocessing steps. Save romstools_param.m and run make_tides in the Matlab session:

```
>>
>> make_tides
```

You should obtain :

```
Start date for nodal correction : 1-Jan-2000
Reading ROMS grid parameters ...
Tidal components : M2 S2 N2 K2 K1 O1 P1 Q1 Mf Mm
Processing tide : 1 of 10
```

...

1.7 Biology

1.7.1 Idealized biogeochemical model : NChlPZD, N2ChlPZD2, N2P2Z2D2

ROMSTOOLS can help for the design of ROMS biogeochemical experiments. For the initial conditions and lateral boundary conditions, WOA provides a seasonal climatology for nitrateD concentration and WOA or SeaWifs can be used to obtain a seasonal climatology of surface chlorophyll concentration. Phytoplankton is estimated by a constant chlorophyll/phytoplankton ratio derived from previous simulations. Zooplankton is estimated in a similar way. The part which should be edited by the user in romstools_param.m is:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
% Open boundaries and initial conditions parameters
% used by make_clim.m, make_biol.m, make_bry.m
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
.....
makebio=1; %1: process initial and boundary data for idealized NPZD type bio model
.....
%
% World Ocean Atlas directory (WOA2001 or WOA2005)
%
woa_dir=[DATADIR,'WOA2005/'];
%
% Pisces biogeochemical seasonal climatology (WOA2001 or WOA2005)
%
woapisces_dir=[DATADIR,'WOAPISCES/'];
%
% Surface chlorophyll seasonal climatology (WOA2001 or SeaWifs)
%
chla_dir=[DATADIR,'SeaWifs/']; %
....
```

Variables description :

- woa_dir=[ROMSTOOLS_dir,'WOA2005/'] : Directory where the World Ocean Atlas 2005 climatology (Conkright et al., 2002) is located. The World Ocean Atlas 2001 climatology can also be used.
- chla_dir=[ROMSTOOLS_dir,'SeaWifs/'] : Directory of the surface chlorophyll seasonal climatology.

Run make_biol (or if the flag makebio=1, make_clim.m will process make_biol.m) in the Matlab session :

>>
>> make_biol

You should obtain :

Add_no3: creating variables and attributes for the OA file
Add_no3: creating variables and attributes for the Climatology file

Ext tracers: Roa = 0 km - default value = NaN
Ext tracers: horizontal interpolation of the annual data
Ext tracers: horizontal interpolation of the seasonal data
time index: 1 of total: 4
time index: 2 of total: 4
time index: 3 of total: 4
time index: 4 of total: 4

Vertical interpolations

NO3...
Time index: 1 of total: 4
Time index: 2 of total: 4
Time index: 3 of total: 4
Time index: 4 of total: 4

CHla...
Add_chla: creating variable and attribute
...
Make a few plots...

The cpp keys related to these biology models are :

- BIO_NChlPZD : Select a 5 components (Nitrate, Chlorophyll, Phytoplankton, Zooplankton, Detritus) biogeochemical model.
- BIO_N2ChlPZD2 : Select a 7 components (Nitrate, Ammonium, Chlorophyll, Phytoplankton, Zooplankton, Small Detritus, Large Detritus) biogeochemical model.
- BIO_N2P2Z2D2 : Select a 8 components (Nitrate, Ammonium, Small Phytoplankton, Large Phytoplankton, Small Zooplankton, Large Zooplankton, Small Detritus, Large Detritus) biogeochemical model.
- DIAGNOSTICS_BIO : Define if writing out fluxes between the biological components.

1.7.2 PISCES biogeochemical model

This latter is a more complex biogeochemical model, firstly coupled to OPA and now a beta version of the model can be coupled with ROMS_AGRIF. It is nicely described in

(Aumont, 2005) provide in the documentation section of ROMS_TOOLS.

This part of ROMS_TOOLS use the World Ocean Atlas, called WOAPISCES. It provides the global data of Iron (Fe), Silicate (SiO3), Oxygen (O2), Phosphate (PO4), DIC (dissolved organic carbon), DOC (dissolved inorganic carbon) and Alkanility. The routines used to process these fields are : make_ini_pisces, make_clim_pisces, make_bry_pisces, make_bio_forcing.m as for the climatological experiments[1].

The part which should be edited by the user in romstools_param.m is:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
% Open boundaries and initial conditions parameters
% used by make_clim.m, make_biol.m, make_bry.m
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
.....
makepisces %1: process initial and boundary data for PISCES biogeochemical model .....
%
% Pisces biogeochemical seasonal climatology (WOA2001 or WOA2005)
%
woapisces_dir=[DATADIR,'WOAPISCES/'];
%
....
```

Variables description :

- woapisces=[DATADIR,'WOAPISCES/'] : Directory where the World Ocean Atlas 2005 climatology is located. It contains the variable needed by PISCES biogeochemical model.

To add boundary conditions of PISCES in the roms_clm.nc computed before, in a matlab session, run make_clim_pisces.

```
>>
>> make_clim_pisces
```

You should obtain :

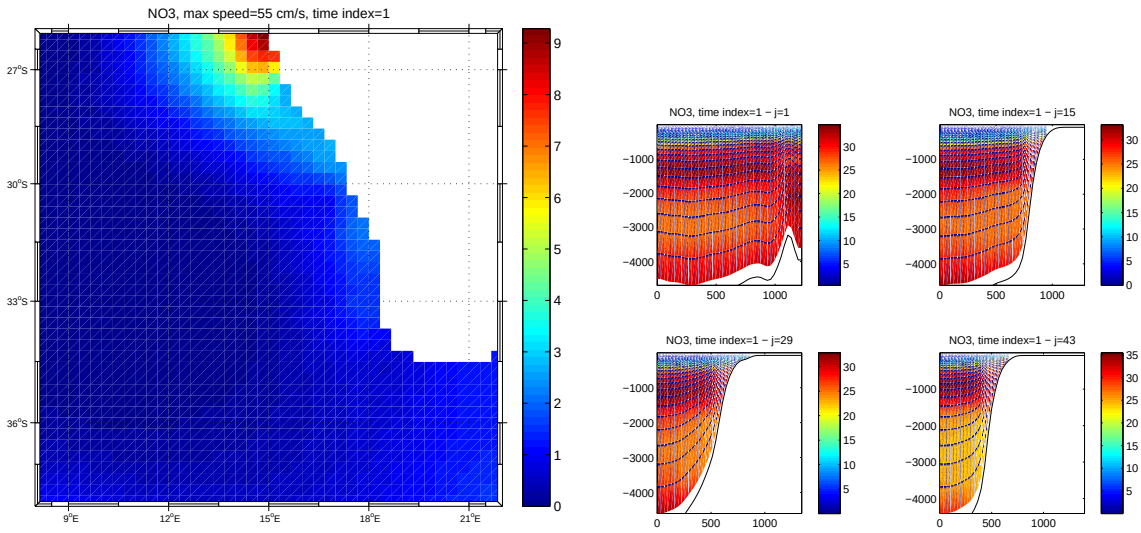
```
Add_no3: creating variables and attributes for the OA file
write no3time
Add_po4: creating variables and attributes for the OA file
Add_sio3: creating variables and attributes for the OA file
Add_o2: creating variables and attributes for the OA file
Add_dic: creating variables and attributes for the OA file
Add_talk: creating variables and attributes for the OA file
Add_doc: creating variables and attributes for the OA file
Add_fer: creating variables and attributes for the OA file

Ext tracers: Roa = 0 km - default value = NaN
Ext tracers: horizontal interpolation of the seasonal data
```

[1] These routines use add_dic.m, add_doc.m, add_fer.m, add_o2.m, add_talk.m, add_sio3.m, add_ini_dic.m, add_ini_doc.m, add_ini_fer.m, add_ini_o2.m, add_ini_talk.m, add_ini_po4.m, add_ini_sio3.m

time index: 1 of total: 12
time index: 2 of total: 12
time index: 3 of total: 12
time index: 4 of total: 12
time index: 5 of total: 12
time index: 6 of total: 12
time index: 7 of total: 12
time index: 8 of total: 12
time index: 9 of total: 12
time index: 10 of total: 12
time index: 11 of total: 12
time index: 12 of total: 12

Similarly, to add initial condition for PISCES variables to roms_ini.nc file, in a matlab session, run make_ini_pisces.m
>>
>> make_ini_pisces



(a) Surface map

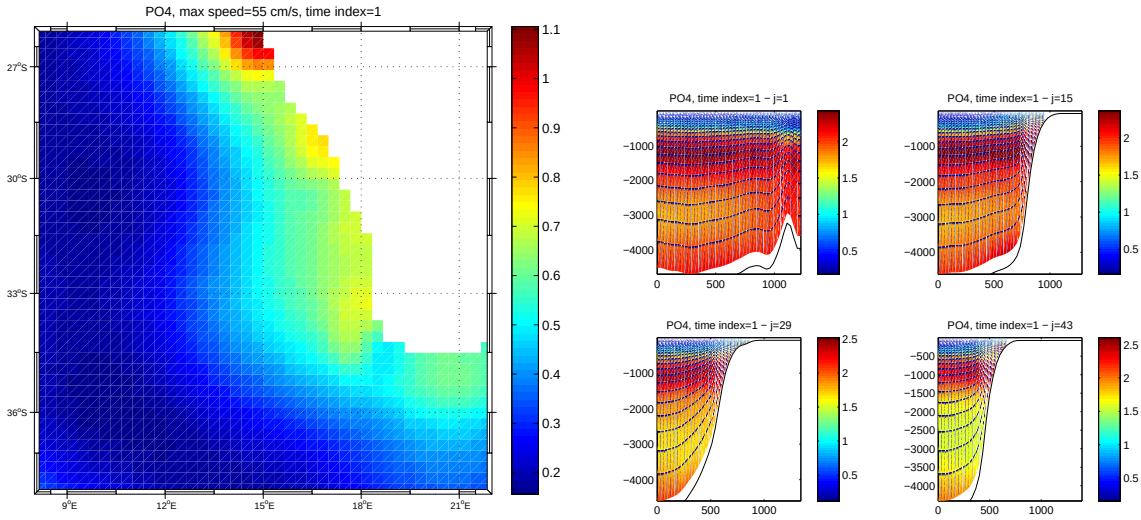
(b) vertical sections along open boundaries

Figure 1.6: Result of make_clim_pisces for the Benguela example : NO3 forcing fields [mMol N m-3].

Finally, to compute the Iron dust deposition forcing file roms_frcbio.nc file, in a matlab session, run make_dust.m :
>>
>> make_dust

If the makepisces =1 in romstools_param.m, **make_clim.m** will process directly **make_clim_pisces.m** **make_dust.**m and eventually **make_ini_pisces.m**. It is exactly the same procedure for the roms_bry.nc files.

The cpp keys related to this biogeochemical model are :



(a) Surface map (b) vertical sections along open boundaries

Figure 1.7: Result of make_clim_pisces for the Benguela example : PO4 forcing fields [mMol P m-3].

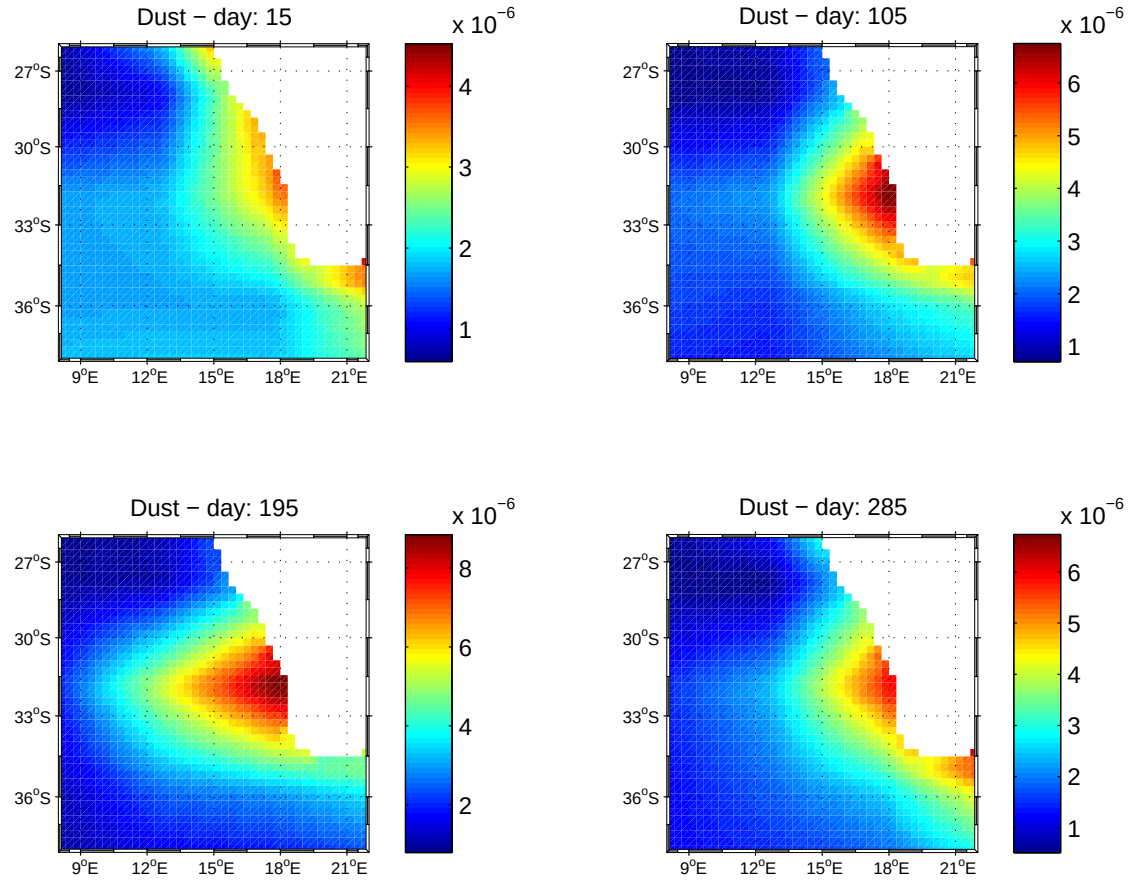


Figure 1.8: Result of make_clim_pisces for the Benguela example : Iron dust deposition forcing fields [nmol Fe m-3].

- PISCES : Select the PISCES biogeochemical model
- DIAGNOSTICS_BIO : Define if writing out fluxes between the biological components.

1.8 Inter-Annual simulations

ROMSTOOLS can help to realize inter-annual simulations. In this context, we rely on Ocean Global Circulations Models (OGCM) for the lateral boundary conditions and a global atmospheric reanalysis for the surface forcing (NCEP). To limit the volume of data which needs to be transfered over the Internet, we use Opendap to extract only the necessary subgrids.

1.8.1 Getting the surface forcing data from NCEP

The Matlab script make_NCEP.m is used to obtain the surface forcing data. It downloads the necessary NCEP surface forcing data (Sea Surface Temperature, Wind stress ...) over the Internet, and interpolates them on the model grid. Since make_NCEP.m works with the bulk parameterization (i.e. the BULK_FLUX and BULK_EP cpp keys should be defined in cppdefs.h), a surface forcing NetCDF file and a bulk NetCDF file are generated for each month of your simulation in the directory ∼/Roms_tools/Run/ROMSFILES/ . The part of the file romstools_param.m that you should change is:

```
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
% 7 Parameters for Interannual forcing (SODA, ECCO, NCEP, ...)
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Download_data = 1; % Get data from the OPENDAP sites
level = 0; % AGRIF level; 0=parent grid
%
NCEP_version = 2; % NCEP version:
% 1: NCEP/NCAR Reanalysis, 1/1/1948 - present
% 2: NCEP-DOE Reanalysis, 1/1/1979 - present
%

% Path and option for using global datasets download from ftp
%
Get_My_Data = 0;
%

if NCEP_version == 1;
My_NCEP_dir = [DATADIR,'NCEP_REA1/'];
elseif NCEP_version == 2;
My_NCEP_dir = [DATADIR,'NCEP_REA2/'];
```

end

My_QSCAT_dir = [DATADIR,'QSCAT/'];
My_SODA_dir = [DATADIR,'SODA/'];
My_ECCO_dir = [DATADIR,'ECCO/'];

%===
%Options for make_NCEP and make_QSCAT_daily
%
NCEP_dir= [FORC_DATA_DIR,'NCEP_',ROMS_config,'/']; % NCEP data directory
makefrc = 1; % 1: Create forcing files
makeblk = 1; % 1: Create bulk files
QSCAT_blk = 1; % Correct NCEP frc/bulk file with the u,v,wspd fields from QSCAT daily data. Download u, v, wspd in the QSCAT frc file

add_tides = 0; % 1: Add the tides (To be done...)

%Overlap parameters :
itolap_qscat=11; %11 days if 1d time reso. QSCAT (should be ¡28)
itolap_ncep=40; %10 days if 6h time res. NCEP (should be ¡4* 28 =112
% ...

Variables description :

- FORC_DATA_DIR : Directory where the different files downloaded over the Internet are stored.
- Download_data : Get data from the OPENDAP sites. Should be 1.
- level : AGRIF level. The parent grid = 0 and the child grid = 1.
- NCEP_dir= [FORC_DATA_DIR,'NCEP_',ROMS_config,'/'] : NCEP data directory. This is where NCEP data downloaded over the Internet are stored.
- makefrc : Switch to define if the forcing file is generated. Should be 1.
- makeblk : Switch to define if the bulk file is generated. Should be 1.
- add_tides : Switch to define if the tidal forcing is added.
- NCEP_version : version of the NCEP reanalysis. 1: NCEP/NCAR Reanalysis, 1/1/1948 - present. 2: NCEP-DOE Reanalysis, 1/1/1979 - 12/31/2001.
- Get_My_Data = 1
- My_NCEP_dir = Path to local global NCEP datasets
- QSCAT_blk = Flag to use the QiuikSCAT wind in the NCEP bulk files
- itolap_qscat = Overlap parameters for the monthly roms forcing files using QuikSCAT daily wind stress.

The overlap parameter is the number of "recovering" time steps between 2 consecutives months

- itolap_ncep = Overlap parameters for the monthly roms forcing (and/or bulk files) using NCEP1 or NCEP2 wind stress(and/or heat fluxes) monthly file

Save romstools_param.m and run make_NCEP in the Matlab session.

Using OpenDAP : Get_My_Data = 0

You should obtain:

```
>> make_NCEP
Read in the grid ROMS_FILES/roms_grd.nc

==========================================
BEGIN DOWNLOAD STEP
==========================================
==========================================
Download NCEP data with OPENDAP or my FTP data
==========================================
==========================================
OPENDAP Procedure
==========================================

Get NCEP data from 2000 to 2000
From http://nomad1.ncep.noaa.gov:9090/dods/reanalyses/reanalysis-2/

Minimum Longitude: 8
Maximum Longitude: 22
Minimum Latitude: -38
Maximum Latitude: -25.8968 Making output data directory
...../Run/DATA/NCEP_Benguela_LR/
==========================================
VNAME IS landsfc
==========================================
- - - - - --
Get time units and time: Get_My_Data is OFF
- - - - - --
Reading: http://nomad1.ncep.noaa.gov:9090/dods/reanalyses/reanalysis-2/6hr/flx/flx
Constraint: time
Server version: dods/3.2
...
```

Using FTP global dataset : Get_My_Data = 1

```
>> make_NCEP
Read in the grid ROMS_FILES/roms_grd.nc
```

```
=============================================
Download NCEP data with OPENDAP or my FTP data
=============================================
=============================================
Direct FTP Procedure
=============================================
Use my own ncep data NCEP2

Get NCEP data from 2000 to 2000
From path/NCEP_REA2/

Minimum Longitude: 8
Maximum Longitude: 22
Minimum Latitude: -38
Maximum Latitude: -25.8968

=============================================
Get_My_Data = 1
Read subgrid from file/data1/gcambon/NCEP_REA2/land.sfc.gauss.nc
=============================================
Get the Land Mask tindex = 1
In case of Get_My_Data ON

Get the Land Mask by using extract_NCEP_Mask_Mydata
Execute extract_NCEP_Mask_Mydata

Get land for year 2000 - month 1

Create path/Run/DATA/NCEP_Benguela_LR/land_Y2000M1.nc
=============================================
VNAME IS air
=============================================

=============================================
Processing year: 2000
=============================================
```

1.8.2 Getting the surface windstress data from QuickSCAT

QuikSCAT daily data from Ifremer OpenDap server

Similarly, The Matlab script make_QuickSCAT_daily.m is used to obtain the daily surface stress forcing provided by the OpenDAP server at Ifremer, France:
http://www.ifremer.fr/dodsG/CERSAT/quikscat_daily.
A surface forcing NetCDF file NetCDF file is generated for each month of your simulation in the directory ∼/Roms_tools/Run/ROMSFILES/.

You shoud edit this part of the file romstools_param.m:

%%
%
% 7 Parameters for Interannual forcing (SODA, ECCO, NCEP, ...)
%
%%
%
% Path to Forcing data
.....
% Options for make_QSCAT_daily and make_QSCAT_clim
%
QSCAT_dir = [FORC_DATA_DIR,'QSCAT_',ROMS_config,'/'];% QSCAT data directory.
QSCAT_frc_prefix = [frc_prefix,'_QSCAT_']; % generic forcing file name for interannual roms simulations with QuickSCAT.
QSCAT_clim_file = [DATADIR,'QuikSCAT_clim/roms_QSCAT_month_clim_2000_2007.nc']; % QuikSCAT climatology file for make_QSCAT_clim.
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

In a Matlab session, run make_QSCAT_daily
>>
>> make_QSCAT_daily

if you download data over the internet using OpenDAP, you should obtain that during the dowload step :
>>
...
Reading: http://www.ifremer.fr/dodsG/CERSAT/quikscat_daily
Constraint: mwst[167:167][78:113][370:409]
Server version: apache-coyote/1.1
Processing day: 1

Reading: http://www.ifremer.fr/dodsG/CERSAT/quikscat_daily
Constraint: zwst[168:168][78:113][370:409]
Server version: apache-coyote/1.1

Reading: http://www.ifremer.fr/dodsG/CERSAT/quikscat_daily
Constraint: mwst[168:168][78:113][370:409]
Server version: apache-coyote/1.1
Processing day: 2
....
>>

QuikSCAT monthly climatology data

If you want to use the QSCAT climatology, computed over 2000-2007, based over these previous QSCAT data, in a Matlab session, run make_QSCAT_clim.

```
>>
>> make_QSCAT_clim
>> ...
```

1.8.3 Getting the lateral boundary conditions

Initial conditions and lateral boundary conditions and can be obtained from several ocean global circulation models (OGCM) such as SODA (Carton et al., 2005) or ECCO (Stammer et al., 1999). The SODA reanalysis is available from 1958 to 2001 and ECCO is available from 1993 until now. The Matlab script make_OGCM.m is used to download data over the Internet, and to perform the interpolations on the model grid. A lateral boundary conditions NetCDF file is generated for each month of your simulation in the directory ∼/Roms_tools/Run/ROMSFILES/ .

The part of the file romstools_param.m that you should change is:

```
%%%%%%%%%%%%%%%%%%
%
% Options for make_OGCM
%
%%%%%%%%%%%%%%%%%%
OGCM = 'SODA'; % Select the OGCM: SODA(1958-2001), ECCO(1993-2005), ...
OGCM_dir = [FORC_DATA_DIR,OGCM,'_',ROMS_config,'/'];
bry_prefix = [ROMS_files_dir,'roms_bry_',OGCM,'_'];
clm_prefix = [ROMS_files_dir,'roms_clm_',OGCM,'_'];
ini_prefix = [ROMS_files_dir,'roms_ini_',OGCM,'_'];
OGCM_prefix = [OGCM,'_'];
rmdepth = 2;

%Overlap parameters : before (_a) and after (_p) the months.
itolap_a=2;   %Overlap parameter at the begining of the months.
itolap_p=2;   %Overlap parameter at the end of the months.
%
```

Variables description :

- OGCM = 'SODA' : Name of the OGCM employed (SODA or ECCO).
- OGCM_dir = [FORC_DATA_DIR,OGCM,'_',ROMS_config,'/'] : OGCM data directory.
- bry_prefix = [ROMS_files_dir,'roms_bry_',OGCM,'_'] : Left part of the boundary file name.
- clm_prefix = [ROMS_files_dir,'roms_clm_',OGCM,'_'] : Left part of the climatology file name.
- ini_prefix = [ROMS_files_dir,'roms_ini_',OGCM,'_'] : Left part of the initial file name.

- OGCM_prefix = [OGCM,'_'] : Left part of the OGCM file name. This is where OGCM data are stored.
- rmdepth = 2 : Number of bottom levels to remove. This is useful when there is no valid data at this level. For example, if the depth in the ROMS domain is shallower than the OGCM depth.
- itolap_a : Overlap parameter at the begining of a month with the next month.
- itolap_p : Overlap parameter at the end of a months with the previous months. Commonly, these two parameters are equal.

Save romstools_param.m and run make_OGCM in the Matlab session. You should obtain:

```
>> make_OGCM
Add the paths of the different toolboxes
Arch : x86_64 - Matlab version : 2006a
Use of mexnc and loaddap in 64 bits.
Download data...

Get data from Y2000M1 to Y2000M3
Minimum Longitude: 12.3
Maximum Longitude: 20.3
Minimum Latitude: -35.5
Maximum Latitude: -26.3815

Making output data directory ../Run/DATA/SODA_Benguela/
Process the dataset: http://iridl.ldeo.columbia.edu./SOURCES/.CARTON-GIESE/.SODA/.v1p4p3
Processing year: 2000
Processing month: 1
Download SODA for 2000 - 1
...SSH
...U
...
```

1.8.4 Running the model for interannual runs

Compile the model with jobcomp (and with the cpp keys BULK_FLUX and BULK_EP defined) and edit the input parameter file ∼/Roms_tools/Run/roms_inter.in as for the climatology experiments. As for the long simulations, a csh script (run_roms_inter.csh) manages the handling of input and output files. It also changes the number of time steps so each month has the correct length. This script takes care of leap years. For example Y1996M2 (February 1996) is 29 days long.

Part to edit in run_roms_inter.csh:

```
#
set MODEL=roms
set SCRATCHDIR=‘pwd‘/SCRATCH
set INPUTDIR=‘pwd‘
set MSSDIR=‘pwd‘/ROMS_FILES
```

```
set MSSOUT=‘pwd‘/ROMS_FILES
set CODFILE=roms
set AGRIF_FILE=AGRIF_FixedGrids.in
#
set BULK_FILES=1
set FORCING_FILES=1
set CLIMATOLOGY_FILES=0
set BOUNDARY_FILES=1
#
# Atmospheric surface forcing dataset (NCEP, GFS,...)
#
set ATMOS=NCEP
#
# Oceanic boundary and initial dataset (SODA, ECCO,...)
#
set OGCM=SODA
#
# Model time step [seconds]
#
set DT=5400
#
# number total of grid levels (1: No child grid)
#
set NLEVEL=1
#
set NY_START=2000
set NY_END=2000
set NM_START=1
set NM_END=3
#
# Restart file - RSTFLAG=0 –> No Restart
# RSTFLAG=1 –> Restart
#
set RSTFLAG=0
#
# Time Schedule - TIME_SCHED=0 –> yearly files
# TIME_SCHED=1 –> monthly files
#
set TIME_SCHED=1
#
#########################################################################
```

Variables definitions:

- MODEL=roms : Name used for the input files. For example roms_grd.nc.
- SCRATCHDIR=‘pwd‘/SCRATCH : Scratch directory where the model is run.
- INPUTDIR=‘pwd‘ : Input directory where the roms_inter.in input file is located.

- MSSDIR=‘pwd‘/ROMS_FILES : Directory where the roms input NetCDF files (roms_grd.nc, roms_frc.nc, ...) are stored.
- MSSOUT=‘pwd‘/ROMS_FILES : Directory where the roms output NetCDF files (roms_his.nc, roms_avg.nc, ...) are stored.
- CODFILE=roms : ROMS executable.
- AGRIF_FILE=AGRIF_FixedGrids.in : AGRIF input file which defines the position of child grids when using embedding.
- BULK_FILES=1 : 1 if using bulk NetCDF files (should be 1 for NCEP).
- FORCING_FILES=1 : 1 if using forcing NetCDF files (should be 1 for NCEP).
- CLIMATOLOGY_FILES=0 : 1 if using XXX_clm.nc files. Using a climatology file for each month can take a lot of disc space. It is less costly to use boundary files (XXX_bry.nc).
- BOUNDARY_FILES=1 : 1 if using XXX_bry.nc files.
- ATMOS=NCEP : name of the atmospheric reanalysis. For the moment it is only NCEP.
- OGCM=SODA : name of the OGCM for the boundary conditions. SODA or ECCO.
- DT=5400 : Model time step in seconds.
- NDAYS = 30 : Number of days in 1 month.
- NLEVEL=1 : Total number of model grids (no embedding: NLEVEL=1).
- NY_START=2000 : Starting year.
- NY_END=2000 : Ending Year.
- NM_START=1 : Starting month.
- NM_END=3 : Ending month.
- RSTFLAG=0 : 1 if restarting a simulation
- TIME_SCHED=1 : (obsolete) 0 if using yearly files, 1 if using monthly files. Since make_NCEP and make_OGCM are creating only monthly files, it should be always 1.

As for ROMS long climatology experiments, inter-annual experiments can be run in batch mode:
>: nohup ./run_roms_inter.csh > exp1.out &

1.9 Embedding

1.9.1 Embedded (child) model preparation

To run an embedded model, the user must provide the grid, the surface forcing and the initial conditions. To name the different files, AGRIF employs a specific strategy: if the parent file names are of the form: XXX.nc, the first child names will be of the form: XXX.nc.1, the second: XXX.nc.2, etc... This convention is also applied for the "roms.in" input files.

A graphic user interface (NestGUI) facilitates the generation of the different NetCDF files. Launch nestgui in the Matlab session (in the ∼/Roms_tools/Run/ directory):

```
>>
>> nestgui
```

A window pops up, asking for a "PARENT GRID" NetCDF file (Figure 1.9). In our Benguela test case, you should select ∼/Roms_tools/Run/ROMSFILES/roms_grd.nc (grid file) and click "open". The main window appears (Figure 1.10).

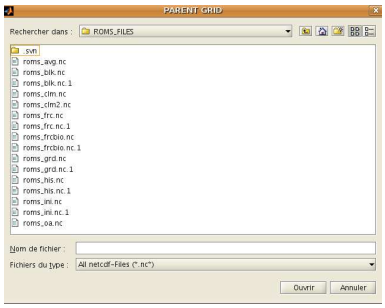


Figure 1.9: Entrance window of NestGUI

To generate the child model you should follow several steps:

1. To define the child domain, click "Define child" and create the child domain on the main window. The size of the grid child (Lchild and Mchild) is now visible. This operation can be redone until you are satisfied with the size and the position of the child domain. The child domain can be finely tuned using the imin, imax, jmin and jmax boxes. Be aware that the mask interpolation from the parent grid to the child grid is not optimal close to corners. Parent/Child boundaries should be placed where the mask is showing a straight coastline. A warning will be given during the interpolation procedure if this is not the case.

2. "Interp child" : It generates the child grid file. Before, you should select if you are using a new topography ("New child topo" button) for the child grid or if you are just interpolating the parent topography on the child grid. In the first case, you should defines what topography file will be used (e.g. ∼/Roms_tools/Topo/etopo2.nc or another dataset). You should also define if you want the volume of the child grid to match the volume of the parent close to the parent/child boundaries ("Match volume" button, it should be "on" by default). You should also define define the r factor (Beckmann and Haidvogel, 1993) for topography smoothing ("r-factor",

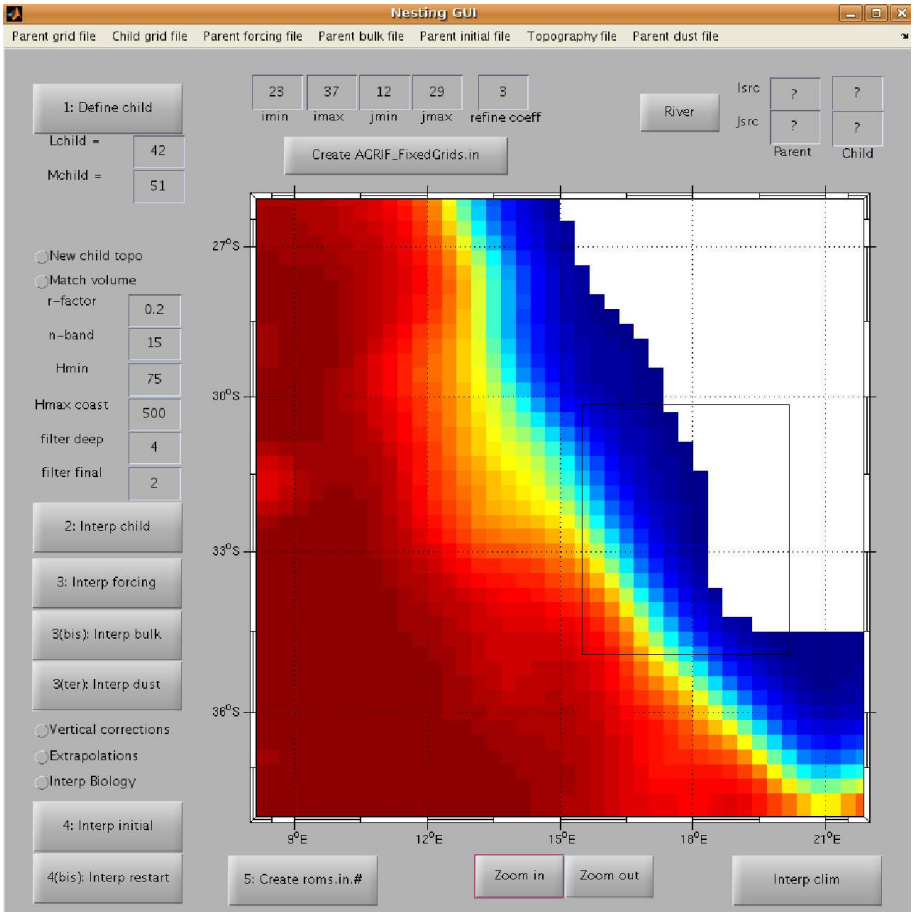


Figure 1.10: The NestGUI main window

0.25 is safe) and the number of points to connect the child topography to the parent topography ("n-band", it follows the relation $h_{new} = \alpha.h_{child} + (1-\alpha).h_{parent}$, where α is going from 0 to 1 in "n-band" points from the parent/child boundaries). You should also select the child minimum depth ("Hmin", it should be lower or equal to the parent minimum depth), the maximum depth at the coast ("Hmax coast"), the number of selective hanning filter passes for the deep regions ("n filter deep") and the number of final hanning filter passes ("n filter final").

3. "Interp forcing": It interpolates the parent surface forcing on the child grid. Select the parent forcing file to be interpolated (e.g. ~/Roms_tools/Run/ROMSFILES/roms_frc.nc). The child forcing file roms_frc.nc.1 will be created. The parent surface fluxes are interpolated on the child grid. You can use "Interp bulk" if you are using a bulk formula. In this case, the parent bulk file (e.g. ~/Roms_tools/Run/ROMSFILES/roms_blk.nc) will be interpolated on the child grid.

4. "Interp initial": It interpolates parent initial conditions on the child grid. Select the parent initial file (e.g. ~/Roms_tools/Run/ROMSFILES/roms_ini.nc). The child initial file (e.g. ~/Roms_tools/Run/ROMSFILES/roms_ini.nc.1) will be created. If the topographies are different between the parent and the child grids, the child initial conditions are vertically re-interpolated. In this case you should check if the options

"vertical corrections" and **"extrapolations"** are selected. **It is preferable to always use these options.**
If there are parent biological variables in the initial files, they are processed. In the case of NPZD type model, there are 4 more variable. In the case of PISCES biogeochemical model, ther is 8 more variables.

5. "Interp dust": It interpolates parent Iron dust forcing file conditions on the child grid. This is needed only in case of PISCES biogeochemical experiments. Select the parent initial file (e.g. ∼/Roms_tools/Run/ROMSFILES/roms_frcbio.nc). The child initial file (e.g. ∼/Roms_tools/Run/ROMSFILES/roms_frcbio.nc.1) will be created.

6. "Interp restart" generates a child restart file from a parent restart file (e.g. ∼/Roms_tools/Run/ROMSFILES/roms_rst.nc). This can be done to "hot start" a child model after the spin-up of the parent model.

7. You can click on "Create roms.in.*" to generate a child input file (roms.in.1) from the parent input file and click on "Create AGRIF_FixedGrids.in" to generate a AGRIF_FixedGrids.in file (the file which defines the child grid position in the parent grid).

8. "River" can be used to locate the river on the coast.

9. "Interp clim" can be useful to generate boundary conditions to test the child model alone.

1.9.2 Compiling and running the model

The ROMS nesting procedure needs a Fortran 95 compiler. For Linux PCs, the Intel Fortran Compiler (ifort) is available at
http://www.intel.com/software/products/compilers/flin/noncom.htm. To be able to compile ROMS with ifort, you should change the corresponding comments in jobcomp.

To activate the AGRIF nesting procedure, define AGRIF in ∼/Roms_tools/Run/cppdefs.h. Moreover, to activate the AGRIF nesting with the 2-way capability, define AGRIF and AGRIF_2WAYS.

It is possible to edit the file AGRIF_FixedGrids.in. This file contains the child grid positions (i.e. imin,imax,jmin,jmax) and coefficients of refinement. A first line gives the number of children grids per parent (if AGRIF_STORE_BAROT_CHILD is defined, only one child grid can be defined per parent grid). A second line gives the relative position of each grid and the coefficient of refinement for each dimension. Edit the input files roms.in.1, roms.in.2 , etc... to define correctly the file names and the time steps. To run the model, simply type at the prompt: roms roms.in.

To visualize the ROMS model outputs for different grid levels, change the value in the "child models" box in roms_gui.

1.10 Operational coastal modeling system

An operating coastal modeling system can be designed following the assumption that large scale offshore dynamics are slow in comparison to the coastal system. The lateral boundary conditions are interpolated from the last available ECCO model outputs and are kept constant during the ROMS simulation. ECCO model outputs are delayed by about two to four weeks, but we suppose that they are still relevant for the present large scale oceanic structure. The Global Forecast System (GFS) is used for the surface forcing. A first day of simulation is run in hindcast mode. This will provide the initial conditions for the next simulated day. Using GFS as surface forcing and ECCO for the lateral boundary conditions, a forecast of 7 days is conducted. A UNIX C-Shell script (/Roms_tools/Run/run_roms_forecast.csh) manages data downloading, the hindcast and forecast simulations and datas storage. The script run_roms_forecast.csh starts Matlab in batch mode to download with OPENDAP the lateral boundary conditions from ECCO and the surface forcing from GFS. It interpolates the data on ROMS grid and launches the hindcast and the forecast runs.

The script run_roms_forecast.csh should be edited to change the directory pathways (HOME, RUNDIR, PATH, LD_LIBRAIRY_PATH, MATLAB,...).

The ROMS input files ∼/Roms_tools/Run/roms_hindcast.in and ∼/Roms_tools/Run/roms_forecast.in should also be edited to change the length of the time step and the number of time steps. The ROMS input file roms_hindcast.in should be defined such as the hindcast run duration is 1 day and a restart file is generated at the end of the hindcast run.

The script run_roms_forecast.csh can be relaunched everyday in batch mode using crontab.

Chapter 2

ROMS_AGRIF 2.0

2.1 The ROMS model

ROMS solves the primitive equations in an Earth-centered rotating environment, based on the Boussinesq approximation and hydrostatic vertical momentum balance. ROMS is discretized in coastline- and terrain-following curvilinear coordinates. ROMS is a split-explicit, free-surface ocean model, where short time steps are used to advance the surface elevation and barotropic momentum, with a much larger time step used for temperature, salinity, and baroclinic momentum. ROMS employs a special 2-way time-averaging procedure for the barotropic mode, which satisfies the 3D continuity equation (Shchepetkin and McWilliams, 2005). The specially designed predictor-corrector time step algorithm used in ROMS allows a substantial increase in the permissible time-step size.

ROMS has been designed to be optimized on shared memory parallel computer architectures such as the SGI/CRAY Origin 2000. Parallelization is done by two dimensional sub-domains partitioning. Multiple sub-domains can be assigned to each processor in order to optimize the use of processor cache memory. This allow super-linear scaling when performance growth even faster than the number of CPUs.

The third-order, upstream-biased advection scheme implemented in ROMS allows the generation of steep gradients, enhancing the effective resolution of the solution for a given grid size (Shchepetkin and McWilliams, 1998). Explicit lateral viscosity is null everywhere in the model domain except in sponge layers near the open boundaries where it increases smoothly close to the lateral open boundaries.

A non-local, K-profile planetary (KPP) boundary layer scheme (Large, 1994) parameterizes the unresolved physical vertical subgrid-scale processes. If a lateral boundary faces the open ocean, an active, implicit, upstream biased, radiation condition connects the model solution to the surroundings (Marchesiello et al., 2001).

More informations and model description can also be found in the SCRUM Manuel (Hedström, K. S. , 1997) and a more recent User Manual on ROMS (Rutgers version[1]), both written by Kate Hedström[2] (Hedström, K. S. , 2009) [3]. These documents are available on the ROMS_AGRIF web site : http://roms.mpl.ird.fr in the documentation section.

[1] http://myroms.org

[2] Kate Hedström, University of Alaska Faibanks, Center for Arctic Region Supercomputing Center, University of Alaska Fairbanks,

[3] Many thanks to Kate Hedstroëm for this work.

2.2 Nesting capabilities, 1-WAYS and 2-WAYS using the AGRIF procedure

2.2.1 Introduction

To address the challenge of bridging the gap between near-shore and offshore dynamics, a nesting capability has been added to ROMS and tested for the California Upwelling System (Penven et al., 2006). The method chosen for embedded griding takes advantage of the AGRIF (Adaptive Grid Refinement in Fortran) package (Blayo and Debreu, 1999; Debreu, 2000; Debreu and Blayo, 2003; Debreu and Vouland, 2003; Debreu and Blayo, 2008). AGRIF is a Fortran 95 package for the inclusion of adaptive mesh refinement features within a finite difference numerical model. One of the major advantages of AGRIF in static-grid embedding is the ability to manage an arbitrary number of fixed grids and an arbitrary number of embedding levels.

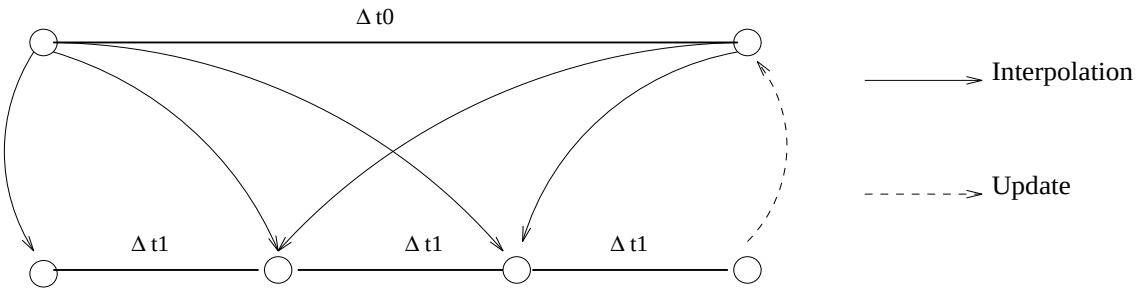


Figure 2.1: Temporal coupling between a parent and a child grid for a refinement factor of 3. The coupling is done at the baroclinic time step.

A recursive integration procedure manages the time evolution for the child grids during the time step of the parent grids (Figure 2.1). In order to preserve the CFL criterion, for a typical coefficient of refinement (say, a factor of 3 for a 5 km resolution grid embedded in a 15 km grid), for each parent time step the child must be advanced using a time step divided by the coefficient of refinement as many time as necessary to reach the time of the parent (Figure (2.1)). For simple 2-level embedding, the procedure is as follows:

1. Advance the parent grid by one parent time step.
2. Interpolate the relevant parent variables in space and time to get the boundary conditions for the child grid.
3. Advance the child grid by as much child time steps as necessary to reach the new parent model time.
4. Update point by point the parent model by averaging the more accurate values of the child model (in the case of 2-way embedding).

The recursive approach used in AGRIF allows the specification of any number of embedding level. Other cpp keys are related to AGRIF, they are in set_global_definitions.h and set_obc_definitions.h files. These ones are the default conditions, are located in the ROMS_AGRIF code sources and should not be edit by standard user.

2.2.2 AGRIF nesting procedure

To have a better undersatnding of the nesting capabilties of ROMS using AGRIF, it can be useful to report to the homepage of the AGRIF project and papers related to its application to ROMS.

1. AGRIF homepage : *http://www-ljk.imag.fr/MOISE/AGRIF/*
2. AGRIF 1 ways evaluation : Evaluation and application of the ROMS 1-way, embedding procedure to the central california upwelling system, (Penven et al., 2006)
3. Paper 2ways-nesting part I : Idealized configuration.
4. Paper 2ways-nesting part II : Realistic configuration.

2.3 Changelog since ROMS_AGRIF 1.1

- New diffusive-advection schemes : RSUP3 (Marchesiello et al , 2009)

  To avoid unacceptable spurious diapycnal mixing, a new advection scheme has been proposed and validate : the RSUP3 scheme. The diffusion is split from advection and is represented by a rotated biharmonic diffusion scheme with flow-dependent hyperdiffusivity satisfying the Peclet constraint. The rotated diffusion operator is designed for numerical stability, which includes improvements of linear stability limits and a clipping method adapted to the sigma-coordinate.

  This scheme induce a time step smaller than the third-order upstream biaised diffusive advective scheme used in the version 1.0. It is activated by the use of the cppkeys **TS_SPLIT_UP3** for tracers and **UV_SPLIT_UP3** for momentum in the cppdefs.h file.

  To avoid numerical instabilities in the sponge where there is enhanced diffusion/diffsuivity, a classical laplacian diffusion can be applied by the use of the cppkey **SPONGE_DIF2** and **SPONGE_VIS2** in the cppdefs.h file.

- Two-ways AGRIF nesting : Ref (**??**)

  As presented before, it is the capability of the fine grid to update data in the coarse grid. With this procedure, we are now able to get the impact of high resolution on the more coarser reolution, in a context of upscaling. To activate the two ways nesting, you need to define the **AGRIF** and **AGRIF_2WAY** cpp-keys.

- Bulk formulation :
  Desciption of the bulk formulation coded by Patrick.

- Online diagnostics and I/O:

  New diagnostics and outputs are now available in the ROMS_AGRIF 2.0.

  Wind stresses, windspeed, and heat fluxes (latent, sensible, long-wave and solar short wave) can be written in the netCDF history and average files. Moreover, bottom boundary layer thickness and euphotic depth layer in case of biological experiments can be saved. For more information, you can refer at the section 2.6.

  Improvmement have also been carried out on the tracer and momentum equation term diagnostics.

  From now, the tracer equation terms are in *dia.nc* and *dia_avg.nc* netcdf file with flags that permit to choose exactly the term you want to write in the netCDF files. By default this diagnostics are written in a divergence flux form, (∂uT_x, ∂vT_y, ...) but they can be written in an "advective form" : $u\partial T_x$, $v\partial T_y$, ... by using the **DIAGNOSTICS_TS_ADV** cpp key.
  Some term have been added : the term integrated over the mixed layer depth (cppkeys **DIAGNOSTICS_TS_MLD**. The mixed layer depth is computed online, from the closure module.

The differents term of the tracer equation, that can be diagnose, for each tracer, expressed in ${}^oC.s^{-1}$, are:

- Time evolution term (called "rate" term)
- Zonal advective term
- Meridian advective term
- Vertical advective term
- Horizontal mixing term
- Vertical mixing term
- Nudging + Surface forcing term (called Tforc term)
- In the case of use **DIAGNOSTICS_TS_MLD** some additional terms are diagnosted :
  - Time evolution term integrated over the surface mixed layer depth (MLD hereafter)
  - Zonal advective term integrated over the MLD
  - Meridian advective term integrated over the MLD
  - Vertical advective term integrated over the MLD
  - Horizontal mixing term integrated over the MLD
  - Vertical mixing term integrated over the MLD
  - Nudging + Surface forcing term integrated over the MLD
  - Entrainement term at the base of the mixed layer

Concerning the momentum equation term, the differents term of the equation can be saved in history *diaM.nc* and average *diaM_avg.nc* netCDF files. As the tracer, there are flags to choose exactly the term you want to write in the netCDF file.

The differents terms of the momentum equation, expressed in $m.s^{-2}$, that can be diagnose (for u and v) are :

- Time evolution term (called "rate" term)
- Pressure gradient term
- Coriolis term
- Zonal advective
- Meridian advective
- Vertical advective
- Horizontal mixing
- Vertical mixing

2.4 Parameters description : *parameter.h*

In this section, we present the more important parameters to configure your own roms_agrif 2.0 run. These parameters are :

- **Test case or realistic run**:
  ...
  #if defined BASIN $-----> $ ***Test case***
  parameter (LLm0= 60, MMm0= 50, N= 10)
  #elif defined REGIONAL $-----> $ ***Realistic run***
  # elif defined BENGUELA_LR
  parameter (LLm0= 41, MMm0= 42, N= 32) ! $<--$ BENGUELA_LR
  # else
  parameter (LLm0=39, MMm0= 32, N= 20)
  # endif
  ...
  LLm0 MMm0 N

- **Grid size**:
  - LLm0: Dimension (ghost points included) in the ξ direction.
  - MMm0: Dimension (ghost points included) in the η direction.
  - N: Number of ρ-vertical points, in the vertical grid.

- **Parallelization**:
  ....
  !
  ! Domain subdivision parameters:
  ! ====== ========== ==========
  ! NPP Maximum allowed number of parallel threads;
  ! NSUB_X,NSUB_E Number of SHARED memory subdomains in XI- and
  ! ETA-directions;
  ! NNODES Total number of MPI processes (nodes);
  ! NP_XI,NP_ETA Number of MPI subdomains in XI- and ETA-directions;
  !

  AUTOTLING (implemented by Laurent Debreu): cppkeys that enable to compute the optimum subdomains partition in terms of computation time.

- **Tides**:
  ...
  #if defined SSH_TIDES —— defined UV_TIDES
  integer Ntides
  parameter (Ntides=8)$---> $ ***Number of wave in the total tidal signal***
  #endif
  ...

2.5 CPP-keys description *cppdefs.h*

In this section, we present the differents cpp keys used to define the numerical or physical options in ROMS_AGRIF. These latters are ordered in differents sections and described in Table 2.1.

TYPE	CPP KEYS NAME
TEST CASE	BASIN CANYON_A CANYON_B GRAV_ADJ INNERSHELF OVERFLOW SEAMOUNT SHELFRONT SOLITON UPWELLING INTERNAL VORTEX REGIONAL : realistric configuration
Basic options	
Configuration Name	BENGUELA
Parallelization	OPENMP MPI PARALLEL_FILES AUTOTILING
Embedding	AGRIF AGRIF_2WAY
Open Boundary Conditions	TIDES OBC_EAST OBC_WEST OBC_NORTH OBC_SOUTH
Tides	TIDES SSH_TIDES UV_TIDES TIDERAMP
Applications	BIOLOGY FLOATS STATIONS
Next page→	

TYPE	CPP KEYS NAME
	PASSIVE_TRACER
	SEDIMENT
	BBL
More advanced options	
Model dynamics	
	SOLVE3D
	UV_COR
	UV_ADV
Grid configuration	
	CURVGRID
	SPHERICAL
	MASKING
Input/Output and Diagnostics	
	AVERAGES
	AVERAGES_K
	DIAGNOSTICS_TS
	DIAGNOSTICS_TS_ADV
	DIAGNOSTICS_TS_MLD
	DIAGNOSTICS_UV
Equation of State	
	SALINITY
	NONLIN_EOS
	SPLIT_EOS
Surface Forcing	
	QCORRECTION
	SFLX_CORR
	DIURNAL_SRFLUX
	BULK_FLUX
	LW_ONLINE
	BULK_EP
	BULK_SMFLUX
	BULK_WVEC
	BULK_WSTR
Lateral Tracer Mixing	
	MIX_GP_TS
	MIX_S_TS
	MIX_EN_TS
	TS_DIF2
	TS_DIF4
	TS_SPLIT_UP3
Lateral Momentum Mixing	
	MIX_GP_UV
	MIX_S_GP
	UV_VIS2
	UV_VIS4

Next page→

TYPE	CPP KEYS NAME
	UV_SPLIT_UP3
Sponge Layer	
	SPONGE
Lateral Forcing	
1-Climatology strategy : 3D fields covering the whole domain	
	CLIMATOLOGY
	ZCLIMATOLOGY
	M2CLIMATOLOGY
	M3CLIMATOLOGY
	TCLIMATOLOGY
2-Boundary strategy : 1D fields only on OBC points	
	FRC_BRY
	Z_FRC_BRY
	M2_FRC_BRY
	M3_FRC_BRY
	T_FRC_BRY
Nudging	
	ZNUDGING
	M2NUDGING
	M3NUDGING
	TNUDGING
	ROBUST_DIAG
Bottom Forcing	
	ANA_BSFLUX
	ANA_BTFLUX
Point Sources - Rivers	
	PSOURCE
	ANA_PSOURCE
Vertical Mixing	
	BODYFORCE
	BVF_MIXING
	LMD_MIXING
	LMD_SKPP
	LMD_BKPP
	LMD_RIMIX
	LMD_CONVEC
	LMD_DDMIX
	LMD_NONLOCAL
Open Boundary Conditions	
	OBC_M2SPECIFIED
	OBC_M2FLATHER
	OBC_M2CHARACT

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TYPE	CPP KEYS NAME
	OBC_M2ORLANSKI OBC_M2ORLANSKI OBC_VOLCONS OBC_M3ORLANSKI OBC_TORLANSKI OBC_M3SPECIFIED OBC_TSPECIFIED

Table 2.1: Description of the CPP keys used in the cppdefs.h file

Test Case

CPP KEYS NAME	Description
BASIN	Must be defined for running the Basin Example.
CANYON_A	Must be defined for running the Canyon_A Example.
CANYON_B	Must be defined for running the Canyon_B Example.
GRAV_ADJ	Must be defined for running the Gravitational Adjustment Example.
INNERSHELF	Must be defined for running the Inner Shelf Example.
OVERFLOW	Must be defined for running the Gravitational/Overflow Example.
SEAMOUNT	Must be defined for running the Seamount Example.
SHELFRONT	Must be defined for running the Shelf Front Example.
SOLITON	Must be defined for running the Equatorial Rossby Wave Example.
UPWELLING	Must be defined for running the Upwelling Example.
INTERNAL	Must be defined for running the Internal tides example.
VORTEX	Must be defined for running the Baroclinic Vortex Example.
REGIONAL	Must be defined if running realistic regional simulations.

Table 2.2: Test Case related CPP keys

Parallelization

CPP KEYS NAME	Description
OPENMP	Activate the Open-MP parallelization protocol.
MPI	Activate the MPI parallelization protocol.
PARALLEL_FILES	Activate the I/O writing on multiprocessor.
AUTOTILING	Activate the subdomains partitionning optimization.

Table 2.3: Parallelization related CPP keys

Preselected options

```
# ifdef MPI
#   undef PARALLEL_FILES
# endif
# undef AUTOTILING
```

Embedding

CPP KEY NAME	Description
AGRIF	Activate the (1-WAYS) nesting capabilities.
AGRIF_2WAYS	Add the the 2-WAYS nesting (feedback from child to parent grid) capabilities.

Table 2.4: Embedding related CPP keys

Open Boundary Conditions I

CPP KEY NAME	Description
OBC_EAST	Open eastern boundary.
OBC_WEST	Open western boundary.
OBC_SOUTH	Open southern boundary.
OBC_NORTH	Open northern boundary.

Table 2.5: Open Boundary Conditions (basic) related CPP keys

Tides

CPP KEY NAME	Description
TIDES	Activate the forcing og tides at open-boundaries.
SSH_TIDES	Define for processing sea surface elevation tidal data at the model boundaries.
UV_TIDES	Define for processing ocean current tidal data at the model boundaries.
TIDERAMP	Apply a ramping of the tidal current, (in general 2 days) at initialization. Warning! This should be off when restarting the model.

Table 2.6: Tides forcing related CPP keys

Preselected options
ifdef TIDES
define SSH_TIDES
define UV_TIDES
define TIDERAMP
endif

Applications

CPP KEY NAME	Description
BIOLOGY	Activate the biogeochemical module.
FLOATS	Activate floats.
STATIONS	Store model outputs for each time step at different station locations.
PASSIVE_TRACER	Add a passive tracer.
SEDIMENT	Activate the sediment module.
BBL	Activate the bottom boundary layer module.

Table 2.7: related CPP keys

Preselected options:
undef BIOLOGY
undef FLOATS
undef STATIONS
undef PASSIVE_TRACER
undef SEDIMENT
undef BBL

Model dynamics

CPP KEY NAME	Description
SOLVE3D	Define if solving 3D primitive equations.
UV_COR	Activate Coriolis terms.
UV_ADV	Activate advection terms.

Table 2.8: Model dynamics related CPP keys

Preselected options:
define SOLVE3D
define UV_COR
define UV_ADV
ifdef TIDES
define SSH_TIDES
define UV_TIDES
define TIDERAMP
endif

Grid configuration

CPP KEY NAME	Description
CURVGRID	Activate curvilinear coordinate grid option.
SPHERICAL	Activate longitude/latitude grid positioning.
MASKING	Activate land masking in the domain.

Table 2.9: Model grid related CPP keys

Preselected options:
define CURVGRID
define SPHERICAL
define MASKING

Input - Output and Diagnostics

CPP KEY NAME	Description
AVERAGES	Define if writing out time-averaged data.
AVERAGES_K	Define if writing out time-averaged vertical mixing.
DIAGNOSTICS_TS	Define if writing out tendency terms for the tracer equations.
DIAGNOSTICS_TS_ADV	Activate advection formulation for tendency term for the tracer equations.
DIAGNOSTICS_TS_MLD	Activate integration over the mixed-layer (MLD) for the tendency term for the tracer equation.
DIAGNOSTICS_UV	Define if writing out tendency terms for the momentum equations.

Table 2.10: I/O related CPP keys

Preselected options:
define AVERAGES
define AVERAGES_K
undef DIAGNOSTICS_TS
ifdef DIAGNOSTICS_TS
undef DIAGNOSTICS_TS_ADV
undef DIAGNOSTICS_TS_MLD
endif
undef DIAGNOSTICS_UV

Equation of state

CPP KEY NAME	Description
SALINITY	Define if using salinity.
NONLIN_EOS	Activate the nonlinear equation of state.
SPLIT_EOS	Activate the split of the nonlinear equation of state in a adiabatic part and a compressible part for the reduction of pressure gradient errors (Shchepetkin and McWilliams, 2003).

Table 2.11: Equation of state related CPP keys

Preselected options:
define SALINITY
define NONLIN_EOS
define SPLIT_EOS

Surface Forcing

CPP KEY NAME	Description
QCORRECTION	Activate net heat flux correction.
SFLX_CORR	Activate freshwater flux correction.
DIURNAL_SRFLUX	Activate diurnal modulation of the short wave radiation flux.
BULK_FLUX	Activate the bulk parametrization.
BULK_EP	Activate the bulk parametrization for salinity fluxes.
LW_ONLINE	Activate online long-wave radiation calculation using model sst.
BULK_SMFLUX	Activate the bulk parametrization for surface momentum stress and/or wind
BULK_WVEC	Compute the wind speed amplitude from the wind speed vector (uwnd and vwnd) read in the bulk file.
BULK_WSTR	Activate the bulk parametrization for wind stress calculation. Compute the windstress (sustr and svstr) from the wind speed vector, mentioned above.

Table 2.12: Surface forcing related CPP keys

Preselected options:
define QCORRECTION
define SFLX_CORR
define DIURNAL_SRFLUX
undef BULK_FLUX
ifdef BULK_FLUX
define LW_ONLINE
define BULK_EP
undef BULK_SMFLUX
define DIURNAL_SRFLUX
endif

ifdef BULK_EP
undef QCORRECTION
undef SFLX_CORR
endif
ifdef BULK_SMFLUX
undef BULK_WVEC
define BULK_WSTR
endif

Lateral Tracer mixing

CPP KEY NAME	Description
MIX_GP_TS	Activate mixing on geopotential (constant Z) surfaces.
MIX_S_TS	Activate mixing on iso-sigma level surfaces.
MIX_EN_TS	Activate mixing on isopygnal level surfaces.
TS_DIF2	Activate Laplacian horizontal mixing of tracer.
TS_DIF4	Activate Bilaplacian horizontal mixing of tracer.
TS_SPLIT_UP3	Activate the rotated split upstream advection-diffusion scheme for tracer equation. (Marchesiello et al , 2009)

Table 2.13: Lateral Tracer mixing related CPP keys

Preselected options:
define MIX_GP_TS
define TS_DIF2
undef TS_SPLIT_UP3

Lateral Momentum Mixing

CPP KEY NAME	Description
MIX_GP_UV	Activate mixing on geopotential (constant Z) surfaces.
MIX_S_UV	Activate mixing on iso-sigma (constant sigma) surfaces.
UV_VIS2	Activate Laplacian horizontal mixing of momentum.
UV_VIS4	Activate Bilaplacian horizontal mixing of momentum.

Table 2.14: Lateral Momentum mixing related CPP keys

Preselected options:
define UV_VIS2
define MIX_GP_UV
undef UV_SPLIT_UP3

Sponge Layer

CPP KEY NAME	Description
SPONGE	Activate areas of enhanced viscosity/diffusion close to the lateral open boundaries.

Table 2.15: Sponge layer related CPP keys

Lateral forcing

CPP KEY NAME	Description
CLIMATOLOGY	Activate processing of climatology data.
ZCLIMATOLOGY	Activate processing of sea surface height climatology.
M2CLIMATOLOGY	Activate processing of barotropic velocities climatology.
M3CLIMATOLOGY	Activate processing of baroclinic velocities climatology.
TCLIMATOLOGY	Activate processing of tracer climatology.
FRC_BRY	Activate direct boundary forcing
Z_FRC_BRY	Activate boundary forcing for zeta.
M2_FRC_BRY	Activate boundary forcing for barotropic velocities.
M3_FRC_BRY	Activate boundary forcing for baroclinic velocities
T_FRC_BRY	Activate boundary forcing for tracers.

Table 2.16: Lateral forcing related CPP keys

Preselected options:

```
# define CLIMATOLOGY
# ifdef CLIMATOLOGY
#   define ZCLIMATOLOGY
#   define M2CLIMATOLOGY
#   define M3CLIMATOLOGY
#   define TCLIMATOLOGY
.....

# endif

# undef FRC_BRY
# ifdef FRC_BRY
#  define Z_FRC_BRY
#  define M2_FRC_BRY
#  define M3_FRC_BRY
#  define T_FRC_BRY
# endif
```

Nudging

CPP KEY NAME	Description
ZNUDGING	Activate nudging layer for zeta.
M2NUDGING	Activate nudging layer for barotropic velocities.
M3NUDGING	Activate nudging layer for baroclinic velocities.
TNUDGING	Activate nudging layer for tracer.
ROBUST_DIAG	Activate strong tracer nudging in the interior for diagnostic simulations.

Table 2.17: Nudging related CPP keys

The nudging layer has the same location than sponge layer. In the sponge/nudging layer, the signal, tracers and momentum, is nudged towards climatology using a nudging coefficient τ_{out} expressed in $s-1$, equal to the inverse of the coefficient $TauM_{out}/TauT_{in}$ in the namelist roms.in

Preselected options:
define CLIMATOLOGY
ifdef CLIMATOLOGY
.....
define ZNUDGING
define M2NUDGING
define M3NUDGING
define TNUDGING
undef ROBUST_DIAG
endif

Bottom forcing

CPP KEY NAME	Description
ANA_BSFLUX	Define if using analytical bottom salinity flux
ANA_BTFLUX	Define if using analytical bottom temperature flux.

Table 2.18: Bottom forcing related CPP keys

Preselected options:
define ANA_BSFLUX
define ANA_BTFLUX

Point Sources - Rivers

CPP KEY NAME	Description
PSOURCES	Define if using point sources (rivers)
ANA_PSOURCES	Define if using analytical vertical profiles for the point sources (using fluxes defined in roms.in)

Table 2.19: Point Sources and Rivers related CPP keys

Preselected options:
undef PSOURCE
undef ANA_PSOURCE

Vertical Mixing

CPP KEY NAME	Description
BODYFORCE	Define if applying surface and bottom stresses as bodyforces
BVF_MIXING	Activate a simple mixing scheme based on the Brunt-Väisälä frequency
LMD_MIXING	Activate Large/McWilliams/Doney mixing (LMD-KPP closure)
LMD_SKPP	Activate surface boundary layer KPP mixing (LMD-KPP closure)
LMD_BKPP	Activate bottom boundary layer KPP mixing (LMD-KPP closure)
LMD_RIMIX	Activate shear instability interior mixing (LMD-KPP closure)
LMD_CONVEC	Activate convection interior mixing (LMD-KPP closure)
LMD_DDMIX	Activate double diffusion interior mixing (LMD-KPP closure)
LMD_NONLOCAL	Activate nonlocal transport (LMD-KPP closure)

Table 2.20: Vertical mixing related CPP keys

Preselected options:
undef BODYFORCE
undef BVF_MIXING
define LMD_MIXING
ifdef LMD_MIXING
define LMD_SKPP
define LMD_BKPP
define LMD_RIMIX
define LMD_CONVEC
undef LMD_DDMIX
undef LMD_NONLOCAL
endif

Open Boundary Conditions II

CPP KEY NAME	Description
OBC_VOLCONS	Activate mass conservation enforcement at open boundaries.
OBC_M2SPECIFIED	Activate specified open boundary conditions for ubar and vbar.
OBC_M2ORLANSKI	Activate 2D radiation open boundary conditions for ubar and vbar.
OBC_M2FLATHER	Activate Flather open boundary conditions for ubar and vbar.
OBC_M2CHARACT	Activate open boundary conditions based on characteristic methods.
OBC_M3SPECIFIED	Activate specified open boundary conditions for u and v.
OBC_M3ORLANSKI	Activate 2D radiation open boundary conditions for u and v.
OBC_M3CHARACT	Activate open boundary conditions based on characteristic methods for u and v.
OBC_TSPECIFIED	Activate specified open boundary conditions for tracers.
OBC_TORLANSKI	Activate 2D radiation open boundary conditions for tracers.
OBC_TUPWIND	Activate upwind open boundary conditions for tracers.

Table 2.21: Open Boundary Condition related CPP keys

Preselected options:

```
# ifdef TIDES
#  define OBC_M2FLATHER
# else
#  undef OBC_M2SPECIFIED
#  undef OBC_M2FLATHER
#  define OBC_M2CHARACT
#  undef OBC_M2ORLANSKI
#  ifdef OBC_M2ORLANSKI
#   define OBC_VOLCONS
#  endif
# endif
# define OBC_M3ORLANSKI
# define OBC_TORLANSKI
# undef OBC_M3SPECIFIED
# undef OBC_TSPECIFIED
```

2.6 Namelist description : *roms.in*

2.6.1 Exemple of South Benguela Test Case

title:
South Benguela TEST MODEL
time_stepping: NTIMES dt[sec] NDTFAST NINFO
720 3600 60 1
S-coord: THETA_S, THETA_B, Hc (m)
7.0d0 0.0d0 5.0d0
grid: filename
roms_grd.nc
forcing: filename
roms_frc.nc
bulk_forcing: filename
roms_bulk.nc
climatology: filename
roms_clm.nc
boundary: filename
roms_bry.nc
initial: NRREC filename
1
roms_ini.nc
restart: NRST, NRPFRST / filename
720 −1
roms_rst.nc
history: LDEFHIS, NWRT, NRPFHIS / filename
T 72 0
roms_his.nc
averages: NTSAVG, NAVG, NRPFAVG / filename
1 72 0
roms_avg.nc
primary_history_fields: zeta UBAR VBAR U V wrtT(1:NT)
T T T T T 30*T
auxiliary_history_fields: rho Omega W Akv Akt Aks HBL HBBL Bostr Wstr UWstr VWstr rsw rlw lat sen HEL
F F T F T F T T T T T T 10*F
primary_averages: zeta UBAR VBAR U V wrtT(1:NT)
T T T T T 30*T
auxiliary_averages: rho Omega W Akv Akt Aks HBL HBBL Bostr Wstr Wstr UWst rsw rlw lat sen HEL
F T T F T F T T T T T T 10*F
rho0:
1025.d0
lateral_visc: VISC2, VISC4 [m^2/sec for all]
0. 0.
tracer_diff2: TNU2(1:NT) [m^2/sec for all]
$30 * 0.d0$

tracer_diff4: TNU4(1:NT) [m^4/sec for all]
$30 * 0.d11$
vertical_mixing: Akv_bak, Akt_bak [m^2/sec]
0.d0 $30 * 0.d0$
bottom_drag: RDRG [m/s], RDRG2, Zob [m], Cdb_min, Cdb_max
3.0d−04 0.d−3 0.d−3 1.d−4 1.d−1
gamma2:
1.d0
sponge: X_SPONGE [m], V_SPONGE [m^2 / sec]
$150.e3$ 100.
nudg_cof: TauT_in, TauT_out, TauM_in, TauM_out [days for all]
1. 360. 3. 360.
diagnostics: ldefdia nwrtdia nrpfdia /filename
T 72 0
roms_dia.nc
diagnostics_history_fields [4]: TXadv(1:NT !!EXACT!!) TYadv TVadv THmix TVmix ... Tforc Trate TXadvml TYadvml TVadvml THmixml TVmixml Tforcml Tentml Trateml
T T T T T T T T T T T T T T T T T T T T T T T T T T
T T T T T T
diag_avg: ldefdia_avg ntsdia_avg nwrtdia_avg nprfdia_avg /filename
T 1 72 0
roms_dia_avg.nc
diagnostics_average_fields: TXadv(1:NT !!EXACT!!) TYadv TVadv THmix TVmix ... Tforc Trate TXadvml TYadvml TVadvml THmixml TVmixml Tforcml Tentml Trateml
T T T T T T T T T T T T T T T T T T T T T T T T T T
T T T T T T
diagnosticsM: ldefdiaM nwrtdiaM nrpfdiaM /filename
T 72 0
roms_diaM.nc
diagnosticsM_history_fields [5]: MXadv MYadv MVadv MCor MPrsgrd MHmix MVmix MRate
T T T T T T T T T T T T T T T T
diagM_avg: ldefdiaM_avg ntsdiaM_avg nwrtdiaM_avg nprfdiaM_avg /filename
T 1 72 0
roms_diaM_avg.nc
diagnosticsM_average_fields: MXadv MYadv MVadv MCor MPrsgrd MHmix MVmix MRate
T T T T T T T T T T T T T T T T
diagnostics_bio: ldefdiabio nwrtdiabio nrpfdiabio /filename
T 72 0
roms_diabio.nc
diagbio_avg: ldefdiabio_avg ntsdiabio_avg nwrtdiabio_avg nprfdiabio_avg /filename

[4] For each flag, you have to define T or F fior the tracer corresponding. In case of physical experiments, we have two tracers, T and S, so we have to define 2 logical value for each terms. In case of PISCES biogeochemical experiment, we have T, S and 24 more tracers. So we have to define 26 logical value for each term. For example, in this case replace T T by T T 24*T if you want all the PISCES biogeochemical tracer diagnostics

[5] In the case of momentum equation term, we have only 2 logical flags to define by diagnostic term, one for u and one for v

T 1 72 0
roms_diabio_avg.nc
biology: forcing file
roms_frcbio.nc
sediments: input file
sediment.in
sediment_history_fields: bed_thick bed_poros be3d_fra(sand,silt)
T F T T
bbl_history_fields: Abed Hripple Lripple Zbnot Zbapp Bostrw
T F F T F T
floats: LDEFFLT, NFLT, NRPFFLT / inpname, hisname
T 6 0
floats.in
floats.nc
float_fields: Grdvar Temp Salt Rho Vel
F F F F F
stations: LDEFSTA, NSTA, NRPFSTA / inpname, hisname
T 400 0
stations.in
stations.nc
station_fields: Grdvar Temp Salt Rho Vel
T T T T T
psource: Nsrc Isrc Jsrc Dsrc Qbar [m3/s] Lsrc Tsrc
2
3 54 1 200. T T 5.0.
3 40 0 200. T T 5.0.

2.6.2 Description

Keywords	Descriptions
title	
time_stepping	NTIMES : Number of time step for the run. dt : Baroclinic time step for the run [in s] NDTFAST : Number of bariotropic time step in one baroclinic time step. NINFO : frequency of output in time steps.
S-coord	THETA_S: s-coordinate surface control parameter, $0 <$ **theta_s** $<$ 20 THETA_B: s-coordinate bottom control parameter, $0 <$ **theta_b** $<$ 1 Hc(m): Width of the surface or bottom topography layer in which higher vertical resolution is required during stretching.
grid	
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KEYWORDS	DESCRIPTIONS
	/filename: Name of the grid file.
forcing	/filename: Name of the surface forcing file : wind stress, atmospheric fluxes (E-P, net heat fluxes) and nudging coefficients towards dQ/dSST.
bulk_forcing	/filename: Name of the bulk forcing file for atmospheric forcings.
climatology	/filename: Name of the open boundaries conditions (t, s, $\bar{u}$, $\bar{v}$, u, v). These files are 3d in space, covering the whole domain.
boundary	/filename: Name of the open boundaries conditions (T, S, $\bar{u}$, $\bar{v}$, u, v). These files are covering only the open-boundaries slices, inducing files much smaller than the "climatology" ones.
initial	NRREC: Record number of the restartfile to read as the initial conditions. /filename: Name of the file containing initial state.
restart	NRST: Frequency of writing NRPFRST 0: writing several records every NRST time steps. -1: overwriting record every NRST time steps /filename
history	LDEFHIS: flag (T/F) if writing history files NWRT: Frequency of writing NRPFHIS: 0: writing several records every NWRT time steps. -1: overwriting record every NRST time steps /filename: Name of the gistory file
averages	NTSAVG: Starting timestep for the accumulation of output time-averaged data. For instance, you might want to average over the last day of a thirty-day run. NAVG: frequency of writing NRPFAVG: 0: writing several records every NWRT time steps. -1: overwriting record every NAVG time steps /filename
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KEYWORDS	DESCRIPTIONS
primary_history_fields	Flags of written primary variables in history netCDF file
auxiliary_history_fields	Flags of written auxiliary variables in history netCDF file
primary_averages	Flags of written primary variables in history netCDF file
auxiliary_averages	Flags of written variables in average netCDF file
rho0	Mean density used in the Boussinesq equation.
lateral_visc	VISC2: Laplaplacian background viscosity VISC4: Bilaplacian background viscosity
tracer_diff2	TNU2(1:NT): Laplacian background diffusivity for each tracer.
tracer_diff4	TNU4(1:NT): Laplacian background diffusivity for each tracer.
vertical_mixing	Coefficient in case of use of analytical vertical mixing scheme.
bottom_drag	RDRG [m/s]: Drag coefficient in case of linear bottom stress formulation. RDRG2: Drag coefficient in case of constant quadratic bottom stress formulation. Zob [m]: Rugosity length in case of Von-Karman quadratic bottom stress formulation Cdb_min: Minimum value of the drag coefficient in case Von-Karman quadratic bottom stress formulation. Cdb_max: Maximum value of the drag coefficient in case Von-Karman quadratic bottom stress formulation.
gamma2	Free slip boundary condition. 1 mean free slip condition are ON.

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KEYWORDS	DESCRIPTIONS
sponge	X_SPONGE [m]: widthness of the sponge layers. V_SPONGE [m^2/sec]: Value of the viscosity and diffusity enhanced value at the boundary point in the nudging/sponge layer. These value are enhanced following a linear profil in the sponge/nudging layer, from the interior value to the max value V_SPONGE at boundary.
nudg_cof	TauT_in [days]: Nudging time scale for tracer signal going inward the domain. This coefficient is used at boundary point and impose a strong nudging towards climatology external data. TauT_out [days]: Nudging time scale for tracer signal going outward the domain. This coefficient is used at boundary point and impose a smooth nudging towards climatology external data. This coefficient is also used in the nudging/sponge layer to add a smooth nudging towards data. This is on only if the CLIMATOLOGY boundary stategy is used, not the BRY one. TauM_in [days]: Same as above, but concerning the momentum equations. TauM_out [days]: Same as above, but concerning the momentum equations.
diagnostics	ldefdia: Boolean flag to activate the tracer equation "snap-shot" diagnostic file writing nwrtdia: Frequency of writing nrpfdia: nrpfdia: 0: writing several records every nwrtdia time steps. -1: overwriting record every nwrtdia time steps /filename: Name of the file tracer equation diagnostic file.
diagnostics_history_fields	Flags of written tracer equation term in history netCDF file
diag_avg	ldefdia_avg: Boolean flag to activate the tracer equation average diagnostic file writing ntsdia_avg: Starting timestep for the accumulation of output time-averaged data. For instance, you might want to average over the last day of a thirty-day run. nwrtdia_avg: Frequency of writing and average time.
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KEYWORDS	DESCRIPTIONS
	nprfdia_avg: nrpfdia_avg: 0: writing several records every nwrtdia_avg time steps. -1: overwriting record every nwrtdia_avg time steps /filename: Name of the file tracer equation average diagnostic file.
diagnostics_average_fields	Flags of written tracer equation term in average netCDF file
diagnosticsM	Same format as **diagnostics** but for the momentum equation. ldefdiaM: nwrtdiaM: nrpfdiaM: /filename:
diagnosticsM_history_fields	Flags of written momentum equations terms in history netCDF file
diagM_avg	Same format as **diag_avg** but for the momentum equation. ldefdiaM_avg: ntsdiaM_avg: nwrtdiaM_avg: nprfdiaM_avg: /filename
diagnosticsM_average_fields	Flags of written momentum equations terms in average netCDF file
diagnosticsM_bio	Same format as **diagnostics** ldefdiabio nwrtdiabio nrpfdiabio / filename
diagbio_avg	Same format as **diag_avg** ldefdiabio_avg ntsdiabio_avg nwrtdiabio_avg nprfdiabio_avg / filename
biology	Name of the file containing the Iron dust forcing if using PISCES biogeochemical mode.

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KEYWORDS	DESCRIPTIONS
sediments	
sediment_history_fields	bed_thick bed_poros bed_fra(sand,silt)
bbl_history_fields	Abed Hripple Lripple Zbnot Zbapp Bostrw
floats	Lagrangian floats application Same format as **diagnostics** LDEFFLT NFLT NRPFFLT / inpname, hisname
floats_fields	Type of fields computed for each lagrangian floats.
station_fields	Fixed station application. Same format as **diagnostics** LDEFSTA NSTA NRPFSTA / inpname, hisname
psource	Nsrc Isrc Jsrc Dsrc Qbar [m3/s] Lsrc Tsrc

Table 2.22: Description of the roms.in file

Bibliography

Beckmann, A., Haidvogel, D.B., 1993. Numerical simulation of flow around a tall isolated seamount. Part I: Problem formulation and model accuracy. Journal of Physical Oceanography 23, 1736-1753.

Blanke, B., Roy, C., Penven, P., Speich, S., McWilliams, J.C., Nelson, G., 2002. Linking wind and upwelling interannual variability in a regional model of the southern Benguela, Geophysical Research Letters 29, 2188-2191.

Blayo, E., Debreu, L., 1999. Adaptive mesh refinement for finite-difference ocean models: First experiments. Journal of Physical Oceanography 29, 1239-1250.

Debreu, L., Blayo, E., 2008. Special Issue on Multi-Scale Modelling: Nested Grid and Unstructured Mesh Approaches. Ocean Dynamics 58, 415-428. doi 10.1007/s10236-008-0150-9

Marchesiello, P., Debreu, L., Couvelard, X. 2009. Spurious diapycnal mixing in terrain-following coordinate models: The problem and a solution. Ocean Modelling 26, 156-169

Aumont, O. 2005. PISCES biogeochemical model description. Internal report, 36 pages

Carton, J.A., Giese, B.S., Grodsky, S.A., 2005. Sea level rise and the warming of the oceans in the Simple Ocean Data Assimilation (SODA) ocean reanalysis. Journal of Geophysical Research 110, C09006, doi:10.1029/2004JC002817.

Casey, K.S., Cornillon, P., 1999. A comparison of satellite and in situ based sea surface temperature climatologies. Journal of Climate 12, 1848-1863.

Conkright, M.E., R.A. Locarnini, H.E. Garcia, T.D. O Brien, T.P. Boyer, C. Stephens, J.I. Antonov, 2002. World Ocean Atlas 2001: Objective Analyses, Data Statistics, and Figures, CD-ROM Documentation. National Oceanographic Data Center, Silver Spring, MD, 17 pp.

Da Silva, A.M., Young, C.C., Levitus, S. 1994. Atlas of surface marine data 1994, Vol. 1, algorithms and procedures, NOAA Atlas NESDIS 6, U. S. Department of Commerce, NOAA, NESDIS, USA, 74 pp.

Debreu, L., 2000. Raffinement adaptatif de maillage et méthodes de zoom - application aux modèles d'océan, 2000, Ph.D. thesis, Université Joseph Fourier, Grenoble.

Debreu, L., Blayo, E., 2003. AGRIF: Adaptive Grid Refinement In Fortran. *submitted to ACM Transactions on Mathematical Software - TOMS.*

Debreu, L., Vouland, C., 2003. AGRIF: Adaptive Grid Refinement In Fortran. [Available online http://www-lmc.imag.fr/IDOPT/AGRIF/index.html].

Di Lorenzo, E., Miller, A.J., Neilson, D.J., Cornuelle, B.D., Moisan, J.R., 2003. Modeling observed California Current mesoscale eddies and the ecosystem response . International Journal of Remote Sensing, in press.

Egbert, G., Erofeeva, S., 2002. Efficient inverse modeling of barotropic ocean tides, Journal of Atmospheric and Oceanic Technology 19, 183-204.

Flather, R.A., 1976. A tidal model of the northwest European continental shelf. Mémoires de la Société Royale des Sciences de Liège, 10, 141-164.

Haidvogel, D.B., Arango, H.G., Hedstrom, K. , Beckmann, A., Malanotte-Rizzoli, P., Shchepetkin, A.F., 2000. Model Evaluation Experiments in the North Atlantic Basin: Simulations in Nonlinear Terrain-Following Coordinates. Dynamics of Atmospheres and Oceans 32 , 239-281.

Haney, R.L., 1991. On the pressure force over steep topography in sigma coordinate ocean models. Journal of Physical Oceanography 21, 610-619.

Jackett, D.R., McDougall, T.J., 1995. Minimal Adjustment of Hydrostatic Profiles to Achieve Static Stability. Journal of Atmospheric and Oceanic Technology 12, 381-389.

Large, W.G., McWilliams, J.C., Doney, S.C., 1994. Oceanic vertical mixing: a review and a model with a nonlocal boundary layer parameterization. Reviews in Geophysics 32, 363-403.

MacCready, P. M., R. D. Hetland, W. R. Geyer, Long-Term Isohaline Salt Balance in an Estuary. Continental Shelf Research, 22, 1591-1601.

Marchesiello, P., McWilliams, J.C., Shchepetkin, A., 2001. Open boundary condition for long-term integration of regional oceanic models. Ocean Modelling 3, 1-21.

Marchesiello, P., McWilliams, J.C., Shchepetkin, A., 2003. Equilibrium structure and dynamics of the California Current System. Journal of Physical Oceanography 33, 753-783.

Penven, P., Roy C., Lutjeharms, J.R.E., Colin de verdière, A., Johnson, A., Shillington, F., Fréon, P., Brundrit, G., 2001. A regional hydrodynamic model of the Southern Benguela. South African Journal of Science 97, 472-476.

Penven, P., Debreu, L., Marchesiello, P., McWilliams, J.C., 2006. Application of the ROMS embedding procedure for the Central California Upwelling System. Ocean Modelling 12, 157-187.

Penven, P., Marchesiello, P., Debreu, L., Lefèvre, J., 2007. Software tools for pre- and post-processing of oceanic regional simulations. Environmental Modelling and Software, in press.

Reynolds, R.W., Smith, T.M., 1994. Improved global sea surface temperature analyses using optimum interpolation. Journal of Climate. 7, 929-948.

Shchepetkin, A.F., McWilliams, J.C., 1998. Quasi-monotone advection schemes based on explicit locally adaptive dissipation. Monthly Weather Review 126, 1541-1580.

Shchepetkin, A.F., McWilliams, J.C., 2003. A method for computing horizontal pressure-gradient force in an ocean model with a non-aligned vertical coordinate. Journal of Geophysical Research 108.

Shchepetkin, A.F., McWilliams, J.C., 2005. Regional Ocean Model System: a split-explicit ocean model with a free-surface and topography-following vertical coordinate. Ocean Modelling 9, 347-404.

Smith, W.H.F., Sandwell, D.T., 1997. Global seafloor topography from satellite altimetry and ship depth soundings. Science 277, 1957-1962.

Stammer, D., Davis, R., Fu, L.L., Fukumori, I., Giering, R., Lee, T., Marotzke, J., Marshall, J., Menemenlis, D., Niiler, P., Wunsch, C., Zlotnicki., V., 1999. The consortium for estimating the circulation and climate of the ocean (ECCO) - Science goals and task plan - Report N°1. Techical report, Jet Propulsion Laboratory - Massachusetts Institute of Technology - Scripps Institution of Oceanography.

Hedstrom, K. S., 1997. SCRUM Manuel, Institute of Marine and Coastal Sciences, Rutgers University, USA

Hedstroem, K. S., 2009. DRAFT Technical Manual for a Coupled Sea-Ice/Ocean Circulation Model (Version 3), U.S Department of the Interior, Mineral Management Service, Anchorage, Alaska, Arctic Region Supercomputing Center, University of Alaska Fairbanks, Contract M07PC13368