Contents

1. Introduction

This guide provides a brief introduction to the models that make up the Coupled Ocean-Atmosphere-Wave-Sediment Transport Modeling System (COAWST), as well as the additional user settings required for specific projects. As shown in Figure 1.1, COAWST uses several models and programs that will be presented below:

- **COAWST**: Core of the coupled numerical modeling system. More information in the section 1.7;
- **ROMS**: The hydrodynamic model. More information in the Section 1.1;
- **Sea Ice**: The sea ice model, coupled to ROMS. In this guide we use the Budgell's Sea Ice Model. More information in the Section 1.2;
- **WRF**: The atmospheric model. More information in the Section 1.3;
- ***wrf***: Executable program to start the WRF atmospheric simulation. More information in the section **??**;
- ***real***: Executable program to generate the initial condition and the boundary forces of the WRF. More information in the Section **??**;
- ***WPS***: Package with three programs to generate the files to be used in *real*. More information in the Section **??**;
- ***geogrid***: Program to, mainly, generate the WRF grid domain. More information in the section **??**;
- ***ungrib***: Briefly, the program that extracts the data in *GRIB* format. More information in the Section **??**;
- ***metgrid***: Briefly, the program that interpolates the data generated by *ungrib*. More information in the Section **??**;
- **SWAN**: The wave model. More information in the Section 1.4;
- **MCT**: The set of codes that couples the previous models. More information in the Section 1.5;
- **SCRIP**: Package that interpolates and remaps the model's grids to allow the models to be coupled. More information in the section 1.6.

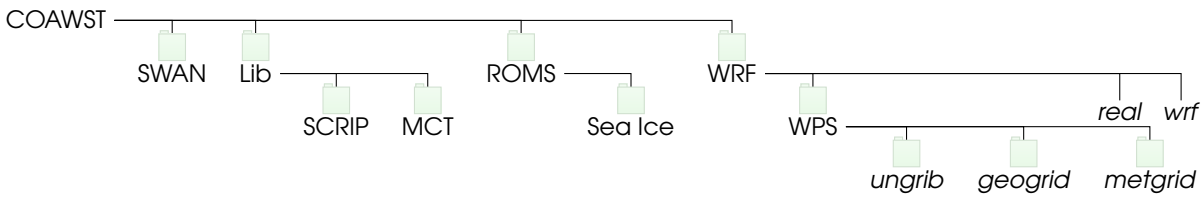

Figure 1.1. COAWST folder structure

When writing this guide, we chosed to use Python as a programming language for some steps. It is a programming language designed with a philosophy of emphasizing the importance of the programmer's effort over the computational effort and prioritizes code readability over speed or expressiveness. The language has a wide and active community, which facilitates the search information by the user, as there is an extensive collection of libraries and documents on the internet.

Python Brazil (*http://python.org.br*) offers great help for beginners, providing introductions about the language and also a guide to use Python for scienfic purposes.

We also use MATLAB as a language. It is a paid, but high-performance interactive software focused on the numerical calculation. The MATLAB Answers website is a platform created to offer help to the users about the language. The site is avaliable at https://www.mathworks.com/matlabcentral/answers/index,

1.1 Regional Ocean Modeling System

The Regional Ocean Modeling System (ROMS; Shchepetkin & McWilliams, 2005) is a three-dimensional ocean model with free surface, vertical sigma coordinate with sigma vertical coordinates (that follow the terrain) and solve primitive equations. The model uses the Reynolds average and the finite difference method to solve the Navier-Stokes equations using hydrostatic approximations and Boussinesq (cite Haidvogel2008).

The hydrostatic equations of momentum use a split-explicit time-step scheme, where the barotropic and baroclinic modes are solved separately, in different finite numbers of steps of time, to solve the free surface equations and it is integrated vertically. This structure separate time-steps frames maintains the volume conservation and consistency preservation that are necessary for the tracers (Haidvogel et al., 2008; Shchepetkin & McWilliams, 2005).

The model solves the horizontally equations through orthogonal curvilinear coordinates of the Arakawa-C grid type (Arakawa & Lamb, 1977). Vertically, the coordinates follow the features of the terrain and allow you to adjust the resolution along the water column. To guarantee the conservation of momentum, the grid uses econd order finite differences (Haidvogel et al., 2008).

ROMS is a model that has free code and its development has the contribution of the user community. Currently, the version used in COAWST is managed by Dr. Hernan Arango of Rutgers University. To access the model code, is necessary to register on the ROMS website (*https://www.myroms.org/*) The site has a extremely useful and very active forum to discuss about questions and suggestions. You can access here: (*https://www.myroms.org/forum*)

We recommend to read the ROMS Technical Manual, written by Hedström (2018). This manual has several information about the equations and algorithms of the model and examples of test cases.

1.2 Budgell's Sea Ice Model

The Sea Ice Model, proposed by Budgell (2005), has the same time and grid steps as the ROMS model and shares the same parallel encoding structure for use with Message Passing Import (MPI). Thus, allows dynamic and thermodynamic modeling where sea ice predominates, such as at high latitudes.

The main attributes of the model, according to Hedström (2018), are:

- Hunke & Dukowicz (1997) and Hunke (2001) elasctic-viscous-plastic dynamics;
- Mellor & Kanta (1989) thermodynamics;
- Orthogonal-curvilinear coordinates;
- Arakawa & Lamb (1977) grid;
- Smolarkiewicz & Grabowski (1990) advection of tracers;
- Lemieux et al. (2015) landfast ice parameterization.

1.3 Weather Research & Forecasting Model

The Weather Research and Forecasting (WRF; Skamarock et al., 2008) is a model developed by the National Centers for nvironmental Prediction (NCEP), the National Center for Atmospheric Research (NCAR) and research groups from different universities.

To integrate the governing equations over time, the Advanced Research WRF (ARW) uses low frequency modes that are integrated using the third-order Runge-Kutta scheme, and the integrated acoustic and gravity (high frequency) modes with a lower time step. By this way, the numerical stability is maintained through a "forward-backward" scheme for acoustic modes that propagate horizontally and an implicit scheme for acoustic modes for vertical propagation and buoyancy oscillations (Skamarock et al., 2008).

The WRF model uses an Arakawa-C type grid (Arakawa & Lamb, 1977), where normal speeds are staggered halfway through the grid of thermodynamic variables, as shown in the schematic representation illustrated in Figure 1.2.

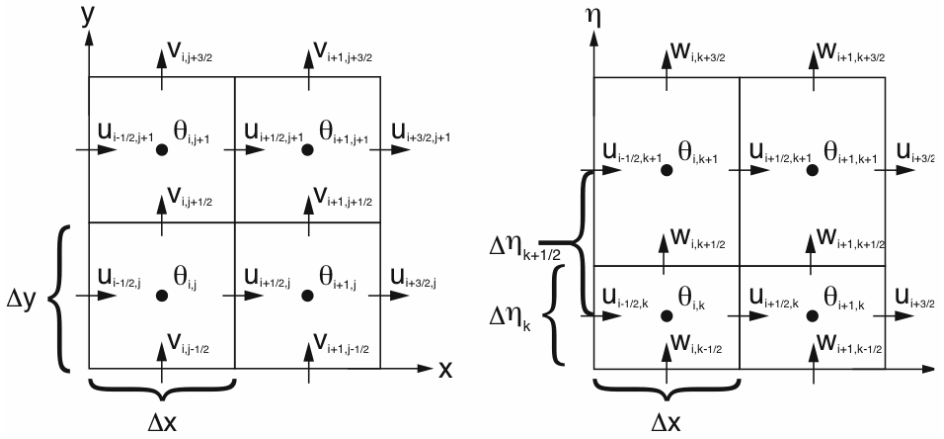

Figure 1.2. Horizontal and vertical grid of Weather Research and Forecast (WRF) using the Arawaka-C grid. The horizontal and vertical components of velocity (**u**, **v** and **w**) are positioned along the faces of the grids and the thermodynamic variables (θ) are positioned in the center of each grid.
Author: Skamarock et al. (2008).

It is important to note that the WRF, without coupling with other models, simulates the surface roughness based on the ratio of roughness to wind shear proposed by Charnock (1955), as exemplified in the following equation 1.1:

$$Z_0 = Z_{ch}\frac{u_*^2}{g} \tag{1.1}$$

Where Z_0 é a roughness, Z_{ch} is the Charnock parameter (a dimensionless value of 0,018), u_* the frictional speed (m/s) and g the gravity acceleration(9,81 m/s^2).

The WRF is avaliable at: *http://www2.mmm.ucar.edu/wrf/users/download/get_source.html*

1.4 Simulating Waves Nearshore

The Simulating Waves Nearshore (SWAN; Booij et al., 1996, 1999) is a third generation model, designed to simulate coastal regions with shallow waters and local currents. The model is widely used in the numerical forecast of the Simulating Waves Nearshore (SWAN; Booij et al., 1996, 1999) is a third generation model, designed to compute in coastal regions with shallow waters and local currents. The model is widely used in the numerical forecast of waves in coastal regions, estuaries, channels and others, being able to use fields of wind, bathymetry and currents provided by other models (Booij et al., 1996, 1999).

Silva (2013) and Booij et al. (1996; Booij et al., 1999) list the main characteristics of the SWAN:

- Wave propagation in time and space, shoaling, refraction due to current and depth, frequency shifting due to currents and non-stationary depth;
- Wave generation by wind;
- Whitecapping, bottom friction and depth-induced breaking;
- Dissipation due to aquatic vegetation, turbulent flow and viscous fluid mud;
- Wave-induced set-up;
- Propagation from laboratory up to global scales;
- Transmission through and reflection (specular and diffuse) against obstacles;
- Diffraction.

More features can be found in SWAN website, avaliable at: *http://swanmodel.sourceforge.net/*.

1.5 Model Coupling Toolkit

The Model Coupling Toolkip (MCT; Jacob et al., 2005; Larson et al., 2005; Warner et al., 2008) is a set of open-source scripts, written in Fortran90 that allow the transmission and transformation of the different data necessary for model coupling. During initialization, model domains are broken down into segments that are distributed between processors, allowing models to be coupled also in parallel.

According to the MCT website, (*http://www.mcs.anl.gov/research/projects/mct/*), the toolkit provides the following core coupling services:

- A component model registry;
- Domain decomposition descriptors;
- A time averaging and accumulation buffer datatype;
- A general spatial grid representation capable of supporting unstructured grids;
- Parallel tools for intergrid interpolation;
- Tools for merging data from multiple components for use by another component;
- A programming model similar to that of the Message Passing Interface.

1.6 Spherical Coordinate Remapping Interpolation Package

O Spherical Coordinate Remapping Interpolation Package (SCRIP; Jones, 1998, 1999) is freely available for download at *https://github.com/SCRIP-Project/SCRIP*. The package is distributed together with COAWST modeling system. This package is used for projects that use more than one model and with different grids (with different spatial resolutions). SCRIP will generate the interpolation weights that will be used to remap the data between the different grids of the different models.

In COAWST, SCRIP was modified to generate a single file (in NetCDF format) that contains the weights based in each model grid.

1.7 Coupled-Ocean-Atmosphere-Wave-Sediment Transport Modeling System

The COAWST Warner et al., 2010, 2008) uses the WRF as the atmospheric model, the ROMS as the hydrodynamic model, the SWAN as the wave model and the sediment transport model Community Sediment Transport Modeling Project (CSTM; Warner et al., 2008), each one coupled by the MCT (Warner et al., 2010, 2008). The frequency with which this information is exchanged between the different models is adjusted by the user.

The coupling between the models allows the different physical processes that occur in both oceanic and atmospheric environments to be identified and analyzed with greater accuracy when compared to simulations without active coupling.(Miller et al., 2018; Pullen et al., 2018).

WARNING This guide does not use CSTM. In case you are interested, there is a study on the transfer of sediments during Hurricane Isabel (2003) by Warner et al. (2010).

As shown in Figure 1.3, the informations exchanged between models are:

- WRF -> ROMS: surface shear and liquid heat fluxes (calculated in ROMS from the components of latent and sensitive heat fluxes) shortwave and longwave radiation, atmospheric pressure, relative humidity, air temperature, clouds, precipitation and wind components ;
- ROMS -> WRF: sea surface temperature;
- SWAN -> ROMS: surface and bottom wave direction, height, length, period, energy dissipation and lower orbital speed;
- ROMS -> SWAN: bathymetry, surface elevation, height of the sea and average currents in depth;

- SWAN -> WRF: roughness of the sea surface (calculated in WRF from the significant wave height, length and period);
- WRF -> SWAN: wind at 10m.

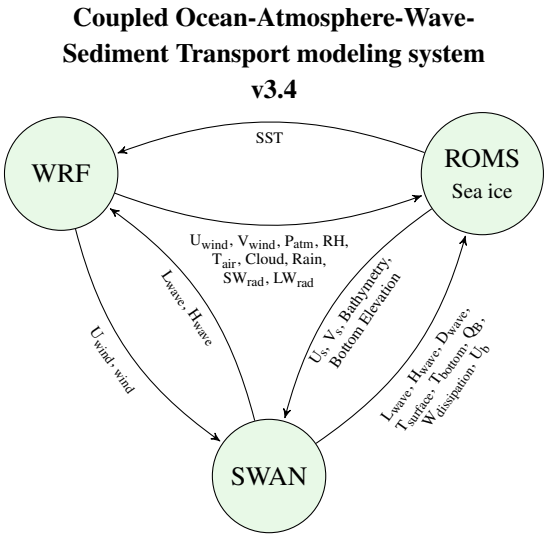

Figure 1.3. Diagram about the exchange of information between the main models that make up the COAWST modeling system. (Warner et al., 2008)

The Woods Hole Coastal and Marine Science Center page provides an experimental presentation on real time of COAWST (Sea Surface Temperature, Sea Surface Height, Significant Height Wave, Current and Wind Vectors and Sediment Dispersion) in the eastern United States and Gulf of Mexico. The content is available at: *https://woodshole.er.usgs.gov/project-pages/cccp/public/COAWST.htm*.

1.8 Materials needed to use this guide

To compile COAWST, this guide uses a cluster with parallel communication and a nonparallel Linux OS with Gfortran. If you choose to compile in on a computer with different specifications, use the original COAWST user manual as a reference, available in the modeling system repository. In this case, see how to download COAWST in the **??** section.

We will use Ubuntu 19.04 LTS. It is important to maintain the same systems operational, as other version may conflict with some libraries used by the *model2roms* toolkit or the COAWST itself.

WARNING This guide uses COAWST v. 3.6.

2. COAWST in a parallel cluster

2.1 About our cluster Kerana

The CRAY XE machine, also called Kerana, is a cluster with massively parallel architecture, with 84 processing nodes and 2688 cores and is located at CPTEC/INPE, in Cachoeira Paulista, São Paulo. For having the ability to parallelize operations through the MPI interface, the cluster is ideal for using numerical models with high spatial resolution and temporal.

> **WARNING** To compile COAWST on a computer without parallel communication, see chapter ??.

2.2 Signing up a user account

To start the process of applying for a user account in Kerana, it is necessary that the computer in the INPE's premises have a fixed IP. Your advisor or supervisor is required to send an email to *Helpdesk*(*helpdesk.cptec@inpe.br*) informing the MAC address, hostname and reason for the request. If the computer already has a fixed IP assigned, it also need to be informed to be changed.

With the fixed IP configured, contact the *Helpdesk*(*helpdesk.cptec@inpe.br*) to request a form to use Kerana.

2.3 Signing in to the Kerana cluster

Access will be done entirely through the computer terminal. You will need two primary commands: *ssh* for accessing and manipulating files and folders and *sftp* to download and upload files.

Para acessar e modificar arquivos e pastas, digite no terminal, substituindo *name.surname* pelo usuário fornecido pelo *Helpdesk*:

WARNING From now on, whenever the guide shows the user as *name.surname*, change to your username provided by the Helpdesk.

```
ssh -Y name.surname@acesso-hpc.cptec.inpe.br -p 2000
```

To do download and/or uploads, use:

```
sftp -P2000 name.surname@acesso-hpc.cptec.inpe.br
```

WARNING It is not possible to download and upload multiple files at the same time using *sftp*. One tip is to compress into a single *tar* file and then unzip them.

To add files from your computer to Kerana:

```
put file.tar.gz
```

To extract Kerana files to your computer:

```
get file.tar.gz
```

2.4 File repository

Certain files are needed in each user's area to facilitate the use of the cluster. You will find them in the directory:

```
/scratch/adriano.sutil/repositorio/
```

To copy the files to your area, type:

```
cp -r /scratch/adriano.sutil/repositorio /scratch/name.surname
```

WARNING From now on this guide will use the files that are inside this repository, so it is essential that they are in your area.

2.5 Kerana environment

It is necessary to activate some modules in the cluster to compile COAWST. In this case, open the file *.bashrc* which is located at the root directory of your user.

```
vim .bashrc
```

Add the following commands at the end of the file, changing only *name.surname* to your username:

```
module load java
module load netcdf

export PATH=/scratch/name.surname/repositorio/Softs/nedit/5.5:$PATH
export PATH=/scratch/name.surname/repositorio/Softs/bin:$PATH

export PHDF5=${HDF_DIR}
export WRFIO_NCD_LARGE_FILE_SUPPORT=1

export PATH=/home/luciano.pezzi/local/bin:$PATH
export JASPERINC=/home/luciano.pezzi/local/include
export JASPERLIB=/home/luciano.pezzi/local/lib
export LD_LIBRARY_PATH=/home/luciano.pezzi/local/lib:$LD_LIBRARY_PATH
```

Save and type in the terminal:

```
source .bashrc
```

2.6 Downloading COAWST

WARNING COAWST v3.6 is already in the repository within the Kerana cluster, as discussed in Section 2.4.

To download COAWST, send an email to Dr. John Warner (*jcwarner@usgs.gov*), one of the heads behind the coupled regional modeling.

After access is granted, with the user credentials and password provided by Dr. John Warner, type in the command the command below, changing the textit myusrname to your username.

```
svn checkout --username myusrname https://coawstmodel.sourcerepo.com/coawstmodel/COAWST
```

Add the COAWST folder to your Kerana desktop using *sftp*, as in the Section 2.3.

2.7 Automating the compilation of COAWST in Kerana

> **WARNING** This guide uses COAWST version 3..

To speed up the process, it is possible to automate some compilation steps. Enter the directory:

```
cd /scratch/name.surname/COAWST/WRF/arch
```

Open the file *Config.pl*:

```
nedit Config.pl
```

Look for the lines:

```
printf "\nEnter selection [%d-%d] : ",1,$opt ;
$response = <STDIN> ;
```

And replace <*STDIN*> to 42, as in the example below:

```
printf "\nEnter selection [%d-%d] : ",1,$opt ;
$response = 42 ;
```

Open the file *configure.defaults*:

```
nedit configure.defaults
```

Look for the *TRADEFLAG*, option, which is on line 1262, approximately:

```
TRADEFLAG = CONFIGURE_TRADEFLAG
```

And modify to:

```
TRADEFLAG = -traditional
```

These modifications will select the configurations of the Kerana cluster (*CRAY CCE (ftn/gcc): Cray XE and XC (dmpar)*), among those available to use COAWST, as in Figure 2.1.

```
  1. (serial)   2. (smpar)   3. (dmpar)   4. (dm+sm)   PGI (pgf90/gcc)
  5. (serial)   6. (smpar)   7. (dmpar)   8. (dm+sm)   PGI (pgf90/pgcc): SGI MPT
  9. (serial)  10. (smpar)  11. (dmpar)  12. (dm+sm)   PGI (pgf90/gcc): PGI accelerator
 13. (serial)  14. (smpar)  15. (dmpar)  16. (dm+sm)   INTEL (ifort/icc)
                                         17. (dm+sm)   INTEL (ifort/icc): Xeon Phi (MIC architecture)
 18. (serial)  19. (smpar)  20. (dmpar)  21. (dm+sm)   INTEL (ifort/icc): Xeon (SNB with AVX mods)
 22. (serial)  23. (smpar)  24. (dmpar)  25. (dm+sm)   INTEL (ifort/icc): SGI MPT
 26. (serial)  27. (smpar)  28. (dmpar)  29. (dm+sm)   INTEL (ifort/icc): IBM POE
 30. (serial)               31. (dmpar)                 PATHSCALE (pathf90/pathcc)
 32. (serial)  33. (smpar)  34. (dmpar)  35. (dm+sm)   GNU (gfortran/gcc)
 36. (serial)  37. (smpar)  38. (dmpar)  39. (dm+sm)   IBM (xlf90_r/cc_r)
 40. (serial)  41. (smpar)  42. (dmpar)  43. (dm+sm)   PGI (ftn/gcc): Cray XC CLE
 44. (serial)  45. (smpar)  46. (dmpar)  47. (dm+sm)   CRAY CCE (ftn/gcc): Cray XE and XC
 48. (serial)  49. (smpar)  50. (dmpar)  51. (dm+sm)   INTEL (ftn/icc): Cray XC
 52. (serial)  53. (smpar)  54. (dmpar)  55. (dm+sm)   PGI (pgf90/pgcc)
 56. (serial)  57. (smpar)  58. (dmpar)  59. (dm+sm)   PGI (pgf90/gcc): -f90=pgf90
 60. (serial)  61. (smpar)  62. (dmpar)  63. (dm+sm)   PGI (pgf90/pgcc): -f90=pgf90
```

Figure 2.1. Computational options available for selection when compiling COAWST.

Now, in the same file, look for the following lines:

```
printf "Compile for nesting? (1=basic, 2=preset moves, 3=vortex following) [default 1]: " ;
}
$response = <STDIN> ;
```

And change *<STDIN>* to the basic WRF atmospheric model nesting mode, as in the following example:

```
printf "Compile for nesting? (1=basic, 2=preset moves, 3=vortex following) [default 1]: " ;
}
$response = 1 ;
```

2.8 Compiling the MCT

WARNING This guide uses COAWST v 3.6.

Each new user must compile the MCT before compiling COAWST. The first step is to use the *setup_pgi.sh* file. This file was copied from the previous repository, it is essential to change the directories contained therein. So open the file:

```
nedit setup_pgi.sh
```

If necessary, change the directories according to the name of your COAWST folder and execute the file to load the necessary modules:

```
source setup_pgi.sh
```

The libraries will be activated, as shown in Figure 2.2:

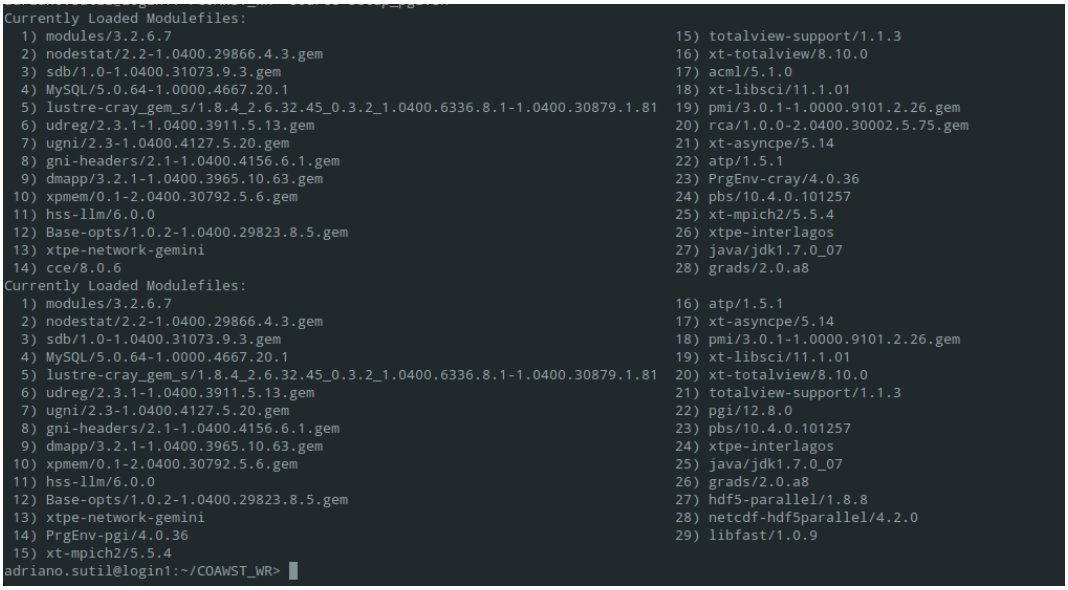

Figure 2.2. Modules activated in the cluster with the file *setup_pgi.sh* with user adriano.sutil.

Enter the MCT folder directory:

```
cd /home/name.surname/COAWST/Lib/MCT
```

Open the file *Makefile.conf*:

```
nedit Makefile.conf
```

And modify the file as follows:

WARNING Remember to change the *name.surname*!

```
FC              = ftn
FCFLAGS         = -O2
F90FLAGS        =
REAL8           = -r8
ENDIAN          = -Mbyteswapio
INCFLAG         = -I
INCPATH         =
MPILIBS         =
DEFS            = -DSYSLINUX -DCPRPGI
FPP             = cpp
FPPFLAGS        = -P -C -N -traditional
CC              = cc
ALLCFLAGS       = -DFORTRAN_UNDERSCORE_ -DSYSLINUX -DCPRPGI -O
COMPILER_ROOT   =
BABELROOT       =
PYTHON          =
PYTHONOPTS      =
FORT_SIZE       =
CRULE           = .c.o
90RULE          = .F90.o
F90RULECPP      = .F90RULECPP
INSTALL         = /home/name.surname/COAWST/Lib/MCT/install-sh -c
MKINSTALLDIRS   = /home/name.surname/COAWST/Lib/MCT/mkinstalldirs
abs_top_builddir= /home/name.surname/COAWST/Lib/MCT/
MCTPATH         = /home/name.surname/COAWST/Lib/MCT/mct
MPEUPATH        = /home/name.surname/COAWST/Lib/MCT/mpeu
EXAMPLEPATH     = /home/name.surname/COAWST/Lib/MCT/examples
MPISERPATH      =
libdir          = /home/name.surname/COAWST/Lib/MCT/pgi/lib
includedir      = /home/name.surname/COAWST/Lib/MCT/pgi/include
AR              = ar cq
RM              = rm -f
```

Install the MCT by typing the following commands:

```
make
make install
```

Observe the messages that appear in the terminal and look for errors. If not, the MCT was successfully compiled.

2.9 CCompiling the Sandy test case

There are some test cases within COAWST to be compiled and worked on. In this case we'll compile Hurricane Sandy's project, which couples and nests WRF, ROMS and SWAN. First, it is necessary to know

the structure of COAWST files and folders.

The typical COAWST directory structure is exemplified in Figure 2.3. Mainly, we will use the folders *Projects* e *Work* to work on.

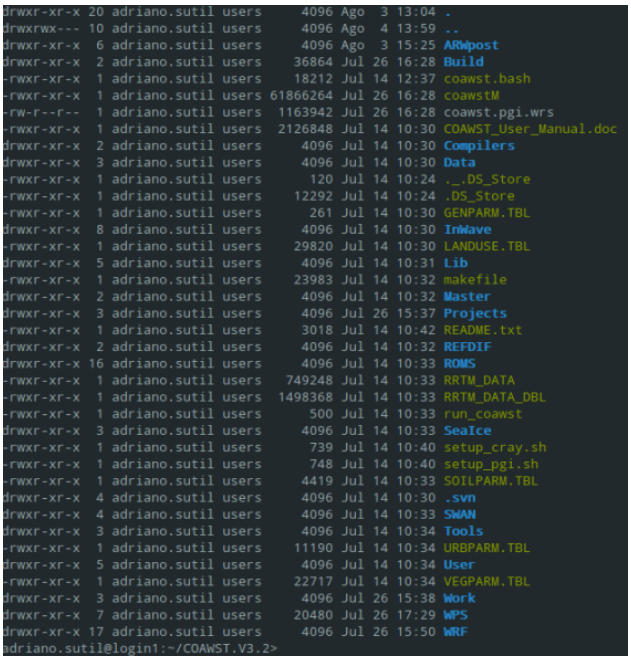

Figure 2.3. Representation of the main COAWST folder and subfolders.

2.9.1 Projects folder

To organize the projects, in the directory *COAWST/Projects/Sandy* are all the files used to simulate the Sandy case. The following files must be inside:

- Bound_spec_command
- coastline.mat
- coupling_sandy.in
- create_sandy_application.m
- hycom_info.mat
- ijcoast.mat
- multi_1.at_10m.dp.201210.grb2
- multi_1.at_10m.hs.201210.grb2
- multi_1.at_10m.tp.201210.grb2
- namelist.input
- ocean_sandy.in
- roms_master_climatology_sandy.m
- roms_narr_Oct2012.nc
- roms_narr_ref3_Oct2012.nc
- Rweigths.txt

- Sandy_bdy.nc
- Sandy_clm.nc
- Sandy_clm_ref3.nc
- sandy.h
- Sandy_ini.nc
- Sandy_ini_ref3.nc
- Sandy_init.hot
- Sandy_ref3_init.hot
- Sandy_roms_contact.nc
- Sandy_roms_grid.nc
- Sandy_roms_grid_ref3.nc
- Sandy_swan_bathy.bot
- Sandy_swan_bathy_ref3.bot
- Sandy_swan_coord.grd
- Sandy_swan_coord_ref3.grd
- scrip_sandy_moving.nc
- scrip_sandy_static.nc
- specpts.mat
- swan_narr_Oct2012.dat
- swan_narr_ref3_Oct2012.dat
- swan_sandy.in
- swan_sandy_ref3.in
- tide_forc_Sandy.nc
- TPAR10.txt
- TPAR11.txt
- TPAR12.txt
- TPAR13.txt
- TPAR14.txt
- TPAR15.txt
- TPAR16.txt
- TPAR17.txt
- TPAR18.txt
- TPAR1.txt
- TPAR2.txt
- TPAR3.txt
- TPAR4.txt
- TPAR5.txt
- TPAR6.txt
- TPAR7.txt
- TPAR8.txt
- TPAR9.txt
- USeast_bathy.mat
- Uweigths.txt
- Vweigths.txt
- wrfbdy_d01
- wrfinput_d01
- wrfinput_d02
- wrflowinp_d01

- wrflowinp_d02

2.9.2 Work folder

To make the management of simulations easier, it is suggested, for each new user, the creation of the *Work* folder in main COAWST directory, with each project inserted separately within it. It is in this folder that will be simulated the test case.

```
cd /scratch/name.surname/COAWST
mkdir Work
cd Work
mkdir Sandy
```

The folder */scratch/name.surname/COAWST/Work/Sandy* must contain the following files

- run_sandy.sh
- limpa.sh
- link.sh

The file *run_sandy.sh* will be used to start the simulation, *link.sh* creates symbolic links in the folder *Work*, that will be used by the models, and *limpa.sh* is used to clear the folder if an error occurs and a new integration needs to be started. The files are inside the folder */repositorio/work_coawst*.

Therefore:

```
cd /scratch/name.surname/repositorio/work_coawst
cp limpa.sh link.sh run_sandy.sh /scratch/name.surname/COAWST/Work/Sandy
```

Go to the directory */scratch/name.surname/COAWST/Work/Sandy* and open the file*run_sandy.sh*:

```
cd /scratch/name.surname/COAWST/Work/Sandy
nedit run_sandy.sh
```

Search for the following commands and modify the directories according to your username:

```
PBS -o /scratch/name.surname/COAWST/Work/Sandy/rws_total.out
ROOTDIR=/scratch/name.surname/COAWST
```

2.9.3 Compiling the test case

Go to the Sandy project folde:

```
/home/name.surname/COAWST/Projects/Sandy
```

Open the following files to make changes to the next steps:

- coupling_sandy.in
- swan_sandy.in
- swan_sandy_ref3.in
- ocean_sandy.in

```
nedit coupling_sandy.in swan_sandy.in swan_sandy_ref3.in ocean_sandy.in
```

Look for the command line below in the file *coupling_sandy.in*:

```
OCN_name = Projects/Sandy/ocean_sandy.in
```

And replace with:

```
OCN_name = /scratch/name.surname/COAWST/Projects/Sandy/ocean_sandy.in
```

In the files*swan_sandy.in* and *swan_sandy_ref3.in* complete all directory paths below:

Modify:

```
READGRID COORDINATES 1 'Projects/Sandy/Sandy_swan_coord.grd' 4 0 0 FREE
READINP BOTTOM 1 'Projects/Sandy/Sandy_swan_bathy.bot' 4 0 FREE
&READINP WIND 1 'Projects/Sandy/swan_namnarr_30Sep10Nov2012.dat' 4 0 FREE
INITIAL HOTSTART SINGLE 'Projects/Sandy/Sandy_init.hot'
```

By:

```
READGRID COORDINATES 1 '/scratch/name.surname/COAWST/Projects/Sandy/Sandy_swan_coord.grd' 4 0 0 FREE
READINP BOTTOM 1 '/scratch/name.surname/COAWST/Projects/Sandy/Sandy_swan_bathy.bot' 4 0 FREE
&READINP WIND 1 '/scratch/name.surname/COAWST/Projects/Sandy/swan_namnarr_30Sep10Nov2012.dat' 4 0 FREE
INITIAL HOTSTART SINGLE '/scratch/name.surname/COAWST/Projects/Sandy/Sandy_init.hot'
```

In the file *ocean_sandy.in* look for the command lines like below:

```
MyAppCPP = SANDY
VARNAME  = ROMS/External/varinfo.dat
GRDNAME == Projects/Sandy/Sandy_roms_grid.nc \
           Projects/Sandy/Sandy_roms_grid_ref3.nc
ININAME == Projects/Sandy/Sandy_ini.nc \
           Projects/Sandy/Sandy_ini_ref3.nc
NGCNAME =  Projects/Sandy/Sandy_roms_contact.nc
BRYNAME == Projects/Sandy/Sandy_bdy.nc
FRCNAME == Projects/Sandy/roms_narr_Oct2012.nc \
           Projects/Sandy/roms_narr_ref3_Oct2012.nc
```

And replace with:

```
MyAppCPP = Sandy
VARNAME  = /scratch/name.surname/COAWST/ROMS/External/varinfo.dat
GRDNAME == /scratch/name.surname/COAWST/Projects/Sandy/Sandy_roms_grid.nc \
           /scratch/name.surname/COAWST/Projects/Sandy/Sandy_roms_grid_ref3.nc
ININAME == /scratch/name.surname/COAWST/Projects/Sandy/Sandy_ini.nc \
           /scratch/name.surname/COAWST/Projects/Sandy/Sandy_ini_ref3.nc
NGCNAME =  /scratch/name.surname/COAWST/Projects/Sandy/Sandy_roms_contact.nc
BRYNAME == /scratch/name.surname/COAWST/Projects/Sandy/Sandy_bdy.nc
FRCNAME == /scratch/name.surname/COAWST/Projects/Sandy/roms_narr_Oct2012.nc \
           /scratch/name.surname/COAWST/Projects/Sandy/roms_narr_ref3_Oct2012.nc
```

Go back to the main COAWST folder and open the file *coawst.bash*:

```
cd /scratch/name.surname/COAWST
nedit coawst.bash
```

Search for the following commands and modify, if necessary:

```
export   COAWST_APPLICATION=JOE_TC
export   MY_ROOT_DIR=${HOME}/COAWST
export   MY_HEADER_DIR=${MY_PROJECT_DIR}/Projects/JOE_TC
```

By:

```
export   COAWST_APPLICATION=Sandy
export   MY_ROOT_DIR=${HOME}/COAWST
export   MY_HEADER_DIR=${MY_PROJECT_DIR}/Projects/Sandy
```

Activate the modules again into the file *setup_pgi.sh*, and then compile the project with the command:

```
./coawst.bash -j 4  1> coawst.pgi.sandy 2>&1 &
```

This command will create the text file *coawst.pgi.sandy* where you can follow the progress of the compilation. Open the text file with the following command and look for the final message, as in Figure 2.4.

```
nedit coawst.pgi.sandy
```

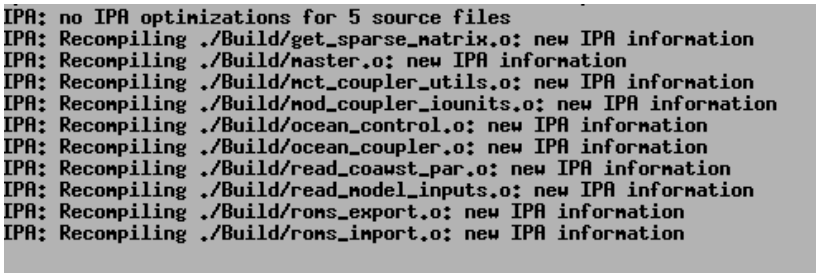

Figure 2.4. Final message after compiling COAWST.

If you want to follow the progress of the compilation through the terminal, use the command:

```
tail -f coawst.pgi.sandy
```

WARNING The compilation process is long!

Ready! In the main COAWST directory, a file called *coawstM* will be created. In this file all the information about your project will be compiled. Now with COAWST compiled, we will start the test case.

2.10 Simulating the Sandy Test Case

To simulate the case, search for the file in *Work/Sandy*. Type it:

```
cd /scratch/name.surname/COAWST/Work/Sandy
nedit run_sandy.sh
```

WARNING The *Work* folder should contain the files *clean.sh*, *link.sh* and *run_sandy.sh*. They can be found in the folder used as a repository. See Section 2.9.2.

When opening the file, check if the directories are in accordance with your username and type the command below to start the integration.

```
qsub run_sandy.sh
```

WARNING The command *qsub* will submit you job. It will send the executed script to a batch of the cluster, reserving a part of the processors for its simulation.

The process will generate two files to follow the evolution of the simulation: *log.out* and *log.err*. To open, use:

```
nedit log.out log.err
```

Or look directly at the terminal with the command:

```
tail -f log.out
```

The outputs of the simulations will be stored in the *Work/Sandy* folder. If an error occurs, clean the desktop with the command:

```
./limpa.sh
```

WARNING The simulation of the test case Sandy may take several hours when integrating using 3 processors.

Bibliography

Arakawa, A. & V. R. Lamb (1977). "Computational design of the basic dynamical processes of the UCLA general circulation model". In: *Methods in Computational Physics* 17, pp. 173–265. DOI: 10.1016/B978-0-12-460817-7.50009-4.

Booij, N., L. H. Holthuijsen & R. C. Ris (1996). "The SWAN Wave Model for Shallow Water". In: *Coastal Engineering Proceedings* 25, pp. 668–675. DOI: 10.9753/icce.v25.%25p.

Booij, N., R. C. Ris & L. H. Holthuijsen (1999). "A third-generation wave model for coastal regions: 1. Model description and validation". In: *Journal of Geophysical Research: Oceans* 104.C4, pp. 7649–7666. DOI: 10.1029/98JC02622. URL: http://dx.doi.org/10.1029/98JC02622.

Budgell, W. P. (2005). "Numerical simulation of ice-ocean variability in the Barents Sea region". In: *Ocean Dynamics* 55, pp. 370–387. DOI: 10.1007/s10236-005-0008-3.

Charnock, H. (1955). "Wind stress on a water surface". In: *Quarterly Journal of the Royal Meteorology Society* 81.350, pp. 639–640. DOI: 10.1002/qj.49708135027.

Haidvogel, D. B., H. G. Arango, W. P. Budgell, B. D. Cornuelle, E. Curchitser, E. Lorenzo, K Fennel, W. R. Geyer, A. J. Hermann, L. Lanerolle, J. Levin, J. C. McWilliams, A. J. Miller, A. M. Moore, T. M. Powell, A. F. Shchepetkin, C. R. Sherwood, R. P. Signell, J. C. Warner & J. Wilkin (2008). "Ocean forecasting in terrain-following coordinates: Formulation and skill assessment of the Regional Ocean Modeling System." In: *J. Comput. Physics* 227.7, pp. 3595–3624. DOI: 10.1016/j.jcp.2007.06.016.

Hedström, K. S. (2018). "Technical Manual for a Coupled Sea-Ice/Ocean Circulation Model (Version 5)". In: *OCS Study BOEM 2016-037*. URL: https://www.boem.gov/uploadedFiles/BOEM/BOEM_Newsroom/Library/Publications/BOEM_2016-037.pdf.

Hunke, E. C. (2001). "Viscous-plastic sea ice dynamics with the evp model: linearization issues". In: *Journal of Computacional Physics* 170, pp. 18–38.

Hunke, E. C. & J. K. Dukowicz (1997). "An elastic-viscous-plastic model for sea ice dynamics". In: *Journal of Physical Oceanography* 27, pp. 1849–1868.

Jacob, R. L., J. W. Larson & E. T. Ong (2005). "M x N Communication and Parallel Interpolation in Community Climate System Model Version 3 Using the Model Coupling Toolkit." In: *IJHPCA* 19.3, pp. 293–307. DOI: 10.1177/1094342005056116.

Jones, P. W. (1998). *A User's Guide for SCRIP: A Spherical Coordinate Remapping and Interpolation Package version 1.5*. Los Alamos, NM. URL: http://oceans11.lanl.gov/svn/SCRIP/trunk/SCRIP/doc/SCRIPusers.pdf.

— (1999). "First and Second Order Conservative Remapping Schemes for Grids in Spherical Coordinates". In: *Monthly Weather Review* 127, pp. 2204–2210. DOI: 10.1175/1520-0493(1999)127<2204:FASOCR>2.0.CO;2.

Larson, J. W., R. L. Jacob & E. T. Ong (2005). "The Model Coupling Toolkit: A New Fortran90 Toolkit for Building Multiphysics Parallel Coupled Models." In: *IJHPCA* 19.3, pp. 277–292. DOI: 10.1177/1094342005056115. URL: http://dblp.uni-trier.de/db/journals/ijhpca/ijhpca19.html#LarsonJO05.

Lemieux, J. -F., B. Tremblay, F. Dupont, M. Plante, G. C. Smith & D. Dumont (2015). "A basal stress parameterization for modeling landfast ice". In: *Journal of Geophysical Research* 120, pp. 3157–3179. DOI: 10.1002/2014JC010678.

Mellor, G. L. & L. Kanta (1989). "Journal of Geophysical Research". In: *An ice-ocean coupled model* 94.10, pp. 937–954.

Miller, A. J., M. Collins, G. Silvio, T. G. Jensen, V. Misra, L. P. Pezzi, D. W. Pierce, D. Putrasahan, H. Seo & Y.-H. Tseng (2018). "Coupled ocean-atmosphere modeling and predictions". In: *Journal of Marine Research* 42.3, pp. 361–402. DOI: 10.1357/002224017821836770.

Pullen, J., R. Allard, H. Seo, A. J. Miller, S. Chen, L. P. Pezzi, T. Smith, P. Chu, J. Alves & R. Caldera (2018). "Coupled ocean-atmosphere forecasting at short and medium time scales". In: *Journal of Marine Science* 17, p. 1.

Shchepetkin, A. F. & J. C. McWilliams (2005). "The regional oceanic modeling system (ROMS): a split-explicit, free-surface, topography-following-coordinate oceanic model". In: *Ocean Modelling* 9, pp. 347–404. DOI: 10.1016/j.ocemod.2004.08.002.

Silva, P. E. D. (2013). "Caracterização do padrão de ondas na costa do Brasil por meio de modelagem numérica". Dissertação de Mestrado. São José dos Campos, SP: Meteorologia, Instituto Nacional de Pesquisas Espaciais.

Skamarock, W. C., J. B. Klemp, J. Dudhia, D. O. Gill, D. M. Barker, M. G. Duda, X.-Y. Huang, W. Wang & J. G. Powers (2008). "A Description of the Advanced Research WRF Version 3." In: NCAR TN-475+STR.

Smolarkiewicz, P. K. & W. W. Grabowski (1990). "The multidimensional positive definite advection transport algorithm: non-oscillatory option". In: *Journal of Comp. Phys.* 86, pp. 355–375.

Warner, J. C., B. Armstrong, R. He & J. B. Zambon (2010). "Development of a Coupled Ocean–Atmosphere–Wave–Sediment Transport (COAWST) Modeling System". In: *Ocean Modelling* 35.3, pp. 230–244. DOI: 10.1016/j.ocemod.2010.07.010.

Warner, J. C., C. R. Sherwood, R. P. Signell, C. K. Harris & H. G. Arango (2008). "Development of a three-dimensional, regional, coupled wave, current, and sediment-transport model." In: *Computers & Geosciences* 34.10, pp. 1284–1306. DOI: 10.1016/j.cageo.2008.02.012.