Tutorial 01 LiveCROCO: Basic Use

1 Purpose

In this tutorial we will review the basic instructions for using the LiveCROCO virtual machine, based on Sepúlveda et al. (2011), which will allow you to to have a work environment with CROCO and CROCO_TOOLS in your PC.

2 VirtualBox

Virtual machines are autonomous work environments that you can install in your PC, which do not require a hard drive partition. First you need a software that you can run virtual machines. In this case we will use the software **VirtualBox**, where we will install a Linux virtual machine and many of the necessary software to run CROCO. We will name this virtual machine **LiveCROCO**.

Make sure you have enough RAM, 4GB or more, and hard disk space, more than 100GB free to use.

Note that the screen information you see here may be different, depending on your operating system.

2.1 VirtualBox installation

Install **VirtualBox** from this web page

```
1 https://www.virtualbox.org/
```

Figure 1: VirtualBox web site

and install in your PC.

2.2 LiveCROCO installation

Download the this file.

```
1 http://mosa.dgeo.udec.cl/LiveCROCO/LiveCROCO_v1.3.0a.ova
```

Attention that it is a 16GB file!

To verify that the file was completely downloaded in Linux we use the command **md5sum**

```
1 md5sum LiveCROCO_v1.3.0a.ova
```

you should get

```
c39691f82b9b1e7df4489490d5fdf0a0  LiveCROCO_v1.3.0a.ova
```

while in the Windows command prompt you can do

```
certutil -hashfile LiveCROCO_v1.3.0a.ova MD5
```

Open the **VirtualBox** software and select the **File** tab. Select the **Import virtualized service...** option (Fig. 2)

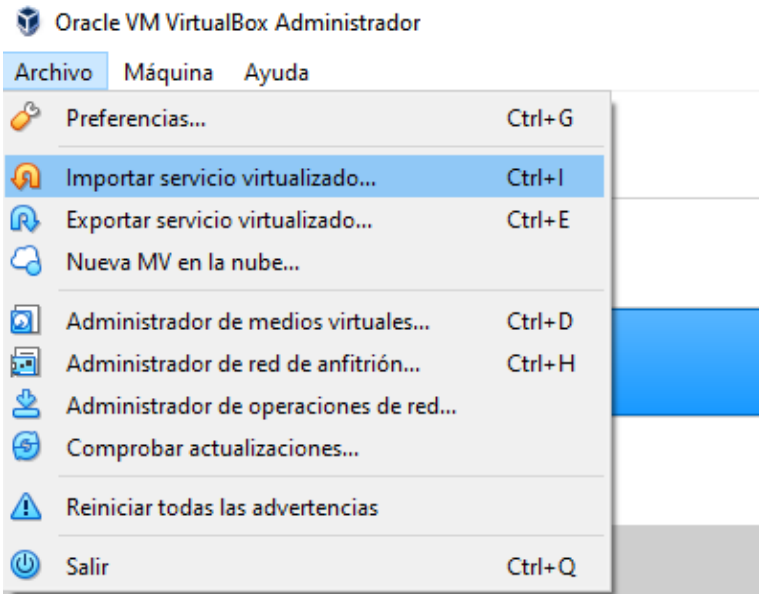

Figure 2: Importing virtualized service

Then find the .ova file you just downloaded (Fig. 3)

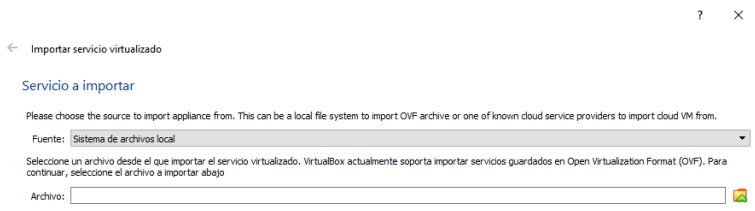

Figure 3: Find virtualized service

and select it (Fig. 4).

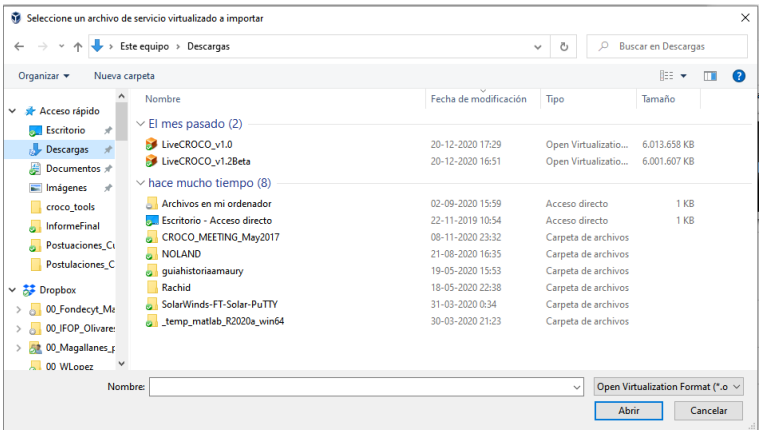

Figure 4: Select virtualized service

Press **Next** button (Fig. 5)

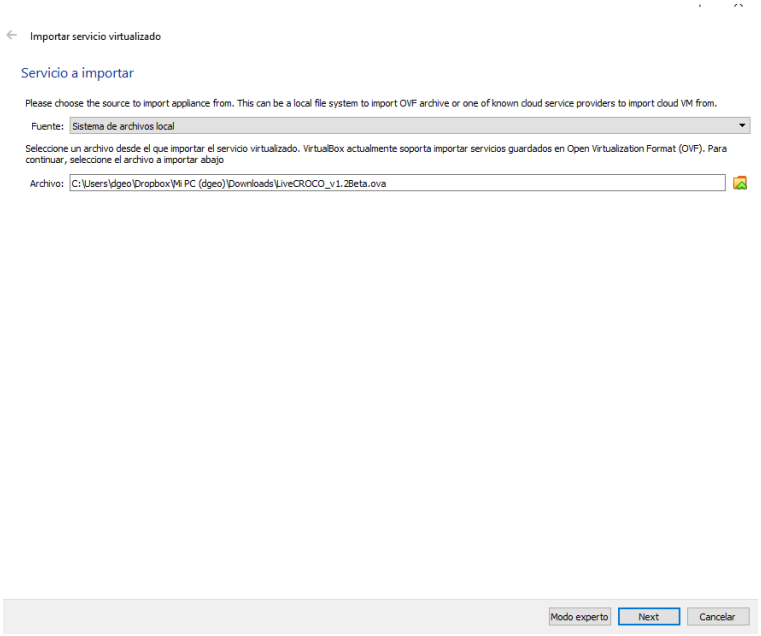

Figure 5: Upload the file

and then **Import** (Fig. 6).

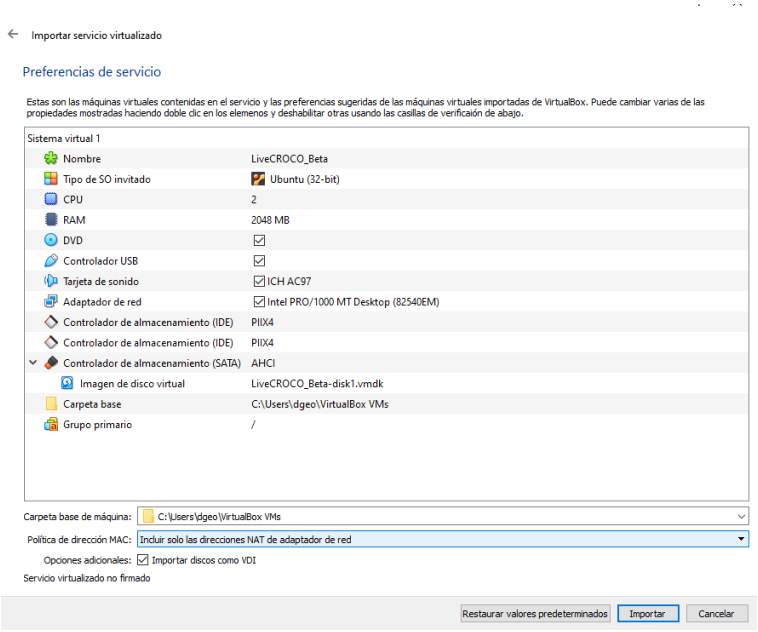

Figure 6: Starting the installation

This start the installation process (Fig. 7).

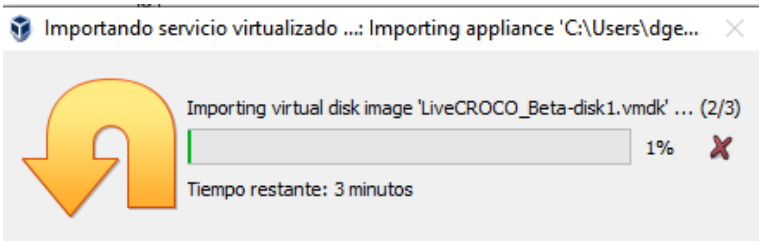

Figure 7: Virtualized service installation bar

When the installation is finished, you will see a screen similar to this, showing the virtual machine you just imported among your options (Fig. 8).

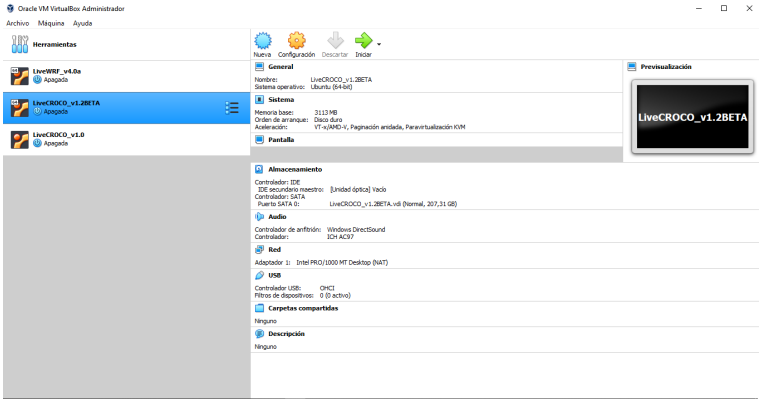

Figure 8: Virtual machines available

Select **LiveCROCO_v1.2.1b** option and press the start button (green arrow). That will activate the virtual machine and after a while you can see this Fig. 9

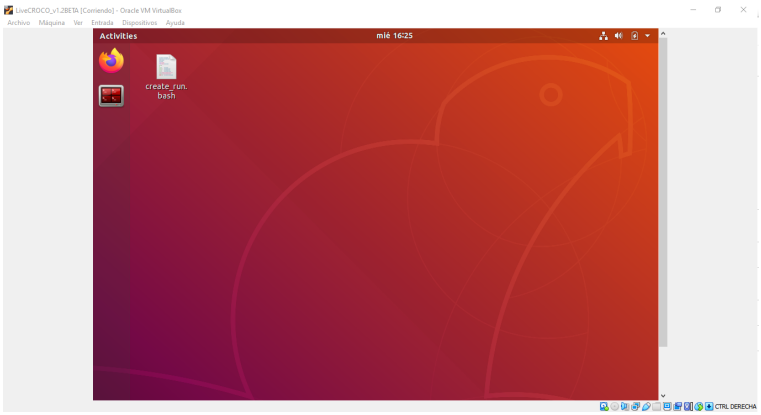

Figure 9: LiveCROCO home screen

The username and password is *livecroco*. Whit this user you can use *sudo*.

3 Using LiveCROCO

3.1 Creating the working directory Run_BENGUELA_LR

The simplest example of CROCO is the configuration called BENGUELA_LR which corresponds to a low resolution Benguela Upwelling domain. This is the default configuration in CROCO code and what we will do is similar to what is described in Penven et al. (2001)

First step is open the terminal clicking in red icon on the left, under the Firefox symbol, and in the terminal type

```
cd Desktop
```

then

```
./create_config.bash
```

showing

```
Your choices :
 - CROCO_DIR        : /home/livecroco/croco
 - TOOLS_DIR        : /home/livecroco/croco_tools
 - CONFIG_HOME_DIR  : /home/livecroco/Desktop
 - CONFIG_WORK_DIR  : /home/livecroco/Desktop
 - CONFIG_NAME      : Run
 - OPTIONS          : oe-dev
 Do you want to proceed ? [Y/n]

```

and pressing the Y key shows

```
 Creating configuration ...

```

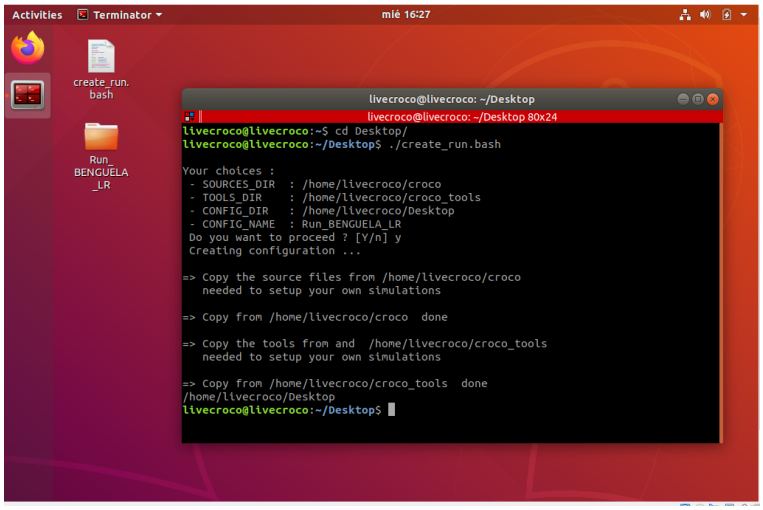

Figure 10: Creating a configuration in LiveCROCO

This script makes a directory with the name given in CONFIG_NAME with all codes necessary to run your simulation, this will be your working directory. The content of this folder should be similar to the following:

```
cppdefs.h              domain_def.xml          namelist_pisces_ref       SCRATCH
create_config.bash.BCK  field_def.xml_full      namelist_pisces_ref.1     sediment.in
CROCO_FILES            iodef.xml               oct_start.m               start.m
croco.in               jobcomp                 param.h                   TEST_CASES
croco.in.1             Misc                    README_XIOS               xios_launch.file
croco_inter.in         NAMELIST_OANALYSIS      run_croco.bash
crocotools_param.m     namelist_pisces_cfg     run_croco_forecast.bash
DATA                   namelist_pisces_cfg.1   run_croco_inter.bash
```

4 Compiling CROCO

First the CROCO executable is compiled using the following instructions

```
cd Run
./jobcomp
```

and the code compilation start with the following lines on the screes

```
OPERATING SYSTEM IS: Linux
cp: -r not specified; omitting directory '/home/livecroco/croco/OCEAN/../PISCES/SED'
  file namelist_pisces exists in Run directory
Checking COMPILEAGRIF...
Checking COMPILEMPI...
Checking COMPILEXIOS...
Checking COMPILEOASIS...
Checking COMPILEOMP...
cpp -traditional -DLinux -P -I/usr/include
-ICROCOFILES/AGRIF_INC mpc.F > mpc_.f
gfortran -O3 -fdefault-real-8 -fdefault-double-8  -o mpc mpc_.f
cpp -traditional -DLinux -P -I/usr/include
-ICROCOFILES/AGRIF_INC cppcheck.F | ./mpc > cppcheck_.f
gfortran -c -O3 -fdefault-real-8 -fdefault-double-8 cppcheck_.f
-o cppcheck.o
gfortran -O3 -fdefault-real-8 -fdefault-double-8  -o cppcheck
cppcheck.o
cat cppdefs.h cppdefs_dev.h > mergcpp.txt
```

You have to wait a couple of minutes for the **gfortran** compiler to generate the executable file. When the build finishes successfully, you will see the following lines on your screen

```
_rho.o def_floats.o init_arrays_floats.o random_walk.o
get_initial_floats.o init_sta.o wrt_sta.o step_sta.o
interp_sta.o def_sta.o init_arrays_sta.o biology.o o2sato.o
sediment.o bbl.o MPI_Setup.o MessPass2D.o MessPass3D.o
exchange.o autotiling.o zoom.o update2D.o set_nudgcof_fine.o
zoombc_2D.o zoombc_3D.o uv3dpremix.o t3dpremix.o update3D.o
zoombc_3Dfast.o Agrif2Model.o send_xios_diags.o
cpl_prism_define.o cpl_prism_put.o cpl_prism_init.o
cpl_prism_get.o cpl_prism_getvar.o cpl_prism_grid.o -L/usr/lib
-lnetcdff -Wl,-Bsymbolic-functions -Wl,-z,relro -Wl,-z,now
-lnetcdf -lnetcdf
mv a.out croco
```

On the last line you see how the compiled file **a.out** (default name) is renamed **croco**. That is the executable we will use.

5 Creating the input files

To create the input files to be read by the **croco** executable we will use a catalog of functions called **CROCO_TOOLS**. These functions were written in Matlab (Penven et al., 2008) and have been adapted to work in Octave, using the OCTCDF package.

5.1 Using Octave

To create the input files using Octave we start with

```
octave-cli
```

First define the search paths of the tools used by CROCO_TOOLS

```
oct_start
```

showing

```
>> oct_start
Add the paths of the different toolboxes
```

Then we write the instruction to generate the model grid, which is described in the file **croco_grd.nc** that will be generated in the **CROCO_FILES** directory

```
>> make_grid
mkdir: cannot create directory ‘/home/livecroco/Desktop/Run/CROCO_FILES/’:
File exists

 Making the grid: /home/livecroco/Desktop/Run/CROCO_FILES/croco_grd.nc

 Title: Benguela 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...
   CROCO 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 ...

 Filter topography ...
 Apply a filter on the Deep Ocean to reduce isolated seamounts :
   4 pass of a selective filter.
 Apply a selective filter on log(h) to reduce grad(h)/h :
   20 iterations - r_max = 0.27931
   29 iterations - r_max = 0.24975
 Smooth the topography a last time to prevent 2DX noise:
   2 pass of a hanning smoother.

 Write it down...
```

and we will get Fig. 11

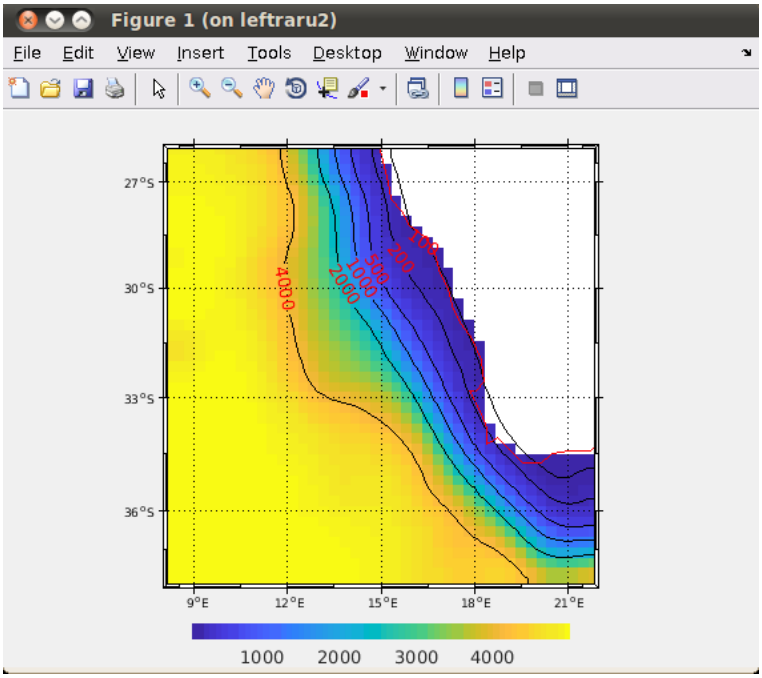

Figure 11: Final map of the Benguela domain

The next instruction is **make_forcing** which generates the file **croco_frc.nc** with the atmospheric forcing information.

```
>> make_forcing
mkdir: cannot create directory ‘/home/livecroco/Desktop/Run/CROCO_FILES/’:
File exists

Benguela Model

 Read in the grid...

 Create the forcing file...
Getting taux for time index 1
Getting tauy for time index 1
Getting taux for time index 2
Getting tauy for time index 2
Getting taux for time index 3
Getting tauy for time index 3
Getting taux for time index 4
....
Getting shortrad for time index 7
Getting shortrad for time index 8
Getting shortrad for time index 9
Getting shortrad for time index 10
Getting shortrad for time index 11
Getting shortrad for time index 12
>>
```

showing 7 figures, Figs 12-15.

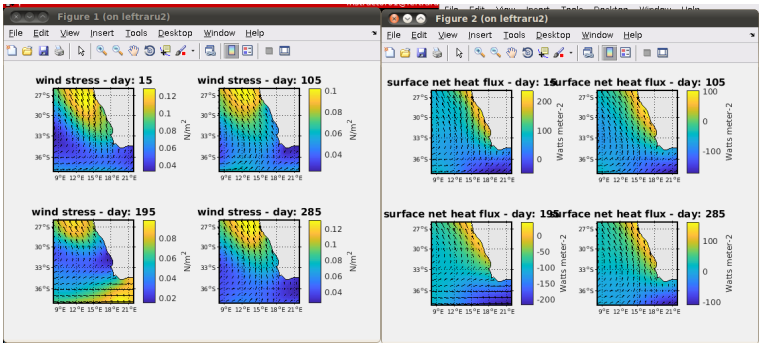

Figure 12: Atmospheric forcing variables: surface wind stress and net surface heat flux

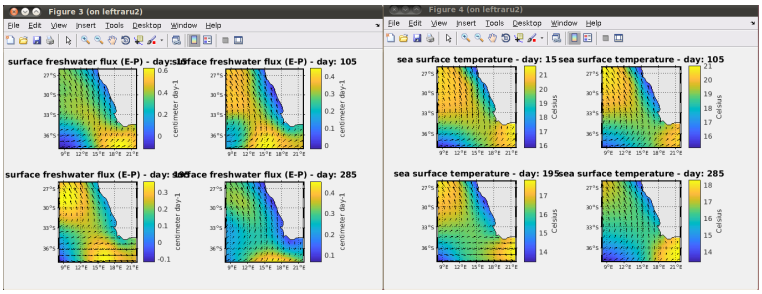

Figure 13: Atmospheric forcing variables: fresh water surface balance (E-P) and sea surface temperature

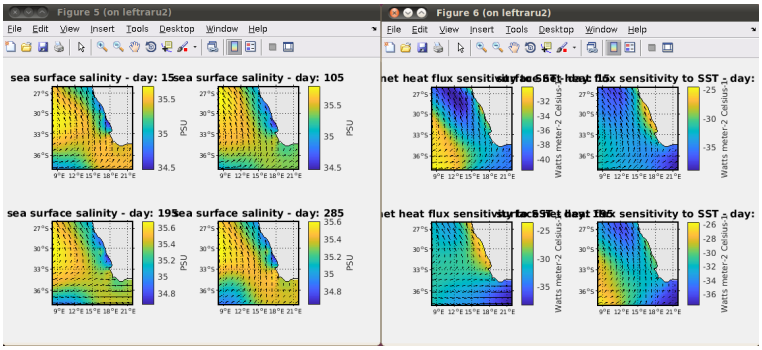

Figure 14: Atmospheric forcing variables: sea surface salinity and sea surface temperature sensitivity of latent heat flux

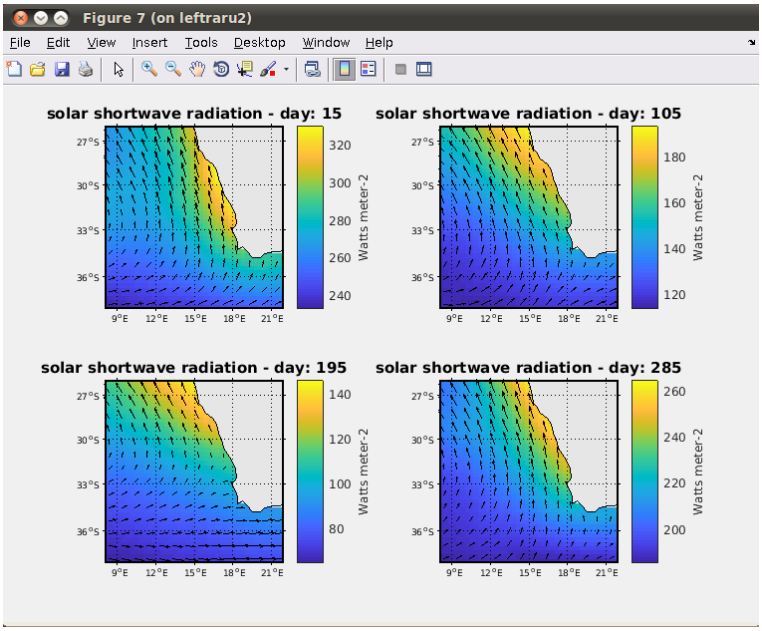

Figure 15: Atmospheric forcing variables: shortwave solar radiation.

Now we do **make_bry**to create the file **croco_bry.nc** with the ocean boundary condition

```
make_bry
>>mkdir: cannot create directory ‘/home/livecroco/Desktop/Run/CROCO_FILES/’:
File exists

ans =  1
temp_month_data = /home/livecroco/DataSets/WOA2009/temp_month.cdf
temp_ann_data = /home/livecroco/DataSets/WOA2009/temp_ann.cdf
salt_month_data = /home/livecroco/DataSets/WOA2009/salt_month.cdf
salt_ann_data = /home/livecroco/DataSets/WOA2009/salt_ann.cdf

 Making the file: /home/livecroco/Desktop/Run/CROCO_FILES/croco_bry.nc

```

showing 8 figures, similar to Fig. **??**.

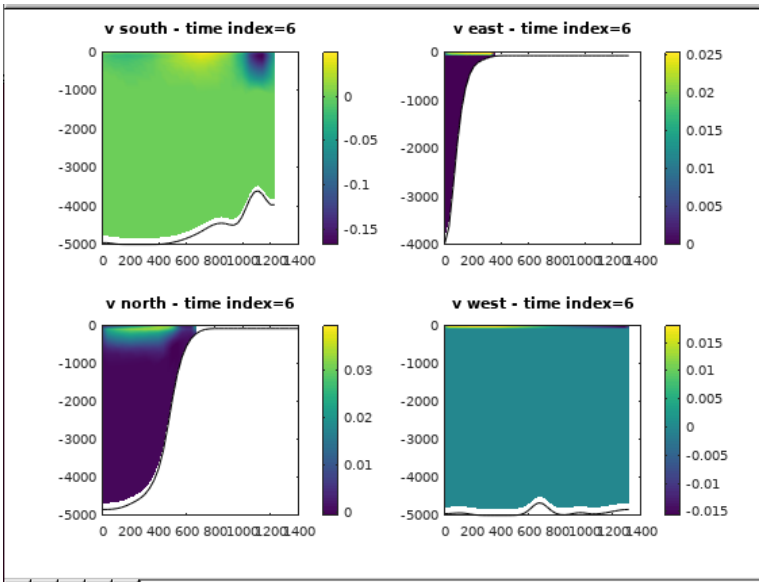

Figure 16: Oceanic lateral forcing variables: vertical sections of v velocity at t = 6.

Finally we use the command that creates the initial conditions file **croco_ini.nc**, which is **make_ini**.

```
octave:3> make_ini
mkdir: cannot create directory ‘/home/livecroco/Desktop/Run/CROCO_FILES/’: File exists
ans =  1

 Making initial file: /home/livecroco/Desktop/Run/CROCO_FILES/croco_ini.nc

 Title: Climatology

 Creating the file : /home/livecroco/Desktop/Run/CROCO_FILES/croco_ini.nc
 VTRANSFORM = 2

 Interpolations / extrapolations
```

and produces plots like Fig. 17.

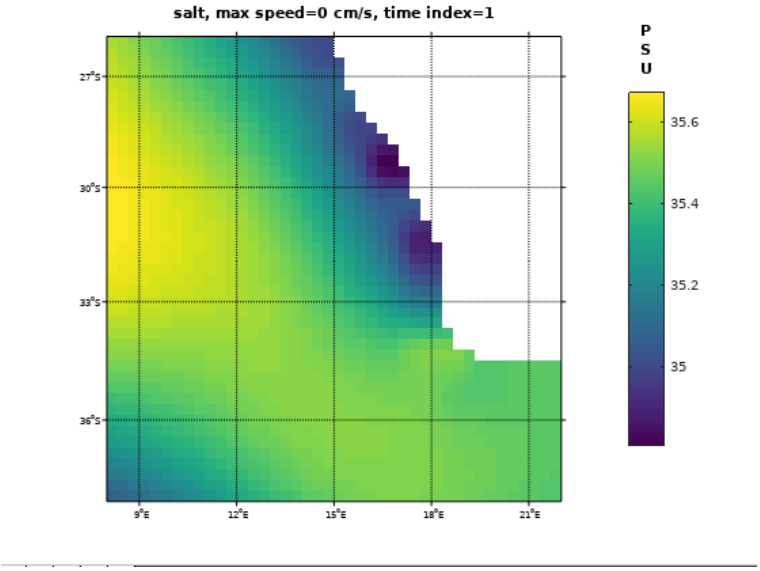

Figure 17: Oceanic surface salinity at t = 1.

```
croco_bry.nc croco_frc.nc croco_grd.nc croco_ini.nc
```

The files you get should be the same as those found in

```
http://mosa.dgeo.udec.cl/LiveCROCO/Tutorial01/ArchivosIniciales/
```

if you had problems with this step, copy those files to the **CROCO_FILES** directory to proceed to the next section using the instructions

```
cd CROCO_FILES
wget http://mosa.dgeo.udec.cl/LiveCROCO/Tutorial01/ArchivosIniciales/croco_grd.nc
wget http://mosa.dgeo.udec.cl/LiveCROCO/Tutorial01/ArchivosIniciales/croco_frc.nc
wget http://mosa.dgeo.udec.cl/LiveCROCO/Tutorial01/ArchivosIniciales/croco_bry.nc
wget http://mosa.dgeo.udec.cl/LiveCROCO/Tutorial01/ArchivosIniciales/croco_ini.nc
```

6 Running climatological simulation

To run simulation you have to write, from working directory **Run**

```
./run_croco.bash
```

and you will get

```
Getting croco from /home/livecroco/Desktop/Run
Getting croco_bry.nc from /home/livecroco/Desktop/Run/CROCO_FILES
/bin/cp: cannot stat '/home/livecroco/Desktop/Run/CROCO_FILES/croco_bry.nc':
No such file or directory
Getting croco_grd.nc from /home/livecroco/Desktop/Run/CROCO_FILES
Getting croco_frc.nc from /home/livecroco/Desktop/Run/CROCO_FILES
Getting croco_blk.nc from /home/livecroco/Desktop/Run/CROCO_FILES
/bin/cp: cannot stat '/home/livecroco/Desktop/Run/CROCO_FILES/croco_blk.nc':
No such file or directory
Getting croco_clm.nc from /home/livecroco/Desktop/Run/CROCO_FILES
Getting croco_runoff.nc from /home/livecroco/Desktop/Run/CROCO_FILES
/bin/cp: cannot stat '/home/livecroco/Desktop/Run/CROCO_FILES/croco_runoff.nc':
No such file or directory
Getting croco_ini.nc from /home/livecroco/Desktop/Run/CROCO_FILES
Getting croco_inter.in from /home/livecroco/Desktop/Run

Writing in croco_inter.in
USING DT       = 3600
USING NFAST    = 60
USING NUMTIMES = 720
USING NUMAVG   = 72
USING NUMHIS   = 720
USING NUMRST   = 720

Computing for Y1M1
mié ene  6 23:45:40 -03 2021
```

7 Output files

Once simulation finishes successfully, we will find the output files in **CROCO_FILES** directory.

8 Results display

8.1 ncdump

The **ncdump** tool is very useful for displaying contents of NetCDF file. Remember that both input files and output files of CROCO are in NetCDF format.

The command

```
ncdump -h SCRATCH/croco_avg_Y1M1.nc  | less
```

will show information about the content of the **croco_avg_Y1M1.nc** file

```
netcdf croco_avg_Y1M1 {
dimensions:
        xi_rho = 43 ;
        xi_u = 42 ;
        eta_rho = 44 ;
        eta_v = 43 ;
        s_rho = 32 ;
        s_w = 33 ;
        time = UNLIMITED ; // (120 currently)
        auxil = 4 ;
variables:
        char spherical ;
                spherical:long_name = "grid type logical switch" ;
                spherical:option_T = "spherical" ;
                spherical:option_F = "cartesian" ;
        float xl ;
                xl:long_name = "domain length in the XI-direction" ;
                xl:units = "meter" ;
```

In this way we can see details such as dimensions of domain and number of time steps recorded there. We can compare this to our estimates of number of time steps it should record, for example. To exit **ncdump** you have to press **q** key.

8.2 ncview

The **ncview** program is very useful for previewing files, in NetCDF format. For this we do

```
ncview SCRATCH/croco_avg.nc
```

this shows us the following interface

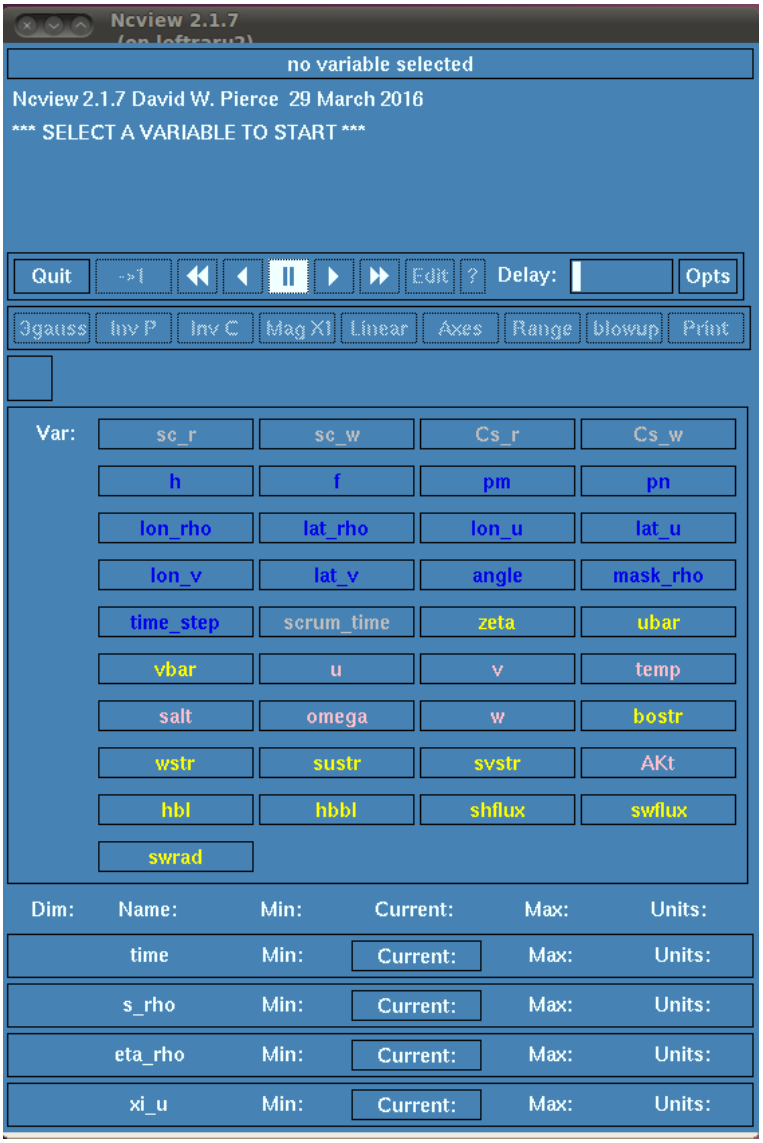

Figure 18: Graphic interface of ncview.

clicking the variable **temp** gives

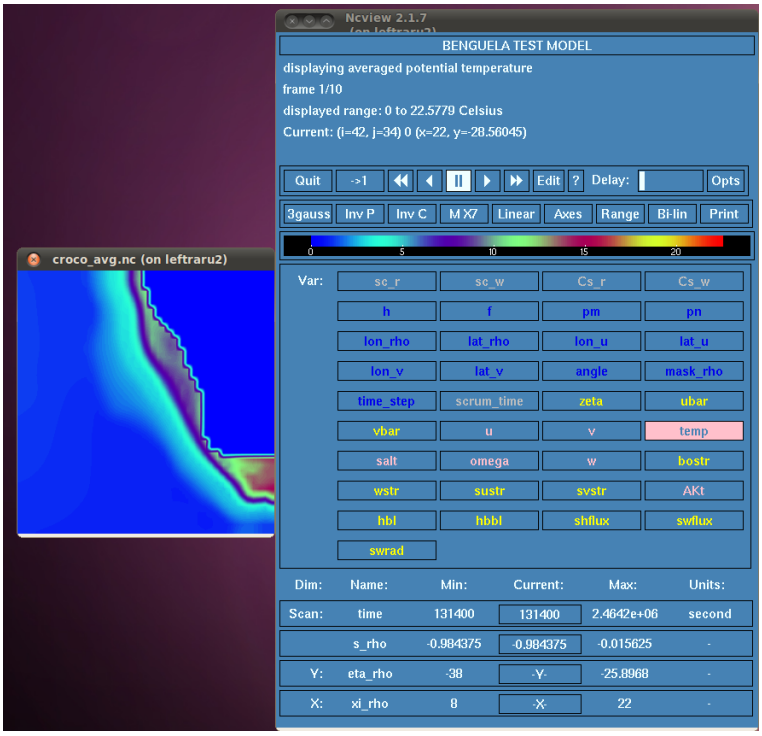

Figure 19: Sea temperature

This figure shows us the sea temperature in deepest sigma layer of model. If we want to see the values of sea surface temperature, we click the right mouse button on the box that has value **-0.984375** that corresponds to vertical level **s_rho** that we want to analyze. Doing this changes the value of that box to **-0.015625**. It is also convenient to click on button that says **Bi-lin**, so that ncview does not interpolate values that were calculated in each cell. Once this is done we get the following figure

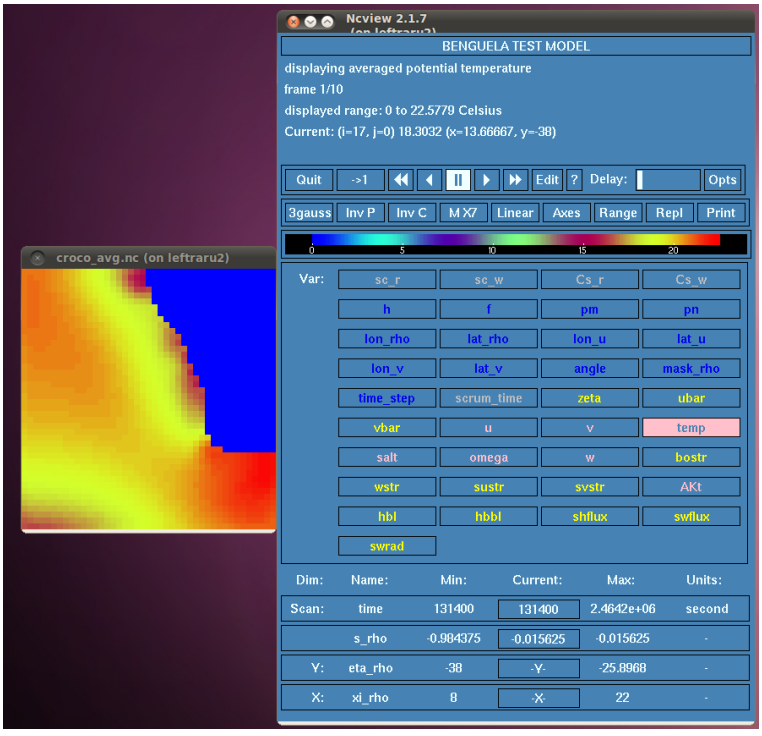

Figure 20: Surface temperature

If we now click with the mouse on any point of the sea, ncview shows us the time series, on surface, of that variable.

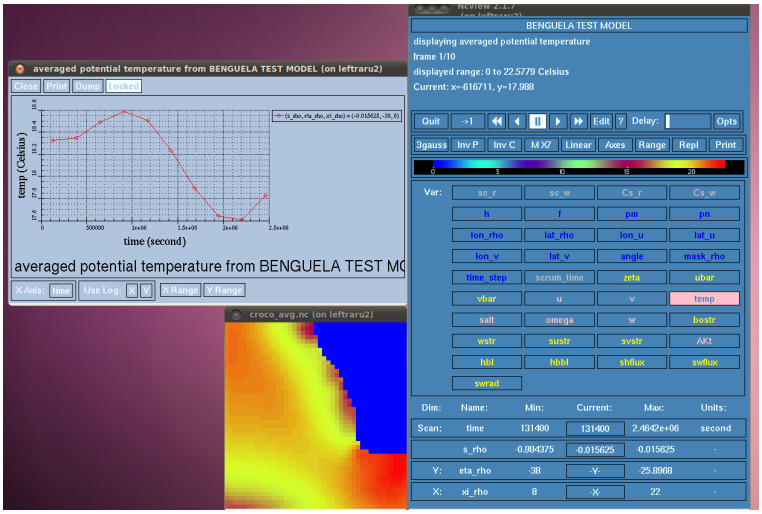

Figure 21: Times series

In summary, **ncview** is a very fast and simple tool that allows us to have an immediate visualization of files. It is very useful to use it to see if results are, at first sight, reasonable.

8.3 CROCO_TOOLS

CROCO_TOOLS contains several functions that are useful for visualizing results of our simulation. These functions do not allow making various types of graphs such as vertical sections, surface maps, depth profiles, time series and others. The detail of its use is described in another tutorial.

9 Advanced details

There are important aspects to running a simulation using **CROCO** that depends on how we configure the files.

```
crocotools_param.m
cppdefs.h
param.h
croco.in
```

In this case, everything is limited because these files are preconfigured for the **Run** example. In the next tutorial we will discuss what to modify from those files to study the area that is of interest to you.

10 Conclusion

In this tutorial you learned how to install the **LiveCROCO** virtual machine, compile the **croco** model, and prepare the input files with the **croco_tools** code. In addition, the basic simulation for the Benguela zone was run and the results visualized using **ncview**.

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Mauro Santiago

If you found this tutorial useful, please send a postcard to:

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Concepción
Chile

11 References

Penven, P., Roy, C., Brundrit, G. B., De Verdière, A. C., Fréon, P., Johnson, A. S., Lutjeharms J. R. E. & Shillington, F. A. (2001). A regional hydrodynamic model of upwelling in the Southern Benguela. South African Journal of Science, 97(11-12), 472-475.

Penven, P., Marchesiello, P., Debreu, L., & Lefèvre, J. (2008). Software tools for pre-and post-processing of oceanic regional simulations. Environmental Modelling & Software, 23(5), 660-662.

Sepúlveda, H. H., Artal, O. E., & Torregrosa, C. (2011). LiveROMS: A virtual environment for ocean numerical simulations. Environmental Modelling & Software, 26(11), 1372-1373.

12 Helpful Links

12.1 CROCO model

http://www.croco-ocean.org

12.2 CROCO user forum

https://forum.croco-ocean.org/questions/

12.3 CROCO tutorials

https://croco-ocean.gitlabpages.inria.fr/croco_doc/index.html

12.4 OctCDF package

http://modb.oce.ulg.ac.be/mediawiki/index.php/Octcdf

12.5 LiveCROCO Video: Basic Steps

https://www.youtube.com/watch?v=caxqeAgBM-U

13 Errata Compendium

- If you get an error message like this

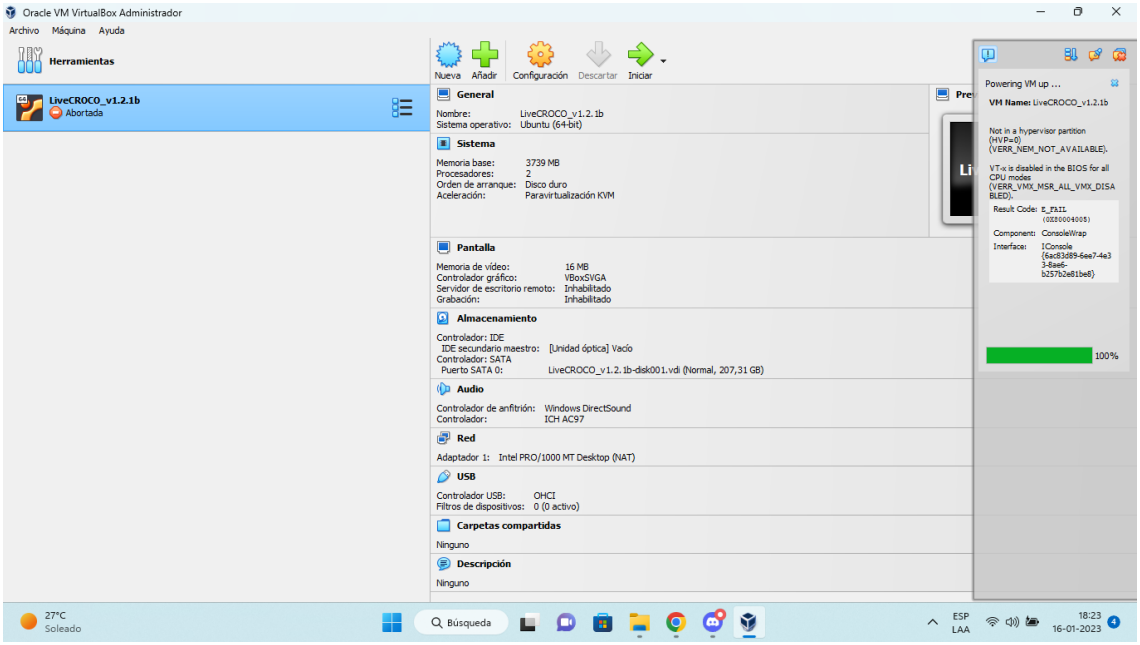

Figure 22: Error message when launching the virtual machine

when launching the virtual machine Fig. 22, you might need to activate virtualization in the BIOS of your machine (thanks to Valentina Nuñez for pointing out this issue).