# Tutorial 05 CROCO: NH - Idealized Cases

## 1. Purpose

In this tutorial we will learn to run several idealized cases that include the non-hydrostatic code in CROCO.

### 1.1. Installation

```
mkdir CONFIG
cd CONFIG
cp ~/../instructor01/CONFIG/create_config.bash .
nano create_config.bash
```

to edit the file and modify the following lines to

```
MACHINE="LEFTRARU"

CROCO_DIR=/home/courses/instructor01/MODEL_git/croco/croco
TOOLS_DIR=/home/courses/instructor01/MODEL_git/croco/croco_tools

MY_CONFIG_NAME=BENG_CLASSIC

# Home and Work configuration directories
# ---------------------------------------
MY_CONFIG_HOME=${PWD}
MY_CONFIG_WORK=${PWD}

options=( all-dev )
```

Now type

```
./create_config.bash
```

And we are all set to start.

### 1.2. Basic Steps

The basic steps to run an idealized case are:

1. Edit **cppdefs.h**
2. Compile using **jobcomp**
3. Select the correct **.in** file from **TEST_CASES** directory
4. Run compiled executable **croco**
5. Plot using Matlab scripts in **TEST_CASES** directory

# 2. INTERNAL SOLITON

The non-hydrostatic solver is tested with several analytical solutions and laboratory experiments. The Internal Soliton test case is setup from the experiment of Horn et al. (2001). It illustrates the processes acting on an interfacial basin-scale standing wave known as an internal seiche, neglecting the Earth's rotation.

## 2.1. Configuration

```
#define  ISOLITON        /* Internal Soliton Example */
```

After compilation we can use

```
./croco TEST_CASES/croco.in.Isoliton
```

## 2.2. Results

Using the script **plot_isoliton.m** we get

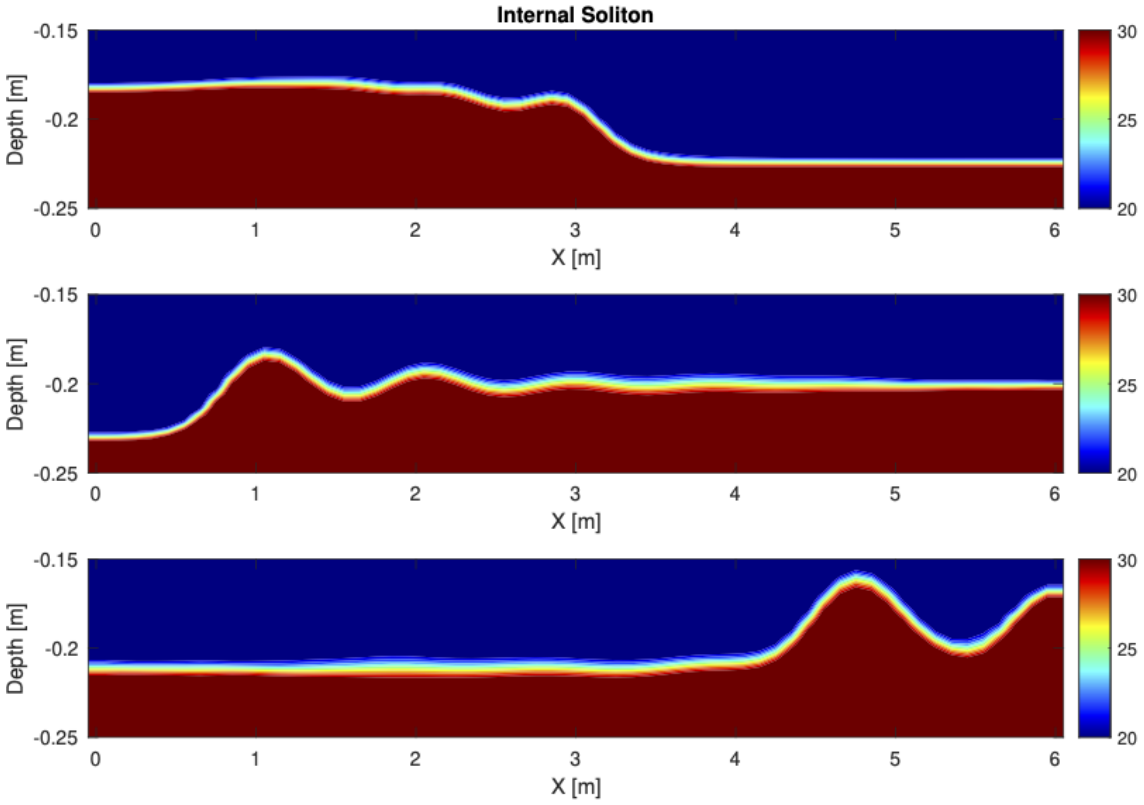


Figura 1: Test case NH : Internal Soliton

Try this example with different advection schemes

# 3. Kelvin-Helmholtz Instability

This test case runs a Kelvin-Helmholtz instability between two fluid layers. It is part of experiments conducted with CROCO by Penney et al. (2020). The numerical simulations are performed using the non-hydrostatic, non-Boussinesq version of CROCO. While numerical simulations of KH instabilities are often considered in a periodic domain with rigid lid conditions for the upper boundary, the implementation presented here uses a free-surface upper boundary, with periodic lateral boundary conditions in the x- and y-directions.

The results are sensitive to the resolution (**1 m by default**) and the choice of advection schemes and diffusion operator (implicit in the advection schemes or explicit).

## 3.1. Configuration

```
#define  KH_INST         /* Kelvin-Helmholtz Instability Example */
```

After compilation we can use

```
./croco TEST_CASES/croco.in.KH_INST
```

## 3.2. Results

Using the script **plot_kh_inst.m** we get

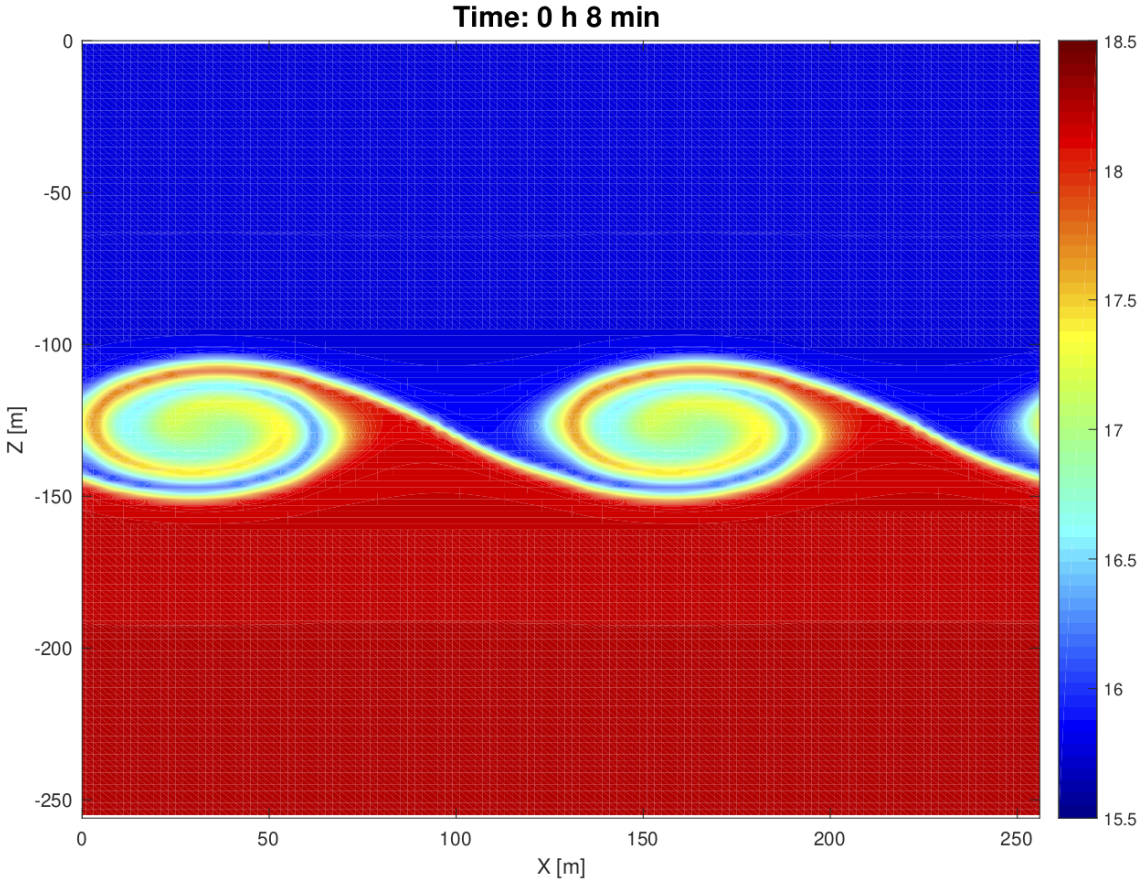


Figura 2: Test case NH : Kelvin-Helmholtz Instability

Do an animation of this case. First download the file

`http://mosa.dgeo.udec.cl/CROCO2022/AdvancedCourse/Tutorial05/QTWriter.m`

and set

```
makemovie = 1;
```

in **plot_kh_inst.m** before you run it.

# 4. Gravitational Adjustment

The goal of this test case, also known as Lock-Exchange experiment, is to evaluate different numerical advection schemes on representing the adiabatic process in a dam breaking experiment. At the initial time, a vertical density front separates two density classes. Adjustment occurs in which lighter water moves above heavier water (Shin et al., 2004). The model experiments are designed to reproduce the lock-exchange problem described in Ilicak et al., 2012).

A non-hydrostatique version can be run (define NBQ) in a smaller domain of 3 m by 30 cm and resolution of **1 cm**. In this case, Kelvin-Helmholtz instabilities develop along the front during the gravitational adjustment.

## 4.1. Configuration

```
#define  GRAV_ADJ        /* Gravitational Adjustment Example */
```

and in the section

```
!                       Gravitational Adjustment Example
!                       ============= ========== =======
```

set

```
# define  NBQ
```

After compilation we can use

```
nano TEST_CASES/croco.in.Grav_adj_nbq
```

and change **dt[sec]** to 0.01 and **NTIMES** to 2000 and then run

```
./croco TEST_CASES/croco.in.Grav_adj_nbq
```

## 4.2. Results

Using the script **plot_grav_adj.m** we get

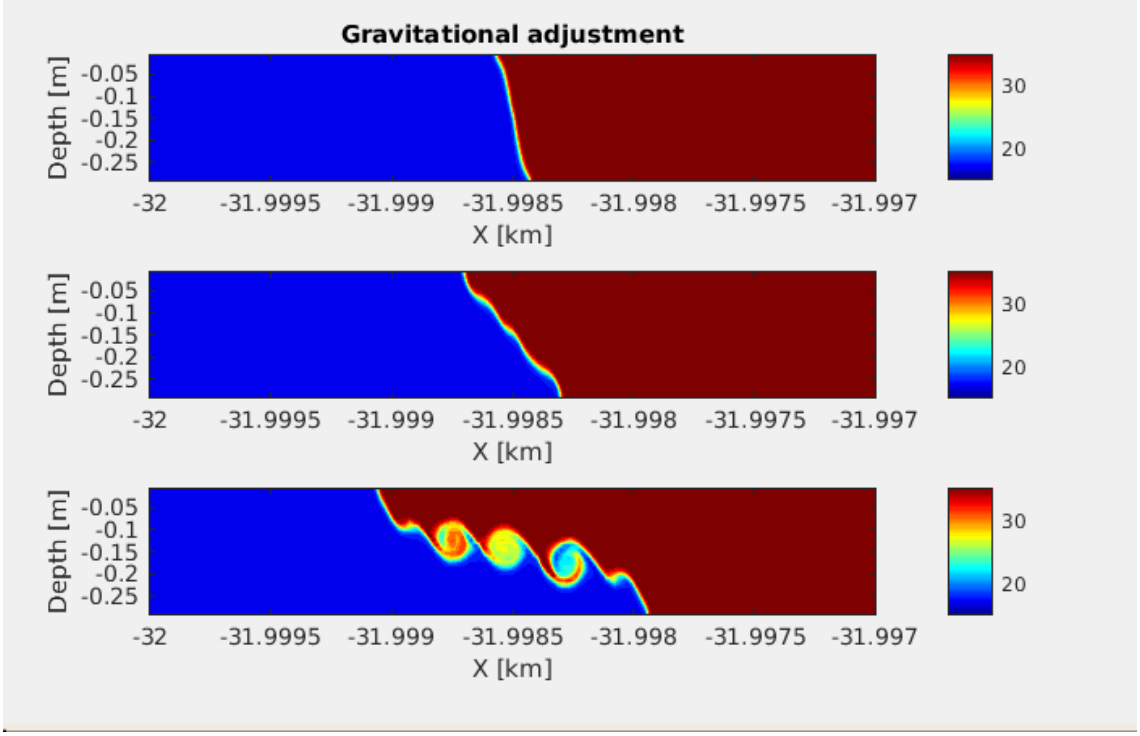


Figura 3: Test case NH : Gravitational Adjustment

Compare with the classic gravitational adjustment result. To do this reverse the configuration to

```
# undef  NBQ
```

compile and run by typing

```
./croco TEST_CASES/croco.in.Grav_adj
```

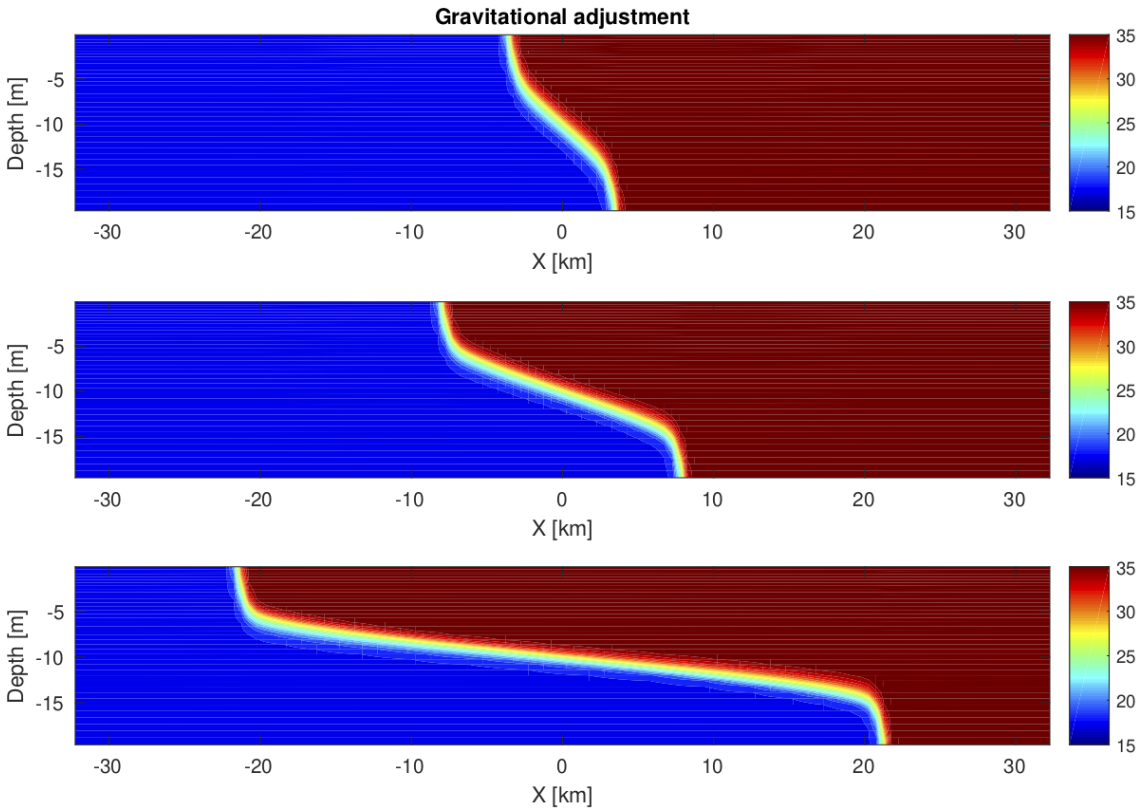


Figura 4: Classic : Gravitational Adjustment

Do an animation of these cases!

## 5. Other examples

- SWASH
- TANK

## 6. Conclusion

In this tutorial you practiced some idealized cases in **CROCO** that include the non-hydrostatic dynamics.

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# 7. References

Test Cases
https://croco-ocean.gitlabpages.inria.fr/croco_doc/model/model.test_cases.html

Internal Soliton

Horn, D.A., J. Imberger, & G.N. Ivey, (2001).
The degeneration of large-scale interfacial gravity waves in lakes.
J. Fluid Mech., 434:181-207.

Kelvin-Helmoltz Instability

Penney, J., Morel, Y., Haynes, P., Auclair, F., & Nguyen, C. (2020).
Diapycnal mixing of passive tracers by Kelvin{Helmholtz
instabilities. Journal of Fluid Mechanics, 900, A26.

Gravitational Adjustment

Shin, Dalziel, S., Linden, P, 2004: gravity currents produced
by lock exchange. Journal of Fluid Mechanics, 521, 1{34.

Ilicak, M, Adcroft, A., Griffies, S., Hallberg, R., 2012: Spurious
dianeutral mixing and the role of momentum closure. Ocean Modelling,
45{46, 37{58.

# Appendix A: Old CROCO framework

You can recover the old CROCO code framework creating a configuration with **create_config.bash** by defining

```
# Configuration name
# ------------------
MY_CONFIG_NAME=BENG_CLASI
```

and

```
options=( all-dev )
```

so when you type

```
./create_config.bash
```

you get in the **BENG_CLASI** directory

```
-rw-r--r-- 1 student60 courses  32K Jan 19 11:27 cppdefs_dev.h
-rw-r--r-- 1 student60 courses  42K Jan 19 11:27 cppdefs.h
-rwxr-xr-x 1 student60 courses  24K Jan 19 11:27 create_config.bash.bck
drwxr-xr-x 2 student60 courses 4.0K Jan 19 11:27 CROCO_FILES
-rw-r--r-- 1 student60 courses 9.1K Jan 19 11:27 croco_forecast.in
-rw-r--r-- 1 student60 courses 9.1K Jan 19 11:27 croco_hindcast.in
-rw-r--r-- 1 student60 courses 8.9K Jan 19 11:27 croco.in
-rw-r--r-- 1 student60 courses 8.9K Jan 19 11:27 croco.in.1
-rw-r--r-- 1 student60 courses 8.9K Jan 19 11:27 croco_inter.in
-rw-r--r-- 1 student60 courses 1.6K Jan 19 11:27 croco_stations.in
-rw-r--r-- 1 student60 courses  18K Jan 19 11:27 crocotools_param.m
drwxr-xr-x 2 student60 courses 4.0K Jan 19 11:27 DATA
-rwxr-xr-x 1 student60 courses 9.4K Jan 19 11:27 jobcomp
drwxr-xr-x 2 student60 courses 4.0K Jan 19 11:27 MUSTANG_NAMELIST
drwxr-xr-x 2 student60 courses 4.0K Jan 19 11:27 NAMELIST_OANALYSIS
-rw-r--r-- 1 student60 courses 5.5K Jan 19 11:27 namelist_pisces_cfg
-rw-r--r-- 1 student60 courses 5.5K Jan 19 11:27 namelist_pisces_cfg.1
-rw-r--r-- 1 student60 courses  22K Jan 19 11:27 namelist_pisces_ref
-rw-r--r-- 1 student60 courses  22K Jan 19 11:27 namelist_pisces_ref.1
-rw-r--r-- 1 student60 courses 2.3K Jan 19 11:27 oct_start.m
-rw-r--r-- 1 student60 courses  31K Jan 19 11:27 param.h
-rwxr-xr-x 1 student60 courses 4.3K Jan 19 11:27 process_xios_xml.sh
-rwxr-xr-x 1 student60 courses 8.0K Jan 19 11:27 run_croco.bash
-rwxr-xr-x 1 student60 courses 7.3K Jan 19 11:27 run_croco_forecast.bash
-rwxr-xr-x 1 student60 courses  11K Jan 19 11:27 run_croco_inter.bash
-rw-r--r-- 1 student60 courses 2.8K Jan 19 11:27 sediment.in
-rw-r--r-- 1 student60 courses 4.2K Jan 19 11:27 start.m
drwxr-xr-x 3 student60 courses  16K Jan 19 11:27 TEST_CASES
-rw-r--r-- 1 student60 courses 1.2K Jan 19 11:27 town.dat
```