OASIS and Coupling with CROCO

CROCO Coupling Team
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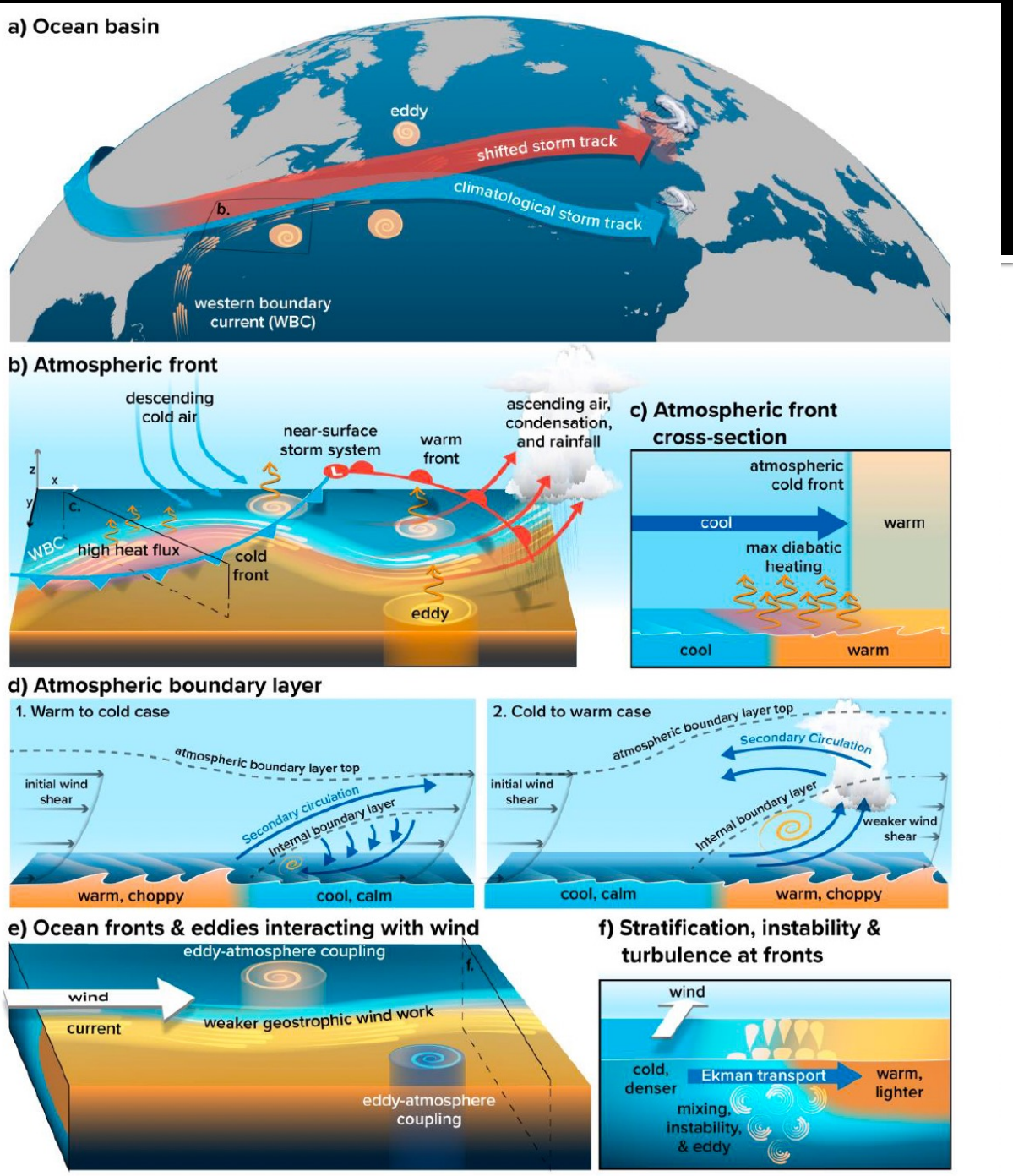
CROCO Sud
Coastal and Regional Ocean COmmunity model

Summer School, South Africa 2022

Why do we want to couple ?



The CLIVAR Air-Sea Interactions group, Journal of Climate, Accepted

Parameterization of energy transfer between the air-sea interface

Momentum and heat transfer fluxes

$$H_s = \rho_a c_{pa} \overline{w'T'} = -\rho_a c_{pa} u_* T_*$$

$$H_l = \rho_a L_e \overline{w'q'} = -\rho_a L_e u_* q_*$$

$$\tau = \rho_a \overline{w'u'} = -\rho_a u_*^2$$

Bulk formulations

Bulk formulation

$$= \rho_a c_{pa} C_h S (T_s - \theta)$$

$$= \rho_a L_e C_e S (q_s - q)$$

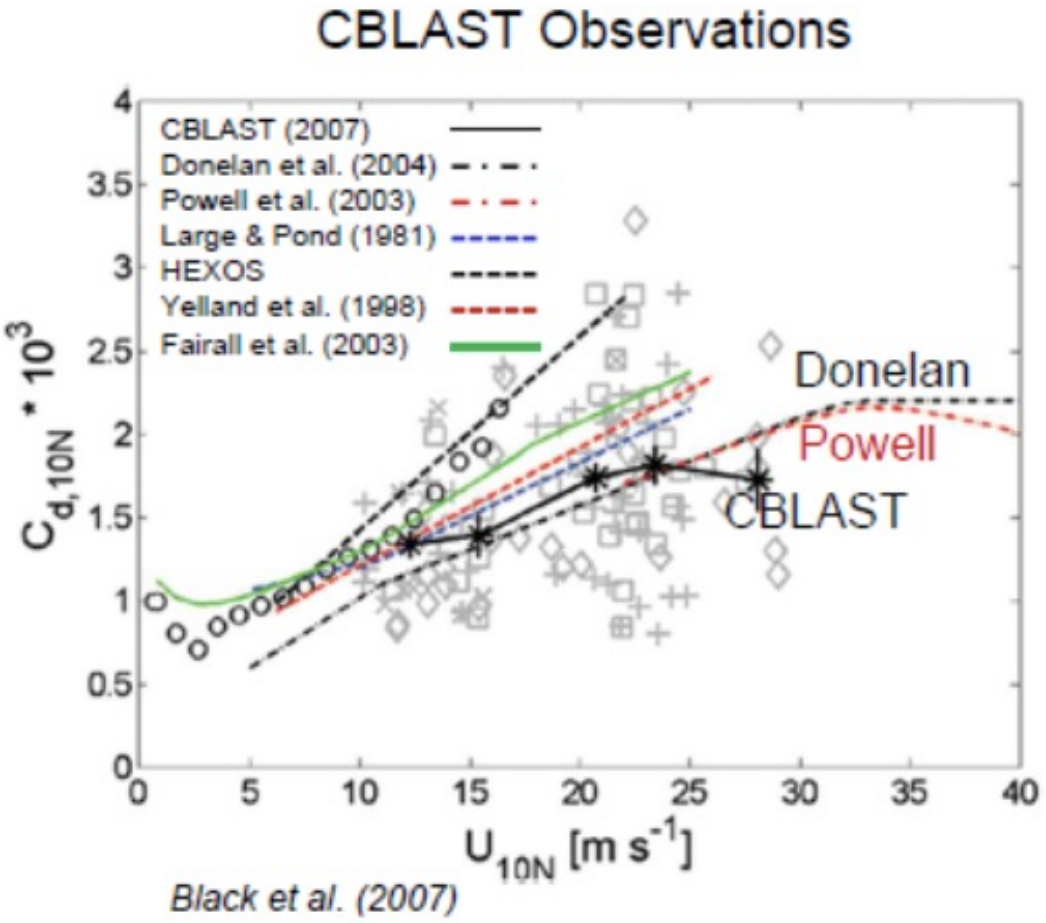
$$= \rho_a C_d S (u_{si} - u_i)$$

with S=wind speed

Requested variables:

- Ocean surface fields (SST, currents, wind)
- Transfer coefficients

Parameterization of energy transfer between the air-sea interface



Black et al. (2007)

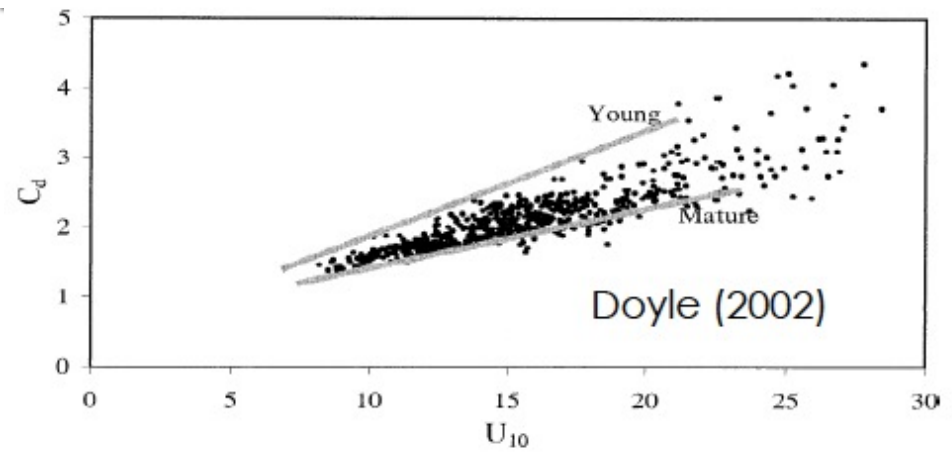
$$\vec{\tau} = \rho C_D \vec{u} \left\| u \right\|$$

$$C_D = \left[\frac{\kappa}{\ln\left(z / z_0\right)} \right]^2$$

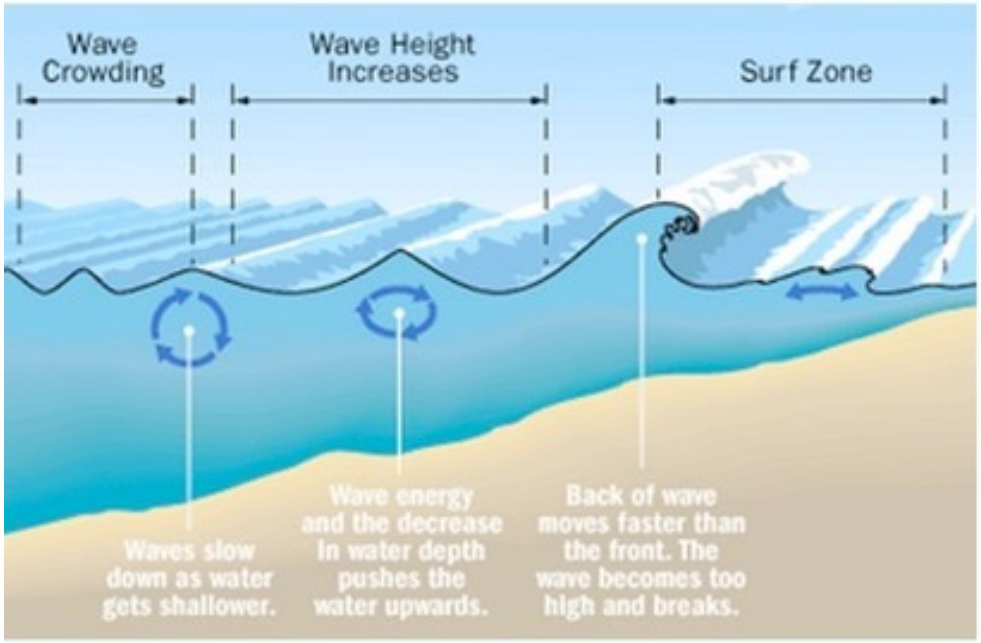
$$z_0 = \alpha \frac{u_*^{\,2}}{g}$$

α : Charnock coefficient

Wave Feedback

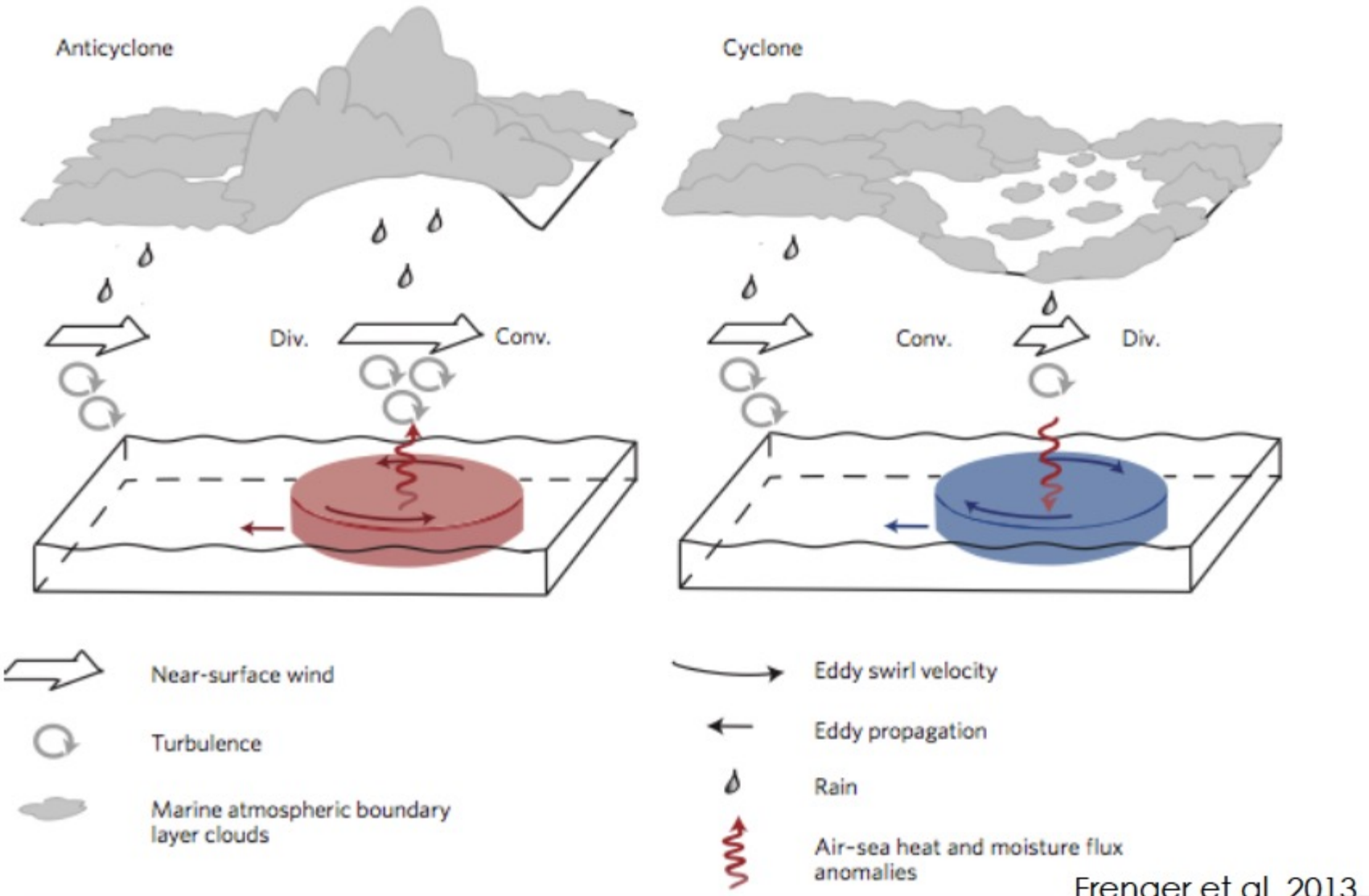


- Drag coefficient depends on sea state



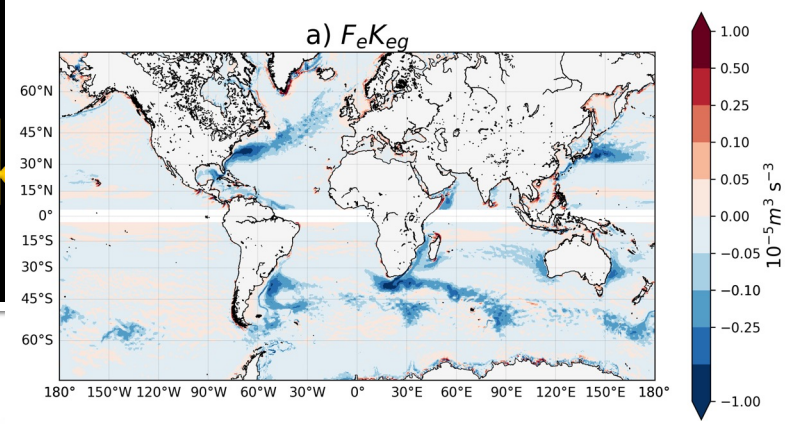
- Importance/predominance of wave-induced circulation in coastal/littoral regions

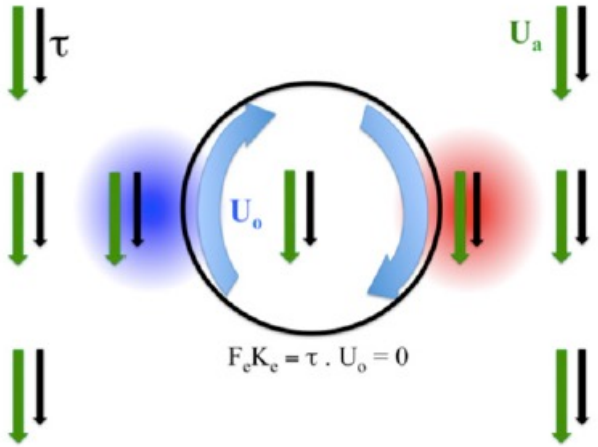
Thermal Feedback



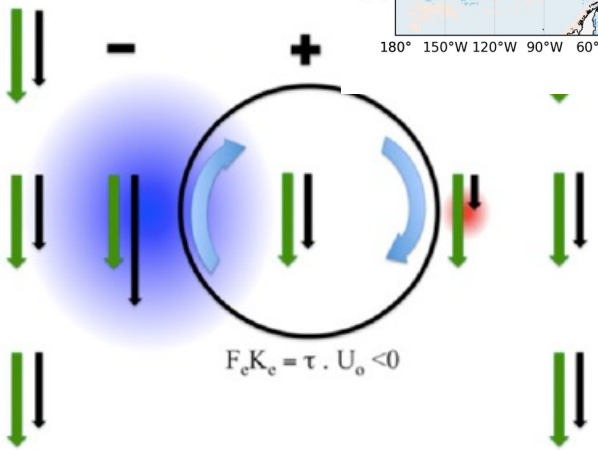
Frenger et al. 2013

Mechanical Feeback

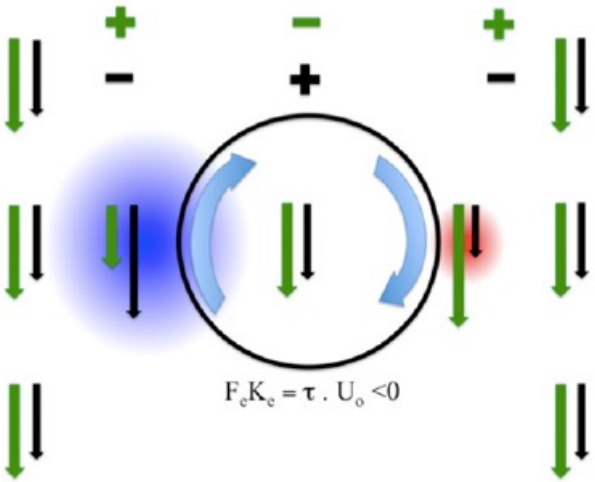




a) No Current Feedback



b) Current Feedback to the Surface Stress



c) Current Feedback to the Surface Stress and Wind

Renault et al., 2016a

Why do we want to couple

- Strong 2-way ocean-atmosphere interactions
  - ✓ At (sub)mesoscale
  - ✓ Extreme events
  - ✓ In the tropics

- Strong 2-way interactions between waves and currents
  - ✓ In frontal regions
  - ✓ In coastal regions
  - ✓ In strong current regions

- Bulk formulations only valid under some condition
  - ✓ Moderate wind conditions (except for some formulations developed for high winds)
  - ✓ fully developed waves
  - ✓ Relatively large spatial scales
  - ✓ Relatively low frequency O(day)
  - ✓ What happens in other conditions?

Processes to model when coupling

Processes to model when coupling

- Ocean - Atmosphere
  - ✓ SST feedback to heat flux computation in the atmosphere
  - ✓ Current feedback to momentum and heat fluxes computation
  - ✓ Water flux taking into account rainfall from the atmospheric model
  - ✓ Solar flux from the atmospheric model

- Wave - Atmosphere
  - ✓ Roughness evolution according to sea state
  - ✓ Sea spray

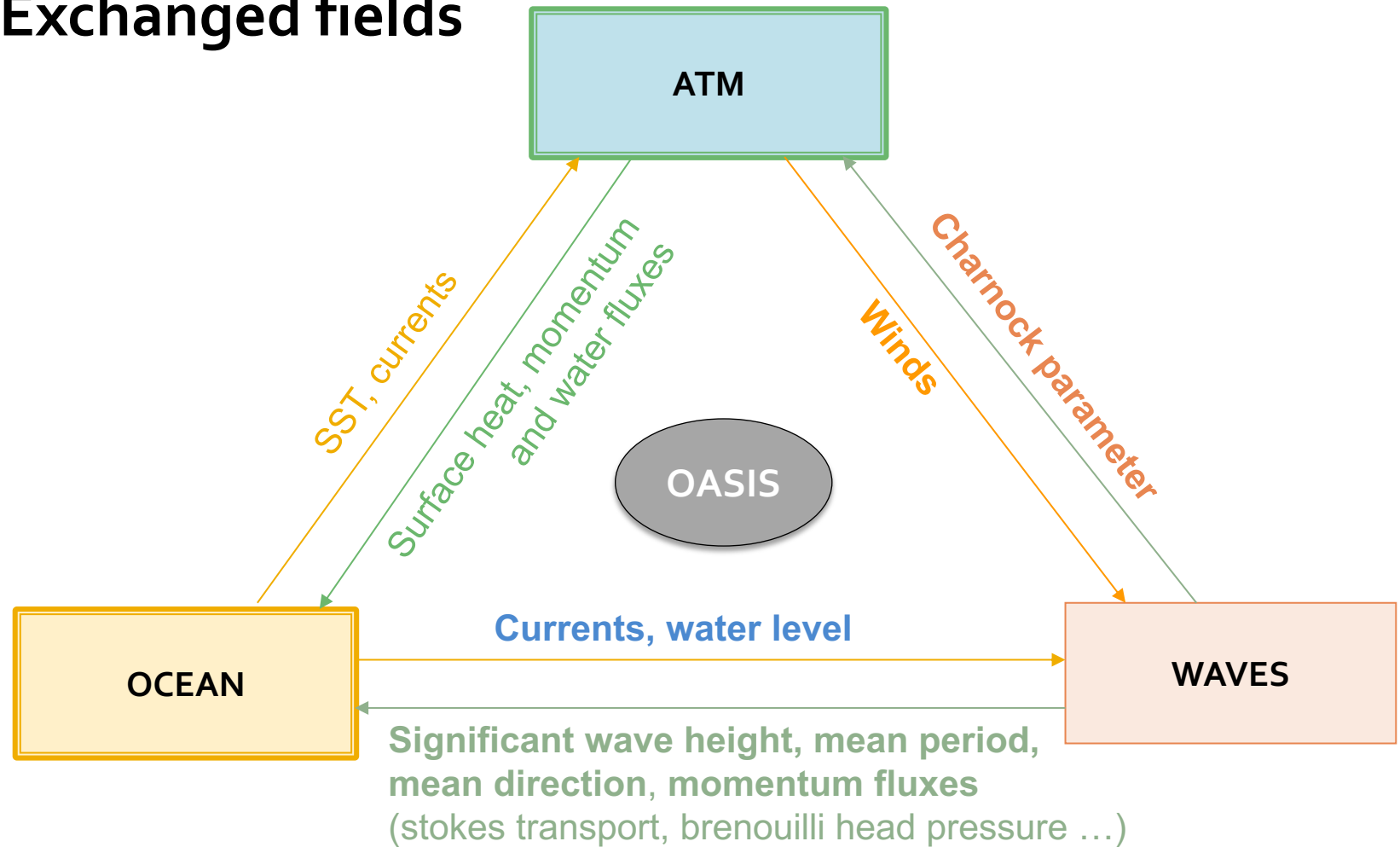
Processes to model when coupling

- Ocean - Wave

  - ✓ Impact of evolving water level on waves
  - ✓ Impact of current on waves evolution (refraction, etc)
  - ✓ Wave-induced circulation (stokes drift and transport, acceleration by breaking)
  - ✓ Enhanced mixing due to wave breaking
  - ✓ Surface and bottom streaming (wave-induced thin viscous boundary layer)
  - ✓ Mass flux due to wave rollers
  - ✓ Wave-induced pressure effects
  - ✓ Wave-induced additional diffusivity
  - ✓ Wave-induced setup

Coupling implementation scheme

Exchanged fields



The OASIS Coupler

- Set of libraries, developed and distributed by CERFACS (Toulouse, France). It performs:
  - Coupling and time interpolations (PSMILE library)
  - Parallel exchanges (MCT library)
  - Grid interpolations (SCRIPR library)
- A namelist file to configure the exchanges and transformations to be performed

Advantages:

- Common interface for different models: WRF, Meso-NH/ARPEGE/Surfex, LMD-Z, WW3, CROCO, MARS3D, NEMO
- Synchronous (best performance) or asynchronous coupling available
- Easy implementation in the models: a few calls to the library functions to add, and a few dedicated routines

The OASIS Coupler

OASIS architecture

- Initialization: call oasis_init(...)
  call oasis_get_localcomm(...)
- Grid definition: call oasis_write_grid (...)
- Local partition definition: call oasis_def_partition (...)

- ***Coupling field exchange: in model time stepping loop***
  - call oasis_put (..., time, var_array. ...)
  - call oasis_get (..., time, var_array, ...)
  - user external configuration: => define source / target model
    => tune the coupling frequency
    => select the transformations and regridding

The OASIS Coupler

Additional routines dedicated to coupling, which contain the calls to oasis functions:

Before the temporal loop:

- **cpl_prism_init.F** — initialization of OASIS, local MPI com
- **cpl_prism_define.F** — domain partition, definition of exchanged fields as read in the namcouple
- **cpl_prism_grid.F** — definition of grids for the coupler

main.F (or zoom.F)

get_initial.F

In the temporal loop:

- **cpl_prism_put.F** — sending of arrays from CROCO to OASIS
- **cpl_prism_getvar.F** **cpl_prism_get.F** — reception of coupled fields from OASIS, eventual grid and units transformations

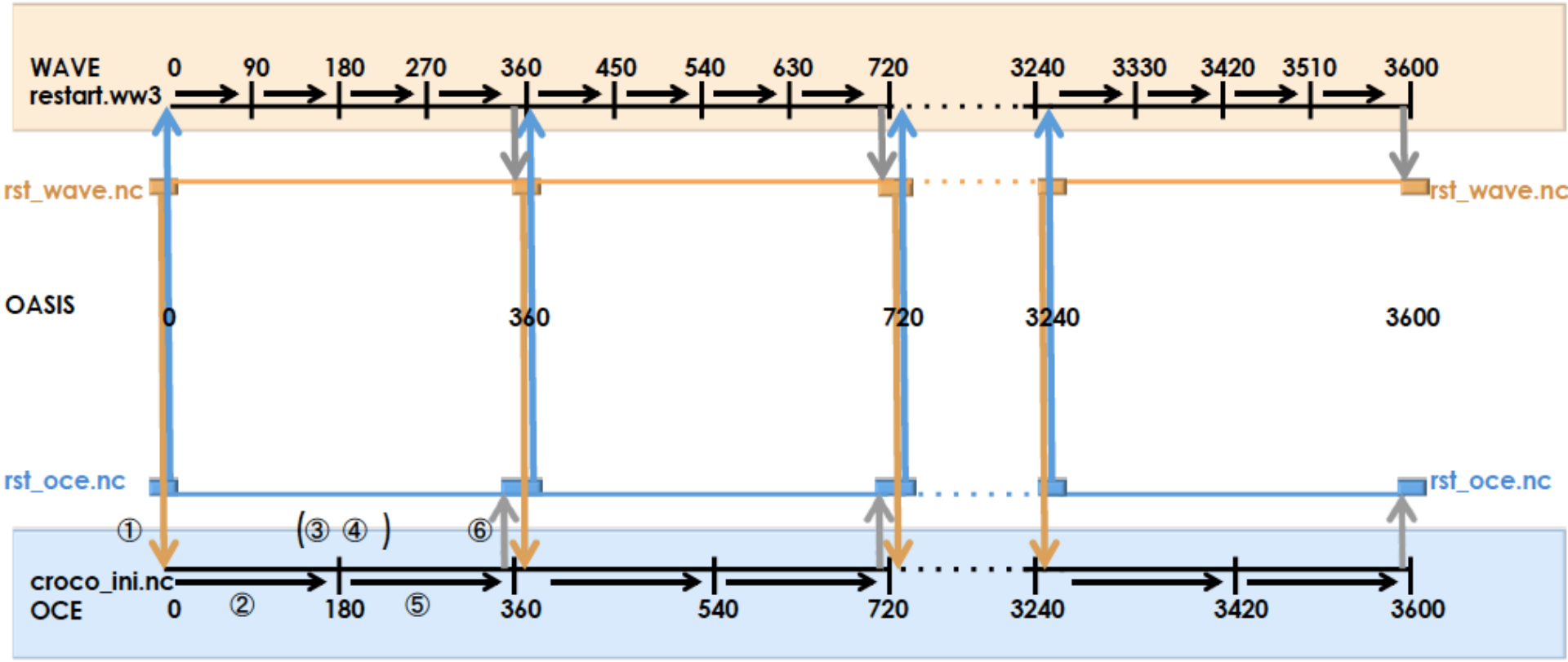
step.F

- **mpi_roms.h** — definition of variables/parameters related to OASIS operations

Schematic picture of the coupling sequence

dt_{wave} = 90s
dt_{oce} = 180 s
$dt_{coupling}$ = 360s for both models

Instantaneous field exchange



advance model time step
send model field to the coupler
receive ocean field from the coupler
receive wave field from the coupler

model time line
OASIS time lines

Steps to setup a coupled simulation

(1) Get source codes

(2) Set-up your configuration architecture and environment using: croco/create_config.bash (all-prod-cpl option)

(3) Compile OASIS

(4) Compile your models in coupled mode (with the same netcdf libraries and compilers, NB: CROCO can alternatively be compiled when launching the run within the coupling toolbox)

(5) Perform pre-processing for your different models

(6) Use the coupling toolbox to set-up and run your coupled

Steps to setup a coupled simulation

(1) Get source codes

Suggested architecture:
mkdir $HOME/croco
mkdir $HOME/oasis
mkdir $HOME/wrf
mkdir $HOME/ww3
mkdir $HOME/CONFIGS

CROCO
cd $HOME/croco

https://www.croco-ocean.org/croco-project/
tar -zxvf croco-v1.0.tar.gz
tar -zxvf croco_tools-v1.0.tar.gz

Or

git clone https://gitlab.inria.fr/croco-ocean/croco.git
git clone https://gitlab.inria.fr/croco-ocean/croco_tools.git

OASIS
cd $HOME/oasis

git clone https://gitlab.com/cerfacs/oasis3-mct.git

WRF
cd $HOME/wrf

git clone https://github.com/wrf-croco/WRF.git

WPS
git clone https://github.com/wrf-model/WPS.git
git checkout tags/v4.2

WW3
cd $HOME/ww3

git clone https://github.com/NOAA-EMC/WW3

Steps to setup a coupled simulation

(2) Set-up your configuration architecture and environment using: croco/create_config.bash (all-prod-cpl option)

-> useful to get paths, env var, and scripts to facilitate compilation, etc)

cd $HOME/CONFIGS
cp $HOME/croco/croco/create_config.bash

Edit **create_config.bash** : paths, settings
./create_config.bash

You should now have YOUR_CONFIG directory
cd $HOME/CONFIGS/YOUR_CONFIG

Check the **myenv_mypath.sh** file, eventually edit path if necessary

Steps to setup a coupled simulation

(3) Compile OASIS

OASIS

cd $HOME/oasis/oasis3-mct/oasis3-mct/util/make_dir
cp $HOME/croco/croco/SCRIPTS/SCRIPTS_COUPLING/OASIS_IN/make.DATARMOR .

Check the paths in make.DATARMOR
In make.inc set the include to the absolute path of your make.DATARMOR:
include $(home)/oasis/oasis3-mct/util/make_dir/make.DATARMOR

Compilation:
make realclean -f TopMakefileOasis3 > oasis_clean.out
make -f TopMakefileOasis3 > oasis_make.out

Steps to setup a coupled simulation

(4) Compile WRF

OPTION 1 : "A la mano"

cd $HOME/wrf/WRF

Classical compilation :
./clean –a
./configure
Check and eventually edit configure.wrf, then:
./compile em_real

OPTION 3: using provided

cd $HOME/CONFIGS/YOUR_CONFIG

Check your paths in myenv_mypath.sh

cd WRF_IN
qsub DATARMOR.compile.wrf.pbs

OPTION 2 : "A la mano" with some help

cd $HOME/wrf/WRF

A few scripts are provided to help you compile : First set a few environment variables:
cat $HOME/croco/croco/SCRIPTS/SCRIPTS_COUPLING/SCRIPTS_TOOLBOX/MACHINE/DATARMOR/myenv.DATARMOR* myenv.sh
source myenv.sh

Then copy the appropriate configure files :
cp $HOME/croco/croco/SCRIPTS/SCRIPTS_COUPLING/WRF_IN/CONFIGURE_WRF/DATARMOR/* .

./clean –a
cp configure.wrf.uncoupled configure.wrf
./compile em_real > compile_uncoupled.log

./clean -a
cp configure.wrf.coupled configure.wrf
./compile em_real > compile_coupled.log

Steps to setup a coupled simulation

(4) Compile WPS

OPTION 1 : "A la mano"

cd $HOME/wrf/WPS

Classical compilation :
./clean –a
./configure
Check and eventually edit configure.wps, then:
./compile

OPTION 2 : "A la mano" with some help

cd $HOME/wrf/WPS

A few scripts are provided to help you compile : First set a few environment variables:
cat $HOME/croco/croco/SCRIPTS/SCRIPTS_COUPLING/SCRIPTS_TOOLBOX/MACHINE/DATARMOR/myenv.DATARMOR* myenv.sh
source myenv.sh

Then copy the appropriate configure files :
cp $HOME/croco/croco_tools/Coupling_tools/WRF_WPS/configure.wps.MACHINE .

./clean –a
cp configure.wrf.MACHINE configure.wps
./compile > compile_wps.log

Steps to setup a coupled simulation

(4) Compile CROCO

OPTION 1 : "A la mano"

cd $HOME/CONFIGS/YOUR_CONFIG/CROCO_IN

Check and edit :
param.h => grid and MPI settings
cppdefs.h => CPP options
jobcomp.h => paths and compilers

Compile
./jobcomp

Eventually move the executable to another name :
mv croco croco.frc
or
mv croco croco.ow

OPTION 2 : automatic compilation when running

In $HOME/CONFIGS/YOUR_CONFIG/mynamelist.sh

You can set online compilation of CROCO:

Online Compilation
export **ONLINE_COMP=1**

Steps to setup a coupled simulation

(5) Preprocessing

CROCO
cd $HOME/CONFIGS/YOUR_CONFIG/PREPRO/CROCO

Check and edit paths in start.m
Check and edit settings and paths in crocotools_param.m
In matlab for climatological input files :
start
make_grid
make_forcing
make_bry
make_ini

WRF
cd $HOME/CONFIGS/YOUR_CONFIG/PREPRO/WRF_WPS

Rename and edit configure.namelist.wps_BENGUELA for your own configuration
Check and edit settings and paths in run_wps.bash
Check CPUs in job.wps.pbs and launch it: qsub job.wps.pbs

WW3

Follow WW3 preprocessing tutorial

Or eventually create grid files from croco grid with: make_ww3_grd_input_files_from_croco_grd.m

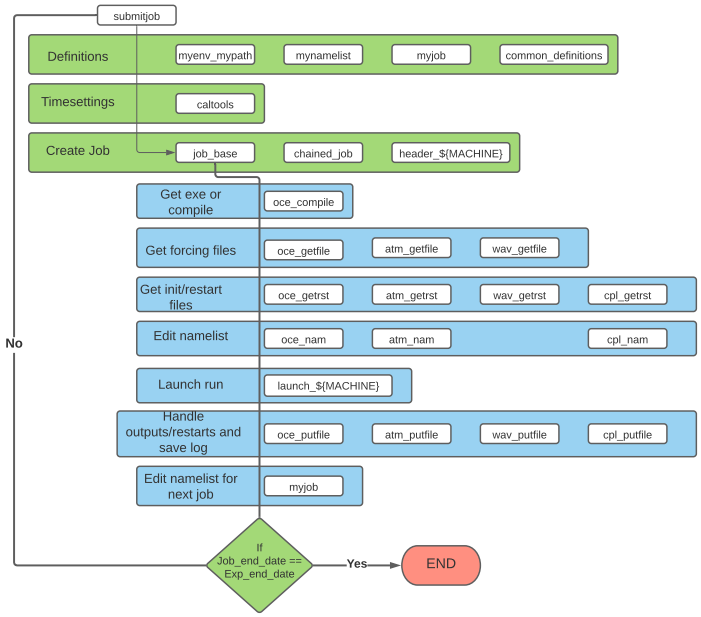
Steps to setup a coupled simulation

(6) Coupling toolbox philosophy and workflow:

The user edit:

* **myenv_mypath.sh** : environment settings, and paths
* **mynamelist.sh** : settings for the experiment (which models, time stepping, input files…)
* **myjob.sh** : settings for the job (dates nota

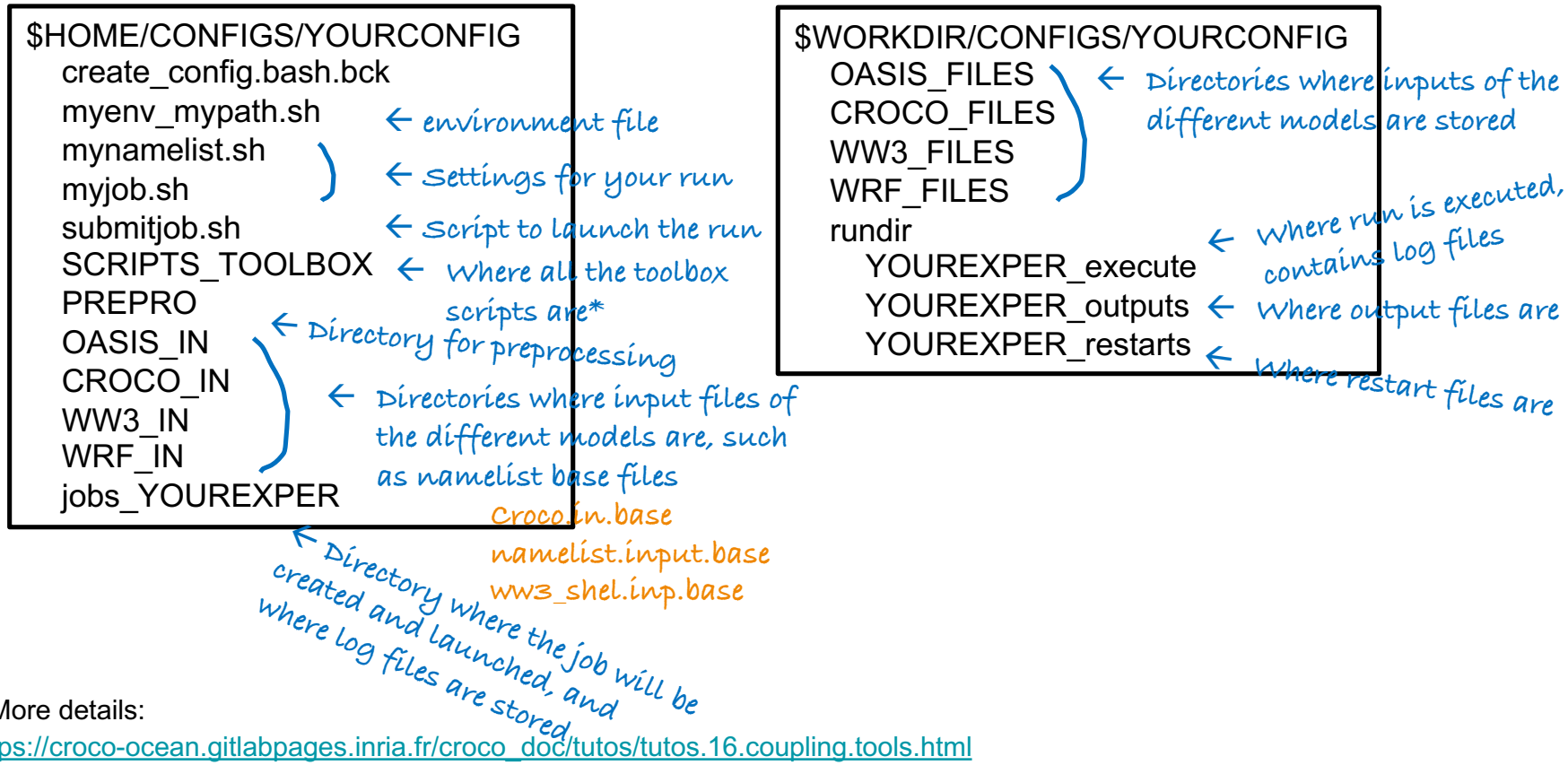
Then the user launch the job with **./submitjob.sh**



<u>The coupling toolbox manages:</u>

- CROCO compilation if requested
- getting models input files
- preparing OASIS restart files
- editing namelists (for models and OASIS)
- launching the run
- putting output files
- eventually looping for another job

Steps to setup a coupled simulation



* More details:
https://croco-ocean.gitlabpages.inria.fr/croco_doc/tutos/tutos.16.coupling.tools.html

What to check in case of error…

In case of error, you should check:

- The job output file: in $HOME/CONFIGS/YOURCONFIG/jobs_YOUREXPER : YOUREXPER_YYYYMMDD_YYYYMMDD.o*

- The models' log files: either in $**HOME**/CONFIGS/YOURCONFIG/**jobs_YOUREXPER**/YYYYMMDD_YYYYMMDD or in $**WORKDIR**/CONFIGS/YOURCONFIG/rundir/**YOUREXPER_execute**/YYYYMMDD_YYYYMMDD
  croco.log rsl.error.0000 log.ww3

- OASIS log files:
  nout.000000 debug.0?.000000

Typical issues are:

- Files not found: check your file names, and location
- Unconsitent dimensions of the grids in the different files: check models grid files, OASIS grids and masks files, OASIS remapping weight files, namelists of models and OASIS (namcouple)
- Unconsistency in exchanged variables: check namcouple
- Model blow up: check the log files, if blow up is due to CFL (unrealistic speed, or segmentation fault) decrease the model time step

References

- Example of CROCO Online documentation

http://www.croco-ocean.org/documentation/

- A few references:
  - ✓ Jullien et al., 2020
  - ✓ Renault et al., 2016ab,…,2020ab
  - ✓ Seo et al., 2016, 2017
  - ✓ Masson et al., in preparation
  - ✓ Voldoire et al. 2017: Coupling with OASIS within SURFEX (in discussion online):

http://www.geosci-model-dev-discuss.net/gmd-2017-91/