ICTP RegCM

Description and basic installation guide

PWF Cameroon
School on Climate Science
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University of Dschang

ICTP – ESP – Graziano Giuliani <ggiulian@ictp.it>

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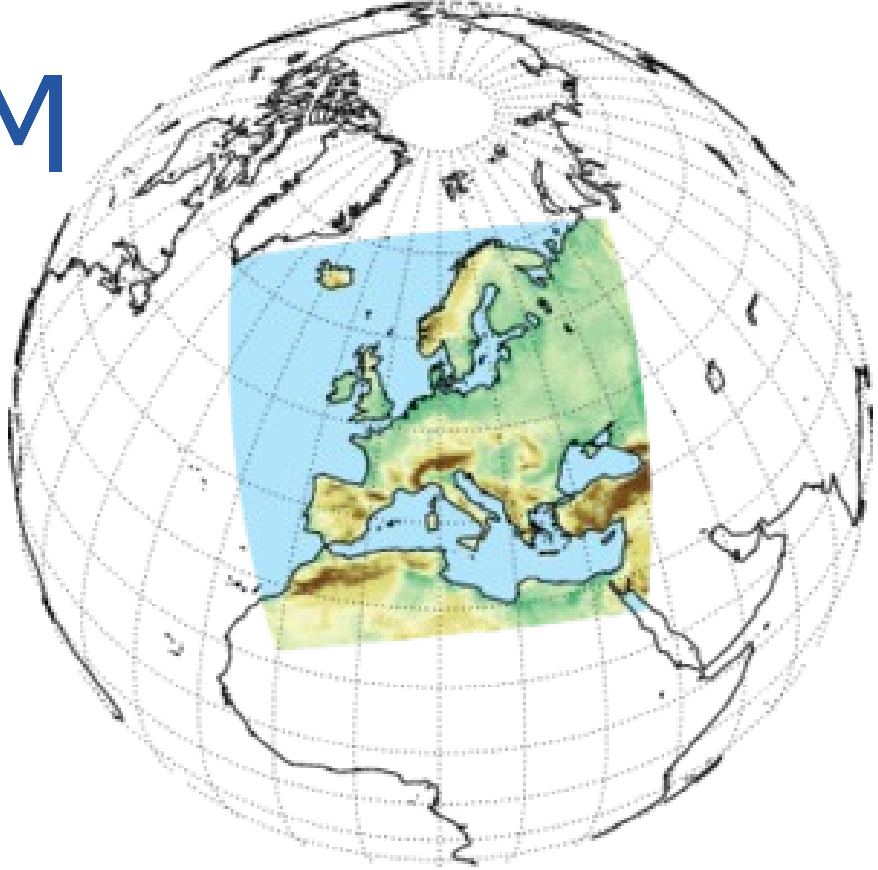
The Abdus Salam
International Centre
for Theoretical Physics

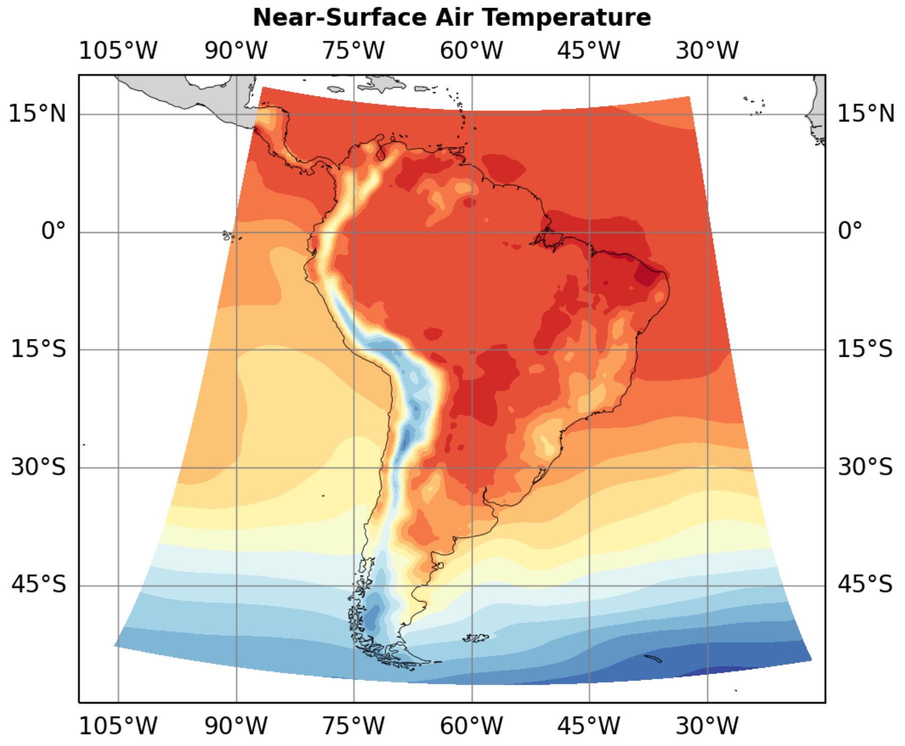
ICTP RegCM

- RegCM1
  - Dickinson et al. (1989), Giorgi and Bates (1989)
- RegCM2
  - Giorgi et al. (1993a,b)
- RegCM2.5
  - Giorgi and Mearns (1999)
- RegCM3
  - Pal et al. (2007)
- RegCM4
  - Giorgi et al. (2012)
- RegCM5
  - Giorgi et al. (2023)



Projection

- RegCM supports different Earth projections
  - Mercator – cylindrical, good for equatorial zones
    - https://en.wikipedia.org/wiki/Mercator_projection
  - Stereographic – plane-point, good for polar zones
    - https://en.wikipedia.org/wiki/Stereographic_projection
  - Lambert conformal – conical, tangent or secant, good for mid-latitudes
    - https://en.wikipedia.org/wiki/Lambert_conformal_conic_projection
  - Rotated (oblique) mercator – cylindrical, a rotation followed by a mercator, all season
    - https://en.wikipedia.org/wiki/Oblique_Mercator_projection
  - Rotated latitude-longitude – official CORDEX projection



Dynamical Cores

Solve one form or another of the Navier-Stokes equations for the motion of fluids.

RegCM4

Hydrostatical core (Giorgi 1989)

Non-hydrostatical core (Coppola et al, 2022)

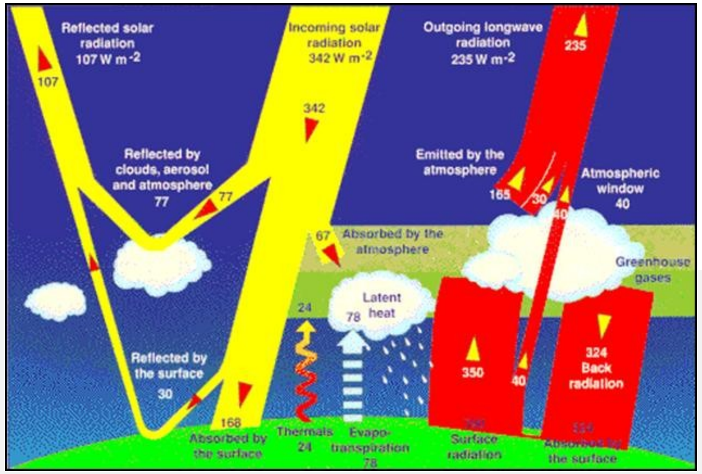
RegCM5

NH-MOLOCH core (Giorgi et al, 2023)

Hydrostatic core cannot be used for horizontal resolutions < 10km

Users are invited to test and report over the new Dynamical core of RegCM5

Radiation Scheme



Solves the equation for the radiation transmission in the atmosphere

CAM CCM3 (Kiehl 1996)

Simple scheme with SW and LW

RRTM-G

RRTM is a rapid radiative transfer model which utilizes the correlated-k approach to calculate fluxes and heating rates efficiently and accurately. State of the art with high accuracy relative to line-by-line results for single column calculations with high efficiency for GCM

http://rtweb.aer.com/rrtm_frame.html

Cumulus

Solves cumulus scheme evolution for resolution > 3 km

Tiedtke

Used in ECMWF operational NWP model. Generically global good performances over land.

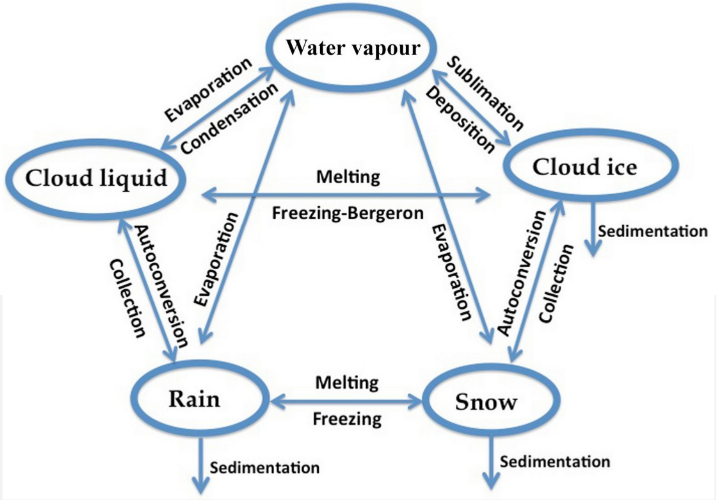
Kain – Fritsh

Developed for intermediate resolution (~25km) over Ocean. Fast response for NWP application, can sometimes over-react for climate applications.

MIT (Emanuel)

Mass flux scheme developed by legend Kerry Emanuel, low overall bias but poor representation of extremes. Can create instabilities.

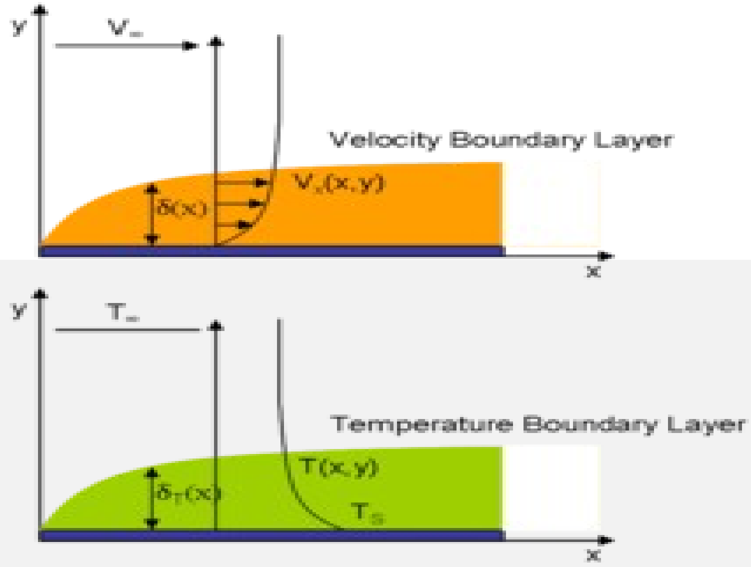
Microphysics



Parameterize in-cloud microphysics and phase status changes

- Warm Rain – SUBEX scheme
    - Should be used only for resolutions > 20 km. Missing ice phase.
- Nogherotto-Tompkins scheme
    - Developed by ICTP to work in RegCM from ideas now in the ECMWF model code
- WRF Simple Microphysics 5 species WSM5
    - Code borrowed and adapted from WRF NWP model. Used to verify the NoTo Scheme performances as a reference implementation with ice phase.

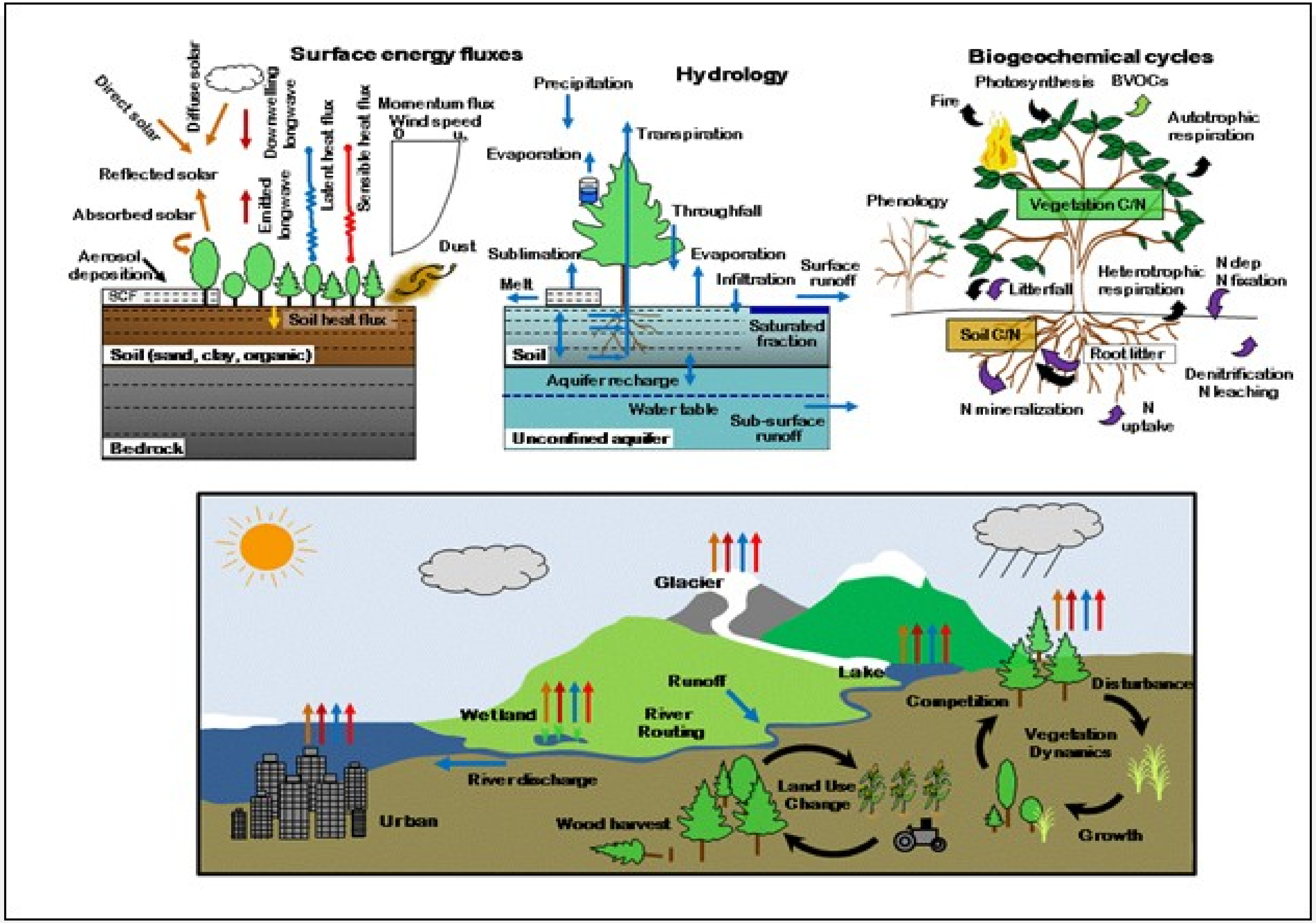
PBL scheme



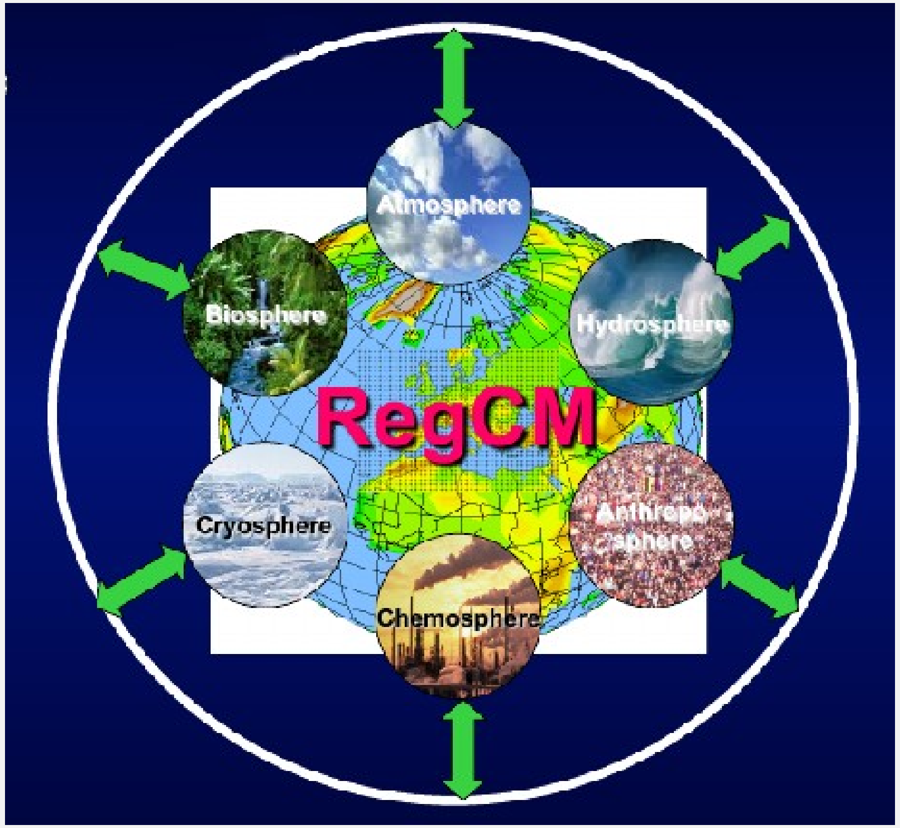
Solve eddy diffusion and transport in the planetary boundary layer.

- Non-local Holtslag scheme (Holtslag, 1990)
- UW-PBL (O’Brien et al. 2011)

CLM4.5 surface model



RegCM-ES in RegESM



https://github.com/uturuncoglu/RegESM

RegCM installation 1

Requisites

-2) Some reasonable computing resources. Minimal would be a multi-core system. Laptops STRONGLY discouraged. Best HPC cluster with high speed interconnect.
-1) A LOT of storage. Depending on the resolution/options multi Terabyte data volumes are very likely. USB data transfer are Slooooow.
0) Unix like OS (WSL in windows can be used, MacOS or Linux OK, the second one BETTER)
1) Fortran compiler – GNU gfortran = Intel OneApi = Nvidia nvfort all ok.
2) MPI library: used for parallel execution. From multi-core to multi-node.
3) NetCDF library with netCDF4 support (HDF5)

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On any linux distro, all is ready packaged. Keys are netcdf and mpi.
On ubuntu: `apt install libnetcdff-dev openmpi-dev`
Multiple options can be available for MPI.

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RegCM installation 2

```
ictptutor@ins45071:~$ cd

ictptutor@ins45071:~$ git clone https://github.com/ICTP/RegCM.git

ictptutor@ins45071:~$ cd RegCM

ictptutor@ins45071:~$ git checkout ictp_devel

ictptutor@ins45071:~/RegCM$ bash bootstrap.sh

ictptutor@ins45071:~/RegCM$ ./configure --enable-clm45

ictptutor@ins45071:~/RegCM$ make version

ictptutor@ins45071:~/RegCM$ make install
```

RegCM installation 3

Creating a run environment on ICTP cloud machine

```
ictptutor@ins45071:~$ cd

ictptutor@ins45071:~$ mkdir testrun

ictptutor@ins45071:~$ cd testrun

ictptutor@ins45071:~/testrun$ mkdir input output

ictptutor@ins45071:~/testrun$ ln -sf \
       /media/ictpuser/PWF_Cam2/RegCM_Data/tutorial RCMDATA

ictptutor@ins45071:~/testrun$ cp \
       /media/ictpuser/PWF_Cam/Distribution/Users/ggiulian/PWF/WAS.in .
```

RegCM installation 3-bis

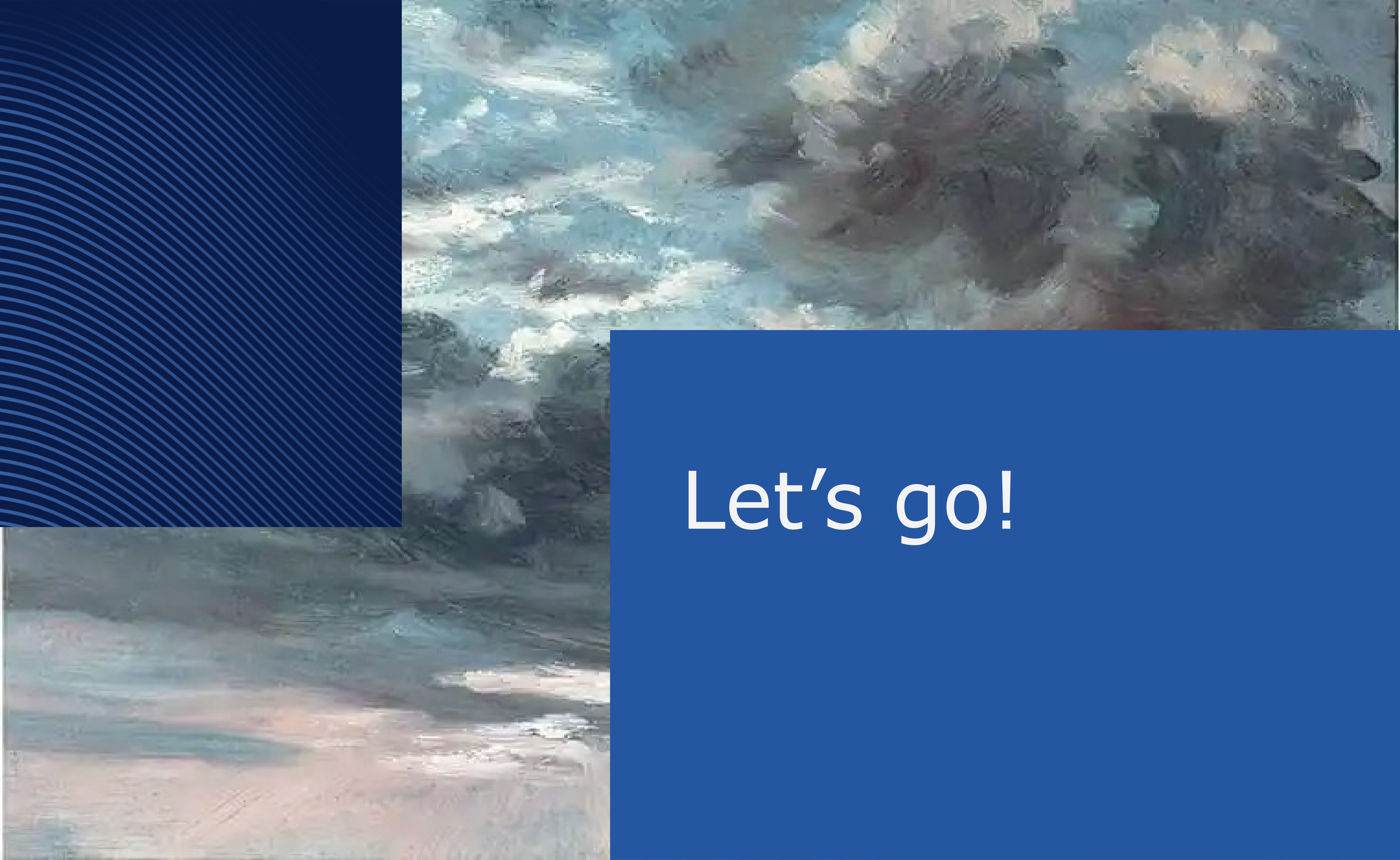
Creating a run environment on another system:

```
ictptutor@ins45071:~$ cd

ictptutor@ins45071:~$ mkdir testrun

ictptutor@ins45071:~$ cd testrun

ictptutor@ins45071:~/testrun$ mkdir input output

ictptutor@ins45071:~/testrun$ ln -sf ~/regCM/bin .

ictptutor@ins45071:~/testrun$ [ copy data ~550 GB from disk OR download them from
              http://clima-dods.ictp.it/regcm4/tutorial ]

ictptutor@ins45071:~/testrun$ wget \
              http://clima-dods.ictp.it/Users/ggiulian/PWF/WAS.in
```

RegCM test run

VERY BASIC hindcast simulation

```
ictptutor@ins45071:~/testrun$ ./bin/terrainCLM45 WAS.in     # <= Create static

ictptutor@ins45071:~/testrun$ ./bin/mksurfdataCLM45 WAS.in  # <= Static for CLM45

ictptutor@ins45071:~/testrun$ ./bin/sstCLM45 WAS.in         # <= SST interpolation

ictptutor@ins45071:~/testrun$ ./bin/icbcCLM45 WAS.in        # <= BC created

ictptutor@ins45071:~/testrun$ ln -sf ~/RegCM/Testing/RRTM_DATA/* . <= RRTM data

ictptutor@ins45071:~/testrun$ mpirun ./bin/regcmMPICLM45 WAS.in  # <= Model
```



Let’s go!