Getting started with the IPSL tools: modipsl and libIGCM

Exercises for Training course

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!!! Please read this first introduction carefully !!!

The aim of this document is to give you all the information to know about how to install, compile and launch simulations with reference configurations using ***modipsl*** and ***libIGCM*** environment.
During the exercises, we show you step by step how to handle these tools and simulations but you will have to search in the IGCMG documentation for all of the details : http://forge.ipsl.jussieu.fr/igcmg_doc. It's all part of the training!

The present document contains an introduction section (0.) followed by 12 sections with exercises (see the table of contents thereafter). Depending on your knowledge of modipsl and libIGCM, we advise you to use this document as follows:

- ***For beginners*** (if you never used the tools or just a little bit), first you have to focus on **sections 1 and 2** which detail how to *install, compile and launch a basic simulation*. Note that subsection 2.6 is only useful for LMDZ users (LMDZ and LMDZOR).
  If you have time, you can then continue with **sections 3 to 7**.
  If you finish all of them, you can then choose some other exercises from section 8 to 12, depending on your future use of the tools.
- ***For more advanced users***, we advise to still start with sections 1 and 2 as you will need the *basic simulation* for other sections. But you should not spend too much time on these two sections.
  Then continue with sections 3 to 7 to learn about *debugging, post-processing and monitoring*.
  If you finish all of them, you can then choose some other exercises from section 8 to 12, depending on your future use of the tools.
- Note that **section 11** about **Ensemble** is only for users who know what an Ensemble is. If you don't, that probably means that you won't need to do ensemble runs.

- Exercise using NEMO configuration (section 8) is proposed as a complement.

All exercises can be done at ***Jean-Zay/IDRIS*** or at ***Irene/TGCC*** and most of them at ***Ciclad/IPSL*** and ***obelix/LSCE***.
For ***Ciclad/IPSL***, you can only do the following sections: **0 -> 2.3** ; **3** ; **7.3** ; **10**.

To work at ***Jean-Zay/IDRIS***, you have to log in to the pre-processing front-end (otherwise the compilation of XIOS will not work):

ssh your_login@jean-zay-pp.idris.fr

Exercises proposed in this training session are using LMDZOR_v6 (LMDZ + ORCHIDEE) and ORCHIDEE_trunk (ORCHIDEE offline) configurations. But everything you will learn will be usable with all models configuration (IPSLCM6, LMDZORINCA, etc.)

Table of content

0. Introduction

0.1 How to correctly install your environment?

Before working with modipsl/libIGCM on IDRIS or TGCC you need to install your environment. For this you will find all the necessary information here:

https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/ComputingCenters

Take some time to read information about the machine you are using:

- ➔ For IDRIS files systems
  https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/ComputingCenters/IDRIS#Thingstoknowaboutfilesystems
- ➔ For TGCC files systems
  https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/ComputingCenters/TGCC#Aboutfilesystems
- ➔ Working on Ciclad/IPSL
  https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/ComputingCenters/ESPRImesocenter
- ➔ Working on Obelix/LSCE
  https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/ComputingCenters/LSCE

Note on environment variables:

Warning : In this document, we mainly use the disk spaces' environment variables for IDRIS (`$WORK`…). If you are on **Irene** replace it by `$CCCWORKDIR`, and `/data/$USER/` if you are on **Ciclad**.
For other environment variables, please refer to the documentation of each machine (see above).

0.2 Subscribe to plateform-users mailing list

Before working with **modipsl/libIGCM** and IPSL's models, you need to subscribe to the **plateform-users mailing list**. Do this by following the link :

https://listes.ipsl.fr/sympa/info/platform-users

1. Install and compile

In this section, you will learn how to install the tools and compile the configuration. All commands needed are listed in the text.

Start with creating a new directory in your `$WORK`.

Warning : in all commands, replace `$WORK` by **`$CCCWORKDIR`** if you are on **Irene**, and **`/data/$USER/`** if you are on **Ciclad**.

```
mkdir $WORK/MYFIRSTTEST ; cd $WORK/MYFIRSTTEST
```

1.0 Install modipsl

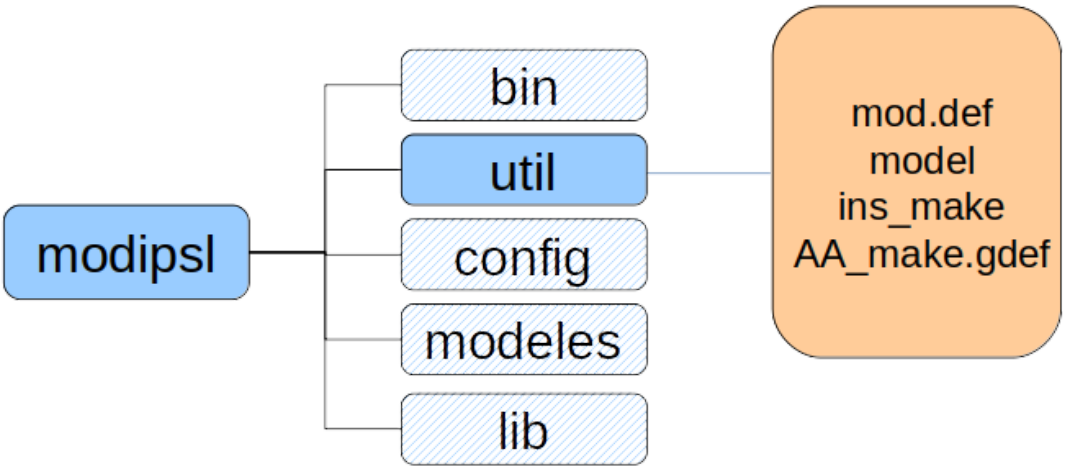
Download modipsl:

```
svn co http://forge.ipsl.jussieu.fr/igcmg/svn/modipsl/trunk modipsl
```

Other method: as you have installed the IPSL environment, you can use the command ***`svn_ano`*** on TGCC and IDRIS, instead of the previous one to download modipsl:

```
mkdir $WORK/MYTESTALIAS ; cd $WORK/MYTESTALIAS ; svn_ano
```

Explore **`modipsl/`** directory. You can see that some directories are empty. To download one model's configuration and all associated scripts you will use a script stored in `modipsl/util/` directory.
Compare your `modipsl/` tree and the following diagram.



You can find the description of all these directories here :
https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Install#Themodipsldirectories

Scripts stored in `util/` directory can be used to :

- Choose the models configuration to download (`mod.def`)
- Download this configuration (`model`)
- Create a makefile adapt to this configuration and the supercomputer where you are working (`ins_make`, `AA_make.gdef`) (If you extract a configuration older than v6.2)

Explore `util/` directory:

```
cd $WORK/MYFIRSTTEST/modipsl/util
ls
```

1.1 Extract LMDZOR_v6 configuration

Note for Ciclad users:
Because all configurations cannot run efficiently on Ciclad, the experiment used for the purpose of this training will be different than for the other machines: it shall be an ORCHIDEE offline run, whose creation procedure is slightly different. Please refer to the notes indicated in the instructions.

Description: The script ***`model`*** is used to download a specific predefined configuration with the model source codes and tools needed. The script uses the file ***`mod.def`*** that contains

specifications for each predefined configuration. Use the command `./model -h` to see all existing configurations and `./model -h config_name` for information of a specific configuration. Same information can be found by reading the `mod.def` file. You can find information on how you can read the `mod.def` file on this page:
https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Install#Syntaxinmod.def

Question 1a Using `./model -h` command, find which version of LMDZ, ORCHIDEE and libIGCM are currently defined in the configuration **LMDZOR_v6.2_work**? Note the SVN revision number and SVN branch or tag name. Verify that you can find the same information in the `mod.def` file.

Note on Subversion (SVN) - a version control software :

IPSL models are saved via svn, this allows to keep track of changes done over the time, backup and store all previous versions, centralize all existing developments done on each model.

Each modification on svn will match with a revision number and a save path (with prefix trunk, tag or branches). To know them, you should use the command `svn info`.

For TGCC and IDRIS users (for Ciclad users see below) :

```
cd $WORK/MYFIRSTTEST/modipsl/util
./model -h
./model -h LMDZOR_v6.2_work
vi mod.def
```

Now download the configuration LMDZOR_v6.2_work by using the script `model`. Note: for the first extraction passwords for ORCHIDEE and LMDZ are needed.

```
./model LMDZOR_v6.2_work
```

For Ciclad users:

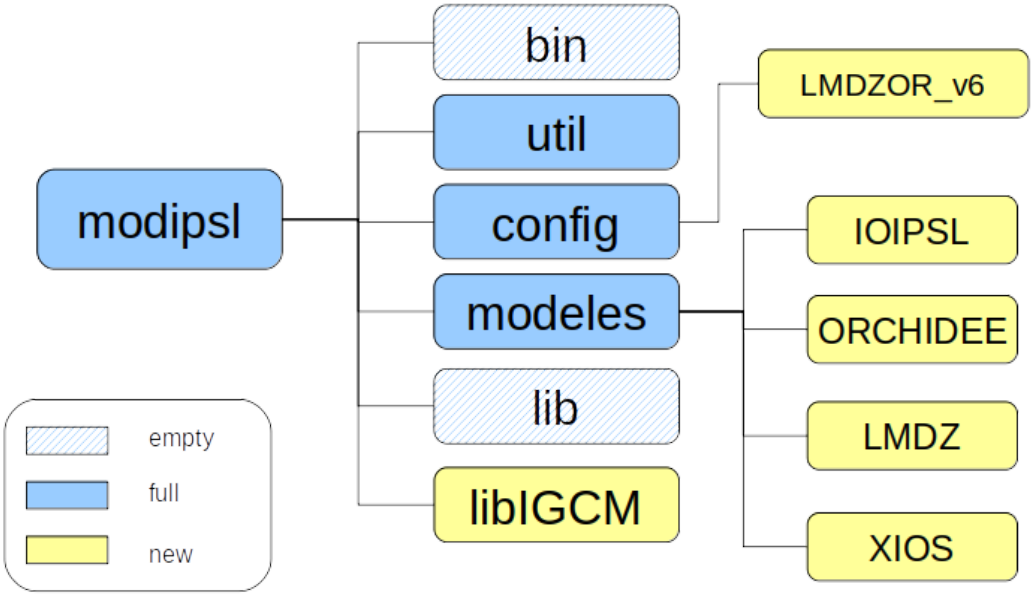
Download the ORCHIDEE_trunk_TP configuration by using the `model` script.

```
./model ORCHIDEE_trunk_TP
```

When prompt for password:

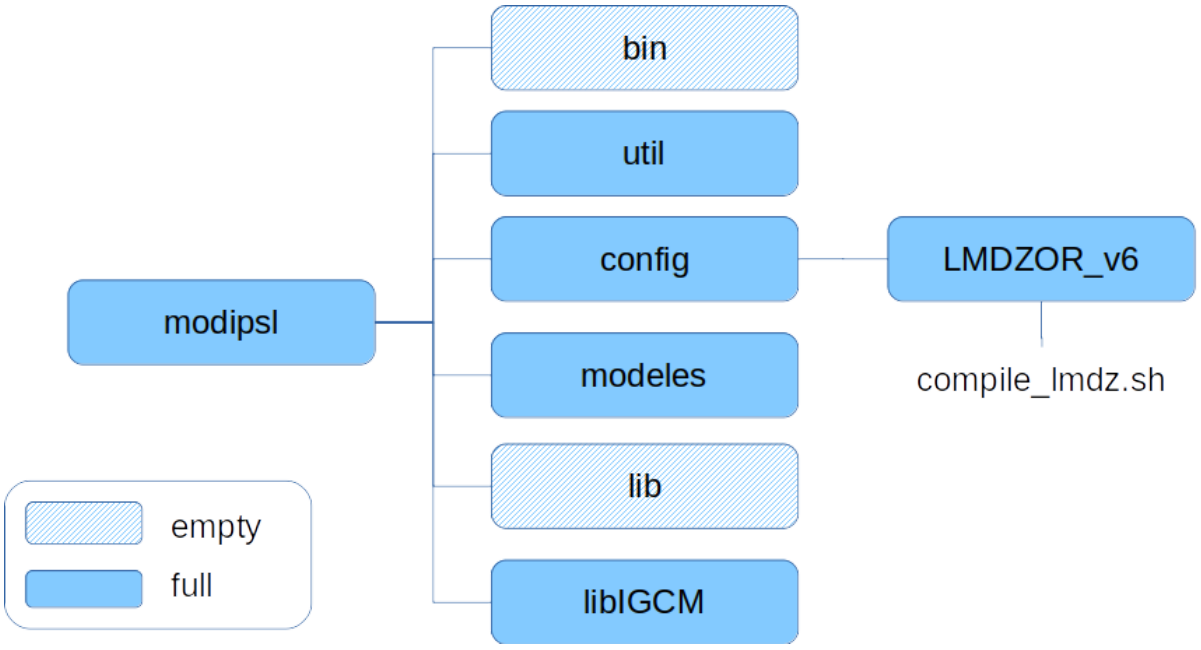
hit enter and then use ORCHIDEE / LMDZ logins credentials given at the beginning of the day.

Now explore the directories in `modipsl`. You can see in *`modipsl/modeles`* that you have one directory per model. You also find the directory *`modipsl/config/LMDZOR_v6`* (*`modipsl/config/ORCHIDEE_OL`* for ciclad) and the directory *`modipsl/libIGCM`*. Type *`svn info`* in each model directory to get information about the extracted version and compare them with your answer to question 1.a.



1.2 Compile with the resolution 144x142x79

We use a specific script to launch the configuration compilation. This script is found in config/LMDZOR_v6 directory.



Question 1b Open the compilation script and try to find all options available for the compilation. Find which resolution is the default one, then launch compilation for the resolution 144x142x79. You can use these page https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Compile#Scriptforconfigurations_v6.2andnewer to help you to understand the script syntax.

We will use the LMDZOR default resolution 144x142x79 for the atmosphere. To compile, you use the compilation script `compile_lmdzor.sh` with option the chosen resolution:

```
cd $WORK/MYFIRSTTEST/modipsl/config/LMDZOR_v6
./compile_lmdzor.sh -resol_atm 144x142x79
```

For Ciclad users:

We will compile an ORCHIDEE offline configuration, using the `compile_orchidee_ol.sh` script.

```
cd /data/$USER/MYFIRSTTEST/modipsl/config/ORCHIDEE_OL
./compile_orchidee_ol.sh
```

Today (2021-01-29) for Training course:

Launch the compilation as explained above.

In case that the compilation duration is too long, you can copy the executable in your bin directory:

At TGCC (replace `**computer**` by `irene-amd` or `irene-skl`):
```
cp ${R_IN}/TRAINING/MODIPSL_HandsOn_20210129/LMDZOR_v6/**computer**/bin/* $CCCWORK/MYFIRSTTEST/modipsl/bin/.
```

At IDRIS:
```
cp ${R_IN}/TRAINING/MODIPSL_HandsOn_20210129/LMDZOR_v6/jean-zay/bin/* $WORK/MYFIRSTTEST/modipsl/bin/.
```

At Ciclad :
```
cp ${R_IN}/TRAINING/MODIPSL_HandsOn_20210129/ORCHIDEE_OL/ciclad/* /data/$USER/MYFIRSTTEST/modipsl/bin/.
```

Where `${R_IN}` is :

- `TGCC → /ccc/work/cont003/igcmg/igcmg`
- `IDRIS → /gpfswork/rech/psl/commun`
- `Ciclad → /projsu/igcmg`

You also have to create the environment file (it will be use by the simulation to install the environment):

```
cd modipsl/config/LMDZOR_v6/ARCH
```
or
```
cd modipsl/config/ORCHIDEE_OL/ARCH
```

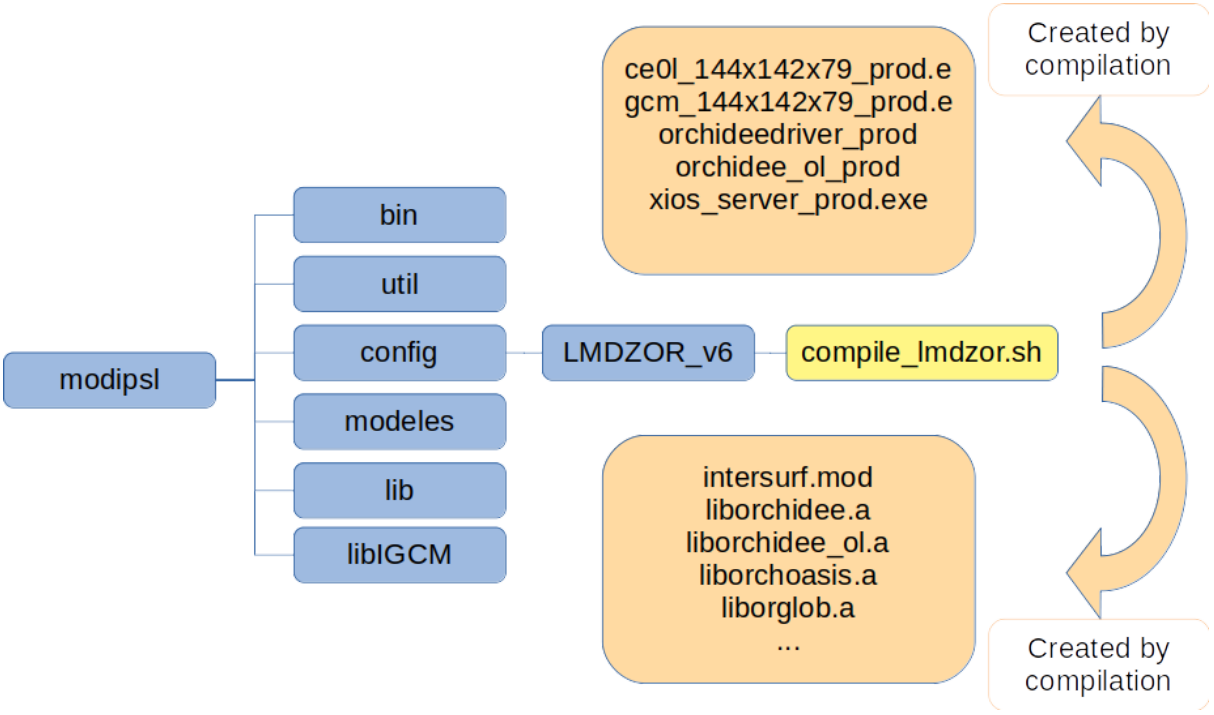
Then: (replace `**computer**` by `irene-amd`, `irene-skl`, `jean-zay` or `ciclad`)
```
ln -s arch-**computer**.env arch.env
```

Comments on compilation

The compilation creates executables which are necessary for the launch of the simulation. Note that the executables are done for the specific configuration of models that you have downloaded (see 1.1 section).

When the compilation is over you will find executables in the directory *`modipsl/bin`*. The compilation takes between 30 and 60 minutes depending on the platform. After the first compilation, if you run a new one, only modified files and files depending on them will be compiled.

Remember to verify that the executables are present in the directory ***`modipsl/bin`*** !



In the case of LMDZOR_v6 configuration, the executables *orchideedriver_prod* and *xios_server_prod.exe* are specific to the offline model. In the following exercises we will use the coupled configuration and ce0l, gcm, and xios_server executables.

Question 1c How can you do if you want to recompile the whole code? Open the compilation script and check the different script options.

Specific installation of LMDZ at obelix/LSCE:

Read more about using LMDZ at obelix here:
https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/ComputingCenters/LSCE

2. Basic simulations

For Ciclad's users: *Orchidee_ol doesn't work exactly like other configurations (as described below). You can read this section to know how other configurations works, and then do what is written in the array "ciclad" at the end of part 2.1.*

In a configuration with the same executable we can choose between several types of experiments. All experiments available are stored in `EXPERIMENTS/` directory.

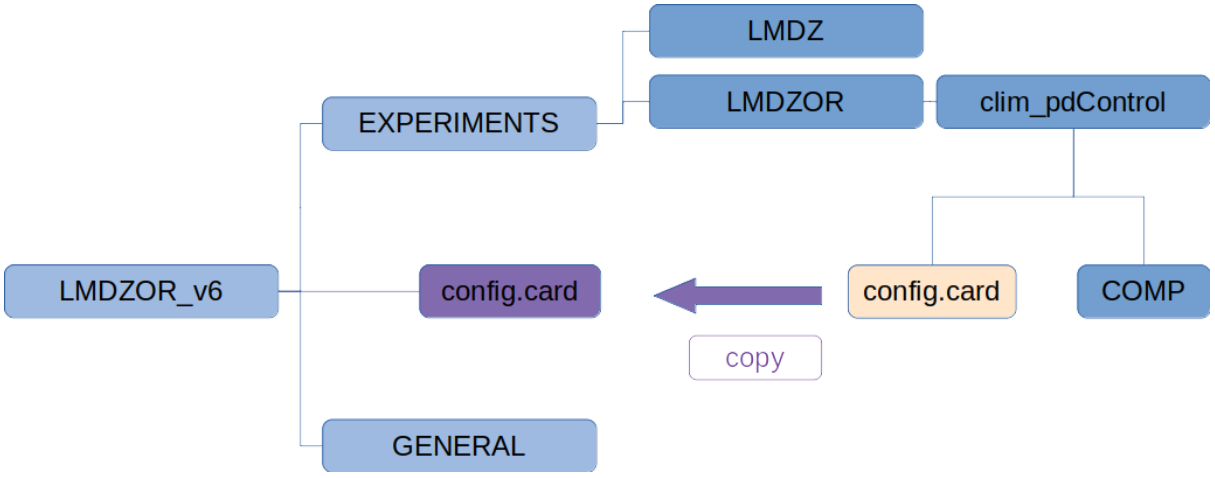
For example, with LMDZORINCAREPR configuration (lmdz + orchidee + inca + reprobus) you can launch a lmdz simulation, or lmdzor, or lmdzorinca, or lmdzrepr, or lmdzorincarepr and **all of them share the same executable**.

So once you have chosen which model configuration you want to work with, you have to download it and make the compilation, and then you can choose which type of experiment you want to use.

2.1 Create first experiment directory

In the `EXPERIMENTS` directory you can find different predefined experiments which you can possibly run using the configuration you extracted. For the LMDZOR_v6 case, you can choose between LMDZOR and LMDZ type of experiments.

For this exercise we will create an experiment from `LMDZOR/clim_pdControl`. To do this we copy the `config.card` found in `EXPERIMENTS/LMDZOR/clim_pdControl` to the directory `config/LMDZOR_v6/`.



The simulation directory will be created with information found by libIGCM in the file `config.card`. Before creating this directory, we need at least to indicate the simulation name. Depending on the machine you are logged in, you also have to change parallelization's information (see below).
The script `modipsl/libIGCM/ins_job` **will be used to create the simulation directory** from the simulation's name in `config.card`.

Now follow the instructions:

```
cd $WORK/MYFIRSTTEST/modipsl/config/LMDZOR_v6
cp EXPERIMENTS/LMDZOR/clim_pdControl/config.card .
```

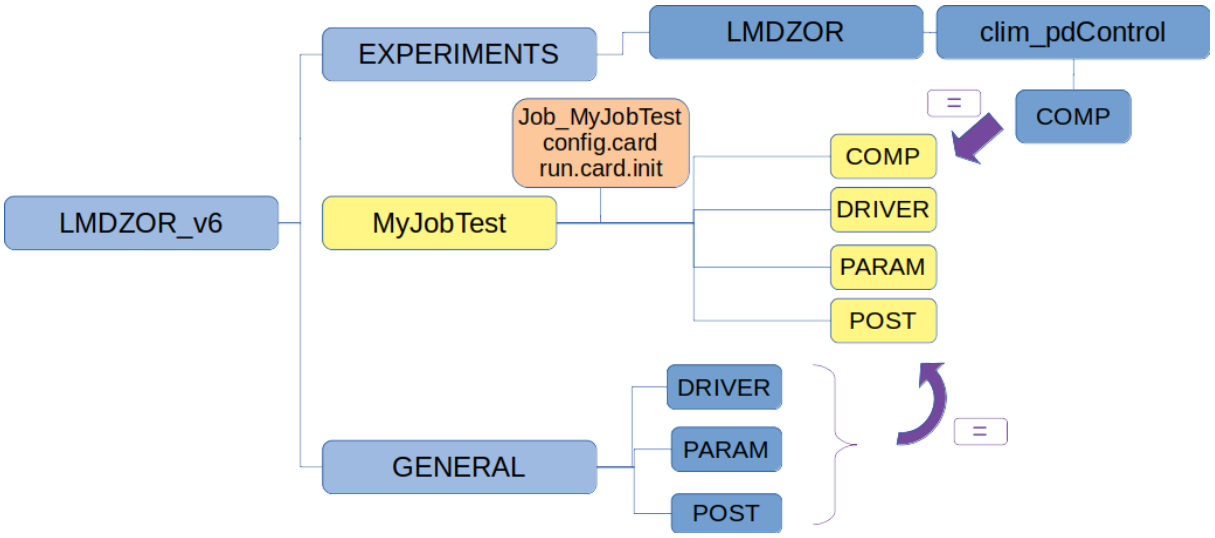
```
vi config.card
      # Modify JobName=MyJobTest
      # Modify Executable part for the parallelization
[Executable]
ATM= (gcm_${ResolAtm}_${OptMode}.e, lmdz.x, 71MPI, 8OMP)
SRF= ("", "")
SBG= ("", "")
IOS= (xios_server_${OptMode}.exe, xios.x, 1MPI)

       # On obelix, change to 7 MPI and 1 OMP in ATM
       # On Irene skl or amd, change nothing for parallelization
       # On JeanZay, change 8 OMP by 5 in ATM

../../libIGCM/ins_job    # At JeanZay enter your project ID
                           # At Irene enter your project ID and default
                         # answer for other questions

cd MyJobTest
```

The submission directory has been created with the same name as the `JobName`. Explore this directory and compare to the following diagram.



For Ciclad users:
Since the experiment used on Ciclad is an ORCHIDEE offline run, the procedure for creating the experiment is a little bit different: we do not copy a `config.card` file into the parent directory. Instead, you only have to copy prepared directories as an experiment directory. We will also customize our domain so that it is not too large. In any case, the `modipsl/ins_job` script is still used to create the job eventually.

```
cd /data/$USER/MYFIRSTTEST/modipsl/config/ORCHIDEE_OL
cp -r OOL_SEC_STO_FG2 MyJobTest
cd MyJobTest
vi config.card # => Change JobName=MyJobTest
               # SpaceName=TEST
               # Modify Executable part for the parallelization
OOL= (orchidee_ol_${OptMode}, orchidee_ol, 3MPI)
IOS= (xios_server_${OptMode}.exe, xios.x, 1MPI)

# Domain customization
vi PARAM/run.def
# Add these lines
LIMIT_WEST = -10.
LIMIT_EAST = 20.
LIMIT_NORTH = 60.
LIMIT_SOUTH = 30.

../../../libIGCM/ins_job
```

2.2 Define and launch your first simulation of 1 day

In this subsection, you will prepare and launch your first test simulation.

Generally, before any important experiment, it is good practice to check the good behaviour of the workflow with a test simulation. In particular, we need to check that pre and post processing stages do not induce any errors and that the simulation meets our expectations.

How to define a simulation?

To define a simulation, you need to answer the following questions :

1. **Which date to start and finish the simulation ?**
2. **Is your simulation a TEST, DEVT or PROD ? This choice define where your simulation output will be store**
   https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Running#Theoutputfiles
3. **Which calendar will you use ?**
   https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Setup#config.card
4. **Which initial states files ?**
5. **Which boundaries files ?**
6. **Which output variables ? With which frequency ?**
7. **Which post-processing ?**

If the simulation is a TEST (like in this exercise) we cannot answer the last question (number 7). For this training session, we will use default arguments in `config.card` for questions 3, 4, 5 and 6. The 7th question will be seen in a later exercise.

Setup the `config.card`

You must be in the directory specially created for your simulation (`MyJobTest/`).

Now setup the `config.card` to do a short 1 day simulation. (`DateEnd` = last day of simulation):

```
DateBegin=1980-01-01
DateEnd=1980-01-01
```

This is a first test simulation so keep `SpaceName=TEST`. This option will deactivate pack functions and no archiving will be done. Output will therefore be found on `$SCRATCHDIR` (Irene) or `$SCRATCH` (JeanZay).

```
JobName=MyJobTest
#----- Short Name of Experiment
ExperimentName=clim
#----- DEVT TEST PROD
SpaceName=TEST
LongName="LMDZOR configuration"
TagName=LMDZOR
#D- Choice of experiment in EXPERIMENTS directory
ExpType=LMDZOR/clim_pdControl
```

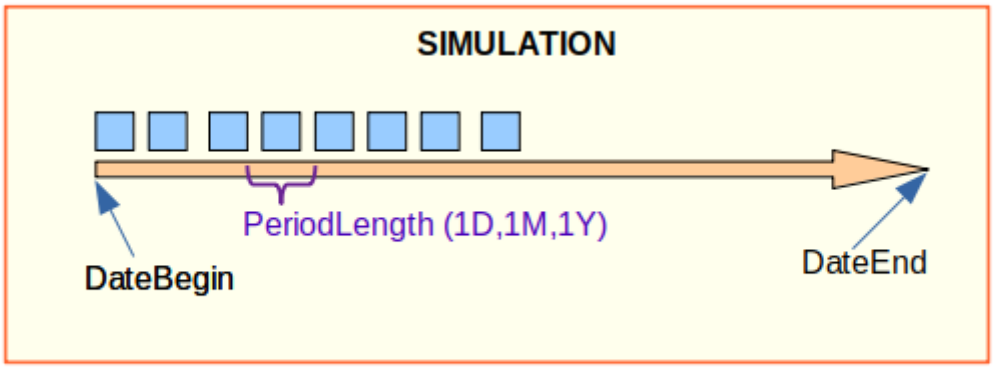
Note for Ciclad users:
You should find `LongName` as empty, `TagName=OL2`, `ExperimentName=test`, and no `ExpType` field. All of these settings are normal.

For a 1 day simulation you will indicate `PeriodLength=1D`:

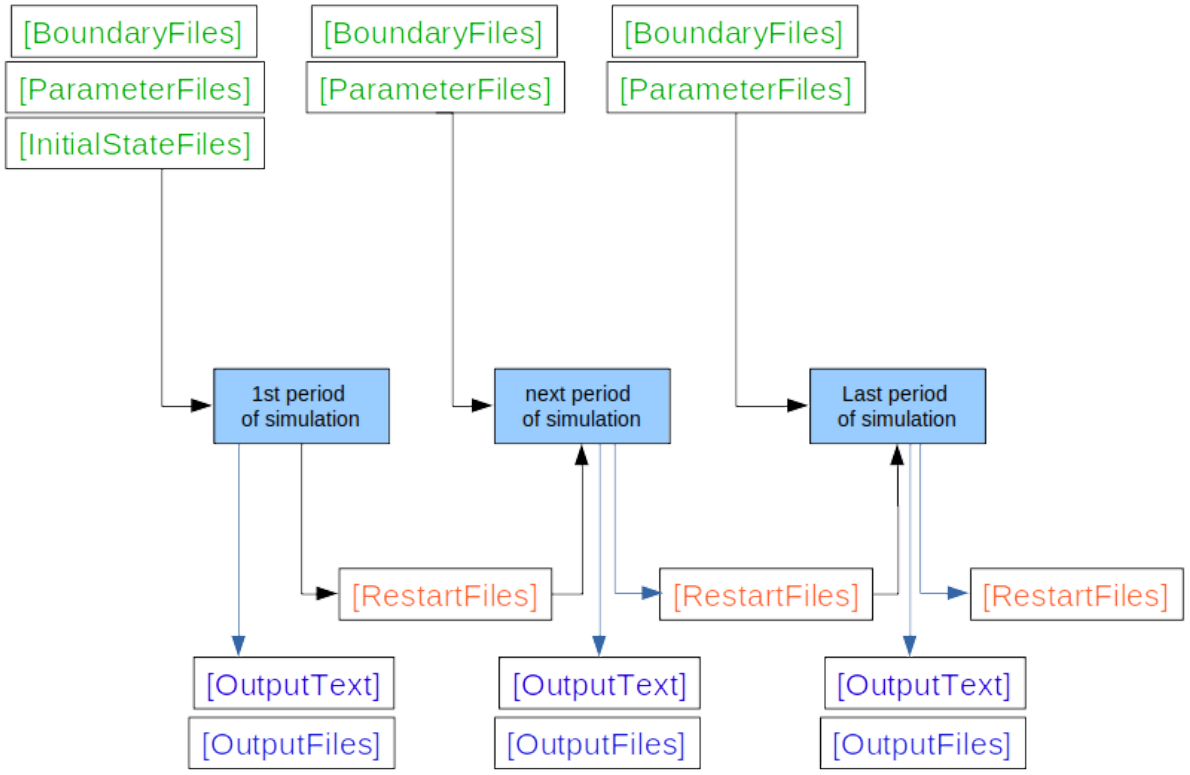
```
PeriodLength=1D
```

What is a period?

A simulation is a succession of **periods**.



At the end of each of them the simulation creates output files used for some of them as input files for the next period.



Post-processing in `config.card`

We will deactivate all post-processing in `config.card` (you will see how to use them in sections 2.4 and 4.):

```
#D-- Post -
[Post]
#D- PackFrequency determines the frequency of pack submission
PackFrequency=NONE
```

```
#D- TimeSeriesFreqency determines the frequency of post-processing submission
#D- Set NONE to deactivate the creation of all time series
TimeSeriesFrequency=NONE
#D- SeasonalFrequency determines the length for each seasonal average
#D- Set NONE to deactivate the creation of all seasonal avereage
SeasonalFrequency=NONE
#D- Offset for seasonal average first start dates ; same unit as SeasonalFrequency
#D- Usefull if you do not want to consider the first X simulation's years
SeasonalFrequencyOffset=0
#D- If you want to produce compute PCMDI metrics from seasonal average
#D- Set TRUE or FALSE to activate/deactivate the metrics computation.
MetricsPCMDI=FALSE
```

The main job `Job_MyJobTest`

This file is the one which is used by the job scheduler to launch the simulation. It needs information in the header which are specific to the machine you are using.

Now you have to verify the header in the main job `Job_MyJobTest` and then you can submit the job.
You can find here https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Setup#Jobheaders a documentation on job headers syntax for Irene and Jean Zay.

To launch a test (on Jean Zay or Irene) you need to modify the CPU time and indicate that you will use the queue test.

- **Header for Jean Zay:**

```
#######################
## JEANZAY    IDRIS ##
#######################
#SBATCH --job-name=MyJobTest    # Job Name
#SBATCH --output=Script_Output_MyJobTest.000001       # standard output
#SBATCH --error=Script_Output_MyJobTest.000001        # error output
#SBATCH --nodes=9
#SBATCH --exclusive
#SBATCH --ntasks=72   # Number of MPI tasks
#SBATCH --hint=nomultithread        # 1 processus MPI par par physical core (no
hyperthreading)
#SBATCH --time=00:30:00             # Wall clock limit (seconds)
#SBATCH --account for@cpu
#SBATCH --qos=qos_cpu-dev                          # Queue test
```

- **Header for Irene skl or rome:**

```
######################
## IRENE   TGCC/CEA ##
######################
#MSUB -r MyJobTest                              # Job name
#MSUB -o Script_Output_MyJobTest.000001 # Standard output
#MSUB -e Script_Output_MyJobTest.000001 # Error output
#MSUB -eo
#MSUB -n 976                                    # Number of MPI tasks allocated
#MSUB -x                                        # Node exclusivity
#MSUB -T 1800                                   # Wall clock limit (seconds)
#MSUB -Q test                                   # Test queue (max: 1800 seconds)
#MSUB -A gen****                                # Project allocation
#MSUB -q skylake         (or  rome )                    # Partition used
#MSUB -m store,work,scratch                     # Visible spaces
```

(for Irene, the wall clock limit for test queue is 1800 seconds maximum, if you are not running on test you can ask for 86400 seconds max).

- **Header for Ciclad:**

This should come up as default:

```
######################
##   CICLAD   IPSL ##
######################
#PBS -N MyFirstTest
#PBS -m a
#PBS -j oe
###PBS -q h12   # Queue for 12 hours at ciclad only
#PBS -o Script_Output_MyFirstTest.000001
#PBS -S /bin/ksh
#PBS -v BATCH_NUM_PROC_TOT=4
#PBS -l nodes=1:ppn=4
#PBS -l mem=6gb
#PBS -l vmem=30gb
```

Launch the job

Now, use one of these commands (depending on your machine) to launch the job:

`sbatch` (IDRIS) / `ccc_msub` (TGCC) / `qsub` (Obelix, Ciclad)

```
cd $WORK/MYFIRSTTEST/modipsl/config/LMDZOR_v6/MyJobTest/

JeanZay: sbatch Job_MyJobTest
Irene: ccc_msub Job_MyJobTest
Obelix, Ciclad: qsub Job_MyJobTest
```

The file `run.card`: to follow the status of your simulation

To know the status of your simulation a file `run.card` is created. Please read the pages https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Running#Statusoftherunningsimulation and https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Running#Endofthesimulation for more information.

Then, use this file to check if your simulation is well finished.

You can also use the following commands to check the job queue and check if your simulation is waiting/is still running/has finished:

squeue (IDRIS) / ***ccc_mpp*** (TGCC) / ***qstat*** (Obelix)

To see only yours jobs you can add the option ***-u $user***.

JeanZay : `squeue -u $USER`
Irene: `ccc_mpp -u $USER`
Obelix, Ciclad: `qstat -u $USER`

How to delete a job?

scancel (IDRIS) / ***ccc_mdel*** (TGCC) / ***qdel*** (Obelix, Ciclad) followed by your job ID:

On JeanZay

```
squeue -u $USER
>> JOBID PARTITION    NAME  USER ST    TIME  NODES NODELIST(REASON)
>>  389685 cpu_p1 LMDZOR02  rpsl592  R     11:05 15 r5i7n[9-23]
scancel 389685
```

On Irene

```
ccc_mpp -u $user
>> USER         ACCOUNT    BATCHID  NCPU   QUEUE      (...)
>> p24cozic     aercmip6   3351314  624    skylake    (...)
ccc_mdel 3351314
```

On Ciclad

```
qstat -u $USER
Job ID    Username     Queue Jobname       SessID  NDS   TSK   (...)
-----------------------------------------------------------------
358288    tlurton      short MyFirstTest   57960    1     4    (...)
qdel 358288
```

Explore the ***Script_Output_*.0001*** file and ***run.card*** in the submit directory.
If your simulation has a problem the first thing to do is to read and analyse the file Script_Output. It will give you first important information on your simulation.

https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/CheckDebug#AnalyzingtheJoboutput:Script_Output

Explore the output directories.

Question 2a Which files are produced and where are they stored ? You did not find any files in the archive directory at `$STORE` (Jean Zay) or `$CCCSTOREDIR` (Irene)? Why not?
Help with this documentation to answer this question
https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Running#Theoutputfiles

If needed, how to clean up and relaunch

If an error occurred and you need to relaunch the whole experiment, **you need to erase all output created during previous submission**, stored in the different `IGCM_OUT/LMDZ/JobName` directories:

- IDRIS: `$WORK`, `$SCRATCH` and `$STORE`,
- TGCC: `$CCCSTOREDIR`, `$CCCSCRATCHDIR` and `$CCCWORKDIR`,
- Obelix: within `/home/scratch01/login`.
- Ciclad : `/data/login/`

In the submit directory you also have to remove `run.card`.

To ease the cleaning, the script `clean_PeriodLength.job` in ***libIGCM*** can be used. This script will clean up everything related to the last period that failed. Note that this script does not work if the `run.card` is missing or if you have `PeriodState=Completed` or `PeriodState=Running` in `run.card`. (in these two cases you can modify PeriodState to Fatal to allow clean_PeriodLength.job to work)

To use this script, stay in the submit directory `modipsl/config/LMDZOR_v6/MyJobTest`:

```
../../../libIGCM/clean_PeriodLength.job  #  Read  questions  and
answer yes to erase files.
```

2.3 Continue the simulation 4 more days

Now you want to continue your simulation for more days. For this you need to change in `config.card` the `DateEnd`.
NB: Do not change `DateBegin`.

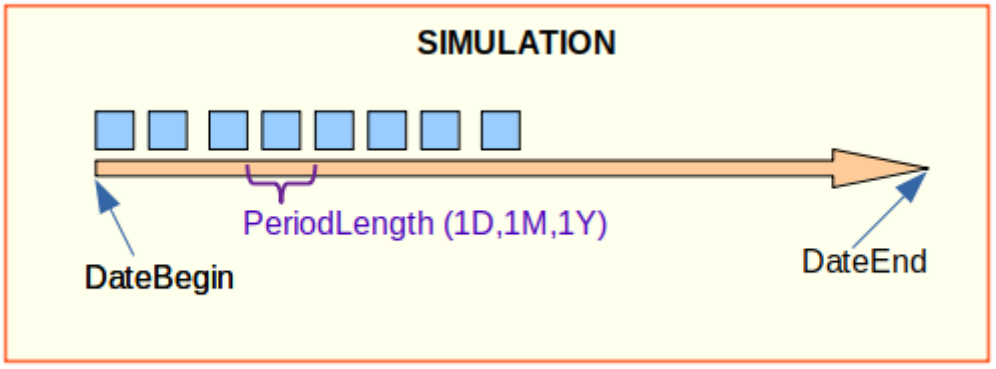
You also need to indicate to `run.card` that you will re-launch the simulation by changing `PeriodState=Completed` into `PeriodState=OnQueue`.

Do this for 4 more days:

```
vi config.card # →  Modify DateEnd
vi run.card # → modify PeriodState
sbatch Job_MyJobTest / ccc_msub Job_MyJobTest / qsub Job_MyJobTest
```

Question 2b How many times did the job go into the queue?

Your simulation will be submitted 4 times, because it's a succession of 4 simulations of 1 day. At the end of each **period** the simulation is submitted one more time to launch the next **period.**



To avoid all these submissions, you will modify the parameter **`PeriodNb`** in the main Job. PeriodNb will be the number of Period that can be launch in the CPUtime.

Question 2c : create a new simulation of 5 days, always with `PeriodLength=1D`, but with a different `PeriodNb` parameter to launch the job only one time on queue.

Question 2d Look in your first simulation run.card. How long did one day take? Did all days take the same time?

Once done with the test simulation, we need to be sure that we have all the wanted output files and that they store all the variables required to analyse the simulation.

To know where are stored your output files on TGCC and IDRIS, you can read this page https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Running#Theoutputfiles

Question 2e Look in your scratchdir to check all directories and files created by your simulation.

In the next exercise you will do a simulation in PROD mode. Like this you will see the difference between these two modes.

2.4 Create another simulation with pack

This exercise can not be done on obelix or on ciclad because the pack function is not activated on these computers.

Create a new experience of type `LMDZOR/clim_pdControl`. This time we will also activate the archiving Pack functionality. The pack is activated when ***`SpaceName=PROD`*** or ***`DEVT`***. In this example, put ***`SpaceName=DEVT`***.

To test the pack functionality, set `PackFrequency=2M` in this exercise.
Launch 4 months with 1 month period length.

```
cp EXPERIMENTS/LMDZOR/clim_pdControl/config.card .

vi config.card
  # Modify : JobName
  # Modify : DateEnd=1980-04-30
  # Modify : PeriodLength=1M
   # Modify number of OMP threads if you are running on Obelix or JeanZay
(as before)
  # Activate pack : SpaceName=DEVT, PackFrequency=2M
  # Desactivate TimeSeries and Seasonnal average as before

../../libIGCM/ins_job

cd MyJobTest3

vi Job_MyJobTest3
  # for information : one month on JeanZay take between 550 and 650s CPU
Time. Define the CPU Time and the queue in function of this.
```

```
sbatch Job_MyJob / ccc_msub Job_MyJob
```

Continue with next exercises while this job is running.
Check how it is proceeding in the queue every now and then.

Question : explore output directories, can you understand what was done ?
Read this page to check what you understood correctly and what it's really done
https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Running#ConcatenationofPACKoutputs

2.5 Use differents forcing files

Forcings Files are divided in two categories : Initial States Files and Boundary files. They are defined in ***COMP/model.card*** (`COMP/lmdz.card`, `COMP/orchidee.card` etc.) files.

Initial State Files : these files give information on the state (atmospheric concentrations, temperatures etc.) of your domain at the beginning of the simulation. To start a new simulation you can choose to use default files given by modeles, or to start from the state of a previous simulation, or use the atmosphere state from one, and surface from another…
Read this documentation to learn how you can do these 3 choices
https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Setup#Setupinitialstateforthesimulation

Boundary Files : There are two kinds of boundaries files, those depending on time and those that will not change during the whole simulation.
https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Setup#TheBoundaryFilessection

Exercise :
Do a new simulation of 5 days using as an initial state file the restart created at the end of your simulation *MyJobTest*.
NB: It's not a problem if the date of the restart is not the date previous the beginning of your simulation. By coherence it's better, but it's not mandatory

```
vi config.card

#D-- Restarts -
[Restarts]
OverRule=y
#D- Last day of the experience used as restart for all components
RestartDate=1980-01-05
#D- Define restart simulation name for all components
RestartJobName=MyJobTest
#D- Path Server Group Login
```

```
RestartPath=$SCRATCH/IGCM_OUT/LMDZOR/TEST/clim  # use $CCCSCRATCHDIR on TGCC
```

Question : which files start.nc, startphy.nc, sechiba_rest_in.nc are used? Read the Script_output file to answer this question.

Exercise : modify `COMP/orchidee.card` to use the PFTmap of the current year of simulation, by using the variable `${year}`

Question : Verify in Script_output file you use the file you want.

2.6 CREATE_clim and CREATE_amip : Experiments to create initial state files and boundary conditions for LMDZ

This exercise can not be done on obelix or on ciclad.

`EXPERIMENT/LMDZ/CREATE_clim` and `EXPERIMENTS/LMDZ/CREATE_amip` are two experiments set-up that launch the program ***`ce01.e`***, a program based on LMDZ. This program is used to create initial state files (***`start.nc`*** and `startphy.nc`) and boundary condition files (`limit.nc`, `climoz_LMDZ.nc`) needed by LMDZ. The normal use of the LMDZOR_v6 configuration is to first run the experiment CREATE_clim or CREATE_amip and then the experiment clim or amip. The CREATE_clim/_amip experiment needs to be done only one time per resolution.

You will now launch the CREATE_clim experiment. Note that for a standard use of CREATE_clim you don't need to change anything.
Now install the submit directory for CREATE_clim:

```
cd modipsl/config/LMDZOR_v6
cp EXPERIMENTS/LMDZ/CREATE_clim/config.card .

../../libIGCM/ins_job

cd ELC-144x142x79
```

The directory ELC-144x142x79 was created and the config.card was moved inside. The resolution in the JobName was taken from the ***`config.card`*** file (parameter *ResolAtm*).

This experiment will launch the executable ***ce01_144x142x79_prod.e***. It is possible to use a test class because the run will not take more than a few minutes. You can set the test class in the beginning of the Job_ELC-144x142x79.

Submit the job as before:

```
sbatch Job_ELC-144x142x79  ccc_msub Job_ELC-144x142x79 /
    qsub Job_ELC-144x142x79
```

Output files are found in the directory ***IGCM_OUT/LMDZ/ELC-144x142x79*** on the $STORE at IDRIS, in $CCCSTOREDIR at TGCC or at /home/scratch01/login at obelix.

Explore the script output text file in the submit directory and the files in the output directory ELC-144x142x79.

Question 2e Where can you find the output? Which files are produced and where are they stored?

Question 2f What type of calendar is used? How many days contains a year? Check also the number of time step in the output file limit.nc. Do you know how you can change the calendar that has been used?

Question 2g Now create a new experiment clim_pdControl using boundaries files created by `ELC-144x142x79`. For this in COMP/lmdz.card you will modify the path for start.nc, startphy.nc, limit.nc and climoz_LMDZ.nc files.

2.7 Summary on how to extract, compile and launch a simulation

1. **Download modipsl**

```
mkdir $WORK/MYFIRSTTEST ; cd $WORK/MYFIRSTTEST
svn co http://forge.ipsl.jussieu.fr/igcmg/svn/modipsl/trunk modipsl
```

2. **Extract a configuration** (ex: LMDZOR_v6)

```
cd $WORK/MYFIRSTTEST/modipsl/util
./model LMDZOR_v6.2_work
```

3. Compil

```
cd $WORK/MYFIRSTTEST/modipsl/config/LMDZOR_v6
./compil_lmdzor.sh [options]
```

4. Create experiment directory

```
cd $WORK/MYFIRSTTEST/modipsl/config/LMDZOR_v6

cp EXPERIMENTS/LMDZOR/clim_pdControl/config.card .

vi config.card   ### Modify at least JobName=MyJobTest & // options

../../libIGCM/ins_job   # At JeanZay enter your project ID
                          # At Irene enter your project ID and default
                          answer for other questions
```

5. Launch simulation

```
cd $WORK/MYFIRSTTEST/modipsl/config/LMDZOR_v6/MyJobTest/

sbatch Job_MyJobTest / ccc_msub Job_MyJobTest /
 qsub Job_MyJobTest
```

3. Debug

We will now work on three small exercises for debugging. For these exercises we will use files prepared and stored :

- At irene, TGCC:
`/ccc/work/cont003/igcmg/igcmg/TRAINING/MODIPSL_HandsOn_20210129/LMDZOR_v6`

- At jean-zay, IDRIS :
`/gpfswork/rech/psl/commun/TRAINING/MODIPSL_HandsOn_20210129/LMDZOR_v6`

- At Ciclad:
`/projsu/igcmg/TRAINING/MODIPSL_HandsOn_20210129/ORCHIDEE_OL/TP_3/`

3.0 How can you analyze the Job Output : Script_Output ?

If your simulation has a problem the first thing to do is to read and analyse the file Script_Output. It will give you first important information on your simulation.

https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/CheckDebug#AnalyzingtheJoboutput:Script_Output

3.1 Debug : setup error

On Irene or on JeanZay copy the file lmdz.card_1 from the directory above into the lmdz.card file in the COMP sub-directory in your submit directory. You can choose one of the submit directory from the previous exercises or create a new one.

On Ciclad copy the file sechiba.card_1 from the directory above into the sechiba.card file in the COMP sub-directory in your submit directory (use an OOL_SEC_STO_FG2 experiment).

Now launch the simulation and debug it. Don't forget to clean up as done in exercise 2 before re-launching the simulation. Use clean_PeriodLength.job to do this.

Question 3b What was the error?

On Irene and JeanZay copy the lmdz.card_2 and debug again. On Ciclad copy the sechiba.card_2 and debug again. **Question 3c** What was the error?
On Irene and JeanZay copy the lmdz.card_3 and debug again. On Ciclad copy the sechiba.card_3 and debug again. **Question 3d** What was the error? If you don't find the solution you can try to find the difference between your actual lmdz.card file and the last one that was working.

3.2 Debug : error during the simulation

If you add a "print" directive in a model you can check during the simulation the output in the temporary directory RUN_DIR/.
Try to add a "print" in LMDZ or ORCHIDEE model

```
cd modipsl/modeles/LMDZ/libf/phylm/
vi physiq_mod.90
Look for line
   IF (iflag_pbl/=0) THEN
And add just before
write(lunout,*) 'debug LMDZ - iflag_pbl = ', iflag_pbl

OR

cd modipsl/modeles/ORCHIDEE/src_sechiba
vi sechiba.f90
Look for line
   IF ( river_routing .AND. nbp_glo .GT. 1) THEN
And add just before
WRITE (numout,*) 'debug ORCHIDEE - river_routing = ', river_routing
```

Note : The unit use by the `WRITE` instruction will be different from one model to another one.

Re-compile your models and launch a test of 1 month. Now don't wait the of the simulation, check your simulation id and go on the RUN_DIR directory (on the scratchdir),

```
cd $SCRATCH/RUN_DIR/Id_job/****/   (JeanZay)
cd $CCCSCRATCHDIR/RUN_DIR/Id_job/****/   (Irène)
ls
```

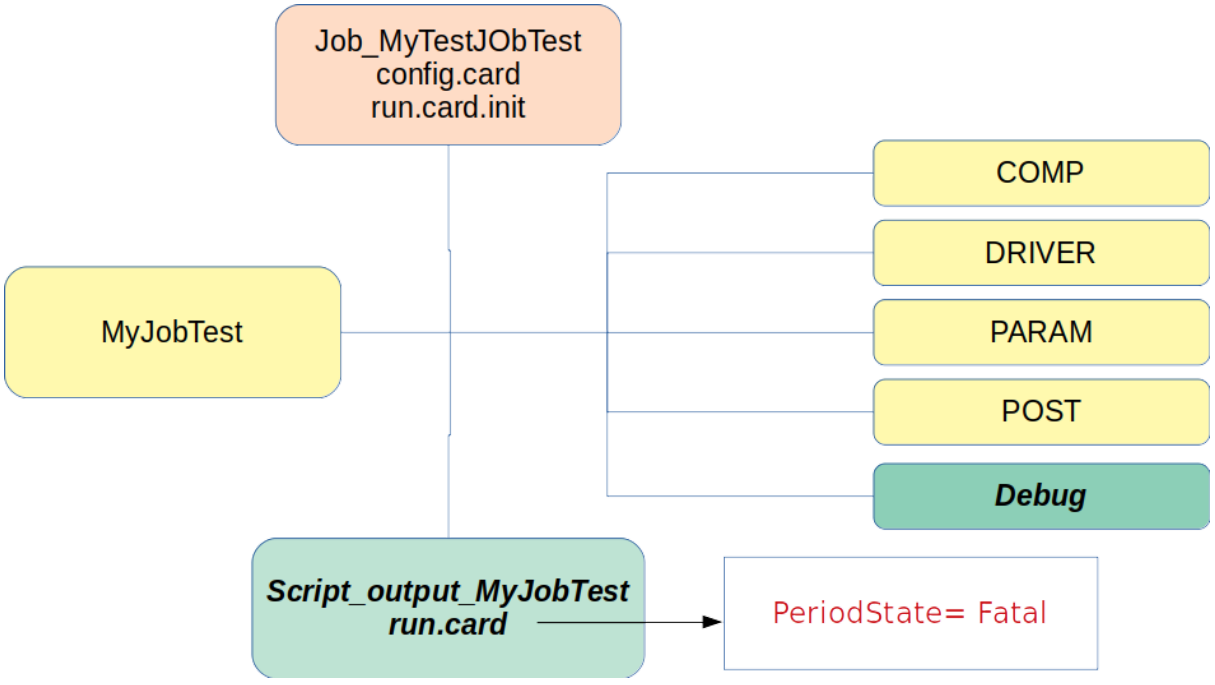
To look values of your previous print you need to open for LMDZ files `out_lmdz.x.out_***`, or for ORCHIDEE files `out_orchidee_****`.

In each case you can notice that there are several output files, there is one by OMP threads (if you are running a parallel simulation). In each of them you will find the output text print for this specific threads or proc.

If you have a problem during a simulation, you can try to debug by adding print in yours models.

3.3 Compilation in debug mode

When a simulation doesn't finish successfully, it create a new directory called `Debug` in your experiment directory.



You can read the description of this directory here
https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/CheckDebug#TheDebugdirectory

Errors are stored in the file `Debug/***_out_lmdz.x.err` even for other models than LMDZ.
In this file you will find information for each proc mpi. You can read that there is a bug but there is no more information on the localisation of this bug. It's because to compile we use permissives options that will not track precisely bug.

To obtain more clues on a bug we need to recompile in debug. For this you will use the option "debug" of the compilation script.

```
./compile_lmdzor.sh -debug
```

Create a new simulation and modify the file *config.card* to indicate we will use the debug executable.

```
vi config.card   → modify Optmode=debug
```

This new simulation will crash again, but now you will find more information in the file `Debug/***_out_lmdz.x.err`.

In most of the cases you will have the number of the line where the code crash. To find these information, you can read all the files or look for the key word “gcm” (the name of LMDZ main program).

For example :

```
9forrtl: severe (174): SIGSEGV, segmentation fault occurred
9Image          PC                Routine            Line     Source
9lmdz.x         0000000005146D79  Unknown            Unknown  Unknown
9libpthread-2.17.s  00002AAAB10C45D0  Unknown        Unknown  Unknown
9lmdz.x         0000000000AA8C70  physiq_mod_mp_phy       1619  physiq_mod.f90
9lmdz.x         00000000009872B2  callphysiq_mod_mp       81
callphysiq_mod.f90
9lmdz.x         0000000000979F74  calfis_loc_             729  calfis_loc.f
9lmdz.x         0000000000687DAA  call_calfis_mod_m       214
call_calfis_mod.f90
9lmdz.x         00000000004AF7AE  leapfrog_loc_           807  leapfrog_loc.f
9lmdz.x         0000000000427DCA  MAIN__                  454  gcm.f90
9libiomp5.so            00002AAAB3DE0ED3  __kmp_invoke_micr Unknown  Unknown
9libiomp5.so            00002AAAB3DA3726  Unknown           Unknown  Unknown
9libiomp5.so            00002AAAB3DA50FD  __kmp_fork_call   Unknown  Unknown
9libiomp5.so            00002AAAB3D66020  __kmpc_fork_call  Unknown  Unknown
9lmdz.x         0000000000424A19  MAIN__                  445  gcm.f90
9lmdz.x         000000000041EC62  Unknown                 Unknown  Unknown
9libc-2.17.so   00002AAAB4105495  __libc_start_main       Unknown  Unknown
9lmdz.x         000000000041EB69  Unknown                 Unknown  Unknown
```

will telling you that there is a problem at line 1619 on physiq_mod.f90, call by callphysiq_mod.f90 at line 81, call by calfis_loc.f at line 729, call by call_calfis_mod.f90 at line 214, call by leapfroc_loc.f at line 807, call by gcm.f90 at line 454.
Warning : all lines numbers don't refer to the code sources, but to pre-compile sources

```
In LMDZ : modeles/LMDZ/libo/computer_resolution/.config/ppsrc/
In ORCHIDEE: modeles/ORCHIDEE/build/ppsrc/
In INCA : modeles/INCA/build/ppsrc/
In NEMO/PISCES :
modeles/NEMOGCM/CONFIG/ORCA1_LIM3_PISCES/BLD/ppsrc
```

4. Create time series

4.1 Launch 5 years with default time series

This exercise is done to understand how to control the creation of time series. It is also an opportunity to test the supervisor. We will use here an ORCHIDEE offline configuration with a small horizontal domain just to have a model that runs quickly. The principle is the same for all configurations.

Install a new modipsl, download the configuration ORCHIDEE trunk and compile.

```
mkdir MYPOSTTEST; cd MYPOSTTEST
svn    co    http://forge.ipsl.jussieu.fr/igcmg/svn/modipsl/trunk
modipsl
cd modipsl/util
./model ORCHIDEE_trunk_TP
cd ../config/ORCHIDEE_OL
 ./compile_orchidee_ol.sh
```

In this configuration it is not needed to create the experiment directory. Instead different experiment directories already exist : OOL_SEC_STO_FG**, OOL_SEC, FORCESOIL and SPINUP_ANALYTIC_FG1 are experiences that follow the standard rules described in this tutorial.

The DRIVER directory does not exist but “drivers" are found in the COMP directory.

SPINUP and ENSEMBLE are experiments that are more complicated and are not taught in the course. We will here work with the OOL_SEC_STO_FG2 experiment which is a full ORCHIDEE offline setup with sechiba and stomate components.

Copy the OOL_SEC_STO_FG2 directory into a new one, modify config.card and create the job.

For Orchidee offline configurations it is better to run with PeriodLength=1Y. Use a regional domain by setting LIMIT parameters in run.def. Because we change to a smaller domain, no need to run on many processors. For this case, change to 3MPI for orchidee_ol in config.card.

```
cp -r OOL_SEC_STO_FG2 MyPostExp
cd MyPostExp

vi config.card # => Change JobName, SpaceName=DEVT
               # PeriodLength=1Y, DateEnd=1905-12-31,
               # PackFrequency=5Y, TimeSeriesFrequency=5Y,
               # SeasonalFrequency=5Y
               # OOL= (orchidee_ol_${OptMode}, orchidee_ol, 3MPI)
               # IOS= (xios_server_${OptMode}.exe, xios.x, 1MPI)


vi PARAM/run.def
# Add these lines
LIMIT_WEST = -10.
LIMIT_EAST = 20.
LIMIT_NORTH = 60.
LIMIT_SOUTH = 30.

../../../libIGCM/ins_job
```

Set `PeriodNb=5` and `#MSUB -T 3600` (on TGCC supercomputers) or `#SBATCH --time=01:00:00` (on JeanZay) in the main job and submit using `sbatch`, `ccc_msub` or `qsub` depending on the platform.

4.2 Use supervisor during run time

After about 20 min the simulation and the post processing are expected to be finished. (if it's still not done, go back to the question of part 2.5 during this simulation).

Check the supervision web interface to follow the pack and time series status.

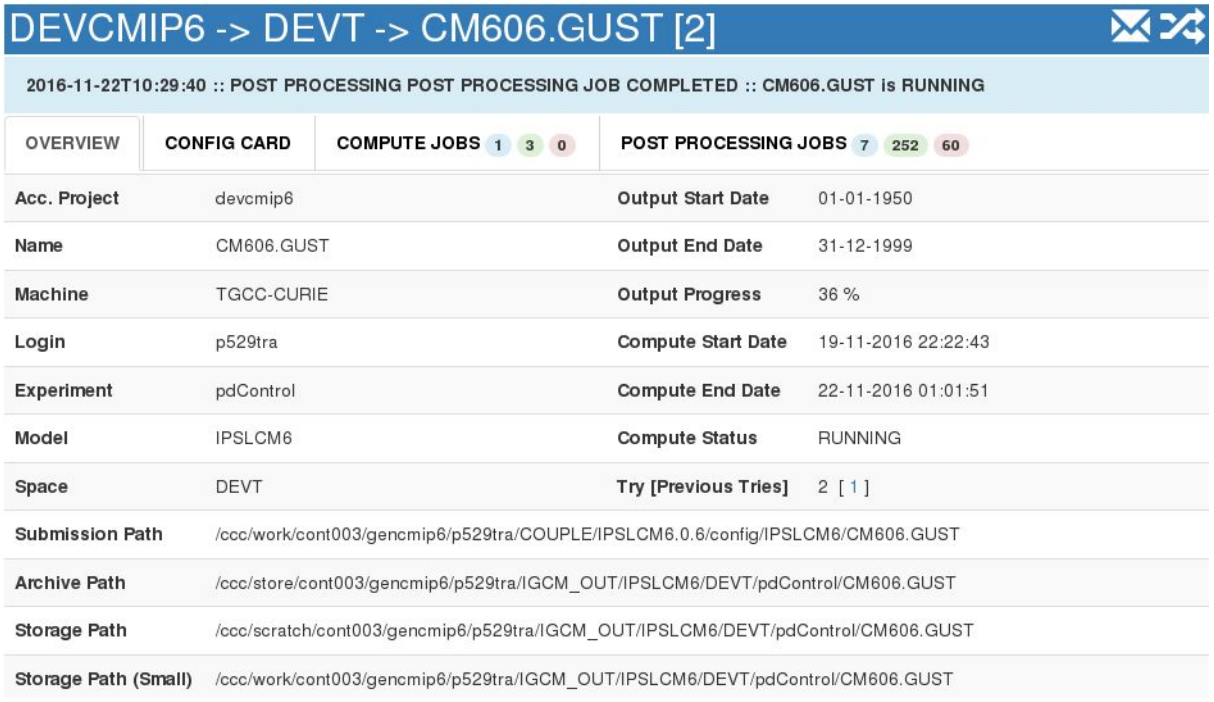
Go to the following web interface to see how the simulation is going. Try to understand what kind of information are gathered at that page : https://hermes.ipsl.upmc.fr

Find the summary of a simulation of interest.

Try the different search options. Explore links and displays that are available on the page.

What is the status of your compute job? Find the link to the graphical monitoring.

What is the status of your post-processing job?



DEVCMIP6 -> DEVT -> CM606.GUST [2]

2016-11-22T10:29:40 :: POST PROCESSING POST PROCESSING JOB COMPLETED :: CM606.GUST is RUNNING

OVERVIEW | CONFIG CARD | COMPUTE JOBS 1 3 0 | POST PROCESSING JOBS 7 252 60

Acc. Project	devcmip6	Output Start Date	01-01-1950
Name	CM606.GUST	Output End Date	31-12-1999
Machine	TGCC-CURIE	Output Progress	36 %
Login	p529tra	Compute Start Date	19-11-2016 22:22:43
Experiment	pdControl	Compute End Date	22-11-2016 01:01:51
Model	IPSLCM6	Compute Status	RUNNING
Space	DEVT	Try [Previous Tries]	2 [1]
Submission Path	/ccc/work/cont003/gencmip6/p529tra/COUPLE/IPSLCM6.0.6/config/IPSLCM6/CM606.GUST		
Archive Path	/ccc/store/cont003/gencmip6/p529tra/IGCM_OUT/IPSLCM6/DEVT/pdControl/CM606.GUST		
Storage Path	/ccc/scratch/cont003/gencmip6/p529tra/IGCM_OUT/IPSLCM6/DEVT/pdControl/CM606.GUST		
Storage Path (Small)	/ccc/work/cont003/gencmip6/p529tra/IGCM_OUT/IPSLCM6/DEVT/pdControl/CM606.GUST		

Question : once the simulation and post-treatment are completed, you can check Time Series (see in the following directories `IGCM_OUT/…./JobName/???/Analyse/TS_MO)`

4.3 Add variables to time series and relaunch with the TimeSeriesChecker.job

All variables in the output files can be used to create time series. A selection of variables are done by default and defined in card files (COMP/*.card)
Now add the creation of time series for the variables "`z0h`" and "`z0m`". First be sure that they are produced and exist in `sechiba_history.nc` file (in directory `IGCM_OUT/…./JobName/SRF/Output/MO/`). Then add in COMP/`sechiba.card`:

```
[Post_1M_sechiba_history]
Patches = ()
GatherWithInternal= (lon, lat, veget, time_counter, time_counter_bnds, Areas, Contfrac)
TimeSeriesVars2D = (riverflow, coastalflow, nobiofrac, ....,z0h,z0m)
```

Find the documentation about the script `TimeSeries_Checker.job` and launch it to create missing and new time series.
For remind the web documentation is available here : https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc and the part related to TimeSeries_Checker is here :

https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/CheckDebug#RestarttheTimeserieswithTimeSeries_checker.job

Before launching the TimeSeries_Checker.job, you have to modify the POST_REDO/run.card file as follows to allow the creation of new time series over the whole simulation period :

```
TimeSeriesCompleted=
```

As mentionned in the documentation, you have first to answer “n” to the question “Run for real (y/n) ?” asked when you launch ./TimeSeries_Checker.job. That allows you to see the two sechiba missing variables. Then, launch again and answer “y” to create missing Time series.

Question : check that Time Series for `z0h` and `z0m` was created.

5. Monitoring and Inter-monitoring

The monitoring is a web-interface tool that visualizes the global mean over time for a setup of key variables. Inter-monitoring web-interface allows to simultaneously monitor various simulations. More details can be found in:
http://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Running#Monitoringandintermonitoring

5.1 Monitoring

Visualize for example the monitoring on the web for **CM61-LR-pi-03 simulation** (IPSLCM6-CMIP6 piControl simulation performed on Curie-TGCC)

https://vesg.ipsl.upmc.fr/thredds/fileServer/work/p86maf/IPSLCM6/PROD/piControl/CM61-LR-pi-03/MONITORING/index.html

5.2 Inter-monitoring

5.2.1 from web interface tool “webservices”

Now you will use the web interface tool “inter-monitoring" to superpose several simulations. The default inter-monitoring is found at address :
http://webservices2017.ipsl.fr/interMonitoring/.
For this exercise choose following 2 simulations : **CM61-LR-pi-03** (IPSLCM6-CMIP6 piControl simulation performed on Curie-TGCC) and **CM61-pi-valid.02.JZ** (IPSLCM6 piControl simulation performed on JeanZay-IDRIS). These simulations have been used to validate porting on JeanZay.
To do the inter-monitoring comparaison, set the corresponding paths :

- CM61-LR-pi-03:

http://vesg.ipsl.upmc.fr/thredds/catalog/work/p86maf/IPSLCM6/PROD/piControl

- CM61-pi-valid.02.JZ:

http://vesg.ipsl.upmc.fr/thredds/catalog/work/p86caub/IPSLCM6/DEVT/piControl

And follow the following Mini how to use the inter-monitoring :
Go to http://webservices2017.ipsl.fr/interMonitoring/

- **Step 1:** Enter the first path and click on the button List Directories.
- **Step 2:** You'll see a list of all simulations at this path. Go back to step 1.
- **Step 1 bis:** Go back to step 1, enter the second path ***and click on Append Directories.***
- **Step 2 bis:** You'll now see all simulations on the 2 paths. Choose the two simulations with the corresponding names. (use the mouse and type ctrl to select only 2 simulations). Click on Search files.
- **Step 3:** Select one variable and click on Validate.

- **Step 4:** Choose default setting for “plot01:Time series" and click on Validate. Then click on the button below called “Prepare and run the ferret script”.
- Now a ferret script will appear on the screen and one image. Click on the button “Run this script on the server” below on the page. The inter-monitoring for all variables will now appear on the screen.

Note : CM61-pi-valid.02.JZ simulation is shorter than CM61-LR-pi-03. Back to the Step 4 to select only the part 1850-1900 (using “Dates range” cursor) which is the common period between both simulations then click again on “Prepare and run the ferret script”.

5.2.2 from supervisor interface

It is possible to use supervisor interface to superpose simulations referenced in supervisor database.

Step 1 : https://hermes.ipsl.upmc.fr

Step 2 : Find different members r5, r6 and r7 of simulations CM61-LR-scen-ssp370 by using “Filter by name” and choosing “tgcc-irene” for Machine and “ * “ for StartDate (be patient, that could take a while…)

Step 3: Tick “IM” for both simulations and right click on IM (top of the column) select “Open Inter-Monitoring”

6. Modify output using XIOS

Output in IPSL models are managed by XIOS library. Read this documentation https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Tools#ShortpresentationonhowtomanageoutputsfilesusingXIOSmodelinIPSLconfigurations to have an idea on how you can write a diagnostic in an output file using XIOS.

6.1 Create a new output file for ORCHIDEE

The different output files and their contents in ORCHIDEE are defined in the file ***modeles/ORCHIDEE/src_xml/file_def_orchidee.xml***
This file can be modified to contain specific output if needed. The key words _AUTO_ can be changed directly in the file or using the variables in `orchidee.card`, `sechiba.card` and `stomate.card` (section `[UserChoices]`). To save a variable, the file must also be listed in `orchidee`/`sechiba`/`stomate.card` (section `[OutputFiles]`). The same method is used working coupled to LMDZ or using ORCHIDEE in offline mode. The only difference is the name of the comp.card: `orchidee.card` for coupled to LMDZ and `sechiba.card` when running in offline mode. For this exercise, use a test in offline mode because it is faster to run.

In this exercise you should create a new output file from ORCHIDEE containing only rain and snow fall on daily average. The variables are already output from the model using `xios_send_field` and they are declared in the `field_def_orchidee.xml` with the id `precip_rain` and `precip_snow`. If you want to see where in the model they are written, search for `precip_` and `xios` in `ORCHIDEE/src*/*` using

```
grep precip_ src_*/* | grep xios
```

in `modipsl/modeles/ORCHIDEE/` folder.

Set up the file with following specifications:

- The file should be named `myoutput_orch.nc`
- The name of the variables in the output file should be "`rainfall`" and "`snowfall`"
- Keep the default unit, mm/s
- File output frequency should be daily average. You have to set the file attribute ***output_freq="1d"***
- File attribute ***enabled=.TRUE.***

Do the following:

1. Continue in the same modipsl where you installed ORCHIDEE offline in exercise 4
2. Add a section in `file_def_orchidee.xml` with the specifications as above. Take example on how the first file `sechiba_history` is defined and do in similar way just below or above:

```
<file id="sechiba0" name="myoutput_orch" output_level="1" output_freq="1d"
enabled="true">

<field_group group_ref="remap_1d" grid_ref="grid_landpoints_out" >
  <field field_ref="precip_rain" level="0" name="rainfall" level="1"/>
  <field field_ref="precip_snow" level="0" name="snowfall" level="1"/>
</field_group>

</file>
```

3. Create a new experiment called "`MyPostExp2`" similar to `MyPostExp` used in 4.1. You can start from a copy of `MyPostExp as follows`:

```
cp -r MyPostExp MyPostExp2
cd MyPostExp2

vi config.card    # Change JobName

# Remove files related to MyPostExp
rm Job_MyPostExp run.card Script_Output_MyPostExp.000001

# Create a new job
../../../libIGCM/ins_job
```

Note : you don't need to recompile because you didn't make modification in the code. The xml files are read directly during the execution.

4. Add the new file to be stored in ***`COMP/sechiba.card`*** (see example of `1M_sechiba_history.nc`)
   In `[OutputFiles]` section :

```
(myoutput_orch.nc, ${R_OUT_SRF_O_D}/${PREFIX}_1D_myoutput_orch.nc,
Post_1D_myoutput_orch), \
```

Also define the new Post section "`Post_1D_myoutput_orch`" and add the two new variables to be produced as TimeSeries.

```
[Post_1D_myoutput_orch]
Patches = ()
GatherWithInternal = (lon, lat, time_counter, time_centered,
time_centered_bounds)
TimeSeriesVars2D = (rainfall, snowfall)
ChunckJob2D = NONE
TimeSeriesVars3D = ()
ChunckJob3D = NONE
Seasonal = ON
```

Submit using `sbatch`, `ccc_msub` or `qsub` depending on the platform.

Question : Verify that this new file is created and TimesSeries of two variables exist : since these variables are daily outputs, you have to search into ...SRF/Analyse/**TS_DA**/

6.2 Enable a new output file in LMDZ

Similarly to the ORCHIDEE mechanism described above, the different output files and their contents in LMDZ are defined in the files
modeles/LMDZ/DefLists/file_def_*_lmdz.xml
You can see that there are quite a few of these files. Each one describes the contents of one possible output file for LMDZ. These files may differ by the time averaging used to output variables (monthly means or instantaneous values for example) or may come from different parts of the LMDZ model (the *COSP* ones for example are output by the COSP simulator embedded in LMDZ).
As for the ORCHIDEE example above, the files can be modified to contain specific output if needed. The key words _AUTO_ can be changed directly in the file or using the variables in `lmdz` (section `[UserChoices]`). To save a variable, the file must also be listed in `lmdz.card` (section `[OutputFiles]`) but you will see that most of the files are mentioned (and saved) in the default `lmdz.card`.

In this exercise, you will enable a new output file from LMDZ containing high frequency hourly average values of the sea-level pressure. Sea-level pressure is already output from the model using `xios_send_field` and is declared in the `field_def_lmdz.xml` with the id `slp`. So you will just need to declare the new file without modify the code or the field_def.xml file. If you want to see where in the model they are written, all LMDZ output variables are defined and written in the LMDZ routine `phys_output_write_mod.F90` which can be found in the
`modipsl/modeles/LMDZ/libf/phylmd/` folder.

If you looked at the files mentioned above, you will have noticed that there already exists a file ***modeles/LMDZ/DefLists/file_def_histhf_lmdz.xml*** containing specifications to output average values every 3 hours of a long list of variables in a file called histhf. We will modify this file to output the desired file and variable.

Set up the file with following specifications:

- The file should be named `myoutput_lmdz.nc`
- The level of the variable `slp` should be set to 5. We will set `output_level` to 5; that means that only variables with a `level` less than or equal to 5 will be written out to the file. You can constat that for default LMDZ's output files output_levels parameters are not defined (they are set to _AUTO_). Values are managed from *lmdz.card* file in the section *[UserChoices]*.
- File output frequency should be hourly average. You have to set the file attribute ***output_freq="1h"***
- File attribute ***enabled=TRUE***

Do the following:

1. Continue in the same modipsl where you installed LMDZOR in exercise 2.1
2. Modify `LMDZ/DefLists/file_def_histhf_lmdz.xml` with specifications given above:

```
<file id="myoutputid" name="myoutput_lmdz" output_freq="1h"
output_level="5" enabled="true" compression_level="4">
…
   <field field_ref="slp" level="5" />
…

</file>
```

3. Create a new experiment called "`MyJobTestLMDZ`" similar to `MyJobTest` used in 2.1. You can start from a copy of `MyJobTest as follows`:

```
cp -r MyJobTest MyJobTestLMDZ
cd MyJobTestLMDZ

vi   config.card          #   Change   JobName,   Set   Date=1980-01-05,   Set
PeriodLength=5D

# Remove files related to MyPostExp
rm Job_MyPostExp run.card Script_Output_MyPostExp.000001

# Create a new job
../../../libIGCM/ins_job

# Make sure the following two lines are in the header of your job file
# for jean-zay
#SBATCH --cpus-per-task=4
#SBATCH --qos=qos_cpu-dev
```

Note : you don't need to recompile because you didn't make modification in the code. The xml files are read directly during the execution.

4. Add the new file to be stored in ***COMP/lmdz.card*** (see example of `histhf.nc`)
   In `[OutputFiles]` section :

```
(myoutput_lmdz.nc, ${R_OUT_ATM_O_H}/${PREFIX}_HF_myoutput_LMDZ.nc, NONE), \
```

Submit using `sbatch`, `ccc_msub` or `qsub` depending on the platform.

Question : Verify that this new file is created and that it contains the `slp` variable.

6.3 XIOS in other models

NEMO, REPROBUS, and INCA models also use XIOS to manage output files.

Where can you find the xml files for these models ?

```
NEMO : modipsl/config/***/GENERAL/PARAM/ (note that directory
will be copy in your simulation directory)
REPROBUS : modipsl/modeles/REPROBUS/XML
INCA : modipsl/modeles/INCA/src/INCA_XML
```

These 3 models use Xios by the same way than LMDZ and ORCHIDEE.
You can find here a documentation for XIOS in Inca model
https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/Models/INCA#ManageoutputusingXIOS
And here for XIOS in Nemo model https://zenodo.org/record/3248739#.XhhOAOEo8ax on page 229.

7. Check your quota

Do the exercises below on the computing center where you have a login.
Remember that you will find the questions' answers in the presentation of the first day and in the IGCMG doc.

7.1 For login at IDRIS

Use the command `idrquota -m` to check the HOME quota, `idrquota -w` for WORK quota and `idrquota -s` for STORE quota.

Question 7a

- Is the quota individual or per project?
- What happens to the other users if you exceed the quota?
- Which type of files do you store in your HOME?

7.2 For login at TGCC

At TGCC space and number of inodes (files and directories) are limited. Use the command `ccc_quota` to show your current quota and the limits on all file systems. Analyse what you see on the screen.

Question 7b

- Is the quota individual?
    - What happens to the other users if you exceed the quota?
- What is your global score?
- What means by "non_files"?
- Which file systems have a limit on the number of inodes?
- What is the size of the files that you are supposed to store at the STOREDIR?

To facilitate the clean you can use the command "find" to list all small files at STOREDIR.

```
cd $CCCSTOREDIR
find . -type f -size -32M
```

7.3 For login at IPSL/Ciclad

At Ciclad, you have individual quota for your home and for the data space. Use the **`quota`** command to check the quota

7.4 For login at LSCE/obelix

At the LSCE cluster there is an individual quota only at your home, at `/home/users/login`. Use the **`quota`** command to check the quota at your home. At the other disks there are no quota control but they can saturate. Use **`df -h`** to see the occupation of the disks.

Question 7c

- To which disk do you have write permission?
- What happens to the other users if you saturate a disk?

Note that the default base directory for the archive of output files is defined in libIGCM to `/home/scratch01/yourlogin` for obelix. This scratch directory might be purged and therefore you have to change to save your important simulations on another disk. You can change archive by setting the variable "`ARCHIVE`" directly in the config.card or change it in `modipsl/libIGCM/libIGCM_sys_obelix.ksh`.

8. Install and run NEMO-PISCES

This exercise is separated in 2 parts. The first part presents the basic steps to run and install NEMO-PISCES and the second part allows to get much deeper in the use of a configuration of NEMO-PISCES.

First part: In this exercise, we will first perform a 1 month simulation of the coupled ocean-biogeochemical model NEMO-PISCES, using 30 MPI processes for NEMO and 1 MPI process for XIOS.

Download modipsl as before and then install the NEMO_v6.5 configuration :

```
mkdir $WORK/NEMO_STD ; cd $WORK/NEMO_STD
svn co http://forge.ipsl.jussieu.fr/igcmg/svn/modipsl/trunk modipsl

cd modipsl/util
./model NEMO_v6.5
```

Compile the ORCA2_ICE_PISCES configuration:

```
cd ../config/NEMO_v6   ;  ./compile_nemo.sh
```

Create your first job for NEMO:

```
cp EXPERIMENTS/ORCA2_ICE_PISCES/core/clim/config.card .
```

Now set up the `config.card` to do the simulation. You can see that for the configuration ORCA2_ICE_PISCES. There are 3 components : OCE for ocean, ICE for Sea-Ice and MBG for PISCES.

Modify in `config.card` the following:

```
vi config.card
JobName=OR2Si3P1 ; SpaceName=TEST ; DateEnd=1948-01-31 ; PeriodLength=1M
```

Create the job as usual :

```
../../libIGCM/ins_job
```

Question8a : Explore the `COMP/opa9.card` (`COMP/pisces.card`) to see the inputs files needed for OPA and PISCES

Question8b Explore in `PARAM/NAMELIST/ORCA2` the namelists (`namelist_core_clim_cfg`) to see some parameters for the run

Question8c Explore in `PARAM/XML/file_def_nemo*` files where the output fields are managed for OPA/SI3/PISCES resp.

Submit the job as usual:

```
cd OR2Si3P1
sbatch Job_OR2Si3P1 / ccc_msub Job_OR2Si3P1
```

Question8d Explore the `Script_Output` file and `run.card` in the submit directory

Question8e Explore the output directories where the output files are stored : `OCE/Output` ; `ICE/Output`; `MBG/Output`

Continue the simulation for one more month.

Second part: in this 2nd exercise, we will perform a 1 year long simulation of the coupled ocean-biogeochemical model NEMO-PISCES in an offline mode (ORCA2_OFF_PISCES), using 30 MPI processes for NEMO and 1 MPI process for XIOS. Here, only the biogeochemical fields are computed, NEMO outputs are used to force the dynamical state of the ocean. This allow to explore specific biogeochemical features with lower computational costs. We will see how to create a 5 days outputs file and also the good practice to modify the pisces parameters if needed.

Compile the ORCA2_OFF_PISCES configuration:

```
cd $WORK/NEMO_STD/modipsl/config/NEMO_v6/ ; ./compile_nemo.sh OFFLINE &
```

Create the job for NEMO-PISCES offline:

```
cp EXPERIMENTS/ORCA2_OFF_PISCES/clim/config.card .
```

Set up the config.card to do the simulation. You can see that for the configuration ORCA2_OFF_PISCES, there is only 1 component : MBG for PISCES.

Modify in config.card the following lines:

```
vi config.card
JobName=OR2OFFPIS1 ; SpaceName=TEST ; DateEnd=1850-12-31
```

Create the job :

```
../../libIGCM/ins_job
```

Question8f : Explore the `COMP/pisces.card` to see the inputs files from NEMO needed for PISCES

Question8g Explore in `PARAM/NAMELIST/ORCA2` the `namelist_offline_clim_cfg` to see the parameters for the run

Submit the job as usual:

```
cd OR2OFFPIS
sbatch Job_OR2OFFPIS1 / ccc_msub Job_OR2OFFPIS1
```

Question8h Explore the output directories where the output files are stored : `MBG/Output`.

We will now create a new NEMO-PISCES offline configuration. We will modify the `config.card`, the `pisces.card`, and the `file_def_nemo-pisces_offline.xml` to get output of some fields at a frequency of 5 days. We will also see how to modify the parameters in the `namelist_pisces_cfg` file.

Create a new NEMO-PISCES offline configuration

```
cd $WORK/NEMO_STD/modipsl/config/NEMO_v6/
cp EXPERIMENTS/ORCA2_OFF_PISCES/clim/config.card .
```

Modify in `config.card` the following:

```
vi config.card
JobName=OR2OFFPIS2 ; SpaceName=TEST ; DateEnd=0001-12-31 ;
[MBG]
WriteFrequency="5D 1M 1Y"
```

Create the job :

```
../../libIGCM/ins_job
```

Edit the `pisces.card` to add 5 days outputs for `*.ptrcT` file :

```
cd OR2OFFPIS2/
vi COMP/pisces.card
```

Add the following line in the `[OutputFiles]` list of the `pisces.card` file:

```
...
(${config_UserChoices_JobName}_5d_ptrc_T.nc,${R_OUT_MBG_O_D}/${PREFIX}_5D_
ptrc_T.nc   , NONE   ) , \
...
```

Add in the `PARAM/XML/file_def_nemo-pisces_offline.xml` the variables NO3, PO4, Si, Fer, DCHL, NCHL in the specific group of 5d files.

```
vi PARAM/XML/file_def_nemo-pisces_offline.xml
```

Replace the `<!-- 5d files -->` line below:

```
<file_group     id="5d_pis"     output_freq="5d"          output_level="10"
enabled="_AUTO_"/>  <!-- 5d files -->
```

by the following lines in the `file_def_nemo-pisces_offline.xml`

```
<file_group       id="5d_pis"       output_freq="5d"       output_level="10"
enabled="_AUTO_">  <!-- 5d files -->
<file id="file35" name_suffix="_ptrc_T" description="pisces sms variables"
>
<field field_ref="PO4"         name="PO4"   />
<field field_ref="NO3"         name="NO3"   />
<field field_ref="Si"          name="Si"    />
<field field_ref="NCHL"        name="NCHL"  />
<field field_ref="DCHL"        name="DCHL"  />
</file>
</file_group>
```

We have finished to set up the configuration to get biogeochemical fields at an output frequency of 5 days for the `*ptrc_T` file.

Now we will see how to modify the parameters of the namelist of pisces. For instance, we will remove the sediment source of Fe and will explore the impacts for surface Fe, chlorophyll, nitrate, and Si, particularly in coastal regions.

open the `pisces.card`

```
vi COMP/pisces.card
```

question8j: Find where the reference namelist of pisces is stored. Open the the file.

```
vi ../../../modeles/NEMOGCM/CONFIG/SHARED/namelist_pisces_ref
```

All the parameters of pisces are listed here. This file should not be modified if you want/need to change some pisces parameters

question8k: Explore the `namelist_pisces_ref`

Copy the parameter for inputs deposition from the `namelist_pisces_ref` in the `namelist_pisces_cfg` of your configuration.

Copy the line below from the `namelist_pisces_ref`

```
   ln_ironsed  =  .true.   ! boolean for Fe input from sediments
```

Paste the copied line in the `namelist_pisces_cfg` in the section of nampissbc:

```
vi PARAM/NAMELIST/namelist_pisces_cfg
```

change the boolean value to switch off the Fe input from sediment in the `namelist_pisces` cfg

```
   ln_ironsed  =  .false.
```

submit the job:

```
cd OR2OFFPIS2
sbatch Job_OR2OFFPIS2 / ccc_msub Job_OR2OFFPIS2
```

question8l: Explore the output directories where the output files are stored to check whether the 5d `*ptrc_T` file has been created: `MBG/Output`

question8m: Compare the annual output files of the 2 offline configurations (OR2OFFPIS1, OR2OFFPIS2) and explore the differences on surface Fe,CHL, NO3, and Si.

9. REDO

Sometimes, because of machine problems (or other unknown reasons), output files are missing. Here is how to recover missing output files. The general method is explained on FAQ of the documentation:

http://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc/FAQ#HowdoIrestartasimulationtorecovermissingoutputfiles

As an example, we suggest you to :

- launch a 6 days simulation of LMDZOR experiment, with packs frequencies of 2 days
- remove output files for 1 pack of the simulation
- apply the method to recover missing output files

9.1 Launch a 3 days simulation of LMDZOR experiment

```
cd modipsl/config/LMDZOR_v6
cp EXPERIMENTS/LMDZOR/clim_pdControl/config.card .

vi config.card
    # Modify JobName=MyJobTest-6D
    # SpaceName=DEVT
    # Note : REDO method does not work with TEST as SpaceName
    # DateBegin=1980-01-01
    # DateEnd=1980-01-06
    # PeriodLength=1D
    # PackFrequency=2D
    # TimeSeriesFrequency=NONE
    # SeasonalFrequency=NONE
    # Modify Executable part for the parallelization
[Executable]
ATM= (gcm.e, lmdz.x, 71MPI, 8OMP)
SRF= ("", "")
SBG= ("", "")
IOS= (xios_server.exe, xios.x, 1MPI)

     # At obelix only, change to 7 MPI and 1 OMP in
     # At Irene, change nothing for parallelization
     # At JeanZay, change 8 OMP by 5 or 10
```

```
../../libIGCM/ins_job  # At JeanZay enter your project ID
                       # At Irene enter your project ID and default answer for other
questions

cd MyJobTest-6D
vi Job_MyJobTest-6D
   # Modify the job header to launch on test queue
   # Modify the periodNb to not relaunch the simulation between two period of simulation.
PeriodNb=6

  # Modify the LMDZ's outputs files frequencies (cancelled monthly outputs, and activated
    daily ones)
vi COMP/lmdz.card
output_level_histmth = NONE
output_level_histday = 10

  # Modify the ORCHIDEE's outputs files frequencies (cancelled monthly outputs, and
    activated daily ones)
vi COMP/orchidee.card
output_freq_sechiba_history = 1d
output_freq_sechiba_out_2 = 10800s
output_freq_sechiba_history_4dim = 1d

Vi COMP/stomate.card
output_freq_stomate_history = 1d
output_freq_stomate_ipcc_history = 1d


Submit the job
```

9.2 Remove daily output file for ATM component of the day 2 (i.e 1980-01-02)

Check `($CCCSTOREDIR on TGCC)`
`$STORE/IGCM_OUT/LMDZOR/DEVT/clim/MyJobTest-6D/ATM/Output/DA/MyJobTest-6D_19800103_19800104_1D_histday.nc exists...` then remove it

```
rm -f
$STORE/IGCM_OUT/LMDZOR/DEVT/clim/MyJobTest-6D/ATM/Output/DA/MyJob
Test-6D_19800103_19800104_1D_histday.nc
```

9.3 Apply the method to redo day 3 and 4 of the simulation (to recover missing output file)

```
# Handling of the restart files of the end of the first period (day one and two) to redo the second period (day three and four) of the new simulation

mkdir -p $STORE/IGCM_OUT/LMDZOR/REDO/clim/MyJobTest-6D
cd $STORE/IGCM_OUT/LMDZOR/REDO/clim/MyJobTest-6D
mkdir -p RESTART
cd RESTART
cp
../../../../DEVT/clim/MyJobTest-6D/RESTART/MyJobTest-6D_19800101_
19800102_restart.tar .

# Set up of the new simulation

cd modipsl/config/LMDZOR_v6
cp -pr MyJobTest-6D MyJobTest-6D-REDO
cd MyJobTest-6D-REDO

# In this new directory, change the run.card and config.card file and set the following parameters to:
vi run.card
   # we will do as if the REDO simulation already done the two firsts days, and now we want to continue our simulation
   # PeriodDateBegin= 1980-01-03
   # PeriodDateEnd= 1980-01-03
   # CumulPeriod= 3 # Specify the same period in the run.card of initial simulation
   # PeriodState= OnQueue
   # SubmitPath= ...modipsl/config/LMDZOR_v6/MyJobTest-6D-REDO
   # remove lines for periods 3 to 6 at the end of the file (because in our REDO simulations, these periods don't yet exist)
vi config.card
# you don't need to change the name of the simulation, neither the DateBegin of the simulation
    # SpaceName=REDO
    # DateEnd= 1980-01-04
```

```
Submit the Job
```

Once the job is finished you can have a look on the file :

$STORE/IGCM_OUT/LMDZOR/REDO/clim/MyJobTest-6D/ATM/Output/DA/MyJobTest-6D_19800103_19800104_1D_histday.nc

Once validated the new run (same results as the previous one : comparaison of restart files at the end of the second period), you can copy the new file in the initial directory :

```
cp
$STORE/IGCM_OUT/LMDZOR/REDO/clim/MyJobTest-6D/ATM/Output/DA/MyJob
Test-6D_19800103_19800104_1D_histday.nc
$STORE/IGCM_OUT/LMDZOR/DEVT/clim/MyJobTest-6D/ATM/Output/DA/.
```

10. Output files manipulations

This section will propose some exercises to present you common tools used in the climate/meteo community to manipulate data. This is not an exhaustive list of tools and the idea is to perform the same basic output manipulations and let you see which one seems the most suitable for you. Be careful however only one simple use case, and some tools could appear complicated compared to others whereas it could be different for complex analysis ; that's why there is a quick conclusion paragraph where we bring additional information and a point a view of the best usage. This is only a point and everybody has to discuss with people, read docs and test them to conclude.

Note that we won't speak about Climaf in this section

10.0 Protocol and environment

10.0.1 Protocol

In the following sections you will use several tools/languages to load the daily atmospherical output file produced by LMDZ. Extract the "2m-temperature" field (`t2m`) and save it as a timeserie file. Then we propose to compute a zonal and global weighted mean (using latitude cosine) and finally plot them.

Note that you could use another variable or output instead.

We provide you, for each environment, a daily output file from a one month LMDZ simulation for this practical but you can work directly on your own output files.

- *Ciclad*:

```
/projsu/igcmg/TRAINING/MODIPSL_HandsOn_20210129/Data/MyJobTest_19800101_19800130_1D_histday.nc
```

- *Irene*:

```
/ccc/work/cont003/igcmg/igcmg/TRAINING/MODIPSL_HandsOn_20210129/Data/MyJobTest_19800101_19800130_1D_histday.nc
```

- *Jean-Zay*:

```
/gpfswork/rech/psl/commun/TRAINING/MODIPSL_HandsOn_20210129/Data/MyJobTest_19800101_19800130_1D_histday.nc
```

Now create a new directory "*`MYDIR`*" and copy example file (or your own outputs) from correct path (see above):

```
mkdir MYDIR
cd MYDIR
cp CORRECT_PATH_ABOVE/MyJobTest_19800101_19800130_1D_histday.nc .
```

Note that in next sections, we'll use `$MYDIR` to refer to your new directory containing output file to analyse. This copy is to avoid potential multi-access during this practical, but in reality you could work directly with the output files.

10.0.1 Environment

Before starting you need to check that the following modules are available (revision could be different in function of the computer): `module list`

```
1) netcdf/4.7.2-mpi        2) nco/4.8.1
3) ferret/7.2              4) netcdf/4.7.2-mpi
5) ncview/2.1.7-mpi        6) cdo/1.9.7.1
7) ncl/6.6.2-mpi           8) python/3.7.5
```

With standard IPSL environment installed on supercomputer all modules will be available (see documentation). Otherwise you could add them using `module load` command as follow:

Jean-Zay

```
module load nco
module load cdo
module load ncview
module load ferret
module load ncl
module load python/3.7.5
```

Irene

```
module load netcdf-fortran/4.4.4
module load nco/4.9.1
module load cdo/1.9.5
module load ncview/2.1.7
module load ferret/7.2
module load ncl_ncarg/6.3.0
module load python3
```

Ciclad

```
module load netcdf4/4.4.1.1-parallel-ifort
module load nco/4.7.x
```

```
module load cdo/1.9
module load ferret/7.4.3
module load ncl/6.6.2
module load python/3.6-anaconda50
```

If you haven't installed xarray before on ciclad, you need it if you want to test this library. Here is the installation through Conda environment (locate installation of modules):

```
conda create -n py36env python=3.6 # Create conda environment with python 3.6
source activate py36env # load environment (the prompt change when you're inside)
conda install xarray matplotlib netcdf4
```

10.1 Network Common Data Form (NetCDF) format

In the IPSL models the output format is NetCDF. NetCDF is "*self-describing, machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data"* (from Wikipedia). This is a binary format and need some tools and/or a particular library to use them.

When the NetCDF library is installed on a computer, some basic manipulation tools are supplied. This is the case of the `ncdump` command which allow you to see the content of a netCDF file.

Use it with the option `-h` to get header information only, no data:

```
cd $MYDIR
ncdump -h MyJobTest_19800101_19800130_1D_histday.nc
```

Question: Look at the file structure, how is composed ? Explore other variables or components (SBG, MBG, OCE, ICE…). Are they structured in the same way ?

Informations: https://www.unidata.ucar.edu/software/netcdf/

10.2 NetCDF Operator (NCO)

We're going to use the atmospherical output file produced in the "basic exercise" (section 1) copy in your account in 10.0.1 section.

The general atmospheric file `MyJobTest_19800101_19800130_1D_histday.nc` contains a lot of variables (list is in `lmdz.card`). To avoid manipulating this big file, we'll first create our own timeseries file for the 2D temperature *t2m* (this is the same process done during a simulation in post-processing jobs).

To extract this variable use `ncks` as follow:

```
cd $MYDIR
ncks -v t2m MyJobTest_19800101_19800130_1D_histday.nc t2m_TS.nc
```

Question: Check the output file content using `ncdump -h`
Now, to calculate an area-averaged index, you first need to add the *latitude weights* to the file with `ncap2` before computing average with `ncwa` (-O option is to overwrite file):

```
# Add cos(latitude) to balance all grid point contribution
ncap2 -h -O -s "weights=cos(lat*3.1415/180)" t2m_TS.nc t2m_TS.nc
# Global average
ncwa -h -O -w weights -a lat,lon t2m_TS.nc t2m_glob_mean.nc
# Zonal average
ncwa -h -O -a lon t2m_TS.nc t2m_zon_mean.nc
```

Question: add the keyword `time` before each command and note the time elapsed to compare performances with CDO presented in the following section.

Conclusion: NCO is a very common set of several tools used through a terminal. It is generally installed on computation centers and frequently updated. As shown in the exercise before it creates a lot of intermediary files if you need to perform a complex analysis but it is optimized to perform quickly some complex analysis and use large files. There is no visualisation in NCO.

Informations: http://nco.sourceforge.net

10.3 Climate Data Operators (CDO)

CDO is a set of tools very useful to manipulate climate data. Its usage is close to NCO (see previous section) with its own operators. The CDO syntax is the following :

`cdo <operator>,<option> input.nc output.nc`

Let's start with variable extraction with the `selvar` operator:

```
cd $MYDIR
cdo selvar,t2m MyJobTest_19800101_19800130_1D_histday.nc t2m_TS_CDO.nc
```

Question: Check the output file content using `ncdump -h`. You could print information and simple statistics for each field of a dataset using `cdo info t2m_TS_CDO.nc` (mean is computed without the area weights).

Now perform the same analysis than before: global weighted average with `fldmean` (use directly grid info to find area weights) and zonal one using `zonmean`:

```
# Global average
cdo fldmean t2m_TS_CDO.nc t2m_glob_mean_CDO.nc
# Zonal average
cdo zonmean t2m_TS_CDO.nc t2m_zon_mean_CDO.nc
```

Question: add the keyword `time` before each command and note the time elapsed to compare performances with NCO presented in previous section.

Conclusion: CDO is a set of tools, developed by the Max Planck institute, similar to NCO. The syntax is a bit different but it allows to perform almost the same things. Sometime it is easier to perform some analysis with CDO, sometimes with NCO. Both could be used and chained. However the memory optimisation seems better with NCO. It also create temporary files to clean after and doesn't propose visualisation. The documentation is not so easy to find on the internet.

Informations: https://code.mpimet.mpg.de/projects/cdo

10.3 NetCDF Visual browser (NCView)

NCView is a very basic NCDF file visual browser. We propose to use it to show outputs from previous exercises and let you play with its basic interface (need to select the *t2m* variable):

```
# plot global mean
ncview t2m_glob_mean.nc
# show zonal average
ncview t2m_glob_mean.nc
```

Conclusion: It could be useful to check quickly file content and show data (with >> you could play data along an axis) ; but it is still very basic and doesn't allow to perform analysis.

Informations: http://meteora.ucsd.edu/~pierce/ncview_home_page.html

10.4 Ferret

Open ferret and load the *t2m timeserie* file (created with NCO in 10.2) or the global daily one *histday* otherwise:

```
cd $MYDIR
ferret # go into ferret app

##### IN FERRET ####
USE MyJobTest_19800101_19800130_1D_histday.nc
SAVE/FILE="t2m_TS_FERRET.nc" t2m[d=1]
use t2m_TS_FERRET.nc
show data/f 2 ! show all info in dataset 2 (ie t2m TS)
```

Note: Ferret is not case sensitive so it ignores lower and upper case for commands and variable names.

Now you will compute the zonal mean using `@ave` command to do it (Ferret automatically weighted average using grid properties) and show it with `shade`:

```
shade t2m[y=@ave, d=2]
```

And then plot the global average:

```
plot t2m[x=@ave,y=@ave, d=2]
```

Conclusion: It is a very good tool for quick sanity checks. Very easy to load/save data, basic data manipulation (averages, sums) and plot timeseries and 2D view.

Otherwise syntax is not very friendly (there is no variables but aliases saved), generate bad image quality (need to use PyFerret to solve this), only few doc and not very active developments.

Informations: https://ferret.pmel.noaa.gov/Ferret/
Short tutorial: https://ferret.pmel.noaa.gov/Ferret/documentation/ferret-tutorial-script

10.5 NCAR Command Language (NCL)

NCL is an environment developed by NCAR people. It was very popular in the weather and climate community, particularly for the large panel of visualisation proposed.

First, you'll start the NCL environment using `ncl` command line (use `ctrl+d` to exit):

```
ncl
```

Then you'll create a `t2m` timeserie from model output file ; using `addfile()` function to load model output, then select the variable to finally create a new output with `"c"` option and write it:

```
df  = addfile("MyJobTest_19800101_19800130_1D_histday.nc","r")
temp = df->t2m                    ; store t2m in a variable
fout=addfile("t2m_TS_NCL.nc","c") ; create out file
fout->t2m=temp                    ; write temp in t2m variable
```

Note: You could show quick information about a variable using `printVarSummary` command. For example to look at the temperature info: `printVarSummary(temp)`

Question: Quit ncl via `ctrl+d` and look inside the new created file using `ncdump -h`

Now continue loading the t2m file just created to compute the weighted global using `wgt_areaave_Wrap` (`Wrap` is to keep metadata) function and then plot it into a "*ave.png*" file (don't forget to start the ncl program first!):

```
df  = addfile("t2m_TS_NCL.nc","r"); read t2m TS
temp = df->t2m                    ; store t2m in a variable
lat  = df->lat                    ; store lat in a variable
rad  = 4.0*atan(1.0)/180.0
clat = cos(lat*rad)               ; lat cosine
globav = wgt_areaave_Wrap(temp, clat, 1.0, 0) ; global average

; *** create graphic into ave.png file ***
```

```
wks = gsn_open_wks("png","globave")      ; send graphics to PNG
file
res = True
res@tiYAxisString= globav@long_name + " (" + globav@units + ")"
res@tiXAxisString= "Time Steps"
res@tiMainString = "Global Weighted Average"
x = ispan(0,dimsizes(globav)-1,1)      ; create x-axis
plot = gsn_csm_xy(wks,x,globav,res)    ; create plot
```

Question: you could have a look at the output in the *globave.png* file using for example `display` command such as `display globave.png`

Now proceed to the zonal mean using `dim_avg_n_Wrap` which averaged the rightmost dimension (so you need to permute them if it is not the `lon`):

```
df  = addfile("t2m_TS_NCL.nc","r"); read t2m TS
temp = df->t2m                    ; store t2m in a variable
zave = dim_avg_n_Wrap(temp,2)     ; zonal average (=dim 2)

; *** create graphic into ave.png file ***
wks  = gsn_open_wks("png","zonal") ; send graphics to PNG file
res                  = True                ; plot mods desired
res@tiMainString     = "Hovmoller"         ; title
res@tmXBLabelStride   = 2                      ; tick mark label
stride
res@tiYAxisString    = "Time"              ; y axis title
res@tiXAxisString    = "Lat"               ; x axis title

res@cnFillOn         = True                ; color on
res@lbLabelStride    = 2                   ; every other label
res@lbOrientation    = "Vertical"          ; vertical label bar
res@cnLinesOn          = False                 ; turn off contour
lines
res@cnFillPalette    = "gui_default"    ; set color map
res@cnLevelSpacingF  = 1                   ; contour spacing

plot = gsn_csm_time_lat(wks, zave, res )   ; plot zonal ave
```

Question: you could have a look at the output in the *zonal.png* file using for example `display` command such as `display zonal.png`

Conclusion: NCL is a very powerful tool with a good documentation and community. For about 1 year, the developers announced that the environment won't be updated but all the functionalities will become a Python library PyNIO and PyNGL for the graphical part. The

project is called the Geosciences Community Analysis Toolkit (GeoCAT), and now get a specific website. So we advise you to directly use the Python version.

Informations: http://www.ncl.ucar.edu and https://geocat.ucar.edu (Python version)

10.6 Python

First you probably need to load python3 module: `module load python/3.7.5` and then start `python3`. If you work on ciclad don't forget to activate the Conda environment (`source activate py36env`).

10.6.1 NetCDF4 / Numpy

Read NetCDF file, extract *t2m* variable and write its timeserie:

```
from netCDF4 import Dataset, num2date, default_fillvals

import numpy as np
import matplotlib.pyplot as plt

# load dataset
fnc=Dataset("MyJobTest_19800101_19800130_1D_histday.nc",
mode='r')
# extract t2m and dimension variables
temp = fnc.variables['t2m']
time = fnc.variables['time_counter']
lati = fnc.variables['lat']
long = fnc.variables['lon']

# Create output file
fout = Dataset("t2m_TS_NC.nc", mode='w')
# create dimensions
fout.createDimension('time_counter', None)
fout_tdim   =   fout.createVariable('time_counter',   time.dtype,
('time_counter',))
fout.variables['time_counter'][:] = time[:]
for ncattr in time.ncattrs(): # copy metadata
     fout_tdim.setncattr(ncattr, time.getncattr(ncattr))

fout.createDimension('lat', len(lati))
fout_latdim = fout.createVariable('lat', lati.dtype, ('lat',))
fout.variables['lat'][:] = lati[:]
for ncattr in lati.ncattrs():
     fout_latdim.setncattr(ncattr, lati.getncattr(ncattr))
```

```
fout.createDimension('lon', len(long))
fout_londim = fout.createVariable('lon', long.dtype, ('lon',))
fout.variables['lon'][:] = long[:]
for ncattr in long.ncattrs():
     fout_londim.setncattr(ncattr, long.getncattr(ncattr))

# create variables
temp_var      =      fout.createVariable('t2m',      temp.dtype,
('time_counter', 'lat', 'lon'),fill_value=True)
for ncattr in temp.ncattrs():
     # patch for some version of python
     if(ncattr == '_FillValue'):
          continue
     temp_var.setncattr(ncattr, temp.getncattr(ncattr))
fout.variables['t2m'][:] = temp[:]

fout.close() # close file
```

Now load the timeserie file and compute zonal and global averages using `numpy`:

```
ftemp=Dataset("t2m_TS_NC.nc", mode='r')
temp = ftemp.variables['t2m']
lat = ftemp.variables['lat']
wgt = np.cos(np.deg2rad(lat))    # lat cosine
zave= np.average(temp, axis = 2) # zonal average
gave= np.average(zave, axis = 1, weights = wgt) # global weighted
```

And plot results using `matplotlib` library:

```
plt.show(block=False)  # let you continue to write
plt.plot(gave)
plt.figure()           # create new figure
plt.contourf(zave, cmap=plt.cm.YlOrBr)
plt.colorbar()         # show colorbar
plt.show()
```

10.6.1 XArray

XArray library is a Python package that makes working with labelled multi-dimensional arrays simple. It is based on Numpy and Pandas and use Matplotlib by default to plot data.

Let's start with the t2m TS file creation in python (don't forget to start Python using `python` command). If you work on ciclad don't forget to activate the Conda environment (`source activate py36env`):

```
import xarray as xr
import numpy as np
import matplotlib.pyplot as plt
ds = xr.open_dataset("MyJobTest_19800101_19800130_1D_histday.nc")
temp = ds.t2m                    # store t2m in a variable
temp.to_netcdf("t2m_TS_XR.nc") # write temp in t2m variable
```

Now compute zonal and global averages (need to first compute zonal):

```
dst = xr.open_dataset("t2m_TS_XR.nc")
temp=dst.t2m
wgt = np.cos(np.deg2rad(dst.lat)) # lat cosine
zave= temp.mean(dim="lon") # zonal average
gave=(zave*wgt).sum(dim=('lat'))/wgt.sum(dim=('lat'))#glob ave weighted
```

And plot results using `matplotlib` library:

```
plt.show(block=False)  # let you continue to write
plt.plot(gave)
plt.figure()           # create new figure
plt.contourf(zave, cmap=plt.cm.YlOrBr)
plt.colorbar()         # show colorbar
plt.show()
```

Note: when computing averages with XArray internal functions, the metadata will be kept. You could see it if you try to print variables `print(zave)`.

Conclusion:

- NetCDF is the basic library which allows you to work at a very low level in the same way that other environments based on it. It is powerful but need to explicit a lot of things (in particular create dimensions and metadata) that could afraid users.
- XArray in another way, adds a lot of very confortable simplicity to manipulate netCDF files and to manage metadata. It is powerful too and allow to convert data in other numpy types to use other libraries but need a bit of learning.

In a general way, Python seems to become the reference language for data analysis in climate or other field through the impressive amount of libraries available (maybe too much) and each user get its favourite's ones.

Informations: NetCDF4 - https://unidata.github.io/netcdf4-python/netCDF4/index.html
XArray - http://xarray.pydata.org

11. Ensembles (advanced users)

Note that this section about **Ensemble** is only for users who know what an Ensemble is. If you don't, that probably means that you won't need to do ensemble runs.

Here **ensemble** defines a set of several simulations using exactly the same configuration but differing only by changing the initial conditions. Two different types of changes are possible via libIGCM: "Perturbation of initial condition ensemble" or "ensemble with different starting dates".

> *We give here an example of config.card and ensemble.card to generate 2 members, starting date 1851. A white noise (of 0.1) is applied to the SST of a restart of a historical simulation.*

Attention:

1. **FOR THIS TOPIC it was checked on TGCC irene machine but could be done on Jean-Zay**
2. **FOR THIS TOPIC you have to use IPSLCM6.1.11-LR model**

```
To extract IPSLCM6.1.11-LR model you've to do :
cd modipsl/util
./model IPSLCM6.1.11-LR
cd ../config/IPSLCM6
gmake # instead of compiling (very long) copy the exe (see below)
```

For Irene compilation duration is too long, you can copy the executable in your bin directory:

At TGCC (replace `**computer**` by `irene-amd` or `irene-skl`):

```
cp
${R_IN}/TRAINING/MODIPSL_HandsOn_20210129/IPSLCM6.1.11-LR/**comput
er**/bin/* $CCCWORK/MYFIRSTTEST/modipsl/bin/.
```

And add a `.resol` file in your `MODEL_PATH/config/IPSLCM6/` with following content:

```
ORCA1LIM3xLMD144142-L79
RESOL_ATM_3D=144x142x79
```

To configure an ensemble of simulations with slightly different perturbed initial conditions it is possible to use "`ins_job -e`" option.

To use this option a new configuration card file ensemble.card file is needed.

There are two types of possible ensembles you could create directly with *libIGCM* :

- [Ens_PERTURB] : configures a set of periodic (annual) simulations from a Start date to an End date, with a defined number of members (ie random perturbations to initial state)
- [Ens_DATE] : configures a set of simulations using several restart dates from one or several simulations

NOTE: for ensemble, **JobName** param in config.card IS TO BE THE SAME that **NAME** param in ensemble.card

Important:
Check that in your config.card there is a “[Ensemble]” section as follow:

```
#============================
[Ensemble]
#D- Ensemble run ? 'y' or 'n'
#D- If 'y', fill in ensemble.card !!
EnsembleRun=y
EnsembleName=
EnsembleDate=
EnsembleType=
```

Check (only if you’ve got a problem during ensemble creation):

```
vi $CCCWORK/MYFIRSTTEST/modipsl/libIGCM/ins_job


If you’ve got an error like :
“mkdir: cannot create directory '/ENSEMBLE_TMP': Permission denied”
Check in libIGCM/ins_job value of RUN_DIR:

RUN_DIR="${CCCWORK}/ENSEMBLE_TMP"

(try RUN_DIR="${TMPDIR}/ENSEMBLE_TMP"
```

Now you’ll start to create your new ensemble experiment in your model from *decadal* Template:

```
cd modipsl/config/IPSLCM6
cd EXPERIMENTS/IPSLCM/
```

```
svn update
cp EXPERIMENTS/IPSLCM/decadal/config.card .
cp EXPERIMENTS/IPSLCM/decadal/ensemble.card .
```

Now you'll configure an example of a [Ens_PERTURB] ensemble. Start editing config.card:

```
vi config.card  # Modifiy using these following lines
    JobName=ENS
    SpaceName=TEST
    DateBegin=1851-01-01
    DateEnd=1851-12-31
    PeriodLength=1Y
```

And now configure ensemble properties in ensemble.card (for IRENE here, Jean-Zay below):

```
vi ensemble.card # write this following lines (for IRENE only)
    [Ens_PERTURB]
    active=y
    NAME=ENS
    MEMBER=2
    LENGTH=1Y

   BEGIN_INIT=18810101
   END_INIT=18811231
   PERIODICITY=1Y

   PERTURB_BIN=(AddNoise, CPL, sstoc, O_SSTSST, 0.1)

   INITFROM=CM61-LR-pi-03
   INITPATH=${R_IN}/RESTART/IPSLCM6/PROD/piControl
```

For Jean-Zay users, in use following piControl simulation for this exercise in ensemble.card:

```
vi ensemble.card # write this following lines (for Jean-Zay only)
    [Ens_PERTURB]
    active=y
    NAME=ENS
    MEMBER=2
    LENGTH=1Y
```

```
BEGIN_INIT=18510101
END_INIT=18511231
PERIODICITY=1Y

PERTURB_BIN=(AddNoise, CPL, sstoc, O_SSTSST, 0.1)

INITFROM=CM61-pi-valid.02
INITPATH=$STORE/../../../rech/psl/commun/IGCM_OUT/IPSLCM6/DEVT/piControl
```

And now create your ensemble set of simulation ENS and start it:

```
../../libIGCM/ins_job -e # At JeanZay enter your project ID
                         # At Irene enter your project ID and default answer for other questions

cd ENS
vi Qsub.ENS1851.sh # script used to launch all sims (only to understand the idea)

chmod 755 Qsub.ENS1851.sh # set to executable
sh Qsub.ENS1851.sh # submit all members

This shell script launches 2 jobs that are running 2 starting
date experiences.

To see if Job are running you can do:

ccc_mstat -u yourusername # for Irene
qstat -u yourusername # for Jean-Zay
```

On Irene, this example generates 2 members of simulation starting in 1851 (`BeginDate` in config.card), from year 1881 of the restart simulation :
`${R_IN}/RESTART/IPSLCM6/PROD/piControl/CM61-LR-pi-03`

On Jean-Zay, this example generates 2 members of simulation starting in 1851(`BeginDate` in config.card), from year 1881 of the restart simulation :
`$STORE/../../../rech/psl/commun/IGCM_OUT/IPSLCM6/DEVT/piControl/CM61-pi-valid.02`

White Noise is applied to SST ; you can check perturbed variables here:

On Irene:
`$CCCWORKDIR/IGCM_IN/IPSLCM6/JobNameYEAR/JobNameYEAR-0$member/CPL/Restart`

On Jean-Zay:

`$WORK/IGCM_IN/IPSLCM6/JobNameYEAR/JobNameYEAR-0$member/CPL/Restart`

In this example JobNameYEAR is “ENS1851”, and subdirectories are ENS1851-01 and ENS1851-02.
The submission directory has been created with the same name as the `JobNameYEAR`. In this directory there are as many directories as number of members. Look at `JobNameYEAR` directory and explore subdirectories.
In `JobNameYEAR` there is a shell script that can be launched (chmod 755 `Qsub.ENS1851.sh; sh Qsub.ENS1851.sh`) . With this script all members of all years will be launched.

For more information see documentation :

https://forge.ipsl.jussieu.fr/igcmg_doc/wiki/Doc#Ensemblesetup

12. Coupled model

The aim of this part is to apply ***what you have learnt in part 2*** : performing extraction, compilation and run of the whole coupled (ocean-atmosphere) model configuration IPSLCM6.2_work. So you have to :

- Extract modipsl
- Extract IPSLCM6.2_work configuration
- Compile (./compile_ipslcm6.sh)

Today (2021-01-29) for Training course:

Launch the compilation as explained above.

In case the compilation duration is too long, you can copy the executable in your bin directory:
In next line each time you see `**computer**` you need to look at the choices and take the one for your case.

```
cp
${R_IN}/TRAINING/MODIPSL_HandsOn_20210129/IPSLCM6.2_work/**comput
er**/bin/* .../modipsl/bin/.
```

Where ${R_IN} is :

- TGCC → /ccc/work/cont003/igcmg/igcmg
- IDRIS → /gpfswork/rech/psl/commun

And create the environment file (it will be use by the simulation to install the environment)

```
cd modipsl/config/IPSLCM6/ARCH
ln -s arch-**computer**.env arch.env
```

- Set up a 5 days piControl experiment (IPSLCM/piControl_TEST experiment)
  - SpaceName=TEST
  - PackFrequency=NONE
  - TimeSeriesFrequency=NONE
  - SeasonalFrequency=NONE
- Launch the simulation
- Check output files of the simulation