

IPSL-CM5A2 configuration

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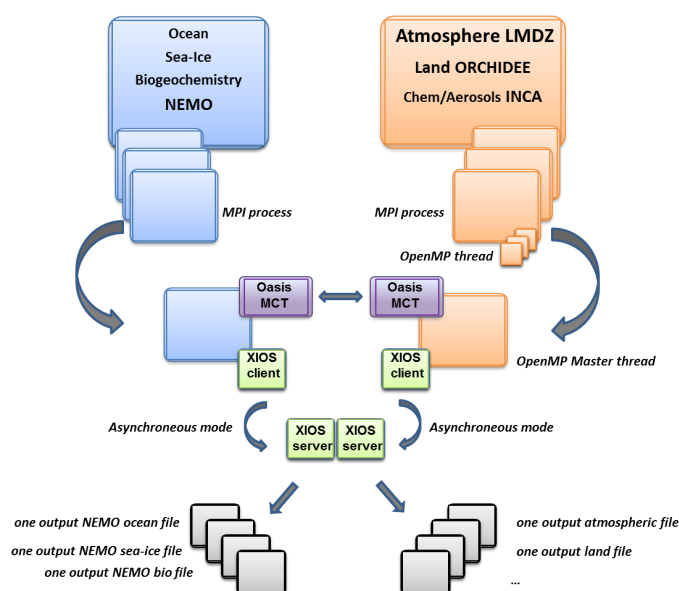
Person in charge: Arnaud Caubel

1. IPSL-CM5A2 model

IPSL-CM5A2 is an **IPSL coupled climate model** including atmosphere, land, ocean, sea ice and carbon cycle. The goal of this model is to reproduce IPSLCM5A-LR version, with reduced computing times to allow to run long simulations (i.e thousands of years) within reasonable time. Main characteristics of this model are **ORCA2-LIM2-PISCES x LMD 96x95x39, old LMDZ physics, ORCHIDEE with Choisisnel hydrology (2 layers)**. This model uses both recent component versions and recent technical developments (hybrid parallelization MPI-OpenMP, XIOS 2.0 as input-output library, OASIS3-MCT parallel coupler) that allow to reach **56 simulated years per day** on about 300 computing cores. This model is available on Ada (IDRIS) and Curie (TGCC) supercomputers and benefits from last developments of libGCM running environment.

IPSL-CM5A2 model includes :

- model components :
 - **LMDZ** as atmospheric model ;
 - **NEMO** as ocean model including sea ice (LIM2) and marine biogeochemistry (PISCES) ;
 - **ORCHIDEE** as land model ;
- tools :
 - **OASIS3-MCT** as parallel coupler ;
 - **XIOS 2.0** as I/O library ;
 - **libGCM** as running environment (scripts) to run the model and to perform post processing ;



2. Technical details

IPSL-CM5A2 model is available at following resolutions/configurations :

- **IPSL-CM5A2** : LMDZ(Old Physics) 96x95x39-ORCHIDEE(Choisisnel) - NEMO-LIM2-PISCES ORCA2

The resolution of LMDZ is 96x95 (3.75° in longitude and 1.875° in latitude) with 39 vertical levels. The ocean configuration is ORCA2 : global ocean with a tripolar grid with one South Pole, one North Pole above Siberia and one North Pole above northern America. The resolution is 2°. In the tropical region, the latitudinal resolution decreases to 1/2°. There are 31 vertical levels.

IPSL-CM5A2 is composed of following components and tools :

```
#-H- IPSLCM5A2    IPSLCM5A2 coupled configuration
#-H- IPSLCM5A2    1st frozen IPSLCM5A2 version
#-H- IPSLCM5A2    NEMOGCM branch nemo_v3_6_STABLE revision 6665
#-H- IPSLCM5A2    XIOS2 trunk revision 858
```

```

#-H- IPSLCM5A2 IOIPSL/src svn tags/v2_2_2
#-H- IPSLCM5A2 LMDZ5 trunk rev 2595
#-H- IPSLCM5A2 ORCHIDEE version trunk rev 3525
#-H- IPSLCM5A2 OASIS3-MCT 2.0_branch rev 1129
#-H- IPSLCM5A2 IPSLCM5A2 svn
#-H- IPSLCM5A2 libIGCM trunk rev 1330
#-M- IPSLCM5A2 arnaud.caubel@sce.ipsl.fr
#-C- IPSLCM5A2 IOIPSL/tags/v2_2_2/src HEAD 8 IOIPSL/src modeles
#-C- IPSLCM5A2 trunk/ORCHIDEE 3525 14 ORCHIDEE modeles
#-C- IPSLCM5A2 branches/OASIS3-MCT_2.0_branch/oasis3-mct 1129 15 oasis3-mct .
#-C- IPSLCM5A2 LMDZ5/branches/testing 2595 11 LMDZ modeles
#-C- IPSLCM5A2 CONFIG/UNIFORM/v6/IPSLCM5A2 HEAD 8 IPSLCM5A2 config
#-C- IPSLCM5A2 trunk/libIGCM 1330 10 libIGCM .
#-C- IPSLCM5A2 branches/2015/nemo_v3_6_STABLE/NEMOGCM 6665 7 . modeles
#-C- IPSLCM5A2 XIOS/trunk 858 12 XIOS modeles

```

2.0.1. How to use it

Here are the commands you need to know if you want to retrieve and compile the IPSL-CM5A2 model and if you want to setup and run a piControl experiment (pdControl is also available):

```

mkdir YOUR_DIRECTORY ; cd YOUR_DIRECTORY
svn_ano # svn co http://forge.ipsl.jussieu.fr/igcmg/svn/modipsl/trunk modipsl
cd modipsl/util
./model IPSLCMA2
cd ../config/IPSLCMA2
gmake # by default ORCA2xLMD9695-L39
cp EXPERIMENTS/IPSLCM5/EXP00/config.card .
vi config.card # modify JobName (at least) : MYJOBNAME, restarts
../../util/ins_job # Check and complete job's header
cd MYJOBNAME
vi Job_MYJOBNAME # modify PeriodNb, adjust the time, headers ...
llsubmit Job_MYJOBNAME # IDRIS
ccc_msub Job_MYJOBNAME # TGCC

```

2.0.2. Restart files

Default IPSL-CM5A2 configuration starts from **VLRun01** simulation at the date of **3699-12-31**. The monitoring of this simulation is available here : <http://esgf.extra.cea.fr/thredds/fileServer/work/p25sepul/IPSLCM6/DEVT/piControl/VLRun01/MONITORING/index.html>

2.0.3. Output level

By default, **low output levels** are activated : monthly and daily outputs for atmospheric component, monthly and/or yearly outputs for other components. Remind that you have to think of the output you need before launching a long simulation.

2.0.4. Lengths, frequencies

2.0.4.1. Period length

Default period length is 1Y, i.e in config.card :

```
PeriodLength=1Y
```

Note that clean_PeriodLenght.job will remove last period files, i.e last simulated year files.

2.0.4.2. Pack Frequency

Default pack frequency is 10Y, i.e in config.card :

```
PackFrequency=10Y
```

Note that since `clean_latestPackperiod.job` works on the latest pack period, `clean_latestPackperiod.job` will remove files from latest 10Y pack period. `clean_latestPackperiod.job` can also be used several time in a row to delete several 10Y pack periods.

2.0.4.3. Rebuild frequency

Since we run with XIOS (server mode) as output library, **the rebuild step is not needed anymore.**

2.0.5. Computing centres

The basic configuration (default configuration) runs on Curie TGCC and Ada IDRIS machine and uses 302 computing cores : 1 process for XIOS, 45 processes for NEMO, and 32 MPI processes and 8 OpenMP thread for LMDZ. This configuration allows you to run 56 simulated years per day. In order to use less computing ressources, it is possible to run on 160 cores (38 simulated years per day) as follows : 1 process for XIOS, 31 processes for NEMO, and 32 MPI processes and 4 OpenMP thread for LMDZ. To do that, you have to :

- Modify `config.card` as follows :

```
#=====
#D-- Executable -
[Executable]
#D- For each component, Real name of executable, Name of executable for oasis
ATM= (gcm.e, lmdz.x, 32MPI, 4OMP)
SRF= ("" ,"" )
SBG= ("" ,"" )
OCE= (opa, opa.xx, 31MPI)
ICE= ("" ,"" )
MBG= ("" ,"" )
CPL= ("" ,"" )
IOS= (xios_server.exe, xios.x, 1MPI)
```

- create the new job :

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

- Modify `PARAM/namelist_ORCA2_cfg`

```
jpni      = 1      ! jpni  number of processors following i (set automatically if < 1)
jpnj      = 31     ! jpnj  number of processors following j (set automatically if < 1)
jpni_j    = 31     ! jpni_j number of local domains (set automatically if < 1)
```

- submit the job : `ccc_msub` (or `lsubmit`) `Job_MYJOBNAME`

Because of load-balancing (difference between ocean computing time and atmosphere computing time), not all of the configurations (in terms of number of process/threads) are efficient. If you want to run a configuration with less cores, ask Arnaud Caubel what would be the optimum configuration.

2.0.5.1. IDRIS Ada features

The basic configuration (default configuration) runs on Ada (IDRIS). In order to use efficiently computing ressources, you have to use Intel environment. To do that you have to :

- ask IDRIS assistance (mail to `assist@...`) to be authorized to use Ada full node and (`# @ node = N`) option.
- specify the environment you want to use when you do the `../../libIGCM/ins_job` command as follows :

```
Hit Enter or give MPI Environement (default is IBM), possible MPI environments are IBM (MPI IBM) and Intel (MPI Intel)
Intel
MPIEnvironment is Intel
```

3. Tuning and evaluation of the model

Person in charge: Pierre Sepulchre

Tuning strategy

Apart from obtaining better computing performances, one aim of setting up IPSL-CM5A2 was to overcome the cold bias depicted in global surface air temperature (t2m) in IPSL-CM5A -explained by the lack of tuning for this latter version (Dufresne et al., 2013)- while trying not to worsen the long standing biases of the model (especially the warm bias of the ocean surface over equatorial upwelling regions and the presence of a double ITCZ in the equatorial eastern Pacific). Therefore we define a tuning strategy that responds to one single target: increasing the global t2m to reach the value of 13.5°C at equilibrium with pre-industrial boundary conditions.

First we ran a first simulation of CM5A2 forced by CMIP5 pre-industrial boundary conditions, the ocean component initiated by the routinely-used levitus climatologies. DECRIRE simul CM6.VLR.4.0.1 ici.

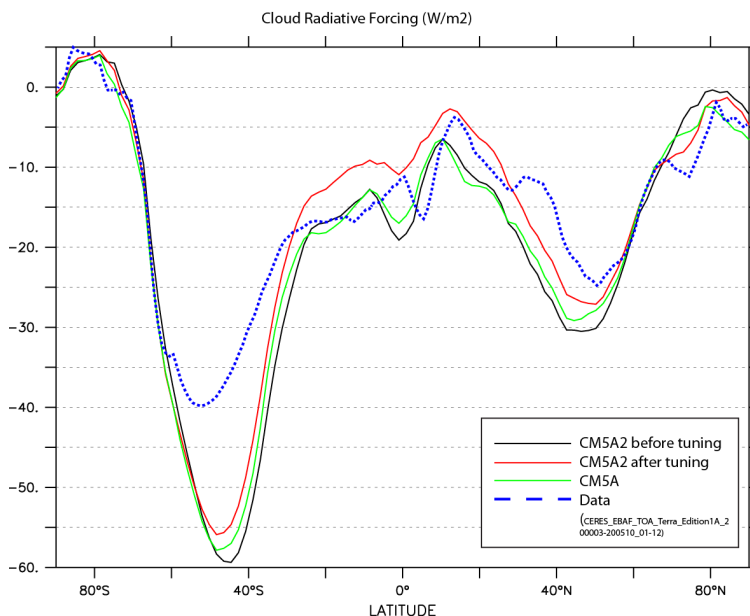
Prior to tuning, CM5A2 pre-industrial run depicts annual t2m values lower than CM5A, stabilizing at ca. 11.29°C after 1000 years of simulation, whereas CM5A depicted t2m stabilized at ca. 12.06°C. This ca. 0.8°C cooling between the 2 versions is associated with a stronger negative radiative forcing in CM5A2 at mid-latitudes and along the equator and a negative anomaly in both surface and top of atmosphere (TOA) radiative balance between CM5A2 (-0.28 W.m-2) and CM5A (+0.18 W.m-2). The reason for these differences between two rather close versions of the ISPL model remains to be explained.

Choice was made to act on cloud microphysics to alter their radiative effect and in turn the global temperature. According to Sundqvist (1978), the rate of precipitation formation is related to the amount of water in the cloud. As described in Hourdin et al. (2013), a threshold for condensed water (0.418 g/kg before tuning) needs to be reached for rainfall to start precipitating. , with a time constant τ_{conv} for auto-conversion (set at 1800 s):

$$(dq_{\text{lw}})/dt = -q_{\text{lw}}/\tau_{\text{conv}} [1 - e^{-(q_{\text{lw}}/clw)^2}]$$

where q_{lw} is the mixing ratio, clw is the in-cloud water threshold for autoconversion, τ_{conv} is a time constant for auto-conversion (here set at 1800 s). Decreasing clw is expected to lower cloud density and reduce the net cloud radiative forcing, as depicted in sensitivity experiment CLDLCL in Hourdin et al. (2013). Here we carried out forced-by-SSTs LMDZ simulations, keeping in mind that a change by 1 W.m-2 in the net radiative balance shifts global t2m by 1K (Hourdin et al. 2013). Two simulations were run with clw set at 0.316 and 0.250 g/kg, respectively, to define the sensitivity of surface and TOA radiative budget to this parameter.

	Control	Exp 1	Exp 2
clw (g/kg)	0.418	0.316	0.250
CRF (W/m-2)	-21.56	-18.94	-17.10
BILS (W/m2)	0.176	2.737	4.544



Setting clw at 0.316 g/kg provides a slightly too strong increase in the cloud radiative forcing (+2.61 W.m-2) that echoes in surface heat budget (+2.56 W.m-2) in the atmosphere-only simulation. These figures are confirmed in the coupled simulation, that depicts annual t2m reaching 13.75°C and BILS stabilizing at 0.19 W/m2 after 500 years of simulation. From these experiments we hypothesize that setting clw at 3.25 g/kg would be the right choice to reach the +2.2 target in t2m and bils. Thus we branched a new coupled experiment on the previous one and let the model run for 1000 years for all the slow components to reach equilibrium. We obtain a net surface heat flux of 0.11 W.m-2 and a global air temperature at surface of 13.56°C.