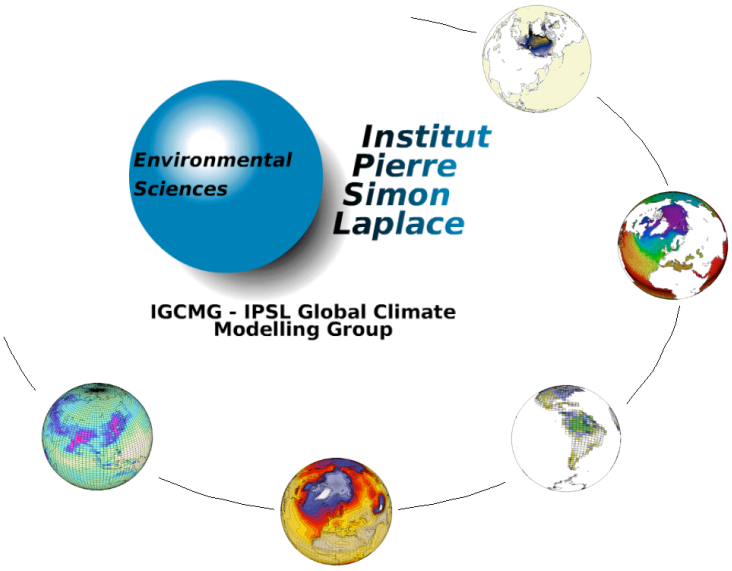

IPSL Earth System Model

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Description of the main components

IPSL is currently working on the 5th generation of its coupled model (IPSLCM). Since beginning of 90's five different generations of IPSLCM have been build, validated and used for climate science: simulation and understanding of past, present and future climate. Each one incorporate scientifically and technical upgrades to follow state-of-the-art in climate modelling. Earth system model (IPSL ESM) means coupled model including chemistry and biogeochemistry components. IPSLESM uses different models and tools.

The components of IPSLESM:

- The atmospheric model LMDZ. Refer: http://lmdz.lmd.jussieu.fr/
- The NEMO ocean model, including sea ice and marine biogeochemistry. Refer: http://www.nemo-ocean.eu/
- The ORCHIDEE model of continental surfaces including carbon cycle. Refer: http://orchidee.ipsl.jussieu.fr/
- The INCA model of chemistry and aerosols. Refer: http://www-lsceinca.cea.fr
- The REPROBUS model of stratospheric chemistry. Refer: http://ether.ipsl.jussieu.fr/etherTypo/index.php?id=1283&L=1
- The OASIS coupling module developed at CERFACS. Refer: http://oasistrac.cerfacs.fr

The tools used by IPSLESM:

- The user interface for the access to the IPSL models: modipsl. Refer: http://forge.ipsl.jussieu.fr/igcmg/wiki/ModipslBeginner
- The library for the IPSL model inputs/outputs: IOIPSL. Refer: http://www.ipsl.jussieu.fr/~ioipsl/WWW2
- The IO server to separate IO from models. Refer: http://forge.ipsl.jussieu.fr/ioserver/browser
- The library of ksh functions and standardised jobs to run the model: libIGCM. Refer: http://forge.ipsl.jussieu.fr/libigcm
- The scripts for post processing: atlas and monitoring. Refer: http://dods.ipsl.jussieu.fr/fast

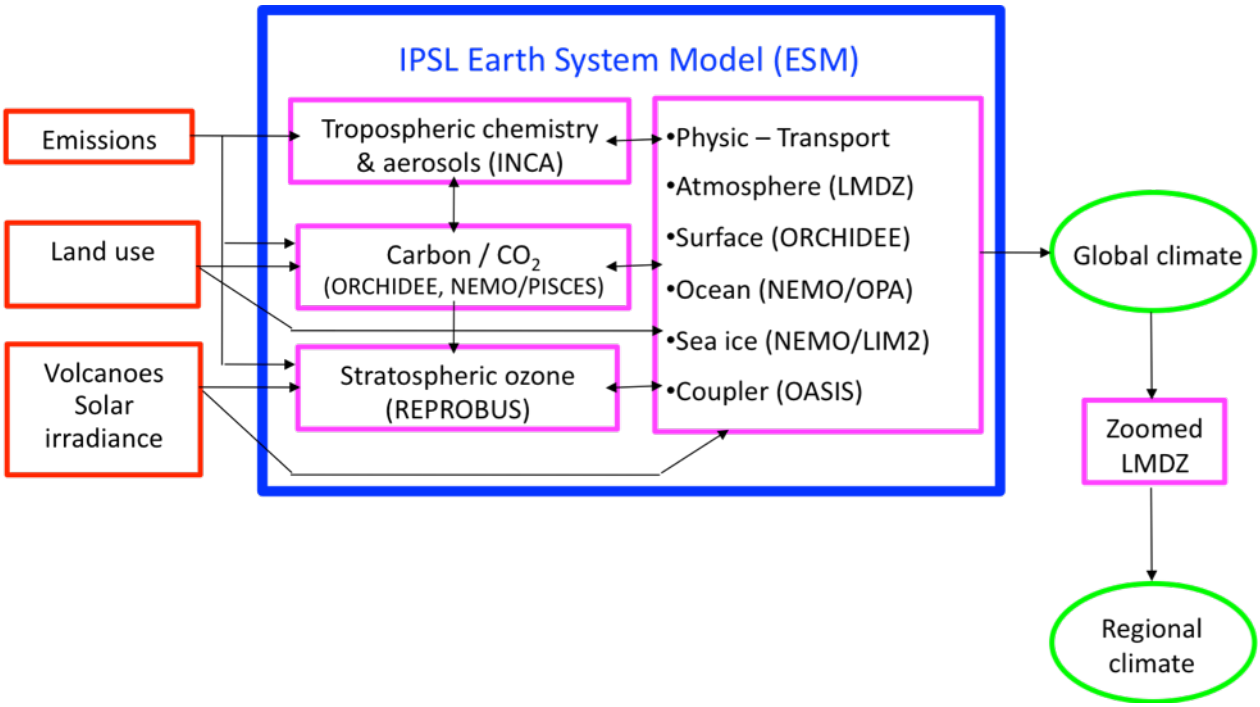


Figure 1 : IPSL Earth System Model

The IPSLCM4 coupled model has been described in Marti et al. [Note IPSL n° 26].

Main differences between IPSLCM4 and IPSLESM are:

- The implementation of NEMO instead of OPA 8 as oceanic component;
- The possibility to run LMDZ and ORCHIDEE on a set of processors;
- The horizontal and vertical resolution of the atmosphere;
- The carbon cycle included in continental and oceanographic compartments;
- The link with the tropospheric and stratospheric chemistry (through files or not);
- The version of the coupler: OASIS3;
- The libIGCM usage for running simulations;
- The atlas and monitoring facilities added.

Assembling guide

General information about coupling interfaces and interpolations in IPSLCM4 (previous version of IPSL coupled model) is available. Refer chapters 3.1, 3.2, 3.3 in
http://dods.ipsl.jussieu.fr/omamce/IPSLCM4/DocIPSLCM4/FILES/DocIPSLCM4_color.pdf

Specificities of current IPSLESM model: Interface Atmosphere-Ocean

The OASIS coupler (version 3) is used to synchronize, interpolate and exchange fields between atmospheric and oceanic components. Several fields are exchanged in the current IPSLESM model.

Technical exchanges Atmosphere -> Ocean:

1) Wind stress along X axis of geocentric referential (U point)
2) Wind stress along Y axis of geocentric referential (U point)
3) Wind stress along Z axis of geocentric referential (U point)
4) Wind stress along X axis of geocentric referential (V point)
5) Wind stress along Y axis of geocentric referential (V point)
6) Wind stress along Z axis of geocentric referential (V point)
7) Wind speed 10m
8) Wind stress module
9) Total rain (ocean and ice)
10) Total snow (ocean and ice)
11) Total evaporation (ocean and ice)
12) Ice evaporation
13) Total solar heat flux (ocean and ice)
14) Total non solar heat flux (ocean and ice)
15) Solar heat flux on ice
16) Non solar heat flux on ice
17) Non solar heat flux derivative
18) Iceberg calving
19) Liquid run-off (river + direct)
20) Atmospheric CO2 concentration

The atmospheric component averages its coupling fields on a coupling period and sends them to Oasis coupler.
It is needed to change only one parameter to switch LMDZ atmospheric model from forced configuration to coupled configuration (specify `type_ocean=couple` in parameter file at running time).

Both oceanic coupling fields and atmospheric coupling fields are exchanged between the models for every coupling period (specified in `namcouple` file), i.e. currently one day in IPSL coupled model.

Technical exchanges Ocean -> Atmosphere

1) Sea surface temperature (weighted by ocean fraction)
2) Sea ice fraction
3) Weighted Sea Ice Temperature (weighted by sea ice fraction)
4) Weighted Sea ice albedo (weighted by sea ice fraction)
5) Current surface along X axis of geocentric referential
6) Current surface along Y axis of geocentric referential
7) Current surface along Z axis of geocentric referential
8) Ocean Carbon flux

The oceanic component averages (via Oasis3 PSMILE library, use of keyword AVERAGE in `namcouple` file) its oceanic coupling fields on a coupling period and send them to Oasis coupler.

Two CPP keys (`key_coupled` and `key_oasis3`) are needed at the compilation step to couple NEMO component with atmospheric model using OASIS3. The generic coupling interface of NEMO_v3_2 is currently used in IPSL model, that means coupling parameters (coupling fields, referentials, …) are specified in NEMO `namelist` file, as follows :

```
!-----------------------------------------------------------------------
&namsbc_cpl    !   coupled ocean/atmosphere model        ("key_coupled")
!-----------------------------------------------------------------------
                                       ! send
cn_snd_temperature= 'weighted oce and ice'   ! 'oce only' 'weighted oce and ice' 'mixed oce-ice'
cn_snd_albedo     = 'weighted ice'           ! 'none' 'weighted ice' 'mixed oce-ice'
cn_snd_thickness  = 'none'                   ! 'none' 'weighted ice and snow'
cn_snd_crt_nature = 'mixed oce-ice'          ! 'none' 'oce only' 'weighted oce and ice' 'mixed oce-
ice'
cn_snd_crt_refere = 'cartesian'              ! 'spherical' 'cartesian'
cn_snd_crt_orient = 'eastward-northward'     ! 'eastward-northward' or 'local grid'
cn_snd_crt_grid   = 'T'                      ! 'T'
                                       ! receive
cn_rcv_w10m       = 'coupled'                ! 'none' 'coupled'
cn_rcv_taumod     = 'none'                   ! 'none' 'coupled'
cn_rcv_tau_nature = 'mixed oce-ice'          ! 'oce only' 'oce and ice' 'mixed oce-ice'
cn_rcv_tau_refere = 'cartesian'              ! 'spherical' 'cartesian'
cn_rcv_tau_orient = 'eastward-northward'     ! 'eastward-northward' or 'local grid'
cn_rcv_tau_grid   = 'U,V'                    ! 'T' 'U,V' 'U,V,F' 'U,V,I' 'T,F' 'T,I' 'T,U,V'
cn_rcv_dqnsdt     = 'coupled'                ! 'none' 'coupled'
cn_rcv_qsr        = 'conservative'           ! 'conservative' 'oce and ice' 'mixed oce-ice'
cn_rcv_qns        = 'conservative'           ! 'conservative' 'oce and ice' 'mixed oce-ice'
cn_rcv_emp        = 'conservative'           ! 'conservative' 'oce and ice' 'mixed oce-ice'
cn_rcv_rnf        = 'coupled'                ! 'coupled' 'climato' 'mixed'
cn_rcv_cal        = 'coupled'                ! 'none' 'coupled'
/
!-----------------------------------------------------------------------
&namsbc_cpl_co2   !   coupled ocean/biogeo/atmosphere model           ("key_cpl_carbon_cycle")
!-----------------------------------------------------------------------
cn_snd_co2        = 'coupled'         ! send    :  'none' 'coupled'
cn_rcv_co2        = 'coupled'         ! receive : 'none' 'coupled'
/
```

Note that all the coupling fields (both atmospheric and oceanic fields) are written out thanks to OASIS3 PSMILE library (i.e. use of keyword `EXPOUT` in `namcouple` configuration file).

Time scheme and conservation in IPSLCM5

In IPSLCM5, at the beginning of each coupling time step, the coupler exchanges the fields between models. The fields are averaged over a coupling period (i.e. one day). The time scheme is the following:

- NEMO ocean model computes sea surface temperature and sea ice properties (surface temperature, albedo, fraction) during day n.
- The surface properties are sent to LMDZ at the end of the day n. LMDZ receives them at the beginning of the day n+1 and uses them to run over day n+1.
- LMDZ sends the fluxes computed during day n+1, averaged over the day.
- NEMO receives these fluxes at the beginning of the day n+2 and uses them as surface conditions during the day n+2

This means that the fluxes used by NEMO during day n+2 are computed by LMDZ using the sea-ice fraction of day n. In IPSLCM5, LMDZ sends the flux over sea-ice `Qice` and the total flux `Qtotal = Qoce.foce + Qice.fice`. The flux over free ocean is computed in NEMO as `Qoce = (Qtotal – Qice. fice )/foce` (ocean fraction can not reach zero in our sea-ice model). The total flux is strictly conserved.

Compiling and running Environment

This guide describes how to access one configuration of IPSLESM: IPSLCM5A, to compile it and how to run a first experiment including post-processing.

Short summary of commands required:

```
mkdir NEWDIR ; cd NEWDIR
svn co http://forge.ipsl.jussieu.fr/igcmg/svn/modipsl/trunk modipsl
cd modipsl/util
./model IPSLCM5A
./ins_make
cd ../config/IPSLCM5A/
gmake
cp –pr EXP00 MYEXP ; cd MYEXP
vi config.card
../../util/ins_job
vi Job_EXP00
qsub Job_EXP00
```

Modipsl access:

Modipsl is a set of tools to describe and access different configurations of IPSLESMs. Once you have checkout `modipsl` in a new directory, you can access to different configurations of IPSLESM.

```
mkdir NEWDYR ; cd NEWDIR
svn co http://forge.ipsl.jussieu.fr/igcmg/svn/modipsl/trunk modipsl
```

This command creates a hierarchy of directories used later:

- `util/` utilities directory
- `bin/` executables
- `config/` main directory to follow one configuration
- `doc/` directory for part of documentation including text of licences
- `lib/` shared libraries
- `modeles/` sources of different components
- `tmp/` temporary files like compilation listing

At this stage, only `util` directory contains useful files:

- `mod.def` text file with settings of the different configurations : components, tags, servers, …
- `model` shell script used to extract one configuration
- `ins_make` shell script used to install customised `Makefiles`
- `AA_make.gdef` text file with the description of compilation options for different computers
- `ins_job` shell script used to install the standard job
- `w_i_h` shell script used internally to find the prefix of the current computer

List of configurations:

The command `model –h` shows the usage and lists all the configurations managed through `modipsl`. Example :

```
> cd modipsl/util
> ./model -h

model extracts the components of a model
```

```
Usage    :
model [-h]
model [-h] model_name
model [-e] [-H] [-v] model_name
h             : this help
h model-name  : help on model
e             : extract model
H             : suppress the tags and take the HEAD version
v             : verbose mode
Defaults      : -e

model_name in :
IOIPSL
IOIPSL_PLUS
libIGCM
IPSLCM5A
ORCHIDEE_OL
LMDZ4OR_v3
LMDZINCA_v3
NEMO
...
```

IPSLCM5A access:

```
cd modipsl/util
./model IPSLCM5A
```

This command checkout sources for all the components and tools for IPSLCM5A configuration a specific configuration of IPSLESM. These sources come from different `cvs` and `svn` server. For some servers, passwords are required. You need to contact us to know them.

- Component name of the component
- Tag tag required for this component. ? for HEAD (`cvs`) or last revision (`svn`)
- System `cvs` or `svn`
- Server description of the specific `cvs` or `svn` server
- Directory directory as known on the `cvs` or `svn` server
- Local directory name of the local directory. . means `modipsl` level itself.

The above fields are present in `mod.def` file and are outputted with –`h` option of `model`:

```
> ./model -h IPSLCM5A

model : IPSLCM5A

IPSLCM5A coupled configuration
CMIP5 version 30/04/2010
NEMO svn branches/CMIP5_IPSL 1854
XMLF90 svn trunk revision 54
XMLIO_SERVER svn trunk revision 54
IOIPSL/src svn tags/v2_2_0
LMDZ4 trunk revision 1368
ORCHIDEE tag orchidee_1_9_4_2
OASIS3 tag ipslcm5a
IPSLCM5A svn
libIGCM trunk revision 265

Component 1 : IOIPSL/tags/v2_2_0/src
Tag       1 : HEAD
```

```
System    1 : svn
Server    1 : http://forge.ipsl.jussieu.fr/igcmg/svn
Directory 1 : IOIPSL/src
Local Dir 1 : modeles
Component 2 : ORCHIDEE
Tag       2 : orchidee_1_9_4_2
System    2 : cvs
Server    2 : sechiba@cvs.ipsl.jussieu.fr:/home/ssipsl/CVSREP
Directory 2 : .
Local Dir 2 : modeles
Component 3 : OASIS3
Tag       3 : ipslcm5a
System    3 : cvs
Server    3 : anonymous@cvs.ipsl.jussieu.fr:/home/ioipsl/CVSROOT
Directory 3 : prism
Local Dir 3 : .
Component 4 : LMDZ4/trunk
Tag       4 : 1368
System    4 : svn
Server    4 : http://svn.lmd.jussieu.fr/LMDZ
Directory 4 : LMDZ4
Local Dir 4 : modeles
Component 5 : CONFIG/IPSLCM/IPSLCM5A
Tag       5 : HEAD
System    5 : svn
Server    5 : http://forge.ipsl.jussieu.fr/igcmg/svn
Directory 5 : IPSLCM5A
Local Dir 5 : config
Component 6 : trunk/libIGCM
Tag       6 : 265
System    6 : svn
Server    6 : http://forge.ipsl.jussieu.fr/libigcm/svn
Directory 6 : libIGCM
Local Dir 6 : .
Component 7 : branches/CMIP5_IPSL/NEMO
Tag       7 : 1854
System    7 : svn
Server    7 : --username nemo_user http://forge.ipsl.jussieu.fr/nemo/svn
Directory 7 : .
Local Dir 7 : modeles
Component 8 : branches/CMIP5_IPSL/UTIL
Tag       8 : 1854
System    8 : svn
Server    8 : --username nemo_user http://forge.ipsl.jussieu.fr/nemo/svn
Directory 8 : .
Local Dir 8 : modeles
Component 9 : XMLF90
Tag       9 : 54
System    9 : svn
Server    9 : http://forge.ipsl.jussieu.fr/ioserver/svn
Directory 9 : .
Local Dir 9 : modeles
Component 10 : XMLIO_SERVER/trunk
Tag       10 : 54
System    10 : svn
Server    10 : http://forge.ipsl.jussieu.fr/ioserver/svn
Directory 10 : XMLIO_SERVER
Local Dir 10 : modeles
```

Note: `log` *file is created in directory* `util` *with the trace of the configuration loaded by* `model` *command.*

IPSLCM5A compilation:

```
./ins_make
```

This command installs `Makefiles`. These `Makefiles` are build by concatenation `of AA_make.ldef`, part of `AA_make.gdef` and `AA_make`. `AA_make.gdef` contains a set of compile variables (name of compiler, options for compilation and link, name of NetCDF library …) for a lot of computers. The selected lines of `AA_make.gdef` are cleaned to exclude the name of the machine. The command outputs with the name of computer used and the list of `Makefiles` produced.

```
> ./ins_make

Installation of makefiles, scripts and data for sx8brodie

Installation in ../config/IPSLCM5A
Path from Makefile to modipsl/util : ../../util
Installation in ../modeles/IOIPSL/src
Path from Makefile to modipsl/util : ../../../util
Installation in ../modeles/ORCHIDEE
Path from Makefile to modipsl/util : ../../util
Installation in ../modeles/ORCHIDEE/src_global
Path from Makefile to modipsl/util : ../../../util
Installation in ../modeles/ORCHIDEE/src_parallel
Path from Makefile to modipsl/util : ../../../util
Installation in ../modeles/ORCHIDEE/src_parameters
Path from Makefile to modipsl/util : ../../../util
Installation in ../modeles/ORCHIDEE/src_sechiba
Path from Makefile to modipsl/util : ../../../util
Installation in ../modeles/ORCHIDEE/src_stomate
Path from Makefile to modipsl/util : ../../../util
Installation in ../modeles/NEMO/WORK
Path from Makefile to modipsl/util : ../../../util
```

Note: `ins_make` uses `w_i_h` script to find the name of the computer you are logged in. To force a specific computer, add `–t` option. Example:

```
ins_make –t sx8brodie
```

Tools and libraries required :

- Svn is required. For more information, refer: http://subversion.apache.org/
- FCM is required for LMDZ and INCA compilation. Add `fcm/bin` to your `PATH` after installing it on your computer. For more information, refer: http://research.metoffice.gov.uk/research/nwp/external/fcm/
- NetCDF library and include are required. Once installed, let put NetCDF library and include directory in `AA_make.gdef` file. For more information about NetCDF, refer: http://www.unidata.ucar.edu/software/netcdf/

You can launch the compilation with `gmake` command in the `config/IPSLCM5` directory.

```
cd ../config/IPSLCM5A/
gmake
```

Note: By default resolutions used are ORCA2 for the ocean and 96x95x39 for the atmosphere. You can change the resolution to other values. With 19 levels in atmosphere, use: ORCA2xLMD5655 (56x55x19 points for LMDZ), ORCA2xLMD9695 (96x95x19 points for

LMDZ), and with 39 levels in the atmosphere: ORCA2xLMD9695-L39 (96x95x39 points for LMDZ) and ORCA2xLMD144142-L39 (144x142x39 points for LMDZ). Let use the resolution as target for the `make`. *Example:*

```
gmake ORCA2xLMD144142-L39
```

Note: `.resol` *file is created at the end of the compilation to keep the information about resolution used.*

IPSLCM5A first experiment:

In the directory `config/IPSLCM5A`, you will find a sub-directory `EXP00` that includes files for running one experiment for 1 year of simulation, including post-processing. You will find also a sub-directory `piControl` for a piControl-like experiment. You will also find a sub-directory `historical` with an historical-like experiment. Let explore these sub-directories to know more about piControl and historical experiments.
`EXP00` contains:

- A file named `config.card`
- A directory: `COMP`
- A directory: `PARAM`
- A directory: `POST`

These files drive libIGCM by describing the different components, inputs files (text or NetCDF), outputs files, restarts files, post-processing and monitoring files.
`config.card` is the main file that describes the simulation to run. Please, edit it to fix the name of your simulation (`EXP00` by default). You also need to check information regarding initial state. Sometimes it's useful to start from an other simulation i.e. Restart.

```
cp –pr EXP00 MYEXP ; cd MYEXP
vi config.card
../../../util/ins_job
```

This command installs the standard job, a copy from `libIGCM/AA_job` file, customizes it for your computer. This job is able to run a simulation and auto-submitted to loop on different periods to complete the duration of the experiment.

```
vi Job_EXP00 ; qsub Job_EXP00
```

You will also need to adapt the header of the job for your computer (time limit, memory limit). Let replace `qsub` by the command usually used to submit a job on your computer.

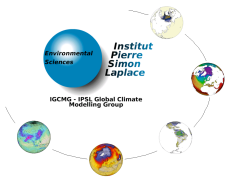
config.card

Different sections exist in config.card file. They start after a keyword included between `[]` :

- `[Compatibility]` to check libIGCM revision.
- `[UserChoices]` to set experiment parameters: Name, ExperimentName, SpaceName, Dates, Period, Number of processors.
  Example:

```
JobName=RUN1
ExperimentName=pdControl
SpaceName=DEVT
DateBegin=1950-01-01
DateEnd=1959-12-31
PeriodLength=1M
JobNumProcTot=4
```

- `[Restarts]` to set Restart information like : Name of the experiment, Dates of



the restart, …

- `[ListOfComponents]` to set the list of model components included in this particular configuration
- `[ATM], [OCE], [ICE], [MBG], [SRF], [SBG], [CPL]` : one for each component of the configuration. In fact the job loop on this list of components.
- `[Executable]` to describe which component has its own executable or is embedded in an other one
- `[Post]` to set some general post-processing options.

COMP directory

This directory includes two files for each component of the configuration: a `card` and a `driver`.
Card file describes different sections named by a keyword included between [] :

- `[Compatibility]` to check libIGCM revision
- `[UserChoices]` to set specific parameters for this component
- `[InitialStateFiles]` List of files used to set initial state ie if no Restart conditions exist
- `[BoundaryFiles]` List of files describing boundary conditions ie files required for a complete simulation without change during a simulation. Some parameters are allowed: `${Year}`
- `[ParametersFiles]` List of input text files
- `[RestartFiles]` List of files required for restart operation of this component: name of outputs and inputs restart files from one period to the next
- `[OutputText]` List of output text files
- `[OutputFiles]` List of output files to be stored on the file server
- `[Post_1M_histmth]` and other `[Post…]` sections: The description of post-processing operations (see later) for each Output File

Driver file describes different `ksh` functions of standard names that will be called by the standard job:

- `ATM_Initialize`: called at the beginning of the job to initialize parameters required by the ATM component
- `ATM_Update` : called at the beginning of each period to update parameters required by the ATM component
- `ATM_Finalize` : called at the end of the job to clean the ATM component

PARAM directory

This directory includes the different `ParametersFiles` described in the different cards.
More information about the parameters is available into the main documentation of each model.

- LMDZ :
  - cosp_input_nl.txt
  - cosp_output_nl.txt
  - gcm.def_144x142x39
  - gcm.def_56x55x19
  - gcm.def_96x95x19
  - gcm.def_96x95x39
  - physiq.def_L19
  - physiq.def_L39
  - run.def
  - traceur.def
- ORCHIDEE :
  - orchidee.def
- NEMO :
  - namelist_ORCA2
  - namelist_ice_ORCA2
  - namelist_pisces_ORCA2
  - namelist_top_ORCA2
  - iodef.xml
  - xmlio_server.def

- OASIS :
  - cf_name_table.txt
  - namcouple_ORCA2xLMD144142
  - namcouple_ORCA2xLMD5655
  - namcouple_ORCA2xLMD9671
  - namcouple_ORCA2xLMD9695

Common files on file server

Different card files list the files used by each component. These files are installed on file server in a shared data account. `R_INIT` is used as initial directory for initial conditions. `R_BC` is used as initial directory for boundary conditions. There names are : `~/IGCM/INIT` and `~/IGCM/BC`

LMDZ:

- Initial state files:
  - These files are stored for all resolution in `R_INIT/ATM/IPSLCM5A` directory. Some files are used with a local name added after the principal name.
    - Albedo.nc
    - amipbc_sic_1x1_clim.nc amipbc_sic_1x1.nc
    - amipbc_sst_1x1_clim.nc amipbc_sst_1x1.nc
    - ECDYN.nc.20020101 ECDYN.nc
    - ECPHY.nc
    - Relief.nc
    - Rugos.nc
    - landiceref.nc
    - clim03_LMDZORINCAREPRO_1995.nc climoz.nc
  - This file contains the ocean/land mask used to have same information in ocean and atmosphere that depends on resolutions of atmosphere and ocean models.
    - ORCA2.3xLMD9695/o2a.nc
- Boundary conditions files to describe chemistry previously prepared by INCA and Reprobus. They depend on atmospheric horizontal resolutions:
  - R_BC/ATM/IPSLCM5A/LMD9695/AR5/HISTORIQUE/aerosols_11YearsClim_1995.nc aerosols1980.nc
  - R_BC/ATM/IPSLCM5A/LMD9695/AR5/HISTORIQUE/aerosols_11YearsClim_1855.nc aerosols.nat.nc
  - R_BC/ATM/IPSLCM5A/LMD9695/AR5/HISTORIQUE/climoz_LMDZ_1995.nc climoz_LMDZ.nc

ORCHIDEE :

- Initial state files. These files are independent of the resolution:
  - R_INIT/SRF/IPSLCM5A/soils_param.nc
  - R_INIT/SRF/IPSLCM5A/routing.nc
  - R_INIT/SRF/IPSLCM5A/PFTmap_IPCC_2000.nc PFTmap.nc

STOMATE :

- Boundary conditions files for the surface biogeochemistry :
  - R_BC/SRF/IPSLCM5A/reftemp.nc

NEMO-OPA9 :

- Boundary conditions files for the ocean in ORCA2.3 resolution:
  - R_BC/OCE/IPSLCM5A/ORCA2.3/ahmcoef
  - R_BC/OCE/IPSLCM5A/ORCA2.3/bathy_level.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/bathy_meter.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/coordinates.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/data_1m_potential_temperature_nomask.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/data_1m_salinity_nomask.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/geothermal_heating.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/runoff_1m_nomask.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/subbasins.nc

- R_BC/OCE/IPSLCM5A/ORCA2.3/chlaseawifs_c1m-99-05_smooth_ORCA_R2.nc chlorophyll.nc
- R_BC/OCE/IPSLCM5A/ORCA2.3/data_1m_chlorophyll_nomask.nc
- R_BC/OCE/IPSLCM5A/ORCA2.3/Tides_K1_drg_ORCA_R2.nc K1rowdrg.nc
- R_BC/OCE/IPSLCM5A/ORCA2.3/Tides_M2_drg_ORCA_R2.nc M2rowdrg.nc
- R_BC/OCE/IPSLCM5A/ORCA2.3/tmaskitf_ORCA2_bis.nc mask_itf.nc
- R_BC/OCE/IPSLCM5A/ORCA2.3/kRGB61.txt

NEMO-PISCES :

- Boundary conditions files for the ocean biogeochemistry tracers in ORCA2.3 resolution:
  - R_BC/OCE/IPSLCM5A/ORCA2.3/data_1m_DIC_nomask.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/data_1m_Alkalini_nomask.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/data_1m_O2_nomask.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/data_1m_NO3_nomask.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/data_1m_PO4_nomask.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/data_1m_Si_nomask.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/data_1m_DOC_nomask.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/data_1m_Fer_nomask.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/dust.orca.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/bathy.orca.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/river.orca.nc
  - R_BC/OCE/IPSLCM5A/ORCA2.3/ndeposition.orca.nc

OASIS :

- Initial state files for the coupler for ORCA2.3 and LMD 96x95 horizontal resolutions:
  - R_INIT/CPL/IPSLCM5A/ORCA2.3xLMD9695/flxat.nc
  - R_INIT/CPL/IPSLCM5A/ORCA2.3xLMD9695/sstoc.nc
- Boundary files for the coupler for ORCA2.3 and LMD 96x95 horizontal resolutions:
  - R_BC/CPL/IPSLCM5A/ORCA2.3xLMD9695/grids.nc
  - R_BC/CPL/IPSLCM5A/ORCA2.3xLMD9695/masks.nc
  - R_BC/CPL/IPSLCM5A/ORCA2.3xLMD9695/areas.nc
  - R_BC/CPL/IPSLCM5A/ORCA2.3xLMD9695/mozaic.wa2o
  - R_BC/CPL/IPSLCM5A/ORCA2.3xLMD9695/mozaic.wo2a wo2a.tsg
  - R_BC/CPL/IPSLCM5A/ORCA2.3xLMD9695/mozaic.wa2o.runoff wa2o.run
  - R_BC/CPL/IPSLCM5A/ORCA2.3xLMD9695/mozaic.wa2o.calvin wa2o.cal

The job

libIGCM includes `AA_job`: a standardised script. The job is customised for a specific computer and installed in `EXP00` directory through `ins_job` command. It is based on the architecture specified in Figure 3.

libIGCM also includes a set of standard jobs used on server for post-processing.

- `AA_rebuild_fromArchive` standardised script launched by the job to start post-processing operations on the post-processing server. It finishes by submitting `create_ts` and `create_se`
- `AA_rebuild_fromWorkdir` same script when temporary files are stored on file system shared by computer and post-processing server
- `AA_create_se` standardised script launched to calculate seasonal averages for Outputfiles excluding those with Seasonal=OFF. It finishes by submitting all atlas jobs
- `AA_create_ts` standardised script launched to rearrange variables into time series. ChunckJob2D and ChunckJob3D give the duration of time series for 2D and 3D variables. One file per variable and per ChunckJob2D/3D is produced. It finishes by submitting monitoring.
- `AA_atlas_LMDZ` automatised atlas for LMDZ component
- `AA_atlas_ORCA_LIM` automatised atlas for NEMO/ORCA_LIM component
- `AA_atlas_ORCHIDEE` automatised atlas for ORCHIDEE component
- `AA_monitoring` standardised script launched at the end of `create_ts` to prepare monitoring figures.

Note: `ins_job` *customizes jobs prefixed by* `AA_` *as for* `AA_job` *by selecting headers adapted to the computer you use. . The prefix* `AA_` *is deleted from the file name and suffix* `.job` *is added for the resulting file. Example:* `AA_create_se` *gives* `create_se.job`

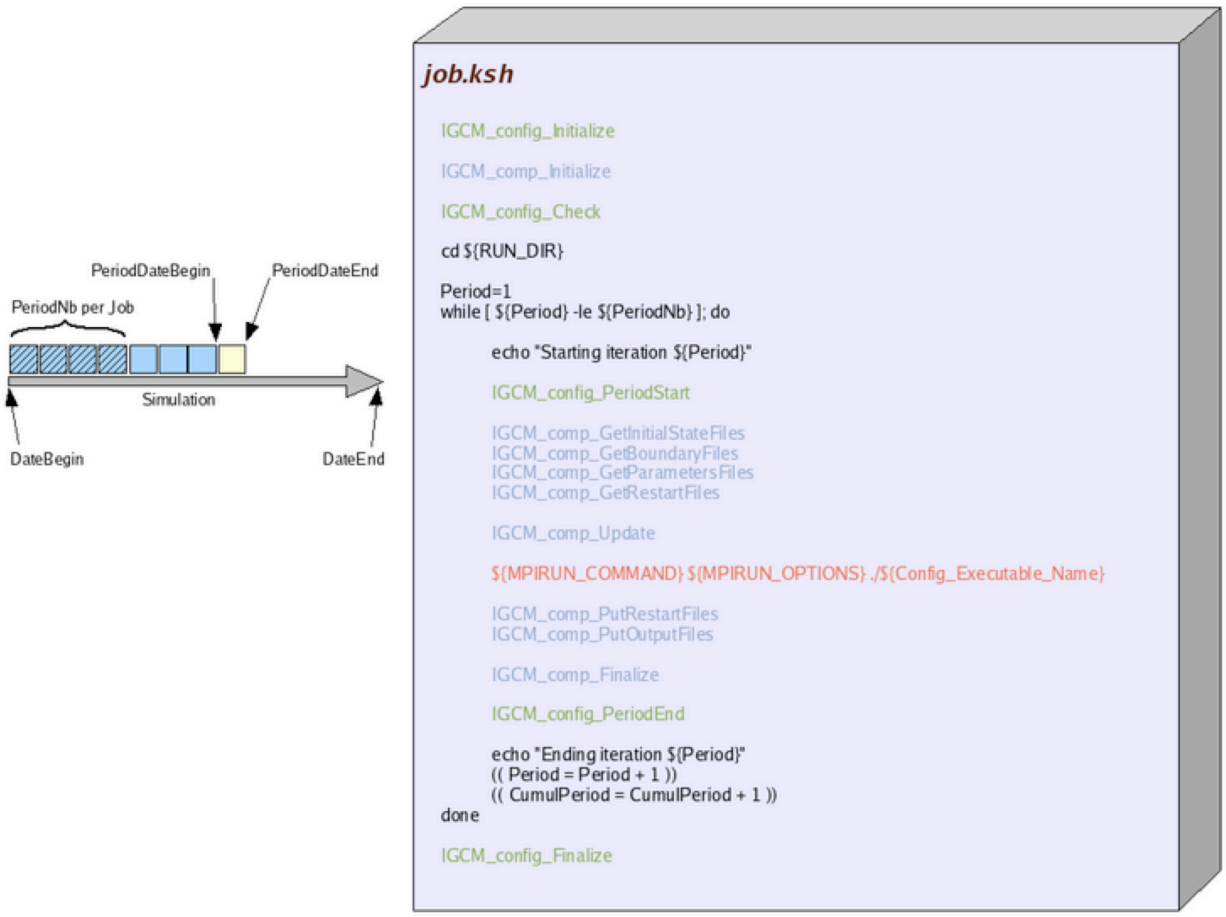


Figure 3 : Standard Job schema

Following a simulation:

run.card file:

In the `EXP00` directory, `run.card` is a file describing the simulation and used to store temporary parameters: current dates of the simulation, current status of the simulation, period number, status of post-processing, …
`run.card` is backed up into file `run.card.bak` at the beginning of each iteration. This backup file could be used instead of `run.card` itself to continue a simulation after some unexpected crash.

Results stored on file server:

The hierarchy used on the file server separates OutputFiles into different directories regarding the time period: `DA` for daily outputs, `MO` for monthly outputs and `HF` for high frequency outputs. Post-treatments produces Analyse files stored also in different subdirectories depending on the time information: `SE` for seasonal average, `TS_MO` for time series with monthly value.

```
IGCM_OUT/
`-- IPSLCM5A
   `-- DEVT                    # SpaceName in config.card
      `-- pdControl            # ExperimentName in config.card
         `-- EXP00
              |-- ATLAS
              |-- ATM
              |   |-- Analyse
              |   |   |-- SE
              |   |   `-- TS_MO
              |   |-- Debug
```

```
|    |-- Output
|    |   |-- DA
|    |   `-- HF
|    |   `-- MO
|    `-- Restart
|-- CPL
|    |-- Analyse
|    |   `-- SE
|    |-- Debug
|    |-- Output
|    |   |-- DA
|    |   `-- MO
|    `-- Restart
|-- Exe
|-- ICE
|    |-- Analyse
|    |   |-- SE
|    |   `-- TS_MO
|    |-- Debug
|    |-- Output
|    |   `-- MO
|    `-- Restart
|-- MBG
|    |-- Analyse
|    |   |-- SE
|    |   `-- TS_MO
|    |-- Debug
|    |-- Output
|    |   `-- MO
|    `-- Restart
|-- MONITORING
|-- OCE
|    |-- Analyse
|    |   |-- SE
|    |   `-- TS_MO
|    |-- Debug
|    |-- Output
|    |   |-- DA
|    |   |-- INS
|    |   `-- MO
|    `-- Restart
|-- Out
|-- SBG
|    |-- Analyse
|    |   |-- SE
|    |   `-- TS_MO
|    |-- Debug
|    |-- Output
|    |   `-- MO
|    `-- Restart
`-- SRF
     |-- Analyse
     |   |-- SE
     |   `-- TS_MO
     |-- Debug
     |-- Output
     |   `-- MO
     `-- Restart
```

Outputs files :

This files are described in the different card under the [OutputFiles] section. `PREFIX` is a variable used to describe the simulation and the period of time simulated. For example, simulation EXP00, simulation of 1860 January month: `EXP00_18600101_18600131`

LMDZ :

- ATM/Output/MO/PREFIX_1M_dynzon.nc
- ATM/Output/MO/PREFIX_1M_histmth.nc
- ATM/Output/MO/PREFIX_1M_histmthCOSP.nc
- ATM/Output/MO/PREFIX_1M_histmthNMC.nc
- ATM/Output/DA/PREFIX_1D_histday.nc
- ATM/Output/DA/PREFIX_1D_histdayCOSP.nc

- ATM/Output/DA/PREFIX_1D_histdayNMC.nc
- ATM/Output/HF/PREFIX_HF_histhf.nc
- ATM/Output/HF/PREFIX_HF_histhfCOSP.nc
- ATM/Output/HF/PREFIX_HF_histhfNMC.nc

ORCHIDEE
- SRF/Output/MO/PREFIX_1M_sechiba_history.nc
- SRF/Output/MO/PREFIX_1M_sechiba_out2.nc
- SRF/Output/MO/PREFIX_1M_watchout.nc

STOMATE
- SBG/Output/MO/PREFIX_1M_stomate_history.nc

NEMO-OPA9 :
- OCE/Output/EXP00_mesh_mask.nc
- OCE/Output/MO/PREFIX_1M_scalar.nc
- OCE/Output/MO/PREFIX_1M_grid_T.nc
- OCE/Output/MO/PREFIX_1M_grid_U.nc
- OCE/Output/MO/PREFIX_1M_grid_V.nc
- OCE/Output/MO/PREFIX_1M_grid_W.nc
- OCE/Output/MO/PREFIX_diaptr.nc
- OCE/Output/DA/PREFIX_1D_grid_T.nc
- OCE/Output/DA/PREFIX_damping.coeff.nc
- OCE/Debug/PREFIX_output.abort.nc
- OCE/Output/INS/PREFIX_output.init.nc

NEMO-LIM2
- ICE/Output/MO/PREFIX_1M_icemod.nc
-

NEMO-PISCES :
- MBG/Output/MO/PREFIX_1M_ptrc_T.nc
- MBG/Output/MO/PREFIX_1M_ diad_T.nc
- MBG/Output/MO/PREFIX_1M_ dbio_T.nc

OASIS :
- CPL/Output/DA/PREFIX_1D_cpl_atm.nc
- CPL/Output/DA/PREFIX_1D_cpl_oce.nc
- CPL/Output/MO/PREFIX_1M_cpl_atm.nc
- CPL/Output/MO/PREFIX_1M_cpl_oce.nc

Post-processing files:

Post-processing files are produced by an ensemble of jobs running on the post-processing server. You will find information about this additional jobs on your `WORKDIR/IGCM_OUT` or `SCRATCHDIR/IGCM_OUT` directory on it.
These parameters come from **`[Post]`** section in **`config.card`**:

- `RebuildFrequency=5Y` Frequency of rebuild submission on post-processing server. Here `5Y` means for each 5 years. Put `NONE` if you don't want to rebuild files produced by sub-domain on post-processing server. They will be recombined on the computer itself
- `RebuildFromArchive=true` Files to be recombined could come from Archive (file server) or from a common file system accessible from the computer and from the post-processing server.
- `TimeSeriesFrequency=10Y` If you want to produce time series, this flag determines frequency of post-processing submission. Here `10Y` means for each 10 years. (`NONE` if you don't want)
- `SeasonalFrequency=10Y` If you want to produce seasonal average, this flag determines the period of this average. Here `10Y` means for each10 years. (`NONE` if you don't want)
- `SeasonalFrequencyOffset=0` Offset for seasonal average first start dates in same unit as `SeasonalFrequency`. Useful if you do not want to consider the first X simulation's years.

These parameters come from **[Post_1M_histmth]** and other **[Post…]** sections associated with Output Files in **card**:

- `[Post_1M_histmth]` keyword to associate this section `[Post_1M_histmth]` with `histmth` output file
- `Patches=(Patch_...)` name of the patch used to select only one time counter into histmth file
- `GatherWithInternal=(lon,lat,…)` list of coordinates variables kept for assembling time series files
- `TimeSeriesVars2D = (bils, cldh,…)` list of 2D variables to be reassembled into time series.
- `ChunckJob2D = 50Y` indicate the maximum extension of a time series in year. When we reach that maximum a new one start
  - `ChunckJob2D = NONE` `NONE` means no splitting
  - `ChunckJob2D = OFF` `OFF` means time series suspended for this file
- `TimeSeriesVars3D = (temp, theta,…)` list of 3D variables to be reassembled into time series
- `ChunckJob3D = 10Y` Frequency of 3D variables time series splitting to keep reasonable file size. `NONE` or `OFF`.
- `Seasonal=ON` `ON` to produce seasonal averages, `OFF` to suspend the production of it.

Jobs:

This figure shows the list of jobs used for one simulation, for running it on main computer and for its post-processing on post-processing server to produce automatised atlas and monitoring to follow selected variables.

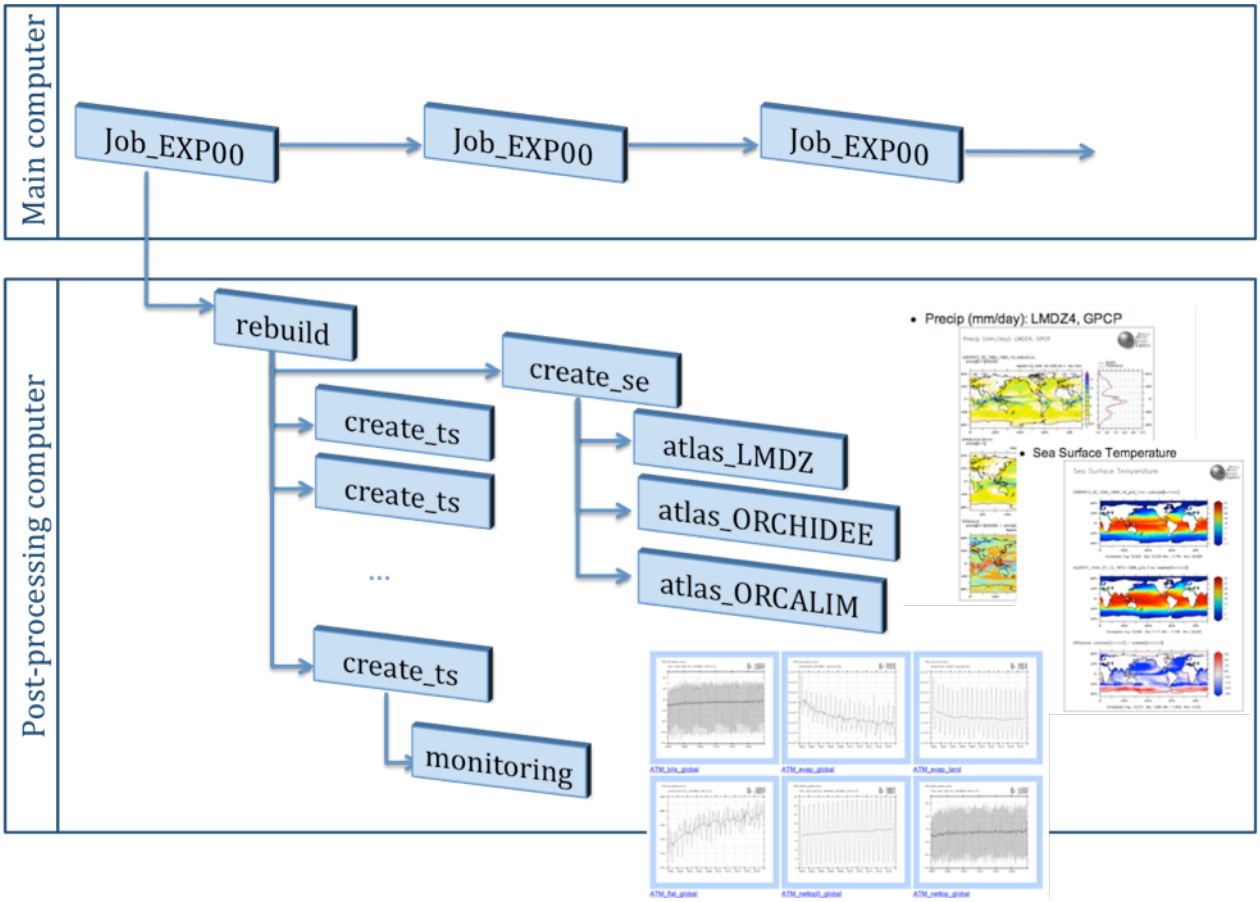


Figure 4 : libIGCM jobs workflow

Computers usually used:

This model runs each day on a list of computer summarized in the next table. Modipsl and libIGCM need to

be installed before used on all computers.

Centre	Main computer	Type	Batch	File server	Accessibility	Post-processing server	Type	Batch
IDRIS	brodie	NEC SX-8	NQS	gaya	File transfer	ulam	IBM Xeon	LoadLeveler
IDRIS	vargas	IBM Power6	LoadLeveler	gaya	File transfer	ulam	IBM Xeon	LoadLeveler
CCRT	mercure	NEC SX-8/9	NQS	acier	DMNFS	cesium	HP	LSF
CCRT	titane	Bull XeonNehalem	LSF	acier	DMNFS	titane	Bull Xeon Nehalem	LSF

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