Getting started with the IPSL tools: modipsl and libIGCM

Answers to questions in training_exercises_2022.pdf

Revised for April 2022 training sessions.

1. Check your quota

Question 1a:

- *Is the quota individual? What happens to the other users if you exceed the quota?*

Quota is attributed for each project for the entire group and not individually, so be careful of your own practices to avoid blocking all the group.

- *What kind of quotas do you have?*

There are quota on space and quota on inodes.

- *What is the meaning of “non_files"?*

“Non_files” means directories or symboliks links.

- *Which type of files do you store in your HOME? your WORK? and your STORE?*

In your $HOME: small files, such as configuration files (`.bash_login` for example).
In your $WORK: your working space, i.e. where you download the files for your simulation and launch it.
In your $STORE: for archive, where outputs of your simulations will be copied. For big files.

Question 1b:

- *Is the quota individual? What happens to the other users if you exceed the quota?*

Quota is attributed for each project for the entire group and not individually, so be careful of your own practices to avoid blocking all the group.

- *What kind of quotas do you have?*

There are quota on space and quota on inodes.

- *What is your global score?*

This score reflects how close you are from the recommended usage of the STOREDIR filesystem.

- *What is the meaning of “non_files"?*

“Non_files” means directories or symboliks links.

- *Which type of files do you store in your HOME? your WORKDIR? and your STOREDIR?*

In your $HOME: small files, such as configuration files (`.bash_login` for example).
In your $CCCWORKDIR: your working space, i.e. where you download the files for your simulation and launch it.
In your $CCCSTOREDIR: for archive, where outputs of your simulations will be copied. For big files.

- *What is the size of the files that you are supposed to store in the STOREDIR?*

The expected size of files is between 10Gb and 1Tb.

2. Install and compile

2.1 Extract LMDZOR_v6 configuration

Question 2a *Using* `./model -h` *command, find which version of LMDZ, ORCHIDEE and libIGCM are currently defined in the configuration* ***LMDZOR_v6.2.2.*** *Note the SVN revision number and SVN branch or tag name. Verify that you can find the same information in the* `mod.def` *file.*

Answer 2a:

	`./model -h LMDZOR_v6.2.2`	`vim mod.def;  /LMDZOR_v6.2.2`
LMDZ	Component : LMDZ6/branches/IPSL-CM6A-MR Revision : 3855	#-C- LMDZOR_v6.2_work LMDZ6/branches/IPSL-CM6A-MR 3855
ORCHIDEE	Component : branches/ORCHIDEE_Quest/ORCHIDEE Revision : 7086	#-C- LMDZOR_v6.2_work branches/ORCHIDEE_Quest/ORCHIDEE 7086
libIGCM	Component : trunk/libIGCM Revision : 1545	#-#-C- LMDZOR_v6.2_work trunk/libIGCM 1545

2.2 Compile with the resolution 144x142x79

Question 2b: *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.*

Answer 2b:

Compilation option available : "-parallel" "-arch" "-xios" "-debug" "-dev" "-prod" "-resol_atm" "CE0L" "-full" "-full_xios" "-full_lmdz" "-full_orch" "-netcdf_lib_seq"
Default resolution : resol_atm=144x142x79

Question 2c: *How can you recompile the whole code? Open the compilation script and check the different script options.*

Answer 2c:

Use the option “-full”

```
./compile_lmdzor.sh -resol_atm 144x142x79 -full
```

3. Basic simulations

3.2 Define and launch your first simulation of 1 day

Question 3a: *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?*
Answer 3a: Files produced during the run are listed in *Script_Output_*.0001* (see below ***"DIR AFTER RUN EXECUTION").*** Some of them (restart files, output files, debug files) are stored on `$CCCSCRATCHDIR` (Irene) or `$SCRATCH` (JeanZay) and ordered by component, for example `$SCRATCH/IGCM_OUT/LMDZOR/TEST/clim/MyJobTest/ATM/Output` `$SCRATCH/IGCM_OUT/LMDZOR/TEST/clim/MyJobTest/ATM/Restart` `$SCRATCH/IGCM_OUT/LMDZOR/TEST/clim/MyJobTest/ATM/Debug`

These files are stored on `$CCCSCRATCHDIR` (Irene) or `$SCRATCH` (JeanZay) rather than archive directory (*`$STORE` (Jean Zay)* or *`$CCCSTOREDIR` (Irene)*) because of `SpaceName=TEST`, which means it is not a "production" run (`SpaceName=PROD`) or a "development" run (`SpaceName=DEVT`).

3.3 Continue the simulation 4 more days

Question 3b: *How many times did the job go into the queue?*
Answer 3b:
To do 4 more days we change `DateEnd` in `config.card` as

```
DateEnd=1980-01-05
```

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.**

Question 3c: *create a new simulation of 5 days, always with* `PeriodLength=1D`*, but with a different* `PeriodNb` *parameter to submit the job only one time to the queue.*
Answer 3c:

```
PeriodNb=5
```

in the Job file allows to perform 5 runs within the same Job submission instead of 1 run per Job submission (since PeriodLength=1D, 1 run means here 1D run).

Question 3d: *Look into your first simulation run.card file. How long did one day take? Did every day take the same time?*
Answer 3d: The 1st day (= 1st run) takes more time than the following days. That's because initial work (maps interpolations,...) is needed by ORCHIDEE to start a simulation with no restart files. Following days take less time than the 1st one, because restart files are used to initialize the state of the models.

3.4 Create another simulation with pack

Question 3e: *explore the output directories, can you understand what was done ?*
Answer 3e: On scratch directory (`$CCCSCRATCHDIR` (Irene) or `$SCRATCH` (JeanZay)) , there is no output files in Output directories:
`$SCRATCH/IGCM_OUT/LMDZOR/DEVT/clim/MyJobTest2/ATM/Output`
That's because a pack step is achieved to concatenate output files and store the result on the archive directory (`$STORE` (Jean Zay) or `$CCCSTOREDIR` (Irene)). This pack step is activated by defining *PackFrequency* in config.card. The concatenated output files are stored on archive directory thanks to *SpaceName=DEVT*. Since *PackFrequency=2M,* the pack step is achieved every 2 months runs. Since the period of the simulation is 4 months, Output directories of archive directory contains files over the period 19800101_19800228 and files for the period 19800301_19800430 (see `$STORE/IGCM_OUT/LMDZOR/DEVT/clim/MyJobTest2/ATM/Output).`

3.5 Use different forcing files

Question 3f: *which files are used as start.nc, startphy.nc, sechiba_rest_in.nc ? Read the Script_output file to answer this question.*
Answer 3f: in Script_Output file of the 1st period (=1st day), you can see the files used as restart files by each component of the model :

```
IGCM_sys_GetBuffer                                                    :
…IGCM_OUT/LMDZOR/TEST/clim/MyJobTest/ATM/Restart/MyJobTest_19800105_restart.nc start.nc
IGCM_sys_GetBuffer                                                    :
…IGCM_OUT/LMDZOR/TEST/clim/MyJobTest/ATM/Restart/MyJobTest_19800105_restartphy.nc startphy.nc
IGCM_sys_GetBuffer                                                    :
…IGCM_OUT/LMDZOR/TEST/clim/MyJobTest/SRF/Restart/MyJobTest_19800105_sechiba_rest.nc sechiba_rest_in.nc
```

Question 3g: *Verify in the Script_output file you use the file you want.*

Answer 3g: in Script_Output files :

```
IGCM_sys_Cp                                                                    :
/ccc/work/cont003/igcmg/igcmg/IGCM/SRF/PFTMAPS/CMIP6/ESA-LUH2v2/historical/15P
FT.v1/PFTmap_1980.nc PFTmap.nc
```

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

Question 3h: *Where can you find the output? Which files are produced and where are they stored?*
Answer 3h: Output files are found in the directory ***IGCM_OUT/LMDZ/ELC-144x142x79/ATM/Output*** on the archive filesystem $STORE at IDRIS or $CCCSTOREDIR at TGCC.
Output directory contains 3 sub-directories as follows :

- Boundary : boundary conditions files ELC-144x142x79_clim_limit.nc and ELC-144x142x79_climoz_LMDZ.nc.
- Grid : grid file ELC-144x142x79_grilles_gcm.nc contains information related to the grid used by the model (lon, lat,...).
- Restart : intial state files for physics and dynamics of LMDZ : ELC-144x142x79_clim_start.nc ELC-144x142x79_clim_startphy.nc.

Question 3i: *What type of calendar is used? How many days contains a year? Check also the number of time steps in the output file limit.nc. Do you know how you can change the calendar that has been used?*
Answer 3i: The calendar type is defined in config.card as follows :

```
CalendarType=noleap
```

A year of noleap calendar contains 365 days as you can see by dumping limit.nc output file :

```
netcdf ELC-144x142x79_clim_limit {
dimensions:
        points_physiques = 20306 ;
        time = UNLIMITED ; // (365 currently)
```

The calendar can be changed in config.card by choosing leap, noleap or 360d.

Question 3j: *Now create a new experiment clim_pdControl using the boundaries files created by ELC-144x142x79. For this you will modify the path in COMP/lmdz.card for start.nc, startphy.nc, limit.nc and climoz_LMDZ.nc files.*

Answer 3j: You have to modify lmdz.card as follows to use boundaries files previously generated and stored on archive directory :

```
ListNonDel=
…
(...IGCM_OUT/LMDZ/ELC2022-144x142x79/ATM/Output/Boundary/ELC-144x142x79_climoz_LMDZ.nc, climoz_LMDZ.nc),\
(...IGCM_OUT/LMDZ/ELC-144x142x79/ATM/Output/Boundary/ELC-144x142x79_clim_limit.nc, limit.nc),\
…
```

and as follows to use initial state files previously generated and stored on archive directory :

```
[InitialStateFiles]
List=
(.../IGCM_OUT/LMDZ/ELC2022-144x142x79/ATM/Output/Restart/ELC-144x142x79_clim_start.nc, start.nc),\
(.../IGCM_OUT/LMDZ/ELC2022-144x142x79/ATM/Output/Restart/ELC-144x142x79_clim_startphy.nc, startphy.nc)
```

Check config.card contains :

```
[Restarts]
#D- by default: config.card describes no restart for all components
#D-                ie start from Levitus or limit files
#D- If you want to restart all components from the same simulation,
#D-      put OveRule flag to 'y' and set the next 3 parameters
OverRule=n
```

in order to use restart files defined in [InitialStateFiles] part of lmdz.card.
You can check the files used by the run in Script_Output :

```
IGCM_sys_Get :
…/IGCM_OUT/LMDZ/ELC-144x142x79/ATM/Output/Restart/ELC2022-144x142x79_clim_start.nc start.nc
IGCM_sys_Get :
…/IGCM_OUT/LMDZ/ELC-144x142x79/ATM/Output/Restart/ELC2022-144x142x79_clim_startphy.nc startphy.nc
…
IGCM_sys_Get :
…/IGCM_OUT/LMDZ/ELC2022-144x142x79/ATM/Output/Boundary/ELC2022-144x142x79_climoz_LMDZ.nc climoz_LMDZ.nc
IGCM_sys_Get :
…/IGCM_OUT/LMDZ/ELC2022-144x142x79/ATM/Output/Boundary/ELC2022-144x142x79_clim_limit.nc limit.nc
```

4. Debug

4.1 Debug : setup error

Question 4a: *What was the error?*
Answer 4a:
Add the missing line:

```
(${R_IN}/ATM/LIMIT/AMIP.v20180427/interpol/${RESOL_ATM_XY}_eORCA1.2_365d/limit_1979_2008_clim.nc, limit.nc),\
```

with no character after "\" !

after line:
`(${R_IN}/ATM/OZONE/UReading/historical.v20160711.v2/interpol/${RESOL_ATM_XY}/climoz_LMDZ_1979_2008_clim.nc, climoz_LMDZ.nc),\`

Question 4b: *What was the error?*
Answer 4b:
Replace line:
`(${R_IN}/ATM/LIMIT/AMIP.v20180427/interpole/${RESOL_ATM_XY}_eORCA1.2_365d/limit_1979_2008_clim.nc, limit.nc),\`

by:

```
(${R_IN}/ATM/LIMIT/AMIP.v20180427/interpol/${RESOL_ATM_XY}_eORCA1.2_365d/limit_1979_2008_clim.nc, limit.nc),\
```

Question 4c: *What was the error?*
Answer 4c:
Remove trailing spaces after "\" in line:

```
(${R_IN}/ATM/LIMIT/AMIP.v20180427/interpol/${RESOL_ATM_XY}_eORCA1.2_365d/limit_1979_2008_clim.nc, limit.nc),\
```

The symbol "\" must be the last character of the line otherwise the following lines will be ignored.

5. Create time series

5.1 Launch 5 years with default time series

Question 5a: *once the simulation and post-treatment are completed, you can check Time Series (see in the following directories IGCM_OUT/…./JobName/???/Analyse/TS_MO) on archive directory.*
Answer 5a: Time Series files have been created and stored on archive directory (`$STORE` (Jean Zay) or `$CCCSTOREDIR` (Irene), see :
`…/IGCM_OUT/OL2/DEVT/test/MyPostExp/SRF/Analyse/TS_MO`
and
`…/IGCM_OUT/OL2/DEVT/test/MyPostExp/SBG/Analyse/TS_MO`

Question 5b: *check that Time Series for z0h and z0m were created.*
Answer 5b: TimeSeriesChecker.job indicates two variables are missing as Time Series.

2022-01-06 20:57:27 ----------Debug3--> Missing time series from 1M_sechiba_history in /ccc/store/cont003/gencmip6/p86caub/IGCM_OUT/OL2/DEVT/test/MyPostExp2022/SRF/Analyse/TS_MO :
2022-01-06 20:57:27 ----------Debug3-->
MyPostExp2022_19010101_19051231_1M_z0h.nc
2022-01-06 20:57:27 ----------Debug3-->
MyPostExp2022_19010101_19051231_1M_z0m.nc
2022-01-06 20:57:27 --------Debug2--> **95% files OK**. for period 19010101-19051231

`TimeSeriesChecker.job` generate missing variables and store them in :
`…/IGCM_OUT/OL2/DEVT/test/MyPostExp/SRF/Analyse/TS_MO/MyPostExp2022_19010101_19051231_1M_z0h.nc`
and
`…/IGCM_OUT/OL2/DEVT/test/MyPostExp/SRF/Analyse/TS_MO/MyPostExp2022_19010101_19051231_1M_z0m.nc`

Then `TimeSeriesChecker.job` indicates 100% of Time Series requested have been generated:

2022-01-06 21:04:55 --Debug1--> SRF
2022-01-06 21:04:55 --------Debug2--> 2D time series activated for Post_1M_sechiba_history
2022-01-06 21:04:55 --------Debug2--> **100% files OK**. for period 19010101-19051231

8. Modify output using XIOS

Question 8a: *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/*
Answer 8a: The new file was packed and stored on archive directory $STORE at IDRIS or $CCCSTOREDIR at TGCC :

```
ncdump -h
…/IGCM_OUT/OL2/DEVT/test/MyPostExp2/SRF/Output/DA/MyPostExp2_19010101_19051231_1D_myoutput_orch.nc
…
        float rainfall(time_counter, lat, lon) ;
                rainfall:long_name = "Rainfall rate" ;
                rainfall:units = "mm/s" ;
                rainfall:online_operation = "average" ;
                rainfall:interval_operation = "1800 s" ;
                rainfall:interval_write = "1 d" ;
                rainfall:cell_methods = "time: mean (interval: 1800 s)" ;
                rainfall:_FillValue = 9.96921e+36f ;
                rainfall:missing_value = 9.96921e+36f ;
                rainfall:coordinates = "time_centered" ;
        float snowfall(time_counter, lat, lon) ;
                snowfall:long_name = "Snowfall rate" ;
                snowfall:units = "mm/s" ;
                snowfall:online_operation = "average" ;
                snowfall:interval_operation = "1800 s" ;
                snowfall:interval_write = "1 d" ;
                snowfall:cell_methods = "time: mean (interval: 1800 s)" ;
                snowfall:_FillValue = 9.96921e+36f ;
                snowfall:missing_value = 9.96921e+36f ;
                snowfall:coordinates = "time_centered" ;
…
```

and time series have been created and stored :

```
…/IGCM_OUT/OL2/DEVT/test/MyPostExp2/SRF/Analyse/TS_DA/MyPostExp2_19010101_19051231_1D_rainfall.nc
…/IGCM_OUT/OL2/DEVT/test/MyPostExp2/SRF/Analyse/TS_DA/MyPostExp2_19010101_19051231_1D_snowfall.nc
```

Question 8b : *Verify that this new file is created and that it contains the slp variable.*
Answer 8b: The new file is created and stored on scratch filesystem :
…/IGCM_OUT/LMDZOR/TEST/clim/MyJobTestLMDZ/ATM/Output/HF/**MyJobTestLMDZ_19800101_19800105_HF_myoutput_lmdz.nc**
and this file contains :

```
ncdump -h MyJobTestLMDZ_19800101_19800105_HF_myoutput_lmdz.nc
…
float slp(time_counter, lat, lon) ;
                slp:long_name = "Sea Level Pressure" ;
                slp:units = "Pa" ;
                slp:online_operation = "average" ;
                slp:interval_operation = "900 s" ;
                slp:interval_write = "1 h" ;
                slp:cell_methods = "time: mean (interval: 900 s)" ;
                slp:_FillValue = 9.96921e+36f ;
                slp:missing_value = 9.96921e+36f ;
                slp:coordinates = "time_centered" ;
…
```

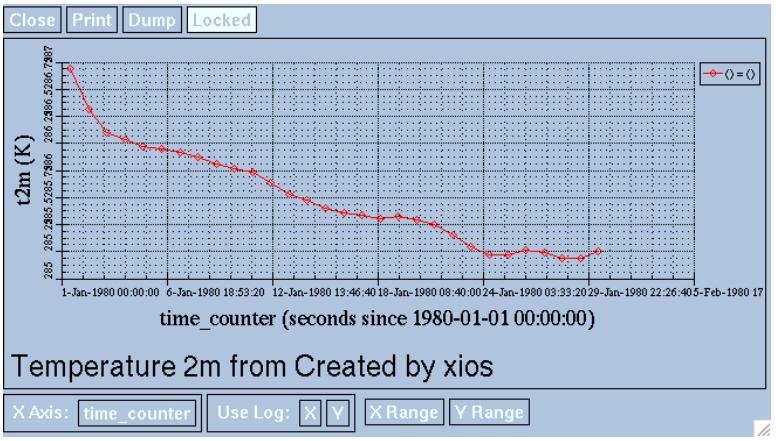
9. Output files manipulations

Question 9a: *Look at the file structure, how is it composed ? Explore other variables or components (SBG, MBG, OCE, ICE…). Are they structured in the same way ?*
NetCDF is a self-describing data format and all NetCDF files are structured in the same way. The ncdump command allows you to access information (“dimensions” section and “variables” section) about data the file contains.

Question 9b: *Check the output file content using ncdump -h*
Only the variable “t2m” is in the output file.

Question 9c and 9e: *Compare computing performances between NCO and CDO treatment.*
CDO treatment is faster than NCO treatment which besides needs to compute explicitly weights needed for the global and zonal means.

Section 9.3: *Use NCview with global t2m average.*



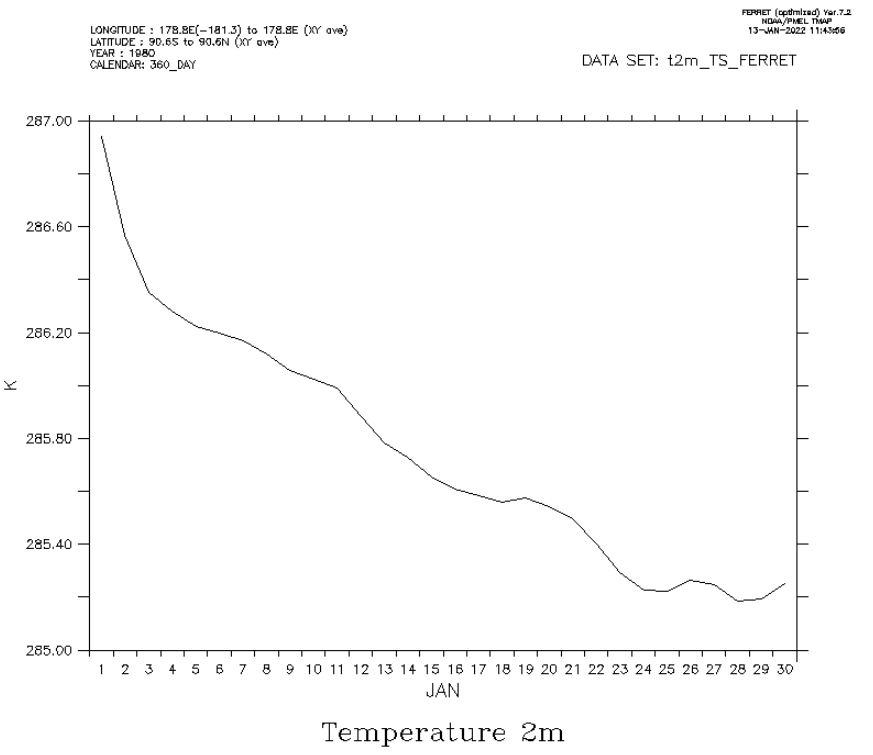
NCview quick snapshot of global mean temperature file

Section 9.4: *Ferret show infos.*

```
yes? show data/f 2
        currently SET data sets:
        2> ./t2m_TS_FERRET.nc  (default)

 name  title                I        J       K       L
 T2M   Temperature 2m                1:144   1:143   ...       1:30
        K on grid GDZ1 with 9.96921E+36 for missing data
        X=178.8E(-181.3):178.8E  Y=90.6S:90.6N

  time range: 01-JAN-1980 12:00 to 30-JAN-1980 12:00 Calendar:360_DAY
```



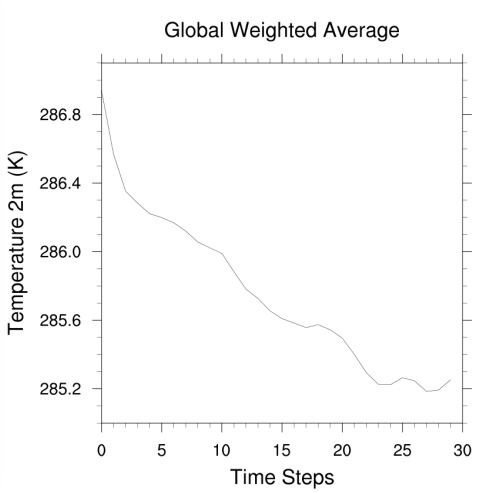
Ferret : plot global mean temperature

Question 9f: *Look with ncdump to the new NCL file.*

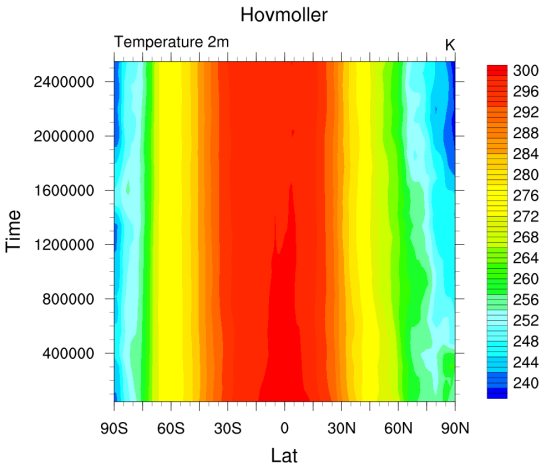
```
>> ncdump -h t2m_TS_NCL.nc
netcdf t2m_TS_NCL {
dimensions:
   time_counter = 30 ;
   lat = 143 ;
   lon = 144 ;
variables:
   float t2m(time_counter, lat, lon) ;
         t2m:long_name = "Temperature 2m" ;
         t2m:units = "K" ;
         t2m:online_operation = "average" ;
         t2m:interval_operation = "900 s" ;
         t2m:interval_write = "1 d" ;
         t2m:cell_methods = "time: mean (interval: 900 s)" ;
         t2m:_FillValue = 9.96921e+36f ;
         t2m:missing_value = 9.96921e+36f ;
         t2m:coordinates = "time_centered" ;
   double time_counter(time_counter) ;
         time_counter:axis = "T" ;
         time_counter:standard_name = "time" ;
         time_counter:long_name = "Time axis" ;
         time_counter:calendar = "360_day" ;
         time_counter:units = "seconds since 1980-01-01 00:00:00" ;
         time_counter:time_origin = "1980-01-01 00:00:00" ;
         time_counter:bounds = "time_counter_bounds" ;
   float lat(lat) ;
```

```
        lat:axis = "Y" ;
        lat:standard_name = "latitude" ;
        lat:long_name = "Latitude" ;
        lat:units = "degrees_north" ;
    float lon(lon) ;
        lon:axis = "X" ;
        lon:standard_name = "longitude" ;
        lon:long_name = "Longitude" ;
        lon:units = "degrees_east" ;
}
```

Question 9g & 9h: *Plot NCL output files ; ave.png for global mean and zonal.png for zonal one*

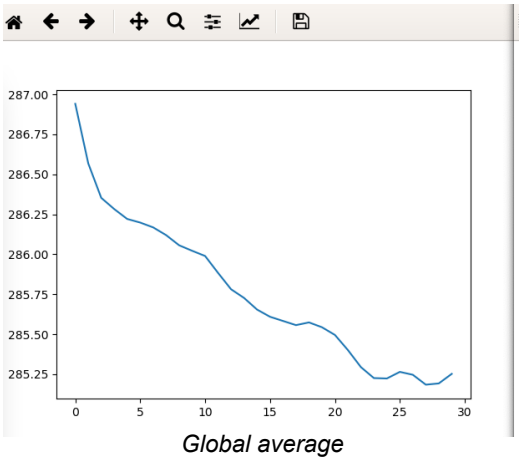


NCL : display of ave.png file

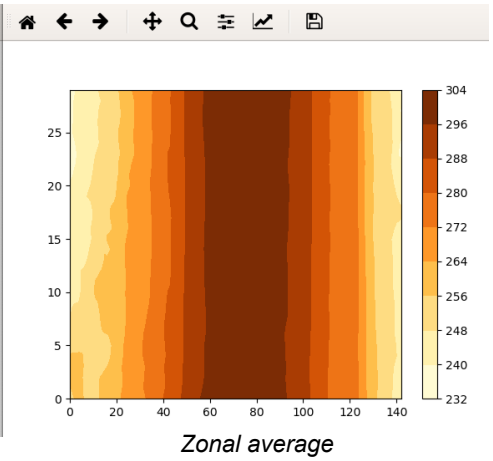


NCL: display of the zonal.png file

Section 9.6 NetCDF4 & Xarray exercises: *Plot output files*



Global average



Zonal average

10. Install and run NEMO-PISCES

Question 10a: Explore the `COMP/opa9.card` and `COMP/pisces.card`

In the opa9.card file, you will find all the input files needed to run the dynamical core of NEMO such as atmospheric forcing, radiative forcing, and precipitation files etc…, as well as files related to the grid of the considered configuration etc…

```
ListNonDel= (${opa9_UserChoices_R_FORCING}/u_10.15JUNE2009_fill.nc           , u_10_CORE2_fill.nc), \
            (${opa9_UserChoices_R_FORCING}/v_10.15JUNE2009_fill.nc           , v_10_CORE2_fill.nc), \
            (${opa9_UserChoices_R_FORCING}/t_10.15JUNE2009_fill.nc           , t_10_CORE2_fill.nc), \
            (${opa9_UserChoices_R_FORCING}/q_10.15JUNE2009_fill.nc           , q_10_CORE2_fill.nc), \
            (${opa9_UserChoices_R_FORCING}/ncar_rad.15JUNE2009_fill.nc       , ncar_rad_CORE2_fill.nc), \
            (${opa9_UserChoices_R_FORCING}/ncar_rad.15JUNE2009_fill.nc       , ncar_rad_CORE2_fill.nc), \
            (${opa9_UserChoices_R_FORCING}/ncar_precip.15JUNE2009_fill.nc    , ncar_precip_CORE2_fill.nc), \
            (${opa9_UserChoices_R_FORCING}/ncar_precip.15JUNE2009_fill.nc    , ncar_precip_CORE2_fill.nc), \
            (${opa9_UserChoices_R_FORCING}/slp.15JUNE2009_fill.nc            , slp_CORE2_fill.nc), \
            (${opa9_UserChoices_R_FORCING}/weights_core_orca2_bilinear_noc.nc, weights_bilinear.nc), \
            (${opa9_UserChoices_R_FORCING}/weights_core_orca2_bicubic_noc.nc , weights_bicubic.nc), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/${ORCAGRID}_coordinates.nc, coordinates.nc), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/${ORCAGRID}_coordinates_xios.nc, coordinates_xios.nc ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/${ORCAGRID}_domain_cfg.nc, domain_cfg.nc ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/${ORCAGRID}_maskMFO.nc, maskMFO.nc ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/${ORCAGRID}_resto.nc, resto.nc ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/${ORCAGRID}_subbasins.nc , subbasins.nc    ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/${ORCAGRID}_mixing_power_bot.nc, mixing_power_bot.nc),\
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/${ORCAGRID}_mixing_power_pyc.nc, mixing_power_pyc.nc),\
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/${ORCAGRID}_mixing_power_cri.nc, mixing_power_cri.nc),\
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/${ORCAGRID}_decay_scale_bot.nc, decay_scale_bot.nc),\
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/${ORCAGRID}_decay_scale_cri.nc, decay_scale_cri.nc),\
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/${ORCAGRID}_sali_ref_clim_monthly.nc, sali_ref_clim_monthly.nc), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/${ORCAGRID}_eddy_viscosity_3D.nc, eddy_viscosity_3D.nc ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/${ORCAGRID}_geothermal_heating.nc, geothermal_heating.nc),\
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/conservative_temperature_WOA13_decav_clim_ORCA2.nc, conservative_temperature_WOA13_decav_clim_ORCA2.nc), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/absolute_salinity_WOA13_decav_clim_ORCA2.nc, absolute_salinity_WOA13_decav_clim_ORCA2.nc), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/sss_absolute_salinity_WOA13_decav_clim_ORCA2.nc, sss_absolute_salinity_WOA13_decav_clim_ORCA2.nc), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/runoff_core_monthly_ORCA2.nc, runoff_core_monthly.nc),\
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/OPA/chlorophyll_ORCA2.nc, chlorophyll.nc)
```

In the pisces.card file, you will find all the input files related to PISCES such as initial states of nutrients from the World Ocean Atlas 2009 observational climatologies, total DIC and alkalinity from the GLODAP V2.1 compiled data, biogeochemical inputs from rivers, atmospheric nitrate deposition, Fe inputs from dust and sediments etc ...

```
ListNonDel= (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/TDIC_GLODAPv2.1_annual_r360x180xl31.nc, data_DIC_nomask.nc ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/TALK_GLODAPv2.1_annual_r360x180xl31.nc , data_ALK_nomask.nc ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/O2_WOA2009_monthly_r360x180xl31.nc     , data_OXY_nomask.nc ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/PO4_WOA2009_monthly_r360x180xl31.nc    , data_PO4_nomask.nc ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/Si_WOA2009_monthly_r360x180xl31.nc     , data_SIL_nomask.nc ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/NO3_WOA2009_monthly_r360x180xl31.nc    , data_NO3_nomask.nc ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/DOC_PISCES_monthly_r360x180xl31.nc     , data_DOC_nomask.nc ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/Fer_PISCES_monthly_r360x180xl31.nc     , data_FER_nomask.nc ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/weights_3D_r360x180_orca2_bilinear.nc    , weights_3D_r360x180_bilin.nc ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/Dust_inca_LOI/DUST_INCA_LOI6012-histAER_1M_1850.nc, dust.orca.nc       ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/Ndep_input4MIPs/Ndep_input4MIPs_surfaceFluxes_CMIP_NCAR-CCMI-2-0_gn_185001-185012-clim.nc, ndeposition.orca.nc), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/Dust_inca_LOI/weights_LMD144142_ORCA2_bilinear.nc , weights_lmd144142_bilin.nc ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/Ndep_input4MIPs/weights_CMIP_NCAR-CCMI_ORCA2_bilinear.nc, weights_2d_bilin.nc), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/pmarge_etopo_ORCA2.nc                  , bathy.orca.nc      ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/river_global_news_ORCA2.nc             , river.orca.nc      ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/par_fraction_gewex_clim90s00s_ORCA2.nc  , par.orca.nc        ), \
            (${R_IN}/OCE/NEMO/${opa9_UserChoices_ORCA_version}/PISCES/Solubility_T62_Mahowald_ORCA2.nc       , solubility.orca.nc ), \
            (${R_IN}/OCE/NEMO/FORCINGS/GHG/CFCs_CDIAC.dat                  , CFCs_CDIAC.dat     ), \
            (${R_IN}/OCE/NEMO/FORCINGS/GHG/CO2_OMIP6_1600_2014.txt         , atcco2.txt         )
```

Question 10b: Explore in `PARAM/NAMELIST/ORCA2` the `namelist_core_clim_cfg` file

This file contains, among other parameters, the initial temperature and salinity states from the World Ocean Atlas 2013 climatologies (&namstd) as well as the names of the CORE 2

atmospheric forcing variables and their reading frequencies used for this configuration (&namsbc_blk).

```
!-----------------------------------------------------------------------
&namtsd        !    Temperature & Salinity Data  (init/dmp)            (default: OFF)
!-----------------------------------------------------------------------
   !                       ! =T  read T-S fields for:
   ln_tsd_init = .true.          !  ocean initialisation
   ln_tsd_dmp  = .true.          !  T-S restoring   (see namtra_dmp)

   cn_dir = './'     !  root directory for the T-S data location
   !___________!_________________________!___________________!___________!_____________!________!___________!__________________!__________!_______________!
   !           !  file name              ! frequency (hours) ! variable  ! time interp.!  clim  ! 'yearly'/ ! weights filename ! rotation ! land/sea mask !
   !           !                         !  (if <0  months)  !   name    !   (logical) !  (T/F) ! 'monthly' !                  ! pairing  !    filename   !
   sn_tem = 'conservative_temperature_WOA13_decav_clim_ORCA2.nc',     -1.     ,'votemper',    .true.    , .true. , 'yearly'  ,    ''    ,    ''    ,    ''
   sn_sal = 'absolute_salinity_WOA13_decav_clim_ORCA2.nc'       ,     -1.     ,'vosaline',    .true.    , .true. , 'yearly'  ,    ''    ,    ''    ,    ''
/
```

```
!-----------------------------------------------------------------------
&namsbc_blk    !   namsbc_blk  generic Bulk formula                  (ln_blk =T)
!-----------------------------------------------------------------------
   !                    !  bulk algorithm :
   ln_NCAR    = .true.     ! "NCAR"      algorithm   (Large and Yeager 2008)
   ln_taudif  = .false.    !  HF tau contribution: use "mean of stress module - module of the mean stress" data

   cn_dir = './'  !  root directory for the bulk data location
   !___________!_____________________________!___________________!___________!_____________!________!____________!____________________!__________!_______________!
   !           !            file name        ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ !  weights filename  ! rotation ! land/sea mask !
   !           !                             !  (if <0  months)  !   name    !   (logical)  !  (T/F)  ! 'monthly' !                    ! pairing  !    filename   !
   sn_wndi     = 'u_10_CORE2_fill'           ,        6.         , 'U_10_MOD',   .false.    , .true. , 'yearly'  , 'weights_bicubic.nc'  , 'Uwnd'   , ''
   sn_wndj     = 'v_10_CORE2_fill'           ,        6.         , 'V_10_MOD',   .false.    , .true. , 'yearly'  , 'weights_bicubic.nc'  , 'Vwnd'   , ''
   sn_qsr      = 'ncar_rad_CORE2_fill'       ,       24.         , 'SWDN_MOD',   .false.    , .true. , 'yearly'  , 'weights_bilinear.nc' , ''       , ''
   sn_qlw      = 'ncar_rad_CORE2_fill'       ,       24.         , 'LWDN_MOD',   .false.    , .true. , 'yearly'  , 'weights_bilinear.nc' , ''       , ''
   sn_tair     = 't_10_CORE2_fill'           ,        6.         , 'T_10_MOD',   .false.    , .true. , 'yearly'  , 'weights_bilinear.nc' , ''       , ''
   sn_humi     = 'q_10_CORE2_fill'           ,        6.         , 'Q_10_MOD',   .false.    , .true. , 'yearly'  , 'weights_bilinear.nc' , ''       , ''
   sn_prec     = 'ncar_precip_CORE2_fill'    ,       -1.         , 'PRC_MOD' ,   .false.    , .true. , 'yearly'  , 'weights_bilinear.nc' , ''       , ''
   sn_snow     = 'ncar_precip_CORE2_fill'    ,       -1.         , 'SNOW'    ,   .false.    , .true. , 'yearly'  , 'weights_bilinear.nc' , ''       , ''
   sn_slp      = 'slp_CORE2_fill'            ,        6.         , 'SLP'     ,   .false.    , .true. , 'yearly'  , 'weights_bilinear.nc' , ''       , ''
/
```

Question 10c: Explore in `PARAM/XML/file_def_nemo*`

In the files_def_nemo-oce.xml, file_def_nemo-top.xml, and file_def_nemo-ice_ORCA2.xml, you will find all the variables for each model component, i.e., ocean, sea ice, and marine biogeochemistry, that are written to the output files for each output frequency.
Below is the list of the biogeochemical variables from the PISCES output file at a frequency of 1 month:

```
<file_group id="1m_pis" output_freq="1mo" output_level="_AUTO_" enabled="_AUTO_" > <!-- real monthly files -->


  <file id="file33" name_suffix="_ptrc_T" description="pisces sms variables" enabled=".TRUE." >
    <field field_ref="e3t"       name="E3T"      long_name="T-cell thickness" />
    <field field_ref="DIC"       name="DIC"      operation="average" freq_op="1mo" level="2" > @DIC_e3t / @e3t </field>
    <field field_ref="Alkalini"  name="Alkalini" operation="average" freq_op="1mo" level="2" > @Alkalini_e3t / @e3t </field>
    <field field_ref="O2"        name="O2"       operation="average" freq_op="1mo" level="2" > @O2_e3t / @e3t </field>
    <field field_ref="CaCO3"     name="CaCO3"    operation="average" freq_op="1mo" level="2" > @CaCO3_e3t / @e3t </field>
    <field field_ref="PO4"       name="PO4"      operation="average" freq_op="1mo" level="2" > @PO4_e3t / @e3t </field>
    <field field_ref="POC"       name="POC"      operation="average" freq_op="1mo" level="2" > @POC_e3t / @e3t </field>
    <field field_ref="Si"        name="Si"       operation="average" freq_op="1mo" level="2" > @Si_e3t / @e3t </field>
    <field field_ref="PHY"       name="PHY"      operation="average" freq_op="1mo" level="2" > @PHY_e3t / @e3t </field>
    <field field_ref="ZOO"       name="ZOO"      operation="average" freq_op="1mo" level="2" > @ZOO_e3t / @e3t </field>
    <field field_ref="DOC"       name="DOC"      operation="average" freq_op="1mo" level="2" > @DOC_e3t / @e3t </field>
    <field field_ref="PHY2"      name="PHY2"     operation="average" freq_op="1mo" level="2" > @PHY2_e3t / @e3t </field>
    <field field_ref="ZOO2"      name="ZOO2"     operation="average" freq_op="1mo" level="2" > @ZOO2_e3t / @e3t </field>
    <field field_ref="DSi"       name="DSi"      operation="average" freq_op="1mo" level="2" > @DSi_e3t / @e3t </field>
    <field field_ref="Fer"       name="Fer"      operation="average" freq_op="1mo" level="2" > @Fer_e3t / @e3t </field>
    <field field_ref="BFe"       name="BFe"      operation="average" freq_op="1mo" level="2" > @BFe_e3t / @e3t </field>
    <field field_ref="GOC"       name="GOC"      operation="average" freq_op="1mo" level="2" > @GOC_e3t / @e3t </field>
    <field field_ref="SFe"       name="SFe"      operation="average" freq_op="1mo" level="2" > @SFe_e3t / @e3t </field>
    <field field_ref="DFe"       name="DFe"      operation="average" freq_op="1mo" level="2" > @DFe_e3t / @e3t </field>
    <field field_ref="GSi"       name="GSi"      operation="average" freq_op="1mo" level="2" > @GSi_e3t / @e3t </field>
    <field field_ref="NFe"       name="NFe"      operation="average" freq_op="1mo" level="2" > @NFe_e3t / @e3t </field>
    <field field_ref="NCHL"      name="NCHL"     operation="average" freq_op="1mo" level="2" > @NCHL_e3t / @e3t </field>
    <field field_ref="DCHL"      name="DCHL"     operation="average" freq_op="1mo" level="2" > @DCHL_e3t / @e3t </field>
    <field field_ref="NO3"       name="NO3"      operation="average" freq_op="1mo" level="2" > @NO3_e3t / @e3t </field>
    <field field_ref="NH4"       name="NH4"      operation="average" freq_op="1mo" level="2" > @NH4_e3t / @e3t </field>
  </file>
```

Question 10d: Explore the `Script_Output` and `run.card` files

The Script_Output file provides you with all the information about the model configuration used in your experiment before and after the run. You will find there the different steps and files needed and produced during your experiment. If an error occurred in the execution of your run, this is where you should first look for information to understand what went wrong.

The run.card file provides you with information about the computing period, the status of the job and the real Cpu time.

```
#============================================================
[Configuration]
#Compute date of loop
PeriodDateBegin= 1948-02-01
PeriodDateEnd= 1948-02-28
CumulPeriod= 2
# State of Job "Start", "Running", "OnQueue", "Completed"
PeriodState= Completed

SubmitPath= /gpfsssd/scratch/rech/omr/romr014/LIBIGCM_TP/NEMO_STD/modipsl/config/NEMO_v6/ORCA2_ICE_PISCES
simuid= 80784aa5-bc07-4c67-bd96-4829dccd72fa
#============================================================
[PostProcessing]

#RebuildRunning=y/n
#RebuildToComplete=number of dir to rebuild
#RebuildDateID=PeriodDateEnd correspondant au dernier flag de RebuildFrequency=true

TimeSeriesRunning= n
TimeSeriesCompleted= 19480131

#============================================================
[Log]
# Executables Size
LastExeSize= ( 48799176, 0, 0, 22500080 )

#-----------------------------------------------------------------------------------------------------------------------------------------------------------------------
# CumulPeriod | PeriodDateBegin |   PeriodDateEnd |       RunDateBegin |         RunDateEnd |     RealCpuTime |     UserCpuTime |      SysCpuTime | ExeDate
#-----------------------------------------------------------------------------------------------------------------------------------------------------------------------
#           1 |        19480101 |        19480131 | 2022-03-14T18:02:11 | 2022-03-14T18:05:29 |       197.42000 |         0.01000 |         0.03000 | OCE_Mar_14_13:00-IOS_Mar_14_13:02
```

Question 10e: Explore the output directories (`OCE/Output`, `ICE/Output`, `MBG/Output`)

The output directories are located on the scratch directory of your machine (Jean Zay or Irene) as the run was performed in the TEST case (cf. config.card):
/$SCRATCH/IGCM_OUT/NEMO/TEST/clim/OR2Si3P1/

To continue the simulation for 1 month, set in the run.card file the period state to “OnQueue”:

```
# State of Job "Start", "Running", "OnQueue", "Completed"
PeriodState= OnQueue
```

Change in the config.card file the date end of the job:

```
#-- Begin and end of Job
#-- "YYYY-MM-DD"
DateBegin=1948-01-01
DateEnd=1948-02-28
```

and submit the job:

```
sbatch Job_OR2Si3P1 / ccc_msub Job_OR2Si3P1
```

Question 10f: Explore the `COMP/pisces.card`

As with the previous configuration, you will find all the necessary input files for PISCES. In the *offline* case, the CORE atmospheric forcing files are no longer needed. Instead, you will find the oceanic forcing files (dyna_grid_*.nc) used to simulate the climatological state of the ocean over a year and used to compute the biogeochemical fields by the PISCES model.

```
ListNonDel= (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/GRIDS/ORCA2_domain_cfg.nc, domain_cfg.nc), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/DYNA/dyna_grid_T.nc, .), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/DYNA/dyna_grid_U.nc, .), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/DYNA/dyna_grid_V.nc, .), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/DYNA/dyna_grid_W.nc, .), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/TDIC_GLODAPv2.1_annual_r360x180xl31.nc, data_DIC_nomask.nc ), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/TALK_GLODAPv2.1_annual_r360x180xl31.nc , data_ALK_nomask.nc ), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/O2_WOA2009_monthly_r360x180xl31.nc     , data_OXY_nomask.nc ), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/PO4_WOA2009_monthly_r360x180xl31.nc    , data_PO4_nomask.nc ), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/Si_WOA2009_monthly_r360x180xl31.nc     , data_SIL_nomask.nc ), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/NO3_WOA2009_monthly_r360x180xl31.nc    , data_NO3_nomask.nc ), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/DOC_PISCES_monthly_r360x180xl31.nc     , data_DOC_nomask.nc ), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/Fer_PISCES_monthly_r360x180xl31.nc     , data_FER_nomask.nc ), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/weights_3D_r360x180_orca2_bilinear.nc    , weights_3D_r360x180_bilin.nc ), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/Dust_inca_LOI/DUST_INCA_LOI6012-histAER_1M_1850.nc, dust.orca.nc       ), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/Dust_inca_LOI/weights_LMD144142_ORCA2_bilinear.nc , weights_lmd144142_bilin.nc ), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/Ndep_input4MIPs/Ndep_input4MIPs_surfaceFluxes_CMIP_NCAR-CCMI-2-0_gn_185001-185012-clim.nc, ndeposition.orca.nc), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/Ndep_input4MIPs/weights_CMIP_NCAR-CCMI_ORCA2_bilinear.nc, weights_2d_bilin.nc), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/pmarge_etopo_ORCA2.nc                 , bathy.orca.nc      ), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/river_global_news_ORCA2.nc            , river.orca.nc      ), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/par_fraction_gewex_clim90s00s_ORCA2.nc   , par.orca.nc       ), \
          (${R_IN}/OCE/NEMO/${pisces_UserChoices_ORCA_version}/PISCES/Solubility_T62_Mahowald_ORCA2.nc        , solubility.orca.nc ), \
          (${R_IN}/OCE/NEMO/FORCINGS/GHG/CFCs_CDIAC.dat                  , CFCs_CDIAC.dat     ), \
          (${R_IN}/OCE/NEMO/FORCINGS/GHG/CO2_OMIP6_1600_2014.txt         , atcco2.txt         )
```

Question 10g: Explore in `PARAM/NAMELIST/ORCA2` the `namelist_offline_clim_cfg`

Here the &namsbc_blk section describing the atmospheric forcing variables (see question 10b) is now empty. Instead, it is the &namdta_dyn section that is filled with the variables read by PISCES to simulate the annual seasonal variations of the ocean and used to compute the biogeochemical variables in the *offline* mode.

```
!-----------------------------------------------------------------------
&namdta_dyn    !   offline ocean input files                    (OFF_SRC only)
!-----------------------------------------------------------------------
   ln_dynrnf       =  .false.    !  runoffs option enabled (T) or not (F)
   ln_dynrnf_depth =  .false.    !  runoffs is spread in vertical (T) or not (F)
!   fwbcorr        = 3.786e-06   !  annual global mean of empmr for ssh correction

   cn_dir      = './'      !  root directory for the ocean data location
   !___________!_________________________!___________________!___________!_____________!________!___________!__________________!__________!_______________!
   !           !  file name              ! frequency (hours) ! variable  ! time interp.!  clim  ! 'yearly'/ ! weights filename ! rotation ! land/sea mask !
   !           !                         !  (if <0  months)  !   name    !   (logical) !  (T/F) ! 'monthly' !                  ! pairing  !    filename   !
   sn_tem      = 'dyna_grid_T'           ,       120.        , 'votemper'  , .true.    , .true. , 'yearly'  , ''                 , ''       , ''
   sn_sal      = 'dyna_grid_T'           ,       120.        , 'vosaline'  , .true.    , .true. , 'yearly'  , ''                 , ''       , ''
   sn_mld      = 'dyna_grid_T'           ,       120.        , 'somixhgt'  , .true.    , .true. , 'yearly'  , ''                 , ''       , ''
   sn_emp      = 'dyna_grid_T'           ,       120.        , 'sowaflup'  , .true.    , .true. , 'yearly'  , ''                 , ''       , ''
   sn_fmf      = 'dyna_grid_T'           ,       120.        , 'iowaflup'  , .true.    , .true. , 'yearly'  , ''                 , ''       , ''
   sn_ice      = 'dyna_grid_T'           ,       120.        , 'soicecov'  , .true.    , .true. , 'yearly'  , ''                 , ''       , ''
   sn_qsr      = 'dyna_grid_T'           ,       120.        , 'soshfldo'  , .true.    , .true. , 'yearly'  , ''                 , ''       , ''
   sn_wnd      = 'dyna_grid_T'           ,       120.        , 'sowindsp'  , .true.    , .true. , 'yearly'  , ''                 , ''       , ''
   sn_uwd      = 'dyna_grid_U'           ,       120.        , 'uocetr_eff', .true.    , .true. , 'yearly'  , ''                 , ''       , ''
   sn_vwd      = 'dyna_grid_V'           ,       120.        , 'vocetr_eff', .true.    , .true. , 'yearly'  , ''                 , ''       , ''
   sn_wwd      = 'dyna_grid_W'           ,       120.        , 'wocetr_eff', .true.    , .true. , 'yearly'  , ''                 , ''       , ''
   sn_avt      = 'dyna_grid_W'           ,       120.        , 'voddmavs'  , .true.    , .true. , 'yearly'  , ''                 , ''       , ''
/
```

Question 10h: Explore the output directories where the output files are stored (`MBG/Output`)

Files can be found:
/$SCRATCH/IGCM_OUT/NEMO/TEST/clim/OR2OFFPIS1/

Question 10i: Find where the reference namelist of PISCES is stored

To find the path where the namelist_pisces_ref is stored, open the pisces.card in the COMP directory of your configuration.

Question 10j: Explore the `namelist_pisces_ref`

The namelist_pisces_ref file contains all the biogeochemical parameters that can be modified without recompiling the PISCES code. The values of all these parameters have been tuned for a global configuration at 2° resolution. They can be modified by copying the ones you want to modify into the namelist_pisces_cfg file. The values modified in namelist_pisces_cfg will then automatically overwrite the reference value in the code execution directory. Thus, you can always go back to the initial values of the modified parameters by opening the namelist_pisces_ref whose path is in the pisces.card file.

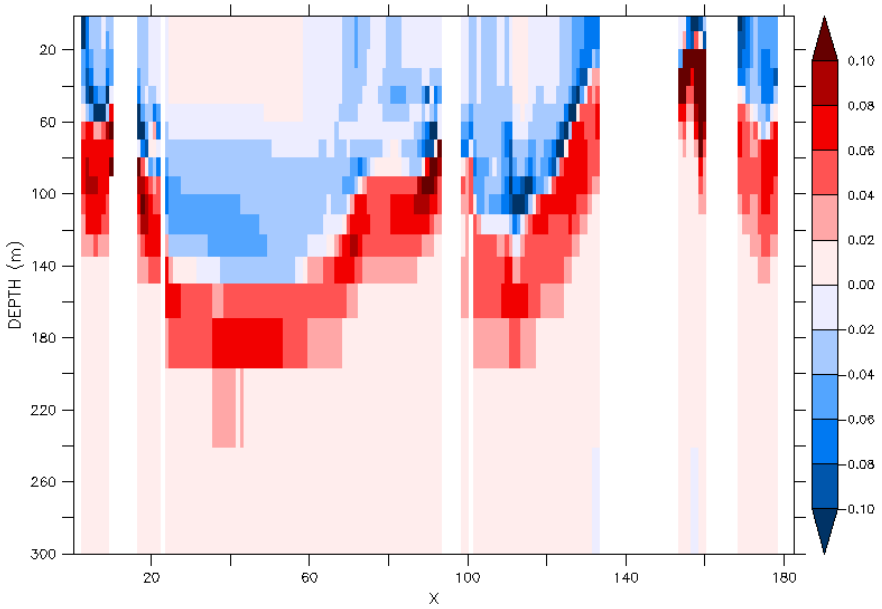
Question 10k: Explore the output directories (`MBG/Output`)

Files can be found:
/$SCRATCH/IGCM_OUT/NEMO/TEST/clim/OR2OFFPIS2/

Question 10l: Compare the annual output files of the 2 *offline* configurations (OR2OFFPIS1, OR2OFFPIS2)

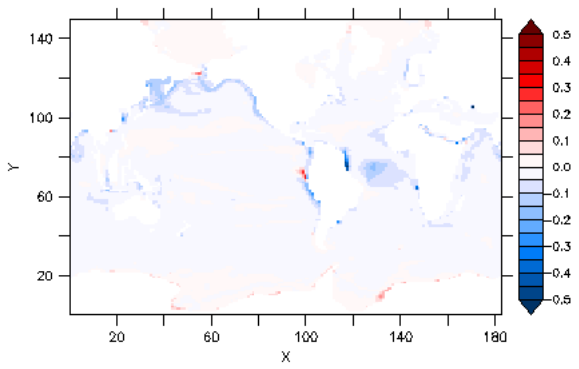
Here we plot the difference in annual means of total chlorophyll (DCHL+NCHL) and surface NO3, Si, and Fe (x1.e3) between the two experiments (OR2OFFPIS2 minus OR2OFFPIS1).

By increasing the sensitivity of phytoplankton to low light availability, the ability of phytoplankton to assimilate nutrients at depth increases. This is illustrated by the increase in the chlorophyll maximum at depth in the oligotrophic regions of tropical oligotrophic gyres, here in the North Atlantic associated with a deepening of the nutricline.

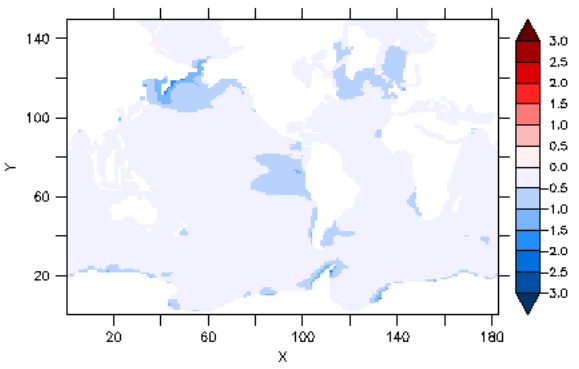


CHL difference, North Hemisphere

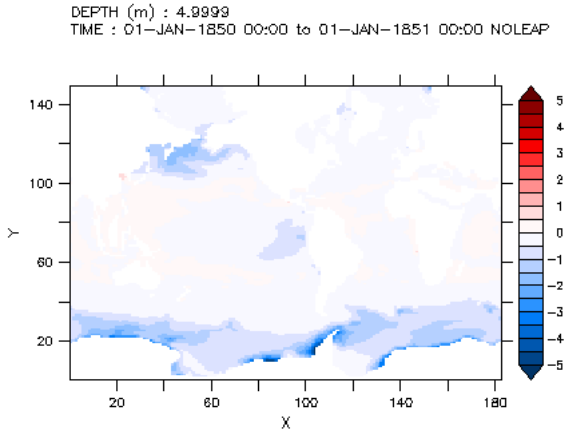
The deepening of the nutricline in tropical regions results in a decrease in the supply of macronutrients to the surface, which is particularly visible in upwelling regions. This leads to a decrease in surface chlorophyll in tropical coastal regions for NO3 and Si.
This adaptation also leads to increased surface chlorophyll at high latitudes. The increase in primary production induces a decrease in NO3 concentrations near the coasts at high latitudes, a decrease even more pronounced for Si at high latitudes as diatoms predominate in these regions. In the tropical band, the increase in pi-slope leads to an increase in surface Fe concentrations. Here, the mechanisms that control this increase are more difficult to understand, but this illustrates the impact of a change in a parameter on the surface distribution of this trace metal.



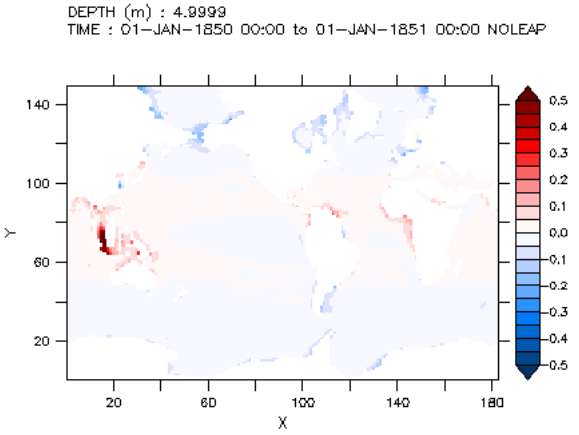
Total Chlorophyll difference



NO3 difference



Si difference



Fer difference (nmol/L)

13. ICOLMDZOR configuration

Question13a: *use "-h" option to know all options of the compilation script* `compile_icolmdzor.sh`*. Which command will you launch to create executables for the regular grid and the icosaedral grid ? Which command will you launch to create only the executable for the icosaedral grid ?*
Answer 13a: options available for this script are "`-ico_only, -reg_only, -ce0_only, -full, -regular_latlon, -debug, -dev, -prod(default)`". You can find their meaning in the "-h" description.

To create the executable to run on icosaedral grid, and the executable to run on regular grid, you need to launch

```
./compile_icolmdzor.sh
```

The executables create will be

- `xios_server_prod.exe`
- `icosa_lmdz_prod.exe`
- `gcm_144x142x79_prod.e`
- `ce0l_144x142x79_prod.e`

You can note that default regular resolution is 144x142x79, and default mode is prod.

To create only the executable to run on icosaedral grid, you need to launch

```
./compile_icolmdzor.sh -ico_only
```

In this case you will create only executables for xios and ICOLMDZOR :

- `xios_server_prod.exe`
- `icosa_lmdz_prod.exe`

Question 13b: *Do you see any differences with LMDZOR output files produced in part 2 ?*
Answer 13b: There is no difference in terms of grid the variables are written on. The model run on an icosaedral grid but the variables are interpolated (and written) by XIOS on a regular grid in output files in order to facilitate the analysis.