Structure of LMDZ

The basic requirement for running the GCM LMDZ is to have a Fortran compiler (G95 for example) installed in a PC under LINUX. The library NetCDF should be properly installed before installing the GCM.

After downloading the compressed "tar" file "`gcm_lmdz.tar.gz`", it is now necessary to retrieve the GCM and its structure by the "tar" command: "`tar -zxvf gcm_lmdz.tar.gz`". Now go to the directory "`cd gcm_lmdz/lmdz32_7245`":

```
Makefile (containing instructions for model compiling)
         (one needs to indicate the NetDCF path: DNETCDF)
         (the current compiler is the free compiler g95)
libo (empty directory, to receive the compiled libraries)
libf (containing the fortran codes)
     grid : dimensions and grid of the model (72x45x19)
     dyn3d: dynamic equations and model's main programme
     filtrez: programmes for polar region filtring
     phylmd: physical package of the model
     bibio: NetCDF interface for input and output
```

To compile, it is just necessary to enter the UNIX command "gmake" (or "make") in the directory "lmdz32_7245". When the compilation is accomplished, an executable code "`atmosx`" is created. The model is now configured to run under perpetual January.

To launch the execution "`atmosx`", it is also necessary to have five other associated files: "`run.def`", "`limit.nc`", "`qsol_climato.nc`", "`start.nc`", "`startphy.nc`".

The file "`run.def`" is the main configuration file. In particular, it contains the duration (in days) of the simulation (line 16) and the frequency of output recording (line 88, in days: 0.25 means 4 records per day). "`limit.nc`" and "`qsol_climato.nc`" contain boundary conditions, in particular the SST. "`start.nc`" and "`startphy.nc`" contain initial conditions.

During execution of "`atmosx`", the history of the simulation is recorded in two "history" files: "`histday_surface.nc`", "`histday_stdlevs.nc`". Two other files are produced after execution. They are the restarting files for pursuring the simulation: "`restart.nc`" et "`restartphy.nc`"

Existing configurations for running the model

Several configurations of model are already prepared and ready to be used for execution launching, in the directory "gcm_lmdz":

```
"real_land":
     "cntl": control simulation
     "omega": omega of the earth divided by 3
     "norelief_100": surface high topography reduced to 100 m
     "a2_2100": configuration for A2 scenario, year 2100
"aqua_planet":
     "zonal_symmetric": SST of the aquaplanet is symmetric
          "aqua0": control simulation
          "aqua0_omegasur3": (omega of the earth divided by 3
     "zonal_3waves": 3 waves are in zonal SST variation
          "aqua3": control simulation
          "aqua3_omegasur3": omega of the earth divided by 3
"divers_lmdz": Several Fortran programmes for manipulating
               history files or creating new configurations.
```

Further exercises to be realized

- Design an experiment showing the divergence of model trajectories when a small perturbation is introduced into initial conditions. Evaluate the validity period of numerical weather forecasting.

- Design an experiment showing the divergence of model trajectories for a same initial state, but with a modification in the model's physical parameterization. Put clouds transparent for radiative transfer, for example.

- Study the response of the atmosphere to an anomaly of the SST, in tropics and extratropics respectively.

- Climate sensitivity can be defined as $\lambda = dT_s/dF$, where dF is the radiative perturbation at the tropopause (or top of the atmosphere), dT_s is the surface air temperature response. A direct evaluation of λ is to calculate dT_s when a perturbation dF is introduced in the system. An alternative is to introduce globally an anomaly dT_s to the SST, and then evaluate the variation of radiative budget dF. Evaluate λ by the second method for different configurations of the atmosphere (Ω changed, for example).

Manipulation and creation of new configurations

Several Fortran programmes for manipulating history files or creating new configurations are available in the directory "divers_lmdz":

- `demo_netcdf_writing.F`: Programme demonstrating how to write a 2-D or 3-D variables in NetCDF
- `analyse_lmdz.F`: Perform the post-processing of LMDZ, calculate the means, variances, cross-terms, etc.
- `tracer_limit.F`: Convert some variables of "limit.nc" from its 1-D grid into a latitude-longitude grid, which can then be used in the graphic tool GRADS.
- `tracer_start.F`: Convert the principal variables of the initial state "start.nc" from its staggered grid into a single latitude-longitude grid, useful for graphic tool GRADS.
- `melanger_2start.F` This programme reads two files of initial states "start.nc.1" and "start.nc.2", and then performs a mixing "$\alpha \times x_1 + (1-\alpha) \times x_2$" and write the results into a third file "restart.nc".
- `modif_start_relief.F`: This programme modifies the topography of the model in the file of initial state "start.nc". This modification changes also consequently the surface pressure. To guarantee a good calculation of the surface pressure and to minimize the initial choc introduced to the model, the topography change is limited to 100 m. To go further, one needs to repeat the procedure, and run the GCM a few days for each iterative step.
- `modif_limit_aqua.F`: This programme prescribes the SST, through analytical functions, for a model configuration of Aqua-planet
- `modif_limit_sst_ideal.F`: This programme introduces an anomalous SST structure to the boundary-condition file "limit.nc"