Using the CSIRO Mk3L climate system model
Part 2: Working with Mk3L

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1. Input files

Input files

- The model requires three types of input files:

control file	configures the model for a particular simulation
restart file(s)	initialise(s) the model at the *start* of a simulation
auxiliary files	provide the boundary conditions *during* a simulation

- The model may be configured for a particular scenario by modifying one or more of these files
- See Chapters 4 and 5 of the Users Guide for further information

Boundary conditions: atmosphere model

- Bottom boundary conditions:
  - Sea surface temperatures
  - Ocean currents
  - Topography
  - Albedo
  - Vegetation and soil types
- Radiative boundary conditions:
  - CO_2 transmission coefficients
  - Ozone mixing ratios

Boundary conditions: ocean model

- Upper boundary conditions:
  - Sea surface temperatures
  - Sea surface salinities
  - Surface wind stresses
- Bottom boundary conditions:
  - Bathymetry

Boundary conditions: coupled model

- Bottom boundary conditions:
  - Topography
  - Bathymetry
  - Albedo
  - Vegetation and soil types
- Radiative boundary conditions:
  - CO_2 transmission coefficients
  - Ozone mixing ratios

2. Output files

Output files

- The model generates three types of output:

diagnostic information	written to standard output
output files	save the state of the model *during* a simulation
restart file(s)	save(s) the state of the model at the *end* of a simulation

- The output files contain the simulated climate
- See Chapter 6 of the Users Guide for further information

Exercise 1: Diagnostic information

- Get the course material for today:

```
cd
tar zxvf /srv/scratch/z3210932/week2.tar.gz
```

- This contains typical output from a coupled model simulation
- The diagnostic information is saved in the file `out.00001`
- Using the `less` command, examine the contents of this file
- Table 4.4 of the Users Guide will be useful here

What is netCDF?

- network Common Data Form
- A self-describing, machine-independent data format
- Probably the most common data format in the climate sciences
- The names of netCDF files usually end with `.nc`
- The command `ncdump` can be used to examine the contents of netCDF files
- See `http://www.unidata.ucar.edu/software/netcdf/`

Exercise 2: netCDF

- Load netCDF by entering the command:

```
module load netcdf
```

- Use ncdump to examine the contents of the sample atmosphere model output file, stsc_spi62.nc. Try commands such as:

```
ncdump -h stsc_spi62.nc
ncdump -c stsc_spi62.nc
ncdump stsc_spi62.nc | less
```

Ferret

- A free visualisation and analysis package
- Specifically designed for visualising climatic data
- Makes it a breeze to visualise, analyse and manipulate the contents of netCDF files
- Very powerful and easy-to-use averaging, interpolation and re-gridding capabilities
- Your new best friend!
- See `http://ferret.pmel.noaa.gov/Ferret/`

Basic Ferret commands

`use <file>`	Load the netCDF file `<file>`
`show data`	List the data which is available
`list <variable>`	List the values of `<variable>`
`plot <variable>`	Produce a line plot of `<variable>`
`shade <variable>`	Produce a shade plot of `<variable>`
`fill <variable>`	Produce a filled plot of `<variable>`
`contour <variable>`	Produce a contour plot of `<variable>`
`exit` or `q`	Exit

Basic Ferret transformations

- If the variable `tsc` contains surface air temperature as a function of longitude and latitude, then these expressions have the following meanings:

`tsc[i=10,j=8]`	Temperature at gridpoint (10, 8)
`tsc[x=140e,y=35s]`	Temperature at 140°E, 35°S
`tsc[x=90e:180e,y=45s:0]`	Temperature within 90–180°E, 45-0°S
`tsc[i=@ave]`	Zonal-mean temperature
`tsc[i=@ave,j=@ave]`	Global-mean temperature
`tsc[i=@max,j=@max]`	Global-maximum temperature
`tsc[i=@min,j=@min]`	Global-minimum temperature

Exercise 3: Ferret

- Load and run Ferret:

```
module load ferret
ferret
```

- Within Ferret, load the sample atmosphere model output:

```
yes? use stsc_spi62.nc
```

Exercise 3: Ferret

- Try commands such as:

```
show data
fill tsc[k=1,l=1]
fill tsc[k=@ave,l=@ave]
fill tsc[i=@ave,k=@ave]
fill tsc[k=@max,l=@max]
plot tsc[i=@ave,j=@ave,k=@ave]
plot tsc[i=@ave,k=@ave,l=@ave]
plot tsc[x=140e,y=35s,l=@ave]
list tsc[i=@ave,j=@ave,k=@ave,l=@ave]
show transform
```

Exercise 4: Ocean model output

- A sample ocean model output file, `com.spi62.00001.nc`, is provided
- Examine the contents of this file using `ncdump` and Ferret
- Within Ferret, try commands such as:

```
shade/lev=1d temp[k=1,l=1]
fill/lev=1d temp[i=@ave,l=@ave]
fill/lev=2dc motg[l=@ave]
plot mota[y=30n:60n@max,k=@max]
```

- Table 6.1 of the Users Guide will be useful here

3. Running Mk3L for one day

Running Mk3L for one day

- You did this last week!
- The steps involved in running the model were as follows:
    - Create a run directory
    - Copy the executable, control file, restart file and auxiliary files to this directory
    - Run the model

Exercise 5: Running Mk3L for one day

- Change back to the directory containing the test scripts:

```
cd ~/CSIRO_Mk3L/version-1.2/core/scripts/
```

- The script `qsub_test_cpl` runs the coupled model for one day
- Using the `less` command, examine this script carefully
- What would you change to run the model for one month, rather than one day?

4. Running Mk3L for 10 years

Running Mk3L for 10 years

- This involves the same steps as running the model for one day:
  - Create a run directory
  - Put everything there
  - Run the model
- For the ocean model, it's *exactly* the same
- However, the atmosphere model and coupled model can only be run for one year at a time
- So, in this case, we need to re-initialise the model at the start of each year

Exercise 6: Running Mk3L for 10 years

- Change back to the directory containing today's course material:

```
cd ~/week2/
```

- The script qsub_10years runs the coupled model for 10 years
- Using the less command, examine this script carefully
- How does it differ from the script which runs the model for one day?

Exercise 7: Time to do some real modelling!

- Choose one of the following experiments:

exp01	Control simulation
exp02	Mid-Holocene (6,000 years BP)
exp03	Last Glacial Maximum (21,000 years BP)
exp04	Snowball Earth
exp05	$2\times CO_2$
exp06	Water hosing

Exercise 7: Time to do some real modelling!

- For your experiment, change to the appropriate directory e.g.

```
cd ~/week2/exp01/
```

- Now start your experiment e.g.

```
qsub qsub_exp01
```

- Look at the script which carries out each experiment
- How does it differ from the control simulation?

5. Running Mk3L for 10,000 years

Running Mk3L for 10,000 years

- This involves the same steps as running the model for 10 years:
  - Create a run directory
  - Put everything there
  - Run the model
- However, we can't run the model for 10,000 years in one go:
  - It could take more than a year to complete the job
  - The volume of data generated will be enormous
- The solution is to break the job down into manageable chunks
- We also need to archive the output of the model

Exercise 8: Running Mk3L for 10,000 years

- Change back to the directory containing today's course material:

```
cd ~/week2/
```

- `RUN_spi62` is an actual script that was used to carry out a 10,000-year control simulation on the National Facility in Canberra
- Using the `less` command, examine this script carefully
- What does it do?