H08 Manual for Parallel Computing

Acknowledgements

The code on which the parallelization calculations released in H08 v24.1.0 are based was developed by Mr. Takahiro Oda. We would like to express our gratitude by mentioning it here.

- System requirements

  The confirmed system requirements are as follows;

  ・Host OS: Windows 11 Pro 64-bit

  ・Virtual Environment: WSL2

  ・Guest OS: Ubuntu 24.04.1 LTS

  ・Compiler: gfortran version 13.3.0 (ifx version 2025.0.0)

  ・Parallelization API: OpenMP

- Overview

  In H08 v24.1.0, when running lnd/bin/main.sh and cpl/bin/main.sh, two options are available: input 2D data including sea areas and run a conventional calculation or input one-dimensional land-only data and run a parallelized calculation. This manual describes the procedure for creating one-dimensional land-only data from conventional two-dimensional data and performing parallelized calculations.

  The example commands and configuration examples given as examples are all for parallelized land-only one-dimensional calculations of the global 0.5 degree version (.hlf) (MAP=WFDEI, SUF=.hlo, L=67209). To perform calculations at arbitrary resolutions and over arbitrary target areas, edit and use as appropriate.

- Preliminary Presentation

  1. Open adm/Mkinclude with an editor. Add -lgomp for gfortran (-liomp5 for intel fortran compiler) at the end when specifying a library. The following is an example for WSL (Ubuntu) and gfortran users.

     ```
     # For WSL (Ubuntu) users
     LIB          = -L/usr/lib/x86_64-linux-gnu -lnetcdf -lnetcdff -lgomp
     ```

  2. Prepare a file containing 1 for the total number of cells in the land area as land area mask data.

```
$ htcreate 67209 1 lnd/msk/lndmsk.WFDEI.hlo
```

- **Procedure for running parallelized calculations of land surface process module**

1. Complete the preprocessing of the land surface process module, as described in section 8.3 of the Global manual, using the 2D setup.
2. Move to lnd/pre/, check and run prep_lnd_2dto1d.sh. If you wish to run the script at a resolution other than 0.5 degrees global, edit the settings accordingly. This script converts the input data of the land surface process module into one-dimensional data of land area only. After execution is complete, check to see if the conversion has been performed correctly. Antarctica is not included in the calculation, so there is no problem even if it is a missing value.

   * The analysis tool is useful for checking the results. For details, please refer to the H08 Manual Analysis section. To enable the short command, add a setting to ~/.bashrc (~/.zshrc on macOS). The basic settings for land-only one-dimensional data(.hlo) are as follows.

```
LHLO=67209
XYHLO="720 360"
L2XHLO=${DIRH08}/map/dat/l2x_l2y_/l2x.hlo.txt
L2XHLO=${DIRH08}/map/dat/l2x_l2y_/l2x.hlo.txt
LONLATHLO="-180 180 -90 90"
```

3. Change directory to lnd/bin and edit main.sh. The settings are as follows.

```
SUF=.hlo
MAP=.WFDEI
OPTPARA=yes
```

4. Edit main.f in lnd/bin. The setting is as follows.

```
N0l=67209
```

5. Edit calc_leakyb.f in lnd/bin. Numomp indicates the number of threads for parallelization. In this example, it is set to 2, but set it to the number of threads you want to run.

```
parameter    (n0numomp=2)
```

6. Edit Makefile in lnd/bin, and add the following to Macro(settings) section. If you use intel fortran compiler, Replace -fopenmp with -qopenmp.
   Also, add -fopenmp for gfortran (-qopenmp for intel fortran compiler) before -o in Compilation, TARGET1.

```
calc_leakyb.o: calc_leakyb.f
        $(FC) -c ${FCFLAGS} -fopenmp ${INC} $<
```

7. Check the settings and compile everything.

```
$ make all
```

8. Execute main.sh. Now the parallelized computation of the land surface process module will be performed.
9. Move to cpl/pst/ and edit the basic settings of list-watbal.sh to one-dimensional settings referring to 2, and run it. Make sure that the water balance of land (cpl/tab/wat_bal_/) is closed.

- **Procedure for running parallelized calculations of coupled model**

1. Complete the two-dimensional setup up to the preprocessing of the coupled model, which corresponds to Chapter 13, Section 3 of the Global Edition manual.
2. Move to cpl/pre/, check the settings of prep_cpl_2dto1d.sh, and execute it. If you wish to run it with a setting other than 0.5 degrees global, edit the settings accordingly. This script converts the input data of the coupled model to one-dimensional data of the land area only. After execution is complete, check to see if the conversion has been performed correctly.
3. Move to lnd/bin and check the settings of calc_leakyb.f. Set the number of threads for parallel computation in numomp.

```
parameter    (n0numomp=2)
```

4. Check the Makefile. If you have not edited in the land surface process module, add the following to the Macro(settings) section. If you use intel fortran compiler, replace -fopenmp with -qopenmp.

```
calc_leakyb.o: calc_leakyb.f ZAdsv
        $(FC) -c ${FCFLAGS} -fopenmp ${INC} $<
```

   Also add -fopenmp for gfortran (-qopenmp for intel fortran compiler) before -o in Compilation, TARGET1.
5. Check the settings and compile everything.

```
$ make all
```

6. Move to cpl/bin and edit main.sh. The settings are as follows. Refer to 13.4.2 of the Global Manual and set N_C_Experiment.

```
SUF=.hlo
MAP=.WFDEI
LDBG=1
OPTPARA=yes
```

7. Edit main.f. The setting is as follows.

```
N0l=67209
```

8. Edit Makefile in cpl/bin, and add the following to Macro(settings) section. If you use intel fortran compiler, replace -fopenmp with -qopenmp.
   Also, add -fopenmp for gfortran (-qopenmp for intel fortran compiler) before -o in Compilation, TARGET1.

```
calc_leakyb.o: calc_leakyb.f
        $(FC) -c ${FCFLAGS} -fopenmp ${INC} $<
```

9. Compile everything in cpl/bin.

```
$ make all
```

10. Execute main.sh. This will perform the parallelized computation of the coupled model.
11. Move to cpl/pst, edit calc_mean.sh to one-dimensional setting, and execute it.
12. Go back to cpl/bin, refer to 13.4.5 of the Global manual, edit main.sh to the LECD experiment setting and run it.
13. Move to cpl/pst/, edit the basic settings in list_watbal.sh to one-dimensional settings and run it. Make sure all water balances are closed.