

SICOPOLIS V3.0

– Quick Start Manual –

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1 Requirements

- UNIX/LINUX system.
- Fortran 90/95 compiler.
- SICOPOLIS supports output either in native binary or in NetCDF format (see Sect. 5). For the latter, you need an installation of NetCDF version 3.6.x or later (<http://www.unidata.ucar.edu/software/netcdf/>).
- For the shallow shelf approximation solver, the Library of Iterative Solvers for Linear Systems (Lis) version 1.2.x or later is required (<http://www.ssisc.org/lis/>).

2 Installation

- **Option 1: Using subversion**

1. Check out the latest revision (“bleeding edge”) from the subversion repository:

```
svn checkout \  
  svn://nye.lowtem.hokudai.ac.jp/sicopolis_v30/trunk \  
  sicopolis
```

Alternatively, check out pre-release 2 (based on revision 65):

```
svn checkout \  
  svn://nye.lowtem.hokudai.ac.jp/sicopolis_v30/tags/pre-release-02 \  
  sicopolis
```

2. You should then have a new folder “sicopolis” that contains the entire program package.

- **Option 2: Downloading a tarball** (pre-release 2, based on revision 65)

1. Download the gzipped tar archive `sicopolis_v30_pr2.tgz` from the SICOPOLIS web page (<http://sicopolis.greveweb.net/>).
2. Unpacking with the following commands:

```
gunzip sicopolis_v30_pr2.tgz  
tar -x -v -f sicopolis_v30_pr2.tar
```

3. You should then have a new folder “sicopolis” that contains the entire program package.

3 Files and directories in “sicopolis”

- **runs:**

Shell script (bash) `sico.job` for running a single simulation under UNIX/LINUX.

Shell script (bash) `multi_sico.job` for running multiple simulations by repeated calls of `sico.job`.

Subdirectory **headers**: specification files `sico_specs_run_name.h` (*run_name*: name of run).

- Files included for runs `v30_grl40_test_wre1000`, `v30_grl20_test_wre1000` and `v30_grl10_test_wre1000`
→ Greenland Ice Sheet, resolution 40 / 20 / 10 km, $t = 1990 \text{ CE} \dots 2350 \text{ CE}$ [similar to the WRE1000 run by Greve (2004) and run #11 by Greve and Otsu (2007)].
- File included for run `v30_emtp2sge_expA`
→ EISMINT Phase 2 Simplified Geometry Experiment A, resolution 25 km, $t = 0 \text{ ka} \dots 200 \text{ ka}$ (Payne et al. 2000).
- Files included for runs `v30_ant80_paleo04_init`, `v30_ant80_paleo04`, `v30_ant40_paleo04_init` and `v30_ant40_paleo04`
→ Antarctic Ice Sheet, resolution 80 km for `ant80...`, 40 km for `ant40...`, $t = -522 \text{ ka} \dots -422 \text{ ka}$ for the spin-up runs (`...init`), $t = -422 \text{ ka} \dots 0 \text{ ka}$ for the main runs [see Greve (2006) and Greve (2005)].
- Files included for runs `v30_grl40_paleo01_init`, `v30_grl40_paleo01`, `v30_grl20_paleo01_init` and `v30_grl20_paleo01`
→ Greenland Ice Sheet, resolution 40 km for `grl40...`, 20 km for `grl20...`, $t = -422 \text{ ka} \dots -250 \text{ ka}$ for the spin-up runs (`...init`), $t = -250 \text{ ka} \dots 0 \text{ ka}$ for the main runs [similar to run `hf_pmod2` by Greve (2005)].
- File included for run `v30_nhem80_nt012_new`
→ northern hemisphere, resolution 80 km, $t = -250 \text{ ka} \dots 0 \text{ ka}$ [similar to run `nt012` by Greve et al. (1999)].

- **src:**

Directory which contains the main program file `sicopolis.F90`.

- Subdirectory **subroutines/general**: general subroutines, for any modelled domain.

- Subdirectory **subroutines/ant**: subroutines specific for the Antarctic Ice Sheet.
- Subdirectory **subroutines/emtp2sge**: subroutines specific for the EISMINT Phase 2 Simplified Geometry Experiments.
- Subdirectory **subroutines/grl**: subroutines specific for the Greenland Ice Sheet.
- Subdirectory **subroutines/nhem**: subroutines specific for the northern hemisphere.
- Accordingly for Austfonna, Scandinavia, Tibet, ISMIP HEINO, and the north and south polar caps of Mars.

- **sico_in**:

Directory which contains input data files for SICOPOLIS.

- Subdirectory **general**: general input files, for any modelled domain.
- Subdirectory **ant**: input files specific for the Antarctic Ice Sheet.
- Subdirectory **emtp2sge**: input files specific for the EISMINT Phase 2 Simplified Geometry Experiments.
- Subdirectory **grl**: input files specific for the Greenland Ice Sheet.
- Subdirectory **nhem**: input files specific for the northern hemisphere.
- Accordingly for Austfonna, Scandinavia, Tibet, ISMIP HEINO, and the north and south polar caps of Mars.

- **sico_in_searise**:

Directory which contains SeaRISE input data files for SICOPOLIS (SeaRISE = Sea-level Response to Ice Sheet Evolution, multi-model community effort, see http://websrv.cs.umt.edu/isis/index.php/SeaRISE_Assessment and <http://oceans11.lanl.gov/trac/CISM/wiki/AssessmentGroup>).

- Subdirectory **general**: general input files, for any modelled domain.
- Subdirectory **ant**: input files specific for the Antarctic Ice Sheet.
- Subdirectory **grl**: input files specific for the Greenland Ice Sheet.

- **sico_out**:

Empty directory into which output files of SICOPOLIS simulations are written.

- **docu:**

Directory which contains documentation created by Doxygen.

- `html/index.html` → Source code browser (very useful).
- `latex/refman.pdf` → Reference manual (not so user-friendly).

- **license:**

Directory which contains a copy of the GNU General Public License (version 3).

4 How to run a simulation

1. In the script `sico.job` (subdirectory `runs/`), search for “greve”, and replace the path names for `RUN_DIR` and `SRC_DIR` with your own ones.

Also, search for “Compiler”, and replace the variables `F90` and `F90FLAGS` according to the syntax of your own Fortran compiler (`F90FLAGS` should do).

2. In the specification files (subdirectory `runs/headers/`), search for “greve”, and replace the path names for `INPATH`, `OUTPATH` and `ANFDATPATH` (unless set to “none”) with your own ones.
3. The default set-up is to run SICOPOLIS with output in NetCDF format. If you want to create output in native binary format instead, set `NETCDF_FLAG` to ‘no’ (rather than ‘yes’) in `sico.job`, and set `NETCDF` to 1 (rather than 2) in all specification files.
4. The rest is quite simple:

- In order to run simulation `v30_grl40_test_wre1000`, use the script `sico.job`. The command is

```
(./sico.job v30_grl40_test_wre1000) >out_job.dat 2>&1 &
```

(from subdirectory `runs/`, bash required). Accordingly for the other simulations.

- Alternatively, if you prefer to run all simulations consecutively, you may use the script `multi_sico.job`:

```
(./multi_sico.job) >out_mjob.dat 2>&1 &
```

The computing times for the simulations, run with the Intel Fortran Compiler for Linux 11.1 (optimisation options `-xHOST -O3 -no-prec-div`) on an Intel Xeon X5570 (2.93 GHz) PC under openSUSE 11.0 (64 bit), are listed in Table 1.

Run	Model time	Time step	CPU time
v30_grl40_test_wre1000	360 a	10 a	1.0 sec
v30_grl20_test_wre1000	360 a	5 a	7.3 sec
v30_grl10_test_wre1000	360 a	0.5 a	4.7 min
v30_emtp2sge_expA	200 ka	200 a	2.6 min
v30_ant80_paleo04_init	100 ka	100 a	1.2 min
v30_ant80_paleo04	422 ka	100 a	4.2 min
v30_ant40_paleo04_init	100 ka	10 a	0.6 hrs
v30_ant40_paleo04	422 ka	10 a	2.3 hrs
v30_grl40_paleo01_init	172 ka	10 a	9.1 min
v30_grl40_paleo01	250 ka	10 a	14.3 min
v30_grl20_paleo01_init	172 ka	5 a	1.3 hrs
v30_grl20_paleo01	250 ka	5 a	2.0 hrs
v30_nhem80_nt012_new	250 ka	5 a	2.1 hrs

Table 1: Model times, time steps and computing (CPU) times for the simulations (see main text for details).

5 Output files

Output files of simulations are written to directory `sico_out`. Four types are produced:

- **run_name.log:**

ASCII file which lists the main specifications of simulation *run_name*.

- **run_name.ser:**

Time-series file (ASCII) which contains global parameters:

- Time, t
- Surface-temperature anomaly, D_Ts , or glacial index, $glac_ind$ (forcing)
- Sea level, z_sl (forcing)
- Maximum ice thickness, H_max
- Maximum ice elevation, zs_max
- Ice volume, V_g
- Volume of the temperate ice, V_t
- Freshwater production due to melting and calving, V_fw
- Sea-level equivalent of ice volume, z_sle
- Ice area, Aib
- Area covered by temperate ice, Atb
- Water drainage due to basal melting, V_bm
- Water drainage from the temperate layer, V_fld
- Maximum thickness of the temperate layer, H_t_max
- Maximum surface velocity, vs_max

- **run_name.core:**

Time-series file (ASCII) which contains for selected locations `xxx`:

- Time, t
- Surface-temperature anomaly, D_Ts , or glacial index, $glac_ind$ (forcing)
- Sea level, z_sl (forcing)
- Thickness, H_xxx
- Surface velocity, v_xxx

- Basal temperature, T_xxx
- Basal frictional heating, Rb_xxx

For the Greenland Ice Sheet, these data are written for six locations:

GRIP (xxx=GR), GISP2 (xxx=G2), Dye 3 (xxx=D3), Camp Century (xxx=CC), NorthGRIP (xxx=NG), NEEM (xxx=NE).

For the Antarctic Ice Sheet, these data are written for six locations:

Vostok (xxx=Vo), Dome A (xxx=DA), Dome C (xxx=DC), Dome F (xxx=DF), Kohlen (xxx=Ko), Byrd (xxx=By).

For the northern hemisphere and the EISMINT Phase 2 Simplified Geometry Experiments, no such data are written.

- **run_name0001.nc/.erg, run_name0002.nc/.erg, ...:**

Complete set of fields (topography, velocity, temperature etc., written either in NetCDF (*.nc) or in native binary (*.erg) format; see subroutines output_nc and output1, respectively) for selected time slices defined in specifications file. For example, simulation v30_grl40_test_wre1000 produces two files v30_grl40_test_wre10000001.nc, v30_grl40_test_wre10000002.nc, which correspond to 2000 CE and 2350 CE, respectively.

6 Plotting with SICOGRAPH

The output described in Sect. 5 can be visualised with any plotting tool at the user’s preference. One possibility is to use SICOGRAPH, which is part of the SICOPOLIS package and based on the Generic Mapping Tools GMT (<http://gmt.soest.hawaii.edu/>).

6.1 Installation

1. If you do not have an installation of GMT version 4.x yet, download and install the latest version according to the instructions on the GMT web site.
2. Since revision 116, SICOGRAPH is included in the subversion repository of SICOPOLIS. You’ll find it in the directory `sicopolis/tools/sicograph/`.

6.2 Customisation

1. In the program `sicograph.F90`, search for “Compiler”, and define the corresponding variable as either INTEL, NAG, GFORTRAN or G95, depending on which Fortran compiler you use.
2. In the script `sicograph.job`, search for “greve”, and replace the path name for `RUN_DIR` with your own one.

Also, search for “Compiler”, and replace the variables `F90` and `F90FLAGS` according to the syntax of your own Fortran compiler (`F90FLAGS` should do).

By default, SICOGRAPH is linked with the NetCDF library. If this is not necessary (native binary rather than NetCDF output produced by SICOPOLIS), set `NETCDF_FLAG` to ‘no’.

3. In the scripts `plan_view.gmt`, `plan_view_lonlat.gmt`, `time_series.gmt` and `scatter.gmt` (subdirectory `gmt_scripts/`), search for “greve”, and replace the path name for `GMT_SCRIPT_PATH` with your own one.

6.3 Producing plots

In order to plot the output of simulation `v30_gr140_test_wre1000`, use the script `sicograph.job` interactively:

```
./sicograph.job v30_gr140_test_wre1000
```

(bash required; accordingly for the other simulations). You’ll then get a menu which allows you to choose the type of plot you wish to produce. For example, try the option

(1) Ice-surface topography

and enter

Number of time-slice file (with leading zeros) > 0002

Plot (1) with or (2) without colour bar? > 1

Plot (1) with or (2) without contour labels? > 1

You will find the plot in the subdirectory `gmt_scripts/plots/` as file `v30_grl40_test_wre10000002_zs.eps` (in EPS format). As a second example, try

(41) Time series

and in the following sub-menu choose

(5) Total ice volume

This produces the file `v30_grl40_test_wre1000-V_tot.eps` in the subdirectory `gmt_scripts/plots/`.

6.4 Manipulating plot appearance

For all types of plots, the files in the subdirectory `parameter_files/` control the limits and labels of the x - and y -axes. In addition, for the plan-view plots, the files in the subdirectory `gmt_scripts/cpt/` control the colour scales (`*.cpt`) and contour levels (`*.zzz`). If a file is missing, the corresponding parameters are computed automatically.

References

- Greve, R. 2004. Evolution and dynamics of the Greenland ice sheet over past glacial-interglacial cycles and in future climate-warming scenarios. In: *Proceedings of the 5th International Workshop on Global Change: Connection to the Arctic (GCCA5)*, pp. 42–45. University of Tsukuba, Japan. URL <http://hdl.handle.net/2115/30204>.
- Greve, R. 2005. Relation of measured basal temperatures and the spatial distribution of the geothermal heat flux for the Greenland ice sheet. *Ann. Glaciol.*, **42**, 424–432. doi:10.3189/172756405781812510.
- Greve, R. 2006. Large-scale simulation of the Antarctic ice sheet over climate cycles. Hokkaido University Collection of Scholarly and Academic Papers (HUSCAP). URL <http://hdl.handle.net/2115/34433>.
- Greve, R. and S. Otsu. 2007. The effect of the north-east ice stream on the Greenland ice sheet in changing climates. *The Cryosphere Discuss.*, **1** (1), 41–76. doi:10.5194/tcd-1-41-2007.
- Greve, R., K.-H. Wyrwoll and A. Eisenhauer. 1999. Deglaciation of the Northern Hemisphere at the onset of the Eemian and Holocene. *Ann. Glaciol.*, **28**, 1–8. doi:10.3189/172756499781821643.
- Payne, A. J., P. Huybrechts, A. Abe-Ouchi, R. Calov, J. L. Fastook, R. Greve, S. J. Marshall, I. Marsiat, C. Ritz, L. Tarasov and M. P. A. Thomassen. 2000. Results from the EISMINT model intercomparison: the effects of thermomechanical coupling. *J. Glaciol.*, **46** (153), 227–238. doi:10.3189/172756500781832891.