initMIP Greenland

initMIP Overview: Focus on initialization

Earlier large-scale ice sheet experiments e.g. those run during the **ice2sea** and **SeaRISE** initiatives have shown that ice sheet initialization can have a large effect on sea-level projections and gives rise to important uncertainties. Improving initialization techniques is currently a field of active research, which makes it difficult to prescribe one technique as the method of choice for ISMIP6. Instead, we first propose a “Come as you are”- approach, which allows participants to contribute with their currently used model setup and initialization technique for intercomparison (initMIP). This, we hope, allows getting modelers involved early in the ISMIP6 process and keeps the workload for participants as low as possible. Furthermore, the proposed schematic experiments may facilitate to document on-going model development. Starting early in the CMIP6 process implies relying on schematic forcing for the initiation experiments that is independent from CMIP6 AOGCM output, which will only become available later on.

The initMIP-Greenland is the first in a series of ISMIP6 ice sheet model intercomparison activities and is led by Heiko Goelzer. Result of initMIP-Greenland have been published in the following article:

- **Goelzer, H.’**, Nowicki, S., Edwards, T., Beckley, M., Abe-Ouchi, A., Aschwanden, A., Calov, R., Gagliardini, O., Gillet-Chaulet, F., Golledge, N. R., Gregory, J., Greve, R., Humbert, A., Huybrechts, P., Kennedy, J. H., Larour, E., Lipscomb, W. H., Le clec’h, S., Lee, V., Morlighem, M., Pattyn, F., Payne, A. J., Rodehacke, C., Rückamp, M., Saito, F., Schlegel, N., Seroussi, H., Shepherd, A., Sun, S., van de Wal, R., and Ziemen, F. A. (2018). Design and results of the ice sheet model initialisation experiments initMIP-Greenland: an ISMIP6 intercomparison, The Cryosphere, 12, 1433-1460, doi:10.5194/tc-12-1433-2018.

- The model output and forcing data is available in a public archive: Results of the ice sheet model initialisation experiments initMIP-Greenland: an ISMIP6 intercomparison, doi:10.5281/zenodo.1173088

Goals

- Compare and evaluate the initialization methods used in the ice sheet modeling community
- Estimate uncertainty associated with initialization

- Get the ice sheet modeling community started with ISMIP6 activities
- Document on-going model development, as the simple experiments could be repeated with new model versions

initMIP Greenland Experimental setup

Experiments are for the large scale Greenland ice sheet and are designed to allow intercomparison between models of:

(1) the initial state itself and **(2) the response in three schematic forward experiments**:

1. init: Initialization to present day with method of choice
2. **Schematic forward experiments**
    - 2a. ctrl: Unforced control run (100 years)
    - 2b. asmb: Prescribed schematic surface mass balance anomaly (100 years)

The two forward experiments serve to evaluate the initialization in terms of model drift (2a. ctrl) and response to a large perturbation (2b. asmb). For 2a. ctrl, the models are run forward without any anomaly forcing, such that whatever surface mass balance (**SMB**) was used in the initialization technique would continue unchanged. The perturbation in 2b. asmb consists of a given surface mass balance anomaly, which has to be applied relative to the initial SMB inherent to the individual initialization technique. The SMB anomaly in 2b. asmb (the same for each model) is schematic and should not be considered as a realistic projection. The core experiment duration is set to 100 years.

Requirements for the experiments

1. Participants can and are encouraged to contribute with different models and/or initialization method
2. Models have to be able to prescribe a given SMB anomaly
3. No adjustment of SMB due to geometric changes in forward experiments (i.e. no elevation – SMB feedback is allowed)
4. No bedrock adjustment in forward experiment
5. The choice of model input data is unconstrained to allow participants the use of their preferred model setup without modification. Modelers without preferred data set choice can have a look at the ISMIP6 page for possible options.
6. The specific year of initialization (between 1950 and 2014) is equally unconstrained to allow the use of different observational data sets that may be tied to certain time periods.

Prescribed SMB anomaly

The SMB anomaly can be obtained through the ISMIP6 datasets distributed via the Ghub Globus web application. See the instructions document at the end of this wiki. Modeling groups should use the 1km version to conservatively interpolate to their model native grid (see

Appendix 1, below). Files of lower resolution (5 km, 10 km, and 20 km) are provided for groups using the output grid (Bamber et al., 2001) as “native grid”. For `2b. asmb’ as, the amplitude of the SMB anomaly is to be implemented as a time dependent function, which increases step-wise every full year (it is therefore independent of the time step in the model):

SMB(t) = SMB_initialization + SMB_anomaly * (floor (t) / 40); for 0 < t < 40 in years

SMB(t) = SMB_initialization + SMB_anomaly * 1.0; for t > 40 years

where SMB_anomaly is the anomaly provided by ISMIP6 and SMB_initialization is the model specific SMB used for the initialization. The units of SMB_anomaly are (meter ice equivalent/year) with an assumed density of 910 kg/m^3 and 31,556,926 s/yr.

Appendix 1 – Output grid definition and interpolation

All 2D data is requested on a regular grid with the following description. Polar stereo-graphic projection with standard parallel at 70° N and a central meridian of 45° W (315° E) on datum WGS84 (EPSG3413 projection). The lower left cell center is at (-720,000 m,-3,450,000 m) with nx=1,681 and ny=2,881 cells in x and y-direction at full km positions (xmin = -720 km, xmax = +960 km, ymin = -3,450 km, ymax = -570 km). The output should be submitted on a resolution adapted to the resolution of the model and can be 20 km, 10 km, 5 km, 2 km or 1 km. The data will be conservatively interpolated to 1 km resolution for archiving and 5 km resolution for diagnostic processing by ISMIP6.

If interpolation is required in order to transform the SMB forcing to your native grid, and transform your model variables to the initMIP output grid (20 km, 10 km, 5 km, 2 km, 1 km), it is required that conservative interpolation is used. The motivation for using a common method for all models is to minimize model to model differences due to the choice of interpolation method.

Note: The previously requested regular grid was in polar stereo-graphic projection with standard parallel at 71° N and a central meridian of 39° W (321° E) on datum WGS84. The lower left corner is at (-800,000 m, -3,400,000 m) and the upper right at (700,000 m, -600,000 m). This is the same grid (Bamber et al., 2001) used to provide the SMB anomaly forcing previously. This grid was changed to the EPSG3413 projection described above.

A1.1 Regridding Tools and Tips

- An overview of the regridding process can be found on the two Regridding pages below.
- Regridding with CDO contains tools and tips that have been used by ISMIP6 members
- Regridding BISICLES output with ESMF and NCO contains other tools and tips
- ISMIP6 is designing tools to help with the regridding.
- If you need help with conservative interpolation, please email ismip6@gmail.com.

Appendix 2 – Naming conventions, upload and model output data

Please provide:

- one variable per file for all 2D fields
- all variables in one file for the scalar variables
- a completed readme file

A2.1 File name convention

File name convention for **2D fields**:

<variable>_<IS>_<GROUP>_<MODEL>_<EXP>.nc

File name convention for **scalar variables**:

scalar_<IS>_<GROUP>_<MODEL>_<EXP>.nc

File name convention for **readme file**:

README_<IS>_<GROUP>_<MODEL>.doc

where <variable> = netcdf variable name (e.g. lithk) <IS> = ice sheet (AIS or GIS) <GROUP> = group acronym (all upper case or numbers, no special characters) <MODEL> = model acronym (all upper case or numbers, no special characters) <EXP> = experiment name (*init*, *ctrl*, or *asmb*)

For **example**, a file containing the scalar variables for the Greenland ice sheet, submitted by group “JPL” with model “ISSM” for experiment “ctrl” would be called: scalar_GIS_JPL_ISSM_ctrl.nc

If JPL repeats the experiments with a different version of the model (for example, by changing the sliding law), it could be named ISSM2, and so forth.

A2.2 Accessing ISMIP6 datasets and submitting model experiments to Globus

ISMIP6 datasets are distributed via the Ghub Globus web application. Public datasets can be found in Ghub’s [Browse Data] page. ISMIP6-specific initMIP Antarctic (and initMIP Greenland and projection data) can be accessed through the Ghub endpoints via Globus UI. To access and download data, one must create a Ghub account and register with Globus. Instructions to create accounts can be referenced in the **General ISMIP6 Globus Instructions (v. 2023)** instruction document at the end of this wiki.

The document provides instructions on how to use Globus to download Ghub data in general, including the ISMIP6 datasets distributed via Ghub. These datasets are from earlier ISMIP6 activities, such as the initMIP, ABUMIP or projections to 2100. ISMIP6 and GHub is partnered with UB CCR to provide access to large datasets. These datasets are described in detail on our Browse Data page. If you have any questions or issues, please contact us by email at ismip6-at-gmail.com. Please also check the suggested text to acknowledge the many scientists and organizations that made the ISMIP6 data possible.

All your model experiments can be uploaded via Globus/Ghub. See more details on Ghub's Accessing Data wiki. Email ismip6@gmail.com with any questions concerning the above.

A2.3 Model output variables and README file

The README file is an important contribution to the initMIP submission. It may be obtained here or requested by email to ismip6-at-gmail.com

The variables requested in the table below serve to evaluate and compare the different models and initialization techniques. Some of the variables may not be applicable for your model, in which case they are to be omitted (with explanation in the README file). Also, specify missing values in your netcdf file where needed, and fields should be undefined outside of the ice mask.

We distinguish between state variables (e.g. ice thickness, temperatures and velocities) and flux variables (e.g. SMB). Flux variables are defined as positive when the process adds mass to the ice sheet and negative otherwise. Note the different treatment for state variables (snapshots) and fluxes (time average). The standard should be averaging over all native time steps for yearly scalar output and for 5 year periods for 2D fields. Please specify how your reported flux data has been averaged over time in the README file.

Variable	Dim	Type	Variable Name	Standard Name	Units	Comment
2D variables requested every five years, starting at t=0, snapshots for type ST and as five year average for type FL.						
Ice thickness	x,y,t	ST	lithk	land_ice_thickness	m	The thickness of the ice sheet
Surface elevation	x,y,t	ST	orog	surface_altitude	m	The altitude or surface elevation of the ice sheet
Bedrock elevation	x,y,t	ST	topg	bedrock_altitude	m	The bedrock topography (unchanged in forward exps.)
Geothermal heat flux	x,y	C	hfgeoubed	upward_geothermal_heat_flux_at_grou	W m^{-2}	Geothermal Heat flux (unchanged

				nd_level		in forward exps.)
Surface mass balance flux	x,y,t	FL	acabf	land_ice_surface_specific_mass_balance_flux	kg m^{-2} s^{-1}	Surface Mass Balance flux (for areas covered by ice only)
Basal mass balance flux	x,y,t	FL	libmassbf	land_ice_basal_specific_mass_balance_flux	kg m^{-2} s^{-1}	Basal mass balance flux (for areas covered by ice only)
Ice thickness imbalance	x,y,t	FL	dlithkdt	tendency_of_land_ice_thickness	m s-1	dHdt
Surface velocity in x	x,y,t	ST	uvelsurf	land_ice_surface_x_velocity	m $^{s-1}$	u-velocity at land ice surface
Surface velocity in y	x,y,t	ST	vvelsurf	land_ice_surface_y_velocity	m $^{s-1}$	v-velocity at land ice surface
Surface velocity in z	x,y,t	ST	wvelsurf	land_ice_surface_upward_velocity	m $^{s-1}$	w-velocity at land ice surface
Basal velocity in x	x,y,t	ST	uvelbase	land_ice_basal_x_velocity	m $^{s-1}$	u-velocity at land ice base
Basal velocity in y	x,y,t	ST	vvelbase	land_ice_basal_y_velocity	m $^{s-1}$	v-velocity at land ice base
Basal velocity in z	x,y,t	ST	wvelbase	land_ice_basal_upward_velocity	m $^{s-1}$	w-velocity at land ice base
Mean velocity in x	x,y,t	ST	uvelmean	land_ice_vertical_mean_x_velocity	m $^{s-1}$	The vertical mean land ice velocity is the average from the bedrock to the surface of the ice
Mean velocity in y	x,y,t	ST	vvelmean	land_ice_vertical_mean_y_velocity	m $^{s-1}$	The vertical mean land ice velocity is the average from the bedrock to

						the surface of the ice
Surface temperature	x,y,t	ST	litempsnic	temperature_at_ground_level_in_snow_or_firn	K	Ice temperature at surface
Basal temperature	x,y,t	ST	litempbot	land_ice_basal_temperature	K	Ice temperature at base
Basal drag	x,y,t	ST	strbasemag	magnitude_of_land_ice_basal_drag	Pa	Magnitude of basal drag
Calving flux	x,y,t	FL	licalvf	land_ice_specific_mass_flux_due_to_calving	$kg\ m^{-2}\ s^{-1}$	Loss of ice mass resulting from iceberg calving. Only for grid cells in contact with ocean
Land ice area fraction	x,y,t	ST	sftgif	land_ice_area_fraction	1	Fraction of grid cell covered by land ice (ice sheet, ice shelf, ice cap, glacier)
Grounded ice sheet area fraction	x,y,t	ST	sftgrf	grounded_ice_sheet_area_fraction	1	Fraction of grid cell covered by grounded ice sheet, where grounded indicates that the quantity correspond to the ice sheet that flows over bedrock
Floating ice sheet area fraction	x,y,t	ST	sftflf	floating_ice_sheet_area_fraction	1	Fraction of grid cell covered by ice sheet flowing over seawater

Scalar outputs requested every full year, as snapshots for type ST as 1 year averages for type FL. The t=0 value should contain the data of the initialization.						
Total ice mass	t	ST	lim	land_ice_mass	kg	spatial integration, volume times density
Mass above floatation	t	ST	limnsw	land_ice_mass_not_displacing_sea_water	kg	spatial integration, volume times density
Grounded ice area	t	ST	iareag	grounded_ice_sheet_area	m^2	spatial integration
Floating ice area	t	ST	iareaf	floating_ice_shelf_area	m^2	spatial integration
Total SMB flux	t	FL	tendacabf	tendency_of_land_ice_mass_due_to_surface_mass_balance	kg s^{-1}	spatial integration
Total BMB flux	t	FL	tendlibmassbf	tendency_of_land_ice_mass_due_to_basal_mass_balance	kg s^{-1}	spatial integration
Total calving flux	t	FL	tendlicalvf	tendency_of_land_ice_mass_due_to_calving	kg s^{-1}	spatial integration

Appendix 3 – Participating Models and Characteristics

Greenland Standalone Ice Sheet Modeling

Model Characteristics

Model ID	**Numerics**	**Ice Flow**	**Initialization**	**Initial Year**	**Initial SMB**	**Velocity**	**Bed**	**Surface**	**GHF**	**Res min**	**Res max**
ARC-PISM	FD	HYB	SP	2000	RA1		B		SR	5	5
AWI-ISSM1	FE	HO	DE	2000	RA3	RM	M		SR	2.5	35
AWI-ISSM2	FE	HO	DE	2000	RA3	RM	M		SR	2.5	35
BGC-BISICLES1	FV	SSA	DE	1997-2006	HIR	RM	M			1.2	4.8

BGC-BISICLES2	FV	SSA	DE	1997-2006	HIR	RM	M			2.4	4.8
BGC-BISICLES3	FV	SSA	DE	1997-2006	HIR	RM	M			4.8	4.8
DMI-PISM1	FD	HYB	SP	2000	PDD		B		SR	5	5
DMI-PISM2	FD	HYB	SP	2000	PDD		B		SR	5	5
DMI-PISM3	FD	HYB	SP	2000	PDD		B		SR	5	5
DMI-PISM4	FD	HYB	SP	2000	PDD		B		SR	5	5
DMI-PISM5	FD	HYB	SP	2000	PDD		B		SR	5	5
ILTS-SICOPOLIS	FD	SIA	SP	1990	PDD		B		P	5	5
ILTSPIK-SICOPOLIS	FD	SIA	SP	1990	PDD		H		G	5	5
IMAU-IMAUICE1	FD	SIA	SP	1990	RA3		B		SR	5	5
IMAU-IMAUICE2	FD	SIA	SP	1990	RA3		B		SR	10	10
IMAU-IMAUICE3	FD	SIA	SP	1990	RA3		B		SR	20	20
JPL-ISSM	FE	SSA	DA	2012	BOX	RM	M		SR	1	15
LANL-CISM	FE	HO	SP	1961-1990	RA1		M		CTE	4	4
LGGE-ELMER1	FE	SSA	DA	2000-2010	MAR	J	M			1.5	45
LGGE-ELMER2	FE	SSA	DA	2000-2010	MAR	J	M			1	5
LSCE-GRISLI	FD	HYB	DA	2000	MAR	J	M		FM	5	5
MIROC-ICIES1	FD	SIA	DA	2004	RA1		B	B		10	10
MIROC-	FD	SIA	SP	2004	PDD		B			10	10

ICIES2											
MPIM-PISM	FD	HYB	SP	2006	PDD		B			5	5
UAF-PISM1	FD	HYB	SP	2007	RA1		M		SR	1.5	1.5
UAF-PISM2	FD	HYB	SP	2007	RA1		M		SR	3	3
UAF-PISM3	FD	HYB	SP	2007	RA1		M		SR	4.5	4.5
UAF-PISM4	FD	HYB	SP	2007	RA1		M		SR	1	1
UAF-PISM5	FD	HYB	SP	2007	RA1		M		SR	3	3
UAF-PISM6	FD	HYB	SP	2007	RA1		M		SR	4.5	4.5
UCIJPL-ISSM	FE	HO	DE	2007	RA1	RM	M		SR	0.5	30
ULB-FETISH1	FD	HYB	DA	1979-2006	PDD		B	B	FM	10	10
ULB-FETISH2	FD	HYB	DA	1979-2006	PDD		B	B	FM	10	10
VUB-GISM1	FD	HO	SP	2005	PDD		B		SR	5	5
VUB-GISM2	FD	SIA	SP	2005	PDD		B		SR	5	5

Key

Numerical method: **FD**= Finite difference, **FE**= Finite element, **FV**= Adaptive mesh refinement

Ice flow: **SIA**= Shallow ice approximation, **SSA**= Shallow shelf approximation, **HO**= Higher order, **HYB**= Hybrid SIA-SSA

Initialization:	**DA**= Data Assimilation, **SP**= Spin up
Initial SMB:	**RA1**= RACMO2.1, **RA3**= RACMO2.3, **HIR** =HIRHAM5, **PDD**= Positive Degree Day Model, **MAR**= MAR, **BOX**=BOX reconstruction
Basal sliding:	**PL**=Pseudo-plastic, **NP**=Nearly Plastic, **VS**= Viscous Sliding, **WS**= Weertman Sliding
Velocity:	**RM**= Rignot and Mouginot, **J**= Joughin et al.
Bed and surface:	**M**= Morlinghem et al., **B**= Bamber et al., H=Herzfeld
Geothermal Heat Flux (GHF):	**SR**= Shapiro and Ritzwoller, **G**= Greve, **P**=

Purucker, **FM**= Fox Maule et al.,

Model resolution (Res) in km. In case of heterogeneous grid resolution the minimum and maximum resolution are given.

Contributors	Model	Group ID	Group
Nick Golledge	PISM	ARC	Antarctic Research Centre, Victoria University of Wellington, NZ
Martin Rückamp Angelika Humbert	ISSM	AWI	Alfred Wegener Institute for Polar and Marine Research, DE /University of Bremen, DE
Victoria Lee, Tony Payne	BISICLES	BGC	University of Bristol, Bristol, UK
Christian Rodehacke	PISM	DMI	Danish Meteorological Institute, Arctic and Climate, DK
Ralf Greve	SICOPOLIS	ILTS	Institute of Low Temperature Science, Hokkaido University, Sapporo, JP
Ralf Greve, Reinhard Calov	SICOPOLIS	ILTS_PIK	Institute of Low Temperature Science, Hokkaido University, Sapporo, JP / Potsdam Institute for Climate Impact Research, Potsdam, DE
Heiko Goelzer, Roderik van de Wal, Thomas Reerink	IMAUICE	IMAU	Utrecht University, Institute for Marine and Atmospheric Research (IMAU), Utrecht, NL
Nicole Schlegel, Helene Seroussi	ISSM	JPL	NASA Jet Propulsion Laboratory, Pasadena, USA
William Lipscomb, Joseph H. Kennedy	CISM	LANL	National Center for Atmospheric Research, Boulder, CO, USA / Oak Ridge National Laboratory, USA
Fabien Gillet-Chaulet, Olivier Gagliardini	Elmer	LGGE	Laboratoire de Glaciologie et

			Géophysique de l'Environnement, FR
Sébastien Le clec'h	GRISLI	LSCE	Laboratoire des sciences du climat et de l'environnement, FR
Fuyuki Saito, Ayako Abe-Ouchi	IcIES	MIROC	Japan Agency for Marine-Earth Science and Technology, JP / The University of Tokyo, Tokyo, JP
Florian Ziemen	PISM	MPIM	Max Planck Institute for Meteorology, DE
Andy Aschwanden	PISM	UAF	Geophysical Institute, University of Alaska Fairbanks, USA
Helene Seroussi, Mathieu Morlighem	ISSM	UCIJPL	NASA Jet Propulsion Laboratory, Pasadena, USA / University of California Irvine, Irvine, USA
Sainan Sun, Frank Pattyn	FETISH	ULB	Laboratoire de Glaciologie, Université Libre de Bruxelles, Brussels, BE
Philippe Huybrechts, Heiko Goelzer	GISM	VUB	Vrije Universiteit Brussel, Brussels, BE

General ISMIP6 Globus Instructions (v. 2023): Globus_Instructions_ismip6_general_June2023.docx (2 MB, uploaded by Katelyn Eaman 1 year 2 months ago).

References

Bamber, J. L., Layberry, R. L., and Gogineni, S.: A new ice thickness and bed data set for the Greenland ice sheet 1. Measurement, data reduction, and errors, J. Geophys. Res.-Atmos., 106, 33773–33780 (2001).