

initMIP Antarctica



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. As accurately modeling Antarctica at continental scale remains challenging, we offer groups interested in participating but unable to run the entire Antarctic ice sheet to focus on specified basins instead. The initMIP-Antarctica is the first in a series of ISMIP6 ice sheet model intercomparison activities and is led by Helene Seroussi.

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 Antarctica Experimental setup

Experiments are for the large scale or regional Antarctic 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)
- 2c. abmb: Prescribed schematic basal melting anomaly under floating ice (100 years)

The three forward experiments serve to evaluate the initialization in terms of model drift (2a. ctrl) and response to perturbations (2b. asmb and 2c. abmb). 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 perturbation in 2c. abmb consists of a given basal melting anomaly, which has to be applied relative to the initial basal melting inherent to the individual initialization technique and should be applied only to floating ice at any given time of the simulation. The basal melting anomaly for floating ice in 2c. abmb is schematic and should not be considered as a realistic projection. The core experiment duration is set to 100 years.

Regional models

As accurately modeling the entire Antarctic ice sheet remains challenging, we offer groups the option to focus instead on modeling one or more of **five regional basins**:

- Amundsen Basin
- Amery Basin
- Wilkes Land
- Ronne-Filchner Basin
- Ross Ice Shelf Basin

Experiments and parameters for the regional models are similar to the continental scale models. Interested participants can submit results for any basin. Results should be reported on the **same grid as continental scale models** to simplify the analysis. Shapefiles with suggested extent of the regional models (starting from the observed ice divide position and consistent with the basins used in the IMBIE2 effort).

Requirements for the experiments

1. Participants can and are encouraged to contribute with different models and/or initialization methods.
2. Participants can contribute with continental scale models and/or regional models for the regional basins chosen.

3. Models have to be able to prescribe a given SMB anomaly.
4. Models have to be able to prescribe a given basal melting anomaly under the floating ice only.
5. No adjustment of SMB due to geometric changes in forward experiments (i.e. no elevation – SMB feedback is allowed)
6. No bedrock adjustment in forward experiment
7. 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.
8. 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 1 km version to conservatively interpolate to their model native grid (see **Appendix 1**, below).

For experiment 2b. asmb, 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):

$$\text{SMB}(t) = \text{SMB_initialization} + \text{SMB_anomaly} * (\text{floor}(t) / 40); \text{ for } 0 < t < 40 \text{ in years}$$

$$\text{SMB}(t) = \text{SMB_initialization} + \text{SMB_anomaly} * 1.0; \text{ for } t > 40 \text{ years}$$

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/m³ and 31,556,926 s/yr.

Prescribed basal melt anomaly under floating ice

The basal melt anomaly can be obtained via the Ghub Globus endpoints web application on a 1 km grid. Basal melt anomalies are uniform across a basin to accommodate all the possible initial grounding line positions. These anomalies are somewhat similar to the observed basal melt under floating ice, so they lead to a doubling of the ocean induced melting after 40 years for models with initial basal melting close to today's observations.

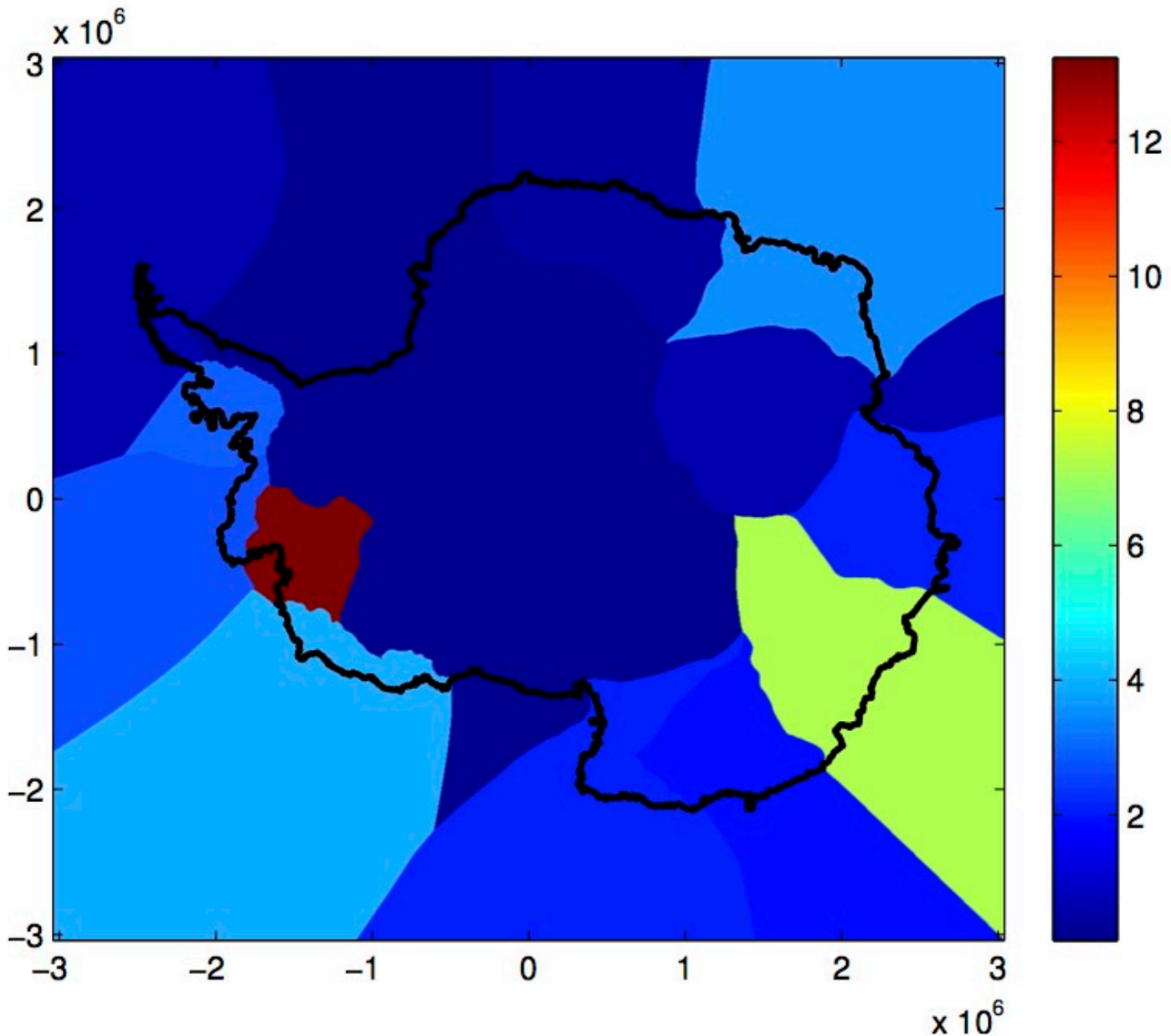
For experiment 2c. abmb, the amplitude of the basal melt anomaly is to be implemented as a time dependent function, similar to experiment 2b. abmb The amplitude of the function applied increases step-wise every full year (it is therefore independent of the time step in the model):

$\text{basal_melt}(t) = \text{basal_melt_model} + \text{basal_melt_anomaly} * (\text{floor}(t) / 40)$; for $0 < t < 40$ in years

$\text{basal_melt}(t) = \text{basal_melt_model} + \text{basal_melt_anomaly} * 1.0$; for $t > 40$ years

where `basal_melt_anomaly` is the anomaly provided by ISMIP6 and `basal_melt_model` is the model specific `basal_melt`. The anomaly should only be applied on floating ice and should be applied on all floating ice, so that area newly ungrounded should include this anomaly on top of the basal melt applied for the *ctrl* run (e.g. depth dependent parameterization) as soon as the ice starts floating. The basal melt anomaly is defined over the entire **Antarctic grid** (see **figure** below), so newly ungrounded areas or ice front advances should also apply this anomaly as long as the ice is freely floating. The units of `basal_melt_anomaly` are (meter ice equivalent/year) with an assumed density of 910 kg/m^3 and $31,556,926 \text{ s/yr}$.

Unlike the SMB forcing, the basal melt anomaly is constant per regional basins, so conservative interpolation is not needed and the basal melt anomaly applied should simply equal the value prescribed for each basin. Several version of this anomaly with different grid resolutions (1 km, 2 km, 4 km, 8 km, 16 km and 32 km) are available on the Ghub Globus endpoints web application



Specific uncertainty analysis

At a later stage and informed by the diversity and similarities of participating models, ISMIP6 will suggest further experiments to explicitly address certain aspects of uncertainty in the initialization. It is hoped that participating groups will contribute to these additional experiments, which apply specific perturbations to the initializations. These would take the form of repeating the experiments with systematic perturbations of the initialization choices, for example:

- Boundary conditions and other datasets
- Parameters
- Model structure
- Methods and judgments, e.g. tolerance for data mismatch or drift

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 71° S and a central meridian of 0° W on datum WGS84. The lower left corner is at (-3,040,000 m, -3,040,000 m) and the upper right at (3,040,000 m, 3,040,000 m). This is the same grid used to provide the SMB and basal melting anomaly forcings. The output should be submitted on a resolution adapted to the resolution of the model and can be 32 km, 16 km, 8 km, 4 km, 2 km or 1 km. The data will be stored on this resolution for archiving and conservatively interpolated on a 8 km resolution for diagnostic processing by ISMIP6. Output should be provided with single precision.

If interpolation is required in order to transform the SMB forcing (1 km grid data) to your native grid, and transform your model variables to the initMIP output grid (32 km, 16 km, 8 km, 4 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.

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 (no need to provide coordinates)
- all variables in one file for the scalar variables
- a completed readme file
- single precision should be used for all output

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*, *asmb*, or *abmb*)

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

scalar_AIS_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).

We distinguish between state variables (ST) (e.g. ice thickness, temperatures and velocities) and flux variables (FL) (e.g. SMB). State variables should be given as snapshot information at the end of one year (for scalars variables) and five year periods (for **2D variables**, see table below), while flux variables are to be averaged over the respective periods. Please specify in your README file how your reported flux data has been averaged over time. Ideally, the standard would be to go average over all native time steps.

Flux variables are defined positive when the process adds mass to the ice sheet and negative otherwise.

Time should be defined in seconds since the beginning of the run (e.g., units should be “seconds since 2007-01-01 00:00:00”).

Variable	Dim	Type	Variable Name	Standard Name	Units	Comment
<i>2D variables requested every five years, starting at $t=0$, snapshots for type ST and as five year average for type FL.</i>						
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
Base elevation	x,y,t	ST	base	base_altitude	m	The altitude of the lower ice 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_flux_at_ground_level	W m^{-2}	Geothermal Heat flux (unchanged in forward exps.)

Surface mass balance flux	x,y,t	FL	acabf	land_ice_surf ace_specific_ mass_balanc e_flux	kg m ⁻² s ⁻¹	Surface Mass Balance flux
Basal mass balance flux	x,y,t	FL	libmassbf	land_ice_ba sal_specific_ mass_balanc e_flux	kg m ⁻² s ⁻¹	Basal mass balance flux
Ice thickness imbalance	x,y,t	FL	dlithkdt	tendency_of_m land_ice_thic kness	s ⁻¹	dHdt
Surface velocity in x	x,y,t	ST	uvelsurf	land_ice_surf ace_x_velocit y	m s ⁻¹	u-velocity at land ice surface
Surface velocity in y	x,y,t	ST	vvelsurf	land_ice_surf ace_y_velocit y	m s ⁻¹	v-velocity at land ice surface
Surface velocity in z	x,y,t	ST	wvelsurf	land_ice_surf ace_upward_ velocity	m s ⁻¹	w-velocity at land ice surface
Basal velocity in x	x,y,t	ST	uvelbase	land_ice_bas al_x_velocity	m s ⁻¹	u-velocity at land ice base
Basal velocity in y	x,y,t	ST	vvelbase	land_ice_bas al_y_velocity	m s ⁻¹	v-velocity at land ice base
Basal velocity in z	x,y,t	ST	wvelbase	land_ice_bas al_upward_v elocity	m s ⁻¹	w-velocity at land ice base
Mean velocity in x	x,y,t	ST	uvelmean	land_ice_vert ical_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_vert ical_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_K at_ground_le vel_in_snow_		Ice temperature at surface

Basal temperature	x,y,t	ST	litempbot	or_firn land_ice_basal_temperature	Ice temperature at base
Basal drag	x,y,t	ST	strbasemag	magnitude_ofPa _land_ice_basal_drag	Magnitude of basal drag
Calving flux	x,y,t	FL	licalvf	land_ice_specific_mass_flux_due_to_calving	Loss of ice mass resulting from iceberg calving. Only for grid cells in contact with ocean
Grounding line flux	x,y,t	FL	ligroundf	land_ice_specific_mass_flux_at_grounding_line	Loss of grounded ice mass resulting at grounding line. Only for grid cells in contact with grounding line
Land ice area fraction	x,y,t	ST	sftgif	land_ice_area_fraction	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_ice1_sheet_area_fraction	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	x,y,t	ST	sftflf	floating_ice_1	Fraction of

sheet area fraction				sheet_area_f raction	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_ma kg ss	spatial integration, volume times density
Mass above floatation	t	ST	limnsw	land_ice_ma kg ss_not_displ acing_sea_w ater	spatial integration, volume times density
Grounded ice area	t	ST	iareag	grounded_ice m ² _sheet_area	spatial integration
Floating ice area	t	ST	iareaf	floating_ice_ m ² shelf_area	spatial integration
Total SMB flux	t	FL	tendacabf	tendency_of_kg s ⁻¹ land_ice_ma ss_due_to_s urface_mass _balance	spatial integration
Total BMB flux	t	FL	tendlibmassb f	tendency_of_kg s ⁻¹ land_ice_ma ss_due_to_b asal_mass_b alance	spatial integration
Total calving flux	t	FL	tendlicalf	tendency_of_kg s ⁻¹ land_ice_ma ss_due_to_c alving	spatial integration
Total grounding line flux	t	FL	tendligroundf	tendency_of_kg s ⁻¹ grounded_ice _mass	spatial integration

Appendix 3 – Participating Models and Characteristics

Antarctica Standalone Ice Sheet Modeling

Model Characteristics

Model	Numerics	Ice Flow	Initializatio n	Initial Year	Initial SMB	Basal Sliding	Initial Grid (km)
ARC	FD	HYB	SP	2000	RA2	PL	16

PISM1, PISM2 AWI	FD	HYB	SP	2000	RA2.3	NP	16
PISM1Eq, PISM1Pal, PISM2Eq, PISM2Pal CPOM	FV	SSA	DA	2010	None	CL	1-8
BISICLES PRELIM ILTS SICO	FD	SIA/SSA	SP	1990	Arth.	WS	8
POLIS IMAU	FD	SSA	SP	2005	RA2.3	VS	64
IMAUICE64 JPL1 ISSM	FE	SSA	DA	2007	RA2	WS	1-50
PSU EQNOFD MEC		HYB	DA+ SP	2007	PDD	WS	16
PSU GLNO	FD	HYB	SP	2007	PDD	WS	16
MEC UCIJPL	FE	HO	DA	2007	RA2	WS	3-50
ISSM ULB	FD	HYB	DA+ SP	2000	MAR	WS	32
FETISH VUB AISM	FD	SIA/SSA	SP	2000	PDD	WS	20
PALEO							

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: **RA2**= RACMO2.1, **RA2.3**= RACMO2.3, **PDD**= Positive Degree Day Model, **MAR**= MAR

Basal sliding: **PL**=Pseudo-plastic, **NP**=Nearly Plastic, **VS**= Viscous Sliding, **WS**= Weertman Sliding



Contributors	Model	Group ID	Group
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General ISMIP6 Globus Instructions (v. 2023):

[Globus_Instructions_ismip6_general_June2023.docx](#) (2 MB, uploaded by Katelyn Eaman 1 year 2 months ago).

