ISMIP6 Projections Antarctica

Overview: Experimental protocol for Antarctic projections

This page describes the experimental protocol for the ISMIP6 projections that target the upcoming IPCC AR6 assessment. Due to the delay in CMIP6 climate simulations, the initial set of ISMIP6 simulations are based on CMIP5 projections. These CMIP5 models were chosen following the assessment presented in **Barthel et al.** (2020). As CMIP6 model outputs became available, ISMIP6 included simulations based on these new models. The experimental framework was revised in September 2018 during an ISMIP6 workshop held in Sassenheim (NL).

The revised protocol described in Nowicki et al. **(2020) and summarized in** Fig. 1 **allows for:**

- **Sampling CMIP scenarios**: main focus is on the high emission RCP8.5, but ice sheet evolution in response to low emission RCP2.6 is also investigated.

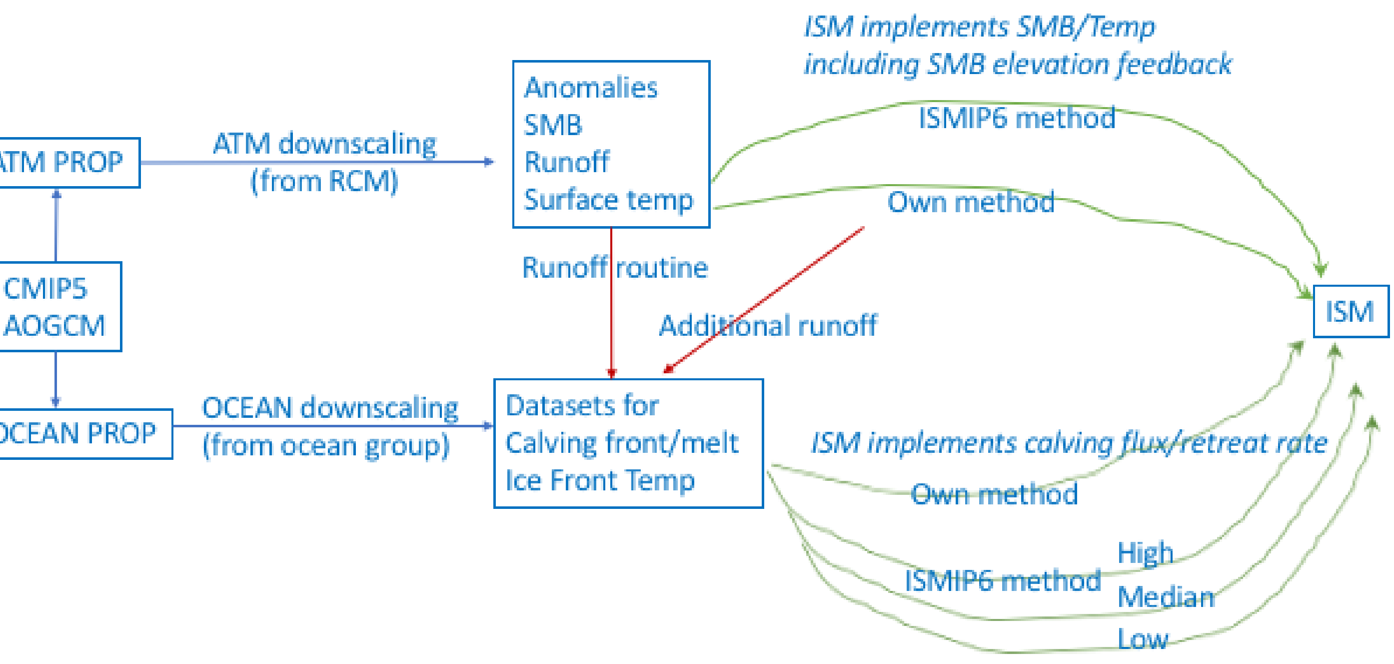
- **Sampling CMIP models**: 6 AOGCMs have been selected from the **CMIP5 model ensemble**: CCSM4, CSIRO-Mk3-6-0, HadGEM2-ES, IPSL-CM5A-MR, MIROC-ESM-CHEM and NorESM1-M. The AOGCMs were identified based on the following steps:

1. Present-day climate near Antarctica in agreement with observations (evaluated by model biases over the historical period);
2. Sample a diversity of forcing (evaluated by differences in projections and code similarities); and
3. Allow only models with RCP8.5 and RCP2.6. The sampling methodology for the CMIP5 models is described in **Barthel et al.** (2020). As CMIP6 models became available, ISMIP6 prepared dataset for CNRM-CM6 (ssp585 and ssp126), CESM2 (ssp585) and UKEM1-CM6 (ssp585). Unlike for the rigorous analysis for the CMIP5 models, the CMIP6 models were selected because of their availability.

ling ice sheet model uncertainty: “standard” and “open” experiments. The “standard” experiments sed on parameterizations developed by the ocean groups, while “open” experiments utilize the eterizations already in use by respective ice sheet models. The open experiments are important as they o sample the uncertainty in processes that are poorly known, as reflected by different parameterizations.

ling ocean forcing uncertainty: the standard experiments include “high”, “mid” and “low” values for cing parameters, as well as two different calibration methods for the basal melt rate parameters (see **ain et al.**, 2020).

iment ranking: This experimental framework results in a series of projections (divided into core and d experiments), a historical run and a control run. Not every ice sheet model will be able to carry out the of experiments, but they are strongly encouraged to participate in the full suite of core experiments **1**, which uses both the **“open”** and **“standard”** experiments/parameterizations). Given that the rd experiments requires new implementations, it is OK to only participate with only the open nents. Similarly, it is OK to only participate with the “standard” experiments. Groups are encouraged to rough the lists presented below (see **Table 1** for core experiments, and targeted experiments will follow starting from the top, and complete as many experiments as possible. This approach of combining core geted experiments is based on **Shannon et al.** (2013): it ensures that all groups do a subset of identical nents, while it also allows faster models to explore the targeted experiment space more fully.



rview of the Antarctic experimental framework

ojections

of the atmosphere and ocean focus groups, a number of CMIP5 AOGCMs have been selected for lone ice sheet model projections. **Table 1** lists the *core experiments* which are the minimum contribution ISMIP6 models, in addition to the initialization experiments listed in **Table 2**.

*encouraged to contribute to the "**standard"*** experiments, but this is not a requirement for participation in *s that have their own methods for implementing ocean and atmosphere forcing, are encouraged to do* ***open"*** experiments (1-4), but these are not compulsory. Models that perform the "open" experiments rameterization of their choice to simulate atmospheric and oceanic forcings, but these ons must use the given CMIP5 AOGCM outputs.

ps that can run many simulations will be encouraged to further explore the ice sheet response using ***riments*** (See Table). These include three additional CMIP5 AOGCMs under RCP8.5, and experiments e ocean forcing uncertainty. Depending on the results of experiments 3 and 7, which consider RCP2.6, GCMs may be suggested with RCP2.6 for models that are able to do many simulations, but these would rity than the completing the set of experiments with the 6 AOGCMs for the RCP8.5 scenario. As CMIP6 becoming available, we are preparing these datasets. The spreadsheet will be updated as new dataset ble. Because there is value in both completing the 6 CMIP5 AOGCMs (to sample the uncertainty in ulations with CMIP6 models, we encourage groups do to as many experiments as possible.

asets needed for the core experiments (**Table 1**) are available on Ghub Globus, as well as the dataset al targeted CMIP5 and CMIP6 models. (See Table)

Experiments based on MIROC5, NorESM1-M and HadGEM2-ES

RCP	AOGCM	Std/open	Ocean Forcing Unc.	Fracture	Note
8.5	NorESM1-M	Open	Medium	None	Low atmospheric change and mid-to-high ocean warming
8.5	MIROC-ESM-CHEM	Open	Medium	None	High atmospheric changes and median ocean warming
2.6	NorESM1-M	Open	Medium	None	Low atmospheric

					change and mid-to-high ocean warming
8.5	CCSM-4	Open	Medium	None	Large atmospheric warming and variable regional ocean warming
8.5	NorESM1-M	Standard	Medium	None	Low atmospheric change an mid-to-high ocean warming
8.5	MIROC-ESM-CHEM	Standard	Medium	None	High atmospheric changes and median ocean warming
2.6	NorESM1-M	Standard	Medium	None	Low atmospheric change and mid-to-high ocean warming
8.5	CCSM4	Standard	Medium	None	Large atmospheric warming and variable regional ocean warming
8.5	NorESM1-M	Standard	High	None	Ocean Forcing Uncertainty, using 95th percentile values
8.5	NorESM1-M	Standard	Low	None	Ocean Forcing Uncertainty, using 5ht percentile values
8.5	CCSM4	Open	Medium	Yes	Experiment with ice shelf hydrofracture
8.5	CCSM4	Standard	Medium	Yes	Experiment with ice shelf hydrofracture
8.5	NorESM1-M	Standard	PIGL	None	Ocean Forcing Uncertainty, using PIGL, gamma

calibration

te, control run, historical run and projections set up

argeted experiments all start on January 2015 and end in December 2100. The start date follows the
ol for projections, while the end date is constrained by the availability of forcing. In many cases, modelers
n a short historical run to bring their models from the "initialization date" to the "projection start date" of
(see **Table 2**).

on date" (or initial state) is left to the modeling groups discretion and can be any time prior to January
ialization date" corresponds to the date assigned to the initialization procedure. Groups can reuse their
ation configuration or generate a new initial state. In the later case, it is important to redo the initMIP
eriments 'asmb' and 'abmb' (see initMIP Antarctica and **Seroussi et al.** 2019), as it will help
how a novel initial state contributes to the uncertainty in ice sheet evolution.

('ctrl') is also needed to evaluate model drift. As for initMIP, the control run is obtained by running the
, keeping the surface mass balance and ocean forcing used in the initialization technique unchanged.
n starts from the initial state (typically before 2015) and should last a minimum of 100 years, the same
e schematic initMIP experiments. The control run should also be sufficiently long to reach 2100. (See
able 2).

e event that initMIP schematic experiments and control run are redone as part of the projection setup,
cy with the projections protocol is more important than consistency with the original initMIP setup. For
tMIP bedrock was not allowed to evolve. However, an ISM planning to run the projection with evolving
planning to redo the initial state, would also rerun initMIP (ctrl, asmb. abmb) with bedrock change.
original initMIP requested 2D output every 5 years, whereas the projections protocol request for yearly
ore if rerunning initMIP, the schematic experiments should be saved yearly.

orical run" is required from each ice sheet model, from which all the projections will branch off. The
tarts at the initMIP state and ends in December 2014. Groups are free to choose how to run the
using:

alysis,
orical run from an RCM,
orical run from an AOGCM,
r combination of multiple datasets

eject multiple historical runs for each individual AOGCM, because this would very much complicate the
y and interpretation. As a consequence, in case AOGCM data is used, please decide for one. ISMIP6
natology for the SMB and surface temperature for each of the AOGCMs used to generate the projection
ll as anomalies.

ntarctica, the SMB and temperature climatology corresponds to 1995-2014, to align with the reference
used by AR6. The Antarctic SMB and temperature anomalies are available from 1950. For the Antarctic
the datasets start from 1850 and the climate model climatology corresponds to 1995-2014. Groups that
prefer to use an Antarctica dataset provided by ISMIP6 are recommended to use NorESM-M climatology

omalies for SMB and surface temperature (in the directory Atmosphere_Forcing/noresm1-m_rcp8.5 ry). See **Appendix A2.2** for accessing the forcing data and directories.

e ocean, modelers can use observational climatology n_Forcing/climatology_from_obs_1995-2017 directory), and/or anomalies n_Forcing/noresm1-m_rcp8.5/1850-1994) directory.

limate model oceanic climatologies (Ocean_Forcing/noresm1-m_rcp8.5/climatology_1995-2014 not intended for use by modelers, but are simply provided so that user can see what was subtracted asets preparation, as the ocean forcing data (Ocean_Forcing/noresm1-m_rcp8.5/1850-1994 directory) is observational climatology and anomalies.

on control" (ctrl_proj) is an unforced simulation that starts at the same ice sheet state as the will run until 2100, and is implemented with zero anomalies. It is meant to capture how much drift arises ical run.

the same historical run (and potentially spin-up) can be used for both the standard and open However, if the implementation of the open and standard experiments requires changes to the ISM that ly different (in terms of physics in the ISM), then modelers are allowed to carry out an historical run for riments and an historical run for the standard experiments.

lization experiments and examples of different initialization start date

Note	start 1 (duration)