CISM contribution to ISMIP6 and beyond

LIWG 2020

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And many thanks to the ISMIP6 community

Contribution in numbers

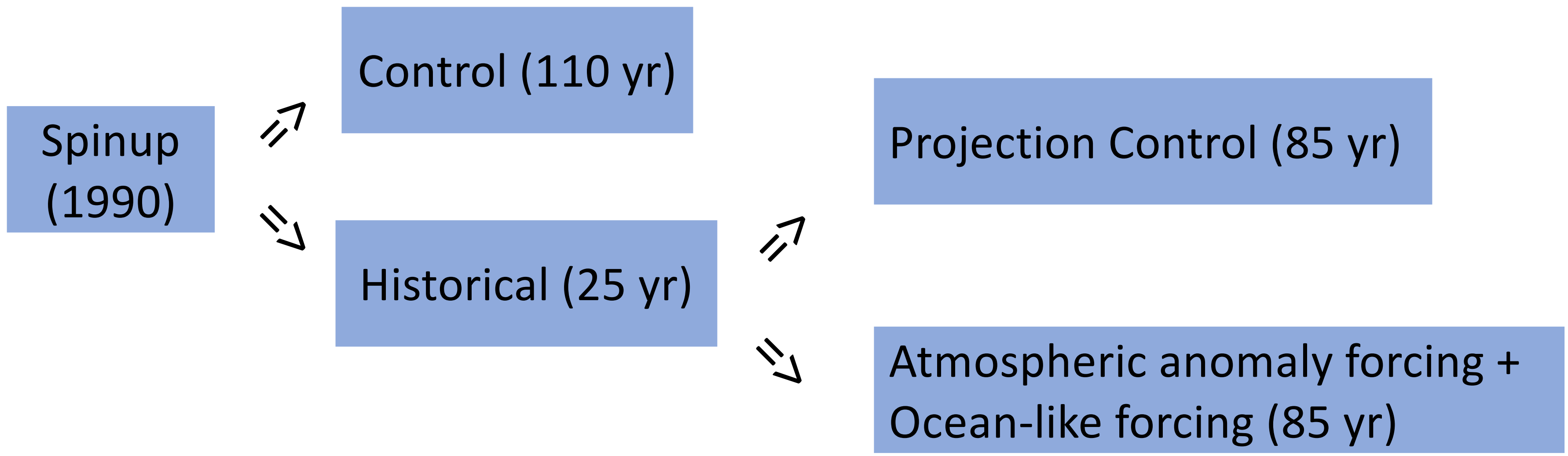
- 14 publications submitted by December 31st (coupled and stand-alone experiments).
- 260+ experiments submitted.
- 220k core hours on Cheyenne for standalone GrIS + AIS ISMIP6 experiments at 4km. (excluding spinups, trial and errors)
- 2M core hours on Cheyenne for coupled runs (excluding trial and errors).
- About 10 TB generated for stand alone (before compression) and about 20 TB for coupled.

Note

Any reference to CISM in this presentation refers to CISM version 2.1 (Lipscomb et al. 2018) or an experimental version branching from CISM 2.1

ISMIP6 Greenland

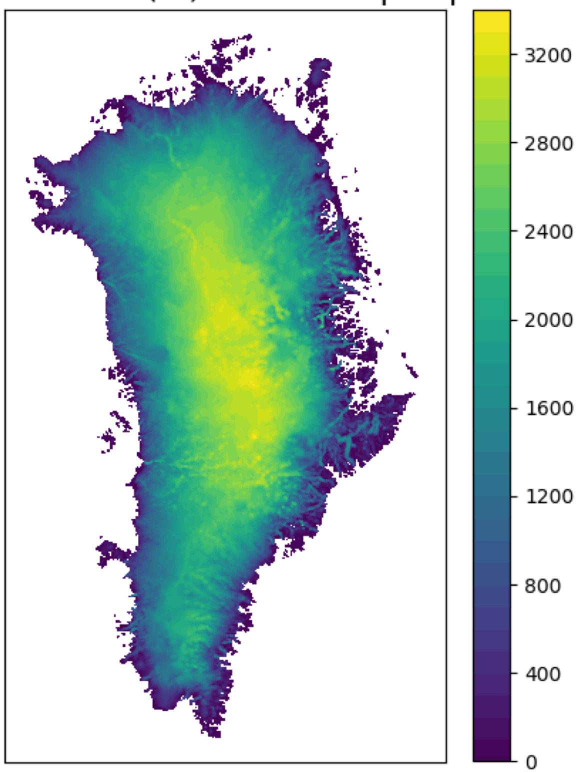
State of the GrIS by 2100



- Atmospheric Forcing:
  - CMIP5 (RCP 2.6, RCP 8.5)
  - CMIP6 (SSP 126 and 585)
- Oceanic forcing:
  - Low, medium, high

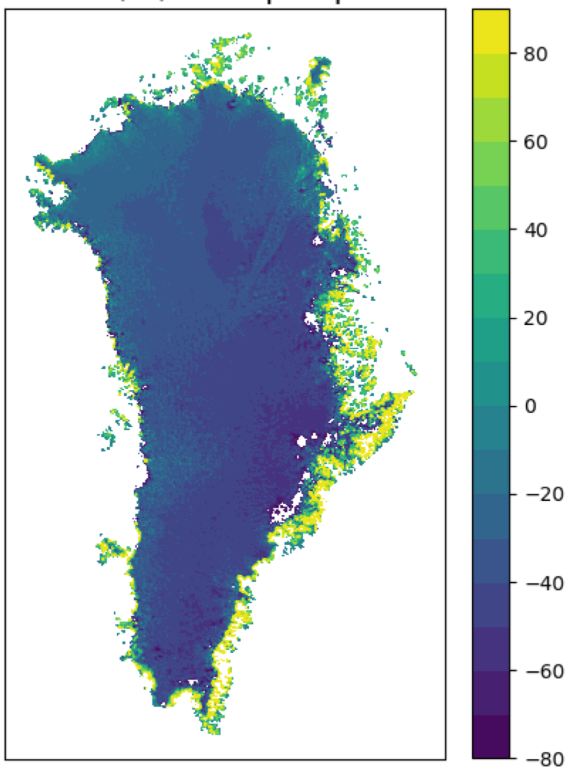
CISM GrIS spinup for 4km runs

Thickness (m) at end of spinup



- Initialized with present day thickness and topography (Morlighem et al. 2014).
- 30 ky spinup using 1980-1999 SMB climatology and surface temperature form MARv3.9 (Fettweis communication, Updated dataset from Fettweis et al. 2017).
- Nudging of basal friction parameters to match present day ice thickness.
- Basal heat flux from Shapiro and Ritzwoller (2004).
- Floating ice calves immediately.

Thick diff (m) btw spinup and obs



- Very good agreement with observations overall.
- Ice too thin in the interior by about 40 m
- Ice too thick around margins and outlet glaciers by about 80 m

GrIS SMB anomaly forcing

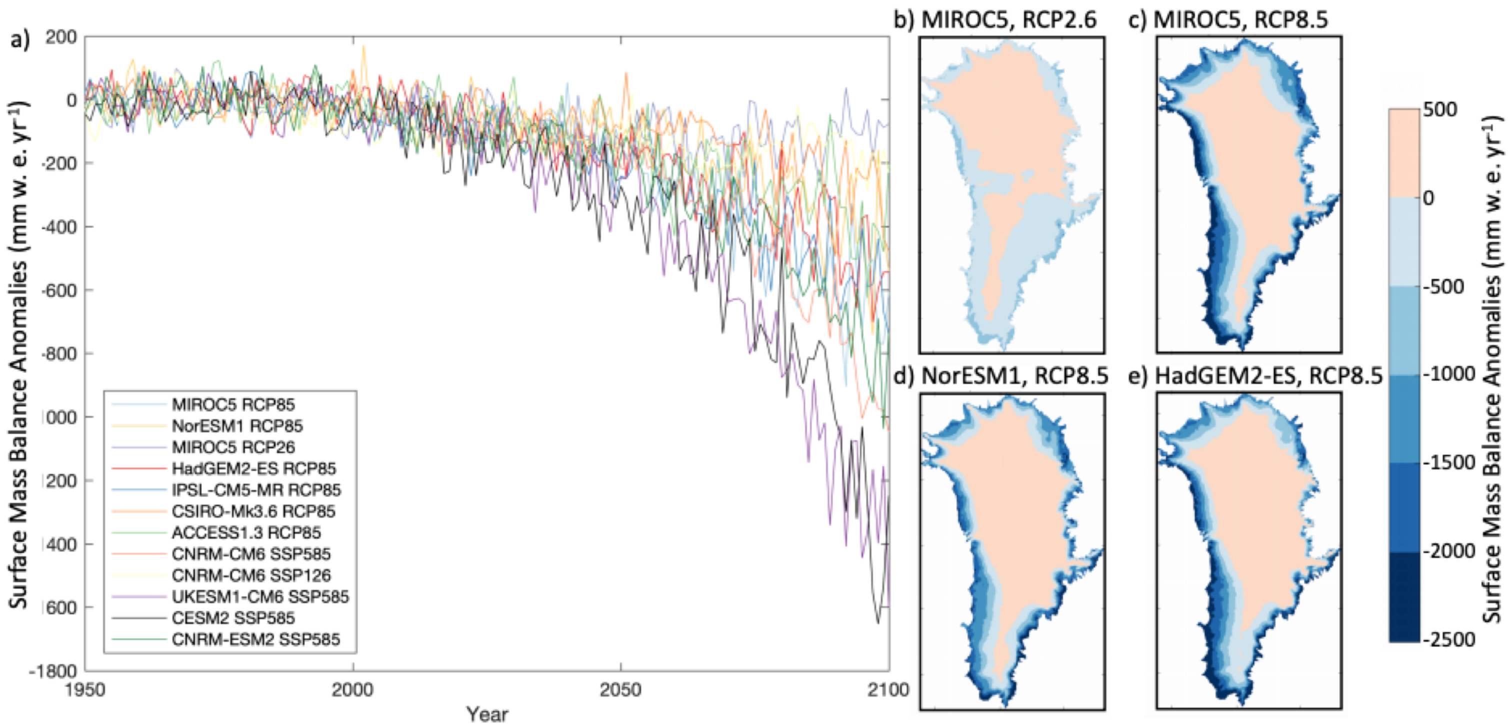
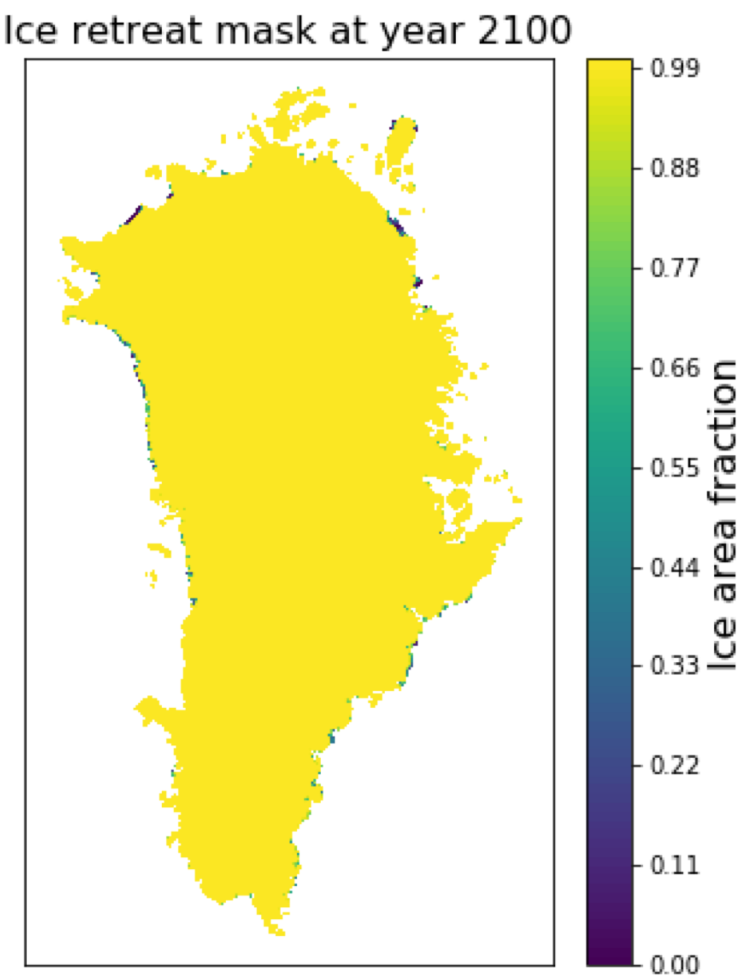


Fig.: (a) Time series of mean SMB anomaly for all model dataset.
(b-e) mean surface mass balance anomaly over the time period 2081-2100
(Figures from ISMIP6 protocol paper, Nowicki et al. submitted)

- The anomaly spread ranges between -1600 and -50 m/yr by 2100.
- All model datasets have similar anomaly patterns.

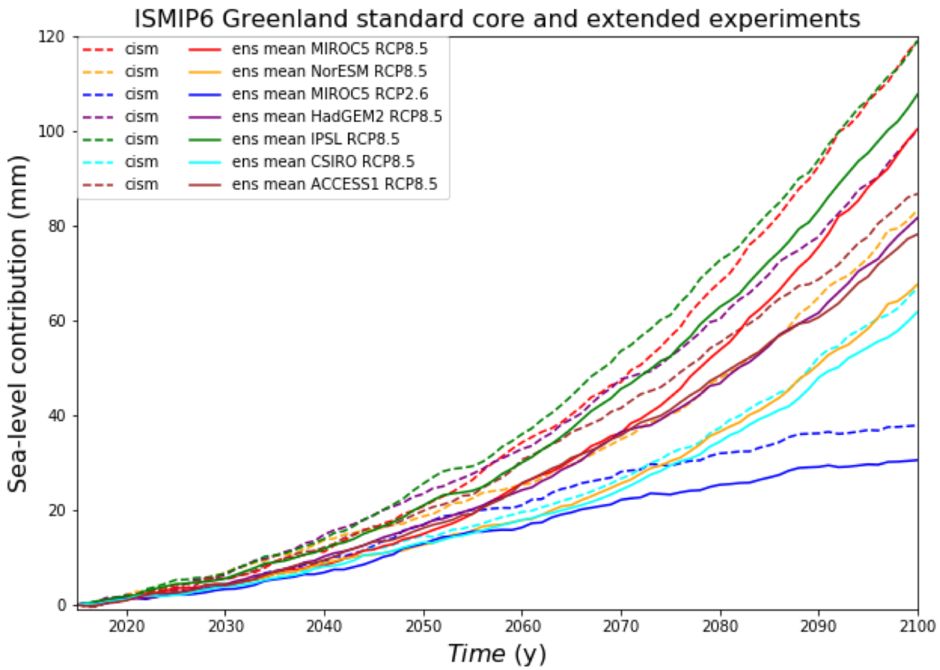
GrIS oceanic anomaly forcing



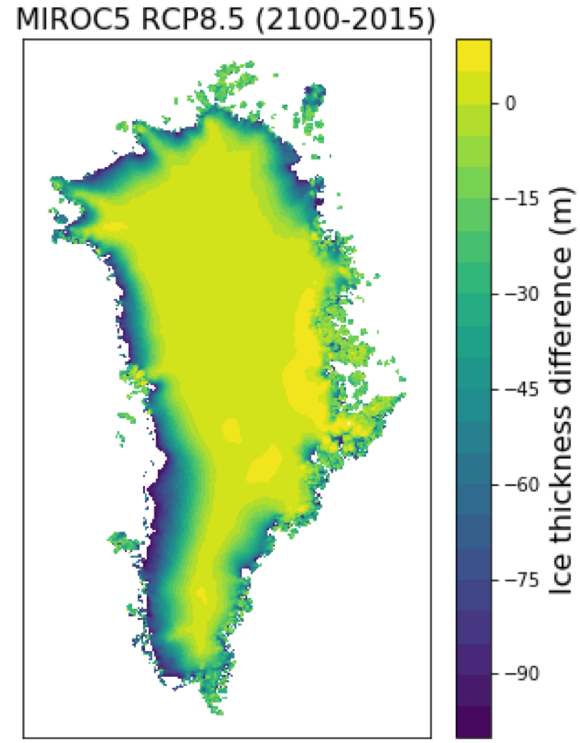
(provided by Heiko Goelzer)

- Retreat rate was generated by Heiko Goelzer for each participating model given model ice masks.
- One rate map per year.
- The retreat rate is applied similarly to a calving rate and the ice area fraction corresponds to the ice ratio in the cell that gets calved out.

GrIS ISMIP6 CISM VS Ensemble means



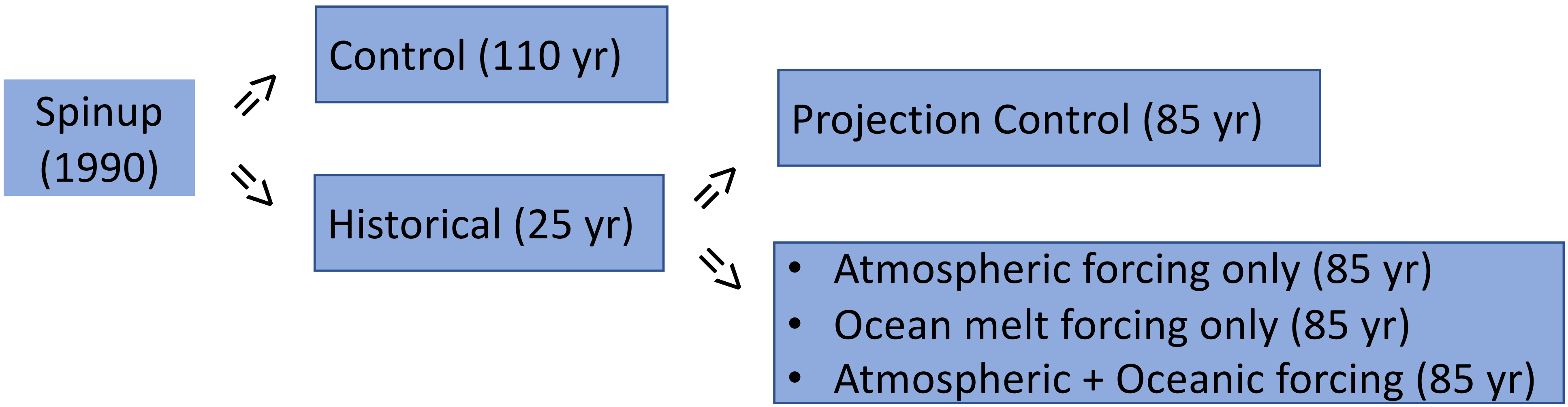
(Ensemble means from Goelzer et al. 2019 submitted)



- CISM predicts more sea level contributions (10-20%) compared to ensemble mean with all forcing datasets.
- For RCP 8.5 scenario:
  - Faster increase in sea level contribution after 2050 (primary due to SMB anomaly forcing).
  - Sea level contribution varies between 60 mm and 120 mm by 2100.
- For RCP 2.6 scenario, slight increase which appear to level off after 2090. (Only one model though!)
- Ice retreat all around coastlines, especially on the West and North.

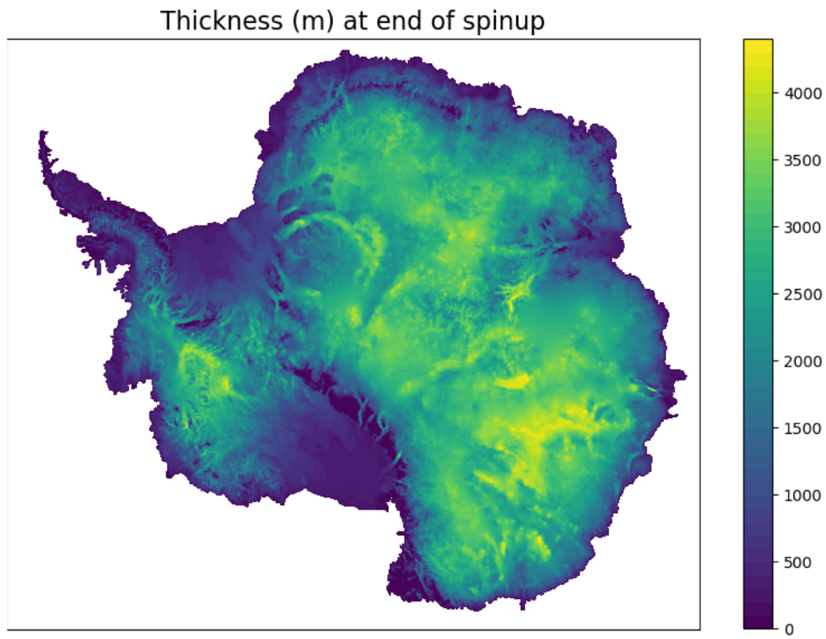
ISMIP6 Antarctica

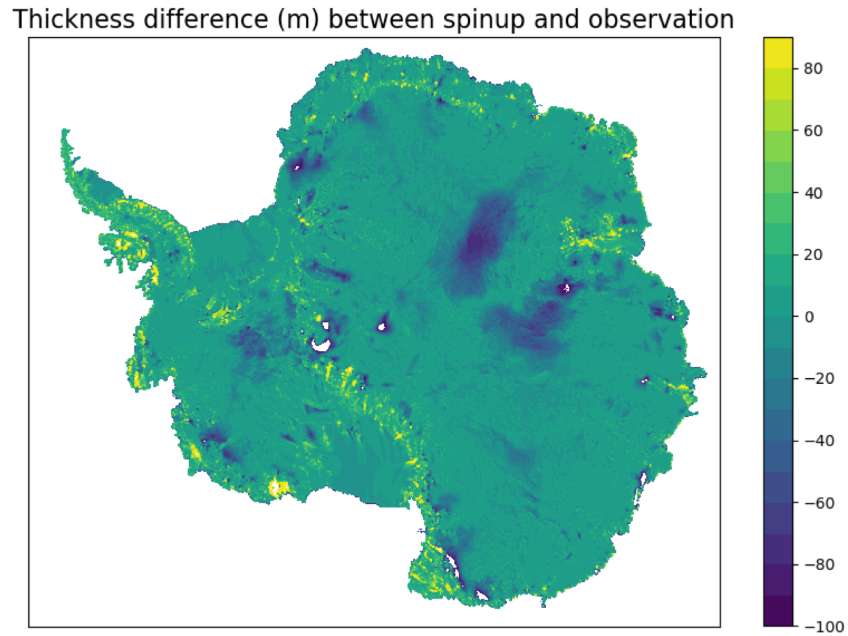
State of the AIS by 2100



- Includes standard and open experiments.
- CMIP5 models: RCP 2.6 and 8.5.
- CMIP6 models: SSP 585 (126).
- Oceanic forcing low, medium, high.

CISM AIS spinup for 4km runs





- Initialized using present day geometry (Morlighem et al. 2019).
- 40 ky spinup using 1979-2016 SMB climatology and surface temperature form RACMO2 (van Wessem et al. 2018).
- Nudging of basal friction parameters (grounded ice) and sub-shelf melt rate (floating ice) to match present day ice thickness and basal melt rates.
- Basal heat flux from Shapiro and Ritzwoller 2004.
- No-advance calving front.
- Very good thickness agreement with observations.

SMB anomaly forcing

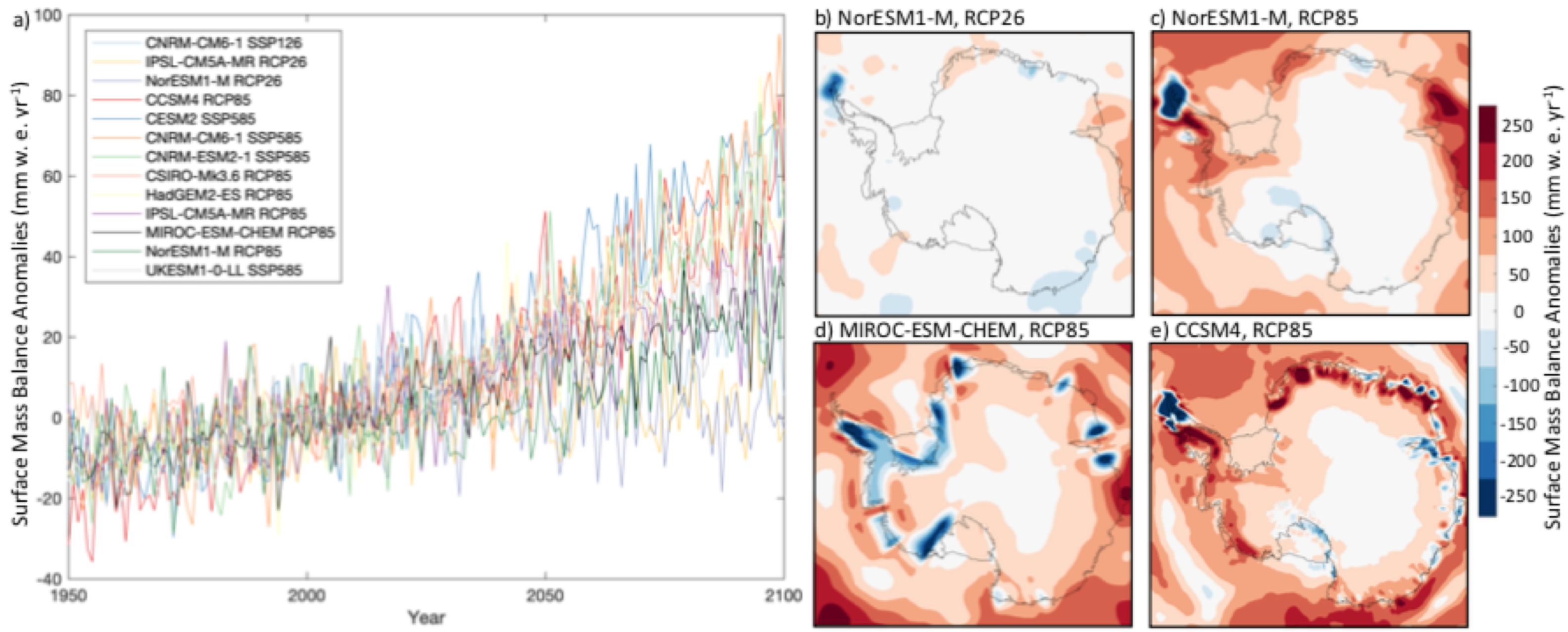


Fig.: (a) Time series of mean SMB anomaly for all model dataset.
(b-e) mean surface mass balance anomaly over the time period 2081-2100.
(Figures from ISMIP6 protocol paper, Nowicki et al. submitted)

- Wide spread of mean SMB anomaly between -10 and 100 m/y by 2100.
- Models have different anomaly patterns.

Thermal forcing anomaly

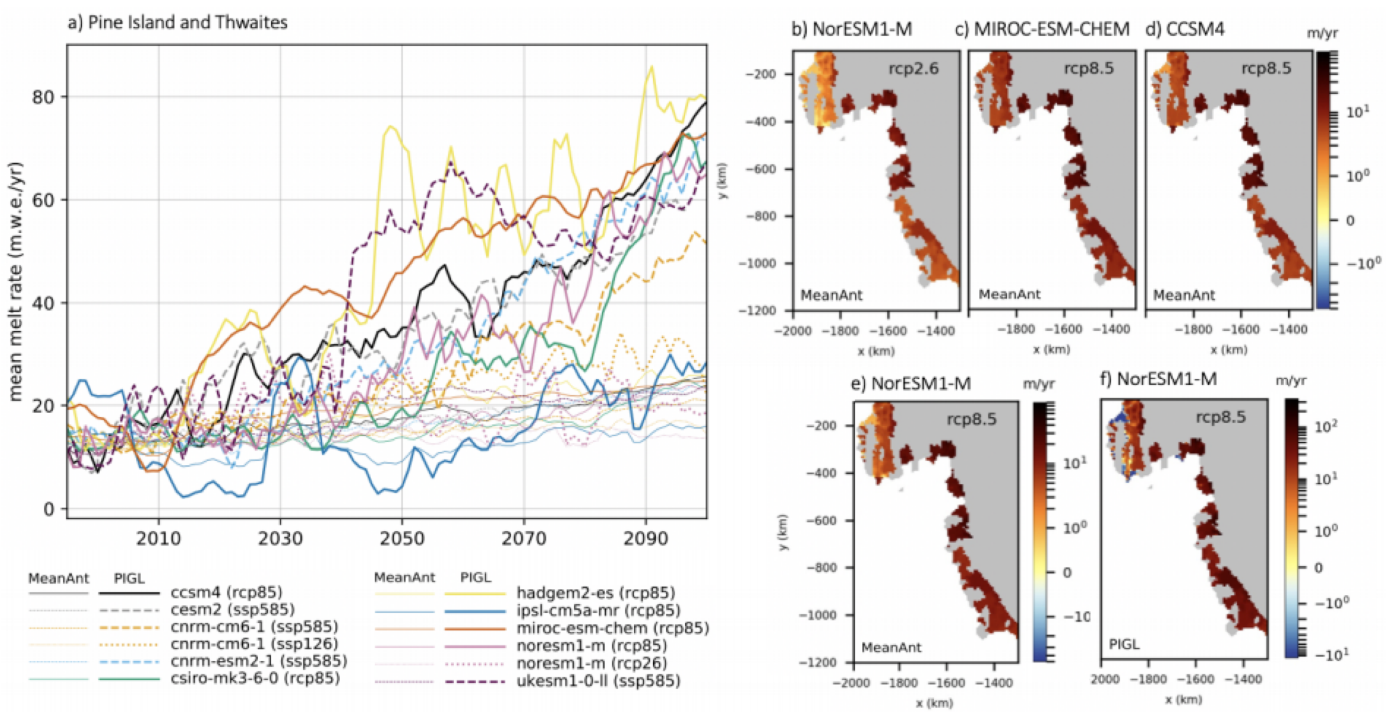
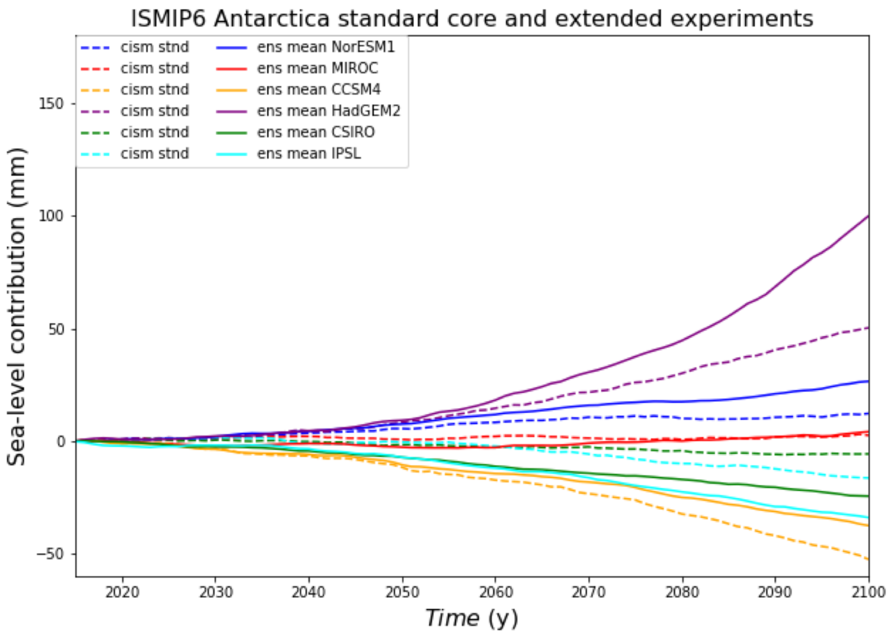
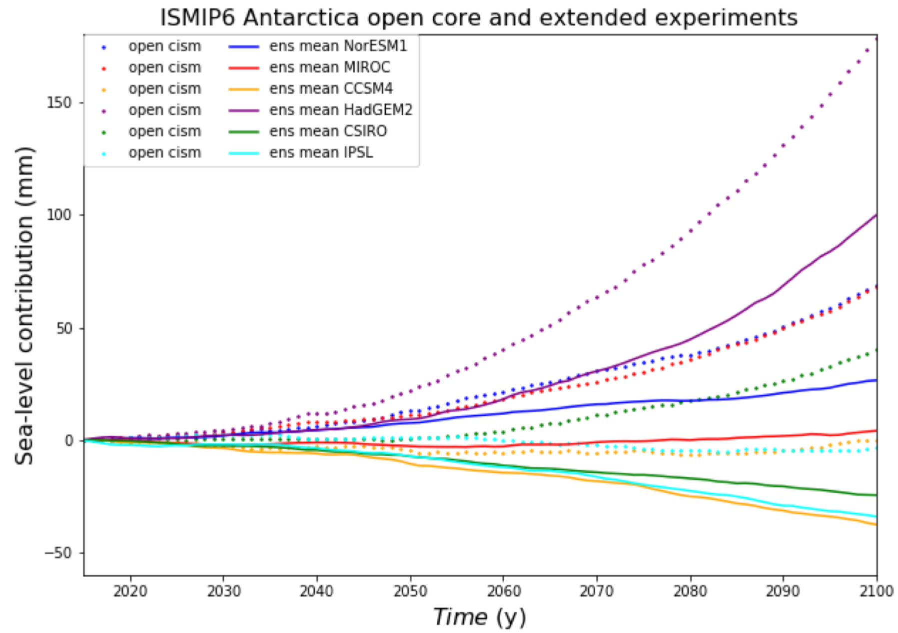


Fig.: (a) Time series of mean cavity basal melt rate for all model dataset for Pine Island and Thwaites.
(b-f) Spatial pattern of mean sub-shelf basal melt rate from 2081-2100.
(Figures from ISMIP6 protocol paper, Nowicki et al. submitted)

- The basal melt rate is obtained using thermal forcing anomaly.
- Mean basal melt rate varies between 10 and 80 m/yr.
- All models have similar spatial patterns in the Amundsen sea.

AIS ISMIP6 CISM VS Ensemble means

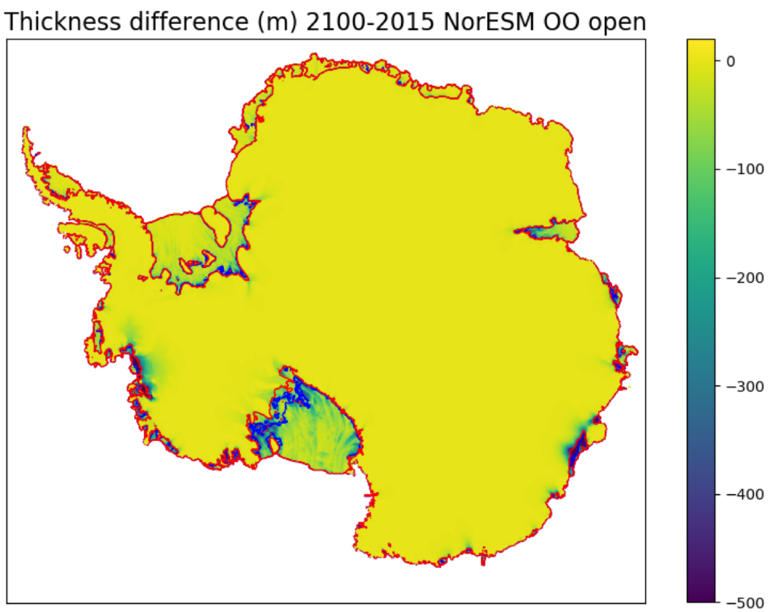


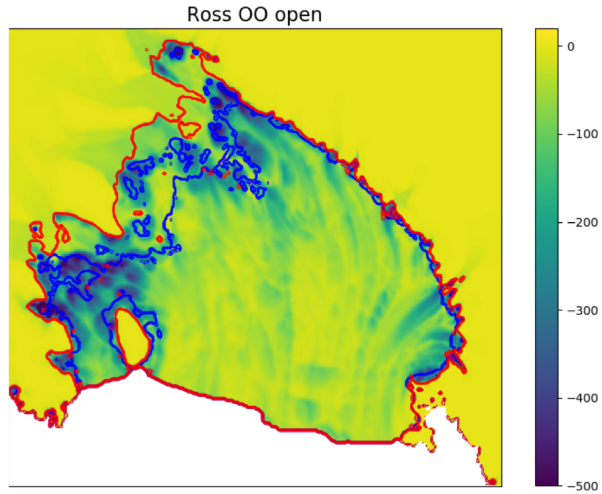


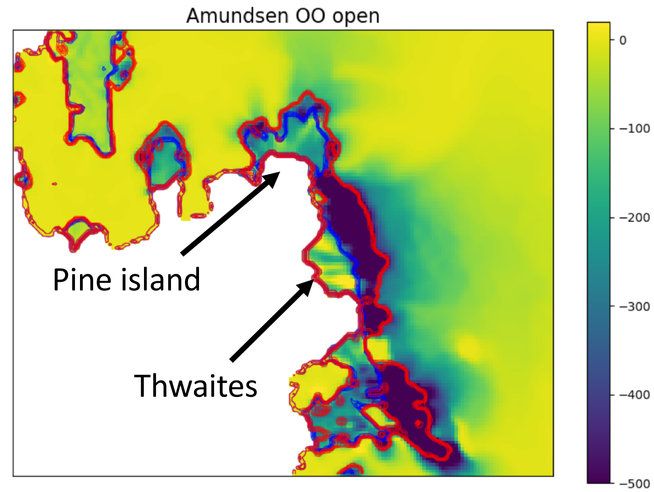
(Ensemble means from Seroussi et al. 2019 submitted)

- Showing RCP 8.5 core and Tier1 experiments only.
- Atmos and basal melt anomalies applied simultaneously.
- Using standard parameterization, CISM leads to lower sea level contributions compared to ensemble mean for most forcing datasets.
- Atmospheric forcing is leading the trend in standard experiments => sea level sink for half of the forcing datasets (increase SMB).
- Open experiments lead to stronger sea level contributions with all forcing datasets.
- Overall, low contribution to sea level by 2100 (lower than Greenland).

AIS thickness change between 2015 and 2100

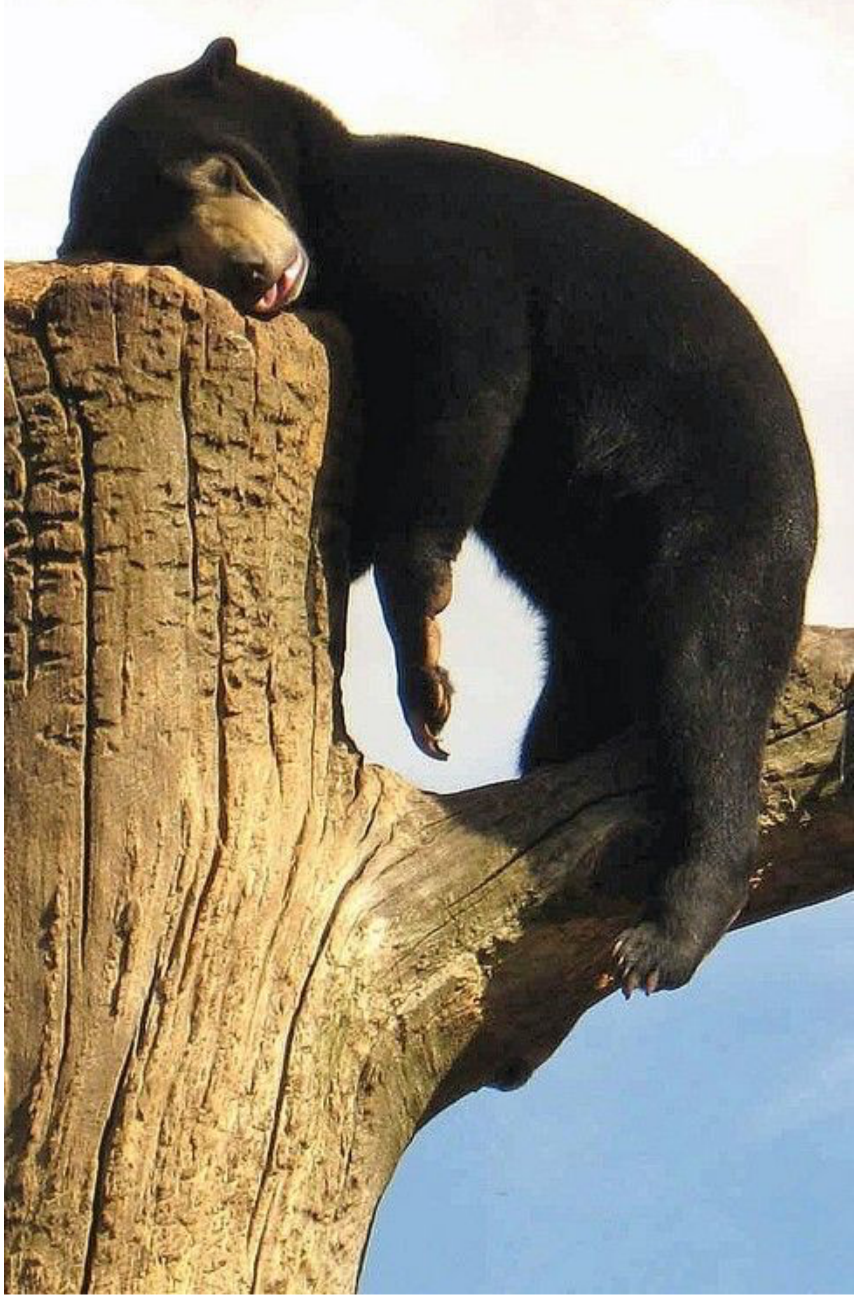






- Strong melt under major ice shelves: Moscow U., Ross, Thwaites,...
- Small or no grounding line retreat outside of Ross and Thwaites.
- Might need to run simulation for longer before we can observe strong impact.
- Grounding line retreat in Ross might not be realistic due to the extrapolation of the thermal forcing from open ocean to grounding line.

Beyond ISMIP6



Beyond ISMIP6: CISM2.2 release

Target: summer 2020

- Grounding-line parameterizations for basal stress and basal melting
- New physics options for sub-ice-shelf melting
- Inversion for basal sliding and sub-shelf melting parameters
- Performance improvements (accelerated Picard; tridiagonal preconditioner; ignore ice-free ocean cells)
- Updated model documentation
- New example test cases for both ice sheets (initMIP)
- Support for CESM coupled (BG) simulations with an interactive Greenland ice sheet
- Support for standalone Antarctic simulations (including initMIP and ISMIP6 projections)
- Support for partly coupled Antarctic simulations in CESM

Some information

CESM summer workshop: June 15th to 18th

CESM tutorial: August 3rd to 7th , application to be sent out soon

LIWG contacts:

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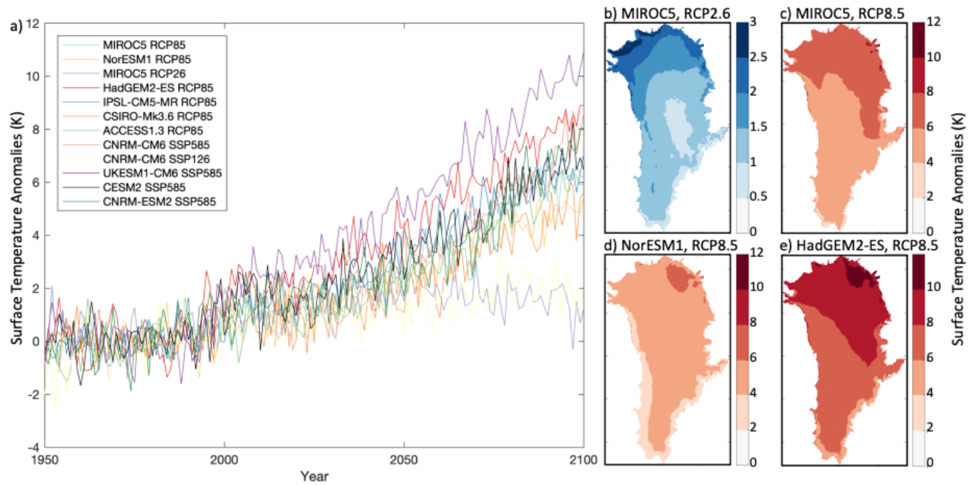
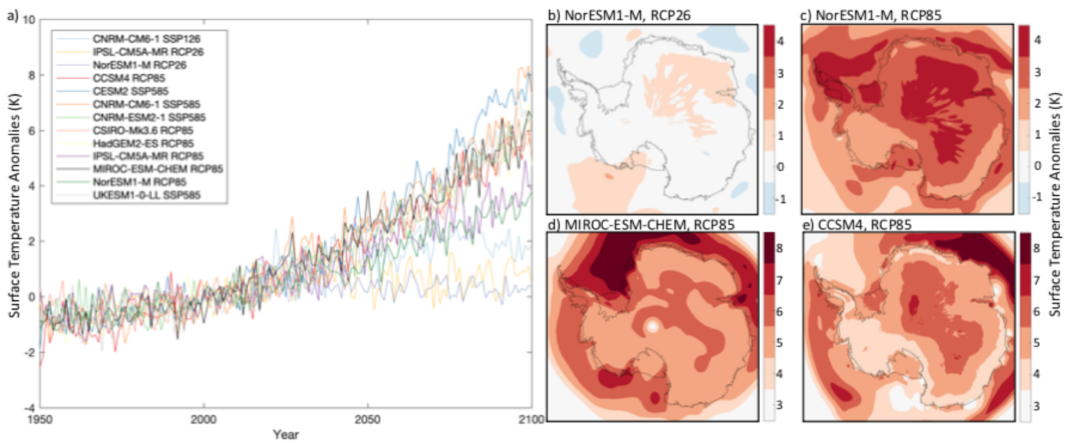
Software liaison: katec@ucar.edu

Thanks

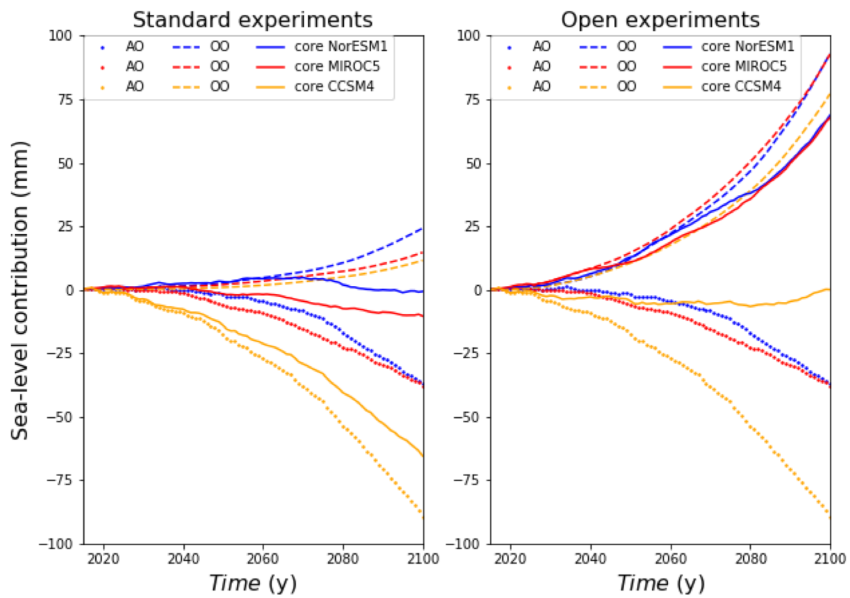
EXTRA



a)
MIROC5 RCP85
NorESM1 RCP85
MIROC5 RCP26
HadGEM2-ES RCP85
IPSL-CM5-MR RCP85
CSIRO-Mk3.6 RCP85
ACCESS1.3 RCP85
CNRM-CM6 SSP585
CNRM-CM6 SSP126
UKESM1-CM6 SSP585
CESM2 SSP585
CNRM-ESM2 SSP585
Surface Temperature Anomalies (K)
Year
b) MIROC5, RCP2.6
c) MIROC5, RCP8.5
d) NorESM1, RCP8.5
e) HadGEM2-ES, RCP8.5
Surface Temperature Anomalies (K)


a)
CNRM-CM6-1 SSP126
IPSL-CM5A-MR RCP26
NorESM1-M RCP26
CCSM4 RCP85
CESM2 SSP585
CNRM-CM6-1 SSP585
CNRM-ESM2-1 SSP585
CSIRO-Mk3.6 RCP85
HadGEM2-ES RCP85
IPSL-CM5A-MR RCP85
MIROC-ESM-CHEM RCP85
NorESM1-M RCP85
UKESM1-0-LL SSP585
Surface Temperature Anomalies (K)
Year
b) NorESM1-M, RCP26
c) NorESM1-M, RCP85
d) MIROC-ESM-CHEM, RCP85
e) CCSM4, RCP85
Surface Temperature Anomalies (K)

Understanding low sensitivity



- Atmospheric forcing is leading the trend in standard experiments.
- Weak basal melt signal with Standard melt parameterization until 2080.
- Atmospheric forcing dominates in standard experiments.
- Strong basal melt signal with Open melt parameterization: linear increase until 2040 and exponential thereafter.