ANTARCTIC GATEWAY PARTNERSHIP

Reducing uncertainties in projections of global sea level rise

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UTAS Ice Sheets Meeting
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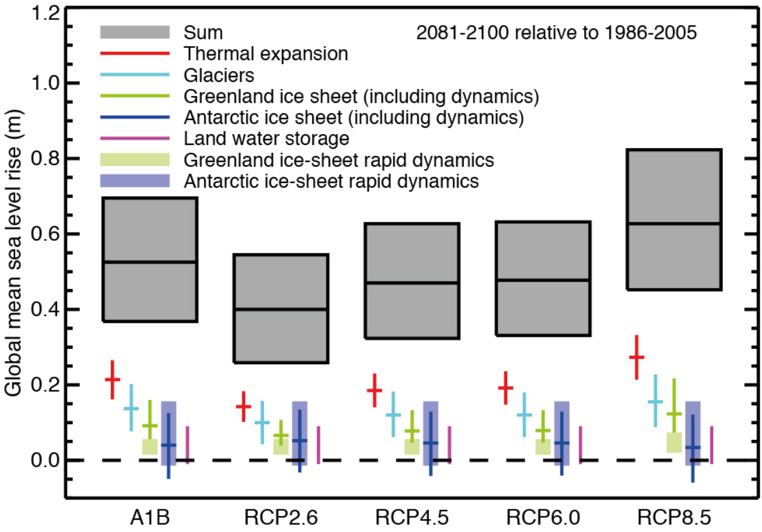
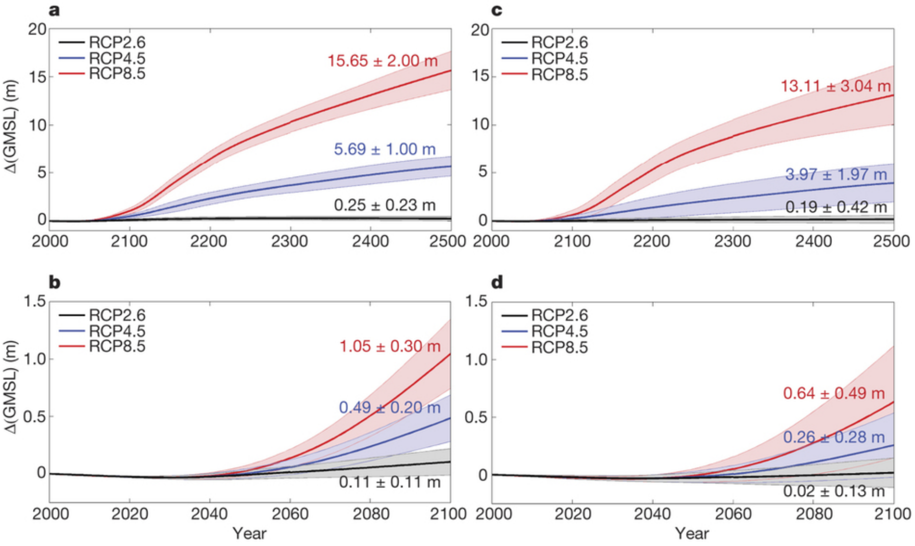
Australian Government
Australian Research Council
UNIVERSITY of TASMANIA AUSTRALIA
CSIRO
Australian Government
Department of the Environment
Australian Antarctic Division
A Special Research Initiative of the Australian Research Council

Likely changes in global sea level by 2081–2100



IPCC AR5 WG1 report (2013)

Future Antarctic contribution to global sea level



DeConto and Pollard (2016), *Nature*

Challenge 1:

Ice sheet models are under-constrained

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PISM
Parallel Ice Sheet Model

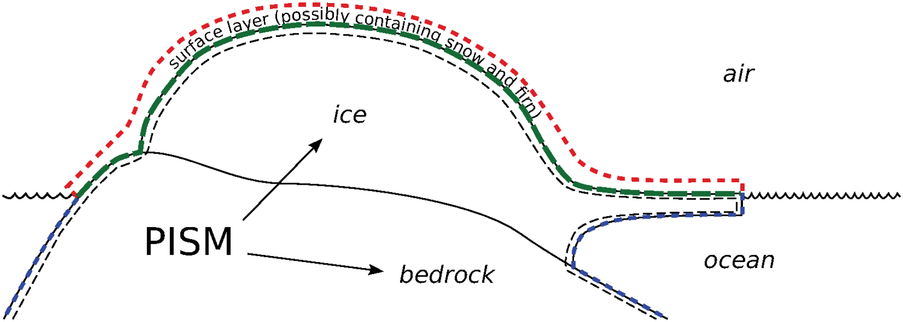


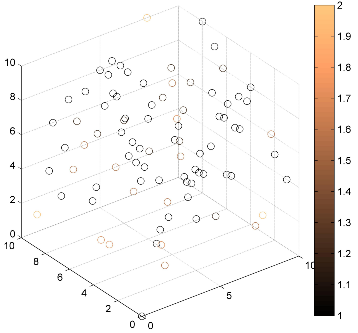
Figure 15: PISM's view of interfaces between an ice sheet and the outside world

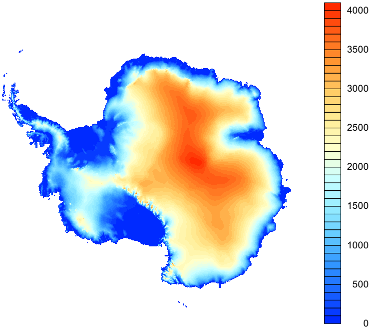
Challenge 1: Ice sheet models are under-constrained

```
mpiexec -n 4 pismr -skip -skip_max 10 -i nomass_20km.nc
-sia_e 3.0 -atmosphere given -atmosphere_given_file
pism_Antarctica_5km.nc -surface simple -ocean pik
-meltfactor_pik 5e-3 -ssa_method fd -ssa_e 0.6 -pik -calving
eigen_calving,thickness_calving -eigen_calving_K 2.0e18
-thickness_calving_threshold 200.0 -stress_balance ssa+sia
-hydrology null -pseudo_plastic -pseudo_plastic_q 0.25
-till_effective_fraction_overburden 0.02
-tauc_slippery_grounding_lines -topg_to_phi 15.0,40.0,
-300.0,700.0 -ys 0 -y 100000 -ts_file ts_run_20km.nc
-ts_times 0:1:100000 -extra_file extra_run_20km.nc
-extra_times 0:1000:100000 -extra_vars thk,usurf,
velbase_mag,velbar_mag,mask,diffusivity,tauc,bmelt,
tillwat,temppabase,hardav,Href,gl_mask -o run_20km.nc
-o_size big
```

Constraining ice sheet model parameterisations

- Use PISM to simulate the past evolution of the Antarctic Ice Sheet.
- Run the model many times. Perturb the model physics each time, sampling as many different parameter combinations as possible.
- Identify the model configurations where the simulated evolution of the ice sheet agrees best with the known history.





Constraining ice sheet model parameterisations

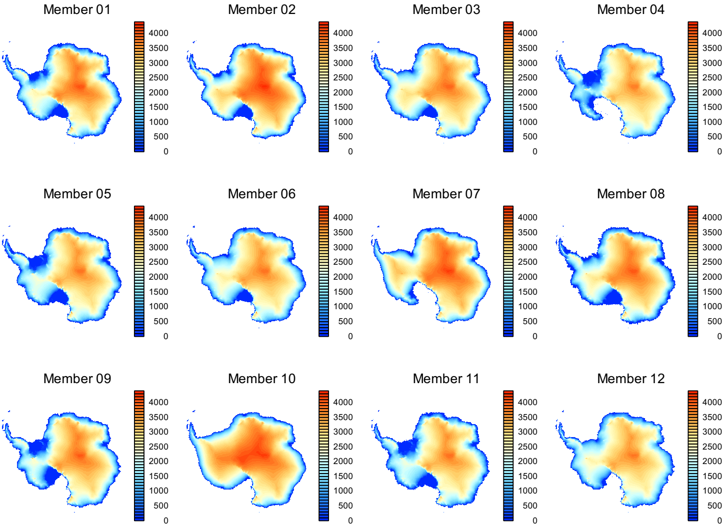
- Current ensembles (6 parameters)

Parameter	Description	Minimum	Maximum
`-sia_e`	Shallow ice enhancement factor	1.0	4.5
`-ssa_e`	Shallow shelf enhancement factor	0.5	1.6
`-pseudo_plastic_q`	Exponent of basal resistance model	0.15	1.00
`-till_effective_fraction_overburden`	Effective till pressure scaling factor	0.01	0.04
`-eigen_calving_K`	Calving rate scaling factor	3.0e16	1.0e19
`-thickness_calving_threshold`	Minimum thickness of floating ice shelves	150.0	300.0

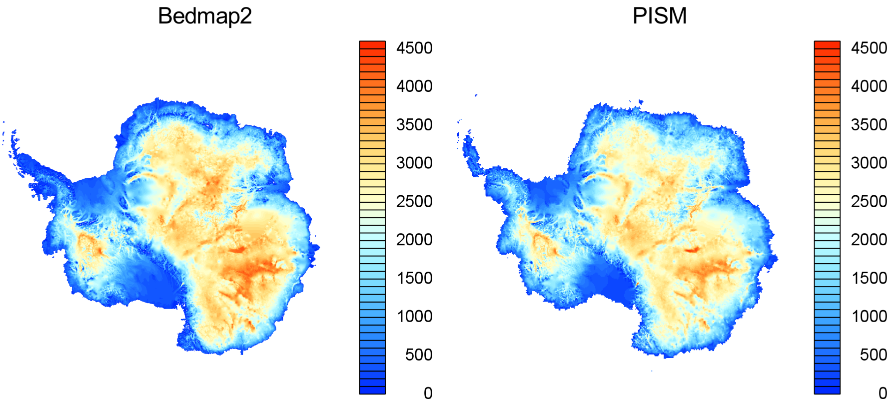
- Future ensembles (10 parameters)

Parameter	Description	Minimum	Maximum
`-topg_to_phi phimin`	Till friction angle (marine history)	5.0	15.0
`-topg_to_phi phimax`	Till friction angle (no marine history)	15.0	40.0
`-topg_to_phi bmin`	Bed elevation (bottom of transition zone)	-1500.0	0.0
`-topg_to_phi bmax`	Bed elevation (top of transition zone)	500.0	1000.0

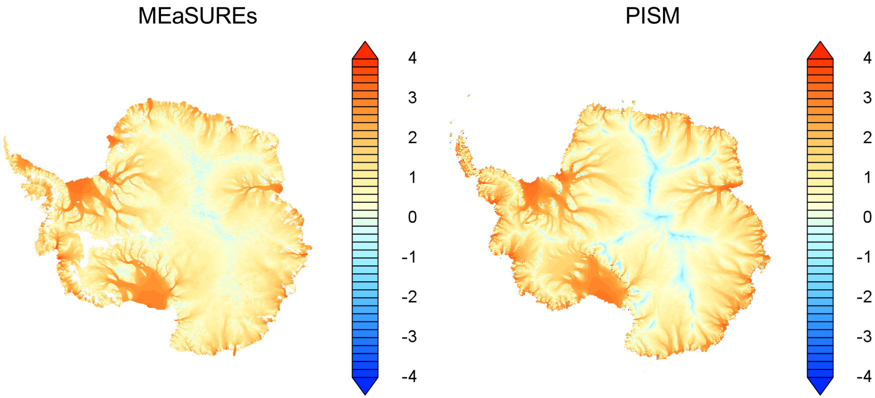
Constraining ice sheet model parameterisations

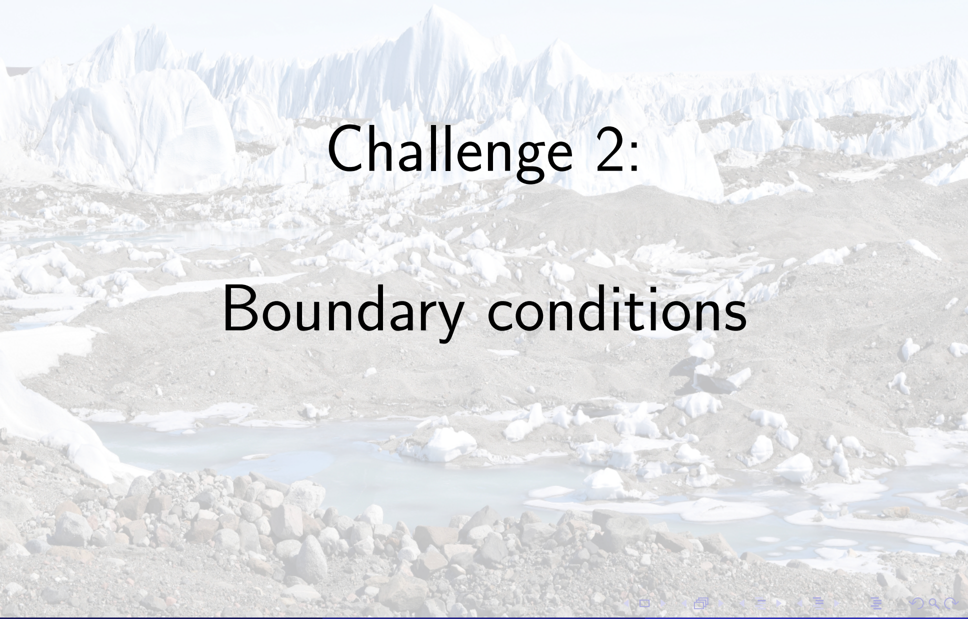


Simulated ice thickness (m)



Simulated ice velocity (logarithm of velocity in m year^{-1})





Challenge 2:

Boundary conditions

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PISM
Parallel Ice Sheet Model

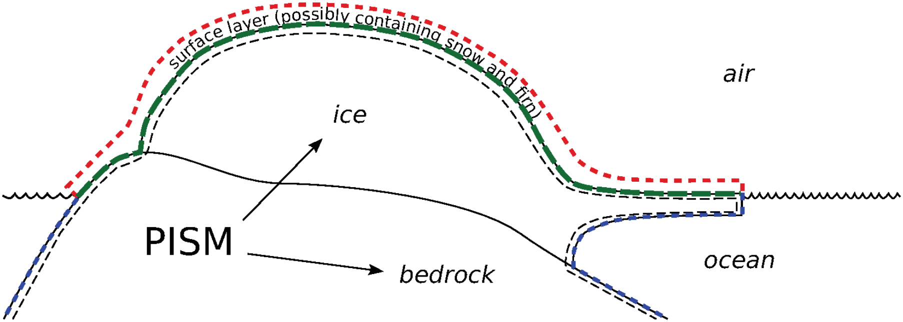
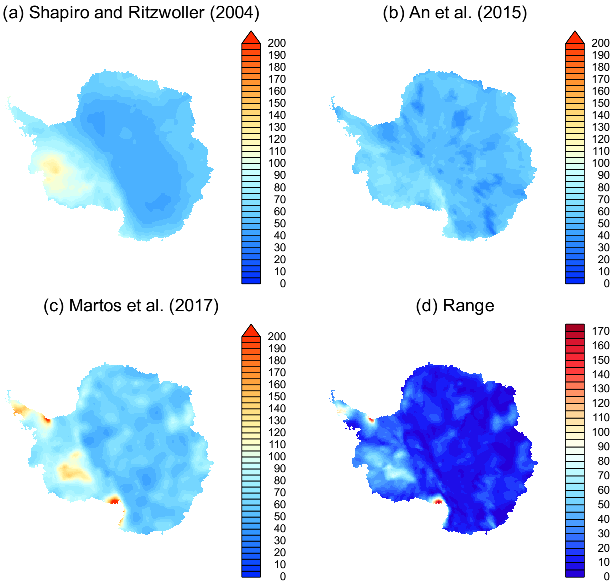
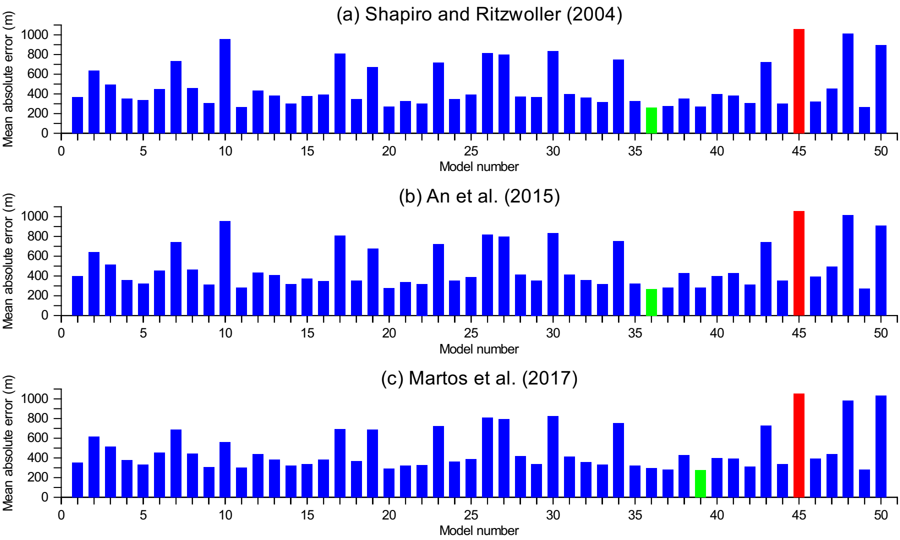


Figure 15: PISM's view of interfaces between an ice sheet and the outside world

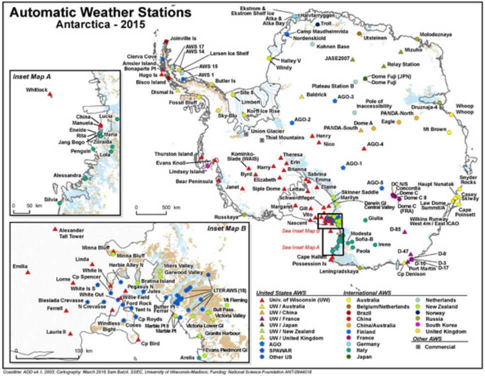
Uncertainty in boundary conditions



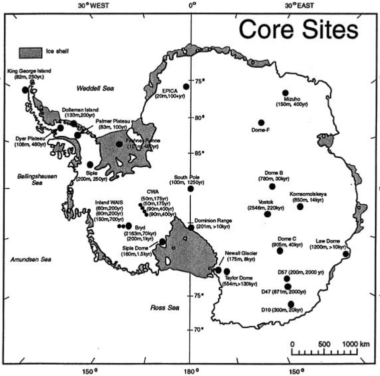
Impact on tuning an ice sheet model



Lack of observational data

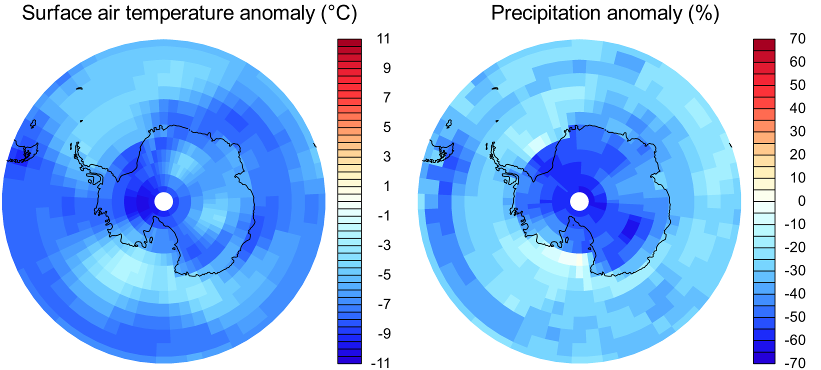


Present



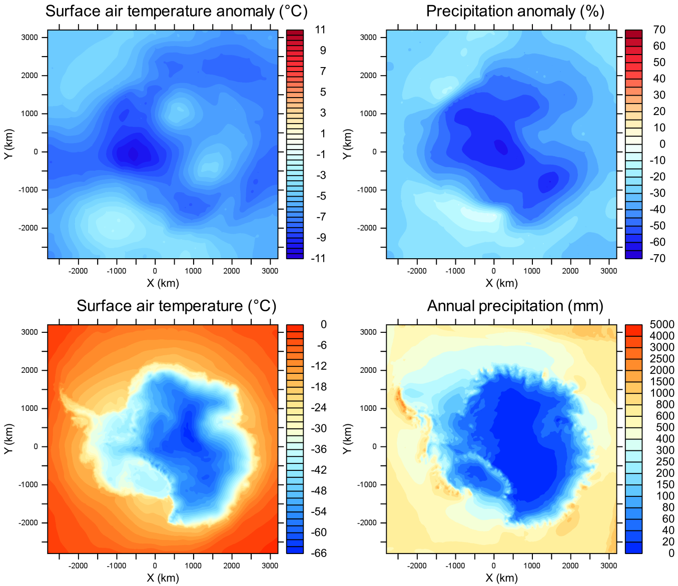
Past

Using climate modelling to generate boundary conditions



- Use the CSIRO Mk3L climate system model to simulate the period 41–0 ka, then 5,000 years into the future under the RCP8.5 scenario

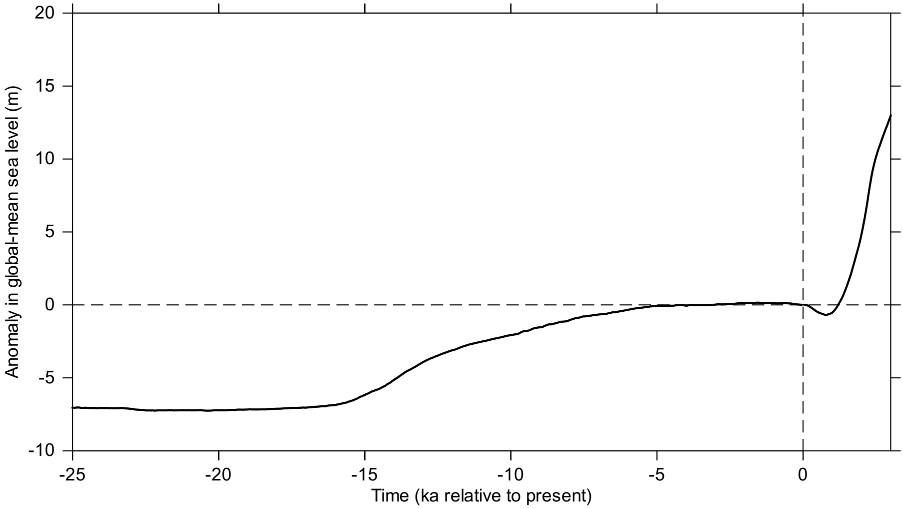
Using climate modelling to generate boundary conditions



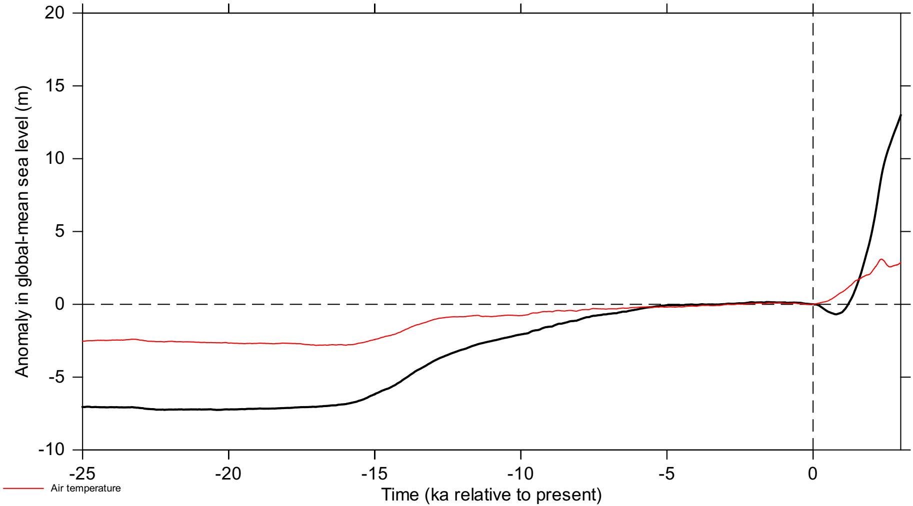
Bringing it all together:

Using the past to constrain the future

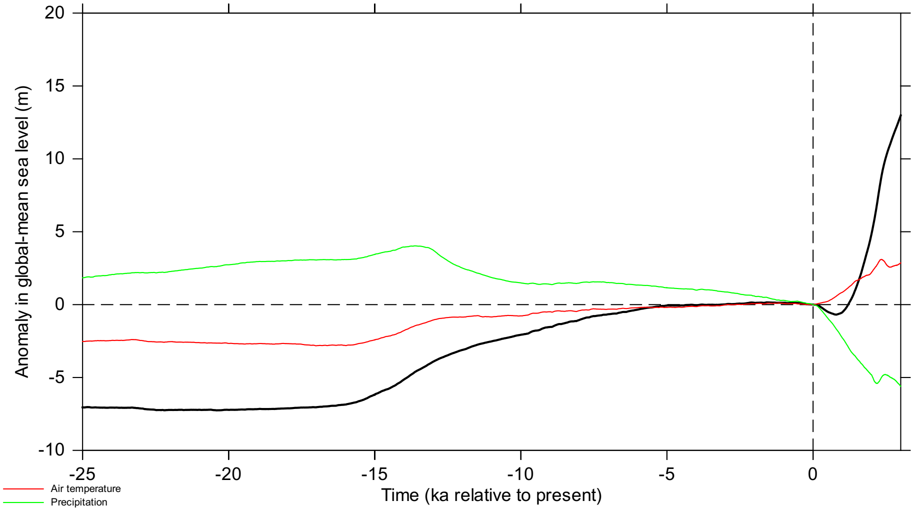
Past and future changes in global-mean sea level



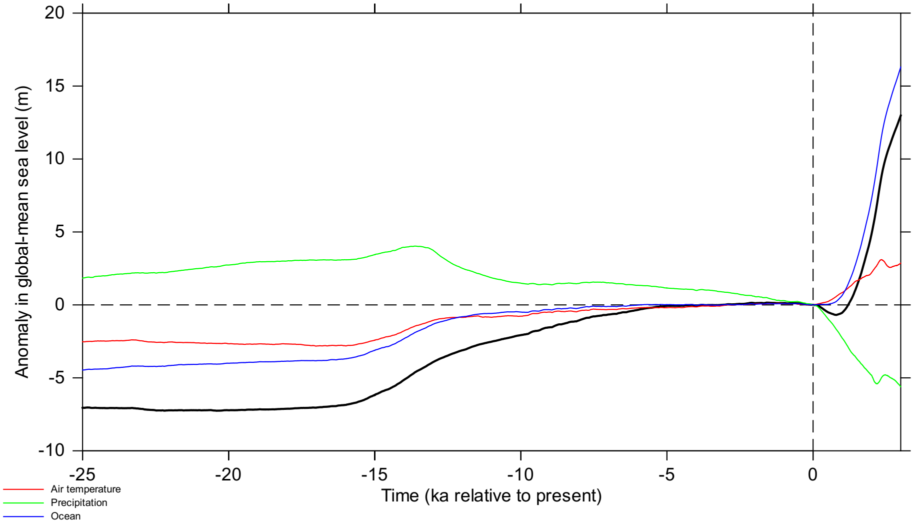
Past and future changes in global-mean sea level



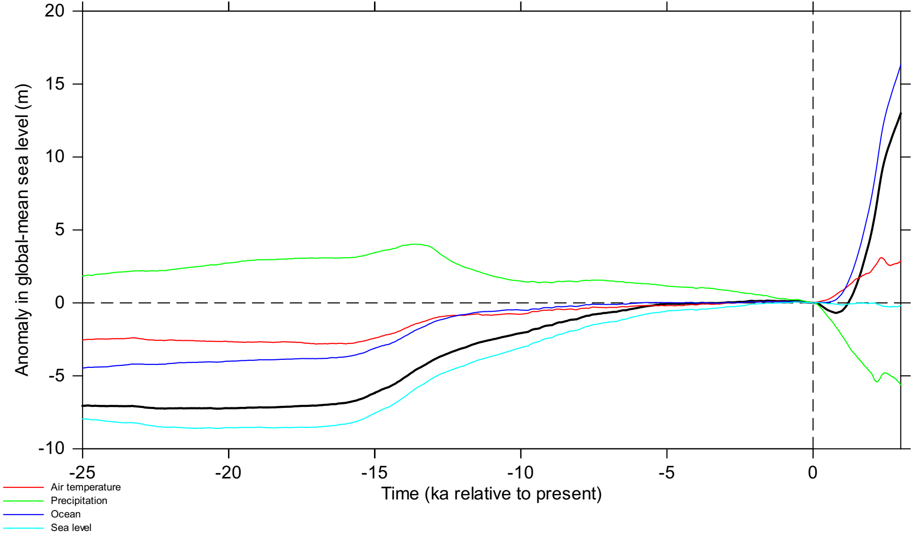
Past and future changes in global-mean sea level



Past and future changes in global-mean sea level



Past and future changes in global-mean sea level



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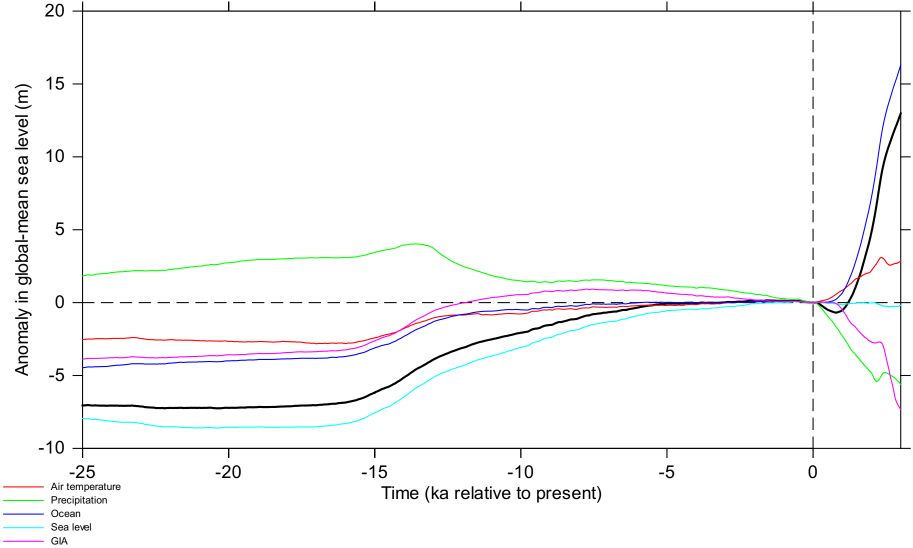
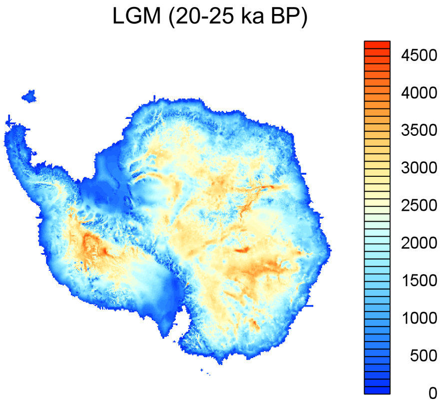
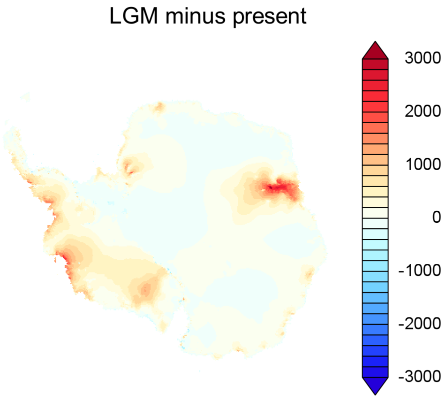
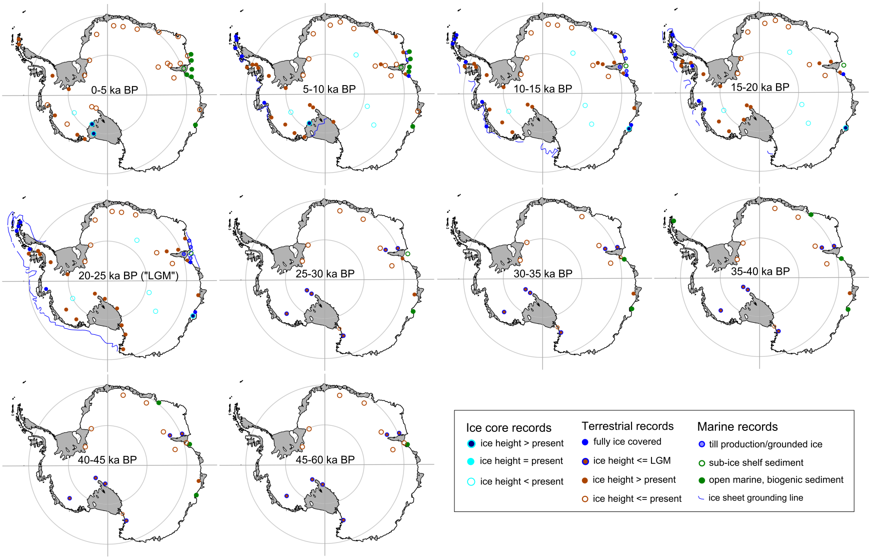


Simulated change in ice thickness (m)





The history of the Antarctic ice sheet (60–0 ka)



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