

Exploring parameter uncertainty in a model of the Antarctic Ice Sheet

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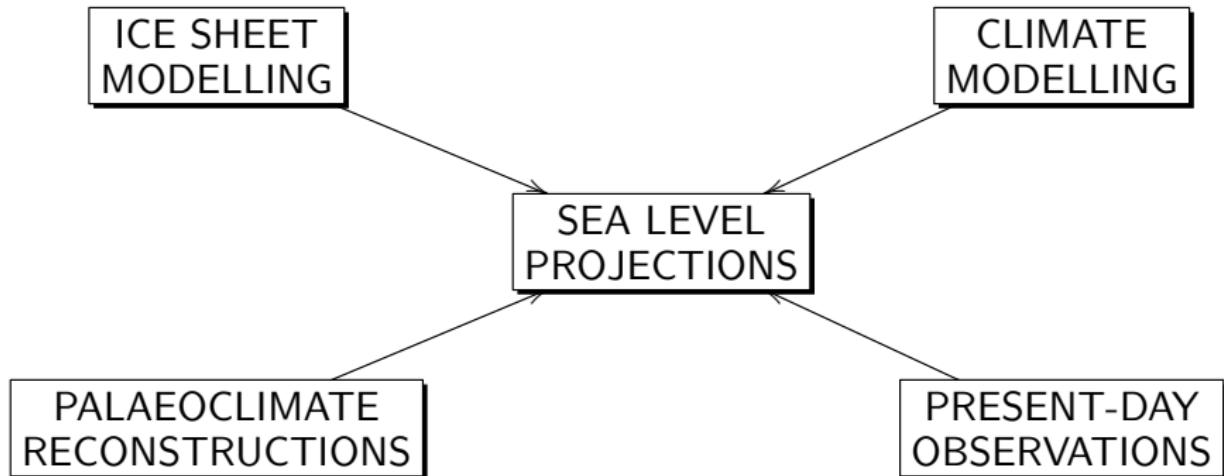
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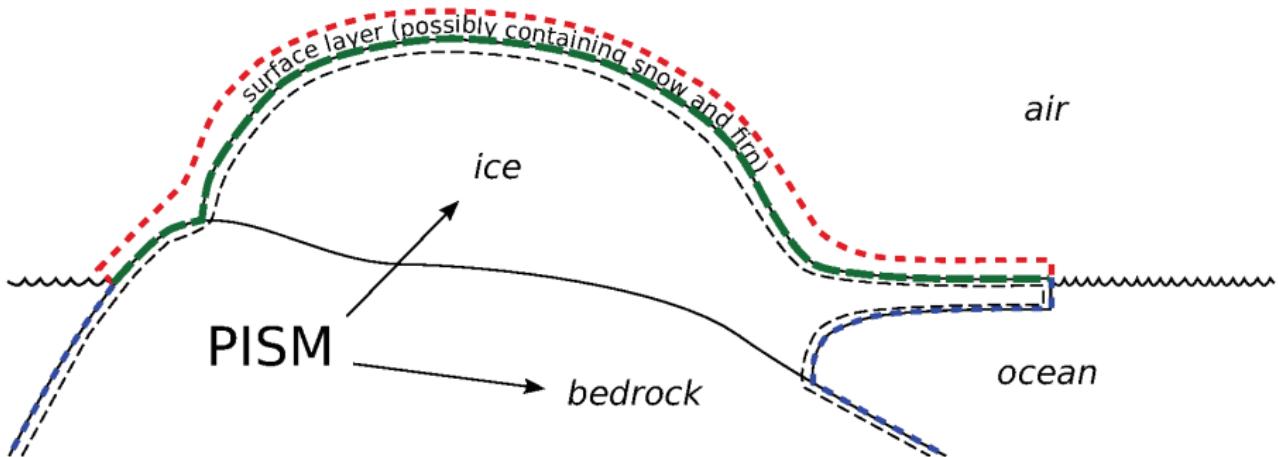
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Generating robust projections of sea level rise

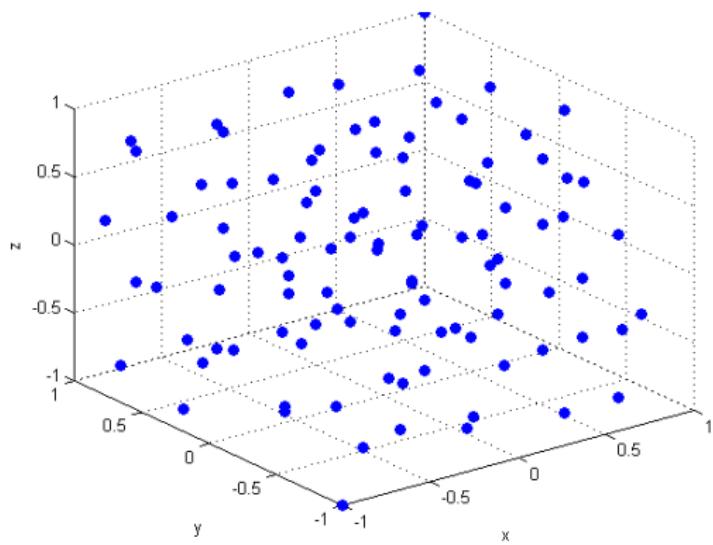


How do we project changes in global sea level?



Exploring uncertainty in ice sheet dynamics

- Problem:
 - There are gaps in our understanding of ice sheet dynamics.
- Solution:
 - Run the model many times, changing the model physics each time to sample as many different physical combinations as possible.



An iterative parameter optimisation process

- ① Identify the parameters to be optimised.
- ② Select the initial ranges for each parameter.
- ③ Construct and run a perturbed-physics ensemble.
- ④ Evaluate each member of the ensemble against observations and determine which regions of parameter space, if any, can be rejected.
- ⑤ Repeat Steps 3 and 4 until the process has converged i.e. until no further changes are made to the ranges of any of the parameters.

Ten physical parameters in an ice sheet model

	Command-line option	Descriptive name
1	-sia_e	Shallow ice enhancement factor
2	-ssa_e	Shallow shelf enhancement factor
3	-pseudo_plastic_q	Exponent of basal resistance model
4	-till_effective_fraction_overburden	Effective till pressure scaling factor
5	-eigen_calving_K	Calving rate scaling factor
6	-thickness_calving_threshold	Minimum thickness of floating ice shelves
7	-topg_to_phi phimin	Minimum till friction angle
8	-topg_to_phi phimax	Maximum till friction angle
9	-topg_to_phi bmin	Elevation of minimum till friction angle
10	-topg_to_phi bmax	Elevation of maximum till friction angle

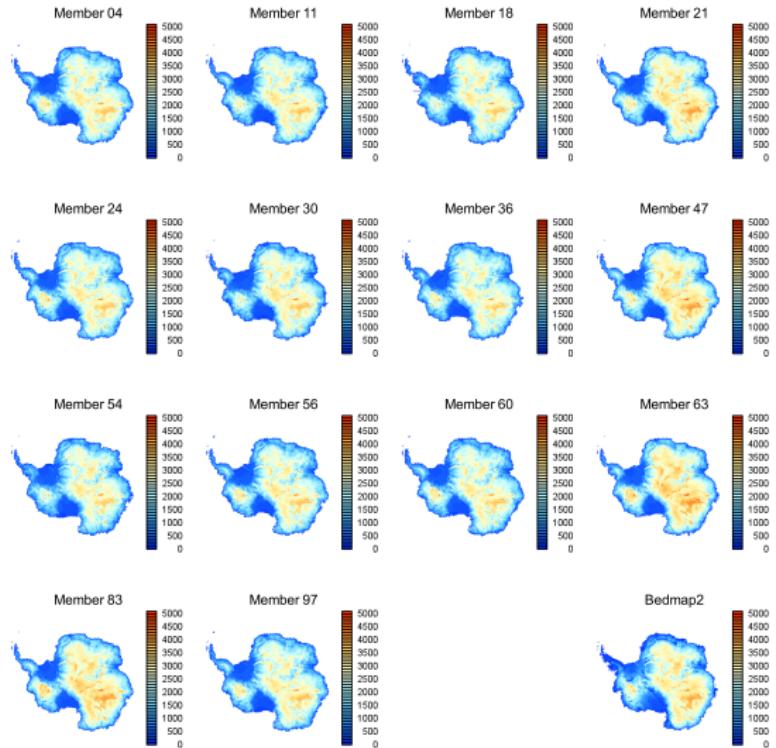
Phipps et al. (in revision), doi:10.5194/gmd-2020-382

Convergence of iterative parameter optimisation process

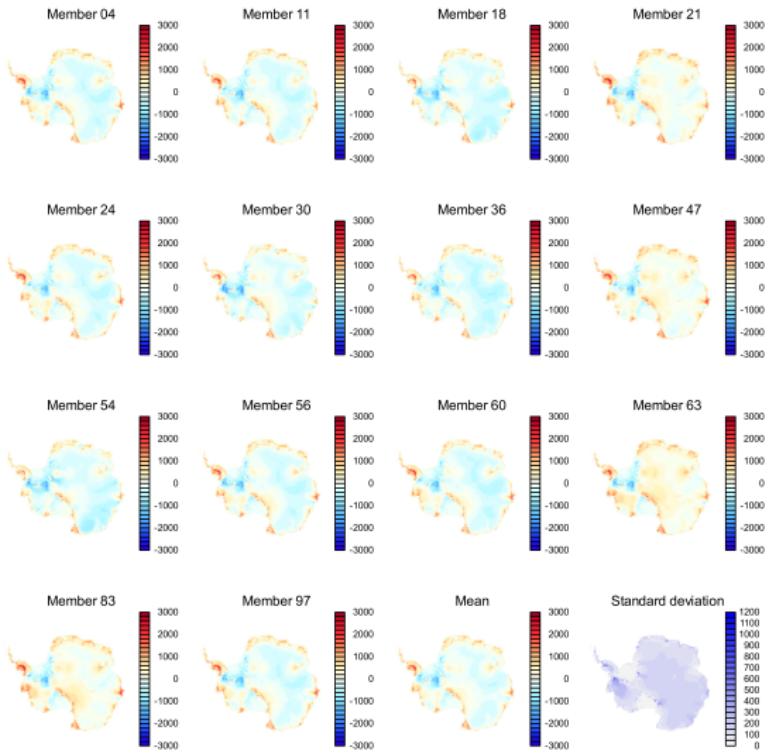
	Iteration 1		Iteration 2		Iteration 3		Iteration 4		Iteration 5	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	1.00	5.00	1.00	4.42	1.00	4.42	1.00	4.42	1.00	4.42
2	0.40	1.60	0.40	1.60	0.68	1.60	0.68	1.60	0.68	1.60
3	0.00	1.00	0.10	0.80	0.00	0.80	0.00	0.56	0.00	0.56
4	0.0100	0.0500	0.0100	0.0500	0.0100	0.0425	0.0100	0.0425	0.0100	0.0425
5	1.00e15	1.00e19	3.76e15	1.00e19	3.76e15	1.00e19	3.76e15	1.00e19	3.70e16	1.00e19
6	150.0	250.0	150.0	250.0	150.0	250.0	169.6	250.0	169.6	250.0
7	1.0	20.0	1.0	20.0	1.0	20.0	1.0	20.0	1.0	20.0
8	20.0	40.0	20.0	40.0	20.0	40.0	20.0	40.0	20.0	40.0
9	-1500.0	-500.0	-1500.0	-500.0	-1500.0	-500.0	-1500.0	-500.0	-1500.0	-500.0
10	-500.0	1000.0	-500.0	1000.0	-500.0	1000.0	-500.0	1000.0	-500.0	1000.0
#	91		93		93		88		91	
E_A	8.8		7.7		6.9		6.4		6.4	
E_V	21.9		21.0		20.2		18.5		18.1	

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Simulated ice thickness for best ensemble members (m)



Error in simulated ice thickness (m)

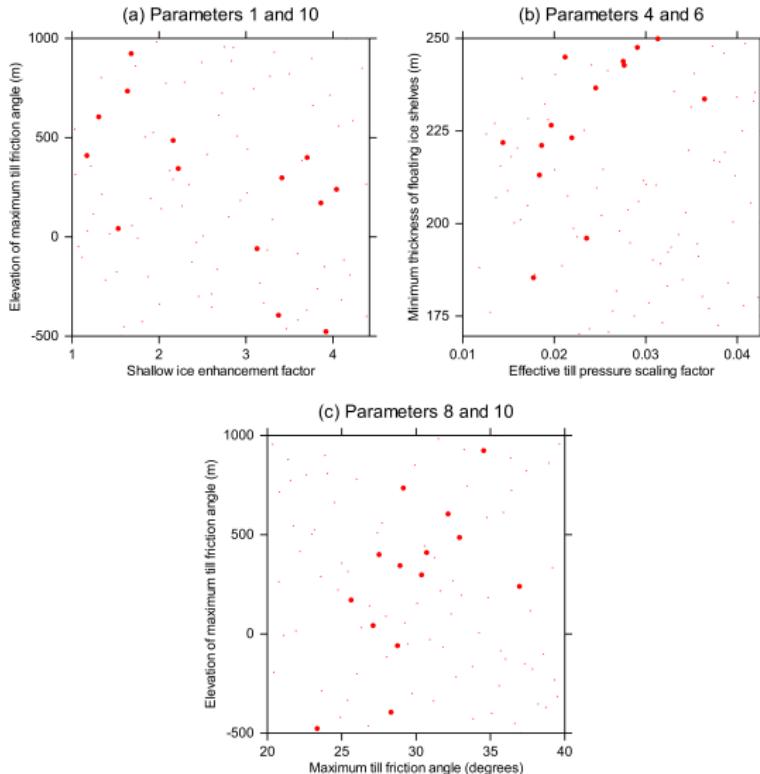


Correlations between pairs of physical parameters

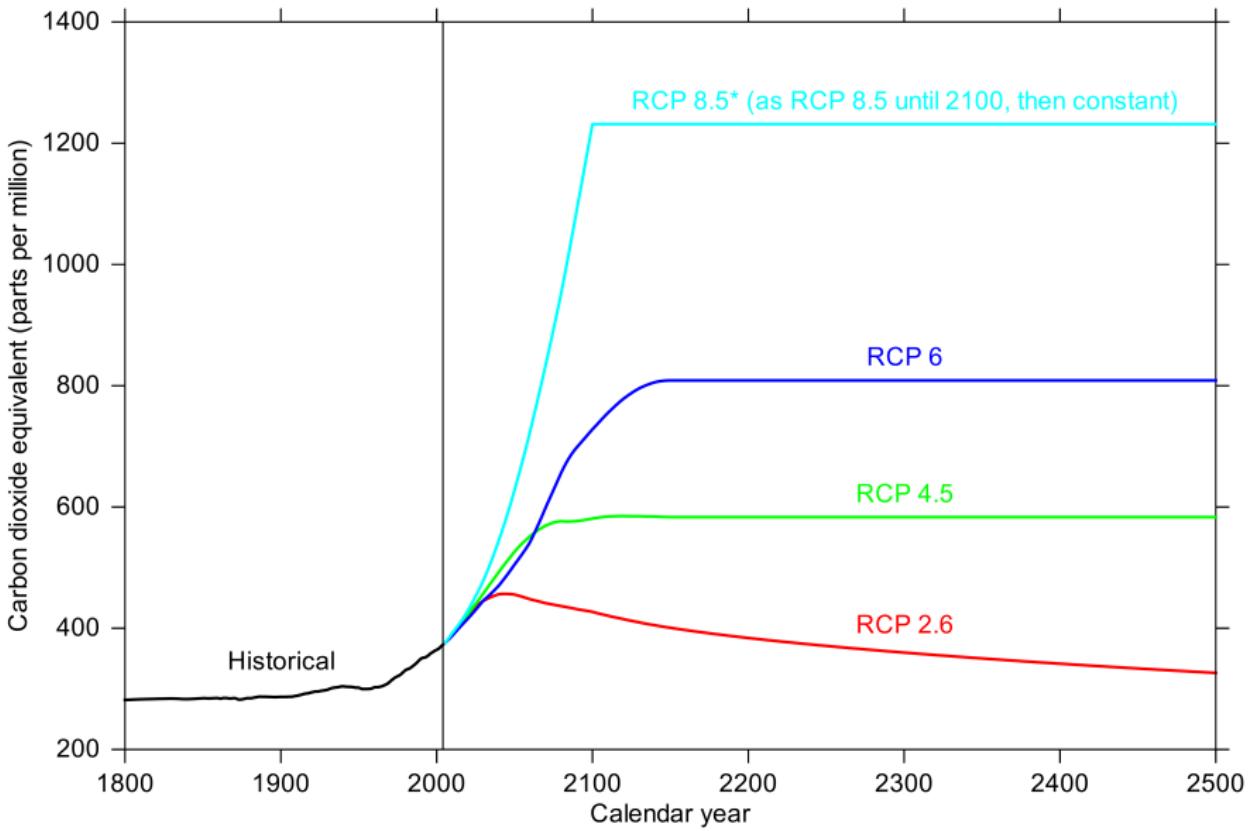
	2	3	4	5	6	7	8	9	10
1	+0.28	-0.22	+0.25	+0.06	-0.16	+0.34	-0.27	-0.17	-0.59
2		+0.57	-0.33	-0.07	-0.32	+0.14	-0.27	-0.22	-0.51
3			-0.60	+0.22	-0.30	-0.17	-0.10	-0.46	-0.28
4				+0.24	+0.57	-0.05	-0.24	+0.28	+0.25
5					-0.21	-0.24	-0.44	-0.62	-0.10
6						-0.07	+0.14	+0.25	+0.49
7							-0.06	0.00	-0.27
8								+0.20	+0.60
9									+0.28

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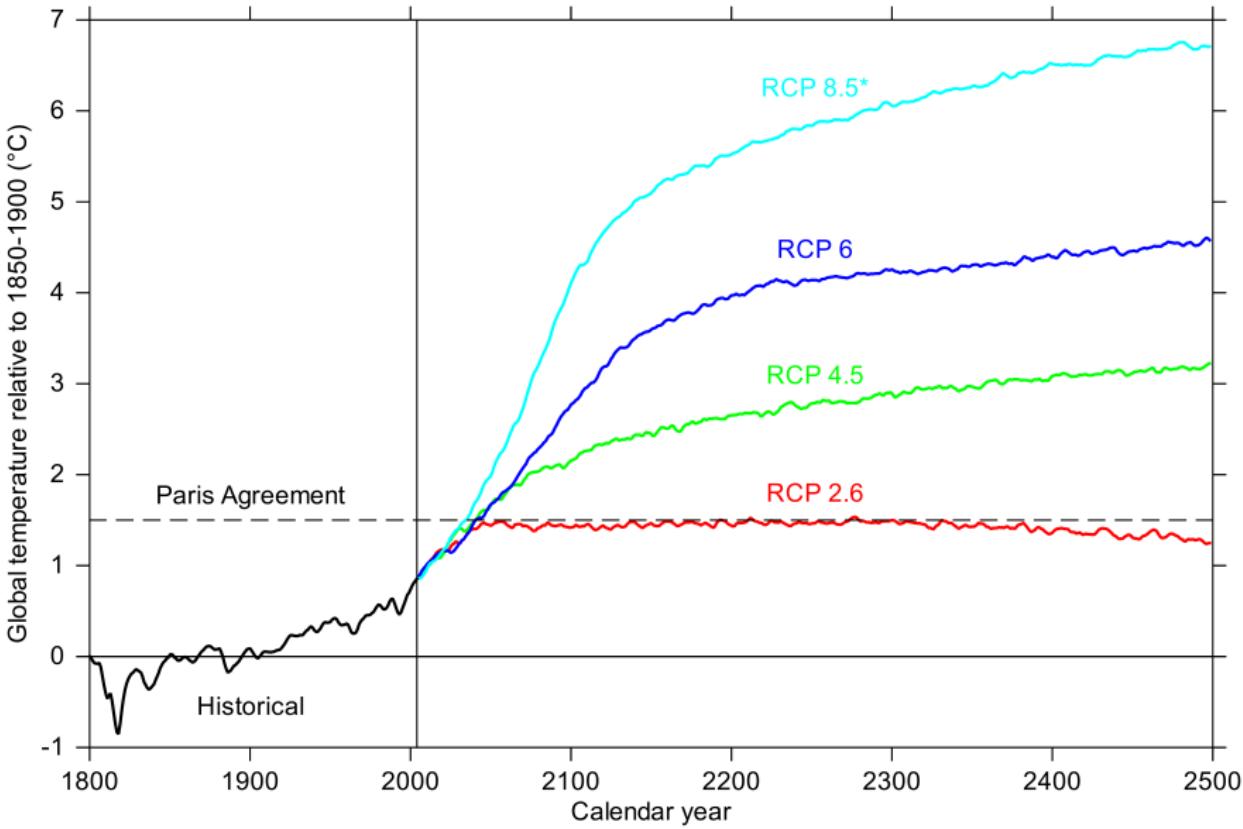
Dependencies between physical parameters



Climate modelling: Simulating the future



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Simulated Antarctic contribution to global sea level

