A history-matching analysis of the Antarctic Ice Sheet since the last interglacial – Part 1: Ice sheet evolution

Supplement Figures



Figure S1: AntICE2 observational constraint database used to history match the Glacial Systems Model. a - f) are the site locations and identification numbers for past ice thickness data (paleoH), past ice extent data (paleoExt), ice core borehole temperature profiles (ICbore) and names, present-day uplift rates (rdotGPS), and past relative sea level data (paleoRSL) respectively.



Figure S2: Diagram summarizing major components of the Glacial Systems Model (GSM).





























Figure S3: Distribution of output metrics and scores for the full ensemble (blue), not-ruled-out-yet (NROY) AN3sig sub-ensemble (orange), and NROY sub-ensemble high variance subset (red).































Figure S4: Distribution of output metrics, scores, and ensemble parameters (detailed in Table 1) for the full ensemble (blue), not-ruledout-yet (NROY) AN3sig sub-ensemble (orange), and NROY sub-ensemble high variance subset (red).























NROY AN3sig HVSS

NROY AN3sig HVSS

0.8

1.0

AN Full Ensemble

NROY AN3sig sub







Figure S5: Distribution of ensemble parameters (detailed in Table 1) for the full ensemble (blue), not-ruled-out-yet (NROY) AN3sig subensemble (orange), and NROY sub-ensemble high variance subset (red).





















TregSSMCut4







Figure S6: Distribution of ensemble parameters (detailed in Table 1) for the full ensemble (blue), not-ruled-out-yet (NROY) AN3sig subensemble (orange), and NROY sub-ensemble high variance subset (red).



Figure S7: Distribution of ensemble parameters (detailed in Table 1) for the full ensemble (blue), not-ruled-out-yet (NROY) AN3sig subensemble (orange), and NROY sub-ensemble high variance subset (red).



Figure S8: Diagram illustrating the history matching analysis methodology.

Table S1: The thresholds imposed on the AntICE2 data-model scores in the history matching analysis. The thresholds to define the AN4sig and AN3sig sub-ensembles are based on internal/external discrepancy bias corrections plus 4 or 3 multiples of the standard deviations, respectively.

Constraint datatype	Score	Bias	Standard deviation
Present-day	WAIS H RMS (waisRMS)	0	161
Present-day	EAIS H RMS (eaisRMS)	16	135
Present-day	Floating ice H RMS (fltRMS)	34	65
Present-day	Ice shelf score (ShSc)	0	1
Present-day	PD grounding line score (GLscor)	0	1
Borehole temp	Borehole ice temp score (Tbm)	0	1
Borehole temp	Ice core site H diff score (Hc)	0	1
Paleo extent	Marine extent score (Mar)	0.14	1.04
Paleo ice thickness	Deglaciated no ice score (nolce)	0.22	1.02
Paleo ice thickness	Glaciation ice score (Ice)	0.15	1
Paleo RSL	RSL score (RSL)	-0.1	1.01
GPS	Uplift rate score (Rdot)	-0.02/0.06	1.06



Figure S9: High variance subset (HVSS; N=18) of simulations in the not-ruled-out-yet (NROY) AN3sig sub-ensemble.

rmu	-0.25	0.01	-0.23	0.2	-0.12	-0.1	0.03	0	0.09	0.12	0.03	0.1	-0.11	-0.03	0.02	0.1	-0.11	0.16	0.06	0.23	-0.11	0.22	0.2	-0.12	-0.23	-0.13	-0.25	0.07	-0.21	-0.15	0.39
fslid	-0.02	-0.03	0.03	0.32	-0.12	-0.06	0.07	0.03	0.04	0.11	0.05	-0.23	-0.1	-0.16	-0.24	-0.26	0.04	-0.18	-0.26	-0.01	0.04	0.01	-0.05	-0.08	0.14	0.05	0.04	0.16	-0.33	-0.1	-0.02
fnflow	0.3	-0.28	0.24	-0.07	0.17	-0.08	0.26	0.27	0.02	0.05	0.09	-0.05	-0.04	0.02	0	-0.06	0.05	0.05	-0.11	0.07	0	0.05	0.09	-0.02	0.03	0.08	0.01	0.35	0.03	-0.1	-0.18
fcalv	-0.11	0.05	-0.14	0.01	-0.03	0.03	-0.14	0.13	0.06	0.11	0.1	0.12	0.09	0.15	0.09	0.15	-0.14	0.08	0.16	0.14	-0.24	0.09	0.19	0.18	0.08	0.15	0.02	0.03	-0.01	0.09	0.02
fdwCrack	-0.15	0.07	0	0.21	-0.03	0.14	-0.01	0.07	-0.41	0.12	-0.02	-0.1	-0.05	-0.08	0.07	0.03	-0.32	0.18	-0.04	0.14	-0.53	0.27	-0.13	0.12	0.12	0.21	0.07	0.19	-0.23	-0.32	0.05
CfcMelt	-0.12	0.25	-0.06	-0.2	-0.13	-0.04	-0.18	-0.06	-0.01	-0.06	0.05	-0.08	-0.11	-0.02	-0.09	-0.11	0.06	-0.01	-0.14	-0.12	-0.01	-0.09	-0.16	-0.16	-0.09	-0.2	-0.07	0.02	0.22	0.34	0.04
wGF1	0.02	-0.21	0.03	-0.1	0.04	0.1	0.07	0.11	0.08	0.15	0.03	-0.12	-0.04	0.29	0.03	0	-0.15	-0.04	0.01	0.02	-0.09	0.02	0	0.05	0.06	0.1	0.06	0.09	0.07	80.0	0.02
fnTdexp	-0.06	0.09	-0.08	0.04	-0.06	-0.11	0.11	0.12	-0.18	0.04	0.28	-0.1	0.02	-0.03	0.05	0.02	0.12	0.08	-0.02	0.19	0.05	0.14	0.24	-0.08	-0.11	0	-0.13	0.05	-0.04	0.01	0.11
fnpre	-0.07	0.02	-0.02	-0.14	0	0.21	-0.24	0.06	0.19	0.06	0.02	0.09	-0.16	-0.18	0.05	0.06	0.09	-0.02	0.09	-0.2	0.06	-0.16	-0.22	0.33	0.34	0.04	0.16	0.3	0.11	0.14	0.38
fSSMdp	0.29	-0.3	0.21	-0.1	0.22	0.12	0.2	0.12	-0.02	-0.09	-0.52	0.13	-0.13	-0.04	0.01	0.04	0.13	-0.02	0.06	-0.01	0.18	0.01	-0.03	0.07	0.04	0.03	0.03	0.18	0.08	-0.02	-0.11
fHPRE	0.02	-0.05	0.01	0.17	-0.08	-0.23	0.08	0.07	0.05	-0.05	0.01	-0.04	-0.02	0.2	-0.12	-0.05	-0.06	-0.02	-0.06	0.12	-0.01	0.09	0.13	-0.22	-0.22	-0.12	-0.17	-0.24	-0.14	0	-0.19
Pexp	-0.21	0.11	-0.09	0.02	0.07	-0.1	0.09	-0.06	-0.06	0.14	0.07	-0.02	-0.09	-0.06	0.08	0.04	-0.03	0.05	0.03	0.05	0.04	0.04	0.05	-0.07	-0.12	-0.01	-0.04	0.23	-0.04	-0.24	-0.13
Tscale	0.08	-0.11	0.12	-0.1	-0.01	-0.09	-0.12	0.17	0.15	-0.02	-0.19	0.15	0.19	0.05	-0.02	-0.1	0.01	-0.13	-0.07	-0.19	0.08	-0.21	-0.12	-0.04	0.05	0.03	0.15	-0.25	0.12	0.3	0.04
rlps	-0.03	0.13	-0.12	0	0.02	-0.22	0.14	-0.16	-0.24	0.05	0.22	0.05	0.05	-0.16	-0.02	0.01	0	0.12	-0.04	0.19	0.03	0.11	0.28	-0.27	-0.33	-0.28	-0.34	-0.22	0.03	0.07	-0.33
fwtPMIP	-0.44	0.18	-0.27	0.11	-0.04	-0.18	-0.04	-0.18	0.02	0.18	0.24	-0.04	0.18	0.29	-0.02	0.18	-0.32	0.12	0.17	0.3	-0.27	0.22	0.37	0.12	-0.02	0.2	-0.04	-0.2	-0.1	-0.08	0.01
fPpmip	-0.04	0.09	0.16	-0.1	0.08	0.04	-0.09	0.01	0.01	-0.02	-0.02	0.06	0.13	-0.18	-0.02	-0.09	-0.01	0.02	-0.13	-0.1	0.02	-0.07	-0.11	-0.02	0.06	0.08	0.12	0.15	0.09	0.14	0
fPEOF1	-0.05	0.05	-0.1	0.12	0.04	-0.02	0.07	-0.05	-0.11	-0.13	-0.05	0.02	0.04	-0.11	-0.03	0.01	0.03	-0.06	0.04	0.02	-0.02	0.02	0.02	0.08	0.09	-0.09	-0.08	-0.02	-0.14	-0.18	0.01
fTEOF1	-0.19	0.17	-0.27	0.19	-0.04	-0.06	0.06	-0.11	-0.11	-0.06	-0.06	-0.04	-0.09	-0.04	-0.03	-0.18	-0.04	0.05	-0.26	0.02	0.01	0.05	-0.02	-0.29	-0.19	-0.33	-0.27	-0.07	-0.19	-0.11	-0.07
fTEOF2	0.14	-0.1	0.07	-0.15	-0.02	-0.24	0.09	0.02	-0.08	0.01	-0.03	-0.15	-0.02	-0.2	0.06	-0.19	0.09	0	-0.24	-0.07	0	-0.02	-0.15	-0.13	0.01	0.03	0.07	-0.05	0.17	0.09	-0.15
fnTEBMscale	0.05	-0.2	-0.01	0.2	0.16	0.13	-0.02	-0.13	0.02	-0.11	-0.23	-0.16	-0.22	0.02	0.02	0.05	0.09	-0.06	0.09	-0.05	0.06	-0.03	-0.08	0.14	0.12	0.02	0.05	0.15	-0.23	-0.22	-0.01
fTwtEBM	0.29	-0.31	0.35	0.2	-0.06	0.06	0.23	0.06	-0.34	-0.09	-0.15	-0.05	-0.16	-0.08	0.05	0.12	0.14	0.2	0.06	0.32	-0.09	0.38	0.14	-0.03	-0.14	0.03	-0.19	0.25	-0.21	-0.36	-0.03
fbedpow	0.13	-0.35	0.01	-0.09	0.01	0.4	0.19	0.15	-0.04	-0.09	0.11	-0.05	-0.14	-0.03	0.36	0.48	-0.1	0.38	0.45	0.23	-0.17	0.24	0.16	0.37	0.02	0	-0.15	0.27	0.04	-0.12	0.07
TregSSMCut0	0.08	-0.22	0.1	-0.04	-0.03	0.4	0.23	-0.05	-0.09	0.09	-0.01	-0.13	-0.2	-0.04	0.2	0.28	-0.2	0.27	0.23	0.11	-0.2	0.25	-0.15	0.27	0.08	0.04	-0.05	0.45	0	-0.25	0.1
TregSSMCut1	-0.2	0.09	-0.08	0.05	0.04	0.04	0.08	-0.02	0.29	-0.02	0.15	-0.12	-0.12	0.17	-0.06	-0.08	-0.2	-0.05	-0.08	0.05	-0.07	0.04	0.06	-0.25	-0.23	-0.18	-0.17	-0.23	-0.02	0.26	0.15
TregSSMCut2	-0.02	0	-0.21	0.04	-0.18	-0.11	0.06	-0.26	0.04	-0.02	0.16	-0.06	-0.17	-0.08	-0.02	0.13	0.03	0.17	0.09	0.2	0.05	0.11	0.3	-0.09	-0.23	-0.14	-0.24	0.16	-0.07	-0.22	0.12
TregSSMCut3	0.02	0.16	-0.11	-0.03	0.3	-0.04	-0.05	-0.2	-0.05	0.12	0.05	-0.14	0.21	80.0	0.05	-0.05	-0.14	-0.1	-0.02	-0.23	0.13	-0.29	-0.07	-0.1	-0.08	-0.25	-0.04	0.04	0.03	0.11	-0.06
TregSSMCut4	0.03	0.03	0.14	-0.08	0.01	-0.12	0.2	0.13	-0.11	0.06	0.08	-0.15	0.33	0.18	-0.1	0.04	-0.08	-0.01	0.05	0.16	0.06	0.1	0.22	-0.1	-0.16	0.04	-0.07	-0.2	0.1	0.17	-0.27
TregSSMCut5	0.14	-0.09	0.13	-0.2	-0.03	0.01	-0.01	0.22	-0.2	-0.05	-0.21	0.22	-0.04	-0.19	0.15	-0.01	0	0.04	-0.03	-0.15	-0.03	-0.04	-0.3	0.07	0.1	-0.08	0.04	-0.16	0.21	0.15	-0.15
POWbtill	0.4	-0.47	0.14	-0.05	0.06	0.08	0.26	0.15	0.12	-0.11	-0.11	0.09	80.0	0.01	0.2	0.12	0.08	0.05	0.14	0.01	0.05	-0.04	0.09	0.44	0.42	0.09	0.06	0.26	0.02	-0.11	-0.15
fSTDtill	-0.14	0.05	-0.08	-0.13	0.02	0.07	0.16	0.07	0.06	0.22	0.13	0.11	-0.18	0.05	0.1	0.13	-0.2	0.15	0.1	0.21	-0.04	0.16	0.23	0.01	-0.11	0	-0.13	0.14	0.09	-0.03	0.07
fSTDslid	-0.06	0.24	-0.09	0.08	-0.06	-0.09	-0.25	-0.09	0.02	-0.17	-0.19	0.1	-0.02	0.07	-0.47	-0.5	0.19	-0.34	-0.49	-0.22	0.17	-0.19	-0.21	-0.28	0.11	-0.14	0.03	-0.18	-0.08	0.05	-0.01
rToceanPhase	0.14	-0.09	-0.01	0.2	-0.2	-0.09	0.08	-0.09	0.12	-0.17	0.09	-0.04	-0.1	-0.12	0.04	-0.02	0.11	0.01	-0.03	-0.09	0.17	-0.12	-0.02	0.09	0.12	0.08	0.12	-0.1	-0.19	-0.28	0.02
rToceanWrm	-0.05	0.1	0.05	-0.36	0.04	0.05	-0.21	0.08	0.01	0.1	0.15	0.15	0.2	-0.05	-0.08	0.01	0.01	-0.07	0.04	0.02	-0.07	0	0.06	0.03	0.03	0.14	0.09	-0.17	0.4	0.61	0.02
rHhp0	0.06	0.06	-0.12	0.16	0.29	0.11	-0.21	0.1	-0.16	-0.3	-0.21	0.09	0.26	0.15	0.01	-0.05	0.27	-0.28	0.07	-0.24	0.25	-0.29	-0.08	0.2	0.28	0.11	0.24	-0.19	-0.13	0.05	-0.06
earthLT	-0.11	-0.05	-0.02	-0.06	-0.05	0	0.03	-0.16	-0.03	-0.04	-0.05	-0.01	-0.31	-0.04	-0.04	-0.03	-0.07	0.04	-0.06	0.09	-0.08	0.13	-0.01	-0.03	-0.01	0.05	-0.02	0.27	0.03	-0.07	0.17
earthUV	0.31	-0.24	0.28	-0.19	-0.08	0.1	0.06	-0.25	-0.04	0.02	-0.19	-0.22	-0.29	-0.26	0.14	0.07	0.29	0.1	0.04	-0.06	0.25	-0.04	-0.09	0.29	0.28	0.21	0.2	0.55	0.15	-0.2	0.08
earthLV	0.2	-0.15	0.17	-0.03	0.15	0.16	0.01	0.2	-0.05	-0.14	0	0.02	-0.09	0.14	0.03	0	-0.05	-0.04	0.02	-0.12	-0.13	-0.08	-0.17	0.11	0.13	0.11	0.16	0.15	0.01	0.02	-0.17
	nolce	Ice	Mar	v121dfG	waisRMS	eaisRMS	firms	ShSc	GLscor	uv0RMSmg	uv0RMSin	RSL	Rdot	Tbm	Я	volg0	volf0	volgWAIS	volgEAIS	arg0	arf0	argWAIS	argEAIS	volg20	volg20diff	arg20	arg20diff	timeLIGmin	volgLIGdiff	argLIGdiff	volgMWPla

Figure S10: Metric/score-parameter correlation heat map of not-ruled-out-yet (NROY) AN3sig sub-ensemble.

NROY subensemble statistics



Figure S11: NROY AN3sig sub-ensemble deglacial ice thickness difference for the interval of a-c) 16-14 ka d-f) 14-12 ka g-i) 12-10 ka j-l) 10-8 ka and their respective grounding lines for the ensemble mean (leftmost column), -2 σ bound (center column), and +2 σ bound (rightmost column).

NROY subensemble statistics



Figure S12: NROY AN3sig sub-ensemble deglacial ice thickness difference for the interval of a-c) 8-6 ka d-f) 6-4 ka g-i) 4-2 ka j-l) 2-0 ka and their respective grounding lines for the ensemble mean (leftmost column), -2 σ bound (center column), and +2 σ bound (rightmost column).