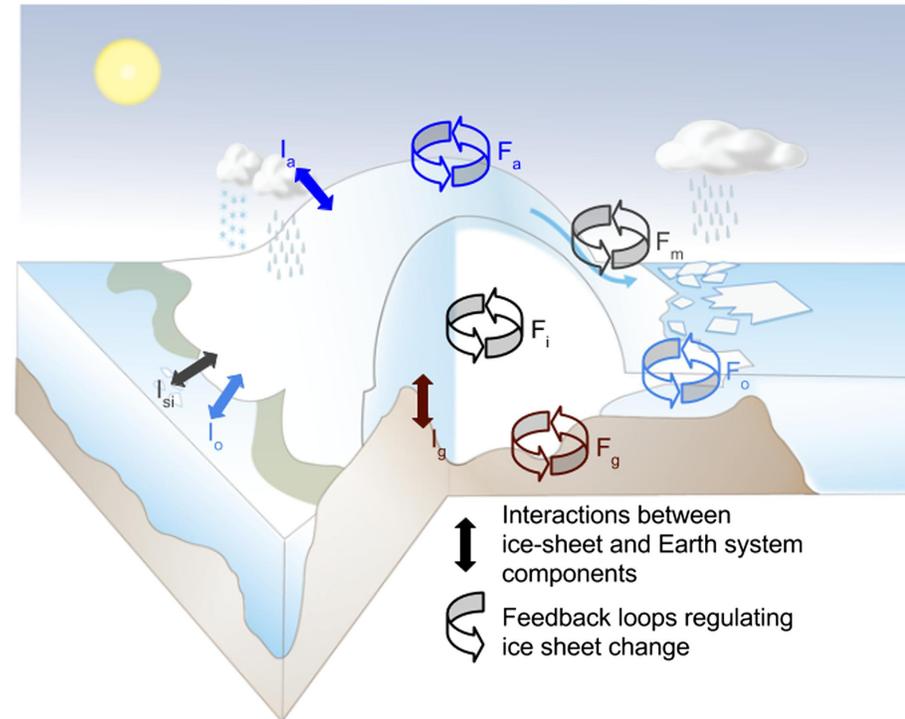


On the contributions from
albedo and elevation feedbacks
to **complete** Greenland ice sheet melt
(Simulations with CESM2-CISM2)

Miren Vizcaino, Michele Petrini, Raymond Sellevold, Sotiria Georgiou, Thirza Feenstra, Katherine Thayer-Calder, William Lipscomb, Gunter Leguy

The GrIS in the Earth System

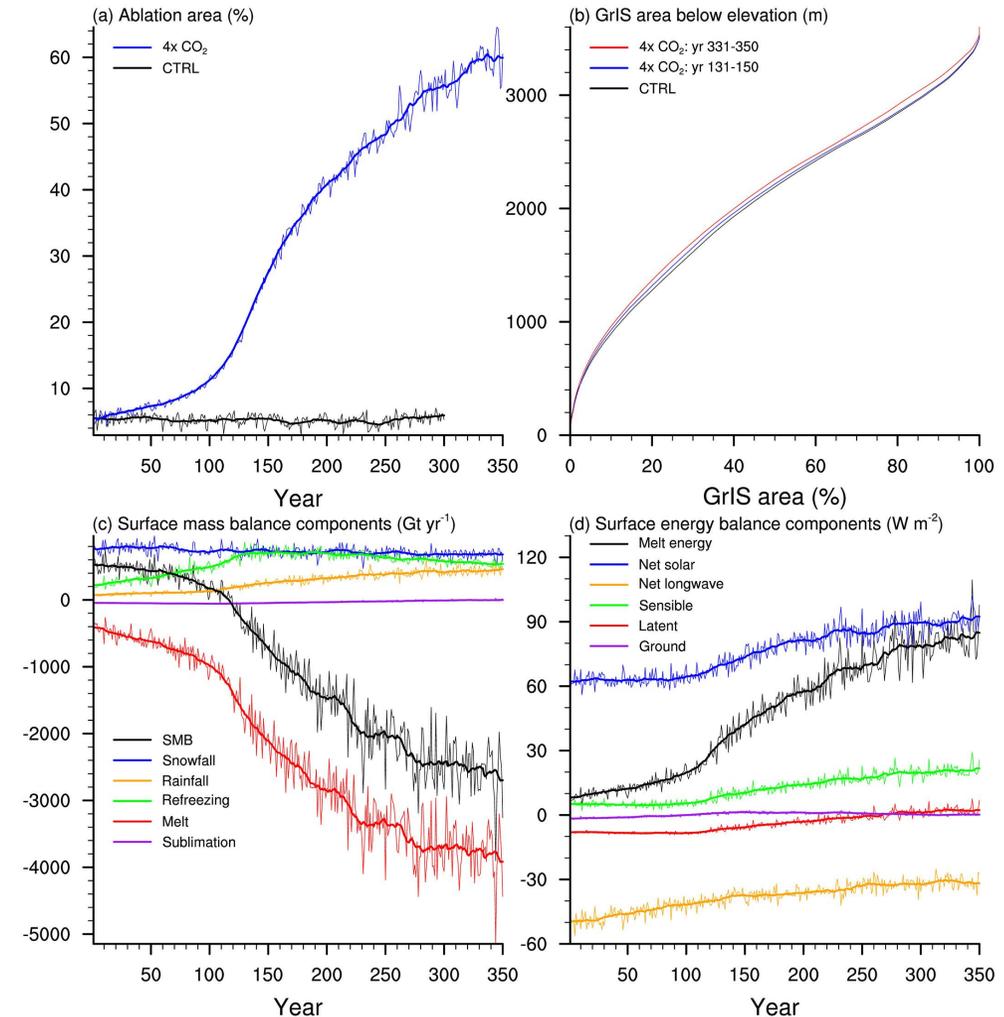
- GrIS is currently contributing to 0.7 mm sea level rise per year
- GrIS is a major tipping element, due to **hypsometry** & positive **feedbacks** (albedo & elevation)
- GrIS is located close to deep water formation regions & its SMB is in the area climatically vulnerable to changes in AMOC

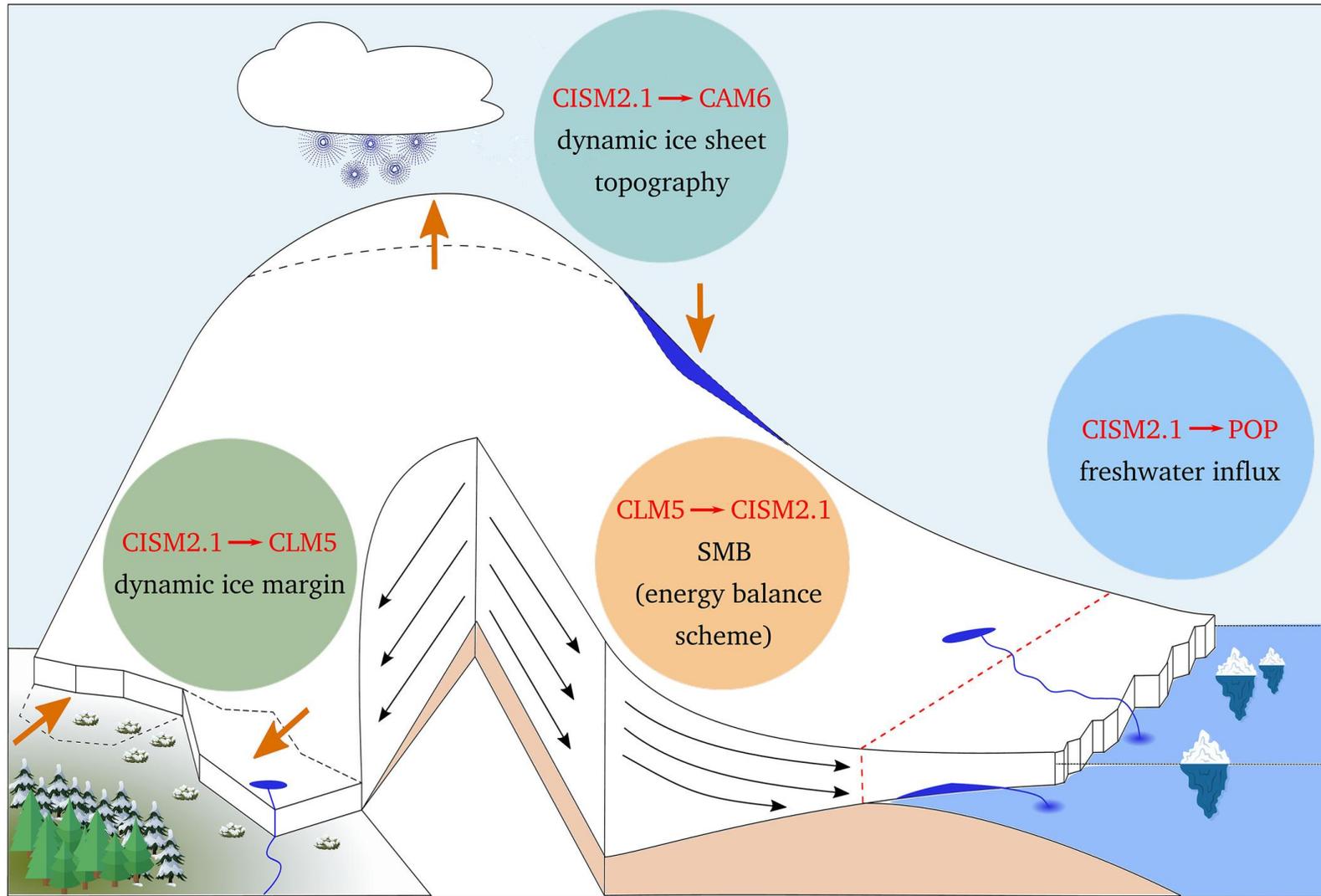


Fyke et al,
2018

GrIS modelled interactively within ESMs

- GrIS projections are mostly based in results from ice sheet models forced with the output of global/ocean models
- Ongoing effort within ISMIP for ESM-ISM, targeting the comparison of two-way coupled and one-way coupled runs
- Published CESM2-CISM2 simulations 1850-2100 & 1% to 4xCO₂ up to model year 350
- Tipping study with CISM2 forced with CESM2 SMB(z) output
- Here, we extend 1% to 4xCO₂ and compare with one-way coupled simulation **to examine role of mass & energy components and feedbacks on mass loss rates**
 - 5x ice sheet model acceleration after year 500

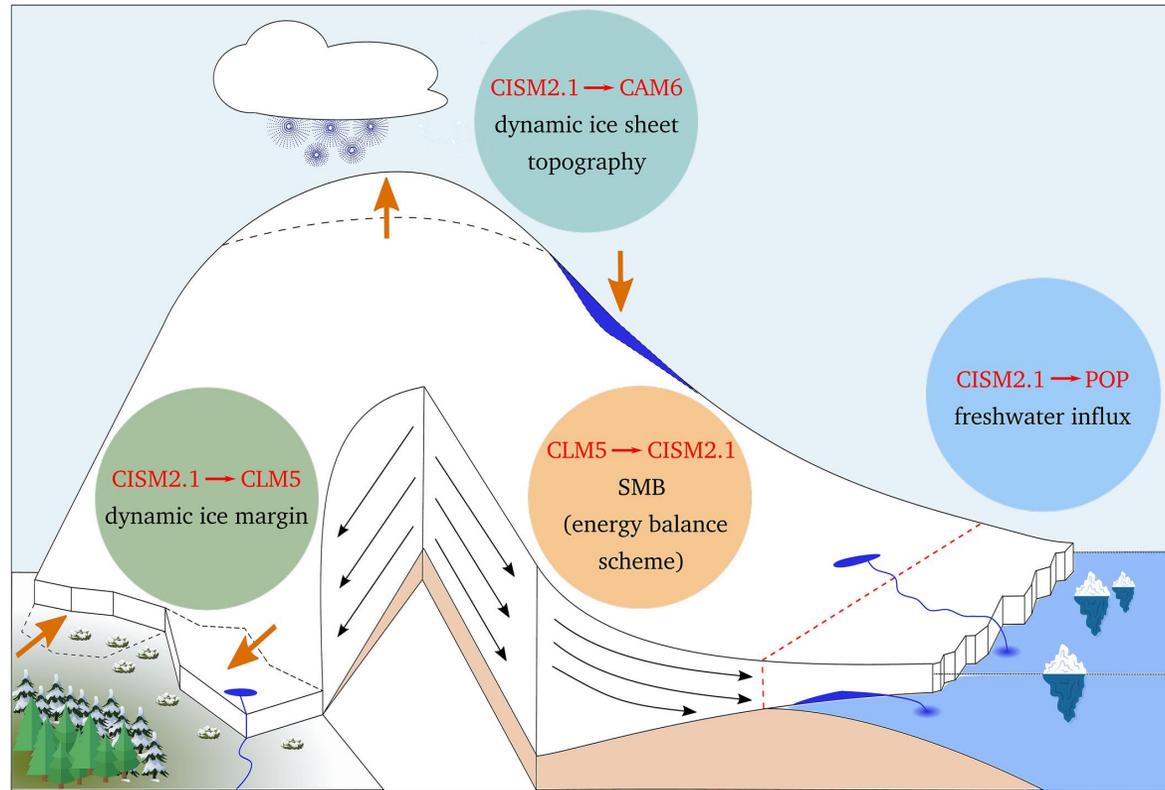




CESM2-CI SM2

*Figure by Michele
Petrini*

We compare two-way and one-way coupled simulations to evaluate **elevation effects on surface mass balance components**



One-way:

- Fixed topography (year 1 of two-way run)
- Fixed pre-industrial freshwater climatology
- Albedo does evolve

SMB=snowfall-runoff-sublimation
(runoff=melt-refreezing)

melt=net radiation+sensible+latent(sublimation)

Ice sheet evolution

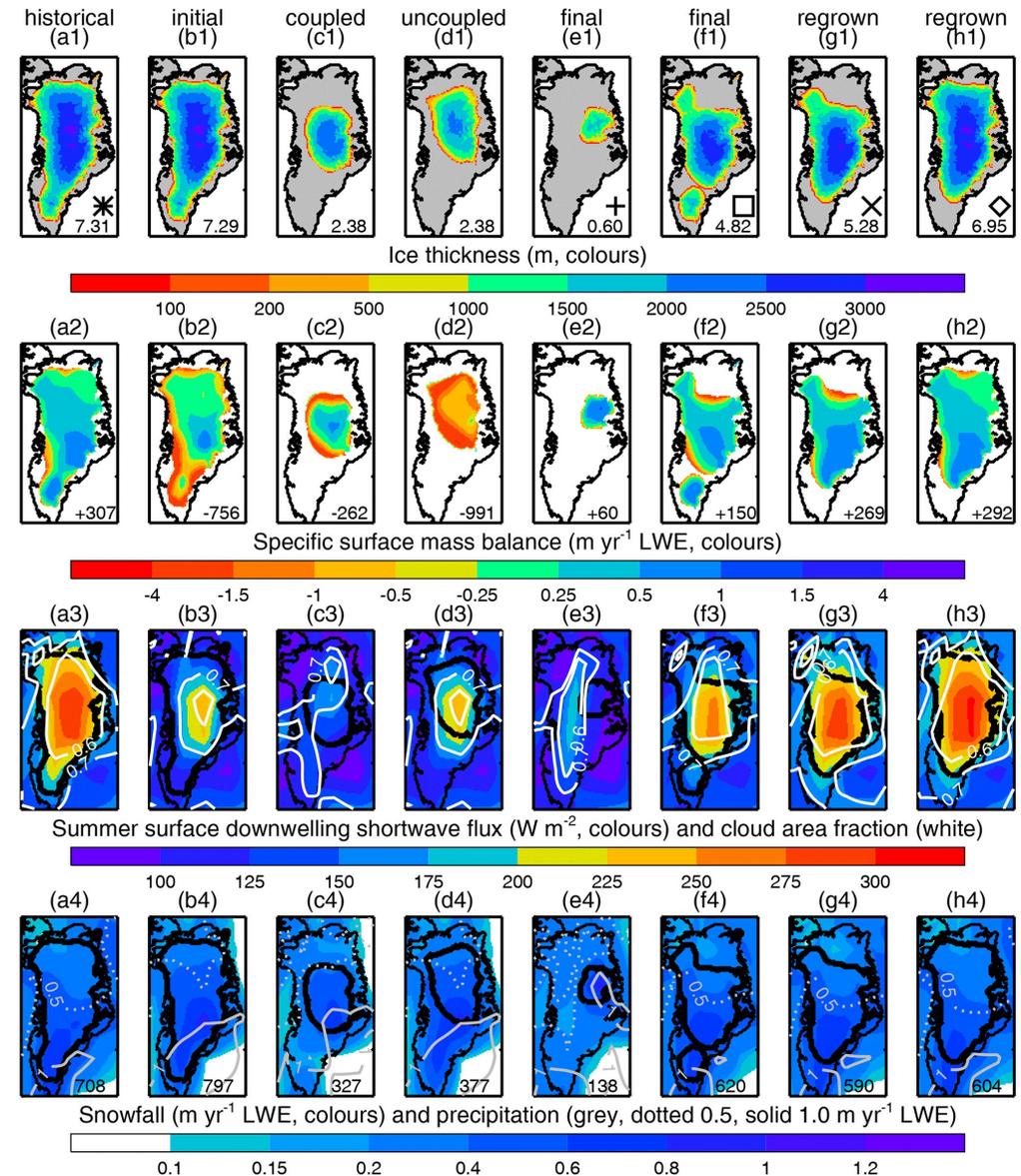


	1-127	127-337	337-915	915-1350	1350-1506	1506-1690
SMB	-3.2	-6.8	-2.9	-5.6	-1.6	-21.5

	100% (yr 0)	75% (yr 411)	50% (yr 720)	25% (yr 1130)
SMB	265 (49)	-1804 (144)	-2782 (237)	-4222 (337)
Precipitation	434 (37)	662 (72)	685 (72)	618 (68)
Runoff	-146 (30)	-2573 (172)	-3508 (240)	-4933 (343)
Sublimation	-23 (1)	7 (5)	41 (8)	90 (12)

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Elevation effects on precipitation



Gregory et al,
2020

Precipitation evolution

*One-way over
original topo*

*Contribution of
one-way lost
area*

*Elevation effect:
two-way minus one-way over common area*

Snowfall versus rainfall changes

Elevation change reduces the accumulation of snowfall due to increased rainfall/snowfall ratio

Melt & refreezing

Elevation effect on melt

	100%	75%	50%	25%
Total change	0 (51)	2369 (151)	3275 (249)	4538 (317)
Global climate change	0 (34)	1994 (188)	2226 (166)	2237 (215)
Ice cover change	0 (0)	-473 (23)	-1167 (69)	-1719 (155)
Elevation change	0 (55)	848 (209)	2217 (390)	4020 (333)
Elevation feedback (%)	0	36	68	89

- In one-way, melt stops increasing by year 500

Sources for melt

	100% (yr 0)	75% (yr 411)	50% (yr 720)	25% (yr 1130)
Melt energy	8.3 (2.0)	94.5 (5.3)	124.6 (9.0)	168.2 (11.9)
SW_{in}	288.5 (4.9)	247.5 (6.0)	244.4 (6.8)	230.2 (10.1)
SW_{out}	226.2 (2.9)	152.1 (5.1)	139.2 (4.6)	109.0 (7.6)
Albedo	0.78	0.61	0.57	0.47
SW_{net}	62.3 (3.1)	95.4 (3.6)	105.2 (5.5)	121.2 (6.2)
SW_{net} contribution (%)	N/A	38	37	37
LW_{in}	231.7 (4.5)	282.9 (3.1)	287.5 (3.2)	298.8 (4.5)
LW_{out}	281.2 (3.6)	311.9 (1.1)	313.5 (0.5)	314.8 (0.3)
LW_{net}	-49.5 (3.0)	-29.0 (2.5)	-26.0 (3.0)	-16.0 (4.2)
LW_{net} contribution (%)	n/a	24	20	21
SHF	5.2 (1.2)	23.5 (1.8)	32.6 (3.5)	41.8 (3.7)
SHF contribution (%)	n/a	21	24	23
LHF	-8.0 (0.3)	4.9 (1.5)	13.5 (2.6)	24.8 (4.0)
LHF contribution (%)	n/a	15	18	21
GHF	-1.6 (0.4)	-0.4 (0.4)	-0.8 (0.4)	-3.7 (0.4)
Non-Rad contribution (%)	n/a	38	43	42

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Temperature & wind contributions to sensible heat flux

JJA

Conclusions

- Under 1% to 4xCO₂ scenario, the GrIS completely melts within 1700 years
- Albedo is key for the energy budget: net solar radiation is the largest contributor (38%) to melt increase
- Elevation change **reduces** snowfall accumulation due to increase in rain to snowfall ratio
- SMB differences between one-way and two-way coupled calculation largely depend on downscaling concept (need to follow-up here)