Large effects of ocean circulation change on GrIS mass loss under moderate scenario

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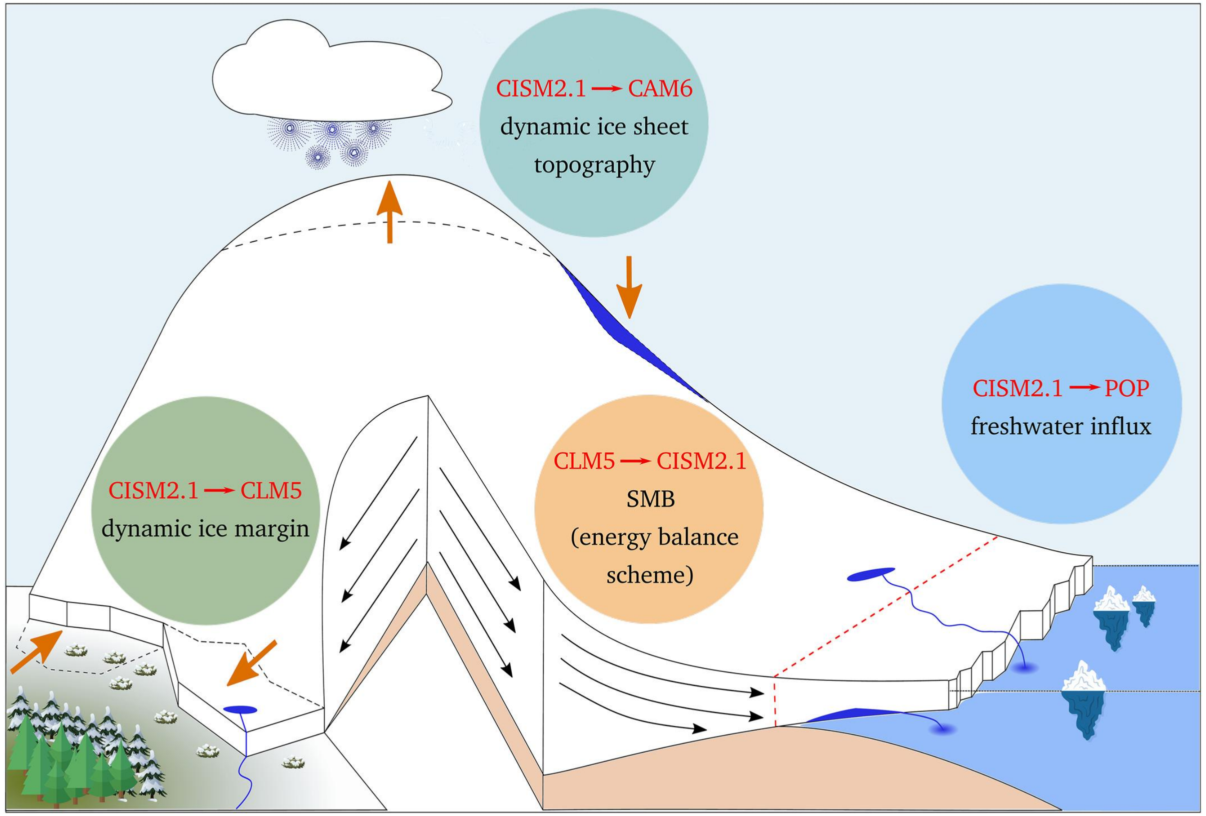
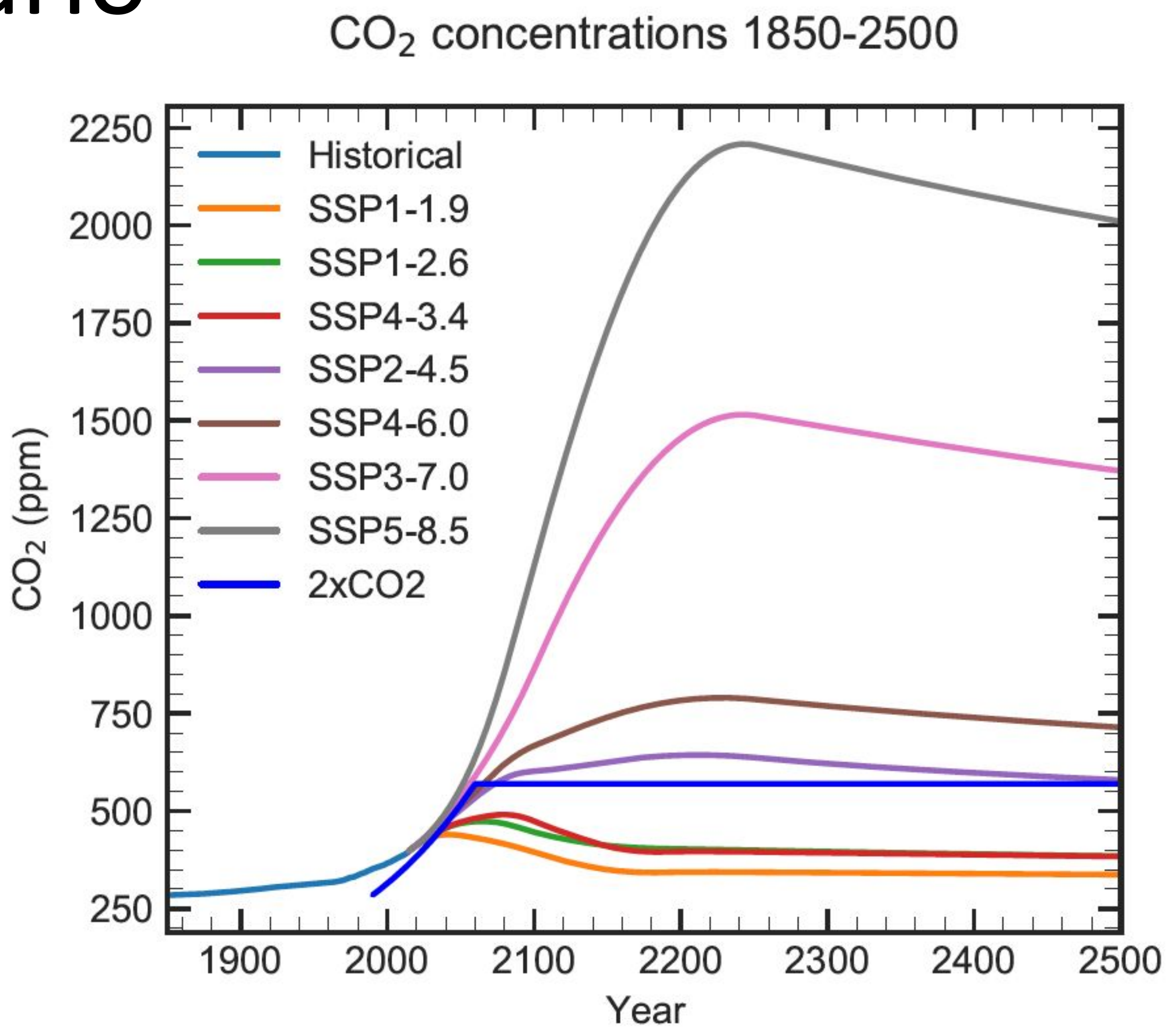
Background

- GrIS mass loss rate have accelerated in the last decades.
- NAMOC projected to weaken in CMIP6 models, with large uncertainty in the results
- Absence of coupling with GrIS as knowledge gap
- Here, we focus on the other side: how NAMOC change affects the GrIS

https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020MS002356



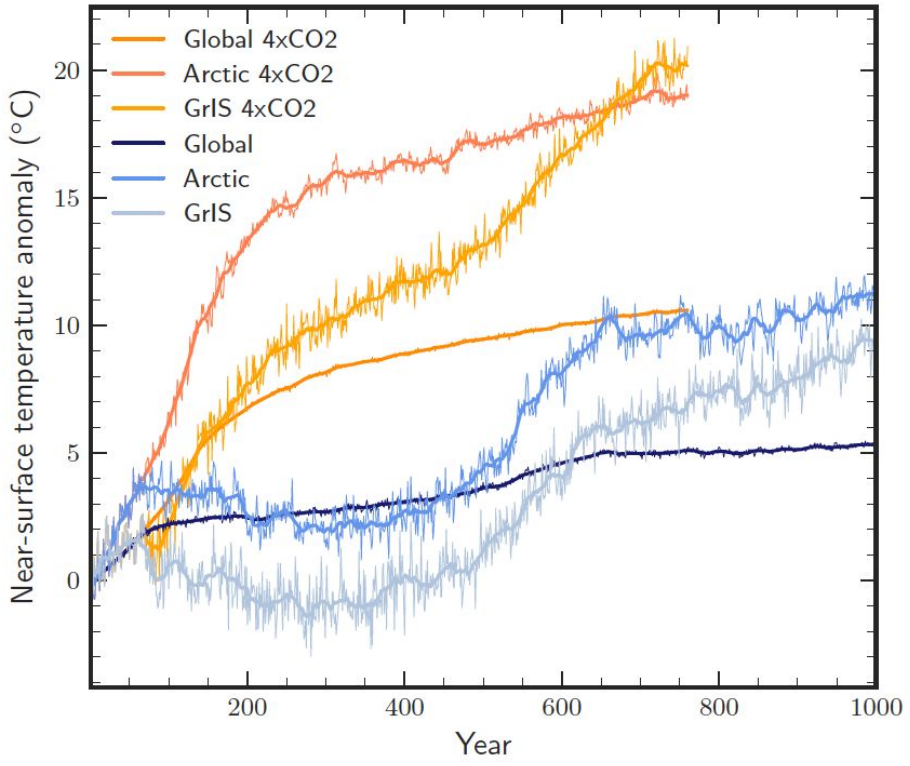
Scenario


CO2 concentrations 1850-2500
2250
2000
1750
1500
1250
1000
750
500
250
CO2 (ppm)
Historical
SSP1-1.9
SSP1-2.6
SSP4-3.4
SSP2-4.5
SSP4-6.0
SSP3-7.0
SSP5-8.5
2xCO2
1900
2000
2100
2200
2300
2400
2500
Year

- Climate

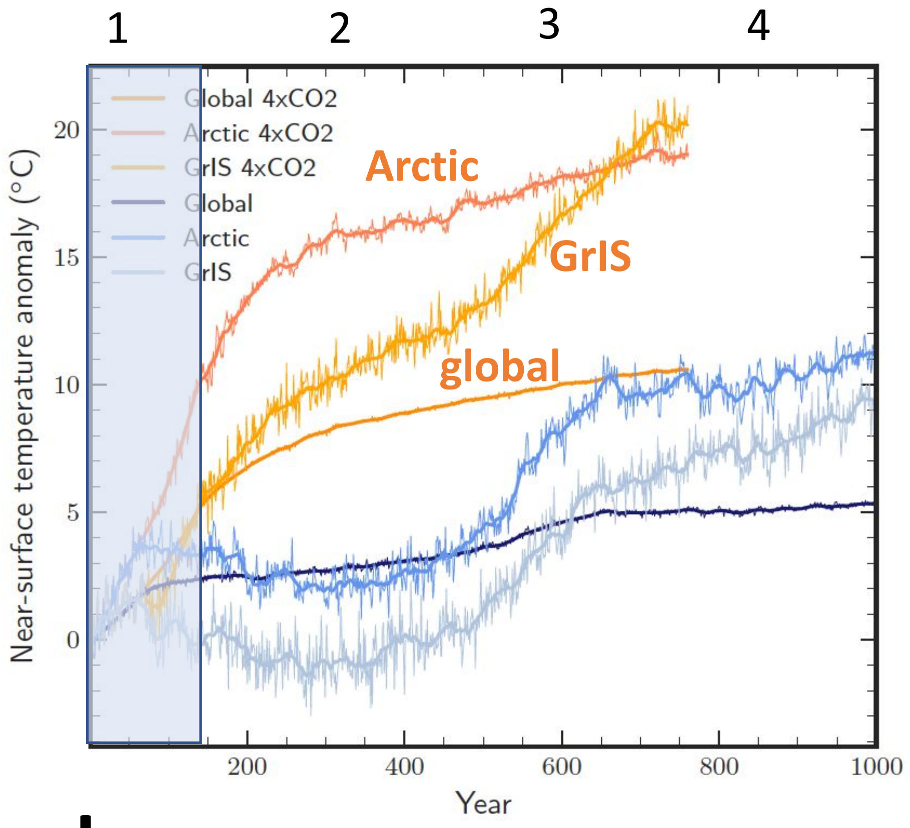
Level of warming

3



- We run 1,000 CESM years, mostly in the Dutch supercomputer (surfSARA)
- We extended a published 4xCO2 simulation (1-350 years) in NCAR supercomputer until full deglaciation (not shown)

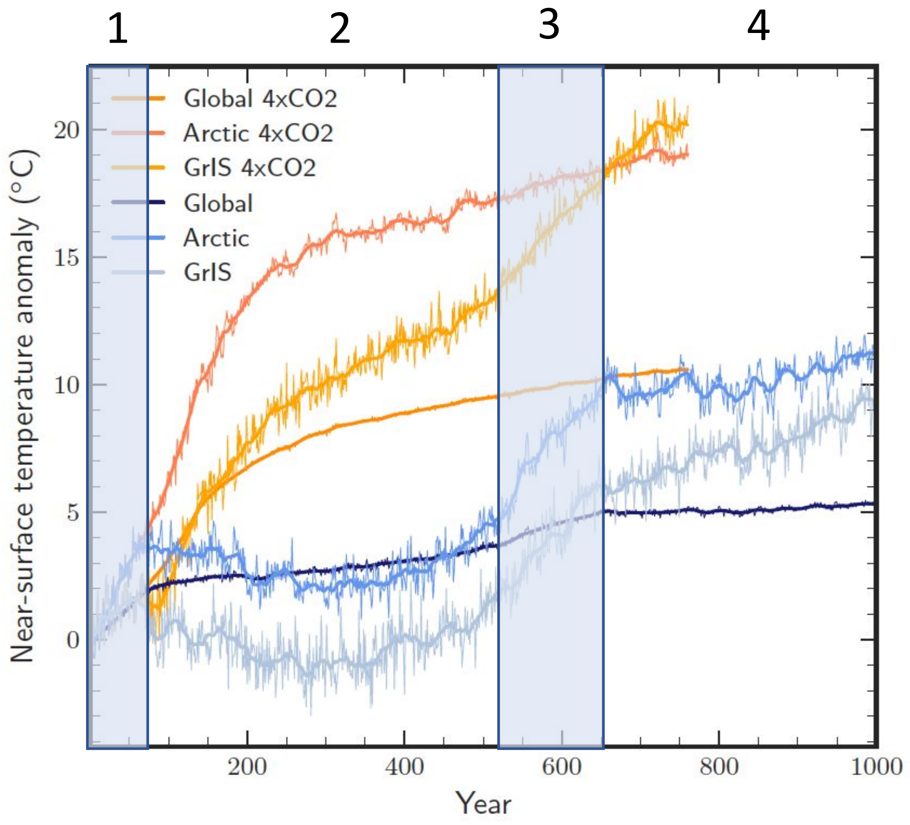
Level of warming: 4xCO2



Annual

- We run 1,000 CESM years, mostly in the Dutch supercomputer (surfSARA)
- Arctic amplification of global warming
- GrIS warms more than the

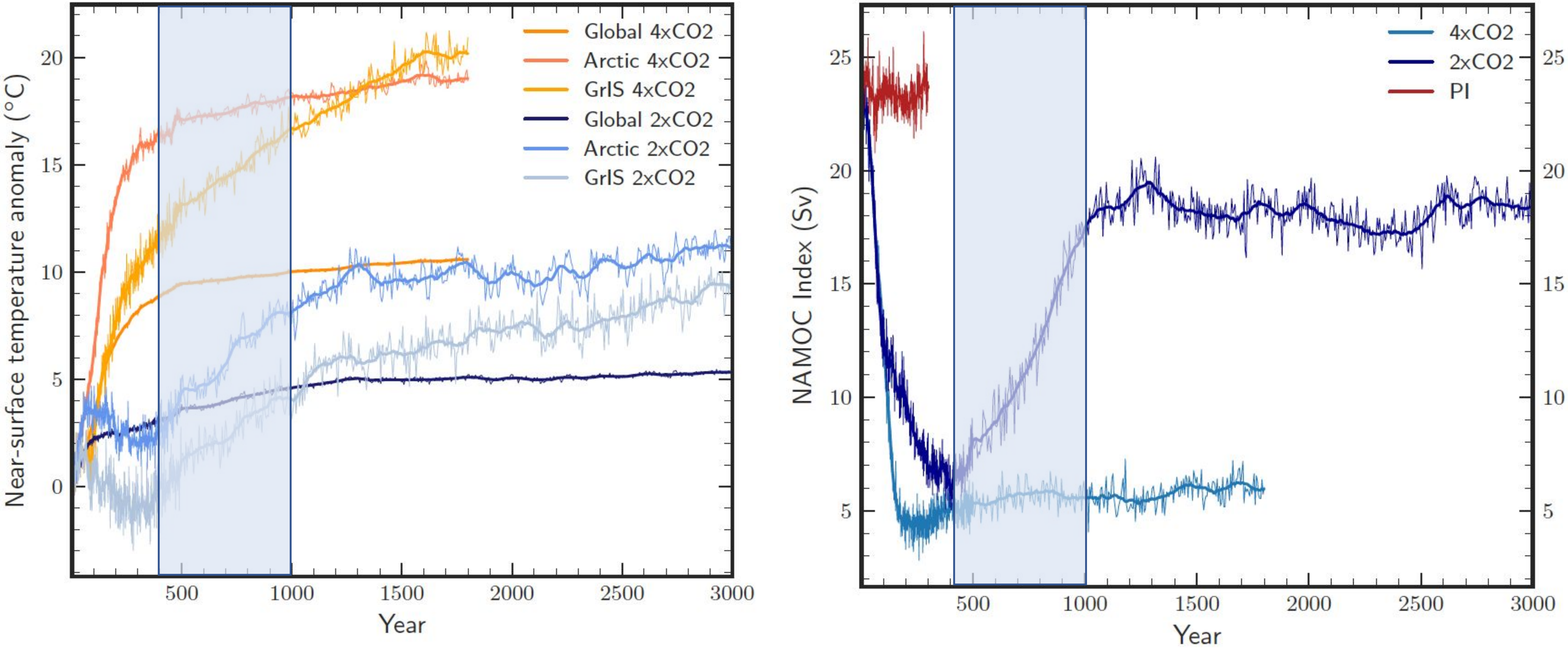
Level of warming

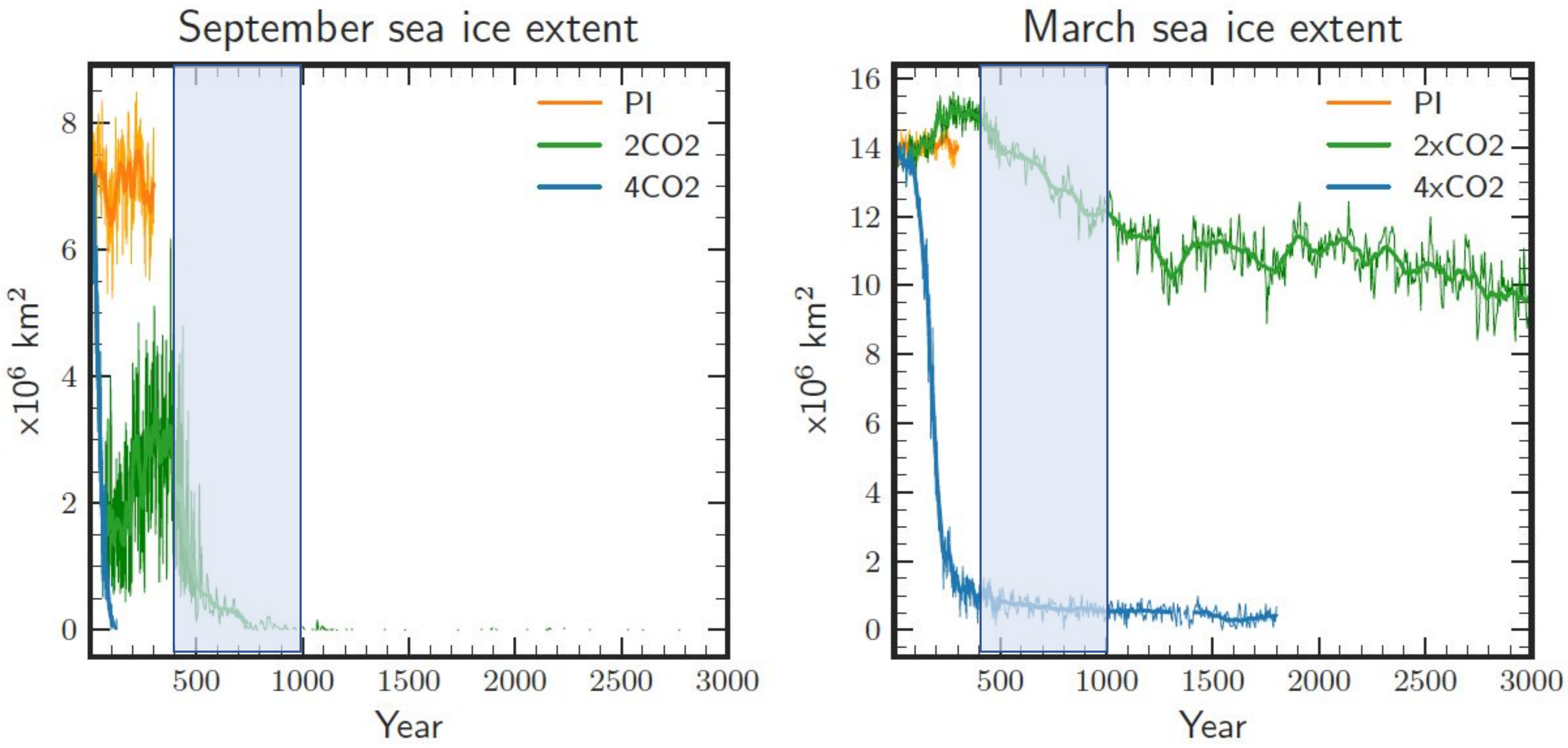


- We run 1,000 CESM years, mostly in the Dutch supercomputer (surfSARA)
- Increased global warming rate between CESM years 500-650
- Greenland cooling
- Arctic temperatures are **less than global** between 250 and 450

Climate

- From year 500, we couple to CISM every 5 years
- Note that the time axis has changed!





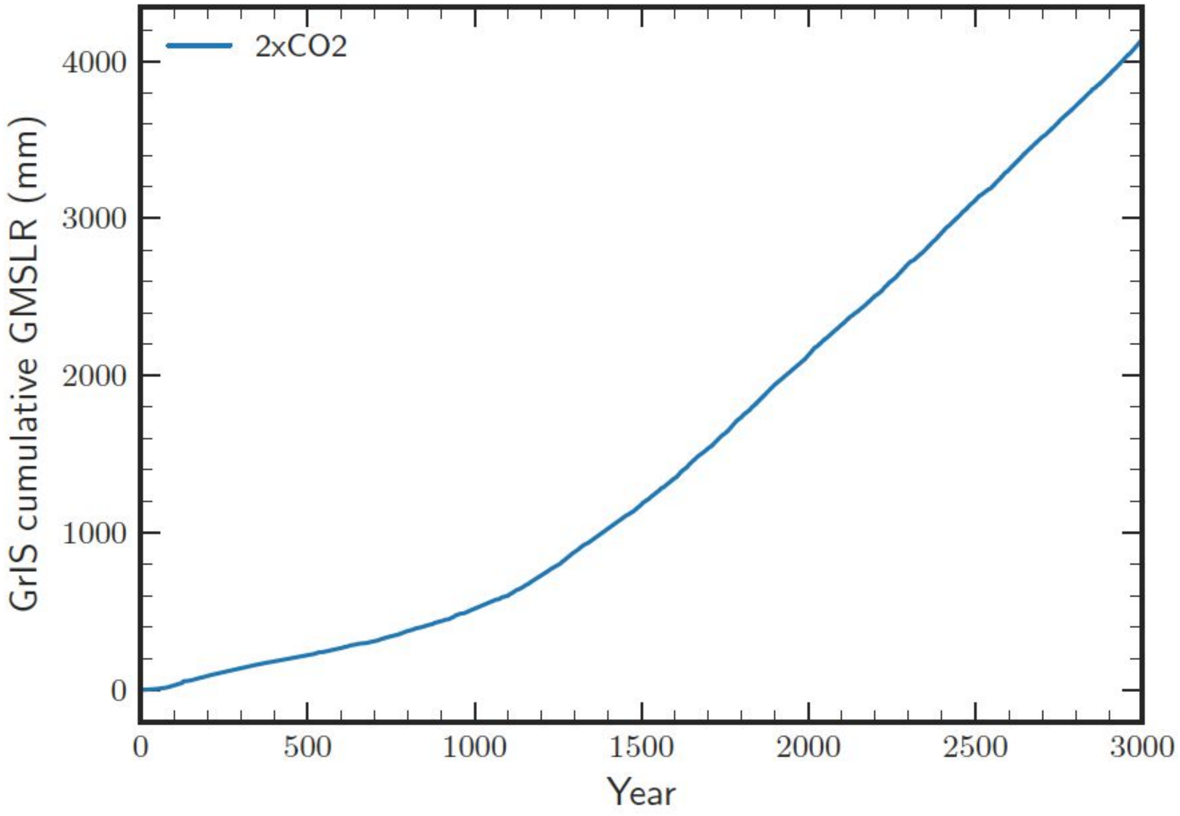
September sea ice extent
March sea ice extent
PI
2CO2
4CO2
2xCO2
4xCO2
x10^6 km^2
Year
0
2
4
6
8
10
12
14
16
500
1000
1500
2000
2500
3000

Conclusions and questions

- In this simulation, NAMOC weakening results in polar reduction of global warming in a moderate scenario
- Do we see this in other simulations (e.g, SSPs?)
- Do we see this in other climate models?
- Do we need to perform a 1:1 extension after year 500 to better account for GrIS-NAMOC coupling?

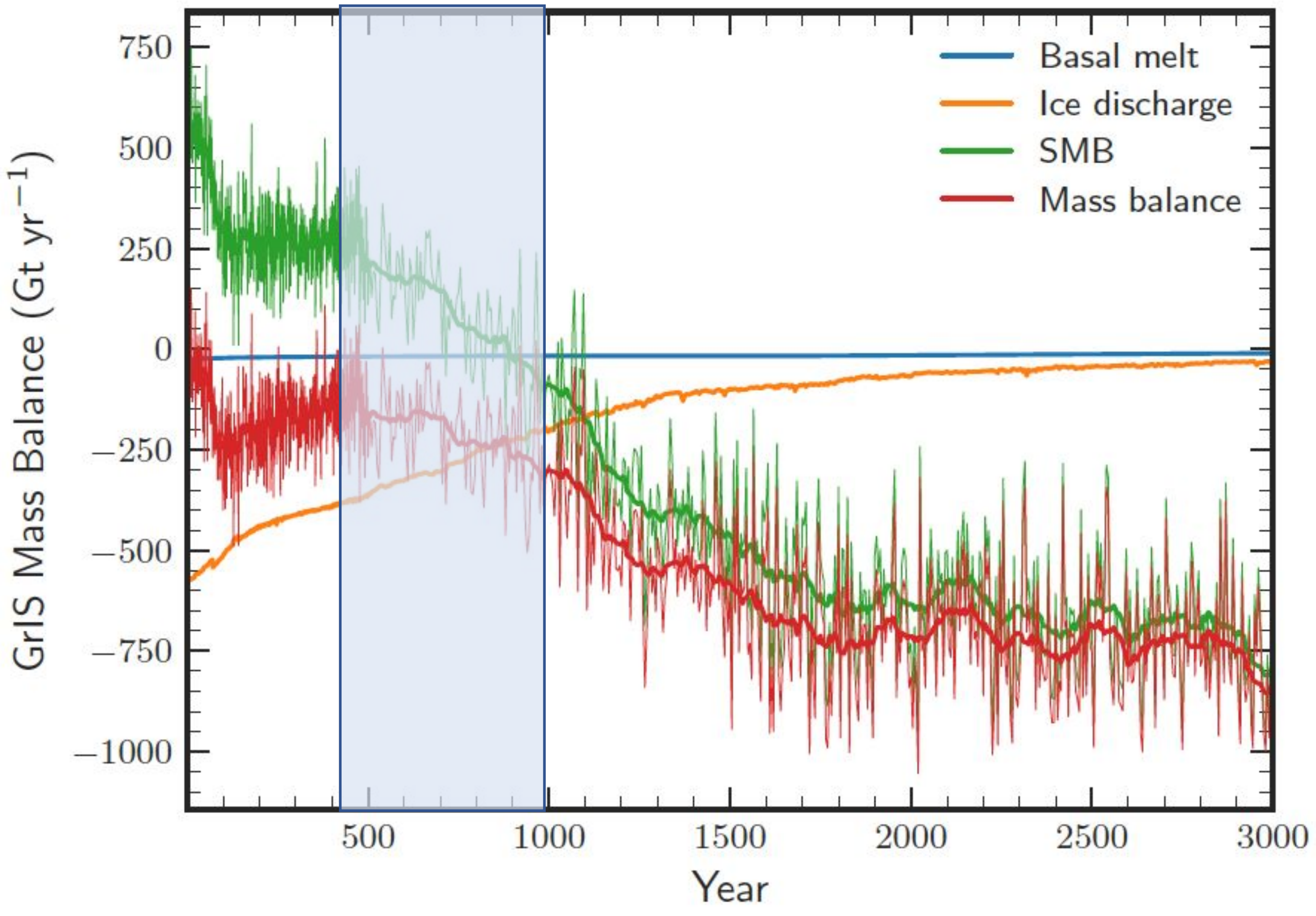
- Ice response

Half of GrIS lost



Rates

MB=SMB-Ice Discharge



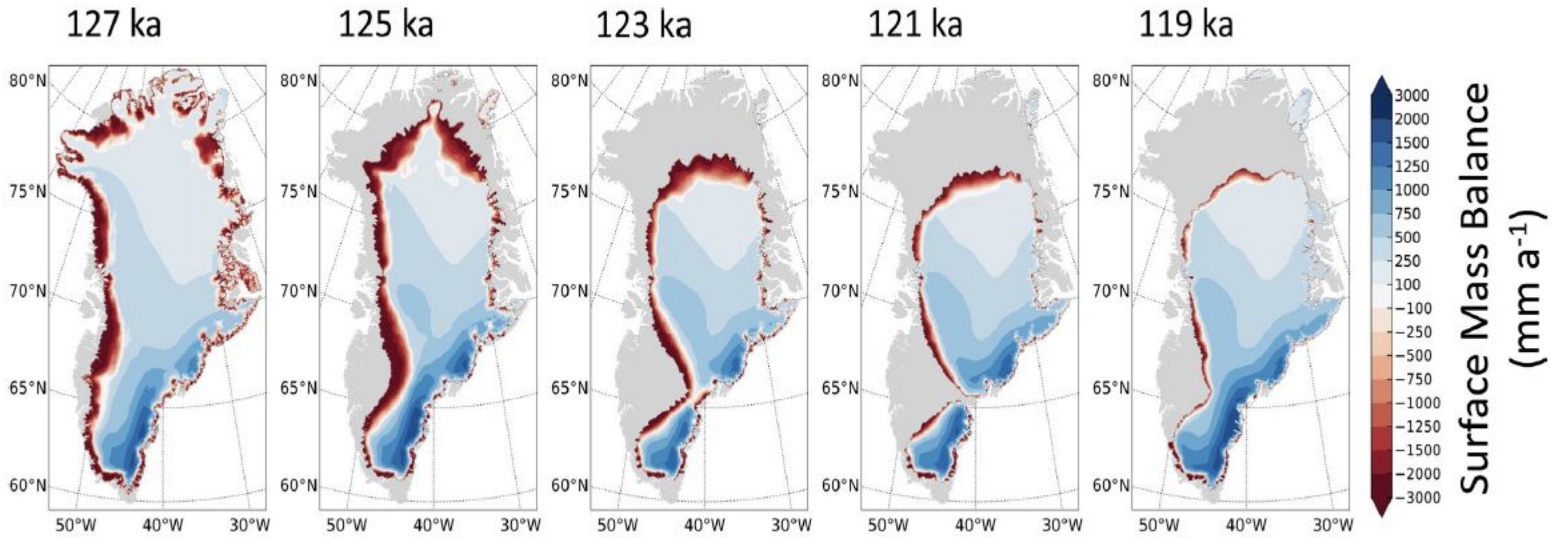
- SMB declines at the time of the NAMOC recovery

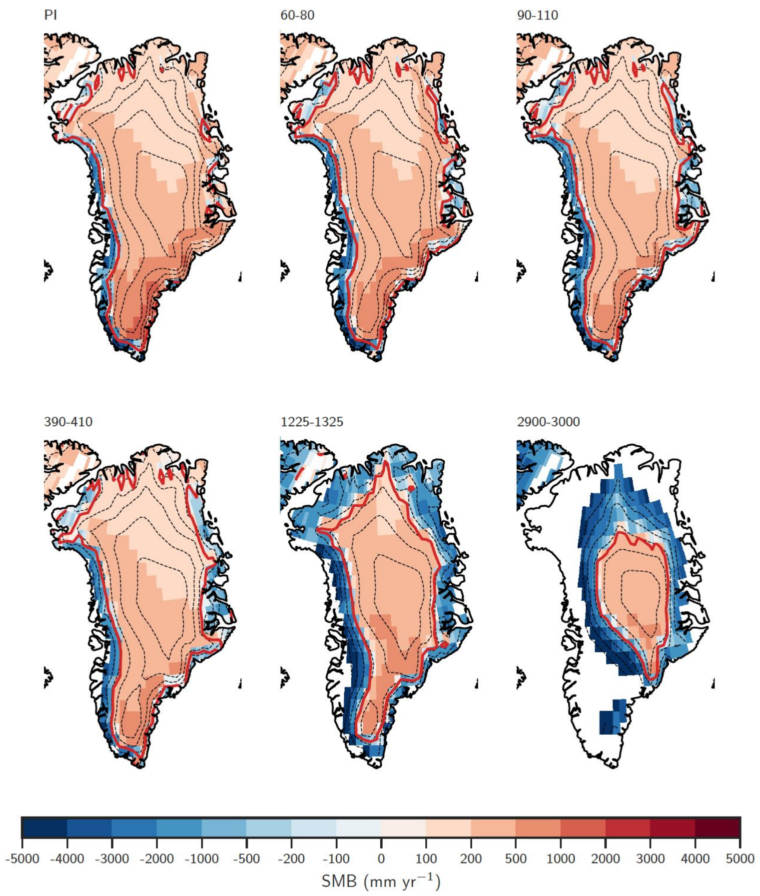
Conclusions

- For this “moderate” forcing scenario, ocean circulation plays a large role on the regional climate of Greenland
- GrIS melt increases with NAMOC recovery

- Ice, detailed

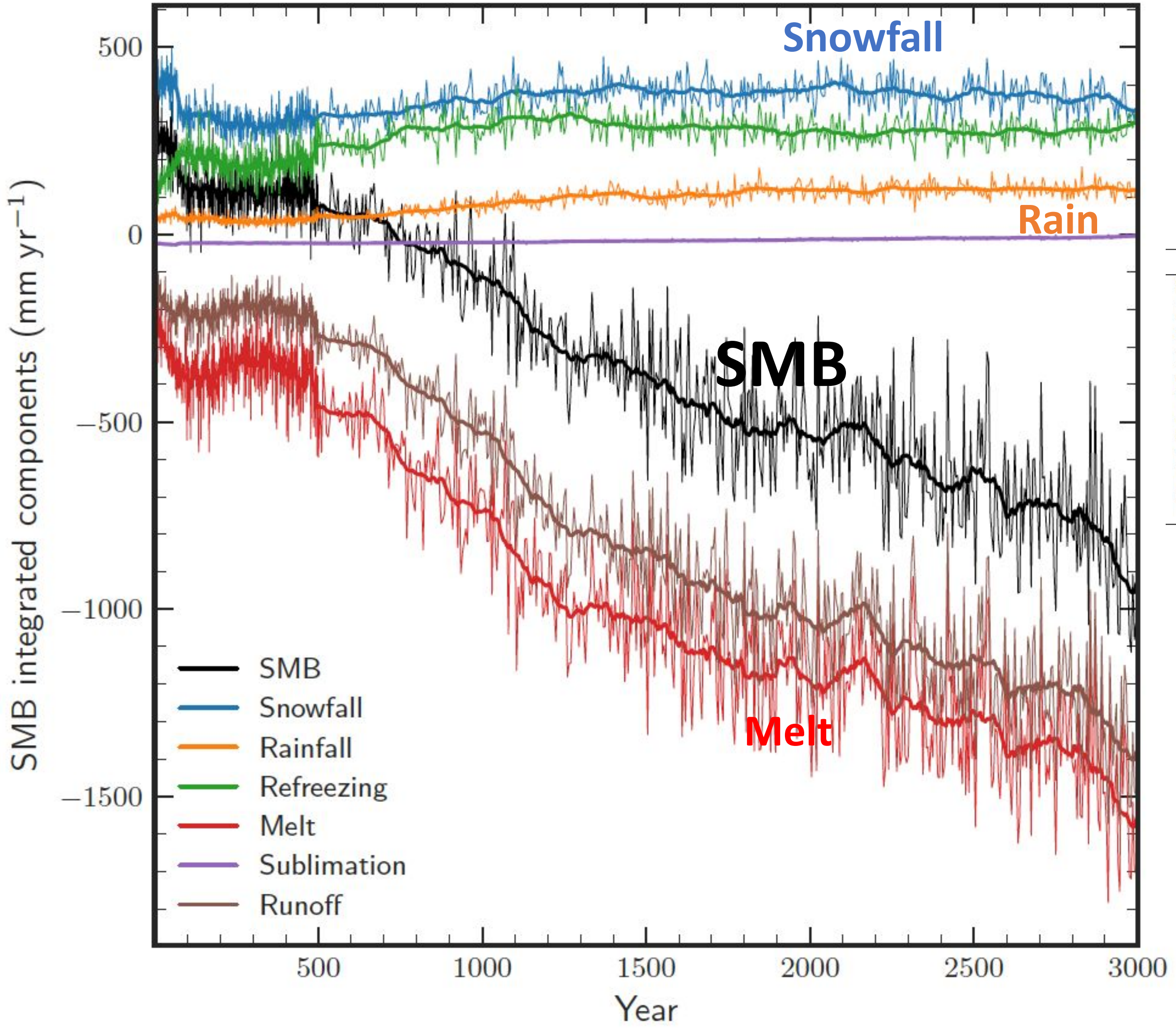
Pattern of deglaciation





- Strong NAMOC in Eemian simulation
- Less northern retreat and more SE retreat in 2xCO2 compared with Eemian

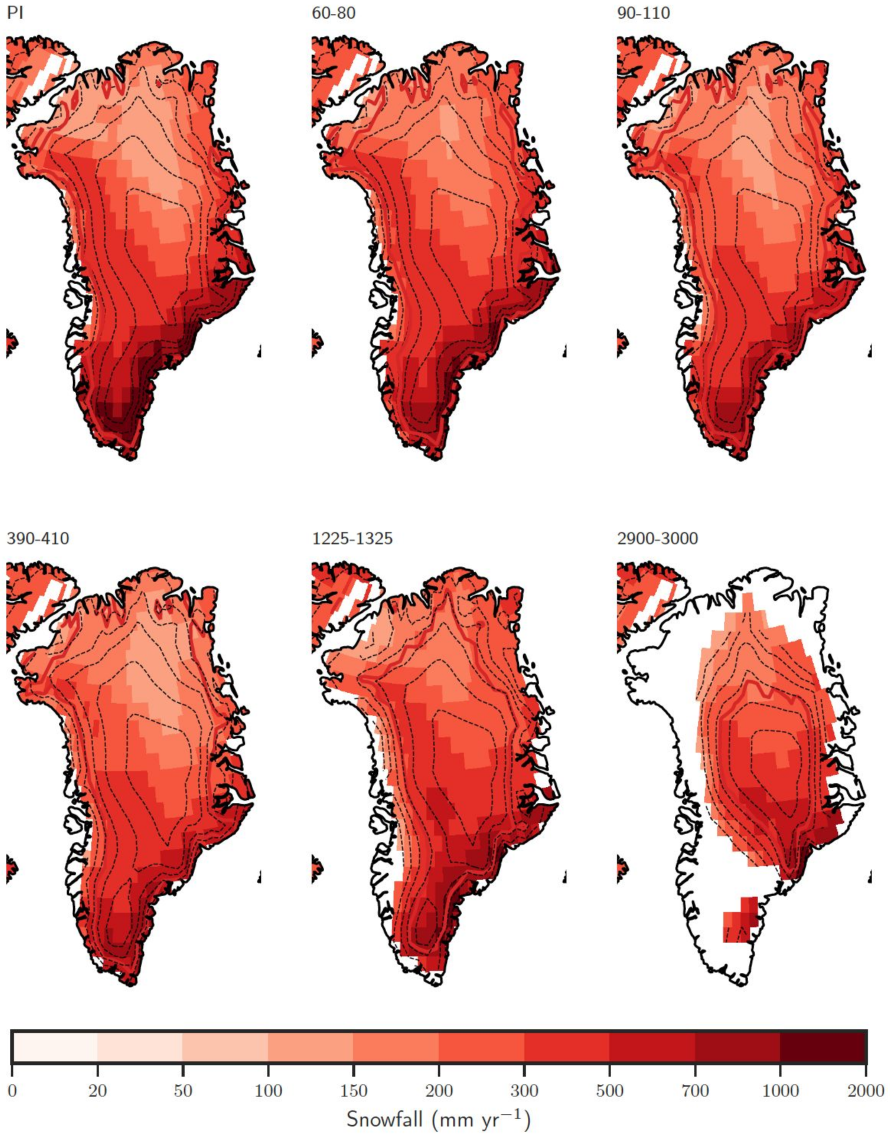
Surface mass balance



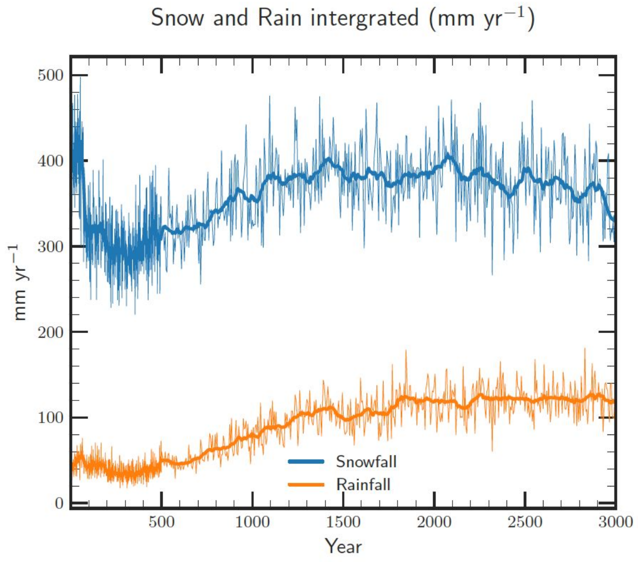
Refreezing

	PI 1-20	Years 60-80	Years 90-110	Years 390-410	Years 1225-1325	Years 2900-3000
SMB	556 (87)	374 (94)	249 (106)	215 (91)	-574 (140)	-899 (139)
Precipitation	863 (74)	846 (111)	699 (62)	657 (55)	844 76)	454 (42)
Snowfall	790 (68)	725 (98)	617 (59)	582 (44)	662 (65)	336 (34)
Rain	73 (11)	100 (20)	81 (14)	75 (16)	183 (28)	118 (18)
Refreezing	221 (53)	388 (47)	413 (82)	371 (75)	554 (46)	281 (27)
Melt	410 (89)	691 (89)	737 (152)	695 (139)	1757 (146)	1511 (150)
Sublimation	45 (4)	49 (6)	44 (3)	42 (3)	31 (4)	5 (4)
Runoff	262 (48)	403 (64)	405 (79)	399 (74)	1386 (122)	1348 (135)
Rain (%)	8.5	12	11.6	11.4	21.7	26
Refreezing (%)	45.8	49	50.5	48.2	28.6	17

Snow

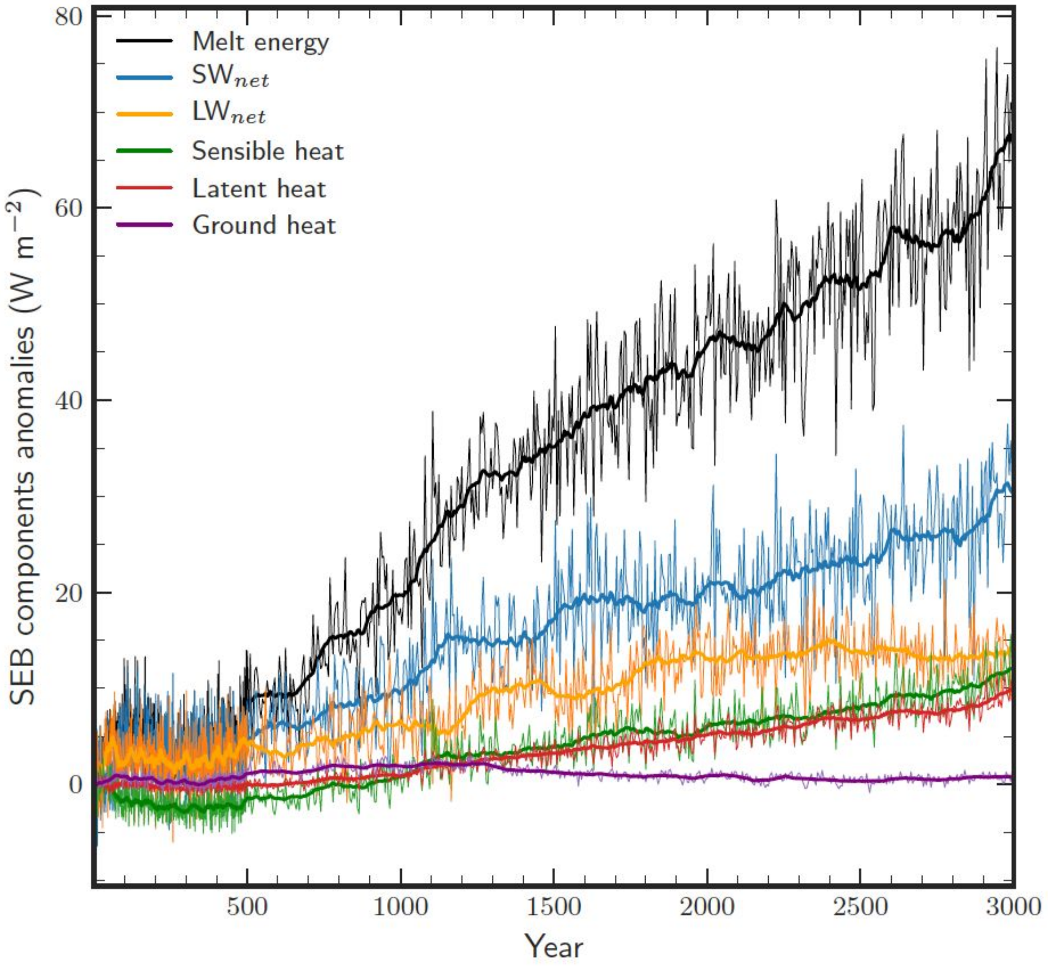


PI
60-80
90-110
390-410
1225-1325
2900-3000
0
20
50
100
150
200
300
500
700
1000
2000
Snowfall (mm yr^{-1})

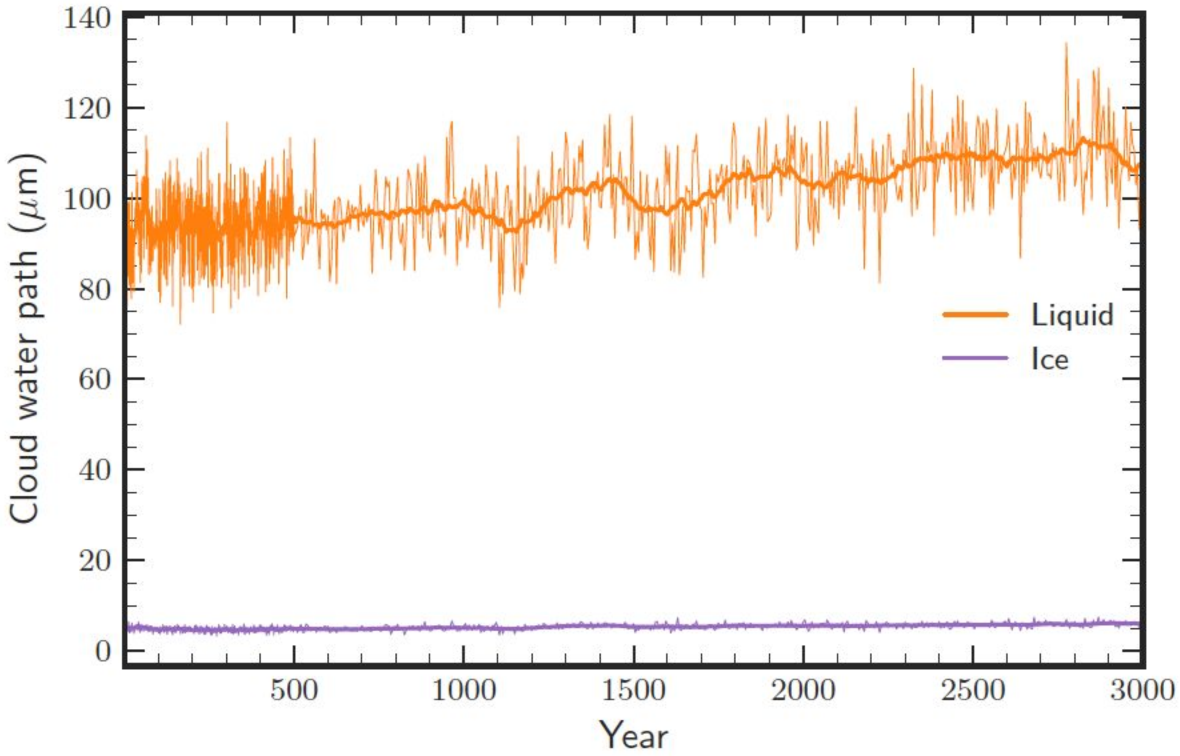


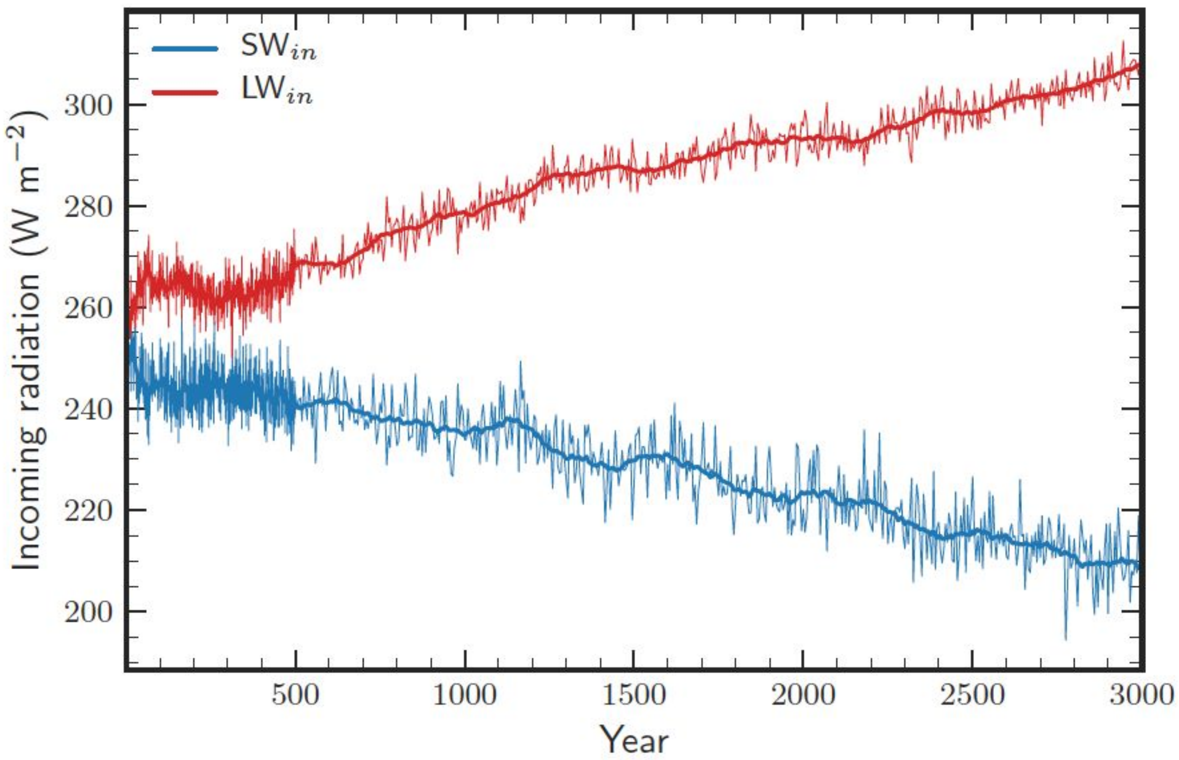
Snow and Rain intergrated (mm yr^{-1})
mm yr^{-1}
0
100
200
300
400
500
Snowfall
Rainfall
500
1000
1500
2000
2500
3000
Year

Energy contributors to melt

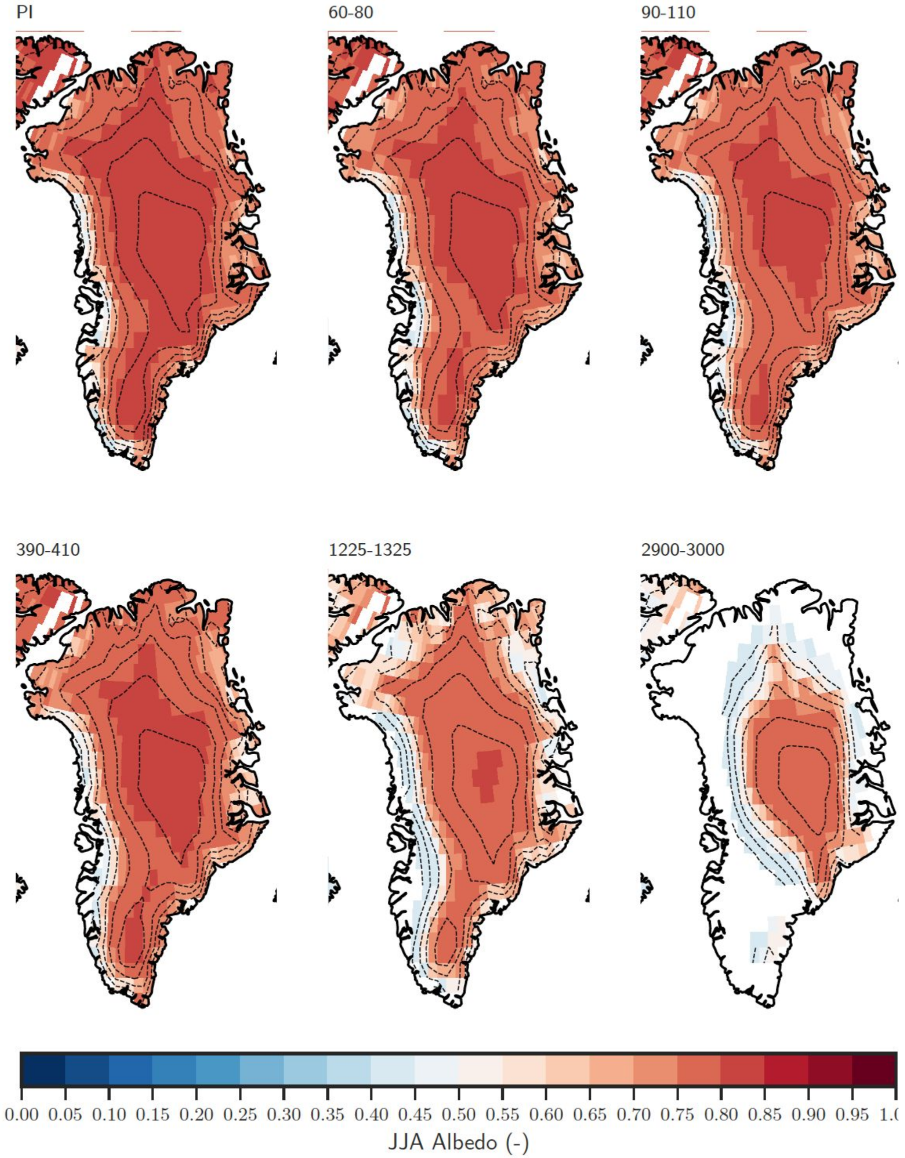


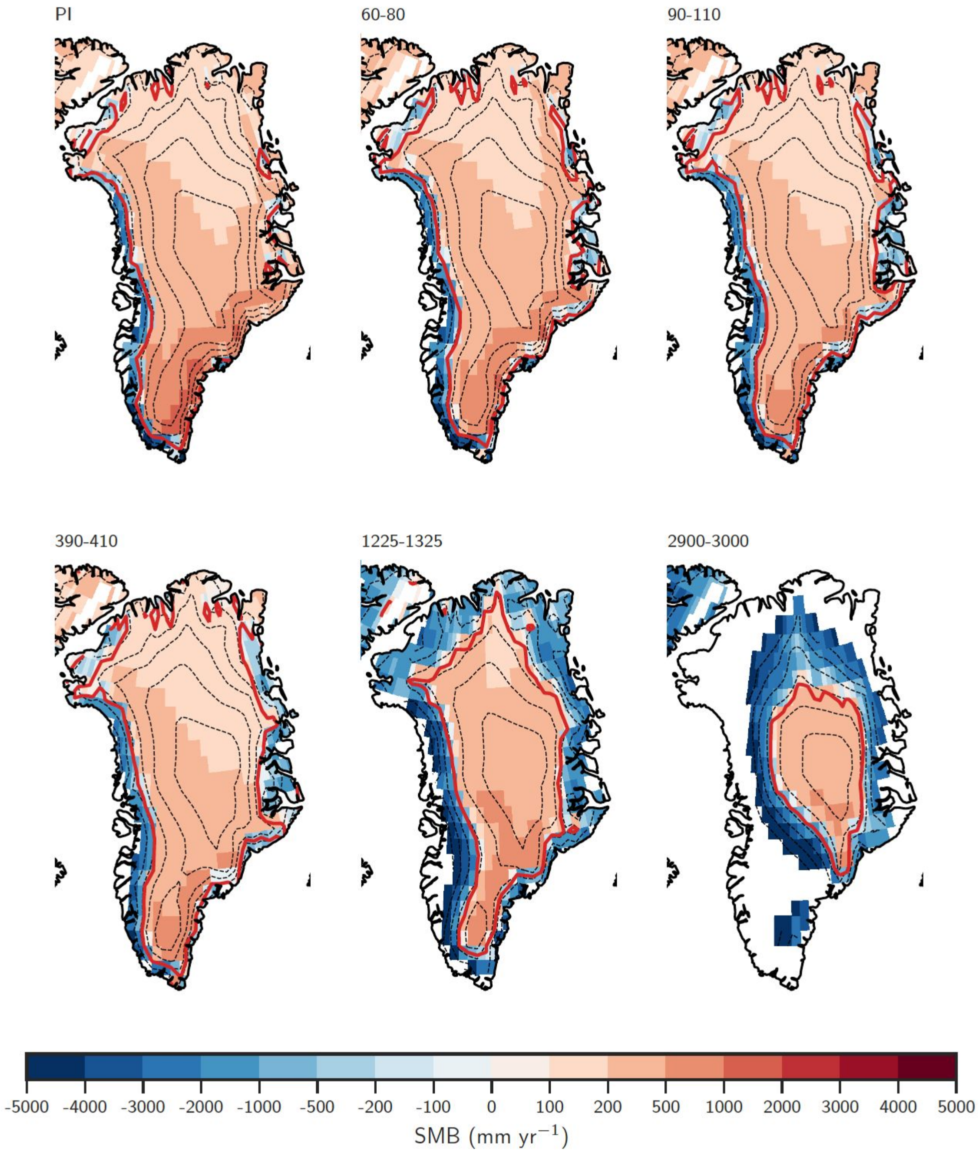
Clouds and incoming radiation





Albedo


PI
60-80
90-110
390-410
1225-1325
2900-3000
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.0
JJA Albedo (-)


PI
60-80
90-110
390-410
1225-1325
2900-3000
-5000 -4000 -3000 -2000 -1000 -500 -200 -100 0 100 200 500 1000 2000 3000 4000 5000
SMB (mm yr^{-1})

Conclusion

- CESM2-CISM2 provides detail in GrIS process with coupling to the global climate

On the role of the climate scientist in times of climate crisis

https://elifesciences.org/articles/84991#x945d7f18

Point of View: Rethinking academia in a time of climate crisis

Anne E Urai, Clare Kelly

Leiden University, Netherlands; Trinity College Dublin, Ireland

	From	To
1. Change the goal	university as business	academic doughnut
2. Get savvy with systems	cog in the machine	gardeners of academic system
3. See the big picture	isolated ivory tower (Earth / Society / Economy)	embedded in society and planet (Earth / Society / Economy)
4. Create to regenerate	rat race	slow science
5. Nurture human nature	lone genius	team science
6. Design to distribute	rich get richer	fair distribution
7. Be agnostic about growth	growth	trust