PROCESSES IN THE FUTURE EVOLUTION OF THE GREENLAND ICE SHEET IN A COUPLED CLIMATE AND ICE SHEET MODEL

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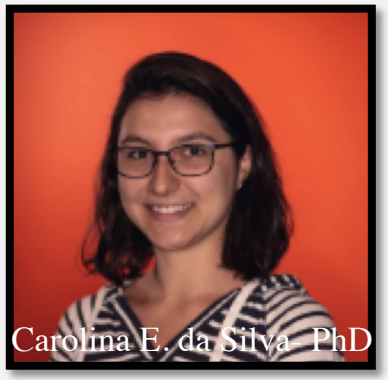
TU Delft

European Research Council
Established by the European Commission

INTRODUCTION


Laura Muntjewerf - PhD


Raymond Sellevold - PhD


Carolina E. da Silva - PhD

DELFT RESEARCH GROUP

	Future (Greenland)	Last deglaciation (Northern Hemisphere)
CESM	**Raymond Sellevold** (GrIS-Arctic connections)	
CESM-CISM	**Laura Muntjewerf** (ISMIP6 projections)	**Sarah Bradley** **Michele Petrini**
POP-CESM-CISM	**Carolina E. de Silva** (ice-ocean interaction)	


Sarah Bradley - Postdoc


Michele Petrini - Postdoc


Miren Vizcaino - PI

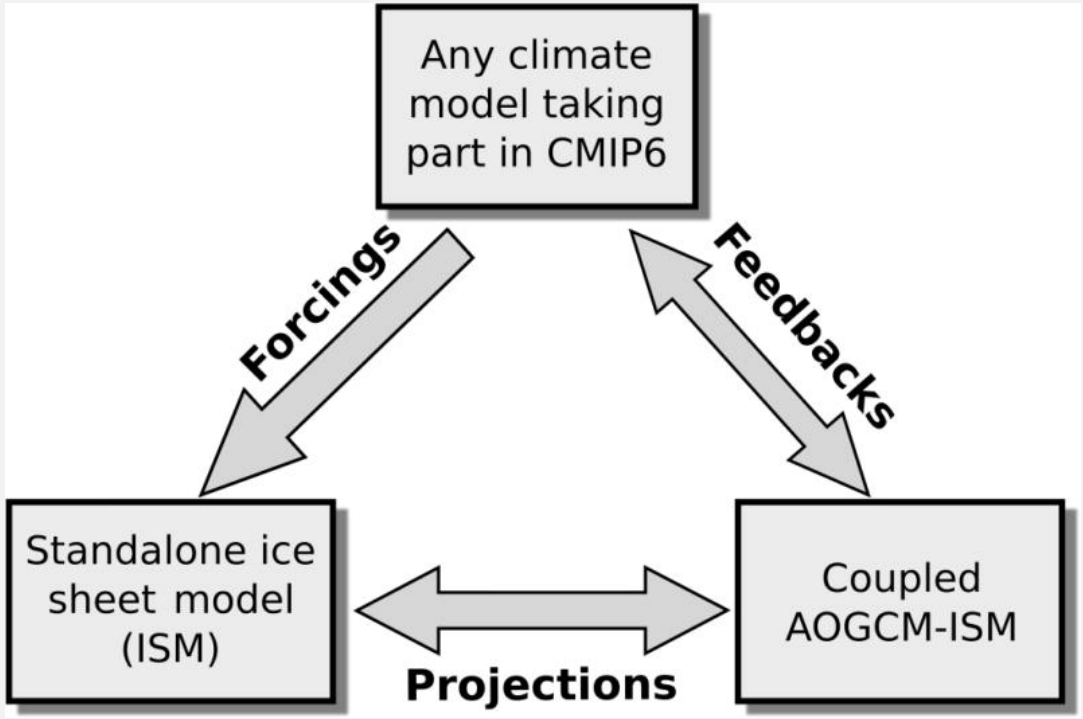
Software engineering support
Bill Sacks, Erik Kluzek (NCAR)

CoupledIceClim
June 2016-May 2021

erc
European Research Council
Established by the European Commission

NWO
Netherlands Organisation for Scientific Research

ICE SHEET MODEL INTERCOMPARISON PROJECT (ISMIP6)



- ISMIP6 is a CMIP6-endorsed MIP
- experiments to explore uncertainty in sea level rise
- Sea-level projections for the IPCC-AR6 in sync with the CMIP scenarios

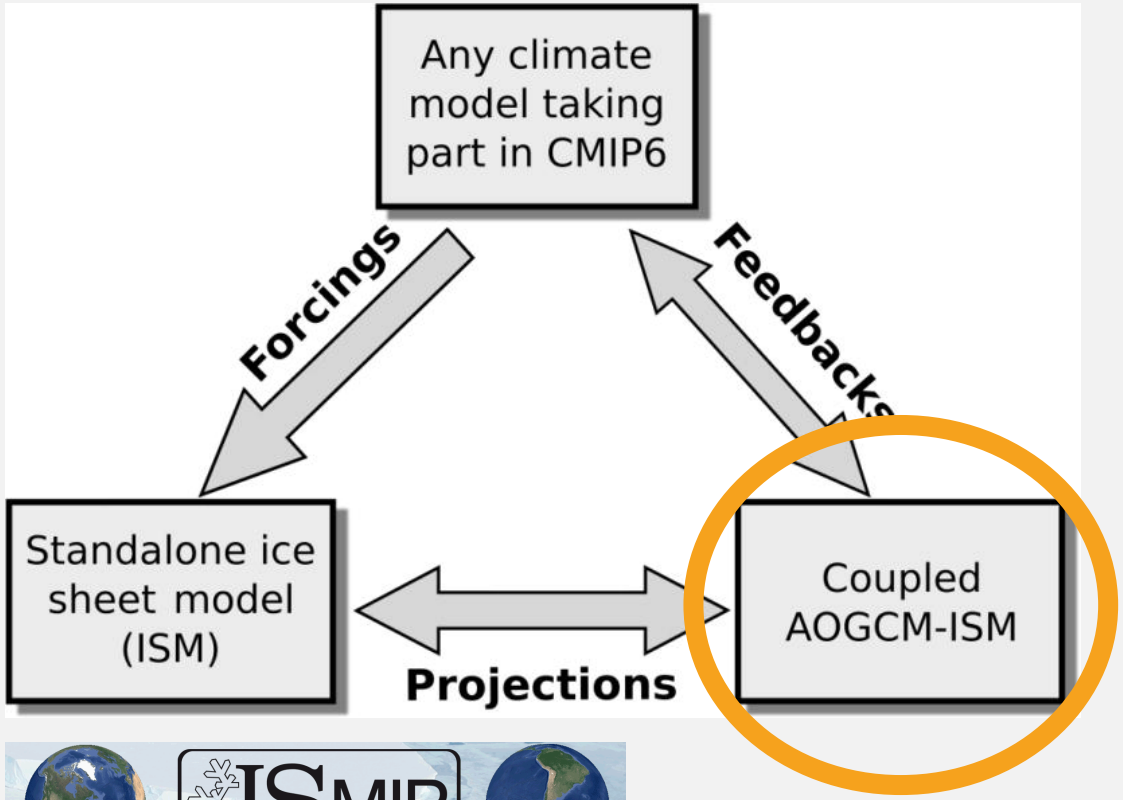
ISMIP6 follows the timeline of CMIP6
→ Submission papers Dec. 2019

ISMIP6 Ice Sheet Model Intercomparison Project for CMIP6

Nowicki et al., 2016

INTRODUCTION

ICE SHEET MODEL INTERCOMPARISON PROJECT (ISMIP6)



Nowicki et al., 2016

CESM2.1 contribution to ISMIP6

As one of the first climate modeling centers; we provide the community with the following coupled AOGCM-ISM runs:

- piControl-withism [300 yrs]
- 1pctCO2to4x-withism & 1pctCO2to4x-ism_non-interactive [500 yrs]
- historical-withism [1850-2014]
- ssp585-withism [2015-2300]

CONTENTS

Fully coupled CESM2.0 AOGCM-ISM:
all components active [BG compset]

Presented here are results from 2 test runs:

- Pre-industrial -1850 steady forcing [40 years]
- 1% yr^{-1} increase CO_2 up till the value of 4 times the pre-industrial concentration [130 years]

NOTE test simulations:

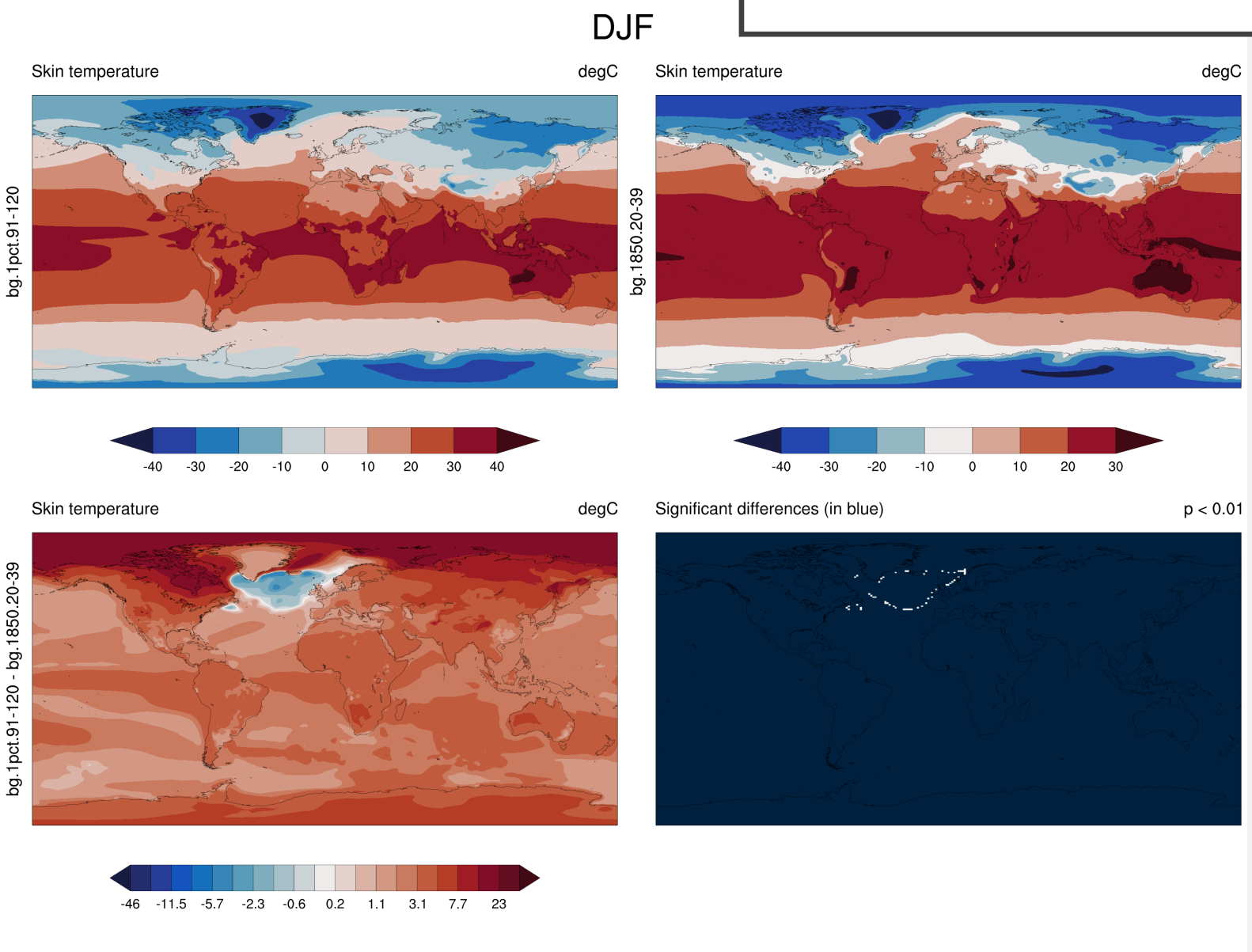
- Too large spun-up initial ice sheet (volume +30% i.e. ~10 m SLE)
- CLM/CICE/MOSART from JG_2, CAM branched from PI #297_yr0078,
- 1pct-run did not complete the full 140 years; ocean component crash at year 130

CONTENTS

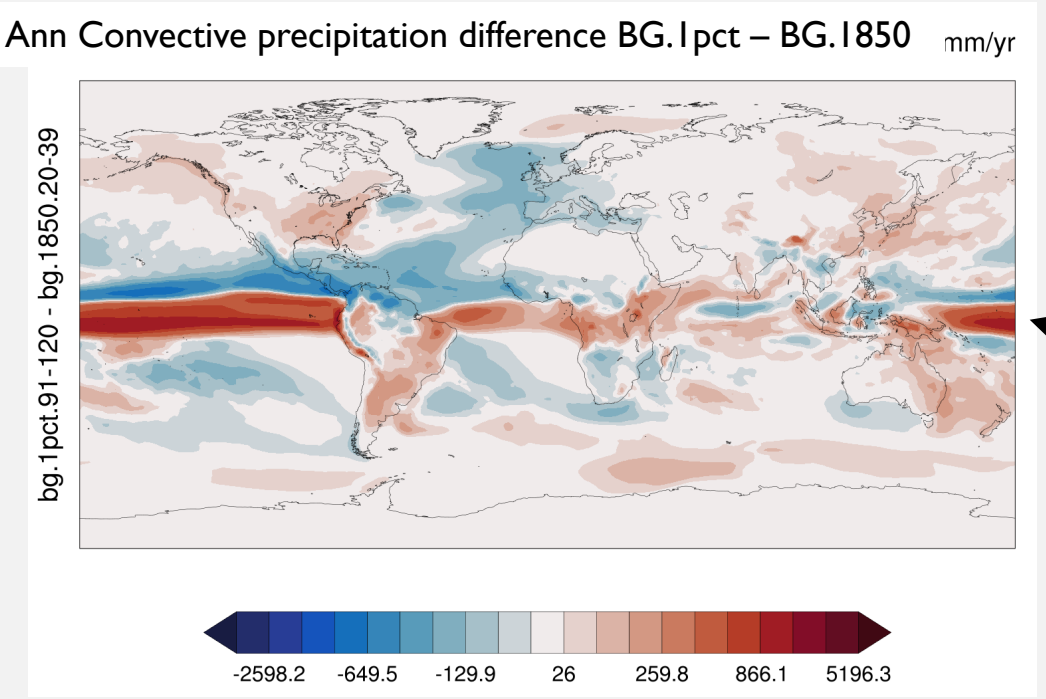
Results

- Global climate
- Arctic climate
- Greenland climate
- Greenland ice sheet evolution

SKIN TEMPERATURE



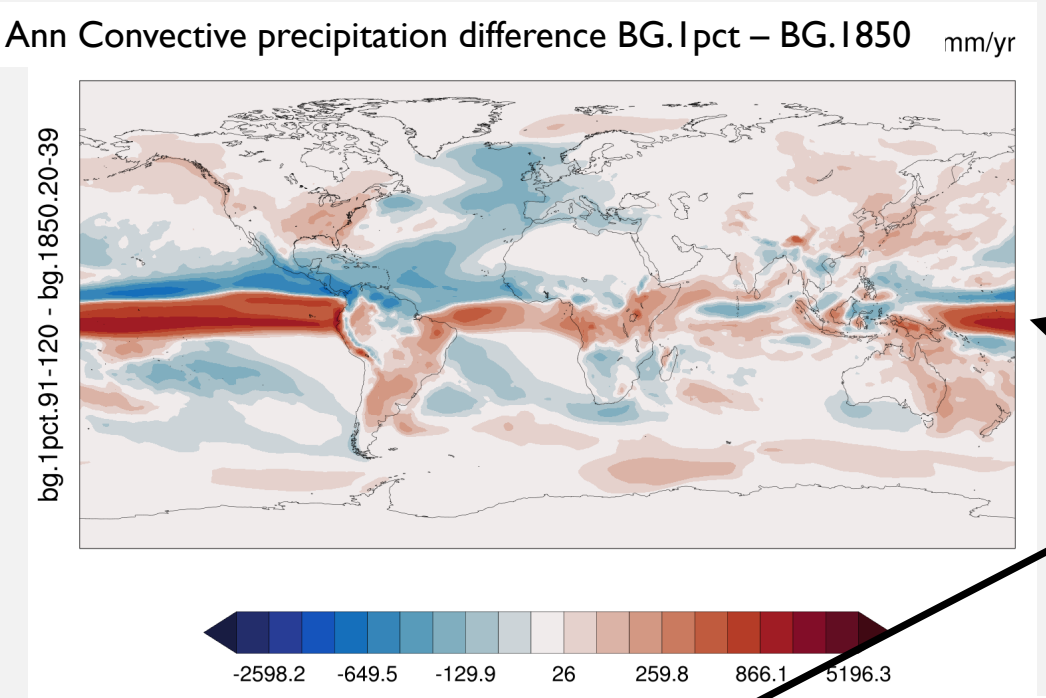
- Polar amplification: larger change in surface temperatures near the poles.
- Cooling patch in the North Atlantic

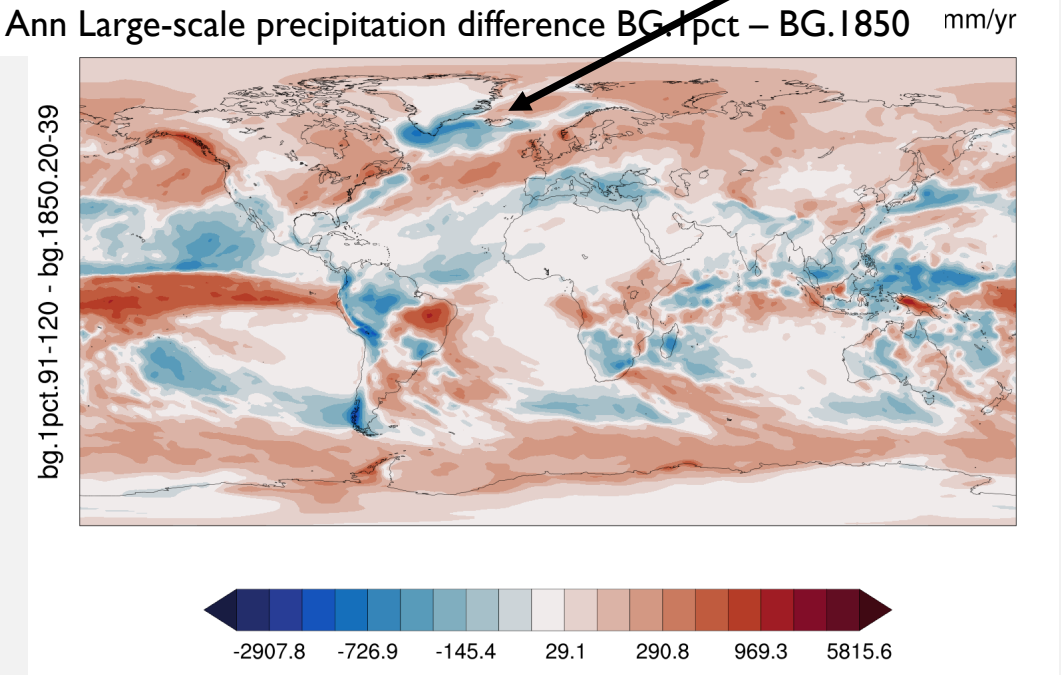


PRECIPITATION

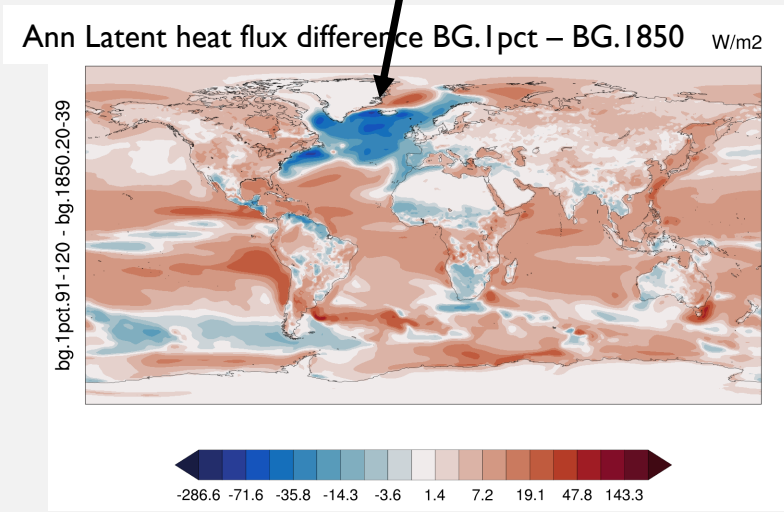
- Southward movement of ITCZ

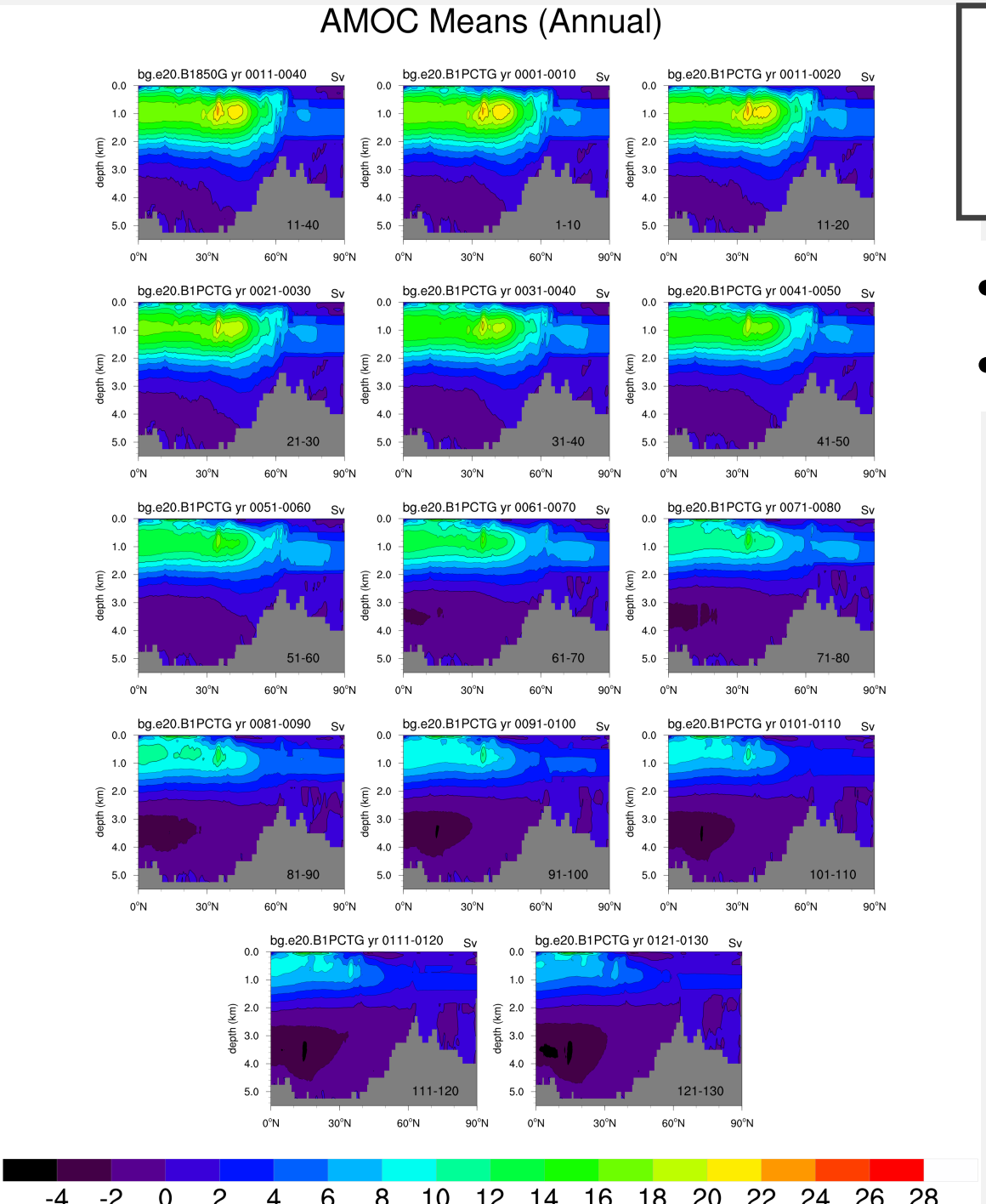
PRECIPITATION





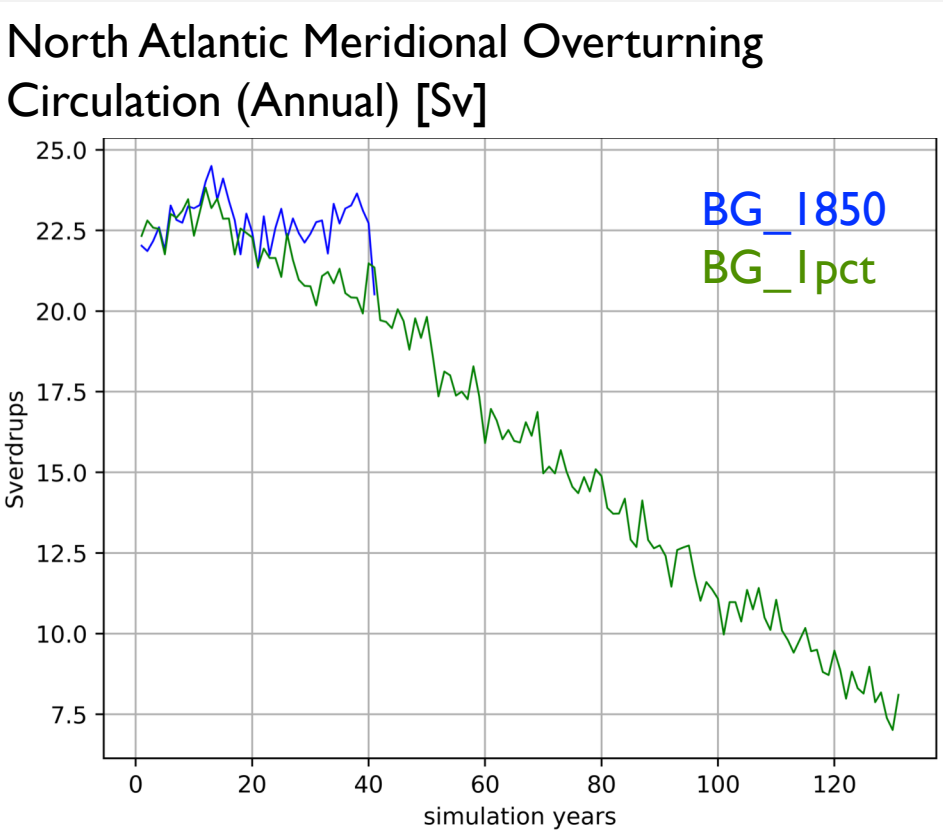
- Southward movement of ITCZ
- Reduced precipitation at the high precipitation region in the South East of Greenland
  - related to the colder ocean surface, less evaporation





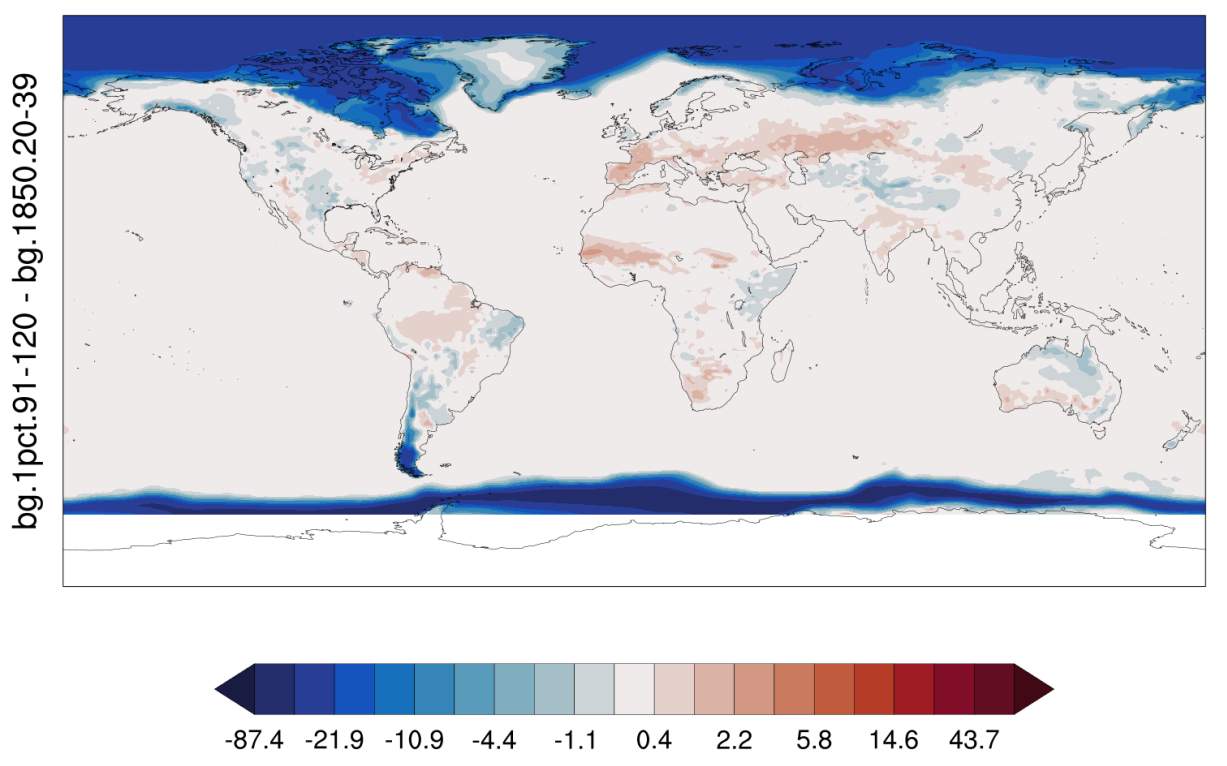
NAMOC COLLAPSE

- NAMOC is weakening a lot
- Maximum is going south

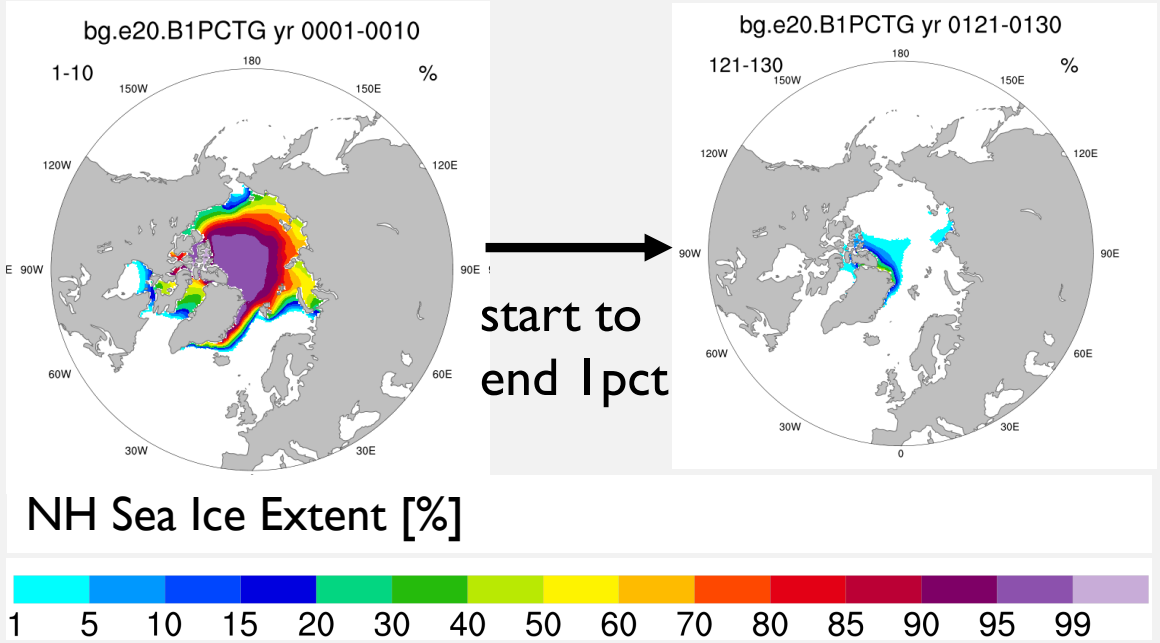


ALBEDO

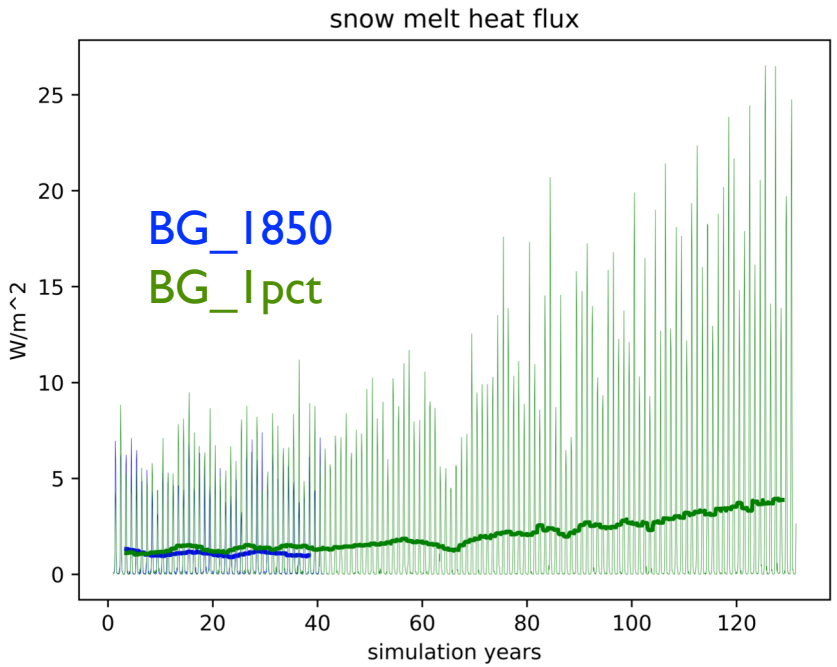
JJA Albedo differences [%] BG.1pct – BG.1850

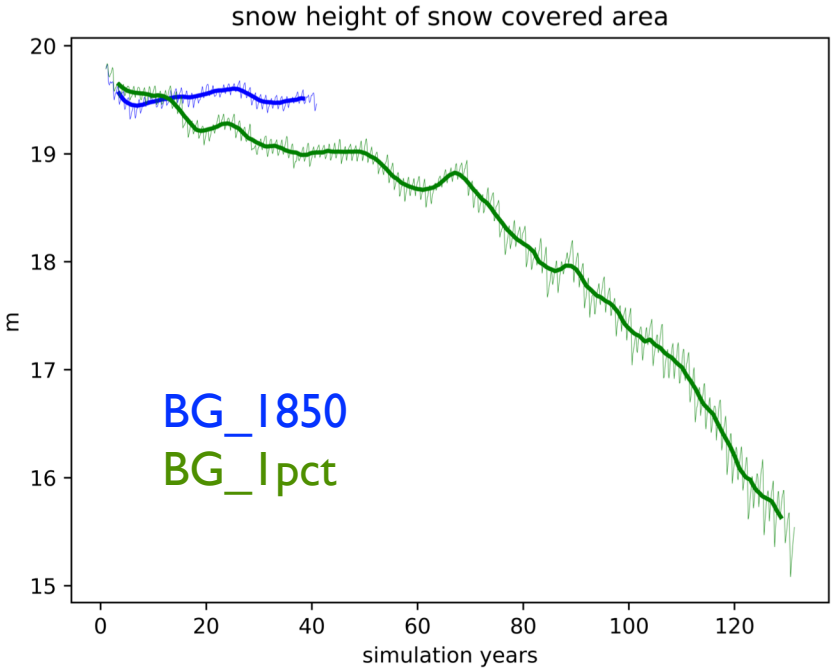


- Albedo decreases at the poles
- Loss of sea ice:
- Only seasonal NH sea ice on by the last decade of the the 1pct run



GREENLAND ICE SHEET SNOW COVER



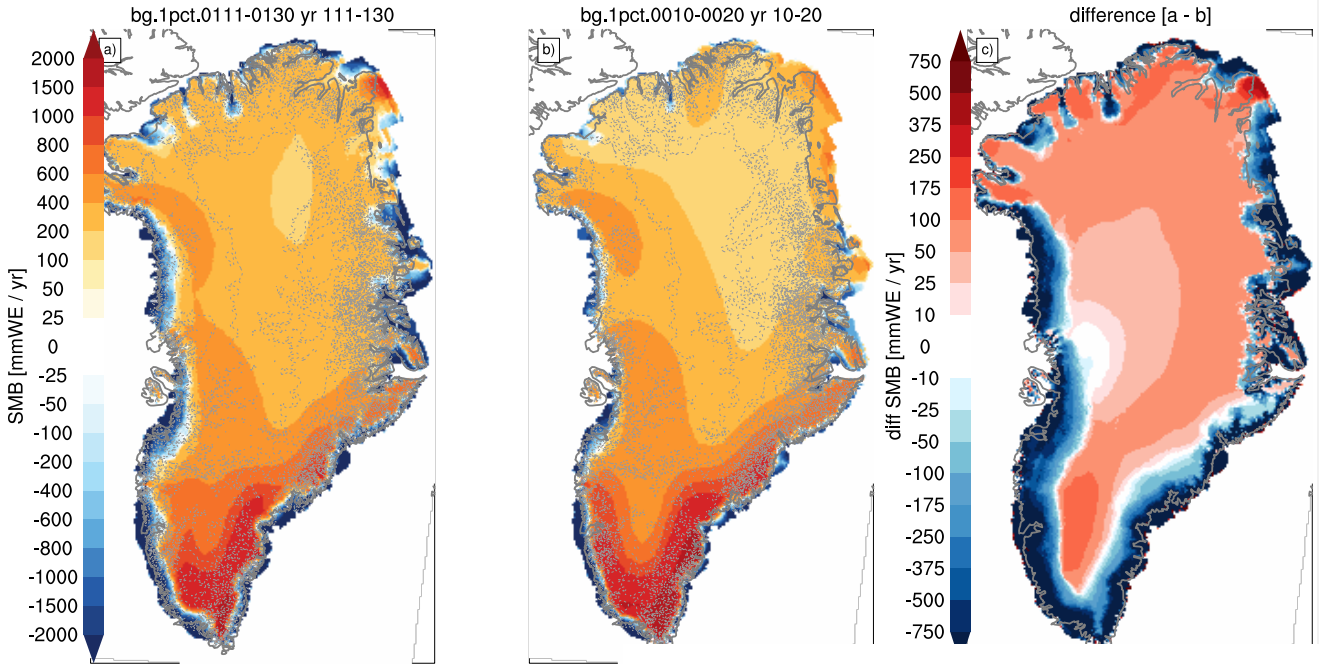


- Greenland ice sheet mean snow melt heat flux [W/m^2] increases
- Seasonal cycle of snow melt heat flux amplifies
- GrIS average snow height [m] decreases

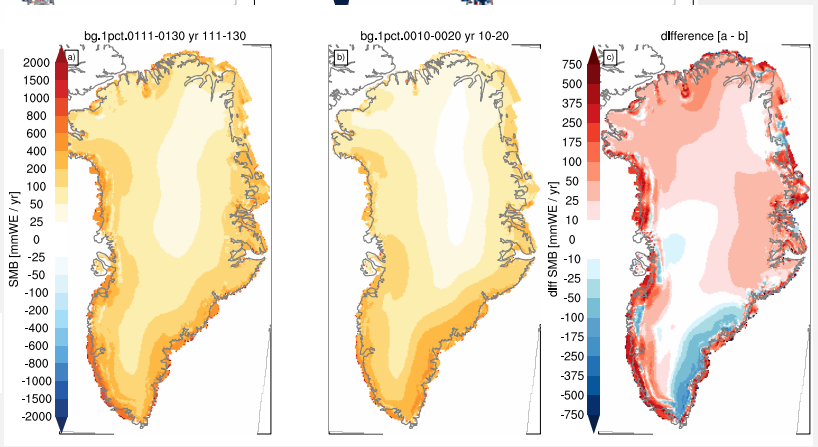
ICE SHEET RESPONSE TO INCREASED CO_2

20 year climatological mean SMB [mmWE/yr] in the 1_pct run:

End | start | difference



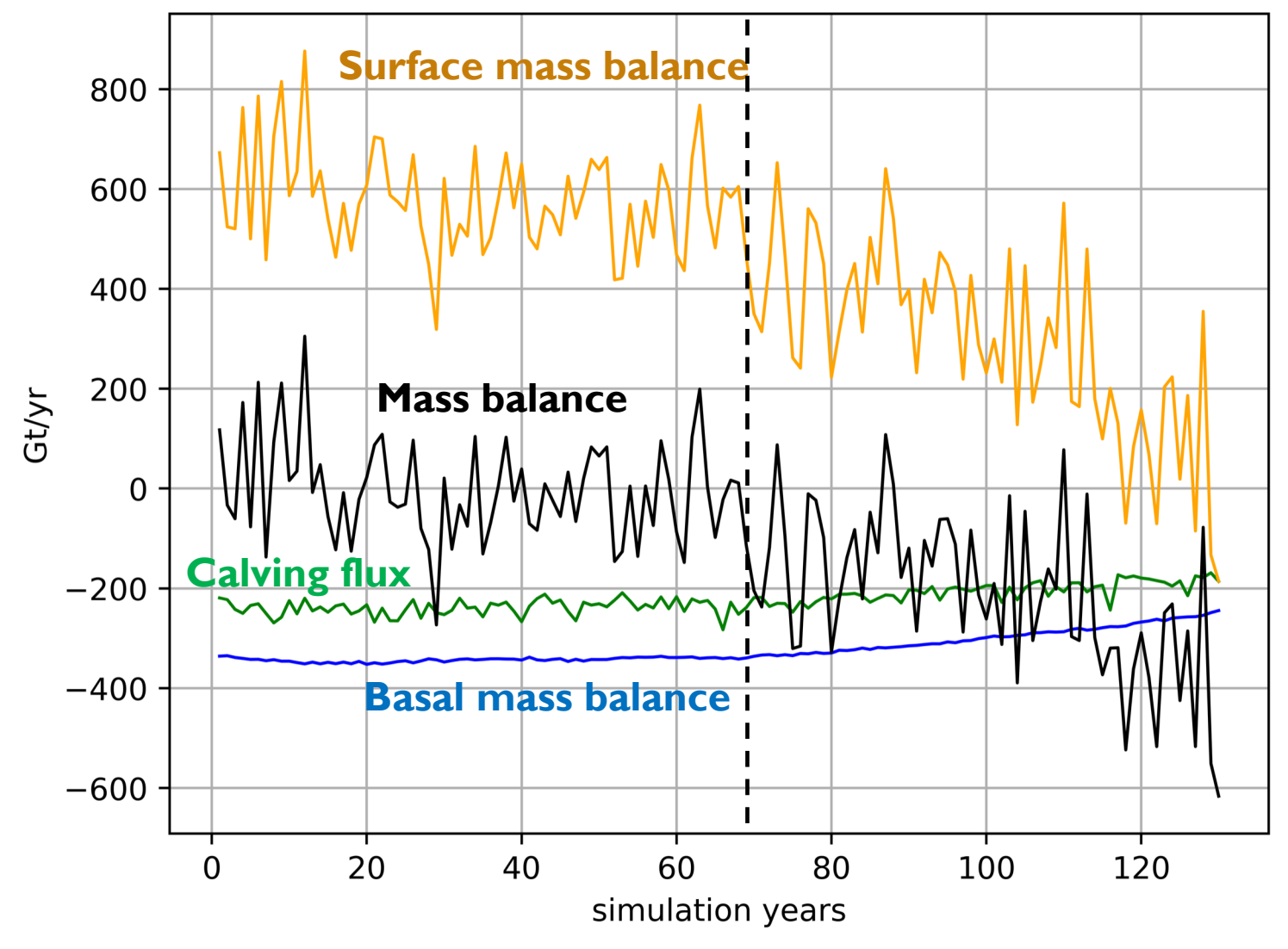
standard deviation:



- Stronger ablation zones at all margins
- Increased accumulation in the interior

- Standard deviation of SMB increases (red) → increased interannual variability, except in the SE high precipitation region

ICE SHEET RESPONSE TO INCREASED CO_2



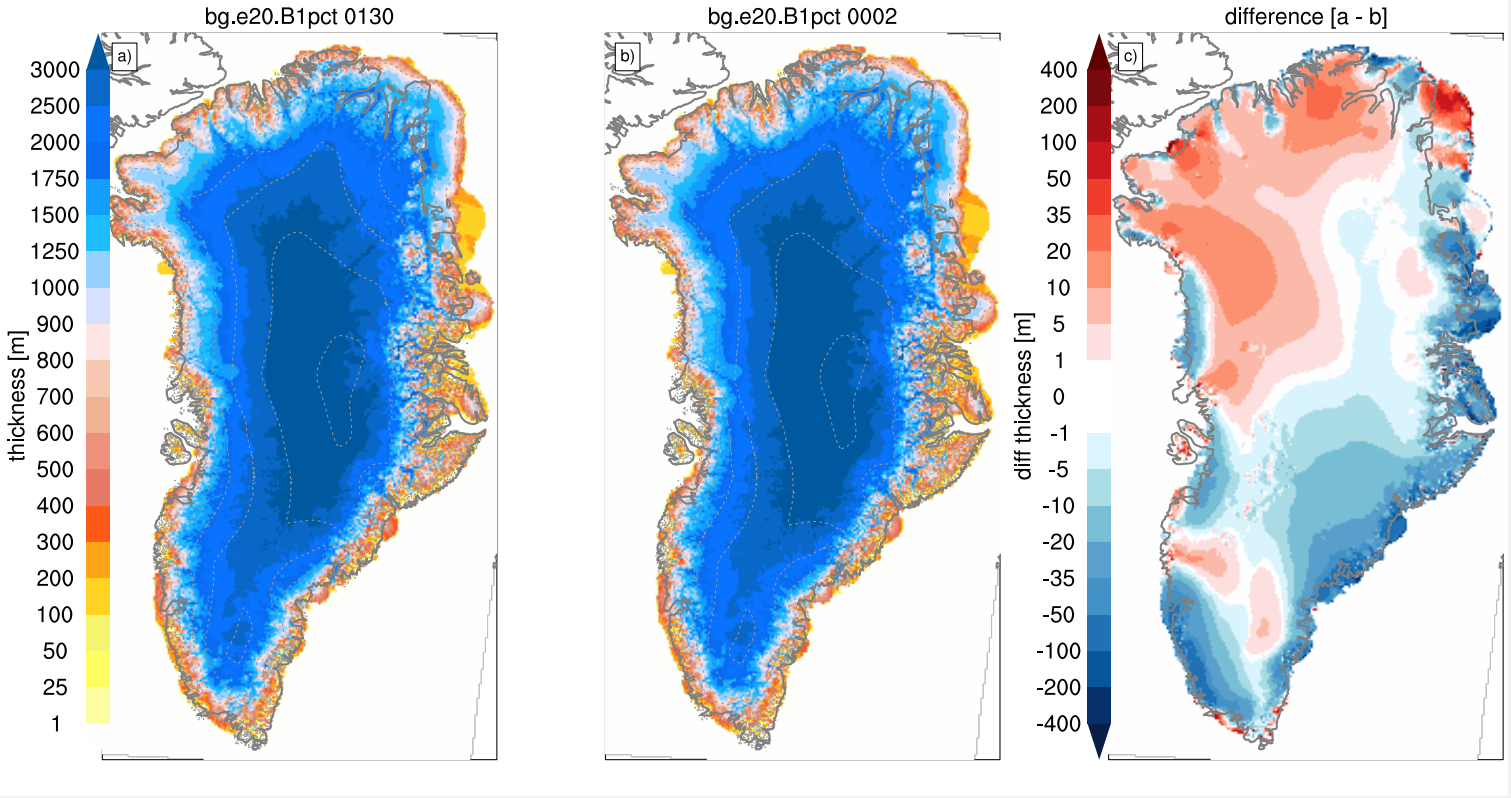
- Mass balance tipping around year 70 [MB < 0]
- After year 70: regime shift in the SMB → accelerated decrease
- Last decade 4 times SMB < 0

Gt/year [std.dev]	year 00-20	year110-130
Mass Balance	**32 [142]**	**-294 [191]**
SMB	617 [124]	168 [164]
Calving	-240 [14]	-191 [16]
BMB	-345 [5]	-271 [11]

ICE SHEET RESPONSE TO INCREASED CO_2

Thickness [m] in the 1 percent run:

End | Start | Difference



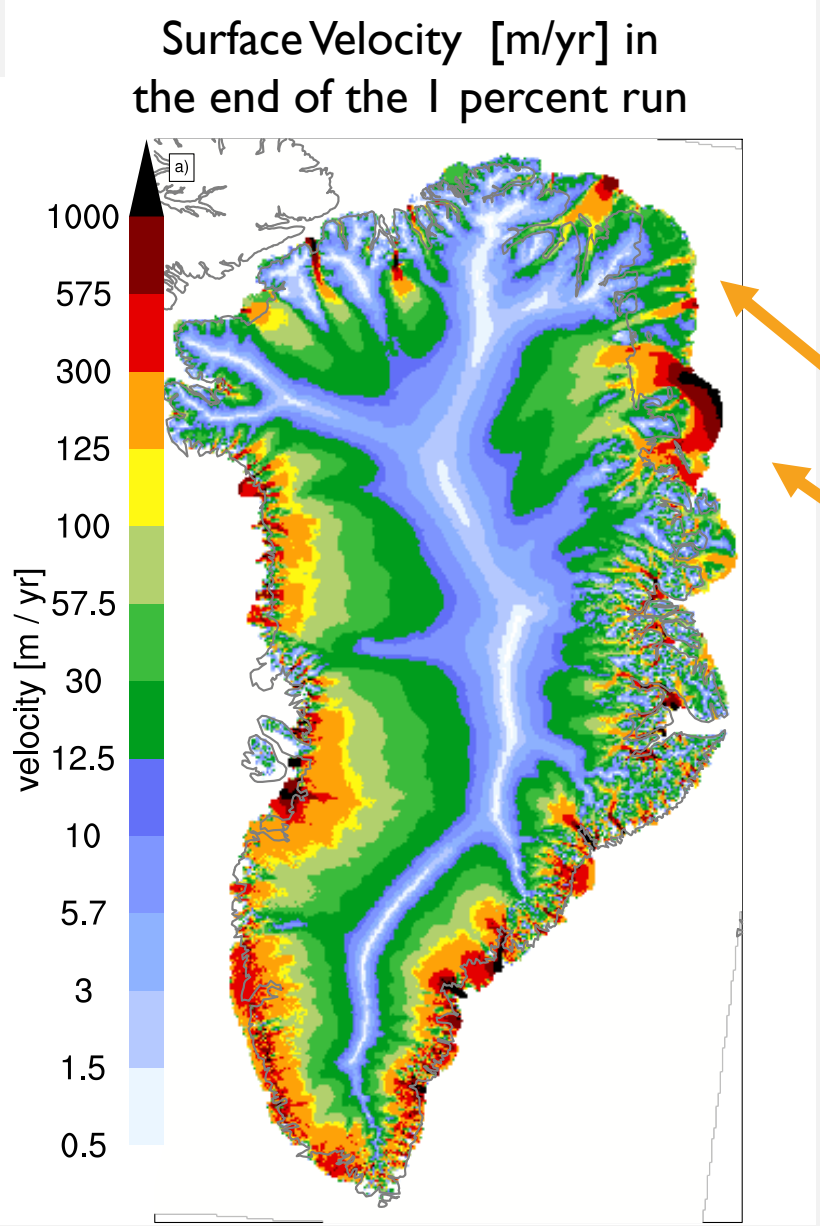
- Mass loss in the South and East part of the Ice Sheet

- Mass gains in the North-West section

→ may be related to increased precipitation

→ may be related to residual trend; volume growth in 1850_control

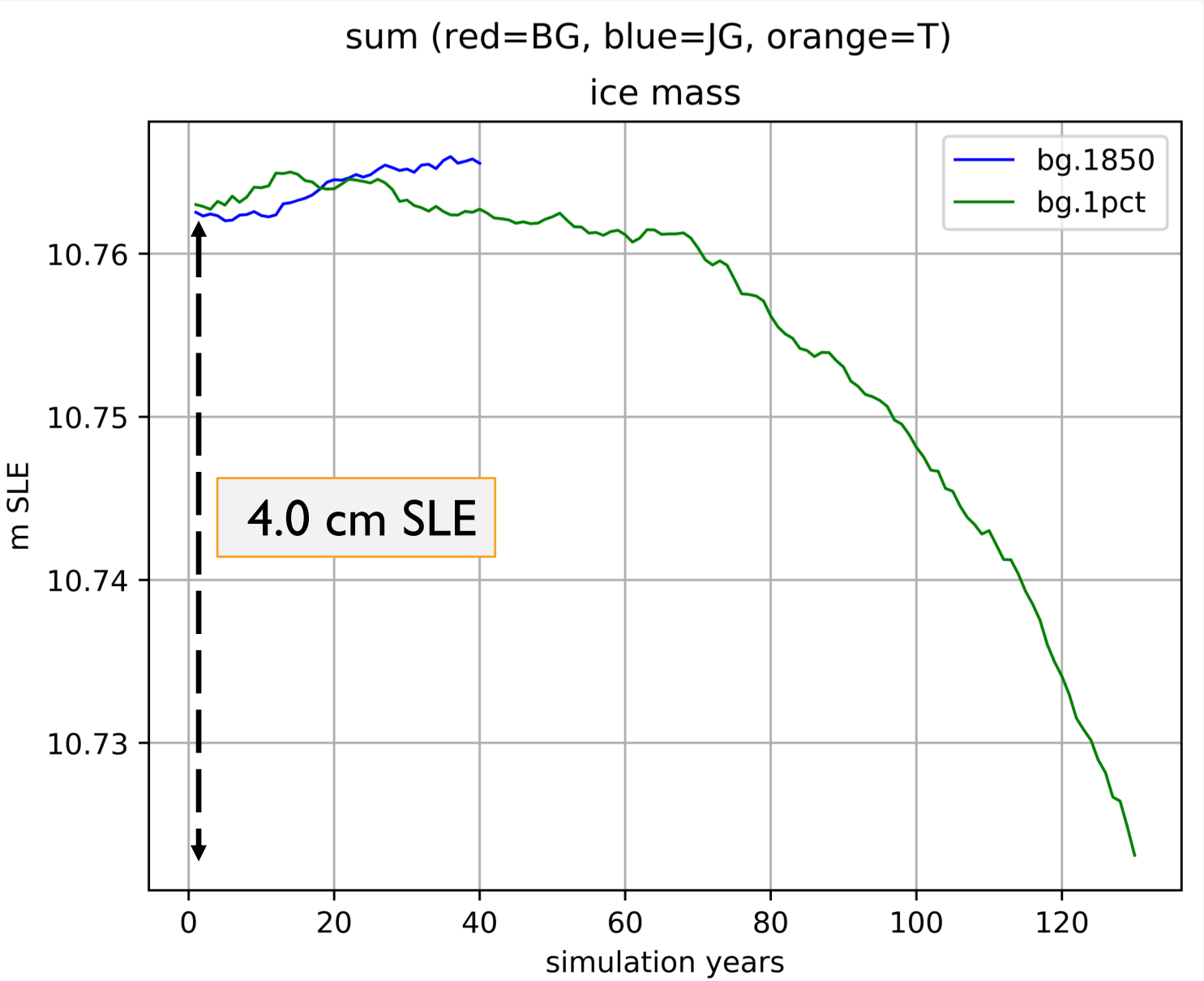
ICE SHEET RESPONSE TO INCREASED CO_2



- Ice sheet velocities don't change much between the start and the end [130 years]

- CISM2.1 has the capability of simulating shelves:
  - shelves that ground
  - floating shelves
- Production ISMIP6 runs will be without shelves

ICE SHEET RESPONSE TO INCREASED CO_2



- Drift ice volume in Control run BG.1850
- Not until doubling of CO_2 there is an acceleration of mass loss [~ year 70] in BG.1pct

- Sea level contribution after 130 years: 4.0 cm with respect to year 1 of BG.1pct

CONCLUSIONS

The **test** simulation of 1% yr^{1} increase CO_2 up till the value of 4 times the pre-industrial concentration **demonstrates the climate-ice sheet coupling in CESM2.1**

Key responses of the global and polar climate to increased levels of CO2

- Global increase in surface temperatures
- NAMOC decrease
- Changes in the Greenland surface mass balance (↓), and contribution to eustatic sea level rise (↑)

OUTLOOK

Current status ISMIP6 runs

- finish the spin-up [presentation later today in the joint session]

Next simulations - to start soon:

- pre-industrial (1850) control
- 1 percent CO_2 increase till 4x CO_2
- Historical 20th century simulation and SSP5-8.5

QUESTIONS?

questions later:

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