ICE-SHEET/CLIMATE MODEL COUPLING: EFFICIENT SPIN-UP PROCEDURE FOR CESM2.1 AND CISM2.1

Laura Muntjewerf, Marcus Lofverstrom, Jeremy Fyke

Many thanks to: Kate Thayer-Calder, Sarah Bradley, William Lipscomb, Keith Lindsay, Mariana Vertenstein, Bill Sacks

CESM Land Ice Working Group Meeting 2019

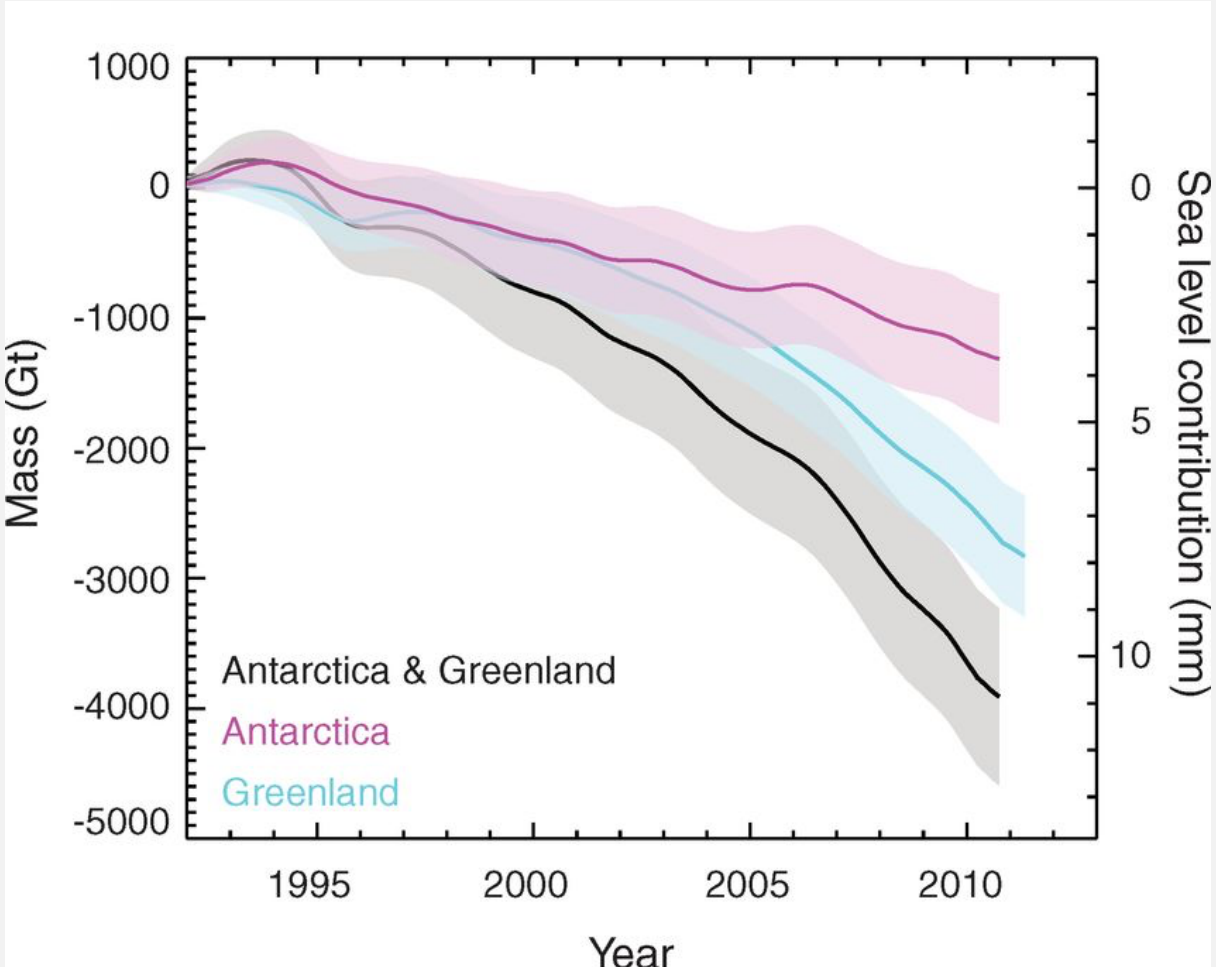
February 4th 2019

TU Delft

European Research Council

Established by the European Commission

GREENLAND IS LOSING MASS



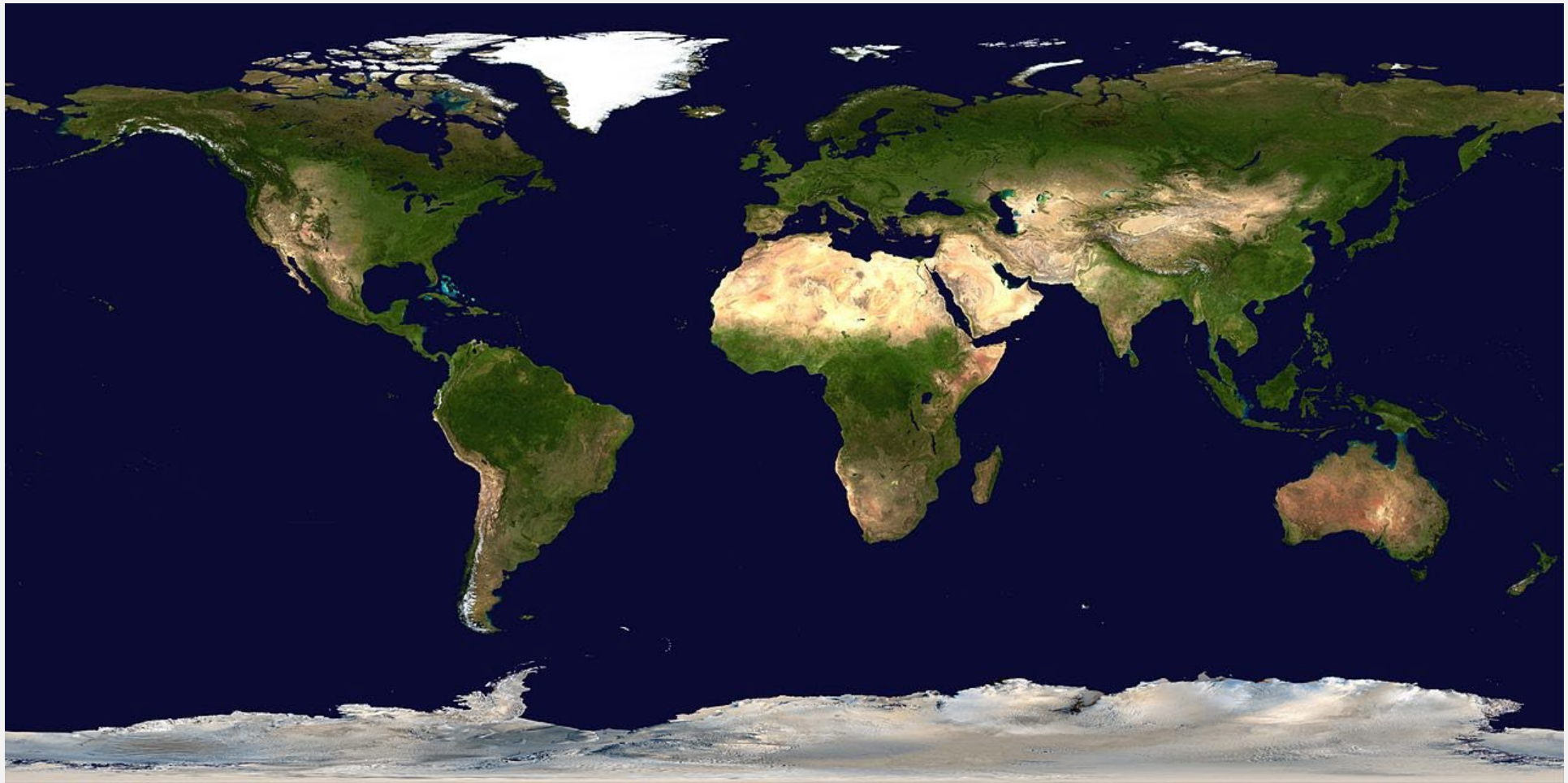
Shepherd et al., 2012

INTRODUCTION

GOAL: MODEL GREENLAND ICE SHEET CONTRIBUTION TO GLOBAL MEAN SEA LEVEL RISE…

INTRODUCTION

… AS PART OF A COUPLED EARTH SYSTEM



INTRODUCTION

WHAT DO WE NEED?

1 A COUPLED CLIMATE/ICE SHEET MODEL **CHECK**

2 STEADY STATE INITIAL CONDITIONS **TODO**

SPIN-UP SIMULATION

CONTENTS

METHOD - SPIN-UP PROCEDURE

Motivation: Coupled ice-sheet/climate system needs long equilibration (~10.000 years) but it's too expensive/slow to do with brute force

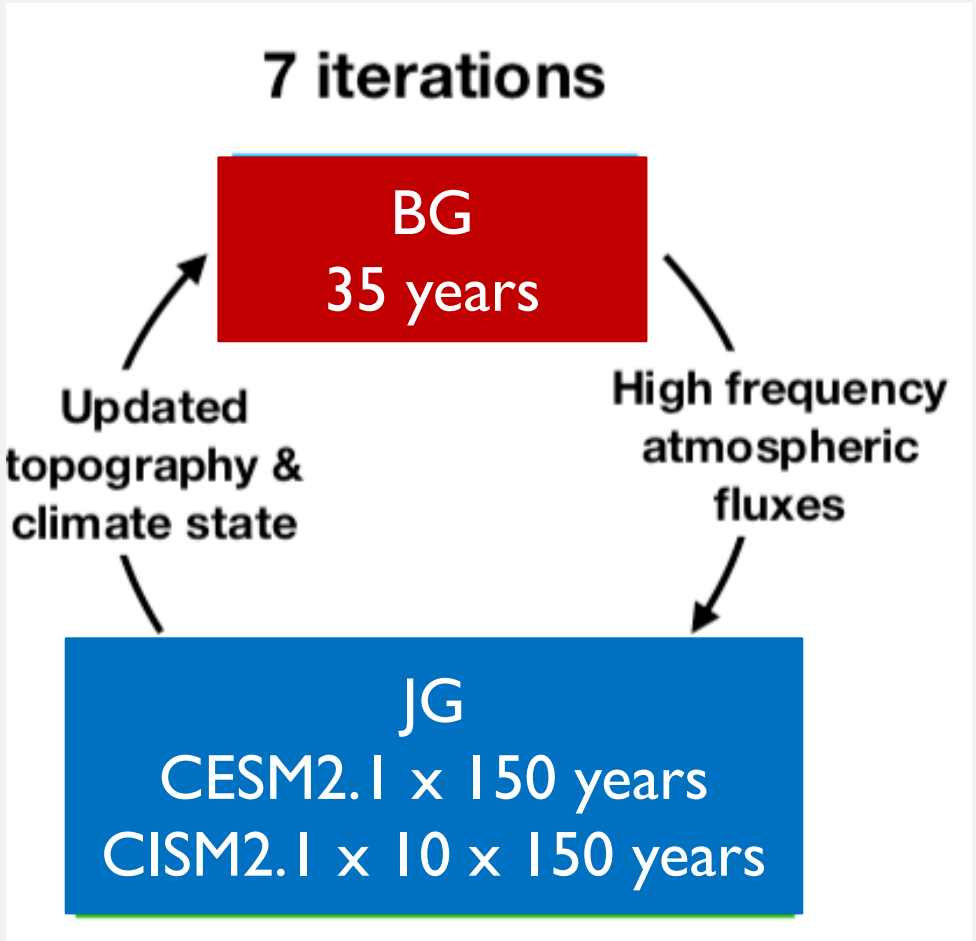
Idea: 'Iterated' spin-up between fully-coupled BG and 'all-active-but-atmosphere' JG simulations.

Implementation: construction of iteration methodology in CESM scripts and code

Production spin-up: Run CESM2.1-CISM2.1 to near-equilibrium under Pre-Industrial forcing protocol (10,000 CISM years)

METHOD - SPIN-UP PROCEDURE

- **BG compset:** all components active, synchronous ice sheet coupling
- **JG compset:** all components except CAM active, data atmosphere, 10x accelerated ice sheet



10,000 CISM2 years

	Cost: 10^6 CPU-hrs
BG synch CISM2	35
BG 10x CISM2	3.5
JG-BG iteration	2

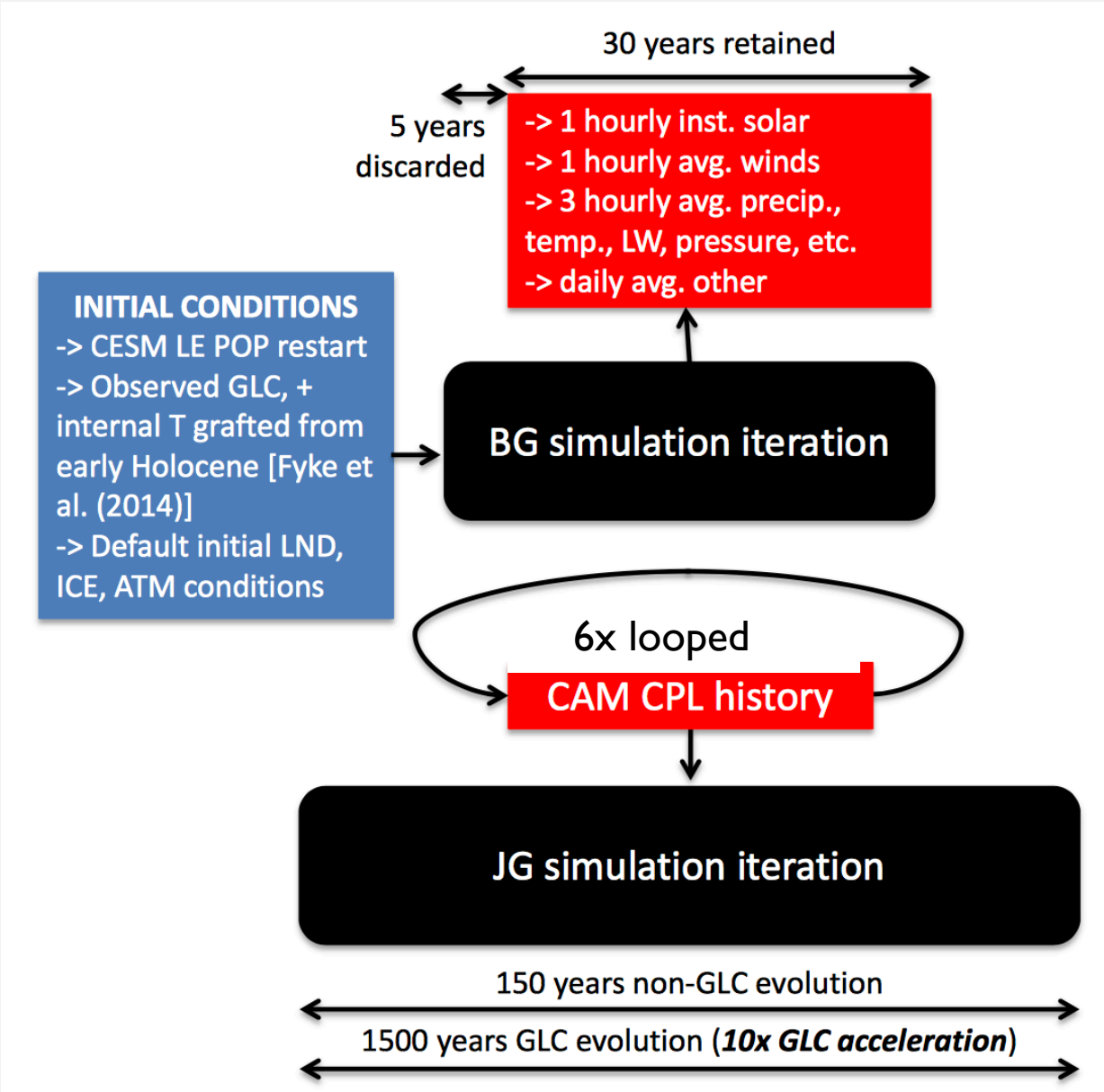
METHOD - SPIN-UP PROCEDURE

Total simulation years:

Atmosphere:	7 * 35 + 65	= **310**
Ocean:	ATM + 6 * 150	= 1210
Land:	„	= 1210
Sea ice:	„	= 1210
Ice sheet:	ATM + 6 * 1500	= **9310**

Parameterizations:

- CLM; no LW downscaling
- CLM; glacier region rain to snow behavior over GrIS adapted
- CISM; revised sliding parameters
- POP: SSS restoring in JG



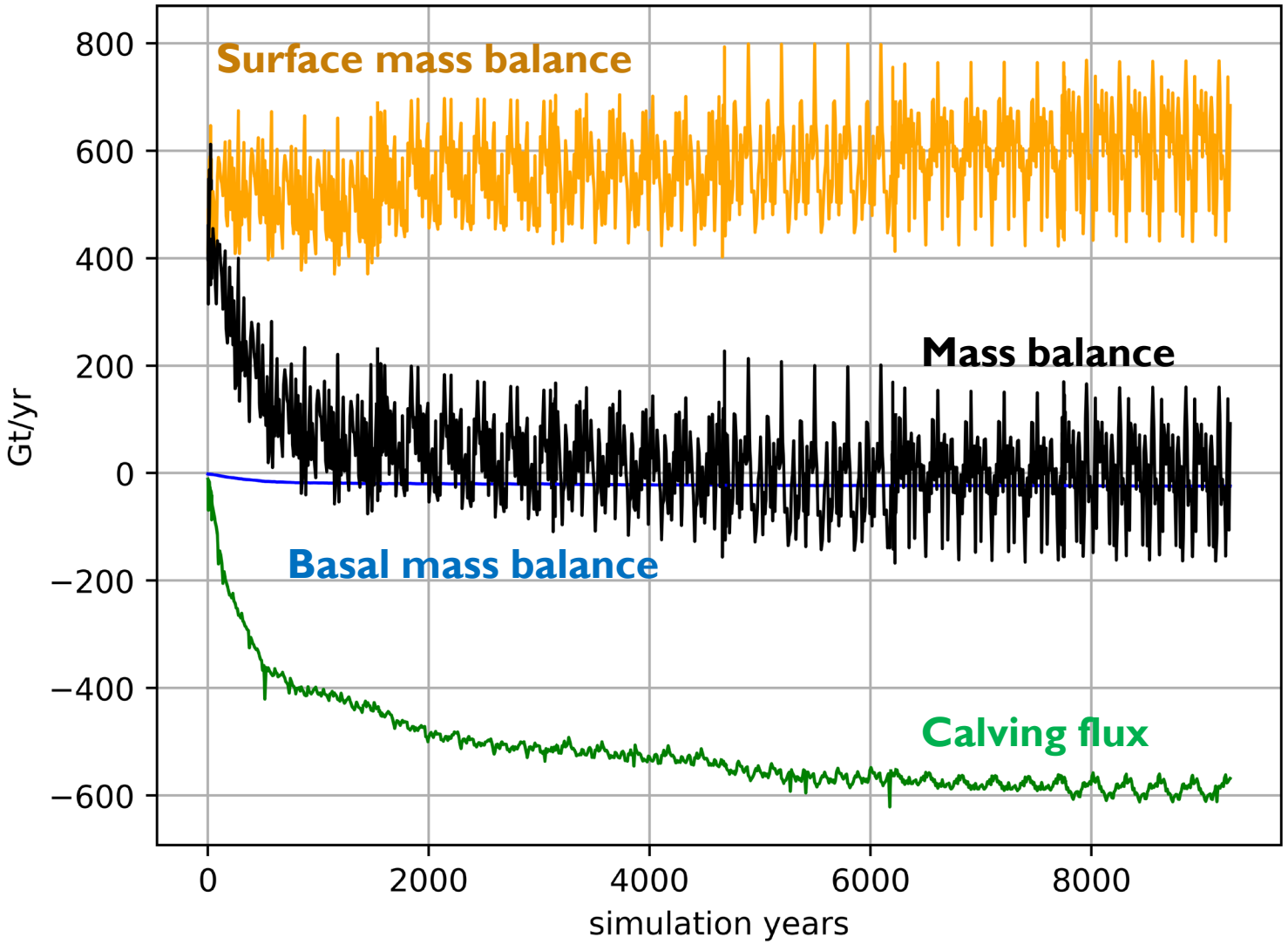
RESULTS - STABILITY

Climate stability is important to determine whether the spin-up simulation has run long enough

- Ice sheet state: mass balance, volume and area
- Ocean: NAMOC stability

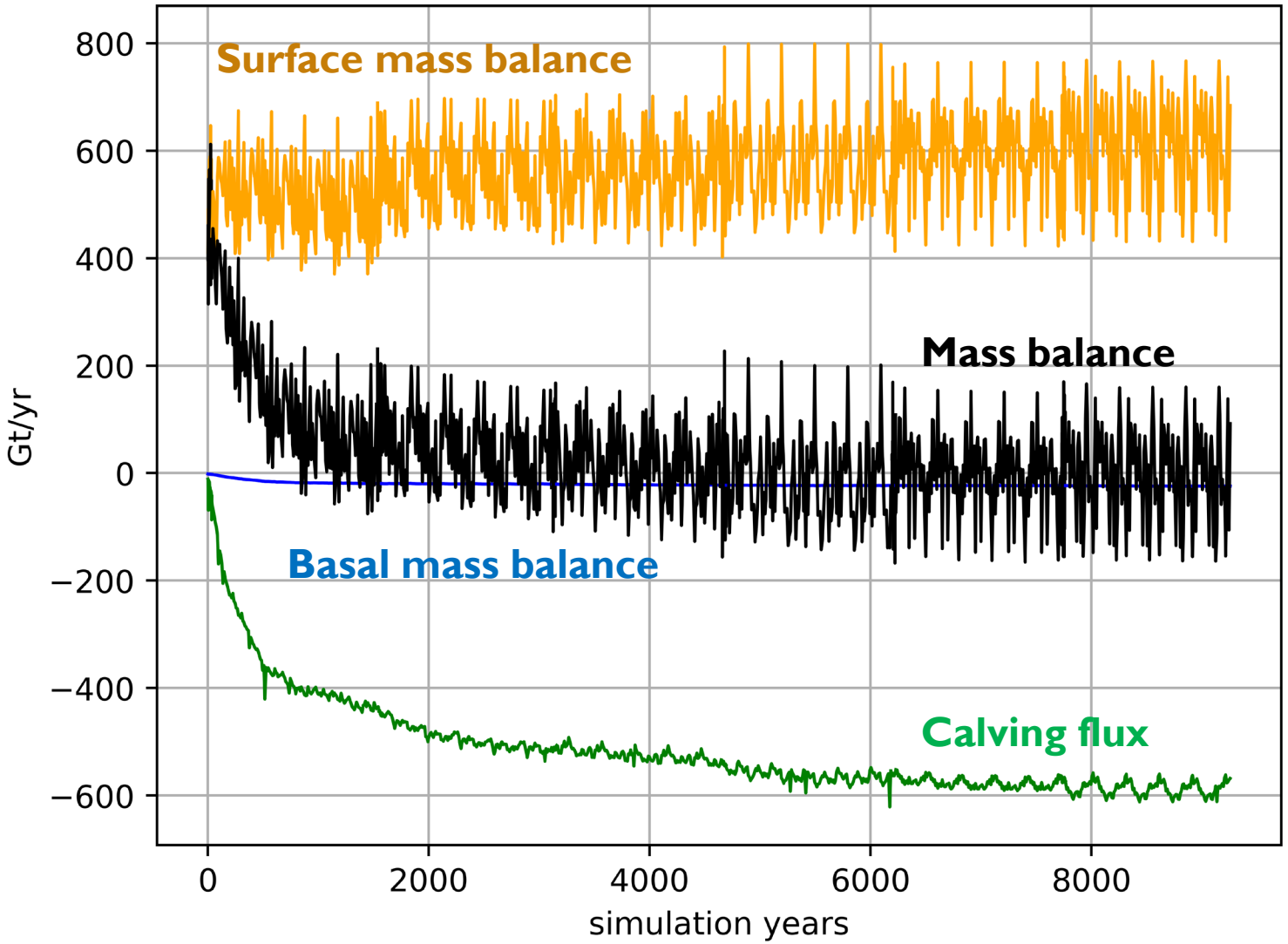
RESULTS - ICE SHEET STABILITY

Greenland Ice sheet final equilibrium



- By end of simulation, the ice sheet is close to equilibrium and has volume, extent in velocities that compare well with observations

RESULTS - ICE SHEET STABILITY



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Residual trend in Greenland Mass Balance after 9000+ CISM years:

-4.8 Gt/yr [std.dev 99.7 Gt/yr]

-0.0134 mm SLE/yr [std.dev 0.276 mm SLE/yr]

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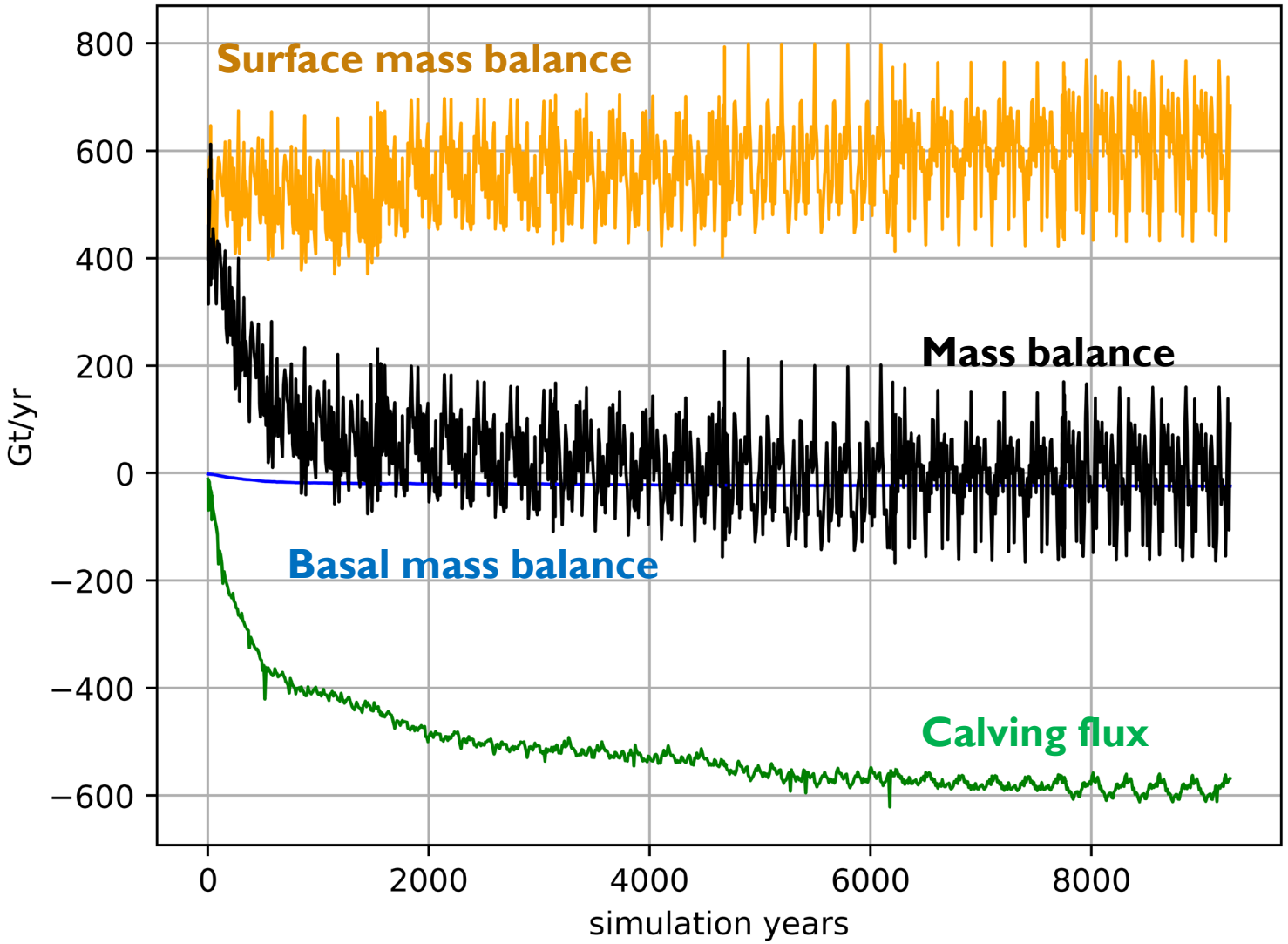

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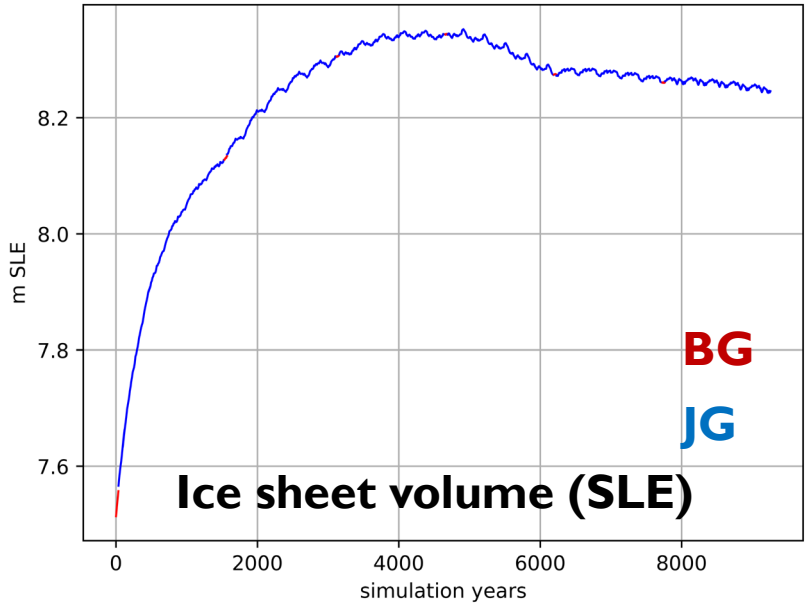

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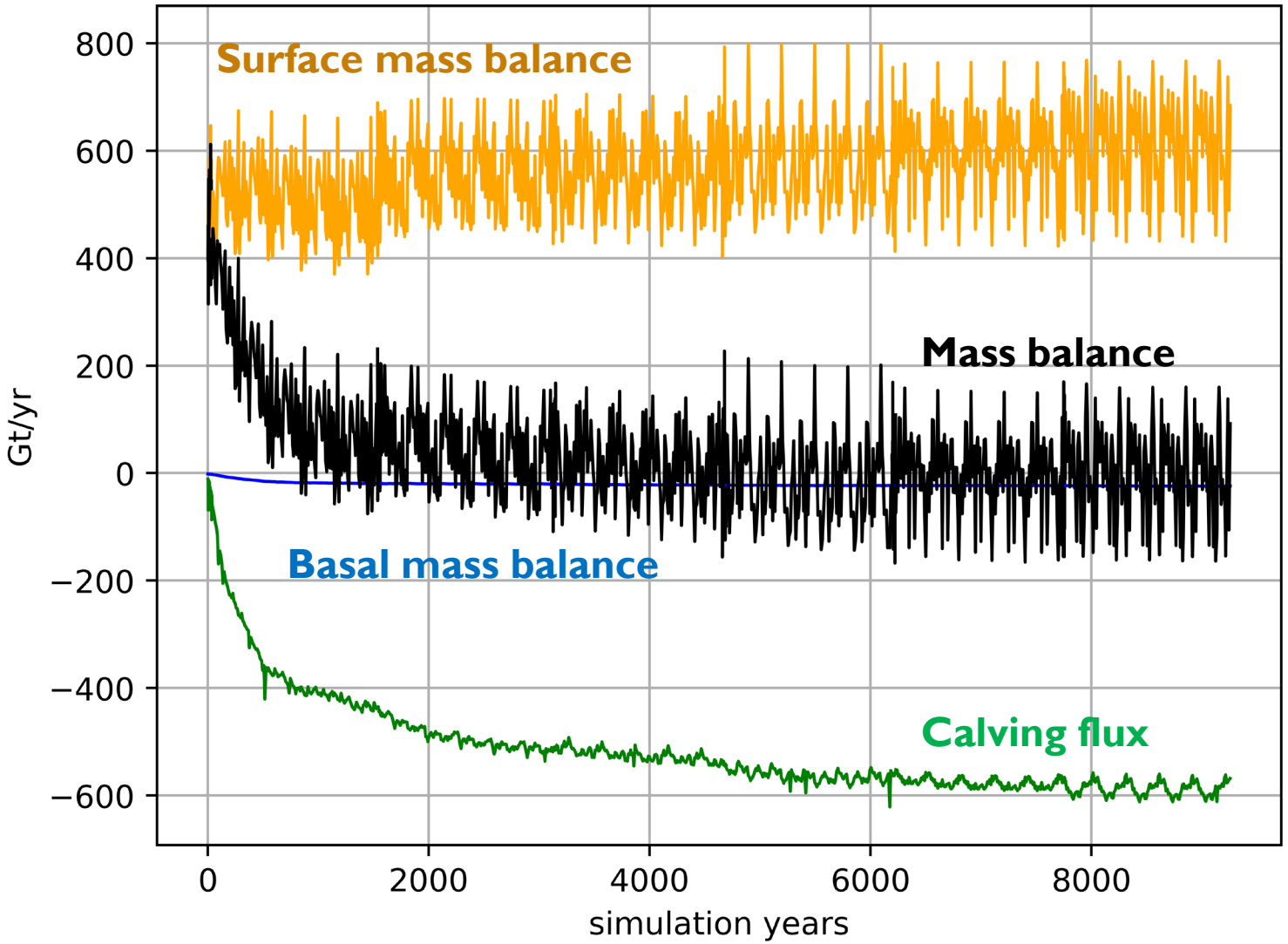

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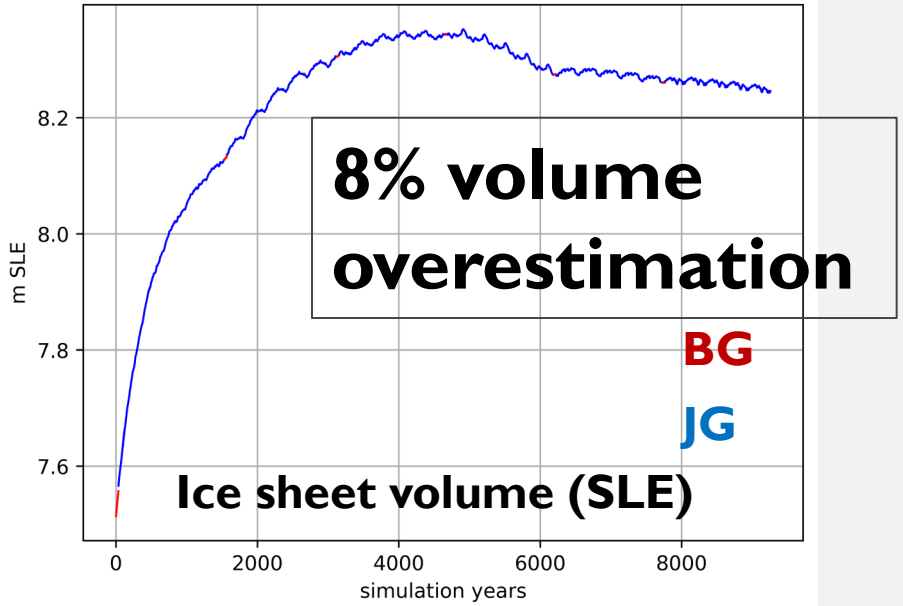
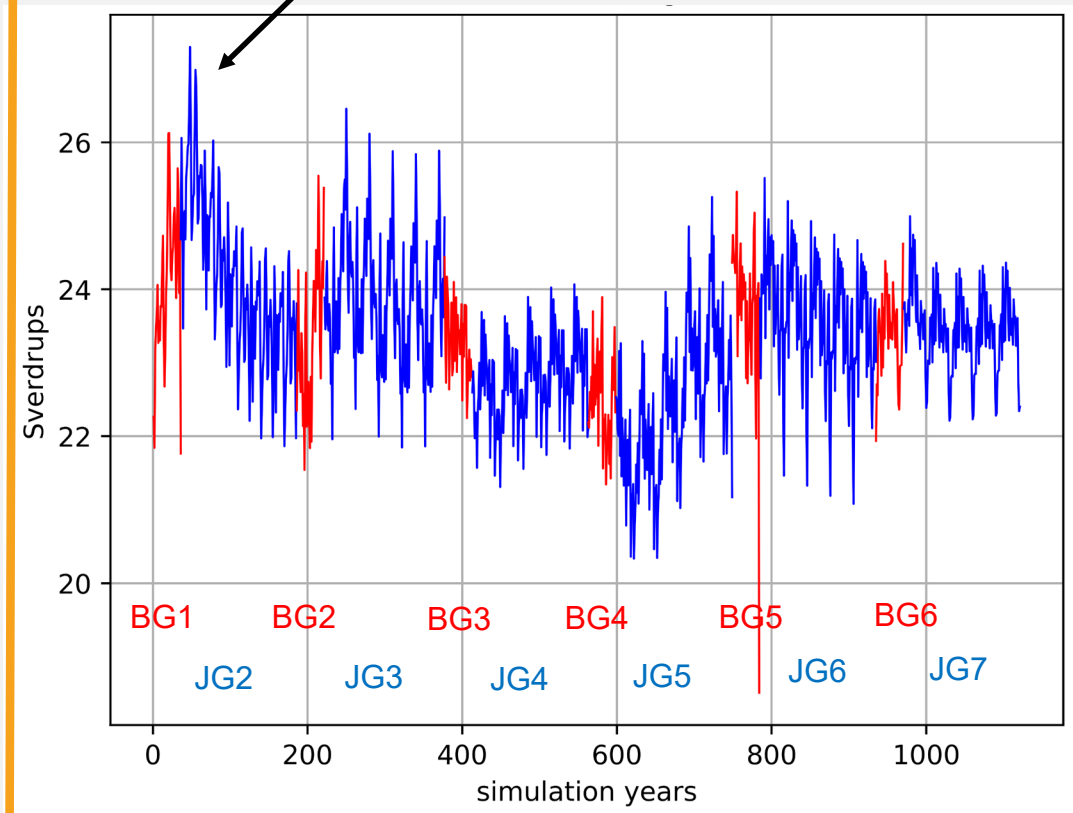


RESULTS - CLIMATE: NAMOC STABILITY

Climate final equilibrium

- NAMOC strength increases when introducing an interactive growing ice sheet



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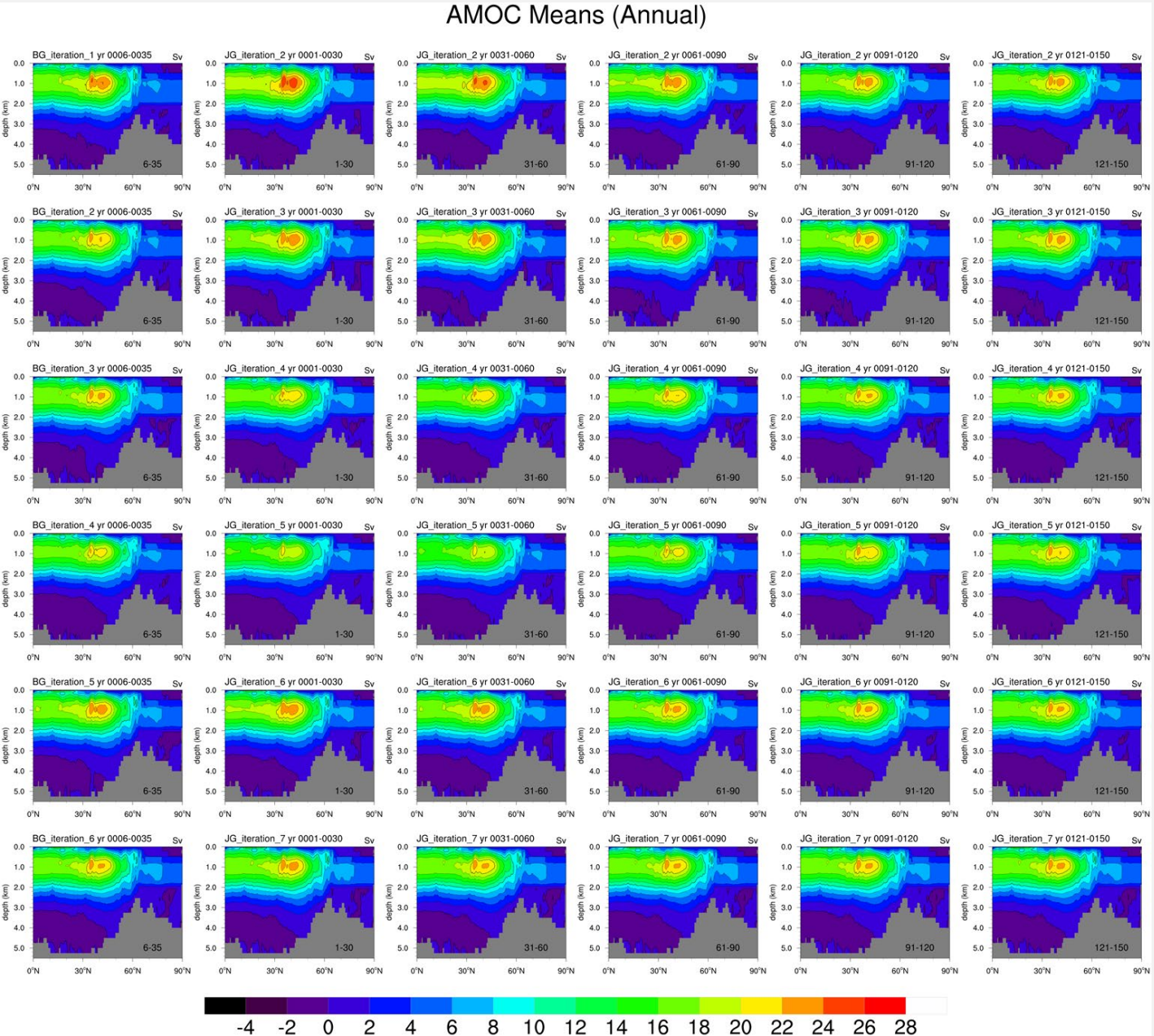
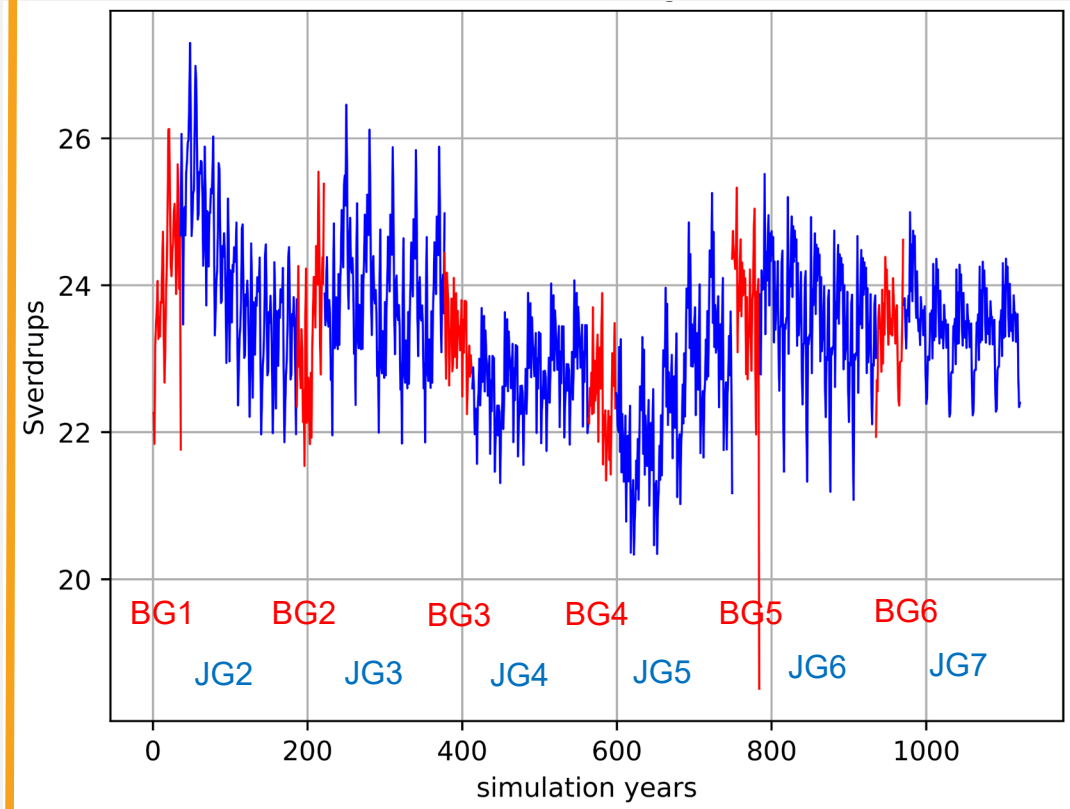


Climate final equilibrium

- NAMOC strength increases when introducing an interactive growing ice sheet
- As the ice sheet stabilizes, the NAMOC index decreases, recovers to similar values as non-interactive simulation (B1850)



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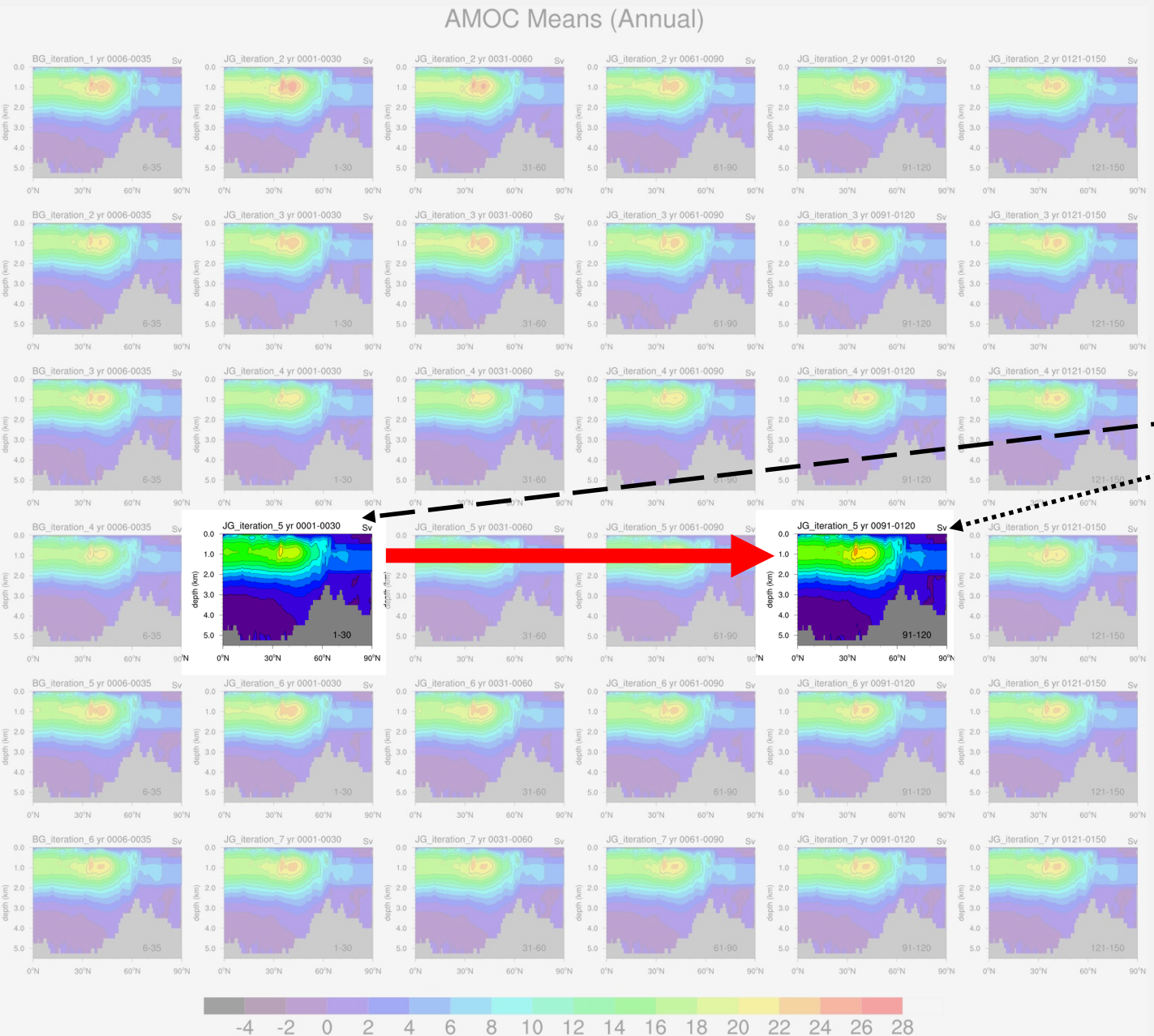
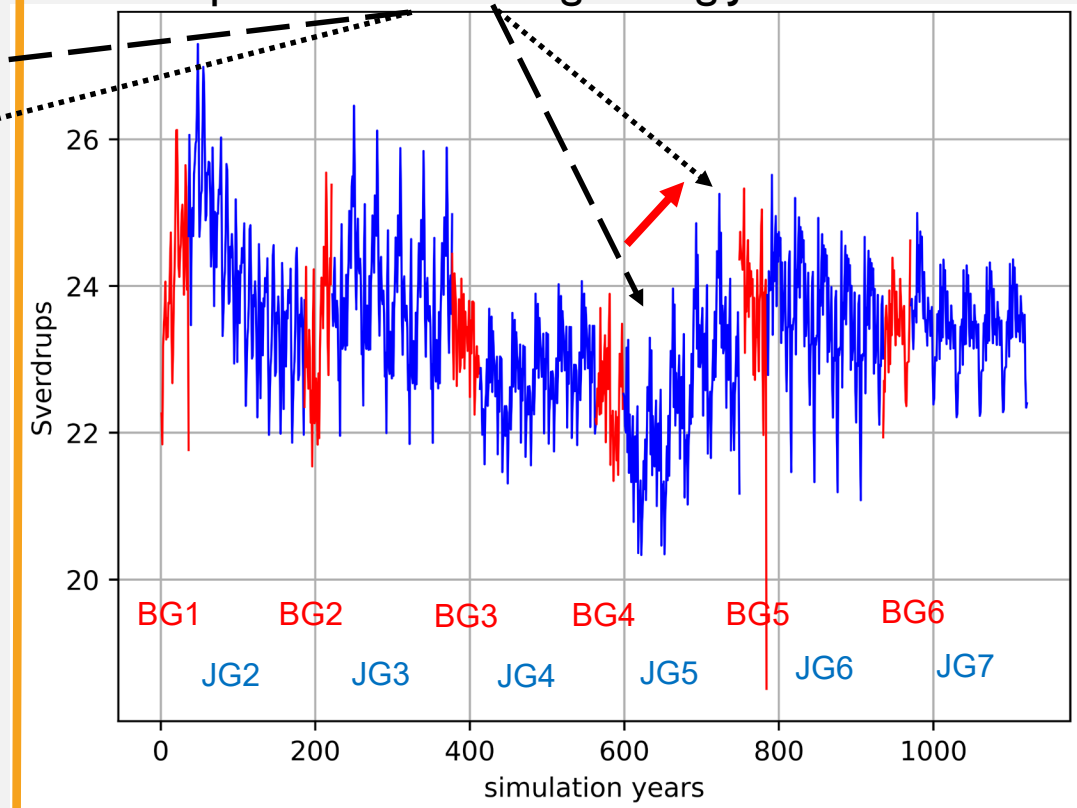


Climate final equilibrium

- NAMOC strength increases when introducing an interactive growing ice sheet
- As the ice sheet stabilizes, the NAMOC index decreases, recovers to similar values as non-interactive simulation (B1850)
- Capable of recovering during JG5 - DATM



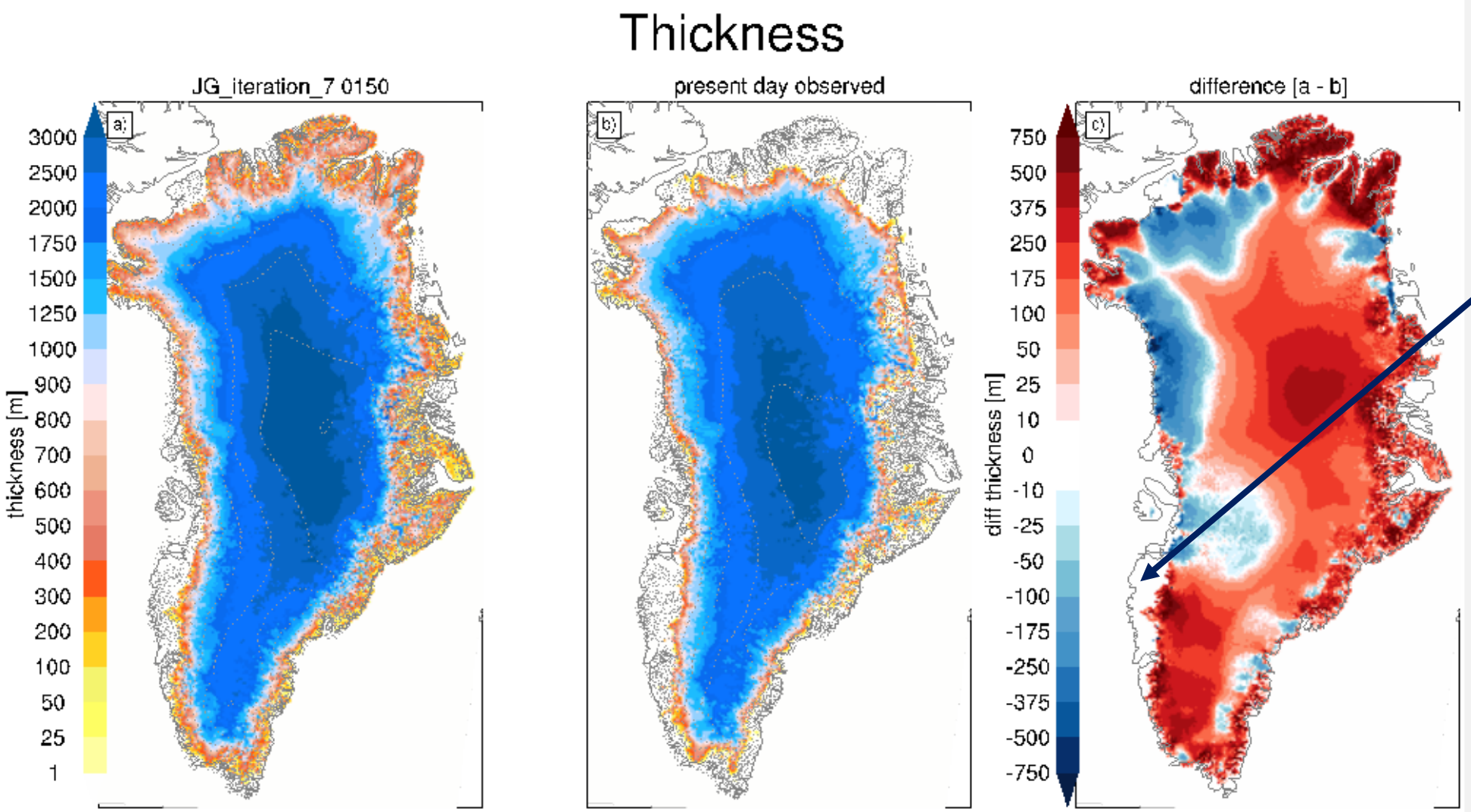
RESULTS - GREENLAND ICE SHEET EVALUATION

Now: what does the Greenland Ice Sheet look like so far?

Evaluation against observations

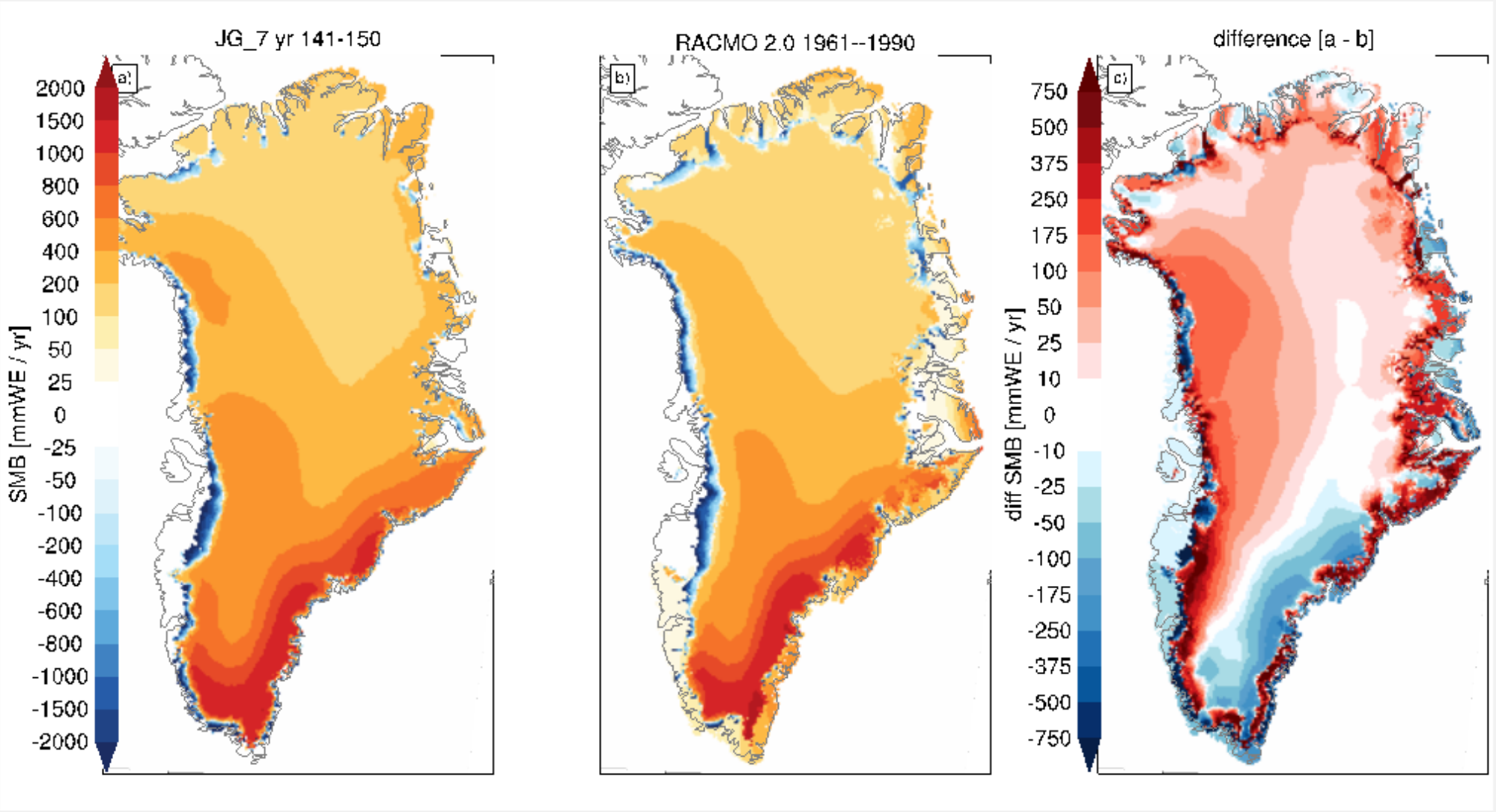
- Ice sheet thickness
- Ice sheet surface mass balance
- Ice sheet velocities

RESULTS - GREENLAND ICE SHEET EVALUATION



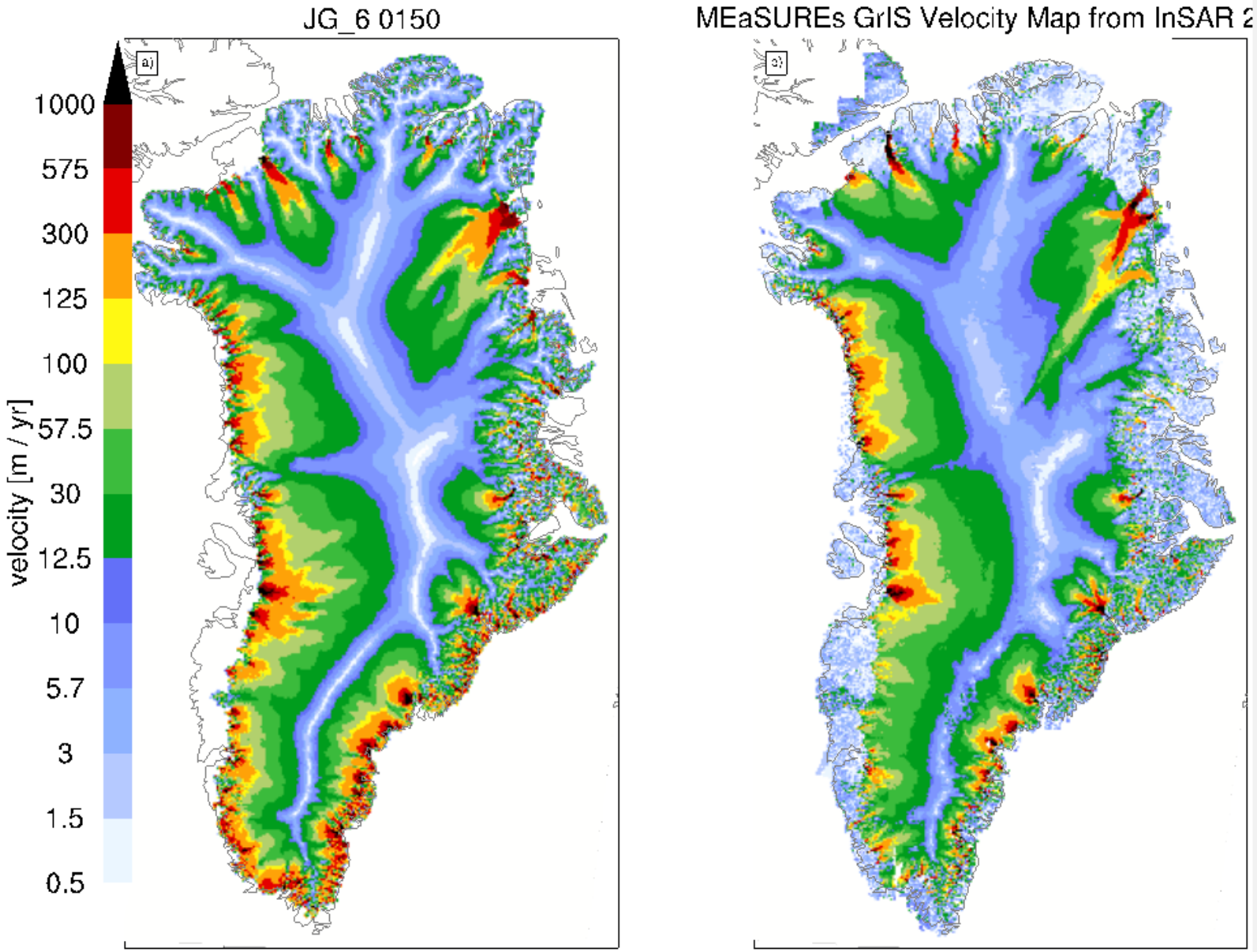
- Too thick in general
- Northern Tundra covered
- Ice free SW tundra!
- Too thin in major outlet glacier drainage basins [relation with velocities?]

RESULTS - GREENLAND ICE SHEET EVALUATION



- Too large SMB compared to RACMO
- Ablation zone in NW and SW well resolved
- Ablation zones in outlet glaciers are present (Petermann)

RESULTS - GREENLAND ICE SHEET EVALUATION



- Velocity magnitudes OK
- Too much fast-flowing ice streams in the south (relates to thickness)
- Northern ice streams very well resolved!

CURRENT STATUS OF SPIN-UP

- Greenland ice sheet realistic ablation zones, realistic velocity field, volume +8% compared to observed
- Stable global climate, stable AMOC

As a main 'goal' of the JG/BG is to reduce the CPU time spent on CAM cycles (CAM is $$$), while still retaining the influence of atmospheric regulation of coupled-system coupling:

- CPU-hrs spent: 1.5 M

OUTLOOK

Finish with 100 years fully-coupled to demonstrate statistical stability

Use the end state as initial conditions for ISMIP6 runs:

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

QUESTIONS?

questions later:

l.muntjewerf@tudelft.nl