Sensitivity of the AMOC to Northern Glacier Melting in Future Climate Change Experiments.

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Background

- IPCC 2001 : None of the GCM model includes melting of land-ice (Greenland, Antarctic and mountain glaciers)

- EMICs: collapse of AMOC for a freshwater input of 0.2 Sv (Rahmstorf, 1995)

- Fichefet et al. (2003) : using Greenland Ice-sheet model coupled to a GCM

$\Rightarrow$ melting of Greenland could be an important term for the AMOC response to global warming

Aim of this work

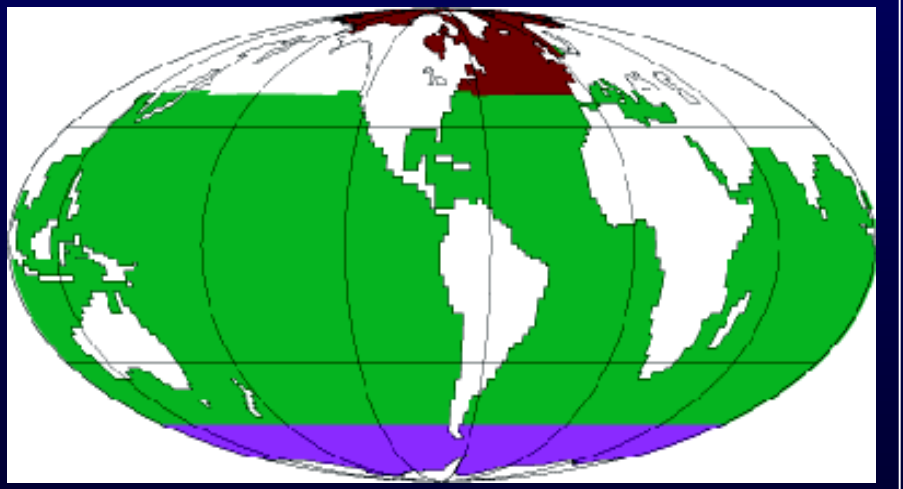
- Estimate simply land ice and snow melting and freshwater return to the ocean, in order to consider the climatic impact of land-ice (glacier) melting in scenario simulation

- Analyze the climatic feedbacks triggered by a weakening of the AMOC due to the additional freshwater input by land-ice melting on a 100 years time-scale

Tool: IPSL-CM4 coupled GCM Paris, France

IPSL-CM4:
- Ocean ORCA2: 2°*(0.5-2°) resolution
- Sea-ice LIM: dynamic-thermodynamic
- Atmophere LMDz: 3.75° resolution
- Land model ORCHIDEE with a correct river routing scheme

Closure of the water budget



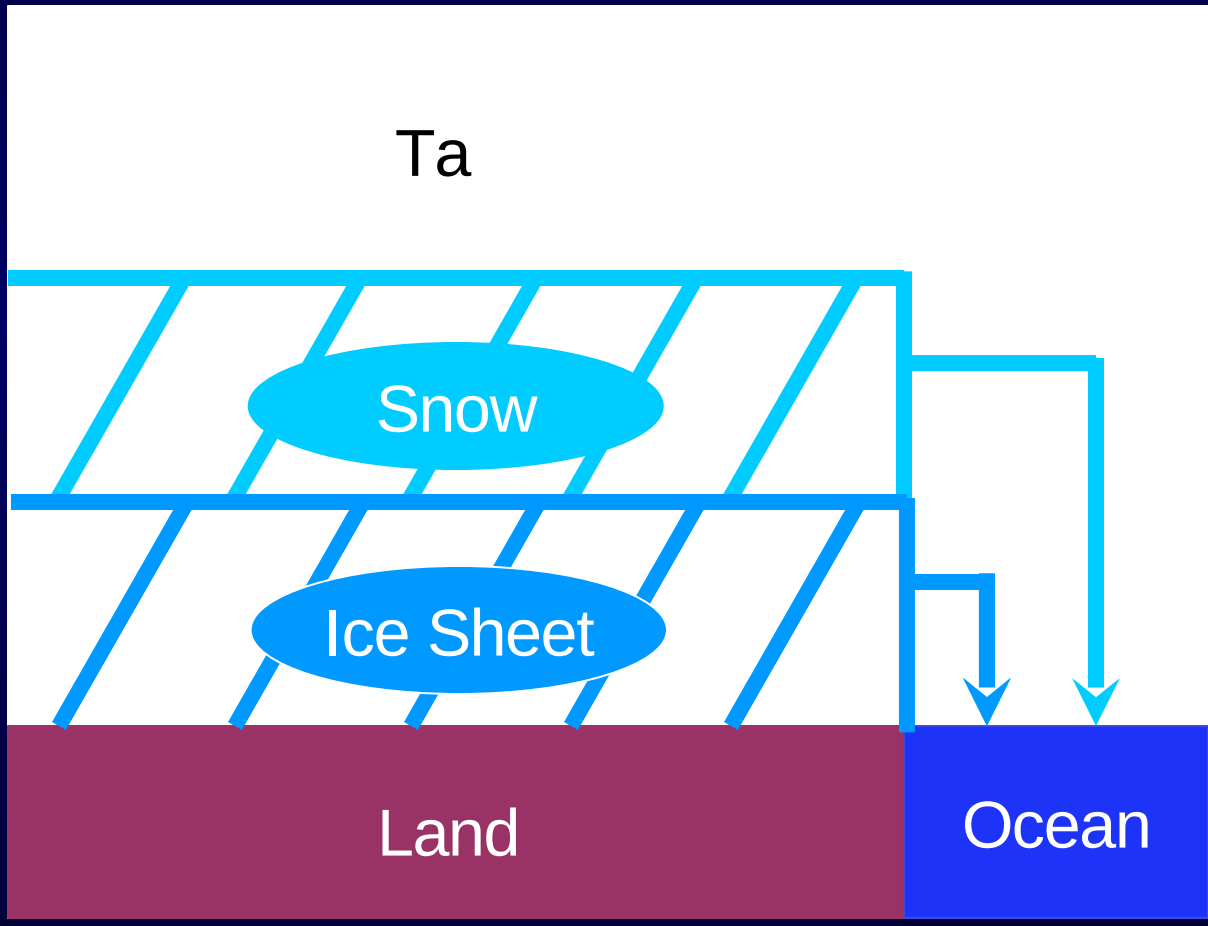
- The land-snow melted can go back to the ocean through runoff
- A crude parametrization of iceberg dynamics is implemented
- The land-ice could also melt in order to simulate glacier melting.

Different regions for the calving

Experimental design (1/2)

Two versions of the IPSL-CM4 model:

2) With Glacier melting



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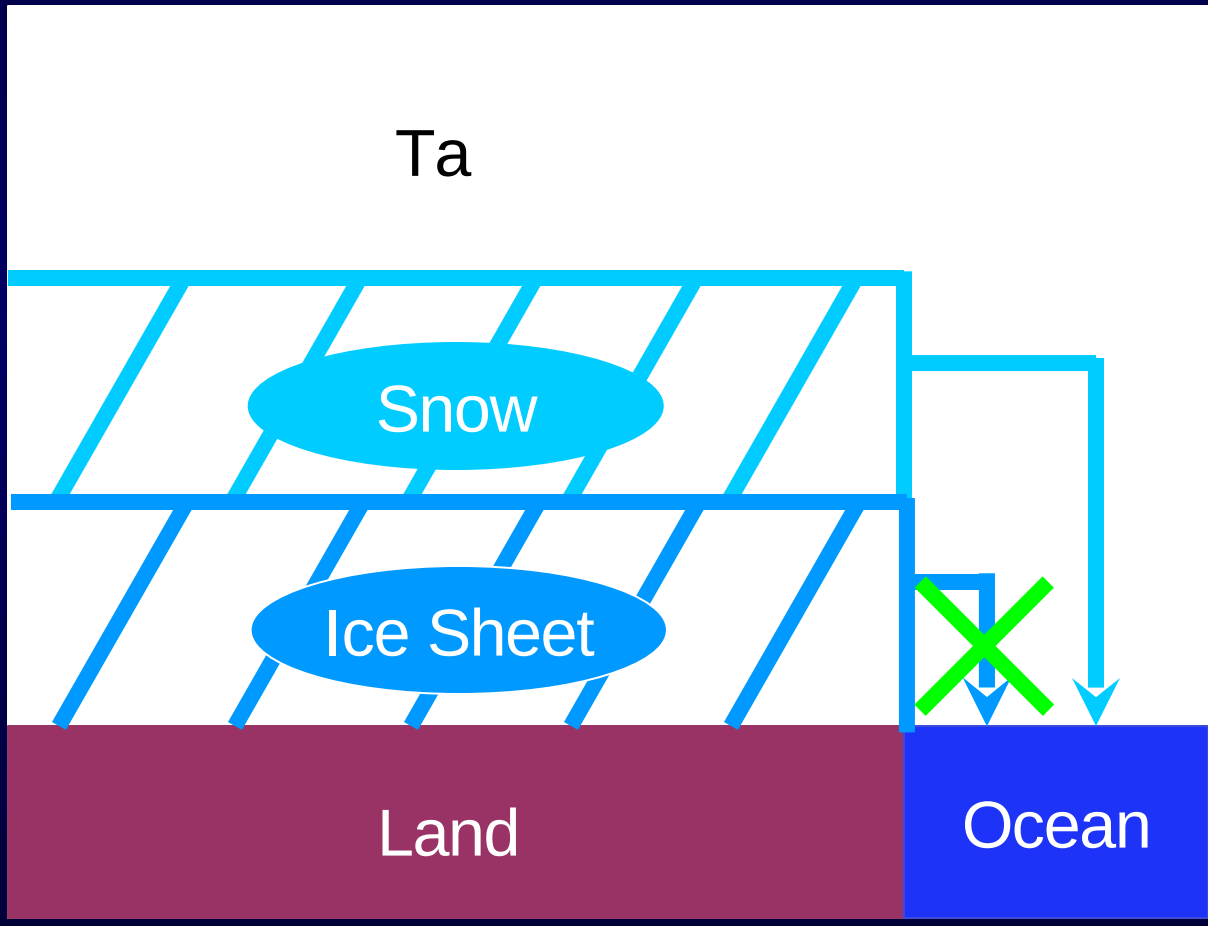
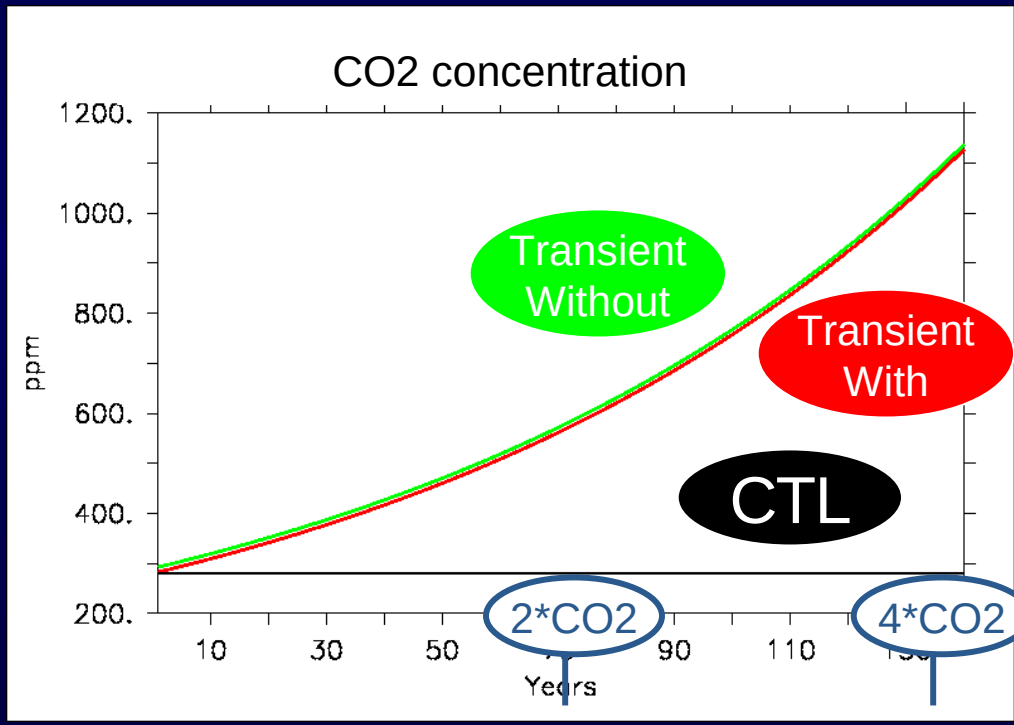


Experimental design (2/2)

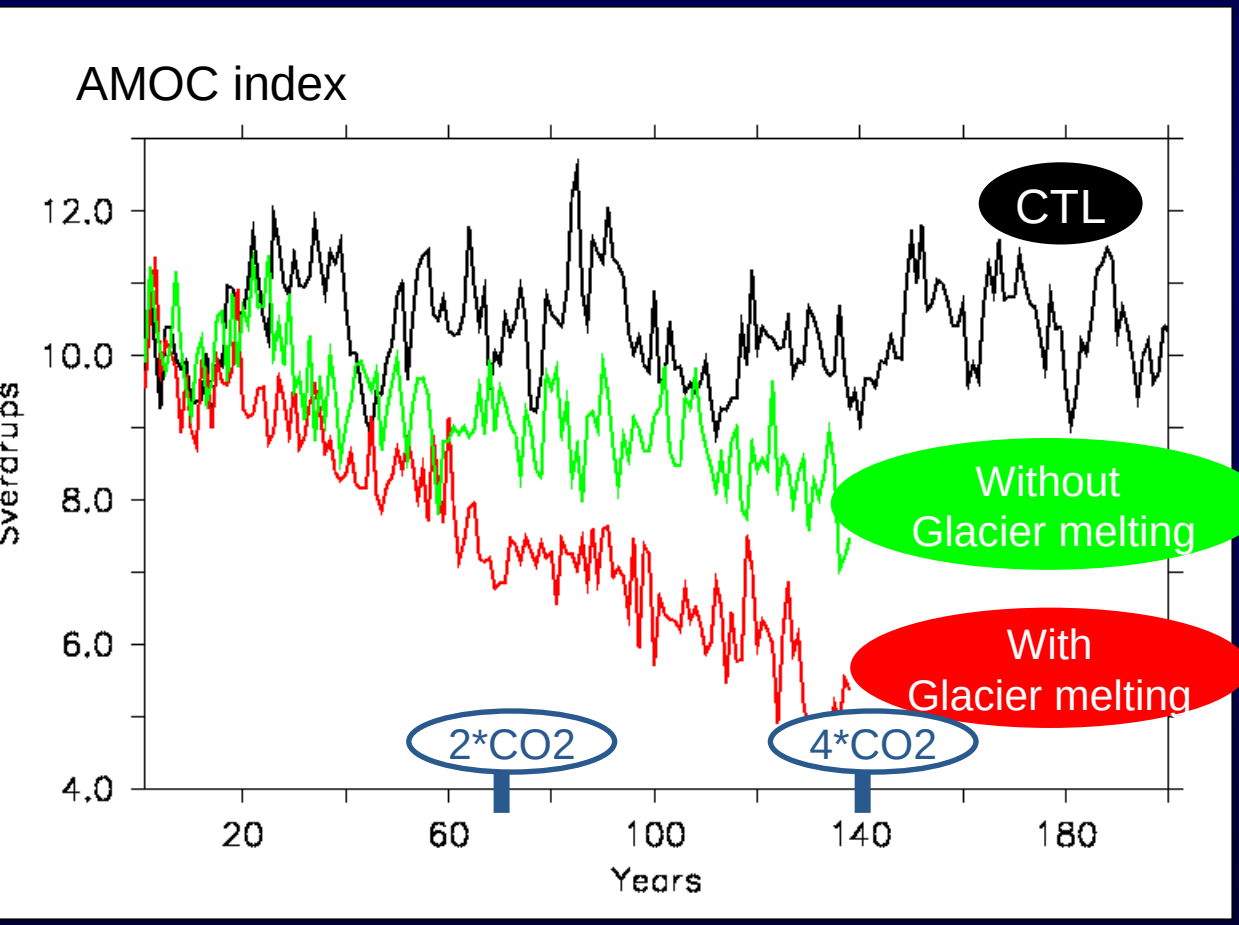
- CMIP2 like scenario: The atmospheric CO2 concentration is increased by 1%/yr, which is an idealized scenario

- We focus on the transient period of 140 years, up to 4*CO2

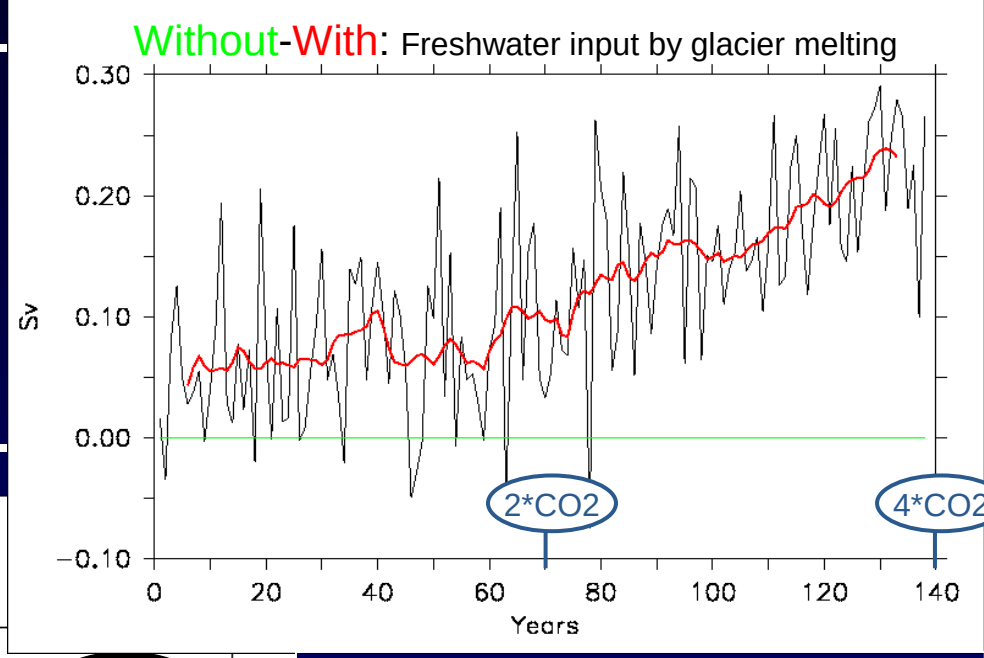


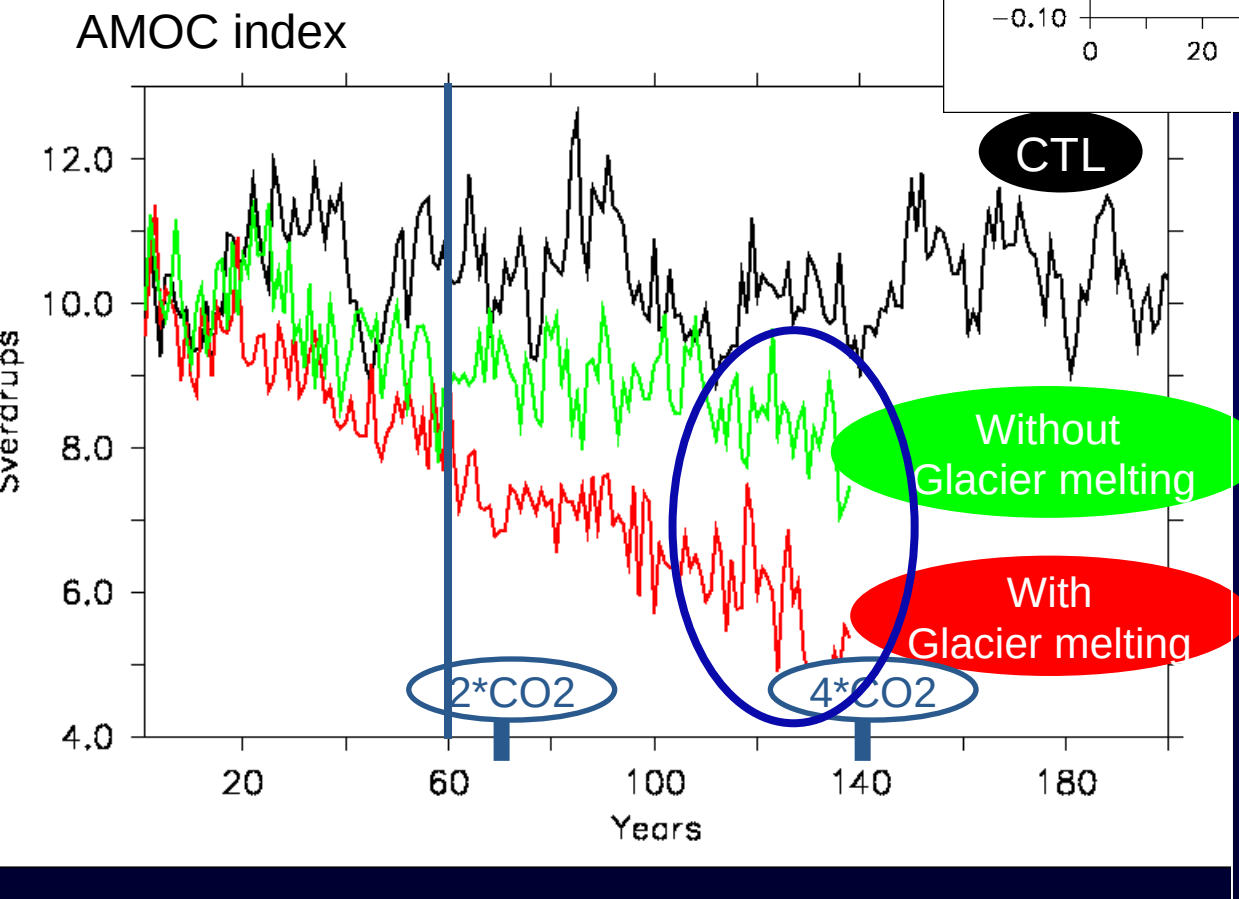
CTL : « *Control* » *pre-industrial simulation*

AMOC response



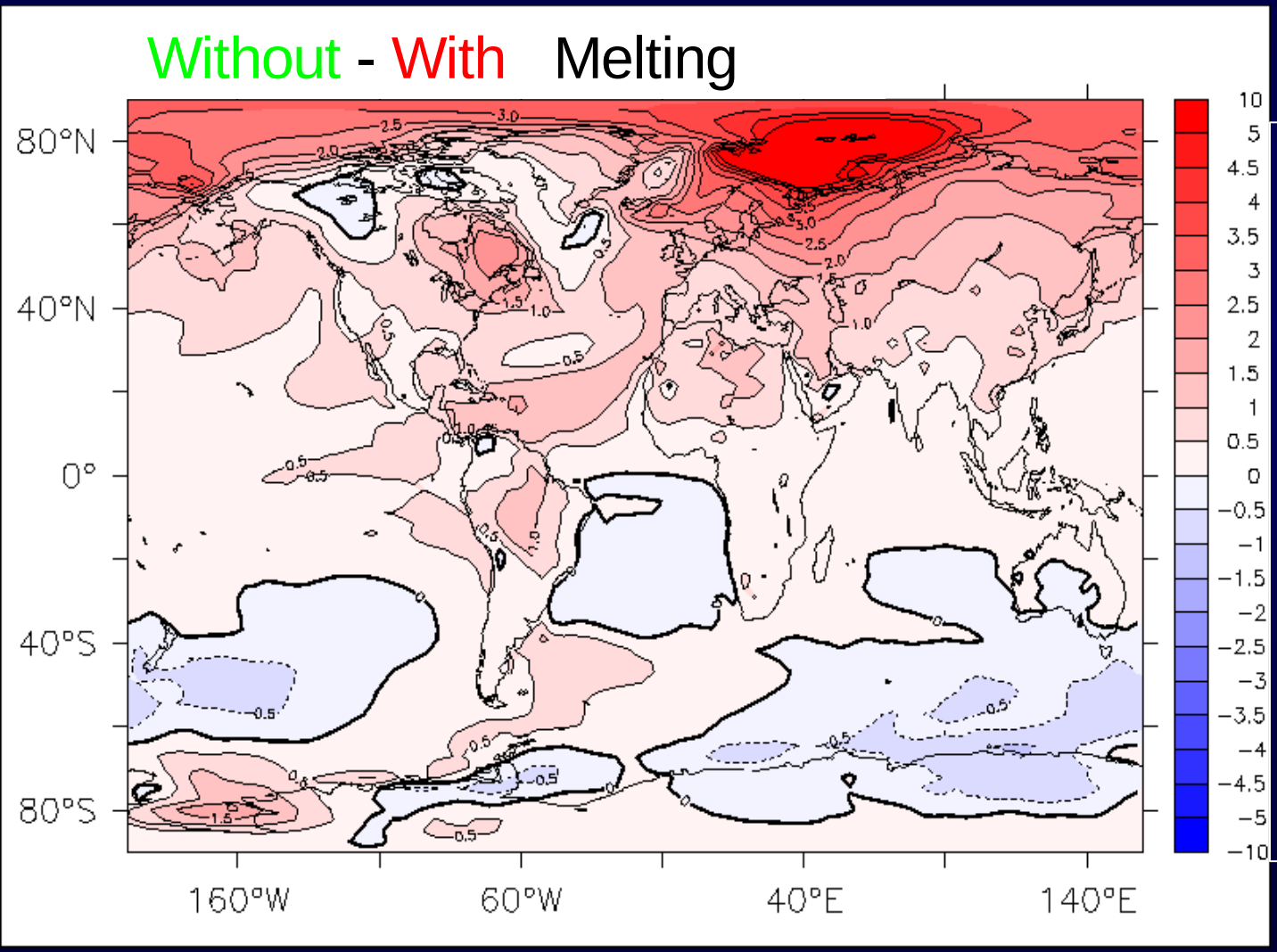
AMOC response and Additional Freshwater input





- About 0.1Sv at 2*CO2 and 0.2Sv at 4*CO2
- 20% of Greenland melted in the 140 years of experiments
- « Worst case » melting scenario (Gregory , 2004)

Difference in Surface temperature between scenarios at 4*CO2: Effect of less AMOC weakening



- Global difference of 0.44 K

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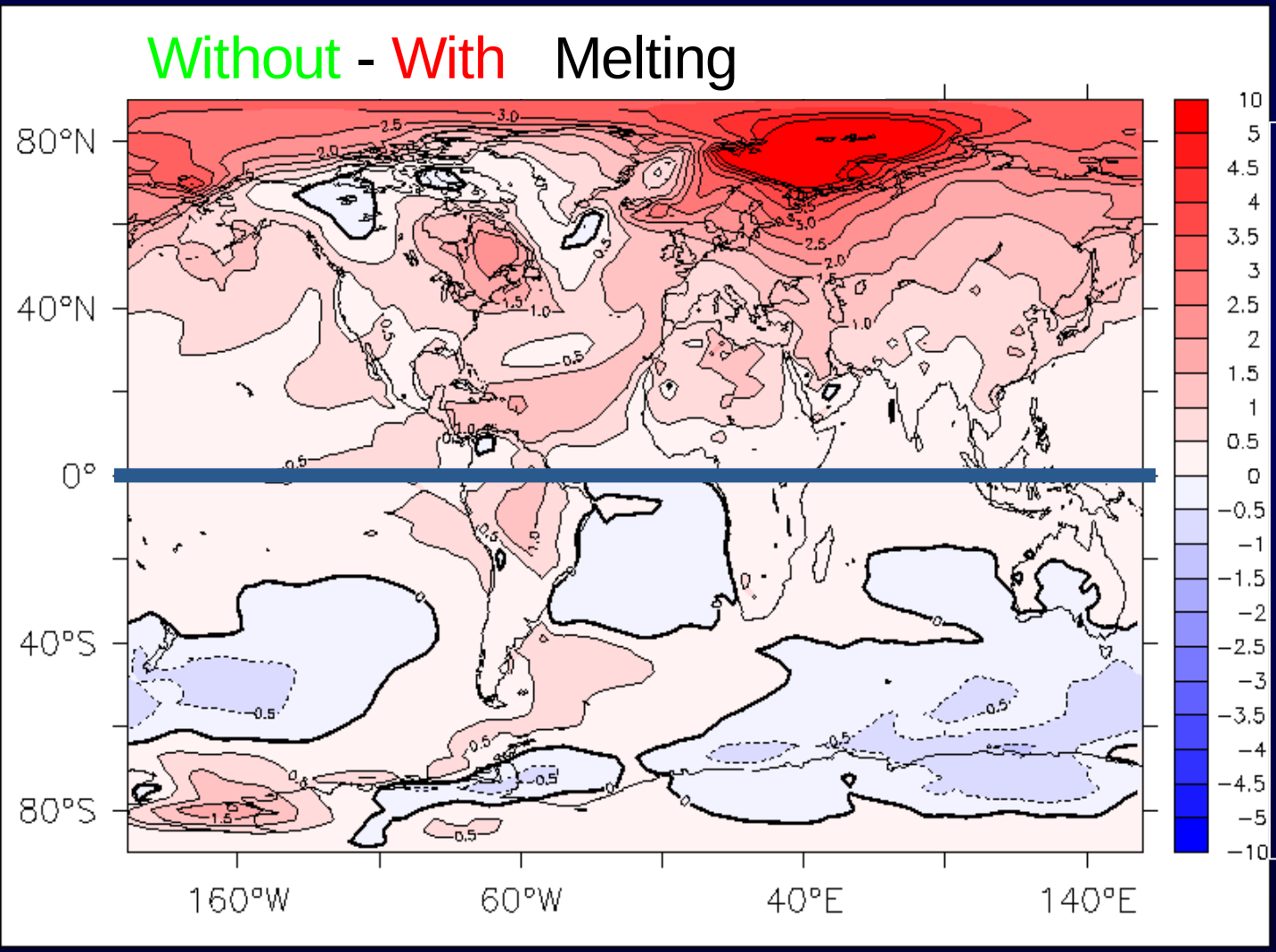

- Global difference of 0.44 K
- Difference of 0.85 K in the North Hemisphere, 0.07 K in the South

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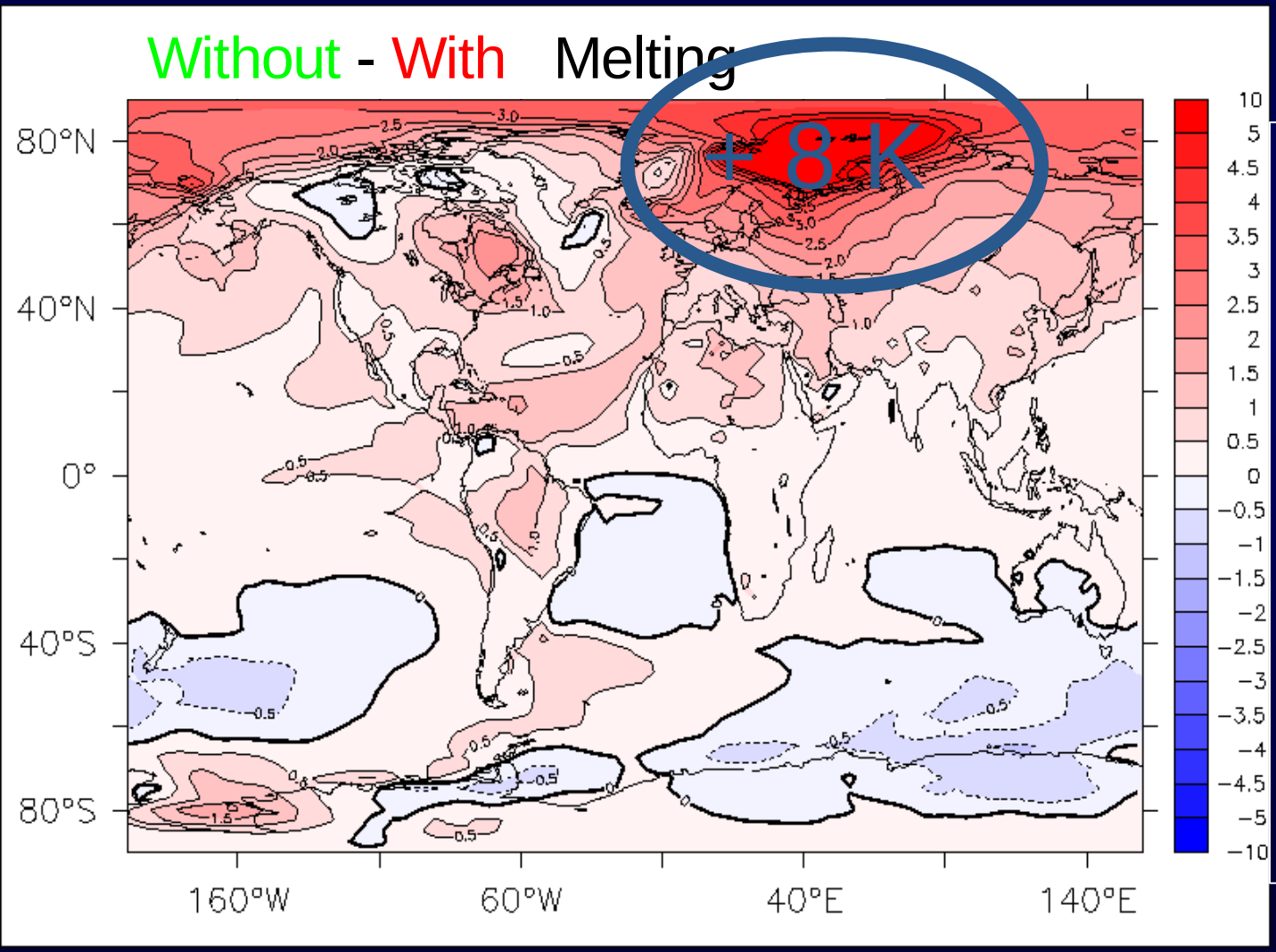

- Global difference of 0.44 K
- Difference of 0.85 K in the North Hemisphere, -0.07 K in the South
- Most of the warming happens where sea-ice cover disapears (Barents Sea)

Additional warming: Two possible ocean processes

1. Local freshening of the Arctic
   => local sea-ice interaction
2. Difference in AMOC
   => Less northward heat transport

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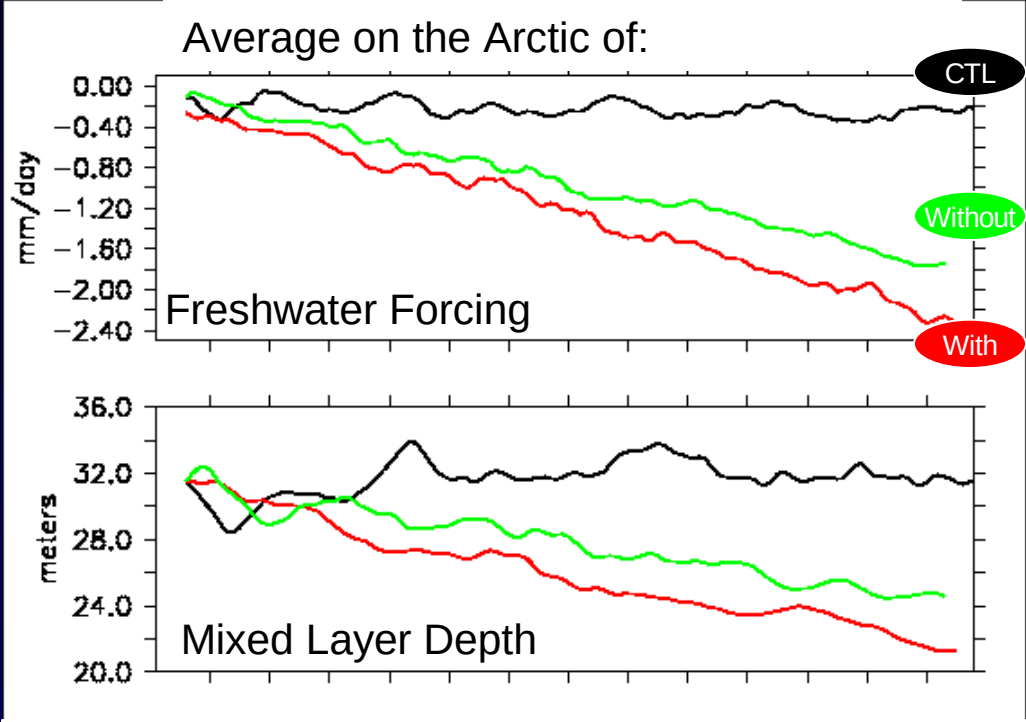

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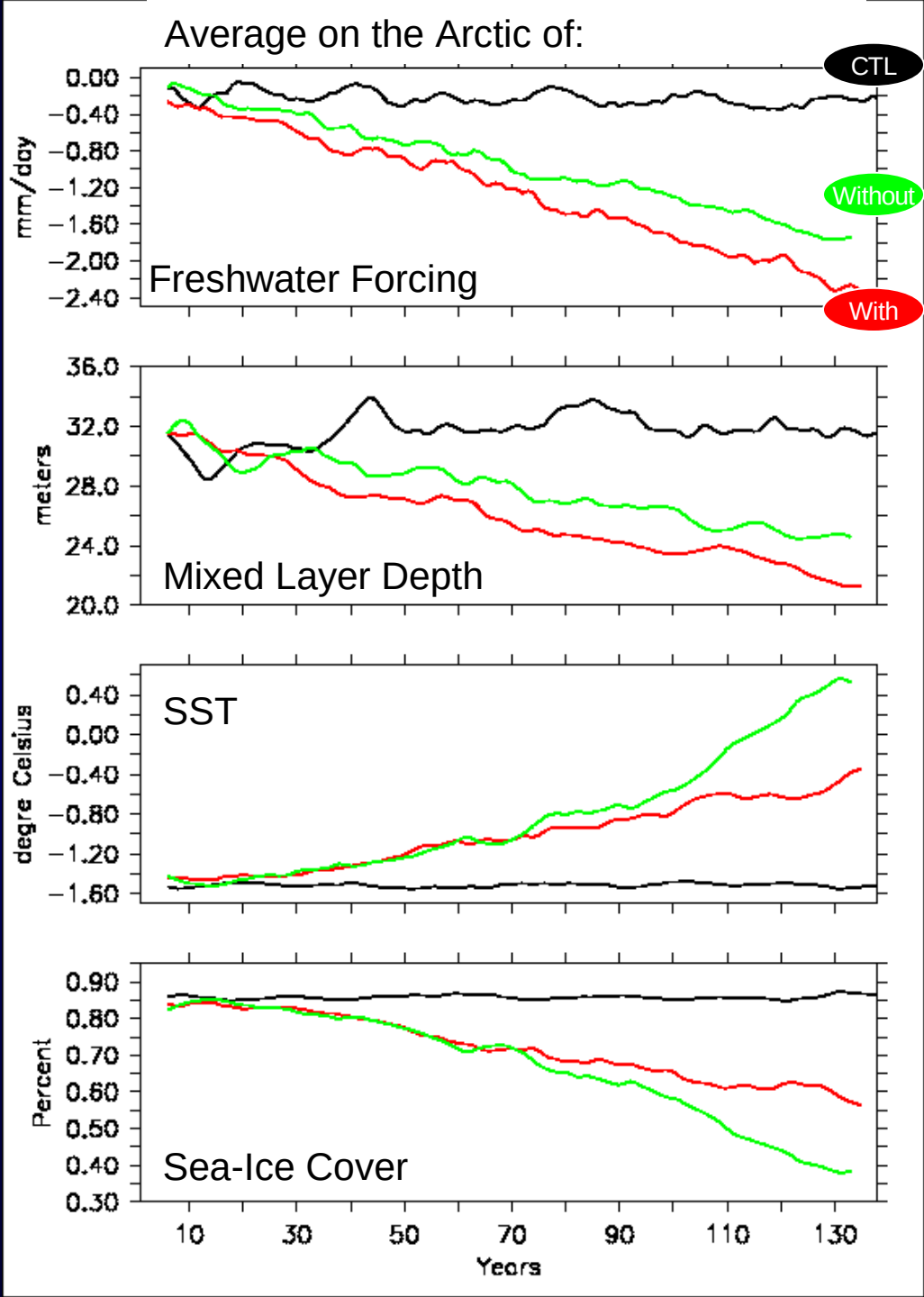

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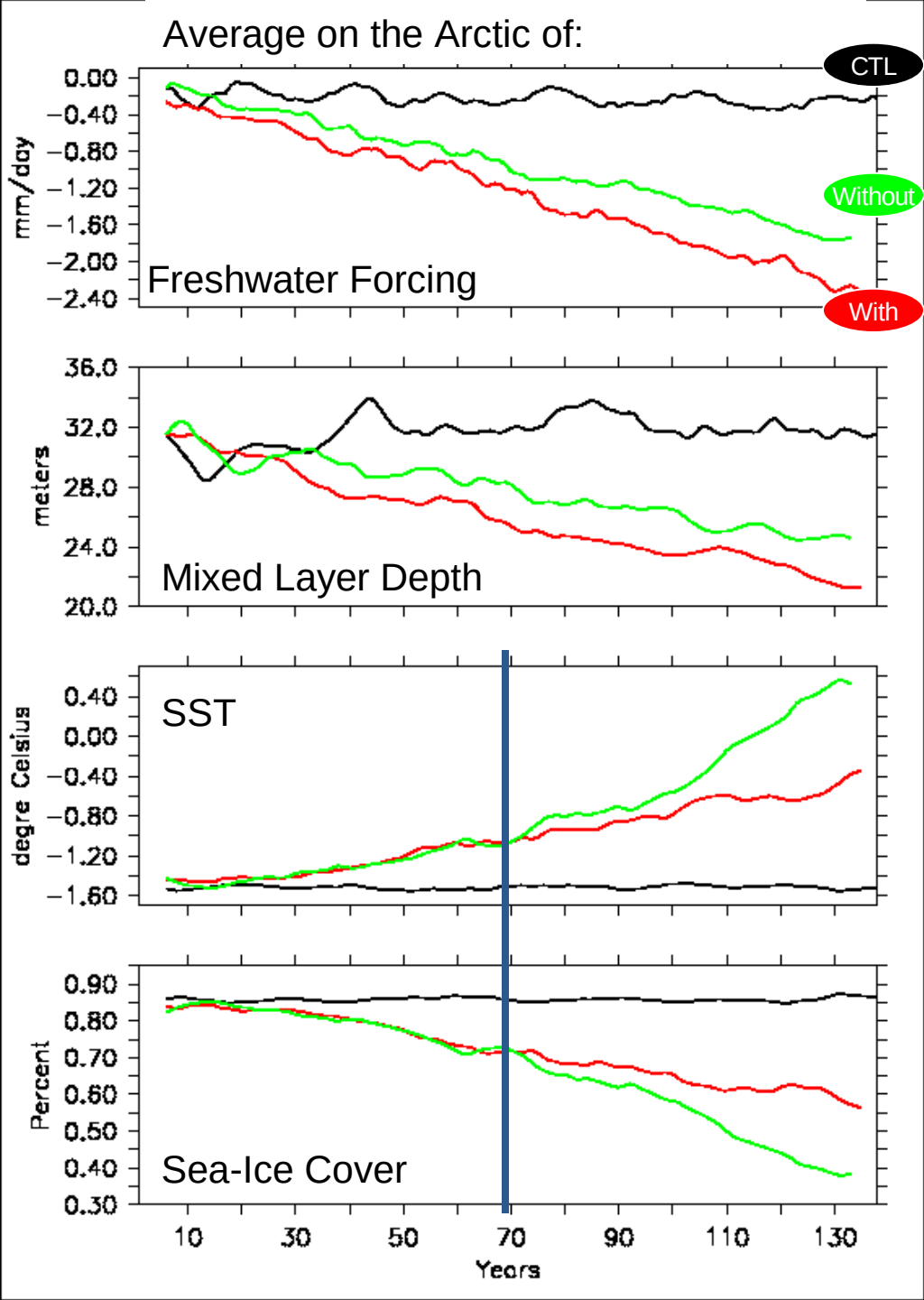
Timing pleads for this process

As difference in heat transport:

+0.17 PW at 20°N

+0.05 PW at 50°N



Conclusions

- Land-ice melting leads to important AMOC weakening in the IPSL-CM4, and thus needs to be taken into account in coupled model
- AMOC changes appear after 60 years of glaciers melting integration, and then trigger a fast positive climate feedback trough sea-ice cover
- Coupling with a full ice sheet model to validate our land-ice parameterization (in progress)

Thank you

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