On the potential for deep convection in the Arctic Basin under a warming climate

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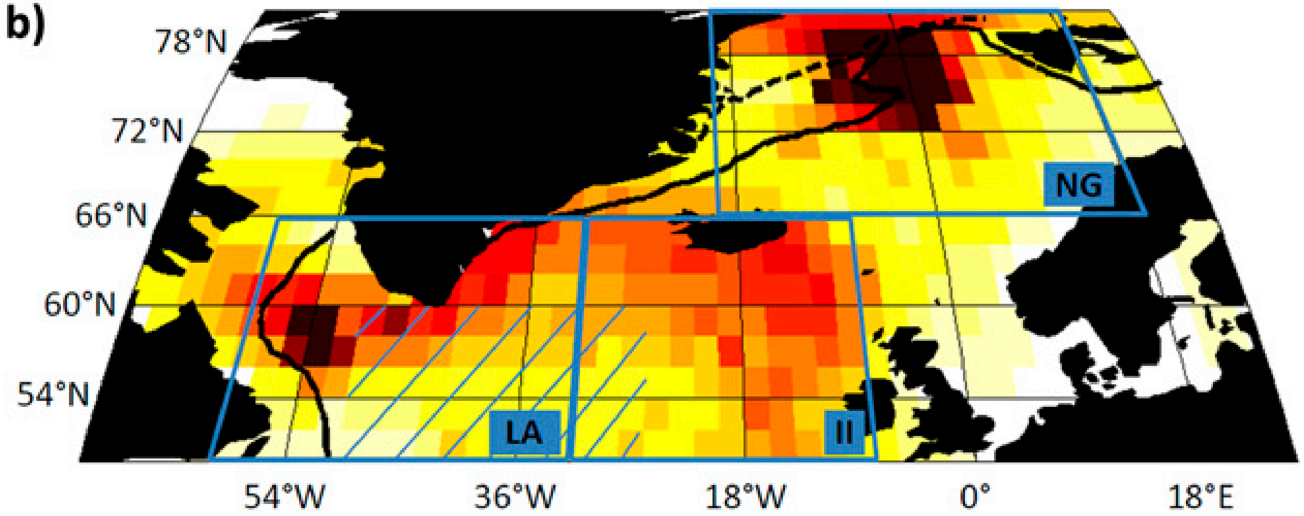
Rationale: deep convection in the North Atlantic

Mean March MLD –
de Boyer Montégut et al. (2004) climatology



Heuzé et al. (2015)

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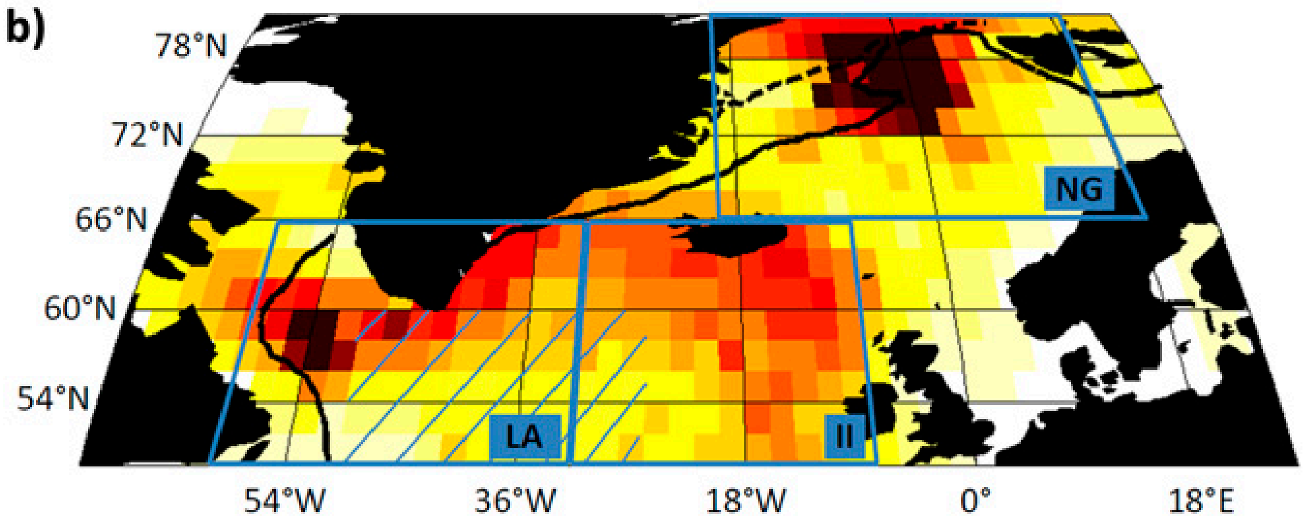

-> Few sites of deep convection

-> Link between deep convection and AMOC ?

Heuzé et al. (2015)

Rationale: sea ice as a convection inhibitor

Mean March MLD –
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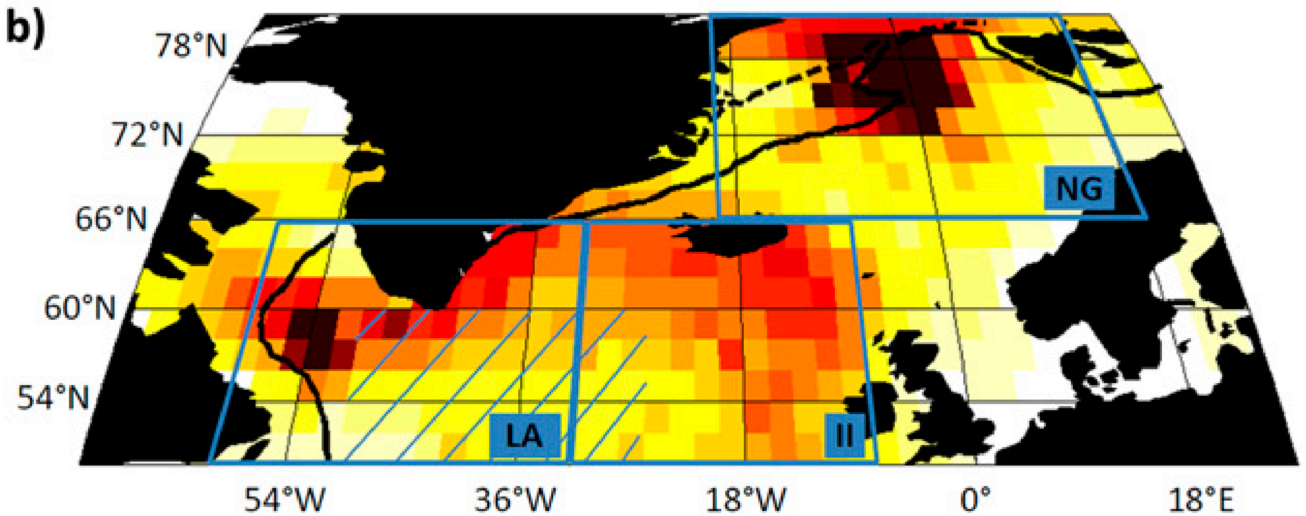


-> Few sites of deep convection

-> Link between deep convection and AMOC ?

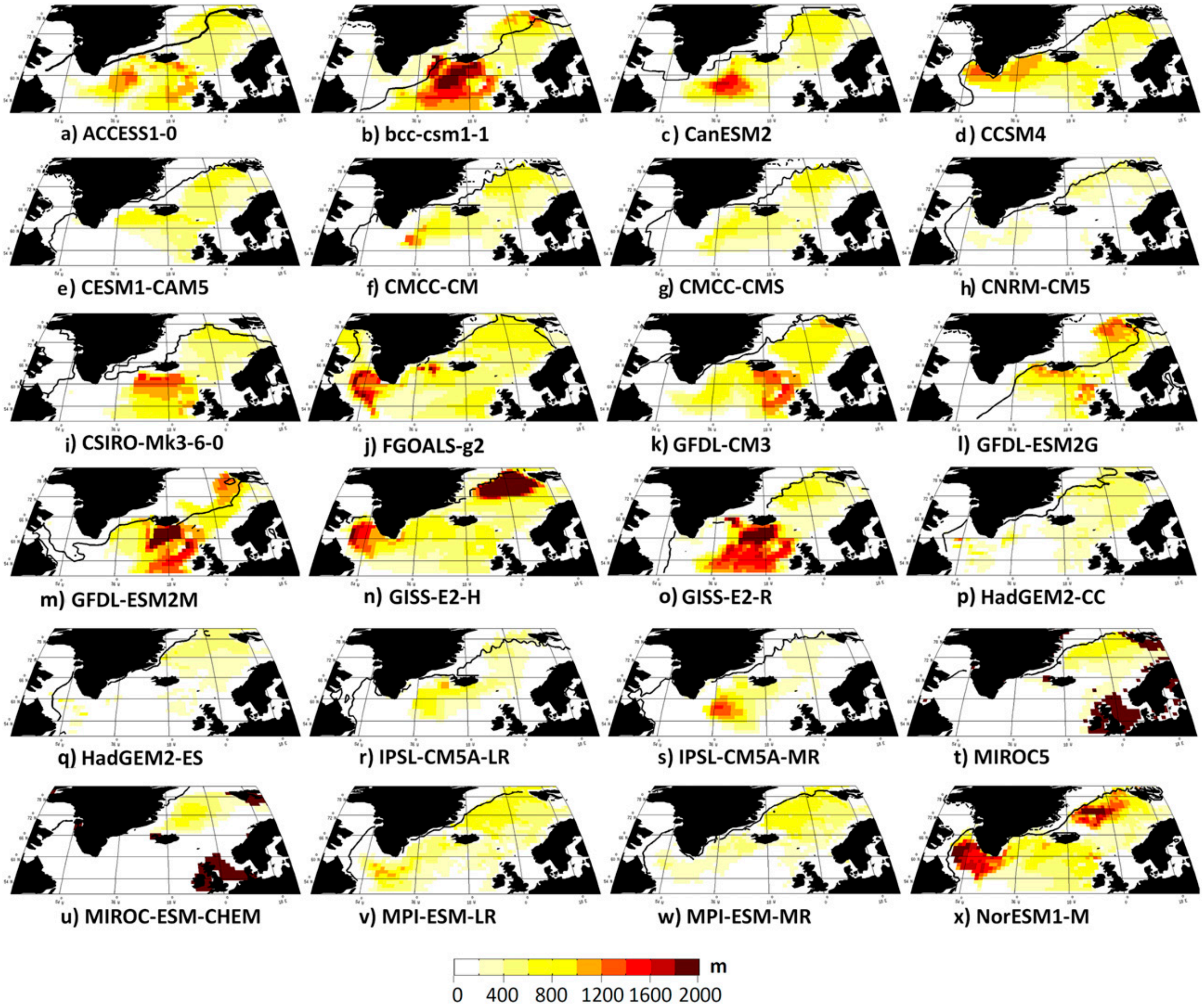
-> Area of deep convection are on average tight to the sea ice edge, where we find huge T/S gradient and atmospheric flux

-> The presence of sea ice tends to limit the exchanges with the atmosphere: the sea ice extent variations explain part of the year-to-year MLD variations

Heuzé et al. (2015)

Rationale: what to expect in a warming climate ?

Mean March MLD – 2081-2100, RCP8.5



-> Shallower MLD in the present-day "convection spots"

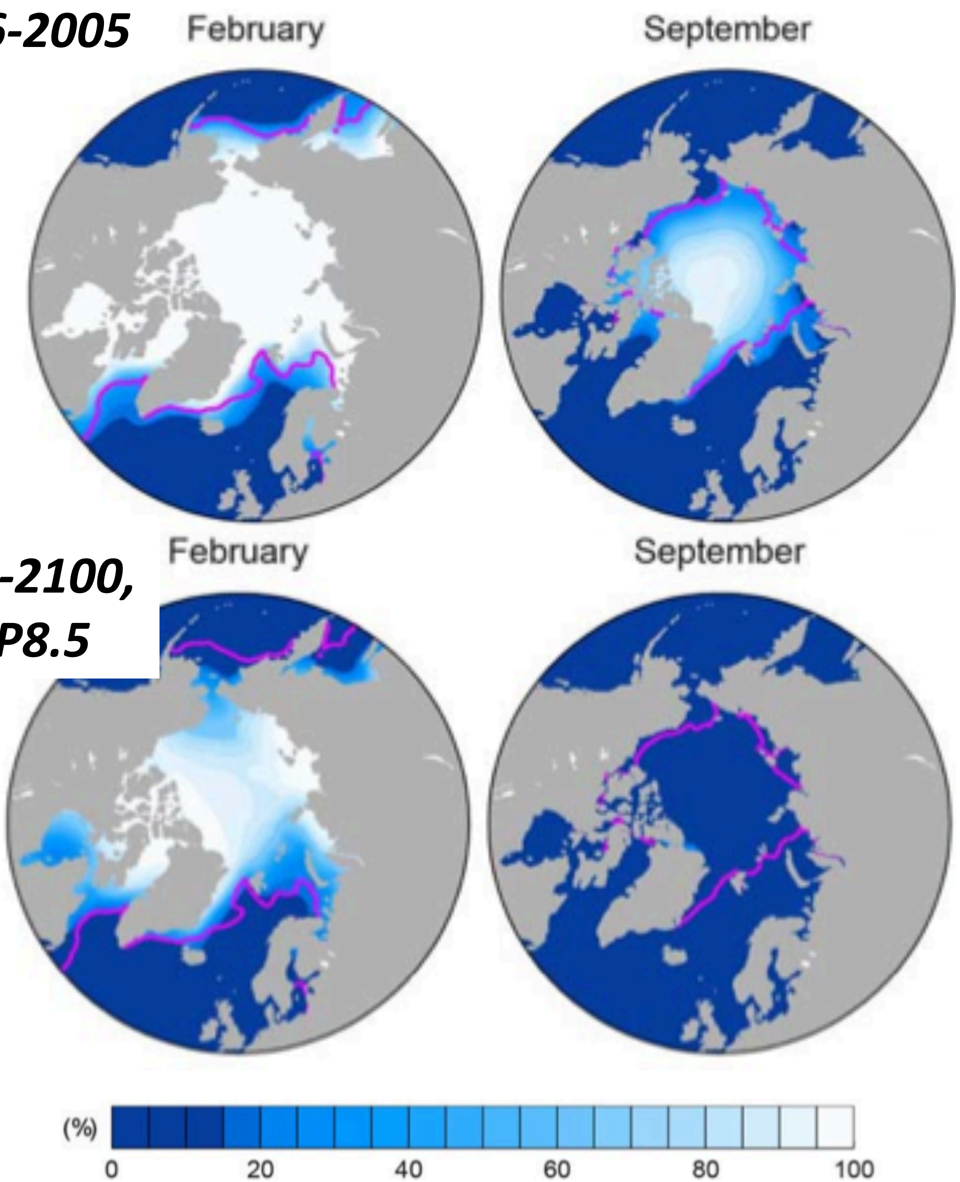
-> Decrease of the AMOC

Heuzé et al. (2015)

Rationale: what to expect in a warming climate ?

_1986-2005_

2081-2100, RCP8.5



Sea ice concentration

-> Shallower MLD in the present-day "convection spots"

-> Decrease of the AMOC

-> Arctic becomes seasonal ice free

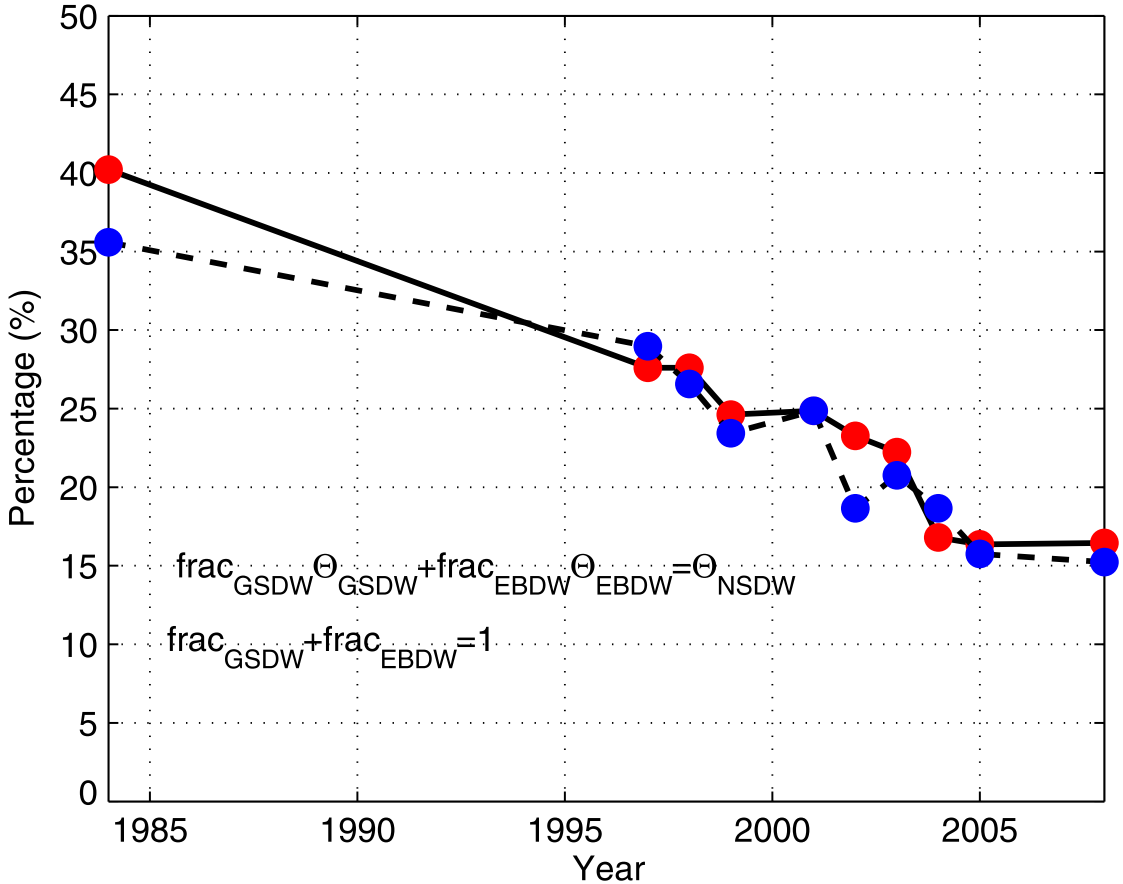
-> Sea ice edge in winter retreats northward as well

-> is there any potential for deep convection in the Arctic ?

IPCC (2013)

Rationale: any evidence that things are already changing ?

Percentage of GSDW in the deep water mass flowing through Fram Strait



-> contribution from dense water formed in the Arctic is increasing

-> export of Arctic-origin dense water has switched from being an intermittent feature to a permanent feature over the past decade.

Langehaug & Falck (2012) – Somavilla et al. (2013)

Methods

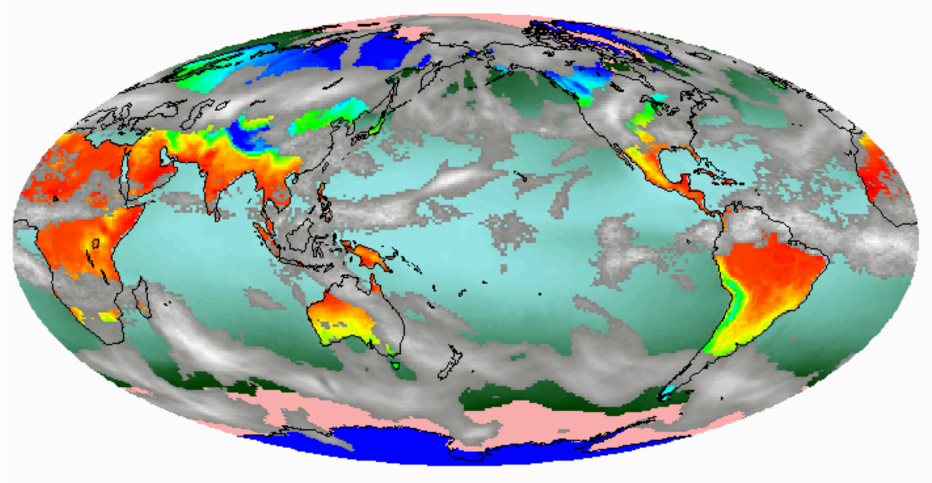
- Outputs from two coupled climate models

  -> *Met office HiGEM (high res. - 1/3° for the ocean component)*

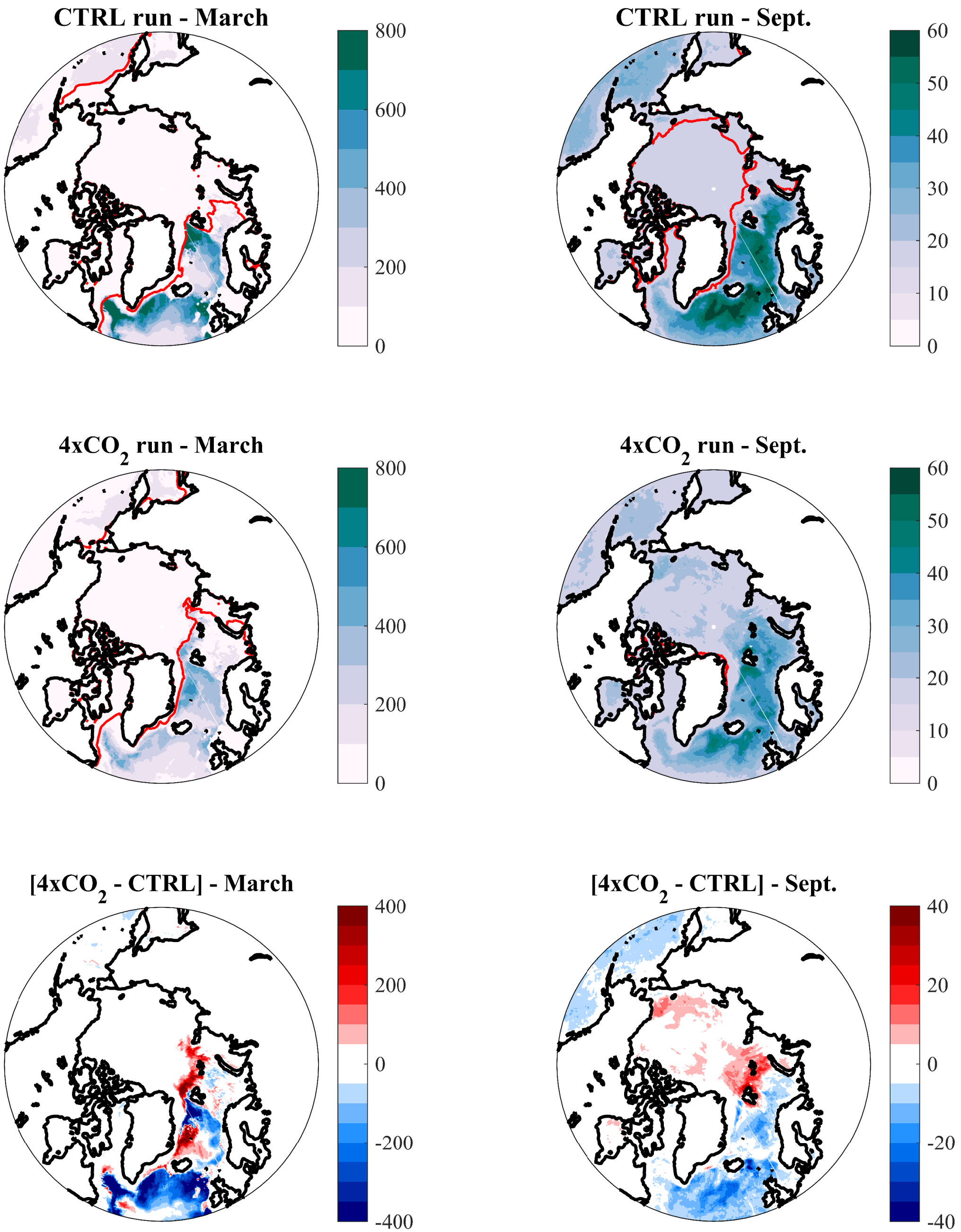
  -> *CNRM climate model (ORCA1 for the ocean)*

- Comparison of two runs: *CTRL and 4 x* CO_2 (roughly comparable with RCP8.5)

- ARIANE Lagrangian model (*Blanke & Raynaud 1997*) applied offline to the CNRM model, following the method described *in Thomas et al. 2015*



MLD change in HiGEM



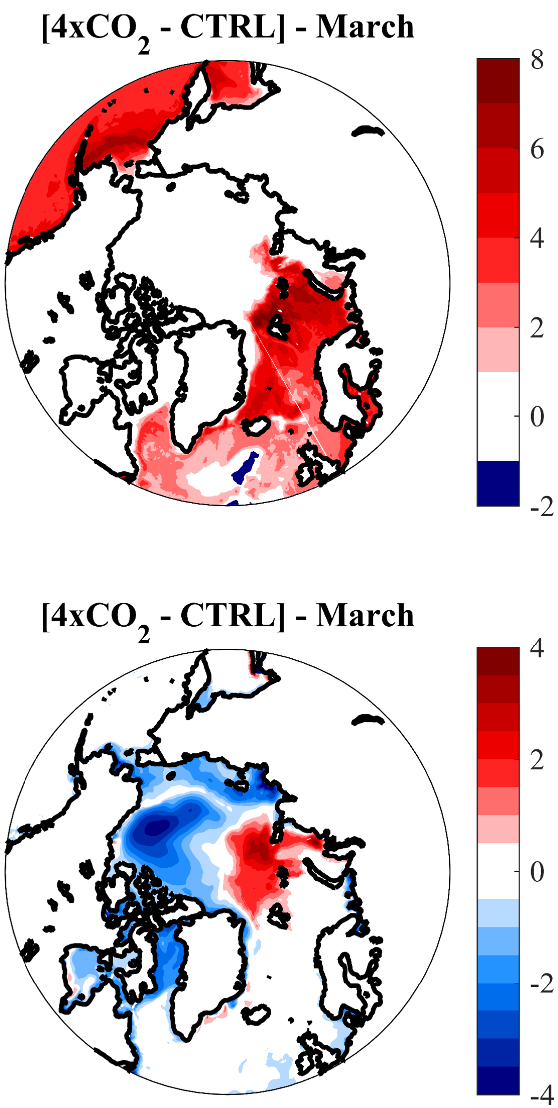
MLD in the Arctic (computed with a criteria in density):

-> shallower MLD in the North Atlantic

-> deeper MLD in the Nordic sea and the Eurasian Basin of the Arctic Ocean, close to the new sea ice edge

-> no change in timing of the convection

MLD change in HiGEM



Change in SST:

-> strong warming in ice free regions

-> large increase of the seasonal cycle

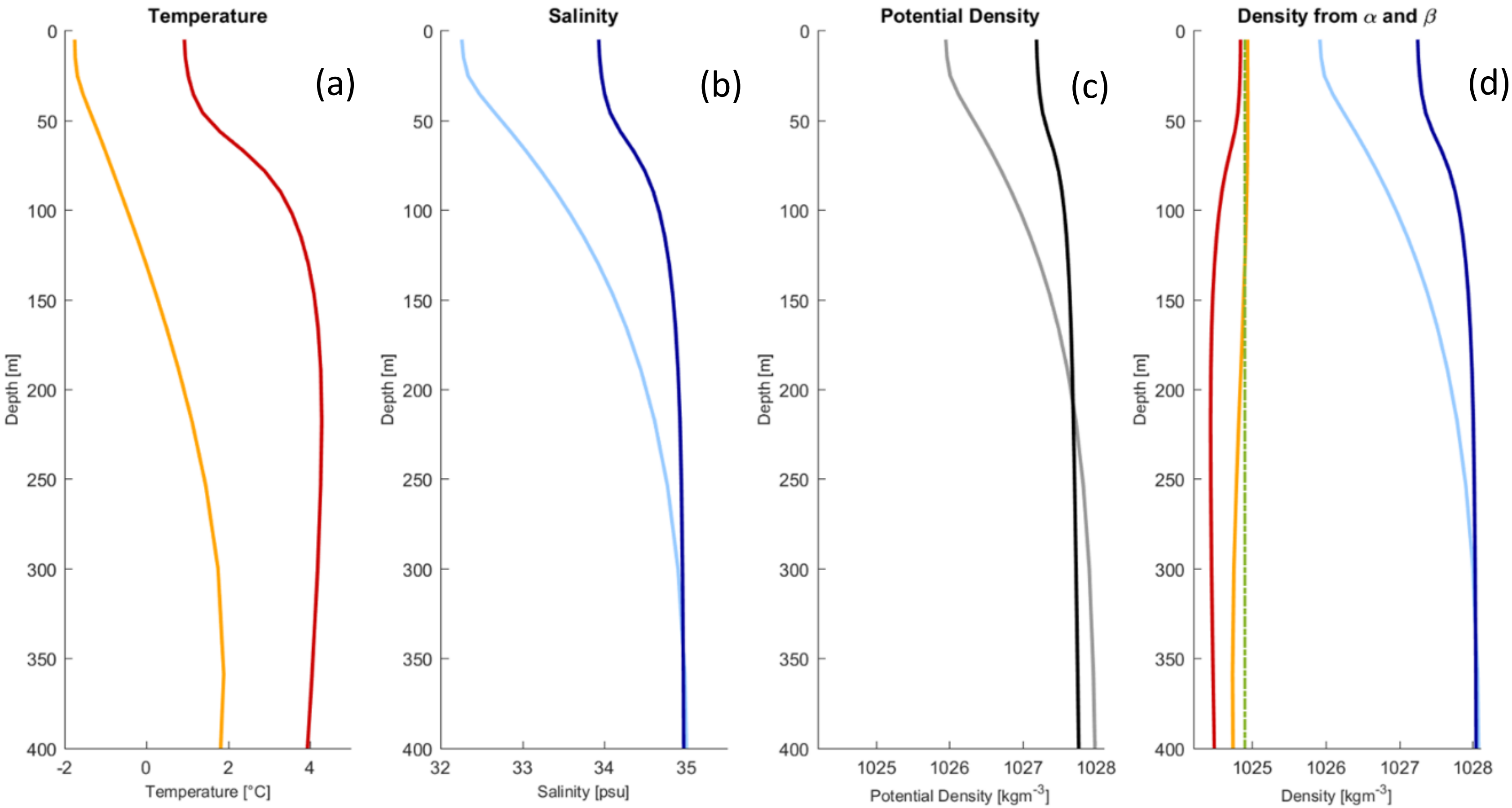
Change in SSS:

-> strong freshening in the Canadian Basin (spin up of the Beaufort Gyre)

-> SSS increases in the Eurasian Basin (AW inflow influence)

MLD change in HiGEM

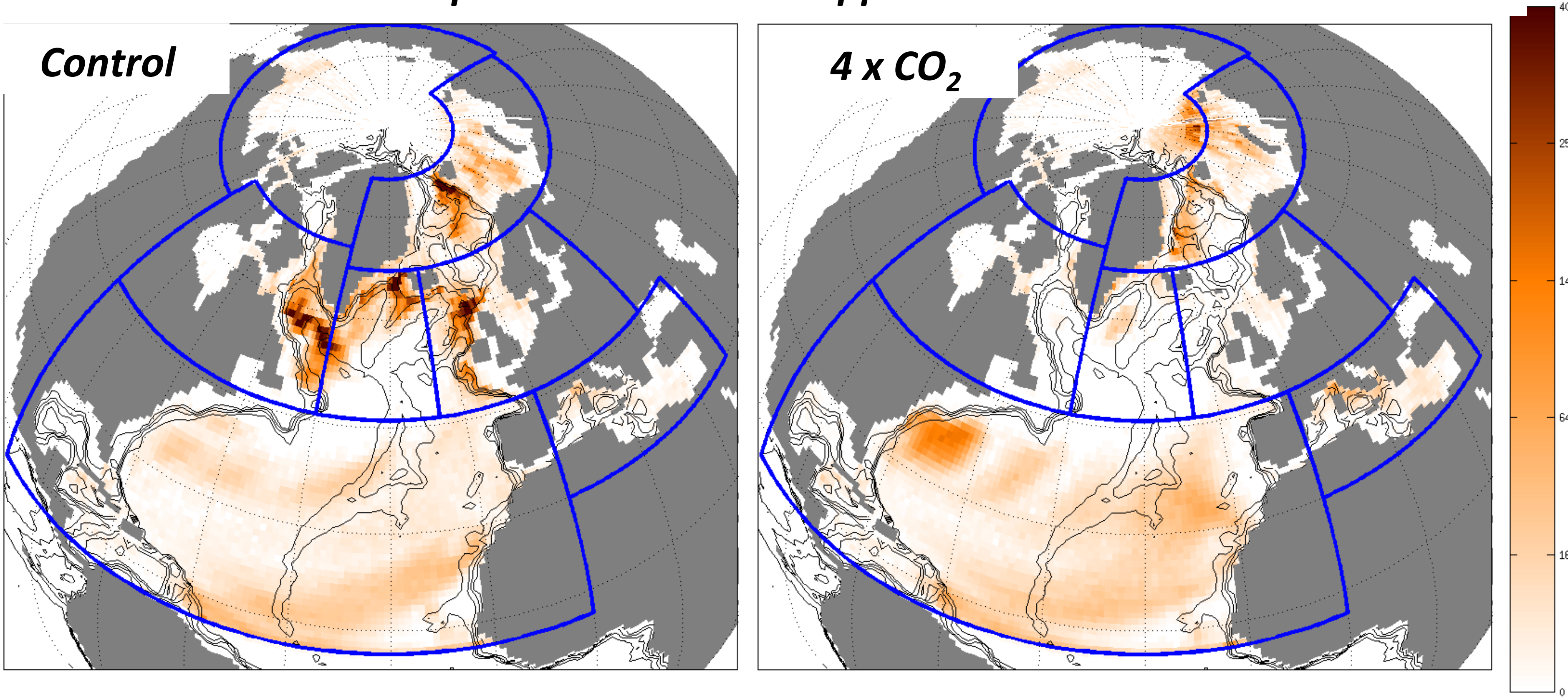
Mean winter T/S and density profiles in the Eurasian Basin



-> the increase of SSS leads to a suppression of the stratification (driven by S) in the Eurasian Basin, making convective events easier to happen…

Change in Arctic MLD : why do we care ?

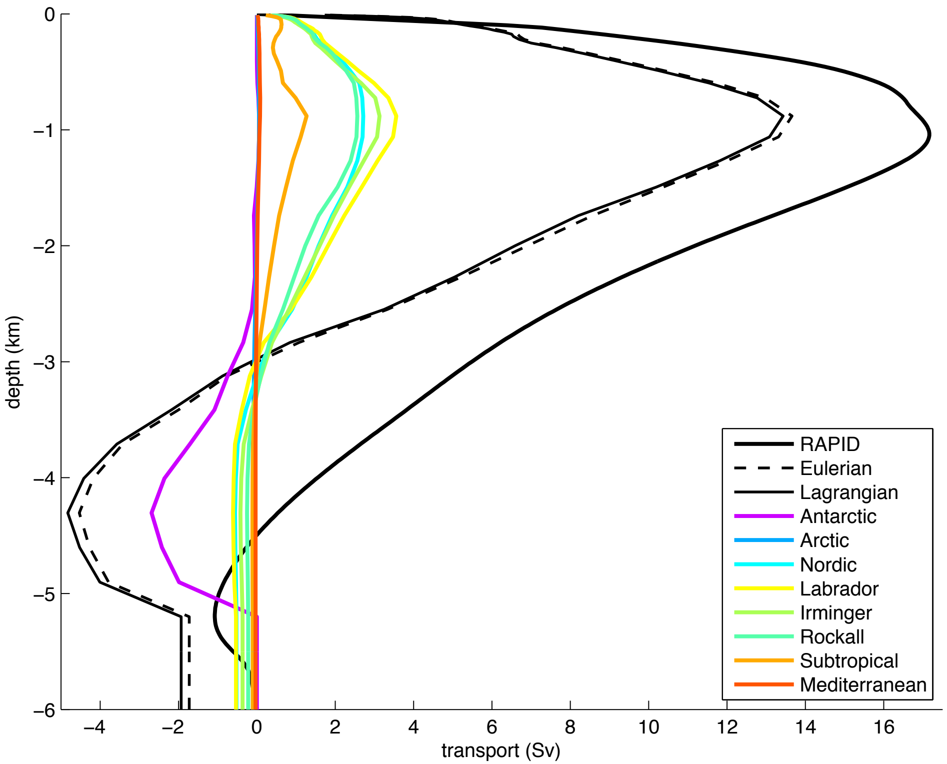
Subduction rate (m/yr) of water that ends at 10°N computed with ARIANE applied to ORCA1

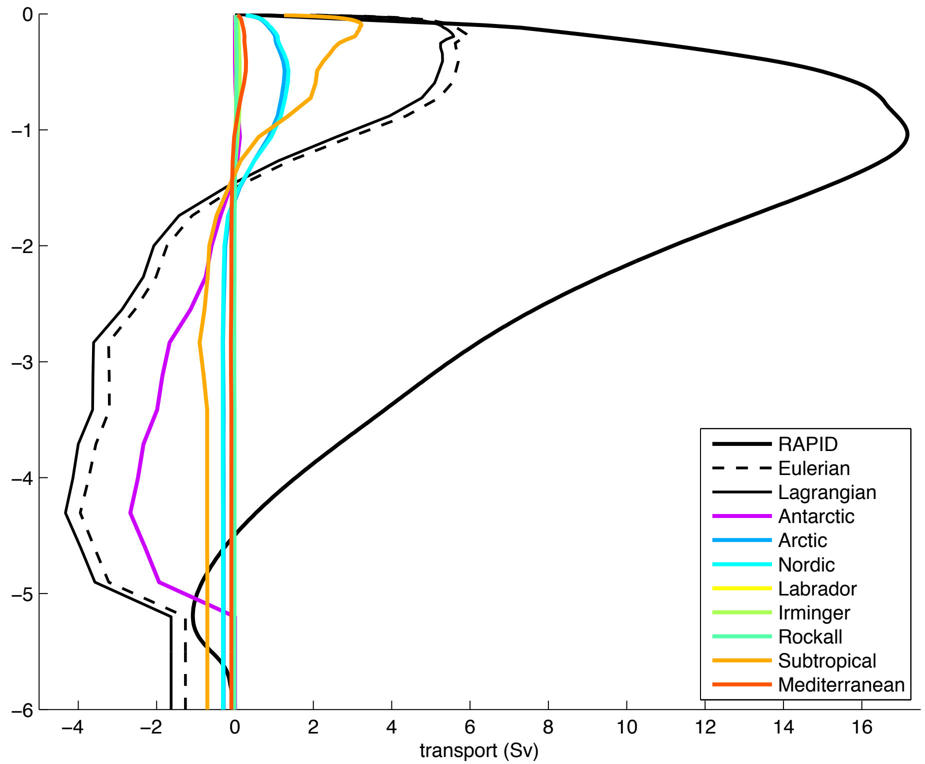


-> backward computation: start at 10°N and run backward in time until it intercepts the base of the time-varying mixed layer

Change in Arctic MLD : why do we care ?

Contribution to the AMOC at 26°N computed with ARIANE applied to ORCA1



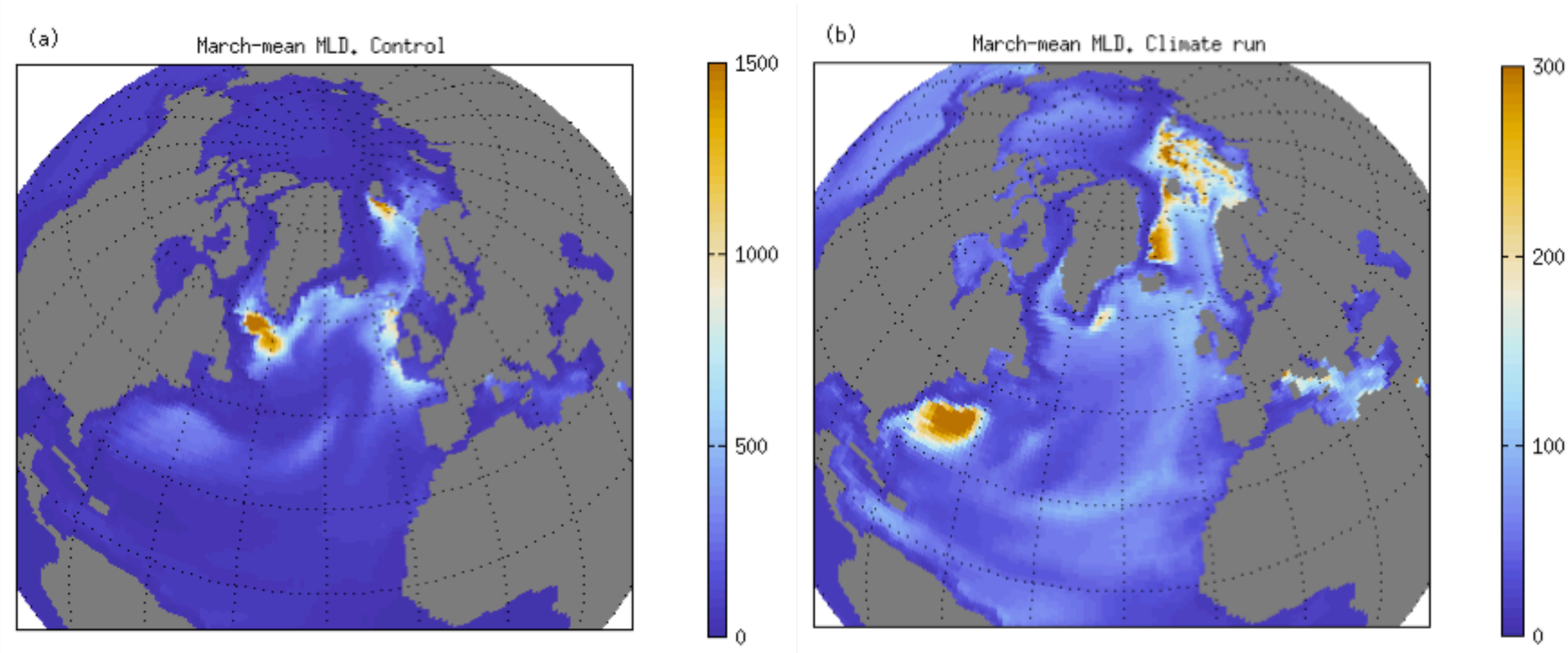


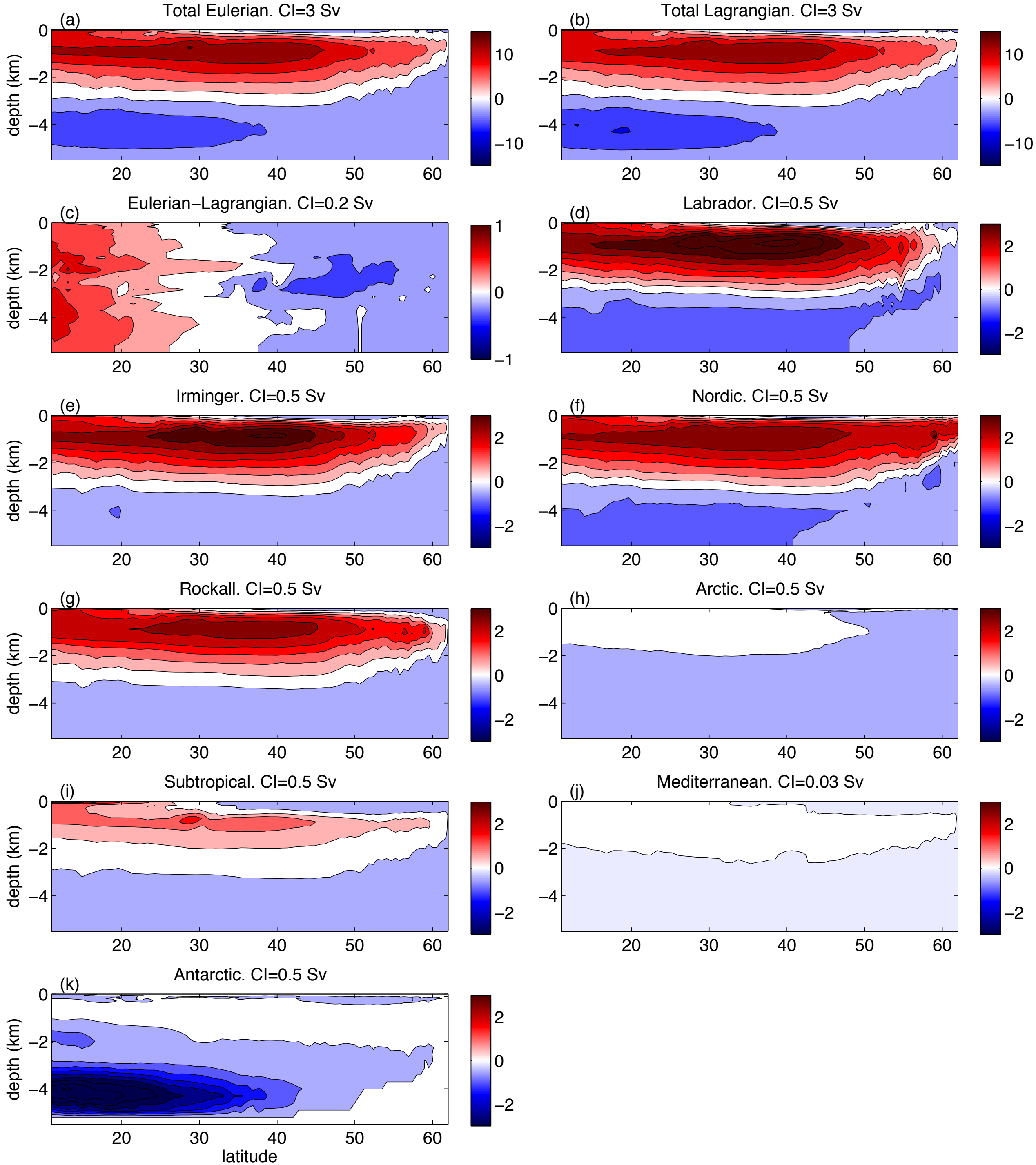
-> Zonal shift of the contributions to the AMOC

- Arctic becomes increasingly important

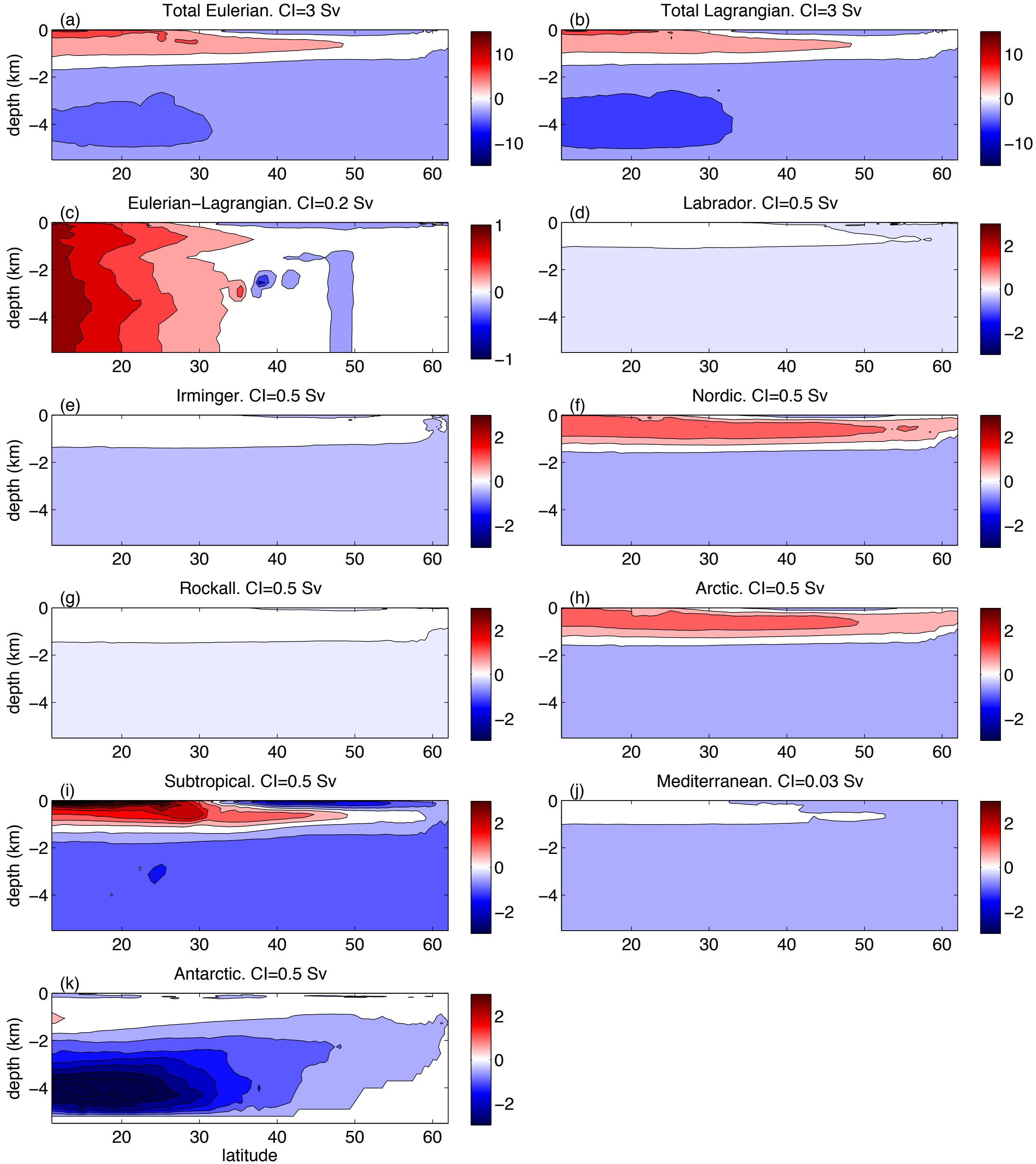
- increase of the subtropical contribution (due to change in stratification)

Spare Slides


(a)
March-mean MLD, Control
1500
1000
500
0
(b)
March-mean MLD, Climate run
300
200
100
0



(a) Total Eulerian. CI=3 Sv
(b) Total Lagrangian. CI=3 Sv
(c) Eulerian−Lagrangian. CI=0.2 Sv
(d) Labrador. CI=0.5 Sv
(e) Irminger. CI=0.5 Sv
(f) Nordic. CI=0.5 Sv
(g) Rockall. CI=0.5 Sv
(h) Arctic. CI=0.5 Sv
(i) Subtropical. CI=0.5 Sv
(j) Mediterranean. CI=0.03 Sv
(k) Antarctic. CI=0.5 Sv
depth (km)
latitude



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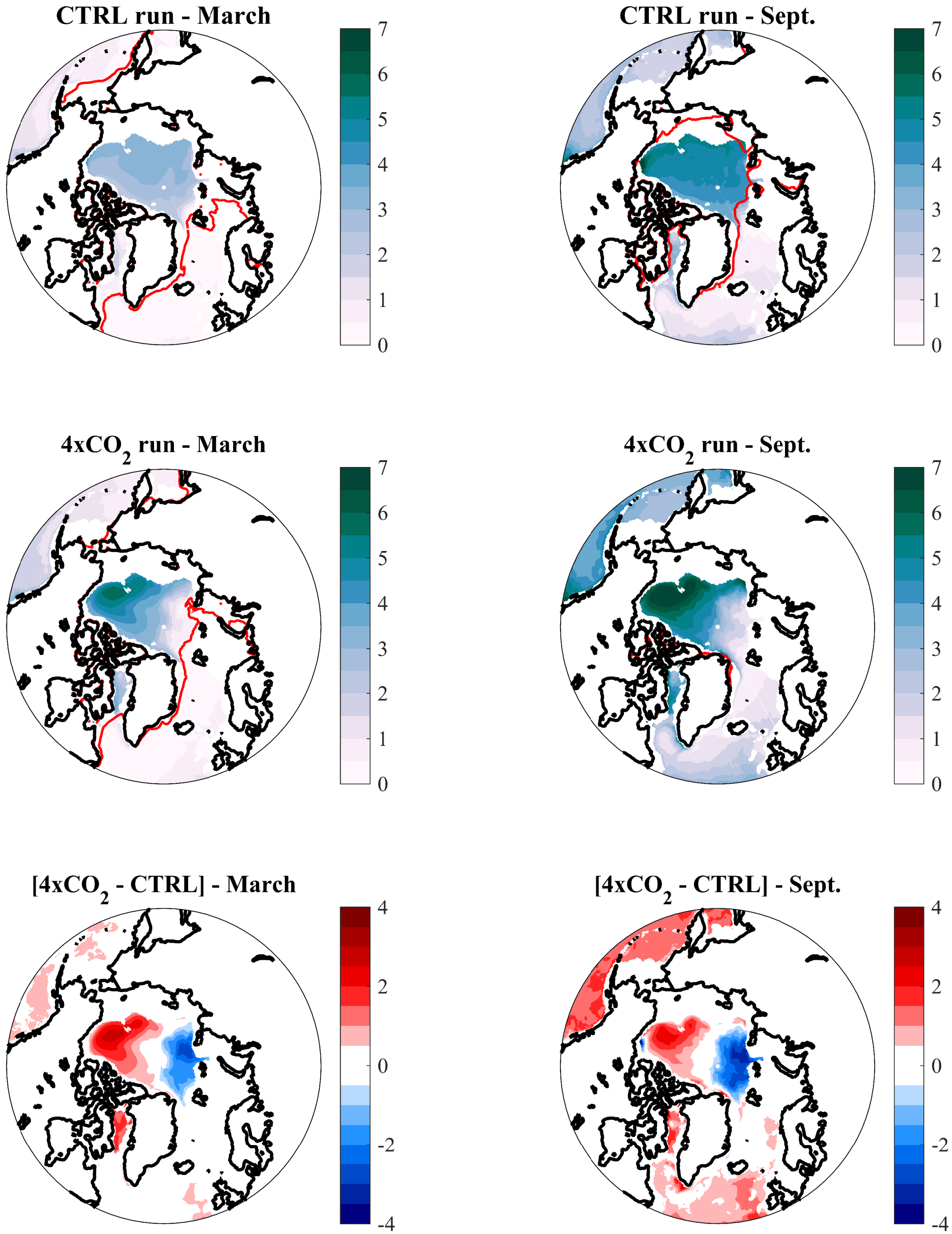
Change of stratification (density difference between 0 and 500 m)



Change of SSH