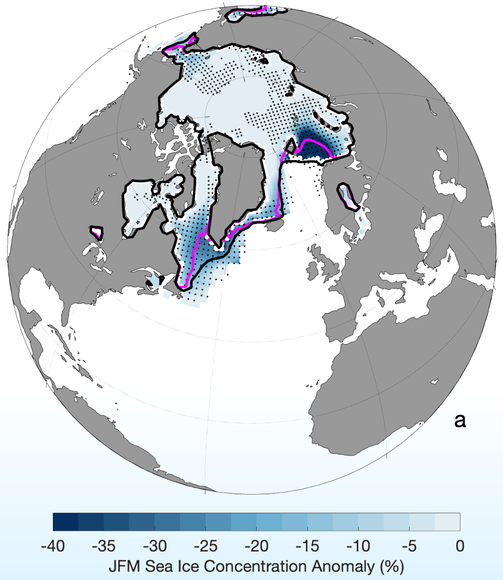
The Transient and Equilibrium Response of the AMOC to Arctic sea ice decline in a coupled model

EGU21-7416

*Amélie Simon[1], **Brady Ferster**[1], Alexey Fedorov[1,2], Juliette Mignot[1], Eric Guilyardi[1,3]*

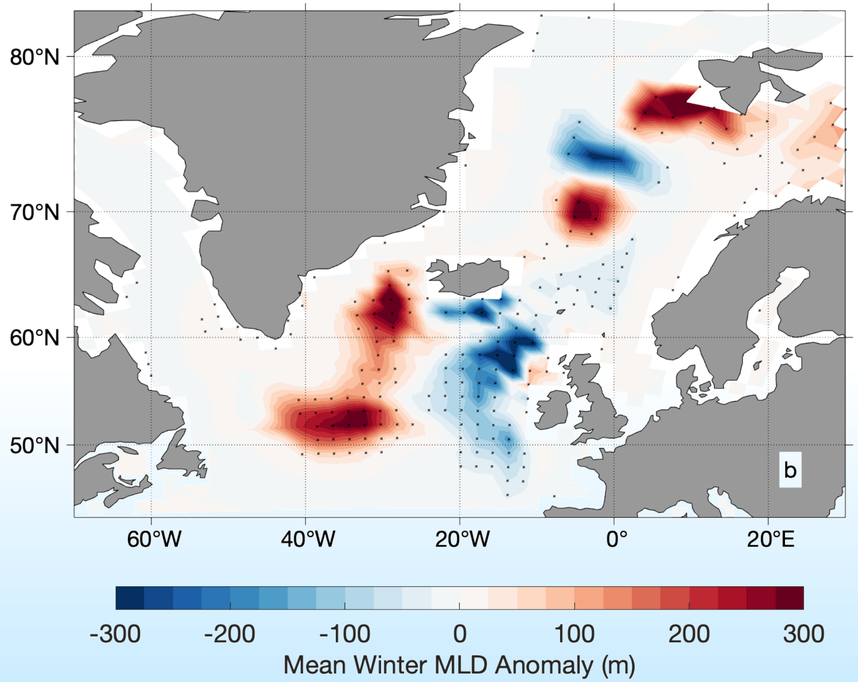
brady.ferster@locean.ipsl.fr

Arctic sea-ice reduction in IPSL-CM5A2 sensitivity experiment

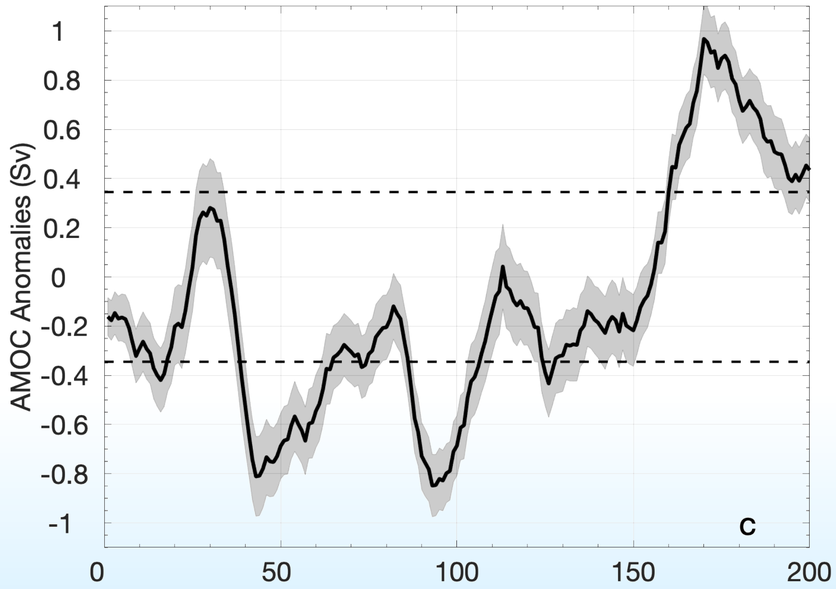


Sensitivity experiment reducing the sea ice and snow albedo by 22.5%, 14 members. The magenta and black contours are the 0.15 sea ice extent in the albedo and control experiments.

Increased convection in the Labrador Sea



Initial weakening of AMOC followed by a recovery of AMOC



AMOC anomalies and spread to 95% confidence level at 40N. The dashed lines are the 95% confidence interval of the control (Sv)

Compensating deep convection changes in response to sea ice retreat in the Iceland basin (decrease) and Labrador Sea (increase) could drive AMOC decrease and recovery.

28 April 2021

SUMMARY

MAKE OUR PLANET GREAT AGAIN

[1]LOCEAN-IPSL (Sorbonne Université, CNRS, IRD, MNHN), Paris, France.
[2]Department of Earth and Planetary Sciences, Yale University, New Haven, CT, USA.
[3]NCAS-Climate, University of Reading, Reading, UK.

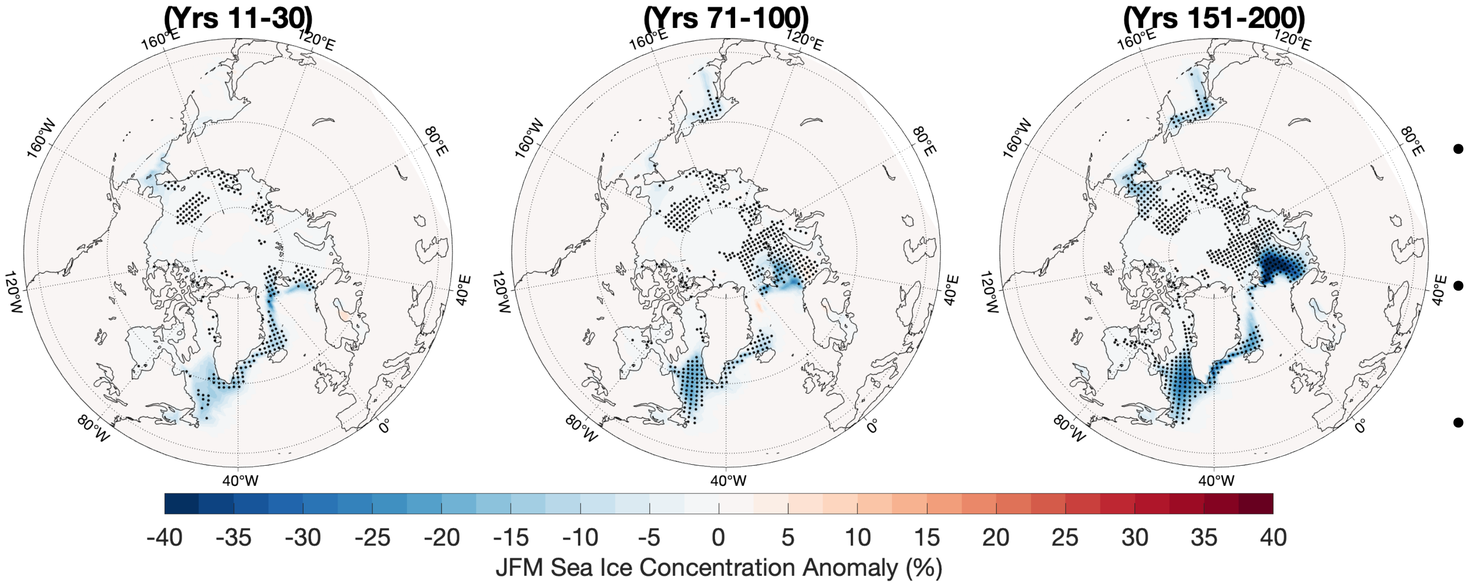
VIDEO PRESENTATION

NEXT

EGU CL4.7

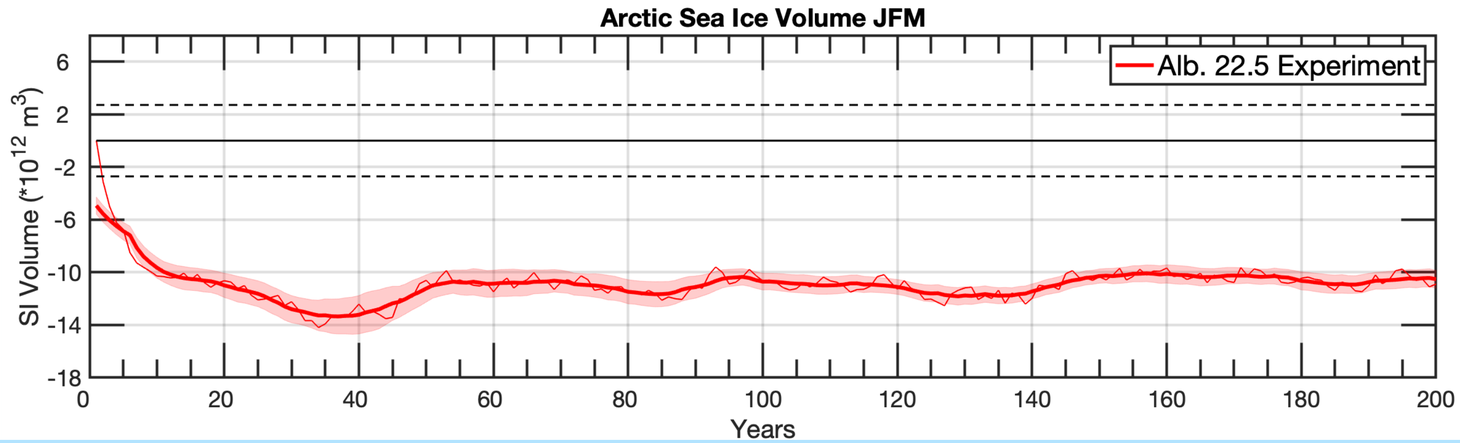
The Experiment: Sea Ice Loss in the Subpolar Atlantic

EGU21-7416



- **Sensitivity experiment** with the coupled model **IPSL-CM5A2**, methods of **Simon et al., 2021**
- Reducing the sea ice and snow cover **albedo by -22.5%** in the to **target the RCP8.5 years 2035-2055** (from CMIP5)
- **14 members** from two restarts, each lasting **200 years**
  - Expanding **9 members** from **Simon et al., 2021**

- **Opening** for **convection** in the **Labrador Sea** within the **initial 11-30 transient response**
- Results in a **~20% reduction in annual sea ice area** compared to the control
- Reaches a **minimum sea ice** by **year 40 (the target)** and maintains into a new state



[1]LOCEAN-IPSL (Sorbonne Université, CNRS, IRD, MNHN), Paris, France.
[2]Department of Earth and Planetary Sciences, Yale University, New Haven, CT, USA.
[3]NCAS-Climate, University of Reading, Reading, UK.

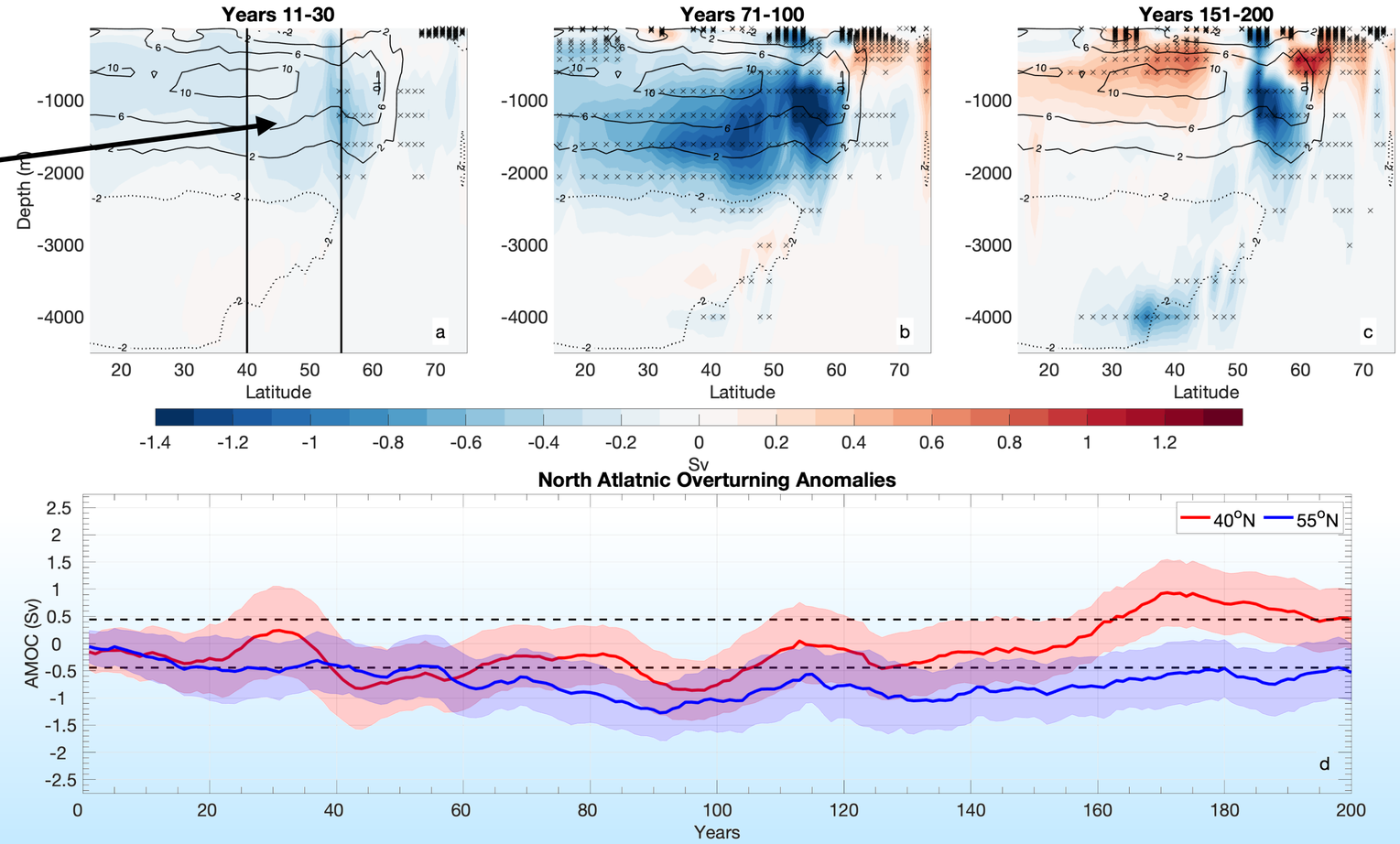
The Decline and Recovery of AMOC

EGU21-7416

- **Weakening** of **AMOC** within the initial 100 years, attributed to the shift and **weakening** of the **subpolar gyre** and **atmospheric westerlies**

- **Recovery** of **AMOC** through the **retreat of sea ice in the Labrador Sea** and **increased dense water formation**
  - **Contributes** to **increased** response in the **Subtropical gyre**

- Recovery **differs** from another **NEMO-based** study of **Oudar et al., 2017**
  - **Our experiment control run** has initial conditions of **increased sea ice** and **reduced convection** in the **Labrador Sea**

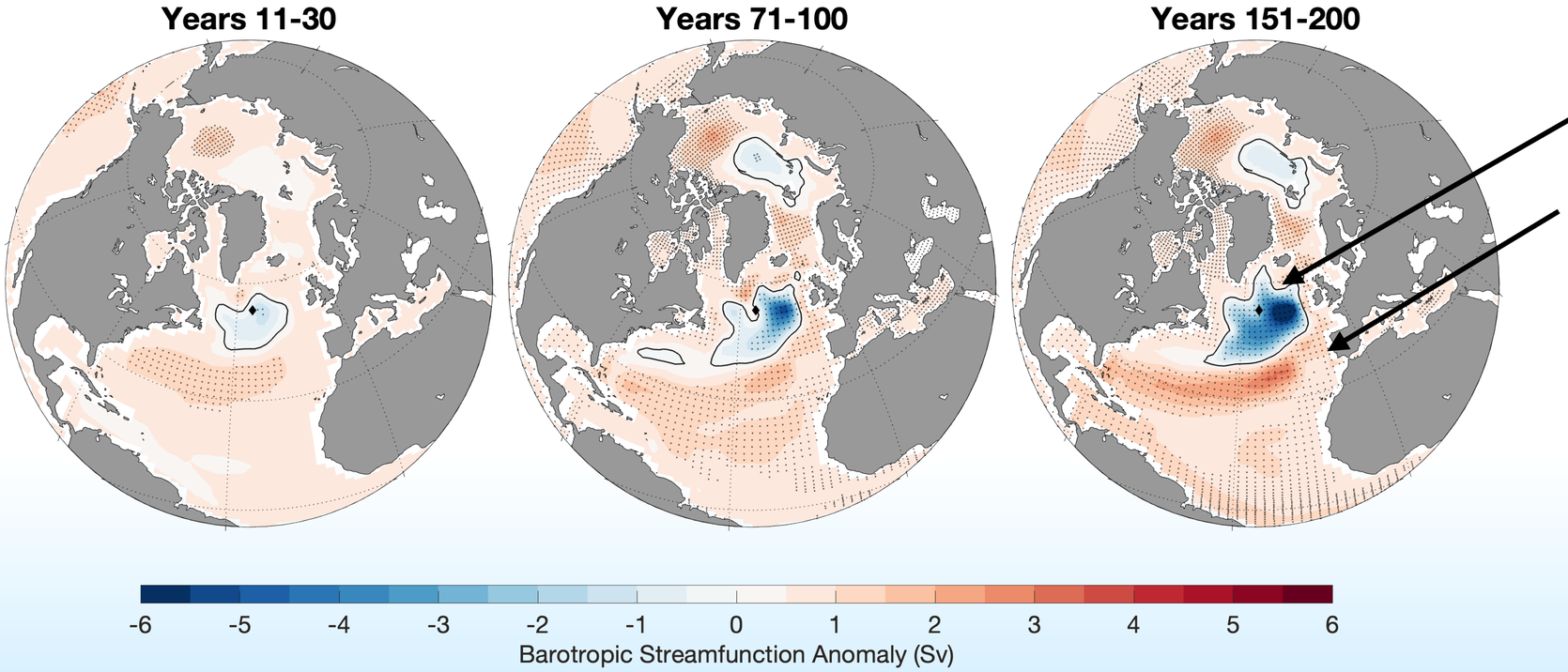


Mean anomalous Atlantic meridional overturning streamfunction (Sv; a-c). Anomalous maximum AMOC (Sv; d) timeseries of 40°N and 55°N, the dashed black lines representing the 95% confidence interval of the control. In b and c the control mean is contoured in black and values significant at the 95% confidence level are denoted with "x". The vertical black lines in c are co-located to the timeseries in plot d

[1]LOCEAN-IPSL (Sorbonne Université, CNRS, IRD, MNHN), Paris, France.
[2]Department of Earth and Planetary Sciences, Yale University, New Haven, CT, USA.
[3]NCAS-Climate, University of Reading, Reading, UK.

The Ocean and Atmosphere Responses

EGU21-7416



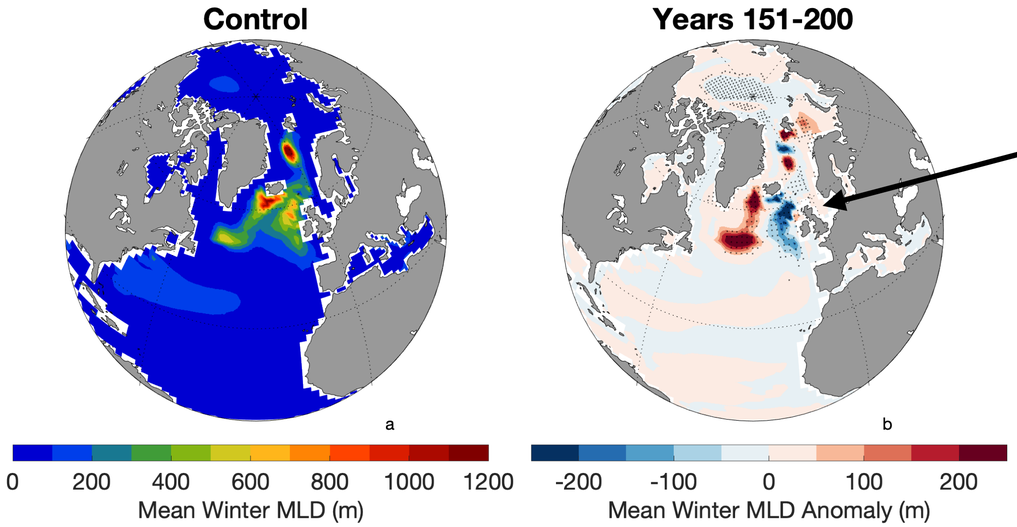
Anomalous albedo experiment barotropic streamfunction (Sv), values exceeding the 95% confidence interval of the control are denoted with a black “x”. The black contour represents the 0.0 Sv anomaly.

- Robust **southward** shift and **eastward expansion** of the **subpolar gyre**
- **Southward shift** of the **Subtropical gyre**
- **Southward shift and weakening of** the **westerlies**
  - Results in **North Atlantic “warming hole”**
  - Drives anomalous **Ekman pumping** in the **Iceland basin**
  - Anomalous **heat and salt transports** into the **Nordic Seas**

[1]LOCEAN-IPSL (Sorbonne Université, CNRS, IRD, MNHN), Paris, France.
[2]Department of Earth and Planetary Sciences, Yale University, New Haven, CT, USA.
[3]NCAS-Climate, University of Reading, Reading, UK.

North Atlantic Deep Convection

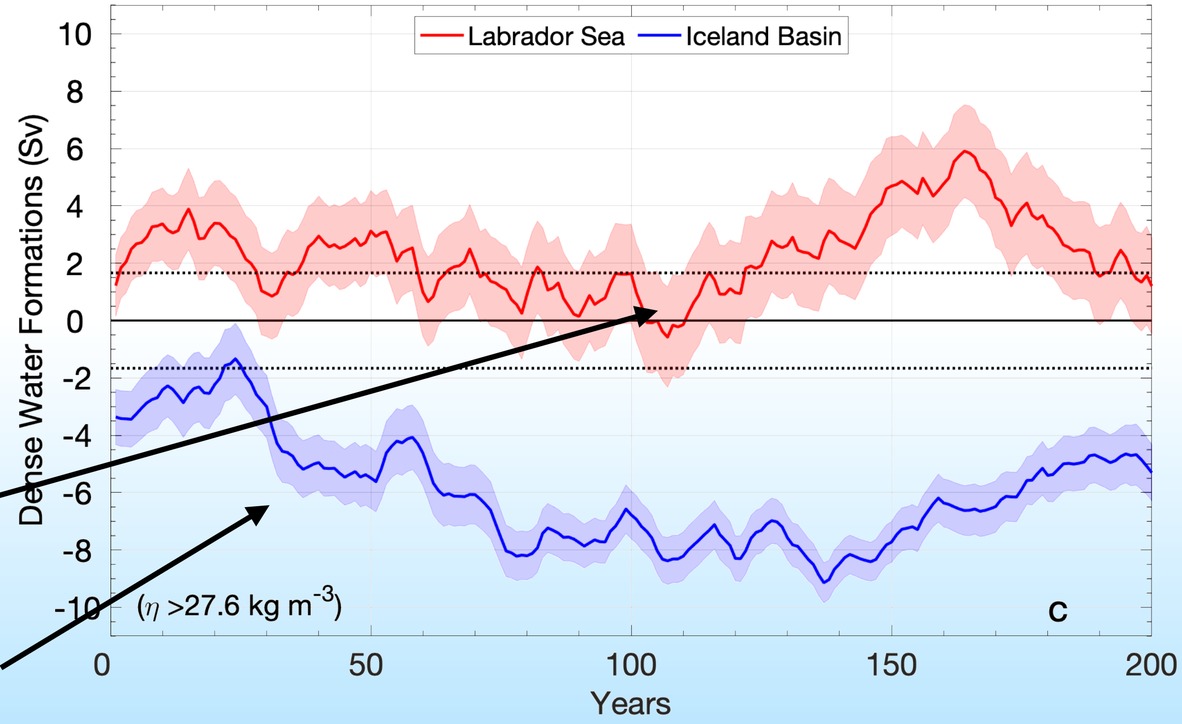
EGU21-7416



Anomalies denoted with a “x” significant at the 95% confidence level.

- Surface **Water mass transformation** to estimate dense water **formation rates** in **each** deep convective **region**
- **Increased Labrador Sea** dense water **formation rates**
  - **Compensates** for **AMOC** recovery
- A **robust decline** in **Iceland basin** dense water **formation rates**

- **Enhanced deep convection** in the **Labrador and Irminger Seas**, **reduced convection** in the **Iceland basin**



Dense water formation rates estimated through a surface water mass transformation analysis. The dashed lines are the 95% confidence interval of the control (Sv) and the shading the ensemble spread.

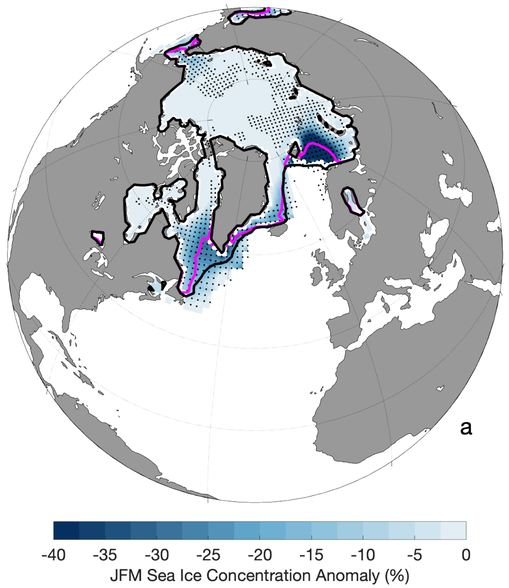
[1]LOCEAN-IPSL (Sorbonne Université, CNRS, IRD, MNHN), Paris, France.
[2]Department of Earth and Planetary Sciences, Yale University, New Haven, CT, USA.
[3]NCAS-Climate, University of Reading, Reading, UK.

The Transient and Equilibrium Response of the AMOC to Arctic sea ice decline in a coupled model

*Amélie Simon[1], **Brady Ferster**[1], Alexey Fedorov[1,2], Juliette Mignot[1], Eric Guilyardi[1,3]*

brady.ferster@locean.ipsl.fr

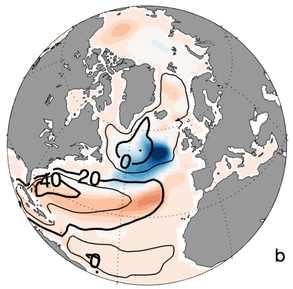
EGU21-7416

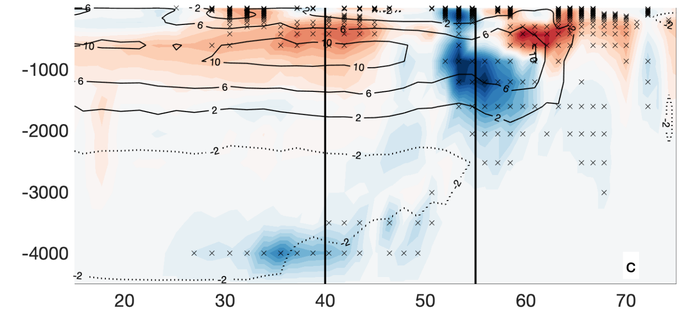


Winter sea ice anomalies for years 151-200. The magenta and black contours are the 0.15 sea ice extent in the albedo and control experiments.

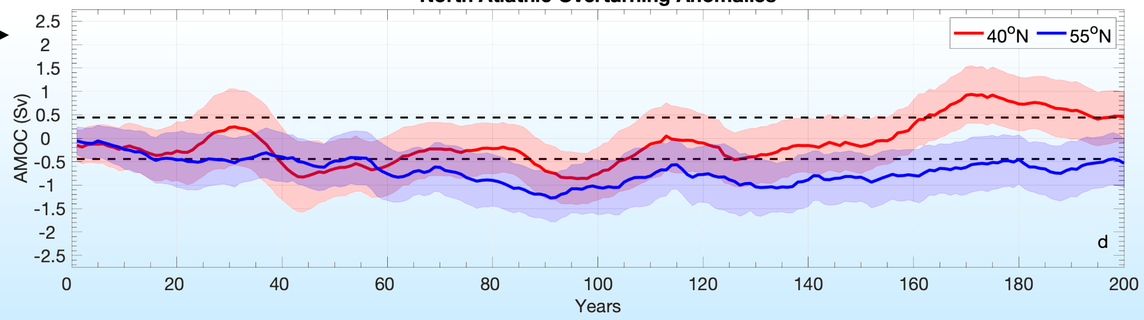
← Ensemble with 20% annual mean Arctic sea-ice reduction in the **IPSL-CM5A2** by reducing the Arctic albedo of sea-ice and snow (a)

Southward shift of the **subpolar gyre** and **westerlies** (b) →





An **initial weakening** of **AMOC** is followed by a **recovery** of **AMOC** (c, d) →



Differs from other **NEMO** based experiment by **Labrador Sea sea ice retreat** and i**ncreased deep convection**

Compensating deep convection changes in response to sea ice retreat in Iceland basin (decrease) and Labrador Sea (increase) could drive AMOC decrease and recovery.

Mean anomalous barotropic streamfunction (Sv; b) and Atlantic meridional overturning streamfunction (Sv; c) for years 151-200. (d) Anomalous maximum AMOC (Sv) timeseries of 40°N and 55°N, the dashed black lines representing the 95% confidence interval of the control. In b and c the control mean is contoured in black and values significant at the 95% confidence level are denoted with “x”. The vertical black lines in c are co-located to the timeseries in plot d

[1]LOCEAN-IPSL (Sorbonne Université, CNRS, IRD, MNHN), Paris, France.
[2]Department of Earth and Planetary Sciences, Yale University, New Haven, CT, USA.
[3]NCAS-Climate, University of Reading, Reading, UK.