Decadal fingerprints of freshwater discharge around Greenland in a multi-model ensemble

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Background

- Greenland ice sheet (GrIS) meting is accelerating in the recent years (Rignot et al. 2011)
- Large uncertainties concerning the impact of GrIS melting on the Atlantic Meridional Overturning Circulation (AMOC) in climate models (Stouffer et al. 2006)
- Complex imprints of additional freshwater flux in the North Atlantic (not simple cooling)

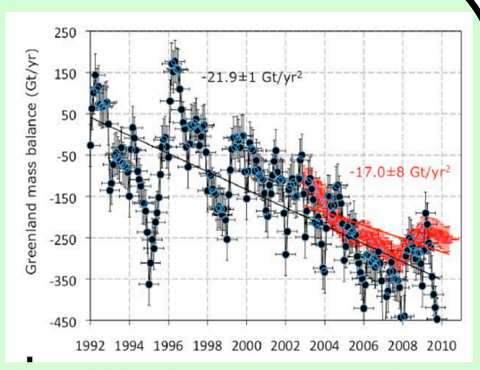

Fig. 1: GrIS melting rate according to Rignot et al. (2011) observations

Aim of this work

- Evaluate the robust fingerprints of additional freshwater input in the North Atlantic in a multi-model framework as well as its impact on the AMOC
- Understand the mechanisms leading to such fingerprints (oceanic or atmospheric)
- Explain the spread for the AMOC sensitivity in climate models in response to hosing

Experimental design

Model	Institute	Type	Ocean	Atmosphere
HadCM3	Hadley Centre	OAGCM	No name 1.25x1.25, L20	HadAM3, 91x76 - L19
IPSLCM5A	Institut Pierre Simon Laplace	OAGCM	NEMO 2°, L31	LMD5, 96x96 - L39
MPI-ESM	MPI	ESM	MPI-OM 1.5°, L40	ECHAM6, T63 - L47
ORCA05	GEOMAR	OGCM	NEMO 0.5°, L46	CORE.v2 forcing
EC-Earth	DMI	OAGCM	NEMO 1°, L42	IFS T159 - L31
BCM2	NERSC	OAGCM	MICOM 2.8°, L35 isopycnal	ARPEGE T63 - L31

Table 1: Description of the participating models

- We consider transient *historical* simulations over the period 1965-2004 from 5 AOGCMs and 1 ocean-only model
- With the same set-up we consider *hosing* experiments with 0.1 Sv added around the Greenland grid-boxes in each model
- We consider the anomalies (significant at 95% level) of the 4th decade between historical and hosing experiments

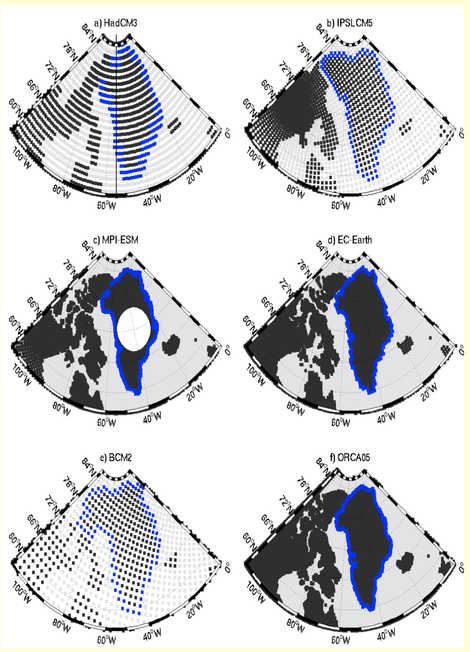

Fig.2: gridboxes concerned by the hosing.

SST and SSS fingerprints

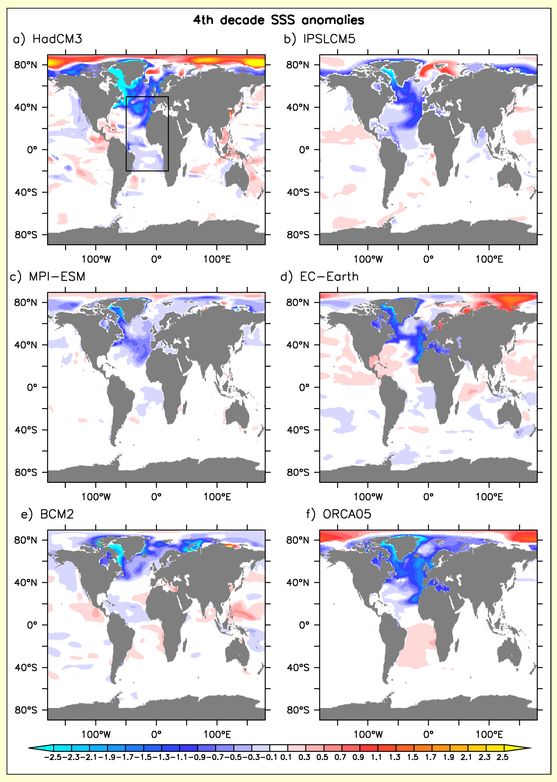

Fig. 3: SSS anomalies and box defintion for the FW leakage in panel a)

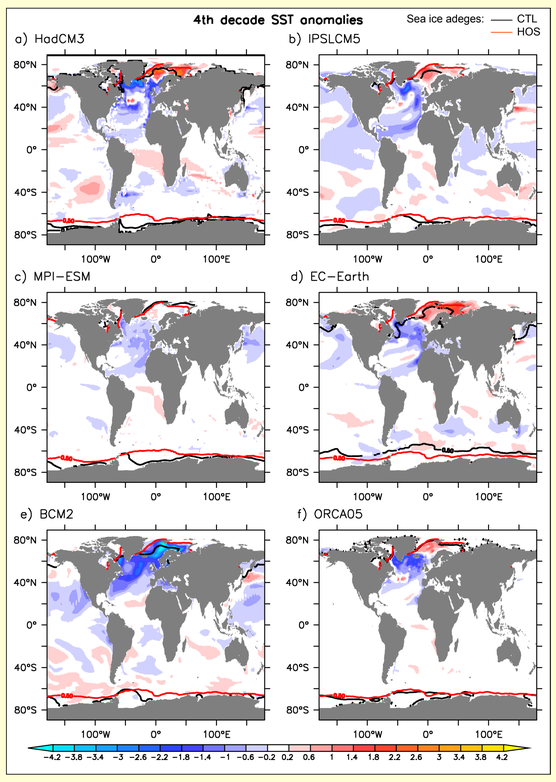

Fig. 4: SST anomalies and sea-ice edges in control and hosing simulation

AMOC response

- Spread for the AMOC response among models
- Related to freshwater (FW) leakage from subpolar to subtropical gyre
- And asymmetry for the limit between the gyres

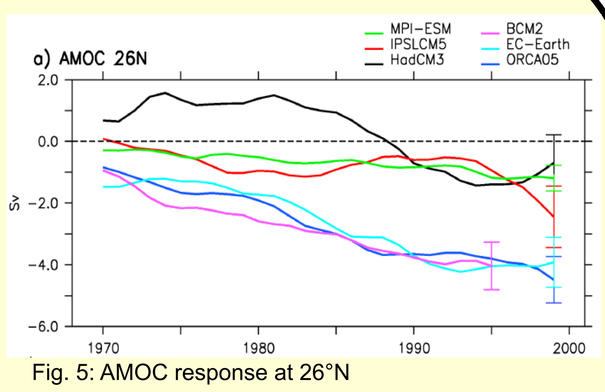

Fig. 5: AMOC response at 26°N

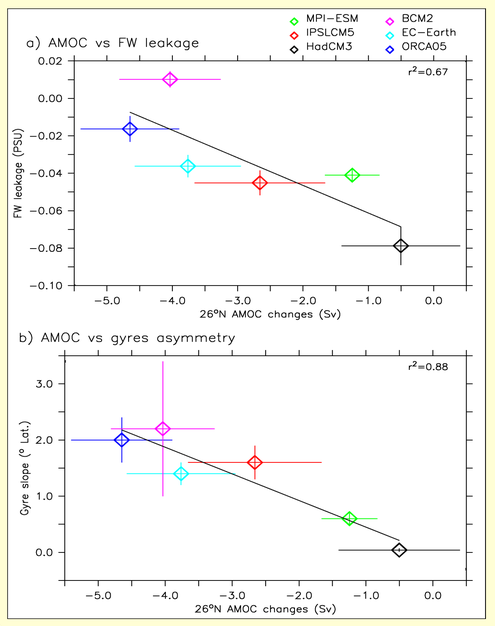

Fig. 6: AMOC changes vs FW leakage and gyre asymmetry

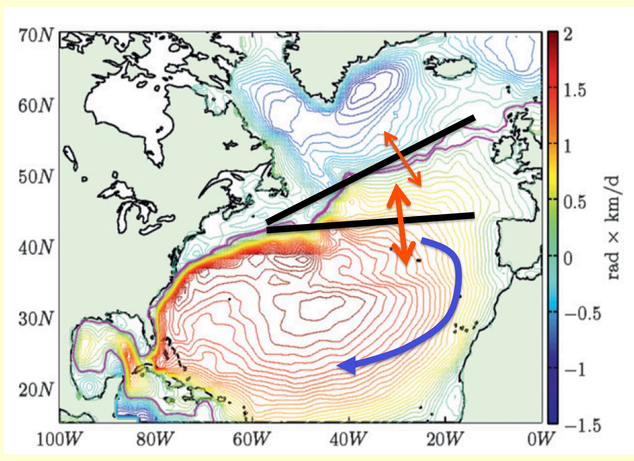

Fig. 7: Scheme of the proposed mechanism, using BSF reconstruction from Rypina et al. (2011)

Explanation for temperature fingerprints

- The freshening of the subpolar gyre caps the subsurface waters, which warms them (less cooling by the atmosphere)
- The anomalies emerges in the Nordic Seas

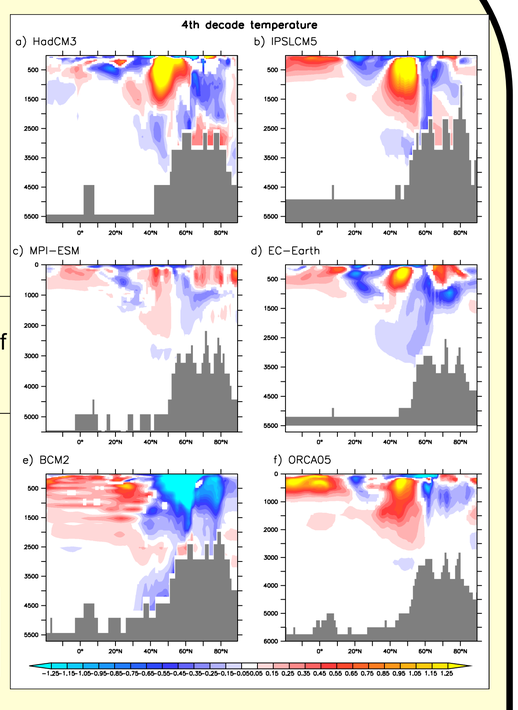

Fig. 8: Latitude depth section of temperature in the Atlantic

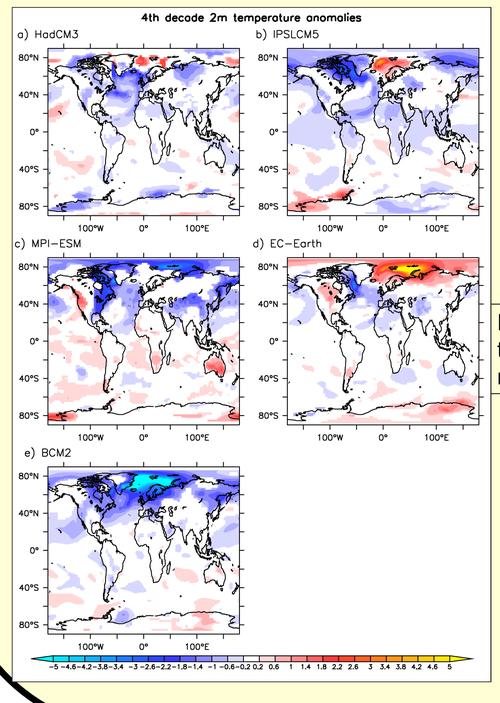

Fig. 3: 2-meter temperature response

- This leads to a large warming in this region in a few models, while others do not
- Large uncertainties for temperature response over Scandinavia

Discussions and conclusions

- Consistent fingerprints in response to FW input around Greenland among 5 AOGCMs:
  - Cooling in most of the Atlantic, slight warming in the Southern Hemisphere
  - Localized warming in the Nordic Seas
  - Fresh water leakage along the Canary Current
  - Increase in SSS around the North Pole in the Arctic
- AMOC weakening is related to the FW leakage intensity: the more freshwater escapes from the subpolar gyre, the lower the AMOC weakens
- This appears to be related with asymmetry between the subpolar and subtropical gyre: the more asymmetric, the lower the FW leakage is

Outlooks

- Is this large spread for the AMOC response also consistent in RCP85 projections? i.e. Can the AMOC weakening be significanlty weakened by GrIS melting?
- Preliminary results seem to indicate it is not the case because the deep ocean is already isolated from the surface i.e. oceanic convection has already almost ceased after 2050.

Reference: Swingedouw D., Rodehacke C., Behrens E., Menary M., Olsen S., Gao Y., Mikolajewicz U., Mignot J., Biastoch A. Decadal fingerprints of fresh water discharge around Greenland in a multi-models ensemble. *Climate Dynamics*, in press