BLUE ACTION

# Impacts of the observed melting of Greenland ice sheet and Arctic land ice over the North Atlantic in a climate model

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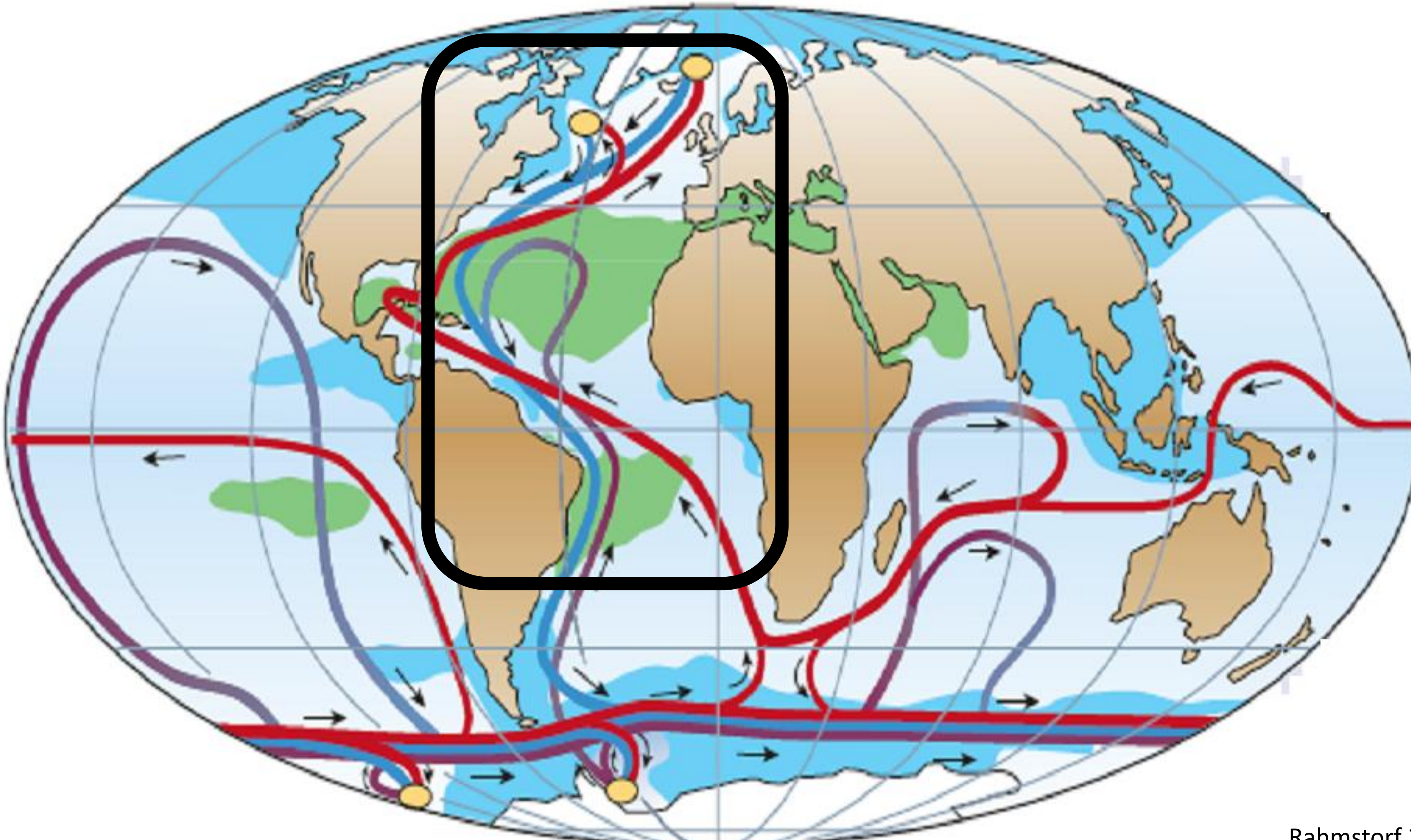
# What is the AMOC?

**AMOC : Atlantic Meridional Overturning Circulation**

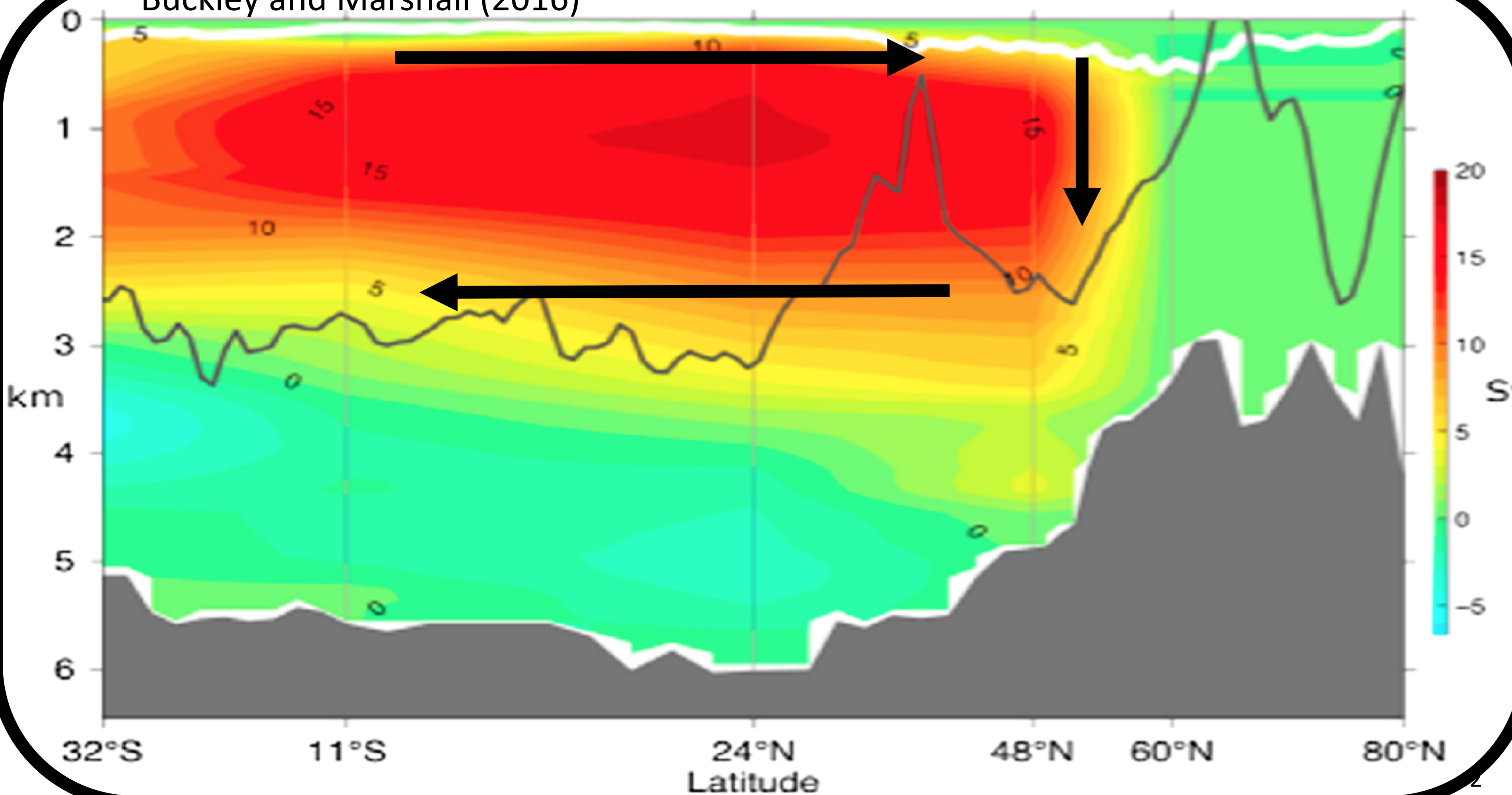


Rahmstorf 2002

# What is the AMOC?

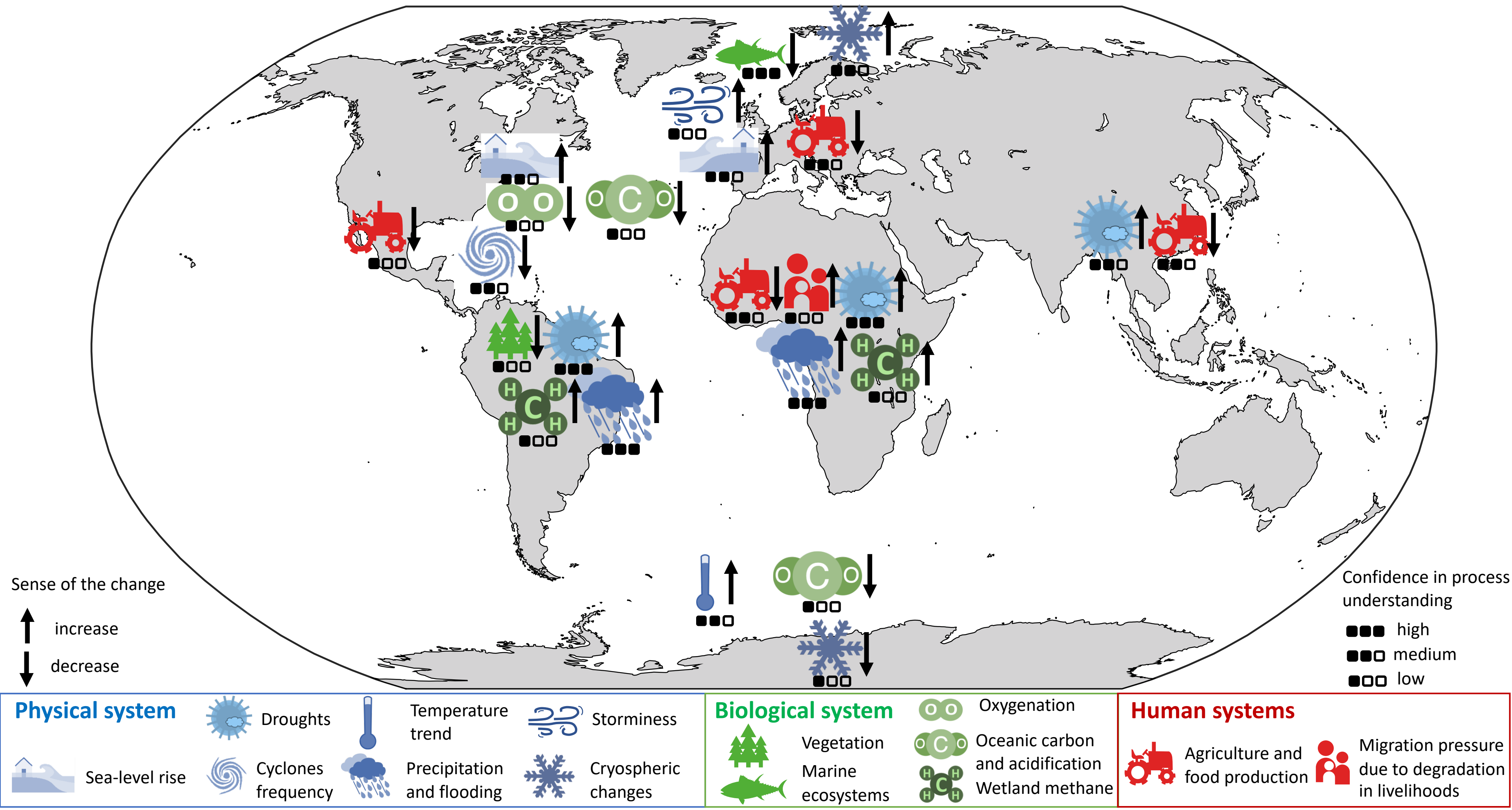
**AMOC : Atlantic Meridional Overturning Circulation**

Buckley and Marshall (2016)



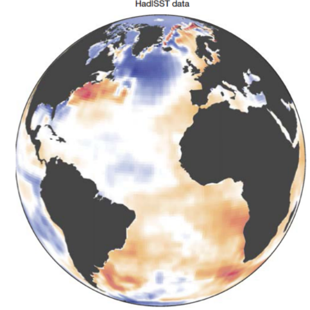
# Is the AMOC important for climate and society?

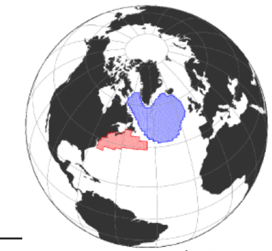
**Representative impacts of an AMOC substantial weakening**



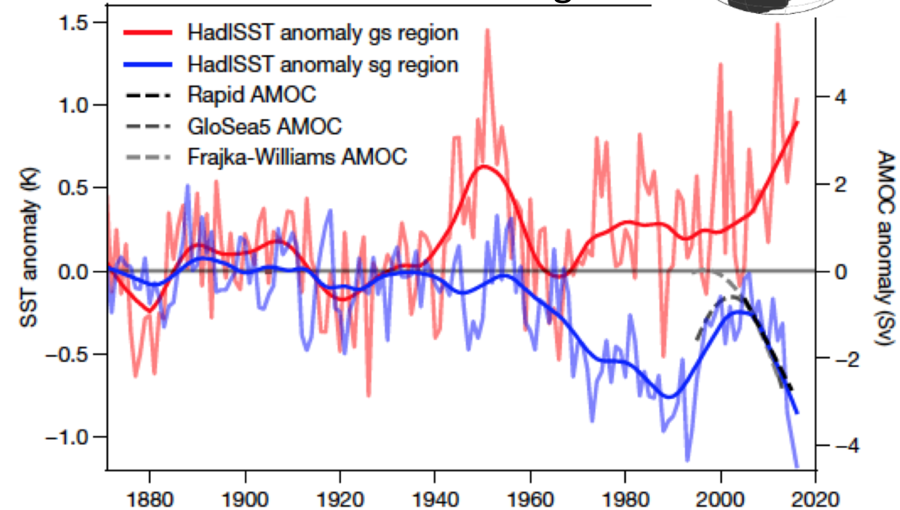
# Is the AMOC weakening?

- Is the AMOC already weakening?
- Paleodata (Thornalley et al. 2018) and SST fingerprints (Caesar et al. 2018) say « possibly » (estimate of **3±1 Sv weakening or 15% decrease**)
- CMIP5 models exhibit **-1.4 ±1.4 Sv** of decrease between 2006-2015 and 1850-1900
- No Greenland ice sheet (GrIS) melting included in the historical simulations
- What is the forced signal from GrIS melting?

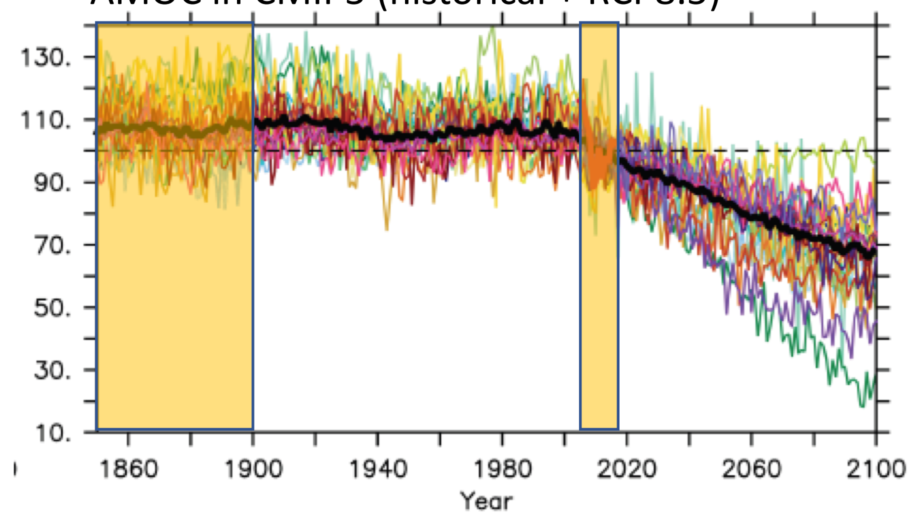


Observed relative SST changes

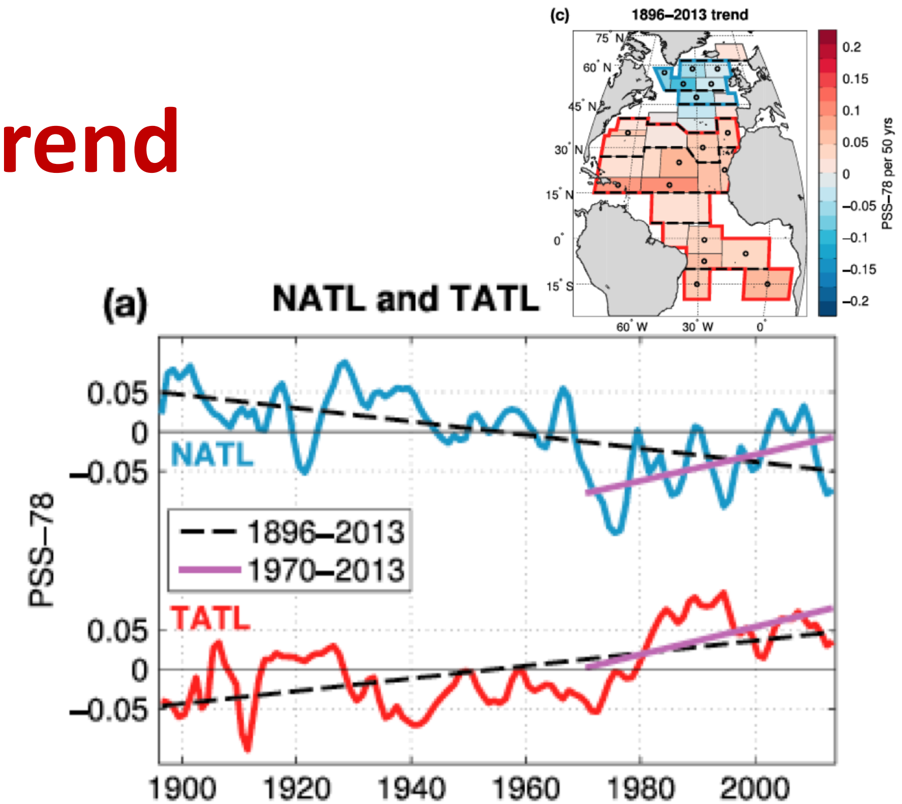



AMOC in CMIP5 (historical + RCP8.5)

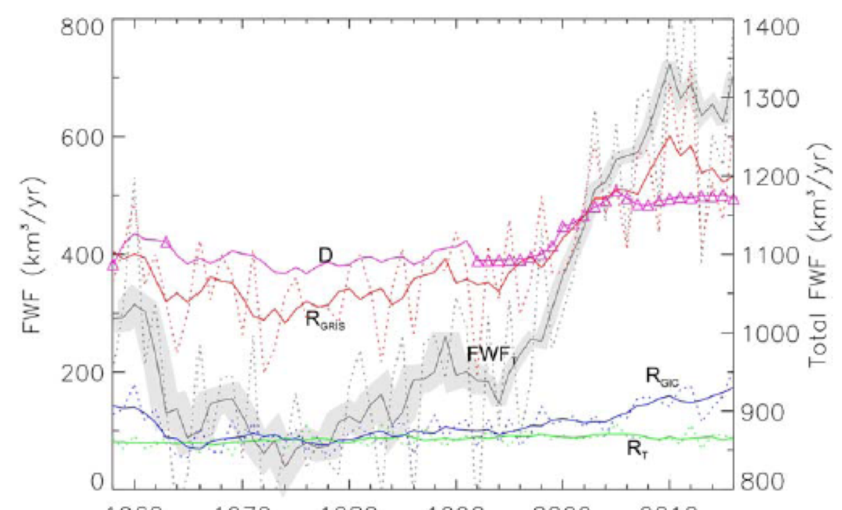


# GrIS melting and SSS trend

- There is a decreasing trend in SSS in the North Atlantic (Friedman et al. 2017)
- The freshwater release from the Greenland ice sheet is strongly increasing (Bamber et al. 2018) in the recent decades but also in the 1920s (Box and Colgan 2013)
- Is there a link between the two? (not clear, e.g. Yang et al. 2016 vs. Dukhovskoy et al. 2019)



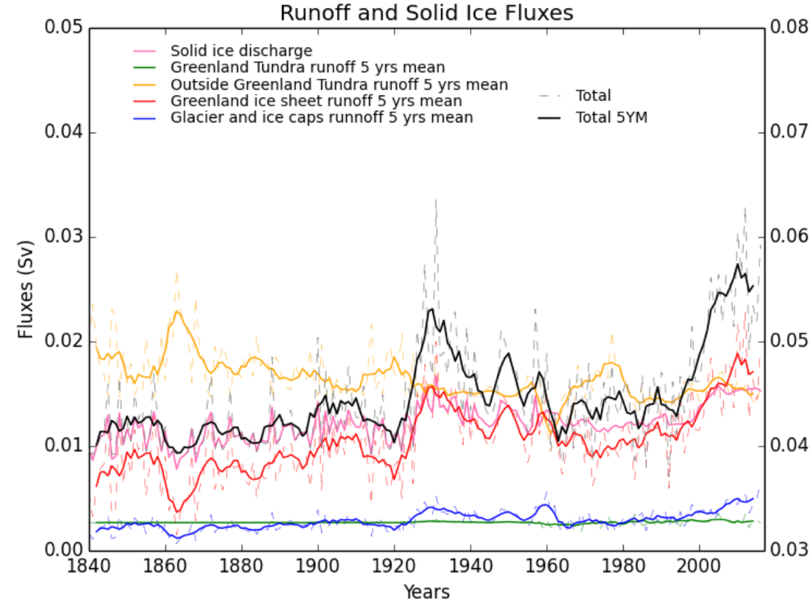

Friedman et al. 2017

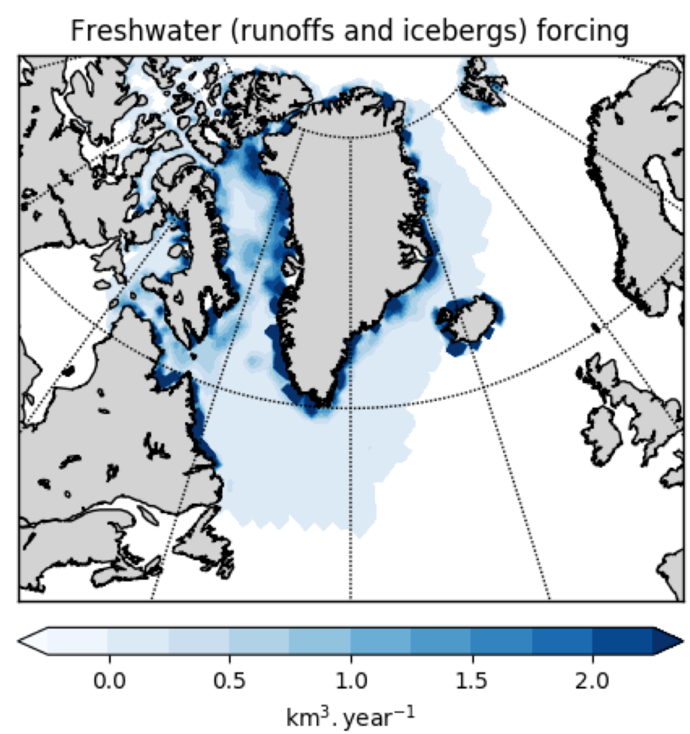



Bamber et al. 2018

# Experimental design

- Use of Bamber et al. (2018) recent reconstruction
- Extension back to 1840 following Box and Colgan (2013)
- Overwrite runoff and calving in the the Greenland region by those observation-based fluxes
- Use of 5 members of historical simulations including this melting since 1920
- Comparison with historical simulations from IPSL-CM6 starting from same initial conditions

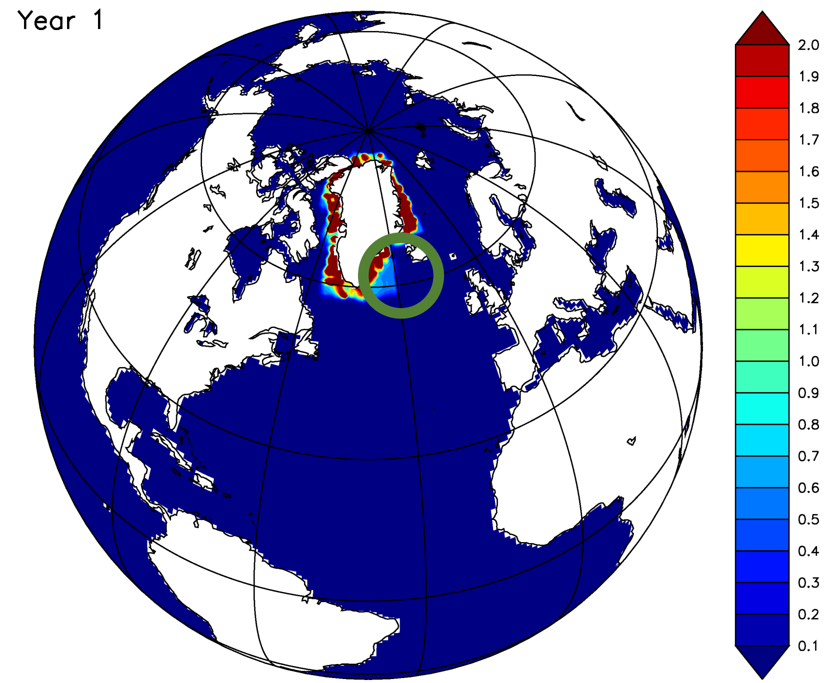


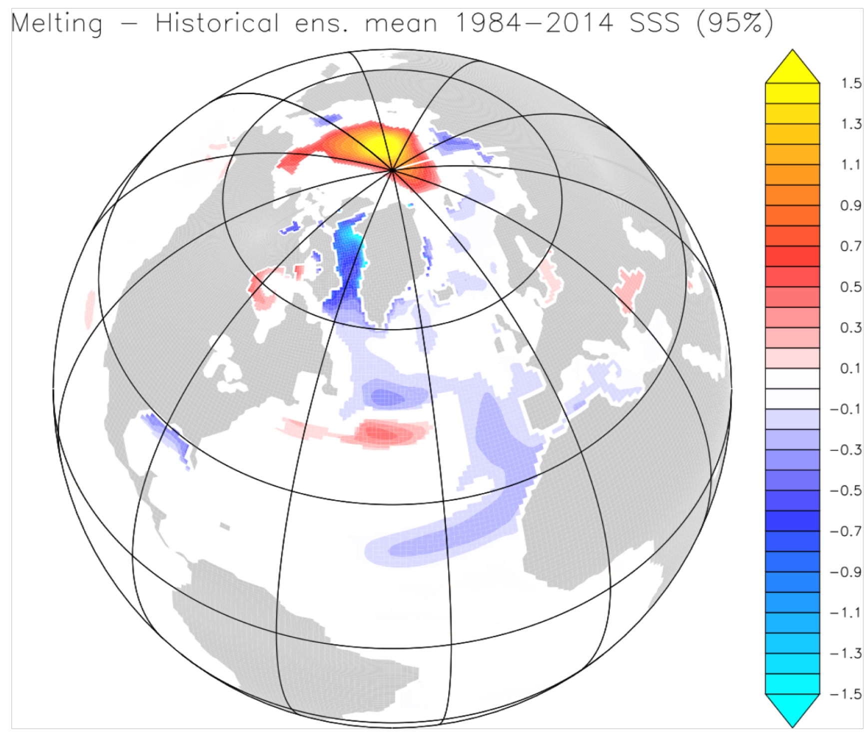



# Spread of the freshwater anomalies

- Use of a passive tracer to evaluate the pathways from the melting at the coast of Greenland (following a climatology of the runoff)

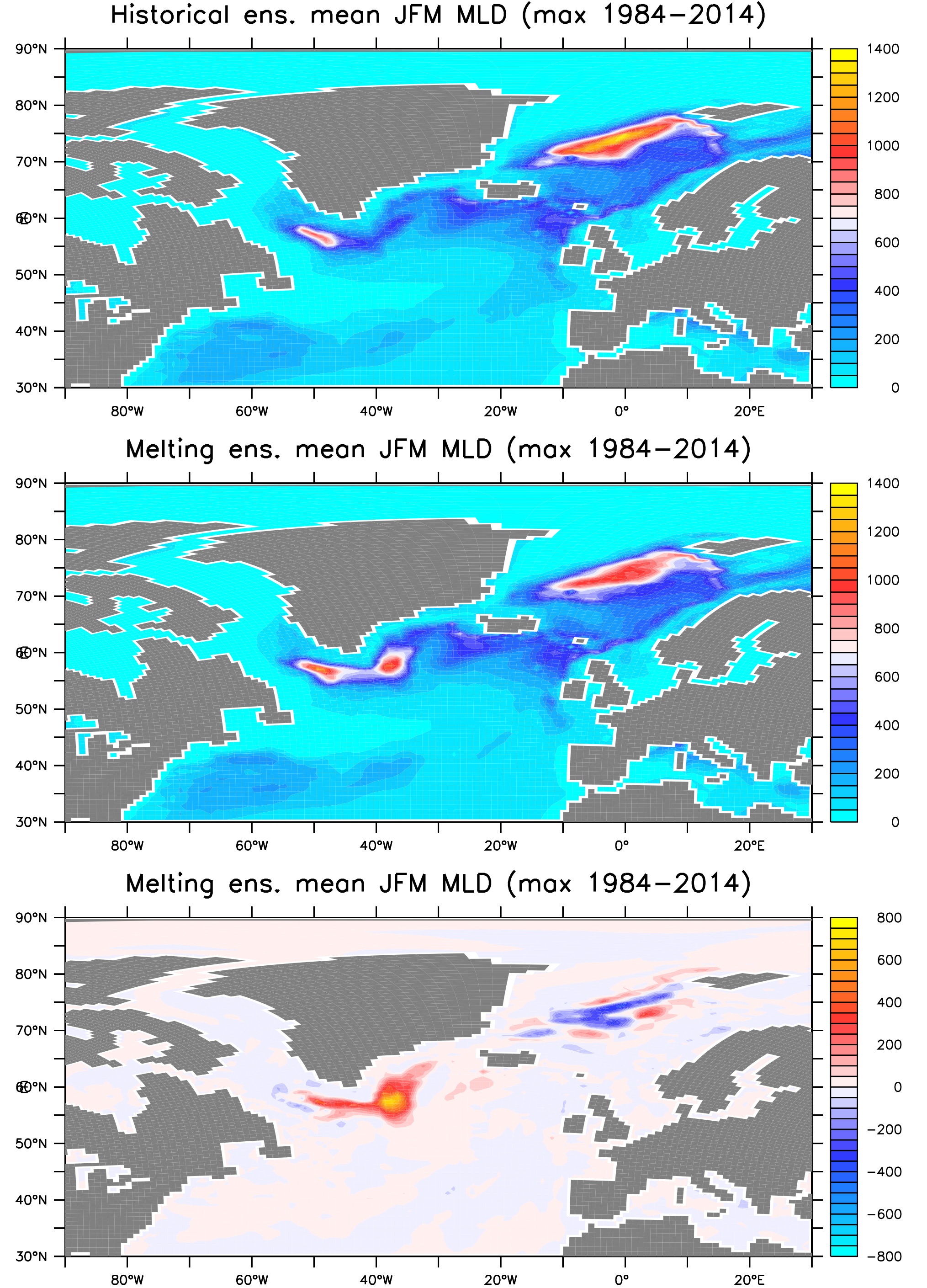
- Propagation of the passive tracer reminiscent of SSS changes, but not exactly the same: the changes in currents have also modified the salinity field, which is an active tracer



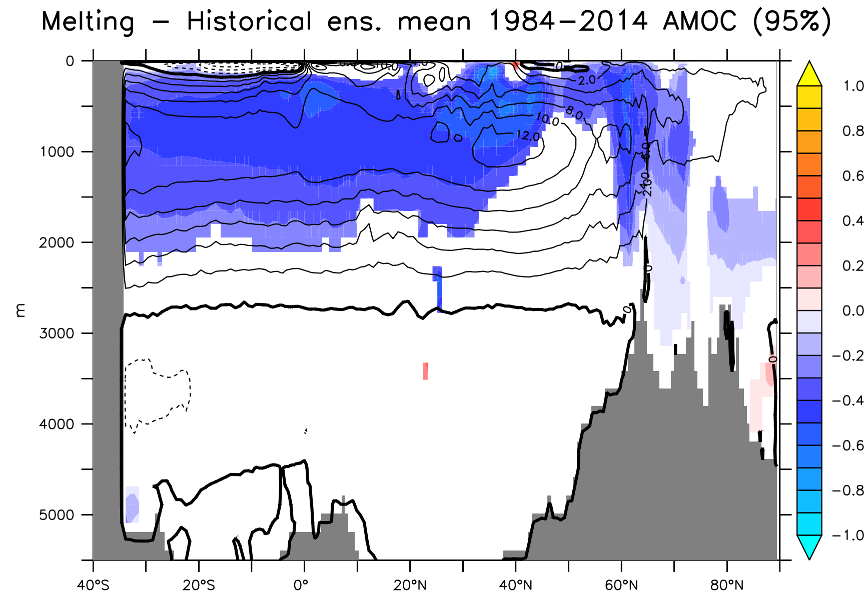
# Convection sites modifications

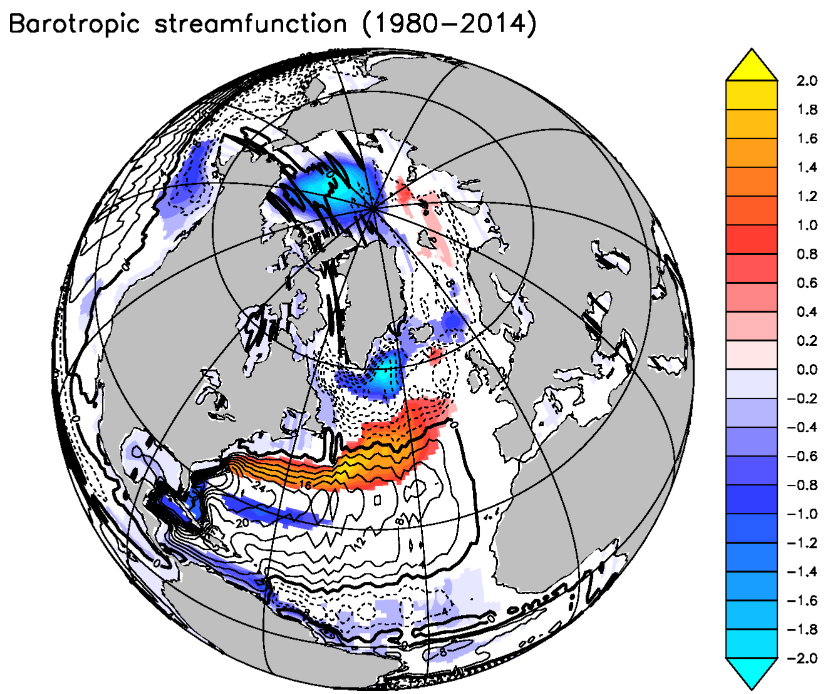
- There are two main convection sites in IPSL-CM6A: one in the Nordic Seas and one in the Labrador Sea
- Sporadic convection in the Irminger Sea, which seems to be reinforced by the addition of melting at the end of the simulations
- Opposing effects from Nordic Seas and Irminger Sea for deep water formation



# Impacts on the ocean circulation

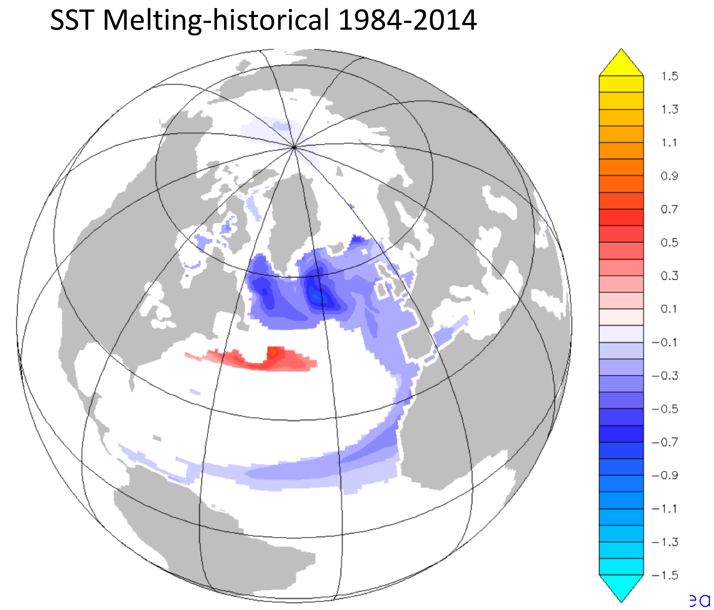
- The AMOC is slightly affected by the freshwater trends
- It weakens by less than 1 Sv
- The barotropic circulation is modified with:
  - A northward and zonal shift of the Gulf Stream
  - An intensification of the subpolar gyre around the Irminger Sea, in line with the convection change
  - An increase in transpolar current and increase of Atlantic water in the Arctic

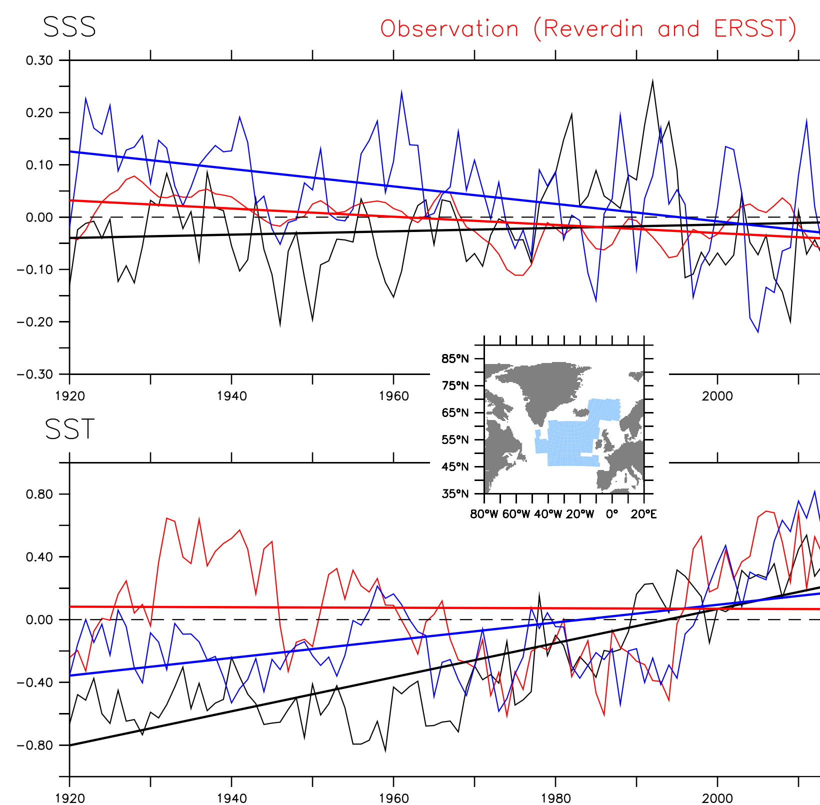


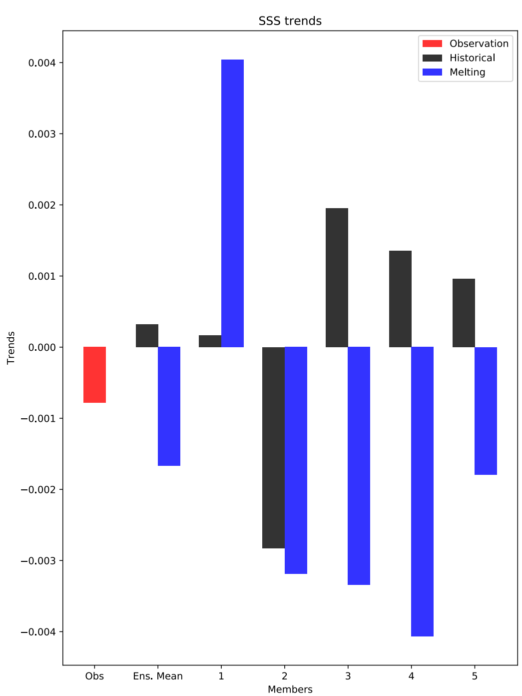



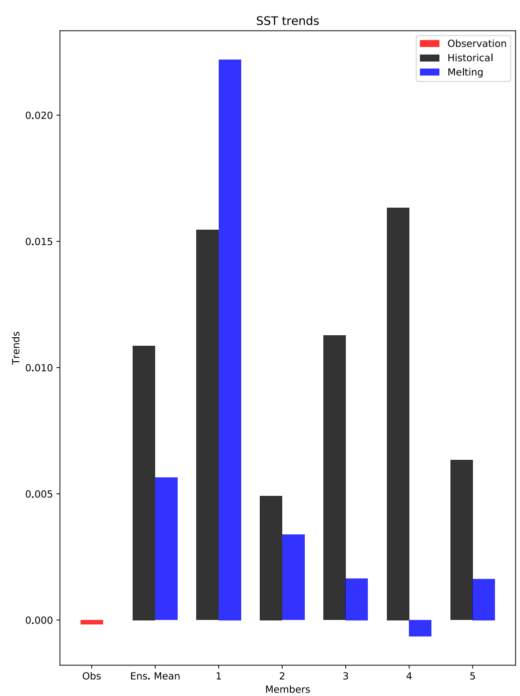
# Impacts on the centennial trend in active tracers

- Clear signature on SST reminiscent of observations (e.g. Caesar et al. 2018)
- The forced trends in the North Atlantic are more in line with observations (to be confirmed…)



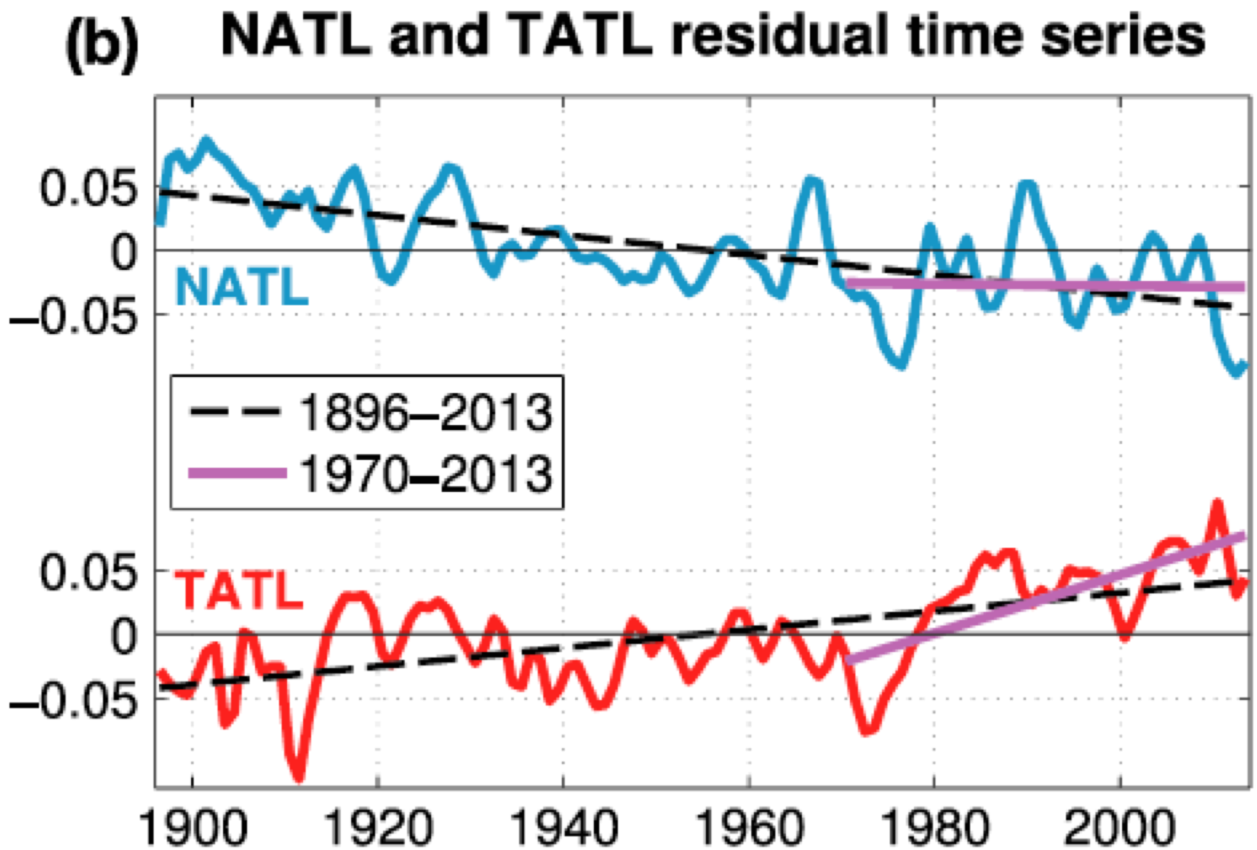
# Conclusions and outlooks

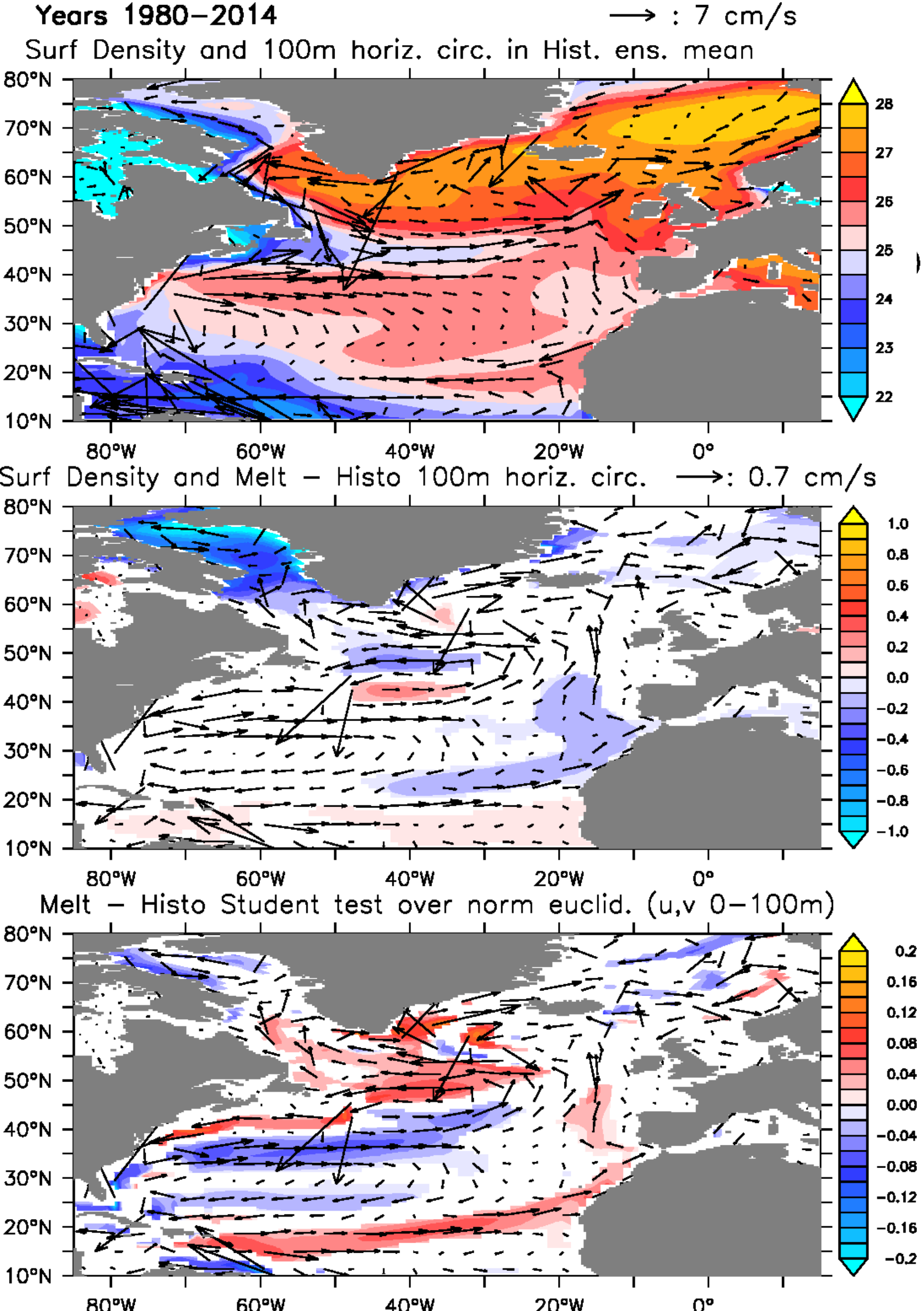
- Including a better representation of GrIS freshwater input impacts the on-going trends in the North Atlantic
- It brings forced SSS trend in the same direction as observation (but still compatible with internal variability) and improve SST trend (if forced…)
- A very slight impact on the AMOC (< 1 Sv)
- Need for a more formal framework to detect any changes in active tracer fields and AMOC

⇒ detection-attribution framework applied to the North Atlantic

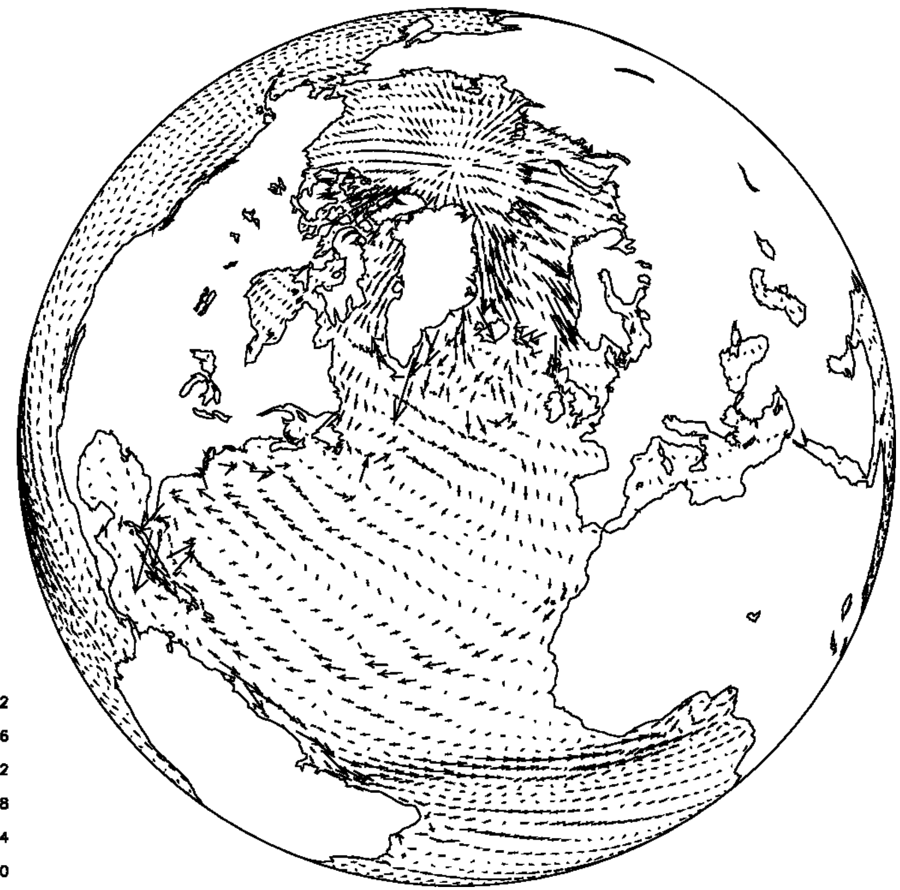

Courtesy of Bruno Ferron, OVIDE 2010

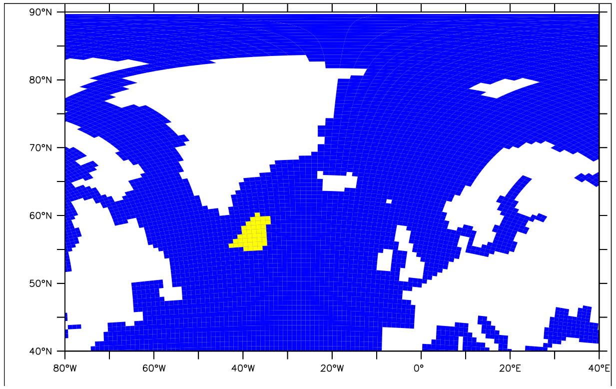
# SSS trend without NAO and AMV signal

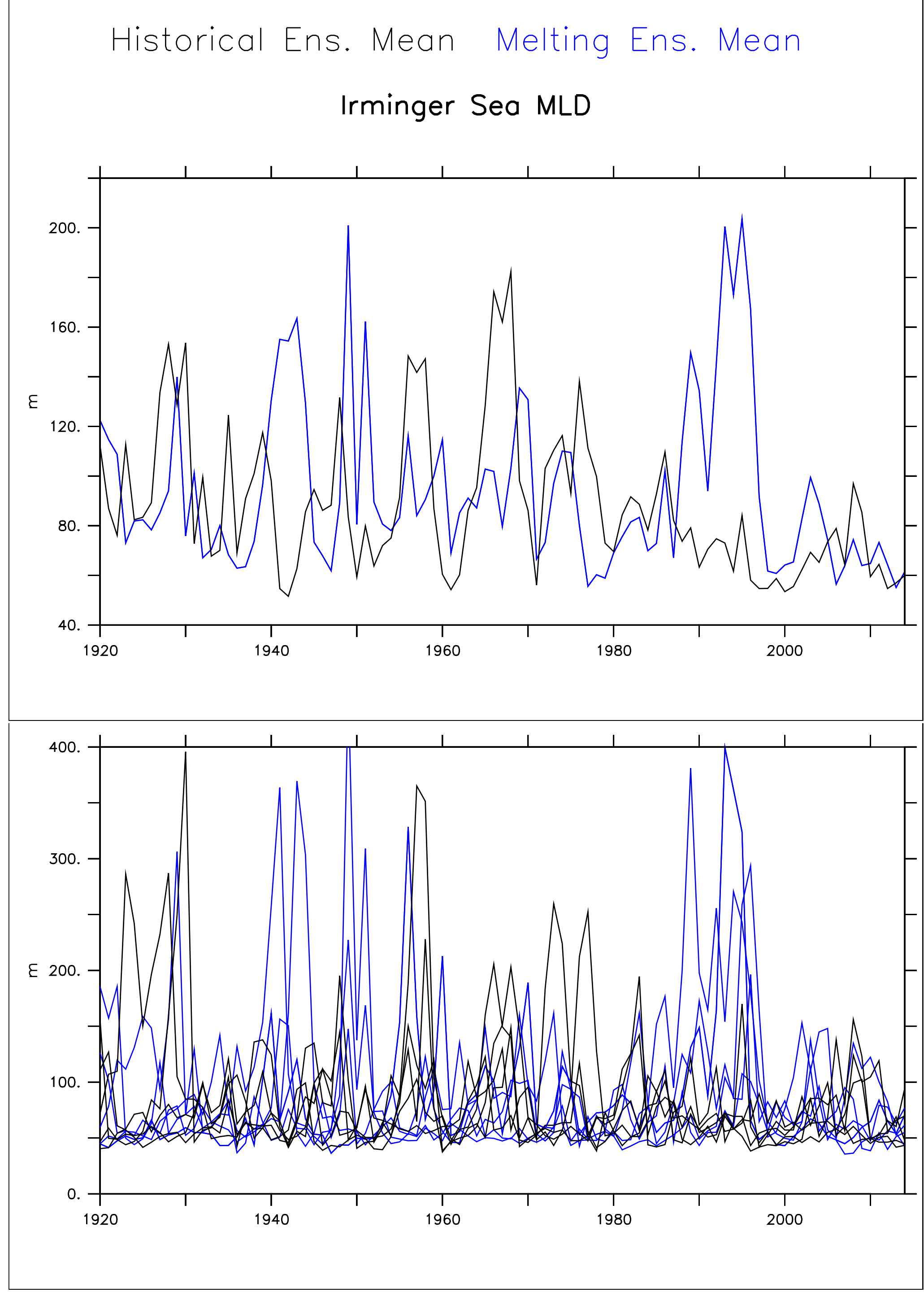





)–m current anomalies (years 1980–2014)




90°N
80°N
70°N
60°N
50°N
40°N
80°W
60°W
40°W
20°W
0°
20°E
40°E


Historical Ens. Mean
Melting Ens. Mean
Irminger Sea MLD
m
40.
80.
120.
160.
200.
0.
100.
200.
300.
400.
1920
1940
1960
1980
2000