

# Abrupt changes in the SPG

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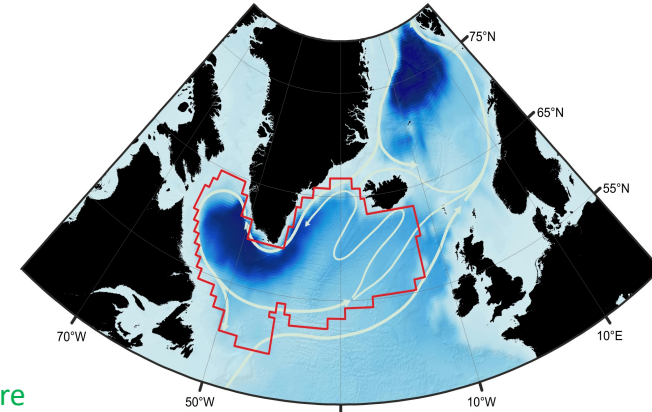
EPOC

Giovanni Sgubin, Simon Michel, Sybren Drijfhout, Juliette Mignot, Marion Devilliers, Julie Deshayes,, Marie-Noelle Houssais, Christophe Herbaut, Vincent Hanquiez,, Kees van Leeuwen, Lucas Almeida...

# Possibility of Abrupt Changes in the North Atlantic in models



- Some CMIP models do show abrupt (<10 years) cooling in the subpolar gyre (SPG)

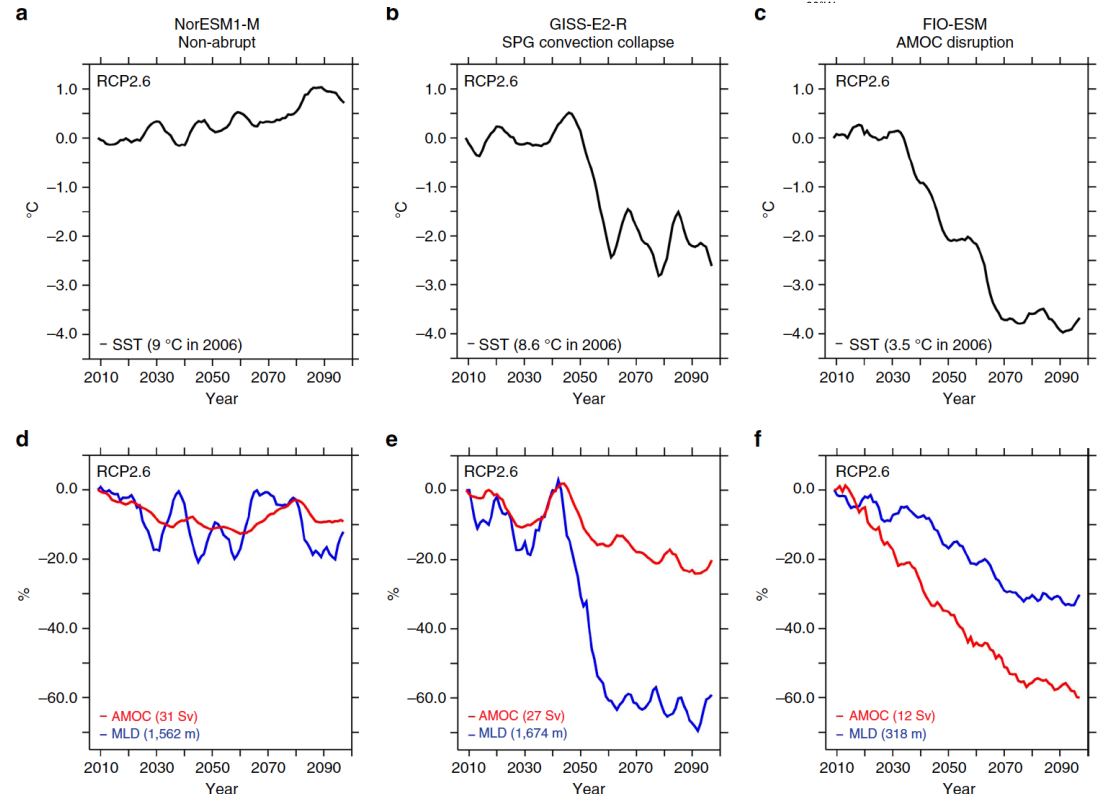


- Two different processes

- Disruption of the AMOC (strong decrease of convection both in the Labrador and Nordic Seas)
- Collapse of convection in the Labrador Sea : can occur in only one decade => **the SPG as a new tipping element**

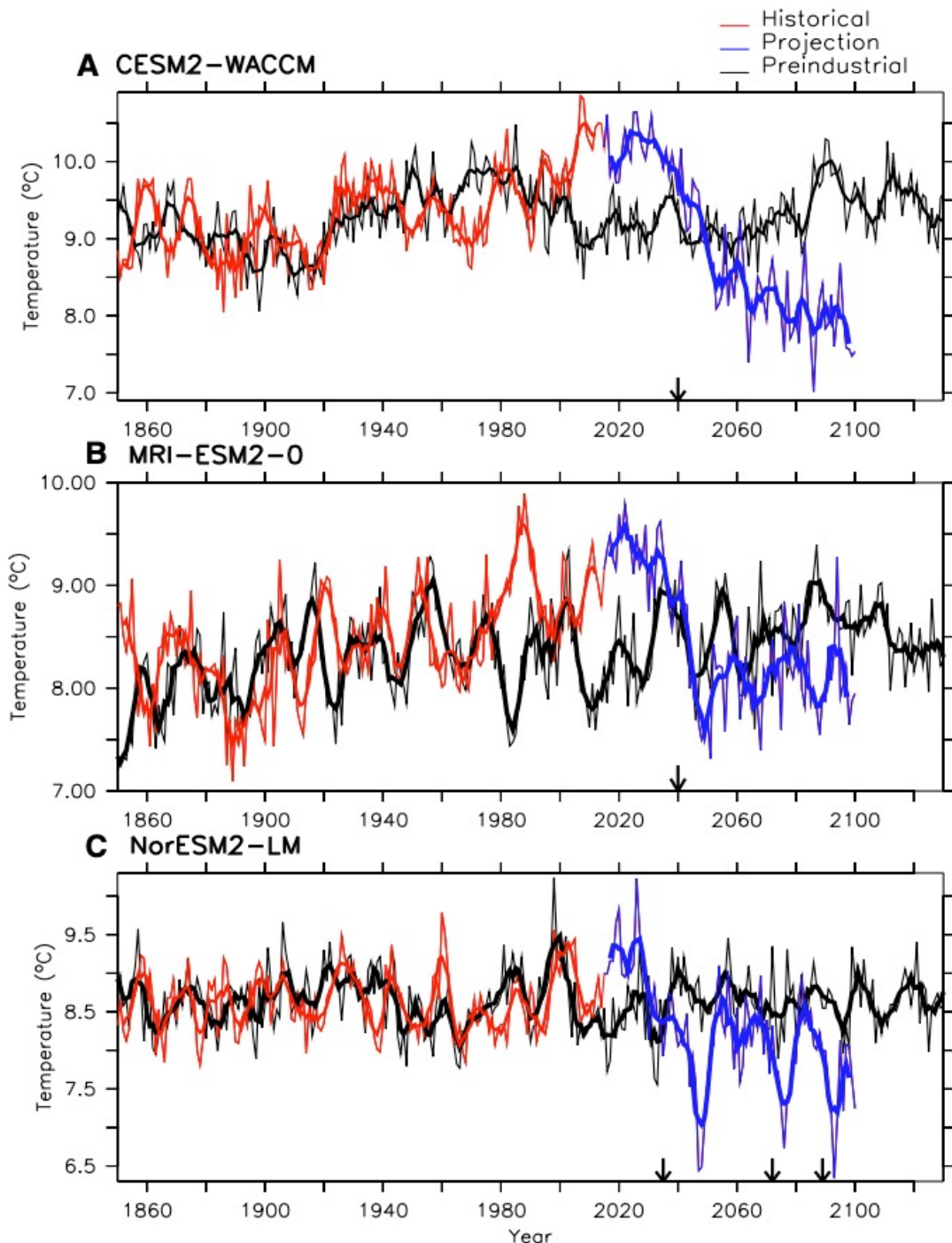
## Changes in the subpolar gyre

- This was true in CMIP5 (Sgubin et al. 2017) and is still the case in CMIP6 for SPG collapse (Swingedouw et al. 2021)

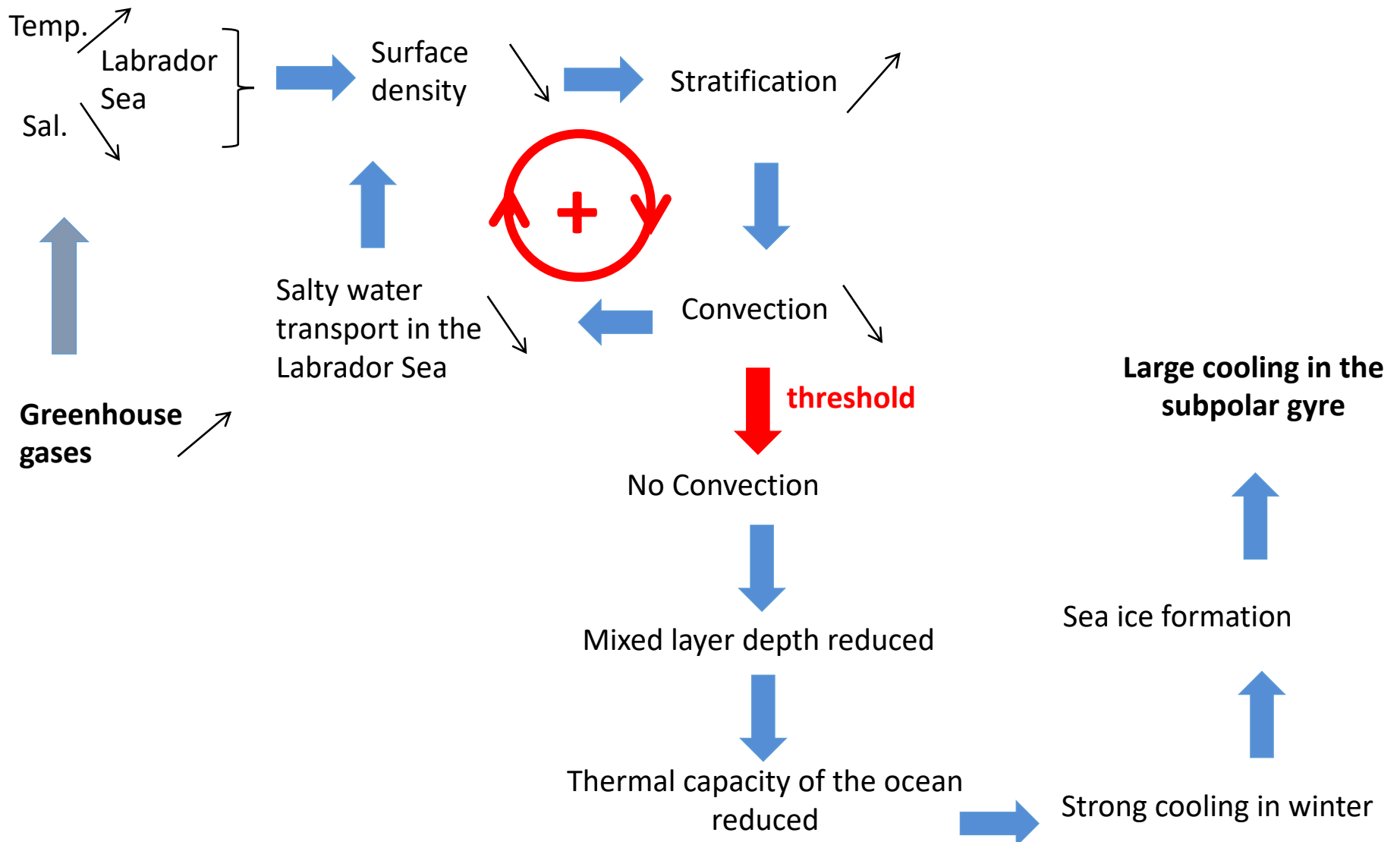


# Possibility of Abrupt the North Atlantic in

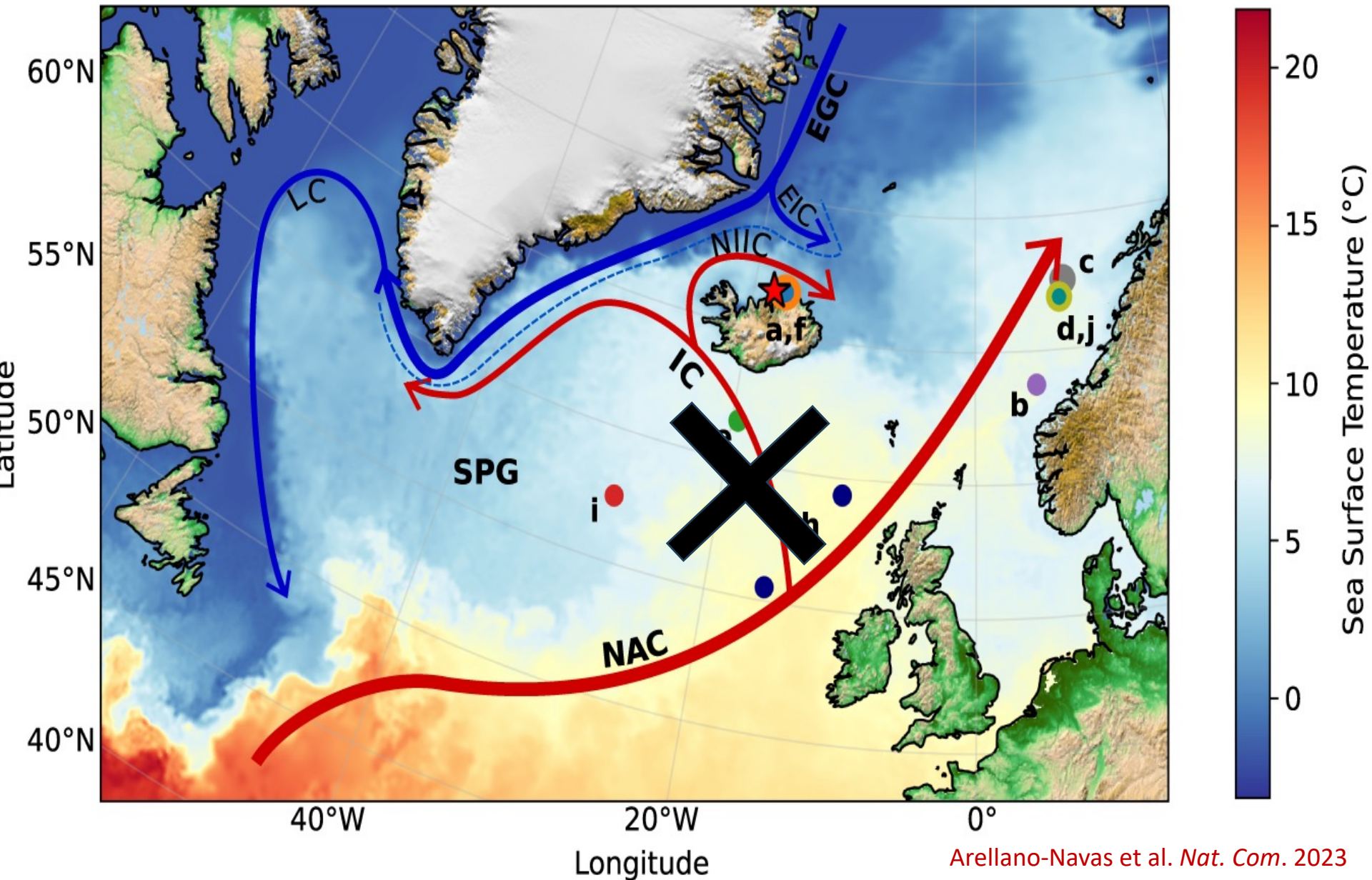
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# Mechanisms at play



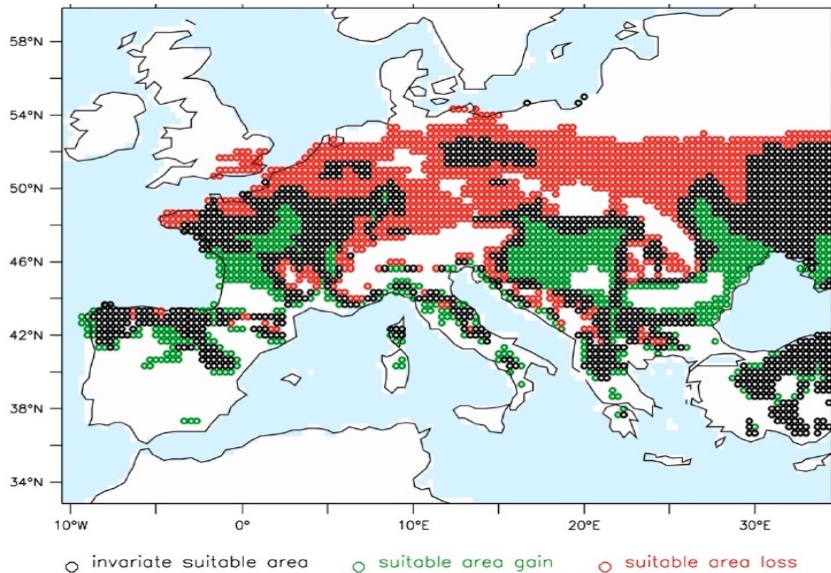
# Mechanisms at play



# Impacts of abrupt decadal cooling

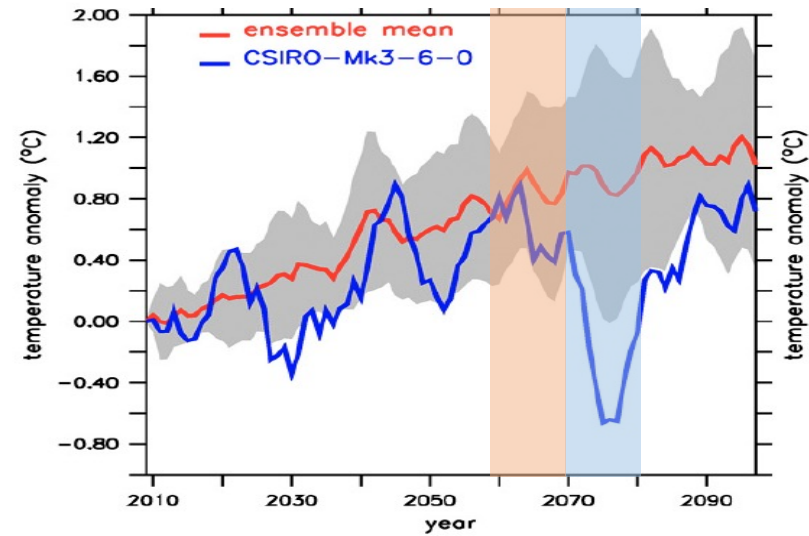
- The impact of these fast (<10 years) events can affect climate of Europe for at least a decade
- Adaptation polycies are poorly accounting for such events
- The exemple of viticulture is enlightening in this respect.

Suitability of Chardonnay  
2069-2078 vs 2059-2068

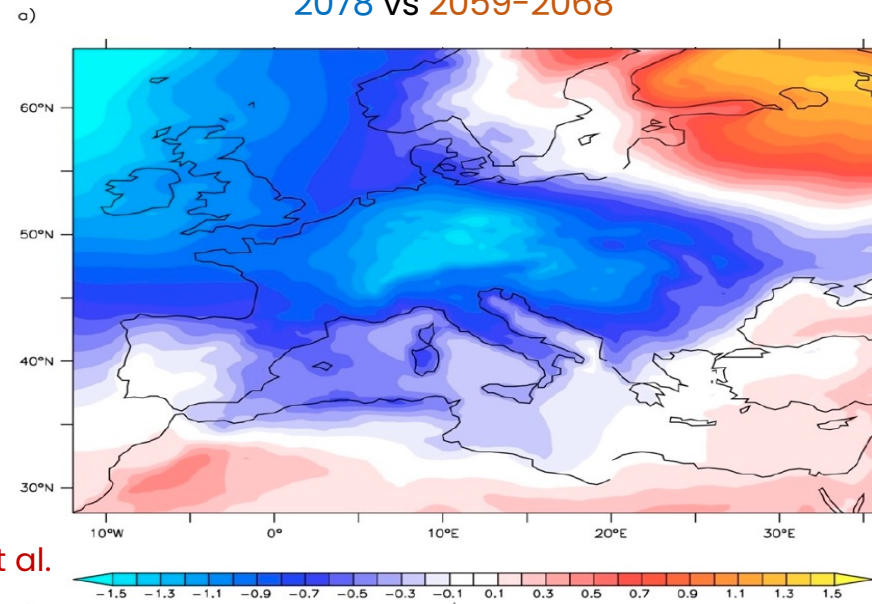


Sgubin et al.  
(2019)

Temperature in the UK

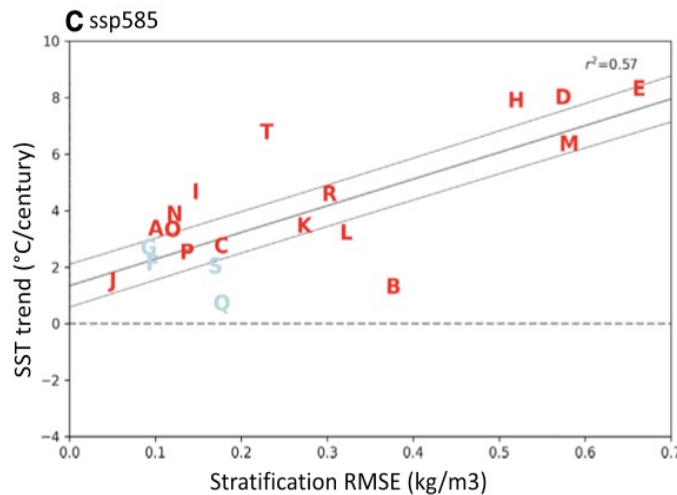
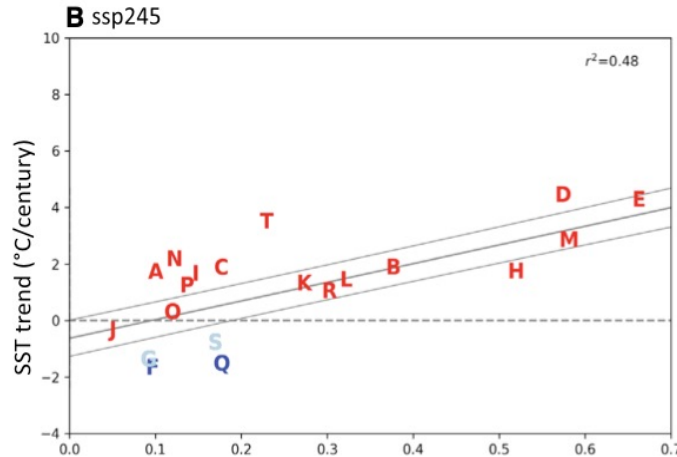
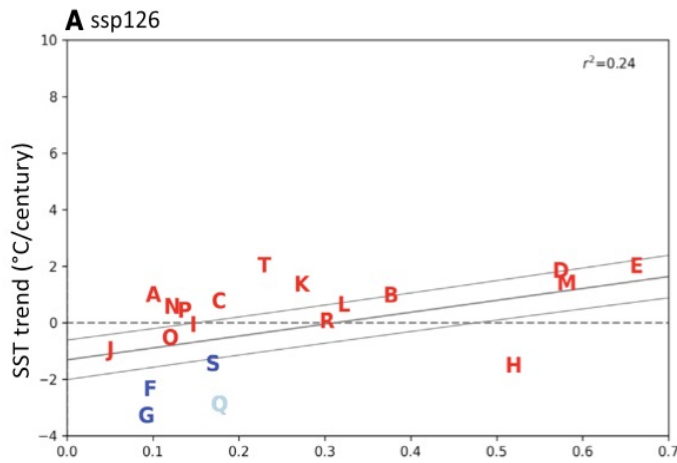
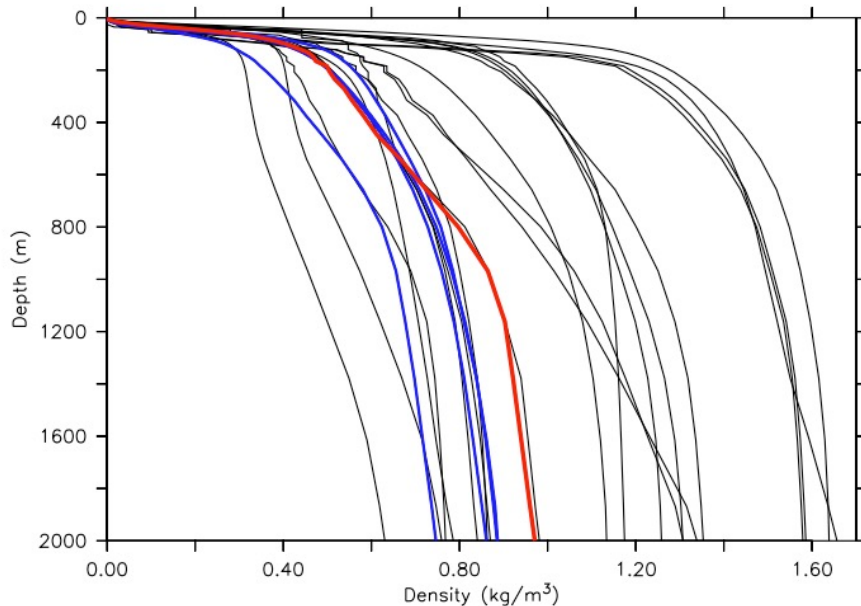


Temperature difference 2069-  
2078 vs 2059-2068



# SPG stratification as an observational constraint

- Stratification in the SPG is a key component of convection process
- Models showing abrupt changes are usually better than the ones showing none
- When using this as **an emergent constraint**, the probability for such a SPG rapid cooling before 2100 can be estimated between **about 36% (CMIP6) to 45% (CMIP5)**

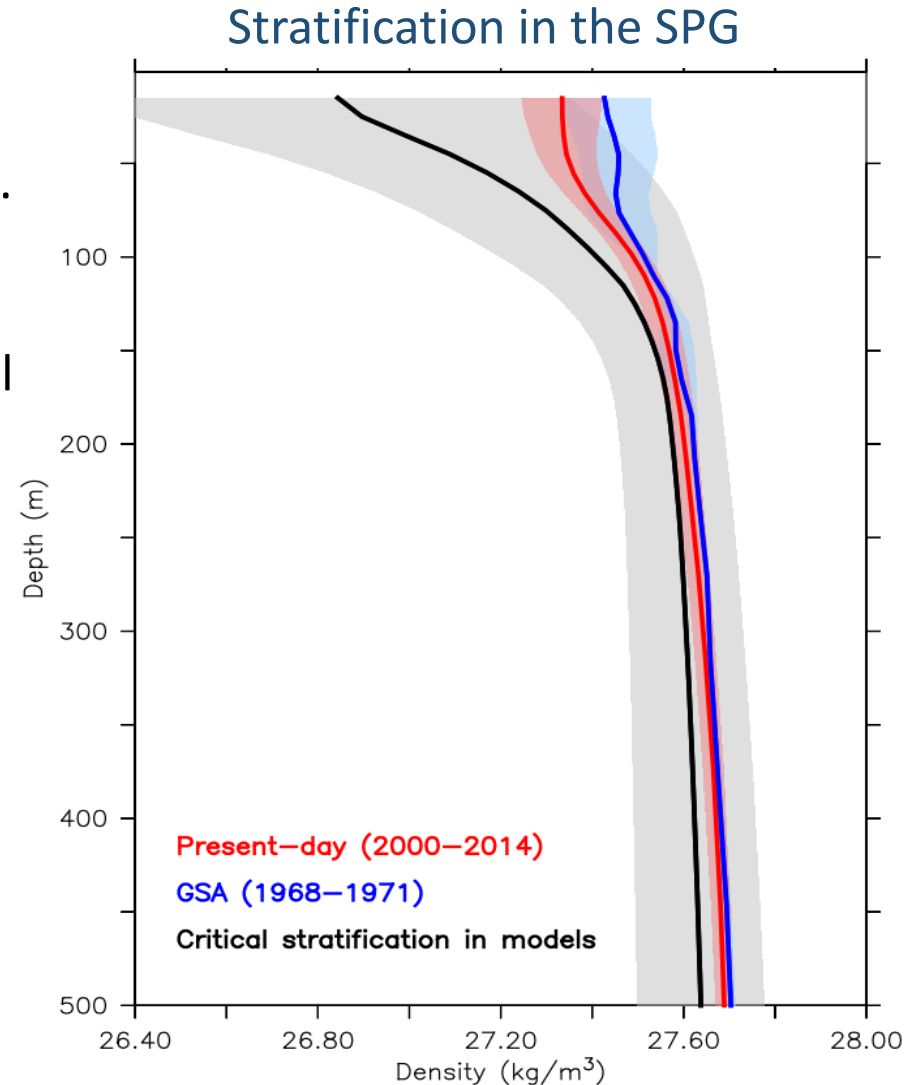


**A:** AWI-CM-1-1-MR  
**B:** BCC-CSM2-MR  
**C:** CAMS-CSM1-0  
**D:** CanESM5  
**E:** CanESM5-CanOE  
**F:** CESM2  
**G:** CESM2-WACM  
**H:** CIESM  
**I:** CNRM-CM6-1  
**J:** GFDL-ESM4  
**K:** INM-CM4-8  
**L:** INM-CM5-0  
**M:** IPSL-CM6A-LR  
**N:** MCM-UA-1-0  
**O:** MIROC6  
**P:** MPI-ESM1-2-LR  
**Q:** MRI-ESM2-0  
**R:** NESM3  
**S:** NorESM2-LM  
**T:** UKESM1-0-LL

**Z** : Model showing an abrupt event for this scenario  
**Z** : Model showing an abrupt event but not for this scenario  
**Z** : Model not showing any abrupt change in all scenarios

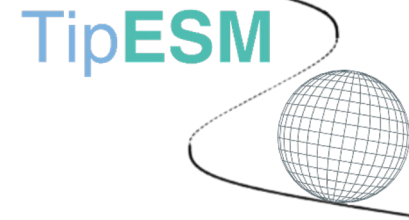
# Proximity to a SPG tipping point?

- To analyse the proximity to tipping points, models can be useful as well, on top of classical early warning statistical approach.
- For instance, since SPG stratification is crucial element of convection, and a useful emergent constraint for the evolution of centennial SST trend, it is interesting to define a **critical stratification**
- This is the stratification just before the large drop in SST
- When estimated in CMIP5 models, we can see that recent days are already in the envelop (66%) of the models just before their abrupt cooling...



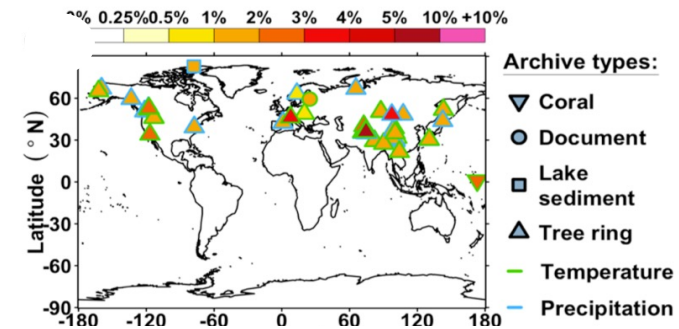


# WP4 of TipESM: Early warning indicators for TPs in the Earth system

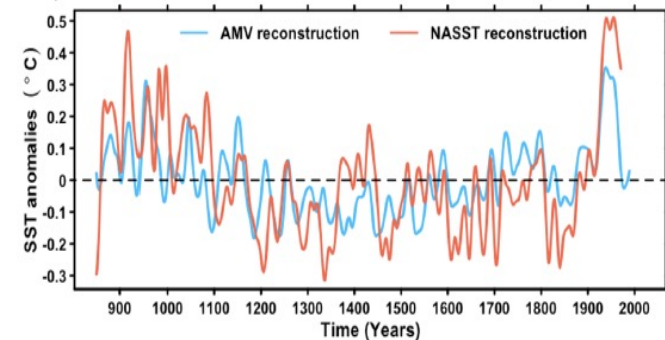


- ❖ Using comprehensive climate models to test statistical indicators.  
e.g. [Boulton et al. \(2014\)](#): we need **at least 250 years** to apply them to the North Atlantic ([Bowers \(2021\)](#) uses **only the last 150 years...**)
  - ❖ Using paleodata can solve this timescale issue ([Michel et al. 2022](#))
  - ❖ Alternatively, we can also use space for time, taking advantage of e.g. HR remote sensing (e.g. [Lenton et al. 2024](#))
  - ❖ Nevertheless, what is missing in this type of indicators is a precise physical understanding related to the real complex system
  - ❖ **Paradigm shift**: going beyond statistical EWI towards **physical/process** understanding, definition of physical **threshold** in the precursors (e.g. [van Westen et al., 2024](#) for the AMOC)
- ⇒ Critical stratification in the subpolar gyre
- ⇒ Change in circulation (local salt advection feedback of the SPG)
- ⇒ ... (future work of Lucas Almeida)

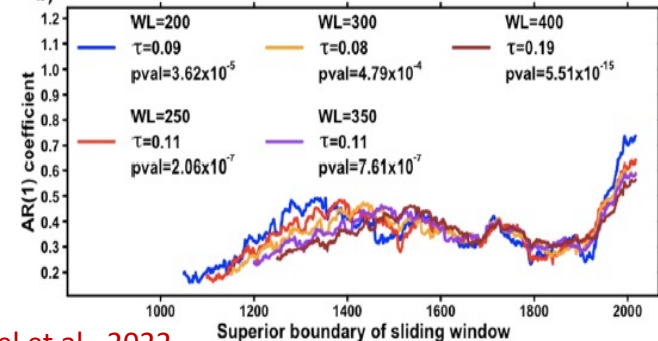
## Internal AMV reconstruction



a) Reconstruction of the North Atlantic SST



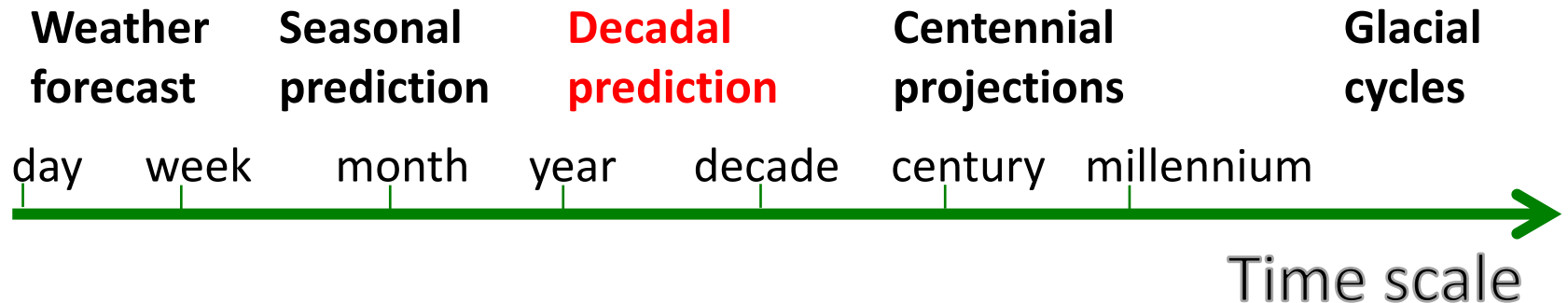
b) Bifurcation test



# Decadal predictions to gain insights on early warnings of abrupt changes

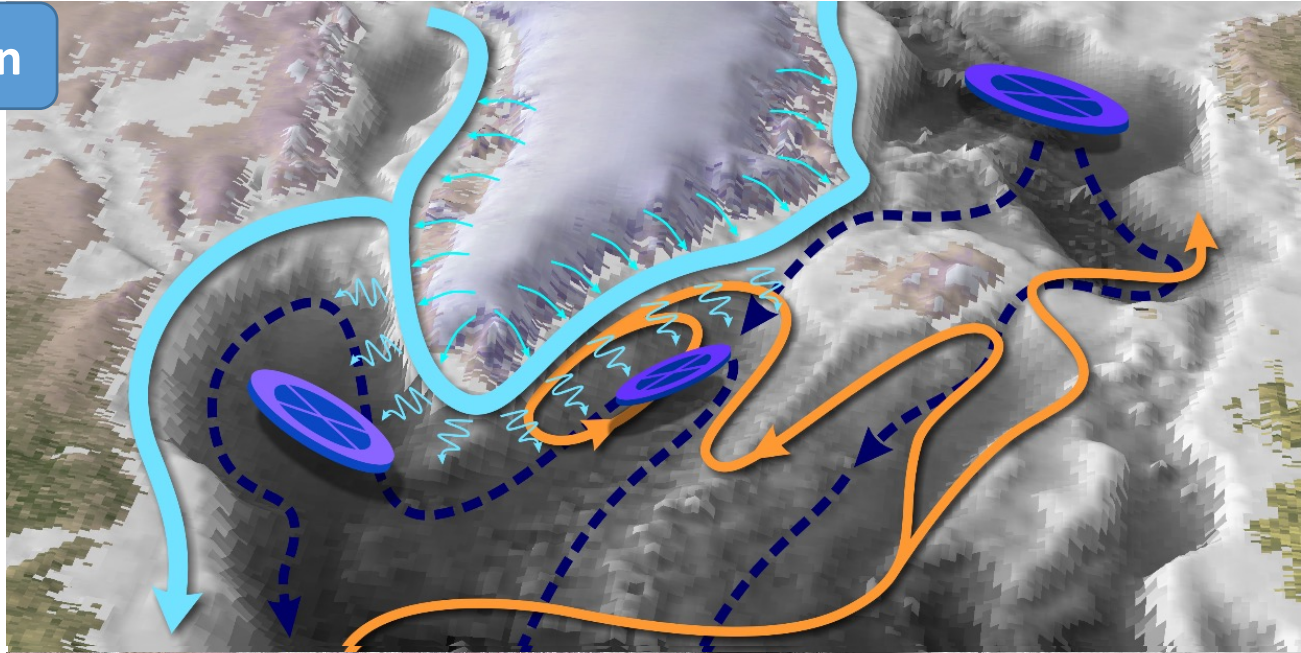
## Initial conditions

e.g. Gu et al.,  
Nat. Com. 2024

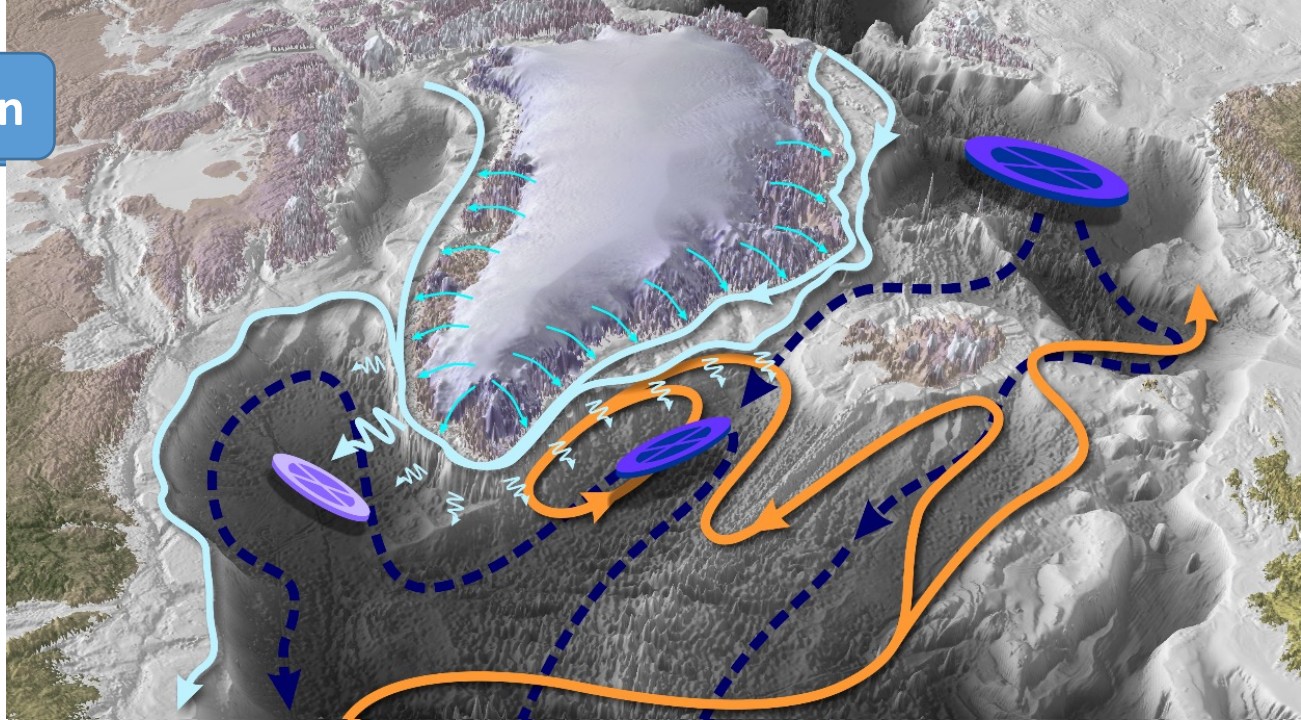


# What about Greenland melting and resolution of models?

Low Resolution



High Resolution



Swingedouw et al., *Frontiers in climate*, 2022

Scheme by  
Vincent  
Hanquiez

# Thank you!

