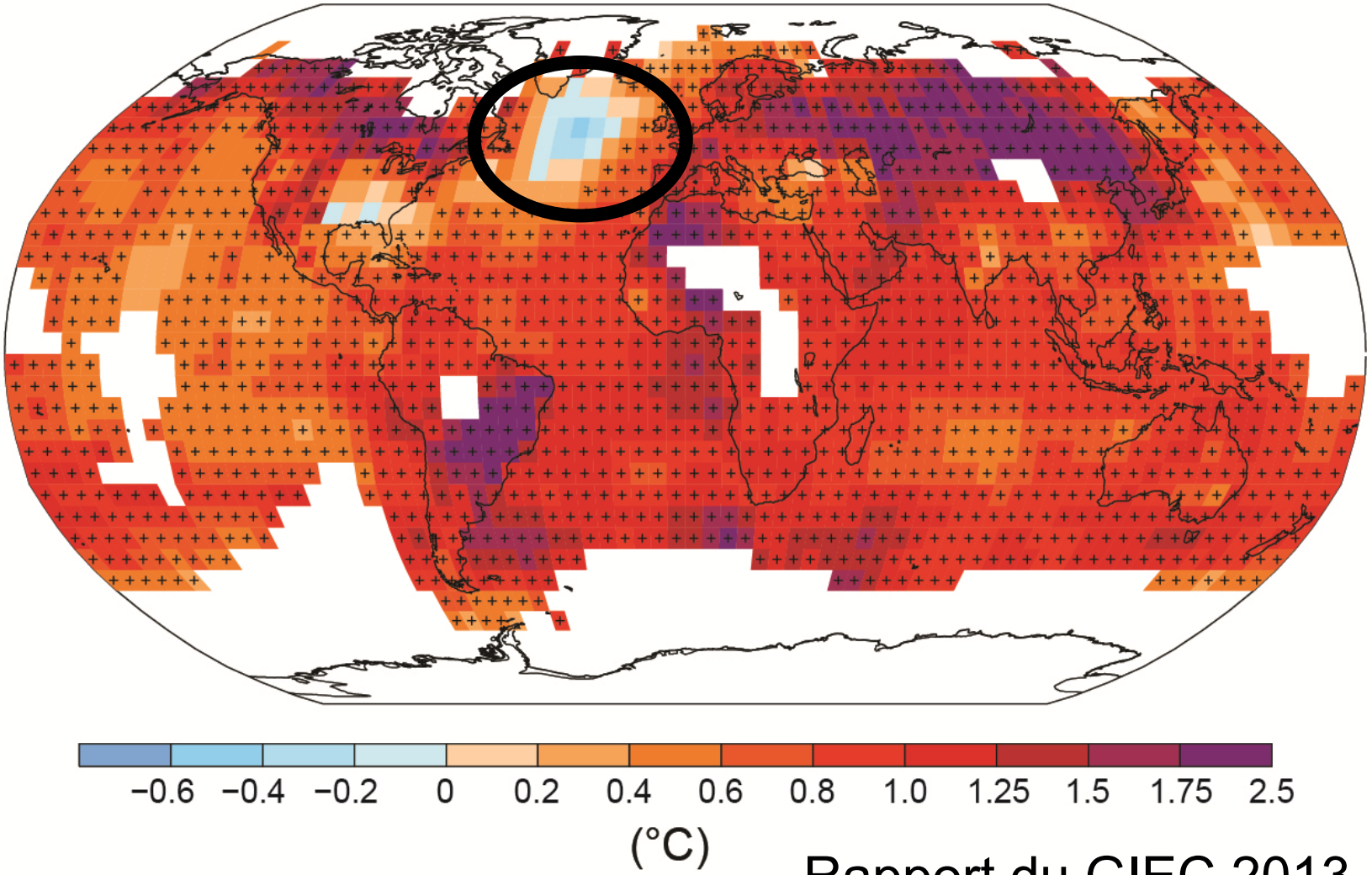
Giovanni Sgubin
& Didier Swingedouw

Changement abrupt de climat en Atlantique Nord

cnrs
EPOC
UMR 5805
université de BORDEAUX

Un climat qui se réchauffe, partout ?

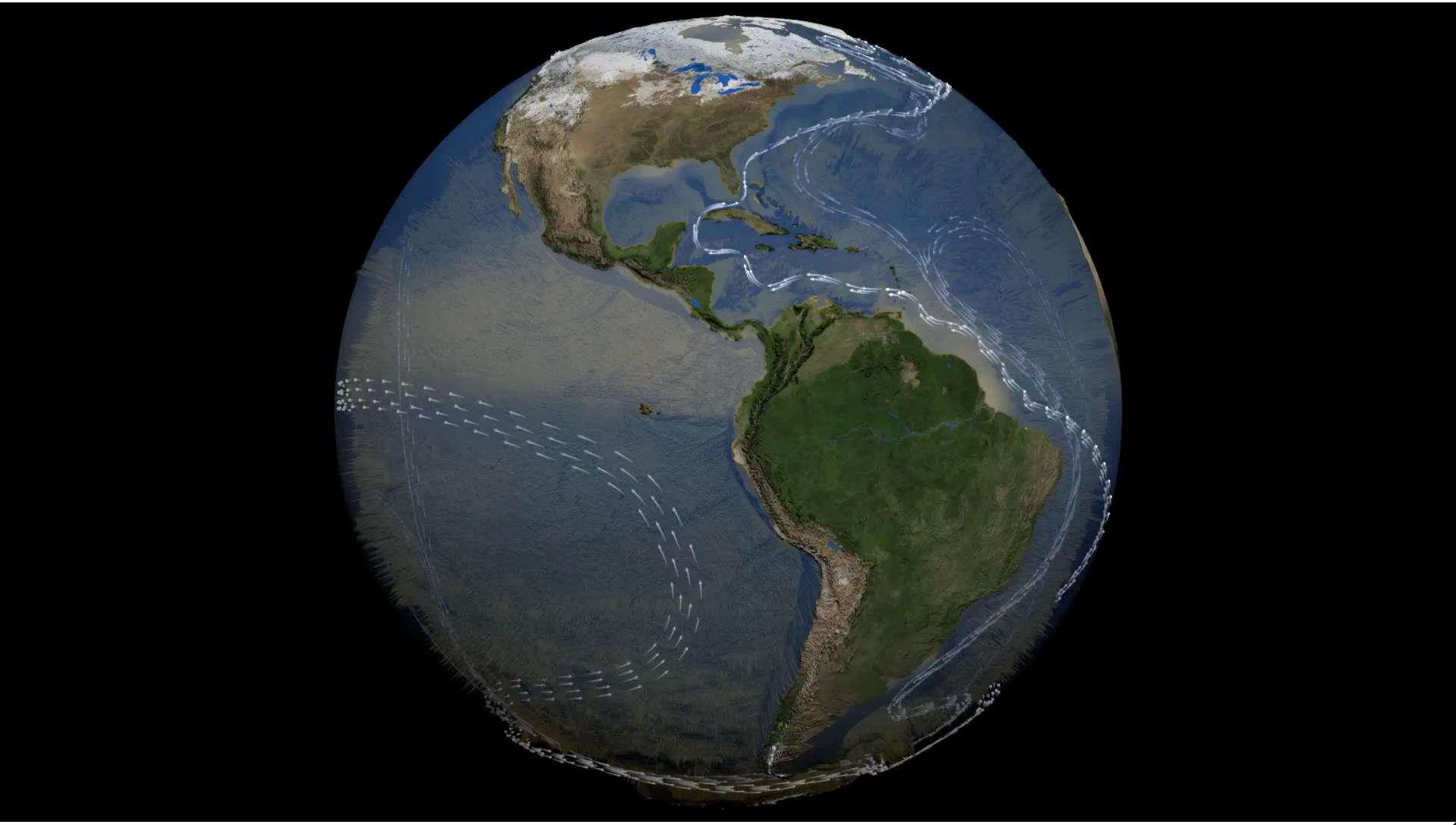
Tendance température (1901-2012)



Données: HadCRUT4

Rapport du GIEC 2013

La circulation océanique de grande échelle

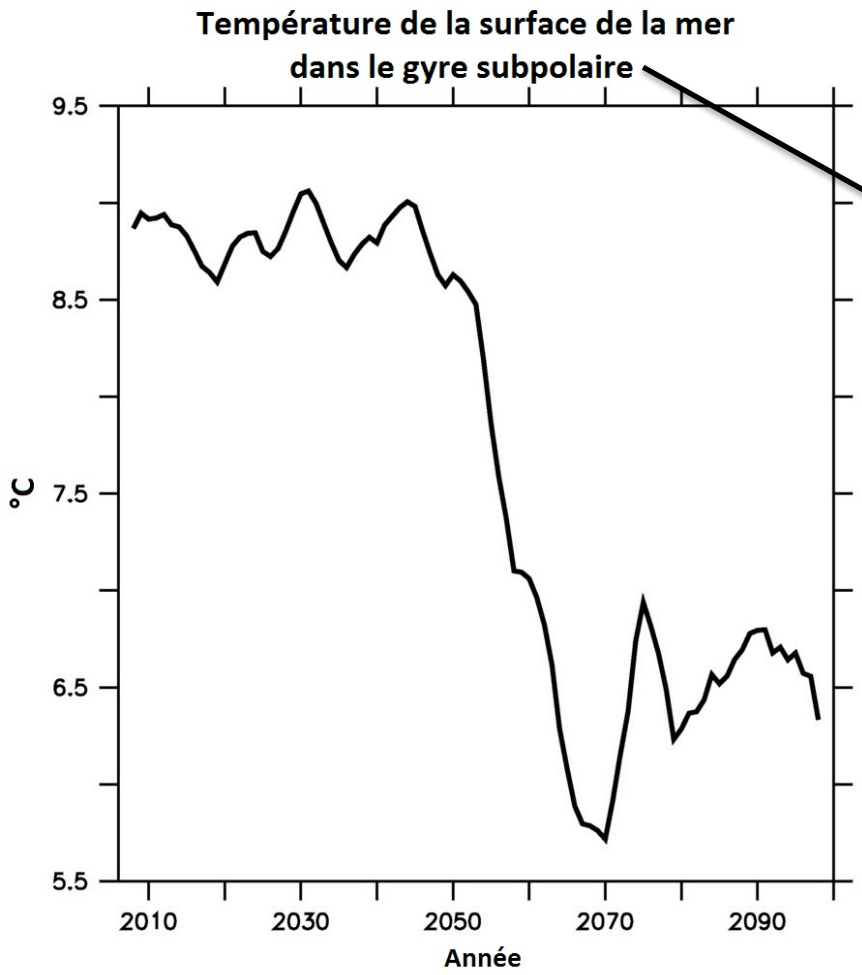


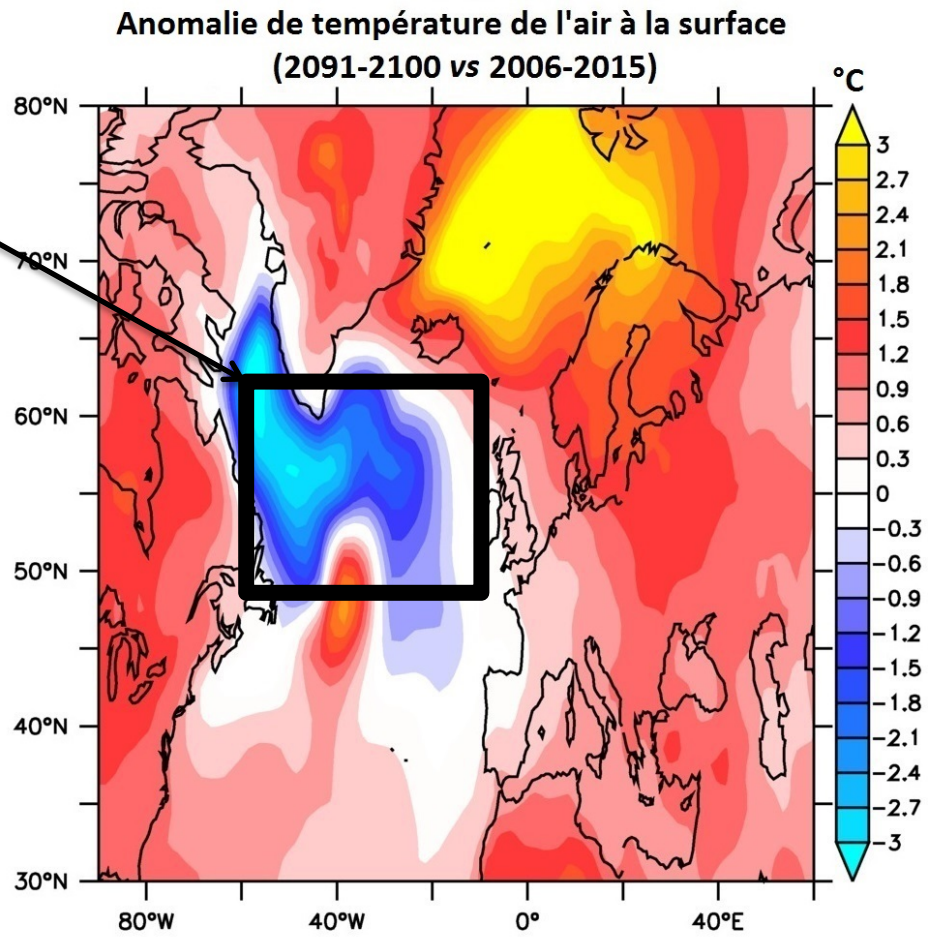
Impact climatique d’un changement océanique

Que nous disent les modèles de climats ?

- GIEC (rapport 2013) : pas de variations rapides de la circulation océanique de très grande échelle
- Sgubin et al. (*Nature Com.* 2017) :
  - Température : incertitude majeure sur l'Atlantique Nord
  - Beaucoup de modèles montrent un refroidissement important en moins de 10 ans
  - Lié à un changement local de convection océanique et pas à la très grande échelle
  - Impact sur les zones côtières, dont Bordeaux…

Un exemple de changement rapide de climat

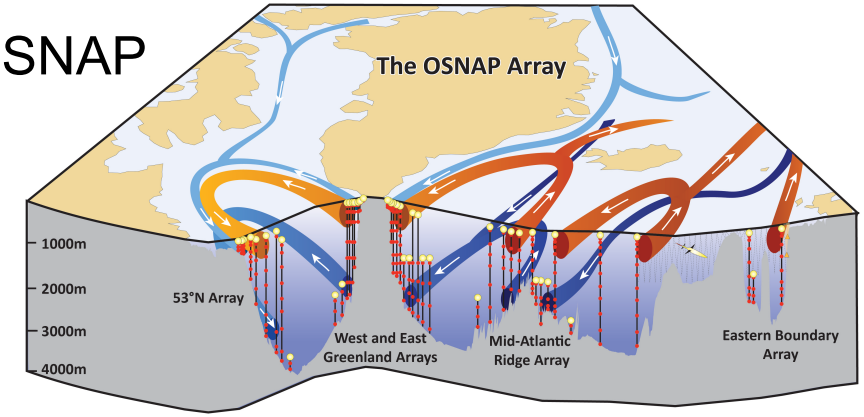




Se produit dans 5 des 11 meilleurs modèles

Implications

- Mesures en Atlantique Nord : projet OSNAP



- Prévision décennale du climat : projet européen BLUE ACTION

- Impact sur la viticulture : projets ***VINTAGE*** REGION AQUITAINE et ***DEFI*** LabEx COTE
  avec **Giovanni Sgubin**

- Reconstruction la circulation océanique dans le passé :
  - projet ***Vademecum*** lefe
  - projet ***HAMOC*** Agence Nationale de la Recherche ANR

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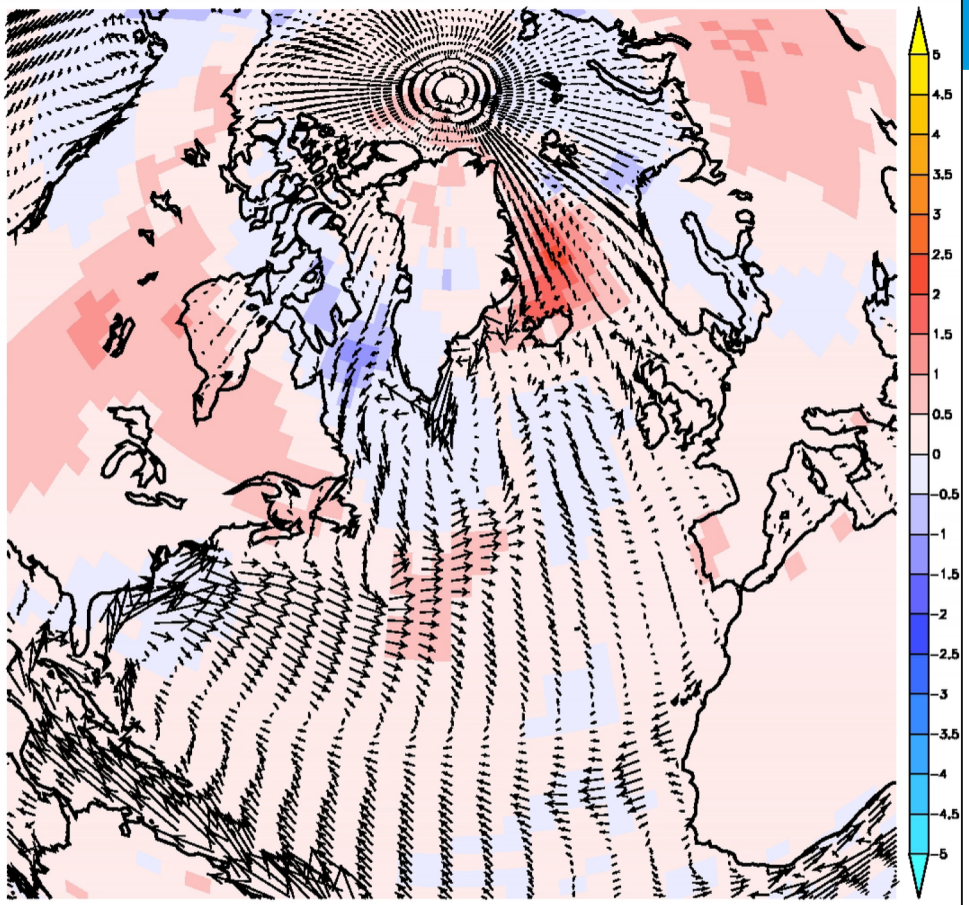
@DidierSwing

2025–2029


5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
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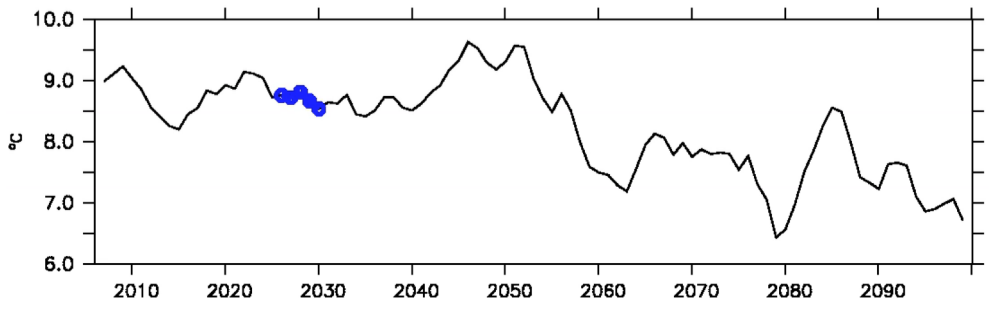
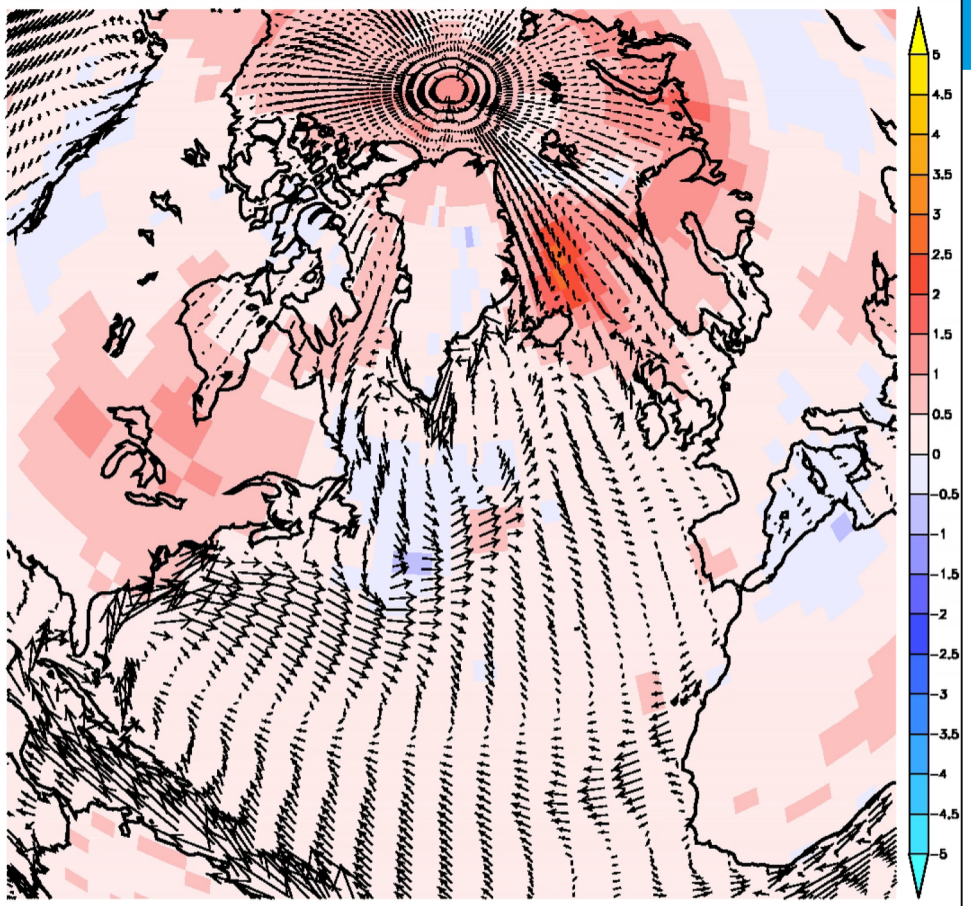
-4.5
-5


10.0
9.0
8.0
7.0
6.0
°C
2010
2020
2030
2040
2050
2060
2070
2080
2090

2025–2029


5
4.5
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3.5
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2.5
2
1.5
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0.5
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-0.5
-1
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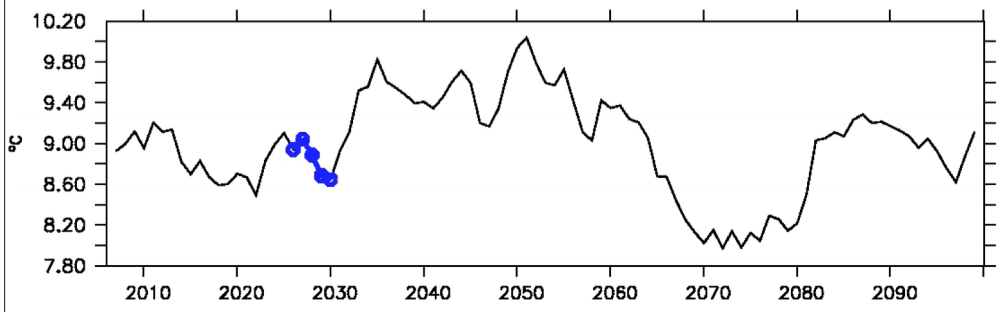
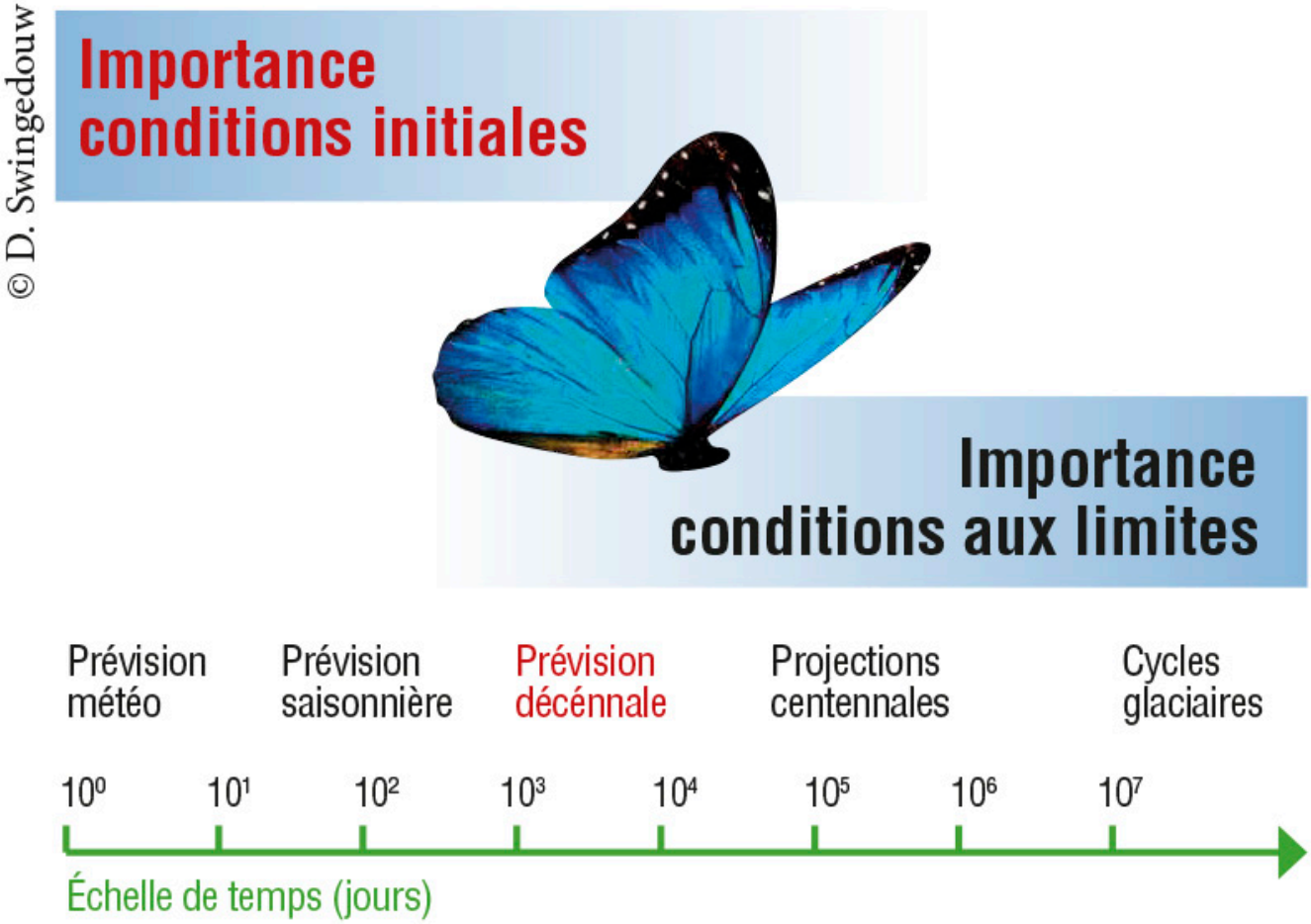
-2
-2.5
-3
-3.5
-4
-4.5
-5

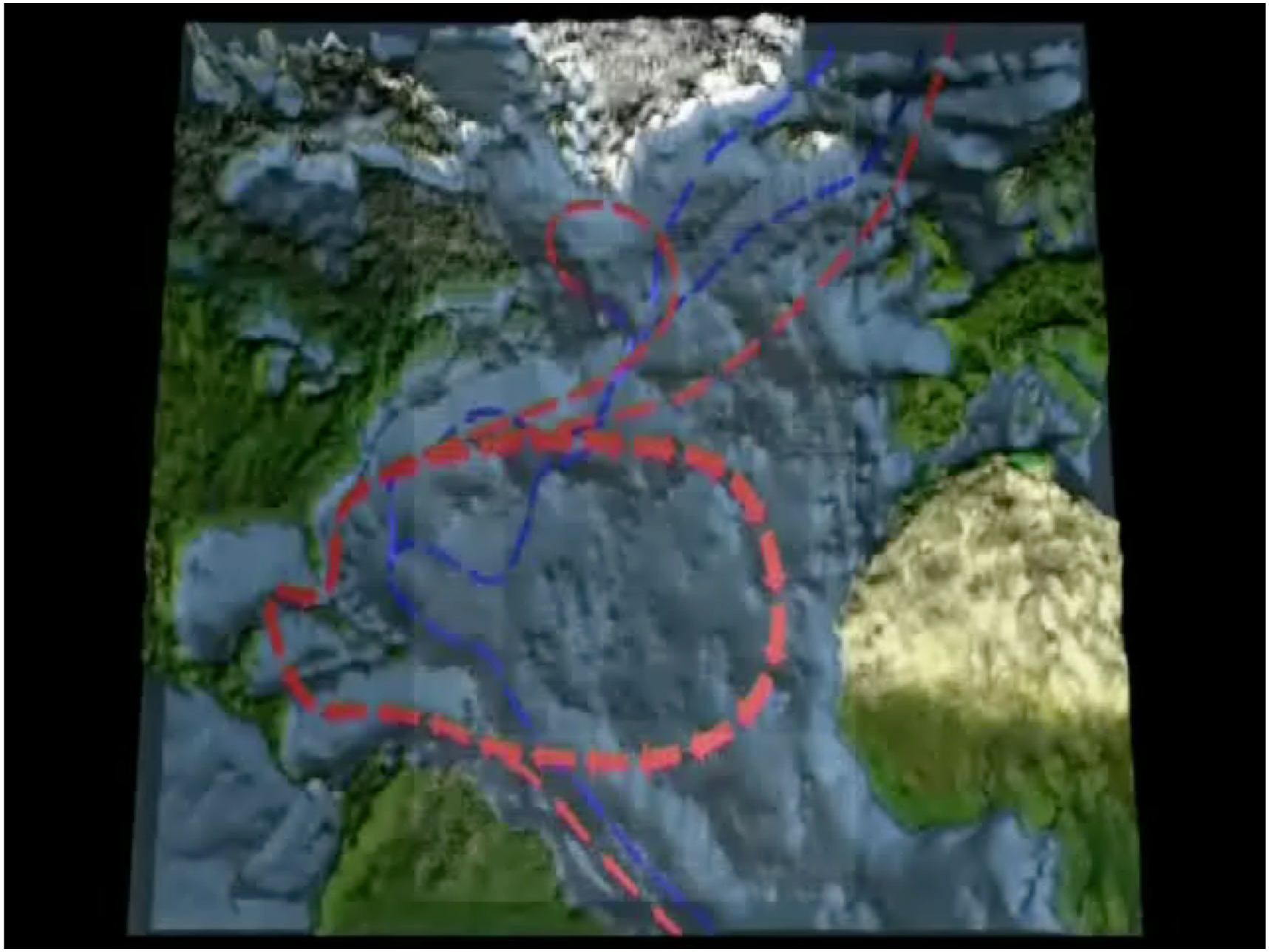

10.20
9.80
9.40
9.00
8.60
8.20
7.80
°C
2010
2020
2030
2040
2050
2060
2070
2080
2090

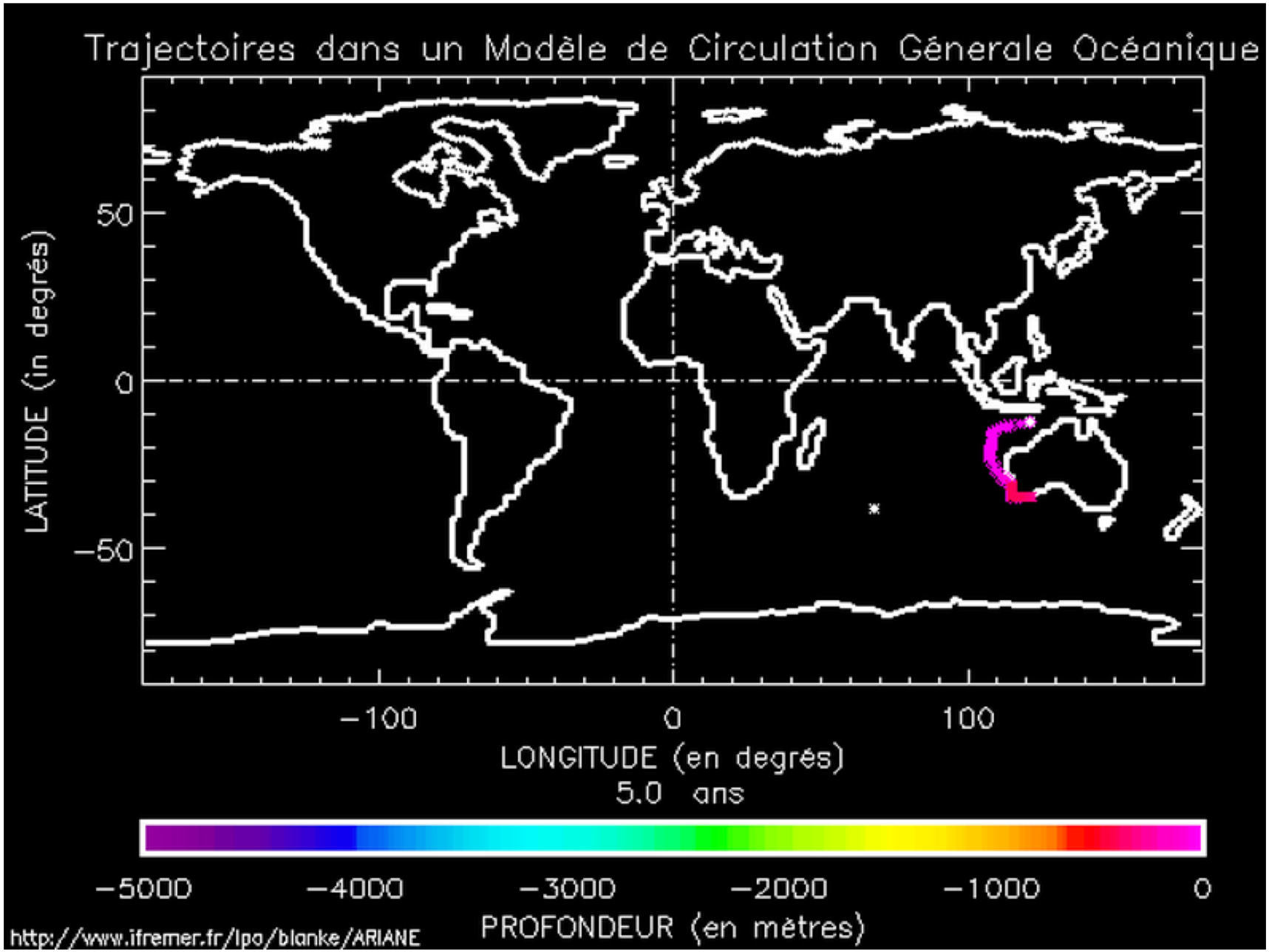
Prévision décennale



▶ *Schéma montrant l'importance relative des conditions initiales et aux limites pour le climat selon les échelles de temps.*


CLIMAT
Modéliser pour comprendre et anticiper

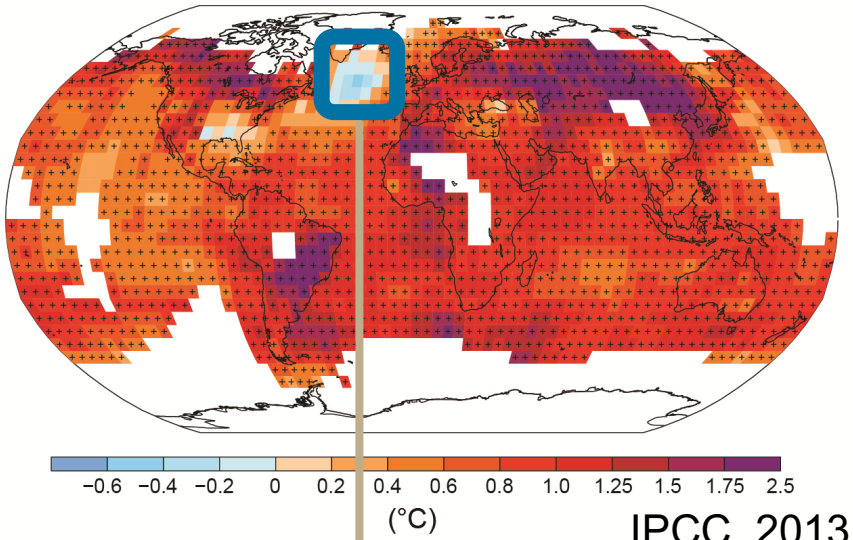



Trajectoires dans un Modèle de Circulation Générale Océanique
50
0
−50
LATITUDE (in degrés)
−100
0
100
LONGITUDE (en degrés)
5.0 ans
−5000
−4000
−3000
−2000
−1000
0
PROFONDEUR (en mètres)
http://www.ifremer.fr/lpo/blanke/ARIANE

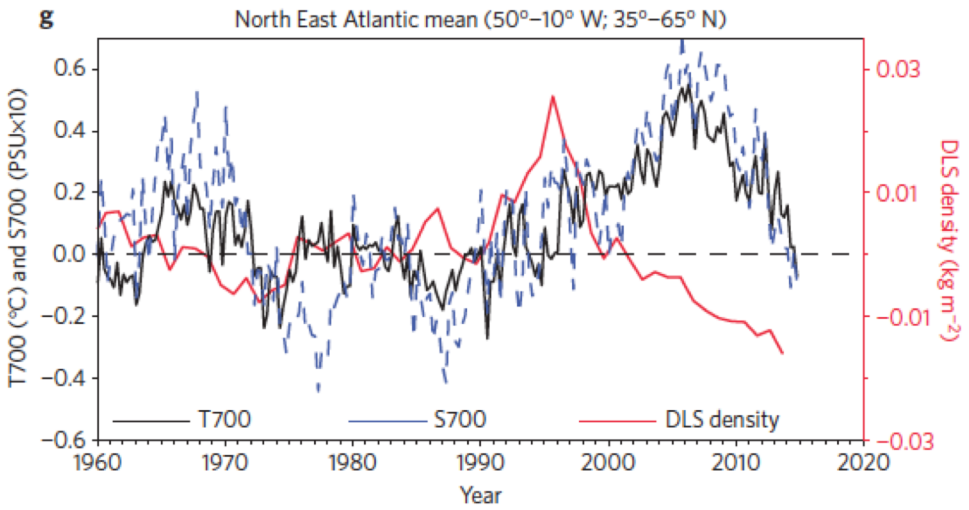
A cold blob in the North Atlantic?

- Warming hole in the North Atlantic over the 20th century
- Abrupt SST variations in the subpolar gyre (Thompson et al. 2010)
- Robson et al. (2016): link with anomalous surface heat flux and Labrador Sea convection

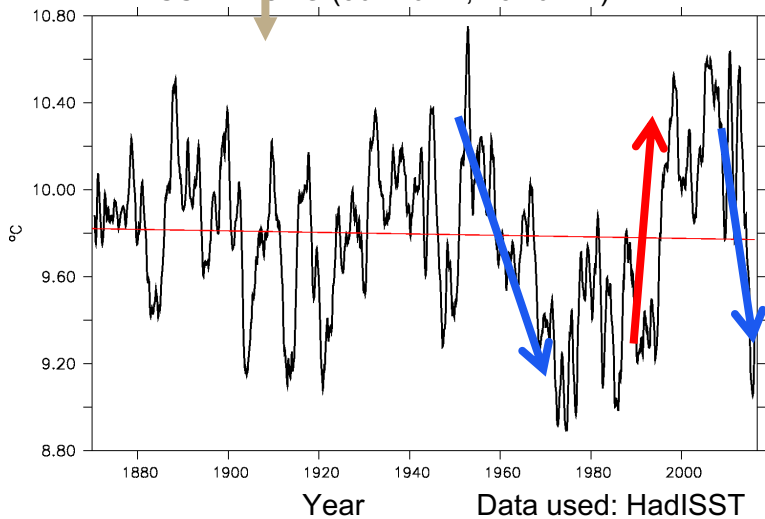
Trend (1901-2012) in surface temperature from HadCRUT4



IPCC. 2013



SST in SPG (50°-20°W; 45°-62°N)



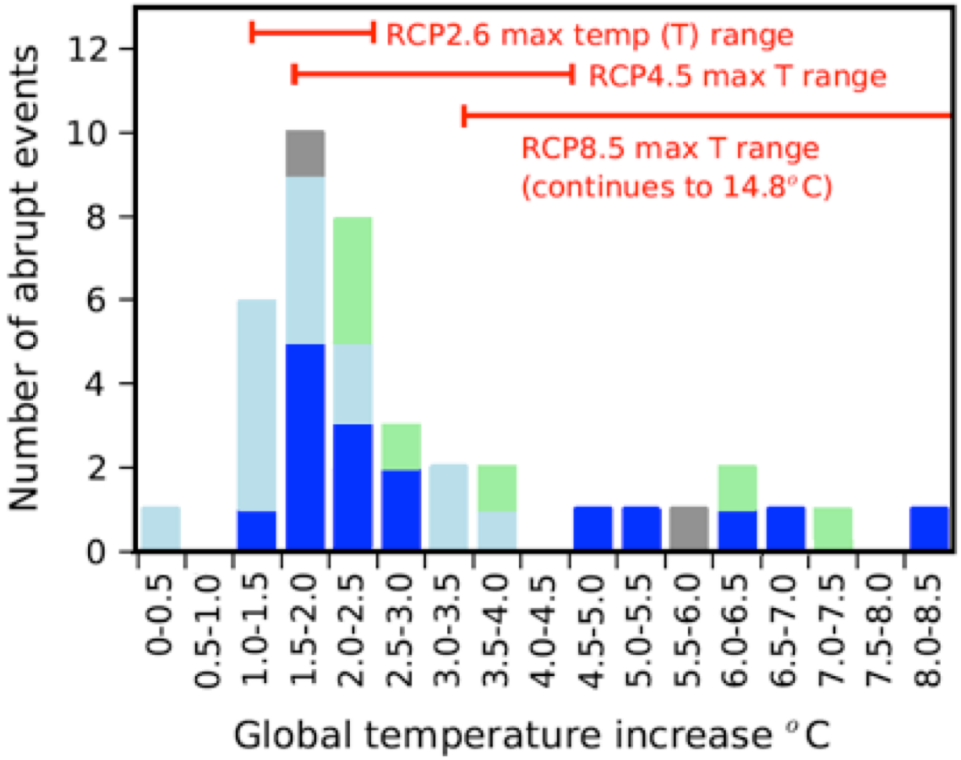
Data used: HadISST

Catalogue of abrupt shifts in Intergovernmental Panel on Climate Change climate models

Sybren Drijfhout[a,b,1], Sebastian Bathiany[c,d], Claudie Beaulieu[b], Victor Brovkin[d], Martin Claussen[d,e], Chris Huntingford[f], Marten Scheffer[c], Giovanni Sgubin[g], and Didier Swingedouw[h]

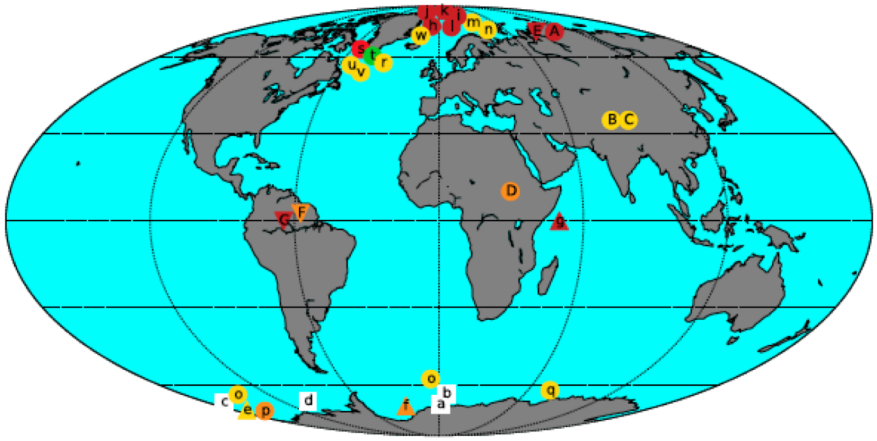
Are the model showing abrupt changes in the subpolar gyre trustworthy?

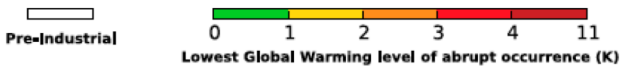
39 abrupt events (in 36% of the realizations)



Sea ice
Circulation
Vegetation
Land Ice

EMBRACE



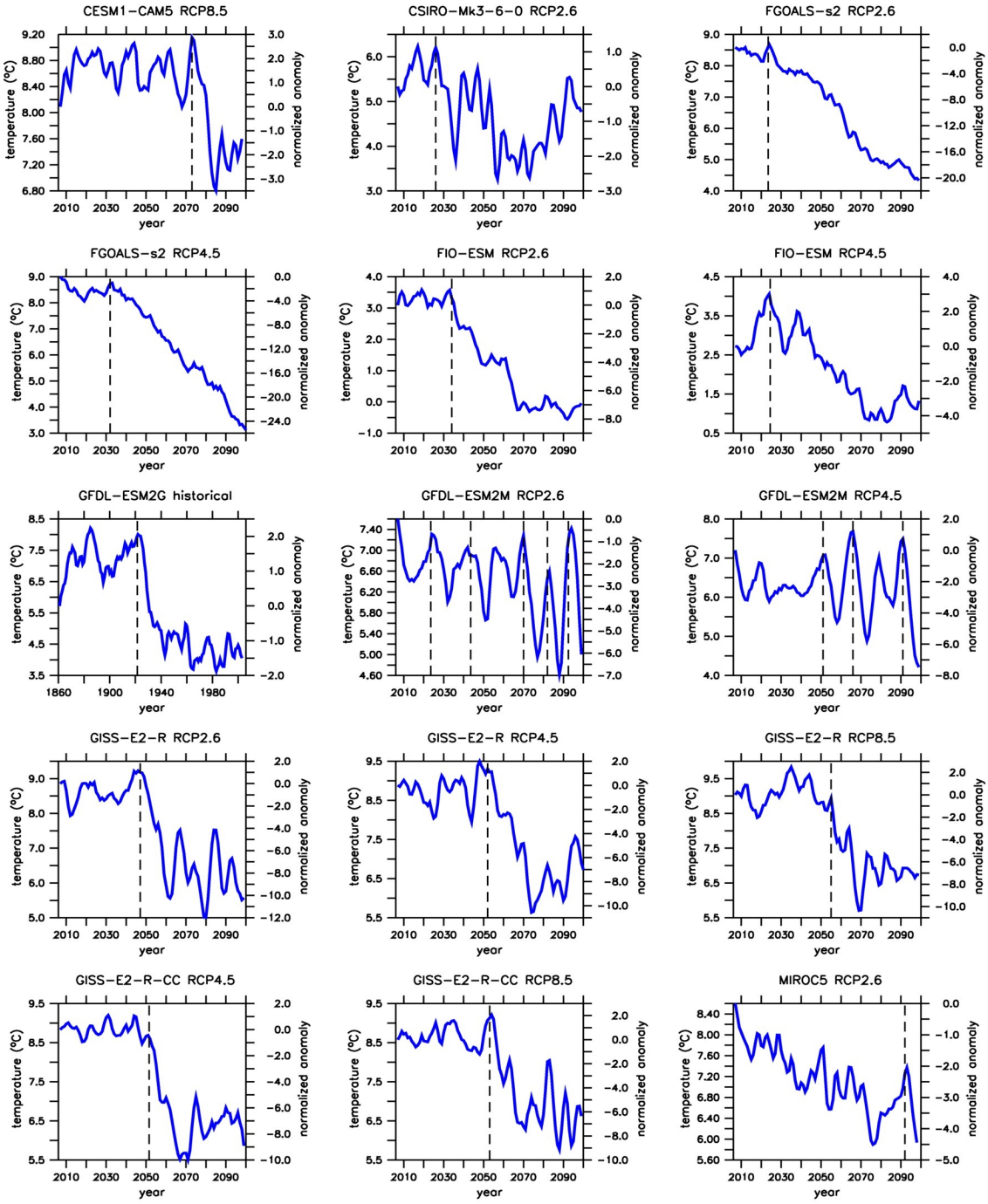


Abrupt cooling events in the SPG

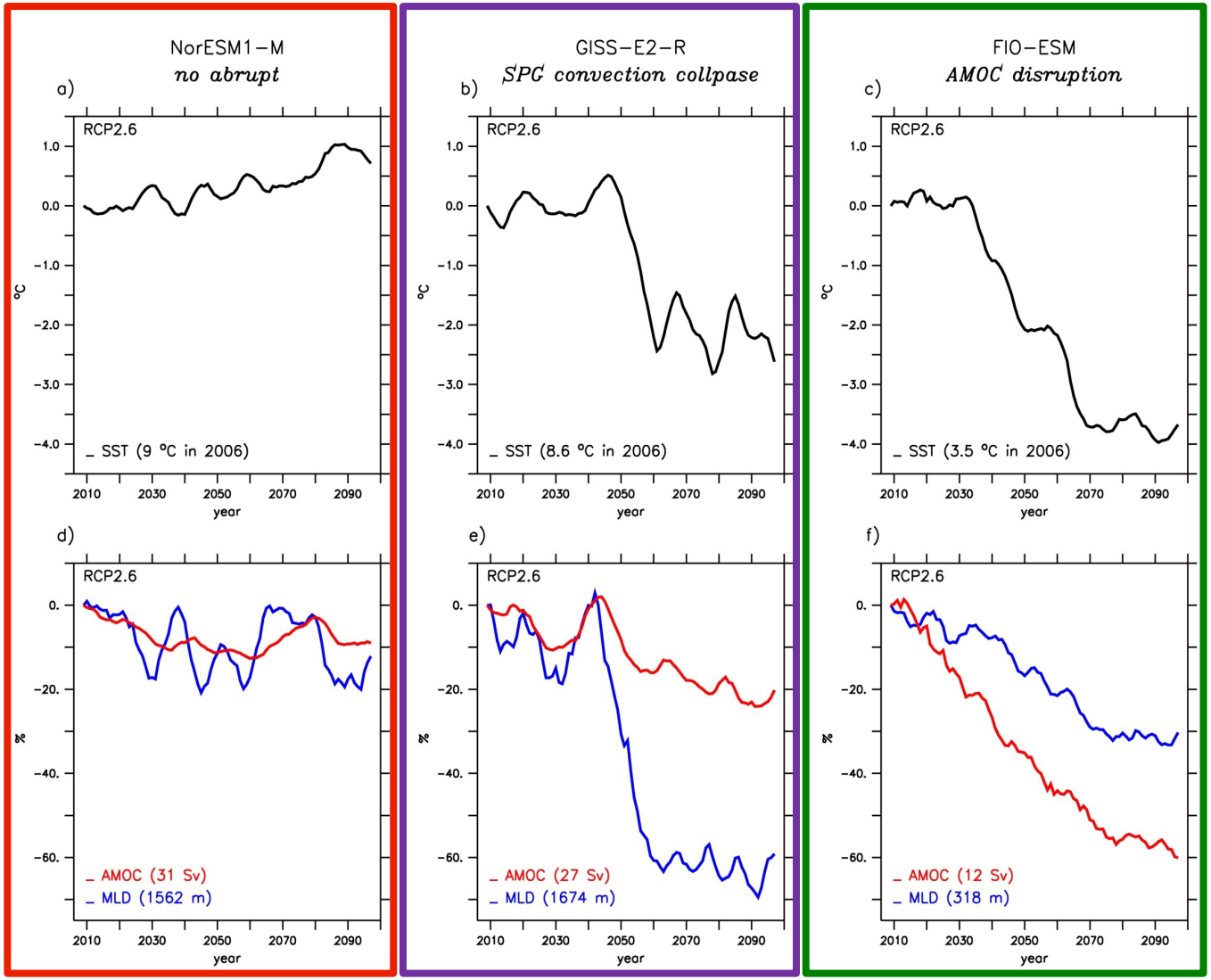
15 abrupt cooling events

1 historical
6 RCP2.6
5 RCP4.5
4 RCP8.5

9 models
(22.5% of the models)



Three main types of SPG changes



non-abrupt **subset (31 models, *i.e.* 77.5%)**

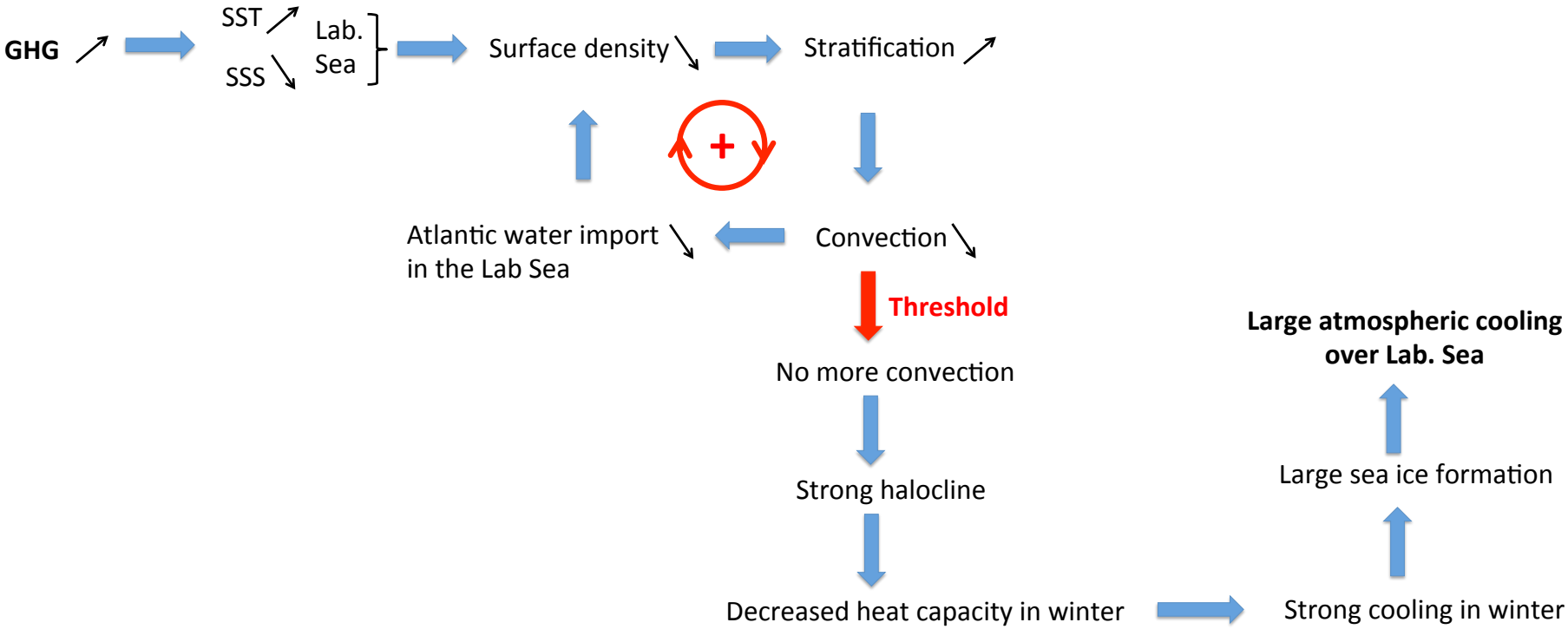
SPG convection collapse **subset (7 models, *i.e.* 17.5%)**

AMOC disruption **subset (2 models, *i.e.* 5%)**

Mechanisms of the convection collapse

From an analysis of key variables of the different convection collapse models, notably based on cross correlation diagnostics, we end up with the following mechanism to explain the 10-year abrupt cooling in the subpolar gyre, in agreement with proposed mechanisms by **Born et al.**

The collapse in convection is salinity driven !



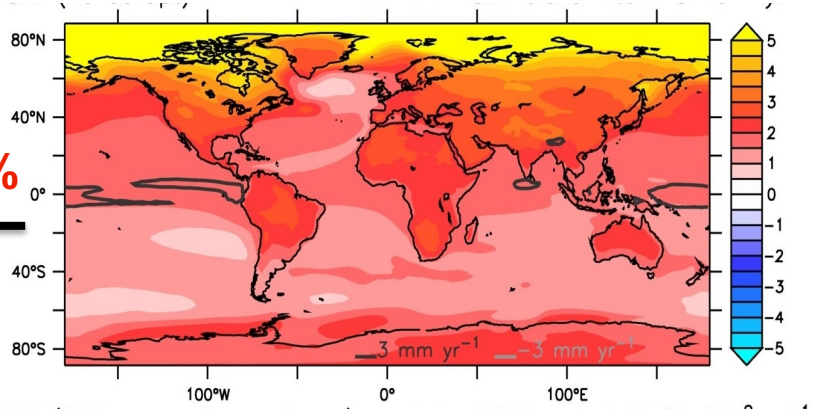
Three different climatic impacts

Surface temperature and precipitation trend (°C/century) of ensemble mean for RCP4.5 scenario

non-abrupt subset

- Warming spread all over the globe

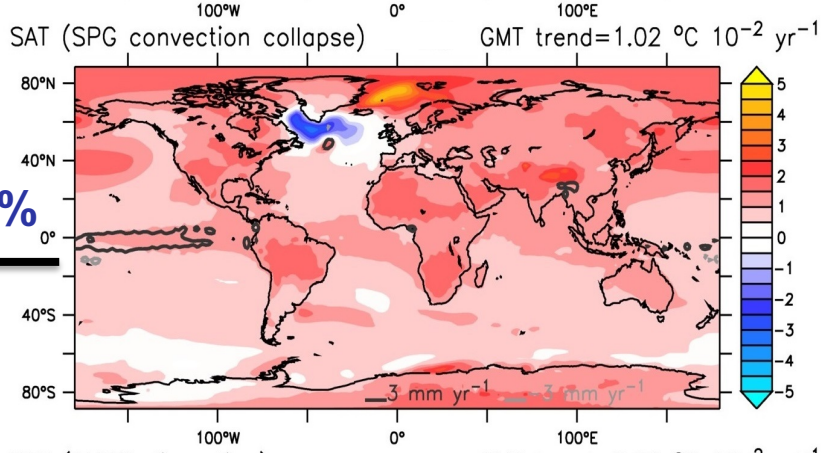
77.5%



SPG convection collapse subset

- Cooling trend over the NA SPG despite a global warming trend
- Strong impact on SAT over highly inhabited regions

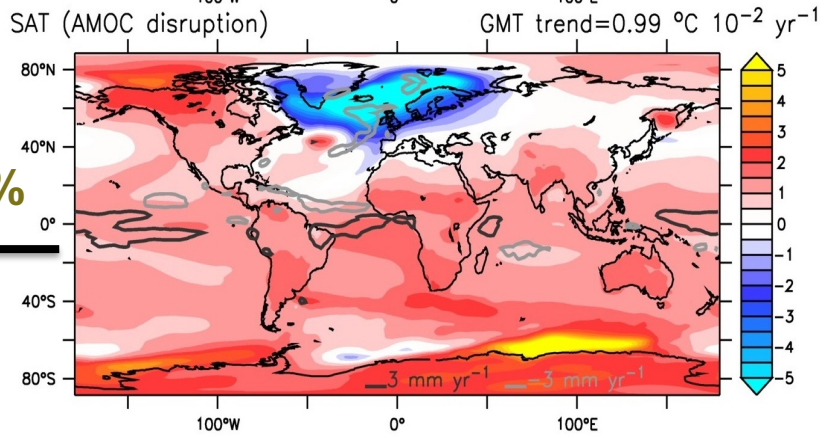
17.5%



AMOC disruption subset

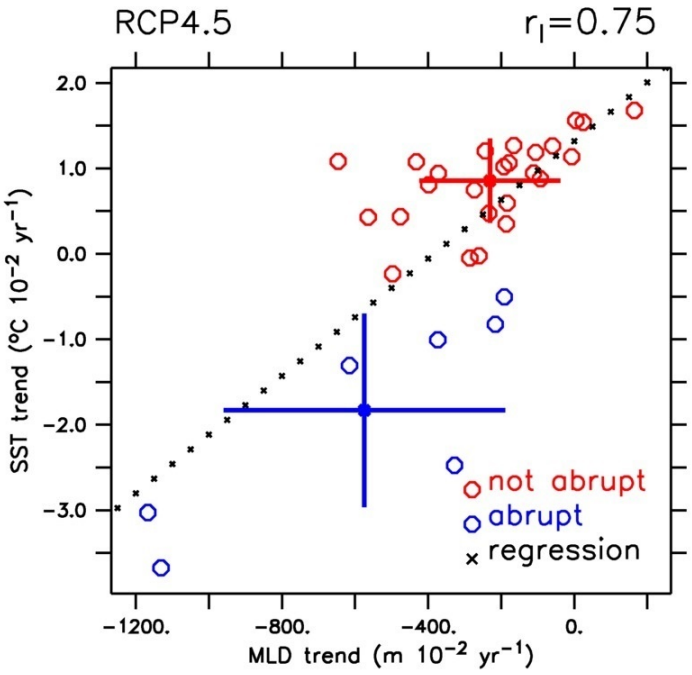
- Strong cooling of all the NA
- Amplified warming in the southern hemisphere (bipolar see-saw effect)
- Shift of the position of the intertropical convergence zone

5.0%



Source of model uncertainty

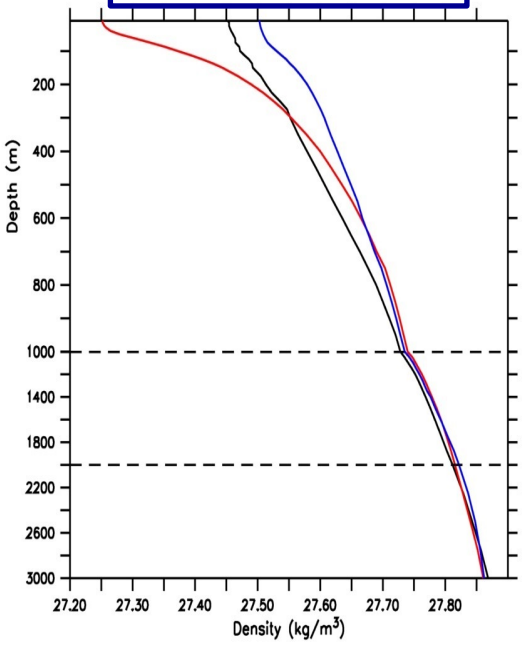
SST trend *vs* MLD trend



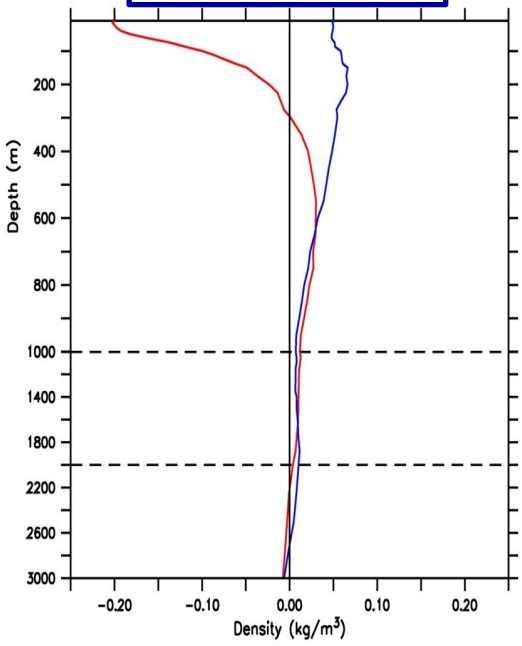
- SST trend over the subpolar NA is well correlated with the MLD trend

- Importance of the **background stratification**

Density profiles



Gap from OBS



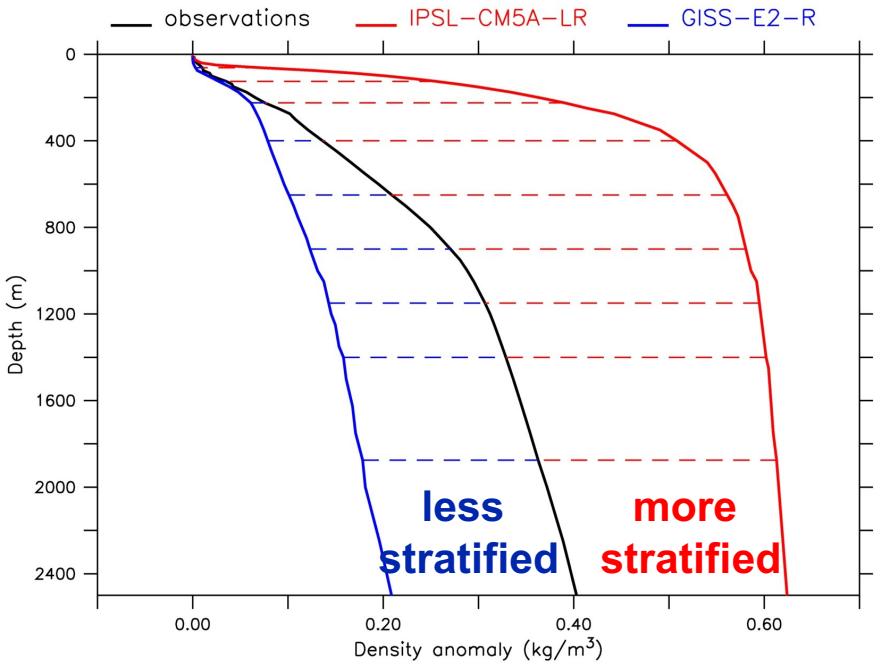
OBS — No abrupt — SPG convection collapse

- Two different configurations for present-day conditions

- If compared with ***OBS***:
- ***No abrupt*** excessively stratified
- ***SPG convection collapse*** models less stratified

The stratification indicator

- We define a stratification index as the density difference with surface density
- We estimate the differences in stratification for each model with observation-based estimate of the stratification in the SPG



-5.88 (kg/m^3) +12.41 (kg/m^3)

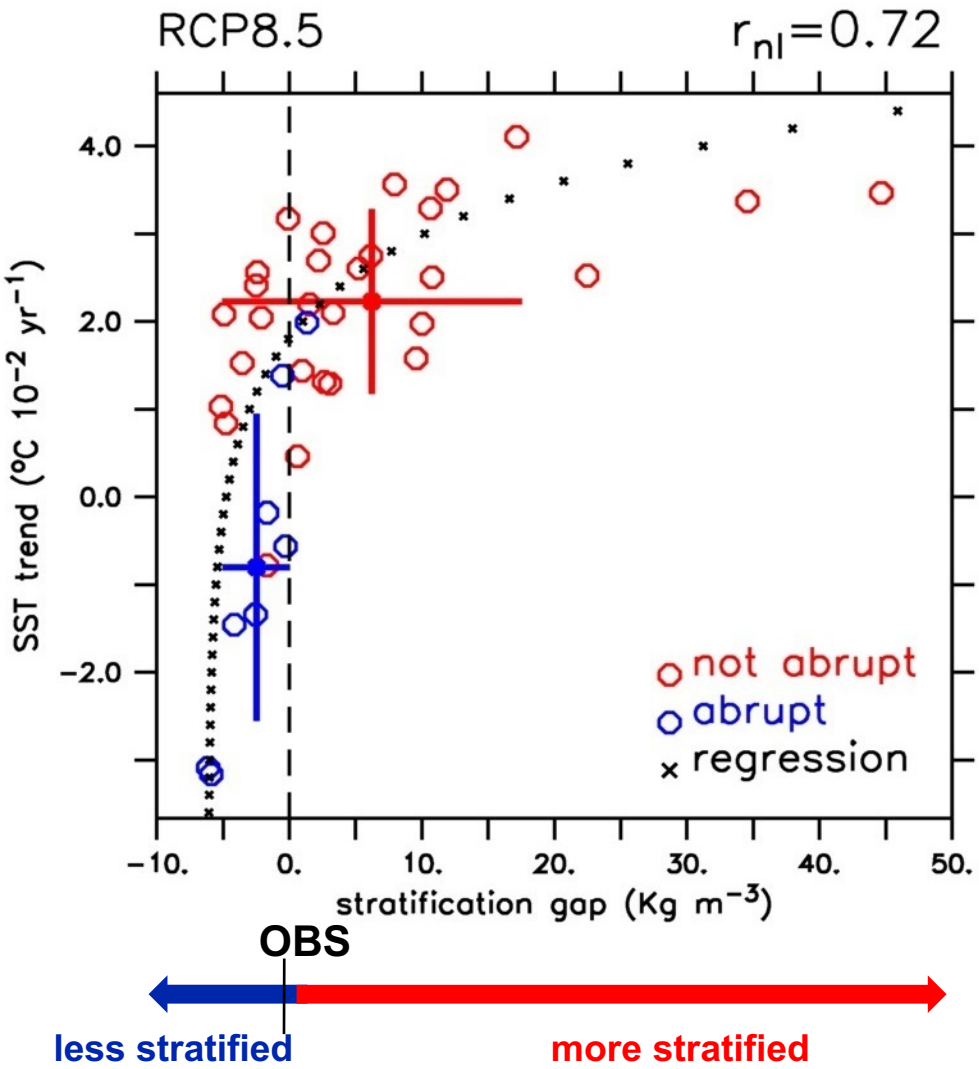
stratification index

$$\Sigma_z \{ (\rho_z-\rho_0)_{model} - (\rho_z-\rho_0)_{OBS} \}$$

Observations: average between GLORYS Reanalysis data (1993-2013) and EN3 Analysis data (1950
Models: mean during the period 1976-2005 of historical simulations

Stratification as an emergent constraint for SST response

- SST trend over the SPG is (non linearly) correlated with the modeled present-day stratification
- *SPG convection collapse* models show a stratification closer to observations than in *no abrupt* models
- A realistic background stratification is a necessary (but not sufficient) condition for the local convection collapse

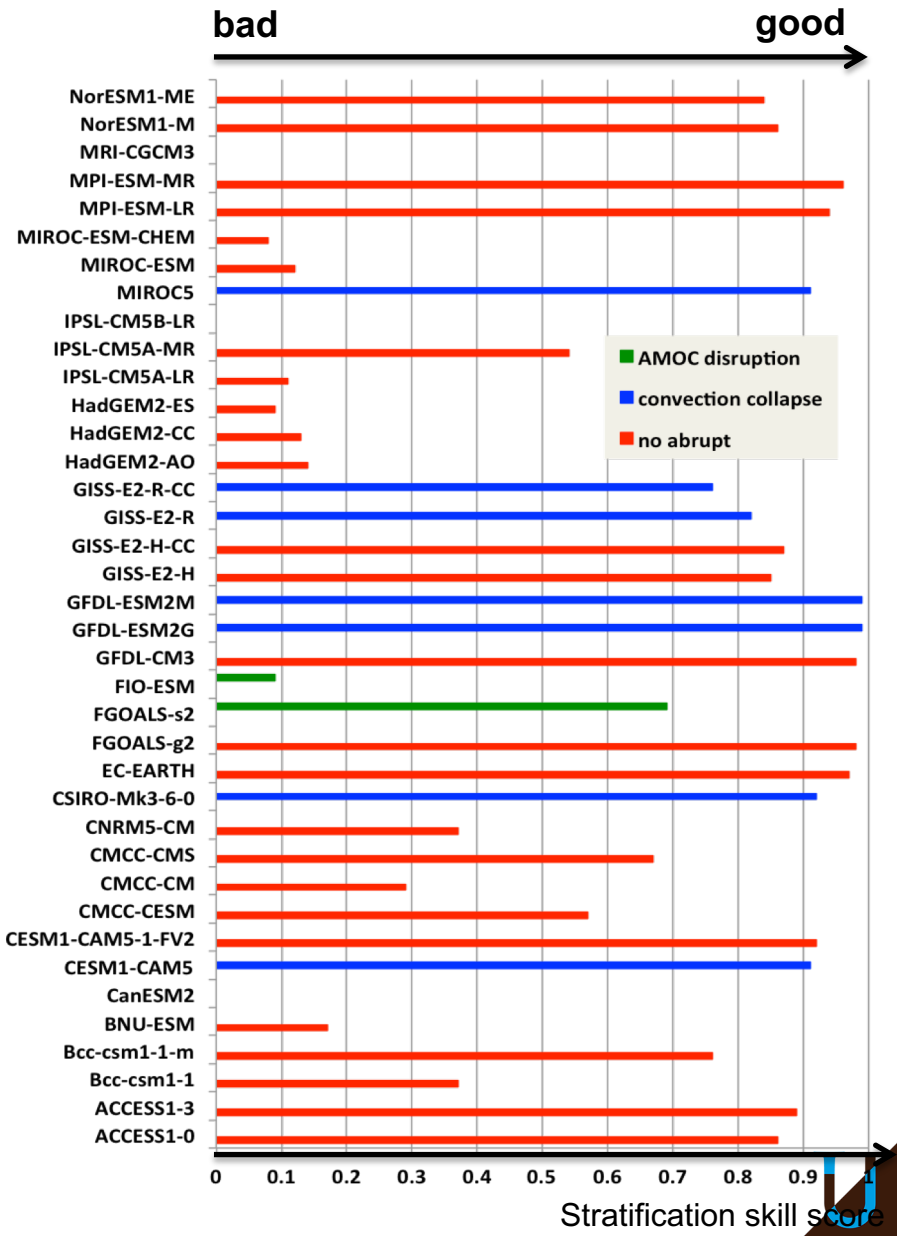


Model evaluation

We defined a model **skill score S** (value between 0 and 1) based on the modeled stratification for present-day conditions

Subset ranking	average S	unweighted occurrence	Occurrence (S>0.9)
1. SPG convection collapse	0.90	17.5%	45.5%
2. non-abrupt	0.54	77.5%	54.5%
3. AMOC disruption	0.39	5.0%	0.0%

When considering only the 11 most skilled models for background stratification, the probability of occurrence of a SPG convection collapse is of 45.5%

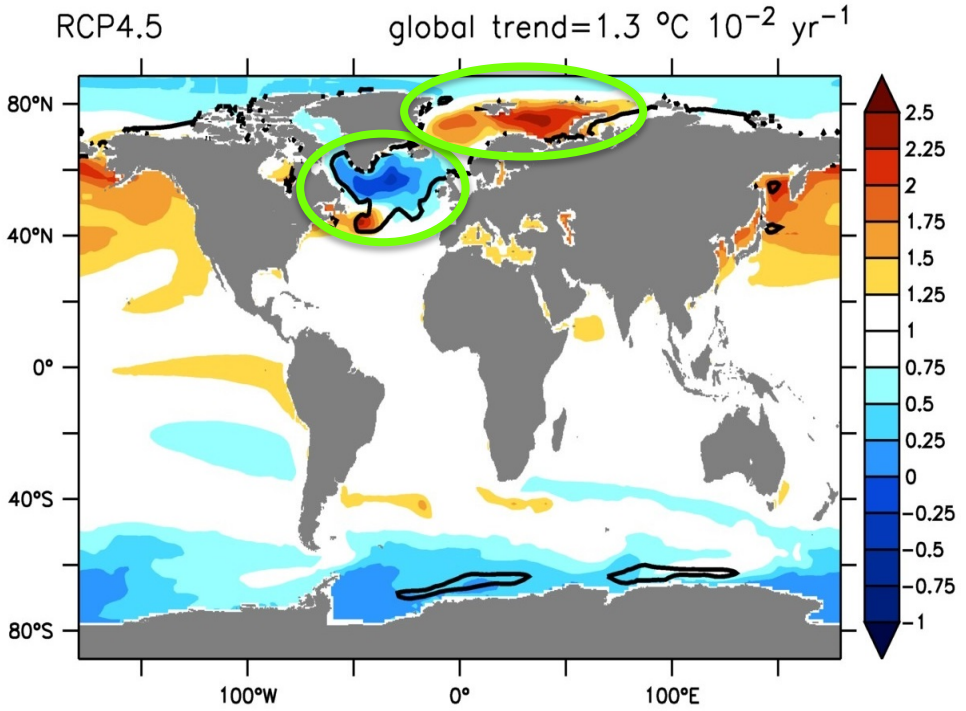


Ensemble mean and spread of SST from CMIP5 model simulations

Changes in SST are not uniform:

- ➔ **amplified warming** in **Nordic Seas**
- ➔ Subdued warming in the subpolar gyre

SST trend normalized by global mean trend



Des réponses très différentes !

Surface air temperature trends over Europe in the different subsets of models