Didier Swingedouw

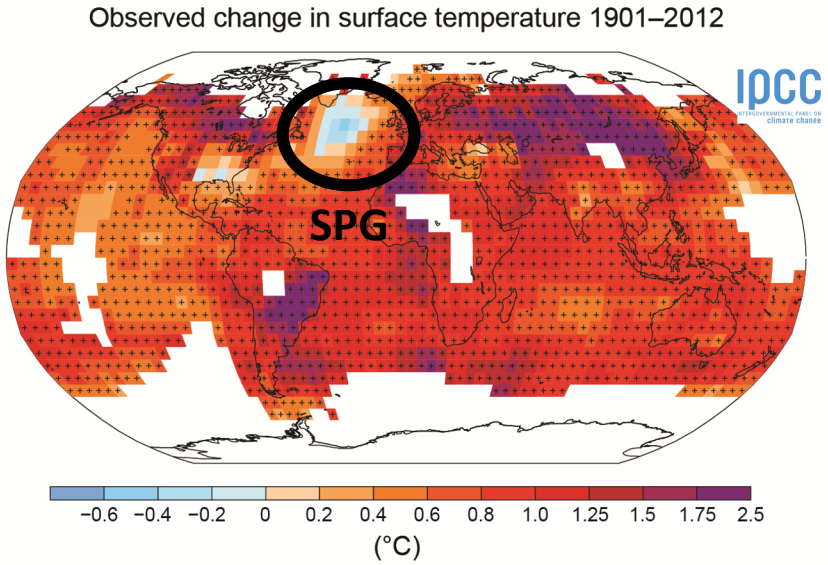
Risks and impacts of abrupt changes in the North Atlantic

Tipping points, extreme events and uncertainty: How can studying the Arctic help us predict future European climate beyond the mean?

Web-conference, 14 October 2020

Where are we now?

- There is an observed **cooling and freshening of the subpolar gyre** (SPG) over the last century
- This might be a fingerprint of an on-going **weakening of the Atlantic ocean circulation**



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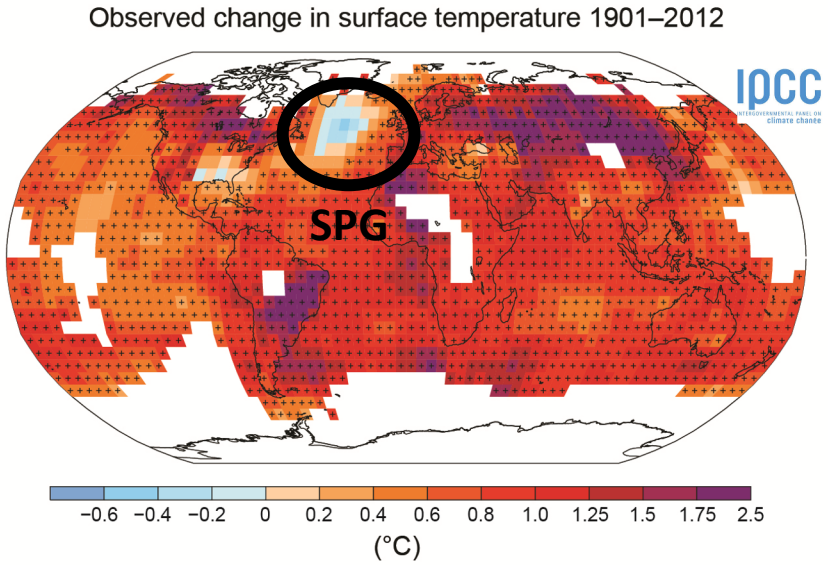
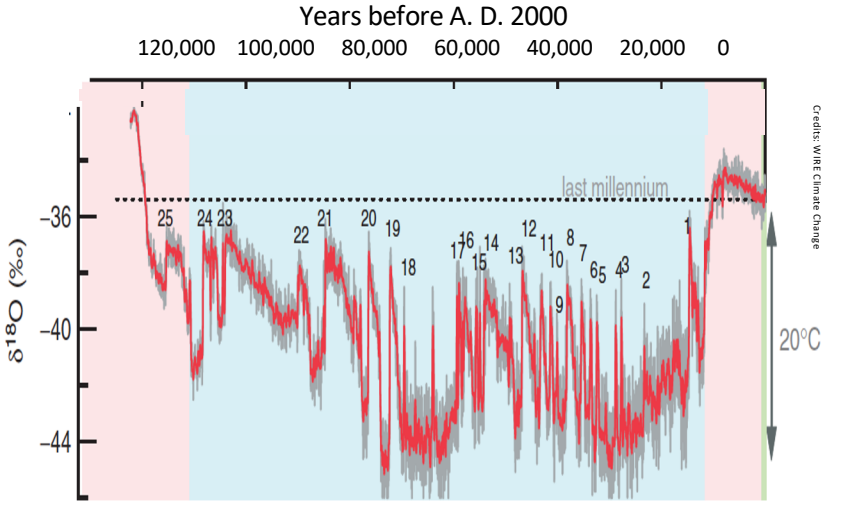
- This might be a fingerprint of an on-going **weakening of the Atlantic ocean circulation**
- Lessons from the past both in glacial and interglacial periods highlight that **abrupt changes/instabilities/tipping points are possible**



Ice core reconstructions

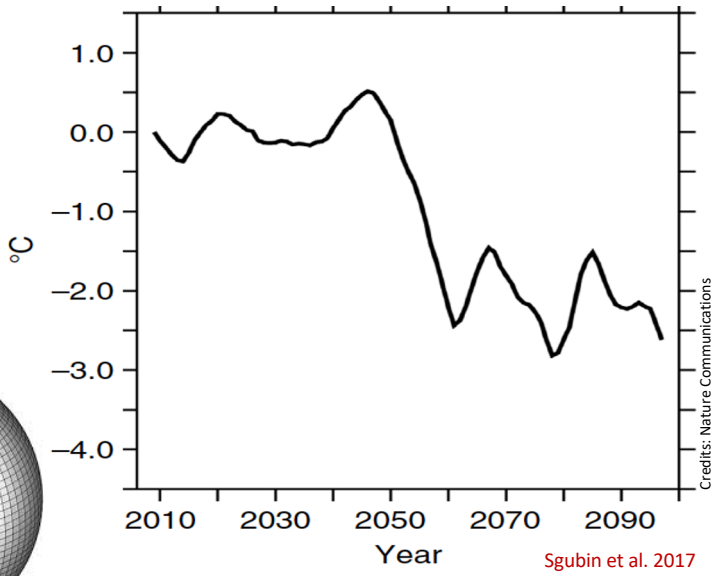


Masson-Delmotte et al. 2012

Possibility of Abrupt Changes in the North Atlantic in climate models

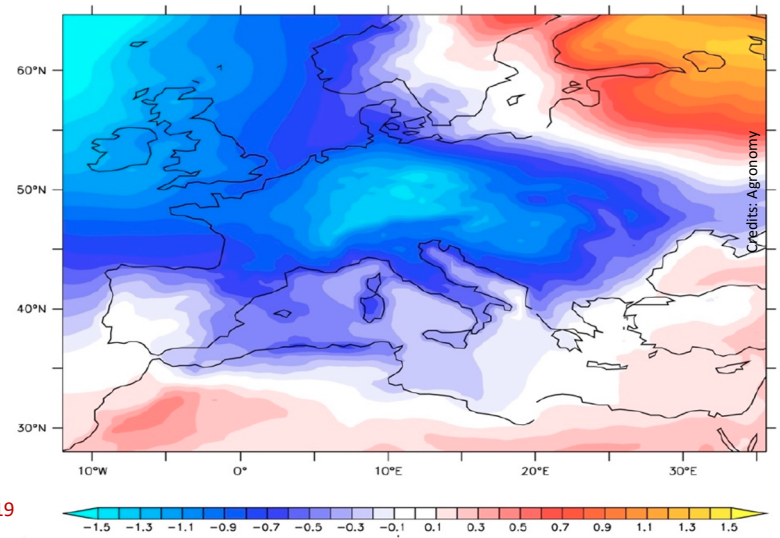
- Some models do show abrupt (<10 years) cooling in the subpolar gyre (SPG)
- The risk for such changes can be estimated between about 20 to 45%

Changes of surface temperature in the subpolar gyre in a model projection



Sgubin et al. 2017

Difference of temperature after and before the shift



Sgubin et al. 2019

- The impact of the decade after the abrupt change, as compared to the former one, can be huge over Europe
- This might put some adaptation measures in agriculture at risk (e.g. viticulture) on a decadal time scale

Large-scale impact of substantial changes in Atlantic circulation

Physical system

- Droughts
- Temperature trend
- Sea level rise
- Cyclones frequency
- Sea ice and snow
- Precipitation and flooding
- Storminess

Biological system

- Vegetation
- Oxygenation
- Marine ecosystems
- Oceanic carbon and acidification
- Wetland methane

Human and managed systems

- Agriculture and food production
- Migration pressure due to degradation in livelihoods

Direction of the change

- Increase
- Decrease

Confidence in process understanding

- High
- Medium
- Low

IPCC INTERGOVERNMENTAL PANEL ON climate change

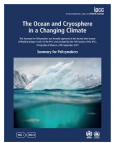


Fig. 6.10 from IPCC SROCC report, 2019

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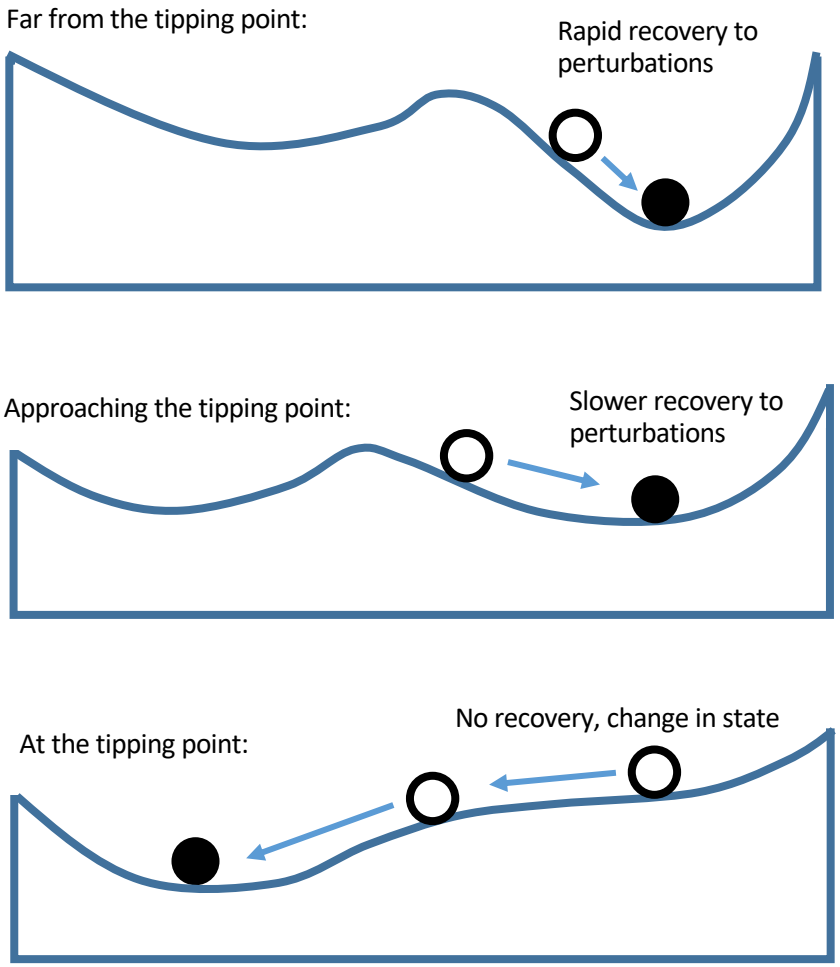
How to have early warnings of such a change?

- Theory from dynamical system teaches us that approaching a tipping point, the climate variability tends to increase
- Recent results (Michel et al. sub.), reconstructing the circulation over the last millennium, indicate that we can see such a change in variability and therefore are approaching a tipping point

Change of temporal variability when approaching the tipping point



Adapted from: Lenton 2011

How to have early warnings of such a change?

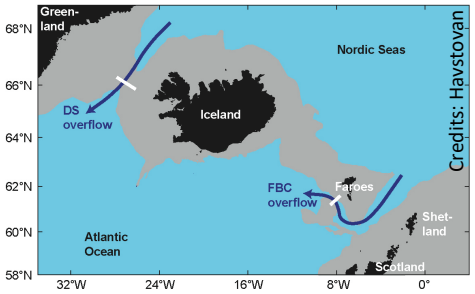
- According to CMIP5 models, we might also be not far from a tipping point in the **stratification of the water column**, a useful early warning for abrupt subpolar gyre changes (Swingedouw et al. 2020)

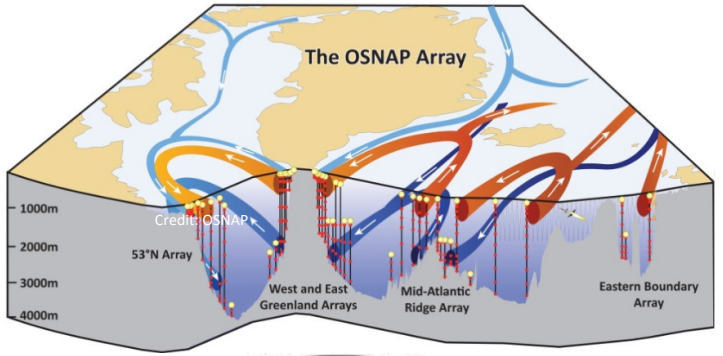
- **Decadal prediction systems** with initialized ocean state including observations might be the most up-to-date tool to predict the risk for such a shift in the coming decades

- Its is necessary to start thinking of **adaptation plans** to be prepared to a potential associated crisis (e.g. COVID)

=> To include in “Destination Earth” EU programme?

Overflow measurements





What are the research gaps?

- **Observation systems** are needed for an efficient early warning system
  - Continue on-going *in situ* arrays and monitoring systems
  - Include more oceanic observations below 2000m
- **Decadal prediction systems** still need further development to:
  - Diminish their offset to observations
  - Avoid drift when launched from observed ocean
  - Better predict the recent cooling in the subpolar gyre since 2015
- Need for **reconstructions of the last few thousands of years** to have better insights on "natural variability" and the approach of a tipping point
- Assessment of the impact of **such low probability - high impact scenario** in **adaptation plans** are poorly accounted for up to now.

Key take-home messages

- Possibility of Abrupt Changes in the North-Atlantic/Arctic in IPCC-type climate models
- They have global impacts (Atlantic marine life, Sahelian precipitations, European heat waves, storms, agriculture, Asian monsoon shift…)
- Decadal prediction systems need to be further developed to have early warnings of such potential abrupt changes

BLUE ACTION

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The Blue-Action project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727852