上海交通大学
SHANGHAI JIAO TONG UNIVERSITY

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上海交通大学海洋学院

气候学与全球变化
Climate and Global Change

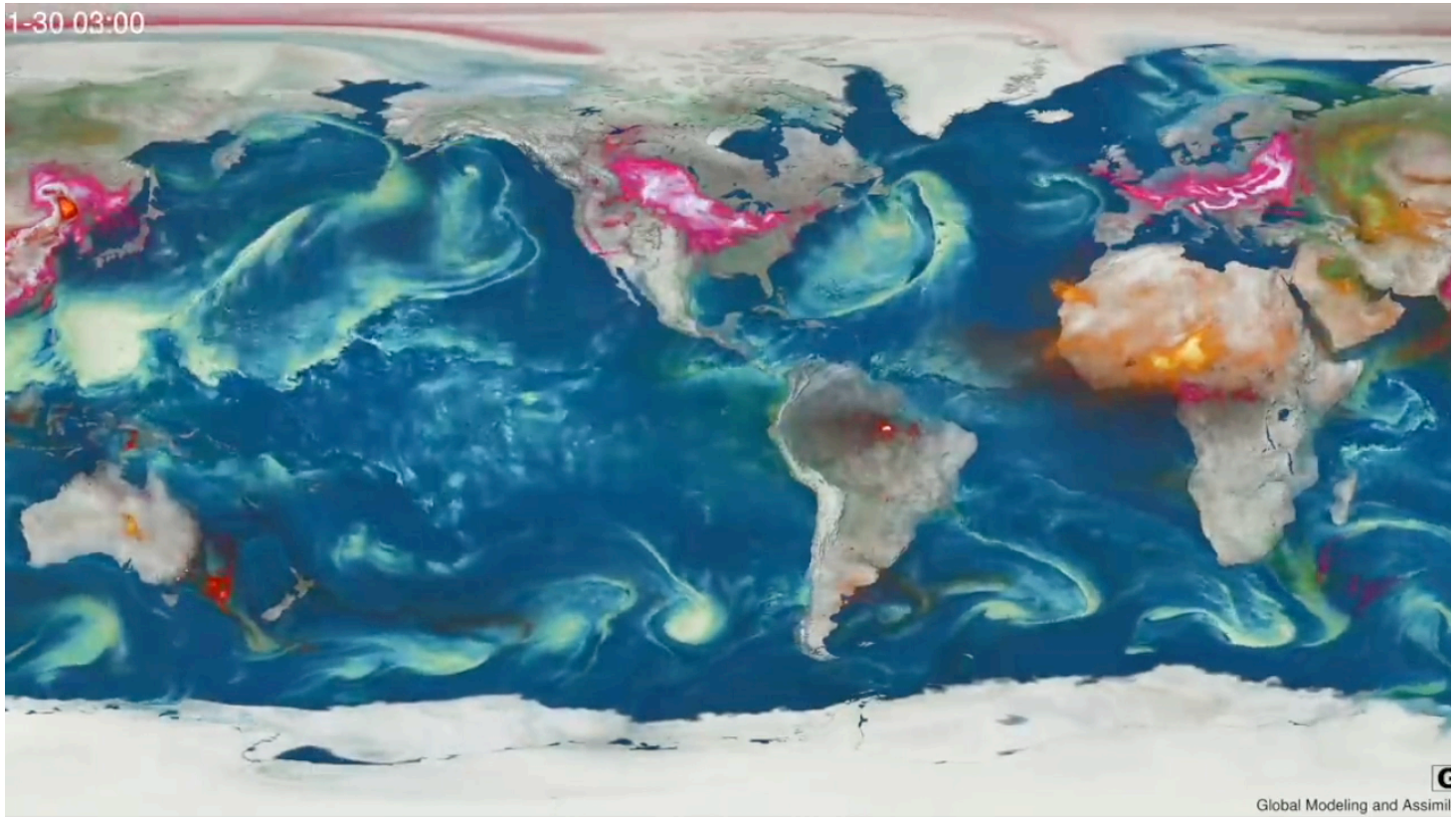
2022.05.31

SCHOOL OF OCEANOGRAPHY
SHANGHAI JIAO TONG UNIVERSITY
上海交通大学 海洋学院

Impacts of climate change

Extreme Events: Wildfires

Unprecedented 2019-2020 Australia bush fire



Article | Published: 15 September 2021

Vast CO_2 release from Australian fires in 2019–2020 constrained by satellite

Ivar R. van der Velde, Guido R. van der Werf, Sander Houweling, Joannes D. Maasakkers, Tobias Borsdorff, Jochen Landgraf, Paul Tol, Tim A. van Kempen, Richard van Hees, Ruud Hoogeveen, J. Pepijn Veefkind & Ilse Aben

Nature **597**, 366–369 (2021) | Cite this article

Article | Published: 15 September 2021

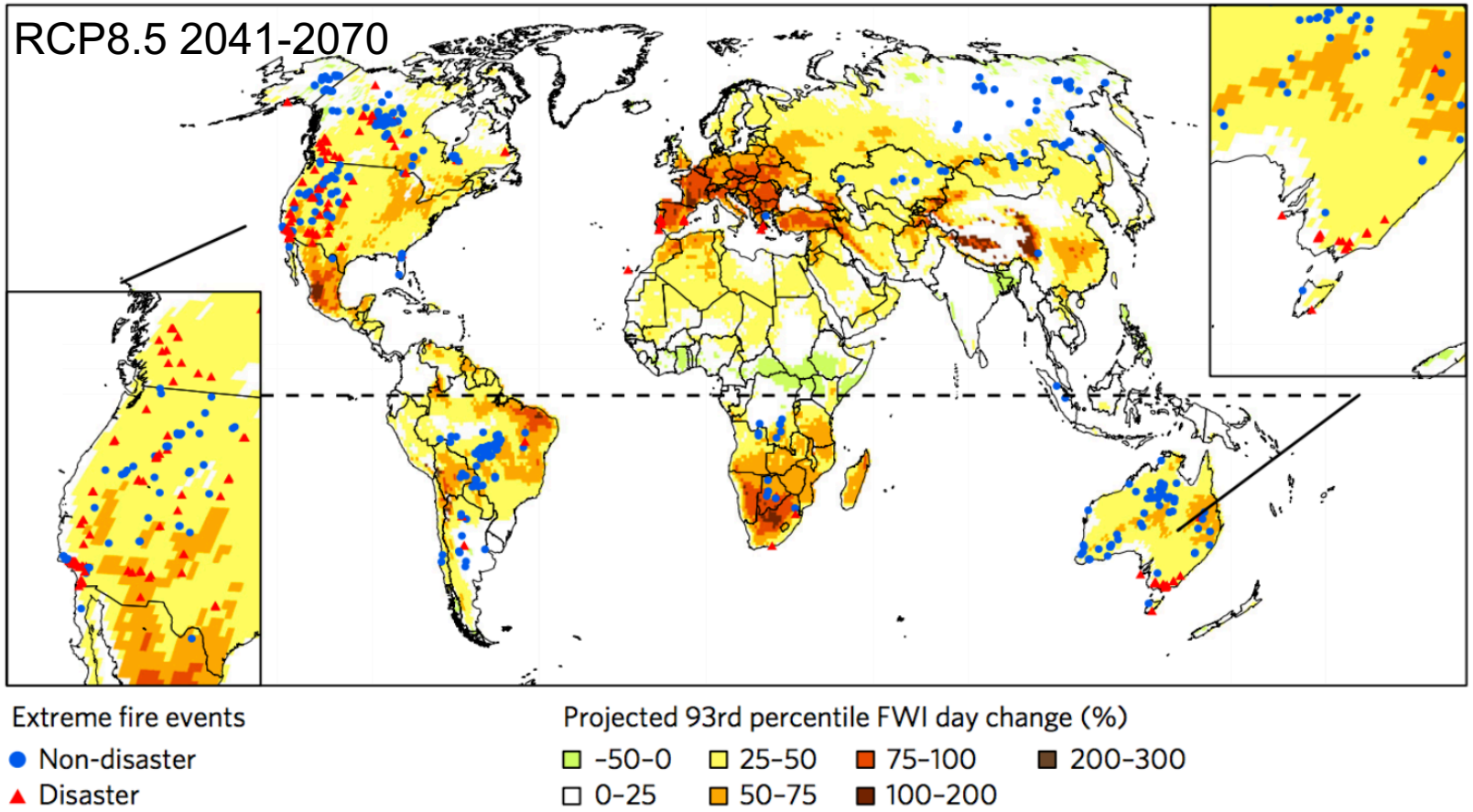
Widespread phytoplankton blooms triggered by 2019–2020 Australian wildfires

Weiyi Tang, Joan Llort, Jakob Weis, Morgane M. G. Perron, Sara Basart, Zuchuan Li, Shubha Sathyendranath, Thomas Jackson, Estrella Sanz Rodriguez, Bernadette C. Proemse, Andrew R. Bowie, Christina Schallenberg, Peter G. Strutton, Richard Matear & Nicolas Cassar

Nature **597**, 370–375 (2021) | Cite this article

Impacts of climate change

Extreme Events: Wildfires

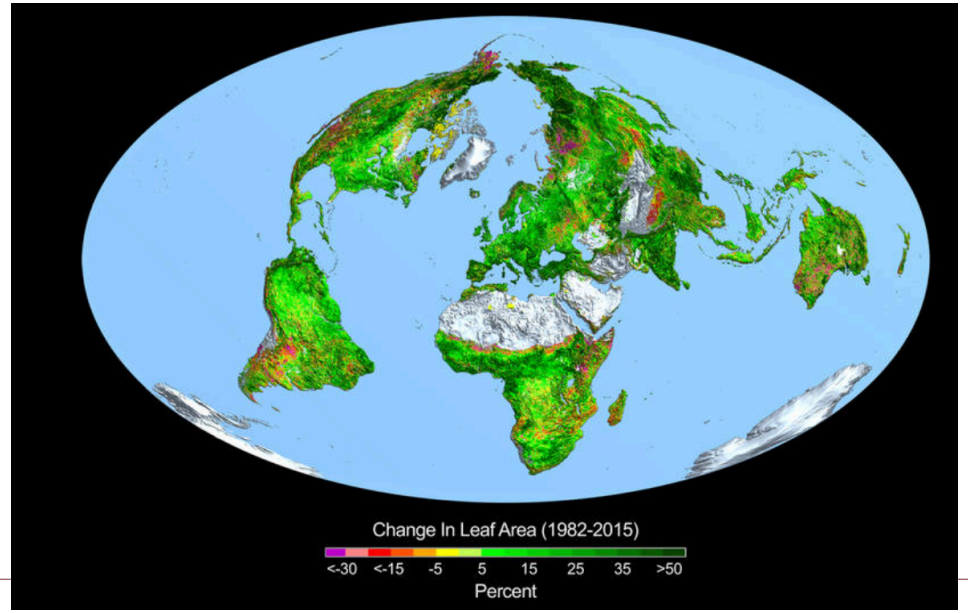


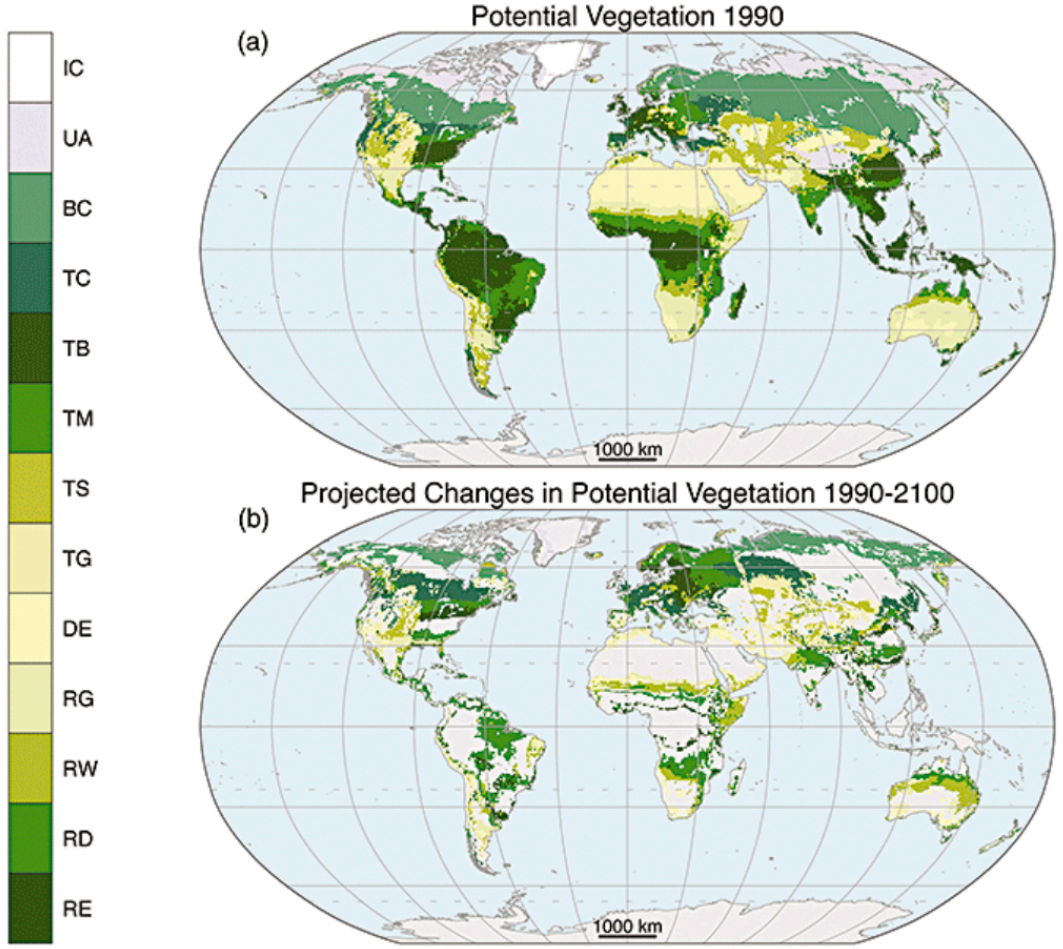
- Wildfire requires dry fuel and ignition;
- Wildfire is a **complex** phenomenon impacted not only by climate but also by other processes such as forest suppression, forest management, human ignition.

Impacts of climate change

Impacts on Vegetation

- “Greening Earth”: higher CO2 level promotes vegetation growth;
- Warming -> poleward shift of species & longer growing season;
- Precipitation will impact vegetation distribution.

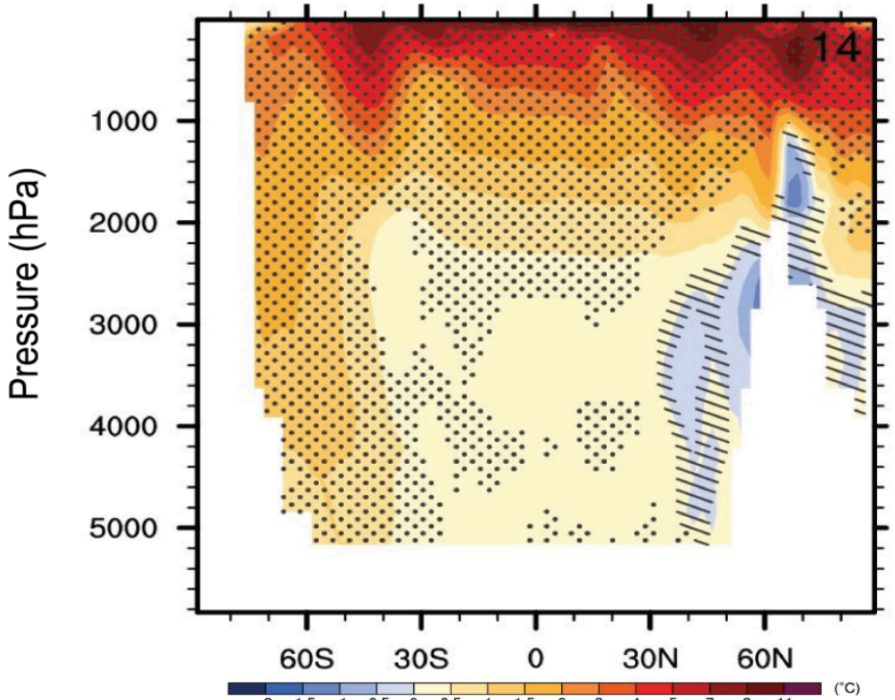


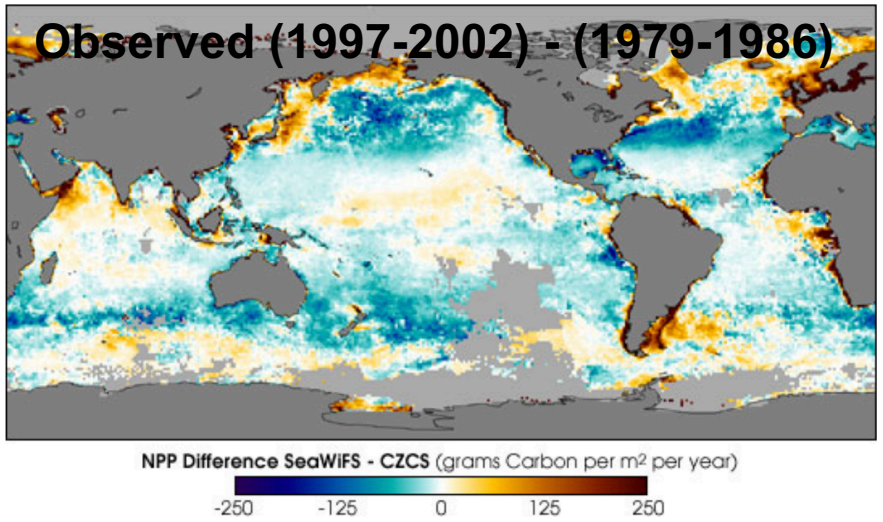


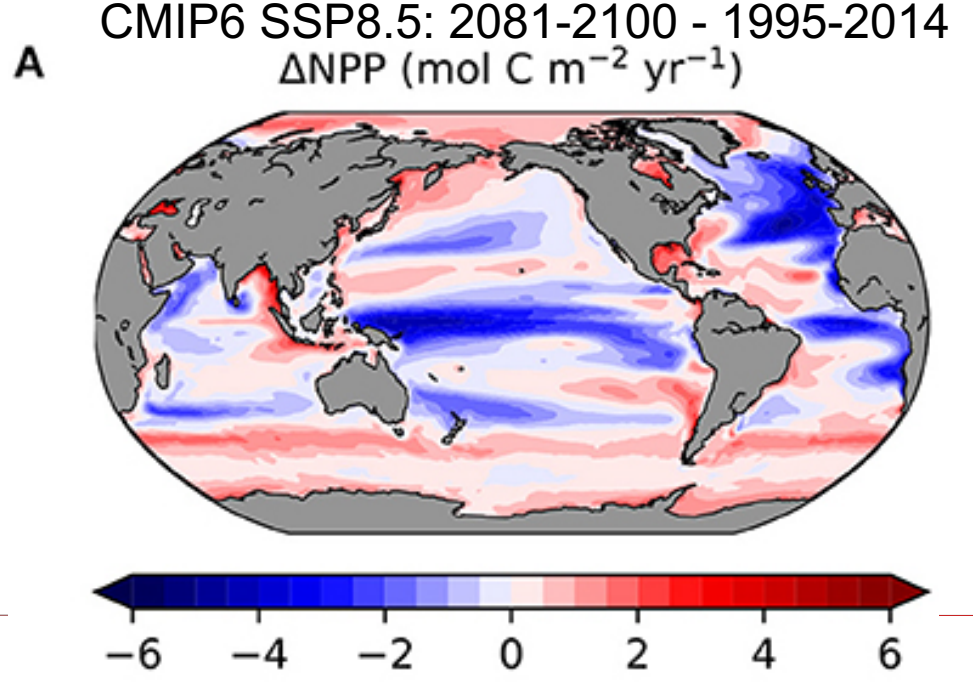
Impacts of climate change

Impacts in Ocean

More stratified ocean
-> less vertical mixing and upwelling of nutrients from the subsurface
-> reduce productivity





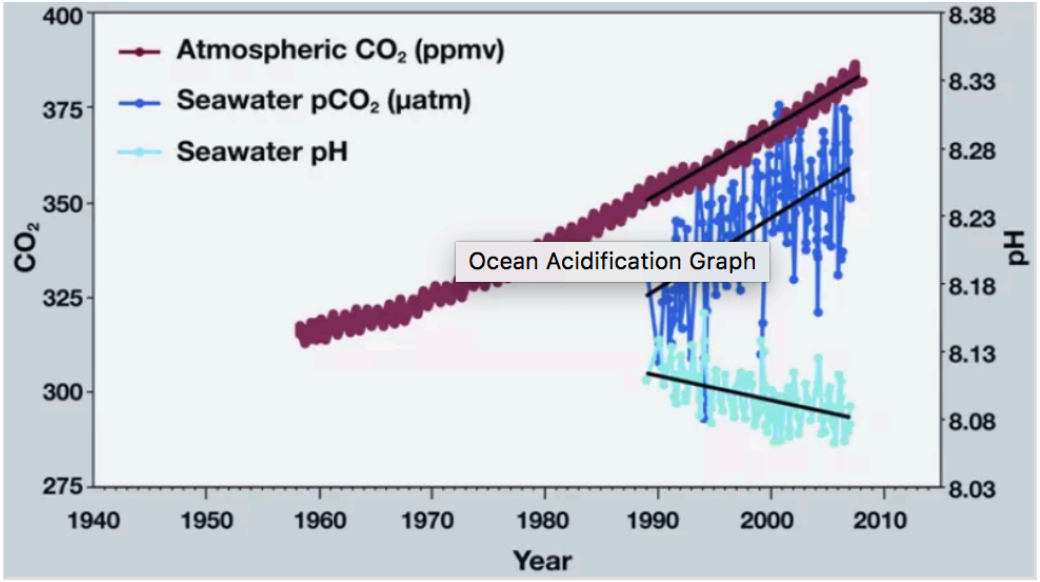


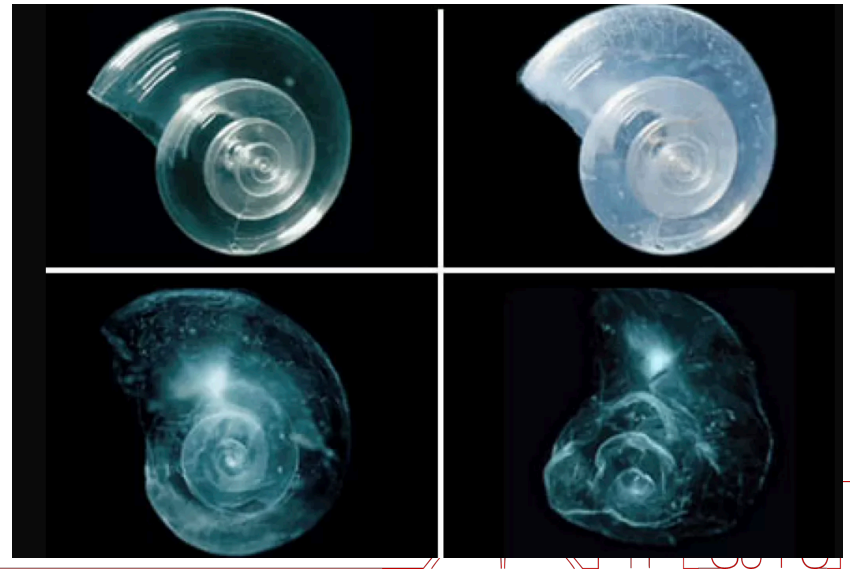
Impacts of climate change

Impacts in Ocean

Coral threatened by

- temperature： bleaching
- ocean acidification



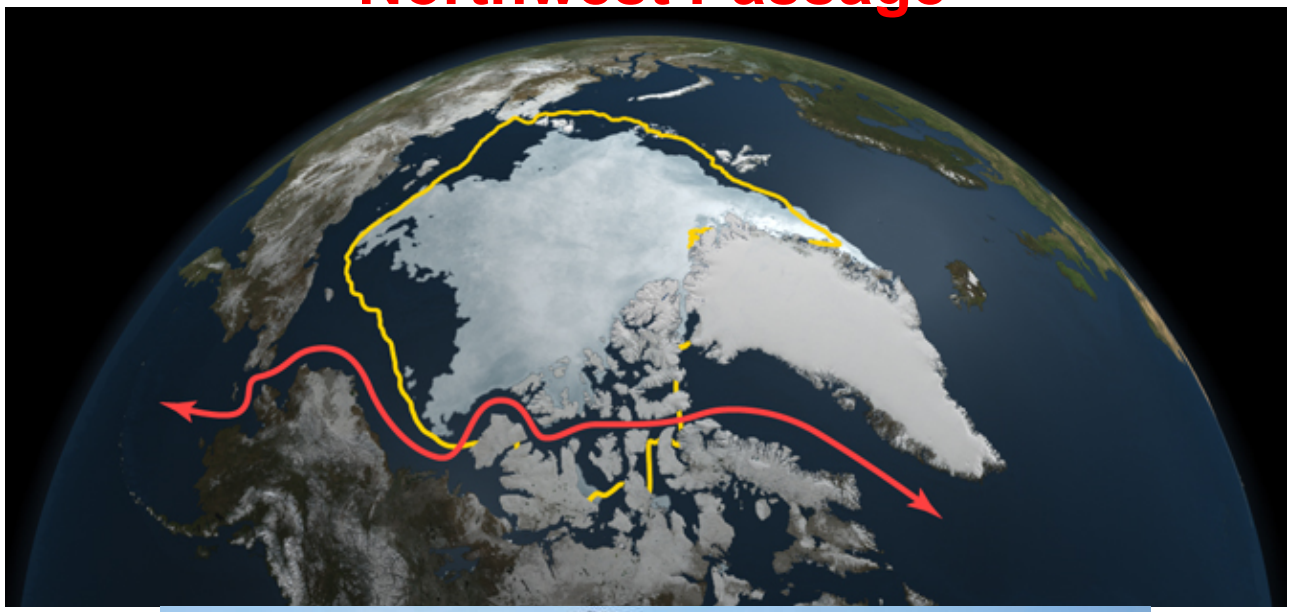


IPCC: “Coral reefs are projected to decline by a further 70-90% at 1.5℃, with larger losses (>99%) at 2℃”

Impacts of climate change

Impacts on human

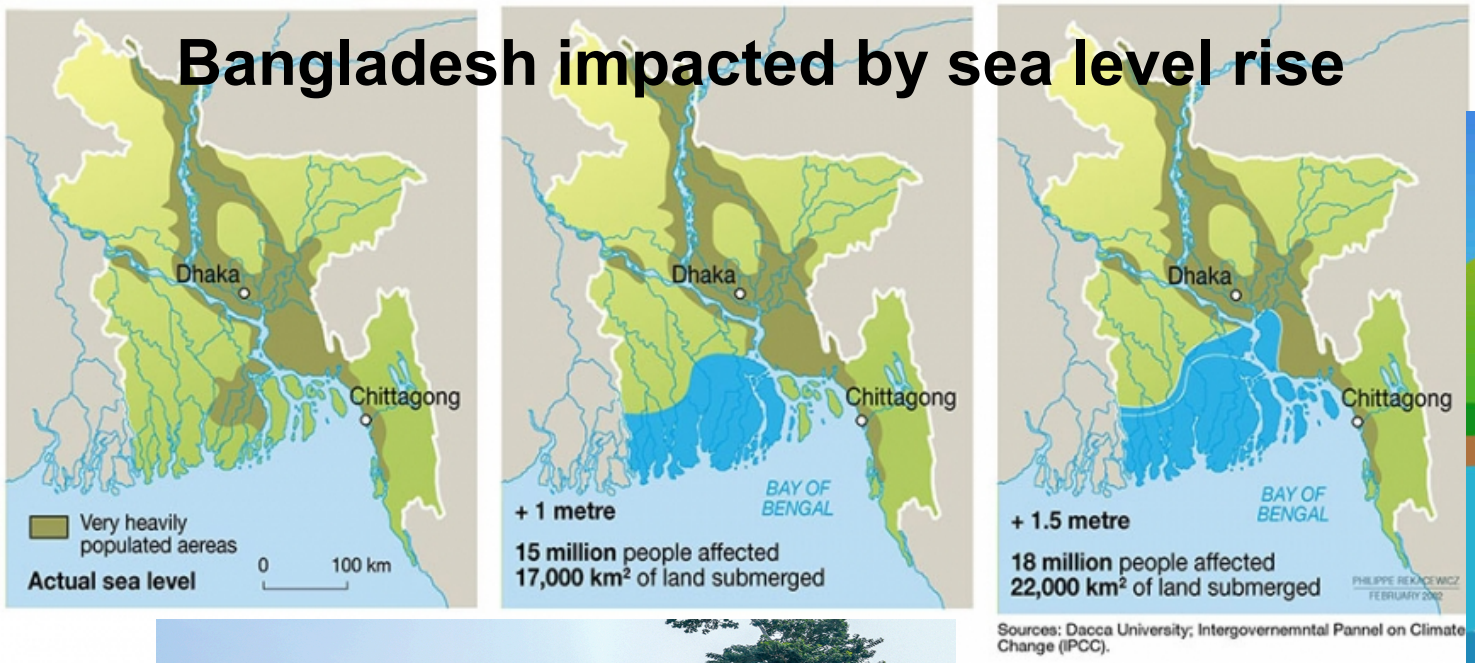
Northwest Passage



Impacts of climate change

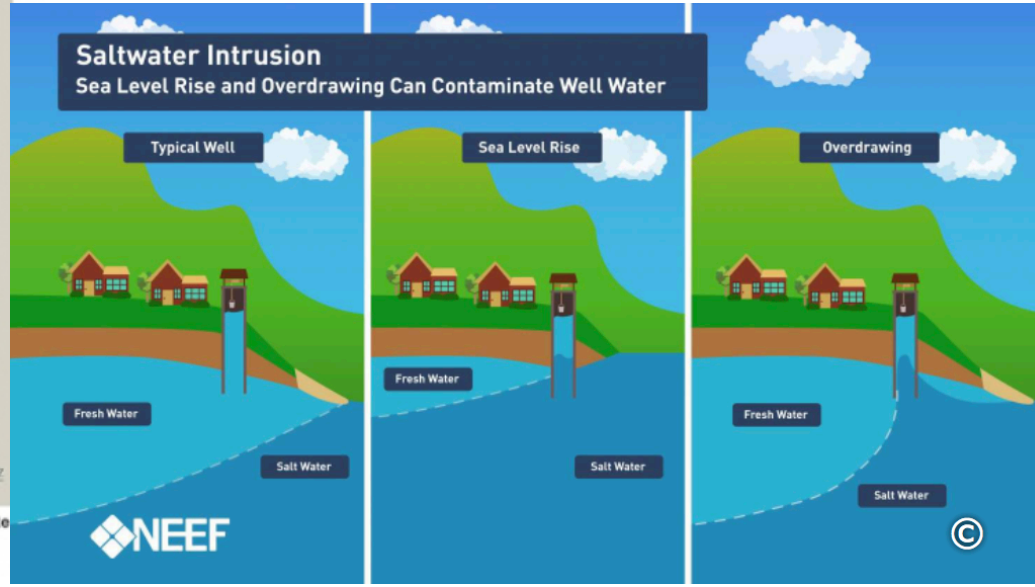
Impacts on human

Bangladesh impacted by sea level rise



Sources: Dacca University; Intergovernemntal Pannel on Climate Change (IPCC).

Freshwater crisis



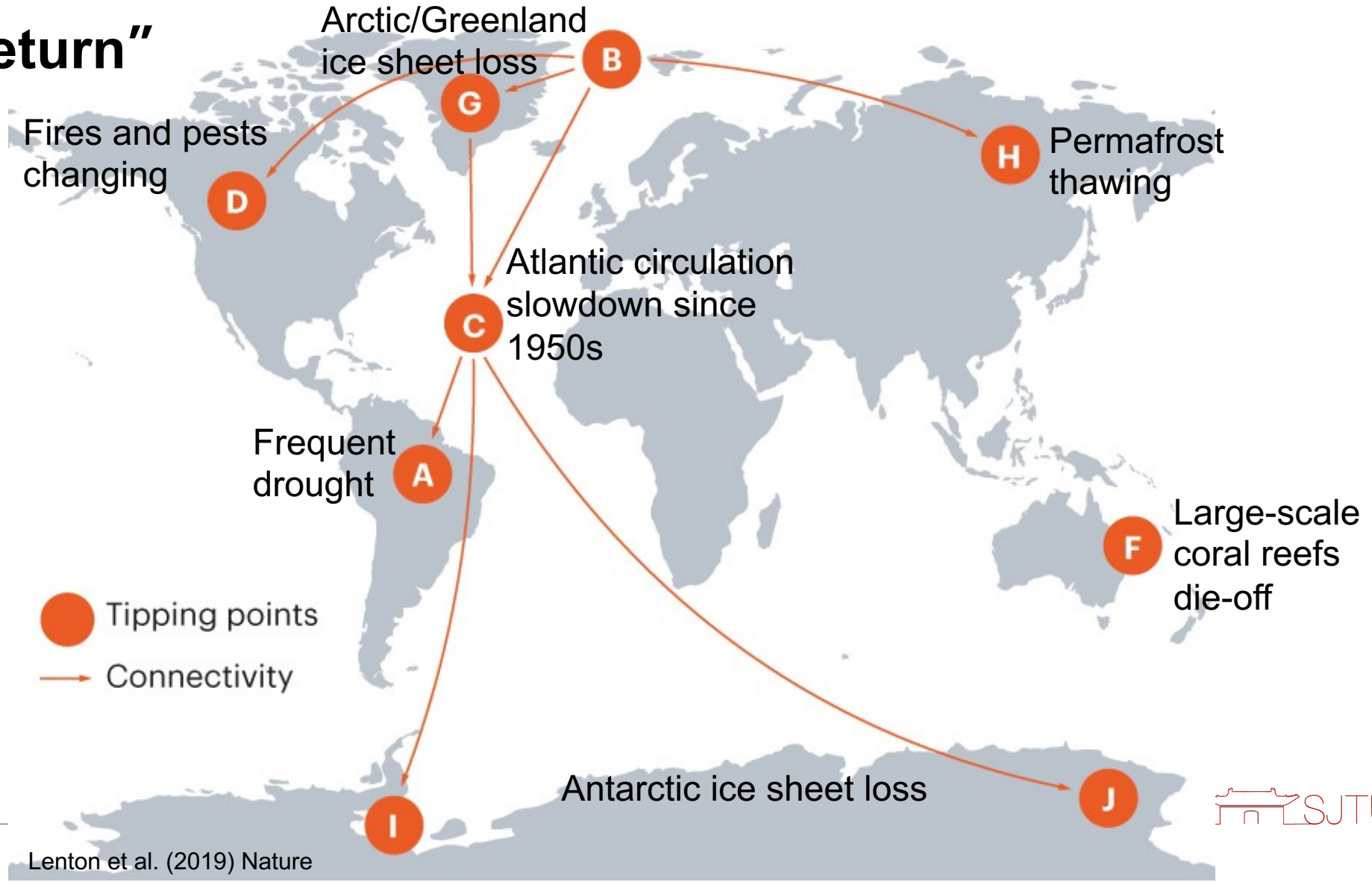
Tipping Points

❖ A tipping point is a threshold that when crossed will lead to an irreversible transition into a different state.

❖ Examples for tipping points are:

- melting of the Greenland ice sheet,
- melting of the West Antarctic ice sheet,
- collapse of the Atlantic meridional overturning circulation,
- ecosystem shifts,
- species extinctions.

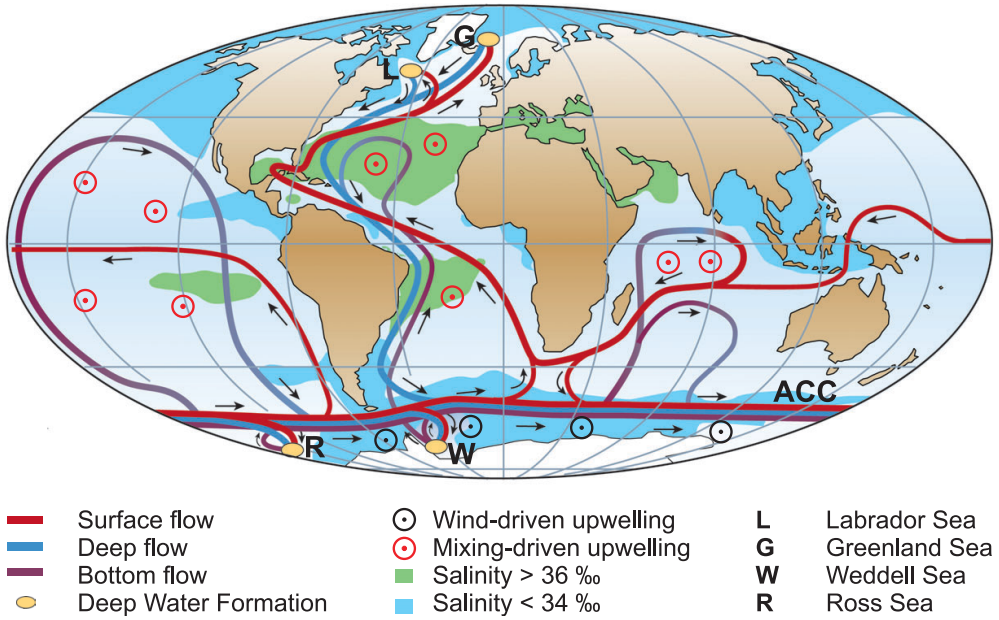
Tipping Points
"points of no return"



Lenton et al. (2019) Nature

Tipping Points

Is the Atlantic Overturning Circulation approaching a tipping point?

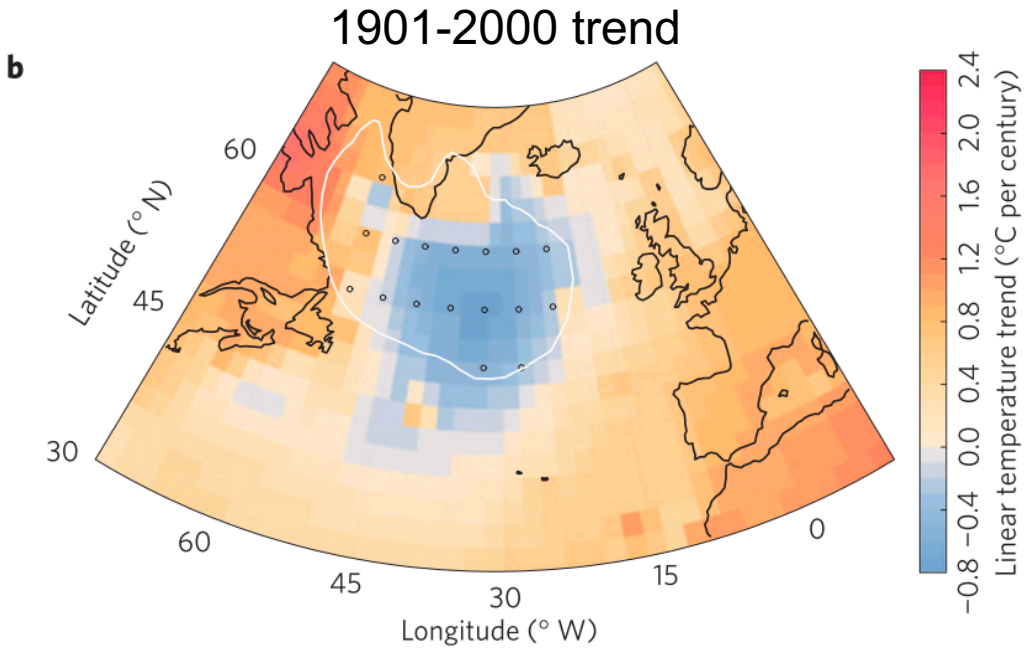


IPCC AR6: “Proxy-based reconstructions suggest that the AMOC was relatively stable during the past 8kyr (medium confidence), with a weakening beginning since the late 19th century (medium confidence), but due to a **lack of direct observations**, confidence in an overall decline of AMOC during the 20th century is low”

AMOC direct observations: RAPID ~2004; OSNAP ~2014

AMOC “fingerprint” (Indirect)

- Subpolar North Atlantic surface temperature (**warming hole**)



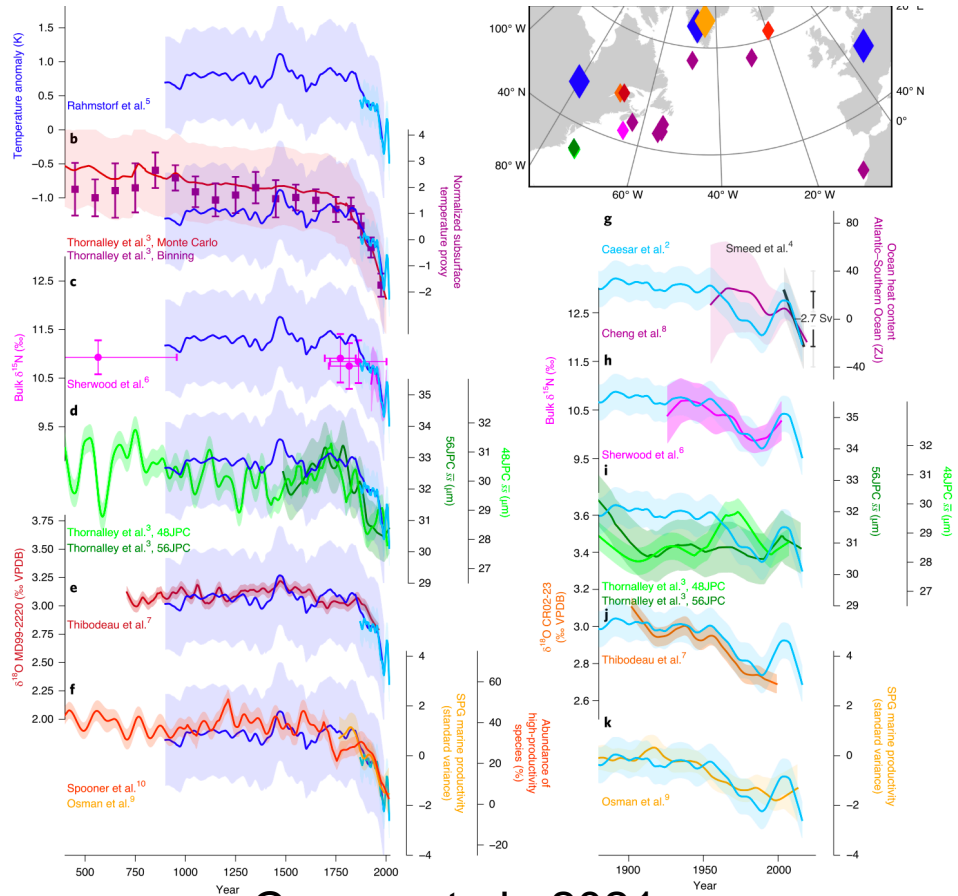
- Florida Current strength

Both suggested ~1.7Sv/Century since 1909

Tipping Points

Is the Atlantic Overturning Circulation approaching a tipping point?

Current Atlantic Meridional Overturning Circulation weakest in last millennium



Caesar et al., 2021

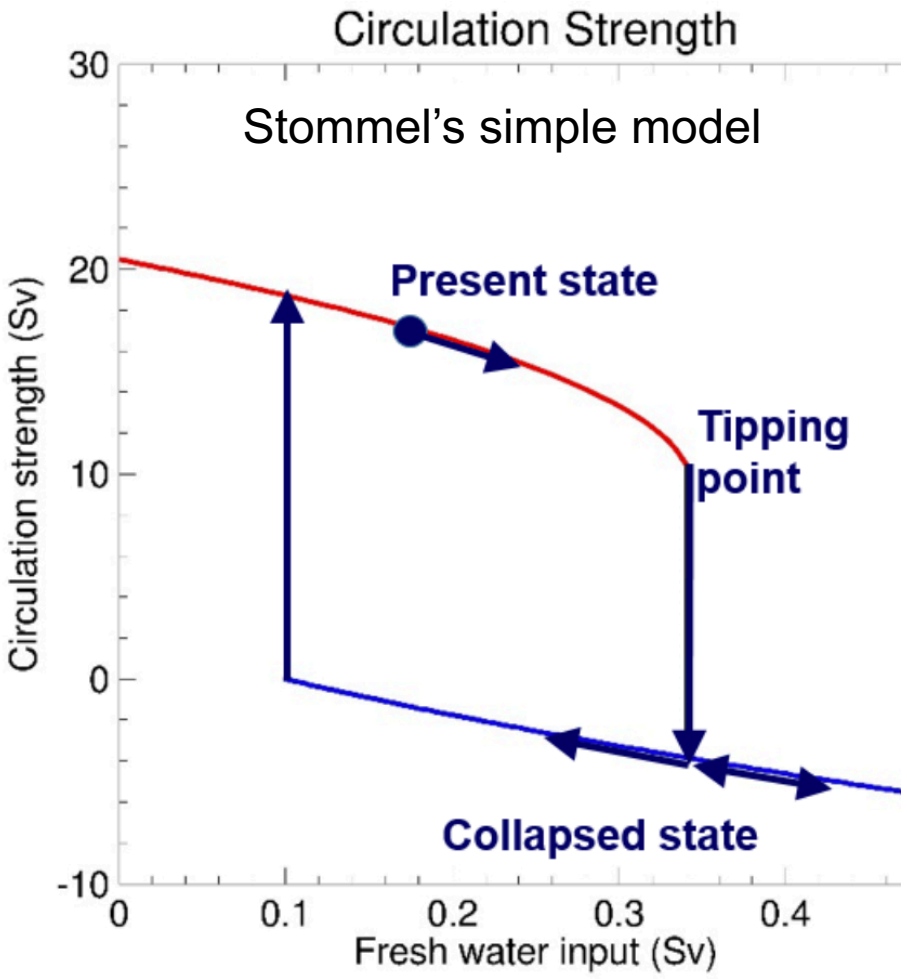
nature geoscience
MATTERS ARISING
https://doi.org/10.1038/s41561-022-00896-4
Check for updates

Atlantic circulation change still uncertain

K. Halimeda Kilbourne[1]✉, Alan D. Wanamaker[2], Paola Moffa-Sanchez[3], David J. Reynolds[4], Daniel E. Amrhein[5], Paul G. Butler[4], Geoffrey Gebbie[6], Marlos Goes[7,8], Malte F. Jansen[9], Christopher M. Little[10], Madelyn Mette[11], Eduardo Moreno-Chamarro[12], Pablo Ortega[12], Bette L. Otto-Bliesner[5], Thomas Rossby[13], James Scourse[4] and Nina M. Whitney[6,14]

Tipping Points

Is the Atlantic Overturning Circulation approaching a tipping point?



ARTICLES
https://doi.org/10.1038/s41558-021-01097-4
nature climate change
Check for updates

Observation-based early-warning signals for a collapse of the Atlantic Meridional Overturning Circulation

Tipping point is close!

Niklas Boers[1,2,3]

The Atlantic Meridional Overturning Circulation (AMOC), a major ocean current system transporting warm surface waters toward the northern Atlantic, has been suggested to exhibit two distinct modes of operation. A collapse from the currently attained strong to the weak mode would have severe impacts on the global climate system and further multi-stable Earth system components. Observations and recently suggested fingerprints of AMOC variability indicate a gradual weakening during the last decades, but estimates of the critical transition point remain uncertain. Here, a robust and general early-warning indicator for forthcoming critical transitions is introduced. Significant early-warning signals are found in eight independent AMOC indices, based on observational sea-surface temperature and salinity data from across the Atlantic Ocean basin. These results reveal spatially consistent empirical evidence that, in the course of the last century, the AMOC may have evolved from relatively stable conditions to a point close to a critical transition.

Solutions

Adaptation

to the **inevitable** climate change

sea level rise
heat waves
heavy precipitations
……

Mitigation

to reduce GHG emissions

Summary

1. Sources and half life of anthropogenic GHG (CO_2, CH_4, CFCs, N_2O, O_3)
2. How aerosols affects the climate (e.g., dust, black carbon)?
3. How land cover change affects the climate?
4. Future climate change: temperature and precipitation (pattern and why?), sea level rise ……
5. Future climate change uncertainty: emission scenarios & climate model

期末复习

第九章 地球气候的演变:

1. 不同观测手段的时间尺度；
2. 不同的代用记录如何反应过去的气候：树轮，石笋，冰芯，珊瑚，黄土, 冰筏碎屑 ；
3. 不同的定年方法及其局限性：放射性定年，年层定年，轨道参数定年;
4. 氧同位素：冰芯，海水，有孔虫 （例：估算海平面变化）；
5. 大西洋中$\delta^{13}C$的分布特征及原因（不同水团）；
6. 解释北大西洋 $^{231}Pa/^{230}Th$ 记录；
7. 地球的碳库（大气、植被、表层海洋、深层海洋、岩石），不同时间尺度上CO_2的源和汇；
8. 地球轨道如何影响气候（倾角，岁差）（轨道季风假说，Green Sahara）
9. 新仙女木事件（记录，成因）

期末复习

第十章 气候敏感性和反馈机制

1. 不同过程如何影响辐射强迫（温室气体, 反照率，气溶胶，云）
2. 什么是气候敏感性？气候敏感性如何估计？
3. 解释反馈过程的原理：普朗克反馈；水汽反馈；温度递减率反馈；冰雪反照率反馈；云反馈

第十一章 气候模式

1. 控制方程（例：利用质量守恒写出PO_4 box model的方程）
2. 如何验证模式？模式的不确定性来源？

第十二章 人类活动引起的气候变化

1. 不同人为排放的温室气体(CO_2, CH_4, CFCs, N_2O, O_3)来自？
2. 气溶胶的气候效应（沙尘，黑碳）
3. 如何预测气候变化，不确定性来源？
4. 未来温度和降水如何变化及其原因？