

Climate Change Impacts on Catastrophic Weather-Related Disasters

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Risks of future global warming

- Concerns about increase in weather-related disasters



Heatwaves

Exposure to heat waves will continue to increase with further warming



Water scarcity

In regions dependent on snowmelt, a 2°C warming could reduce the amount of water available for agriculture by 20% after 2050



Food Security

2°C warming by 2050 could cause food shortages and malnutrition among people living in sub-Saharan Africa, South Asia, Latin America, and small islands



Flood risk

Nearly one billion people in low-lying cities and small islands along the coast could be at risk from sea level rise by mid-century

ホーム > ニュース > 社会

熱中症救急搬送が1週間で9190人、前年比2倍超...搬送者・死者ともに今年最多

9,190 emergency medical evacuations for heat stroke a week, more than double the number of the previous year

暑さ指数(WBGT)

30日(日)14時(予想)

熱中症警戒アラート
東北～沖縄の39都府県対象



WN ウェザーニュース

インド熱波で100人超死亡 気温45度近く、熱中症か

Over 100 deaths in India, nearly 45°C

保存 印刷 共有



東京新聞 TOKYO Web

東京都心36.6℃「猛暑日」7日連続 7月は12日目、過去最多また更新 埼玉・鳩山39.6℃ 明日は？

2023年7月30日 18時55分

7 consecutive hot days in central Tokyo, July 2023



関東地方は30日も勢力の強い高気圧に覆われ、埼玉県鳩山町で最高気温

39.6度を観測するなど、内陸部で39度台の猛烈な暑さとなった。東京都心も36.6度と7日連続で35度以上の猛暑日に。都心の7月の猛暑日は計12日と過去最多を更新した。

Risk of high temperature is increasing

- 1-4th record hot year since the start of statistics (1891) is the past 5 years
統計開始(1891年)以降の暑い年の
4位までが過去5年の記録

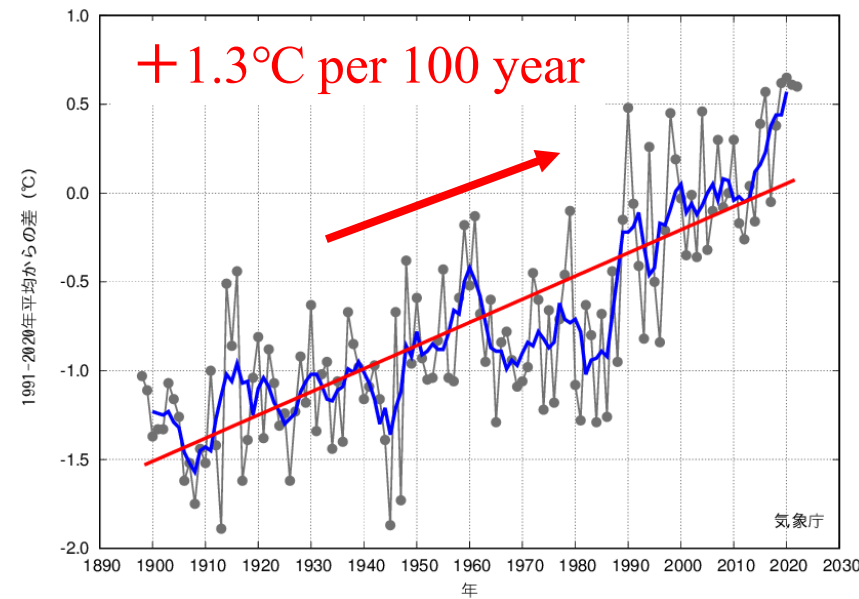
High temperature ranking in Japan:

- 1st: **2020** (+0.65°C)
- 2nd: **2019** (+0.62°C)
- 3rd: **2021** (+0.61°C)
- 4th: **2022** (+0.60°C)
- 5th: 2016 (+0.58°C)

※ Parentheses are changes from 1991-2020 mean

- Impacts on industry, such as outdoor working hours, and health hazards are becoming more apparent.
- Future increases in extreme heat days are also almost certain

Temperature anomaly in Japan
日本の年平均気温偏差

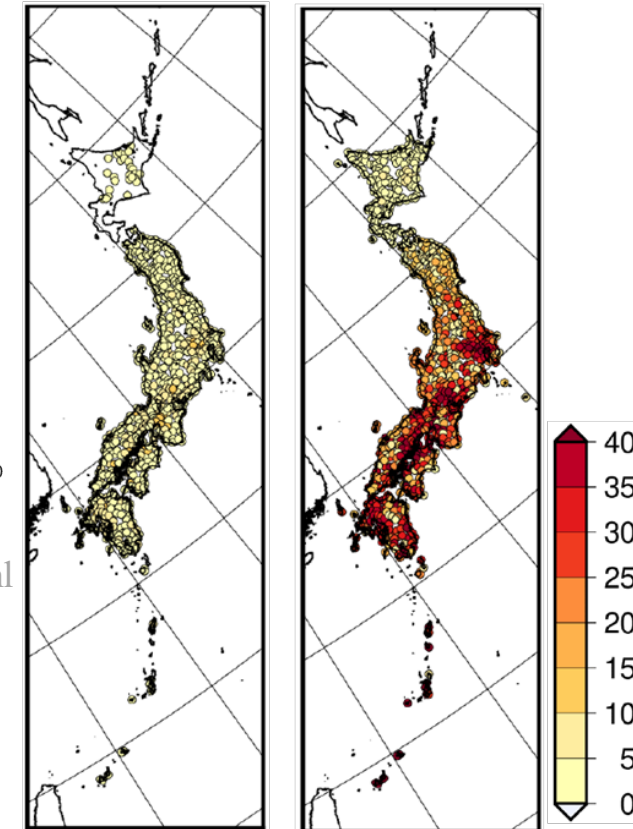


出典: 気象庁Web:
https://www.data.jma.go.jp/cpdinfo/temp/an_jpn.html

Change in annual number of days of extreme heat (days/location)

年間の猛暑日数の将来変化

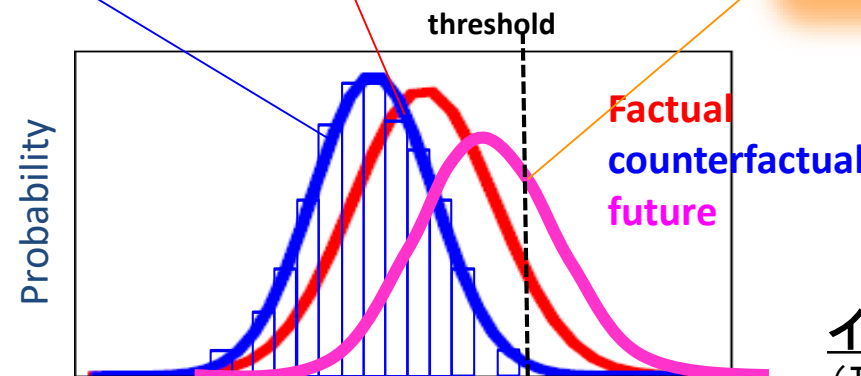
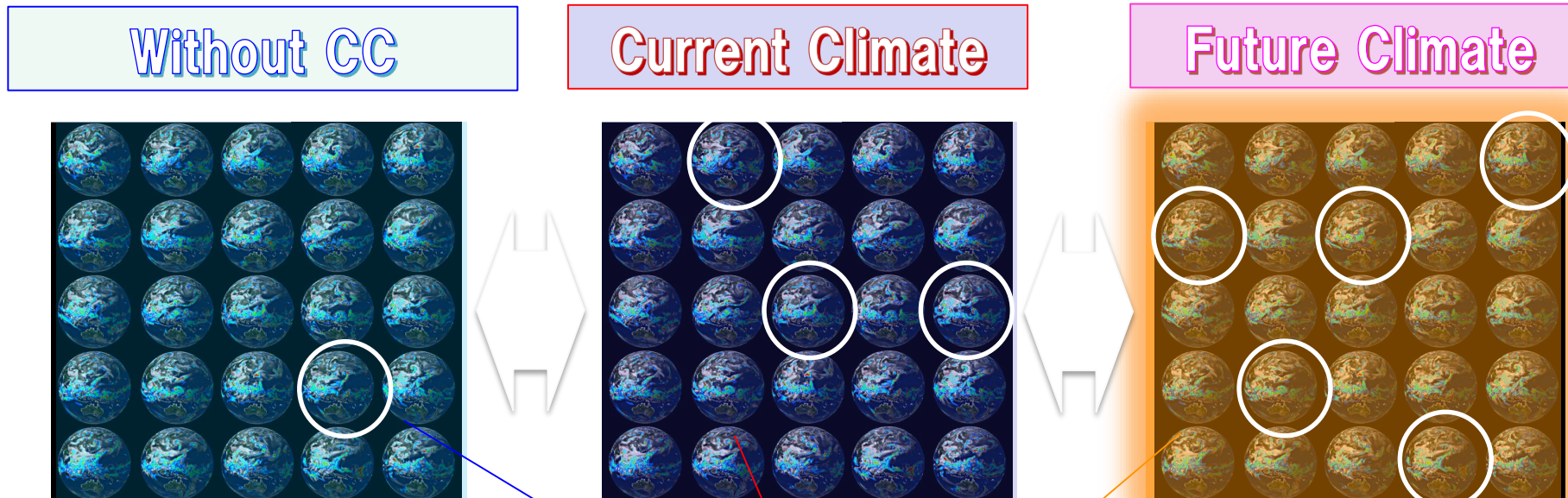
+2°C (2050年頃) +4°C (21世紀末※)



出典: 日本の気候変動2020

Large-Scale Ensemble Climate Experiments

Enable us to assess weather-related disasters by capture the various coincidences that can occur by creating a **large amount of earth** and investigate extreme weather events that appear in some of them.
大量の地球を作り出して起こりうる様々な偶然を捉え、その一部に現れた異常気象を調べる



Event Attribution(EA)実験

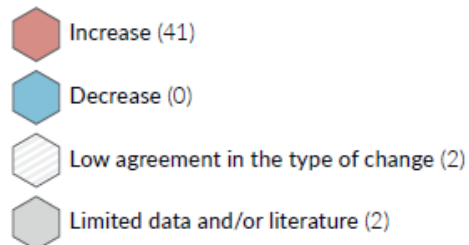
Discussing changes in probability of occurrence of real events

イベント・アトリビュション

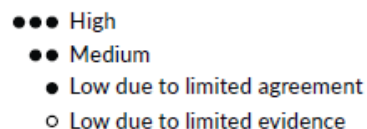
(現実起きたイベントの発生確率の変化を議論)

Climate change has already increased the risk of high temperatures and heavy rainfall

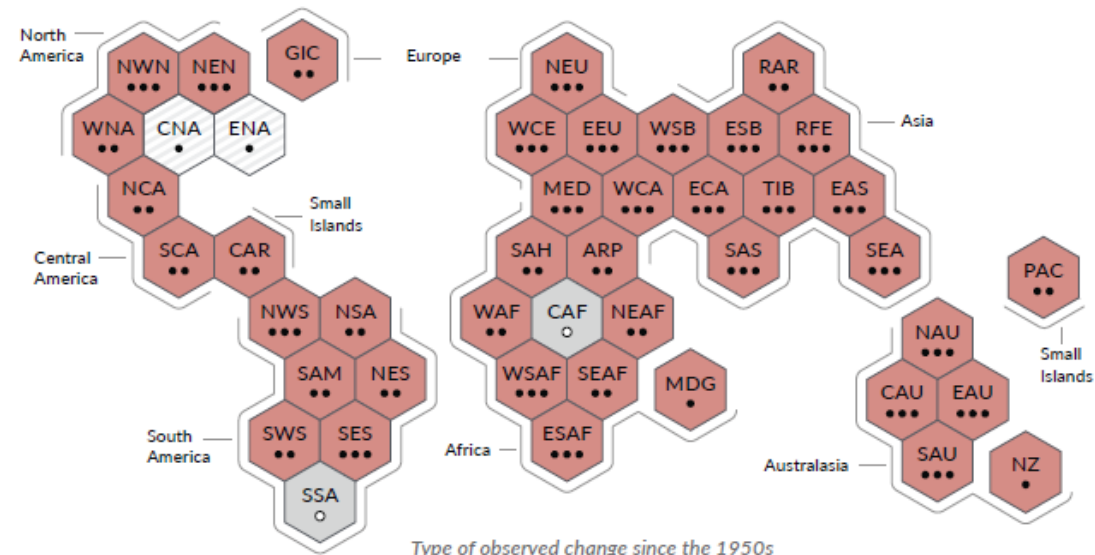
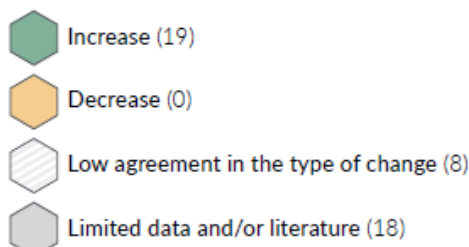
Type of observed change in hot extremes



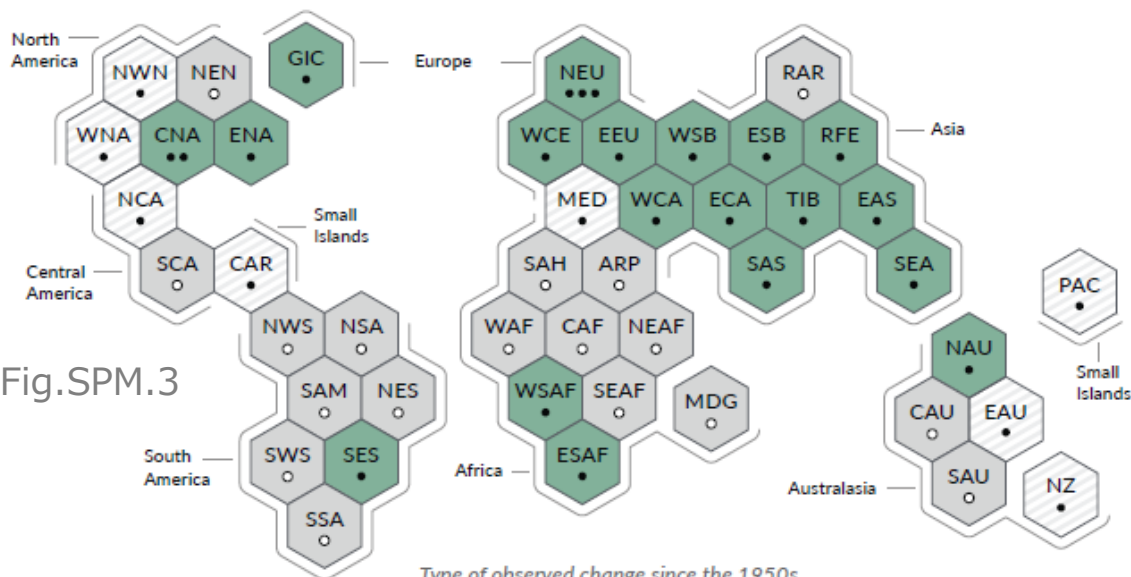
Confidence in human contribution to the observed change



Type of observed change in heavy precipitation



Type of observed change since the 1950s



Type of observed change since the 1950s

Impact of human activity on observed **high temperature** 観測された**高温イベント**に対する人間活動の影響

Impact of human activity on observed **heavy rainfall** 観測された**大雨イベント**に対する人間活動の影響

IPCC AR6 WGI Fig.SPM.3



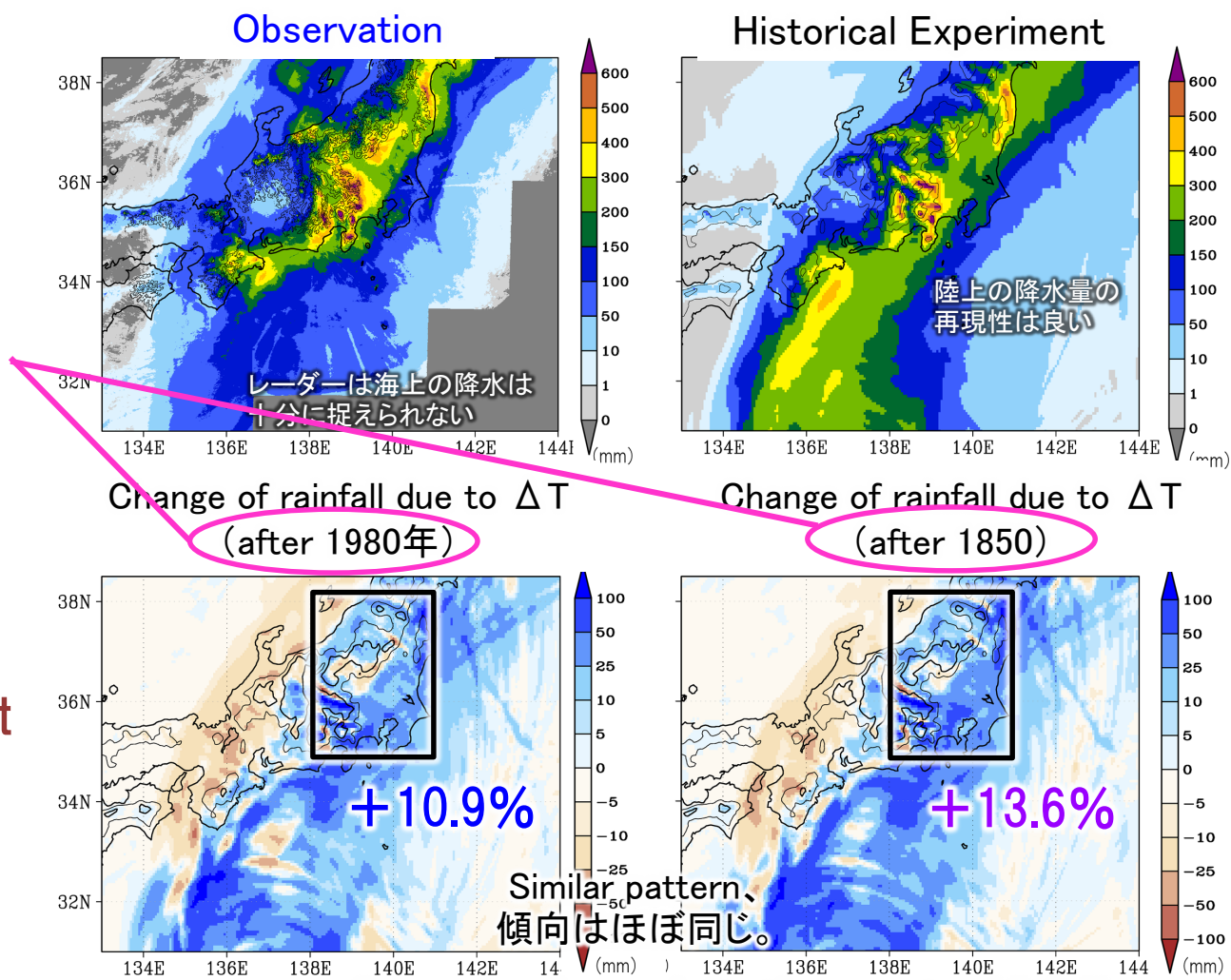
Past climate change increases risk of heavy rainfall events

Effects of Climate Change on East Japan Typhoon Rainfall in 2019

The rise in temperature has increased the rainfall of typhoons in eastern Japan.
 温暖化なしの世界の定義の仕方によっても結果は変動するが、気温上昇によって令和元年東日本台風の雨量が増加したことは明らか。

Global Warming Experiment
 Minus No Warming Experiment

『温暖化あり』実験
 マイナス
 『温暖化なし』実験

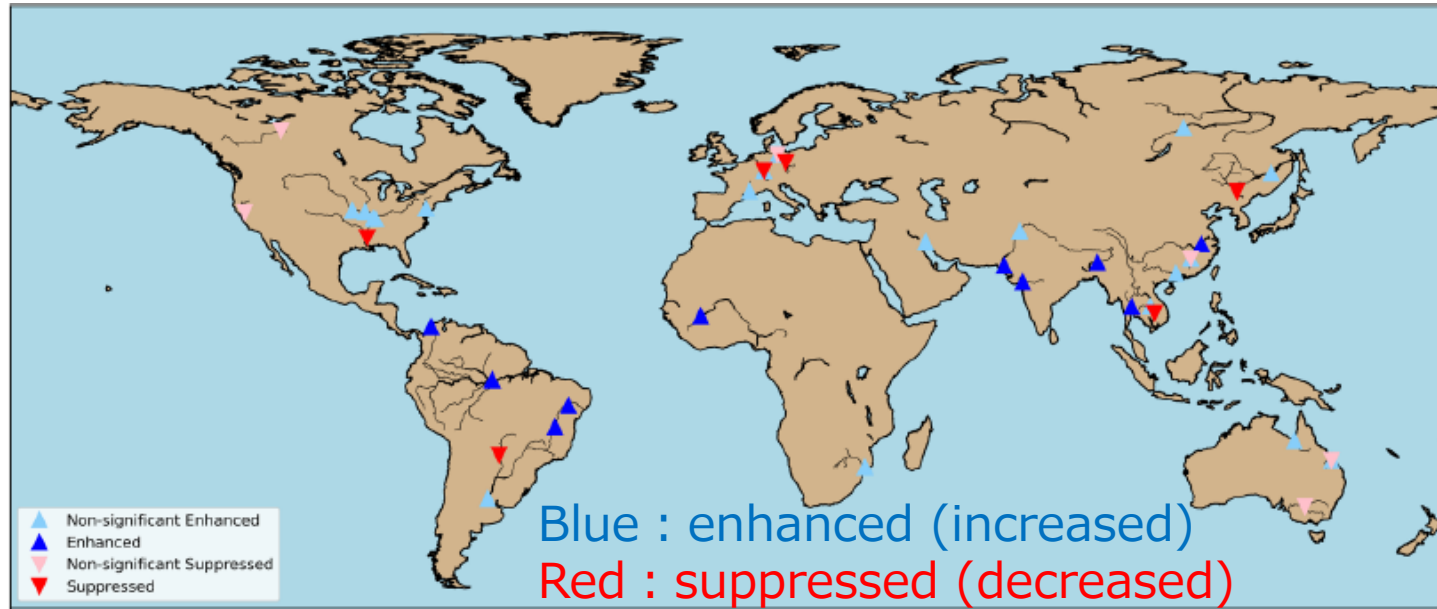


Kawase et al. 2020

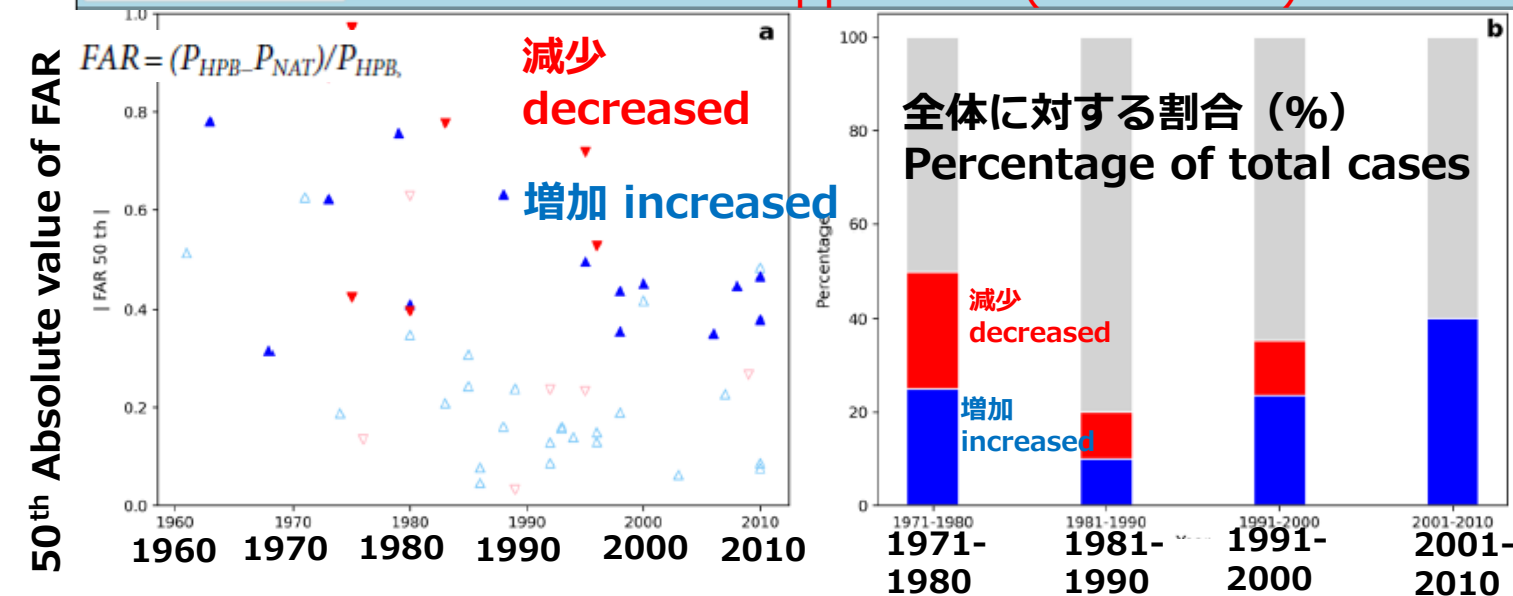
Increased precipitation up to 13.6 %

東北や北陸、関東甲信で、温暖化により降水量が増加

River floods are also more likely to occur due to climate change



- Global warming affects probability of 20 of 52 floods from 1951-2010
- In Asia and northern South America, past climate change has increased the probability of occurrence
- Probability of occurrence increased in all recent floods (enhanced)



Alifu, Hirabayashi et al. (2022), *Sci Rep.*

Climate change will increase the risk of weather-related disasters

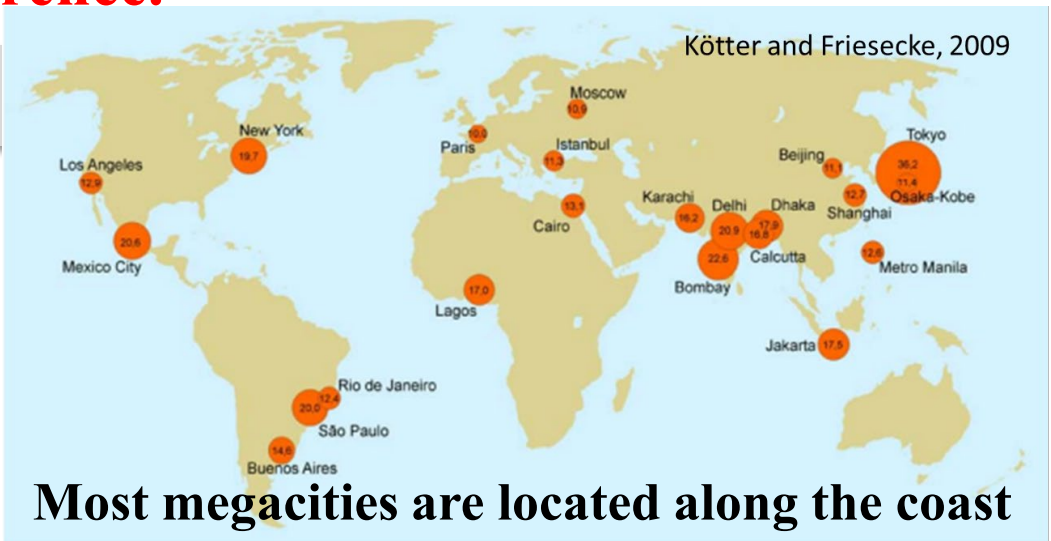
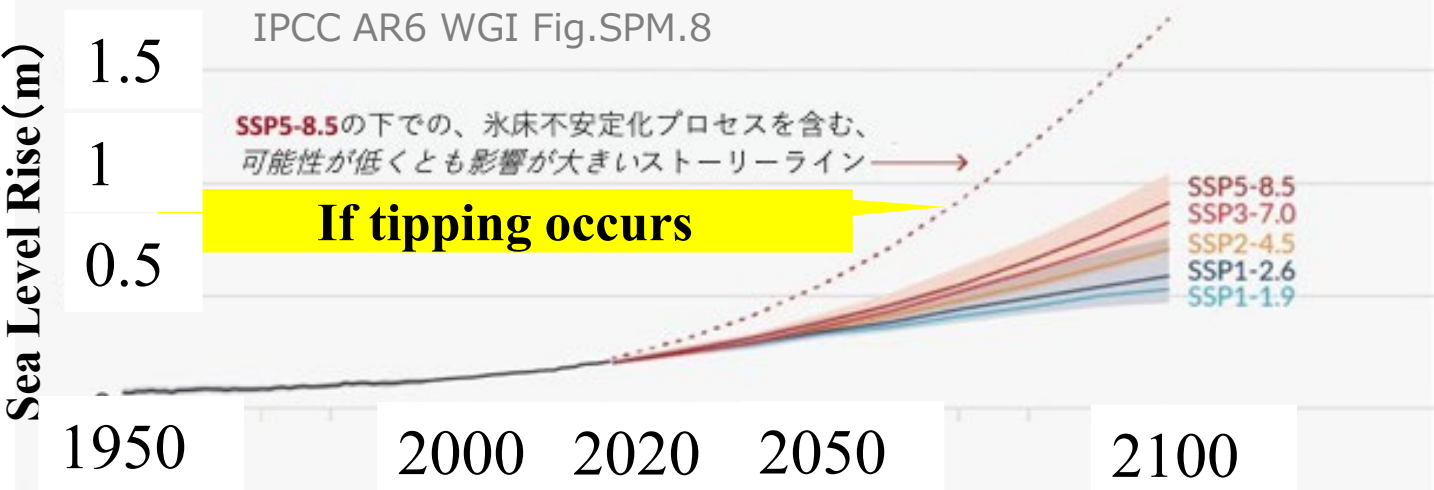


Flooding in Rojana Industrial Estate, Thailand (Oct-Nov 2011)
タイ、ロジャナ工業団地の浸水
Source : MLIT

Increase in heavy rainfall, flooding, extreme temperature
大雨・河川洪水
極端な高温の増加

+ AR6 mentions qualitative impact of TE for the first time
The higher, the greater the probability of occurrence.

Catastrophic Effects of Tipping Element (TE)



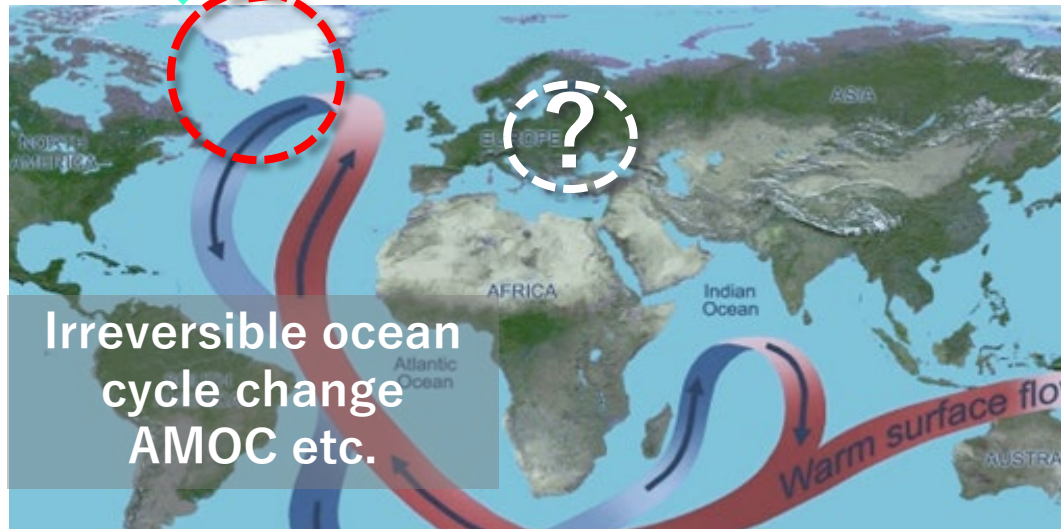
TE: Geophysical critical phenomena: irreversible changes that occur when a certain threshold (tipping) is exceeded

What happens if tipping should occur?

Collapse of ice
sheet,
increased fresh
water supply



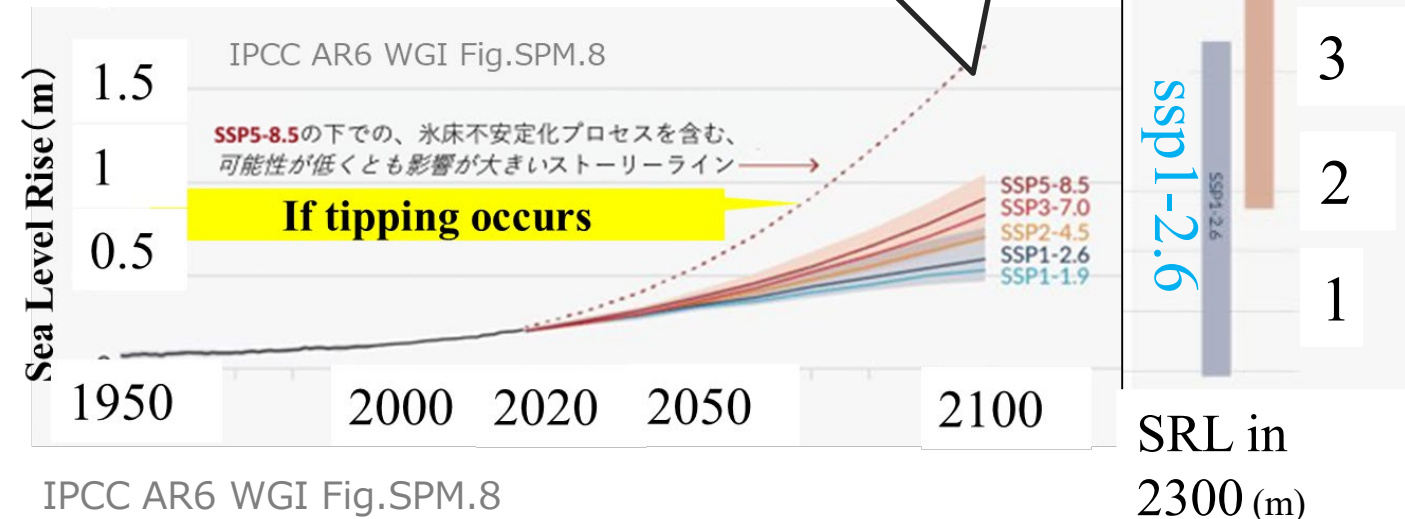
irreversible risk
↓
SLR · AMOC stoppage
↓
Climate ?



※AMOC: Atlantic Meridional Overturning Circulation

If the instability of ice sheets such as in western Antarctic continues, **the upper limit could reach 15 m or more.**

Up to about 1 m by 2100 under SSP-RCP climate scenarios

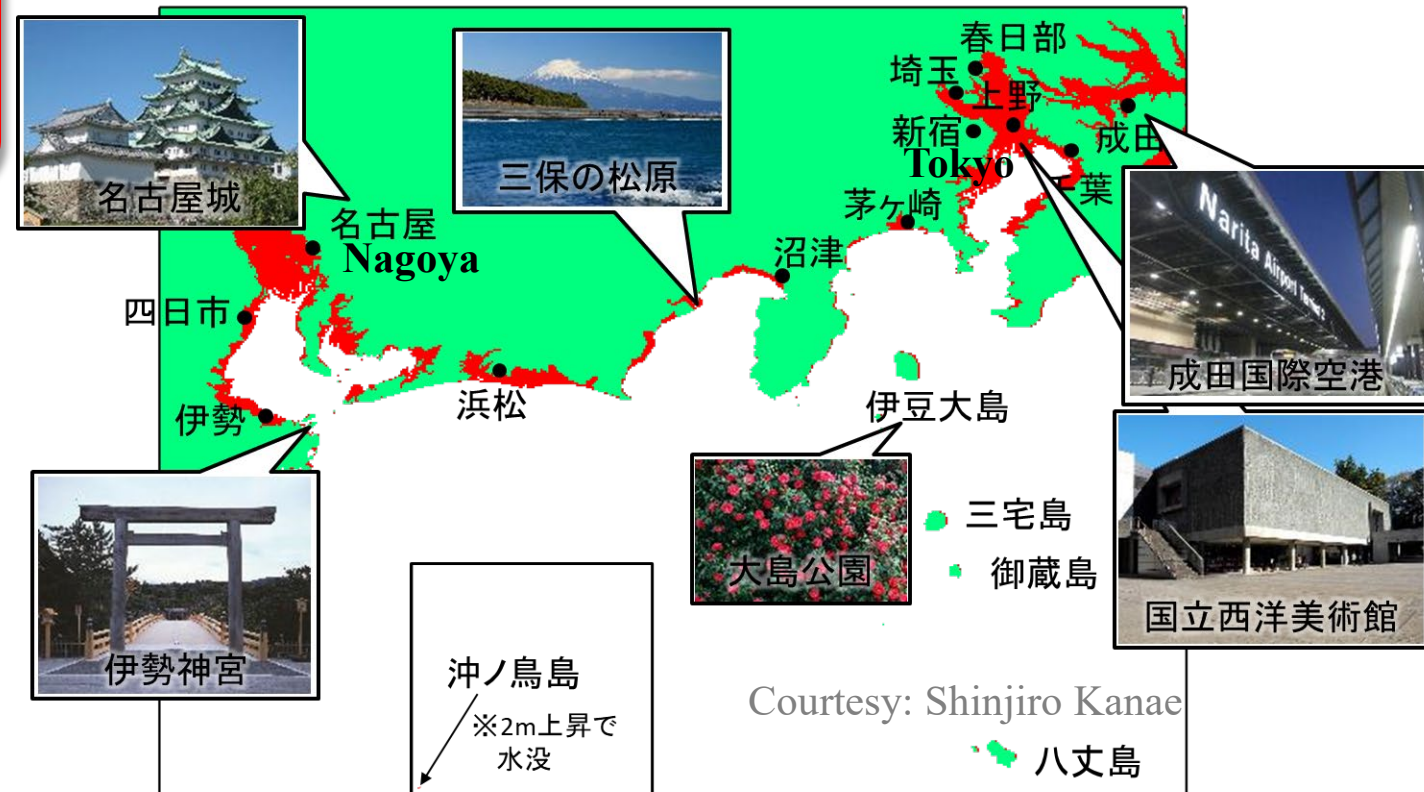




A world map illustrating ocean circulation. A red dashed circle highlights the Arctic region. A white dashed circle with a question mark is positioned over Europe. Two large, curved arrows represent ocean currents: a red arrow labeled 'Warm surface flow' moving from the right towards the left, and a blue arrow moving from the left towards the right. A semi-transparent grey box in the lower-left corner contains the text 'Irreversible ocean cycle change AMOC etc.'.

**Likely loss of much of Japan's coastline
+ Combined with river flooding, typhoons, etc.?**

+7m due to the collapse of the Greenland ice sheet



Courtesy: Shinjiro Kanae

What happens if tipping should occur?

Collapse of ice sheet, increased fresh water supply



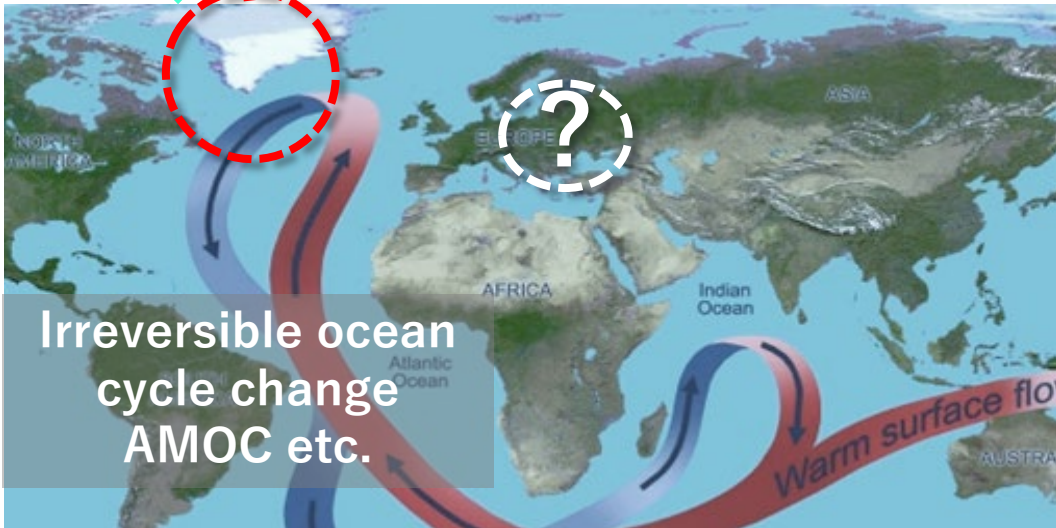
irreversible risk



SLR · AMOC stoppage



Climate ?

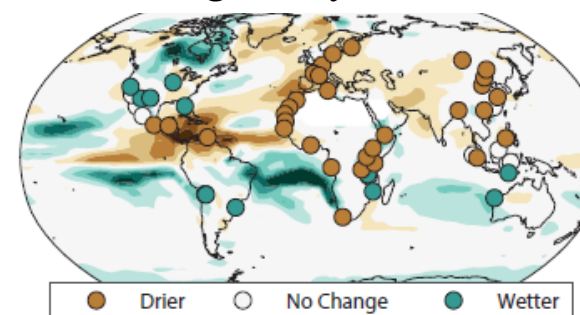


※AMOC: Atlantic Meridional Overturning Circulation

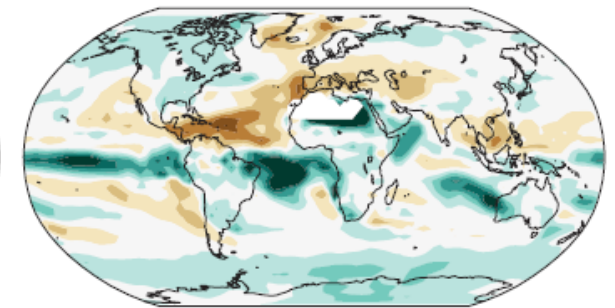
Impact on atmospheric-mediated weather hazards is unknown.

- Younger Dryas period (12,800–11,700 years ago)
 - ✓ Weakening of the African and Asian monsoons
アフリカモンスーン・アジアモンスーンの弱化
 - ✓ Strengthening of Southern Hemisphere monsoon system
南半球のモンスーンシステムの強化
 - ✓ Drying of meso-America and Europe
メソ-アメリカとヨーロッパの乾燥化
 - ✓ Wetting of the mid-latitude North America
北米の中緯度の湿潤化

Younger Dryas Event



AMOC weakening, $2 \times \text{CO}_2$



Dry
乾燥化

IPCC AR6 WGI Fig.8.27

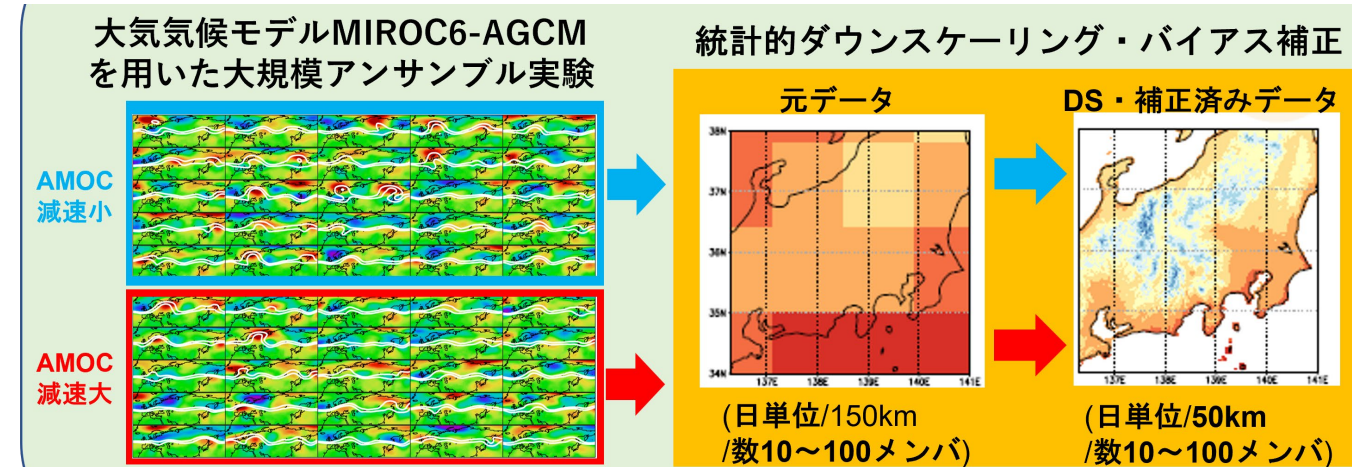
Wet
湿润化

What happens if tipping should occur?

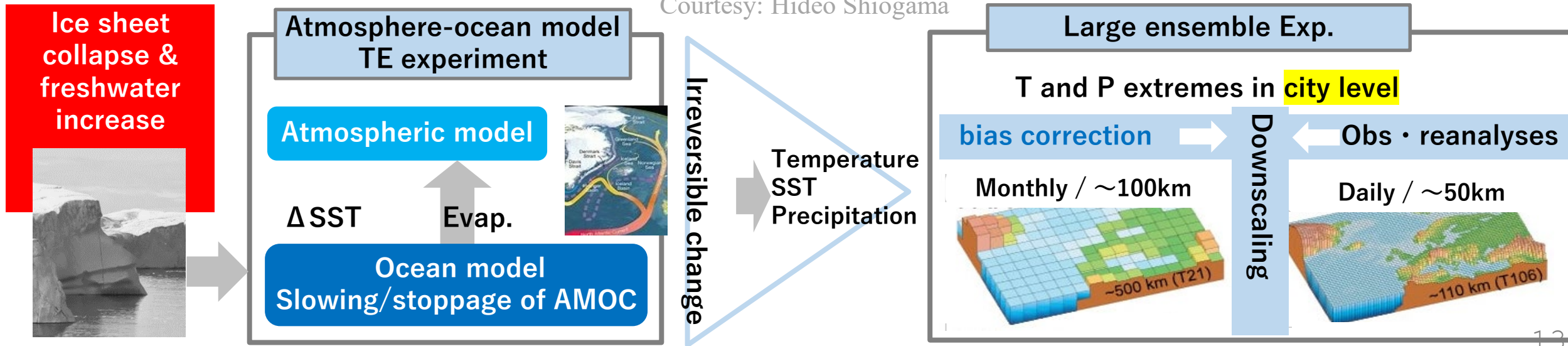
Analyzing relationship between AMOC and weather-related disasters is challenging

- Long-term experiments with coupled models with coarse resolution are needed to study changes in ocean circulation 海洋循環変化の調査には、低解像度モデルによる長期実験が必要
- Downscaling & bias correction are also required 時空間解像度を細かくする「ダウンスケーリング」やバイアス補正も必要

[SII-11-3 project by Ministry of Environment]



Courtesy: Hideo Shiogama



To respond to catastrophic weather disasters

- As climate change advances, the frequency and severity of weather-related disasters, such as heatwaves, heavy rainfall, and flooding, are expected to rise.
- Through the utilization of large ensemble climate experiments, the impact of climate change on weather-related disasters has been confirmed, with projections indicating future rates of increase.
- If our climate goes beyond a tipping point, this might lead to catastrophic changes.
 - ✓ Disastrous sea level rises ranging from several meters to as much as ten meters.
 - ✓ Slowing or cessation of the Atlantic Meridional Ocean Circulation (AMOC) due to the freshwater supply from melting ice sheets.
- A rapid transition to a low-carbon society is imperative in reducing the likelihood of such catastrophic tipping element.
- Since climate change is already underway, promoting appropriate adaptation measures to counter the increasingly frequent weather-related disasters is also of utmost importance.

Panel discussion

- We need to respond to disasters never experienced before due to climate change.
温暖化が進むことでこれまで経験したことのない災害に対応していく必要がある
- Increased flooding in Japan and Asia was predicted more than 15 years ago. The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) incorporated climate change into its river improvement plans only after the number of significant floods increased.
国土交通省が河川整備計画に気候変動を取り入れたのは、顕著な洪水が増えてから。
- To what extent can the government allocate budget for an uncertain future? Many measures are based on a 2°C rise, but is it necessary to assume a case beyond that?
不確実な将来に対して、国はどこまで予算配分できるのか。多くの対策は2°C上昇が基準だが、それを超える場合は想定しなくてよいのか。
- Current actions are important with regard to tipping. Can we take realistic actions to address low-probability events, including those in the far future, such as 300 years from now?
ティッピングが生じるかどうかは現在の行動が重要。しかし、生起確率が非常に小さく、影響が300年後に現れるような現象に対して、実感を持ってどうやって対策できるのか？