気候予測とその利活用の連携に向けて

高薮出＠気象研究所
IPCCシンポジウム＠東京
2022/11/30

2022/11/29 V3

Climate Change
（気候変動）

＊　わたしたちの生活にどういった**影響**があるのか？
＊　**対策**の効果はどのように表れるのだろうか？
＊　**緩和策**の効果はどのように表れるのだろうか？

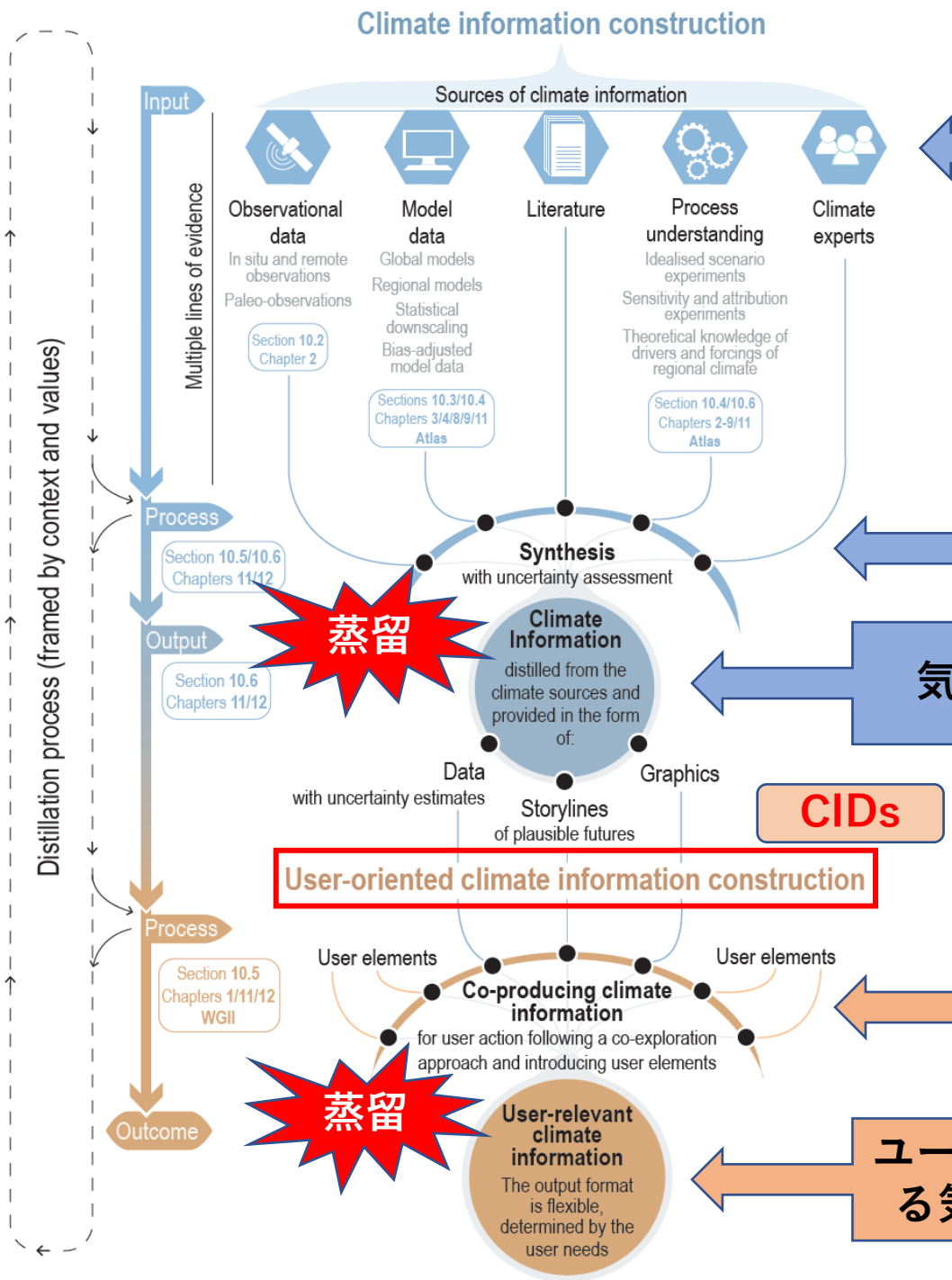
IPCC AR6
WG1: 自然科学的根拠
WG2: 影響・適応・脆弱性
WG3: 気候変動の緩和

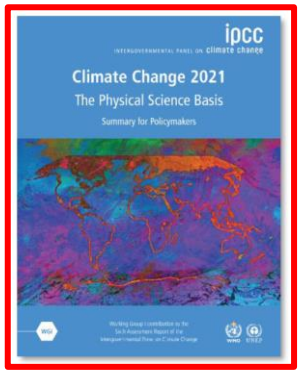
内容

- IPCC WG1 第6次評価報告書の紹介
  - IPCC WG1 は、WG間のhandshakingをどのように考えているのか？
  - いくつかのキーワード
    - ○ 複数系統の証拠（multiple line of evidence）
    - ○ 情報の蒸留（distillation of information）
    - ○ 気候影響駆動要因（CIDs）
    - ○ インタラクティブアトラス（Interactive Atlas）
    - ○ 適応・緩和のセクター毎のファクトシート（Sectoral FS）

- まとめ
  - Handshakingを今後どう実現させてゆけば良いのか？

IPCC WG1 は**複数系統の証拠を蒸留する**ことによって、ユーザが活用できる情報の作成を試みる。





複数系統の証拠

不確実性の評価をしつつ知見をまとめる

気候情報

ユーザと共同で気候情報を作成する

ユーザが求める気候情報

IPCC WG1 AR6 Figure 10.1:
地域気候情報（青）とユーザが活用できる情報（茶色）を構築するプロセスのダイアグラム。

複数系統の証拠➔ 蒸留
ユーザに届けるには、2段階の蒸留を経る

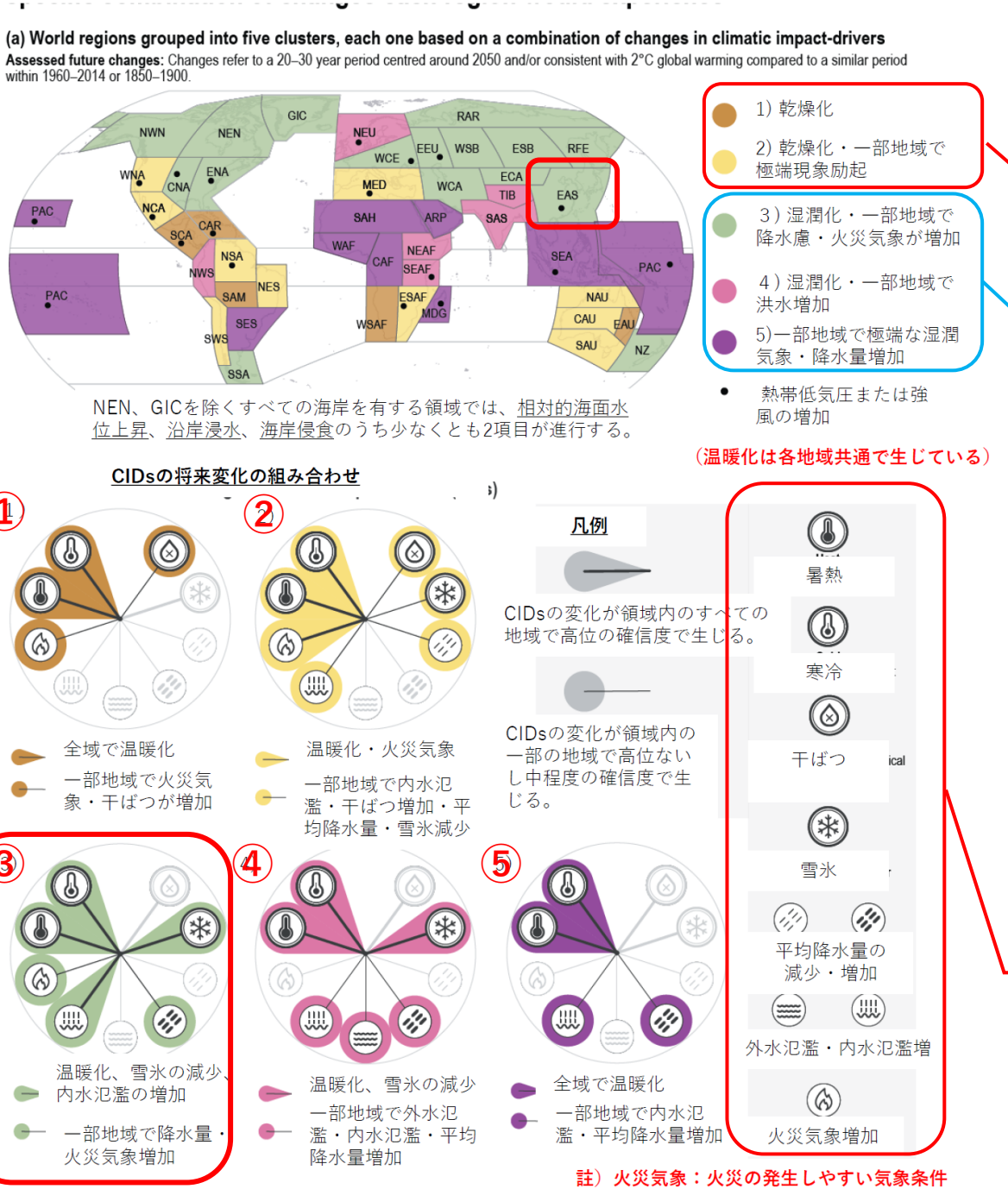
IPCC は 33の**気候影響駆動要因（CIDs）**を評価し、世界を5つのカテゴリーに分けた。

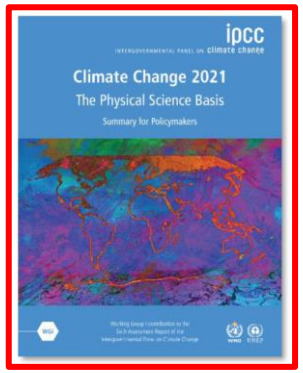
ここに示されているように、主に**“水の循環”**に関わる要素で世界は分割される。

地域 ①・② はより乾燥化するが、
地域 ③・④・⑤ はより湿潤化する。

IPCC WG1 AR6 Fig. TS.22 panel A

気候的な影響駆動要因（CIDs）の世界全域での2°C上昇時の評価結果



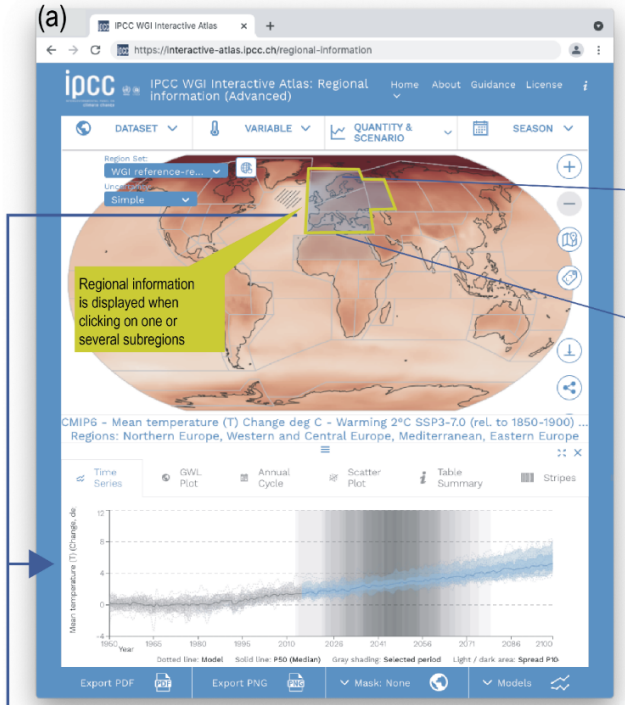


乾燥化する

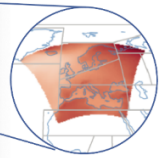
湿潤化する

気候変動駆動要因（CIDs）

IPCC WG1には、双方向的に図を描くサイト「インターラクティブアトラス」が準備されている。



The **Interactive Atlas** allows for **flexible spatial and temporal analyses** of essential climate variables, extreme indices and climatic impact-drivers including multiple lines of evidence to support the assessment of regional climate change:

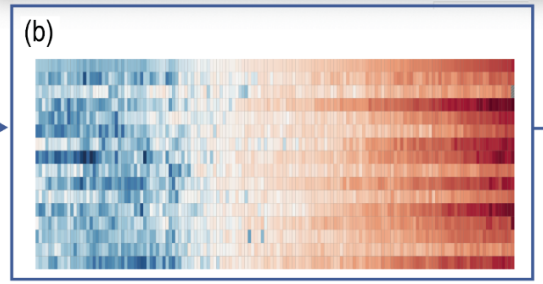


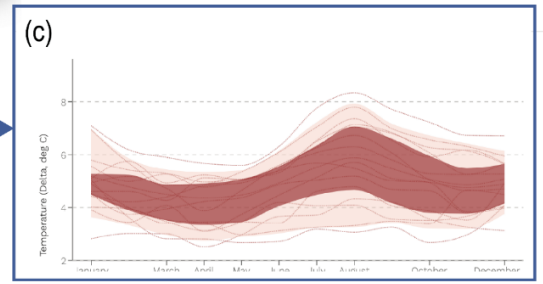
- **Observations**
- **CMIP5**
- **CMIP6**
- **CORDEX,** available for 12 continent-wide domains.

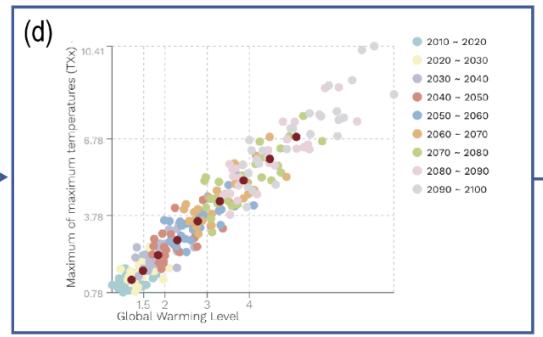
Regional (aggregated) information for reference and typological regions:

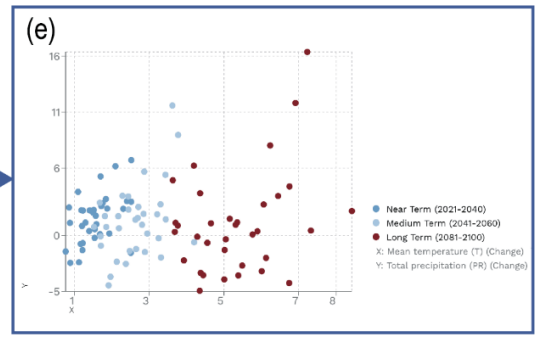
(a) Time series
(b) Stripes
(c) Annual cycle plots
(d) Global warming level (GWL) plots
(e) Scatter plots (e.g. precip. vs temp.)
- Tabular information (not shown)

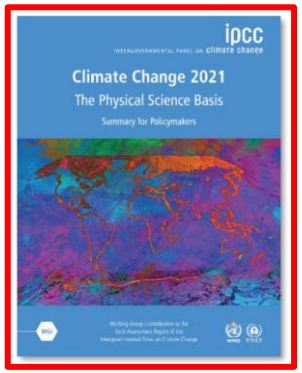
Dimensions of analysis include time periods for scenarios and global warming levels (1.5ºC, 2ºC, 3ºC and 4ºC).









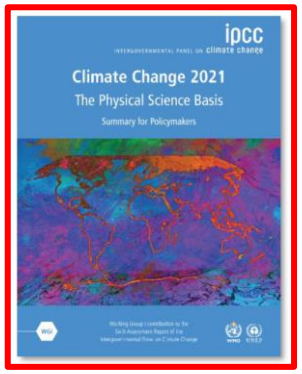


IPCC WG1 AR6 Figure Atlas 8:
Interactive Atlasで双方向的に描ける図の紹介

注意！　現在メンテナンス中でアクセスできません。12/1から再アクセス可能になるので試してみてください。

https://www.ipcc.ch/report/ar6/wg1/

そして、WG1の第12章では, このCIDs を通して、WG1とWG2を関係づけている。



WG1 CIDs

WG2 Ch.5

Sector	Asset	Heat and Cold	Wet and Dry	Wind	Snow and Ice	Coastal	Open Ocean	Other
		Heat and cold temperature; Frost	Mean precipitation; River flood; Heavy precipitation; Landslide; Drought; Fire weather	Mean wind speed; Storm; Sand and dust storm	Snow, glacier and ice sheet; Sea ice; Hail and ice storm; Snow avalanche	Sea level; Coastal flooding	Mean ocean temperature; Marine heatwave; Ocean acidity; Ocean salinity; Dissolved oxygen	Air pollution weather; CO2 at surface; Radiation at surface
Food, Fibre and Other Ecosystem Products (WGII Chapter 5)	Crop systems							
	Livestock and pasture systems							
	Forestry systems							
	Fisheries and aquaculture systems							
Cities, Settlements and Key Infrastructure (WGII Chapter 6)	Cities							
	Land and water transportation							
	Energy infrastructure							
	Built environment							
Health, Well-being and Communities (WGII Chapter 7)	Labour productivity							
	Morbidity							
	Mortality							
	Recreation and tourism[a]							
Poverty, Livelihoods and Sustainable Development (WGII Chapter 8)	Housing stock[b]							
	Farmland[b]							
	Livestock mortality[b]							
	Indigenous traditions							

[a] The Recreation and tourism asset category includes outdoor exercise and the tourism industry (including ecosystem services) assessed in many WGII chapters.

[b] This asset category is distinguished by the threat of a full loss of key investments and living environments rather than a recoverable damage or loss of productivity or profit.

高い

None/low confidence | Low/moderate | High

Impacts and risk relevance

インパクトとリスクの関連の強さ

漁業と養殖のセクターでは、沿岸と海洋の多くの**CIDs**が”高い“インパクトにカウントされている。

IPCC WG1 AR6 Table 12.2 2/2

IPCC WG1 は適応・緩和の各セクターに応じて、**CIDs**の情報をまとめなおしたファクトシートを作成・公開している。

海洋生態系 漁業と養殖

水位上昇

海洋熱波

海洋酸性化

北極海域の氷の融解

Climate information relevant for Marine Ecosystems, Fisheries and Aquaculture

Marine ecosystems encompass coastal land, intertidal and upwelling zones, coastal, shelf and polar seas, the open ocean and deep seas. {WG II, Chapter 3} The fisheries and aquaculture systems include food, fibre and other ecosystem products, and refer to industrial and artisanal fishing, harvesting wild fish and other aquatic organisms, and the farming of aquatic organisms. {WG II, Chapter 5} This Fact Sheet is focused on the marine environment, and information for freshwater systems is provided in the fact sheet for terrestrial and freshwater ecosystems.

Impacts and adaptation options *for marine ecosystems, fisheries and aquaculture are assessed in Report Chapters 3,5 {3.2,3.3, 3.5, 3.6 CCB; 5.8 CCB}, and their mitigation options are assessed in W Chapters 4,7,11,12. {SPM C11.1; TS 5.7; 4.4.2; 7.4.2; 11.4.4; 12.3.1; 12.4.1; 12.4.3}*

Types of Climatic-Impact Drivers (CIDs) that are of high relevance for the sectors addressed in this fact sheet are: Heat and Cold, Snow and Ice, and Coastal and Oceanic. Oceanic CIDs can have implications for marine ecosystems from coral bleaching, changes in phytoplankton blooms, migration, growth, reproduction and survival of marine and aquatic organisms, with implications for fisheries and aquaculture. {WGI: Chapter 5 ES; 5.3.5; Chapter 9, Box 9.2; 12.3.6.1; 12.3.6.3} Coastal CIDs can affect coastal ecosystems, fisheries, aquaculture and tourism. {WG1:12.3.5.2; WGII: Chapter 3, 3.6, 5, 5.8; 5.9} Heat & cold CIDs can affect freshwater species ranges, ecosystem health and aquaculture suitability {WGI: 12.3.1.1; WGII: Chapter 5, 5.9}.

COASTAL CIDs with high relevance for marine ecosystems include relative sea level, coastal flooding and coastal erosion. Coastal flooding in coastal land and intertidal zones is also highly relevant for fisheries and aquaculture systems.

- Uncertainty in the timing of reaching different levels of global mean sea level rise is an important consideration for adaptation planning. {9.6.3}
- It is *very likely to virtually certain* that regional mean relative sea level rise will continue throughout the 21st century, except in a few regions with substantial geologic land uplift rates. Due to relative sea level rise, extreme sea level events that occurred once per century in the recent past are projected to occur at least annually at more than half of all tide gauge locations by 2100 *(high confidence)*. {SPM C.2.5}

TS_Box_4_Figure_1

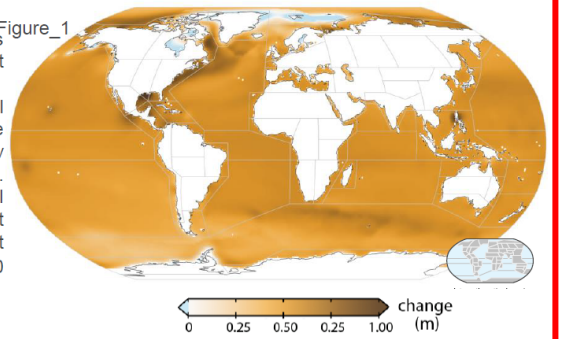
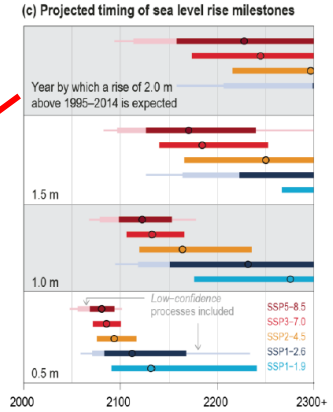


Figure 1: CMIP6 – Projected sea level rise for 2081-2100 (relative to 1995-2014) for medium (SSP2-4.5) emission scenario {Interactive Atlas}.



- Relative sea level rise contributes to increases in the frequency and severity of coastal flooding in low-lying areas and to coastal erosion along most sandy coasts *(high confidence)*. A vast majority of the world's regions are projected to experience an increase in coastal flooding throughout the 21st century *(high confidence)*. {SPM C.2.5; Tab.TS5, 12.4}

Figure 2: Timing of exceedance of global mean sea level thresholds of 0.5, 1.0, 1.5 and 2.0 m, under different SSPs. Lightly shaded thick/thin bars show 17th–83rd/5th–95th percentile low-confidence ranges for SSP1-2.6 and SSP5-8.5. {TS Box 4 Figure 1}{4.3.2, 9.6.1, 9.6.2, 9.6.3, Box 9.4}

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WMO UNEP

OCEANIC CIDs with high relevance for all parts of marine ecosystems include ocean temperature, marine heatwaves, ocean acidification, and can be relevant for fisheries and aquaculture systems. Dissolved oxygen is of high relevance for coastal & shelf seas and upwelling zones.

- It is *virtually certain* that the global upper ocean (0–700 m) has warmed since the 1970s. Marine heatwaves have approximately doubled in frequency since the 1980s *(high confidence)*, and their frequency will continue to increase *(high confidence)* {SPM A.3.1; SPM A.1.6; SPM B.2.3}

y certain that surface s the last 40 years, which is one of the major indicating ocean acidif *dence* that oxygen levels have dropped in r ocean regions since

house gas emissions s ean to future warming *(high confidence)*, acidification *(virtually confidence)* will continue to increase in the 21st century at rates dependent on future emissions. Changes are irreversible at centennial to millennial time scales in global ocean temperature *(very high confidence)*, deep ocean acidification *(very high confidence)* and deoxygenation *(medium confidence)*. {SPM B.5.1}

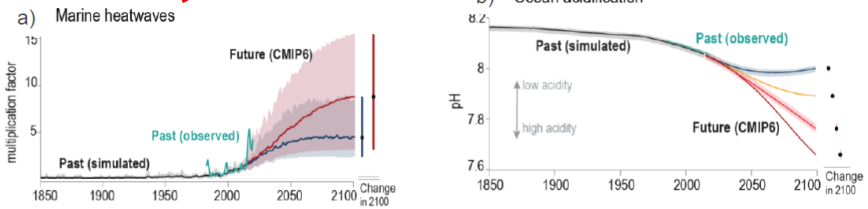


Figure 3: Past and future change in a) marine heatwave days and b) ocean surface pH under varying greenhouse gas emissions scenarios {Figure TS.11}

SNOW & ICE CIDs with potential relevance for marine ecosystems includes sea ice in polar

- In 2011–2020, annual average Arctic sea ice area reached its lowest level since at least 1850 *(high confidence)*. Since the late 1970s, Arctic sea ice area and thickness have decreased in both summer and winter, with sea ice becoming younger, thinner and more dynamic *(very high confidence)*. {SPM A.2.3; TS.2.5 }
- The Arctic is likely September at leas five illustrative sce frequent occurren There is *low confi* of Antarctic sea ic

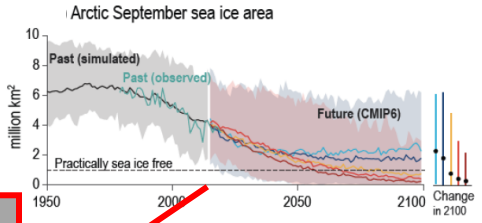
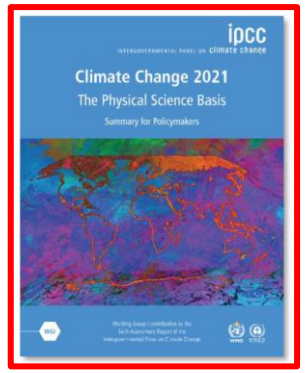


Figure 4: Past and future change in September Arctic sea ice area under varying greenhouse gas emissions scenarios {Figure TS.8}.

HEAT & COLD CID with high potential relevance for marine ecosystems includes surface temperature for coastal land and intertidal zones.

- Compared to 1850-1900, global surface temperature was 1.1ºC higher in 2011-2020, and will *very likely* be higher in 2081-2100, for example by 2.1-3.5 degree in the intermediate scenario (SSP2-4.5). {SPM A.1.2, SPM B.1.1}
- It is *virtually certain* that hot extremes have become more frequent and more intense across most land regions since the 1950s, and vice-versa for cold extremes. Some mid-latitude and semi-arid regions, and the South American Monsoon region, are projected to see the highest increase in the temperature of the hottest days *(high confidence)*, and the Arctic is projected to experience the highest increase in the temperature of the coldest days *(high confidence)*. {SPM A.3.1, SPM B.2.3}

理想的には、あまたの利害関係者が**情報の蒸留**に参加することが歓迎される。



FAQ 10.1: **How can scientists provide useful regional climate information?**
In decision-making, climate information is more useful if the physical and cultural diversity across the world is considered.

Historical trends and observations
Climate simulations
Dominant weather & climate processes
Storylines of complex, high impact events

複数系統の証拠

Distillation involving scientists and stakeholders

蒸留のプロセス

Human health
Agriculture
Water resources
Transportation
Fisheries management
Natural ecosystems
Human habitations
Energy resources

あまたの利害関係者

IPCC WG1 AR6 FAQ10.1, Fig. 1:

Climate information for decision makers is more useful if the physical and cultural diversity across the world is considered.

IPCC WG1 AR6 FAQ 10.1 Fig. 1

まとめ

- 気候研究者とステークホールダーのhandshakeは強く推奨されている
- 国際的に、ユーザが使いやすい温暖化予測情報の提供が期待されている。
- 国内的にもこの事情は変わらない。
- 時に、ユーザの求める情報は多様すぎることがある。
- そのため、ユーザの使いやすい情報を考える際に困難をきたす。
- 学際的な協働がこの分野では望まれている。