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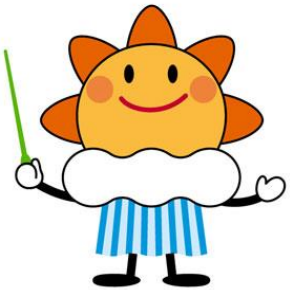
Guidance to Global Warming Projection data

Importance of Climate Change Monitoring and Future Projections

WAKAMATSU Shunya



Schedule of this seminar

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1st Day (9 November 2022)

- Lecture on climate change
- Lecture on IPCC AR6

2nd Day (10 November 2022)

- Lecture on Climate Change Monitoring and Future Projections <- We are here
- Lecture on assessment of future climate change and introduction to your exercise

3rd Day – 4th Day (11 and 14 November)

- (self-study format) Exercise on Observed Trends and Global Warming Projection for your country

5th Day (15 November)

- Your presentation (6 minutes per person)

Goal of this seminar

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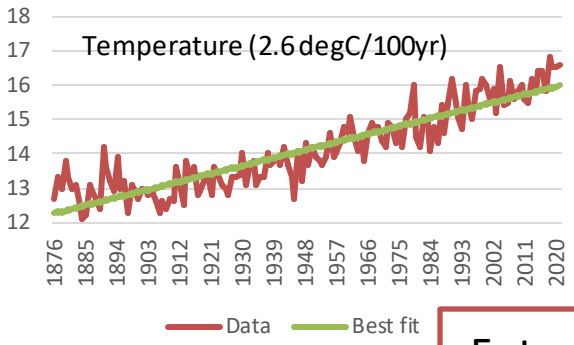
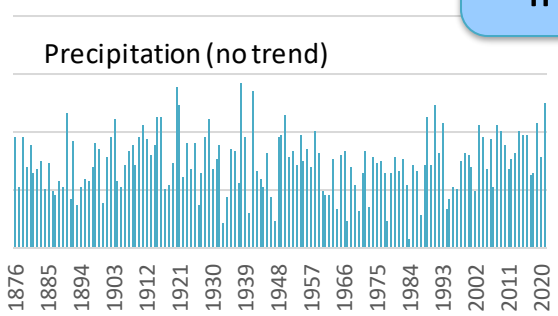
Ex : case of Tokyo (Japan)

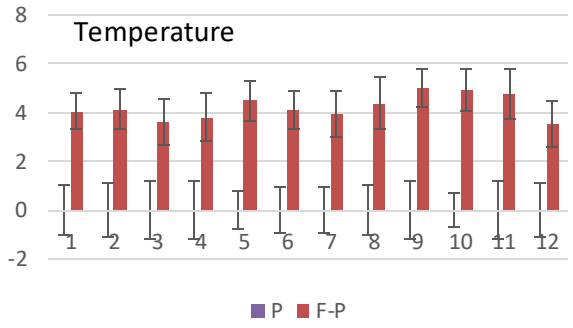
Global warming projection information for your country

Observed Trend

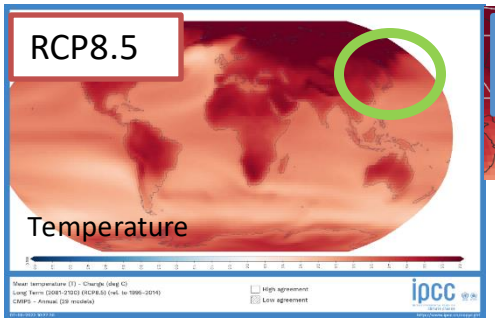




Future Change



Uncertainty (Reliability)



Detailed lectures will be given tomorrow

History of the Earth

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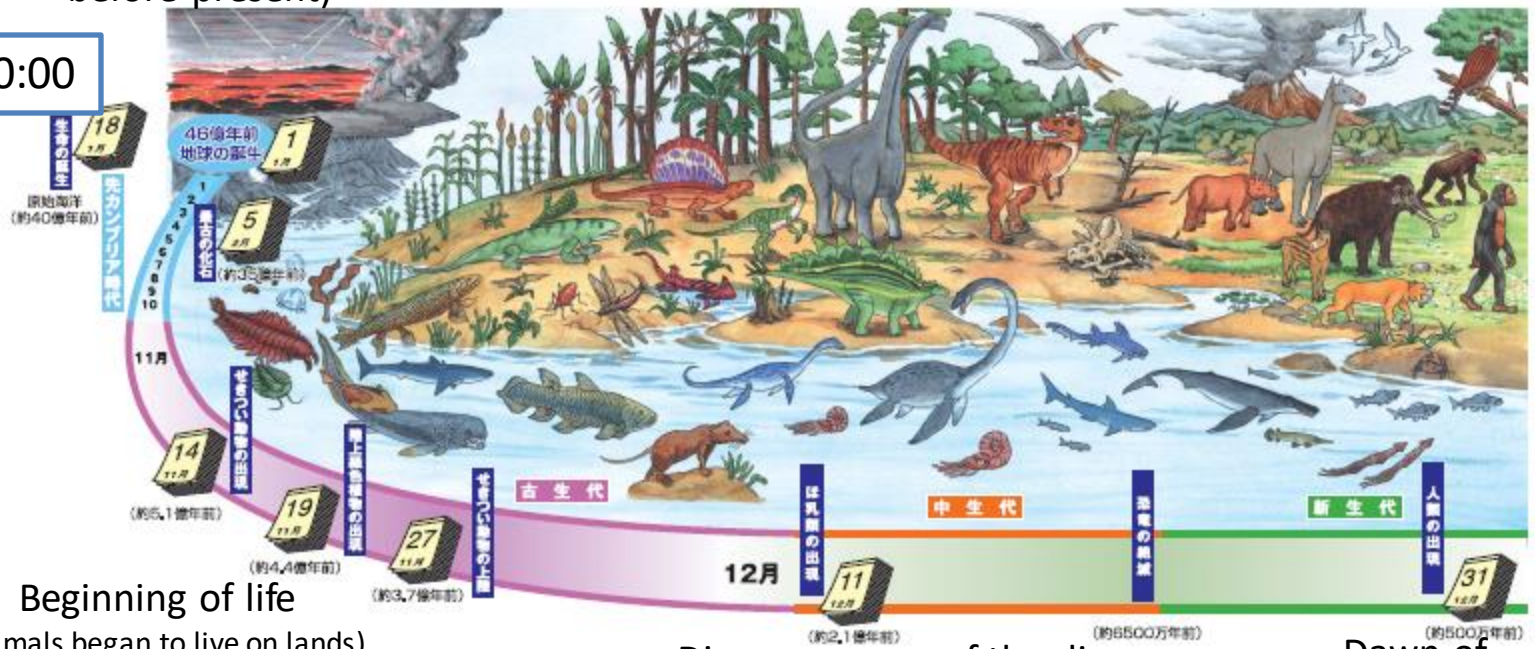
January 1st 00:00

Earth's formation
(4.6 billion years
before present)



Beginning of life
(Animals began to live on lands)
(3.7 billion years before present)

November 27th

Disappearance of the dinosaurs
(65 million years before present)

December 26th

Dawn of
humanity
(5 million years
before present)

December 31th

Source: 環境省リーフレット「いのちはつながっている」

Energy Budget & Global Warming

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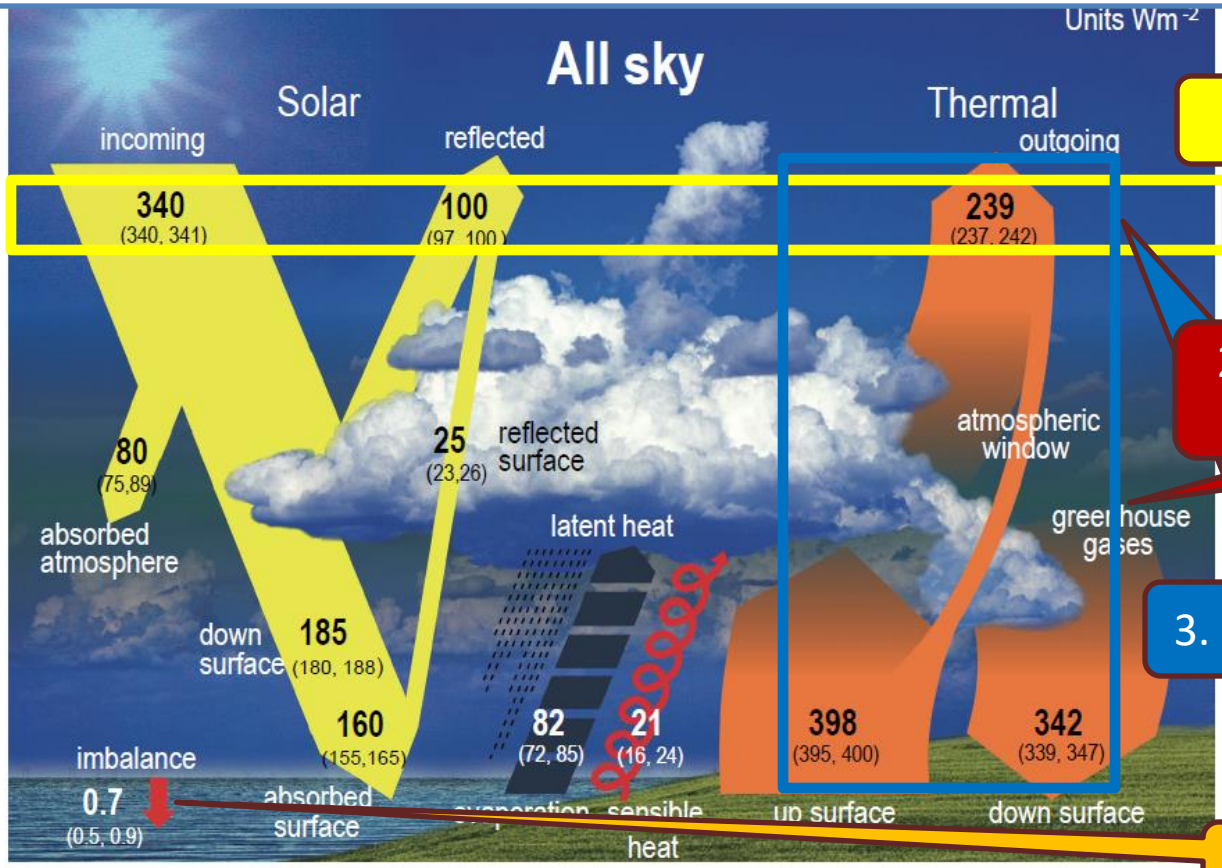
- Increasing concentrations of greenhouse gases due to human activities have led to an greater trapping of the Sun's heat and in turn a warming of the earth's atmosphere and surface known as global warming.

Global mean energy budget of the Earth for the early 21st century



1. Radiative balance at the TOA

Incoming: 340W/m^2,
Outgoing: (100+239)W/m^2

2. Absorption and re-emission of infrared radiation by GHG

3. Reduction of outgoing radiation

Net "accumulating" energy

IPCC AR6 WG1 Figure 7.2

Factors of Climate Change

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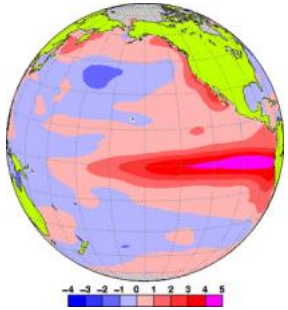
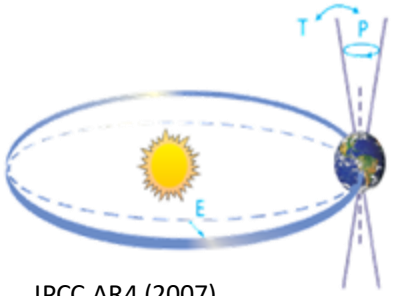
Natural Internal Variability

- El Niño phenomenon



Natural External Factor

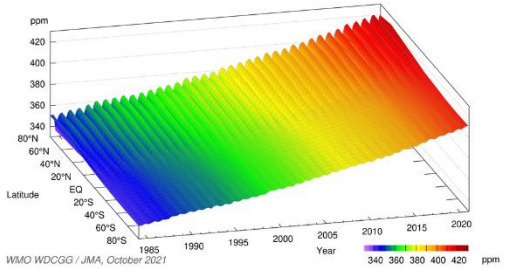
- Eruption of volcanos
- Fluctuation of Sun's activity

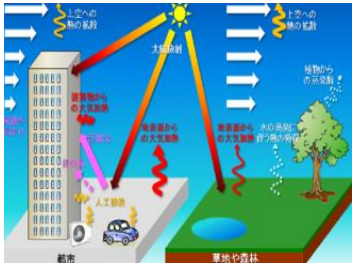


IPCC AR4 (2007)

Anthropogenic Factor

- Change of land use
- Emission of greenhouse gases





https://www.data.jma.go.jp/ghg/kanshi/ghgp/co2_e.html

Long-term change of CO2 concentration

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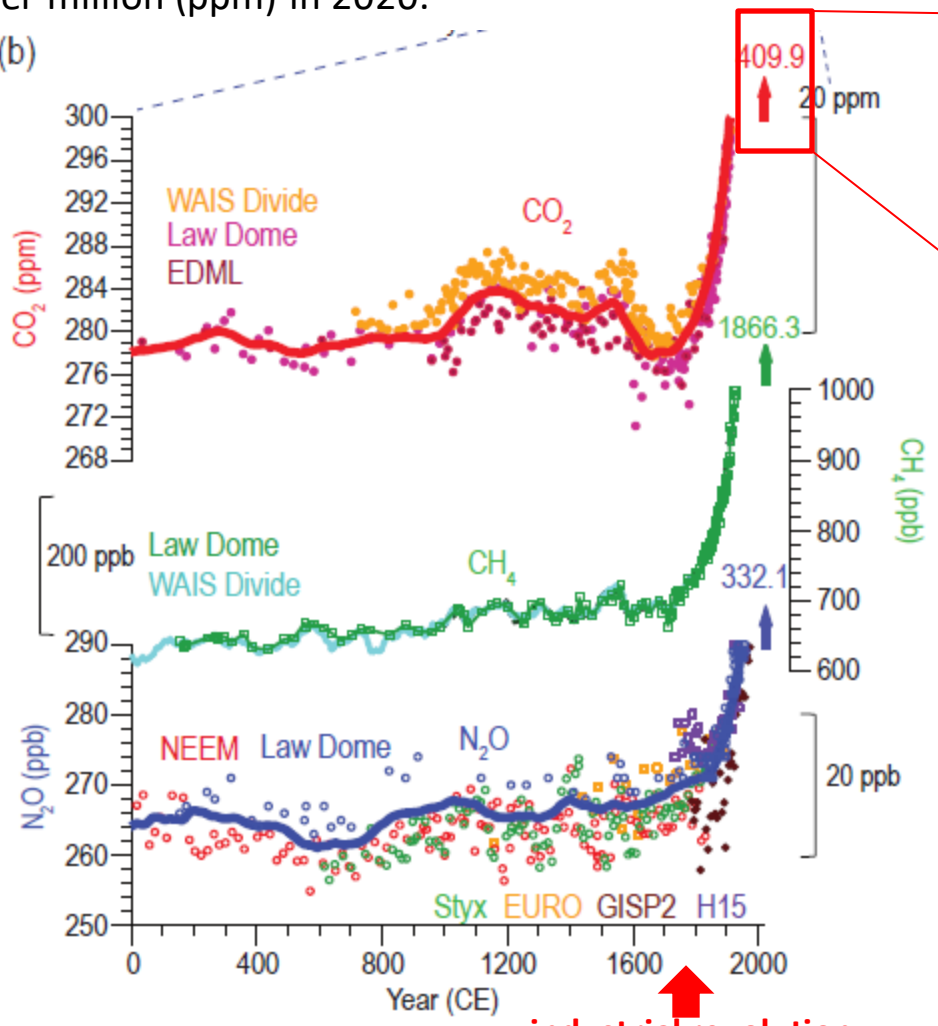
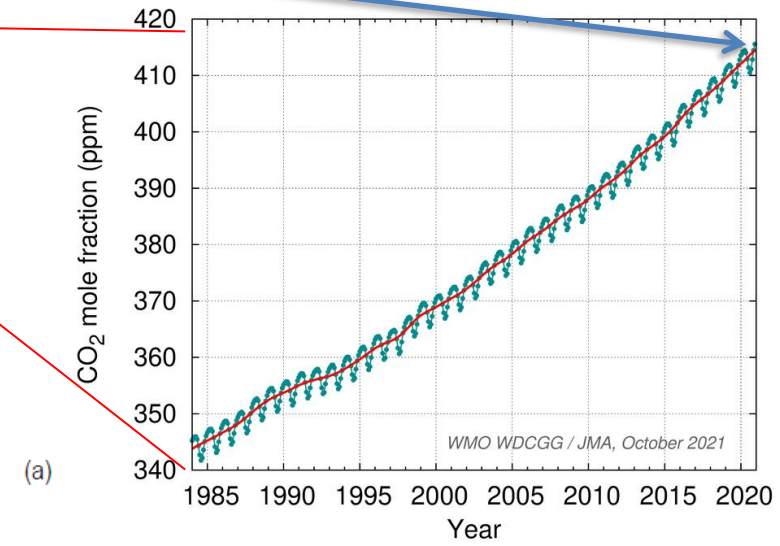
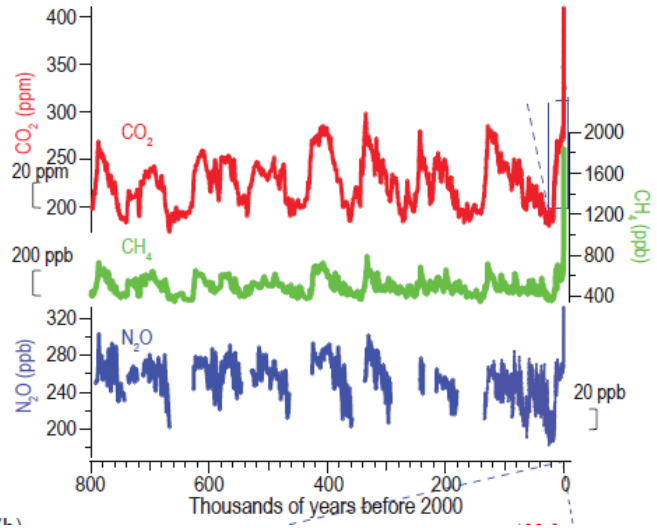
the amount of CO2 in the atmosphere reached 413.2 parts per million (ppm) in 2020.





https://www.data.jma.go.jp/ghg/kanshi/ghgp/co2_e.html



IPCC AR6 WG1 Figure 2.4

Long-term change of global temperature

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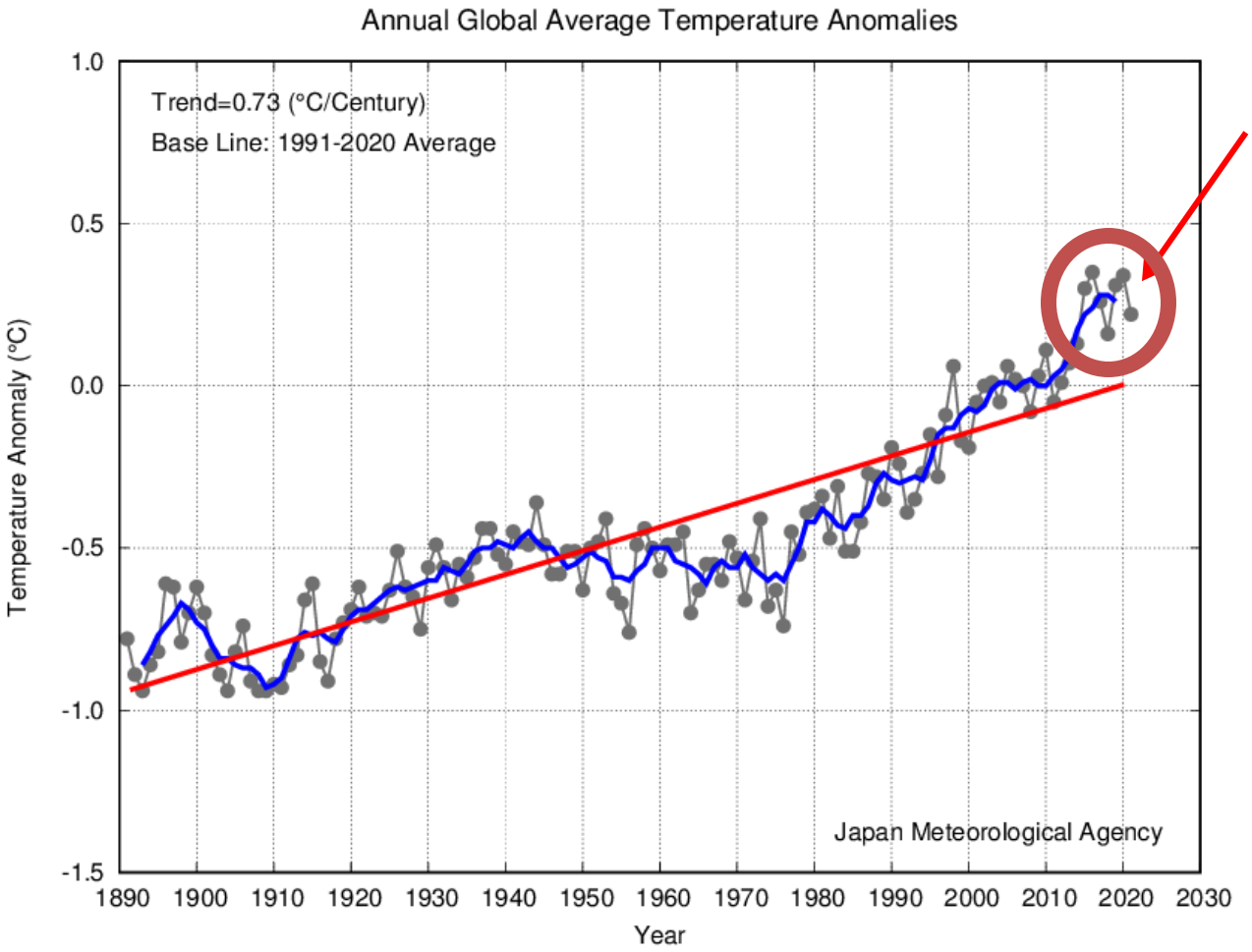

Anomalies are deviation from baseline (1991-2020 Average).
The black thin line indicates surface temperature anomaly of each year.
The blue line indicates their 5-year running mean.
The red line indicates the long-term linear trend.

2014-2021: top eight warmest

Annual global average temperature for 2021 was the 6th warmest since 1891.

Annual global average temperature increases at a rate of about 0.73°C per century.

The past eight years (2014 to 2021) were the eight warmest years for the 131-year period since 1981.

https://ds.data.jma.go.jp/tcc/tcc/products/gwp/temp/ann_wld.html

Long-term change of global temperature

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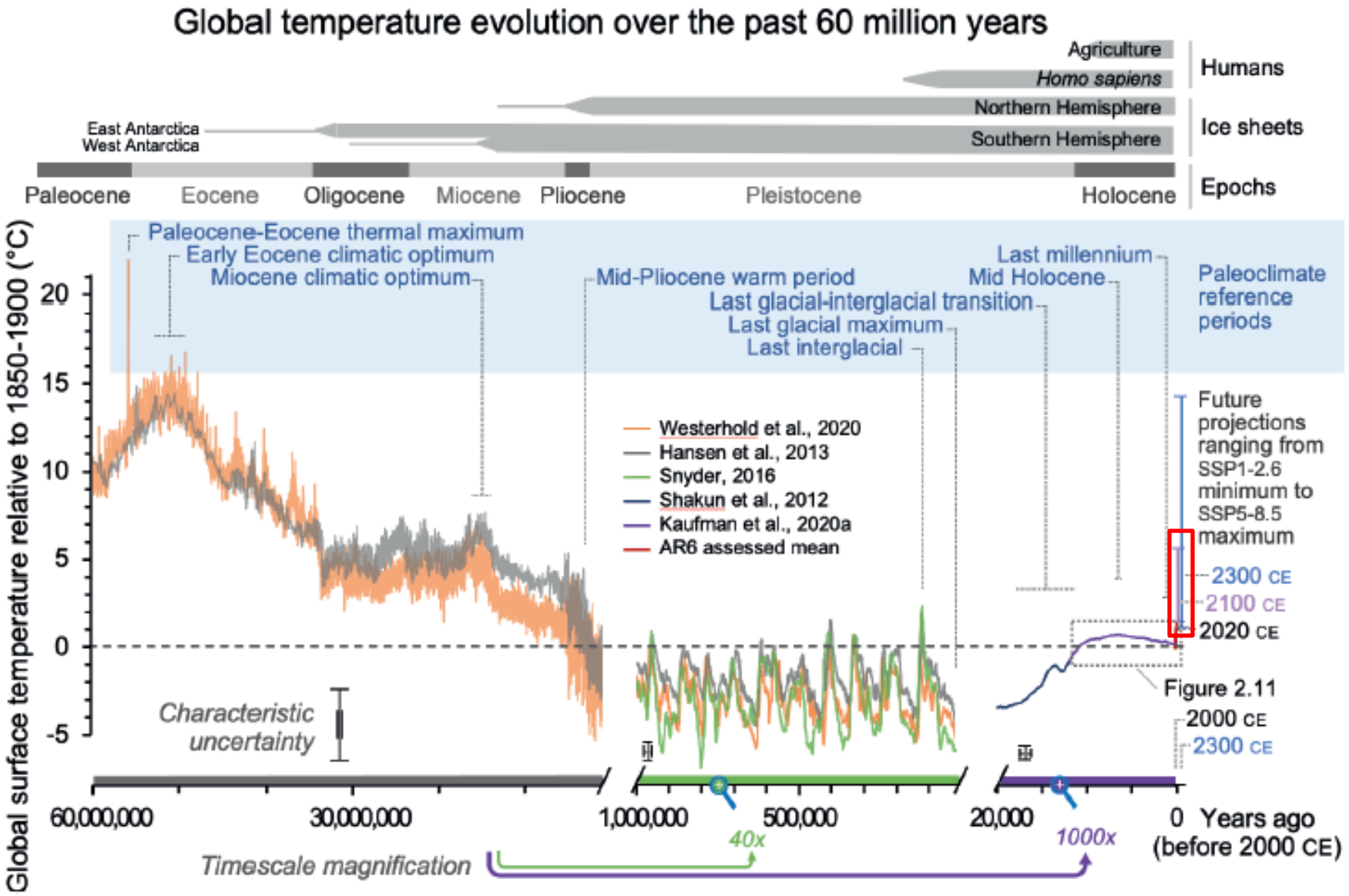
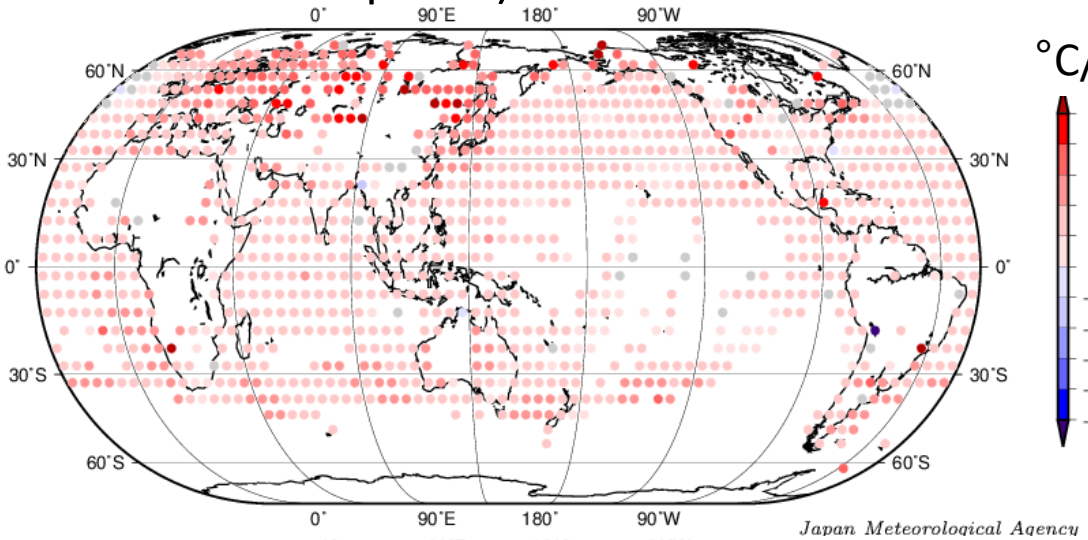


IPCC Fifth Assessment Report (WG1 Figure 5.7)

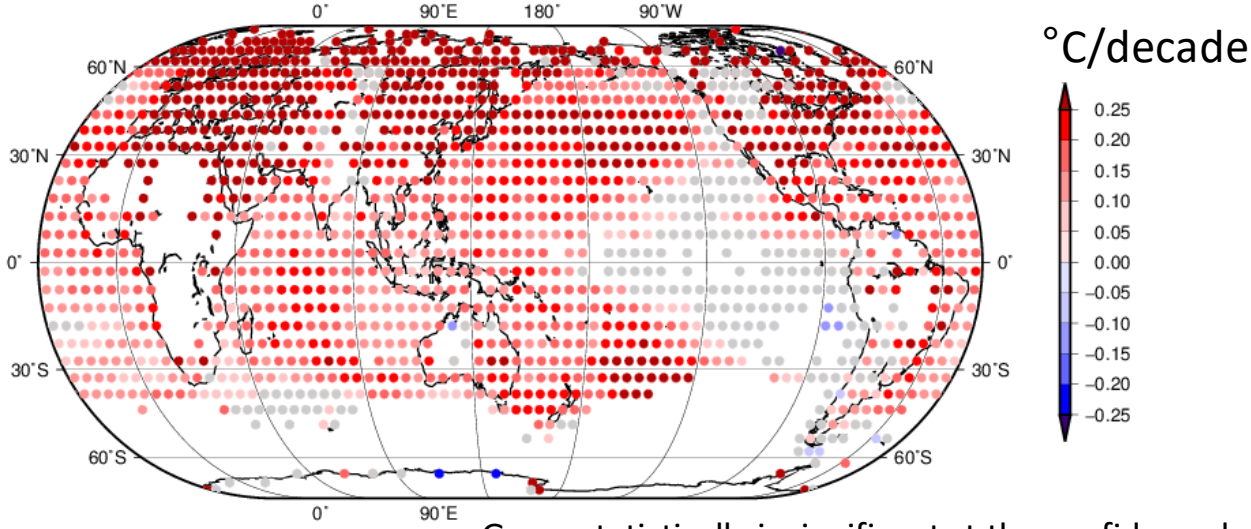
Long-term trend of annual temperature

- “Warming accelerated after the 1970s, but not all regions are warming equally” (IPCC AR6 WG1 Chapter 2)

1891-2021



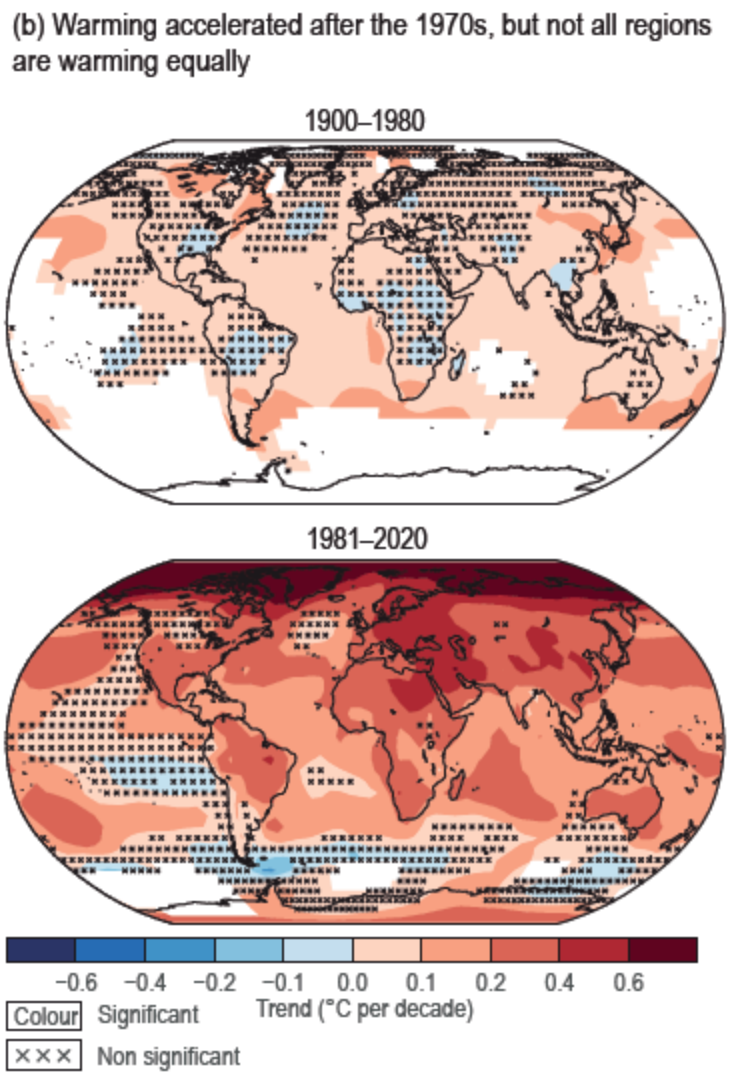
1979-2021



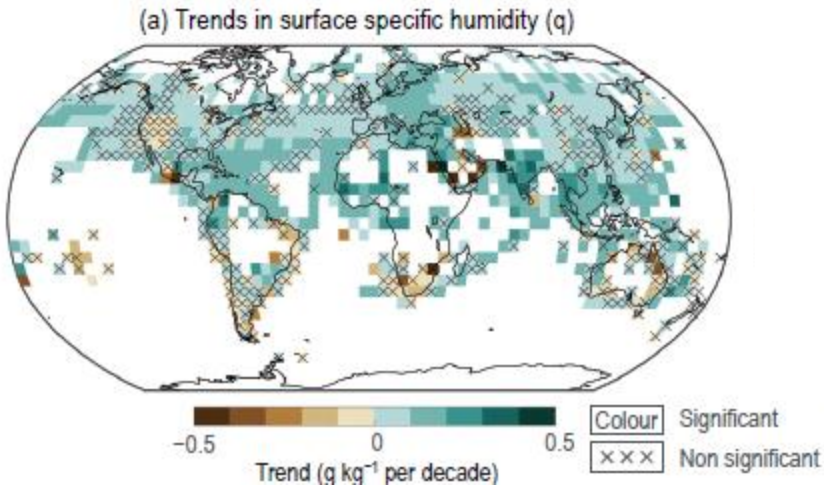
https://www.data.jma.go.jp/cpdinfo/temp/an_wld.html

Grey : statistically insignificant at the confidence level of 90%

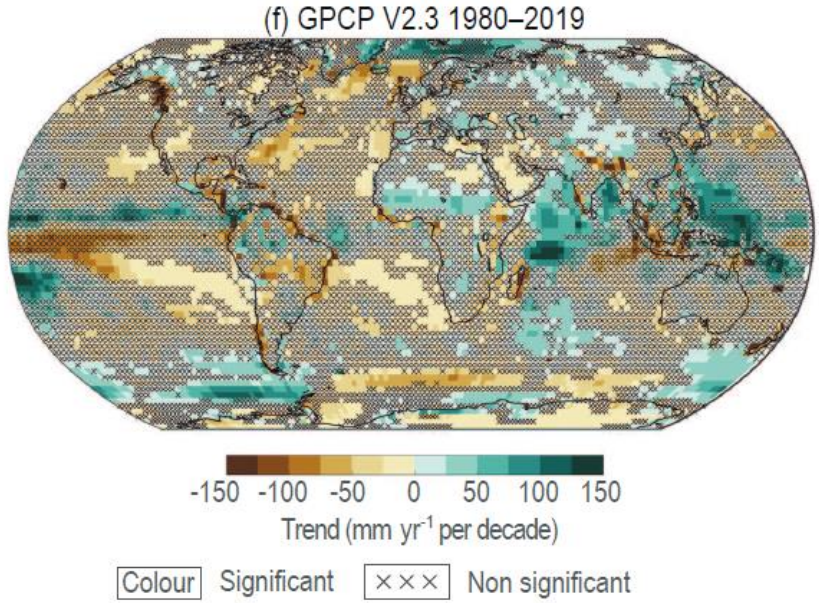
Observed Climate Change



IPCC AR6 WG1 Figure 2.11



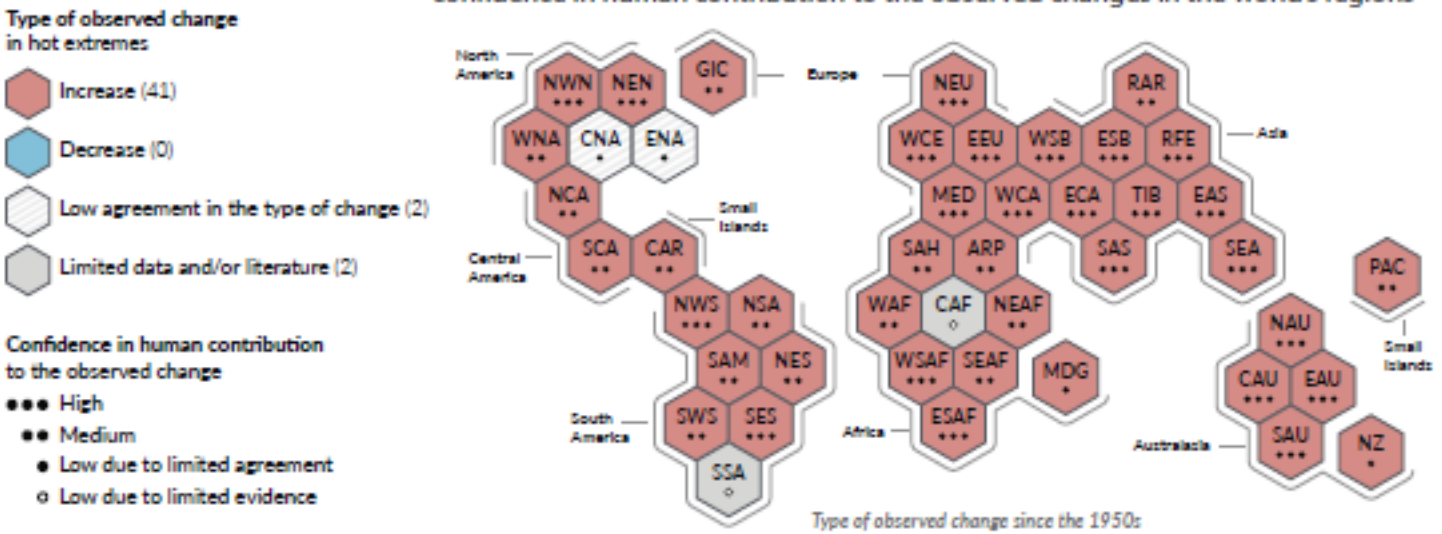
IPCC AR6 WG1 Figure 2.13



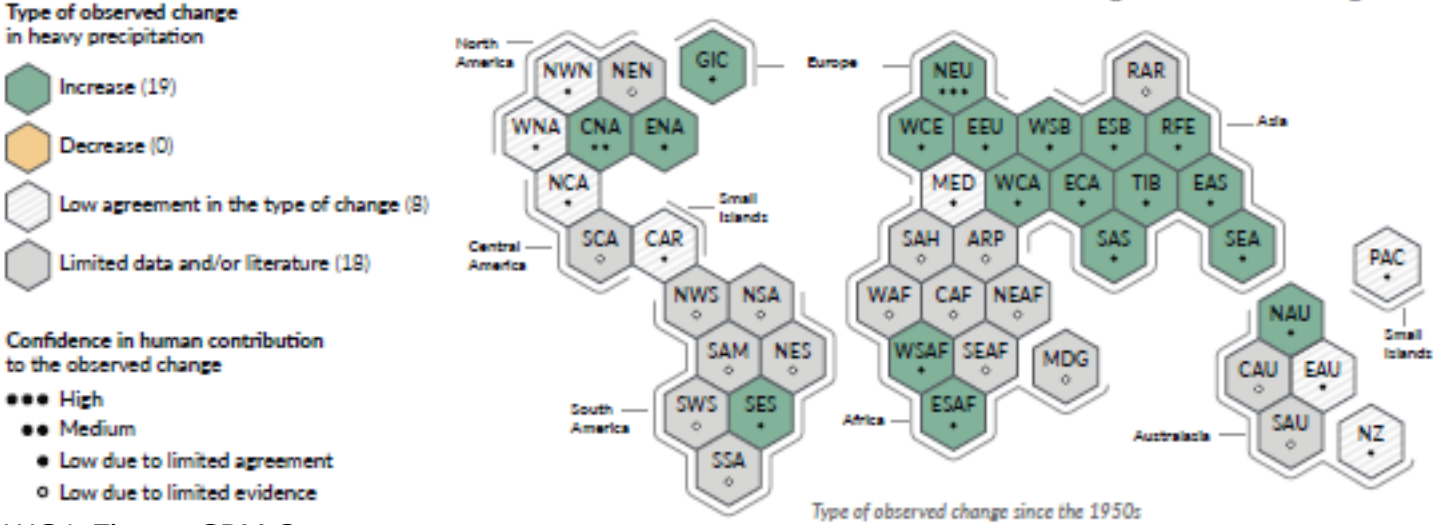
IPCC AR6 WG1 Figure 2.15

Observed Climate Change since 1950s

(a) Synthesis of assessment of observed change in **hot extremes** and confidence in human contribution to the observed changes in the world's regions



(b) Synthesis of assessment of observed change in **heavy precipitation** and confidence in human contribution to the observed changes in the world's regions



IPCC AR6 WG1 Figure SPM.3

Key Regional Risks in Asia

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SIXTH ASSESSMENT REPORT
Working Group I – The Physical Science Basis

Subject to copy edits

ipcc
INTERGOVERNMENTAL PANEL ON climate change

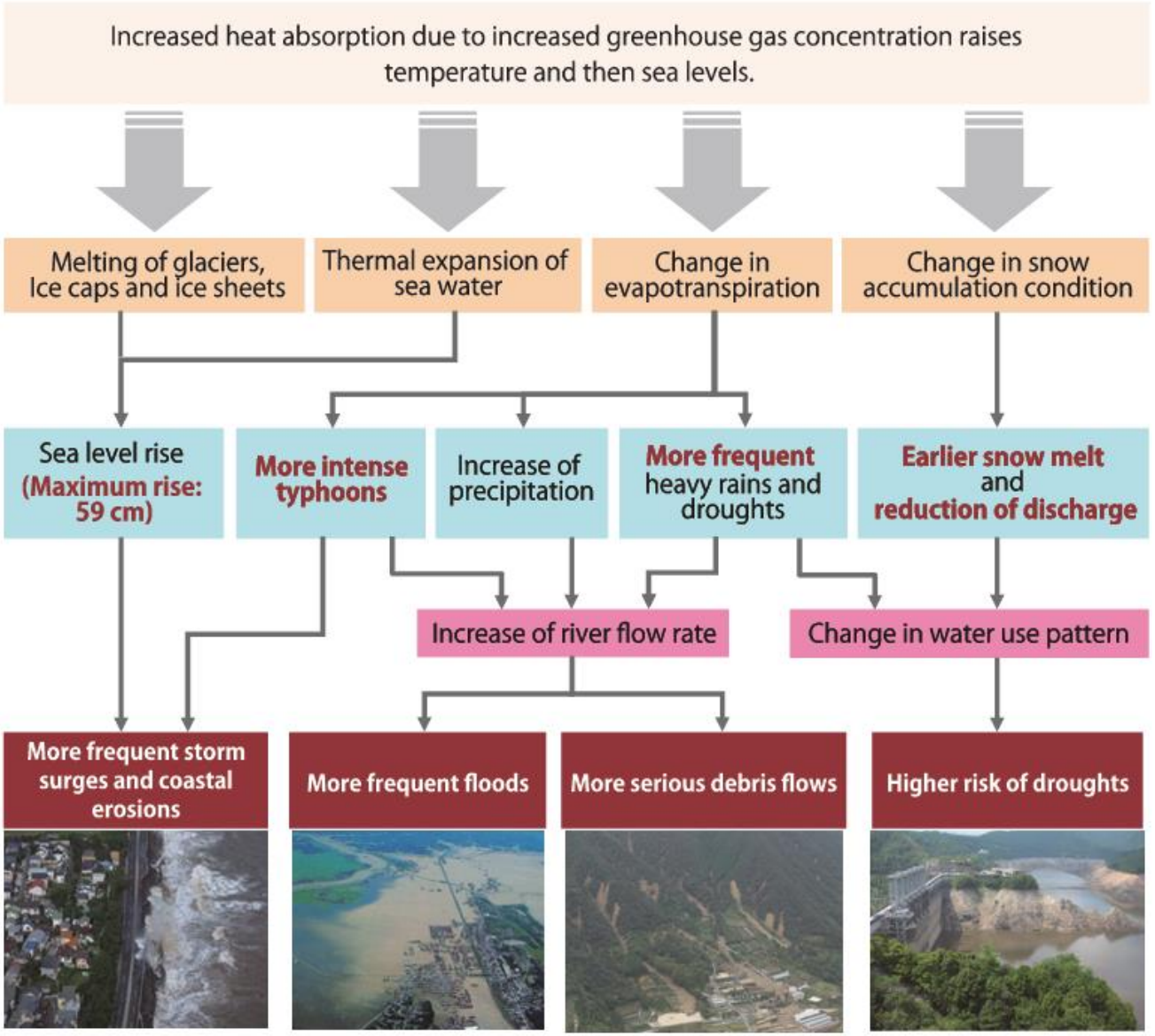
WMO UNEP

Regional fact sheet - Asia

Common regional changes

- The observed mean surface temperature increase has clearly emerged out of the range of internal variability compared to 1850-1900. Heat extremes have increased while cold extremes have decreased, and these trends will continue over the coming decades (*high confidence*).
- Marine heatwaves will continue to increase (*high confidence*).
- Fire weather seasons will lengthen and intensify, particularly in North Asia regions (*medium confidence*).
- Average and heavy precipitation will increase over much of Asia (*high to medium confidence*).
- Mean surface wind speeds have decreased (*high confidence*) and will continue to decrease in central and northern parts of Asia (*medium confidence*).
- Glaciers are declining and permafrost is thawing. Seasonal snow duration, glacial mass, and permafrost area will decline further by the mid-21st century (*high confidence*).
- Glacier runoff in the Asian high mountains will increase up to mid-21st century (*medium confidence*), and subsequently runoff may decrease due to the loss of glacier storage.
- Relative sea level around Asia has increased faster than global average, with coastal area loss and shoreline retreat. Regional-mean sea level will continue to rise (*high confidence*).

Global warming threats the water sector



Ministry of Land, Infrastructure, Transport and Tourism, Japan. *Practical Guidelines* on. Strategic Climate Change. Adaptation Planning. -*Flood Disasters*- https://www.mlit.go.jp/river/basic_info/english/climate.html

Further impacts of climate change

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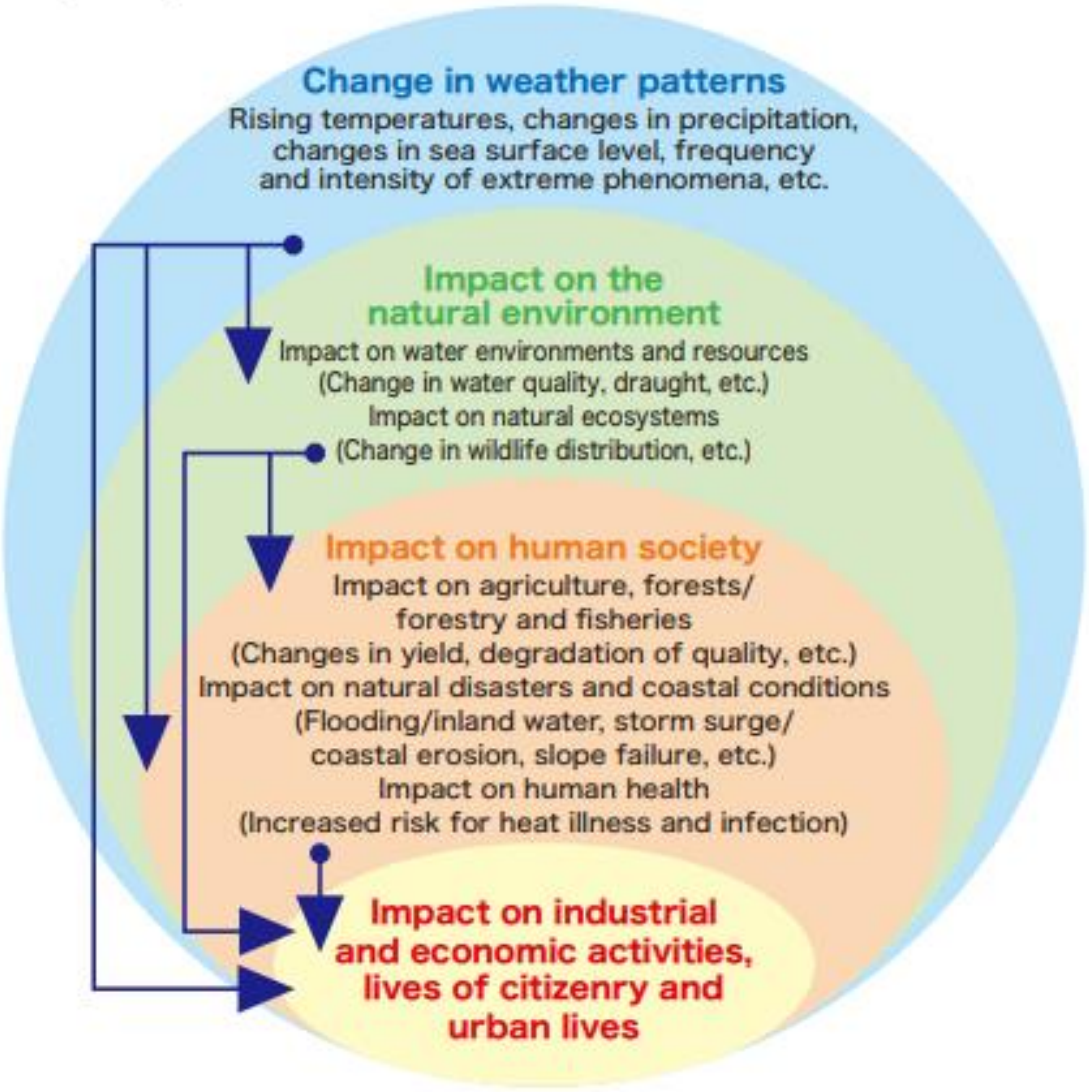
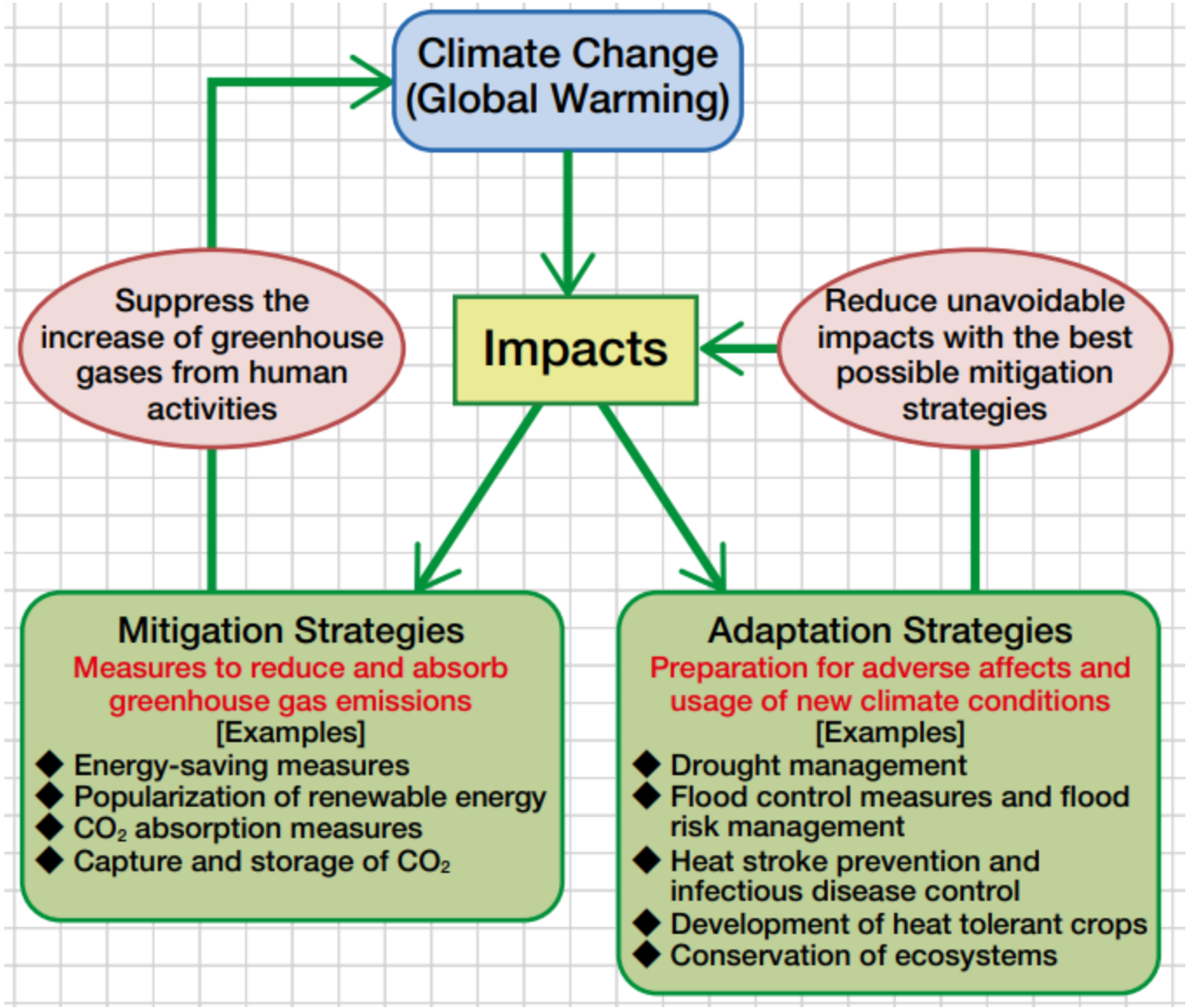


Ministry of the Environment Ministry of Education, Culture, Sports, Science and Technology Ministry of Agriculture, Forestry and Fisheries Ministry of Land, Infrastructure, Transport and Tourism Japan Meteorological Agency "Climate Change in Japan and Its Impacts" https://www.env.go.jp/earth/tekiou/pamph2018_full_Eng.pdf

Adaptation and Mitigation



Ministry of Education, Culture, Sports, Science and Technology, Japan Meteorological Agency, Ministry of the Environment "Climate Change and Its Impacts in Japan" https://www.env.go.jp/en/earth/cc/impacts_FY2012.pdf

History of Climate Change Science

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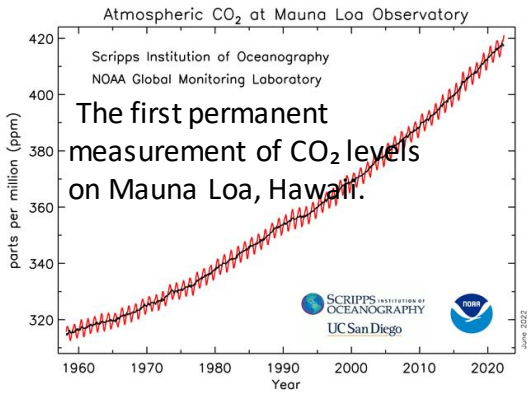
1824 Joseph Fourier indicated the existence of greenhouse effect.

1859 John Tyndall verified the existence of greenhouse effect.

1896 Svante Arrhenius estimated the future temperature change due to global warming.

1975 MANABE Syukuro (awarded Nobel Prize in Physics) and Wetherald made the first GCM which can deal with 2xCO2.
Their first estimate of global climate sensitivity was 2.93 ° C



https://gml.noaa.gov/ccgg/trends/

1957～58 International Geophysical Year

CO2, aurora, cosmic rays, geomagnetism, gravity, solar activity and so on.

1980s Improvement of simulation technique for global warming projection

1988 IPCC (Intergovernmental Panel on Climate Change)

Scientific intergovernmental body under the auspices of the United Nations, and established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). IPCC reports cover "the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation." The 2007 Nobel Peace Prize was shared between the IPCC and Al Gore.

1992 UNFCCC (United Nations Framework Convention on Climate Change)

International environmental treaty negotiated at the "Earth Summit" held in Rio de Janeiro in June 1992. The objective is to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (Article 2)".

https://unfccc.int/

IPCC Sixth Assessment Report (AR6)

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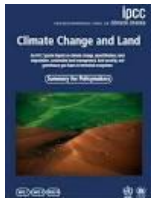

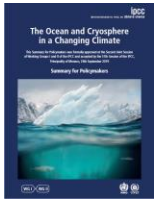

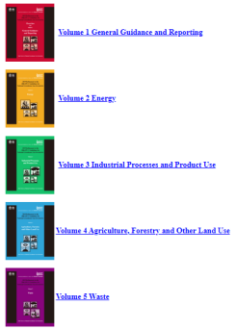

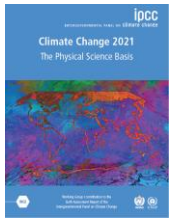

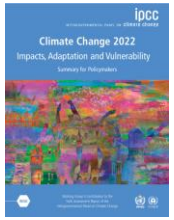

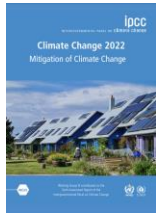

- Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5 degrees Celsius above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty was launched in October 2018..
- Climate Change and Land, an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems was launched in August 2019.
- Special Report on the Ocean and Cryosphere in a Changing Climate was released in September 2019.
- 2019 Refinement to the 2006 IPCC Guidelines on National Greenhouse Gas Inventories was released in May 2019.

- Climate Change 2021: The Physical Science Basis, by IPCC Working Group I in August 2021
- Climate Change 2022: Impacts, Adaptation and Vulnerability, by Working Group II in March 2022
- Climate Change 2022: Mitigation of Climate Change, by Working Group III in April 2022.

- The concluding Synthesis Report is due in 2022 or 2023.

http://www.ipcc.ch/

47th Session of IPCC at Paris on 13-16 March 2018

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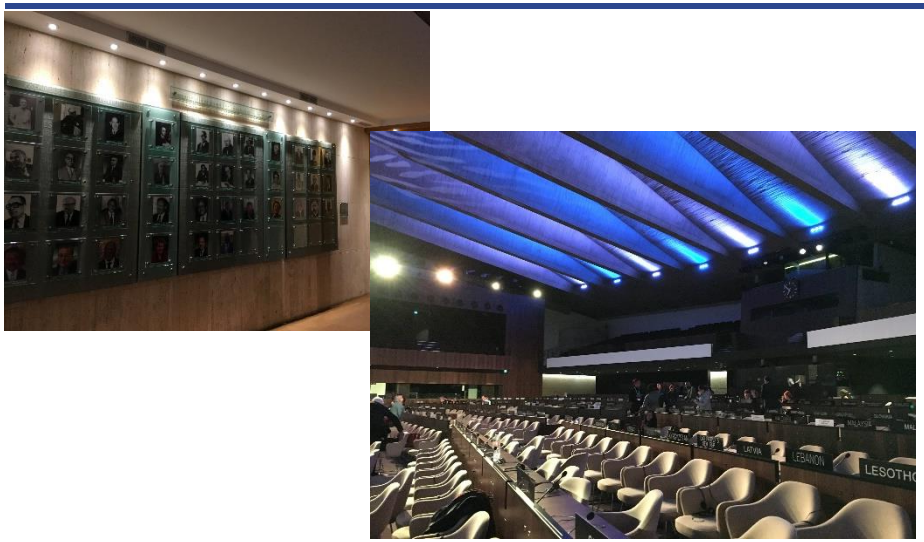
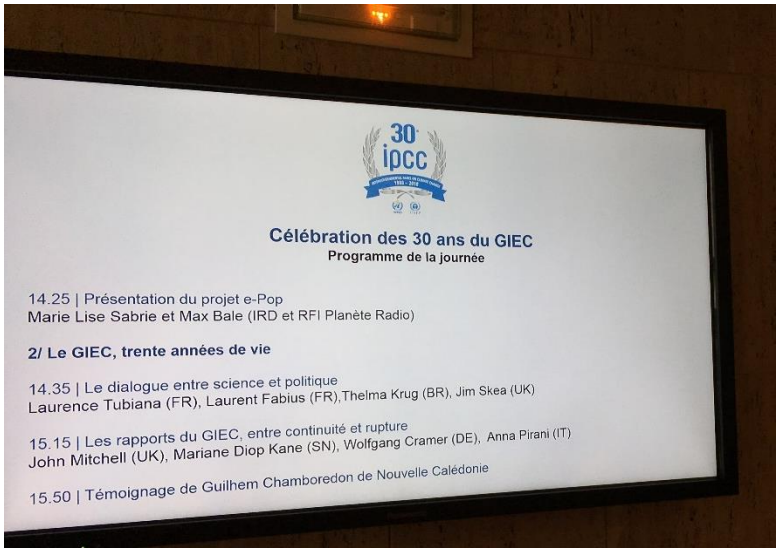
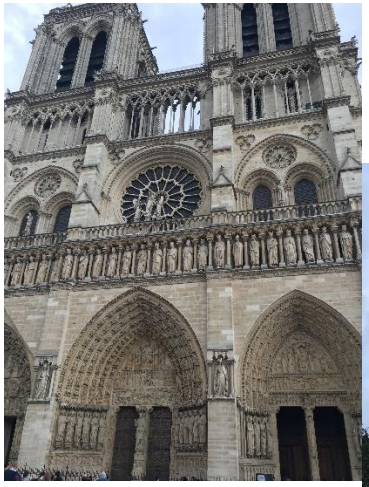


Inside of the headquarters of the UNESCO

Opening Ceremony



IPCC's 30th anniversary commemoration



Paris

Key Agreements in International Negotiations

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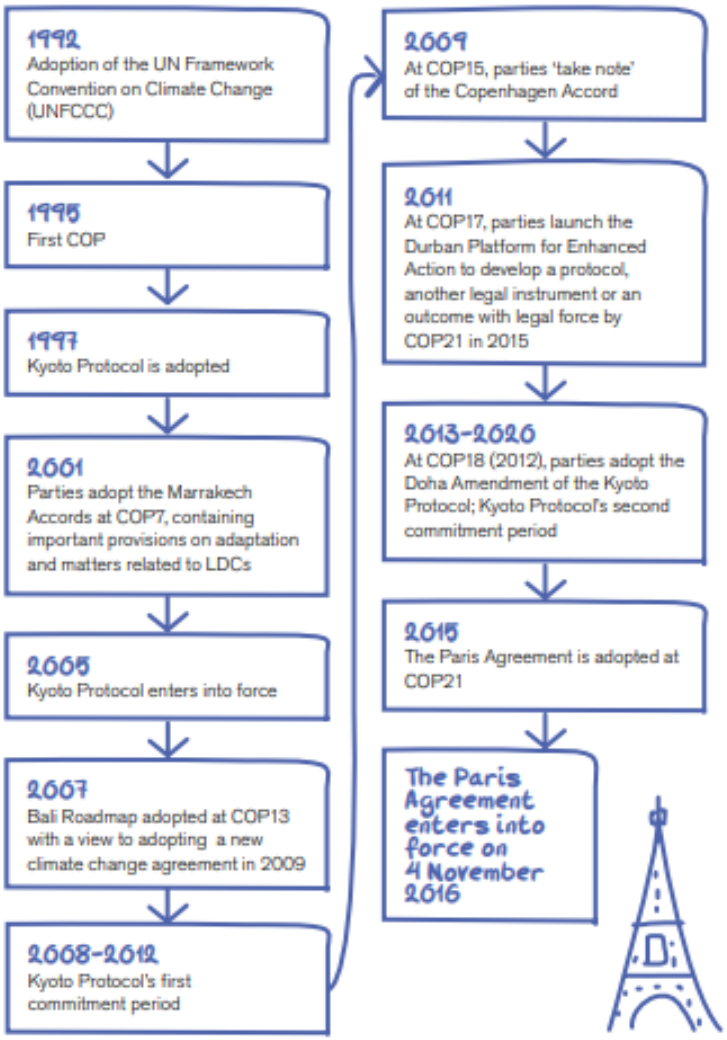

Kyoto Protocol (COP3, 1997)

Legally binding treaty applies to only developed country parties.
Reduce their emissions during 2008-2012 and 2013-2020.

Durban Platform (COP17, 2011)

Set a deadline to agree on new and universal greenhouse gas reduction protocol with legal force by 2015 for the period beyond 2020 .

Paris Agreement (COP21, 2015)

PARIS2015
COP21·CMP11

A universal, legally binding international agreement
Reduce their emissions beyond 2020 to limit global warming to well below 2°C, preferably to 1.5°C.

Becoming a UNFCCC Delegate: What You Need to Know
https://www.uncclearn.org/resources/library/becoming-a-unfccc-delegate-what-you-need-to-know/

Role of JMA

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Cooperation with related ministries and agencies

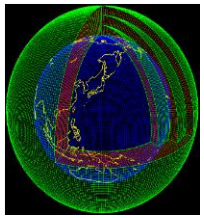
To deal with international and local affairs

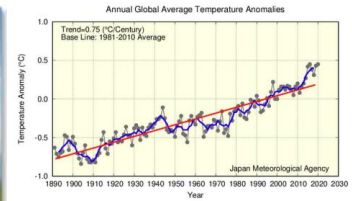
ipcc
INTERGOVERNMENTAL PANEL ON climate change

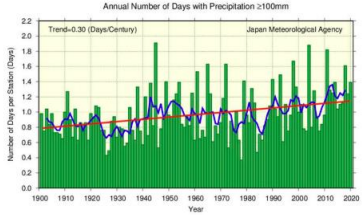
cCcA
Center for Climate Change Adaptation
国立研究開発法人 国立環境研究所
気候変動適応センター

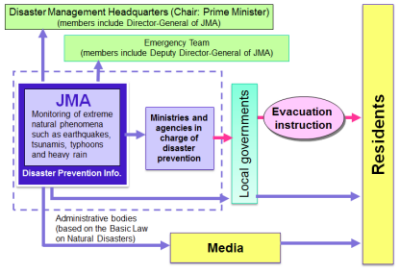
Observation, Monitoring and Issuing Disaster Prevention Information

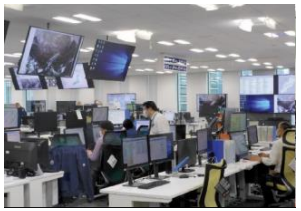
Data Production on climate change











To prevent disaster

To provide scientific knowledge including provision of training as RCC

JMA's latest Global Warming Projection

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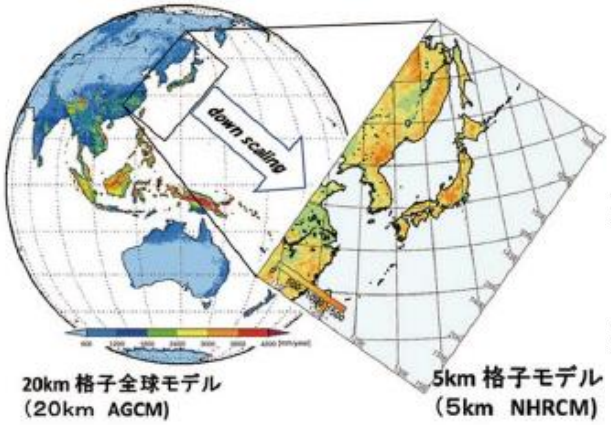
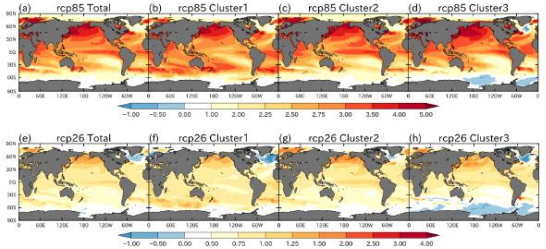
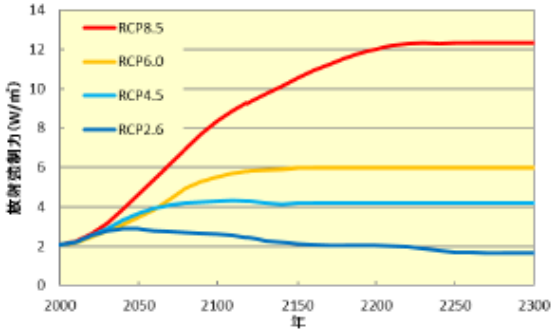
Climate Change in Japan 2020
(MEXT and JMA, 2020)



AGCM run with
four SST clusters

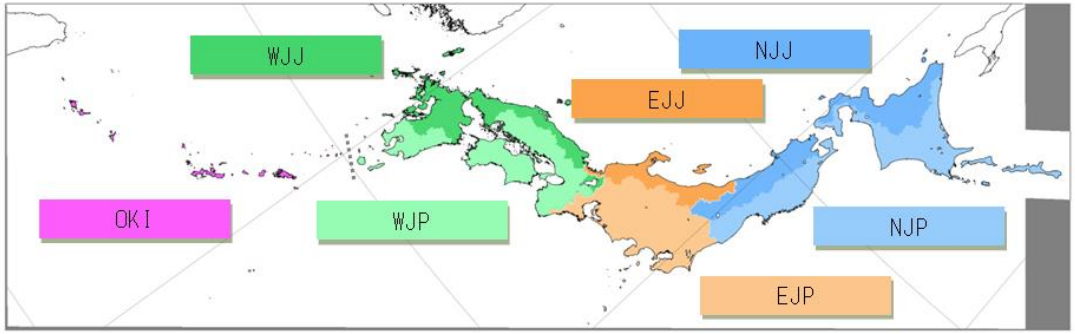


Greenhouse gas emission scenario :
RCP2.6 & RCP8.5



PRE: 1980-1999
FUT: 2076-2095

This report provides essential information for planning and decision-making in climate –change mitigation/adaptation for impact assessment by national and local government bodies.



https://www.data.jma.go.jp/cpdinfo/ccj/index.html
https://www.data.jma.go.jp/cpdinfo/ccj/2020/pdf/cc2020_gaiyo_en.pdf

Future changes in surface temperature

Japan Meteorological Agency

Surface Temperature

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Observed changes

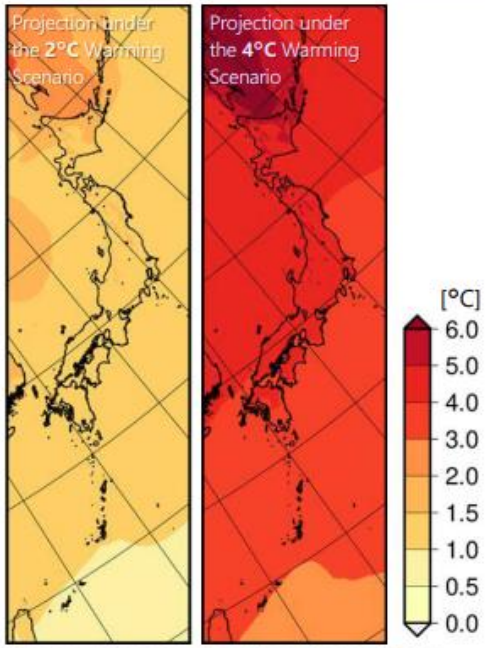
- The annual surface temperature over Japan (based on data from 15 observation stations considered to be relatively uninfluenced by urbanization) increased at a rate of 1.24°C per century between 1898 and 2019.
- Between 1910 and 2019, the annual numbers of days with maximum temperatures of ≥ 30 and ≥ 35°C and minimum temperatures of ≥ 25°C (referred to here as T_{max} ≥ 30°C, T_{max} ≥ 35°C and T_{min} ≥ 25°C days, respectively) have increased, while those of days with minimum temperatures of < 0°C (referred to here as T_{min} < 0°C days) have decreased. In particular, the number of T_{max} ≥ 35°C days has increased significantly since the mid-1990s.

Projections

	2°C Warming Scenario Potential conditions with achievement of the Paris Agreement's 2°C target	4°C Warming Scenario Potential conditions with no future additional mitigation measures
Annual surface temperature over Japan	Approx. 1.4°C increase	Approx. 4.5°C increase
Annual global average surface temperature	Approx. 1.0°C increase	Approx. 3.7°C increase
T_{max} ≥ 35°C days per year	Approx. 2.8-day increase	Approx. 19.1-day increase
T_{min} ≥ 25°C days per year	Approx. 9.0-day increase	Approx. 40.6-day increase
T_{min} < 0°C days per year	Approx. 16.7-day decrease	Approx. 46.8-day decrease

- Under both scenarios, the annual surface temperature over Japan for the end of the 21st century is expected to increase, with more T_{max} ≥ 35°C / T_{min} ≥ 25°C days and fewer T_{min} < 0°C days in many regions.
- The temperature increase over Japan is greater under the 4°C Warming Scenario than under the 2°C Warming Scenario.
- Under the same scenario, higher latitudes correspond to greater increases in temperature. Values are also higher in winter than in summer.

Projections are averages over Japan for the end of the 21st century relative to the end of the 20th century or present, unless otherwise stated.



Changes in annual surface temperature for the end of the 21st century (2076 – 2095 average) relative to the end of the 20th century (1980 – 1999 average)

5

https://www.data.jma.go.jp/cpdinfo/ccj/2020/pdf/cc2020_gaiyo_en.pdf

Future changes in precipitation

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Precipitation

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Observed changes

- While the frequency of daily and hourly extreme precipitation has increased in Japan, that of wet days has decreased (both statistically significant).
- No statistically significant long-term trend is observed in annual or seasonal precipitation over Japan.

Projections

	2°C Warming Scenario Potential conditions with achievement of the Paris Agreement's 2°C target	**4°C Warming Scenario** Potential conditions with no future additional mitigation measures
Annual number of days with precipitation ≥ 200 mm	Approx. x 1.5 increase	Approx. x 2.3 increase
Annual number of events with precipitation ≥ 50 mm/h	Approx. x 1.6 increase	Approx. x 2.3 increase
Annual maximum daily precipitation	Approx. 12% (15 mm) increase	Approx. 27% (33 mm) increase
Annual number of days with precipitation < 1.0 mm	No statistically significant change	Approx. 8.2-day increase

Precipitation ≥ 50 mm/h is torrential rainfall rendering umbrellas useless and creating spray that impairs visibility.

- The frequency and intensity of daily and hourly extreme precipitation over Japan are expected to increase, while those of wet days are expected to decrease.
- No statistically significant change in annual precipitation over Japan is projected.
  There is significant uncertainty in projections on regional and prefectural scales.
- The precipitation system associated with the *Baiu* (seasonal rain) front in June is expected to intensify and be south of its normal location.
  The projection for July is characterized by significant uncertainty.

6

Projections are averages over Japan for the end of the 21st century relative to the end of the 20th century or present, unless otherwise stated.

Future changes in snow

Snowfall and Snow Depth

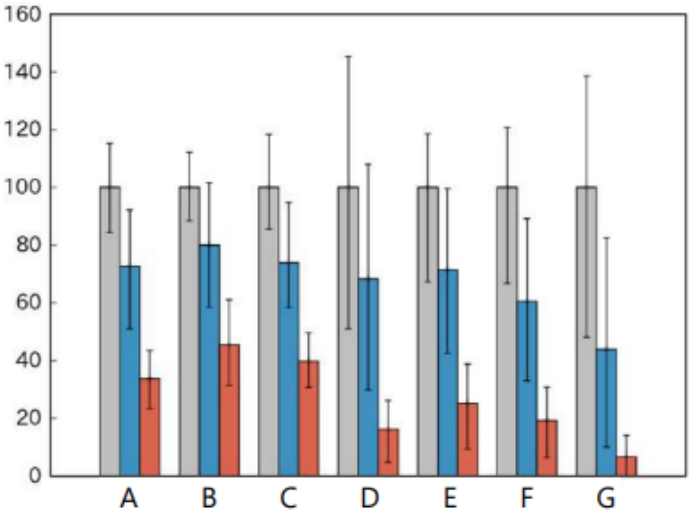
Observed changes

- Data collected at observation stations on the Sea of Japan side of the country indicate that:
  - the annual maximum snow depth in winter has decreased; and
  - the annual number of days with snowfall ≥ 20 cm has decreased.

Projections

	2°C Warming Scenario Potential conditions with achievement of the Paris Agreement's 2°C target	4°C Warming Scenario Potential conditions with no future additional mitigation measures
Annual maximum snow depth and snowfall	Approx. 30% decrease (except Hokkaido and certain other areas)	Approx. 70% decrease (except some areas of Hokkaido)
Snowfall period	/	Shorter (delayed start, early end)
Heavy snowfall (decadal max. in the present climate)	/	Potential increase in Honshu mountainous areas and Hokkaido inland areas

- Outside inland Hokkaido, snowfall and snow depth are expected to decrease as global warming progresses, with a higher likelihood of rain.
- Reduced snowfall amounts do not necessarily correspond to reduced risk of exceedingly rare incidences of extremely heavy snowfall. It should be noted that the confidence level of this projection is low.



Maximum snow depth in winter for the end of the 21st century (2076 – 2095 average) standardized by that for the end of the 20th century (1980 – 1999 average) for A) all Japan; B) Sea of Japan side of northern Japan; C) Pacific side of northern Japan; D) Sea of Japan side of eastern Japan; E) Pacific side of eastern Japan; F) Sea of Japan side of western Japan; and G) Pacific side of western Japan. Grey, blue and red bars represent 1) observations for the end of the 20th century, and projections for the end of the 21st century under the 2) 2°C and 3) 4°C Warming Scenarios, respectively.

Projections are averages over Japan for the end of the 21st century relative to the end of the 20th century or present, unless otherwise stated.

Future changes stated in the report

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Projection Summary

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Projected climate conditions for areas in and around Japan for the end of the 21st century relative to the end of the 20th century or present:

Yellow and purple figures represent the 2°C and 4°C Warming Scenarios (RCP2.6 and 8.5 scenarios), respectively.

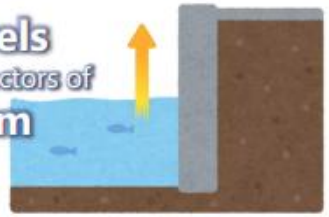
Annual Surface Temperature Increase: approx. 1.4 / 4.5°C

with more T_{max} ≥ 35°C days,
more T_{min} ≥ 25°C days
and fewer T_{min} < 0°C days

Sea Surface Temperature Increase: approx. 1.14 / 3.58°C

The degree of increase is greater than the global average due to geographical characteristics (i.e., greater continental warming than that from ocean and warm currents).

Increased sea levels along the Japanese coast by factors of approx. 0.39 / 0.71 m



Snowfall and Snow Depth Decrease

Rainfall rather than snow
Ongoing risk of heavy snow

Heavy Precipitation Frequency Increase

Annual maximum daily precipitation increase of approx. 12% (15 mm) / 27% (33 mm)
Precipitation ≥ 50 mm/h event increase by factors of approx. 1.6 / 2.3

Reduced Sea of Okhotsk Ice Extent in March by approx. 28 / 70%

The Arctic Sea is expected to be practically ice-free by the mid-21st century under the 4°C Warming Scenario.

Proportion of Strong-Typhoon Increase

Increased Wind Speed and Precipitation Associated with Typhoons

Ongoing Ocean Acidification around Okinawa and southern Japan Similar to those of the Global Average

Projections are averages over Japan for the end of the 21st century relative to the end of the 20th century or present, unless otherwise stated.

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Role of Global Warming Projection Information

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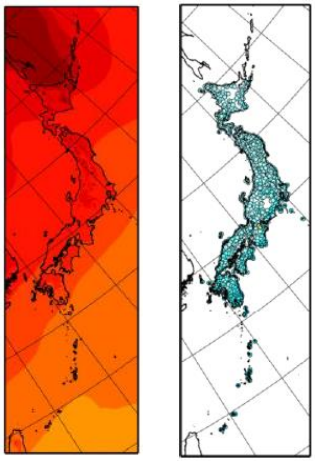
Basic data for adaptations



Detailed climate change projection information

Detailed estimation for impacts on each sector

Appropriate adaptations

Basic data for mitigations

GHG emission reduction target
Planning our future society

Educational activities

Including TCC training seminar

Promotion of people's eco-friendly activity and understanding of the government's efforts
Environmental education

Thank you for your attention!