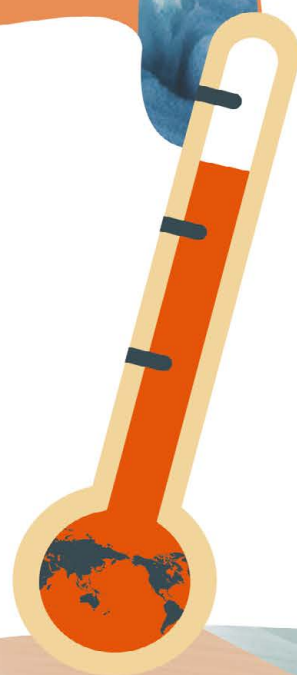


• Geography E-learning Package about •

Climate Change

Version 2.0



香港天文台
HONG KONG OBSERVATORY



優質教育基金
Quality Education Fund

Localizing Climate Education: The Original Aspiration from "Version 1.0"

Looking back to 2017, when the compilation of the “Geography E–Learning Package about Climate Change” was initiated, Hong Kong society's understanding of climate issues was still in its exploratory stages. Internationally, the reality of global warming and related issues was still disputed and educational materials containing insufficient or misunderstood scientific information on climate change were not uncommon across various disciplines. As educators, we deeply recognized the dual challenges in teaching climate issues: ensuring scientific rigor while making the content relatable to students' daily lives was no easy task. Creating a set of teaching materials that broke free from the constraints of traditional textbooks, made complex topics accessible, and maintained scientific authority became an exciting challenge for our center's team. With professional guidance from the Hong Kong Observatory and support from the Quality Education Fund, this climate education project came into being. Guided by the principle of “clarifying climate misconceptions and promoting the integration of knowledge and action”, it integrates the publication of printed and web-based resource packages with the development of a climate change mobile application and an interactive learning toolkit. The project aims to provide systematic learning resources beyond textbooks for geography teachers and students across Hong Kong, as well as those who are interested in the topic.

From Knowledge to Action: Evolving from “Version 1.0” to “Version 2.0”

The first launch of the “Geography E–Learning Package about Climate Change” in 2019 gained widespread recognition within the educational community. With the increasing frequency of extreme weather events and the warning of the IPCC Sixth Assessment Report sounded the alarm, we realized that climate education must advance with the times. In 2023, our center, with the support of the Quality Education Fund, launched Version 2.0 of the Package. Building on the original Version 1.0, the enhancements go beyond revising the booklet content, enriching teaching and learning resources, and innovating with e-learning, they represent a shift in the focus of teaching: moving from “knowledge transfer” to “action-oriented learning”. We aspire for students to evolve from mere “observers” of climate change to “practitioners” of solutions.

Building a Sustainable Future: Collaboration and Legacy in Science Education

There are no shortcuts to solving the climate crisis, and education is the most vital foundation. In this regard, we extend our deepest gratitude to all who have supported this education package. We hope this teaching and learning resource can help the public cultivate scientific literacy through “knowledge”, establish environmental ethics through “empathy”, and adopt low-carbon lifestyle through “action”, working together towards a sustainable future.

Kwok Chi Tai

Principal

Ho Koon Nature Education cum Astronomical Centre (Sponsored by Sik Sik Yuen)

January 2026

II

Preface

Climate change is one of the most pressing global environmental challenges, with far-reaching impacts on ecosystems, societies, and economies. As a coastal metropolis, Hong Kong faces serious threats such as rising temperatures, stronger typhoons, and sea-level rise. To ensure a sustainable future, it urgently needs to take proactive action to contribute to global efforts in mitigating climate change, while also promoting public awareness and support for various adaptation and response measures.

This booklet, jointly developed by the Ho Koon Nature Education cum Astronomical Centre (sponsored by Sik Sik Yuen) and the Hong Kong Observatory, aims to support frontline teachers and students in geography and related disciplines to gain an accurate and in-depth understanding of climate change by leveraging data analysis from the Hong Kong Observatory and international meteorological organizations, along with concrete examples.

This booklet is developed in line with the latest Geography Curriculum and Assessment Guide (Secondary 4–6) issued by the Curriculum Development Institute, Education Bureau, specifically addressing “Topic 7: Climate Change — Long-term Fluctuation or Irreversible Trend?”. It consists of five core chapters:

7.1 Is the climate changing?**7.2 What are the causes of global warming?****7.3 How is the climate change in Hong Kong?****7.4 How will climate change affect us?****7.5 How can we respond to the impacts of climate change?**

This Version 2.0 booklet integrates over 140 years of meteorological data analysis from the Hong Kong Observatory and the latest research findings from the IPCC Sixth Assessment Report (IPCC AR6) published in 2023, offering scientifically rigorous and locally relevant content. These resources not only help students grasp key knowledge of both global and local climate change, but also deepen their understanding of the interactions between human activities and the natural environment, inspiring learning motivation and enhancing teaching and learning effectiveness.

In line with the revised content of this booklet, the “Geography E-Learning Package about Climate Change” Version 2.0 overall emphasizes scientific inquiry and practical application. Therefore, the project team has additionally developed a set of Learning and Teaching Resources. Through case studies provided by the Hong Kong Observatory (such as the urban heat island effect and typhoon risk management), students are guided to conduct data analysis, field studies, and extended research, fostering critical thinking and scientific literacy. At the same time, the Learning and Teaching Resources references international and local frameworks, including the Paris Agreement which came into effect at the end of 2016 and Hong Kong’s Climate Action Plan 2050, encouraging students to propose targeted mitigation and adaptation strategies and to apply their learning outcomes to both classroom assessments and real-world problem solving.

The successful development of this Version 2.0 booklet was made possible through the professional guidance of the Hong Kong Observatory. Special thanks are extended to Dr. Lee Tsz-cheung, Senior Scientific Officer (Climate Forecasting Services and Climate Change Research), and Ms. Chan Man-yee, Chief Experimental Officer (Climate Forecasting Services and Climate Change Research), for their invaluable contributions. We also sincerely appreciate the feedback provided by the Curriculum Development Institute of the Education Bureau, the active participation of frontline staff and students from pilot schools, and the support of international meteorological organizations and related institutions in the use of information.

Project Team, Geography E-learning Package about Climate Change 2.0
January 2026

III

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Acknowledgements

The images and information used in this teaching package have been kindly authorized or used in accordance with regulations by the following organizations and individuals. We wish to record our sincere appreciation herewith.

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- Figure 10 Changes in surface temperature ($^{\circ}\text{C}$ per decade) during 1900–1980 (upper diagram) and 1981–2020 (lower diagram)
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- Figure 17 Cumulative Antarctic Ice Sheet (AIS) and Greenland Ice Sheet (GrIS) mass changes. The estimated uncertainties, very likely range, for the respective cumulative changes are shaded.
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- Figure 19 Annual and decadal global glacier mass change from 1961 until 2018
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Figure 21 Changes in global mean sea level

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Figure 23 Assessments of human-induced hot extremes and heavy precipitation around the world

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4. EU Copernicus European Earth Observation Programme

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Figure 7 The atmospheric concentration of carbon dioxide

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Figure 10 Changes in global surface temperature relative to 1850–1900

Figure SPM.1 Panel (b) in IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3 – 32, doi: 10.1017/9781009157896.001 .]

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9. Canva Education

Figure 13 Hang–dry washed clothes under sunlight to save energy and kill germs.

Figure 14 Bring containers when dining out or ordering takeout.

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7.1 Is the climate changing?

To know about climate change, first we need to understand the difference between weather and climate. Weather describes the conditions of the atmosphere within a short period of time, while climate describes the average meteorological conditions over a long period of time.

Weather and climate vary from region to region. After a brief overview of the global climate, this chapter specifically introduces the climates of China and Hong Kong.

To better understand ongoing climate change, we need to examine the scientific evidence such as the rising global surface temperature, increasing ocean heat content, shrinking sea ice, retreating glaciers and ice sheets as well as rising sea level.

- 1 Weather and climate
- 2 What is the world's climate like?
- 3 What are the climates of China and Hong Kong like?
- 4 Scientific evidence of climate change

1

Weather and climate

Weather describes the conditions of the atmosphere in a place within a short period of time (e.g. several hours, a few days). Climate on the other hand describes the average meteorological conditions in a place over a long period of time. Therefore, climate can be interpreted as the “average weather”. The World Meteorological Organization (WMO) calculates climate parameters based on 30-year averages.



More Information



What is climate?

What is
Climatological
Normal?

1.1 Examples of weather

Temperature (updated at 2025/05/07 12:00)

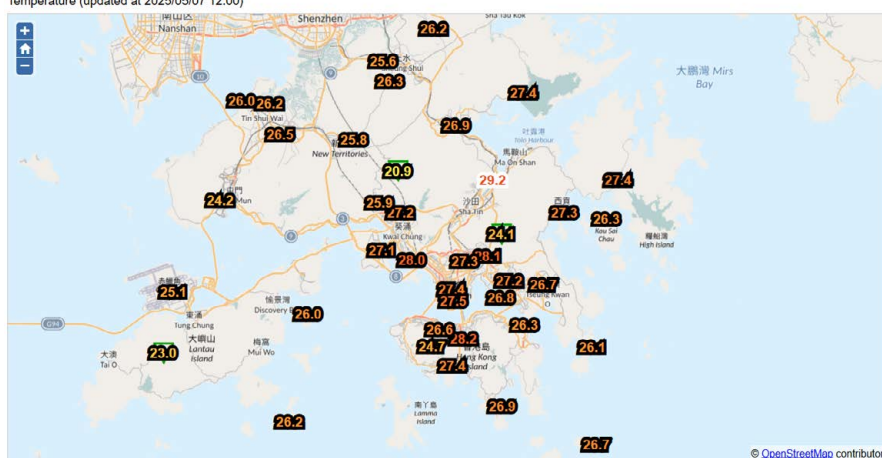


Fig 1a Regional temperatures of Hong Kong (12:00 noon on May 7, 2025)

Source: HKO

Relative Humidity (updated at 2025/05/07 12:00)

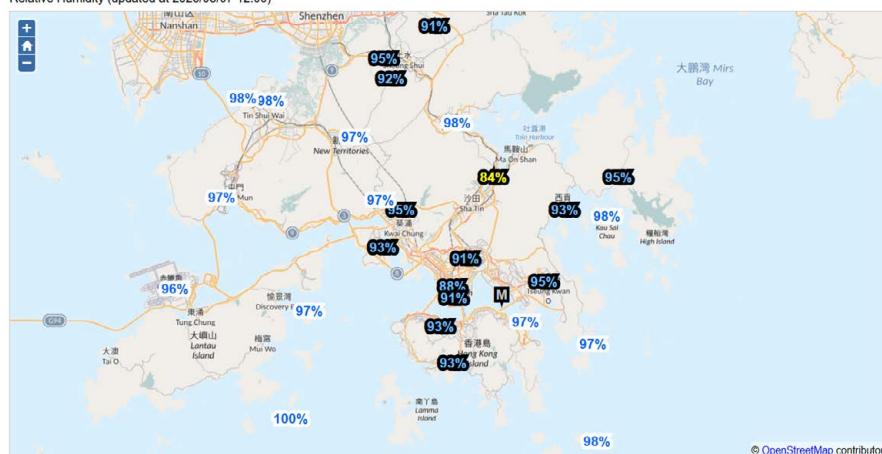


Fig 1b Regional relative humidity of Hong Kong (12:00 noon on May 7, 2025)

Source: HKO

What are the conditions of the atmosphere?

The conditions of the atmosphere refer to the meteorological elements such as temperature, relative humidity, precipitation, air pressure, wind direction and wind speed.

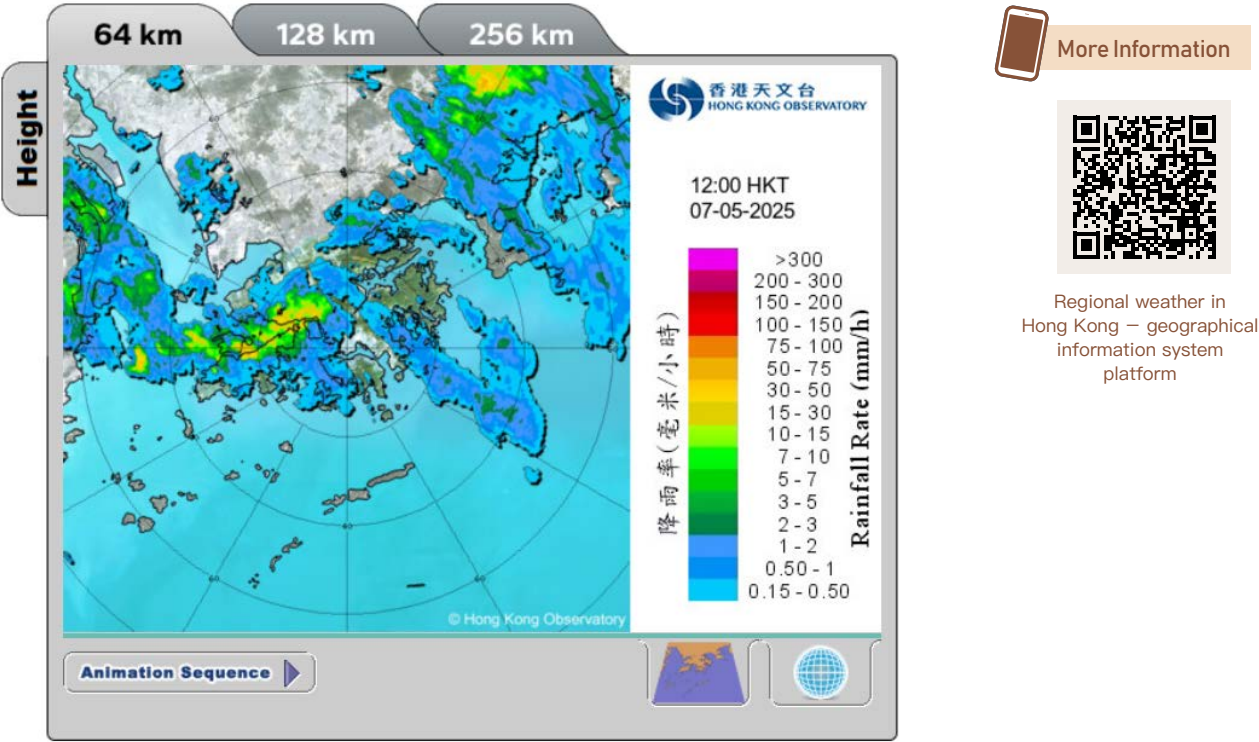


Fig 1c Image of radar echoes (12:00 noon on May 7, 2025)
Source: HKO

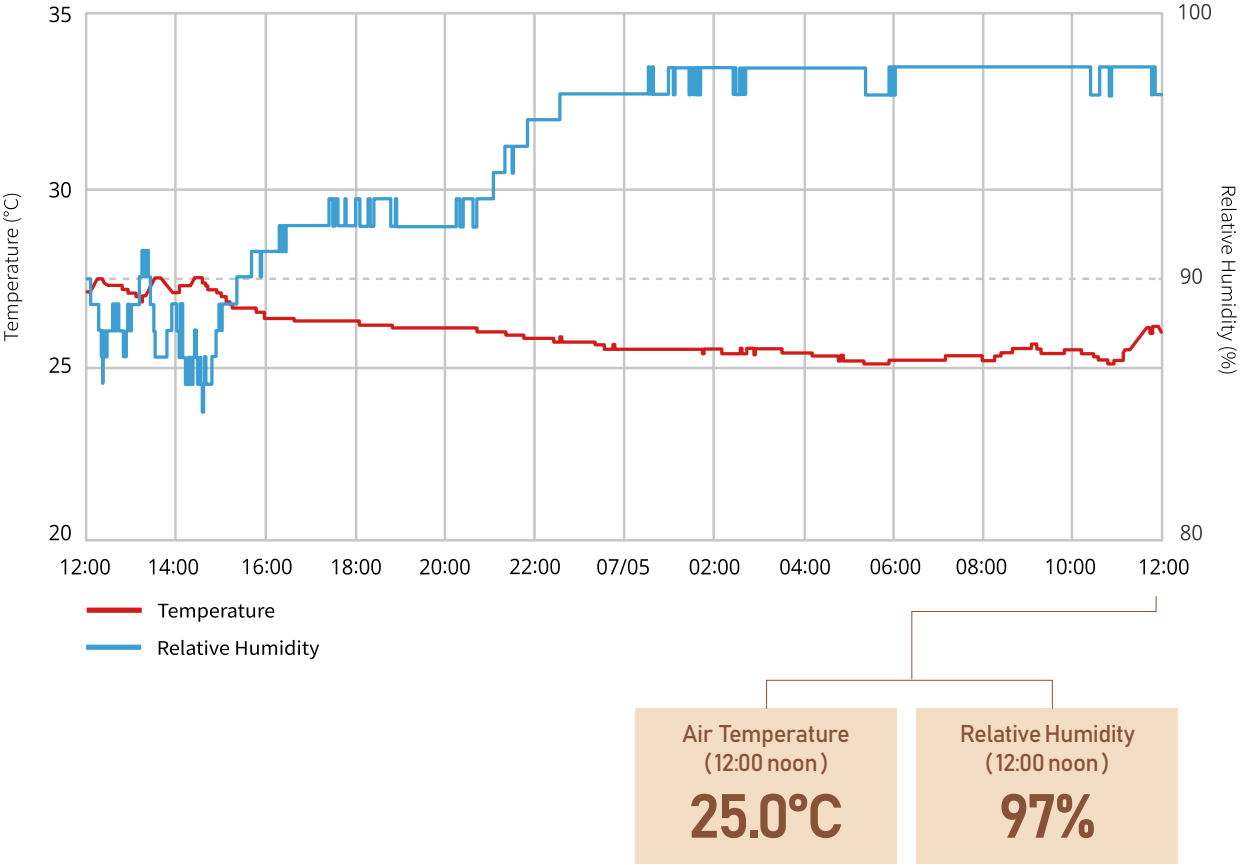


Fig 2 Weather conditions at Tsuen Wan Ho Koon (May 7, 2025)
Source: HKO



1.2 Examples of climate

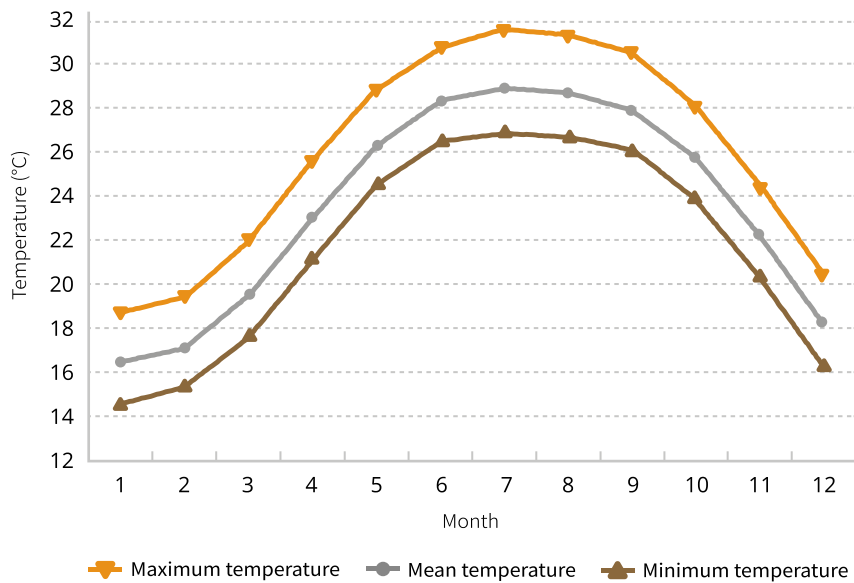


Fig 3 Monthly means of daily maximum, mean and minimum temperatures recorded at the Hong Kong Observatory (HKO) between 1991–2020
Source: HKO



More Information



The ABCs of Climate



Climatological Information from HKO

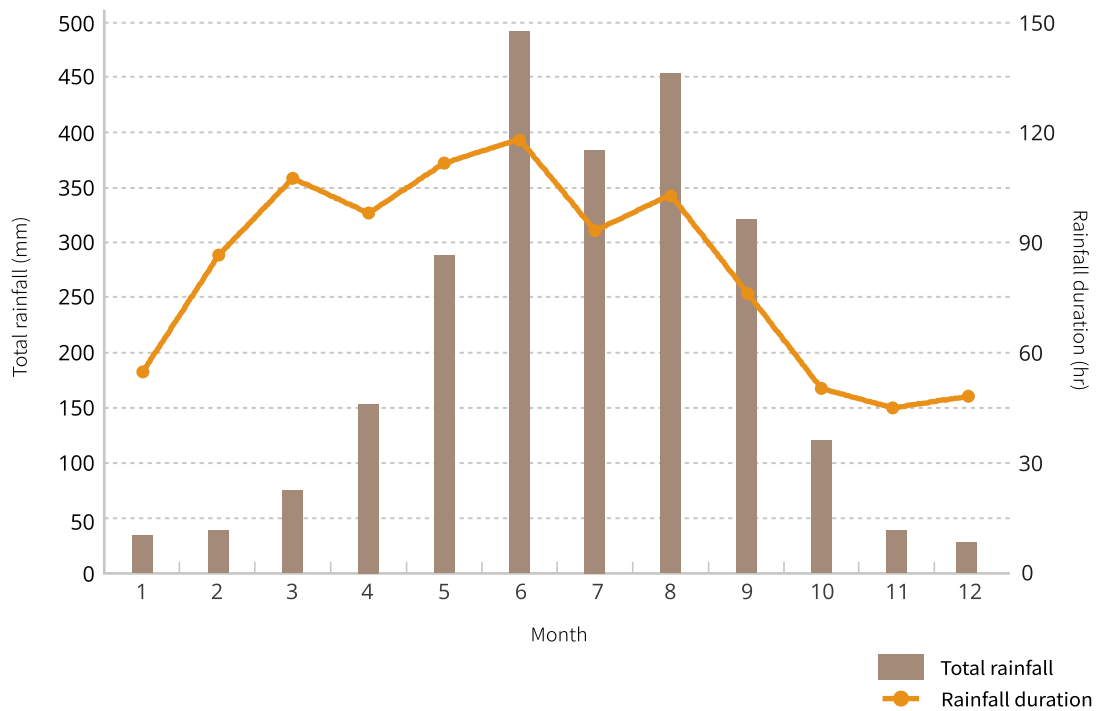
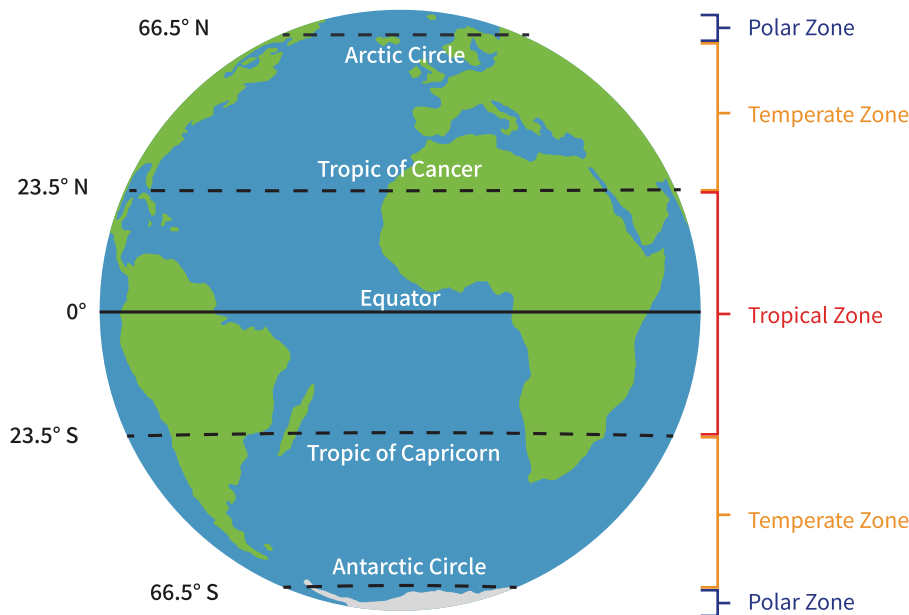


Fig 4 Monthly mean of rainfall recorded at Hong Kong Observatory (HKO) between 1991–2020
Source: HKO

2

What is the world's climate like?



More Information



Climatic zones and the Köppen climate classification

Fig 5

Climatic zones classified by the amount of insolation received

One of the most important factors affecting regional climate is the solar radiation, known as insolation, received. Therefore, one way of climatic classifications is to divide the Earth into climatic zones by the Arctic Circle, the Tropic of Cancer, the Tropic of Capricorn and the Antarctic Circle. Tropical zone refers to the region between the Tropic of Cancer and the Tropic of Capricorn; temperate zone refers to the region between the Arctic Circle (the Antarctic Circle) and the Tropic of Cancer (the Tropic of Capricorn); polar zones are the areas within the Arctic and Antarctic Circles. (Fig.5) Among these climatic zones, the tropical zone receives the greatest amount of insolation, and the polar zones receive the least.

Other climatic classifications may take into account parameters such as temperature, precipitation, duration of precipitation and types of vegetation. Regions with similar parameter characteristics are grouped into the same climatic zone. For example, the Köppen Climate Classification divides the world into five major climatic zones based on three factors: vegetation, temperature and precipitation.

In addition to latitude, other factors such as altitude, topography, distance from the sea, ocean currents and prevailing wind directions, also affect the regional climate.

Altitude	As altitude increases, temperature and air pressure decrease. Generally, the temperature decreases with height by about 6.5° C per 1,000 m.
Topography	Wind is stronger on the windward slope of a mountain, air is forced to rise and cool because of the terrain, resulting in more precipitation. Wind is weaker on the leeward slope of a mountain, air descends and becomes warmer and drier, leading to the foehn effect and a rain shadow, with less precipitation.
Distance from the sea	Water bodies help moderate temperatures, resulting in more stable temperatures in coastal areas. Coastal regions are affected by land and sea breezes.
Ocean currents	Warm currents (e.g. the Gulf Stream) bring warmer and more humid climates to nearby coastal areas, while cold currents (e.g. the California Current) lower coastal temperatures and increase atmospheric stability.
Prevailing wind directions	Onshore winds contain more moisture and brings more precipitation, while offshore winds are drier.

3

What are the climates of China and Hong Kong like?



3.1 Climate of China

In terms of climate types, there are five main types in China: temperate monsoon climate, temperate continental climate, subtropical monsoon climate, tropical monsoon climate, and highland/plateau mountain climate (refer to the Education Bureau's Our Country's Climate and Life Augmented Reality Thematic Map [electronic version]).

3.1.1 Temperate monsoon climate

- Features:** Hot and rainy summers, cold and dry winters, with four distinctive seasons.
- Major distribution:** Mainly located to the north of the Qinling Mountains—Huaihe River line in eastern China, as well as to the east of the temperate semi-arid and arid zones.

3.1.2 Temperate continental climate

- Features:** Dry with little rainfall, extreme continental climate, with the largest annual and diurnal temperature ranges among all climate types.
- Major distribution:** The area to the west of the Daxinganling—Yinshan—Helan Mountains—Qilian Mountains—Bayan Har Mountains line, and to the north of the Kunlun Mountains—Altun Mountains—Qilian Mountains—Hengduan Mountains line.

3.1.3 Subtropical monsoon climate

- Features:** Warm winters, hot summers, with four distinctive seasons. The annual precipitation generally ranges from 1,000 to 1,500 mm, with most rainfall occurring in summer, with no distinct dry season.
- Major distribution:** The area to the south of the Qinling Mountains—Huaihe River line and to the north of the tropical monsoon climate zone in eastern China.

3.1.4 Tropical monsoon climate

- Features:** High temperatures throughout the year, long summers with brief winters. Distinct wet and dry seasons. The year can be divided into three seasons—dry season, rainy season, and hot season. Precipitation mainly comes in summer and relatively scarce in winter.
- Major distribution:** At eastern coastal regions between latitudes 10° and 20° N, mainly in the Leizhou Peninsula, Hainan Island, the South China Sea, and the southern part of Taiwan Island.

3.1.5 Highland climate/plateau mountain climate

- Features:** Long, dry, and cold winters with frequent strong winds, cool and rainy summers with frequent hailstorms, indistinct seasonal changes. Abundant sunshine, temperature decreases with increasing altitude and latitude, distinct wet and dry seasons, with frequent nighttime rain.
- Major distribution:** The Qinghai—Tibet Plateau.



More Information



What are the major climatic features in our country?



PowerPoint Series on Geography of China (3) – Climate of Our Country



Climate and Life of Our Country

The seasonal characteristics of precipitation in China are as follows. In the south, the rainy season starts early, ends late, lasts for a longer period, and is concentrated between May and October. In the north, the rainy season starts late, ends early, lasts for a shorter period, and is concentrated in July and August. Most regions experience more rainfall in summer and autumn and less in winter and spring. The only region in the country dominated by winter rainfall (winter-rain type) is northeastern Taiwan, where winter precipitation accounts for about 35% of the annual total precipitation.

China's precipitation mainly comes from moisture brought by the southeast monsoon from the Pacific Ocean and the southwest monsoon from the Indian Ocean. Annual precipitation varies greatly across regions, following a general pattern as follows. More along the coast than inland, more in the south than in the north, more in mountains than in plains, and more on the windward slopes of the mountains where warm moist air rises than on the leeward slopes.

What is a monsoon?

A monsoon is a seasonal shift in winds that brings either a very rainy or a very dry season to a region. The winds shift because the temperature of the land and the temperature of the water are different as seasons change. Monsoons are usually associated with parts of Asia, and they can happen in many tropical and subtropical regions.

More Information



What is a monsoon?



3.2 Climate of Hong Kong

Hong Kong's climate is sub-tropical, tending towards temperate for nearly half the year. During November and December there are pleasant breezes, plenty of sunshine and comfortable temperatures. Many people regard these as the best months of the year. January and February are cloudier, with occasional cold fronts followed by dry northerly winds. It is not uncommon for temperatures to drop below 10 °C in urban areas. Sub-zero temperatures and frost also occur at times on high ground and in the New Territories.

March and April are milder although there are occasional spells of high humidity. Air traffic and ferry services are occasionally disrupted because of reduced visibility under drizzle and foggy weather.

May to August are hot and humid with occasional showers and thunderstorms, particularly during the mornings. Afternoon temperatures often exceed 31 °C whereas at night, temperatures generally remain around 26 °C with high humidity. There is usually a fine dry spell in July which may possibly last for one to two weeks, or for even longer in some years.

May to November are the months during which tropical cyclones of different intensities may strike Hong Kong, while July to September are the most likely months with tropical cyclones affecting Hong Kong. (Fig.6)

On average, about 30 tropical cyclones form in the western North Pacific or China Seas every year, and about half of them reach typhoon strength (maximum winds of 118 km per hour or more). When a tropical cyclone is

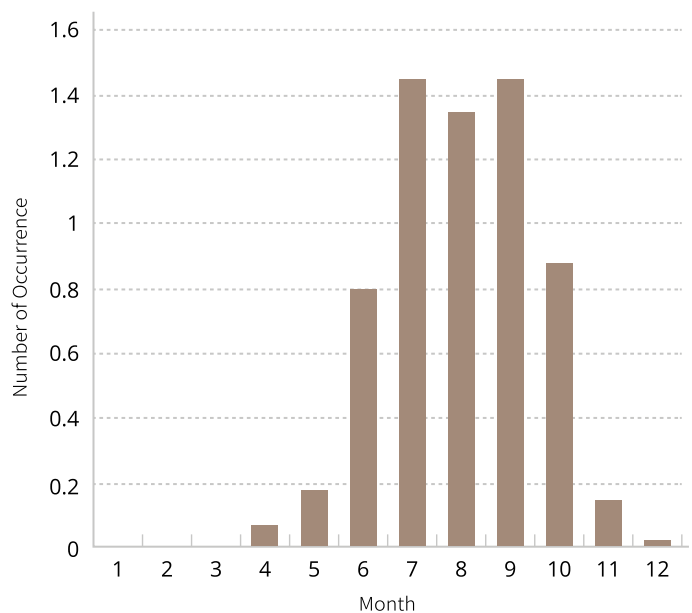


Fig 6 Monthly mean number of occurrences of tropical cyclones affecting Hong Kong (1961–2020)
Source: HKO

about 700 to 1,000 km southeast of Hong Kong, the weather is usually fine and exceptionally hot, but isolated thunderstorms sometimes occur in the evenings. If the centre comes closer to Hong Kong, winds will increase and rain can become heavy and widespread. Heavy rain from tropical cyclones may last for a few days and subsequent landslips and flooding sometimes cause considerably more damage than the winds.

The mean annual rainfall ranges from about 1,400 mm at Ping Chau to more than 3,000 millimetres in the vicinity of Tai Mo Shan. (Fig.7) About 80% of the rain falls between May and September. June and August are usually the wettest months while January and December are usually the driest months. (Fig.8)

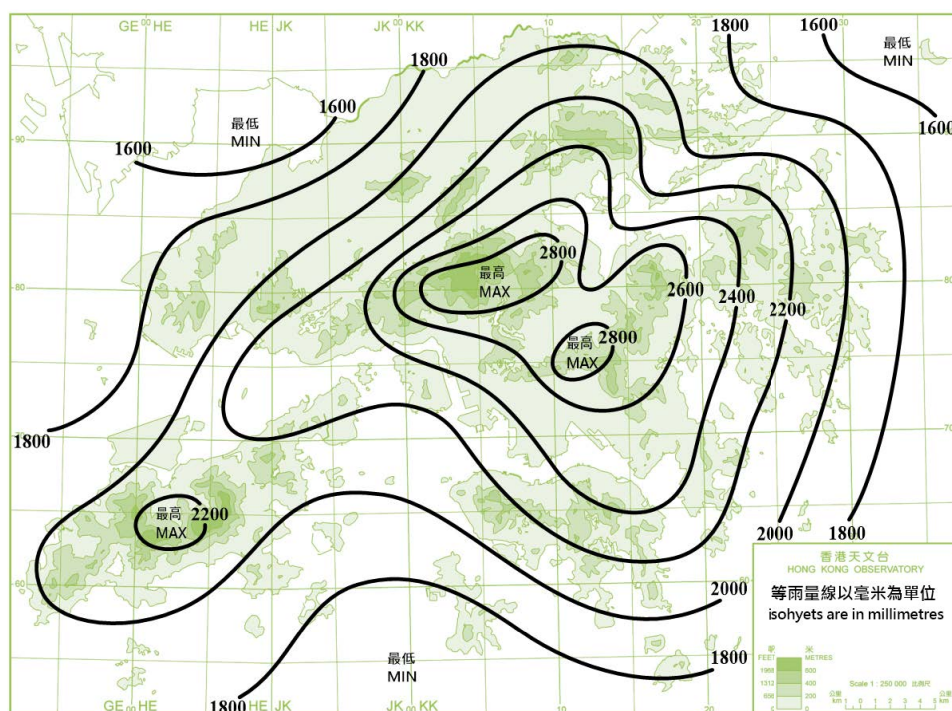


Fig 7 Average annual rainfall distribution in Hong Kong (1991–2020)

Source: HKO

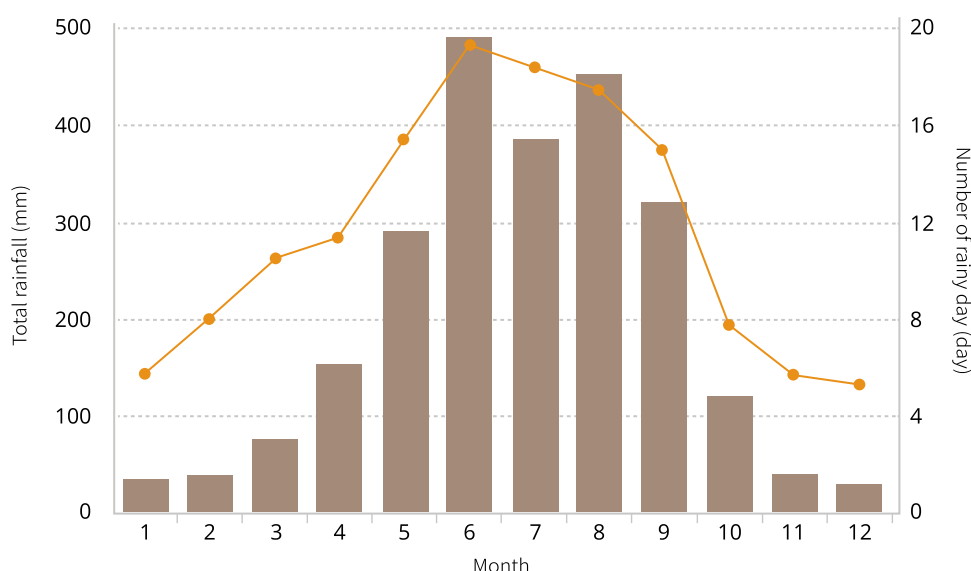


Fig 8 Monthly means of total rainfall and number of rainy day recorded at the Hong Kong Observatory (HKO) between 1991 and 2020

Source: HKO

Severe weather phenomena that can affect Hong Kong include tropical cyclones, strong winter and summer monsoon, monsoon troughs, and thunderstorms with associated squalls that are most frequent from April to September. Waterspouts and hailstorms occur infrequently, while snow and tornadoes are rare.



More Information



Climate of Hong Kong



Monthly Weather Summary



Climate Statistics

4

Scientific evidence of climate change

Numerous studies have shown overwhelming scientific evidence for climate change, with a clear scientific consensus among climate scientists. The scientific evidence of climate change is outlined in the following.



More Information



Vital indicators of
climate change —
Global temperature



4.1 Rising global surface temperature

The analyses of global temperature data from various meteorological institutions and research centers have reached the same conclusion that the average global surface temperature has been increasing significantly over the past hundred years. In January 2025, the World Meteorological Organization (WMO) confirmed that 2024 was the warmest year on record, based on six international datasets. The past ten years (2015–2024) were also the ten warmest years on record. The global mean surface temperature in 2024 was about 1.55° C above pre-industrial levels (Fig.9)

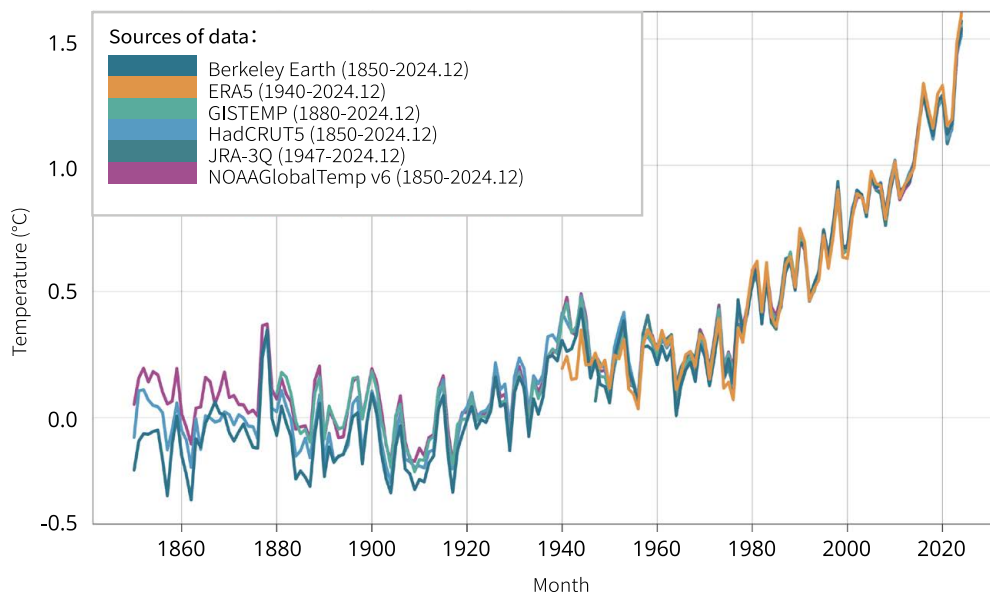


Fig 9 Annual global mean temperature anomalies (1850–2024) relative to a pre-industrial (1850–1900) baseline

Source: WMO

The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) also confirmed that global warming has significantly intensified during the last forty years between 1981 and 2020, with both the scale and intensity of warming greatly increasing when compared to the first eighty years of the 20th century (1900–1980). Warming accelerated after the 1970s, but not all regions are warming equally. (Fig.10)

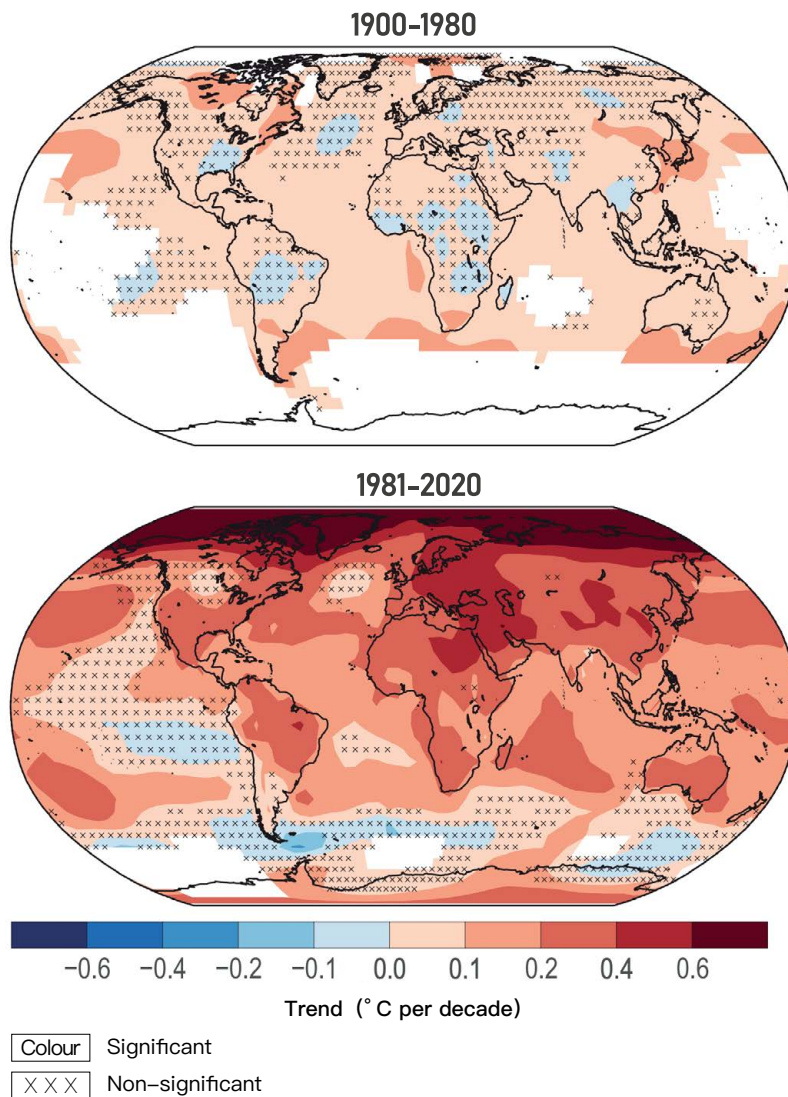


Fig 10 Changes in surface temperature ($^{\circ}\text{C}$ per decade) during 1900–1980 (upper diagram) and 1981–2020 (lower diagram)
Source: IPCC Sixth Assessment Report



More Information



Latest global temperature

Why do snowstorms and extremely cold weather still occasionally occur in some regions under global warming?

Cold events occurring in a specific place at a specific time are just weather, and do not necessarily reflect climate. Against the backdrop of natural climate variability, global warming refers to the increase in global average temperature since the 20th century as a result of human activities. Snowstorms and extremely cold weather are parts of the natural climate variability and are not precluded by global warming. However, global warming has reduced the frequency of extremely cold events over the last few decades. The frequency of extremely cold events is expected to decrease further if global temperature keeps rising in the future.



More Information



Is global warming really at work?



4.2 Increase in sea surface temperature and ocean heat content

The ocean covers more than 70% of the Earth's surface. The heat capacity of ocean is much higher than that of land. Fig.11 and 12 clearly show the long-term increasing trend of sea surface temperature and ocean heat content.



More Information

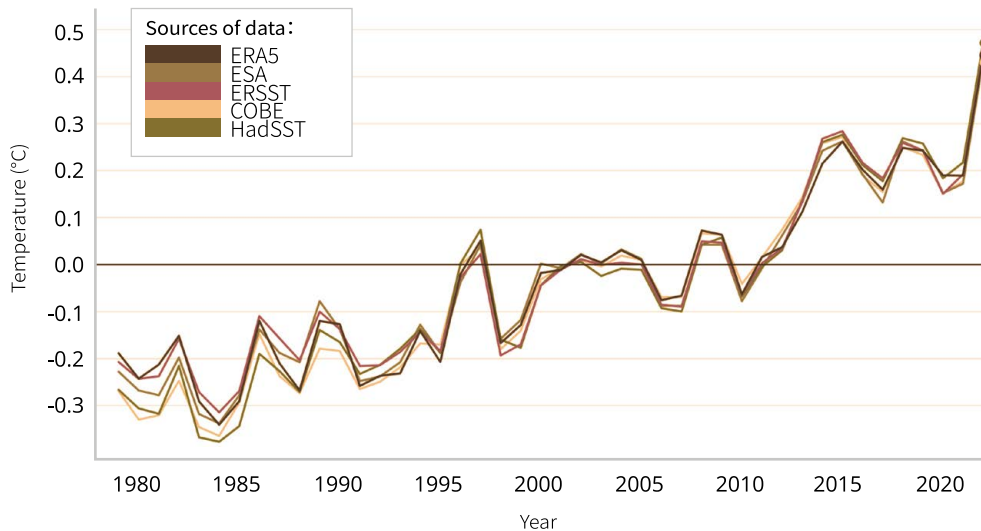


Fig 11 Anomalies in annual sea surface temperature for 60° S – 60° N (relative to the average for the 1991–2020 reference period)
Source : EU Copernicus European Earth Observation Programme



Climate change:
Ocean heat content



The latest ocean
heat content



Ocean heat as 'fuel' for
hurricanes

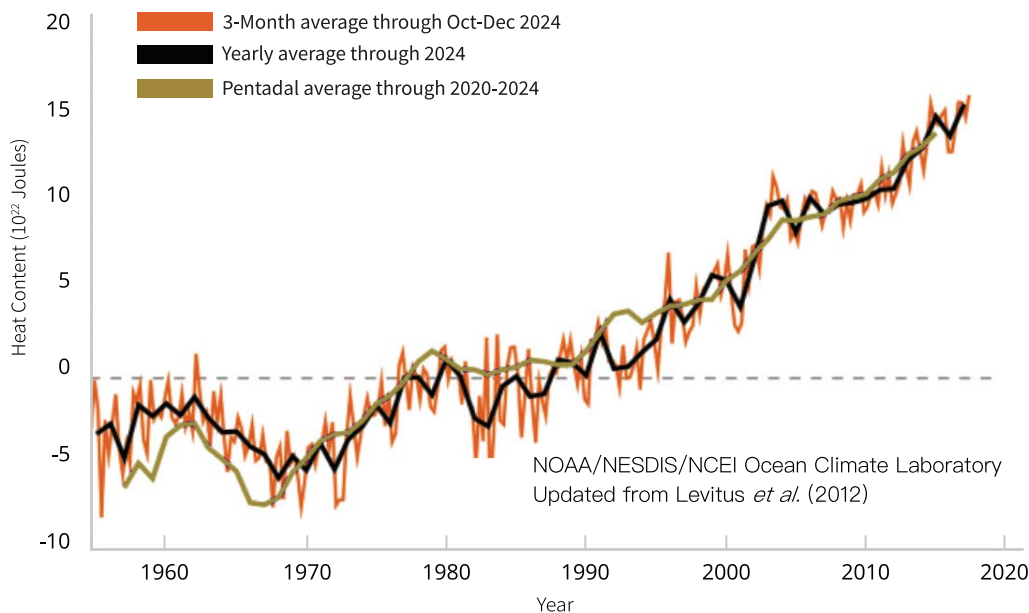


Fig 12 Global ocean heat content (0 – 700m below sea surface)
Source : US National Oceanic and Atmospheric Administration (NOAA)



4.3 Shrinking sea ice

Arctic sea ice area has been decreasing in all months, with the decline particularly prominent in summer. Studies have shown that late summer Arctic sea ice area was smaller than at any time in at least the past 1,000 years. The global sea ice extent has shown an overall decreasing trend. In recent years, Antarctic sea ice extent has fluctuated significantly and dropped to a record low in February 2023 since satellite observations began (as of 2024). (Fig.13,14,15)



Fig 13 Antarctic sea ice (2007)
Source: Acaro

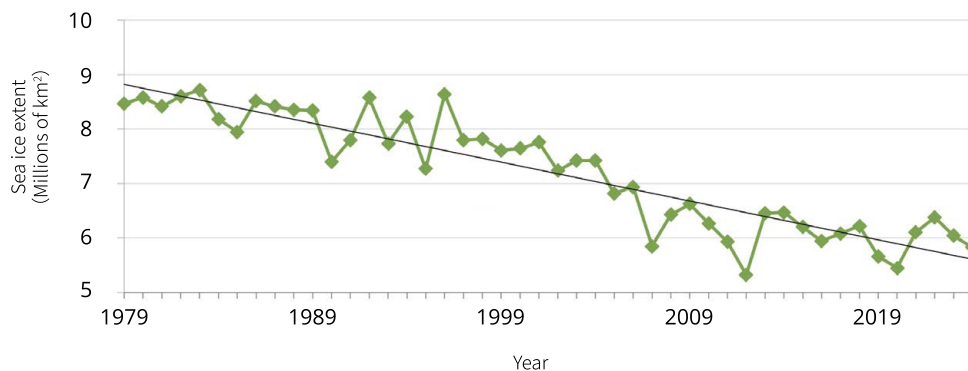


Fig 14 Arctic sea ice extent from July to September (1979–2024)
Source: National Snow and Ice Data Center (NSIDC)



More Information



Arctic interactive sea ice graph from National Snow and Ice Data Center



Change of Arctic sea ice



Change of Antarctic sea ice

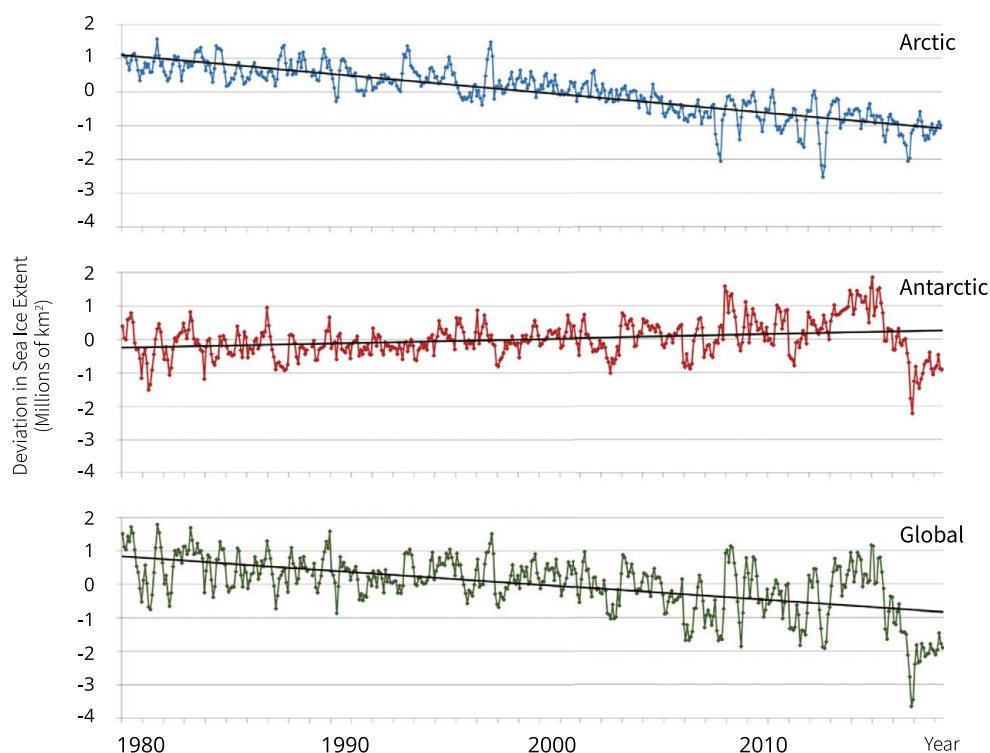


Fig 15 Arctic, Antarctic and global sea ice extent (1979–2024)
Source: National Snow and Ice Data Center (NSIDC)



4.4 Decrease in the Northern Hemisphere snow cover extent



More Information

The Northern Hemisphere spring snow cover extent has been decreasing since 1978, and there is high confidence that this trend extends back to 1950. (Fig.16)

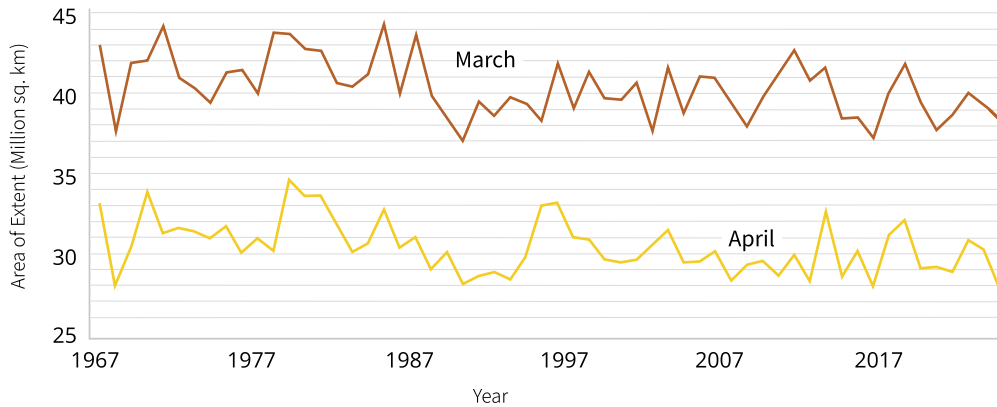


Fig 16 Change in spring snow cover extent of the Northern Hemisphere
Data Source: Rutgers University



The latest mass variation of Antarctic and Greenland ice sheets



NASA studies find previously unknown loss of Antarctic ice



4.5 Mass loss of ice sheets

An ice sheet refers to a vast area of land covered by a continuous layer of ice and snow, which is larger than 50,000 km². At present, such ice sheets are only found in Antarctica and Greenland.

Scientists measure the ice mass variations of Antarctic Ice Sheet and Greenland Ice Sheet with various methods, including satellite measurements of changes in Earth's gravity field, satellite altimetry to track changes in surface elevation and comparisons of inflow and outflow of ice sheets.

The Antarctic Ice Sheet and the Greenland Ice Sheet have lost 2,670 billion tonnes and 4,890 billion tonnes of mass respectively over the period 1992–2020. The rate of total ice sheet loss from 2010 to 2019 was more than four times that of the period from 1992 to 1999. (Fig. 17,18)

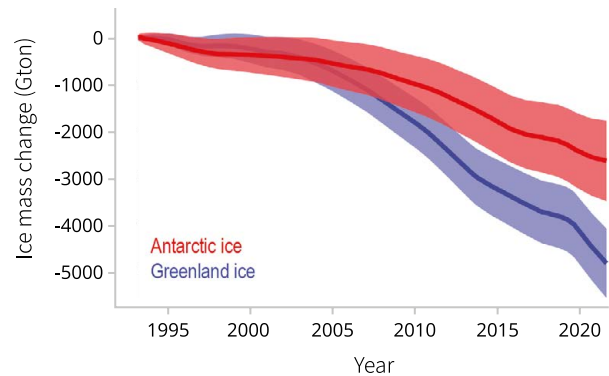


Fig 17 Cumulative Antarctic Ice Sheet (AIS) and Greenland Ice Sheet (GrIS) mass changes. The estimated uncertainties, very likely range, for the respective cumulative changes are shaded.
Source: IPCC Sixth Assessment Report

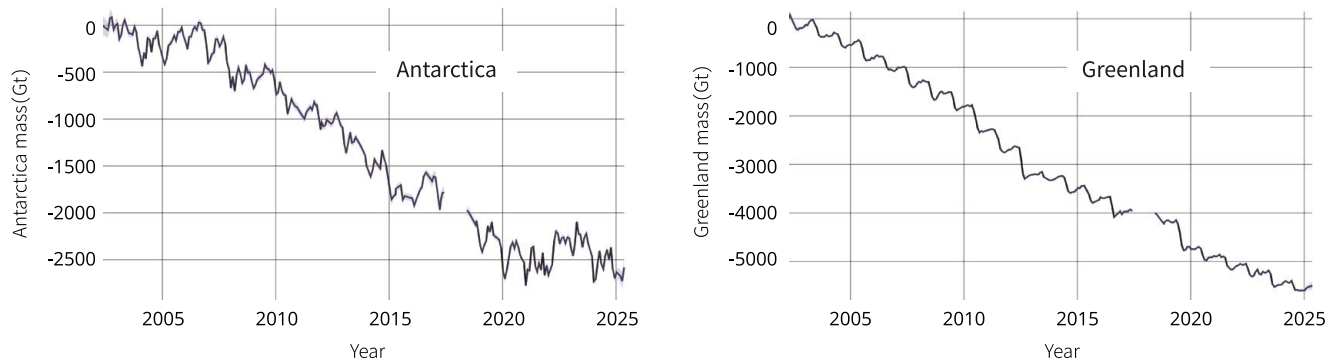


Fig 18 Mass variations of Antarctic ice sheet and Greenland ice sheet since 2002
Source: National Aeronautics and Space Administration (NASA)



4.6 Retreating glaciers

Glaciers lost 6,200 billion tonnes of mass over the period 1993–2019. Global glacier retreat since the 1950s is unprecedented in at least the last 2,000 years. (Fig. 19,20)

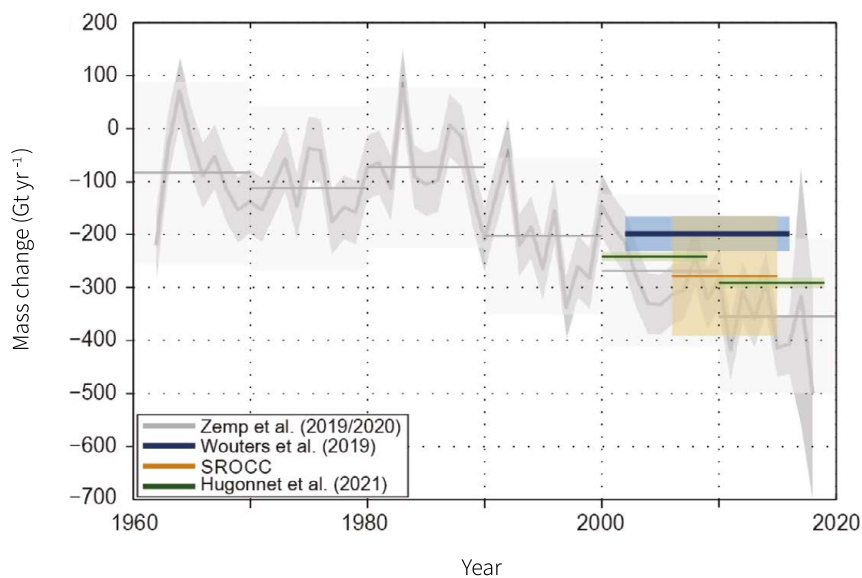


Fig 19 Annual and decadal global glacier mass change from 1961 until 2018
Source: IPCC Sixth Assessment Report



More Information



Latest glacier
mass balance



The film “Chasing Ice”
captured a large glacier
calving event in Greenland



Fig 20 Columbia Glacier, Alaska (left photo: 2009, right photo: 2015)
Source: James Balog and the Extreme Ice Survey



4.7 Sea level rise



More Information



Latest sea level

Seawater expands as it warms and the melting of land-based ice and snow adds water to the oceans, resulting in global sea level rise. The average rate of global mean sea level rise was 1.3 mm per year between 1901 and 1971, increasing to 3.7 mm per year between 2006 and 2018. Global mean sea level has risen faster since 1900 than over any preceding century in at least the last 3,000 years. (Fig. 21)

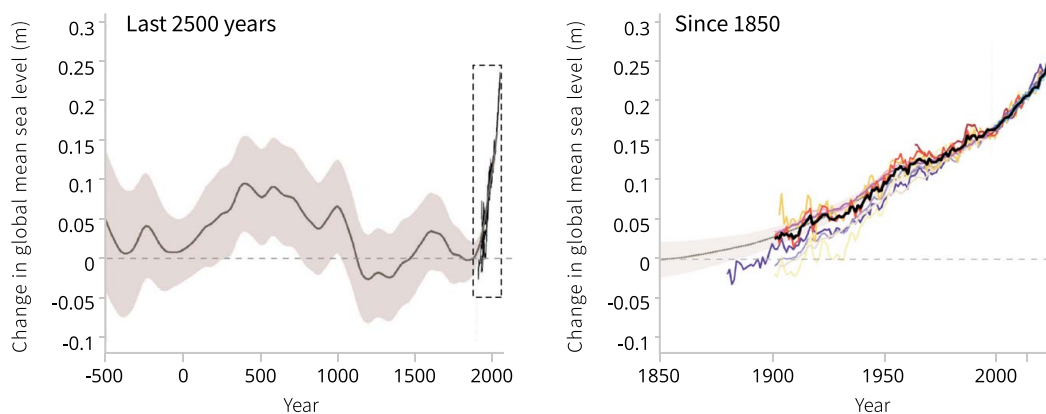


Fig 21 Changes in global mean sea level
Source: IPCC Sixth Assessment Report

As of 2024, the average rate of global mean sea level has more than doubled in the satellite altimetry era (since 1993), increasing from 2.1 mm per year (1993–2002) to 4.7 mm per year (2015–2024). In 2024, global mean sea level attained a new high in the satellite record.(Fig. 22)

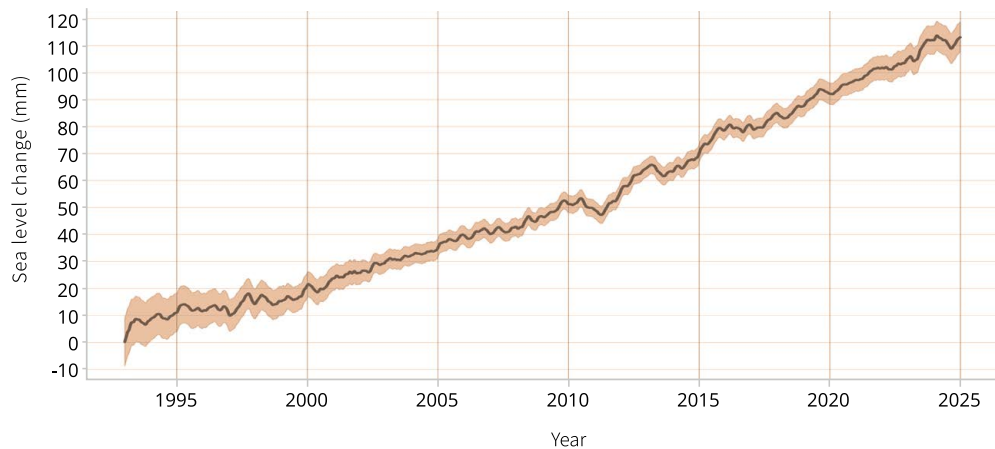


Fig 22 Global mean sea level change
(The seasonal cycle has been removed from the data. The shaded area indicates the uncertainty.)
Source: WMO State of the Global Climate 2024



4.8 More frequent extreme weather events

Human-induced climate change is affecting many weather and climate extremes in every region across the globe. Fig.23a shows that 41 regions around the world have experienced an increase in hot extremes, while Fig.23b shows that 19 regions have experienced an increase in heavy precipitation.

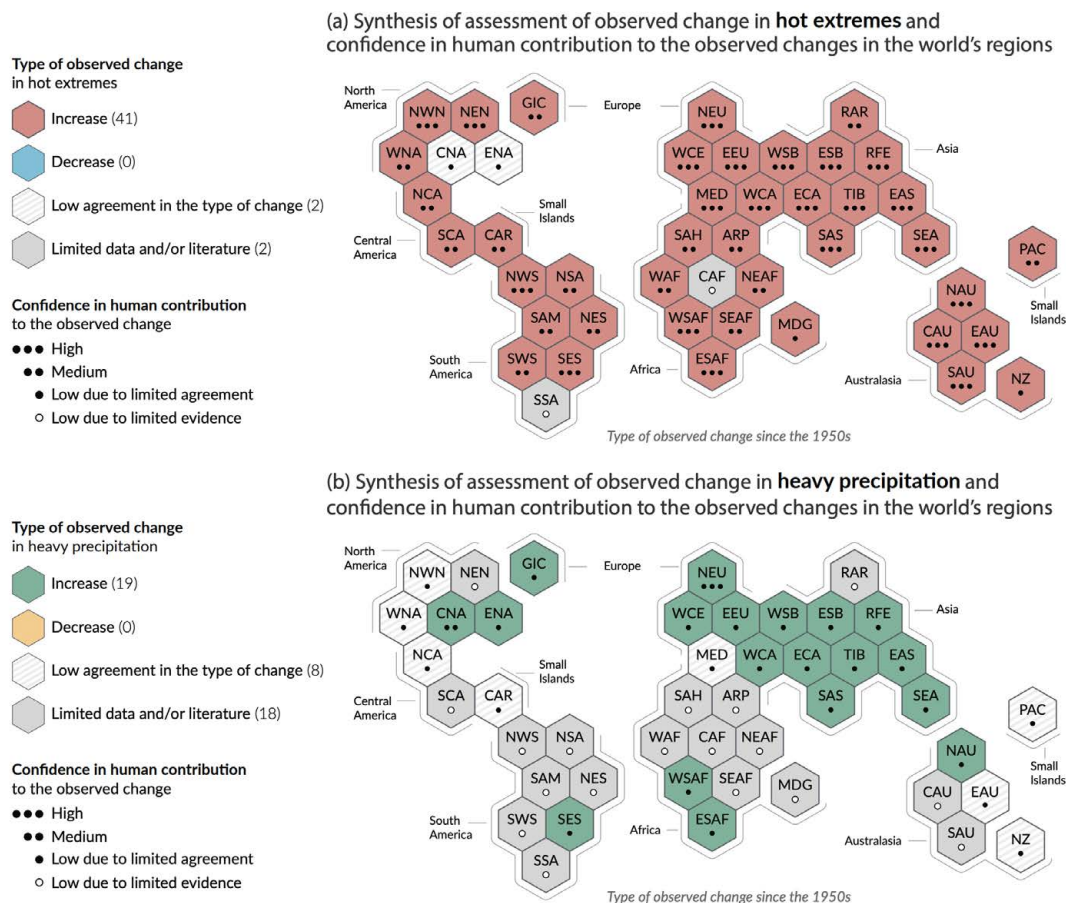


Fig 23 Assessments of human-induced hot extremes and heavy precipitation around the world
Source: IPCC Sixth Assessment Report

What is IPCC?

The Intergovernmental Panel on Climate Change (IPCC), established in 1988 by the World Meteorological Organization and the United Nations Environment Programme, is an international organization which assesses the science on climate change.

1. Main Tasks

1.1 Scientific Assessment

The IPCC conducts comprehensive assessments based on published scientific literature to evaluate and summarize the latest information on climate change, including the causes of climate change, its potential environmental and socio-economic consequences and potential future risks, and the adaptation and mitigation options to respond to its impacts.

IPCC assessments provide scientific information for climate-policy making and are also a key input into the negotiations under the United Nations Framework Convention on Climate Change (UNFCCC).

1.2 Report Compilation

The IPCC publishes assessment reports approximately every 5 to 7 years and also produces special reports and methodology reports. Experts from around the world contribute to the preparation of these reports.

The First Assessment Report in 1990 played a decisive role in the establishment of the United Nations Framework Convention on Climate Change (UNFCCC). The Second Assessment Report in 1995 provided key input to the negotiations of the Kyoto Protocol. The Third Assessment Report in 2001 and a number of special reports provided relevant information for the development of the UNFCCC and the Kyoto Protocol. The Fourth Assessment Report in 2007 confirmed that warming of the climate system was unequivocal. The Fifth Assessment Report in 2013 reaffirmed this finding and concluded that it was extremely likely that human influence had been the dominant cause behind the observed warming since the mid-20th century. This report served as the scientific foundation for the Paris Agreement. In response to the invitation of the Paris Climate Conference (COP21), the IPCC released the Special Report on Global Warming of 1.5° C in 2018.

Between 2021 and 2023, the IPCC released its Sixth Assessment Report in stages. This report reinforced that it is unequivocal that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred.

2. Working Groups and Task Force

The IPCC is composed of three Working Groups responsible for preparing the assessment reports, and a dedicated Task Force on National Greenhouse Gas Inventories, which develops methodologies for countries to measure and report greenhouse gas emissions and removals.

- | | |
|-------------------------------|--|
| a. Working Group I (WGI): | Assesses scientific aspects of the climate system and climate change. |
| b. Working Group II (WGII): | Assesses the impacts of climate change on human and natural systems. Assesses adaptation options. |
| c. Working Group III (WGIII): | Assesses how to stop climate change by limiting greenhouse gas emissions. (Known as "mitigation".) |

3. International Awards

The IPCC builds up and disseminates greater knowledge about man-made climate change, and lays the foundations for the measures that are needed to counteract such change. In recognition of this contribution, the IPCC was jointly awarded the Nobel Peace Prize in 2007 with former U.S. Vice President Al Gore.

In 2022, the IPCC was co-recipient of the Gulbenkian Prize for Humanity, along with the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

More Information



7.1 Chapter Summary

Is the climate changing?

1 Climate and weather

- Weather describes the conditions of the atmosphere in a place within a short period of time. Climate describes the average meteorological conditions in a place over a long period of time.
- The World Meteorological Organization (WMO) calculates climate parameters based on 30-year averages.

2 Global Climate

- The climate of different regions is influenced by the amount of solar energy they receive, and can be classified by latitude into tropical, temperate, and polar zones.
- Other factors affecting climate include altitude, topography, distance from the ocean, ocean currents, and prevailing wind directions.

3 Climates of China and Hong Kong

- Climate of China is affected by the monsoons, and the climate types are complex and diverse, and precipitation is unevenly distributed across time and space.
- Hong Kong has a subtropical monsoon climate, characterized by hot and humid summers and generally cool and dry winters. Common severe weather phenomenon include heavy rain, thunderstorms with associated squalls, tropical cyclones, and strong monsoons.

4 Scientific evidence of climate change

- Global surface temperatures rise. 2024 is the warmest year on record (as of 2024).
 - Sea surface temperature and ocean heat content increase.
 - Ice and snow melt at an accelerating rate.
 - Sea level rise.
 - Extreme weather events have become more frequent, with a significant increase in hot extremes in many regions around the world.
-

7.2 What are the causes of global warming?

To understand the causes of climate change, we must first understand the factors affecting the Earth's temperature, then identify whether they are natural or human-caused.

There are three factors affecting the Earth's temperature, namely, the amount of solar radiation reaching the Earth, the Earth's albedo and the atmospheric concentration of greenhouse gases. This section explains the mechanisms behind these factors and how scientists draw the conclusion of man-made climate change.

1 Factors affecting the Earth's temperature

2 Is global warming natural or human-caused?

What is global warming? What is climate change?

"Global warming" and "climate change" are closely related, but the latter has a broader meaning than the former.

"Global warming" refers to the temperature increase of the entire Earth since the early 20th century due to burning fossil fuels since the Industrial Revolution. The World Meteorological Organization (WMO) states that the global mean temperature in 2024 was about 1.55 °C above pre-industrial levels.

"Climate change" refers to a wide range of global phenomena resulting from burning fossil fuels which increases atmospheric concentration of greenhouse gases. These phenomena include "global warming", sea level rise, the mass loss of the Greenland and Antarctic ice sheets, shrinking Arctic sea ice, glaciers retreat, more frequent extreme weather events as well as changes in phenology.



1

Factors affecting the Earth's temperature

The Sun is the Earth's primary source of energy. Solar radiation reaches the Earth in the form of shortwave radiation (mainly visible light). After going through a series of physical processes including reflection, absorption, evaporation, conduction and radiation, some of the energy is directly reflected back to space, some is distributed among different Earth systems, e.g. atmosphere, ocean, land and ice sheet, and some is radiated back into space in the form of longwave radiation. (Fig. 1)

If the energy reaching the Earth exceeds the energy leaving it, a positive energy imbalance occurs, leading to the warming of the Earth. If the energy reaching the Earth is less than the energy leaving it, a negative energy imbalance occurs, resulting in cooling of the Earth.

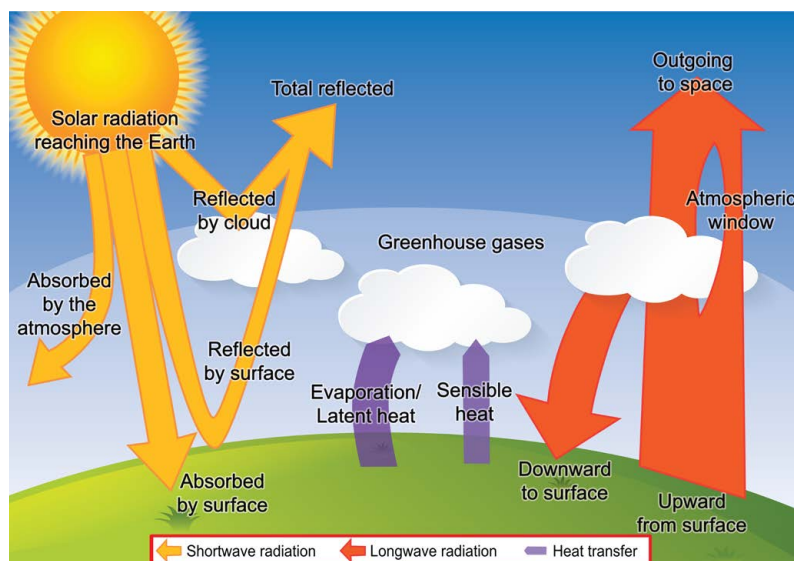


Fig 1

Earth's energy budget

There are three factors affecting the Earth's temperature, namely, the solar radiation reaching the Earth, the Earth's albedo and the atmospheric concentration of greenhouse gases.

Factors affecting the Earth's temperature		Questions	Interpretations
Solar radiation reaching the Earth	Solar activity	Has solar activity increased or decreased in recent years?	The intensity of solar activity affects the output of solar energy.
	Earth's orbit	How does Earth's orbit around the Sun influence the solar radiation reaching the Earth?	The Earth's orbit around the Sun changes over time. These orbital variations affect the distance between the Earth and the Sun, altering the amount of solar radiation reaching the Earth.
Albedo	Surface cover	Why does it matter how much of the Earth is covered by sea ice and snow cover?	Sea ice and snow have high albedo. Hence the changes in ice and snow cover play an important role in regulating the Earth's climate.
	Suspended particulates in the atmosphere	Why may volcanic eruptions increase the Earth's albedo?	Strong volcanic eruptions may lead to the formation of aerosols in the troposphere that helps to reflect large amount of solar radiation back into space.
Atmospheric concentration of greenhouse gases	Natural carbon cycle	Why is carbon dioxide of an undisturbed natural carbon cycle vital for life on the Earth?	Greenhouse gases naturally occur in the atmosphere. The atmospheric carbon dioxide regulates Earth's temperature through the natural greenhouse effect that keeps the Earth warm, creating a climate suitable for many species to flourish.
	Human activities	What is the relationship between human activities and climate change?	Human activities release greenhouse gases into the atmosphere that enhanced the greenhouse effect, causing global warming.



1.1 Solar radiation

Solar radiation refers to the energy continuously emitted by the Sun in the form of electromagnetic waves, also known as solar energy. The electromagnetic waves emitted by the Sun cover a wide range of wavelengths, but the energy is mainly distributed in the ultraviolet, visible, and infrared parts of the spectrum. Most of the energy is concentrated in the visible light and infrared regions of the spectrum, with ultraviolet radiation accounting for only a very small portion.



More Information



Climate Change:
Incoming Sunlight

1.1.1 Solar activity

Fluctuations in solar activity are natural. Satellite-based instruments have been measuring the amount of solar energy reaching the top of the atmosphere (also known as total solar irradiance, TSI) since the late 1970s. The average value of TSI has been found to be about $1,361 \text{ W/m}^2$.

Although solar activity follows a cycle of roughly 11 years, the average fluctuation of TSI over the past several solar cycles is only about 0.1%. For pre-satellite era, TSI variations had to be estimated from sunspot numbers or radioisotope analyses of polar ice and tree rings.

Fig. 2 shows that since the early 20th century, both total solar irradiance and the global average temperature have showed an increasing trend. However, since the mid-20th century, total solar irradiance has shown a decreasing trend, while the global average temperature has continued to rise.

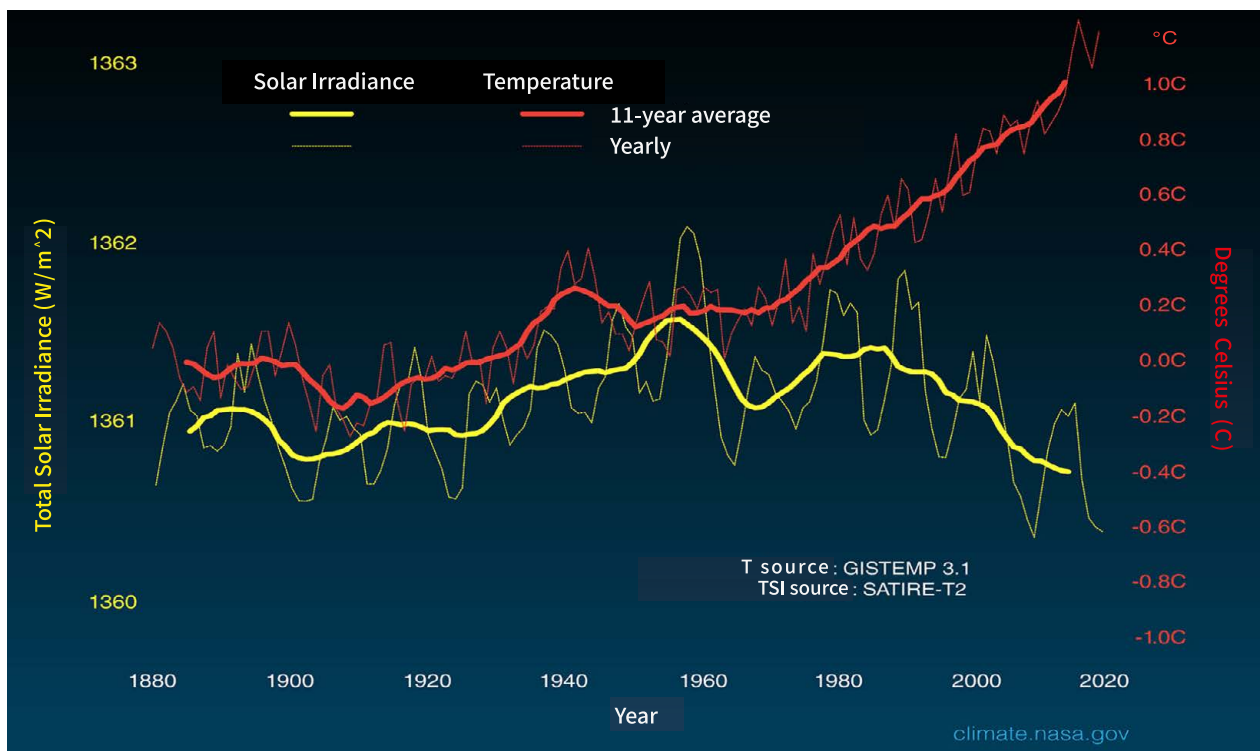


Fig 2 Total solar irradiance and global surface temperature changes
Source: National Aeronautics and Space Administration (NASA)

1.1.2 Earth's orbit (Milankovitch Cycles)

The Earth's orbit around the Sun changes throughout the time. There are also natural variations in the parameters of the Earth's rotation. In the early 20th century, Milutin Milankovitch, a Serbian astronomer, proposed that the advance and retreat of ice ages on Earth were closely related to three orbital geometric parameters of Earth's revolution around the Sun. The variations of these three parameters are referred to as Milankovitch Cycles. See Fig. 3 for further details.

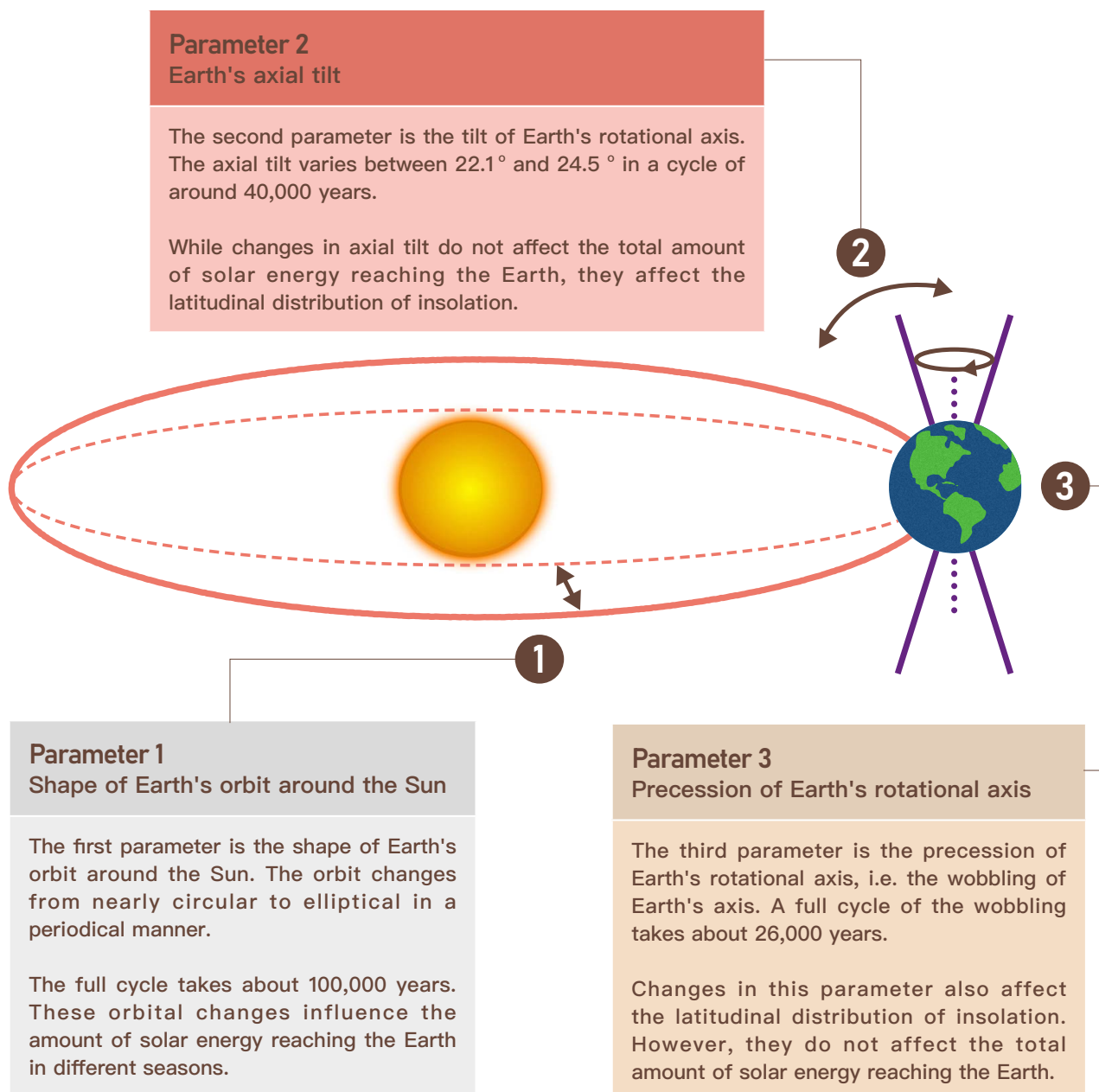


Fig 3 Milankovitch Cycles

1.1.3 Are Milankovitch Cycles responsible for recent climate change?

Milankovitch Cycles are natural variations that occur over timescales of tens of thousands of years. It is difficult to explain the Earth's abrupt warming observed over the past hundred years by Milankovitch Cycles.

According to the Milankovitch Cycles, the Earth should currently be in a cooling phase. This prediction aligns with paleoclimate studies, which reveal that the Earth had been cooling slowly for about five thousand years before the Industrial Revolution. However, this slow cooling trend spanning the past five thousand years was completely reversed by the abrupt warming in the recent century.



More Information



Will the Earth return to ice age again?



1.2 Albedo

1.2.1 Surface cover

Light-coloured surfaces (such as desert, ice and snow cover) have higher albedo than dark-coloured ones (such as forest). At the same time, oceans absorb and store a greater amount of solar radiation than land due to different physical properties. At polar areas, it is found that sea ice reflects about 50–70% of solar radiation, showing a much higher albedo than polar seas. Snow has an even higher albedo than sea ice, reflecting around 90% of the incoming solar radiation. (Fig. 4)

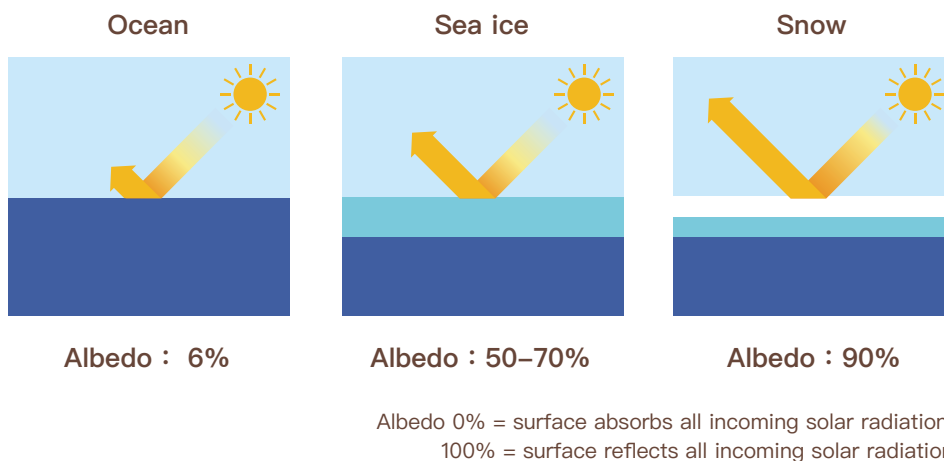


Fig 4 Albedo of different surfaces

Data Source: National Snow and Ice Data Center (NSIDC)

1.2.2 Volcanic eruptions

Volcanic eruptions are natural phenomena which release large amounts of gases, volcanic ash and particulates into the atmosphere. In small-scale eruptions, these gases and particulates are usually well contained in the troposphere, and will likely be washed out by rain within a couple of weeks. Powerful eruptions are capable of blasting large amount of sulfur dioxide (SO_2) into the stratosphere, where it reacts with water vapour to form sulfate aerosols and can remain stable for several years. These tiny sulfate particles are highly effective at reflecting solar radiation back into space, reducing the amount of solar radiation that reaches and heats the Earth's surface. These additional aerosols increase the Earth's albedo and cause a short-term cooling effect.

The 1991 eruption of Mount Pinatubo in the Philippines is one of the examples of major volcanic eruptions leading to a drop in global average temperature. The eruption lowered the global average temperature by about 0.5°C in the following 18 months. However, the temperature returned to the pre-eruption level a few years later. (Fig. 5a, 5b)



More Information



Ultimate Volcanic Expedition: The Cause of Global Warming?

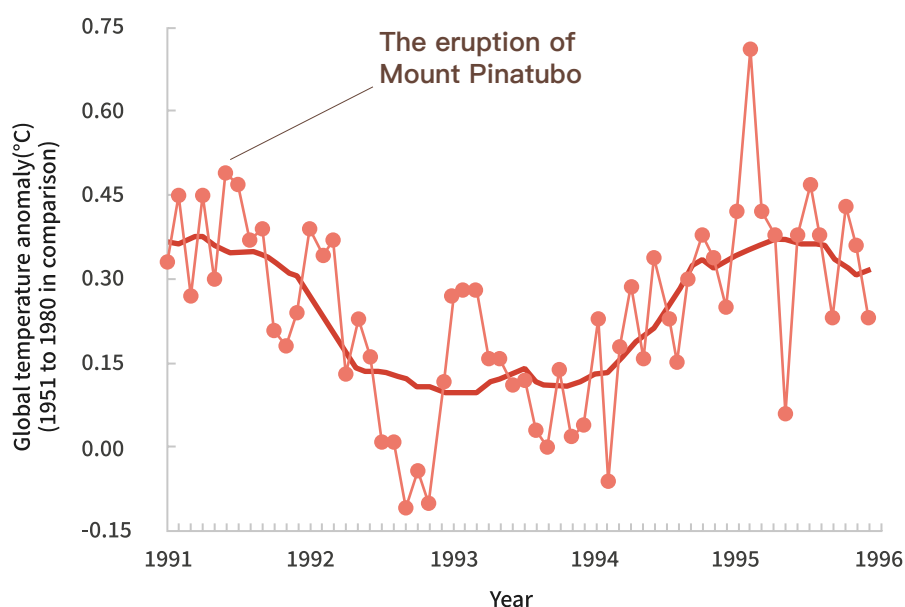


Fig 5a Global average temperature variation (1991 – 1996)

Source: HKO



Fig 5b

The eruption of Mount Pinatubo in the Philippines

Source: U. S. Geological Survey Photograph taken by Richard P. Hoblitt

Do volcanoes emit more carbon dioxide than human activities?

One of the natural factors affecting the climate is volcanic eruptions, in which carbon dioxide is released to the atmosphere. However, as indicated by various studies, over the past century, the annual amount of carbon dioxide emitted by human activities has far exceeded the total emissions from both terrestrial and submarine volcanoes. Data shows that human activities emit at least 60 times more carbon dioxide than volcanoes each year.

More Information



1.2.3 “Climate – Albedo” feedback

“Climate–albedo” feedback is a process where the change in Earth's albedo caused by climate change will amplify climate change. This process creates a positive feedback loop where warming (or cooling) of the planet will promote further warming (or cooling), creating a vicious cycle.

According to Milankovitch, the impact of the three orbital geometric parameters of Earth's revolution around the Sun on the amount of insolation reaching the high latitudes in the Northern Hemisphere, where most of the ice and snow on Earth are found, is particularly important. Variation in ice and snow cover can lead to a positive feedback mechanism.

For example, when the amount of insolation reaching the northern high latitudes decreases, summer heat is not sufficient to melt all the ice and snow precipitated in the preceding winter, leading to an overall increase of ice and snow in the course of the year. Increasing ice and snow will reflect more sunlight back into space, thereby reducing the amount of heat absorbed on Earth. This will set up a vicious cycle that supports further growth of ice and snow. Persistent increase in ice and snow year after year will eventually push the Earth into an ice age.

More Information



According to studies from 2023 and 2024, the Arctic was warming at a rate approximately three times faster than the global average. Positive “climate – albedo” feedback was a major cause of this phenomenon.

Global warming has led to the melting of ice and snow in the Arctic, exposing the darker and less reflective surfaces of land and ocean. The Arctic thus absorbs more solar energy, enhancing warming and accelerating the melting of ice and snow in a vicious cycle.





1.3 Greenhouse gases

The global climate has always been affected by factors such as solar activity, changes in the Earth's orbit, and volcanic activities. However, the continuous increase in greenhouse gas concentrations in the atmosphere has completely surpassed the effects of these natural factors since the Industrial Revolution. Climate change caused by human activities has now become one of the greatest challenges facing humanity.

1.3.1 Types of greenhouse gases

The main greenhouse gases in the atmosphere include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Data shows that the atmospheric concentrations of these greenhouse gases steadily increase. Although water vapour (H_2O) is the primary contributor to the natural greenhouse effect, it is generally believed that its concentration in the atmosphere is not directly affected by human activities.

1.3.2 Greenhouse effect

Greenhouse effect is a term that refers to a physical property of the Earth's atmosphere. If the Earth had no atmosphere, its average surface temperature would be about -18°C , a very low temperature, rather than the comfortable 15°C found today. The difference in temperature is due to a suite of gases called greenhouse gases in the atmosphere.

When solar radiation reaches the Earth, the atmosphere and Earth's surface reflect part of the insolation back into space, which is known as the Earth albedo. At the same time, Earth's surface absorbs part of the insolation, warms, and then emits infrared radiation. A small part of this infrared radiation escapes into space through the atmosphere, while most of it is absorbed and scattered in all directions by atmospheric greenhouse gases. This is how the atmosphere is warmed from below. These gases will eventually re-radiate infrared radiation back to the Earth's surface, keeping the Earth's surface and the lower part of the atmosphere warm. This process is called the natural greenhouse effect. (Fig. 6) Therefore, the concentration of greenhouse gases in the atmosphere directly influences the Earth's overall energy balance.

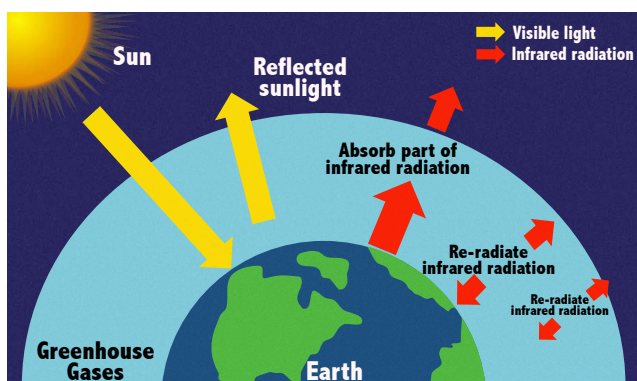


Fig 6

Greenhouse effect
Source: HKO

1.3.3 Carbon cycle

The carbon cycle is a biogeochemical cycle in which carbon is continuously exchanged and recycled among several natural reservoirs, including the atmosphere, oceans, biosphere, rocks and fossil fuels, where carbon is stored.

In an undisturbed natural carbon cycle, these exchanges between reservoirs are approximately balanced.

In the last 800,000 years before the Industrial Revolution, the atmospheric concentration of carbon dioxide fluctuated roughly between 180 and 280 ppm. However, human activities have disrupted the global carbon cycle. In 2023, the atmospheric concentration of carbon dioxide has reached 420 ppm, the highest level in the past 2 million years. (Fig.7)



More Information



Cool Met Stuff:
Greenhouse Effect



Greenhouse effect and
global warming



What is carbon cycle?

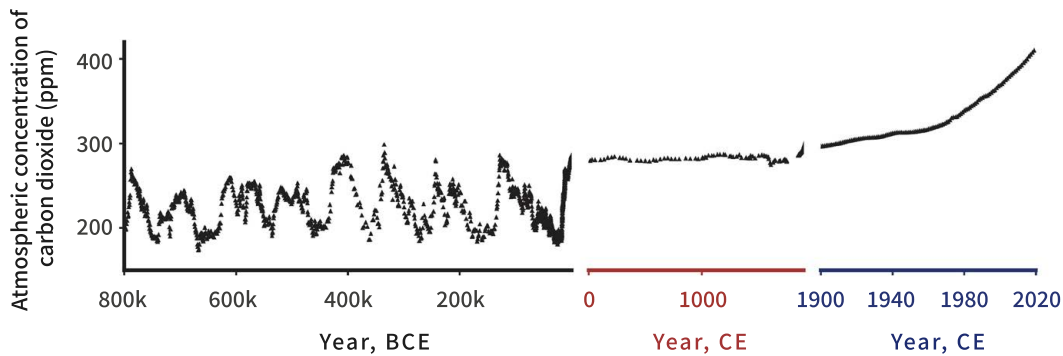
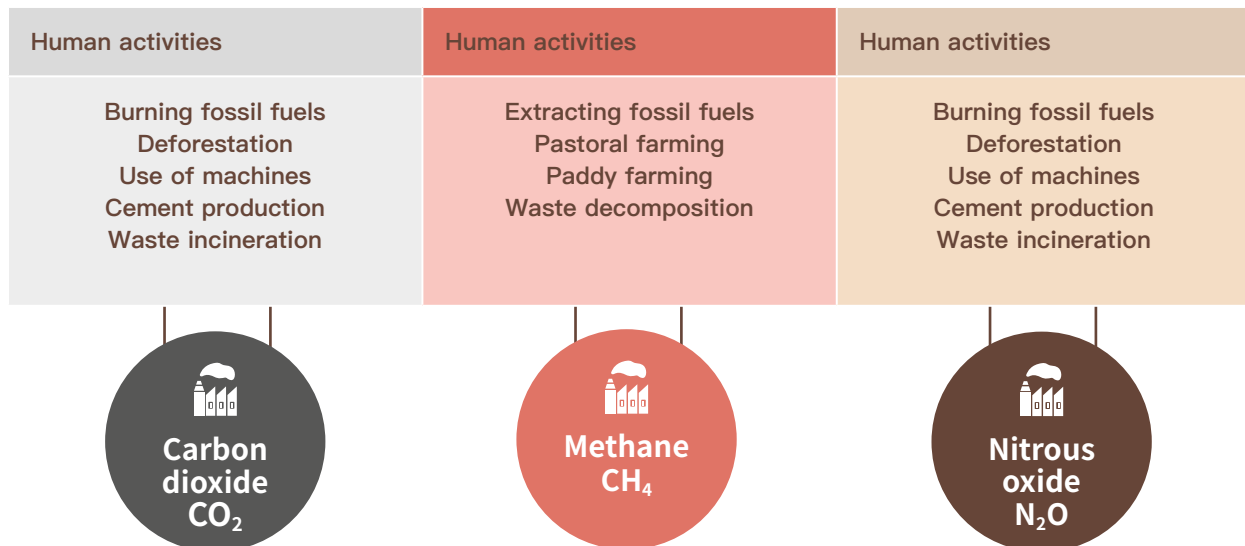


Fig 7 The atmospheric concentration of carbon dioxide
Source: IPCC Sixth Assessment Report

1.3.4 What human activities increase greenhouse gases?

Human activities emit large amount of greenhouse gases to the atmosphere, enhancing the greenhouse effect by trapping more heat energy on Earth and leading to global warming.

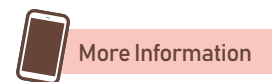


1.3.4.1 Burning fossil fuels

Fossil fuels include coal, oil and natural gas. Humans have extracted and burned massive amounts of fossil fuels for many purposes since the Industrial Revolution, such as power generation, heating and powering machines and vehicles. Large amounts of carbon dioxide, methane and nitrous oxide are emitted to the atmosphere.

1.3.4.2 Deforestation

To acquire land for agricultural and urban development, forests are cut down and then burned on a massive scale. Carbon dioxide is released from the biomass through the burning process. Moreover, plants capable of absorbing and storing carbon dioxide decrease, resulting in increasing atmospheric concentration of carbon dioxide. Data shows that around 178 million hectares of forest were lost globally for 1990–2020.



More Information



Latest atmospheric level of carbon dioxide



Historical trends in atmospheric carbon dioxide

1.3.4.3 Agricultural activities

Pastoral farming emits a lot of methane through cows ruminating, as does paddy farming. The use of large amounts of nitrogen fertilizers releases nitrous oxide. Moreover, agricultural machines are mostly powered by fossil fuels, contributing to carbon dioxide emission.

1.3.4.4 Industrial activities

Industrial activities emit large amounts of anthropogenic greenhouse gases. For example, nylon production releases nitrous oxide and the production of cement releases carbon dioxide. Chlorofluorocarbons (CFCs), which were developed and used as refrigerants and aerosol propellants in the past century, are synthetic gases, intensifying greenhouse effect.

1.3.4.5 Waste treatment

With improving living standard and the rise of consumerism, humans consume resources and produce large amount of waste as well. Waste is mainly treated by incineration or landfilling. The incineration process produces carbon dioxide, methane and nitrous oxide, while waste decomposition in landfills produces methane..

In 2023, the atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased by 51%, 165% and 25% respectively compared to pre-industrial levels. (Fig. 8)

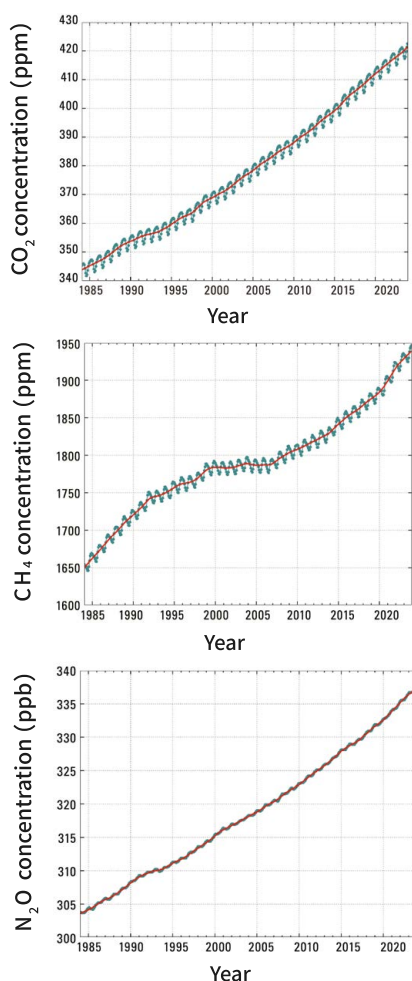


Fig 8

Trends in atmospheric concentrations of carbon dioxide, methane and nitrous oxide
Source: WMO Greenhouse Gas Bulletin



More Information



Simulation of
atmospheric carbon
dioxide



WMO Greenhouse
Gas Bulletin



Latest atmospheric
level of methane



Latest atmospheric
level of nitrous oxide

Temperature variations in troposphere and stratosphere

If solar activity were the main cause of global warming, the temperature of the whole atmosphere would be affected. If global warming is mainly caused by greenhouse gases, the increase in greenhouse gases will increase the temperature in the troposphere while the stratosphere will cool. This is a distinctive characteristic of an intensifying greenhouse effect. Data shows a rising temperature in troposphere while the stratospheric temperature has been declining since the mid-20th century.



More Information



IPCC Sixth Assessment
Report Working Group 1,
chapter 2.3.1.2.2



Couldn't the Sun be the
cause of global warming?

2

Is global warming natural or human-caused?

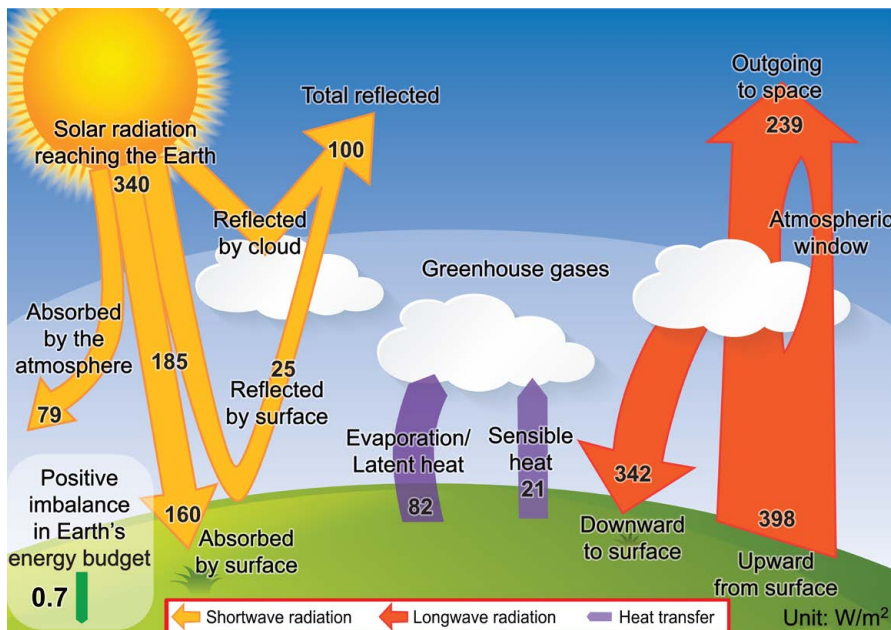


Fig 9

Present-day Earth's energy budget
Source: IPCC Sixth Assessment Report



More Information



The causes of climate change

Scientists synthesized relevant data from multiple studies, and the results indicate that the Earth's current energy budget has an approximate positive imbalance of 0.7 W/m^2 , leading to global warming. (Fig.9)

Why is there an imbalance in the Earth's energy budget? Scientists use computer climate models to simulate the change in global surface temperature over the past 170 years. Fig. 10 shows the simulation results of temperature anomalies under different scenarios. The results align with the observed changes in Earth temperature when both natural factors (solar activities and volcanic eruptions) and human factors (including changes in atmospheric greenhouse gas concentrations and land use, as well as man-made pollution) are considered. Hence, the Sixth Assessment Report of IPCC clearly points out that it is unequivocal that human influence has warmed the atmosphere, ocean and land.

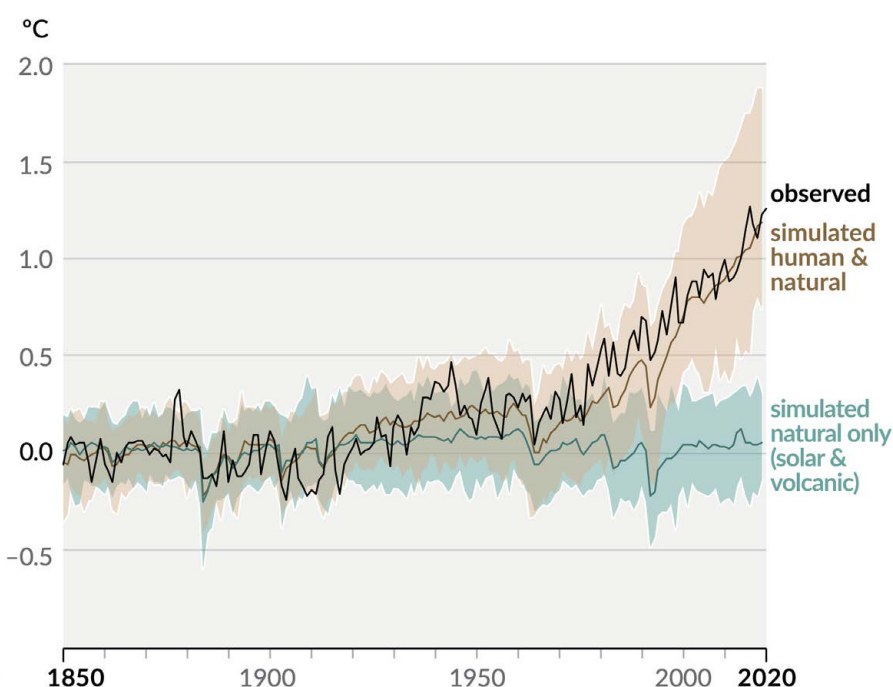


Fig 10

Changes in global surface temperature relative to 1850–1900
Source: IPCC Sixth Assessment Report



2.1 Human-driven factors



More Information



The 97% consensus on global warming

The Sixth Assessment Report of the IPCC summarizes both natural and human factors contributing to global warming. Fig. 11 (a) shows that between 2010 and 2019, the Earth's surface temperature increased by more than 1 °C compared to the baseline period of 1850–1900. Fig. 11 (b) presents attribution research assessing the contributions to global warming, which indicates that human activities are the largest contributor, while natural factors, (such as internal climate variability, solar and volcanic activities) have relatively insignificant contributions. Fig. 11 (c) illustrates findings from radiative forcing studies, which assess the contributions of different factors to global warming. These studies show that various components of human activities (including greenhouse gases, aerosols and their precursors, land use changes, and aviation contrails) have affected global warming, with carbon dioxide and methane being the most significant contributors.

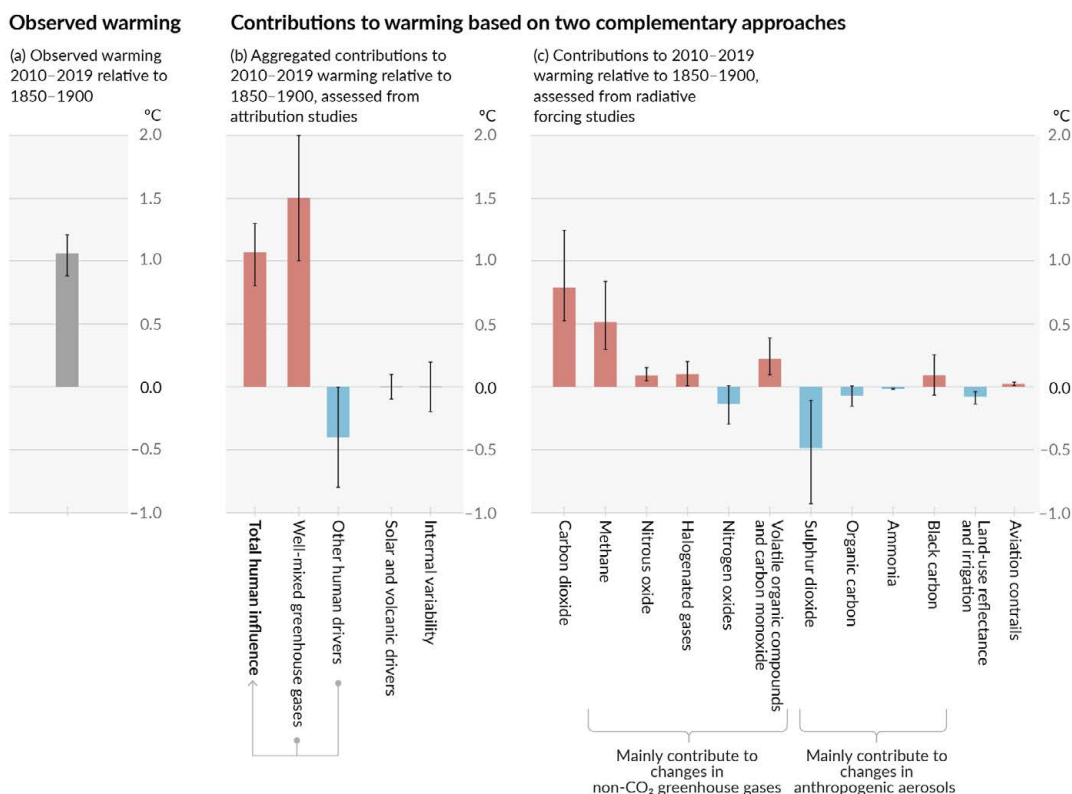


Fig 11 Assessed contributions to observed warming in 2010–2019 relative to 1850–1900

Source: IPCC Sixth Assessment Report



2.2 Scientific consensus

Over the past 30 years, many studies have examined the consensus on human-caused global warming among climate scientists. The scientific consensus has exceeded 90%. Lynas et al. (2021) randomly selected climate-related peer-reviewed papers published since 2012 for analysis. The study found that the scientific consensus on human-caused climate change exceeds 99%. (Fig.12)



Fig 12 Scientific consensus on human-caused global warming among climate scientists

Source: Skeptical Science

Assessment Reports of Intergovernmental Panel on Climate Change (IPCC)

IPCC publishes assessment reports every several years, summarizing the results of scientific research worldwide. The assessment reports represent the scientific consensus on climate change. The IPCC has published six assessment reports since 1990. The main conclusions of each report are as follows.



1990

The First Assessment Report

- Global mean surface temperature has increased by 0.3° C to 0.6° C over the last 100 years
- The magnitude of this warming is broadly consistent with climate model predictions, but it is also similar in scale to natural climate variability



1995

The Second Assessment Report

- The balance of evidence suggests that there is a discernible human influence on global climate



2001

The Third Assessment Report

- The warming over the past 100 years is very unlikely (1–10% chance) to be due to internal variability alone
- Most of the observed warming over the last 50 years is likely to have been caused by increased greenhouse gas concentrations



2007

The Fourth Assessment Report

- Warming of the climate system is unequivocal
- Most of the observed increase in global average temperature since the mid-20th century is very likely (>90% chance) due to the observed increase in human-caused greenhouse gas concentrations



2013

The Fifth Assessment Report

- Warming of the climate system is unequivocal. Since the 1950s, many observed changes are unprecedented over decades to millennia
- It is extremely likely (95–100% chance) that human influence has been the dominant cause of the observed warming since the mid-20th century



2021

The Sixth Assessment Report

- It is unequivocal that human influence has warmed the atmosphere, ocean and land. The rate of global warming is the fastest in at least the past 2,000 years. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred
- Human-induced climate change is already affecting many weather and climate extremes in every region across the globe. Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened since the Fifth Assessment Report



More Information



Global warming:
An imminent crisis

7.2 Chapter Summary

What are the causes of global warming?

1 Climate and weather

Solar radiation

- The Sun is the Earth's primary source of energy. If the energy reaching the Earth exceeds the energy leaving it, the Earth warms.
- Changes in the Earth's orbit affect the amount of solar radiation reaching the Earth, but they occur over timescales of tens of thousands of years. These changes cannot explain the abrupt warming observed over the past hundred years.

Albedo

- Surface cover, such as oceans and sea ice affects the reflection of solar radiation. Climate change leads to the melting of ice and snow, which lowers albedo and accelerates climate change, creating a vicious cycle.
- Volcanic eruptions increase the amounts of atmospheric aerosols, reflecting more solar radiation back into space and reducing the amount of heat absorbed by the Earth.



Greenhouse gases

- Greenhouse gases such as carbon dioxide, methane, and nitrous oxide naturally occur in the atmosphere. The natural greenhouse effect keeps the Earth at a habitable temperature.
- Human activities, such as burning fossil fuels, deforestation, agricultural activities and industrial activities, intensify the greenhouse effect, leading to global warming.

2 Global warming is caused by human activities



Natural factors cannot fully explain the abrupt rise in global temperature. Both research studies and simulations indicate that human activities are the primary cause of global warming.



Over 90% of climate scientists agree that human activities cause global warming, showing a strong scientific consensus.

7.3 How is the Climate Change in Hong Kong?

Hong Kong is not exempt from the impacts of climate change. In line with the global trends, Hong Kong has recorded more hot weather, more extreme rainfall and a continuing rise in sea level. With Hong Kong gradually developing into a densely populated city, urban development has also played a role in affecting the climate of Hong Kong.

- 1 Climate change in Hong Kong
- 2 How does urban development affect the climate of Hong Kong?
- 3 Microclimate

1

Climate change in Hong Kong

The Hong Kong Observatory (HKO) has been conducting meteorological observations since 1884 except during the Second World War (1940–1946). The HKO possesses more than a hundred years of meteorological observation records which are important references for climate change research in Hong Kong.


[More Information](#)


Latest temperature trend



1.1 Temperature rise

Fig. 1 shows a long-term ascending trend of the annual average temperature in Hong Kong. The annual average temperature increased at a rate of about 0.14°C per decade between 1885 and 2024. The increase has become more significant since the latter half of the 20th century.

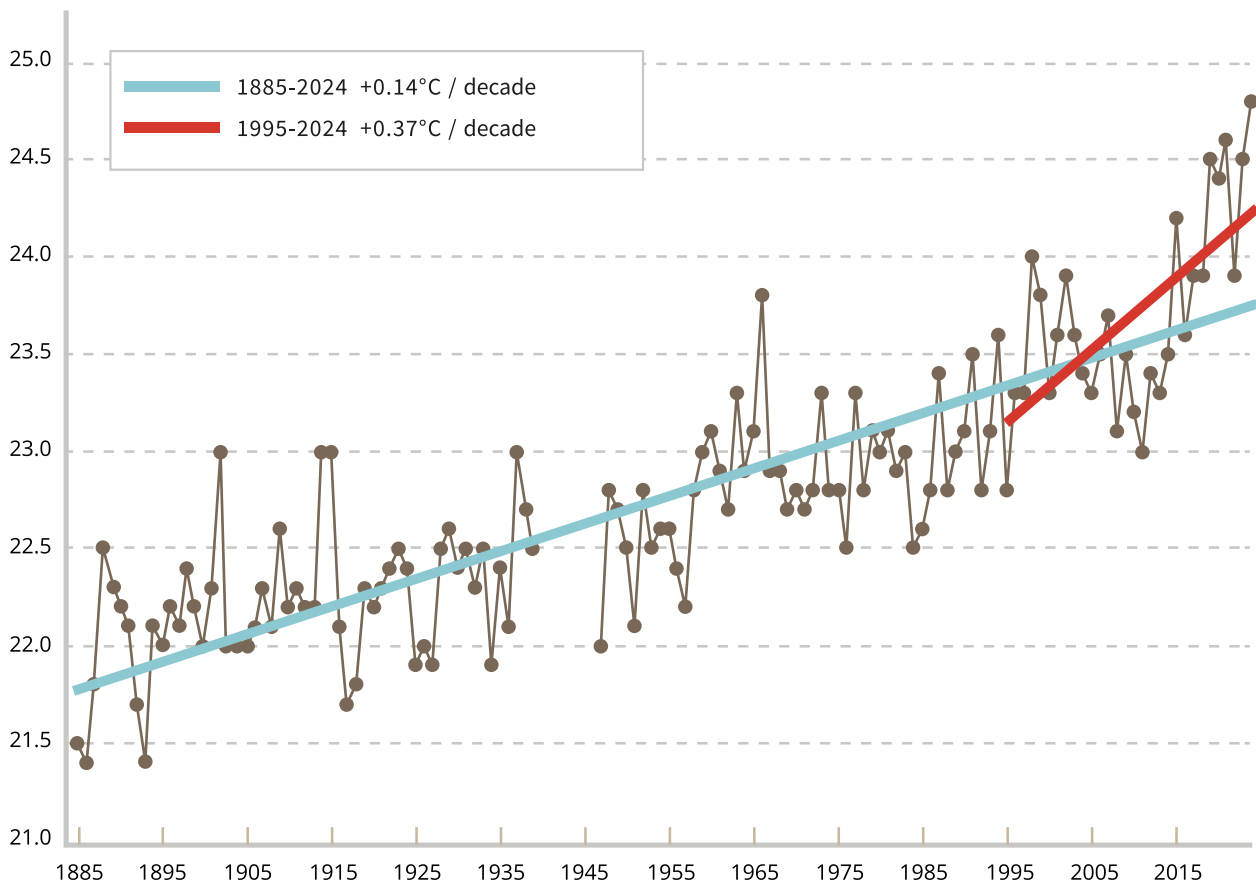


Fig 1 Annual average temperature recorded at the HKO Headquarters (1885–2024)
Source: HKO



1.2 More very hot days and fewer cold days

The numbers of hot nights (with a daily minimum temperature of 28° C or above) and very hot days (with a daily maximum temperature of 33 ° C or above) have increased by a factor of 48 and 10 respectively between 1884 and 2024. (Fig. 2a) In contrast, the number of cold days (with a daily minimum temperature of 12° C or below) shows a decreasing trend. (Fig. 2b)



More Information



Extreme weather events

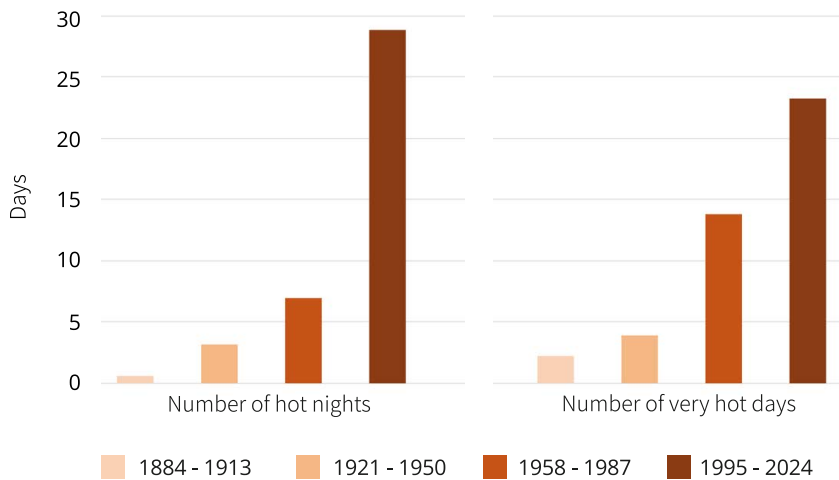


Fig 2a Change in the annual number of hot nights and very hot days in Hong Kong (1884–2024)
Source: HKO

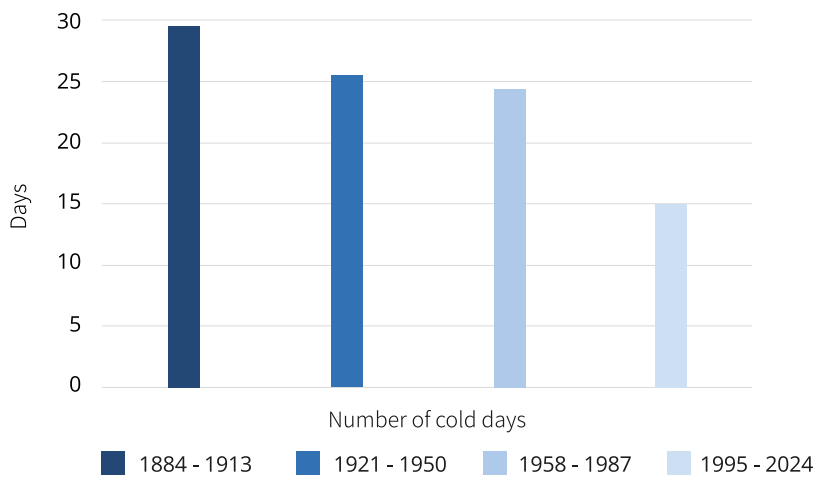


Fig 2b Change in the annual number of cold days in Hong Kong (1884–2024)
Source: HKO



1.3 More frequent and intense extreme rainfall

Recent studies show that extreme rainfall events have become more frequent and intense over the past century. In the past, the highest hourly rainfall record at the Hong Kong Observatory Headquarters used to be broken once every few decades. However, the record has been broken several times in recent decades. As of July 2025, the highest hourly rainfall recorded at the HKO Headquarters was 158.1mm, set in 2023. (Fig. 3)

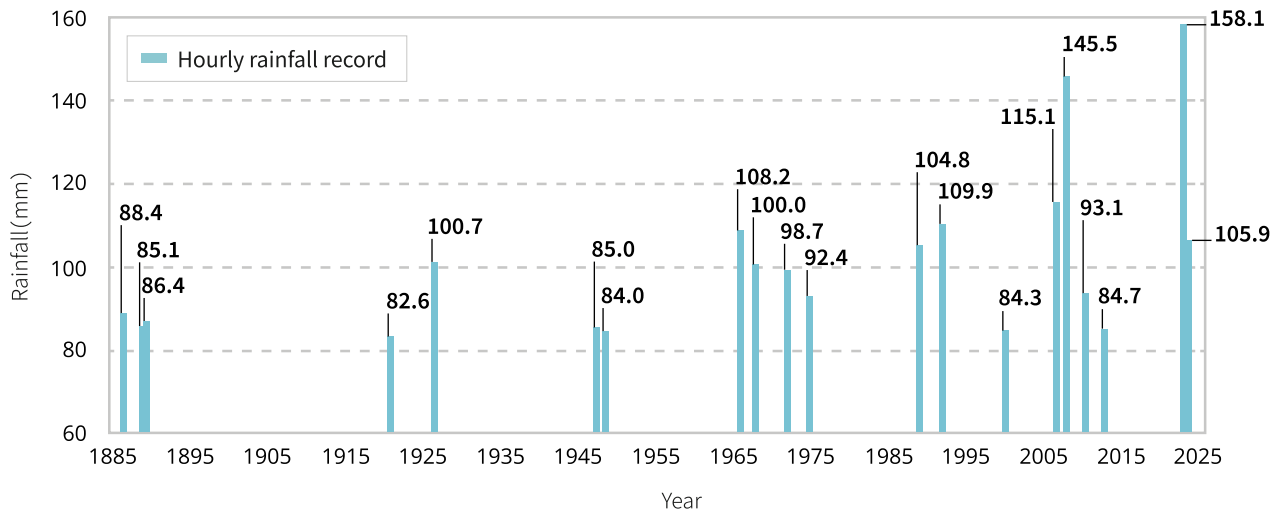


Fig 3 Top 20 hourly rainfall records at the HKO headquarters (1884–2024)

Source: HKO



More Information



1.4 Sea level rise

Tide gauge records in Victoria Harbour have indicated an obvious rise in mean sea level since 1954. On average, the mean sea level at Victoria Harbour rose at a rate of about 32 mm per decade between 1954 and 2024. (Fig. 4)

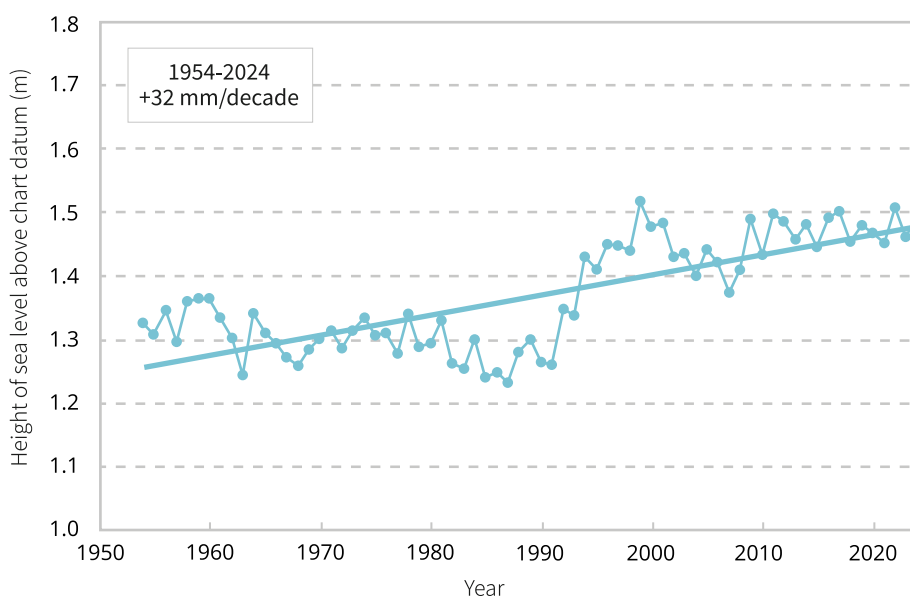


Fig 4 Annual mean sea level at Victoria Harbour (1954–2024)

Source: HKO



Ranking of highest hourly rainfall



Latest sea level trend

2

How does urban development affect the climate of Hong Kong?

Both global warming and local urban development affect the climate of Hong Kong. According to research from the HKO, urban development is one of the factors causing Hong Kong's warming and its contribution could be up to 50%.



2.1 Urban heat island effect

Urbanization leads to changes in land use, intensive building development, increased heat emissions, and a high concentration of human activities, which significantly impact the climate in urban areas. Due to the higher heat capacity of urban buildings and reduced vegetation, the heat balance in cities is affected (Fig. 5). The rate of heat dissipation in urban areas gradually becomes slower than in suburban areas, resulting in the urban heat island effect.

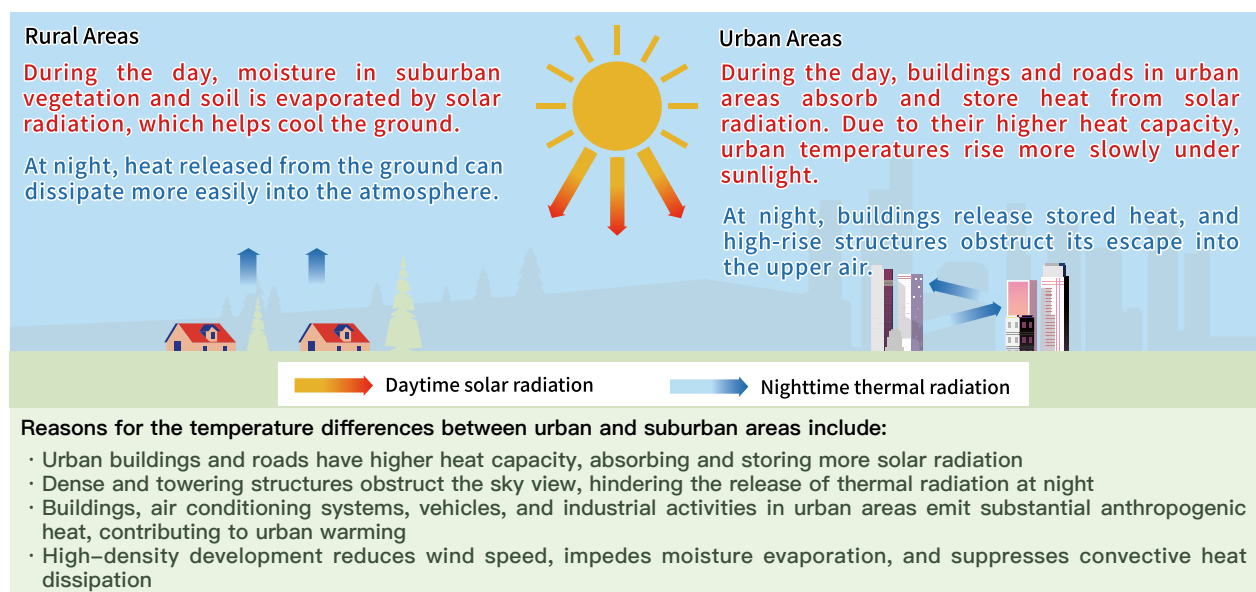


Fig 5 Impacts of urban development on the heat balance in urban areas

In Hong Kong, the urban heat island effect is primarily a nighttime phenomenon and is more significant in winter, especially under stable atmospheric conditions, light winds and clear sky. Fig 6 shows an example from 2021. Under the influence of a continental airstream over southern China, the weather in Hong Kong was fine and dry on 12 and 13 January, 2021. At the night of 12 January and the early morning on 13 January, light winds and clear sky enhanced the radiation cooling, bringing the temperature at Ta Kwu Ling down to a minimum of -0.9°C in the early morning of 13 January. Due to urban development, the cooling in urban areas was much slower than that in rural areas and the minimum temperature recorded at the HKO Headquarters in Tsim Sha Tsui was 10.4°C , more than 11°C higher than that at Ta Kwu Ling.

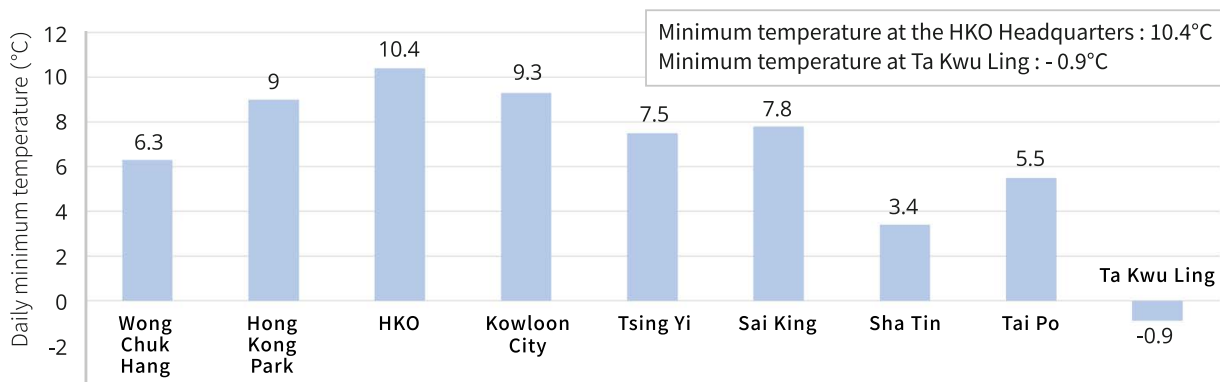


Fig 6 Minimum temperatures in urban and rural areas of Hong Kong on 13 January 2021

Source: HKO



2.2 Impact of urban development on surface winds

The high-rise buildings and dense urban development in Hong Kong have increased land surface friction, obstructing airflow and reducing wind speed in urban areas. Fig. 7 shows that there was no obvious trend in the annual average wind speed at Waglan Island between 1968 and 2024, while the wind speed at King's Park in urban area exhibited a significant downward trend between 1968 and 1990s, but has remained relatively stable since 2000.

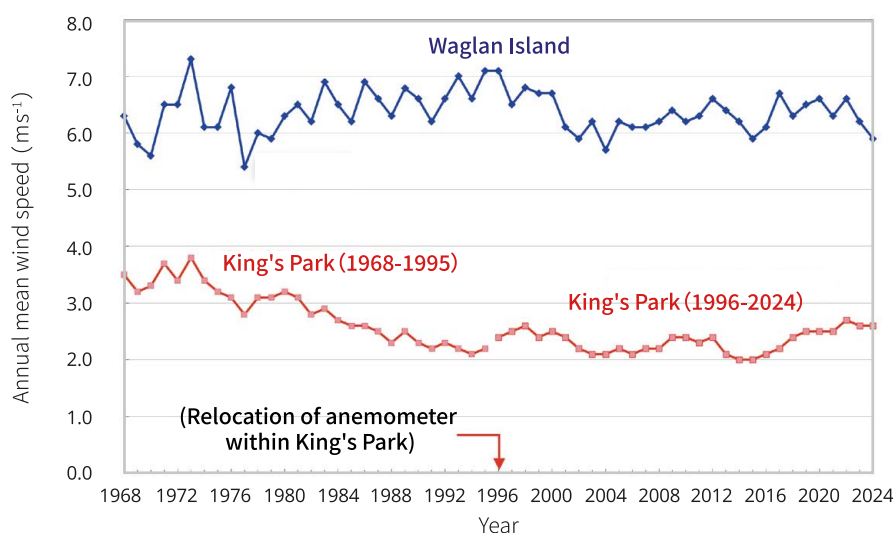


Fig 7 Annual mean wind speeds at King's Park and Waglan Island (1968–2024)

Source: HKO



More Information



Buildings with wall effect



2.3 Other impacts of urban development

Between 1961 and 2024, the annual mean cloud amount in Hong Kong increased at a rate of 1.0% per decade, with the most significant increase occurring from the 1960s to the mid-1980s. (Fig.8) One possible reason for the increase in cloud cover is that human activities release suspended particulates into the atmosphere, increasing the concentration of condensation nuclei and favouring cloud formation. In addition to the increased condensation nuclei in the atmosphere, the urban heat may enhance convection. Both factors favour precipitation. Research from the HKO indicates that the increasing trend in rainfall in urban areas was higher than that in the New Territories and offshore areas between 1956 and 2005.

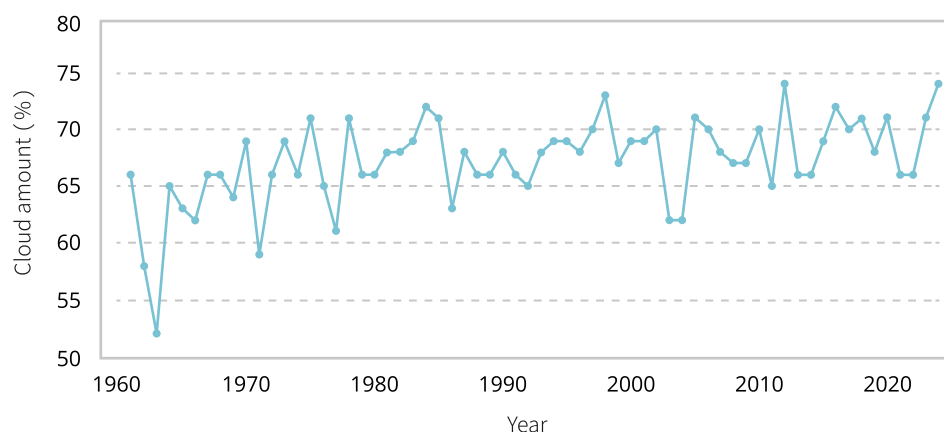


Fig 8 Annual mean cloud amount recorded at the HKO Headquarters (1961–2024)

Source: HKO

Increases in cloud amount and suspended particulates reduce the amount of solar radiation reaching the Earth's surface. The amount of solar radiation observed in Hong Kong showed a significant decreasing trend from 1968 to the early 1980s. From the 1980s to the 1990s, the solar radiation levels remained relatively stable, while an increasing trend has been observed since 2000. (Fig. 9)

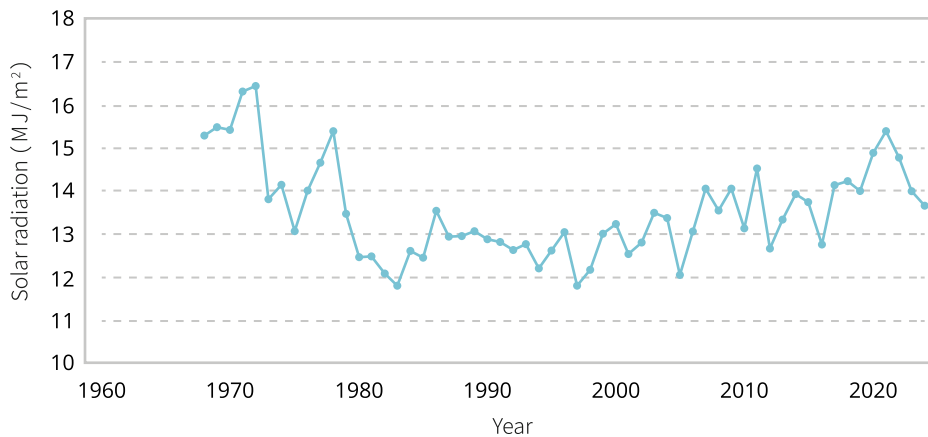
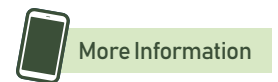


Fig 9 Annual mean daily total global solar radiation recorded at King's Park (1968–2024)
Source: HKO



Climate change in Hong Kong — cloud amount, solar radiation and evaporation

Relative humidity is affected by air temperature and the amount of water vapour in the air. With the same amount of water vapour in the atmosphere, relative humidity decreases with increasing temperature. During the day, the temperature rise in the rural areas is significantly higher than that in urban areas, resulting in lower relative humidity in rural areas. In the evening, the rural areas cool faster than urban areas, leading to higher relative humidity in rural areas. (Fig. 10)

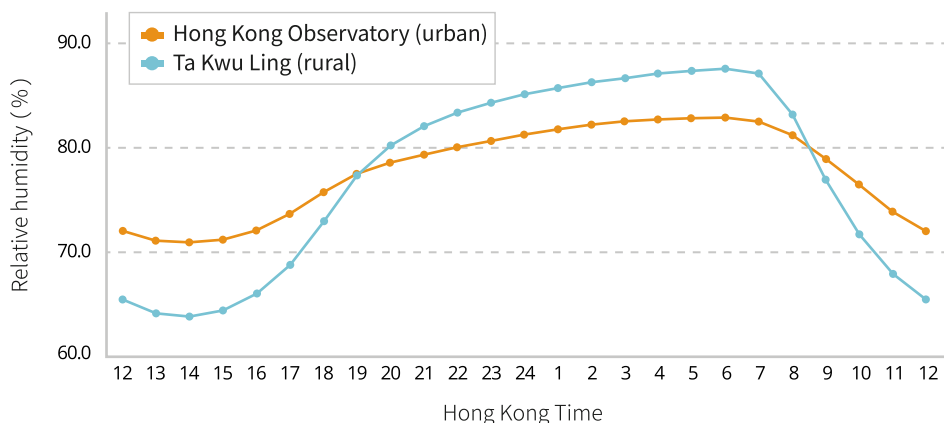


Fig 10 The average diurnal variation of relative humidity at the HKO and Ta Kwu Ling (1989–2024)
Source: HKO

Urban heat island effect and global warming

Urban development causes the urban heat island effect, which makes cities warmer. However, the impact of the urban heat island effect is confined to cities and has limited contribution to global warming. The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) points out that the urban heat island effect has raised global land surface air temperature trends by no more than 10% over the past hundred years.



2.4 Measures to mitigate the urban heat island effect

2.4.1 Enhance urban greening

Trees help with cooling. The temperatures under tree shade are much lower than those on concrete or asphalt surfaces exposed to sunlight. The yellow and orange areas in the thermal image in Fig.11a show that road surfaces and buildings exposed to direct sunlight (as shown in the photo in Fig.11b) have relatively higher temperatures. The blue and dark blue areas show that the temperatures are relatively lower in areas under tree shade. The temperature difference can be 10° C or more. Therefore, increasing the urban greening ratio can offer more tree shades and create a cooler environment for pedestrians.

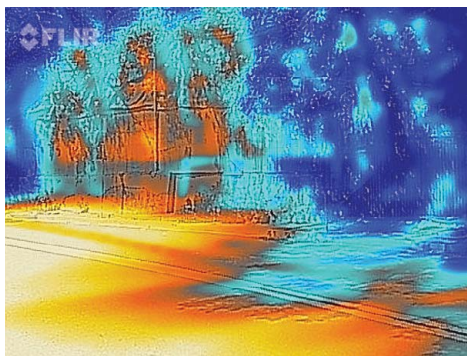


Fig 11a Thermal image



Fig 11b Photo

In addition, increasing urban vegetation coverage, such as through green roofs and vertical greening on building exteriors, can provide shade, reduce surface temperatures, and contribute to cooling through plant transpiration.

2.4.2 Improve building materials

The use of green building materials with high reflectivity and thermal emissivity (such as applying white or reflective coatings on roofs and walls, or paving surfaces with highly permeable materials) can significantly reflect solar radiation, enhance ground moisture evaporation, and reduce surface heat absorption, thereby effectively lowering urban temperatures.

2.4.3 Improve urban planning

Urban planning and design play a crucial role. Building volume, building height, city ventilation and green coverage should all be considered in the planning stage. For example, increasing the distance between buildings can reduce the “wall effect”, enhance natural ventilation and mitigate the urban heat island effect.

3

Microclimate

Although Hong Kong is a small place, the climatic characteristics at a certain location may be different from those prevailing in the surrounding large area. This is due to variations in geographical locations, site environment and weather conditions at a certain time. Even in the same district, the temperature and humidity at different locations can be different. We call this phenomenon “microclimate”.

Microclimate is a specific climatic condition within a small area, mainly affected by factors such as topography, wind direction, building orientation and density, etc.

Take a more prominent example, winds over roads at the city centre or the leeward side of high-rise buildings are generally weaker. Together with other factors such as traffic and heat from buildings, the aforesaid regions become stuffy and heat accumulates, leading to higher temperatures. On the other hand, temperatures over coastal or windward areas are usually relatively lower (Fig. 12). Besides, the construction materials and building density in the urban area also affect the diurnal variations of air temperatures (Fig. 13).



More Information

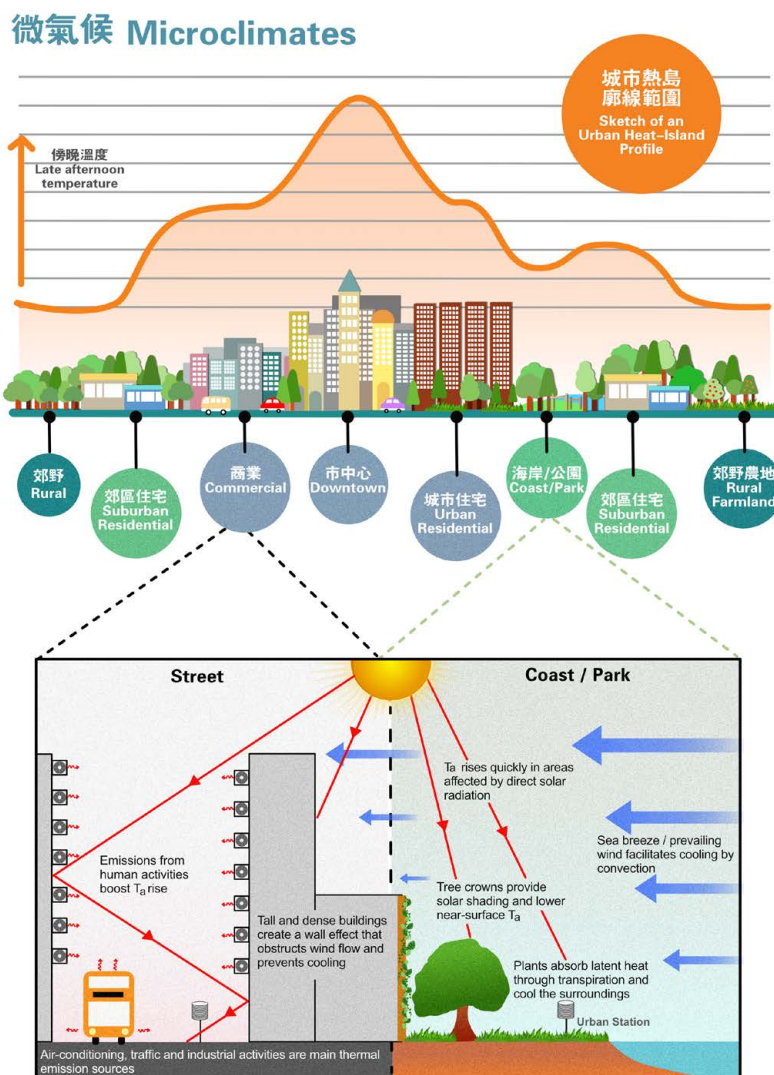
Smart weather:
microclimate

Fig 12 Sketch of an urban heat island profile (top) ; impact of environmental factors and human activities on microclimate (bottom)

Source: HKO

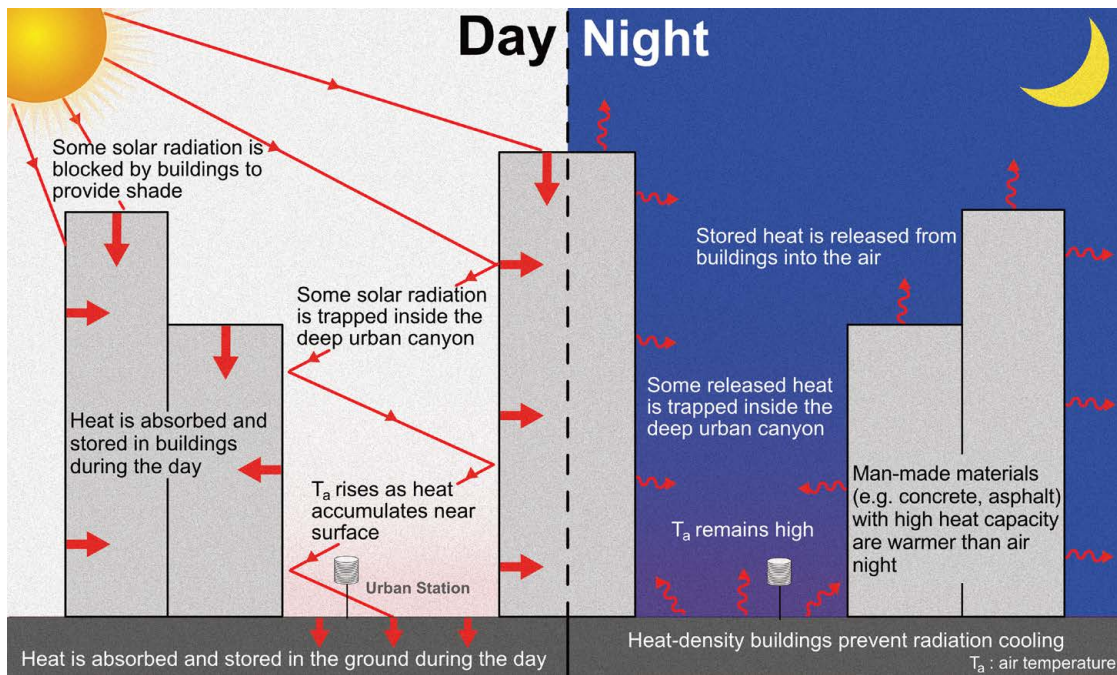


Fig 13 The effects of construction materials and building density on diurnal variations of air temperatures.
Source: HKO

To have a better understanding of the city's microclimate for improving weather information services, Hong Kong Observatory (HKO) has set up a number of urban meteorological monitoring stations ("urban stations" in short) in various districts. While traditional weather stations (e.g. the Meteorological Garden at the HKO Headquarters) are typically set up on lawns, the urban stations are located very close to urban infrastructure and activities (Fig.14 (right)).



More Information



Automatic Regional
Weather Forecast in
Hong Kong & Pearl River
Delta Region



Fig 14 Screenshot of Observatory's "Automatic Regional Weather Forecast in Hong Kong & Pearl River Delta Region" webpage at 11 a.m. on 28 July 2022 (left), showing temperatures recorded at Meteorological Garden at the Hong Kong Observatory Headquarters, the urban stations at Mong Kok and Star Ferry Pier (Tsim Sha Tsui) (right).
Source: HKO

Urban stations can collect microclimate data over the living environment of the public. For example, at 11 a.m. on 28 July 2022 (Fig. 14 (left)), the difference in temperature recorded at the Meteorological Garden in the HKO Headquarters, compared to that recorded at the urban station at Mong Kok, was as large as 4°C, although both are located in the same Yau Tsim Mong District. In addition, it was continuously sunny and very hot in Hong Kong during mid- to late July 2022. Time series traces of hourly average temperatures recorded at the HKO Headquarters and neighbouring urban stations showed significant differences in diurnal variation patterns (Fig.15). Urban microclimate studies can provide basic urban climate information to help improve town planning.

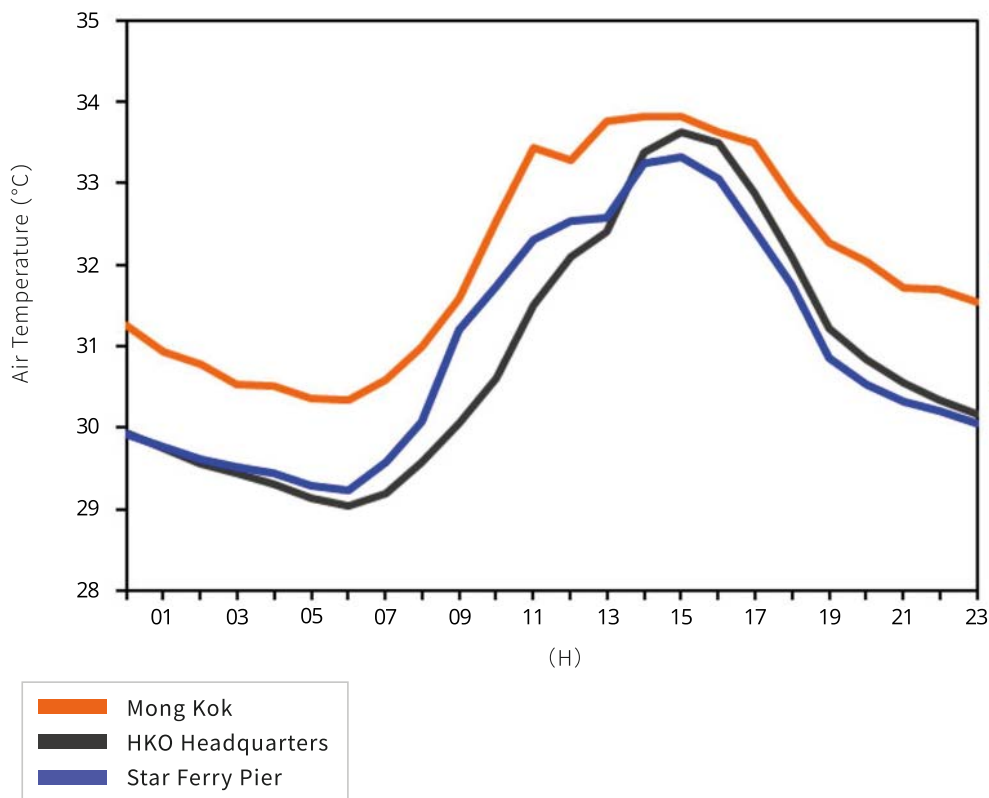


Fig 15 Time series of the hourly average air temperature from 9 to 31 July 2022 at different weather stations.
Source: HKO

7.3 Chapter Summary

How is the Climate change in Hong Kong?

1 Climate change in Hong Kong

The HKO has been conducting meteorological observations since 1884, providing important references for climate change research in Hong Kong.

Temperature rise

The annual average temperature increased significantly, at a rate of about 0.14 °C per decade between 1885 and 2024. The increase has become more pronounced in the latter half of the 20th century.

Changes in extreme weather

Over the past hundred years, the numbers of very hot days and hot nights have increased significantly, while the number of cold days decreased. Extreme rainfall events have become more frequent and intense. As of July 2025, the highest hourly rainfall recorded at the HKO Headquarters was 158.1mm, set in 2023.

Sea level rise

Mean sea level at Victoria Harbour has indicated an obvious rise. On average, the mean sea level rose at a rate of about 32 mm per decade between 1954 and 2024.

2 Impacts of urban development

 In addition to global warming, urban development also affects the climate of a city. The climate of Hong Kong, including temperature, wind speed, rainfall, and cloud amount, is influenced by both global warming and urbanization.

3 Microclimate

 Due to differences in geographical location and surrounding environment, distinct differences in microclimates can exist across different areas of Hong Kong. Urban meteorological monitoring stations collect microclimate data, which helps improve urban planning.

7.4 How will climate change affect us?

This section introduces the impacts of climate change on the natural environment and human society, and discusses the impacts on biodiversity, public health and the economy

1

Impacts on the natural environment

2

Impacts on human society

3

Impacts on Hong Kong

1

Impacts on the natural environment

Climate change disrupts the delicate balance of ecosystems. In response to the changing climate, some terrestrial, freshwater and marine species change their geographical distributions, seasonal behaviours, migration patterns, population sizes, and interactions with other species. Species that cannot adapt quickly enough to the changing climate may decline in number or even face extinction.



1.1 Geographical distribution of species

For those species unable to adapt to warmer environments, they must migrate to cooler areas. While terrestrial species migrate to higher latitudes or elevations, marine species migrate to higher latitudes or deeper oceans. Examples:

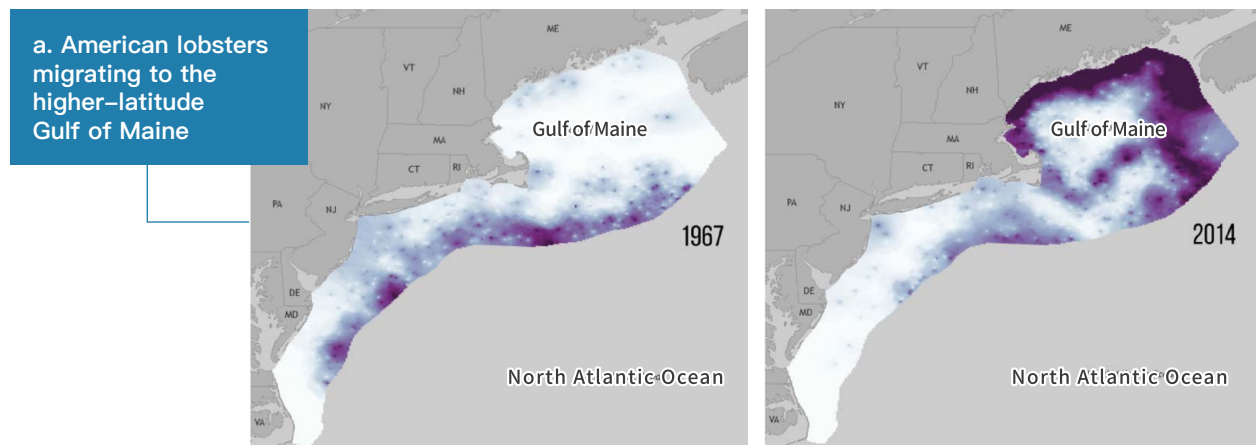


Fig 1

Amounts of lobster caught

Change in American lobster distribution

low

mid

high

Source: NOAA

b. The prairie climate of the Midwest in North America shifting northward into boreal forest zone

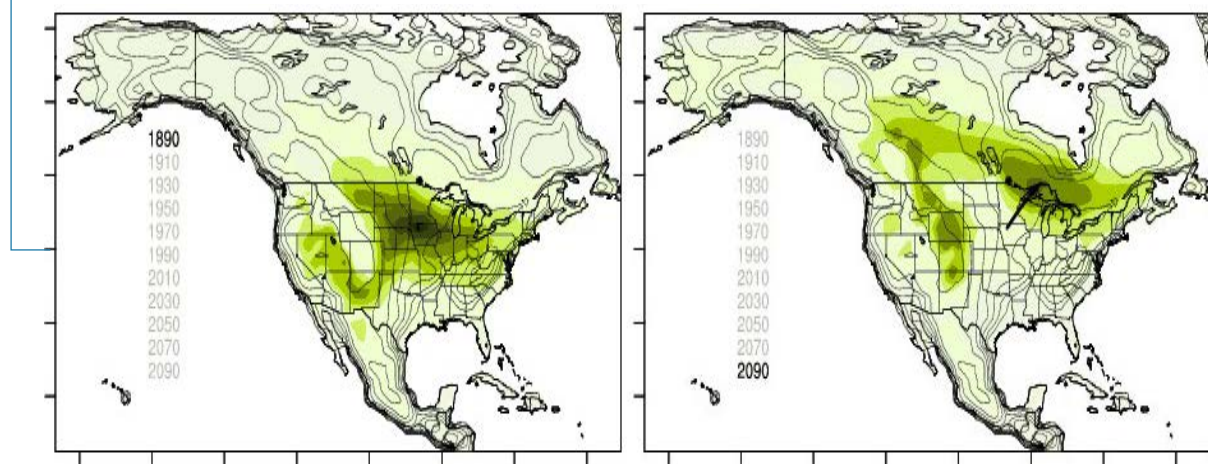


Fig 2

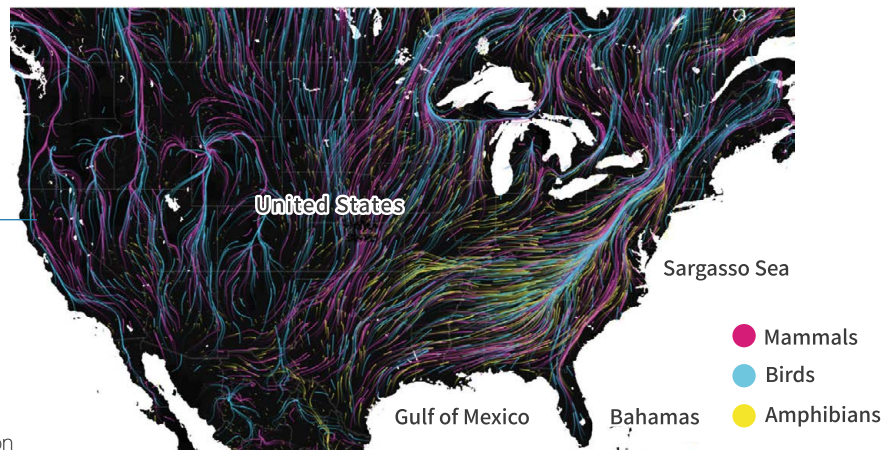
Climate model projection on shifting of prairie climate in North America

Source: Charles Koven, Lawrence Berkeley National Lab

c. Animals in North America (mammals, birds, and amphibians) migrating northward

Fig 3

Projected movements of animals in North America
Source: The University of Washington



Migration may not be a feasible option for species restricted by specific habitats. For example, the Giant Spiny Frog (*Quasipaa spinosa*) in Hong Kong inhabits high-altitude streams on Tai Mo Shan and may have nowhere to go as the climate warms.



1.2 Phenology

Phenology refers to the behaviors and phenomena of organisms that occur in response to seasonal or climatic changes. Climate warming, along with increased precipitation, may extend the growing season for plants in some areas. Changes in seasonal timing can disrupt the migration routes and cycles of migratory birds. An early arrival of spring may cause trees and flowers to bloom earlier and shorten the hibernation periods of animals. A mismatch between bloom time and pollinator arrival can affect plant reproduction and food availability for the pollinators, leading to profound consequences. A mismatch between the timing of migration and breeding of migratory birds and the emergence of their prey significantly reduces the reproduction rate of migratory birds, resulting in long-term impacts on the population size and structure of the species. Phenology refers to the cyclical patterns that emerge from the interactions between plants, animals, and natural seasonal changes. Over time and with the progression of seasons, biological activities correspond with climatic and environmental shifts, forming a regular cycle of adaptation.

However, warming of climate extends the plant growing season and may lead to earlier flowering times. If the emergence of plant pollinators does not adjust accordingly, it can impact plant reproduction and the food sources of pollinators. Similarly, if hibernating animals wake up earlier but face a mismatch in food supply, they may suffer from energy depletion and starvation, increasing the risks of death and lowering their chances of successful reproduction and survival through the winter, ultimately leading to population decline. Seasonal disruptions break the synchrony between plants and animals, potentially upsetting the balance of the ecosystem.



Fig 4 Hong Kong Giant Spiny Frog
Source: Gary Chan



Fig 5 Insect pollination
Source: Dickson Wong

In addition, earlier springs caused by warming of climate may disrupt the migratory routes and schedules of birds, while the growing frequency of extreme weather events poses further threats. Records from the Hong Kong Bird Watching Society indicate that from March 31 to April 1, 2025, the peak migration period of barn swallows coincided with an unseasonably cold spell that lasted for two days. Additionally, Hong Kong's unusually dry and warm weather in March had already hindered insect growth and reproduction. The compound effects resulted in a significantly higher mortality rate compared to previous records. Migratory birds expend substantial energy during each long-distance flight, and as the likelihood of encountering extreme weather and insufficient food resources during their journeys increases, so does their mortality rate.



Fig 6 Barn swallows that pass through Hong Kong in spring for breeding
Source: Gary Chan



1.3 Habitat

Habitat refers to the environment in which a species lives and reproduces. Whether on land or in the ocean, climate change can cause direct or indirect damage to the habitats of species. Examples:

a

A study shows that with high greenhouse gas emissions, by 2100, the persistence of nearly all polar bear populations will be threatened due to a sharp decline in reproduction and survival rates, with the exception of a few high-latitude Arctic subpopulations.



Fig 7 Polar bear and cubs
Source: Pixabay

b

The rising sea surface temperatures in Antarctic coastal regions may negatively affect the rearing of Adélie penguins. Their population in Antarctica is projected to decline by about 60% by the end of this century.



Fig 8 Antarctica Adélie penguin
Source: Jerzy Strzelecki

c

Rising sea levels submerged the habitat of the Bramble Cay melomys, making it the first mammal in the Great Barrier Reef to go extinct as a result of climate change.



Fig 9 Great Barrier Reef Bramble Cay
Source: Ian Bell@Queensland Government



More Information



Effects of extreme weather events on barn swallow in Hong Kong in Spring 2025
(Chinese Only)



Impact on polar bear survival conditions

d

As seawater warms, corals tend to expel the symbiotic algae living in their tissues and turn white. Bleached corals become fragile and weak, and may even die. About one-fourth of the carbon dioxide emitted by human activities is absorbed by the ocean, leading to ocean acidification and affecting coral growth. The death of coral reefs will lead to the loss of habitat or food for many marine species, disrupting the food chain and threatening the ecosystem.

Between 2016 and 2024, five mass coral bleaching events occurred in Australia's Great Barrier Reef. According to the IPCC Sixth Assessment Report, if global warming exceeds 1.5° C, many coral reefs will undergo irreversible changes. Even under a low greenhouse gas emissions scenario, coral reefs still face the risk of widespread decline by the middle of this century.

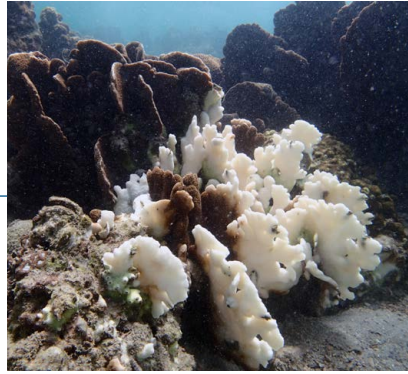


Fig 10

Coral bleaching

Source: Dickson Wong



More Information



Ocean acidification and deoxygenation



Coral bleaching



AR6 Chapter 3: Oceans and Coastal Ecosystems and their Services

e

Wetlands, which are home to a wide variety of species, may be inundated by rising sea levels, leading to habitat loss.

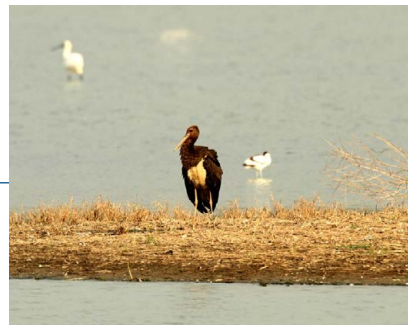


Fig 11

A Wetland habitat

Source: Kwok Chi Tai

f

High temperatures and drought increase the risk of wildfires. Research shows that fire seasons are lengthening across the globe. Habitats for many species will be lost when forests are burned down. Besides, forests face a greater risk of pests and diseases.



Fig 12

NOAA satellites monitored southern California wildfires on 9 January, 2025

Source: NOAA

2

Impacts on human society



2.1 Health

High temperatures are becoming more frequent due to global warming, with heat waves (anomalous high temperatures sustained for an extended period of time) occurring more often, more intense, and lasting longer. Extreme heat can lead to health problems such as heatstroke and heat exhaustion, and increase the morbidity rates of respiratory and cardiovascular diseases.

	Event	Description
a	2003 Heat wave in Europe	- In 2003, the summer temperatures in Europe were much higher than the long-term mean. Research reveals that human influence has more than doubled the chance of the heat wave. - The heat wave led to drought and wildfires. Water levels in major rivers (such as Rhine, Danube) dropped to record lows. This heat wave led to over 70,000 deaths.
b	2010 Heat wave in Russia	- In July 2010, Russia recorded its hottest July since 1880. Research shows that human influence has increased the chance of the heat wave by three times. - This heat wave led to a severe drought with around 9 million hectares of crop perished. Also, widespread wildfires caused severe air pollution. - This heatwave led to an estimated 55,000 deaths.
c	2021 Heat wave in the United States and Canada	- Between 26 and 29 June, 2021, under the influence of a nearly stationary high-pressure system, record-breaking temperatures were observed in the Pacific Northwest region of the United States and western Canada. - On 28 June, temperatures reached 46.7° C in Portland and 42.2° C in Seattle. On 29 June, Lytton in Canada recorded a shocking 49.6° C. - Nearly 700 people died due to the heat wave in British Columbia and Alberta, Canada, while almost 200 deaths were reported in Washington and Oregon in the United States.
d	2022 Heat wave in China	- From 13 June to 30 August, 2022, large areas of central and eastern China experienced a prolonged heat wave, lasting for 79 days. In Chongqing, the daily maximum temperature reached 45° C for two consecutive days. The persistent heat caused negative impacts on agriculture, electricity supply, and human health. During this period, electricity consumption reached record highs in southern regions such as Zhejiang and Shanghai. - A model-based study estimated that the number of deaths related to the 2022 heatwave in China could be up to 50,900.



More Information



More Information



More Information



More Information



Climate warming creates favourable environment for some disease vectors (e.g. mosquitoes) to expand their geographical distribution. Some studies point out that the distribution of mosquitoes will spread to higher latitudes (e.g. the United States, Europe) and higher altitudes, increasing the risk of spreading tropical disease. In 2024, there was a significant increase in dengue cases, with human-induced climate change being one of the contributing factors. In addition, bacteria have become more active, threatening human health.

Global warming may have some positive impacts in certain cold regions as there would be fewer cold related illnesses with generally warmer winters. However, research shows that under a business-as-usual scenario of carbon emissions, the negative health impacts of climate change will disproportionately affect warmer and poorer regions.



2.2 Fishery and agricultural production

According to the IPCC Sixth Assessment Report, human-induced warming has slowed the growth of agricultural productivity in low to mid latitude regions over the past 50 years. Ocean warming and acidification have had adverse effects on some wild fish populations and aquaculture. Climate-related extreme events have led to reduced food supply and rising food prices. In the future, the impacts of climate change on terrestrial and aquatic food production are expected to become increasingly negative, although certain regions may benefit in the short term. In addition, climate change will have negative impacts on food safety.



More Information



Medical alert!
Climate change is
harming our health



Climate change already
damaging health of
millions globally



Deadly heatwaves could
affect 74% of
the world's population



Dengue: the threat to
health now and
in the future



AR6 Chapter 5: Food,
fibre and other ecosystem
products



2.2 Risk of coastal inundation by seawater

Many densely populated cities around the world are situated in coastal areas. Rising sea level not only increases the risk of inundation by seawater, but also heightens the threat of storm surges. In addition, some island nations such as the Maldives in the Indian Ocean, Tuvalu and Kiribati in the Pacific Ocean are facing the threat of being submerged. Hurricane Ian struck the United States in late September 2022, causing severe destruction, particularly in Florida. It brought a catastrophic storm surge to the southwestern coast of Florida, with peak levels reaching 10 to 15 feet above ground level. The hurricane caused 66 direct deaths and 90 indirect deaths, with estimated damages totaling \$112.9 billion in the United States. Tens of thousands of structures were affected, many of which were destroyed. More than 9 million people in the United States lost power due to Ian.



More Information



National Hurricane
Center Tropical Cyclone
Report: Hurricane Ian

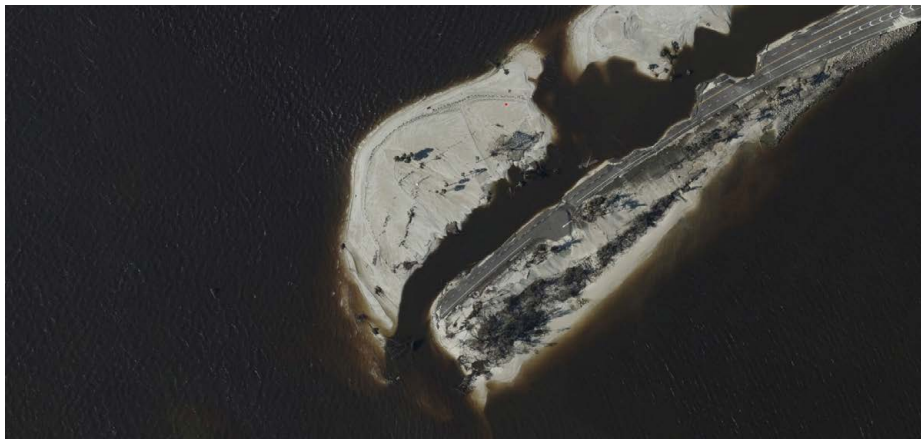


Fig 13 Aerial assessment imagery collected in the aftermath of Hurricane Ian on 29 September, 2022
Source: NOAA

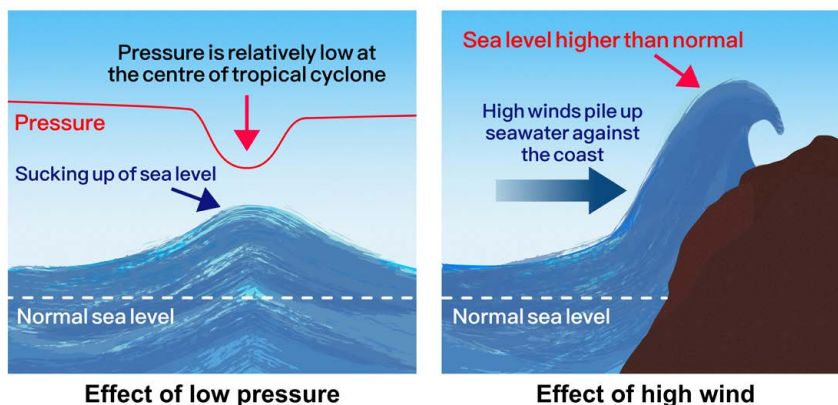


Fig 14 Formation of storm surge

What is storm surge?

Storm surge is a rise of sea level due to the combined effects of low air pressure and high winds associated with tropical cyclones.



More Information



Typhoon Hazards:
Strong Winds, Heavy
Rain, High Seas



2.4 Water resources

In some areas, decrease of precipitation and increase of evaporation may cause lake shrinkage and reduced river discharge, leading to decrease in fresh water resources. The warming climate accelerates melting of glaciers and ice caps, which may increase freshwater supplies in short term. However, the problem of water shortage will emerge immediately if the glaciers and ice caps melt away completely without replenishment.

As sea level rises, seawater intrusion into rivers and groundwater will increase the salinity of fresh water, making the water not suitable for drinking and irrigation.



相關資料



Water scarcity



Fig 15a Arapaho Glacier in 1904
Source: NSIDC



Fig 15b Arapaho Glacier in 2021
Source: NSIDC



2.5 Infrastructure and transport

Extreme weather may damage urban infrastructure such as buildings, transport networks, power supply and communication facilities, disrupting normal functions of cities and even causing economic losses. Buildings and infrastructure built on permafrost may be damaged due to the thawing of permafrost.

The loss of Arctic Sea ice may open up more convenient shipping routes. However, it could also lead to increased human activities and resource extraction, in particular fossil fuels, resulting in more pollution and greenhouse gas emissions.



2.6 Energy supply

Both hydroelectric and thermoelectric power generation (e.g. fossil-fueled, nuclear) rely on adequate water resources (e.g. rivers). In other words, energy production can be affected by climate change. In addition, thermoelectric power generation facilities need water for cooling. Therefore, the temperature of water will also affect energy production.

The IPCC Sixth Assessment Report indicates that climate change has already had negative impacts on hydropower and thermoelectric power generation due to droughts, changes in river flow, and rising water temperatures.

In the future, thermoelectric power capacity is projected to decline. Although the global hydropower capacity is expected to increase, there will be significant regional differences. For example, in the Mediterranean parts of Europe, if warming reaches 3° C, hydropower potential is projected to decrease by as much as 40%.



2.7 Tourism

A number of tourist attractions are being damaged as a result of climate change, for example, coral bleaching and death in Australia's Great Barrier Reef. Sea level rise would also damage tourist facilities in some island countries.



More Information



AR6 Chapter 4: Water



Global coral reefs impacted by largest bleaching event on record



2.8 National security

Climate change is related to national security.

According to the “National Security Law of the People's Republic of China”, national security encompasses major fields including food security, ecological security and polar security. Food security is an important cornerstone for national security and the most important issue that concerns people's livelihood. Climate change intensifies extreme weather events, such as heatwaves and heavy rain, threatening the stability and quality of food production. Ecological security covers the security of water, land, atmosphere and biological species. Climate change disrupts supply and demand of water resources, alters phenology and habitats, and undermines ecosystem stability. It also threatens biodiversity and heightens ecological risks. Additionally, polar regions, at the forefront of scientific research on global environmental and biological changes, are significantly affected by global warming. The polar environments and ecosystems are threatened by the rising temperatures and accelerated melting of snow and ice.



More Information



Twenty major fields
of national security



Fig 16 A holistic approach to national security
Source: National Security Education Day, GovHK

Climate migration

Many studies have found a significant connection between extreme weather events and both domestic and international migration.

According to a World Bank report, by 2050, climate impacts may force 1.9 million Moroccans to migrate from rural areas to urban centers. Climate-driven migration has also reduced the labor force in Caribbean countries, where migration rates are already high.



More Information



Key risks across sectors
and regions



World Bank Report

3 Impacts on Hong Kong

The climatic trends observed in Hong Kong are generally consistent with the global trends. As for the future climate in Hong Kong, the Hong Kong Observatory utilized climate model data from the IPCC Sixth Assessment Report to make projections under various greenhouse gas emissions scenarios, including very low, low, intermediate, high, and very high emissions scenarios.

Under the intermediate greenhouse gas emissions scenario, the annual number of hot nights and very hot days in Hong Kong will increase significantly each year. Under the very high greenhouse gas emissions scenario, by the end of this century, the annual number of hot nights and very hot days is projected to reach 167 and 152 days respectively. For the rest of this century, the average rainfall intensity, the amount and frequency of extreme rainfall events are expected to increase. Regardless of the greenhouse gas emissions scenario, sea level in Hong Kong will continue to rise. (Fig. 17)

	Temperature		Precipitation				Sea level
	Annual number of hot nights (Day)	Annual number of very hot days (Day)	Annual maximum daily rainfall ⁺	Annual maximum 5-day rainfall ⁺	Annual number of extreme rainfall days* (Day)	Average rainfall intensity ## (mm/day)	Annual mean sea level ⁺
Actual observations (1995–2014)	21	14	203mm	382mm	4.3	23.8	1.45m
Projection scenario	Projected mean						Projected median
Projection for very high greenhouse gas emissions scenario (2081–2100)	167	152	Increase 28.1%	Increase 27.3%	6.0	28.3	Increase 0.78m [#]
Projection for intermediate greenhouse gas emissions scenario (2081–2100)	117	95	Increase 16%	Increase 14.2%	5.3	26.4	Increase 0.56m [#]

Fig 17 Future climate of Hong Kong
Source: HKO

+ Projected change relative to 1995–2014 average
Projection for 2100
* Daily rainfall ≥ 100 mm
annual rainfall divided by the number of rain days

As the climate warms, the average intensity of tropical cyclones and their associated rainfall is expected to increase. According to the Hong Kong Observatory, since records began in 1884, the highest one-hour, two-hour, and twelve-hour rainfall records were measured on September 7–8, 2023. Extreme rainfall was triggered by the remnant circulation of Severe Typhoon Haikui, which brought an active southwest monsoon and an extensive trough of low pressure to Hong Kong and the Pearl River Delta region. The event led to widespread severe flooding, landslides, transport disruption etc., causing significant damage to society.

Against the backdrop of global warming, extreme weather events are becoming more frequent, and Hong Kong is not exempt. More intense tropical cyclones will bring greater destructive power, and combined with rising sea levels, the threat of storm surges will also increase.



Fig 18 Condition in Wong Tai Sin District on 8 September, 2023
Source : Commercial Radio Hong Kong



More Information



Super Typhoon
Mangkhut



Super Typhoon
Hato



Super Typhoon
Doksuri



Super Typhoon
Saola

Climate change also affects biodiversity, public health, energy supply, economy and infrastructure in Hong Kong.

Impacts on the natural environment

Biodiversity

More pressure on montane and freshwater ecosystems due to increasing temperature and more frequent extreme weather events; loss of inter-tidal habitats such as coral reefs and mangroves because of sea level rise; change in species distribution and migration patterns as a result of climate change.



Fig 19 Increase in temperature affects the breeding of *Paramesotriton hongkongensis*
Source: Ho Koon Nature Education cum Astronomical Centre

Impacts on the public

Human health	Food and water resources	Energy supply
Chronic illness issues aggravated; risk of heat exhaustion, heat stroke and asthma exacerbated; more accidents and emergency situations; changes in transmission patterns of infectious diseases.	Reduction in local food production due to more frequent extreme weather events; higher water demand because of rising temperature. If food production elsewhere in the world is affected by extreme weather or drought, there will be less food supply and price hikes may be triggered.	Climate warming increases the energy demand for cooling and the pressure on the power supply system, resulting in overloads and power outages. More frequent extreme weather will increase damage risk of power lines and other power supply facilities.
Economy	Infrastructure	
Higher maintenance and insurance costs will be induced by damages caused by extreme weather. The insurance sector will bear higher risks associated with extreme weather.	More frequent extreme rainfall will increase the risks of floods and landslides which can damage building foundations, utility cables and roads, etc. Rising sea level accentuates the risk of storm surge inundation to coastal facilities, especially underground facilities.	

7.4 Chapter Summary

How will climate change affect us?

1 Impacts on the natural environment

Ecosystem changes and habitat destruction

Climate change causes direct or indirect damage to habitats, threatening the survival of species such as polar bears and Adélie penguins. In addition, sea level rise and extreme weather events also affect wetlands and coral reefs.

Species migration

Species are forced to migrate to cooler areas, but for those with limited habitats, such as the Hong Kong Giant Spiny Frog, migration may not be feasible.

Greenhouse gases

The timing of plant and animal behaviors no longer aligns with seasonal changes, affecting reproduction and food chains.

2 Impacts on human society

Health

An increase in hot weather heightens the risks of health issues such as heatstroke, heat exhaustion, respiratory and cardiovascular diseases, as well as certain infectious diseases.

Agriculture

Human-induced warming has slowed the growth of agricultural productivity in low to mid latitude regions. Climate-related extreme events have led to reduced food supply.

Coastal risks

Sea level rise increases the risk of flooding in coastal cities, affecting the economy and infrastructure.

Water resources

In certain regions, the decrease of precipitation, increase of evaporation, melting of glaciers and ice caps, and seawater intrusion may affect fresh water resources.

Infrastructure and transport

Extreme weather may damage urban infrastructure and transport system.

Energy supply

Energy production and demand can be affected by climate change.

Tourism

A number of tourist attractions are damaged as a result of climate change.

National security

Climate change is also a matter of national security, including food security and ecological security.

3 Impacts on Hong Kong

 The climatic trends observed in Hong Kong are generally consistent with the global trends. It is projected that there will be a significant increase in the annual numbers of hot nights and very hot days, more frequent extreme rainfall events and continued rise in sea level.

 Stronger tropical cyclones, along with their associated rainfall and storm surges, will pose greater threats to Hong Kong.

7.5 How can we respond to the impacts of climate change?

This section first introduces the international cooperation in tackling climate change, including two international agreements, the Kyoto Protocol and the Paris Agreement. It then discusses actions in respect of mitigation, adaptation and resilience, as well as individual efforts to combat climate change.

1 International cooperation

2 Government actions

3 Individual actions

1

Impacts on the natural environment

The Intergovernmental Panel on Climate Change (IPCC) was established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1988. The IPCC regularly reviews most up-to-date scientific literature on climate change and prepares assessment reports, providing clear scientific perspectives and objective information to the world, including the scientific basis and causes of climate change, its potential environmental and socio-economic consequences, and the adaptation and mitigation options to respond to the impacts.

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted at the Rio de Janeiro Earth Summit in 1992. It is an international environmental agreement which aims at stabilizing the level of atmospheric greenhouse gas concentrations in order to prevent dangerous human-induced interference with the climate system. To achieve this goal, two important international agreements were adopted by the United Nations, namely, the Kyoto Protocol in 1997 and the Paris Agreement in 2015.



1.1 The Kyoto Protocol

In 1997, the 3rd session of the Conference of the Parties (COP3) of the UNFCCC was held in Kyoto, Japan and adopted the Kyoto Protocol. However, the Protocol did not enter into force until 2005.

1.1.1 Content

The Kyoto Protocol recognizes the principle of “common but differentiated responsibilities”, meaning that combating climate change is a shared obligation among all nations. However, since more developed countries are principally responsible for the current high levels of atmospheric greenhouse gas concentrations due to over a century of industrial activities, the Protocol places a heavier burden on more developed countries than less developed countries in emission reduction. A top-down approach was adopted in negotiating the emission reduction targets among the more developed countries. It is difficult to implement the agreement as each country has to consider its own circumstances and economic interests.

The emission reduction commitment period of the Kyoto Protocol was from 2008 to 2012. The European Union and 37 more developed countries pledged to reduce at least 5% greenhouse gas emissions against 1990 levels.

In 2012, the Doha Amendment to Kyoto Protocol was adopted at the 18th session of the Conference of the Parties (COP18) of UNFCCC, established the second commitment period for emission reductions from 2013 to 2020. Relevant Parties committed to reduce their greenhouse gas emissions by at least 18% against 1990 levels. The Doha Amendment entered into force on December 31, 2020.



More Information



What is the Kyoto Protocol?

1.1.2 Effectiveness

There are criticisms of the effectiveness of the Kyoto Protocol, citing the lack of participation from some more developed countries. For example, the United States in 2001 declared that it had no intention of implementing the Kyoto Protocol, and Canada formally withdrew in 2012. Japan, Russia, and New Zealand chose not to participate in the new emission reduction targets under the Doha Amendment.

During the first commitment period from 2008 to 2012, some more developed countries achieved the emission reduction targets while others did not. Further criticisms focus on the principle of “common but differentiated responsibilities”, as less developed countries are not required to share the responsibility of emission reduction. However, increased emissions from less developed countries have offset the reductions made by more developed countries.

Parties (selected)	Emission reduction pledges for the 1 st commitment period (relative to 1990 levels)	Actual emissions (average value from 2008 to 2012)	Target achieved
European Union (15 countries)	-8%	-18%	✓
Japan	-6%	+4%	✗
Canada	-6%	+24%	✗
Croatia	-5%	-15%	✓
New Zealand	0%	+38%	✗
Russia	0%	-50%	✓

During the second commitment period from 2013 to 2020, the average annual emissions of participating developed countries decreased by 22% compared to 1990 levels, while the European Union saw an average reduction of 23%. 10 countries (9 EU member states and the United Kingdom) reduced their emissions by more than 30% relative to 1990 levels, but 7 countries recorded an increase in their average annual emissions.



1.2 The Paris Agreement

In 2015, the 21st session of the Conference of the Parties (COP21) of UNFCCC took place in Paris, France and adopted the Paris Agreement.

1.2.1 Content

The main goal of the Paris Agreement is to contain global average temperature rise by the end of this century well below 2° C relative to pre-industrial levels and to pursue efforts to limit the temperature rise to 1.5° C in order to avoid the dangerous impacts of climate change. The Paris Agreement entered into force in November 2016 and was later ratified by 195 parties as of 11 March 2025.

Unlike the Kyoto Protocol, the negotiation in the Paris Agreement adopts a bottom-up approach. Each country sets its own Nationally Determined Contribution (NDC), outlining its greenhouse gas emission reduction target and timeline according to its national circumstances. Each country will conduct a review every 5 years and update its own NDC with a more ambitious emission reduction target. Since the countries determine their own emission reduction targets, it is easier to implement the agreement.

1.2.2 Effectiveness

Parties (selected)	Nationally Determined Contribution (NDC) emission reduction targets
China	Carbon dioxide emissions are targeted to peak before 2030, with efforts to achieve carbon neutrality before 2060. By 2030, carbon dioxide emissions per unit of GDP will be reduced by more than 65% compared to 2005 levels.
Japan	Greenhouse gas emissions in fiscal years 2035 and 2040 will be reduced by 60% and 73% respectively, compared to fiscal year 2013 levels.
European Union	Greenhouse gas emissions in 2030 will be at least 55% lower than 1990 levels.
India	Carbon intensity in 2030 will be 45% lower than 2005 level.



1.3 Comparison of the Kyoto Protocol and the Paris Agreement

The Kyoto Protocol	The Paris Agreement
Timeline: ▼ Adopted in December 1997 ▼ Entered into force in 2005 ▼ The 1st Commitment Period 2008–2012 ▼ The 2nd Commitment Period 2013–2020 ▼ Expired in 2020	Timeline: ▼ Adopted in December 2015 ▼ Entered into force in November 2016
Negotiation: • Top–down	Negotiation: • Bottom–up
Approach: • Countries negotiate with one another to set the emission targets.	Approach: • Each country sets its own Nationally Determined Contribution (NDC), outlining its greenhouse gas emission reduction target and timeline.
Targets: • The 1st Commitment Period: The European Union and 37 more developed countries to reduce greenhouse gas emissions by at least 5% against 1990 levels. • The 2nd Commitment Period: Participating parties to reduce greenhouse gas emissions by at least 18% against 1990 levels.	Targets: • To contain global average temperature rise by the end of this century well below 2° C relative to pre-industrial levels and to pursue efforts to limit the temperature rise to 1.5° C in order to avoid the dangerous impacts of climate change. • Each country will conduct a review every 5 years and update its own Nationally Determined Contribution (NDC) with a more ambitious emission reduction target.

IPCC Special Report on Global Warming of 1.5° C (SR15)

In response to one of the decisions made at the United Nations Climate Change Conference in Paris (COP21), the IPCC published the Special Report on Global Warming of 1.5 ° C in October 2018. The Special Report makes an urgent call for policymakers that limiting global warming to 1.5°C would require rapid, far-reaching and unprecedented changes in all aspects of society. The Special Report clearly outlines the multiple benefits of limiting global warming to 1.5° C compared to 2° C, for example:

- 1** a slower rate of sea level rise which enables greater opportunities for adaptation in the human and ecological systems of small islands, low-lying coastal areas and deltas;
- 2** lower impact on terrestrial, freshwater and coastal ecosystems which helps retain more of their services for humans;
- 3** less ocean warming and acidification, hence lower risks to marine biodiversity and ecosystems;
- 4** fewer climate-related risks to health, food security, water supply, human security and economic growth; and
- 5** reduced adaptation needs.

Human activities have already caused approximately 1° C of global warming above pre-industrial levels and we are already witnessing its consequences through more extreme weather, rising sea levels and diminishing Arctic sea ice. To contain global warming to 1.5° C, human-caused carbon emissions have to decline by about 40% from 2010 levels by 2030, reaching net zero around 2050. Current national pledges of emission reductions under the Paris Agreement would not suffice to achieve the goal. The goal can only be achieved if global carbon emissions start to decline well before 2030. Based on the Nationally Determined Contributions (NDCs) for reductions in greenhouse gas emissions made by the countries at the Paris Agreement, a global warming of around 3° C would be more likely by the end of this century[#].

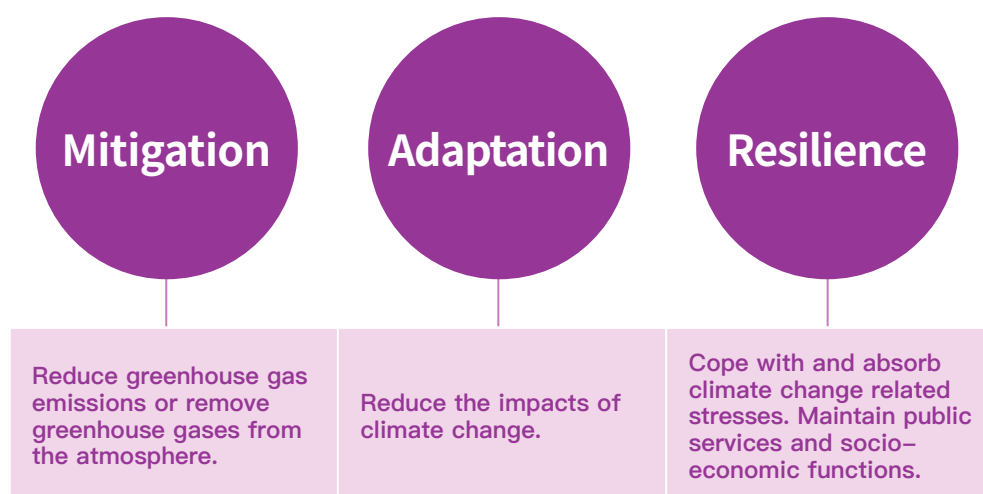
[#] Information as of the compilation of this special report

2

Government actions

Each country has to implement emission reduction measures according to its Nationally Determined Contribution (NDC) in order to mitigate climate change. At the same time, the country also has to be prepared to adapt to impacts of climate change and to strengthen resilience.

Three main strategies in response to climate change:



2.1 Mitigation

Mitigation measures may include the following:

2.1.1 Replace fossil fuels with renewable energy

Reduce the use of fossil fuels and increase the share of solar power, wind power and hydro–electric power in the energy mix.

2.1.2 Improve energy efficiency

Improve energy efficiency. For example, use energy–efficient electrical appliances and fuel–efficient vehicles, install intelligent energy–saving systems in buildings.

2.1.3 Improve waste management

Develop waste–to–energy technologies to efficiently manage urban waste and reduce dependence on fossil fuels.

2.1.4 Afforestation and urban greening

Afforestation increases carbon sinks. Roof greening or vertical greening on buildings provides cooling effects and therefore can reduce energy consumption from air conditioning and alleviate the urban heat island effect by reducing heat absorbed by building surfaces.

2.1.5 Carbon capture and storage

Scientists have been developing technologies to capture atmospheric carbon dioxide and store it underground, in deep oceans or in biomass for the long term. Most of the technologies are still in early stages and not yet ready for large–scale implementation.



Fig 1 Building with vertical greening



Fig 2 Solar panels



Fig 3 Hydro-electric dam
Source: American Public Power Association



2.2 Adaptation

Adaptation measures may include the following:

2.2.1 Coastal and drainage projects

a. Coastal protection structures

Raise the height of seawalls or construct sluices to defend against extreme water levels caused by storms.

b. River channel improvement

Enhance the drainage capacity of river channels.

c. Drainage system planning

flood prevention strategies and improve existing systems. Maintain the systems in good condition and perform preventative maintenance.



Fig 4 Coastal protection structures in Japan
Source: Pekachu



Fig 5 Sluice in River Thames, England and its operation
Source: Kleon3

2.2.2 Building design

Highly reflective materials can reflect more sunlight, reducing the amount of heat absorbed by buildings. Flood-resilient or floating houses can reduce the loss of life and property.



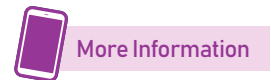
Fig 6 Flood-resilient house
Source: Infrogmaton

2.2.3 Land use planning

Proper land use planning can avoid building important infrastructure such as hospitals in high-risk areas like coastal areas and slopes. Buffer zones such as parks, waterfront promenade should be built in these areas to replace high-density developments. River revitalization and roof greening can alleviate the urban heat island effect effectively.

2.2.4 Food supplies

Develop new crop varieties which are more resistant to high temperature and drought.



More Information



The Future is Ours



Floating houses



2.3 Resilience

By strengthening climate resilience, we can better cope with the stresses caused by climate change. The table below outlines the steps for strengthening climate resilience as suggested by the U.S. National Oceanic and Atmospheric Administration (NOAA).

Steps for strengthening climate resilience		Example from Houston, US (Fig. 7)
I. Explore hazards ▼ ▼ ▼ ▼ ▼ ▼ ▼	- Form a group - Examine past and future extreme weather events for the region - List the “assets” that could be affected, including people, resources, ecosystems, and infrastructure	- Houston, the United States faces extreme rainfall and storm surge inundation - More frequent extreme rainfall and a higher threat of storm surge are projected
II. Assess vulnerability and risks ▼ ▼ ▼ ▼ ▼	- Determine which assets are exposed to impacts of extreme weather - Assess each asset’s vulnerability - Estimate the risk to each asset	The team paid special attention to Houston’s petrochemical industry and the Johnson Space Centre
III. Investigate options ▼ ▼ ▼ ▼ ▼	- Consider all possible solutions - Study similar cases - Identify feasible solutions	The team cooperated with various government departments to compile climate data and conducted research using several resilience enhancement tools
IV. Prioritize and plan ▼ ▼ ▼ ▼ ▼	- Evaluate costs and benefits of each solution and resilience of all departments - Select the best solution	Based on the research results, they built a climate change website and developed 9 guidelines
V. Take action	- Implement the solution - Gain public support - Monitor effectiveness, and revise the resilience plan when necessary	- Provided relevant information to the public - Continue to enrich the website



Fig 7 Houston, the United States faces extreme rainfall and storm surge inundation
Source: Michael Slaten



More Information



Climate Resilience website



2.4 Case study: Hong Kong (City level)

Fig.8 shows Hong Kong's progress in mitigating global warming. In 2023, Hong Kong's total greenhouse gas emissions were about 34.5 million tonnes of carbon dioxide equivalent, showing a decrease of about 20% compared to 2005 when the Kyoto Protocol entered into force, and a reduction of around one-quarter from Hong Kong's peak level of emissions in 2014. The same year, the per capita greenhouse gas emissions were about 4.58 tonnes of carbon dioxide equivalent, which was the lowest since 1990, showing a decrease of nearly 30% compared to 2005 and 2014. As for the local greenhouse gas emissions, electricity generation remains the main source which accounting for about 61% of the total emissions in 2023. Other major sources include transport (18%) and waste management (8%).

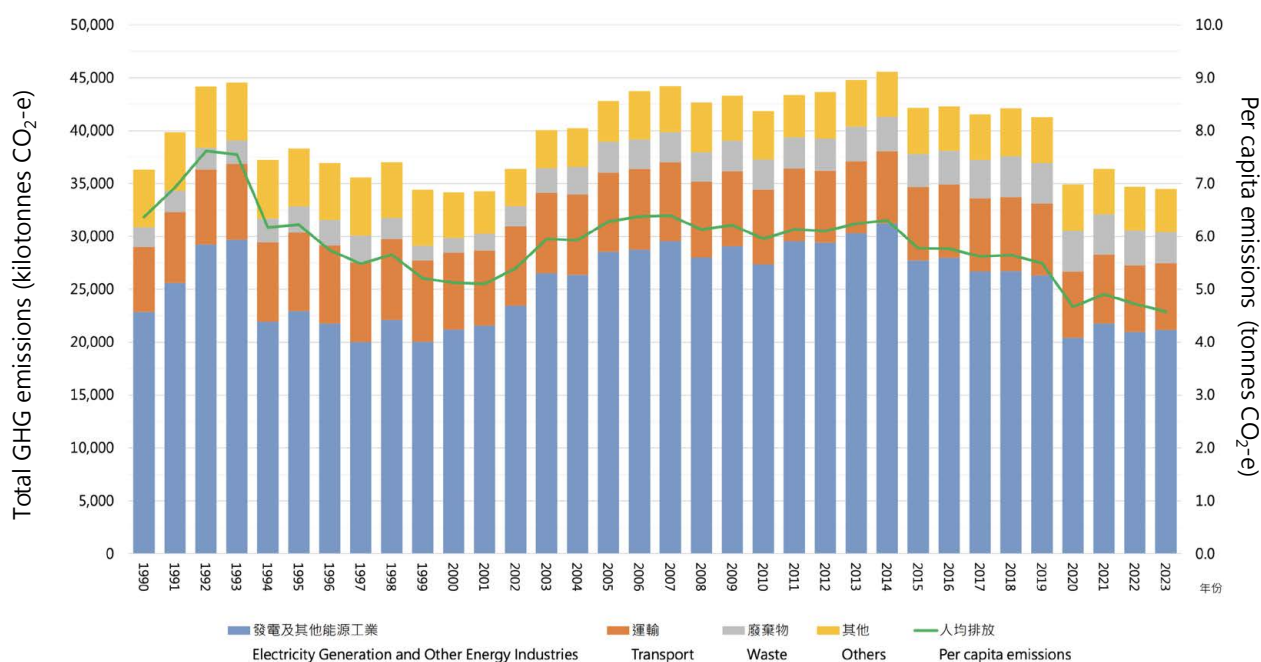


Fig 8 Greenhouse gas emissions trends and carbon emissions sources in Hong Kong

Source: Carbon Neutrality and Sustainable Development, GovHK



More Information



Greenhouse Gas Emissions in Hong Kong



Greenhouse Gas Emissions and Carbon Intensity in Hong Kong



Records show emissions fell in 2023



GHG Emissions and Trends

As part of China's commitment to the Paris Agreement, the Hong Kong SAR Government will strive to achieve carbon neutrality before 2050 and has established the Steering Committee on Climate Change and Carbon Neutrality to formulate an overall strategy. The Hong Kong's Climate Action Plan 2050 has set out more ambitious decarbonization strategies and measures, and strengthened the mid-term target, striving to reduce Hong Kong's carbon emissions by half from the 2005 level by 2035. To achieve this goal and respond to climate change, Hong Kong is taking action in three key areas: carbon reduction, adaptation, and resilience.

2.4.1 Carbon reduction

In recent years, the government has allocated substantial resources to implement various carbon reduction measures, and the two power companies have also invested in decarbonization projects.

a. Net-zero electricity generation

Cease using coal for daily electricity generation; increase the share of renewable energy in the fuel mix for electricity generation to 7.5% to 10% by 2035, and to 15% subsequently; and try out the use of new energy and strengthen co-operation with neighbouring regions to achieve the long-term target of net-zero electricity generation before 2050.

b. Energy saving and green buildings

Reduce the overall electricity consumption of buildings through promoting green buildings, improving buildings' energy efficiency and promoting a low-carbon lifestyle. The goal is to reduce the electricity consumption of commercial buildings by 30% to 40% and that of residential buildings by 20% to 30% from the 2015 level by 2050, and to achieve half of the above targets by 2035.

c. Green transport

Achieve the long-term target of attaining zero vehicular emissions and zero carbon emissions in the transport sector before 2050, through the electrification of vehicles and ferries, development of new-energy transport and measures to improve traffic management. The Government will cease the new registration of fuel-propelled and hybrid private cars in 2035 or earlier. Apart from promoting electric buses and commercial vehicles, the Government also collaborates with the franchised bus companies and other stakeholders to test out hydrogen fuel cell electric buses and heavy vehicles.

d. Waste reduction

To achieve the long-term target of carbon neutrality in waste management before 2050, the Government will strive to develop adequate waste-to-energy facilities by 2035, so as to move away from reliance on landfills for municipal waste disposal.

2.4.2 Adaptation and resilience

a. Strengthen infrastructure

- Establish the Climate Change Working Group on Infrastructure.
- Update infrastructure design standards.
- Undertake studies on strengthening infrastructure under climate change.

b. Combat sea level rise and coastal protection

- Conduct studies on storm surges, waves, and shoreline management.
- Formulate coastal management and improvement measures.

c. Combat extreme rainstorms and tropical cyclones

- Adopt appropriate flood prevention and drainage management measures. (Fig. 9)
- Implement the Inter-reservoirs Transfer Scheme.
- Enhance slope safety.
- Strengthen the flood prevention and drainage capacity of railway and road infrastructure.

d. Combat extreme droughts and safeguard water supply

- Contain fresh water demand growth.
- Build resilience in the fresh water supply with diversified water resources.



Fig 9

Tai Hang Tung Stormwater Storage Tank reduces the surface runoff discharged into the downstream drainage system during heavy rainstorms

Source: Dr. T.C. Lee

**Fig 10**

Examples of enhancing architectural design to combat extreme heat: Evaporation of water in a fountain

e. Combat extreme heat

- Enhance building design. (Fig.10)
- Promote urban forestry.

f. Contingency plan for natural disasters

- The Chief Secretary for Administration chairs an inter-departmental Steering Committee to handle natural disasters of a substantial scale.
- When necessary, activate the Emergency Monitoring and Support Centre to provide a holistic support.
- Conduct regular exercises of various forms.

g. Warning and monitoring

- Disseminate messages via an emergency alert system during emergency situations to remind the public to adopt contingency measures quickly.
- The HKO closely monitors severe weather and storm surges, issues related warnings and bulletins when needed. (Fig.11)
- Monitor data such as water levels in various locations to facilitate speedy analysis of the flooding situations.

h. Transport system

- Update contingency plans to handle emergency situations at major transport infrastructure.
- In the event of an emergency, the Transport Department's Emergency Transport Coordination Centre will activate the relevant contingency plan.

i. Raise community awareness of climate change

- The government collaborates with commercial, professional, academic and community organizations to organise activities related to climate change.
- The HKO conducts studies and makes long-term projections about the impacts of climate change in Hong Kong, providing this information through its website.
- HKO also organizes regular school and public talks, along with other public educational activities, to promote understanding of climate change. (Fig. 12)

**Fig 11**

HKO weather radars provide round-the-clock monitoring for severe weather, including rainstorm and tropical cyclones
Source : HKO

**Fig 12**

HKO enhances public understanding of climate change through outreach activities like open days
Source : HKO



More Information



Government announces
Hong Kong's Climate
Action Plan 2050



2022 Policy Address:
policy measures of
Environment and Ecology
Bureau: Environmental
Protection Legislative
Council Panel on
Environmental Affairs
@31 October 2022



Hong Kong's Climate
Action Plan 2050



Hong Kong West
Drainage Tunnel



Coastal enhancement

3

Individual actions

Just as mankind has played an undeniable role in bringing about climate change, each of us has an inescapable responsibility to mitigate its impact. Regardless of the pledges made by governments under the Paris Agreement, it ultimately falls on us, as citizens of the planet, to achieve the targets set through changes in mindset, lifestyle and consumption behaviour.

Low Carbon Living Tips

What can you do to help combat climate change?

The tips below help us practise low-carbon living and reduce greenhouse gas emissions:



(Source: Carbon Neutral@HK, GovHK)



3.1 Clothing

- 3.1.1 Choose a washing machine with Grade 1 energy label.
- 3.1.2 Choose a washing machine with capacity that meets your household's needs.
- 3.1.3 Wait until there is a full laundry load before using the washing machine.
- 3.1.4 Use fast cold wash programme to save water, electricity and time.
- 3.1.5 Hang-dry washed clothes under sunlight to save energy and kill germs. (Fig. 13)
- 3.1.6 Hand washing clothes is a low-carbon choice.
- 3.1.7 Rethink before buying new clothes. (Each adult clothing generates around 8 kg CO₂-e)
- 3.1.8 Choose clothes that do not require ironing.
- 3.1.9 Donate unwanted clothes to those in need or charity organizations.



Fig 13 Hang-dry washed clothes under sunlight to save energy and kill germs.

Source : Canva Education





3.2 Food

- 3.2.1 Avoid purchasing food more than needed.
- 3.2.2 Buy regional and seasonal food.
- 3.2.3 Buy food with no or minimal packaging.
- 3.2.4 Avoid using one-off disposable containers and utensils.
- 3.2.5 Consume food that is purchased earlier and is close to the expiry date first (first-in-first-out (FIFO) system).
- 3.2.6 Make the best use of leftovers and unconsumed food, such as using leftover food to make new dishes.
- 3.2.7 Allow hot/warm food to cool down to room temperature before putting it in the refrigerator.
- 3.2.8 Avoid setting the refrigerator temperature unnecessarily low.
- 3.2.9 Leave enough space between refrigerators and the walls or cabinets. Trapped heat increases energy consumption.
- 3.2.10 Eat more vegetables. (Shifting from high meat diet to vegetarian diet could reduce your carbon emissions on food up to 80%)
- 3.2.11 Eat more organic food! Organic food produces less carbon emissions by avoiding energy used in producing chemical pesticides and fertilizers.
- 3.2.12 Think about the portion required before cooking/ordering food.
- 3.2.13 Reheat food by using slow-cook pot or simmer burners rather than ovens.
- 3.2.14 Food cooks faster if pots and pans are covered with lids.
- 3.2.15 Bring containers when dining out or ordering takeout. (Fig.14)



Fig 14

Bring containers when dining out or ordering takeout.

Source : Canva Education



3.3 Living

- 3.3.1 Bring your own shopping bags.
- 3.3.2 Avoid purchasing unnecessary items and choose more durable products.
- 3.3.3 Adopt simple packaging and avoid gift wrapping.
- 3.3.4 Turn off lights and electrical appliances when they are not in use.
- 3.3.5 Avoid leaving electrical appliances on standby mode.
- 3.3.6 Choose electrical appliances with Grade 1 energy label.
- 3.3.7 Choose gas appliances with "Voluntary Energy Efficiency Label".
- 3.3.8 Install solar panels on roof and join the Feed-in-Tariff Scheme.
- 3.3.9 Use energy saving LED lighting.
- 3.3.10 Wear light, open the windows and use fans instead of air conditioners.
- 3.3.11 Set the temperature of air conditioners at 24 – 26 °C for comfort and energy conservation.
- 3.3.12 Keep windows and doors closed when the air-conditioner is turned on and use curtains or blinds to block sunlight.
- 3.3.13 Clean the filters of air conditioners regularly.
- 3.3.14 Install a low-flow shower head and take shorter showers.

- 3.3.15 Use instantaneous water heaters as far as practicable. Otherwise, use storage type water heaters with Grade 1 energy label. (Fig.15)
- 3.3.16 For storage type water heater, choose one with the right storage capacity and temperature control that meet the family's needs.
- 3.3.17 Set the water temperature of the water heater at the lowest acceptable level, especially in summer.
- 3.3.18 Switch the water heater off after use.
- 3.3.19 Install low-flow controller in the water tap.
- 3.3.20 Turn off the tap while brushing teeth, applying soap or shaving.
- 3.3.21 Repair water leaks – a dripping faucet can waste up to 76L of water per day.
- 3.3.22 Reduce waste. (3L garbage could generate around 1 kg CO₂-e)
- 3.3.23 Donate unwanted gifts to the needy through relevant organizations.
- 3.3.24 Support clean recycling.

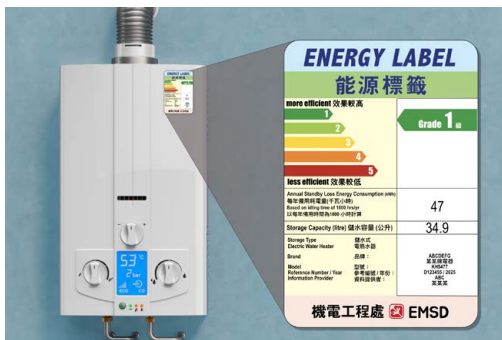


Fig 15 Storage type water heater with Grade 1 energy label.



More Information



Recyclable materials in
Hong Kong



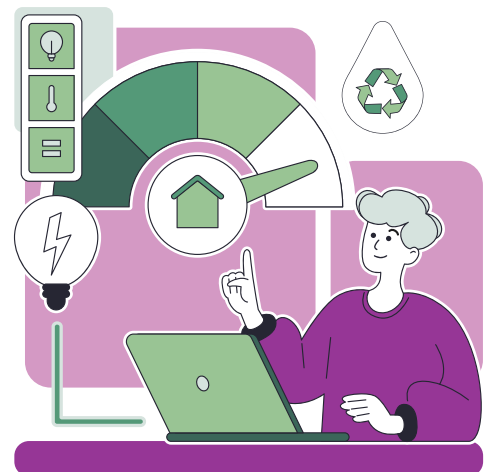
3.4 Travel

- 3.4.1 Use stairways instead of lift.
- 3.4.2 Walk or use public transport.
- 3.4.3 Carpooling when using private cars.
- 3.4.4 Drive less.
- 3.4.5 Drive at proper speed.
- 3.4.6 Keep your vehicle well maintained.
- 3.4.7 Maintain proper tire pressure.
- 3.4.8 Use electric vehicles.
- 3.4.9 Replace overseas business trips by video conferencing or emails.
(A round-trip flight from Hong Kong to Tokyo could generate over 400 kg CO₂-e)
- 3.4.10 High-speed rail's carbon emissions are only about 15% of aircraft and 25% of buses.
- 3.4.11 Opt for low-carbon local tours, such as visiting the country parks and the Hong Kong UNESCO Global Geopark. (Fig.16)



Fig 16

The Hong Kong UNESCO Global Geopark is an ideal destination for a low-carbon local tour



7.5 Chapter Summary

How can we respond to the impacts of climate change?

1 International cooperation

- Intergovernmental Panel on Climate Change (IPCC): Established in 1988, IPCC regularly reviews climate change–related literature and produces reports. These reports cover the scientific basis and causes of climate change, its potential impacts, and strategies for addressing those impacts.
- United Nations Framework Convention on Climate Change (UNFCCC): Established in 1992, its goal is to stabilize greenhouse gas atmospheric concentrations and prevent dangerous human interference with the climate system.
- The Kyoto Protocol and the Paris Agreement are two major international agreements aiming to reduce greenhouse gas emissions. The Kyoto Protocol emphasizes "common but differentiated responsibilities", while the Paris Agreement adopts a system of Nationally Determined Contributions (NDC), encouraging countries to set their own emission reduction targets based on their national circumstances.

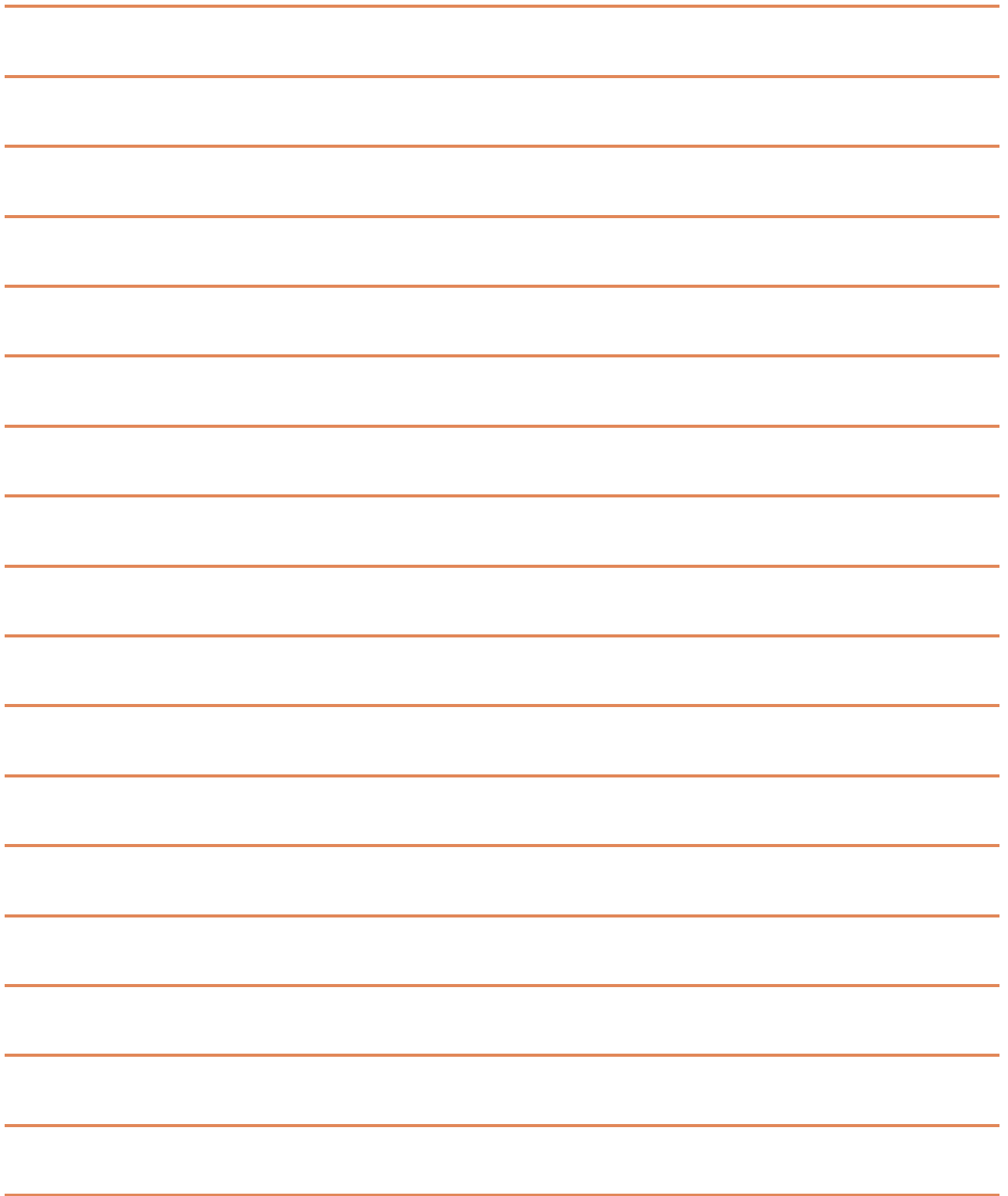
2 Government actions

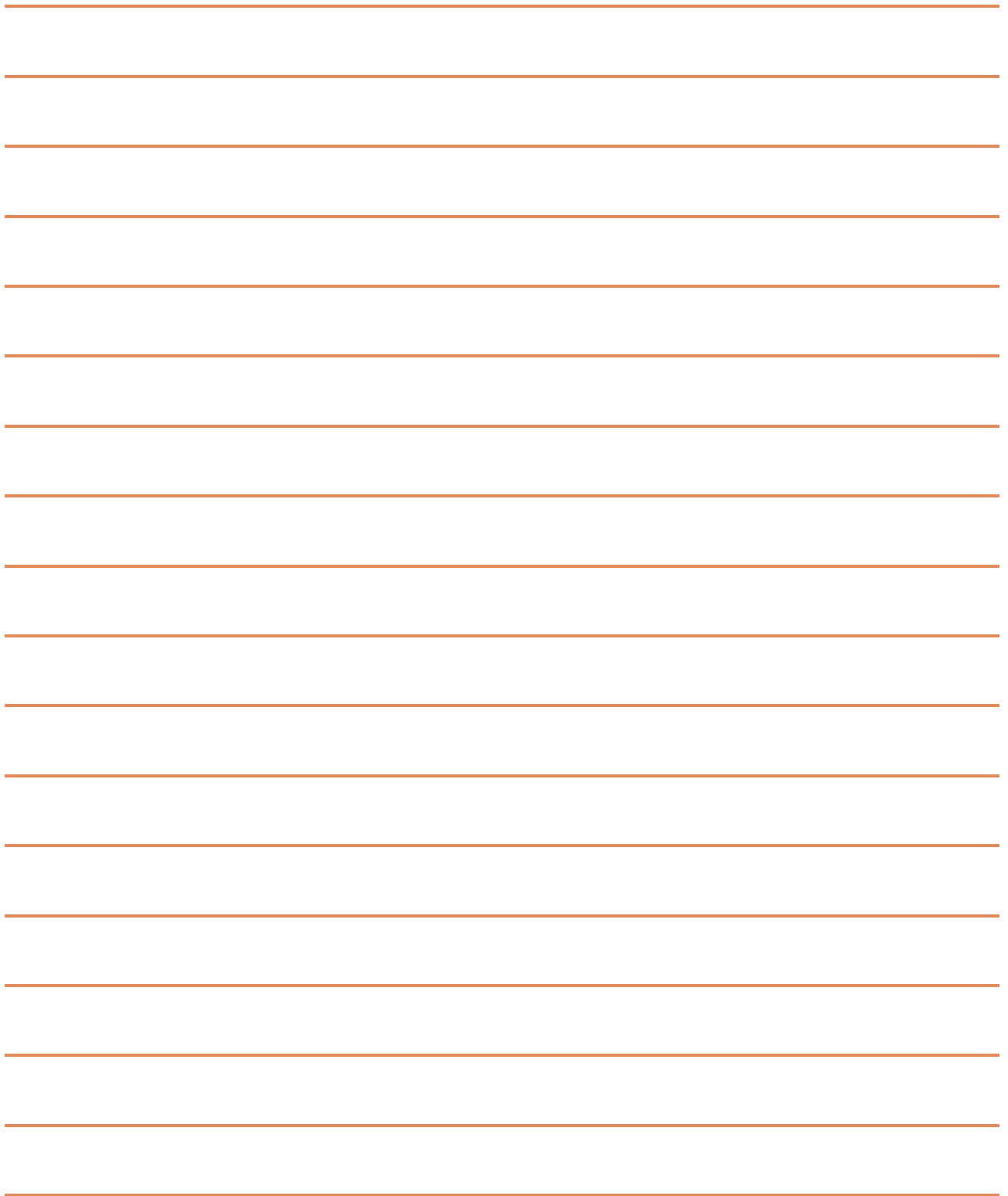
- Each country has to implement concrete measures based on its emission reduction commitment and enhance its resilience to adapt to the impacts of climate change.
- Main strategies include mitigation (reducing greenhouse gas emissions), adaptation (improving infrastructure and land use), and resilience (strengthening societal response).

3 Individual actions

Everyone has a responsibility to reduce carbon emissions by changing their lifestyle. Concrete actions include:

- Clothing: Choose energy–efficient appliances and washing machines; air–dry clothes whenever possible.
 - Food: Reduce food waste, buy locally sourced ingredients, and avoid using disposable containers and utensils.
 - Living: Use energy–saving devices, adjust air conditioning settings, reduce waste at the source, and support recycling.
 - Travel: Use public transport more often, drive less, and consider ride–sharing options.
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