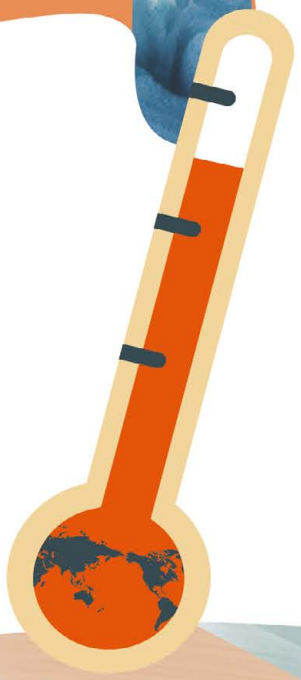
• Geography E-learning Package about •

Climate Change

Version 2.0



香港天文台
HONG KONG OBSERVATORY
優質教育基金
Quality Education Fund

I Foreword

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. Li Tsz-cheung, Senior Scientific Officer (Climate Forecasting Services and Climate Change Research), and Ms. Chan Man-yi, Chief Academic 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 Content

1. Is the climate changing?

2. What are the causes of global warming?

3. How is the climate change in Hong Kong?

4. How will climate change affect us?

5. How can we respond to the impacts of climate change?

IV 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.

7.1 Is the climate changing ?

1. Hong Kong Observatory

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

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

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

Figure 2 Weather conditions at Tsuen Wan Ho Koon (May 7, 2025)

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

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

Figure 6 Monthly mean number of occurrences of tropical cyclones affecting Hong Kong (1961–2020)

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

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

2. World Meteorological Organization (WMO)

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

Figure 22 Global mean sea level change (The seasonal cycle has been removed from the data. The shaded area indicates the uncertainty.)

3. The Intergovernmental Panel on Climate Change (IPCC)

Figure 10 Changes in surface temperature (°C per decade) during 1900–1980 (upper diagram) and 1981–2020 (lower diagram)

Figure 2.11 in IPCC, 2021: Chapter 2. 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 [Gulev, S.K., P.W. Thorne, J. Ahn, F.J. Dentener, C.M. Domingues, S. Gerland, D. Gong, D.S. Kaufman, H.C. Nnamchi, J. Quaas, J.A. Rivera, S. Sathyendranath, S.L. Smith, B. Trewin, K. von Schuckmann, and R.S. Vose, 2021: Changing State of the Climate System. 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, United Kingdom and New York, NY, USA, pp. 287–422, doi: 10.1017/9781009157896.004 .]

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.

Figure 2.24 in IPCC, 2021: Chapter 2. 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 [Gulev, S.K., P.W. Thorne, J. Ahn, F.J. Dentener, C.M. Domingues, S. Gerland, D. Gong, D.S. Kaufman, H.C. Nnamchi, J. Quaas, J.A. Rivera, S. Sathyendranath, S.L. Smith, B. Trewin, K. von Schuckmann, and R.S. Vose, 2021: Changing State of the Climate System. 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, United Kingdom and New York, NY, USA, pp. 287–422, doi: 10.1017/9781009157896.004 .]

Figure 19 Annual and decadal global glacier mass change from 1961 until 2018

Figure 2.23 in IPCC, 2021: Chapter 2. 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 [Gulev, S.K., P.W. Thorne, J. Ahn, F.J. Dentener, C.M. Domingues, S. Gerland, D. Gong, D.S. Kaufman, H.C. Nnamchi, J. Quaas, J.A. Rivera, S. Sathyendranath, S.L. Smith, B. Trewin, K. von Schuckmann, and R.S. Vose, 2021: Changing State of the Climate System. 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, United Kingdom and New York, NY, USA, pp. 287–422, doi: 10.1017/9781009157896.004 .]

Figure 21 Changes in global mean sea level

Figure 2.28 Panel (b) and (c) in IPCC, 2021: Chapter 2. 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 [Gulev, S.K., P.W. Thorne, J. Ahn, F.J. Dentener, C.M. Domingues, S. Gerland, D. Gong, D.S. Kaufman, H.C. Nnamchi, J. Quaas, J.A. Rivera, S. Sathyendranath, S.L. Smith, B. Trewin, K. von Schuckmann, and R.S. Vose, 2021: Changing State of the Climate System. 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, United Kingdom and New York, NY, USA, pp. 287–422, doi: 10.1017/9781009157896.004 .]

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

Figure SPM.3 Panel (a) and (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 .]

4. EU Copernicus European Earth Observation Programme

Figure 11 Anomalies in annual sea surface temperature for 60° S – 60° N (relative to the average for the 1991–2020 reference period)

5. US National Oceanic and Atmospheric Administration (NOAA)

Figure 12 Global ocean heat content (0–700m below sea surface)

6. Acaro

Figure 13 Antarctic sea ice (2007)

7. National Snow and Ice Data Center (NSIDC)

Figure 14 Arctic sea ice extent from July to September (1979–2024)

Figure 15 Arctic, Antarctic and global sea ice extent (1979–2024)

8. Rutgers University

Figure 16 Change in spring snow cover extent of the Northern Hemisphere

9. The National Aeronautics and Space Administration (NASA)

Figure 18 Mass variations of Antarctic ice sheet and Greenland ice sheet since 2002

10. James Balog and the Extreme Ice Survey

Figure 20 Columbia Glacier, Alaska (left photo: 2009, right photo: 2015)

7.2 What are the causes of global warming?

1. National Aeronautics and Space Administration (NASA)

Figure 2 Total solar irradiance and global surface temperature changes

2. National Snow and Ice Data Center (NSIDC)

Figure 4 Albedo of different surfaces

3. Hong Kong Observatory

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

Figure 6 Greenhouse effect

4. U. S. Geological Survey Photograph taken by Richard P. Hoblitt

Figure 5b The eruption of Mount Pinatubo in the Philippines

5. The Intergovernmental Panel on Climate Change (IPCC)

Figure 7 The atmospheric concentration of carbon dioxide

Figure 5.4 in IPCC, 2021: Chapter 5. 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 [Canadell, J.G., P.M.S. Monteiro, M.H. Costa, L. Cotrim da Cunha, P.M. Cox, A.V. Eliseev, S. Henson, M. Ishii, S. Jaccard, C. Koven, A. Lohila, P.K. Patra, S. Piao, J. Rogelj, S. Syampungani, S. Zaehle, and K. Zickfeld, 2021: Global Carbon and other Biogeochemical Cycles and Feedbacks. 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, United Kingdom and New York, NY, USA, pp. 673–816, doi: 10.1017/9781009157896.007 .]

Figure 9 Present-day Earth's energy budget

Figure 7.2 in IPCC, 2021: Chapter 7. 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 [Forster, P., T. Storelvmo, K. Armour, W. Collins, J.-L. Dufresne, D. Frame, D.J. Lunt, T. Mauritsen, M.D. Palmer, M. Watanabe, M. Wild, and H. Zhang, 2021: The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. 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, United Kingdom and New York, NY, USA, pp. 923–1054, doi: 10.1017/9781009157896.009 .]

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 .]

Figure 11 Assessed contributions to observed warming in 2010-2019 relative to 1850-1900

Figure SPM.2 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 .]

6. WMO Greenhouse Gas Bulletin

Figure 8 Trends in atmospheric concentrations of carbon dioxide, methane and nitrous oxide

7. Skeptical Science

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

7.3 How is the Climate Change in Hong Kong?

1. Hong Kong Observatory

Figure 1 Annual average temperature recorded at the HKO Headquarters (1885-2024)

Figure 2a Change in the annual number of hot nights and very hot days in Hong Kong (1884-2024)

Figure 2b Change in the annual number of cold days in Hong Kong (1884-2024)

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Figure 4 Annual mean sea level at Victoria Harbour (1954-2024)

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

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

Figure 8 Annual mean cloud amount recorded at the HKO Headquarters (1961-2024)

Figure 9 Annual mean daily total global solar radiation recorded at King's Park (1968-2024)

Figure 10 The average diurnal variation of relative humidity at the HKO and Ta Kwu Ling (1989-2024)

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

Figure 13 The effects of construction materials and building density on diurnal variations of air temperatures.

Figure 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).

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

7.4 How will climate change affect us?

1. US National Oceanic and Atmospheric Administration (NOAA)

Figure 1 Change in American lobster distribution

Figure 12 NOAA satellites monitored southern California wildfires on 9 January, 2025

Figure 13 Aerial assessment imagery collected in the aftermath of Hurricane Ian on 29 September, 2022

2. Charles Koven, Lawrence Berkeley National Lab

Figure 2 Climate model projection on shifting of prairie climate in North America

3. The University of Washington

Figure 3 Projected movements of animals in North America

4. Gary Chan

Figure 4 Hong Kong Giant Spiny Frog

Figure 6 Barn swallows that pass through Hong Kong in spring for breeding

5. Dickson Wong

Figure 5 Insect pollination

Figure 10 Coral bleaching

6. Pixabay

Figure 7 Polar bear and cubs

7. Jerzy Strzelecki

Figure 8 Antarctica Adélie penguin

8. Ian Bell © Queensland Government

Figure 9 Great Barrier Reef Bramble Cay

9. Kwok Chi Tai

Figure 11 A Wetland habitat

10. National Snow and Ice Data Center (NSIDC)

Figure 15a Arapaho Glacier in 1904

Figure 15b Arapaho Glacier in 2021

11. National Security Education Day, GovHK

Figure 16 A holistic approach to national security

12. Hong Kong Observatory

Figure 17 Future climate of Hong Kong

13. Commercial Radio Hong Kong

Figure 18 Condition in Wong Tai Sin District on 8 September, 2023

14. Ho Koon Nature Education cum Astronomical Centre

Figure 19 Increase in temperature affects the breeding of Paramesotriton hongkongensis

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

1. American Public Power Association

Figure 3 Hydro-electric dam

2. Pekachu

Figure 4 Coastal construction structures in Japan

3. Kleon3

Figure 5 Sluice in River Thames, England and its operation

4. Infrogmation

Figure 6 Flood-resilient house

5. Michael Slaten

Figure 7 Houston, the United States faces extreme rainfall and storm surge inundation

6. Carbon Neutrality and Sustainable Development, GovHK (Environment and Ecology Bureau)

Figure 8 Greenhouse gas emission trends and carbon emission sources in Hong Kong

7. Dr. T.C. Lee

Figure 9 Tai Hang Tung Stormwater Storage Tank reduces the surface runoff discharged into the downstream drainage system during heavy rainstorms

8. Hong Kong Observatory

Figure 11 HKO weather radars provide round-the-clock monitoring for severe weather, including rainstorm and tropical cyclones

Figure 12 HKO enhances public understanding of climate change through outreach activities like open days

9. Canva Education

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

Figure 14 Bring containers when dinning out or ordering takeout.

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