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Climate and Environmental Change in China: 1951–2012

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Climate and Environmental Change in China: 1951–2012

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Preface

Global climate and environmental change is one of the key scientific and societal issues worldwide. The Intergovernmental Panel on Climate Change (IPCC) has published five assessment reports since 1990. The first scientific assessment report of “China Climate and Environmental Change” published in 2005. Subsequently, the first “National Assessment Report on Climate Change” in China was published in 2007 based on the results from the scientific assessment report. These two assessment reports provided important scientific basis for full recognition of China’s climate and environmental change, impacts, and adaptation, attracting much attention from scientific community, governmental agencies, policy makers, and general public as a whole.

In order to further coordinate with the international climate change assessment, synthesize the up-to-date results of climate and environmental change research, and promote the Chinese scientists’ contribution to global change science, China launched the second assessment of “Climate and Environmental Change in China: 2012,” supported by the Chinese Academy of Sciences and the China Meteorological Administration in 2008. The original plan was that the assessment in English should be completed and published in 2012, in line with the completion and publication of the IPCC Fifth Assessment Report in 2013. The Chinese version of “Climate and Environmental Change in China: 2012” was indeed published in 2012 with four volumes: the scientific basis; the impact of vulnerability; mitigation and adaptation of climate and environmental change in China; and a technical summary volume. This English version is a synthesis of the “China climate and environmental Change: 2012” with some additional background of climate, environmental, and geographic information.

This book adopts the procedures and styles of international scientific assessment on climate and environmental change. Based on the most up-to-date scientific research results from national and international literatures, the authors extracted the mainstream views and summarized the major conclusions with concessions from scientific community. All cited references are peer-reviewed articles, especially those articles published in Chinese journals which have limited availability to the

international scientific community. Based on community-recognized major datasets on conclusions, this book provides a comprehensive analysis and assessment on climate and the environment changes, and its impacts, adaptation, and mitigation measures. The aim of the “Climate and Environmental Change in China: 1951–2012” is to introduce the most up-to-date climate change research results by Chinese scientists to international community, enhancing a better understanding of progress on developments of climate change science in China and jointly dealing with the impacts of climate change worldwide.

This book consists of eight chapters. Chapter 1 provides background information on the basic characteristics of climate and environment conditions, and societal and economic developments in China. Chapter 2 introduces the observed evidence of climate and environmental change during the past six decades, followed by discussions on the causes and uncertainties of climate and environmental change in Chap. 3 and on the impacts of climate change on China’s environment, economy, and society in Chap. 4. Chapter 5 describes the projection of climate change by the end of twenty-first century and further discusses the possible implications. Chapter 6 briefly introduces the technologies and policy options on adaptation and mitigation of the impacts of climate and environmental change. Chap. 7 gives the Chinese government’s strategic plans to address climate change. Finally, Chap. 8 summarizes the key findings and important scientific understanding.

The above contents include many aspects of sciences in climate and environmental change, such as in natural, societal, economic, and human dimensions. It is the most updated and authoritative scientific assessment report on understanding climate and environmental change, impacts, adaptation, and mitigation pathways in China. I am so pleased and excited to the publication of this book in English to the world climate research community and general public at large.

There are many colleagues and experts who contributed to this book. They are from the Chinese Academy of Sciences, the China Meteorological Administration, the Ministry of Education, the Ministry of Health, the Ministry of Water Resources, the Oceanic Administration, the Ministry of Agriculture and Forestry, the Development and Reform Commission, the Ministry of Foreign Affairs, the Ministry of Finance, the Chinese society Academy of Sciences, and societal organizations. Publication of this book is a truly team effort with experts from multiple organizations and disciplines. It is a contribution by Chinese climate scientists to better understand world climate and environmental changes.

I would like to express my gratitude to all authors and contributors, reviewer experts, project office, and secretarial group for their hard work and for taking responsibilities. The State Key Laboratory of Cryosphere Science is in charge of the project office and secretary group work. The secretary group consists of Wenhua Wang, Yawei Wang, Aihong Xie, Chuancheng Zhao, Jianbin Xiong, and Fu Sha, and they all have done a lot of fruitful work. I thank Lisa Fan who has done careful work that assured the book quality.

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Due to the complexity and uncertainty of climate and environment research, errors and mistakes may have occurred as well as imperfections in the layout of the book. The editors and chapter authors look forward to comments and suggestions from the readers. Criticisms from readers are the power to improve scientific research and assessment work in future.

Beijing
October 2014

Dahe Qin

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Chapter 1

Climate, Environmental, and Socioeconomic Characteristics of China

Dahe Qin, Shu Tao, Suocheng Dong and Yong Luo

Abstract The features of the natural environment in China were described in this chapter, including topography, hydrology and water resources, cryospheric resources, plants, animals and biodiversity, soil types and land resources, and ocean and islands. After that, an eco-geographical region system of depicting zonal distribution of physiographical factors was introduced. China's climate is governed by its geography and topography, with most of the territory falling in the monsoon zone. The most direct component influencing China's climate is the East Asian atmospheric circulation (monsoon). Climate zoning in China provides a service for targeted industrial and agricultural activities, and socioeconomic development, and also a scientific basis for climate change adaptation. However, China is susceptible

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to weather and climatic disasters. As one of the world's emerging economies, China has experienced rapid and stable socioeconomic development, industrialization, urbanization, and further internationalization since the introduction of reform and opening-up policy, ranking second of gross domestic product (GDP) around the world. At present, China is confronted with two main challenges: addressing climate change in the international arena and protecting its resources and environment with a domestic socioeconomic transition.

Keywords Physiographical factors · Regionalization · China climate · Climate resources · Climate zoning · Weather and climatic disasters · Socioeconomy · Population · Urbanization

1.1 Features of the Natural Environment in China

1.1.1 *Geographical Location and Landmass of China*

China is located on the eastern side of the Eurasian continent and on the west shore of the Pacific Ocean. From north to south, China spans ~5500 km, stretching from the center of the Heilongjiang River north of the town of Mohe in Heilongjiang Province (north of 53°N) to the southernmost Zengmu Reef (near 4°N); from east to west, the nation extends from the confluence of the Heilongjiang River and Wusuli River (west of 135°E) to the Pamir Plateau in the Xinjiang Uygur Autonomous Region (near 73°E), spanning ~5000 km. China has a land area of ~9.6 million km² and is the third largest country in the world, after Russia and Canada. China borders on 14 countries and shares a maritime border with eight countries. China is bordered by North Korea and Russia to the northeast; Kazakhstan, Kyrgyzstan, and Tadjikistan to the northwest; Mongolia to the north; Afghanistan and Pakistan to the west; India, Nepal, and Bhutan to the southwest; and Myanmar, Laos, and Vietnam to the south.

1.1.2 *Topography of China*

China has a “terraced” terrain that gradually descends from the west to the east stepwise in three terraces, linking the mainland and the Pacific Ocean basin through a wide continental shelf. The highest terrace is the Qinghai-Tibet Plateau (the highest plateau in the world), with an average elevation of more than 4000 m and an area of ~250 million km². The Qinghai-Tibet Plateau is composed of seven mountain ranges, from north to south: the Kunlun Mountains, the Altun Mountains, the Qilian Mountains, the Tanggula Mountains, the Karakoram Mountains, the Gangdise Mountains, and the Himalaya Mountains. East of the Kunlun Mountains,

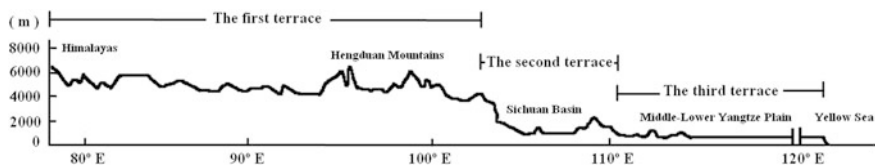


Fig. 1.1 Three terrain terraces in China

the second terrace includes the Qilian Mountains, the eastern rim of the Minshan Mountains, the Qionglai Mountains, and the Hengduan Mountains, and descends to an elevation of 1000–2000 m (some areas are below 500 m). The eastern rim of this second terrace is roughly bounded by the Greater Hinggan Mountains, the Taihang Mountains, the Wushan Mountains, the Wuling Mountains, and the Xuefeng Mountains. The second terrace consists of a series of mountains, plateaus, and basins including the Altai Mountains, the Tianshan Mountains, and the Qinling Mountains; the Inner Mongolia Plateau, the Loess Plateau, and the Yunnan-Guizhou Plateau; and the Junggar Basin, the Tarim Basin, the Qaidam Basin, and the Sichuan Basin, from north to south. The third terrace consists of hills and plains below 500 m in elevation and begins at a line from the Da Xing'an Ling Mountains to the Xuefeng Mountains and ranges eastward to the Pacific Ocean. Here, running from north to south are the Northeast Plain, the North China Plain, and the Middle-Lower Yangtze Plain; there is a wide, low, hilly region in the south Yangtze River area that is referred to as the Southeast Hills. Altitudes in the third terrace range from below 200 to 500 m, with only a few mountains reaching or exceeding 1000 m (Fig. 1.1).

Topography across China is varied and complicated, including plains, plateaus, mountains, hills, and basins. The proportion of various landforms is as follows: mountains, 33 %; plateaus, 26 %; basins, 19 %; plains, 12 %; and hills, 10 %. Including all mountainous areas and rugged plateaus, mountainous areas in China occupy fully two-thirds of total land area.

China has broad deserts and Gobi areas, mainly in the north, including arid and semiarid regions in the northwest and Inner Mongolia. Total desert areas comprise 1.28 million km², occupying 13 % of the country's area. The largest desert area is in the west of Wushaoling and Helan Mountains, and includes the Taklimakan Desert, the Gurbantunggut Desert, the Badan Jaran Desert, and the Tengger Desert (the four largest deserts in China). Around the periphery of large deserts, there is ribbon or ring of Gobi deserts.

1.1.3 Hydrology and Water Resources of China

There are more than 1500 rivers in China, each draining 1000 km² or more. Because most of the large rivers originate in the Qinghai-Tibet Plateau, China is rich in hydropower resources and leads the world in hydropower potential, with reserves of 680 million kW.

China's rivers can be categorized as exterior and interior systems. The catchment area for the exterior rivers, which empty into the ocean, accounts for 64 % of the country's total land area. The Yangtze, Yellow, Heilongjiang, Pearl, Liaohe, Haihe, Huaihe, and Lancang Rivers flow east, and empty into the Pacific Ocean. The Yarlungzangbo River in Tibet flows first east and then south into the Indian Ocean, and the Ertix River flows from the Xinjiang Uygur Autonomous Region to the Arctic Ocean. The catchment area for the interior rivers (those that flow into inland lakes or disappear into deserts or salt marshes) makes up 36 % of China's total land area. The Tarim River in southern Xinjiang is 2179 km long and is China's longest interior river.

China, however, is a country of a severe drought and water shortages. Total freshwater resources are 2.8 trillion m³, accounting for 6 % of global water resources and ranking fourth in the world only after Brazil, Russia, and Canada. The total quantity of Chinese water resources is comparatively great, but its per capita average is only 2200 m³, about 1/4 of the world average value and 1/5 of that of the USA. China's per capita water resources rank it in the 13 most water-poor countries in the world.

1.1.4 Cryosphere of China

The extensive cryospheric resources of China play an important role in the world. China has a large number of mountain glaciers in mid-latitude areas: 46,298 glaciers with a total area of 59,406 km², which is ~0.4 % of the total area of the world's glaciers and ice sheets, 14.6 % of the area of global mountain glaciers, and 47.6 % of the area of Asian mountain glaciers. The ice reserves of China are ~5590 km³ (Table 1.1) (Liu et al. 2000).

Frozen ground in China can be divided into two categories: seasonally frozen ground and permafrost. Seasonally frozen ground occupies more than half of China's territory, with its southern boundary starting from Zhangfeng in Yunnan Province in the west, across Kunming and Guiyang, then around the northern margin of the Sichuan Basin, to Changsha, Anqing, and Hangzhou in the east. The depth of the seasonally frozen ground can be over 3 m in southern Heilongjiang Province, northeastern Inner Mongolia Autonomous Region, and northwestern Jilin Province, and the frozen depth gradually decreases as latitude decreases. The distribution areas of permafrost mainly include the Da Xing'an Ling Mountains and Xiao Xing'an Ling Mountains in the northeast, and the Altai Mountains, Tianshan Mountains, Qilian Mountains, and Tibetan Plateau in the west, accounting for 1/5 of China's land territory.

Frozen ground is divided into three regions in China: the East Region, the Northwest Region, and the Qinghai-Tibet Plateau Region. In the East Region, the distribution area is from the Da Xing'an Ling Mountains and Xiao Xing'an Ling Mountains in the north to the Yangtze River Basin and even to Zhejiang, Hunan, Fujian, and other provinces in some years. In the Northwest Region and the

Table 1.1 Numbers of glaciers in the mountain ranges of China (Liu et al. 2000)

Mountains	Elevation of peaks (m)	Number of glaciers		Area of glaciers		Ice reserves		Average area (km ²)	Coverage of glaciers (%)
		Number	%	km ²	%	km ³	%		
Altai	4374	403	0.87	280	0.47	16	0.28	0.68	0.97
Sawuershan	3835	21	0.05	17	0.03	1	0.01	0.8	0.38
Tianshan	7435	9081	19.61	9236	15.55	1012	18.1	1.02	4.36
Pamirs	7649	1289	2.78	2696	4.54	248	4.45	2.09	11.33
Karakoram ¹	8611	3454	7.46	6231	10.49	686	12.28	1.8	23.42
Kunlun	7167	7694	16.62	12266	20.65	1283	22.95	1.59	2.57
Altun	6295	235	0.51	275	0.46	16	0.28	1.17	0.49
Qilian	5827	2815	6.08	1931	3.25	93	1.67	0.69	1.46
Qiangtang Plateau	6822	958	2.07	1802	3.03	162	2.9	1.88	0.41
Tanggula	6621	1530	3.3	2213	3.73	184	3.29	1.45	1.57
Gangdise	7095	3538	7.64	1766	2.97	81	1.45	0.5	1.16
Nyenchen Tanglha	7162	7080	15.29	10701	18.01	1002	17.92	1.51	9.68
Hengduan	7514	1725	3.73	1580	2.66	97	1.74	0.92	0.44
Himalayas	8848	6475	13.99	8412	14.16	709	12.68	1.3	4.15
Total		46298	100	59406	100	5590	100	1.28	2.5

Note The 142 glaciers under the actual control of Palestine, located upstream of the Klechin River, which is the source of Yarkant River, are not included (these occupy an area of 609 km², and their ice reserves are 72 km³)

Qinghai-Tibet Plateau Region, both seasonally frozen ground and permafrost are extensively distributed. Frozen ground is mainly distributed along latitudinal zones in the East Region and along altitudinal zones in the Qinghai-Tibet Plateau Region, with a combined distribution of the two types in the Northwest Region.

Permafrost in China can be divided into high-latitude permafrost and high-altitude permafrost. The former is located in the Northeast Region, while the latter is found in the mountains and plateaus in the west and also in high mountains in the east (such as the Huanggangliang Mountains of southern Da Xing'an Ling Mountains, the Changbai Mountains, the Wutai Mountains, and the Taibai Mountains). Seasonally frozen ground in China varies significantly within the year, showing distinct seasonal changes. The freeze begins in September and gradually expands from north to south. Both the area and the depth of the frozen ground in China reach a maximum in late winter and early spring, with more than 100 cm and even more than 200 cm in some regions of northern China and the Qinghai-Tibet Plateau. In summer, seasonally frozen ground shrinks continuously, declining to a minimum in August. Autumn and spring are transitional seasons. In autumn, the area and depth of frozen ground increase gradually, while these decrease gradually in the spring. Seasonally frozen area has the longest freezing period (over half a year) in the Da Xing'an Ling Mountains and Xiao Xing'an Ling Mountains and on the Qinghai-Tibet Plateau, while the shortest freezing period is in the Yangtze River Basin and the Huaihe River Basin, lasting about two or three months (Chen and Li 2008).

1.1.5 Animals, Plants, and Biological Diversity in China

China is rich in animal species, with 6222 kinds of vertebrates, including 2404 kinds of terrestrial vertebrates and 3862 species of fish, accounting for ~10 % of vertebrate species in the world. China hosts hundreds of kinds of specific rare animals such as pandas, golden monkeys, the south China tiger, brown-eared pheasant, red-crowned crane, crested ibis, white-flag dolphin, and the Yangtze alligator.

China also has some of the richest plant resources in the world, with more than 32,000 kinds of vascular plants. China has more than 7000 kinds of woody plants, including more than 2800 kinds of trees, among which there are Chinese endemic tree species such as *Metasequoia glyptostroboides*, *Glyptostrobus pensilis*, silver fir, Chinese fir, golden larch, Taiwania, Fujian cypress, dove tree, *Eucommia ulmoides*, and *Camptotheca acuminata*. There are more than 2000 kinds of edible plants and more than 3000 kinds of medicinal plants found in China. Ginseng from the Changbai Mountains, safflower from Tibet, medlar from Ningxia, and *Panax notoginseng* from Yunnan and Guizhou are all famous medicinal plants.

China has a rich biodiversity, occupying a very unique position in the world. Biodiversity experts ranked China as 8th in the 12 most biodiverse countries of the world in 1990. China has the richest biodiversity among Northern Hemisphere countries.

1. High species richness: more than 30,000 species of vascular plants, third in the world after Brazil and Colombia.
2. Abundant endemic genera and species: China has 17,300 endemic species of vascular plants, accounting for more than 57 % of China's vascular plants. It has ~110 endemic mammalian species, occupying ~19 % of the 581 species in China.
3. Ancient flora: Many areas in China preserve ancient relict components of the Cretaceous and Tertiary (because China was not covered by glaciers in the Quaternary Ice Age). For example, China has six of the existing seven families of conifers in the world.
4. Abundant germplasm resources of cultivated plants, domesticated animals, and their wild relatives: China has thousands of years of cultivation history, and so it has the greatest abundance of cultivated plants and domesticated animals in the world.
5. Rich ecosystem types: China has various types of terrestrial ecosystems, including forest, scrub, steppe and savanna, meadow, desert, and alpine tundra. These ecosystems can be further divided into ~600 subecosystems.
6. Complicated and diverse spatial patterns: China has vast territory, undulating landforms, and complex and changeable climates. From north to south, climates range from a cold temperate zone, temperate zone, warm temperate zone, subtropical zone, and tropical zone. Chinese biomes consist of cold temperate coniferous forests, temperate coniferous and broad-leaved mixed forests, warm temperate deciduous broad-leaved forests, subtropical evergreen broad-leaved forests, and tropical seasonal rain forests. From east to west, along the track of reduced precipitation, the mixed coniferous broad-leaved forest and broad-leaved deciduous forest are sequentially replaced by the meadow steppe, typical steppe, desert steppe, steppe desert, typical desert, and dry desert in the north; in the south, there are obvious differences between the evergreen broad-leaved forests of the eastern subtropical zone in the Southern Hills and the evergreen broad-leaved forests of the western subtropical zone in the Yunnan-Guizhou Plateau.

1.1.6 Soil and Land Resources of China

1. Soil types and distribution

China's soil resources are rich, and its soil types are complex. Soil types in China can be classified into red soil, brown soil, cinnamon soil, black soil, chestnut soil, desert soil, fluvo-aquatic soil (including sand ginger chernozem), anthropogenic alluvial soil, paddy soil, wet soil (meadow, boggy soil), saline-alkali soil, endodynamorphic soil, and alpine soil. Among these soil series, the red soil series, which are the most important soil resource in tropical and subtropical regions, are suitable for cash crops, fruit trees, and lumber. From south to north, the spatial distribution