Chapter 2
Physical Geography of China and the U.S.

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China and the U.S. receive currently a lot of attention in the mass media as well as in the academic literature. A comparative physical geography of both countries is an important step to better understand their complex relationships. Landforms, climates, river basins and vegetation patterns of China and the U.S. are respectively introduced, as well as their natural regionalization which is based on the above mentioned factors. The following section focuses on natural disasters including earthquakes, hurricanes/typhoons, floods and droughts. Further, environmental issues and problems are discussed. Finally, all the physical geography features for both countries are compared to show the similarities and differences.

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2.1 Physical Geography

2.1.1 Landforms

2.1.1.1 Topography and landforms of China

The most obvious topographic feature of China is the higher elevation in the west and the lower elevation in the east, which could be visualized in form of steps of a stairway (Fig. 2.1). On top of the stairway—the first topographic step—is the Qinghai-Tibet Plateau in the southwest of China, a mountainous plateau with an average elevation of more than 4,500 m. Here are found a series of east-west or northwest- southeast trending mountain ranges, whose elevation are more than 5,000–6,000 m, including mainly the Hoh Xil Mountain, the Bayan Har Mountain, the Tanggula Mountain, the Gangdise Mountain and the Nyainqentanglha Mountain. The Qaidam Basin, known as a "treasure basin", is embedded inside these mountains. The plateau is surrounded by numerous towering mountains. In the south rises the highest mountain range in the world, the Himalayas Mountains, with an average elevation of more than 6,000 m. The Kunlun Mountains, Altun Mountains, Qilian Mountains in the north, and the Longmen Mountains, Minshan Mountains, Hengduan Mountains in the east form the boundary between the first and the second topographic step (Wang, 2007).

The second topographic step consisting of mainly plateaus and basins, is between the outer margins of the Qinghai-Tibet Plateau and the Daxing'an Ranges, Taihang Mountains, Wushan Mountains, and Xuefeng Mountains. This region contains a series of high altitude mountains from 1,500 to 2,500 m, such as Yinshan Mountains, and Qinling Ranges etc., as well as plateaus from 1,000 to 2,000 m including the Inner Mongolia Plateau, the Ordos Plateau, the Loess Plateau, and the Yunnan-Guizhou Plateau from north to south. The largest basin (Tarim Basin), the second largest basin (the Junggar Basin) and the basin with the lowest elevation (the Sichuan Basin) in China are located here.

The third topographic step consists of plains and peneplains, which extend along the boundary between the Daxing'an Ranges and the Xuefeng Mountains. From north to south, the Northeast Plain, the North China Plain, and the Middle-lower Yangtze River Plain are located with elevations mostly below 200 m. The vast area to the south of the Yangtze River consists of mainly hills with elevations of less than 500 m. To the east of these plains and hills, narrow and long mountains which are north-east trending are found. These mountains include the Changbai Mountains, Central-Shandong Mountains, Xianxia Mountains, Wuyi Mountains and so on, ranging from 500 to 1,500 m. To east of the coastline is a broad continental shelf. Many Islands are distributed here; and the most famous are the Hainan Island and the Taiwan Island.

China contains five kinds of landform types, including mountain, plateau, hill, basin, and plain. Among the five landform types, mountains and plateaus are most

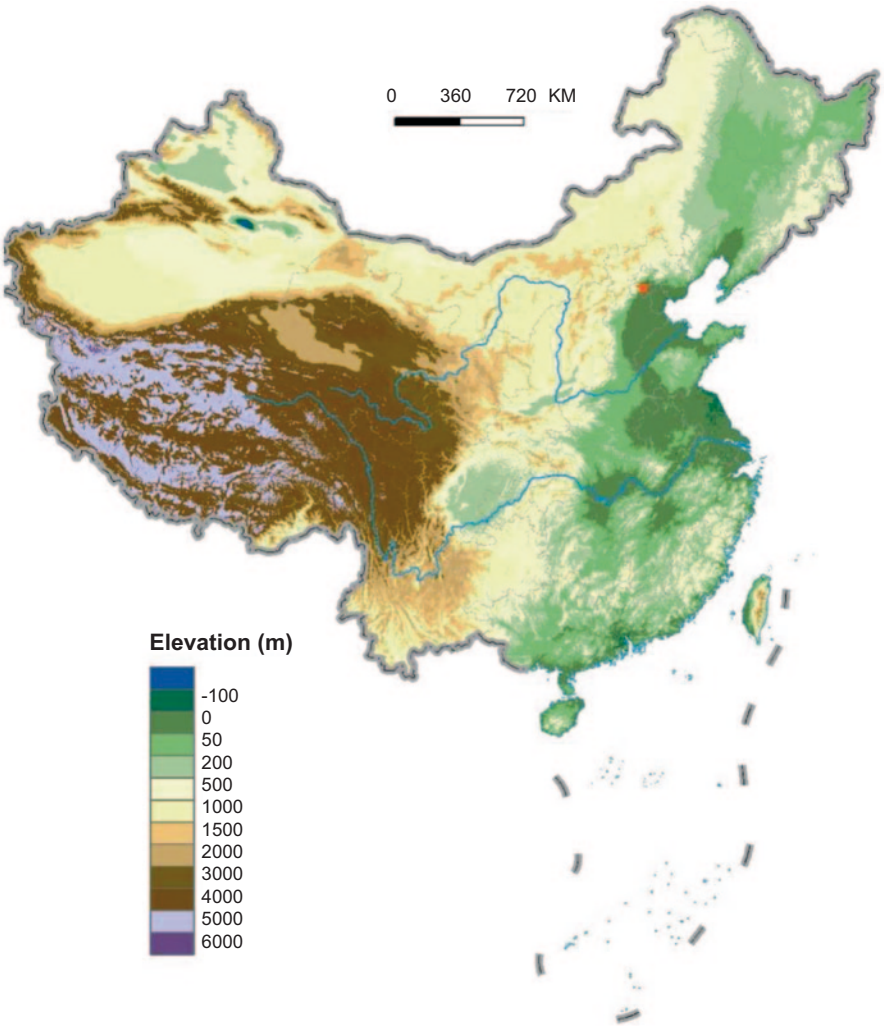

Fig. 2.1 The topography/landforms of China

extensive, accounting for 59% of the total China land area followed by basins (19%), plains (12%), and hills (10%) (Chinese Academy of Sciences, 1985).

China is a mountainous country, where the mountainous regions account for about 65% of its total land area. The crisscrossing mountains constitute the backbone of the landscapes of China and have an impact on the spatial distributions of other landscape types in China. (1) The south-north trending mountain ranges include the Helan, Liupan, and Hengduan (transverse) mountain ranges. These north-south running mountains divide China into an eastern and a western half. In the West, most of the mountains which are northwest or northwest-west trending are

above 3,500 m high, while most of the northeast-north trending mountains in the East are below 3,500 m. (2) There are three major east-west trending mountains, including Yinshan Mountains-Tianshan Mountains, Kunlun—Qinling—Huaiyang Mountains and Nanling Mountains from north to south. The latitudinal distance between them is almost equally 8°. The Qinling Mountain is not only the watershed of the Yellow River, Yangtze River, and Huai River systems, but also an important natural geographical boundary between northern and southern China. (3) The north-west trending mountains are mainly distributed in the western part of China, including the Altay Mountains, Qilian Mountains, Karakorum Mountains, Hoh Xil Mountain, Tanggula Mountain, Gangdise Mountains, Nyainqentanglha Mountains and so on. The western part of the Himalayas in the north of Qinghai-Tibet Plateau is also north-west orientated; however, its eastern portion gradually shifts into east -west orientation, forming an arcuate mountain belt bulging southward. Most of these mountains are high and steep with a frigid climate and generally are covered by glaciers. (4) The north-east trending mountains are mainly distributed in eastern China. They are arranged in form of a West row, an East row, and an outer row respectively from west to east. The West row includes Daxing'an Range, Taihang Mountains, Wushan Mountains, Wuling Hill, Xuefeng Mountains etc. The East row starts from the Changbai Mountains in the north, through Qianshan and the low hills in Luzhong, and then reaches to the Wuyi Mountains in the south. The Outer row consists of the Taiwan Mountains on the island of Taiwan.

The Qinghai-Tibet Plateau, the Inner Mongolia Plateau, the Loess Plateau, and the Yunnan-Guizhou Plateau are the four biggest plateaus in China. The Qinghai-Tibet Plateau lies to the north of the Himalayas Mountains, to the south of the Kunlun, Altun, and Qilian Mountains, and to the west of the Minshan—Qionglai—Jinping Mountains. It is the largest and highest plateau with a frigid climate and glaciers. The Inner Mongolia Plateau, the Loess Plateau, and the Yunnan-Guzhou Plateau, are located in the second topographic step and divided by the Yinshan Mountains, the Qinling Range, and the Dalou Mountains from north to south. Due to the differences in the composition of the materials and the exogenic processes, there are obvious differences among the morphotypes of the landforms on the plateaus. The Inner Mongolia Plateau located in the northern interior, where the climate is dry with little rainfall, is less impacted by fluvial forces but dominated by eolian forces. The plateau surface is relatively well preserved. Covered by soils of loose texture and affected by a strong fluvial process, the surface of the Loess Plateau was severely cut into pieces full of gullies and ridges everywhere. The Yunnan-Guizhou Plateau, also known as the "karst plateau", has a full set of karst landforms with a subtropical humid climate, widespread carbonate rocks, and very well developed karst processes.

The Tarim Basin, the Junggar Basin, the Qaidam Basin and the Sichuan Basin all located in tectonic fault zones, are the four biggest basins in China. The Tarim Basin that contains the largest desert in the country, the Taklimakan Desert, is the biggest basin in China. It has obvious Aeolian denudations and erosions with a closed terrain, an extremely drought prone climate, and a sparse vegetation cover. The second largest basin in China, the Junggar Basin, is a semi-closed basin with a slightly

increased precipitation and a relatively denser vegetation cover. It has vast areas of grasslands and a very developed livestock sector. Due to the abundant water from the melting snow and ice, agriculture thrives in the oases at the edges of the Tarim Basin and the Junggar Basin. In addition, there are many oil and natural gas fields in southern and northern Xinjiang Province. China's third largest and highest basin, the Qaidam Basin, has a dry climate, long hours of sunshine, abundant solar energy resources, and it is rich in salt, metal ores, oil and natural gas resources. The smallest basin in China, the Sichuan Basin, also known as the "land of abundance", is surrounded by many mountains. It has a warm and humid climate, numerous rivers systems, fertile soils, rich natural resources, a dense population, and a developed economy.

China's three largest plains, the Northeast Plain, the North China Plain, and the Middle-Lower Yangtze River Plain, are all concentrated in the third topographic step, among the east-west or north-east trending mountain ranges. With the vast land areas, low and flat terrains, easily accessible by transportation, dense population, and developed cities and towns, they are the nation's major agricultural bases and densely urbanized areas. The Northeast Plain is the biggest plain in China. It is formed by the alluvial deposits of such rivers, as the Heilong River, Nenjiang River, Songhua River, and Liaohe River, and is characterized by the large area of black soils and the widely distributed marshes. The North China Plain is the second largest plain, mainly formed by the alluviums from the Yellow River, the Huaihe River, and the Haihe River. The lands are low lying and flat with gentle slopes where many river beds are above the plains on both sides of the rivers. The phase distribution of the above-ground rivers and the depressions is a unique feature of the North China Plain. The third biggest plain, the Middle-Lower Yangtze River Plain, includes the Dongting Lake Plain, the Poyang Lake Plain, the Jiangsu and Anhui plains along the rivers, and the Yangtze River Delta, distributed like a string of beads from east to west. The Yangtze River Basin, a famous "Land of Abundances" in China, is characterized by a low lying and flat terrain, dense lakes and canals, and large areas of connected rice paddy fields.

China's hills, generally called the "Southeast Hills", are mainly distributed in the third topographic step, and are particularly concentrated in the vast areas to the east of the Xuefeng Mountain and to the south of the Yangtze River. Among them, the hills to the south of the Yangtze River and to the north of Nanling Mountain are called the "South Hills"; whereas the hills to the east of the Wuyi Mountain and within Zhejiang and Fujian provinces are called the "Zhejiang-Fujian Hills". To the north of the Yangtze River, there are not many hills except the Shandong Hills and the Liaodong Hills. The Southeast Hills are largely distributed on the two sides of a series of north-east trending mountains with middle to low altitudes; inside the mountains are many different sizes of scattered red rock basins. Because of the differences in lithological features, the Jiangnan Hills are covered with thick, red sandstones or conglomerates. Zhejiang-Fujian contains extensive granite and rhyolite. The Shandong Hills and Liaodong Hills consist of metamorphic rocks and granite which have been severely cut with a cursive coastline, and numerous bays and islands.

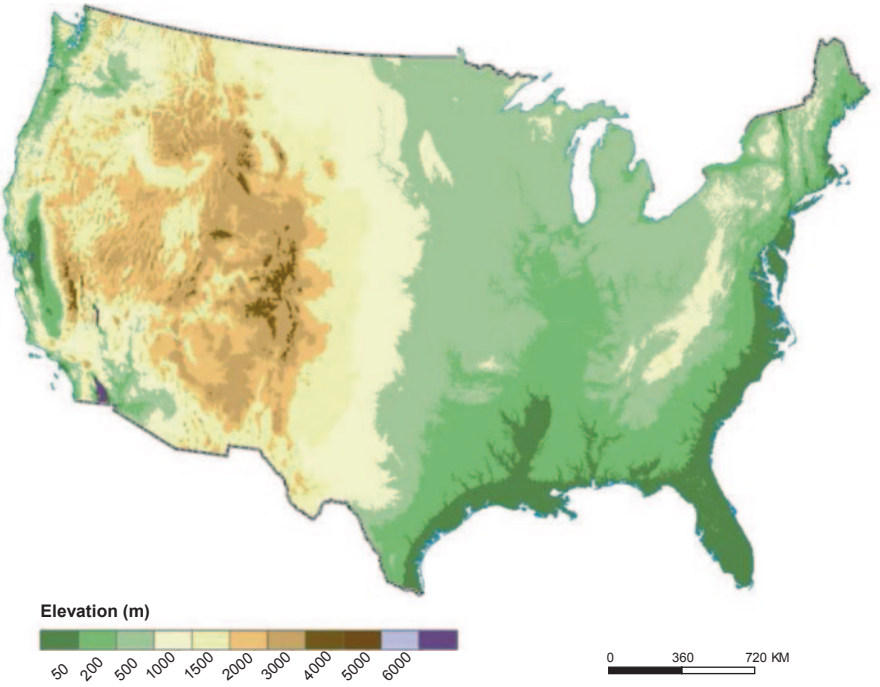

Fig. 2.2 The topography/landforms of the conterminous U.S.

2.1.1.2 The Topography and Landforms of the United States

The most obvious topographic feature of the conterminous U.S. is the higher elevations on the east and west sides and the lower elevations in the vast central plains. In addition, all of its major mountain systems have a north-south alignment. Its terrain can be roughly divided into three zones (Fig. 2.2):

The Western Cordillera System The Western Cordillera starts from Alaska in the north and extends all the way to the American Isthmus in the south, stretching the entire north-south extent of the western conterminous U.S. It is composed of a series of high and wide (usually 2,000–3,000 m high, 800–1,600 km wide) mountain ranges, plateaus, intermountain basins, and valleys that cover approximately one-third of the U.S. land area. Its components are arranged in a series of three large north-south trending bands, with the Rocky Mountains on the east separated from the pacific coastal mountains and valleys on the west by a series of high, heavily dissected intermountain basins plateaus.

The Rocky Mountains in the east, generally high and rugged, stretch more than 4,830 km (3,000 miles) from the Yukon plateau in the western Canada to the Rio Grande River in New Mexico in the southwestern United States. This bulky north-south trending mountains are about 4,830 km (3,000 miles) long; they run through

almost the entire north-south extent of the U.S. This range serves as an important continental divide of the drainage systems. All major rivers in the US, including the Columbia, Colorado, Missouri, and Rio Grande Rivers, originate from the Rocky Mountains and eventually drain into three of the world's Oceans: the Atlantic Ocean, the Pacific Ocean, and the Hudson Bay and eventually Arctic Ocean. The water supply feeding into the rivers and lakes from the runoff and snowmelt off the peaks of the Rocky Mountains accounts for one-quarter of the entire freshwater resources in the United States. The zone of the Intermountain Basins and Plateaus includes, from north to south, the Columbia Plateau, the Central Great Basin, and the Colorado Plateau. This region contains a series of high altitude plateaus ranging from 1,219 to 2,134 m (4,000–7,000 feet) trenched by canyons or hundreds of linear ranges separated by basins of varying size, making it the most complex area in the western United States in terms of its geological structures. The western Pacific Mountains and Valleys are composed of two mountain ranges parallel to the Pacific coast, the Coastal Mountains along the eastern coast of the Pacific and the western Cascade—Sierra Nevada Mountains and the narrow lowlands in between.

The Appalachian Mountains System Running almost parallel to the coastline, the Appalachian Mountains stretch from Alabama in the United States in the south all the way to the Newfoundland and Labrador area of Canada in the north, about 2,600 km in total length and usually 1,000–1,500 m above sea level. Mountains in this region are heavily folded and dissected by the down cutting rivers, forming many parallel ridges, plateaus, and valley topography. In the south, it consists of several parallel mountain ranges that vary gradually southward from 100 to 500 km in width. The system has five unique topographic units, the Piedmont, the Blue Ridge and Great Smokey Mountains, the Ridge and Valley area, the Appalachian Plateau, and the New England section. The Blue Ridge—Smoky Mountains is the system's "backbone", with the highest peak of the entire system at Mount Mitchell at an elevation of 2,037 m. Between the Blue Ridge—Smoky Mountains and the Atlantic Coast is the narrow Piedmont, with general widths between 50–350 km and heights between 50–300 m. Due to the big altitudinal differences between the mountains and the plains, when the rivers flow from the steep slopes of the higher inlands down to the plains, many waterfalls and rapids are created along the edges of the piedmont, which is commonly known as the fall line. The Atlantic Coastal Plain contains many beaches, lagoons, swamps, and mud flats. It has a north-south extent of about 600 km, west-east width of less than 200 km, and local relief of mostly between 30–90 m. The nation's largest peninsula, the Florida Peninsula is located here. Glacial moraines are widely distributed in the Ohio and New York areas, due to the invasion of the glaciations during the Quaternary. The Atlantic Coastal Plain is America's most developed industrial area.

The Great Plains of the Central Area Between the Rocky Mountains and the Appalachian Mountains lie America's vast interior plains, which extend from the border between the U.S and Canada to the Gulf of Mexico. Its north-south extent covers the entire central US, east-west spans 5,000 km, and accounts for one half of the total US territory. It is composed mainly of three physiographic regions: the

Eastern Plain, the Western Plain, and the Southeastern Coastal Plain. The boundary between the Eastern Plain and Western Plain is roughly along the 100 °W meridian. Located north of the Missouri River and the Ohio River, the Eastern Plain contains mainly undulating terrains with lakes and basins of various sizes that were significantly shaped by the past glaciers. Its altitudes are normally below 500 m, with a slightly higher elevation in the southwest. Near the Great Lakes is the Lawrence Plain that is characterized by the low rolling hills and moraines left behind by the retreating glacier. It is the drainage divide between the Gulf of Mexico and the Arctic Ocean. Rivers north of the watershed flow into the Hudson Bay; rivers south of it drain into the Mississippi River and then eventually into the Gulf of Mexico. The Western Plain, also known as the Great Plain, is located between east of the Rocky Mountains and west of the Eastern Plain, with its north-south extent reaching the Canadian and Mexican borders. Its terrain rises gradually from east to west, with elevations at around 500 m near the 100 °W to 1,500 m at the foothills of the Rocky Mountains. It is a high elevation plateau. Although being cut deeply by the east-west trending canyons, its surface remains very flat with very little relief changes, except for the gullies formed by the river erosion. The glacial moraines and tills are widely distributed in the north part of the plain. With flat terrains, fertile soils, and lush grasses, the Great Plains are America's most important agricultural area, also known as the Prairie. The Atlantic Coastal Plains include two parts, the Atlantic Coastal Plain and the Mexico Coastal Plain. This zone is mainly composed of low rolling alluvial deposits from the Mississippi River. Its southern margins are the Mexico Coastal lowlands (below 200 m), including the Mississippi Delta, the world's largest delta with black oily and fertile soils. Many swamps are distributed in the Mississippi River mouth area. Since located in the rising area of the Gulf of Mexico coast, a bird's foot delta was formed at the mouth of the Mississippi River, extending about 100 meters into the ocean every year.

The US contains various kinds of landforms, including mountains, valleys, hills, plains, and plateaus etc. There are many classification systems of land-forms, but the system from the United States Geological Survey (USGS) is the most commonly used one. It divides the landscapes in the US into eight different types, with each of them being further divided into sub types.

The Laurentian Uplands Located near Wisconsin and Minnesota, the Laurentian Uplands is the largest outcrop of the oldest core in North America continent, the Canadian Shield, in the United States. It consists mainly of low altitude hills and mountains that are made of Precambrian igneous rocks or metamorphic rocks. These highly metamorphosed rocks are important sources of iron, copper and other important industrial minerals in the United States.

The Atlantic Coastal Plain The Atlantic Coastal Plain stretches over 3,500 km from Cape Cod in the northeastern U.S to the border with Mexico, and is one of America's flattes areas. The coastal plains from New Jersey to Texas are composed of the Late Cretaceous to Holocene sedimentary rocks that were mainly deposited in the marine environment. A large portion of the deposit is still sands or clays that

have not been hardened into shale or sandstone yet. After several rounds of uplifts, those rocks formed a series of terraces tilting toward the ocean.

The Appalachian Highland The Appalachian Highland, stretching southwest from southeastern Canada to central Alabama in the U.S, is a highland of 2,400 km length and160–480 km width. It consists of a series of mountain belts at an average height of about 900 m. The highest peak of the system, also the highest point in the United States east of the Mississippi River, is Mt. Mitchell (2,037 m) in North Carolina. The landforms include low foothills, hillsides in the Blue Ridge Mountains formed by the metamorphic and granite rocks from the Precambrian to Paleozoic periods, valleys and ridges formed by the folded Paleozoic sediments, the St. Lawrence River valley covered by the glaciers and lake sediments, the gently rolling Appalachian plateau, and the low hills formed by the Paleozoic Cambrian igneous and metamorphic rocks in the New England region.

The Inland Great Plain The Great Plain is an immense inland area that is over 1,600 km long in its east-west extent from the Appalachian Mountains to the Rocky Mountains and north-south extent stretching from the U.S-Canada border to the coastal plain along the Gulf of Mexico. It was once a shallow inland sea. However, over millions of years, it has been gradually covered by the glacial deposits from the Canadian Shield in the north, and the sediments eroded away from the Rocky Mountains in the west and the Appalachian and the Ozark/ Ouachita Mountains in the east. Most of the fluvial sediments came from the marine and rivers during the Mesozoic and Cenozoic periods.

The Inland Highland The Inland Highland is a mountainous area with rugged terrains. It encompasses a large area including eastern Oklahoma, western and northern Arkansas, southern Missouri, and the southeastern corner of Kansas. It is the only main plateau between the Rocky Mountains and the Appalachians and is composed of the Ozark Plateau and the Ouachita Plateau.

The Ozark Plateau is covered by Paleozoic Cambrian igneous and metamorphic rocks, and by the Paleozoic sedimentary limestone or dolomite rocks. In the middle of the plateau, the mountain ridges are mainly about 300–400 m wide and 30–100 m high, gradually increasing toward the south. The Ouachita Plateau is composed of folded sedimentary layers formed in the Paleozoic period. The ridges extend parallel from the east to the west, with elevations generally about 600 m.

The Rocky Mountains The Rocky Mountains, a product with many faults and folds from the orogenies from the Precambrian to the Cenozoic periods, are the major mountains in the western United States. They extend more than 4,830 km from the border with Canada to New Mexico in the southern United States. Its highest peak with an elevation of 4,400 m is Mt. Elbert in Colorado. The eastern edge of the Rocky Mountains rises above the central plains; its western edge includes ranges such as the Wasatch near Salt Lake City and the Bitterroots along the Idaho-Montana border. The Great Basin and Columbia Plateau separate them from the other mountain ranges further west. The Rocky Mountains are the drainage divide of the conterminous United States.

The Intermountain Plateaus The intermountain Plateaus are located west of the southern Rocky Mountains. The linearly structured landforms are a combined result of the great thickness of nearly horizontal rock layers from the Paleozoic, Mesozoic, and Tertiary periods and the dry climate. Due to the continued uplifts and rifts of the crust during the geological history, the plateaus were cut into large rugged horsts and grabens along the fault lines. They are composed of the Colombia Plateau, the Colorado Plateau, and the Basins and Ranges. The plateaus are characterized by a flat surface and many canyons formed from deeply down cutting rivers.

The Pacific Mountain System The Pacific Mountain System is composed of a series of mountain ranges that extend from the US-Canada border along the west coast all the way to the US-Mexico border. It is the youngest and the most active structure in the geological history of the United States. Those folded mountain ranges with steep slopes reflect the ongoing orogenic activities. The major ranges include the volcanically active Cascade Mountains, the young and steep Pacific Borders, and the Sierra Nevada Mountains which are mainly made of granites. The Cascade Mountains form curved north-south belts that extend parallel to the Pacific coastline.

2.1.2 Climates

2.1.2.1 The Climate of China

China is located between the 3° 52'N and 53° 31'N bordering the largest continent (the Eurasia Continent) in the west and facing the world's largest ocean, the Pacific Ocean., in the east. The average annual precipitation is about 650 mm which decreases from the southeast to the northwest. The seasonal distribution of the rainfall is uneven, with most of the precipitation concentrated in the summer and very little in the winter. Due to the impact of the mountain surfaces, the up-lifts of the Tibetan Plateau, and the coastal currents, the climate of China has the following characteristics:

First, the monsoon climate is significant. Under the influence of the seasonal variation of the global wind belts and the land-sea heating sources, the world's most famous monsoon region is formed in the southeast of China. Compared with the east region of the North America at the same latitude in the same Northern hemisphere, the monsoonal effect here is much more noticeable. The boundary of the monsoonal influence is along the Daxinganling—Yinshan Mountain—Helan Mountain—Wushaoling—Bayan Har—Tanggula—eastern Gangdise Mountains. Due to the control of the cold high pressure system in the land surface during the winter, this region is dominated by the northerly wind and the cold and dry climate. On the other hand, during the summer, this region is controlled by the warm low pressure system. Consequently, the southerly wind prevails and brings warm and moist weather conditions to this area. The monsoons influencing China in the summer are classified as the southeastern and southwestern monsoons. The southeastern monsoon originates from the North Pacific Subtropical High pressure system,

and mainly affects the eastern region of China. The southwestern monsoon has two sources, one comes from the southwestern monsoon in the Indian Ocean, which forms a low altitude jet stream in the Arabian Sea, and then affects southwestern and southern China through the Indian Peninsula; the other is from the trade winds in northern Australia, which cross over the equator and then continue to flow northward to affect southern and central China.

Second, the continentality of the climate is strong, which is formed by the large thermal variations of the landmass and the absences of moisture. Its main features in China are large annual temperature variations; the summer solstice and winter solstice are followed immediately by the hottest and coldest months respectively. The temperature in spring is higher than in autumn; the precipitation is concentrated in summer. This climatic continentality in China increases from southeast to northwest. The boundary between the continental climate and the oceanic climate is the line along the Huaihe River-Qinling-West Sichuan Mountains-the Himalayas Mountains.

Third, rain and heat closely correlate in the same period. In the summer, the monsoon from the low latitude area of the Pacific Ocean and the Indian Ocean is warm and humid with the result that the climate is hot and humid. In the winter, the monsoon wind coming off from the Eurasia continent brings cold and dry climate conditions. Consequently, nearly all areas in China receive most of their annual rainfall in the hot summer months. This provides a good climatic environment for the development of agriculture and livestock. However, the instability of the monsoonal precipitation sometimes exacerbates the frequency and magnitude of the damages from the hazardous weather conditions such as drought and floods.

Fourth, due to the vast land size and various landforms, the types of climates are complex and diverse in China, dominated by sub-tropical and temperate climates. Based on such temperature indicators as the accumulated temperature (the average daily temperature >= 100 °C) and the aridity index, Huang Bingwei divided China into 7 temperature zones, 21 natural regions, and 45 sub-regions, indicating the complexity of the climates in China. However, in terms of the classification or zonation of the climates, most regions of China belong to the subtropical and temperate climate zones. Only the islands of Hainan, southern Taiwan, Qiongzhou Peninsula, Leizhou Peninsula, southern Yunnan, and a few other areas are in the tropical climate zone.

China can be divided into six climate zones including the boreal, the temperate, the warm temperate, the subtropical, the tropical, and the highland climate (Zhou, 1993). The boundary between the warm temperate and the subtropical is roughly along the line between the Huai River—the Qinling Mountains, which is also the divide between North China and South China. The line separating the subtropical and the tropical zones roughly passes through the southern part of Taiwan Island, the northern Lezhou Peninsula, and southern Yunnan. Because of the large land extent and being one of the world's leading agricultural areas, the subtropical zone is further divided into the northern, the central, and the southern subtropics. Taking the crop overwintering conditions into account, the tropical zone can be further divided into the marginal tropic, the central, and the equatorial tropics. The climate on the Qinghai-Tibet

Plateau is unique. Unlike the eastern areas in the same latitude, it is not influenced by the cold air masses in the winter, and it has a low temperature in the summer.

Based on such an index as the number of days whose average temperature is ≥100 °C, which is the temperature required for the blossom and the fruit yielding of thermophilic crops, and the average temperature of the warmest month, the Qinghai-Tibet Plateau can be divided into the cold, the cold-temperate, and the highland temperate zones (Fig. 2.3).

2.1.2.2 The Climate of the United States

The conterminous United States is located between 25 °N to 49 °N Parallels. If Alaska and Hawaii are included the latitudinal range reaches from the Arctic Circle to the Tropic of Cancer. The U.S. borders the Atlantic Ocean, the Pacific Ocean, Mexico and the Caribbean Sea. In addition, the north-south alignment of all major mountain ranges on the east and west sides and the vast flat central Great Plains allow the air masses from north or south to sweep freely across the continent's vast interior at high speeds without encountering any natural barriers. Different areas are influenced by different air masses at different times of the year. The southeastern part and the coastal area along the Gulf of Mexico are influenced by the warm currents from the Gulf of Mexico; the west coastal area is impacted by elevations of the landforms and currents of the ocean; the climate in the central area is shaped by the polar cold air masses and the warm currents from the Gulf of Mexico. Consequently, the climates in different areas are very different. However, most of the area has a temperate and subtropical climate (Fig. 2.4).

The climate of the United States has the following characteristics:

Firstly, the types of climate are complex and varied significantly in different regions. The United States contains nearly every major type of climate on earth, varying from polar to subtropical from north to south. The climate in the conterminous United States can be divided into five climate zones. To the east of 100 °W Meridian, from north to south, the climate changes from humid continental, subtropical humid, and then humid tropical climate. The humid continental climate is distributed approximately to the north of the 40 °N Parallel, characterized by the dry-cold winter and mild-rainy summer. The subtropical humid climate is roughly located southeast of the 40 °N Parallel, including the Gulf Coast and most of the Florida Peninsula. The basic characteristics of this climate are its warm summer, mild winter, relatively evenly distributed precipitation throughout the year, concentrated summer precipitation, and no obvious dry season. Only the southern tip of Miami on the Florida Peninsula has the humid tropical climate type. Its main characteristics include hot and humid conditions year round and evenly distributed annual precipitation which is in summer and fall slightly higher, though. To the west of the 100 °W Meridian, the climate is divided into semi-arid, arid, subtropical semi-arid and arid climates from east to west. The climates in those areas have a pronounced continentality, with hot summer, cold winter, little precipitation, and high temperature fluctuation. The northern Great Plains and the Columbia Plateau are governed by a semi-arid climate. The arid climate is limited to the northern

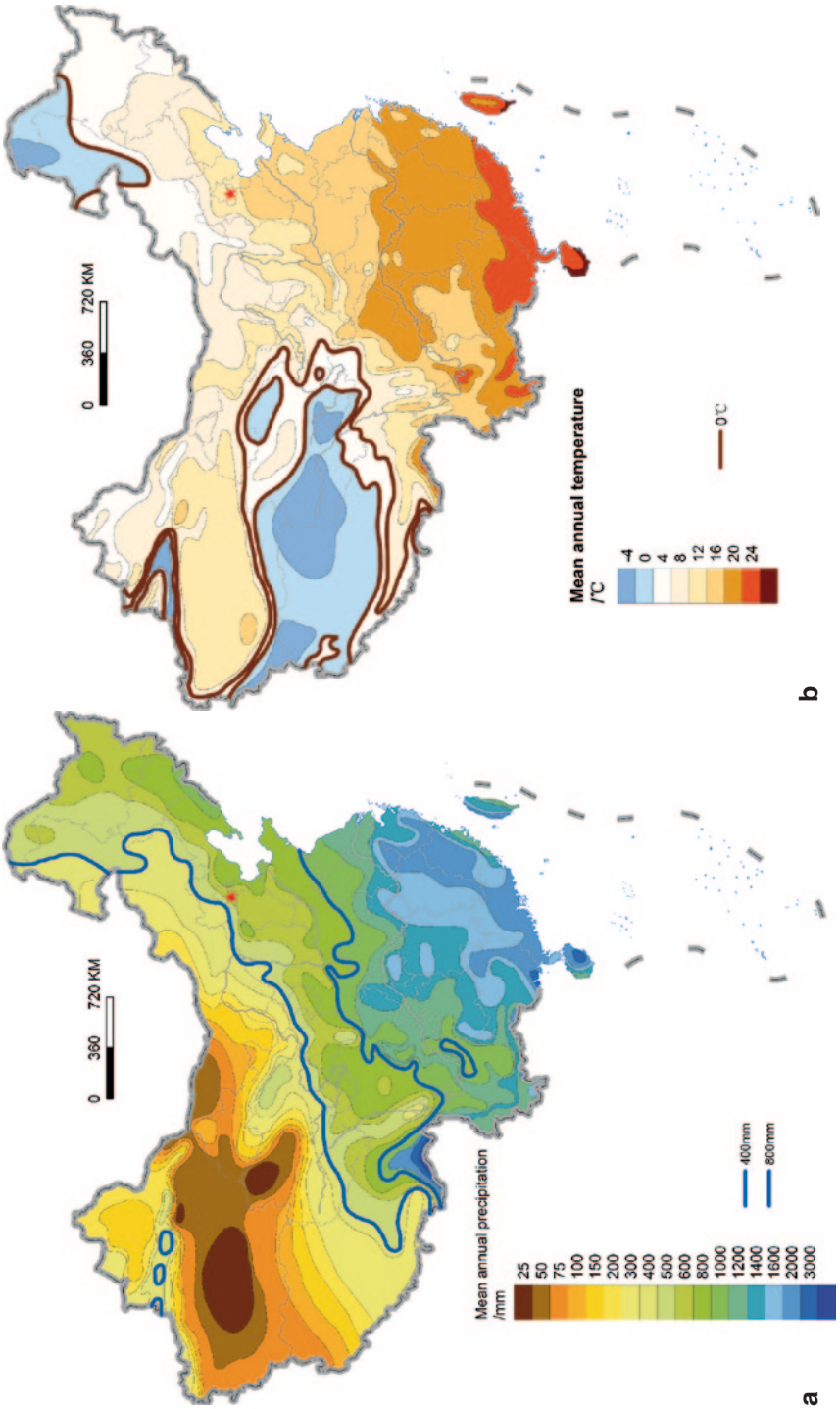

Fig. 2.3 **a** Mean annual precipitation of China. **b** Mean annual temperature of China. **c** Wet and dry zone of China. **d** Climate zone of China

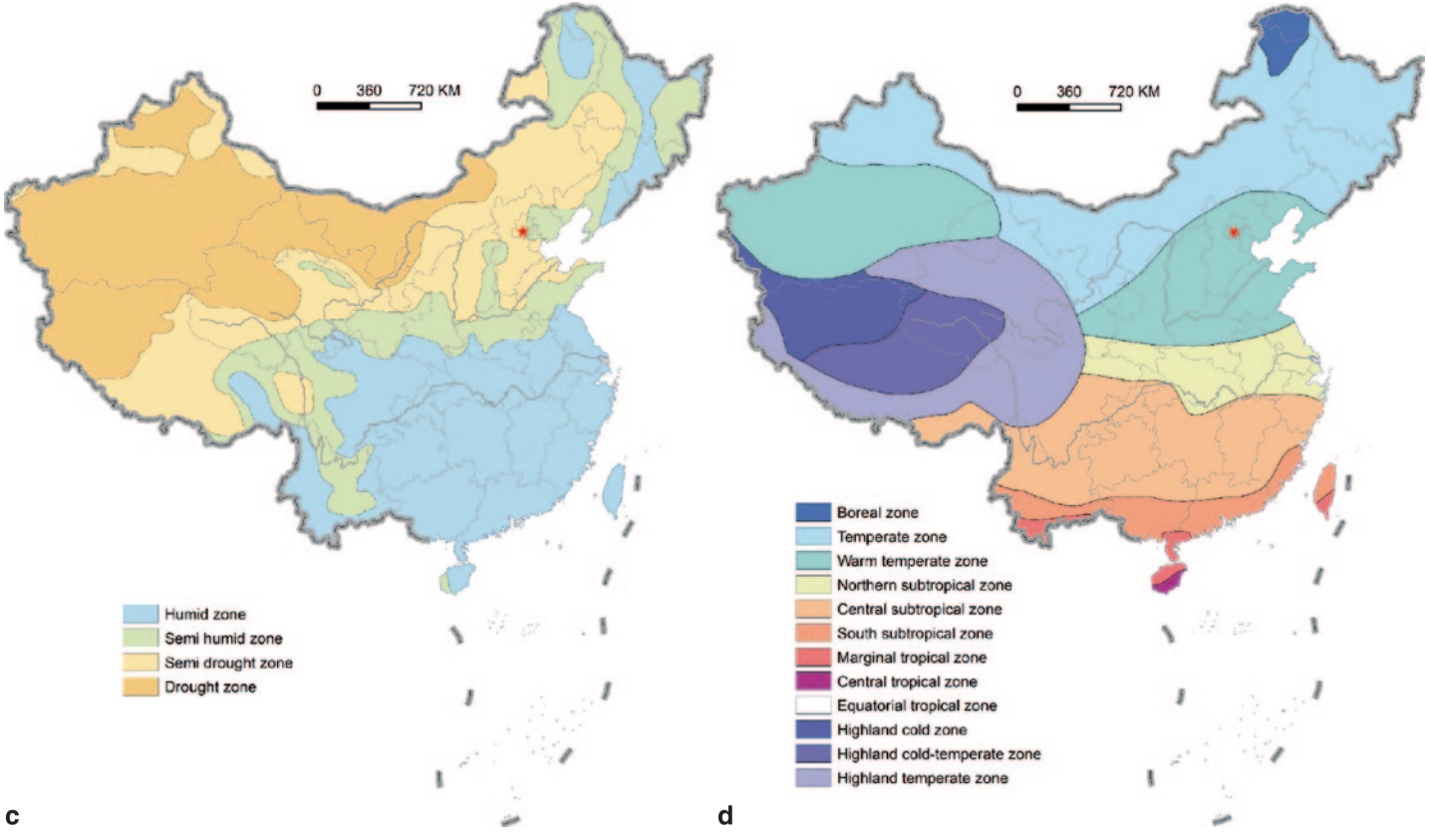

Fig. 2.3 (continued)

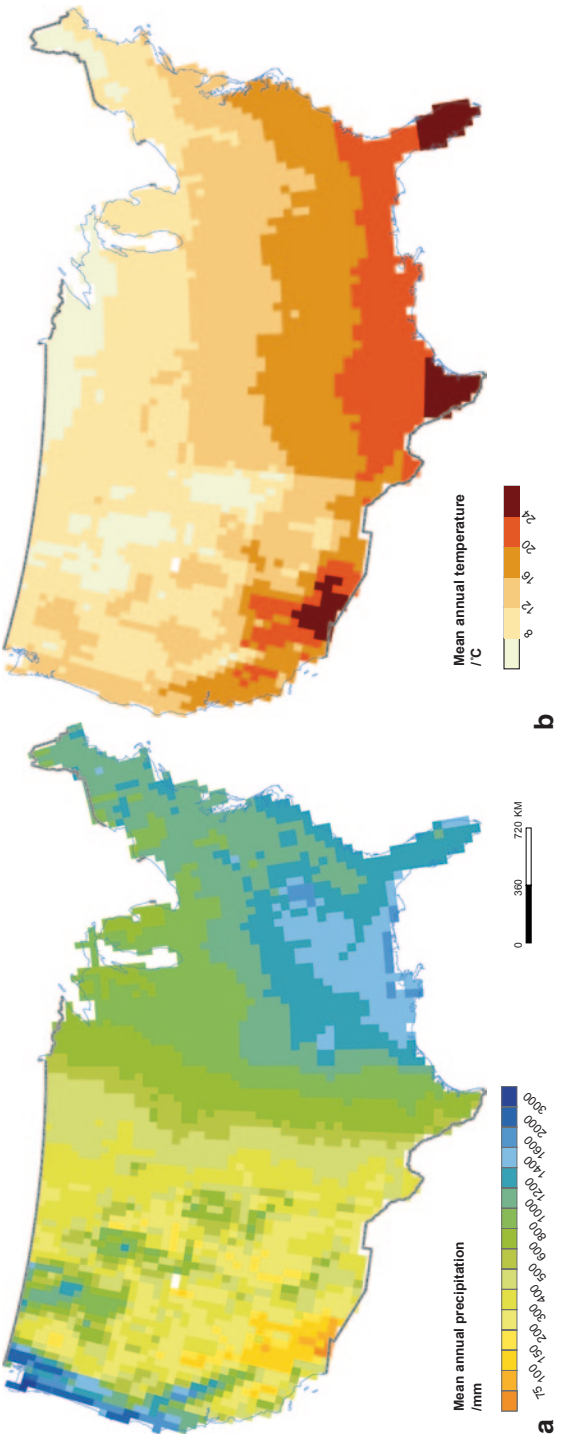

Fig. 2.4 **a** Mean annual precipitation of the conterminous U.S. **b** Mean annual temperature of the conterminous U.S. **c** Relative humidity of the conterminous U.S. **d** Climate zone of the conterminous U.S.

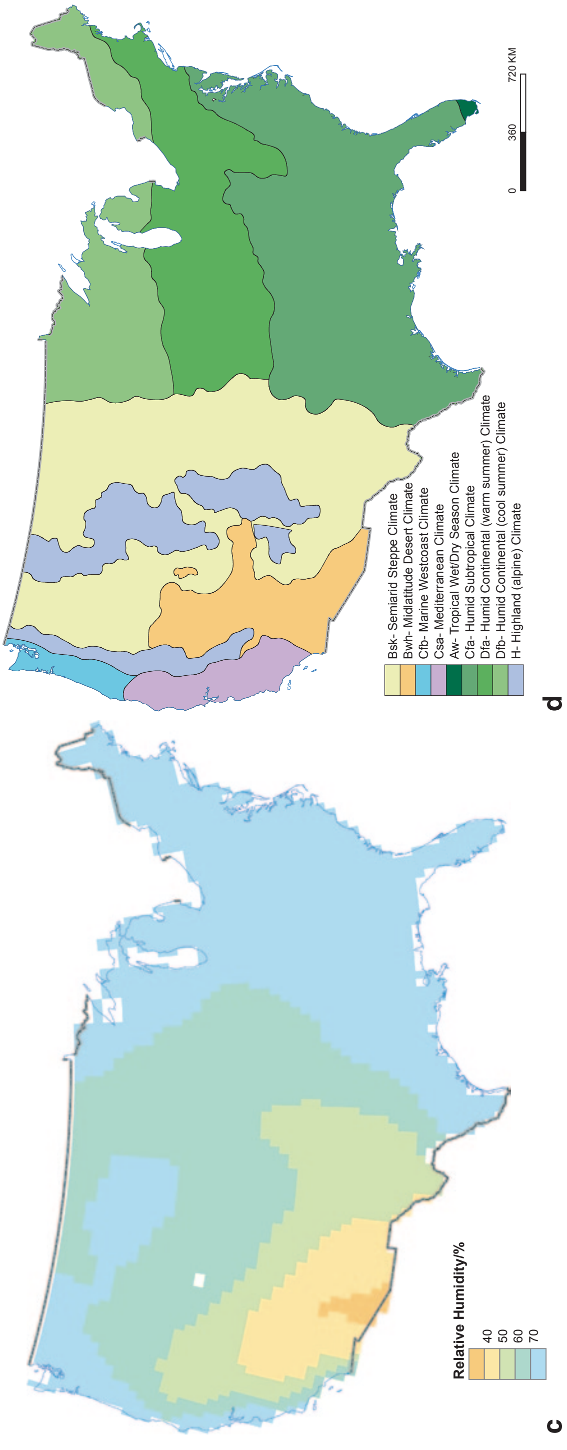

Fig. 2.4 (continued)

Great Basin and Range area, the semi-arid climate to the Great Basin, and the arid type to the southern Great Basin and Range and parts of the Colorado Plateau.

The Rocky Mountains and the Cascade—Sierra Nevada Mountains to the north of the 40 °N Parallel belong to the highland climate zone where the climate is extremely unstable compared to those of the surrounding areas. In addition, it is also characterized by low and rapidly changing temperature, large diurnal temperature range, and small annual temperature variation. The Pacific Coastal areas to the north of the 40 °N Parallel have a temperate maritime climate, with a cool summer, a warm winter, a small annual temperature range, and an evenly distributed precipitation although with autumn and winter accounting for more. Due to the impact of the California cold currents, the regions between 30 °N–40 °N meridians have a Mediterranean climate with a cool summer, a small annual temperature variation, and a decreasing precipitation from north to south.

Secondly, the temperate continental climate dominates. The lofty north-south aligned Cordillera System acts as a massive barrier to the flow of the maritime air masses. Thus, the dominating climate in the US is the temperate and the subtropical climate types, especially the temperate continental climate type. Here the general features of the climate are that it has a cold winter and hot summer with the coldest month in January and the warmest month in July, a large annual temperature range, a moderate annual precipitation, and a summer dominated rainy season. However, when compared with the climates from the Central Asian areas which are also marked by a strong continentality, its degree of continentality is not as extreme. The average annual temperature difference is smaller than in those areas at the same latitudes in Asia. In addition, the degree of concentrated summer rainfall and winter drought is not as obvious as those in Asia.

Thirdly, the distribution of the climate types is unique. All of the climate types in the US have unique distributions and arrangements. There is a contrast between the west and the east in terms of the climate types and alignments. Approximately to the east of the 100 °W Meridian, the climate changes from the humid temperate to the subtropical humid climate from north to south, reflecting the characteristics of a zonal structure. But to the west of the 100 °W Meridian, including the Great Plains and the Cordillera Mountain regions, the dryness increases from east to west, showing the characteristics of a non-zonal structure. In the western coastal areas of the continent the climate type changes sequentially from temperate maritime, to subtropical summer dry, and then to tropical arid and semi-arid climate. Although the climate types vary from north to south regularly, they also extend in west-east direction. Therefore, the climate has an integral embodiment of zonal and non-zonal structures.

2.1.3 Rivers and lakes

2.1.3.1 The River Basins of China

China has numerous rivers, of which more than 1,500 have a drainage area of more than 1,500 km^2. Most rivers flow into the Pacific Ocean, but some drain into the Indian Ocean as well. From north to south, the seven major rivers running into the Pacific

Ocean are the Songhua River, Liaohe River, Haihe River, Huanghe (Yellow) River, Huaihe River, Changjiang (Yangtze) River, and Zhujiang (Pearl) River. The drainage areas of those rivers accounting for 45% of the nation's total territory, are within the Eastern Monsoon climatic zone. Due to the influence of the topography and climate, the distributions of the rivers are not even. In the areas affected by the summer monsoon, the river networks are developed with considerable amount of runoffs. Most of the rivers drain directly into the oceanbecoming China's out-flowing rivers and accounting for 65% of the total land area. For the areas that are not reached by the monsoon, the river networks are sparse with little amount of runoffs. Most of the rivers are not able to flow into the ocean, becoming China's inland rivers and accounting for 35% of the total land area. The watershed boundary between the out-flowing river basins and the inland river basins coincides with the 400 mm isohyet (Fig. 2.5).

The Yangtze River is the longest river in China and the third longest river in the world. It originates from the Glasgow Dandong Snow Mountain, the peak of the Tanggula Mountains, and then passes through 11 provinces, with a length of 6,300 km and a drainage area of about 1,800,000 km^2. In the upstream areas, due to the steep relief of the land and the severely damaged vegetation covers, there are frequent disasters such as serious soil erosions, landslides, and mudflows. They cause frequent droughts, floods, and sedimentations of the soils and sands in the middle-lower streams of the river. Therefore, the protection and construction of the ecosystem in those areas is a top priority. In the lower reaches of the river, the channel is jammed with mud and sand sedimentations. As a result, there are high frequency of droughts and floods, and severe water pollution. Because of the high concentrations of the population and economic activities in these areas, the disaster prevention and mitigation are essential.

The Yellow River, known as China's "mother river", is the second longest river in China. It starts from the Bayan Har Mountain in Qinghai, and then drains through 9 provinces or autonomous regions, before it finally empties into the Bohai Sea in Kenli County of Shandong Province, with a length of about 5,400 km. The Yellow River is famous in the world for its high sediment concentrations and frequent floods. The sediments mainly come from the Loess Plateau in its middle reaches. Once arriving at the lower reaches, the heavy loess soils deposits form the phenomenon of river beds being 3–5 m above the surrounding areas. In the mouth area of the river, the channels have been blocked, extended, and constantly changed, thus becoming the major factor for the formation of the Huanghuaihai Plain.

2.1.3.2 River Basins of the United States

The most distinctive hydrographic feature of the United States is its well-developed drainage networks. According to the statistical data, the U.S has more than 250,000 rivers of all sizes, with more than 20 of them being over 1,000 km long. In addition, there are thousands of big or small lakes in the U.S. The drainage networks formed by these rivers and lakes have become the important pillars for the water recourse, transportation, hydroelectricity, irrigation, inland river transportation, food, and

Fig. 2.5 River Basins of China (I: Eerqisi River Basin; II: Amur River Basin; III: Liaohe River Basin; IV: Haihe Basin; V: Yellow River Basin; VI: Huai River basin; VII: Yangtze River Basin; VIII: Southeast Coastal Rivers Basin; IX: Pearl River Basin; X: Brahmaputra River Basin; XI: Xinjiang Inland River Basin; XII: Inner Mongolia Inland River Basin; XIII: Qinghai Inland River Basin; XIV: Tibet Inland River Basin)

entertainment. Generally, the rivers and lakes can be divided into three major drainage systems (Fig. 2.6).

The Atlantic Drainage System All of the rivers that are located east of the Rocky Mountains and drain into the Atlantic Ocean belong to the Atlantic drainage system. America's largest river, the Mississippi River, occupies a drainage area that spans west to the eastern slope of the Rock Mountains, and east to the western

Fig. 2.6 Major rivers and lakes of the conterminous U.S.

slope of the Appalachian Mountains. It crosses over 31 states and covers the entire north-south extent of the conterminous United States, with a length of 3,734 km. Together with its tributaries, including the Missouri River, Ohio River, Tennessean River, and Arkansas River, it is the fourth longest river system in the world, after the Nile River, the Amazon River, and the Yangtze River. With the drainage area of about 3.1 million km^2, it accounts for 40% of the total continental area in the United States. After the Amazon River and Congo River, it is the world's third largest drainage basin.

The Pacific Drainage System All the rivers that drain into the Pacific Ocean belong to the Pacific drainage system. Its main rivers include the Colorado River and the Columbia River. Those rivers all run through the plateaus with fast moving water and rich water resources.

The Colorado River, the 7th longest river in the US, has its origin on the western slope of the Rocky Mountains. It is 2,333 km in length and covers a drainage area of 703,000 km^2. Up to 98.6% of its total length is inside the United States, and only the remaining 1.4% is in Mexico. It passes through Utah, Arizona, Nevada, and the arid and semi-arid regions of California, before it finally empties into the California Bay through Mexico.

The Columbia River, with a length of 2,001 km, also originates from the Rocky Mountains. It enters the U.S from Canada through the state of Washington. It flows backwards and then to the south for a short distance before finally turning west-

ward. It acts as the border between Washington State and Oregon State. The area of the basin is 668,000 km^2, nearly equivalent to the area of France. Of all the major rivers in the U.S, it has the second largest amount runoff, second only to the Mississippi River. About 90% of its total runoff is dumped into the Pacific Ocean, and only 10% of its water is used for agricultural irrigation.

The Great Lake System The most famous lakes of the United States, the Great Lakes including Lake Superior, Lake Erie, Lake Huron, Lake Ontario, and Lake Michigan, are located between the northeastern United States and Canada. Together, they constitute the largest group of fresh water lakes in the world and cover a total area of 245,000 km^2, with about 2/3 of it being in the U.S and the rest in Canada. Of the five Great Lakes, Lake Superior is the largest that occupies an area of over 84,200 km^2. It is also the largest lake in the world. The five lakes are connected with each other through waterways. Their runoffs drain into the Atlantic Ocean through the Lawrence River. Between Lake Erie and Lake Ontario are the world-famous Niagara Falls.

2.1.4 Vegetations and Soils

2.1.4.1 The Vegetation Distribution of China

Accordingly, vegetation is the most sensitive indicator of the landscape and is often studied as a representative of the land cover. Under the combined influence of various factors, such as climate, topography, and soil, the geographic distribution of vegetation in China has an apparent zonal feature.

Latitudinal Zonation China's north-south extension is over 50 degree of latitude, resulting in solar radiation differences in different areas. Under similar atmospheric moisture conditions, the differences in the atmospheric energy (temperature) lead to the formation of different vegetation zones at different latitudes from north to south. The latitudinal zonal feature is more evident in the humid and semi-humid areas in eastern China. From south to north zones include the tropical seasonal rainforest or rainforest zone, the southern subtropical broadleaf evergreen forest zone, the broadleaf evergreen forest zone, the northern evergreen or broadleaf ever-green forest zone, the warm temperature deciduous broadleaf evergreen forest zone, the temperature mixed forest zone, and the cold temperature deciduous forest zone. The subtropical broadleaf evergreen forest zone is the main area for some of the fruit production, such as citrus, loquat, and bayberry. The northern subtropical evergreen forest zone and the deciduous broadleaf forest zone are most northern for the distribution of the subtropical economic trees in China. The warm temperate broadleaf forest zone is the main growing areas for the deciduous fruit trees such as apples, pears, dates and so on.

The Zonation of Dryness and Wetness China's east-west extension is about 5,000 km long, spanning about 62° of longitude. Under similar thermal conditions, the decreasing atmospheric moisture from east to west caused by the land-sea distribution leads to the zonal variations in vegetation types. The direction the various types of vegetation extend are generally perpendicular to the direction of

the summer monsoon. The vegetation can be divided into two parts by the line of the Kunlun Mountains-Qinhuai River. Vegetation to the north of this boundary line belongs to the temperature, warm temperature zone; vegetation to the south of this boundary line belongs to the subtropical and Qinghai-Tibet highland zone. The zone in the northern half covers a longer west-east extension and has apparently a more varying vegetation feature. From east to west, the vegetation types include mixed forest, semi-humid forest and steppe, semi-arid steppe, semi-arid semi-desert or desert, extreme arid desert and so on.

The Altitudinal Zonation This altitudinal zonation of vegetation refers to the changes in vegetation types due to changes of such factors as air temperature, precipitation, and soil with the increasing elevations of the mountains. On the one hand, the altitudinal vegetation zones are affected by height, mountain trending, relief, rock, soil and other features of the mountains themselves. On the other hand, they are also affected by the location of the mountains. China's vast mountainous areas and the differences in the above mentioned factors lead to various vertical zones of the vegetation. On a large scale, the altitudinal spectrum of the vegetation can be divided into two types, "the humid" and "the dry" types.

In summary, the altitudinal spectrum of the vegetations in the mountainous areas of China has the following characteristics: (1) the altitudinal spectrum is based on the horizontal level of the local area; (2) from south to north, the structure of the eastern humid zones changes from complex to simple, the number of zones decreases and the elevation range where the same zone is prevalent also becomes lower; (3) from the eastern humid regions to the western semi-arid regions, the elevation range where the same vegetation zones are prevalent gradually increase with the increasing degrees of the dryness, thus leading to a simpler the zonation.

2.1.4.2 The Vegetation Distribution of the U.S.

The vegetation distribution in the U.S is closely associated with rainfall, air temperature, soil, and topography. Under the combined influence of various factors, the geographical distribution of the vegetation has several considerable features of zonation.

The Longitudinal Zonation In the U.S, a large area of deciduous broadleaf forests is distributed between the Atlantic Coast in the east and eastern Texas and western Minnesota in the west. West of it is America's vast area of grassland in the central plains. This vast grassland stretches from the state of Indiana all the way to the Rocky Mountains. Approximately at the 98 °W to 100 °W meridian is the boundary between the short grass and tall grass prairie. West of the 100 °W Meridian, because of the blocks from the Cordillera System, the precipitation decreases gradually from east to west. Except for the northwestern Pacific Coastal area, the entire western region receives less than 500 mm of annual rainfall. Consequently, most areas are governed by semi-arid or arid climates. The dominating vegetation is the temperate steppe and prairie. Shrub, thorn bush, and savanna vegetation are distributed in the southern Pacific coast and the southern Rocky Mountain areas.

The Latitudinal Zonation The Eastern United States borders the Atlantic Ocean in the east, the Great Lakes in the north, and the Gulf of Mexico in the south. Although the area contains the Appalachian Mountains, they are not high enough to constitute a climatic barrier. As a result, the East has a very good moisture and heat condition. However, it diversifies gradually form north to south. The dominating vegetation are forests. From north to south, it is classified into zones of temperate coniferous and deciduous mixed forest, temperate deciduous broadleaf forest, and subtropical evergreen forest. In the west, the narrow Pacific Coast area contains the temperature maritime, subtropical summer dry, and tropical arid and semi-arid climate types from north to south. Correspondingly, the vegetation varies from coniferous forest, subtropical evergreen, shrub to tropical desert from north to south.

The Altitudinal Zonation In the Rocky Mountains and western Cascade—Sierra Nevada Mountain areas of the American West, the lofty mountain heights have caused an altitudinal zonation of the climate. Correspondingly, the vegetation on the mountains has also developed an altitudinal zonal distribution. The vertical distribution is related to the latitude, mountain height, and side of the mountain, and so on. For example, in the Rocky Mountains near the south of the 40 °N Parallel, the vegetation varies in the order of deciduous forest, evergreen forest, coniferous forest, mountain steppe, mountain tundra, and permanent snow and ice from the bottom to the top. Each of the three forest zones has a vertical space of more than 650 m. However, in the Rocky Mountains north of the 40 °N Parallel, due to the reduced heights, the zones of the forests disappear. Only the mountain steppe, mountain tundra, and the permanent ice and snow zones are presented. Due to the impact of the Pacific moisture, in the Cascade—Sierra Nevada Mountains, the altitudinal zonation is different from that of the Rocky Mountains. The elevations of the altitudinal zones of the vegetation are lower than those of the Rocky Mountains. In the north, the alpine tundra is distributed at about 2,000 m; in the south, it is distributed at about 3,500 m. Below it, there are three altitudinal zones of the conifer forest. Further down is the woodland and shrub species of the foothills.
The altitudinal distribution is also associated with the aspect and degree of the slope. In the Rocky Mountains, zoning mainly takes place in the eastern or northern slopes. In the Cascade—Sierra Nevada area, the altitudinal zones have been compressed into very narrow bands. In the areas that are drier and steeper, the zoning becomes blurred.

2.2 Natural Disasters

2.2.1 Earthquakes

2.2.1.1 Earthquakes in China

Located between two of the major active zones for earthquakes in the world, the "Circum-Pacific Belt" and the "Mediterranean—Himalayan Belt", China is one of the most active countries for earthquakes. Historically, most of the provinces, autonomous regions, and the municipalities have had many destructive earthquakes (Fig. 2.7).

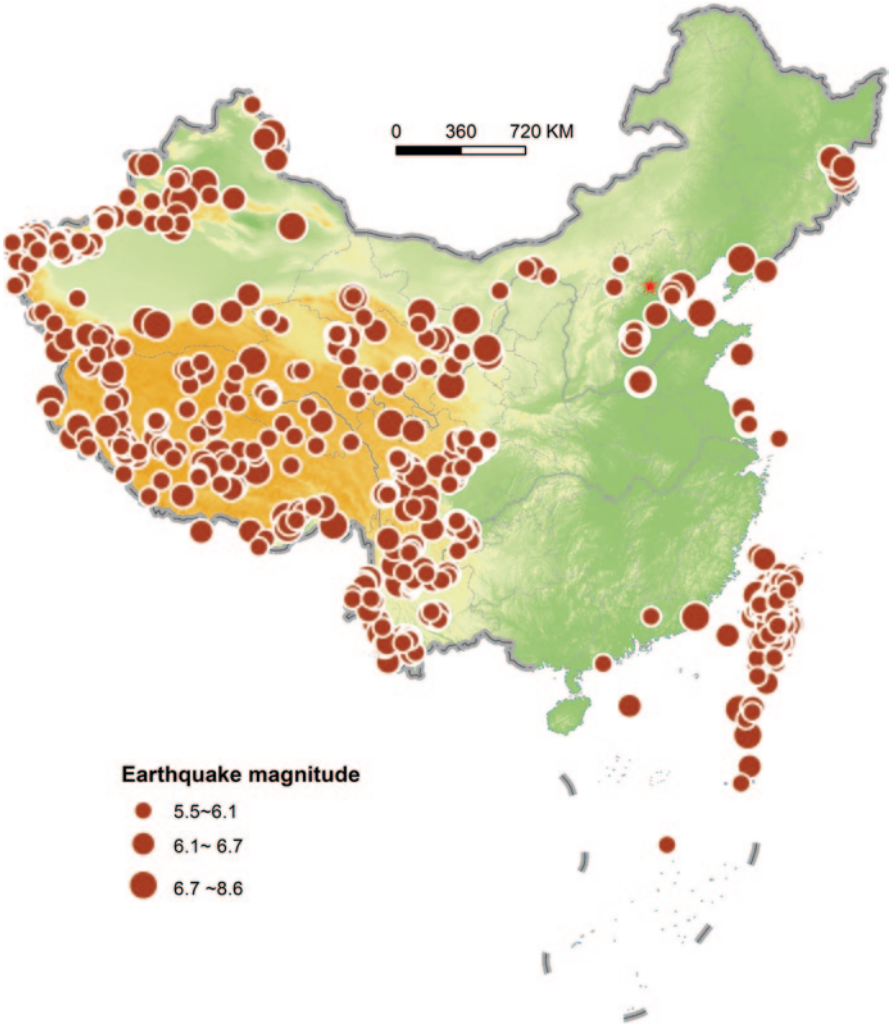

Fig. 2.7 Distribution of earthquake epicenters in China (1990–2012)

The earthquakes in China had high frequencies, large magnitudes, wide areas of distributions, and shallow hypocenters. Statistics indicate that approximately 35 % of all of the earthquakes above magnitude 7 in the world took place in China. Almost one third (1/3) of the entire country, one half (1/2) of the cities and megacities with populations of more than 2–3 millions are located in the zones with potential of having strong earthquakes of larger than 7 magnitude. Of all the 1,200,000 losses of lives in the earthquakes worldwide in the twentieth century, China accounted for 590,000. The earthquake in Wenchuan County of Sichuan Province on May 12, 2008 was the most destructive since the foundation of the People's Republic of

China in 1949. It caused direct economic losses of 845.1 billion Yuan and more than 87,000 fatalities or missing persons.

The distribution of earthquakes in China is uneven. In the western region earthquakes are more active and frequent. In the east, strong earthquakes are mainly found in northern China and southeastern coastal areas. They are stronger but less frequent. According to the existing historical records, taking the 107°E Meridian as the boundary, the West had 91 earthquakes that were over magnitude 7, while the East only had 27 (excluding the earthquakes with deep hypocenters in Taiwan and Northeast China). However, the earthquakes in the East caused more damages than those in the West since the East has a denser population and a more developed economy. The major reason contributing to the stronger earthquakes in the West and weaker ones in the East is that the major forces driving the deformations of the continent in China come from the collisions between the Indian Plate and the Qinghai-Tibet Plateau.

The distribution of the earthquake hazards in China has an apparent zonal feature. They were mostly concentrated as linear bands in Taiwan, Xinjiang, southwestern and northern China. Different regions have different tectonic causes. The tectonic zone for earthquake in Taiwan includes the province of Taiwan and its adjacent oceans, which is the most frequent and active area in China. The occurrences of the earthquakes in this area are associated with the arc-shape structure of the Pacific Ocean and the tectonic movements of the Taiwan Island and its surrounding areas. They are mostly concentrated in the north-northeast (NNE) trending left-lateral reversal strike-slipping faults, the northeast-east (NEE) right-lateral strike-slipping faults, and the active folds on the thrust faults at the western foots of the Central Range.

The Southwest Tectonic Zone includes the entire Qinghai-Tibet Plateau and the western part of the Sichuan-Yunnan Plateau. It is one of the most active areas for earthquakes in the world. This area has been uplifted significantly since the Cenozoic Era, constituting the most magnificent plateau in the World and the area with the thickest crust in China. The earthquakes here are mainly concentrated in the northwest—east-west—north-northwest curved faults and the northeast and north-south faults. The earthquake in Wenchuan in 2008 was the result of the movement of two local faults in this area. The Xinjiang Earthquake Zone, one of the most active areas in China, is characterized mainly by its reverse faults and fault basins. The occurrences of the earthquakes were associated with the huge Cenozoic fault basins and the orogenic movements at those times. The earthquakes mainly take place in the boundary areas between the mountains and the plains.

The tectonic zone in northern China is the best studied area in China for its seismic structures. The most prominent feature of this area is the tension tectonic activities. Since the Neogene, those tectonic movements have been very active. The impacts of the tectonic movements deep underneath the Earth surface are that the crust has been stretched thin, and the upper mantle has been pushed up. In some areas, layers of low velocity are also found. In the shallow parts, rifts and graben-type basins were formed during the active tectonic movements of the faults.

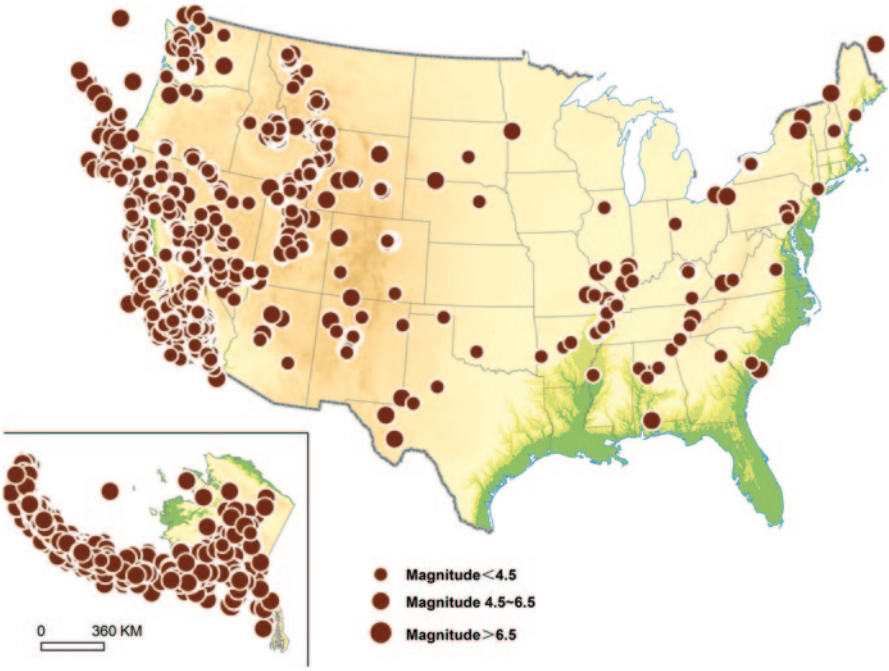

Fig. 2.8 Historical earthquake epicenters of the U.S.

2.2.1.2 Earthquakes in the U.S.

The United States is located on the most active area on earth for earthquakes, the "Circum-Pacific Seismic Belt"; consequently, it is one of the countries with most frequently occurring earthquakes (Fig. 2.8). Historically, earthquakes have taken place in many areas in the US, including many states in the central portions of the continent, and on the East Coast. Nationwide, all 48 conterminous states are vulnerable to earthquakes. At least 39 states have a moderate to very high risk for earthquakes. However, the Pacific Northwest is the most likely place to have earthquakes in the US. There, the Juan de Fuca oceanic plate around the states of Washington and Oregon is gradually subducting 25 km underneath the westward moving North American continental plate. It has the capability of causing magnitude 8 or greater earthquakes (it does not get greater than 9 or so!) that would pose great threats to Seattle, Portland, and other cities.

California is located on the junction of the Pacific Plate and the North American Plate. Due to the interaction between the two big plates, it is an earthquake prone zone. The San Andreas Fault is the major culprit for the earthquakes in California. It starts from the Gulf of California in the south, and then extends north to past Los Angeles and the San Francisco Peninsula. Historically, it has caused many catastrophic damages. The magnitude 7.8 earthquake in San Francisco in 1906 was caused by the San Andreas Fault. It turned most of San Francisco into piles of

debris and caused nearly 3,000 deaths. The magnitude 6.6 earthquake in northwest of Los Angeles in the January 1994 was also on the San Andreas Fault. It caused the collapse of more than 11,000 buildings, collapse and destruction of highways and high rise buildings, breaks of gas or water pipes, distributions of communication systems, and widespread fires. In addition, it directly or indirectly killed 62, injured more than 9,000, and displaced over 25,000 people. The total property losses reached $30 billion.

Because earthquakes occur not very frequent in the Eastern U.S, this has led to a misconception of this area being immune from earthquakes among many peoples. On the contrary, studies indicate that earthquakes in the East could possibly cause more devastating losses because the severe shaking from a similar magnitude earthquake would affect a larger area than in the Western U.S. In addition, unlike the Western U.S, most structures in the Eastern United States are not designed to resist earthquakes. Furthermore, the population density in the Eastern United States is higher than that of the West. Of the largest earthquakes recorded in North America's history, three of them originated from the New Madrid Fault system in a two-month span from 1811 to 1812. The powers from these magnitude 7 earthquakes were enough to force the Mississippi River to temporarily flow backward. With recent tectonic activities in the area, scientists believe that the ancient Ramapo Fault running near New York City might be building up energy to reactivate itself again in the near future.

2.2.2 Hurricanes/Typhoons

2.2.2.1 Typhoons in China

Located on the Northwestern Pacific Coast, China has the highest number of tropical cyclones (typhoons) that reached on its territory and it is one of the countries in the world with the most severe damages from typhoons. On average, about 7.4 typhoons made landfall on China's soil each year, which caused economic losses of about $24.6 billion and 570 deaths. Nearly 20 provinces, municipalities, and autonomous regions in the East have been impacted by typhoons; however, they are more concentrated in the coastal provinces and cities (Fig. 2.9). According to the statistical data, nearly 89 % of typhoons made landfall on the southern coastal areas (Guangdong, Guangxi, Fujian, Hainan and Taiwan), while only 11 % made landfall on Zhejiang Province or the coastal provinces north of it. The number of typhoons which made landfall on Guangdong Province is highest, accounting for nearly 1/3 of the total landfall. It is followed by Taiwan (1/5).

The activity of typhoons in China has a clear seasonality. Typhoons are most likely developing during the period from late summer to early fall. The number of occurrences is the least in February, gradually increases to the highest number in August, and then decreases slowly from September onward. Typhoons take place mainly in July to October, accounting for 68.6 % of all occurrences.

The seasonality of the typhoons' landfall has the following features: (1) in May and June, they are located at the coasts of the southern provinces; (2) in July and

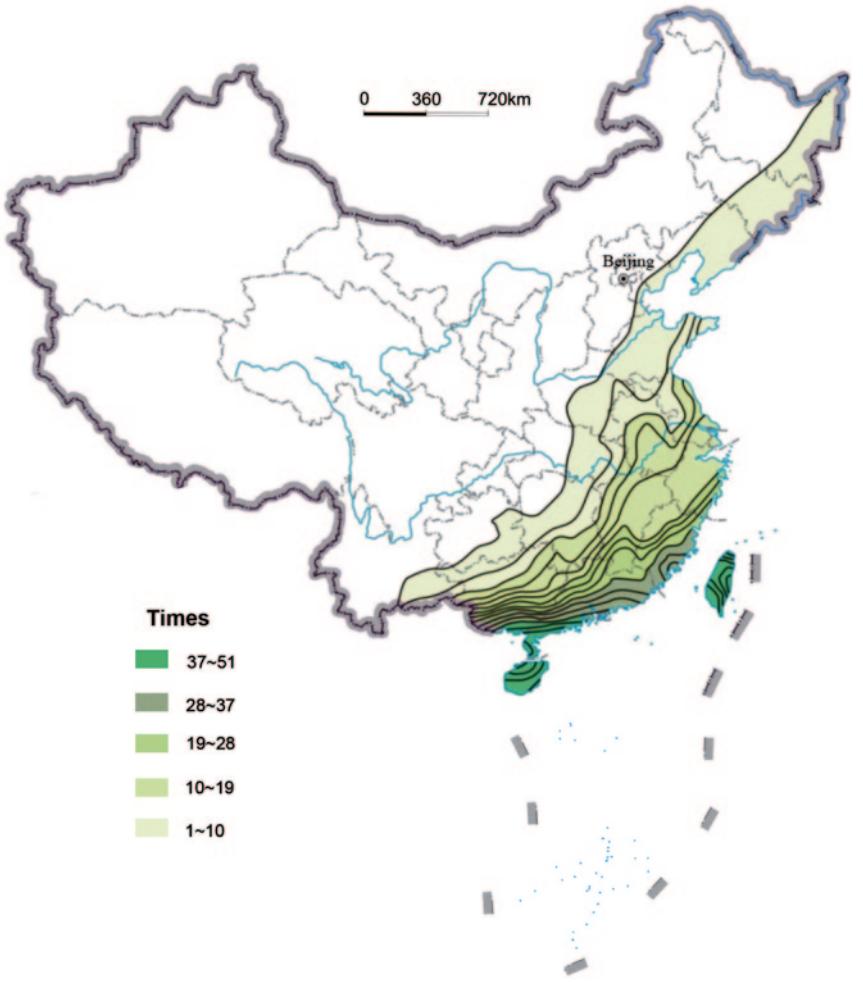

Fig. 2.9 Distribution of typhoons in eastern China (1949–2000 years). (Shi 2003)

August, they are in the areas between Guangdong, Guangxi, Hainan in the south, and the vast coastal areas of Liaoning in the north; (3) in September and October, they are active in the area along the coasts of the Yangtze River Estuary; (4) in November, the active areas are confined to the coasts of Guangdong, Hainan and Taiwan; (5) in December, they make landfall occasionally only on Guangdong.

In addition, the paths of typhoons also change with the seasons. From November to May, it travels northward in the ocean from east of the 130 °E Meridian. When it reaches the south of the 16 °N Parallel, it turns westward to the southern area of the South Sea or makes landfall from southern Vietnam. During June to October, typhoons head northward from the ocean east of the 125 °E Meridian, slightly shifting westward. During the hot summer season, its west moving path is located even further north.

2.2.2.2 Hurricanes/Tornados in the U.S

In the Atlantic Ocean, hurricanes mainly form over the warm tropical and sub-tropical ocean water of at least 26 °C that extends to a depth of 46 m below the surface between 5° and 20 °N. Most of the hurricanes that made landfall in the U.S. originated from a hot and humid area in the Atlantic Ocean, surrounded by west of North Africa, the east coast of the Central America and the Gulf of Mexico coast, known as "Hurricane Alley". Typically, when the low-pressure systems move westward from the west coast of Africa, they will encounter the warm waters of the tropical Atlantic. The warm waters will provide sufficient energy to fuel the development of hurricanes and turn them from the initial stage off the west coast of Africa into monsters to attack the U.S coast.

The strong winds, high waves, storm surges, floods, tornadoes, landslides, and coastal erosions brought forth by hurricanes can cause tremendous property damages and the losses of lives. Not only those in the hurricane-prone areas could suffer from the devastating destructions of the hurricanes, but the residents in the interior areas are vulnerable to the destructive winds, tornadoes and floods from hurricanes as well (Fig. 2.10). More than half of the total U.S. population lives within 80 km of the coast. As population concentrations and development have accelerated along the coastal areas, the damages caused by hurricanes have risen exponentially over time. Historically, six of the 10 costliest disasters in the U.S were caused by the tropical weather systems.

Among them, the Galveston hurricane in 1900 was the deadliest natural disaster in U.S. history, which claimed about 8,000 lives. The New England hurricane in 1938 was the costliest natural disaster of its time, causing about $3 billion in damages. Hurricane Hugo in 1989 caused losses of almost $11 billion for the Carolinas. Hurricane Andrew in 1992 accounted for more than $20 billion of property damages. Hurricane Katrina in 2002 killed 1600 people and caused over $100 billion in damage. Losses from the recent Atlantic hurricane seasons have been keeping rising, with losses of $42 billion in 2004 and hundreds of billions in 2005.

2.2.3 Floods

2.2.3.1 Floods in China

China has always been one of the countries in the world with frequent floods and most destructive damages with regards to its vast territory, complex terrains, and significant monsoonal influence. Floods are the most serious natural disaster in China. Since the twentieth century, the seven biggest rivers alone had 31 large or extremely large floods, 55 large floods, 127 regular floods (Wang, 2006) (2.13 times yearly on average). In recent years, floods have struck nearly 9,670,000 acres of lands with 4,729 fatalities and 2,025,300 destroyed houses each year. They have caused direct economic losses of up to 113,668,000,000 Yuan, accounting approximately for 1–3 % of the national GDP.

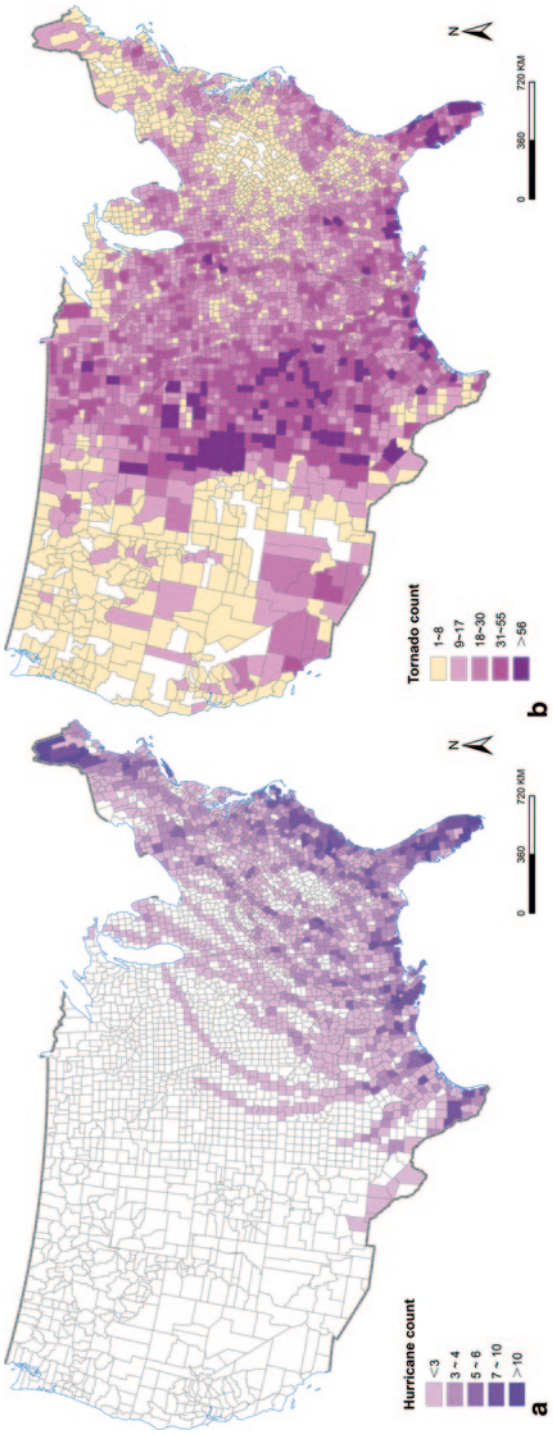

Fig. 2.10 **a** The hurricane distribution in the conterminous U.S. **b** The tornado distribution in the conterminous U.S.

In China, floods occurred in many areas. Historically, every province, autonomous region or municipality has had various kinds of floods (Wang, 2006). The flood patterns in 1949–1965 period and in 1978–2000 period (Fig. 2.11) provide us with some information about their spatial distributions in the past. During the 1949–1965 period, the distribution of the floods in China had an obvious north-east difference. Floods were mainly distributed in the places east of the Hu Huanyong line. Moreover, these eastern areas in the second topographic step suffered from more damages. During the 1978–2000 period, floods declined from the northeast to the southwest and from the southeast to the northwest. Flood frequency declined from the areas east of the Hu Huanyong line to the sub-arid area and from Xinjiang Province to the tropical area. Comparing the patterns in the two periods reveal that floods during the period from 1978–2000 affected larger areas and were more frequent. The center of the extreme floods shifted south-ward, northward, and southwestward from the North Plain (taking Henan as the center). The changes in the flood pattern were mainly the result of influences of changing land uses. On the one hand, humans extend their activities from the plains to the wetlands, particularly with the creation of farmlands from the low wetlands in northern China and from the lakes in the Middle-Lower Yangtze River Plain. On the other hand, the over exploitation on hilly lands and forest lands causes the deterioration of the ecosystem, and severe soil erosion.

2.2.3.2 Floods in the U.S.

Floods are the most costly and frequent natural disaster in the United States. Basically, any normal natural processes, such as summer rains, heavy thunder-storms, or winter snow melts can cause floods, let alone extreme weathers such as hurricanes and heavy thunderstorms. Sometimes, the failure of levees and dams and blocked drainage system in the urban areas can also result in flooding. Floods in the Eastern U.S and the Gulf Coast were mainly caused by hurricanes and storms, while snowmelt and rainstorms were the main causes in the Western U.S. Rainfall intensity and duration are the two most important factors that contribute to flood. When a river receives more water than it can drain, flood occurs. Floods can be slow or fast rising. Within small drainage basins, a brief intense rainfall in the local areas can cause fast-moving but short-lasting flash flood. However, within large drainage basins, floods result from widespread rainfall that last for hours or days.

In the U.S., on average, floods causes more than $6 billion of property damage and kill more people than tornadoes, hurricanes or lightning combined each year. Flooding has claimed more than 10,000 lives since 1900. Nearly half of these deaths were the result of the drivers' underestimations of the depths and power of the moving water. When they drove their cars into the flooded roads, their automobiles were swept downstream. Thanks to progress made in the development of warning systems, floods have claimed fewer lives than they used to during the past several decades. However, they have resulted in more economic losses due to the increased development in the coastal area. For example, the flooding brought by Hurricane Katrina in the late summer of 2005 accounted for a large proportion of the more than

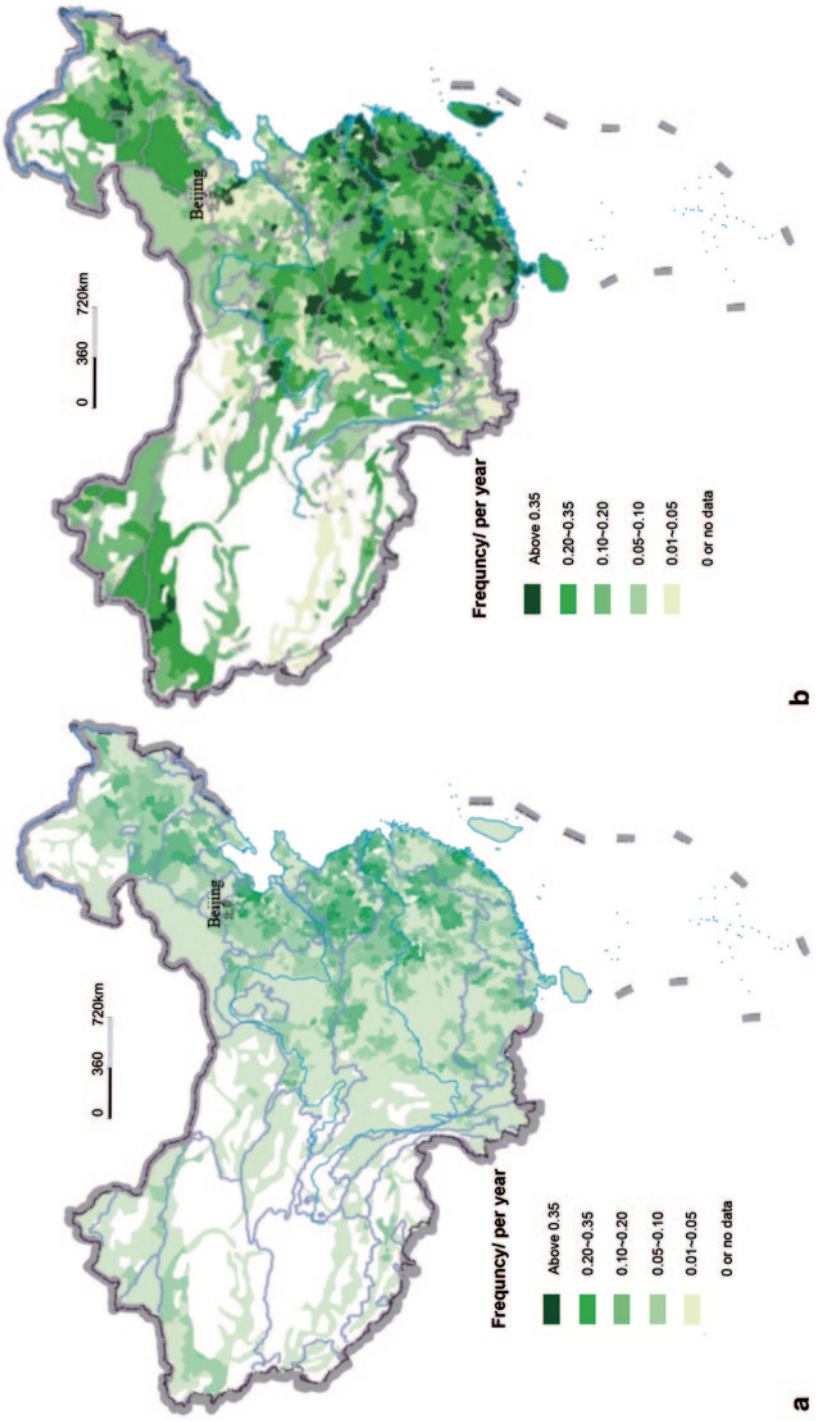

Fig. 2.11 **a** Distribution of flood frequency in China (1949–1965). (Shi 2003). **b** Distribution of flood frequency in China (1978–2000). (Shi 2003)

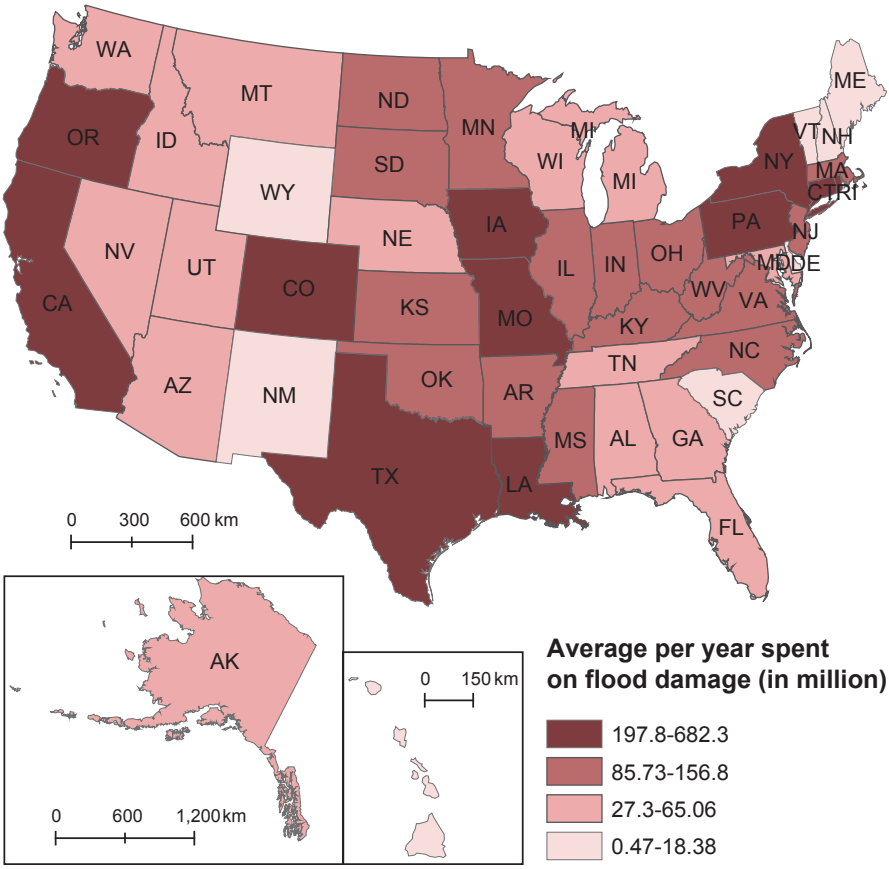

Fig. 2.12 Average per year spent on flood damage by state in millions US$. Quoted from http://www.bigrede.com/floods/

$200 billion of losses, the costliest natural disaster in U.S. history. The costliest flood in U.S history, the 1993 Midwest flood, affected 1/3 of the U.S states, and caused 50 deaths, the breaks of hundreds of levees along the Mississippi-Missouri River, nearly 10,000 home losses, the submergence of hundreds of towns, and the inundation of 15 million acres of farm-land, causing more than 20 billion of economic losses.

2.2.4 Droughts

2.2.4.1 Droughts in China

Droughts are frequent in China. According to the current statistics, China had 1056 droughts during the past 2155 years from 206 B.C. to 1949. With climate change, droughts have affected larger areas and have had higher frequencies in recent years.

Each year, on average, about 21.598 million acres of lands are subject to droughts; of which, 9,496,130 acres would suffer from the drought disasters. It caused 15,405,000 tons of grain losses, drinking water shortage for 29,231,400 people, direct economic losses of 231.664 billion Yuan, and serious influences on China's agricultural production and economic development.

In China, the East has more droughts than the West (Fig. 2.13) (Wang, 2006). During the 1949–1965 years, there were 4 gradient belts from the West to the East including the western low frequency drought band, the mid-west relatively high frequency drought band, the eastern high frequency drought band, and the eastern coast low frequency drought band. Of them, there were 115 counties with high frequencies of more than 0.20, accounting for 5 % of the total droughts nationwide. In the North, droughts were relatively concentrated in the west of Heilongjiang, the middle of Inner Mongolia, and the north of Hebei and Ningxia; in the South, they mainly distributed in the 5 central provinces (Anhui, Hubei, Hunan, Jiangxi and Henan), eastern Sichuan, and northern Guizhou and Yunnan. 480 counties, with approximately 22 % of the total number of droughts, had drought disaster frequencies of more than 0.08. Compared with the 1949–1965 period, the spatial distribution of droughts changed little during the 1978–2000 period, with only slightly reduced number of droughts in the North China Plain. However, the distribution of the severe droughts had a relatively large change in the South. The 5 central provinces all had a lower drought frequency. By contrast, Guizhou had a significant increase in the drought frequency in the same period. During the period, there were 64 counties nationwide with drought disaster frequencies of more than 0.20, accounting for about 2.8 % of the total number of national droughts and half of what was the case in the 1949–1965 period. There were 693 counties nationwide with drought disaster frequencies of more than 0.08, accounting for 34 % of the total of national droughts which are 12 % more than during the 1949–1965 period's level.

A comparison of the drought patterns during the two time periods reveals three main characteristics:

First, the spatial patterns of droughts were different in the East and West. In the later period, the drought frequency in the North was higher than that in the South. The frequencies of droughts had a zonal effect along certain directions. This was possibly the result of the step-like topography, the spatial variation of the precipitation, and the different material responses to the drought disasters. The distributions of the droughts with high values in the North were related to the Southeast monsoon and the ecological degradation of the environment from farming.

Second, during the second period, the extend of the drought area spread westward. Meanwhile, the area with severe drought had been expanded northeastward and southwestward, a reflection of human activities especially regarding exploitation of more dry agricultural lands. During the first period, the total number of counties with drought accounted for 83 % of the national total. However, it increased to 94 % during the second period.

Third, from the viewpoint of land use types, the center of droughts with high values was more stable in the livestock areas, generally in the vicinity of Central to Eastern Inner Mongolia. However, the center in the agricultural areas changed from south to north and from single center to multiple centers (Fig. 2.13).

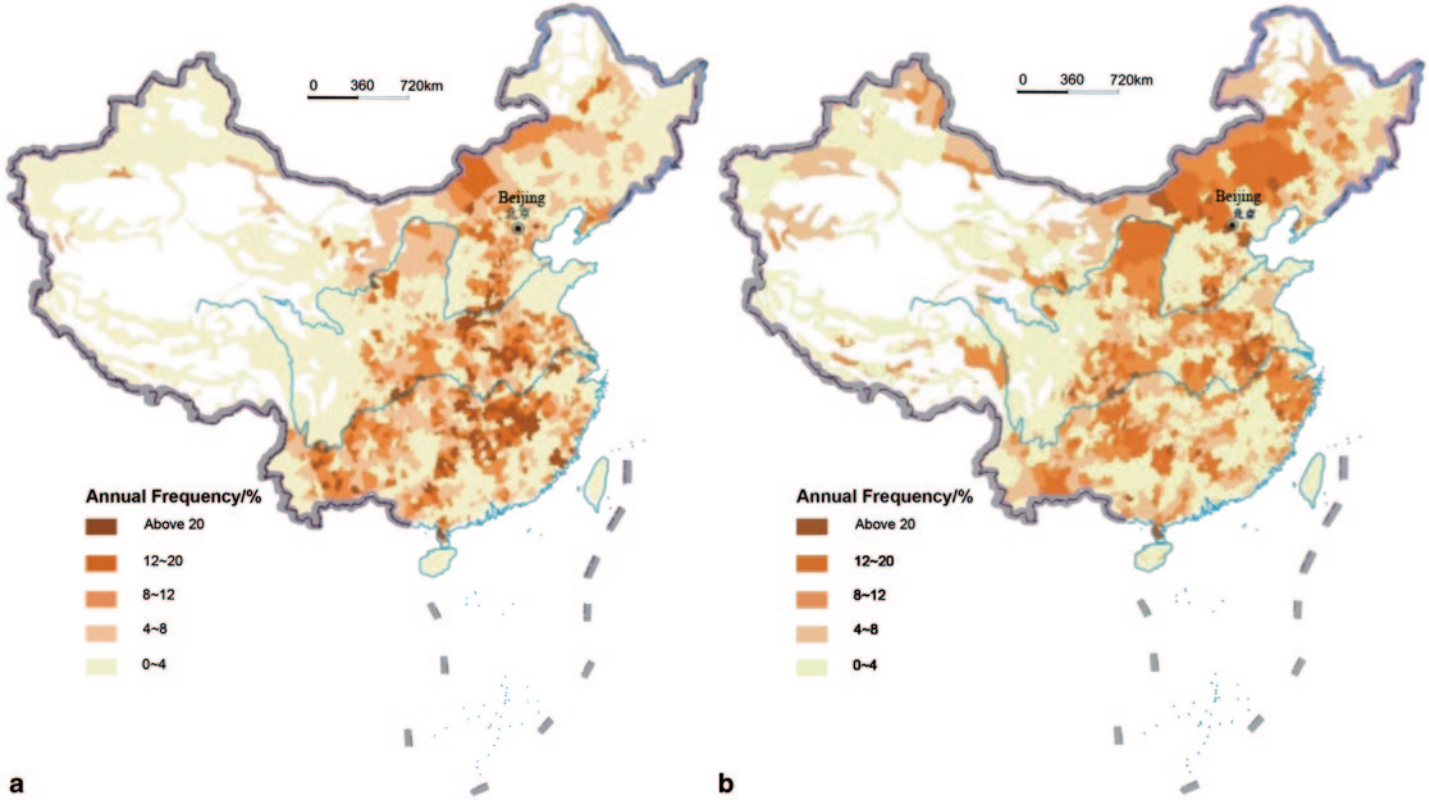

Fig. 2.13 **a** Annual frequency of drought in China (1949–1965). (Wang 2002). **b** Annual frequency of drought in China (1978–2000). (Wang 2002)

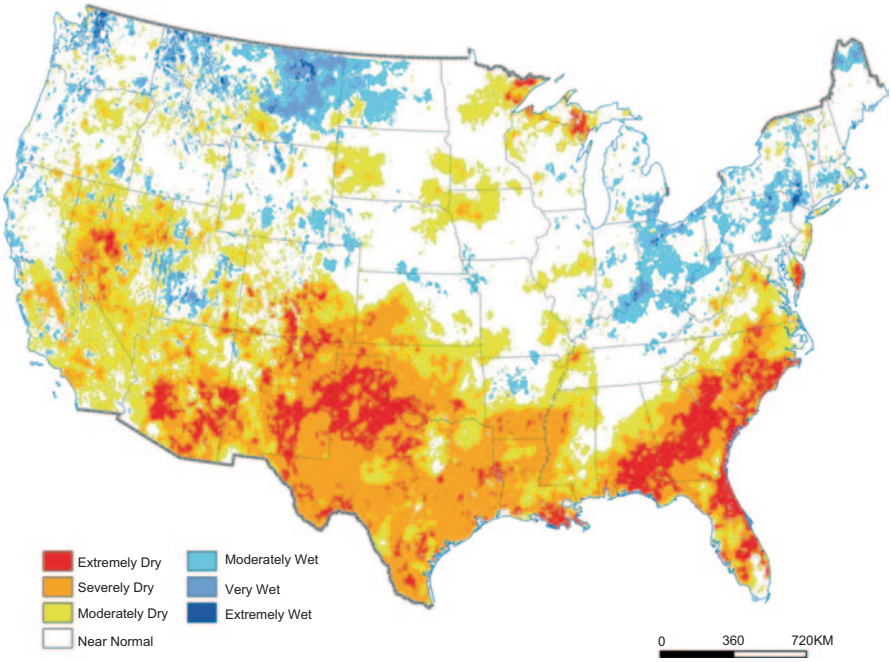

Fig. 2.14 Drought severity index of the conterminous U.S. (August 2012)

2.2.4.2 Droughts in the U.S.

Drought has affected more people in the United States than any other natural hazard. In fact, almost every year, a region somewhere in the U.S. experiences drought. Evidence from the instrumental record indicates that drought can affect any region in the U.S. While the central High Plains seems to have the most persistent droughts, the southern Plains and parts of Texas have the highest frequency of drought. Although much of the natural disasters are brief and short-lived, drought is a more gradual phenomenon, slowly spreading to more areas over time. In extreme cases, drought could last for many years, and could have destructive influences on agriculture and water supplies. The two major droughts of the twentieth century, the 1930s Dust Bowl drought and the 1950s drought, both lasted five to seven years and covered large areas of the conterminous U.S. The drought that affected the largest area during the past 100 years (the period of instrumental record) was the one in July 1934, which threw nearly 80 % of the continental U.S. into moderate to extreme drought.

Historically, drought has caused tremendous damages to the United States, averaging $6–8 billion each year. However, more losses have taken place in recent decades. For example, every year from 1987 to 1989, the losses caused from droughts reached as high as $39 billion, becoming one of the most costly natural disasters documented in U.S. history. Nationwide losses from the drought of 1988 exceeded $40 billion, more than the losses caused by Hurricane Andrew of 1992, the Mississippi River floods of 1993, and the San Francisco earthquake of 1989.

Drought has had a great impact on American societies. For instance, the Dust Bowl in the 1930s caused a massive migration from the Southern Plains to California, changed the agricultural policy on the Plains, and synchronized with the Great Depression, exacerbated the sufferings of millions. Even today, the hundreds of drought related records set up in the 1930s still haven't been broken yet. No other natural disaster in the recorded U.S history has affected so much of the country for so long.

In summary, natural disasters in both China and the U.S have their own characteristics. On one hand, China has a more noticeable monsoon climate; the flood and drought disasters are the most typical types of agricultural disasters; earthquake and typhoon both cause tremendous damages. On the other hand, hurricane/tornado, flood, and earthquake are the major natural disasters of the United States. Because of the influence of the "Circum-Pacific Earthquake Belt", earthquakes have caused destructive damages to both countries. However, China is also affected by the "Mediterranean Sea—the Himalayas earthquake Belt". In addition, China has more complex terrains and landforms; therefore, the earthquakes in China are more complex and could cause more destructive damages. Floods take place frequently on the plains of both countries. However, the limited areas of plains in China are often the most densely settled places and locations for agriculture, population, city and the economy. Therefore, floods and droughts in China are more damaging than those of the U.S. Finally, the coastal areas of both countries are affected by hurricanes (typhoons). Since China's coastal areas have a denser population concentration, they are more vulnerable to hurricanes.

2.2.5 Physical Zonations

2.2.5.1 Physical Zonation of China

Regional differentiation is the theoretical basis for physical zonation. This results in the phenomenon that under the impact of solar radiation and the Earth's internal energy, the natural environment and its present components some degrees of consistencies apply to certain directions but are different for other directions. The most basic and common differentiation applies to phenomena of zonal and non-zonal change. The latter can be divided into humidity zonation (longitudinal zonation) and vertical zonation (altitudinal zonation).

As the field of geography developed in China since the 1950s, the fundamental materials and resources for geographic research have been gradually improved. Accordingly, various zonation schemes have been put forward by many Chinese geographers. The one proposed by Huang Bingwei in 1959 turned out to be the most representative scheme. It is comprehensive and well designed, and has been included into the "Physiographical Atlas of the People's Republic of China" after its revision.

The basic principles for this zonation are that the high-level unit follows the zonal principles but the low-level unit follows the non-zonal principles. The system

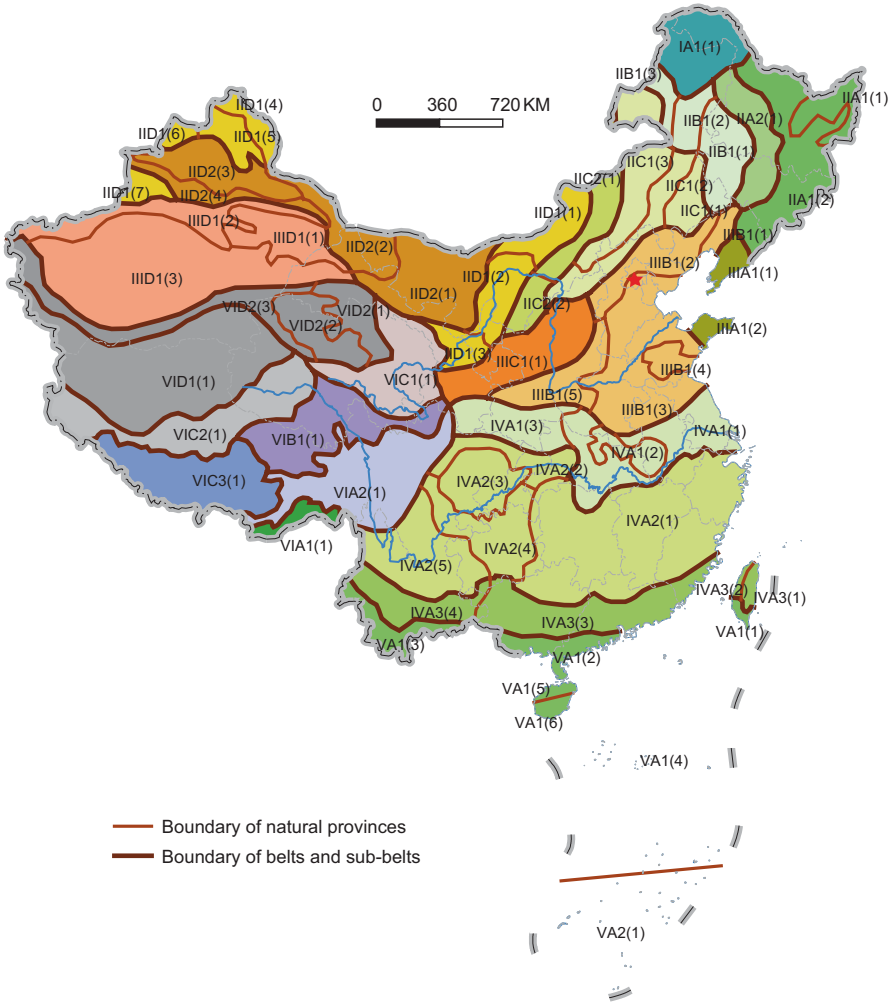

Fig. 2.15 Physical zonation of China (From Physiographical Atlas of the People's Republic of China, 1965)

divides the country into zones from the top to the bottom, based mainly on the method of the superposition of the leading symbols. The scheme divides the nation into three natural areas (the eastern monsoon area, the Northwest Arid Areas and the Qinghai-Tibet Plateau area), 6 heat zones (the equatorial zone, the tropical zone, the subtropical zone, the warm temperate zone, the temperate zone and the cold temperate zone), 18 physical regions and sub-regions, 28 physical belts and sub-belts and 90 physical provinces (Fig. 2.15, Table 2.1).

The Eastern Monsoon Area The boundary of the Eastern Monsoon Area is the east of the Eurasian continent, with low-flat topography, deep soil and notable

Table 2.1 Physical zonation of China

Heat zones	Zonal vegetation
Cold temperate zone	IA1 the bright coniferous forest in cold temperate zone (wet)
Temperate zone	IIA1 the needle broadleaf mixed forest in temperate zone (wet)
	IIA2 the sylvosteppe in temperate zone (wet)
	IIB1 the meadow in temperate zone (sub-wet)
	IIC1 the grassland with dark chestnut soil in temperate zone (sub-wet)
	IIC2 the grassland with light chestnut soil in temperate zone (sub-wet)
	IID1 the semi-desert in temperate zone (sub-wet)
	IID2 the desert in temperate zone (sub-wet)
Warm temperate zone	IIIA1 the broadleaved deciduous forest in warm temperate zone (wet)
	IIIBl the sun-dry broad leaved deciduous forest in warm temperate zone (sub-wet)
	IIIC1 the steppe in warm temperate zone (sun-dry)
	IIID1 the desert in warm temperate zone (dry)
Subtropical zone	IVA1 the broadleaved deciduous forest and broad-leaved evergreen forests in the cool subtropical zone (wet)
	IVA2 the broad-leaved evergreen forests in middle subtropical zone (wet)
	IVA3 the broad-leaved evergreen forests in warm subtropical zone (wet)
Tropical zone	VAl the selva and the monsoon forest (wet)
	VA2 Tropical equatorial rainforest zone (wet)
Cold temperate zone in Qinghai-Tibet plateau	VIAl the broad-leaved evergreen forests in the Qinghai-Tibet Plateau (wet)
	VIA2 Coniferous forest and meadow in the Qinghai-Tibet Plateau (wet)
	VIB1 meadow in the Qinghai-Tibet Plateau (sub wet)
	VIC1 meadow, steppe, forest in the Qinghai-Tibet Plateau (sub-dry)
	VIC2 alpine steppe in the Qinghai-Tibet Plateau (sub-dry)
	VIC3 meadow, steppe in the Qinghai-Tibet Plateau (sub-dry)
	VIDl desert and semidesert in the Qinghai-Tibet Plateau (dry)
	VID2 desert and semidesert in the Qinghai-Tibet Plateau (dry)

monsoon influence. Its wind direction and rainfall vary with the seasons. In summer, the southeast monsoon comes from the ocean which brings plenty of rainfall so that the climate is humid and the hydrographic network is complex. From the south to north, the forest vegetation and soil are different because of the difference in temperature. In addition, influenced by the extensive and long-term human activities, most of the natural forests are no longer in existence and almost all of the arable lands have been reclaimed as farmland. This region, with the high density cities, towns and rural settlements everywhere, is an area where population density is largest and economy is the most active.

The Northwest Arid Area It is located near the center of the Eurasian continent. Since there is less influence from the southeast monsoon and fewer mountains, it has an arid or semiarid climate. There are few rivers, and they are mainly inland rivers. The vegetation types mainly include desert, desert steppe and steppe, mountain

forests and alpine meadows only in the higher mountain elevations. The soil is barren and the salinization common. In the vast basins, there are many mobile and half-mobile sand dunes, which are the main source of sandstorms. In this area, there are fewer human activities compared to the eastern monsoon area. Due to excessive reclamation and overgrazing, frequent sand storms and the grassland degradation are the major problems.

The Qinghai-Tibet Plateau Area It is the largest plateau of the world with an average elevation of more than 4,000 m, thin air, low and cold temperature, intense radiation and strong winds. In the hinterland where there is less moisture coming from the outside, the temperature is so low that there are still many glaciers exist in the high mountains. Due to the harsh environment, plants and animals are rare and the vegetation mainly includes the cold desert and the alpine grassland. In the southeast, canyons are cut deep and the vertical vegetation belt spectrum mainly consists of sub-alpine forests and alpine meadows. In this area, only small populations live and there are even depopulated zones. Human activities are mainly limited to some valley areas.

There are 4 steps in the comprehensive zonation system of China (Table 2.2). The first step divides China into 6 heat zones and 1 extremely cold region according to the surface temperature; the second divides China into 18 natural are-as according to the moisture content; based on the divisions from heat and moisture, the third divides China into natural regions according to the conditions of the soils and the vegetations; the last step further divides China into natural provinces according to the biological and climatic conditions of the natural zones.

2.2.6 Physical Zonation of the U.S.

The physical zonation of the U.S. is based mainly on the ecological features, which classify and divide the continental U.S into various zones and sub-zones according to the characteristics of the ecosystems and various environmental factors that drive the differentiations of their complex components. The zones from this system represent the combinations of the ecosystems with similar functions. It enhances the management of lands from a single isolated resource to the entire catalogue of resources within the ecosystem for the goal of achieving the ecological monitory, biological conservation, and sustainable development. At present, the most commonly used one is the Robert Bailey system, which divides North America into ecoregions and sub-ecoregions based mainly on their climatic conditions and their corresponding vegetations. In reference to the Koeppen climatic classification system, Robert divided the North America into 4 large natural areas and 15 divisions. The conterminous U.S is mainly located in the moist temperate area and the arid area (Table 2.3).

The Humid Temperate Area The main controlling factors of the areas in mid latitude (30 °N to 60 °N) are the tropical and polar air masses. This area is influenced by hurricanes where the majority of precipitations comes from the rising

Table 2.2 The index system for physical zonation in China (Huang 1993)

System	Zonation basis			Significance and description
Natural area (3) (level 0)	Eastern monsoon region, northwest arid area, the Qinghai-Tibetal pine areas; integrated features			Reflect then on-zonal The hue for background (not on map)
Heat zones and the sub-bands (6) (level 0)		Accumulated temperature ≥10 °C	Average temperature of the coldest month	Zonal feature Landscape and agricultural cropping
	Boreal	<1,700 °C	<−28 °C	
	Temperate	1,700–3,200 °C	−28–−8 °C	Code with I–VI (not on map)
	Warm	3,200–4,500 °C	−8–0 °C	
	Subtropical	4,500–8,000 °C	0–16 °C	
	Tropical	>8,000 °C	>16 °C	
	Maximum elevation of plateau farming			
Natural areas, sub-areas(18) (level 1)	Heat zones as basis, similar water and heat mix Dryness: wet < 1 Sub-1 1.2 (1.5) Semi-arid 1.2 (1.5) ~ 2 Drought > 2			Hydrothermal general grid Determine the direction of land use and agriculture Coded with A–D
Sub-zones of natural areas (28) (level 2)	Combination of water-heat as basis Soil (sub-categories), vegetation (formations Programmed) and same land use			Basic unit of zonation Determine land use structure, crop varieties, cropping Coded 1–3 (color representation)

moist air within the hurricane air masses. The seasonal variation of temperature and precipitation is apparent. The seasonal variation of the energy and the temperature is larger than the diurnal variation. The middle latitude area's climate has the distinctive winter, that the tropical climate does not have. The vegetations mainly include the temperate deciduous broadleaf forest, the coniferous forest, and the evergreen trees.

The Dry Area The basic characteristic of dry climates is that the loss of the surface water through evaporation is greater than the precipitation it receives each year. Generally, the dry climates can be divided into two areas: the arid desert and the arid prairie. The semi-arid prairie is a transitional zone between the desert zone and the moist zone. The boundary line between the arid zone and the semi-arid zone is arbitrary, which is usually defined by using one-half of the rainfall between the humid area and the semi-arid prairie. Of all the climates, the dry climate is the most widespread, occupying 1/4 of the Earth's land area.

Table 2.3 The physical zonation of the conterminous U.S. (Bailey 2002)

Area	Division	Equivalent Koppen climates	Zonal vegetation	Principal zonal soil type
Humid temperate Area	Warmer continental	Dcb	Mixed evergreen and deciduous-coniferous forests	Gray brown podozolic
	Hot continental	Dca	Broadleaf forest	Gray brown podozolic
	Subtropical	Cf	Broadleaf-coniferous evergreen, coniferous-broadleaf semi-evergreen forests	Red and yellow podzolic
	Marine	Do	Mixed forests	Brown forest and gray-brown podozolic
	Prairie	Cf, Dca, Dcb	Forest-steppes and prairies, savannas	Prairie soil, chernozems, and chestnut-brown soil
	Mediterranean	Cs	Dry steppe; hard-leaved evergreen forests, open wetland and shrub	Grassland soil
Dry Area	Tropical-subtropical steppe	BSh	Open woodland and semi-deserts, steppes	Sierozem, and brown soil
	Tropical- subtropical desert	BWh	Semi-deserts, deserts	Sierozem, desert soil
	Temperate steppe	BSk	Steppes, dry steppes	Sierozem, desert
	Temperate desert	BWk	Semi-desert, desert	Sierozem, desert

2.3 Environmental Issues and Problems

2.3.1 China's Status Quo and Action Plans

2.3.1.1 Air Pollution

Sulfur dioxide (SO_2), nitrogen oxides (NOx) and particulate matter (PM) are accessed in 325 prefecture-level (and above) cities and 113 major cities according to *the Ambient Air Quality Standard* (GB 3095–1996). It can be concluded from the reports that the atmospheric quality and acid rain pollution status of cities nationwide have stayed steady but are still in heavy contamination of the air in the larger urban-

ized areas, in particular in the three key areas and regional clusters Beijing-Tianjin-Hebei regional cluster, the Yangtze River Delta and the Pearl River Delta, in 2012.

Beijing can serve as an example. The nation's capital has a semi-dry monsoon influenced humid continental climate with a high natural dust precipitation. In recent decades, with the acceleration of industrialization and urbanization processes, there are more than twenty million tons of coal burned, emission from more than five million vehicles and more than 150 million square meter of urban construction area every year in Beijing. All this contributes significantly to the atmospheric pollution. Beijing has suffered frequently from haze and smog since 2013. The air contains a larger density of PM 2.5 particles—those smaller than 2.5 microns in diameter, which can penetrate deep into the lungs—which mainly comes from coal firing and motor vehicle emissions. In addition, the unusual sustainable steady atmosphere and high aerosol concentration make for the continuous accumulation and agglomeration of aerosols, thus increase the persistence of haze and smog. In January 2013, there were only 4 days of clear weather with five times of severe haze pollution processes in Beijing-Tianjin-Hebei regional cluster. Beijing is now struggling to keep a clean air situation as only the wind in winter and the rain in summer can kick out the haze and smog.

The Beijing Government published the *Clear Air Action Plan from 2013 to 2017* in order to significantly improve the air quality which focuses on prevention and control of PM2.5 and promotes emission reduction of multi-contaminants. On Sep 12th, 2013, the Airborne Pollution Prevention and Control Action Plan (2013–2017) unveiled by the State Council sets the goals for the nation's 338 cities. For the Beijing- Tianjin- Hebei regional cluster, concentration levels of PM2.5 particles must be cut by 25% by 2017 from 2012 level, under the plan. In this plan, ten measures are published: (1) Reduce contaminant emission (coal consumption from 68 to 65%; removal of 15 million heavy polluting motor vehicles); (2) Strictly control the new capacity of energy-intensive and heavy-pollution industries (such as a reduction of steel production capacity); (3) Promote cleaner production and develop public traffic; (4) Accelerate the restructuring of energy industry (by increasing the supply of natural gas and non-fossil fuels); (5) Enhance energy efficiency and environmental protection indexes constraints; (6) Promote new system of simulation and restriction of emission reduction and energy conservation; (7) Push industrial transformation and upgrading by laws and standards; (8) Format a mechanism of joint prevention and control of Beijing-Tianjin-Hebei mega-region, Yangtze River Delta mega-region and Pearl River Delta mega-region in order to work on PM2.5 pollution in populated areas and major cities; (9) Severe pollution weather should be taken consideration by local government's public emergency management; (10) Build the social standard of behavior of "share the same breathe and work together", everyone participates and plays their respective duties. "Western countries have spent decades trying to improve their air quality, and are still trying. What China is doing here is trying its best to make improvements happen as soon as possible, but we also need to be realistic about the hardships ahead and prepare for a protracted war against pollution. It's a war that will involve every single member of the public," said Chai Fahe, Vice-President of the Chinese Research Academy of Environmental Sciences (China Daily 2013).

2.3.1.2 Water Pollution

The monitoring of fresh water includes surface water (rivers, lakes and reservoirs) and underground water in China. In *Environmental Quality Standards for Surface Water* (GB 3838–2002), surface water is divided into five classes according to its purpose for use and protection target.

> Class I: mainly for source of water and national nature protection areas
> Class II: mainly for class one protection areas for centralized potable water source, protection areas for rare fishes, spawn ground for fishes and shrimps etc.
> Class III: mainly for class two protection areas for centralized potable water source, protection areas for general fishes and swimming areas
> Class IV: mainly for general industrial water areas and entertainment water areas not directly touched by body
> Class V: mainly for farmland water areas and water areas for general landscape requirement.

If there are several classes of function in the same water areas, the highest class of function will be taken for classification. Different classes of function have different standards accordingly.

In 2012, the country's state-monitored surface water sections were in a light pollution situation. Among the state-monitored surface sections of the Yangtze River, Yellow River, Pearl River, Songhua River, Huaihe River, Haihe River, Liaohe River, the rivers in Zhejiang Province and Fujian Province, the rivers in Northwestern China and the rivers in Southwestern China, the percentage of Class I–III is 68.9%, Class IV–V is 20.9%, and the rest is below Class V (see List of Classes I to V). Major indexes are chemical oxygen demand (COD), 5 days' biochemical oxygen demand (BOD5) and permanganate index.

Among 62 state-monitored lakes and reservoirs, the percentage of Class I–III is 61.3%, Class IV–V is 27.4%, and the rest is below Class V. Major indexes are total phosphorus (TP), chemical oxygen demand (COD), 5 days' biochemical oxygen demand (BOD5) and permanganate index.

Lake Taihu can serve as an example. Taihu Lake, located south of the Yangtze River Delta, is one of the five largest freshwater lakes in China. Since the mid-twentieth century, the lake was polluted gradually with nitrogen and phosphorus materials. Large areas of the lake were in eutrophication, and the quality of freshwater kept deteriorating. In recent decades, the quality level of freshwater was downgraded from mainly Class II to mainly Class IV, and the level of eutrophication upgraded from mainly mesotrophic and mid-eutrophication to severe eutrophication. The Cyanobacteria Event in Taihu Lake happened in May, 2007. A toxic-algae bloom in Wuxi, Jiangsu Province, caused a lack of freshwater for the whole city. The bottled water was sold out in every store and shop. By now, the water quality

at Taihu Lake has improved significantly through technical measures and policies such as cutting pollution sources, salvaging algae, water diversion, dredging and ecological recovery.

2.3.2 Status Quo and Action Plans in the U.S.

The United States of America has been experiencing various kinds of environmental problems. Among them, air pollution and water pollution are the most common and widespread ones.

2.3.2.1 Air Pollution

In general, air pollution in the U.S. consists of particulate pollutants and gaseous pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NOx), ozone (O_3), carbon monoxide (CO), volatile organic compounds (VOC), certain toxic air pollutants, and gaseous metals from fossil fuel fired power plants, industrial facilities, petroleum refineries, and automobiles. Particle pollution (PM2.5 and PM10) includes a mixture of compounds that are from mechanical processes like construction, mining, agriculture, and chemical processes like burning fuels and emitting gases. Generally, they are grouped into five categories: sulfate, nitrate, elemental carbon, organic carbon, and crustal material. Currently in the nation, electric utilities emit over 60% of national SO_2 emissions, agricultural operations emit over 80% of national NH3 emissions, solvent uses contribute about 50% of the national VOC emissions, and automobiles pump out approximately 60% of national CO emissions.

With less than 5% of the world population but the leading consumer nation in the world, the United States is the second largest air polluter, behind only China, and produces nearly 7,000 million metric tons of CO_2 in 2011, accounting for 17–18% of the total greenhouse pollutants worldwide. With the number of automobiles approaching 200 million, automobiles are the single largest primary source of air pollution, emitting over half of the carbon monoxide, a third of the nitrogen oxides, and almost a quarter of the hydrocarbons into the atmosphere. In the United States, on average, four out of five Americans own a car (cars per capita was 0.799 in 2011). Americans' passion for cars has steadily increased over the years. When the Clean Air Act was issued in 1970, only 5% of U.S. household owned 3 or more cars. This number, however, has increased to 19.1% with an average of 2.1 vehicles for every family in 2011.

Secondary pollutants such as ground-level ozone formed from automobile pollutants have caused heavy smoggy skies and harmful dirty air in many US cities, especially in California, where many of the most-polluted cities in the US are heavily concentrated. With warm climate, curved topography, and high traffic volume, it has created a perfect condition for air pollution to generate, linger, and spread. For example, Los Angeles provides the classic example of photochemical smog and thermal inversions being created. According to the California Department of

Motor Vehicles (DMV), as of January 1, 2007, there were 6,675,888 automobiles, commercial vehicles and motorcycles registered in the County of Los Angeles. In the City of Los Angeles alone, there were a total number of 2,499,764 registered vehicles. In addition, people traveling on the roadways in Los Angeles/Orange counties experience the highest hours of delay (93 hours) among the metropolitan areas in the nation. When the enormous amount of harmful gases comes out from the massive number of automobiles, the city's coastal location and topographic setting have trapped and confined those harmful gases in a broad, mountain valley. When cooler air from the ocean slides under the warmer urban air, an inversion layer typically forms around 500 m altitude. Since the surrounding mountain ranges are higher than the inversion altitude, the valley tends to hold in the inversion layer and the pollution under it.

In the U.S., air quality has improved significantly since the Clean Air Act was created in 1970. As of 2010, ozone levels across the country had dropped 13 % since 2000, while particle pollution was 24 % lower, according to the American Lung Association, which began to monitor air quality in 2000. A study led by researchers at Harvard School of Public Health (HSPH) has found beneficial effects between reduced air pollution levels and improved life expectancy in 545 counties in the U.S. from 2000 to 2007. However, despite the progress made for cleaner air, roughly half the people in the United States (50.3 %) live in counties that have at times unhealthy levels of either ozone or particle pollution. Poor air quality has caused significant health risks to people with lung diseases like chronic obstructive pulmonary disease(COPD) and asthma, people with heart disease, diabetics and those who work or exercise outside. On average, air pollution is responsible in the U.S. for an estimated 50,000 premature deaths each year and costs from air pollution-related illness are estimated at $150 billion per year.

2.3.2.2 Water Pollution

Water pollution in the U.S. comes from both "point source" (PS) and "nonpoint source" (NPS). While the sources of water pollutants are almost infinite, point source pollution mainly includes those easily identified as outlet pipe, ditch, channel, tunnel, and conduit from individual industrial and sewage treatment plants. They are discrete, visible, and confined, therefore, are relatively easy to control. Nonpoint source pollution, on the other hand, comes from many dispersed sources; consequently, it is extremely difficult to control. Nonpoint source pollution comes from agricultural practices, residual areas, urban runoff, mining operations, and atmospheric deposition. When rainfall or snowmelt runoff moves over and through the ground, it takes away natural and human-made pollutants into lakes, rivers, wetlands, coastal waters and ground waters. The surface runoff from storm water in urban area is particularly detrimental since all sorts of debris such as sediment, oil, fertilizer, and pesticide residues, as well as organic residues from vegetation, animal droppings, and garbage can be flushed into streams, lakes, and oceans when it drains into the ditches and pipes quickly. Every year, enormous amounts of oil,

paint, lead, grease, and toxic chemicals from automobiles have been washed off from the countless miles of dirty surfaces of paved streets and highways, parking lots, garages, and buildings roofs and lawns.

Agricultural runoff is another leading source of water pollution for rivers and streams, lakes, and bays. According to the latest National Water Quality Inventory, agriculture has contributed to 60% of the impaired river miles and half of the impaired lake areas surveyed by states, territories, and tribes. The substantially increased use of nitrogen, phosphorus and other nutrient fertilizers for boosting crop yields has led to an sharp increase in the amount of contaminants being washed down to the water system around the country. Today, in the United States, most of the phosphorous and organic nitrogen pollution in the water comes from agricultural sources. Of the hundreds of millions pounds of almost 25,000 kinds of pesticide products such as herbicides, fungicides, and insecticides used in the agricultural fields, less than 1% have actually reached the pests. The majority ends up as chemical residues in the nation's rivers, streams, and water bodies. Livestock farms that house hundreds of thousands of pigs, chickens, or cows, produce vast amounts of manure and urine; they also contribute excessive amounts of microbes, nitrate pollution and drug-resistant bacteria to water supplies. Those nutrients have threatened the water quality across the country and often cause algae blooms that cause oxygen insufficiency in the water and destroy aquatic life. For example, a broad "dead zone" that stretches over several thousand miles in the Gulf of Mexico has been forming due to the inadequate level of oxygen to support aquatic life because of the algae blooms from nutrients in animal waste.

Water pollution has become a serious problem around the country. According to a recent US wide assessment study of the water system by EPA, nearly about 44% of the nation's streams, 64% of the lake areas, and 30% of the bay and estuarine areas are not clean enough for fishing and swimming. Another recent study indicated that only 28% of the nation's streams have top healthy biological living conditions in their region. Each year, nearly 20 million Americans fall ill from waterborne parasites, viruses or bacteria that are from the animal waste. Drinking water contaminated with nitrates near animal plants such as hog factories has increased the occurrences of blue baby syndrome, caused deaths in infants, spontaneous abortions, and disease outbreaks. For instance, in the coastal waters in North Carolina, bacteria and viruses from animal waste have been linked to the death of more than one billion fish.

In recent years, the United States has made tremendous advances in controlling point source pollution from industries and sewage treatment plants. Meanwhile, tremendous amounts of efforts have been put into addressing the nonpoint source water pollution issue. In 1987, the country established the Nonpoint Source Management Program by the Clean Water Act Amendments; in 1990, the Coastal Nonpoint Pollution Program was established by the Coastal Zone Act Reauthorization Amendments. Various programs have been initiated from the local governments to deal with water pollution particularly NPS problems. In addition, many public and private groups have developed initiatives and education activities for pollution prevention, pollution reduction, and monitoring. However, those efforts

and achievements could be in jeopardy as we push further into those previously inaccessible places where human could not physically go but rely strictly on technology for resources such as oil. The potential disaster that can be brought forth into our water systems sometimes can be catastrophic and beyond human being's ability to control and manage. For example, when the BP Deepwater Horizon oil well exploration which took place over a mile below the ocean's surface, occurred on April 20, 2010, nobody could go to site to stop the spill before millions of gallons of crude oil had been released into the Gulf of Mexico. The damage that this disaster brought upon the ocean, beaches, shores and wildlife will probably never be fully restorable.

2.4 The Comparison of the Physical Geography

2.4.1 Physical Geography

2.4.1.1 Comparison of Landforms

In China, the topography decreases from west to east in a ladder-like fashion, so most of the rivers originate from the west and flow eastward. This feature has resulted in a gradient development of the water resource. The huge differences in surface reliefs and the very rugged terrains have imposed big obstacles for agricultural productions and transportation infrastructure constructions. The topography of the United States is high in the east and west but low in the middle, which leads to the north-south alignment of most mountains and river networks. The central low and flat Great Plains makes it easy for the two sides to connect with each other, therefore, the difficulty for the development of transportation and resource is relatively minimal.

The two countries share some other common features as well. First, the topography of the two countries has an enormous impact on its respective climate and other natural environments, but it is more evident in China. Both countries have majestic mountains (the Himalayas and the Rocky Mountains respectively) in the west. In China, the uplift of the Qinghai-Tibet Plateau blocks the warm and moist air from the Indian Ocean, which forces the subtropical high pressure system to move further north, causing the northward shifting of the arid and semi-arid areas. The soaring and broad Cordillera Mountains which is composed of a serious of mountain ranges, intermontane basins and plateaus in the western United States has created many barriers to the eastward flows of the Pacific air masses. In the east, the north-south trending Appalachian Mountains, although not very high and wide, is enough to block the warm and humid air masses from the Atlantic Ocean to move westward. In addition, The mountains on the east and west sides have confined polar air mass from Canada, the tropical air mass from the Gulf of Mexico, and the Atlantic air masses to the continent's central portion. This has led to the violent collisions of those air masses with each other, usually causing extreme weathers such as hurricanes and tornados. Furthermore, the vast flat Great Plains does not

cause any problems for the extremely rigid air masses from the Arctic to move southward to bring cold weathers to the immense central and the southeastern plains in the winter.

Second, the landscape types in both countries have affected the agricultural production and the distribution of population and cities significantly. Overall, the populations in the two countries are mostly concentrated in the central and eastern plains. In addition, both countries' economies are generally more developed in the East than in the West. In China, this situation is more apparent. The dominating landform in the United States is plain. The central Great Plains, accounting for about 1/2 of the total land, is very suitable for large-scale farming and the development of transportation systems. While in China, plateaus and mountains are the leading landforms, and plains only occupy about 12 % of its total land area. The high quality farmlands are scarce and scattered, not appropriate for large scale farming by the machinery. This has created greater challenges for farming, and the development of urban and transportation systems.

2.4.1.2 Comparison of Climates

China borders the largest continent (the Eurasia Continent) in the west, and the largest ocean (the Pacific Ocean) in the east. It is a country with the most typical monsoon climate. The United States touches the Pacific Ocean in the west and the Atlantic Ocean in the east. In the U.S, the monsoon climate is not that noticeable, but it has the Mediterranean and the temperate marine climates that China lacks. Additionally, the climates in the two countries are significantly affected by mountain ranges (such as the Himalayas and the Rocky Mountains), but it is more obvious in China. The magnificent Qinghai-Tiber Plateau has created a big thermal contract between the ocean and the land, leading to hotter summer and colder winter.

From the view point of the climatic characteristics, the inlands in both countries are dry and cold in the winter and hot and humid in the summer. The coastal areas are warm and humid, with abundant rainfall. However, China has a more noticeable seasonal variation and ocean-land contrast. As for temperature and precipitation, both countries are warm and moist in the summer, cold and dry in the winter, and generally declining precipitation from southeast to northwest. Nevertheless, China's continentality of climate is more significant and arid and semi-arid area is broader. Although the two countries' west are arid areas, the extent and the scope of the dryness in western China are much more extreme than those of the United States, with a large area of them belonging to the extremely dry lands. For the regional differences in precipitation, the U.S West Coast is affected more by the oceanic currents. Although there is a difference in the amount of precipitation between the East and the West, the disparity is quite small. On the contrary, China' west is located deep inland and is isolated by towering mountains; consequently, the west and east have a significant difference in the amounts of precipitation they receive.

For climate, both countries have various and complex types of climate, and have broad latitudinal zonal distributions of temperate, subtropical, tropical, and

highland climate. However, their differences lie in that China has the world's most typical monsoon climate, and its eastern region is dominated by the monsoon climate, including the tropical monsoon climate, the sub-tropical monsoon climate, the temperate monsoon climate, the temperate continental climate and the highland climate. China's northwestern area is located far away from the ocean and is controlled by the continental air mass; consequently, it has temperate continental climate, except for the highland climate in the area of the Tibetan Plateau. Meanwhile, most parts of the United States belong to the temperate climate and the subtropical climate, with an only exception in the south tip of Florida with a tropical climate. In the United States, the temperate continental climate covers the most extensive area. While the southeast coast has a humid subtropical monsoon climate, the west coast has Mediterranean climate and the temperate continental climate, and limited areas in the western Cordillera Ranges have the highland climate. Therefore, the climate in each of the two countries has its own features.

2.4.1.3 Comparison of Water System and Surface Landscape Zones

Affected by the terrains, most of the rivers in China flow from west to east and finally drain into the Pacific Ocean. On the other hand, due to the existence of two drainage divides in the United States, the Rocky Mountains and the Appalachian Mountains, there exist three river systems, including the one flowing from west to east into the Atlantic Ocean, the one flowing from east to west into the Pacific Ocean, and the one running from north to south into the Gulf of Mexico. In addition, the Great Lakes are a unique feature of the United States water system.

The landscapes in both countries have significant latitudinal and longitudinal zonal features. However, China's topography is more towering and rugged, which has created typical three-dimensional zonal landscapes, i.e., more altitudinal zonal features for the vegetations and the soils. Besides, China's zonation is more obvious from the ocean to the inland, reflected by changes from the arid lands in the northwest to the wet lands in the southeast and the complex changes in the agricultural zones. Affected particularly by the so-called "The world's third pole", the Qinghai-Tibetan Plateau, and the large size population, China has become one of the countries in the world with the largest differences in regional landscapes and human-land systems.

2.4.2 Natural Disasters

China and the U.S are two very different countries. China is a large agricultural country with high population density, accounting for only 6.5% of the world land area but 20% of the world total population. The fast paces of industrialization and urbanization have generated a big pressure to its land and its fragile ecosystem. On the other hand, the U.S. occupies 6.4% of the world land area but only 5% of the world population. It has highly modernized industry and agriculture, and extremely

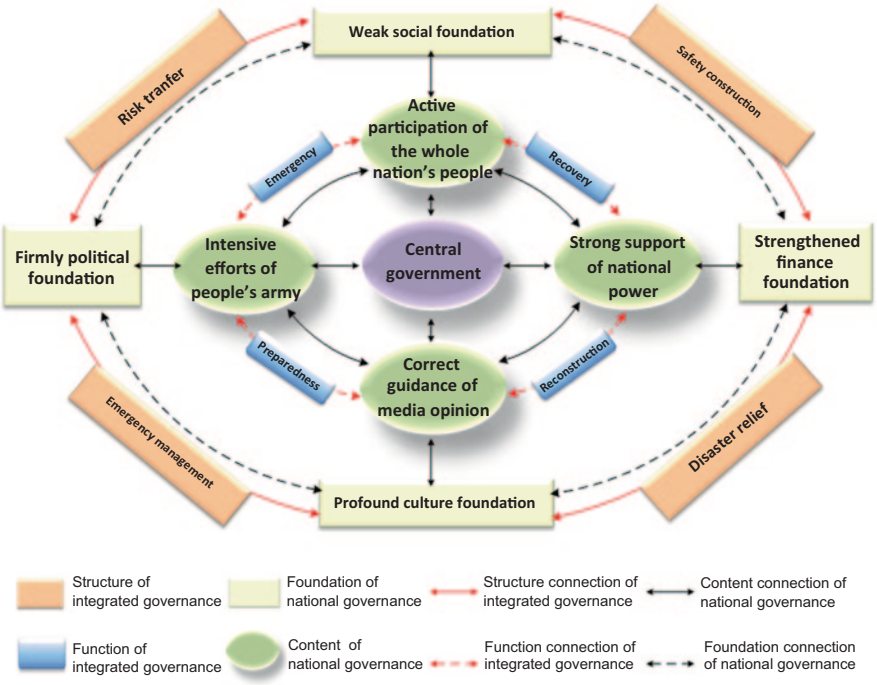

Fig. 2.16 The Chinese government disaster prevention model

developed science and technology. Therefore, when facing the natural disasters of the same intensity, because of the differences in the vulnerabilities of their social ecosystems and the political systems, the two countries have very different ways of dealing with the disaster prevention and mitigation.

Under the leadership of the State Council's Emergency Management Office and the National Disaster Reduction Committee, China implements a disaster prevention system (model) of "Central Leadership, Divisional Responsibility, and the Combination of the Hierarchical Management and the Local Management", as well as the watchful idea of "Prevention First, and One Entity for Prevention, Fighting and Rescue". The structure of the national comprehensive disaster prevention system is composed of the "Safe Fortification, Disaster Relief and Aid, Emergency Management and Risk Transfer". The function of the national comprehensive hazard prevention system is composed of the "Disaster Preparedness, Emergency Response, Recovery and Reconstruction" (Fig. 2.16).

In the United States, under the current federal system, the highest authority of the disaster management is the Department of Homeland Security. The Federal Emergency Management Agency (FEMA) within this Department is the executive agency responsible for the coordination of the cross-region cross-branch operations after an incident. The responsibilities of FEMA include the emergency prevention,

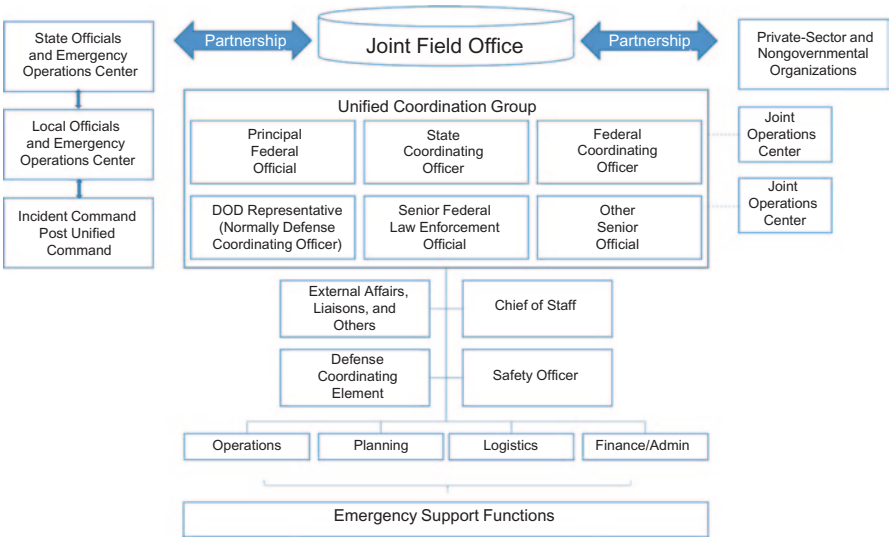

Fig. 2.17 The American government disaster prevention model (National Response Framework of the Homeland Security of America)

the emergency preparedness, the emergency response, the disaster recovery and reconstruction, the protection of public facilities, and the reduction of casualties and property losses. Emergencies are managed at the most-local level possible. However, if the emergency is terrorist related or an "Incident of National Significance", it will become a national event. Under the emergency cases, on behalf of the president, FEMA can coordinate various rescue efforts from the state and local governments, federal authorities, Red Cross, private sectors, nongovernmental organizations, and volunteers to respond to and recover and reconstruct from the disasters. The United States has made a number of response laws and regulations for natural disasters and emergencies, which become the legal basis for the federal government to develop, implement, and support the disaster mitigation plan (Fig. 2.17).

In general, the Chinese government implements a powerful "top—down" disaster management model with a high effect but low efficiency in the utilization of the resources. The US also has a nationwide federal coordination management structure, but it mainly takes the "bottom up" approach to engage in the states as the main components and pays great attentions to the resources from the nongovernment organizations, communities, and individuals. Although its effect of dealing with the disaster is low, the efficiency of using the various resources is high. Therefore, in the prevention of the natural disasters, especially the catastrophic ones, the most efficient effective approach is to combine the "top-level (nationwide) " model from China and the "bottom (local)" model from the United States or other Western countries together. Efforts should be put on strengthening the construction of the legal system, the mechanism, and the various capabilities. It also should exercise the disaster insurance actively, especially the catastrophe insurance, and transfer the risk through effective means to reduce the disaster

losses. Built upon this, the two countries should learn from each other to improve their systems and abilities for disaster prevention and mitigation.

2.4.3 Physical Geography Regionalization

2.4.3.1 The Uplift of the Qinghai-Tibet Plateau and Its Impact on the Regional Climatic Differences

The substantial uplift of the Qinghai-Tibet Plateau over an immense extent was the most significant regional event during the Earth's evolution history since the Cenozoic in China. The rapid uplift of this large plateau not only changed the circulation patterns of the airs on the plateau itself, it also affected the configuration of the modern East Monsoon, intensified the downdraft of the airs in the Northwest. It has completely changed China's regional climatic structures and the physical geographical processes. Generally, when the altitude of the Qinghai-Tibet Plateau reached 3,000 m, its dynamic and thermal functions to the air movements were powerful enough to disrupt the atmospheric circulation patterns in East Asia.

Qinghai-Tibet Plateau, with a land area of nearly 2,500,000 km^2 and accounting for a quarter of China's total land size, is located at 25 °N–40 °N, a transitional region between the Westerlies and the Subtropical High-Pressure Belt. It's more than 4,500 m high altitude embraces up to one third of the Troposphere in the middle latitude area during the winter. It stretches across over 31 longitudinal degrees, approximately 2,700 km long in the east-west orientation, and 15 latitudinal degrees, nearly 1,400 km wide (1/3 of the Westerlies) in the north-south direction. Such a massive obstacle has blocked the ramification process of the Westerlies and the movement of the warm and humid air masses into Asia's interior. Additionally, it has a significant impact on the southward expansion of the winter winds and on the desertification of Asia's interior.

The Dynamic Functions of the Qinghai-Tibetan Plateau The Qinghai-Tibet Plateau plays an important role in blocking the movements of the airs near the surface. In winter, the cold air accumulates on the northern Qinghai-Tibet Plateau and then divides into two parts. While one moves into the Tarim Basin along the Al Jinshan Mountains, the other flows westward or northwestward along the Qilian Mountains into the Hexi Corridor and then continue further south to form the winter wind channel, enhancing the strength of winter wind in the southeastern area. In the summer, on the way to flow northward from the Bay of Bombay, when the Southwest Monsoon meets with the Qinghai-Tibetan Plateau, it is divided into two branches: one along the Himalayas to become an easterly and the other moves along the direction of the mountains into the China's southwest to strengthen the water vapor circulation there. It increases the precipitation in the periphery of the plateau and exacerbates the dry condition in the inner plateau due to the rain shadow effect. In the west part of the Qinghai-Tibet Plateau, when the Westerly is blocked by the plateau in the winter, it is divided into the northern and southern branches, with

the former being much stronger than the latter. The southern branch moves around the south side of the plateau to become a southwesterly, enhancing the dry and hot southwestward flowing air. The northern branch becomes a southwesterly at the north of the plateau. It then bypasses northern Xinjiang to become a northwesterly, further strengthening the strength of the winter wind. In the north of the plateau, a ridge is formed where the subsiding air prevails, further exacerbating the desertification processes in the Northwest. Overall, because of the obstruction from the Qinghai-Tibet Plateau, after the processes of ramification, bypassing, converging and eastward moving, the Westerly has become the strongest wind in the Northern Hemisphere.

The Thermal Functions of the Tibetan Plateau The great thermal differences between the surface of Qinghai-Tibetan Plateau surface and the freely flowing air masses with the same altitude in the atmosphere have produced significant thermal effects on the atmospheric circulations. In summer, like a fireplace thrusting into the atmosphere, the plateau heats up the air near the surface to force it to ascend, while pulling up more airs from the Indian Ocean as supplies to fuel this process. Consequently, it brings abundant monsoon rainfalls. On the contrary, in the winter, the huge plateau is just like a colossal piece of ice, cooling the air above it and forcing the air to flock to the Indian Ocean. It enhances the strength of the southward moving cold air from the North, making it a strong winter wind.

In short, the uplift of the Qinghai-Tibetan Plateau has important implications on forming and developing of the Eastern Asia Monsoon. The uplift of the plateau can be divided into three main phases. In the first phase, about 10–9 Ma ago, the Asian Monsoon began to form; in the second phase about 3.6–2.6 Ma ago, the uplift of the plateau accelerated and the Asian Monsoon in the winter and the summer increased their strengths at the same time; in the last phase since 2.6 Ma ago, with the continuing uplift of the plateau, the variability of the summer and winter monsoon increased and the winter monsoon strengthened. With the uplift of the Qinghai-Tibet Plateau, China's climate can be divided into three unique regions (Table 2.4), which constitute the foundation in shaping China's macro natural landscapes.

2.4.3.2 Reasons for the Climatic Regionalization in the United States

The regionalization of the climate and the physical environment in the U.S is closely associated with the land-sea distribution and the latitudinal zonation. The southeast coast is mainly the subtropical monsoon climate with largely the subtropical evergreen broadleaf forest. As a result of the difference in the thermal properties between the land and sea, in the winter, the Northwesterly is prevailing, bringing cold and dry weather condition; in the summer, the dominating wind is the southeasterly, which brings high temperature and abundant rainfall. The southwest coast (mainly the California coast) has a Mediterranean climate. Due to the control of the subtropical high pressure system in the summer, the weather is hot and dry; in the winter the mid-latitude Westerlies brings warm and humid air to this area that covered by subtropical evergreen conifers. The Northeast Coast is mostly the

Table 2.4 The impact on China's regional climate from the uplift of the Qinghai-Tibet Plateau

Evolution trend of regions	Original background	Major impact
Eastern region -the formation and strengthening of East Asian monsoon system	Ocean-land monsoon, wetter	Southward expansion of the winter wind–strengthening the power The plateau increased the ocean-land monsoon strength– big annual air temperature range, precipitation concentrated in summer The ramification of the Westerly and its disappearance to some extent control the monsoon's path(October/May) Compared with other parts of the same latitude, the temperate zone in the monsoon zone shifted to the south
Northwest -drought	Secluded inland, more arid, with desert, desert steppe, steppe-based vegetation	Accelerated the descending of the accumulation of cold air Water vapor from the Indian Ocean was blocked Drought intensified, extent expanded
Qinghai-Tibet Plateau Area -Cold and arid	Plateau surface < 2,000 m still sub-tropical savanna, steppe climate	The plateau blocked the water vapor from the Indian Ocean and the Pacific Ocean, interior becoming dry Plateau cooling, becoming colder Plateau monsoon

temperate marine climate with temperate deciduous broadleaved forest, influenced by the Westerlies all year long. The warm and humid air taken by the wind from ocean to land brings mild, humid, and rainy weather to the area. In addition, situated in the high latitude area and affected by the frigid tundra climate, the state of Alaska is extremely cold and dry.

The giant ranges (for example the Rocky Mountains and the Appalachian Mountains) also affect the regionalization of the climate and the physical environment in the U.S greatly. The Rocky Mountains is an important climate boundary in the North America continent. It blocks the eastward intrusion of the Polar Air Mass from the Pacific Ocean, the westward move of the Polar Air Mass from Canada, and the tropical Air Mass from the Gulf of Mexico, leading to the great differences between the East and the West in many aspects, such as the distribution of precipitation and temperature. Furthermore, the Rocky Mountains are also an important drainage divide for the river systems. The Appalachian Mountains in the

East prevents the Atlantic water vapor from traveling further into the interior. It has certain influences on the development of the climate zones in the East. However, Because of its relatively low altitude and continuity, its influences to the climate of the U.S are inferior to the Rocky Mountains to the climate of the U.S or the Himalaya Mountains to the climate of China.

The Evolution of the Modern American Topography Outline The outline of the modern American landscapes is formed after a series of events over a long geological history. The core of the North America continent is the ancient land before the Cambrian. With the tectonic movements from the interactions between the continent and its adjacent plates, the outline was developed gradually. During the Archean period, after a series of tectonic movements and collisions, most part of the Great Lakes area tended to rise slowly over a long period so that the ancient crystalline base rocks were widely exposed and a huge hardened and stable continental land mass—the Canadian Shield was gradually formed, as part of the Laurasia. In the south and west of the Canadian Shield, the subsidence was the main tectonic movement with many transgression and regression activities. In the Precambrian, the crystalline rock basement was covered by a deep post-deposition, forming the central platform which covered most of the American central plain. In the eastern central platform, the internal low plains were mainly made of sediments from the Paleozoic, while in the west the Great Plains was made mainly of the Cenozoic sedimentary layers that covered the Paleozoic sedimentary layers.

During the Early Cambrian, the old Atlantic Ocean was formed between the ancient North America and Old Europe, and the old Appalachian Ocean was formed between the ancient North America and the ancient Africa. During the Devonian, with their collisions, the ancient North America and the Old Europe plated developed into the ancient Europe—America continent. After the Devonian, the ancient Gondwana rotated clockwise, causing the ancient Africa and the ancient Europe—America continents to gradually move closer to each other, and finally the two collided in the late Carboniferous sutures, forming the northern Appalachians. Through a lengthy process of the plate activities, the Appalachian geosyncline set off three large-scale mountain orogenic events to form a series of NE—SW trending parallel folds and thrusts. After the creation of the mountains, it went through several long processes of peneplain stages. During the Triassic, the north-south faulting occurred. In the Tertiary, the mountains rose again, and a new erosion process began, resulting in the foot platforms, the Blue Mountains, the Ridge Valley area and the Appalachian Plateau from the southeast to the northwest.

The large-scale upheaval of the Cordillera started from the Mesozoic. The reopening of the Jurassic Atlantic drove the North American Plate moved westward to cause serious of tectonic movements to create the Alaska Range, Cascade Mountains, Sierra Nevada Mountains, and mountains in California Peninsula and so on. From the late Cretaceous to the early Tertiary, the expediting retrograde movement of the plate triggered a serious of large-scale mountain orogenesis in the eastern Cordillera geosynclines, leading to the uplift of the Rocky Mountains, the significant rise of the Colorado Plateau, along with the strong magmatic intrusions and

fault activities. Since the Oligocene, the North American Plate continued to move westward to battle directly with the Pacific Plate. This tectonic event started a new wave of Alpine movements which still last today and led to the formation of the coastal mountains along the Pacific Rim, the folded Sierra Nevada Mountain belts, the significant uplift of the Colorado Plateau, and the block faults within the Great Basin.

The Evolution of the Modern Climate Since the breakup the Pangea, the three major geological structures that shaped the climate in the United States include the erosion of the Appalachian Mountains, the uplift of the West Cordillera and it accompanying volcanic activities, and the uplift of the northeastern margins of the North America continent. When the North America was separated from the Gondwana, the landform was high and active in the east but relatively low and stable in the west. However, as the Appalachian Mountains continued to be eroded away, its impact on the climate reduced greatly. On the other hand, with the continuous uplift of the Cordillera's west margins, its influence on the climate had been increasing. During the past 5 million years alone, generally the western region increased by more than 500–2,500 m, which had a profound impact on this region's climate and biological production. During the Pleistocene, most mountains had reached to 3,000 m high and were covered by snow.

This role exchange between the east and the west had a significant impact on the transformation of the heat and moisture in the continental United States, which led to an extreme climate of the West being getting drier and the Central being more vulnerable to the tropical and polar air masses. The uplift of the northeastern edge in North America, to a large extent, led to the development of the Cenozoic glaciers in this region. During the Cenozoic, this region was uplifted by another 1,500 – 2,000 m. When the mountains and plateaus have been raised to a certain altitude, it formed the climate conditions for the growth of glaciers.

Due to the obstruction from the West Cordillera, the warm and wet air masses from the Pacific Ocean were sharply uplifted to change their characteristics. In addition, the dry and cold air masses originated from the frigid northern cold land and the Arctic ice and snow sheets, because of no natural barriers, can sweep freely across the central continent, reaching to the Gulf of Mexico in the winter. With the north-south alignment of mountains on both sides, the central lowlands becomes an ideal place for the transformation of the tropical wet warm air mass and the polar dry cold air mass. The collision of these two air masses often produced extreme weathers such as severe thunderstorm and cyclones. Other mountains from the West Cordillera Mountains also have a great impact on the climate. For example, the mountains on the California Coast are high enough to prevent the winter storms from the Pacific from moving eastward, resulting in a 100 km long semi-arid region in the west of the Central Valley. The west of the lofty Sierra Nevada Mountain is humid temperate climate, but its east side is a semi-arid climate. There are many similar changes everywhere in the Cordillera, such as the Great Basin with a temperate desert climate even if it is located between 35 °N to 45 °N.

2.5 Conclusions

China and the U.S. are two large countries in terms of land area in the world. They are both located in large continents, with thousands of kilometers from north to south and from east to west. Their vast land areas determine the variety of landforms, climates, vegetation patterns and natural disasters in each country. Their geographical locations in the respective continent and the relative location to oceans entail the similarities and differences in terms of their physical geography. Physical geographical conditions cast in most cases strong influences on human activities and therefore influence regional human-environment interactions. These activities and interactions, e.g. population distribution, agricultural and industrial production, will be elaborated in the following chapters.

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