3 Climate in the Past and Present in the Czech Lands in the Central European Context

Jan Hradecký and Rudolf Brázdil

Abstract

Central Europe and Czech Lands (recent Czech Republic) itself have recently represented an area with a transitional type between the oceanic and continental types of temperate climate. The climate changed during geological history and various climates played an important role in the evolution of landforms due to changes in type and intensity of weathering and earth surface processes. This chapter describes general trends in climate oscillations during the Tertiary and the Quaternary within the Czech Lands and Central Europe. Climatological and hydrological extremes and fluctuations during the last centuries are along with human activity fundamental drivers of recent changes in the landscape evolution.

Keywords

Climate • Tertiary • Quaternary • Climate oscillations • Climatological and hydrological extremes

3.1 Introduction

The relief of the Czech Republic shows distinct signs of polygenesis and its evolution was strongly controlled by climate that underwent considerable changes during the Cenozoic Era. Different climatic conditions influenced the evolution of landforms that represent a parallel to the relief development in contemporary morphoclimatic zones of the Earth. Geomorphological legacy of the oldest Cenozoic periods has greatly been changed in the subsequent phases, particularly cold phases of the Quaternary. Climate reconstructions are based on the modern analysis of stable isotopes in marine sediments and ice cores (e.g. Svensson et al. 2008; Vinther et al. 2010). From the point of view of the region, however, key analyses are mainly paleobotanical (pollen analyses) (e.g. Davis et al. 2003). It is particularly paleobotanical data that make it possible to derive mean annual temperatures and mean precipitation totals for the territory of Central Europe (Mosbrugger et al. 2005). Individual parts of the following text describe climatic conditions in different periods of Cenozoic landscape evolution, mainly in the period of the late Tertiary and the Quaternary, characterised by significant climate oscillation with the displays of the alternation of cold and dry glacial periods and warm and humid interglacial periods. From the point of view of landscape and relief evolution, special phenomena are extreme events whose existence has been recorded but their frequency decreases if we go deeper into the past due to the incompleteness of datasets. The reconstruction of natural extremes that formed the relief of Czech landscape and that comprise particularly hydrometeorological events was derived mainly from documentary and instrumental data (e.g. Brázdil et al. 2005, 2012). The final part of this chapter focuses on contemporary climatic conditions.

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3.2 Tertiary Climates of Central Europe

Unlike the subsequent period of the Quaternary, climatic conditions of the Tertiary were greatly different than those of today and led to the origin of different landform assemblages that can be identified in the landscape of the Czech Republic even nowadays. Sediments that fill basin structures of the Czech Republic, namely organogenic sediments of the rank of coal (e.g. in Mostecká pánev Basin), are other important evidence of different climatic conditions of the Tertiary. From the point of view of paleogeography, very important sediments are Miocene formations of the Carpathian Foredeep.

Tertiary climate was characterised by the alternation of warmer and colder oscillations with a tendency towards gradual cooling (Chlupáč et al. 2002). Climate has been reconstructed in the Wiess Elster Basin in the vicinity of the border between Bohemia and Germany. Paleobotanical analyses show that climate in Central Europe in the period from the Middle Eocene to Lower Oligocene was tropical, with mean annual temperature ranging from 23 to 25 °C, mean annual precipitation from 1,000 mm to 1,600 mm and coldest month mean (CMM) from 17 to 21 °C (Mosbrugger et al. 2005). Lower temperatures were associated with a majority of the Oligocene period with CMM around 5 °C, while the latest Chattian was marked by a temperature peak which was recorded by Mosbrugger et al. (2005) from the Lower Rhine Basin. This peak corresponds to the Late Oligocene Warming known from isotope records (Zachos et al. 2001). The warmest period of the Neogene was the Miocene (Chlupáč et al. 2002) in which the trend of warming continued up to the Middle Miocene. This warming seems to be rather stepwise, while the curves show several short-term variations. In the Weisselster Basin record there is evidence of short-term cooling at the base of the Aquitanian (Mosbrugger et al. 2005). The Middle Miocene temperature peak in Central Europe corresponds to the Middle Miocene Climatic Optimum that is observed globally. After Mosbrugger et al. (2005), the Miocene cooling seems to be between 14 and 13 Ma when considering all different records and analysed climate variables. In the Molasse Basin, CMM decreased more rapidly than in both other regions, and, at the end of the Middle Miocene, CMM dropped below 4 °C. The transition between the Miocene and the Pliocene shows a gradual trend in climate cooling. During the Late Pliocene the cooling intensified and CMM fell below the freezing point (Mosbrugger et al. 2005).

3.3 Quaternary Climatic Cycle

Quaternary evolution in Central Europe is connected with fundamental changes in environmental conditions and essential paleogeographic changes that were related to the transgression of the continental ice sheets, temperature drop and changes in morphogenesis.

A comprehensive overview of landscape evolution is brought by Quaternary climate and sediment model compiled by Ložek (1973, 1999a, b, 2007). The author characterises the evolution using four phases (Fig. 3.1): early glacial period, pleniglacial period, late glacial and interglacial. It is evident that global trends of the climate system oscillation were reflected in regional cycles. On the basis of an extensive set of data about Quaternary sediments Ložek (1999a, b) was able to derive a rather general model that characterises not only climate parameters but also points to the conditions of the evolution of soils and vegetation and the processes of weathering and material deposition. The four phases of Ložek's model are described below.

The phase of early glacial is characterised by the onset of cold climate. Mean annual temperatures range between +3 and −1 °C, depending on the location. Cooling brings a distinct decline in precipitation (mean annual precipitation totals are estimated to 200–400 mm). The landscape undergoes gradual aridization, which becomes evident in pedogenesis and vegetation composition. Interglacial forests are divided into smaller units whose species composition changes towards a boreal forest (taiga). Conifers start to appear, while the species of Central European temperate forest are in recession. Very dry periods bring forth chernozem steppes. The transformation of ecosystems gradually gives rise to cold continental steppes in which grasses and chernozems prevail. Temperatures and precipitation totals continue to decrease, while the cycle passes into the phase of the so-called pleniglacial.

Pleniglacial phase is characterised by the transgression of the continental glacier and conditions of periglacial climate in a great part of the territory. Glaciers start to appear in the topmost areas of mountain ranges and the ice sheet expands into the northernmost parts of the recent Czech Republic territory. Mean annual temperatures drop to −3 to −5 °C, which leads to the occurrence of permafrost. Tree vegetation recedes considerably, while groups of trees only survive in protected areas or vanish totally. The development of vegetation is limited by very low precipitation totals, ranging between 100 and 200 mm/year. Cold and dry climate is

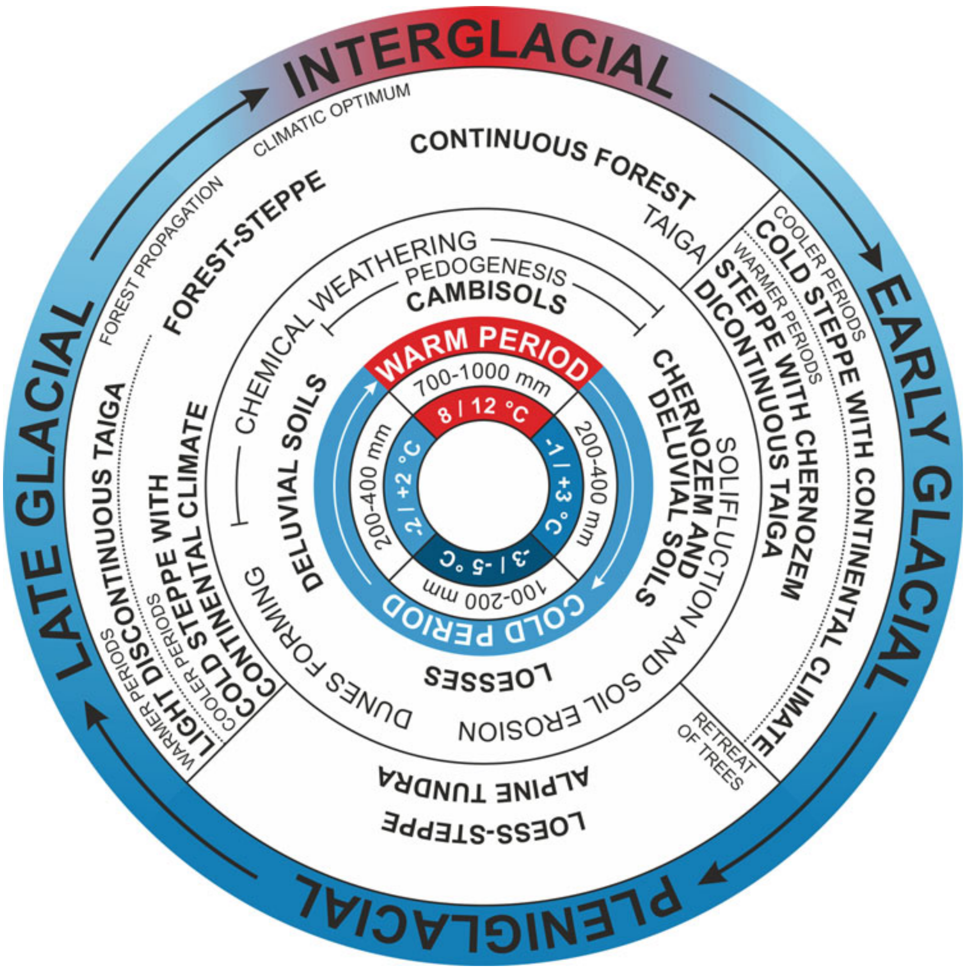

Fig. 3.1 Simplified Quaternary climate and sediment model compiled by Ložek (2007)

marked by strong atmospheric flow and loess deposition. This leads to the formation of cold loess steppes. However, the foreground of the ice sheet and higher locations witness the formation of tundra or sub-alpine ecosystems with cryogenic soils. Soil-forming substrates are very rich in salts and calcium carbonate, which leads to the spreading of halophile and calciphile species. The character of non-glaciated parts of the landscape is significantly affected by intensive congelifraction, presence of permafrost and gelifluction. The period of low temperature is replaced by gradual warming of climate, which leads to temperature oscillation. The landscape starts to enter the period of late glacial.

Mean annual temperatures in *late glacial phase* are still relatively low, ranging between –2 and +2 °C, however, the warming trend and increasing humidity are evident (200–400 mm). The climate is characterised by significant instability, which is reflected by the fact that cold continental steppes are preserved at many places, while the onset of thermophilic vegetation is very slow. Degradation of permafrost makes itself felt both by the increase in the thickness of its active layer and gradual decomposition of continuous permafrost areas into isolated permafrost patches. The retreat of the continental ice sheet along with the deglaciation of the highest mountain ranges brings fundamental changes in environmental conditions. Periods of warm oscillations make conditions for light discontinuous taiga with birch, pine and sea-buckthorn. Colder phases still witness the occurrence of cold continental steppe. Large accumulations of material weathered during cold periods start to be influenced by chemical weathering. Towards the end of the late glacial, forest species start to appear and the area covered by forests gradually extends.

Interglacial phase is a phase of warm climate. Annual temperature means increase greatly (8–12 °C) and the climate becomes more humid (700–1000 mm/year). The landscape changes fundamentally. With the onset of climatic optimum the open landscape is gradually closed by the Central European forest that replaces forest-steppe communities. Soils rich in calcium enable intensive spreading of basophilic species and high temperatures predetermine the spreading of xerophilic communities. Intensive chemical weathering and leaching alkali out of soil gradually gives rise to cambisols. Forest formations change regarding the species and gradual acidification of the surroundings facilitates the spreading of acidophilic species. The continuous forest reaches the phase of climax. However, the climatic system undergoes further development and enters the phase of cooling, which involves the spreading of cold-loving species, acidification intensifies and taiga spreads in the landscape.

3.4 Quaternary Climate in Central Europe

Climate cooling at the end of the Tertiary led to the Pleistocene, characterised by the alternation of cold (glacials) and warm (interglacials) periods. Using marine isotope stages (MIS) as a framework, it is possible to identify 104 stages of cool (52) or warm (52) climate periods during the whole Quaternary (and 103 MIS within the Pleistocene). Early Pleistocene was characterised by the mean annual temperature below 0 °C; however, this very old period in Central Europe is not covered well by precise data. On the basis of geomorphological proxy data, Czudek (2005) estimates that during cold phases of the Early Pleistocene mean annual temperatures dropped to −3 to −4 °C. The formation of cryogenic structures in the southern Moravia can indicate mean monthly temperatures of the coldest month to –20 °C, which would point to the occurrence of continuous permafrost (Vandenberghe 2001b). With respect to the climate of our territory, there is relatively little information on the Middle Pleistocene. Our conclusions are again drawn from proxy data (e.g. ice wedges and a range of pseudomorphoses). Mean annual temperature is estimated for −5 °C. Temperatures of the coldest months were on average around −20 °C or even lower. The Late Pleistocene was characterised by the peak in periglacial landform-shaping processes in the territory of the recent Czech Republic (Czudek 2005). In the Eemian interglacial period mean annual temperatures were around 13 °C and the climate was very humid (Czudek 2005). Subsequent cooling in the Weichsellian glacial period again brought mean annual temperatures below the freezing point (−2 and −5 °C). The greatest drop in temperatures came in the pleniglacial (73–13 ka BP) when in the phase of the Last Glacial Maximum (LGM) mean annual temperatures were −6 to −8 °C; mean January temperatures ranged between −18 and −20 °C. The warmest summer months reached temperatures between 5 and 6 °C (2005). Ložek (1999a) states that climate had continental character, with long and cold winters, short springs, but relatively warm summers. He further mentioned that annual precipitation totals ranged between 100 and 200 mm and they occurred particularly in the warm part of the year. An interesting approach in the reconstruction of environmental conditions during the LGM is brought by the study of Alvaradoa et al. (2011) in which a drop in temperatures by 5–7 °C was confirmed by the analysis of dissolved noble gases in groundwater of the Bohemian Cretaceous Basin. The end of the Pleistocene (Late Pleistocene) was characterised by a distinct increase in temperatures; however, with considerable oscillation between interstadials (Bölling and Alleröd) and stadials (Older and Younger Dryas). Mean annual temperatures in interstadials ranged between 2 and 5 °C, while during stadials they were around −2 to −3 °C (Czudek 2005).

Warming at the end of the Younger Dryas brought radical changes to the environment. Considerable retreat of the glaciers led to the onset of the Holocene interglacial. Climate warming was accompanied by increased precipitation that accelerated vegetation growth and changes in the pedogenetic conditions, weathering and relief evolution. Individual chronozones of the Holocene landscape evolution are shown in Fig. 3.2 including reconstructed temperatures and precipitation totals after Ložek (2007) and Starkel (1990a). In the Preboreal (10,300–9,300 BP) mean annual temperature was by c. 3 °C lower than nowadays. Continuing continental climate was warmed in the course of the Preboreal (9300–8400 BP); mean annual temperature was by 2–3 °C higher than nowadays (Czudek 2005).

Climatic optimum was reached in the Atlantic (8400–5100 BP) in which the mean annual temperature was up to 3 °C higher than today (Czudek, 2005). An important characteristic of the Atlantic climate was significantly higher precipitation, namely by 100 %, if compared with nowadays (Ložek 1999c). The beginnings of the Subboreal (5100–2400 BP) were by 1 °C warmer than the present-day mean. The main feature of the Subboreal period was ambivalence and drier periods alternating with more humid ones and warmer periods alternating with colder ones (Czudek 2005). The period of the Subatlantic (2400 BP—the present day) brought cooling and, at the same time, increased precipitation (Ložek 1999c). Humid climatic phases are reflected in the landslide activity phases in the Carpathian part of the Czech Republic (Pánek et al. 2010) that also correspond with the Polish landslide activity chronology (Fig. 3.2).

The latest pollen data proxies and the relationship of pollen and the climate changes during Holocene are brought by the research of Veron et al. (2014) from the peat bog of Boží Dar (Krušné hory Mts). The authors confirm very cold Late Glacial dominated by *Cyperaceae* grass land (12.5–11.0 kyr BP), the Early Holocene warming and the onset of *Pinus* (11.0–9.0 kyr BP). During the Boreal the temperature increased with an increase in the shade-intolerant *Corylus* and a concurrent decrease in *Pinus* (9.0–8.1 kyr BP). The Atlantic chronozone is classified as the warmest and wettest period of the Holocene characterised by the species of *Alnus* and *Fraxinus* (8.1–4.3 kyr BP). The following Subboreal chronozone was detected as drier and possibly colder and characterised by the decline in temperature-sensitive species (< 4.3 kyr BP). Similar results of temperature trends were

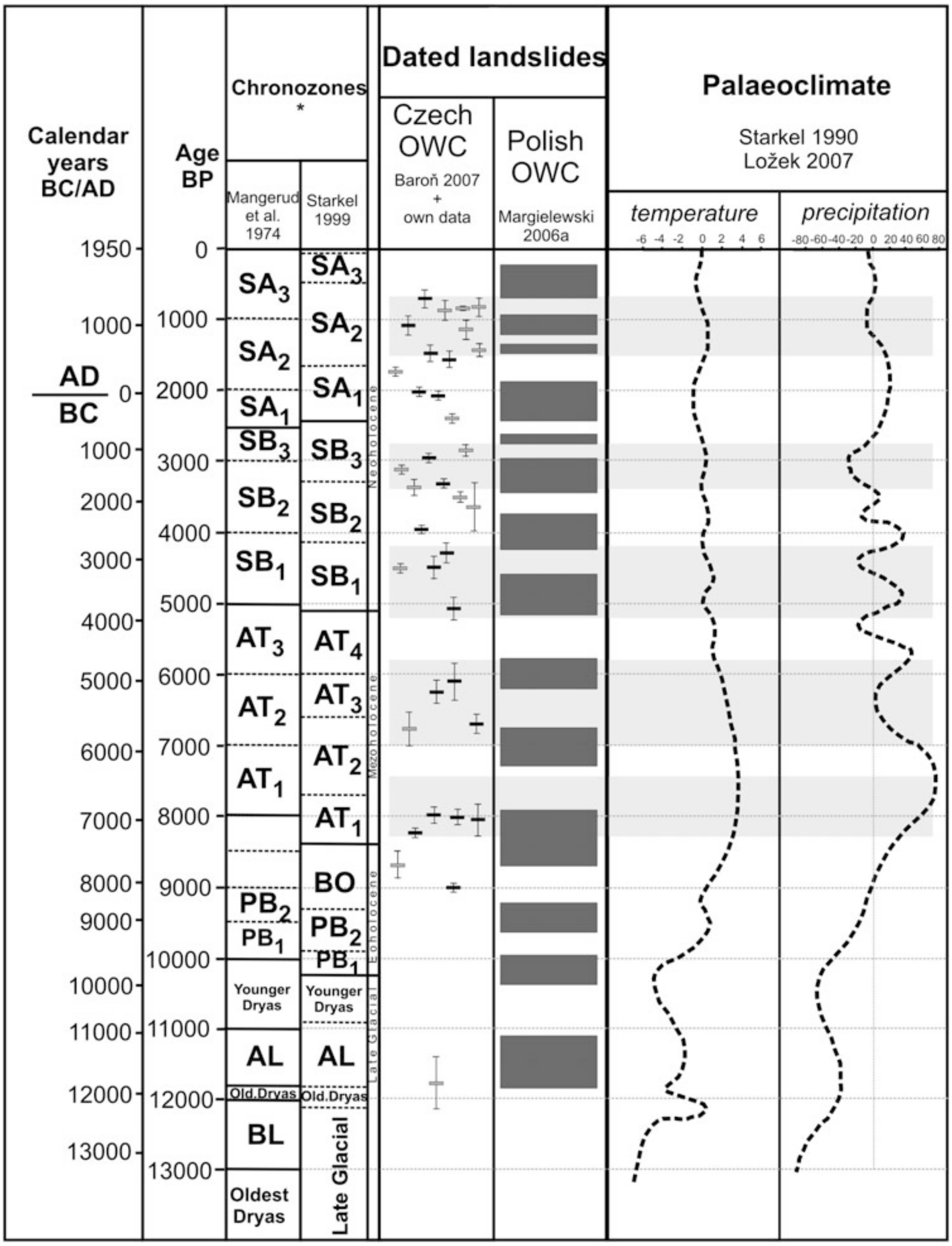

Fig. 3.2 Correlations of dated landslides (both in the Czech and Polish parts of the Flysch Carpathians) with paleoclimate (Pánek et al. 2010). The scheme is based on a diagram performed by Margielewski (2006); time-span of individual chronozones after Mangerud et al. (1974) and Starkel (1999); dated landslides in the Czech part of the Outer Western Carpathians (OWC) after Baroň (2007) (20 cases—*black boxes*) and dating performed by the authors of this study (15 cases—*gray boxes*); dated landslides (landslide phases derived from the dating of 67 landslides) in the western part of the Polish Outern Western Carpathians after Margielewski (2006); paleotemperature and paleoprecipitation after Starkel (1990). Despite the fact that landslides occurred in the Czech part of the OWC throughout the entire Late Glacial and Holocene, significant landslide aktivity clusters (*horizontal grey bars*) are correlated to periods characterised by high precipitation/low temperature

brought by the synthesis of pollen data proxies of all Central Europe made by Davis et al. (2003).

3.5 Climate and Floods of the Past 500 Years in the Czech Lands

Climate of the past millennium is usually divided into Medieval Warm Anomaly (MWA), Little Ice Age (c. 1300–1860) and recent global warming (e.g. Grove 2004; Matthews and Briffa, 2005; Xoplaki et al. 2011; Stocker et al. 2013). High-resolution climatic data in the Czech Lands are related to the beginnings of systematic instrumental meteorological observations. The longest series are available from the Prague-Klementinum station (temperatures from 1775 and precipitation from 1804) and the Brno station (temperatures from 1800, precipitation from 1803) (Brázdil et al. 2012). The data from the period before the instrumental period can be extended with dendrochronological and documentary data. The tree-ring data of fir (*Abies alba* Mill.) were compiled from different places in South Moravia and used for March–July precipitation reconstruction in the 1376–1996 period (Brázdil et al. 2002). Recently this series has been complemented with other samples and used to reconstruct May–June Z-index as a drought indicator from AD 1500 (Büntgen et al. 2011). Because of restrictions of tree-ring-based reconstructions to only a few months of the year (usually of the vegetation period), documentary data related to weather and climate are more promising. They describe directly weather and/or human activities or phenomena with a direct relation to the weather. Their sources are very diverse: annals, memories, chronicles, diaries, letters, economic records, pictures, etc. Weather-related documentary data in the Czech Lands between the eleventh and fifteenth century are relatively scarce and do not allow to obtain a continuous description of climatic patterns (Brázdil and Kotyza 1995). Their density increases after AD 1500. Because of qualitative information in documentary data, the series of temperature indices has to be interpreted in an ordinal scale. For example, in case of the seven degree scale, the following monthly weighted indices are applied: –3 extremely cold, –2 very cold, –1 cold, 0 normal, 1 warm, 2 very warm, 3 extremely warm. Analogously, similar indices are interpreted for monthly precipitation: –3 extremely dry, –2 very dry, –1 dry, 0 normal, 1 wet, 2 very wet, 3 extremely wet. Monthly indices are then summarised to obtain seasonal (indices from −9 to 9) and annual (indices from −36 to 36) information (Brázdil et al. 2005).

In Central Europe, series of temperature indices were created separately for the territory of Germany, Switzerland and the Czech Lands for the 1500–1854 period. They were then combined into one index series for Central Europe, which is fully representative also for the Czech Lands with respect to high spatial temperature correlations. In addition, a mean series of air temperature was calculated from the measurements at 11 Central European stations in South Germany, Switzerland, Austria and Bohemia (Prague-Klementinum) that date back to the year 1760. Finally, these two series were statistically analysed (using standard paleoclimatological method) for the common period of 1760–1854 in order to identify inter-relations and ultimately to reconstruct the temperature from before the year 1760 using several statistical techniques. Based on this stepwise analysis, temperature series of Central Europe could be produced for the seasons and the year for the entire 1500–2007 period (Dobrovolný et al. 2010). The reconstruction is very good and accounts for 81 % of the corresponding annual temperature variability (for seasons from 73 % in autumn to 83 % in winter). The Central European temperatures exhibit a great interannual and interdecadal variability and an increasing trend from the nineteenth century that has been particularly pronounced since the 1970s, which is in agreement with the observed global warming (Fig. 3.3a). The coldest periods occurred in the last three decades of the sixteenth century and in the late seventeenth century. As for seasons, remarkable periods are the coldest 30-year periods in the late sixteenth century (winter 1572–1601, summer 1569–1598) corresponding to *Little-Ice-Age*

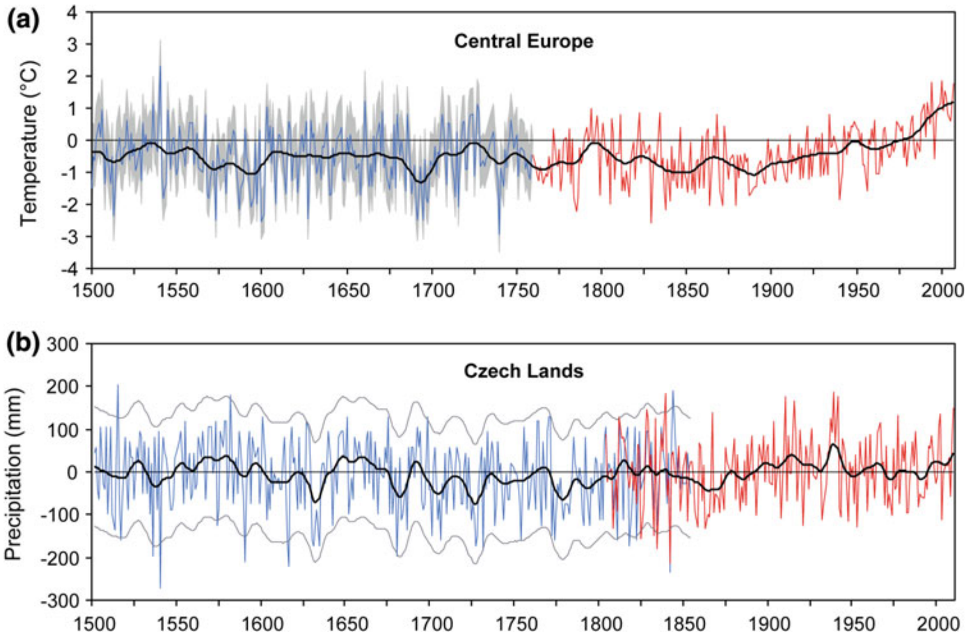

Fig. 3.3 (**a**) Annual temperature fluctuations in Central Europe in the 1500–2007 period derived from documentary and instrumental data and expressed as deviations from the 1961–1990 reference period. Uncertainty limits of reconstructed values are expressed by grey colour (Dobrovolný et al. 2010); (**b**) annual precipitation fluctuations in the Czech Lands in the 1501–2010 period expressed as deviations from the 1961–1990 reference period. Uncertainty limits are given by a 95 % confidence interval (Dobrovolný et al. 2014). Values in both graphs are smoothed by 30-year Gaussian filter; deviations for the pre-instrumental period are in *blue colour*, for the instrumental period in *red colour*

type event sensu Wanner (2000) (see also Matthews and Briffa, 2005). The other existing temperature reconstruction for the Czech Lands is based on winter wheat harvest dates and gives March–June temperatures for the 1501–2008 period (Možný et al. 2012).

The same standard paleoclimatological approach as for temperatures was applied to reconstruct precipitation totals from the series of precipitation indices for the Czech Lands. The 1803–1854 period was used as an overlap period between the series of documentary-based precipitation indices and the mean Czech series calculated from homogenised series of precipitation totals from 14 stations (Dobrovolný et al. 2015). With respect to higher spatial variability of precipitation, the reconstruction of annual totals explains only 36 % of corresponding precipitation variability (for seasons from 26 % in winter to 36 % in autumn). Fluctuations in annual precipitation totals in the last 500 years are characterised by great inter-annual and inter-decadal variability, but generally with missing long-term trends (Fig. 3.3b). The wettest 30-year periods were recorded analogously as for temperatures, in the second half of the sixteenth century (winter 1555–1584, summer 1568–1597).

Fluctuations in floods, which are the most disastrous natural events in the Czech Lands, are another important feature of the climate. Based on meteorological causes of their origin, floods can be divided into winter and summer floods. Winter floods are related to snow melt due to sudden warming (accompanied by rain) or ice jams in rivers and they usually occur from November to April. Summer floods,

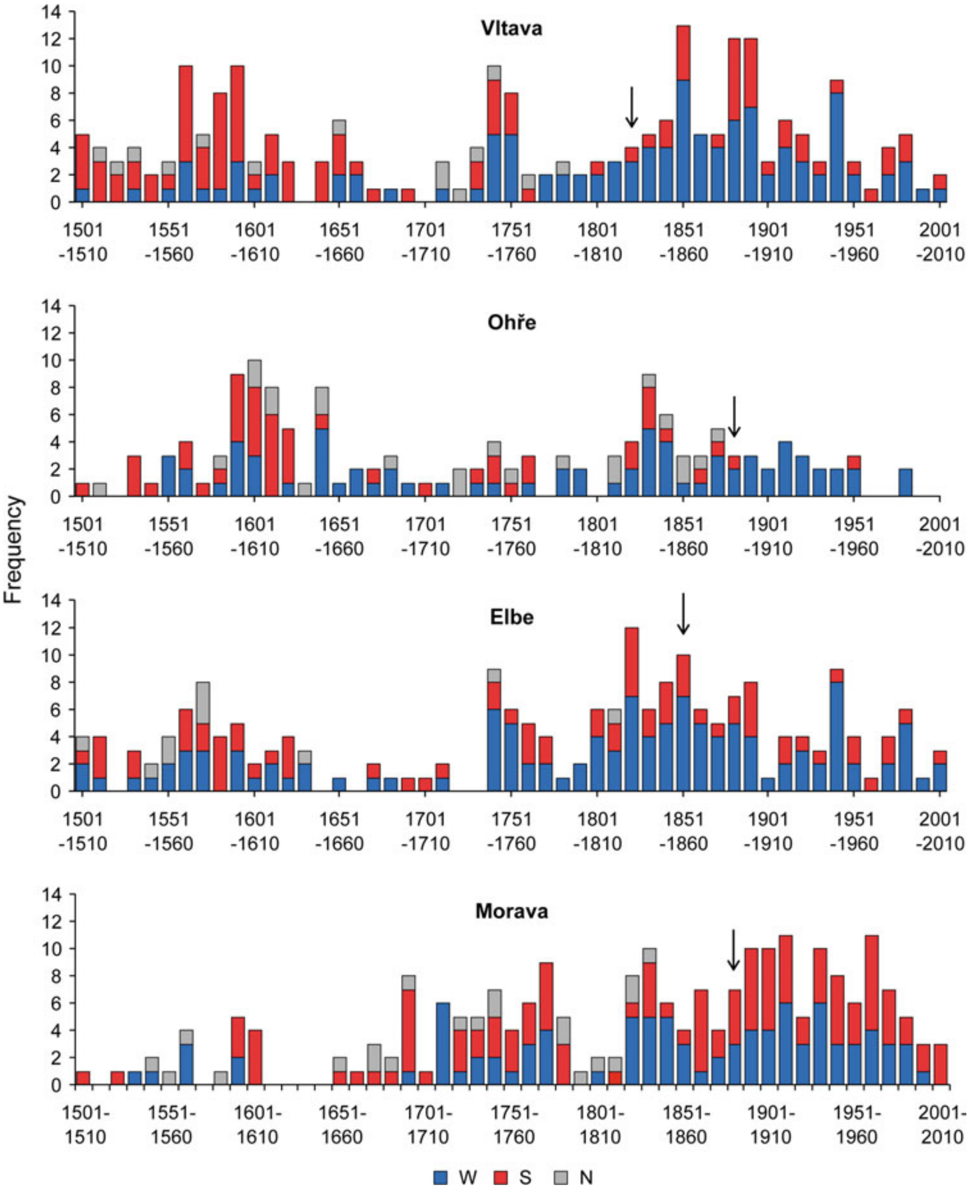

Fig. 3.4 Decadal frequencies of floods in the Czech Lands in the 1501–2010 period with differentiation according to the synoptic type of the flood (*W* winter, *S* summer, *N* not specified): the River Vltava (from České Budějovice to its mouth into the Labe River near Mělník), the Ohře River (from Kadaň to its mouth into the Labe River at Litoměřice), the Labe/Elbe River (from Brandýs nad Labem to Děčín), the Morava River (from Olomouc to Strážnice) (Brázdil et al. 2005, 2011). Arrows mark the beginning of systematic hydrological measurements

Table 3.1 Selected annual climatological characteristics of the geomorphological units of the Czech Republic 1961–1990, (Source: www.chmi.cz)

Station (Geomorphological Unit)[a]	Altitude (m a.s.l.)	Mean temperature (°C)	Mean precipitation (mm)
Červená (Nízký Jeseník)	749	5.5	739
Doksany (Dolnooharská tabule)	158	8.5	454
Cheb (Chebská pánev)	483	7.2	560
Churáňov (Šumava)	1118	4.2	1091
Kuchařovice (Znojemská pahorkatina)	334	8.5	471
Lysá hora (Moravskoslezské Beskydy)	1322	2.6	1390
Milešovka (České středohoří)	837	5.2	555
Plzeň (Plzeňská kotlina)	360	7.3	533
Praha—Karlov (Pražská plošina)	261	9.4	447
Přibyslav (Českomoravská vrchovina)	532	6.6	677
Přimda (Český les)	742	5.8	684
Svratouch (Žďárské vrchy)	733	5.7	762
Praděd (Hrubý Jeseník)	1490	1.1	1129
Ústí nad Orlicí (Svitavská pahorkatina)	402	7.1	763

[a] For the localization of geomorphological units see Fig. 1.1

related to heavy precipitation lasting for several days, are typical of May to October (flash floods do not occur in the studied rivers). Quite rich documentary evidence together with water level and discharge measurements starting in the ninteenth century allow to compile long series of flood frequency for the most important rivers in the Czech Lands (the Labe/Elbe River and its tributaries Vltava and Ohře Rivers in Bohemia, the Morava River in Moravia) from AD 1500 (Fig. 3.4). Despite differences between individual rivers, remarkable maxima of flood frequency are typical of the nineteenth century (mainly winter floods) and of the second half of the sixteenth century (mainly summer floods) (Brázdil et al. 2005).

3.6 Contemporary Climate

The location of the Czech Lands in Central Europe together with their relief and position in relation to the main pressure systems in the Atlantic-European area, influencing atmospheric circulations patterns, are the main factors deciding about spatial and temporal variability of climate in the Czech Republic. This territory falls within the transitory temperate climate zone and therefore the area of interest experiences the influence of both the oceanic and continental climate. Temperature conditions largely reflect location and elevation above the sea level. The highest mean temperatures (more than 10 °C) are measured in lowlands and southern areas of the country and thus Southern Moravia, Osoblažsko area and middle and lower portions of the Labe River belong to the warmest locations (Tolasz et al. 2007). On the other hand, the lowest mean air temperatures are measured in mountainous regions, namely in the highest locations (less than 3 °C) of the Krušné hory Mts., Krkonoše Mts., Šumava Mts., Jizerské and Orlické hory Mts., Králický Sněžník Mts., Hrubý Jeseník Mts. and Moravskoslezské Beskydy Mts. Maximum precipitation is reached in summer half-year. Generally, about 40 % of precipitation falls in summer, 25 % in spring, 20 % in autumn and 15 % in winter. The rainiest locations are found in the highest elevations of the Czech and Moravian ranges where mean annual precipitation considerably exceeds 1200 mm (Krušné hory Mts., Šumava Mts., Jizerské hory Mts., Krkonoše Mts., Orlické hory Mts., Hrubý Jeseník Mts. and Moravskoslezské Beskydy Mts.) (Tolasz et al. 2007). The lowest annual precipitation is measured in Žatec Basin behind the Krušné hory Mts., in the rain shadow area. Other locations with low precipitation throughout the year are Southern and Central Moravia (area of Moravian basins), Polabí area and Opava region. Žatec region, Polabí Lowland and Southern Moravia are also characterised by the highest occurrence of dry periods given by precipitation deficit (Tolasz et al. 2007). Selected climatological parameters for some geomorphological units are presented in Table 3.1.

3.7 Conclusion

The Czech Republic is located in the transition area whose climate results from interaction of both maritime and continental air masses. The geographical position was crucial during the geological history and therefore the paleoclimate was influenced by transgressions and regressions of the Scandinavian ice sheets. The paleoclimate oscillations and historical fluctuations were reconstructed with the use of various proxy data. It is evident that a very important role in the evolution of landforms was played by warm and wet climate of the Tertiary. A complete change started at the end of the Tertiary when the climate pattern changed into Quaternary oscillations between colder and drier periods of the glacials and warmer and wetter periods of the interglacials. Climate changes created conditions for the evolution of periglacial landforms and limited areas were affected by glacier action (the highest mountains were glaciated and the northernmost areas of the recent Czech Republic were covered by masses of the Scandinavian ice sheet (Elsterian and Saalian glacials). Extreme temperatures during the whole Pleistocene are connected with the Last Glacial Maximum (∼26 ka BP) when mean annual air temperatures oscillated between −6 and −8 °C. The Holocene started with higher temperatures and higher precipitation and this led to the evolution of vegetation and changes in landform evolution. Human activities during the Post-Atlantic period created new conditions for the acceleration of alluviation under more humid climate. With the use of the methods of historical climatology and instrumental measurements in the last five centuries it was possible to identify climate and flood fluctuations which are very important in recent landform evolution.

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