Chapter 2
Initial Research of Climate Change in Poland

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Abstract This chapter includes the results of the earliest studies on changes and variability of climatic elements, bioclimatic indices and weather types across Poland. The first pioneering works on climatic studies were presented (since 1858), even if they did not relate to climate change.

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This chapter includes the results of the earliest studies on changes and variability of climatic elements, bioclimatic indices and weather types across Poland. The first pioneering works on climatic studies were presented (since 1858), even if they did not relate to climate change. Already in the nineteenth century, the results of air temperature (e.g. Karliński 1868; Kuczyński 1884), precipitation (e.g. Kremser 1884; Wild 1887), cloudiness (Satke 1898), humidity (Wierzbicki 1878) and snow cover (Satke 1896, 1899) investigations in Polish lands were published in Polish and German.

The climatic history in Poland for the **preinstrumental period** has been reconstructed from various natural archives. Information on climate change during the Holocene period was obtained on the basis of geomorphological, sedimentological and botanical data (Stasiak 1968; Starkel 1977; Ralska-Jasiewiczowa and Starkel 1988, 1991; Starkel et al. 1996; Kotarba and Baumgart-Kotarba 1997) and the most accurate climatic reconstructions were carried out for the historical period (the last millennium) (Niedźwiedź et al. 2015). Based on a literature review, it can be concluded that information on climate change in Poland during historical times were provided mainly by four types of proxy data: documentary evidences, tree rings, lake sediments and geothermal profiles.

The earliest study on Poland's climatic conditions was conducted using documentary evidences (Semkowicz 1922; Polaczkówna 1925). A considerable amount of data can be found in the excerpts from the chronicles (e.g. Walawender 1932; Namaczyńska 1937; Szewczuk 1939; Inglot 1962, 1966, 1968, Rojecki 1965); however, the first climatological interpretation of these historical records was made no longer than 30 years ago by Maruszczak (1988), Sadowski (1991), Limanówka (2001), and Przybylak et al. (2001). Detailed information on the development of historical climatology in Poland was presented by Przybylak et al. (2001).

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The earliest mention of the possibility of conducting dendroclimatological research in Poland comes from 1914 (Merecki 1914). Although preliminary dendroclimatological research started after the Second World War (Zinkiewicz 1946; Ermich 1953), the first reconstruction of climate on the basis of tree rings was presented by Bednarz (1984) for the Tatra Mountains. Since these pioneer work many long tree-ring chronologies were developed for different parts of the country (see summary presented by Zielski et al. 2010). However, development of studies on past climatic changes in Poland based on dendroclimatic records has taken place in the last two decades (e.g. Krąpiec et al. 1998; Cedro 2004; Niedźwiedź 2004; Büntgen et al. 2007; Szychowska-Krąpiec 2010; Koprowski et al. 2012; Opała and Mendecki 2014; Balanzategui et al. 2017).

Another source of paleoclimatic data covering the last millennium is laminated lake sediments, whose potential for paleoenvironmental and paleoclimatic reconstructions has been thoroughly examined for the Lake Gościąż site in central Poland (Ralska-Jasiewiczowa et al. 1992, 1998; Starkel et al. 1996). Recently, high potential for quantitative paleoenvironmental reconstructions was also shown for Lake Żabińskie in north-eastern Poland (Amann et al. 2014; Hernández-Almeida et al. 2015; Larocque-Tobler et al. 2015).

The first use of geothermal profiles in thermally stabilised wells to reconstruct temperature history in Poland over the last 500 years was made by Majorowicz et al. (2001).

In the first half of the twentieth century, there was no work on the long-term variability of **atmospheric circulation** over Poland, but there were publications on the impact of atmospheric circulation on some elements of the climate (Bartnicki 1924; Arctowski 1927; Kaczorowska 1933; Milata 1935; Bartnicki and Kołodziejczyk 1935; Lisowski 1935). In some later works, the role of circulation factors in the formation of the Polish climate was emphasised (Kożuchowski 2003, 2004; Miętus 1996; Wibig 2001). In the second half of the twentieth century, several classifications of circulation types and indices were created (Osuchowska-Klein 1975; Niedźwiedz 1988; Ustrnul 1997; Piotrowski 2009). Attention was also paid to the long-term variability of circulation types, air masses and atmospheric fronts (Parczewski 1964; Niedźwiedz 1996; Kaszewski and Filipiuk 2003). Considering the Vangengeim-Girs hemispheric circulation indices for the European sector, seven circulation periods were distinguished (Degirmendžić et al. 2000).

The analyses of the distribution and variability of **atmospheric pressure** are the basis of research into atmospheric circulation. One of the first studies on the distribution of atmospheric pressure in Poland and Europe includes Gorczyński's work from (1917), in which the author presented 54 maps showing the distribution of monthly and annual isobars in Poland, Europe and all over the globe.

The Kraków series of measurements was subjected to the most detailed study of the meteorological element in question. It was used, among others, in Weisse's (1858), Hann's (1887), and Trepińska's (1988) works. The oldest studies concerned mainly general comparisons of pressure values (their daily and annual courses as well as deviations from the average) between the various stations located in Poland and in Europe. Later studies, mainly Trepińska's works also tackled the issues related to the analysis of trends of changes since 1792 (Trepińska 1988, 1997a; Bärring et al. 2002). The author also made a number of comparisons of a long-term (since 1901) series of pressure measurements in Kraków and Warszawa, as well as in other European cities. Similar studies using a long series of measurements in Warszawa were also made by Ustrnul and Czekierda (2000). In the works mentioned above, it was found, among others, that the long-term variability of average annual pressure values shows a slight increase, which is mainly caused by pressure changes in the winter season. An important characteristic of the long-term variability of pressure throughout the year and in individual months is the occurrence of clear periods of higher or lower values, which is most likely associated with the occurrence of the so-called circular epochs.

Nevertheless, most studies using the atmospheric pressure measurements in Poland are based on shorter measurement series. They usually concern the impact of pressure and its changes on the human body (for example Koźmiński and Michalska 2012) or explain the changes and variability of other meteorological elements (for example Degirmendžić et al. 2004).

The **actinometric measurements** started in Poland at the end of the nineteenth century, but they were of experimental character and were short series. The oldest measurements of solar radiation were carried out in 1894 in the meteorological observatory in Puławy (Kolomijcov 1894). The pioneer of actinometric measurements in Poland, as well as the creator of the instruments used to measure the intensity of solar radiation (Moll-Gorczyński solarimeter, later known as Kipp & Zonen pyranometer), was professor Władysław Gorczyński. He initiated the long-term measurements of global solar radiation in Warszawa starting in 1900 (Gorczyński 1913), and then in Gdynia from 1920 (Gorczyński 1951).

It is known that short-term series of measurements were carried out in Grodzisk during the interwar period (Gorczyński 1911) in Sopot (1928–1935), Gdańsk (1931–1935) (Frischmuth 1935), in Kołobrzeg (Gorczyński 1951), Wrocław (1929–1932) (Grundmann 1933), Ursynów (Gorczyński 1951), Remiszewice near Łódź (June 1932), Januszewice near Opoczno (August–October 1932) (Gorczyński and Ostrowski 1934), Racibórz (1929–1941) (Mackiewicz 1957), the Sudetes Mountains (September–November 1931 and March–November 1932) (Stenz 1959) and in the Tatra Mountains (July–August 1903, January, April and September 1924 and 1935–1939) (Stenz 1925, 1959).

The measurements of solar radiation on a larger scale began in Poland only after the end of World War II, when in 1952, the State Hydrological and Meteorological Institute (PIHM) opened several actinometric stations (Bogdańska et al. 2002). However, it was difficult to carry out the analysis of the components of the radiation budget, especially its spatial distribution aspect, because the number of the stations was insufficient. Additionally, regular measurements were carried out in meteorological stations belonging to a few universities, the Polish Academy of Sciences Institutes (PAN) and the Institute of Soil Science and Plant Cultivation (IUNG). The development of actinometry in Poland, which was observed in the 1950s, provided the source material for numerous climatological research studies. These works were published on the basis of the research on long-term variability and regional differentiation of solar radiation (Kuczmarska and Paszyński 1964a, b; Paszyński 1966; Podogrocki 1977, 1978; Miara et al. 1987; Olecki 1986, 1989; Słomka 1988; Bryś 1994) as well as the fluctuation, trends and periodicity analysis of global solar radiation (Bogdańska and Podogrocki 2000).

Until now, most of the **sunshine** studies have been based on short series of measurements, most often 10-year, and mainly includes the analysis of data from the 1960s and 1970s (Kuczmarski 1990) or earlier periods (Gorczyński 1913; Merecki 1914). Only a few stations in Poland can boast of long, homogeneous heliographic series. These include the IGiGP scientific station of the Jagiellonian University (formerly the Astronomical Observatory), where measurements have been taken continuously in the same place and using the same instrument since 1883. Based on the data from this station, numerous studies have been conducted on the subject of long-term variability of sunshine duration and its causes (among others, Morawska 1963; Matuszko 2014). In Kraków, as in other European cities (Matuszko 2016), one can notice common periods of decreases ("global dimming": 1951–1980) and increases ("global brightening": 1981–1995) in sunshine duration with extreme values occurring in the same years (maximum in 1943, 1921, minimum in 1980). Other stations with long, but partly reconstructed heliographic series, include Wroclaw (Matuszko 2016), Śnieżka, Warszawa and Puławy (Bogdańska et al. 2002).

In addition, the various aspects of **cloudiness** variability in Poland have been analysed for many years, e.g. Satke (1898), Gorczyński and Wierzbicka (1915). Stenz (1952) and Okołowicz (1962) dealt with the problem of spatial variability of cloudiness amount in Poland. Warakomski (1969) reported on the seasonal course of cloud types in Poland. However, the number of papers dealing with the analysis of long-term changes in cloudiness has been very limited. Morawska-Horawska, in her analyses (1963, 1985), described in detail the observational series of cloudiness in Kraków, the longest in Poland, covering the period since 1859.

Air temperature is the element most often analysed and has one of the longest data series. In the case of this element, there have been countless analyses carried out on a local, regional and national (Polish) scale. The oldest and most important are studies by Gorczyński (1913, 1915a, b, 1916, 1918) and Gorczyński and Kosińska (1916), and in the later period by Romer (1947b, 1948/1949). Some of these studies are of particular importance because their results refer to spatial diversity across Europe. The issue of changes and variability of this element was considered for the numerous measuring stations that were located in areas currently in Poland (e.g. in Wroclaw, Gdańsk, Poznań, Puławy, and on Śnieżka). However, most of the oldest studies presenting the variability of air temperature in different aspects concerned Warszawa and, especially, Kraków (Kowalczyk 1881; Karliński 1868, 1876; Kuczyński 1884; Merecki 1899). Nowadays, these series have been subjected to multiple detailed analyses. Studies for Kraków, edited by J. Trepińska (1997b), and those for Warszawa, the author of which is H. Lorenc (Lorenc 2000), contain their review. Owing to the complex history of measurements and observations, it is worth mentioning the temperature series for Gdansk (Miętus 2007; Filipiak 2007).

Air humidity is an element that plays an important role among meteorological processes within the atmosphere; however, the variety of humidity indices makes the global view of air moisture changes difficult to ascertain. Moreover, some methodical difficulties in measuring and computing particular air humidity parameters have been often pointed out.

Despite the above-mentioned doubts about the reliability of the material at hand, studies on trends and distribution of air humidity parameters, in both regional and local aspects, have been conducted for many years. They present diurnal and annual trends in relative air humidity, saturation deficit and, rarely, in vapour pressure. The studies are most often excerpts from greater works, generally monographs of towns or regions. The data used in them are measurement series no longer than 30 years. Attempts to analyse the long-term variability of air humidity were based only on one of the parameters, usually the relative air humidity, or on much shorter observation series. The results describe tendencies at particular locations, and, up to the present, no research concerning the whole area of Poland has been undertaken.

The oldest works, in accordance with global trends, comprised mostly measurement and terminology problems (e.g. Gorczyński 1948; Demiańczuk 1963; Janiszewski 1975). Some studies on annual and seasonal distribution of humidity parameters were conducted on the regional or local scale (e.g. Wierzbicki 1878; Gumiński 1927; Kosiba 1952; Michna 1972), also regarding urban climate conditions (e.g. Tarajkowska 1974; Młostek and Sobik 1984; Gluza and Kaszewski 1984; Kłysik et al. 1985). Air humidity variability was seldom the topic of detailed examination in Poland. Hohendorf was the first (1967, 1969) to take up this topic and described changes in saturation deficit. B. Obrębska-Starklowa and A. Grzyborowska (1997) presented the analysis of air humidity variability made for the plateau section of the Raba River (relative air humidity in the period of 1971–1992), T. Bryś (2003) described air saturation deficit variation in Wrocław over the twentieth century, and A. Wypych (e.g. 2004, 2010) focused on long-term variability of air humidity in Kraków, expressed by most of humidity parameters. Essentially, the conducted studies confirmed the drying of the atmosphere.

The oldest paper on **precipitation** variability in Poland by Kremser (1884) was based on chronological series starting in 1799 for Wroclaw. Further research used the data from Warszawa (Wild 1887; Pietkiewicz 1889). Both authors found spatial differentiation in temporal variability of precipitation between 1813 and 1887. Analysing almost 100-year long precipitation series from Warszawa (1803–1910), Gorczyński (1911) established several precipitation epoch and mentioned the periodic character of precipitation fluctuations. The Warszawa series (1811–1910) was again analysed by Rychliński (1923a, b, 1924, 1927), who discussed indices describing precipitation variability year by year and its periodicity. Moreover, Rychliński (1927) found a diminishing degree of pluvial continentality between 1811 and 1910. This result was later proved by Romer (1947a) who found increased pluvial oceanity between 1851 and 1930 at some stations in Europe, including Poland.

The oldest works on **snow cover** in the Polish area originated at the turn of the nineteenth and twentieth centuries (Satke 1899; Kamińska 1912). They were, however, concerned mostly with the main characteristics of the snow cover and its physical properties, sometimes in individual winter seasons (Satke 1896; Kosińska-Bartnicka 1924). Research on the long-term variability of snow cover began to develop only in the 1990s, with the progress of the investigations of the greenhouse effect and global warming. The first work on this subject was often published in the conference materials (e.g. Głowicki 1996; Piotrowicz 1996; Falarz et al. 1998), or even remained manuscripts (Głowicki and Jaskiewicz 1995). Detailed investigations of the long-term variability of different characteristics of the snow cover in Poznań for almost 70 winter seasons (1920/21-1989/90 with a war break) were conducted (Szustakowska 1991; Bednorz 1999a). As a result, a statistically significant positive trend of the period of potential snow cover duration in Poznań (3 days/10 years) was discovered, among others. It was launched the first research on the influence of atmospheric circulation on the snow cover long-term changes (Bednorz 1999b). A comparison of changes in snow conditions was conducted in the centre of a large city (Kraków) with the rural areas, resulting in a higher rate of decline in the values of snow-related characteristics in the city centre compared with rural areas (Falarz 1998). In addition, research was carried out in the mountainous areas of Poland (Głowicki 1996; Falarz et al. 1998). Within the 105-year snow cover series for the Śnieżka summit, a downward trend of the number of days with snow cover to the end of the 1930s, and a slight positive trend since the turn of the 1930s and 1940s has been observed (Głowicki and Jaskiewicz 1995). Polish-Slovak studies of snow cover on the southern and the northern slope of the Western Carpathians have shown a small negative trend in the number of days with snow cover depth $\geq$ 20 cm and in a maximum depth of snow in most of the investigated stations, except for the area of the Tatra mountains (Falarz et al. 1998). Research has been also done on changes and variability in snow conditions for skiing in the Polish Tatras (Falarz 1999).

Older climatological studies on spatial variability in the direction and speed of **wind** in Poland include the works of Stopa-Boryczka (1989), Niedzwiedz et al. (1985, 1995). At the end of the 1990s, research on climate change and variability in Poland began to emerge. However, in the climatological literature, studies describing the variability of temperature and precipitation in Poland dominate. Few items concern the issue of wind speed variability. Kożuchowski (2004) studied the variability of the speed of geostrophic wind and its components—meridian and zonal over Poland. Lorenc (1996, 2012) noted the increase in incidence of strong winds and whirlwinds. There are numerous publications concerning the forecasts of the change of wind field over Europe. However, the wind speed changes developed by the IPCC (2007) are not conclusive. Some models indicate an increase in the average and maximum wind speeds over Northern and Central Europe, others a decrease in wind. However, all forecasts developed by the IPCC highlight the possibility of a large seasonal wind speed variation, which is associated with a change in the pressure field over the Euro-Atlantic area.

The description of the occurrence of convective phenomena complements the climate characteristics of a given area. These phenomena include, above all, **thunderstorms**, accompanied by strong wind gusts and precipitation including hail, and tornadoes. Compared to most meteorological elements, the research of the phenomena mentioned above does not use measurement data, but mainly visual observations carried out at meteorological stations. Depending on the observation period, the records of such observations were of a different nature and were subject to various changes. Until around the mid-twentieth century, descriptive characteristics could be encountered, although symbols were more and more commonly used in compliance with the rules for describing all atmospheric phenomena. Due to the difficulty in accessing detailed descriptions of the phenomena under consideration and the low level of importance attached to their relatively rare occurrence, the first more comprehensive study of the occurrence of thunderstorms and tornadoes in Poland appeared quite late. Initially, they were concerned about the occurrence of individual phenomena or very short observation periods (Smosarski 1915). The work of Wiszniewski (1949) is considered to be the first study in which longer observational series (1891–1930) was used, followed by the work of Stopa (1962, 1965) which concerns thunderstorms occurring in Poland in 1946–1955. These studies mainly took into account the spatial, annual and long-term diversity of thunderstorm occurrences. Later on, in the 1990s interest in thunderstorms increased again and the research was a continuation of the aforementioned works. However, while conducting these studies special attention was paid to the long-term (since 1885) changes in the occurrence of the described phenomenon (Bielec-Bąkowska 2003, 2013), to the synoptic conditions conducive to the formation of thunderstorms in Poland (Kolendowicz 2005) and to forecasts of their occurrence (Grabowska 2005). An important result of the research was the identification of thunderstorm regions in Poland and the demonstration of the existence of a tendency that the number of thunderstorm days varies depending on the region of the country. The majority of stations with a drop in the number of days with a storm are located northwest of the line connecting Śnieżka and Suwałki, while the remaining stations have positive trends. Recent advancements in technology have also facilitated instrumental monitoring of thunderstorm activity within the use of lightning detection systems. Thanks to PERUN network operating operationally in Poland since 2002, it was possible to develop high-resolution thunderstorm climatologies and explore previously undiscovered aspects such as storm intensity or diurnal cycles (Taszarek et al. 2015; Czernecki et al. 2016).

The occurrence of **tornadoes** in the area of Poland is the least investigated. Most of the works, including the earliest ones, were devoted to descriptions of individual cases (Gumiński 1936; Parczewski and Kluźniak 1959). More detailed studies, often covering longer periods of observation, were only started at the turn of the twenty-first century. They concerned both the spatial and temporal diversity of tornadoes (Lorenc 1996, 2012; Taszarek and Brooks 2015), environmental conditions in which they occur most often (Taszarek and Kolendowicz 2013) and case studies (Taszarek et al. 2016; Taszarek and Gromadzki 2017; Pilguj et al. 2019). Unfortunately, the short period from which reliable reports come from and spatial and temporal inhomogenities do not allow to define reliable long-term trends in the frequency of tornadoes in Poland.

Overall, only a few studies have been devoted to the occurrence of storm precipitation, in particular **hail events**. The oldest studies include those devoted to hail tracks and areas of their most frequent occurrence (Schmuck 1959; Zinkiewicz and Michna 1955; Koźmiński and Rytel 1963). In later years, studies on hail and other storm precipitation types concerned mainly their long-term variability and diurnal cycles, as well as the circulation conducive to their occurrence (Twardosz et al. 2011; Suwała 2014). On their basis, it was found that the most characteristic feature of storm precipitation is their annual course and the occurrence of clear fluctuations in long-term variability of the number of days and the thunderstorm precipitation totals (Twardosz et al. 2011; Bielec-Bąkowska 2014). However, apart from the southern regions of Poland, it is difficult to indicate clear trends in their frequency over longer periods of time (Twardosz et al. 2011; Bielec-Bąkowska 2014). In recent years, the application of machine learning techniques in radar data and numerical weather prediction models allowed for more detailed analysis of atmospheric potential for producing hail events in Poland (Czernecki et al. 2019). The rapid development of the European Severe Weather Database also enabled the assessment of large and very large hail events over the course of a few recent years (Pilorz 2015).

Lisowski and Bartnicki (1935) analysed the mean number of **days with fog**, for particular months, and for 19 localities. Their analyses covered additionally the frequency of fog in the periods spring-summer and autumn-winter in 28 stations placed in the areas which belonged to Poland before the Second World War. Gumiński (1952a) studied the annual course of fog occurrence in central and eastern Poland using data from the period 1929–1938. Prawdzic and Sucheta (1975) presented the mean number of days with fog in particular months and for the whole year, for 15 stations in the Pomorze and Mazury regions, for the period 1951–1960, while Piwkowski (1976) used data from 18 stations across the country and demonstrated the annual course of fog occurrence and the frequency of their origin and duration in seasons in the years 1961–1970. Morawska (1966) analysed data from the period 1861–1960 from Kraków and described multi-annual variability of the number of days with fog, together with the relationship between fog frequency, wind speed and air temperature. A similar study was published for Warsaw by Janiszewski (1967), with the application of data from the period 1948–1962.

Research of long-term changes of **bioclimatic conditions** is undertaken only in the last 20 years. Different biometeorological indices are used as the measures of bioclimate. Such studies were done by few research teams, mostly in the Institute of Geography and Spatial Organization of the Polish Academy of Sciences. As the first studies of the changes of bioclimatic conditions have based on data from Jagiellonian University station in Botanic Garden (UJBG) in Cracow. The data covered the period of 1901–2000. As the bioclimatic measures, the authors (Błażejczyk et al. 2003) have used Subjective Temperature (STI) and Insulation Predicted (Iclp) indices. The changes in STI and Iclp were analysed on the background of changes in air circulation. The research was continued by Błażejczyk and Twardosz (2010) who have studied changes in Wind Chill Temperature (*WCT*), *HUMIDEX,* accepted level of physical activity (*MHR*) as well as Physiological Subjective Temperature (*PST*) and Physiological Strain (*PhS*) indices at UJBG station in Cracow in the longer period of 1826–2006. Owczarek (2009) in her PhD thesis for the northern Poland has applied data for the period 1951–2000 to analyse changes in PhS, HL, STI, WCT and Heat Stress Index (HSI). In the last decade the changes of bioclimatic conditions were studied by Bąkowska (2011) for Kołobrzeg, Poznań and Szczawno in the period 1951–2000. She has used PST, Iclp and MHR indices and furthermore—the newly developed Universal Thermal Climate Index (UTCI). UTCI was also used by Błażejczyk et al. (2015) and Kuchcik (2017) for the periods 1966–2012 and 1975–2014 as predictor of mortality risk in Poland.

The new definition of climate as a perennial weather regime (weather groups, weather types) was defined in the 1920s by Wojejkow and then disseminated by Fedorov. Nowadays, the **weather types** are understood as the result of: (1) genetic weather classification, the starting point of which is the analysis of synoptic situations (synoptic weather types) or (2) morphological classifications, in which several meteorological elements are analysed in total.

This second approach is the basis for research in complex climatology (a research stream initiated by E.E. Fiedorow). In Poland, this research trend was developed among others by Gumiński (1952b), Zinkiewicz (1953), and Wodzińska and Osuchowska (1963).

Nevertheless, the greatest contribution to learning about the Polish climate based on the classification of weather types was made by Woś (1999, 2010). While the frequency of occurrence of various weather types in Poland is well known, their long-term variability and change in trends have not been analysed in detail. Only Piotrowicz (2010) determined the variability of weather types in Kraków on the basis of a 108-year series of measurements (1901–2008).

The issue of climate change and climate **projections for the future** based on global climate models GCMs appeared in the scientific literature in the 1990s, along with increasingly visible signals of global warming and after the first IPCC report. Polish researchers have also taken up this topic. One of the first papers using global climate models was the article by Gutry-Korycka et al. (1994). In this paper, the authors used GCM models to predict changes in the spatial distribution of climate variables in hydrological models.

In 2000, the results of research of the ACACIA project (**A** **C**oncerted **A**ction Towards A Comprehensive **C**limate **I**mpacts and **A**daptations Assessment for the European Union) were published. This project assessed climate impacts and potential adaptation in Europe until the 2080 s (Parry 2000). ACACIA developed four scenarios on the basis of a combination of the UKCIP and SRES approaches. Temperature and precipitation projections for Poland can be found among the results (average value for the whole territory).

In the following years, European research projects enabled further development of studies on climate projections for Poland at a much higher resolution. Thus, projection results for Poland from the MICE and ENSEMBLES projects have become available. While in the MICE project (**M**odelling the **I**mpact of **C**limate **E**xtremes), the results from the Hadley Centre Regional Climate Model (HadRM3-P), with spatial resolution 0.44° by 0.44°, were used in the analysis of future changes in the characteristics of precipitation and temperature (e.g. Szwed et al. 2007), the ENSEMBLES project (Ensembles-Based Predictions of Climate Changes and their Impacts) produced a set of regional climate models RCMs, which cover Europe with a spatial resolution of about 25 by 25 km and outline just one possible vision of the future, corresponding to a specific SRES emission scenario, A1B. All in all, they also enabled the study of a greater number of climate variables (e.g. Van der Linden and Mitchell 2009).

Other results of the current research of climate change and variability are discussed in particular chapters of parts II–IV of the volume.

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