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BOOK SERIES ON CLIMATE RECONSTRUCTION OF THE CZECH LANDS

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Historical climatology is defined as a "research field situated at the interface of climatology and (environmental) history dealing mainly with documentary evidence and using the methodology of both climatology and history" (Brázdil *et al.,* 2005). Following the same source, "(i) It aims at reconstructing temporal and spatial patterns of weather and climate, as well as climate related natural disasters, for the period prior to the creation of national meteorological networks (mainly for the last millennium); (ii) It investigates the vulnerability of past societies and economies to climate variations, climate extremes and natural disasters and (iii) It explores past discourses and the social representations of the climate". The main sources of Historical Climatology range from documentary written evidence, instrumental data and material sources, such as pictorial evidence or floodmarks that specify the spatial extension of extreme weather events, as well as 'natural' sources. This diversity explains the interdisciplinarity of this research domain, as biologists, geographers, geologists, historians, meteorologists and physicists work together to reconstruct climates of the past. This reconstruction also contributes to help to understand the present and to project future climate changes.

Historical Climatology is a rather recent research field. According to Brázdil *et al.* (2005), there were some early studies in the 19th century, but the great development in this field began in the 20th century. Reference scholars in the area are Gordon Manley (1902-1980), Hermann Flohn (1912-1997), Hubert Lamb (1913-1997), Emmanuel Le Roy Ladurie (*1929) and Christian Pfister (*1944), who is frequently considered the founder of modern Historical Climatology. Several other scientists, such as R. Brázdil, D. Camuffo, D. Wheeler, H. Wanner, J. Luterbacher, among many others, have written a vast number of papers in international peer-reviewed journals such as *Climate Change*, *The Holocene*, *Climates of the Past*, *International Journal of Climatology*. After the first steps of individuals and of small research groups in Western and Central Europe until the 1990s, several projects gathered scientists from a greater number of countries and contributed to the pronounced development in this field, "stimulated by the discussion related to enhanced greenhouse effect" (Vol. VII). From the ADVICE (Annual to Decadal Variability in Climate in Europe, 1996-1998) to the *Millennium* Project (2006-2010) the internationalisation became greater and the interdisciplinary was significantly developed.

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Rudolf Brázdil (*1951) is the current President of the recently founded *International Society for Historical Climatology and Climate History*. Together with several colleagues from different countries he has produced a large number of papers on this topic, including two synthesis papers in *Climatic Change*, in 2005 and 2010. However, he also devoted himself to the study of the past climates in his own country, exploring new and original historical sources.

The present review deals with the series "The History of the Weather and Climate in the Czech Lands (Bohemia, Moravia and Silesia)"[2] since the year 1000. The first volume was edited in 1995 as a special issue of the *Zürcher Geographishe Schriften* and the following nine volumes were published by the Masaryk University in Brno (Czech Republic). The first author of every book is Rudolf Brázdil. Eight issues are written in English and two in Czech, with long and comprehensive summaries in English and translations of figures' and tables' captions. Location maps are very useful, particularly to foreign readers, as well as great number of clear and informative figures and tables. Although all the issues are very well presented and organized, the last four books are hardbacks of excellent editorial quality. Last, but not least, outstanding reproductions of documents and instrumental data are also to be found in these volumes (as for example, amazing photographs of the same area, flooded and dry).

I. CLIMATE VARIABILITY STUDIES BASED MOSTLY ON DOCUMENTARY SOURCES (975-1800)

Further to the results from dendroclimatology, "documentary evidence provides the only source of information that enables reconstruction of the climate in the Czech Lands to a high degree of temporal accuracy in the pre-instrumental period" (Vol. XVIII: 106). The authors have compiled a large amount of good quality documentary data and they dedicated eight volumes to present, analyse and interpret data (I, II, III, IV, VI, VII, VIII and X). The data retrieved were also used to cross-check information with other countries of Central Europe.

Volume I introduces new aspects of climate change between 975 and 1500 in the Czech Lands. Most sources are written narrative reports, sometimes concerning economic issues and there are also a few individual sources. It also aims at discussing the temporal thresholds of the so-called Medieval Warm Period (MWP) and the beginning of the Little Ice Age (LIA). H. Lamb had referred that the MWP in Central Europe lasted from 1150 until 1300. However, the findings of Brázdil *et al.* (Vol. I) are not totally in accordance with Lamb's, although they have found a predominance of warm summers when compared to cold winters in the above referred period. Before mid-13th century and after 1380s (with the exception of the 1320s and 1480s) most months were humid and cold until 1500. Yet, the period 1340-1380 can be considered a temperature optimum and there were a large percentage of warm months from 1260s to 1380s. This proves that climate fluctuations vary a lot spatially, that local sources must always be used and that climate fluctuations can only be extrapolated spatially in climatic homogeneous nearby regions, more so when it comes to precipitation.

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[2] The books' references are included at the end of this review

Volumes II, III and X deal with 16th century documentary data. Volumes II and III are based on daily qualitative weather records, retrieved from almanacs and diaries kept by learned persons until the end of the 16th century. During this century there was a general increase in education in the Czech Lands "after the period, when the view of the world was strongly affected by metaphysics, a new rational spirit of Renaissance and Humanism set in" (Vol. III: 9). Daily weather reports are often included in astrometeorological publications, as meteorological data should serve "for the improvement and testing of the credibility of astrometeorological forecasts" (Vol. III: 8, quoting Hellmann, 1926). Volume X, the last one of the series, issued in 2013, presents a synthesis on the climate of the 16th century in the Czech Lands, and is based on a large number of different documentary sources, from daily weather observations to written sources of narrative character, and to economic and financial records. The different types of sources are first described in detail, followed by an explanation of the main weather characteristics of each year of the 16th century. Next, data are indexed in a seven-degree monthly classification, that is, from extremely cold (-3) to extremely hot (+3), and from extremely dry (-3) to extremely wet (+3). Tables containing monthly indices referring to the Czech Lands are presented and discussed; the results are compared with neighbouring Central European indicators of climate variability and analysed in the context of circulation in Central Europe. The authors conclude that the 16th century was cooler, when compared with the 1961-1990 reference average (Vol. X: 236). "The last three decades [of the 16th century] were even the coldest for winter and summer among the 30-year periods of the past 500 years". There are hardly any differences referring to annual rainfall values between the 16th century and 1961-1990. However, there were particularly rainy years from 1550s to the 1580s.

In the 16th century solar radiation shows a slight decreasing tendency as the volcanic activity and the resulting dust veil index was high (also leading to a negative radiative forcing especially during the last decades of the 16th century, Vol. X: 238). In short, both the natural forcing factors and Brázdil *et al.* findings for the Czech Lands (Vol. X) agree in that "there was a steady deterioration of the climate towards the end of the century" including also a higher frequency of hydrometeorological extremes with adverse consequence in human society.

"This book summarises and puts into a new context the results of many papers related to the 16th century" (Vol. X: 238). The worsening of climate in the Czech Lands corresponds with the occurrence of a "Little-Ice-Age-type-event" in Central Europe (references in Vol. X). At the same time remarkable advances of alpine glaciers took place.

Volume IV shows how written sources of economic character may be employed for the study of climate fluctuation between the 15th and the 17th centuries. In the Czech Republic unique books of accounts (p. 112) have been preserved in the town of Louny. The town's expenses and incomes are reported from 1450 to 1472. One example is the reports of the "Distributa", that is, the written evidence of the payment of Saturday wages for the accomplishment of various kinds of works, which gives direct and indirect information about weather during the previous week: "hay harvest, works in vineyards, cutting of ice on the river or between the mill wheels, carrying out water from flooded cellars", as well as releasing ice from water mills, clearing snow, repairing bridges, window panes and roofs. After 1632 only monthly account data are to be found which does not allow meteorological interpretation (Vol. IV: 13). The meteorological character of a certain season and the occurrence of individual weather extremes and related damage can be deduced from the documentary data.

Extreme weather events are dealt with in several issues: Vol. VI refers to strong winds, Vol. VII to historical and recent floods, Vol. VIII to extreme events in the 18th century and Vol. X to the extremes that occurred in the 16th century.

Vol. VI starts with a very interesting history of wind measurements and presents a synthesis of data and information of the pre-instrumental era and of the period of systematic instrumental observations. As measurement devices vary a lot, series are often non--homogenous so that long series of anomalies could not be constructed. However, it was possible to systematically detect and analyse extreme patterns of weather" trying to characterize the changing climate (...) by means of changing in the behaviour of extreme weather patterns" (Vol. VI: 244), such as changes in the occurrence of strong winds, types of damages and number of casualties. The authors conclude that there is an urgent need for the systematic excerption from archives of still unknown information (Vol. VI: 245) in order to permit the standardisation and dissemination of wind extreme events. New data referring to the 16th century is included in Vol. X.

Vol. VII is entirely dedicated to historical and recent floods. In Vol. X further descriptions of 16th century floods are added and analysed. The authors describe the types of floods (due to extreme rainfall and/or melting snow and/or due to ice blockages), followed by an exhaustive source description. Some epigraphic sources are particularly interesting, such as the watermarks on the Vltava River in Prague, that allows comparison of instrumental and pre-instrumental peak water levels from 1481 to the present and cross-checking different types of sources. Regarding the instrumental period, the authors describe the chronology of the floods in selected rivers of the Czech Republic (such as the "imperial" rivers: the Vltava and the Elbe), the basin hydrologic characteristics including, wherever possible, the synoptic causes of extreme rainfall and a comprehensive analysis of selected floods. In the case of historical floods, a chronology and description of floods detected through documentary data are presented. The most disastrous and frequent flooding occurred in the 19th century and at the end of the 16th century. Since mid-19th century the total number of floods has declined. However, a flood of the same amplitude will have more disastrous consequences currently than in the past, due to an increase of human "pressure", including increased imperviousness of the areas near the river channels. The period in which floods were more common has changed: the winter-type floods (mixed: due to snow melt and rainfall) were more repeated until mid-19th century (end of the Little Ice Age); on the other hand, floods generated by rainfall are more frequent "in the period subject to global warming" (Vol. VII, p. 368). It is not yet possible "to give a definite answer to the question of to what extent the most recent disastrous floods (..) are a possible consequence of the anthropogenically conditioned process of global warming and whether in the coming years similar disasters will occur with the same or greater frequency". However, the increment of rain-caused floods may be due to marked warming, producing decreased snow cover and ice, which are the two other causes of floods. Extremes of similar intensity give rise to more flood damage nowadays (Vol VII: 287) "for example, comparing the years 1990-1999 with the decade 1950-1959, the number of large natural disasters grew fourfold and economic losses fourteenfold" (Vol. VII: 287, quoting Munich Re, 1999), as "floods and windstorms follow immediately behind earthquakes in the statistics" (same source). In vol. X other extreme events of the 16th century are added, such as droughts (already analysed in detail in a book not included in this series – Brázdil *et al.,* 2007), locust outbreaks and other "natural phenomena" (landslides, earthquakes and weather impact in viticulture).

Vol. VIII refers to the study of a particular documentary source of the region of Olomouc (eastern part of the Czech Republic) from the diaries of the Hradisko Monastery, which are an outstanding source of weather information. Other records from the Olomouc Jesuits and Franciscans, as well as those of the Piarists of Stará Voda were used to complete and verify the series. The daily records contain brief weather descriptions and longer reports on extreme events. Qualitative information on temperature characteristics, cloudiness, precipitation, strong winds, fogs, frosts, hails, and thunderstorms are compiled within the diaries for the 1693-1783 period.

II. CLIMATE VARIABILITY STUDIES BASED MOSTLY ON INSTRUMENTAL DATA (18TH CENTURY ONWARDS)

Volumes V and IX deal with instrumental data. Vol. V refers to early instrumental measurements in Moravia between 1771 and 1775, "as a consequence of the interest of physicians oriented on the neo-Hippocratic hypothesis". Volume IX presents a synthesis of temperature and precipitation fluctuations during the instrumental period in the Czech Lands. The first meteorological measurements took place in 1719, but the continuous systematic measurements began in 1775 in Prague-Klementinum, in connexion with the astronomical observatory.

As R. Brázdil and co-authors write (Vol. IX: 11), "this publication concentrates upon the analysis of long-term temperature and precipitation fluctuations during the instrumental measurements in the Czech Lands". The study was based on ten meteorological stations for temperature and fourteen for precipitation, chosen upon verification of data homogeneity and consulting station's metadata (e.g. information concerning the history of measurements at the given station). The non-homogeneities in the data may be due to changes in station location, instruments, instrument setting, observation time, observers, etc. The data were analysed with respect to spatial correlations, fluctuation and trends, as well as cyclicity using wavelet analysis. Results are presented in the context of Central European climate variability. The relationships of temperature and precipitation with the North Atlantic Oscillation (NAO) and the Central European Zonal Index (CEZI) are compared. NAOI and CEZI explain certain aspects of temperature variability, particularly during the winter, although CEZI presents higher correlations with Czech temperatures and partly with precipitation as well (Brázdil *et al.,* 2009). The common longest period for all stations studied was 1883-2010. Significant positive trends were found with accelerated warming from the 1970s onwards. No specific trends referring to precipitation were found; instead, precipitation fluctuations were clearly detected. Furthermore, there is a higher spatial coherency of the temperature than of precipitation series, as rainfall is frequently, particularly during the summer, a results of convective processes (Vol. IX: 121).

III. CONCLUSION

In short, as the documentary and instrumental data from the Czech Land are very diverse and rich and the authors have great expertise in historical climatology, this series of volumes greatly contributes to the comprehension of climate variability in Central Europe, to the discussion about anthropogenic causes of global warming, to the dissemination of results, also at the national level, and to encourage and support research on historical climatology.

The main conclusions concerning climate characteristics in the Czech Lands are the existence of (i) warm decades between 1340s and 1380s and of warm summers within the so-called Medieval Warm Period (recently renamed Medieval Warm Anomaly); (ii) a climate deterioration during the 2nd half of the 16th century, including "little-Ice-Age-type" events; (iii) positive temperature trends, particularly from the 1970s onwards; (iv) no trends of precipitation values; (v) great variability of precipitation in the past, as currently verified; (vi) decreasing number of floods from mid-1900s onwards (although present consequences are frequently more disastrous due to human pressure). The results are put in the context of central Europe climate variability and the authors believe that if new sources are found, these books will provide a good basis for further development.

Meanwhile, the authors have written several papers in peer-reviewed international journals, but in the books presented here one can find more details on the sources, their potentialities and interpretation problems for different periods of the last centuries, as well as detailed statistical methodologies' descriptions to homogenise and analyse trends and variability of instrumental data. As the indices compiled from these data sets are important for climate reconstruction in the Czech Lands, the authors include discussions on indexing methodologies in relative scales (from -3 to +3 or from -1 to +1) and on the problem of missing values. Furthermore, the construction of long series by combination of indexed and instrumental series is explained in detail. When an overlapping period exists between indexed and instrumental series, then a calibration and verification of the indexed series is possible and a final reconstruction of temperature (in ºC) or precipitation values or anomalies (in mm) may be carried out for the whole period.

Homogenised instrumental data of Czech stations (Vol. IX) are presented and can be sent to the reader on request. In most of the books a comprehensive description and in some cases complete transcriptions of sources (translated to English) are included and will certainly be extremely useful to those working in those topics.

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VOLUMES OF THE REVIEWED SERIES

Vol. I: Brázdil R, Kotyza O (1995) *The History of Weather and Climate in the Czech Lands. Period 1000--1500*. Zürcher Geographische Schriften 62, Zürich: 260 p.

Vol. II: Brázdil R, Kotyza O (1996) *The earliest daily observations of the weather in the Czech Lands.* Masaryk University, Brno: 177 p.

Vol. III: Brázdil R, Kotyza O (1999) *Daily weather records in the Czech Lands in the sixteenth century II*. Masaryk University, Brno: 228 p.

Vol. IV: Brázdil R, Kotyza O (2000) *Utilisation of economic sources for the study of climate fluctuation in the Louny region in the fifteenth–seventeenth centuries.* Masaryk University, Brno: 350 p.

Vol. V: Brázdil R, Valášek H, Sviták Z, Macková J (2002) *Instrumental meteorological measurements in Moravia up to the end of the eighteenth century*. Masaryk University, Brno: 250 p.

Vol. VI: Brázdil R, Dobrovolný P, Štekl J, Kotyza O, Valášek H, Jež J (2004) *Strong winds*. Masaryk University, Brno: 378 p.

Vol. VII: Brázdil R, Dobrovolný P, Elleder L, Kakos V, Kotyza O, Květoň V, Macková J, Müller M, Štekl J, Tolasz R, Valášek H (2005) *Historical and recent floods in the Czech Republic*. Masaryk University, Czech Hydrometeorological Institute, Brno – Praha: 370 pp.

Vol. VIII: Brázdil R, Černušák T, Řezníčková L (2011) *The weather and climate in the region of Olomouc, Czech Republic, based on Premonstratensian diaries kept by the Hradisko monastery and Svatý Kopeček priory, 1693-1783.* Masaryk University, Brno: 272 p.

Vol. IX: Brázdil R, Bělínová M, Dobrovolný P, Mikšovský J, Pišoft P, Řezníčková L, Štěpánek P, Valášek H, Zahradníček P (2012) *Temperature and precipitation fluctuations in the Czech Lands during the instrumental period.* Masaryk University, Brno: 236 p.

Vol. X: Brázdil R, Kotyza O, Dobrovolný P, Řezníčková L, Valášek H (2013) *The climate in the Czech Lands during the 16th century.* Masaryk University, Brno: 286 p.

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