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WHEN DID THE LITTLE ICE AGE END AND THE RECENT GLOBAL WARMING START IN HUNGARY? LATE REFLECTIONS ABOUT A SCIENTIFIC FAITH DEBATE

Abstract

We try to find answer to the question: when did the Little Ice Age end and the Recent Global Warming start in Hungary? Based on the temperature time series of Budapest and data about the freezing of the Danube from the 1810s the cooling of the climate is perceiveable. The cool-cold and rainy climate system showed two centres of gravity during the 19th century, the first in the 1830s and 1840s, the second in the last two decades of the 19th century. Furthermore, despite the rising of the temperature the climate remained mostly cool and wet until the 1940s. According to the global tendencies there is no obvious climate change trend, though the temperature became colder in decades' average, but the fluctuations were very hectic, as usual in transition periods. The diminution in the quantity of precipitation already started in the 1940s though, and proved to be stable. The breakthrough of the Recent Global Warming's climate system became apparent from the 1980s based on the data of Budapest's time series. That's when the 'mediterranean climate-scissors' opened, and the Danube's basin became warmer and drier. Even if we examine the tendency of the temperature and precipitation changing in the 20th century separately, we can't get a clear picture. The warming obviously shows from the last decade of the 19th century, but according to the researchers who are sceptic about Recent Global Warming we can't use one of the biggest cooling downs in history that occured in the last third of the 19th century as a reference point. The climate regime that was significantly more pluvial than the reference period lasted till the 1940s, and there are no signs of the climate becoming significantly drier prior to the 1980s. If we consider the rise of temperature as the only indicator of the Global Warming, then the warming started in the last decades of the 19th century in Hungary as well. If we consider the decrease in the amount of precipitation to be decisive, then this process started in the 1940s, although there was no significant drying tendency before the 1970s.

Key words: climate history, climate change, Little Ice Age, Recent Global Warming, Carpathian Basin

Słowa kluczowe: historia klimatu, zmiany klimatyczne, mała epoka lodowcowa, globalne ocieplenie, basen karpacki

The incentive for writing this brief study was one of the biggest traumas of my career as a researcher. It took place in 2000, the set was an auditorium of the Hungarian Academy of Sciences in Budapest, and the occasion was the defence of a climatological academic doctoral dissertation about the regional specificities of the Recent Global Warming in Hungary. For a while it seemed that the discussion was going as expected, embedded in meteorological terminology, thus guaranteeing the serene indifference of the nonexpert. However, somewhere around the middle a distinguished member of the evaluation committee stood up and claimed that in his opinion the theory of global warming was nothing more than an assumption, hence considered anything that was based on this unfounded hypothesis meaningless, uninteresting and worthless from the scientific point of view. To dispel any doubts he also added, with remarkable honesty, that for the previously mentioned reasons he would give zero points during the vote. This statement did little good for the mood, and I felt especially hard hit because the candidate had partly been working with data which I'd produced. Also I was going to submit my academic dissertation about climate history during the following months, which I mainly founded on these climate history time series. Truth be told, what I thought about this person on the spot could hardly be included in a scientific article, to put it bluntly I considered the opinion of this comittee member highly unrealistic and malicious. Fortunately I had better luck than my colleague, this person who doubted the efficiency of climatic reconstruction didn't undertake the review of my dissertation, thanks to which I didn't become the victim of a scientific faith debate during my defence. But still I couldn't get it out of my head, and as I was proofreading the Hungarian edition of John R. McNeill's book about 20th century environmental history[1], going through the chapter on climate history again I faced the question: is contemporary global climate change a vague hypothesis or a reality?

Modern tendencies in global climate changes

Examining the committee member's perspective is a historical question, meaning whether he could have thought that recent global warming didn't exist based on Hungarian and international research data that were available at the turn of the millennium. One of the sources must have been the second IPCC report from 1995 as the third report from 2001 wasn't available yet[2].

[1] J.R. McNeill, *Something New Under the Sun: An Environmental History of the Twentieth-Century World*, Washington 2001, s. 416. Hungarian translation published in 2011 by Publisher Ursus Libris.

[2] The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide

The other climate historical database was Budapest's temperature and precipitation time series, whose homogenization had already been carried out by Tamás Szentimrey[3].

The 1995 IPCC report, published in June 1996, firmly announced that global warming existed, and the decisive factor of this process was the growth of carbon dioxide concentration due to augmenting industrial activity and environmental effects of energy production[4]. Not every meteorologist of the time agreed with these statements. In the Wall Street Journal Frederick Seitz accused the editors of manipulating the report. According to Seitz the editors left out some previously accepted statements like the hypothesis of climate change remained debatable until the uncertainity caused by the instability of the climate system could be cleared. Omitting these sentences basically changed the conclusion of the report, and Seitz didn't hesitate to name the people responsible for the manipulation[5].

The second IPCC climate historical diagram indicates the warming tendency of the 20th century, but taking into consideration the fluctuation during the previous centuries Seitz's doubts don't seem absolutely groundless (Diagram 1). Examining the climatic processes of the 20th century in detail is especially unsettling (Diagram 2). It is clearly followable and recordable that the warming tendency in the first third of the century shows a fraction in the beginning of the 1940s, until the middle of the 1970s no significant climate changing tendency could be perceived, there was even a slight cooling down. In view of later developments climate history named the second third of the century 'cooling' or 'recooling'. During the 1960s in scientific circles arose the possibility of the return of the Pleistocene ice age as well as the greatest climatic threat to humanity. The view that the Pleistocene ice age which started 2.5–3 million years ago didn't actually end has many followers among glaciologists to this day, that's why they call the geological present Flandrian interglacial.

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the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts. Since its inception in 1988 the IPCC has prepared five multivolume assessment reports: 1990, 1995, 2001, 2007 and 2014.

[3] T. Szentimrey, *Multiple Analysis of Series for Homogenization (MASH), Proceedings of the Second Seminar for Homogenization of Surface Climatological Data*, Budapest, Hungary; WMO, WCDMP-No. 41, 1999, pp. 27–46.

[4] J.T. Houghton, L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg, K. Maskell, eds., *Climate Change 1995. The Science of Climate Change. Contribution of WGI to the Second Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge 1996, s. 588. Reports available on the website of IPCC: http://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf (27-12-2015).

[5] About debate see: http://stephenschneider.stanford.edu/Publications/PDF_Papers/WSJ_July11_96.pdf (dostęp: 27.12.2015).

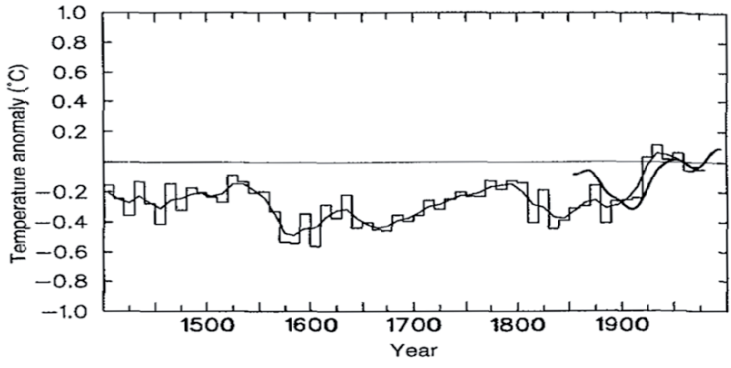

Diagram 1. Annual temperature anomalies from the beginning of the 14th century until the end of the 20th century based on historical, scientific and instrumental time series. (Source: Second IPCC Report: www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf, 27-12-2015)

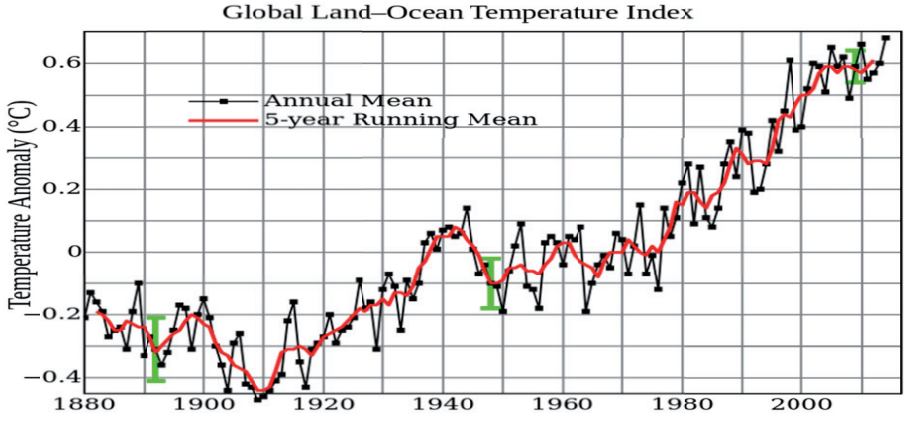

Diagram 2. Global mean surface temperature change from 1880 to 2014, relative to the 1951–1980 mean.
(Source: NASA GISS: http://data.giss.nasa.gov/gistemp/ 12-09-2015)

Hungarian time series

After sparse antecedents, regular instrumental observations started in Hungary in 1755 at the University of Nagyszombat (now Trnava, Slovakia). In 1777 Queen Maria Theresa relocated the university to Buda,[6] where meteorological observations were launched from 1st January 1780, though there is only a continuous

[6] Buda was founded on the western and Pest on the eastern side of Danube, which connected and separated these cities. Finally Buda and Pest were officially unified in 1873.

time series about the formation of temperature as the precipitation time series was initiated only in 1841. The professional literature uses different versions of Buda's time series that mostly differ in the homogenisation of the original time series. For the analysis of long-term climate history processes I used Budapest's monthly temperature time series distributed on the meteorological website 'Váraljamet'[7] and the precipitation time series homogenized by Tamás Szentimrey.

I diverged from the long-term climate history research in two aspects, first, I haven't just analysed the absolute value of temperature and precipitation time series and the time series composed of them but also the discrepancy of monthly averages from a specific reference period. Regarding the reference period there are two criteria stated by the meteorological professional literature, on the one hand, it has to be at least a 30-year span, on the other hand it has to be a period with non-obvious and ambiguous climatic tendency. When I was scientifically socialized during the 1980s and '90s the six decade period between 1901 and 1960 was the widely accepted reference period, thus in my earlier works I compared the data of my climate historical reconstruction with this period's average. At the same time the 1961–1990 reference period's average was dominant around the turn of the millennium in the professional meteorological literature. There is no international concensus regarding the reference average, but taking to heart the advice of my meteorologist colleague, Petr Dobrovolný, I followed the escalating tendency in the meteorological professional literature. The other difference from standard climate history studies is that I didn't represent and analyse my time series in month-season-year structure but in 'real time'. This means that I put the divergence from average between 1961 and 1990 into order, in the case of temperature starting from the January of 1780 followed by February, March, April and so on. The precipitation time series starts with the January of 1841 and proceeds with the following months as well. The strongest point of this approach is that it makes the accumulating climatic differences visible.

Long-term tendencies in the Carpathian Basin's climate during the 19TH and 20TH centuries

The 'real time' time series that show difference from the average can be used not only to research climatic tendencies but to detect the accumulation of divergencies more precisely than in conventional time series analysis. Let's see what this method is capable of or rather what its time series shows regarding the long-term climate changes in the Carpathian Basin.

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[7] Website of Váraljamet: http://www.varaljamet.eoldal.hu/cikkek/climate_budapest.html (dostęp: 27.12.2015).

The international climate history literature differentiates three big cooling downs during the Little Ice Age in Europe: the middle of the 14th century, the middle of the 17th century and the middle of the 19th century. During the characteristic periods of the Little Ice Age the climate became cool and rainy in the Carpathian Basin. The shifting of the precipitation balance is indicated by that from the 14th century the water level of Lake Balaton[8] was constantly rising, and the settlements on the Southern shoreline were continually retreating, several of them even disappeared. The cool and pluvial climate regime supposedly culminated in the 17th century, when Lake Balaton's level was metres higher, and there were even three islands at the time (Tihany, Szigliget and Fonyód). Then in the 18th century a temporary warming appeared and the climate was close to the 20th's averages.[9] The cold-cool — and mostly wet in the Carpathian Basin — climate system characteristic of the Little Ice Age returned for the last time in the 19th century (Diagram 3). Based on the temperature time series for Budapest and data about the freezing of the Danube from the 1810s the cooling of the climate is perceiveable. The cool-cold and rainy climate system showed two centres of gravity during the 19th century, the first in the 1830s and 1840s, the second in the last two decades of the 19th century, futhermore despite the rising of the temperature the climate remained mostly cool and wet until the 1940s. According to the global tendencies there is no obvious climate change

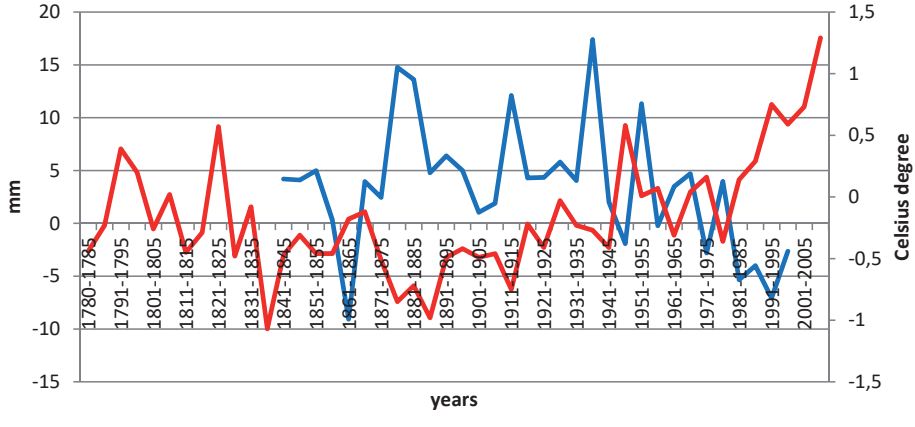

Diagram 3. The divergences of Budapest's yearly temperature (from 1780) and precipitation (from 1841) time series's five-year moving average from the 1961–1990 period's average.

[8] Lake Balaton is the largest lake in Central Europe which is a tectonic origin, shallow ditch lake: length 77 km; width change around 1.3–14 km, averagely 7.8 km; surface 594 km².

[9] L. Rácz, *Climate history of Hungary since 16th century: Past, present and future*, Discussion papers, 28. Pécs: Center for Regional Studies, Hungarian Academy of Sciences, 1999.

trend, though the temperature became colder in decades' average, but the fluctuations were very hectic as usual in transition periods. The diminution of the precipitation quantity already started in the 1940s though, and proved to be stable. The breakthrough of the Recent Global Warming's climate system became apparent from the 1980s based on the data of Budapest's time series. That's when the 'mediterranean climate-scissors' opened, and the Danube's basin became warmer and drier. Even if we examine the tendency of the temperature and precipitation changing in the 20th century separately, we can't get a clear picture. The warming is obviously showing from the last decade of the 19th century, but according to the researchers who are sceptical about Recent Global Warming we can't use one of the biggest cooling downs in history that occured in the last third of the 19th century as a reference point. The climate regime that was significantly more pluvial than the reference period lasted till the 1940s, and there are no signs of the climate becoming significantly drier prior to the 1980s.

Climate history interpretation of annual temperature time series

It is also interesting to take a look at the seasonal temperature time series made using a (almost) traditional climatological approach, on which I executed only two minor modifications. First, I used 'real time' in the case of seasons as well, so the months of the following year's seasons follow each other in the time series. Second, even in these cases I represented the divergences from the average temperature and precipitation between 1961 and 1990. Climate history researches show that in Central Europe climatic changes are stronger during the winter or winter half-year than in the summer or summer half-year's temperature range.

The temperature of winters (Diagram 4) throughout the 19th century remained below the reference period's average, and winters from the 1840s until the beginning of the 20th century were especially cold. The aspect of winter precipitation is much more diverse, there were specifically wet periods in the 1870s and '80s, but the middle of the century had dry winters. At the same time a powerful warming already started in the first decade of the 20th century, but it's important to note that the warming culminating in the 1920s started from a strong minus, and only the medium values of the 1920s exceeded the reference period average. The recooling in the 1930s was already perceptible in the Danube Basin regarding the winter temperature range, and this temperature characteristic remained until the end of the 1960s. Moreover, excluding the 1930s, winters were mostly precipitating till the end of the 20th century, the cold and snowy winter character intensified especially at the turn-of-the-cen-

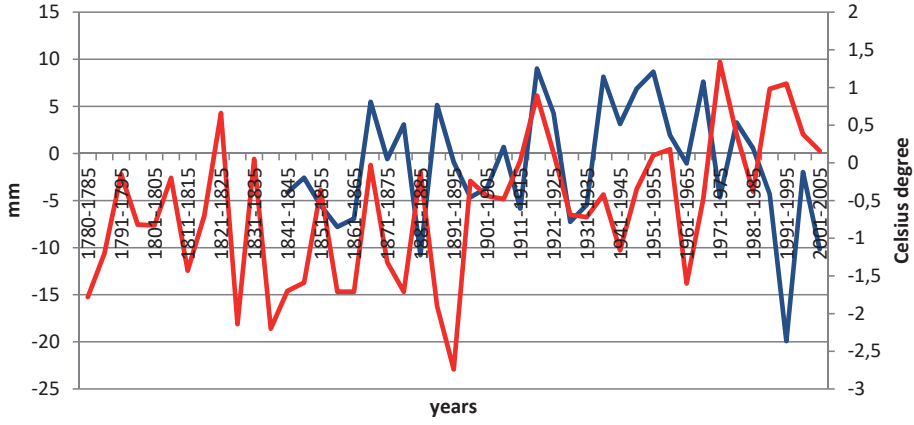

Diagram 4. The divergence of winter temperature (from 1780) and precipitation (from 1841) five year moving averages of Budapest from the averages of the 1961–1990 period.

tury recooling. Nevertheless, in the 1970s a let-up in winter temperature similar in scale to the warming that occured in the first third of the 20th century started (or rather continued), accompanied by a significant precipitation decrease from the 1980s.

During the hundred years between 1830 and 1930 most of the springs (Diangram 5) had an average temperature way beyond that of the reference period. The last third of the 19th century was especially cold and pluvial. From the 1910s until the middle of the century the spring temperature range showed

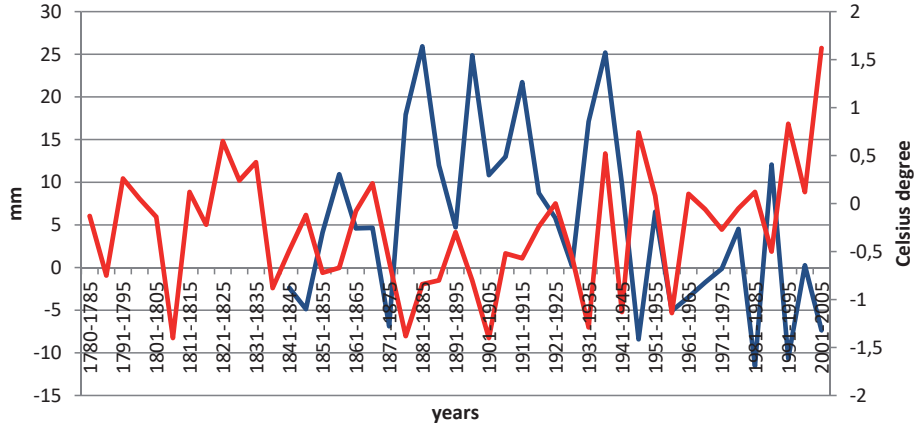

Diagram 5. The divergence of spring temperature (from 1780) and precipitation (from 1841) five years moving averages of Budapest from the averages of the 1961–1990 period.

notable variability, but the quantity of precipitation stayed permanently above the median of the reference period. The tendency of warming in spring became obvious from the 1960s, which was followed by a strong decrease in the amount of precipitation, with major fluctuation though. Warm and dry springs have become dominant since 1990.

The temperature tendency of summers differs fundamentally from the other seasons' long-term temperature development (Diagram 6). According to the time series from the beginning of observations until the end of the 1870s for almost a century the summer month average temperature was well above (!) the standard of decades between 1961–1990, which at least shades the aspect of cooling down of the Little Ice Age in the 19th century. The only exception that is statistically provable was the second half of the 1810s, when summers weren't actually absent but summer weather did become a little cooler. From the second half of the 19th century warm summers were accompanied by irregular but mostly rainier weather than that of the reference period. There was a significant change in the last decades of the 19th century though, from the beginning of the 1880s till the middle of the 1930s summer medium temperatures remained under the average of the reference period, and the amount of precipitation dropped noticeably as well. Paradoxically the climate change caused by the cooling down in the 20th century led to considerable warming and more raining in the summer in Hungary. In the middle of the century the temperature tendency of summers was contrary to the temperature tendencies of winters and springs, although there seemed to be a slight connection to the temperature range of autumns. In the 1970s and 1980s the trend

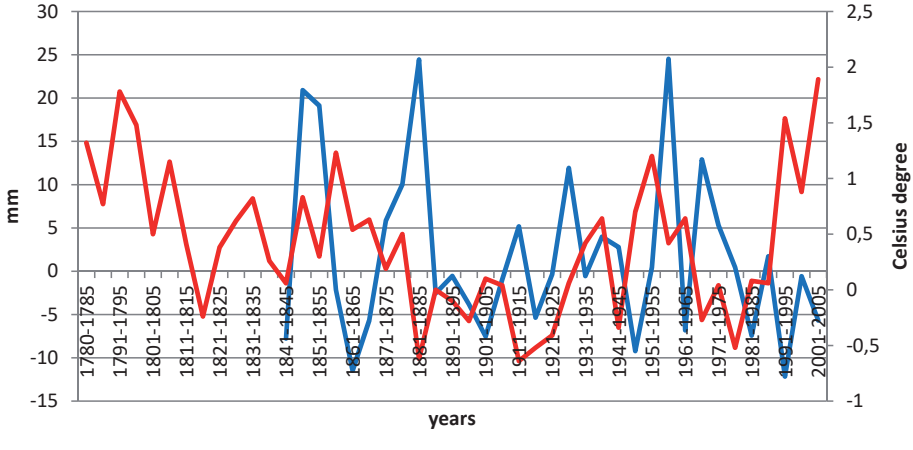

Diagram 6. The divergence of summer temperature (from 1780) and precipitation (from 1841) five years moving averages of Budapest from the averages of the 1961–1990 period.

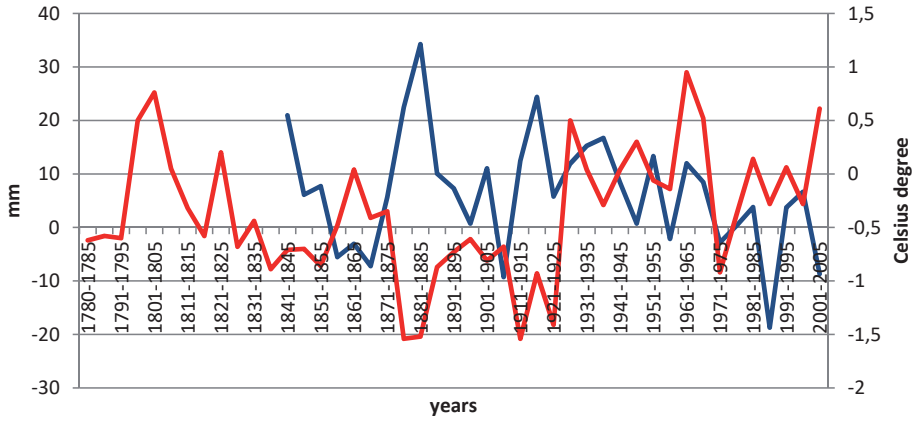

Diagram 7. The divergence of autumn temperature (from 1780) and precipitation (from 1841) five years moving averages of Budapest from the avegares of the 1961–1990 period.

of warm summers was interrupted, but from the 1990s the average temperature of summers were 1–1.5°C above the medium values of the 1961–1990 period, which was followed by the permanent decline in the amount of precipitation.

With the exception of a few years the average temperature of the autumn months was for 150 years, from the beginning of the observations in Budapest until the middle of the 1920s, well under the median of the reference period (Diagram 7). During this time, not counting the 1860s, autumns were much rainier than over the reference period. In the 1930s there was a moderate warming which with considerable fluctuation lasted till the beginning of the 1970s, thus following the more dynamic warming tendency of summers in the middle of the century. While this transitional period autumn weather remained pluvial, the amount of precipitation decreased, and this trend is still proceeding. The last third of the 20th century went on with autumn weather cooler than that of the reference period, the powerful warming manifested only during the first decade of the 21st century.

After the yearly and seasonal climate history review maybe it is worthwhile to observe the climate changes of the vegetational period as well, as these approximately seven months have a distinguished significance regarding the functioning of human society (Diagram 8). In the professional literature the vegetational period constitutes that part of the year when the daily average temperature is likely to reach 5°C, which in Hungary is the span between April and October. It is clearly visible that from the beginning of meteorological observations to the end of the 1860s the vegetational period was permanently and uniformly warm. Between the 1870s and the end of the 1930s the veg-

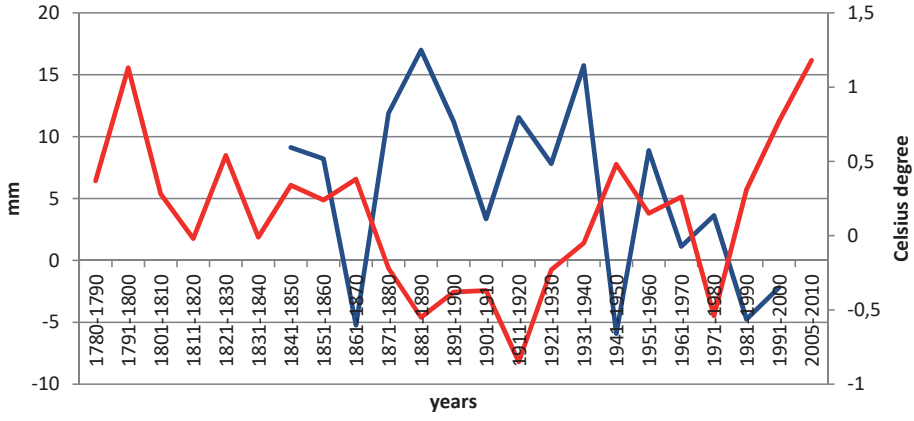

Diagram 8. The divergence of the vegetational period temperature (from 1780) and precipitation (from 1841) five years moving averages of Budapest from the averages of the 1961–1990 period.

etational period became cool and extremly pluvial. The second third of the 20th century has no obvious climatic tendency concerning temperature or the amount of precipitation. Nevertheless, from the 1980s the warming and drying climatic tendency is certainly determinable.

Since when is the Recent Global Warming demonstrable in Hungary?

In regard to the attitude of the decisive personalities in international scientific public life, the fourth report of the IPCC published in 2007 not only closed the debate about the truth of Recent Global Warming but also corrected the exaggerated warming forecast.[10] Nowadays there is no standard scientific public body that doesn't treat Recent Global Warming as a fact. At the same time the controversy about the reality of Global Warming couldn't be considered as settled a decade and a half ago. It has to be considered as well that the delimitation of climate periods in time shows great diversity in space. Scandinavian researchers date the termination of the mediaeval warm period and the beginning of the Little Ice Age to the 13th century[11], in Switzerland to the middle of the 14th century[12],

[10] Fourth report of IPCC see: https://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm (27.12.2015).

[11] A. Nesje, S.O. Dahl, T. Thun, Ø. Nordli, *The 'Little Ice Age' glacial expansion in western Scandinavia: summer temperature or winter precipitation?*, "Climate Dynamics" 30/7, June 2008, pp. 789–801.

[12] Ch. Pfister, *Wetternachhersage. 500 Jahre Klimavariationen und Naturkatastrophen (1496–1995)*, Bern 1999.

and in Germany only to the beginning of the 15th century[13]. The evaulation of the end of the Little Ice Age is controversial as well, in Western Europe the conclusion of the Little Ice Age and the beginning of Recent Global Warming is usually marked at the second half of the 19th century, but in Scandinavia they consider it the 1920s, and the European glaciers reached their positions prior to the Little Ice Age only by the middle of the 20th century. It isn't simple to determine the turn of the climate regime in the Danube basin. If we consider the rise in temperature as the only indicator of Global Warming, then the warming started in the last decades of the 19th century in Hungary as well. If we consider the decrease in the amount of precipitation to be decisive, then this process started in the 1940s, although there was no significant drying tendency before the 1970s. If we view the cool and precipitating climate regime as characteristic of the Little Ice Age, then this plainly determined the climate of the Carpathian basin until the 1910s, or with some restrictions till the 1940s. Furthermore, I wouldn't be able to categorize the climate character of the middle third of the 20th century. After my climate historical research if I ask myself again what I think about the opinion of the committee member, then objectively I have to say that he was wrong about the judgement of the reality of the Recent Global Warming.

Summary

Even if we examine separately the tendency of the temperature and precipitation changing in the 20th century, we can't get a clear picture. The warming is obviously showing from the last decade of the 19th century, but according to the researchers who are sceptic about Recent Global Warming we can't use one of the biggest cooling downs in history that occured in the last third of the 19th century as a reference point. The climate regime that was significantly more pluvial than the reference period lasted till the 1940s, and there are no signs of the climate becoming significantly drier prior to the 1980s. If we consider the rise of temperature as the only indicator of the Global Warming, then the warming started in the last decades of the 19th century in Hungary as well. If we consider the decrease in the amount of precipitation to be decisive, then this process started in the 1940s, although there was no significant drying tendency before the 1970s.

[13] R. Glaser, *Klimageschichte Mitteleuropas. 1000 Jahre Wetter, Klima, Katastrophen*, Darmstadt 2001.