REPRINT

FROM

World Resource Review

volume 7 number 4

THE 19TH CENTURY DISCUSSION OF CLIMATE VARIABILITY AND CLIMATE CHANGE: ANALOGIES FOR THE PRESENT DEBATE?

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Keywords: Climate Change, Natural Variability, Political Responses, Social, Political and Economic Consequences, Anthropogenic Change, Public Discourse

ABSTRACT

Toward the end of the nineteenth and at the beginning of twentieth century significant discussions occurred among geographers, meteorologists and "climatologists" concerned with the notion of climate variability (Klimaschwankungen) and anthropogenic climate change (Klimawandel/ Klimaänderungen), for instance, due to deforestation and reforestation. We identify two protagonists of this debate, Eduard Brückner and Julius Hann, who both accept the notion of climate variability on the decadal scale, but respond in very different ways to the discovery of climate change. Brückner assessed the impact of climate variability on society (e.g., on health, the balance of trade, emigration to the USA), and tried to bring these to the attention of the public, whereas Hann limited himself to the immediate natural scientific problem of monitoring and documenting climate variability.

We suggest that these discussions and the formation of national governmental and parliamentary committees almost 100 hundred years ago, are not merely of historical interest. In view of presents discussion of climate variability and anthropogenic climate change, and the need for of adequate socio-economic response strategies, past and now neglected arguments may prove important for methodological and theoretical as well as for practical

reasons. The past discussions represent a significant social and intellectual analogy for the present situation.

INTRODUCTION: THE CONCEPT OF CLIMATE VARIABILITY AND CLIMATE CHANGE

> Zahllos sind die Hypothesen und Theorien, die über Änderungen des Klimas in der Vergangenheit aufgestellt wurden und naturgemäß mehr oder minder lebhaft das Interesse weiterer Kreise in Anspruch nahmen, lässt doch der strenge Nachweis einer in vergangenen Zeiten vor sich gegangenen Änderung des Klimas sofort den Gedanken an die Möglichkeit einer zukünftigen Änderung auftauchen; eine solche aber könnte sich nicht ohne einschneidende Wirkung auf das wirthschaftliche Leben der Völker vollziehen.
> Brückner (1890:2)

The concepts of "climate variability", "climate change" and "climate impact" attract an enormous interest not only in the climatological, meteorological and oceanographic community (von Storch and Hasselmann, 1995) but also in sciences concerned with climate-sensitive systems, such as biometeorology, ecology or the social sciences.

Discussion of "the climate problem"[1] is by no means limited to the scientific community. It has drawn a great deal of interest from a general public (Lacey and Longman, 1993) perhaps haunted by anticipations of catastrophic developments as a consequence of future anthropogenic climate change (cf. Stehr and von Storch, 1995). Evidence of a public and scientific preoccupation with of "the climate problem" are such institutions as the "Intergovernmental Panel on Climate Change" (IPCC) and International Conferences aimed at the establishment of International Climate Conventions.

Most of the scientific and general public interprets the climate problem as a new challenge. Yet, although for much of past two centuries "climatologists" and meteorologists have been convinced, and have considered it to be almost an axiom, that global climate is a constant,[2] some 19th

[1]We place the expression "climate problem" in quotations marks since it is not well defined. Natural scientists associate with this expression the understanding, prediction and, possibly, control of climate variability. Social scientists, on the other hand, consider the perception of climate, and the social and political implications of this perception, as the "climate problem".

[2]Brückner (1889:2) notes that during the 19th century a distinct disciplinary division with respect to the issue of climate change could be observed: Geographers and geologists were more inclined to consider a persistent climate change to be a reality while meteorologists defended the thesis that climate is a constant. Brückner (1890:2) offers an explanation why most professional meteorologists and many geographers at the time were rather silent on the issue of climate change; as a matter of fact, he observes that they were embarrassed to engage in research and discussion about climate change. The reason for the reluctance is the wealth of competing hypotheses about climate

century climatologists, geographers and meteorologists recognized that climate is not a steady phenomenon (e.g., Brückner, 1890; Hann, [1883] 1893:362), recognizing that climate varies not only on geological time scales (1000s of years and longer) but also on decadal and century time scales due to natural and anthropogenic processes.

The dynamic processes which were discussed at the turn of the last century as the source of climate variability and change were different. The "natural variability", unrelated to man's activities, was in a speculative manner attributed to astronomical factors, such as the solar activity, and to processes in the interior of the earth. In addition, the idea of deterministic periodic processes attracted much attention among climatologists. Anthropogenic "climate change" was thought to be the result of such activities as de- and reforestation or new cultivation of land in North America, for instance. The possibility that anthropogenic emissions of carbon dioxide might alter the global climate was first suggested by the physicist Svante Arrhenius (1896; 1903), but the concept was not taken seriously, or simply not well understood, by the climatologists of the day who for the most part were geographers interested in descriptive approaches.[3]

The intensive debate among climatologists at the turn of the century quickly receded into the background when a new disciplinary consensus emerged that remained predominant until recently that the global climate system contained overriding equilibrating processes providing resilience against secular climate fluctuations; fluctuations that did occur were seen as distributed around a fairly stable mean climatic condition. Thus, the discussion in question and its findings are now virtually forgotten.[4] Stehr (1995) relates the disappearance of the climate variability discussion to the emerging prominence of racial theories in the first part of the 20th century, at least in Germany. Some of these anthropological theories, as put forward, for example, by Sombart ([1911] 1951:324; 1938), Ploetz (1911) or Hellpach (1938), require explicitly constant climatic conditions. Another reason why the perception of climate variations on historical time scales became unpopular may be the rejection of "catastrophism" and the acceptance of "'uniformitarism'' in geology. This concept was proposed by Lyell, one of the founding fathers of modern geology, in 1830 - and led finally to the denial of the existence of the Little Ice Age by Lyell himself (after van Andel [1994: 397]).

change formulated earlier in the century. But previous efforts only resulted in many contradictory voices about the nature of climate change, so that climatologists became than reluctant to add to the cacophony of mere opinions.

[3]It should also be noted that Arrhenius (for example, 1903:479) was not all that seriously alarmed about the changes in the global climate induced by growing CO_2 emissions. He anticipated that natural equilibrating processes would produce the necessary adjustments and that any noticeable changes in the composition of the atmosphere may be more than 1000 years away.

[4]Among recent accounts of climate change the work discussed here is not incorporated (e.g., Flohn 1985).

In this essay, we therefore attempt to recover for methodological, theoretical and practical reasons a significant cluster of the spirited discussions among geographers, meteorologists and climatologists that occurred toward the end of the past and at the beginning of this century. We propose to analyze the dynamics of the discussion, and the degree to which it was introduced to the general public, with the explicit intention of comparing the situation at the time with the present discussions of climate variability and change and of climate policies designed to avoid or mitigate the risk of climate change or to allow for a smooth adaptation.

We concentrate on two of the main contributors to this early discussion of climate variability and change on time scales of decades, namely Eduard Brückner and Julius Hann, both professors in Vienna for a significant part of their lives. First, we introduce brief curricula vitae of these two prominent scientists and summarize their main climatological achievements. Second, we discuss their different social roles, their attitudes towards the role of the public, and their understanding of their own work as part of multiple contexts in which they attempted to play different functions. We show that the two protagonists Brückner and Hann, represent roles and self-conceptions that strikingly resemble present-day roles of climatologists in discussions within and outside the scientific community about the scientific significance and the social impact of climate variability and change. However, the similarities do not end here. Scientists also tried to extend their influence to the formation of national and regional governmental bodies dealing with the threats of anthropogenic climate change, and there are parallels in the conceptions and in the nature of discussions that ensued. We suggest that the contemporary "climate problem", as perceived by scientists and the public at the turn of the century, constitutes a valuable historical analogy for present debates on the "climate problem".

EDUARD BRÜCKNER

One of the central protagonists in the debate at the turn of the century about global climate variability and its significance for society was the geographer Eduard Brückner. Born July 27, 1863 in Jena, Germany, and died at the age of 65 in 1927 in Vienna, Austria. Brückner studied at the universities of Dorpat (now: Tartu, Estonia), Dresden, and Munich and completed his doctorate with a dissertation on the ice fields in the Salzach region in Austria under Albrecht Penck in Munich. On the strength of his dissertation, be was appointed professor of geography at the university of Bern. He left Switzerland in 1904 for two years at the university of Halle in Germany and finally moved as the successor of his former teacher Penck to the University of Vienna (cf. Oberhummer, 1927).

Brückner in 1890 published the first extensive book-length discussion of recent climate fluctuations, that is of climatic fluctuations in "historical times".[5] Brückner (1984:1) credits the head of the Bavarian meteorological services, C. Lang, with the discovery of decadal scale climate variability in a study of the climate of the Alps (Lang, 1885). After 1890, Brückner published only a few smaller articles on the observational evidence of climate variability (Brückner, 1895, 1902).[6] What is in the present context of particular importance, though, are his articles on the social consequences arising from the climate fluctuations, such as emigration, immigration and migration patterns (Brückner, 1912; [1912] 1915) or on harvests, the balance of trade of countries and shifts in the political predominance of nations (Brückner, 1894, 1895, 1909).

Brückner's methods are mainly limited to the exploratory statistical analysis of time series since confirmatory tools such as confidence intervals or hypothesis testing were not developed in combination with what might be called common sense. He is unfamiliar with dynamical arguments (for instance, concerning the geostrophic wind, which was well known among meteorologists of these days) and he was unaware of theories concerning the general circulation of the atmosphere (he failed to acknowledge the different dynamic character of the tropics as opposed to the extratropical westerly regime).

Brückner's work on climate change is none the less, quite distinctive. Although he was mainly concerned with establishing the fact of climatic fluctuations and their probable periodicity, he also reflected on the likely reasons for the observed climate fluctuations and he employed his observations as a tool for predicting impending climate changes.[7] In addition, Brückner also speculated about the geographical and socio-economic impact of climate change. He was convinced that the issue is both of considerable scientific merit and that future climate changes are of great importance to well-being of society as the well as for the strategic and economic balance of political and economic powers.

He therefore presented his conclusions about serious repercussions associated with climate change anticipated for the end of the past century in the form of oral publications addressing the general public and especially

[5]We note in passing the curiosity that Brückner claimed in 1890 to have available about 100 year's of reliable data - that is about the same amount of reliable data contemporary climatologists believe to have at hand.

[6]Brückner explains the small number of articles on the observational evidence as the result of a lack of new and appropriate meteorological data on the issue.

[7]An example of such a prediction is the 1915 statement that by 1920 "we may expect a maximum of humidity" in the United States (Brückner, 1915: 132). This prediction exploits two pieces of information: First, the presence of Brückner's 35-year oscillation and secondly the observation that precipitation was at its minimum around 1900. (Whether these data are correct remains to be seen.) Brückner did not spell out another prediction based on the same reasoning, namely that in the middle of the 1930's the United States would again suffer from dry conditions. On the continental scale, his forecast was incorrect (Bradley, 1987: Figure 6), but in a regional sense his forecasts were consistent with actual developments: The Great Salt Lake exhibited maximum lake levels from 1910 to 1930, and a sharp drop in the early 1930's. Also the "Dust Bowl" dry episode that lead to persistent disastrous harvest failures in Central North America took place in the mid 1930's.

affected segments of the public, for example, farmers. As a result, in 1889, Brückner presented his initial findings on climate change not only to a congress of professional geographers in Berlin, but a year earlier also in a public lecture entitled "Is our climate changing ?" at the University of Dorpat (today: Tartu, Estonia) that was duly noted in the local press (Brückner, 1888). Later Brückner (1894, 1909) published newspaper articles about the general issue of climate change as well as about its specific economic and social consequences. His work on climate variability was discussed at length in the contemporary press (e.g., Neue Freie Presse, Vienna, February 11, 1891). As a result of these activities and the response they generated, Brückner's work on climate variability found a considerable echo among the scientific community of climate researchers, geographers (e.g. Huntington, [1915] 1924:25), and physicists (e.g., Arrhenius, 1903:570-571), but to some extent also among the public at large.

EDUARD BRÜCKNER'S ANALYSIS OF CLIMATE VARIABILITY

In the following section we summarize Brückner's attempt to synthesize the observational evidence for global-scale simultaneous climate variability from his limited data and limited computing power.

Brückner (1889:2) indicates that he was first alerted to the possibility of climate change, aside from information about shrinking glaciers in the Alps, as the result of observations about changing water levels in the Baltic, the Caspian and the Black Sea. The changes in the water levels appeared to follow a specific pattern. The rhythm of the changes resembled changes in the glaciers of the Alps.

Core dimensions of the analysis of climate change in the late nineteenth century are temperature and precipitation. All other meteorological elements play a subsidiary role. Thus, Brückner focuses first and foremost on changes in the volume of rain and he links the water levels to the amount of rainfall in a region.

In his detailed discussion of "recent" climate fluctuations Brückner (1890) justifies his approach by referring to the studies of Richter (1883), Lang (1885) and Swarowsky (1886). Richter concluded that the cause for the secular variations of one certain glacier (Obersulzbachgletscher in Austria) are wet and dry periods lasting for several years in that particular region. Lang proved this result to be valid for the entire region of the Alps. Swarowsky stated a striking correlation between the variation of water level of the Neusiedler See, a lake without any outlet near the Austrian-Hungarian border, and the secular variations of the glaciers in the Alps, thereby proving that lakes without an outlet are excellent indicators of secular climate variability.

In his book on climate variability, Brückner starts his analysis with a careful investigation of the largest "lake" without an outlet in the world, the

Caspian Sea. Brückner draws from this study the conclusion that Lang's results not only hold for the Alps but may be extended to the vast catchment area of the Caspian Sea (Brückner, 1890:86).

This inductive method of extending results from a smaller region to a larger one is, by the way, typical for Brückner's approach and consequently he searches in data available from several other lakes without an outlet all over the world for signals due to secular variations. Brückner states that the mere existence of water variations in the lakes allows to presume that secular climate fluctuations take place in the corresponding catchments (Brückner 1890:115). In a further step Brückner applies the concept of linking water levels of lakes to the rainfall in the corresponding regions also to lakes with an outlet (Flusseen) and even rivers thereby stating the existence of a more or less synchronous climate fluctuation over the entire land mass of the world (Brückner, 1890:132).

Brückner mentions several times that the cause for the secular climate variations are unknown (Brückner, 1890:115,132) and deals with this question by mainly investigating the available precipitation and temperature data ending up with the careful suggestion of a 36-year-period oscillation in the global meteorological conditions. He attributed this periodicity to some unknown solar forcing mechanism (Brückner, 1890:240,242) but was aware that no observational evidence for such an oscillation exists. In this context Brückner denies any connection between secular climate fluctuations and variations of sunspot activity (Brückner, 1890:242).

In order to trace secular climate fluctuations further back Brückner studied also the observed data of the ice conditions of the rivers, the grape harvest and the abundance of strong winters. According to the data Brückner was able to identify 25 secular cycles during the last 1000 years (Brückner 1890:286).

Based on this 35-year period oscillation Brückner prognoses a dry period at the turn of the century (Brückner 1890:286,287) with severe consequences in crops for continental regions, like Northern America, Sibiria and Australia. It is noteworthy that this predictive scheme would have enabled Brückner to predict the "dust bowl" in the central part of the United States which actually took place during the Thirties of this century.

JULIUS HANN

Another well known professional climatologists of these days was Julius Hann, who was born in Wartberg, Austria. He studied mathematics, physics, geology and geography at the University of Vienna. After a career in teaching, he became professor of physics at the University of Vienna and in 1897 professor of meteorology at the University of Graz. Between 1900 and 1910 he occupied the newly created chair for cosmological physics at the University of Vienna and served as director of the Institute for Meteorology and Geodynamics. As Brückner (1923:152) points out in his obituary, Hann may have been the most important meteorologist of his day and can be considered to be one of the founders of modern meteorology as the science of the physics of the atmosphere. He was descriptively oriented, that is, keen to establish the observational basis for various meteorological phenomena. In addition, Hann was for more than fifty years editor of the Meteorologische Zeitschrift. Hann was an enemy of speculative thinking; his main goal was to establish the facts (Brückner, 1923:155). He died in 1921 at the age of 83 in Vienna.

Julius Hann compiled the first textbook on climatology. He first published his Handbuch der Klimatologie in 1883, seven years prior to Brückner's publication of his findings on decadal climate variability. The Handbuch appeared in a number of subsequent editions and became a classic in climatology (cf., Brückner, 1922; Köppen, 1923:vi; Knoch, 1932:viii).[8]

JULIUS HANN'S DESCRIPTION OF CLIMATE VARIABILITY

In contrast to later of the Handbuch, its first edition summarizing the state of knowledge in climatology --, then still defined as an auxiliary science (Hilfswissenschaft) of geography (Hann, 1883:5; also Köppen, 1923:1) --, did not explicitly deal with the issue of climate variability. Reflecting the preoccupation of the day with the issue of periodicity of climate, Hann distinguishes between two types of climate fluctuations, namely "progressive" (that is, persistent transformations, or, in modern terms "climate change" (e.g., von Storch and Hasselmann, 1995) and "cyclical" changes (that is, fluctuations or oscillations around a constant mean with certain characteristic times or periods; in modern terms "climate variability"). The relevant time period for climate changes that conform to cyclical patterns may be based on either a deductive (by postulating certain forcing mechanism, such as the sun's activity) or inductive reasoning (by screening the observational record). It should be possible, according to Hann, to trace progressive climate change to either long-term trends of the temperature of the core of the earth or of the output of the sun. But Hann does not take up these explanations in detail.

As far as relevant empirical material is concerned, Hann ([1883] 1897:390) referred to both non-instrumental and instrumental observations of temperature and precipitation as well as general accounts or conclusions about climate changes of a wide variety of observers and found in disparate historical records. He placed considerable emphasis on the critical examination of the observational climatic record. Obviously such data can be used only if the procedure of observing, archiving and, possibly, correcting the

[8]An English edition based on the second edition of the German version of the Handbook was published in 1903 (Hann, 1903).

raw data is kept constant (cf., Jones, 1995). The historical data available to Hann did in general not satisfy this homogeneity condition. He found on close examination that the data recorded in the previous 150 years were almost always contaminated by time-variable biases due to changing observational practices; the oldest instrumental records invariably were started in rapidly expanding cities, and therefore reflect "urbanization"[9], while rain gauges were first placed on higher elevations (e.g., roofs) causing severe biases in measurements (cf., Karl, et al., 1993).

On the basis of such methodical pitfalls concerning the quality of the data, Hann was in general rather skeptical of scientific claims identifying climate variability and change in the observational record. In particular he inferred that the evidence for systematic trends ("progressive changes") of the climate during the historical period based on the available data from different centuries, continents and countries is not substantial (e.g., Hann, [1883] 1897:390). It had been hypothesized that the continental United States of America of the 19th century was been subject to an anthropogenic climate change due to the progressive anthropogenic transformation of nature in the course the colonialization. Hann concluded with Whitney (1894), that there is no hard evidence for a climate change as the result on the North American continent (Hann, [1883] 1897:392).

In case of climate variability Hann was less reluctant. He was skeptical about strictly periodic climate fluctuations,[10] especially in regard to any hypothesized connection between variations in sunspot activities (that represents, at the same time, an example for a deductive determination of periodicity) and meteorological elements such as temperature, precipitation or changes in the formation of ice fields. On the contrary, he concluded that the influence of sun spot activity on climate patterns is be insignificant. Moreover, he rejected the possibility of any predetermination or causal linkage between climatic variations and sun spots activities (Hann, [1883] 1897: 394).

Hann considered Brückner's quasi-oscillatory 35-year cycles much more favorably since it was based on rich data from very different sources. Brückner's discovery seemed valid for many regions and periods, and was supported by observations about changes in the extension of Alpine ice fields as described by Richter in 1891. It could, furthermore, be verified by

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[9]Hann's used the expression "city-temperatures".

[10]It was most fashionable then to search for periodicities in data time series. Earlier, Fourier had shown how to decompose any time series into a finite sum of periodic components, making it thus in principle possible to extract "dominant periodicities". Unfortunately, the stochastic character (e.g., Jenkins and Watts, 1968) of the time series was not yet properly understood then so that almost all periods were found in one or the other data seta as being dominant. When using these periodicities for forecast purposes, the periodicity always disappeared. The reason for this behavior is now well understood, but must have had a very frustrating effect on scientists at the turn of the century. Remnants of the hunt for periodicities are still virulent and are even now pursued by mathematically insufficiently trained scientists and hobby scientists.

examining data from other regions. Hann ([1883] 1897:400) made no serious independent attempts to clarify the dynamics of Brückner's observational evidence. Instead he limited himself to efforts to establish the existence of the patterns of climatic fluctuations. Hann highlighted the fact that Brückner's observations manage to shed light on contradictory accounts of climate variations in specific localities since they "obviously" must have been advanced during different phases of the 35-year period.

Indeed, the second edition of the Handbuch, published in 1897, contains a forty-page separate section on climate variability that centers on Brückner's research. In the fourth edition of the Handbuch, published in 1932, Karl Knoch had succeeded Hann as author of the Handbuch, (Hann and Knoch, [1883] 1932). This fourth edition deals even more systematically with climate variability, even if the summary is rather skeptical. Much prominence is given to contributions that attempt to demonstrate the stability of the climate in historical times and point to the absence of evidence for secular change (see Berg, 1914).

CLIMATE VARIABILITY AND ITS SOCIETAL IMPORTANCE

It was obvious to Brückner that climate variability and climate change have a direct effect on many aspects of society, including the economy, ecology, human health, or even the balance of power among nations. It is therefore of interest to inquire how Brückner and Hann responded to the challenge of offering their findings to the scientific and general public as warnings of impending climate change but also as instruments to design strategies to deal with climate variations. Interestingly, the two scientists reacted very differently.

Hann disregarded societal impact entirely. He did not even mention possible social consequences of climatic fluctuations. Consistent with the then prevailing self-conception of climatology as a largely descriptive (e.g., Hann and Knoch, [1883] 1932:3) "young" science (e.g., Köppen, 1923:v), Hann examined the existing evidence on climate variability and change and attempted to establish whether the data supported arguments for changes in climate phenomena.

Brückner, on the other hand, not only discussed the nature and extent of climatic fluctuations but emphasized their possible consequences for society.[11] Although the dynamic causes for the observed variations were still obscure, he was convinced that there was every reason to believe that the practical consequences of the fluctuations were of great significance (cf., Brückner, 1889:11).

[11]In his 1890 monograph, Brückner (1890:273-290) devotes an entire chapter to these matters: "Die Bedeutung der Klimaschwankungen für Theorie und Praxis" (The importance of climate variability for theory and practice).

In the terminology of present-day social science, Brückner's findings represent a form of "practical knowledge" (Stehr, 1991). Brückner begins with the type of disturbances that might be induced by climate variability: The area covered by ice-field varies, the size, the water level, the appearance or even presence of lakes and rivers, the extent of floods is sensitive to climatic conditions. Such disturbances would have a major impact on shipping and commercial patterns and, to a minor extent, on agriculture. Changing water levels and the duration of ice covers on rivers and streams, in particular, would impact on the ability to navigate these waters and therefore the ease with which goods may be moved. Another most important aspect concerns agriculture (see also Brückner, 1894). Climatic fluctuations have also a significant influence on agriculture even if the effect depends considerably on the harvested product. Brückner concluded that more than two thirds of above-average agricultural outputs in (Central and Western) Europe coincided with the warm and dry periods and an equal proportion of poor agricultural yields with the wet and colds climatic periods. In more maritime climates enhanced summer rain would cause harvests to fail whereas in more continental climates, such as in Central North America or Russia the summer rain would be favorable for agriculture (Brückner, 1894:2, 1915:137-138). In his 1915 paper Brückner summarizes the relationship between climate-related harvests and migration to America in a number of impressive curves, which we reproduce here as Figure 1 (All data are five yearly means).

Brückner (1890:279-282) also hypothesized the existence of a firm

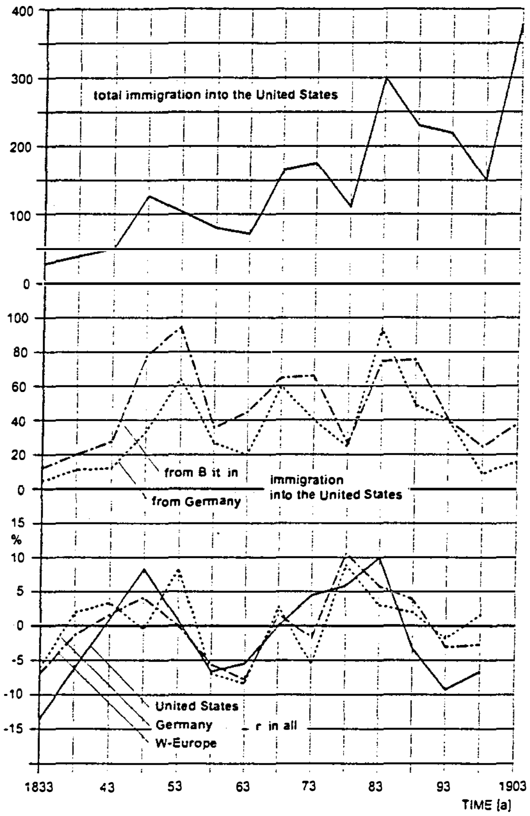

Figure 1 Rainfall variations (in percentage departures from a normal) in Europe and the United States and emigration to the United States. After Brückner (1915)

connection between climatic fluctuations and health. He offered one example only, namely a relationship between the appearance of typhoid and the level of the ground water which would be controlled by slowly varying climatic factors. Having examined records of typhoid-mortalities in Central Europe, Brückner attributed at least a portion of the observed improvement in the incidence of typhoid-mortality since the last wet period (around 1860) -- in addition to benefits derived from improvements in the sanitation -- to recovering ground water levels as the result of a shift from dryer to wetter climates. He claimed that the record for Basel (Switzerland; see Figure 2) would reveal a clear coincidence of climate variations and variability in typhoid mortality (Brückner, 1890:280). In Figure 2 the light line represents the raw data, and the heavy line represents the data after subtraction of the linear trend and of the mean value.

On the basis of his 35-year "mode of natural variability" and of his analysis of the climate sensitivity of civilization, Brückner (1890:279, 287; 1915:132) predicted a number of impending detrimental social consequences of climatic variability, in particular serious economic crises for regions that had benefitted from a favorable climate in recent decades, especially areas such as the United States, Russia and Australia, located within the continental climate regions. These regions, Brückner argues, must expect an inevitable shift to dryer weather resulting in significant crop failure and the destruction of hundreds of thousand of livelihoods.

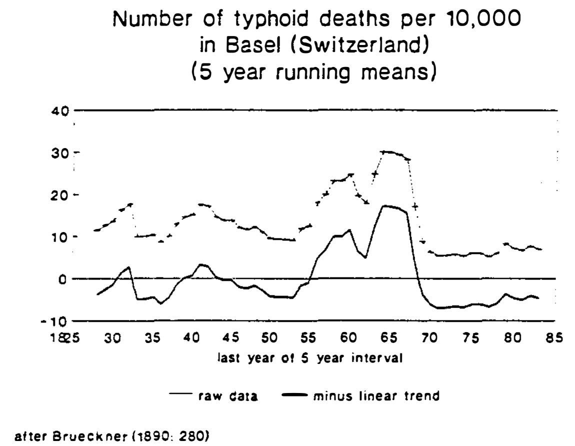

Figure 2 Number of typhoid related deaths per 10,000 in Basel (Switzerland): the data have been smoothed with a five-year running mean filter

THE ANALOGIES

The situation in the late 19th century is in some respects similar to the present situation. Scientists began to realize that climate is not a constant but undergoes significant variations. It was also understood that climate might vary systematically (in Hann's words: progressively) as a response to human activities as well as temporarily (in Hann's words: cyclically) reflecting natural processes.

The reasons for natural climate variability were unknown - speculative hypotheses related it to variable output of the sun or other "cosmic" processes. In a similar manner as today, many scientist mistook slow climate variations for indications of systematic change.

Anthropogenic climate change was thought to be instituted through modifications of the land surface, in particular de- and reforestation, and cultivation of land. Because of the obvious importance of climate on various segments of economy and social organization, scientists were, and are today again, confronted with the problem whether they should inform, or even warn, society about impending climate fluctuations. Some, like Hann, restricted themselves to the mere monitoring and analysis of the observational evidence and addressed only scientific circles. Others, like Brückner, felt the responsibility to speak to the public while similar to present-day "activist"-scientists he apparently did not go as far as they in demanding specific political actions. Others did, however. An example is F.B. Hough (1878; quoted after Brückner, 1890:15), who demanded on behalf of the American Association for the Advancement of Sciences (AAAS) reforestation programs to avoid the further drying up of the North American Continent.

The protagonists of anthropogenic climate change, or, in the, in modern terms, environmentally conscious scientists had an impact on the governmental-administrative level. Their message was that modifications of the environment, and in particular deforestation (sometimes also reforestation), would be an agent of climate change. To abate climate change therefore required reforestation programs - and such demands were often met favorably by government. In many countries governmental or parliamentary committees level were instituted, for instance in Prussia, Russia, France and Italy (cf., Brückner, 1890:14-19).

We do not know how successful Brückner himself was in his attempt to translate his knowledge into political action. Since he was convinced of climate variability he did not advocate conventional cures such as reforestation. He instead suggested adaptation, to make the best of the unavoidable natural variations.

The specific episode we have recounted reminds us that the burgeoning genre of popularized science that surrounds present-day discussions of climate change is by no means new. Nor is it novel to acknowledge the uncertainties that surround scientific data on climate variability.[12] It appears that the issue of climate change lends itself well to

[12]Brückner also offers an explanation for the cognitive descensus among meteorologists during the century about the specific thrust of climate changes, that is, were observed changes a signal either the onset of a dry or wet climate pattern? The answer, according to Brückner (1890:289), is straightforward. Climate changes affect the predictions made by climatologists. During a dry period, general predictions about a dryer climate flourish and during a wet period, predictions that the climate is headed toward greater precipitation predominate. Moreover, the conclusion

such popularization. Perhaps it does so because the issue goes to the heart of our modern common sense understanding of the natural climate as benevolent and trustworthy.

The global frame, some like to think, is essentially a novel framework. But, as our case demonstrates, global environmental changes were been predicted by science even in the 19th century. For Brückner, climate was clearly a global system.

Similarly, considerable energy was then, and is now being spent by politicians, the public and others on the issue of climate change; in each case, scientists played a major role in achieving broad based attention for the issue of climate change. And politics endorsed the issue. In the past, however, the political response was mostly regional not global.

The debate that may have existed or ensued in science about the credibility of the phenomenon did not do much to affect public opinion. The same may be said for the present-day discussion about global warming.

CONCLUSIONS

Our discussion of climate variability and climate change at the end of the 19th century lead to a number of conclusions which we consider relevant on methodical, theoretical and practical grounds:

(1) The debate on natural climate variability and anthropogenic climate change is not new. A similar debate, almost forgotten today, was going on a century ago. The protagonists were in a situation similar to that of contemporary scientists. Brückner, in particular, reminds as of contemporary "activist" scientists, who are typically splendid scientists in their field. Brückner overlooked that he did not have the expertise to predict the societal response to adverse climatic conditions, to cope with adverse conditions by improving hygiene standards (the typhoid forecast), by perfecting the railway system (the forecast concerning the ice on the rivers) or by allowing for artificial watering of agricultural land (the forecast concerning harvests).

(2) One of the noteworthy features of the early debate on the nature and consequences of climate change among climatologists, geographers and meteorologists is also the degree to which intellectual boundaries among scientific fields even then prevented the participants from incorporating perspectives and findings dealing with exactly the same phenomena that had been advanced in other disciplines. After all, there had been for decades a lively and vigorous debate among philosophers and in the emerging social sciences about the impact of climatic conditions on psychological and social

in the meteorological literature that deforestation reduces precipitation almost always occurs during dry periods while suggestions that forestation increases precipitation occur more frequently during wet climatic periods.

processes. The main assertions of this debate ultimately proved to be inconclusive and were rejected not only as one-dimensional, first at the turn the twentieth century in France and German and later in the United States, but also as irrelevant to the distinctive claims advanced by social science discourse. That is, the domains of the physical and the social milieu had become successfully separated in science.

(3) In the end, however, a consensus emerged among climatologists (e.g., Berg, 1914:67) that in "historical times" the global climate has been constant; that neither a warming trend nor a trend toward less precipitation can be observed. The singular preoccupation in the debate about climate variations one hundred years ago was the periodicity of observed fluctuations in temperature and precipitation, not any secular climate as signaled by an increase in the volume of CO_2 in the atmosphere. That such a possibility, as the result of increased usage of fossil fuels, indeed existed was discussed alongside Brückner's 35-year period theory in a textbook on cosmic physics by Svante A. Arrhenius (1903). However, none of the climatologists of the day took up the challenge. Instead, they agreed that climate change was not a significant matter and soon other issues began to dominate scientific discussions and public discourse.

ACKNOWLEDGEMENT

We are grateful to Volker Meja for his editorial and substantive advice.

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