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Ice Age theory: a correspondence between Milutin Milanković and Vojislav Mišković

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Abstract: Ice Ages (IA) and their glacial periods can be regarded as significant natural hazards (NH). Unfortunately, the knowledge of hominid evolution that occurred during IAs, in such extreme climatic fluctuations, is preserved almost exclusively in mythology. The omission of more scientific discourse regarding the history of NH during IAs should be rectified for posterity. As our civilization will likely have to cope with the beginnings of a new glacial phase, a more complete understanding of the mechanisms of IA climate dynamics is crucial.

This paper presents an unpublished correspondence between M. Milanković, a polymath and the founder of the Astronomical theory of Ice Ages (ATIA), and the astronomer V. Mišković, one of Milanković's major contributors to the development of his theory. Additional insight related to the ATIA by M. Milanković is given, particularly regarding the succession of glacial and interglacial periods on Earth. In this completely preserved correspondence, taking place from 1924 until 1952, also reside letters concerning the research of M. Milanković and V. Mišković as it relates to the research of Alfred Wegener and Wladimir Köppen. These letters are on the topic of M. Milanković's 1920's work. At the Astronomical Observatory in Belgrade, M. Milanković found useful data in the observatory's publications and orchestrated the numerical calculations he needed for his ATIA with V. Mišković aid.

Keywords: Climate dynamic, Glacial periods, Alfred Wegener, Wladimir Köppen, Belgrade Astronomical Observatory

1 Introduction

The Ice Age (IA) can be regarded as an important and interesting geological natural hazard (NH) due to its strong influence on the climate and geomorphology. Altogether, this leads to dramatic changes in the environment, such as its appearance and the lifestyles of plants and animals. Where many species may quickly disappear, many others (including *Homo sapiens*) may make extraordinary efforts to adapt. The waste of glacial landforms all over the globe is preserved and warns that in the future, human civilization may experience such extreme climatic and environmental challenges again [1]. One of the clearest descriptions of this phenomenon can be found in the book “Ice Ages: Solving the Mystery” [2], as:

“Twenty-thousand years ago, the earth was held in thrall by relentlessly probing fingers of ice—ice that drew its power from frigid strongholds in the north, and flowed southward to bury forests, fields, and mountains. Landscapes that were violated by the slowly moving glaciers would carry the scars of this advance far into the future. Temperatures plummeted, and land surfaces in many parts of the world were depressed by the unrelenting weight of the thrusting ice. At the same time, so much water was drawn from the ocean to form these gargantuan glaciers that sea levels around the world fell by 350 feet, and large areas of the continental shelf became dry land. This period in the earth's history has come to be called the ice age.”

It is more than clear that the IA represents potentially catastrophic geological NH, at least from our present-day understanding of extreme phenomena. Due to the present day, temporary absence of glacial period phenomena (the previous glacial period having ended about 12 kyr ago, and there being an ongoing scientific debate regarding when the next glacial period will begin) IA is often omitted from discussions on NH. IA phenomena is almost never clearly categorized and defined as an important natural disaster [3, 4]. Here there will be no discussion of why this is. Instead, the intent is to point out some other important historical moments that have contributed to the IA phenomenon that was explored throughout the yet unpub-

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lished correspondence of Milutin Milanković, the founder of the Astronomical theory of Ice Ages (ATIA) [5], and Vojislav Mišković, a major contributor to the development of this theory.

All unpublished correspondence between these famous individuals attracts great interest. Will they shed a different light on known events, open up as of yet untouched topics for study, or pose new questions? That was the case with the correspondence between M. Milanković and V. Mišković. The unpublished correspondence of these two academicians and Serbian scientists has undoubtedly attracted the attention of their biographers, scientists, and many others. Insight into a majority of their correspondence, that took place from 1924 to 1952, is available as a total of 27 letters as well as numerous picture postcards. Their topics range from the private, to the expert and the scientific. In this paper we present the as of yet unpublished correspondence between M. Milanković and V. Mišković, with the objective of shedding light on M. Milanković's work related to ATIA.

This paper is organized as follows: in Section 2, after the brief biographies of M. Milanković and V. Mišković, we present the beginning of their correspondence; in Section 3 we present comments on letters that mention the scientific collaboration of Alfred Wegener and Wladimir Köppen with M. Milanković. We also cover events regarding the membership of M. Milanković and V. Mišković in the Serbian Royal Academy of Sciences and Arts (SRASA) (Belgrade, Serbia) and the Yugoslav Academy of Sciences and Arts (YASA) (Zagreb, Croatia), as well as lectures that they presented at both academies. The first results suggesting the occurrence of ATIA are discussed in Section 4. In Section 5 we outline some of our reflections on M. Milanković's personality as a man and as a scientist. Finally, Section 6 is devoted entirely to our conclusions.

2 Developing the concept of the Astronomical theory of Ice Ages – a correspondence between Milutin Milanković and Vojislav Mišković

2.1 Brief biographies of Milutin Milanković and Vojislav Mišković

Milutin Milanković (Dalj, Austro-Hungarian Empire [now in Croatia], 1879–1958, Belgrade, Yugoslavia [now in Ser-

bia]), (Fig. 1) graduated from the Vienna College of Technology, obtaining his Ph.D. in 1904. He came to Belgrade in 1909 and became a professor at the University of Belgrade. In the school year 1926/27, he was the Dean of the Faculty of Philosophy and for a short time. From December 1950 to June 1951, he was the Head of the Astronomical Observatory in Belgrade [6]. Milanković was one of the founders of the astronomical and modern mathematical climate modeling [5, 7].

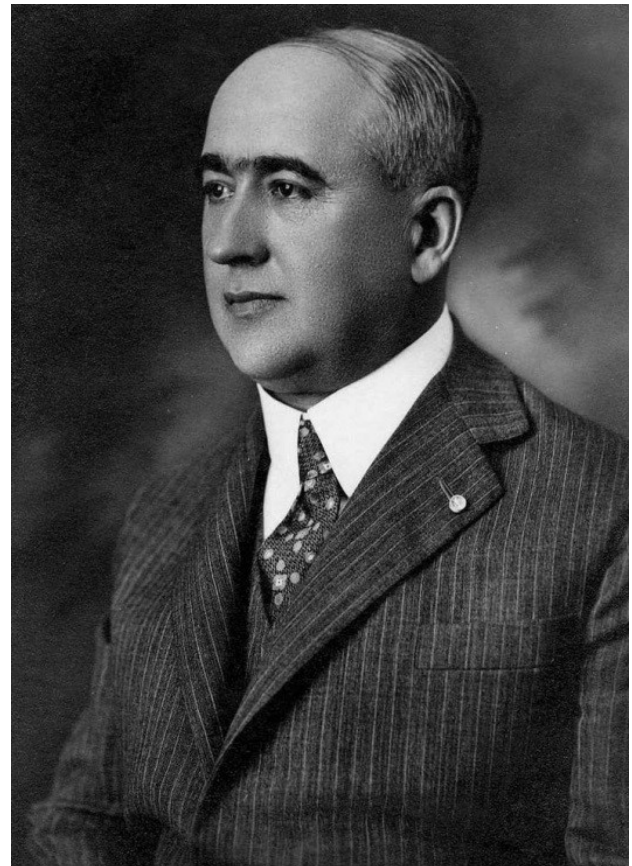


Figure 1: Milutin Milanković (1879–1958), academician, one of the founders of modern climatology and the mathematical modeling of climate.

Vojislav Mišković (Fužine, Austro-Hungarian Empire [now in Croatia], 1892–1976, Belgrade, Yugoslavia [now in Serbia]) (Fig. 2) received his university education and earned his Ph.D. in France in 1924. He worked in observatories in Marseille and Nice. He was elected a member of the Astronomical Society of France (Société Astronomique de France) in 1925. Following the proposal of Milanković in 1925, he was invited and appointed in Belgrade as Associate Professor of Practical Astronomy. He succeeded in raising the work of the Astronomical Observatory to the



Figure 2: Vojislav Mišković (1892–1976), academician, founder and Director of the Astronomical Observatory in Belgrade.

level of the most advanced European observatories of that time, and he led it ambitiously and energetically in two periods 1926–1950 and 1951–1954, what was of invaluable help to M. Milanković during the creation of ATIA.

2.2 Milutin Milanković and Vojislav Mišković's correspondence of 1924

M. Milanković and V. Mišković met in person in Belgrade in October 1923 [8]. Their intensive correspondence began in 1924, as M. Milanković spent most of his time in Belgrade, and V. Mišković was employed from 1922 to 1925 at "Observatoire du Mont Gros" in Nice, France.

From the first letter that V. Mišković sent to M. Milanković on January 4, 1924, it is evident that Milanković intended to deliver a lecture in France at the Astronomical Society of France. The appropriate person to negotiate this with was the French astronomer Aymar de la Baume Pluvinel (1860–1938), a member of the Astronomical Society of France and its president at the time (from 1913 to 1919).

From the correspondence, it is not clear how the lecture was going to be arranged – seemingly by V. Mišković himself. The authors also do not have any record of whether that lecture actually took place.

January 4, 1924, Observatoire du Mt. Gros, Nice

Dear Professor (M. Milanković, author's note),

I avail myself of the occasion of the beginning of the New Year to send you these few lines as an expression of my honest and best wishes. At the same time, allow me to briefly mention to you the topic we talked about during my stay in Belgrade. Short before my leave you told me to wait with asking information from Mr. De la Baume Pluvinel about the way of organizing your lecture at the Soc. Astr. de F. (Note of the author: Société Astronomique de France). If I can be of any help in this, please do not forget that it is necessary for me to know when and in what range you would want me to pose questions to them. And I hope that it will be favorable. Please accept the expressions of my utmost respect.

V. Mišković

Knowing about the cooperation of V. Mišković with M. Milanković, some scientists addressed V. Mišković with appeals to receive copies of a few scientific papers by M. Milanković that they wished to study. One of them was Gaston Fayet (1874–1967), Director of the Observatory Mont Gros in Nice, who asked for a reprint copy of a paper about solar radiation. Regarding the request, V. Mišković informed M. Milanković about it in a letter dated September 28, 1924.

September 28, 1924, Bourg S. Maurice (Savoie) Dear Professor (M. Milanković, author's note),

...

I would finally like to make another appeal to you. The Director of our Observatory, Mr. G. Fayet, would like to get acquainted with your work on solar radiations and he would appreciate if you could send him a copy of it.

Appreciating in advance your kindness and the favor you would do if you would like to reply to this letter (by registered mail), dear Professor, please accept the expressions of my loyalty and my best respect.

V. Mišković

This letter by V. Mišković does not mention the exact title of the paper that G. Fayet was interested in, but it was probably (to the best of the authors' knowledge) the paper "The Mathematical Theory of Heat Phenomena Caused by Solar Radiation" [9].

M. Milanković immediately fulfilled the request of G. Fayet and informed V. Mišković about it in the post scriptum of his October 4, 1924 letter, saying that he had sent the paper on that same day, October 4, 1924.

3 A correspondence regarding cooperation between Milutin Milanković, Alfred Wegener, and Wladimir Köppen

3.1 The Congress in Innsbruck

The first personal contact of M. Milanković with A. Wegener (1880–1930) was in Innsbruck, Austria [10]. Before that, M. Milanković had corresponded in writing with him and his father-in-law W. Köppen (1846–1940). Due to familial reasons, M. Milanković hesitated in attending the Congress of German Naturalists and Physicians that was to be held at the end of September in 1924 in Innsbruck. He eventually decided to go, after being informed that the famous A. Wegener would deliver a lecture there on September 25 [11].

W. Köppen and A. Wegener completed their important book, “*Climates of the Earth's Past*” [12], in 1924, just in time for the Congress. In that way, A. Wegener was able to place the publication triumphantly on the lectern [11]. Greene [10] wrote: “It is because of Milankovich that we know about Wegener at Innsbruck”.

A. Wegener's paper contained a chapter in which M. Milanković presented his method and calculation results. Previously, the work of M. Milanković was only somewhat known to the scientific community, especially his insolation curve of the surface of the Earth. Serious attention and wide acceptance followed after W. Köppen and A. Wegener included M. Milanković's work in their book, especially after Wegener's lecture at the Congress in Innsbruck.

A few days after the Congress, on September 27, 1924, M. Milanković wrote a letter to A. Wegener [10] saying that the lecture stimulated his interest in many topics and asked how could he obtain a copy of A. Wegener's work “*The Origin of Continents and Oceans*” [13]. M. Milanković also asked for a copy of Wegener's Innsbruck lecture, so that it could be published in French and in Serbian [10], which shows that M. Milanković had plans to publish it in France and counted on the help of V. Mišković to do so.

In a letter dated December 17, 1924, M. Milanković informed V. Mišković, for the first time, about A. Wegener, his work, and the Congress in Innsbruck (Fig. 3). In the same letter to V. Mišković, M. Milanković mentioned a paper written by the Robert W. Sayles (1878–1942) who worked at the University Museum at Harvard in Boston, USA. However, M. Milanković stated that the paper was inferior when compared to A. Wegener's. That paper was first published in English with the title “*Dilemma of Paleocli-*

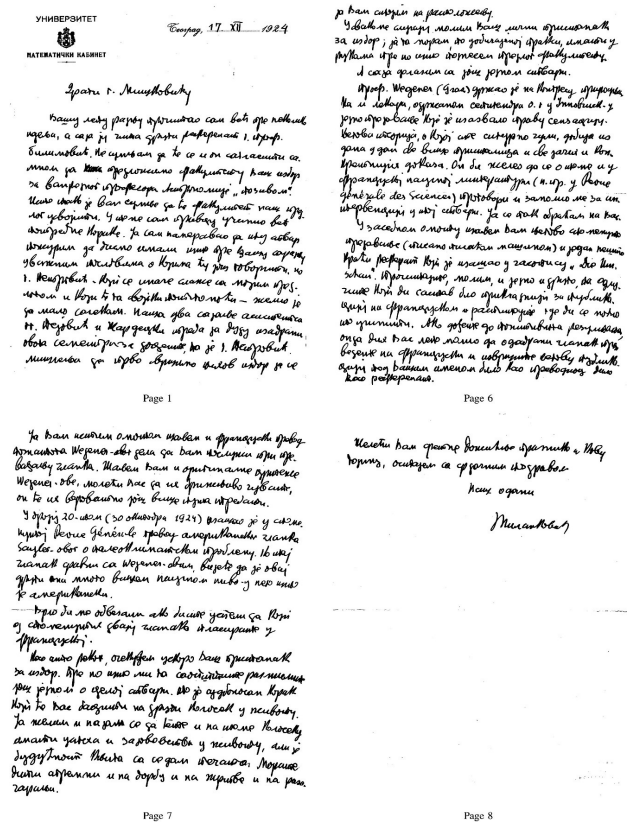


Figure 3: Facsimile of a part of the letter (in Serbian Cyrillic), dated December 17, 1924, that Milutin Milanković sent to Vojislav Mišković, discussing for the first time Alfred Wegener and the Congress in Innsbruck.

matologists” [14] in June 1922. In it, R. B. Sayles wrote that many hypotheses on IAs came and went, but those with the greatest staying power were those stating that changes in the warming of the Earth were linked to either the activity of the Sun or volcano eruptions that threw out great quantities of dust into the atmosphere [14].

17 December 1924, Belgrade

Dear Mr. Mišković,

...

I will now present another topic.

At the Congress of Natural Scientists and Physicians held in September this year in Innsbruck (Austria), Professor Wegener (Graz, Austria) gave a lecture that caused a real sensation. His theory, as you had probably heard, kept attracting all the more adherents every day and all the more strong and concrete evidence. He would like to see it in the French scientific literature (e.g., in *Revue Générale des Sciences*) and he asked in that matter for my translation. I, for myself, address you. Under a separate cover I am sending you his letter that I mentioned (typed on a typewriter) and one somewhat short paper that was published in the mag-

azine “Die Umschau.” Please read them both and decide which paper would be more appropriate for publication in French and find out where it could be done. If you deem it positive, I kindly ask you to translate the chosen paper into French and publish it with your name as translator or reviewer.

In this letter I am also sending you the French translation of another famous paper of Wegener to help you with translation. I am also sending you original drawings of Wegener, kindly asking you to take good care of them because he will probably need them on many more occasions.

In the issue No. 20 (of 30 October 1924), a translation of an American paper by Sayles on the paleoclimatic problem was published in the mentioned *Revue Générale* (“Dilemma of Paleoclimatologists”). Whoever compares this paper with the article of Wegener will see that the latter is at the much higher scientific level than the American one.

I would be very much obliged to you if you could manage to present any of the mentioned papers in France.

Sincerely yours,

Milanković

V. Mišković wanted to do what M. Milanković had proposed in a letter dated December 17, 1924 and immediately contacted the editor of the journal *Revue Générale des Sciences*. However, it became evident that it did not go as he and M. Milanković had planned.

Philippe Le Vigouroux [15], in his paper “The First World War and Its Consequences on the Acceptance of Wegener’s Theory in France”, said that bilateral scientific relations with Germany became colder immediately after the First World War. The Allied institutions organized a boycott of German scientists, and the behavior of French scientists was completely in accordance with that trend. Driven by the wish to renounce German scientists, they wrote pamphlets, and that sentiment was reiterated during the International Geological Congress that took place in Brussels in 1922 [15]. This can shed more light on the content of the letter written by V. Mišković to M. Milanković on December 31, 1924.

Nice, December 31, 1924.

Dear Professor (M. Milanković, author’s note),

...

I am now coming to the topic on which I should give you my answer. Concerning the work of Prof. Wegener, I promise to read it as soon as possible, and on the basis of that I will edit the paper about him. The idea about the translation of the article from “Die Umschau” does not look promising, and here is why. The very analysis of a German paper in French magazines is not very popular here, and plus there is a strong reason against the translation of a German analysis of a German paper (V. Mišković underlined the words

in the letter, author’s note). We have a very favorable contribution to our cause—and let us use it: Wegener’s paper was also published in French by the publisher Blanchard. In that form, the publication of my paper in any of these *Revue*s cannot be met by any difficulties or obstacles. And as I said, you can deem this issue solved. I am still engaged in this mission, there are two spots in the Mediterranean Sea, but even with this, I promise you that this matter will not be late....

Yours,

Mišković

However, Wegener’s paper translated to French by Manfred Reichel was published by the publisher Blanchard in 1924 [16]. In a subsequent letter, V. Mišković stated he was still fully dedicated to carrying out M. Milanković’s plans of publishing the papers of A. Wegener in French journals.

Nice, January 18, 1925

Dear Professor (M. Milanković, author’s note),

I am writing to you about the paper of Wegener. As much as I was considering it a pleasant duty to carry out the mission that you gave me, today it is somewhat less pleasant to have to write about it in this way. As I had already said in my last letter, I edited one paper of about 4–5 pages of Wegener’s lectures and according to your wishes I sent it to Dr. Magnin, editor of the *Revue gen. des sciences*. I am sending you the original of his letter that I received two days ago as the reply to my demarche.

He says that in No. 30 of 1922, there was quite a long article of Mr. Gagnebin on Wegener’s papers. Besides that, there is already an article in print by M. Gignoux about the same topic. He deems that the readers of *Rev. gen. des sc.* have been sufficiently exposed to Wegener’s theory and papers. Do you want to try with other magazines? Of course, less important and more popular than *Rev. gen.* In my opinion it can be done. Take out from Wegener’s papers the arguments which relate to astronomical topics like the variations of latitude and longitude and publish an article about it either in the *Bull. de la Soc. Astr. de la France* (note of the author: *Bulletin de la Société Astronomique de France*) (Flammarion) or *Belge*. Please make a decision and inform me as soon as possible, and I shall do anything I can on my part. Expecting your reply, dear Professor, I am extending to you the expression of my loyalty and my sincere respect.

Mišković

Unfortunately, the ideas of M. Milanković and V. Mišković and their intention to publish these papers were met with difficulty. The same situation occurred with Wegener’s theory, first discussed in France only when it was presented by the Swiss geologist Elie Gagnebin (1891–1949) [15] in the article mentioned by V. Mišković [17]. The

article that V. Mišković stated as being in print, was written by geologist Maurice Gignoux (1881–1955).

Belgrade, January 19, 1926

Dear Mišković,

...

Yours truly,

Milanković

P.S.

I would like to withdraw my article, that is, your translation of it that I had sent to Bull. de la Soc. Astr. de France (author's note: Bulletin de la Société Astronomique de France) because in recent months (the paper of Soergel and the article of Schoenberg) brought the results that significantly overcame what I had presented in that article. What is your opinion of that?

Wolfgang Soergel (1887–1946) studied the stratigraphy of the IA and the significance of periglacial deposits, like loess and gravel terraces, on the river Ilm, southwest of Leipzig (Germany) and the river Saale. He carried out calculations and found out that there had been a succession of 11 periods of cold summers and 11 periods of hot summers. He published these findings as an article titled “*The diluvial terraces of Ilm and their importance for subdividing the Ice Age*” [18] and published data regarding the correlation between relief landforms and the radiation curves of M. Milanković [19].

Some of M. Milanković's other contemporary colleagues also recognized great potential in applying his orbital calendar to solve the problem of loess-palaeosol sequences chronostratigraphy in the Danube Basin [20]. Serbian geologist Vladimir Laskarev [21] and Hungarian scholar Gyula Bacsák [22] were the first to use M. Milanković's IA calendar to calculate the length of Pleistocene environmental phases, recorded in Danube loess-paleosol sequences [23]. These studies were highly innovative for their time, despite inadequate correlations of paleosols and loess units, according to the sequence of ‘cold’ and ‘warm’ stages as defined by M. Milanković's insolation variations [24, 25].

3.2 An invitation to contribute to “*Handbook of Climatology*”

In 1927, W. Köppen and A. Wegener sent M. Milanković an invitation to collaborate [26]. M. Milanković asked V. Mišković to help with calculations, which V. Mišković then accepted. When V. Mišković finished his part of the work, he personally handed those calculations to M. Milanković at the end of the November of 1929 [11].

M. Milanković completed his work and on May 4, 1930, traveled to Graz to see W. Köppen, and deliver his manuscript personally. W. Köppen examined it and immediately realized its significance, sending it to Berlin to be included as an introduction to the “*Handbook of Climatology*” [11, 27]. This paper of M. Milanković's was also treated as an independent scientific paper, thus the Gebrüder Bornträger publishing company published it also as a separate book, “*The Mathematical Science of Climate and Astronomic Theory of Climate Variations*” [28].

At the Astronomical Observatory in Belgrade, there were three pinwheel desktop mechanical calculators, the most advanced mechanical calculating instruments of that time. Two of them are still in possession of the Astronomical Observatory today: the *Original Odhner Göteborg*, serial number 11-133296, made in Sweden, and the “*Brunsviga*” *System Trinks*, manufactured in Germany by Grimme, Natalis & Co. AG, Braunschweig, serial number 64117 (Fig. 4) [29]. Those calculators were used for many important numeric calculations in the fields of astronomy and climatology, among them the calculations that served M. Milanković as a foundation for his, nowadays well-known and widely accepted, ATIA [11].



Figure 4: Desktop mechanical calculators on display at the library of the Astronomical Observatory in Belgrade (Photo: N. Janc, June 2015).

For the calculations presented in the publications of the Astronomical Observatory, such as “*Yearbook*”, V. Mišković used those same machines (Fig. 5).

Mathematical Institute of the University, Belgrade, November 24, 1930

Dear Mišković,

Perusing through and reading your “Yearbook”, I noticed that one part of your tables could be used in my arti-

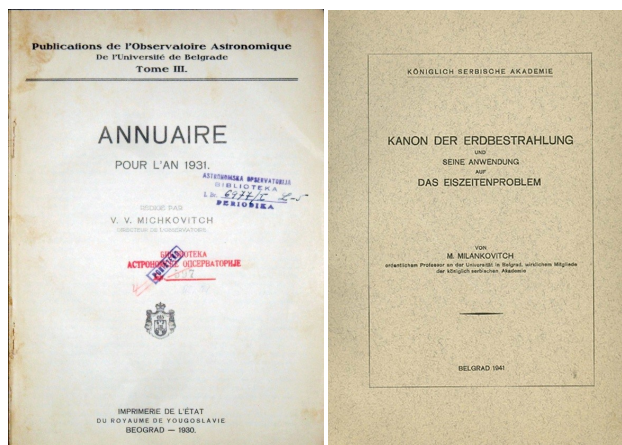


Figure 5: Title pages of the *Yearbook of the Astronomical Observatory for 1931* and Milanković's *Kanon der Erdbestrahlung* from 1941.s

cle “Drehbewegungen der Erde” (author’s note: *Rotational movements of the Earth*) for “*Handbuch der Geophysik*” (author’s note: *Handbook of Geophysics*) on which I am currently working. I marked those tables and also figures on the enclosed list. Some of the tables could be even better used if processed in more detail, for example, Table 5: *Lange Tage und Nächte der Polarzonen* (author’s note: *long days and nights in the polar zones*). The research of polar areas by scientific expeditions and scientific studying of obtained results are very intense now, thus, it would be interesting to have in the *Handbuch* data as detailed as possible on mentioned phenomena. As for tropical zones, it would be interesting to give data on the days of passing of the Sun through the zenith and about the length of such days.

That is why I would kindly ask you to edit for me the marked tables for “*Handbuch*” and process them as needed. We will talk more about this, and I am sending this letter so that you would have more time to think about it before our conversation.

I would need these tables for the second half of December. Having confidence in your tested assistance, I thank you in advance, with the most cordial greetings.

Yours, Milanković

A separate list by M. Milanković, with the names of tables that were interesting to him, was enclosed with the letter but was not saved. M. Milanković consulted and delegated V. Mišković to perform any necessary calculations. For his collaborators, V. Mišković chose Dragoslav Mitrinović (1908–1995) and Stanimir Fempl (1903–1985). V. Mišković, D. Mitrinović, and S. Fempl made calculations of the secular changes of astronomic elements of the orbit of the Earth, covering the past 600,000 years [11].

D. Mitrinović was at the Astronomical Observatory from 1926 until the end of 1934. In December 1928, the Secretary of Education was asked to assign Mr. S. Fempl to the Astronomical Observatory. S. Fempl was a math teacher’s assistant at a high school in Pančevo (a city in Northern Serbia, located at the mouth of the river Tamiš into the Danube) at that time. V. Mišković deemed him to be of exceptional worth, as when S. Fempl was a university student, he also attended lectures in astronomy and could help with many projects. He could help V. Mišković with lectures and lab exercises for attendees, partake in night sky observations, and help with preparations for the publication of the “*Yearbook*” an international obligation of the Observatory [30]. D. Mitrinović and S. Fempl later became renowned professors at the University of Belgrade, as well as authors of numerous university-level mathematical textbook.

M. Milanković became a full member of the SRASA in 1925. Five years earlier, he was elected as its corresponding member, and also as a corresponding member of the YASA [11]. In a letter from Nice written on February 2, 1925, V. Mišković wrote to M. Milanković asking him if he could send him his lecture on A. Wegener’s work after delivering it to the Academy”.

M. Milanković held his inaugural speech to the Academy on the topic “*A Calendar of the Earth’s Past*” at the annual meeting on March 7, 1925. In his lecture he talked about how his cooperation with W. Köppen began and about the results that A. Wegener presented at the Congress in Innsbruck. An agreement was made that V. Mišković would translate M. Milanković’s speech into French, which V. Mišković then did, informing M. Milanković of the accomplished task in a letter dated June 8, 1925.

Nice, June 8, 1925

Dear Professor (M. Milanković, author’s note),

I did not waste time:

I immediately started working on the translation of your lecture and now, after ten days of polishing it and copying it, I think that you will be satisfied.

I must admit, though, that I am not at my best in this kind of translation. Our mathematical text is much easier for me, and on the other hand, I found some terms that were quite unfamiliar to me. So, for example, on page 9, I could not find an appropriate French expression for “optimum” and also I am not sure that the French call glaciation “glaciation” (but they understand the word). Our astronomers here, and even the Director, do not have much knowledge about it. I hope that my translation is completely understandable. A propos to these ideas, have you seen in

Revue Scientifique the article of Boccardi related to Wegener's theory?

V. Mišković

In July, from Semmering, Austria, M. Milanković wrote and thanked V. Mišković for his efforts and his successful translation, stating that he had to change only a few technical terms. V. Mišković replied with apologies for the errors and mistakes of a technical nature, as M. Milanković “took his attention from the skies and lowered him into the glaciers of prehistoric Ice Ages”.

M. Milanković presented the most important results of his work on May 26, 1930 in the SRASA. It was afterwards published as a paper entitled: “*The Astronomical Theory of Secular Variations of Climate*” [31].

4 Astronomical theory of Ice Ages – the first results

At the invitation of W. Köppen, M. Milanković wrote a new paper in 1929, where he stated that he intended to study secular insolation changes on a large number of parallels on the northern and southern hemispheres. He consulted V. Mišković and delegated the performing of calculations to him. For collaborators on that project, V. Mišković chose D. Mitrinović and S. Fempl. On the basis of those calculations, M. Milanković completed his work [11, 27, 28, 32].

M. Milanković presented the most important results of his research on May 26, 1930 at the SRASA. Afterwards, it was published as a paper titled: “*The Astronomical Theory of Secular Variations of Climate*” [31] a paper that created the perfect conditions for the establishment of a final version of the ATIA that appears dozens of years later [5].

5 Discussion

In addition to their correspondence and scientific cooperation, M. Milanković and V. Mišković had other qualities in common. They were both from the Austro-Hungarian Empire, were both educated at prestigious universities (Vienna and Paris), and both opted to build their scientific careers in Serbia/Yugoslavia, a region that, along with other small and less developed areas, rushed to join the larger community of European nations working on modern scientific developments. Both of them helped work towards that goal. Their determination was far from some blind patriotism, but was rather simply to show the scientific results that they achieved. The ATIA was far from

a project to raise the level of university education in Serbia/Yugoslavia, but rather represented a work of exceptional value in and of itself. They exhibited, through their own work, that a modest but capable person can achieve exceptional scientific results even when working in a less prestigious or less well-funded province.

The elite education of polymath M. Milanković was similar to that of the great Renaissance minds. He wrote several popular literary works covering various topics in science, for example: “*Through Space and the Centuries*”, “*In the Realm of Science*”, “*Isaac Newton*”, “*The Personality of Mihailo Petrović*”, “*Pythagoras and His School*”, and “*Memories, Adventures, and Gaining Insight from 1909 to 1944*” [33].

From his formal education as a civil engineer and constructor, a career path that sharpened his methodical and meticulous approach to defining and solving problems, to his status as an elite mathematician with an above average perception of space, M. Milanković devoted his full attention to the implementation of all his skills and talents in his research efforts on the climates of the Earth and Mars. It was a long journey that lasted several decades, and a full appreciation of his success came only posthumously.

There are many examples in the history of science of ingenious scholars not being properly recognized in their time. Milanković's heliocentric theory irritated his egocentric, geo-scientist peers. For instance, the likes of Albrecht Penck (1858–1945) and Richard Foster Flint (1902–1976), during his participation at the 3rd and 4th Congresses of the International Union for Quaternary Research (INQUA) in Vienna and Rome [34]. According to [35], M. Milanković, in 1953 returned from the fourth Congress of INQUA (the International Association for the Study of the Quaternary) in Rome very depressed. At the congress, several individuals were loudly and unprofessionally contesting his theories; even the Chairman, famous American scholar R. F. Flint, interrupted his speech because he exceeded the allotted speaking time [34, 35]. M. Milanković died in 1958 with this great bitterness. Only someone of extraordinary perseverance could endure living a life with such frequent challenges, particularly when he was absolutely confident in the correctness of his ideas and work.

M. Milanković and V. Mišković lived relatively long lives. However, being 13 years older, M. Milanković could not see that interest for his ATIA was spreading worldwide. Luckily, V. Mišković lived to witness that Pleistocene stratigraphy everywhere in the world had begun to reflect the same climatic rhythm defined in the ATIA [36, 37]. The contributions of V. Mišković and other younger collaborators became recognized much later than the initial publication dates of M. Milanković's main studies. According

to current customs and rules in scientific publications, V. Mišković could even be listed as a co-author in some present-day studies.

It is interesting that hominid evolution occurred during the dramatic climatic fluctuations of the Quaternary IA. For example, anatomically modern humans became dominant over Neanderthals on the European continent during the abrupt climatic shift from a warm to cold stage, associated with a huge volcanic eruption that was estimated to have occurred about 40,000 years ago [38, 40]. The development of prehistoric cultures and civilization at large is related to the present interglacial Holocene [40]. Up until now, humans adapted to both cold and warm modes of climatic variation. What will happen in the future when humanity experiences the challenges of the next glacial period? The ATIA, as established by M. Milanković and his associates, is a good base to utilize in the proper forecasting of the next glacial period. This is crucial for securing adequate preparations in anticipation of the devastating consequences mankind may face in future.

Milanković's theory (ATIA) based on celestial mechanics represents the culmination of two-centuries-long effort to open the most reliable view over the climate change problem based on orbital geometry dynamics [31]. In 1976, global paleoclimatic project CLIMAP (Climate Long-Range Investigation, Mapping and Prediction) proved geologically the relevance of Milanković's orbital forcing of climate changes. The Pleistocene stratigraphy everywhere in the world reflects the effect of the three astronomical cycles [37]. Even older geological cycles of various marine and continental records have the same climatic rhythm. Therefore, Milanković using numerical modeling has started an overall synchronization of celestial mechanics and geological dynamics preserved in worldwide distributed different types of geological deposits [34].

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