

# A Passenger Through the Ice Ages:

## Milutin Milankovitch (1879 – 1958)

by Milos Rastovic

One of the most difficult riddles in the history of Earth science is: what has caused the changes to the Earth's climate since the Ice Ages? Milutin Milankovitch—a Serbian geophysicist, climatologist, astrophysicist, and mathematician—is best known in the history of science for postulating the most significant theory ever made for the cause of the Ice Ages. His theory relates to the long-term climate changes to the Earth's orbital motion.

NASA, the United States National Aeronautics and Space Administration, has ranked Milankovitch among the 15 best scientists in history, those who have shaped our civilization<sup>1</sup>. Peter Huybers, a professor of Earth and Planetary Sciences at Harvard University, tested many hypotheses about climate changes, and he confirmed the one proposed by Milankovitch. The astronomical or orbital rotation theory, the Milankovitch Theory of Climate Changes, states that slow changes and variations in the Earth's orbit throughout history coincide with the periods of deglaciations, the gradual melting away of glaciers, over the past million years. According to Huybers:

"These periods of deglaciation saw massive climate changes... We ought to understand what caused these massive changes in past climates if we are to predict long-term changes in future climates with any confidence. And at least now we know with greater than 99 percent confidence that interaction between obliquity [the changing angle] and precession [motion in the direction of the earth's axis

of rotation] are among the factors that contribute to deglaciation."<sup>2</sup>

Through experimentation, Huybers tested the connection between the Earth's orbital cycles and deglaciations. He constructed glacial cycles and added similar distortions to geological data, such as noise and errors in timing. He explained the results:

"At the same time we're seeing high obliquity, we also tend to get an alignment with precession whenever deglaciation occurs... When you get that alignment, the radiation that the Northern Hemisphere receives during summer increases by tens of watts per meter squared, and if large Northern ice sheets are present, they tend to disintegrate. These statistical findings agree exactly with what Milutin Milankovitch, a Serbian geophysicist, proposed in the first half of the 20th century... It could also be that orbital forcing causes a rise in atmospheric CO<sub>2</sub>, and that it's the increased CO<sub>2</sub> that drives the loss of ice sheets."<sup>3</sup>

Milankovitch's hypothesis concerning the causes of the Ice Ages is based upon claims made in the 19th century by French scientist Joseph Adhemar and Scottish scientist James Croll. Adhemar suggested that glaciation occurs when long winters coincide with the Earth's aphelion, the farthest point in the Earth's orbit around the Sun. Croll, however, proposed that glaciation occurs whenever the Earth's aphelion coincides with times during the winter when the intensity of insolation, or solar radiation, is weakest.

In the journal *Nature*, Huybers with Maureen E. Raymo, a Professor of Earth Sciences at Boston University, further described Milankovitch's suggestion about the influence of the Earth's orbit on the glaciation, or the times when the Earth is covered by glaciers:

"He [Milutin Milankovitch] argued that glaciation occurs when insolation [solar radiation] intensity is weak at high northern latitudes during summer. This happens when both Earth's spin axis is less tilted with respect to the orbital plane and aphelion coincides with summer (not winter) in the Northern Hemisphere. According to Milankovitch, when there is less insolation during the summer, snow and ice persist through the year, gradually accumulating into an ice sheet."<sup>4</sup>

While Huybers was the first to test the connection between the Earth's orbital cycles and deglaciations, Milutin Milankovitch was the first to launch and mathematically prove this hypothesis in the first half of the 20th century.

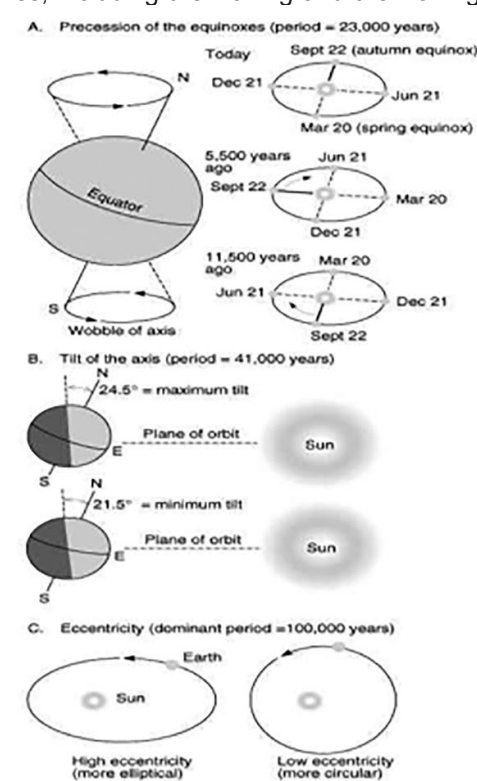
Milankovitch's theory claims that a dom-



inant factor in Earth's orbital motion around the Sun is cyclic variations and interaction between the Earth and the Sun. According to Milankovitch, there are three basic elements of these cyclic variations throughout history:

1. Earth's eccentricity (departure from circularity) in which the Earth changes its circular orbit to the elliptical (a period of 105,000 years),
2. Obliquity -- changes in the angle (axial tilt) with respect to the plane of the Earth's orbit (a period of 41,000 years), and
3. Precession through time -- changes in the direction of the Earth's axis rotation (a period of 22,000 years).<sup>5</sup>

Milankovitch posited that these three elements of cyclic variations have an effect on the long-term Earth's climate changes, including the waxing and the waning



of the Ice Ages. Today, this theory of the three factors is known collectively as the Milankovitch Cycles.

Milankovitch was born on May 28, 1879, in the town of Dalj, Slavonia, which was part of the Austro-Hungarian Empire, but it is now located in present-day Croatia. According to his autobiography *Recollection, Experiences and Vision*, his ancestors had lived in Dalj for two and a half centuries. The third generation of his family was intellectuals, including his grandfather Todor, who finished Law School<sup>7</sup>. Milan Milankovitch, Milutin's father, was a landlord, merchant, and local politician who died when Milutin was six years old. Jelisaveta, Milutin's mother, and his uncle, Vasa Maucevic, subsequently raised Jelisaveta's six children. Three of them died from tuberculosis in their youth. Because of his own poor health, Milankovitch received his elementary education at home from private teachers, friends, and relatives such as his grandfather, Uros Milankovitch, who was a renowned philosopher.

After attending high school in Osijek, Milankovitch studied civil engineering at the Vienna Institute of Technology. In 1904, he received a Ph.D. in technical science. While working as an engineer in Vienna, he registered six innovations and designed many bridges, aqueducts, and power plants in Austro-Hungary.

Despite a very successful career as an engineer, Milankovitch reached a turning point in his life in 1909 when he accepted an offer from Serbian scientists Jovan Cvijic, Mihailo Petrovic, and Bodgan Gavrilovic and became a professor of rational mechanics, celestial mechanics, and theoretical physics at the University of Belgrade. While he continued to design bridges and other structures in Serbia, he mostly focused his research on the long-standing puzzle of the Ice-Ages, insolation, and the Earth's temperature.

In 1914, when World War I broke out, Milankovitch was in his native Dalj on his honeymoon with his wife Hristina Topuzovic, an opera singer. The Austro-Hungary authorities arrested him because he was a Serbian citizen, and he was put in a prison camp in Nezider. Milankovitch described his life in prison in this way:

"The heavy iron door closed behind me... I sat on my bed, looked around the room and started to take in my new social circumstances... In my hand luggage which I brought with me were my already printed or only started works on my cosmic problem; there was even some blank paper. I looked over my works, took my faithful ink pen and started to write and calculate... When after midnight I looked around in the room, I needed some time



1. See NASA Earth Observatory, [http://earthobservatory.nasa.gov/Features/category.php?cat\\_id=13](http://earthobservatory.nasa.gov/Features/category.php?cat_id=13)

2. Reuell, Peter. "Of Orbits and Ice Ages: Researcher Confirms That Axis Shifts Help to Propel Temperature Changes." *Phys.org*, January 11, 2012. <http://phys.org/news/2012-01-orbits-ice-ages-axis-shifts.html>

3. Reuell, Peter. "Of Orbits and Ice Ages: Researcher Confirms That Axis Shifts Help to Propel Temperature Changes." *Phys.org*, January 11, 2012. <http://phys.org/news/2012-01-orbits-ice-ages-axis-shifts.html>

4. Raymo E., Maureen, and Huybers, Peter. "Unlocking the Mysteries of the Ice Ages." *Nature*. Vol. 451, January 17, 2008.

5. See NASA Earth Observatory. *On the Shoulder of Giants: Milutin Milankovitch (1879-1958)*. <http://earthobservatory.nasa.gov/Features/Milankovitch>

6. Pitman, D. Sean. "Milankovitch Cycles and the Age of the Earth." July 2006, <http://www.detectingdesign.com/milankovitch.html>

7. Milankovic, Milutin. *Uspomene, Doživljaji, Saznanje*. Zavod za Udzbenike i Nastavna Sredstva, Belgrade, 1997, page 10.

8. See [http://en.wikipedia.org/wiki/Milutin\\_Milankovic](http://en.wikipedia.org/wiki/Milutin_Milankovic)

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## Milutin Milankovitch (1879 – 1958)

to realize where I was. The small room seemed to me like an accommodation for one night during my voyage in the Universe.”<sup>8</sup>

When Milankovitch's Professor, Emanuel Czuber, from the Vienna Institute of Technology heard that his former student was in prison, he immediately intervened. As a result, Milankovitch was sent to Budapest where he spent a great deal of time in the library. After World War I (1914 – 1918), Milankovitch returned to Belgrade and continued to work as a Professor at the University of Belgrade until his retirement in 1955.

In addition to his theory of climate change, he also made a major contribution to revising two of the most widely used calendars in the Western World – the Julian and the Gregorian. In 1923, at a congress of all of the Eastern Orthodox churches held in Constantinople, Milankovitch proposed a revision of the old Julian and Gregorian calendars.

According to Milankovitch, in the next 900 years, seven leap years should be removed from the Julian calendar. Instead of the 225 leap years, which were in the old Julian calendar, there should be only 218 leap years, because every 128 years the Julian calendar delays for one day. He also found that the Gregorian calendar was not exact because it lost one day every 3,300 years.

For Milankovitch, leap years have to be divisible by four without a remainder. Secular years can be leaped if the number of their centuries is divided by ten, with a remainder of two or six. As a result, Milan  
*continued from page 13*

kovitch's year is 365. 24222 days, which is very close to the tropical year (a complete cycle of season) of 365.24219 days. The difference between Milankovitch's findings and the tropical year is only two seconds per year. Or rather, in the next 43,200 years the difference will be only one day. For this reason, Milankovitch's calendar is the most exact calendar in human history. Although the Eastern Orthodox churches accepted his calendar, it was never implemented.

Among the many books he had published, the *Canon of Insolation on the Earth and Its Application to the Problem of the Ice Ages* was the most important. In this book, he explained his crucial theory proposed in the 1920th, later known as Milankovitch Theory, about the cause of climate change, the relationship between insolation and atmosphere, and the Ice Ages. According to Milankovitch, the Earth's orbit around the Sun varies be-



tween circular and elliptical in a 105,000 year cycle. When the Earth's orbit around the Sun is more elliptical, there is a greater distance between the Earth and the Sun. Consequently, the Earth when in perihelion (the closest point to the Sun) is warmer than in aphelion (the farthest point from the Sun). He also found that a smaller angle of the Earth's axis means less seasonal differences. By contrast, a greater angle of the Earth's axis means a warmer summer and cooler winter.

Unfortunately, Milankovitch Theory was neglected for more than 50 years until J. D. Hays, John Imbrie, and N. J. Shackleton published a paper in 1976 in the journal *Science*. They found that Milankovitch Theory corresponded to the periods of climate changes.<sup>9</sup> As a result, the National Research Council of the U.S. National Academy of Sciences confirmed Milankovitch Theory in 1982:

“...orbital variations remain the most thoroughly examined mechanism of climate change on time scales of tens of thousands of years and are by far the clearest case of a direct effect of changing insolation on the lower atmosphere of Earth.”<sup>10</sup>

By the beginning of World War II in 1941, Milankovitch was 63 years old. During the war, he published another autobiography-- *Recollection, Experiences and Vision*, and the popular science history books *Through Space and Centuries* and *Through the Realm of Science*. About his scientific work, Milankovitch said:

“In my scientific vocation I have found a pleasant shelter, by which I was protected from much turbulence that shook the world. Under that roof I have prepared and equipped my scientific workshop, segregated from the wider world but in constant spiritual connection with famous

scientists, I have created my scientific area, my indisputable spiritual property. In this workshop I have spent forty years including short breaks writing and publishing my papers.”<sup>11</sup>

After the war, Yugoslavia was under Communist regime. While Milankovitch's only child, Vasko, immigrated to Australia, Milankovitch and his wife Hristina decided to stay in Yugoslavia.

Milankovitch was a member of the Serbian Academy of Sciences and Arts, the Yugoslav Academy of Sciences and Arts, and the German Academy of Naturalists “Leopoldine” in Halle. In the recognition of Milankovitch's contribution to science, the International Astronomical Union (IAU) named after Milankovitch a crater on the moon in 1970, a crater on Mars in 1973, and a main belt of asteroids, discovered in 1936 (1605 Milankovitch)<sup>12</sup>. Since 1993, the Milutin Milankovitch Medal has been awarded for contributions in the field of climate by the European Geophysical Society.<sup>13</sup>

Milankovitch died on December 12, 1958 in Belgrade, and was buried in Dalj. Today, his house in Dalj is the Milutin Milankovitch Cultural and Scientific Center, which promotes the legacy of Milankovitch by organizing cultural and scientific events, and by popularizing science.

Two international symposiums, one in 2004 and another in 2009, were organized under the patronage of the United Nations Educational Scientific and Cultural Organization (UNESCO) in honor of Milankovitch's scientific achievements. In 2012, because of Milankovitch's great contribution to science, the Serbian National Bank issued a bill with his image.

In 2012, Andre Berger of the Universi-

te de Catholique Louvian in Belgium, Fedor Mesinger of the Serbian Academy of Sciences and Arts, and Djordje Sijacki of the University of Belgrade edited a volume entitled *Climate Change*, a compilation of the papers presented at the 2009 international symposium honoring Milutin Milankovitch. In it, they wrote the following dedication to Milankovitch's legacy:

“Thus, understanding paleoclimate, following in the footsteps of Milankovitch not only adds to our basic knowledge of the history of the world we live in, but it also adds to our abilities to anticipate future climate changes as the emission of greenhouse gases by the increasing world population continues with little abatement in sight.”<sup>14</sup>

Milankovitch's son, Vasko, wrote the book *The Memory of My Father*, and, in it, described the character of his father in a very interesting way through a childhood memory:

“Father was barely 5'7” tall (1.70 m) and of fine frame. He had a prominent forehead and bushy brows over brown eyes which are always alert and quietly smiling. ...He was not the bespectacled-professor-type of scientist as he enjoyed nature and loved all things aesthetically harmonious and maintained a constant interest in history, literature, painting and sculpture. ...His love for abstract pleasures did not preclude him from earthy enjoyment. He enjoyed a glass of fine wine with his meals and would later relax with a favorite cigar. He often shared a good joke, and not necessarily a clean one, either.

Mother was the master of our family. Father would call her the “Home Secretary,” and always showed her great respect. He was the well-looked-after guest with no household duties.

He was popular with the ladies due to his excellent manners and because he was a good raconteur. His widely read book of popular astronomy, written in the form of letters to a lady friend, added to his popularity with women. What those ladies never knew was that he really did not have a very high opinion of the fairer sex. ...He thought that they are less objective than men and with a nervous system more fragile. The real thread of larger problems would somehow escape them. ...in other words, he was a real male chauvinist!

I often recall an event of my youth.... Father and I were vacationing in Austria [where Vasko fractured his collar bone and was treated at the local hospital].

Later that afternoon and throughout dinner, father was very absent-minded

9. See NASA Earth Observatory. *On the Shoulder of Giants: Milutin Milankovitch (1879-1958)*. <http://earthobservatory.nasa.gov/Features/Milankovitch/milankovitch>. Also, see J.D. Hays, John Imbrie, and N.J. Shackleton. “Variations in the Earth's Orbit: Pacemaker of the Ice Ages.” *Science*, 194, no.4270, 1976: 1121- 1132.

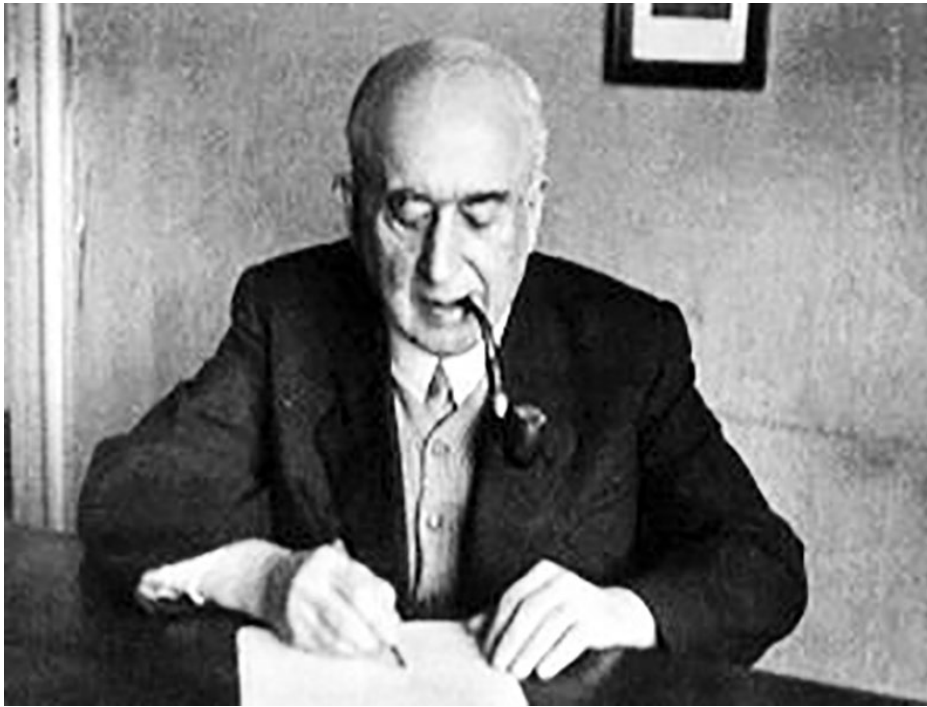
10. National Research Council. *Solar Variability, Weather, and Climate*, Washington, D.C.: National Academy Press, 1982, page 7.

11. See [http://en.wikipedia.org/wiki/Milutin\\_Milankovitch](http://en.wikipedia.org/wiki/Milutin_Milankovitch)

12. See International Astronomical Union (IAU), [www.iau.org/public/naming](http://www.iau.org/public/naming)

13. See European Geophysical Society. Awards & Medal – Milutin Milankovic Medal. <http://www.egu.eu/awards-medals/award/milutin-milankovic.html>

14. Berger, Andre, Fedor Mesinger, and Djordje Sijacki. *Climate Change*. New York: Springer, 2012.



which was most unusual for him. [Vasko was put to bed around 10:00 and Milutin left the door open in case Vasko needed him.] Instead of going to bed, he went to his desk, pulled some large sheets of paper from the centre drawer, lit the desk lamp and sat down. Something unusual must have happened, I thought. He never worked after dinner....

Father began writing fast, as I had never seen him before. The effect of my injection had worn off and the splint was cutting painfully into my shoulders and I could not sleep. He got up, put his foot on the chair and his elbow on his knee, took his glasses off and looked at me. He was not seeing me—he looked through me. He put the paper away, took out a new sheet and started writing again.

The woolen strap was hurting me. I called out for him to lift me and put some cotton wool under the strap, but I could see that he did not hear me.

He kept on writing and then he stopped and looked at the paper in front of him. He seemed to be revising all that he had written down, talking to himself.... Then he stopped. He then took out another sheet of paper and started writing again, but slowly this time. The tension on his face gradually dispersed and his usual calm expression returned. Finally he slowed down and then stopped altogether.

He looked up and, recalling my presence, said, "Sorry, I forgot about you. Do you need anything?" He lifted me into a comfortable position on the pillows, put pads of cotton wool behind the strap and said, "I think I've got it." "You got what?" I asked. "The differential equation covering the movement of the Poles. This equation has eluded me for quite some time. I am right now." He patted me on my sound shoulder, went into his room and, a couple minutes later, I could hear him gently snoring."

*Article originally published in and reprinted courtesy of Serb World U.S.A.*

## HAPPY BIRTHDAY, YOUR HIGHNESS

BELGRADE - His Royal Highness Crown Prince Alexander celebrated his 72nd birthday on July 17 in the company of his immediate family. "Thanks to everyone who sent birthday cards and messages," he said warmly.

As is customary, the Palace has released the annual film of the Prince's activities for the past year. It's available on YouTube and runs approximately 17 minutes; and includes many pictures of Canadian and American events and people as well as visits throughout the world to promote Serbia and help its people. Search on YouTube: 17 July 2016 - 17 July 2017 - HRH Crown Prince Alexander. While there, you will also be able to subscribe to the Royal Serbian Channel and see many other film clips of Royal activity.



## OBITUARY

### GEORGE MIRICH

It is with great sadness we report the passing of a lifelong member of Holy Trinity Serbian Orthodox Church in Youngstown, Ohio, George Mirich, 75, who fell asleep in our Lord Jesus Christ on June 20, 2017.

George was born October 12, 1941 in Lowellville, Ohio, one of six sons and seven daughters, to +Pete and +Mary (Brinsko) Mirich. He graduated from Lowellville High School in 1959, then sold life insurance for nine years for Mutual of Omaha. George also was the owner of GMHR, Inc., a spray-painting contractor for 35 years and was retired from General Motors Lordstown Fabricating Plant after 19-1/2 years.

For 45 years, George served on the Church Board, more than 20 years of those as its president. Through his leadership as chairman, the parish enjoyed continuous success at their Friday Night Fish Dinners. He really enjoyed working with people.

He was an officer in Serb National Federation Lodge #237 and a member of the Eastern Orthodox Men's Society of Youngstown.

George is survived by his daughter Melanie Belich of Bridgeville, PA, sons George Mirich Jr., at home, and Louis Mirich of Youngstown; as well as grandchildren Jaden and Ilija Belich; several brothers, sisters, nieces and nephews. In addition to his parents, George was preceded in death by brothers John, Mike and Pete, Jr., and sister Marianne Berich.

Father Bosko Stojanovic offered a prayer service with the Holy Trinity Church Choir singing the responses. Funeral service was offered by His Grace Bishop Irinej, Reverend Fathers Bosko Stojanovich, Dragan Goronjic, Sava Medakovich, Golic and Sinisa Hrvacevic. A daca took place at the Serbian memorial Hall prepared by the Circle of Serbian Sisters after the funeral.

George will be greatly missed but not ever forgotten. Memory eternal.

--CT



## DELIVERIES BENEFIT HEALTHCARE IN NIS

NIS, SERBIA – Last month Their Royal Highnesses Crown Prince Alexander and Crown Princess Katherine delivered a 3D mammography machine worth \$300,000 to the Centre for Radiology at the Clinical Centre Nis. On the same day they presented a patient monitor worth \$10,000 for the pediatric surgery and orthopedics unit there. These donations were by way of the Princess Katherine Foundation in cooperation with the American company Hologic, Inc., and Lifeline New York. The Royals were accompanied Kyle Scott, Ambassador of the United States of America to Serbia and Momcilo Miric of Hologic.

"The Foundation donated a mobile mammography to the Clinical Centre Nis in 2009 and to this day it has examined more than 100,000 women," said Her Highness. "I am happy that the American company Hologic has realized how much (we are) fighting to prevent breast cancer and has donated this \$300,000 mammography machine.

The Crown Princess Katherine Foundation has been advocating breast cancer prevention since its founding. This is the fifth mammography machine delivered to improve the conditions of diagnosis and treatment. Helping children's hospitals is also a priority for the Foundation's work.

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