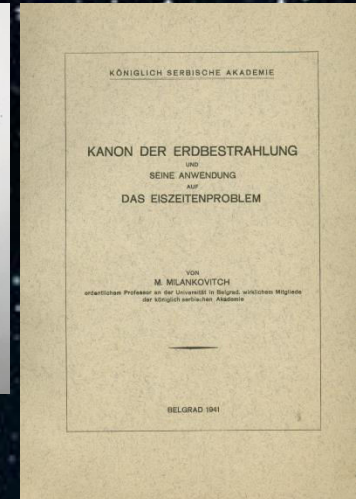
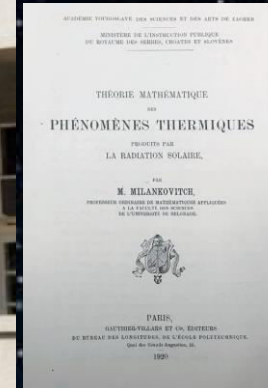
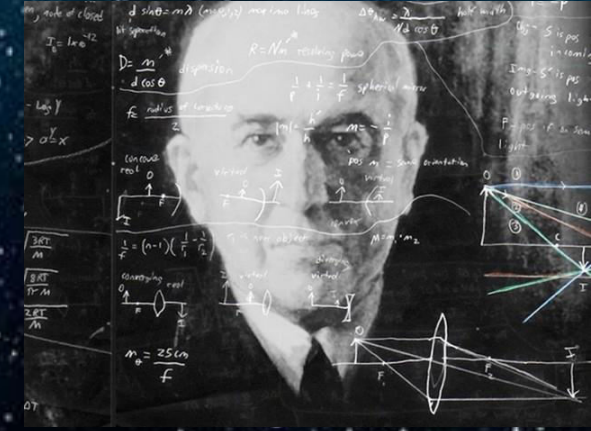


100 YEARS OF MILANKOVIC'S THEORY OF CLIMATE CHANGE

Milutin Milankovic's opus as a subject of scientometrics



Stela Filipi Matutinović

Bibliometrics

Bibliometrics is the use of statistical methods to analyze books, articles and other publications, developed at the beginning of 20th century.

Bibliometric laws try to formulate statistical data distributions of publications mathematically.

The frequency distribution of productivity of authors, journals, institutions or citations always has a small core of most productive and a long tail of less productive ones.



SCIENTOMETRICS

Scientometrics is a subfield of bibliometrics. It is a method of quantitative research of development of science as an information process. Subjects of research are individual scientific documents, citations, authors, institutions, journals, etc.

Basic postulate is that the only credible indicators for scientific contribution of a scientist by his colleagues are: large number of citations, citation context analysis and the occurrence of eponym – term containing the name of a scientist.



Citation sources for research

Citations are the best source of information about the links between scientific documents that show the flow of information through the corpus of science, but citation indexes are necessary for that.

Eugene Garfield created the first citation index in 1964 – Science Citation Index.

Bibliographic databases that cover citations:

Web of Science (1900-) ~ 60.000.000 records from ~ 25.000 journals

Scopus (1996-) ~ 60.000.000 records from ~ 25.000 journals, books ...

Academic search engines that cover citations:

Google Scholar (launched 2004) ~ 390.000.000 records

Microsoft Academic (launched 2016) ~ 240.000.000 records



Milanković in scientometrics literature

Werner Marx et al. (2017) searched for the most cited items on climate change in Web of Science 1980-2014 and found 222.060 articles with 10.932.050 citations, of which 239.887 (2,2%) citations were for works published before 1971. **Only 226 of those old publications (0,09%) were cited more than 100 times.**

„Canon of Insolation“ by Milanković was cited 353 times, and was on 13th place on the citedness rank list.

Authors concluded that first 35 publications on the list were cornerstones of modern science about the climate.



Marx, W., Haunschuld, R., Thor, A., Bornmann, L., 2017, Which early works are cited most frequently in climate change research literature? A bibliometric approach based on Reference Publication Year Spectroscopy. *Scientometrics*, 110, pp. 335–353

Table 1 The most frequently cited references from specific reference publication years in Figs. 1 and 2, which have been cited by papers dealing with climate change

From: [Which early works are cited most frequently in climate change research literature? A bibliometric approach based on Reference Publication Year Spectroscopy](#)

No	RPY	Reference/comment	NCR
CR1	1686	E. Halley: An historical account of the trade winds, and monsoons, observable in the seas between and near the tropicks, with an attempt to assign the physical cause of the said winds. Philosophical Transactions of the Royal Society of London 16(179–191), 153–168 (1686)	22
		<i>Edmond Halley (1656–1742) was an English astronomer, geophysicist, and meteorologist, well known for computing the orbit of the apocryphous Halley's Comet. In the paper on trade winds and monsoons he published results from his Helonian expedition. He identified solar heating as the cause of atmospheric motions</i>	
CR2	1735	G. Hadley: Concerning the cause of the general trade-winds. Philosophical Transactions of the Royal Society of London 39(436–444), 58–62 (1735). doi: 10.1098/rstl.1735.0014	24
		<i>The publication by George Hadley (1682–1768) describes an atmospheric circulation system that bears the author's name (Hadley Cell). This circulation system is intimately related to the trade winds, the tropical rainbelts, the subtropical deserts, and the jet streams</i>	
CR3	1753	C. Linnaeus: Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis 1 (10th ed.). 80 (Stockholm, Sweden: Laurentius Salvius, pp. [1–4], 824 pages (1753)	80
		<i>The publication is one of the major publications of the Swedish botanist, zoologist, and physician Carlus Linnaeus (1707–1778) and introduced the Linnaean taxonomy. The first edition of the book was printed 1733. The tenth edition (1753) is considered the starting point of zoological nomenclature</i>	
CR4	1798	T.R. Malthus: An essay on the principle of population. In Oxford World's Classics reprint. Printed for J. Johnson, in St. Paul's Church-Yard, London, UK (1798)	71
		<i>The book was first published in 1798 under the alias Joseph Johnson. The author Thomas Robert Malthus (1768–1834) stated that sooner or later population will be checked by famine and disease, leading to what is known as a Malthusian catastrophe</i>	
CR5	1847	C. Bergmann: Über die Verhältnisse der Wärmeökonomie der Thiere zu ihrer	206

No	RPY	Reference/comment	NCR
		Größe. In: Göttinger Studien, I. Abt., 595–708 (1847)	
		<i>The paper by the German biologist Carl Bergmann (1814–1885) describes what has been named Bergmann's rule. A principle that states that populations and species of larger size are found in colder environments, and species of smaller size are found in warmer regions</i>	
CR6	1859	C. Darwin: On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for life. Murray, London, UK (1859)	292
		<i>This seminal publication by Charles Darwin (1809–1882) is considered to be the foundation of evolutionary biology. The book attracted widespread interest upon its publication and generated scientific, philosophical, and religious discussion until present</i>	
CR7	1854	H.F. Blanford: On the connexion of the Himalaya snowfall with dry winds and seasons of drought in India. Proceedings of the Royal Society of London 37(232–234), 3–22 (1854). doi: 10.1098/rpl.1854.0003	107
		<i>Henry Francis Blanford (1834–1893) was a British meteorologist who made long-term weather forecasts using the link between snow in the Himalayas and rainfall in the rest of India. Using this method, he was able to predict a deficient monsoon in 1885</i>	
CR8	1896	S. Arrhenius: On the influence of carbonic acid in the air upon the temperature of the ground. Philosophical Magazine and Journal of Science Series 5(41), 237–276 (1896)	311
		<i>Svante Arrhenius (1859–1927) was the first scientist who calculated how changes in the levels of carbon dioxide in the atmosphere could alter the surface temperature through the greenhouse effect. He predicted that emissions of carbon dioxide from the burning of fossil fuels were large enough to cause global warming. His prediction of a global temperature rise through doubling the carbon dioxide concentration is close to recent predictions. Until around 1970, experts refused the hypothesis because they found that he had grossly oversimplified the climate system</i>	
CR9	1899	T.C. Chamberlin: An attempt to frame a working hypothesis on the cause of glacial periods on an atmospheric basis. Journal of Geology 7, 545–584, 667–685, 751–787 (1899)	111
		<i>Thomas Chrowder Chamberlin (1843–1928) was an influential American geologist. In his 1899 paper he proposed the possibility that changes in climate could result from changes in the concentration of atmospheric carbon dioxide—thereby supporting the theory of Arrhenius (1896)</i>	
CR10	1916	F.E. Clements: Plant succession: An analysis of the development of vegetation. Publication 242 (512 pages), Carnegie Institution of Washington, Washington, USA (1916)	125
		<i>Frederic Edward Clements (1874–1945) was an American plant ecologist and pioneer in the study of vegetation succession</i>	



No	RPY	Reference/comment	NCR
CR11	1932	G.T. Walker and E.W. Bliss: World weather V, Memoirs of the Royal Meteorological Society 4(36), 53–84 (1932). http://www.rsmets.org/publications/classic-papers	343
		<i>Sir Gilbert Thomas Walker (1868–1958) was a British physicist and statistician. He is best known for his groundbreaking description of the Southern Oscillation, a major phenomenon of global climate, for discovering Walker Circulation, and for greatly advancing the study of climate in general</i>	
CR12	1941	H. Jenny: Factors of soil formation: A system of quantitative pedology. Dover Publications Inc., New York, USA (1963). Originally published: McGraw-Hill, New York, USA (1941)	354
		<i>The monograph by Hans Jenny is an advanced treatise on theoretical soil science and includes a study of soil-forming factors and processes of soil genesis. It is an extension of the first part of the course "Development and morphology of soils" at the College of Agriculture of the University of California</i>	
CR13	1941	M. Milankovic/Milankovitch: Canon of insolation and the ice-age problem (Kanon der Erdbestrahlung und seine Anwendung auf das Eiszeitenproblem). Royal Serbian Academy special publications, Section of Mathematical and Natural Sciences 132, V33, 633 pages, Belgrade, Yugoslavia (1941). English translation by N. Peacock: Canon of insolation and the ice age problem. Alven Global, 636 pages (1998)	352
		<i>Milutin Milankovic/Milankovitch (1879–1958) explained how the earth's long-term climate changes (in particular the ice ages occurring in the geological past of the earth) are caused by changes in the position of the earth in comparison to the sun, now known as Milankovitch Cycles</i>	
CR14	1945	H.B. Mann: Nonparametric tests against trend. Econometrica 13(3), 245–259 (1945)	908
		<i>The paper by Henry B. Mann discusses tests of randomness against trends</i>	
CR15	1948	C.W. Thornthwaite: An approach toward a rational classification of climate. Geographical Review 38(1), 55–94 (1948)	1078
		<i>The American climatologist and geographer Charles Warren Thornthwaite (1899–1963) devised a moisture based climate classification system (that is still in use worldwide) by monitoring the soil water budget</i>	
CR16	1948	H.L. Penman: Natural evaporation from open water, bare soil and grass. Proceedings of the Royal Society of London A—Mathematical and Physical Sciences 193(1032), 120–145 (1948)	663
		<i>In the paper two theoretical approaches to the evaporation from saturated surfaces are outlined</i>	
CR17	1950	J.M. McCrea: On the isotopic chemistry of carbonates and a paleotemperature scale. Journal of Chemical Physics 18(6), 849–857 (1950). doi: 10.1063.1.1747785	318
		<i>The temperature variation of the fractionation of oxygen in exchange reactions</i>	



Milanković in scientometrics literature

John Levin (2017) used Milanković as an example of how translation to English of his „Kanon“ in 1969 enhanced the potential for dissemination of his ideas, since English became „lingua franca“ in science after 1970`s.

Tony van Raan (2004) used his works that get more and more citations over time as an example of „sleeping beauties“ in science, since **only works of fundamental significance for the development of science have increasing number of citations a century after been published.**



Eugene Garfield`s HistCite

E. Garfield, founder of Science Citation Index and one of the founders of scientometrics, created and used HistCite software to analyze citations in SCI 1900-2010. He chosed 178 highly cited important natural science authors from the period of “little” science (until 1950`s), and Milanković was one of them.

← → ↻ 🏠 garfield.library.upenn.edu/histcomp/milankovic

Papers citing Milutin Milankovic

Word(i) List (1850) Word count: 6071, All words count: 8829

Records: 784, Authors: 1313, Journals: 288, Cited References: 33540, Yearly output | Document Type | Language | Institution | Institution w

Page 1 of 10: [1 2 3 4 5 6 7 8 9 10]

#	Word	Recs	TLCS	TGCS
1	ICE	100	795	6893
2	CLIMATE	145	683	6408
3	VARIATIONS	53	610	3109
4	ORBITAL	67	547	4734
5	AGES	27	413	3725
6	EARTHS	16	399	2279
7	CLIMATIC	71	381	4329
8	MODEL	55	352	3076
9	THEORY	39	331	3371
10	INSOLATION	37	296	2683
11	ASTRONOMICAL	46	294	1654
12	RESPONSE	25	279	1616
13	ORBIT	6	264	1370
14	PACEMAKER	4	262	1365



Milanković`s citations research in Serbia

Sociologist Vojin Milić found that **in SCI 1965-1989 Milanković was the most cited Serbian author.**

Astronomer Milan Dimitrijević found that **in SCI 1945-2000 Milanković was the most cited Serbian astronomer.**

Bibliography of articles citing Milanković in SCI 1945-2006 was published in the book 8 of his Selected Works.



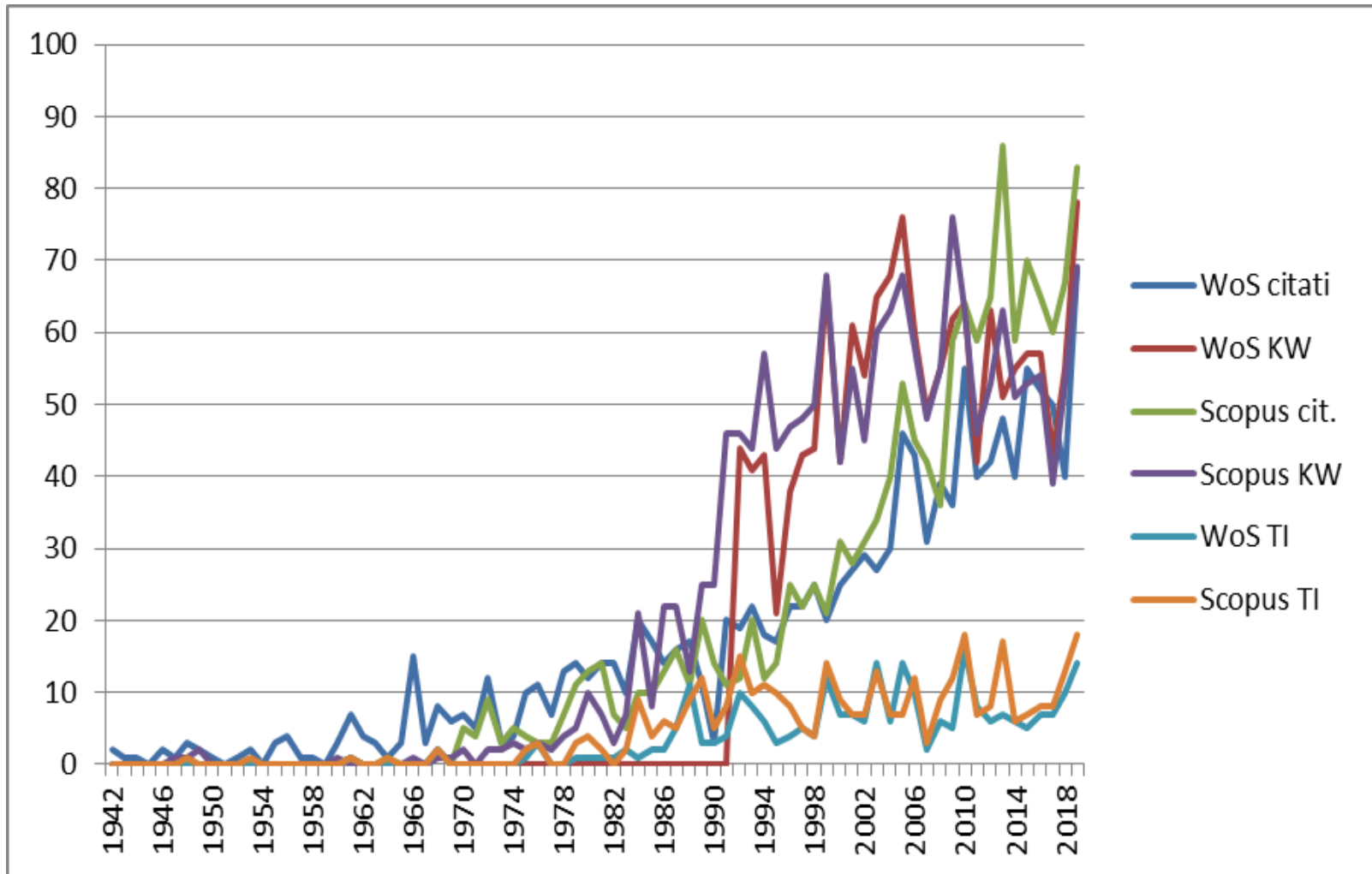
Milanković in databases WoS and Scopus

Search for citations of Milankovic`s works and of records with his name in title, abstract and key words was performed for all available years.

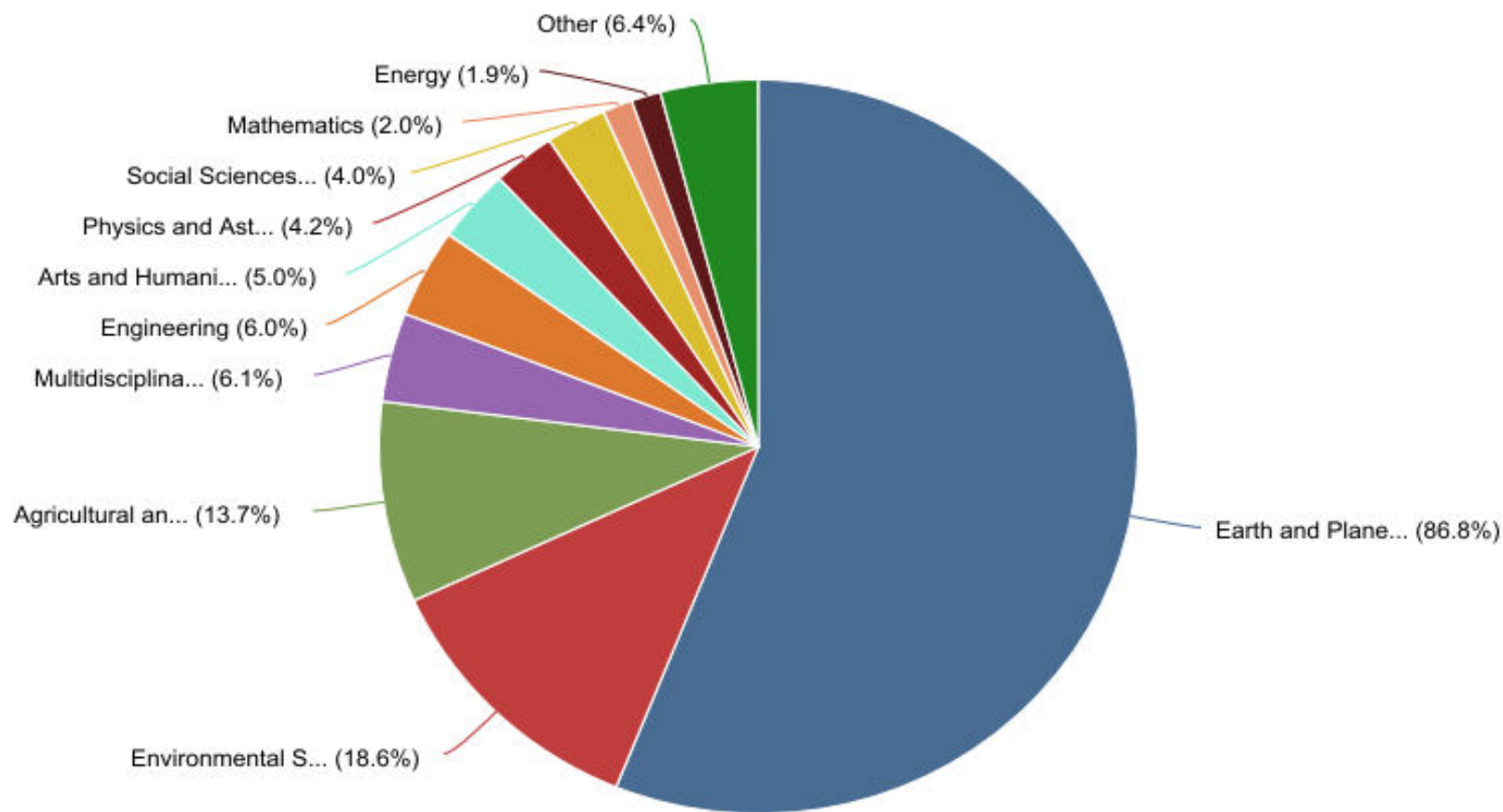
There is clear trend of growing number of citations and mentioning of his name in both databases. That is characteristic only for works of fundamental importance, usual trend is declining after a peak in 5-10 years.



Citations, key words and title words in WoS and Scopus 1941-2019

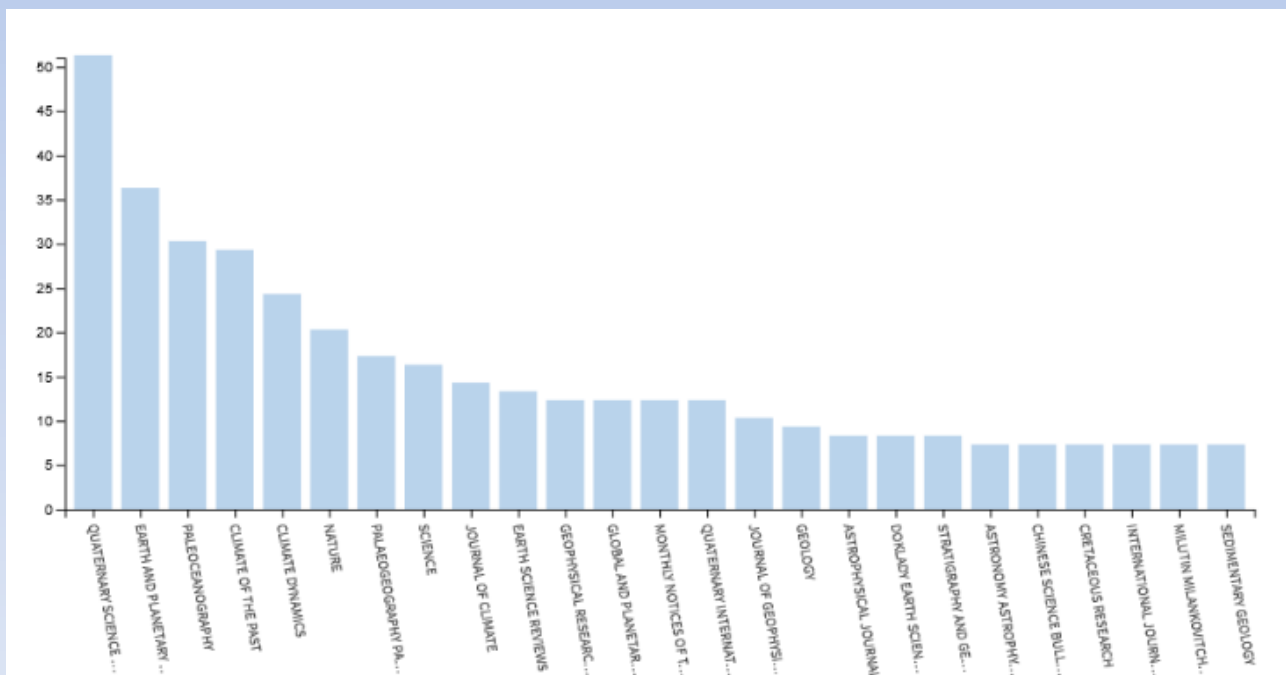


Distribution of citing articles according to research areas in Scopus



WoS 1996-2019

There were 2730 authors from 70 countries citing Milanković.
98% articles were in English, 1% in French and a few in Russian, German and Chinese languages.
The distribution between journals show the multidisciplinary use of his results.



Profile of Milutin Milanković in Google Scholar

Navigation bar with browser address bar, search bar, and Google Scholar logo.



Milutin Milankovic

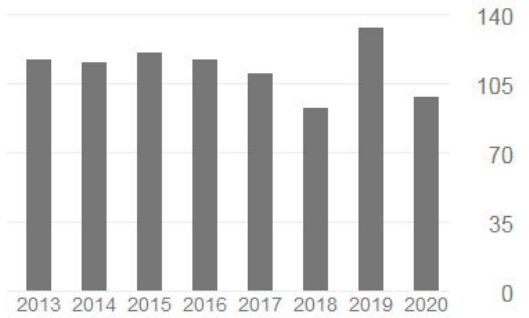
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Verified email at milutinmilankovic.rs
climatology astronomy geophysics

Cited by [VIEW ALL](#)

	All	Since 2015
Citations	2927	674
h-index	13	9
i10-index	17	9

TITLE	CITED BY	YEAR
Kanon der Erdbestrahlung und seine Anwendung auf das Eiszeitenproblem MK Milankovitch Royal Serbian Academy Special Publication 133, 1-633	956	1941
Mathematische klimalehre und astronomische theorie der klimaschwankungen M Milankovitch Handbuch der Klimatologie 1	624	1930
Canon of insolation and the iceage problem MM Milankovitch Koniglich Serbische Akademie Beograd Special Publication 132	608	1941
Théorie mathématique des phénomènes thermiques produits par la radiation solaire M Milankovitch Paris	404	1920



Results from used databases until the end of year 2019

Database	No. citations	No. articles with keywords	No. articles with title words	No. articles with citations and keywords
Web of Science 1920-2019	1317	1458	255	242
Scopus 1996-2019	1426	1756	352	308
Google Scholar	2444	29768	1021	-
Microsoft Academic	440	1996	398	-



Discussion

According to praxis of citation in scientific literature it is expected that number of citations would be bigger or equal to number of keywords, but it is less in all four databases.

Less than 10% of records in WoS and Scopus contain both citations to Milankovic`s works and key word or title containing his name.

Number of mentioning Milanković is nearly twice bigger than number of citing articles or number of articles with his name in title or key words, and is growing.

This result indicates that his name became an eponym.



Eponyms in science

Eponyms are scientific terms formed after a person – scientist or inventor who was the first to discover or to communicate to others some invention, theory, discovery etc. In literature, they serve as implicit citations. True eponym is achieved when:

- The event (method, rule, law etc.) is commonly called by its discoverer`s name
- It is included in the indexes of standard texts in the field
- It is used as a heading in texts
- The event is implicitly cited by the use of eponym.

Robert Merton stated that eponymy is an important mechanism of recognizing scientific contribution.

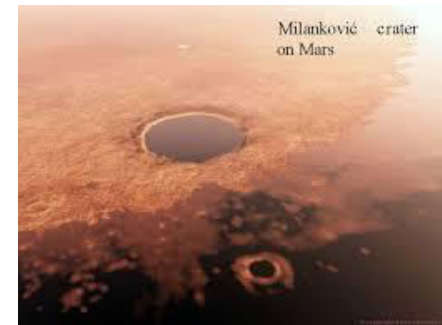
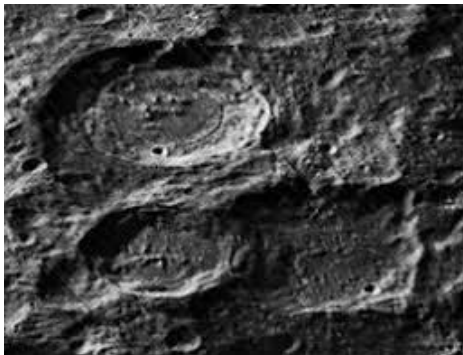
Creation of eponyms is a part of stimulation system for science development, since it gives great and long-lasting moral reward to scientists by their peers.



Eponyms in astronomy

First eponyms in astronomy appeared in 1651 when Riccolli published in *Almagestum novum* a map of the Moon whose features were labeled with names of famous astronomers. This praxis continues, and is present in many sciences.

Named after Milanković are one lunar crater and one crater on Mars, asteroid 1605 and Milutin Milankovic Medal of the European Geosciences Union.



Eponyms and citation

When a scientist`s name becomes an eponym it influences the number of his citation, since it became part of the scientific language. This phenomenon is called “**obliteration by incorporation**” (R. Merton)

In his essay about eponyms as a route to immortality, Eugene Garfield wrote:

“**That kind of uncitedness happens to those whose work has become so well known (and presumably been previously so heavily cited) that one finds it at first tedious, then unnecessary, and finally actually gauche to cite such man at all**”.



Milanković in databases WoS and Scopus 1992-2019

In WoS there are 55% records mentioning Milanković without citing his works.

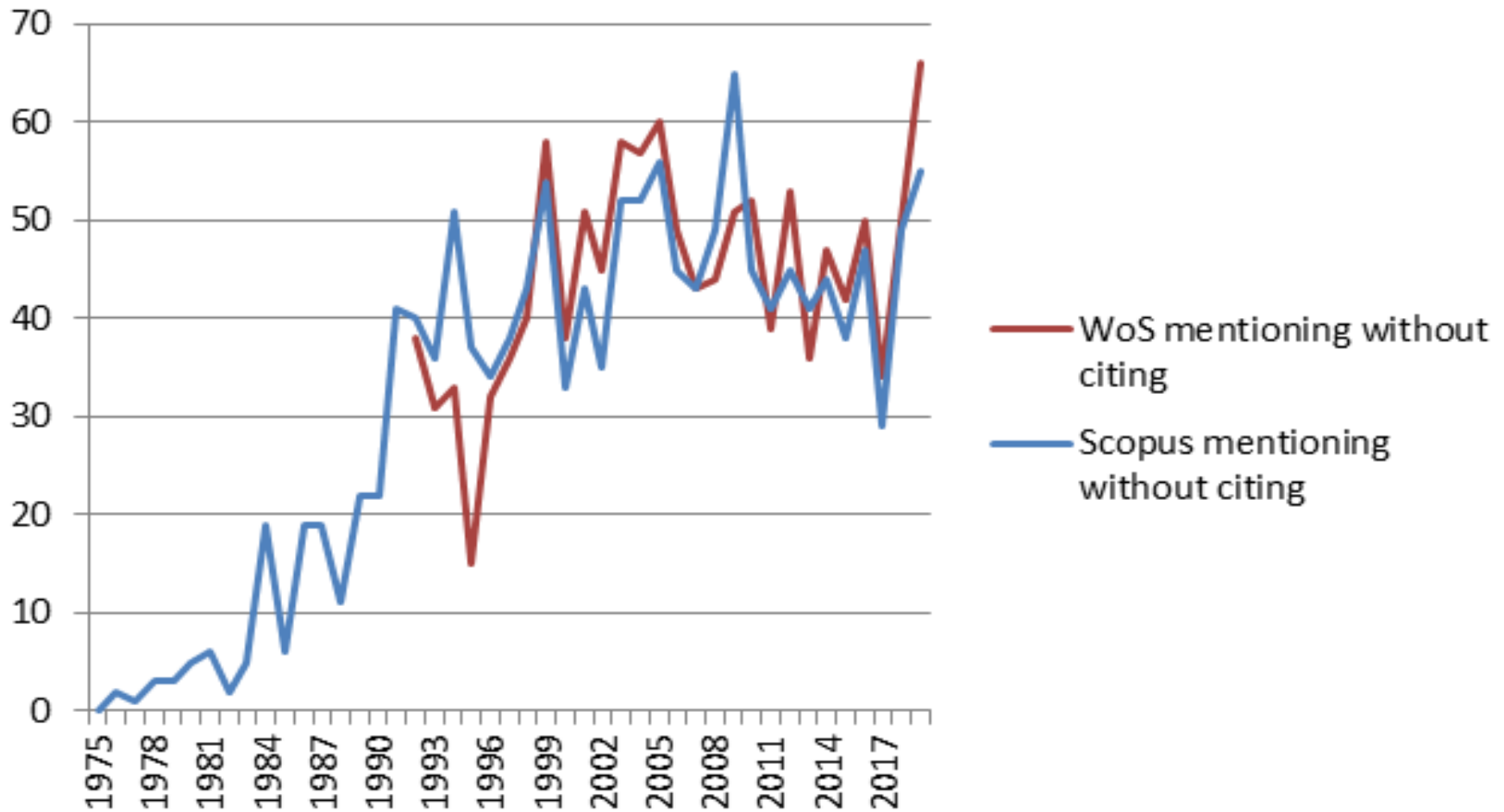
In Scopus there are 25% records mentioning Milanković without citing his works.

The growing trend of mentioning his name without citation is present in both databases.

It is clear evidence that his works had been obliterated by incorporation and become an eponym.



Records mentioning Milanković without citing his works



Milanković in encyclopedias

Milutin Milankovitch
Serbian mathematician and geophysicist

WRITTEN BY
Doug Macdougall
Emeritus Professor of Earth Sciences, Scripps Institution of Oceanography, University of California, San Diego, California.
[See Article History](#)

Alternative Titles: Milutin Milanković, Milutin Milankovich

Milutin Milankovitch, Milankovitch also spelled **Milanković** or **Milankovich**, (born May 28, 1879, Dalj, Austria-Hungary [now in Croatia]—died December 12, 1958, Belgrade, Yugoslavia [now in Serbia]), Serbian

Milutin Milanković

From Wikipedia, the free encyclopedia

Milutin Milanković (Serbian Cyrillic: Милутин Миланковић [milūtin milā.nkɔvits̩], sometimes **anglicised as Milankovitch**; 28 May 1879 – 12 December 1958) was a Serbian **mathematician, astronomer, climatologist, geophysicist, civil engineer and popularizer of science**.

Milanković gave two fundamental contributions to global science. The first contribution is the "Canon of the Earth's **Insolation**", which characterizes the climates of all the planets of the **Solar system**. The second contribution is the explanation of Earth's long-term **climate changes** caused by changes in the position of the Earth in comparison to the **Sun**, now known as **Milankovitch cycles**. This explained the **ice ages** occurring in the geological past of the Earth, as well as the climate changes on the Earth which can be expected in the future.

He founded planetary climatology by calculating temperatures of the upper layers of the Earth's atmosphere as well as the temperature conditions on planets of the inner Solar system, **Mercury, Venus, Mars**, and the **Moon**, as well as the depth of the atmosphere of the outer planets. He demonstrated the interrelatedness of **celestial mechanics** and the Earth sciences, and enabled consistent transition from celestial mechanics to the Earth sciences and transformation of **descriptive sciences into exact ones**.

Contents [hide]

- Life
 - Early life
 - Middle years
 - Construction engineering
 - Planet's insolation
 - Orbital variations and ice age cycles

Milankovitch, Milutin (1879–1958), and milankovitch theory

Authors and affiliations
George Kukla, Rhodes W. Fairbridge

Reference work entry

Part of the *Encyclopedia of Earth Science* book series (EES)

Milutin Milankovitch developed the theory of orbital control of terrestrial insolation and climate change. He was of Serbian origin, born in Dalj (Slavonia) in what is now Croatia. He obtained his PhD in 1904 in Vienna and worked as a civil engineer for 5 years before going to the University of Belgrade as Professor of Applied Mathematics.

Milankovitch, Milutin

CENGAGE Views 1,645,406 Updated Oct 9 2020

MILANKOVICH (MILANKOVITCH), MILUTIN

(*b.* Dalj, Austria-Hungary [now Croatia], 28 May 1879; *d.* Belgrade, Yugoslavia, 12 December 1958),

celestial mechanics, mathematical physics, climatology, geophysics, civil engineering, history of science.

Wikipedia list of climate scientists

- Carl Mears, American, senior scientist at Remote Sensing Systems
- Gerald A. Meehl (1951-), American climatologist at NCAR.
- Katrin Meissner, German and Australian physical oceanographer and climate scientist, director of the Climate Change Research Centre at University of New South Wales
- Patrick Michaels (1950-), American climatologist.
- Milutin Milanković (1879-1958), Serbian, **Milankovitch cycles**.
- John F. B. Mitchell, British, climate modelling and detection and attribution of climate change
- Fritz Möller (1905-1983), German, early modeling of CO2 greenhouse effect

100 YEARS OF MILANKOVICH'S THEORY OF CLIMATE CHANGE
1920 2021 20

Oxford English Dictionary 2019

The screenshot shows a web browser window with the URL <https://www.lexico.com/definition/milankovitch>. The page header includes the Lexico logo, "Powered by OXFORD", and navigation options for "UK DICTIONARY" and "Milankovitch". The main content area displays the meaning of Milankovitch in English, its pronunciation, and social media links. A "WORD OF THE DAY" section features the word "ratted" with its pronunciation and part of speech. Below this is a section titled "These Foreign Words And Phrases Are Now Used In English" with an image of globes and a "Feedback" button.

Home > UK English > Milankovitch

Meaning of Milankovitch in English:

Milankovitch

(also **Milankovic**, **Milankovich**)

Pronunciation /mɪˈlʌŋkəvɪtʃ/

NOUN

Meteorology

Attributive and in the genitive. Designating theories and concepts arising from Milankovitch's study of the earth's climate; "Milankovitch cycle" noun any of three cyclic variations in the orbit of the earth around the sun (involving respectively the eccentricity of the orbit, the obliquity of the earth's axis, and the precession of the

WORD OF THE DAY

ratted

/ˈrɑtɪd/
ADJECTIVE

These Foreign Words And Phrases Are Now Used In English

Feedback



Milanković on NASA website



GLOBAL CLIMATE CHANGE
Vital Signs of the Planet



FACTS ARTICLES SOLUTIONS EXPLORE RESOURCES NASA SCIENCE

FEATURES | February 27, 2020

Milankovitch (Orbital) Cycles and Their Role in Earth's Climate

By Alan Buis,
NASA's Jet Propulsion Laboratory

Our lives literally revolve around cycles: series of events that are repeated regularly in the same order. There are hundreds of different types of cycles in our world and in the universe. Some are natural, such as the change of the seasons, annual animal migrations or the circadian rhythms that govern our sleep patterns. Others are human-produced, like growing and harvesting crops, musical rhythms or economic cycles.

Cycles also play key roles in Earth's short-term weather and long-term climate. A century ago, Serbian scientist Milutin Milankovitch hypothesized the long-term, collective effects of changes in Earth's position relative to the Sun are a

MILUTIN MILANKOVITCH (1879-1958)
by Steve Graham - March 24, 2000

The Serbian astrophysicist Milutin Milankovitch is best known for developing one of the most significant theories relating Earth motions and long-term climate change. Born in 1879 in the rural village of Dalj (then part of the Austro-Hungarian Empire, today located in Croatia), Milankovitch attended the Vienna Institute of Technology

"MILANKOVITCH DEDICATED HIS CAREER TO DEVELOPING A MATHEMATICAL THEORY OF CLIMATE."

On the Shoulders of Giants
Milutin Milankovitch
Orbital Variations
Milankovitch Theory
Links and References

Orbital Cycles
Three periodic motions in Earth's orbit, known as Milankovitch cycles, contribute a predictable amount of variation to Earth's climate over time frames of tens of thousands to hundreds of thousands of years.

- 100,000-year cycles
Changes in Eccentricity
(Orbit Shape)
- 26,000-year cycles
Axial Precession
(Wobble)
- 41,000-year cycles
Changes in Obliquity
(Tilt)

climate.nasa.gov



Earth's Milankovitch (Orbital) Cycles

Small cyclical variations in Earth's orbit, wobble and axial tilt play key roles in influencing Earth's climate on

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100 YEARS of
MILANKOVICH'S THEORY of
CLIMATE CHANGE





100 YEARS OF MILANKOVIC'S THEORY OF CLIMATE CHANGE

Conclusion

Milanković achieved his life goal and built his “eternal and inviolable scientific estate” by becoming an eponyme.

This analyze shows that by plain counting of citations, without concern of obliteration by incorporation in scientific language, can not give the realistic picture of his place in world science..

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100 YEARS of
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CLIMATE CHANGE



Thank you for your attention!

Stela Filipi Matutinović
stela.filipi1@gmail.com