DISCUSSION PAPER

NATURAL RHYTHMS OF CLIMATE VARIABILITY AND ANTHROPOPRESSURE (ANTHROPOPRESSURE WILL NOT OVERCOME THE NATURAL RHYTHMS OF CLIMATE VARIABILITY)

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Abstract. The transformations of the Earth's atmosphere have always been conditioned by cosmic-astronomical factors and natural "life processes of the Earth." Human pressure has been increasing for several thousand years, but only in the last three centuries has anthropopressure reached a global scale, modifying the state of the atmosphere. The rhythm of energy fluctuations over the last approximately 130,000 years, including the youngest millennia (the so-called Late Glacial and Holocene) and contemporary times with human influence, allow us to predict the approaching end of the current climatic optimum.

Keywords: paleoclimate, anthropopressure

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Constant fluctuations have marked the history of Earth's atmosphere. This results from the cyclicality of cosmic-astronomical processes (the rotation time of our galaxy, changes in the eccentricity of Earth's orbit around the Sun, variations in the tilt of Earth's axis concerning the ecliptic, precession, and changes in solar radiation) and the Earth's "response" to incoming external energy impulses.

The existence of organic life (about 3.5 billion years ago), the appearance of photosynthetic organisms (cyanobacteria, approximately 2.6 billion years ago), and the "biological explosion" coupled with the "Great Oxidation Event" (about 600 million years ago; Stankowski 2023) introduced the Earth into a rhythm of oxygen-carbon transformations. The long-term interaction of cosmic-astronomical phenomena with the "life processes of Earth" led to the saturation of the lower troposphere with free oxygen and the generation of a protective ozone layer in the stratosphere. In both of these zones, the concentration of O_2 and O_3 undergoes temporal and spatial fluctuations. Variability in oxygen-carbon and temperature-humidity conditions plays a decisive role in the functioning of life on Earth.

The Earth's thermal situation is modified by tectonic phenomena (which alter the distribution of land and oceans, affecting global heat distribution) and volcanic phenomena influencing atmospheric composition. The complexity of Earth's natural functioning has resulted in significant

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changes not only in temperature but also in the displacement of climatic zones and atmospheric gas composition.

Throughout Earth's history, there have been mass extinctions (eliminating even >75% of species), reaching the rank of geological stratigraphy. Over the geologically well-documented last 600 million years (Phanerozoic), numerous changes have occurred in the Earth's climate and landscape. Over the last approximately 300 million years, notable events include:

- A prolonged cold period – the Carboniferous-Permian "megaglacial";
- A Late Paleozoic and Mesozoic warm period – a "megainterglacial" with equatorial heat distribution reaching the polar regions;
- The ongoing Cenozoic "megaglacial" with continuous Antarctic glaciation (for over 40 million years) and Northern Hemisphere glaciation (for less than 10 million years), both with varying extents.

During this last "megaglacial," glacial and interglacial periods occurred rhythmically, with lower-order cycles such as stadials and interstadials, phases and interphases, and numerous smaller-scale rhythms.

During the last half a million years, there have been climatic changes with a basic rhythmicity of about 100,000 years. Cold phases dominated over much shorter periods of warmth. This variability is illustrated in a modified temperature fluctuation graph adapted from Earle (2019). The original graph has been supplemented with a predicted, not-so-distant cooling trend, schematically indicating the role of anthropopressure,

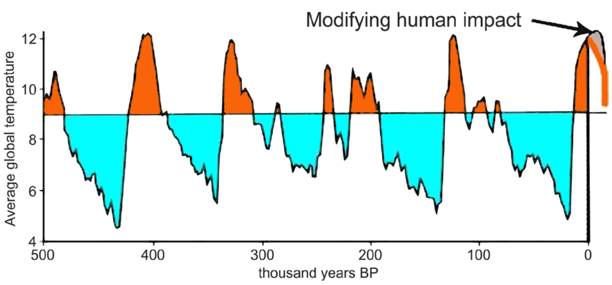

Fig. 1. Approximate 100,000-year cycles over the past 500,000 years, with a likely impending cooling trend and the role of anthropopressure. The color highlights the phases of warmth and cold, with a reference to the current average annual temperature for Poland. The segment of the graph to the right of time 0 (the present) represents a forecast, as discussed later in the text.

which extends and intensifies the natural thermal optimum.

Let us turn to the rhythmic changes in the Earth's thermals and selected aspects of nature during the last about 150,000 years. These are presented by a collection of graphs, taken from various scientific publications and academic textbooks. This collective illustration aims to show the convergence of changes over time, of the different ranges of Earth's nature, allowing for a maximum reduction of written text. The graphics reflect the results of the research:

- ice cores from Antarctica and Greenland (after Burrougher 2001), confirmed by identical trends in temperature change, in the record of planktonic and benthic foraminifera in oceanic bottom sediments, including those from the equatorial Pacific (Shackleton 1967, Shackleton, Obdyke 1973),
- temperature variability of surface ocean waters exemplified by the North Atlantic – core 53°N and 22°W (after Dawson 1992, citing Lancett at al. 1973),
- ocean water level fluctuations (after Shackleton 1987, also Dawson 1992, citing Shackleton 1987),
- and finally, the concentration of carbon dioxide and methane in the atmosphere (modified illustrations after Dawson 1992 and Houghton 2009).

The coincidence of all the diagrams illustrating the temporal variability of different aspects of the Earth's nature and from various climatic zones points to a global expression of the occurring phenomena. Spectacular are the warming of the so-called Eemian interglacial (around 115,000 years ago) and the prolonged cooling of the Weichselian (Vistulian) glacial with numerous lower-order thermal fluctuations and an apogee around 20,000 years ago, followed by a warming trend, the so-called Late Glacial.

During the fluctuations of the Earth's thermal conditions in the Late Glacial period, abrupt warming events occurred, with the most pronounced ones around 14,700 and 11,700 years ago, leading to temperature increases of up to 10°C within just 50 years. These abrupt warming events have been documented through studies of Greenland ice cores conducted at the University of Copenhagen. Detailed analyses of dust impurities in the ice during the 11,700-year

BP fluctuation allowed Fordham et al. (2020) to determine their Asian and North African origins, proving the occurrence of global atmospheric circulation changes at that time, expressed through shifts in climatic zones. Additionally, significant temperature fluctuations during the 12,580–11,440 BP period were identified by Goslar (1996), who dated the bottom deposits of Lake Gościąż (near Włocławek, Poland). The thermal anomaly of 11,700 years BP, was associated with the end of the Late Glacial, which is now recognised by the International Commission on Stratigraphy of the International Union of Geological Sciences (IUGS) as the caesura, still ongoing, of the Holocene interglacial (after the electronic version of the publication 'A new formal division of Holocene stratigraphy', Leszek Marks 2011).

The two graphs of the six-segment Figure 2 show the variability in carbon dioxide and methane concentrations from the Eemian interglacial to the present. These graphs also align with the previous ones, namely those depicting temperature changes and sea level fluctuations. The highest concentrations of carbon dioxide and methane during interglacials (Eemian and Holocene) result from the intensification of biological activity and the abundance of organisms within the oxygen-carbon system, as well as the release of methane from organic deposits, such as the degradation of permafrost or submarine methane hydrates. Less intense increases in atmospheric carbon dioxide and methane concentrations also occurred during warming phases within glacial periods.

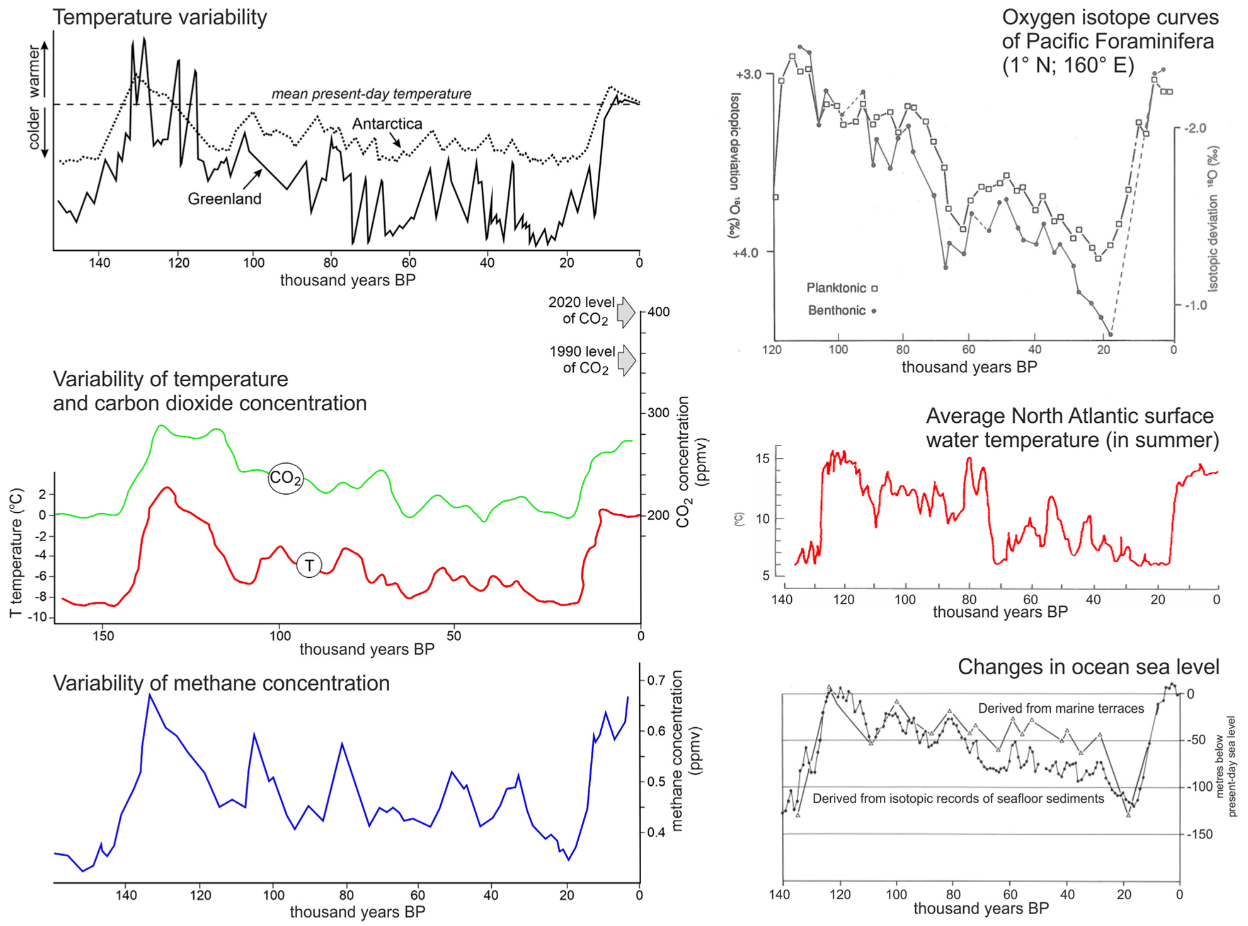

Fig. 2. Converging trends of changes in selected aspects of nature during the last c. 130,000 years, according to different authors. The graphs reflect values specific to certain areas. The lateral variability applies not only to temperature, the annual averages of which, for example, for different areas of Eurasia, vary from around +20°C in the SW to −50°C at the NE edge. CO_2 and CH_4 concentrations are also characterised by regional as well as seasonal variability. Changes in CO_2 content in the northern and southern hemispheres, as well as during summer and winter, are temperature and humidity driven (cf. illustration in 'Dwutlenek węgla w atmosferze Ziemi', Wikipedia – Polish version). Annual rhythms are also marked by fluctuations in the extent of so-called ozone holes (cf. 'Dziura ozonowa', Wikipedia – Polish version).

At the peak of the last glacial period (before and around ~20,000 years ago), photosynthetic organisms produced little oxygen due to the limitations of growing seasons. This began to change with the trend of rising temperatures. By the end of the so-called Pleniglacial (~19,000–15,000 years ago) and throughout the Late Glacial and early Holocene (~15,000–10,000 years ago), the activity of photosynthetic organisms increased significantly, leading to a rise in atmospheric oxygen and carbon dioxide concentrations. During this time, there were catastrophic multi-decade thermal fluctuations, as previously mentioned. To reiterate, the most recent of these (~11,700 years BP) marks the beginning of the Holocene.

The youngest formally recognized stratigraphic unit, the still-ongoing interglacial, is divided into:

- Early Holocene (11,700–8,230 BP),
- Middle Holocene (8,230–4,250 BP),
- Late Holocene (4,250 BP to present, with "0" marking the BC/AD transition).

During this interpretation of the Holocene, significant temperature and humidity fluctuations occurred. Notably, two anomalous, deep, and short-lived cooling events took place around 8,200 years BP and 4,200 years BP.

Across vast areas of the Northern Hemisphere, biocenoses developed, generating both oxygen and carbon dioxide. A spectacular example of environmental changes was the Sahara, where from 8,500 to 3,500 years BP, settlements engaged in agriculture thrived, as documented by rock carvings. Another notable example was the tectonic structure of the Dead Sea, where water levels fluctuated by several dozen meters. The highest levels occurred between 9,800–8,000 years BP and 5,500–3,500 years BP, with a brief but catastrophic peak around 3,000 years BP, followed by moderate humidification around 2,000 years BP, coinciding with the BC/AD transition. Additionally, vast areas west of the Jordan Rift Valley and the Dead Sea were still covered by evergreen forests around 3,000 years BP, but desertification followed thereafter.

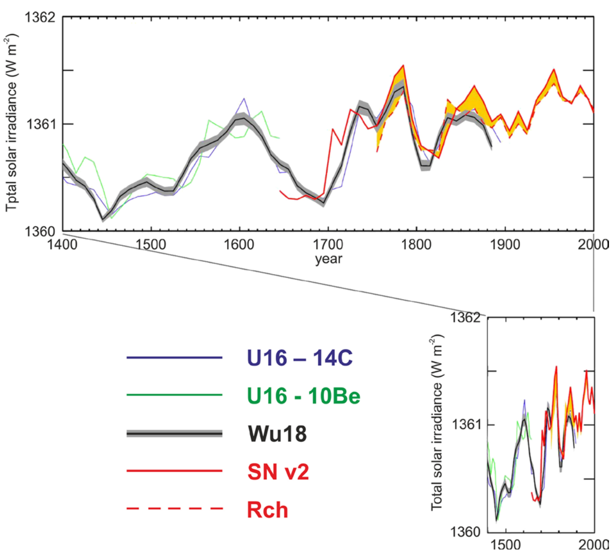

Fig. 3. Variations in solar constant based on combined isotopic data from multiple measurement series, spanning the period since about 1400 AD according to Wu et al. (2018).

During the warming that occurred in the middle Holocene (the so-called Atlantic period), there were numerous peat bogs in the northern European zone. Danish analyses of the macroresidues contained in their profiles (content of the stomatal apparatus of birch leaves) provided data on natural changes in the concentration of CO_2 in the atmospheric air. In the time interval 8,000–7,500 years ago, the carbon dioxide content ranged from 270 to 330–340 ppm, and from 7,500–7,000 years ago, it stabilised at just over 300 ppm. The documented naturalistic variability of CO_2 concentrations will be used later in the paper to interpret the role of humans in this regard during their pressure on the environment – in the so-called Anthropocene (Zalasiewicz et al. 2011).

Also, the last millennium was not free of thermal and moisture fluctuations. First, there was the warming of the Early Medieval Warm Period (~900–1400 AD), in which temperatures were slightly higher than today. There were significant wetter periods and periods of drought. Add to this that this period saw the exploration of the Normans, from the western areas of Scandinavia through Shetland, the Faroe Islands, Iceland, Greenland to Newfoundland. The latter they called Vinland – the land of the wine. The favourable conditions for settlement in Vinland and the SW areas of Greenland, proved to be short-lived.

From c. 1400 to c. 1850 AD, the so-called Little Ice Age (LIA) lasted with two distinct cold phases with a warm fluctuation separating them (~1600 AD). The bimodality of the LIA cooling and the onset of the 19th and 20th century warming are also documented by changes in solar activity (see Usoskin I.G. 2017, also online: 'Aktywność słoneczna w ostatnich 9000 lat', Wikipedia – Polish version, with suggestive graphs, summing up reconstructions of the decadal mean sunspot number and more recently ongoing direct measurements of the solar constant and ^{14}C and ^{10}Be isotopic measurement data). During the LIA, glaciers developed extensively in the northern hemisphere (Jania 1985, 1993), and the Baltic Sea froze to the extent that direct communication between southern Scandinavia and continental Europe was possible (including army marches, in the course of the Thirty Years' War).

With the warming that began in the 19th century and continues to this day, human pressure on the natural environment coincided – the onset of the Industrial Revolution (the era of "coal and steam"; let us add that water vapor is the most significant greenhouse factor; clouds also play an important role—dark ones absorb heat, while light ones reflect it). A sudden increase in human pressure on the environment occurred in the 1940s with the advent of the technological revolution. The previously regional extent of this pressure reached a global level, even extending into the "foyer of space" (with numerous orbiting devices and a vast amount of space debris).

The ever-increasing intensity of anthropopressure does not hold a dominant role in climate change. It is a modifying factor in the energetic mechanisms of natural phenomena, which have not ceased to operate. The overall trends in climate change rhythms will continue to be determined by the complex nature of galactic phenomena, the energy-magnetic fluctuations of the Sun, and their interactions with Earth's magnetic field.

The analysis of solar constant variability, reaching back thousands of years, and especially over the last few centuries, confirms the previously mentioned bimodality of LIA cooling periods, separated by a warming phase. Moreover, it allows for the prediction of a cooling period similar to LIA, possibly occurring as early as the late 21st century or in the 22nd century. The peak phase of the Holocene interglacial appears to be coming to an end, as schematically shown in the Figure 1 (the far-right segment, beyond the "0" boundary). Due to human pressure, the temperature and temporal expression of the interglacial maximum is being extended.

The role of humans in climate change is a subject of controversy. There are two main perspectives, differing in their interpretation of temperature changes, particularly regarding the role of carbon dioxide. Currently, both in theory and in the political-business sphere, the dominant position is that of the Intergovernmental Panel on Climate Change (IPCC). Man appears to be the main agent of climate change, primarily through excessive carbon dioxide emissions, which drive the increase in temperature. In the case of the IPCC's stance, the concept – attributed to Protagoras (5th century BC) but overcome by Socrates (5th–4th century BC) – that ultimately everything depends on humans, has resurfaced once again. The anthropo-catastrophic perspective was widely promoted over a decade ago in the highly suggestive film *An Inconvenient Truth*.

A separate perspective is presented by a large group of specialists working within the Nongovernmental International Panel on Climate Change (NIPCC), who do not take such a dire view of global warming and the pernicious role of carbon dioxide in the Earth's atmosphere. This stance was also supported by renowned scientists featured in the movie *The Cold Truth*.

The diverse paleoenvironmental data cited in this paper primarily indicate the decisive role of astronomical factors in climate and environmental changes. This also applies to fluctuations in greenhouse gas concentrations, including carbon dioxide. Its concentration increase, due to positive feedback mechanisms, leads to rising temperatures. However, it is difficult to identify similar mechanisms for the reduction of this gas's concentration, which has occurred repeatedly in the past.

If carbon dioxide were the main driver of temperature fluctuations, its concentration variations would have to be enormous. Data from the early decades of the 20th century provide insight into the extent of such fluctuations, particularly in comparison to the warming of the Atlantic period in the mid-Holocene (as discussed earlier). At the beginning of the 20th century, CO_2 concentration was around 300–310 ppm. In the 1960s, it was approximately the same as during the Atlantic maximum. Currently, CO_2 levels are around ~400 ppm. If this entire difference is attributed to human activity, anthropogenic pressure accounts for no more than 15–18%.

Man is undoubtedly and variously degrading the natural environment. It is absolutely necessary to protect the environment in a RATIONAL manner, without falling into extreme solutions. There are no zero-emission technologies, therefore, each technology determines the use of the earth's resources, the need for energy, and so on. An equally important pro-environmental measure must be ADAPTIVE, in relation to environmental change.

If we really want (and we should) to reduce pressure on the environment, then we need to work effectively to eliminate the militarisation of the world. There is no other domain of life that is so resource-intensive and plundered, has such a negative impact on the lithosphere, hydrosphere, and atmosphere, brings enormous human tragedy and destruction requiring material- and energy-intensive reconstruction, and finally environmentally burdensome disposal. The much-publicised dangerous carbon footprint of militarisation is unparalleled in any other domain of life.

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