Global climate change, CO_2 and climatic catastrophes

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A b s t r a c t. I refer to the ongoing discussion between the climatic skeptics and mainstream scientists and highlight some skeptical argumentation, arguing that the current warming is not unprecedented in its magnitude nor dynamics and in the geological past the correlation between temperature and CO_2 was frequently zero or negative. There is no evidence that CO_2 was the triggering factor for global temperature changes. There are significant climate drivers other than greenhouse gases which may, at least partly, explain the current warming. Arguments are provided to support the notion that the solar irradiance coupled with cosmic rays, oceanic oscillation and changes in atmospheric aerosols can explain much of the warming since preindustrial times. Finally, the current global environmental trends do not indicate impending climatic catastrophe. Nevertheless, I emphasize that the development of human civilization undoubtedly influenced global climate, and that some anthropogenic influences are still to be studied. Many feedbacks between atmosphere, ocean, land and human activities remain poorly known and there are reasons to decouple economic development from the burning of fossil fuels.

Keywords: *global climate change, CO_2, climatic catastrophes*

INTRODUCTION

In one of the last issues of the *Przegląd Geologiczny* (vol. 73, no. 2) one can find two contradictory papers. One published by Hubert Wierzbowski (2025) who claims that CO_2 played a major role in long-term climate forcing during Phanerozoic history and that anthropogenic emissions can cause a rise in surface temperatures marking the end of the present icehouse conditions of the Earth's climate. Another paper was written by Leszek Marks (2025) who downplays the role of anthropogenic greenhouse gases (GHGs) in shaping the current global warming and underscores natural climatic variability. The argumentation of Marks is against the mainstream "scientific consensus" expressed by the recent IPCC report (IPCC, 2023) or *Klimatyczne ABC* (Budziszewska *et al*., 2023). However, the IPCC (2021) states: *It is very likely that well-mixed GHGs were the main driver of tropospheric warming since 1979* leaving some room for other drivers of the climate change. In other words, the IPCC is not *virtually certain* about this issue (Kause *et al*., 2022).

The so called "scientific consensus" seems to be weakened if one realizes that two Nobel Prize winners in physics (John Clauser and Ivar Giaever) object to the notion that CO_2 plays a decisive role. Among the best known skeptics from the West are: William Happer (atomic physics, optics and spectroscopy; Princeton University), Richard Lindzen (atmospheric physicist; Massachusetts Institute of Technology), Judith Curry (climatologist; Georgia Institute of Technology) and John Christy (climatologist; University of Alabama). The last of these was awarded NASA's Medal for Exceptional Scientific Achievement and the Special Award by the American Meteorological Society for developing a global, precise record of earth's temperature from operational polar-orbiting satellites. Lindzen and Christy were both leading authors of sections of the 2001 IPCC report. However, for years they try to change the dominant climate narrative about the leading role of CO_2 (Lindzen, Christy, 2024). There are numerous other skeptics, especially among geologists, palaeoclimatologists and physical geographers, e.g. some Polish geologists who signed *Stanowisko KNG* (2019), Don Easterbrook (Western Washington University), Wibjörn Karlén (Stockholm University), Ole Humlum (University of Oslo), but also climatologists and geophysicists who express their views in the European Institute for Climate and Energy EIKE (Lüdecke, 2023) or Clintel Foundation publications (Crok, May, 2023). The skeptical group in Poland was recently joined by Piotr Kowalczak, a hydrologist from the Institute of Meteorology and Water Management National Research Institute (Kowalczak, 2024).

I did not conduct any survey among scientists, but it is probable that skeptics are outnumbered by those who agree with the main statements of IPCC. The message of Wierzbowski (2025) is moderate and not alarming. However, Szymon Malinowski (atmosphere physicist, University of Warsaw), the creator of the popular Internet portal *Nauka o klimacie* and the hero of the documentary film *It's OK to panic* warns about an upcoming climate catastrophe. Clearly, the issue of the global climate change has become strongly political, and emotional.

Here, I would like to stress some argumentation put forward by the skeptics. I argue that:

- ❏ the current warming is not unprecedented in its magnitude nor dynamics,
- ❏ in the geological past the correlation between temperature and CO_2 was frequently zero or negative, and there is no evidence that CO_2 was the triggering factor for global temperature changes,
- ❏ there are significant climate drivers other that GHGs which overlap and may, at least partly, explain the current warming, and finally
- ❏ that the current global environmental trends do not indicate impending climatic catastrophe.

That is not to say that anthropogenic emissions of GHGs are irrelevant, as they intensify the greenhouse effect, but the climate sensitivity remains unclear (Koonin, 2024). Gradual decoupling of economic development from

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the burning of fossil fuels is necessary for a variety of reasons. For millennia, human population remained under 1 bn and in ~200 years it exceeded 8 bn. The accompanying deforestation, development of agriculture, industry, transportation and growth in built-up areas must have influenced global climatic conditions. Rapid development of human civilization has changed forest cover, global albedo, water circulation, modified concentration of atmospheric greenhouse gases, aerosols or atmospheric ionization, and so on. All these actions overlap with very complex natural processes.

IS THE CURRENT WARMING UNPRECEDENTED?

The global average surface-air temperature has risen by circa 1.5°C since 1900 AD (Fig. 1A), but is this unprecedented in magnitude and speed of warming? First and foremost, there are no precise global temperature records long enough to unequivocally answer this question. The longest series of measurements obtained with the use of ground thermometers is for central England and this clearly shows that in the years AD 1695– 1735 mean annual air temperature for this area rose by at least 2°C (HadCET, 2025). It is sometimes argued that the Medieval Warm Period (MWP) followed by the Little Ice Age (LIA) were rather regional climatic changes. However, temperature reconstructions based on *multi-proxy* data from the whole Northern Hemisphere (Fig. 1B) published by Moberg *et al*. (2005) and further supported by tree-ring data provided by Schneider *et al*. (2015) indicate that the average surface-air temperature in the MWP was similar to that at the beginning of 21st century at least throughout the Northern Hemisphere. In the interpretation of global temperature based on *multi-proxy* data one must keep in mind that these have relatively low resolution; therefore, they may not record rapid short-term climatic shifts (Marks, 2025).

A different situation exists with relatively high-resolution *proxy* derived from ice cores. In this case they show climatic shifts in the glaciated regions that do not necessarily represent the global climatic situation. However, the climatic conditions of the Arctic are very important for the whole planet, because of sea ice-induced global albedo and permafrost methane feedbacks, and because the global ocean conveyor belt is strongly linked to the Arctic Ocean. There is strong evidence that the Arctic was warmer in the MWP than in the 21st century. Glacier ice melting rates reconstructed from Lomonosovfonna glacier indicate that summer temperatures over Svalbard were at least as warm as the summers of 2001 and 2000 (Virkkunen *et al*., 2007). There is grass dated to the MWP found *in situ* beneath the Longyearbyen glacier in Svalbard which indicates that the glacier must have been much smaller than at present (Humlum *et al*., 2005) and expanded due to climatic cooling after the MWP (the glacier is non-surging).

If we go further back into Earth's history, we find that during the Holocene Thermal Maximum (HTM) the Arctic was even warmer. According to Kaufman *et al*. (2004) the Arctic was on average 1.6 ±0.8°C warmer than average temperature of the 20th century. The data from the Greenland ice core (Döring, Leuenberger, 2022) indicate that the HTM was significantly warmer than the MWP and that the whole Holocene temperature record was punctuated by numerous very rapid jumps 2°C up or down from the mean (Fig. 1C). Higher-than-today temperatures of the HTM

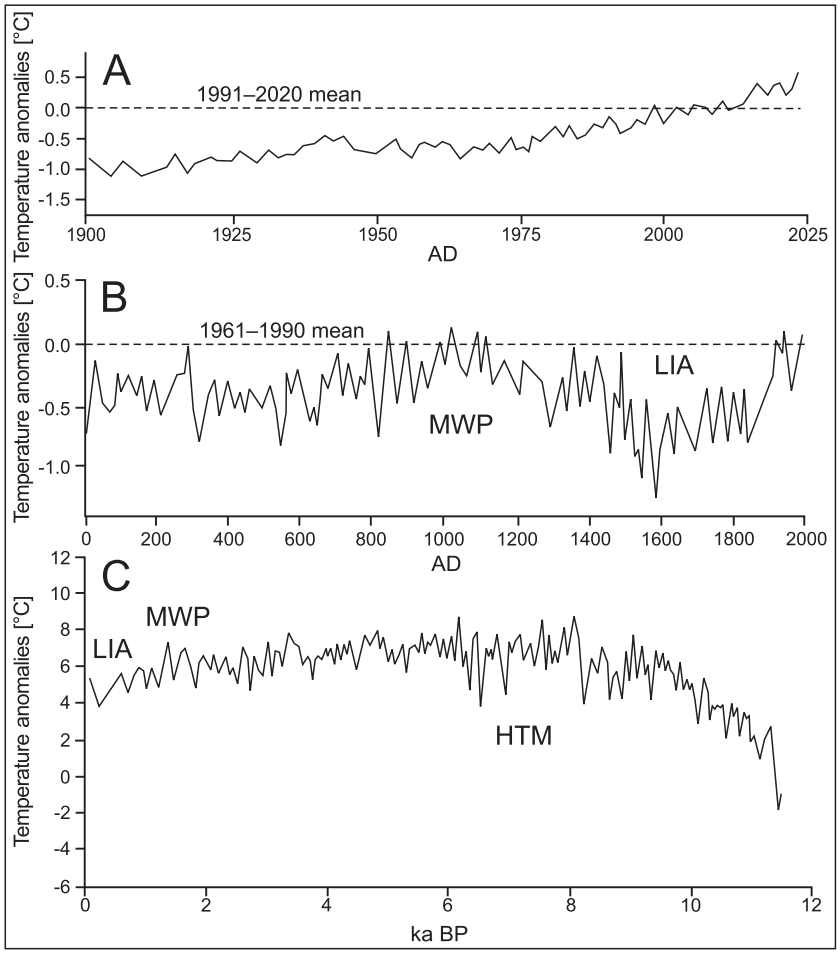

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Fig. 1. A – global average surface-air temperature measured since 1900 AD (Sanchez-Lugo *et al*., 2024, modified); **B** – N Hemisphere temperature reconstructed from *multi-proxy* data (Moberg *et al*., 2005, modified); **C** – hybrid reconstruction of temperature from Greenland Ice core (Döring, Leuenberger, 2022, modified); HTM – Holocene Thermal Maximum, MWP – Medieval Warm Period, LIA – Little Ice Age

and of the MWP in the Arctic can be also inferred from Björnsson (2017) who shows how small and fragmented the Vatnajökull ice cap (Iceland) was between 4000–1000 ka BP. Moreover, a warmer Arctic in the HTM is indicated by thaw unconformities found in contemporary permafrost which testify to a deeper-than-now active layer (Lacelle *et al*., 2014). A much smaller volume of glaciers and permafrost in the HTM can, finally, be inferred from the global sea level record. Lewis *et al*. (2008) show that, at the tectonically stable coast of Australia, sea level was 0.5–1.5 m higher that today in HTM. The recent publication of Creel *et al*. (2024) provides arguments that global mean sea level exceeded early industrial levels after 7.5 ka BP, reaching 0.24 m above present by 3.2 ka PB.

Unequivocal evidence of higher-than-now global sea level in HTM is discordant with the recent IPCC report (2023). It is clear that temperature reconstructions by models which are mainly based on the CO_2 concentration are simply wrong. Renssen *et al*. (2012) performed modelling of global atmosphere-ocean-vegetation interactions but apart from GHGs they considered also variations in orbital parameters, the influence of Early Holocene deglaciation (e.g., melt-water fluxes) and changes in topography and surface albedo. The results showed the warmest HTM conditions at high latitudes in both hemispheres reaching as much as 5°C above the preindustrial level although they found temporal heterogeneity of the HTM.

There is much local evidence for warmer-than-now climatic conditions outside of polar regions. Archaeological studies performed in Poland (Stupnicka *et al*., 2006) show that in the Migration Period (300–600 AD) warmer and dryer conditions were common. This is inferred from the fact that remains of human settlements are found buried in the fluvial deposits or peat of contemporary flood-prone areas and from traces of warm-loving plants (e.g., grapes) found in northern Poland.

The "hockey-stick" curve of the global temperature rise, produced by Mann *et al*. (1998, 1999) and advocated by alarmists and IPCC, does not fit to other global or polar temperature change reconstructions based on *multi-proxy* data discussed above (Fig. 1). The curve was criticized by McIntyre and McKitrick (2005) on the bases of data selection bias and improper statistical procedures. Further criticism on the "hockey-stick" can be found in Marks (2025).

THE SIGNIFICANCE OF CO_2 IN DRIVING GLOBAL TEMPERATURE

In geological records the global mean surface temperature (GMST) is more or less correlated with CO_2 , but there is no evidence or premise (e.g., time-lag relationship) that this greenhouse gas was the triggering factor for temperature changes. Wierzbowski (2025) cites Judd *et al*. (2024) who claim: *There is a strong correlation between atmospheric carbon dioxide concentrations and GMST, identifying CO_2 as the dominant control on variations in Phanerozoic global climate*. They show a graph depicting general positive correlation, but careful analysis suggests that for about half of its length the correlation is zero or negative (Fig. 2). For periods of positive correlation Judd *et al*. (2024) do not show any time lag which would imply that the temperature changes resulted from changes in CO_2 concentration. The temperature and CO_2 decoupling may be best visible in the Cretaceous record. Barral *et al*. (2017) wrote in one of the *Nature* journals: *CO_2 is considered the main greenhouse gas involved in the current global warming and the primary driver of temperature throughout Earth's history. However, the soundness of this relationship across time scales and during different climate states of the Earth remains uncertain*.

What else might provide better correlation with global temperature except for CO_2 in the Phanerozoic? Shaviv *et al*. (2023) built a model which shows that the general decline in CO_2 concentration in this eon was offset by the increasing solar luminosity. As a result, the dominant long-term temperature variations occurred due to the periodic passages of the solar system through the galactic spiral arms. This resulted in changes in Earth's atmospheric ionization which in turn modified global albedo by cloud formation.

Another problem in supporting the narrative about the leading role of CO_2 is the publication of Shakun *et al*. (2012) titled: *Global warming preceded by increasing carbon dioxide concentrations during the last deglaciation*. However, the authors provide information that do not justify such title. On page 49 they write: *Our results indicate that CO_2 probably leads global warming over the course of the deglaciation* (notice the term "probably") and on the next page one can read: *An important exception is the onset of deglaciation, which features about 0.3°C of global warming before the initial increase in CO_2 c. 17.5 kyr ago. This finding suggests that CO_2 was not the cause of initial warming*." The lead of temperature over CO2 (recorded in Antarctic ice) during Pleistocene glacial–interglacial transitions still remains an irrefutable fact (Ganopolski, Roche, 2009).

There is a famous "Holocene conundrum" (Liu *et al*., 2014; Kaufman, Broadman, 2023) pertaining to the period from 5000 BP to LIA where discrete CO_2 rise was accompanied by a gradual fall in temperature. The study of climatic changes in the Holocene by Mayewski *et al*. (2004) provides information that our epoch underwent abrupt climatic changes driven by multiple factors, but that changes in the concentrations of CO_2 and CH_4 followed rapid temperature shifts and were not the cause of them.

Wierzbowski (2025) and the IPCC refer to models which are based on the assumption of a CO_2-temperature

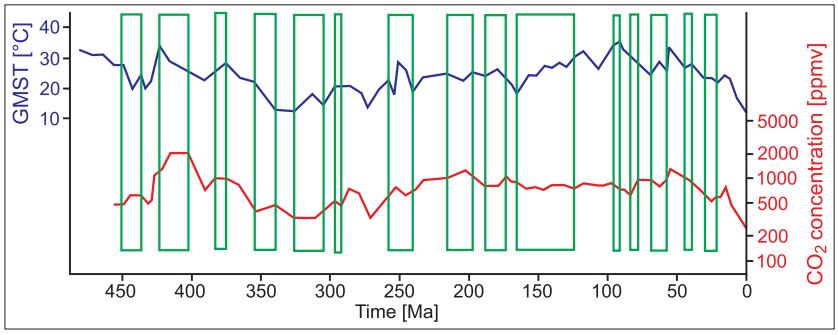

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Fig. 2. Phanerozoic global mean surface temperature (GMST) and atmospheric CO_2 concentration after Judd *et al*. (2024), modified. Green rectangles show periods when CO_2 does not correlate positively with GMST

dependency. However, the current atmospheric observations contradict such models in several ways. For example, one of the most important features of glaciations (the icehouse climate) was an enhanced latitudinal temperature gradient and the IPCC models assume that this gradient is weakening now. However, as indicated by Lindzen and Christy (2024), observations show that the gradient is relatively stable. Another weakness of the models is that they show the quickest warming in the upper tropical troposphere. This again is not supported by direct measurements (Christy, McNider, 2017; McKitrick, Christy, 2018). There are also other discordances between the IPCC models and reality, such as the significant slowdown of Greenland ice sheet melt observed since 2013 (Geological Survey of Denmark, 2025) or the still-stand of Arctic September sea ice since about 2008 (Arctic Sea Ice, 2025).

CLIMATE DRIVERS OTHER THAN GREENHOUSE GASES

Marks (2025) described numerous internal and external factors which influence abrupt climatic changes. In this section I would like to extend some of the issues mentioned by Marks and offer a slightly different approach.

Changes in insolation due to Earth's orbital variations or/and to solar variability played a central role in the global climatic changes in the Holocene (Mayewski *et al*., 2004; Steinhilber *et al*., 2009). The Maunder Minimum (1645 to 1715 AD) corresponds with the coldest parts of the LIA after which solar activity increased (Scafetta, West, 2007), and since solar cycle 15 (1913–1923) the solar energy emitted to the Earth has been elevated (Fig. 3). It is clear that the total solar flux (irradiance) was much lower in preindustrial times that in the 20th and 21st centuries. The current cycle 25 is exceptionally high (Lindsey, 2021).

Global air temperature was relatively stable between circa 1998 and 2015, but afterwards it began to rise again with greatest positive anomalies in years 2023 and 2024 (Global Temperature Report, 2025). According to Goessling *et al*. (2024) the recent temperature rise was boosted by decline in low cloud cover resulting in a record low planetary albedo. The decline in low cloud cover was accompanied be a strong El Niño followed by a strong La Niña event. The year 2015 is an inflection point at which tropospheric aerosol concentrations changed their trend from rising to declining (Rémy *et al*., 2024) which resulted from several reasons e.g. reduction in air pollution in China, decreasing trends in wildfires, wetting of Sahel (see next section). Solar activity is closely coupled with galactic cosmic radiation entering the Earth's atmosphere thus modifying its ionization which in turn influences cloud cover (Svensmark, 2007). However, the exact mechanism is yet unknown, because global clouds are under the profound influence of many other processes, most importantly the El Niño Southern Oscillation (Kumar *et al*., 2023).

These changes in solar irradiance and atmospheric aerosols are accompanied by the Atlantic Multidecadal Oscillation (AMO, 2022) which correlates strongly with air temperature in Europe (ESOTC, 2022) and with global surface temperature. The general temperature rise between 1980 and 2015 clearly correlated with the rise of the AMO index (the value of this index is still elevated). Zampieri *et al*. (2017) showed that, in spring and summer, significant changes in European weather regimes (air pressure, precipitation and temperature anomalies) occur with the phase shifts of the AMO. According to Moore *et al*. (2017) the AMO significantly intensified in the mid-19th century, so it could not have been influenced by anthropogenic GHGs.

Volcanic activity plays an additional role in shaping the rate of the temperature rise. There were more significant eruptions during preindustrial times and in the years 1963–1991, which correlate with times of low air temperature (Kobashi *et al*., 2017; Sanchez-Lugo *et al*., 2024). If the volcanic signal (cooling due to volcanic aerosols) was removed, the climate warming rate would be much less (Christy, McNider, 2017). On the other hand, the recent huge Hunga Tonga–Hunga Ha'apai eruption on the floor of Pacific ocean (2021–2022) ejected much water vapor (the most important greenhouse gas) and Jenkins *et al*. (2023) argue that it will probably have (or already has) an effect on the GMST rise.

Volcanic eruptions, changes is desert areas, wildfires, industry and land use changes influence the concentration of atmospheric aerosols. However, there are also other more periodic sources of water vapor condensation nuclei. Scafetta *et al*. (2020) found that the 60-year-long oscillation of Jupiter's orbit correlates well with Earth's temperature and rainfall during the Indian monsoon, and the Northern Atlantic Variability. They show long-term records testifying that when Jupiter's orbit is more eccentric (which is the contemporary situation), there are fewer asteroids and comets nearby the Earth. This in turn may result in less cosmic dust in the Earth's atmosphere, and therefore less clouds, which would boost GMST.

These natural cycles can overlap with each other and mutually reinforce climatic changes. As shown by Yang *et al*. (2016) and Wang *et al*. (2017), these phenomena can explain at least a significant part of observed warming since 1980's.

Among anthropogenic factors, besides emissions of GHGs, emissions of aerosols and land use changes, one should also realize that during the Cold War there were on average 50 nuclear weapon tests per year (Nuclear Weapon Tests, 2025). Each nuclear explosion increased atmosphe-

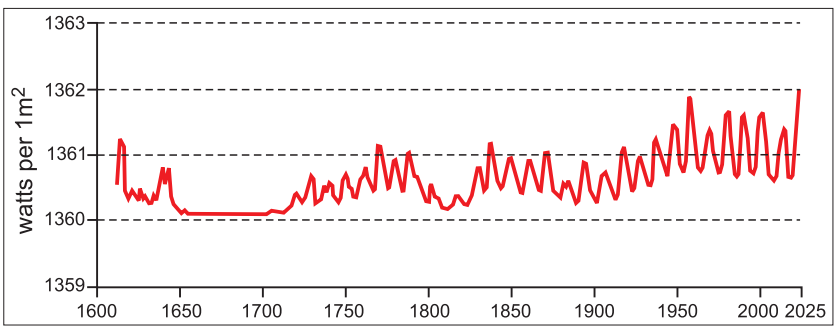

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Fig. 3. Total solar irradiance (Lindsey, 2021, modified)

ric ionization and thus increased cloud thickness (Harrison *et al*., 2020). After the fall of the USSR there was a significant reduction of global cloudiness (Devasthale, Karlsson, 2023) which could be linked with the drastic reduction of anthropogenic ionization of the atmosphere. This global decline in cloudiness corresponds with the rise of GMST in 1990s.

CLIMATIC CATASTROPHE

Messages on the World Meteorological Organisation website are alarming: *WMO report documents spiralling weather and climate impacts* (WMO, 2025). Such information is repeated by politicians and in school textbooks which leads many people to psychological disorders or depression. However, this narrative is poorly supported by the data. From 1980 until 2000 there was indeed a sharp rise in the number of reported floods and extreme weather events (Fig. 4A), but this was caused by developments in environmental monitoring which lead to increased detection of events, mostly of small scale. Since 1975 floods became less deadly at the global scale, not only thanks to better protection but also due to a relatively stable number of floods (Jonkman *et al*., 2024). In Europe, in the 21st century there is a decreasing trend in flooded area, fatalities and economic losses (Paprotny *et al*., 2018). However, there is a rising trend in flash floods which calls for better monitoring and preparedness (Al-Rawas *et al*., 2024). Tropical cyclones exhibit sinusoidal oscillations in frequency and strength with no rising trends (Alimonti *et al*., 2022; Maue, 2025) and there is no rising trend in sandstorms or other events related to strong winds.

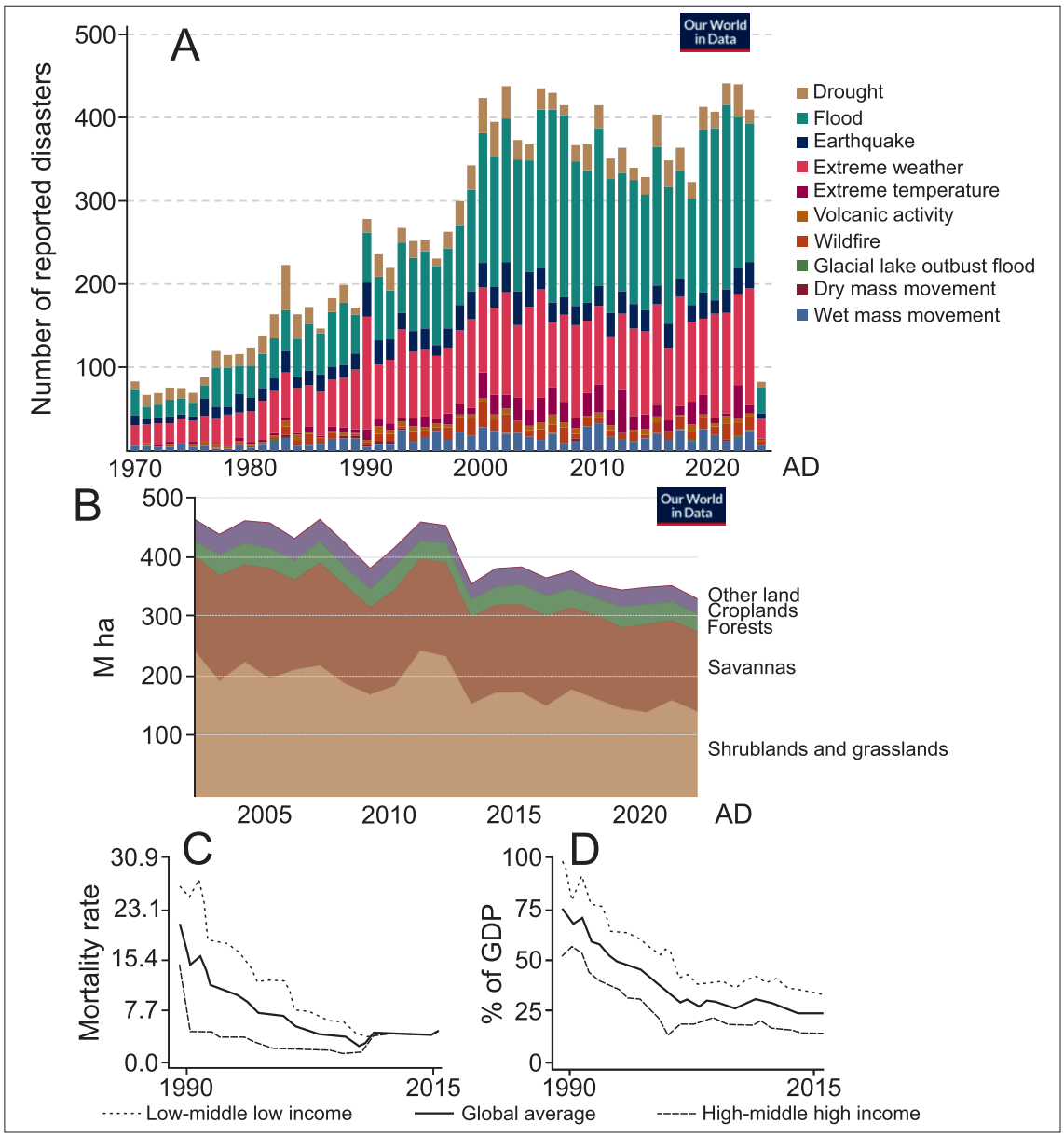

Fig. 4. **A** – annual global number of reported natural disasters (extreme weather includes tornadoes, hailstorms, thunderstorms, sandstorms, blizzards, and extreme wind events); source: EM-DAT, CRED / UCLouvain (2024) after *Number of recorded natural disaster events* (2025), modified; **B** – annual global area of wildfires; source: Global Wildfire Information System (2022) after Samborska, Ritchie (2024), modified; **C** – fatalities per 10 000 people exposed population and D) material loss (% of GDP) for the climate-related hazards; source: Formetta, Feyen (2019) modified

In a few countries there is a rising trend in wildfires. However, unexpectedly, the global area of wildfires declined in the 21st century (Fig. 4B) which translated to a decline in emissions of CO_2 and $PM_{2.5}$ from this source (Andela *et al*., 2017; Chen *et al*., 2023; Samborska, Ritchie, 2024). Perhaps the fires in Australia in 2019–2020 were unprecedented, but only for New South Wales and Queensland, not for the whole country. Canadian fires in 2023 were extraordinary and do not align with the general trend, but they were not unprecedented (Rott, 2023). The main factors responsible for the recent fires in the Los Angeles area (January 2025) were strong winds, typical for the winter season in southern California, and numerous faults in the poorly maintained electric grid, not global warming (Goldberg, 2025).

Formetta and Feyen (2019) provided empirical evidence that globally, our vulnerability to climate-related hazardous events exhibits declining trends, both in human mortality and material losses (Fig. 4C). This decline obviously results from economic development but also from the fact that there is no general rising trends natural disasters.

Some coastal zones are threatened by the global mean sea level (GMSL) rise, and the IPCC reports show a continuously increasing rate of this process. However, Frederikse *et al*. (2020) shows that the rate of GMSL rise changes in a sinusoidal fashion: in the first 3 decades of the 20th century it was declining (down to ~0.8 mm yr^{-1}), then in went up to 2.4 mm yr^{-1} (1940), later it declined to ~0.5 mm yr^{-1} (1965) and later on it started to rise again. In the 21st century, the sea level trend is ~3.4 mm yr^{-1} (Global Ocean Mean Sea Level, 2025). Paradoxically, despite the GMSL rise, low lying atolls in Pacific grow in size due to the natural accumulation of sand (Kench *et al*., 2018) which is against the common notion of low-lying islands drowning. The future of the global sea level trend is uncertain if one realizes that the Greenland ice sheet melting has slowed down since 2013 (Geological Survey of Denmark, 2025) and the negative trend for Antarctic ice sheet mass turned to positive couple of years ago (Antarctic Ice Mass, 2025).

This is not to say that there are no disturbing phenomena. For example there is a recent rise in heat waves and aridity. However, the long-term registry of heat wave index calculated for USA shows no increasing trend. In years 1930–1936 this index had several times higher values than nowadays (Heath Wave Index, 2025). Public opinion is informed that nowadays heat kills more and more people which is correct, but why are we not informed that globally cold kills fewer and fewer? In all climatic zones, including the tropics, deaths attributable to cold is circa 10 times greater than deaths due to heat. Therefore, the death toll from thermal discomfort declines even in the tropics (Egondi *et al*., 2015; Son *et al*., 2016; Fu *et al*., 2018; Scovronick *et al*., 2018; Masselot *et al*., 2023).

The Palmer Drought Severity Index calculated for the whole globe (Fig. 5A) showed no significant trend for the years 1950–2020 (Barichivich *et al*., 2024) and allowed one to infer that the area of arid land frequently and sharply changes from year to year between 15 and 25% of the total land area. The peaks of aridity closely overlap with El Niño events and are exceptionally high when there is additional overlap with high sholar activity. However, the last four years experienced a rise of the arid area to 30%. This was

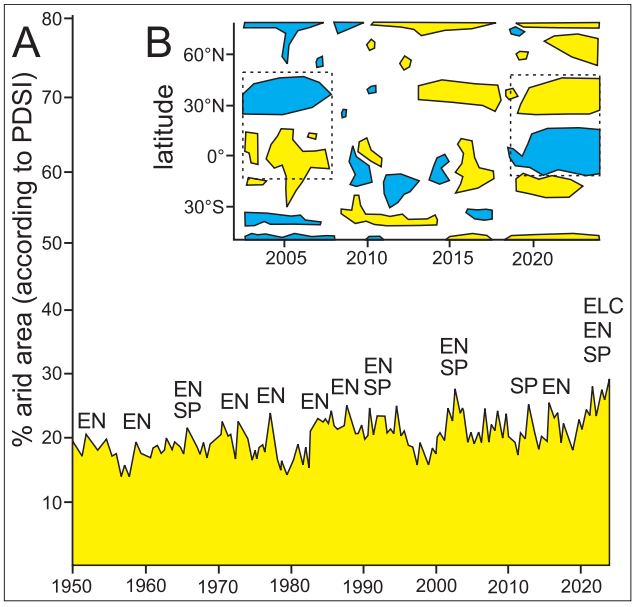

Fig. 5. A – The Palmer Drough Severity calculated for the global land surface (Barichivich *et al*., 2024, modified); **B** – zonal means of monthly terrestrial water storage anomalies (Rodell, Wiese, 2024, modified); yellow indicates decreased water storage and blue increased storage; EN – El Niño, SP – solar activity peak, ELC – exceptional low cloudiness; dashed-lines (Figure B) show the interchanging pattern

influenced by the strong El Niño immediately followed by strong La Niña in 2023–2024, exceptionally strong solar activity, and record low planetary albedo caused by a strong decline in low cloud cover. Goessling *et al.* (2024) put forward three possible processes to explain the declining low cloud cover (with a current negative trend that began in 2015):

- ❏ internal variability (e.g., influence of AMO),
- ❏ an emerging low-cloud feedback (resulting from a rising greenhouse effect),
- ❏ aerosol effects.

In the modelling performed by Boucher *et al.* (2012) rising CO_2 concentrations result in lowering of low cloud cover and rising aridity. However, the current decline in clouds corresponds very well with the global decline in atmospheric aerosols leaving the question about the cause of low cloud decline unanswered.

Figure 5B (dashed rectangular areas) shows that the zonal means of monthly terrestrial water storage anomalies (Rodell, Wiese, 2024) exhibit an interesting pattern which probably results from ocean-atmospheric oscillations. The northern position of the drying area pushes the global aridity index up partly due to the fact that there is much more landmass in the Northern Hemisphere. Contemporary strong wetting of the Sahel is manifested by Lake Chad which experiences a significantly increasing trend in water volume (Sylvestre *et al*., 2024). This constitutes a great benefit for the poorer inhabitants of this region.

The mainstream narrative is that the warming supercharges extreme weather events. However, there is evidence that colder periods in Earth's history (e.g., LIA) experienced more frequent or severe storminess and flooding than industrial times (Barriendos, Rodrigo, 2006; Stupnicka *et al*., 2006; Nazzareno *et al*., 2021; Stachowska *et al*., 2024). This also pertains to droughts (Woodhouse, Overpeck, 1998; Duch, 2021) and wildfires (Stephens *et al*., 2007).

CONCLUSIONS AND FINAL REMARKS

The following statements can be put forward.

1. Anthropogenic emissions of GHGs influence contemporary warming, but the climate sensitivity is uncertain and the role of CO_2 in driving or triggering numerous global climatic changes throughout geological history is debatable. The claim that current warming is unprecedented (due to emissions of GHGs) is not supported by geological and glaciological evidence. In the geological past, correlation between CO_2 and temperature was frequently zero or negative and in times of positive correlation, best seen in the Pleistocene, the CO_2 rises lagged behind temperature rises. The models used by IPCC significantly disagree with current observational data (e.g., temperature of the upper tropical troposphere, longitudinal thermal gradient or Arctic sea ice extent).
2. Solar irradiance coupled with cosmic rays and oceanic oscillations (e.g., AMO) can explain much of the warming since preindustrial times when solar energy flux was much lower than now. The current solar cycle (no 25) is the strongest ever recorded in terms of total solar irradiance and in years 2023–2024 it overlapped with a strong El Niño immediately followed by a strong La Niña and record low global cloudiness. These processes probably resulted in the recent aridity rise.
3. Some anthropogenic influences on global climate are still poorly studied, e.g. atmosphere ionization by nuclear testing or emissions of aerosols, both influencing cloud formation. There is an interplay between natural and anthropogenic factors and many feedbacks between atmosphere, ocean, biosphere and human activities remain poorly known and may be visible with delay.
4. Except for flash floods and recent increase is aridity in the N hemisphere, there are no rising global trends in the number of climate-related dangerous events such as tropical cyclones, wildfires or floods in general. Despite population growth, which translates to the rising exposure to hazards, there is a declining trend in mortality and material losses as a % of exposed GDP. This indicates that global climate change and the development of human civilization result in the fact that we are less vulnerable to climatic hazards. There is no guarantee that this positive situation will continue in the future, but current trends do not indicate impending climatic catastrophe.

However, prolonged reliance on fossil fuels should be reduced as they are non-renewable, result in air pollution and emissions of GHGs which may trigger unwanted environmental feedbacks. Adaptation to climatic changes (they occurred in past and will occur in the future) and building resilience to dangerous climate-related events is important. In the light of rising demands, improvements to water management seems crucial. However, I argue that the narrative of approaching climatic catastrophe, and a global misery caused by disastrous weather-related events, is poorly supported by observational data.

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