



## PETRÓPOLIS (BRAZIL) AND CLIMATE CHANGE: LESSONS FOR THE WORLD

*PETRÓPOLIS (BRASIL) E AS MUDANÇAS CLIMÁTICAS: LIÇÕES PARA O MUNDO*

*PETRÓPOLIS (BRASIL) Y EL CAMBIO CLIMÁTICO: LECCIONES PARA EL MUNDO*

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### **Abstract:**

Brazil experienced one of the largest storms in its history in 2022, which may illustrate the fate of ongoing global climate change. The city of Petrópolis was once known for its mild and pleasant climate, recognized by the Brazilian emperors in the 19th century. Deforestation on the city's hillsides, coupled with the climate changes brought about by anthropic actions in recent decades, have transformed the resting place of royalty into a periodic flood trap. The phenomenon, and its consequences, alert us to the need to recognize the risks that humanity runs if there is no change in the way we deal with the environment.

**Keywords:** flooding; climate change; human action; cities; rainfall.

### **Resumo:**

O Brasil passou por uma das maiores tempestades de sua história em 2022, o que pode ilustrar o destino das mudanças climáticas globais em curso. A cidade de Petrópolis já foi conhecida por seu clima ameno e agradável, reconhecido pelos imperadores brasileiros no século XIX. O desmatamento nas encostas da cidade, aliado às mudanças climáticas provocadas por ações antrópicas nas últimas décadas, transformou o local de descanso da realeza em uma armadilha de inundações periódicas. O fenômeno e suas consequências nos alertam para a necessidade de reconhecer os riscos que a humanidade corre se não houver uma mudança na forma como lidamos com o meio ambiente.

**Palavras-chave:** inundações; mudanças climáticas; ação humana; cidades; chuvas.

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**Resumen:**

Brasil sufrió en 2022 una de las mayores tormentas de su historia, que puede ilustrar el destino del actual cambio climático global. La ciudad de Petrópolis era antaño conocida por su clima suave y agradable, reconocido por los emperadores brasileños en el siglo XIX. La deforestación de las laderas de la ciudad, unida a los cambios climáticos provocados por la acción antrópica en las últimas décadas, han transformado el lugar de descanso de la realeza en una trampa de inundaciones periódicas. El fenómeno, y sus consecuencias, nos alertan sobre la necesidad de reconocer los riesgos que corre la humanidad si no se produce un cambio en la forma en que tratamos el medio ambiente.

**Palabras clave:** inundaciones; cambio climático; acción humana; ciudades; precipitaciones.

Since imperial days, the Brazilian city of Petrópolis, just north of Rio de Janeiro, has enjoyed popularity because of the mild summer climate of its mountainous region. It was so pleasant that it caught the attention of Emperors Pedro I and Pedro II. Weather events in 2011, 2013 and 2022, however, have produced hard times in Petrópolis (Fernandes e Fullen, 2020). Climate change deniers predictably have repudiated any linkage of weather events to climate change. Recent advances in meteorology and climate modeling, however, increasingly have undermined their economically self-serving skepticism.

During the intense summer heat in the low-lying city of Rio de Janeiro, the emperor would transfer his government to the mountainous imperial city, even for as long as six months, taking advantage of Petrópolis's mild climate. Pedro II perceptively warned of the risks of building on hillsides, especially risks posed by prolonged rains. Indeed, the 19th century saw rains lasting up to 20 days but, in the absence of destabilizing hillside development, such rains did not produce disasters like those produced by prolonged rains today. Human influence then was relatively limited (Brooke, 2014). The emperor's wisdom was ignored then, just as the wisdom of science is commonly ignored today, including by the former Brazilian president (Casarões e Flemes, 2019). The hillsides of Petropolis were unwisely developed and occupied, and other developments likewise have accelerated climate change: the Amazon continues to be devastated, and greenhouse gas emissions rise. As a result, extreme weather events increase in frequency and intensity. Once the city's hills were covered by vegetation (figure 1), but the vegetation gradually disappeared as the climate changed and, later, as climate change warnings were ignored. Today we see predicted consequences of climate change materializing, but climate change deniers nonetheless reject the evidence, especially via social media (Silva, 2021).

Petrópolis demonstrates that climate and environment are indeed related. Local and global actions undermining environmental quality and resilience therefore will have increasingly catastrophic effects on the climate (McNutt, 2013). Hundreds of people in Petrópolis lost their lives in rains lasting just a few hours in March 2022, and economic losses were enormous. This may be a prelude to what the world will face more generally in coming decades if too little is done to effectively prevent and decrease actions that are causing and exacerbating climate change (Fawzy et al., 2020).

The following month, April 2022, in the middle of the Brazilian autumn, another extreme weather event demonstrated what awaits us in relation to climate change. A four-day rainstorm in Rio de Janeiro broke a historic rainfall record. It was one of the largest storms in Brazilian history, and the volume of rainfall in four days was greater than the largest volume ever recorded for the entire month of April in the region. And the escalation of extreme rainfall has not stopped in Brazil. In February 2023, the largest rainfall in the history of this country was recorded, with almost unbelievable 700 mm inundating the northern coast of São Paulo, causing much destruction and death. We now must anticipate and prepare for such events, because we cannot immediately reverse the processes that led us to these extremes before these phenomena become more common (Hulme, 2020). In the longer term, of course, we must reverse this

escalation, or risk this regimen of catastrophes becoming permanently established (Rich, 2019).

At the same time, we must use, in a thoughtful way, this type of event to inform and educate the population. It is important to highlight that at the same time that these climate phenomena intensify, the spread of false news about climate change also grows. Again, Brazil, its former president Jair Bolsonaro (in office 2019-2022), and a significant part of its population, illustrate the extent of this problem. Throughout this president's mandate, environmental issues were summarily ignored, environmental protection services (especially with regard to the crucial Amazon rainforest) were weakened or dismantled, and false information regarding the importance of preservation spread like wildfire (Silva, 2022). It is relevant to highlight how fake news was, and continues to be, disseminated "efficiently", through social networks and the internet (Araújo, 2020; Ricard e Medeiros, 2020), and how today many people, even including those with above-average education levels, firmly believe in these untruths about environmental issues.

It is imperative that the organized sectors of society prepare to meet the urgent demand of undoing the damage caused by misinformation, especially in relation to the environment. It will be necessary to use all means and all expertise to reach the various population strata. Schools, traditional media (despite their lesser reach today), the companies that own social networks – which should contribute substantially to this process, given their responsibility for the damage – need to participate (Zarocostas, 2020). A central goal should be providing citizens with knowledge and tools that enable them to check the accuracy of the information they receive. Salient events, such as the abnormal storm in Petrópolis, should be used pedagogically to alert the population and their leaders about the urgency of the challenges, and of the potential of each to help to face them.

But perhaps this is only a temporary phenomenon, limited in time and to certain places? It's not likely. The year 2023 will go down in the climate record books as a witness to unprecedented thermal extremes, signaling that the planet is at a critical point in its climate history. What happened in Petrópolis may have been a mild prelude. July and August 2023 have been marked by an incessant string of heat records, and it looks set to be the hottest year ever. In the Northern Hemisphere, heatwaves were relentless, setting records in India and Japan, while the Mediterranean and North America experienced temperatures that exceeded 40°C. Brazil experienced unprecedented heat records in successive waves. Paradoxically, the Southern Hemisphere (especially Australia) experienced exceptionally mild temperatures during its winter, demonstrating that it will be difficult to make any confident predictions, the only certainty being that the temperature is rising globally owing to human activities.

The core of this climate phenomenon lies in climate change, exacerbated in 2023 by the return of El Niño, a phenomenon characterized by rising temperatures in Pacific waters, catalyzing extreme weather events (Philander, 1983). The continuing rise in temperatures is not just a meteorological narrative; it is a clear and unequivocal warning of the urgency of global action. The impact transcends geographical boundaries, demanding a unified response from all nations. Brazil, through its National Institute of Meteorology (INMET), issued a red alert in the week of November 13-17, 2023, of a high

level of danger due to the heat wave that was hitting 15 Brazilian states, an unprecedented event. This illustrates how this country is strongly affected by the combination of a natural phenomenon (El Niño) added to global warming caused by human action.

The climate crisis of 2023 is not restricted to setting atmospheric records. The overheating of the oceans (Guzman, 2013), the planet's great thermal regulators, deserves to be highlighted. Responsible for absorbing 90% of the excess heat generated by human activity since the Industrial Revolution, these large volumes of water are becoming increasingly heated. Since April 2023, the average surface temperature of the oceans has reached unprecedented levels. Between July 31 and August 31, this temperature daily surpassed the previous record, dated March 2016, reaching an ominous 21°C, far above all previous measurements. This oceanic overheating not only triggers atmospheric changes, but also intensifies humidity, resulting in more intense rainfall and feeding the energy available for tropical cyclones, yet another explanation for what happened in Petrópolis. This further demonstrates the interconnectedness of climate patterns.

The consequences of these climatic extremes are not merely academic; they have tangible ramifications. In Brazil, for example, it is speculated that the warming of the oceans contributed to the formation of the extratropical cyclone that hit Rio Grande do Sul, resulting in more than 30 deaths, also in 2023. In addition, biodiversity is facing increasing threats, while the oceans' ability to absorb CO<sub>2</sub>, an essential element in mitigating climate change, is being exceeded (Barre, La, 2011). We are facing a critical crossroads, at which the choices made now will shape the future not only of our nations, but even of the planet as a whole.

The response to global warming must not be delegated to isolated efforts. The interconnectedness of climate ecosystems requires effective global collaboration. 2023 is a call to collective action, a call for nations to overcome geopolitical barriers and join forces in implementing robust environmental policies. Immediate action is crucial to break the vicious cycle of climate warming. Time, that scarce resource, is not on our side, and inaction in the face of this crisis could result in irreversible consequences.

The current climate changes are unprecedented in recent history, with ubiquitous impacts in all regions of the globe. The Intergovernmental Panel on Climate Change (IPCC) report highlighted that climate change has already left its mark on every corner of the Earth, not only setting new temperature records, but also uniquely reshaping the world as we know it (Masson-Delmotte et al., 2022). No region will be spared the effects of these changes, entailing human and economic costs of remarkable magnitude, which considerably outweigh the costs associated with implementing mitigating actions. Distinct regions such as southern Africa, the Mediterranean, the Amazon, the western United States, and Australia are destined to face increases in droughts and fires, adversely impacting livelihoods, agriculture, water systems, and ecosystems. Changes in snow and ice patterns and river flooding are projected to be critical factors affecting infrastructure, transportation, energy production, and tourism in several regions, including North America, the Arctic, Europe, and the Andes (Boehm, Sophie; Schumer, 2023).

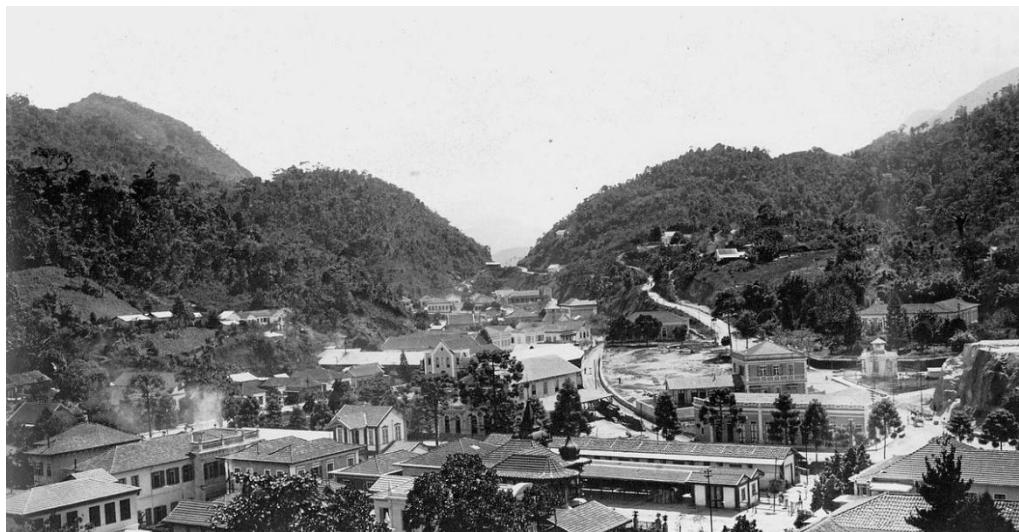
The IPCC report emphasizes that a continued rise in global temperatures of 1.5°C, 2°C or 4°C will lead to increasingly dangerous and costly consequences (Legg, 2021). The intensification of extreme weather phenomena such as intense rainfall, prolonged droughts, and heat waves, as well as irreversible events such as melting ice sheets (Barnes e Kaiser, 2009) and ocean acidification (Gattuso e Hansson, 2011), is inevitable as emissions persist. The report warns of the increasing likelihood of reaching points of no return, such as the collapse of the Greenland and Antarctic ice sheets, with significant implications for global coastlines. The transformation of carbon sinks, such as land and oceans, from effective absorbers of carbon dioxide to emitting sources represents an imminent risk and could result in uncontrolled warming. The example of the southeastern Amazon rainforest, no longer acting as a carbon sink (Brienen et al., 2015), highlights the impacts not only on global climate goals, but also on fundamental aspects of food and water security, as well as on the preservation of regional biodiversity, raising concerns about irreversible losses.

Examples of this type of necessary reaction can also be found in Brazil. These use credible knowledge coming from the academic environment yet manage to reach a wide audience. One of the central figures is Átila Iamarino (PhD in microbiology) who has more than a million followers on his YouTube channel, a regular column in a prominent Brazilian newspaper, and a constant presence in other media. In all these venues he specializes in explaining scientific issues and demystifying a lot of fraudulent news that are spread in the Brazilian virtual universe (Oliveira Mendes, de et al., 2020). It is also worth mentioning the work of Natália Pasternak, from the Question of Science Institute, which uses mechanisms from the internet itself with the intention to counteract false news and enlighten people (Taschner, 2018). However, these initiatives are still timid, sporadic, limited (in comparison to the size and scope of the problem), and often focused on the health field, no less important than the environmental issue. However, it is necessary to broaden the themes, to fight with these tools and others that may arise, to punish those who spread fake news, and to unite society in the face of this new social challenge.

It is important to call on all sectors of society to get involved in this effort. For example, religions or religious organizations need to abandon the belief that nature belongs to humanity and become part of the solution to the environmental issue. Religions need to incorporate environmental protection into their discourse as an imperative, as a motto of their own religiosity, and find elements in their culture that reinforce this vision of the relationship between humanity and nature (Silva, 2023). This convergence of forces from the scientific, religious, and political fields is especially important in countries where these boundaries are unclear and which are key to the climate crisis, such as Brazil and the United States.

The Brazilian city of Petrópolis, once prized for its mild climate, has become a symbol of contemporary climate challenges. Recent extreme weather events highlight the interconnection between local and global actions, from reckless hillside development to the ongoing destruction of the Amazon. The denial of the climate crisis, driven by economic interests, is increasingly discredited by scientific advances. The tragedy in Petrópolis, associated with historic rainfall records in Brazil, serves as a warning of the urgency of collective action. Disinformation, exemplified by Bolsonaro's government,

highlights the need for education and awareness to tackle the crisis. The lesson is clear: the response to climate challenges must be global, requiring collaboration between sectors of society, the media and social networking companies, while time to reverse this critical course is rapidly running out.



**Figure 1:** City of Petrópolis, 1889. Source: LAGO, Pedro Correa do. Coleção Princesa Isabel: Fotografia do século XIX "Princess Isabel Collection: 19th Century Photography". Capivara, 2008. [https://commons.wikimedia.org/wiki/File:Petropolis\\_1889\\_01.jpg](https://commons.wikimedia.org/wiki/File:Petropolis_1889_01.jpg) This work is in the public domain in its country of origin and other countries and areas where the copyright term is the author's life plus 70 years or fewer.



**Figure 2:** Landslide at Morro da Oficina, in Petrópolis. 02/17/2022 REUTERS/Ricardo Moraes. As the city's hillsides were populated with construction and deforestation, the result was the effect on the landscape and the tragedy of the landslide with deaths.

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