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# THE RELATIONSHIP BETWEEN THE REDUCTION IN THE KINETIC ENERGY OF THE WINDS AND THE WARMING OF THE EARTH

***Carlos Henrique Silva Dias***
Civil Engineer
https://www.linkedin.com/in/carlos-henrique-silvadias-a6b622249/

***Fernanda Christina Teotônio Dias Troysi***
PhD in Mechanical Engineering - PUC MG
https://lattes.cnpq.br/0775840085703413

***Anna Leticia Teotônio Dias***
Graduation in Pharmacy - UFMG
https://www.linkedin.com/in/leticiateotonio

**Abstract:** This work explores pivotal events since the Industrial Revolution that played a key role in reducing the kinetic energy of winds and its correlation with global warming. While the factors that contribute to rising temperatures are widely discussed, attention to the elements that directly contribute to the planet's cooling is remarkably scarce. Atmospheric circulation, essential in this context, is being increasingly impacted.

In the atmosphere, the cohesion of air, acting as a unified body due to the absence of vacuum, highlights the importance of obstacles in the free circulation of air, significantly influencing the movement of air masses.

The transport of heat from the surface to the upper layers of the troposphere by moist air is crucial for reducing Earth's temperature. Primary cooling occurs in trade winds, where rising moist air, upon reaching high altitudes, radiates heat into space, contributing to a reduction in temperature in tropical areas.

The vital presence of winds in atmospheric circulation is compromised by the increase in the Earth's roughness due to urbanization, resulting in turbulence that reduces the kinetic energy of the winds.

The Industrial Revolution and accelerated population growth since 1800 drove urban concentration, resulting in a vertical expansion of cities. Currently, 5% of the planet's surface is occupied by urban centers, and it is predicted that 61% of the world's population will live in urban areas by 2025, contributing to the increase in this statistic.

The scarcity of measures that contribute to reducing the interference of buildings in wind circulation patterns in large cities is alarming, making it necessary to conduct studies and define guidelines to guide constructions in a sustainable manner, promoting more balanced approaches to urban Development.

Urban expansion can be positively explored with efficient planning in the construction of new buildings, helping to mitigate wind turbulence caused by surface roughness, resulting in greater heat transfer from the earth's surface to space.

**Keywords:** Atmospheric circulation; cooling of the planet; vertical expansion of cities; roughness of the earth's surface; urban Development

## CONTEXTUALIZATION AND DISCUSSION

Air exhibits low thermal conductivity, being 0.0026 w/mK, as indicated by Nick Connor, 2020. However, when such an element is in motion, it becomes a highly influential agent in rapidly changing the temperature of the entire a region or even a country as a whole. Meteorological phenomena, such as cold fronts, exemplify this impact, resulting in substantial decreases of up to 15ºC in a matter of hours over an extensive geographic area.

The Trade winds, coming from the tropic's region (AYOADE 2003) are heated in their trajectory towards the meteorological equator region, there they receive even more heat and humidity, due to the low pressure and high temperature they move towards the higher layers of the troposphere.

Humid wind plays an essential role in reducing Earth's temperature, resulting from its ability to transport heat from the planet's surface to the upper layers of the troposphere. In this process, heat is then radiated into space, contributing significantly to the global cooling mechanism.

The vertical thermal gradient in this process is approximately -6.5ºC for every 1000 meters of altitude, reaching temperatures below -60ºC, according to the U.S. Navy Weather Research Facility. This already dry and cold air, when it begins to descend towards the tropics (Hadley cell), contributes to reducing the temperature in these areas, illustrated in Figure 1.

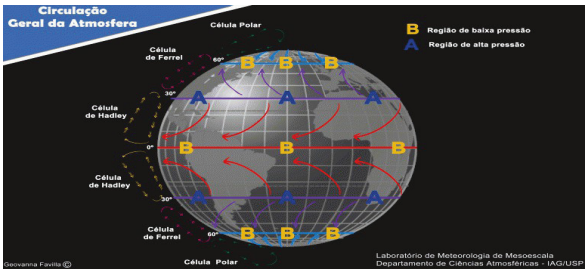



Figure 1.

In the atmosphere, given the absence of vacuum, the reduction in the kinetic energy of the winds interferes with the air circulation in its entirety. In past centuries, such as in the 13th century, planet Earth was distinguished by the predominance of extensive vegetation cover, in marked contrast to the current reality found in urban areas, as shown in Table 1 below.

| Description of the land | Zo (mm) |
|---|---|
| Very smooth terrain, ice, mud | 0,01 |
| Open sea in calm condition | 0,20 |
| Rough sea | 0,50 |
| Snow | 3,00 |
| Lawn | 8,00 |
| Rough pasture | 10,00 |
| Landing field | 30,00 |
| Plantations | 50,00 |
| Few trees | 100,00 |
| Many trees, few building | 250,00 |
| Tall forests | 500,00 |
| Suburb | 1.500,00 |
| Urban centers | 3.000,00 |

Table 1. Roughness length

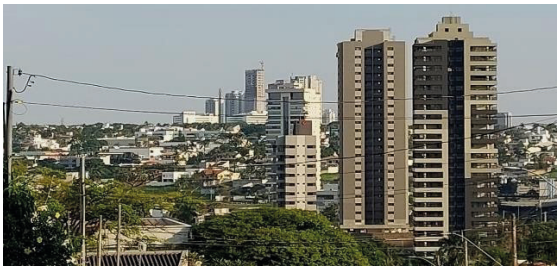
Source: Adapted from Meanwell (2002).

In untouched nature, a gradual transition between biomes is observed, characterized by a smooth growth in the height of the landscapes. This phenomenon contrasts with the urban environment, where tall buildings often rise immediately next to shorter structures, as exemplified in Figure 2 with photos captured by the authors.

A.

Savannah next to: Uberlândia-MG

B.



District: Morada da Colina, Uberlândia-MG

One of the main catalysts for the increase in the planet's roughness was the Industrial Revolution. This crucial period, marked by the intensification of production and demand for services, triggered a significant rural exodus to urban areas.

Furthermore, added to this migratory movement, there is the significant population growth that, from 1800 onwards, the planet reached the milestone of 1 billion people, and, later, increasing exponentially, in 1922 it reached 2 billion people, 4 billion in 1975 and, currently, in 2023, the extraordinary mark of 8 billion inhabitants in the world will be reached.

The dizzying increase in the global population, combined with the trend of urban concentration, triggered an exponential demand for buildings, resulting in a scenario of vertical expansion of cities.

According to data presented by renowned architect and urban planner Jorge Wilheim, it is estimated that by 2025, 61% of the world's population will live in urban areas. Comparing this projection with the year 1975, this figure was only 37%, therefore highlighting the

marked demographic transition. (Bulletin of the Institute of Advanced Studies of ``Universidade de São Paulo``).

Regarding the occupation of areas by urban centers, currently the figure is 5% of the planet's surface. Although the level of occupancy may seem low, the distancing of growth from urban centers with the implementation of appropriate measures to minimize the impact of these large agglomerations on wind circulation is worrying. An example of this is that in the land use and occupation laws of the large cities we researched, we did not find a single mention of anything that would lead to a reduction in the roughness of the urban region in relation to wind circulation, the criteria for approval of constructions High rates are mostly based on the traffic capacity of the roads, the distances and the height in relation to the plane route.

Therefore, it reflects the scarcity of studies and guidelines that seek to evaluate and guide construction in order to reduce interference with wind patterns, providing a more sustainable and balanced approach to urban development.

Given the irregularity in the occupation of the planet's surface, influenced by several factors, such as the level of development, in addition to the population density of each country or region, the interference in the circulation of winds presents considerable variation from one region to another. Therefore, these areas of greater urban development, due to the increase in surface roughness, tend to feel the effects of the reduction in the volume of circulating air more pronouncedly. In other words, the increase in roughness implies less heat transfer to space, limiting the phenomenon of cooling of the Earth's temperature in this specific region.

Figures 3 and 4 below, night images captured by NASA, corroborate the understanding not only of the irregular occupation of metropolitan areas, but also of the increase in roughness, creating obstacles in the circulation of winds.

Figure 3. United States

Night image of the planet's surface captured by the ISS released by NASA.

Figure 4. European Continent

Night image of the planet's surface captured by the ISS released by NASA.

Finally, according to studies presented during the Planet Under Pressure event, organized by the United Nations, these indicate that in the next two decades, urban areas are expected to expand by 1.5 million square kilometers. However, this trend can be positively explored through meticulous planning of the construction of new buildings, which, if oriented and executed efficiently, such a process can contribute to mitigating wind turbulence, caused by surface roughness,

and, consequently, in greater transfer of heat from the Earth's surface to space.

## CONCLUSION

The present work highlights crucial events since the Industrial Revolution that played a fundamental role in reducing the kinetic energy of winds, correlating with global warming. Although the factors of temperature increase are widely discussed, attention to the elements of planetary cooling is notably scarce, with essential atmospheric circulation being increasingly affected. The vital presence of winds in atmospheric circulation is compromised by the roughness of the Earth due to urbanization, contributing to the reduction of the kinetic energy of winds.

The Tropics region emerges as particularly sensitive to energy reduction, as air masses, upon returning from the troposphere, have smaller volumes and higher average temperatures. The increasing roughness of the planet since the Industrial Revolution, which boosted urban development, is undeniable, resulting in the loss of kinetic energy of the winds and, consequently, in the reduction of their speed, impacting the volume of air circulating in the Hadley cell throughout the time.

The lack of measures to reduce the interference of buildings in wind patterns in large cities is worrying, and it is urgent to conduct studies and establish guidelines to guide construction in a sustainable way, seeking more balanced approaches to urban development.

However, there is a positive opportunity in urban expansion: efficient planning in the construction of new buildings can mitigate wind turbulence caused by surface roughness, resulting in greater heat transfer from the earth to space. Therefore, the integration of sustainable approaches in urbanization becomes crucial to face emerging challenges, offering promising perspectives for balanced and resilient urban development in the context of climate change.

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