

REVISÃO DE LITERATURA IDENTIFICADO

ESTUDO PRELIMINAR SOBRE BLOQUEIOS ATMOSFÉRICOS E SEUS IMPACTOS SOBRE O CLIMA NO ESTADO DO RIO GRANDE DO SUL NO PERÍODO DE ABRIL A MAIO DE 2024

PRELIMINARY STUDY ON ATMOSPHERIC BLOCKING AND ITS IMPACTS ON THE CLIMATE IN THE STATE OF RIO GRANDE DO SUL DURING THE PERIOD FROM APRIL TO MAY 2024

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RESUMO

Introdução: As mudanças climáticas decorrem de causas naturais e atividades humanas, com o IPCC relatando 90% de certeza de que as emissões de gases de efeito estufa (GEE) causadas pelo homem desde a Revolução Industrial provocam o aumento das temperaturas. Entre abril e maio de 2024, um bloqueio meteorológico atípico reteve um enorme corredor de umidade atmosférica sobre o Rio Grande do Sul, Brasil, causando inundações históricas em 80% do estado. **Objetivo:** Identificar os fatores que levaram às inundações no estado do Rio Grande do Sul entre abril e maio de 2024. **Resultados:** Um aumento de 1,5°C acima dos níveis pré-industriais representa um limite crítico para o aquecimento global. O Acordo de Paris busca limitar a temperatura a esse patamar, uma vez que o IPCC alerta para impactos severos caso ele seja ultrapassado. Formalmente, o IPCC define essa ultrapassagem com base em uma média de 20 anos. Estima-se que o limite de 1,5°C será ultrapassado entre 2018 e 2037 em cenários de altas emissões, ou entre 2028 e 2035 em cenários de baixas emissões. Entre abril e maio de 2024, no Rio Grande do Sul, temperaturas acima da média persistiram por dias devido a um padrão de bloqueio de alta pressão. Esse excesso de energia estagnou uma frente fria, provocando chuvas intensas e inundações históricas que afetaram 80% do estado. **Conclusão:** Apesar dos avanços nos primeiros programas espaciais, os astronautas das missões Apollo sofreram deficiências nutricionais, o que demonstra que os hábitos alimentares persistem no espaço. Sistemas eficazes de alimentação espacial devem equilibrar as restrições da missão com opções familiares, nutritivas e atraentes. As melhorias no cardápio e nas embalagens das missões Apollo estabeleceram as bases para que sistemas futuros protegessem o bem-estar fisiológico e psicológico dos astronautas.

Palavras-chave: Temperatura Inundações, Efeito Estufa, Frente Fria, Astronautas.

ABSTRACT

Introduction: Climate change stems from natural causes and human activities, with IPCC reporting 90% certainty that human-driven GHG emissions since the Industrial Revolution cause rising temperatures. In April–May 2024, an atypical weather blockage trapped a massive atmospheric moisture corridor over Rio Grande do Sul, Brazil, causing historic flooding across 80% of the state. **Aim:** To identify the factors that led to the floods in the state of Rio Grande do Sul between April and May 2024. **Results:** A 1.5°C increase above pre-industrial levels represents a critical threshold for global warming. The Paris Agreement seeks to limit the temperature to this ceiling, as the IPCC warns of severe impacts if it is exceeded. Formally, the IPCC defines this exceedance as a 20-year average. It is estimated that the 1.5°C limit will be exceeded between 2018 and 2037 in high-emission scenarios, or between 2028 and 2035 in low-emission scenarios. Between April and May 2024, in Rio Grande do Sul, above-average temperatures persisted for days due to a high-pressure blocking pattern. This excess energy stalled a cold front, causing intense rainfall and historic floods that affected 80% of the state. **Conclusion:** Despite advancements in early space programs, Apollo astronauts suffered nutritional deficits, proving that diet habits persist in space. Effective space food systems must balance mission constraints with familiar, nutritious, and appealing options. Apollo's menu and packaging improvements laid the groundwork for future systems to protect astronauts' physiological and psychological well-being.

Keywords: Temperature Floods, Greenhouse Effect, Cold Front, Astronauts..

INTRODUCTION

Climate change is an undeniable fact. It can stem from natural causes (such as variations in solar radiation and Earth's orbital movements) or result from human industrial activities ¹. The United Nations (UN), through the Intergovernmental Panel on Climate Change (IPCC), generates data and states with 90% certainty that the rise in Earth's temperature is caused by human activity.

Since the Industrial Revolution, carbon dioxide—a greenhouse gas (GHG)—has been emitted on a massive scale. During this period, the gas's initial concentration of 280 ppm rose to the current 400 ppm. Consequently, human activities have influenced climate change since the Industrial Revolution ¹.

Climate and weather exhibit dynamic and cyclical behavior (following the seasons). In Brazil, both are influenced by temperatures in the Atlantic and Pacific Oceans. In recent decades, the warming of these ocean waters (associated with El Niño and La Niña phenomena) has driven the formation of clouds containing vast amounts of water vapor. These rain clouds, known as “cumulonimbus”, follow a counter-clockwise path across the South American continent, entering the landmass near the state of Pará, Brazil. This moisture corridor acts as an “aerial river,” transporting large volumes of water vapor that precipitate over western South America and Brazil, including the country's southern region. Between

April and May 2024, an atypical weather blockage (caused by a stalled high-pressure zone) kept this moisture corridor stationary over the state of Rio Grande do Sul for approximately 21 days, resulting in rainfall of around 100 mm per day. The result was a historic flood that affected 80% of the state, a phenomenon not seen since 1941 ². The aim of this study was to identify the factors that led to the floods in the state of Rio Grande do Sul between April and May 2024.

METHOD

This study consists of an integrative literature review employing document analysis and a descriptive approach, conducted to answer the following question: what factors contributed to the impact caused by the floods in the state of Rio Grande do Sul between April and May 2024? The criteria used for the inclusion or exclusion of the researched references were: relevance to an event with social impact during the specified period; climate change; climatology; availability in free PDF format online; publication in Portuguese or English; and accessibility via Google and Google Scholar. The study was conducted entirely between 2024 and 2026.

RESULTS

1. THE AVERAGE INCREASE IN TEMPERATURES AND THE LIMIT AT 1.5 °C

When referring to global warming, a number is always cited: the global average temperature. And when this number is cited, the value of an increase of 1.5 °C above pre-industrial levels was determined as a critical threshold, in the anthropogenic political panorama, for Climate Change ³¹.

The Paris Agreement aimed to advance efforts to somehow limit global atmospheric warming induced by human society to up to 1.5°C.

It was established in an IPCC report that warming greater than 1.5 °C will promote negative impacts on a wide range of sectors. Throughout history, the first months above the 1.5 °C limit occurred during the peak of the 2015-16 El Niño (Figure 1). Therefore, the IPCC formally defines the crossing of a temperature threshold as exceeding the midpoint in the first period of 20 years. If we imagine that the first 20-year period with average temperatures

greater than 1°C higher was between 1850-1900 (considered representative of pre-industrial levels), then it was the period between 2002 and 2021, so the 1°C threshold it was considered a crossover in 2012³.

The IPCC covers a multi-year period, and exceeding a threshold is only definitively identified several years after the event has occurred.

Using data obtained since 1850, it is possible to model and evaluate typical levels of interannual and decadal variability in global average temperatures. It can be said that it is unlikely that the 1.5 °C threshold would have been exceeded if the average observed in the most recent 11 years had not reached 1.4 °C. Although these levels have not yet been reached (as the average for the period between 2011-2020 was 1.10 °C above the 1850-1900 average, and the warmest individual years 1.26 °C above that average), This is expected to happen within 10 to 20 years. The central estimate for the period of exceeding the predicted threshold of 1.5 °C points to the interval between 2018 and 2037, in high emissions scenarios, between 2025 and 2044, in low emissions scenarios between 2028 and 2035, respectively.

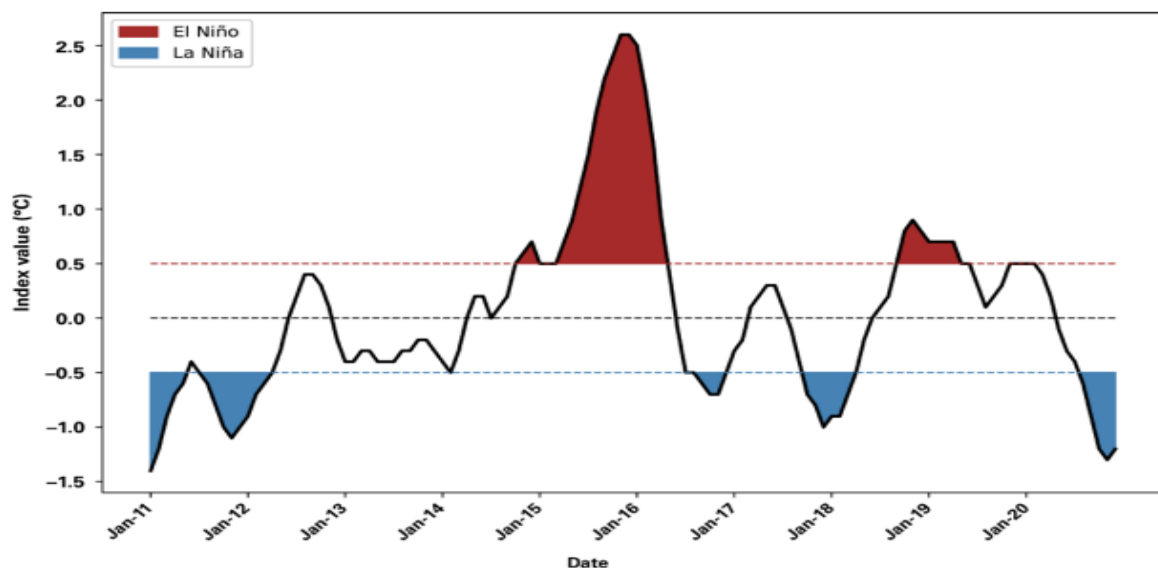


Figure 1: The NOAA Oceanic Niño 3.4 Index for the 2011-2020 decade. These values, when maintained above 0.5 °C, are indicative of El Niño events (red) and those below -0.5 °C are indicative of La Niña events (blue). Source: NOAA³

2. PRECIPITATION

As of 2010, there have been large regional fluctuations in precipitation (with some regions having an abnormally rainy decade and others having an abnormally dry decade during the same period), especially in subtropical regions, where precipitation fluctuates greatly from year to year and from place to place. . For the remaining indicators, trends are consistent (across most of the world) and indicators on a global scale provide a good summary of the state of the climate. Regarding precipitation, regional changes have better accuracy than indicators on a global scale. It can be said that some of the biggest impacts occur when there are deviations from the average (both positive and negative) for several years.

Precipitation in the decade 2011-2020 compared to the reference period 1951-2000 (Figure 2), shows that northern Eurasia had one of the largest areas of consistent above-average precipitation during the decade (extending from the Nordic countries to east, covering a large part of the Russian Federation), where precipitation in most of this area in the period between 2011 and 2020 was 10 to 20% higher than the 1951-2000 average. It was also a wet decade in western China, Pakistan, northwestern India, the southern coast of the Arabian Peninsula, the eastern United States, Western Australia (excluding the southwest), and parts of subtropical South America.

There was also a long-lasting drought that prevailed in many subtropical regions of the world, which resulted in average rainfall in the decade being 10% lower than in the reference period 1951-2000.

On the other hand, the decade features above-average and extreme wet conditions across most of Asia. 2020 was exceptionally wet in parts of China, Pakistan, the eastern and central United States, the Upper Midwest, the Northern Rockies and the Great Plains, while 2011 was the wettest year in the Northeast .

The strong El Niño event in 2015-2016 promoted strong precipitation anomalies in several parts of the world. This rainfall (in much of Southern Africa) was well below average in the period between 2014 and 2016. From May to October 2015, Oceania recorded rainfall 32% below average, which allowed forest fires to break out that year, and the Amazon basin was also significantly drier than average in 2015 and 2016.

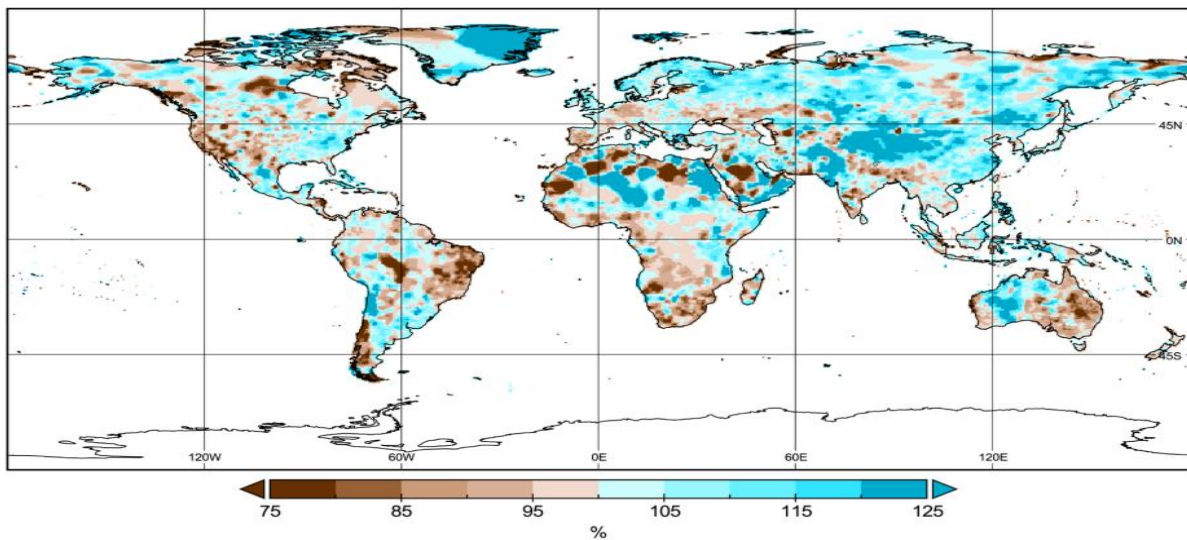


Figure 2: Percentage of Normals, Reference 1951-2000 2011-2020. World map indicating average annual precipitation rates over the period 2011-2020, expressed as a percentage for the average for the reference period between 1951-2000 ³.

The last part of the decade (2018, 2019 and 2020), however, was rainy in the northern hemisphere section of Africa (monsoon region), with approximately 10% above average. However, in late 2019 and early 2020, conditions became wet, which led to an extreme increase in rainfall in many countries during the decade. In 20 out of 97 countries their climate reports showed (except South America and the southwest Pacific) levels of daily precipitation higher or equal to higher in the period between 1961-2020, and during the decade, slightly above the long-term average. Long-term trends in these indicators are difficult to assess through national reports, as some countries have experienced substantial changes in their observation network over time (including the opening or closing of stations in particularly humid areas).

3. THE CLIMATE OVERVIEW FOR THE PERIOD OF APRIL AND MAY 2024 IN RIO GRANDE DO SUL

In the period from April 26th ⁴ to May 20th ⁵, 2024, in the state of Rio Grande do Sul, the maximum and minimum temperatures remained above the historical average for several days. In the city of Porto Alegre, capital of the state of RGS, located in the southeast region of the state, where the natural channel of the Guaíba river carries the waters of the mountainous region of the state, directing them to the lagoons called Lagoa dos Patos and Lagoa Mirim, the

maximum temperatures were above the average for 6 days (Figure 3) and minimum temperatures were above the average for 17 days (Figure 4). This extra energy was the result of a blockage caused by a zone of continental high pressure. This resulted in the parking of the cold front, which became a stationary front, generating rainfall levels over the state that remained between 60 and 100 mm. As a result, a historic flood submerged 80% of the state. Overcoming the historic flood of 1941 ². This blockage began to weaken from May 20th, causing the stationary front to move to the north, which interrupted the intense rainfall.

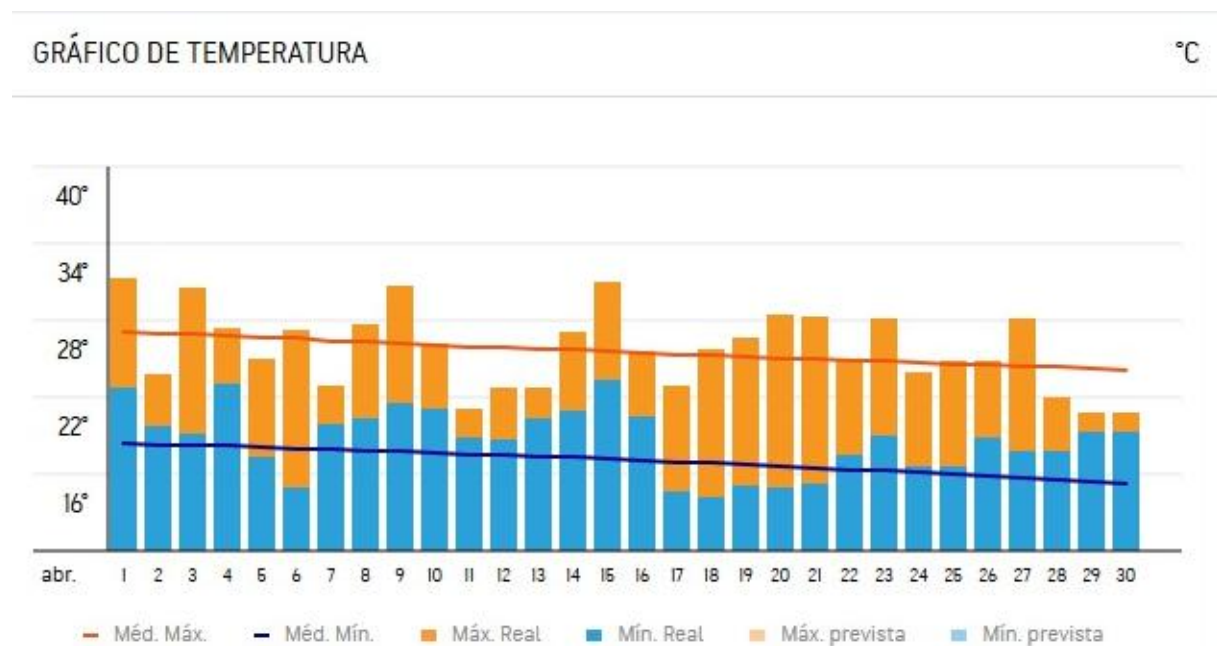


Figure 3: Temperature variation in the city of Porto Alegre - RGS in the period April 2024 ⁴.

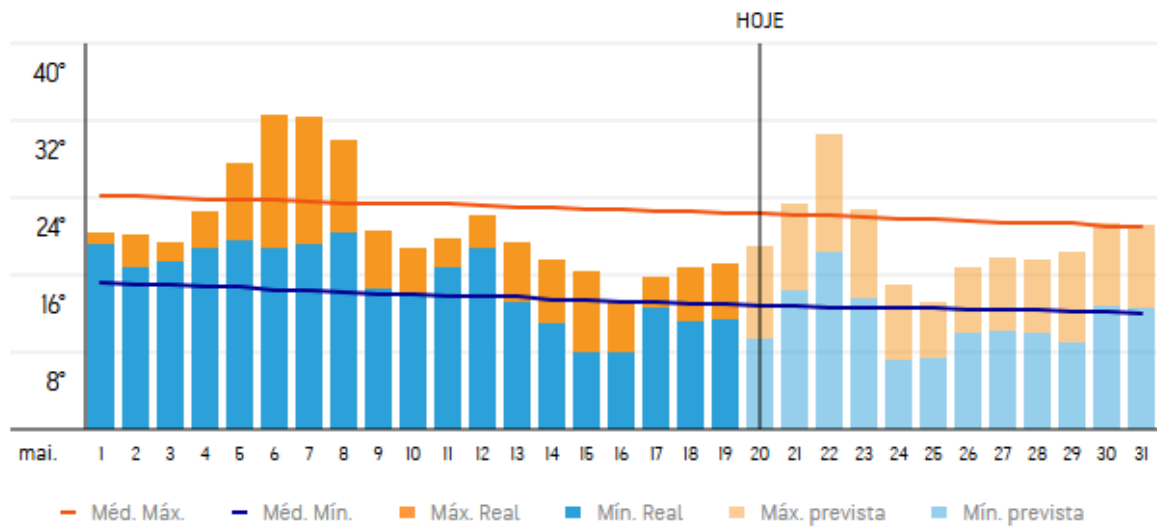


Figure 4: Variation in temperature in the city of Porto Alegre - RGS in the period from May 2024⁵.

CONCLUSION

Improvements and advancements in space food systems were achieved during the Mercury, Gemini, and Apollo programs. Nevertheless, with few exceptions, Apollo astronauts did not consume sufficient nutrients, resulting in a loss of weight, fluids, and electrolytes, a common occurrence. The Apollo project's food program demonstrated that human eating habits do not change easily and that adequate nutrition begins with appropriate foods presented to the consumer in a familiar manner.

A food system designed for space use must meet program constraints and provide adequate nutrition to maintain physiological balance amidst mission-specific stresses. Such a system must rely on nutritious, easy-to-prepare foods with familiar flavors and textures that offer enjoyment, relaxation, safety, and satiety.

Modifications to the Apollo food system aimed to improve astronaut nutrition. Individual food items and in-flight menus were altered as nutritional countermeasures against weight loss. Unique food items were developed, seeking a balance of nutrition, high acceptability, and the convenience of ready-to-eat, long-shelf-life products. Specialized food packaging was also developed.

Space program experience has shown that future space food systems will require efforts to maximize their potential in supporting physiological and psychological balance, as well as the well-being of astronauts and crews. The achievements of the Apollo food program represent a significant starting point.

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