# HAILSTORM MITIGATION STRATEGIES IN AGRICULTURAL REGION - A CASE STUDY OF PIRAÚBA - MINAS GERAIS

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***Question:*** *How can hail monitoring by the GLOBE Program, using satellites, help the civilian population avoid catastrophes?*
***Hypothesis:*** *Satellite monitoring and meteorological data collection by the GLOBE Program enable the prediction and mitigation of hail impacts, reducing damage to agriculture, infrastructure, and the civilian population.*
***Background:*** *Hail is a meteorological phenomenon characterized by the precipitation of ice chunks formed within cumulonimbus clouds. It can range from small particles to destructive ice blocks. Hail has a significant impact on agriculture, vehicles, roofs, and power grids. The GLOBE Program, celebrating its 30th anniversary, uses satellite monitoring technology to predict and study this phenomenon, helping prevent disasters.*
***Method:***

1. *Collection of meteorological data via satellites and ground stations of the GLOBE Program.*
2. *Analysis of atmospheric conditions that favor hail formation.*
3. *Identification of high-risk regions through climate pattern observation.*
4. *Dissemination of early warnings to minimize impacts.*
5. *Evaluation of the effectiveness of protective measures, such as hail nets and cloud seeding.*

***Results:*** *Continuous monitoring by the GLOBE Program has led to advancements in hailstorm prediction, contributing to the reduction of losses in agriculture and urban areas. The real-time dissemination of information improves responses to extreme weather events.*
***Conclusion:*** *The use of satellites and civilian participation in meteorological monitoring are essential for disaster prevention related to hail. The GLOBE Program plays a fundamental role in integrating scientific data with community observations, increasing safety and resilience for affected populations.*

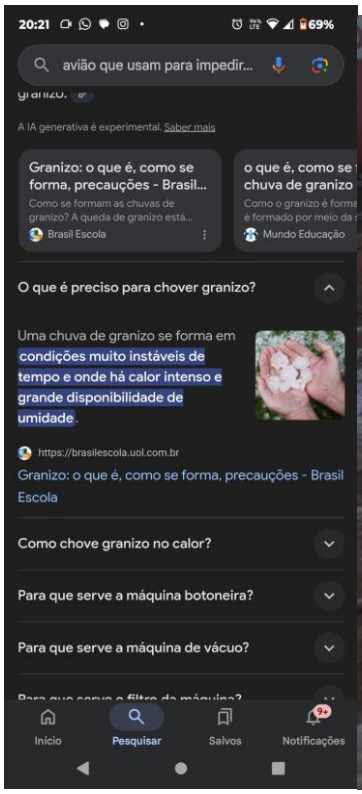
**Abstract** Hail is a meteorological phenomenon characterized by the precipitation of ice formed within cumulonimbus clouds. Depending on its size and intensity, it can cause severe damage to agriculture and infrastructure. This study discusses the types of hailstorms, mitigation methods—focusing on hail cannons—and the use of the GLOBE Program to monitor this phenomenon. Although hail cannons are used in agricultural regions, their effectiveness is questioned, with alternative techniques such as hail nets and cloud seeding being recommended. The study also analyzes the impacts of hailstorms in Piraúba, Minas Gerais, and proposes mitigation solutions for the region.

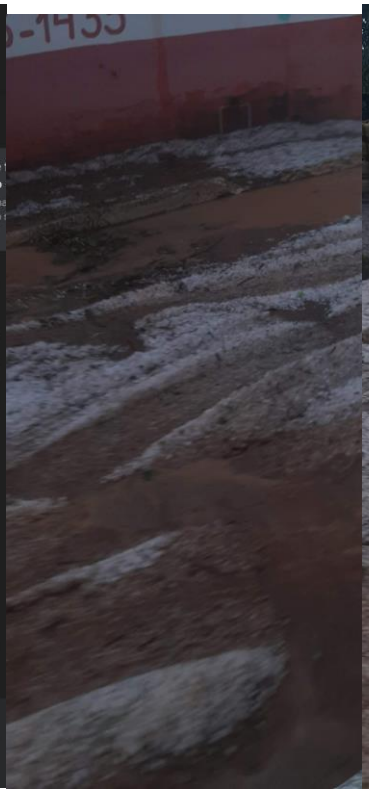
**1. Introduction** Hail can have negative impacts on agriculture, infrastructure, and the safety of affected communities. In the municipality of Piraúba, Minas Gerais, frequent hailstorm episodes have been recorded, resulting in material damage and losses for the population. Thus, this study aims to investigate the impacts of this phenomenon and present mitigation strategies.

**2. Methodology** The research utilized data from the GLOBE Program to analyze the occurrence of hailstorms in Piraúba, evaluating the frequency and intensity of the phenomenon. Information about events recorded by students and citizen scientists was collected and compared with official meteorological data. Additionally, a literature review was conducted on mitigation methods, including hail cannons, protective nets, and cloud seeding.

**3. Results and Discussion** The analyzed data indicate that hail can have severe impacts on agriculture and infrastructure, reinforcing the need for effective mitigation strategies. The use of hail cannons lacks solid scientific evidence regarding its effectiveness, while methods such as protective nets and cloud seeding show better results.

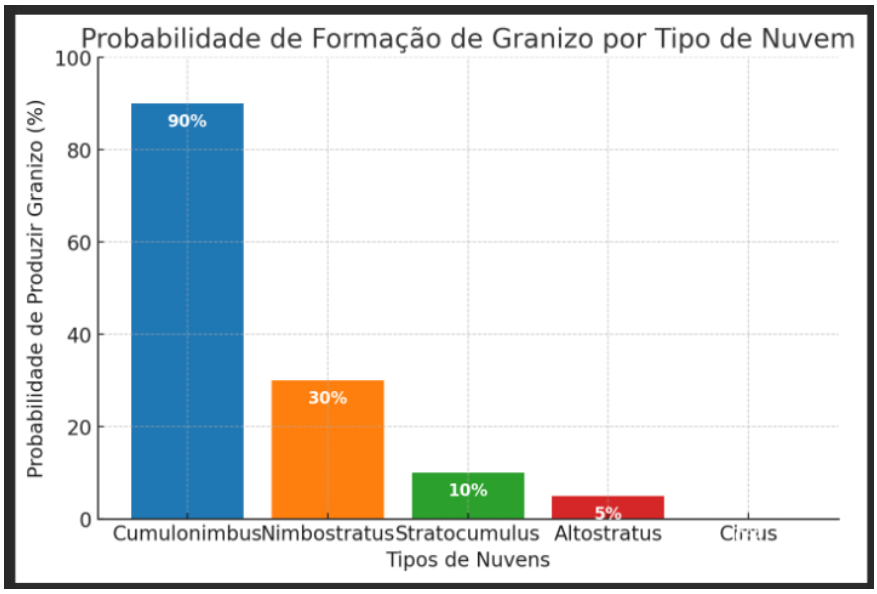
In Piraúba, one of the suggested measures is the implementation of hail nets to protect crops, along with continuous monitoring through the GLOBE Program. Awareness campaigns and training for farmers are also essential to minimize losses.

**4. The Role of the GLOBE Program** The GLOBE Program can assist in monitoring hailstorms by engaging students and citizen scientists in data collection, improving local meteorological records. Through systematic observations, such as measuring hail size, recording storm frequency, and analyzing weather patterns, the program helps build a comprehensive database. This information can be used by researchers and authorities to predict and mitigate future hail events, supporting the development of more effective protective measures in regions like Piraúba.

**5. Conclusion** Hailstorms pose a significant threat to regions like Piraúba, Minas Gerais. The use of proven strategies, such as protective nets and cloud seeding, combined with monitoring via the GLOBE Program, can help reduce the damage caused by this phenomenon. The implementation of educational and structural measures is essential to ensure the safety of the population and the sustainability of local agriculture.




**Graph Analysis**

**Cumulonimbus (90%):** These clouds are mainly responsible for the formation of hail. These clouds have a large vertical extension, with parts that reach very cold regions of the atmosphere, favoring the formation of ice stones.

**Nimbostratus (30%):** Although less common for hail, these dense, dark clouds can occasionally produce small ice stones, especially if they are associated with storm systems.

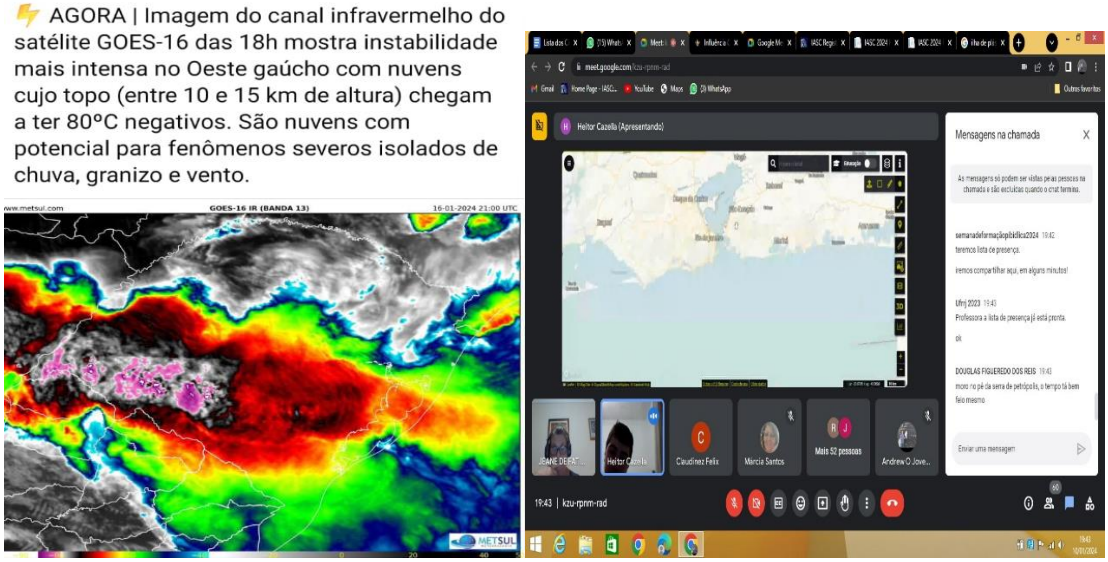
**Stratocumulus (10%):** These are lower clouds and do not usually generate hail, but under specific conditions they can form small ice particles.

**Altostratus (5%):** These are at medium altitudes and are more associated with light and continuous rain than with hail.

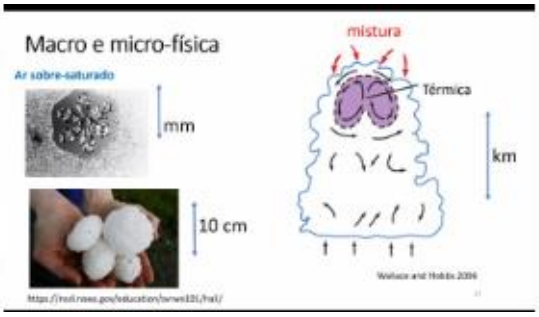
**Cirrus (0%):** These are thin, high clouds, composed of ice crystals, but are not capable of forming hail due to their structure and location in the atmosphere.

**Conclusion**

The graph highlights that cumulonimbus clouds are the most dangerous when it comes to hail, and it is important to pay attention to weather alerts when these clouds are present.








*Hail consists of ice stones that form within clouds with significant vertical extension. A very cold atmosphere is necessary for hail formation.*

*Hail forms inside cumulonimbus clouds, the same clouds that often cause heavy rain, lightning, and strong winds. These clouds and hail can form at any time of the year, as long as atmospheric conditions are favorable.*

*Cumulonimbus clouds have great vertical extension, with parts reaching atmospheric regions where the temperature is several degrees below 0°C. This extreme cold leads to ice formation, which is responsible for generating atmospheric electrical discharges.*

*Ice stones fall from clouds when they become heavy enough to overcome the strong upward wind currents inside cumulonimbus clouds.*

*In recent years, hailstorms have become common in various regions of Brazil, including Minas Gerais. This meteorological phenomenon results from a combination of factors, such as the formation of storm clouds and the presence of cold air in the atmosphere.*

*Hailstorms can cause material and human damage, especially in urban areas and during periods of high pedestrian and vehicle flow. The impact of ice stones can damage roofs, vehicles, crops, and injure people caught outdoors.*

*A hailstorm is a meteorological phenomenon characterized by the fall of ice stones from the sky during a storm. Hail forms when water droplets freeze at high altitudes in the atmosphere, where temperatures are extremely low. These droplets become small ice pellets that grow as they are carried by the updraft of a storm cloud.*

*As hailstones grow, they can become increasingly heavy and fall at high speeds, causing damage and destruction. The intensity of a hailstorm can vary significantly, with hailstones ranging in size from a few millimeters to several centimeters in diameter.*

*Hailstorms are more common in regions with significant temperature variation between the ground and the atmosphere, especially in temperate or subtropical climates. However, they can also occur in tropical regions, particularly in mountainous areas.*

*To minimize the effects of these storms, it is important for local authorities to be prepared to act quickly, providing assistance to those affected and implementing preventive measures, such as pruning trees that could fall in strong winds and reinforcing building structures that may be damaged.*

*Additionally, it is crucial for the population to remain attentive to weather alerts and adopt safety measures, such as seeking shelter in secure locations and avoiding being outdoors during storms. With these precautions, it is possible to reduce the impact of hailstorms and ensure the safety and well-being of the population.*

*Sudden temperature changes can trigger hailstorms. Cities may suffer destruction, with roofs punctured by the impact of large hailstones.*




**Note:** The use of hail cannons as a mitigation strategy is based on the emission of shock waves into the atmosphere to disrupt hail formation. While widely used in some agricultural regions, scientific studies have questioned their effectiveness. Some proponents argue that hail cannons can reduce the size of hailstones or prevent their formation altogether. However, their success rate remains debated, and alternative strategies, such as protective nets and cloud seeding, have shown more consistent results in hailstorm mitigation.

**We need to provide for the future:**

*Global Distribution of Hail Occurrences*
*A world map showing the most affected regions.*
*Increase in Hail Frequency (Recent Years) – A line graph showing the trend of increasing events over the years.*
*Economic Damage Caused by Hail – A bar graph comparing financial losses in different countries.*
*Hail Impact on Agriculture – A comparison of the percentage of crops affected by hailstorms.*
*GLOBE Measurements – A graph showing data collected by citizen scientists on the frequency and intensity of hail.*