Assessing Ground Freezing Depth Variability During an El Niño Winter: A Frost Tube Approach

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Abstract

El Niño is a periodic climate phenomenon marked by warmer than average sea surface temperatures in the Pacific Ocean, which can influence weather patterns in Southeast Michigan, potentially causing warmer winters with less snowfall and unusual precipitation patterns. El Niño events have implications greater than warmer weather, such as pest control. For example, mosquitoes need only a few centimeters of standing water to breed, and El Niño events generally stimulate insect outbreaks. This research utilized frost tube methodology to investigate the possible impact of **El Niño** winter conditions on ground freezing dynamics. At the study site, a frost tube was placed to monitor ground freezing depth throughout the winter season. Data on air temperature, surface temperature, snowpack depth, and other parameters were collected to assess relationships with ground freezing dynamics.

The study focused on highlighting how El Niño winters possibly impact **ground freezing depth**, recognizing possible implications on infrastructure management and specie interactions in urban environments. Inverse relationships were observed between air temperature and freezing depth, freezing depth and surface temperature, and snowpack depth and air temperature. In contrast, direct relationships were observed between snowpack depth and freezing depth. These findings suggested snowpack insulation, considering any time a snowpack was present, the ground freezing depth was >0 centimeters. However, further analysis is required to fully understand the underlying mechanisms and implications of those mechanisms. Future research should aim to expand the scope of inquiry by incorporating additional variables and extending data collection across multiple winter seasons across multiple sites.

Introduction

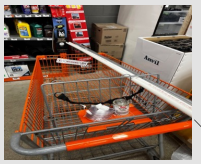
The freezing depth of the ground during winter months is a critical aspect of environmental and infrastructural management, particularly in regions with temperate climates like Southeast Michigan. Understanding the factors that influence ground freezing depth is essential for various sectors, including construction, agriculture, pest management, and water resource management. One significant climatic phenomenon that can impact ground freezing dynamics is El Niño. El Niño events, characterized by warmer-than-average sea surface temperatures in the equatorial Pacific Ocean, can lead to disruptions in global weather patterns, including altered precipitation regimes and temperature anomalies (See Figure 1). While numerous studies have investigated the effects of El Niño on atmospheric and oceanic processes, relatively few have examined its influence on ground freezing dynamics, particularly in regions like Southeast Michigan.

Hypotheses

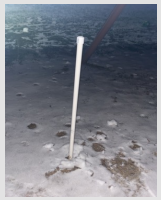
Null Hypothesis:

We believe changes in air temperature, snowpack depth, and surface temperature collectively do not influence ground freezing levels in Southeast Michigan.

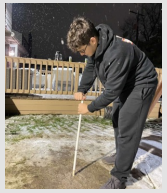
Methodology



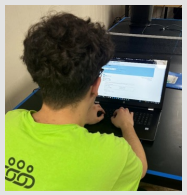
Researchers built frost tube with PVC, clear tubing, food coloring, water, and a PVC cap.



Researchers located frost tube site to collect measurements, determining GPS location of the site, and installed the frost tube.

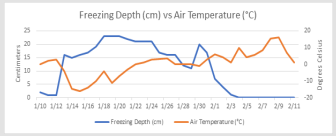


Researchers collected 1 sample per day at the same time from January through February, following GLOBE protocols to measure parameters using the frost tube and the ETEKCITY LaserGrip 774 Infrared Thermometer.

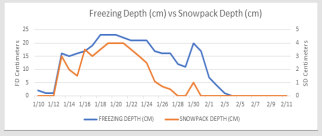


Researchers compiled data and entered it in a spreadsheet then uploaded them directly into the GLOBE website database, then analyzed data for trends and/or patterns.

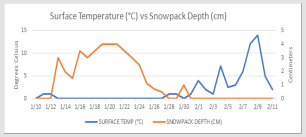
Results



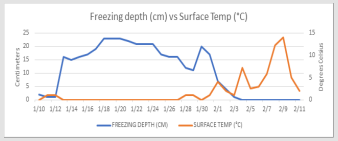
Freezing depth vs Air temperature: Typically, as air temperature decreased, freezing depth levels increased.



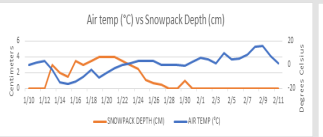
Freezing depth vs Snowpack depth: Freezing depth and snowpack showed a direct correlation.



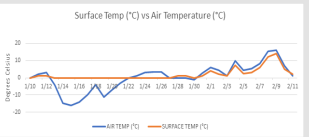
Surface temperature vs Snow Pack Depth: Surface temperature and snowpack showed an inverse correlation.



Freezing depth vs Surface temperature: Freezing depth and surface temperature showed an inverse correlation.



Air temperature vs Snowpack depth: Typically, as air temperature decreased, snowpack depth levels increased, and vice versa..



Surface temperature vs Air temperature: As air temperature increased, so did the surface temperature; and vice versa.

Conclusion

Our initial research plan aimed to investigate ground freezing dynamics during an El Niño winter in Southeast Michigan from November through February. However, the limited occurrence of significant cold and snow during our research period posed a challenge to our original approach. With only 32 events observed, conducting a comprehensive analysis based on such restricted data would not have provided a representative understanding of ground freezing dynamics. Recognizing this limitation, we began to examine from the first major snow event, aiming to elucidate the influences of air temperature, snowpack depth, and surface temperature on ground freezing levels. Upon completing our research, our findings revealed significant correlations between changes in air temperature, snowpack depth, and surface temperature, and their collective impact on ground freezing levels in Southeast Michigan. This underscores the intricate relationship between these environmental variables and highlights the need to consider multiple factors in understanding ground freezing processes accurately.

Reflecting on our research methods, we identified several areas for potential improvement. One such area is the expansion of our sampling sites to include a greater variety of locations across Southeast Michigan. By incorporating sites with diverse environmental characteristics, such as urban, suburban, and rural areas, we could capture a more comprehensive understanding of ground freezing dynamics across different. In conclusion, we hope our research contributes to the body of knowledge on ground freezing dynamics in Southeast Michigan, particularly during El Niño winters. While limitations exist, including the scarcity of significant precipitation events during our research period, our findings underscore the importance of considering multiple environmental factors in understanding ground freezing processes. Moving forward, expanding our sampling sites and leveraging advanced laboratory equipment could further enhance the depth and accuracy of our research findings. Additionally, continued mentorship and collaboration will be crucial in advancing our understanding of ground freezing dynamics and its implications for Southeast Michigan's environment and infrastructure.

Recommendations

Moving forward, expanding our sampling sites and leveraging advanced laboratory equipment could further enhance the depth and accuracy of our research findings. Additionally, continued mentorship and collaboration will be crucial in advancing our understanding of ground freezing dynamics and its implications for Southeast Michigan's environment and infrastructure.

Acknowledgements

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