HSLU Lucerne University of Applied Sciences and Arts

Comparing Skies

A Cross-Planetary Study of Earth's and Mars's Atmospheric Patterns

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Background and Motivation

Recent studies have shown that the Earth is experiencing increasingly volatile weather patterns characterized by rising global temperatures, intensified storm cycles, and unpredictable seasonal behavior, contributing to widespread ecological and societal disruption. Recent research[1] highlights a 1.2°C increase in global average temperatures over the past century, leading to rising sea levels and worsening natural disasters. Parallel studies[2] on Mars reveal intriguing climatic dynamics, including significant dust storms and temperature fluctuations that mirror Earth's own environmental challenges.

However, a comprehensive comparative analysis of Earth and Mars weather patterns remains largely unexplored. The literature indicates a gap in cross-planetary studies, particularly in the use of Martian data to contextualize and potentially mitigate Earth's climatic crises. This project aims to bridge this gap by synthesizing weather datasets from both planets to reveal underlying climate trends and interactions.

This project aims to leverage Data Warehouse and Data Lake Systems to analyze and compare weather patterns from Earth and Mars. With global warming being a pivotal concern for Earth's future that is becoming harder and harder to ignore, understanding extraterrestrial climates can provide new insights into our own planetary weather changes and sustainability.

[1] https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/202113
[2] https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2022GL101752

Due to its proximity to Earth, scientists have kept their telescopes pointed at Nergal[3], the great hero, as the Babylonians called the "wandering star" we call Mars. The researchers have posed multiple questions that revolve around Mars, from the possibility of existence of life to the viability of living on Mars. Our goal is to investigate the latter, while also exploring what insights can be collected from studying the weather conditions on our neighboring planet to better understand the patterns that can be observed on Earth.

Fortunately, NASA (the National Aeronautics and Space Administration) provides extensive information through their APIs, allowing researchers, developers, and enthusiasts worldwide to access a vast amount of data about space exploration. That includes Mars Weather Service API, that presents a unique opportunity to study Martian weather, by offering daily weather reports from Elysium Planitia, Mars.

Problem Statement

Despite the growing body of research on global warming, most studies are confined to Earth, with limited understanding of extraterrestrial climates. This project addresses the gap by analyzing Martian weather patterns in relation to Earth's, exploring whether the data collected can be used to help study the current events on Earth and if Mars could serve as a potential alternative habitat as we face escalating climate change challenges.

It is also important to consider who benefits from the collection of this data. Since global warming is an issue that affects every living creature on Earth (from wildlife that have their habitats decimated by either human action or natural disasters, to flora, to humans), this project may have multiple targets, but its main beneficiaries are Humans.

Business Questions

In the present chapter, we highlight the fundamental questions that drive our project's purpose. These questions guarantee that everyone involved in the project has the same target in mind, since asking the right questions lays the foundation for data-driven decisions and help us determine what can be considered relevant or discarded and how we need to proceed with analyzing the data[4].

Key questions

1. How do the temperature variations on Mars compare with Earth's over comparable time periods?
2. What insights can Martian atmospheric conditions provide about Earth's future weather patterns and global warming trends?
3. Can data-driven analysis of Martian weather predict the viability of human life on Mars?

[3] https://mars.nasa.gov/allaboutmars/mystique/history/early/

[4] https://www.linkedin.com/pulse/navigating-success-crucial-role-key-business-questions-naqi-abbas/

Data Sources

This project relies on two primary data sources to conduct a comparative analysis of weather patterns on Earth and Mars. Below are the details of the data sources we will be using:

1. **NASA Mars Weather Service API:** It provides vital daily weather data from Mars, including temperature, wind speed, and atmospheric pressure, collected by the InSight lander. It's essential for understanding Martian climate trends.
2. **Earth Weather Data Sources:** We use two significant sources for Earth's weather data:
    2.1. **Mapbox Weather API:** Provides real-time global weather data.
    2.2. **NOAA National Weather Service API:** Delivers a comprehensive range of weather data across the United States, adding depth to our Earth weather analysis.

Objectives

The key objectives of the present project are structured as follows:

* Establish a comprehensive data warehouse system integrating NASA's Mars weather data with Earth's weather datasets.
* Analyze and compare temperature trends, atmospheric conditions, and other relevant weather parameters between Earth and Mars.
* Assess the viability of Mars as a habitat for future human colonization in the context of global warming.

Project Report Output

- **Integrated Data Warehouse**: Develop a comprehensive data warehouse system that successfully integrates NASA's Mars weather data with Earth weather datasets. This system should provide a structured, accessible platform for cross-analysis of Earth-Mars weather patterns, enabling efficient retrieval and comparison of meteorological parameters.
- **Comparative Analysis Report**: A report that compares temperature trends, atmospheric conditions, and other relevant weather parameters between Earth and Mars. This document should include visualizations, statistical analyses, predictive models, and interpretative discussions.
- **Policy and research recommendations**: Based on the results of the comparative analysis, the report should provide actionable recommendations for policymakers, researchers, and the scientific community. These may include strategies for mitigating the effects of global warming, considerations for future Mars exploration missions, or areas for further research.
- **Future directions**: A section within the report dedicated to suggesting future research opportunities based on the findings of the project. This should identify gaps in current knowledge, propose new research questions, and outline potential methodologies to explore these further.

Addressee: Scientific and Academic Community

Name: Dr. Luna Starfield

Current Position: Associate Professor of Planetary Science, Institute for Space and Environmental Studies.

Field of Expertise: Climatology and planetary science with a focus on comparative planetary environments.

Research Interests: Understanding planetary weather patterns, climate change, and the potential for life on other planets.

Education: Ph.D. in environmental science, master's in astrophysics.

Relevance to Project:

With a solid foundation in planetary science and climatology, Dr. Starfield has spent years delving into the intricacies of weather dynamics on both Earth and extraterrestrial environments. By providing us with critical data and insights, Dr. Starfield plays a pivotal role in deciphering complex weather patterns and contributing to our understanding of planetary climates. This collaboration is instrumental in advancing our project goals, facilitating the discovery of new patterns, and improving our overall analysis.

Use of study results:

- The findings may inspire Dr. Starfield to initiate new research projects or experiments focused on comparative planetary climates or the implications of Martian weather for human colonization.
    - The results could serve as the basis for grant proposals seeking funding for further research on planetary weather patterns and their implications for Earth's climate system and future Mars missions.
- Dr. Starfield could integrate the results of the comparative analysis into university courses on planetary science, climatology, and environmental studies, providing students with current, real-world data.

Methodology

This project will employ a comparative data analysis approach, integrating data from NASA's InSight Mars Weather Service API and Earth weather databases.

Key steps include:

* Data Collection: Extracting weather data from the respective APIs and databases.
* Data Integration: Consolidating Martian and Earth weather data into a unified data warehouse.
* Data Analysis: Using visualization, statistical and machine learning techniques to compare weather patterns and identify trends.

* Interpretation: Assessing the implications of Martian weather data for global warming and potential human colonization.

The preliminary plan splits tasks into 5 key milestones, described and planned as follows:

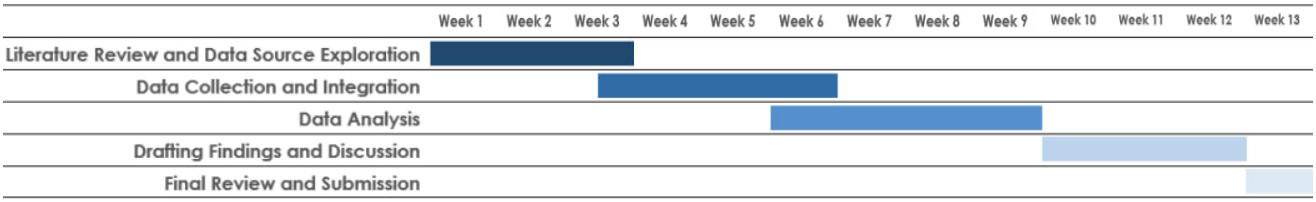

Figure 1 - Scheduling

Literature

Data

- **NASA Mars Weather Service API Documentation:** https://api.nasa.gov/assets/insight/InSight%20Weather%20API%20Documentation.pdf
- **Earth Weather Data Sources:**
  - **Mapbox Weather API:** https://www.mapbox.com/weather
  - **NOAA National Weather Service (NWS) API:** https://www.weather.gov/documentation/services-web-api
- **Data Warehousing and Lake Systems:**
  - Laurent, D., Laurent, D., & Madera, C. (2020). Data Lakes (1st ed.). Wiley-ISTE.
  - Gorelik, A. (2019). The Enterprise Big Data Lake: Delivering on the Promise of Hadoop and Data Science in the Enterprise (Illustrated ed.). Sebastopol, California: O'Reilly UK Ltd.

Comparative Planetary Climatology

- Modeling the martian atmosphere with the LMD global climate model https://www.researchgate.net/publication/42798521_Modeling_the_martian_atmosphere_with_the_LMD_global_climate_model
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- Challenges to the Sustainability of Space Exploration https://www.researchgate.net/publication/248947457_Challenges_to_the_Sustainability_of_Space_Exploration
- Annual 2021 Global Climate Report: https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/202113

Additional Resources

- NASA Mars Exploration Program: https://mars.nasa.gov/
- European Space Agency (ESA) Mars: https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/Mars