Climate Change in Finland

SGD: *Climate Action*

Motivation

When I arrived in Finland as an exchange student, one of my first questions was: "When does the snow usually fall and stay?" The response was usually along the lines of "Recently because of climate change, it is hard to tell". The responses highlighted a broader issue: seasons are becoming increasingly unpredictable in countries like Finland, where winter has always been a defining feature. Understanding climate change goes beyond snowfall; it's about recognizing the impacts on daily life, from shifting temperatures to varying seasonal weather patterns. These changes directly affect citizens and visitors alike, making it crucial to explore and understand the effect climate change has had in recent times. With this project, I aim to create an interactive visualisation that helps users understand and explore how climate change is changing the Finnish environment.

Deployed app link: https://finland-climate-change.streamlit.app/

Source code link: https://github.com/marcelomoreno26/finland_climate_change/

Relevance

Finland's winters are becoming more unpredictable due to climate change, with snow arriving later and melting earlier. Milder winters bring more rain than snow, affecting ecosystems, winter sports, and infrastructure, while disrupting Finland's cultural link to long, snowy winters. Rising temperatures also cause frequent temperature swings and unpredictable precipitation, which complicate agriculture, forestry, and urban planning. The changing weather increases the risk of extreme events, like cold snaps or unseasonable warmth. This disruption impacts daily life, with unpredictable weather affecting transportation and tourism, and ski resorts and winter-based businesses are adjusting to these changes, creating economic challenges. Therefore, analyzing the impact and magnitude of these changes is crucial for understanding and mitigating their effects.

Data Collection and Preprocessing

For this project, I focused on climate change indicators specific to Finland. The key indicators to analyse include temperature fluctuations, snowfall, and precipitation levels. The main data source is the Finnish Meteorological Institute through their open data API. Data is available from 1960-present with over 400 stations all around the country. The following are the indicators that will be used.

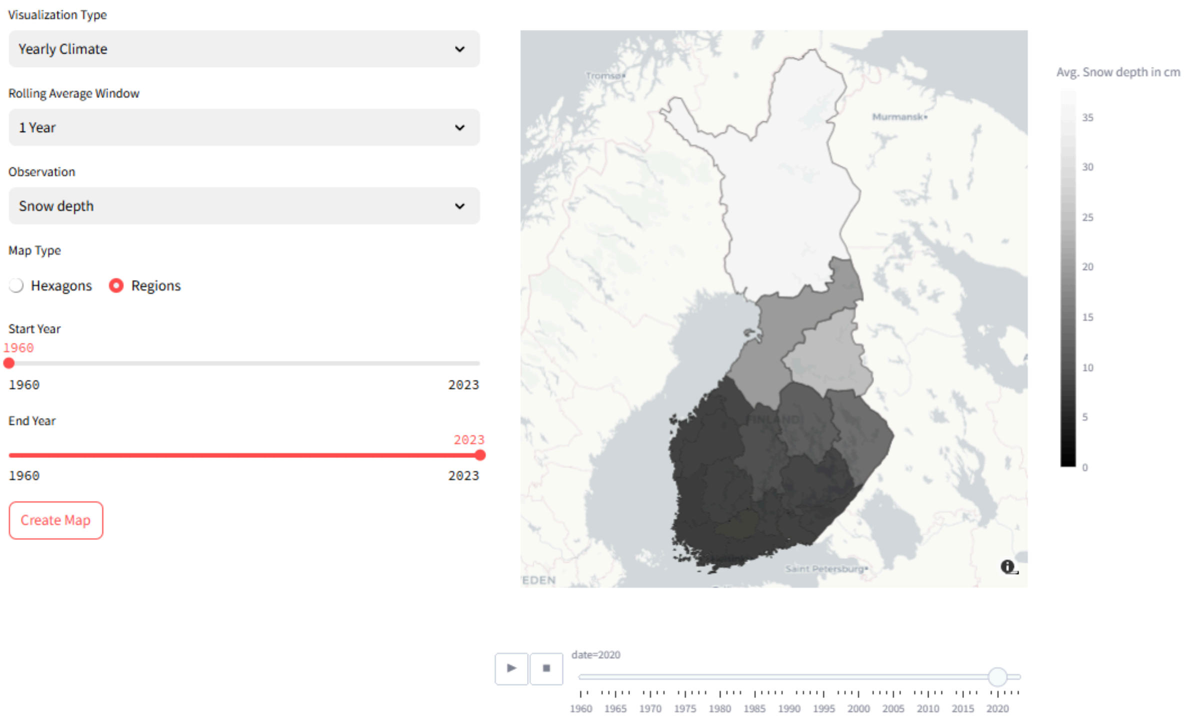
- **Temperature changes** over time, measured in degrees Celsius, including annual and seasonal variations.
- **Snow depth**, measured in centimetres, tracking the frequency, duration, and depth of snow cover.
- **Precipitation levels**, measured in millimetres, focusing on rainfall and how it has shifted across seasons.

The Finnish Meteorological Institute's open data API is well-documented and their spans decades, allowing for thorough analysis of climate trends. In the data retrieval it was noted that a lot of the stations only contained values for some and not all of the indicators, nonetheless, all of the indicators contain at least 300 data points from different stations around the country per day making more than enough for the visualisation. The data was originally retrieved with a daily frequency because my initial intention was to make plots to show daily patterns. However, I realized only monthly and yearly data reveal trends, thus, it would have been more efficient to just retrieve data from the monthly endpoint. Since the API is slow at times, all the historical data has been retrieved and stored and pre-processed allowing the visualization to be more reliable and fast.

The API retrieves data for different stations with the longitude and latitude given for each. To be able to visualize the data as will be described later on i.e. with hexagonal grids and also divided by regions, it was necessary to make some transformations of the data. The Finnish map was divided into around 256 hexagons. For each hexagon and each time period, the value assigned was that of the closest station to the hexagon's centroid during that time period (detailed implementation can be found in the preprocessing folder of source code). To obtain the regional data, the hexagons were assigned to each region and the average of all the hexagons within a region during a time period were taken as its observed value. Within the application some preprocessing is made as well in order to match and adapt the visualisation to the users filters.

Interactive Choropleth Map Visualizations

Interactive choropleth maps show how Finland's climate has changed over time, using animations where each frame represents a different time period. Users can explore data such as temperature, snow depth, or precipitation across different months or years. The maps include options for applying a rolling window (e.g., 1, 5, or 10 years) to smooth data and highlight long-term trends. The figure below shows an example of how the map visualization is structured.



Year-Round Monthly Climate (5-Year Focus)

This visualization shows how monthly climate patterns, such as snow depth or precipitation, change over a five-year period. It cycles through all 12 months, helping users see seasonal patterns and how they evolve. For instance, it can reveal how January snow levels or July rainfall varied across Finland during 1980–1984 compared to 2015–2019.

Climate Data Over Time

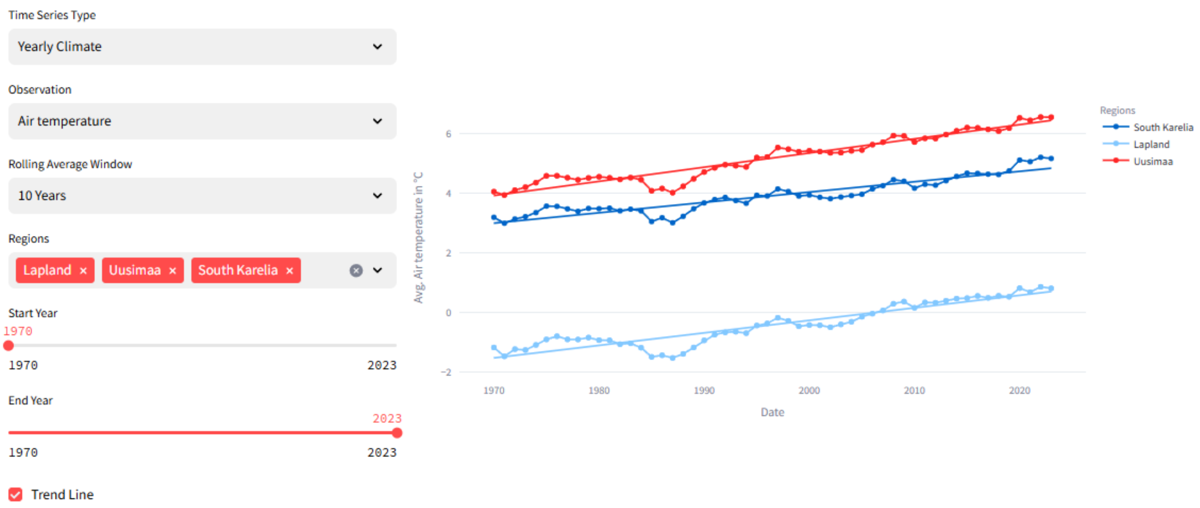
This map shows long-term changes by either focusing on a specific month across years (e.g., January from 1960 to 2020) or looking at yearly averages. Users can uncover trends like how January snow depths have decreased over decades or how annual precipitation totals have shifted over time.

Comparison to a Baseline

This visualization compares current data to a historical baseline and highlights differences as anomalies. Users can compare a specific month's data (e.g., January 1970 snow depth) to its rolling baseline (e.g., 1961–1970) or examine yearly averages against a similar baseline. This helps identify changes like warmer winters or drier summers relative to past conditions.

Time Series Visualizations

Time series visualizations display climate data trends over time for specific administrative regions in Finland. Users can filter by regions, time periods, and variables like temperature, precipitation, or snow depth to examine how they change. Rolling averages can be applied to smooth the data and highlight long-term trends, making it easier to observe gradual changes over time.



Yearly Climate Data

This visualization highlights yearly averages for selected regions over a custom time range. It allows users to explore trends like increasing temperatures or shifts in precipitation by applying filters and smoothing the data with rolling averages. For instance, users can analyze how yearly average temperatures in Uusimaa have changed from 1990 to 2020.

Single-Month Over Time Climate

This visualization focuses on how climate variables for a specific month (e.g., January or July) evolve across years. It provides a detailed view of long-term changes for that month, such as tracking how February snow depth trends in Northern Finland shifted between 1970 and 2020.

Year-Round Monthly Climate

This option visualizes all 12 months of climate data across a selected time range. Users can observe how patterns change month by month, offering a comprehensive view of seasonal trends. For example, users can examine how temperatures and snowfall behaved month by month in Finland during the years 2010 and 2011, providing a detailed year-round perspective.

Tools

The main tool used was Streamlit which allows for rapid development of interactive dashboards with python using libraries like plotly.

Ensuring Usability and Interaction

I believe that anyone living in Finland, whether they are part of the general public or policymakers, as well as tourists (past, present, and future), and those with a deep interest in climate change, will find this visualisation highly valuable. **They will learn** how Finland's seasons have shifted over recent decades, how average temperatures have steadily risen, and how precipitation patterns are becoming more unpredictable. **When doing** tasks such as selecting climate indicators (e.g. snow depth), adjusting the time slider to explore these shifts across different years or specific months, or visualizing data by regions, users will be able to interact with detailed data in an intuitive and meaningful way. This interaction will enable them to visualise the full extent of climate change's effects across Finland. As for the success indicators of the visualisation **we will know when we see** users engaging deeply with the dashboard—spending significant amounts of time exploring different combinations of indicators, timeframes, and regions. Further evidence of success includes users making comments or interesting questions about the climate data or even discussing how they recall living the weather changes seen in the visualization.

Kind of Interactions

Users of the visualisation will engage with multiple interactive components designed to make exploring the data intuitive and informative. For Animated Maps, users can select climate indicators such as temperature, precipitation, or snow depth, and choose a rolling window to calculate averages (1 year, 5 years, or 10 years). This allows them to identify long-term patterns and anomalies by comparing data across different years or periods. The ability to focus on specific months or compare a single month across different years helps pinpoint seasonal changes. For Time Series Graphs, users can view long-term trends by selecting climate indicators and regions, with options to include trend lines. This helps uncover gradual changes and significant patterns over time. Regional filters enable a detailed look at localised climate changes. Using both Animated Maps and Time Series Graphs together can lead to deeper insights. Discovering a pattern in a time series graph can prompt further exploration on the maps to see how that pattern manifests spatially, and vice versa. This interactive approach allows users to experiment with different combinations of indicators, time ranges, and regions, leading to comprehensive explorations and discoveries. The dashboard serves as an exploratory tool for both brief insights and extended investigation, helping users understand complex climate patterns in Finland

Time

Visualising time is essential for understanding the impacts of climate change. By incorporating temporal data, we can observe how climate indicators such as temperature, precipitation, and snow depth have evolved over the years. This temporal perspective allows us to identify long-term trends, seasonal variations, and anomalies that are crucial for comprehending the full extent of climate change. The dashboard's ability to animate these changes over time provides a dynamic and engaging way to explore the data, making the impacts of climate change more tangible and understandable.

Climate patterns are inherently seasonal, and understanding these patterns sometimes requires comparing the same months across different years. The visualization helps in identifying shifts in seasonal patterns, such as changes in the onset and duration of winter. For example, users can compare January temperatures over several decades to see how winter severity has altered, providing a clearer picture of seasonal shifts due to climate change.

Climate data can be highly variable from year to year, making it challenging to discern long-term trends from short-term fluctuations. Adding a rolling window over longer periods helps to smooth out this variability, revealing the underlying trends more clearly. By reducing the noise caused by annual anomalies, users can better understand the overall direction and magnitude of climate changes.

The rolling windows and displaying trend lines in time series graphs is crucial for revealing the real effects of climate change over time. These visualisations can show both overall trends and seasonal variations, helping users to see how climate indicators have changed not just annually, but within specific seasons. For instance, a trend line might reveal a steady increase in average temperatures over decades, while seasonal analysis could show that winters are warming faster than summers. This dual perspective is vital for a comprehensive understanding of climate dynamics.

Temporal visualisations are also effective in highlighting anomalies. By identifying these anomalies, users can gain insights into the variability and unpredictability of climate change. For example, a sudden spike in temperature or an unexpected snowfall can be easily spotted and analysed. Understanding these anomalies is important for recognizing the immediate impacts of climate change and preparing for future extreme events.

Different users will find various aspects of the temporal insights valuable. Policymakers will benefit from long-term trends and seasonal shifts for developing informed climate policies and adaptation strategies. Tourists can use recent data on weather patterns and seasonal changes to plan their visits and activities. Residents who have lived through specific anomalies might find it interesting to see these events in the context of long-term data, enhancing their understanding of personal experiences within broader climate trends.

Space

To effectively visualise the impact of climate change in Finland, the project employs animated choropleth maps, which are crucial for quickly identifying patterns over time. The use of colour maps enhances this visualisation by making it intuitive and easy to understand. For instance, snow depth is represented using a Greys colour map, where whiter areas indicate more snow and darker areas indicate less snow, facilitating a clear visual association. Rainfall is depicted with a Blues colour map, where bluer areas signify more rain and whiter areas signify less rain. Temperature is shown using a Red-Blues colour map, with blue indicating colder temperatures, red indicating hotter temperatures, and white representing 0 degrees Celsius. For comparing specific years and months, a diverging Red-Blues colour map is used: red indicates less snow or higher temperatures, while blue indicates more snow or lower temperatures, making it intuitive as blue denotes colder conditions. For precipitation, a similar intuitive colour map can be used, where darker greens indicate higher precipitation levels and red lower.

The map of Finland can be displayed with varying levels of detail, either through hex grids, which cover the entire country with about 256 hexagons, or by the 19 administrative regions. This flexibility is useful for different stakeholders, as it allows for both broad overviews and detailed regional analyses. For example, policymakers might prefer regional views to understand administrative impacts, while researchers might use hex grids for more granular data analysis.

The choropleth maps are not only animated through time but also interactive, allowing users to pause the animation and use tooltips to see exact values for any region at any given time by hovering over the area of interest. Users can also zoom in and out to focus on specific areas or view the entire country, which is particularly useful for detailed analysis or broader overviews. This interactivity enhances the usability of the visualisation for various parties, providing insights into specific regions or overall trends.

Understanding how different parts of Finland, particularly the northern and southern regions, are affected by climate change is crucial. Visualising the entire map over time can reveal significant insights into these regional impacts. For instance, northern regions might experience more pronounced changes in snow cover and temperature fluctuations, while southern regions might see more variability in precipitation patterns. This comprehensive view helps in identifying and understanding the broader impacts of climate change across the country, driving more informed decisions and actions.

Expected Results

From a technical standpoint, this project aims to offer users a comprehensive view of how Finland's climate is evolving due to climate change. Users will be able to explore various regions of Finland and analyse trends over time. The visualisation should appeal to a wide audience—from policymakers and researchers to the general public—providing them with the data they need to understand the ongoing changes in their environment and make informed decisions.

From a personal perspective, the goal is to go beyond presenting data and provoke an emotional response in users. By focusing on how climate change affects daily life in Finland, whether through more erratic snow falls or rising temperatures, I hope to create a deeper sense of connection to the issue. The visualisations will aim to evoke concern and urgency, motivating users to take personal action, whether by adjusting their lifestyle, advocating for policies, or simply being more mindful of their environmental impact.

Ultimately, the project aims to communicate complex climate data in an accessible and practical way, helping to raise awareness and encouraging evidence-based action.