VISUAL ANALYTICS FOR SINGAPORE'S WEATHER

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INTRODUCTION

Understanding Singapore's changing weather patterns is critical for a wide range of socio-economic planning and environmental preservation efforts. However, the existing tools for visualizing Singapore's historical weather data are few and often static, offering limited insights and lacking the depth necessary for comprehensive analysis.

The motivation behind our project stems from the need to provide a dynamic, interactive tool that can offer deeper insights into Singapore's weather. To fill this gap, we developed this interactive R Shiny application, to make this data accessible and understandable to a broader audience, thereby supporting better-informed decision-making.

DATASET

Our dataset comprises historical daily records of rainfall and temperature across 11 locations in Singapore, spanning from 2021 to 2023. It provides a detailed look into the climate variations experienced in recent years.

The dataset was retrieved from Weather.gov.sg, and all missing values were imputed using simple moving average.

SHINY APP OVERVIEW

The Shiny app comprises three key modules:

Exploratory & Confirmatory Data Analysis

Univariate Forecasting

Spatial Interpolation

Each module was designed to offer users a way to apply analytics and visualization to understand and draw insights from the dataset.

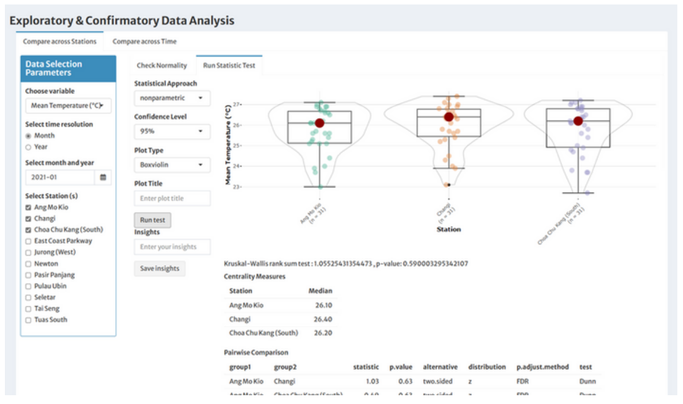
1. **Exploratory & Confirmatory Data Analysis**: Enables analysis of climate variables across stations and time periods, using statistical tests and interactive plots to identify weather patterns.
2. **Univariate Forecasting**: Combines exploratory analysis, decomposition, and advanced forecasting with seasonal adjustment for accurate weather predictions across multiple stations.
3. **Spatial Interpolation**: Generates isohyet/isotherm maps from sparse data, using interpolation techniques to estimate conditions at unmonitored locations, informed by data from Singapore's weather stations.

MODULE 1: EXPLORATORY & CONFIRMATORY DATA ANALYSIS

This module provides tools for conducting comparative analyses of weather data over different spatial and temporal scales, filling a gap where no existing tool offers such capabilities. It is designed to help users explore and understand weather patterns across various locations and time frames.

Core Functionalities

- **Normality Assumption Test**: Enables users to perform normality tests on daily rainfall or temperature data across different regions or time periods. The outcomes of these tests guide the selection of suitable statistical methods for further confirmatory data analysis.
- **Statistical Test**: Offers interactive violin and box plots for visual comparison of climate variable distributions across different stations or time periods. Users have the flexibility to customize plot titles and add their insights, enhancing the analysis experience.



MODULE 2: UNIVARIATE FORECASTING

This module offers a comprehensive toolkit for exploring weather data across multiple stations and comparing forecasting models for specific stations. It enables users to conduct exploratory analysis and time series decomposition, enhancing understanding of weather trends. The module stands out for its capability to adjust forecasts for seasonality, providing tools to detect and correct seasonally affected time series data for more precise forecasting.

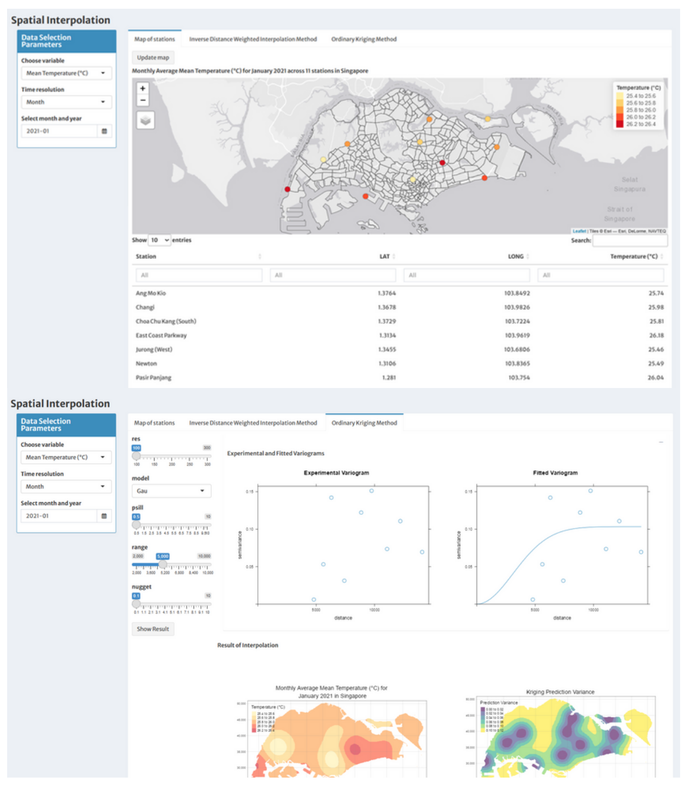
Core Functionalities

- **Exploratory Time Series:** Offers interactive tools for comparing weather variables across stations.
- **Time Series Decomposition:** Provides a detailed breakdown of time series into trend, seasonality, and residuals, employing robust statistical analysis.
- **Forecasting with Seasonal Adjustment:** Leverages "feasts" and "fable" for advanced forecasting capabilities, including the detection and adjustment for seasonality.
- **Comprehensive Analysis and Prediction:** Combines dynamic visuals, in-depth temporal analysis, and advanced forecasting techniques for a thorough analysis and accurate weather forecasting.

MODULE 3: SPATIAL INTERPOLATION

In this module, users can generate isohyet (rainfall) and isotherm (temperature) maps using two different spatial interpolation techniques. Users will be able to modify input parameters and observe how this changes the interpolation results.

We developed it to address the issue of weather data being limited to specific locations and the common inaccuracies or gaps in data, even with many stations in Singapore. Spatial interpolation helps us use the existing sparse data to estimate weather conditions at unmonitored locations.



Core Functionalities

- **Interactive Map:** Users can visualize point data for rainfall and temperature at 11 weather stations across Singapore.
- **Inverse Distance Weighting (IDW)**: This interpolation method estimates conditions at unmonitored locations by weighing the influence of nearby data points based on their proximity.
- **Ordinary Kriging**: This is a more advanced interpolation method that considers distance and spatial relationship between points to provide more accurate estimates.

FUTURE WORK

We aim to enrich our dataset with additional climate variables like humidity, wind speed, and air quality indices to deepen our analysis of weather phenomena. We plan to integrate more sophisticated forecasting models, including machine learning and deep learning algorithms, to improve the accuracy of our weather predictions. This will involve continuous model training and validation to adapt to changing climate patterns. Additionally, incorporating real-time weather data feeds will transform our application into a dynamic tool for both historical analysis and current weather tracking. This will require developing robust data ingestion pipelines and ensuring the scalability of our platform.