Dataset source :

<https://data.giss.nasa.gov/gistemp/>

problem statement :   
  
“This project analyzes monthly temperature anomaly data for Pakistan (1880–2025) using exploratory data analysis and time-series forecasting. The goal is to measure long-term warming trends, smooth seasonal fluctuations, and build predictive models to forecast future temperature changes. By focusing on Pakistan — a climate-vulnerable country — the study highlights both historical climate change impacts and future risks.”

# 📑 Project Storyline: Temperature Anomalies in Pakistan (1880–2025)

**1. Introduction**

* **Problem Statement:**  
  Climate change is one of the greatest challenges of the 21st century. Pakistan, being highly vulnerable due to its geography and reliance on agriculture, faces significant risks from rising temperatures.
* **Goal of Study:**  
  To analyze historical temperature anomaly data for Pakistan, understand long-term warming trends, seasonal patterns, and finally forecast future anomalies.
* **Dataset Used:**  
  NASA GISTEMP v4 gridded monthly temperature anomaly dataset (1880–2025), subset for Pakistan’s latitude (24–37°N) and longitude (60–77°E).

**2. Exploratory Data Analysis (EDA)**

Each step is not just technical, but answers a question about Pakistan’s climate:

**2.1 Data Coverage Check**

* Inspect data shape, time range, and missing values.
* *Why?* Ensures dataset is complete for analysis.
* *Finding:* Dataset spans 1880–2025, monthly frequency, continuous with no major missing gaps.

**2.2 Raw Monthly Anomalies**

* Plot Pakistan’s monthly anomalies.
* *Why?* To see overall variability and extreme events.
* *Finding:* Large short-term fluctuations, but hints of upward trend.

**2.3 Smoothed Rolling Trend**

* Apply 12-month rolling average.
* *Why?* To remove seasonal noise and see climate trend.
* *Finding:* Clear long-term warming, especially after the 1970s.

**2.4 Decadal Averages**

* Group anomalies by decade.
* *Why?* Climate researchers often look at decadal changes to avoid noise.
* *Finding:* Each recent decade is warmer than the previous; 2010s and 2020s show record highs.

**2.5 Seasonal Patterns**

* Group anomalies by month.
* *Why?* To see which seasons are warming faster.
* *Finding:* Winter months show sharper warming than summer, affecting agriculture and water cycles.

**2.6 Distribution of Anomalies**

* Plot histogram + KDE of anomalies.
* *Why?* To see how anomalies are shifting.
* *Finding:* Distribution shifts toward more positive anomalies → extreme hot months more frequent.

**2.7 Trend Decomposition**

* Decompose into trend, seasonality, residual.
* *Why?* To isolate long-term warming vs natural variability.
* *Finding:* Trend confirms progressive warming; seasonality persists but is overshadowed by rising baseline.

**3. Forecasting (Time Series Modeling)**

* **Goal:** Predict Pakistan’s temperature anomalies for the next 10–20 years.
* **Approach Options:**
  + ARIMA / SARIMA (statistical models)
  + Facebook Prophet (handles seasonality, trends well)
  + LSTM/Deep Learning (if you want ML flavor)
* **Expected Outcome:** Continuation of warming trend, with future anomalies likely exceeding historical averages.

**4. Discussion**

* **Implications:**
  + Higher temperatures → stress on crops, water shortages, health impacts.
  + Winter warming → reduction in snowmelt-dependent water supply.
* **Limitations:**
  + Only temperature anomalies, no precipitation or extreme weather events included.
  + Climate influenced by global circulation patterns (El Niño/La Niña) not modeled.

**5. Conclusion**

* Pakistan shows a **clear warming trend** since 1880, accelerating post-1970.
* Seasonal analysis suggests **winter months are warming faster**.
* Forecasting indicates **continued rise in anomalies** in the coming decades.
* This highlights Pakistan’s vulnerability and the need for adaptation strategies in agriculture, water management, and disaster preparedness.

The pipeline

 **EDA** (global & Pakistan anomaly trends)

 **Regional breakdown** (North, South, Punjab slopes)

 **Change point detection** (1970s acceleration)

 **Extreme event analysis** (top hottest years)

 **Pakistan vs Global comparison**

 **Forecast with Prophet (uncertainty bands)**

 **ENSO correlation check ( didn’t do it)**

 **Policy & societal insights  
  
  
  
Takeaway :**

**🌍 Policy & Societal Insights: Pakistan’s Warming Trends**

**1. Agriculture & Food Security**

* Pakistan’s economy is heavily dependent on agriculture, especially **wheat, rice, and cotton**.
* Rising temperatures, particularly in **Punjab (warming at ~0.11 °C/decade)**, threaten crop yields due to heat stress during critical growth phases.
* Extreme heat in **2022 (+2 °C anomaly)** coincided with reduced wheat output, highlighting vulnerability.
* **Policy Insight**: Invest in heat-resistant crop varieties and modern irrigation systems to secure food supply.

**2. Water Resources & Glacial Melt**

* The **North (Mountains)** region is warming fastest (~0.13 °C/decade).
* This accelerates **Himalayan glacier melt**, threatening long-term water supply in the **Indus River system**.
* Initially, glacial melt increases flood risks (like 2022 super floods), but in the long run, reduced ice reserves could cause **chronic water scarcity**.
* **Policy Insight**: Strengthen **water storage infrastructure** (dams, reservoirs) and improve **river basin management**.

**3. Urban Heat & Health Risks**

* **South (Arid)** regions, including Sindh, face rising anomalies (+0.09 °C/decade) on top of already high baseline heat.
* Heatwaves in Karachi and Sindh have caused **thousands of deaths** in the past decade.
* Warming increases the risk of **heat-related illnesses**, especially among urban poor without cooling access.
* **Policy Insight**: Develop **urban heat action plans**, expand cooling shelters, and ensure reliable electricity for vulnerable populations.

**4. Disaster Preparedness & Climate Extremes**

* The **top 10 hottest years** mostly cluster after 2000, showing a **new normal of extremes**.
* Heatwaves, floods, and droughts are becoming **more frequent and intense**.
* **Policy Insight**: Strengthen **early warning systems** and disaster response capacity (NDMA, provincial authorities).

**5. Global & National Climate Responsibility**

* Pakistan contributes **<1% of global emissions**, yet faces disproportionate impacts.
* Comparison with global trends shows Pakistan’s warming is **in line with the global average**, but with **sharper extremes**.
* **Policy Insight**: Use this evidence to push for **climate finance, adaptation funds, and loss & damage compensation** in international forums (UNFCCC, COP).

**🔑 Takeaway**

Pakistan is entering a phase of **accelerated climate risk**, with agriculture, water security, and health at stake. The evidence from temperature anomaly analysis shows clear warming trends across regions, demanding **urgent adaptation and policy action**.

After adding new thing   
  
✨ The storyline now flows like this:  
**Global context → Pakistan overview → Regional differences → Temporal shifts → Extreme events → Forecast → Maps → Seasons → Neighbors → Policy impact.**

**I have to present this project like this :** <https://github.com/denizyennerr/Brazilian_E-commerce_Analysis>