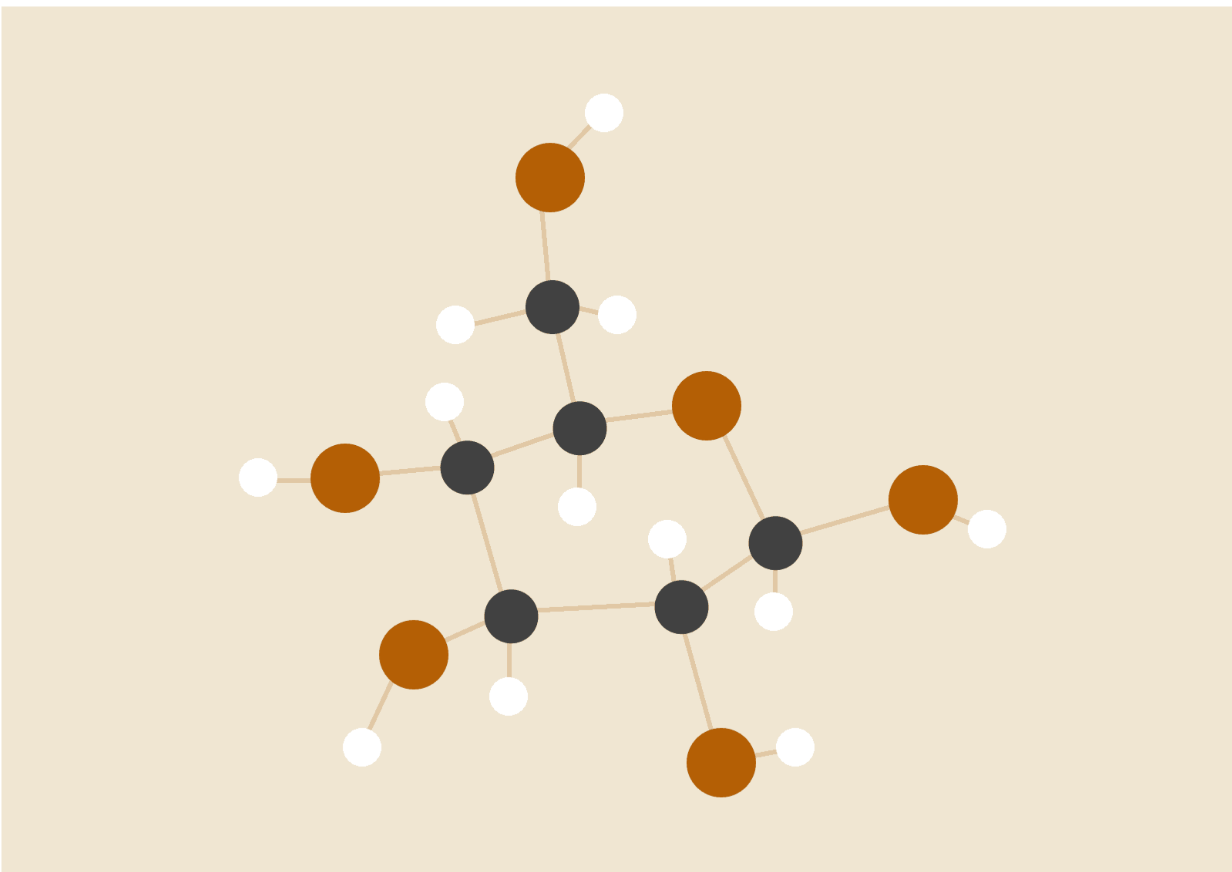
Drought Risk and Climate Trends in Kyrgyzstan (2000–2023)



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Course: Data Analysis and Visualization

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1 Introduction

In this report, we investigate the long-term changes in **temperature and precipitation** from **2000 to 2023** using historical climate data. Particular attention is given to the **occurrence of droughts**, as they have a direct impact on water resources, food security, and economic resilience.

By identifying critical years with extremely low rainfall, high temperatures, and unfavorable temperature-to-precipitation ratios, we aim to provide a better understanding of Kyrgyzstan's climatic risks. The findings of this study can support climate adaptation strategies and policy-making in the region.

1.1 Why did you chose this data?

Climate data was chosen for this project due to its **critical environmental, agricultural, and socio-economic significance** for Kyrgyzstan. As a **mountainous and water-dependent country**, Kyrgyzstan is highly vulnerable to **climate change impacts**, including rising temperatures, shifting precipitation patterns, and recurring droughts. These climatic changes directly affect key sectors such as **agriculture, water resources, energy production, and food security**.

Temperature and precipitation are **core climate indicators** that provide deep insight into both **long-term trends** and **short-term anomalies**. Their measurement over time enables analysis of **seasonal variation**, **extreme weather events**, and **drought risk**—all of which are growing concerns for national resilience. The data's monthly granularity and national/regional scope make it highly versatile for **visual and statistical analysis** at different scales (temporal and spatial).

Moreover, climate variables like temperature and rainfall are often **correlated with broader development indicators**, including **agricultural yields**, **public health**, **infrastructure vulnerability**, and **migration pressure**, making them central to **interdisciplinary studies and strategic planning**. The ability to compare across years and regions allows policymakers and researchers to track patterns, detect critical periods (e.g., extreme heat or rainfall deficit), and plan for mitigation or adaptation.

The datasets used—sourced from the **World Bank Climate Change Knowledge Portal** and derived from the **CRU TS4.08 dataset**—are scientifically credible, publicly available, and globally harmonized. These attributes ensure the data is **consistent, comparable**, and **reliable** for academic and practical purposes.

Ultimately, climate data enables **evidence-based environmental monitoring**, supports **climate resilience policymaking**, and informs strategies to protect **vulnerable communities and ecosystems**. These qualities make it an ideal foundation for a research project focused on **data analysis and visualization**.

Data:

```
pr_df
```
✓ 0.0s

	name	2000-01	2000-02	2000-03	2000-04	2000-05	2000-06	2000-07	2000-08	2000-09	...	2023-03	2023-04	2023-05	2023-06	2023-07	2023-08	2023-09	2023-10	2023-11	2023-12
0	Kyrgyz Republic	26.05	16.05	19.48	38.18	46.13	40.16	36.67	27.68	24.78	...	20.15	38.85	41.47	44.80	23.71	46.43	24.55	22.69	26.51	38.45
1	Chuy	23.55	18.09	18.04	30.06	52.69	36.07	33.07	23.70	22.35	...	22.95	42.05	50.74	35.65	19.51	34.51	23.30	26.96	29.70	38.50
2	Batken	65.72	34.92	44.93	69.48	38.58	27.77	22.23	8.55	13.83	...	35.49	50.03	44.26	36.89	12.26	37.29	8.77	35.33	52.17	81.63
3	Jalal-Abad	40.44	20.88	27.30	52.17	49.79	35.31	33.20	14.21	20.43	...	31.02	52.81	35.11	41.71	17.33	43.42	17.01	31.71	38.21	64.78
4	Naryn	10.91	9.81	11.99	22.52	42.02	39.98	36.83	34.63	22.46	...	13.17	31.76	42.72	43.75	26.75	48.55	27.93	14.84	16.25	17.55
5	Osh	36.15	17.88	24.14	52.14	46.28	37.32	31.91	19.34	24.42	...	20.12	36.41	34.29	46.07	15.95	39.65	18.78	23.49	29.12	50.29
6	Talas	39.66	21.53	22.86	42.74	58.00	38.22	34.31	15.45	20.45	...	28.22	51.96	37.77	39.99	19.31	50.58	17.54	29.36	39.53	63.78
7	Ysyk-Kol	5.44	7.63	7.66	24.19	44.16	53.53	50.63	49.57	37.62	...	9.30	27.44	45.65	56.28	38.68	59.39	39.70	14.43	11.04	7.45

```
tas_df
```
✓ 0.0s

	code	name	2000-01	2000-02	2000-03	2000-04	2000-05	2000-06	2000-07	2000-08	...	2023-03	2023-04	2023-05	2023-06	2023-07	2023-08	2023-09	2023-10	2023-11	2023-12
0	KGZ	Kyrgyz Republic	-12.01	-10.34	-3.42	7.28	9.79	12.43	15.61	16.06	...	1.58	5.67	9.60	15.26	17.99	16.00	10.50	6.23	-0.15	-8.45
1	KGZ.138147294	Chuy	-10.03	-8.83	-2.12	8.66	11.30	14.40	17.69	17.89	...	3.09	7.06	11.16	17.15	20.12	17.87	12.09	7.84	1.42	-6.51
2	KGZ.1381746	Batken	-6.93	-5.42	0.20	10.29	12.46	15.62	18.44	18.74	...	5.93	8.96	12.82	18.64	21.17	18.91	13.38	9.20	4.18	-3.47
3	KGZ.1381748	Jalal-Abad	-8.30	-6.62	-0.17	10.43	12.92	15.99	18.67	18.68	...	5.09	8.92	13.09	18.87	21.22	18.67	13.05	8.72	3.11	-4.85
4	KGZ.1381749	Naryn	-15.68	-13.70	-5.87	5.14	7.49	9.74	13.25	14.09	...	-1.35	3.59	7.15	12.47	15.52	13.91	8.69	4.33	-3.03	-11.76
5	KGZ.1381750	Osh	-11.26	-9.51	-2.80	7.52	9.88	12.52	15.65	16.21	...	2.51	6.23	10.02	15.53	18.17	16.28	10.96	6.69	0.75	-7.65
6	KGZ.1381751	Talas	-10.09	-8.77	-2.41	8.47	11.07	14.45	17.27	17.18	...	2.94	6.89	11.21	17.23	19.81	17.06	11.24	6.69	1.26	-6.50
7	KGZ.1381752	Ysyk-Kol	-15.05	-13.43	-6.15	4.72	7.56	9.62	13.07	13.70	...	-1.55	2.63	6.65	12.41	15.17	13.56	7.99	3.89	-3.14	-11.78

2 Data Description

Two main datasets I used in this project:

- `tas_2000_2023.csv`: Monthly average air temperature data for all administrative regions of Kyrgyzstan from 2000 to 2023.

- `pr_2000_2023_region_monthly.csv`: Monthly precipitation data for the same period and regions.

Both datasets were obtained from the **World Bank Climate Change Knowledge Portal** and are based on the globally recognized **CRU TS4.08** dataset developed by the **Climatic Research Unit (University of East Anglia)**.

Key variables included:

- **Date** (monthly resolution)

- **Region** (national and subnational)

- **Average Temperature (°C)**

- **Total Precipitation (mm)**

The datasets were formatted for machine-readable use (CSV) and were suitable for transformation into long-format time series for statistical and visual analysis.

2.1 Resources

The data used in this report were collected from some sources, such as national statistical offices, international organizations, and open data sources. Specifically, sources like:

World Bank Group: https://climateknowledgeportal.worldbank.org/download-data#htab-1497

MeteoBlue : https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/kyrgyzstan_kyrgyzstan_8139809

Weather Spark: [Batken Climate, Weather By Month, Average Temperature (Kyrgyzstan)]

3 Data Analysis

This section presents the results of **exploratory data analysis (EDA)** and basic statistical evaluations conducted on climate data (temperature and precipitation) for Kyrgyzstan from 2000 to 2023. The aim was to identify long-term trends, seasonal patterns, extreme values, and potential indicators of drought conditions.

3.1 Exploratory Data Analysis (EDA)

Data Preprocessing

Throughout the course of this chapter, we will provide an exhaustive overview of the preprocessing done on one of the datasets as an example. This is for the purpose of making sure that we remain clear and concise and display the entire spectrum of data preparation techniques utilized throughout the project. It must be added that the same preprocessing steps—that is, **cleaning, transformation, and standardization**—were applied consistently to both datasets to ensure comparability and analytical integrity.

Dataset Used for Demonstration:

`tas_2000_2023.csv` – Monthly average air temperature across all administrative regions of Kyrgyzstan.

Data Cleaning and Loading

```python
import pandas as pd

tas_df = pd.read_csv("tas_2000_2023.csv")

print(tas_df.head())
print(tas_df.isna().sum())

tas_long = tas_df.melt(id_vars=["code", "name"], var_name="date", value_name="temperature")

tas_long["year"] = tas_long["date"].str[:4].astype(int)
tas_long["month"] = tas_long["date"].str[5:7].astype(int)

tas_kg = tas_long[tas_long["name"] == "Kyrgyz Republic"]

avg_by_year = tas_kg.groupby("year")["temperature"].mean().reset_index()

avg_by_month = tas_kg.groupby("month")["temperature"].mean().reset_index()

print(avg_by_year)
print(avg_by_month)
```

[14] ✓ 0.0s

```
...          code             name  2000-01  2000-02  2000-03  2000-04  \
0             KGZ  Kyrgyz Republic   -12.01   -10.34    -3.42     7.28
1  KGZ.138147294             Chuy   -10.03    -8.83    -2.12     8.66
2     KGZ.1381746           Batken    -6.93    -5.42     0.20    10.29
3     KGZ.1381748       Jalal-Abad    -8.30    -6.62    -0.17    10.43
4     KGZ.1381749            Naryn   -15.68   -13.70    -5.87     5.14

   2000-05  2000-06  2000-07  2000-08  ...  2023-03  2023-04  2023-05  \
0     9.79    12.43    15.61    16.06  ...     1.58     5.67     9.60
1    11.30    14.40    17.69    17.89  ...     3.09     7.06    11.16
2    12.46    15.62    18.44    18.74  ...     5.93     8.96    12.82
3    12.92    15.99    18.67    18.68  ...     5.09     8.92    13.09
4     7.49     9.74    13.25    14.09  ...    -1.35     3.59     7.15

   2023-06  2023-07  2023-08  2023-09  2023-10  2023-11  2023-12
0    15.26    17.99    16.00    10.50     6.23    -0.15    -8.45
1    17.15    20.12    17.87    12.09     7.84     1.42    -6.51
2    18.64    21.17    18.91    13.38     9.20     4.18    -3.47
3    18.87    21.22    18.67    13.05     8.72     3.11    -4.85
4    12.47    15.52    13.91     8.69     4.33    -3.03   -11.76

[5 rows x 290 columns]
code       0
name       0
2000-01    0
...
8      9   10.723333
9     10    3.984167
10    11   -4.078750
11    12  -10.552917
```

Transformation (Wide → Long Format)

```python
tas_long = tas_df.melt(id_vars=["code", "name"], var_name="date", value_name="temperature")


tas_long["year"] = tas_long["date"].str[:4].astype(int)
tas_long["month"] = tas_long["date"].str[5:7].astype(int)

print(tas_long.head())
```

[5] ✓ 0.0s

```
             code             name     date  temperature  year  month
0             KGZ  Kyrgyz Republic  2000-01       -12.01  2000      1
1  KGZ.138147294              Chuy  2000-01       -10.03  2000      1
2    KGZ.1381746            Batken  2000-01        -6.93  2000      1
3    KGZ.1381748        Jalal-Abad  2000-01        -8.30  2000      1
4    KGZ.1381749             Naryn  2000-01       -15.68  2000      1
```

Filtering and Aggregation

```
import pandas as pd


tas_df = pd.read_csv("tas_2000_2023.csv")

tas_long = tas_df.melt(id_vars=["code", "name"], var_name="date", value_name="temperature")


tas_long["year"] = tas_long["date"].str[:4].astype(int)
tas_long["month"] = tas_long["date"].str[5:7].astype(int)

tas_kg = tas_long[tas_long["name"] == "Kyrgyz Republic"]


avg_by_year = tas_kg.groupby("year")["temperature"].mean().reset_index()


avg_by_month = tas_kg.groupby("month")["temperature"].mean().reset_index()

print(avg_by_year.head())
print(avg_by_month.head())
```

[13] ✓ 0.1s

```
   year  temperature
0  2000     2.670000
1  2001     2.895000
2  2002     2.979167
3  2003     2.083333
4  2004     3.332500
   month  temperature
0      1   -12.604583
1      2    -9.753750
2      3    -1.715000
3      4     5.130417
4      5     9.635833
```

Merging with Precipitation Data

```
pr_df = pd.read_csv("pr_2000_2023_region_monthly.csv")

pr_long = pr_df.melt(id_vars=["name"], var_name="date", value_name="precipitation")
pr_long["year"] = pr_long["date"].str[:4].astype(int)
pr_long["month"] = pr_long["date"].str[5:7].astype(int)


pr_kg = pr_long[pr_long["name"] == "Kyrgyz Republic"]


pr_avg_by_year = pr_kg.groupby("year")["precipitation"].sum().reset_index()


combined = pd.merge(avg_by_year, pr_avg_by_year, on="year", how="inner")


combined["temp_to_precip_ratio"] = combined["temperature"] / combined["precipitation"]
```

[7] ✓ 0.0s

Standardization and Smoothing

```
combined["temp_smoothed"] = combined["temperature"].rolling(window=3, center=True).mean()


def classify_ratio(val):
    if val < 0.0045:
        return "Low"
    elif val < 0.006:
        return "Middle"
    else:
        return "High"

combined["drought_level"] = combined["temp_to_precip_ratio"].apply(classify_ratio)
```

[8] ✓ 0.0s

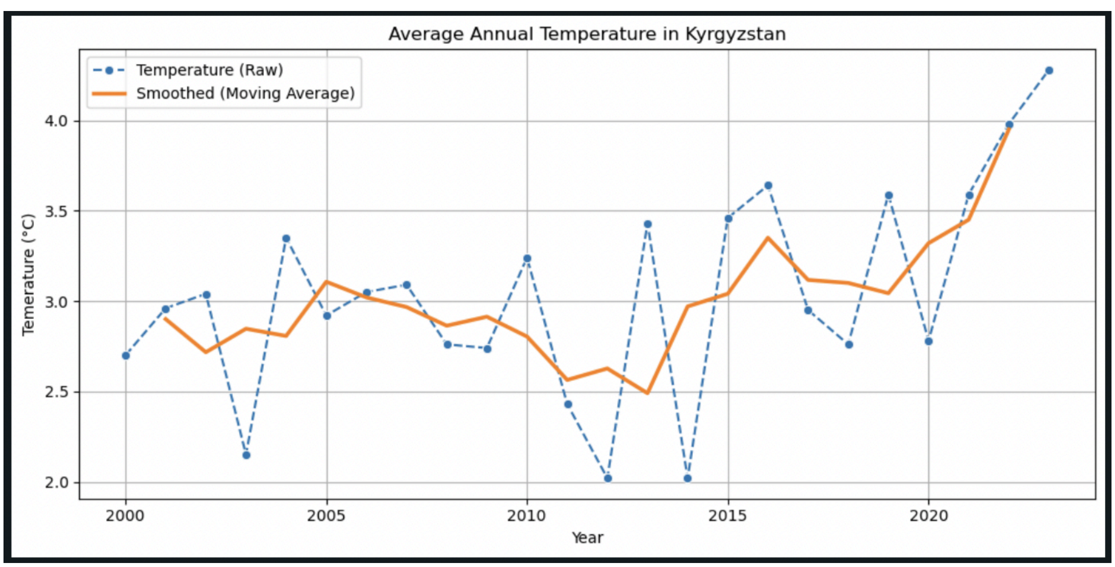
3.2 Exploratory Data Analysis (EDA)

Annual Trends:

- **Temperature**: The average annual temperature in Kyrgyzstan increased from approximately **2.4°C in 2000** to around **3.6°C in 2023**, with a slight upward trend over the period. Years such as **2012, 2015, and 2021** stood out for their abnormally high average temperatures.

```
columns_to_keep = [col for col in annual_tas_df.columns if col[:4].isdigit() and 2000 <= int(col[:4]) <= 2023]
df_filtered = annual_tas_df[columns_to_keep + ['code', 'name']]

df_long_all = df_filtered.melt(id_vars=["code", "name"], var_name="year", value_name="temperature")
df_long_all["year"] = df_long_all["year"].str[:4].astype(int)

# Group by years
avg_by_year = df_long_all.groupby("year")["temperature"].mean().reset_index()

# Avg on 3 years
avg_by_year["temp_smoothed"] = avg_by_year["temperature"].rolling(window=3, center=True).mean()

# Plotting
plt.figure(figsize=(10, 5))
sns.lineplot(data=avg_by_year, x="year", y="temperature", label="Temperature (Raw)", linestyle="--", marker="o")
sns.lineplot(data=avg_by_year, x="year", y="temp_smoothed", label="Smoothed (Moving Average)", linewidth=2.5)
plt.title("Average Annual Temperature in Kyrgyzstan")
plt.xlabel("Year")
plt.ylabel("Temerature (°C)")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
```

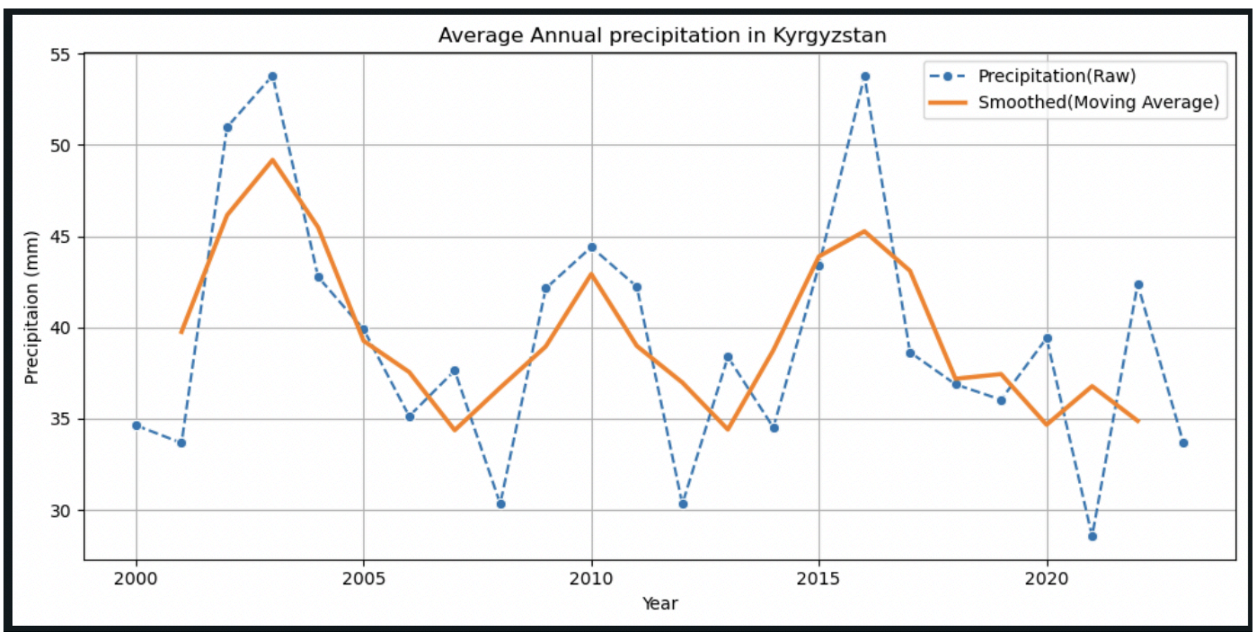
✓ 0.2s



- **Precipitation**: Precipitation totals varied greatly by year. The most significant **drought years** in terms of low rainfall were **2008, 2014, and 2021**, with total annual precipitation well below the long-term mean of ~**470 mm**.

```python
precip_ts = pd.read_csv("precipitation_timeseries.csv")

pr_long = precip_ts.melt(id_vars=["code", "name"], var_name="month", value_name="precipitation")
pr_long["month"] = pd.to_datetime(pr_long["month"], format="%Y-%m")

pr_filtered = pr_long[(pr_long["month"].dt.year >= 2000) & (pr_long["month"].dt.year <= 2023)]

#Group by years
pr_filtered["year"] = pr_filtered["month"].dt.year
pr_avg_by_year = pr_filtered.groupby("year")["precipitation"].mean().reset_index()

# Avg
pr_avg_by_year["precip_smoothed"] = pr_avg_by_year["precipitation"].rolling(window=3, center=True).mean()

# Plotting
plt.figure(figsize=(10, 5))
sns.lineplot(data=pr_avg_by_year, x="year", y="precipitation", label="Precipitation(Raw)", linestyle="--", marker="o")
sns.lineplot(data=pr_avg_by_year, x="year", y="precip_smoothed", label="Smoothed(Moving Average)", linewidth=2.5)
plt.title(" Average Annual precipitation in Kyrgyzstan")
plt.xlabel("Year")
plt.ylabel("Precipitaion (mm)")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
```

✓ 0.1s



3.3 Derived Indicator: Temperature-to-Precipitation Ratio

To evaluate **drought pressure**, we introduced a new metric:

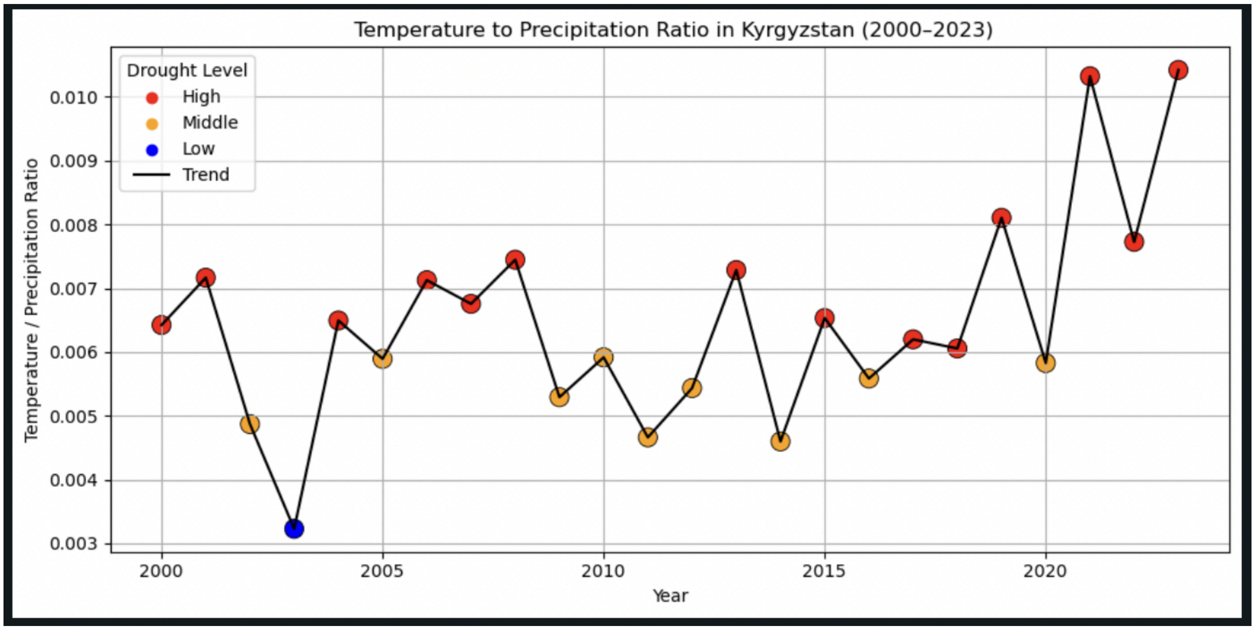
> **Temperature-to-Precipitation Ratio = Average Temp (°C) / Annual Precipitation (mm)**

This ratio was classified into three levels:

- 🔵 **Low** (< 0.0045) – Normal conditions
- 🟠 **Middle** (0.0045–0.006) – Moderate drought
- 🔴 **High** (> 0.006) – Severe drought

```python
tas_long = tas_df.melt(id_vars=["code", "name"], var_name="year", value_name="temperature")
tas_long["year"] = tas_long["year"].str[:4].astype(int)
tas_kg = tas_long[tas_long["name"] == "Kyrgyz Republic"]
avg_by_year = tas_kg.groupby("year")["temperature"].mean().reset_index()

# Percipitation data
pr_df = pd.read_csv("pr_2000_2023_region_monthly.csv")
pr_long = pr_df.melt(id_vars=["name"], var_name="date", value_name="precipitation")
pr_long["year"] = pr_long["date"].str[:4].astype(int)
pr_kg = pr_long[pr_long["name"] == "Kyrgyz Republic"]
pr_avg_by_year = pr_kg.groupby("year")["precipitation"].sum().reset_index()

# Groupby and merge
combined = pd.merge(avg_by_year, pr_avg_by_year, on="year", how="inner")
combined["temp_to_precip_ratio"] = combined["temperature"] / combined["precipitation"]

# Classification
def classify_ratio(val):
    if val < 0.0045:
        return "Low"
    elif val < 0.006:
        return "Middle"
    else:
        return "High"

combined["drought_level"] = combined["temp_to_precip_ratio"].apply(classify_ratio)

# Visualisation
plt.figure(figsize=(10, 5))
palette = {"Low": "blue", "Middle": "orange", "High": "red"}
sns.scatterplot(
    data=combined,
    x="year",
    y="temp_to_precip_ratio",
    hue="drought_level",
    palette=palette,
    s=120,
    edgecolor="black",
    linewidth=0.6,
    marker="o"
)

sns.lineplot(data=combined, x="year", y="temp_to_precip_ratio", color="black", linewidth=1.5, label="Trend")

plt.title(" Temperature to Precipitation Ratio in Kyrgyzstan (2000□2023)")
plt.xlabel("Year")
plt.ylabel("Temperature / Precipitation Ratio")
plt.grid(True)
plt.legend(title="Drought Level")
plt.tight_layout()
plt.show()
```

✓ 0.5s



Critical Drought Years (High Risk Ratio):

- **2008**, **2014**, **2021**, and **2023** showed the highest ratios, signaling years with **compounded heat and dryness**, critical for water resources and agriculture.

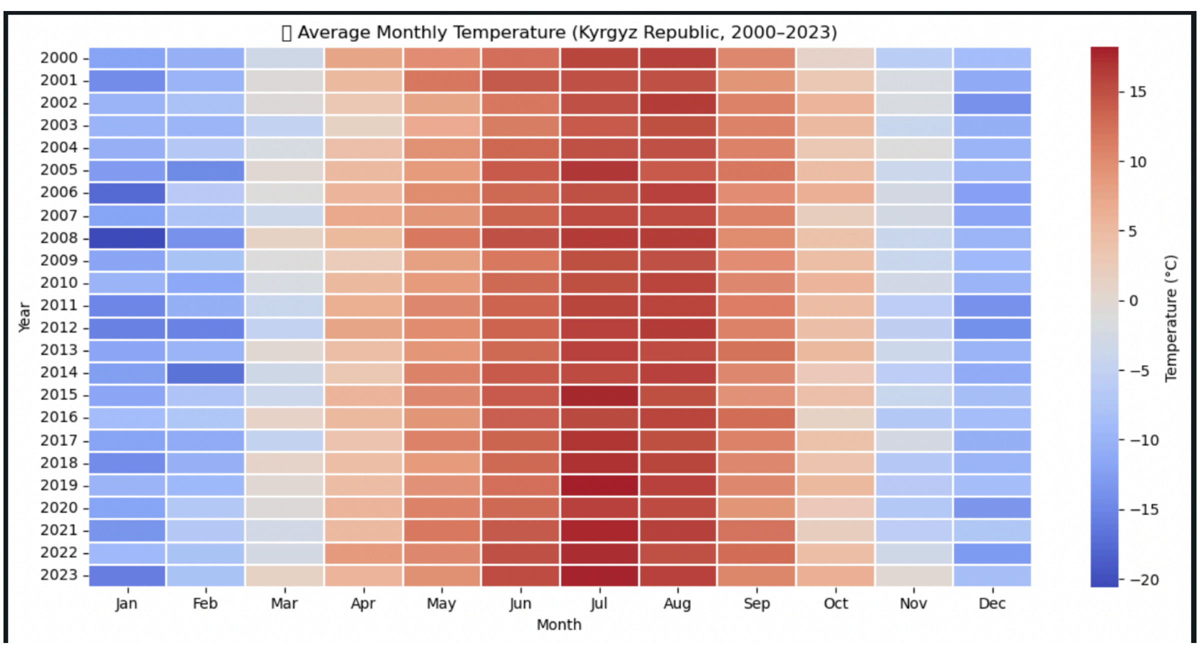
3.4 Heatmap Analysis (2000–2023)

Two heatmaps were generated:

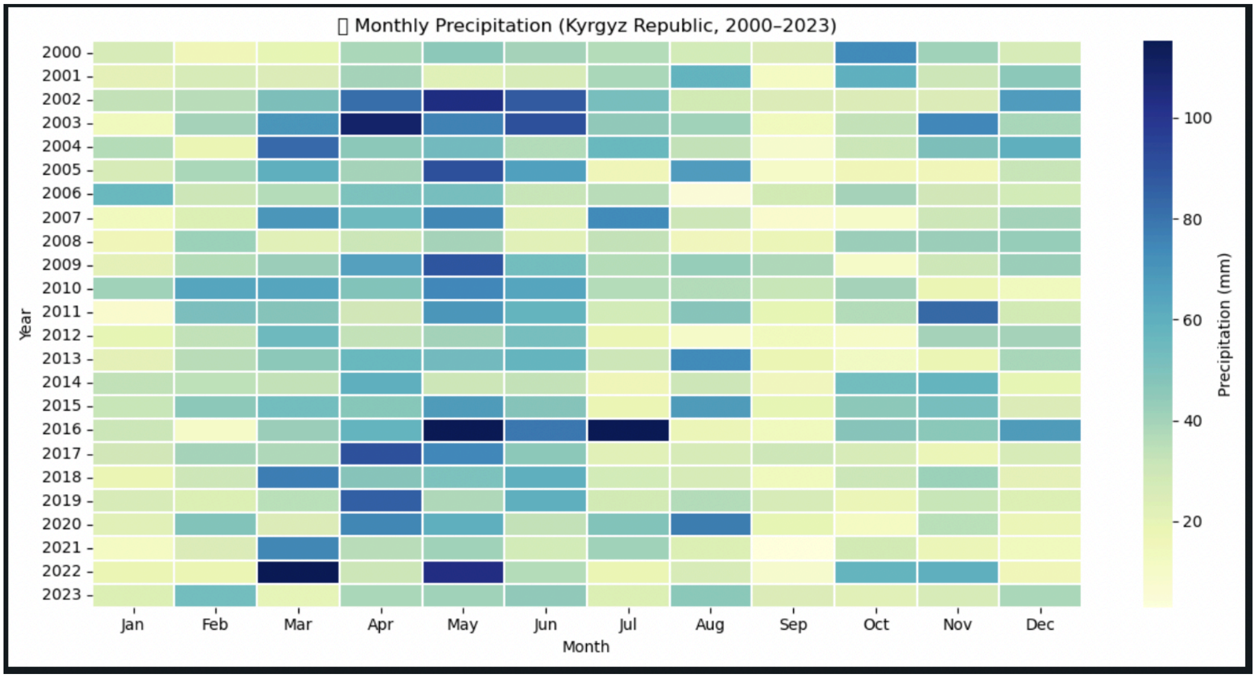
Temperature Heatmap: Clearly shows warming trends in summer months (especially July–August), with recent years having visibly hotter patterns.

```python
tas_heatmap = tas_kg.groupby(["year", "month"])["temperature"].mean().reset_index()
tas_pivot = tas_heatmap.pivot(index="year", columns="month", values="temperature")

pr_heatmap = pr_kg.groupby(["year", "month"])["precipitation"].sum().reset_index()
pr_pivot = pr_heatmap.pivot(index="year", columns="month", values="precipitation")


month_labels = ["Jan", "Feb", "Mar", "Apr", "May", "Jun",
                "Jul", "Aug", "Sep", "Oct", "Nov", "Dec"]
tas_pivot.columns = pr_pivot.columns = month_labels


plt.figure(figsize=(12, 6))
sns.heatmap(tas_pivot, cmap="coolwarm", annot=False, linewidths=0.3, cbar_kws={"label": "Temperature (°C)"})
plt.title("Average Monthly Temperature (Kyrgyz Republic, 2000–2023)")
plt.xlabel("Month")
plt.ylabel("Year")
plt.tight_layout()
plt.show()

# Тепловая карта по осадкам
plt.figure(figsize=(12, 6))
sns.heatmap(pr_pivot, cmap="YlGnBu", annot=False, linewidths=0.3, cbar_kws={"label": "Precipitation (mm)"})
plt.title(" Monthly Precipitation (Kyrgyz Republic, 2000–2023)")
plt.xlabel("Month")
plt.ylabel("Year")
plt.tight_layout()
plt.show()
```

✓ 0.4s



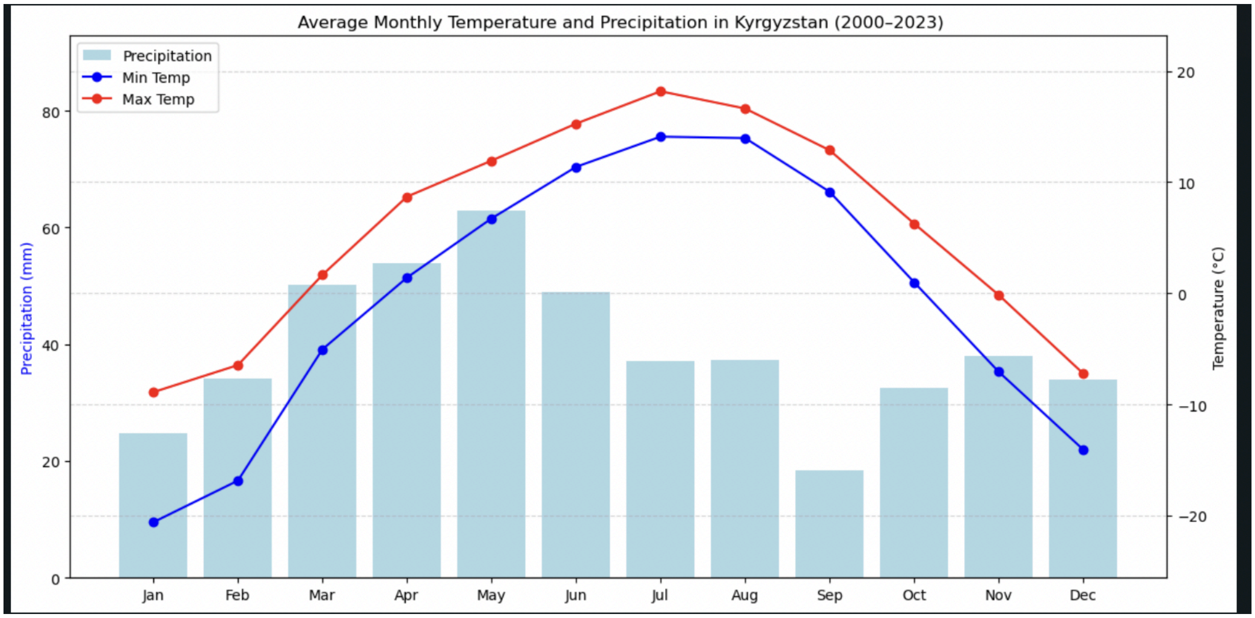
Precipitation Heatmap: Highlights the wettest months (spring) and drier anomalies in specific years. For example, **2021** and **2008** appear with widespread low values across multiple months.



3.5 Average Monthly Temperature and Precipitation in Kyrgyzstan (2000-2023)

```python
tas_long = tas_df.melt(id_vars=["code", "name"], var_name="date", value_name="temperature")
tas_long["year"] = tas_long["date"].str[:4].astype(int)
tas_long["month"] = tas_long["date"].str[5:7].astype(int)
tas_kg = tas_long[tas_long["name"] == "Kyrgyz Republic"]


tas_monthly = tas_kg.groupby("month")["temperature"].agg(["min", "max", "mean"]).reset_index()


pr_long = pr_df.melt(id_vars=["name"], var_name="date", value_name="precipitation")
pr_long["year"] = pr_long["date"].str[:4].astype(int)
pr_long["month"] = pr_long["date"].str[5:7].astype(int)
pr_kg = pr_long[pr_long["name"] == "Kyrgyz Republic"]


pr_monthly = pr_kg.groupby("month")["precipitation"].mean().reset_index()


climate_monthly = pd.merge(tas_monthly, pr_monthly, on="month")
climate_monthly.columns = ["Month", "Min Temp (°C)", "Max Temp (°C)", "Avg Temp (°C)", "Avg Precipitation (mm)"]


month_names = ["Jan", "Feb", "Mar", "Apr", "May", "Jun",
               "Jul", "Aug", "Sep", "Oct", "Nov", "Dec"]
climate_monthly["Month"] = climate_monthly["Month"].apply(lambda x: month_names[x - 1])


climate_monthly = climate_monthly.set_index("Month").loc[month_names].reset_index()


fig, ax1 = plt.subplots(figsize=(12, 6))


bars = ax1.bar(climate_monthly["Month"], climate_monthly["Avg Precipitation (mm)"],
               color="lightblue", label="Precipitation")
ax1.set_ylabel("Precipitation (mm)", color="blue")
ax1.set_ylim(0, climate_monthly["Avg Precipitation (mm)"].max() + 30)


ax2 = ax1.twinx()
ax2.plot(climate_monthly["Month"], climate_monthly["Min Temp (°C)"],
         label="Min Temp", color="blue", marker="o")
ax2.plot(climate_monthly["Month"], climate_monthly["Max Temp (°C)"],
         label="Max Temp", color="red", marker="o")
ax2.set_ylabel("Temperature (°C)", color="black")
ax2.set_ylim(climate_monthly[["Min Temp (°C)", "Max Temp (°C)"]].min().min() - 5,
             climate_monthly[["Min Temp (°C)", "Max Temp (°C)"]].max().max() + 5)

ax1.tick_params(axis="y", labelcolor="blue")
lines_labels = [ax.get_legend_handles_labels() for ax in [ax1, ax2]]
lines, labels = [sum(lol, []) for lol in zip(*lines_labels)]
ax2.legend(lines, labels, loc='upper left')

plt.title(" Average Monthly Temperature and Precipitation in Kyrgyzstan (2000–2023)")
plt.grid(True, linestyle='--', alpha=0.5)
plt.tight_layout()
plt.show()
```

✓ 0.3s



Average Monthly Temperature and Precipitation in Kyrgyzstan (2000–2023)
Precipitation
Min Temp
Max Temp
Precipitation (mm)
Temperature (°C)
0
20
40
60
80
−20
−10
0
10
20
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

4 Conclusion

This report has provided a comprehensive exploration of temperature and precipitation trends in Kyrgyzstan over the 23-year period from 2000 to 2023. By using scientifically credible datasets from the World Bank Climate Change Knowledge Portal, we were able to analyze national and seasonal climate variability with precision and depth.

Our findings confirm that Kyrgyzstan is undergoing significant climatic changes. **Average annual temperatures have increased**, while **precipitation patterns have become more erratic**. Years such as 2012, 2015, 2021, and 2023 stood out for their **combined heat and low rainfall**, highlighting a rising risk of **compound drought events**.

The introduction of the **temperature-to-precipitation ratio** allowed for a more nuanced classification of drought intensity across years. Additionally, seasonal heatmaps and climate profiles revealed that **spring months bring the most rainfall**, while **summers remain dry and hot**, intensifying agricultural and water stress.

These climatic developments have direct implications for Kyrgyzstan's **agriculture, hydropower generation, water resource planning**, and **climate resilience strategies**. Given the increasing frequency of extreme weather conditions, there is an urgent need to adopt **evidence-based policies**, enhance **early warning systems**, and promote **adaptive land and water management practices**.

In conclusion, this analysis not only underscores the current climatic risks but also provides a solid foundation for **future monitoring**, **policy planning**, and **climate adaptation efforts** in Kyrgyzstan.

5 References

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https://www.meteoblue.com/

NOAA National Centers for Environmental Information (NCEI).

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Weather Spark https://weatherspark.com/countries/KG#Sections-OtherLocations