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Climatic Trends in Cities in ShaanXi Province: An Temperature Analysis Using Geospatial Data and Statistical Techniques

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Abstract

Global warming stands as a crucial research focus in the 21st century, with historical temperature data serving as the primary reference standard for understanding climate change. This paper presents a comprehensive study on climate change patterns in Shaanxi Province, China, utilizing temperature data collected from meteorological stations over the past four decades. The research employs rigorous methodologies for data collection, processing, and analysis, offering insights into the temperature trends and variability of each prefecture-level city within the province. Through spatial interpolation, statistical calculations, and temporal aggregation, the study reveals a consistent and significant increase in average temperatures across all cities. These findings underscore the urgency of addressing climate change impacts at the regional level and stress the importance of localized strategies for adaptation and mitigation.

Keywords: Climatic Shifts; Temperature Analysis; Shaanxi Province; Data-driven Simulation; Spatial Interpolation.

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1. Introduction

In recent decades, climate change and its associated impacts have emerged as one of the most formidable challenges confronting humanity. The Earth's climate system is currently undergoing unprecedented shifts, primarily instigated by human activities that release greenhouse gases into the atmosphere. These activities have given rise to the phenomenon known as global warming, signifying the sustained increase in Earth's average surface temperature [1]. This temperature surge carries profound ramifications for ecosystems, economies, societies, and the well-being of both current and future generations [2].

Over the past few decades, there has been a conspicuous and concerning upward trajectory in the Earth's temperature. This unequivocal pattern underscores the pressing need to comprehend the root causes and consequences of this warming trend. The Intergovernmental Panel on Climate Change (IPCC), a preeminent authority in the field of climate science, has consistently stressed the unequivocal scientific consensus attributing this warming to human activities, especially the combustion of fossil fuels and deforestation [3]. The accumulation of greenhouse gases in the atmosphere results in heat retention, leading to disruptions in the Earth's climate patterns [4].

Examining temperature change patterns is of paramount importance for several critical reasons. Firstly, temperature serves as a fundamental barometer of the Earth's climate system [5]. Alterations in temperature wield a significant influence over a multitude of ecological processes, impacting species distribution, migration patterns, and overall survival rates. Ecosystems have adapted to specific temperature ranges over millennia, and deviations from these ranges can upset the intricate balance of natural systems. Secondly, temperature fluctuations exert far-reaching effects on global water cycles. Rising temperatures can trigger the thawing of glaciers and polar ice, contributing to escalating sea levels. This phenomenon poses an imminent threat to coastal communities, many of which are densely populated and economically vital. Additionally, temperature shifts can perturb precipitation patterns, resulting in changes in the frequency, intensity, and distribution of droughts and rainfall [6]. These alterations have substantial implications for agricultural productivity and global food security. Thirdly, a comprehensive understanding of temperature trends is indispensable for evaluating the accuracy of climate models and forecasts. Climate models depend on historical temperature data for calibration and use this information to formulate projections about future climate changes. Validating these models against observed temperature trends allows scientists to refine their predictions, thereby equipping policymakers with precise information for both mitigation and adaptation strategies [7].

This study endeavours to enhance our comprehension of climate change by scrutinizing temperature data pertaining to a specific region over recent decades. In pursuit of this goal, this study aim to address the following research inquiries:

1) What are the observed temperature patterns and trends evident in Shaanxi Province, China, over the past few decades?
2) Are there any distinctive patterns or irregularities discernible within the temperature data that could offer valuable insights into the underlying factors influencing temperature fluctuations?

3) How do the observed temperature trends correlate with the broader global climate change patterns and forecasts generated by climate models?

This study carries substantial implications for both scientific comprehension and the formulation of effective policy measures. Firstly, an exhaustive examination of temperature data can yield valuable insights into the localized manifestations of global climate change. While global averages provide a broad overview, regional analyses, such as figure 1 shown, enable us to pinpoint subtleties and variations that might be obscured when examined solely at the global level. These insights prove indispensable for crafting targeted adaptation strategies tailored to address specific regional vulnerabilities.

Figure 1: 10-year average temperature in Shaanxi Province (2010-2019)

Secondly, the findings emerging from this study can make meaningful contributions to the ongoing dialogues surrounding climate policy. In an era where nations are grappling with the imperative to curtail greenhouse gas emissions and transition toward sustainable energy sources, empirical data on temperature trends can significantly enrich discussions and negotiations. It can offer compelling evidence regarding the urgency of immediate action while underscoring the potential repercussions of failing to act promptly.

Lastly, this research enriches the broader scientific discourse on climate change by furnishing a comprehensive case study. Climate change is a multifaceted phenomenon governed by a multitude of interacting variables, and each region responds uniquely to these changes. The insights generated by this study can serve to refine existing climate models and validate predictive scenarios. Consequently, this contributes to enhancing the credibility of climate science and promotes a more informed public discourse on this critical issue.

In conclusion, climate change and global warming constitute among the most paramount challenges confronting our era, and the comprehension of temperature patterns stands as a pivotal step toward addressing their far-reaching impacts. Subsequently, this paper will proceed to delineate the methodology employed for temperature data analysis, delve into the outcomes of the analysis, and offer conclusions that augment our broader comprehension of climate change. Through this research endeavor, our aspiration is to illuminate the regional ramifications of global warming, provide insights into the factors steering temperature fluctuations, and make meaningful contributions to the ongoing endeavors geared towards both mitigation and adaptation to climate change.

2. Related Works

The IPCC report in 2018[8] assesses the impacts of 1.5°C global warming on ecosystems, economies, and societies, highlighting the benefits of limiting global warming to this threshold. The latest IPCC report in 2021[9] synthesizes current knowledge about the physical basis of climate change, including temperature changes, attributions, and observed impacts. Swain and his colleagues.[10] identifies atmospheric patterns that contribute to extreme temperature and precipitation events in the United States, providing insights into the mechanisms behind these events. Samset and his colleagues.[11] simulates the potential climate impacts of removing anthropogenic aerosol emissions, indicating that their presence has masked a portion of the warming from greenhouse gases. Li and his colleagues.[12] establishes an exposure-response relationship between future climate change and heat-related mortality in China, underscoring the importance of adaptation strategies. Wuebbles and his colleagues.[13] uses CMIP5 climate model data to assess climate extremes in the United States, indicating increases in extreme events and their implications. Zscheischler and his colleagues.[14] examines the risk of compound climate events (e.g., heatwaves and droughts) in the future, emphasizing the need for holistic risk assessment. Jacox and his colleagues.[15] analyzes the influence of the 2015/2016 El Niño on the California drought, illustrating the complex interactions between climate drivers. Lafferty and his colleagues.[16] explores the relationship between temperature changes and infectious disease dynamics, highlighting the potential for altered disease transmission patterns. Gidden and his colleagues.[17] provides a comprehensive dataset of emissions pathways under different socioeconomic scenarios for use in CMIP6 climate models, facilitating robust climate change projections. Li and his colleagues[18] quantifies the impact of urban heat island effects on heating and cooling energy consumption in the United States, highlighting the energy implications of temperature changes.

Shen and his colleagues.[19] use satellite observations to quantify the effects of the conversion of open lands (i.e., grassland and cropland) and natural forests to plantation forests and their associated biophysical processes (i.e., albedo and evapotranspiration (ET)) on land surface temperature (LST) in Guangdong Province, China. Abdi[20] evaluate the extent of land cover and land surface temperature change between 1999 and 2009. For more scientific urban planning, further analysis about the effect of urbanization on LST should focus on the compound stress from climate change and urbanization [21]. Dang and his colleagues.[22] utilized a time series of Landsat images to investigate the Land Surface Temperature (LST) of dry seasons between 1989 and 2019 in the Bac Binh district, Binh Thuan province, Vietnam. Dang and his colleagues.[22] aims to monitor LST change, and its relationship to land-cover change during the last 30 years. Prasetya and his colleagues.[23] aim to analyze the change in land surface temperatures on New Guinea Island using a cubic spline method, autoregressive model, and multivariate regression. Devi and his colleagues.[24] aim to investigate the change in land surface temperatures on the island from 2000 to 2019. To understand the spatiotemporal patterns of LST change, Yang and his colleagues.[25] conduct a spatiotemporal analysis using the Mann–Kendall trend analysis method with time series of mean annual surface temperature extracted from the moderate resolution imaging spectroradiometer/Terra daily LST product from 2000 to 2018. Song and his colleagues.[26] study the spatiotemporal pattern and influencing factors of land surface temperature change in china from 2003 to 2019.

Table 1: Summarization of related study

Focus Area	Author and Year	Research Focus
Climate Assessment	IPCC (2018)[8]	Assessing impacts of 1.5°C global warming on ecosystems, economies, and societies, emphasizing the benefits of limiting global warming to this threshold.
Climate Assessment	IPCC (2021)[9]	Synthesizing current knowledge about the physical basis of climate change, including temperature changes, attributions, and observed impacts.
Extreme Weather Events	Swain and his colleagues.[10]	Identifying atmospheric patterns contributing to extreme temperature and precipitation events in the United States, offering insights into the mechanisms behind these events.
Aerosol Effects	Samset and his colleagues.[11]	Simulating the potential climate impacts of removing anthropogenic aerosol emissions, revealing that their presence has masked a portion of the warming from greenhouse gases.
Health Implications	Li and his colleagues.[12]	Establishing an exposure-response relationship between future climate change and heat-related mortality in China, underscoring the importance of adaptation strategies.
Climate Extremes	Wuebbles and his colleagues.[13]	Using CMIP5 climate model data to assess climate extremes in the United States, indicating increases in extreme events and their implications.
Compound Climate Events	Zscheischler and his colleagues.[14]	Examining the risk of compound climate events (e.g., heatwaves and droughts) in the future, emphasizing the need for holistic risk assessment.
Climate Drivers	Jacox and his colleagues.[15]	Analyzing the influence of the 2015/2016 El Niño on the California drought, illustrating complex interactions between climate drivers.
Infectious Disease Dynamics	Lafferty and his colleagues.[16]	Exploring the relationship between temperature changes and infectious disease dynamics, highlighting the potential for altered disease transmission patterns.
Emissions Data	Gidden and his colleagues.[17]	Providing a comprehensive dataset of emissions pathways under different socioeconomic scenarios for use in CMIP6 climate models, facilitating robust climate change projections.
Urban Heat	Li and his	Quantifying the impact of urban heat island effects on heating and

Islands	colleagues[18]	cooling energy consumption in the United States, addressing energy implications of temperature changes.
Land Surface Temperature	Shen and his colleagues.[19]	Quantifying effects of land conversion and biophysical processes on land surface temperature (LST) in Guangdong Province, China.
Land Cover Change	Abdi[20]	Evaluating extent of land cover and land surface temperature change between 1999 and 2009, suggesting further analysis regarding urbanization and climate change impacts [14].
LST Monitoring	Dang and his colleagues.[22]	Investigating Land Surface Temperature (LST) changes in the Bac Binh district, Vietnam, and its relationship to land-cover changes over 30 years.
LST Analysis	Prasetya and his colleagues.[23]	Analyzing land surface temperature changes on New Guinea Island using statistical methods.
LST Analysis	Devi and his colleagues.[24]	Investigating land surface temperature changes on the island from 2000 to 2019.
LST Analysis	Yang and his colleagues.[25]	Conducting spatiotemporal analysis of mean annual surface temperature trends from 2000 to 2018.
LST Analysis	Song and his colleagues.[26]	Studying spatiotemporal patterns and influencing factors of land surface temperature change in China from 2003 to 2019, using both linear and nonlinear methods to analyze time-series LST trends.
Arctic Warming	Henry and his colleagues.[27]	Showing that enhanced Arctic continental winter warming with increased greenhouse gases results from land's smaller surface heat capacity compared to the ocean.

Trends of time-series LST were analyzed by using both linear and nonlinear methods. Henry and his colleagues.[27] show that an enhanced increase of Arctic continental winter temperatures with increased greenhouse gases is a robust consequence of the smaller surface heat capacity of land (compared to ocean), without recourse to other processes or feedbacks. There are also other influential works [27]. Table 1 shows the summarization of related study with focus area and citation.

In general, there is a wealth of relevant studies on global climate, but there are fewer studies on the climate of Shaanxi, an inland region of China. The present study analyses the climate of Shaanxi over the past 40 years on the basis of previous work and compares the temperature changes in 10 cities and towns in Shaanxi Province, which to a certain extent fills the gaps in related studies.

3. Materials and Methods

Analyzing long-term trends in temperature data is crucial for understanding the overarching patterns of climate change. In this paper, we identify significant shifts in temperature over extended periods in Shaanxi, which can provide insights into the magnitude and direction of climate change.

3.1. Data Collection

The "Daily meteorological dataset of basic meteorological elements of China National Surface Weather Station (V3.0)" is a valuable resource that provides comprehensive and high-quality meteorological data from surface weather stations across China. This dataset is essential for understanding climate patterns, variability, and trends in one of the world's most geographically diverse and populous countries.

The dataset is sourced from the China National Surface Weather Station network, which consists of numerous weather stations strategically located across different regions of China. These weather stations are operated by the China Meteorological Administration (CMA) and are equipped with advanced instruments to measure various meteorological elements, including temperature, precipitation, wind speed, humidity, atmospheric pressure, and more. The data collection follows international standards and quality control protocols to ensure the accuracy and reliability of the collected data.

Table 2: Key meteorological elements in the dataset

Data	Example
Maximum, minimum, and average temperature	14.0℃
Precipitation (rainfall and snowfall)	3.2mm
Wind speed	5m/s
Relative humidity	70%
Atmospheric pressure	1.0
Sunshine duration	11h

The dataset covers a significant time span, with records available from the early 20th century up to the present day. This long temporal coverage enables researchers to analyze historical climate trends, interannual variability, and potential shifts in meteorological patterns over decades. It provides spatial coverage across the entire territory of China, encompassing diverse geographical regions ranging from the high-altitude Tibetan Plateau to coastal areas and inland plains. This wide coverage facilitates the study of regional climate variations and the impacts of climate change on different ecosystems and communities within China. The dataset includes daily observations of various essential meteorological elements, such as: Maximum, minimum, and average temperature, Precipitation (rainfall and snowfall), Wind speed and direction, Relative humidity, Atmospheric pressure, Sunshine duration, Evaporation.

The dataset is typically provided in a structured format, with each entry representing daily measurements of meteorological variables at a specific weather station. Entries are organized chronologically, allowing researchers to track changes in meteorological conditions over time. To ensure data integrity and accuracy, the dataset undergoes rigorous quality control processes. This includes identifying and correcting errors, filling data gaps, and homogenizing records to account for changes in observation practices, instruments, or station locations.

The "Daily meteorological dataset of basic meteorological elements of China National Surface Weather Station (V3.0)" serves a multitude of purposes across various fields:

1) Climate Research: Researchers utilize the dataset to analyze long-term climate trends, detect anomalies, and understand variations in meteorological conditions.
2) Impact Assessment: The data supports studies on climate change impacts, including shifts in temperature, precipitation patterns, and extreme weather events on local ecosystems, agriculture, water resources, and human health.
3) Model Validation: The dataset is used to validate climate models, enhancing the accuracy of projections and simulations related to China's climate dynamics.
4) Policy Formulation: Governments and policymakers rely on the dataset to develop informed climate adaptation and mitigation strategies, especially in the context of China's commitment to addressing climate change.
5) Infrastructure Planning: The data aids in the design and construction of infrastructure resilient to changing climate conditions, such as building codes, urban planning, and disaster preparedness.

The dataset can be accessible through the China Meteorological Data Sharing Service System or other authorized platforms provided by CMA. Researchers, climatologists, policymakers, and other interested parties can request access to this dataset for scientific and policy-related purposes.

In conclusion, the "Daily meteorological dataset of basic meteorological elements of China National Surface Weather Station (V3.0)" is a comprehensive and reliable collection of meteorological data from China's national weather station network. Its wide coverage, long temporal span, and essential meteorological variables make it an invaluable resource for understanding climate dynamics, assessing climate change impacts, and informing climate-related policies and decisions within China and beyond.

3.2. Data Processing

The data processing methodology involves a series of steps to transform raw meteorological indicator data into processed temperature data at various spatial and temporal scales. This process involves data filtering, spatial interpolation, administrative boundary analysis, and statistical calculations. The detailed description of each step in the data processing method is as follows.

1) Data Filtering Based on Geographical Location

In this step, the raw meteorological indicator data from various weather stations are filtered based on their geographical coordinates, specifically focusing on Shaanxi Province, China. The latitude and longitude information of the meteorological stations are used to identify data points within the boundaries of Shaanxi Province. Other meteorological indicators besides average temperature are excluded at this stage, as only the day-by-day average temperature values are retained for further analysis.

2) Spatial Interpolation for Average Temperature Raster Map

Once the relevant data points are identified within Shaanxi Province, the next step is to create a day-by-day average temperature raster map for the entire province. Interpolation techniques are used to estimate temperature values at locations where observations are not available. The inverse distance weight (IDW) method is employed for this purpose. The IDW method calculates the temperature at a specific location as a weighted average of observed temperatures from nearby locations, with weights inversely proportional to the distance.

IDW is a commonly used spatial interpolation technique in geospatial analysis. It assigns weights to observed data points based on their distance from the location where the value is being estimated. The closer the data point, the higher its weight in the estimation process. The IDW formula is:

$$Z_p = \frac{\sum_{i=1}^{n} \frac{Z_i}{d_i^p}}{\sum_{i=1}^{n} \frac{1}{d_i^p}} \qquad (1)$$

Where: Z_p is the estimated value at location p. Z_i is the observed value at data point i. d_i is the distance between the estimation point p and data point i. n is the number of observed data points. p is the power parameter that influences the weight distribution (usually between 1 and 2).

3) Administrative Boundary Analysis and City-level Aggregation

Using the administrative boundaries of prefecture-level cities in Shaanxi Province, the day-by-day average air temperature values are aggregated for each city. This aggregation process involves overlaying the temperature raster map with administrative boundary polygons to determine the average temperature within each administrative unit. The result is a dataset containing day-by-day average temperature values for each prefecture-level city.

4) Calculation of Monthly and Yearly Average Temperatures

From the day-by-day average temperature dataset for each prefecture-level city, the next step involves calculating the month-by-month average temperatures. This calculation aggregates the daily average temperature values for each month, providing insights into the seasonal temperature patterns within each city. Subsequently, the year-by-year average temperature is computed by aggregating the monthly average temperatures for each year.

3.3. Summary of Data Process

In short, the data process steps are as follows:

1) Filtering: Select relevant data points within Shaanxi Province based on geographical coordinates (latitude and longitude). Retain only day-by-day average temperature values.
2) Spatial Interpolation: Use the IDW method to create a day-by-day average temperature raster map for Shaanxi Province, estimating temperature values at unsampled locations.

3) Administrative Boundary Analysis: Overlay the temperature raster map with administrative boundaries to aggregate temperature values for each prefecture-level city.
4) Monthly and Yearly Calculation: Compute month-by-month average temperatures by aggregating daily averages within each month. Calculate year-by-year average temperatures by aggregating monthly averages within each year.

4. Results and Discussion

4.1. Geographic location analysis of Shaanxi Province

Shaanxi Province, located in the central region of China, as figure 2 shown, is a land of diverse landscapes, shaped by its unique topography and climatic variations. Shaanxi Province includes ten cities, they are Xi'an, Tongchuan, Baoji, Xianyang, Weinan, Yan'an, Hanzhong, Yulin, Ankang and Shangluo. The province is renowned for its historical significance, cultural heritage, and natural beauty. Its geography and climate play a pivotal role in influencing its ecosystems, economy, and way of life.

Shaanxi Province exhibits a varied topography characterized by highlands, plateaus, mountains, plains, and basins. It is flanked by the Qinling Mountains to the south and the Loess Plateau to the north, creating a distinct geographical diversity. Qinling Mountains: Stretching along the southern border of the province, the Qinling Mountains are a prominent geographical feature. They act as a natural boundary between the subtropical and temperate zones, leading to varying climatic conditions on either side. Loess Plateau: The northern part of the province is dominated by the Loess Plateau, characterized by its distinctive loess soil deposits. This area features rolling hills and deep gullies formed by erosion, creating a visually striking landscape. Guanzhong Plain: Positioned in the central region, the Guanzhong Plain is a fertile and densely populated area. This flat plain is encircled by mountains and hosts the provincial capital, Xi'an, a city rich in historical heritage. Basins and Valleys: Numerous smaller basins and valleys are scattered across the province, contributing to its geographic diversity. The Wei River Basin and the Hanjiang River Basin are two significant examples.

Figure 2: Location of Shaanxi Province in China

Shaanxi Province spans three major climatic zones due to its geographical diversity and its location between the Yellow River and Yangtze River watersheds. These climatic zones shape the province's weather patterns, seasons, and precipitation levels.

Mesothermal Monsoon Climate (Northern Part of Northern Shaanxi): This northern region experiences a mesothermal monsoon climate, characterized by distinct seasons and a relatively large temperature range. Winters are cold and dry, while summers are hot and humid. The Great Wall traverses this area, further influencing its climate.

Warm-Temperate Monsoon Climate (Central Guanzhong and Northern Part of Northern Shaanxi): The central Guanzhong area and the northern part of northern Shaanxi experience a warm-temperate monsoon climate. Summers are warm and rainy, with a distinct wet season due to the East Asian monsoon. Winters are cold, but not as harsh as in the northern region.

North-Subtropical Monsoon Climate (Southern Shaanxi): The southern part of Shaanxi Province falls under the influence of a north-subtropical monsoon climate. Summers are hot and humid, with abundant rainfall. Winters are relatively mild, and the area experiences less temperature variation compared to the northern regions.

In conclusion, Shaanxi Province's geography and climate create a tapestry of landscapes and climatic patterns. The interplay between mountains, plateaus, basins, and river systems gives rise to a diversity of ecosystems and agricultural practices. The province's climatic variations, influenced by monsoons and geographic features, shape the lives of its residents, influence economic activities, and contribute to its historical and cultural identity.

4.2. Geographic location analysis of Shaanxi Province

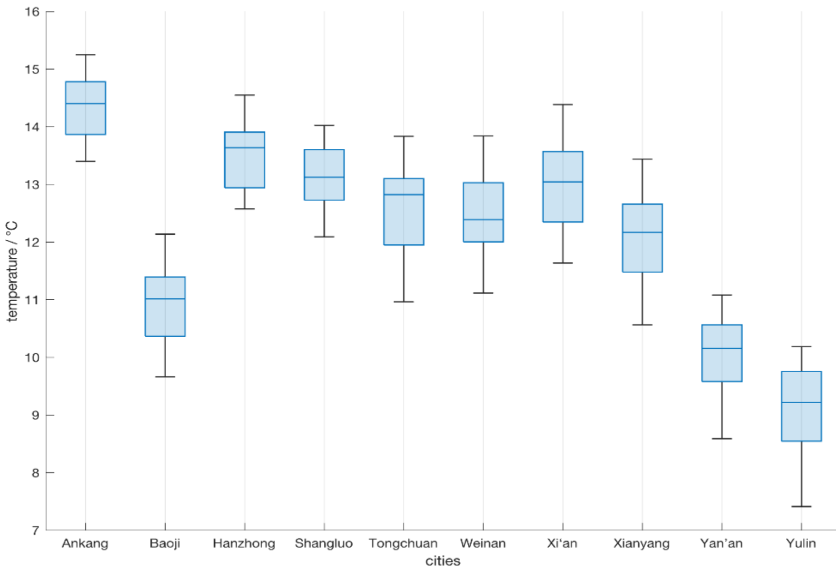

Figure 3: Temperature distribution in the cities for the last 40 years

We summarized and analyzed the average annual temperatures of 10 prefecture-level cities in Shaanxi Province from 1980 to 2020, and the results are shown in Figure 3. In general, Ankang has the highest temperature, followed by Hanzhong, Xi'an, Shangluo, Tongchuan, Weinan, and Xianyang, and Baoji, Yan'an, and Yulin have the lowest temperatures. This is basically consistent with the latitudinal distribution of these cities.

4.3. Temperature variations by the cities

A line graph of the average annual temperatures for each city in Shaanxi Province gives Figure 4. It is easy to see that the temperatures in each city have been oscillating upward over the past 40 years. Although the temperature increase varies from city to city, it is basically between 0.5 degree Celsius and 1 degree Celsius. In years such as 1987, 1997, and 2013, the temperature in each city has risen significantly, exceeding 1 degree Celsius.

4.4. Average temperature per 10 years for each city

Through computer simulation, a comparative picture of the average temperature per 10 years in each city of Shaanxi Province, China, can be obtained, as shown in Fig.4 in the next page. This picture gives a very good visualization of the increase in temperature in the various cities of Shaanxi Province in the last 40 years.

4.5. Advantages of the Methodology

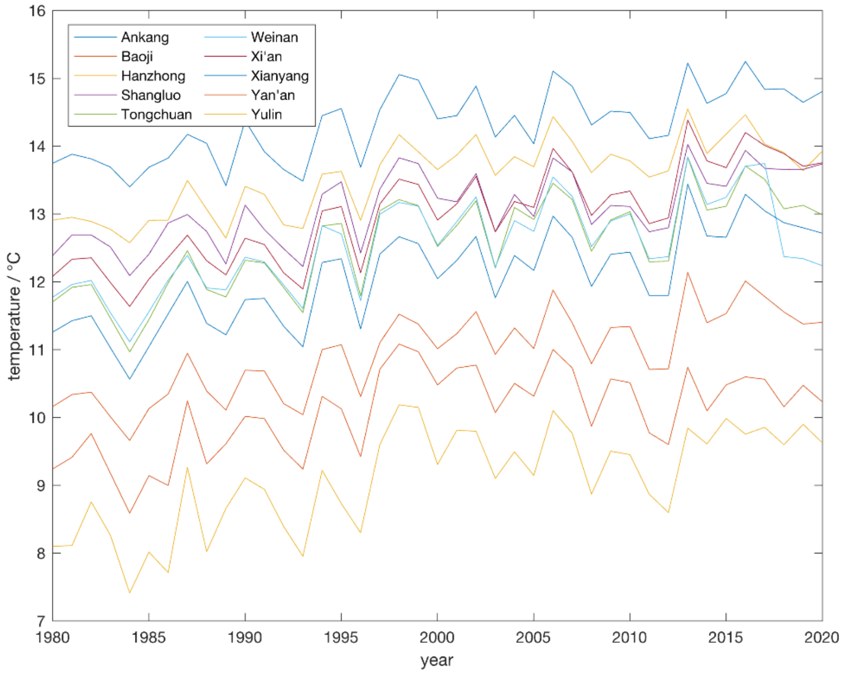

Figure 4: Temperature variations by cities

The methodology takes advantage of the spatial distribution of meteorological stations to create a detailed temperature raster map for the entire Shaanxi Province.

The administrative boundary analysis allows for temperature aggregation at the city level, enabling localized temperature analyses.

By calculating monthly and yearly averages, the methodology captures both short-term seasonal variations and long-term trends.

4.6. Limitations and Considerations

The accuracy of the interpolation depends on the density and distribution of meteorological stations. Sparse station coverage may lead to less accurate estimations in remote areas.

The IDW method assumes spatial correlation based solely on distance, which might not fully capture complex temperature patterns influenced by terrain, land cover, and local climate features.

Data quality and homogeneity are crucial for accurate results. Station relocation, instrument changes, and observation practices can introduce biases.

4.7. Application and Significance

The processed temperature data derived from this methodology can provide insights into regional climate patterns, trends, and variability within Shaanxi Province, as Figure 5 shown. These insights are valuable for climate research, impact assessment, policy formulation, and urban planning. The dataset can be used to identify temperature changes over time, understand local climate dynamics, and support evidence-based decision-making in sectors such as agriculture, water resources, and public health.

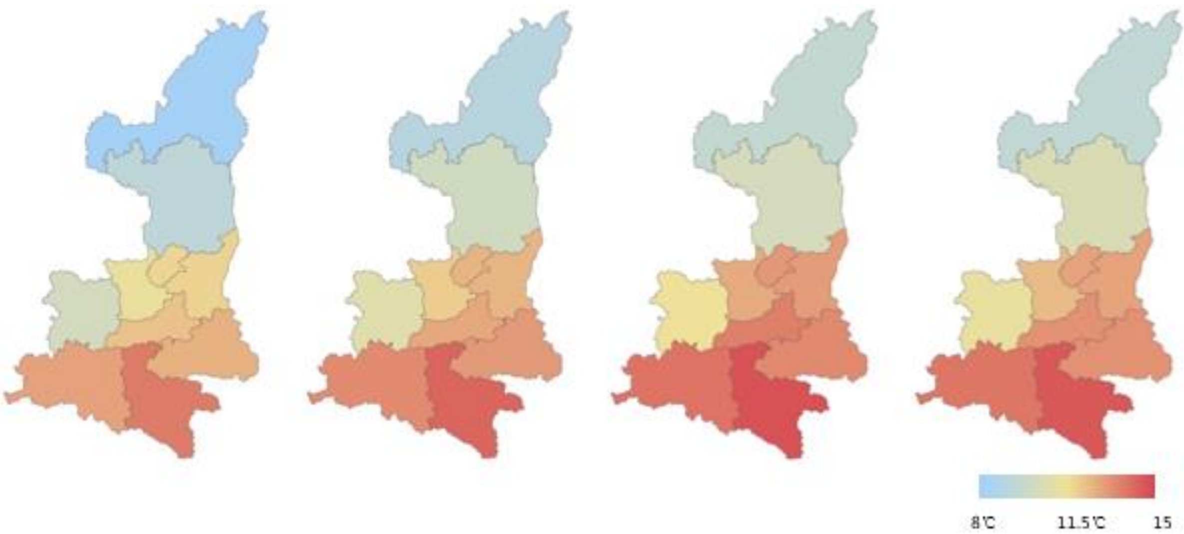

Figure 5: Comparison of average temperatures per decade in cities in Shaanxi Province, China (1980-1989, 1990-1999, 2000-2009, 2010-2019)

In conclusion, the detailed data processing methodology involves a step-by-step process of filtering, spatial interpolation, administrative boundary analysis, and statistical calculations to transform raw meteorological data into processed temperature information at various spatial and temporal scales. This methodology enables researchers to extract meaningful insights into temperature variations and trends in Shaanxi Province, facilitating informed assessments of climate dynamics and their impacts.

5. Conclusions

This study sheds light on the alarming temperature rise observed in Shaanxi Province over the last 40 years. The meticulous analysis of temperature data using robust methodologies has revealed a consistent upward trend across all prefecture-level cities.

The implications of this temperature increase are far-reaching, affecting ecosystems, agriculture, water resources, and human well-being. In this study, the distribution of temperatures was analysed only down to the administrative level of prefecture-level cities. Because of the distribution of different terrains such as plains, mountains, and basins in Shaanxi, there are differences in climate change in different areas of Shaanxi Province. Subsequent studies can continue to delve into smaller administrative divisions and combine climate analyses with topographic features.

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