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Research Article

Analysis of climate change in Chelyabinsk and Kurgan: effects of temperature and precipitation from 1990 to 2020 based on CRU data

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ABSTRACT

This study analyzes climate patterns in the Kurgan and Chelyabinsk regions of Russia using high-resolution data from the Climate Research Unit (CRU) between 1990 and 2020. The research focuses on how temperature and precipitation have evolved over time and their impacts on local ecosystems, agriculture, and water resources. Using MATLAB for visualization, temperature and precipitation maps were created for January and July across five time periods to understand the spatial and temporal variations in these regions. The analysis revealed a noticeable increase in temperature, with warmer winters and hotter summers in both regions. Precipitation patterns showed a shift, with a significant decrease in winter precipitation (January) and an increase in summer rainfall (July). These findings highlight the need for targeted regional climate adaptation strategies to cope with changing weather patterns and ensure sustainable management of resources.

1. INTRODUCTION

Mapping and analyzing climate data, particularly temperature and precipitation, is significant for understanding the impacts of climate alter on regional environments and agriculture. The improvement of tools and methods to precisely represent climatic varieties enables better-informed decision-making for resource management, urban arranging, and natural security. Among different data sources, the Climate Inquire about Unit (CRU) dataset has been widely adopted for worldwide and regional studies due to its high-resolution, gridded climate data determined from station estimations [1]. In Russia, especially within the Kurgan and Chelyabinsk regions, climatic changes over the past few decades have raised concerns regarding water resource accessibility and temperature extremes, impacting agribusiness and the nearby economy [2]-[3].
Researchers have connected MATLAB as an effective tool to process and visualize climate data, advertising flexibility in producing maps that successfully show spatial patterns in temperature and precipitation [4]-[5]. MATLAB's Mapping Tool kit, along with climate datasets like CRU, encourages the creation of detailed and high-quality maps that offer assistance visualize climate patterns and designs [6]. Past studies have highlighted the importance of high-resolution maps for capturing localized climatic varieties and advising adaptation strategies at the regional scale [7]-[8].
The Kurgan and Chelyabinsk regions are arranged within the Ural Government Area, a region that experiences a differing climate with particular regular designs. The later patterns in temperature rise and precipitation variability emphasize the need for region-specific climate analysis. Utilizing CRU data for these areas allows for an precise evaluation of temporal and spatial changes, giving basic experiences into neighborhood climate elements [9]-[10]. MATLAB-based mapping permits researchers to produce both temporal and spatial analyses, offering a vigorous system for visualizing territorial climate inconstancy [11].
This consider points to create and analyze precipitation and temperature maps for the Kurgan and Chelyabinsk regions utilizing CRU data and MATLAB's progressed mapping capabilities. Such maps are expected to uncover critical spatial and temporal patterns, upgrading understanding of how climate change is influencing these regions. Moreover, these findings might advise territorial adjustment methodologies and contribute to broader climate models by giving region-specific data for calibration [12]-[13].

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Past analyses have appeared that higher temperatures and changes in precipitation patterns can increase the hazard of dry spells in certain areas whereas compounding flooding in others. Such conditions require nitty gritty climate mapping to aid in water asset administration and adjustment arranging [14]-[16].
Utilizing CRU data to form climate maps for Kurgan and Chelyabinsk districts gives important experiences into the historical and current patterns of precipitation and temperature inconstancy, advertising a establishment for prescient climate models [17]. The integration of CRU data with MATLAB mapping capacities upgrades data visualization, empowering analysts to distinguish inconsistencies and long-term patterns successfully. High-resolution climate maps inferred from this approach support the examination of neighborhood climate marvels and serve as important inputs for ecological and agricultural modeling [18]-[20].
This inquire about will focus on creating precipitation and temperature maps for Kurgan and Chelyabinsk utilizing CRU data in MATLAB, to survey both spatial and temporal changes in climate patterns over these regions. By analyzing the spatial dissemination of temperature and precipitation, the study aims to recognize basic climatic zones that require observing and to supply experiences for future climate adjustment procedures [21]-[23].

2. RELATED WORK

Mapping and analyzing climate data utilizing geospatial tools have picked up noteworthy consideration in recent a long time, as analysts and policymakers look for to get it and moderate the impacts of climate change. This area surveys past studies on climate mapping, particularly focusing on the application of MATLAB and CRU data in analyzing precipitation and temperature patterns.
A few thinks about have illustrated the utility of the CRU dataset for evaluating climate patterns over time. CRU data, with its tall spatial and transient resolution, has demonstrated important in analyzing regional climate patterns, especially in zones where station data are limited or inadequate [23]. In regions like Russia, where climatic conditions are differing and data accessibility changes, CRU information has been fundamental for conducting spatially broad investigations [24]-[25]. Also, CRU reliable data scope from 1901 ahead provides a solid establishment for considering long-term climate variability and its regional impacts [26].
The utilize of MATLAB in climate data visualization and analysis is well-documented, particularly for creating spatial maps and performing slant analysis. MATLAB Mapping Toolbox empowers analysts to make customized climate maps, permitting for detailed spatial analysis of temperature and precipitation patterns [27]. Considers have appeared that MATLAB progressed capabilities, such as data insertion and graphical customization, make it perfect for processing climate data and creating outwardly natural maps [28]-[29]. For example, Zhang et al. [30] utilized MATLAB to analyze climate designs in East Asia, demonstrating how spatially express maps can uncover bits of knowledge into regional climate inconstancy.
In the context of Russian climate studies, different research endeavors have been directed at understanding regional climate patterns in zones just like the Ural Government Locale, which incorporates the Kurgan and Chelyabinsk districts. These zones have experienced eminent changes in temperature and precipitation, driven by both characteristic variability and anthropogenic factors [31]. Thinks about demonstrate that temperature has been rising, whereas precipitation patterns have gotten to be more sporadic, posturing challenges for agriculture and water management [31]-[32]. Analysis of such patterns is vital for adjusting nearby foundation and agrarian hones to manage with changing climate conditions.
Other works have focused on utilizing CRU data and MATLAB to model and map climate conditions over time. For occasion, Lin and Brown [34] utilized CRU data in combination with MATLAB Mapping Tool stash to make high-resolution temperature maps over diverse seasons, which made a difference in understanding regular varieties. This approach has been received in different studies to distinguish zones helpless to climate extremes and inform neighborhood adjustment methodologies [35]. The high spatial determination of CRU data is especially profitable for creating detailed maps that capture localized climate wonders [36].

3. DATA AND METHODOLOGY

3.1 Data

The Climate Research Unit (CRU) data could be a comprehensive worldwide dataset that gives historical records of different climate factors, such as temperature and precipitation, in a gridded format. This dataset could be a broadly utilized asset in climate research due to its high spatial resolution, broad transient scope, and unwavering quality. CRU data is determined from a thick arrange of climate stations around the world, which experience thorough quality control and standardization to ensure consistency and accuracy over regions and over time [41]-[42].
One of the most points of interest of the CRU dataset is its long-term scope, which dates back to 1901. This broad historical record permits researchers to analyze climate patterns and inconstancy over more than a century, giving an important standard for understanding long-term climatic changes [3]. CRU data is accessible in several forms, each giving overhauls and refinements to make strides spatial resolution, data completeness, and rectification of inclinations. The foremost

commonly utilized dataset, CRU TS (Time-Series), is available at a spatial resolution of 0.5° x 0.5°, making it perfect for regional climate studies [43].

The CRU dataset incorporates fundamental climate factors such as monthly temperature midpoints, least and maximum temperatures, precipitation, humidity, and other metrics basic for climate and natural research. In studies centered on the Kurgan and Chelyabinsk regions in Russia, the CRU dataset permits analysts to look at spatial and transient changes in temperature and precipitation patterns, capturing varieties that might affect agriculture, water assets, and environment steadiness [44]-[45].

3.2 Study Area

The Chelyabinsk and Kurgan locales are located within the southern portion of the Ural Federal Area of Russia. Chelyabinsk is situated around between 53.7N to 55.3°N scope and 59.6°E to 61.6°E longitude, while Kurgan lies assist east between 53.5°N to 56.2°N latitude and 63.0°E to 66.5°E longitude. These regions experience a continental climate, characterized by cold winters and warm summers. The think about zone is of intrigued due to its differing climatic conditions, which impact agriculture, water resources, and local ecosystems. By analyzing climate data, this thinks about points to get it the spatial and temporal varieties in temperature and precipitation designs over these districts [46]-[47].

Fig. 1. Show location map of study area.

3.3 Mapping algorithm in MATLAB packages

This algorithm breaks down each step to assist visualize temperature and precipitation data utilizing MATLAB. Underneath is the step-by-step outline for the algorithm, with each portion deciphered into plain language:

- Goal: Create climate maps (for temperature and precipitation) that visualize data over particular regions, such as Kurgan and Chelyabinsk, utilizing CRU data.
- Input: CRU dataset for month to month or yearly temperature and precipitation.
- Output: Climate maps for temperature and precipitation, visualized for a particular region over time.

Step 1: Data uploading and Preprocessing:

1. Upload CRU Climate Information:
   - Upload the CRU data records that contain temperature and precipitation data.
   - Characterize the scope, longitude, and time measurements from the data.
2. Extricate R egion of Intrigued (ROI):
   - Recognize the latitude and longitude boundaries for the region of intrigued (e.g., Kurgan and Chelyabinsk).

- Filter data to include as it were the data focuses that drop inside these geographical boundaries.

3. Convert Time Units (on the off chance that necessary):
   - In the event that the time measurement is put away in an incoherent format, convert it to a standard arrange (e.g., year/month) for less demanding elucidation and visualization.

Step2: Data Preprocessing:

1. Calculate Month to month or Yearly Averages:
   - For each grid point within the region, calculate the average temperature and precipitation over the whole time period.
   - Utilize the following equations:

   Average of temperature:

$$T_{avg} = \frac{1}{N} \sum_{i=1}^{N} Ti \quad (1)$$

   Average of precipitation:

$$P_{avg} = \frac{1}{N} \sum_{i=1}^{N} Pi \quad (2)$$

2. Calculate Anomalies (Discretionary):
   - Calculate the anomaly for each time step, which appears how much each time step veers off from the average.
   - Utilize the equations:

   Temperature anomaly:

$$T_{anomaly} = T - T_{avg} \quad (3)$$

   Precipitation anomaly:

$$P_{anomaly} = P - P_{avg} \quad (4)$$

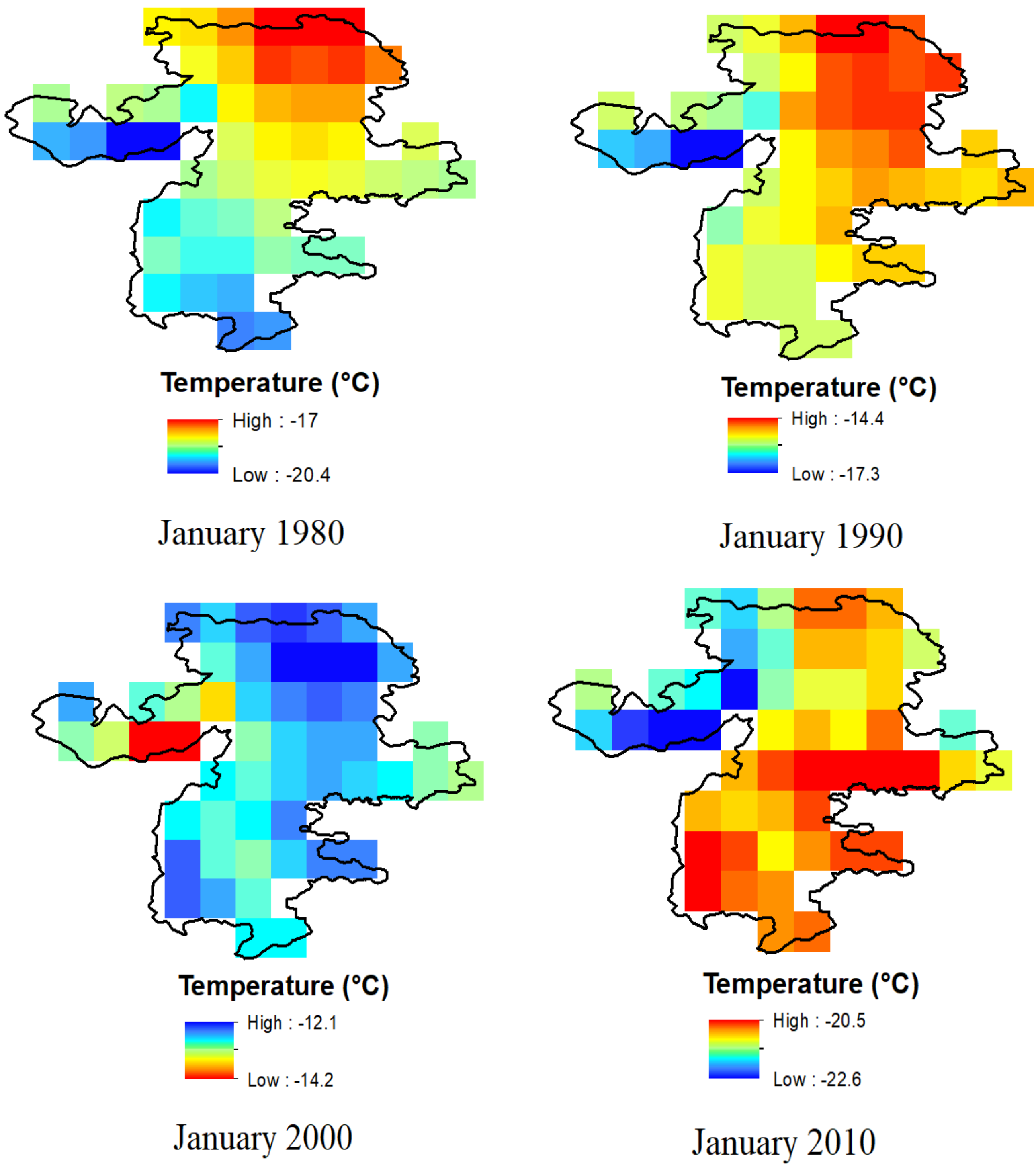
3. Seasonal or Annual Conglomeration (Optional): Total month to month data to make seasonal or yearly averages on the off chance that required for analysis.

Step 3: Visualization of Climate Maps:

1. Set Up Geographic Framework:
   - Initialize a map to set up a geographical projection for the characterized region.
   - Include coastlines or country boundaries to supply setting for the map.
2. Plot Temperature Map:
   - Show a color-coded map to appear the average temperature data.
   - Utilize color concentrated or slopes to represent temperature values over the region.
3. Plot Precipitation Map:
   - Comparative to the temperature map, make a color-coded map for average precipitation.
   - Utilize color concentrated to show shifting levels of precipitation across the region.
4. Plot Anomalies (Optional):
   - On the off chance that irregularities were calculated, make extra maps to imagine these anomalies for a specific time step (e.g., a particular year or month).
   - Highlight noteworthy deviations from the mean values.
5. Customize and Save Figures:
   - Include important titles, labels, legends, and other customization to make strides meaningfulness.
   - Save the map as a picture record for future utilize or publication.

4. RESULTS

This map appears the spatial conveyance of temperature change in Chelyabinsk based on data from five time periods between 1980 and 2020. Diverse colors on the map appear the ranges of temperature change, with red showing the greatest increase and blue showing the most prominent decrease. The maps appear spatial variety in temperature change due to natural variables such as territory, urban extension, or human exercises. This sort of examination is valuable for understanding the impacts of climate alter and distinguishing the foremost influenced regions for natural arranging.
Figure 2. show the temperature impact in Chelyabinsk for January for five different time period.


Temperature (°C)
High : -17
Low : -20.4
January 1980
Temperature (°C)
High : -14.4
Low : -17.3
January 1990
Temperature (°C)
High : -12.1
Low : -14.2
January 2000
Temperature (°C)
High : -20.5
Low : -22.6
January 2010

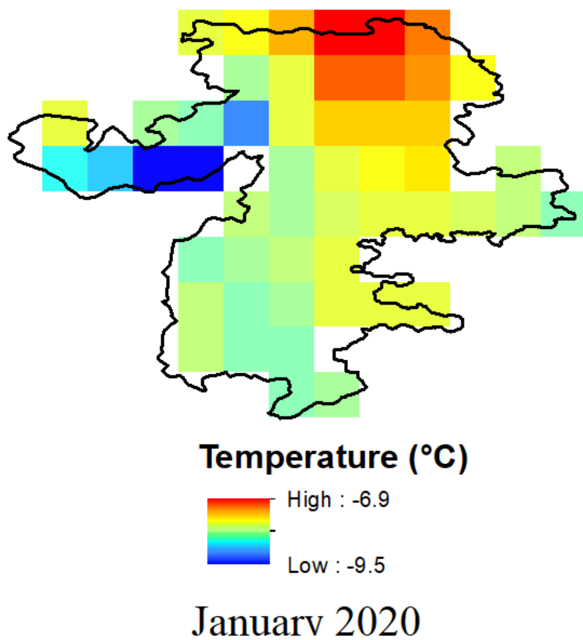
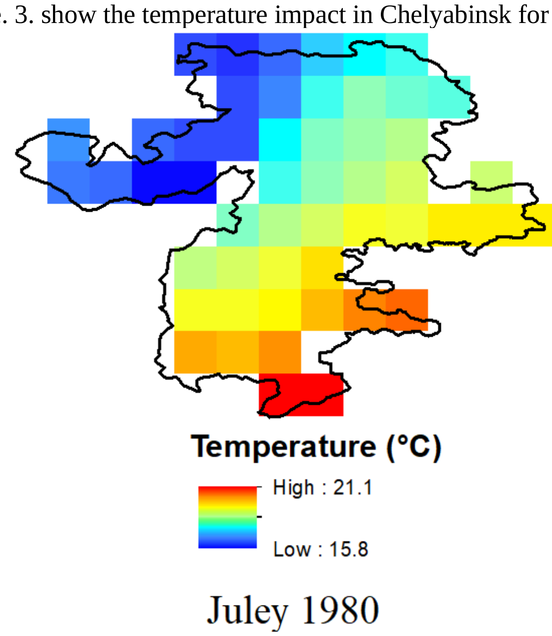
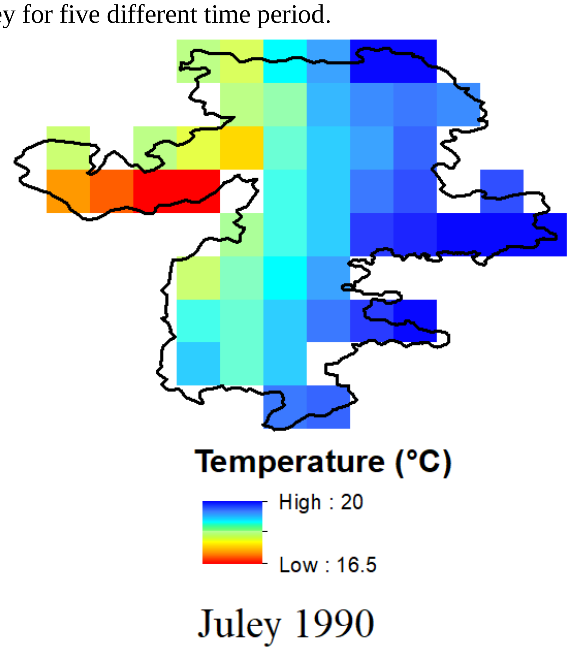


Fig. 2. Show the Temperature change for January in Chelyabinsk for fifth different time periods from 1980 to 2020.

The maps appear the dispersion of temperature changes in Chelyabinsk during July, showing direct temperatures reflecting the summer impact. The red color demonstrates the areas with the highest temperatures during this month, whereas the other colors reflect the spatial contrasts in temperature changes. This analysis is imperative for evaluating the effect of climate change on regions amid the summer.
Figure. 3. show the temperature impact in Chelyabinsk for Juley for five different time period.





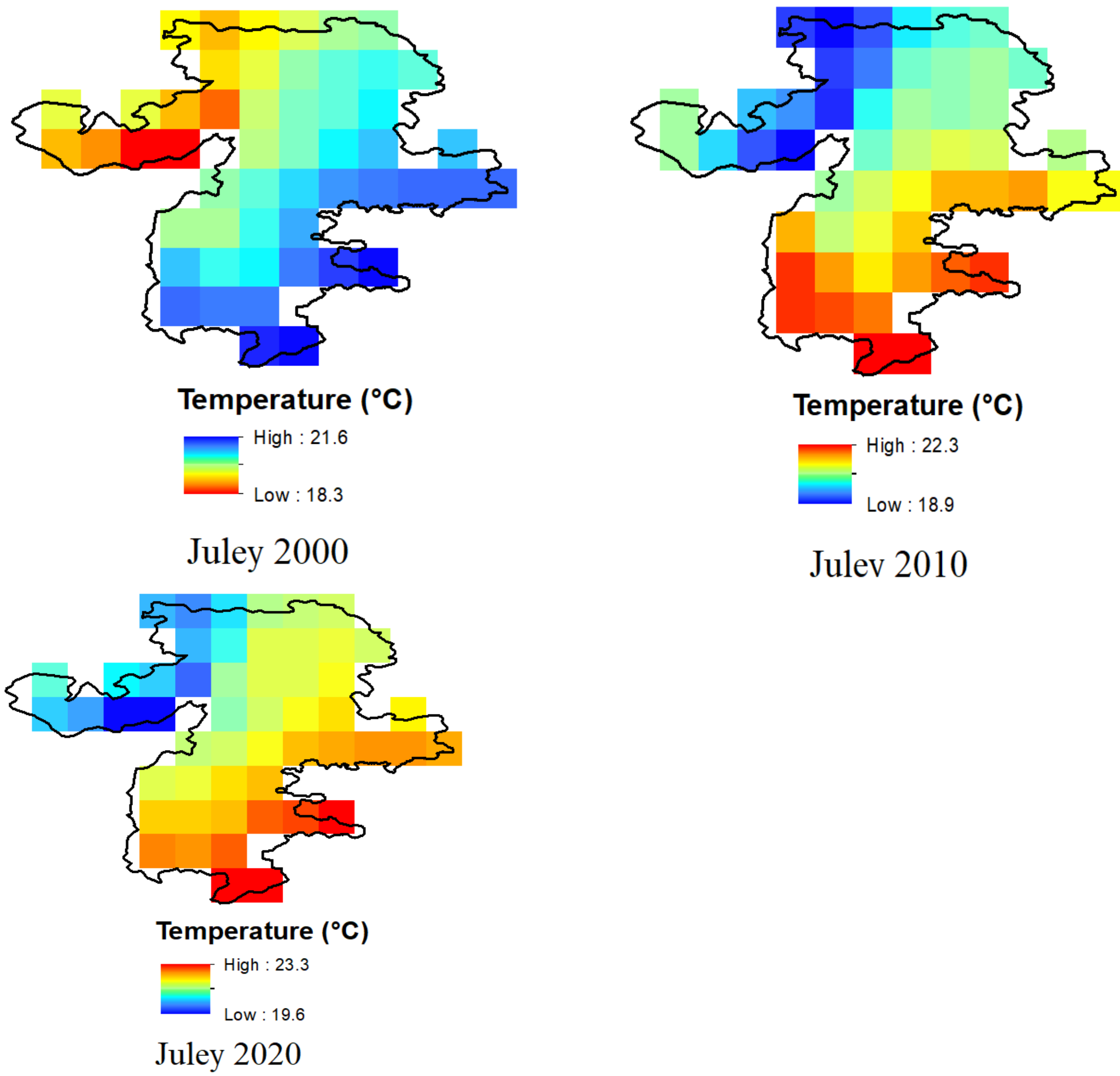
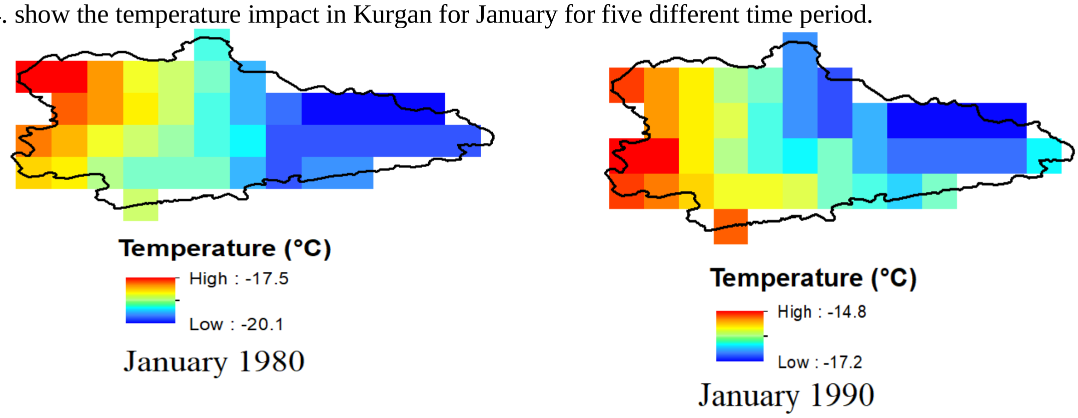


Fig. 3. Show the Temperature change for Juley in Chelyabinsk for five different time periods from 1980 to 2020.

The maps appear the dissemination of temperature changes within the city of Kurgan amid the month of January, the coldest month. The data was analyzed for five diverse time periods between 1980 tell 2020. The colors on the maps appear the temperature change ranges, with dark blue showing the coldest regions, whereas light colors represent ranges with less temperature drops.

Figure 4. show the temperature impact in Kurgan for January for five different time period.



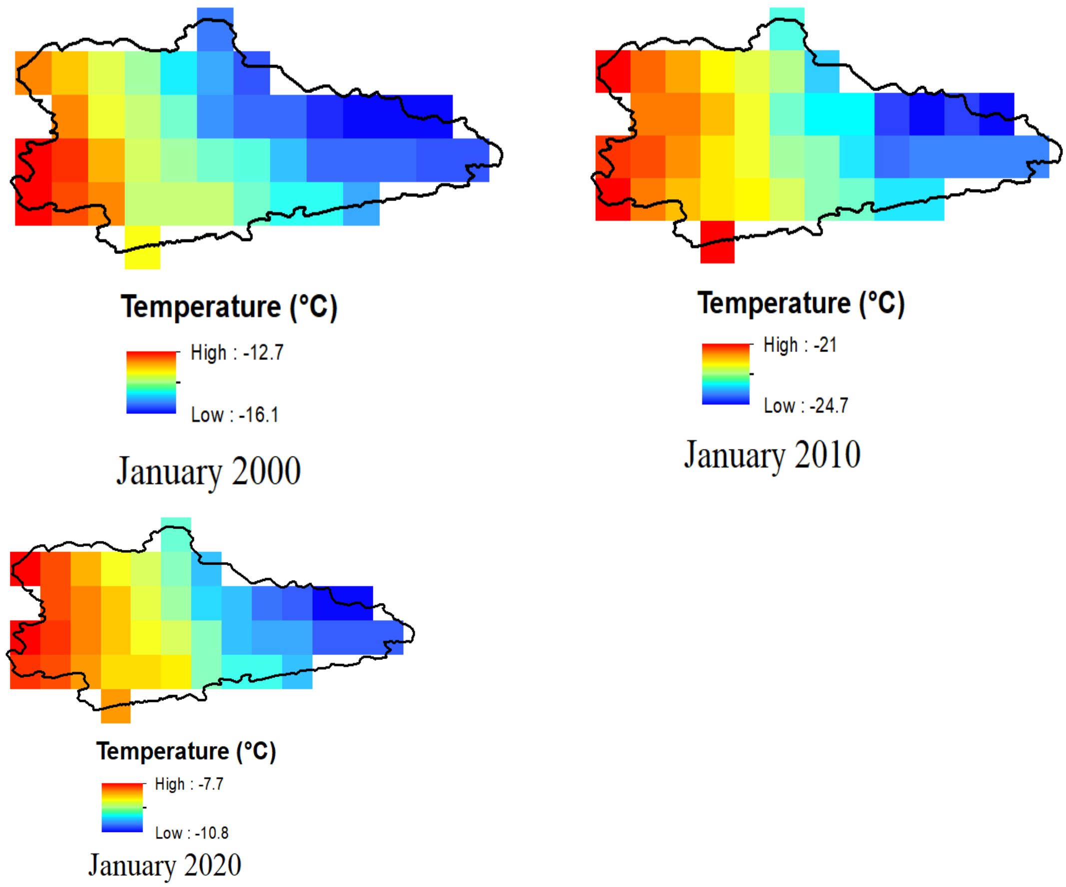
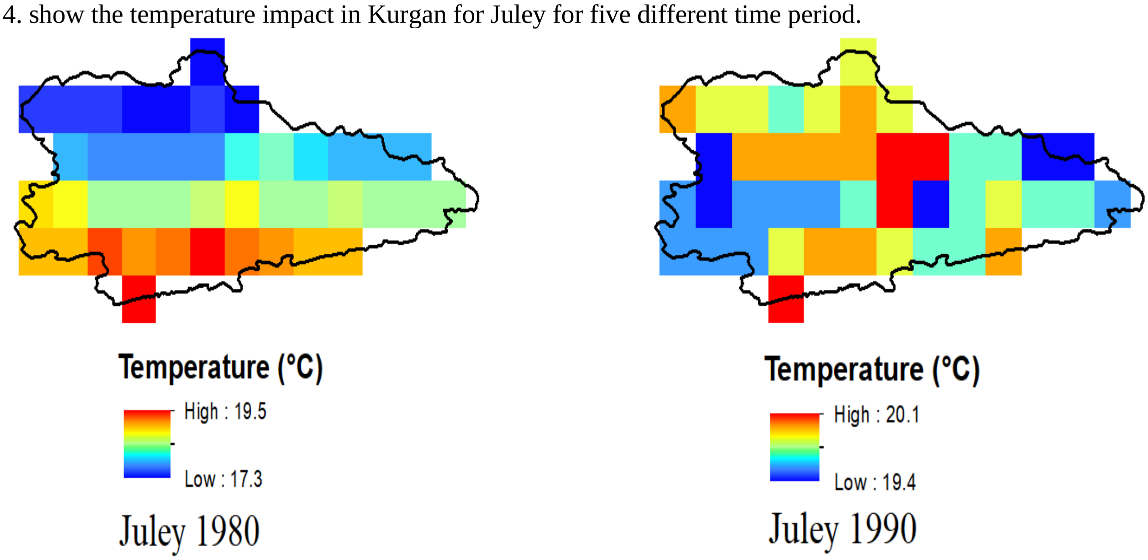
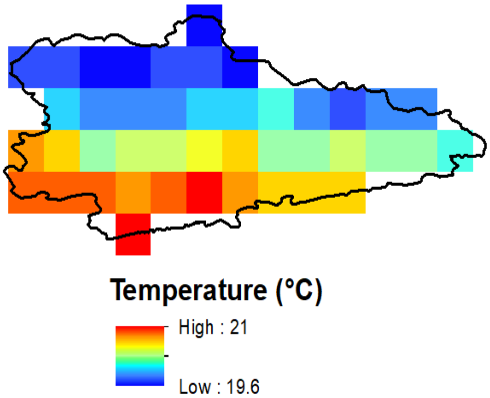


Fig. 4. Show the Temperature change for Juley in Kurgan for five different time periods from 1980 to 2020 in January.

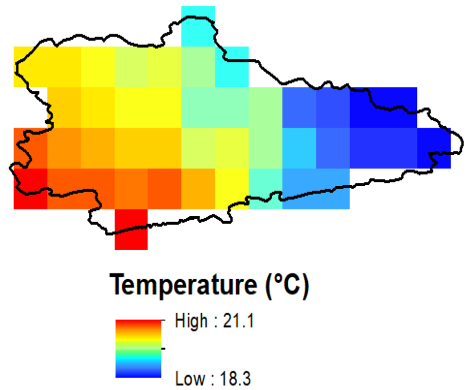
The maps appear the temperature change within the city of Kurgan amid the month of July, when the climate is direct, and the period witnesses the highest yearly temperatures. Data was analyzed from five diverse time periods between 1980 tell2020. The maps appear the spatial variety of temperature change in this month, which makes a difference to get it the climate impacts related with summer and to identify the foremost affected regions.

Figure. 4. show the temperature impact in Kurgan for Juley for five different time period.

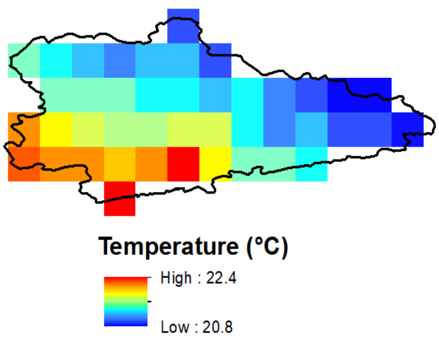




Juley 2000



Juley 2010

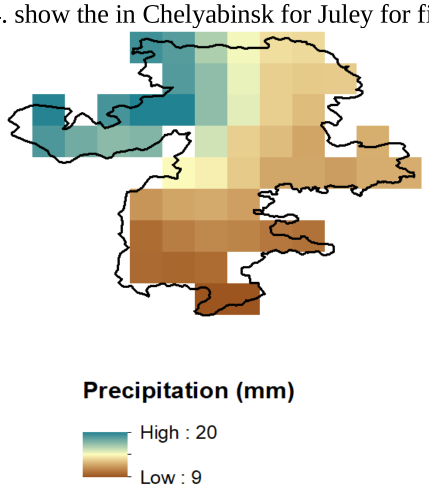


Juley 2020

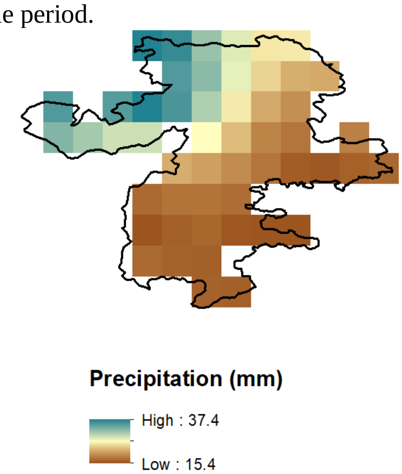
Fig. 5. Show the Temperature change for Juley in Kurgan for five different time periods from 1980 to 2020 in January.

The maps show the average Precipitation in Chelyabinsk for January, with a color gradient used to represent different values. The brown areas represent the lowest rainfall, around 100%, and are concentrated in the southern part of the region. In contrast, the green and blue areas are in the northern and northwestern parts, indicating higher rainfall. The yellow and beige colors in the middle of the gradient represent average rainfall distributed between the regions. Through the gradient, there appears to be a clear difference in the distribution of rainfall between the north and south, with more rainfall in the northwest and less in the south. These patterns may be the result of topographical factors or local climate influences that affect the distribution of rainfall at this time of year.

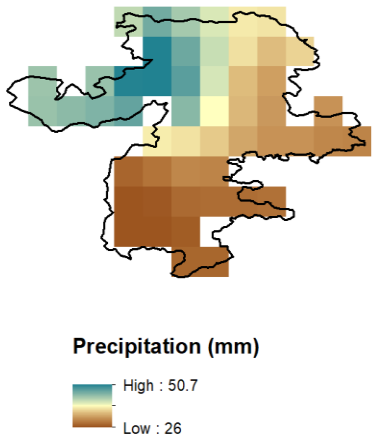
Figure. 4. show the in Chelyabinsk for Juley for five different time period.



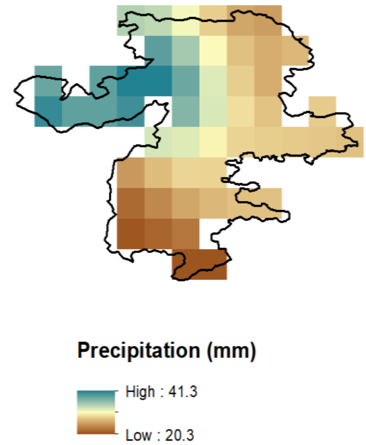
January 1980



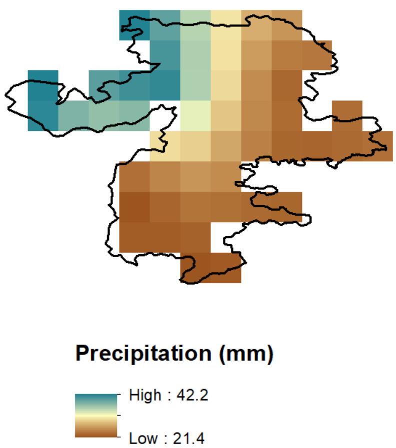
January 1990



January 2000



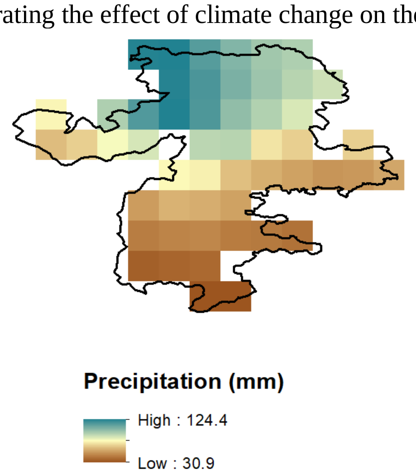
January 2010



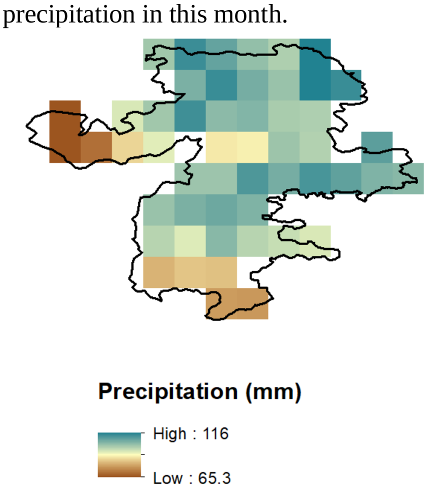
January 2020

Fig. 6. Show the precipitation change in Chelyabinsk for five different time periods from 1980 to 2020 January.

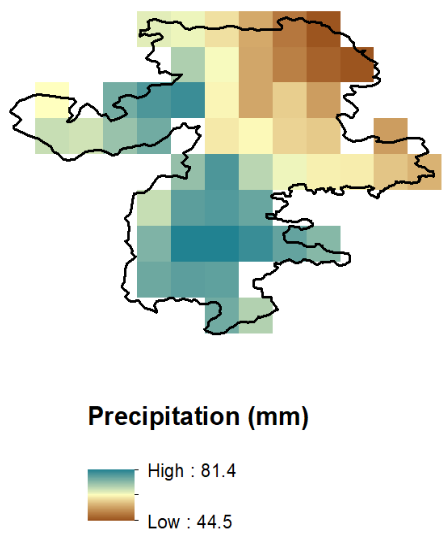
In Chelyabinsk, there's a clear change in precipitation rates between the time periods of 1990 and 2020, especially during July. Within the 1990s, precipitation rates were direct, but a continuous increase in precipitation was watched in afterward periods, with the highest rates amid the period 2010-2020. The maps reflect this alter by extending the blue and green regions, demonstrating the effect of climate change on the increment in precipitation in this month.



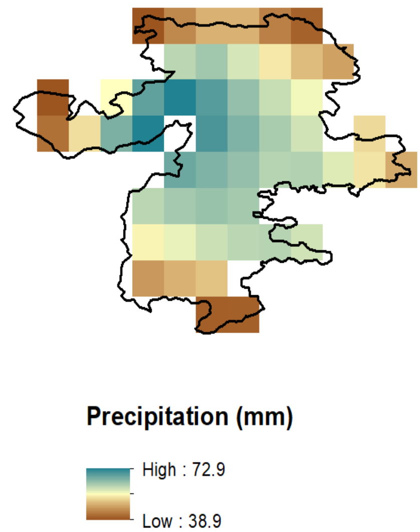
Juley 1980



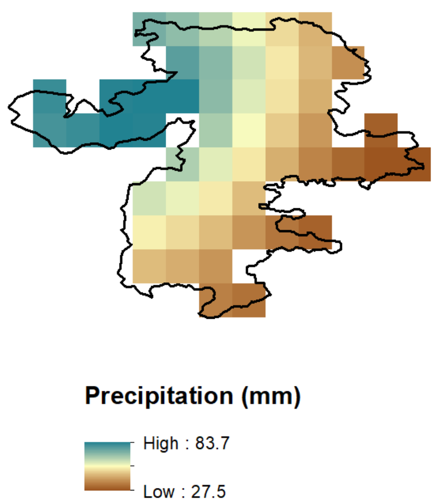
Juley 1990



Juley 2000



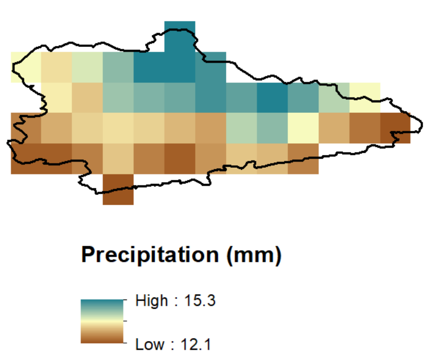
Juley 2010



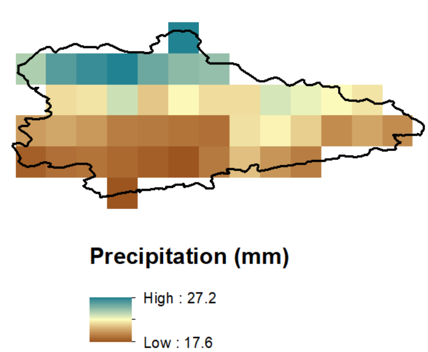
Juley 2020

Fig. 7. Show the precipitation change for Juley in Chelyabinsk for five different time periods from 1980 to 2020 Juley.

In Kurgan, January precipitation rates have diminished essentially between 1990 tell 2020. The maps appear the decrease in precipitation by growing the brown colors that represent the least precipitation values. This diminish reflects the effect of climate change that has led to drier winter conditions.



January 1980



January 1990

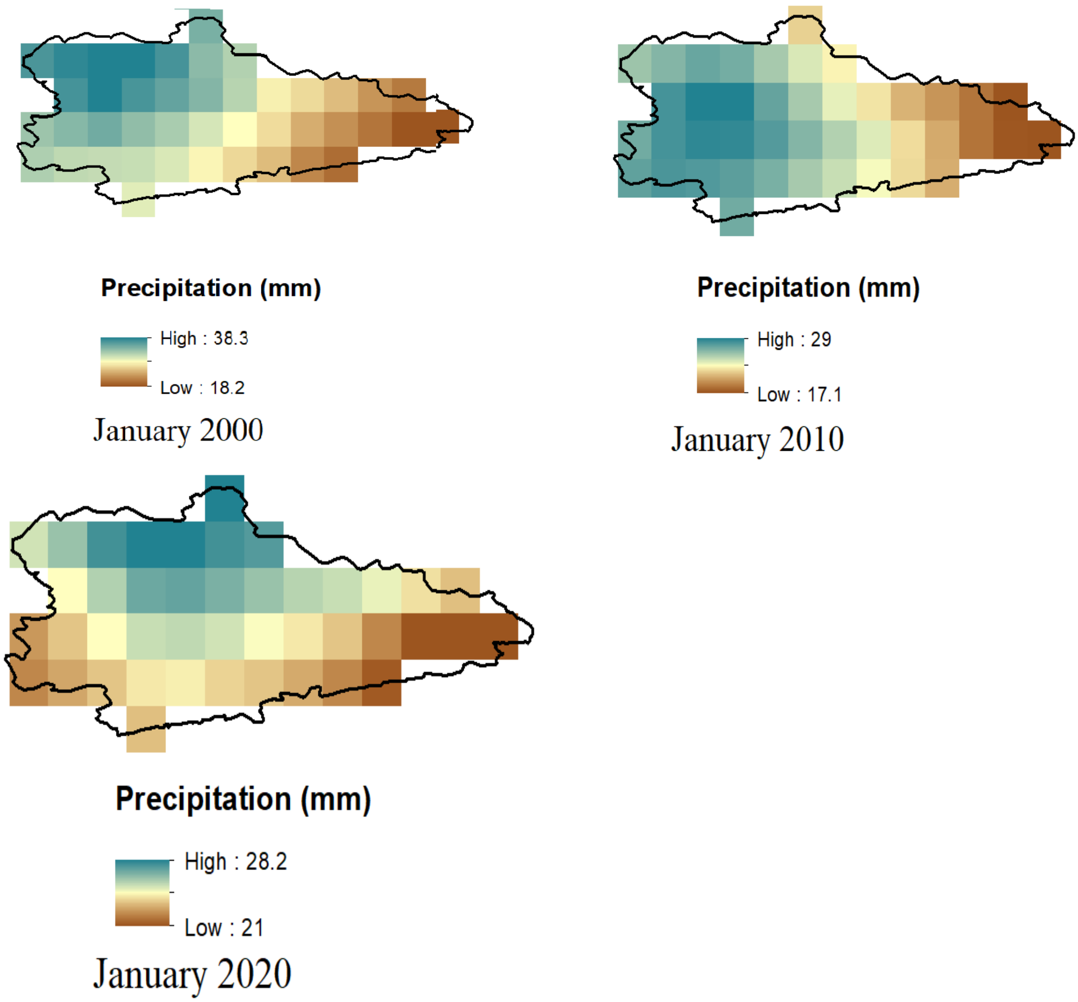
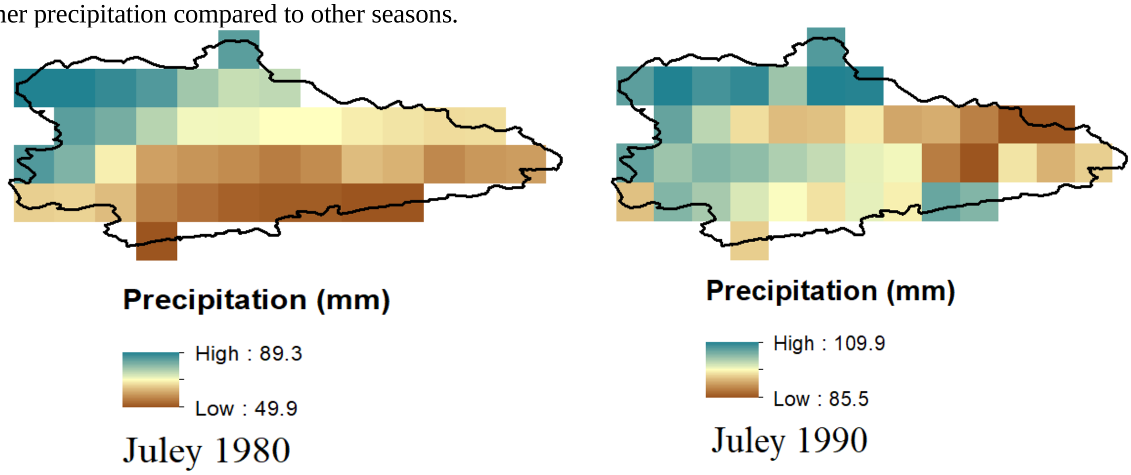


Fig. 8. Show the precipitation change for January in Chelyabinsk for five different time periods from 1980 to 2020 January.

In Kurgan, Juley precipitation rates have expanded altogether between 1990 and 2020, with this month having the highest precipitation rates amid the summer. The maps appear the extension of blue and green colors, which reflect the highest precipitation values during this period. This increase reflects the effect of climate change, which has driven to an increment in summer precipitation compared to other seasons.



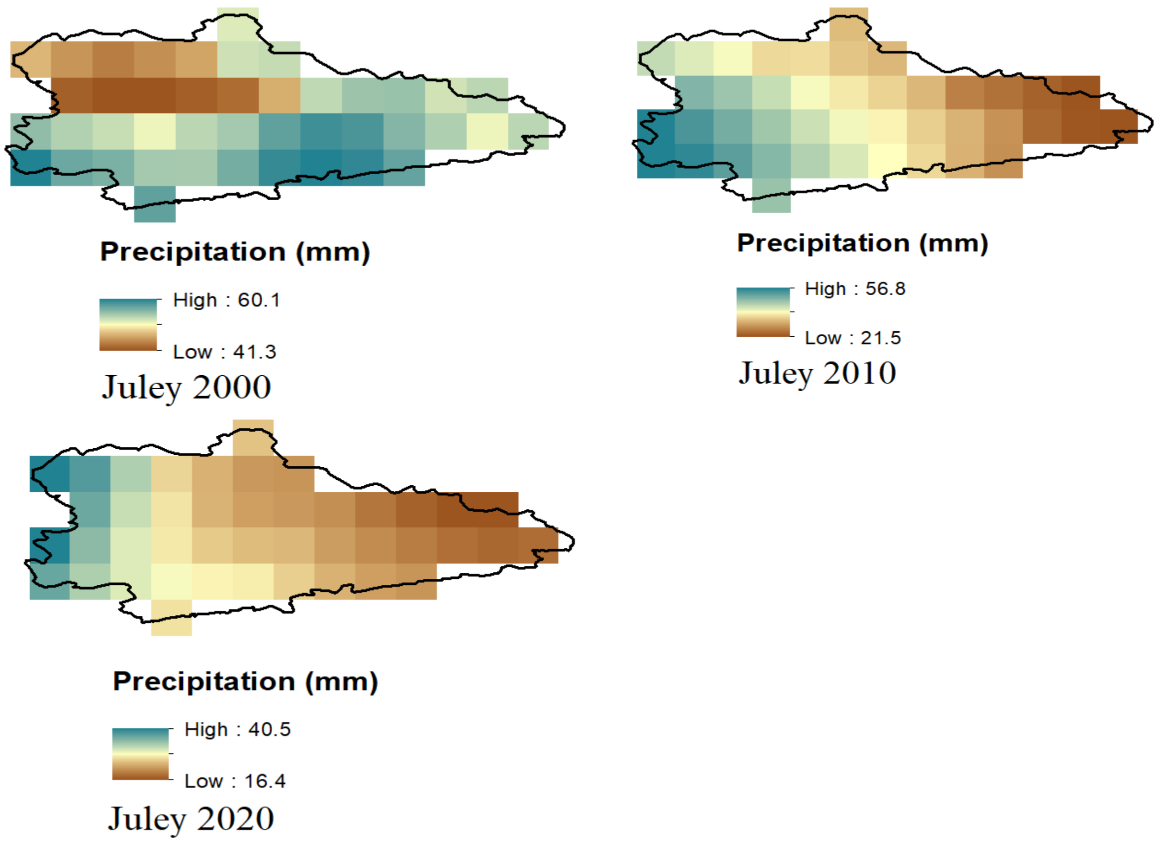


Fig. 9. Show the precipitation change for Juley in Chelyabinsk for five different time periods from 1980 to 2020 in Juley.

5. CONCLUSION

The discoveries from this study appear significant shifts in temperature and precipitation patterns over the past three decades in Kurgan and Chelyabinsk. The expanding temperature and changing precipitation patterns, particularly the decrease in winter and increase in summer precipitation, point to the continuous impacts of climate change. These changes posture challenges for local agribusiness and water resource administration, encouraging the execution of regional adjustment methodologies. The nitty gritty climate maps created utilizing CRU data and MATLAB provide valuable bits of knowledge into the local climate dynamics and will contribute to future climate models for better resource administration.

Conflicts Of Interest

The authors should pledge that they don't have any conflict of interest in regards of their research. If there are no conflict of interest then authors can declare the following "The authors declare no conflicts of interest".

Funding

The funding section of your journal paper template should provide a concise and transparent declaration of the financial support received to carry out the research presented in your paper.

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