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ORIGINAL PAPER

Statistical analysis of extreme temperatures in India in the period 1951–2020

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Abstract

Extreme temperatures are directly related to the occurrence of atmospheric extreme events, such as draughts, wildfires, and pollution level increases in urban areas. Policy makers, as well as society, can address such phenomenon by developing and applying methods which estimate and anticipate maximum temperature occurrences. In this research, we aim to develop a spatiotemporal model which analyzes maximum temperature trends values in the Indian 543 microregions between 1951 and 2020. In 27% of those, a maximum temperature above 45°C was observed, at least in a year. Our analysis indicates further that 80% microregions have maximum temperatures above above 40°C. Additionally, the results unveiled that East, Southwest, and Northwest microregions were the ones where the maximum temperatures had a higher increase with 2°C being the average. The model developed is based on a Generalized Extreme Value (GEV) methodology, to estimate the maximum temperature values from 20 and 50 years. The projection for 20 years showed that in 15.83% of those microregions, at least one occurrence of a maximum temperature above 45°C would occur; while in 50 years, it would happen in 21.54% of the microregions analyzed.

Keywords Extreme temperatures · Extreme value theory · Generalized extreme value · India

1 Introduction

There is an increasing number of studies and debates focusing on global warming, trying to unveil its causes and the possible solutions. The rise of the temperatures on Earth, caused by the greenhouse effect (a natural process responsible for the maintenance of globe's heat), is one of its causes, intensified by human's production of greenhouse gases. Considering this situation, the International Panel for Climate Change (IPCC) stated that the twentieth century was the hottest, with temperatures rising 0.7°C on planet Earth, and predicting its continuous growth throughout the twenty-first century, if large-scale actions to contain this event are not adopted.

Temperature increases has catastrophic consequences, among which, the increase of the living costs, the effects on the economy, the extinction of plant and animal species, and, above all, the risks on human health. Those effects have been studied for different parts of the globe, like Africa (Mugambiwa and Rukema 2019) and the Middle East and North Africa (Driouech et al. 2020). Nevertheless, according to Nagaveni and Anand (2017), one of the main geographical areas to feel the impacts of climate change is southern Asia, mainly India, since "the country is depleting natural resources, thus destroying its environment, mainly due to urbanization, industrialization and economic growth". To prevent depleting natural resources, India is going through a negative socio-economic and environmental change. "Water and air quality worsen day by day due to the increase of various pollutants in the atmosphere. Moreover, the sectors subject to the greatest exposure to climate change are the country's coastal ecosystems, biodiversity and agricultural productivity".

According to the Joint Research Institute on Global Change, in 2009, India had lots of water resources to be used in sanitation, agriculture, cooking, and for drinking. Nevertheless, from one year to the other, India decreases 34% of its available water, making over-exploitation a concern since it might also be affected by climate change. Additionally, the increase on the temperature and its bigger

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variability within the seasons can lead to a faster melt of Himalayas' glaciers, having as its consequence floods when the glacial lakes surpass their natural limits. In the future, these changes may include less water resources, impacting in the agriculture, urban water supply, and hydropower.[1]

Taking into consideration the context presented, students from all parts of the globe have been looking for and developing methods to predict the significant increases in temperature and the places where that phenomenon is more likely to take place. Among the methods researched, the Community Earth System Model low-warming simulations was used to analyze temperature increase in Africa (Mugambiwa and Rukema 2019), and the Regional Climate Model ALADIN-Climate to predict it for the Middle East and North African countries (Driouech et al. 2020). Nevertheless, Extreme Value Theory (EVT) stressed out due to being able to space-time model and predict extreme events, allowing to identify in which regions extreme temperatures may occur and to predict it, so public policies and solutions can be applied.

In fact, EVT is a powerful branch of Statistics and Probability which focus on distribution tails (upper or lower), enabling to quantify events considered extreme or rare through the analysis of minimum or maximum sample groups. It has been studied and used for a long time, applied to different research areas for observing infrequent events—from management risks (McNeil and Zentrum 1999) to performance analysis in emerging markets (Gençay and Selçuk 2004), as well as to analyze the changes in the temperature in Argentina (Rusticucci and Tencer 2008).

In this study, we aim to apply EVT to model extreme temperature occurrences in the 543 geopolitical Indian microregions, to analyze and identify which of them are more susceptible to this event, as well as to generate different levels of return.

We used the data from the India Meteorological Department (IMD) for the Indian subcontinent, and gridded daily maximum temperature data at 1 degree resolution. We can consider the data used unique, since it provides continuous daily information on the maximum and minimum temperatures from 1951 to 2020, with equal spatial intervals, taken from conventional and remote sensing platforms. This data has been authenticated by several researchers who analyzed and evaluated India's temperature extremes (Attri and Rathore 2003; Dash and Mamgain 2011; Dube and Rao 2005; Kjellstrom et al. 2009; Pai et al. 2004; Pingale et al. 2013; Satyanarayana and Rao 2020; Seneviratne et al. 2012; Simmons et al. 2010). In fact, high temperatures, droughts, and floods are dangerous events which can occur frequently due to climatic changes. Research on climate change and, more specifically, about the changes on high temperatures are significant ways to manage the environmental resources on a sustainable way. Thus, it is important to have a complete knowledge on temperature's pattern on a changing environment, helping decision-making and the communities to adapt to extreme climate events.

This paper is divided in five sections (with the first being the introduction and the fifth the conclusion). Section 2 discusses the EVT, the asymptotic distributions of maximum and the generalized distribution of extreme values. Section 3 aims to describe this study's methodology—the statistics used, thematic maps construction, prediction of the Generalized Extreme Value (GEV) parameters through the maximum likelihood method, test for quality of fit and return levels. Section 4 presents the main results.

2 Methodology

As stated previously, EVT is applied to model minimum and/or maximum data of observable variables, focusing on the tail of the distribution (as other statistical modeling method) and, thus, being a powerful tool to estimate events that rarely occur or which have not occurred yet, from different scientific domains—from financial crises to natural disasters (tsunamis, meteor impacts, earthquakes, among others). In this sense, we have developed EVT to

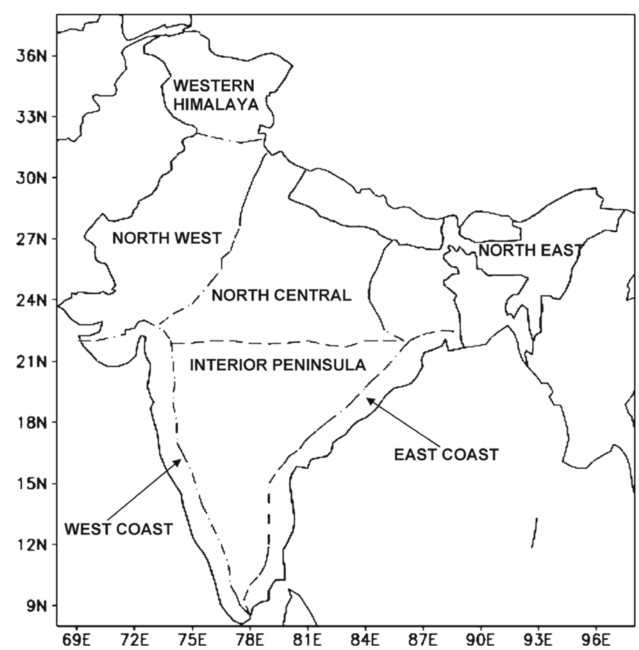
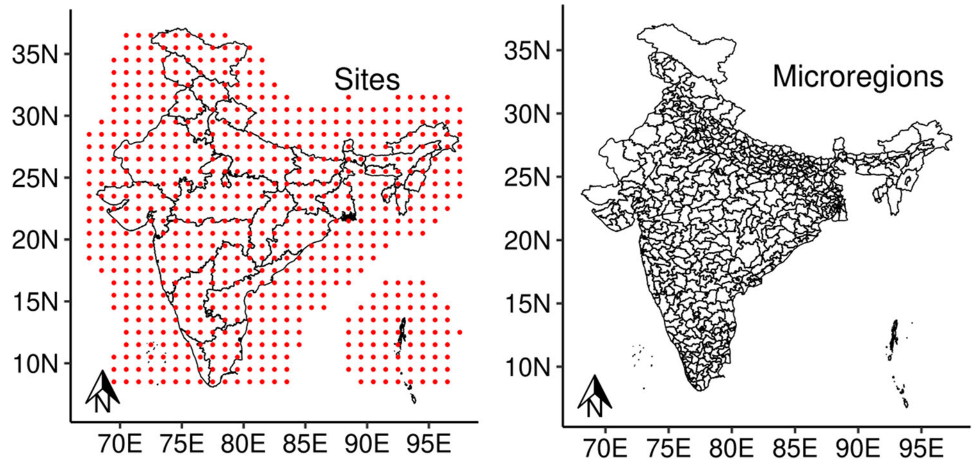


Fig. 1 Climatic regions of India: North-West India, North-East India, Central India, and Peninsular India

[1]The impacts on agriculture are already occurring and are one of Indian's government main concern. It is noticed that many farmers are committing suicide, since the droughts destroy their harvests, not being able to pay their loans and having no return on the investments made.

Fig. 2 Political division of India's microregions



create a predictive model to quantify the extreme events. That justifies why there are several publications regarding it, in different areas: to analyze long and short-term strategies in the Brazilian market (Monte-mor et al. 2014) or to study selling stocks in emerging markets (Gençay and Selçuk 2004) in Economy; or even to predict maximum temperatures in Colombia (Núnez-Galeano and Giraldo-Osorio 2016). Despite these studies being relatively recent, and according to Gumbel (1958), the interest in developing extreme event predictive models go back to the seventeenth century, being related to astronomy studies. Fisher and Tippett (1928) exposed the first fundamentals in 1928, introducing three possible types of asymptotic distributions of extreme values, known as Gumbel, Fréchet, and Weibull distributions. Although those first steps nowadays, it was (Gumbel 1958) who published the first study that formalizes the statistical application of these distributions, with his methodology being often applied. We also must consider (Gnedenko 1943) contribution, for showing the necessary and sufficient conditions for the existence of asymptotic distributions of extreme values.

2.1 Main limit results

Consider a sample $(X_1, X_2, \ldots, X_n)$ of independent and identically distributed (iid) arbitrary variables from a main population which distribution function (df) F is unknown.

Considering that $M_n = max_{X_1 \leq i \leq X_n}, (X_i)$ is the maximum of the sample, and assuming that there are normalizing constants $a_n > 0, b_n \epsilon R$ and that there is non-degenerate G, such that, for all x,

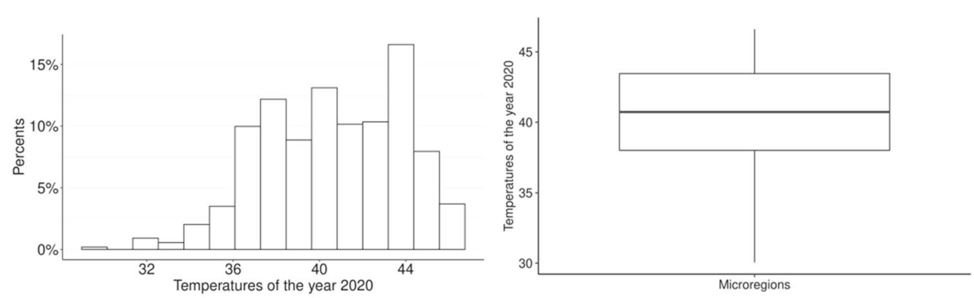
$$\lim_{n \to +\infty} P\left(\frac{M_n - b_n}{a_n} \leq x\right) = G(x).$$

If we choose the proper normalizing constants, G is considered the Generalized Extreme Value (GEV) distribution,

$$G(x) \equiv G(x|\xi) := \begin{cases} \exp\left(-(1+\xi x)^{-1/\xi}\right), & 1+\xi x \text{ if } \xi \neq 0 \\ \exp\left(-\exp(-x)\right), x \epsilon R & \text{if } \xi = 0 \end{cases},$$

given here in the von Mises-Jenkinson (Monte-mor et al. 2014; Coles 2001). By introducing the shape parameter ξ: Weibull ($\xi < 0$), Gumbel ($\xi = 0$), and Fréchet ($\xi > 0$), the GEV model enables to unify the three possible limit max-stables distributions. The shape parameter ξ is linked to the weight of the right-tail and frequently denominated extreme value index (EVI). We can also introduce two more parameters, λ related to location, and δ related to scale. Considering our case study and the unknown character of the normalizing constants $a_n > 0$ and $b_n \in R$, we integrate

Fig. 3 Histogram and boxplot of maximum temperatures for the year 2020



(a) Histogram. (b) Boxplot.

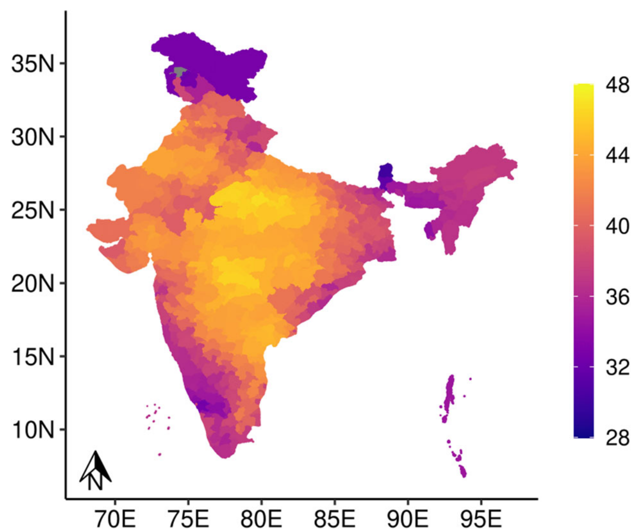


Fig. 4 Maximum temperatures in each microregion in the year 2020

them in the GEV distribution related to location and scale parameters (λ and δ,) taking us to the model

$$G(x|\xi,\lambda,\delta) := \begin{cases} \exp\left\{-\left(1+\xi\left(\frac{x-\lambda}{\delta}\right)\right)^{\frac{-1}{\xi}}\right\}, 1+\xi\frac{x-\lambda}{\delta} & \text{if } \xi \neq 0 \\ \exp\left\{-\exp\left(-\frac{x-\lambda}{\delta}\right)\right\}, x\epsilon R & \text{if } \xi = 0 \end{cases}.$$

For parameters (ξ; λ; δ) estimation, maximum likelihood estimation (MLE) method was used because of its adaptability to changes in model structure (Coles 2001). We use the standard parameters of the gev.fit function from the ismev package for the maximum-likelihood fitting optimization method, which uses the Nelder–Mead algorithm and a maximum of 1000 iterations (see Heffernan and Stephenson (2018) for more details).

Histogram, a Quantile Plot, a Return Level Plot, or a Probability Plot can be used to check the model, with block maxima, the largest observations and the peaks-over-threshold being the most important methods used by the Statistics of Univariate Extremes domain area (Coles 2001).[2]

Return levels (R_p) and return period (p) estimate gave probabilistic inference about upcoming threat. For stationary model, the return level associated with $1/p$ return period is given by

$$R_p = \begin{cases} \mu + \frac{\sigma}{\xi}\left\{1 - \left[-\ln\left(1-\frac{1}{p}\right)\right]^{\xi}\right\}, & \text{if } \xi \neq 0 \\ \mu - \sigma \ln\left[-\ln\left(1-\frac{1}{p}\right)\right], & \text{if } \xi = 0 \end{cases}$$

where R_p is the return level or event intensity associated with the return period; p, μ, σ are known as location and scale parameters, respectively; and ξ shape of distribution (Coles 2001).

[2]For an EVT overview and related topics, see Coles (2001).

3 Data and study area

India is geographically located between latitude 8.4 and 37.6 N and longitude 68.7 and 97.25°E. Considering its climatic characteristics, the distribution and occurrence pattern of temperature, for regions—North-West India (NW India), North-East India (NE India), Central India, and Peninsular India (Fig. 1).

To pursue this study, we used the maximum annual temperatures observed in 702 sites in India, between 1951 and 2020. The goal is to identify the microregions which are considered susceptible to extreme temperatures, to recognize the authorities responsible for those places.

To establish the sites, we considered the smaller areas of India's political microregions. That enables us to reduce the generality of the temperatures. In fact, if we considered even larger regions, it would not be possible to identify the approximate or the exact location of the extreme temperatures. This option also allows an improvement on the effectiveness of preventive measures to be studied and applied, and an easier identification of the political leaders responsible for those sites.

To interpolate those places, interpolation by the nearest neighbors up to 0.5° latitude and longitude was used, a deterministic interpolation that shows the nearest or the geometrically most convenient points in all directions. The 0.5° distance was selected due to the fact of being half the distance from one site to the other, not allowing the algorithm to choose two sites in the same direction and applying the mean of the temperatures registered in those places. This interpolation method was used because it is easy and fast, justifying being frequently applied in sampled studies. According to Olivier and Hanqiang (2012), there is a higher performance of the algorithm nearest neighbors when compared to conventional interpolating algorithms since the interpolation creates time series for microregions. For the microregions that for some year did not result in any value after the interpolation, another nearest neighbors interpolation was performed considering the average of the temperatures of the neighboring microregions of the border. To build a suitable database, series that had less than 30 years of data were excluded, resulting in the exclusion of the microregion Andaman and Nicobar.

We presented thematic maps of descriptive statistics (minimum, maximum, median, and median absolute deviation), as well as boxplot and histograms to analyse the temperature variability. We used DataMeet[3] for building India as well its States and Union Territories maps. We considered 28 States and 7 Union Territories based on the ECI

[3]http://projects.datameet.org/maps/, Community created maps of India, 2021.

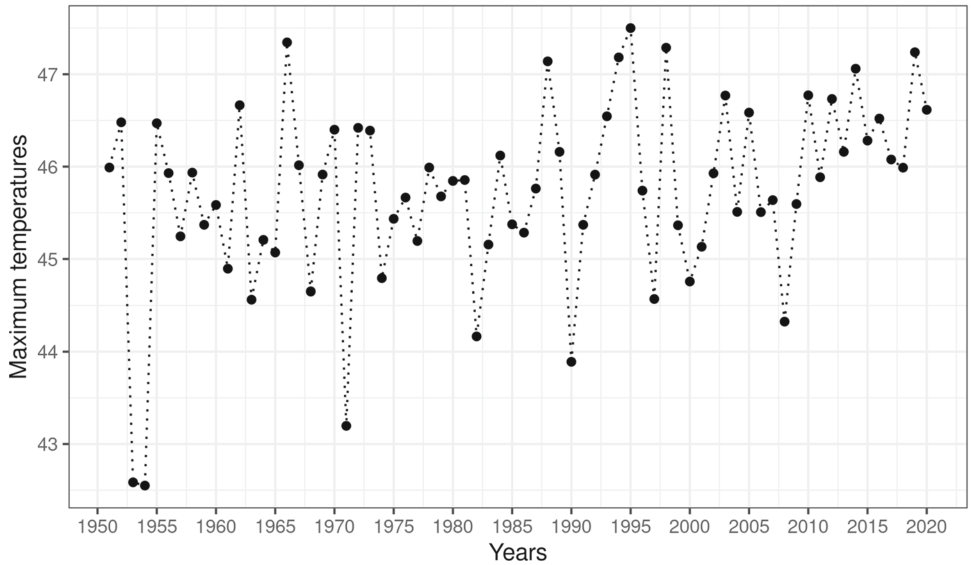


Fig. 5 Maximum annual temperatures in India in the period 1951 to 2020

Polling Station Locations Website.[4] Figure 2 shows India's geo-political microregions divisions.

The EVT modeling used annual data of maximum temperature in the different Indian microregions. The methodology adopted enabled to develop thematic maps identifying the microregions susceptible to higher temperatures and their return levels.

All statistical analysis were performed using the R software, version 4.0.2. (Team 2021). We used the rgdal, (version 1.5-12 (Bivand et al. 2021)) and ggplot2, (version 3.3.2 (Wickham 2016)) packages from the R library. In particular, the rgdal package was used for reading the map of India, while ggplot2 was used for the plots. The ismev package (version 1.42 (Heffernan and Stephenson 2018)) was used for data analysis, as it has a specific function to analyse extreme values.

4 Results

India integrates 543 microregions. In the last year of this study, 2020, about 58% of them registered, at least for one day of the year, a temperature above 40°C, and 6% registered an even higher temperature, above 45°C. Figure 3 shows the histogram and the boxplot of the maximum temperatures in 2020.

Figure 4 shows the maximum temperatures in 2020 according to the microregions. A large part of India, mainly central India, faced maximum temperatures above 43°C between 1951 and 2020. Oppositely, the lowest annual temperatures, not exceeding 35°C, were registered in Eastern and Southwestern regions.

Moreover over the full period from 1951 to 2020 the annual temperatures ranged from 42.5°C in year 1954 (Shimla) to 47.5°C in year 1995 (Banswara) (Fig. 5.)

In the chronological period mentioned, the highest increase in the temperature was registered in East, Southwest, and Northwest regions, as we can see in Fig. 6, which represents annual maximum temperature's amplitude. Despite a significant increase in most of the country, there are several microregions in the central region which face a temperature decrease, and others where there was just a small variation on the temperature.

Figure 7 demonstrates the median, median absolute deviation, minimum, and the maximum temperatures in the 70 years analyzed, showing a major concern, as in 27% of Indian's microregions there were temperatures above

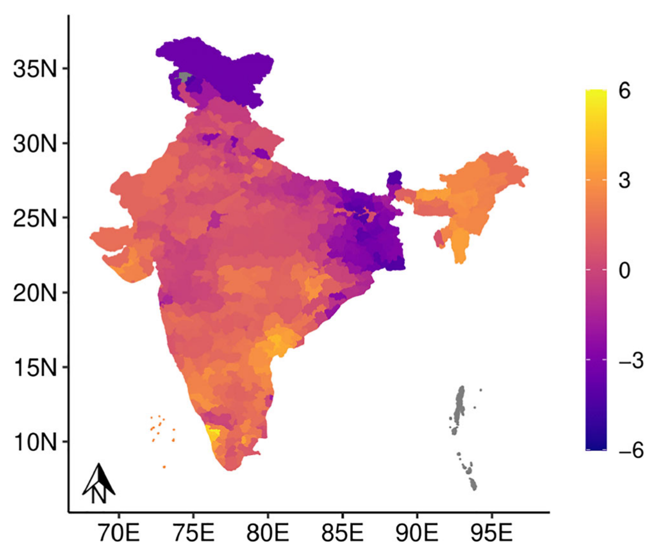


Fig. 6 Amplitude of annual maximum temperatures over the period 1951 to 2020

[4] http://psleci.nic.in/

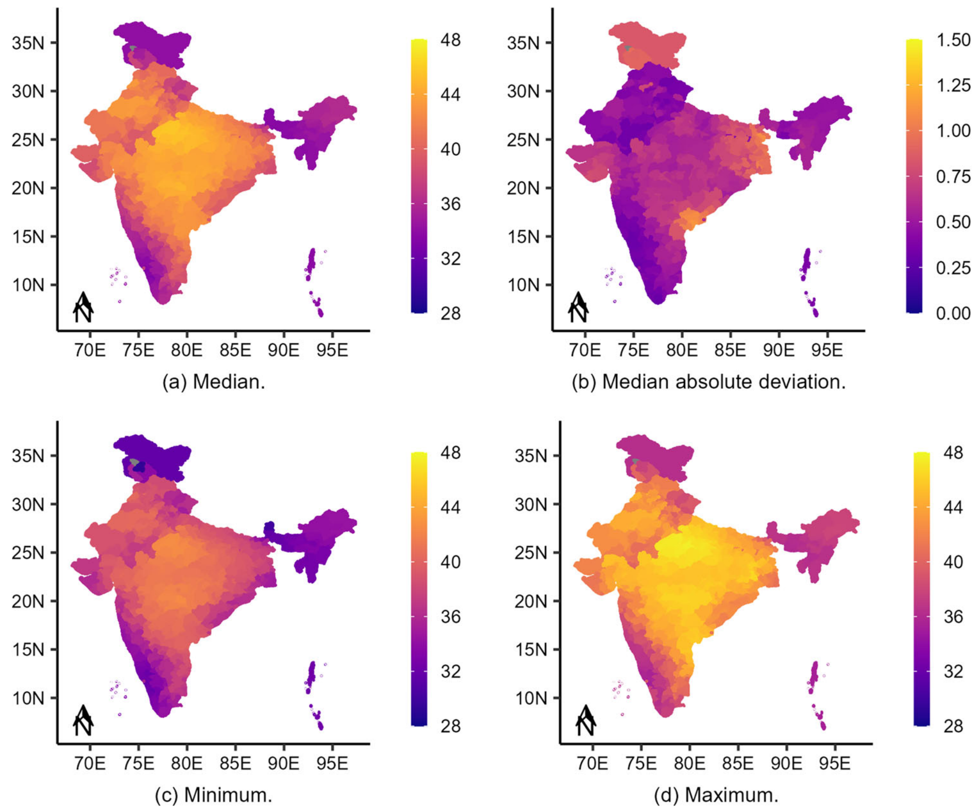


Fig. 7 (a) Median, (b) median absolute deviation, (c) minimun, and (d) maximum of annual temperatures over the period 1951 to 2020

45°C and 80% above 40°C per year. Those temperatures are not consistent with the human body resistance to high temperatures. According to Tita et al. (2009), human body resistance is within the limits of 36.1 to 37.5°C, depending on air humidity. Considering that the maximum annual temperatures observed in central India already exceed 40°C, that could represent a great risk of survival.

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The GEV prediction power was tested (except the microregions of Andaman & Nicobar, Tonk - Sawai Madhopur, Ajmer, Pali, and Jaunpur), the data were separated into two sets, data from 1951 to 2000 and from 2001 to 2020. With the data from 1951 – 2000, a GEV was modeled for each microregion and generated a forecast for the next 20

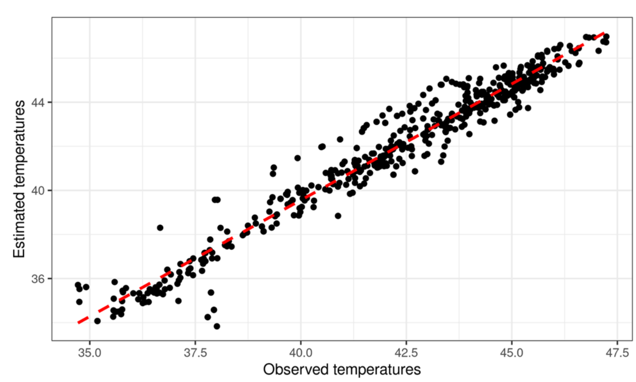
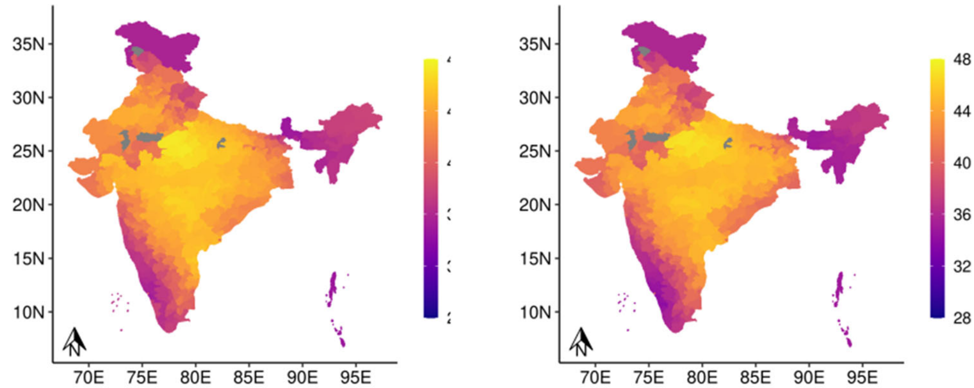


Fig. 8 Observed against predicted temperatures by the model over the period 1951 to 2000



(a) Observed. (b) Predicted.

Fig. 9 (a) Observed and (b) predicted temperatures of maximum temperature

years. This value is compared with data from 2001 − 2020. Coles (2001) says that the GEV forecast for n years, in some year the observed value will exceed or be very close to the theoretical quantity $1 - \frac{1}{p}$. Of the 538 GEV forecasts for the 20 years (2000 to 2020), 145 were higher than the real observed value, being 27% of the microregions. Figure 8 shows the scatter plot of observed and predicted values.

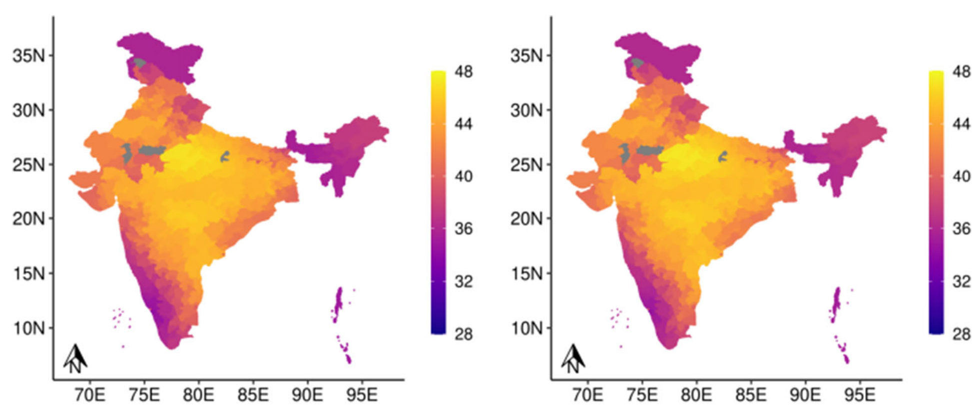
The GEV prediction power was considered satisfactory, 97% of predicted values were greater than observed values or the difference between them was less than 1, with the root o mean square error (RMSE) of 0.687. Figure 9 shows the observed and predicted values on the maps. The analysis of the model's diagnosis for all the microregions hightlighted the validity of fitted models.

The GEVs distributions for two different return levels of 20 and 50 years are presented in Fig. 10. In the case of the former, the maximum value was 47.02°C and with 95% confidence interval extending from 46.84 to 47.21°C while the minimum value was 34.33°C and with a 95% confidence interval extending from 34.09 to 34.56°C. In the case of the 50 years return period, the maximum value was higher reaching 47.21°C and with 95% confidence interval extending from 47.00 to 47.41°C. The minimum value in this case was also higher (34.60°C) and with a 95% confidence interval extending from 34.32 to 34.88°C.

Nevertheless, when compared with the chronology studied, there is a temperature decrease in some microregions. Specifically, 32% of these regions had maximum temperatures higher than 45°C in the period 1951–2020. Despite that fact, the results are still worrying since the temperature's increase represents a risk for human survival.

5 Conclusion

With this study, we aimed to estimate the main extreme parameters of interest according to the maximum annual temperatures in India's microregions, between 1951 and 2020. We developed a descriptive analysis materialized in thematic maps, which unveiled the worrying situation in Indian central region. Additionally, although in the East and Southwest regions, the maximum temperatures were the lowest; it was where a higher increase was observed. Twenty seven percent of the microregions face a temperature higher



(a) (b)

Fig. 10 The 20-year (a) and 50-year (b) return levels for each microregion and for the period 1951–2020 than 45°C, above the limit of human body resistance as we have seen.

Applying the adjustment quality test, 538 out of 543 models were proven to be effective.The predictive power of the models was tested and found to be satisfactory, with a root mean square error of 0.687.

That enabled to develop return levels for 20 and 50 years, demonstrating that 22% of the microregions will face temperatures above 45°C if the authorities do not apply measures to fight and prevent this phenomenon.

Appendix A: Parameters, confidence intervals, theoretical and empirical curve of extreme temperatures

Table 1 Model parameters MLE and 95% confidence interval (CI95%) for the Indian microregions

Microregion	μ (CI95%)	σ (CI95%)	ξ (CI95%)
ADILABAD	43.97 (43.84;44.1)	1 (0.9;1.1)	−0.44(−0.52; −0.36)
AGRA	42.54 (42.43;42.65)	0.88 (0.8;0.96)	−0.46(−0.53; −0.39)
AHMEDABAD EAST	42.16 (42.02;42.3)	1.1 (0.99;1.21)	−0.4(−0.48; −0.32)
AHMEDABAD WEST	42.16 (42.02;42.3)	1.1 (0.99;1.21)	−0.4(−0.48; −0.32)
AHMEDNAGAR	41.32 (41.22;41.42)	0.78 (0.71;0.85)	−0.4(−0.47; −0.33)
AJMER	41.26 (41.17;41.35)	0.74 (0.67;0.81)	−0.48(−0.54; −0.42)
AKBARPUR	44.41 (44.26;44.56)	1.18 (1.07;1.29)	−0.44(−0.5; −0.38)
AKOLA	43.66 (43.53;43.79)	0.98 (0.88;1.08)	−0.51(−0.59; −0.43)
ALAPPUZHA	34.36 (34.28;34.44)	0.62 (0.57;0.67)	−0.09(−0.14; −0.04)
ALATHUR	32.64 (32.55;32.73)	0.66 (0.6;0.72)	0(−0.05; 0.05)
ALIGARH	40.66 (40.55;40.77)	0.84 (0.76;0.92)	−0.52(−0.59; −0.45)
ALIPURDUARS	33.32 (33.2;33.44)	0.93 (0.85;1.01)	−0.17(−0.24; −0.1)
ALLAHABAD	43.97 (43.83;44.11)	1.13 (1.03;1.23)	−0.37(−0.42; −0.32)
ALMORA	38.04 (37.96;38.12)	0.65 (0.59;0.71)	−0.42(−0.49; −0.35)
ALWAR	42.45 (42.34;42.56)	0.83 (0.75;0.91)	−0.51(−0.57; −0.45)
AMALAPURAM	41.68 (41.49;41.87)	1.49 (1.34;1.64)	−0.42(−0.5; −0.34)
AMBALA	39.48 (39.37;39.59)	0.85 (0.77;0.93)	−0.48(−0.54; −0.42)
AMBEDKAR NAGAR	43.24 (43.08;43.4)	1.23 (1.12;1.34)	−0.44(−0.49; −0.39)
AMETHI	43.96 (43.81;44.11)	1.17 (1.07;1.27)	−0.37(−0.42; −0.32)
AMRAVATI	43.74 (43.61;43.87)	0.97 (0.88;1.06)	−0.38(−0.45; −0.31)
AMRELI	39.77 (39.63;39.91)	1.1 (1;1.2)	−0.34(−0.41; −0.27)
AMRITSAR	40.75 (40.66;40.84)	0.71 (0.64;0.78)	−0.64(−0.72; −0.56)
AMROHA	38.52 (38.43;38.61)	0.7 (0.63;0.77)	−0.55(−0.61; −0.49)
ANAKAPALLE	39.1 (38.92;39.28)	1.36 (1.23;1.49)	−0.4(−0.47; −0.33)
ANAND	42.54 (42.4;42.68)	1.06 (0.96;1.16)	−0.33(−0.4; −0.26)
ANANDPUR SAHIB	41.36 (41.25;41.47)	0.87 (0.79;0.95)	−0.42(−0.47; −0.37)
ANANTAPUR	39.63 (39.53;39.73)	0.77 (0.7;0.84)	−0.27(−0.34; −0.2)
ANANTNAG	34.29 (34.07;34.51)	1.74 (1.58;1.9)	−0.48(−0.53; −0.43)
ANDAMAN & NICOBAR	33.62 (33.49;33.75)	0.68 (0.59;0.77)	−0.3(−0.4; −0.2)
AONLA	40.42 (40.33;40.51)	0.73 (0.67;0.79)	−0.37(−0.43; −0.31)
ARAKKONAM	40.7 (40.56;40.84)	1.06 (0.97;1.15)	−0.24(−0.29; −0.19)
ARAKU	40.09 (39.93;40.25)	1.23 (1.12;1.34)	−0.36(−0.43; −0.29)
ARAMBAG	38.79 (38.59;38.99)	1.53 (1.38;1.68)	−0.44(−0.51; −0.37)
ARANI	40.6 (40.46;40.74)	1.06 (0.97;1.15)	−0.23(−0.29; −0.17)
ARARIA	36.8 (36.64;36.96)	1.2 (1.09;1.31)	−0.25(−0.32; −0.18)
ARRAH	40.6 (40.51;40.69)	0.72 (0.65;0.79)	−0.44(−0.5; −0.38)
ARUNACHAL EAST	35.92 (35.81;36.03)	0.79 (0.71;0.87)	−0.26(−0.35; −0.17)
ARUNACHAL WEST	35.45 (35.35;35.55)	0.73 (0.66;0.8)	−0.15(−0.25; −0.05)
ASANSOL	41.73 (41.54;41.92)	1.49 (1.36;1.62)	−0.32(−0.38; −0.26)
ASKA	39.31 (39.15;39.47)	1.25 (1.13;1.37)	−0.39(−0.47; −0.31)

Table 1 (continued)

Microregion	μ (CI95%)	σ (CI95%)	ξ (CI95%)
ATTINGAL	34.82 (34.74;34.9)	0.6 (0.55;0.65)	−0.26(−0.31; −0.21)
AURANGABAD	42.45 (42.29;42.61)	1.27 (1.15;1.39)	−0.45(−0.52; −0.38)
AURANGABAD	42.09 (41.99;42.19)	0.8 (0.72;0.88)	−0.42(−0.5; −0.34)
AUTONOMOUS DISTRICT	34.5 (34.4;34.6)	0.75 (0.67;0.83)	−0.09(−0.2; 0.02)
AZAMGARH	42.74 (42.58;42.9)	1.24 (1.12;1.36)	−0.5(−0.56; −0.44)
BADAUN	39.23 (39.15;39.31)	0.65 (0.59;0.71)	−0.47(−0.54; −0.4)
BAGALKOT	39.33 (39.23;39.43)	0.75 (0.68;0.82)	−0.46(−0.54; −0.38)
BAGHPAT	39.68 (39.58;39.78)	0.75 (0.67;0.83)	−0.66(−0.74; −0.58)
BAHARAMPUR	40.2 (40.02;40.38)	1.4 (1.27;1.53)	−0.31(−0.39; −0.23)
BAHRAICH	42.2 (42.04;42.36)	1.26 (1.15;1.37)	−0.39(−0.43; −0.35)
BALAGHAT	43.53 (43.4;43.66)	1.01 (0.91;1.11)	−0.5(−0.58; −0.42)
BALASORE	39.03 (38.85;39.21)	1.41 (1.28;1.54)	−0.27(−0.33; −0.21)
BALLIA	42.56 (42.4;42.72)	1.23 (1.12;1.34)	−0.42(−0.47; −0.37)
BALURGHAT	38.15 (38;38.3)	1.06 (0.95;1.17)	−0.09(−0.22; 0.04)
BANASKANTHA	41.83 (41.69;41.97)	1.11 (1.01;1.21)	−0.25(−0.3; −0.2)
BANDA	44.66 (44.52;44.8)	1.11 (1.01;1.21)	−0.41(−0.47; −0.35)
BANGALORE CENTRAL	36.7 (36.61;36.79)	0.71 (0.65;0.77)	−0.2(−0.27; −0.13)
BANGALORE NORTH	36.7 (36.61;36.79)	0.71 (0.65;0.77)	−0.2(−0.27; −0.13)
BANGALORE RURAL	36.7 (36.61;36.79)	0.71 (0.65;0.77)	−0.2(−0.27; −0.13)
BANGALORE SOUTH	36.81 (36.71;36.91)	0.73 (0.66;0.8)	−0.2(−0.27; −0.13)
BANGAON	39.2 (39.01;39.39)	1.47 (1.34;1.6)	−0.38(−0.44; −0.32)
BANKA	39.71 (39.62;39.8)	0.7 (0.64;0.76)	−0.4(−0.46; −0.34)
BANKURA	41.16 (40.97;41.35)	1.45 (1.32;1.58)	−0.32(−0.38; −0.26)
BANSGAON	42.42 (42.26;42.58)	1.27 (1.15;1.39)	−0.48(−0.54; −0.42)
BANSWARA	38.66 (38.58;38.74)	0.62 (0.56;0.68)	−0.4(−0.45; −0.35)
BAPATLA	42.56 (42.39;42.73)	1.33 (1.2;1.46)	−0.35(−0.43; −0.27)
BARABANKI	43.32 (43.16;43.48)	1.23 (1.13;1.33)	−0.38(−0.42; −0.34)
BARAMATI	39.54 (39.45;39.63)	0.72 (0.65;0.79)	−0.34(−0.41; −0.27)
BARAMULLA	32.7 (32.7;32.7)	5.52 (NaN;NaN)	−1.18 (NaN;NaN)
BARASAT	38.19 (38;38.38)	1.51 (1.37;1.65)	−0.41(−0.47; −0.35)
BARDHAMAN PURBA	40.88 (40.68;41.08)	1.5 (1.36;1.64)	−0.37(−0.44; −0.3)
BARDHAMAN-DURGAPUR	40.88 (40.68;41.08)	1.5 (1.36;1.64)	−0.37(−0.44; −0.3)
BARDOLI	41.26 (41.14;41.38)	0.91 (0.83;0.99)	−0.36(−0.42; −0.3)
BAREILLY	40.38 (40.29;40.47)	0.7 (0.63;0.77)	−0.44(−0.52; −0.36)
BARGARH	43.2 (43.06;43.34)	1.05 (0.95;1.15)	−0.36(−0.43; −0.29)
BARMER	40.89 (40.79;40.99)	0.77 (0.7;0.84)	−0.41(−0.46; −0.36)
BARPETA	33.51 (33.43;33.59)	0.61 (0.55;0.67)	0.07(−0.03; 0.17)
BARRACKPUR	38.19 (38;38.38)	1.51 (1.37;1.65)	−0.41(−0.47; −0.35)
BASIRHAT	38.19 (38;38.38)	1.51 (1.37;1.65)	−0.41(−0.47; −0.35)
BASTAR	41.56 (41.41;41.71)	1.12 (1.02;1.22)	−0.33(−0.4; −0.26)
BASTI	42.94 (42.78;43.1)	1.24 (1.13;1.35)	−0.44(−0.49; −0.39)
BATHINDA	42 (41.89;42.11)	0.84 (0.76;0.92)	−0.57(−0.63; −0.51)
BEED	42.65 (42.53;42.77)	0.89 (0.81;0.97)	−0.42(−0.49; −0.35)
BEGUSARAI	41.25 (41.07;41.43)	1.42 (1.28;1.56)	−0.5(−0.57; −0.43)
BELGAUM	37.59 (37.51;37.67)	0.64 (0.58;0.7)	−0.44(−0.5; −0.38)
BELLARY	38.76 (38.67;38.85)	0.7 (0.63;0.77)	−0.31(−0.38; −0.24)
BERHAMPUR	39.53 (39.38;39.68)	1.13 (1.03;1.23)	−0.32(−0.4; −0.24)
BETUL	43.47 (43.34;43.6)	1 (0.9;1.1)	−0.53(−0.6; −0.46)
BHADOHI	43.49 (43.33;43.65)	1.22 (1.12;1.32)	−0.35(−0.39; −0.31)

Table 1 (continued)

Microregion	μ (CI95%)	σ (CI95%)	ξ (CI95%)
BHADRAK	39.38 (39.21;39.55)	1.29 (1.18;1.4)	−0.24(−0.3; −0.18)
BHAGALPUR	40.07 (39.98;40.16)	0.7 (0.64;0.76)	−0.41(−0.48; −0.34)
BHANDARA-GONDIYA	44.04 (43.91;44.17)	1.01 (0.91;1.11)	−0.47(−0.56; −0.38)
BHARATPUR	41.14 (41.05;41.23)	0.71 (0.64;0.78)	−0.53(−0.59; −0.47)
BHARUCH	42.12 (41.99;42.25)	0.99 (0.9;1.08)	−0.33(−0.39; −0.27)
BHAVNAGAR	40.97 (40.83;41.11)	1.07 (0.97;1.17)	−0.3(−0.36; −0.24)
BHILWARA	38.98 (38.9;39.06)	0.64 (0.59;0.69)	−0.34(−0.38; −0.3)
BHIND	45.14 (44.99;45.29)	1.14 (1.03;1.25)	−0.48(−0.55; −0.41)
BHIWANDI	38.24 (38.14;38.34)	0.79 (0.72;0.86)	−0.37(−0.43; −0.31)
BHIWANI-MAHENDRAGARH	42.92 (42.8;43.04)	0.9 (0.81;0.99)	−0.56(−0.64; −0.48)
BHONGIR	42.79 (42.66;42.92)	0.98 (0.89;1.07)	−0.38(−0.46; −0.3)
BHOPAL	43.78 (43.63;43.93)	1.17 (1.06;1.28)	−0.46(−0.53; −0.39)
BHUBANESWAR	38.72 (38.57;38.87)	1.18 (1.08;1.28)	−0.27(−0.33; −0.21)
BIDAR	42.33 (42.2;42.46)	0.96 (0.86;1.06)	−0.38(−0.47; −0.29)
BIJAPUR	41.03 (40.92;41.14)	0.85 (0.77;0.93)	−0.41(−0.48; −0.34)
BIJNOR	40.19 (40.08;40.3)	0.83 (0.76;0.9)	−0.48(−0.53; −0.43)
BIKANER	42.91 (42.8;43.02)	0.88 (0.79;0.97)	−0.66(−0.73; −0.59)
BILASPUR	43.57 (43.43;43.71)	1.08 (0.97;1.19)	−0.48(−0.56; −0.4)
BIRBHUM	41.21 (41.01;41.41)	1.52 (1.38;1.66)	−0.32(−0.38; −0.26)
BISHNUPUR	40.46 (40.26;40.66)	1.51 (1.37;1.65)	−0.41(−0.47; −0.35)
BOLANGIR	42.71 (42.58;42.84)	1.02 (0.92;1.12)	−0.36(−0.43; −0.29)
BOLPUR	40.89 (40.7;41.08)	1.48 (1.34;1.62)	−0.34(−0.41; −0.27)
BULANDSHAHR	39.76 (39.66;39.86)	0.78 (0.71;0.85)	−0.48(−0.53; −0.43)
BULDHANA	43.4 (43.28;43.52)	0.95 (0.86;1.04)	−0.5(−0.57; −0.43)
BUXAR	42.56 (42.4;42.72)	1.23 (1.12;1.34)	−0.42(−0.47; −0.37)
CHALAKUDY	33.51 (33.43;33.59)	0.62 (0.57;0.67)	−0.03(−0.08; 0.02)
CHAMARAJANAGAR	34.75 (34.67;34.83)	0.65 (0.59;0.71)	−0.19(−0.25; −0.13)
CHANDAULI	43.27 (43.12;43.42)	1.19 (1.09;1.29)	−0.43(−0.48; −0.38)
CHANDIGARH	41.48 (41.31;41.65)	1.33 (1.2;1.46)	−0.47(−0.53; −0.41)
CHANDNI CHOWK	41.67 (41.56;41.78)	0.82 (0.74;0.9)	−0.53(−0.6; −0.46)
CHANDRAPUR	44.43 (44.3;44.56)	0.99 (0.89;1.09)	−0.48(−0.57; −0.39)
CHATRA	42.71 (42.55;42.87)	1.26 (1.14;1.38)	−0.46(−0.52; −0.4)
CHENNAI CENTRAL	41.2 (41.05;41.35)	1.14 (1.04;1.24)	−0.23(−0.28; −0.18)
CHENNAI NORTH	41.2 (41.05;41.35)	1.14 (1.04;1.24)	−0.23(−0.28; −0.18)
CHENNAI SOUTH	40.49 (40.34;40.64)	1.19 (1.09;1.29)	−0.3(−0.36; −0.24)
CHEVELLA	42.28 (42.15;42.41)	0.98 (0.87;1.09)	−0.47(−0.59; −0.35)
CHHINDWARA	43.2 (43.07;43.33)	0.98 (0.89;1.07)	−0.44(−0.51; −0.37)
CHHOTA UDAIPUR	42.43 (42.3;42.56)	1.01 (0.92;1.1)	−0.34(−0.4; −0.28)
CHIDAMBARAM	39.4 (39.29;39.51)	0.83 (0.74;0.92)	−0.49(−0.59; −0.39)
CHIKKBALLAPUR	37.43 (37.34;37.52)	0.7 (0.63;0.77)	−0.18(−0.26; −0.1)
CHIKKODI	37.45 (37.37;37.53)	0.65 (0.59;0.71)	−0.46(−0.53; −0.39)
CHITRADURGA	37.21 (37.12;37.3)	0.68 (0.62;0.74)	−0.23(−0.29; −0.17)
CHITTOOR	39.48 (39.36;39.6)	0.9 (0.82;0.98)	−0.27(−0.34; −0.2)
CHITTORGARH	39.13 (39.05;39.21)	0.65 (0.6;0.7)	−0.33(−0.38; −0.28)
CHURU	43.06 (42.94;43.18)	0.9 (0.81;0.99)	−0.62(−0.69; −0.55)
COIMBATORE	34.86 (34.77;34.95)	0.69 (0.63;0.75)	−0.19(−0.25; −0.13)
COOCHBEHAR	33.27 (33.15;33.39)	0.9 (0.82;0.98)	−0.16(−0.23; −0.09)
CUDDALORE	39.4 (39.29;39.51)	0.83 (0.74;0.92)	−0.49(−0.59; −0.39)
CUTTACK	39.63 (39.48;39.78)	1.14 (1.04;1.24)	−0.26(−0.32; −0.2)

Table 1 (continued)

Microregion	μ (CI95%)	σ (CI95%)	ξ (CI95%)
DADRA & NAGAR HAVELI	38.97 (38.86;39.08)	0.88 (0.8;0.96)	−0.39(−0.45; −0.33)
DAHOD	42.48 (42.35;42.61)	1.03 (0.94;1.12)	−0.35(−0.41; −0.29)
DAKSHINA KANNADA	34.15 (34.08;34.22)	0.57 (0.52;0.62)	−0.21(−0.26; −0.16)
DAMAN & DIU	38.82 (38.68;38.96)	1.03 (0.93;1.13)	−0.48(−0.57; −0.39)
DAMOH	44.16 (44.02;44.3)	1.07 (0.97;1.17)	−0.4(−0.46; −0.34)
DARBHANGA	40.25 (40.08;40.42)	1.34 (1.22;1.46)	−0.37(−0.43; −0.31)
DARJEELING	33.22 (33.09;33.35)	1.01 (0.92;1.1)	−0.19(−0.26; −0.12)
DAUSA	40.82 (40.73;40.91)	0.7 (0.63;0.77)	−0.54(−0.61; −0.47)
DAVANAGERE	35.88 (35.8;35.96)	0.6 (0.55;0.65)	−0.25(−0.31; −0.19)
DEORIA	41.91 (41.75;42.07)	1.24 (1.12;1.36)	−0.51(−0.58; −0.44)
DEWAS	43.59 (43.44;43.74)	1.13 (1.02;1.24)	−0.49(−0.56; −0.42)
DHANBAD	41.93 (41.74;42.12)	1.48 (1.35;1.61)	−0.3(−0.35; −0.25)
DHAR	43.15 (43.02;43.28)	1.04 (0.94;1.14)	−0.47(−0.54; −0.4)
DHARMAPURI	37.7 (37.6;37.8)	0.74 (0.67;0.81)	−0.26(−0.32; −0.2)
DHARWAD	36.64 (36.57;36.71)	0.57 (0.52;0.62)	−0.32(−0.37; −0.27)
DHAURAHRA	42.28 (42.12;42.44)	1.22 (1.12;1.32)	−0.38(−0.42; −0.34)
DHENKANAL	41.22 (41.08;41.36)	1.12 (1.02;1.22)	−0.3(−0.36; −0.24)
DHUBRI	33.48 (33.39;33.57)	0.7 (0.64;0.76)	−0.12(−0.19; −0.05)
DHULE	41.12 (41.01;41.23)	0.84 (0.76;0.92)	−0.42(−0.48; −0.36)
DIAMOND HARBOUR	38.19 (38;38.38)	1.51 (1.37;1.65)	−0.41(−0.47; −0.35)
DIBRUGARH	36.01 (35.9;36.12)	0.8 (0.72;0.88)	−0.26(−0.36; −0.16)
DINDIGUL	37.21 (37.12;37.3)	0.71 (0.65;0.77)	−0.34(−0.39; −0.29)
DINDORI	40.7 (40.6;40.8)	0.79 (0.72;0.86)	−0.41(−0.48; −0.34)
DOMARIYAGANJ	42.36 (42.2;42.52)	1.24 (1.13;1.35)	−0.45(−0.5; −0.4)
DUM DUM	38.19 (38;38.38)	1.51 (1.37;1.65)	−0.41(−0.47; −0.35)
DUMKA	41.55 (41.35;41.75)	1.51 (1.38;1.64)	−0.33(−0.39; −0.27)
DURG	43.52 (43.38;43.66)	1.07 (0.97;1.17)	−0.45(−0.53; −0.37)
EAST DELHI	40.31 (40.2;40.42)	0.87 (0.79;0.95)	−0.49(−0.55; −0.43)
ELURU	42.1 (41.91;42.29)	1.46 (1.31;1.61)	−0.44(−0.53; −0.35)
ERNAKULAM	33.51 (33.43;33.59)	0.62 (0.57;0.67)	−0.03(−0.08; 0.02)
ERODE	35.42 (35.32;35.52)	0.74 (0.67;0.81)	−0.21(−0.27; −0.15)
ETAH	39.87 (39.79;39.95)	0.66 (0.6;0.72)	−0.33(−0.38; −0.28)
ETAWAH	45.11 (44.96;45.26)	1.17 (1.06;1.28)	−0.49(−0.56; −0.42)
FAIZABAD	43.29 (43.13;43.45)	1.22 (1.12;1.32)	−0.4(−0.44; −0.36)
FARIDABAD	41.41 (41.3;41.52)	0.87 (0.78;0.96)	−0.56(−0.63; −0.49)
FARIDKOT	41.37 (41.27;41.47)	0.82 (0.75;0.89)	−0.48(−0.53; −0.43)
FARRUKHABAD	44.42 (44.27;44.57)	1.17 (1.06;1.28)	−0.42(−0.48; −0.36)
FATEHGARH SAHIB	41.32 (41.21;41.43)	0.85 (0.78;0.92)	−0.44(−0.49; −0.39)
FATEHPUR	44.28 (44.13;44.43)	1.17 (1.07;1.27)	−0.41(−0.46; −0.36)
FATEHPUR SIKRI	42.26 (42.16;42.36)	0.79 (0.72;0.86)	−0.51(−0.57; −0.45)
FIROZABAD	42.87 (42.76;42.98)	0.84 (0.76;0.92)	−0.5(−0.56; −0.44)
FIROZPUR	42.9 (42.78;43.02)	0.95 (0.86;1.04)	−0.53(−0.59; −0.47)
GADCHIROLI-CHIMUR	43.83 (43.7;43.96)	1 (0.91;1.09)	−0.38(−0.45; −0.31)
GANDHINAGAR	42.16 (42.02;42.3)	1.1 (0.99;1.21)	−0.4(−0.48; −0.32)
GANGANAGAR	41.29 (41.19;41.39)	0.77 (0.68;0.86)	−0.72(−0.81; −0.63)
GARHWAL	36.71 (36.63;36.79)	0.59 (0.54;0.64)	−0.29(−0.36; −0.22)
GAUHATI	33.86 (33.78;33.94)	0.6 (0.54;0.66)	0.02(−0.08; 0.12)
GAUTAM BUDDHA NAGAR	40.74 (40.63;40.85)	0.86 (0.78;0.94)	−0.45(−0.5; −0.4)
GAYA	42.65 (42.48;42.82)	1.35 (1.22;1.48)	−0.48(−0.55; −0.41)

Table 1 (continued)

Microregion	μ (CI95%)	σ (CI95%)	ξ (CI95%)
GHATAL	39.38 (39.17;39.59)	1.58 (1.42;1.74)	−0.46(−0.54; −0.38)
GHAZIABAD	40.79 (40.68;40.9)	0.84 (0.76;0.92)	−0.49(−0.55; −0.43)
GHAZIPUR	43.01 (42.85;43.17)	1.23 (1.12;1.34)	−0.46(−0.52; −0.4)
GHOSI	42.74 (42.58;42.9)	1.24 (1.12;1.36)	−0.5(−0.56; −0.44)
GIRIDIH	41.93 (41.74;42.12)	1.46 (1.33;1.59)	−0.36(−0.42; −0.3)
GODDA	40.67 (40.48;40.86)	1.44 (1.3;1.58)	−0.39(−0.46; −0.32)
GONDA	42.98 (42.82;43.14)	1.23 (1.12;1.34)	−0.42(−0.47; −0.37)
GOPALGANJ	41.91 (41.75;42.07)	1.24 (1.12;1.36)	−0.51(−0.58; −0.44)
GORAKHPUR	42.26 (42.1;42.42)	1.26 (1.15;1.37)	−0.47(−0.53; −0.41)
GULBARGA	41.99 (41.86;42.12)	0.95 (0.85;1.05)	−0.41(−0.5; −0.32)
GUNA	44.61 (44.46;44.76)	1.14 (1.03;1.25)	−0.42(−0.49; −0.35)
GUNTUR	42.54 (42.35;42.73)	1.44 (1.3;1.58)	−0.37(−0.45; −0.29)
GURDASPUR	40.06 (39.97;40.15)	0.69 (0.63;0.75)	−0.46(−0.51; −0.41)
GURGAON	42.05 (41.94;42.16)	0.86 (0.77;0.95)	−0.59(−0.66; −0.52)
GWALIOR	45.25 (45.1;45.4)	1.18 (1.06;1.3)	−0.53(−0.61; −0.45)
HAJIPUR	41.77 (41.59;41.95)	1.41 (1.27;1.55)	−0.5(−0.57; −0.43)
HAMIRPUR	41.18 (41.08;41.28)	0.74 (0.66;0.82)	−0.65(−0.74; −0.56)
HAMIRPUR	44.96 (44.81;45.11)	1.15 (1.05;1.25)	−0.41(−0.47; −0.35)
HARDOI	43.48 (43.33;43.63)	1.18 (1.07;1.29)	−0.41(−0.46; −0.36)
HARDWAR	38.58 (38.47;38.69)	0.86 (0.78;0.94)	−0.53(−0.6; −0.46)
HASSAN	34.32 (34.24;34.4)	0.6 (0.55;0.65)	−0.23(−0.28; −0.18)
HATHRAS	39.93 (39.83;40.03)	0.79 (0.72;0.86)	−0.48(−0.54; −0.42)
HATKANANGLE	37.06 (36.98;37.14)	0.61 (0.56;0.66)	−0.33(−0.39; −0.27)
HAVERI	37.06 (36.98;37.14)	0.6 (0.55;0.65)	−0.31(−0.36; −0.26)
HAZARIBAGH	42.23 (42.05;42.41)	1.37 (1.25;1.49)	−0.39(−0.45; −0.33)
HINDUPUR	38.87 (38.77;38.97)	0.75 (0.68;0.82)	−0.21(−0.28; −0.14)
HINGOLI	43.85 (43.72;43.98)	0.98 (0.88;1.08)	−0.48(−0.56; −0.4)
HISAR	41.54 (41.43;41.65)	0.87 (0.78;0.96)	−0.54(−0.61; −0.47)
HOOGHLY	39.2 (39.01;39.39)	1.47 (1.34;1.6)	−0.38(−0.44; −0.32)
HOSHANGABAD	43.34 (43.21;43.47)	1.03 (0.93;1.13)	−0.46(−0.53; −0.39)
HOSHIARPUR	40.26 (40.17;40.35)	0.68 (0.62;0.74)	−0.54(−0.6; −0.48)
HOWRAH	38.19 (38;38.38)	1.51 (1.37;1.65)	−0.41(−0.47; −0.35)
HYDERABAD	42.59 (42.46;42.72)	0.98 (0.89;1.07)	−0.34(−0.41; −0.27)
IDUKKI	34.34 (34.26;34.42)	0.63 (0.58;0.68)	−0.21(−0.26; −0.16)
INDORE	43.33 (43.19;43.47)	1.1 (0.99;1.21)	−0.53(−0.61; −0.45)
INNER MANIPUR	33.93 (33.82;34.04)	0.84 (0.76;0.92)	−0.15(−0.24; −0.06)
JABALPUR	43.54 (43.41;43.67)	1.03 (0.93;1.13)	−0.49(−0.57; −0.41)
JADAVPUR	38.19 (38;38.38)	1.51 (1.37;1.65)	−0.41(−0.47; −0.35)
JAGATSINGHPUR	38.88 (38.72;39.04)	1.24 (1.13;1.35)	−0.24(−0.3; −0.18)
JAHANABAD	42.15 (41.98;42.32)	1.32 (1.19;1.45)	−0.48(−0.56; −0.4)
JAIPUR	42.37 (42.27;42.47)	0.79 (0.71;0.87)	−0.59(−0.67; −0.51)
JAIPUR RURAL	42.29 (42.19;42.39)	0.8 (0.72;0.88)	−0.55(−0.61; −0.49)
JAJPUR	39.83 (39.67;39.99)	1.22 (1.11;1.33)	−0.26(−0.32; −0.2)
JALANDHAR	40.52 (40.43;40.61)	0.69 (0.62;0.76)	−0.54(−0.6; −0.48)
JALAUN	44.66 (44.51;44.81)	1.14 (1.04;1.24)	−0.45(−0.51; −0.39)
JALGAON	42.57 (42.46;42.68)	0.86 (0.78;0.94)	−0.39(−0.45; −0.33)
JALNA	43.12 (43;43.24)	0.92 (0.83;1.01)	−0.47(−0.54; −0.4)
JALORE	40.05 (39.96;40.14)	0.68 (0.62;0.74)	−0.35(−0.4; −0.3)
JALPAIGURI	33.32 (33.2;33.44)	0.93 (0.85;1.01)	−0.17(−0.24; −0.1)

Table 1 (continued)

Microregion	μ (CI95%)	σ (CI95%)	ξ (CI95%)
JAMMU	37.45 (37.28;37.62)	1.26 (1.14;1.38)	−0.37(−0.46; −0.28)
JAMNAGAR	38.19 (38.05;38.33)	1.08 (0.98;1.18)	−0.26(−0.34; −0.18)
JAMSHEDPUR	41.76 (41.57;41.95)	1.47 (1.34;1.6)	−0.24(−0.3; −0.18)
JAMUI	41.47 (41.28;41.66)	1.49 (1.34;1.64)	−0.49(−0.57; −0.41)
JANGIPUR	40.53 (40.34;40.72)	1.46 (1.32;1.6)	−0.28(−0.35; −0.21)
JANJGIR-CHAMPA	43.52 (43.38;43.66)	1.06 (0.96;1.16)	−0.41(−0.48; −0.34)
JAUNPUR	43.37 (43.21;43.53)	1.22 (1.12;1.32)	−0.38(−0.42; −0.34)
JAYNAGAR	37.91 (37.71;38.11)	1.53 (1.38;1.68)	−0.45(−0.53; −0.37)
JHALAWAR-BARAN	40.06 (39.96;40.16)	0.74 (0.67;0.81)	−0.49(−0.56; −0.42)
JHANJHARPUR	40.03 (39.86;40.2)	1.28 (1.17;1.39)	−0.33(−0.39; −0.27)
JHANSI	44.96 (44.81;45.11)	1.13 (1.02;1.24)	−0.44(−0.51; −0.37)
JHARGRAM	41.04 (40.86;41.22)	1.43 (1.3;1.56)	−0.31(−0.36; −0.26)
JHUNJHUNU	42.48 (42.37;42.59)	0.83 (0.75;0.91)	−0.54(−0.6; −0.48)
JODHPUR	41.1 (41;41.2)	0.78 (0.71;0.85)	−0.39(−0.44; −0.34)
JORHAT	35.87 (35.76;35.98)	0.8 (0.72;0.88)	−0.23(−0.33; −0.13)
JUNAGADH	38.79 (38.65;38.93)	1.1 (1;1.2)	−0.36(−0.43; −0.29)
KACHCHH	39.54 (39.4;39.68)	1.05 (0.95;1.15)	−0.35(−0.43; −0.27)
KADAPA	41.05 (40.93;41.17)	0.92 (0.84;1)	−0.32(−0.39; −0.25)
KAIRANA	41.83 (41.7;41.96)	0.98 (0.89;1.07)	−0.48(−0.54; −0.42)
KAISERGANJ	43.09 (42.93;43.25)	1.23 (1.13;1.33)	−0.4(−0.44; −0.36)
KAKINADA	40.56 (40.38;40.74)	1.4 (1.27;1.53)	−0.36(−0.43; −0.29)
KALAHANDI	42.26 (42.12;42.4)	1.04 (0.93;1.15)	−0.43(−0.53; −0.33)
KALIABOR	34.88 (34.78;34.98)	0.75 (0.68;0.82)	−0.09(−0.19; 0.01)
KALLAKURICHI	39.4 (39.29;39.51)	0.83 (0.74;0.92)	−0.49(−0.59; −0.39)
KALYAN	38.31 (38.21;38.41)	0.75 (0.68;0.82)	−0.34(−0.41; −0.27)
KANCHEEPURAM	40.54 (40.4;40.68)	1.07 (0.98;1.16)	−0.24(−0.3; −0.18)
KANDHAMAL	40.75 (40.61;40.89)	1.03 (0.93;1.13)	−0.35(−0.43; −0.27)
KANGRA	39.66 (39.58;39.74)	0.66 (0.6;0.72)	−0.41(−0.46; −0.36)
KANKER	43.47 (43.34;43.6)	1.02 (0.93;1.11)	−0.32(−0.39; −0.25)
KANNAUJ	44.03 (43.88;44.18)	1.18 (1.07;1.29)	−0.43(−0.49; −0.37)
KANNIYAKUMARI	35.87 (35.79;35.95)	0.6 (0.55;0.65)	−0.29(−0.34; −0.24)
KANNUR	33.5 (33.43;33.57)	0.57 (0.52;0.62)	−0.2(−0.25; −0.15)
KANPUR	43.63 (43.47;43.79)	1.24 (1.13;1.35)	−0.43(−0.48; −0.38)
KANTHI	38.74 (38.54;38.94)	1.53 (1.39;1.67)	−0.39(−0.45; −0.33)
KARAKAT	42.45 (42.29;42.61)	1.27 (1.15;1.39)	−0.45(−0.52; −0.38)
KARAULI -DHOLPUR	42.76 (42.65;42.87)	0.83 (0.75;0.91)	−0.6(−0.68; −0.52)
KARIMGANJ	33.68 (33.58;33.78)	0.75 (0.67;0.83)	−0.09(−0.19; 0.01)
KARIMNAGAR	43.19 (43.06;43.32)	0.99 (0.9;1.08)	−0.35(−0.42; −0.28)
KARNAL	41.92 (41.81;42.03)	0.87 (0.78;0.96)	−0.57(−0.64; −0.5)
KARUR	37.21 (37.12;37.3)	0.71 (0.65;0.77)	−0.34(−0.39; −0.29)
KASARAGOD	33.63 (33.56;33.7)	0.57 (0.52;0.62)	−0.2(−0.25; −0.15)
KATIHAR	38.62 (38.46;38.78)	1.14 (1.03;1.25)	−0.18(−0.28; −0.08)
KAUSHAMBI	44.34 (44.19;44.49)	1.15 (1.05;1.25)	−0.38(−0.43; −0.33)
KENDRAPARA	38.87 (38.71;39.03)	1.24 (1.13;1.35)	−0.25(−0.31; −0.19)
KEONJHAR	41.22 (41.05;41.39)	1.3 (1.18;1.42)	−0.29(−0.35; −0.23)
KHADOOR SAHIB	40.93 (40.84;41.02)	0.71 (0.64;0.78)	−0.57(−0.64; −0.5)
KHAGARIA	40.17 (40.08;40.26)	0.71 (0.65;0.77)	−0.4(−0.46; −0.34)
KHAJURAHO	44.49 (44.35;44.63)	1.06 (0.96;1.16)	−0.43(−0.49; −0.37)
KHAMMAM	42.49 (42.32;42.66)	1.29 (1.17;1.41)	−0.39(−0.47; −0.31)

Table 1 (continued)

Microregion	μ (CI95%)	σ (CI95%)	ξ (CI95%)
KHANDWA	43.48 (43.35;43.61)	1.01 (0.91;1.11)	−0.54(−0.61; −0.47)
KHARGONE	43.01 (42.89;43.13)	0.96 (0.87;1.05)	−0.43(−0.49; −0.37)
KHEDA	42.29 (42.15;42.43)	1.05 (0.95;1.15)	−0.36(−0.43; −0.29)
KHERI	42.01 (41.85;42.17)	1.22 (1.12;1.32)	−0.38(−0.43; −0.33)
KHUNTI	42.09 (41.92;42.26)	1.29 (1.18;1.4)	−0.33(−0.38; −0.28)
KISHANGANJ	35.64 (35.5;35.78)	1.1 (1;1.2)	−0.21(−0.28; −0.14)
KODARMA	42.15 (41.96;42.34)	1.5 (1.36;1.64)	−0.4(−0.47; −0.33)
KOKRAJHAR	33.47 (33.39;33.55)	0.64 (0.58;0.7)	−0.01(−0.09; 0.07)
KOLAR	38.07 (37.97;38.17)	0.78 (0.71;0.85)	−0.25(−0.33; −0.17)
KOLHAPUR	36.25 (36.17;36.33)	0.59 (0.54;0.64)	−0.32(−0.38; −0.26)
KOLKATA DAKSHIN	38.19 (38;38.38)	1.51 (1.37;1.65)	−0.41(−0.47; −0.35)
KOLKATA UTTAR	38.19 (38;38.38)	1.51 (1.37;1.65)	−0.41(−0.47; −0.35)
KOLLAM	34.67 (34.59;34.75)	0.6 (0.55;0.65)	−0.2(−0.25; −0.15)
KOPPAL	40.39 (40.29;40.49)	0.8 (0.72;0.88)	−0.38(−0.46; −0.3)
KORAPUT	40.08 (39.93;40.23)	1.12 (1.01;1.23)	−0.37(−0.45; −0.29)
KORBA	43.31 (43.17;43.45)	1.06 (0.96;1.16)	−0.51(−0.57; −0.45)
KOTA	39.68 (39.6;39.76)	0.65 (0.59;0.71)	−0.38(−0.43; −0.33)
KOTTAYAM	34.36 (34.28;34.44)	0.62 (0.57;0.67)	−0.09(−0.14; −0.04)
KOZHIKODE	32.99 (32.91;33.07)	0.61 (0.56;0.66)	−0.21(−0.26; −0.16)
KRISHNAGIRI	37.77 (37.67;37.87)	0.78 (0.71;0.85)	−0.26(−0.34; −0.18)
KRISHNANAGAR	40.19 (40;40.38)	1.48 (1.34;1.62)	−0.36(−0.43; −0.29)
KURNOOL	41.47 (41.36;41.58)	0.86 (0.78;0.94)	−0.36(−0.44; −0.28)
KURUKSHETRA	40.77 (40.65;40.89)	0.94 (0.85;1.03)	−0.51(−0.57; −0.45)
KUSHI NAGAR	42.26 (42.1;42.42)	1.26 (1.15;1.37)	−0.47(−0.53; −0.41)
LADAKH	33.67 (33.53;33.81)	1.08 (0.98;1.18)	−0.31(−0.39; −0.23)
LAKHIMPUR	35.85 (35.74;35.96)	0.79 (0.71;0.87)	−0.22(−0.32; −0.12)
LAKSHADWEEP	34.04 (33.97;34.11)	0.55 (0.5;0.6)	−0.09(−0.16; −0.02)
LALGANJ	43.05 (42.9;43.2)	1.21 (1.1;1.32)	−0.44(−0.49; −0.39)
LATUR	42.92 (42.79;43.05)	0.96 (0.87;1.05)	−0.41(−0.5; −0.32)
LOHARDAGA	42.44 (42.28;42.6)	1.25 (1.14;1.36)	−0.43(−0.49; −0.37)
LUCKNOW	43.63 (43.47;43.79)	1.24 (1.13;1.35)	−0.43(−0.48; −0.38)
LUDHIANA	42.86 (42.75;42.97)	0.89 (0.81;0.97)	−0.48(−0.54; −0.42)
MACHHLISHAHR	43.27 (43.12;43.42)	1.19 (1.09;1.29)	−0.43(−0.48; −0.38)
MACHILIPATNAM	42.48 (42.29;42.67)	1.47 (1.32;1.62)	−0.43(−0.52; −0.34)
MADHA	40.21 (40.11;40.31)	0.77 (0.7;0.84)	−0.39(−0.47; −0.31)
MADHEPURA	39.71 (39.54;39.88)	1.31 (1.19;1.43)	−0.35(−0.42; −0.28)
MADHUBANI	40.03 (39.86;40.2)	1.28 (1.17;1.39)	−0.33(−0.39; −0.27)
MADURAI	37.59 (37.49;37.69)	0.74 (0.68;0.8)	−0.15(−0.2; −0.1)
MAHABUBABAD	42.68 (42.53;42.83)	1.15 (1.04;1.26)	−0.35(−0.42; −0.28)
MAHARAJGANJ	42.26 (42.1;42.42)	1.26 (1.15;1.37)	−0.47(−0.53; −0.41)
MAHARAJGANJ	41.72 (41.56;41.88)	1.23 (1.12;1.34)	−0.43(−0.49; −0.37)
MAHASAMUND	43.03 (42.9;43.16)	1.03 (0.93;1.13)	−0.38(−0.46; −0.3)
MAHBUBNAGAR	42.28 (42.15;42.41)	0.98 (0.87;1.09)	−0.47(−0.59; −0.35)
MAHESANA	41.7 (41.56;41.84)	1.07 (0.97;1.17)	−0.34(−0.42; −0.26)
MAINPURI	42.16 (42.05;42.27)	0.84 (0.76;0.92)	−0.49(−0.55; −0.43)
MALAPPURAM	33.16 (33.08;33.24)	0.61 (0.56;0.66)	−0.18(−0.23; −0.13)
MALDAHA DAKSHIN	40.08 (39.9;40.26)	1.36 (1.23;1.49)	−0.3(−0.38; −0.22)
MALDAHA UTTAR	39.16 (39;39.32)	1.21 (1.09;1.33)	−0.22(−0.32; −0.12)
MALKAJGIRI	42.59 (42.46;42.72)	0.98 (0.89;1.07)	−0.34(−0.41; −0.27)

Table 1 (continued)

Microregion	μ (CI95%)	σ (CI95%)	ξ (CI95%)
MANDI	40.14 (40.05;40.23)	0.71 (0.65;0.77)	−0.46(−0.51; −0.41)
MANDLA	43.51 (43.38;43.64)	1.02 (0.92;1.12)	−0.5(−0.57; −0.43)
MANDSOUR	43.24 (43.09;43.39)	1.14 (1.03;1.25)	−0.42(−0.49; −0.35)
MANDYA	35.19 (35.1;35.28)	0.68 (0.62;0.74)	−0.24(−0.3; −0.18)
MANGALDOI	34.17 (34.07;34.27)	0.72 (0.65;0.79)	−0.04(−0.14; 0.06)
MATHURA	41.86 (41.75;41.97)	0.84 (0.76;0.92)	−0.47(−0.54; −0.4)
MATHURAPUR	37.95 (37.76;38.14)	1.5 (1.36;1.64)	−0.38(−0.45; −0.31)
MAVAL	37.76 (37.67;37.85)	0.7 (0.64;0.76)	−0.37(−0.44; −0.3)
MAVELIKKARA	34.06 (33.98;34.14)	0.6 (0.55;0.65)	−0.12(−0.16; −0.08)
MAYILADUTHURAI	38.68 (38.58;38.78)	0.77 (0.7;0.84)	−0.35(−0.42; −0.28)
MAYURBHANJ	40.75 (40.58;40.92)	1.34 (1.22;1.46)	−0.33(−0.4; −0.26)
MEDAK	42.49 (42.36;42.62)	0.96 (0.87;1.05)	−0.35(−0.43; −0.27)
MEDINIPUR	38.74 (38.54;38.94)	1.53 (1.39;1.67)	−0.39(−0.45; −0.33)
MEERUT	40.65 (40.55;40.75)	0.8 (0.71;0.89)	−0.68(−0.76; −0.6)
MIRZAPUR	43.55 (43.4;43.7)	1.14 (1.04;1.24)	−0.41(−0.46; −0.36)
MISRIKH	43.42 (43.26;43.58)	1.22 (1.11;1.33)	−0.43(−0.48; −0.38)
MIZORAM	33.73 (33.63;33.83)	0.72 (0.65;0.79)	−0.06(−0.15; 0.03)
MOHANLALGANJ	43.47 (43.32;43.62)	1.21 (1.1;1.32)	−0.4(−0.45; −0.35)
MORADABAD	40.74 (40.64;40.84)	0.79 (0.72;0.86)	−0.49(−0.55; −0.43)
MORENA	45.05 (44.9;45.2)	1.18 (1.06;1.3)	−0.51(−0.59; −0.43)
MUMBAI NORTH	38.15 (38.04;38.26)	0.87 (0.79;0.95)	−0.39(−0.45; −0.33)
MUMBAI NORTH-CENTRAL	39.81 (39.72;39.9)	0.71 (0.65;0.77)	−0.39(−0.46; −0.32)
MUMBAI NORTH-EAST	38.63 (38.54;38.72)	0.68 (0.62;0.74)	−0.39(−0.46; −0.32)
MUMBAI NORTH-WEST	38.15 (38.04;38.26)	0.87 (0.79;0.95)	−0.39(−0.45; −0.33)
MUMBAI SOUTH	38.99 (38.89;39.09)	0.74 (0.67;0.81)	−0.44(−0.52; −0.36)
MUMBAI SOUTH -CENTRAL	40.45 (40.35;40.55)	0.77 (0.7;0.84)	−0.44(−0.52; −0.36)
MUNGER	38.61 (38.53;38.69)	0.64 (0.59;0.69)	−0.34(−0.39; −0.29)
MURSHIDABAD	40.2 (40.02;40.38)	1.4 (1.27;1.53)	−0.31(−0.39; −0.23)
MUZAFFARNAGAR	40.1 (39.99;40.21)	0.83 (0.75;0.91)	−0.54(−0.61; −0.47)
MUZAFFARPUR	41.27 (41.09;41.45)	1.36 (1.23;1.49)	−0.45(−0.52; −0.38)
MYSORE	33.5 (33.42;33.58)	0.62 (0.57;0.67)	−0.24(−0.29; −0.19)
NABARANGPUR	40.58 (40.42;40.74)	1.22 (1.1;1.34)	−0.36(−0.44; −0.28)
NAGALAND	35.14 (35.03;35.25)	0.78 (0.7;0.86)	−0.16(−0.26; −0.06)
NAGAPATTINAM	38.49 (38.39;38.59)	0.8 (0.73;0.87)	−0.38(−0.45; −0.31)
NAGARKURNOOL	42.32 (42.2;42.44)	0.94 (0.85;1.03)	−0.45(−0.53; −0.37)
NAGAUR	41.54 (41.44;41.64)	0.76 (0.69;0.83)	−0.51(−0.58; −0.44)
NAGINA	39.88 (39.78;39.98)	0.76 (0.69;0.83)	−0.48(−0.54; −0.42)
NAGPUR	43.29 (43.16;43.42)	1 (0.9;1.1)	−0.41(−0.49; −0.33)
NAINITAL-U.N.	36.62 (36.51;36.73)	0.83 (0.75;0.91)	−0.32(−0.4; −0.24)
NALANDA	38.6 (38.52;38.68)	0.62 (0.57;0.67)	−0.36(−0.41; −0.31)
NALGONDA	42.86 (42.72;43)	1.04 (0.93;1.15)	−0.44(−0.54; −0.34)
NAMAKKAL	37.61 (37.52;37.7)	0.73 (0.66;0.8)	−0.25(−0.31; −0.19)
NANDED	43.33 (43.2;43.46)	1.01 (0.91;1.11)	−0.42(−0.51; −0.33)
NANDURBAR	42.37 (42.25;42.49)	0.9 (0.82;0.98)	−0.37(−0.42; −0.32)
NANDYAL	41.74 (41.62;41.86)	0.91 (0.82;1)	−0.41(−0.5; −0.32)
NARASARAOPET	42.67 (42.51;42.83)	1.25 (1.13;1.37)	−0.37(−0.44; −0.3)
NARSAPURAM	42.31 (42.11;42.51)	1.53 (1.38;1.68)	−0.46(−0.55; −0.37)
NASHIK	39.57 (39.47;39.67)	0.75 (0.68;0.82)	−0.35(−0.41; −0.29)
NAVSARI	39.79 (39.67;39.91)	0.9 (0.82;0.98)	−0.36(−0.43; −0.29)

Table 1 (continued)

Microregion	μ (CI95%)	σ (CI95%)	ξ (CI95%)
NAWADA	42.14 (41.96;42.32)	1.39 (1.25;1.53)	−0.49(−0.57; −0.41)
NELLORE	42.14 (41.98;42.3)	1.24 (1.13;1.35)	−0.27(−0.33; −0.21)
NEW DELHI	39.75 (39.65;39.85)	0.81 (0.74;0.88)	−0.45(−0.51; −0.39)
NILGIRIS	34.57 (34.48;34.66)	0.67 (0.61;0.73)	−0.18(−0.24; −0.12)
NIZAMABAD	42.72 (42.59;42.85)	0.98 (0.88;1.08)	−0.35(−0.44; −0.26)
NORTH EAST DELHI	38.37 (38.29;38.45)	0.64 (0.58;0.7)	−0.44(−0.5; −0.38)
NORTH GOA	35.53 (35.46;35.6)	0.56 (0.51;0.61)	−0.34(−0.41; −0.27)
NORTH WEST DELHI	39.91 (39.82;40)	0.71 (0.64;0.78)	−0.59(−0.66; −0.52)
NOWGONG	34.04 (33.93;34.15)	0.77 (0.69;0.85)	−0.1(−0.21; 0.01)
ONGOLE	42.58 (42.43;42.73)	1.14 (1.03;1.25)	−0.35(−0.42; −0.28)
OSMANABAD	42.36 (42.24;42.48)	0.91 (0.82;1)	−0.39(−0.47; −0.31)
OUTER MANIPUR	34.22 (34.11;34.33)	0.81 (0.73;0.89)	−0.14(−0.25; −0.03)
PALAKKAD	33.23 (33.15;33.31)	0.63 (0.57;0.69)	−0.15(−0.21; −0.09)
PALAMU	43.14 (42.99;43.29)	1.18 (1.07;1.29)	−0.44(−0.49; −0.39)
PALGHAR	38.61 (38.51;38.71)	0.8 (0.73;0.87)	−0.37(−0.43; −0.31)
PALI	41.36 (41.25;41.47)	0.88 (0.79;0.97)	−0.58(−0.66; −0.5)
PANCHMAHAL	42.42 (42.29;42.55)	1.04 (0.95;1.13)	−0.34(−0.41; −0.27)
PARBHANI	42.84 (42.72;42.96)	0.9 (0.81;0.99)	−0.42(−0.49; −0.35)
PASCHIM CHAMPARAN	41.07 (40.91;41.23)	1.26 (1.14;1.38)	−0.45(−0.52; −0.38)
PATALIPUTRA	41.09 (41;41.18)	0.73 (0.66;0.8)	−0.53(−0.6; −0.46)
PATAN	41.89 (41.75;42.03)	1.09 (0.99;1.19)	−0.27(−0.33; −0.21)
PATHANAMTHITTA	34.59 (34.51;34.67)	0.6 (0.55;0.65)	−0.25(−0.31; −0.19)
PATIALA	41.51 (41.37;41.65)	1.06 (0.96;1.16)	−0.41(−0.48; −0.34)
PATNA SAHIB	39.43 (39.34;39.52)	0.68 (0.62;0.74)	−0.37(−0.42; −0.32)
PEDDAPALLE	43.58 (43.45;43.71)	1.03 (0.94;1.12)	−0.35(−0.42; −0.28)
PERAMBALUR	39.34 (39.24;39.44)	0.8 (0.73;0.87)	−0.31(−0.37; −0.25)
PHULPUR	43.92 (43.77;44.07)	1.17 (1.07;1.27)	−0.36(−0.4; −0.32)
PILIBHIT	40.36 (40.27;40.45)	0.68 (0.61;0.75)	−0.46(−0.53; −0.39)
POLLACHI	34.08 (33.99;34.17)	0.69 (0.63;0.75)	−0.19(−0.25; −0.13)
PONDICHERRY	38.47 (38.37;38.57)	0.78 (0.71;0.85)	−0.36(−0.43; −0.29)
PONNANI	33.14 (33.06;33.22)	0.61 (0.55;0.67)	−0.01(−0.07; 0.05)
PORBANDAR	38.23 (38.08;38.38)	1.1 (1;1.2)	−0.24(−0.32; −0.16)
PRATAPGARH	43.66 (43.51;43.81)	1.18 (1.08;1.28)	−0.37(−0.41; −0.33)
PUNE	38.24 (38.15;38.33)	0.68 (0.62;0.74)	−0.27(−0.33; −0.21)
PURI	38.72 (38.57;38.87)	1.18 (1.08;1.28)	−0.27(−0.33; −0.21)
PURNIA	39.07 (38.9;39.24)	1.24 (1.12;1.36)	−0.23(−0.31; −0.15)
PURULIA	41.92 (41.74;42.1)	1.39 (1.27;1.51)	−0.3(−0.35; −0.25)
PURVI CHAMPARAN	41.07 (40.91;41.23)	1.26 (1.14;1.38)	−0.45(−0.52; −0.38)
RAE BARELI	43.85 (43.7;44)	1.18 (1.08;1.28)	−0.39(−0.44; −0.34)
RAICHUR	41.37 (41.25;41.49)	0.89 (0.8;0.98)	−0.38(−0.47; −0.29)
RAIGAD	36.73 (36.65;36.81)	0.64 (0.58;0.7)	−0.36(−0.43; −0.29)
RAIGANJ	36.86 (36.72;37)	1.06 (0.96;1.16)	−0.17(−0.26; −0.08)
RAIGARH	43.37 (43.23;43.51)	1.1 (0.99;1.21)	−0.49(−0.56; −0.42)
RAIPUR	43.76 (43.62;43.9)	1.09 (0.98;1.2)	−0.44(−0.52; −0.36)
RAJAHMUNDRY	41.8 (41.61;41.99)	1.47 (1.32;1.62)	−0.42(−0.51; −0.33)
RAJAMPET	40.46 (40.34;40.58)	0.96 (0.88;1.04)	−0.25(−0.3; −0.2)
RAJGARH	43.96 (43.81;44.11)	1.16 (1.05;1.27)	−0.44(−0.51; −0.37)
RAJKOT	40.04 (39.89;40.19)	1.13 (1.03;1.23)	−0.3(−0.37; −0.23)
RAJMAHAL	40.03 (39.85;40.21)	1.35 (1.22;1.48)	−0.32(−0.4; −0.24)

Table 1 (continued)

Microregion	μ (CI95%)	σ (CI95%)	ξ (CI95%)
RAJNANDGAON	43.81 (43.67;43.95)	1.04 (0.94;1.14)	−0.44(−0.52; −0.36)
RAJSAMAND	40.1 (40.01;40.19)	0.7 (0.64;0.76)	−0.33(−0.37; −0.29)
RAMANATHAPURAM	36.93 (36.84;37.02)	0.68 (0.62;0.74)	−0.38(−0.45; −0.31)
RAMPUR	38.5 (38.41;38.59)	0.73 (0.66;0.8)	−0.47(−0.52; −0.42)
RAMTEK	43.93 (43.8;44.06)	0.98 (0.88;1.08)	−0.46(−0.55; −0.37)
RANAGHAT	40.19 (40;40.38)	1.48 (1.34;1.62)	−0.36(−0.43; −0.29)
RANCHI	42.18 (42.01;42.35)	1.31 (1.19;1.43)	−0.36(−0.41; −0.31)
RATLAM	42.62 (42.49;42.75)	1.01 (0.92;1.1)	−0.37(−0.43; −0.31)
RATNAGIRI -SINDHUDURG	35.9 (35.83;35.97)	0.55 (0.5;0.6)	−0.3(−0.36; −0.24)
RAVER	43.4 (43.28;43.52)	0.96 (0.87;1.05)	−0.46(−0.53; −0.39)
REWA	44.33 (44.19;44.47)	1.1 (1;1.2)	−0.4(−0.45; −0.35)
ROBERTSGANJ	43.57 (43.43;43.71)	1.13 (1.03;1.23)	−0.44(−0.49; −0.39)
ROHTAK	43.14 (43.02;43.26)	0.9 (0.81;0.99)	−0.55(−0.62; −0.48)
SABARKANTHA	42.08 (41.94;42.22)	1.09 (0.99;1.19)	−0.29(−0.35; −0.23)
SAGAR	44.08 (43.93;44.23)	1.13 (1.03;1.23)	−0.41(−0.47; −0.35)
SAHARANPUR	37.93 (37.82;38.04)	0.86 (0.77;0.95)	−0.42(−0.51; −0.33)
SALEM	37.61 (37.52;37.7)	0.73 (0.66;0.8)	−0.25(−0.31; −0.19)
SALEMPUR	41.97 (41.81;42.13)	1.24 (1.13;1.35)	−0.46(−0.52; −0.4)
SAMASTIPUR	41.08 (40.9;41.26)	1.38 (1.25;1.51)	−0.46(−0.53; −0.39)
SAMBALPUR	41.84 (41.7;41.98)	1.08 (0.98;1.18)	−0.36(−0.42; −0.3)
SAMBHAL	39.59 (39.49;39.69)	0.75 (0.68;0.82)	−0.49(−0.55; −0.43)
SANGLI	38.99 (38.89;39.09)	0.74 (0.67;0.81)	−0.44(−0.52; −0.36)
SANGRUR	41.12 (41.01;41.23)	0.87 (0.79;0.95)	−0.52(−0.59; −0.45)
SANT KABIR NAGAR	42.83 (42.67;42.99)	1.23 (1.12;1.34)	−0.45(−0.5; −0.4)
SARAN	41.96 (41.79;42.13)	1.3 (1.17;1.43)	−0.47(−0.55; −0.39)
SASARAM	43.14 (42.98;43.3)	1.22 (1.11;1.33)	−0.47(−0.54; −0.4)
SATARA	37.96 (37.88;38.04)	0.65 (0.59;0.71)	−0.38(−0.45; −0.31)
SATNA	44.53 (44.39;44.67)	1.07 (0.97;1.17)	−0.43(−0.49; −0.37)
SECUNDERABAD	42.59 (42.46;42.72)	0.98 (0.89;1.07)	−0.34(−0.41; −0.27)
SHAHDOL	43.48 (43.34;43.62)	1.05 (0.95;1.15)	−0.48(−0.55; −0.41)
SHAHJAHANPUR	40.94 (40.85;41.03)	0.73 (0.66;0.8)	−0.46(−0.53; −0.39)
SHEOHAR	40.74 (40.57;40.91)	1.34 (1.22;1.46)	−0.36(−0.42; −0.3)
SHILLONG	34.07 (33.98;34.16)	0.63 (0.56;0.7)	0(−0.11; 0.11)
SHIMLA	40.93 (40.84;41.02)	0.73 (0.66;0.8)	−0.61(−0.69; −0.53)
SHIMOGA	35.05 (34.98;35.12)	0.54 (0.49;0.59)	−0.25(−0.3; −0.2)
SHIRDI	40.71 (40.61;40.81)	0.75 (0.68;0.82)	−0.38(−0.45; −0.31)
SHIRUR	39 (38.91;39.09)	0.7 (0.64;0.76)	−0.38(−0.45; −0.31)
SHRAWASTI	42.85 (42.69;43.01)	1.24 (1.13;1.35)	−0.42(−0.47; −0.37)
SIDHI	43.78 (43.64;43.92)	1.06 (0.97;1.15)	−0.41(−0.46; −0.36)
SIKAR	42.64 (42.53;42.75)	0.84 (0.75;0.93)	−0.58(−0.66; −0.5)
SIKKIM	33.18 (33.04;33.32)	1.08 (0.99;1.17)	−0.25(−0.3; −0.2)
SILCHAR	33.91 (33.8;34.02)	0.77 (0.69;0.85)	−0.15(−0.25; −0.05)
SINGHBHUM	41.86 (41.68;42.04)	1.38 (1.26;1.5)	−0.28(−0.34; −0.22)
SIRSA	41.41 (41.3;41.52)	0.89 (0.81;0.97)	−0.52(−0.59; −0.45)
SITAMARHI	40.74 (40.57;40.91)	1.34 (1.22;1.46)	−0.36(−0.42; −0.3)
SITAPUR	43.14 (42.98;43.3)	1.22 (1.11;1.33)	−0.41(−0.46; −0.36)
SIVAGANGA	37.93 (37.83;38.03)	0.74 (0.67;0.81)	−0.31(−0.37; −0.25)
SIWAN	41.72 (41.56;41.88)	1.23 (1.12;1.34)	−0.43(−0.49; −0.37)
SOLAPUR	41.56 (41.45;41.67)	0.87 (0.79;0.95)	−0.39(−0.47; −0.31)

Table 1 (continued)

Microregion	μ (CI95%)	σ (CI95%)	ξ (CI95%)
SONIPAT	42.59 (42.48;42.7)	0.88 (0.79;0.97)	−0.55(−0.62; −0.48)
SOUTH DELHI	41.35 (41.24;41.46)	0.87 (0.79;0.95)	−0.44(−0.49; −0.39)
SOUTH GOA	35.53 (35.46;35.6)	0.56 (0.51;0.61)	−0.34(−0.41; −0.27)
SREERAMPUR	38.19 (38;38.38)	1.51 (1.37;1.65)	−0.41(−0.47; −0.35)
SRIKAKULAM	39.54 (39.37;39.71)	1.28 (1.16;1.4)	−0.36(−0.42; −0.3)
SRINAGAR	33.97 (33.66;34.28)	2.48 (2.25;2.71)	−0.65(−0.7; −0.6)
SRIPERUMBUDUR	40.85 (40.71;40.99)	1.12 (1.02;1.22)	−0.25(−0.31; −0.19)
SULTANPUR	43.44 (43.29;43.59)	1.21 (1.11;1.31)	−0.38(−0.42; −0.34)
SUNDARGARH	42.69 (42.54;42.84)	1.15 (1.04;1.26)	−0.41(−0.48; −0.34)
SUPAUL	38.18 (38.01;38.35)	1.27 (1.15;1.39)	−0.34(−0.41; −0.27)
SURAT	41.37 (41.24;41.5)	0.98 (0.89;1.07)	−0.26(−0.32; −0.2)
SURENDRANAGAR	41.19 (41.05;41.33)	1.07 (0.97;1.17)	−0.38(−0.45; −0.31)
SURGUJA	43.26 (43.12;43.4)	1.09 (0.99;1.19)	−0.44(−0.49; −0.39)
TAMLUK	38.79 (38.59;38.99)	1.53 (1.38;1.68)	−0.44(−0.51; −0.37)
TEHRI GARHWAL	37.75 (37.67;37.83)	0.6 (0.55;0.65)	−0.38(−0.44; −0.32)
TENKASI	35.31 (35.23;35.39)	0.61 (0.56;0.66)	−0.29(−0.34; −0.24)
TEZPUR	35.12 (35.02;35.22)	0.72 (0.65;0.79)	−0.09(−0.19; 0.01)
THANE	38.15 (38.04;38.26)	0.87 (0.79;0.95)	−0.39(−0.45; −0.33)
THANJAVUR	38.75 (38.65;38.85)	0.79 (0.71;0.87)	−0.46(−0.54; −0.38)
THENI	36.4 (36.32;36.48)	0.66 (0.6;0.72)	−0.31(−0.36; −0.26)
THIRUVANANTHAPURAM	34.82 (34.74;34.9)	0.6 (0.55;0.65)	−0.26(−0.31; −0.21)
THOOTHUKKUDI	35.88 (35.8;35.96)	0.62 (0.57;0.67)	−0.33(−0.39; −0.27)
THRISSUR	33.14 (33.06;33.22)	0.61 (0.55;0.67)	−0.01(−0.07; 0.05)
TIKAMGARH	44.92 (44.77;45.07)	1.12 (1.02;1.22)	−0.42(−0.49; −0.35)
TIRUCHIRAPPALLI	38.75 (38.65;38.85)	0.79 (0.71;0.87)	−0.46(−0.54; −0.38)
TIRUNELVELI	35.87 (35.79;35.95)	0.6 (0.55;0.65)	−0.29(−0.34; −0.24)
TIRUPATI	41.4 (41.25;41.55)	1.15 (1.05;1.25)	−0.24(−0.29; −0.19)
TIRUPPUR	35.42 (35.32;35.52)	0.74 (0.67;0.81)	−0.2(−0.26; −0.14)
TIRUVALLUR	41.01 (40.87;41.15)	1.09 (1;1.18)	−0.23(−0.28; −0.18)
TIRUVANNAMALAI	39.68 (39.56;39.8)	0.93 (0.85;1.01)	−0.28(−0.34; −0.22)
TONK - SAWAI MADHOPUR	40 (39.91;40.09)	0.69 (0.63;0.75)	−0.49(−0.55; −0.43)
TRIPURA EAST	33.66 (33.57;33.75)	0.66 (0.6;0.72)	−0.02(−0.11; 0.07)
TRIPURA WEST	33.75 (33.67;33.83)	0.64 (0.58;0.7)	−0.02(−0.1; 0.06)
TUMKUR	36.17 (36.08;36.26)	0.69 (0.63;0.75)	−0.24(−0.3; −0.18)
TURA	33.55 (33.46;33.64)	0.65 (0.59;0.71)	−0.09(−0.16; −0.02)
UDAIPUR	39.21 (39.12;39.3)	0.68 (0.62;0.74)	−0.33(−0.38; −0.28)
UDHAMPUR	35.76 (35.6;35.92)	1.22 (1.1;1.34)	−0.33(−0.42; −0.24)
UDUPI CHIKMAGALUR	34.63 (34.56;34.7)	0.57 (0.52;0.62)	−0.23(−0.28; −0.18)
UJIARPUR	41.25 (41.07;41.43)	1.42 (1.28;1.56)	−0.5(−0.57; −0.43)
UJJAIN	43.44 (43.29;43.59)	1.13 (1.01;1.25)	−0.56(−0.65; −0.47)
ULUBERIA	38.79 (38.59;38.99)	1.53 (1.38;1.68)	−0.44(−0.51; −0.37)
UNNAO	43.47 (43.32;43.62)	1.21 (1.1;1.32)	−0.4(−0.45; −0.35)
UTTARA KANNADA	35.37 (35.3;35.44)	0.53 (0.48;0.58)	−0.29(−0.34; −0.24)
VADAKARA	32.99 (32.91;33.07)	0.61 (0.56;0.66)	−0.21(−0.26; −0.16)
VADODARA	42.86 (42.72;43)	1.05 (0.95;1.15)	−0.34(−0.41; −0.27)
VAISHALI	41.32 (41.15;41.49)	1.3 (1.17;1.43)	−0.48(−0.55; −0.41)
VALMIKI NAGAR	41.6 (41.44;41.76)	1.26 (1.14;1.38)	−0.51(−0.58; −0.44)
VALSAD	39.98 (39.87;40.09)	0.87 (0.79;0.95)	−0.38(−0.44; −0.32)
VARANASI	43.27 (43.12;43.42)	1.19 (1.09;1.29)	−0.43(−0.48; −0.38)

Table 1 (continued)

Microregion	μ (CI95%)	σ (CI95%)	ξ (CI95%)
VELLORE	39.43 (39.32;39.54)	0.88 (0.8;0.96)	−0.28(−0.34; −0.22)
VIDISHA	43.63 (43.49;43.77)	1.1 (1;1.2)	−0.47(−0.54; −0.4)
VIJAYAWADA	42.6 (42.41;42.79)	1.41 (1.27;1.55)	−0.38(−0.46; −0.3)
VILUPPURAM	39.74 (39.62;39.86)	0.9 (0.82;0.98)	−0.28(−0.34; −0.22)
VIRUDHUNAGAR	35.59 (35.51;35.67)	0.64 (0.58;0.7)	−0.31(−0.38; −0.24)
VISAKHAPATNAM	39.09 (38.92;39.26)	1.33 (1.2;1.46)	−0.43(−0.51; −0.35)
VIZIANAGARAM	39.09 (38.92;39.26)	1.33 (1.2;1.46)	−0.43(−0.51; −0.35)
WARANGAL	43.17 (43.03;43.31)	1.06 (0.96;1.16)	−0.33(−0.4; −0.26)
WARDHA	43.99 (43.86;44.12)	0.97 (0.88;1.06)	−0.44(−0.52; −0.36)
WAYANAD	33.36 (33.28;33.44)	0.62 (0.57;0.67)	−0.2(−0.25; −0.15)
WEST DELHI	40.1 (40;40.2)	0.74 (0.66;0.82)	−0.59(−0.67; −0.51)
YAVATMAL-WASHIM	44.24 (44.11;44.37)	0.99 (0.89;1.09)	−0.42(−0.5; −0.34)
ZAHIRABAD	42.53 (42.4;42.66)	0.97 (0.88;1.06)	−0.36(−0.44; −0.28)

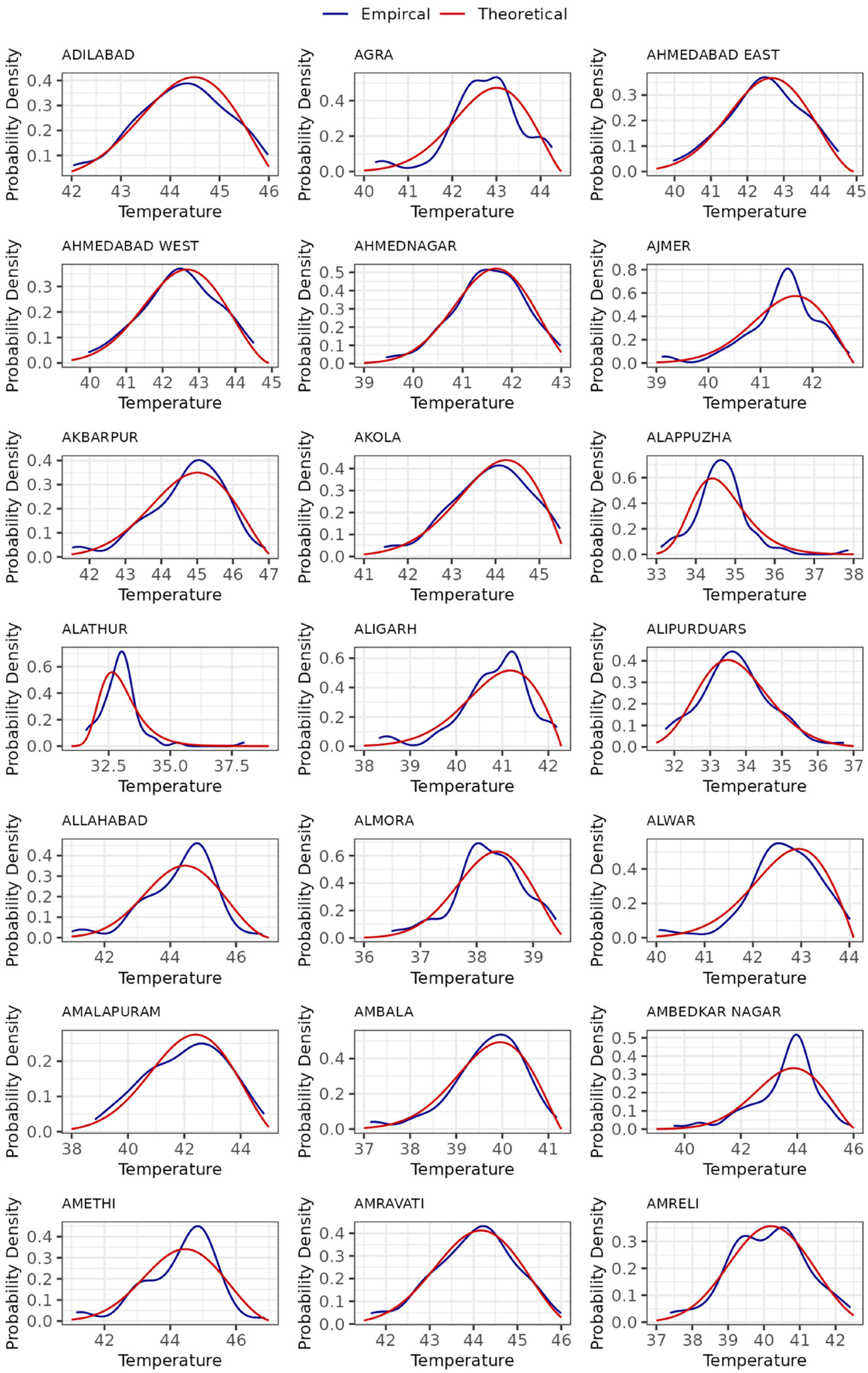


Fig. 11 Theoretical and empirical curve of extreme temperatures in microregions Adilabad, Agra, Ahmedabad East, Ahmedabad West, Ahmednagar, Ajmer, Akbarpur, Akola, Alappuzha, Alathur, Aligarh, Alipurduars, Allahabad, Almora, Alwar, Amalapuram, Ambala, Ambedkar Nagar, Amethi, Amravati, Amreli

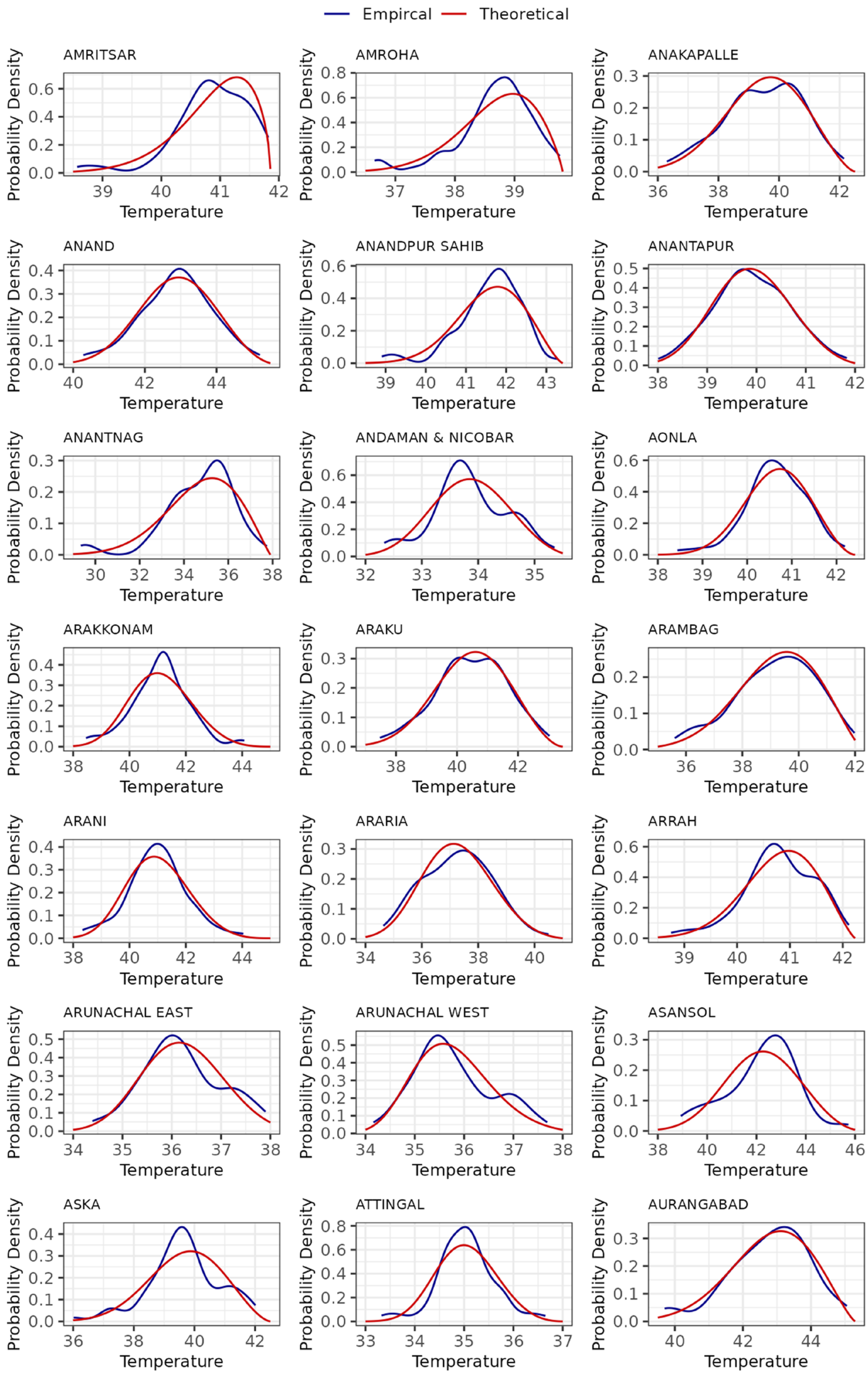


Fig. 12 Theoretical and empirical curve of extreme temperatures in microregions Amritsar, Amroha, Anakapalle, Anand, Anandpur Sahib, Anantapur, Anantnag, Andaman & Nicobar, Aonla, Arakkonam, Araku, Arambag, Arani, Araria, Arrah, Arunachal East, Arunachal West, Asansol, Aska, Attingal, Aurangabad

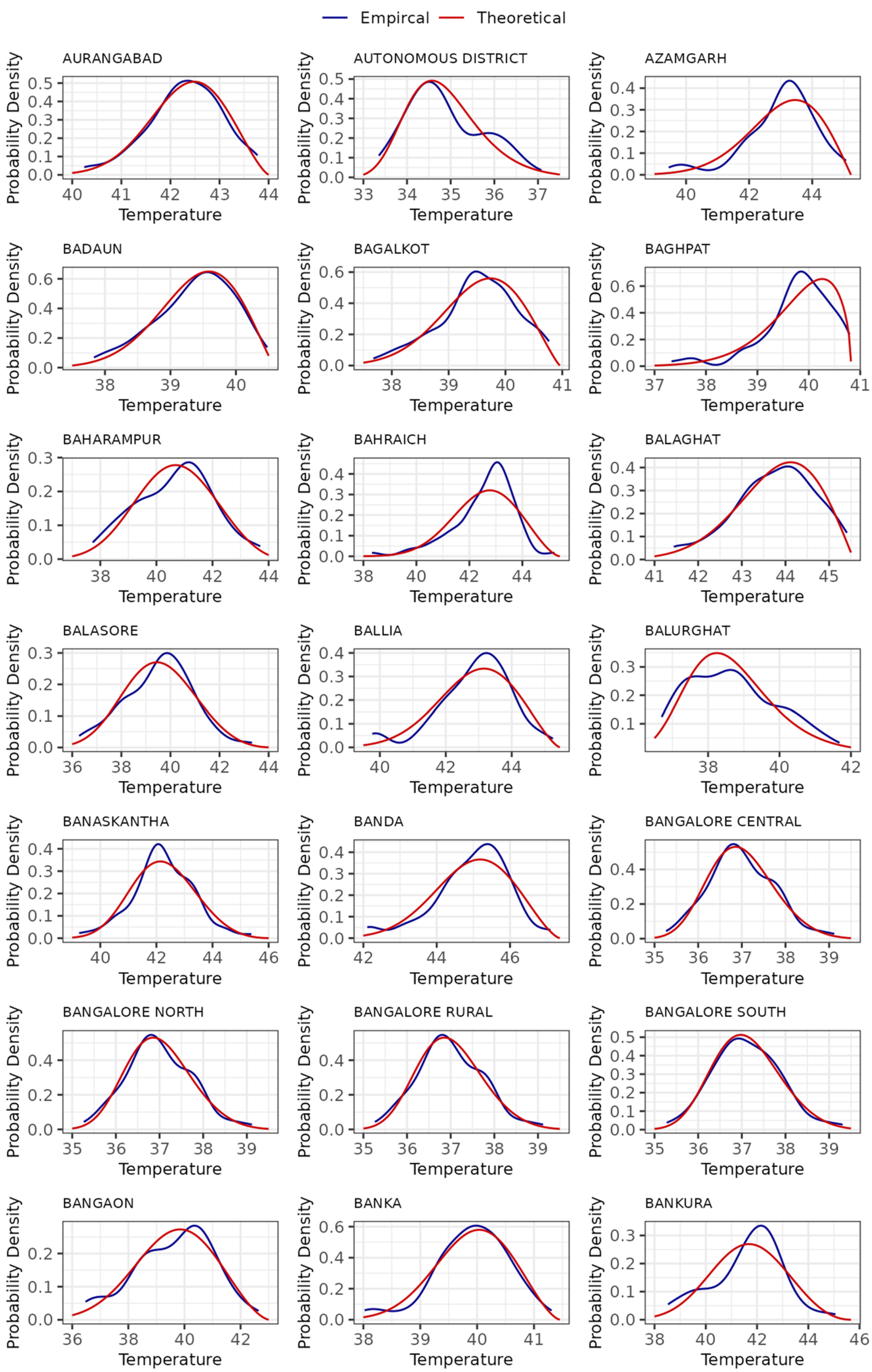


Fig. 13 Theoretical and empirical curve of extreme temperatures in microregions Aurangabad, Autonomous District, Azamgarh, Badaun, Bagalkot, Baghpat, Baharampur, Bahraich, Balaghat, Balasore, Ballia, Balurghat, Banaskantha, Banda, Bangalore Central, Bangalore North, Bangalore Rural, Bangalore South, Bangaon, Banka, Bankura

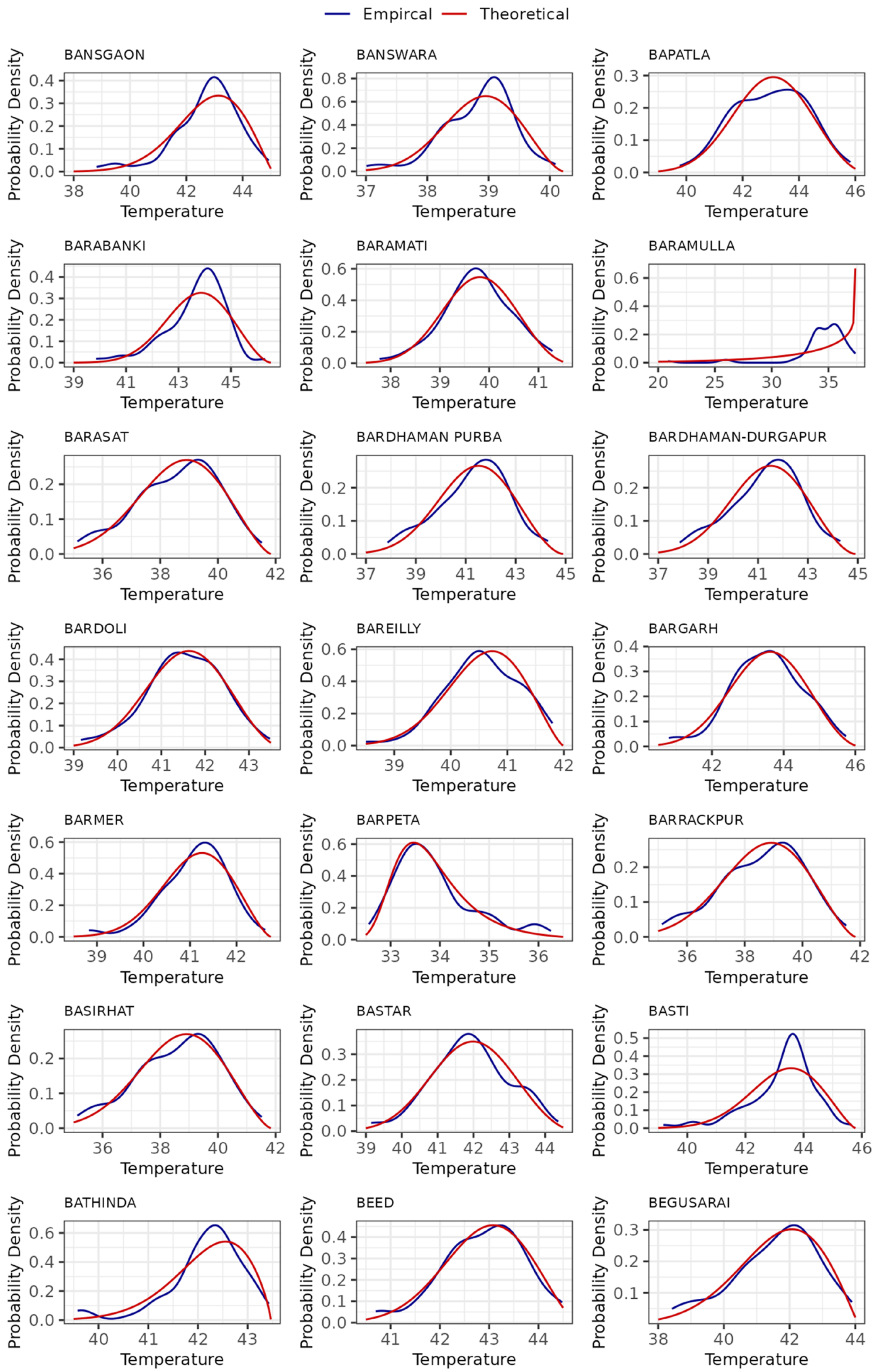


Fig. 14 Theoretical and empirical curve of extreme temperatures in microregions Bansgaon, Banswara, Bapatla, Barabanki, Baramati, Baramulla, Barasat, Bardhaman-Durgapur, Bardhaman Purba, Bardoli, Bareilly, Bargarh, Barmer, Barpeta, Barrackpur, Basirhat, Bastar, Basti, Bathinda, Beed, Begusarai

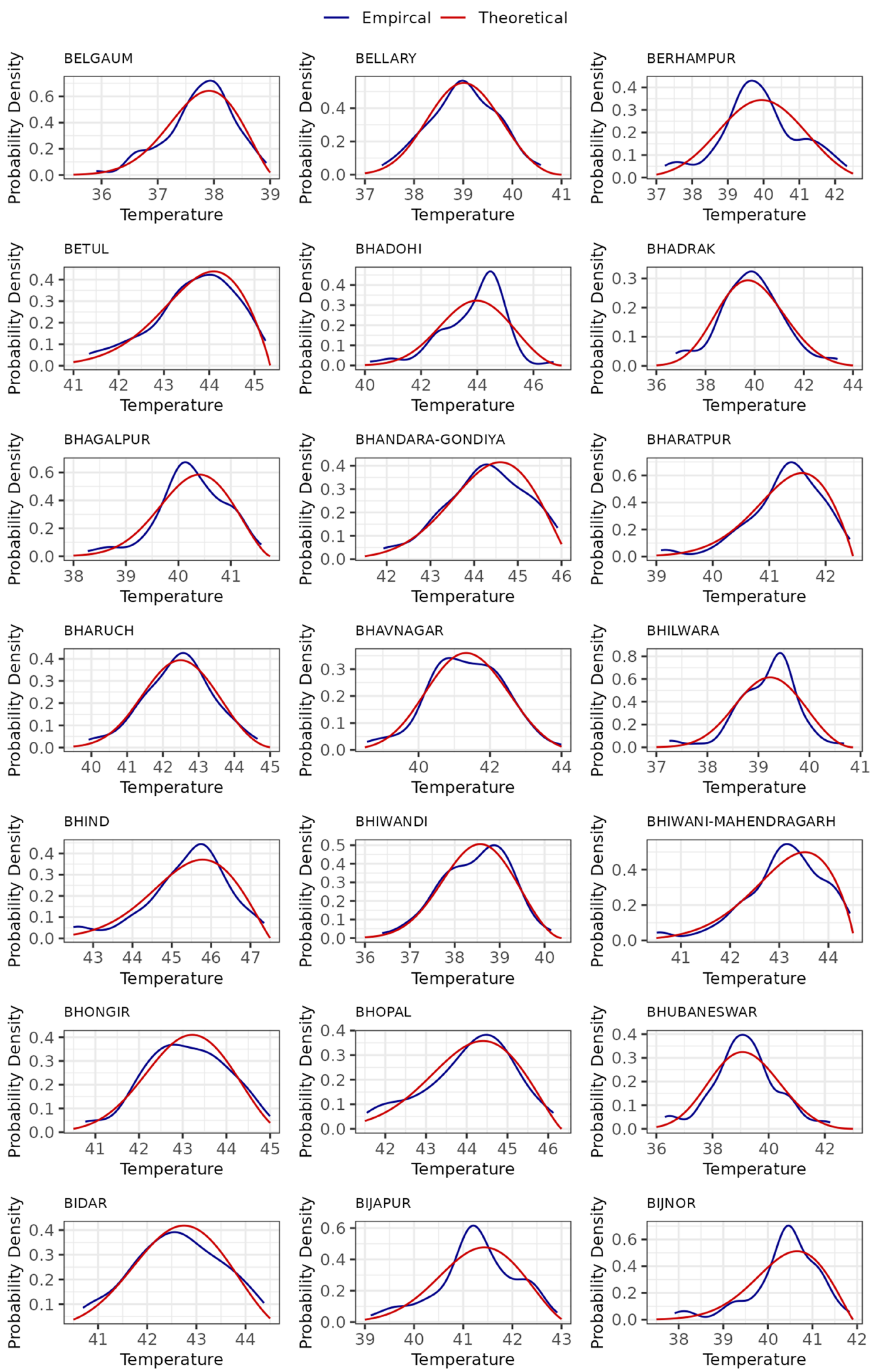


Fig. 15 Theoretical and empirical curve of extreme temperatures in microregions Belgaum, Bellary, Berhampur, Betul, Bhadohi, Bhadrak, Bhagalpur, Bhandara-Gondiya, Bharatpur, Bharuch, Bhavnagar, Bhilwara, Bhind, Bhiwandi, Bhiwani-Mahendragarh, Bhongir, Bhopal, Bhubaneswar, Bidar, Bijapur, Bijnor

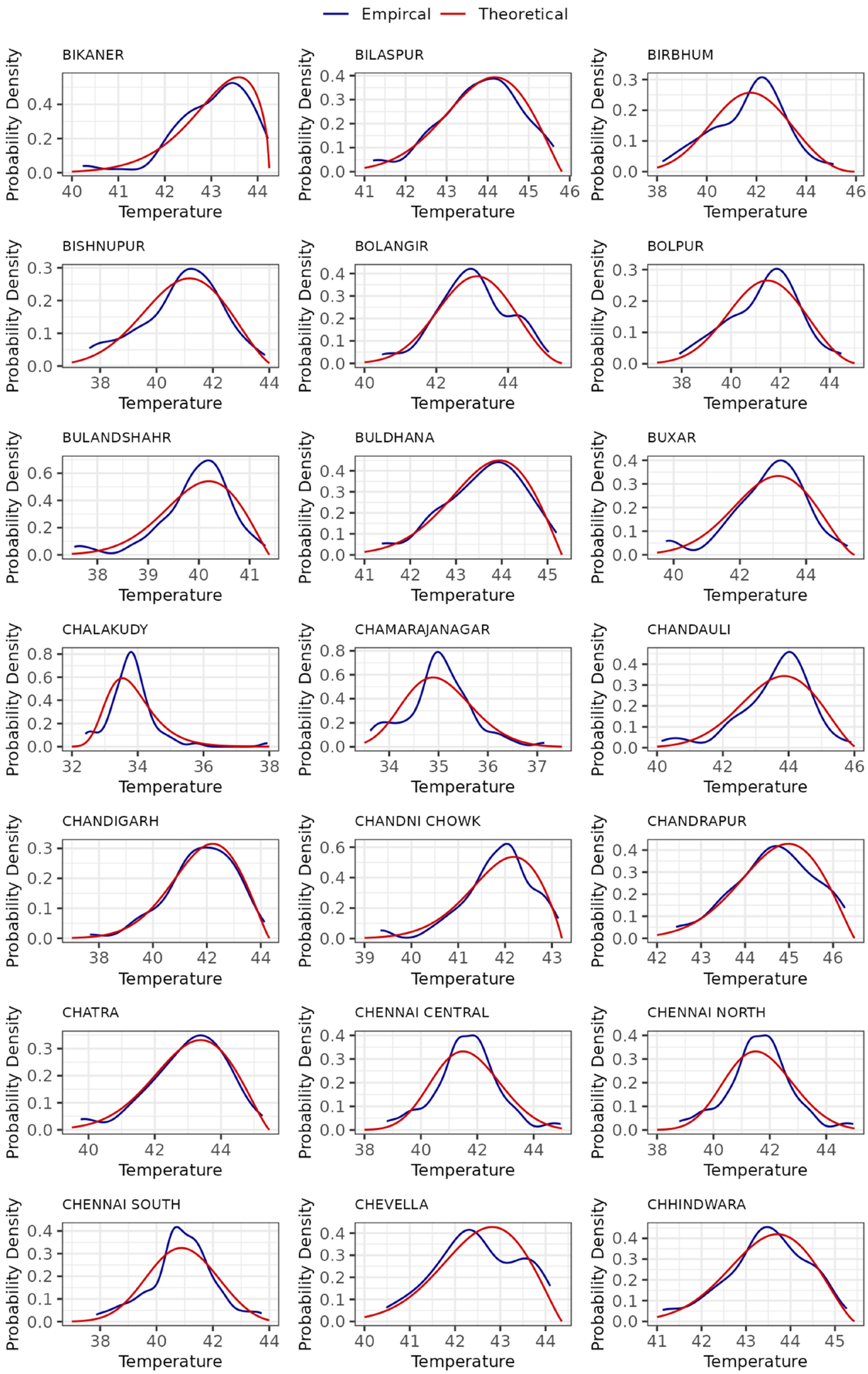


Fig. 16 Theoretical and empirical curve of extreme temperatures in microregions Bikaner, Bilaspur, Birbhum, Bishnupur, Bolangir, Bolpur, Bulandshahr, Buldhana, Buxar, Chalakudy, Chamarajanagar, Chandauli, Chandigarh, Chandni Chowk, Chandrapur, Chatra, Chennai Central, Chennai North, Chennai South, Chevella, Chhindwara

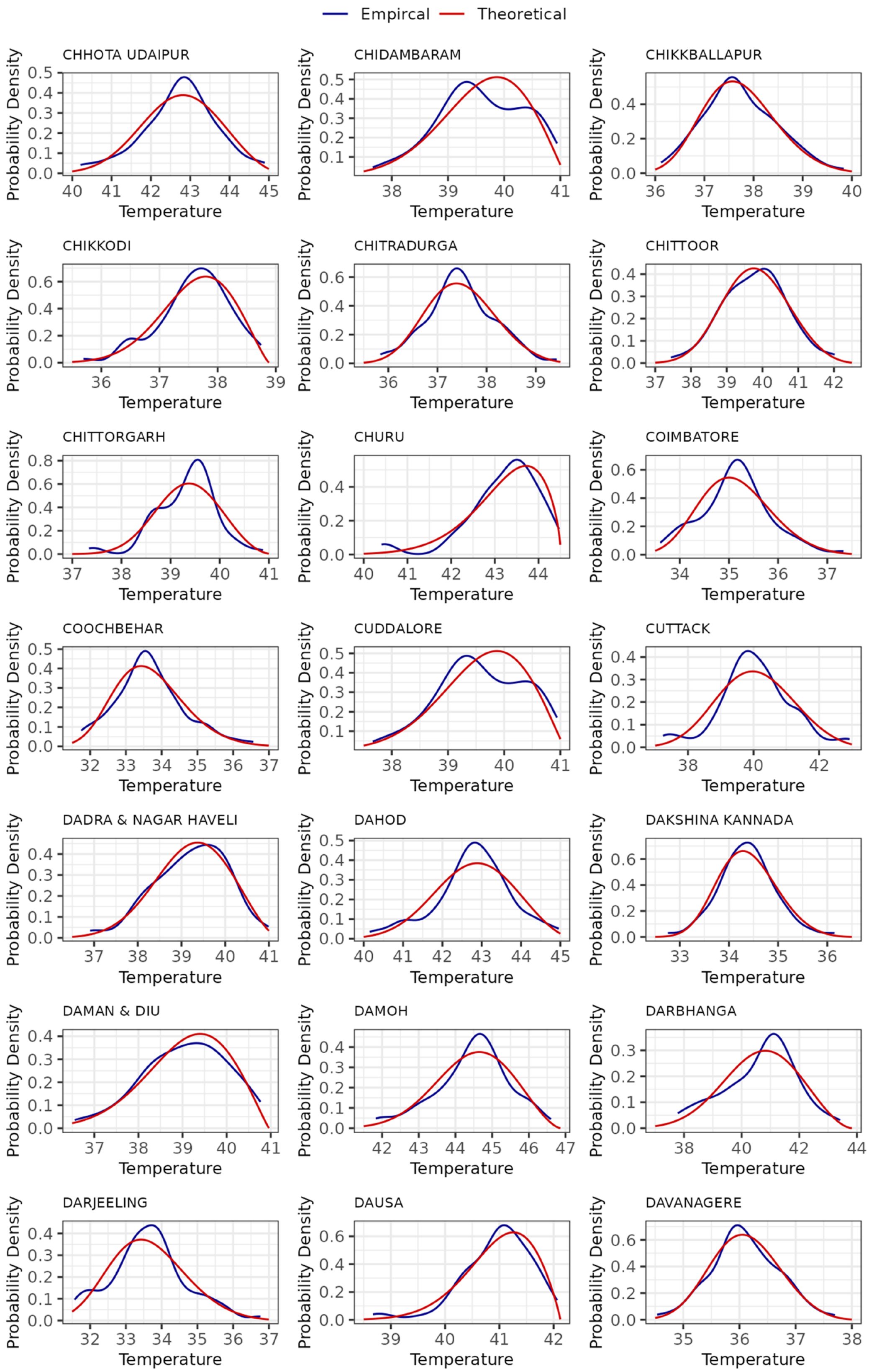


Fig. 17 Theoretical and empirical curve of extreme temperatures in microregions Chhota Udaipur, Chidambaram, Chikkballapur, Chikkodi, Chitradurga, Chittoor, Chittorgarh, Churu, Coimbatore, Coochbehar, Cuddalore, Cuttack, Dadra & Nagar Haveli, Dahod, Dakshina Kannada, Daman & Diu, Damoh, Darbhanga, Darjeeling, Dausa, Davanagere

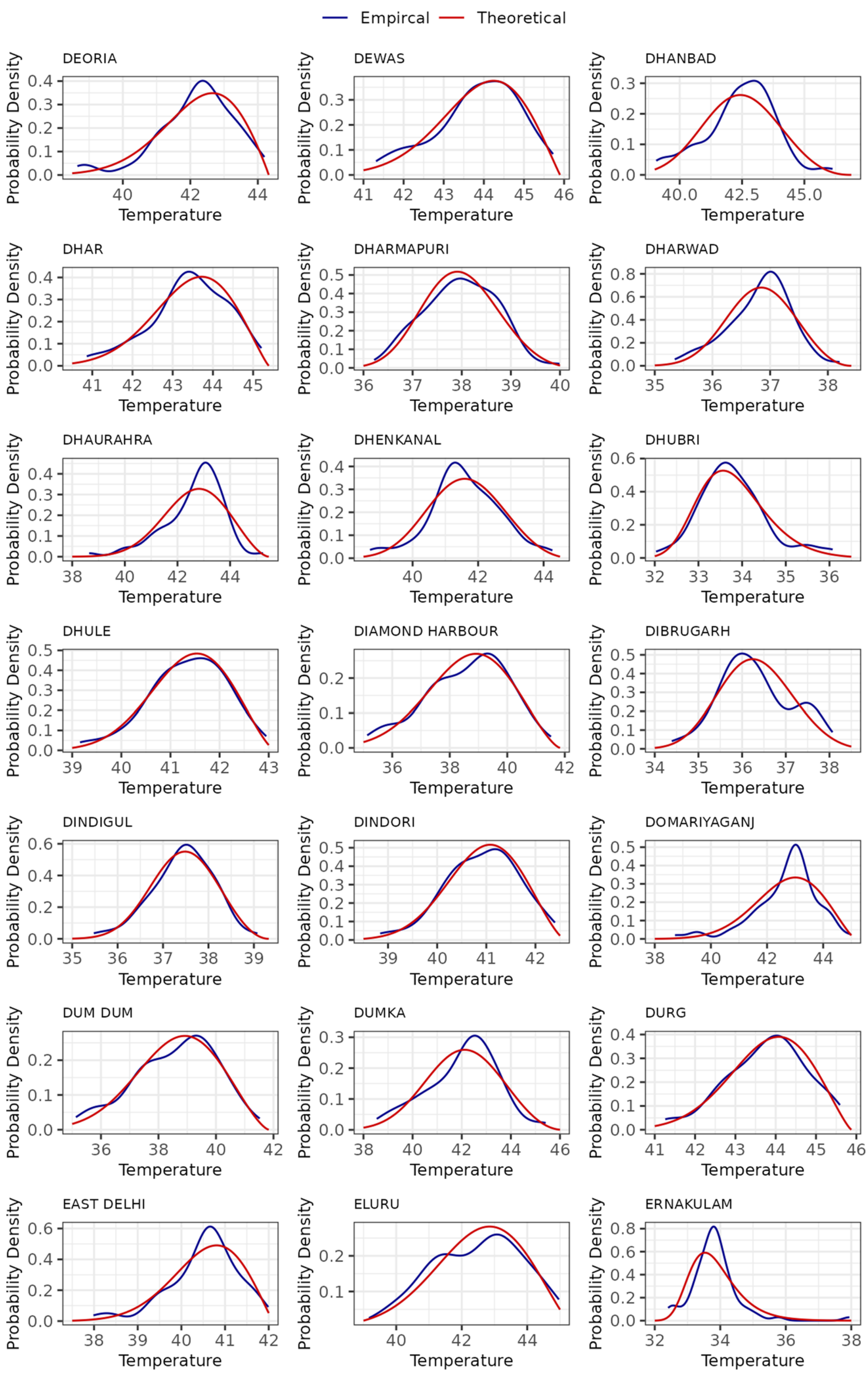


Fig. 18 Theoretical and empirical curve of extreme temperatures in microregions Deoria, Dewas, Dhanbad, Dhar, Dharmapuri, Dharwad, Dhaurahra, Dhenkanal, Dhubri, Dhule, Diamond Harbour, Dibrugarh, Dindigul, Dindori, Domariyaganj, Dum Dum, Dumka, Durg, East Delhi, Eluru, Ernakulam

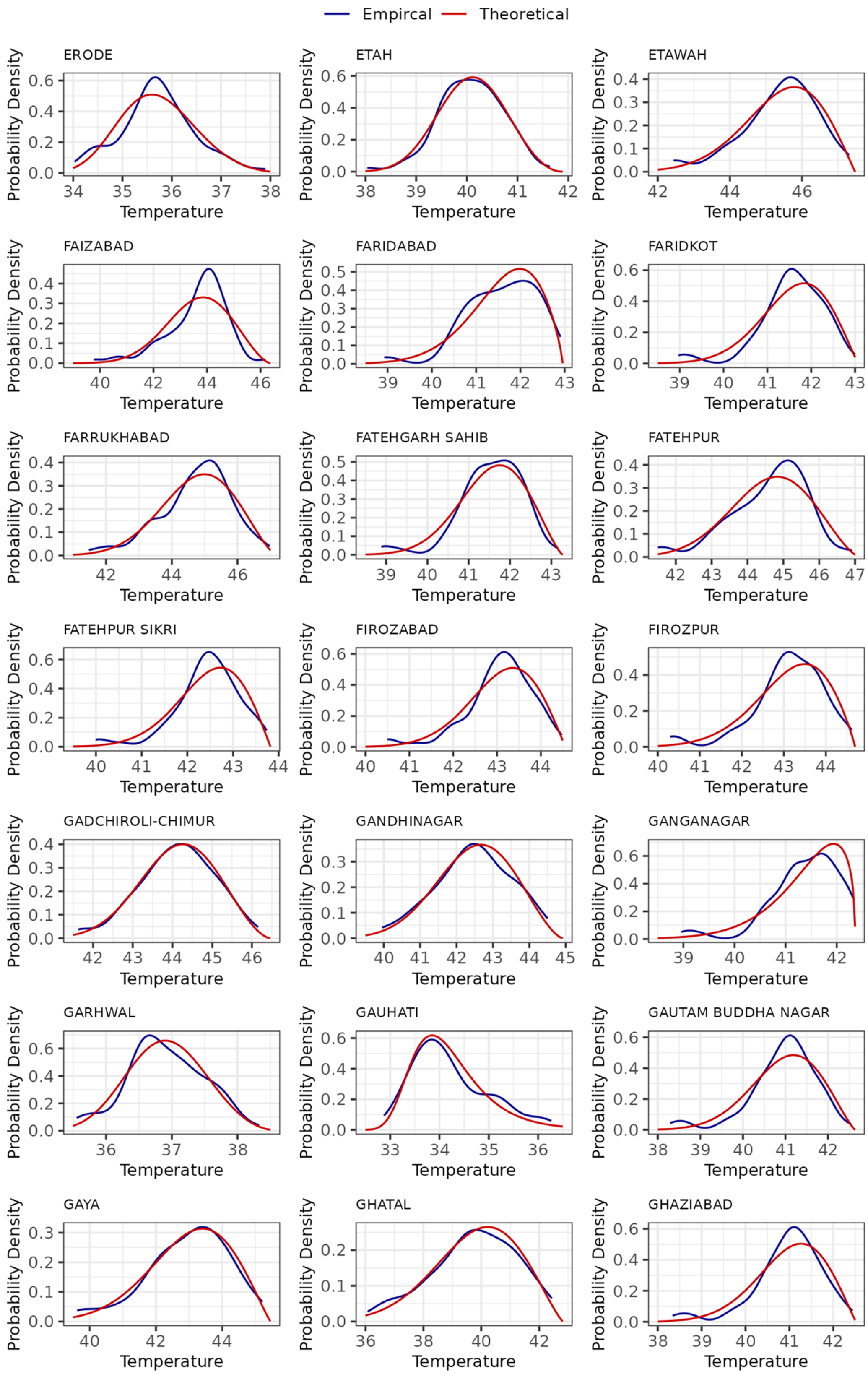


Fig. 19 Theoretical and empirical curve of extreme temperatures in microregions Erode, Etah, Etawah, Faizabad, Faridabad, Faridkot, Farrukhabad, Fatehgarh Sahib, Fatehpur, Fatehpur Sikri, Firozabad, Firozpur, Gadchiroli-Chimur, Gandhinagar, Ganganagar, Garhwal, Gauhati, Gautam Buddha Nagar, Gaya, Ghatal, Ghaziabad

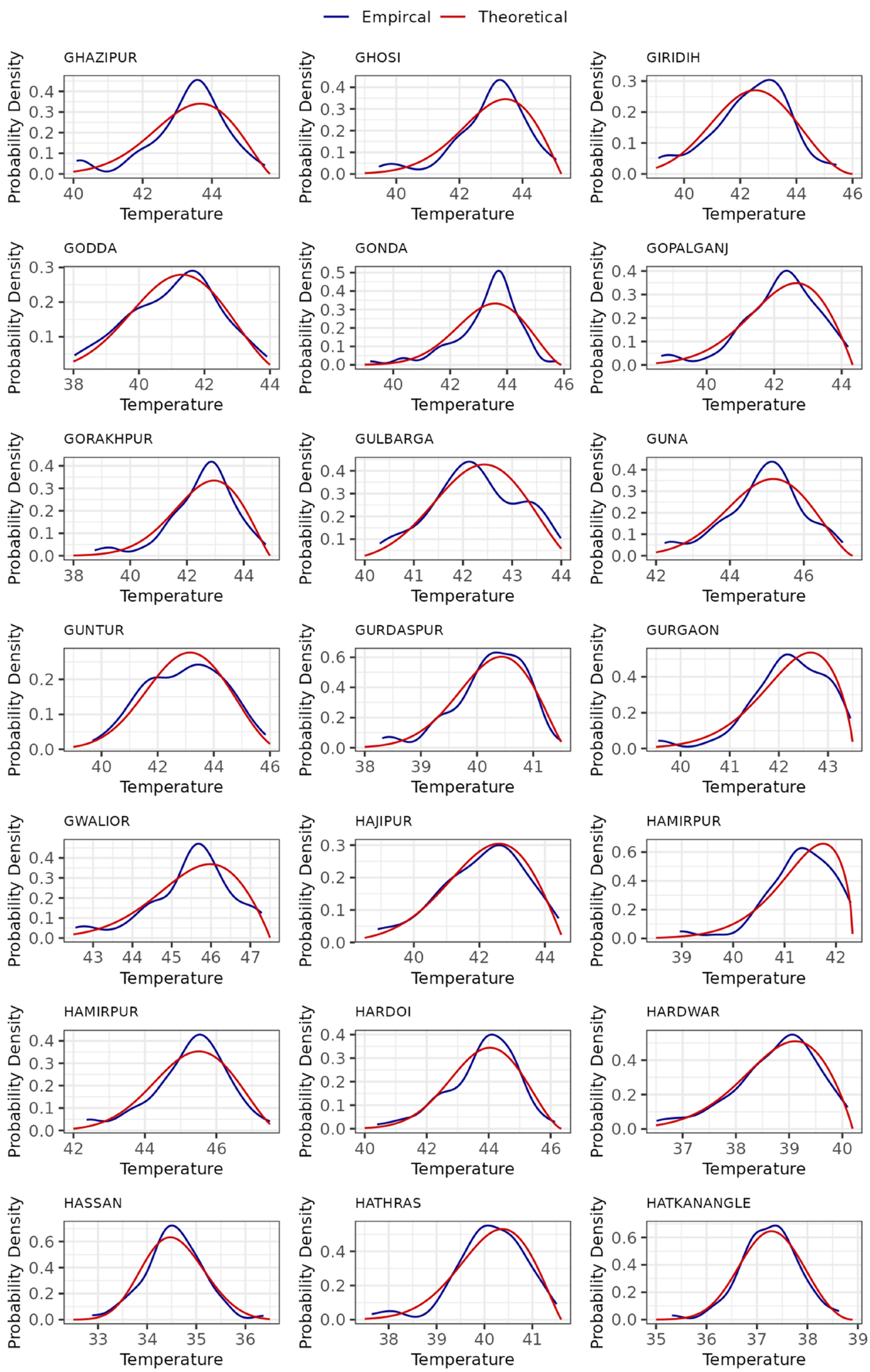


Fig. 20 Theoretical and empirical curve of extreme temperatures in microregions Ghazipur, Ghosi, Giridih, Godda, Gonda, Gopalganj, Gorakhpur, Gulbarga, Guna, Guntur, Gurdaspur, Gurgaon, Gwalior, Hajipur, Hamirpur, Hamirpur, Hardoi, Hardwar, Hassan, Hathras, Hatkanangle

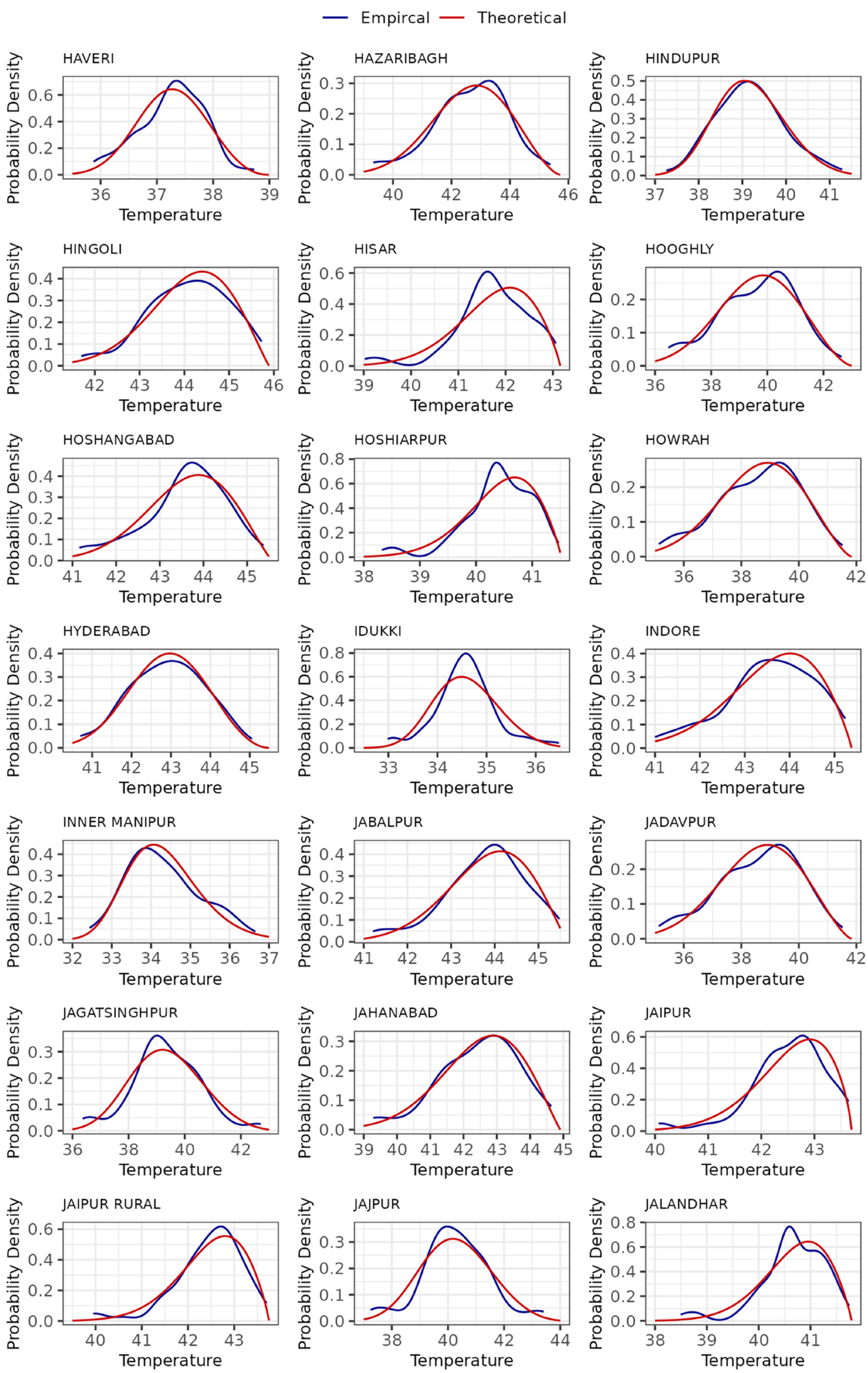


Fig. 21 Theoretical and empirical curve of extreme temperatures in microregions Haveri, Hazaribagh, Hindupur, Hingoli, Hisar, Hooghly, Hoshangabad, Hoshiarpur, Howrah, Hyderabad, Idukki, Indore, Inner Manipur, Jabalpur, Jadavpur, Jagatsinghpur, Jahanabad, Jaipur, Jaipur Rural, Jajpur, Jalandhar

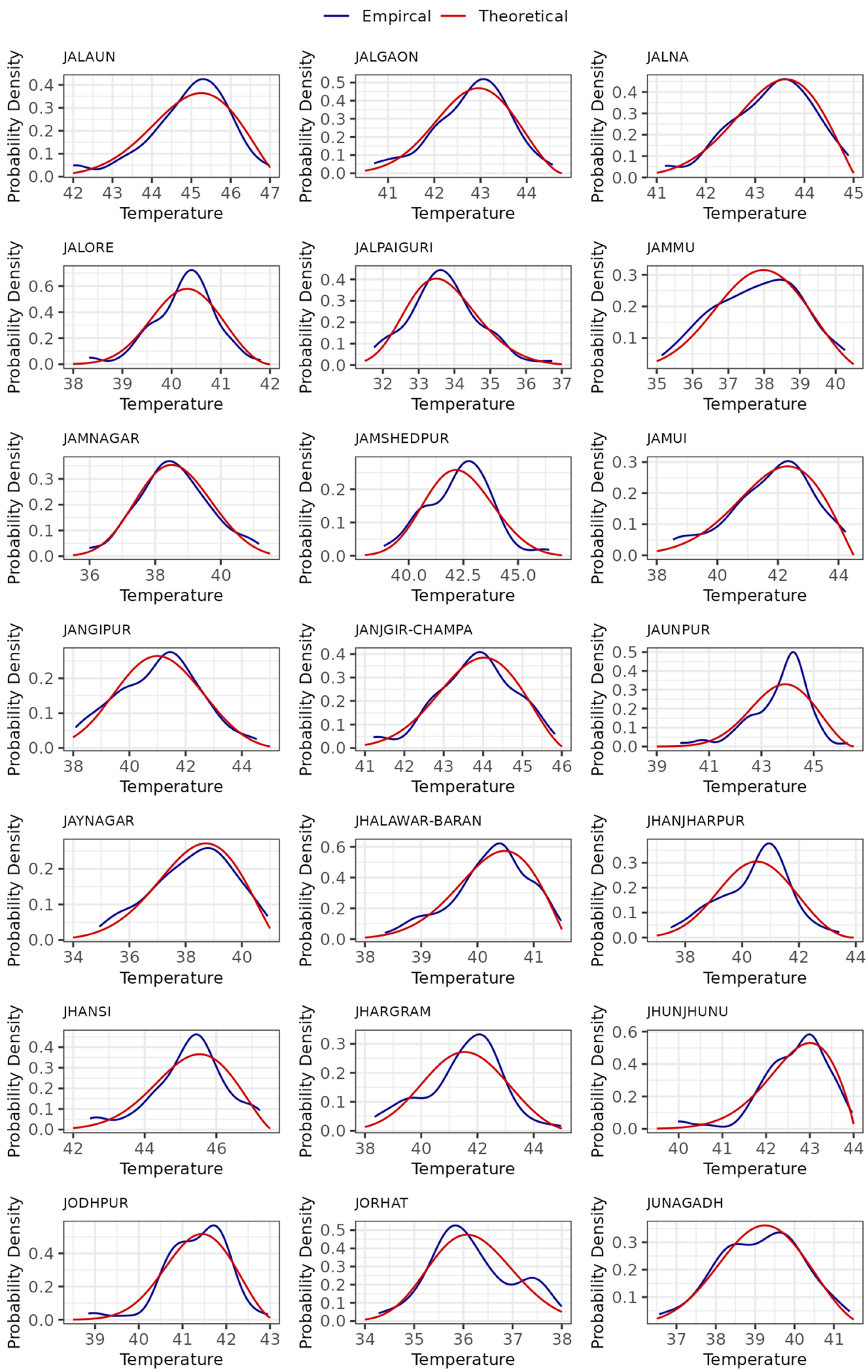


Fig. 22 Theoretical and empirical curve of extreme temperatures in microregions Jalaun, Jalgaon, Jalna, Jalore, Jalpaiguri, Jammu, Jamnagar, Jamshedpur, Jamui, Jangipur, Janjgir-Champa, Jaunpur, Jaynagar, Jhalawar-Baran, Jhanjharpur, Jhansi, Jhargram, Jhunjhunu, Jodhpur, Jorhat, Junagadh

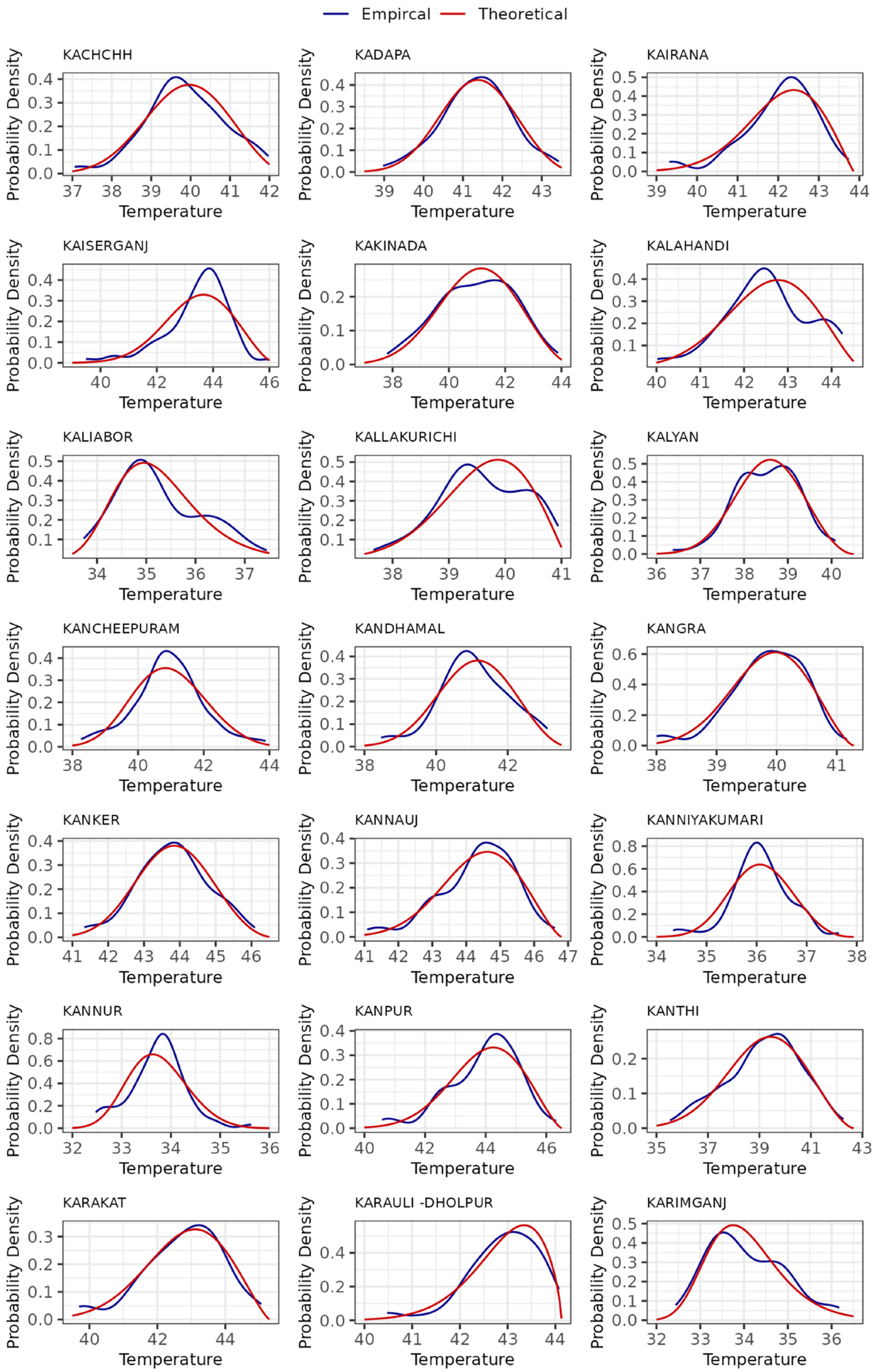


Fig. 23 Theoretical and empirical curve of extreme temperatures in microregions Kachchh, Kadapa, Kairana, Kaiserganj, Kakinada, Kalahandi, Kaliabor, Kallakurichi, Kalyan, Kancheepuram, Kandhamal, Kangra, Kanker, Kannauj, Kanniyakumari, Kannur, Kanpur, Kanthi, Karakat, Karauli -Dholpur, Karimganj

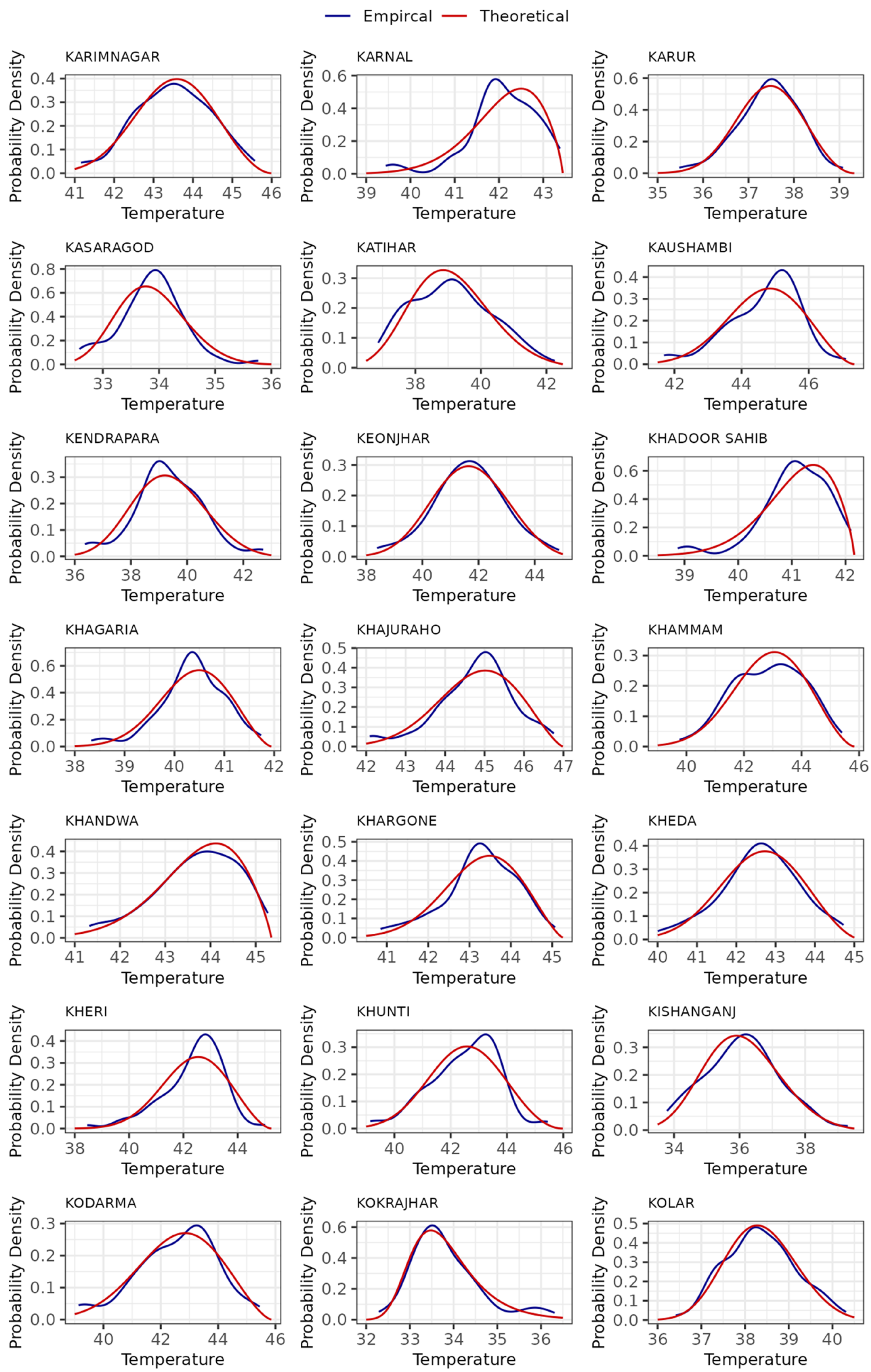


Fig. 24 Theoretical and empirical curve of extreme temperatures in microregions Karimnagar, Karnal, Karur, Kasaragod, Katihar, Kaushambi, Kendrapara, Keonjhar, Khadoor Sahib, Khagaria, Khajuraho, Khammam, Khandwa, Khargone, Kheda, Kheri, Khunti, Kishanganj, Kodarma, Kokrajhar, Kolar

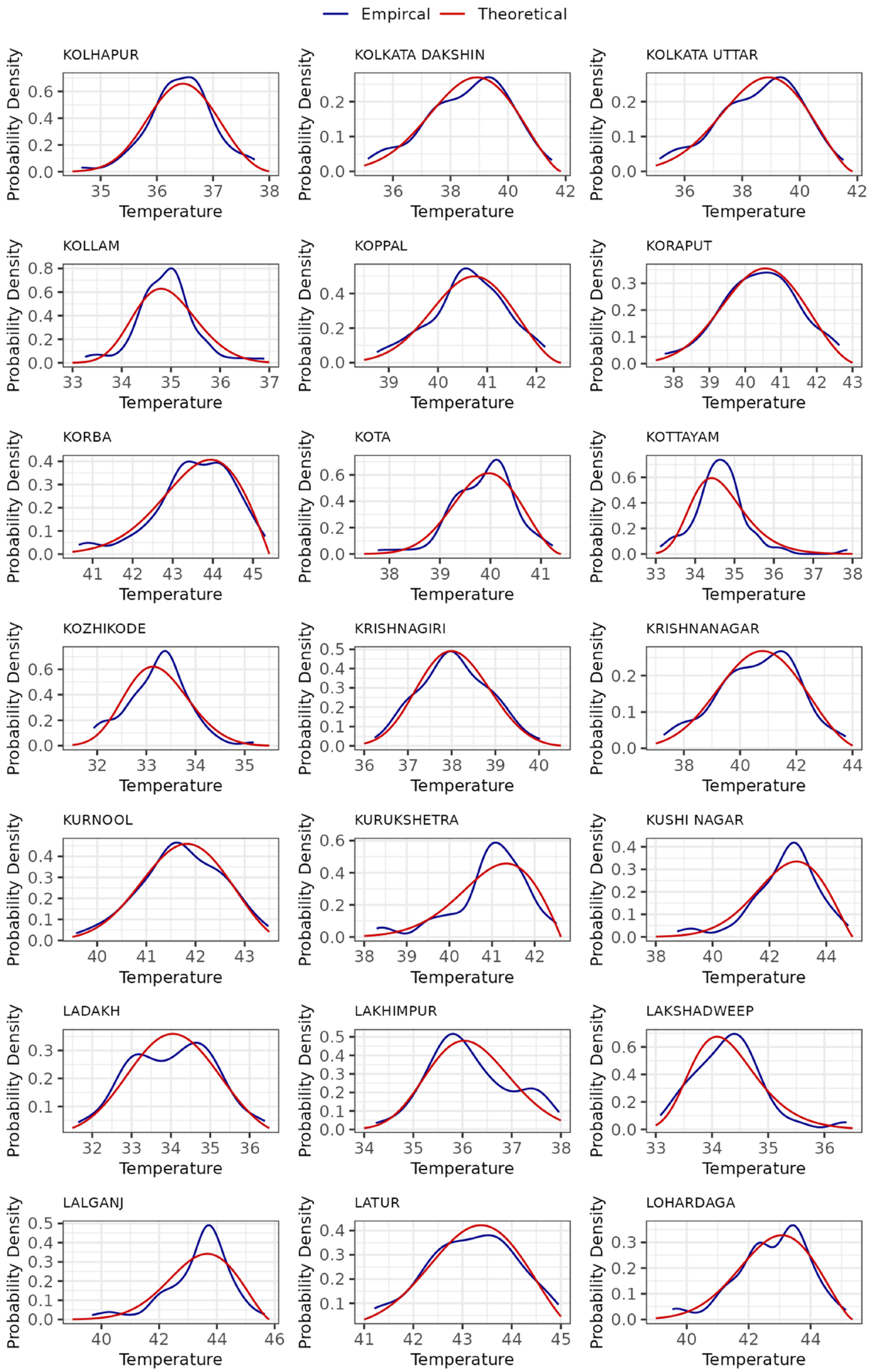


Fig. 25 Theoretical and empirical curve of extreme temperatures in microregions Kolhapur, Kolkata Dakshin, Kolkata Uttar, Kollam, Koppal, Koraput, Korba, Kota, Kottayam, Kozhikode, Krishnagiri, Krishnanagar, Kurnool, Kurukshetra, Kushi Nagar, Ladakh, Lakhimpur, Lakshadweep, Lalganj, Latur, Lohardaga

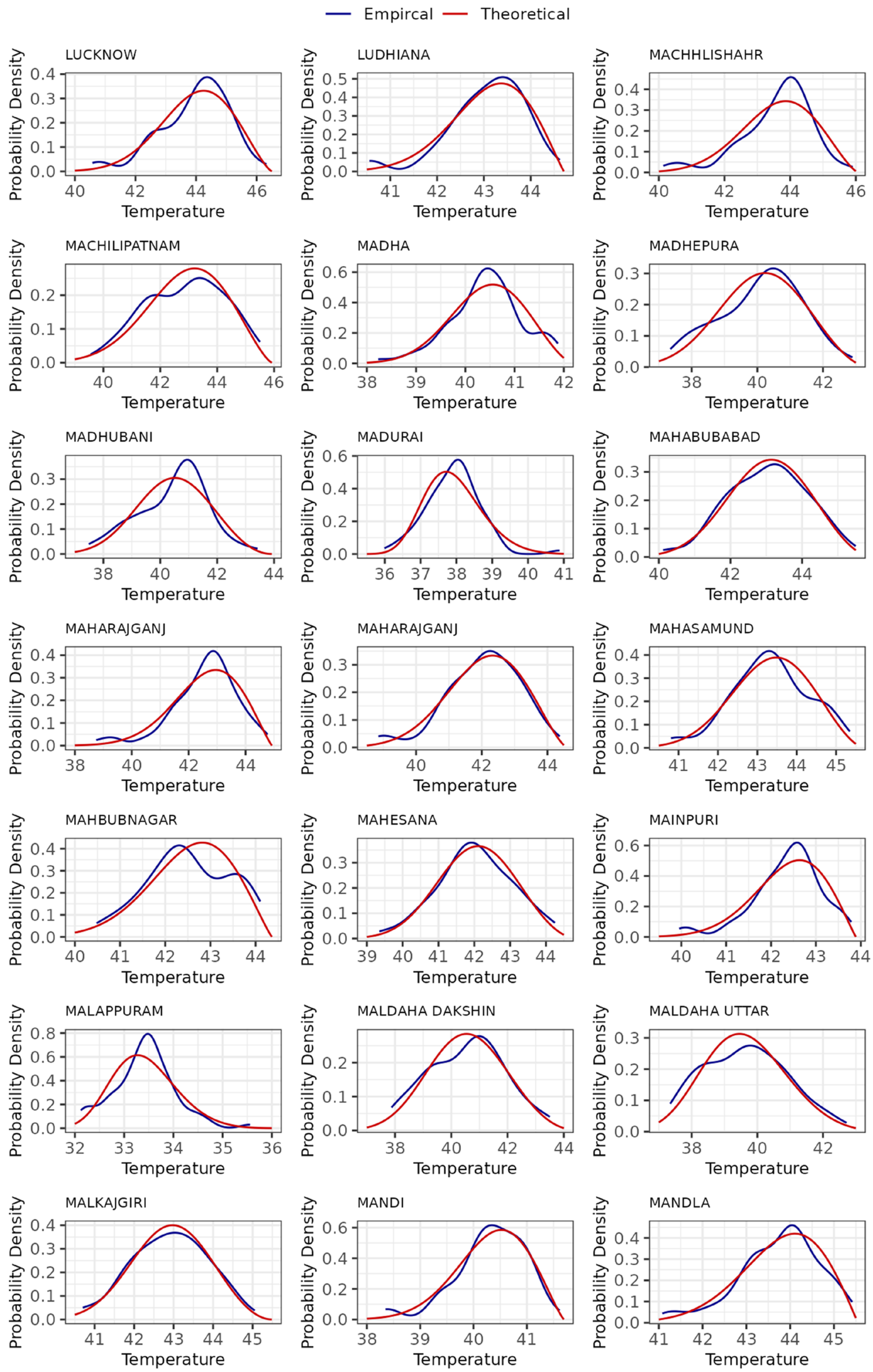


Fig. 26 Theoretical and empirical curve of extreme temperatures in microregions Lucknow, Ludhiana, Machhlishahr, Machilipatnam, Madha, Madhepura, Madhubani, Madurai, Mahabubabad, Maharajganj, Maharajganj, Mahasamund, Mahbubnagar, Mahesana, Mainpuri, Malappuram, Maldaha Dakshin, Maldaha Uttar, Malkajgiri, Mandi, Mandla

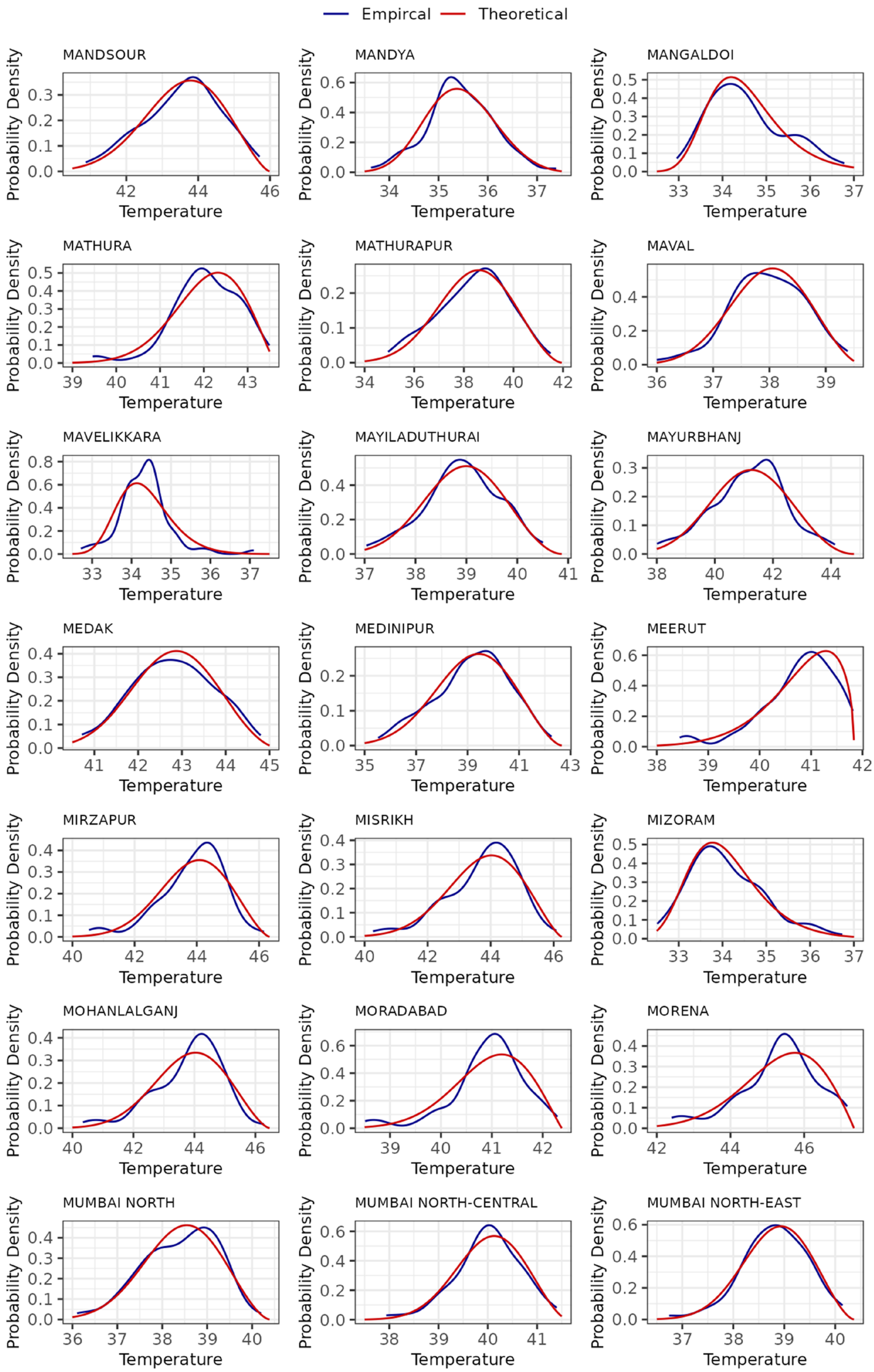


Fig. 27 Theoretical and empirical curve of extreme temperatures in microregions Mandsour, Mandya, Mangaldoi, Mathura, Mathurapur, Maval, Mavelikkara, Mayiladuthurai, Mayurbhanj, Medak, Medinipur, Meerut, Mirzapur, Misrikh, Mizoram, Mohanlalganj, Moradabad, Morena, Mumbai North, Mumbai North-Central, Mumbai North-East

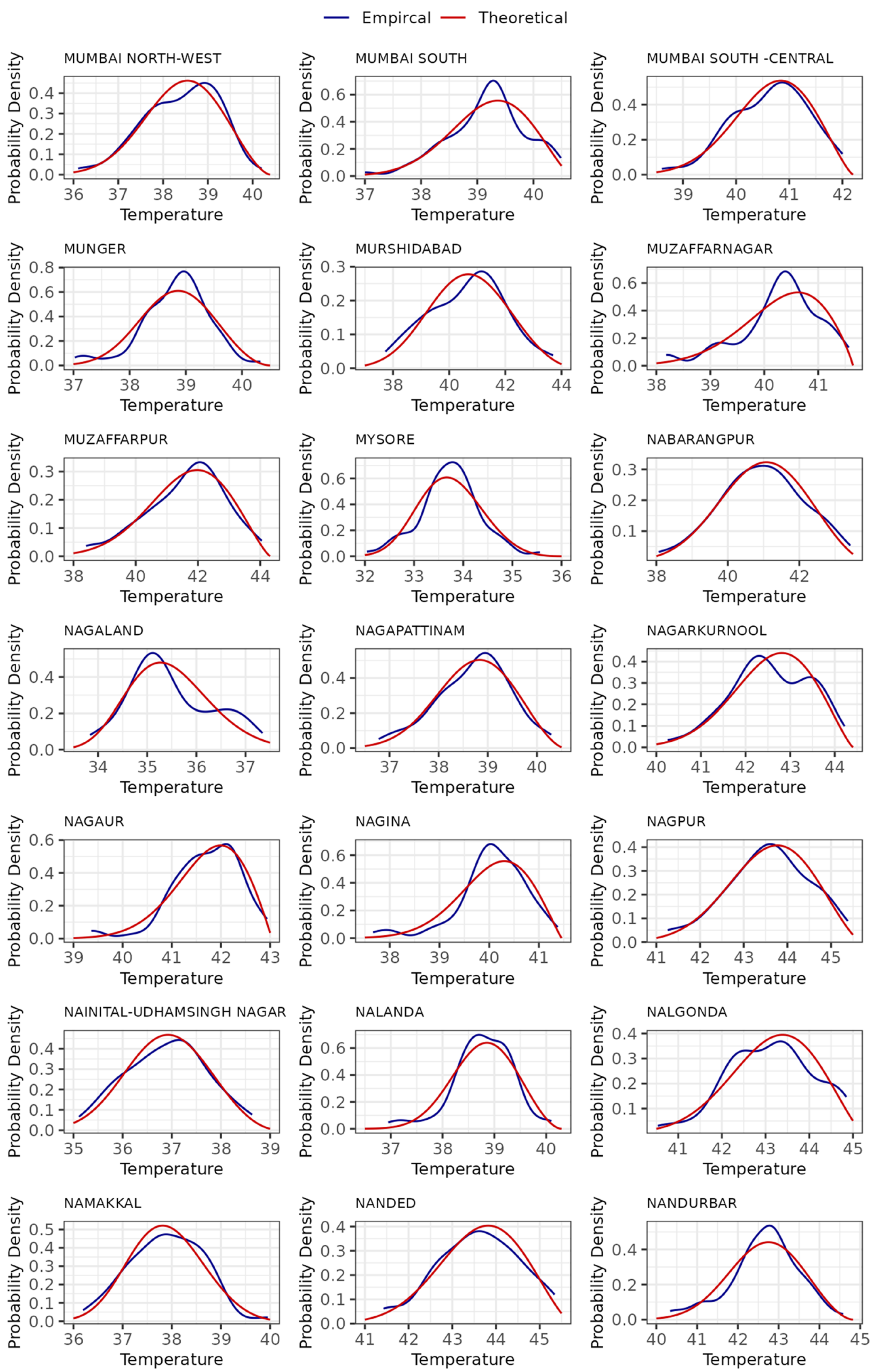


Fig. 28 Theoretical and empirical curve of extreme temperatures in microregions Mumbai North-West, Mumbai South, Mumbai South - Central, Munger, Murshidabad, Muzaffarnagar, Muzaffarpur, Mysore, Nabarangpur, Nagaland, Nagapattinam, Nagarkurnool, Nagaur, Nagina, Nagpur, Nainital-Udhamsingh Nagar, Nalanda, Nalgonda, Namakkal, Nanded, Nandurbar

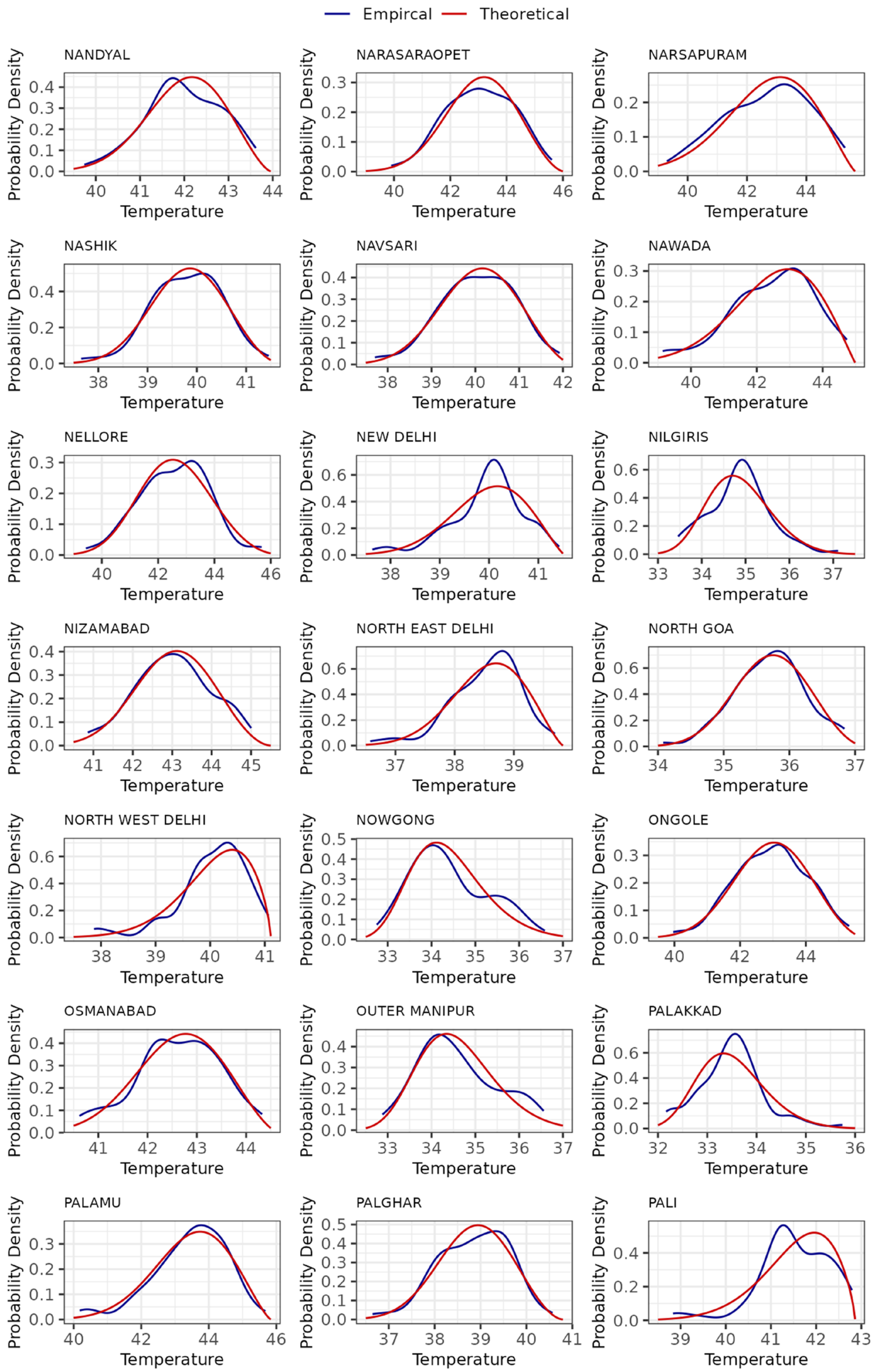


Fig. 29 Theoretical and empirical curve of extreme temperatures in microregions Nandyal, Narasaraopet, Narsapuram, Nashik, Navsari, Nawada, Nellore, New Delhi, Nilgiris, Nizamabad, North East Delhi, North Goa, North West Delhi, Nowgong, Ongole, Osmanabad, Outer Manipur , Palakkad, Palamu, Palghar, Pali

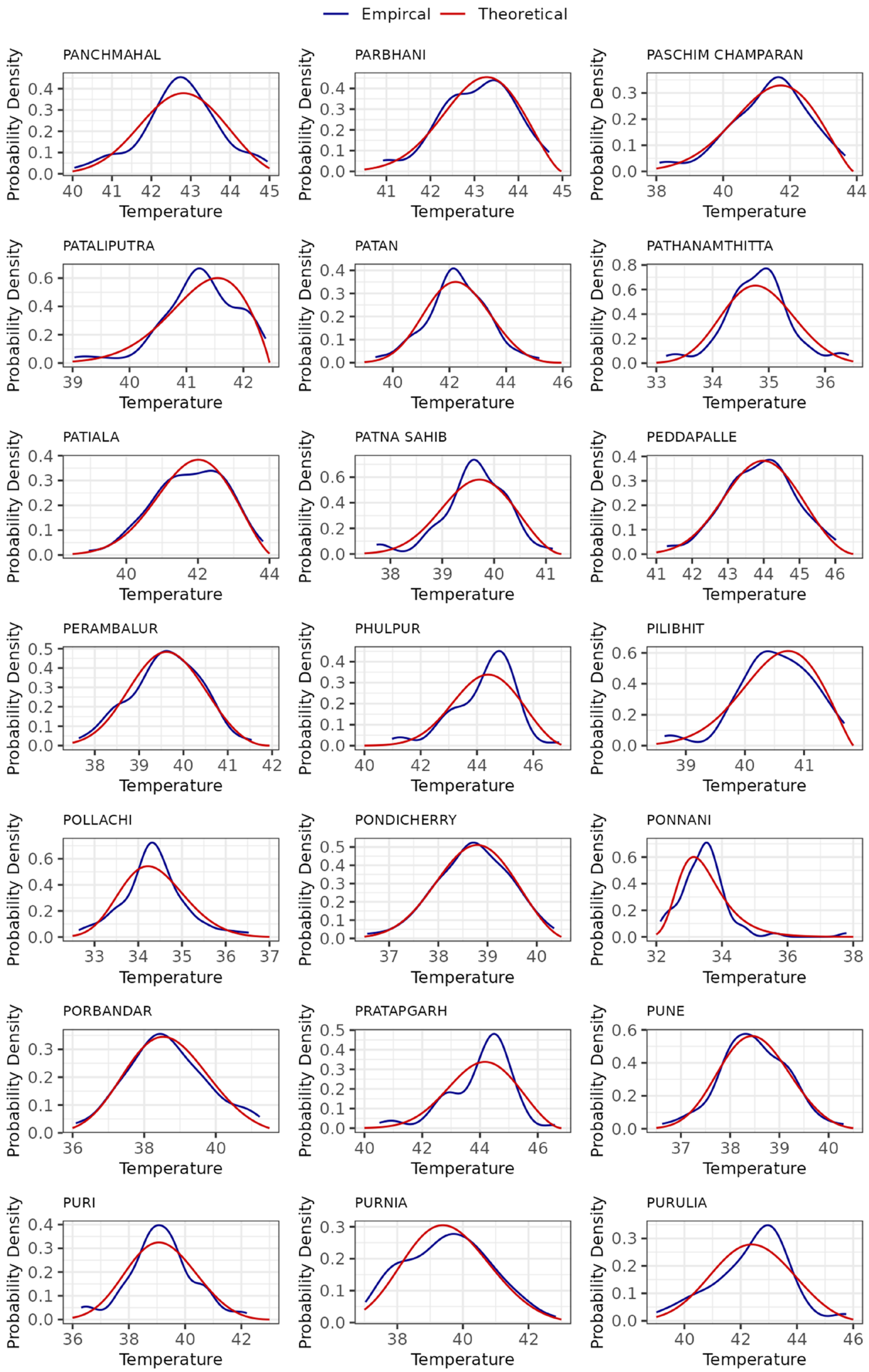


Fig. 30 Theoretical and empirical curve of extreme temperatures in microregions Panchmahal, Parbhani, Paschim Champaran, Pataliputra, Patan, Pathanamthitta, Patiala, Patna Sahib, Peddapalle, Perambalur, Phulpur, Pilibhit, Pollachi, Pondicherry, Ponnani, Porbandar, Pratapgarh, Pune, Puri, Purnia, Purulia

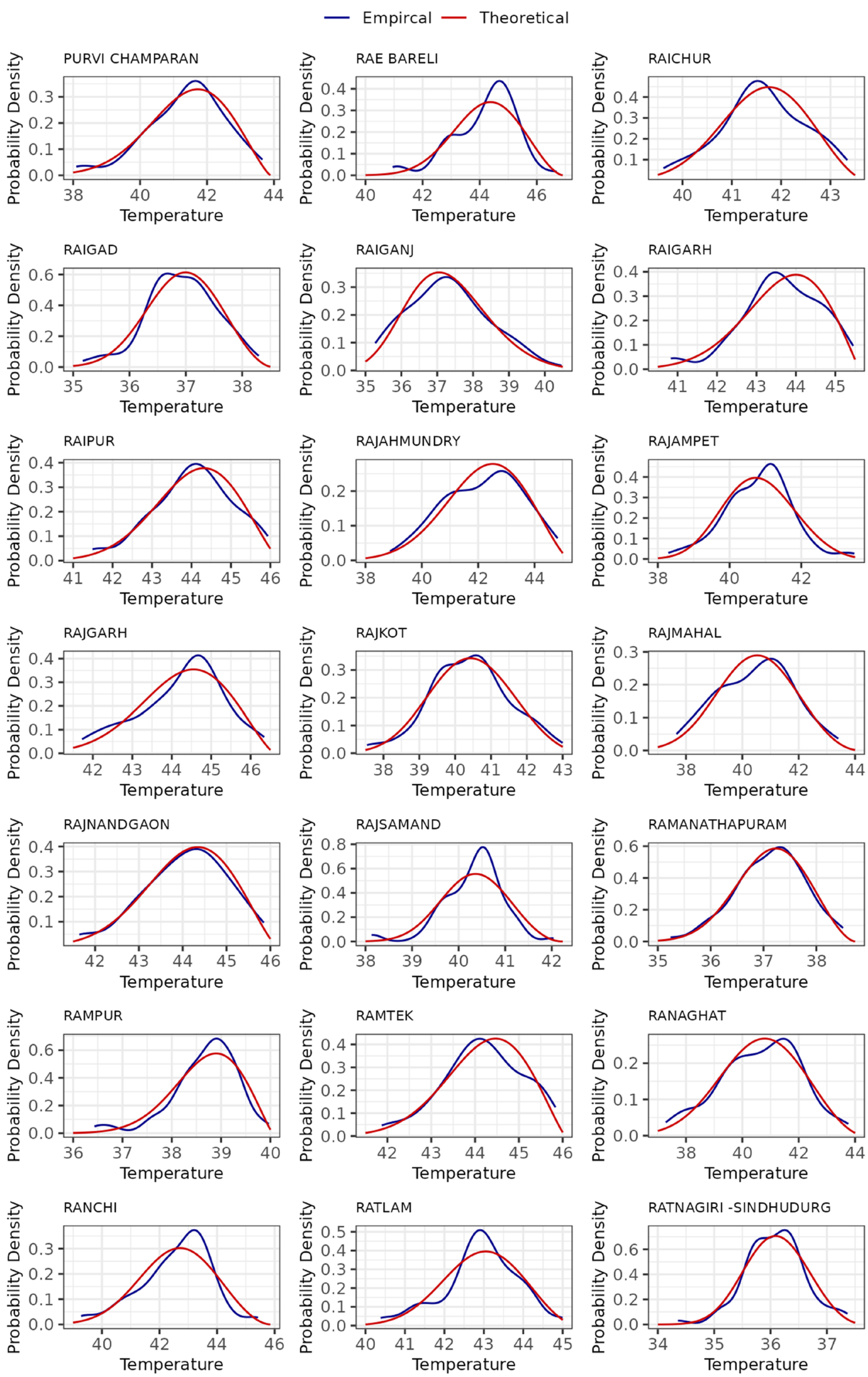


Fig. 31 Theoretical and empirical curve of extreme temperatures in microregions Purvi Champaran, Rae Bareli, Raichur, Raigad, Raiganj, Raigarh, Raipur, Rajahmundry, Rajampet, Rajgarh, Rajkot, Rajmahal, Rajnandgaon, Rajsamand, Ramanathapuram, Rampur, Ramtek, Ranaghat, Ranchi, Ratlam, Ratnagiri -Sindhudurg

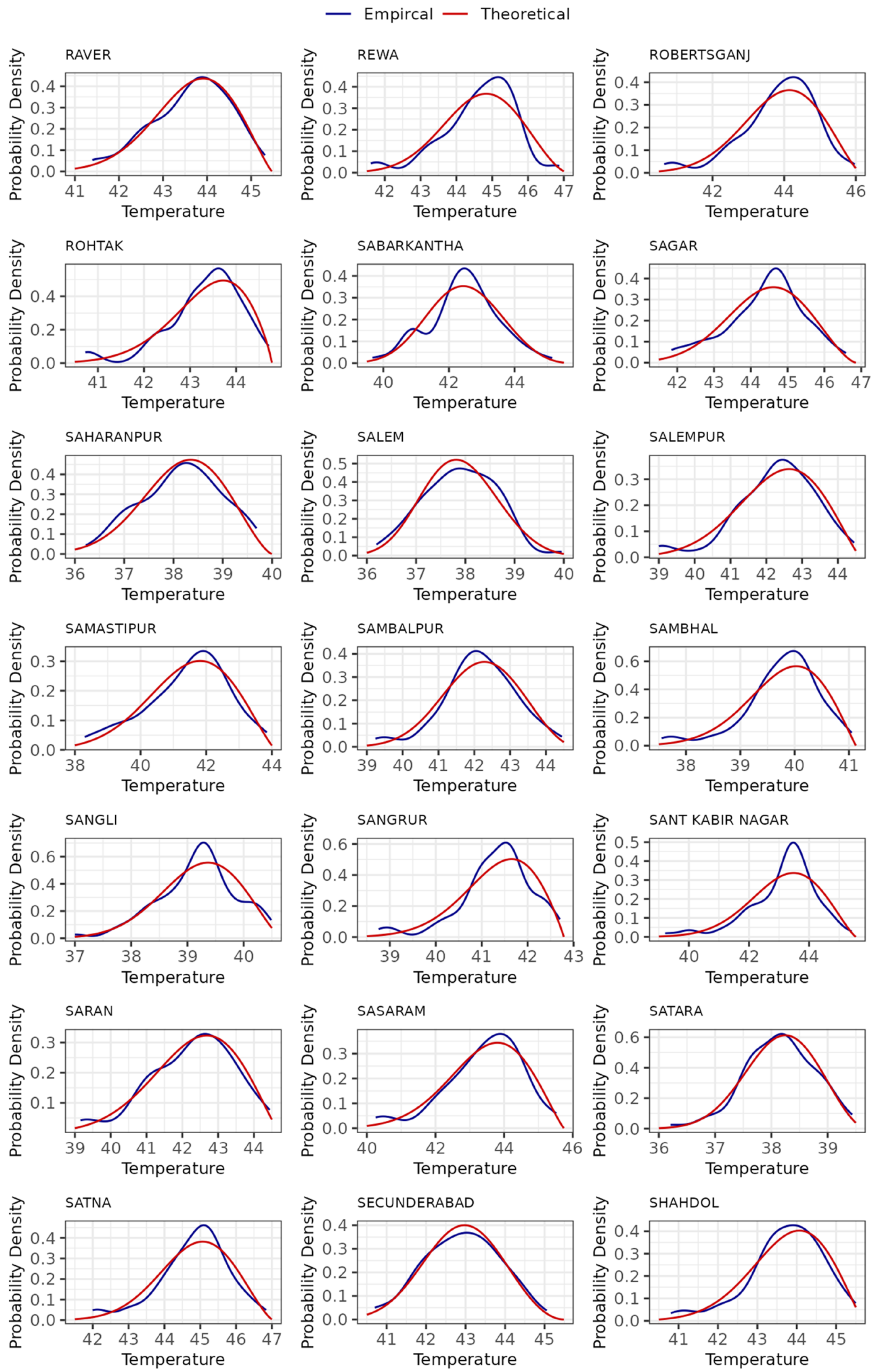


Fig. 32 Theoretical and empirical curve of extreme temperatures in microregions Raver, Rewa, Robertsganj, Rohtak, Sabarkantha, Sagar, Saharanpur, Salem, Salempur, Samastipur, Sambalpur, Sambhal, Sangli, Sangrur, Sant Kabir Nagar, Saran, Sasaram, Satara, Satna, Secunderabad, Shahdol

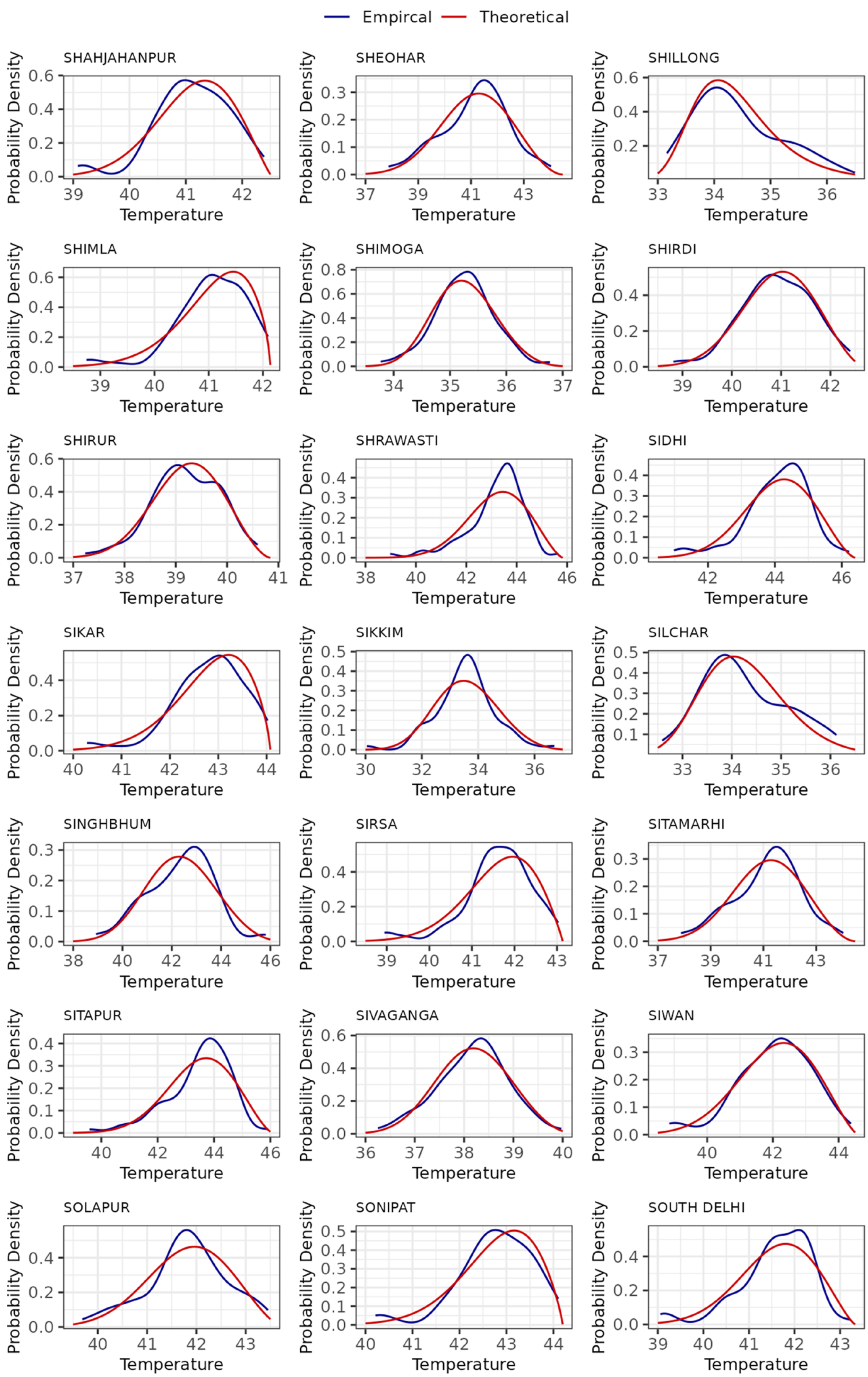


Fig. 33 Theoretical and empirical curve of extreme temperatures in microregions Shahjahanpur, Sheohar, Shillong, Shimla, Shimoga, Shirdi, Shirur, Shrawasti, Sidhi, Sikar, Sikkim, Silchar, Singhbhum, Sirsa, Sitamarhi, Sitapur, Sivaganga, Siwan, Solapur, Sonipat, South Delhi

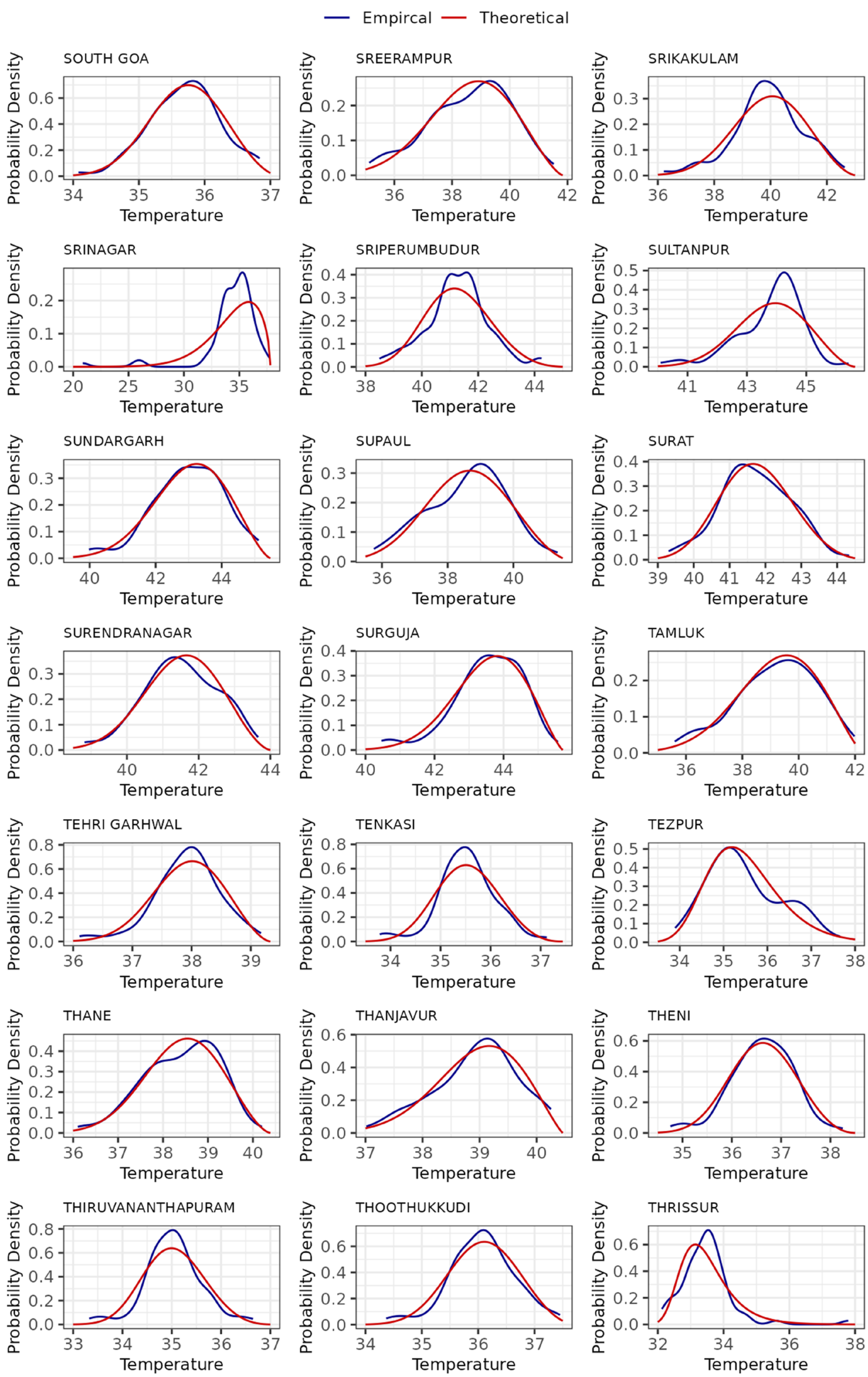


Fig. 34 Theoretical and empirical curve of extreme temperatures in microregions South Goa, Sreerampur, Srikakulam, Srinagar, Sriperumbudur, Sultanpur, Sundargarh, Supaul, Surat, Surendranagar, Surguja, Tamluk, Tehri Garhwal, Tenkasi, Tezpur, Thane, Thanjavur, Theni, Thiruvananthapuram, Thoothukkudi, Thrissur

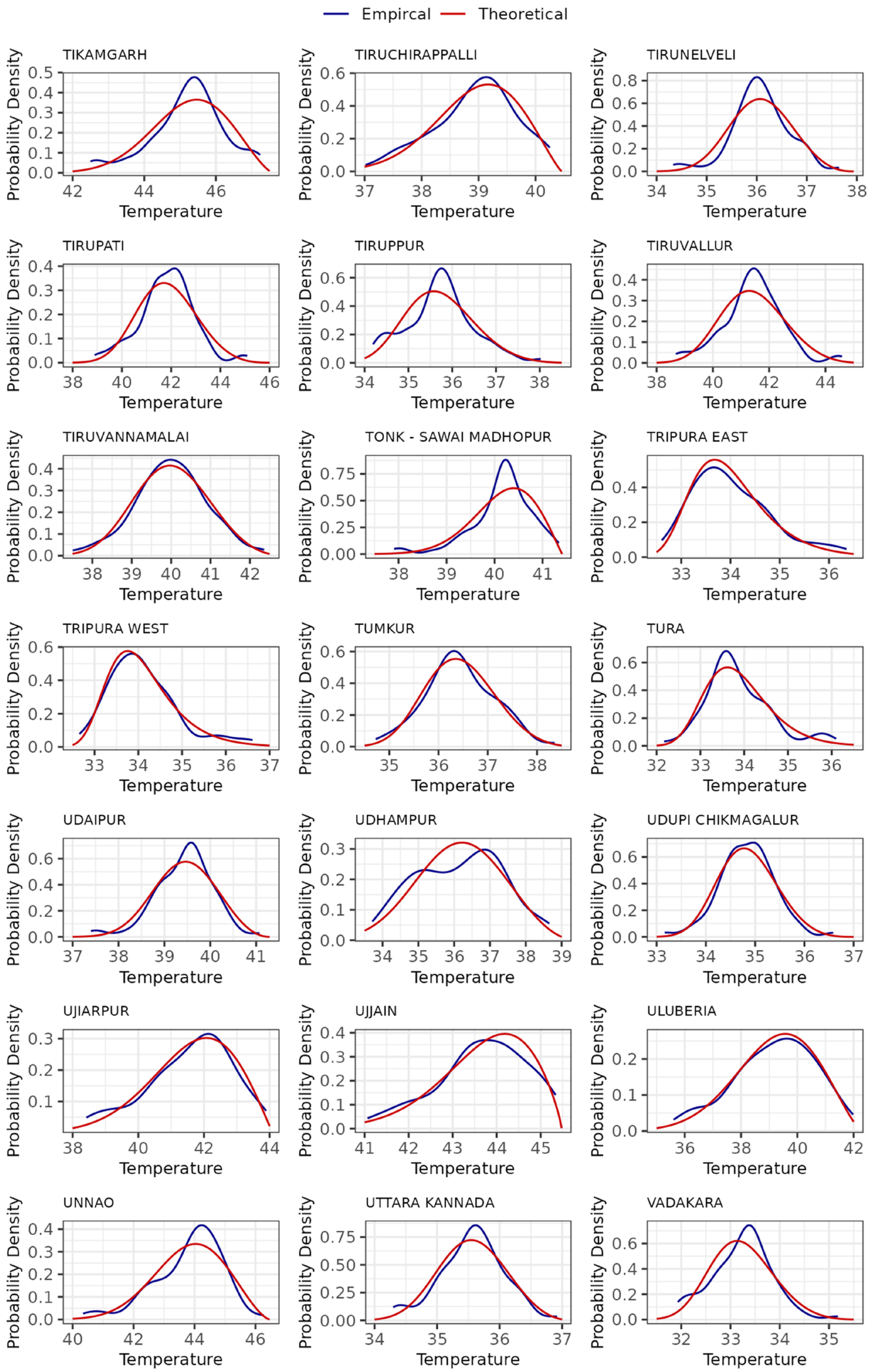


Fig. 35 Theoretical and empirical curve of extreme temperatures in microregions Tikamgarh, Tiruchirappalli, Tirunelveli, Tirupati, Tiruppur, Tiruvallur, Tiruvannamalai, Tonk - Sawai Madhopur, Tripura East, Tripura West, Tumkur, Tura, Udaipur, Udhampur, Udupi Chikmagalur, Ujiarpur, Ujjain, Uluberia, Unnao, Uttara Kannada, Vadakara

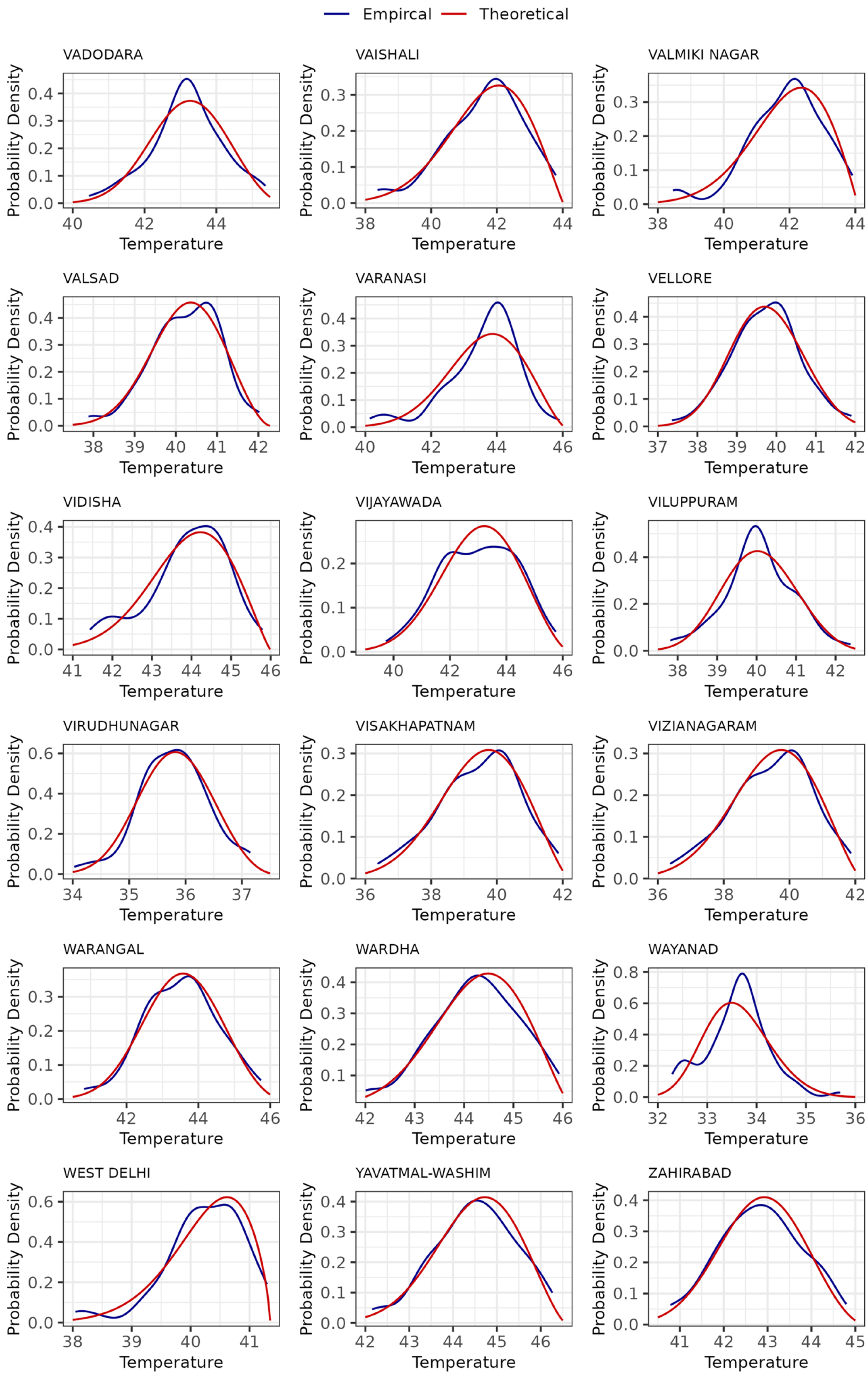


Fig. 36 Theoretical and empirical curve of extreme temperatures in microregions Vadodara, Vaishali, Valmiki Nagar, Valsad, Varanasi, Vellore, Vidisha, Vijayawada, Viluppuram, Virudhunagar, Visakhapatnam, Vizianagaram, Warangal, Wardha, Wayanad, West Delhi, Yavatmal-Washim, Zahirabad

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Availability of data and material The datasets generated during and/or analysed during the current study are available in Supplementary Material.

Code availability Not applicable.

Declarations

Ethics All authors have addressed the Ethics requirements and standards.

Consent to participate All authors consent to participate.

Consent for publication All authors consent for publication.

Competing interests The authors declare no competing interests.

References

Attri SD, Rathore L (2003) Simulation of impact of projected climate change on wheat in India. Int J Climatol 23:693–705. https://doi.org/10.1002/joc.896

Bivand R, Keitt T, Rowlingson B (2021) Rgdal: bindings for the 'Geospatial' data abstraction library. R package version 1.5-27. https://CRAN.R-project.org/package=rgdal

Chernoff H, Lehmann EL (1954) The use of maximum likelihood estimates in χ^2 tests for goodness of fit. Ann Math Stat 25(3):579–586. https://doi.org/10.1214/aoms/1177728726

Coles S (2001) An introduction to statistical modeling of extreme values. Springer, New York

Dash SK, Mamgain A (2011) Changes in the frequency of different categories of temperature extremes in India. J Appl Meteorol Climatol 50:1842–1858. https://doi.org/10.1175/2011JAMC2687.1

Driouech F, Elrhaz K, Moufouma-Okia W, Arjdal K, Balhane S (2020) Assessing future changes of climate extreme events in the CORDEX-MENA region using regional climate model ALADIN-climate. Earth Syst Environ 4:477–492. https://doi.org/10.1007/s41748-020-00169-3

Dube R, Rao GP (2005) Extreme weather events over India in the last 100 years, vol 9

Fisher RA, Tippett LHC (1928) Limiting forms of the frequency distribution of the largest or smallest member of a sample. Math Proc Camb Philos Soc 24:180–190. https://doi.org/10.1017/S0305004100015681

Gençay R, Selçuk F (2004) Extreme value theory and value-at-risk: relative performance in emerging markets. Int J Forecast 20:287–303. https://doi.org/10.1016/j.ijforecast.2003.09.005

Gnedenko B (1943) Sur la distribution limite du terme maximum d'une serie aleatoire. Ann Math 44:423–453. https://doi.org/10.2307/1968974

Gumbel EJ (1958) Statistical theory of extreme values and some practical applications: a series of lectures. U. S. Govt. Print Office, Illinois. https://books.google.com.br/books?id=R8kCH9CIJrAC

Heffernan JE, Stephenson AG (2018) Ismev: an introduction to statistical modeling of extreme values. R package version 1.42. https://CRAN.R-project.org/package=ismev

Kjellstrom T, Kovats S, Lloyd S, Holt T, Tol R (2009) The direct impact of climate change on regional labor productivity. Arch Environ Occup Health 64:217–27. https://doi.org/10.1080/19338240903352776

McNeil A, Zentrum E (1999) Extreme value theory for risk managers. Economics

Monte-mor DS, Sanfins MAdS, Nossa SNN, Teixeira AJCT (2014) Aplicação da teoria de valores extremos e da análise fundamentalista em estratégias long-short: Uma análise de pair tradings do mercado brasileiro. Rev de Educação e Pesquisa em Contabilidade (REPeC) 8:271–288. https://doi.org/10.17524/repec.v8i3.1109

Mugambiwa S, Rukema J (2019) Rethinking indigenous climate governance through climate change and variability discourse by a Zimbabwean rural community. Int J Clim Chang Strateg Manag 11:730–743. https://doi.org/10.1108/IJCCSM-11-2018-0074

Murthy VK, Gafarian AV (1970) Limiting distributions of some variations of the chi-square statistic. Ann Math Stat 41(1):188–194. https://doi.org/10.1214/aoms/1177697199

Nagaveni PL, Anand A (2017) Climate change and its impact on India: a comment. NLUO Law J, 81–97. https://doi.org/10.2139/ssrn.3830209

Núnez-Galeano L, Giraldo-Osorio JD (2016) Adaptation of the L-moments method for the regionalization for maximum annual temperatures in Colombia. Ingenieria y Universidad 20:373–389. https://doi.org/10.11144/Javeriana.iyu20-2.almr

Olivier R, Hanqiang C (2012) Nearest neighbor value interpolation. Int J Adv Comput Sci Appl, 3. https://doi.org/10.14569/ijacsa.2012.030405

Pai D, Thapliyal V, Kokate D (2004) Decadal variation in the heat and cold waves over India during 1971-2000. Mausam 53:281–292. https://doi.org/10.54302/mausam.v55i2.1083

Pingale DS, Khare D, Jat M, Adamowski J (2013) Spatial and temporal trends of mean and extreme rainfall and temperature for the 33 urban centres of the arid and semi-arid state of Rajasthan, India. Atmos Res 138:73–90. https://doi.org/10.1016/j.atmosres.2013.10.024

Rusticucci M, Tencer B (2008) Observed changes in return values of annual temperature extremes over Argentina. J Climate 21:5455–5467. https://doi.org/10.1175/2008JCLI2190.1

Satyanarayana GC, Rao DVB (2020) Phenology of heat waves over India. Atmos Res 245:105078. https://doi.org/10.1016/j.atmosres.2020.105078

Seneviratne S, Nicholls N, Easterling D, Goodess C, Kanae S, Kossin J, Luo Y, Marengo J, Mcinnes K, Rahimi M, Reichstein M, Sorteberg A, Vera C, Zhang X (2012) Changes in climate extremes and their impacts on the natural physical environment: an overview of the IPCC SREX report. Cambridge University Press, Cambridge, p 12566

Simmons AJ, Willett KM, Jones PD, Thorne PW, Dee DP (2010) Low-frequency variations in surface atmospheric humidity, temperature, and precipitation: inferences from reanalyses and monthly gridded observational data sets. J Geophys Res Atmos 115:1–21. https://doi.org/10.1029/2009JD012442

Team RC (2021) R: a language and environment for statistical computing. R version 4.0.3. R Foundation for Statistical Computing, Vienna, Austria. R Foundation for Statistical Computing https://www.R-project.org/

Tita SW, Oghogho I, Adebayo A, Odikayor D, Essien M (2009) Human body resistance and temperature measurement device. Adv Mater Res 62-64:153–158. https://doi.org/10.4028/www.scientific.net/AMR.62-64.153

Wickham H (2016) Ggplot2: Elegant graphics for data analysis. R package version 3.3.5. Springer, New York. https://ggplot2.tidyverse.org

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