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## Wavelet Analysis of Average Monthly Temperature New Delhi 1931-2021 and Forecast until 2110

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### ABSTRACT

The identification method in the CurveExpert-1.40 software environment revealed asymmetric wavelets of changes in the average monthly temperature of New Delhi from 1931 to 2021. The maximum increment for 80 years of the average monthly temperature of 5.1 °C was in March 2010. An analysis of the wave patterns of the dynamics of the average monthly temperature up to 2110 was carried out. For forecasting, formulas were adopted containing four components, among which the second component is the critical heat wave of India. The first component is the Mandelbrot law (in physics). It shows the natural trend of decreasing temperature. The second component increases according to the critical law. The third component with a correlation coefficient of 0.9522 has an annual fluctuation cycle. The fourth component with a semi-annual cycle shows the influence of vegetation cover. The warming level of 2010 will repeat again in 2035-2040. From 2040 the temperature will rise steadily. June is the hottest month. At the same time, the maximum temperature of 35.1 °C in 2010 in June will again reach by 2076. But according to the second component of the heat wave, the temperature will rise from 0.54 °C to 16.29 °C. The annual and semi-annual cycles had an insignificant effect on the June temperature dynamics. Thus, the identification method on the example of meteorological observations in New Delhi made it possible to obtain summary models containing a different number of components. The temperature at a height of 2 m is insufficient. On the surface, according to space measurements, the temperature reaches 55 °C. As a result, in order to identify more accurate asymmetric wavelets for forecasting, the results of satellite measurements of the surface temperature of India at various geographical locations of meteorological stations are additionally required.

**Keywords:** New Delhi; Average monthly temperature; Waves of behavior; 1931-2021; Sum of wavelets; Verification; Forecasts up to 2110

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**ARTICLE INFO**

Received: 31 January 2023 | Revised: 20 February 2023 | Accepted: 22 February 2023 | Published Online: 28 February 2023

DOI: <https://doi.org/10.30564/jasr.v6i2.5447>

**CITATION**

Mazurkin, P., 2023. Wavelet Analysis of Average Monthly Temperature New Delhi 1931-2021 and Forecast until 2110. Journal of Atmospheric Science Research. 6(2): 1-20. DOI: <https://doi.org/10.30564/jasr.v6i2.5447>

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## 1. Introduction

Our opinion is that we don't understand much about climate dynamics. Contradictory climatic processes of warming or cooling occur at different points on the earth's landmass. In India, for example, due to the strong influence of the Himalayas and monsoons from the Indian Ocean, global warming is indeed observed.

There is only one reason for this—for 4000 years of the evolution of Indian civilization, rich natural forests and large swamps have completely disappeared.

The farmers of India have always been at war with the forests. They had to win land plots in the forests for crops <sup>[1]</sup>. Based on descriptive statistics from a large number of statistical samples, Kumar et al. <sup>[2]</sup> clearly conclude that deforestation is the main cause of global warming and climate change. The problem of climate change is difficult to fight because it is too late to do anything. Our opinion is that we don't understand much about climate dynamics.

By 2050, parts of India and Pakistan are predicted to experience heat waves with a probability exceeding 60% per year. The seriousness of the problem is so great, notes the Times of India (March 9), that it is proposed to consider the organization of mass "climate migration" as one of the measures.

The Indian Meteorological Department (IMD) writes in its annual report on the country's climate that 2021 was not only the fifth warmest year since 1901. But in the last decade, that is, in the period 2012-2021, it was also the warmest on record. In addition, 11 of the 15 warmest years on record were between 2007 and 2021. Rising average temperatures in India may have an increasing cascading effect on extreme weather events <sup>[3]</sup>.

Abnormally high temperatures due to heat waves can be fatal to humans and animals. Temperatures are rising across India, with a trend toward a decrease in the frequency of cold waves <sup>[4]</sup>.

The climate of India due to the relief is very diverse. Four types of it are distinguished on the territory: Dry tropical, humid tropical, subequatorial monsoon and high mountain. In the north, the

Himalayas fence off the cold Asian winds, and in the northwest, a significant territory is occupied by the Thar Desert, which attracts warm, humid monsoons. Monsoons determine the characteristics of the climate throughout India <sup>[5]</sup>.

Time series of global or regional surface air temperatures are important for climate change studies <sup>[6]</sup>. At the same time, the sun heats the earth's surface unevenly. The equator receives more heat, the poles of the planet are smaller. As a result, the temperature gradient is one of the main forces that drive the ocean and the atmosphere of the planet. In the tropics, the climate system receives energy, and in temperate and polar latitudes it gives it away <sup>[7]</sup>.

The energy of solar radiation absorbed by the earth's surface, as well as the thermal radiation of the earth's surface itself from the inside, is ejected into space through the atmospheric transparency window, the ejection depends on variations in the area of cloud cover. However <sup>[8]</sup>, an increase in the area of cloud cover in the lower layers of the atmosphere will simultaneously lead to both a decrease and an increase in temperature. Because of this, the energy balance of the earth before and after an increase in the area of cloudiness by 2% will remain almost at a zero level.

To understand long-term climate fluctuations, Bhargawa and Singh <sup>[3]</sup> analyzed data over a period of 40 years (1978-2018) on 10 climatic parameters that affect climate dynamics. The results showed that the strongest global climate change occurred by the end of 2018 compared to natural variability in the late 1970s.

According to Slama <sup>[10]</sup>, global warming is still considered to be related to the cause of CO<sub>2</sub> emissions. Directly and at the same time instantly affecting the heating of the surrounding air is the heat released by fossil fuels. Anthropogenic heat is estimated at 17415 1010 kWh/year; this heat causes an increase in temperature by an average of 0.122 °C per year, or 12.2 °C per century.

In the article <sup>[11]</sup> Ullah et al. note that mountain ecosystems are considered sensitive indicators of global warming; even small variations in tempera-

ture can lead to significant shifts in the local climate. The main causes are greenhouse gases and deforestation. Appropriate policies are needed to conserve forests, wildlife, prevent hunting, control pollution, increase plantations, awareness, control regional climate change, etc.

The purpose of the article is to identify asymmetric wavelets of the average monthly temperature in New Delhi from 1931 to 2021 by the identification method <sup>[8-12]</sup>, then analyze the wave patterns of the climate and make tentative forecasts of the average monthly temperature until 2110.

## 2. Materials and methods

The assumption of M. Milankovich about the constancy of the albedo of the earth's surface during the interglacial periods was replaced in the article <sup>[18]</sup>. The new hypothesis assumes that anomalies in the mean annual temperature of the surface layer of the atmosphere are associated with interannual changes in the planetary albedo and thermal inertia of the earth's hydrosphere. In another article <sup>[18]</sup>, Zavalishin considered two hypotheses of modern warming on the planet: natural and anthropogenic. The work proved that the hypothesis of natural warming is much more probable than the hypothesis of warming due to anthropogenic influence. At the same time, it was shown that the displacement of the sun from the center of mass of the solar system directly affects the temperature of the surface atmosphere in various synoptic regions of Eurasia.

We will not rush to identify causal relationships in warming in India according to the New Delhi weather station, but we will show stable patterns that are revealed in the dynamics of the average monthly temperature for 1931-2021.

A series of average monthly surface temperatures according to the New Delhi meteorological station was taken from the site <http://www.pogodaiklimat.ru/history/42182.htm> (Accessed 22.04.2022).

**Table 1** gives a fragment of average monthly temperatures in New Delhi from the initial data array for identifying asymmetric wavelets.

January 1, 1931 ( $\tau=0$ ) is taken as the beginning

of the time reference (years) according to the dynamic series of average monthly temperatures. For each month of the year, its specific time is taken according to the expression (Year 1931) + month / 12. Here, the calculation of the month is taken as follows: January = 1; February = 2 etc. Then, from January 1931 to December 2021, the time has passed in 91 years, in connection with this, the indicative forecast can be made for the forecast horizon equal to the basis of the forecast according to the weather station, that is, until 2021 + 91 = 2112. Our calculations were performed until 2110.

**Table 1** gives a fragment from the data array of the New Delhi meteorological station of the average monthly temperature of the surface air layer at a height of 2 m. In this complete table, there are  $91 \times 12 = 1092$  values of the average monthly temperature without gaps. Then the representativeness of the dynamic series is 100%.

**Table 2** compares the warmest monthly average temperature in 91 years in 2010 with the start of registration at the New Delhi weather station in 1931 (**Figure 1**), as well as the latest 2021 with the same start.

Warming in descending order of average monthly temperature occurred in March (5.1), February (3.5), April (3.0), November (2.2), October (1.6), and May (1.6). Cooling compared to 1931 occurred in August (-0.2), July and September (-0.3), December (-0.5), June (-0.6) and January (-1.7). If the difference in average monthly temperatures in 1931 was equal to  $35.1 - 15.2 = 19.9$  °C, then in 2010 it became equal to  $34.7 - 13.7 = 21.0$  °C. At the same time, the maximum shifted from June 1931 to May 2010.

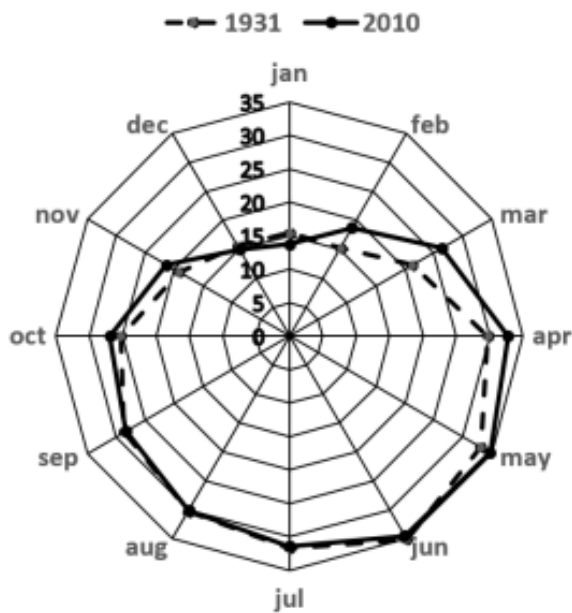
However, in 2021, the maximum average monthly temperature returned again, as in 1931, to the month of June. As can be seen from the data in **Table 2**, in 2010 the temperature maximum shifted to May. At the same time, the difference in the average monthly temperature in June 2021, compared to January, became equal to  $32.4 - 12.9 = 19.5$  °C. Such a drop in 1931 was equal to  $35.1 - 15.4 = 19.7$  °C. At the same time, in March, the temperature increase in 2010 occurred by 5.1 °C compared to 1931, and in 2021 this difference decreased to 3.8 °C.

**Table 1.** Average monthly air temperature data (°C) in New Delhi for 1931-2021.

Year	January			July			December	
	Time $\tau$	Temper. $t$	...	Time $\tau$	Temper. $t$	...	Time $\tau$	Temper. $t$
1931	0.083	15.4	...	0.583	31.7	...	1	15.5
1932	1.083	15.6	...	1.583	31.7	...	2	14.7
1933	2.083	12.3	...	2.583	29.4	...	3	15.8
...	...	...	...	...	...	...	...	...
2019	88.083	14.1	...	88.583	32.0	...	89	13.2
2020	89.083	13.7	...	89.583	31.5	...	90	15.2
2021	90.083	12.9	...	90.583	31.5	...	91	14.5

**Table 2.** Average monthly temperatures in New Delhi.

Month	1931	2010	$\Delta t, ^\circ\text{C}$	1931	2021	$\Delta t, ^\circ\text{C}$
Jan	15.4	13.7	-1.7	15.4	12.9	-2.5
Feb	15.2	18.7	3.5	15.2	18.6	3.4
Mar	21.2	26.3	5.1	21.2	25.0	3.8
Apr	29.7	32.7	3.0	29.7	28.6	-1.1
May	33.1	34.7	1.6	33.1	30.4	-2.7
Jun	35.1	34.5	-0.6	35.1	32.4	-2.7
Jul	31.7	31.4	-0.3	31.7	31.5	-0.2
Aug	30.3	30.1	-0.2	30.3	30.9	0.6
Sep	28.6	28.3	-0.3	28.6	29.0	0.4
Oct	25.3	26.9	1.6	25.3	26.0	0.7
Nov	19.1	21.3	2.2	19.1	18.8	-0.3
Dec	15.5	15	-0.5	15.5	14.5	-1.0



**Figure 1.** Charts of average monthly temperatures in New Delhi.

From the data of **Table 2** and **Figure 1**, it can be seen that the temperature increment sharply decreased

in May (from 1.6 to  $-2.7^\circ\text{C}$ ). Thus, the average monthly temperature clearly shows the oscillatory perturbation of the regional climate. Other meteorological parameters also influence the process of oscillatory climate adaptation to the local geophysical conditions of New Delhi.

The maximum increment for 80 years of average monthly temperature in New Delhi at  $5.1^\circ\text{C}$  was in March 2010 (**Figure 2**).

As can be seen from **Figure 2**, the 2021 average monthly temperature increment chart is inside the 2010 increment chart. Only August and September increased their increment by 2021 compared to 2010. Then it turns out that, in comparison with the data on the average annual temperature <sup>[12]</sup>, the changes in the average monthly temperature are more informative.

Oscillations (the so-called asymmetric wavelet signals), as the sum of the quanta of the behavior of

the surface air layer at a height of 2 m at the New Delhi weather station, in the general case, are written by the formula <sup>[12-16]</sup> of the general form of oscillatory adaptation.

$$y = \sum_{i=1}^m y_i, y_i = A_i \cos(\pi x / p_i - a_{8i}), A_i = a_{1i} x^{a_{2i}} \exp(-a_{3i} x^{a_{4i}}), p_i = a_{5i} + a_{6i} x^{a_{7i}} \quad (1)$$

where  $y$  is the dependent factor,  $i$  is the number of the (1),  $m$  is the number of a component in the (1),  $x$  is the influencing factor,  $a_1...a_8$  are the parameters of the model (1) that take numerical values during structural and parametric identification program environment CurveExpert-1.40 (URL: <http://www.curveexpert.net/>) according to statistical data,  $A_i$  is the amplitude (half) of the wavelet (axis  $y$ ),  $p_i$  is the half-period of oscillation (axis  $x$ ).

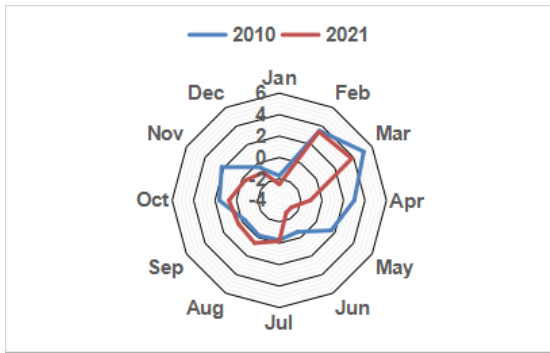


Figure 2. Diagram of monthly average temperature increments in New Delhi.

According to formula (1) with two **fundamental physical constants**  $e$  (the Napier number or the number of time) and  $\pi$  (the Archimedes number or the number of space), a series of **quantized wavelet signals** is formed. In our example, these are the behavioral quanta of the mean monthly temperature. The concept of a wavelet allows one to abstract from the physical meaning of statistical series and consider their additive decomposition into components (behavior quanta). The general equation is obtained as a sum of wavelets.

A signal is a material carrier of information. And we understand information as a **measure of interaction**. A signal can be generated, but it is not required to receive it. A signal can be any physical process or part of it. It turns out that the change in the set of unknown signals has long been known, for example,

through a series of measurements (**Table 1**). However, there are still no models of the distributions of the average annual temperature in dynamics and the influence of the geographical coordinates of city centers on temperature change.

The amplitude  $y = A$  at  $a_2 = 0$  and  $a_4 = 1$  turns into the Laplace law (in mathematics), Mandelbrot (in physics), Zipf-Pearl (in biology) and Pareto (in econometrics). A trend is formed when the oscillation period  $a_{5i}$  tends to infinity. Most often, the trend is formed from two members of the formula (1).

### 3. Results and discussion

The time series of mean annual <sup>[8]</sup> and mean monthly temperatures at the New Delhi meteorological station from 1931 to 2021 turned out to be relatively complex in their changes. But at the same time, these series are more informative in comparison with other cities in Europe and Asia for understanding regional climate changes.

The first scenario of conditional forecasting for future orientation up to 2110 was carried out according to the model (1) containing four components. Then, with additional asymmetric infinite-dimensional wavelets, model (1) included the sum of 12 components. The third scenario contained 16 more wavelets for 91 mean monthly temperature values for August. At the same time, in the third scenario of the tentative forecast for the future, a total of 28 components of model (1) was revealed.

The average monthly temperature is a physical quantity that is a measure of the monthly average kinetic energy of the translational movement of molecules, in our case, air molecules in the surface layer at a height of 2 m above the land surface at the New Delhi weather station. Therefore, the average monthly temperature is a continuous physical quantity, the initial series of values of which should not be subjected to transformations. However, averaging over a month is quite acceptable due to the influence of the moon's circulation around our planet on the earth's climate. But at the same time, groupings by time intervals for the artificial summing up of numerical data under linear models are

categorically unacceptable.

The linear method is universal in all four quadrants of the rectangular coordinate system. Therefore, in the identification method, the linear formula is used as the beginning of the modeling process in the CurveExpert-1.40 software environment to identify a non-linear trend. In its final form, the trend contains clearly non-linear formulas, and wavelets cannot be obtained from linear equations at all.

### 3.1 Wavelets of New Delhi monthly average temperature dynamics

#### *Features of CurveExpert-1.40 software environment*

The method of identifying the sum of asymmetric wavelets (1) was carried out sequentially by the residuals from the previous pattern, that is, as the previous stable pattern is revealed, the point residuals on the graph already show the possibility of continuing the identification process.

At the same time, the arithmetic mean of the average monthly temperature in New Delhi for 91 years and 12 months, equal to 25.14 °C, was taken at the beginning of the simulation. The standard deviation of this arithmetic mean is 6.7593 °C. In this case, the correlation coefficient as a measure of adequacy is equal to 0.

Then a two-term trend was revealed (**Figure 3**), containing two regularities. The first component is the Mandelbrot law (in physics)  $y = a \exp(-bx)$  of the exponential decrease in the mean monthly temperature. The same law is known in mathematics as the Laplace law, in biology-Zipf-Pearl, in econometrics-Pareto. This exponential formula shows the natural trend from 1931 to 2021 of a slow decrease in the average monthly temperature. Such a natural reason for the decline is the cosmic cold that endlessly surrounds the planet Earth. Therefore, with any oscillatory perturbations of the global climate in the earth's atmosphere, the planet will eventually cool down in billions of years.

The second and subsequent components of the general model (1) show changes in the average monthly temperature depending on planetary, including regional, primarily anthropogenic influences. As

is known<sup>[17,18]</sup>, the variability of natural warming due to the influence of the sun is more probable in comparison with the anthropogenic impact.

Therefore, the second component of the trend for New Delhi for 91 years increases according to the power mathematical function  $y = ax^b$ . But it turned out that the influence of the Himalayas gives an increase in the average monthly temperature even according to the law of "double" growth according to the formula of the anomalous biotechnical<sup>[12-16]</sup> law of prof. P.M. Mazurkin  $y = ax^b \exp(cx^d)$ . Here, the negative sign of the activity of inhibition of the increase in the parameter received a positive value  $\pm c$ , therefore, the product of two laws of growth was formed-power law and according to the modified Mandelbrot law under the condition  $d \neq 1$ . Then the trend has grown over time and it is necessary to take geo-technological measures to eliminate the second, and even the first, component of the trend.

The trend is always a special case of an asymmetric wavelet (1) provided that the half-period of oscillations is many times greater than the measurement time interval, in our case 91 years.

The correlation coefficient of the two-component trend is only 0.0198, which seems to be very negligible in terms of the level of adequacy. But it turned out that even with 28 components of the dynamics, the influence of the second component of the trend is the most significant.

The first wobble, with a correlation coefficient of 0.9522, is an infinite-dimensional wavelet, meaning it starts much earlier than 1931 and will continue well beyond 2021. This infinity is provided by the amplitude, which decreases with time according to the Mandelbrot law. Therefore, a distinctive feature of the annual cyclicity is the continuous decrease in the amplitude of fluctuations, which will favorably affect the regional climate of India.

The second oscillation with a semi-annual cycle is typical not only for air temperature, but also for the concentrations of various greenhouse gases, especially for CO<sub>2</sub>. For carbon dioxide, it was assumed that the cycles of half a year are influenced by the vegetation cover of both hemispheres of the earth.

Apparently, the vegetation cover (grass + shrubs + trees) of India for 4000 years has been severely depleted by people for the needs of agriculture.

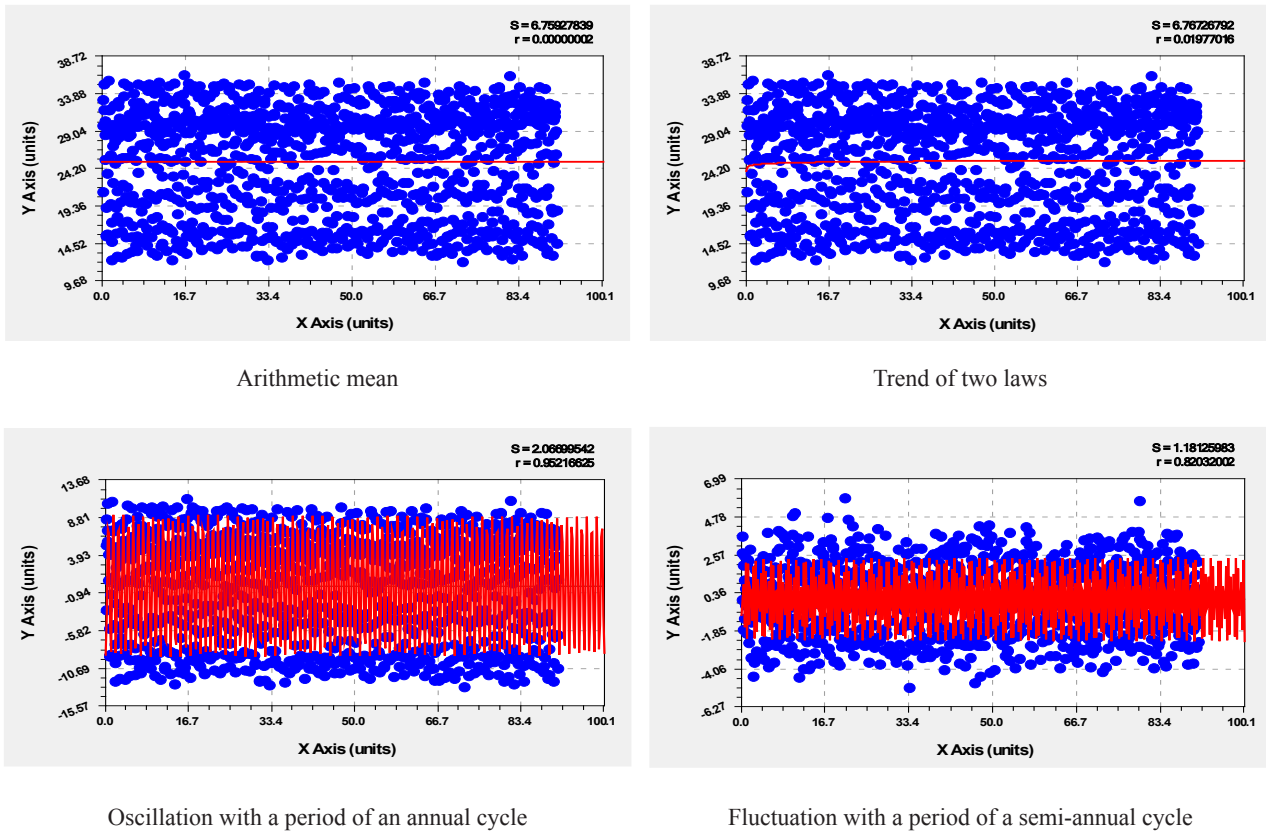
The second wavelet with a correlation coefficient of 0.8203, which is much higher than the strong coupling level of 0.7, has an increasing amplitude according to our modified Mandelbrot law of exponential growth.

All these four components were identified together

in the CurveExpert-1.40 software environment.

**Four components of the general mathematical regularity**

According to the computational capabilities of the CurveExpert-1.40 software environment, the main of which is the list of identifiers alphabetically in the English language by the first 19 letters, **Table 3** shows the parameters of the model (1) with five significant digits, and **Figure 4** shows a graph of the general pattern.

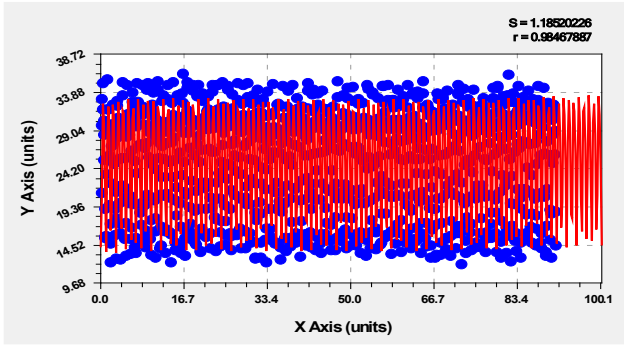


**Figure 3.** Dynamics of the average monthly temperature in New Delhi for 1931-2021 according to the computational capabilities in the CurveExpert-1.40 software environment (in the upper right corner: *S* standard deviation; *r* correlation coefficient).

**Table 3.** Dynamics of average monthly temperatures in New Delhi for 1931-2021.

Asymmetric wavelet  $y_i = a_{1i}x^{a_{2i}} \exp(-a_{3i}x^{a_{4i}}) \cos(\pi x / (a_{5i} + a_{6i}x^{a_{7i}}) - a_{8i})$

<i>i</i>	Amplitude (half) oscillation			Half cycle oscillation			Shift	Coef. correl. <i>r</i>
	<i>a</i> <sub>1<i>i</i></sub>	<i>a</i> <sub>2<i>i</i></sub>	<i>a</i> <sub>3<i>i</i></sub>	<i>a</i> <sub>4<i>i</i></sub>	<i>a</i> <sub>5<i>i</i></sub>	<i>a</i> <sub>6<i>i</i></sub>		
1	23.99317	0	0.0031983	1	0	0	0	
2	0.70194	0.38093	-0.014504	0.84550	0	0	0	0.9847
3	-9.20090	0	0.00025230	1	0.5	0	0.33219	
4	1.18494	0	-0.65220	0.021793	0.25	0	4.37689	



**Figure 4.** Graph of the general mathematical regularity of the four components of the average monthly temperature in New Delhi for 1931-2021.

The correlation coefficient of 0.9847 relates a composite pattern of four components in terms of the level of adequacy to a super strong (0.95 or more) factorial relationship. The other wave components of the model (1) will sequentially appear on the residuals, so the level of adequacy will increase.

The exponential growth activity for the fourth component of the pattern is 0.65220, which is a very high value. However, the rate of temperature increase at the New Delhi meteorological station is very small and amounts to only 0.021793. Such parameters of the law of growth are still encouraging that experts will find ways to reduce the average monthly temperature in the future.

**Distribution of the relative error of the four-component model**

The number of points  $n$  (pieces) distributed in intervals of 1 °C of the relative error  $[\Delta]$  (°C) of the model (1) with the parameters from **Table 3** is given

in **Table 4**. The relative error varies from +22 to -23%, which is within the margin of error of  $\pm 30\%$  acceptable for environmental studies.

Then the error changes according to the Gauss law (**Figure 5**) with additions in the form of four wavelets in the form of a five-term equation.

$$n = n_1 + n_2 + n_3 + n_4 + n_5 \tag{2}$$

$$n_1 = 81.19311 \exp(-0.017123([\Delta] + 0.054267)^2),$$

$$n_2 = A_1 \cos(\pi([\Delta] + 30) / p_1 + 0.31110),$$

$$A_1 = -4.17162 \cdot 10^{-128} ([\Delta] + 30)^{99.98851} \exp(-0.012693([\Delta] + 30)^{2.38818}),$$

$$p_1 = 2.15178,$$

$$n_3 = A_2 \cos(\pi([\Delta] + 30) / p_2 - 2.95272),$$

$$A_2 = -5.30474 \cdot 10^{-86} ([\Delta] + 30)^{85.67795} \exp(-2.91956([\Delta] + 30)^{1.01269}),$$

$$p_2 = 0.81791 + 0.0090604([\Delta] + 30)^{1.01094},$$

$$n_4 = A_3 \cos(\pi([\Delta] + 30) / p_3 - 0.39260),$$

$$A_3 = 3.03395 \cdot 10^{-26} ([\Delta] + 30)^{23.90826} \exp(-0.57596([\Delta] + 30)^{1.048237}),$$

$$p_3 = 3.90251 + 0.00011685([\Delta] + 30)^{2.23048},$$

$$n_5 = A_4 \cos(\pi([\Delta] + 30) / p_4 - 0.43605),$$

$$A_4 = 3.62160 \cdot 10^{-9} ([\Delta] + 30)^{7.36654} \exp(-0.0021021([\Delta] + 30)^{2.20851}),$$

$$p_4 = 0.063641 + 0.046264([\Delta] + 30)^{0.74578}.$$

The normal distribution law (Gaussian law), together with even one with a wavelet, barks a very high level of adequacy (more than 0.95) with a correlation coefficient of 0.9558.

**Table 4.** Distribution of the relative error of the model from Table 3.

Interval $[\Delta]$ , °C	Qty $n$ , pcs	Interval $[\Delta]$ , °C	Qty $n$ , pcs	Interval $[\Delta]$ , °C	Qty $n$ , pcs	Interval $[\Delta]$ , °C	Qty $n$ , pcs	Interval $[\Delta]$ , °C	Qty $n$ , pcs
22	1	10	6	3	89	-4	64	-11	7
16	2	9	15	2	80	-5	58	-12	7
15	4	8	19	1	99	-6	39	-13	7
14	5	7	34	0	0	-7	46	-14	1
13	3	6	44	-1	80	-8	26	-15	3
12	9	5	59	-2	93	-9	17	-16	3
11	2	4	70	-3	80	-10	16	-23	3



### 3.2 General formula (1) for the average monthly temperature with 12 components

#### Additional components of the model (1)

Subsequently, the identification method was used to build up asymmetric components from four components to reach 12 (Table 5) pieces. The first four components can be placed together in the CurveExpert-1.40 software environment (Table 3), and the remaining components of the general model (1) were identified individually.

This method of sequential modeling makes it possible to achieve a level of adequacy in terms of the correlation coefficient up to 1. The modeling is completed after reaching the residuals from the last component to the modeling error, which is less than the temperature measurement error.

From a physical point of view, each component is a separate quantum of climate behavior at a given point on the earth. The sum of wavelets (1) characterizes the oscillatory climate adaptation to the influence of many different factors. The high quantum certainty of the behavior of the average monthly temperature makes it possible to decompose the dynamic series into behavior quanta to a level where the modeling error becomes even less than the measurement error of 0.05 °C.

However, in this case, many components will have a correlation coefficient much less than the 0.1 level. Such correlation coefficients (less than 0.3) are not taken into account at all in the existing mathematical statistics. In Table 5, we stopped the process of wavelet identification at the level of adequacy by the correlation coefficient of 0.0580.

#### Analysis of graphs of average monthly temperature

As can be seen from the graphs in Figures 6 and 7, the length of the oscillation graphs, even for infinite-dimensional wavelets, is different.

It can be seen from the data in Table 5 that almost all additional perturbation waves obey the Mandelbrot law. But at the same time, part of the oscillations increases, and the other part decreases, in amplitude. It is necessary to identify cause-and-effect relation-

ships for oscillations decreasing in amplitude.

As a result, the atmosphere of New Delhi shows a violent wave reaction over time. Therefore, it is necessary to analyze more carefully those fluctuations that have a decline in amplitude in the future.

#### 12-component model error distribution

With an increase in the number of wavelets in the general model (1), the relative modeling error gradually decreases.

The number of points  $n$  in the dynamic series of residuals is distributed without gaps. Due to the relatively small error of modeling by the general equation (1) with 12 components, the temperature interval was also taken equal to 1 °C. Then the permissible relative error  $[\Delta]$  (°C) of the model (1) with the parameters from Table 5, after the 12th component, is given in Table 6.

The relative error is in the range of 23 to -19% (Figure 8).

Then the error changes according to the Gauss law with additional fluctuations in the form of a general equation:

$$n = 100.11057 \exp(-0.022609([\Delta] - 0.076252)^2) + 7.69774 + 10^{-18}([\Delta] + 25)^{17.213023} \exp(-0.33399([\Delta] + 25)^{1.15822}) \times \cos(\pi([\Delta] + 25) / (3.02798 - 1.40488([\Delta] + 25)) + 2.80420) \quad (3)$$

The normal distribution law (Gaussian law) is observed with adequacy in terms of the correlation coefficient of 0.9891. An additional wavelet showing the oscillatory adaptation of the mean monthly temperature also gives the value of the correlation coefficient of 0.6190. As a result, the overall adequacy of the relative error after the 12th component in the sum (1) will be equal to 0.9936.

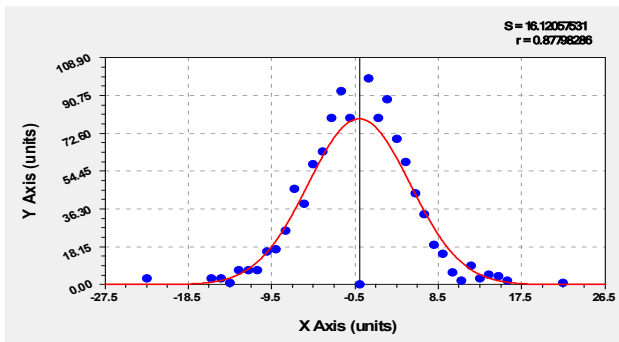
#### Comparison of models with four and 12 components

Table 7 shows comparative data on the relative error of two quantized models - with four and 12 components (Figure 9).

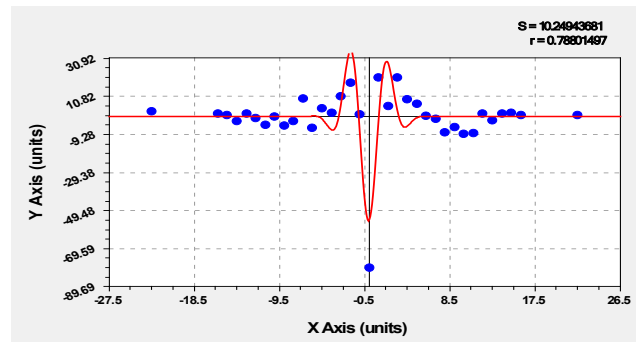
From the data in Table 7, it can be seen that August has the smallest error for both models. Then it turns out that it is quite possible to perform forecasting only on the basis of a model of four components.

Table 5. Dynamics of average monthly temperatures in New Delhi for 1931-2021.

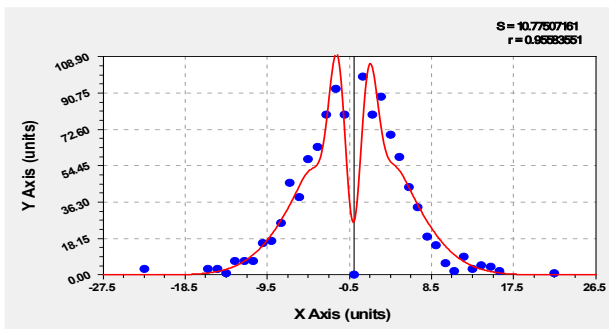
Asymmetric wavelet $y_i = a_{1i}x^{a_{2i}} \exp(-a_{3i}x^{a_{4i}}) \cos(\pi x / (a_{5i} + a_{6i}x^{a_{7i}}) - a_{8i})$									Coef. correl. $r$
$i$	Amplitude (half) oscillation			Half cycle oscillation			Shift		
	$a_{1i}$	$a_{2i}$	$a_{3i}$	$a_{4i}$	$a_{5i}$	$a_{6i}$	$a_{7i}$	$a_{8i}$	
5	-0.77866	0	0.049759	1	1.54931	0.19297	1.28120	4.11672	0.1178
6	0.11383	0	-0.00021302	1.92174	6.46965	0.0023525	1.52916	1.38105	0.1195
7	-0.00046760	0	-6.29355	0.0052852	5.32375	-4.74250	-0.18477	4.52957	0.1733
8	0.17311	0	0.00021873	1	2.50208	0.0025872	1.09110	1.82138	0.1057
9	0.13799	0	-0.0063418	1	1.65259	-0.0018465	1.00690	-4.28053	0.1171
10	-0.33772	0	0.038165	1	0.84645	0.0058586	1.49887	2.65045	0.0787
11	0.25699	0	0.024305	1	0.75658	-0.00033547	1	0.11626	0.0733
12	-0.17091	0	0.015905	1	1.03886	-0.00036249	1	-1.91769	0.0580



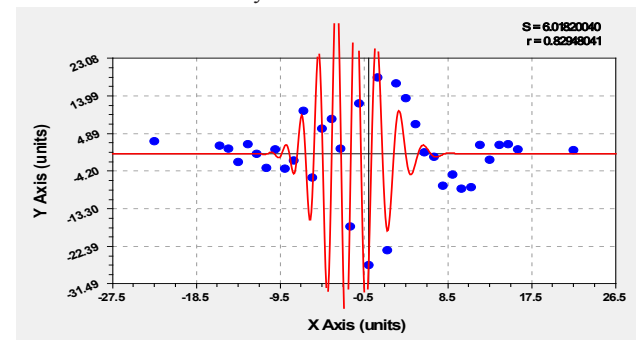
Gauss's law of normal distribution



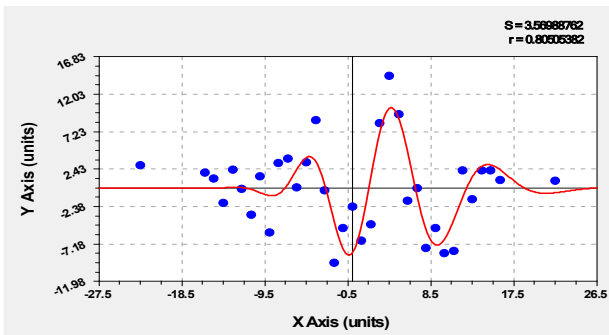
Asymmetric wavelet



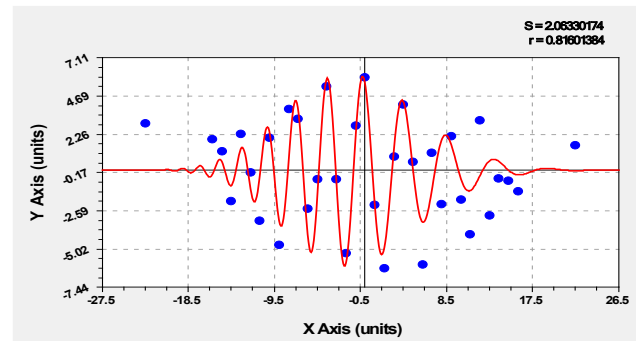
Gauss law and wavelet



The second oscillation of the model error

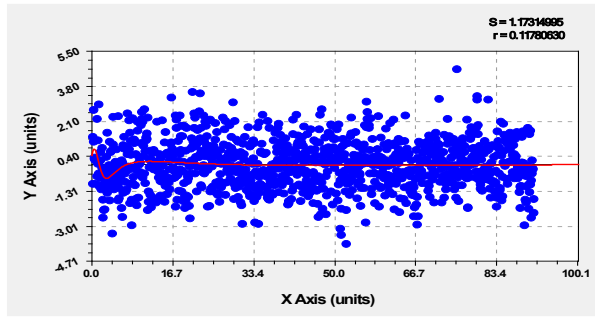


The third oscillation of the model error

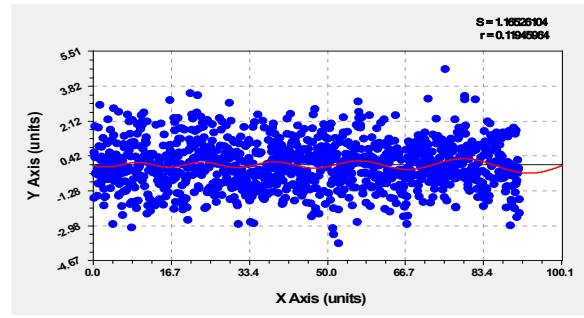


Fourth swing of model error

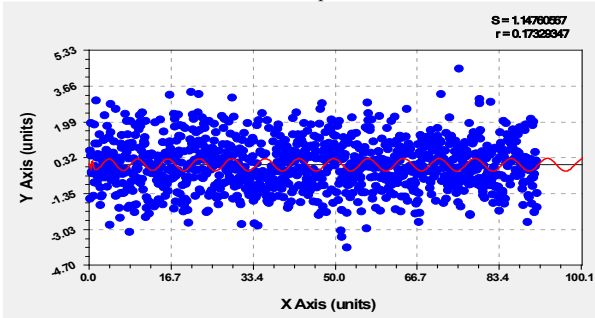
Figure 5. Graphs of the relative error of the five-component model.



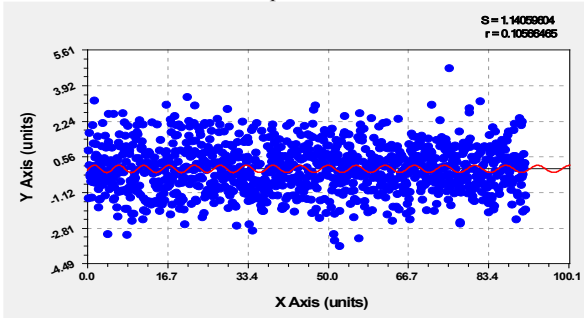
Fifth component



The sixth component of the model

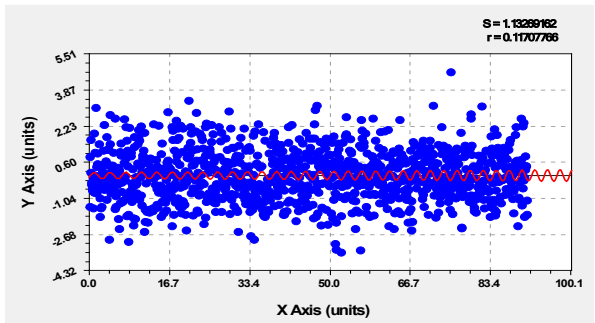


Seventh component

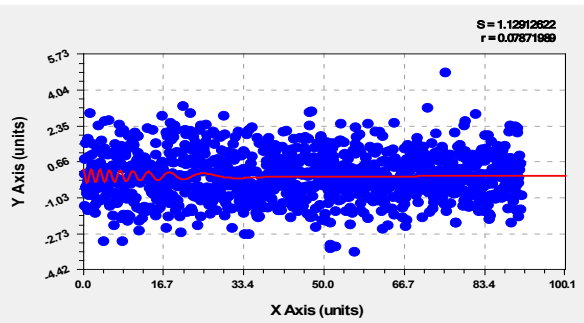


Eighth component

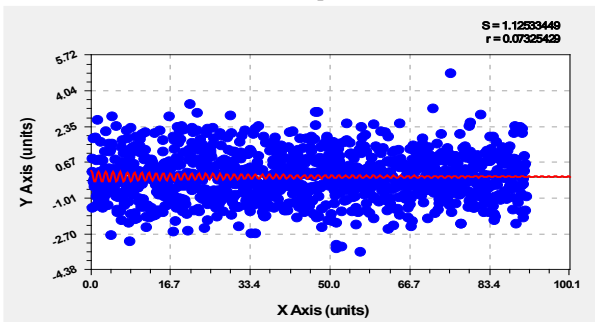
Figure 6. New Delhi monthly average temperature by additional components.



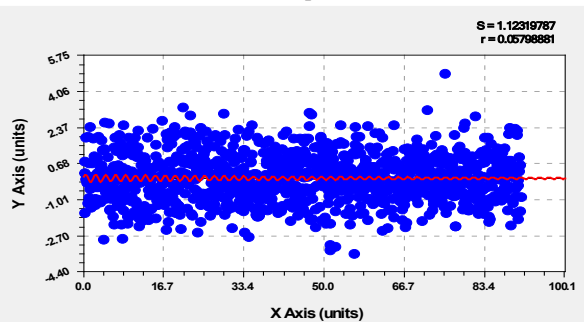
Ninth component



10th component



11th component

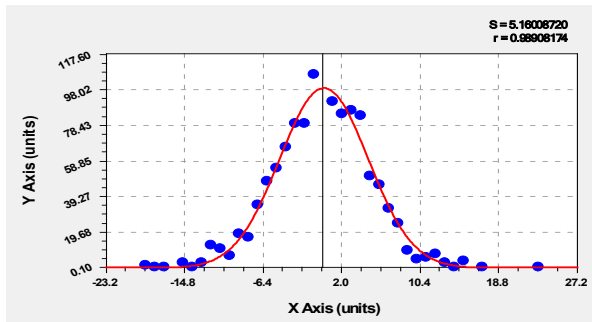


12th component

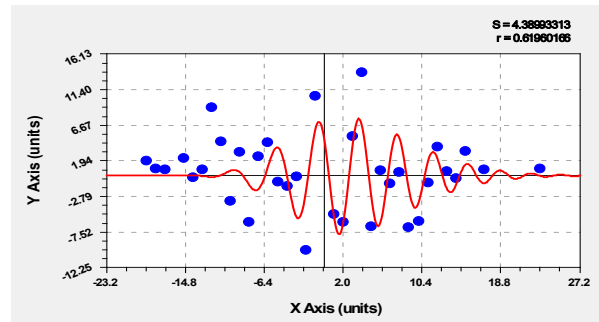
Figure 7. New Delhi monthly average temperature by latest components.

Table 6. Distribution of model error after the 12th component.

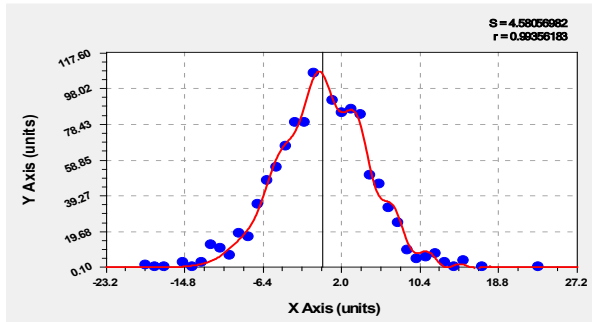
Interval [Δ], °C	Qty n, pcs	Interval [Δ], °C	Qty n, pcs	Interval [Δ], °C	Qty n, pcs	Interval [Δ], °C	Qty n, pcs	Interval [Δ], °C	Qty n, pcs
23	1	10	5	3	87	-5	55	-12	13
17	1	9	10	2	85	-6	48	-13	3
15	4	8	25	1	92	-7	35	-14	1
14	1	7	33	-1	107	-8	17	-15	3
13	3	6	46	-2	80	-9	19	-17	1
12	8	5	51	-3	80	-10	7	-18	1
11	6	4	84	-4	67	-11	11	-19	2



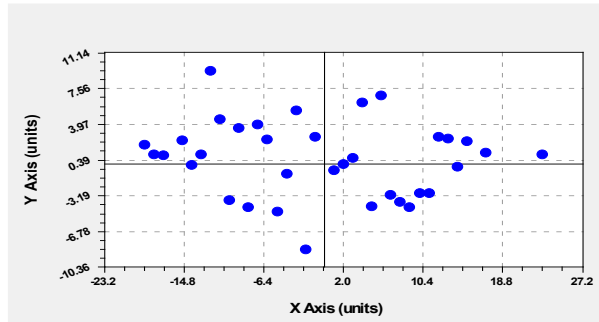
Gauss's law of normal distribution



Error fluctuation



Gauss' Law and Oscillation



Residuals after Gauss' law and fluctuations

Figure 8. Graph of the relative error distribution after the 12th wavelet.

Table 7. Relative error of models, %.

Month	Model contains	
	4 comp	12 comp
Jan	5.69	5.26
Feb	5.91	5.92
Mar	5.15	4.83
Apr	4.28	3.80
May	3.46	3.18
Jun	3.63	3.57
Jul	3.26	3.10
Aug	2.66	2.51
Sep	2.73	2.81
Oct	2.72	2.71
Nov	3.52	3.30
Dec	4.35	4.82

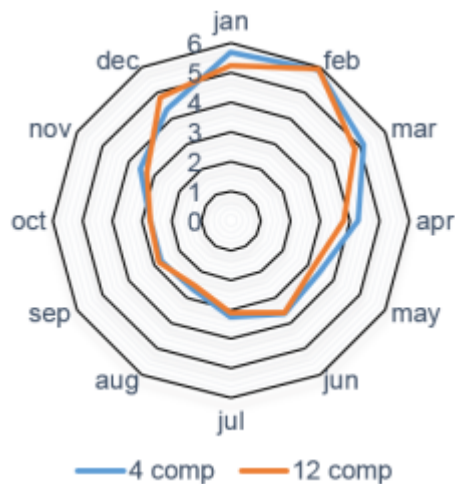


Figure 9. Graphs of comparison of the relative error of models.

At the same time, the critical thermal wave (increasing the second component in Table 3) is in this model and, therefore, a further increase in the number of wavelets becomes unjustified. If there were a supercomputer, then the joint identification of all possible components is possible. Such a technique can give a change in the second component of the critical thermal wave.

Then, for further modeling by identifying formula (1) from the data in Table 1, we will accept only a part of the array for August.

### 3.3 General formula (1) for the average monthly temperature for August

#### The structure of the general model for August 1931-2021

Table 8 shows the following components of model (1) for additional 16 components. Surprisingly, each month gives a lot of additional quanta of the behavior of the surface layer of the atmosphere at a height of 2 m in New Delhi.

All 16 wave equations are finite-dimensional wavelets. For them, according to the graphs, it is quite possible to roughly determine the left and right boundaries of the location of the graph on the x-axis.

In this regard, these solitons (solitary waves) seem to appear and then disappear with time. Therefore, apparently, the reasons for the emergence of finite-dimensional wavelets lie in the behavior of the atmosphere itself, as well as space objects located in

sectors of the earth's orbit plane for different months. In our opinion, only infinite-dimensional temperature wavelets depend on the cosmic influences of the sun and the planets of the solar system.

#### Characteristics of dynamics graphs for August

As can be seen from the graphs in Figure 10, not all components of model (1) affect the conditional forecast in the near future, but only those that continue in terms of amplitude values in the future. At the end of the dynamic series, new fluctuations may additionally arise, which then, after several months, will continue into the future. It is this circumstance that does not allow making working forecasts for more accurate sums of 12 and 28 components, since models with an increased number of components become too sensitive to the influence of even small (with a correlation coefficient less than 0.1) wavelet signals.

As a result, the physical value of the average monthly (influence of the sun and the moon), as well as the average annual (influence of the sun) temperature, has two contradictory properties.

First, the time series of temperature, which has a high quantum certainty in behavior, allows decomposing up to the measurement error into a large number of asymmetric wavelets. Then it turns out that the average monthly temperature gets a quantum certainty due to the fact that each wavelet separately represents a separate quantum of the behavior of the climate system at the weather station in New Delhi. Note that other meteorological parameters do not have quantum certainty in their behavior.

Secondly, with an increase in the number of components in the general summary model (1), due to the high sensitivity, the predictive ability of the sum of wavelets is gradually lost. Even next year, the calculated average monthly temperature may not coincide with the actual temperature in many respects. In this regard, it turns out to be sufficient for looking into the future, a model of four components according to the parameters given in the values in Table 3. And for the New Delhi weather station, the second component becomes the decisive wavelet, which becomes the critical wavelet and characterizes a strongly growing heat wave.

**Table 8.** Dynamics of average monthly temperatures in New Delhi for 1931-2021 for August.

Asymmetric wavelet $y_i = a_{1i}x^{a_{2i}} \exp(-a_{3i}x^{a_{4i}}) \cos(\pi x / (a_{5i} + a_{6i}x^{a_{7i}}) - a_{8i})$									Coef. correl. $r$
$i$	Amplitude (half) oscillation			Half cycle oscillation			Shift		
	$a_{1i}$	$a_{2i}$	$a_{3i}$	$a_{4i}$	$a_{5i}$	$a_{6i}$	$a_{7i}$	$a_{8i}$	
13	3.47710e-6	8.50848	0.32835	1	0.36199	1.47479	1.01006	-2.66873	0.4194
14	-1.28535	0.29959	0.088382	1	5.25491	-0.088847	1	-4.18195	0.4925
15	-3.8370e-9	6.10340	0.10093	1.01977	1.55201	0	0	-2.25724	0.2747
16	0.70396	0	0.50141	0.20109	2.00648	-4.5732e-5	1.25112	-0.79170	0.2878
17	8.7308e-27	17.55018	0.18058	1.04346	8.61288	0	0	-5.04691	0.3685
18	-0.0053663	1.14901	0.00015363	1.90943	1.10816	0.045767	0.74931	0.86680	0.4058
19	-9.401e-28	34.44084	8.81058	0.52596	0.99962	0	0	0.57564	0.3583
20	-15908.61	4.04026	12.64317	0.18869	1.25195	0	0	0.037839	0.6217
21	-22.15650	2.24725	6.61109	0.18846	4.16157	0.015145	1.29649	1.72332	0.2660
22	-0.073147	0	-0.00013415	1.96363	2.76671	-0.0011047	1.03183	2.08059	0.2123
23	-3.559e-16	10.56709	0.15209	1.00601	2.57131	-0.0008103	1.20407	-5.84608	0.2477
24	1.8458e-10	7.14673	0.13089	0.99281	1.88417	-0.0005876	1.20551	-2.65356	0.3686
25	2.8793e-19	13.79026	0.25010	0.99909	5.41479	-0.0002402	1.56399	3.76089	0.3858
26	2.87943e-5	3.71815	0.21272	0.83732	1.77738	-0.0003534	1.16645	0.92034	0.3769
27	-1.5177e-6	4.16863	0.0014979	2.13676	5.44870	-0.26388	0.47163	-2.97005	0.2885
28	-0.11530	0.95160	0.050027	1.33562	1.03027	0	0	-2.19074	0.6866

Everything in nature is subject to vibrational adaptation. The air is so changeable that on the surface of the earth there are many fluctuations, first of all, in air temperature. Why can a dynamic series be decomposed into a large set of oscillations? Other meteorological parameters are not amenable to wavelet analysis. We don't know yet. Also, New Delhi is a unique geographic point on earth, the dynamics of the average monthly temperature which is clearly determined by the heat wave in the form of the second critical fluctuation.

This heat wave, in our opinion, has a decisive influence on the productivity of the vegetation cover in India.

A paper by Singh et al. [19] attempts to estimate and predict the impact of climate on crop yields using future temperature predictions in India's agro-climatic zones. It was found that rainfall had a positive effect on the yield of most crops, but not enough to offset the effect of temperature.

**Model error distribution for August**

With an increase in the number of wavelets up to 28 in model (1), the relative modeling error decreases. At the same time, 91 temperature values remain for August.

The number of points in the dynamic series of residuals after the 28th component is distributed, due to the small modeling error, over the intervals of the average monthly temperature in August every 0.5 °C. Then the permissible relative error  $[\Delta]$  (°C) of the 28th component of the model (1) is given in **Table 9**.

The relative error is in the range of 2 to -2%.

Then the error changes according to the Gauss law (**Figure 11**) with one additional oscillation in the form of a general equation.

$$n = 45.09105 \exp(-1.25253([\Delta] + 0.045182)^2) + 5.95989([\Delta] + 2.5)^{1.54256} \exp(-0.46127([\Delta] + 2.5)) \times \cos(\pi([\Delta] + 2.5) / (1.31852 - 0.12463([\Delta] + 2.5)) - 1.27987) \quad (4)$$

As can be seen from the graphs of the distribution of residues after model (4), they get almost zero value.

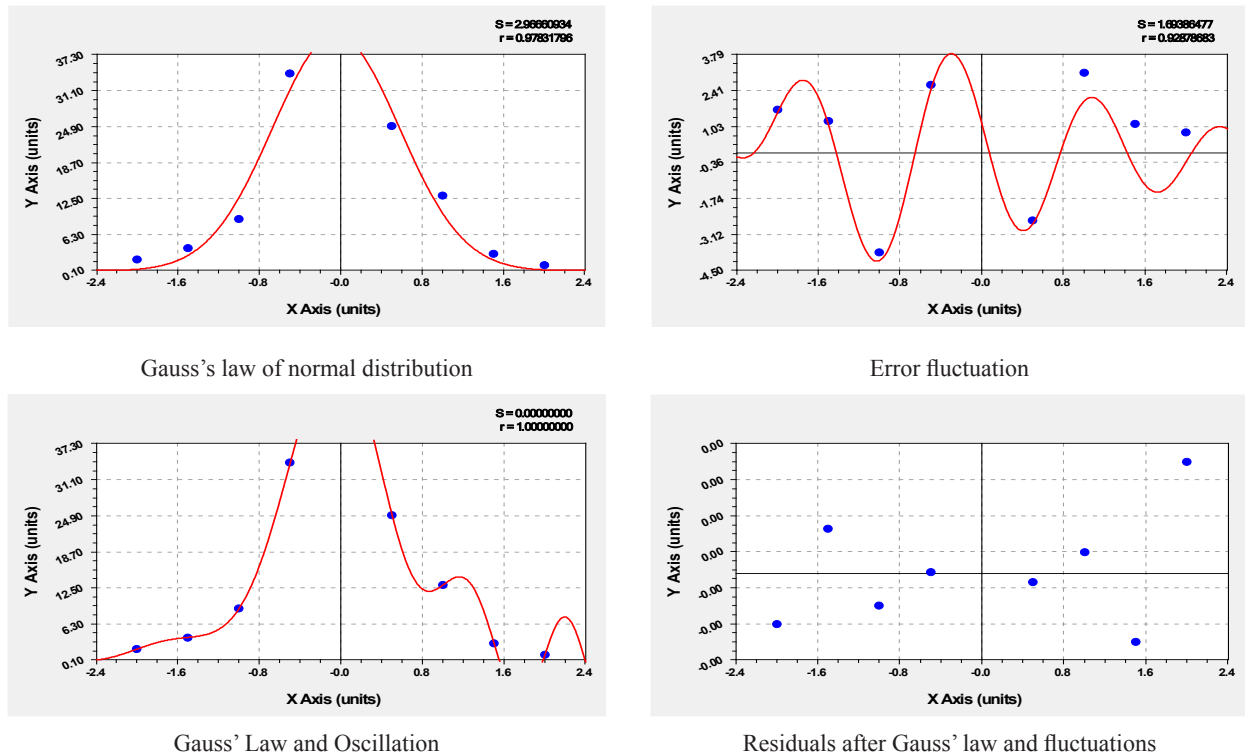


Figure 11. Relative error distribution plots after the 28th wavelet.

## 4. Forecast for the four-term model until 2110

### 4.1 New Delhi monthly average temperature forecast

On many examples of modeling by the identification method, it was noticed that with an increase in the number of components, the sensitivity of conditional forecasting increases sharply. Therefore, for orientation to the future, models with several components are sufficient, of which some component is critical, simultaneously identified in the CurveExpert-1.40 software environment with a high overall correlation coefficient (in Table 3 for a four-term model it is 0.9847).

It can even be argued that if a critical component appears, then the simulation can be immediately stopped.

After identifying the critical heat wave, the forecast for the future is clearly non-obvious due to the fact that there is a quantum uncertainty in the behavior of India, due to the presence and growth of

the critical heat wave. Therefore, attention should be paid to understanding the essence of the climate crisis, for example, in comparison with the climate dynamics in Beijing and other large Asian cities. It is important for India to urgently adopt a national reforestation program, as was done in China in 1970 (in the US since 1960).

The forecasting possibilities decrease with the increase in the number of wavelets in the sum (1). Already in the near future, new micro-fluctuations may appear, which can dramatically change the forecast trends in the past. To verify the predictive model, it is enough to wait one year (12 months) to obtain the actual values of the average monthly temperature. Then, a year later, the previously created predictive model is re-identified, containing wavelets for the future. This is how conditional forecasts are refined in the iterative forecasting mode every year.

In Table 3, the parameters of model (1) are given with five significant figures. However, in the calculations we used all 11 significant figures.

For example, a model with four components is

written as:

User-Defined Model:

$$y = a * \exp(-b * x) + c * x^d * \exp(e * x^f) - g * \exp(-h * x) * \cos(\pi * x / 0.5 - i) + j * \exp(k * x^l) * \cos(\pi * x / 0.25 - m) \tag{5}$$

Coefficient Data:

a = 2.39931742757E+001    b = 3.19834420708E-003  
 c = 7.01935956544E-001    d = 3.80930974140E-001  
 e = 1.45040504760E-002    f = 8.45501296252E-001  
 g = 9.20090113775E+000    h = 2.52299200889E-004  
 i = 3.32186333451E-001    j = 1.18493842254E+000  
 k = 6.52201603490E-001    l = 2.17933213594E-002  
 m = 4.37689258906E+000

After calculations in the Excel software environment using formula (5), graphs (Figure 12) of the average monthly temperature for each month from 1931 to 2110 were obtained.

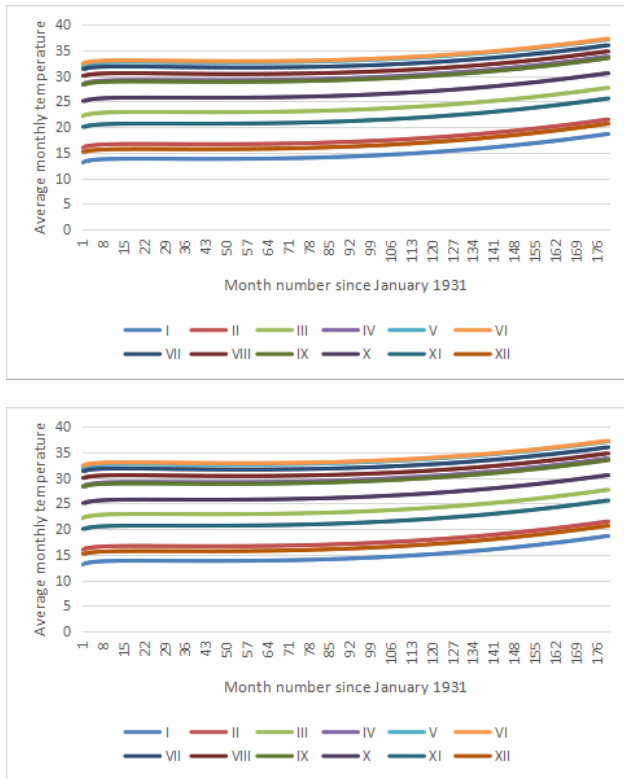


Figure 12. Monthly average temperature forecasts up to 2110.

For all months of each year, there is an increase in the average monthly temperature. The warming level of 2010 will repeat again in 2035-2040. Therefore, a period of 25-30 years since 2010 can be taken

as a stage of a slight cooling in India. However, from 2040, the average monthly temperature will steadily increase.

Table 10 shows the temperature values for 12 months.

Table 10. Forecast for the four-component model for all 12 months.

Month	Forecast basis			Forecast horizon			
	1931	2010	2021	2030	2040	2070	2110
Jan	15.4	13.7	12.9	14.46	14.76	16.04	18.72
Feb	15.2	18.7	18.6	17.33	17.62	18.88	21.55
Mar	21.2	26.3	25.0	23.55	23.84	25.08	27.73
Apr	29.7	32.7	28.6	29.76	30.04	31.26	33.86
May	33.1	34.7	30.4	33.16	33.43	34.61	37.18
Jun	35.1	34.5	32.4	33.36	33.62	34.78	37.31
Jul	31.7	31.4	31.5	32.1	32.36	33.51	36.04
Aug	30.3	30.1	30.9	30.86	31.13	32.3	34.85
Sep	28.6	28.3	29.0	29.42	29.69	30.9	33.5
Oct	25.3	26.9	26.0	26.39	26.68	27.94	30.59
Nov	19.1	21.3	18.8	21.38	21.68	22.96	25.66
Dec	15.5	15.0	14.5	16.41	16.71	18.01	20.73

As in 1931, starting from 2021 and beyond, June becomes the hottest month. At the same time, the maximum temperature of 35.1 °C in June will reach only by 2076. For this month, the minimum temperature was: 1936-31.2 °C; 2001-31.1 °C; 2008-30.9 °C. The coldest June was in 2008.

Figure 13 shows a radar chart for three forecast years (2040, 2070 and 2110) compared to 2010. The diagram clearly shows that by month 2110 covers the average monthly temperature of other years.

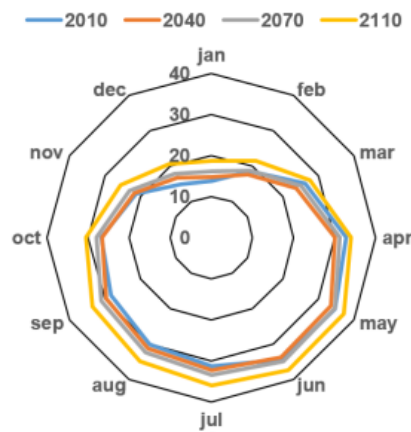


Figure 13. Average monthly temperatures compared to 2010.



Thus, from 2010 to 2076, nature gives the population of India the opportunity to increase the forest area, as well as manage to reduce the average monthly temperature by geo technical measures <sup>[12]</sup> during this period of time.

#### 4.2 Critical New Delhi heatwaves in June

Further, for hot June, we consider separately the changes in the average monthly temperature over the time interval from 1931 to 2110.

Figure 14 shows graphs for June, built according to formula (5).

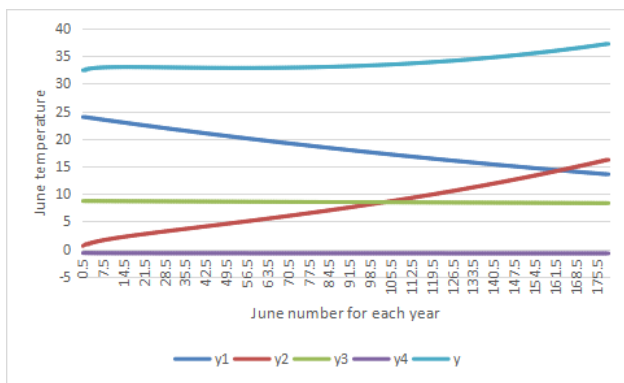


Figure 14. Graphs of the components of the June temperature in New Delhi.

The first component of the influence of cosmic cold from 1931 to 2110 decreases from a temperature of 23.95 to 13.51 °C, that is, a decline in the natural tendency will occur by  $23.95 - 13.51 = 10.44$  °C. But, for the same period of time in 180 years. According to the second component in the form of an anomalous bio technical law, the average June temperature will increase from 0.54 to 16.29 °C, that is, the increase in heat will be 15.75 °C. This growth was influenced by two major causes: Firstly, the anthropogenic reduction of the vegetation cover of India in favor of agricultural plants; secondly, the strengthening of the geophysical influence of the Himalayas on blocking the winds and isolating the climate of India.

The annual and semi-annual cycles had an insignificant effect on the dynamics of the June temperature. The third component of the annual dynamics gave a decrease in the average monthly temperature

from 8.70 to 8.31 °C, that is, over 180 years there will be a decrease in temperature by 0.39 °C. Similarly, according to the fourth component of the semi-annual cycle, the decrease in June temperature will be from -0.74 to -0.81, that is, by only 0.07 °C.

These data show that the revolutions of the earth around the sun and the vegetation cover on the land of both hemispheres of our planet have little effect on the thermal balance of India. The critical thermal wave is created by the second component (5).

### 5. Conclusions

The wave patterns of the average monthly temperature at the New Delhi meteorological station from 1931 to 2021 revealed by the identification method in the form of a sum of wavelet signals made it possible to give a conditional forecast up to 2110. At the New Delhi meteorological station, the oscillatory adaptation of the local climate according to the average monthly temperature in the near future will far exceed the global warming rates predicted in the IPCC CMIP5 report for the entire land mass of the earth.

At the same time, it should be taken into account that the surface of India heats up to 45 °C in summer, which is a tenth or higher than the air layer at a height of 2 m in a weather station. Temperatures rise even higher on paved roads and concrete urban areas (up to 55 °C <sup>[20]</sup>).

The maximum increment in 80 years of average monthly temperature in New Delhi of 5.1 °C was in March 2010.

Warming in descending order of average monthly temperature occurred in March (5.1), February (3.5), April (3.0), November (2.2), October (1.6) and May (1.6 °C). Cooling in comparison with 1931 occurred in August (-0.2), July and September (-0.3), December (-0.5), June (-0.6) and January (-1.7 °C). If the difference in average monthly temperatures in 1931 was equal to 19.9 °C, then in 2010 it became equal to 21.0 °C.

At the beginning of the modeling process, the identification of asymmetric wavelet signals revealed a trend containing two regularities. The first compo-

ment is the Mandelbrot law (in physics) of the exponential decrease in the mean monthly temperature. The same law is known in mathematics as the Laplace law, in biology - Zipf-Pearl, in econometrics - Pareto. It shows a natural trend from 1931 to 2021 of a slow decrease in the average monthly temperature. Such a natural cause of decline is the cosmic cold that endlessly surrounds planet Earth. Therefore, with any oscillatory perturbations of the global climate in the earth's atmosphere, the planet will eventually slowly cool down in billions of years.

The second component of the trend for New Delhi for 91 years is growing according to a mathematical power function  $y = ax^b$ . But it turned out that the influence of the Himalayas gives an increase in the average monthly temperature even according to the law of "double" growth according to the formula of the anomalous biotechnical law  $y = ax^b \exp(cx^d)$  of prof. P.M. Mazurkin. Here, the sign of the decreased activity got a positive value  $\pm c$ , therefore, a product of two growth laws was formed—a power function and a modified Mandelbrot law under the condition  $d \neq 1$ . The trend has grown over time and it is necessary to take geo-technical measures to eliminate the second component of the trend.

The third component of the four-component model is the first fluctuation with a correlation coefficient of 0.9522, which is an infinite-dimensional wavelet, that is, it starts much earlier than 1931 and continues much further than 2021. This infinity is provided by the amplitude, which decreases with time according to the Mandelbrot law. Therefore, a distinctive feature of the annual cyclicity is the continuous decrease in the amplitude of fluctuations, which will favorably affect the regional climate of India.

The second fluctuation (a fourth component of the summary model) with a semi-annual cyclicity is typical not only for air temperature, but also for the concentrations of various greenhouse gases, especially for CO<sub>2</sub>. For carbon dioxide, it was assumed that the cycles of half a year are influenced by the vegetation cover of both hemispheres of the earth. Apparently, the vegetation cover (grass + shrub + trees) of India for 4000 years has been severely depleted by people

for the needs of agriculture.

For all months of each year, there is an increase in the average monthly temperature. The level of warming before 2010 will repeat again in 2035-2040. Therefore, a period of 25-30 years can be taken as a stage of a slight cooling in India. However, from 2040, the average monthly temperature will steadily increase. As in 1931, starting from 2021 and beyond, June becomes the hottest month. At the same time, the maximum temperature of 35.1 °C in June will reach only by 2076. For this month, the minimum temperature was: 1936-31.2 °C; 2001-31.1 °C; 2008-30.9 °C. The coldest June was in 2008.

For the hottest of all 12 months of June, the first component of the influence of cosmic cold from 1931 to 2110 decreases from a temperature of 23.95 to 13.51 °C, that is, the decline in the natural tendency will occur by  $23.95 - 13.51 = 10.44$  °C. But, for the same period of time in 180 years. according to the second component in the form of an anomalous biotechnical law, there will be an increase in the average June temperature from 0.54 to 16.29 °C, that is, an increase in heat will be 15.75 °C. This growth was influenced by two major reasons: Firstly, the anthropogenic reduction of the vegetation cover of India in favor of agricultural plants; secondly, the strengthening of the geophysical influence of the Himalayas on blocking and isolating the climate of India.

The annual and semi-annual cycles had an insignificant effect on the dynamics of the June temperature. The third component of the annual dynamics gave a decrease in the average monthly temperature from 8.70 to 8.31 °C, that is, over 180 years, the temperature will decrease by 0.39 °C. Similarly, according to the fourth component of the semi-annual cycle, the June temperature will decrease from -0.74 to -0.81, that is, by only 0.07 °C.

## Conflict of Interest

There is no conflict of interest.

## Funding

This research received no external funding.

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