

ARTICLE

# Quantum Biophysics of the Atmosphere: Factor Analysis of the Annual Dynamics of Maximum, Minimum and Average Temperatures from 1879 to 2017 to Hadley English Temperature Center (Hadcet)

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ABSTRACT

Factor analysis of annual dynamics from 1879 to 2017 was carried out by the method of identification of stable regularities: maximum, minimum and average air temperature of Central England according to HadCET. The sample capacity was 139 rows. In factor analysis, time is excluded, and it acts only as a system-forming factor that ensures the relationship between the three parameters of climate and weather. Therefore, the adequacy of the dynamics models is taken into account in the diagonal cells of the correlation matrix. In addition to time, different lists of objects are possible in factor analysis. The coefficient of correlation variation, that is, a measure of the functional relationship between the parameters of the system (annual weather at the weather station in Central England) is 0.8230 for trends, 0.8603 taking into account the annual dynamics of the four-membered model obtained from the computational capabilities of the software environment CurveExpert-1.40, and 0.9578 for the full up to the error of measurement wavelet analysis of the dynamics of the values of three factors. In all three methods of factor analysis, the meteorological parameter «average Annual temperature» was in the first place as the influencing variable, the «Maximum temperature» was in the second place, and the «Minimum temperature» was in the third place. As the dependent measure in these areas there are three kinds of temperature. The comparison shows that among the binary relations between the three temperatures, the average temperature on the maximum air temperature in the surface layer of the atmosphere has the greatest influence on the correlation coefficient 0.9765. At the same time, all six equations refer to strong connections, so there is a high quantum certainty between the three types of temperature. But when predicting the most meaningful essence showed the maximum temperature.

## 1. Introduction

At various points of the Earth, meteorological stations have accumulated many time series, for example, the temperature of the air in the surface layer. According to

Hadcetma processed the series of maximum, minimum and average annual temperature of Central England. In this paper, we combine these three parameters and show the method of factor analysis. In the future, the number of

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factors can be increased to 25-50, including meteorological data of land, ocean, stratosphere and troposphere and other objects.

In factor analysis, each binary relation contains a trend and a set of wavelet signals. Moreover, the trend is a special case of a super-long wavelet oscillation period. As a result, the General statistical model of dynamics is a bundle consisting of a set of solitary waves (wavelets) with variable amplitude and oscillation period. After statistical modeling of rank (instead of dynamic series, for example, on the list of objects included in the system) and binary distributions, factor analysis is carried out on the adequacy of monar (in the diagonal cells of the correlation matrix) and binary relations, which allows to make ratings of factors as influencing parameters and as dependent indicators on the values of the correlation coefficient.

The proposed methodology for the identification of clearly nonlinear stable regularities [4-11] allows us to distinguish the waves of monarch and binary relations between all measured and considered factors, which can be compared with heuristic representations of specialists in the study and management of climate and weather.

Therefore, the practical application of our methodology involves iterative identification, at least every year (and for monthly data every month). At the same time, each time an approximate forecast is made for the length of the forecast horizon equal to the base of the forecast. The identification method allows to identify the most significant parameters of the studied system of any kind and strong binary relations between them, which will need to further improve the accuracy and speed of future measurements.

Our method of identification of the general wavelet equation (solitary wave) from the measured statistics will complement and refine the climate mitigation scenarios up to 2100 described in article [1].

However, we believe that according to the available dynamic series. Other scientists have not been able to identify wave patterns so far. Therefore, climatologists and meteorologists have taken the path of simplifying time series. This is manifested in the fact that the indicators are grouped data, for example, moving average for periods of 10 years, and only linear or linearized models are used.

The water regime of meadows [4] and carbon dynamics in Europe [6,7] change according to wavelets of universal design [5].

Then we distinguish two types of quanta of behavior:

First, in dynamics, each factor is divided into the sum of wavelets, that is, in time, the factor is represented as a bundle of solitary waves (solitons) and this process is characterized as *quantum unraveling*;

Secondly, the mutual influence of the above three factors with uniform or uneven periodicity of measurements additionally obtains quantum entanglement in some boundaries.

Thus, any phenomenon or process can be estimated by the level of adequacy (correlation coefficient) of decomposition of the functional connectivity of the system into quantum entanglement and quantum entanglement.

It turned out that in quantum meteorology [8,10] can distinguish the quantum fitopatologia [9,11] for vegetation period of plants.

Plant growth is a complex process. In the process of plant ontogenesis growth is observed during the main stages of its life cycle [14-16]. Therefore, in further studies it is possible to identify patterns of influence of meteorological parameters on the dynamics of vegetative organs of plants.

## 2. Source Data

Data on three types of air temperature in the surface layer are given in Table 1 (ssn\_HadCET\_max.txt, ssn\_HadCET\_min.txt, ssn\_HadCET\_mean.txt).the data are described in articles [2,3,12,13]. For the beginning  $\tau=0$  of the reference dynamics was adopted in 1879, and for the end of the measurement time – 2017. In all known time series apply a uniform scale. Table 1 is no exception. However, non-uniform time scales can be used, for example, with omissions, which significantly increases the predictive capabilities of our method for identifying stable patterns [5].

**Table 1.** Maximum, minimum and average annual temperatures

Year	Time $\tau$ , years	Air temperature, °C		
		maximum $t_{max}$	minimum $t_{min}$	average $\bar{t}$
1879	0	10.52	4.36	7.44
1880	1	12.54	5.63	9.10
1881	2	12.12	5.03	8.58
1882	3	12.99	5.94	9.47
1883	4	12.70	5.38	9.04
2013	134	13.29	5.92	9.61
2014	135	14.75	7.15	10.95
2015	136	14.17	6.45	10.31
2016	137	14.18	6.51	10.34
2017	138	14.30	6.87	10.58

(according to the Headset from 1879 to 2017)

When analyzing the factors time is excluded, and it acts only as a strategic factor that provides the relationship between ramapura-metriclima and weather. Therefore, the adequacy of the dynamics models is taken into account in the diagonal cells of the correlation matrix. In addition to time, different lists of objects are possible in factor analysis.

### 3. Wave and Trend Identification

Wavelet signal, as a rule, of any nature (object of study) is mathematically recorded by the wave formula [5] of the form

$$\begin{aligned}
 y_i &= A_i \cos(\pi x / p_i - a_{8i}), \\
 A_i &= a_{1i} x^{a_{2i}} \exp(-a_{3i} x^{a_{4i}}), \\
 p_i &= a_{5i} + a_{6i} x^{a_{7i}},
 \end{aligned}
 \tag{1}$$

where  $y$  – the index (dependent factor),  $i$  – the number of the component model (1),  $m$  – number of members in the model (1),  $x$  – explanatory variable (influencing factor),  $a_1...a_8$  – the parameters of the model (1) taking the numerical values in the course of structural-parametric identification in the software environment CurveExpert-1.40 (URL: <http://www.curveexpert.net/>),  $A_i$  – amplitude (half) of the wavelet (axis  $y$ ),  $p_i$  – half-period of oscillation (axis  $x$ ).

According to the formula (1) with two *fundamental physical constants*  $e$  (the Neper number or the number of time) and  $\pi$  (the Archimedes number or the number of space), a *quantized wavelet signal* is formed from within the phenomenon and/or process under study. The concept of wavelet signal allows us to abstract from the physical meaning of many statistical series of measurements and consider their additive decomposition into components in the form of a sum of individual wavelets.

A signal is a material carrier of information. And we understand information as *a measure of interaction*. A signal can be generated, but its reception is not required. 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 the series of three-hour meteorological measurements. However, there are still no statistical models of both dynamics and mutual connection between the four weather parameters at this weather station.

The trend is formed when the period of oscillation  $a_{5i}$  tends to infinity. Most often, the trend is formed from two members of the formula (1).

All models in this paper have been identified in the special case where the model parameter  $a_2=0$ , by a two-term formula

$$y = a \exp(-bx^c) + dx^e \exp(-fx^g)
 \tag{2}$$

where  $y$  – the dependent measure,  $x$  – influencing variable,  $a-g$  – model parameters (2) identified in the software environment CurveExpert-1.40.

### 4. Factor Analysis Identification of the Trend

Table 2 shows the *correlation matrix* of binary relations and the rating of three factors obtained by the identification method [5] according to Table 1. In our example, in the diagonal cells we put the correlation coefficient of the trend according to the dynamics models from 1879 to 2017.

**Table 2.** Correlation matrix of factor analysis and factor rating after the identification patterns of the trend (2)

Influencing factors (characteristic $x$ )	Dependent factors (indicators $y$ )			Amount $\sum r$	Place $I_x$
	$t_{max}, ^\circ C$	$t_{min}, ^\circ C$	$\bar{t}, ^\circ C$		
Maximum temperature $t_{max}, ^\circ C$	0.6086	0.8733	0.9760	2,4579	2
Minimum temperature $t_{min}, ^\circ C$	0.8761	0.5618	0.9590	2,3969	3
Annual mean temperature $\bar{t}, ^\circ C$	0.9765	0.9592	0.6168	2,5525	1
The sum of the correlation coefficients $\sum r$	2,4612	2,3943	2,5518	7,4073	-
Place $I_y$	3	2	1	-	0.8230

*The coefficient of correlation variation*, that is, a measure of the functional relationship between the parameters of the system (annual weather at the weather station), is equal to  $7.4073 / 3^2 = 0.8230$ . As the influencing variable at the first place was the meteorological parameter «Annual mean temperature», the second «Maximum temperature» and in third place – «Minimum temperature». As the dependent measure in these areas there are three kinds of temperature.

In total, there were six strong regularities according to the formula (2) with a mutual relationship between the temperatures with a correlation coefficient of not less than 0.7. Diagonally turned trends with adequacy 0.5-0.7 average.

### 5. Factor Analysis by Identification of the Wave Equation

At the information technology level, the 23rd Hilbert problem (development of methods of variational calculus) was solved by us [5].

At the same time, *the variation of functions* is reduced to the conscious selection of stable laws and the construction of adequate stable laws on their basis. We adhere to the concept of Descartes on the need to apply an algebraic equation of General form directly as a finite mathematical

solution of unknown differential or integral equations. A new class of wave functions (1) was proposed for this purpose.

The concept of vibrational adaptation in nature suggests that between the selected factors in Table 1. There are dependencies in the form of wave equations. However, it turned out that there is no wave connection between these three factors, which indicates the presence of quantum entanglement of meteorological data. Only the dynamics of the 139 Lettre parameters allow the identification of many wavelets. Four terms of equation (1) were jointly identified by the computational capabilities of the software environment CurveExpert-1.40.

The adequacy of the models in Table 3 is given by four members of the general model (1), containing one or two trend members (2) and two or three wave-equinox dynamics for the diagonal cells of the correlation matrix.

**Table 3.** Correlation matrix of factor analysis and factor rating after trend (2) identification of binary wavelet relations (1) dynamics

Influencing factors (characteristic $x$ )	Dependent factors (indicators $y$ )			Amount $\sum r$	Place $I_x$
	$t_{max}, ^\circ C$	$t_{min}, ^\circ C$	$\bar{t}, ^\circ C$		
Maximum temperature $t_{max}, ^\circ C$	0.7011	0.8733	0.9760	2,5504	2
Minimum temperature $t_{min}, ^\circ C$	0.8761	0.7131	0.9590	2,5482	3
Annual mean temperature $\bar{t}, ^\circ C$	0.9765	0.9592	0.7086	2,6443	1
The sum of the correlation coefficients $\sum r$	2,5537	2,5456	2,6436	7,7429	-
Place $I_y$	2	3	1	-	0.8603

The coefficient of correlation variation is  $7.7429 / 32 = 0.8603$ . The rating of influencing and dependent factors in comparison with Table 2 has not changed.

Previously it was shown that up to errors of measurement of temperature it is possible to carry out the wavelet analysis. For the maximum temperature, 57 members were obtained, for the minimum temperature, 64, and for the average annual temperature, 188 members. Then practically the correlation coefficient will rise to 1 (Table 4).

**Table 4.** Correlation matrix of factor analysis and factor rating trend (2) for binary relations and wavelet set (1) dynamics

Influencing factors (characteristic $x$ )	Dependent factors (indicators $y$ )			Amount $\sum r$	Place $I_x$
	$t_{max}, ^\circ C$	$t_{min}, ^\circ C$	$\bar{t}, ^\circ C$		
Maximum temperature $t_{max}, ^\circ C$	1	0.8733	0.9760	2,8493	2
Minimum temperature $t_{min}, ^\circ C$	0.8761	1	0.9590	2,8351	3
Annual mean temperature $\bar{t}, ^\circ C$	0.9765	0.9592	1	2,9357	1
The sum of the correlation coefficients $\sum r$	2,8526	2,8325	2,9350	8,6201	-
Place $I_y$	2	3	1	-	0.9578

The coefficient of correlation variation became equal to 0.9578 and the rating of influencing and dependent factors in comparison with Table 2 and 3 did not change.

If the remains after the wavelet analysis are not further modeled, then experts say about some noise. But we believe that noise can only be called residues that are

**Table 5.** The parameters of models of the dynamics of the meteorological data in Table 1

Number $i$	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. corr. $r$	
	The amplitude (half) the fluctuations				The half-period of oscillations					Shift
	$a_{1i}$	$a_{2i}$	$a_{3i}$	$a_{4i}$	$a_{5i}$	$a_{6i}$	$a_{7i}$	$a_{8i}$		
Maximum air temperature dynamics										
1	9.75509	0	0.32695	0.39408	0	0	0	0	0.7011	
2	4.76899	0.20451	0	0	0	0	0	0		
3	0.60554	0	0.00067008	1.30655	331.51060	-2.16881	1.00023	-0.15038		
4	0.44184	0	0.037403	0.75225	7.11016	-0.00096285	1.50572	1.66394		
Minimum air temperature dynamics										
1	4.47820	0	-0.10237	0.22512	0	0	0	0	0.7131	
2	0.11964	0	-0.0086459	1	3.82002	0.50590	0.71167	1.65200		
3	-0.17853	0	-7.95574e-6	2.26277	3.65855	0.014686	0.54239	-0.10801		
4	0.049902	0	-0.0016021	1.43297	11.44579	0.037200	0.60525	5.90933		
Dynamics of average annual air temperature										
1	8.34895	0	0.00083403	1.44674	0	0	0	0	0.7086	
2	0.069430	0.94925	0	0	0	0	0	0		
3	-0.070861	0	-0.47413	0.25105	218.12924	-0.24701	1.34031	-3.30961		
4	4.05019	0	1.35915	0.22971	6.27630	0.00042187	2.55027	1.81124		

equal to or less than the measurement error. Therefore, part of the noise exceeding the measurement error should be attributed to quantum entanglement. And the share of parameter values determined by the revealed regularities should be attributed to *quantum unraveling*.

## 6. Regularities of Air Temperature Dynamics

Table 5 shows the values of the model parameters (1). It shows that parts of the trend are special cases of the General wavelet.

Let's take dynamic models containing four terms (one-two for a trend and two-three asymmetric wavelets). As a rule, models of any dynamics (at different time counts: year, month, day, hours, minutes) can be brought to a finite set of wavelet signals by identification method. The criterion for stopping the identification process is only the measurement error. Each wavelet thus becomes a separate quantum of behavior (the structure of macro-objects in comparison with their behavior can be taken constant). For example, the average air temperature in Central England for the years 1659-2017 according to Hadley-CentreCentralEnglandTemperature (HadCET) before the measurement error  $^{\circ}\text{C}$  is characterized by a set of 188 wavelets.

A negative sign in front of the model component indicates that it is critical to increase the values of the meteorological parameter. For example, in the dynamics of the minimum air temperature, the third member of the model in Table 5 is a crisis for increasing this factor over time.

The first term of the model (2) of the trend is the modified law of Laplace (in mathematics), Mandelbrot (in physics), Tsipf-Pearl (in biology) and Pareto (in econometrics). It shows an exponential decrease (for maximum and average annual temperature) or increase (for minimum air temperature) over time.

As a rule, the first member of the model is a natural component, and the second and subsequent members of the model show biotechnical, in particular anthropogenic, influence. Then it turns out that the second term according to the exponential growth law gives a dynamic growth of the maximum and average air temperature. Apparently, the second term of the trend shows anthropogenic influence.

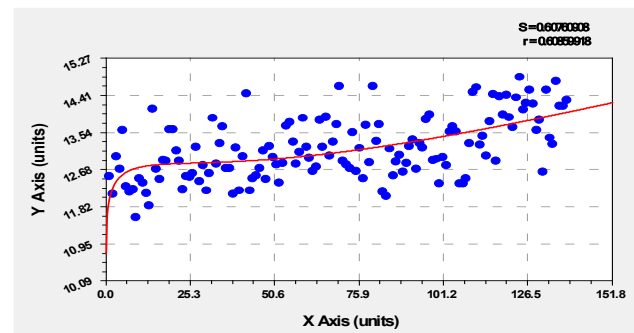
The third-fifth members have the amplitude of the oscillation according to the law of exponential growth or death (Laplace's law according to the exponential law of growth in the second member of the minimum temperature). Sevilleta are infinite-dimensional, because due to the law of Laplace, the change of the amplitude shows the continuation values to 1879 and after 2017.

## 7. Graphs of Air Temperature Dynamics

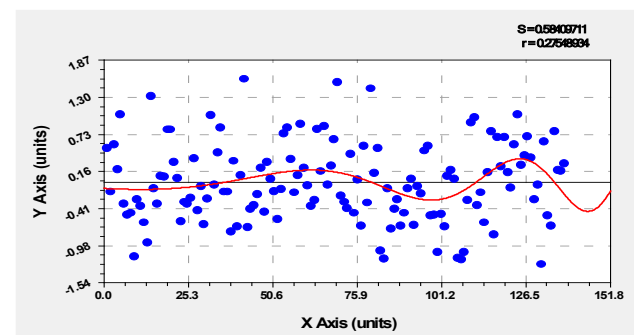
### 7.1 Maximum Air Temperature Dynamics

The adequacy of the model (1) according to Table 5 is equal to the correlation coefficient 0.7011 (Figure 1).

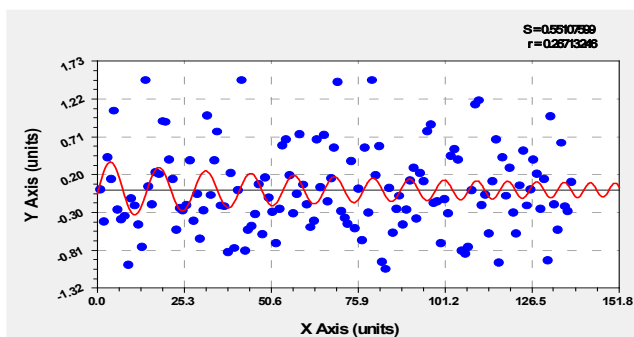
Trend contains two members (Figure 1) and obtained a correlation coefficient of 0.6086. Moreover, the pattern is clearly nonlinear, so we consider attempts to apply linear models in climatology to be an obvious simplification. Although the linear equation has a correlation coefficient of 0.5610, however, in the identification method [5] we use the linear model only at the beginning of the modeling process. The reason for the "love" of scientists to approximate linear trends lies in only one thing – linear models are universal to the positive and negative halves of the abscissa. Therefore, linear models are valid only on short dynamic series, and on long ones, as in this example in 139 years, linear trends are very rough, and primitive.



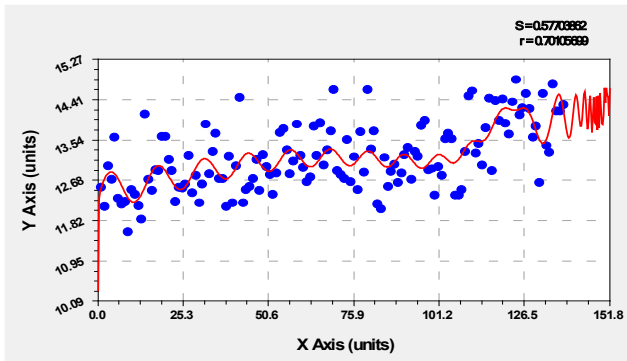
Two-term trend



First oscillation



The second oscillation



The residues of the model from Table 5

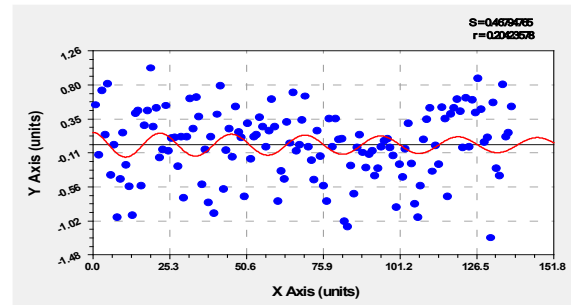
**Figure 1.** Graphs of four members of the model (1) maximum temperature dynamics: S-dispersion; r-correlation coefficient

The first wavelet as the third term of the general model (1) (Figure 1) with a correlation coefficient of 0.2755 after the Union changed sign in amplitude and became the law of exponential death. This led to tremor (shaking after 2017). The second wavelet with the adequacy of 0.2671 has not changed in design. As can be seen from the general schedule for the four members, after 2017 there is a tremor (jitter) due to a significant decrease in the half-period of oscillations.

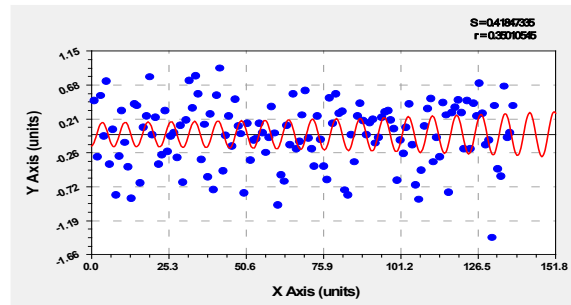
### 7.2 Minimum Air Temperature Dynamics

The first wavelet shows a slow decrease in the amplitude of the oscillation according to Laplace's law of exponential death, with the half-period of the oscillation growing from 10.59745 years (approximately equal to the solar activity cycle on average 11.3 years) in 1879. The hesitation calms down and is not dangerous for the future.

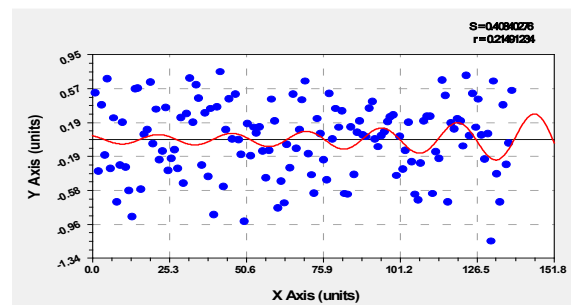
Due to the negative sign of the second wavelet tries to reduce with increasing amplitude by the law of exponential growth tendency to increase the minimum temperature. When this wave increases the period of oscillation and also calms down.



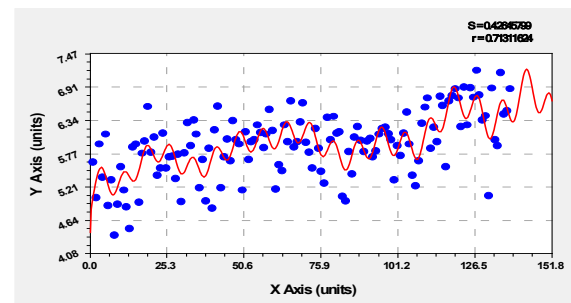
First oscillation



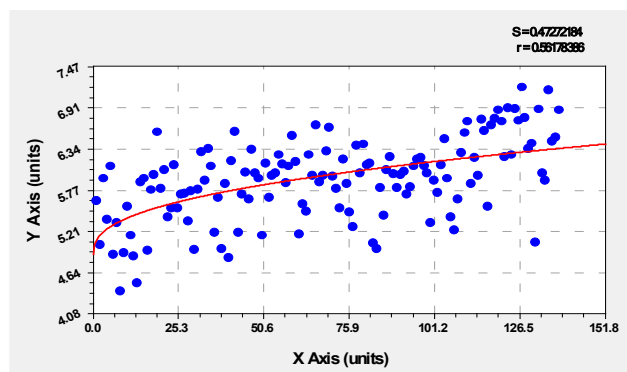
The second oscillation



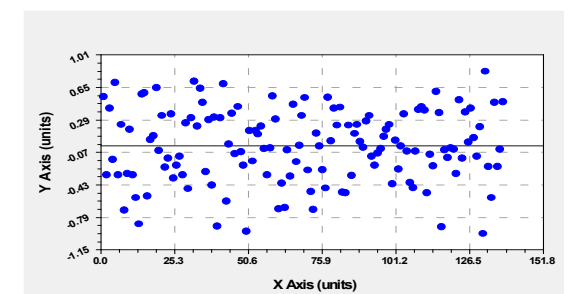
Third oscillation



One member of the trend and three variations



Single-member trend



After the remains of four members

**Figure 2.** Graphs of the General model (1) minimum air temperature dynamics

The third wavelet increases the amplitude according to the law of exponential growth and also with an increase in the half-period from 11.63078 (approximately the cycle of solar activity) in 1879, that is, this wave also calms down. This fact means only one thing: the greatest danger to climate change is the dynamics of the maximum temperature with chaotic changes in the future.

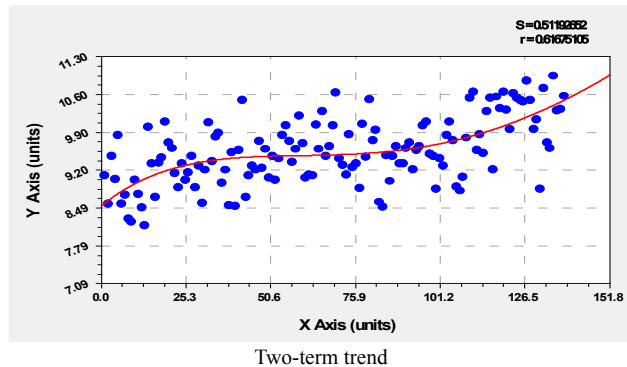
As can be seen from the general graph for the four members, after 2017 there is also a small tremor (shaking), but it is smaller compared to the maximum temperature. It turned out that this jitter will be changed by other wavelets. For the residues shown in figure 2 by the points at the end, another 60 components were obtained by the formula (1). The stop of the simulation was performed after reaching the residuals (absolute simulation error) of the measurement error at the end of the 19th century at  $\pm 0.05^{\circ}\text{C}$ .

Other vibrational perturbations can be identified from the residuals, but the correlation coefficients will be much less than 0.1.

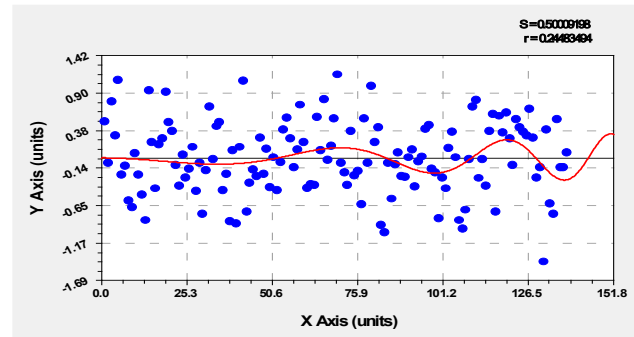
### 7.3 Dynamics of Average Annual Air Temperature

With a correlation coefficient of 0.7086, a four-membered model with strong coupling adequacy was obtained (Figure 3) for a number since 1879. And for the series from 1659 0.5893 was obtained, that is, with an average level of adequacy with a correlation coefficient from 0.5 to 0.7. It follows that increasing the length of the dynamic series in retrospect reduces the adequacy of the simulation.

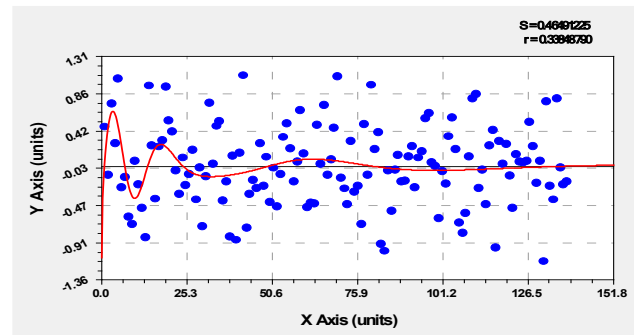
The trend contains two members and has a correlation coefficient of 0.6168, which is greater than 0.5618 for the single-term trend of the minimum temperature and 0.6086 for the two-term trend of the maximum temperature. The intensity of the exponential growth of the average temperature equals 1.03071 that more than 1. Therefore, for the second term, the increase in the average temperature of Central England is accelerated. In comparison with the maximum temperature, the intensity of the exponential growth is  $1.03071 / 0.39342 = 2.62$  times more.



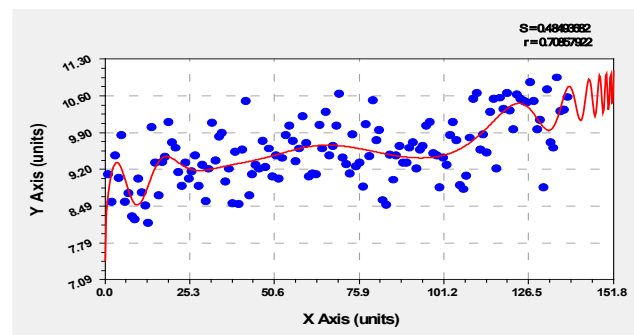
Two-term trend



First oscillation



The second oscillation



Two members of the trend and two wavelet

**Figure 3.** Graphs of the General model (1) dynamics of average annual temperature

Because of the negative sign, the first wavelet is focused on reducing the average annual temperature. At the same time, this desire increases in amplitude, but increases in frequency of oscillation in 1879, the period of oscillation was 2 55.65055 111.3 years. This period is almost 10 times the cycle of solar activity or 5 times the cycle of the sun's core around itself. Similarly, the second wavelet in 1879 had a period of oscillation of 2 5.96040 11.92 years, that is, equal to the cycle of solar activity.

Then it can be concluded that until the end of the XIX century, the climate was more clearly subject to the cycles of solar activity, but then humanity introduced chaotic changes in the vibrational adaptation of climate and weather.

The graph of the four-membered model in Figure 3 shows that after 2018, the average temperature, as well as the maximum air temperature, receives a tremor or jitter with an in-

creasing frequency of oscillation as a result, the climate as it goes to the dressing, as it happens before the car accident.

### 8. Binary Relations between Different Temperatures

Binary relations, and without any pre - conditions of selection, are necessary to assess the level of adequacy of mutual relations between the accepted factors. Due to the quantum entanglement of the relations between the factors, the wave equations for (1) are not obtained, so only the trend model (2) was adopted for identification. Then the correlation coefficient shows quantum certainty, and the difference  $1 - r$  gives quantum entanglement.

#### 8.1 Effect of Maximum Air Temperature

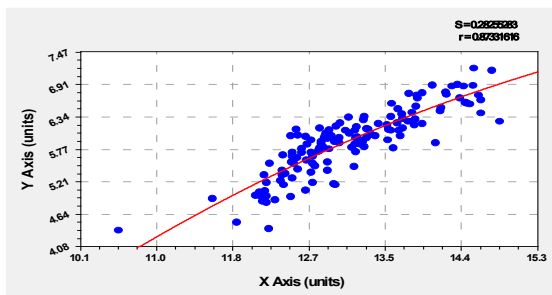
The other two factors are affected by this air parameter according to the two-term trend formulas (Figure 4):

- the effect of the maximum temperature on the minimum temperature with a correlation coefficient 0.8733 trend (2) as an equation

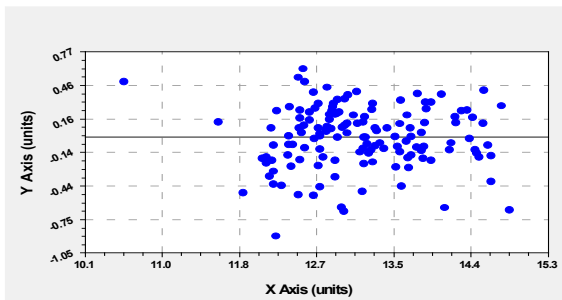
$$t_{\min} = -11.36693 \exp(-0.054204 t_{\max}^{1.14678}) + 0.93529 t_{\max}^{1.16677} \exp(-0.027815 t_{\max}^{1.21768}) \quad (3)$$

- the effect of the maximum temperature on the average temperature at a correlation coefficient of 0.9760 according to the formula

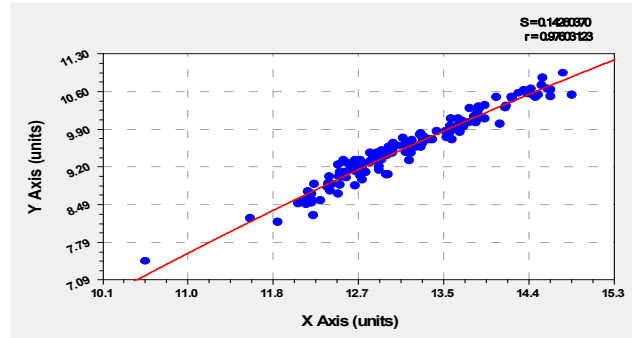
$$\bar{t} = -5.43734 \exp(-0.050581 t_{\max}^{1.07379}) + 0.98493 t_{\max}^{1.07640} \exp(-0.011358 t_{\max}^{1.23682}) \quad (4)$$



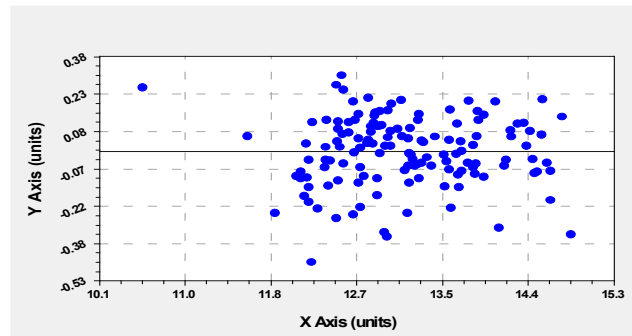
At minimum temperature 0.8733



After the remains of two members of the trend (3)



Average temperature 0.9760



After the remains of two members of the trend (4)

**Figure 4.** Effect of maximum air temperature on other parameters: left column-trend charts; right column-trend balances

As the maximum temperature increases, both other temperatures begin to rise with negative values of  $-11.37\text{ }^{\circ}\text{C}$  for the minimum temperature and  $-5.44\text{ }^{\circ}\text{C}$  for the average temperature. In this case, the second member receives a complete construction of the biotechnical law [5]. From the residues in Figure 4 it can be seen that their location relative to the axis of the abscissa is not visible patterns.

#### 8.2 Effect of Minimum Air Temperature

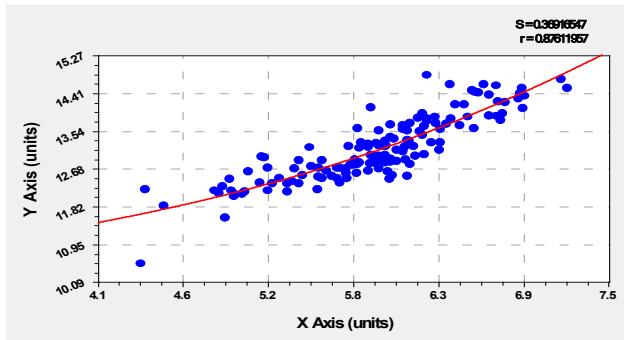
Figure 5 shows graphs of the effect on other parameters.

Graphs of the left column with quantum certainty (disarray) are characterized by equations:

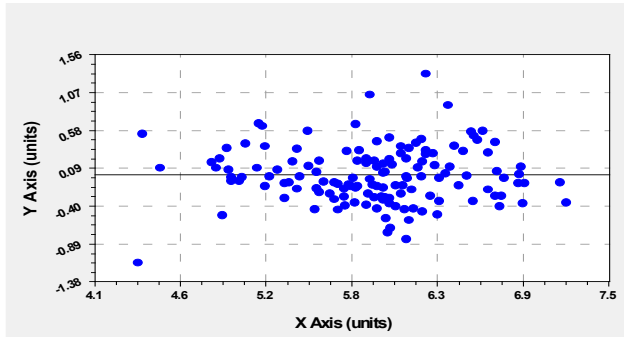
- the effect of the minimum temperature on the maximum temperature at a correlation coefficient of 0.8761 according to the formula

$$t_{\max} = 7.99814 \exp(-0.028312 t_{\min}^{2.16364}) + 1.31757 t_{\min}^{1.19252} \quad (5)$$

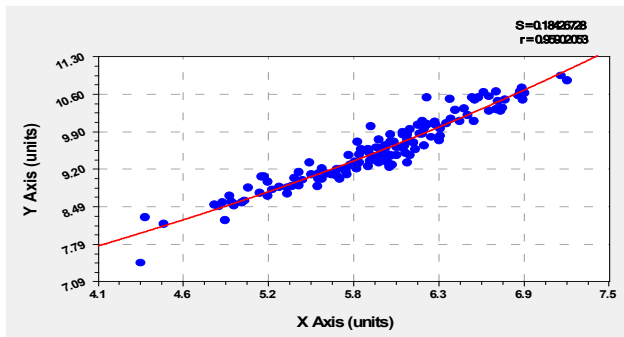




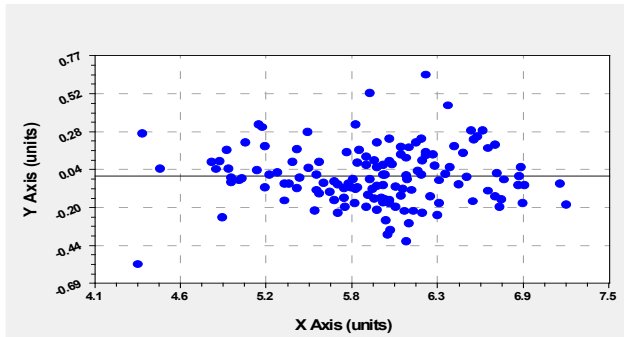
At maximum temperature 0.8761



After the remains of two members of the trend (6)



Average temperature 0.9590



After the remains of two members of the trend (7)

**Figure 5.** Effect of minimum air temperature on other parameters: left column-trend charts; right column-trend balances

- the effect of the minimum temperature on the average temperature with a correlation coefficient of 0.9590 in the expression

$$\bar{t} = 3.90185 \exp(-0.026934 t_{\min}^{2.20399}) + 1.17222 t_{\min}^{1.11458} \quad (6)$$

With increasing minimum temperature on the first member, other types of temperature decreases, but on the second member in the form of a demonstration of the law grow with intensity 1.19252 and 1.11458. Quantum entanglement of residues is heterogeneous: in the middle of the minimum temperature there is a crowding of points.

### 8.3 Effect of Average Air Temperature

This effect is shown by the graphs in Figure 6, which have been identified by equations of the form:

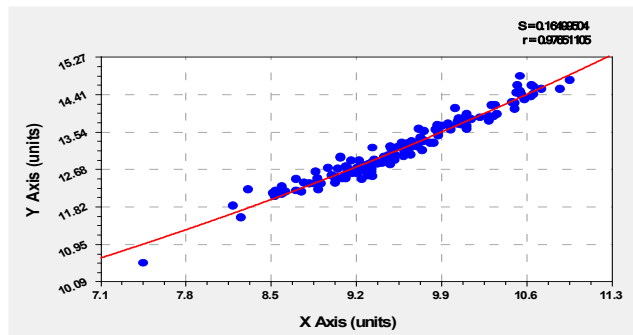
- the effect of the average temperature on the maximum temperature at a correlation coefficient of 0.9765 for the formula

$$t_{\max} = 4.16442 \exp(-0.0069492 \bar{t}^{-2.44380}) + 0.94934 \bar{t}^{1.13900} \quad (7)$$

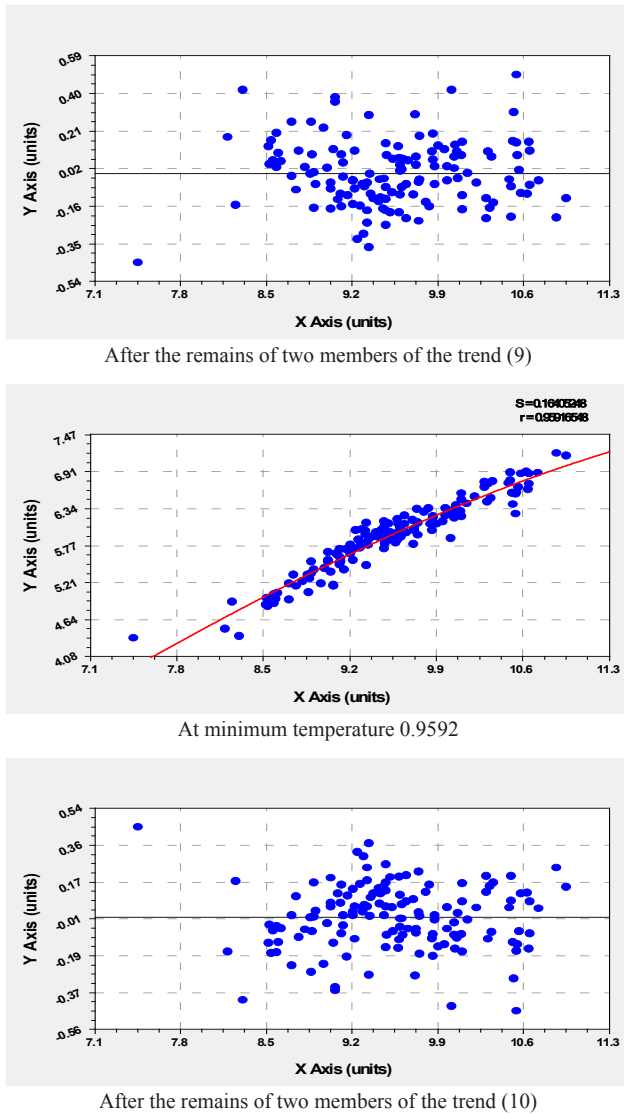
- the effect of the average temperature minimum temperature with coefficient of correlation 0.9592 by the formula

$$t_{\min} = -3.73112 \exp(0.071287 \bar{t}^{-1.15935}) + 0.88263 \bar{t}^{1.31899} \exp(-0.0065474 \bar{t}^{1.15314}) \quad (8)$$

The comparison shows that the greatest influence with the correlation coefficient 0.9765 is exerted by the average temperature on the maximum air temperature in the surface layer of the atmosphere. At the same time, all six equations refer to strong connections, so there is a high quantum certainty between the three types of temperature. But when predicting the greatest heuristic (meaningful) essence showed the maximum temperature.



At maximum temperature 0.9765



**Figure 6.** Influence of average air temperature on other parameters: left column-trend charts; right column-trend balances

At zero values of the influencing variables according to the previous formulas, we obtain the limit theoretical values of the dependent indicators (Table 6).

**Table 6.** Limit values of meteorological parameters at zero values of influencing variables by equations (3-8)

Influencing factors (characteristic $x$ )	Dependent factors (indicators $y$ )		
	$t_{max}, ^\circ C$	$t_{min}, ^\circ C$	$\bar{t}, ^\circ C$
Maximum temperature $t_{max}, ^\circ C$	-	-11.37	-5.44
Minimum temperature $t_{min}, ^\circ C$	8.00	-	3.90
Annual mean temperature $\bar{t}, ^\circ C$	4.16	-3.73	-

From the data of the Table 6 it is seen that the most dangerous is the change in the maximum temperature,

when at zero maximum temperature the minimum temperature in the year reaches  $-11.37 ^\circ C$ .

Figure 4 shows that the minimum temperature was always positive and its lowest value was  $4.36 ^\circ C$  in 1879. In the same year, the maximum temperature also had a minimum value of  $10.52 ^\circ C$ . In the future, both of these indicators only increased, respectively, to 6.87 and  $14.30 ^\circ C$  in 2017. Then lowering the maximum temperature to  $0 ^\circ C$  becomes a climatic disaster.

### 9. Quantum Entanglement between Temperatures

In Figure 5-8, quantum entanglement is characterized by residues in the second column of the graphs. The correlation coefficient of quantum entanglement is determined by the expression (Table 7).

**Table 7.** Values of correlation coefficients by equations (3-8)

Influencing factors (characteristic $x$ )	Dependent factors (indicators $y$ )	Correlation coefficient quantum behavior	
		unraveling	entanglement
Maximum temperature $t_{max}, ^\circ C$	$t_{min}, ^\circ C$	0.8733	0.1267
	$\bar{t}, ^\circ C$	0.9760	0.0240
Minimum temperature $t_{min}, ^\circ C$	$t_{max}, ^\circ C$	0.8761	0.1239
	$\bar{t}, ^\circ C$	0.9590	0.0410
Annual mean temperature $\bar{t}, ^\circ C$	$t_{max}, ^\circ C$	0.9765	0.0235
	$t_{min}, ^\circ C$	0.9592	0.0408

We introduce a new concept – *quantum unraveling*, which shows the adequacy of the identification of mathematical regularities in the form of wavelet signals. Therefore, the adequacy of *quantum unraveling* is characterized by the same value of the correlation coefficient, which was obtained during the application of the method of identification of asymmetric wavelets.

As can be seen from Table 7, the quantum entanglement of three meteorological parameters is very small.

In the simplest case, the sides along the abscissa and ordinate axes of the rectangle describing the swarm of points (up to 3300 points the software environment can show the entire swarm) become the boundaries of the residues on the graphs in Figure 4-6.

Coordinates of the centers of the remnants of the swarm can be adopted an arithmetic average of the values on the abscissa and the ordinate. There may be special centers for fashion and other statistical indicators of the sample.

## 10. Conclusions

For each ground-based weather station, it is necessary to study *the point distributions* of meteorological measurements. Pair connections between meteorological parameters allow studying the *quanta of climate* and weather behavior for different time periods: long-term, annual, plant ontogenesis period<sup>[8-11]</sup>, seasonal, monthly, weekly, daily, hour and minute.

Then we distinguish two types of quanta of behavior:

First, in dynamics, each factor is divided into the sum of wavelets, that is, in time, the factor is represented as a bundle of solitary waves (solitons) and this process is characterized as *quantum unraveling*;

Secondly, the mutual influence of the above three factors with uniform or uneven periodicity of measurements additionally obtains *quantum entanglement* in some boundaries.

Thus, any phenomenon or process can be estimated by the level of adequacy (correlation coefficient) of decomposition of the functional connectivity of the system behavior into *quantum unraveling* and quantum entanglement.

The concept of vibrational adaptation in nature suggests that between the selected factors in Table 1. There are dependencies in the form of wave equations. However, it turned out that there is no wave connection between these three temperature factors, which indicates the presence of a sufficiently strong quantum entanglement of meteorological data.

If the remains after the wavelet analysis are not further modeled, then experts say about some noise. But we believe that noise can only be called residues that are equal to or less than the measurement error. Therefore, part of the noise exceeding the measurement error should be attributed to quantum entanglement. And the share of parameter values determined by the revealed regularities should be attributed to *quantum unraveling*.

*The coefficient of correlation variation*, that is, a measure of the functional relationship between the parameters of the system (annual weather at the weather station), is equal to  $7.4073 / 3^2 = 0.8230$ . As the influencing variable at the first place was the meteorological parameter «Annual mean temperature», the second «Maximum temperature» and in third place – «Minimum temperature». As the dependent measure in these areas there are three kinds of temperature.

The comparison shows that among the binary relations between the three temperatures, the greatest influence with the correlation coefficient 0.9765 is exerted by the average temperature on the maximum air temperature in

the surface layer of the atmosphere. At the same time, all six equations refer to strong connections, so there is a high quantum certainty between the three types of temperature. But when predicting the greatest heuristic (meaningful) essence showed the maximum temperature.

The hierarchy of statistical climatology methods based on the identification of stable laws and regularities is as follows: 1) formation of tabular model and cluster analysis of factors; 2) rating of objects and subjects in a given system of factors; 3) ranking distributions or wavelet-analysis of dynamics of factors; 4) analysis of the vibrational adaptation of the system parameters; 5) factor analysis of the performance of the system; 6) the rating of the influencing and dependent factors; 7) analysis of binary relations between factors; 8) fractal analysis of wavelets; 9) preparation of predictive models for dynamics wavelets; 10) multivariate hierarchical modeling.

Methods 3-7 have been shown in this article.

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