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Fito Urban Meteorology: Influence of the Amount of the Temperature on the Ontogeny of the Leaves of the Silver Birch

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ABSTRACT

The development of birch foliage is very sensitive to changes in temperature in the surface layer of the atmosphere. The goal is a comparison of the amount of the three-hour air temperatures with the dynamics of growth and development accounting-leaf birch in the vegetation period. The behavior of each leaf occurs as an oscillatory adaptation to changes in the environment of this leaf. Moreover, adaptation takes place on the set of decreasing quanta of interaction. By date of measurement 20 leaves over the growing period of the silver birch received quantum state in a pure environmental growing conditions. In phytometeorology, the first level of quantization of meteorological data is to account for the beginning and end of the growing season of birch. Refusal of the average daily temperature and the transition to measurements in three hours gives an oscillation with a constant half-cycle of 0.50003 days. This wavelet has a correlation coefficient of 0.6880, which is much higher than the other 27 members of the General model. Leaves grow and develop during the growing season by vibrational adaptation to the sum of temperatures. The greatest correlation coefficients are the length and width of the accounting sheet of birch. It is necessary to continue research of dynamic series of temperature at meteorological stations with dynamics of behavior of leaves of a birch tree and other types of trees. This will help to develop phytometeorology for many parts of the Earth and identify patterns of phytoclimate to counteract increasing global warming.
KEY WORDS: birch leaves, the vegetative period, the dynamics of amounts, temperatures settings 20 account leaves, the dynamics of behavior, wavelet analysis

1. INTRODUCTION

Biometeorological assessment of climate and air quality in Germany is performed for urban and landscape planning [34]. Mostly biometeorologia cities need to humans [31]. The microclimate in the urban environment forms a community of trees, shrubs and grass lawns. The article deals with phytometeorology, in particular, the effect of the sum of temperatures on the leaves of birch in ontogenesis during the growing season.

The article [1] shows the existence of an asynchronous relationship between the temperature of the near-surface air layer in different zones of the Earth. This temperature is affected by direct solar radiation [2], but it also depends on the terrain. The city of Yoshkar-Ola is located in a flat area, so the influence of the terrain can be neglected. It ranks tenth in the country among clean cities.

According to [3], meteorological factors affect air pollution, and in summer air temperature strongly influences. The forecast of temperature [9] according to the climatic model of Germany showed that the average temperature increase will be 1 ^{0}C until 2100 in summer. At the same time, from January to may there is a strong temperature fluctuation due to cyclonic influences [10]. During 1966-2013 there was a noticeable increase in summer temperatures [14]. The dynamics shows a more uniform temperature distribution in summer [20, 22].

Metric parameters of leaves [19] depend on the vegetation period. This period depends on the temperature and increases over the years [21]. When the vegetation period increases, the sum of active temperatures changes little [23]. In [24, 33] the average daily temperature is accepted, but for the account of the day and night periods it is necessary to accept measurements of temperature in 3 hours.

In Berlin [25] for 252 the tree of lime in the cores by the distance from the center to the periphery was revealed changes of the increment of the thickness of the trees for 50 to 100 years. Seven tree species in Europe [51] showed nonlinear dependence of plant development on temperature and microclimate. In Biometeorology there is uncertainty for the future. In [50] shows the influence of urban vegetation on the thermal comfort of man, equal to 22,2 ^{0}C. A rational phytoclimate will locally counteract global warming.

Climate change affects birch and oak trees in the United States [52]. With the increase in air temperature there is an increase in the amount of pollen and the vegetation time changes. Seasonal patterns are also observed for insects [46]. The article [49] considers the activity of leaves of perennial grass horseradish in the growing season. For tomatoes, comfortable conditions are created at a temperature of 25-26 ^{0}C and a relative humidity of 50-70% [29]. They like fog formation. In agriculture, the results are compared monthly [28] with the current climatic conditions. In [31] the analysis of articles for 1974-2017 from the journal «Biometeorology» is given.

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The forests of China have nonlinear oscillations of the leaf surface [27]. At the same time, winter cooling conditions can strongly influence bud blooming [42]. Vegetation of India is considered through temperature fields and vegetation index [45]. At the same time, birch is the most effective in water use [43]. According to [30], adaptive strategies are acceptable in the future: the vegetative mass of plant leaves is more related to air temperature.

The leaves unfold as a reaction to the warming of the air. For many species of trees the temperature range 0-5 ^{0}C is effective. Global warming leads to higher tree growth rates [26]. The birch is affected by the increase in temperature and ozone. Higher temperature and more biomass, more carbon accumulates due to global warming [32].

The vegetation period becomes one of the important ecosystem processes, as the development of leaves is very sensitive to air temperature. Therefore, the future of climate in leaf observations [44]. It is especially promising to monitor the behavior of glandular hairs on the surface of birch leaves [48]. The leaves produce them throughout the growing season.

2. MATERIALS AND METHODS

The main object of global environmental monitoring can be birch with leaves without cutting [4-8; 11-13; 15-18]. Birch forests of the Northern hemisphere (Holarctic Kingdom according to [47]) occupy half of the world along the Arctic ocean.

Adequate models with wave components were obtained on account of the leaves of the young birch trees grown in environmentally friendly conditions. It is proved that air pollution suppresses the mechanism of oscillatory adaptation of leaves in the process of annual (seasonal) ontogenesis.

The regularities showing relatively weak influence of groups of five leaves located on separate branches, depending on the azimuth, radius from the axis of the trunk and the angle of adjunction of the branch to the trunk of a young birch [12, p.118-166] are also obtained. Each record sheet was marked with a white thread with a tag with the number of the sheet tied to the petiole at the base of the sheet.

The method of measuring the length, width, perimeter and area of leaves includes such actions [15-18]. On a sheet put a transparent pallet with a grid (cages 2×2 mm) so that the average line along a pallet coincided with an axis of a longitudinal vein of a leaf. Then the sheet with a pallet is photographed with a digital camera with the function of storing photographs. On the computer, the photo sheet is cut, then increased to count the cells to A4 format.

In contrast to [12] in this article the last point on the fact of falling of the sheet is excluded, since the death of the sheet is observed at non-zero parameters. Added a new parameter-the sum of temperatures every three hours (table 1) at the meteorological station of the village of Medvedevo (2 km from young birch).

Table 1. The dynamics of the air temperature since the beginning of the growing season the leaves of the silver birch

Date	Term, clock	Time t, day	Temperature air's T, ^{0}C	The sum of temperatures $\sum T$, ^{0}C	Amount to settle $\sum_T = \sum T / 100$
02.05.2014	1	0.042	9.8	9.8	0.1
	4	0.167	7.7	17.5	0.2
	7	0.292	7.7	25.2	0.3
	10	0.417	17.1	42.3	0.4
	13	0.542	19.6	61.9	0.6
	16	0.667	19.5	81.4	0.8
	19	0.792	19.1	100.5	1.0
	22	0.917	13.5	114.0	1.1
03.05.2014	1	1.042	11.8	125.8	1.3
	4	1.167	10.5	136.3	1.4
	7	1.292	8.5	144.8	1.4
	10	1.417	7.1	151.9	1.5
	13	1.542	5.8	157.7	1.6
	16	1.667	10.2	167.9	1.7
	19	1.792	7.6	175.5	1.8
	22	1.917	12.3	187.8	1.9
…	…	…	…	…	…
01.10.2014	1	152.042	3.7	19719.6	197.2
	4	152.167	5.2	19724.8	197.2
	7	152.292	5.4	19730.2	197.3
	10	152.417	5.2	19735.4	197.4
	13	152.542	5.1	19740.5	197.4
	16	152.667	5.4	19745.9	197.5
	19	152.792	3.8	19749.7	197.5
	22	152.917	6.8	19756.5	197.6

The current time is counted every three hours. The air temperature is taken according to the meteorological station. Then the temperature cumulate is calculated. During the growing season formed the sum of temperatures in 19756.5 ^{0}C. To obtain acceptable values for the calculation is taken by the formula $\sum_T = \sum T / 100$ division by 100.

Table 2 shows a fragment of experimental data with birch leaves.

Table 2: Comparison of the sum of air temperatures with the parameters of 20 leaves of birch

№ p / n	Date	Time t, day	No. sheet's	Amount $\sum_T$	a, mm	b, mm	P, cm	S, cm^2
1	02.05.2014	0	1	0.1	0	0	0	0
2	21.05.2014	19	1	21.9	26.0	20.2	7.35	3.32
3	29.05.2014	27	1	34.9	34.4	26.6	12.73	7.66
4	05.06.2014	34	1	45.6	42.0	33.8	13.58	9.04
5	19.06.2014	48	1	63.8	49.6	41.8	14.99	14.90
6	03.07.2014	62	1	81.6	54.4	46.2	19.23	17.84
7	24.07.2014	83	1	112.4	62.2	50.4	19.80	20.36
8	21.08.2014	111	1	156.3	69.0	57.2	32.24	24.44
9	04.09.2014	125	1	173.2	62.2	50.4	29.98	21.64
10	17.09.2014	138	1	185.7	54,4	46,2	19,23	17,84
11	24.09.2014	145	1	191.3	49,6	41,8	14,99	14,90
12	02.05.2014	0	2	0.1	0	0	0	0
13	21.05.2014	19	2	21.9	26.4	20.4	8.20	3.50
14	29.05.2014	27	2	34.9	34.8	27.0	12.73	7.66
15	05.06.2014	34	2	45.6	42.4	34.2	13.58	9.04
16	19.06.2014	48	2	63.8	50.0	42.2	17.25	14.90
…	…	…	…	…	…	…	…	…
216	24.07.2014	83	20	112.4	68.8	57	27.44	27.70
217	21.08.2014	111	20	156.3	76.4	65	32.81	28.52
218	04.09.2014	125	20	173.2	68.8	57	30.83	24.34
219	17.09.2014	138	20	185.7	62.0	50,4	20,36	19,80
220	24.09.2014	145	20	191.3	54.0	45,8	17,25	17,94

It adopts the following conventions:

t - current time from the moment of birch buds blooming (may 2, 2014) to the last measurement in the growing season, day (September 24, 2014);

$\sum_T$ - the sum of temperatures from the moment of bud blooming of birch hung every three hours of measurements at the meteorological station, 0.01^{0}C;

a - leaf length along the main vein, measured from the junction of the petiole with the leaf plate of the plant to the end of the leaf apex, mm;

b - the width of the sheet at the extreme points across the sheet plate or the total width of the sheet in the largest cross-section of the sheet, mm;

P - the perimeter of the sheet, cm;

S - the area of the sheet, measured by the number of cells 2×2 mm in size and the number of cells located along the perimeter of the sheet, cm^2.

The physical and mathematical approach assumes understanding of a dynamic series on the vegetation period as reflection of some compound process of vital activity of accounting leaves. The behavior of each sheet occurs as an oscillatory adaptation to changes in the environment of this sheet. And adaptation happens for many decreasing quanta of interaction.

Under this assumption, any equation of the wave component in the vibrational adaptation quantum can be written as a wavelet signal [35-41]

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

where A_i – amplitude (half) of asymmetric wavelet (axis y); p_i – half-period of oscillation (axis x); $a_{1i} \ldots a_{8i}$ - model parameters (1) obtained in pairs from statistical data in the software environment CurveExpert-1.40 (http://www.curveexpert.net/) according to tables 1 and 2; i - the number of the member (1).

According to the formula (1) with two ***fundamental physical constants*** e (the Neper number, or the number of time) and π (the Archimedes number, or the number of space), a ***quantized wavelet signal*** is formed from within the phenomenon and/or process under study. And these quanta are arranged one behind the other according to the law of the fractal Mandelbrot. The concept of asymmetric wavelet in the unknown signal (1) allows us to abstract from the physical meaning of the series of distributions by the values of the studied and measured factors.

3. Dynamics of air temperature during the growing season of birch leaves

From the almost infinite series of three-hour temperature measurements at the meteorological station, we distinguish the quantum state in the form of the sum of wavelets (table 3), determined by the growing season of birch leaves. Thus, the first level of quantization of meteorological data is to take into account the beginning and end of the growing season. The vegetation period of the leaves depends on the location of the meteorological station on land, as well as on the year of measurement, the biological species of the plant and its age.

A total of 28 wavelets were formed in table 3, it turned out that the wavelet analysis can be continued further, but the wave patterns are obtained with very small correlation coefficients. The first two non-wave members form a trend (trend). However, the trend is a wave with an almost infinite period of oscillation, much greater than the length of the growing season. Therefore, in our understanding, the trend is also a quantum of behavior. The first term is the law of exponential growth, and it characterizes the process of warming on Earth. The second member of the trend is the law of exponential growth, and the crisis growth due to the negative sign, due to the decrease in the amount of solar radiation by the autumn. Thus, the trend with two members shows the seasonal change in the temperature of the surface layer of the atmosphere.

Table 3: Parameters of temperature dynamics wavelets during the growing season of birch leaves

Number i	Asymmetric wavelet $y_i = a_{1i} x^{a_{2i}} \exp(-a_{3i} x^{a_{4i}}) \cos(\pi x/(a_{5i} + a_{6i} x^{a_{7i}}) - a_{8i})$								Corel. coefficient. r
	The amplitude (half) the fluctuations				Half-period of oscillation			shift	
	a_{1i}	a_{2i}	a_{3i}	a_{4i}	a_{5i}	a_{6i}	a_{7i}	a_{8i}	
1	0.41351	0	-3.28833	0.037035	0	0	0	0	0.8253
2	-3.46253e-6	2.97644	0	0	0	0	0	0	
3	2.72834	0	0.00017960	1	-31.35434	42.44642	0.094531	2.60818	
4	-5.74920	0	0.014594	1.02390	5.03424	0.098726	0.63419	2.68630	
5	4.97101	0	8.61365e-5	1.59608	0.50003	0	0	-2.14578	
6	-1.37580	0	-0.0011110	1	17.03445	0.022053	0.84459	2.29248	0.3129
7	-1.42412	0	0.011504	1	6.76695	0.71671	0.45994	1.60219	0.1652
8	-0.0022698	0	-0.12331	0.80332	7.24013	0	0	-2.50247	0.1643
9	-2.49185	0	0.0093000	1	-4.20092	5.85285	0.097608	2.54280	0.3250
10	-0.37946	0	-3.69833e-5	2.15641	8.45450	-0.018547	1.00005	-1.29626	0.2343
11	-1.44159	0	0.00069336	1	3.67078	0	0	4.80100	0.3386
12	-0.73175	0	0.00057932	1.28180	3.20679	-0.00040111	1.17381	-3.47102	0.1653
13	-1.22432	0	0.0046372	1	9.20751	-6.47580e-5	1.60342	2.95897	0.2378
14	3.61357	0	0.10135	1	2.07721	0	0	-0.11635	0.1776
15	-0.34866	0	-0.0035590	1	1.72541	0	0	2.70053	0.1303
16	0.92157	0	0.012497	1	0.49120	0	0	0.57189	0.1309
17	0.26148	0	-0.042796	0.62078	4.88074	-0.00026566	1.37946	-2.16811	0.1425
18	-7.22867	0	0.93623	1	0.83667	-0.022759	0.97175	0.55149	0.1391
19	-0.46871	0	-0.0024568	1	3.45104	0.33562	0.062194	0.87030	0.1654
20	0.54200	0	0.0043089	1	3.20606	0.00076691	1.18155	1.51076	0.1187
21	0.94708	0	0.012767	1	2.35252	0	0	0.25485	0.1406
22	-0.88337	0	0.090120	0.51547	7.75878	0.00010371	1.51115	-0.31483	0.1296
23	0.76149	0	0.0055582	1	10.71743	0	0	-3.27681	0.1587
24	-0.57585	0	-0.00024575	1.52197	25.80825	0.00057160	1.37317	-1.98207	0.2247
25	-1.36832	0	0.0084705	1	2.55302	0.035400	0.33017	-3.34739	0.2557
26	0.27381	0	-0.00042279	1	6.29151	0	0	1.71078	0.0910
27	1.94352	0	0.093669	1	1.26180	0.79313	1.31170	0.44099	0.0656
28	1.36909e-8	0	-15.96346	0.021632	7.23191	-1.57756	0.061395	-0.65613	0.1793

All other 26 members of the model (1) are infinite-dimensional wavelets operating before and after the growing season. Provided a_{4i} = 1 oscillation amplitude varies according to Laplace's law (in mathematics), Mandelbrot (in physics), pearl (in biology) and Pareto (in econometrics).

Together, the first five members (on the computational capabilities of the software environment CurveExpert-1.40) gave a measure of adequacy by the correlation coefficient 0.8263. This value is greater than 0.7, so even the first five members already give an adequacy level of «strong bond». All 28 members will give an even greater correlation coefficient, but this requires a special software environment for a supercomputer. Half-period varies from-31.35434 to 25.80825 days. Moreover, 10 oscillations have a constant half-period, the rest received variable values during the growing season.

The graphs of the first six members from table 3 are shown in figure 1.

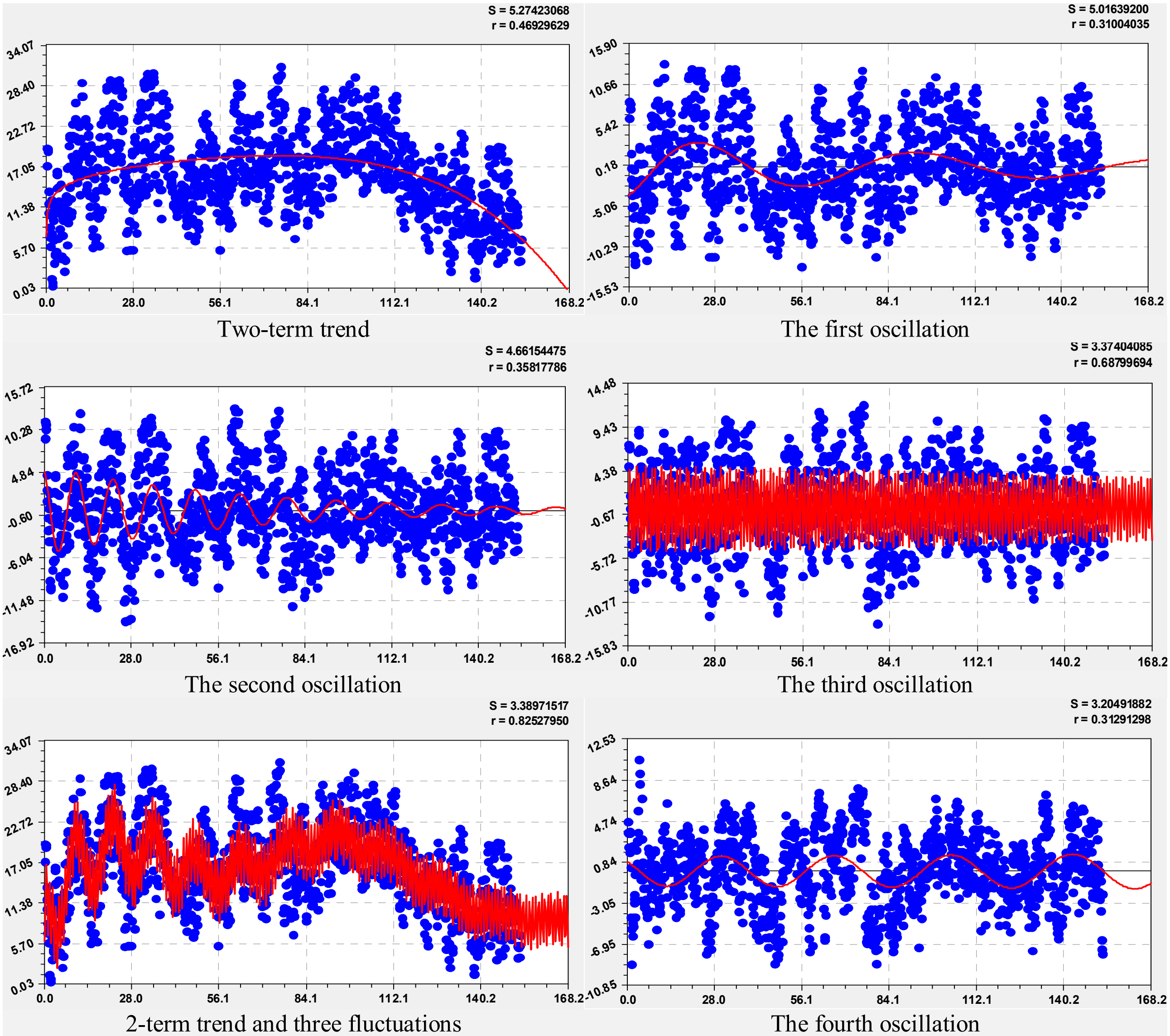


Figure 1. Trend charts and four wavelets with parameters from table 3

The rejection of the average daily temperature and the transition to measurements in three hours gives an oscillation with a constant half-period of 0.50003 days. As can be seen from the graph in figure 1, the fifth term has a correlation coefficient of 0.6880, which is much higher than the rest of the members. In second place is the trend with the adequacy of 0.4693. Thus, the daily dynamics of air temperature in three hours is the most significant.

There are known arrays of accumulated data on the surface air temperature at a particular meteorological station, which begin from the beginning of registration, that is, for decades. It turns out that if you measure the parameters of birch leaves in the growing season, it is possible to combine the behavior of the leaves with the sum of three-hour temperature measurements.

4. Dynamics of parameters of birch leaves during the growing season

By date of measurement 20 leaves over the growing period [12] obtained the quantum state (defined asymmetric wavelet), a young birch in the clean environmental conditions of growth (table 4, Fig. 2).

In contrast to [4-8; 11-13; 15-18], this article does not take into account the day of registration of complete leaf fall. Therefore only considers the last measurements of parameters of leaves in a growing condition. In the future, we must find ways accurate registration of the moment of rejection of the sheet by the tree, as well as the moment of blooming of kidneys of the sheet.

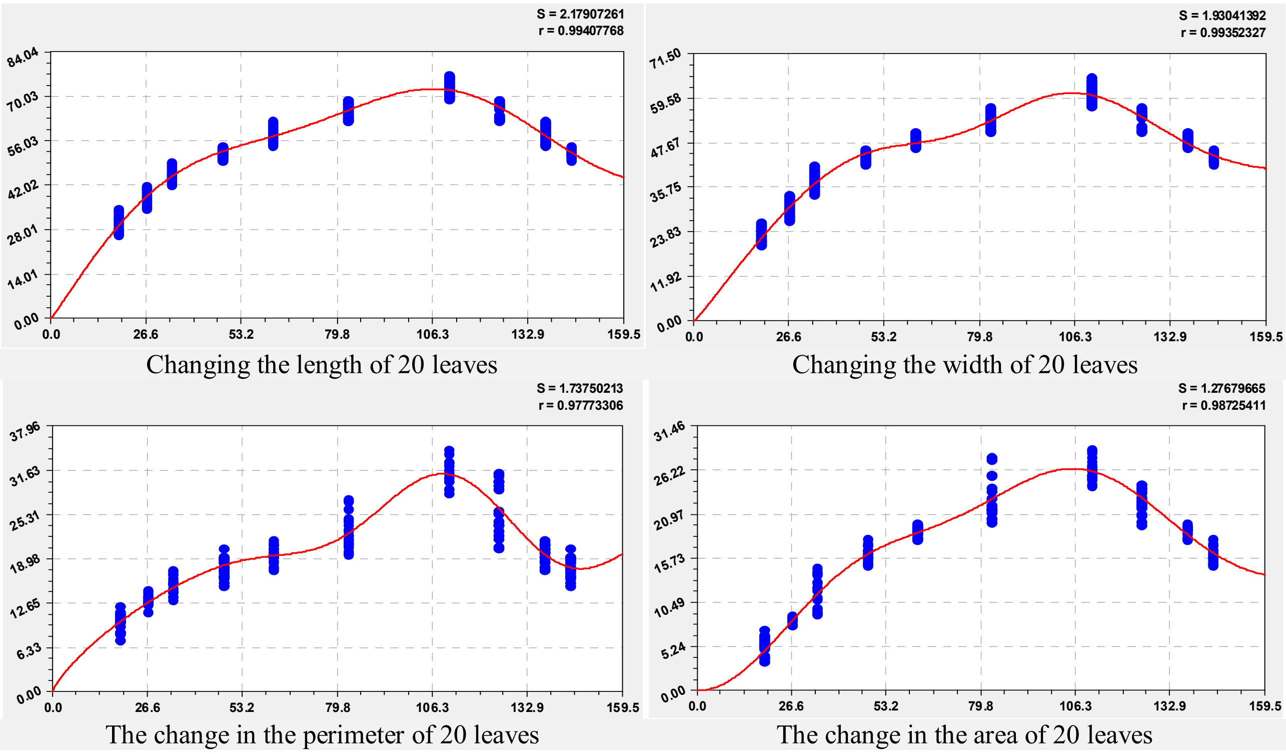
In contrast to [4-8; 11-13; 15-18], this article does not take into account the day of registration of complete leaf fall. Therefore only considers the last measurements of parameters of leaves in a growing condition. In the future, we must find ways accurate registration of the moment of rejection of the sheet by the tree, as well as the moment of blooming of kidneys of the sheet.

Table 4: Wavelets dynamics of birch leaves parameters during the growing season

Number i	Asymmetric wavelet $y_i = a_{1i} x^{a_{2i}} \exp(-a_{3i} x^{a_{4i}}) \cos(\pi x / (a_{5i} + a_{6i} x^{a_{7i}}) - a_{8i})$								Corel. coefficient r
	The amplitude (half) the fluctuations				Half-period of oscillation			shift	
	a_{1i}	a_{2i}	a_{3i}	a_{4i}	a_{5i}	a_{6i}	a_{7i}	a_{8i}	
Dynamics of length of 20 birch leaves									
1	1.39167	1.09775	0.011964	0.99952	0	0	0	0	0.9941
2	0.099609	0.90365	0	0	45.95292	2.34423e-5	2.26544	0.96089	
Dynamics of width of 20 birch leaves									
1	0.87929	1.17816	0.012850	0.99995	0	0	0	0	0.9935
2	8.83115e-6	3.45915	0.0055617	1.32250	40.30155	3.19642e-5	2.25014	1.92260	
The dynamics of the perimeter 20 of birch leaves									
1	1.06342	0.77818	0.00075485	1.39010	0	0	0	0	0.9777
2	-7.13684e-14	8.45338	0.068671	1	294.77474	-206.02919	0.036475	3.52828	
The dynamics of the area of 20 birch leaves									
1	0.013004	2.13263	0.023108	0.99981	0	0	0	0	0.9873
2	0.0016393	1.81936	0.00069461	1.55362	41.16744	2.41281e-5	2.24202	1.88031	

Figure 2 shows graphs of the dynamics of four parameters in 20 leaves of birch.

They show the measurement points, and the line – the average graph of the model with the parameters from table 4. The most appropriate correlation coefficient 0.9941 0.9935 and the dynamics of length and width on average 20 leaves. It turned out that similar models of dynamics are revealed for each sheet of a set of 20 leaves. This circumstance allows not to be engaged in averaging of values of parameters, and to measure at each registration sheet temperature of a place of growth and other meteorological parameters. We dream of devices for automatic registration of many indicators for the vegetation period of the registration sheet.



Changing the length of 20 leaves

Changing the width of 20 leaves

The change in the perimeter of 20 leaves

The change in the area of 20 leaves

Figure 2. Graphs of parameters dynamics in 20 leaves of young birch

In this case, the equation for the width has a complete design. In addition, the width of the sheet is more convenient in future dimensions. Then, for mass measurements in many points of the city of Yoshkar-Ola, it is necessary to take accounting leaves in one zone of the crown of the birch hanging in the predominant direction of the wind (North-West) and photograph only the measurement of the width of the sheet. The length of the sheet can be determined on an enlarged photograph with the definition of the scale of measurements.

5. Dynamics of the sum of temperatures during the growing season of birch leaves

Active temperature – the minimum temperature at which the vegetation of a particular plant species begins. The sum of active (effective) temperatures characterizes the amount of heat. In this case, we do not use the average daily temperature, but actually measured at the meteorological station temperature values every three hours.

The sum of temperatures (table 2) shows the stored energy. This cumulative figure was more convenient in comparison with the current air temperature. The beginning of the dynamics is the moment of birch buds blooming, and the end is the last measurement of leaf parameters before their subsidence.

Table 5 shows the parameters of the model (1) with a correlation coefficient of 0.9999.

Table 5: Dynamics of the sum of temperatures and its influence on the parameters of birch leaves

Number i	Asymmetric wavelet $y_i = a_{1i} x^{a_{2i}} \exp(-a_{3i} x^{a_{4i}}) \cos(\pi x / (a_{5i} + a_{6i} x^{a_{7i}}) - a_{8i})$								Corel. coefficient r
	The amplitude (half) the fluctuations				Half-period of oscillation			shift	
	a_{1i}	a_{2i}	a_{3i}	a_{4i}	a_{5i}	a_{6i}	a_{7i}	a_{8i}	
Dynamics of the amount of 0.01T temperatures over the growing period of the leaves of birch									
1	0.59065	1.24165	0.0026768	0.99860	0	0	0	0	0.9999
2	0.51011	0	-0.53646	0.28435	44.37374	-1.77626e-5	2.29264	2.17075	
The effect of the sum of temperatures on the length of 20 leaves of birch									
1	1.80482	0.92850	0.0076228	0.98558	0	0	0	0	0.9939
2	1.82225	0	-3.97285e-5	2.09431	43.40640	0.31637	0.76543	1.48122	
The effect of accumulated temperatures at a width of 20 leaves of the silver birch									
1	2.77029	0.68854	0.00011379	1.64620	0	0	0	0	0.9938
2	0.39753	0	-0.019306	0.98201	41.52704	0.00010330	2.06204	3.86705	
The influence of the amount of temperatures on the perimeter of the 20 leaves of the silver birch									
1	4.04012	1.12737	1.41961	0.19515	0	0	0	0	0.9779
2	0.00058887	0	-1.26350	0.39173	103.22191	-1.39091	0.65227	-5.73573	
The effect of the sum of temperatures on the area of 20 leaves of birch									
1	0.14572	1.16878	0.00015458	1.69323	0	0	0	0	0.9876
2	0.17470	0	-0.0081304	1.17515	22.84272	0.0024102	1.64321	1.61033	

The trend in the form of biotechnical law [35-41] gives the correlation coefficient 0.9992. Then it turns out that all the quanta of influence (Fig. 3) the amount of temperature in the absence of trend within 1 – 0.9992 = 0.0008.

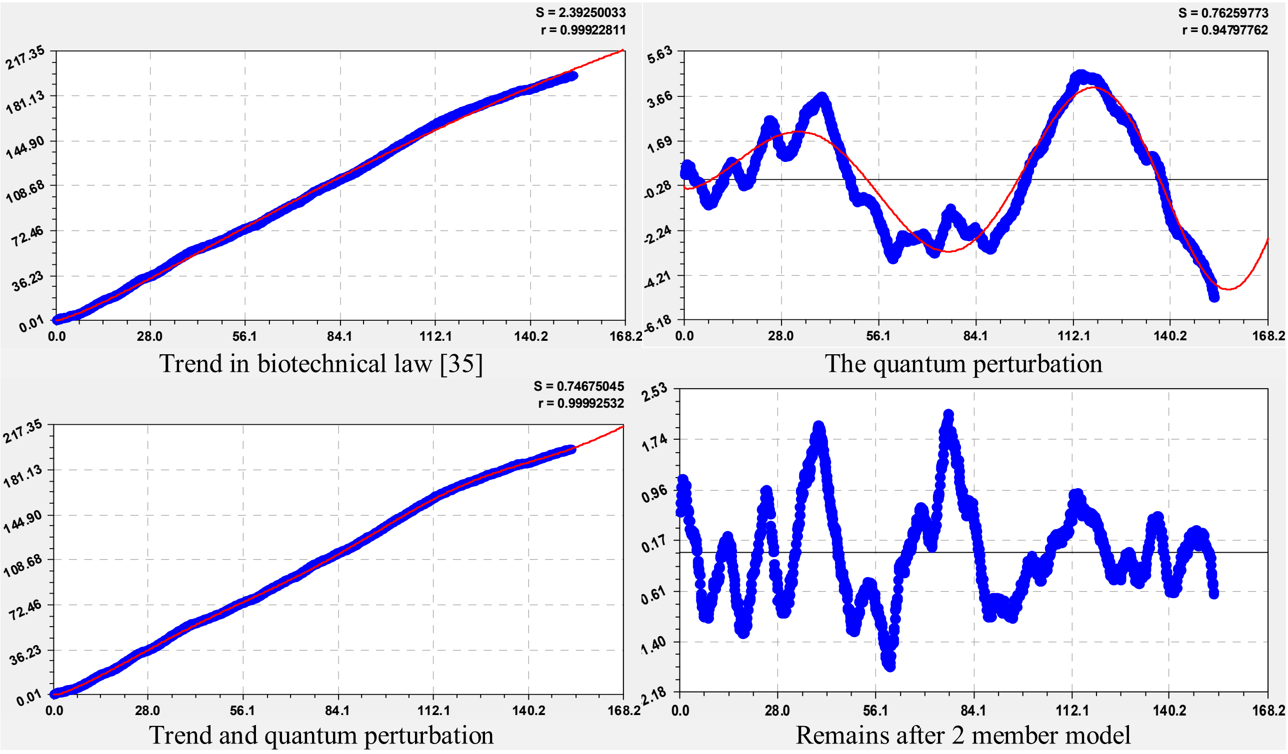


Figure 3. Dynamics of the amount of 0.01T temperatures over the growing period of the leaves of birch

The residues after the 2-term model with parameters from table 5 in figure 3 show the possibility of identifying other wavelets, but with smaller values of the correlation coefficient. It is the quanta with small values of the sum of temperatures that determine the vital activity of the leaves and the whole birch tree as a whole.

Leaves in the growing season grow and develop vibrational adaptation to the sum of temperatures. It is necessary to continue studies of temperature time series at meteorological stations with the dynamics of behavior of birch leaves (and other tree species).

This will help to develop phytometeorology for many parts of the Earth and identify patterns of phytoclimate to counter global warming.

6. The effect of the sum of temperatures on the growth of birch leaves along the length

Next, consider the effect of the sum of temperatures on the four indicators in 20 leaves. The parameters of models with one quantum are given in table 5.

Figure 4 graphs the change in the length of leaves from the amount of temperatures.

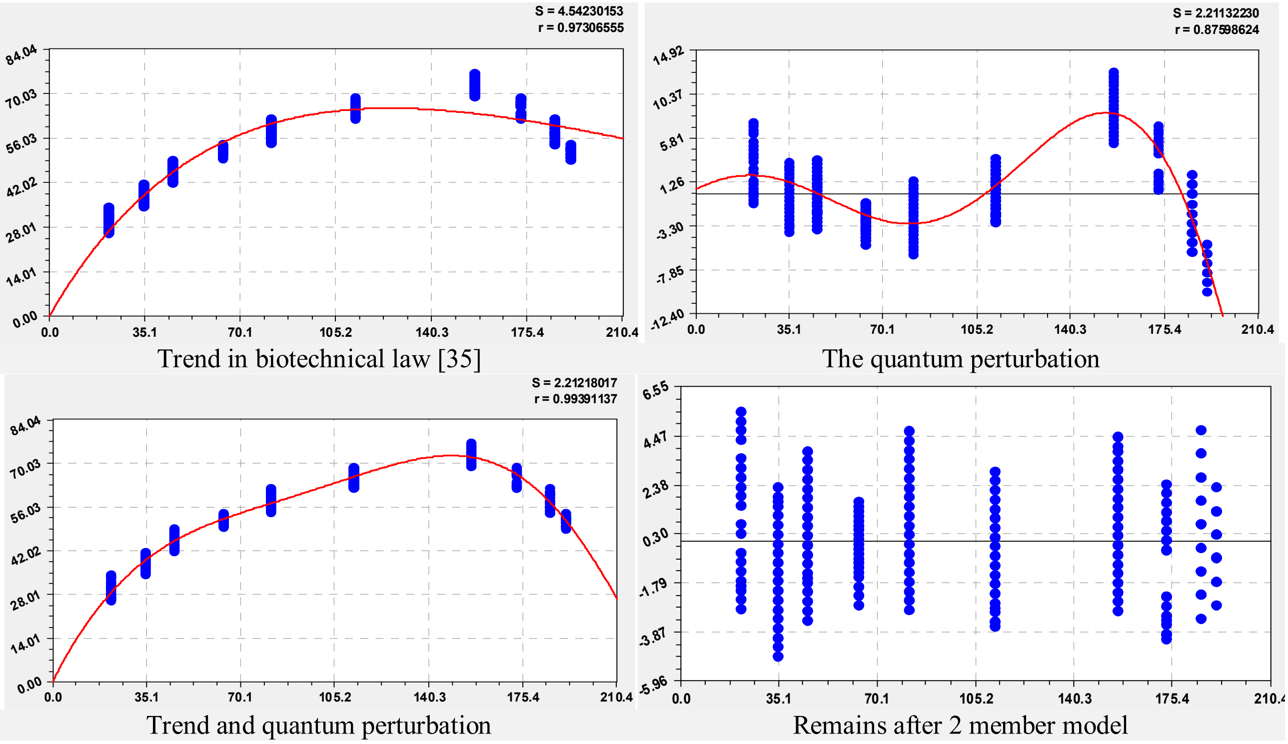
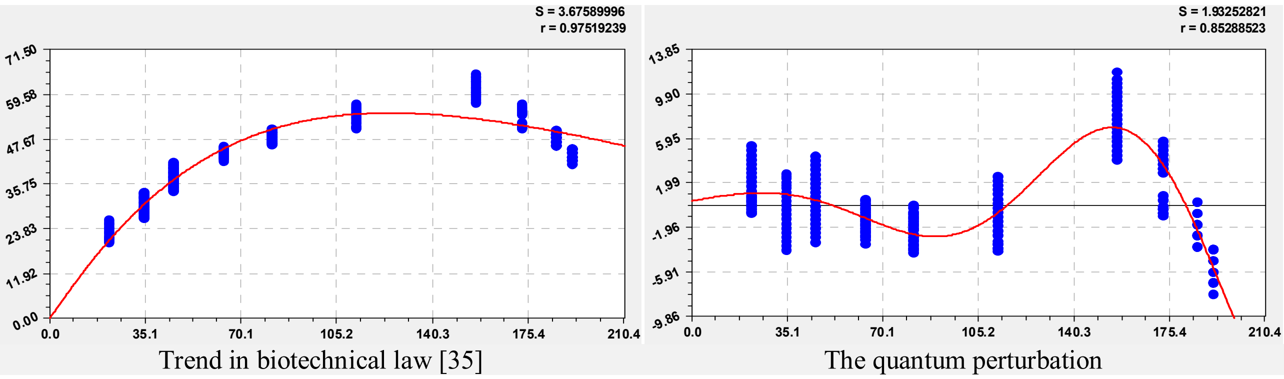


Figure 4. The effect of accumulated temperatures during the growing season 0.01T on a length of birch leaves

Compared with the dynamics of the influence of vegetation time, the influence of the sum of temperatures every three hours gives a clearer picture. For example, the trend and quantum perturbation on the graph in figure 4 show a sharp decline in the length of the sheet, and on the graph in figure 2, the change in time does not give such a sharp decrease. This fact shows that not time has power over the process of vegetation, namely the sum of temperatures.

7. The effect of the sum of temperatures on the growth of birch leaves in width

From the data of table 5 and figure 5, it can be seen that the width and length of the sheet gets almost the same adequacy with correlation coefficients 0.9938 and 0.9939. The half-period of oscillations at the beginning of the growing season have a length equal 43.40640 (the actual amount of temperature 4340.640 ^{0}C), and have a width equal 41.52704.



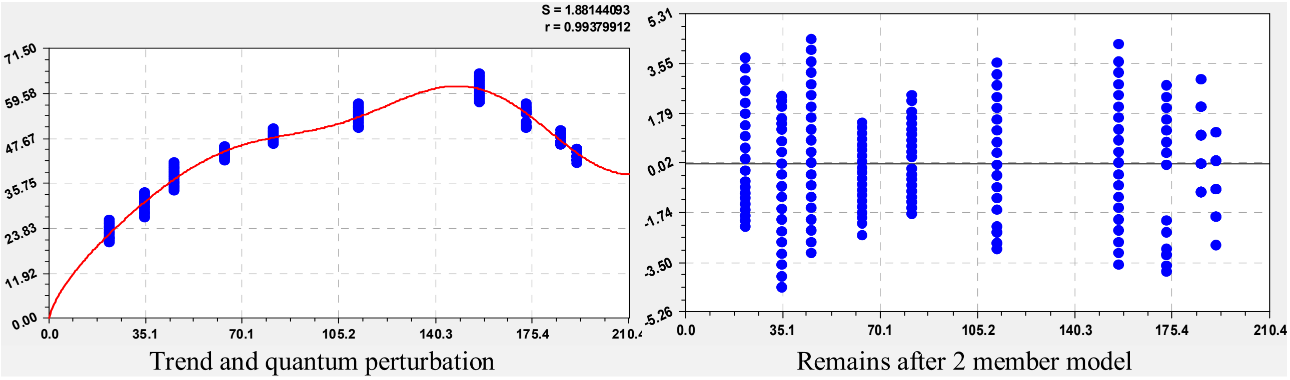


Figure 5. The effect of accumulated temperatures during the growing season 0.01T width of birch leaves

However, the effect of the sum of the temperatures at the end of vegetation period the width of the sheet more relaxed in comparison with the length.

8. Influence of the sum of temperatures on growth of leaves of a birch on perimeter

The perimeter and area of the sheet are more difficult to measure. Figure 6 shows that the graph of the two-term model even rises at the end of the growing season.

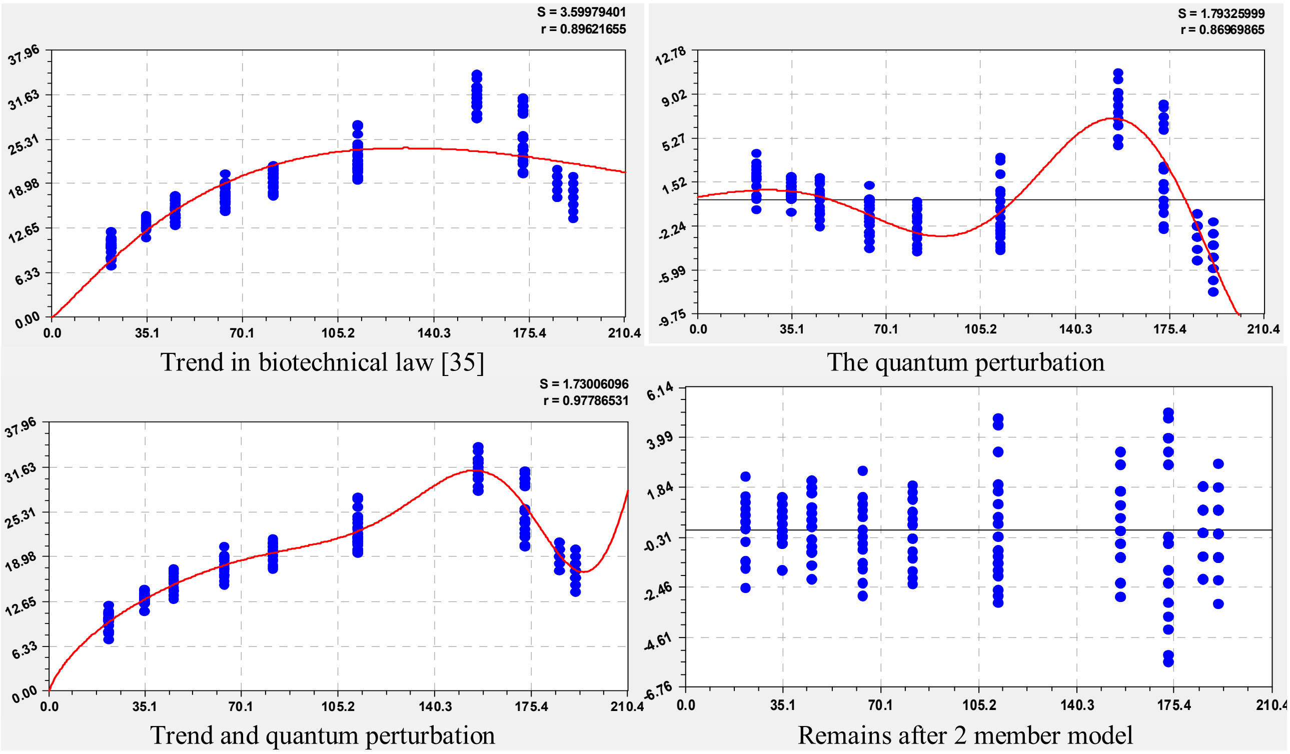


Figure 6. The influence of the amount of temperature 0.01T for vegetation on the perimeter of the birch leaves

At the same time, according to table 5, the largest half-period for four leaf parameters is observed, equal to 103.22191 (actually 10322.191 ^{0}C). Then the perimeter can be excluded from the method of further experiments.

9. The effect of the sum of temperatures on the growth of birch leaves by area

The graph in figure 7 shows an analogy with the change in sheet length.

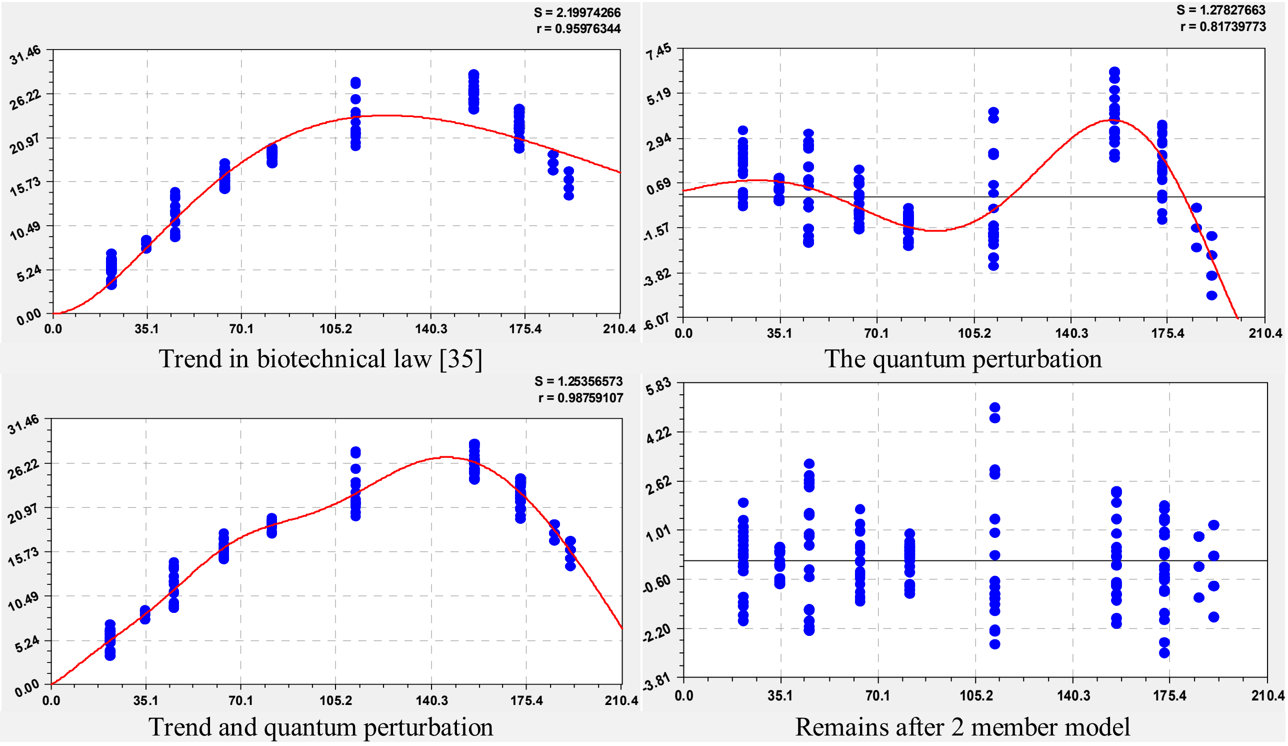


Figure 7. The influence of the amount of 0.01T temperatures during the growing season on leaf area birch

The leaf area receives a minimum half-period of oscillation 22.84272 (2284.272 ^{0}C), which is almost two times less than the length of the sheet.

10. Comparison and selection of the best leaf parameter

The greatest correlation coefficients are the length and width of the accounting sheet of birch. For comparison of their influence together with the sum of temperatures (table 5) factor analysis was carried out. The parameters of two-term models of binary relations are given in table 6, and their graphs are given in figure 8.

Table 6: Dynamics of the sum of temperatures and its influence on the parameters of birch leaves

Number i	Asymmetric wavelet $y_i = a_{1i}x^{a_{2i}}\exp(-a_{3i}x^{a_{4i}})\cos(\pi x/(a_{5i}+a_{6i}x^{a_{7i}})-a_{8i})$								Corel. coefficient r
	The amplitude (half) the fluctuations				Half-period of oscillation			shift	
	a_{1i}	a_{2i}	a_{3i}	a_{4i}	a_{5i}	a_{6i}	a_{7i}	a_{8i}	
The influence of the length 20 leaf width leaf birch									
1	0.69920	1.04098	0	0	0	0	0	0	0.9999
2	0.016603	1.74512	0.050575	1	46.96518	-1.09957	0.75480	0.091003	
The influence of the length of the leaves 20 on the perimeter leaves of the silver birch									
1	0.070577	1.40810	0	0	0	0	0	0	0.9746
2	-1.37091	0.069358	0	0	151.02271	-1.08042	1.08727	-2.87306	
Influence of length of 20 leaves on the area of birch leaves									
1	0.017479	1.71230	0	0	0	0	0	0	0.9964
2	-1.48456e-10	7.36007	0.022392	1.42805	27.73899	-0.32405	0.78446	-0.81630	
The effect of the width of 20 leaves on the length of birch leaves hanging									
1	1.63729	0.92322	0	0	0	0	0	0	0.9998
2	-1.91961e-8	5.80711	0.0021147	1.96512	58.73322	-0.98344	0.90157	-1.87608	
The effect of the width of 20 leaves on the perimeter of birch leaves hanging									
1	0.048399	1.56764	0	0	0	0	0	0	0.9740
2	-1.66466	0.62571	0.052712	1	181.37338	-4.87406	0.84531	-2.68186	
The effect of the width of 20 leaves on the area of birch leaves hanging									
1	0.035631	1.60172	0	0	0	0	0	0	0.9975
2	-0.0026341	1.35447	0	0	1.80491	0.020648	1.27789	-1.41629	

The adequacy of binary relations is very high. The trend is characterized by a simple indicative law. The amplitude of wave equations varies from exponential to biotechnical law in truncated and complete forms. The model parameter a_{6i} for most binary relationships has a negative sign, indicating the increasing influence of leaf length and width. In other words, there is an increase in the frequency of mutual influence fluctuations with the growth of the length or width of the leaves.

From the graphs in figure 8 you can see that the changes in the perimeter and area, depending on the length and width, received some variation of values. This is due to errors in measurements that appear due to the difficulty in counting cells along the perimeter and inside the surface of the sheet.

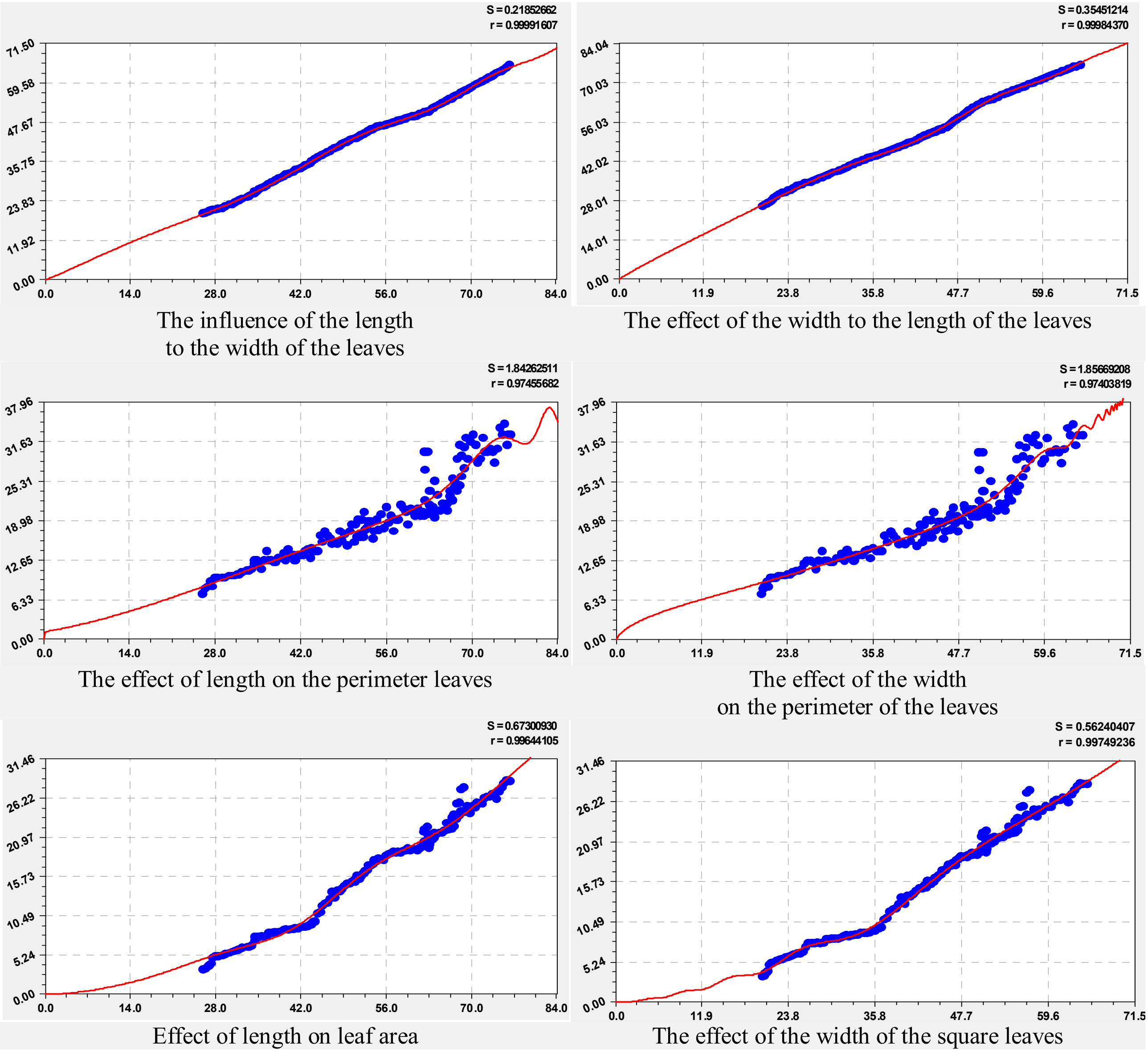


Figure 8. Charts the influence of the length and width of 20 birch leaves in other settings

Table 7 shows the correlation coefficients of the regularities of all distributions. The influence of the sum of the temperatures was taken from the data of table 5, and in the diagonal cells of the influence of the length and width of the leaves the correlation coefficients of the dynamics patterns from table 4 were set.

Table 7: Correlation matrix and factor rating

Factors how to explain variables x	Factors-indicators y				The sum of coeff. correl..	Rating I_x
	a, mm	b, mm	P, cm	S, cm^2		
The sum of temperatures $\sum_T$	0.9939	0.9938	0.9779	0.9876	3.9532	3
Sheet length a, mm	0.9941	0.9999	0.9746	0.9964	3.9650	1
Sheet width b, mm	0.9998	0.9935	0.9740	0.9975	3.9648	2
The sum of coeff. correl..	2.9878	2.9872	2.9265	2.9815	11.8830	-
Rating I_y	1	2	4	3	-	

The coefficient of correlation variation of many factors of the physical object of study (in General), that is, biological, chemical, technological, socio-economic, etc., is equal to the ratio of the total amount of correlation coefficients to the product of the number of factors in rows and columns. As a result, an indicator characterizing the entire system under study is formed.

In our example, according to table 7, the coefficient of correlation variation is 11.8830 / (3 4) = 0.9903. This value is very high for assessing the functional connectivity of individual elements of the «air temperature-leaves of birch» in environmentally friendly conditions.

The coefficient of correlative variation is used when comparing different objects of research. In this case, the type of the system under study does not affect the specified verification criterion, and the correlation variation depends entirely on the internal properties of the system under study.

According to the rating among the influencing variables in the first place was the length of the young birch leaf, the second-the width of the sheet, and only in third place – the sum of temperatures. As an indicator, the first place is also the length of the sheet, the second-the width of the sheet. We have previously excluded the perimeter and leaf area. The length and width of the leaves are almost the same adequacy. Therefore, due to the simplicity of measurements in future experiments, we take the width of the sheet.

11. CONCLUSION

Our invention [15-18] relates to engineering biology and bioindication of the surrounding part of the crown of trees of the air environment by measurements of dynamics, primarily in the time of active life of plants from the beginning of Bud blooming to the last day of ontogenesis, mainly in the process of vital activity of growth organs of various species of woody plants, for example, in the form of accounting leaves without taking them with a simple and small leaf blade: Linden, maple field or American, birch, poplar.

The proposed invention can be used for environmental and technological monitoring of the development and growth of young woody plants, in particular, for young forest trees, as well as for the quality of the foliage of trees in urban parks, alleys, roadside strips and other tree plantations, natural afforestation of wastelands, former construction sites and other land reclamation, natural forest regeneration on the deposits of agricultural land.

The physical and mathematical approach assumes understanding of ***a dynamic series*** on the vegetation period as reflection of some compound process of vital activity of accounting leaves. The behavior of each sheet occurs as an oscillatory adaptation to changes in the environment of this sheet. And adaptation happens for many decreasing quanta of interaction. By date of measurement 20 leaves during the vegetation period birch povilas received quantum state in a pure environmental growing conditions.

In contrast to [4-8; 11-13; 15-18], this article does not take into account the day of registration of complete leaf fall. Therefore only considers the last measurements of parameters of leaves in a growing condition. In the future, we must find ways accurate registration of the moment of rejection of the sheet by the tree, as well as the moment of blooming of kidneys of the sheet.

The current vegetation time is taken into account every three hours. The air temperature in the surface layer is taken from the meteorological station. Then the temperature cumulate is calculated. From a number of three-hour measurements of temperature at the meteorological station, we distinguish the quantum state in the form of the sum of wavelets, determined by the growing season of birch leaves as a seasonal quantum of time. Thus, in phytometeorology, the first level of quantization of meteorological data is to take into account the beginning and the end of the growing period of birch or other subspecies.

The rejection of the average daily temperature and the transition to measurements in three hours gives an oscillation with a constant half-period of 0.50003 days. This wavelet has a correlation coefficient of 0.6880, which is much higher than the other 27 members. In second place is the trend only with the adequacy of 0.4693. Daily temperature dynamics in three hours is the most significant.

The sum of temperatures shows the stored energy. This cumulative figure was more convenient in comparison with the current air temperature. The beginning of the dynamics is the moment of birch buds blooming, and the end is the last measurement of leaf parameters before their subsidence.

Leaves in the growing season grow and develop vibrational adaptation to the sum of temperatures. It is necessary to continue studies of temperature time series at meteorological stations with the dynamics of behavior of birch leaves (and other tree species). This will help to develop phytometeorology for many parts of the Earth and identify patterns of phytoclimate to counteract increasing global warming.

The coefficient of correlation variation of the set of factors of the object of study is equal to the ratio of the total sum of the correlation coefficients to the product of the number of factors in rows and columns. As a result, an indicator characterizing the entire system of factors under study is formed. It for our experiments is equal to 0.9903. This value is very high for assessing the functional connectivity of individual elements of the "air temperature-leaves of birch" in environmentally friendly conditions.

The greatest correlation coefficients are the length and width of the accounting sheet of birch. Therefore, the perimeter and leaf area were excluded from the factor analysis. According to the rating among the influencing variables in the first place was the length of the young birch leaf, the second-the width of the sheet, and only in third place – the sum of temperatures. As an indicator, the first place is also the length of the sheet, the second-the width of the sheet. The length and width of the leaves are almost the same adequacy. Therefore, due to the simplicity of measurements in future experiments, we take the width of the sheet.

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