APPLYING THE MODEL FOR TRANSFORMATION OF THE ANNUAL CLIMATIC WIND ROSE IN THE AIR POLLUTION MODELING FROM POINT SOURCE

N. Gromkova,[1] *I. Butchvarov*[2]

Geophysical Institute, Bulgarian Academy of Sciences, 1113 Sofia, Acad. G. Bonchev Str., block 3, Bulgaria – www.geophys.bas.bg
1 Department of Atmospheric Physics – gromkova@geophys.bas.bg
2 Department of Geomagnetism and Gravimetry – buch@geophys.bas.bg

Abstract. The necessity to transform the standard (for Bulgaria) climatic 8-point wind roses, named *Observed Wind Roses* here (OWR), appears in connection with the determination of the climatic (annual mean) air pollution concentration field from a point source, that is the purpose of most Environmental Impact Assessments. Using an 8-point wind rose for calculating the pollution by existing applied models – a Gaussian plume model for a continuous point source, the concentration isopleths follow the 8 compass directions of the wind rose and it seems that between them there is no pollution. A more adequate qualitative concentration field should be obtained by using a better-described wind rose at a given place, defined in more compass directions. The development of a simple algorithm for the transformation of the OWR, in the general case, defined in n-point to m-point, where $n > m$ or vice versa $n < m$, is the purpose of the present paper. The new rose will be named *Transformed Wind Rose* (TWR).

Keywords: air pollution, wind rose.

Abbreviations:

OWR – *Observed Wind Roses*
TWR – *Transformed Wind Rose*
DWR – *Discrete Wind Rose*
PWR – *Primitive Wind Rose*
c.d.f. – *cumulative distribution function*
p.d.f. – *probability density function*

Introduction

The standard wind roses (a diagram depicting the distribution of wind direction and speed at a location over a given period of time) are represented with 8 compass directions – one for each 45º of the horizon, which have one-letter code for the cardinal compass directions – N, E, S and W, and two-letter codes for the intercardinal ones – NE, SE, SW and NW. In Bulgaria, the annual climatic 8-point wind roses (the percentage of the cases where the wind is blowing from each of the 8 compass directions) are obtained by statistical processing of a 16-point scale meteorological observation records from a mechanical anemometer at 10 m height (Climatic reference book of Bulgaria, 1982). For convenience, this rose will be further named *Observed Wind Roses* (OWR) and will be examined in the present paper.

The necessity to transform the 8-point wind roses appears in connection with the determination of the annual mean air pollution concentration field from a point source. Using this 8-point wind rose (for example, Fig. 1) for calculating the pollution by existing applied models – for example the software PLUME (Gromkova, 2000), the concentration isopleths follow the 8 compass directions of the wind rose and it seems that between them there is no pollution – Fig. 2 (the effect of discretization).

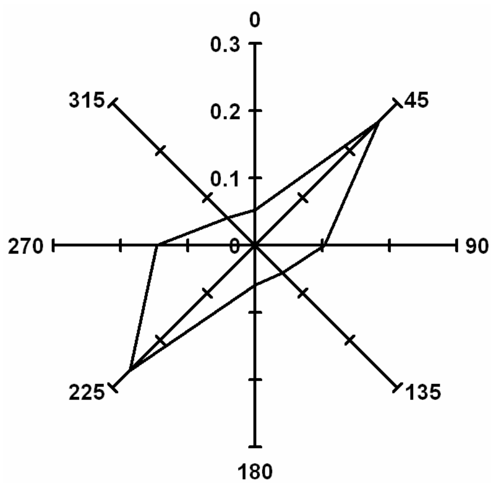


Fig. 1. OWR, Rousse climatic station.

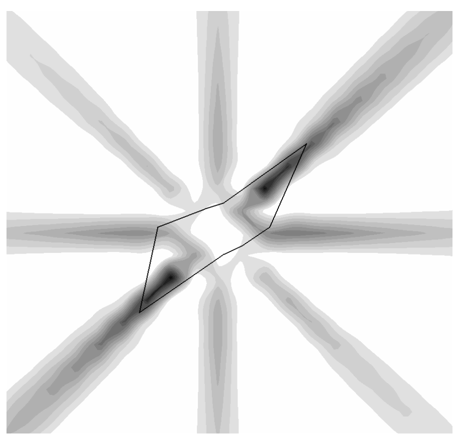


Fig. 2. Mean annual surface air pollution from point source, applying standard OWR rose.

A more adequate qualitative concentration field should be obtained by using a better-described wind rose at a given place, defined in more compass directions. In general at the Bulgarian airports, there are automatic digital meteorological stations where 12- and 16-point roses can be obtained from hourly data sets but such stations are few and generally the data sets in them are for a short period, i.e. they are not climatic representative.

The development of a simple algorithm for the transformation of OWR, in the general case, defined in *n*-point to *m*-point, where $n > m$ or vice versa $n < m$, is the purpose of the present paper. The new rose will be named *Transformed Wind Rose* (TWR) or depending of the context – calculated *Discrete Wind Rose* (DWR) too.

The TWR in more compass directions than the OWR will be used for calculating the concentration field mentioned above and it will be demonstrated that the TWR's pollution isopleths in this case are more adequate.

Main principles

Formulation

For the goals of the study, it is assumed that at a given point of the Earth surface the wind direction is a stochastic phenomenon (event), depending on many independent random variables.

Let $p(x)$ is an integrable simple real and non-negative function, where the domain of variation of x is R_1 – the set of real number ($x \in R_1$) with range:

$$p(x) \rightarrow \begin{cases} = 0, & x \le 0, \\ \ge 0, & 0 < x \le 360, \\ = 0, & x > 360. \end{cases}$$

Without decreasing the extension of the conclusions it is assumed that $p(x)$ is a continuous or partially continuous function.

Let also

$$\int_0^{360} p(x)\,dx = 1.$$

Then exists a function

$$F(x) = \int_{-\infty}^{x} p(z)\,dz, \qquad z \in R_1,$$

such as:

$$F(x) \rightarrow \begin{cases} = 0, & x \le 0, \\ \le 1, & 0 < x \le 360, \\ = 1, & x > 360. \end{cases}$$

In terms of the Probability theory (Wilks, 1967, Gnedenko, 1969) the functions $p(x)$ and $F(x)$ are defined as *probability density function* (p.d.f.) and *probability* or *cumulative distribution function* (c.d.f.). Implicitly it is supposed that the set of real numbers R_1 has dimension “degrees”.

When it is assumed that the wind direction is a stochastic event, it is possible to associate to it a random variable X with a corresponding c.d.f. – $F(x)$ and a p.d.f. – $p(x)$, defined as:

$$P\{X < x'\} = F(x), \qquad x' \in R_1,$$

where $P\{X < x'\}$ expresses the probability the random variable X to be less then x'.

Then, for the stochastic event *wind direction* with corresponding c.d.f. and p.d.f. the integrals $N(x_i)$ defined in expressions below:

$$N(x_i) = \int_{x_i - t}^{x_i + t} p(z)\,dz = F(x_i + t) - F(x_i - t)\ ,\ i = 2, 3, \ldots, n, \qquad (1)$$

$$N(x_1) = \int_{360-t}^{360} p(z)\,dz + \int_{0}^{t} p(z)\,dz = F(t) + F(360) - F(360 - t), \qquad i = 1\ (x_1 = 0), \qquad (2)$$

where $x_i = 2(i - 1)t$ are the compass directions, n is their number and $t = 180/n$ is the half-distance between the compass directions, represent the probability the wind direction to belong to the respective half-open interval $(x_i - t, x_i + t]$ for $i \neq 1$ and $(360 - t, 360]$, $(0, t]$ for $i = 1$ or

$$N(x_i) = P\{x_i - t < X \leq x_i + t\}$$

and

$$N(x_1) = P\{360 - t < X \leq 360\} + P\{0 < X \leq t\}.$$

For convenience, the p.d.f. $p(x)$ of the wind direction will be further named *Primitive Wind Rose* (PWR).

Relation between p.d.f. *p*(*x*) and OWR

Let $(x_1, \ldots, x_k)$ be a sample from a population of the random variable X realizations – the anemometer read values of the wind direction at a given location for a long period and let the p.d.f. of the random variable X is $p(x)$. The statistical processing upon these rough observations for obtaining the OWR (of the frequency) are as follows: the elements of the sample are arranged so that every single realization x_l, $l = 1, 2, \ldots, K$, is included within the relevant interval $x_i - t < x_l \leq x_i + t$ ($i = 1, 2, \ldots, n$, x_i – the compass directions) and the number of the realizations falling between a given interval are divided by the total number K. Precisely, these values represent the OWR. They are given in percentages (%) in the Climatic reference book of Bulgaria, 1982. In the present paper they will be named $\hat{N}_i$ and normalized to unity, i.e.

$$\sum_{i=1}^{n} \hat{N}_i = 1.$$

In other words, the OWR evaluated in this way represents a histogram of a sample from the population of the random variable X realizations with p.d.f. $p(x)$ and empirical estimate of the integrals $N(x_i)$ (equations (1) and (2)) in the corresponding compass directions.

All presented above shows that if the p.d.f. $p(x)$ (PWR) of the random variable X at a given point is known using the integrals (1) and (2) the wind rose named *Transformed Wind Rose* (TWR) in an arbitrary number of compass directions can be found. How to find the p.d.f. $p(x)$ (PWR) using the OWR will be demonstrated further down in this paper.

Determination of *p*(*x*)

General

If the elements of the sample (x_1, …, x_k) are arranged in ascending order of the magnitude such as $x_{(1)}< \dots <x_{(k)}$, these ordered values of *X* will be referred to as order statistics - ($x_{(1)}$, …, $x_{(k)}$) (Wilks, 1967). Different methods for determining the *p*(*x*) upon order statistics are known – for instance Vapnik, 1979. However, the rough read data (x_1, …, x_k) are not available for processing, i.e. the mentioned methods would not be used. So the p.d.f. *p*(*x*) has to be determined using the OWR, i.e. using the empirical estimate $\hat{N}_i$ (which are dependent random variables) of the integrals $N(x_i)$ – equations (1) and (2).

A possibility to find *p*(*x*) is to test a non-parametric statistical hypothesis upon the empirical estimate $\hat{N}_i$. However, to create appropriate statistic for testing a non-parametric statistical hypothesis in this case is a very difficult study in the theory of determination of p.d.f. *p*(*x*) or here the so called PWR (Vapnik, 1979) and therefore this possibility will not be discussed in the present paper. A practical and easy method for determination of *p*(*x*) should be proposed below, based on assumption that p.d.f. *p*(*x*) belongs to a given class of parametric functions.

Determination of *p*(*x*) as a function of a parameter *θ*

Let the function *p*(*x*) depend on the unknown parameter $\boldsymbol{\theta}$ which is a vector with components θ_j,. j = 1, 2, …, k, and the analytical expression of $p(x,\boldsymbol{\theta})$, continuous or partially continuous, is known. It is assumed that the parameters θ_j belong to the open subset R_k – k-dimensional Euclidean space. Then if $N(x_i)$ and $N(x_1)$ in the integrals (1) and (2) are substituted by the empirical estimates $\hat{N}_i$ and $\hat{N}_1$, and afterward solving the obtained algebraic equations system (the equations (3) and(4)) the appropriate values of θ_j can be found:

$$\hat{N}_i = \int_{x_i - t}^{x_i + t} p(z,\boldsymbol{\theta})\, dz \ , \ i = 2, 3, \dots, n, \tag{3}$$

$$\hat{N}_1 = \int_{360-t}^{x_i - t} p(z,\boldsymbol{\theta})\, dz \ + \int_{0}^{t} p(z,\boldsymbol{\theta})\, dz \ , \ i = 1. \tag{4}$$

In other words the data $\hat{N}_i$ must be interpolated or approximated in a specific way.

After determining the parameters θ_j, using the formulas (1) and (2), where *p*(*x*) is substituted by $p(x,\boldsymbol{\theta})$, *n* is substituted by another number of compass directions, for example *m*, and changing *t* and x_i respectively, the new rose of wind frequency can be obtained – *Transformed Wind Rose*. Proposals about the analytical form of the function $p(x,\boldsymbol{\theta})$ will be given in Section 4.

Comment

To estimate stochastically how adequate the chosen function $p(x,\boldsymbol{\theta})$ represents the real p.d.f. of the wind frequency, which correspond to the data $\hat{N}_i$ in a given meteorological station, it is necessary to proceed with the following steps: 1) to collect data of the wind frequency not used for calculating $\hat{N}_i$ in that meteorological station; 2) to create a statistic on this collection with c.f.d. independent from the parameter $\boldsymbol{\theta}$, taking into consideration that the read data have a p.f.d. – the already chosen function $p(x,\boldsymbol{\theta})$, 3) to test a parametric statistical hypothesis with this statistic how far the obtained value of that parameter is from the true value of $\boldsymbol{\theta}$ and 4) to admit or reject the obtained value (Wilks, 1967, Lemon, 1979).

The quantities $\hat{N}_i$, however, are dependent random variables and it will be a very difficult theoretical task (as in the case of a non-parametric statistical hypothesis) to proceed through all these steps. As the goal here is purely practical, later on $\hat{N}_i$ will be assumed as determinate values and only a geometrical criterion of the differences between the true and the calculated p.f.d. will be given in some theoretical examples.

Proposals about the analytical form of the function $p(x,\theta)$

Two simple models (variants) will be proposed:

Variant 1. A broken-line function such that between every two compass directions there is only one straight line, i.e. $p(x,\boldsymbol{\theta}) = a_i + b_i x$, $i = 1, 2, \ldots, n$. In the point of the compass directions – x_i – the straight lines have equal values (an example is given in Fig. 6 in Section 6.1.1 – the firm broken line). In the points $x = 0$ and $x = 360$ the first and the last straight lines have equal values too. The vector $\boldsymbol{\theta}$ is decomposed to two vectors – $\boldsymbol{a}$ and $\boldsymbol{b}$, with the components respectively a_i and b_i in this case, i.e. $p(x,\boldsymbol{\theta}) = p(x,\boldsymbol{a},\boldsymbol{b})$.

Variant 2. A discrete function in the form of straight lines parallels to the abscissa (an example is given in Fig. 6 in Section 6.1.1 – the dashed line), i.e. $p(x,\boldsymbol{\theta}) = a_i = \text{const}$, where:

$$a_i = \hat{N}_i / 2t$$

in the intervals $(x_i - t, x_i + t]$ for $i = 2, 3, \ldots, n$, and $(360 - t, 360]$ and $(0, t]$ for $i = 1$, i.e. $x_1 = 0$.

Note: The graphics in Fig. 6 are obtained using as a true p.f.d. $p(x)$ the function from equation (5).

The first function is chosen for two reasons:

1. It is assumed that the p.f.d. between two directions varies linearly and in this interval the probability is bigger towards the compass direction where the wind frequency is higher.
2. The determination of the coefficients a_i – the y-intercept and b_i – the slope of the line, is relatively easy and analytically exact.

This function however has one disadvantage – it is not positive for all OWR. This case occurs when the OWR is much extended. For this reason the second function (variant 2) is proposed. In this case the condition $p(x,\boldsymbol{a}) \geq 0$ is satisfied always.

Later it will be demonstrated on theoretical examples that the model of variant 1 is better but if in this variant the condition $p(x,\boldsymbol{a},\boldsymbol{b}) \geq 0$ is not satisfied, then it is preferable to use variant 2 to obtain a TWR with more wind compass directions for calculating the mean annual air pollution field (the isopleths of concentration) from a point source instead of using an OWR with less wind compass directions.

The determination of the parameter $\boldsymbol{\theta}$ (i.e $\boldsymbol{a}$ and $\boldsymbol{b}$) is presented in the separate paper of this research (further down in this journal).

Some definitions

The notions *Primitive Wind Rose* and *Discrete Wind Rose* were introduced above. Two types of PWR and DWR according to the context will be recognized: *analytically defined* and *calculated*.

Analytically defined PWR and DWR

An example of an *analytically defined* PWR as a continuous function of the horizon angle is:

$$p(x) = a\,sin(\frac{k\pi x}{180}) + \frac{1}{360}, \;\; 0 < x \leq 360, \tag{5}$$

for $k = 1, 2, 3, \ldots$ and $|a| \leq 1/360$. With such given parameters a and k, the expression (5) satisfies the requirements to be a p.d.f. of a random variable. Precisely, the p.d.f. defined by an analytical mathematical formula like equation (5) will be named *analytically defined* PWR.

The integrals (1) and (2) in this case have the form:

$$N(x_i) = \frac{360a}{k\pi}sin(\frac{k\pi}{n})sin(\frac{k\pi x_i}{180}) + \frac{1}{n}. \tag{6}$$

When the quantities $N(x_i)$ are calculated from an analytical expression received after integration from an analytically defined PWR (as equation (5)) they will be named *analytically defined* DWR (see equation (6)).

Calculated PWR and DWR

As mentioned in Section 2 if the p.d.f. $p(x)$ can be found, then the TWR in arbitrary number of m compass directions can be calculated. An algorithm for obtaining this PWR from an OWR is described in the separate paper of the present research. Precisely, the PWR obtained by using the described algorithm will be named *calculated* PWR. The quantities $N(x_i)$ (the integrals (1) and (2)) calculated from such obtained *calculated* PWR will be named *calculated* DWR or TWR.

Application of the algorithm for transforming wind roses (tests)

Several theoretical tests were carried out. Practical examples, using OWR, will be presented in further paper.

Analytically defined PWR by formula (5)

Parameter *k* = 2 and calculated DWR for 16 compass directions

In Fig. 3 the *analytically defined* PWR calculated by formula (5) for $k = 2$ and $a = 1/720$ is presented in standard mode – in polar coordinates, and in Fig. 4 and Fig. 6 – in Cartesian ones (the smooth curve – left defined scale), where the circle (the horizon) is developed over the abscissa.

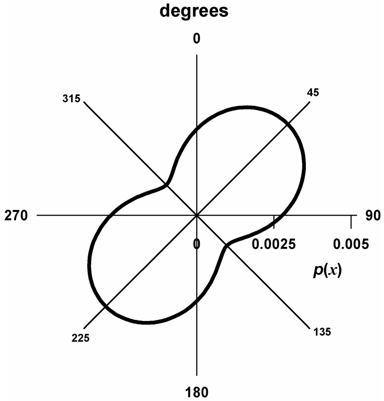


Fig. 3. Analytically defined PWR, $k = 2$, $a = 1/720$.

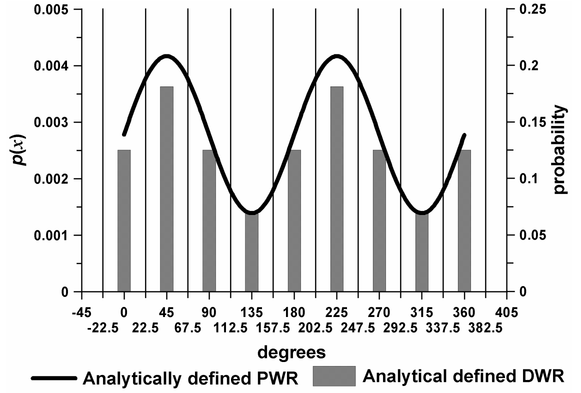


Fig. 4. Analytically defined PWR and DWR, $k = 2$, $a = 1/720$.

In Fig. 4 the analytically defined DWR, calculated by formula (6), is presented as a histogram (right defined scale) and in Fig. 5 – in polar coordinates for the parameters *a* and *k* mentioned above and $n = 8$, i.e. 8 compass directions, $x_i = 0, 45, 90, ...,315$.

As the PWR is exactly known, the analytically defined DWR in Fig. 5 is the true wind rose for 8 compass directions. Let this rose be considered as an OWR (but the true one). Applying the method described in the previous Sections on this OWR**,** a calculated PWR's are obtained. In Fig. 6 the firm broken line is calculated by variant 1 and the dashed line – by variant 2.

Let the analytically defined DWR for $n = 16$ (formula (6)), i.e. for 16 compass directions, $x_i = 0, 22.5, 45, …, 315$, be calculated. It is the true one because the analytical PWR is known. Using the calculated PWR (Fig. 6, the broken lines) the calculated DWR's by the integrals (1) and (2) for 16 compass directions according to the two variants are obtained too.

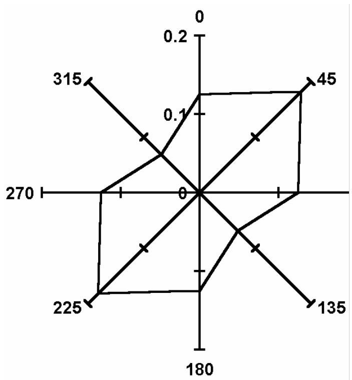


Fig. 5. Analytically defined DWR, k = 2, a = 1/720, 8 directions.

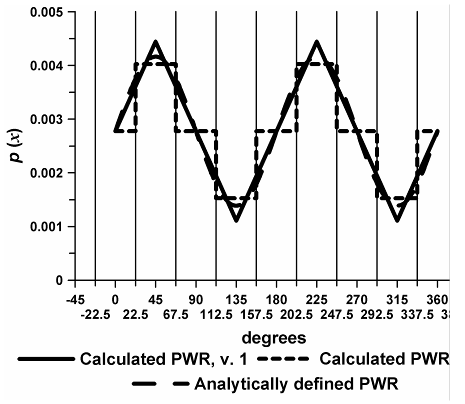


Fig. 6. Analytically defined and calculated PWR's, k = 2, a = 1/720.

A comparison between the true 16-compass direction wind rose and the calculated ones according to the two variants using the described method is given in Fig. 7 in polar coordinates and in Fig. 8 – in Cartesian ones. It is seen that there is a great correspondence between the roses. A quantitative criterion will be presented further down.

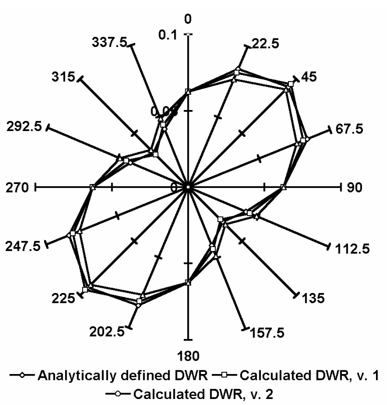


Fig. 7. Analytically defined and calculated DWR's, k = 2, a = 1/720, 16 directions.

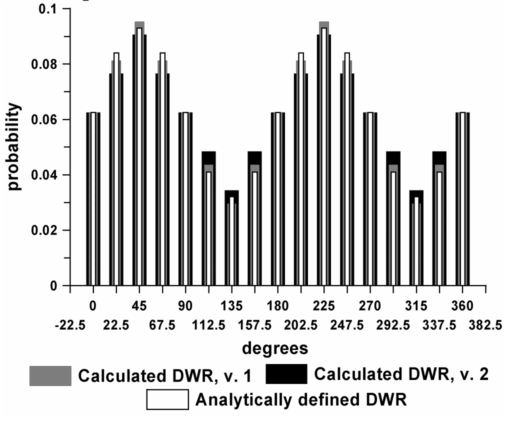


Fig. 8. A nalytically defined and calculated DWR's, k = 2, a = 1/720, 16 directions.

Parameter *k* = 3 and calculated DWR for 16 compass directions

Another example is a continuous smooth curve defined by the formula (5) for k = 3 and a = 1/720 shown in Fig. 9 in polar coordinates and in Figures 10 and 12 – in Cartesian ones (the smooth curve, left defined scale). This example is chosen to demonstrate that the proposed method can be applied on wind rose with more then one maximum – 3 in this case. The analytically defined DWR calculated by formula (6) for pointed *k* and *a*, and $n = 8$, is shown in Fig. 10 as a histogram (right defined scale) and in Fig. 11 – in polar coordinates.

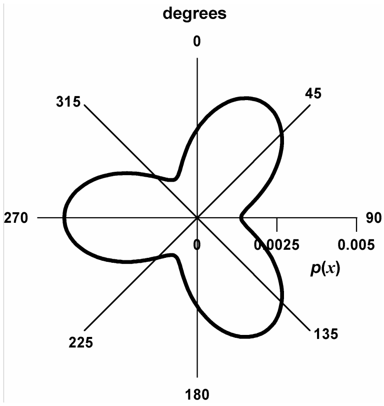


Fig. 9. Analytically defined PWR, $k = 3$, $a = 1/720$.

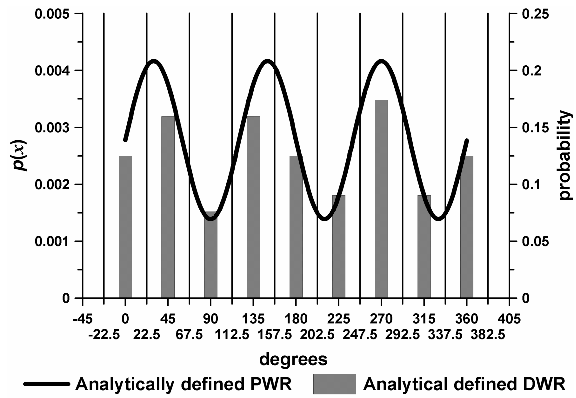


Fig. 10. Analytically defined PWR and DWR, $k = 3$, $a = 1/720$.

As the PWR is exactly known, the analytically defined DWR in Fig. 11 is the true wind rose for 8 compass directions as it was in the previous example. Let this rose be considered as an OWR (but the true one). Applying the method, described in the previous Sections, on this OWR, a calculated PWR's are obtained. In Fig. 12 the firm broken line is calculated by variant 1 and the dashed line – by variant 2.

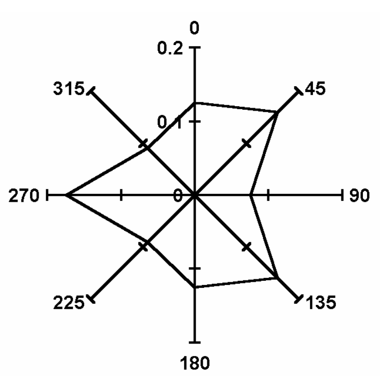


Fig. 11. Analytically defined DWR, $k = 3$, $a = 1/720$, 8 directions.

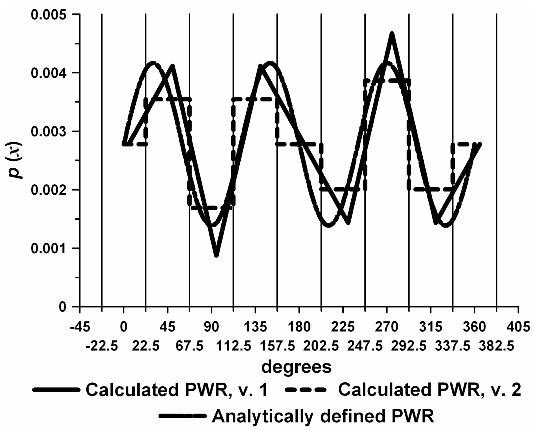


Fig. 12. Analytically defined and calculated PWR's, $k = 3$ $a = 1/720$.

In Fig. 13 in polar coordinates and in Fig. 14 in Cartesian ones the analytically defined DWR (the true one) for $n = 16$ (formula (6)) and the calculated DWR's obtained by the integrals (1) and (2) for 16 compass directions according to the two variants using the calculated PWR (Fig. 12, the broken lines) are presented.

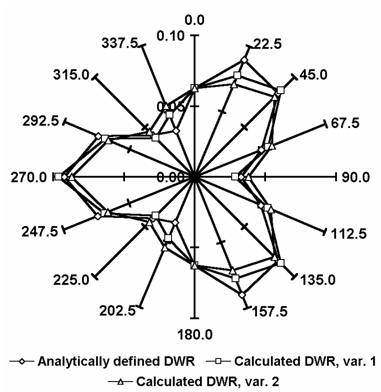


Fig. 13. Analytically defined and calculated DWR's, $k = 3$, $a = 1/720$, 16 directions.

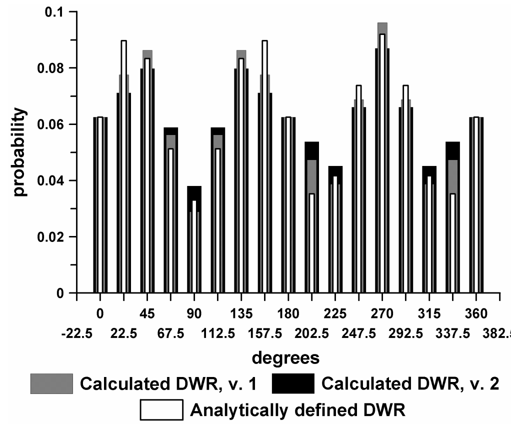


Fig. 14. Analytically defined and calculated DWR's, $k = 3$, $a = 1/720$, 16 directions.

Geometrical criterion of the reliability

The values of the analytically defined DWR and of the calculated DWR's for 16 compass directions using the calculated PWR's (Fig. 4 and Fig. 12 – the broken lines), as the last obtained from the 8 compass directions analytically defined DWR (formula (6)) for the tests in Sections 6.1.1 and 6.1.2 are shown in Table 1.

To estimate the precision of the obtained 16-point calculated DWR's, the root mean square deviations (RMSD) r between these calculated DWR's and the 16-point analytically defined DWR's (the true one) were calculated:

$$r = \sqrt{\frac{\sum_{i=1}^{16} (N_i - \overline{N}_i)^2}{15}} ,$$

where N_i are the values of the analytically defined DWR's, and $\overline{N}_i$ – of the calculated DWR's. The results are presented in the last row of Table 1. It is seen that the RMSD of variant 1 – r_1, in both tests are considerably less (about 10 times) than the analytically defined and calculated DWR's minimum values, and the deviations of variant 1 are 2 times less than of the 2-nd – r_2, one.

Table 1. Wind rose values and RMSD.

Direction degrees	Test in paragraph 6.1.1, k = 2			Test in paragraph 6.1.2, k = 3		
	Analytically defined DWR N_i	Calculated DWR $\overline{N}_i$		Analytically defined DWR N_i	Calculated DWR $\overline{N}_i$	
		Variant 1	Variant 2		Variant 1	Variant 2
0.0	0.06250	0.06250	0.06250	0.06250	0.06250	0.06250
22.5	0.08403	0.08126	0.07657	0.08973	0.07762	0.07117
45.0	0.09295	0.09532	0.09064	0.08334	0.08628	0.07983
67.5	0.08403	0.08126	0.07657	0.05122	0.05624	0.05891
90.0	0.06250	0.06250	0.06250	**0.03303**	**0.02887**	**0.03800**
112.5	0.04097	0.04374	0.04843	0.05122	0.05624	0.05891
135.0	**0.03205**	**0.02968**	**0.03437**	0.08334	0.08628	0.07983
157.5	0.04097	0.04374	0.04843	0.08973	0.07762	0.07117
180.0	0.06250	0.06250	0.06250	0.06250	0.06250	0.06250
202.5	0.08403	0.08126	0.07657	0.03527	0.04738	0.05383
225.0	0.09295	0.09532	0.09064	0.04166	0.03872	0.04517
247.5	0.08403	0.08126	0.07657	0.07378	0.06876	0.06609
270.0	0.06250	0.06250	0.06250	0.09197	0.09613	0.08700
292.5	0.04097	0.04374	0.04843	0.07378	0.06876	0.06609
315.0	0.03205	0.02968	0.03437	0.04166	0.03872	0.04517
337.5	0.04097	0.04374	0.04843	0.03527	0.04738	0.05383
	RMSD	r_1=0.00236	r_2=0.00558	RMSD	r_1=0.00710	r_2=0.01068

Comparison between the annual mean ground level air pollution concentrations from a point source using an 8–point *analytically defined* DWR and *analytically defined* and *calculated* DWR's in more compass directions

The test example in Paragraph 6.1.1 is used to demonstrate the ability to improve the annual mean pollution concentration picture of proposed above model, applying the Bulgarian PLUME model (Gromkova, 2000). The ground level concentrations from a point source, applying *analytically defined*_DWR, k = 2, a = 1/720 in 8 directions (Fig. 5) is shown on Fig. 15a. The necessary wind speeds are of the same value – 3 m/s – in all directions to be excluded their influence in diffusion process. It is seen very clearly, that the concentration isopleths follow the 8 wind directions. On the next figures (15b, 15c and 15d) the analytically defined DWR's, $k = 2$, $a = 1/720$, in 16, 32 and 64 directions, respectively are used. Only when the wind rose with 64 directions is applied the concentration isopleths take an adequate qualitative shape of ground level pollution – Fig. 15d.

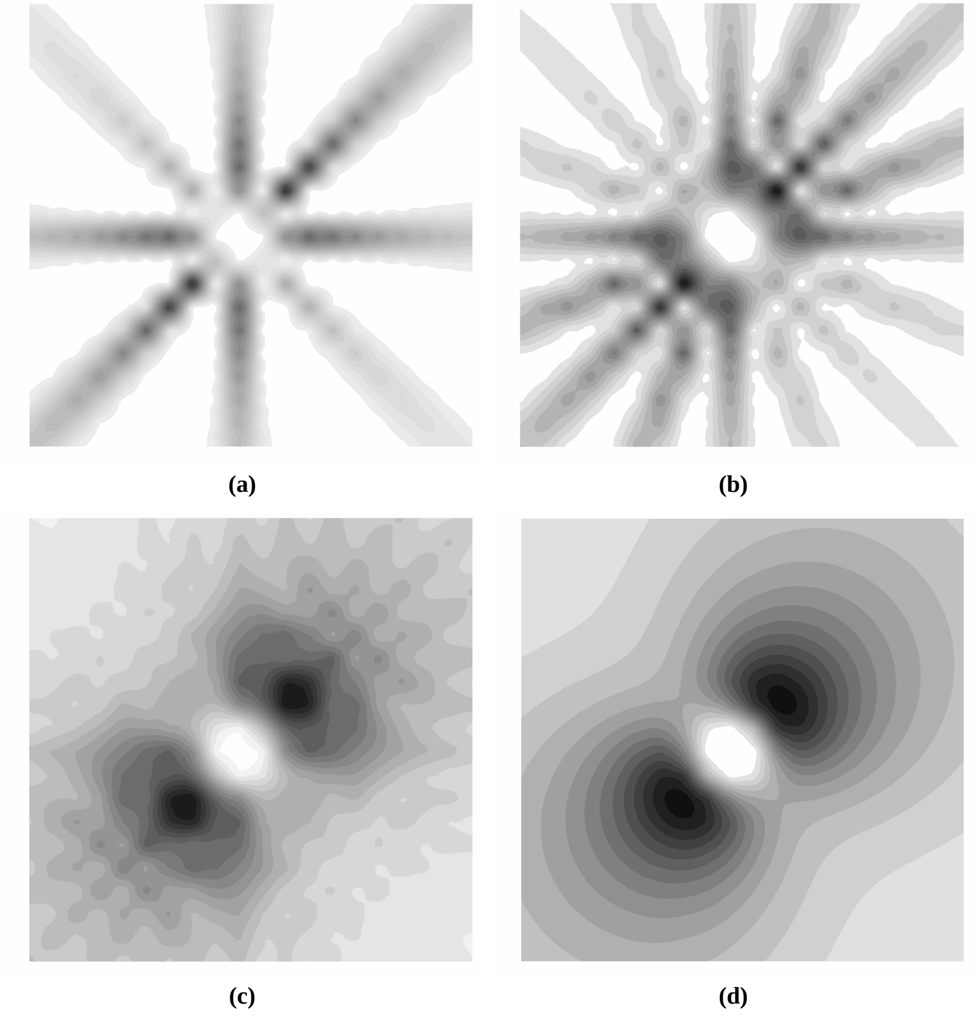
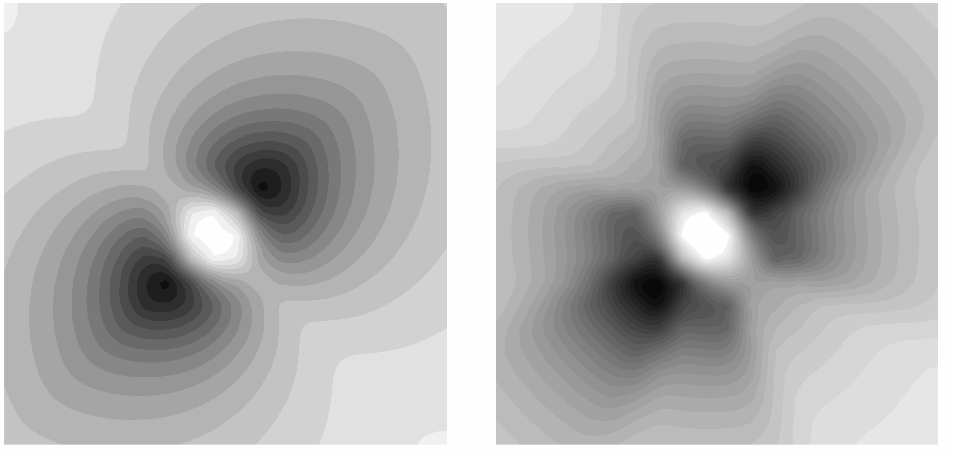


Fig. 15. Mean annual surface air pollution from point source, applying *analytically defined* DWR's, $k = 2$, $a = 1/720$, /equation (6)/ for: 8 – (a), 16 – (b), 32 – (c) and 64 – (d) directions, respectively.

The pictures of concentration isopleths with *calculated* DWR's, $k = 2$, $a = 1/720$, for 16 and 32 directions have the same shape as *analytically defined* DWR (15b and 15c), i.e. the concentrations follow the directions. *Calculated defined* DWR, $k = 2$, $a = 1/720$ in 64 directions is used of the proposed wind rose transformation model to obtain the annual mean ground level pollution isopleths – Fig. 16a and 16b for variant 1 and variant 2, respectively. As it is seen the picture with variant 1 model (Fig. 16a) is almost identical with *analytically defined* DWR (Fig. 15d). The variant 2 gives second maximal concentrations aside of the first one and is the auxiliary to variant 1, in case of negative *calculated* PWR, only. Nevertheless it is better than using only 8 direction wind rose in calculations.



(a) **(b)**

Fig. 16. Mean annual surface air pollution from point source, applying *calculated* DWR's, $k = 2$, $a = 1/720$ in 64 directions by (a) – variant 1 and (b) – variant 2.

Conclusions

Using an 8-point wind rose for calculating the air pollution by existing applied models – a Gaussian plume model for a continuous point source, the concentration isopleths follow the 8 compass directions of the wind rose and it seems that between them there is no pollution. A more adequate qualitative concentration field should obtained by using a better-described wind rose at a given place, defined in more compass directions according to the described method.

References

Climatic reference book of Bulgaria, Part 4, WIND, 1982.

Gnedenko, B. V., 1969. *Course of Probability Theory*, 400pp.,"Nauka", Moscow (in Russian).

Gromkova N., 2000. Dispersion regulatory model for designing new industrial stacks - software PLUME, http://www.geophys.bas.bg/bgj/2000_v26.htm.

Lemon, E., 1979. *Tests of Statistical Hypothesis*, 408pp., "Nauka", Moscow (in Russian).

Vapnik, V. N., 1979. .*Reconstruction of dependence according to the empirical data*. 447pp., "Nauka", Moscow (in Russian).

Wilks, S., S., 1967. *Mathematical Statistics,* 632pp., "Nauka", Moscow (in Russian).

Прилагане на модел за трансформиране на годишната климатична роза на вятъра за моделиране на замърсяването от точков източник

Н. Громкова, И. Бъчваров,

Резюме. Необходимостта да се преобразува стандартната за България климатична 8-румбова роза на вятъра (наречена тук *Наблюдателна Роза на Вятъра* (НРВ)) възникна във връзка с определянето на концентрацията на климатичното (средногодишното) замърсяване на въздуха от точков източник, което е основна цел на оценката на въздействието върху околната среда (т.н. ОВОС). Когато се използва 8-румбова роза на вятъра за изчисляване на замърсяването по съществуващите приложни модели – напр. Гаусовия Plume model за непрекъснат точков източник, изолиниите на концентрацията следват 8-те румба на розата на вятъра и изглежда, като че ли между тях няма замърсяване. По-адекватно поле на замърсяване може да се получи, ако се използва роза с повече румба. Целта на настоящата работа е прилагането на алгоритъм за възстановяване полето на вятъра, т.е. преобразуване на НРВ (в общия случай), от роза с n румба в роза с m румба, като е без значение дали $n > m$ или $n < m$. Новополучената роза е наречена *Преобразувана Роза на Вятъра* (ПРВ).