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Characteristics of forecasting meteorological conditions of air pollution over Odesa

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ABSTRACT

Formulation of the problem. The level of atmospheric air pollution in large cities is influenced by a number of factors, among which the most important are the emissions of pollutants into the air, the characteristics of the sources of admixtures, the landscape features, synoptic and meteorological conditions (Vystavnaya, Zubkovych 2014). The influence of the latter is associated with the scattering, washing out and transformation of harmful substances in the atmosphere, as well as the significant variability of their concentrations in space and time. The characteristics of the wind regime (wind direction and velocity), temperature inversions, and formation of low-troposphere currents are among the meteorological factors that most influence the concentrations of contaminants in the layer of atmosphere near the surface (Ivus 2017), (Agayar 2018) Shevchenko 2020).

The purpose of the article is to develop and improve methods of forecasting meteorological conditions of atmospheric pollution over industrial areas of Odesa, as well as characterize the variability of meteorological values over the Northwest Black Sea.

Methods. the data of four-time observations (01, 07, 13, 19 hours) for the main pollutants on the network of eight stationary posts for the February, April, July and October of 2011 are used as the initial materials. The catalog of typical synoptic processes over the territory of Ukraine for the period of 2011-2015 is compiled at the Department of Meteorology and Climatology of the OSENU. To clarify specific synoptic situations, synoptic maps of all levels (ground-level, AT-925, AT-850, AT-700 and AT-500) from the archive of the ARMSin ('automatic forecaster workstation'- program for processing synoptic maps that is applied in Ukraine.

Results. 1. CO concentrations in the city of Odesa increase with distance from the coastal strip in to the depth of land with maximum values in places with high traffic load, regardless of the season; 2. Absence of industrial facilities and meteorological conditions contribute to the low level of air pollution around post N 8. Exceedance of the maximum allowable concentrations of carbon monoxide is observed in 6 out of 8 observation posts; 3. Favorable conditions for the accumulation of admixtures are formed in peripheral processes with low-gradient pressure fields, in front parts of cyclones and in low-motion and small cyclones with the same air mass; 4. Temperature inversions almost always accompanied the accumulation of harmful admixtures in the ground layer of air above Odesa.

Scientific novelty and practical significance. In this article we have analyzed influence of meteorological conditions on the level of atmospheric air pollution in Odesa region. For these purposes the more nuanced-based method of forecasting was adapted. We have demonstrated that its use has efficiency at the present time for improvement of operative prognostic units work for the Northwest Black Sea region. Such conclusions may be identified as a result of empirical findings.

Keywords: *maximum allowable concentration, air pollution, delay layer, light wind, synoptic processes, inversion, alternative method of forecasting atmospheric air pollution.*

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Formulation of the problem. The level of atmospheric air pollution in large cities is influenced by a number of factors, among which the most important are the emissions of pollutants into the air, the characteristics of the sources of admixtures, the landscape features, synoptic and meteorological conditions (Vystavnaya, Zubkovych 2014) [21], [3,4,14,15]. The influence of the latter is associated with the scattering, washing out and transformation of harmful substances in the atmosphere, as well as the significant variability of their concentrations in space and time. The characteristics of the wind regime (wind direction and velo-city), temperature inversions, and formation of low-troposphere currents are among the meteorological factors that most influence the concentrations of contaminants in the layer of atmosphere near the surface (Ivus 2017),[8, 9, 10], (Agayar 2018) [1], [6, 7] Shevchenko 2020) [18, 20].

The relevance of the problem is determined by the fact that atmospheric air is the most important natural resource for all living beings, and human health, to a large extent, depends on its quality.

That is why scientific research on the assessment of anthropogenic load on the air basin of large industrial cities, as well as the development of methods for forecasting and regulating it, taking into account legal and regulatory aspects, are relevant problems of our time.

Purpose of the work is to develop and improve methods of forecasting meteorological conditions of atmospheric pollution over industrial areas of Odesa, as well as characterize the variability of meteorological values over the Northwest Black Sea.

Aim of this work is to develop and improve methods for forecasting meteorological conditions of air pollution over the industrial areas of Odesa, as well as to characterize the variability of meteorological values over the North-Western black sea region.

Materials and research methods. Materials and method of research: the data of four-time observations (01, 07, 13, 19 hours) for the main pollutants on the network of eight stationary posts for the February, April, July and October of 2011 are used as the initial materials. The catalog of typical synoptic processes over the territory of Ukraine for the period of 2011-2015 is compiled at the Department of Meteorology and Climatology of the OSENU (Ivus 2015). To clarify specific synoptic situations, synoptic maps of all levels (ground-level, AT-925, AT-850, AT-700 and AT-500) from the archive of the ARMSin (‘automatic forecaster workstation’- program for processing synoptic maps that is applied in Ukraine. The Department and radiosonde data for the same period were also applied to clarify specific synoptic situations.

Empirical findings.

1.1. Air pollution monitoring stations description

To characterize the influence of meteorological conditions on atmospheric air quality over the North-Western Black Sea region, we used the data of the Black and Azov Seas Hydrometeorological Center on the content of atmospheric air pollutants of carbon monoxide (CO) in Odesa, wind characteristics and air temperature at eight pollution monitoring stations for the period from June to December, 2011. The posts are located in different parts of Odesa and characterized by varying degrees of air pollution within the city (Fig. 1) Further research was based on identifying the repeatability of increased levels of air pollution. Carbon monoxide (CO) concentration data were used as a characteristic of air pollution. Although this impurity belongs to class of hazard of air pollution, it is a major marker of contamination. The concentration limit for CO is 5.0 mg/m^3.

At all stations, both in winter and summer seasons, the highest excess of the short-term exposure limit/ maximum permissible concentration (MPC) of carbon monoxide in Odesa was 8 mg/m^3 single dose. For the whole period, there was no double altitude of MPC (Table 1). As can be seen from the table, high carbon dioxide concentrations were observed at six of eight pollution monitoring posts. However, their distribution over time was rather uneven. In most cases, high CO concentration was recorded in June (9 cases) at posts N16 and 19, in July (9 cases) - at posts N10 and 15. These 2 months were characterized by the highest number of cases of exceeding the MPC of carbon monoxide.

Summer months in the south of Ukraine have high temperatures and there is no precipitation for a long time. Such weather processes contribute to the accumulation of pollutants in the air. In other months, only single cases of high concentrations were observed. Post number 8, located in the resort area of Odesa, and also recorded the concentration of CO at 7 mg/m^3 in October and November, which is rather the exception for this observation post.

October, November and December proved to be the most quite in terms of air pollution. This can be explained by the increased ability of the atmosphere to disperse admixtures due to the activation of cyclone processes during this period, which determines the formation of strong winds and precipitation. At the same time, the maximum permissible concentrations have never been exceeded at more than two monitoring stations.

An important role in the formation of the level of air pollution during the year is among other played by ground and elevated inversions of air temperature (Ivus 2012, Kipenko 2002, Snizhko 2011). The inversion is characterized by the height of the lower boundary of the inversion layer, its thickness and the so-called inversion depth, that is, the temperature difference at the upper and lower boundaries of the layer (Vystavnaya, Zubkovych 2014).

For cases of exceedance of the MPC of carbon monoxide, the vertical structure of the atmosphere was examined using radio sounding data at 00 UTC at Odesa Hydrometeorological observatory. Radiosonding is carried out once per day in Ukraine and alternative data on radiosonding does not exist. Therefore synoptic analysis is using the available existing data. The inversion parameters for the study period are given in Table 2.

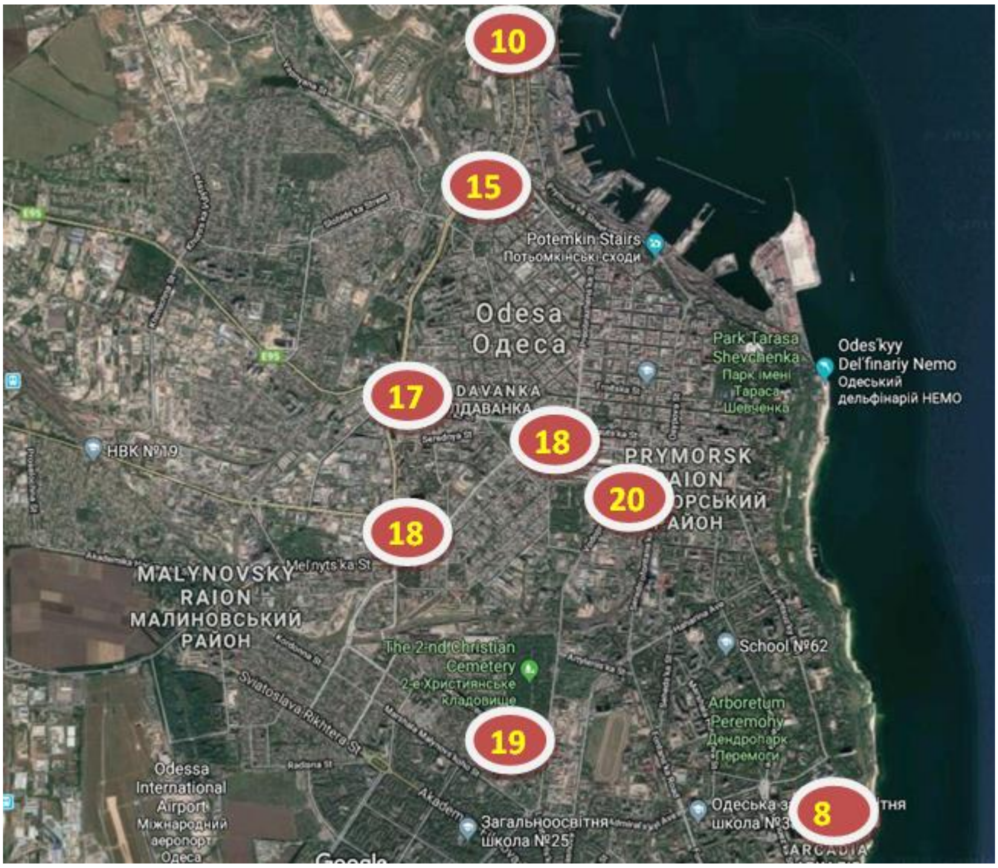

Fig. 1. Schematic representation of air pollution monitoring stations location in Odesa by numbers.

Table 1

Observation dates and values of excess carbon monoxide content (mg/m^3)
at monitoring stations N8, 10, 15, 16, 18 and 19 (Odesa, 2011)

Post	month													
	VI		VII		VIII		IX		X		XI		XII	
	date	mg/m3	date	mg/m3	date	mg/m3	date	mg/m3	date	mg/m3	date	mg/m3	date	mg/m3
№8									18	7	10	7		
№10	29	6	1	5										
			4	5										
			6	6										
			12	5										
			25	7										
			27	6										
			28	5										
			29	5										
№15	29	6	1	5	26	5	7	7						
			4	5										
			6	6			8	5						
			12	5										
			25	7	27	8	21	5						
			27	6										
			28	5			22	7						
			29	5										
№16	1	5	26	5									5	5
	6	5												
	7	5												
	15	6												
№18													2	5
													5	5
№19	3	5					19	7	13	5				
	20	5												
	21	5					28	7						
	30	5												

It should be noted that the ground inversion layer was observed at all days with a high content of contaminants in the air over Odesa, with the exception of several. Ground inversions, whose depth ranged from 200 m to 400 m, prevailed, only on December 5, 2011, the inversion expanded to an altitude of 600 m, an altitude inversion of 500 m was observed, and the change of temperature varied from 0.2 °C. to 4.1 °C.

Inversions were formed in different baric fields. Atmospheric dynamic processes have a significant effect on both the local concentration values and the total CO content in the atmosphere. In many cases, the origin of the air mass explains the observed changes in the gas composition of the atmosphere (Snizhko, 2011). Complex synoptic methods (physical and statistical methods and other) are used for the analysis of the atmospheric pollution conditions, which take into account the complex of meteorological conditions and synoptic situations that determine the distribution and accumulation of admixtures (Ivus, 2012). With the low activity development of processes and stagnant phenomena (weak wind), the conditions that most contribute to pollution are created. If the atmospheric processes are active, the surface air layers are quickly cleared.

Table 2

Characteristics of temperature inversions determined from radiosoundings at 00 UTC over Odesa in 2011

Date	Type of inversion	Parameters of inversion			Characteristics of wind near the ground
		ΔH, м	ΔT, °C	γ, °C	S
03.06	ground	380	4,1	-1,1	315 / 1
07.06	ground	180	2,9	-1,6	270 / 2
15.06	ground	210	2,2	-1,0	315 / 2
20.06	ground elevated	210 240	2,4 0,2	-1,1 -0.1	270 / 1
21.06	ground	210	0,8	-0.4	300 / 3
29.06	ground	410	0,5	-0,1	180 / 1
30.06	ground	250	0,4	-0,2	Calm
01.07	ground	190	2,3	-1,2	225 / 2
06.07	ground	390	1,6	-0,4	180 / 2
12.07	ground	200	0,9	-0,5	Calm
14.07	ground	210	2,0	-0,9	360 / 1
15.07	ground	410	2,4	-0,6	320 / 1
25.07	ground	360	1,7	-0,5	Calm
26.07	ground	200	3,6	-1,8	360 / 1
27.07	ground elevated	200 360	0,4 1,6	-0,2 -0,5	Calm
29.07	ground	190	1,0	-0,6	360 / 1
30.07	ground	220	0,0	-0,0	20 / 3
26.08	ground	340	2,3	-0,7	340 / 3
30.08	ground	230	1,1	-0,5	45 / 1
19.09	ground	230	0,8	-0,3	90 / 1
02.12	ground elevated high-altitude	230 350 340	0,8 2,7 1,4	-0,3 -0,8 -0,4	275 / 2
5.12	ground high-altitude	600 500	3,9 0,1	-0,7 -0,7	250 / 4

Considering the circulation of air masses near the surface (Table 3), it can be noted that the conditions for the accumulation of admixtures mainly created low-gradient baric fields and peripheral processes.

1.2. Main emission sources and air pollution problems

The characteristics of the wind regime (direction and velocity) are related to the meteorological factors that most influence the concentrations of contaminants in the surface atmosphere. The effect of wind direction on the content of admixtures in the air of large cities is best traced when the sources of harmful substances are concentrated within one or more industrial zones located outside the city (Ivus 2012, Snezhko 2011, Glushkov 2017, Landsberg 1981, etc.) In Odesa, a large part of the pollutants get into the air from mobile sources, motor transport, which are dispersed all over the city, so finding the dangerous wind directions for the city is a difficult task.

Table 3

Identification of synoptic processes at high levels of carbon monoxide concentration over Odesa in 2011

Date	The nature of the baric field
03.06; 15.06 26.08; 19.09	Southwestern periphery of the anticyclone
07.06; 26.07 02.12; 29.07	Crest
21.06	eastern periphery of the anticyclone
14.07; 15.07	low pressure gradient field
20.06; 25.07; 30.08;	Anticline
30.06	eastern periphery of the cyclone
01.07; 06.07; 27.07; 30.07; 5.12	Basin
29.06; 12.07	low pressure gradient field

In the paper wind speeds at observation posts № 8 and № 20 are compared. As can be seen from Fig. 1, post № 20 locates near a very complex traffic intersection and urban development. The impact of wind direction on urban air pollution is determined not only by the location of the emission sources, but also by the terrain and local circulation. It is worth noting that city streets with dense high-rise buildings cause changes in wind speed and direction and cause local circulation. Therefore, irrespective of the season, the wind speed at post № 20 (red line, Fig. 2) is much lower than the wind speed at post № 8 (blue line), except some cases. So during the period from June to September at post №20, the average daily wind speed did not exceed 2 m/s, with the onset of the autumn season the wind speed increased slightly and reached up to 3 m/s, and only in several days of October the wind was 5-6 m/s.

Therefore, there is no clear relationship between wind speed and concentrations of carbon monoxide in the atmosphere of Odesa. The absence of such dependence is the result of a large number of mobile sources of pollution in the city. Urban streets with dense high-rise buildings cause changes in wind speed and direction, and cause local circulation and calm conditions (Wapler, 2013). Wind speed at post № 20 is characterized by a large number of calm conditions and weak wind speeds of up to 2-3 m/s. The content of carbon monoxide in the air increases at calm and speed of 1 m/s (Fig. 2).

Exceedance of the maximum permissible concentrations of carbon monoxide is observed at 6 out of 8 observation posts, but their distribution in time and space is rather uneven. The autumn season compared to the summer is characterized by a smaller number of such cases, which is explained by the activation of the atmospheric circulation processes and, as a result, the increased ventilation of the atmosphere.

1.3. Forecasting method of meteorological conditions of atmospheric pollution

Considering the circulation of air masses near the earth's surface, it can be noted that the predominantly low-gradient baric fields and peripheral processes created the conditions for the accumulation of admixtures.

Therefore, for short-term forecasting the meteorological conditions of atmospheric pollution over Odesa, a more nuanced-based method was proposed. It may be expedient for its operational use and for the use of predictors of different class, including those that can only be described qualitatively. It also allows to assess the essence of the influence of individual factors such as wind, types of synoptic circulation, inversions and other. Also, it takes into consideration complex of factors that influence on air pollution objectively, i.e. in this case the empirical-statistical relationship between the presence of inversion and different predictors is revealed by the method of discriminant analysis. Based on the results of the calculations of the discriminant functions and based on physical considerations, a list of 8 potential forecasts that influence the formation of stagnant air over the city is formed:

1. ΔP_0 – Laplacian pressure near the earth's surface (hPa) to determine the nature of the surface baric field ($\Delta P_0 > 0$ - cyclone, $\Delta P_0 < 0$ - anticyclone) and to account for the sign of vertical motions;

2. p‘- concentration values ($mg \cdot m^{-3}$) of pollutants in the previous day;

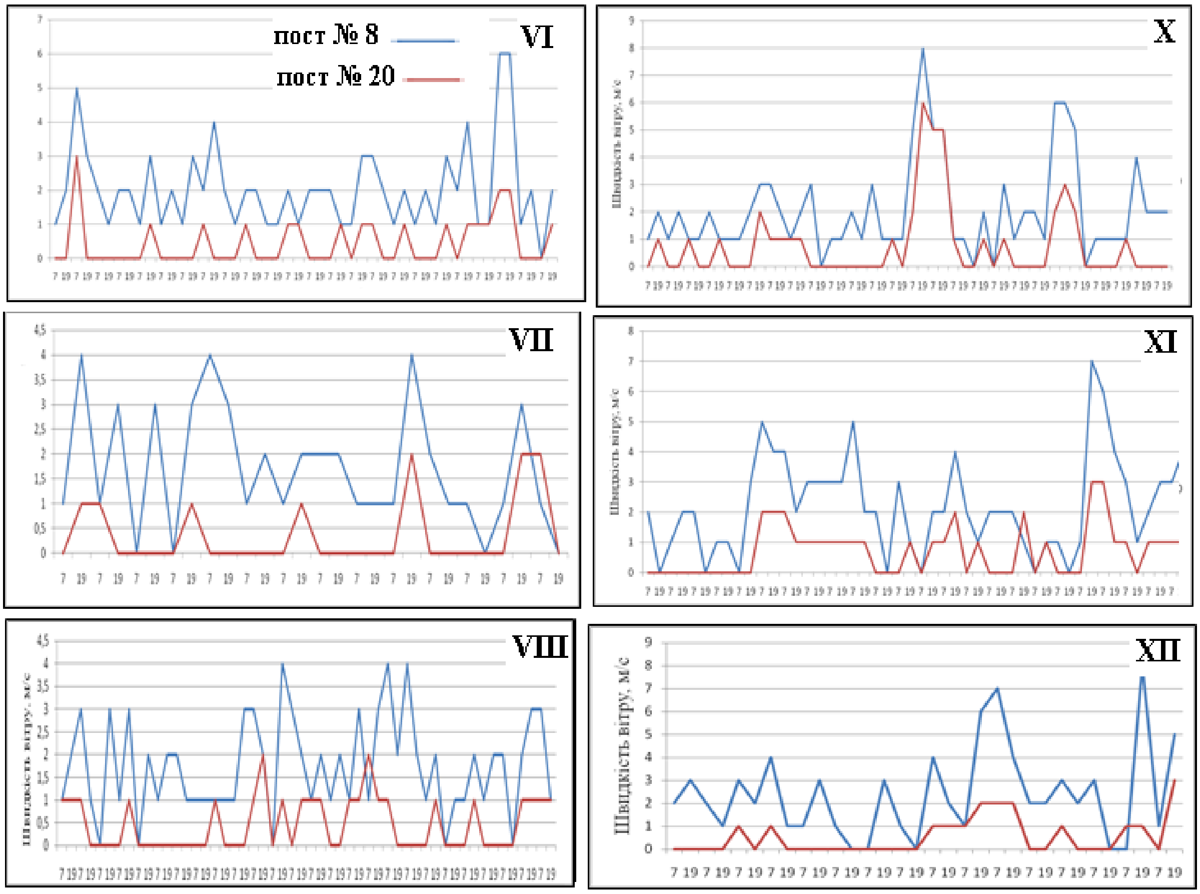

Fig. 2. Graph of daily wind speed change (7 and 19 UTC) at air pollution monitoring posts № 8 and № 20 in Odesa, June-August, October-December, 2011

3. V_0 і V_{925} – wind speed (m-s^{-1}) near the earth's surface and at 925 hPa;

4. dd_0 і dd_{925} – wind direction (hail) near the earth's surface and at 925 hPa;

5. dd_0 - dd_{925} – the difference between wind directions (hail) near the earth's surface and at the level of 925 hPa;

6. Δ V - wind speed difference (m-s^{-1}) at 925 hPa and near the earth's surface;

7. Δ T - difference in air temperature (°C) near the earth's surface and at the level of 925 hPa.

8. $\bar{\gamma}$ - average vertical temperature gradient in the layer 0-500 m (°C / 100 m);

The predictor ΔP_0 is calculated according to the prognostic charts with a time of 24 hours, the predictors $\bar{\gamma}$, V_{925}, dd_{925}, Δ V, Δ T – are determined according to radio sounding over Odesa at the time 00 UTC, and the predictors V_0, dd_0 and p '- according to the observation post # 15, which is located in Kherson Square, that is, in the area of the main emission sources of harmful substances.

The set of predictors should more fully describe the initial state of the atmosphere, so only the most basic, physically sound and strongly related to the predictor should be selected, since increasing the number of predictors may reduce the predictive efficiency of given method.

Before constructing discriminant functions, the selection of the most informative predictors by the Mahalonobis's parameter (Δ^2) was made. Thus, the final list included 14 predictors, which were used in the construction of all discriminatory functions regardless of the type of inversions, season, synoptic situation and timing of the forecast.

$$\Delta^2 = \sum_{i=1}^{m}\sum_{j=1}^{m} d_{ij} \sum_{k}^{g} n_k \left(\bar{x}_{ik} - \bar{x}_i\right)\left(\bar{x}_{jk} - \bar{x}_j\right) -$$

Mahalonobis's distance, (1)

$\bar{x}_{ik}$– average value of the *i*-th predictor in the *k*-th group.

Here *m* is the number of variables; n_k is the volume of the *k*-th sample; d_{ij} is the element of the inverse covariance matrix $\|k\|$, which is calculated as follows:

$$K = \frac{\sum_{k=1}^{g} S_k}{\sum_{k=1}^{g} n_{k-g}}, \quad (2)$$

where $S_k = \{S_{jl}^{k}\} = \sum (x_{ijk} - \bar{x}_{ik}) \cdot (x_{ilk} - \bar{x}_{jk})$ (*j=L=1, m; k* – group number).

Next, find the regression coefficients b_i and the free term a:

$$b_i = \sum_{j=1}^{m} d_{ij} \cdot \bar{x}_{jk};\ a = -\frac{1}{2}\sum_{j=1}^{m} \quad \sum_{i=1}^{m} d_{jl} \cdot \bar{x}_{jk} \cdot \bar{x}_{ik} \qquad (3)$$

and construct the discriminant function in the final form:

$$F_k = \sum_{j=1}^{m} b_i\, x_{ijk} + a \ (k = 1,2). \qquad (4)$$

The discriminant functions (5) - (8), obtained for the forecast of meteorological conditions of atmospheric pollution (exceeding the MPC level at the post # 15) over the industrial zone of Odesa with a duration of 24 h depending on the season, have the form:

$$\text{January: } F = 3{,}6\cdot10^{-4}\,p' - 1{,}8\cdot10^{-4}V_0 - 1{,}1\cdot10^{-5}\,\bar{\gamma} + 4{,}8\cdot10^{-5}; \qquad (5)$$

$$\text{April: } F = 5{,}2\cdot10^{-4}\,p' - 2{,}5\cdot10^{-4}V_0 + 2{,}3\cdot10^{-5}\,\Delta V + 3{,}2\cdot10^{-5}; \qquad (6)$$

$$\text{July: } F = 3{,}5\cdot10^{-4}\,p' - 3{,}3\cdot10^{-4}V_0 - 8{,}7\cdot10^{-5}\,\Delta P_0 - 5{,}1\cdot10^{-5}; \qquad (7)$$

$$\text{October: } F = 4{,}1\cdot10^{-4}\,p' - 2{,}9\cdot10^{-4}V_0 - 3{,}8\cdot10^{-5}\,\Delta P_0 + 4{,}3\cdot10^{-5}; \qquad (8)$$

where, if F> 0, admixtures are expected to accumulate, and if F <0, dispersion is expected.

In order to improve the prognostic capabilities of the alternative method, the discriminant equations (9) and (10) are obtained, taking into account the type of synoptic process at which admixtures accumulate. Thus, to predict the conditions of air pollution in July in the presence of the anticyclone field (type 3) and peripheral processes (type 1) use the formulas:

$$F = 5{,}2\cdot10^{-4}\,p' - 4{,}3\cdot10^{-4}\,\Delta P_0 + 2{,}9\cdot10^{-5}; \qquad (9)$$

$$F = 6{,}1\cdot10^{-4}\,p' - 7{,}1\cdot10^{-4}\,V + 4{,}1\cdot10^{-5}; \qquad (10)$$

where if F> 0, admixtures accumulation is predicted, and if F <0, dispersing is predicted.

The effectiveness of the alternative method of forecasting meteorological conditions of pollution was tested on dependent (July 2011-2015) and independent (July 2009) material. The results obtained indicate that the effectiveness of the proposed method is at the level of current regional forecasts (Kiptenko 2012, Glushkov 2017).

Here are some general recommendations for applying this method:

1. The proposed method can be used to forecast the weather conditions for 24 hours during all seasons.

2. In the alternative forecast, it is possible to apply the pollutants concentration data of previous day, not only at post N 15.

3. The procedure of inversion prediction by this method should be preceded by an assessment of the macro-synoptic situation, because in the case of sharply marked active fronts and significant baric gradients (more than 2-3 hPa/100 km), the calculation of discriminant functions is not performed.

The main criteria for January, April, July and October 2011-2015 are calculated to evaluate the quality of the alternative forecast of meteorological pollution conditions over Odesa on the modern meteorological and synoptic material. All information about the success of the forecast method is presented in Table 4.

On the whole, the overall validity (U,%) of the alternative method of forecasting the meteorological conditions of pollution over Odesa was high, amounting to 87% in January,80% in April, 92% in July and 85% in October, i.e. the prognostic technique works well on independent material throughout the last decade.

As can be seen from table 4, the validity of forecasting the presence of pollution conditions (U_{ph}, %) is higher than the general one and reached 88-94%. The validity of forecasting the absence of meteorological conditions of pollution ($U_{no\ ph}$, %) in July and October was almost equal to U_{ph}, but it was lower by 5% in July.

The prediction of meteorological conditions (P_{ph}, %) during all study periods exceeded 80%. The absence of admixture accumulation conditions ($P_{no\ ph}$ %) was best predicted in July (93%).

M.O. Bagrov's (Ivus , 2012) calculations of the reliability criterion showed that he accepted the minimum value (0.71) in October, and in the remaining months it ranged from 0.77 to 0.88, i.e. the prognostic technique is reliable.

The use of the Piercy-Obukhov's (T) forecast quality criterion for the estimation of the meteorological conditions of pollution over Odesa revealed that he took only positive values (from 0.70 to 0.83), that is, the phenomenon prediction (P_{ph}) exceeded the ratio of false forecasts of the phenomenon to the actual number of days without phenomena (Ivus 2012).

Conclusions

In this article we have analyzed influence of meteorological conditions on the level of atmospheric air pollution in Odesa region. For these purposes the more nuanced-based method of forecasting was adapted. We have demonstrated that its use has efficiency at the present time for improvement of operative prognostic units work for the Northwest Black Sea region. Such conclusions may be identified as a result of empirical findings:

1. CO concentrations in the city of Odesa increase with distance from the coastal strip into the depth of land with maximum values in places with

Table 4

Quality criteria of the alternative forecast the meteorological conditions of pollution over Odesa (2011-2015)

Forecast	Observed		Sum	U	U + P
	Phenomenon	No phenomena			
January					
Phenomenon	72	10	82	88	177
No phenomena	9	60	69	87	173
Sum	81	70	151		
P	89	86			
			T=0,75	H=0,77	
April					
Phenomenon	69	9	78	88	176
No phenomena	10	62	72	86	173
Sum	79	71	150		
P	87	87			
			T=0,75	H=0,78	
July					
Phenomenon	75	5	80	94	184
No phenomena	8	67	75	89	182
Sum	83	72	155		
P	90	93			
			T=0,83	H=0,88	
October					
Phenomenon	65	12	77	84	170
No phenomena	11	67	78	86	171
Sum	76	79	155		
P	86	85			
			T=0,70	H=0,71	

high traffic load, regardless of the season;

2. Absence of industrial facilities and meteorological conditions contribute to the low level of air pollution around post N 8. Exceedance of the maximum allowable concentrations of carbon monoxide is observed in 6 out of 8 observation posts

3. Favorable conditions for the accumulation of admixtures are formed in peripheral processes with low-gradient pressure fields, ifront parts of cyclones and in low-motion and small cyclones with the same air mass;

4. Temperature inversions almost always accompanied the accumulation of harmful admixtures in the ground layer of air above Odesa.

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Використання та основні рекомендації прогнозу метеорологічних умов забруднення повітря над Одесою

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Однією з важливих ланок в системі моніторингу охорони чистоти атмосфери повітря є дослідження режиму формування шкідливих домішок і прогнозування рівня забруднення залежно від характеру макромасштабної циркуляції, стану граничного шару атмосфери і місцевих фізико-географічних умов, що особливо актуально для районів з великою кількістю промислових підприємств, які є постійним джерелом забруднення атмосфери. У статті розглянути результати дослідження метеорологічних та синоптичних умов забруднення атмосферного повітря в різних районах Одеси, та запропонований альтернативний метод прогнозу метеорологічних умов забруднення для промислових районів Одеси при різних типах синоптичних процесів. Для аналізу умов забруднення атмосфери застосовують такі синоптичні методи, що враховують комплекс метеорологічних умов та синоптичних ситуацій, які визначають розповсюдження та накопичення домішок. Особливу увагу приділено малоактивному розвитку процесів й застійних явищ (слабкий вітер), при яких створюються умови, що найбільш сприяють забрудненню. Якщо ж атмосферні процеси активні, то приземні шари повітря швидко очищаються. В статті розглядається альтернативний метод, який може бути доцільним для оперативного використання через його зручність та можливість застосування предикторів різного класу, в тому числі таких, які можна описати лише якісно. Він дозволяє також об'єктивним шляхом оцінити сутність впливу окремих факторів та їх комплексу на забруднення повітря, тобто у даному випадку методом дискримінантного аналізу виявлена емпірико-статистична залежність між наявністю інверсії та різними предикторами. За результатами розрахунків дискримінантних функцій та виходячи з фізичних міркувань, сформовано перелік 8 потенційних предикторів, які впливають на утворення застоїв повітря над містом.

Ключові слова: *гранично допустима концентрація (ГДК), забруднення повітря, затримуючий шар, слабкий вітер, синоптичні процеси, інверсія, альтернативний метод прогнозу забруднення атмосферного повітря.*

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