ATMOSPHERIC AIR POLLUTION AND TRANSFORMATION PROCESSES OF DEPOSITION IN THE FOREST ECOSYSTEM OF THE ŚWIĘTOKRZYSKIE MOUNTAINS REGION*

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Abstract: Over 10-year experience of the Świętokrzyskie Mountains region integrated environmental monitoring undoubtedly revealed that deposition systems with complexes of spatiotemporal values and consequent reactions to transformation processes of heavy-changeable and easy-changeable in time elements of ecosystems, require a new deepen expression. Every Earth's system consists of complexes of selffunctioning elements, which interoperate in performing some defined regulating functions, to its existence necessary. Even small deviations from natural and close to optimal levels of functioning in ecosystems can have negative effects on living organisms having their niches in them.

This is why it is necessary to recognise deeply and more comprehensively the emission systems in the atmosphere with their transmissions in time and space along with induced transformations in the atmosphere, hylosphere and pedosphere depending on meteorological parameters. Without a suitable processing this knowledge cannot be directly used in natural environment planning, and management and of environmental policy implementation by decision makers.

Localisation of ICP IM station Święty Krzyż in low mountains with dominating emissions from W and SW directions with oceanic air masses along with changeable from E and SE directions of continental air have specific geographical values for regional and local emissions examination on the background of remote continental and intercontinental emissions.

Keywords: emission, transmission, transformation, deposition, time-space, asymmetry.

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1. Introduction

Biological systems form complicated products with unparalleled elsewhere precision, efficiency and speed (Eddington 1958). Maintenaning of the organization in these systems is not – and cannot be – reached by methods of the centralized management. The order can be maintain only within a self-organisation system, what enable adaptation to changing environmental conditions (Prigogine 2000). Self-organisation processes are unbalanced and irreversible in the space-time. Within a certain time, they can have different consequences in ecosystems, depending on diversity of time dimension scales in which they simultaneously – but with different speed – take place, though the time arrow is always turned in the same direction (Davies 1974). It has been confirmed by the fourth law of thermodynamics experimentally formulated by Jørgensen & Nielsen (1998): „if in the system the egzergy flow takes place, then this system uses this stream to extend content of its own egzergy to increasingly grow away from the thermodynamical equilibrium. If for the utilization, maintaining and reductions of this egzergy a greater number of processes is accessible then this kind of form of organization will be selected which, in given conditions, will provide this system with the greatest quantity of egzergy".

Hitherto existing research of ecosystems became a base of principle knowledge about entropies of functioning in real asymmetries of their time and space (Davies 1974, Prigogine 2000). However, this knowledge cannot be utilised directly, without suitable converting, in the environmental planning and management and in the implementation of environmental policy. The knowledge of activity should be separated from the basic knowledge. This means that it should be accessible so called „high-availability knowledge" – the knowledge of resources with reference to the knowledge of targets, which is „the knowledge of orientation" (Snow 1954, Mittelstrass 1995, Barkmann 2002). According to Lovelock (2003), the uncertainty of the future of the Earth's ecosystems and the fear of pollution consequences of the natural environment are results of the ignorance about the planetary system of the regulation. Every functioning Earth's system consists of sets of components functioning and cooperating towards certain regulative functions, which are indispensable for its existence. Even small deviations from natural – almost optimum – levels can have fatal results for the life of organisms that have their own niches in it.

Over 10-year experience of integrated environmental monitoring in the Świętokrzyskie Mountains regions undoubtedly revealed that in geoecosystem functioning deposition systems with complexes of their spatio-temporal values, consequent reactions to processes of transformations of heavy-changeable and easy-changeable in time elements of ecosystems, require a new and deepen expression.

In a general outline, the above mentioned state of the „high-availability knowledge" is relative to the state of the knowledge on the system of emissions to the atmospheric air with its transmission in the space and time as well as induced by its transformation in the atmosphere, hylosphere and pedosphere, depending on the meteorological parameters.

2. Materials and methods

In the paper methodical principles of the integrated system of emissions functioning in the atmospheric air with their transmission and transformations in geo-ecosystem are presented. They are illustrated with examples from the Integrated Environemtal Monitoring Station Święty Krzyż in the Świętokrzyskie Mountains. These are data from meteorological observations from the years 1994-2003 gained over by means of the automatic apparatuses of the Vaisala company. They were situated at the height of 543,5 m asl, on the 30-meter-high tower made of steel, 6 metres over the the forest canopy. A dominating forest community is the acidic Carpathian beech forest (*Dentario glandulosae-Fagetum* Klika 1927, Matuszkiewicz 1964). This community is also included into the upland mixed fir forest (*Abietetum Polonicum* Dziub. 1928, Br.-Bl. et Vlieg 1939). The influence of the regional emissions on the bulk deposition was presented on the basis of measurement results of 30-minute concentrations of dust and CO during the period 1st-30th September 2002 with the use of the dust analyser FAG-62 APDA-351E and of the analyser APMA-CO, APMA-350E (Horiba company).

3. Emissions, their transmissions in air and transformations in the forest ecosystem

3.1. Emissions and their transmissions

Bulk deposition (BD) in a given geographical localisation consists of primary and secondary substances proceeding from three kinds of natural and anthropogenic emissions (Fig. 1), originating from point, superficial and lineal sources. Primary substances of the earthly and cosmic origin and secondary substances, which are products of primary substances transformations in the air, are components of remote intercontinental and *continental emissions* (*CE*), mid-range *regional emissions* (*RE*) and short-range *local emissions* (*LE*). Under the circulation of air masses the emitted primary substances and compounds proceeding from above mentioned three kinds of emissions, in the processes of transmission (*TRA1, TRA2, TRA3*) in time and spaces quantified with the length of their transport, are subject of summation, dilution, moderating and at least partly transformations to new substances considerably more harmful for living organisms. Finally, they are deposited. The speed of transmissions and degree of transformations during their sojourn in the atmospheric air are relative to their composition, concentrations and height of the expulsion to the atmosphere, geographical arrangement of air masses movements as well as morphology and roughnesses of the Earth's surface. Depending on every local distribution primary and secondary components of substances and compounds of emissions are deposited from the atmospheric air or indirectly through the plant layer in a form of the *canopy deposi-*

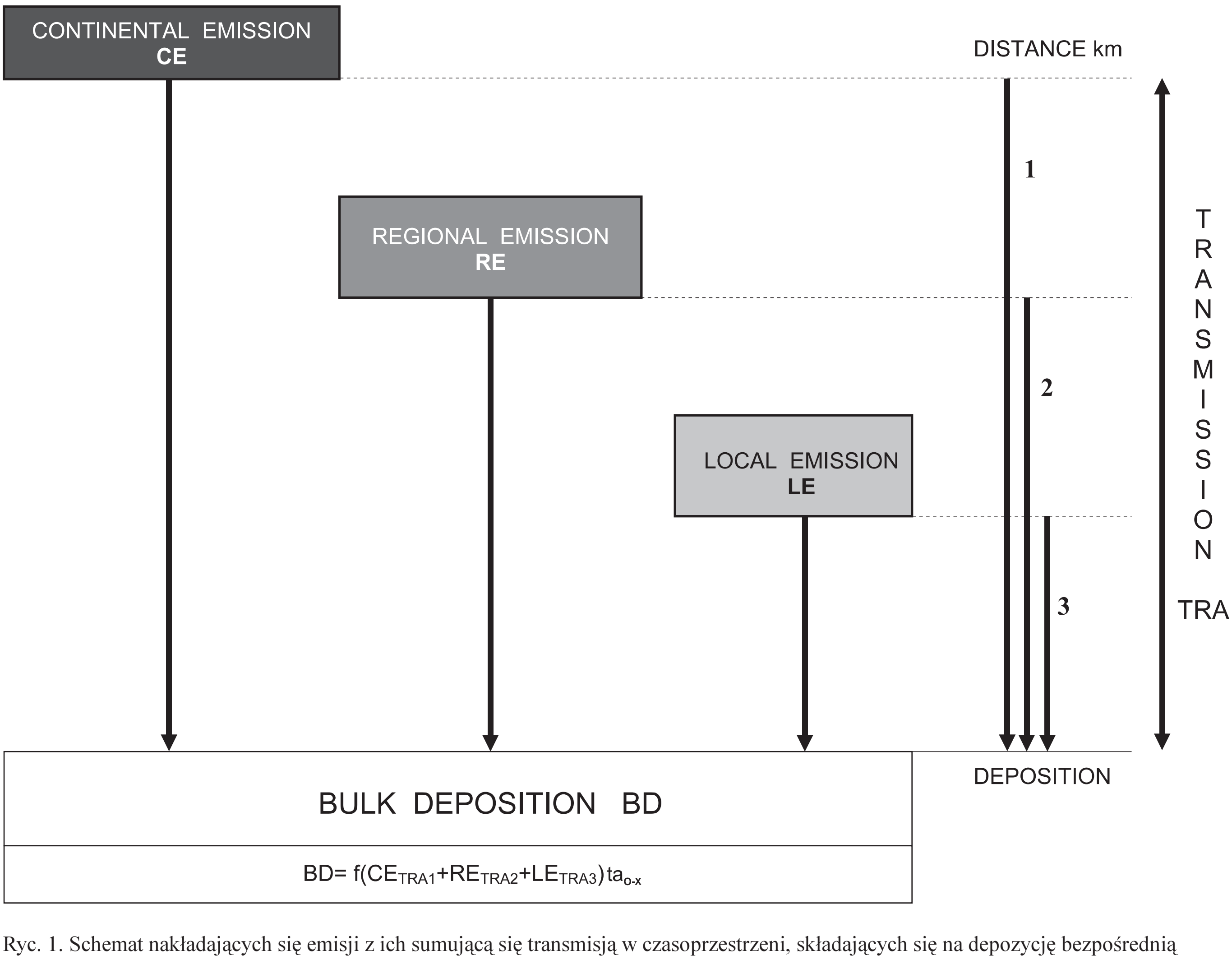
tion (*CD*) or directly to the soil surface and surface waters in a form of *bulk deposition* (*BD*). It is a complex function of distance during a *certain time* (t) in the *atmospheric air* (a). A simple form of the equation of the bulk deposition can be expressed as follows:

$$BD(kg*ha^{-1}y^{-1})=f(CE_{TRA1}+RE_{TRA2}+LE_{TRA3})ta_{o\text{-}x}$$

It is well known that emissions in the atmospheric air consist of gas-compounds along with liquid and solid parts that have proprieties of aerosols. In the process of *transmission* (*TRA*) primary aerosols of biological, pedogenic, volcanic, marine and cosmic origin show the greatest transformation activity. As a consequence of multiple chemical and thermal interactions with gas-substances they convert into secondary aerosols of changeable chemical composition and proprieties in time and space (Iwlew 1982, Brimblecombe 1986, Spranger 1992).

3.2. Transformations of emissions and total deposition

On the transmission way, emissions are subject to cumulative transformations in liquid, solid and of gas phases qualitatively and quantitatively independend from the emitting sources. Then, the deposition from the atmospheric air reaches the surface of polypedon mosaics (Fig. 2) in a form of *bulk deposition* (*BD*) or into the hylosphere space in a form of *canopy deposition* (*CD*). Further subsequent transformations in the space of above-ground plant organs – in hylosphere, result in formation of the *total deposition* (*TD*), which is a function of synergistic bulk deposition and its *biogenic transformation* (*TRB*) in the hylosphere. This asymmetric process lasts all the time with changing intensities and spatially diverse intensifications of the positive and negative entropies development in time and space, which are references for received information. This way a sim-

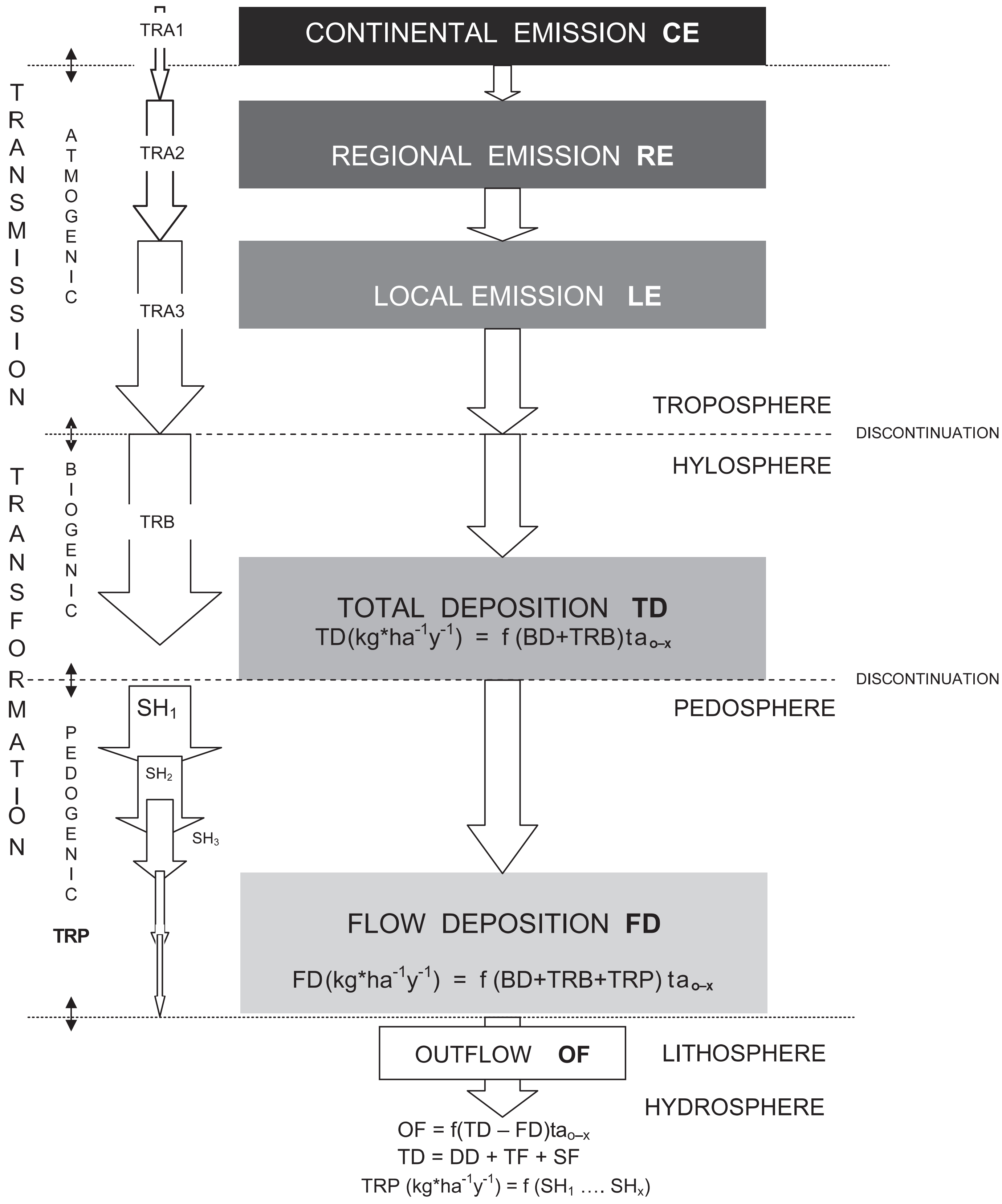


Ryc. 1. Schemat nakładających się emisji z ich sumującą się transmisją w czasoprzestrzeni, składających się na depozycję bezpośrednią

Fig. 1. Scheme of overlapping emissions taking part in the bulk deposition with their additive transmission in the time-space

Ryc. 2. Schemat przebiegu transformacji emisji z ich depozycjami w hylosferze i pedosferze z odpływem

Fig. 2. Scheme of emission transformations course with their depositions in the hylosphere and pedosphere; including the outflow



plified equation of total deposition over the soil surface can be expressed as follows:

$$TD(kg*ha^{-1}y^{-1})=f(BD+TRB)ta_{o-x}$$

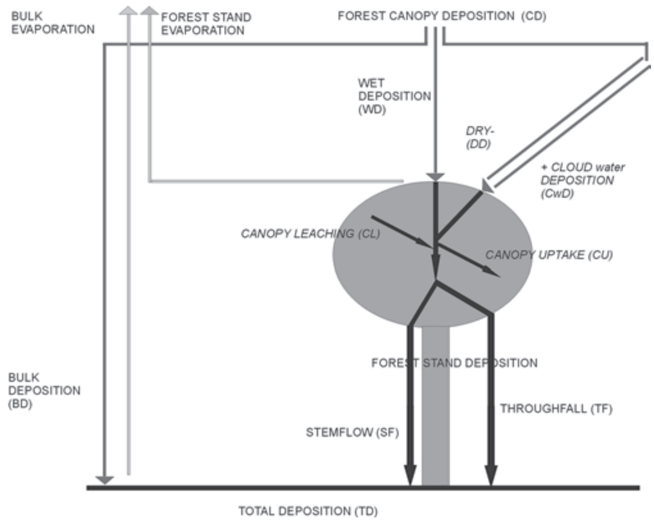
Diverse deposition products penetrating through the pedosphere are subjects of *pedogenic transformation* (*TRP*) with formation of multidirectional *flow deposition* (*FD*) in the space dimension, with a prominent differentiating participation of plant roots and assemblages of soil organisms. This deposition is a subject to significant changes and transformations in time and space within the reach of consequent sequences of *soil horizons* (*SH*) depending with the mosaic character of polypedons. As a result, the deposition obtained pedogenic features in a smaller of bigger degree. Its new essential feature is a presence of colloidal organic matter, immobilized in soil horizons or found in suspension of migrating soil solutions. On the passage from soils to the bedrock, subsoil or to adjacent polypedons the *outflow* (*OF*) occured. Taking into account the flow deposition in the ecosystem the total deposition consist of sums of bulk deposition, biogenic transformation deposition in hylosphere and pedogenic transformation deposition in the pedosphere, as functions of time and space dimension:

$$TD(kg*ha^{-1}y^{-1})=f(BD+TRB+TRP)ta_{o-x}$$

In presented successive creating of knowledge on quantitative-qualitative transformations of the total deposition the attention should be paid to three distinct border and material discontinuities between atmosphere-hylosphere-pedosphere-lithosphere (Fig. 2). Their common features are dividing borders of change trends of deposition features, which ought to be examined on the basis of polarizing coincidence and anticoincidence criteria of their assessments (Riedl 2000, Spranger 1992).

3.3. Depositions and their transformations in hylosphere

Special difficulties in qualification of total deposition relates to the hylosphere in which differentiating quantitative and qualitative features in different seasons of the year are biogroups of trees, their generic composition, crown density, density of assimilative organs in crowns and multi-layer structure of the forest stand. The research of Neumeister et al. (1997), Haase & Neumeister (1998, 1999), Jóźwiak (2001), Kruszyk (2001), Kozłowski (2003) reviled strong spatial determinations of paths and areas of flows through the



Ryc. 3. Schemat systemu depozycji bezpośredniej, depozycji drzewostanowej i całkowitej z transformacjami w hylosferze

Fig. 3. Scheme of the bulk deposition system, forest stand deposition and total deposition with transformations in hylosphere

forest stand of substances descending from above mentioned depositions from the tree canopy. Along these paths the essential ecological meaning has delivering of emission substances in *wet deposition* (*WD*), *cloud water deposition* (*CwD*) and especially *dry deposition* (*DD*) along with paths of their outflow in a form of the *stemflow* (*SF*) and *throughfall* (*TF*).

The above mentioned depositions are subjects to significant and various biogenic transformations at the space of tree canopy as a result of *canopy leaching* (*CL*) and *canopy uptake* (*CU*). Quantitative and qualitative features of the tree canopy deposition decide about the quality and intensity of transformations of precipitation waters in the space of the forest stand and finally during the flow through the *forest bottom plants layer* (*HF*) to the soil surface. The difference between throughfall and stemflow is called *canopy deposition difference* (*KDD*).

The space of tree crowns is considered as a water reservoir (Spranger 1992), which in case of the wet/or cloud water deposition fills in and then, in a lineal dependence from the rainfall, generates forest stand deposition consisting of throughfall and stemflow (Fig. 3). The capacity of this reservoir depends on so called surface of the receptor willing surface of total surface of assimilation organs and shoots as well as from the roughness and porosities of the bark surface of different trees in their bio-groups. Total deposition in the forest stand, with regard to the gaps between crowns, can be a sum of throughfall, stemflow and *bulk deposition flow be-*

tween crown gaps (*BDF*) on specified areas in a certain time:

$$TD(kg*ha^{-1}y^{-1})=f(SF+TF+BDF)ta_{o-x}$$

The time-space dimension (ta) has a mosaic feature, which characteristics depend on above mentioned space systems of biogroups of trees, generic composition, density of tree crowns and gaps between them, multi-layer structure of the forest stand. The whole complex of these systems in the forest stand is unstable. It is also a subject to continuous unsymmetrical progressive and regressive seasonal and long-term transformations. In such conditions record value of the total deposition of the forest ecosystem is approximated and limited in its currentness in time and space.

The aggressiveness of the influence of the tree canopy deposits on the vegetation and the total deposition on the soil environment can be regulated by evaporation of water from plants and soil surface, depending on weather conditions causing increasing concentrations of migrating contaminated solutions. However, it has to be underlined that in the balance of the total deposition there are effects not only of direct depositing of emissions from the atmospheric air, but also differentiation effects of the quantity self-regulating and buffering reaction of different kinds in plant community. Forest plant communities have self-regulation abilities and possibilities, which are not present at the level of individual organisms.

4. Origin of emissions and size of depositions in the Świętokrzyskie Mts.

The Monitoring Station Święty Krzyż is situated on the lower part of an Pleistocene cryoplanation terrace, on the denudation concave part of the northern slope of the main Łysogóry Mountains massif, at the height of 513,5 m a.s.l. This massif is built of Cambrian quartzite, inter-bedded with binds and grey-wackes, covered with non-carbonate Eolian silt layers and loesses of different thickness as well as slope solifluction and covers. The elevation of this massif of about 300 m beyond the circumjacent upland and its northern exposition are factors of a specific influence air mass from prevailing south and west directions with diverse moisture and contamination originating from the remote transportation (Fig. 4).

During the years 1994-2003, with average yearly air temperatures of 6,7°C and considerable oscillations from 4,9 to 7,9°C higher average air temperatures of 10,7°C, with average deviations from 9,0 to 13,1°C, were connected with weak winds from NE to S directions. Air masses had lower average temperatures - 7,3°C. Yearly total precipitations – 762 mm with considerable deviations in individual years from 573 to 906 $mm*yr^{-1}$ – are indirectly proportional to average yearly temperatures.

With prevailing weaker winds from eastern directions lower total precipitations were connected of the average 182,4 mm. More intensive winds from westerly directions bring higher average precipitation – 464,5 $mm*yr^{-1}$. Low average relative humidity – 72,3%, with oscillations from 69,5 to 76,3%, correlates with continental higher air temperatures at small speeds of winds and low precipitation from eastern and south-eastern directions Higher average atmospheric humidity at 80,4%, with deviations from 79,2 to 81,4% correlates with higher precipitation of the oceanic origin and with higher wind speed from westerly directions.

Masses of moister and cooler air of the oceanic origin (Atlantic) migrating from the distance at least 1600-1800 km from over Western Europe contain smaller concentrations of dust, CO and O_3 as well as greater concentrations of $S-SO_2$, Mg, Na and Cl. Drier and warmer air masses from over Northern Africa, from the distance of at least 2150 km south and from steppes of Ukraine and Turkmenian deserts, from the distance to over 2000 km south-east, contain greater concentrations of dust, CO and O_3, and smaller concentrations of $S-SO_2$, Na and Cl.

Strong emissions of anthropogenic origin from industrial and densely urbanised areas have the essential influence on the chemism of intercontinental arid and maritime air masses, with very diverse in moisture contaminating natural and anthropogenic emissions. These are eg. Moravian-Ostrawa Basin, Lower Lusitanian Brown Coal Area, Upper Silesian Industrial Zone, Koniński and Bełchatowski Brown Coal Zone, West Ukrainian Industrial and Mining Zone from the distances from 200 to over 1000 km. Emissions of continental and regional range overlap with short-lasting high concentrations of the local origin from distances smaller in general than 200 km.

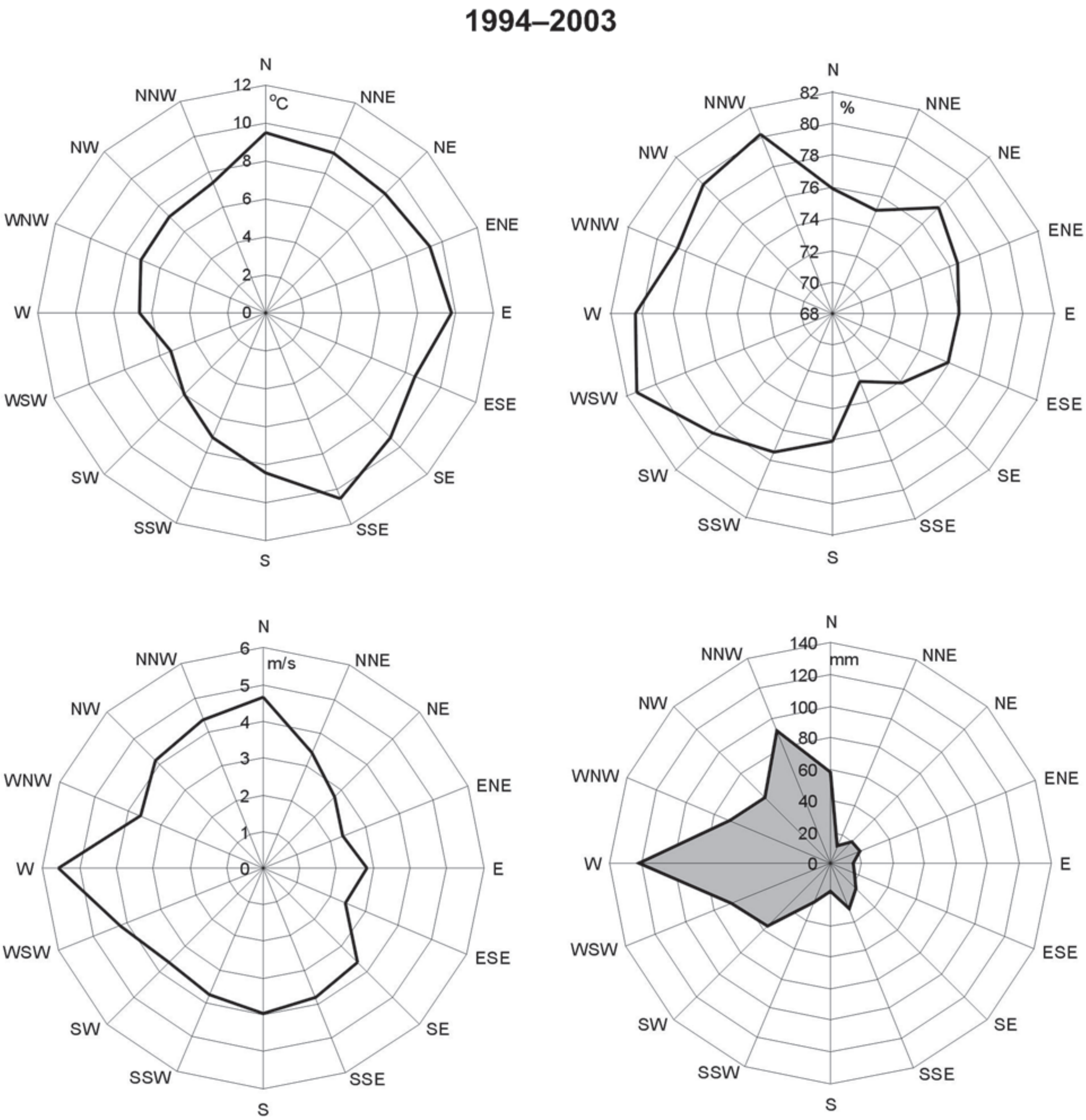
The size of depositions in the area of the Integrated Monitoring Station Święty Krzyż has its own prevailing geographical conditionings, which are pointed out by in the region of Europe (De Vries et al. 1999). The bulk deposition of SO_4, NH_4, Ca, Mg, K is, similarly as given by De Vries for the Central-Eastern Europe, specificantly higher than in Boreal and Atlantic climatic regions, and also in the Polish Lowland (Table 1). In the area of Poland the growing influence of the elevation above sea level on the concentrations SO_4, NH_4, Ca in bulk deposition the has the essential significance. On the other hand, concentrations of NO_3, Mg, K and Na depend in greater degree on directions and speed of winds along with precipitations. According to Kozłowski (2003) in the Station Święty Krzyż during the years 2001-2002 the bulk deposition of SO_4+NO_3 was 1928 $mol_c*ha^{-1}*yr^{-1}$, and cations $NH_4+Ca+Mg+K$ = 2311 $mol_c*ha^{-1*}yr^{-1}$. On the other hand, according to De Vries et al. (1999), in the central-eastern region the values are as follows:

$SO_4+NO_3=1140\ mol_c*ha^{-1}*yr^{-1}$

and for ions

$NH_4+Ca+Mg+K=1324\ mol_c*ha^{-1}*yr^{-1}$.

However, the throughfall in the Świętokrzyskie Mountains was many times higher than in the Central-Eastern region of Europe (Table 2), especially NO_3 differed 2-3 times, NH_4 about 3-times, Mg 4,5-5-times and



Ryc. 4. Średnie wielkości niektórych elementów meteorologicznych w latach 1994-2003 w zależności od kierunków transportu mas powietrznych na obszarze Stacji Zintegrowanego Monitoringu Święty Krzyż

Fig. 4. Mean values of some meteorological elements from the years 1994-2003 depending on directions of the air mass transportation in the Integrated Monitoring Station Święty Krzyż site

Table 1. Annual average bulk deposition (BD) fluxes of maior elements as a function of geographic region in Europe (according to De Vries et al. 1999, Kozłowski 2003 supplemented, Wawrzoniak (Edit.) 2002, 2003)

Tabela 1. Średnie roczne przepływy opadu bezposredniego (BD) głównych elementów składowych jako funkcja geograficznego regionu w Europie (wg De Vries et al. 1999, Kozłowski 2003 uzup., Wawrzoniak (red.) 2002, 2003)

Region	N[1)]	Bulk deposition in $mol_c\ ha^{-1}a^{-1}$ *Opad atmosferyczny* ($mol_c\ ha^{-1}a^{-1}$)						
		SO_4	NO_3	NH_4	Ca	Mg	K	Na
North / Boreal	40	170	106	95	49	54	32	154
North / Boreal Temperate	11	239	184	153	71	41	31	136
West / Atlantic	47	500	280	435	191	183	57	778
Central / East	143	703	311	197	666	150	196	186
Central / Poland[2)]	148	800	328	824	979	241	354	247
Central / Małopolska[2)]	27	1142	398	996	1501	322	354	291
Central / Carpathian Mts[2)]	19	1399	368	1030	2598	666	213	482
Central / Świętokrzyskie Mountains[3)]	1	1193	735	548	692	945	126	178
Southern / Mediterranean	27	628	334	442	618	285	130	868

[1)] N = number of plots, [2)] 2001-2002 [3)] 2001-2003

Ca and K – over twice. Additionally, it was observed a significant differentiation of values depending on the species composition of the forest. In the coniferous forest througfall was SO_4+NO_3 = 5725 mol_c*ha^{-1}*yr^{-1}, and totals of NH_4+Ca+Mg+K were 6 979 mol_c*ha^{-1}*yr^{-1}, while in the deciduous forest deposition was considerably lower SO_4+NO_3 = 3574 mol_c*ha^{-1}*yr^{-1}, and similarly NH_4+Ca+Mg+K=6 172 mol_c*ha^{-1}*yr^{-1}, with domination of SO_4, NO_3, NH_4 and Ca in the coniferous forest and Mg and K in the deciduous forest. Contents of the K ion in througfall over 10-times higher than in bulk deposition were in the forest of Święty Krzyż, while in the Central-Eastern region only 3-times higher (Table 2).

5. A case of air contamination by distant sources on the basis of bulk deposition measurements in Świętokrzyskie Mts.

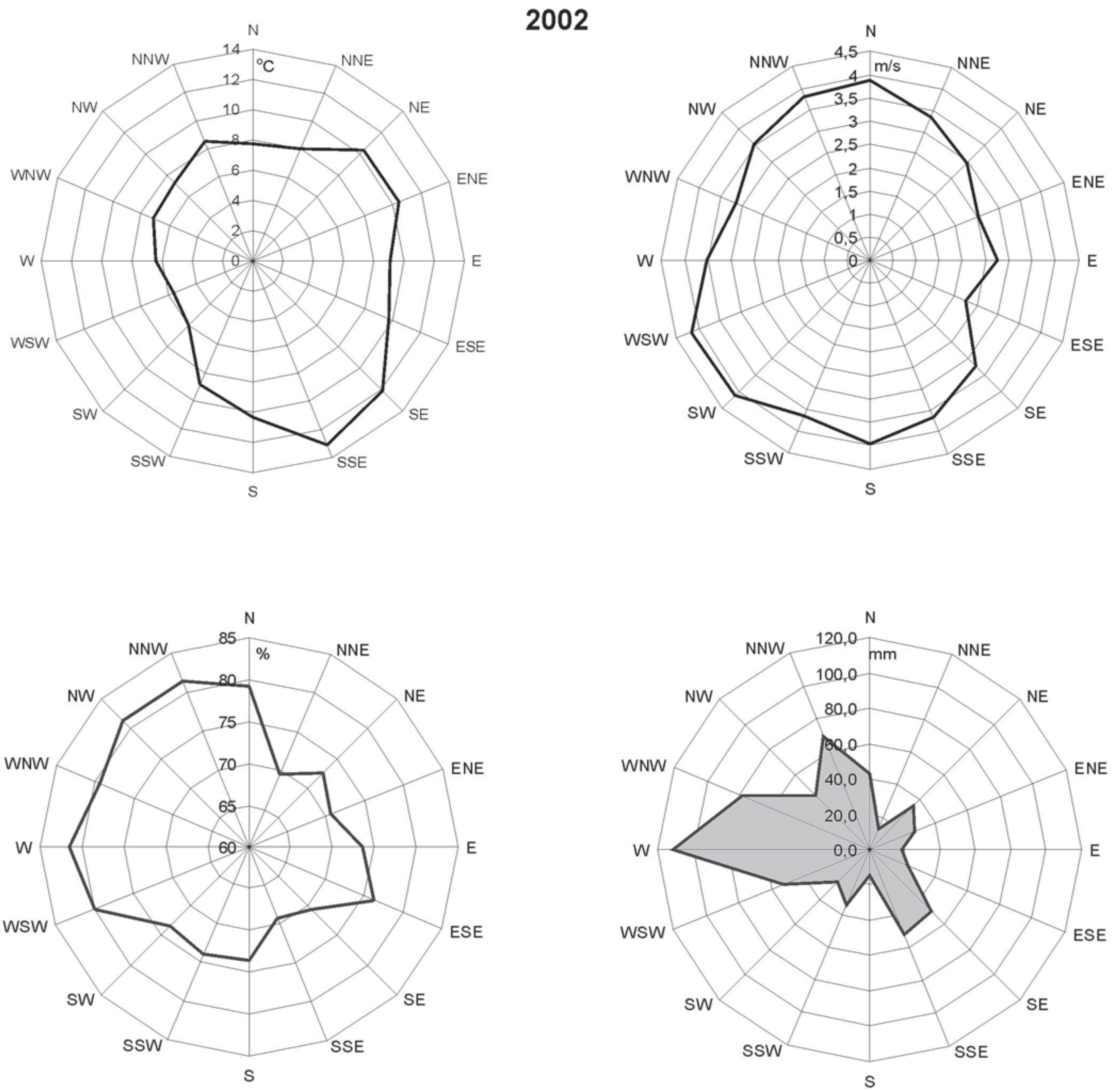
In the year 2002 the distribution of the wind speeds and total precipitation on world directions was similar to the years 1994-2003 (Fig. 4, 5). Within temperature distribution the highest average appeared from directions SSE to SW, with correlating lower atmospheric humidity from directions SE to SW. During 3rd and 4th September, at the average speed of winds from 243,6 to 346,5 km*$24h^{-1}$, from directions mostly SE (Fig. 6, Table 3), the atmospheric air became grey-white with a poor visibility and macroscopically perceptible smell of CO_2. After the three-day-change to winds from S, W and NW, between 9th and 13th of September, this phenomenon grew stronger with prevailing wind directions

Table 2. Anual average throughfall of maior elements as a function of geographic region in Europe (according to De Vries et al. 1999, Kozłowski 2003, supplemented)

Tabela 2. Średnie roczne przepływy depozycji podkoronowej (TF) głównych elementów składowych jako funkcja geograficznego regionu w Europie (wg De Vries et al. 1999, Kozłowski 2003, uzup.)

Region	N[1)]	Throughfall in $mol_c\ ha^{-1}a^{-1}$ *Opad podkoronowy* ($mol_c\ ha^{-1}a^{-1}$)						
		SO_4	NO_3	NH_4	Ca	Mg	K	Na
North / Boreal	40	235	78	64	103	96	154	263
North / Boreal Temperate	11	344	126	88	157	112	269	230
West / Atlantic	60	981	428	887	405	358	511	1037
Central / East	26	2068	819	640	989	365	618	303
Central / Świętokrzyskie Mts[3)]	1							
Coniferous forest		3206	2519	1893	2175	1636	1275	530
Deciduous forest		2029	1725	1712	1313	1735	1412	379
Southern / Mediterranean	26	657	355	307	756	321	429	707

[1)] N = number of plots, [2)] 2001-2003

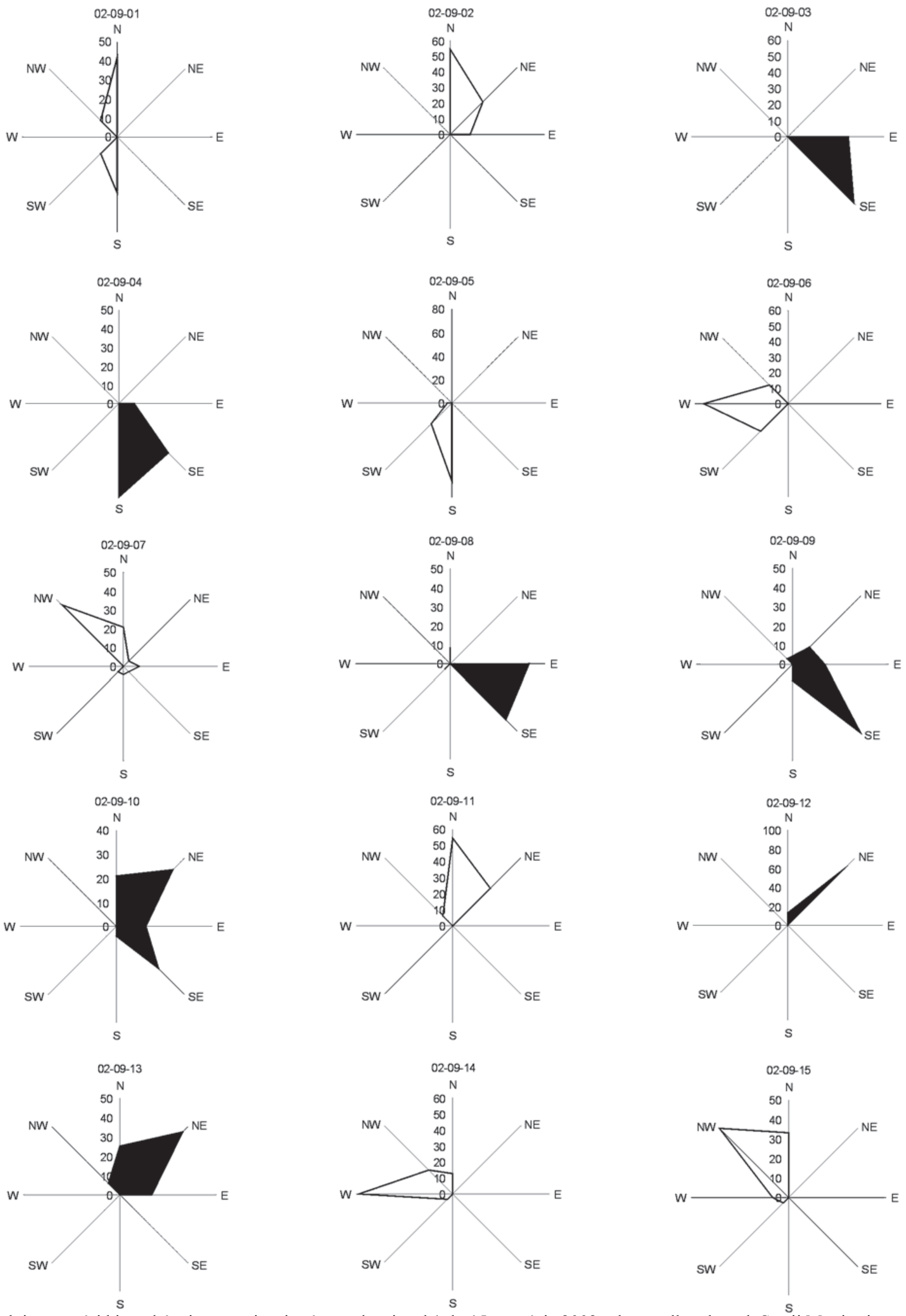


Ryc. 5. Średnie wielkości niektórych elementów meteorologicznych w roku 2002 w zależności od kierunków transportu mas powietrznych na obszarze Stacji Zintegrowanego Monitoringu Święty Krzyż

Fig. 5. Mean values of some meteorological elements in the year 2002 depending on transport directions of air masses in the Integrated Monitoring Station Święty Krzyż site

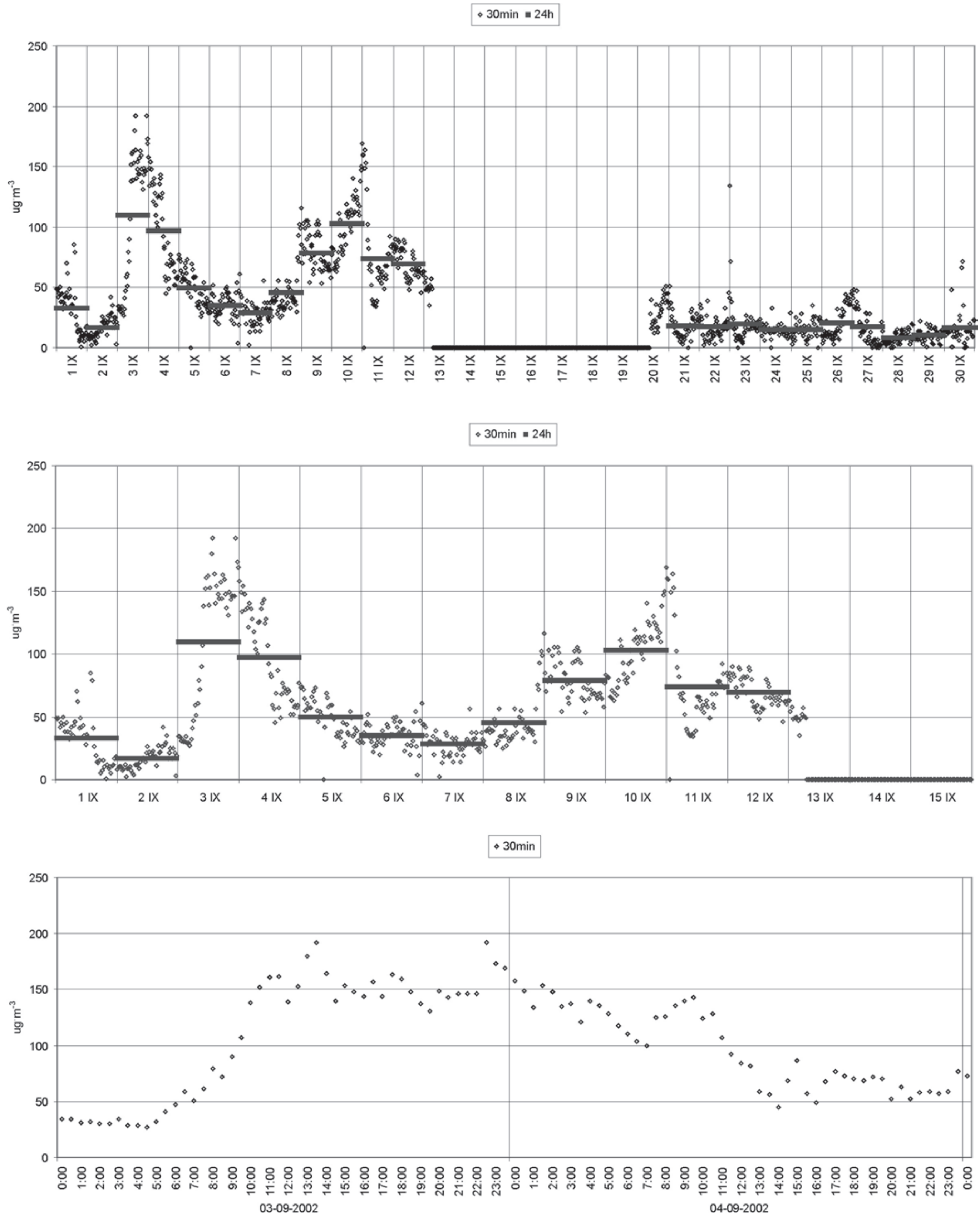
from E to SE, SE and NE to SE with average speeds from 190,1 to 345,5 km*24h^{-1}. From the days 1st to 3rd of September in the morning with average dust concentrations 22,6 $\mu g{\cdot}m^{-3}$ to the 4th september the dust concentration increased to157 $\mu g{\cdot}m^{-3}$ with the maximum at 192 $\mu g{\cdot}m^{-3}$ till the 8th of September it grew smaller to the average 33 $\mu g{\cdot}m^{-3}$. The second maximum was reached in days 10th and 12th September with the value 78,9 $\mu g{\cdot}m^{-3}$ and on 11th September it reached 140 $\mu g{\cdot}m^{-3}$. In this day, after several hours of the wind direction change to N to NE (Fig. 6), the dust concentration suddenly decreased to below 50 $\mu g{\cdot}m^{-3}$ and then, after stabilisation of the wind from the NE direction, it increased above 90 $\mu g{\cdot}m^{-3}$.

The dust concentration in the period from 1st to 3rd September was proceeded by 2,3-times increased concentration of CO in the air, with averages from 295,9 to 667,9 $\mu g{\cdot}m^{-3}$ which in the course of 3rd September quickly



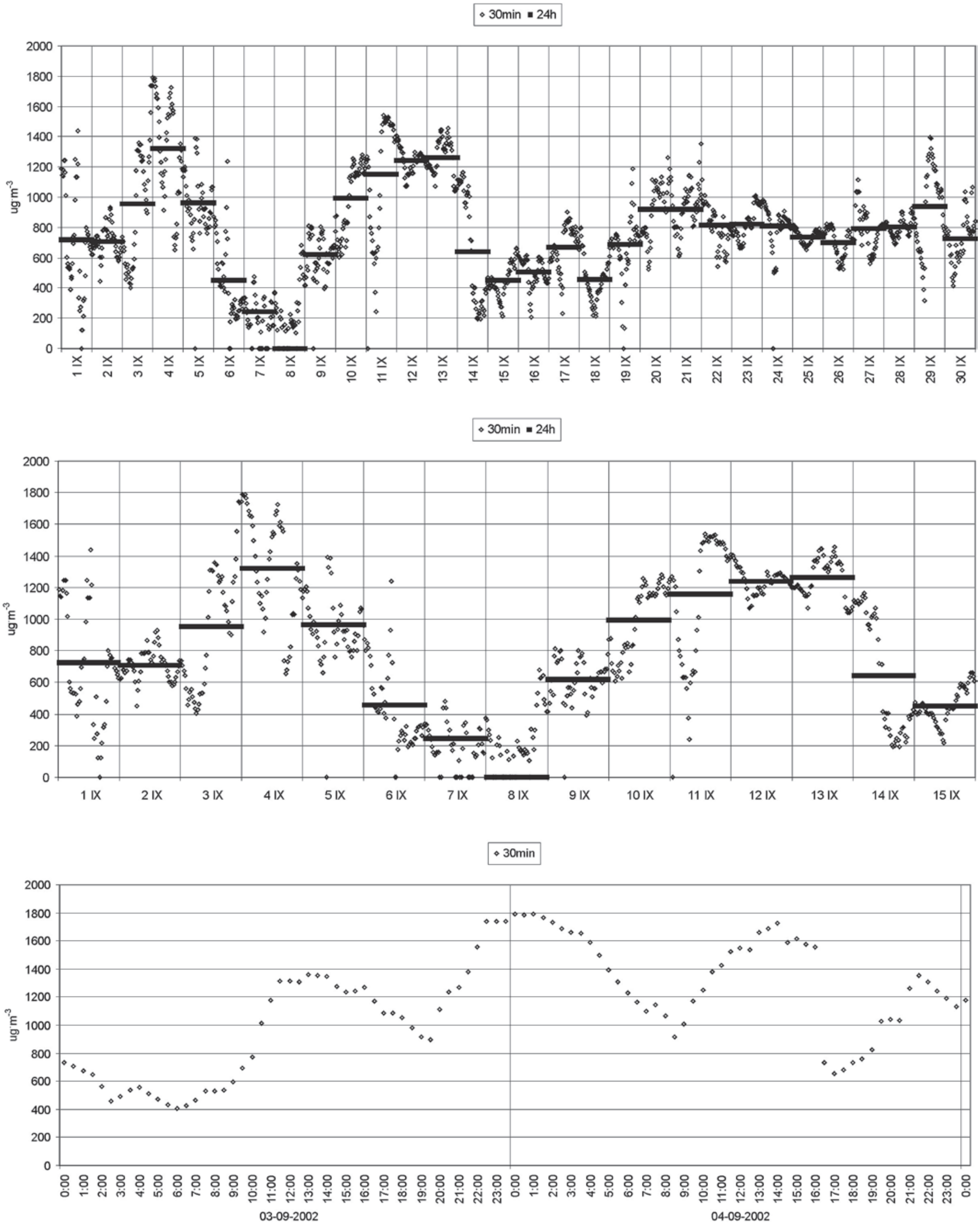
Ryc. 6. Średnie wartości kierunków i natężenia wiatrów w okresie od 1 do 15 września 2002 roku, według danych Stacji Monitoringu Święty Krzyż

Fig. 6. Mean values of wind directions and intensities during the period 1st-15th September 2002 according to data from the Integrated Monitoring Station Święty Krzyż site



Ryc. 7. Przebiegi trzydziestominutowych wartości stężeń pyłu zawieszonego w powietrzu atmosferycznym od 1 do 15 września oraz w dniach 3-4 września 2002 roku na Stacji Zintegrowanego Monitoringu Święty Krzyż

Fig. 7. Courses of 30-minute values of dust concentrations in the atmospheric air from the periods 1st-15th September and 3rd-4th September 2002 in the Integrated Monitoring Station Święty Krzyż site



Ryc. 8. Przebiegi trzydziestominutowych wartości stężeń CO w powietrzu atmosferycznym w dniach od 1 do 15 września oraz w dniach 3-4 września 2002 roku na Stacji Zintegrowanego Monitoringu Święty Krzyż

Fig. 8. Courses of 30-minute values of the CO concentrations in the atmospheric air from the periods 1st-15th September and 3rd-4th September 2002 in the Integrated Monitoring Station Święty Krzyż site

Table 3. Atmospheric air contamination in the period 1st - 15th September 2002 with dust and CO of the forest fire origine in Ukraine on the background of prevailing directions of winds and their speed in the Monitoring Station Święty Krzyż area

Tabela 3. Kontaminacja powietrza atmosferycznego w dniach 1 - 15 września 2002 r. pyłem zawieszonym i CO pochodzącymi z pożaru lasu na Ukrainie na tle dominujących kierunków wiatru i ich prędkości na Stacji Monitoringu Święty Krzyż

Days and hours *Dni i godziny*	N_{30min}	CO $\mu g \cdot m^{-3}$			Suspended dust $\mu g \cdot m^{-3}$ *Pył TSP* $\mu g \cdot m^{-3}$			Dominating wind directions *Dominujący kierunek wiatru*
		mean	min.	max.	mean	min.	max.	
09-01 13:30 - 09-01 18:30	11	295,9	121,0	482,0	29,0	7,0	85,0	N
09-01 19:00 - 09-03 9:00	87	667,9	402,0	932,0	22,6	1,0	90,0	N, NE
09-03 12:00 - 09-03 16:00	9	1299,4	1236,0	1357,0	157,1	139,0	192,0	E, **SE**
09-03 22:30 - 09-04 3:30	11	1733,4	1651,0	1791,0	151,8	121,0	192,0	**SE**, S
09-04 4:00 - 09-04 11:00	15	1242,3	916,0	1589,0	124,3	100,0	143,0	**SE**, S
09-04 11:30 - 09-04 16:00	10	1600,9	1556,0	1724,0	68,0	45,0	92,0	**SE**, S
09-06 4:00 - 09-08 19:00	127	290,0	107,0	568,0	33,6	2,0	55,0	W, NW, E
09-09 19:30 - 09-10 9:30	77	646,4	394,0	846,0	78,9	30,0	111,0	SE, NE
09-11 11:00 - 09-13 20:00	126	1307,8	1012,0	1523,0	65,4	35,0	92,0	NE, **E**
09-14 11:30 - 09-15 23:30	73	400,7	216,0	638,0				W, NW

increased to 1733,4 $\mu g \cdot m^{-3}$. Concentrations of CO in the air decreased to average 290,0 $\mu g \cdot m^{-3}$ with the minimum 107 $\mu g \cdot m^{-3}$ with winds changing on 4th September from SE to S and then during 5th to 8th September to SW, W and NW (Table 3, Fig. 8). With winds from the NE and E directions on 12th and 13th September the second maximum of the CO concentration in the air was formed at the average of 1307,8 $\mu g \cdot m^{-3}$, with a short lasting maximum of 1523,0 $\mu g \cdot m^{-3}$.

From the courses of 30-minute concentrations on 3rd and 4th September (Fig. 7, 8) it is visible that dust concentrations on 3rd September within 6 hours increased with the average value of 28,3 to 57,4 and then to 144,0 $\mu g \cdot m^{-3}$ in following 6 hours. Within further several hours this day, also in the course of 4th September the dust concentration decreased. On 3rd and 4th September the CO concentration in the air showed a specific pulsating and growing dynamics with shorter 3-4 hourly quick increases of concentrations and then 8-9 hourly falls of contaminations. From intercourse of qualitative elements in bulk deposition it could be accepted that the air contamination was a consequence of the fire of large masses of the plant material. The media news reported that in this period within the distance of over 200 km E a great fire of the forest (peatbogs) took place in Western Ukraine.

6. Recapitulation and conclusions

It is known that a quick recognition and the distribution of knowledge about the state of the natural environment can shorten preparations and reaction to forthcoming threats. We can also assume that the growing consciousness of potential threats will enable us to work out new methods of prevention of threat consequences. As yet, our knowledge about possible consequences of man's activities in the natural environment is so much fragmentary that it almost excludes formulating of useful and even short-term prognoses of disastrous events with their results on the ecosystem.

The most important factor, and least recognized, is the time in the multidimensional space-time. Similarly as in the Universe, in every single space of the ecosystem a great numbers of time clocks strike. Each of these strikes is a single change in some place of the space (Davies 1974, Smolin 2004). In spaces of ecosystems there are tendencies towards creation of asymmetric complex structures in respect of time dependent on it, with multiple and multilateral related flows of the energy both in biotic as and abiotic systems as well as energy streams and matter between them. In these systems emission conditions, proprieties of biotic and abiotic substrata along with regional and local systems of habitat factors belong to independent variables, which have their own specific geographical conditionings.

Attempts of elaboration of guides to data utilization from geoecosystems to describe and model critical risks and loads, medium- and long-term changes in habitat conditions meet serious methodical difficulties (De Vries et al. 1999, Block et al. 2000, Barkmann 2002, Kowalkowski 2003). Their most important elements are as follows:

1) emissions from natural and anthropogenic sources affect various elements of ecosystems from the atmospheric air directly and indirectly through products of their transmission and transformation in some tem-

porary phases and in the spatial location in the form of the bulk deposition and tree canopy deposition;

2) multidimensional character of the space-time results in asymmetric character of quantities and qualities of the above mentioned depositions, changing their own proprieties and trends of these changes along discontinuity lines on entries from the atmospheric air to hylosphere and from the hylosphere to the pedosphere,
3) emissions, that flow through hylosphere actively change its features; in the same time they are subject to unbalanced and unstable, with circular frequency pulsating in time and mosaic in space biogenic transformations, depending on variable in the time-space biogroups of trees, their generic composition, density of assimilative organ within tree crowns and gaps between them, multi-layer character of the plant communities and structure of the forest stand,
4) in the transformats of depositions flowing through hylosphere the essential part is played by self-regulation and buffering reactions of each kinds of plant in their multi-age and multi-layer communities,
5) diversified in time and space products of deposition transformations in the hylosphere in a form of flow deposition, after entering the pedosphere, are subject to pedogenic deposition transformations with their active influence on proprieties of soil horizons, and then they form the washout at the border with the lithosphere or with surrounding soil units,
6) total deposition is a sum of the bulk deposition from the atmospheric air, biogenic transformation deposition in the hylosphere and pedogenic transformation deposition in the pedosphere which are functions of multidimensional factors of time and space in the continental, regional and local scales,
7) localisation of the Integrated Monitoring Station Święty Krzyż in low mountains, with dominating emissions from western directions with oceanic air masses and from eastern and south-eastern directions, with continental air masses has a specific geographical value in the investigation of emission influence on forest ecosystems.

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ZANIECZYSZCZENIA POWIETRZA ATMOSFERYCZNEGO I PROCESY TRANSFORMACJI OPADÓW W EKOSYSTEMIE LEŚNYM REGIONU GÓR ŚWIĘTOKRZYSKICH

Streszczenie

W opracowaniu przedstawiono założenia metodologiczne systemu zintegrowanego funkcjonowania emisji w powietrzu atmosferycznym z ich transmisjami i transformacjami w geoekosystemie leśnym, zilustrowany przykładami danych ze Stacji ZMŚP Święty Krzyż w Górach Świętokrzyskich . W krótkim zarysie omówiono źródła i funkcje depozycji bezpośredniej (BD, wpływ hylosfery na transformację depozycji bezpośredniej (BD), wpływ hylosfery na transformację depozycji dachu koron (CD) i wpływ pedosfery na transformację depozycji całkowitej (TD). Dokonana została także próba zobiektywizowania zakresu reprezentatywności Stacji Bazowej Święty Krzyż, rozpatrując geograficzną odrębność depozycji atmosferycznej mezoregionu Gór Świętokrzyskich, klimatyczne uwarunkowania imisji z powietrza atmosferycznego i przypadek kontaminacji powietrza atmosferycznego przez odległe źródła na podstawie depozycji bezpośredniej. We wnioskach stwierdzono, że lokalizacja Stacji ZMŚP Święty Krzyż w wyniesionych ponad otoczenie Górach Świętokrzyskich z dominującymi przemiennie imisjami z kierunków wschodniego do południowo-wschodniego oraz południowo-zachodniego do zachodniego z kontynentalnymi i morskimi masami powietrza o rozdzielnych kontaminacjach emisjami posiada swoisty geograficzny indywidualizm i jest niezbędnym dopełniającym składnikiem sieci ZMŚP.