ACTA CLIMATOLOGICA ET CHOROLOGICA
Universitatis Szegediensis, Tomus 40-41, 2007, 135-146.

THE RELATION OF METEOROLOGICAL ELEMENTS AND BIOLOGICAL AND CHEMICAL AIR POLLUTANTS TO RESPIRATORY DISEASES

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Összefoglalás – A dolgozat a Kárpát-medence fölött, a téli hónapokban (december, január és február), valamint elsősorban a parlagfű pollinációjához köthető nyári – kora őszi időszakban (július 15. – október 15.) előforduló jellegzetes időjárási típusok és a fennállásuk során megfigyelt biológiai [*Ambrosia* (parlagfű) pollen] és kémiai légszennyezők (fő légszennyező anyagok) feldúsulásakor mérhető koncentrációi közötti összefüggések feltárásával, illetve mindezeknek a légúti betegségekre gyakorolt hatásával foglalkozik. A dolgozat adatbázisa 13 meteorológiai elem, 8 légszennyező paraméter, továbbá a légúti betegségek 9 BNO kódjának napi értékeit tartalmazza az 1999-2003 közötti ötéves periódusra vonatkozóan. A jellegzetes időjárási típusok objektív definiálása a faktoranalízis és a clusteranalízis módszereinek alkalmazásával történt. Eredményeink azt mutatják, hogy a nyári – kora őszi időszakban az összes betegszám a középhőmérséklettel, a maximum hőmérséklettel és a minimum hőmérséklettel arányosan változik, ugyanakkor a légúti megbetegedések gyakrabban fordulnak elő alacsony relatív nedvesség mellett. A téli hónapokban viszont nincs kapcsolat a meteorológiai változók és a betegszámok között. A nyári – kora őszi időszakban az összes betegszám csökken, ha alacsonyak a PM_{10}-, NO-, NO_2 és O_{3max} koncentrációk, és növekszik, ha azok magasak. A téli hónapokban – csakúgy, mint a nyári - kora őszi periódusban – az alacsony NO-koncentráció esetén az összes betegszám kisebb, míg magas NO-koncentráció alkalmával az megnövekszik. A nyári – kora őszi periódusban az összes betegszám a *7.* és *8.* időjárási típusokban volt a legmagasabb. A legalacsonyabb összes betegszám a *2.* típus idején mutatkozott. Megjegyzendő, hogy a parlagfű pollenszórása augusztus 15. – szeptember 15. között kulminál, s ez lényeges szerepet játszik a 2. típus alacsony betegszámában.

Summary – This paper determines the relationship of the characteristic weather types of the Carpathian Basin in the summer – early autumn period (July 15 – October 15) and the winter months (December, January and February) with the levels of chemical (CO, NO, NO_2, NO_2/NO, O_3, O_{3max}, SO_2, PM_{10}) and biological (*Ambrosia* - ragweed pollen) air pollutants, and their effect on respiratory diseases. The database comprises daily values of thirteen meteorological parameters; furthermore, those of eight chemical and one biological pollutants for the period 1999-2003. The objective definition of the characteristic weather types was carried out by using Factor and Cluster Analysis. In the winter months there is no relation between the meteorological variables and the number of patients. In the summer – early autumn period the total number of patients decreases, if levels of PM_{10}, NO, NO_2, O_{3max} and ragweed pollen are low and it increases if these concentrations are high. At the same time, the total number of patients decreases both with high and low values of NO_2/NO. In winter only one important result was received: the total number of patients is proportional to the levels of NO. In the summer – early autumn period the total number of patients was the highest, when the weather types *7* and *8* were found over the Carpathian Basin. The lowest total number of patients occurred during weather type *2*. Pollen release of ragweed culminates between August 15 – September 15 and this fact is important in the low patient numbers of weather type *2*.

Key words: weather types, Ambrosia pollen, chemical air pollutants, asthma, rhinitis, BNO-code, Lorenz diagram, factor analysis, cluster analysis, ANOVA weather classification, Tukey-test

1. INTRODUCTION

Recently, in the U.S. 11.7% of the population have seasonal hay-fever allergies and about 6.7% suffer from asthma [in 2004: 6%; in 1980: 3% (*U.S. Center for Disease Control and Prevention, Atlanta*)]. *Rimpela et al.* (1995) describes a three-fold increase of physician-diagnosed asthma and allergic rhinitis among Finnish adolescents in the period 1977-1991. Studies indicate that asthma and allergic conditions are most prevalent in the UK, Australia and New Zealand. High rates have also been reported for Chile. Concerning Europe, intermediate prevalence rates are seen in Southern Europe (*Lundback,* 1998). Though *Lundback* (1998) gives an account of the lowest rates of asthmatic diseases from Central Europe (*Lundback,* 1998); however, in the Carpathian Basin it is not the case (*Makra et al.,* 2004; 2005). In Hungary, about 30% of the population has some type of allergy, 65% of them have pollen-sensitivity, and at least 60% of this pollen-sensitivity is generated by the pollen of ragweed *(Ambrosia)* (*Járai-Komlódi,* 1998). 50-70% of the patients suffering from allergy are sensitive to ragweed pollen (*Mezei et al.,* 1992). It is a shocking fact that the number of patients with registered allergic illnesses has doubled and the number of cases of allergic asthma has become four times higher in Southern Hungary by the late 1990s over the previous 40 years (*Mezei et al.,* 1992; *Farkas et al.,* 1998). Based on the period 1990-1996, *Ambrosia* pollen comprises about half (47.3%) of the total pollen number of the different species over Southern Hungary (*Makra et al.,* 2004). Though this ratio depends substantially from the values of the meteorological elements year by year (in year 1990: 35.9%, while in year 1991: 66.9%), *Ambrosia* is considered the most important aeroallergen species in Hungary (*Juhász,* 1995; *Makra et al.,* 2004, 2005; *Béres et al.,* 2005). Nevertheless, we have to remember that the diagnosis of asthma has also certainly developed significantly during this period (*Rimpela et al.,* 1995; *Makra et al.,* 2004).

Respiratory diseases can frequently result in the death of adults. The roles of meteorological or environmental factors in the development of respiratory diseases have already been proved by popular observations and medical practice as well as medical reports since the age of Hyppocrates. General characteristics of the weather, such as temperature, atmospheric humidity, wind directions and air pollution can influence the development of respiratory diseases. Although interesting results were received for children (*Jaklin et al.,* 1971; *Fielder,* 1989; *Beer et al.,* 1991) and adult populations (*Goldstein,* 1980), when studying the effect of meteorological parameters on respiratory diseases, the joint effect of meteorological parameters, chemical and biological air pollutants on the development of respiratory diseases have not yet been studied.

The influence of the weather elements on mortality, as well as the connection of meteorological parameters and respiratory diseases have already been widely studied in the related literature. At the same time, the relationship of weather types and respiratory diseases have yet scarcely been analysed (e.g. *Danielides et al.,* 2002).

One of the main aims of the study is to determine an objective, reliable classification system of weather types ruling the region over Szeged, Southern Hungary during the summer and winter months, by applying multivariate statistical methods. Then, for each weather type, characterised by homogeneous temperature and humidity relations, concentrations of *Ambrosia* pollen grains and those of the main chemical air pollutants; furthermore, the frequency of respiratory diseases are assessed. Afterwards, the spatial distribution of the mean sea level pressure fields and the levels of the chemical and biological air pollutants as well as the frequency of the respiratory diseases in the area of Szeged have been calculated for the different weather types for the North-Atlantic –

European region in order to reveal the possible relations between the prevailing weather conditions,. Thereafter, the significance of the differences in the concentration and frequency values of the specific weather types is established.

2. TOPOGRAPHY OF SZEGED REGION

The city of Szeged, the largest settlement in SE Hungary (20°06'E; 46°15'N) is located at the confluence of the Tisza and Maros Rivers. The area is characterised by an extensive flat landscape with an elevation of 79 m a.s.l. The built-up area covers a region of about 46 km^2 with approx. 155,000 inhabitants.

3. DATABASE

The air pollution monitoring station is located in Szeged's downtown in a crossroad with heavy traffic. Sensors, measuring the concentrations of the chemical air pollutants, are placed 3 m above the surface.

The database, containing the meteorological parameters and the chemical pollutants, consists of the 30-minute averages of the five-year period 1999 – 2003 for the summer – early autumn period (July 15 – October 15) and the winter months (December, January and February). As for the biological pollutants, the daily counts of *Ambrosia* pollen grains were considered for the summer – early autumn period of the above five-year term.

3.1. Meteorological parameters

The 13 meteorological parameters used are: mean temperature (T_{mean}, °C), maximum temperature (T_{max}, °C), minimum temperature (T_{min}, °C), diurnal temperature range ($T_{range} = T_{max} - T_{min}$, °C), day-to-day change in mean temperature (ΔT_{mean}), day-to-day change in maximum temperature (ΔT_{max}), day-to-day change in minimum temperature (ΔT_{min}), mean relative humidity (RH, %), day-to-day change in relative humidity (ΔRH, %), mean atmospheric pressure at sea level (P, mb), day-to-day change in mean atmospheric pressure (ΔP, mb), mean water vapour pressure (VP, hPa), day-to-day change in mean vapour pressure (ΔVP, hPa). Considering humidity parameters, water vapour pressure is the most important in assessing the effect of humidity to human body, since it involves the total amount of water in the air.

Daily sea-level pressure fields measured at 00 UTC come from the ECMWF (European Centre for Medium-Range Weather Forecasts) Re-Analysis ERA 40 project. The investigated area is in the North-Atlantic – European region between 30°N–70.5°N latitudes and 30°W–45°E longitudes. The grid network is established with a density of 1.5°x1.5°, which indicates 28x51 = 1428 grid points for the region.

3.2. Air pollutants

3.2.1. Chemical air pollutants

The elements considered are the daily average mass concentrations of CO, NO, NO_2, SO_2, O_3 and PM_{10} ($\mu g \cdot m^{-3}$), the daily ratios of NO_2/NO and the daily maximum mass concentrations of O_3 ($\mu g \cdot m^{-3}$).

3.2.2. Biological air pollutants

In Szeged, the pollen content of the air has been examined with the help of a "Hirst-type" pollen trap (*Hirst,* 1952) (Lanzoni VPPS 2000) since 1989. The air sampler is located on top of the building of the Faculty of Arts, University of Szeged (20 m above the city surface). Daily pollen data were obtained by counting *Ambrosia* pollen grains on four longitudinal transects (*Käpylä and Penttinen,* 1981).

3.3. Parameters of the respiratory diseases

The rest of the database, namely the daily number of patients registered with asthma and rhinitis for the period examined, comes from the Thorax Surgery Hospital, Csongrád County, Deszk, Southern Hungary. Altogether 9 groups of symptoms of respiratory diseases and their cumulative occurrences were taken into account. In the summer – early autumn period altogether 26,703 patients, while in the winter months 14,507 patients were registered with respiratory diseases (*Table 1a-b*). Most of the patients live in Szeged or in the neighbouring villages.

The Thorax Surgery Hospital, Csongrád County, Deszk is situated about 10 km from the monitoring station in Szeged downtown, from where the data of the meteorological elements and those of the chemical air pollutants are originated. Most of the patients were treated as out-patients, only a fraction of them were registered as in-patients. For studying relation of respiratory diseases to meteorological parameters and air pollutants, the regsitration date of the patients was used.

4. METHODS

The relationship between the incidence of partly the respiratory diseases and partly the meteorological parameters as well as the chemical and biological air pollutants was assessed by using (a) Pearson's χ^2-test, the most commonly used procedure for testing the independence of row and column classification in an unordered contingency table; (b) factor analysis (FA), which reduces the dimensionality of a large data set of p correlated variables, expressing them in terms of m ($m < p$) new uncorrelated ones: the factors (*Jolliffe,* 1986; *Danielides et al.,* 2002); and cluster analysis (CA), which classifies a series of n observations into different, characteristic homogeneous groups: the clusters (*Anderberg,* 1973; *Hair et al.,* 1998).

Table 1a Parameters of patients registered with respiratory diseases, summer – early autumn period (July 15 – October 15)

Patient			**Age**			
Sex	Number	%	Average	S.d.*	Min.	Max.
Women	15,480	58.0	44.4	15.3	8	90
Man	11,223	42.0	40.7	16.6	6	84
Total	26,703	100.0	42.8	16.0	6	90

*S.d. = Standard deviation

Table 1b Parameters of patients registered with respiratory diseases, winter months (December, January and February)

Patient			**Age**			
Sex	Number	%	Average	S.d.*	Min.	Max.
Women	8,396	57.9	49.4	15.7	8	93
Man	6,111	42.1	45.4	18.0	10	93
Total	14,507	100.0	47.7	16.8	8	93

*S.d. = Standard deviation

When determining the synoptic types, only meteorological parameters are taken into account, excluding pollution data. Hence, the differences of the mean pollution levels calculated for each synoptic type need further statistical evaluation. This is performed by the method of one-way Analysis of Variance (ANOVA) for each pollutant. By using the method, significant differences in pollutant concentrations and frequency of the respiratory diseases of the different synoptic types (clusters) can be determined. Finally, Tukey's honestly significant difference test is applied in order to quantitatively compare the mean air pollution levels and the frequency of the respiratory diseases between each pair of synoptic type (pairwise multiple comparisons) (*Sindosi et al.,* 2003; *Makra et al.,* 2006).

For each objective weather type, average daily isobar maps on the basis of daily sea-level pressure data calculated at each grid point of the investigated region were constructed by applying the Surfer 7.00 software.

All statistical computations were performed with SPSS (version 9.0) software.

5. RESULTS

5.1. The meteorological and pollution parameters and the total number of patients

The values of the meteorological and pollution parameters were classified into 5-5 quintiles, so that the first quintile comprised the lowest 20% of the ranked data of the given variable, while the fifth quintile comprised the highest 20% of them. Then, the frequencies of the meteorological and pollution parameters were calculated in the given quintiles. In this way, contingency tables were prepared for each meteorological and pollution parameter in the summer – early autumn period and the winter months. Pearson's χ^2-test was applied partly to the contingency tables of the 13 meteorological and 9 pollution parameters in the summer – early autumn period and to those of the 13 meteorological and 8 pollution parameters in the winter months. Then the *0*-hypothesis of independence was tested between the parameters' quintiles and the total number of patients. If the independence is true, it means that the meteorological and pollution parameters do not influence the total number of patients; while, in reverse case, relation can be indicated between them. The reason to apply contingency tables instead of Pearson's correlation was that the distribution of the total number of patients was not normal. As a result of the χ^2-test, among the 13 meteorological variables in the summer – early autumn period 4 variables (T_{mean}, T_{max}, T_{min}, RH), while in the winter months 0 variable show statistically significant relation to the total number of patients (namely, the independence is not fulfilled at $p = 0.01$ significance level). In the winter months day-to-day change of the maximum temperature (ΔT_{max}) and the mean atmospheric pressure (P) influence mainly the total number of patients; however, this relation is not significant in either case. On the basis of the χ^2-test, in the summer – early autumn period 5 (PM_{10}, NO, NO_2, NO_2/NO, O_{3max}) of the 8 chemical pollutants as well as the biological pollutant (*Ambrosia* pollen), while in the winter months only NO (only at the 5% significance level) shows significant relations to the total number of patients (probability of independence is higher than 1% but lower than 5%).

The relationships of the total number of patients and the meteorological and pollution parameters indicating significant connection are represented with Lorenz curves. Only the Lorenz curves of those meteorological elements are analysed, which show significant relation to the total number of patients. The total number of patients decreases if mean temperature is low, since on these days (quintiles 1 and 2) the gradient of the Lorenz curve is the lowest; furthermore, its gradient increases with the increasing mean temperature. T_{max} and T_{min} covary highly with T_{mean}; hence, low values of these parameters also decrease chances of the illness. At the same time, respiratory diseases frequently occur during low relative humidity (the gradient of the Lorenz curve is the highest in the first quintile) (*Fig. 1*). In the winter months there are no significant relations between the total number of patients and the meteorological elements; hence, the Lorenz curves are not analysed in this case.

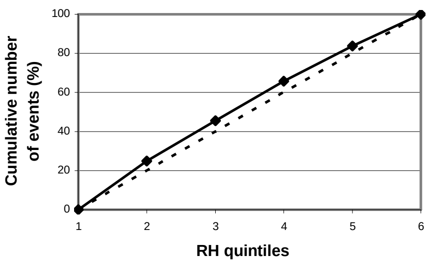

Fig. 1 Lorenz curve of relative humidity and the total number of patients, summer – early autunmn period (July 15 – October 15)

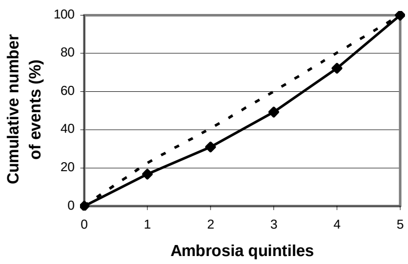

Fig. 2 Lorenz curve of *Ambrosia* pollen and the total number of patients, summer – early autunmn period (July 15 – October 15)

The total number of patients decreases if concentrations of PM_{10}, NO, NO_2 and O_{3max} are low and, in turn, it increases if they are high. In the case of NO_2/NO the situation is a bit different: the total number of patients decreases either with low, or with high value of the ratio. Low ratio of NO_2/NO is basically determined by low NO_2 level while high ratio of NO_2/NO is resolved by low NO level. At the same time, it has been presented that the total number of patients decreases with both low NO_2 concentrations and low NO levels. On the other hand, the total number of patients changes parallel to *Ambrosia* pollen levels: low (high) patient number is related to low (high) pollen levels (*Fig. 2*). Since in the winter months significant relation can only be detected between NO concentrations and the total number of patients, Lorenz diagram of only these two variables are analysed. In the winter months, similarly to the summer – early autumn period, the total number of patients is low (high) when NO levels are low (high).

5.2. Factor and Cluster Analysis

5.2.1. Summer – early autumn period (July 15 – October 15)

The application of factor analysis to the meteorological variables resulted in 5 factors, which explained 86.71% of the total variance. Then, cluster analysis was applied to the five-factor factor score time series (465 factor scores = 465 days) in order to classify them objectively into groups of days with characteristic weather types. Cluster analysis resulted in eight weather types (clusters) (*Fig. 3*). Each cluster contained at least 5.6% of all the days examined. Through all the summer only two main pressure systems rule the weather of the Carpathian Basin: the Icelandic low and the Azores high. The difference between these pressure systems is fairly small both in terms of the mean values of the parameters examined and in the spatial distribution of the atmospheric pressure. After that, daily mean sea level pressure fields of the eight weather types (clusters) and 30-day frequencies of the days of types were determined. Furthermore, mean values of meteorological and pollution parameters, as well as the patient numbers were calculated.

In order to decide whether the total number of patients depends on the weather types on a statistical basis, Pearson's χ^2-test was applied. If the 0-hypothesis of independence is fulfilled, then patient numbers do not depend on the weaher types; while, in the opposite case, relation can be detected between them. As a result, we received that the probability of independence is *0*; namely, patient numbers are in close relation to the weather types. The total number of patients was the highest in weather types *7* and *8*. These types are high pressure systems with high temperature and low relative humidity and occur almost exclusively between July 15 – September 15. The lowest values appeared during weather type *2*. This is also a high pressure system with high temperature and low relative humidity and basically occurs between July 15 – August 15. It should be noted that the pollen release of ragweed culminates only following this period, and this is an important fact in the low patient numbers of type *2*.

In order to decide whether the mean sea level pressure fields of the eight main types (clusters) of the North-Atlantic – European region differ significantly from each other, χ^2-test was applied with the assumption of independence (*0*-hypothesis). As a result, mean sea level pressure fields for half of the possible 28 cluster pairs; namely, for those of pairs *1-2, 1-5, 1-7, 1-8, 2-4, 2-7, 2-8, 3-6, 3-8, 4-6, 4-8, 6-7, 6-8* and *7-8* can be considered independent, while in the other half of cluster pairs independence is not fulfilled.

Then, an analysis of the inter-weather type comparison of concentrations of the chemical and biological pollutants and that of the patient numbers with different disease types was performed by means of analysis of variance (ANOVA). Inter-weather type differences of CO, PM_{10}, NO, NO_2, O_3, O_{3max}, SO_2, (daily mean concentrations), *Ambrosia* (daily concentrations) and those of total number of patients (frequency) are significant at 1% significance level for the following asthmatic and allergic diseases with their BNO codes: J3010 [allergic rhinitis from pollen (allergic hay-fever)], J3020 (other seasonal allergic rhinitis) and J3030 (other allergic rhinitis), while those of total number of patients for the respiratory disease J3040 (allergic rhinitis, without specifcation) at 2% significance level.

Performing pairwise comparisons (Tukey's difference tests), significant differences were found at both 5% and 1% significance levels. There are no two weather types, for which each parameter, indicating significant inter-weather type differences (13 of 19 parameters), differ significantly. The highest inter-weather type difference can be experienced for the daily values of seven parameters in the following pairwise comparisons: types *1-7, 3-7* and *4-7*. On the other hand, types *4-5* and *4-6* (no significant difference in the daily values of any parameter) as well as types *1-5, 2-8, 3-6* and *5-6* (significant difference in the daily values of 1 parameter) are mostly similar. Pairwise multiple comparisons indicated significant differences in the daily values of at least 6 (of the 13) parameters for the following cluster pairs: types *1-3* (6 parameters: CO, PM_{10}, NO, NO_2, O_{3max} and SO_2); types *1-7* (7 parameters: CO, PM_{10}, NO_2, O_3, O_{3max}, SO_2 and J3030); types *2-3* (6 parameters: CO, NO, O_3, O_{3max}, SO_2 and *Ambrosia*); types *3-7* (7 parameters: NO, O_3, O_{3max}, J3010, J3020, J3030 and Pat. no. = total number of patients); types *3-8* (6 parameters: CO, NO, O_3, SO_2, J3010 and J3040); furthermore, types *4-7* (7 parameters: PM_{10}, NO_2, O_3, O_{3max}, J3010, J3030 and Pat. no. = total number of patients). The daily pollen levels of *Ambrosia* show significant differences only between weather types *2*-3. Among the 28 pairs of types formed from the 8 weather types (clusters) received, 9 pairs (types *1–7, 2-7, 2-8, 3-5, 3-7, 3-8, 4-7, 4-8* and *5-7*) show significant differences in the daily frequencies of some of the respiratory diseases and in the total number of patients.

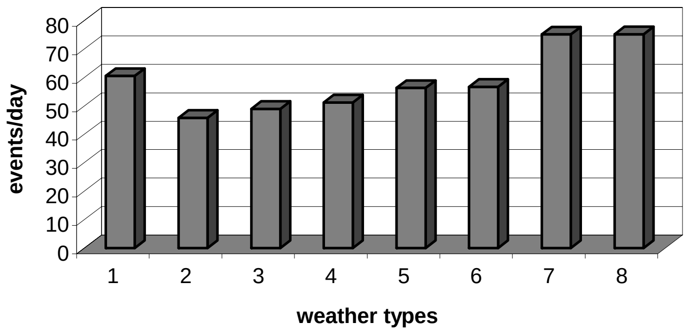

Fig. 3 Frequency of the patients registered with respiratory diseases in the eight weather types (clusters) received, summer – early autumn period (July 15 – October 15)

On the whole, in decreasing order, weather types *7* and *3* differ mostly from the others, since pairwise multiple comparisons showed significant differences for the daily values of the most parameters between them and the other types. This is mainly due to macrocirculation reasons. During type *3*, an anticyclone centre pressure system is found over the Carpathian Basin, with the highest atmospheric pressure, lowest temperature and clear and calm weather. During type *7*, the Azores high pressure system penetrates over Ukraine, through the Carpathian Basin. In this case daily temperature parameters are the highest and relative humidity is the lowest. Besides, weather is also clear and calm. The ultimate reason might be that these weather types differ substantially in the temperature parameters and relative humidity. Type *5* and *6* can be considered as transitional ones, since they indicate the least significant pairwise differences for the variables examined.

5.2.2. Winter months (December, January and February)

The application of the factor analysis to the time series of the meteorological elements resulted in 5 factors, which explained 85.39% of the total variance. Afterwards, cluster analysis was applied to the five-factor factor score time series, as a result of which 9 homogeneous clusters of the days were determined and their main characteristics were established (*Fig. 4*). The clusters received comprise at least 6% of the days examined. Since in the winter months ITCZ draws southward, Middle-Europe becomes the running field of the weather fronts. The nine characteristic clusters involve the main weather types (*Fig. 4*), for which mean values of the meteorological and pollution parameters as well as mean frequency values of the total number of patients were calculated.

The dependence of the total number of patients from the weather types was calculated by using the Pearson's χ^2-test. If the *0*-hypothesis of independence is fulfilled, it means that total number of patients does not depend on the weather types and in reverse case there is a relation between them. As a result, the probability of the *0*-hypothesis of independence is very high: 0.7210. Hence, in the winter months there is no relation between the weather types and the patient numbers. The low variability of the total number of patients belonging to the nine weather types confirms the above result. The highest patient numbers are found in the weather types *3* and *4*, while the lowest numbers in the type *8*. Since there is no statistical relation between the weather types and the total number of patients the synoptic background and meteorological characteristics of the weather types comprising extreme patient numbers are not analysed in detail.

In order to determine whether sea level pressure fields of the nine clusters classified for the North-Atlantic European region differ significantly from each other, χ^2-test was applied with the assumption of independence as *0*-hypothesis. On the basis of our calculations, sea level pressure fields of clusters *1-4, 1-8, 2-5* and *8-9* are considered independent from each other. At the same time for 32 of the total 36 cluster pairs independence is not fulfilled.

For calculating the effect of the individual weather types on the pollution levels and the total number of patients, the ANOVA of the variables examined was performed. According to the analysis of variance, the daily mean concentrations of the chemical pollutants (with the exception of NO_2/NO) and the daily frequency values of the respiratory disease with the BNO-code J3020 (other seasonal allergic rhinitis) show significant difference between the individual weather types at 1% significance level.

Since significant differences were found in the above-mentioned mean concentrations and frequencies Tukey's honestly significant difference test was applied in order to receive pairwise multiple assessment of the differences mentioned. Statistically significant differences are detemined at 5% and 1% signifiance levels, respectively. It can be established that between weather types *3-8, 3-9, 5-6* and *5-7* daily mean concentrations of five pollutants (in fact, the most pollutants) show significant differences. Clusters *2-9, 3-4* and *5-9* (with no significant difference in the daily value of any parameter) and clusters *1-8, 1-9, 7-9* and *8-9* (with significant difference in the daily value of 1 parameter) are mostly similar. The daily frequency values of the respiratory disease BNO-code J3020 (other seasonal allergic rhinitis) show significant difference in 4 (of the total 36) cluster pairs formed of the nine weather types. Weather types *3* and *6* differ most from the others, since their pairwise multiple comparisons to the other types showed significant differences in the daily values of most parameters. During type *3*, cyclonic pressure patterns rule the Carpathian Basin with high temperature and humidity parameters and low atmospheric pressure. On the other hand, during type *6* an anticyclone ridge situation is found over the Carpathian Basin, with high atmospheric pressure, temperature and humidity parameters. Type *9* can be considered transitional, since this one shows the least significant differences in the daily values of the parameters considered in the pairwise multiple comparisons of the weather types.

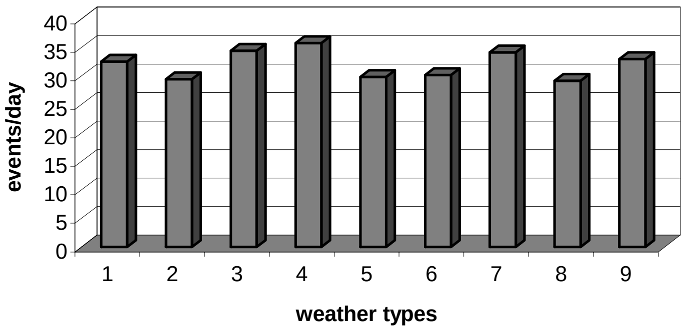

Fig. 4 Frequency of the patients registered with respiratory diseases in the nine weather types (clusters) received, winter months (December, January and February)

6. CONCLUSIONS

The paper analyses the relationship of daily values of meteorological parameters, chemical and biological air pollutants and the daily frequency values of respiratory diseases for Szeged, Southern Hungary, during characteristic sea level pressure systems. Specific weather types determined by these pressure systems were defined both for the summer – early autumn period and the winter months, which play an important role in separating daily pollutant levels and daily frequency values of respiratory diseases. According to the results, 4 variables (T_{mean}, T_{max}, T_{min}, RH) show statistically significant relationship to the total number of patients. Namely, total number of patients changes proportionally to the mean temperature, maximum and minimum temperatures; on the other hand, respiratory diseases occur more frequently during low relative humidity. At the same time, in the winter months there is no relation between the meteorological variables and the total number of patients.

In the summer – early autumn period the total number of patients decrease if PM_{10}, NO, NO_2 and O_{3max} concentrations are low and increase if they are high. At the same time, the total number of patients decreases either with low or with high ratio of NO_2/NO. *Ambrosia* pollen levels are the most sensitive of all the variables to the total number of patients and their relation is characterised by direct proportionality. In the winter months, similarly to the summer – early autumn period, low NO levels go with low total number of patients, while in case of high NO concentrations the total number of patients increases.

In the summer – early autumn period, the total number of patients was highest in weather types *7* and *8*. These types are of high pressure patterns with high temperatures and low humidity and they occur almost exclusively between July 15 – September 15. The lowest total number of patients appears during type *2*. This is also a high pressure formation with high temperature and low humidity and occurs mostly between July 15 – August 15. Pollen release of ragweed reaches its peak values after this period, which plays an important role in the low patient numbers of type *2*.

In the summer – early autumn period, weather types *2*, *3* and *4* have a basic role in separating frequency values of respiratory diseases indicated with their BNO-codes of J3010, J3020, J3030 and Pat. No. (= total number of patientss). During all the three weather types the Carpathian Basin is ruled by high pressure systems. Furthermore, types *2* and *3* have an important role in classifying chemical air pollutants, too. In the winter months, types *3* and *5* have a determinative role in separating levels of chemical air pollutants. Type *3* is characterised by zonal cyclonic air currents over the Carpathian Basin, while type *5* is an anticyclone ridge situation.

The meteorological and pollutant parameters, their variation and covariation indicate strong relation to respiratory diseases. Hence, the above results might serve as important information for illness preventive actions.

Acknowledgements – The authors thank the Department of Analysis and Methodology, Hungarian Meteorological Service for providing the sea-level pressure data for the investigated period. This study was supported by EU-6 Quantify project (No.003893 (G0CE)).

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