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SEPARATION OF THE CURRENT AND PAST METEOROLOGICAL PARAMETERS IN INFLUENCING THE CURRENT POLLEN CONCENTRATIONS

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Summary: A new procedure is introduced in order to separate the effects of the current and past meteorological elements influencing the current pollen concentration for different taxa. The data set covers an 11-year period (1997-2007) including daily pollen counts of 19 taxa and 4 climate variables (mean temperature, precipitation total, global solar flux and relative humidity). Results are evaluated with special interest to the interactions between the phyto-physiological processes and the meteorological elements for each taxon. The taxa examined can be classified into three groups, namely arboreal deciduous (AD), arboreal evergreen (AE) and herbaceous (H) taxa. It was found that a better comparison can be established if the taxa are separated within each group according to the starting month of their pollination season. Within the group of AD taxa, *Alnus, Populus* and *Ulmus* are marked by a late summer – early autumn peak of the role of past meteorological elements exceeding the role of the current ones almost all over the pollen-free period. For *Juglans, Morus, Platanus* and *Quercus*, the major weights of the current meteorological elements in the spring and early summer show the most characteristic contribution to the pollen production. For AE taxa, the picture is not clear. For H taxa, the curves of *Cannabis, Plantago, Rumex* and *Urtica* indicate the most equalized course of weights. *Ambrosia, Artemisia* and Chenopodiaceae comprise the highest weights of the past weather conditions of all taxa until at least three months before the start of the pollination.

Key words: pollen season, climate change, respiratory allergy, factor analysis with special transformation

1. INTRODUCTION

Recently, the earth's ecosystem has been experiencing a global warming. Projections of future climate change suggest further global warming, sea level rise and an increase in the frequency of some extreme weather events (Parry et al. 2007). By the late 21st century, distributions of European plant species are projected to have shifted several hundred kilometres to the north (Parry et al. 2007, Lindner et al. 2010). The rate of change will exceed the ability of many species to adapt. As for plant phenology, the timing of seasonal events in plants is changing across Europe due to changes in the climate conditions. Between 1971 and 2000, the average advance of spring and summer was 2.5 days per decade. The pollen season starts on average 10 days earlier and is longer than it was 50 years ago (Feehan et al. 2009).

Climate change in association with an extended urbanization, with high levels of vehicle emissions in urban areas, and living in an artificial environment with little movement exert negative impact on individuals in most industrialized countries. Hence, these factors may contribute to explaining the increasing frequency of respiratory allergy and asthma (D'Amato 2011). Pollen is an important trigger of respiratory diseases. Both quantity related (total annual pollen counts, annual peak pollen counts) and phenological (start, end and duration of the pollen season) characteristics of different taxa are functions of the meteorological variables. Greater concentrations of carbon dioxide and, consequently, higher temperatures may increase pollen quantity and induce longer pollen seasons (Ziska et al. 2003, Clot 2008). Pollen allergenicity can also increase as a result of these changes in climate. Furthermore, there is evidence that high levels of traffic-derived air pollutants may interact with pollen and bring about more intense respiratory allergy symptoms (Hjelmroos et al. 1999, Motta et al. 2006). Accordingly, global warming may induce a wide pollen-related public health problem; for which the societies should be prepared in time.

The main aim of this paper is to study an extended spectrum of airborne pollen characteristics (19 plant taxa) for the Szeged region in Southern Hungary. A novel procedure is introduced in order to separate the effect of the past and current weather conditions in influencing current pollen production of the different taxa. This kind of separation has not been demonstrated in the literature. Results are evaluated with special attention to the interactions between the phyto-physiological processes and the climate elements; furthermore, they are compared for each taxon based on different aspects.

Predicting the pollen season characteristics (e.g. the start of the pollen season) as early as possible is of basic importance in order to prepare sensitive people in time for the days of pollen dispersion. Our analysis helps to identify those key periods and meteorological variables which most affect the daily pollen counts of the given taxon. Changing climate involves different changes in the weather elements of each season. A potential importance of the procedure is that a period with a changing climate that may have a major impact on the current pollen counts can be detected by the past of climate elements.

2. MATERIALS

2.1 Location and data

Szeged (46.25°N; 20.10°E), the largest settlement in South-eastern Hungary is located at the confluence of the rivers Tisza and Maros. The area is characterised by an extensive flat landscape of the Great Hungarian Plain with an elevation of 79 m above sea level. The city is the centre of the Szeged region with 203,000 inhabitants.

The pollen content of the air was measured by a 7-day recording Hirst type volumetric spore trap (Hirst 1952). The air sampler is located on top of the building of the Faculty of Arts at the University of Szeged, approximately 20 m above the ground surface (Makra et al. 2010). Meteorological variables include daily values of mean temperature (T, °C), relative humidity (RH, %), global solar flux (GSF, W m^{-2}) and precipitation total (P, mm), respectively. They were collected in a meteorological station located in the inner city area of Szeged. The data set consists of daily pollen counts (daily pollen count m^{-3} of air) of 19 taxa taken over the 11-year period 1997-2007. With their Latin (English) names they are: *Alnus* (alder), *Ambrosia* (ragweed), *Artemisia* (mugwort), *Betula* (birch), *Cannabis* (hemp), Chenopodiaceae (goosefoots), *Juglans* (walnut), *Morus* (mulberry), *Pinus* (pine), *Plantago* (plantain), *Platanus* (plane), Poaceae (grasses), *Populus* (poplar), *Quercus* (oak), *Rumex* (dock), *Taxus* (yew), *Tilia* (linden), *Ulmus* (elm) and *Urtica* (nettle). These 19 taxa produce 93.2% of the total pollen amount for the given period. Taxa with the highest pollen levels include *Ambrosia* (32.3%), Poaceae (10.5%), *Populus* (9.6%) and *Urtica* (9.1%) that together account for 61.5% of the total pollen production.

The pollen season is defined by its start and end dates. For the start (end) of the season we used the first (last) date on which 1 pollen grain m^{-3} of air is recorded and at least 5 consecutive (preceding) days also show 1 or more pollen grains m^{-3} (Galán et al. 2001). For a pollen type, the longest pollen season in the 11-year period was considered.

2.2 Factor analysis with special transformation

Factor analysis identifies any linear relationships among subsets of examined variables and this helps to reduce the dimensionality of the initial database without substantial loss of information. First, a factor analysis was applied to the initial datasets consisting of 9 variables (8 explanatory variables including 4 climatic variables in the past and the same 4 climatic variables on the actual day, and 1 resultant variable defined by the daily pollen concentration of the given taxa) transforming the original variables to fewer variables. These new variables (called factors) can be viewed as latent variables explaining the joint behaviour of past and current meteorological elements as well as current pollen concentration variables. The number of retained factors can be determined by different criteria. The most common and widely accepted one is to specify a least percentage (80%) of the total variance in the original variables that has to be achieved (Jolliffe 1993, Liu 2009). After performing a factor analysis, a special transformation of the retained factors was made to discover to what degree the above-mentioned explanatory variables affect the resultant variable and to give a rank of their influence (Jahn and Vahle 1968). When performing factor analysis on the standardized variables, factor loadings received are correlation coefficients between the original variables and, after rotation, the coordinate values belonging to the turned axes (namely, factor values). Consequently, if the resultant variable is strongly correlated with the factor (the factor has high factor loading at the place of the resultant variable) and - within the same factor - an explanatory variable is highly correlated with the factor, then the explanatory variable is also highly correlated with the resultant variable. Hence, it is advisable to combine all the weights of the factors together with the resultant variable into one factor. Namely, it is effective to rotate so that only one factor has a large weight with the resultant variable. The remaining factors are uncorrelated (are of 0 weights) with the resultant variable (Jahn and Vahle 1968). This latter procedure is called special transformation.

3. RESULTS

Airborne pollen concentrations can be influenced not only by the current values of the meteorological elements, but also by their past values. As it is hard to distinguish between the effect of the current and past values of the meteorological variables no attempt has been made so far to determine the relative weight of these two components in influencing the measured current pollen concentration. In our present approach the current meteorological elements (daily mean temperature, daily relative humidity, daily global solar flux and daily precipitation total) were characterised by their actual values, while past meteorological elements were described by their cumulative values. These elements were considered since they indicate the highest impact on pollen production (Galán et al. 2000, Bartková-Ščevková 2003, Štefanič et al. 2005, Kasprzyk 2008, Makra and Matyasovszky 2011).

The calculation procedure and main results are presented in detail for Poaceae, because this species group has the longest pollen season in Hungary and significantly contributes to the total annual pollen production. In order to assess the effect of the antecedent and current meteorological conditions on the current Poaceae pollen concentration, the 1st-day, 2nd-day, ..., 180th-day values of both the pollen concentration and the four meteorological elements of the current pollen season were taken. (The duration of the Poaceae pollen season in Szeged lasts from April 16 until October 12, namely 180 days. (Table 1).). The values of these meteorological variables were then cumulated for 186-day, 185-day, ..., 1-day periods starting 186 days, 185 days, ..., 1 day before the actual day of the actual pollen season. This is because there are 186 days between the end of the previous-year pollen season and the beginning of the actual pollen season. Hence, 186 9-dimensional data sets were produced and a factor analysis with special transformation was performed for each of them (Figs. 1-3). The altogether 5496 factor analyses carried out for all the 19 taxa resulted in 3 and 4 factors, except for *Artemisia* (2 factors).

Table 1 Plant habits and phenological pollen season characteristics

Taxa	[1]Plant habit	Pollen season		
		Start	End	Duration, day
Alnus	AD	Feb 3	Apr 8	65
Betula	AD	Mar 22	May 8	48
Juglans	AD	Apr 12	May 19	38
Morus	AD	Apr 18	May 22	35
Platanus	AD	Apr 8	May 20	43
[2]***Populus***	**AD**	Feb 27	Apr 20	53
Quercus	AD	Apr 2	May 11	40
Tilia	AD	May 16	Jul 1	47
Ulmus	AD	Feb 6	Apr 8	62
Pinus	AE	Apr 25	Jun 8	45
Taxus	AE	Feb 13	Apr 15	62
[2]***Ambrosia***	**H**	Jul 15	Oct 15	93
Artemisia	H	Jul 18	Oct 9	84
Cannabis	H	Jun 6	Sep 3	90
Chenopodiaceae	H	Jun 22	Oct 11	112
Plantago	H	May 12	Aug 29	110
[2]**Poaceae**	**H**	Apr 16	Oct 11	180
Rumex	H	May 13	Aug 12	92
[2]***Urtica***	**H**	May 4	Sep 26	146

[1]AD: arboreal deciduous, AE: arboreal evergreen, H: herbaceous;

[2]**Bold:** taxa with the highest pollen levels in Szeged region

The main findings for Poaceae are as follows (Fig. 2, 2nd panel from above, right). The total weights (summarized absolute values) of the factor loadings for the past meteorological variables are decreasing from day 186 until day 58 (disturbed by a sudden local maximum on day 90). Then, a strong increase can be observed reaching a local maximum on day 20, which is followed by a steep decrease until present. The total weights of the factor loadings for the current climate parameters are below those of the past climate variables between days 186 and 128, as well as between days 42 and 10. However, between days 128 and 42, as well as between day 10 and the present the effect of the current climate is stronger.

From day 15 until present the total weights sharply decrease. In general, this is in agreement with our preliminary expectation that current climate has a higher importance close to the current pollen release; while back in time the role of both the past and current climate varies depending on periods. The effect of the current climate begins to increase on day 90 (i.e. 90 days preceding April 16 (Table 1) corresponding to the date January 16).

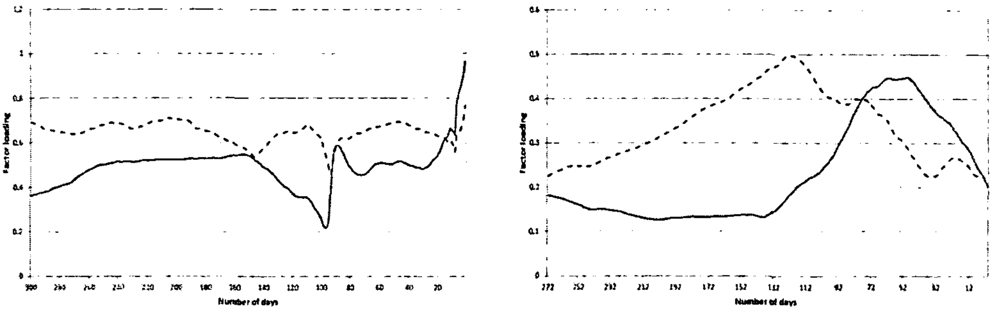
It can be concluded after a further analysis of the curves in Figs. 1-3 and 4 that from mid-October to mid-January temperature and global solar flux can determine the future pollen production, whereas from mid-January the role of precipitation increases as the water-storage of the soil must be restored before the start of the vegetation. Current effects of global solar flux, precipitation and relative humidity indicate peak values a few days before the pollination season and exceed their past effects in this period. Water and light are required to start photosynthesis, namely vegetative and generative processes that are essential for the pollen production. Even if the past meteorological conditions were optimal for grasses the current precipitation and global solar flux can overwrite the past effects, and early April weather conditions are essential for the pollen production. Although the weight of relative humidity also increases by early April this is only a consequence of the beginning photosynthesis facilitated by an increased global solar flux and precipitation. As a result, these latter two meteorological parameters are the most essential factors of pollen production for grasses and temperature has only a regulating effect.

Poaceae contains lots of species and the start of their pollen season differs notably. Therefore, any changes in precipitation, temperature or global solar flux may change the species composition significantly. The change in dominant grass species was observed in several landscape types in Hungary during the recent years (Deák 2010, 2011, 2012).

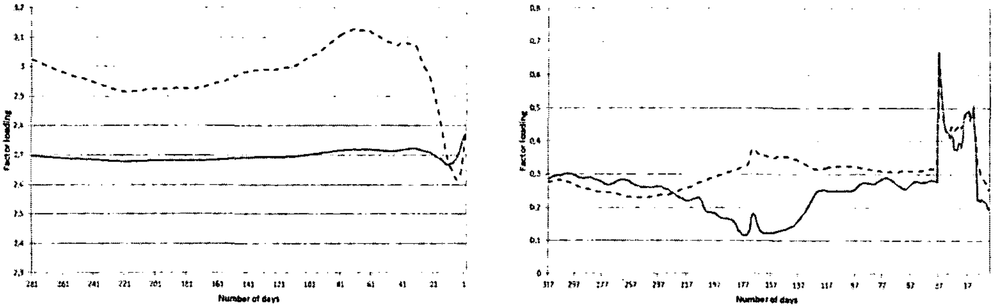
For *Alnus,* the weights of the past meteorological parameters are somewhat higher compared to those of the current ones with only small variability in most of the pollen-free season (Fig. 1, 1st panel from above, left). This is because *Alnus* requires stable weather conditions for a longer period. *Alnus* can be found in wetlands – in marsh forests or alongside streams in hilly and montane areas that ensure an equalized microclimate. In late September and early October the water-level is the lowest in the wetlands and the soil surface often dries out.

For *Ambrosia*, the total weights of the factor loadings for the past meteorological variables are gradually increasing from the first pollen-free day following the last *Ambrosia* pollen season until the middle of March (Fig. 1, 1st panel from above, right). Then, until present, the importance of the past climate parameters is decreasing. The total weights of the factor loadings for the current climate parameters (solid line) are very low from day 272 until day 138. Then they are increasing steeply, reaching their top values between the days 62 and 50. During the last 50 days until the start of the current *Ambrosia* pollen season the total weights are sharply decreasing. The effect of the past climate is greater on the current *Ambrosia* pollen concentration from day 272 until day 77, while from this day until present the current climate has higher weight in influencing the current *Ambrosia* pollen level. The effect of the current climate begins to increase on day 138 (i.e. 138 days preceding July 15, corresponding to the date February 28) (Fig. 4).

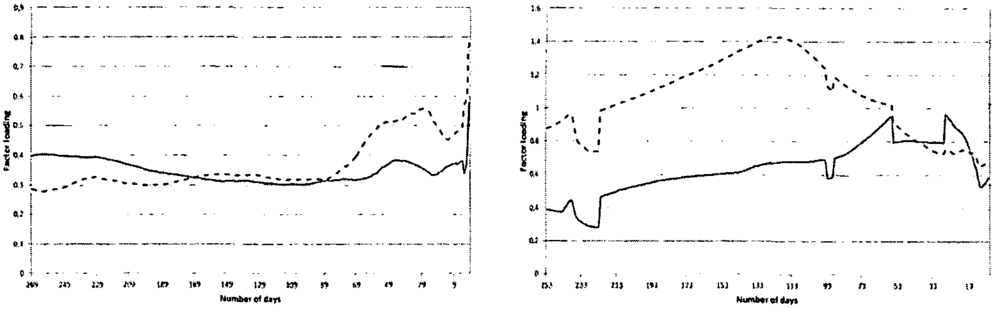
For *Artemisia,* the past meteorological elements have a much more important effect on pollen production, especially between mid-April and mid-June. The past climate conditions can thus compensate the possible negative effects of the current meteorological conditions. The effect of the current weather conditions becomes more important just 1-2 weeks before the pollination season in early July, whereas the weight of the past ones suddenly drops down.



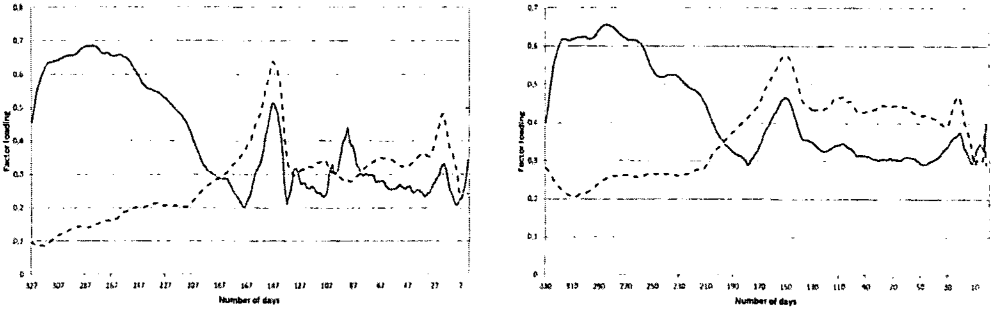
Alnus *Ambrosia*



Artemisia *Betula*

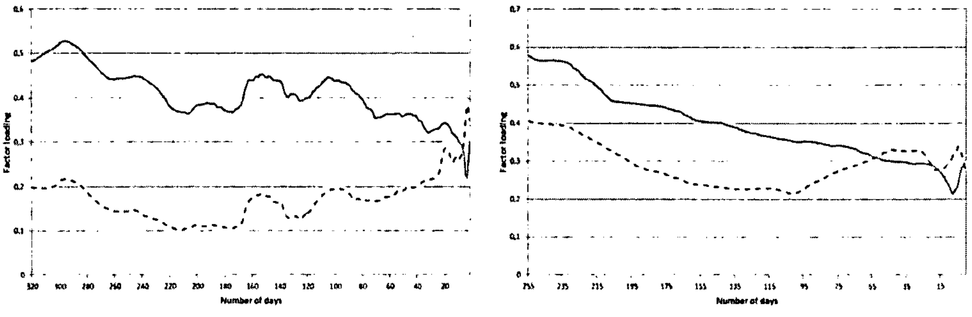


Cannabis Chenopodiaceae

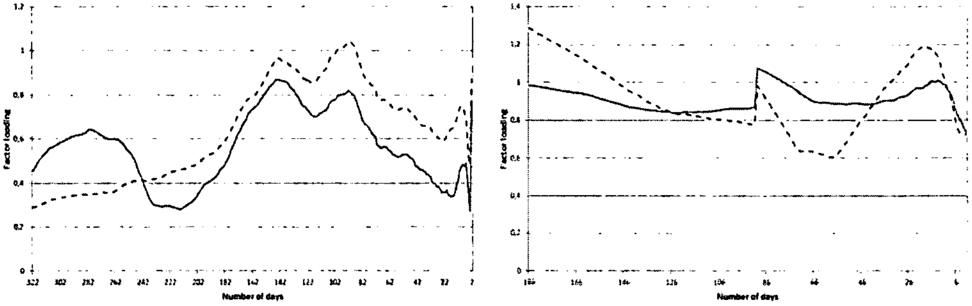


Juglans *Morus*

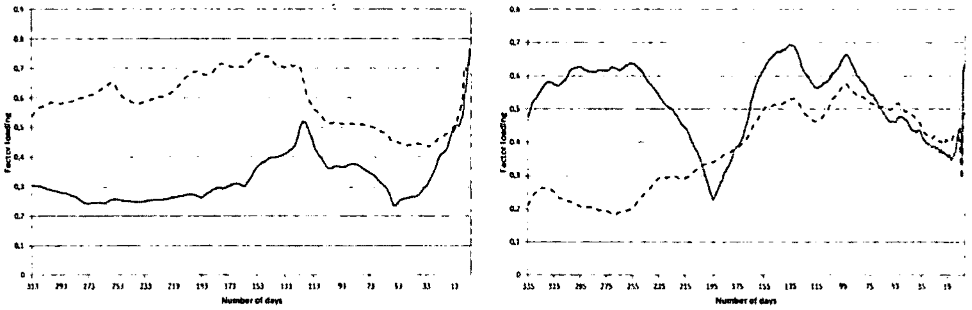
Fig. 1 Total weights of the factor loadings for the current (solid line) and past (dashed line) meteorological elements influencing the current pollen concentrations for the different taxa



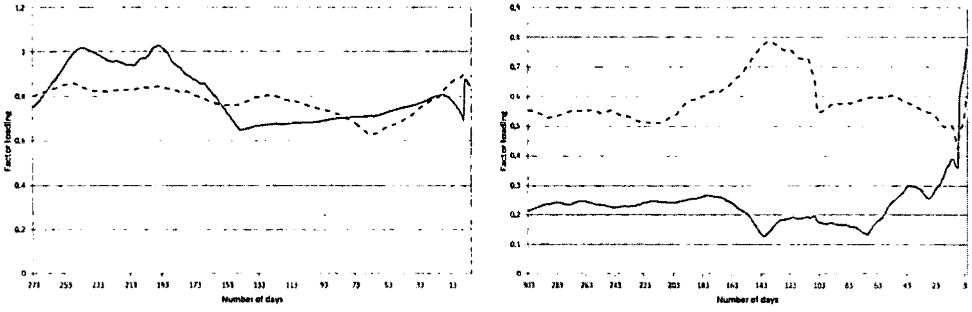
Pinus *Plantago*



Platanus Poaceae



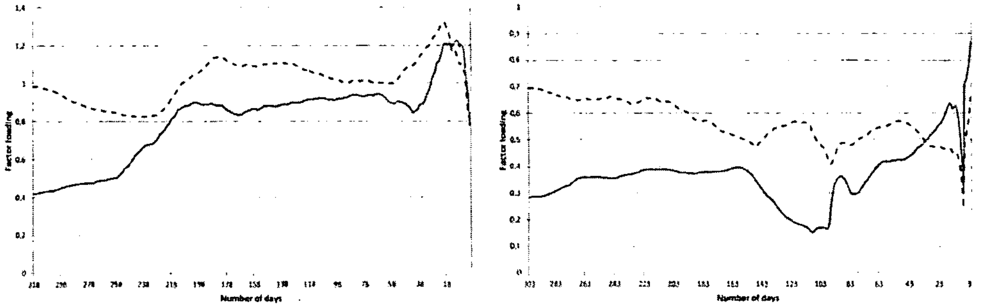
Populus *Quercus*



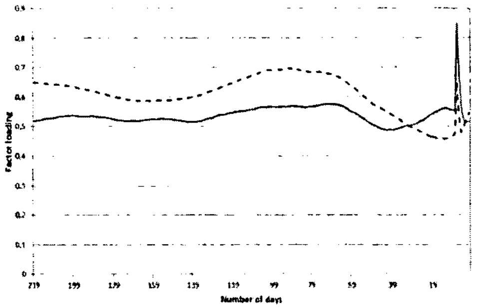
Rumex *Taxus*

Fig. 2 Total weights of the factor loadings for the current (solid line) and past (dashed line) meteorological elements influencing the current pollen concentrations for the different taxa

For *Betula*, the effect of the past and current meteorological elements is very similar in the pollen-free season, except the period from August until the end of the autumn when the difference between the weights of the past and current meteorological parameters is the highest with the bigger weights of the past elements (Fig. 1, 2nd panel from above, right). This is because by the end of the summer and during the autumn the water-storage of the soil becomes an important factor for the species of this genus that originally occurs in pioneer montane forests and marsh forests in areas with cooler and humid microclimate (Horváth et al. 1995). From the second half of October, due to the lower temperatures and increasing precipitation, the role of the current meteorological elements increases. Their weight suddenly exceeds the past effects after mid-February.



Tilia *Ulmus*

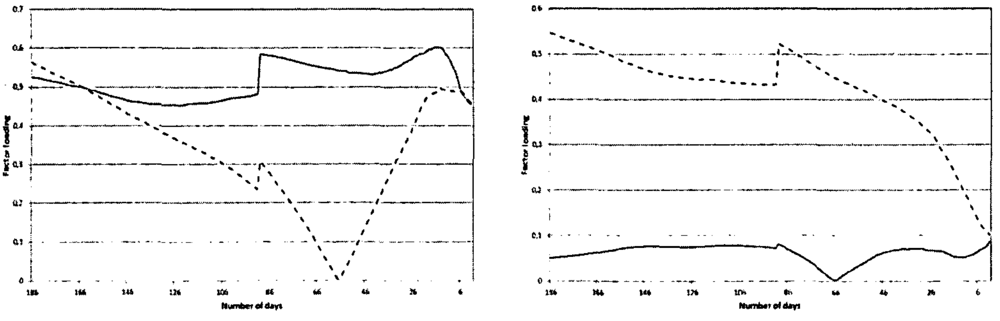


Urtica

Fig. 3 Total weights of the factor loadings for the current (solid line) and past (dashed line) meteorological elements influencing the current pollen concentrations for the different taxa

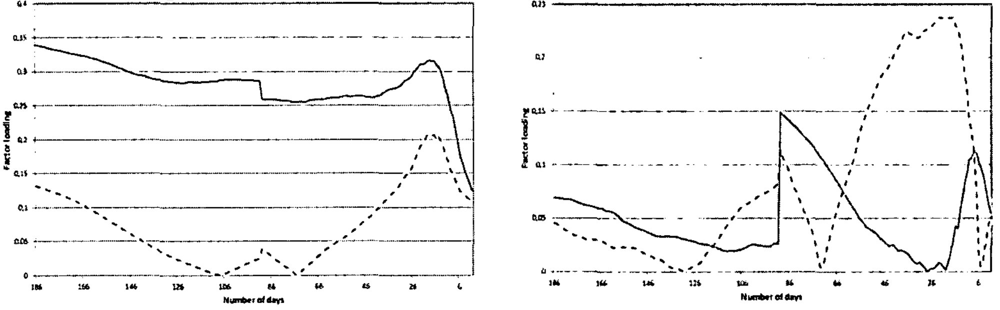
For *Cannabis*, the past and current weather conditions have a balanced role after the end of the previous pollination period (Fig. 1, 3rd panel from above, left). The weights of current meteorological elements are slightly higher from early September until the middle of December. Afterwards, there is no significant difference between the effects of the past and current weather conditions. But from early March the effect of the past weather conditions increases reaching its maximum after a little drop by the beginning of the pollen season.

For the Chenopodiaceae family, after the end of the previous pollen season (October 11), the weights of the past meteorological elements are higher than those of the current ones (Fig. 1, 3rd panel from above, right). The effects of both the current and past meteorological elements show a slight increase until March with two small parallel drops. These drops occur in early November and in the second half of March.



global solar flux

temperature



relative humidity

precipitation

Fig.4 Weights of the factor loadings for the current (solid line) and past (dashed line) meteorological elements influencing the current pollen concentrations for Poaceae

For *Juglans,* water income and higher temperatures could be the major factors influencing the run of the curves (Fig. 1, 4th panel from above, left). After the end of the previous pollen season, the weight of current meteorological elements is higher reaching the maximum weight in early July when the lack of water can be a major influencing factor. Following July, the role of the current meteorological elements suddenly decreases and from the middle of October the weight of the past meteorological elements exceeds that of the current ones and they are dominant until early April (start of the pollen season). Two major peaks (in early November and at the turn of March and April (two weeks before the pollen season)) can be identified. Both can be associated with high precipitation events or possible milder periods.

The shape of the curves for *Morus* (Fig. 1, 4th panel from above, right) is similar to those for *Juglans* but with a few differences. The role of the current meteorological elements highly dominates after the previous pollen season: its maximum weights occur in the mid-May – mid-August period. From mid-August, the weight of current meteorological elements begins to drop sharply and the importance of the past meteorological elements starts to grow from late September. Whilst from mid-November the weight of the past weather elements exceed that of the current ones until the preceding week of the pollen season.

Pinus and *Plantago* genera are sensitive especially to the current weather conditions (Fig. 2, 1st panel from above). The past meteorological elements seem to have the smallest effect on these taxa of all analyzed in the study. The current weather conditions have the largest effect on these genera with gradually decreasing weights from the end of the previous pollen season (late May for *Pinus* and late September for *Plantago*). For *Plantago,* this decrease is continuous, while for *Pinus* two smaller peaks (in mid-November and mid-January) can be observed.

For *Platanus,* the weights of the current meteorological elements exceed those of the past climate in the summer period (late May – early August) (Fig. 2, 2nd panel from above, left). The effect of current climate elements is the highest in June and July. After mid-August, the weights of the past climate elements slightly exceed those of the current ones. Both show an increasing trend in the autumn and winter period. The shape of the curves of both the past and current meteorological variables is nearly parallel for the period between mid-August and the beginning of the new pollen season.

For *Populus,* the past meteorological elements have higher weights compared to the current climate parameters except 2-3 days before the start of the pollen season (Fig. 2, 3rd panel from above, left). This is due to the fact that representatives of these species are mainly found on floodplains or in areas influenced by groundwater-flow, like the sand lands of the Danube-Tisza Interfluve. In floodplain areas the floods of former years lay fresh deposits on which new stands of poplars can germinate. Floodplains always reflect to past meteorological elements via the water-level of the rivers as the increase and decrease of water-level – which is followed also by groundwater – occurs with a delay after a dry or wet period. In the sand lands of the Danube-Tisza Interfluve the Poplar forests are fed by precipitation and stands situated in the blow-outs of the groundwater-flows are supplied by water with a delay of even several days or weeks (Herke 1934, Miháltz 1966, Rónai 1975, Margóczi et al 2008). Due to hydrogeographical reasons *Populus* stocks are mainly influenced by past weather events.

For *Quercus,* the weight of the current meteorological elements is much higher than that of the past climate parameters from mid-May until mid-August (Fig. 2, 3rd panel from above, right). At the beginning of August, the weights of the current meteorological factors begin to decrease sharply and reach their minimum at the middle of September, whereas the role of the past climate parameters shows a moderately increasing trend until the end of December.

For *Rumex,* only small differences can be observed in the weights of the current and past meteorological elements between the previous and the new pollen seasons (Fig. 2, 4th panel from above, left). The current meteorological elements have the largest weights with major peaks in early September and at the end of October which seems favourable for the optimal seed production as well (especially on dry and warm days).

For *Taxus,* the past meteorological elements have a prominent role between the previous and the new pollen seasons except the few days before the beginning of the new pollination period in early February when the current meteorological elements become dominant (Fig. 2, 4th panel from above, right). The weight of the current climate elements definitely increases from the beginning of December comprising two local minima.

Tilia seems to be sensitive to the past weather conditions as the weights of the past meteorological elements are higher than those of the current ones except for several days before the start of the pollen season when the current weather conditions become a bit more important (Fig. 3, 1st panel from above, left). The difference between the roles of current and past weather elements is the highest at mid-May after the end of the previous pollen season. The smallest differences occur at the beginning of September and mid-March.

For *Ulmus,* also the major role of the past weather conditions can be identified except for a few days before the start of the new pollen season when the weights of the current meteorological parameters exceed those of the past ones (Fig. 3, 1st panel from above, right).

The difference between the effect of the past and current weather conditions is the highest after the end of the previous pollen season (early April). The effect of the past meteorological elements is dominant; however, their weights moderately decrease from the start of the pollen-free period involving two local maxima in mid-October and mid-December.

The shape of the curves for *Urtica* is the most equalized of all taxa (Fig. 3, 2nd panel from above, left). After finishing the previous pollen season, the past meteorological elements have slightly larger weights against the current ones and their slight temporal changes are parallel until the beginning of April. For the pollen production the period of early January – early March seems dominant.

4. DISCUSSION AND CONCLUSIONS

Climate change can modify the pollen season characteristics of different allergenic taxa in diverse ways and can exert a substantial influence on habitat regions. To our knowledge, a comprehensive spectrum of the regional pollen flora was only analysed in three studies, namely in Clot (2003) 25 plant taxa, Damialis et al. (2007) 16 plant taxa and Cristofori et al. (2010) 63 plant taxa, respectively. Though these studies provided a broad survey and a detailed analysis on the pollen season characteristics and trends of a large number of taxa, they did not examine the effect of the temporal distribution of the values of the meteorological parameters on the current pollen levels. The present study analyses one of the largest spectra with 19 taxa. Our study can be considered unique in the sense that it separates the effects of the current and past meteorological elements that influence the current pollen concentrations.

Changing climate involves different changes in the weather elements of the individual seasons. A potential importance of our procedure is that a period with a changing climate that may have a major impact on the current pollen counts can be detected by the past of meteorological elements.

As regards the taxa with the highest pollen concentrations, *Ambrosia* genus has only one species, namely *Ambrosia artemisiifolia* (Common Ragweed) in the Szeged region that appears both in the urban environment and in the countryside. Ragweed occurs especially frequently west of the city. The ruling north-western winds can easily transport pollen into the city. Since in the sandy region, northwest of Szeged, stubble stripping is not necessary for ground-clearance due to the mechanical properties of sandy soils *Ambrosia* can spread unchecked. Owing to newly-built motorways around Szeged, several farmland areas have been left untouched for a long time that also favour the expansion of *Ambrosia*. Several species of the Poaceae family, namely *Agropyron repens* (Common Couch), *Poa trivialis* (Rough Meadow-grass), as well as *Poa bulbosa* (Bulbous Meadow-grass) over untouched areas, furthermore *Poa angustifolia* (Narrow-leaved Meadow-grass) and *Alopecurus pratensis* (Meadow Foxtail) in the floodplain and along the dyke surrounding the Szeged region represent a substantial proportion of pollen in the city. Along the urban lakesides *Phragmites australis* (Common Reed) is the most frequent Poaceae. Furthermore, on short grass steppes of sand, loess and saline areas *Festuca pseudovina* and *Festuca rupicola* also occur. For the *Populus* genus, natural species of *Populus alba* (White Poplar) and *Populus canescens* (Grey Poplar) are the most frequent in the city and are characteristic in floodplain forests along the Tisza and Maros Rivers. In addition, cultivated poplars such as I-273 Poplar and *Populus x euramericana* (Canadian Poplar) and its variants are frequently planted in urban parklands, public places, as well as along roads in peripheries. The *Urtica* genus with its only species of *Urtica dioica* (Common Nettle) in the Szeged region is prevailing in the floodplain forest underwood of the Tisza and Maros Rivers, road- and channel-sides and in locust-tree plantations around the city. *Urtica* also occurs in the neglected grassy lands of the city area (Deák 2010).

The remaining species seldom occur here. *Alnus* species are only found in the Botanical Garden of Szeged. Pollen of *Artemisia, Cannabis,* Chenopodiaceae and *Rumex* can come from neglected areas of both the city and its surroundings, as well as from stubble pastures. *Betula, Juglans, Pinus, Platanus, Taxus* and *Tilia* species have been planted exclusively in public places and gardens; they have no natural habitats in the Szeged region. However, since the 1960s *Pinus* (*Pinus sylvestris* and *Pinus nigra*) species have been extensively planted in the sandy regions north-west of Szeged within the framework of an afforestation programme. Their pollen can easily reach Szeged with the north-western winds. *Morus* is planted along avenues and in public places. *Plantago* species occur in natural grassy areas of both the city and its surroundings. *Quercus* species are planted along the embankment surrounding the city, as well as north of the city. *Ulmus* is planted in the city too; however it is not very common. *Ulmus minor* is quite frequent in all landscape types around Szeged on boundaries, road-sides and channel-sides. Its scattered mono-dominant plantations can appear in loess landscapes and saved-side floodplains, as well as rarely in sand landscapes. In the above-mentioned places the formerly planted *Ulmus pumila,* as an adventive species, also occurs, but its spread is not characteristic. Large natural stands of *Ulmus minor* together with *Ulmus laevis* live in the oak-elm-ash alluvial forests alongside the River Maros where planted and spontaneous stands both appear. They can be found spontaneously even in the willow-poplar alluvial forests thanks to the mature stands of the Pécska forest on the Romanian side (Deák 2010).

The taxa examined can be classified into three groups, namely arboreal deciduous (AD), arboreal evergreen (AE) and herbaceous (H) taxa. It was found that a better comparison can be established if the taxa are separated within each group according to the starting month of their pollination season. Within the group of AD taxa, *Alnus, Populus* and *Ulmus* are marked by a late summer – early autumn peak of their past meteorological elements exceeding those of the current ones almost all over the pollen-free period. For *Juglans, Morus, Platanus* and *Quercus,* the major weights of the current meteorological elements in the spring and early summer involve the most characteristic contribution to the pollen production. A few days before the start of the new pollen season the current weather conditions are predominant for all AD taxa (Figs. 1-2, Table 1). AE taxa comprise only *Pinus* and *Taxus*, but their curves are totally reverse without any similarity (Figs. 1-2; Table 1). For H taxa, Poaceae is the only taxon starting its pollination in April, so it is excluded from further analysis. Since the pollen season of *Cannabis* and Chenopodiaceae starts in early and late June, these taxa are listed into the groups pollinating from May and July, respectively. In this way, the curve of the taxa pollinating from May (*Cannabis, Plantago, Rumex* and *Urtica*) indicate the most equalized course of weights in the study. For *Cannabis, Plantago* and *Rumex* the effect of the current weather conditions is more important from the beginning of the pollen-free season, while just before the start of the new pollen season the weights of the past climate elements are more remarkable, except *Urtica* (Fig. 1, Fig. 3, Table 1). *Ambrosia, Artemisia* and Chenopodiaceae comprise the highest weights of the past weather conditions of all taxa until at least three months before the start of the pollination that are characteristic in determining the pollen production. However, some days or weeks before the start of the new pollen season the current climate elements have a higher importance (Fig. 1, Table 1).

. We should remark that water is much more essential to genera dominated by trees like *Quercus*, *Platanus*, *Pinus*, *Morus*, *Juglans*, *Betula* and *Alnus*. In this way, autumn and winter precipitation income influences their growth and pollen production potentials more than for herbaceous plants.

Note, that our findings for assessing the effect of the antecedent and current meteorological conditions on the current pollen concentration are valid only for variations of the daily pollen concentrations accounted for by the above-mentioned eight explanatory variables and nothing is known about the variance portion not explained by these variables.

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