A new software-based characterisation of the pollen season by using climate specific pollen indicators

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Abstract:

The EU Strategy on adaptation to climate change (2013) called the attention that climate change might potentially increase the seasonality and duration of allergic disorders like hay fever or asthma. Because it is of high importance to evaluate the pollen exposure of population living in different geographical and climatic regions in order to adjust information and adaptive measures, tools for calculation and visualization of pollen indicators were developed to aid creating reports and scientific publications. Taking into account the above mentioned needs climate related pollen indicators were developed by WHO/ECEH Bonn Office with the contribution of Member States within the frames of CEHAPIS project . In this article we present two new software-based tools for calculate and visualizes climate related pollen indicators: the UNIPHE (Use of Sub-national Indicators to Improve Public Health in Europe) platform and P.E.A.S. (Pollen Exposure Analyser Software), respectively. UNIPHE platform is available at http://data.uniphe.eu. and the P.E.A.S software is freely accessible at the link http://data.uniphe.eu/software-tools

The effect of climate change on pollen seasons

The 4th Assessment Report of IPCC (2007) states that climate change has caused an earlier onset of the spring pollen season in the Northern Hemisphere. It is reasonable to conclude that allergenic diseases caused by pollen, such as allergic rhinitis, have experienced some concomitant change in seasonality. There is limited evidence that the length of the pollen season has also increased for some species.

Furthermore the EU Strategy on adaptation to climate change (2013) called the attention that **c**limate change might potentially increase the seasonality and duration of allergic disorders like hay fever or asthma with implications for direct costs in terms of care and medicines, as well as lost working hours. The 5th Assessment Report of IPCC (2014) stated that warmer conditions generally favour the production and release of air borne allergens. Visual monitoring and experiments have shown that increases in air temperature cause earlier flowering. Progressively increasing temperatures may modify the global pollen load (Ariano et al 2010), the start, duration and intensity of the pollen season are likely to change significantly with the projected likely increase temperature of 1.8° to 4.0°C in this century (Solomon et al. 2007) thus likely to influence the already high prevalence of allergic respiratory diseases, e.g. asthma and allergic rhinitis and affect the rate of allergic sensitization across long periods.

Changes in the spatial distribution of natural vegetation, such as the introduction of new aeroallergens into an area, increases sensitisation (Voltolini et al., 2000; Asero, 2002). The pollen map of Europe is changing also as a result of cultural factors: for example, importation of plants such as birch and cypress for urban parklands (Ziska et al 2003), greater international travel e.g. colonization by ragweed in France, northern Italy, Austria, Hungary (D'Amato 2007). Ragweed (*Ambrosia artemisiifolia*) - an invasive plant with highly allergenic pollen, presents important health risks in many parts of Europe (Cecchi et al., 2006, Rybnicek and Jaeger, 2001, Šikoparija et al, 2009).

Adaptation measures identified to date include aeroallergen monitoring and forecasting, allergenic plant management, planting practices and policies, access to health care, education and awareness raising. Therefore it is of high importance to evaluate the pollen exposure of population living in different geographical and climatic regions in order to adjust information and adaptive measures.

The development of climate related indicators

Taking into account the above mentioned facts and observation the WHO/ECEH Bonn Office with the contribution of Member States has developed climate related indicators within the frames of CEHAPIS project (supported by DG Sanco)[1].

Four allergen plants were selected for the indicators: (a) Alder/*Alnus*; (b) Birch/*Betula*; (c) Grasses/Poaceae; and (d) Ragweed/*Ambrosia* (Páldy et al. 2014). Those stand for high sensitisation rates, fairly good European both geographical (from Nordic to Mediterranean countries) and temporal coverage of the flowering season from spring to autumn. The pollen out of the selected indicator taxa: **alder** (*Alnus*) and **birch** (*Betula*), cause serious health problems, primarily in the northern and north-western parts of Europe, but also in Hungary. Their pollination period is important in relation to the impacts of climate change. The third indicator is the family of **true grasses** (Poaceae). Due to the large number of species within the family, their blooming and pollen season is long. Their effects are felt mostly in the atlantic, continental, and mediterranean regions. The fourth indicator is **ragweed** (*Ambrosia*), and especially the common ragweed (*Ambrosia artemisiifolia* L.). The reason why it was selected is because its pollen is strongly allergenic, and also because, as an invasive weed, it causes significant agricultural damage, especially in Central Europe.

The indicator set is based on daily airborne pollen immission measurements in continuous volumetric samplers (e.g. Hirst type, Burkard) by standard methods. The data of the existing monitoring stations representing different climatic regions of the country is recommended to be used. Each climatic zone needs to be characterized by a sufficient number of stations. Only data from stations located in populated areas are recommended to be used in the analysis. Census data for the smallest territorial units available is used to estimate the population living in a defined area (usually within 10-30 km radius) of each station depending on the local geographical situation as well the from the distance between monitoring stations.

The indicators used for each of the above mentioned taxa are the following: **the beginning, the end, and the length of the pollen season**; **the yearly maximum pollen concentration**; and the **total pollen load** (number of pollen grains/m^3). The beginning of the season is the day of the year when the pollen count reached or exceeded 1% of the yearly total pollen count. According to the definition, the end of the season is the day of the year when the yearly pollen count reached 99% of the cumulative pollen count.

[1] Climate Change, Environment and Health Action Plan and Information System - CEHAPIS Co-funded by EC DG Sanco SPC 2007WHO03

In case of the especially significant ragweed, other parameters characterising the population exposure are also available. These are **the population weighted average pollen concentration, the weighted length of the pollen season, and the weighted proportion of allergenic days.** These complex indicators aim to estimate the allergenic effect while taking into account the potential exposure of the population.

An interactive information platform to visualise the climate specific pollen indicators

The pollen reports of the Hungarian Aerobiological Network (coordinated by the **National Institute of Environmental Health, Budapest**, NIEH) use parameters describing the extent of pollen exposures (e.g. country average, weekly average, weekly maximum pollen concentration). However, the time and length of the season and the geographic distribution of the pollen concentration must also be taken into account in order to better assess the pollen exposure of the population. Until 2011, these parameters were only available in the yearly reports, but due to our developments, they are now available throughout the season. The UNIPHE (Use of Sub-national Indicators to Improve Public Health in Europe) project[2] was started in 2009 with the co-operation of six Member States of the EU in order to develop and apply country- and smaller scale environmental health indicators. The geographic system is based on the Nomenclature of Units for Territorial Statistics (NUTS). The role of the Hungarian partner (NIEH) was to establish a database at subnational level synchronised with the Environment and Health Information System (ENHIS[3]) and to develop an online, interactive data-retrieval web surface for this database. The application is available under http://data.uniphe.eu.

Concerning the above described four indicator taxa information is available for almost the entire period of the monitoring activity of the Aerobiology Network through the UNIPHE application. The database, undergone a data cleaning process (screening, verification) contains the daily pollen concentration data of 18 stations from 1999 to 2014, updated annually. The pollen counts on days being out of the ragweed pollen season according to phonological observation, are not included in the UNIPHE database.

The data can be accessed according to the indicators on several scales (national, regional, county, settlement), in different time units, and in different display modes. The three-year moving average option can assist in smoothing variability, while the national averages shown on the diagrams and the map figure type on the settlement scale can help determine spatial variability. This smallest geographic scale typically represents the city and its agglomeration with a 17.5 km radius, specified for Hungary, around the a given aerobiological monitoring station (Figure 1).

[2] supported by DG SANCO No 2008 13 04)
[3] http://data.euro.who.int/eceh-enhis/Default2.aspx

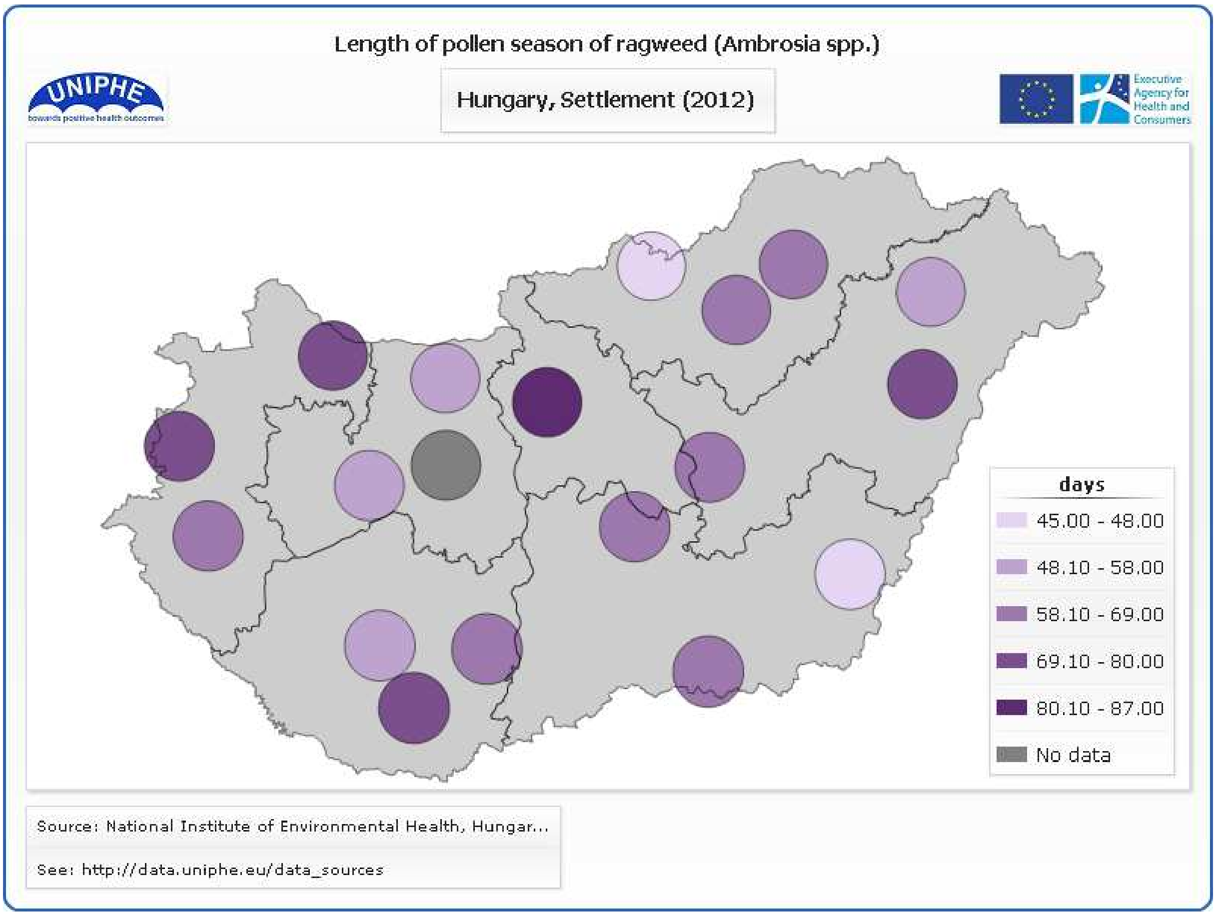

Fig. 1: Regional differences in the length of the ragweed pollen season (in days) in 2012 in Hungary by the UNIPHE information system

We can access the population weighted pollen exposure values on larger, e.g. regional (NUTS3), scales (Figure 2).

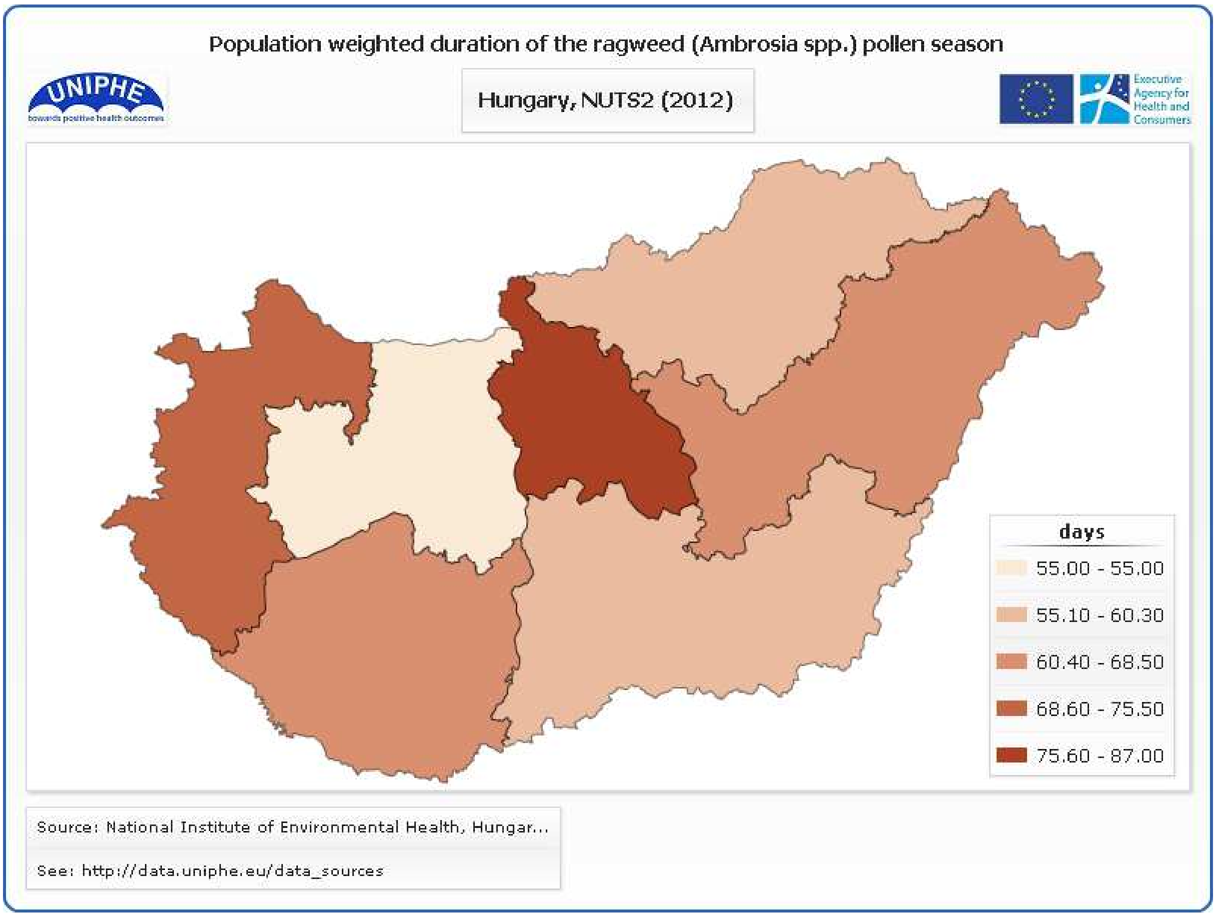

Fig. 2: Population-weighted length of pollen season (in days) in 2007, Hungary by the UNIPHE information system

It is also important to note that at the line chart option (on the settlement scale) we can deselect those cities with Aerobiology Stations that are irrelevant for our question (Figure 3).

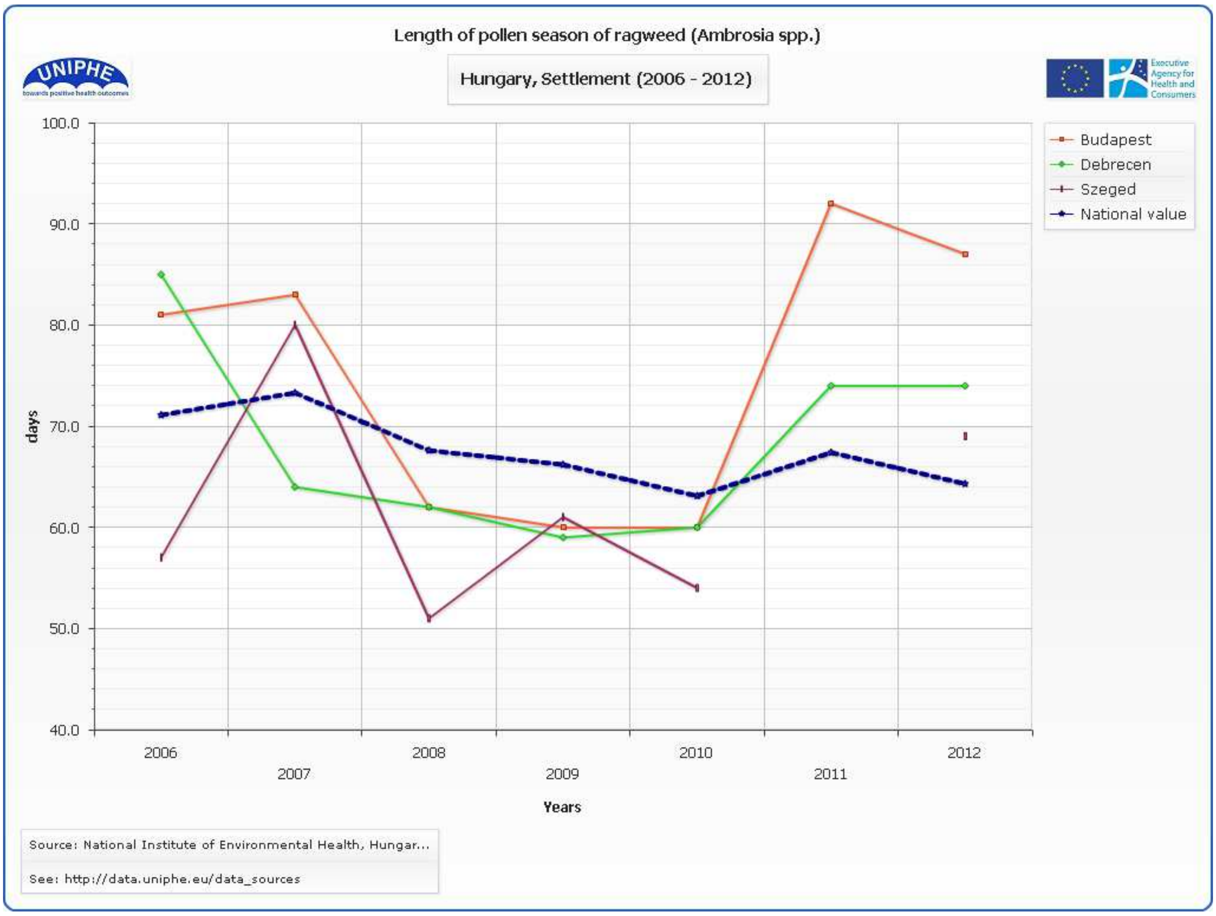

Fig. 3: Annual changes in the length of the ragweed season between 2006 and 2012, in Budapest, Debrecen and Szeged in relation to the national average by the UNIPHE information system

A new software to calculate the climate related indicators

Besides the methodology of the calculation of the indicators, a special software tool (Pollen Exposure Analyser Software, P.E.A.S.) was elaborated to compute the indicators (Bobvos et al., 2014). The software enables to calculate the start and end of pollen period (DOY), length of the pollen season (days), severity of the pollen period (annual sum and daily maximum of pollen grains (grains/m^3), population-weighted proportion of days with the allergenic concentration of pollen; population-weighted average exposure to the pollen; population-weighted duration of the pollen season. The added value of the software in comparison to the UNIPHE indicator system is that the regions can be defined individually eg. according to climate regions, land use, relief etc).

The beta version of the software was tested with the data of the Hungarian Aerobiological Network in 2014, the results of underlying computations and demonstration maps was published in 2015. The P.E.A.S software is freely accessible on the homepage of the NIEH at http://data.uniphe.eu/software-tools. We hope that the climate specific indicators and the software will be a useful tool to understand trends in the epidemiology of pollen allergy in different regions of Europe.

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