Current stage and future perspectives of bioaerosol research in Europe

Wednesday, 1 February 2023 - Thursday, 2 February 2023

Book of Abstracts

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The emission sources in airborne birch pollen modelling

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Air pollution from anthropogenic, biogenic and geogenic sources contributes to increased mortality and lower quality of life. Allergenic pollen in the air, a biogenic pollutant, might lead to the development of pollinosis in a quarter of the adult population and a third of all children in Europe. Future climate and land-use changes may increase the amount of allergenic pollen in the air and prolong the pollen season. Mitigation measures against airborne pollen requires proper modelling and forecasting of allergenic pollen.

We use the pollen transport model SILAM (System for Integrated modeLling of Atmospheric coMposition), driven by ECMWF ERA5 meteorology in a bottom-up emission approach for the period 1982-2019 for the Belgian territory. The pollen source emission maps are key inputs into SILAM.

Here we quantify how spatially-varying pollen emission sources affect the modelled airborne birch pollen levels in a Monte-Carlo approach. This preliminary analysis indicates that the selection of median emission values of a gridcell increases the correlation between the modelled and in-situ observed pollen levels with 16%. In a forecasting framework, it is critical to select prior to the start of the pollen season the best map with pollen emission sources. This might be done by constructing relationships between the pre-pollen season vegetation state and meteorology and the expected birch pollen loads of the up-coming season. We will present an overview of our efforts to select the best pollen emission source map based on a-priori knowledge.

2

Exploring Allergenic Pollen in the Norwegian Atmosphere

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Background & Aims: The environment of the Scandinavian country of Norway is exceptionally diverse. This is primarily the result of its wide-ranging latitude, longitude, altitude and high microscale topographical heterogeneity. This has contributed to complex climatological gradients and allowed for many different habitats and species. While the identification of Norwegian species has long been ongoing the modern monitoring of Norwegian pollen started in Trondheim in 1980. Since then, the pollen monitoring network has expanded to encompass twelve locations spanning the length of the country. However, relatively little is still known of how pollen in Norway varies both spatially and temporally and what type of environmental factors that influence the variation. This is especially relevant for allergenic pollen that elicit immunological reactions in the Norwegian public. We have recently started a new project aimed at gaining new and detailed understanding of the Norwegian allergenic pollen landscape and factors that influence pollen variation. The primary main objective is the creation and dissemination of updated and informative pollen calendars for each allergenic pollen type. Furthermore, the second main objective is to use local meteorology and statistical models to develop more in-depth understanding of spatiotemporal pollen variation.

Methods: The Norwegian pollen monitoring network monitors six main types of allergenic pollen: alder (*Alnus*), birch (*Betula*), grass (Poaceae), hazel (*Corylus*), mugwort (*Artemisia*) and willow (*Salix*). The pollen season is monitored from the start of the year to the 30th of September, generally considered the end of the growth period. For the pollen calendars to be reliable only recent and comparable data were used, with the years between 2007 and 2022 (16 years) being averaged to construct the calendars for the twelve locations. Four aspects of the pollen season were used: First to last observation of the season, SPIn 95% and timing of high and very high pollen concentration thresholds, with the threshold varying between pollen types.

Results: Calendars representing the three main allergenic pollen types have been consolidated so far: alder, birch and grass. The alder pollen season occurs between the beginning of February to the end of April, with six of the twelve locations having negligible SPIn. The main birch pollen season occurs between the middle of April to the end of June, with high and very high concentrations occurring for a substantial time in four locations between April and May. The main grass pollen season occurs between the beginning of June to the end of August, with high concentrations rarely being observed for most locations.

Conclusion: Large variation were observed in the timing and the presence of high pollen concentrations between the locations, likely due to the complexity of the Norwegian environment. The project will continue developing new knowledge of the Norwegian pollen landscape with multiple publications on the near horizon.

3

Distribution of common ragweed (ambrosia artemisiifolia) plant and pollen in Latvia and factors affecting them

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Common ragweed (ambrosia artemisiifolia) is an invasive plant species in Europe and other parts of the world, originating from Central and North America. Its pollen can cause allergic reactions. The plant also can invade agricultural lands, causing decrease in harvest, as well as being a threat to biodiversity. Under the influence of various factors, its spread in Europe is growing rapidly and introducing itself to new territories.
A survey was conducted to gather data, where people in Latvia have come across common ragweed, its location and environment. To understand common ragweed presence historically, herbarium data was analysed from 1979 to 2019 in Latvia. Every herbarium sample had the date when it was collected, the location and the environment. All ragweed locations were plotted using ArcMap.
Survey data shows that common ragweed was mostly found in Riga or near other cities, often noting that there was bird feed nearby. Most sightings were during August and September months. Herbarium data shows, that most samples were collected in Riga or nearby. They were found in urban environments, near railways, side of streets, mostly in September and October months. Comparing to historical data, from 1979 to 2005 there were 36 plant samples collected in herbarium, yet just in 2022 there were 37 sightings of common ragweed recorded by the survey participants, possibly showing the spread of the plant.
To further this study, another survey will be conducted- collecting data on public health regarding to common ragweed pollen. Survey will include questions on health during pollen season, symptoms, effect on daily life etc. Pollen concentration data will be analysed for correlations with meteorological data. The aim of this study is to understand how common ragweed is introduced in Latvia, how people are affected by common ragweed pollen and what factors affect the spread of common ragweed in Latvia.

4

Airborne pollen in urban parks in Thessaloniki, Greece: pollen taxa and concentrations and associated allergy risks

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Background - Pollen in the air reflects vegetation on the ground and, therefore, pollen monitoring provides valuable information on vegetation dynamics. Concurrently, it is an essential tool for assessing the air quality with respect to allergenic particles of biological origin. Urban parks provide a series of ecosystem services, but they can also act as sources of allergenic particles, thus impacting negatively human health. We studied airborne pollen in Thessaloniki, at breast height, in urban parks of the city that differ in a number of features, and also at rooftop level, at the aerobiological station of the city. We aimed at (i) identifying the plant taxa that considerably contribute pollen to the air of the parks, (ii) estimating pollen concentrations in each park and how they vary with time, and (iii) evaluating parks after the concentrations of the most abundant and allergenic pollen taxa.

Methods - Six urban parks (sampling stations) were selected in the city of Thessaloniki. Sampling was conducted in 2021, with the use of portable volumetric samplers. Once per week, 20-min air samples were collected from all stations. Pollen grains in each sample were counted and identified under an optical microscope at x400 magnification and were expressed as pollen grains m-3 per unit of time. Only taxa contributing with more than 1% of the total yearly sum, as recorded at the aerobiological station of the city, were taken into consideration. We calculated their main pollen seasons per station using the percentage method. Then, we explored their concentration and pollen season patterns in order to identify the main pollen sources across Thessaloniki as well as the parks of the city that are associated with higher allergenic risk.

Results - A total of 44 pollen taxa were detected in the air near the ground, ranging between 33 and 37 in each station. Cupressaceae, Quercus, Urticaceae, Platanus, Pinaceae, and Poaceae were the most abundant taxa; they are also among the most allergenic. These six taxa accounted for 84% to 93% of the total airborne pollen in the urban parks studied. Their main pollen season (MPS) started in all stations, in late January to February, with Cupressaceae pollen appearing first and Quercus pollen last (April), but durations differed. For all pollen taxa, the peak was observed from late February (Cupressaceae) to early July (Poaceae). The seafront park had the lowest concentration of airborne pollen for four of the most abundant taxa (Cupressaceae, Quercus, Pinaceae and Poaceae). Therefore, it can be considered as of the lowest allergenic risk. Nevertheless, this does not hold true for Urticaceae pollen, the concentration of which was the highest there.

Conclusion - Airborne pollen is not homogeneously distributed in the city. Pollen abundance of the different taxa is site specific, depending on the local vegetation, hence, the associated allergy risk is not the same everywhere. The seafront area of the city is characterized by the lowest amounts of allergenic pollen from woody taxa, except for Platanus, but it has high concentrations of Urticaceae pollen.

Acknowledgements - This research study was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the "1st Call for H.F.R.I. Research Projects to support Faculty Members & Researchers and the procurement of high-cost research equipment grant"(Project Number: 3456).

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Quantification of airborne fungal spores during wheat harvest season by traditional and automatic measurements

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Pannonian plain during wheat harvest is considered a source of airborne fungal spores detected also in other parts of Europe. Airborne fungal spores were counted from Hirst-type volumetric samples collected in Novi Sad in July 2019 and simultaneous measurements using Rapid-E (Plait SA) were performed.
Predominant spores detected were Cladosporium, Alternaria, and Coprinus-type and they constituted most of the total spores count (>90%). Alternaria and Cladosporium were more abundant in the morning while most of the Coprinus-type, Ganoderma, and hyaline spores'peaks were recorded during night hours, therefore, justifying differentiation to "dry"and "wet"spores. Hyaline spores record was positively correlated to humidity and precipitation rather while Alternaria was negatively correlated to humidity.
The automatic bioaerosol measurements were able to quantify total fungal spores after training an AI-based classification model on measurements when the notable quantity of spores was recorded while no pollen was present in the air. For differentiation between fungal spores, a better training dataset is required and detectors need to be more sensitive to record the weak intensity of fungal spores' fluorescence.

6

Longer, later, higher: changes in Betula pollen season in Ukraine from 2009 to 2022

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Introduction: Birch pollen is a leading source of allergies in the spring. About a quarter of people with seasonal allergies in Ukraine are sensitive to it, which makes birch pollination an urgent issue of the healthcare system. Birch produces and releases pollen in a certain period and with a certain intensity, which depends on environmental conditions and their changes. It should also be taken into account that this plant has a biennial pollen cycle in Ukraine, which causes significant exacerbation of symptoms in patients with the intermittent rhinitis in even years. Therefore, it is the task of aerobiologists to carry on regular pollen monitoring to contribute in prevention of contact of patients with the source of their allergy. However, the general tendencies of pollination change not only within the season, but also over a long period of time. These changes are primarily due to the climate change, which have been especially evident in recent years. Therefore, the purpose of our work was to identify the trends of these changes over the period of aerobiological monitoring in 2009-2022.
Method: Pollen collection was carried out by volumetric method using a Burkard trap of a Hirst type located at a height of 25 meters above the ground. It was located on the roof of the National Pirogov Memorial Medical University, Vinnytsya. Obtained air specimens were stained and analyzed under a light microscope with a magnification of X400. Statistical processing of the obtained data was carried out using the facilities of the European Aeroallergen Network and the Excel 2013 Program.
Results: Pollen trends revealed the tendency of the season delay: in 2009 the season started on March 25 (84th day of the year), in 2022 –on April 9 (99th day). Accordingly, the birch flowering peak date shifted from April 21 (111 days in 2009) to May 4 (124 days in 2022). May 4 was the last day of birch pollination in 2009, while in 2022 the end of the season shifted by a week to May 13 (day 133).
Along with the shift of the birch period to the later time, the amount of pollen grains that it produces has also changed: there is a trend towards an increase of pollen Index. In odd year 2009, 522 pollen

grains/m3 were collected, and in 2021 there were 1667.3 of them, which is three times more. The pollen index of even years ranged from 9604 pollen grains/m3 in 2010 to 13696.4 pollen grains/m3 in 2022. The highest pollen index was recorded in the year 2014: 22832.7 pollen grains/m3; with a peak concentration 3791.4 pollen grains/m3. There is also an increasing trend in pollen peak values: 76 grains/m3 in 2009 vs 1485.2 grains/m3 in 2022.
Conclusions: so, birch pollination season in Ukraine starts later, lasts longer and, accordingly, ends later. In addition, the concentration of pollen has increased. These data should be used for pollen forecast in order to prevent excessive contact with allergens in patients with pollen allergy. It is important to continue implication of volumetric sampling in order to control Betula pollination changes due to climate change.

7

Regional sensitivity to Ambroais and Artemisia pollen in Ukraine.

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Seasonal allergy affects the largest number of Ukrainians in late summer. The main allergens of this period are the pollen of Ambrosia and Artemisia.
Since mugwort's flowering starts earlier, it causes the first symptoms in patients. Allergic reactions to ragweed pollen persist until the end of October or even mid-November. Therefore, our work aimed to determine the level of regional sensitivity of the population of Ukraine to ragweed and mugwort pollen.

Sensitization data of 20033 patients who underwent allergy diagnosis using the Alex2 test in 2020-2022 was analyzed.
Components taken into account for the analysis included ragweed(Amb a) and mugwort extract(Art v), as well as individual ragweed allergens Amb a 1 and Amb a 4 and mugwort allergens Art v 1 and Art v 3.

According to the Alex2 test scale, the sensitivity threshold to certain allergens is sIgE > 0.31 kU/L. It was found that 6097 people were sensitive to either ragweed extract or one of its allergens. 3145 people were sensitive to mugwort allergens or its extract. Regional affiliation was established for 3171 patients sensitive to ragweed and 1563 patients sensitive to mugwort, or 15.83% and 7.80%, respectively. Moreover, 2468 people (12.32%) were simultaneously sensitive to ragweed and mugwort pollen.
The highest level of sensitization was observed in the population of the southeastern regions, the Steppe zone. In the city of Dnipro, 55.05% and 55.90% of the tested were sensitive to Ambrosia and Artemisia, respectively. Lower numbers were seen for neighbouring regions: Odesa (34.59% for ragweed and 14.14 % for mugwort), Kherson (38.33% and 17.49%, accordingly) and Mykolaiv (45.45% of residents were sensitive to ragweed, no mugwort sensitization was observed).
In Poltava, the number of patients sensitized to ragweed was 42.63%, to mugwort –18.42%; in Kharkiv –36.21% and 17.49%, respectively.
In the northern regions, in particular, Sumy, sensitization to Ambrosia artemisiifolia and Artemisia vulgaris was approximately at the same level –11.75% and 10.60%, accordingly. In Rivne, the percentage of sensitivity to ragweed was 12.94%, to mugwort –7.06%.
In the capital, Kyiv, sensitization to ragweed - 20.84%, and mugwort –13.33%.
It turned out that the sensitization of the residents of Zhytomyr was surprisingly high: 25% of the tested were sensitive to ragweed, and 33.33 % - to mugwort.
In the central regions, such as Vinnytsia and Cherkasy, sensitization to ragweed was 9.20% and 32.35% and mugwort –13.79% and 12.74%, respectively.
The lowest rates of sensitization to ragweed and mugwort were observed in the western regions of Ukraine –Lviv (6.88% and 8.06%), Ivano-Frankivsk (5.18% and 8.09%) and Khmelnytskyi (6.67% and

13.33%). The relatively high sensitivity to ragweed (13.46%) and mugwort (7.69%) in residents of Zakarpattia can be explained by the ragweed infestation from Hungary.

Although sensitization to Ambrosia artemisiifolia pollen is not necessarily equal to sensitization to Artemisia vulgaris pollen, the risk of combined sensitivity remains relatively high. Therefore, the sensitization of residents of Zhytomyr and Kyiv needs the additional attention of aerobiologists and allergists.

8

Regional Specifics of fungal sensitization in Ukraine

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Due to the lack of modern diagnostic methods, fungal allergy remains an underdiagnosed and undertreated disease, the reasons for which are not always well-understood. Thus, the aim of our work was to analyze the specifics of regional sensitization to fungal allergens in Ukraine in order to improve control of this disease.

To achieve this goal, a dataset of 20 033 patients tested with component-resolved molecular Alex2 test was used. Patients lived in 17 out of 25 regions of Ukraine.

It was established that sensitization to fungal allergens varied from 7,69 % of tested individuals in the Transcarpathian region (Western region Ukraine) to 22,99% (Center) and 22,82% (North-East) in Vinnytsia and Kharkiv regions, respectively. The third highest rate of sensitive patients (21,42 %) was in the Dnipro region (East of Central Ukraine). Low levels of fungal sensitization, instead, were recorded in other Western regions like Lviv (9,57 %), Ivano-Frankivsk (12,3%) and Rivne (12,35 %). In such a Northwestern region like Zhytomyr, sensitization to fungi was not determined at all. Southern regions, located at sea, where sensitization to fungal spores can be expected due to high humidity, held the 6th (Mykolaiv, 18,18 %), 7th (Odesa, 17,79 %) and 9th (Kherson, 17,00 %) positions respectively.
Sensitization to Alternaria was the most significant among all fungal sensitization. Rates of Kharkiv (18,88 % of tested individuals), Dnipro (18,29 %) and Mykolaiv (18,18 %) prevailed here. There were the lowest in Western Ukraine: 7,77 % in Ivano-Frankivsk, 5,61 % in Lviv and 1,92% in Transcarpathia.

Thus, clear regional patterns of fungal sensitization are seen in Ukraine, with its prevalence in Central and Northeast regions and with the lowest rates of such sensitivity in Western regions of Ukraine. Southern regions were in the middle by the levels of general fungal sensitization and on the top (Mykolaiv) in terms of sensitivity to Alternaria –the main factor of fungal allergy in Ukraine.

9

Google trends suggest the highest interest to birch pollen allergy at the first splash over pollen treshold

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Internet customers'behaviour can give a clue to practitioners on the improvement of approaches they utilize to control a seasonal allergy. Tracking the behaviour of Internet customers, one can see how it coincides with environmental changes that can promote the symptoms. Based on this data, it is possible to adjust measures of prophylaxis of seasonal allergies. So, the aim of our work was to track the interest of users to search queries "Birch"and "Birch allergy"and compare them with the patterns of Betula flowering in Ukraine.
The data of Google trends suggested that the highest levels of interest in the query "birch"during the years 2018-2022 on the territory of Ukraine was observed in the regions located in the forest zone, where Betula has the widest spread. Despite of the war, in the year 2022, this list included Sumy and Chernihiv'regions, which were affected by the war in the spring of 2022. Other key regions were Ternopil', Zhytomyr, Volyn and Rivne oblasts. All are located in the forest zone of Ukraine. Interestingly, the same trend was observed in all studied years preceding year 2022, yet, interest to birch was higher.
What is more, peaks of this interest coincided rather with the beginning than with the peak of the season in all investigated years. For example, in 2022 the highest rate of the "birch"queries was observed on March 30, just on the first day of the season, when Betula pollen concentrations exceeded a pollen symptoms threshold in 25 pollen grains / m3 established for birch in Ukraine by our earlier studies.
Query "birch allergy"was much less popular, and its peaks were observed all year round: from 22 to 26 of March, from 1st to 7th of May, from June 26 to July 2, 2022, and from 8 to 14th of January 2023. Peaks in May, June and July may suggest either a lack of data on pollen allergy in customers or their will to check what factors may cause symptoms in summer. Peaks of interest to birch allergy in January and March can be evidence of customers'preparation for the time of the possible symptoms. Thus, Google trends suggest the highest interest in birch pollen allergy at the beginning of the pollen season, when the first symptoms'threshold is reached, and a month prior to a season, possibly due to the will to be ready for the season start.

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Detecting plane trees in the city using open access remote sensing data: chances and challenges.

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Plane trees (Platanus sp.) are common ornamental city trees in Poland, planted often along roads, avenues and in parks. Their number has been increasing in recent years, however they produce large amount of wind-transported pollen, which can induce allergy symptoms. It is very likely that plane tree allergy will be more frequent in near future, especially in urban societies. Allergy sufferers can partially limit the contact with plane pollen by avoiding places with high concentrations during pollen season. It is possible thanks to pollen concentration forecasting, based mostly on source location data. Unfortunately available street greenery inventories are lacking for most of cities while acquisition and maintenance are expensive and time consuming. Growing accessibility of remote sensing technology, for instance consumer grade drones, makes opportunity to efficiently detect location of specific plants. Nevertheless for large areas it is still often beyond possibilities of local authorities and data acquired this way can be quickly outdated. Therefore this study explores potential of using access free, remote sensing data to detect plane trees in highly urbanized environment of Poznań.
Airborne laser scanning point cloud was used to derive location of treetops above 6 meters tall. Then small part of them (n = 912) from city center was manually marked to one of four classes: young plane tree, mature plane tree, other species or artifacts. Three aerial photo orthomosaics in CIR and RGB composition, as well as point cloud were used to extract variables values. Circular buffers (r = 1 m) around treetops were used to avoid shadowing effect, overlapping crowns influence and other obstacles. Random Forest machine learning classifier was applied to assess variables importance and tag treetops in 2 km radius around standard, Hirst-type volumetric pollen trap. The model performed

well during 10-fold cross validation on training set (OA ≈ 86%, κ ≈ 80%), however when implemented on broader area, significant overestimations in number of plane trees are observed. Pollen concentration data and wind direction was also compared with predicted number of plane trees in eight main directions from pollen monitoring station. Result showed that using open access remote sensing data to detect trees producing allergenic pollen is promising alternative method, although it has many limitations, as these products were not planned for plant research. One of the most serious issue in this method seems to be "radial shift"effect. Real position misalignment of objects above ground surface, compared to pixels representing them on basic orthophotomap, is causing noises in spectral characteristic, making detection challenging. To summarize, better accuracy is possible to achieve through well suited data acquisition. However using free of charge public administration data to scientific purposes can be beneficial to our knowledge about pollen sources.

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Health risks associated with fungal aeroallergens at public places after Covid-19 pandemic

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The presence of some specific fungal spores in a public place is becoming a serious health issue in many parts of the world. The allergenic potential of fungal spores and its sensitization in the local population is increasing after COVID-19 pandemic. An investigation regarding the concentration and seasonal occurrence of fungal aeroallergens at selected public places was carried out for two years in different cities of Pakistan. The high concentration of fungal spores belonging to Aspergillus, Alternaria, Fusarium, Mucor, Rhizopus, Penicillium, Cladosporium, Phoma and Epicocum were isolated from the air around the public places. The quantitative and qualitative analysis of isolated aerial fungal species revealed that maximum spore concentration was calculated from April to October. The clinical record of regular visitors of these sites revealed that the number of patients having respiratory disorders have been increased. The fungal species of Aspergillus, Mucor, Rhizopus, Penicillium, Phoma and Alternaria were dominant in all selected places. The seasonal variations in fungal spores was also recorded, and some fungal spores were restricted to specific metrological conditions. The presence of fungal spores having allergenic potential may cause serious health concerns as sensitization to bioaerosols has been increased after COVID-19 pandemic.

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A Modified Spectroscopic Approach for the Real-Time Detection of Pollen and Fungal Spores at a Semi-Urban Site Using the WIBS-4+

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Primary biological aerosol particles (PBAP) such as pollen and fungal spores has received attention in recent years owing to the increased awareness of their impacts on human and plant health. Real-time methods based on spectroscopy/holography are now favoured over the traditional volumetric Hirst method, which is very labour intensive and time consuming. The Wideband Integrated Bioaerosol Sensor (WIBS) and its generational models have been deployed previously for the detection of bioaerosols in a range of different environments. The WIBS operates on the basis of light induced fluorescence and provides information on a particle's size, shape and fluorescent characteristics. In this study, a modified Wideband Integrated Bioaerosol Sensor (WIBS) 4+ model was evaluated for its ability to detect and differentiate ambient PBAP classes. The WIBS-4 model was

adapted to include 2 additional fluorescent detection bands designed to target pollen specific fluorophores such as chlorophyll which has been shown in previous work.
The WIBS-4+ was deployed for a period of 50 days at a semi-urban sampling site in Saclay. Following various filtering and unsupervised learning methods it was concluded that the WIBS-4+ was capable of detecting and differentiate between broad bioaerosol classes. The additional channels improved clustering attempts, making k-means clustering a possible solution for high-resolution WIBS data and also allowed for the improved differentiation between tree (R2 = 0.8), herbaceous (R2 = 0.6) and grass (R2 = 0.4) pollen and fungal spores (R2 = 0.8).
During the sampling campaign meteorological and air quality data were also recorded in order to examine the effects that these parameters play on the concurrent pollen and fungal spore concentrations sampled by the Hirst and the fluorescent aerosol particles sampled by the WIBS-4+. Temperature was the most influential parameter in terms of pollen production and release, showing strong positive correlation with herb and grass pollen and a notable negative correlation with tree pollen. On the other hand, relative humidity and rainfall were the most influential parameters for fungal spore concentrations.
Due to the proximity of the sampling site to a major urban the influence of non-biological pollutants on sampling site, and Hirst /WIBS signals, were also examined. The vast majority of air quality parameters had a negative association with fungal spore concentrations. Whereas SO4, organic matter, ozone (O3) and Less-Oxidized Oxygenated Organic Aerosols (LOOOA) illustrated notable positive correlations with daily pollen concentrations, attributed to similarities in preferential meteorological conditions and geographical origins. In the case of the WIBS-4+, several fluorescent aerosol particle classes showed strong correlation with recorded air pollutants. Black carbon and NOx concentrations possessed incredibly high associations (r>0.7) with B, BC and E type particles indicating the overall potential of the WIBS as not only a bioaerosol monitor but potentially as an air quality monitor.

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Towards integrated and automated bioaerosol monitoring and assessment systems

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Aerobiology in Ukraine:outcomes of the war

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Trends in Alternaria and Cladosporium spore seasons in Poznan, Poland during 1996-2020

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The fungal spores of the genus Alternaria and Cladosporium are among the most common causes of allergy reactions. Therefore, the investigation of changes in the pattern of spore seasons, along with their causes, is essential in the context of assessing future allergic risk. The main aim of the study was to determine the temporal variation in Alternaria and Cladosporium spore seasons in

Poznań over 25 years (1996-2020) and indicate their possible causes as well as consequences for city residents. These analyses were performed based on: 1) the fungal spore data collected by the volumetric sampler of Hirst design located in the Poznań city centre, 2) local meteorological data, and 3) land use change data within 30km from the monitoring station. The annual sum of Alternaria and Cladosporium spores increased significantly ($p<0.05$) during the studied period ($r2=0.51$ and $r2=0.38$, respectively).
Similarly, the number of days with elevated levels of spores, i.e. 100 s/m3 for Alternaria and 3000 s/m3 for Cladosporium, also significantly ($p<0.05$) increased. The annual sums of spores were related to several meteorological parameters, for example positively with minimum June temperature and number of thunder days, and negatively with number of days with rain, fogginess and dew. This suggests that weather conditions have a clear effect on the intensity of the Alternaria and Cladosporium spore seasons. No clear impact of land use changes on spore concentration was observed. In summary, the increase in the fungal spore level in Poznań is presumably caused by the changes in climate during the last decades, although the impact of other factors such as changes in agricultural practices (e.g. fungicide uses, crop types, no-till farming) should also be taken into account and considered in further studies.

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eDNA analysis of pollen and spores from central England during 2016-2018

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