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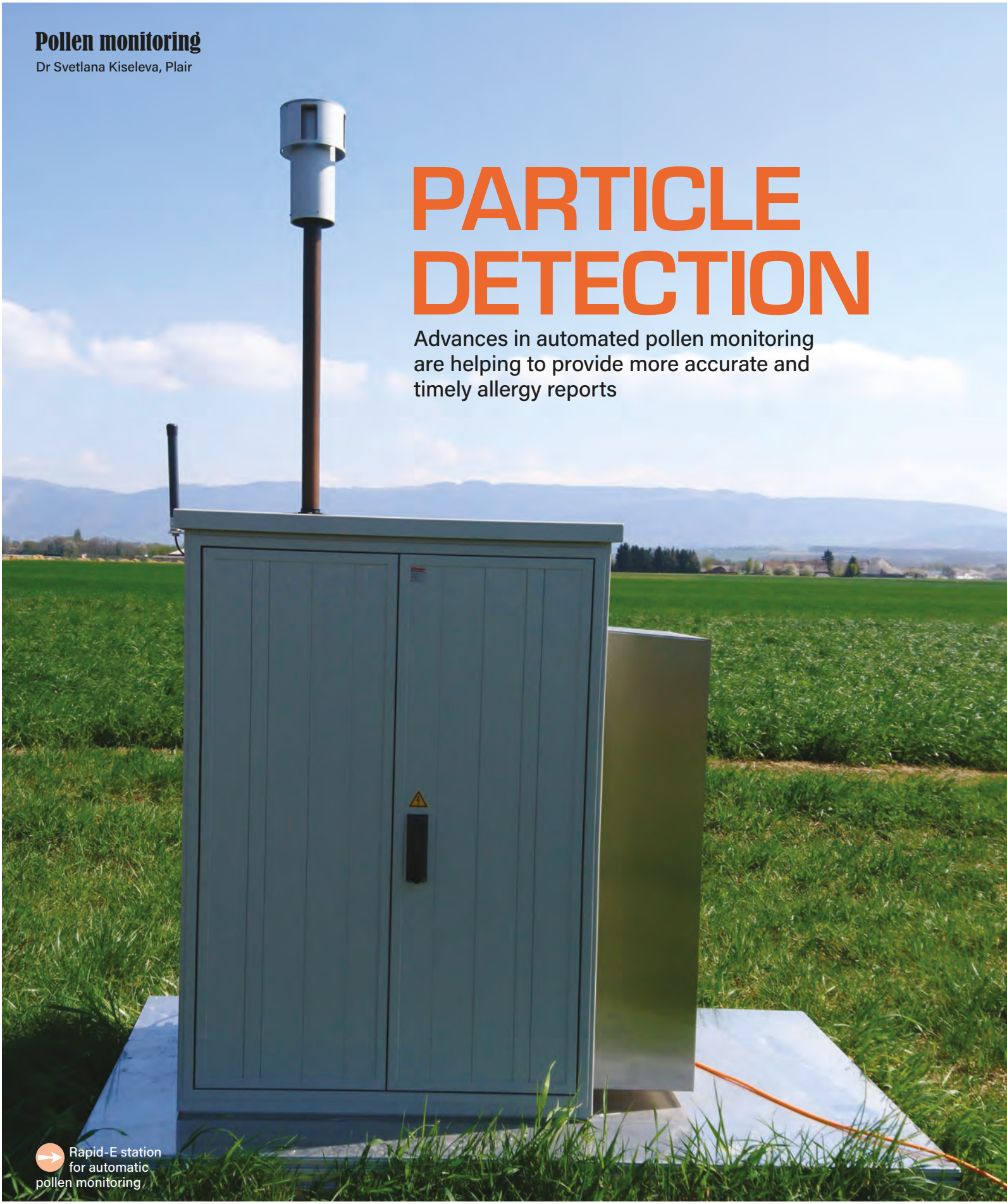
PARTICLE DETECTION

Advances in automated pollen monitoring are helping to provide more accurate and timely allergy reports



Rapid-E station for automatic pollen monitoring

Pollen allergies are costly. According to the European Federation of Allergy and Airways Diseases (EFA), the total spend on asthma is estimated at €72.2bn (US$88.8bn) per year in Europe alone. Globally, pollen grains from trees, weeds and grasses are estimated to affect 25-30% of the world's population. Airborne pollen measurement networks are therefore essential in helping to prevent, diagnose and treat pollen-related allergies.

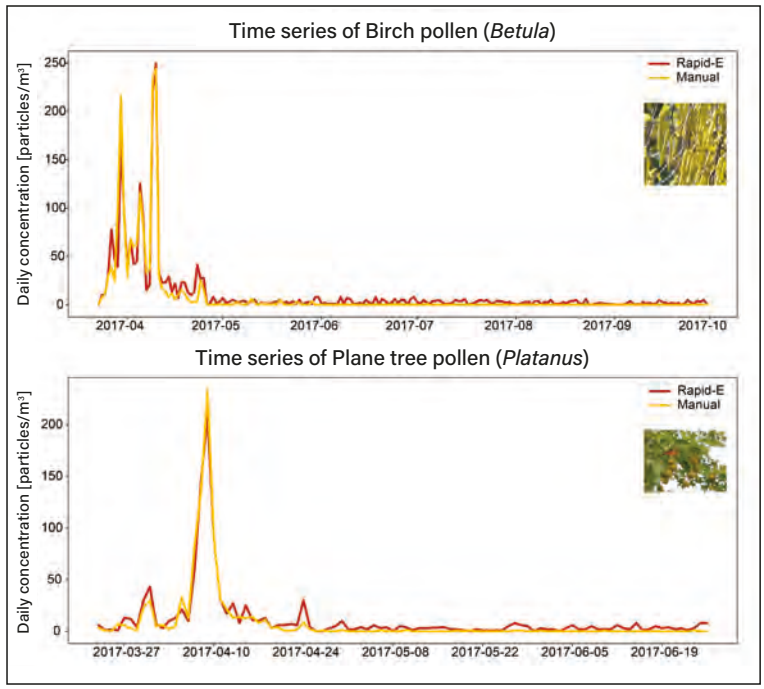
The Rapid-E from Plair is an all-optical aerosol detector that makes real-time pollen observations possible. Also referred to as the Real-Time Airborne Particle Identifier, it is designed to instantaneously detect and identify allergens, such as pollens and spores, as well as other particulates including air pollutants and dust. The instrument has been tested and evaluated for automatically counting 15 pollen species, including birch, hazel, pine, cypress, oak, ash, plantain, plane, hornbeam and elm trees. It can also account for foxtail grass, orchard grass, vernal grass, ragweed and sorrel. New pollen species can also be added to the system via a simple calibration process.

Rapid-E is equipped with an outdoor housing that withstands continuous outdoor operation in all weather conditions. It also includes an online dashboard, the PlairGrid, to display real-time data acquired in the field. The PlairGrid enables hourly viewing and management of data, as well as daily counts of different pollen types.

DATA RESOLUTION: POLLEN COUNT PER HOUR

Rapid-E uses proprietary laser-sensing technology for real-time analysis of airborne particles, as a result of research and development at the University of Geneva, Switzerland. Several prototype generations were developed and tested under practical field conditions. After several predecessors, Rapid-E was optimized for more efficient detection of particles in the range 0.5-100µm. The instrument automatically counts up to hundreds of thousands of particles per hour and analyzes each individual airborne particle by means of interaction with light – scattering and fluorescence.

Rapid-E generates real-time data with the highest resolution to date – down to pollen count per hour. This provides an important input for weather services and allergy experts, who that can use Rapid-E measurements for reliable short- and long-term pollen forecasting. In comparison, alternative methods for pollen monitoring still depend on particle samplers and time-consuming manual pollen identification under the microscope. This requires trained personnel and involves high running costs. Such data is only available after a delay of two to eight days and only for a limited number of monitoring sites.



Time series of Birch pollen (*Betula*) and Plane tree pollen (*Platanus*) over six months of continuous measurement using Rapid-E

SUCCESS STORY

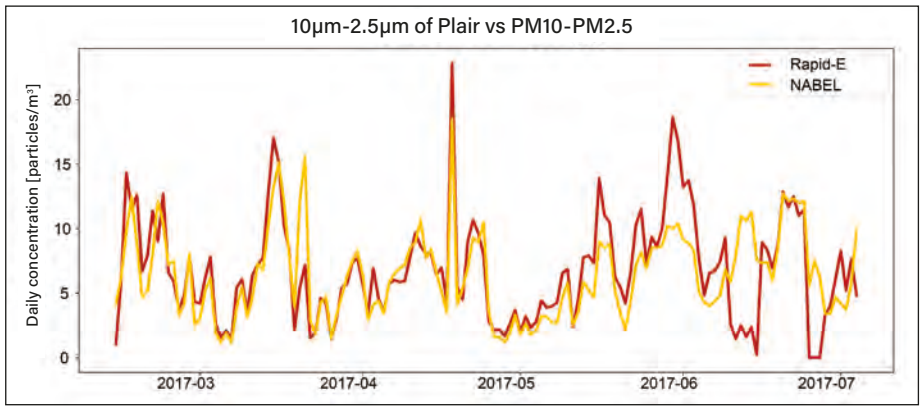
In 2017 the first Rapid-E was installed in Brussieu, France, near the coordination center of the RNSA, the French national aerobiology network, which is the only official source of pollen counts in France. Automatic pollen measurements were performed continuously over eight months side by side with the traditional method based on a Hirst-type pollen trap. During the season, RNSA experts calibrated Rapid-E on 15 pollen species, which were added to the instrument's library. This library contains the features of typical optical fingerprint signals of pollen species obtained by the Rapid-E's detectors. Using these features, which are unique for each pollen type, proprietary artificial intelligence (AI) algorithms were able to identify and extract the time series of pollen species from the raw data. Rapid-E followed calibrated species over the full season, achieving a precision range of 73-98%. Moreover, correlation with the manual total pollen attained 90% accuracy.

The graph above shows the time series measurements of birch (*Betula*) and plane tree (*Platanus*) pollen. It includes the data obtained by the Rapid-E and the Hirst-type pollen trap used as the reference. The yellow line represents the manual counts from the Hirst-type pollen trap installed next to the Rapid-E. The purple line represents the time series of automatic pollen counting extracted from the Rapid-E raw data, thanks to the sophisticated algorithms.

CASE STUDY: SIMULTANEOUS POLLEN AND AIR POLLUTION MONITORING

Allergies are also known to be aggravated by air pollution. In 2017 a project supported by the Swiss Federal Office for the Environment (FOEN), in partnership with MeteoSwiss, tested Rapid-E on its ability to track pollen and air pollution. Three Rapid-E instruments were installed in the cantons of Geneva, Vaud and Ticino, at the measuring sites of MeteoSwiss and FOEN. The focus was made on the detection of coarse dust particles ($PM_{10-2.5}$) and particles containing traces of polycyclic aromatic hydrocarbons (PAHs). PAH originates from road traffic and industrial emissions, and exposure to it is considered hazardous due to its link to lung cancer.

Standard instruments such as optical counters (Fidas-200 from Palas and EDM #180 from GRIMM Aerosol Technik & Co) and filter samplers for PAH collection (DIGITEL Aerosol Sampler DHA-80) provided by FOEN were run in parallel to compare results from Rapid-E for air pollution monitoring. It is important to note that while methods for dust measurement are conducted in real time, the detection of



Comparison of $PM_{10-2.5}$ measurements between Rapid-E (average daily mass concentration of particles between 2.5µm and 10µm) and reference data provided by the Swiss National Air Pollution Monitoring Network (NABEL) for Magadino station

pollutants such as PAHs is generally carried out with manual methods using sampling from filters. The filters are analyzed by gas chromatography coupled to a mass spectrometer (GC-MS analysis).

Together with air pollutants, all three Rapid-E instruments had to count different types of pollen such as birch, hazel, ash, hornbeam, plane tree, cypress, orchard grass, ragweed and others. So the main challenge of this project was to have the same measurement instrument capable of separating organic and non-organic dust from pollen grains with further identification of species, all in real time. Similar to the previous case, Rapid-E was first calibrated to local pollen species in Vaud by MeteoSwiss. The performed calibrations were then automatically applied to the other two Rapid-E instruments. To verify and compare the Rapid-E measurements, the Hirst-type pollen samplers were run in parallel and operated by MeteoSwiss experts.

The measurement campaign lasted for five months and exceeded initial expectations. All calibrated pollen species were identified and counted with a precision of 80-95% compared with the counts obtained with the Hirst traps. In addition to the high precision reached in pollen species identification, Rapid-E achieved a false positive identification rate of approximately 5% per pollen species.

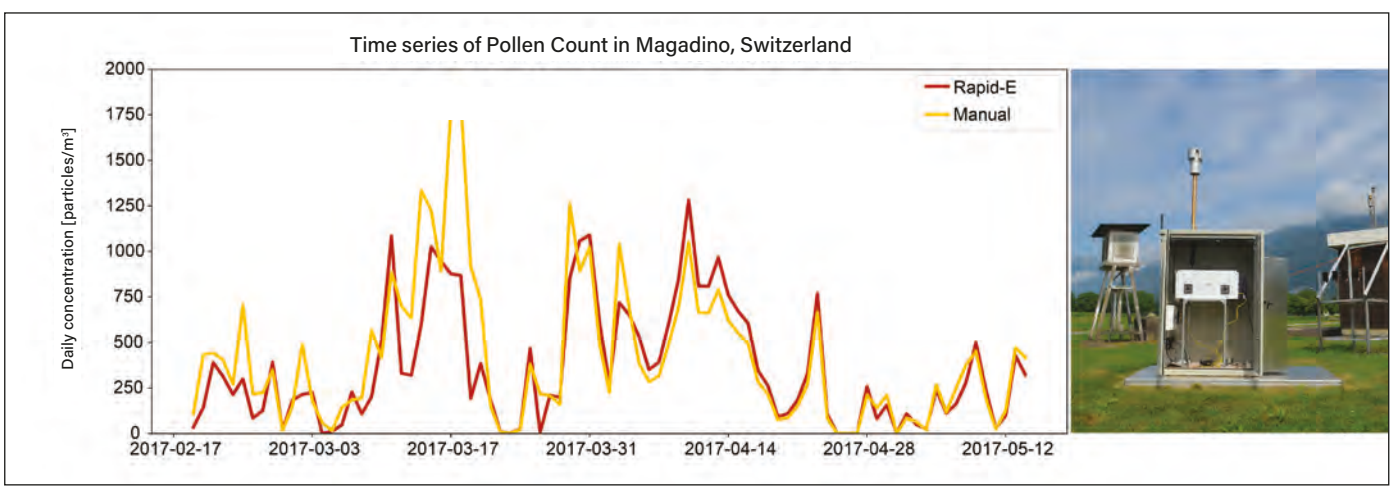
For air pollution detection, all three Rapid-E instruments demonstrated around 90% correlation with standard environmental monitors for $PM_{10-2.5}$ and PM_{10} values through the whole period.

The most innovative part of the project was to evaluate Rapid-E's capabilities in detecting traces of PAHs in solid dust particles. To verify the obtained results, a standard daily PAH filter sampling and post-laboratory analysis were performed. At the end of the campaign all three instruments could identify and count particles containing fluoranthene/pyrene mixture with correlation more than 70% compared with filter sampling. These compounds typically originate from traffic and heating systems. A second group of PAHs also successfully identified spectral signatures such as that of the compound retene. The presence of this group perfectly coincided with reports of forest fire, especially in Ticino canton.

FUTURE PERSPECTIVE

According to Plair, the projects to date have demonstrated the versatility of Rapid-E in environmental monitoring for health and air quality applications. In the case of pollen monitoring, while the instrument has been tested for the detection of pollen specific to Europe, Rapid-E can also be applied to new regions. In such a case, the instrumentation must be calibrated to local pollen varieties to ensure the most precise means of identification.

Simultaneous monitoring of dust and PAH containing particles by Rapid-E opens new horizons to combine all measurements in one instrument. Real-time data on pollen generated by Rapid-E enables forecasting models to be improved with better dissemination of the pollen risk levels, which can lead to better risk management for allergic diseases, improved planning for outdoor activities, and cost reduction. In addition precise data on air pollutants provides the necessary tools to help cities determine and better manage sources of air pollution. ▮



Time series of total pollen count measured by Rapid-E and comparison with the reference