Accurate real-time bioaerosol monitoring

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Biological aerosols (mainly pollen and fungal spores, but also bacteria, viruses and plant debris) are released into the air by plants, fungi, and other living organisms. They are ubiquitous in the atmosphere, although their concentration and composition can vary significantly in time and by location. Bioaerosols can act as cloud condensation nuclei as well as ice nuclei, influencing the hydrological cycle and climate. Moreover, pollen monitoring can underpin ecology studies on vegetation shifts and invasive species, e.g. related to fragile ecosystems in high Alpine regions or the Arctic which are greening rapidly due to climate change. Information on bioaerosols is also crucial for agriculture and forestry, where real-time data about the presence of pathogens, mostly fungi, are necessary for protecting agricultural production and developing knowledge-based technologies.

For more than sixty years, bioaerosol monitoring networks were based on manual methods, i.e. particles were collected on a suitable substrate and then counted with an optical microscope. These methods suffer from poor time resolution (typically 24 hours) and long delays in data availability (typically 7-9 days).

Recent technological developments and machine learning (ML) have made it possible to automate bioaerosol monitoring, revolutionising the information that can be made available to end-users. In this work, we will present a laboratory-based method for characterising the performance of automated bioaerosol monitors as a whole unit (i.e. hardware plus identification algorithms) based on the use of well-controlled pollen aerosols and a reference method for particle counting known as Lagrangian Particle Tracking (LPT) using the Double-Pulse Shake-the-Box (STB) processing algorithm. The experiments were carried out with the SwisensPoleno Jupiter bioaerosol monitor (Swisens, Switzerland). This monitor combines light scattering, inline digital holography and ultraviolet laser-induced fluorescence (UV-LIF) with artificial intelligence, providing measurements of particle size and shape, number concentration and particle identification/classification. The performance of the ML algorithm was characterised in terms of pollen-taxon true-positive classification rate under controlled environmental conditions, and the calibration of the total particle number concentration was extended up to 70 µm to cover almost the entire size range of airborne pollen particles. Based on this, a new method has been developed to determine taxon-specific calibration factors for the Poleno, which are traceable to national standards. The method can be applied to any type of bioaerosol monitor.

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