SOMETHING'S IN THE AIR – BUT WHAT EXACTLY?

In winter, nitrogen oxide emissions from road traffic increase in cities like Vienna, affecting people's health. To date methods for measuring this provided only an incomplete picture. A research group from Vienna is now trying to close the gap.

Stefan Schreier stands 130 meters above the ground in front of a sheer drop. He adjusts a device in a stainless steel housing with a lens pointing up into the sky, mounted on the highest platform of the Arsenal radio tower in Vienna. A fibre optic cable runs from the device to a small maintenance room equipped with a spectrometer and a laptop. Since 2018, this scientific instrument has been measuring pollutants in the air above Vienna, especially nitrogen dioxide, which has attracted heightened public attention as a combustion by-product from diesel engines. In combination with two identical devices installed on buildings of the University of Natural Resources and Applied Life Sciences and on the University of Veterinary Medicine, the units monitor Vienna's city centre and measure air quality in areas that were previously inaccessible to scientific investigation.

Measuring device for scattered light

Air quality measurements are normally carried out close to the ground. The City of Vienna has a network of 17 measuring stations distributed throughout the city. These stations carry out point measurements, but do not enable the city to determine what the distribution of the pollutants is over the city. Environmental physicist Stefan Schreier and his team at the University of Natural Resources and Applied Life Sciences in Vienna now want to close this gap in a project funded by the Austrian Science Fund FWF. They use a measuring instrument called "MAX-DOAS", short for "Multi AXis Differential Optical Absorption Spectroscopy". Spectroscopes like the three MAX-DOAS units in Vienna measure characteristic deviations in the colour composition of light. The necessary know-how comes from Bremen, where Schreier wrote his PhD thesis at the Institute of Environmental Physics, which is also a partner in the project. The project's great novel achievement: "For the first time, we can now directly measure the vertical distribution of nitrogen dioxide over the Vienna city area," explains the researcher.

3D image of pollutant distribution

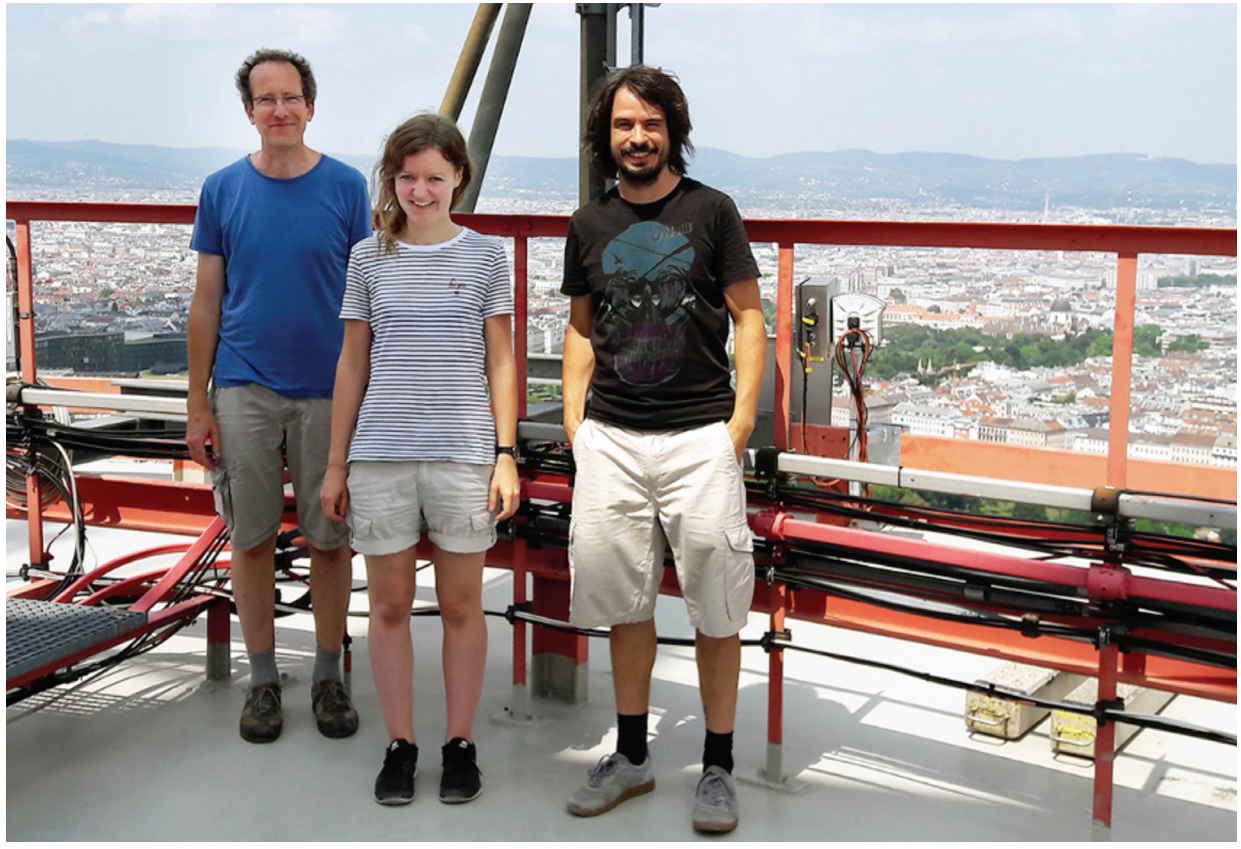
Depending on the weather conditions and the amount of aerosols in the air, the three instruments can look several kilometres into the distance. Since their measuring ranges overlap, special opportunities arise, as Schreier explains: "We try to derive the spatial distribution of nitrogen dioxide from the many horizontal measurements of the three MAX-DOAS devices." According to the researcher, the method can be compared to the functioning of computer tomography. The resulting three-dimensional picture of the distribution of nitrogen dioxide over Vienna is the project's main objective. For instance, measurements from 2019 showed how, on a day with an easterly wind, the polluted air from the busy streets and industrial areas in the southeast of the city is transferred to the west.

New measuring techniques enable 3D images that show the distribution of air pollutants, as in this pilot project. Source: Kezia Lange

Complementing satellite measurements

But the researcher is also working towards a greater goal: information on nitrogen dioxide distribution in the atmosphere is provided also by a satellite operated by ESA that measures nitrogen dioxide in the Earth's atmosphere from space. "The first instrument of this kind was launched into space in 1995," reports principal investigator Schreier: "It had a spatial resolution of more than a hundred times a hundred kilometres per pixel. The Tropomi spectrometer on board the European satellite Sentinel-5p has been conducting measurements since 2017. Its data provide a global picture of the nitrogen dioxide distribution with a horizontal resolution of seven by three kilometres, which corresponds to a few pixels spanning the city."

The satellite measurements are expected to furnish important information about health-affecting air pollutants. It is not known exactly, however, how much these measurements tell us about the air quality just above the ground – i.e. where people are located. The MAX-DOAS instruments installed by Schreier and his team are thus designed to help validate the ESA data. "Satellite measuring devices cannot be repaired if their reliability deteriorates," explains Schreier. "Therefore, it is important to be able to compare the results with terrestrial measurements so that they can be corrected if necessary." Also, satellite measurements do not indicate the exact elevation at which the nitrogen dioxide is found.



The project team from left: Andreas Richter, Kezia Lange (Bremen) and principal investigator Stefan Schreier (BOKU Vienna). Source: Helmut Kropf

Measuring for ESA

ESA takes a keen interest in the topic, which is why it launched a campaign in 2016 comparing different DOAS devices, in which Schreier's team took part: "Our first device was tested in Bremen after it had been built. Immediately afterwards a measurement campaign by ESA took place in Holland, involving MAX-DOAS instruments from different research groups." Schreier's measuring device did well in that campaign, as can be gleaned from a recently published paper. In late 2016, after the end of the campaign, the device was installed in Vienna and has been busy measuring since then. A few months later the second MAX-DOAS device also arrived in the Austrian capital. "In the course of the project, I felt that having a third device in the south of the city would be interesting," says Schreier. In 2018, a third measuring device from the University of Bremen was then installed on the 155-metre-high Arsenal radio tower in Vienna's 3rd district.

Monitoring of other pollutants

There are practical reasons for why Schreier's team is currently focusing on nitrogen dioxide, as the researcher explains: "Nitrogen dioxide is the trace gas that can best be detected by means of the DOAS method." In a next step, the Vienna MAX-DOAS measurements are however designed to look into other pollutants, including particulate matter. "We also measure gases that are responsible for the formation of ground-level ozone, which is very harmful to human health," says Schreier. The latter is work in progress. The five-year project will run until 2021.

Personal details

Stefan Schreier is an environmental physicist at the University of Natural Resources and Applied Life Sciences in Vienna. His research focuses on ground- and satellite-based remote sensing of trace gases and aerosols in the atmosphere, in particular on absorption spectroscopy with emphasis on the chemical composition of the troposphere.

Publications

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Author Contact Details

scilog, editorial staff, Austrian Science Fund FWF • Tel: +43/1-505 67 40-8117 • **Web: https://scilog.fwf.ac.at**