Traffic density, wind and air stratification influence concentrations of air pollutant nitrogen dioxide

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In connection with the effects of the COVID-19 pandemic, satellite measurements made headlines showing how much the air pollutant nitrogen dioxide (NO_2) had decreased in China and northern Italy. In

Germany, traffic density is the most important factor. However, weather also has an influence on NO2 concentrations, according to a study by the Leibniz Institute for Tropospheric Research (TROPOS), which evaluated the influence of weather conditions on nitrogen dioxide concentrations in Saxony 2015 to 2018 on behalf of the Saxon State Office for Environment, Agriculture and Geology (LfULG). It was shown that wind speed and the height of the lowest air layer are the most important factors that determine how much pollutants can accumulate locally.

In order to determine the influence of various weather factors on air quality, the team used a statistical method that allows meteorological fluctuations to be mathematically removed from long-term measurements. The air quality fluctuates, in some cases very strongly, due to different emissions and the influence of the weather. Until now, however, it has been difficult to estimate, what share legal measures such as low emission zones or diesel driving bans have and what share the weather influences have in the actual air quality? With the method used, this will be easier in the future.

NO_2 is an irritant gas which attacks the mucous membrane of the respiratory tract, causes inflammatory reactions as an oxidant and increases the effect of other air pollutants. As a precursor substance, it can also contribute to the formation of particulate matter. Limit values have been set in the EU to protect the population: For nitrogen dioxide, an annual average value of 40 micrograms per cubic meter of air applies ($\mu g/m^3$). To protect the health of the population, measures must be taken if these limit values are not complied with. In 2018/2019, for example, various measures were taken in Germany, ranging from a reduction in the number of lanes (e.g. in Leipzig) to driving bans for older diesel vehicles (e.g. in Stuttgart).

To evaluate the effectiveness of such measures, it would be helpful to

determine the exact influence of weather conditions. The Saxon State Office for Environment, Agriculture and Geology (LfULG) therefore commissioned TROPOS to carry out a study on the influence of weather factors on NO2 concentrations and provided its measurement data from the Saxon air quality measurement network and meteorological data for this purpose. The researchers were thus able to evaluate data from 29 stations in Saxony over a period of four years, which represent a cross-section of air pollution—from stations at traffic centers to urban and rural background stations and stations on the ridge of the Erzgebirge mountains. They also calculated the height of the lowest layer in the atmosphere and incorporated data from traffic counting stations in Leipzig and Dresden into the study. A method from the field of machine learning was used for the statistical modeling, the application of which in the field of air quality was first published by British researchers in 2009.

In this way, the study was able to demonstrate that the traffic density at all traffic stations is most significantly responsible for nitrogen oxide concentrations. However, two weather parameters also have a significant influence on nitrogen dioxide concentrations: wind speed and the height of the so-called mixing layer. The latter is a meteorological parameter that indicates the height to which the lowest layer of air, where the emissions mix, extends. "It was also shown that high humidity can also reduce the concentration of nitrogen dioxide, which could be due to the fact that the pollutants deposit more strongly on moist surfaces. However, the exact causes are still unclear," says Dominik van Pinxteren.

The statistical analysis has also enabled the researchers to remove the influence of the weather from the time series of pollutant concentrations: Adjusted for the weather, the concentration of nitrogen oxides (NOx) decreased by a total of 10 micrograms per cubic meter between 2015 and 2018 on average over all traffic stations in Saxony. In urban and rural areas and on the ridge of the Erzgebirge, however, NOx

concentrations tend to remain at the same level. Even though there have been some improvements in air quality in recent years, there are good scientific arguments for further reducing air pollution.

In a way, this also applies to premature conclusions from the corona crisis: in order to find out how strong the influence of the initial restrictions on air quality actually was, the influence of the weather would have to be statistically removed in a longer series of measurements. To this end, investigations for the Leipzig area are currently underway at TROPOS, as is a Europe-wide study of the EU research infrastructure for short-lived atmospheric constituents such as aerosol, clouds and trace gases (ACTRIS), the German contribution to which is coordinated by TROPOS. Tilo Arnhold

More information: Dominik van Pinxteren et al. (2020): Meteorological influences on nitrogen dioxide: Influence of weather conditions and weathering on nitrogen dioxide concentrations in outdoor air 2015 to 2018. Series of publications of the LfULG, issue 2/2020 (in German only)

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