PM2.5 levels over Europe during the first COVID19 lockdowns were controlled by NH3

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Ammonia (NH3) has played a vital role in the evolution of human population. Today it is recognized to have negative influence, not only for the environment, but also for human population and the climate.

The largest portion of atmospheric ammonia originates from nitrogen fertilizers, and thus agriculture, while another important source is livestock.

In previous years, atmospheric ammonia observations were mostly ground-based with sparse monitoring networks resulting in large emission uncertainties in regions poorly covered by measurements. Today, satellite products are available to record daily ammonia concentrations providing useful information on its atmospheric abundance.

The COVID-19 outbreak in 2020 affected all segments of life in a detrimental way. As a measure to inhibit further spread of the virus, authorities took strict social, travel and working restrictions for months, which resulted in improved air quality. Guevara et al. (2021) reported average emission reductions in Europe to be 33% for NO_x, 8% for non-methane volatile organic compounds (NMVOCs), and 7% for SO_x during the strictest lockdowns in 2020, while more than 85% of the total reduction is attributed to road transport.

While the COVID-19 lockdown impact on primary emissions has been studied extensively, how ammonia emissions were affected in Europe is unknown. The latter is very important and may have largely moderated the atmospheric levels of particulate matter, because of ammonia's contribution to secondary aerosol formation. Here, we use satellite ammonia and a novel inversion algorithm to infer ammonia emission changes before, during and after the European lockdowns in 2020. We validate the results against ground-based observations from EMEP (https://emep.int/mscw/). Finally, we calculate the resulting impact on the formation of PM2.5 using a chemistry transport model (CTM).

Ammonia posterior emissions declined by -9.8% as compared to the same period over the previous four years (Fig. 1). Interestingly, the posterior emissions are insensitive to the meteorological conditions in 2020. Although the obtained posterior emissions for the reference period are very similar with respect to annual variance, emissions during the lockdown dropped outside the emissions variance of the reference period.

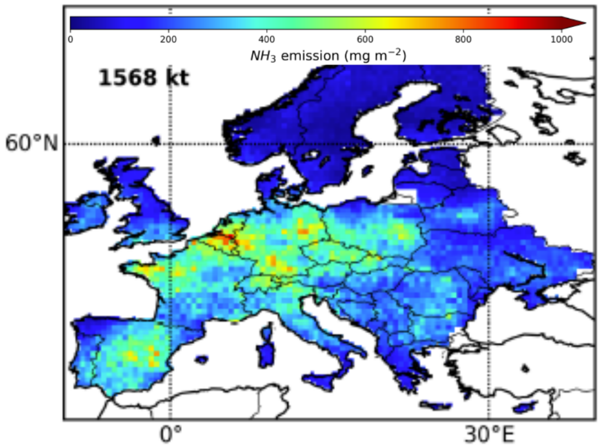

Figure 1. Posterior NH3 in the first half of 2020.

During the lockdown, activities stopped, and emissions decreased with an immediate effect on SO_2 and NO_x (Guevara et al., 2021). SO_2 and NO_x reduction caused less production of sulfuric and nitric acids with a rapid twofold effect on the lifetime of ammonia (Fig. 2): (i) Less available atmospheric acids caused less ammonia removal towards secondary aerosol production (PM2.5) and therefore the loss-rates declined leading to accumulation of ammonia in its free form; (ii) ammonia originates mainly from agriculture and livestock, whose emissions continued to increase in 2020.

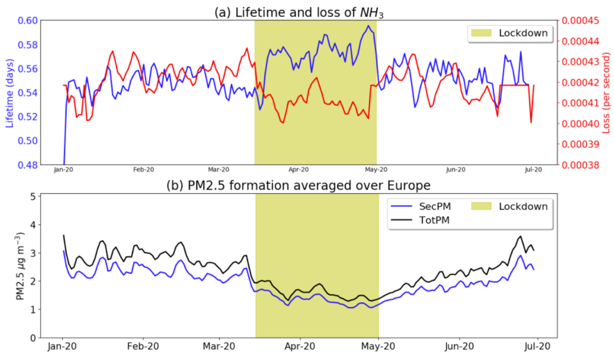

Figure 2. Lifetime and loss of NH3 in relation with secondary aerosol formation.

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