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Variations in European ammonia emissions due to daily weather fluctuations and climate change

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Ammonia plays an important role in atmospheric processes. It is the main alkaline component in the atmosphere and is highly reactive in forming either aerosols or by depositing fast to most surfaces including sensitive ecosystems. The geographical distribution of ammonia emission has been highly studied, while the temporal variations have been somewhat neglected. Climate and daily meteorology affects the temporal distribution and the amount of ammonia emissions. This forms an important feed-back mechanism e.g. by changing ammonia emissions thus affecting aerosol composition and the sensitive ecosystems through associated nitrogen depositions. This feed-back mechanism has so far been overlooked in climate change and earth system science studies.

Here we assess annual variations in ammonia emissions in central and Northern Europe as well as emission changes due to projected temperature changes in the future. We use the dynamical ammonia emission model (Skjøth et al., 2011) within the DAMOS system (Geels et al., 2012) with focus on the period 2000-2100. The model use hourly meteorological data from the MM5 model and bias-corrected climate data from the ENSEMBLES project. The model reproduces hourly changes in ammonia emissions due to climate and is also capable of taking into account changes in production methods as well as policy measures. Here we study the effect of climate change on five main agricultural sources to ammonia: 1) heated stables, 2) open cattle barns, 3) storage facilities, 4) animal waste and mineral fertilizer 5) grazing animals. Climate change increase emissions due to increased temperatures. The expected increase in ammonia emissions is typically 20-40% for cattle barns, storage facilities and application of manure in form of animal waste. Heated stables (e.g. pigs and poultry) are only marginally affected by climatic changes as these sources typically are heated to maintain a constant temperature. The heated stables therefore have a more or less uniform emission profile throughout the year. The model study also show large geographical variations in overall annual emission potential with more than a factor of three higher ammonia emissions from storage facilities in Northern Italy compared to Northern Europe. Similar, but smaller variations are also seen for other sources as well on national scale such as in Germany, France and Italy.

Climate also affects the seasonality of agricultural production. This is taken into account by the model by simulating earlier application of fertilizer due to a change in crop growth. However, a society-climate feedback mechanism that leads to adaption within the agricultural sector (e.g. changes in crop types from barley to sun flower) has not been included.

Overall, the study shows that the variations in meteorology cause variations in the ammonia emissions that can be of the same magnitude as the variations in current national ammonia emission inventories, e.g. from identical source types within a country. These variations can be substantial for large countries like Germany, France and the UK. This suggests that the effect of daily fluctuations in meteorology as well as an overall geographical dependent climatic effect on ammonia emissions must be dynamically incorporated into modern Chemistry-Transport Models or Earth System Models. One method could be to adopt a similar methodology for ammonia as for Biogenic Volatile Organic Compounds for an improved assessment of nitrogen deposition and particle formation of nitrogen containing compounds.

References:

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