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Model assessment and validation of ammonia emissions from agriculture at high spatial and temporal resolution over Europe

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Ammonia emissions to the atmosphere have increased substantially in Europe since 1960, largely due to agricultural practices including intensive livestock production and the use of fertilizers. These practices have enhanced deposition of ammonia and ammonium in the form of solutes, gases and particles causing negative societal impacts on health and terrestrial ecosystems. Due to the limited availability of ground-based measurements, models are used to assess large-scale ammonia emissions from agriculture. The modeled emissions are in turn used in chemistry transport models (CTMs) to assess ammonia concentration and deposition. One of the CTMs, LOTOS-EUROS, combined with the MACC-III emission model, is used to create grid maps of annual ammonia emissions over Europe at a spatial resolution of 7km x 7km. However, MACC-III does not distinguish differences in crop types, housing and storage systems, and manure application technique in its spatial allocation. Furthermore, it utilizes very simple parameterizations for the seasonal variation to allocate ammonia emissions over one year, not taking into account local agricultural management. This limits the capability to reproduce observed spatial and seasonal variations in the ammonia concentrations of rural regions with agricultural activities.
This paper describes a novel ammonia emission model that quantifies emissions from agriculture at a higher spatial detail and gives insight to the temporal dynamics over the course of a year. The higher spatial detail is realized by embedding INTEGRATOR into MACC-III. INTEGRATOR is a model that assesses greenhouse gases and nitrogen fluxes from agricultural sectors at high spatial resolution and accounts for differences in crop types and grass, grazing, manure application and housing and storage systems. The much more detailed temporal distribution comes from the integration of the TIMELINES model, which provides predictions of timelines of key agricultural operations across Europe. The emission estimates were imported into LOTOS-EUROS and validated with ground-based measurements and satellite observations. The total columns obtained from the renewed ammonia emission estimates showed a better correspondence with IASI satellite observations than the ones retrieved with the original MACC-III results. Furthermore, at selected grounds stations from the European Monitoring and Evaluation Program (EMEP) framework, newly modeled surface ammonia concentrations demonstrate closer temporal variations with in-situ measurements.

Keywords: ammonia emission, atmospheric modelling, agriculture