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Global NH₃ emissions from livestock management : development of a module within a land surface model and impact on atmospheric chemistry

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Ammonia (NH₃) is a key species in the atmosphere, playing a crucial role in air quality and climate through the formation of sulfate and nitrate particles. Moreover, NH₃ surface deposition alters ecosystems. About 85% of NH₃ global anthropogenic emissions are related to food and feed production and in particular to the use of mineral fertilizers and manure management. Even though the estimate of the emissions from livestock can reach 36 Tg N/yr, they are generally not represented explicitly in global land surface models. Most global chemistry transport models rely on bottom-up emission inventories subject to large uncertainties. Our objective consists of replacing these external emissions data by dynamical emissions computed by ORCHIDEE, a terrestrial ecosystem model including the carbon and the nitrogen cycles. This new version of the ORCHIDEE model includes a detailed integrated scheme for livestock management, from housing and storage to grazing emissions. Ultimately, our work aims at developing an interactive nitrogen cycle model in a coupled climate-chemistry-vegetation model in order to investigate the impact of NH₃ emissions from livestock on atmospheric chemistry and climate, and the associated feedbacks.

In this study, we describe and present global NH₃ emissions from livestock calculated based on the new version of the ORCHIDEE land surface model. We evaluate NH₃ emissions simulated by ORCHIDEE with previous inventories and model estimates. An analysis of key parameters driving the soil NH₃ emissions (pH of the manure, the timing of the N application, the surface atmospheric concentration etc...) have also been performed in order to assess the sensitivity of the simulated emissions. Last, we investigate the impact of prescribing these new simulated emissions on atmospheric chemistry, using the global atmospheric chemistry transport model LMDZ-OR-INCA. The simulated NH₃ atmospheric columns are evaluated by global and regional comparisons with the spaceborne IASI instrument measurements. The products used are monthly gridded NH₃ distributions using morning observations of IASI-(Metop)A and IASI-(Metop)B for the period 2011-2017. In addition, we compare the ammonia atmospheric columns simulated based on the dynamical livestock emissions and based on reference bottom-up emission inventories. Finally, we investigate the impact of the different NH₃ emission inventories on key atmospheric species

concentrations.