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Soil NO inventory from large scale farming in France: impact on atmospheric NO_2 and O_3 concentrations

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Objectives and Methodologies

In a previous paper [1] we developed a model predicting NO emissions from soils, based on relationships between soil nitrification and NO emission rates obtained from laboratory incubations. The model was successfully tested against experimental field data. In this model, the NO production represents about 2% of the total nitrification rate. The nitrification rate itself is calculated as the product of three functions depending on topsoil temperature, ammonium content, and moisture content. Here, we report results of a nation-wide inventory of NO emissions from arable land, carried out in France using a simplified version of our NO model and a survey of current agricultural practices.

The survey of agricultural practices was conducted at the regional scale; it included information's about the doses and timing of fertilizer nitrogen applications for major crops including cereals, oil crops, and industrial crops. Legume, perennial and horticultural crops, grasslands were not considered in this study. In France, the selected crop area represent about 57% of the global agricultural land cover (277 725.65 km^2). Using the areas and the time distributions of the nitrogen applications over the whole year for each of the selected crops, we produced average time series of soil $N\text{-}NH_4$ content per hectare for the 22 French administrative regions. To take endogenous NH_4production resulting from the net mineralisation of soil organic matter into account, a background content of 0.9 kg N-NH_4 ha^{-1} was added year-round to the above time series.

The new algorithm of soil NO emission, including seasonal variations of soil NH_4 contents, was subsequently included into the MM5-CHIMERE model of atmospheric chemistry and transport [2]. In this version, soil water contents and temperature were provided at the European scale by the MM5 model [3]. Impacts of the soil NO sources on the NOx and O_3 concentrations were then evaluated in the Western Europe.

Major Results

The mean time series of soil NH_4 content pinpointed large differences from one region to the other in timing and in magnitude. The NH_4 contents per hectare varied largely with the day of year (DOY), and depended on the distribution of the areas affected to the various crops for each region. Major nitrogen inputs are carried out between early in February through the end of May, with a peak occurring in February and March for the Northern regions, and in April for the Southern regions. For the regions with the highest yields of production, the mean nitrogen inputs are around 180 kg N ha^{-1} and are only around 70 kg N ha^{-1} for the lowest ones. Over the total cropped area considered (160 171 km^2 in size), the NO-soil emissions represented about 49.6 Kt EQ NO_2 an^{-1}. The ratio between N-NO source and N-input is equal to 0.80%, and represents about 1.23% of the ammonia nitrogen inputs. In France, arable land would contribute to about 5% of the nation-wide NO sources.

Using the CHIMERE model, the additional NO_2 and O_3 concentrations resulting from the NO soil sources were then estimated. In France, during the month of June 2003, the NO-soil source resulted in an average increase of 0.2 to 0.7 ppb for NO_2, and from 2 to 3 ppb for O_3. The contribution of these sources was highest in intensive agricultural regions, in the large Parisian basin.

References

[1] P. Laville, C. Hénault, B. Gabrielle, D. Serça. Measurement and modelling of NO fluxes over maize and wheat crops during their growing seasons: effect of crop management (accepted for publication in Nutriment Cycling in Agro Ecosystem).

[2] http://euler.lmd.polytechnique.fr/chimere/index.html

[3] http://www.mmm.ucar.edu/mm5/