AN AMMONIA EMISSION MODEL FOR FERTILISER APPLICATIONS SUITABLE FOR USE IN CLIMATE CHANGE SCENARIOS

Mark R. Theobald[1], David Makowski[2], Carole Bedos[3], Julie Ramanantenasoa[3], Sophie Génermont[3]

[1] Higher Technical School of Agricultural Engineering, Technical University of Madrid (UPM), Madrid, Spain
[2] INRA, AgroParisTech, UMR 122 Agronomy, F-78850 Thiverval-Grignon, France
[3] INRA, AgroParisTech, UMR 1091 EGC, Environment and Arable Crops, F-78850 Thiverval-Grignon, France

INTRODUCTION

The field-application of organic and mineral fertilisers is a large source of ammonia (NH_3) emissions in Europe. In addition to management factors (e.g. fertiliser application rates), these emissions are strongly dependent on soil properties and climatic conditions. Including this dependence in the NH_3 emission data used in chemical transport models (CTMs, such as the EMEP Unified Model) would improve the spatial and temporal distributions of the emissions. This is particularly important for climate change simulations since changes in air temperatures and precipitation patterns could have a large influence on the temporal and spatial distribution of NH_3 emissions from fertilisers. In this work, meta-models have been developed for three fertiliser types (slurry, farm yard manure; FYM and the mineral fertiliser urea ammonium nitrate; UAN) using emission estimates from a modified version of the process-based model Volt'Air[1,2] for a large range of European soil and climate conditions. These simple meta-models, which have a much shorter run-time than Volt'Air, are suitable for inclusion into the emission routines of CTMs using spatial soil data and the CTM meteorological data in order to better represent the spatial and temporal distributions of NH_3 emissions.

META-MODEL DEVELOPMENT

Soil data

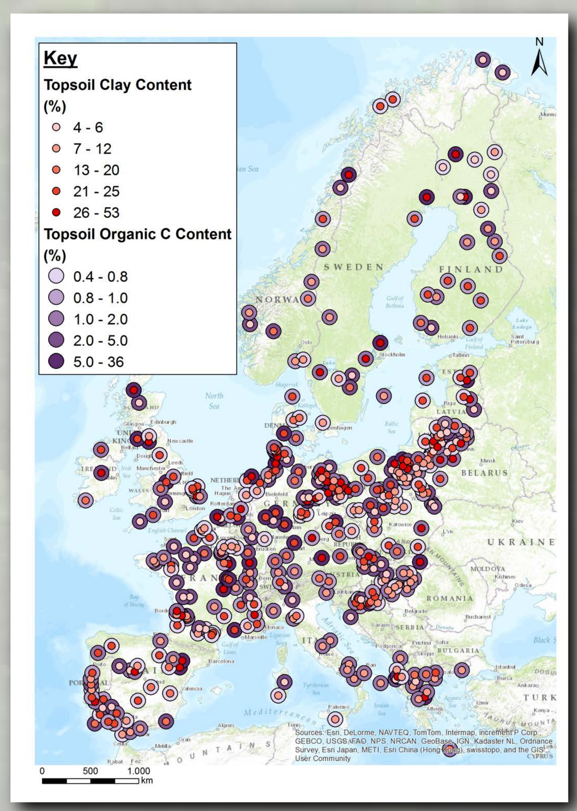

Figure 1: Spatial distribution of two of the soil parameters used. Sources: European Soil Database[3] and FAO Harmonized World Soil Data Base[4].

Meteorological data

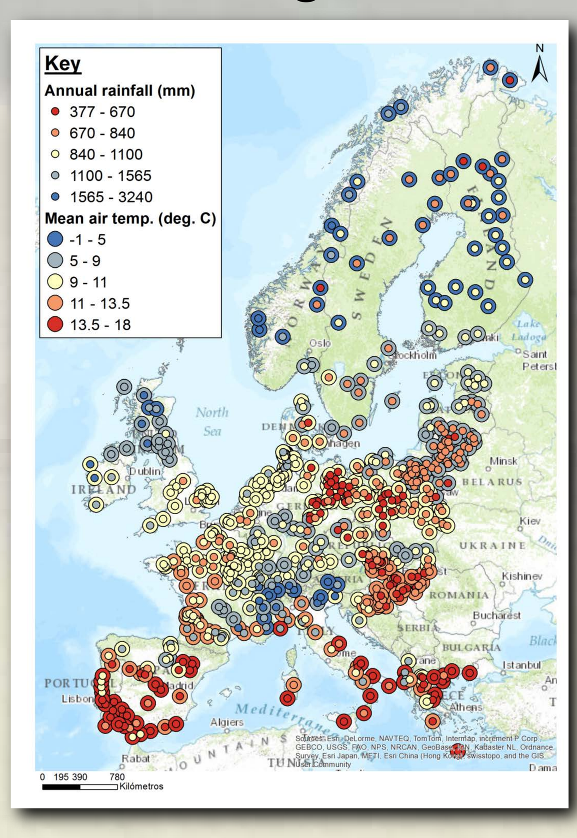

Figure 2: Spatial distribution of two of the meteorological variables used (taken from the 2008 simulation of the EMEP MSC-W model).

1. Soil physical and chemical parameters and hourly meteorological data collected for 522 European locations.

2. Volt'Air simulations for spring and summer applications of slurry, FYM and UAN for all 522 locations for representative agricultural practices.

3. Analysis of model predictions.

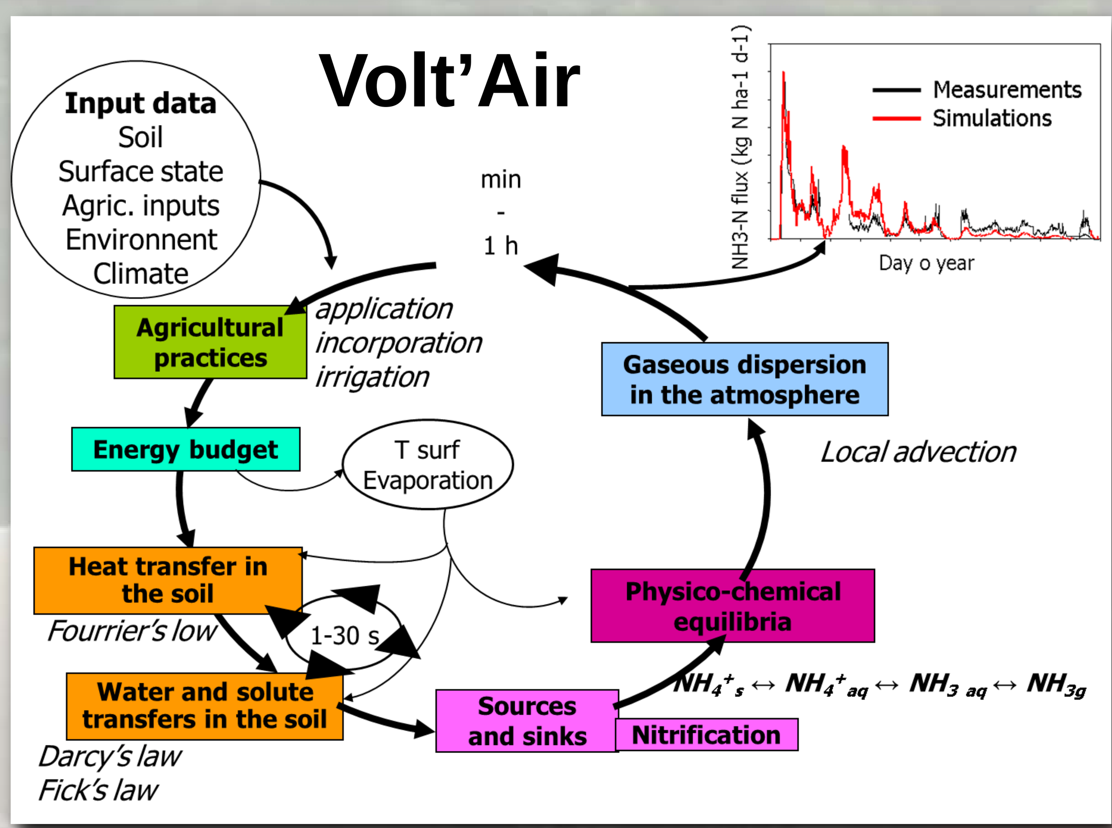

Figure 3: Schematic of the Volt'Air process-based model.

4. Development and evaluation of three meta-model formulations to predict the percentage of total ammoniacal nitrogen (TAN) emitted in the Volt'Air simulations using the soil and meteorological variables:

Meta-model 1: Multiple linear regression of the logarithm of total emission (% TAN)

Meta-model 2: Multiple linear regression of the transformed total emission:

$$t(\%TAN) = \ln\left[\frac{1}{(100/\%TAN)-1}\right]$$

Meta-model 3: Multiple linear regression of the residuals after fitting a logistic curve to the temperature response of the total emission

Volt'Air emission predictions

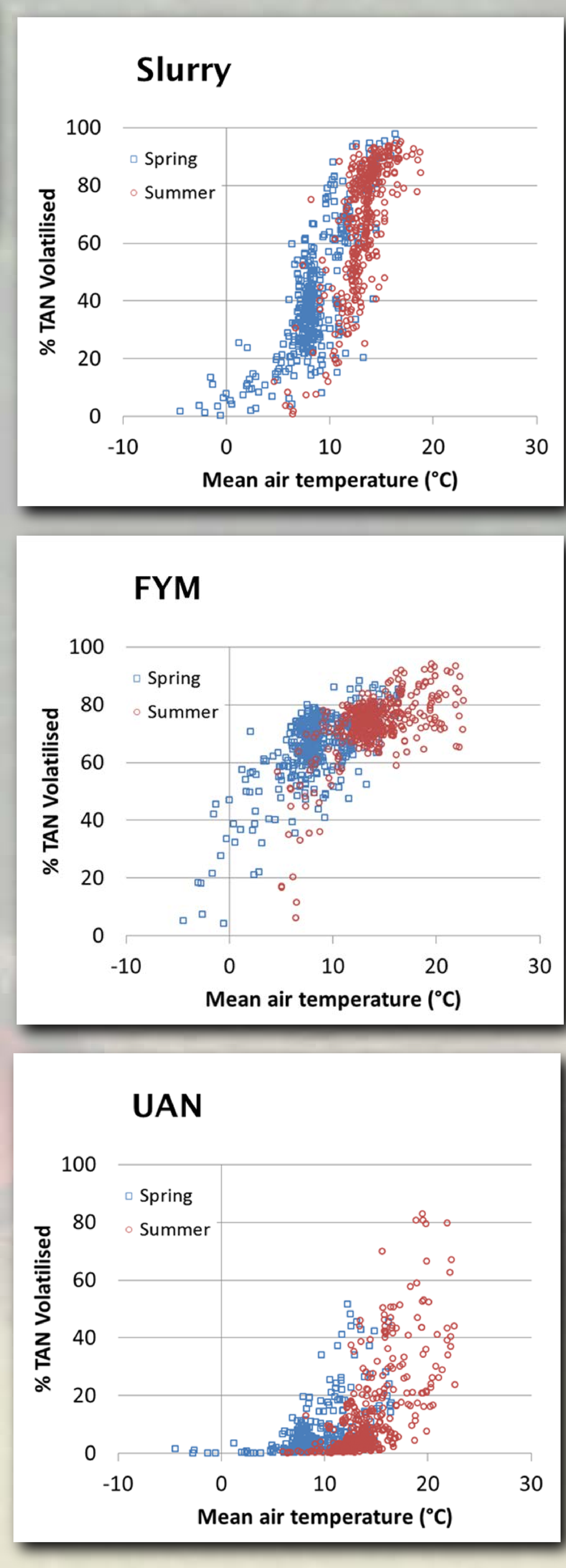

Figure 4: Model predictions of the percentage of total ammoniacal nitrogen (TAN) emitted in each simulation for the three fertiliser types plotted against mean air temperature following application

EVALUATION OF THE META-MODELS

- A performance assessment of the three meta-model formulations shows that Meta-model 2 recreates the Volt'Air predictions best overall although Meta-model 3 performed better for FYM (Table 1);
- The best overall model (Meta-model 2) deviates from the Volt'Air predictions for slurry, FYM and UAN by an average of 16%, 8% and 24%, respectively;
- The predictions of this model correlate well with those of Volt'Air, except for FYM, due to the small range of the majority of the Volt'Air predictions and an overestimation of emissions for the low emission scenarios (Figure 5), although the mean error is smallest for this fertiliser type;
- For slurry, FYM and UAN, the mean emission predictions of Meta-model 2 (55%, 70%, 9%, respectively) compare well with the emission factors from the EMEP/EEA air pollutant emission inventory guidebook[5] (55%, 79% and 10%, respectively).
- Further work is needed to validate the meta-model predictions and extend the model to include different management practices (e.g. application rates, application methods, etc.)

Metric	Meta-model 1	Meta-model 2	Meta-model 3
Slurry			
Relative root mean squared error (RRMSE)	0.29	**0.22**	**0.22**
Relative mean absolute error (RMAE)	0.21	**0.16**	0.17
Coefficient of determination (R^2)	0.69	**0.77**	**0.77**
FYM			
Relative root mean squared error (RRMSE)	0.13	0.11	**0.10**
Relative mean absolute error (RMAE)	0.10	0.08	**0.07**
Coefficient of determination (R^2)	0.48	0.59	**0.61**
UAN			
Relative root mean squared error (RRMSE)	1.11	**0.48**	0.65
Relative mean absolute error (RMAE)	0.36	**0.24**	0.45
Coefficient of determination (R^2)	0.74	**0.88**	0.77

Table 1: Summary of the performance evaluation for each meta-model formulation and for each fertiliser type. Values in bold blue type indicate the best performing model for each metric.

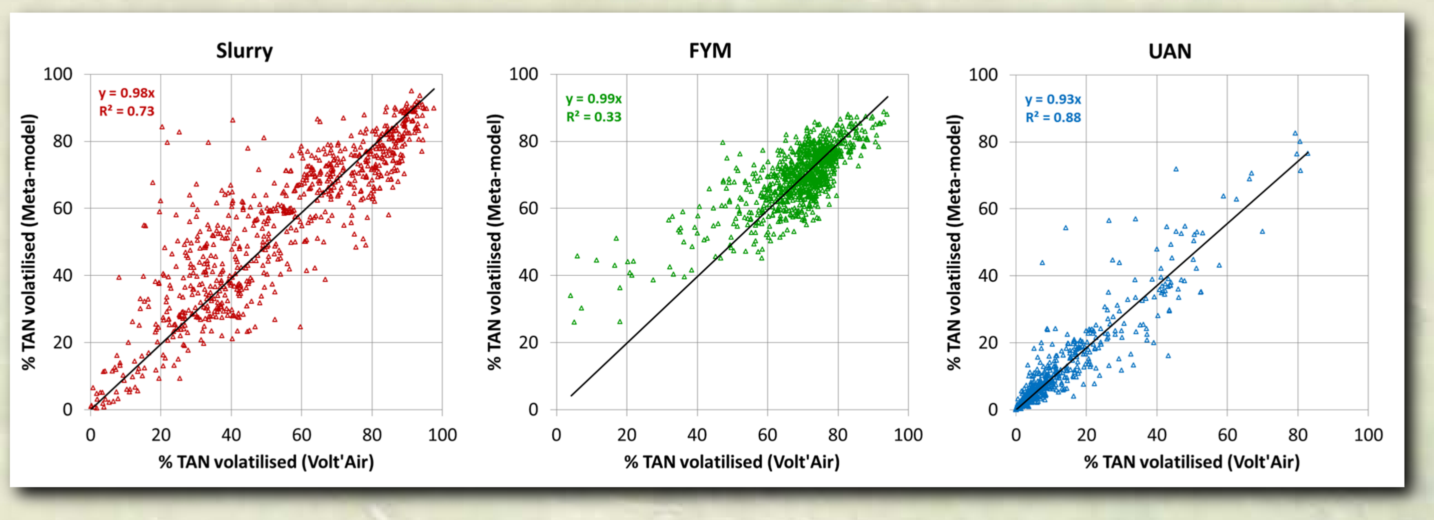

Figure 5: Predictions by Meta-model 2 of the proportion of TAN volatilised plotted against the Volt'Air predictions for the three fertiliser types. Note: Regression line has been forced through the origin.

REFERENCES AND ACKNOWLEDGEMENTS

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[3] Panagos Panos. The European soil database, 2006. GEO: connexion, 5 (7), pp. 32-33.
[4] FAO/IIASA/ISRIC/ISS-CAS/JRC, 2008. Harmonized World Soil Database (version 1.0). FAO, Rome, Italy and IIASA, Laxenburg, Austria.
[5] EMEP/EEA air pollutant emission inventory guidebook 2013.

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