Sensitivity of the process-based model DNDC on microbiological parameters

Adrian Leip, Marco Follador, Stefano Tarantola, Mirko Busto, Nathalie Villa-Vialaneix

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Leip A.[1], Follador M.[1], Tarantola S.[2], Busto M.[1], Villa-Vialaneix N.[3.4]

1) European Commission, Joint Research Centre, Institute for Environment and Sustainabilit

2) European Commission, Joint Research Centre, Institute for the Protection and Security of the Citizen

3) IUT de Perpignan (Dpt STID, Carcassonne), Univ. Perpignan Via Domitia, France

4) Institut de Mathématiques de Toulouse, Université de Toulouse, France

adrian.leip@jrc.ec.europa.eu

Overview

Process-based model such as DNDC rely on a large numbers of parameters which were defined by the model developer on the basis of existing references. Subsequently, some values have been changed to improve model performance for specific applications, often without adequate documentation. Many of these parameters are thus estimates of the real values appropriate for local conditions introducing approximation errors for applications at larger scales. Spatially explicit datasets might be required for some parameters for which model output is highly sensitive. We will present a sensitivity analysis of 38 mainly micro-biological internal parameter of DNDC-EUROPE.

Methods

We test 38 mostly, currently internal, soil microbiological parameters required to simulate rates of nitrification, denitrification, and soil organic matter turnover on its sensitivity to estimated rates of N_2O fluxes and nitrate leaching. The selected parameter include microbiological parameters describing population dynamics of denitrifying and nitrifying organisms as well as the characterization of soil carbon pools and their mineralization rates. The shape of the probability density functions was assumed to be triangular, when the range of a parameter could be obtained from literature data. In such cases, the default value was set as the mode and the maximum and minimum values of the rages were set as the extremes of the distribution. When no information on the range was available, we opted for a normal distribution with a CV of 20% around the nominal values. Input data for simulations of N_2O and N-leaching with the DNDC-EUROPE model model set-up are described in detail elsewhere (Follador *et al.*, 2011; Leip *et al.*, 2008).

First, a list of sample points from the marginal pdfs of the k input parameters using a quasi-Monte Carlo generator (Sobol', 1967) is generated. It consists of blocks of with $k+2$ rows, where the first two rows are the coordinates of two independent realizations A and B and the subsequent k rows represent points having in turn all coordinates from A but one that is from B. In order to achieve convergence we generated 166 blocks resulting in 6640 simulations to be carried out at each simulation unit.

Second, we apply both a machine learning, a random forest meta-model (Villa-Vialaneix *et al.*, 2011), and the method of Sobol' as improved by Saltelli et al (2010). Here we focus on the random-forest approach.

Sensitivity of DNDC to the internal parameters was tested indirectly by (i) developing a R-metamodel based on the first 200 simulations carried out at 997 randomly selected HSMUs from the training set as described in Follador *et al*. (2011). The importance of the variables is then as the increase in the mean square error (MSE) when the variable's values in the out-of-sample observations (OOB) for each tree are randomly permuted before running the simulation. A decrease in the goodness of prediction, compared to the performance obtained with the original variable's value, defines the score of importance. As this assessment is based on OOB, it does not depend on the learning process and on the way the regression is built.

Results

Figure 1 shows the ranking of the importance for the tested parameters for the simulation of N_2O fluxes and N-leaching with the random-forest model. Most important parameters for both fluxes are parameters related to denitrification, i.e. the ratio of denitrifiers to total microbial biomass and the maintenance coefficient of denitrifiers on NO. N_2O fluxes were not sensitive on tested "soil parameters", but C/N ratio of humads and biomass was important for N-leaching. The tested nitrification parameter played a minor role for both N-fluxes. Parameters controlling soil carbon dynamics are particularly important for N_2O fluxes, ranking third and forth in importance.

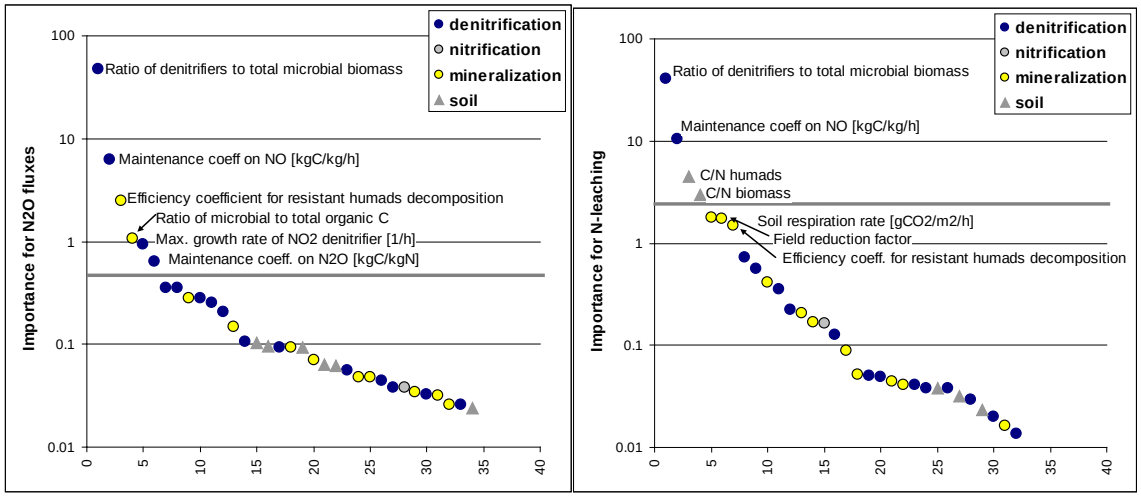

Fig. 1. Ranking of importance of tested microbiological parameters

References

Follador M., Leip A. and Orlandini L. (2011). Assessing the Cross-Compliance effects on European agricultural environment with DNDC-EUROPE. Environ. Pollut. doi:10.1016/j.envpol.2011.01.025

Leip A., Marchi G., Koeble R., Kempen M., Britz W. and Li C. (2008). Linking an economic model for European agriculture with a mechanistic model to estimate nitrogen and carbon losses from arable soils in Europe. *Biogeosciences* 5 (1): 73-94.

Saltelli A., Annoni P., Azzini I., Campolongo F., Ratto M. and Tarantola S. (2010). Variance based sensitivity analysis of model output. Design and estimator for the total sensitivity index. *Computer Physics Communications* 181 (2): 259-270.

Sobol' I. M. (1967). Distribution of points in a cube and approximate evaluation of integrals. *Zh. Vych. Mat. Mat. Fiz. 7: 784–802 (in Russian); U.S.S.R Comput. Maths. Math. Phys. 7: 86–112 (in English).*

Villa-Vialaneix N., Follador M., Ratto M. and Leip A. (2011). Metamodels comparison for the simulation of N2O fluxes and N leaching from corn crops. *Environmental Modelling and Software* submitted.