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Sensitivity of the process-based model DNDC on microbiological parameters

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Abstract

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.

Objective

- Test mechanistic model DNDC (Denitrification Decomposition) on ist sensitivity of internal paremeters
- Output parameters tested: N2O fluxes, NO fluxes, carbon stock changes and N-leaching
- Identify parameter for which the output parameters are insensitive → model simplification
- Identify parameters for which the output parameters are most sensitive → additional efforts required to provide spatially explicit values of the parameters

Method

1) 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.
2) DNDC is run for 800 blocks of *k*+2 rows with realizations of the *k* parameters (→ 32000 runs for each spatial unit)
3) Sensiitivity analysis is done with two different methods
   - Method of Sobol' as improved by Saltelli et al (2010)
   - A random forest meta-model (Villa-Vialaneix *et al.*, 2011)

#	Acronym	Parameter description	Value	Process	Distribution
1	DRF	Specific decomposition rate - field reduction factor	0.045	soil carbon turnover	Normal
2	EFFRB	Efficiency coefficient for labile humads decomposition	0.67	soil carbon turnover	Triangular
3	srh	Soil respiration rate per hour	0.16	soil carbon turnover	Triangular
4	RBO	Ratio of microbial to total organic C	0.02	soil carbon turnover	Triangular
5	SRB	Sulfate reducing bacteria	0.9	soil carbon turnover	Normal
6	krcvl	Specific decomposition rate residues, very labile	0.25	soil carbon turnover	Normal
7	krcl	Specific decomposition rate residues, labile	0.074	soil carbon turnover	Normal
8	krcr	Specific decomposition rate residues, resistant	0.02	soil carbon turnover	Normal
9	KRB	Rate of decomposition (fast decomposable microbes)	0.12	soil carbon turnover	Normal
10	hrb	Rate of decomposition (slow decomposable microbes)	0.04	soil carbon turnover	Triangular
11	EFFNO	Efficiency coefficient for resistant humads decomposition	0.2	soil carbon turnover	Triangular
12	KCI	Half-saturation value of soluble carbon	0.017	soil carbon turnover	Normal
13	KNI	Half-saturation value of nitrogen oxides	0.083	soil carbon turnover	Normal
14	FD	Ratio of denitrifiers to total microbial biomass	0.05	denitrification	Triangular
15	um_no3	Max. relative growth of NO3- denitrifiers	0.67	denitrification	Normal
16	um_no2	Max. relative growth of NO2 denitrifiers	0.67	denitrification	Normal
17	um_no	Max. relative growth of NO denitrifiers	0.34	denitrification	Normal
18	um_n2o	Max. relative growth of N2O denitrifiers	0.34	denitrification	Normal
19	YMC	Max growth rate of denitrifiers on soluble carbon	0.503	denitrification	Normal
20	MC	Maintenance coefficient on carbon	0.0076	denitrification	Normal
21	m_no3	Maintenance coefficient on NO3	0.09	denitrification	Normal
22	ym_no3	Maximum growth rate on NO3	0.401	denitrification	Normal
23	R		0.29	denitrification	Normal
24	m_no2	Maintenance coefficient on NO2	0.349	denitrification	Normal
25	ym_no2	Maximum growth rate on NO2	0.428	denitrification	Normal
26	ym_no	Maximum growth rate on NO	0.151	denitrification	Normal
27	m_no	Maintenance coefficient on NO	0.0792	denitrification	Normal
28	ym_n2o	Maximum growth rate on N2O	0.151	denitrification	Normal
29	m_n2o	Maintenance coefficient on N2O	0.0792	denitrification	Normal
30	D_O2	O2-diffusion in air	0.07236	denitrification	Normal
31	K35	Nitrification rate at 35ºC	25	nitrification	Triangular
32	QK	Crop maintenance respiration quotient	2	soil	Normal
33	RCNRVL	C/N ratio residue, very labile	5	soil	Normal
35	RCNR	C/N ratio residue, resistant	100	soil	Triangular
36	RCNB	C/N ratio microbial biomass	10	soil	Normal
37	RCNH	C/N ratio humads	10	soil	Normal
38	RCNM	C/N ratio humus	10	soil	Normal

Results

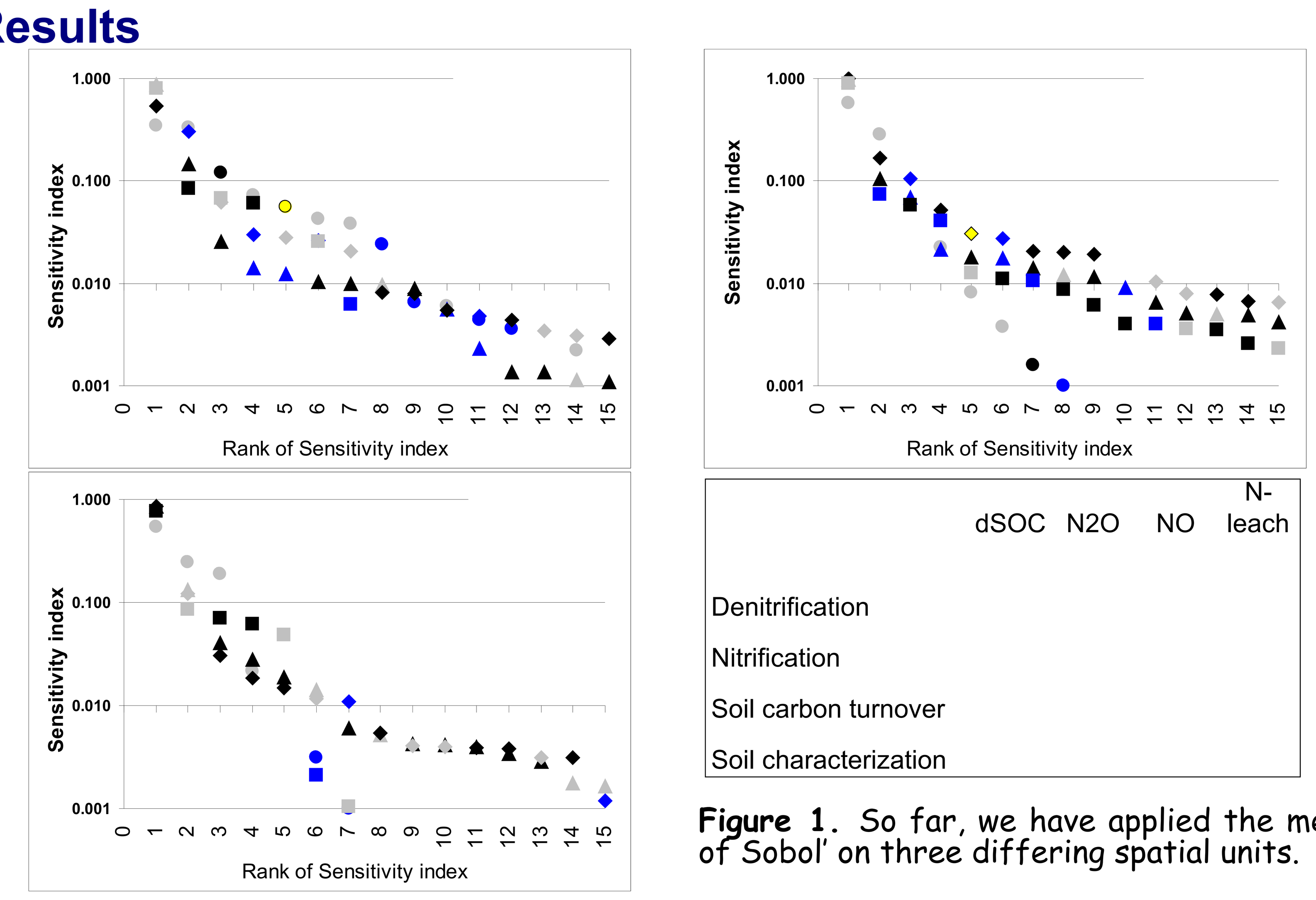

Figure 1. So far, we have applied the method of Sobol' on three differing spatial units.

	345		941		9744	
Max. relative growth of NO2 denitrifiers	*NO*	*0.99*				
Specific decomposition rate - field reduction factor	*N2O*	*0.97*	dSOC	0.24	*N2O*	*0.88*
Specific decomposition rate residues, labile	*Nlch*	*0.90*			*Nlch*	*0.80*
Ratio of denitrifiers to total microbial biomass			*N2O*	*0.85*		
Ratio of denitrifiers to total microbial biomass			*NO*	*0.85*	*NO*	*0.54*
Ratio of denitrifiers to total microbial biomass			*Nlch*	*0.77*		
Soil respiration rate per hour	*dSOC*	*0.58*	*dSOC*	*0.54*	*dSOC*	*0.33*
Ratio of microbial to total organic C			dSOC	0.19	dSOC	0.35
Efficiency coefficient for resistant humads decomposition	dSOC	0.29				
C/N ratio humus					dSOC	0.31

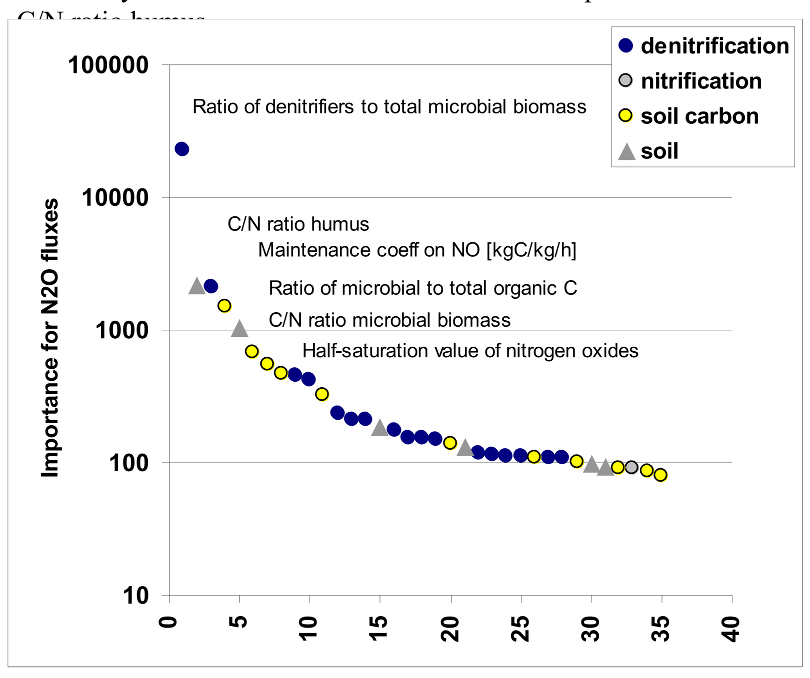

Figure 2. For comparison, the figure shows the importance of the parameters for N2O fluxes as estimated by the random forest model.

- Alltogether, the output variables showed to be sensitive towards about 50% of the tested parameters
- The ranking of the sensitivities is depending on the output variable and the environmental condition at the spatial unit
- N2O emissions show strongest sensitivity to denitrifier/total microbial biomass and the specific decomposition rate. Sensitivity for N2O and NO dominated by few parameters
- dSOC has highest sensitivity on soil respiration rate

Conclusions

- Additional screening is done on 150 NCUs selected also for input-uncertainty analysis
- For futher reducing uncertainty in simulating N and C turnover in agricultural soils at the regional scale, spatially explicit datasets of the most important parameters must be developed: Will it be possible?

References.

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