

Multi-site Sensitivity analysis of DNDCv.Can model to predict N₂O emissions from German croplands with maize, rapeseed and wheat

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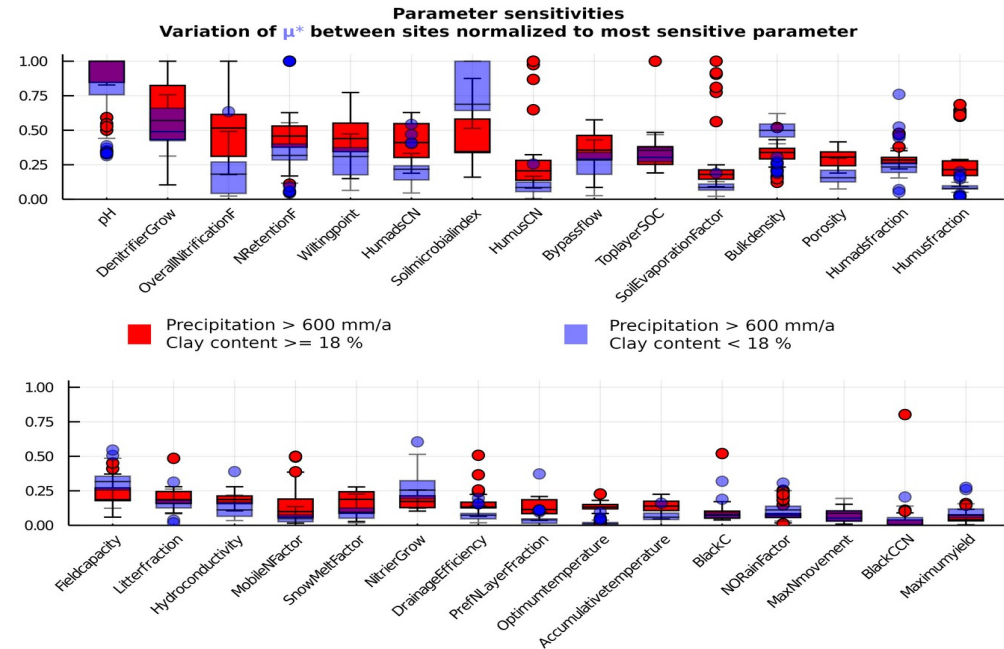


Data set

- Consists of 19 field sites and 174 treatments
- Over 125 000 observations
 - Soil and plant physiochemical parameters
 - Greenhouse gas emissions
- Covering time span of 1989-2016 (1251 model years)

Morris sensitivity analysis

- DNDCv.Can models sensitivity analysis for all treatments
- 45 parameters and 500 parameter set trajectories
- Classification of sites by soil and climate
- Sets of ranked most sensitive parameters is variable between sites
 - Identification of global, regional and local parameters
 - Indications for assessing regional mitigation effects



- DeNitrification DeComposition (DNDC) model is a process-based model to simulate:
 - Crop growth
 - Soil Temperature and moisture, carbon and nitrogen dynamics and nitrogen leaching
 - Emissions of N_2O , NO , N_2 , NH_3 , CH_4 and CO_2
- DNDCv.Can¹ is an improved version of DNDC model
 - Improved simulation of soil hydrology and tile drainage
 - Heterogenous soil profiles and root functions up to 2m soil depth
 - Improved water table simulation

¹Ward Smith, Brian Grant, Zhiming Qi, Wentian He, Andrew VanderZaag, Craig F. Drury, Matthew Helmers, Development of the DNDC model to improve soil hydrology and incorporate mechanistic tile drainage: A comparative analysis with RZWQM2, Environmental Modelling & Software, Volume 123, 2020, <https://doi.org/10.1016/j.envsoft.2019.104577>

Morris Sensitivity analysis

- One parameter per each model run changed (OAT sensitivity analysis)
- Three metrics (σ_i , μ_i , μ_i^*) used to assess the importance of a parameter
 - Elementary effects (EE) of a parameter (i)
 - X_x corresponds to any parameter set within accepted parameter space
 - Δ is change in the parameters value
 - Mean of EE_i (μ_i)
 - Mean of absolute EE_i (μ_i^*)
 - Standard Deviation of EE_i (σ_i)
- The more the metrics value deviate from 0, the more sensitive model is for the parameter

$$EE_i(X) = \frac{Y(X_1, \dots, X_{i-1}, X_i + \Delta, X_{i+1}, \dots, X_i - Y(X_x))}{\Delta}$$

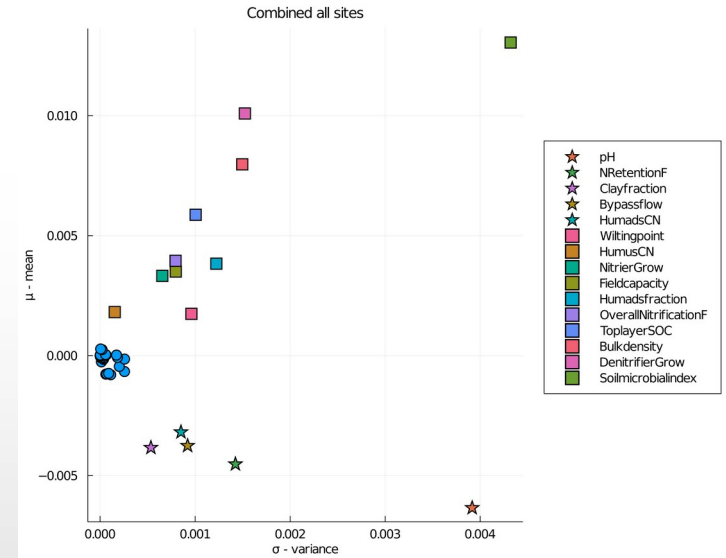
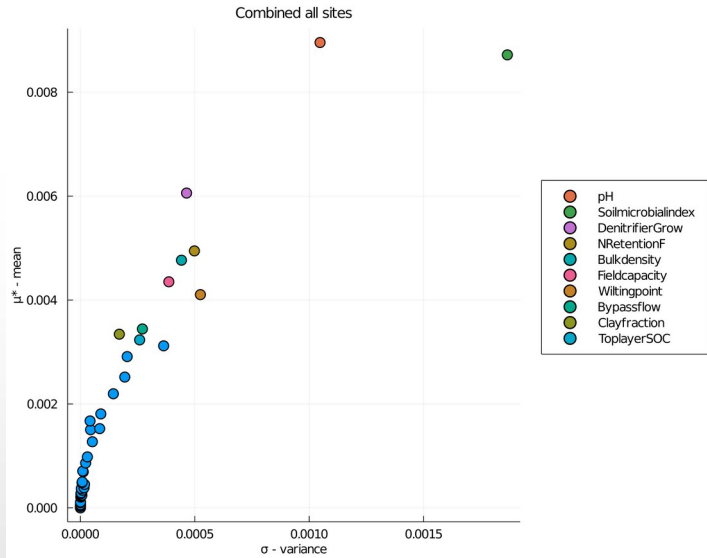
$$\mu_i = \frac{1}{r} \sum_{j=1}^r EE_i(X^j)$$

$$\mu_i^* = \frac{1}{r} \sum_{j=1}^r |EE_i(X^j)|$$

$$\sigma_i = \sqrt{\left(\frac{1}{(r-1)} \sum_{j=1}^r (EE_i(X^j) - \mu_i) \right)^2}$$

Morris Sensitivity analysis

- 45 parameters were used in the sensitivity analysis with 500 parameter set trajectories
- resulting to 23 000 model runs



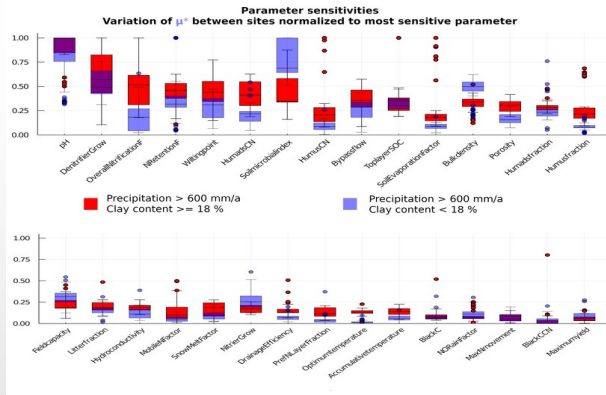
Morris Sensitivity and classification of sites

- To compare parameter sensitivities between sites, parameter EE_i was normalized against sites most sensitive parameter
- The sites were classified in 4 groups
 - 1) Precipitation $\geq 600\text{mm a}^{-1}$ and soil clay content $\geq 18\%$
 - 2) Precipitation $\geq 600\text{mm a}^{-1}$ and soil clay content $< 18\%$
 - 3) Precipitation $< 600\text{mm a}^{-1}$ and soil clay content $< 18\%$
 - 4) Precipitation $< 600\text{mm a}^{-1}$ and soil clay content $\geq 18\%$
- Parameter sensitivities across sites showed large variation with environmental conditions

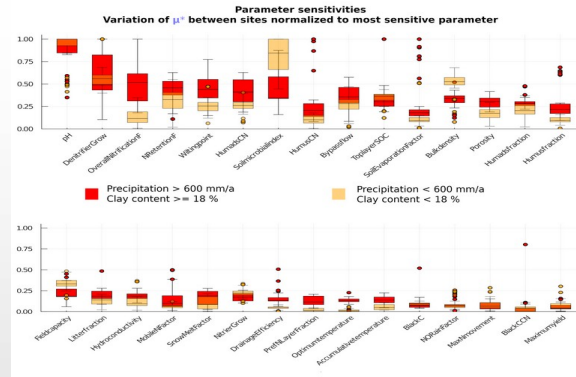
Morris Sensitivity and classification of sites

- Parameter sensitivities across sites showed large variation with environmental conditions
 - With lower clay content ammonia availability for nitrifier diminished
→ sensitivity of the model on soil organic carbon contents decreased
 - Wet soil conditions (high precipitation and soil clay content)
→ Parameters controlling macropore flow and water holding increase in importance

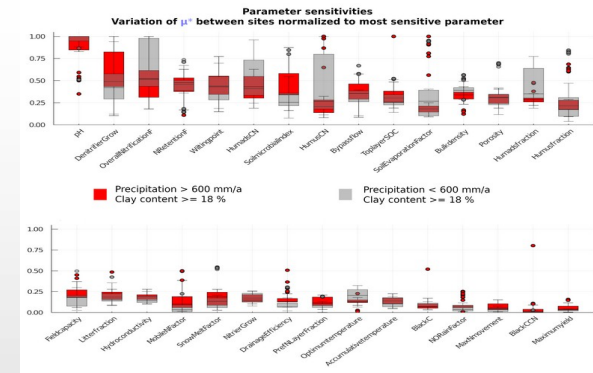
Group 1 vs Group 2



Group 1 vs Group 3



Group 1 vs Group 4



Conclusions

- Across all sites DNDC model was in general sensitive to pH, microbial growth and activity parameters, soil organic carbon contents and C/N ratios and soil clay content
- Classification of sites according to climatic and soil physical properties showed distinct differences between groups
 - Identification of global, regional and local parameters for the calibration of DNDC
 - Indications for assessing regional mitigation effects

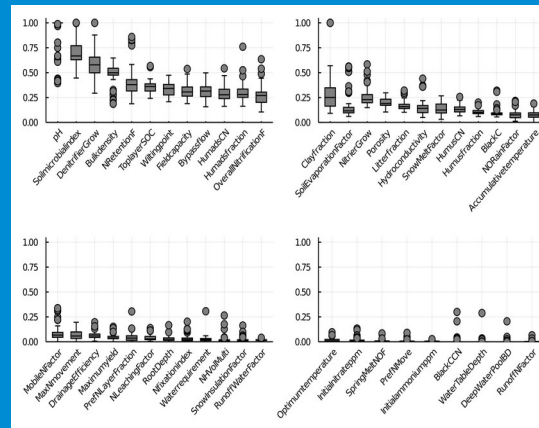
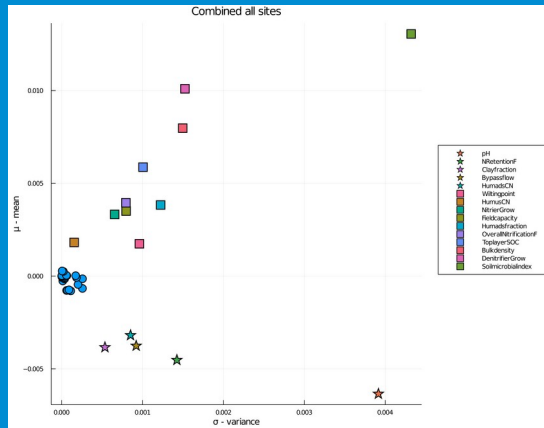
Project: THG-EMOBA

Effects of data requirements and uncertainty on prediction accuracy for model based evaluation and mitigation of nitrous oxide emissions from raw material cropping systems

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<https://www.thuenen.de/en/ak/projects/effects-of-data-requirements-and-uncertainty-on-prediction-accuracy-for-model-based-evaluation-and-mitigation-of-nitrous-oxide-emissions-from-raw-material-cropping-systems-thg-emoba/>



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