Simulation of nitrous oxide emissions in typical agricultural catchments in Austria

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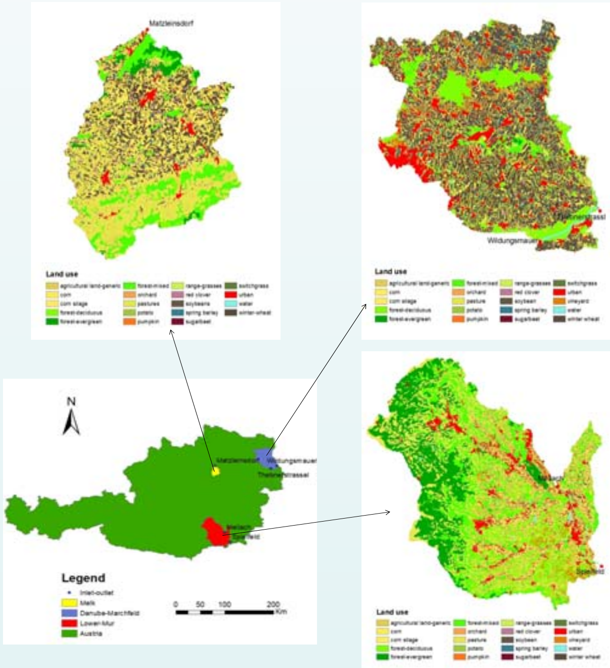
Introduction

Nitrous oxide (N_2O) is a potent greenhouse gas and two-thirds of the total anthropogenic N_2O emissions stem from agricultural activities. However, in the SWAT model, the process that simulating N_2O emissions is still not sufficient. This study is to build an N_2O submodule based on the SWAT model.

Study catchments



catchment	Area (km²)	Agriculture (%)	Forest (%)	Pasture (%)
Melk	282	62.87	22.01	12.10
Danube-Marchfeld	1514	73.77	13.84	0.4
Lower-Mur	2279	24.82	53.18	14.64

Management operations

In Austria, the ÖPUL program (Österreichisches Programm für die Umweltgerechte Landwirtschaft) is part of the Austrian Rural Development Program 2014-2020. In Austria, 81.7% of agricultural land is part of the ÖPUL program. Several of the measures in the program are relevant to N_2O emissions from agricultural fields.

Crops	AGRL	GRAP	PAST	RNGE	CSIL	SOYB	OELK	BARL
ÖPUL(N kg/ha)	150	100	140	120	180	60	100	150
Crops	POTA	SWCH	CLVR	SGBT	CORN	WWHT	ORCD	
ÖPUL(N kg/ha)	150	40	25	130	160	135	100	

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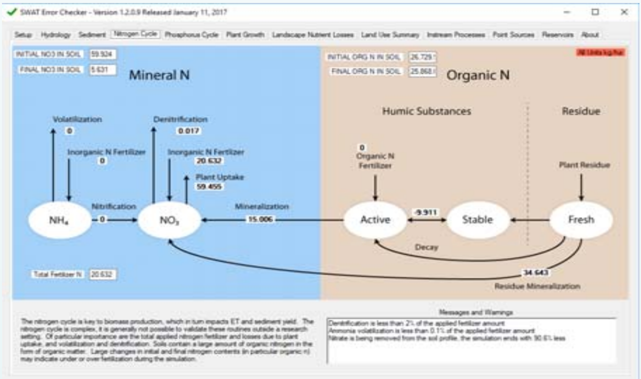
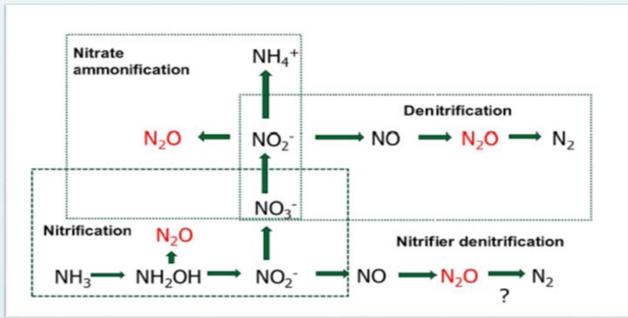
Methodology

The SWAT model was developed to simulate the impact of management decisions on agricultural nutrients flows, land use and land management practices. SWAT also includes a simplified version of erosion productivity impact calculator model (EPIC) to simulate crop growth process and yield. SWAT calculates the amount of nitrate lost to denitrification, but does not have further process for the simulation of N_2O emissions from denitrification.

Nitrogen cycle in SWAT



Nitrogen cascade



Calibration and validation results for discharge

Variable		p-factor	r-factor	R2	NS	PBIAS	KGE	RSR	MNS
FLOW_OUT_1	calibration	0.84	1.19	0.84	0.79	15.2	0.81	0.45	0.52
	validation	0.84	0.99	0.9	0.88	-2.1	0.92	0.34	0.63
FLOW_OUT_3	calibration	0.8	1.05	0.82	0.78	15.4	0.76	0.46	0.56
	validation	0.78	0.87	0.9	0.9	-8.3	0.89	0.32	0.63
FLOW_OUT_8	calibration	0.69	0.94	0.74	0.7	14.8	0.73	0.54	0.5
	validation	0.69	0.85	0.81	0.8	0.1	0.9	0.44	0.58

This table shows the calibration and validation results of Melk catchment. The calibration data period is from 1985-1999 (not including the warm up period), and the validation data period is from 2000-2015. Flow-out-1 is the outlet of Melk catchment.

Nitrate calibration is going on

Future work

Impact factors of N_2O emissions

Management related factors

- N application rate and timing;
- Fertilizers type;
- Type of crops;
- Sowing and harvest timing;
- Irrigation;
- Residues;
- Tillage systems; policy

Measurement related factors

- Length of measurement period;
- Frequency of measurement;
- Spatial distribution measurement;
- Surface and subsurface measurement

Environment factors

- Soil moisture and aeration;
- Soil temperature;
- Soil texture;
- Soil pH and salinity.
- Nitrate or ammonium concentration;
- Available organic carbon;
- Microbial population;
- Other essential nutrients.

Due to the heterogeneous nature of impact factors, N_2O exhibits a large spatial and temporal variability. The main impact factors were chosen to simulate N_2O emissions according to the conditions of the research catchments.
Integrating the calibrated outputs and main impact factors, we use the following equations to calculate N_2O emission.

Nitrous oxide calculation

1. Applying a set of equations to model the total denitrification rate (N_2+N_2O)

$$D_{Ntotal} = \min[Fd(NO_3^-), Fd(C)] * Fd(IF)$$

D_{Ntotal} is the denitrification rate per unit area (production of N_2+N_2O); Fd(NO3-) is the maximum total N gas flux per unit area for a given soil NO_3^- level (assuming total soil C is not limiting); Fd(C) is the maximum total N gas flux per unit area for a given total soil C level (assuming soil N is not limiting); and Fd(IF) is functions that represent the effects of impact factors (Wagena,2017; Shrestha 2018).

2. Partitioning N_2 from N_2O.

$$R_{(N2/N20)} = \min[Fr(NO_3^-), Fr(C)] * Fr(IF)$$

$R_{(N2/N2O)}$ is the ratio of N_2 to N_2O, and Fr(NO_3^-), Fr(C) and Fr(IF) represent the effects of soil NO_3^--N, total soil C and impact factors on the ratio of N_2 to N_2O, respectively (Wagena,2017; Shrestha 2018).

Expectations

- After running N_2O submodule, I will get N_2O emissions from different crops in research catchments.
- Based on the outputs and results of SWAT and N_2O submodule, we can give recommendation about agricultural management practices for sustainable development.

References

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