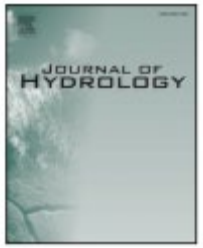

SWAT ungauged: Water quality modeling in the Upper Mississippi River Basin

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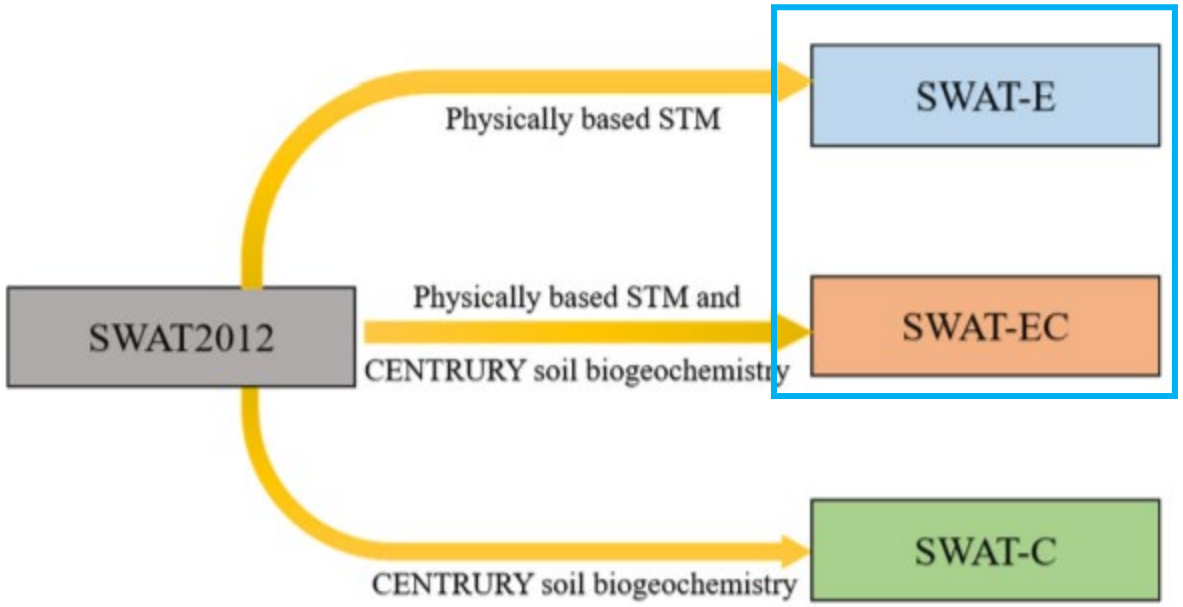
Problem: Current watershed-scale dynamics are simplified in hydrologic and surface water quality models. They require calibration of parameters, which limits their applicability to ungauged basins or those with less available data.

Research justification: Previous research suggests that integrating physical processes instead of simplified numerical relationships can improve uncalibrated modeling at ungauged locations

Research goal: Contribute to the field of continuous model evaluation and improvement, particularly in order to make models more useful in large ungauged basins or those lacking enough data for full calibration.

Research application: Improvements made to the SWAT model, tested on the upper Mississippi River basin



$$T_{soil}(z) = \gamma T_{soil}^{'}(z) + (1-\gamma)[d(\bar{T}_{Aair} - T_{sur}) + T_{sur}]$$

$$\frac{\partial T}{\partial t} = \frac{\partial}{\partial x}\left(\frac{k}{C} \bullet \frac{\partial T}{\partial x}\right)\frac{s}{C}$$

Fig. 2. Model structure difference between SWAT2012, SWAT-E, SWAT-C, and SWAT-EC. STM: energy balanced soil temperature module; CENTRUY: CENTRUY-based soil organic matter algorithm.

Advantages:

- Uses temperature, thermal conductivity, volumetric heat capacity, vertical distance, and latent heat
- calculates changes in snow and soil due to heat conduction and exchange (physical thermal properties)

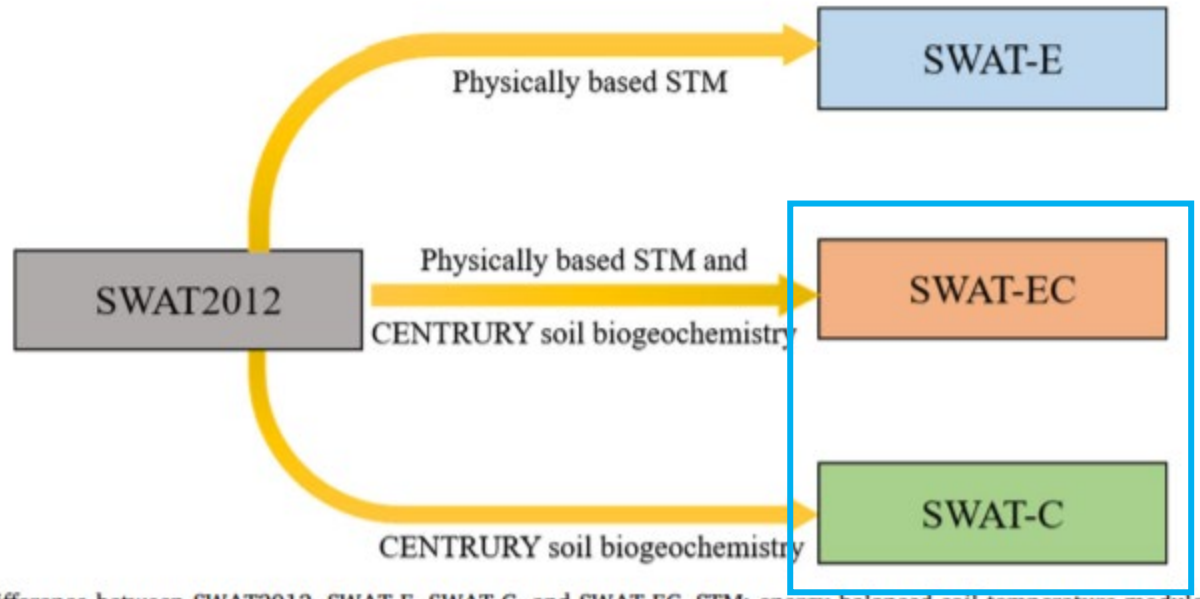


Fig. 2. Model structure difference between SWAT2012, SWAT-E, SWAT-C, and SWAT-EC. STM: energy balanced soil temperature module; CENTRUY: CENTRUY-based soil organic matter algorithm.

PAPRAN model

CENTURY soil organic matter algorithm

Advantages:

-CENTURY simulates carbon cycling as well as nitrogen and better representation of soil organic matter

- More detailed modeling of SOM residue, different calculations for decomposition, and coupled C & N cycling (i.e. more biochemical processes represented)

Table 2
Model performance on monthly water quantity and quality by four versions of SWAT model at three monitoring sites in the UMRB.

		SWAT2012			SWAT-C			SWAT-E			SWAT-EC		
Variable	**Subbasin**	**R^2**	**NS**	**P_{bias} (%)**	**R^2**	**NS**	**P_{bias}(%)**	**R^2**	**NS**	**P_{bias} (%)**	**R^2**	**NS**	**P_{bias} (%)**
Stream Flow	63	0.65	0.31	19	0.68	0.39	14	0.83	0.58	20	0.82	0.62	14
	95	0.71	0.55	16	0.73	0.60	10	0.84	0.71	17	0.84	0.73	11
	100	0.68	0.41	24	0.71	0.50	19	0.84	0.62	25	0.85	0.69	19
Sediment	63	0.28	0.23	34	0.30	0.25	29	0.51	0.30	39	0.47	0.30	36
	95	0.51	0.50	-14	0.54	0.51	-23	0.73	0.71	-6	0.73	0.72	-17
	100	0.57	0.48	32	0.59	0.53	27	0.77	0.57	37	0.77	0.62	32
NO_3-N	63	0.53	0.37	38	0.47	0.27	41	0.68	0.61	15	0.57	0.47	30
	95	0.51	-2.51	-18	0.55	-0.14	19	0.68	-4.48	-56	0.61	0.02	6
	100	0.71	0.57	0	0.61	0.57	16	0.73	-0.18	-35	0.65	0.61	2
Total-N	63	0.56	0.20	-2	0.53	0.36	7	0.70	0.11	-10	0.62	0.54	11
	95	0.59	-1.60	-40	0.56	-0.04	-4	0.66	-2.79	-56	0.63	0.18	-1
	100	0.66	0.08	-18	0.60	0.42	0	0.73	-0.30	-30	0.68	0.59	3

Note: shaded numbers indicate enhanced SWAT has lower R^2 or NS values than SWAT2012 or has higher absolute values of P_{bias} than SWAT2102.

Conclusions and thoughts:

- Models based more in physical processes reduce bias and improve seasonal variability
- Biogeochemical processes are complex, making it difficult to improve on nitrate and nitrogen using these physical processes
- Improving the integration of physically-based processes in advantageous to developing models for large ungauged basins

How may this align or contrast with advantages / disadvantages to modeling simplifications we've discussed in class?