Simulating potassium load from a dairy farming watershed with the modified SWAT Model

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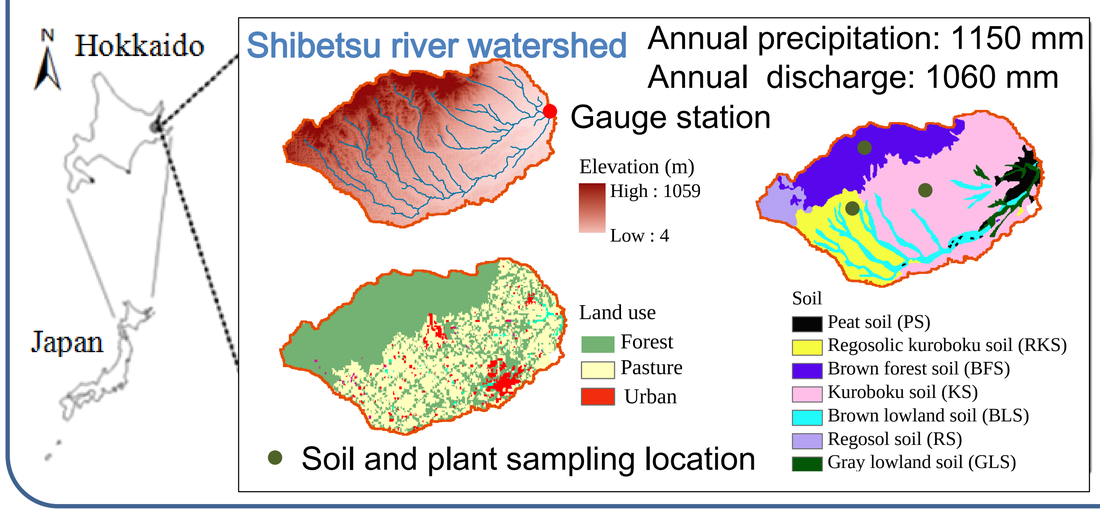
G-MOD

Scientifical context and objectives

The SWAT model was modified (SWAT-K) by including the main Potassium (K) dynamic processes to simulate river K load and K budget at watershed scale.

The SWAT-K model was applied in a dairy farming watershed, Japan (672 km²) to a) evaluate the ability of the new module in this context, b) quantify the K load to stream, and c) quantify each process involved in K dynamic.

Study site and data



Data and Sampling Laboratory analysis

Stream discharge and pasture yield (2003-2008) Website

Water and sediment (2003-2008) Automatic sampler

Plant (2013) Harvested pasture

Soil (2013) (0 – 5 cm)

Water samples: Sediment and K concentration

Plant samples K content

Soil samples K solid-liquid distribution

K content

Sediment samples K solid-liquid distribution

Methodology

Sampling and Analysis

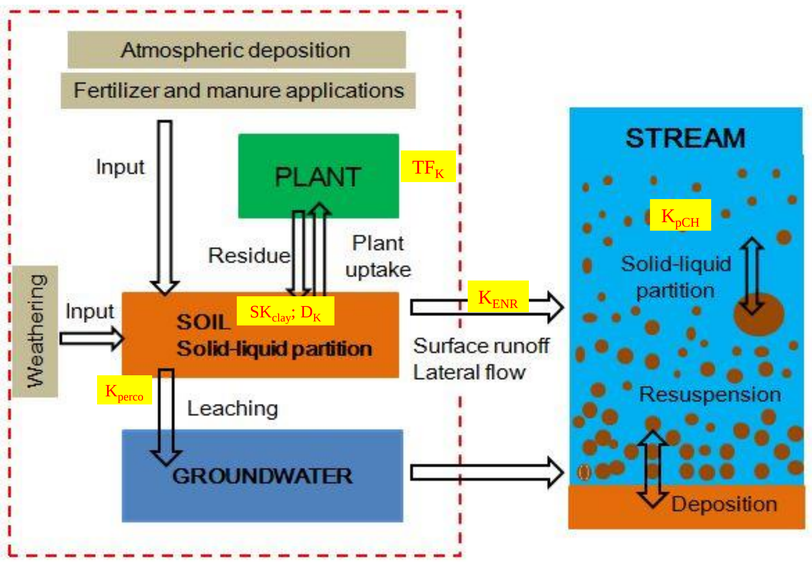
Model modification & setup

Model calibration & validation

Model evaluation

Model simulation results

Modelling approach



Conceptual model of K fate and transport in SWAT-K

Parameters		Range	Value
K movement in soil and transport from soil to reach			
SK_{clay}	Solid-liquid distribution coefficient normalized for soil clay content (ml g^{-1})	0 - 500	320
PERCOK	K percolation coefficient	0 - 1	0.9
K_{ENR}	K enrichment ratio	0 - 10	5
K in reach			
K_{pCH}	K solid-liquid distribution coefficient (m^3 g^{-1})	0 - 5 E-03	1E-05
Soil to plant transfer of K			
TF_K	Soil to plant transfer factor	0 - 20	2
Depth distribution of K uptake			
D_K	K uptake distribution parameter	0 - 100	5

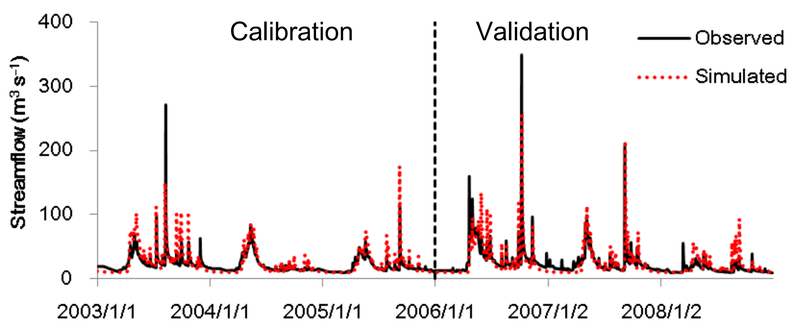
Model calibration & validation

Streamflow: 2003-2005; 2006-2008

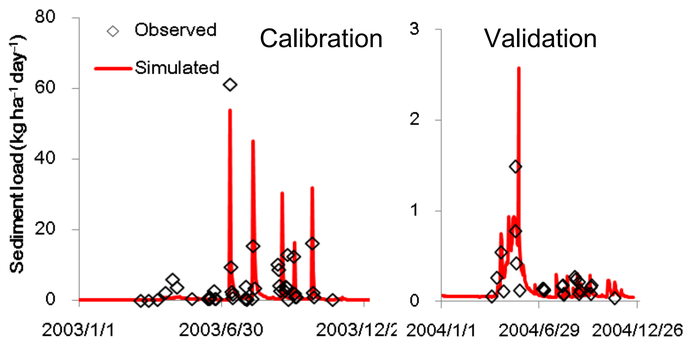
Sediment and K load: 2003; 2004

Results : Calibration and Validation

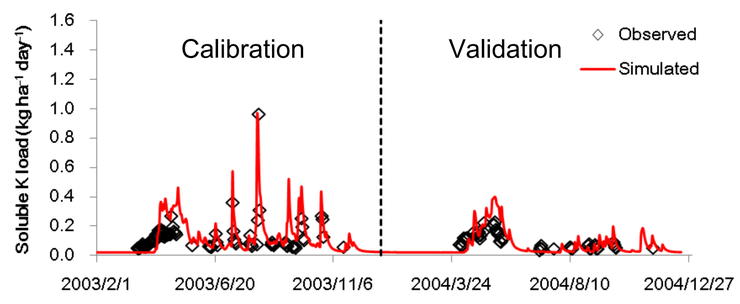
Streamflow



Sediment



Stream K load



Model performance

Model performance	R^2	E_{NS}	PBIAS	R^2	E_{NS}	PBIAS
	Calibration			Validation		
Streamflow	0.60	0.40	14%	0.87	0.61	7%
Sediment load	0.62	0.48	10%	0.64	0.61	14%
Soluble K load	0.59	0.42	35%	0.57	0.39	24%

Model evaluation

$$R^2 = \left\{ \frac{\sum_{i=1}^{n}(X_{oi} - \overline{X_{oi}})(X_{si} - \overline{X_{si}})}{\left[\sum_{i=1}^{n}(X_{oi} - \overline{X_{oi}})^2\right]^{0.5}\left[\sum_{i=1}^{n}(X_{si} - \overline{X_{si}})^2\right]^{0.5}} \right\} \quad E_{NS} = 1 - \frac{\sum_{i=1}^{n}(X_{oi} - X_{si})^2}{\sum_{i=1}^{n}(X_{oi} - \overline{X_{oi}})^2} \quad PBIAS(\%) = \left[\frac{\sum_{i=1}^{n}(X_{oi} - X_{si})}{\sum_{i=1}^{n} X_{oi}}\right] * 100$$

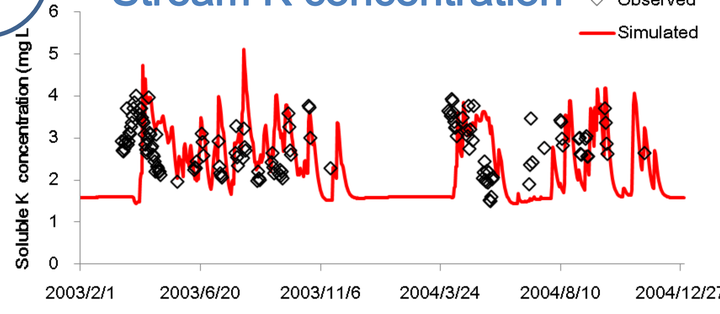
Plant K uptake

Model performance	PBIAS
Harvest pasture biomass	10%
Harvest pasture K uptake	2.1%

K budget (2003-2008)

Simulated K budget	Mean (kg K ha^{-1})
N input by rainfall and fertilizer	90.0
N input by weathering	33.0
Net K uptake by vegetation	17.7
K in surface runoff	1.5
K in subsurface flow	24.5
K in EXT (External groundwater)	8.0
K leaching out of soil profile	21.0
Soil K balance	82.8

Stream K concentration



Results : simulations

Conclusions

(1) The SWAT-K model was successfully used to estimate the soluble K load to stream and pasture K uptake in the Shibetsu river watershed.

(2) The K budget was investigated based on the simulation results of SWAT-K model. Reducing the amount of applied K is recommended.

(3) The SWAT-K model is now able to be applied and tested in other agricultural watersheds under different soil and climate conditions.

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