Modifying the Soil Temperature Module in SWAT for Application in Atlantic Canada ---Module Development, Validation and Impacts on Watershed Modelling

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1. Snow cover insulation effects

Empirical soil temperature module of SWAT is ineffective in Atlantic Canada with significant snow cover. This results in incorrect predictions on water flow and nutrient loadings on watersheds in winter.

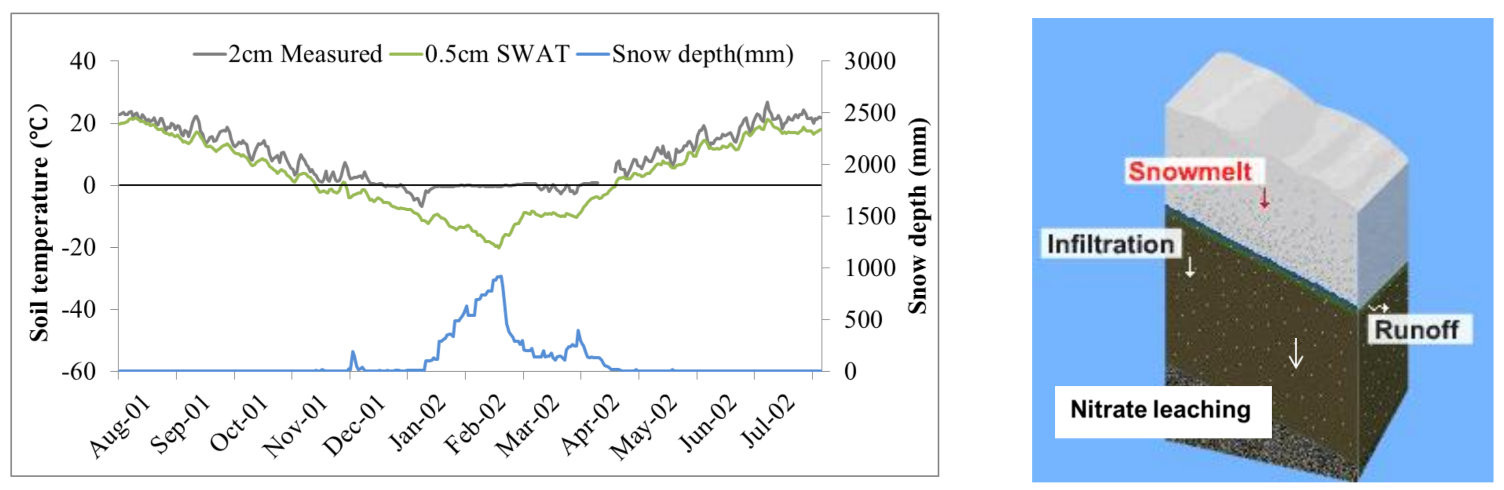

Fig.1 Snow insulation effects on soil temperature and infiltration & nitrate leaching.

2. Physically-based module

Heat conduction through snow and soil layers

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

T-temperature
t-time step (daily)
x-vertical distance
k-thermal conductivity
C-volumetric heat capacity
s-latent heat source/sink

Coded in fully-implicit discretized form and solved by tridiagonal-matrix algorithm

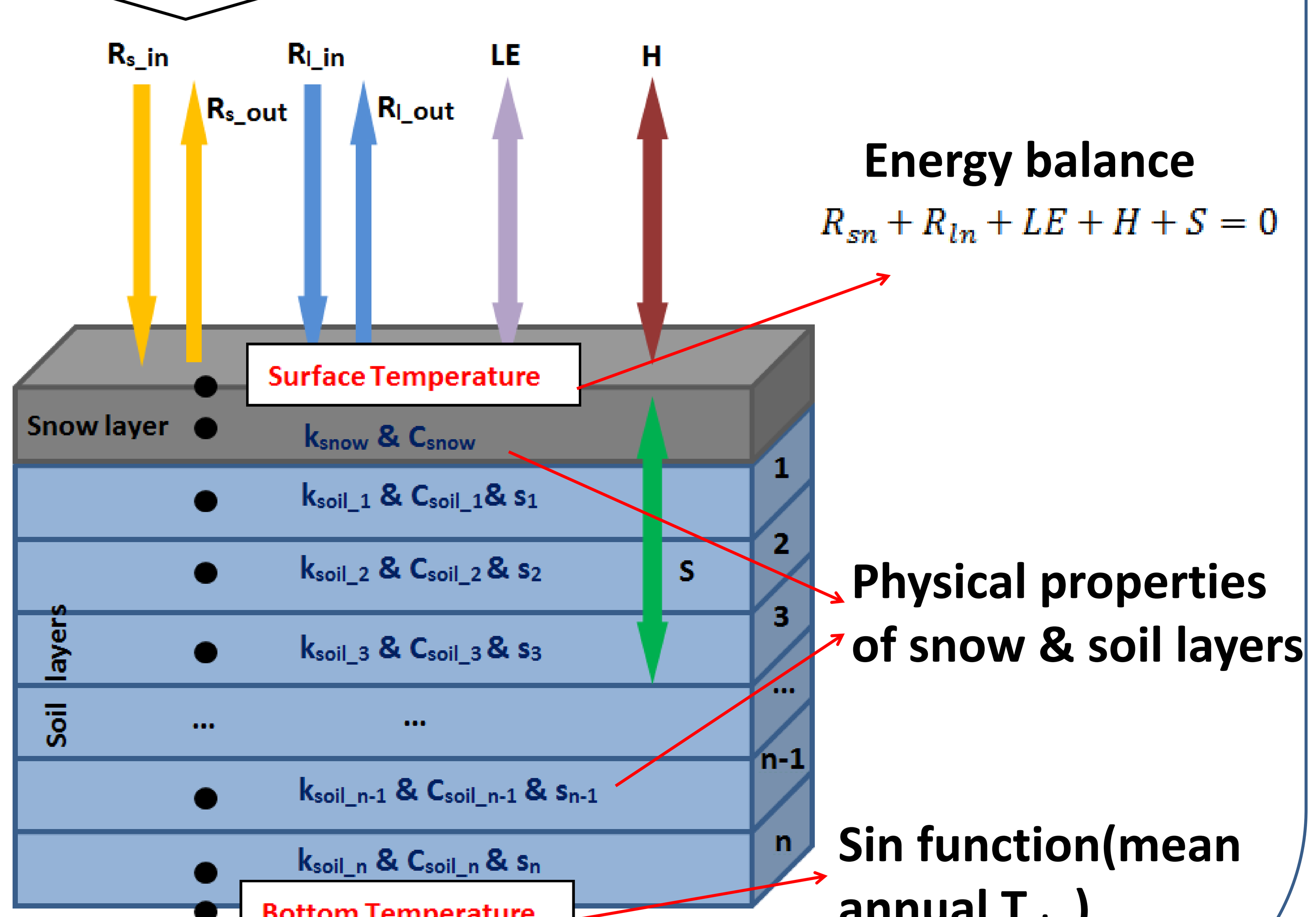

Fig.2 Scheme of physical module.

3. Study site: Black Brook Watershed

Area :14.5 km^2 (65% agricultural, 21% forested)
Elevation: 170 to 260 m (rolling landscape)

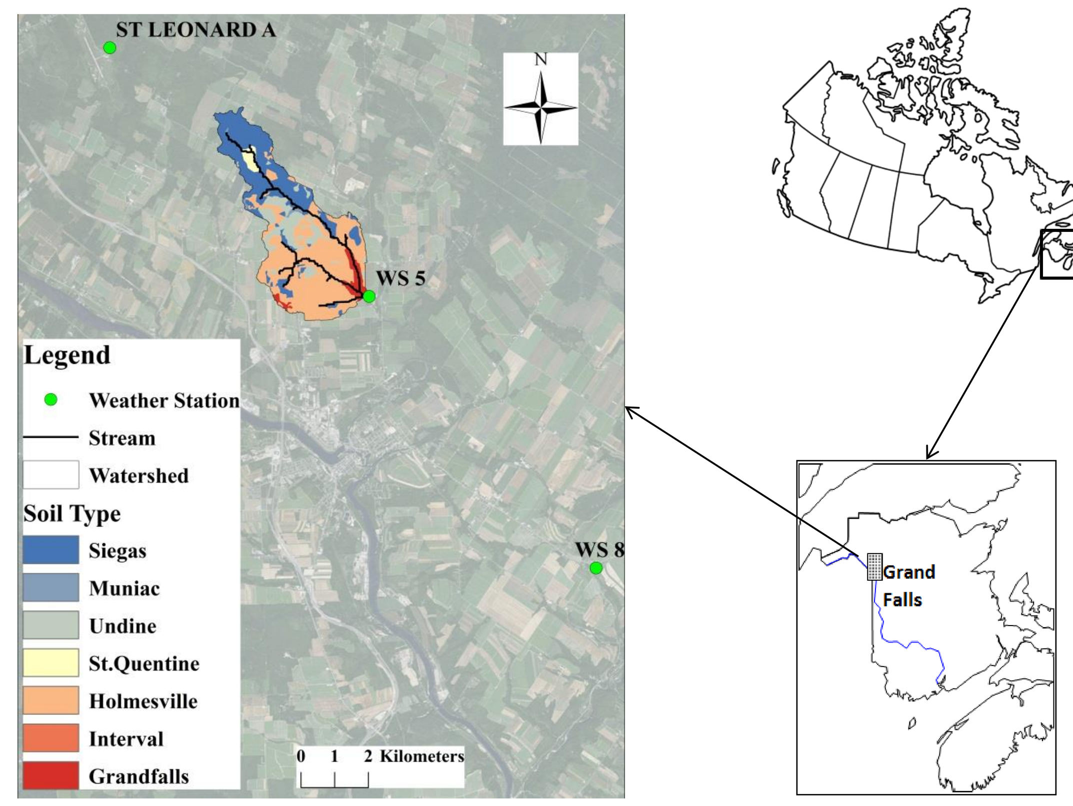

Fig.3 Study site & monitoring stations location.

4. Soil temperature prediction

Empirical module severely underestimates soil temperatures in winter (-10 to -20˚C), while the new module results are more consistent with measured temperatures (within a range of -2 to 2˚C).

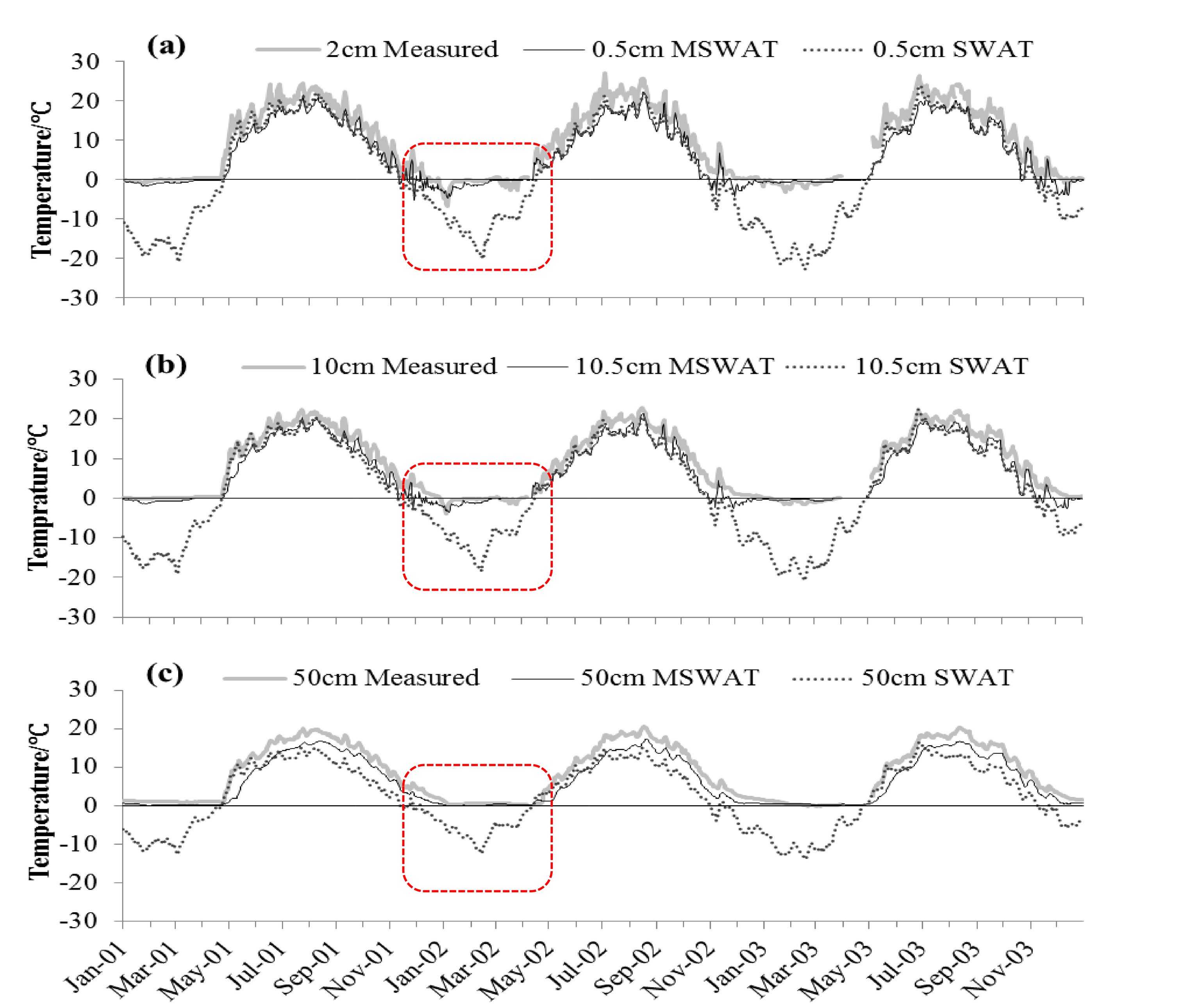

Fig.4 Comparison of predicted with measured daily soil temperatures for both modules.

5. Water flow & nutrients loadings

Modified SWAT (MSWAT) enhances modelling accuracies on baseflow discharge, total discharge, sediment, NO_3-N and Sol-P loadings in the watershed mainly in early winter and snowmelt period.

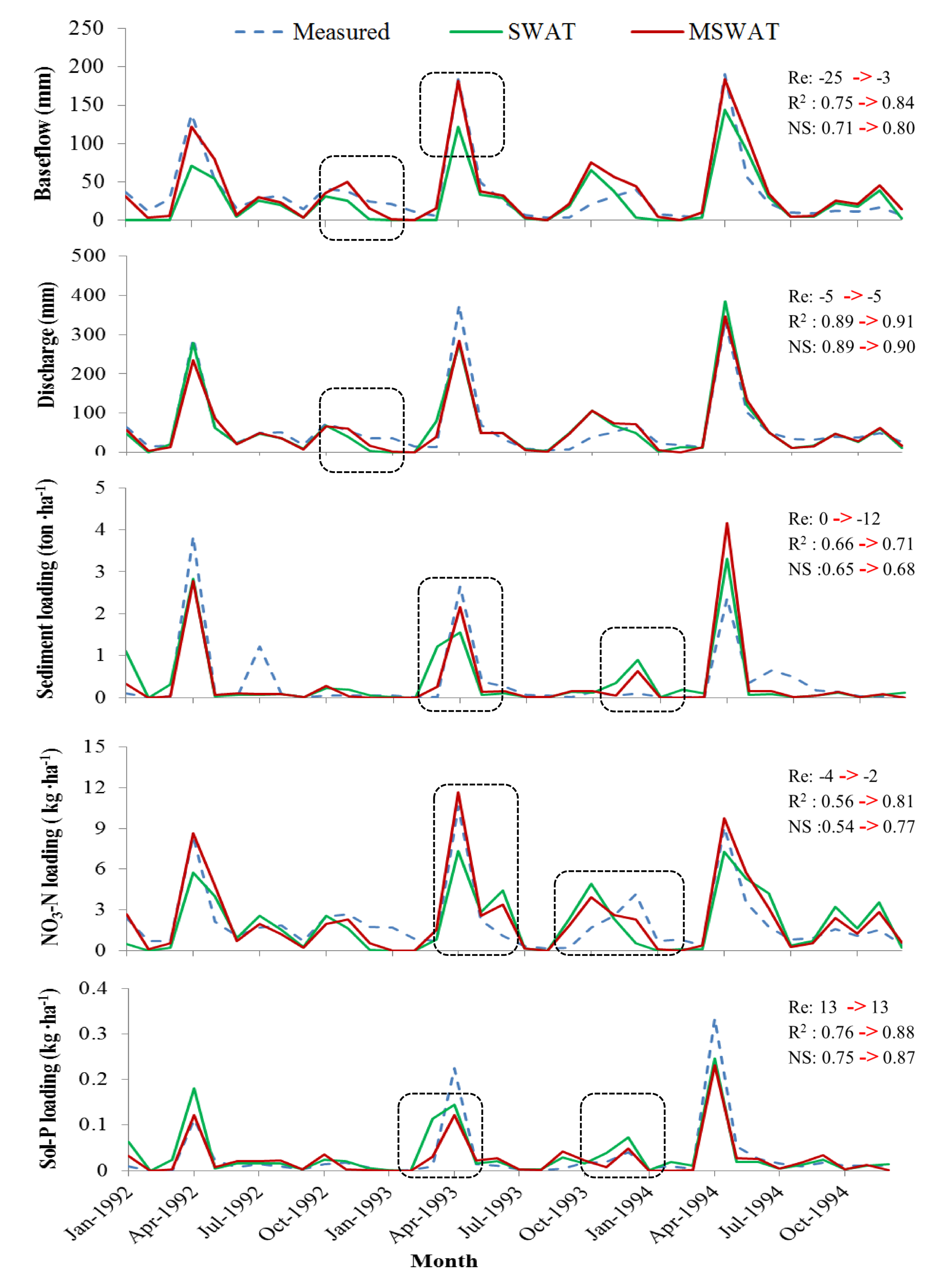

Fig.5 Comparison of predicted with measured monthly baseflow, discharge, sediment, NO_3-N and Sol-P loadings for both models.

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