Uncertainty analysis of nonpoint source pollution modeling:

An important implication for Soil and Water Assessment Tool

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Contents

1. Background
2. Sources of uncertainty
3. Methods of uncertainty analysis
4. Implications
The SWAT model accounts for most of the key processes of NPS pollution at basin scale.
Uncertainty in NPS modeling

- Meteorological processes
- Complexity of watersheds
- Ecological processes
- Natural randomness
- Insufficient knowledge
Sources of uncertainty

- **Input data uncertainty**
  1. Changes in natural conditions
  2. Limitations of measurement
  3. Lack of data

- **Structural uncertainty**
  1. The assumptions and simplification in the model
  2. Application of the model under conditions that are not quite consistent with the model design

- **Parameter uncertainty**
  Parameters attained through empirical estimation and optimization of observed data cannot ensure the precision and reliability of the predicted results
Model input

- Precipitation
  - Interpolation method
  - Accuracy of measured date
- DEM
- LULC
- Soil type

Density of rain gauges

Resolution of GIS data
Intensively distributed rain gauges are usually recommended.

Single- and multi-gauge calibrations exhibited no apparent differences.

- 50ha → one well-located station
- 20km → the threshold distance between stations

Watershed characteristics
Interpolation method

Variation of elevation is not considered.

Centroid method

Those rain gauges far from the centroids will be neglected.

Elevation

Variation of elevation is not considered.
Interpolation method

Selection of an appropriate interpolator

1. Global interpolators with more precise description of rainfall spatial variability for large watersheds

2. The centroid method can provide adequate accuracy in small watersheds

The Kriging method

The inverse distance weighted method
Interpolation method

Input uncertainty

Hydrologic modeling

NPS simulation

(a) Monthly flow

(g) Monthly Org N

(c) Monthly sedi

(i) Monthly dissolved N
Measurement errors

Rain measurement involves complicated processes

- Complexity of the environment
- Constrains of tools
- Lack of calibration

Measurement errors

![Histograms for Flow, Sediment, TP, OrgN](Images)
GIS data

Land characteristics

- Digital elevation model (DEM)
- Soil type
- Land use-land cover (LULC)

Geographic Information System (GIS)
DEM was identified as a determining role in the selection of the appropriate combination of resolutions.
Model parameter

Conceptual group

✓ Large number
✓ Model structure

Calibration

Physical group

✓ Measured
✓ Estimated

UNCERTAINTY
Model parameter

Uncertainty of model outputs

Only a few parameters significantly affected the uncertainty of the outputs

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Model parameter

Parameter range

Small adjustments may derive significant uncertainty especially near the upper and lower limits of parameter range.

It is preferable to obtain a confidence range of each parameter within which models can be well-calibrated.
Model parameter

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Model users should check if any information related to the watershed characteristics and its underlying hydrologic Processes.

Equifinality

Different parameter groups may introduce the similar results
Determining the PDF of each parameter is a critical step when uncertainty analysis is conducted.

- Sufficient number of simulation is required to satisfy the convergence precision.
- A proper sampling method is recommended.
Targeted management

Uncertainty of NPS outputs displayed apparent variation among different land use types.
Model parameter
Model parameter

- **Dry land**
  - Conservation practices
  - Proper land cover

- **Paddy**
  - Nutrient management

- **Yellow earth**
  - Grazing practices

- **Purple soil**
  - Vegetation density
Model parameter

- A greater uncertainty in the high-flow period
- Multiple calibrations should be conducted at different hydrological conditions

Temporal variation
Model structure

Inaccurate description of watershed system

Evapotranspiration

Flow routing

Snow accumulation and melt

Ensemble prediction
# Methods of uncertainty analysis

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Methods of uncertainty analysis

One factor at a time (OTA)

✓ Easy to program; low computational requirements.

Sequential Uncertainty Fitting, ver. 2 (SUFI-2)

✓ Semi-automated; all sources of uncertainty are accounted for.

First-order error analysis (FOEA)

✓ Simple but with much hypothesis adopted.

Monte Carlo

✓ Flexible; abundant simulation times are required to achieve reliable prediction.
Methods of uncertainty analysis

Generalized Likelihood Uncertainty Estimation (GLUE)
- Huge sampling quantity; all sources of uncertainty are accounted for.

Bayesian inference
- Strong dependence on the formulation of likelihood function.

Bootstrap
- High dependency on original samples; wide scope of application.
Implication

EPIC & APEX Models

HSPF Model

AGNPS & AnnAGNPS models

Other H/NPS models sharing much similarity

SWAT | Soil & Water Assessment Tool
Implication

- Input and structural uncertainty should be paid more emphasis.

- The interaction effect between these three sources of uncertainty deserves more attention.
检索结果：主题=（"nonpoint source" or "non-point source"）AND 主题=（uncertainty）
时间跨度=所有年份，数据库=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, CCR-EXPANDED, IC。
检索结果：216

精炼检索结果
结果内检索

Web of Science 类别

- WATER RESOURCES (101)
- ENVIRONMENTAL SCIENCES (75)
- GEOSCIENCES MULTIDISCIPLINARY (40)
- ENGINEERING CIVIL (38)
- ENGINEERING ENVIRONMENTAL (38)
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Thank you for your attention!

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