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Interfacing SWAT with Systems Analysis Tools: A Generic Platform

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- Parameter identifiers for SWAT
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  - SWAT_SA_Interface
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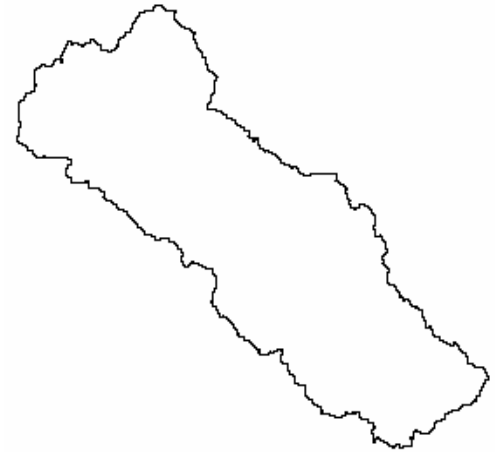
Problems and requirements in distributed watershed modeling (1)

- Problem 1:

  How to cope with the distributed parameters

  – Increase of parameter number



If 1 subbasin has 20 parameters

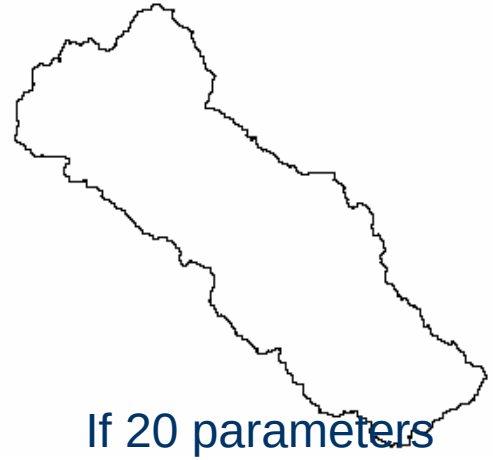
Then 60 subbasins would have around 20*60 parameters

Problems and requirements in distributed watershed modeling (1)

- Problem 1:

  How to cope with the distributed parameters

  – Increase of parameter number
  – Increase of the computation time in calibration/uncertainty analysis



If 20 parameters need 5 hours to estimate

Then 20*60 parameters need how long?

Problems and requirements in distributed watershed modeling (1)

- Problem 1:

  How to cope with the distributed parameters

  – Increase of parameter number
  – Increase of the computation time in calibration/uncertainty analysis
  – Identifiability problem - because not not all outlets are observed.

  This also leads to numerical problems.

Requirement: Reduce parameter number

(regionalize, or apply same changes on parameters)

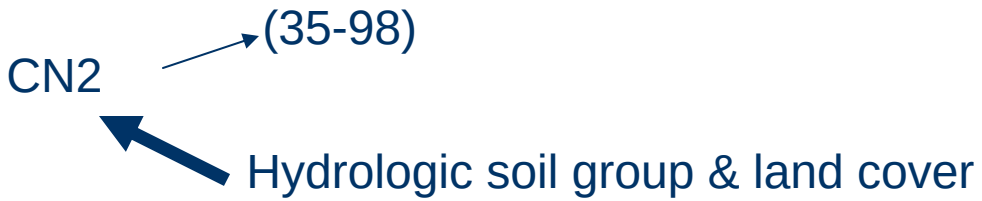
Problems and requirements in distributed watershed modelling (2)

- Problem 2

  How to deal with parameter dependence

  – Besides meaningful ranges, most parameters have their physical or conceptual meanings, which depend on several factors (influential factors)

For example in SWAT:



Requirement: consider parameter influential factors in the distributed watershed modelling

Problems and requirements in distributed watershed modelling (3)

- Problem 3

  How to efficiently change the parameter value and use different system analysis tools?

- Manually? (Tedious)

- Change source code?

  Has problems for re-implimentation, poor code quality, extension to different system analysis programs, etc.

Furthermore, different system analysis tools have different advantages and we want to make use of them.

Requirement: An standard interface between watershed model and systems analysis tools

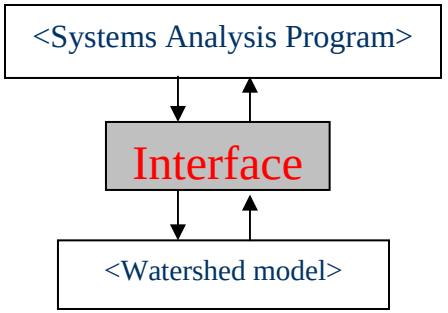
Problem

Requirement

- Problem 1: How to cope with the distributed parameters → Reduce parameter number
- Problem 2: How to deal with parameter dependence → Consider influential factors

Parameter identifier ?

- Problem 3: How to efficiently change the parameter value and use different system analysis tools?



Parameter identifier

Definition: a group of parameters which have same information, and this information leads to aggregate parameters and reduce parameter number

- For lumped parameters

  1. A model parameter is a Parameter identifier
  2. Calibrating a Parameter Identifier is to calibrate a model parameter

- For distributed parameters

  1. A Parameter Identifier is a group of parameters (…)
  2. Calibrating a Parameter Identifier is to calibrate a group of parameters

Parameter identifier for SWAT

x__<parname>.<ext>__<hydrogrp>__<soltext>__<landuse>__<subbsn>

Where:

x — the type of change to be applied to the given parameter:
v –Change the parameter value by replacement,
a –Change the parameter value by adding an additional value
r – Change the parameter value by some percentage

<parname> SWAT parameter name, for example, CN2---Curve Number

<ext> SWAT file extension code for the file containing the parameter; for example, mgt---management file extension in SWAT

Parameter identifier for SWAT

x__<parname>.<ext>__<hydrogrp>__<soltext>__<landuse>__<subbsn>

Where:

<hydrogrp> soil hydrological group (‘A’,’B’,’C’ or ‘D’);

<soltext> soil texture name;

<landuse> name of the landuse category;

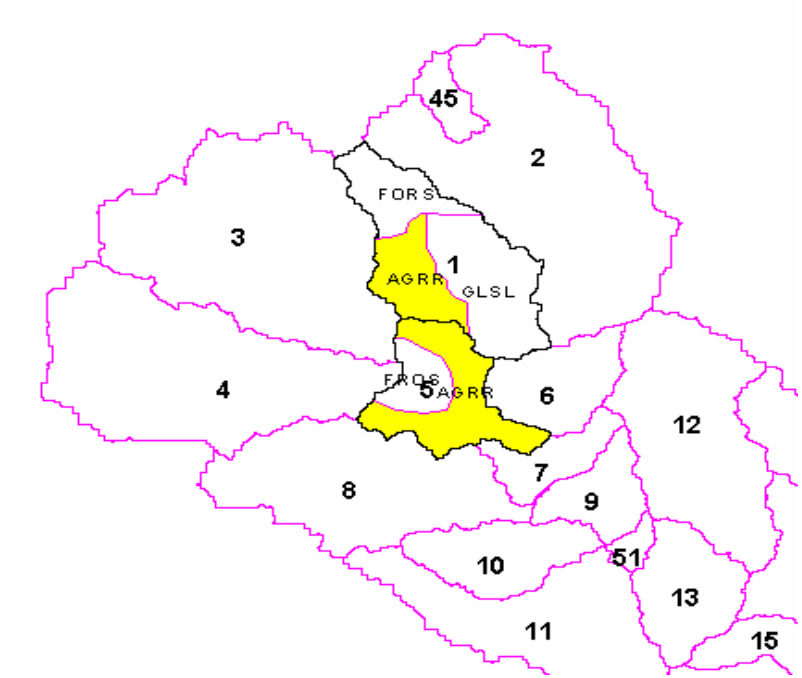
< subbsn> Subbasin number, crop index, fertilizer index and rainfall date. Its meaning depends on <ext>:
-sub extention: subbasin number(s)
-crp: the number(s) of the crop index;
-frt: the number(s) of the fertilizer index;
-pcp, this date(s) of the rainfall data;

For example: “1,3-5,10-21,22”

Parameter identifier for SWAT

- Example:

  a__CN2.mgt_____AGRR__1,5 = 5



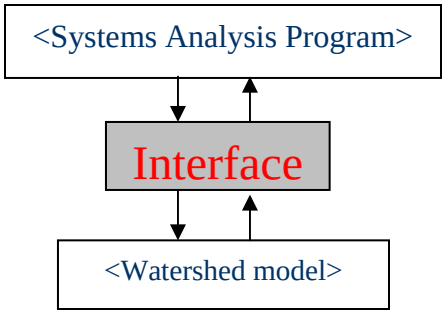
Problem

Requirement

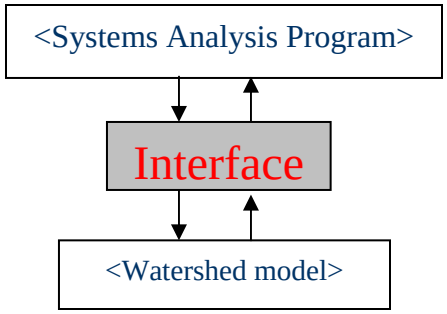
- Problem 1: How to cope with the distributed parameters
- Problem 2: How to deal with parameter dependence

Parameter identifier

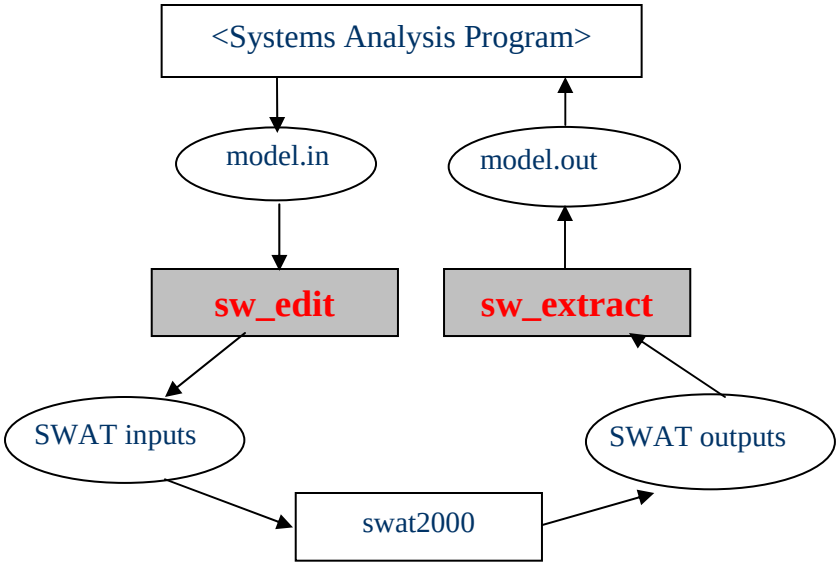
- Problem 3: How to efficiently change the parameter value and use different system analysis tools?



SWAT_SA_Interface



Generic interface

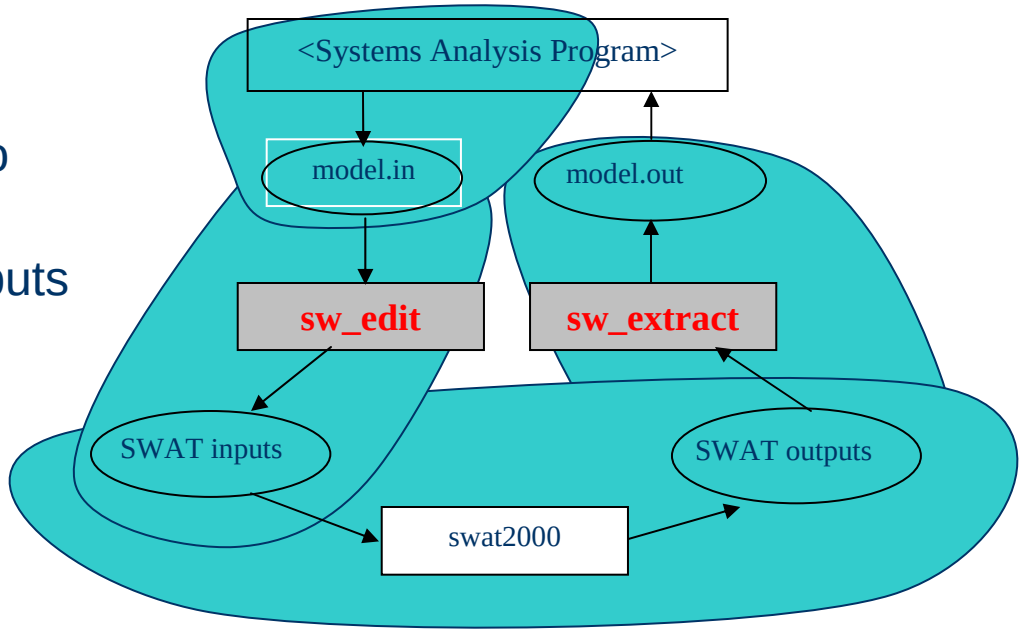


Generic interface for SWAT
(Modified from Reichert, 2005)

SWAT_SA_Interface

- This Interface: 2 executable files- sw_edit & sw_extract
- <Sys. A. Pro> writes parameter identifier values to model.in
- sw_edit changes SWAT inputs according to model.in
- Run swat2000 model (read swat inputs and get swat ouputs)
- sw_extract extracts swat output of interest for <Sys. A. Pro>

Procedure



Generic interface for SWAT (Modified from Reichert, 2005)

Introduction of some system analysis programs

- UNCSIM (Reichert, 2005, http://www.uncsim.eawag.ch):
  - Parameter estimation (algorithm includes SCE etc)
  - Sensitivity and identifiability analysis
  - Parameter uncertainty (Markov Chain Monte Carlo technique)
- SUFI (Abbaspour, 2004):
  - Based on efficient Latin Hypercube Sampling technique
  - Used for sensitivity analysis, parameter estimation and uncertainty analysis
- SCEM-UA (Vrugt, 2004):
  - A Markov Chain Monte Carlo sampler
  - Combination of the SCE and Metropolis algorithm
  - Used for parameter estimation and uncertainty analysis

Application

In the Chaohe Basin,China

Introduction of the Chaohe Basin

- The North of China, and part of it within Beijing City
- It is a very important water source supply for Beijing City
- Area: 5,340 km^2
- Annual rainfall: average 530 mm (350-690 mm)
- Flow: average 9.3m^3/s (1.89 - 28.12m^3/s)

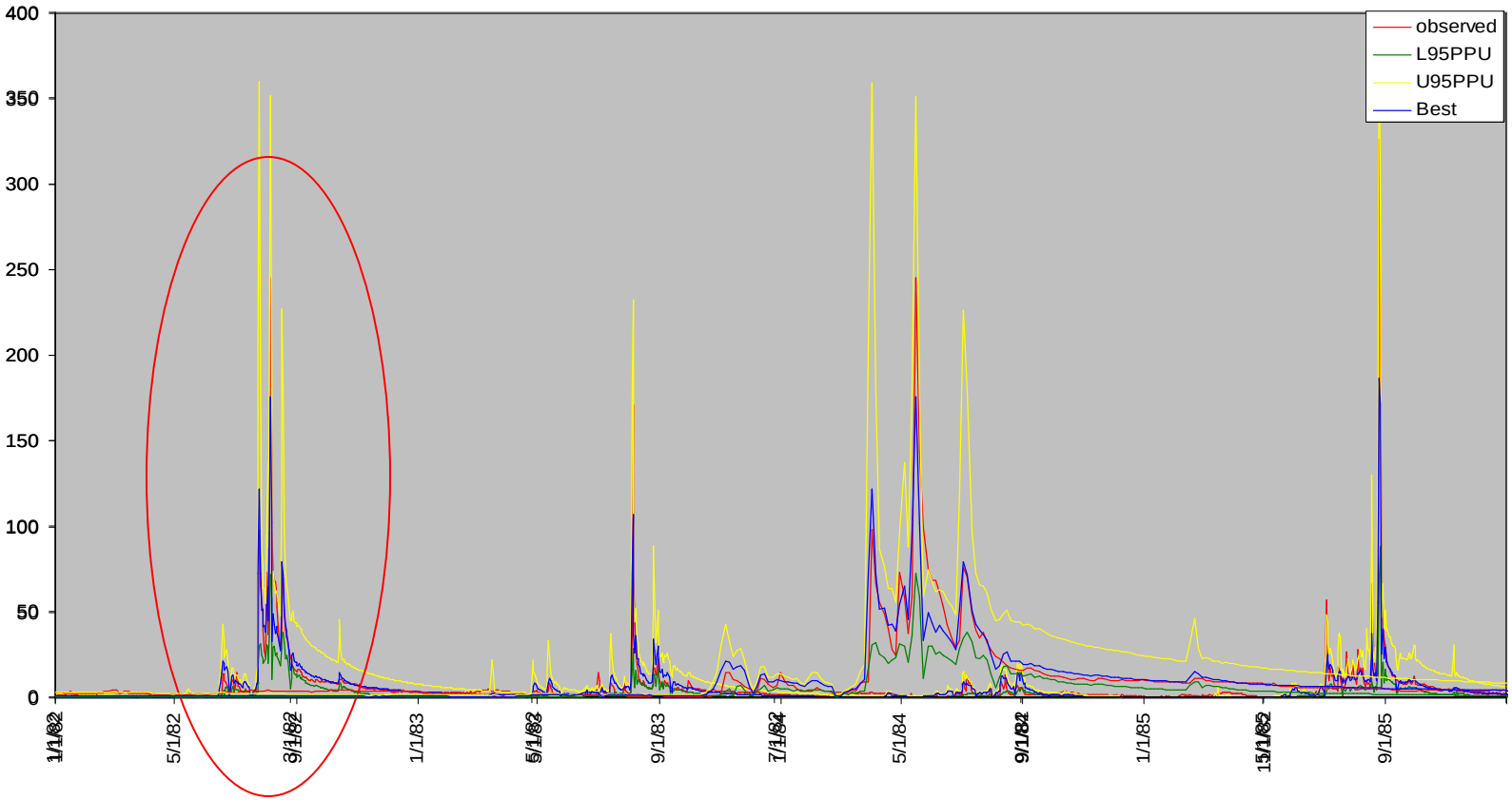
Parameter selection

Parameter identifier	Meaning of parameter	Min	Max
a__CN2.mgt	curve number	-25	5
v__ESCO.hru	soil evaporation compensation factor	0	1
v__EPCO.hru	Plant uptake compensation factor	0	1
r__SOL_K.sol	soil hydraulic conductivity	-0.7	0.7
a__SOL_AWC.sol	soil available water capacity	0	0.1
v__ALPHA_BF.gw	base flow alpha factor	0	1
r__SLSUBBSN.hru	average slope length	-0.4	0.4
a__CH_K2.rte	effective hydraulic conductivity in main channel alluvium	0	50
a__OV_N.hru	overland manning roughness	0	0.1
v__GW_DELAY.gw	groundwater delay time	0	250

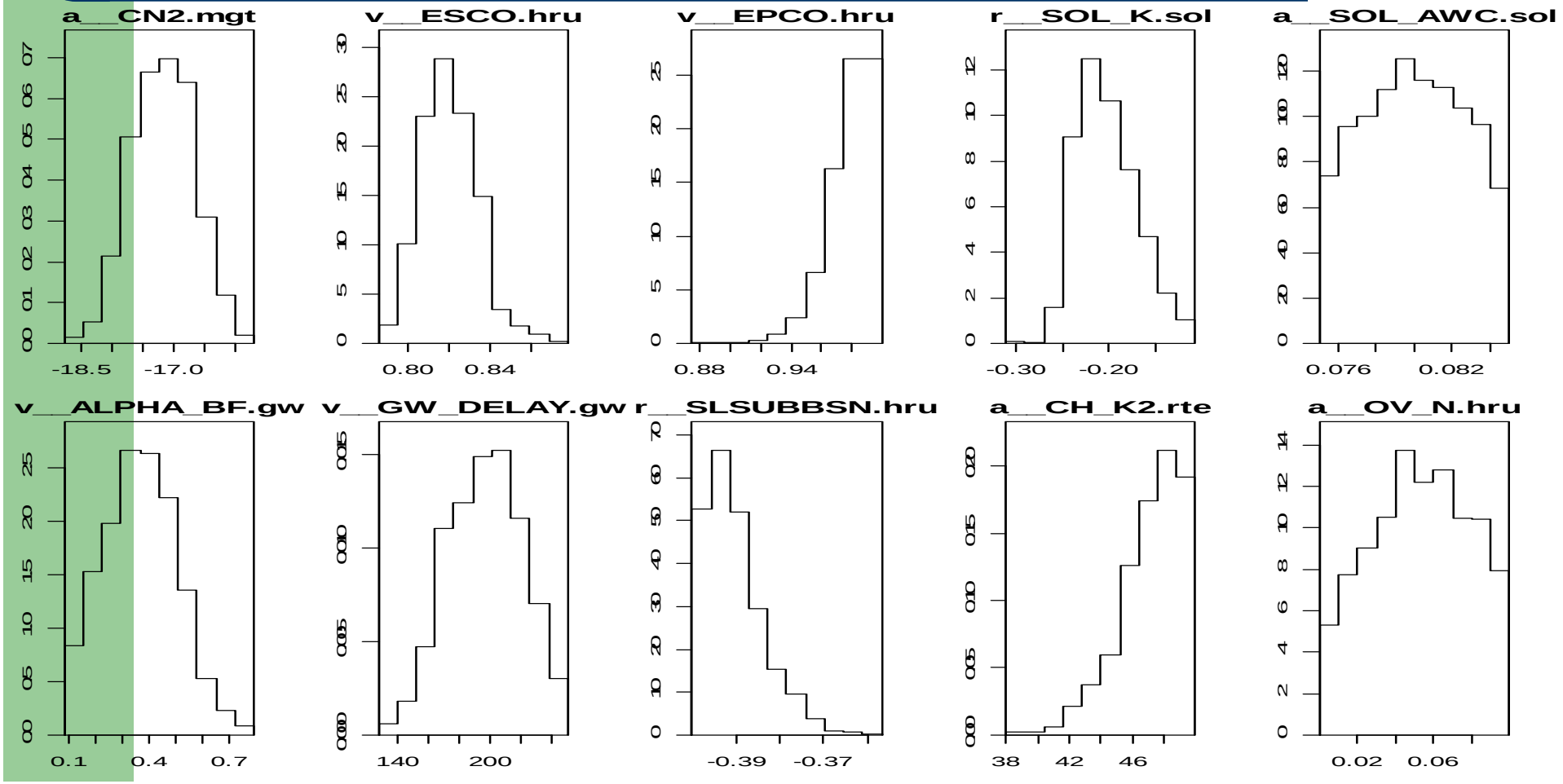
Result (based on SUFI): Parameter Uncertainty

Parameter identifier	lower uncertainty range	upper uncertainty range
a__CN2.mgt	-25	-6.6
v__ESCO.hru	0.34	1
v__EPCO.hru	0.49	1
r__SOL_K.sol	-0.29	0.53
a__SOL_AWC.sol	0.029	0.088
v__ALPHA_BF.gw	0.42	1
v__GW_DELAY.gw	42.3	50
r__SLSUBBSN.hru	-0.4	0.12
a__CH_K2.rte	16.9	50.7
a__OV_N.hru	0.023	0.074

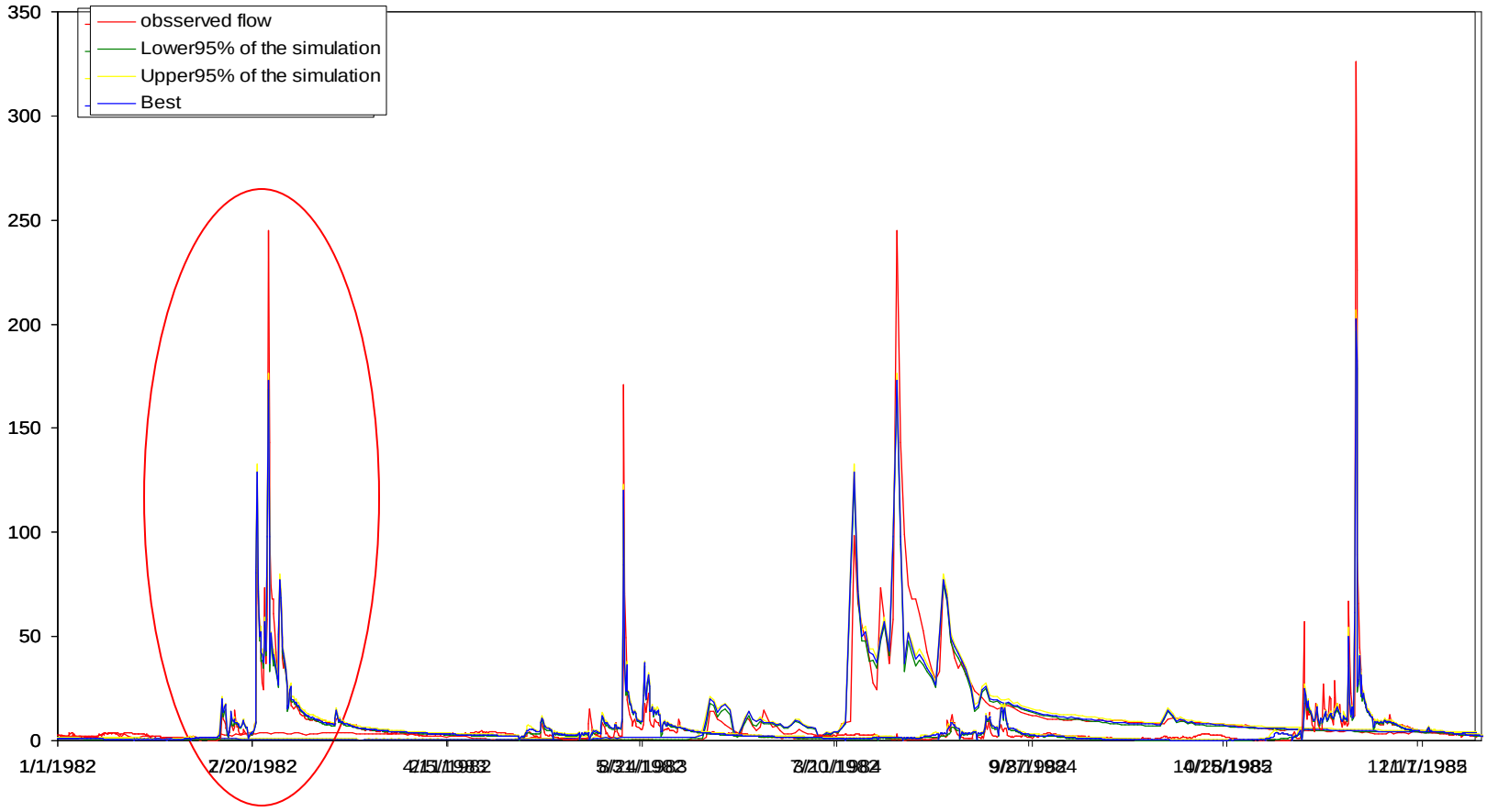
Result (based on SUFI): Simulation Uncertainty



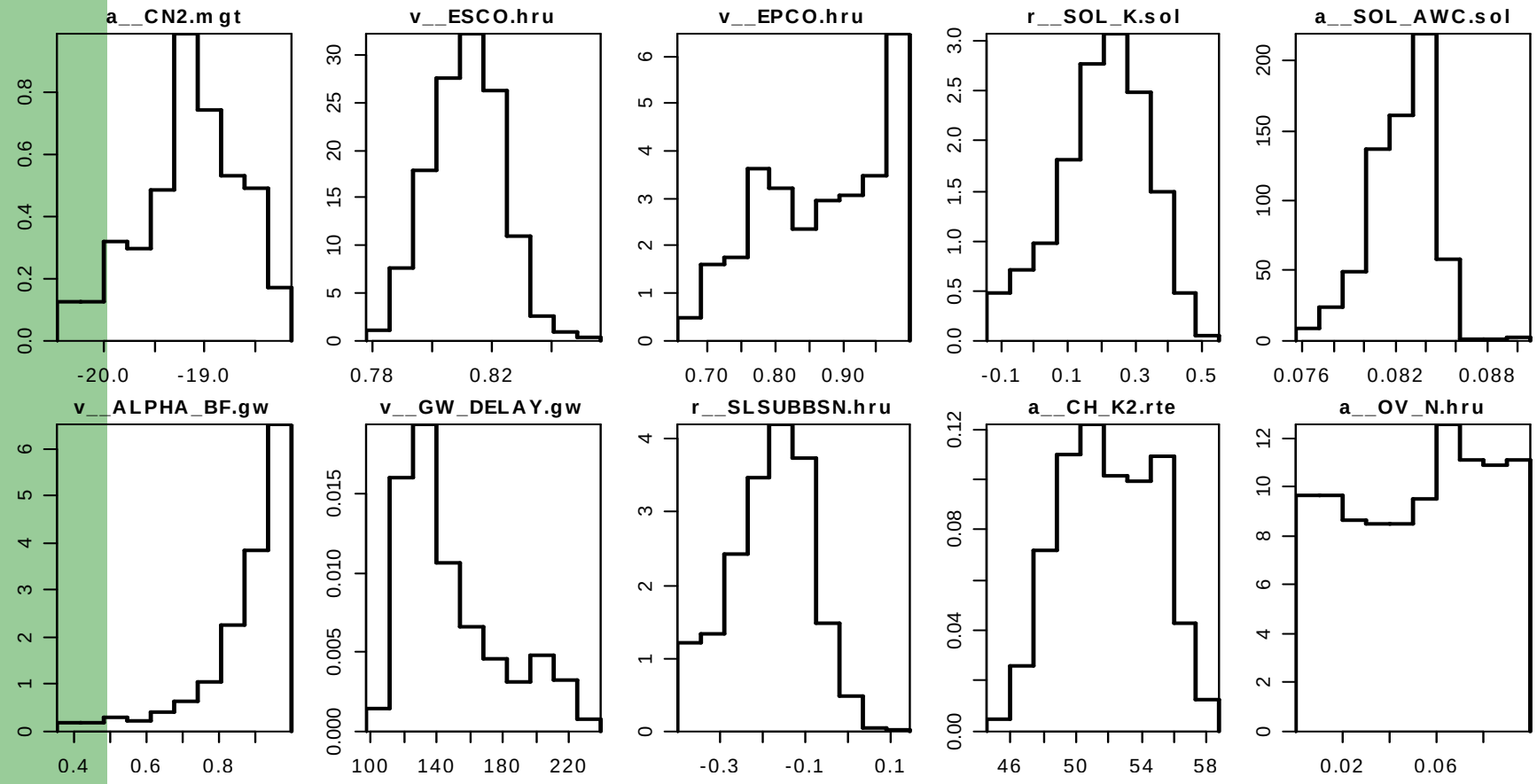
Result (based on SCEM-UA): Parameter Uncertainty



Result (based on SCEM-UA): Simulation Uncertainty



Result (Based on UNCSIM)



Conclusion

- The concept of parameter identifiers is essential for dealing with the large number of parameters and the assignment of meaningful spatial distributions
- The SWAT_SA_Interface greatly facilitates the process of calibration and uncertainty analysis
- From the case study, SUFI has the wider parameter uncertainties and prediction uncertainties than SCEM-UA and Metropolis-Hasting MCMC (Applied in UNCSIM).
- In the case study, parameter uncertainty is not sufficient for prediction uncertainty. Input and model structural uncertainties should be considered.

Thank you for your attention!