SWAT 2005
Zurich, Switzerland
July 14th, 2005

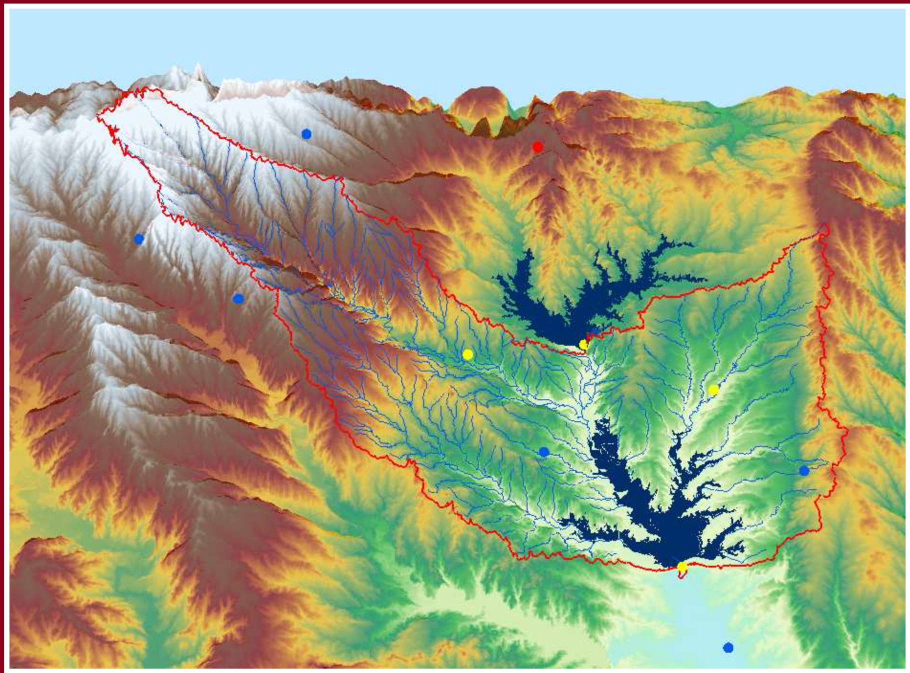
Two-Step Calibration Method for SWAT

Francisco Olivera, Ph.D.
Assistant Professor
Huidae Cho
Graduate Student

Department of Civil Engineering
Texas A&M University
College Station - Texas

SWAT 2005
Zurich, Switzerland
July 14th, 2005

Can we extract spatial information from temporal data?



Francisco Olivera, Ph.D.
Assistant Professor
Huidae Cho
Graduate Student

Department of Civil Engineering
Texas A&M University
College Station - Texas

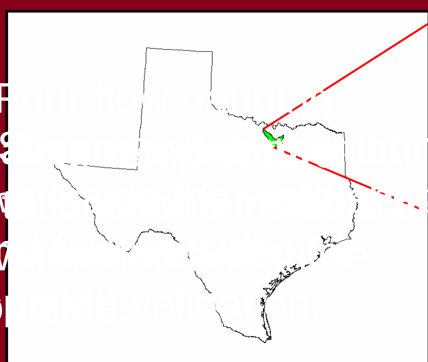
Objective

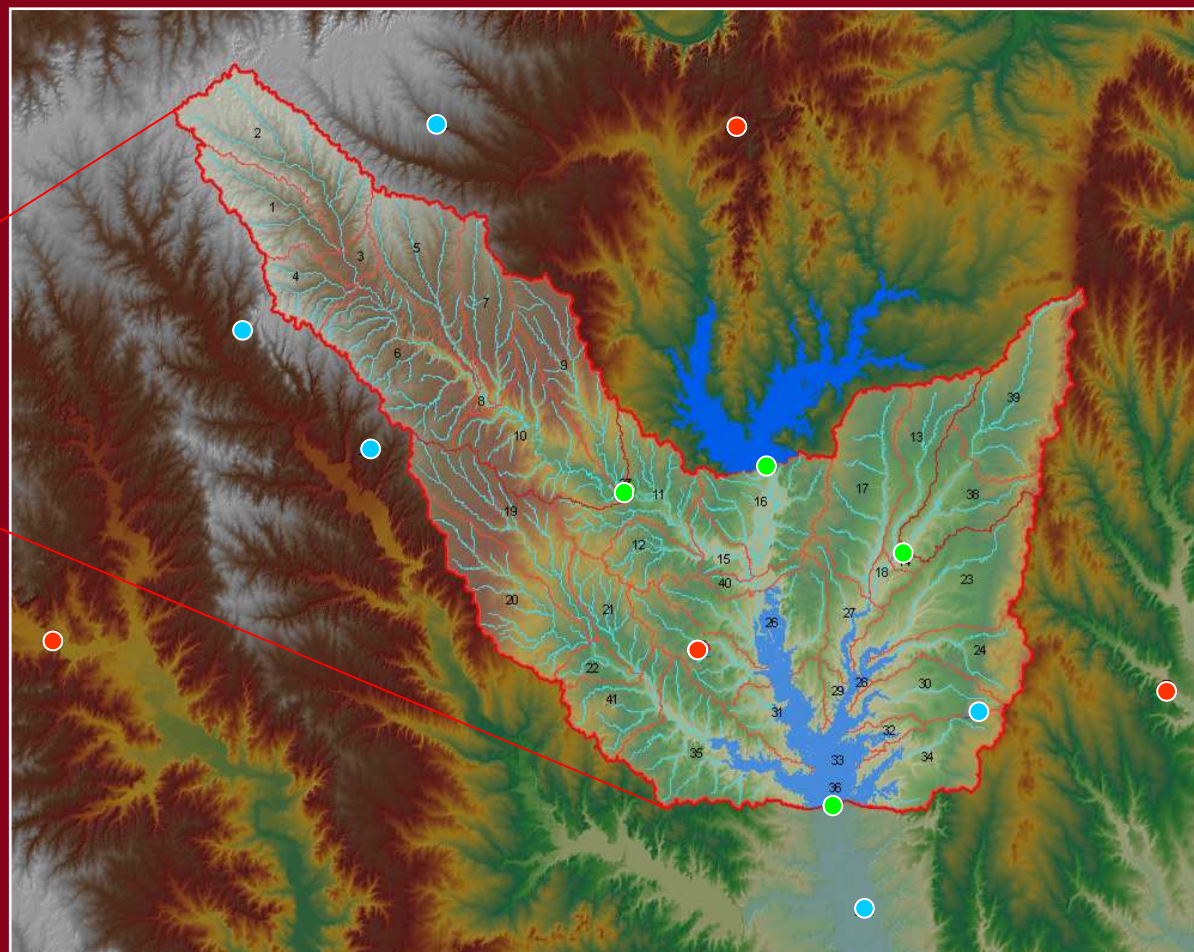
- **Given:** A calibration routine that adjusts the terrain parameters independently for each sub-basin and HRU (i.e., extracts spatial information).

- **Hypothesis:** A model that can reproduce the system’s responses for a “long” period of time has the correct parameter spatial distribution.

Lake Lewisville Watershed

Area: 2500 km^2

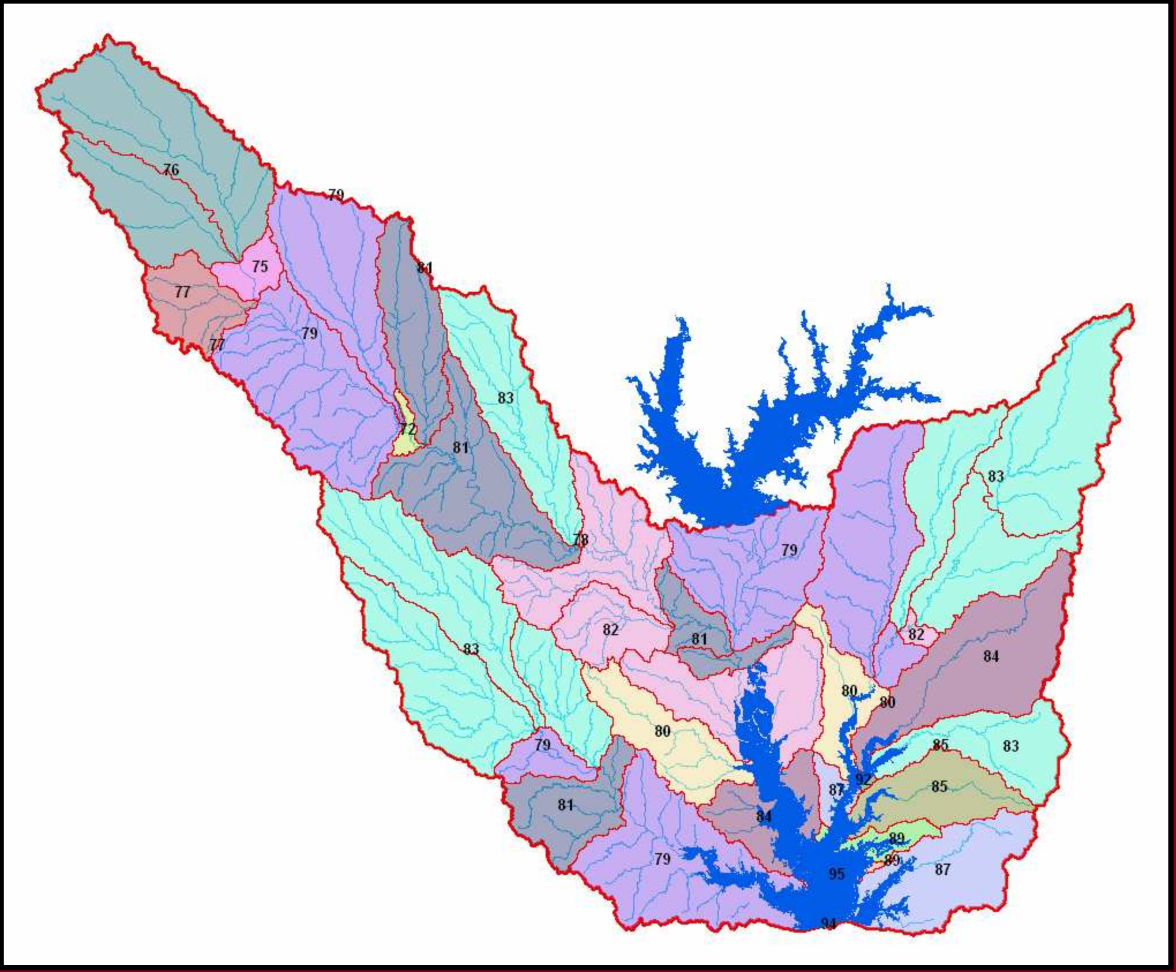




Period of record: 1987 – 1999

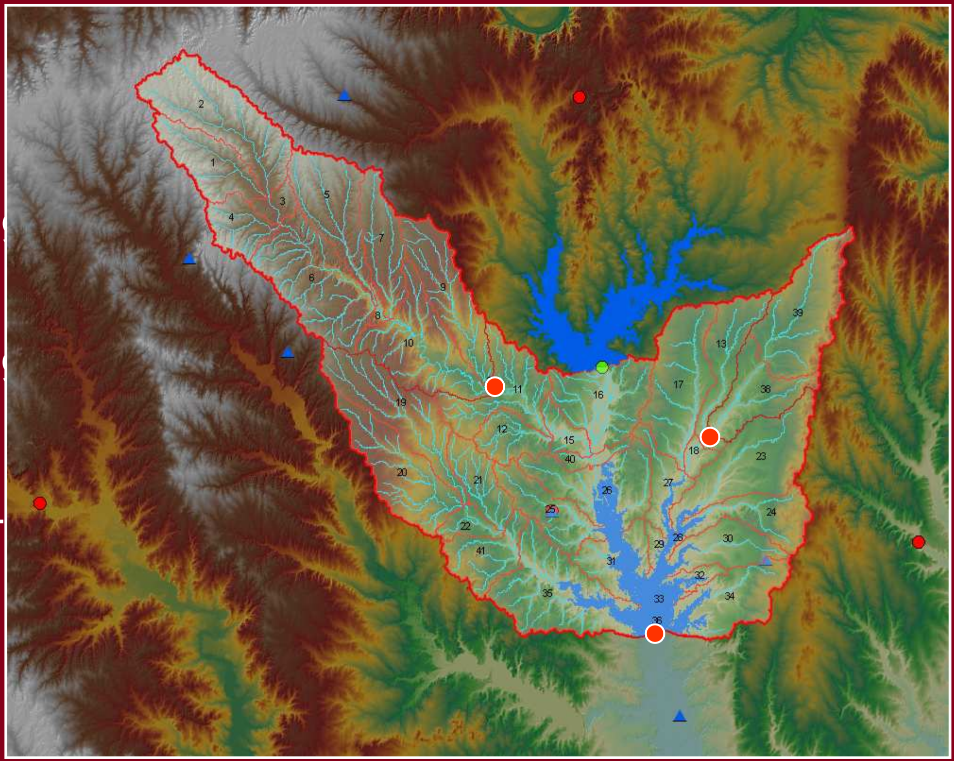
Lake Lewisville Watershed

Curve number



Calibration and validation

- Three-year warm-up period.
- Calibration periods:
  - One year: [1992-1994] + [19
  - …
  - Six years: [1987-1989] + [19
- Validation period:
  - Four years: [1993-1995] + [1
- Calibration location
- Validation location



Calibration parameters

Parameter	Description
CN2	SCS runoff curve number
SOL_AWC	Soil available water capacity (mm H_2O/mm soil)
ESCO	Soil evaporation compensation factor. Whenever the upper layer cannot meet the evaporative demand, SWAT extracts more soil water from the lower layer.
GWQMN	Threshold depth of water in the shallow aquifer required for return flow to occur (mm H_2O)
GW_REVAP	Groundwater “revap” coefficient. Revap is the process by which water moves into the overlying unsaturated zone from the shallow aquifer by the capillary fringe or deep-rooted plants.
REVAPMN	Threshold depth of water in the shallow aquifer for “revap” or percolation to the deep aquifer to occur (mm H_2O)
CH_K2	Effective hydraulic conductivity in main channel alluvium (mm/hr)
ALPHA_BF	Baseflow alpha factor (days) is a direct index of groundwater flow response to changes in recharge.
OV_N	Manning’s “n” value for overland flow
SLOPE	Average slope steepness (m/m)
SLSUBBSN	Average slope length (m)

Calibration levels

- **Watershed:** All sub-basin and HRU parameters are adjusted by applying one single parameter-change rule over the entire watershed.
- **Sub-basin:** All sub-basin and HRU parameters are adjusted by applying a different parameter-change rule in each subbasin. Follows watershed calibration.
- **HRU:** Each HRU parameter is adjusted differently. Follows sub-basin calibration.

Parameter-change rules

- Method A (plus/minus): $-0.05 < \alpha < 0.05$

$$P_{i+1} = P_i + (P_{max} - P_{min})\,\alpha$$

- Method B (factor): $0.9 < \alpha < 1.1$

$$P_{i+1} = P_i + (P_i - P_{min})\,\alpha$$

- Method C (alpha): $-0.5 < \alpha < 0.5$

$$P_{i+1} = P_i + (P_{max} - P_i)\,\alpha$$

Initial conditions

- Initial conditions for the iterative calibration process:
  - **Non-uniform:** parameter values based on land-use and soil-type data.
  - **Uniform:** average parameter values throughout the watershed … **let the calibration process extract the spatial information**.

Objective functions

- Sum of the square of the residuals (SSR)

$$SSR = \sum (Q_{simulated} - Q_{observed})^2$$

- Sum of the absolute value of the residuals (SAR)

$$SSR = \sum \left| Q_{simulated} - Q_{observed} \right|$$

- No logQ or Q in the denominator was used because some flows were zero.

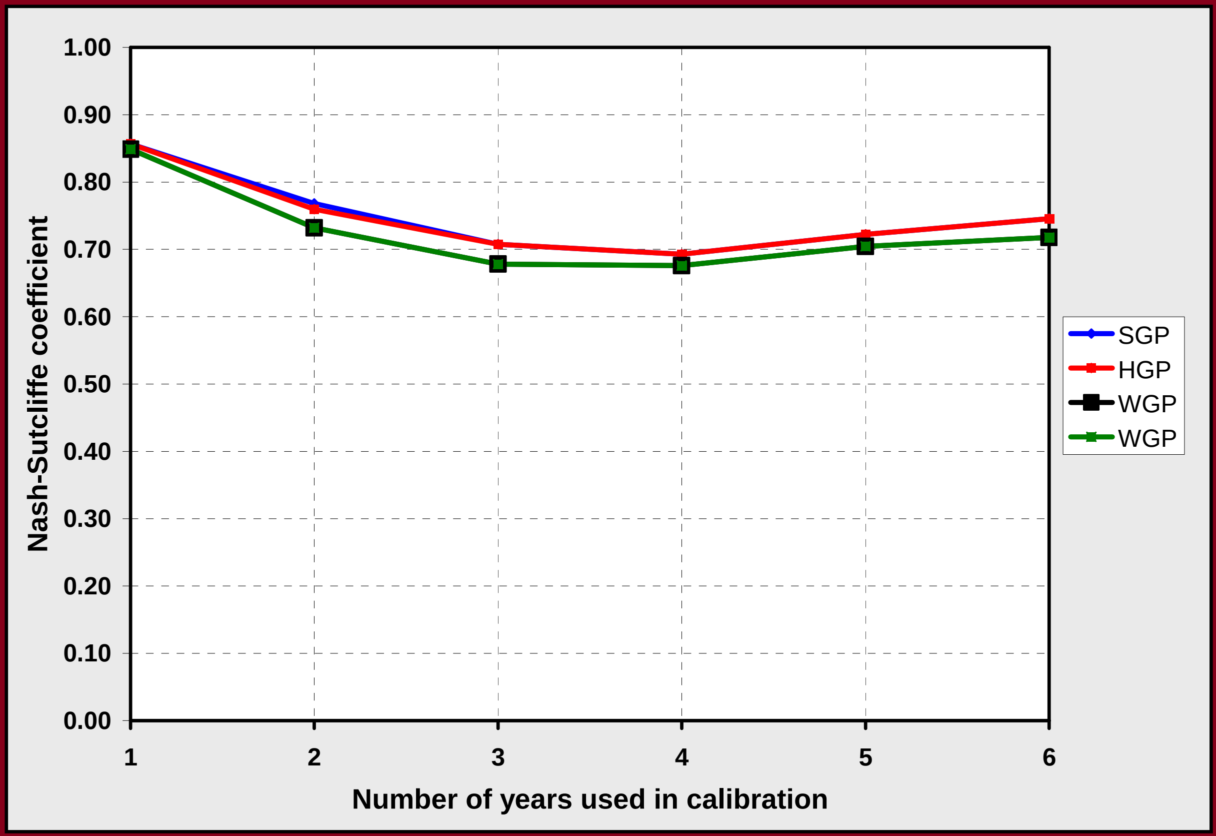
Model efficiency

- Model efficiency was evaluated with the Nash-Sutcliffe coefficient:

$$\mathrm{NS} = 1 - \frac{\sum (\mathrm{Q}_{\mathrm{simulated}} - \mathrm{Q}_{\mathrm{observed}})^2}{\sum (\overline{\mathrm{Q}} - \mathrm{Q}_{\mathrm{observed}})^2} = 1 - \frac{\mathrm{SSR}}{\sum (\overline{\mathrm{Q}} - \mathrm{Q}_{\mathrm{observed}})^2}$$

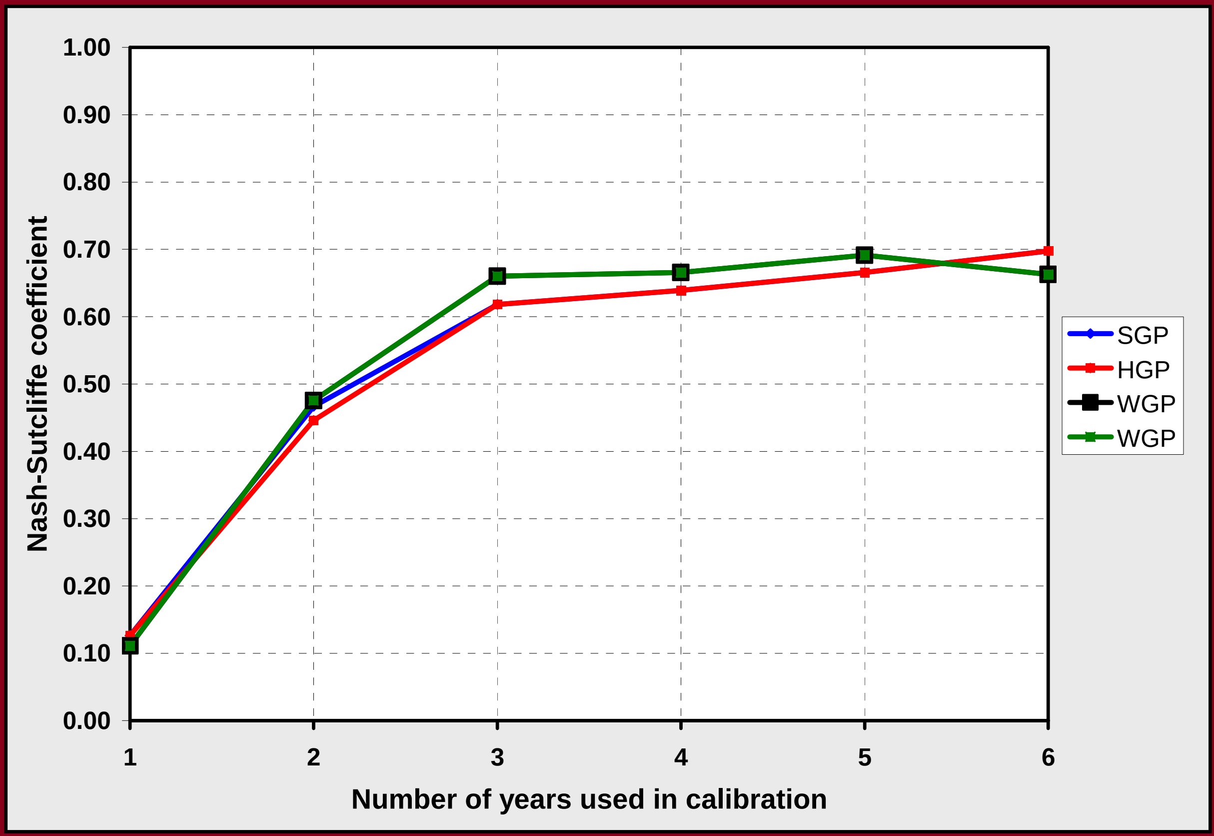
where $\overline{\mathrm{Q}}$ is the long-term flow average (i.e., the predicted flows with “no model”).

Hydrologic unit



The increase in NS between subbasin and watershed is small, and between HRU and subbasin is negligible.

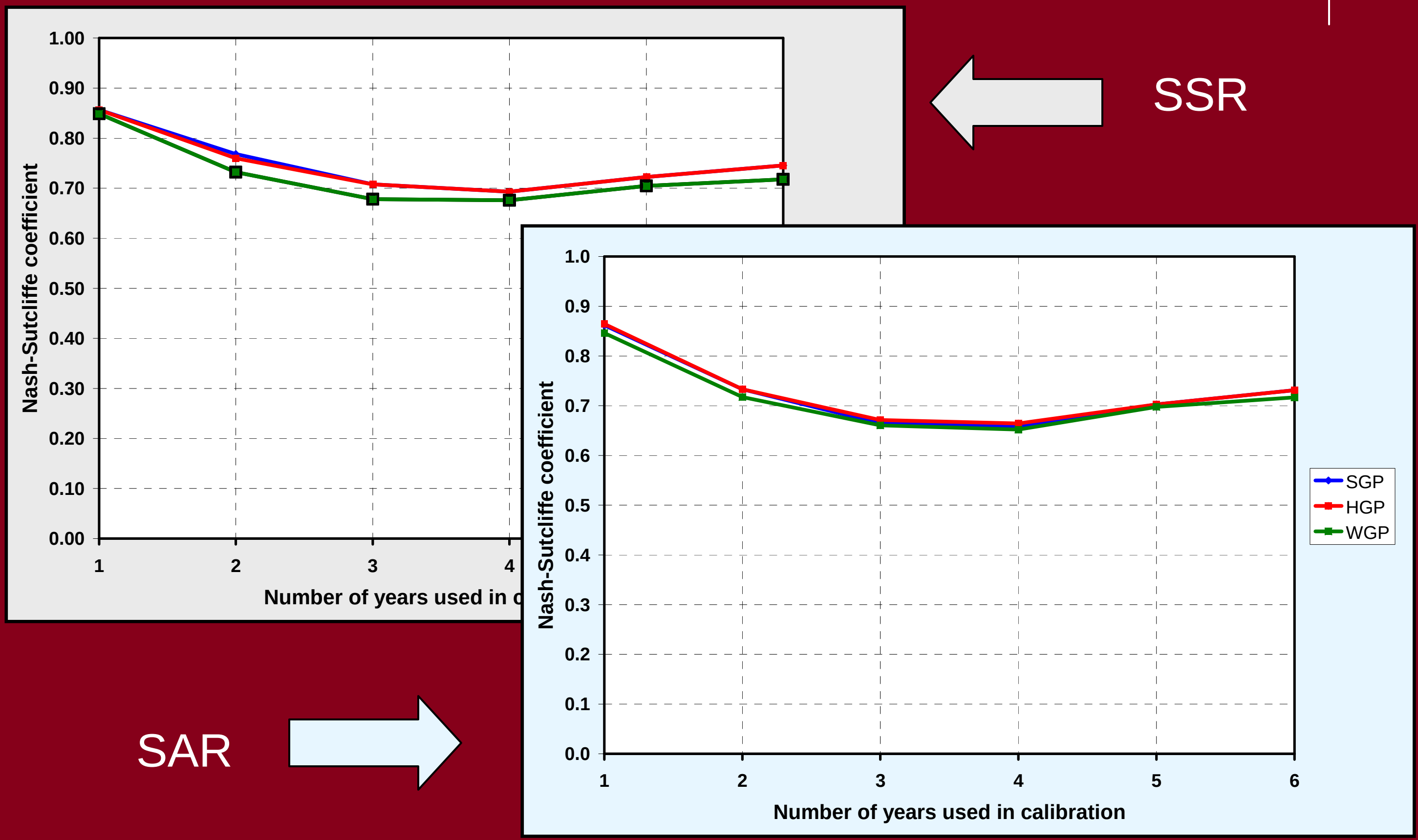
Hydrologic unit



The decrease in NS between subbasin and watershed is small, and between HRU and subbasin is negligible.

Objective function

Calibration // Distributed // Plus-minus // 42

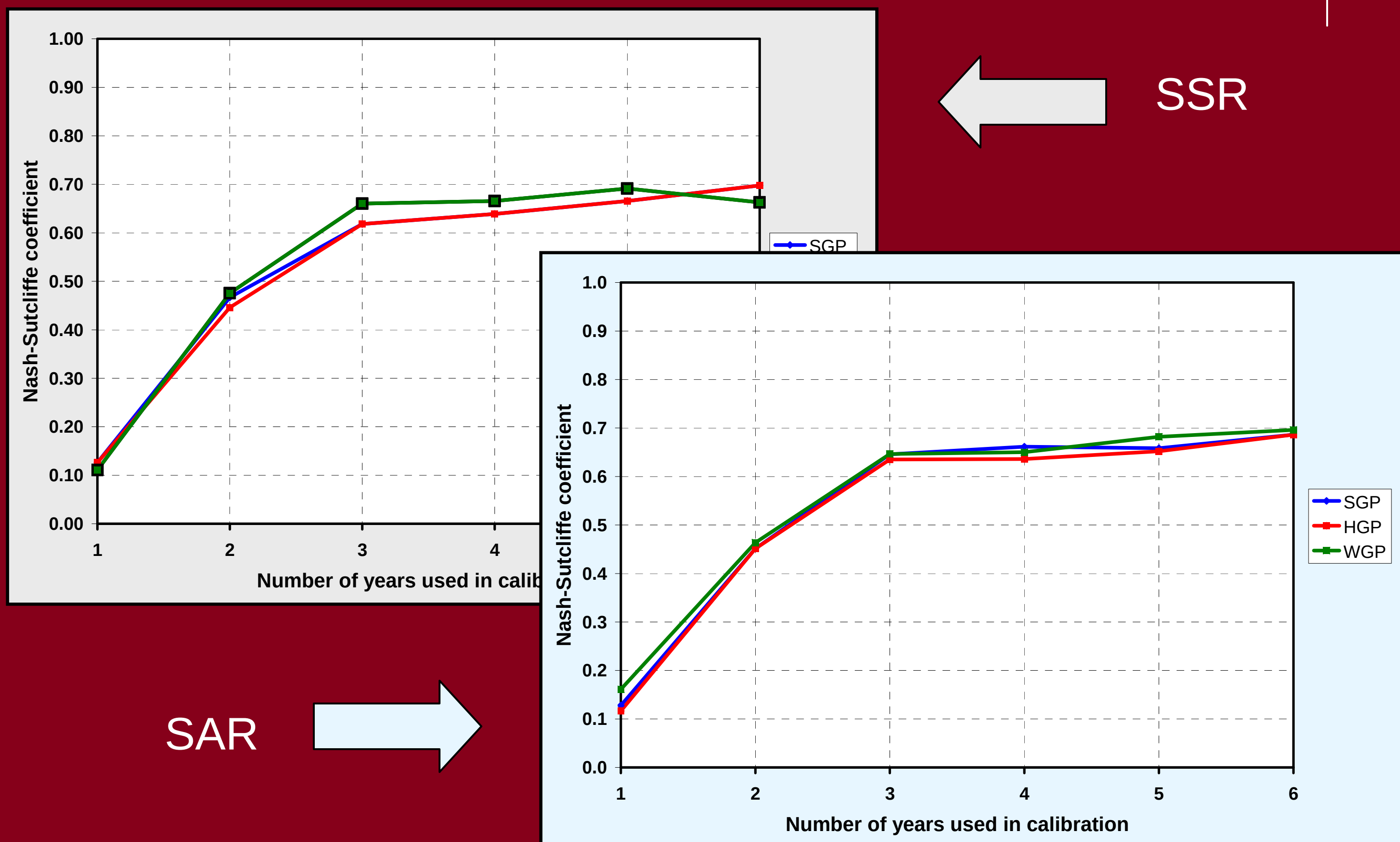


The increase in NS between subbasin and watershed is small, and between HRU and subbasin is negligible.

Objective function

Validation // Distributed // Plus-minus // 42

SSR

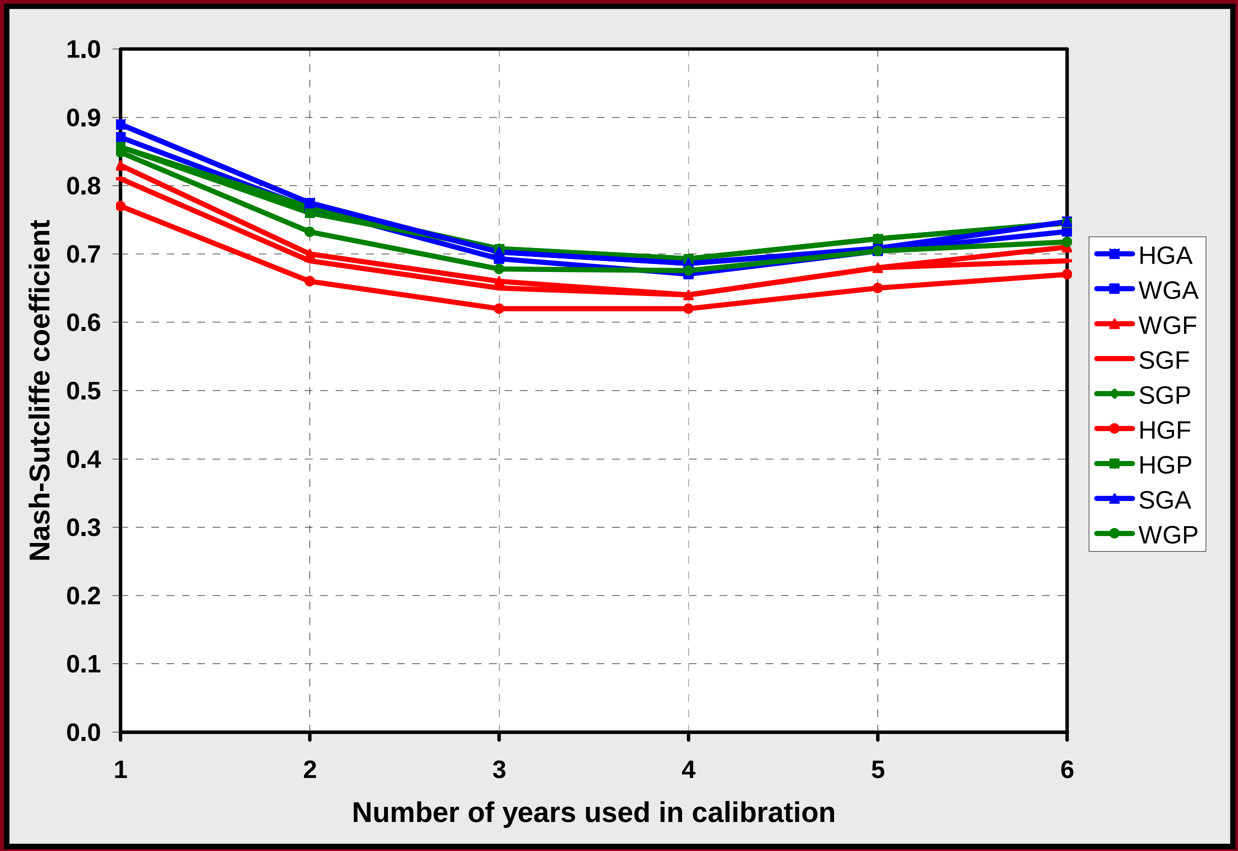


SAR

The increase in NS between subbasin and watershed is small, and between HRU and subbasin is negligible.

Parameter change function

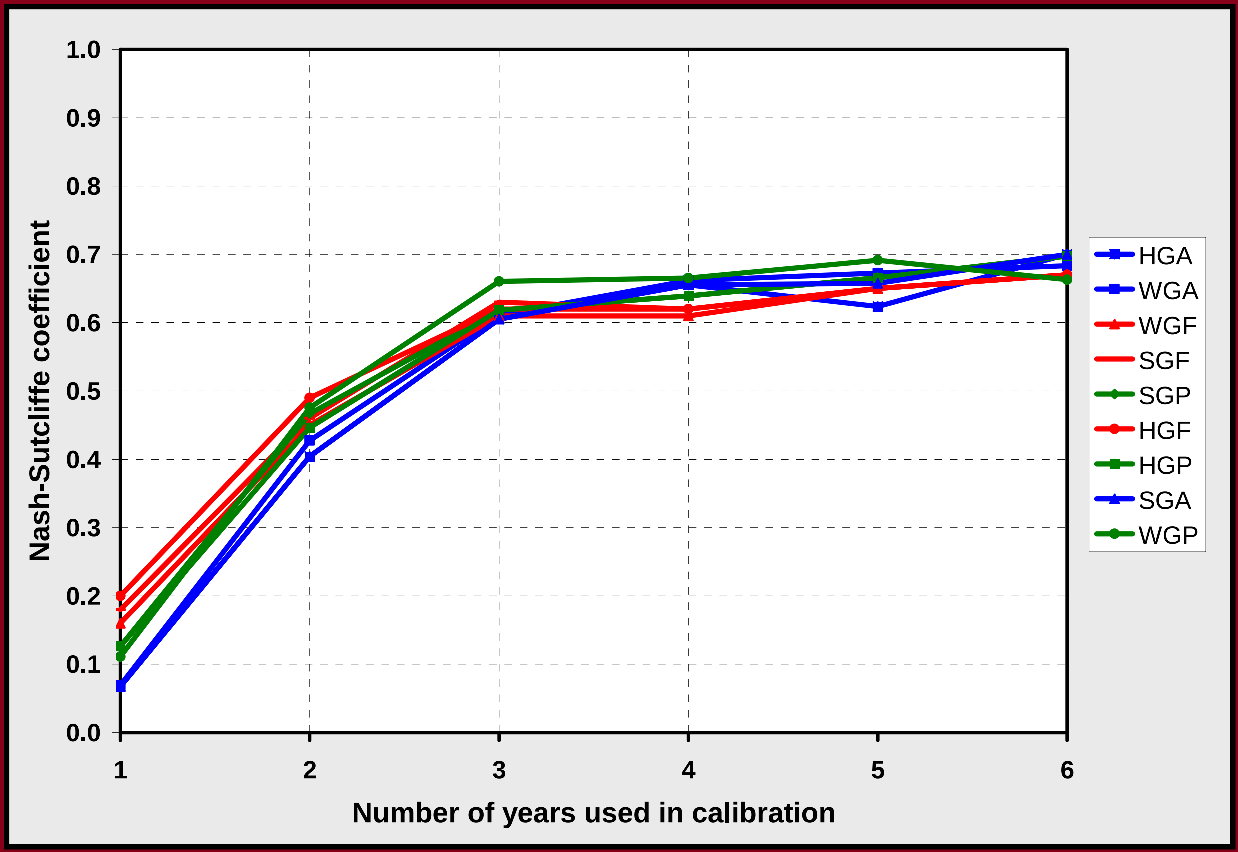
Calibration // SSR // Distributed // 42



The NS values for the *factor* parameter-change-function are slightly lower than for the other functions.

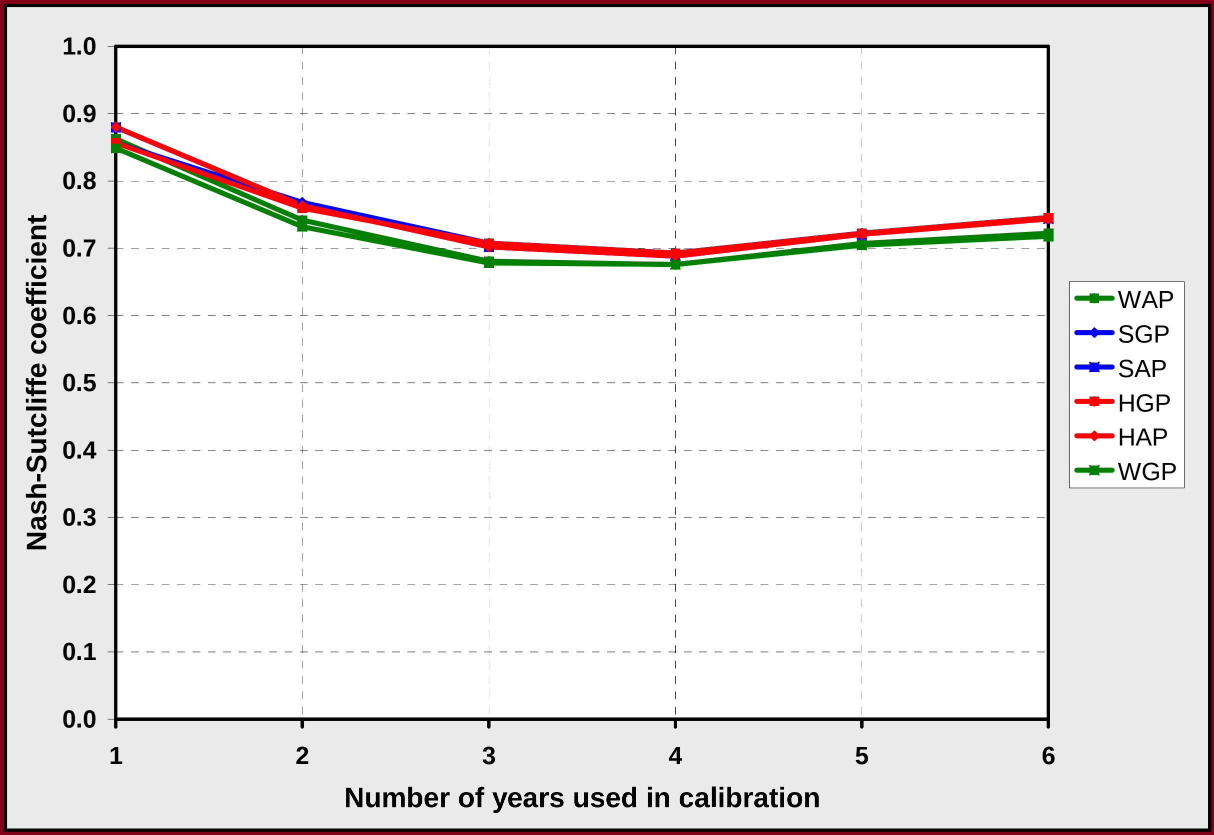
Parameter change function

Validation // SSR // Distributed // 42



Spatial variability

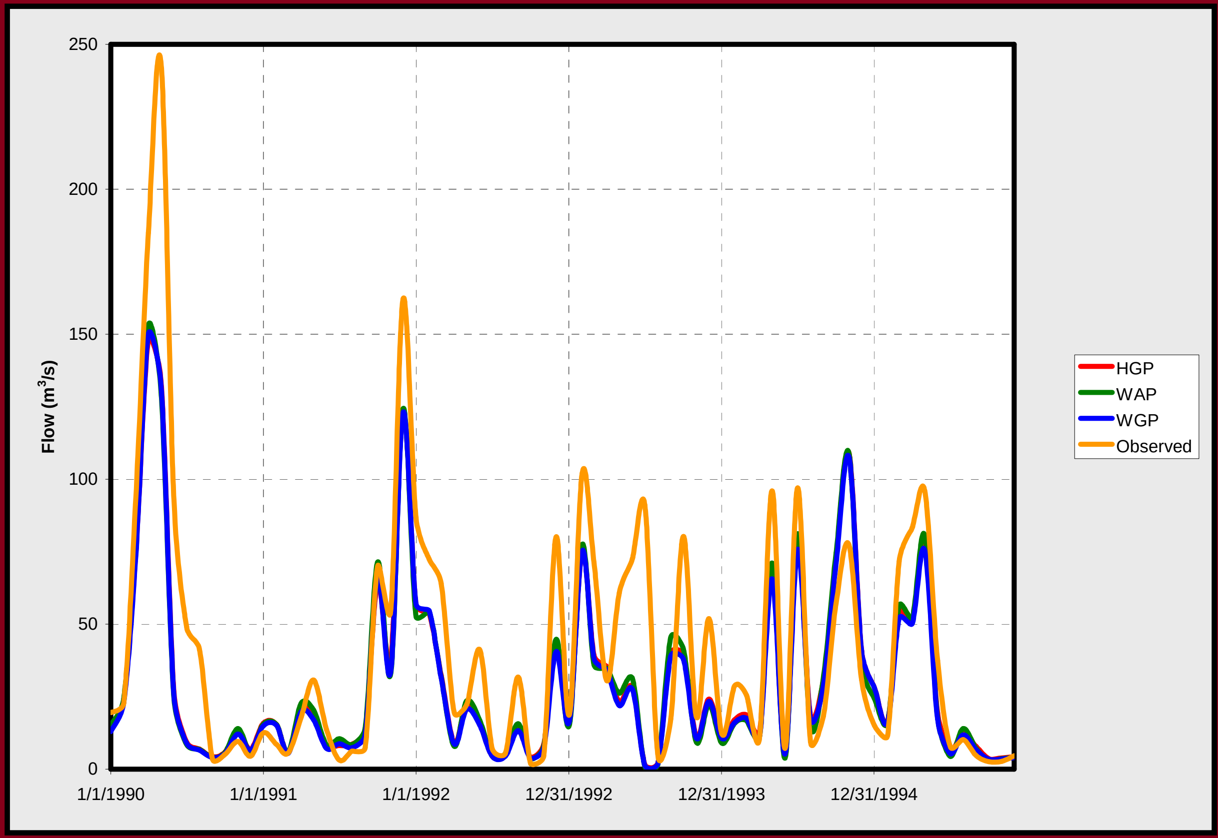
Calibration // SSR // Plus-minus // 42



The NS values are not significantly affected by the initial assumed spatial variability.

Hydrographs - Calibration

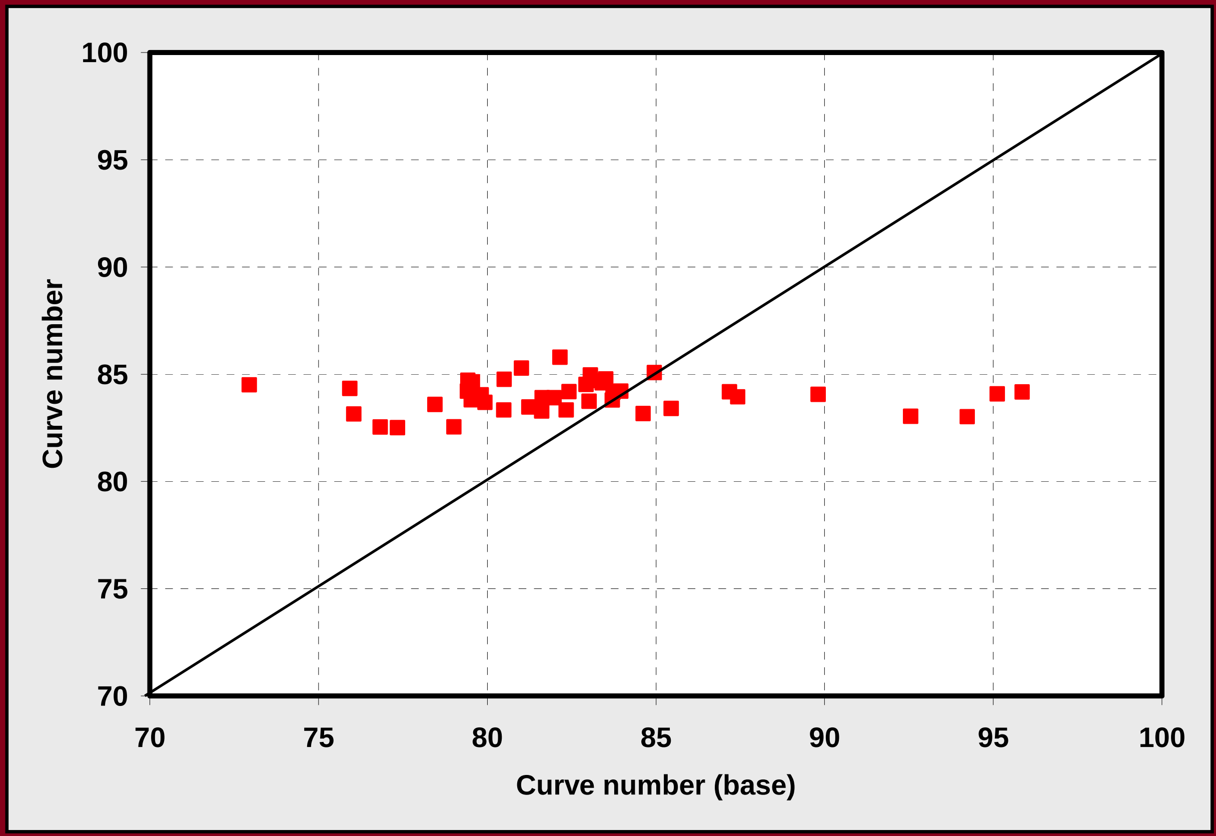
Calibration // SSR // Plus-minus // 42



The simulated hydrographs are fundamentally equal even though the initial conditions before the calibration were very different.

Parameter values

SSR // Average // Plus-minus // HRU

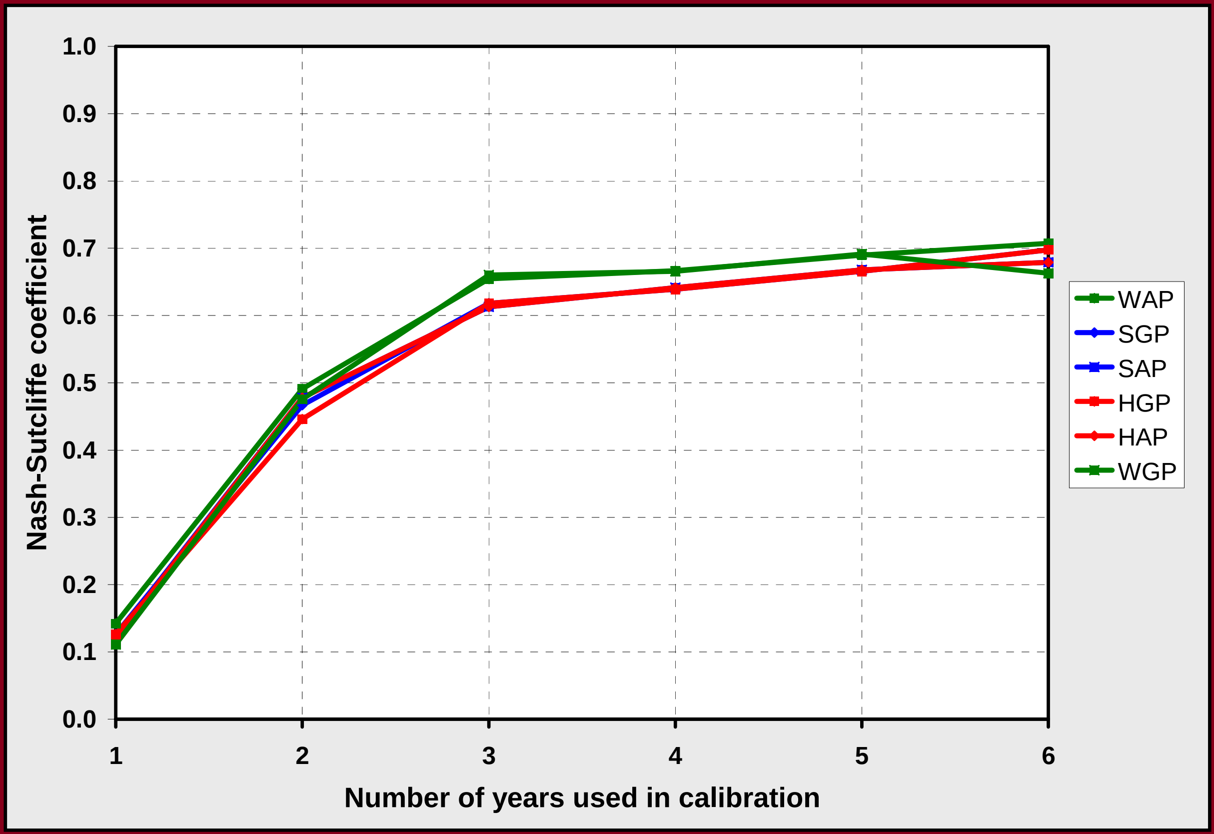


SSR // Distributed // Plus-minus // Watershed

Same results were obtained from significantly different sets of initial parameters.

Spatial variability

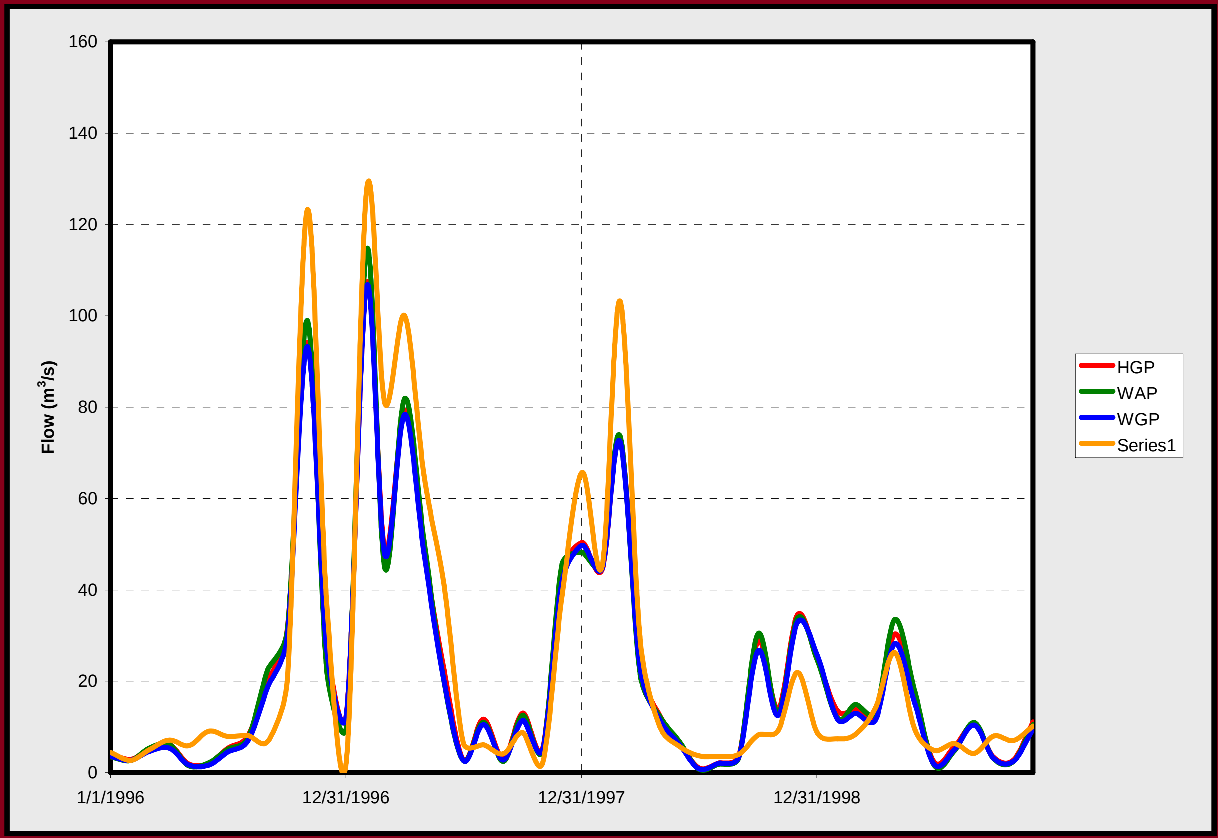
Validation // SSR // Plus-minus // 42



The NS values are not significantly affected by the initial assumed spatial variability.

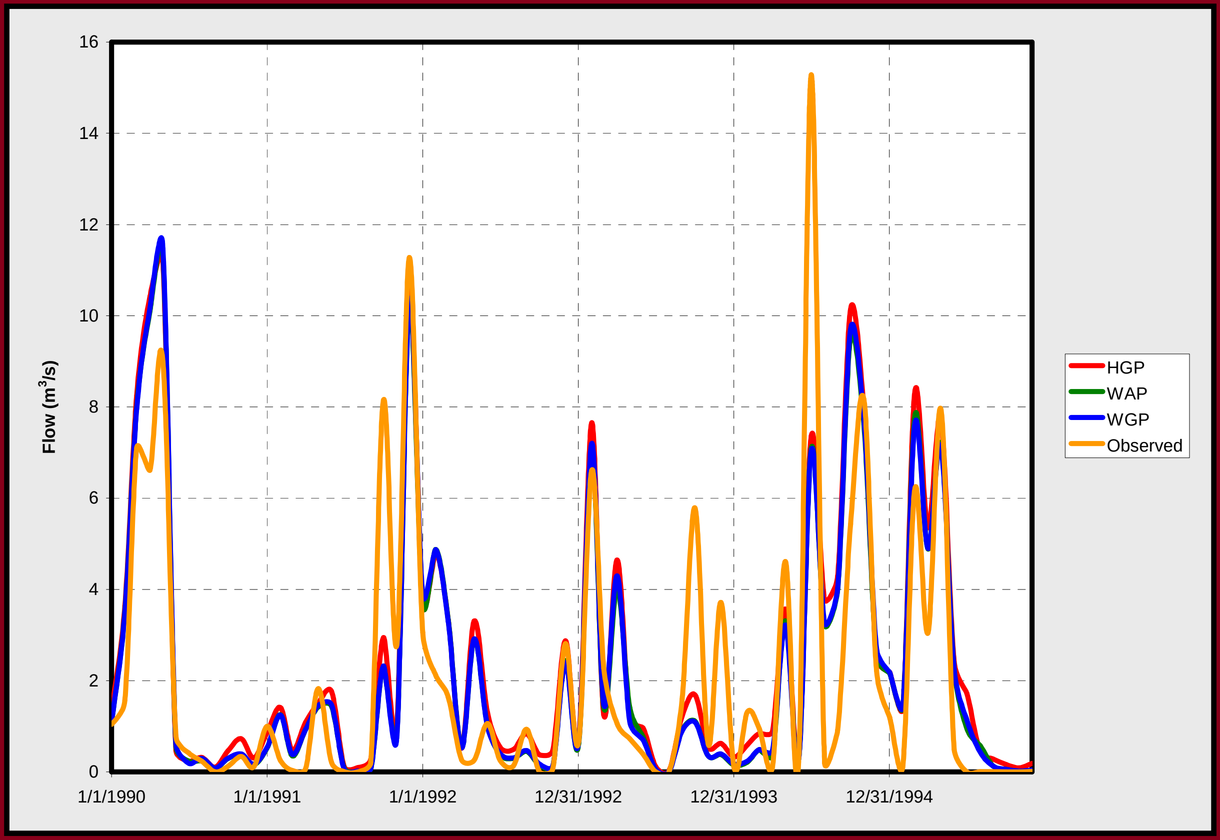
Hydrographs - Validation

Validation // SSR // Plus-minus // 42



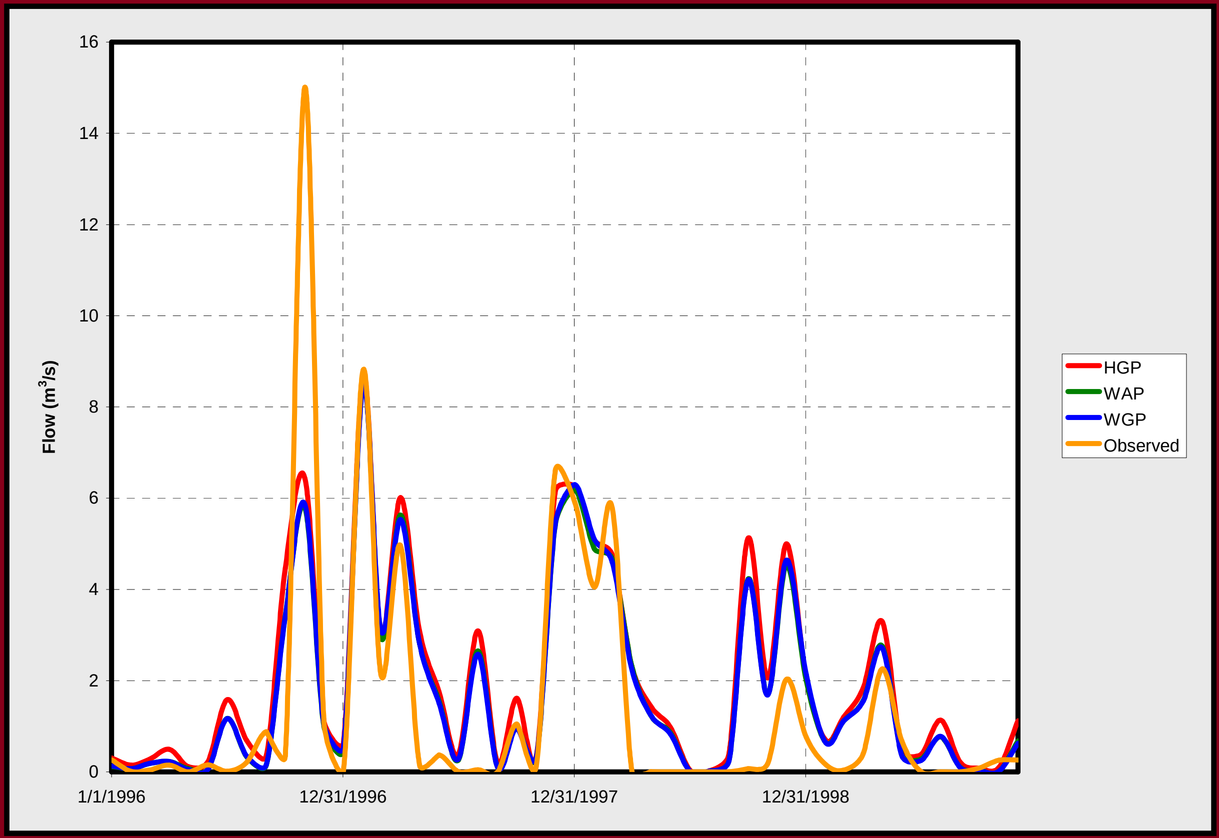
The simulated hydrographs are fundamentally equal even though the assumptions during calibration were very different.

Spatial validation



The initial assumed spatial variability does not make a significant difference; however, the watershed-based calibration is more accurate.

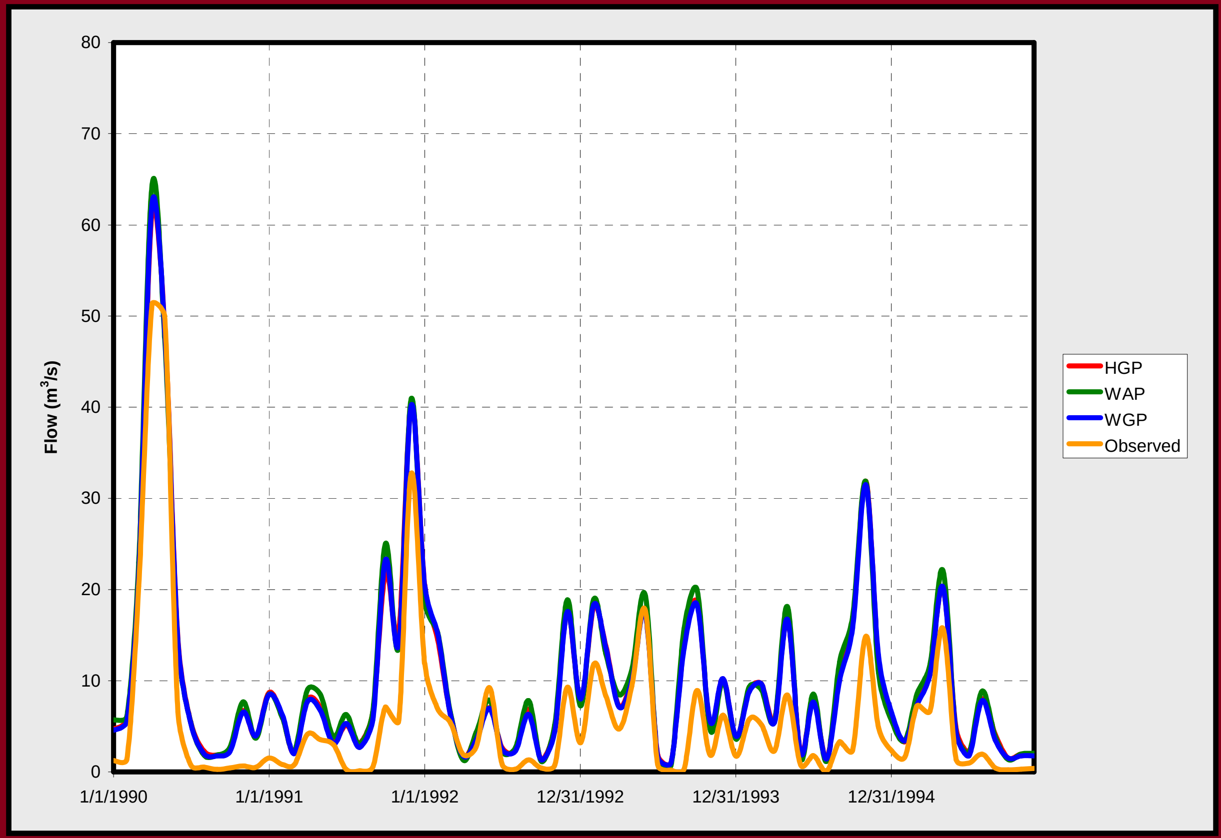
Spatial and temporal validation



In validation over space and time, the watershed-based calibration with an average initial spatial variability has the highest NS values.

Spatial validation

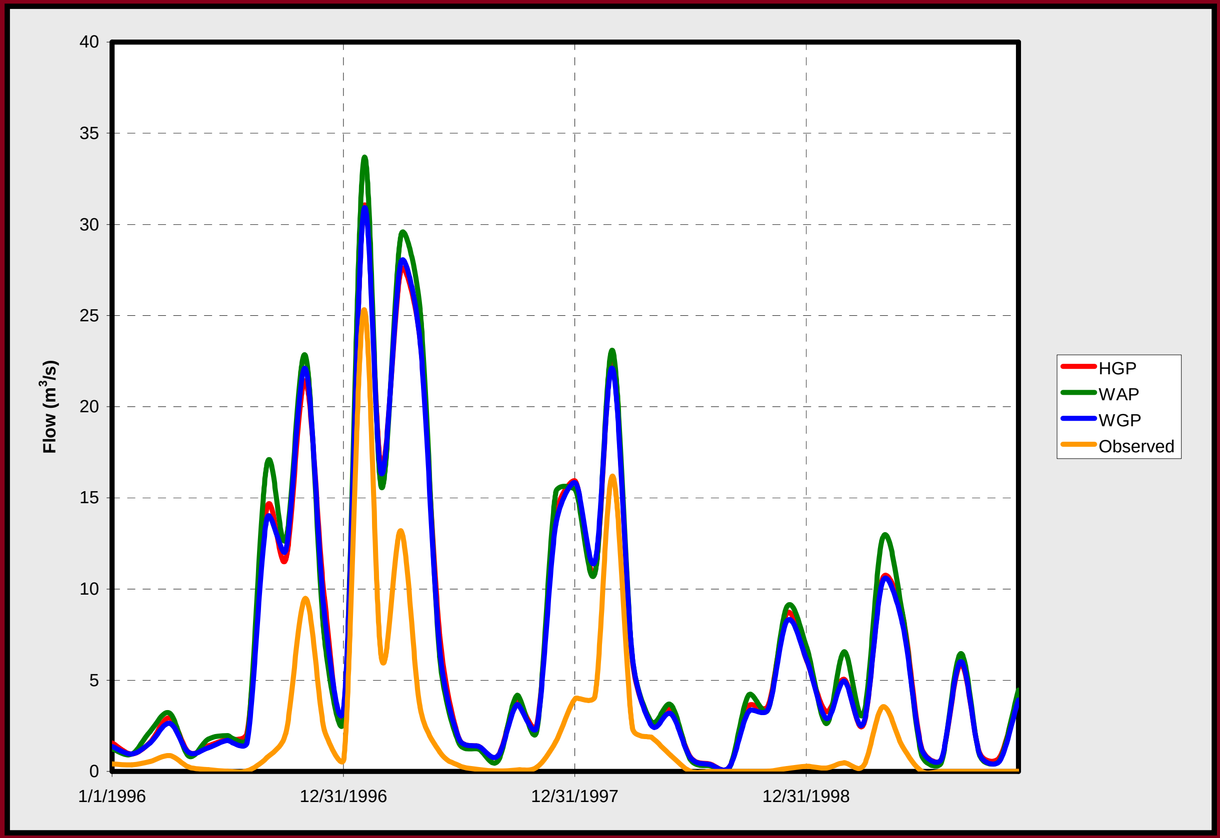
Calibration // SSR // Plus-minus // 37



Not even the watershed-based calibration using the spatial variability defined by the soil and land use data produces a good NS value.

Spatial and temporal validation

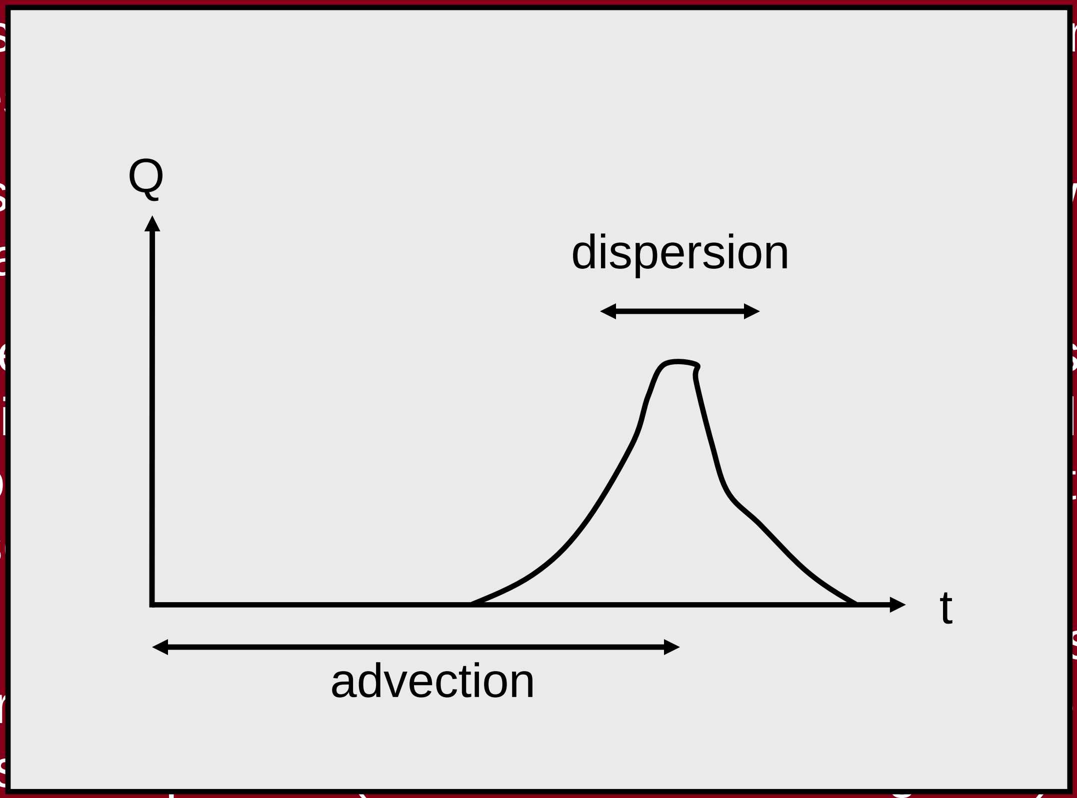
Validation // SSR // Plus-minus // 37



Not even the watershed-based calibration using the spatial variability defined by the soil and land use data produces a good NS value.

Discussions

- Dispers me water particle
- Becaus hen and where a
- The effe ses proporti e the effect o roid) increas
- In smal s (i.e., unit hydrogr eps respons



Conclusions

- It was not possible to “extract hydrologic information from temporal data” for the 2,500-km^2 Lake Lewisville watershed.
- The effect of the spatial variability was small compared to the effect of hydrodynamic dispersive processes in the system.
- The number of years used for calibrating the model was fundamental for determining the parameter values.
- The parameter-change rule and the selected objective function did not significantly affect the calibration process.

Questions?