SWAT

SWAT 2005 3rd international conference

July 11-15, 2005
Zurich, Switzerland

# Evaluation of models using SWAT2005

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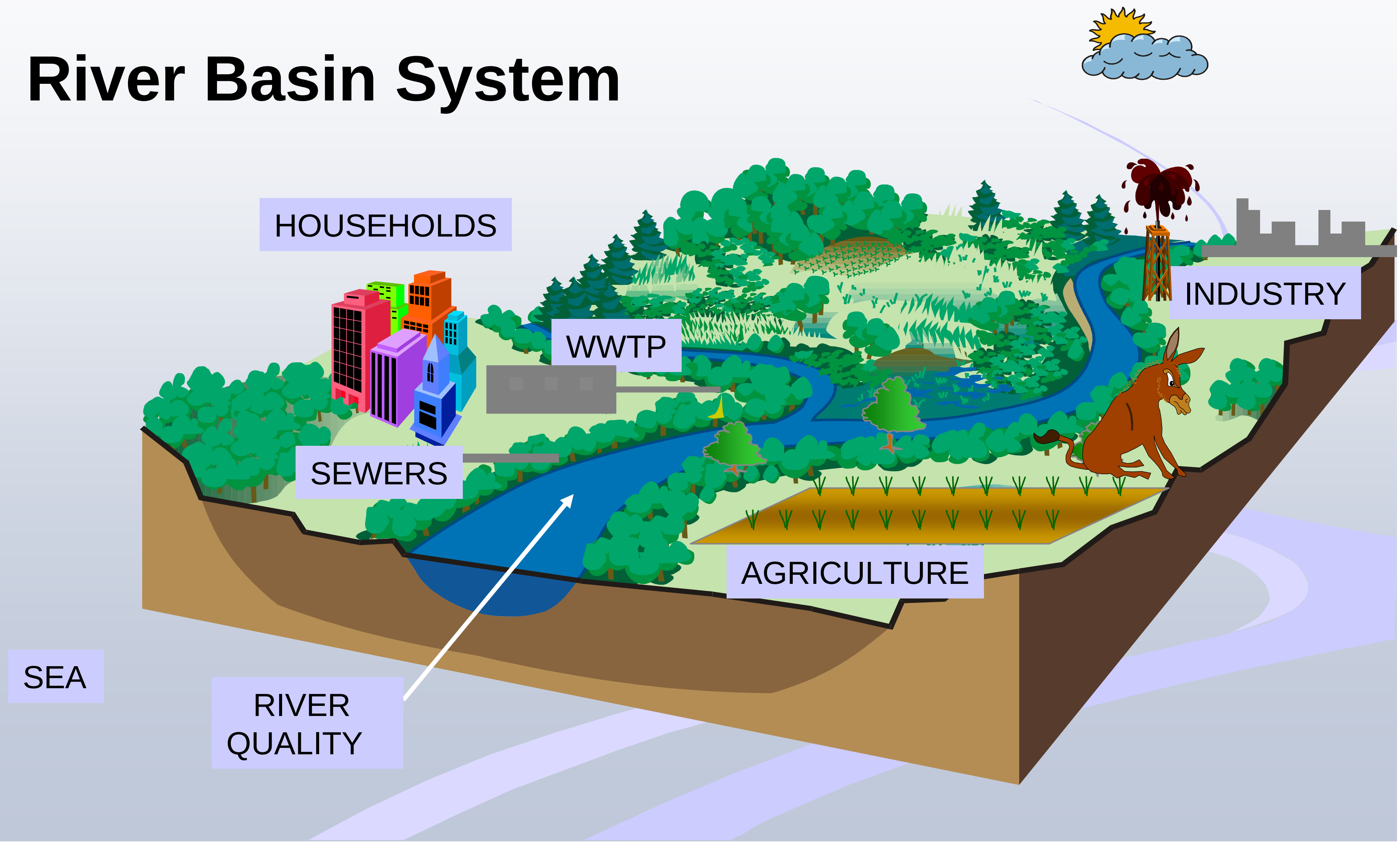
## Problem



# River Basin System



# Problem

VERY COMPLEX

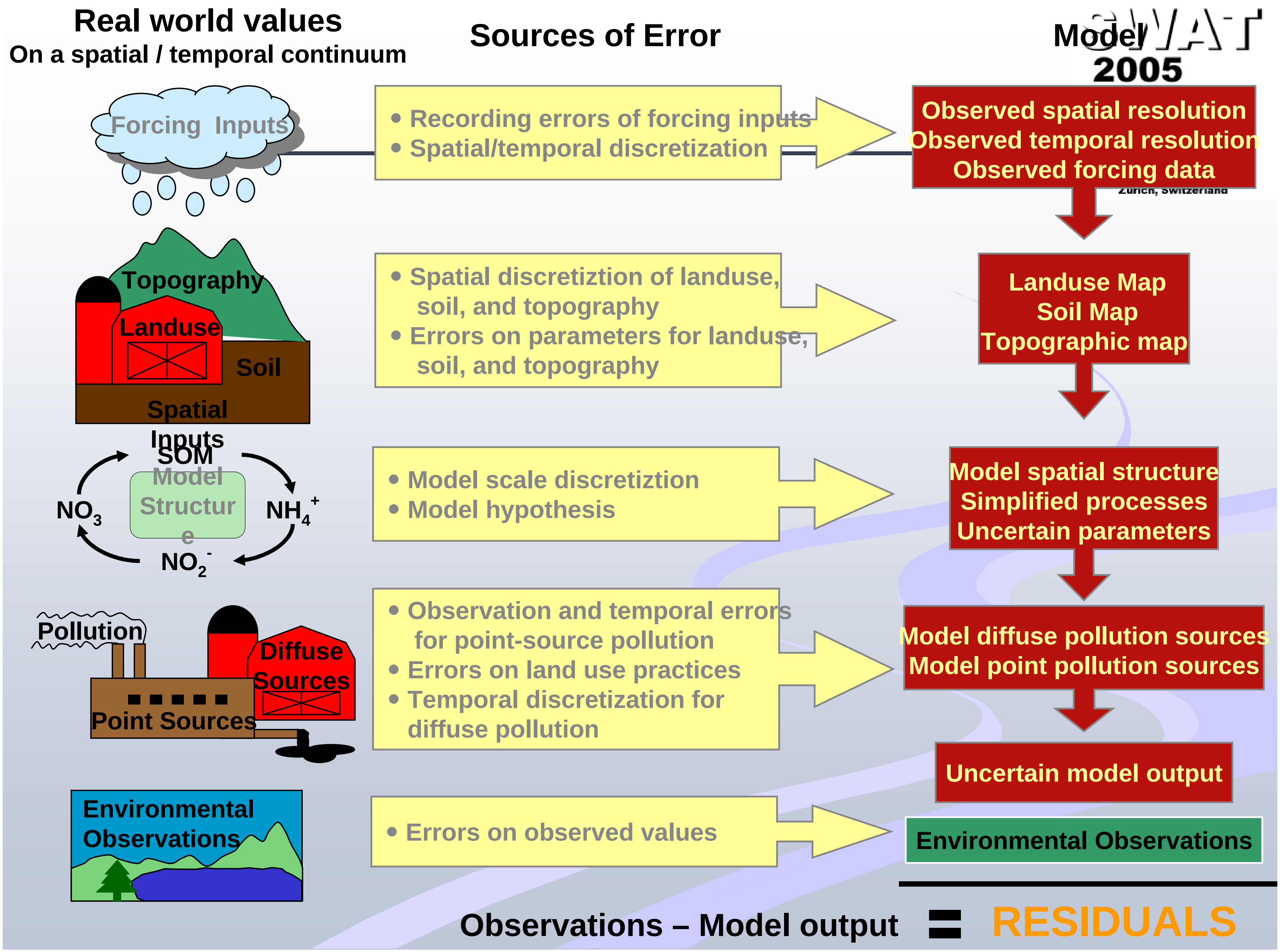
- temporal variability (climate, seasons, weather, human activity)
- spatial variability (land use, river network)

$\Rightarrow$ NEED FOR COMPUTER MODELS

$\Rightarrow$ PROBLEMS TO SOLVE

- many factors of the system are not or poorly known
- all systems are different
- Do models describe reality ? comparison to observations
- Are model results confident ?

•Must Calibrate models but also evaluate them in prediction mode


Real world values
On a spatial / temporal continuum
Sources of Error
Model
2005
Forcing Inputs
Recording errors of forcing inputs
Spatial/temporal discretization
Observed spatial resolution
Observed temporal resolution
Observed forcing data
Zurich, Switzerland
Topography
Landuse
Soil
Spatial Inputs
Spatial discretiztion of landuse, soil, and topography
Errors on parameters for landuse, soil, and topography
Landuse Map
Soil Map
Topographic map
SOM
Model Structure
$NO_3$
$NH_4^+$
$NO_2^-$
Model scale discretiztion
Model hypothesis
Model spatial structure
Simplified processes
Uncertain parameters
Pollution
Diffuse Sources
Point Sources
Observation and temporal errors for point-source pollution
Errors on land use practices
Temporal discretization for diffuse pollution
Model diffuse pollution sources
Model point pollution sources
Uncertain model output
Environmental Observations
Errors on observed values
Environmental Observations
Observations – Model output = RESIDUALS

# Sources of UNcertainty

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→ Parametric Uncertainty - focus of most uncertainty methods

→ Model structural uncertainty

→ Data uncertainties

- Output uncertainty (errors in streamflow uncertainty)
- Input uncertainty (errors in rainfall )

→ Inadequate data

→ Last three harder to assess but important

→ For decision makers estimates of combined or predictive uncertainty needed

# Uncertainty analysis

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ParaSol

Parameter Solutions

# ParaSol:
## calibration

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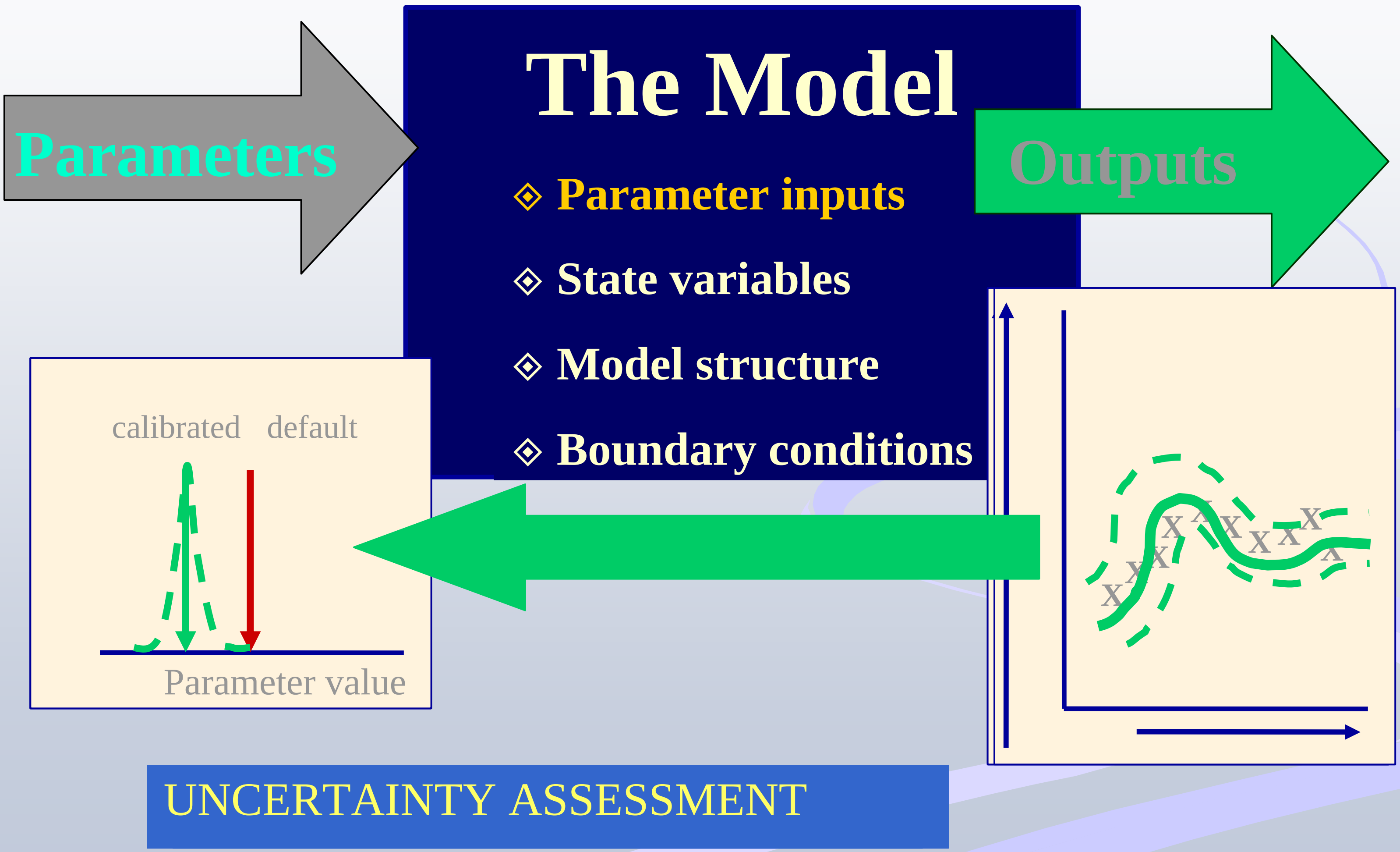

# Uncertainty analysis

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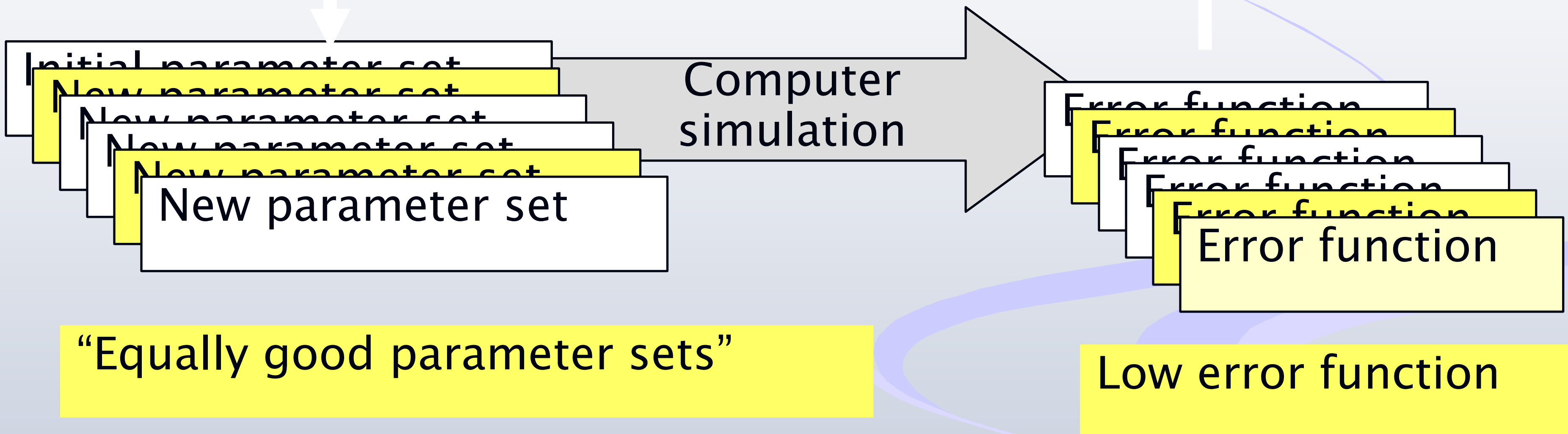

# ParaSol

Multi-objective calibration based on SCE-UA for minimisation of Global Optimisation Criterion (GOC)

$$GOC = \sum_{m=1}^{M} \frac{OF_m * N_m}{OF_{m,\min}}$$

Statistics

Threshold for GOC to define “good” parameter sets

Confidence ranges for parameter and/or model outputs

## Errors (Sources of Uncertainty) in Modelling

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| Sources of Error | Size of Error | Statistical Analogy |
|---|---|---|
| Data | A | Measurement and Sampling Error |
| Calibration Period Comparison | A-B | Standard Error of the Estimate |
| Evaluation Period Comparison | A+C | Standard Error of the Prediction |

Typical uncertainty analysis focuses on A-B
But evaluation period, A+C, has information about the level of trust (uncertainty) we should have in our models.

After - Singh 1988 - Hydrologic Systems Rainfall-Runoff Modelling

# A Way Forward



→ Existing uncertainty methods typically
- Involve some subjective decision making on acceptability of simulations (e.g. GLUE)
- Or make overly strict assumptions about model and data correctness and thus have unreasonably small uncertainty bounds (e.g. BARE method and ParaSol discussed in next talk)
- Beven and Young (2003) advocate methods between these two extremes

→ Singh's framework provides a way out.
- Use the evaluation period to determine model parameter set acceptability?
- But how? Here we present one option.

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# Sources of UNcertainty

## SUNGLASSES

Sources of UNcertainty
GLobal Assessment using
Split-SamlpES

# SUNGLASSES:
## calibration + validation

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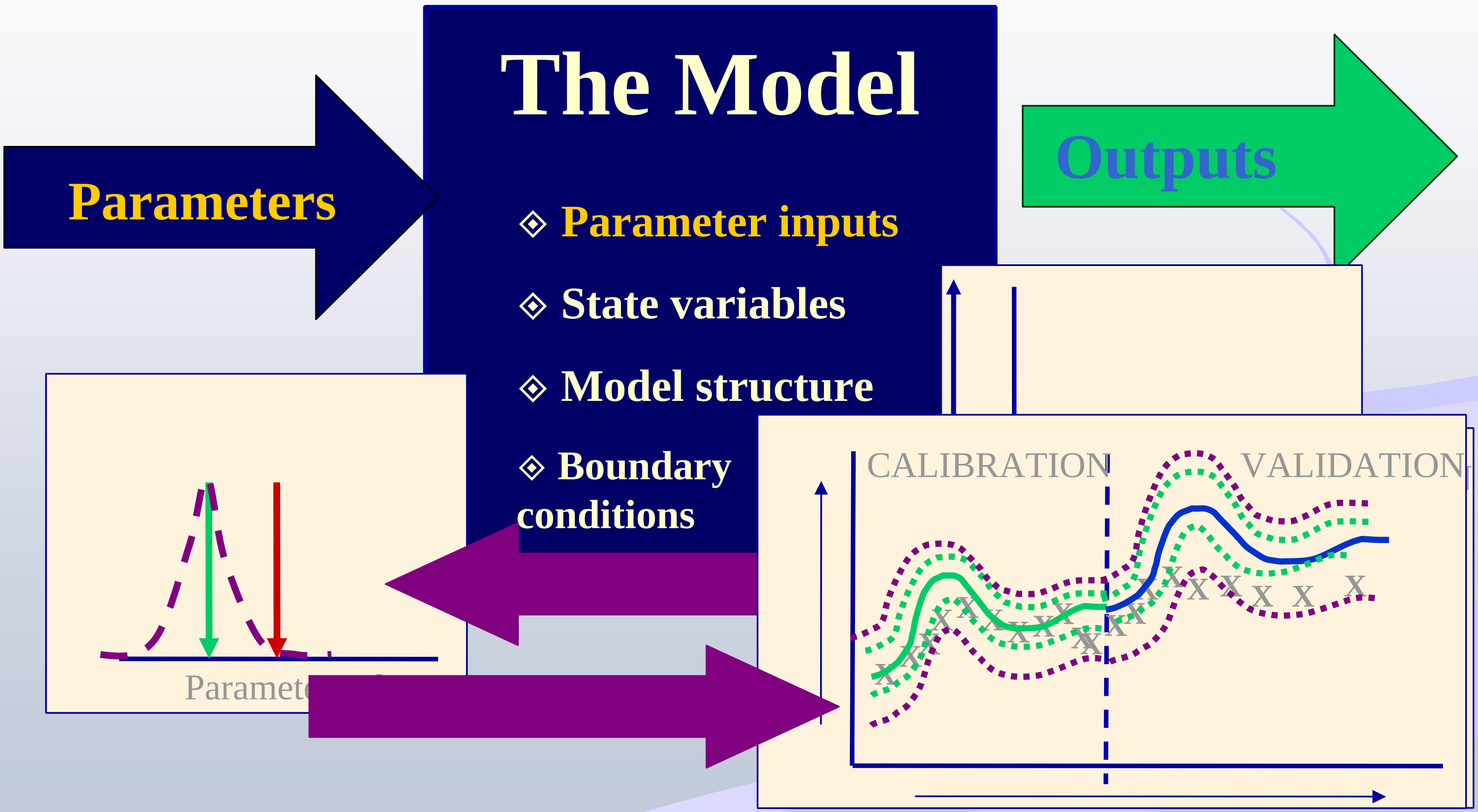

## ParaSol versus SUNGLASSES Uncertainty

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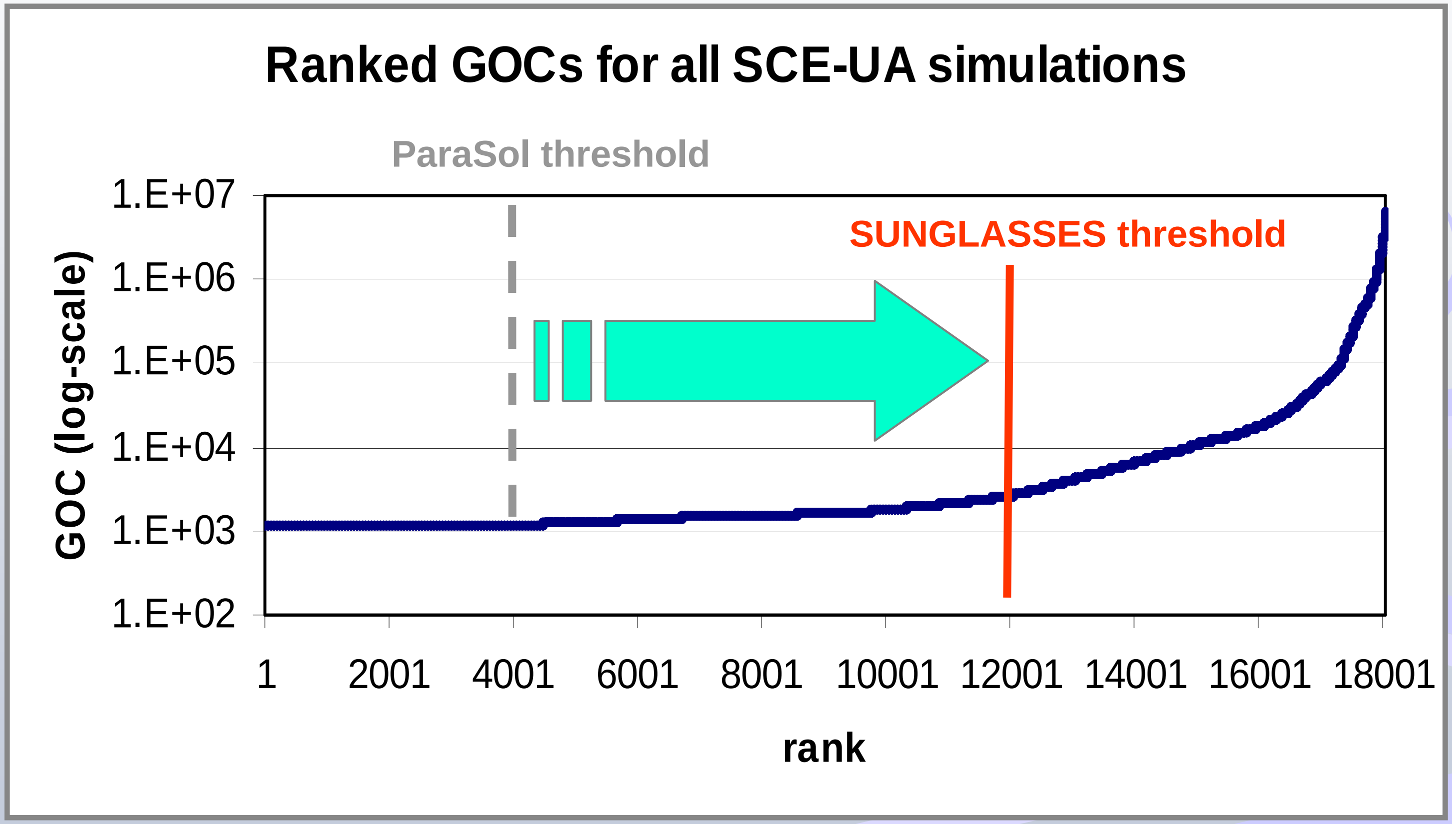
# IF PREDICTIONS ARE BIASED: threshold is increased!




**➔OUTPUT UNCERTAINTY INCREASES**

# SWAT application: Honey creek

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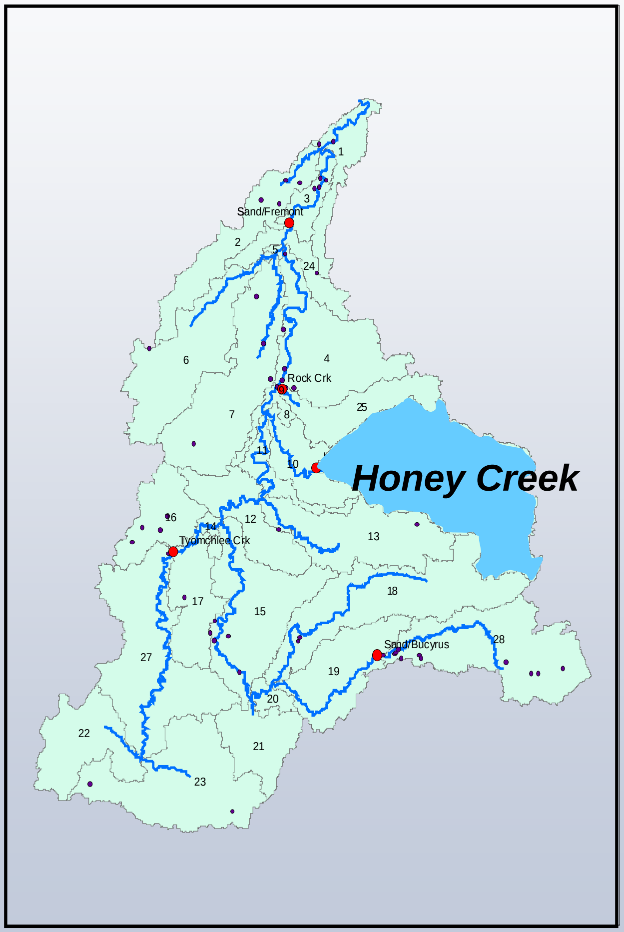
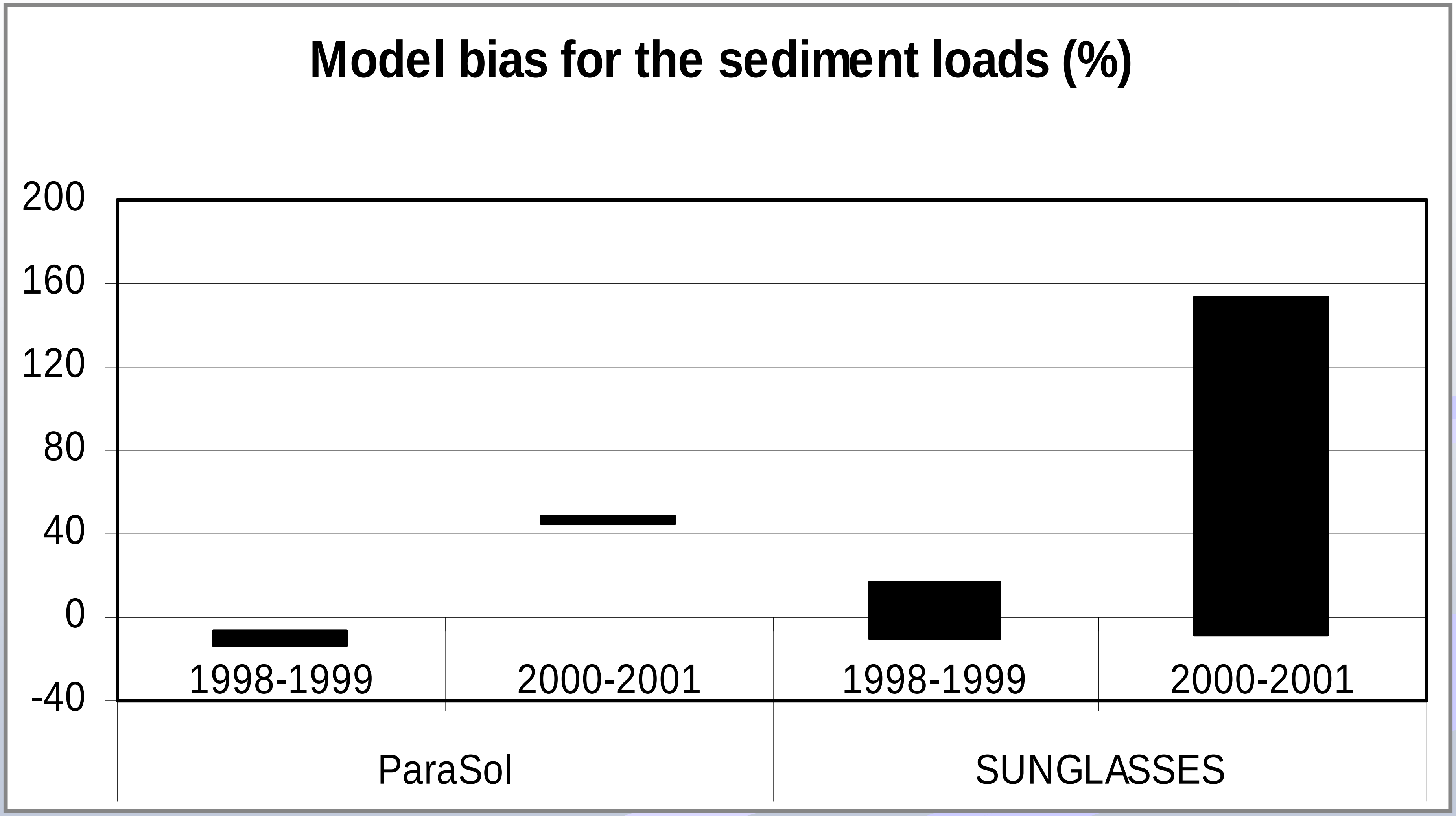



- Sandusky watershed, Lake Erie, Ohio
- 338 km2
- SWAT model by University of Florida – Sabine Grunwald and others
- 1 subbasin, 5 HRU’s, 1 river reach, 1 point source

# SWAT Sediments Results



# Results

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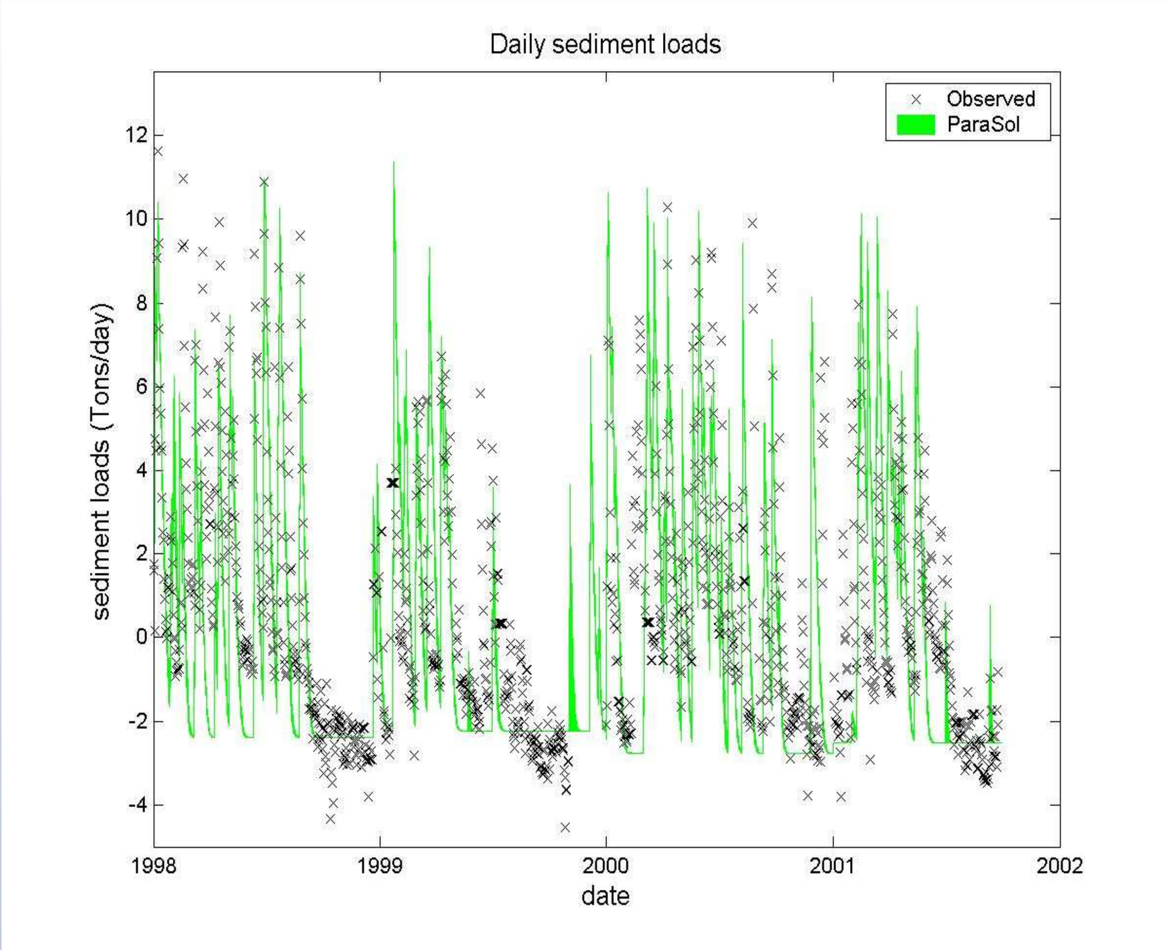

# Results

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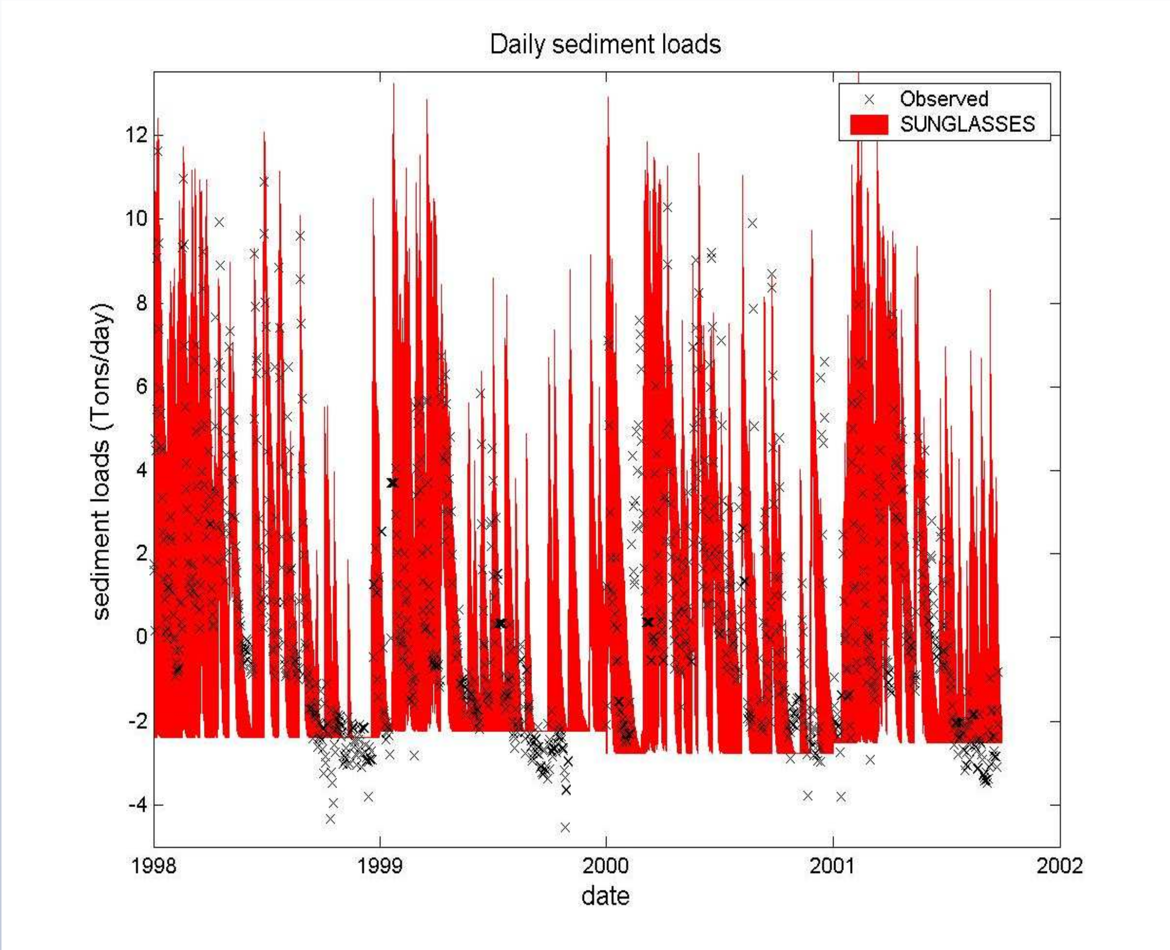

# SUNGLASSES

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- The Sources of UNcertainty GLobal Assessment using Split SamplES
- Accounts for global uncertainty without identification of the sources.
- Acceptability based on model criteria to be used for decisions (e.g. total water or nutrient export)
  - Honey Creek model sediment load important
  - Thus use model bias to determine bounds - uncertainty bounds should include the zero bias case.
- Split-Sampling strategy
  - Calibrate with first time period (develop population using SCE-UA)
  - Establish acceptability with second period.

## Conclusion

- Parameter uncertainty is only small part of global uncertainty when enough data is available
- SUNGLASSES is able to catch that uncertainty
- SUNGLASSES does not denote cause of uncertainty but instead quantifies the global uncertainty bound

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