

# Sensitivity, optimisation and uncertainty analysis for the model parameters of SWAT

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# Questions

- How to calibrate water quality models?
- Are results reliable?
- Is the pollution abatement plan sufficient to get water quality according to legislation?
- Can an “equally good” calibration lead to different decisions?

# Uncertainty framework

New model with many parameters



Sensitivity analysis

Important parameters



Optimisation

Best parameter set



Uncertainty analysis

Good parameter sets



Scenario analysis

Uncertainty on results

ParaSol

# Uncertainty framework

Many parameters



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# Sensitivity Analysis

- What parameters have biggest impact on error functions?  
sampling parameters



analyse changes to output

METHOD

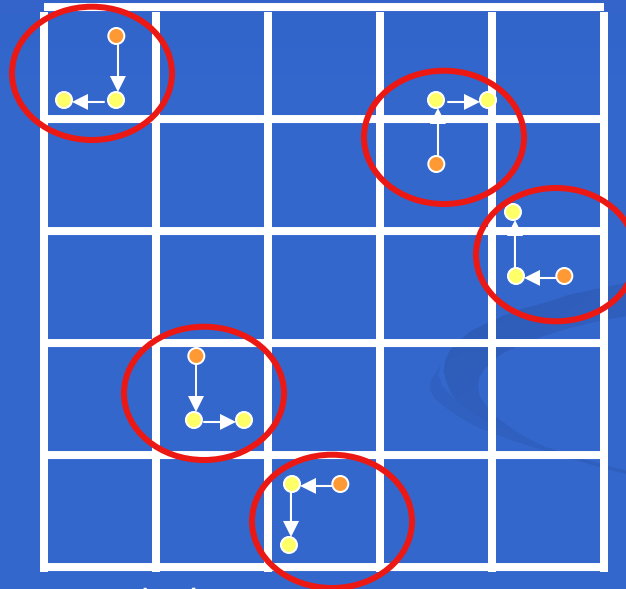
Combining

- Latin Hypercube &
- One-Factor-At-a-Time sampling

# Sensitivity Analysis

## Latin Hypercube sampling

- divide parameter range in  $m$  intervals
- “Randomly” sample  $m$  points in a way that each interval has 1 point



### One factor at a Time:

- Change at each Latin Hypercube point each parameter one by one
- $m$  sensitivity results: average and variance
- Ranked parameters

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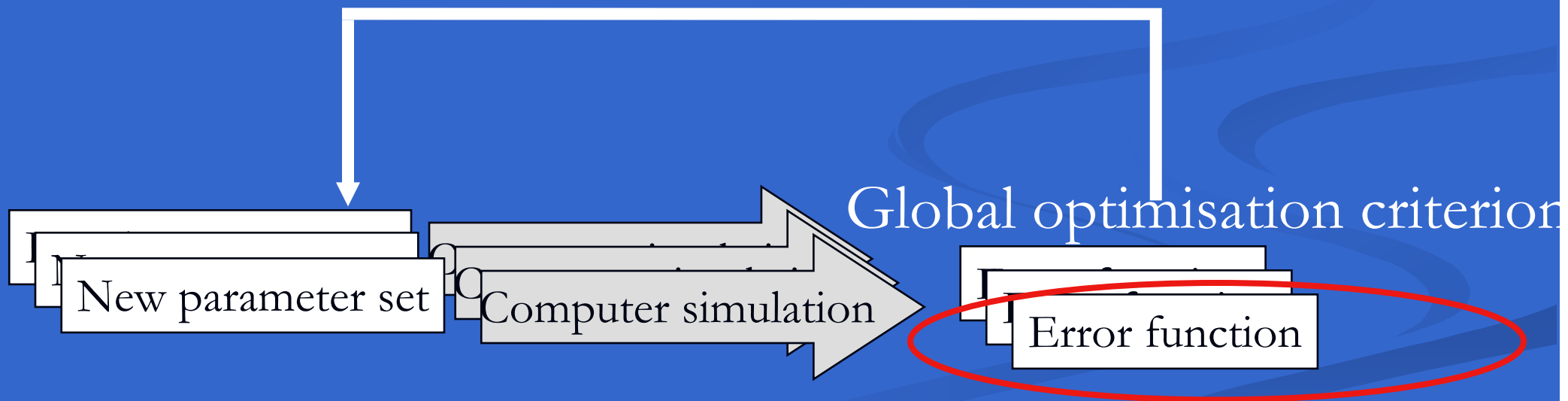
ParaSol

# Automated optimisation

Shuffled Complex Evolution method

- combined global & local methods
- efficient & effective

METHOD





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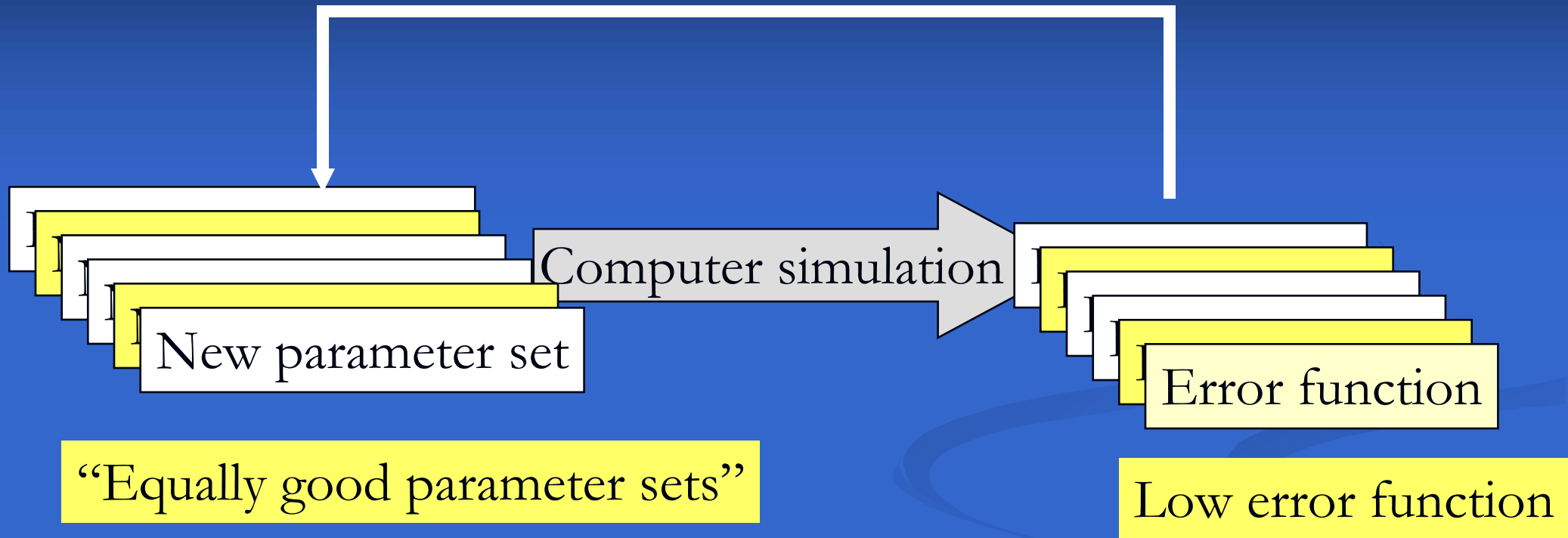


Scenario analysis

Uncertainty on output

ParaSol

# Uncertainty analysis



# Uncertainty method

Global optimisation criterion



Statistics

Threshold to define “good” parameter sets



Selection of parameter sets and corresponding outputs

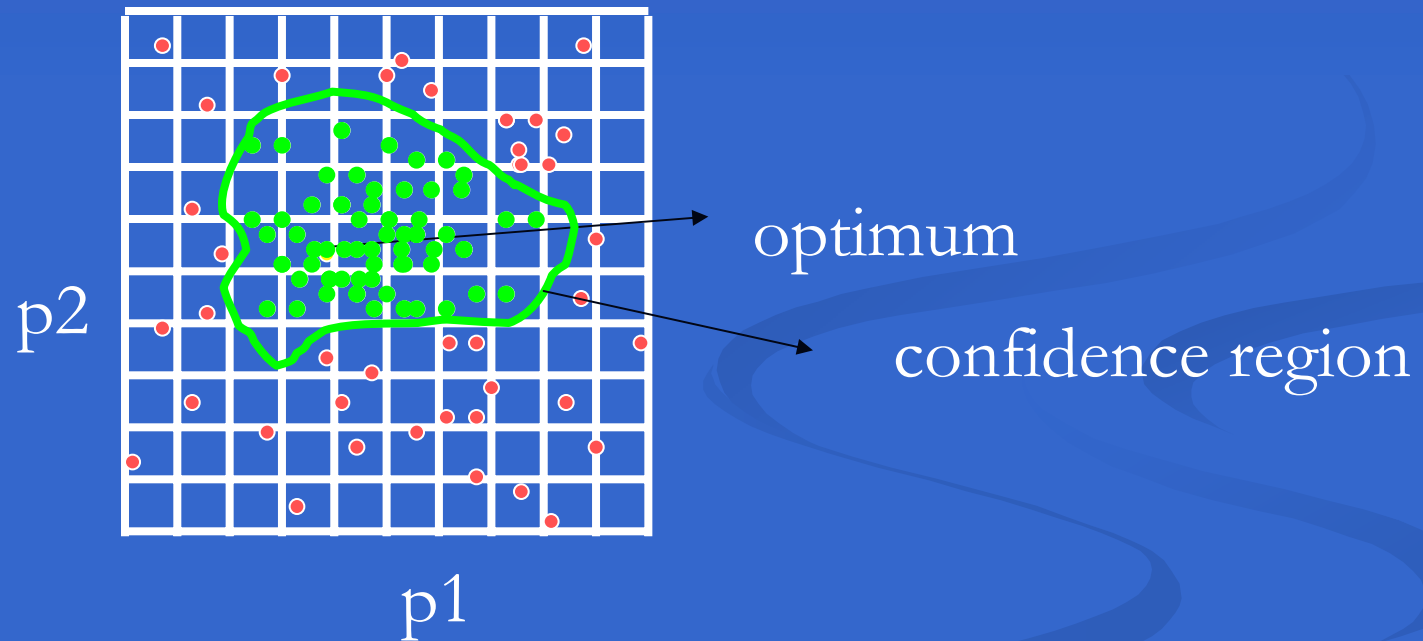


Confidence ranges for parameter and/or model outputs

# Uncertainty method

Optimisation using Shuffled Complex Evolution method

Selecting confidence region using Xi-square or Bayesian statistics

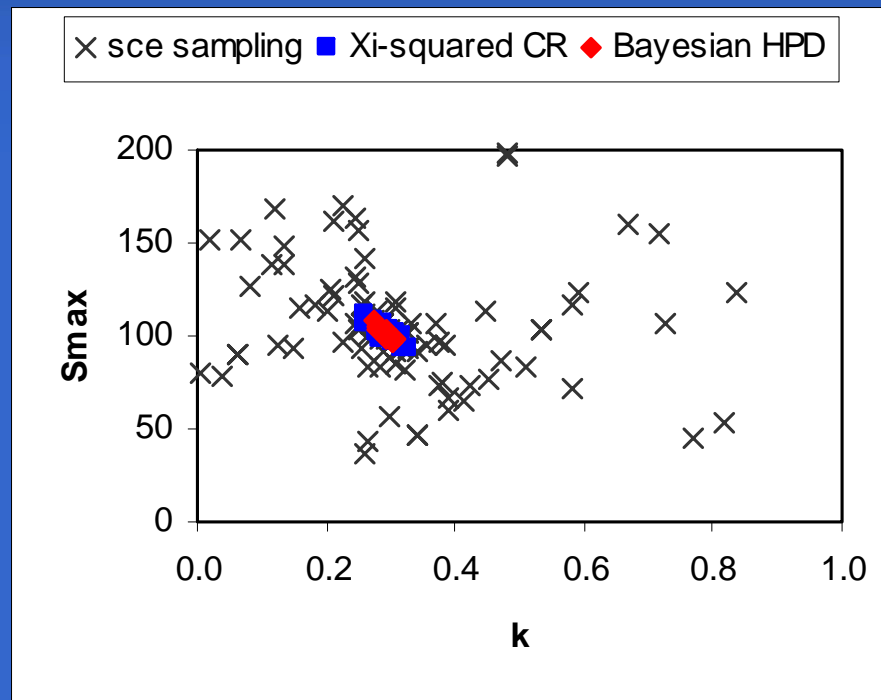


$$\text{Xi-squared } F(b_i) = F(b_i^*) [1 + \chi_{e_j, *}( \sigma_j^2 )]$$

Bayesian:  $F(b_i) \sim 95\%$  cumulative probability for  $F(b)$

# Uncertainty method

SIMPLE model example: 2 parameters



Xi-squared Threshold = Minimum GOC\* $[1 + \chi_{e_j, *}( \sigma_j^2 )]$

Bayesian: Threshold  $\sim$  95% cumulative probability for GOC

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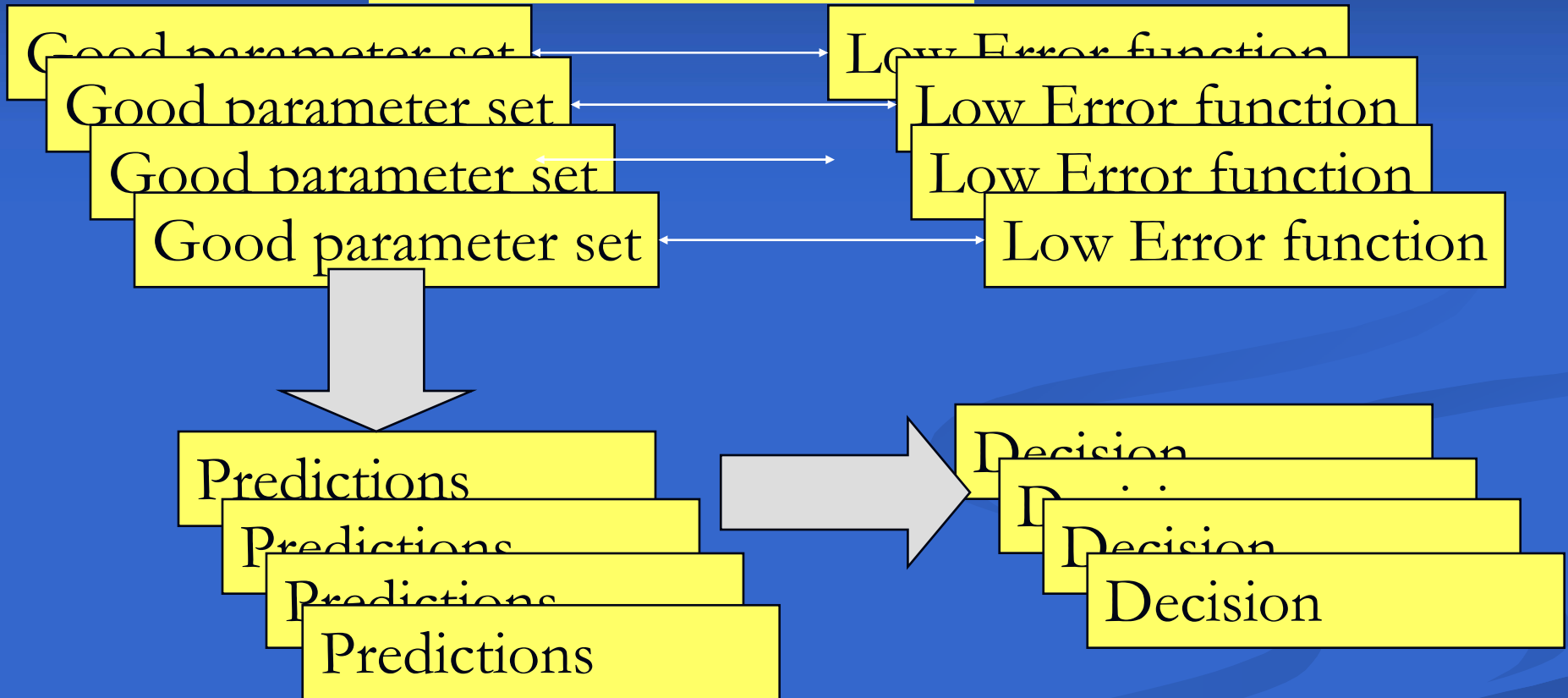


Scenario analysis

Uncertainty on results

# Predictive uncertainty analysis

“Equally good models”

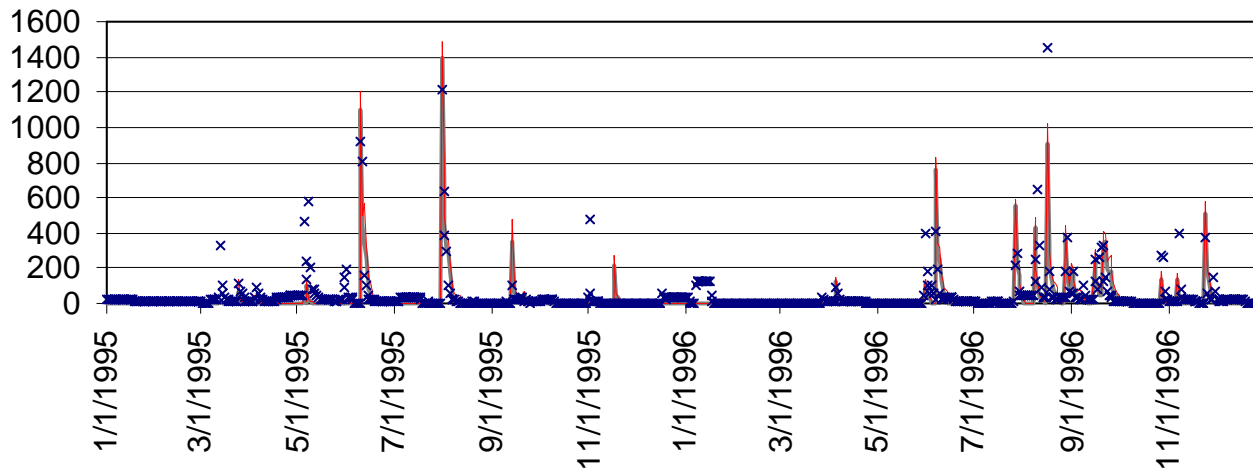


# Case: Bosque Watershed

Flow at site 2 (m<sup>3</sup>/s)

35  
30  
25  
20  
15  
10  
5  
0  
1/1/1995

Sediments at site 2 (mg/l)



x observations  
— MIN  
— MAX



# Conclusion

- ParaSol is efficient method to conduct parameter uncertainty analysis on complex models
- Parameter uncertainty is only small part of global uncertainty when enough data is available
- ParaSol allows for objective comparison on optimization methods/model structure/data

# Acknowledgement

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**Thank you for your attention!**