



Principles of Uncertainty Evaluations

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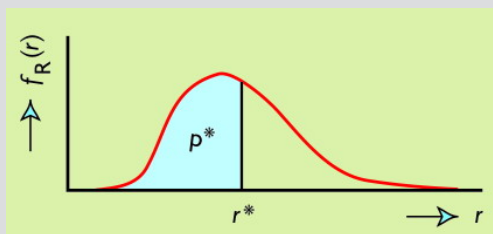
WEFTEC 2010 Workshop 203:
How will your Wastewater Plant Really Run? Evaluating Risk
in Design and Operation



workshops




Definitions




What do we use this for?

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Accuracy and Precision



High **accuracy**,
but low **precision**



High **precision**,
but low **accuracy**

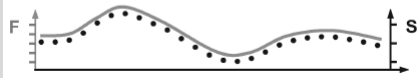
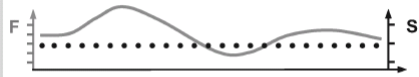
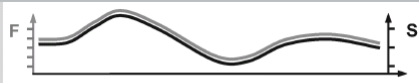
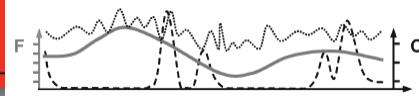
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Modelling project steps



Project definition	Data collection	Model Set-up	Calibration and Validation	Simulation
<ul style="list-style-type: none"> Define Objectives Context and framing Determine Requirements 	<ul style="list-style-type: none"> Influent data Physical data Operational settings Performance data Additional information 	<ul style="list-style-type: none"> Influent model Biological model Hydraulic model Aeration system model Clarifier model Interfaces between models Model technical aspects 	<ul style="list-style-type: none"> Model parameters selection Model evaluation 	<ul style="list-style-type: none"> Alternatives evaluation and future "what-if" scenarios
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">↑ Identify</div> <div style="text-align: center;">↑ Identify</div> </div>			<div style="text-align: center;">↑ Evaluate</div>	<div style="text-align: center;">↑ Evaluate</div>
			<div style="background-color: yellow; padding: 5px; border: 1px solid black;">Uncertainty</div>	<div style="background-color: red; color: white; padding: 5px; border: 1px solid black;">Accuracy</div>

Distributions in WWT

- Measurement errors
- Variability in
 - Influent flow/concentrations
 - Effluent quality
- Equipment faults (MTBF)
- Uncertainty in model predictions

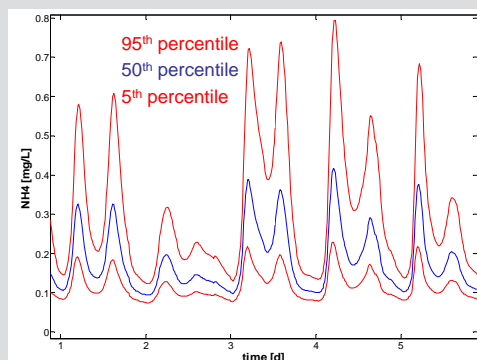


Sampling

- Affects observed variability - uncertainty
 - e.g. grab sampling for DO at 10am vs. continuous DO monitoring
- Uncertainty  when frequency 
- Averaging (composite sampling) reduces uncertainty/variability significantly
- Effluent standard definitions...
 - e.g. yearly average vs. 2h composite samples

Definitions

- Variability  Uncertainty



in blue:
temporal variability
due to influent
variability

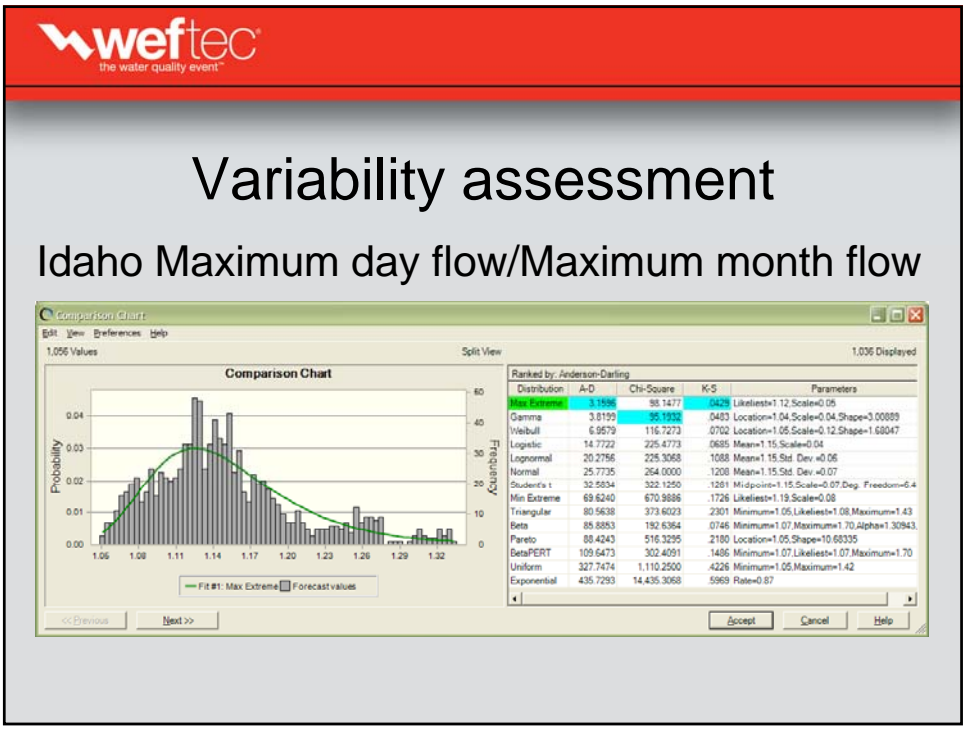
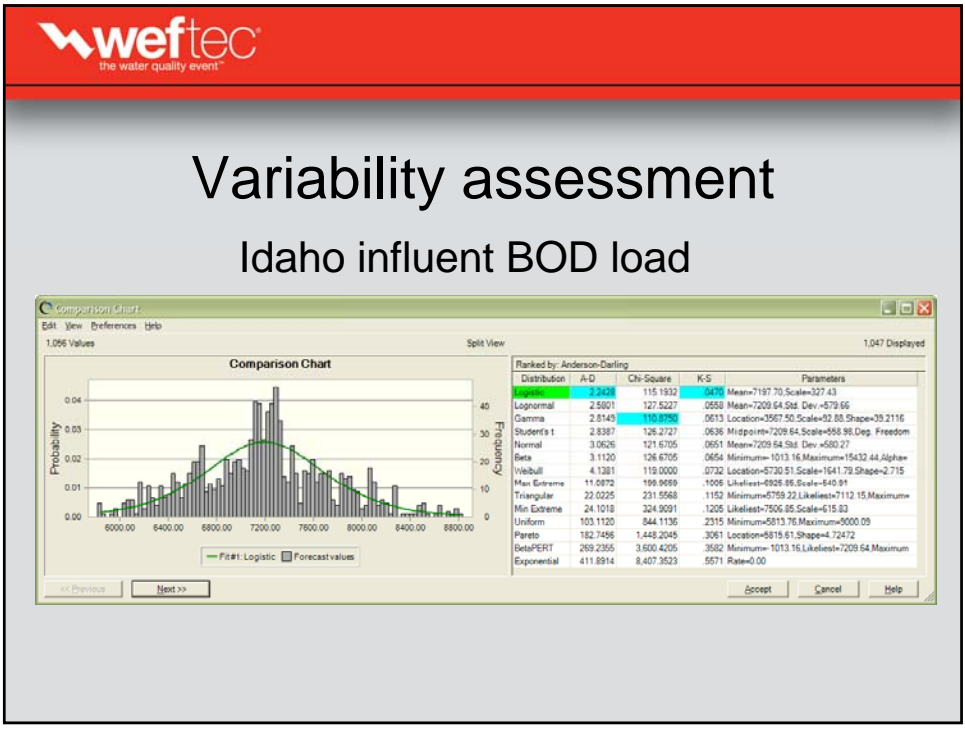
in red:
uncertainty band
due to parameter
uncertainty

Definitions

- Variability ↔ Uncertainty
 - Uncertainty can be reduced by more research
 - Variability is intrinsic, cannot be reduced
- Sources of uncertainty/variability
 - Inputs (influent, operations, temperature, future, ...)
 - Parameters (constants in the model)
 - Model structure (equations)
 - Software (model implementation and numerics)

Uncertainty/Variability evaluations

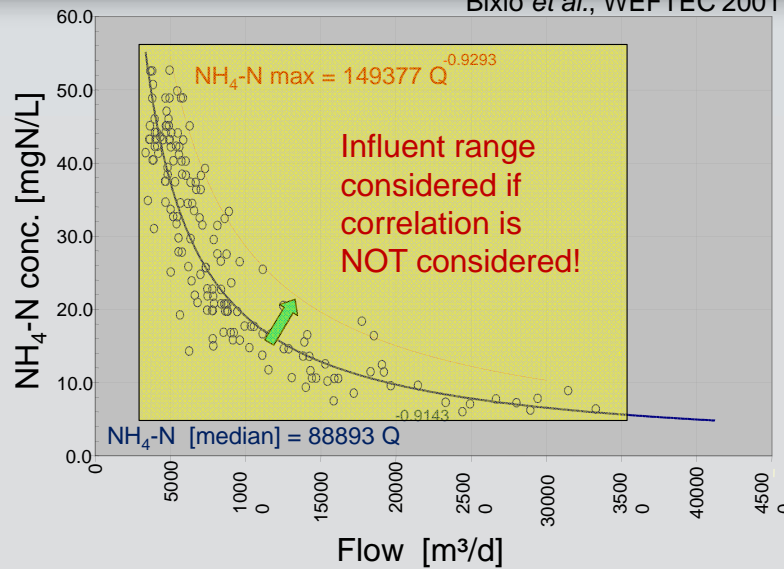
- Uncertainty/Variability assessment
 - Quantify sources of uncertainty/variability
- Uncertainty/Variability propagation
 - Quantify the uncertainty/variability in our model results as a consequence of the different sources of uncertainty/variability



Variability assessment

- Correlations between variables:
 - Not considering them leads to overestimation of the uncertainties/variability in the model predictions !

Bixio *et al.*, WEFTEC'2001

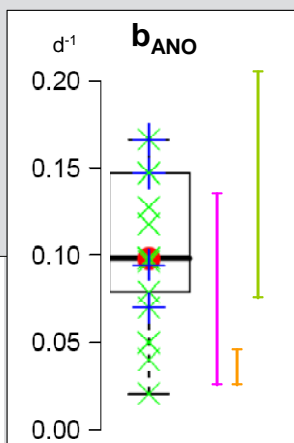


Uncertainty Assessment

- Parameter uncertainty

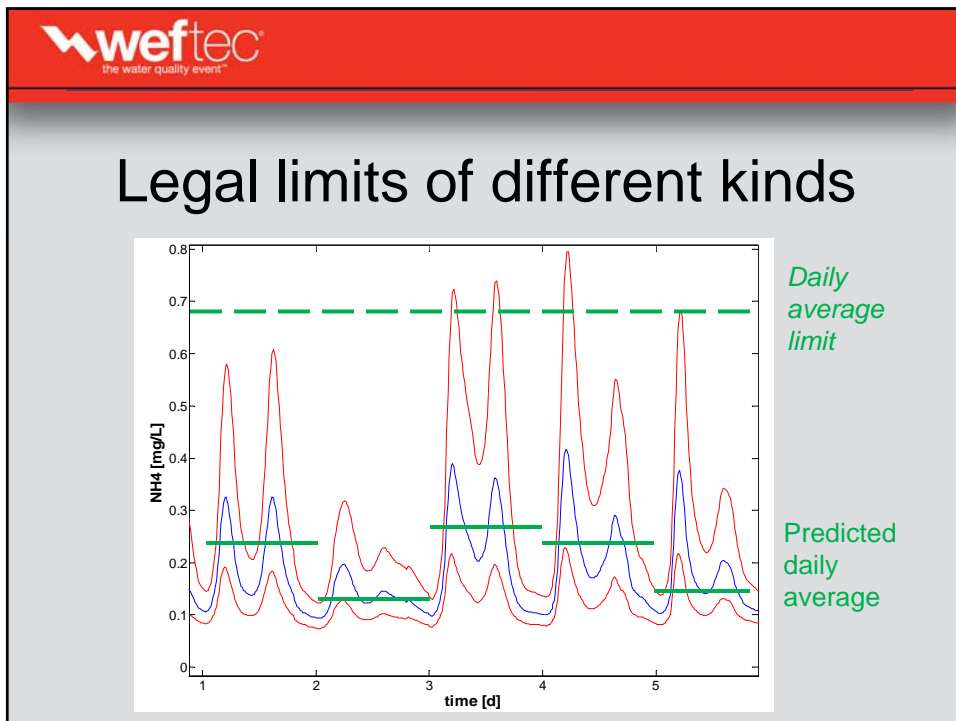
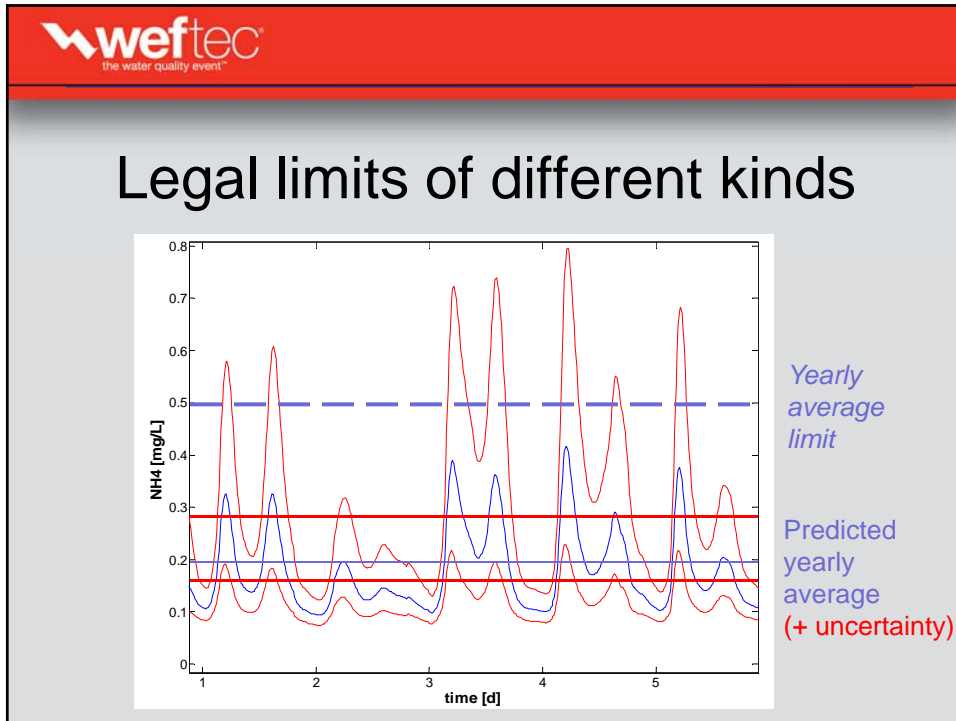
Hauduc et al. (2010):

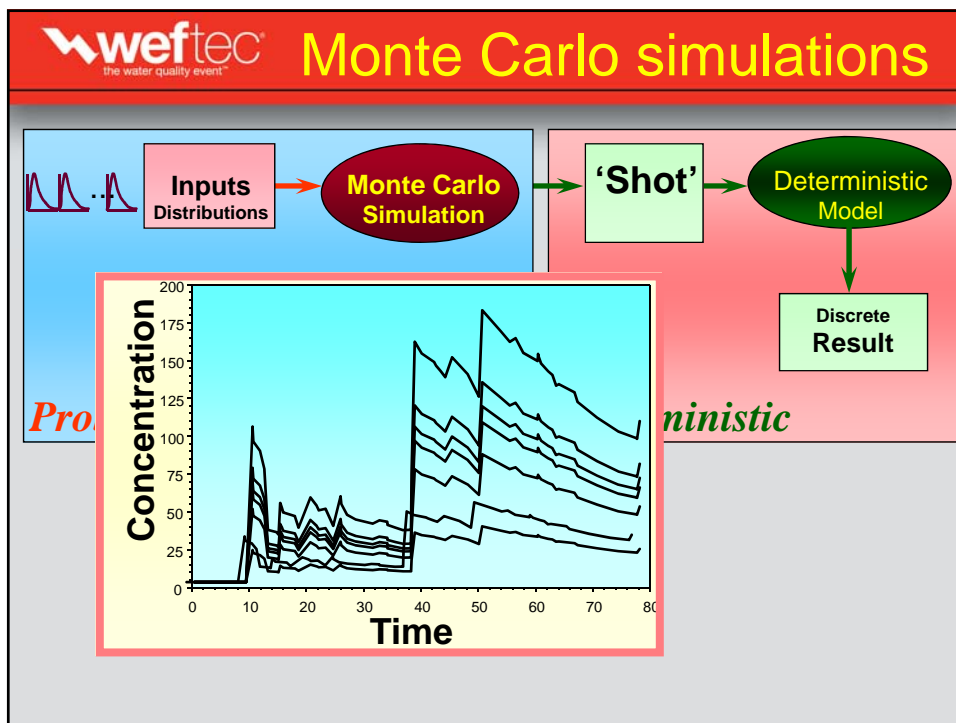
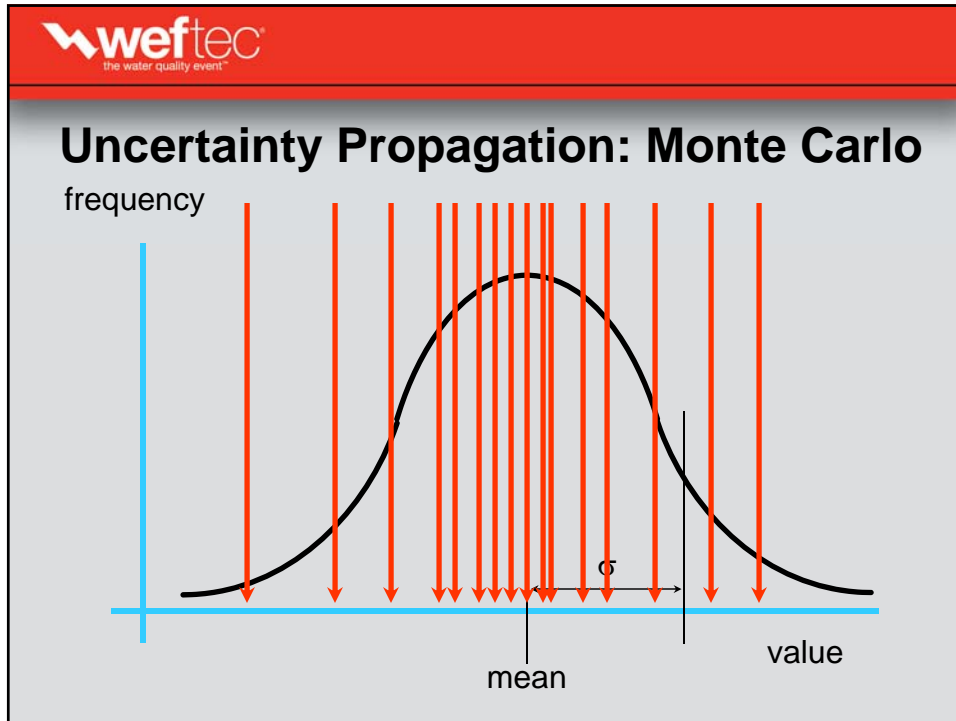
Database of ASM1
& ASM2 calibrations

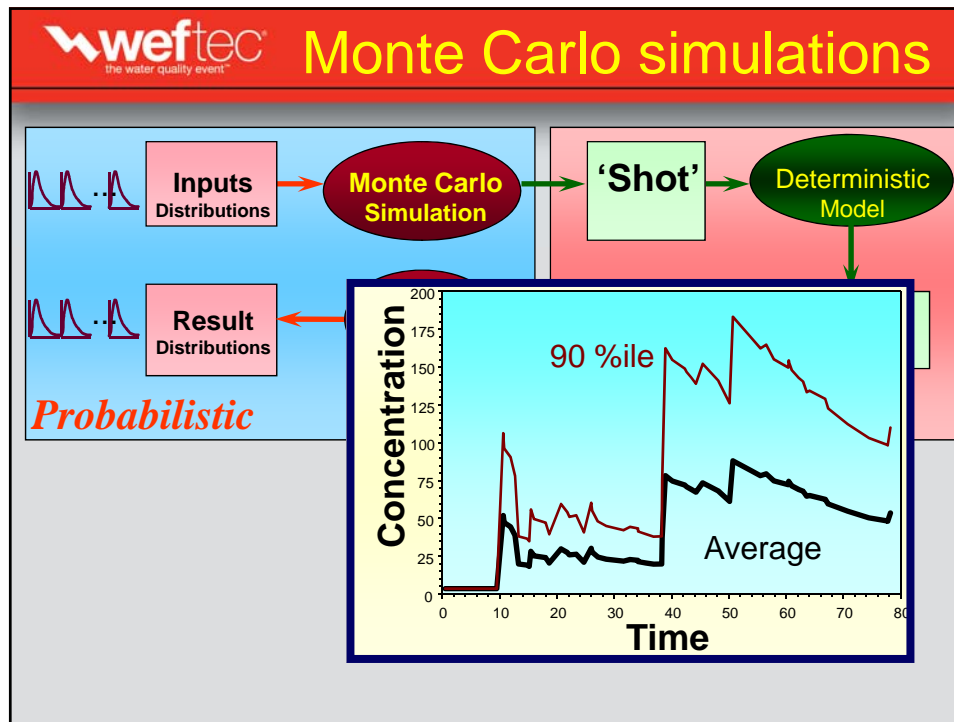


Uncertainty Assessment

- Scenario Uncertainty
- Probably the largest uncertainty source:
 - What's gonna happen at my plant in the next 30 years?
 - Influent load
 - Influent composition
 - New legal requirements







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Why all this?

- Uncertainty/Variability assessment and propagation are:
 - The basis for quantitative risk assessment
 - Risk of failure
 - Risk = [Probability of failure] * [Cost of failure]
 - Essential for informed decision-making
 - Easy to do ... So, why not?

Take home

- Definitions
- Uncertainty \leftrightarrow Variability
- Sources
- Evaluation
 - Assessment (correlations!)
 - Propagation (Monte Carlo)
- Informed decision-making under risk

