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Quantifying uncertainties in watershed nutrient loads: apportionment of uncertainty sources

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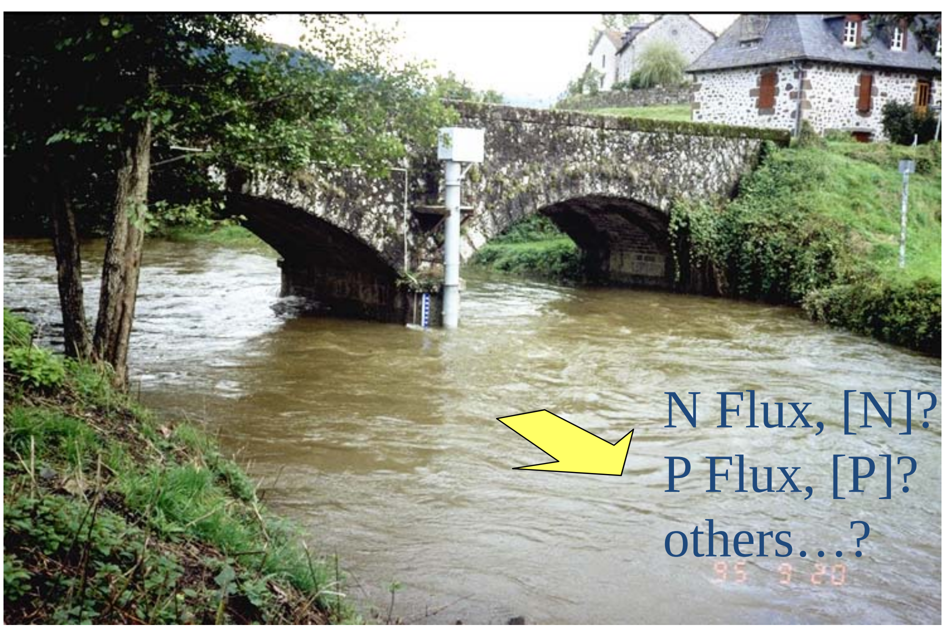
Monitoring water quality in agricultural watersheds



Sources of uncertainties when measuring nutrient loads

- Uncertainties on flow rates and cumulated flow
- Uncertainties associated with infrequent sampling
- Uncertainties due to the sampling location in the water column
- Uncertainties due to sample degradation between sampling and analysis
- Uncertainties of laboratory analyses

Optimizing Monitoring

- What should I be particularly careful about to lower uncertainties on loads and improve confidence in my results?

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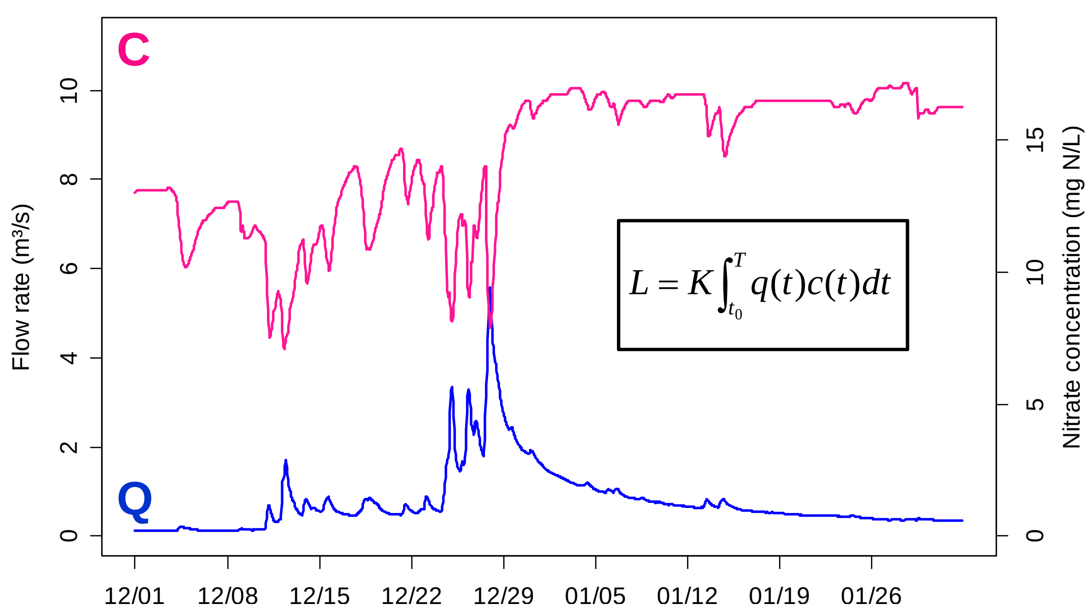
In a perfect world, perfect continuous data…



Video: daily sampling interval

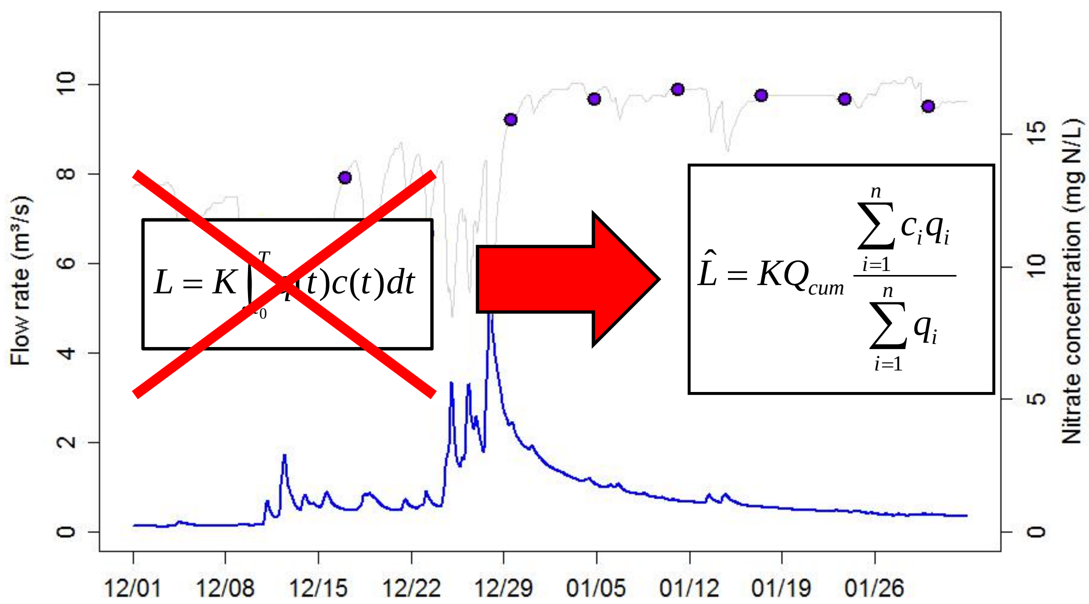
Video

Sampling interval: 6 days

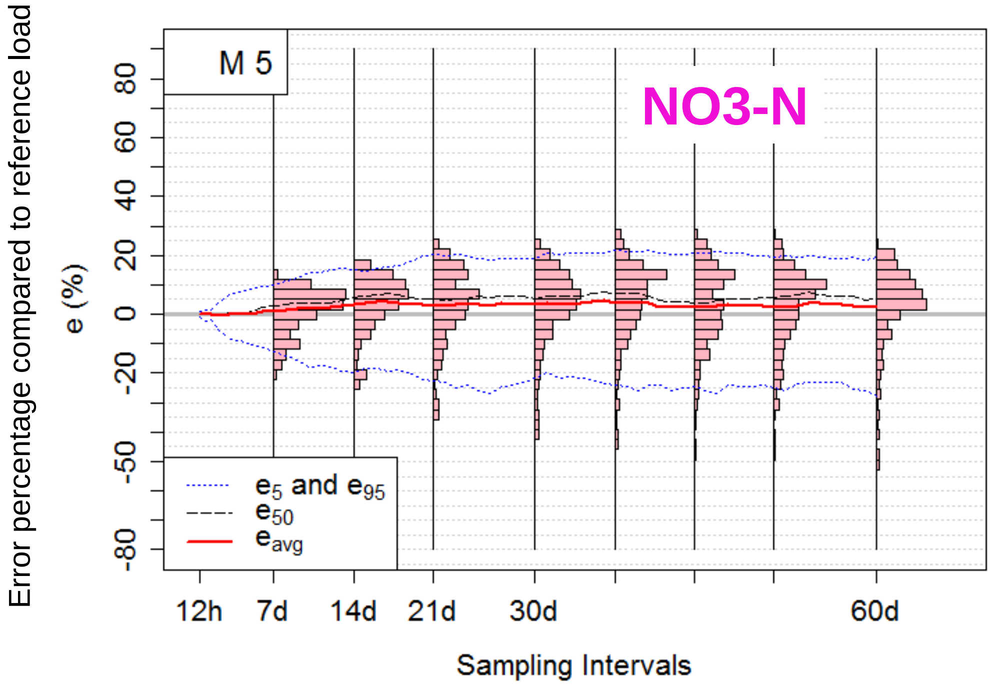
Video

Sampling interval: 10 days

Video



Flow weighted average: least bad method



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Uncertainties on flow

- Difficult to fully estimate
- Approach chosen:
  - o Flow estimated using rating curves
  - o Errors due to
    - o number of gauged points,
    - o hysteresis of the stage discharge relationship
    - o Mathematical relationship chosen as rating curve

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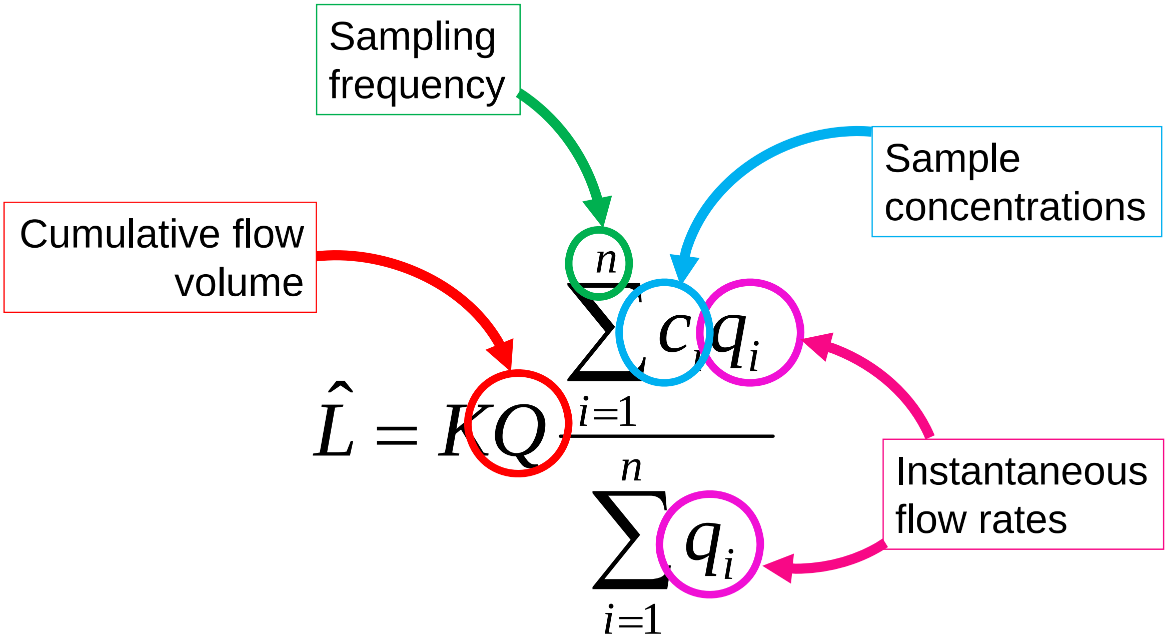
Video: 10 gauging points

Video

Video: 26 gauging points

Video



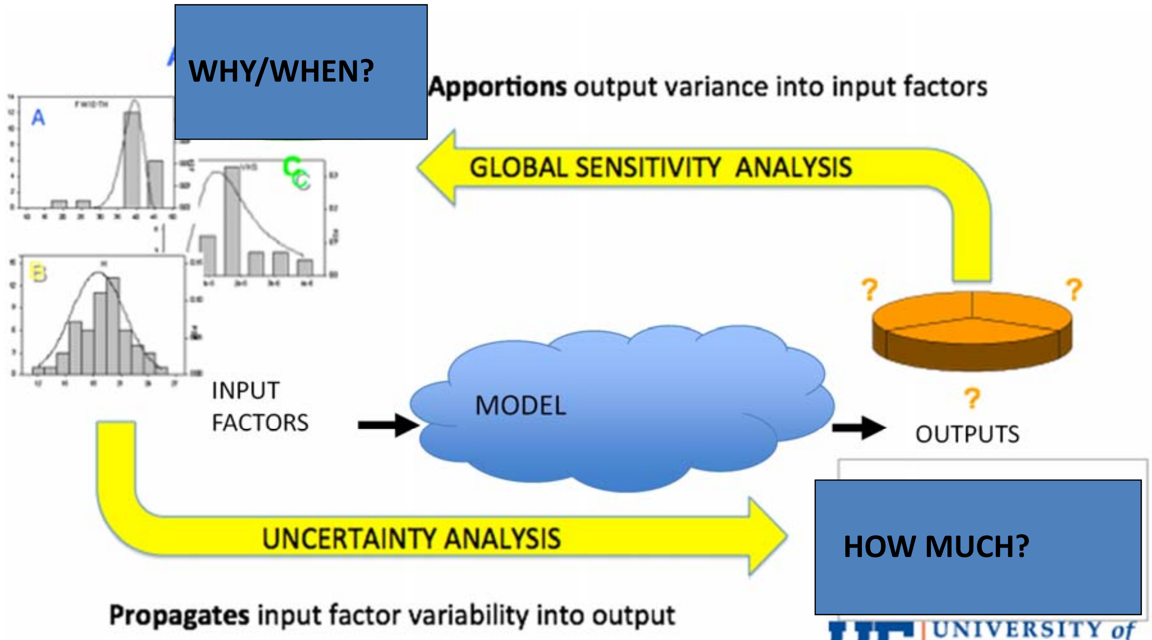
$$\hat{L} = KQ\frac{\sum_{i=1}^{n} c_i q_i}{\sum_{i=1}^{n} q_i}$$

Calculating cumulative uncertainty

$$E_P = \sqrt{\sum_{i=1}^{n}(E_1^2 + E_2^2 + E_3^2 + \ldots + E_n^2)}$$

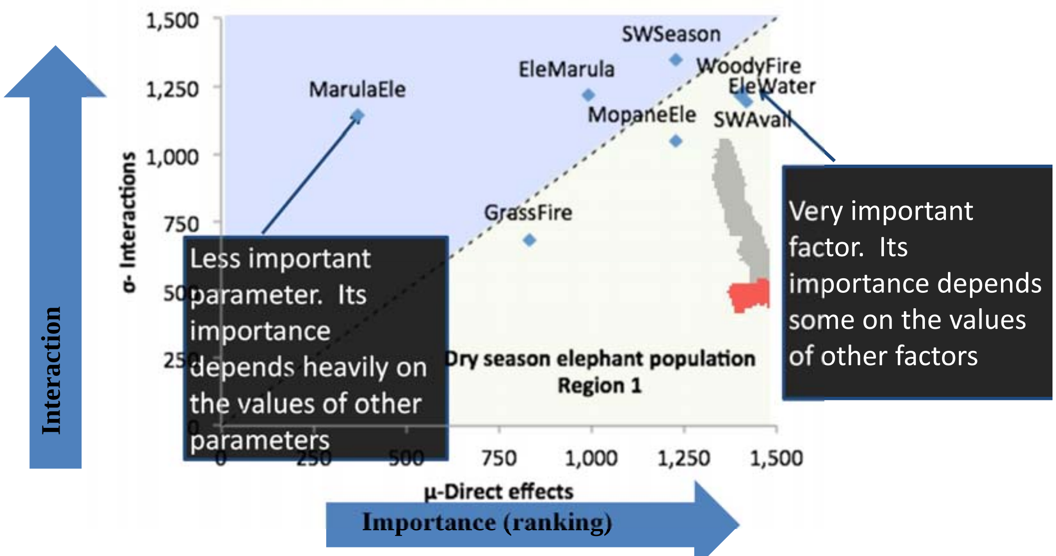
Global Sensitivity Analysis (GSA)

Global Sensitivity/Uncertainty Analysis



Step 1: Screening (Morris Method)

- qualitative measure of importance (μ*) and interaction (σ) of input factors

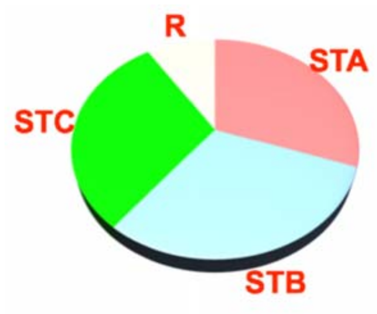


- Used as a screening method to reduce number of important factors

Step 2: Variance Decomposition

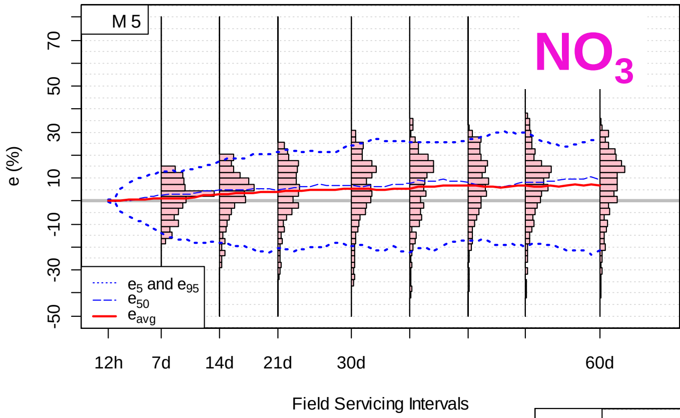
$$V(Y) = V_1 + V_2 + \ldots + V_k + R$$

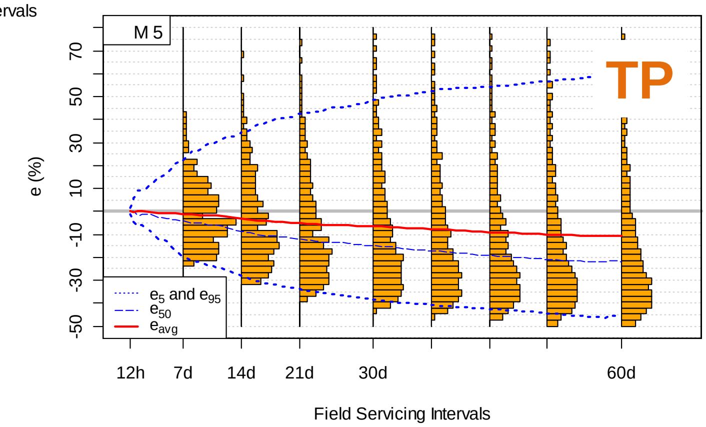
V(Y) – variance of output, V_i – variance due input factor X_i,
k – nr of uncertain factors, R - residual



Simulations

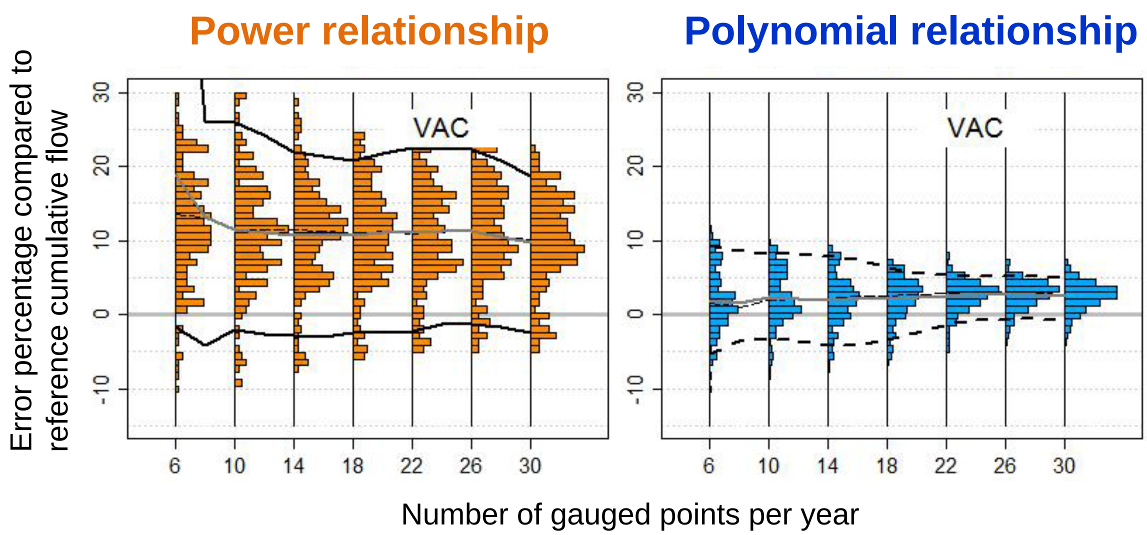
- Reference data with continuous Q and WQ
- Errors on annual loads
- Variables
  - NO_3, TP
  - Sampling frequency





Simulations

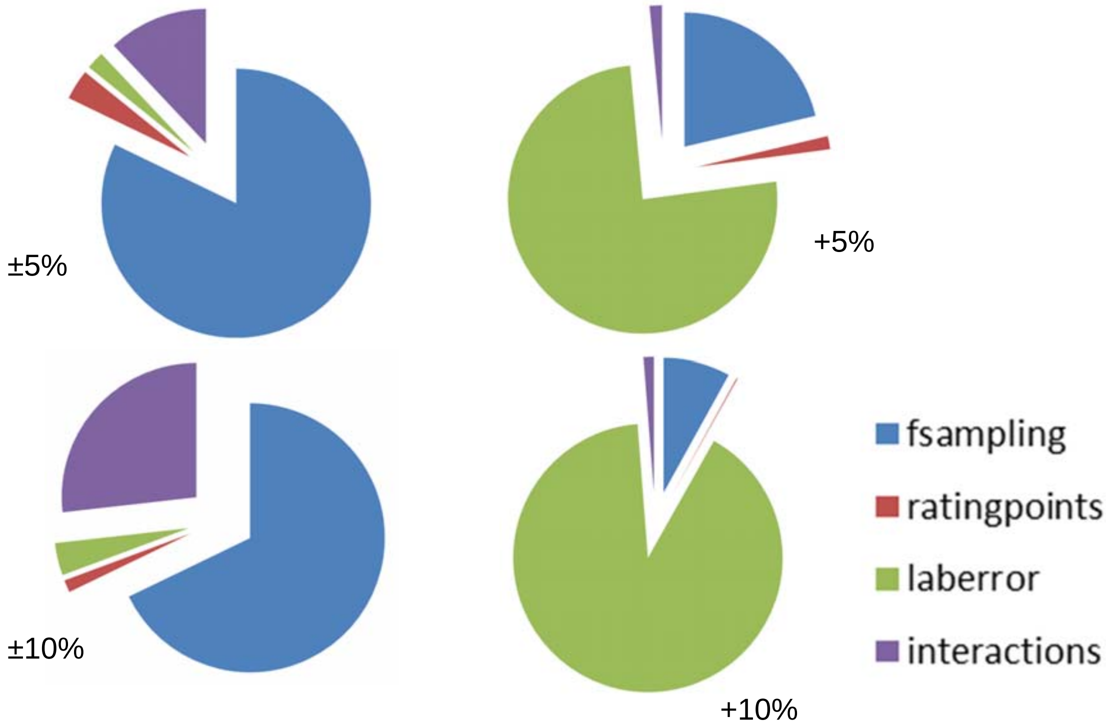
- Reference data with continuous Q and WQ
- Errors on annual loads
- Variables
  - NO_3, TP
  - Sampling frequency
  - Number of gauged points
  - Type of rating curve



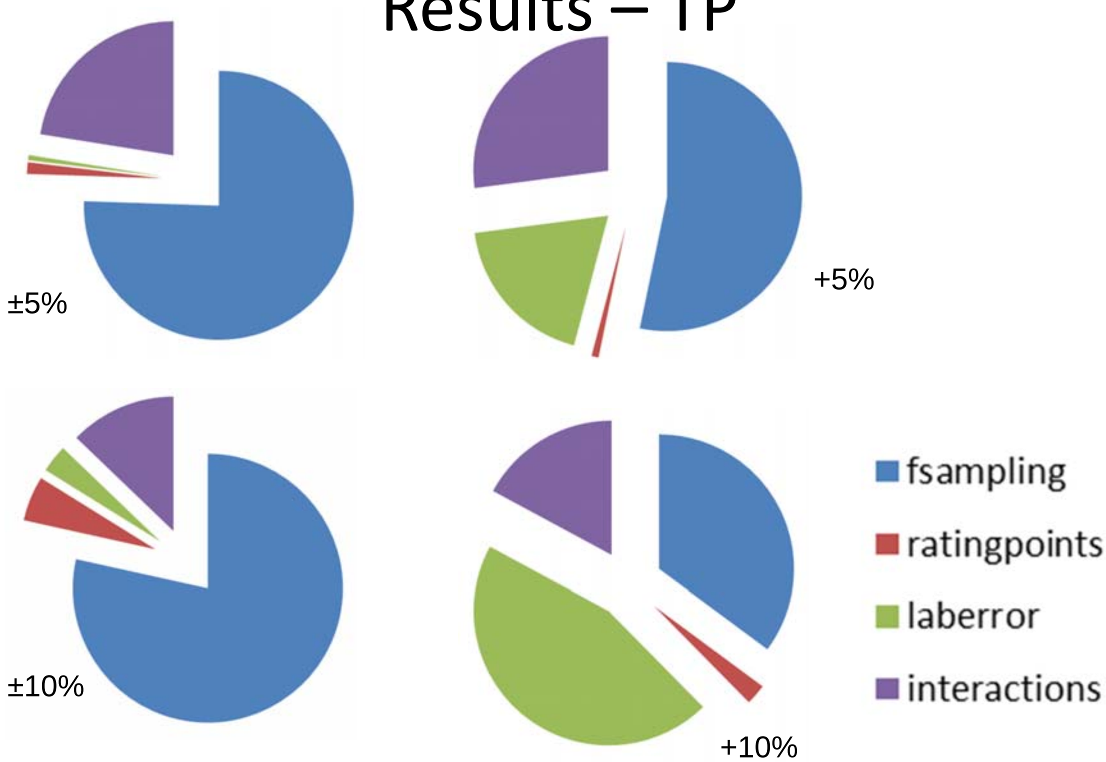
Simulations

- Reference data with continuous Q and WQ
- Errors on annual loads
- Variables
  - NO_3, TP
  - Sampling frequency
  - Number of gauged points
  - Type of rating curve
  - Lab errors: systematic (e.g. + 5%) or random (e.g. ±5%)

Results – nitrate



Results – TP



Conclusion

- The GSA approach very useful tool for uncertainties on nutrient loads
- Random lab errors weigh little on the overall uncertainties
- Errors due to the number of gauged points small
- Rating curve type very important
- Results may vary dramatically with watersheds and nutrients