Impact of input uncertainties on predictions of a distributed hydrological model

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Outline

• Motivation and Objectives of the study
• Methodological approach
• Case Study
• Results
• Conclusions
Motivation

Precipitation

\[ M(X, \Phi) \]

\[ Q_{\text{sim}} = ??? \]

\[ X, Q_{\text{obs}} \]

\( X \): Input variables
\( \Phi \): Model parameters, state variables
\( Q \): Discharge [m³/s]

Detailed process descriptions
Detailed representation of catchment characteristics
Limited predictive capability
Necessity to calibrate
Performance for validation events often disappointing
Uncertainties disturb parameter estimation
Motivation

• Least Squares Parameter estimation scheme is based on clear assumptions about error characteristics
• Uncertainties in input data provoke compensation effects in calibration which reflects in distortion of parameters
  • Spatial averaging (intensity, depth,…)
  • Temporal averaging
• …but, little is known about the structure of errors
Objectives

- What kind of errors in model predictions are induced by simplified representation of rainfall field?
- What general characteristics can be revealed and do they conform with assumption of LS estimation?
- What are important features of errors?
- How could the calibration scheme and in turn predictive performance of the model be improved?
Methodology

Application of a Distributed hydrological model ($WBr^2M$) to the Besòs catchment (1024km$^2$):

- Representation of spatial variability of soil, landuse and rainfall
- Detailed soil moisture modelling in a grid column
Assumptions

Semi-synthetic work environment:
Corrected and adjusted radar images represent the ‘true’ rainfall field

- Calibration of WBr\(^2\)M with ‘true’ rainfall
- Generation of ‘true’ reference hydrographs for a set of observed events
Input Uncertainty

Interpolation techniques based on rain gauge observations
Uncertainty about true spatial rainfall field

• Uniform
• Thiessen Polygon
• External Drift Kriging
• Spline

Distribution of rainfall error
Error Definition

Residuals: \( \varepsilon_i = Q_{i,\text{ref}} - Q_{i,\text{sim}} \)

- Positive error: under prediction
- Negative error: over prediction

Analysis of error characteristics (check of LS-estimation assumptions)

- Normally distributed
- Zero mean (non biased) constant variance
- Independent of each other and predictions
Residual time plots

UNIF

TPM

EDK

SPLINE

ε [m³/s]  t [min]

ε [m³/s]  t [min]

ε [m³/s]  t [min]

ε [m³/s]  t [min]
Errors vs. predictions

UNIF

TPM

EDK

SPLINE

\( \varepsilon [\text{m}^3/\text{s}] \)

\( \text{sim} \ Q [\text{m}^3/\text{s}] \)
Resumé

- Interpolation methods introduce uncertainty about 'true' precipitation field: also in real application cases?!
- Examined by means of a semi-synthetic case study (control uncertainty to attribute errors to specific source)
- Diagnostic plots: residual time plots, error scatters (residual vs. prediction)
- LS assumptions violated – adaptation of error model for parameter estimation
- Systematic error induces bias in parameters due to compensation characteristics of the model
- Spatial variation of rainfall field error induces spatial variation of runoff error
Results

• What has to be expected in 'real' application case?
  • What do we really know about uncertainties?
• How can inevitable uncertainty be considered?
• Which estimator is appropriate?
• Which estimation scheme is appropriate?
Conclusions

- Case and data dependence
- Data transformation (stabilise error variance)
- Time series models for auto-correlation
- Descriptive model (representing important general features) for input uncertainty to consider in calibration
- Systematic bias (multiplication model)
- Multi site calibration scheme, tailored error models
- Spatial distribution of rainfall is crucial information for runoff generation processes
Thank You!

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