A comparison of parameter regionalisation strategies for the water quantity module of the SWAT with application to the Scheldt river basin

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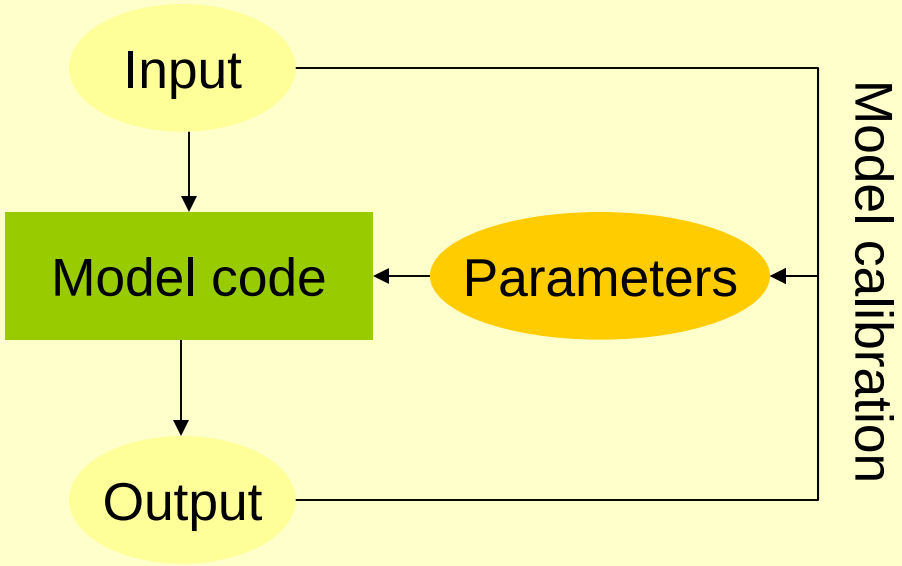
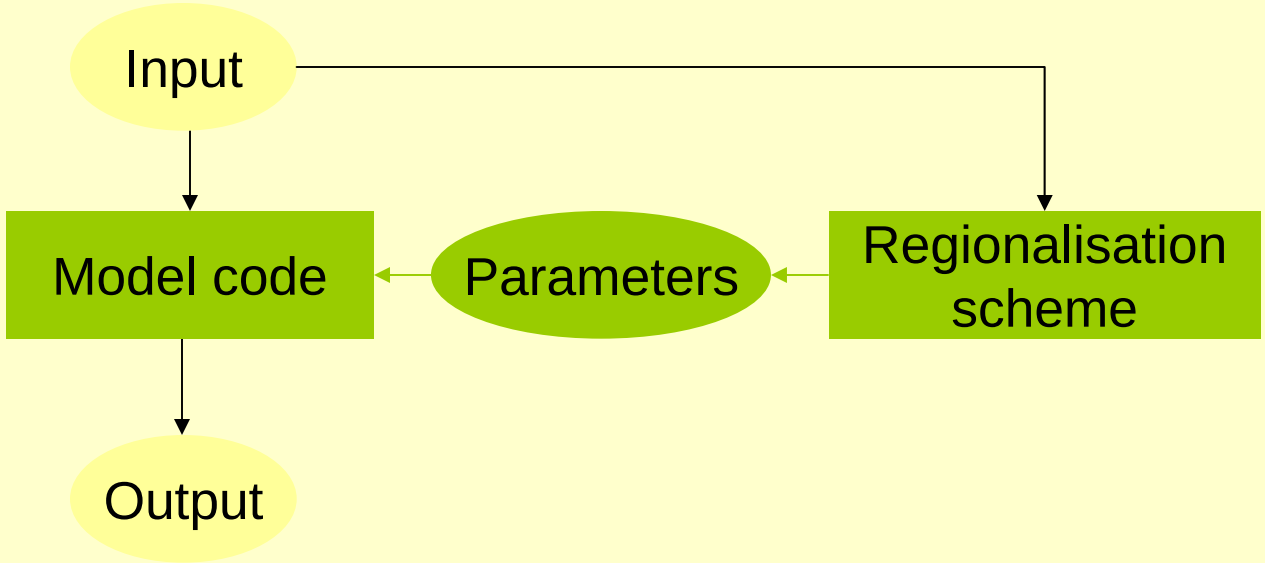
Parameter estimation in applied modelling



A case-specific model calibration is not always possible:

* parameters for ungauged areas?
* parameters for post-change conditions when modelling the impact of land use or climate change?

Regionalisation of model parameters



Regionalisation schemes can estimate parameters when a case-specific calibration is not possible:

* regionalisation schemes are based on model simulations in gauged catchments
* parameters are linked to more readily available data

Aim & Objectives

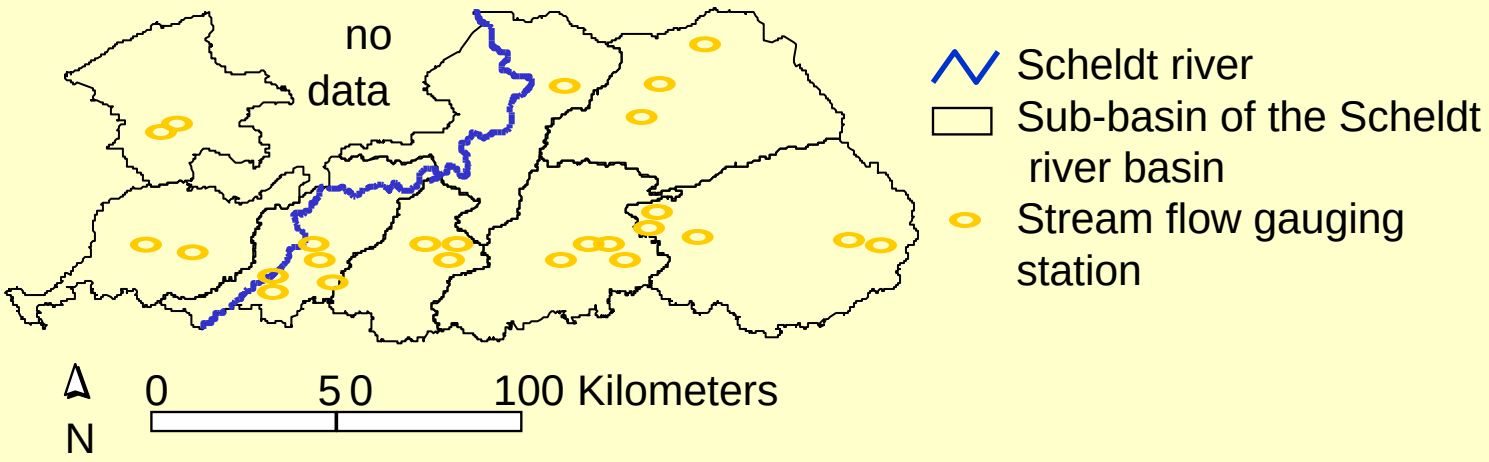
Aim:

Compare different parameter regionalisation schemes for the Flemish part of the Scheldt River basin

Objectives:

* assess the required complexity of parameter regionalisation schemes: can default SWAT settings be used? Or does one need a more complex regionalisation scheme?
* evaluate the model performance obtained with regionalisation schemes of varying complexity at different temporal scales (daily, monthly, yearly time step)

Site description

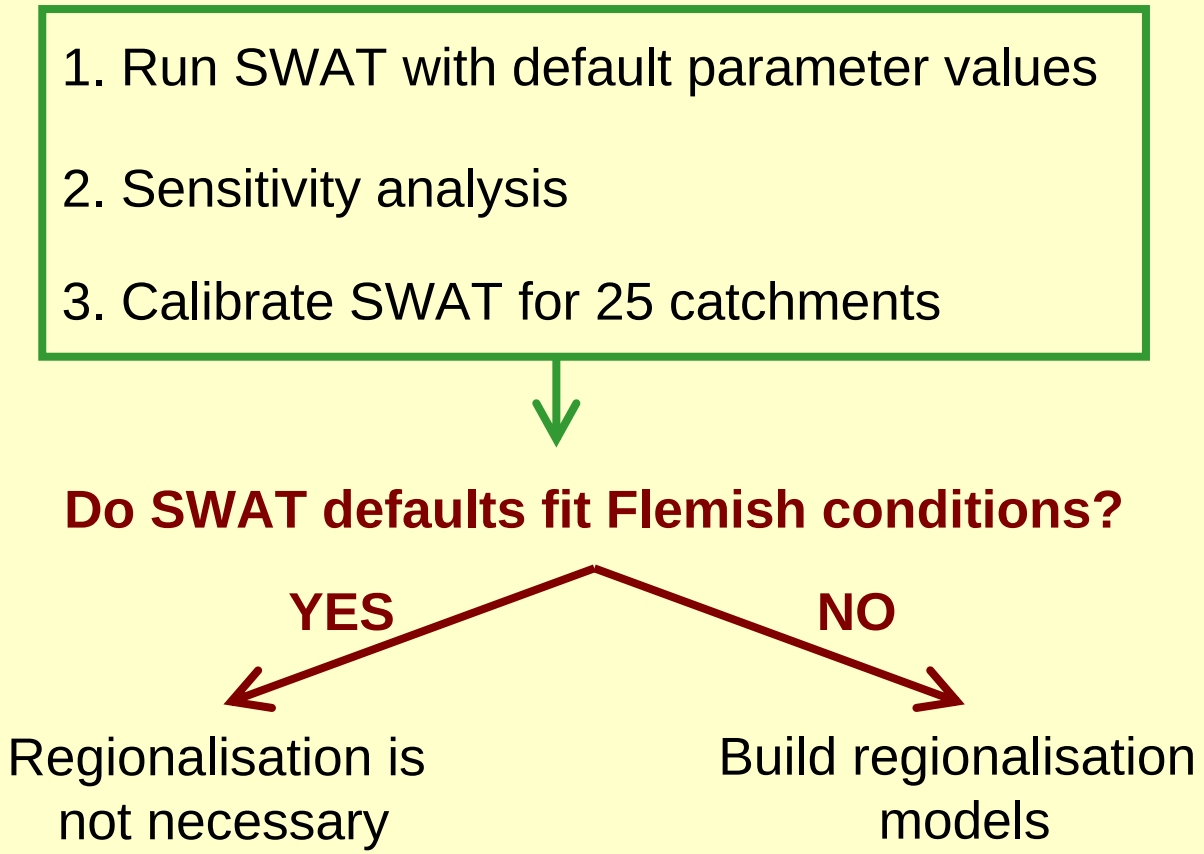


The model was calibrated for 25 catchments (2-210 km²)

* North: flat topography, sandy soils, aquifer at shallow depth

* South: rolling topography, loamy soils, aquifer at greater depth

General outline of the method



Sensitivity analysis and model calibration

The most sensitive model parameters that need to be adjusted to attain an acceptable model behaviour:

* **3 surface flow related parameters**

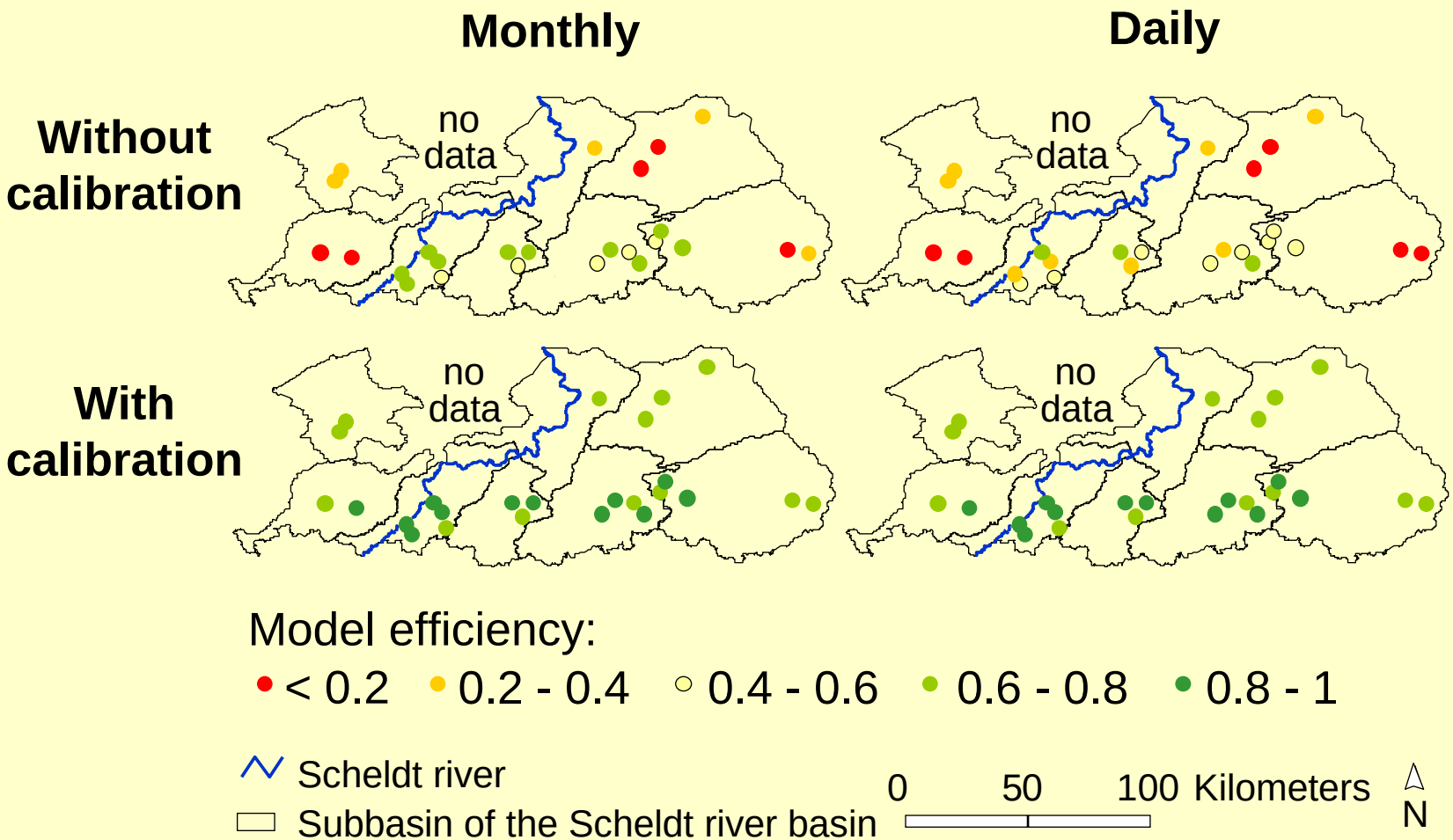
  CN2, SOL_AWC, SOL_K were calibrated as **relative** values

* **4 base flow related parameters**

  GW_DELAY, ALPHA_BF, GW_REVAP, REVAPMN were calibrated as **exact** values

Parameters were manually calibrated versus daily stream flow observation for the period 1990-1995 and validated for the period 1996-2001

Do SWAT defaults fit Flemish conditions?



In general, default settings to not suit Flemish catchments

Parameter regionalisation schemes

Six types of regionalisation schemes were considered:

* Baseline scenario: SWAT defaults
* Average parameter optima for the studied region
* Location-based, single parameter approach
* Location-based, parameter set approach
* Attribute-based, linear approach
* Attribute-based, nonlinear approach

Location-based regionalisation schemes

Parameter set zones: I II III

Average GW_REVAP: 0.11 0.14 0.16

N 0 50 100 Kilometers

Zones were delineated with a hierarchical clustering algorithm

3 parameter set zones were distinguished

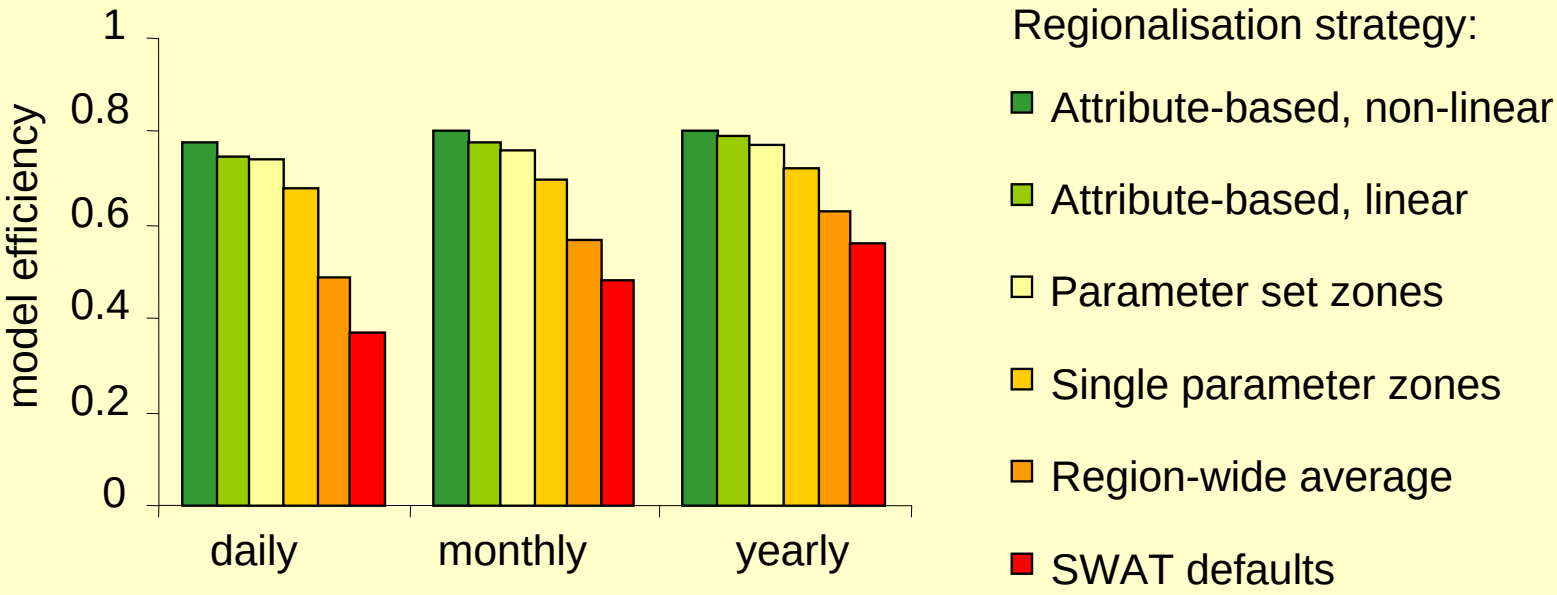
For the single parameter zonation, 2 to 4 zones were delineated for each parameter

Attribute-based regionalisation schemes

- GWREVAP and REVAPMN = f(slope, shallow aquifer, %forest, %sand)
- GW_DELAY = f(slope, clay subsoil, shallow aquifer)
- ALFA_BF = f(elongation, shallow aquifer, slope)
- SOL_K and SOL_AWC = f(slope, %forest)
- CN2 = f(drainage density, %forest in buffer area)

Overall, the slope and the % of the area with an aquifer at shallow depth are the most important catchment attributes

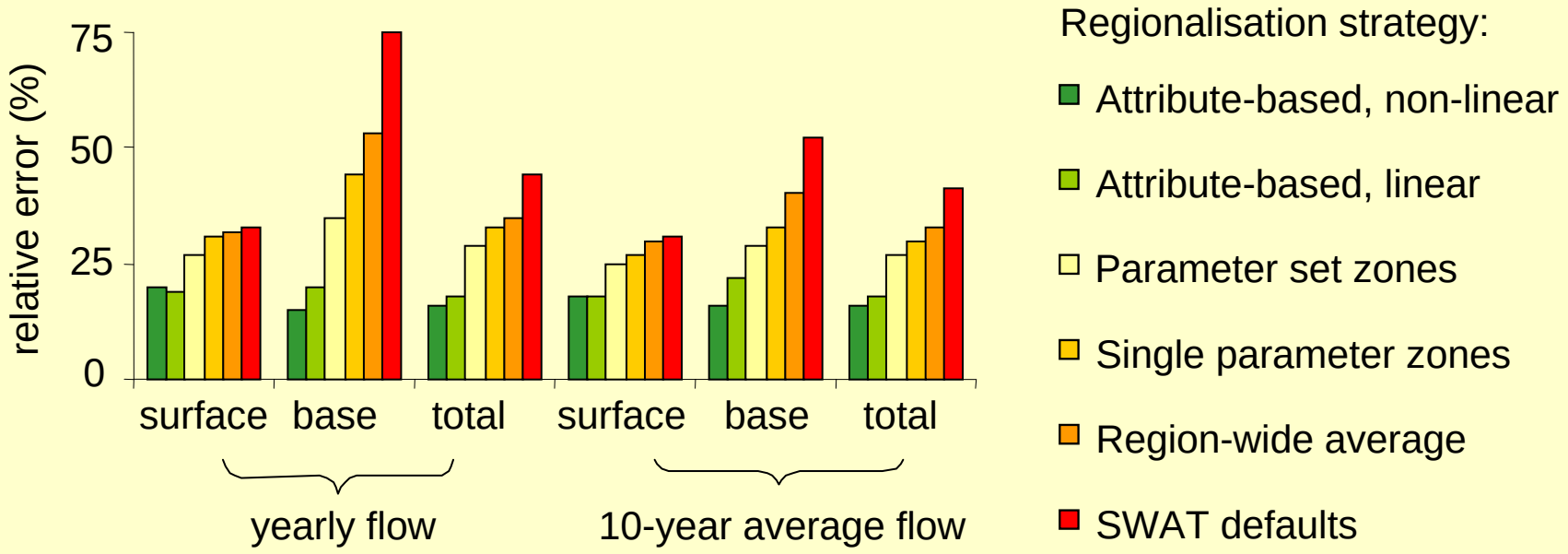
Performance of regionalisation schemes
(1) total stream flow



Attribute- and location-based regionalisation schemes lead to higher model performances than region-wide averages or SWAT defaults

Benefits of more complex regionalisation schemes decrease with increasing time step

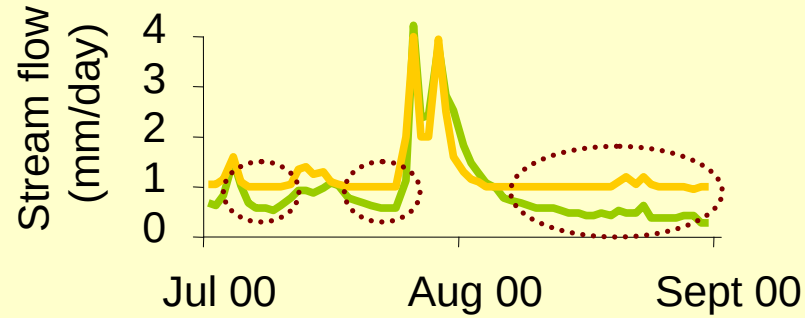
Performance of regionalisation schemes
(2) flow components



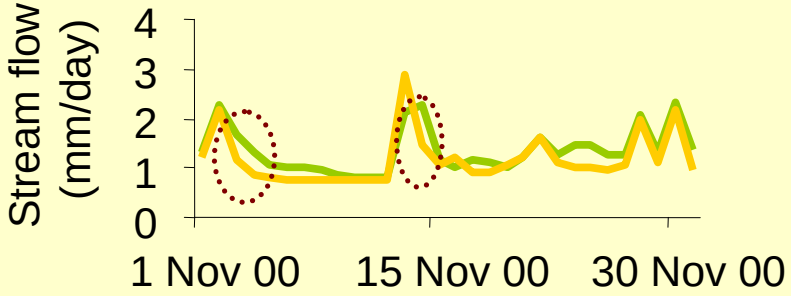
For the simplest parameter estimation strategies, base flow simulation is much more problematic than surface runoff simulation

The relative error of the more complex regionalisation techniques amounts about 20% for surface as well as for base flow simulation

Typical problems with default settings



In the north, default settings tend to overestimate base flow



The main problem in the south are errors in timing and steepness of base flow recessions

Observed Simulated

Regionalisation schemes vs. default settings

Overestimation of base flow is caused by an inadequate parameterisation of the revap process

* the attribute-based regionalisation: relates revap parameters to the depth of the water table

* the location-based regionalisation: zones coincide with this catchment attribute

Errors in timing and steepness of recessions are solved by regionalising GW_DELAY and ALPHA_BF

Attribute-based vs. location-based

The difference in performance between attribute-and location-based regionalisation schemes is small

The preferred regionalisation strategy depends on:

* the **model structure**: attribute-based regionalisation is expected to perform relatively better for physically based models
* the **objective** of the model application
* the **characteristics of the study area** e.g. the heterogeneity of the area

Conclusion

Default SWAT settings do not fit Flemish conditions

Location- or attribute-based regionalisation can increase the performance of the model esp. for simulations with a daily time step

The difference in performance between the more complex regionalisation strategies is small, the final selection of a regionalisation model should also depend on the objectives of the study