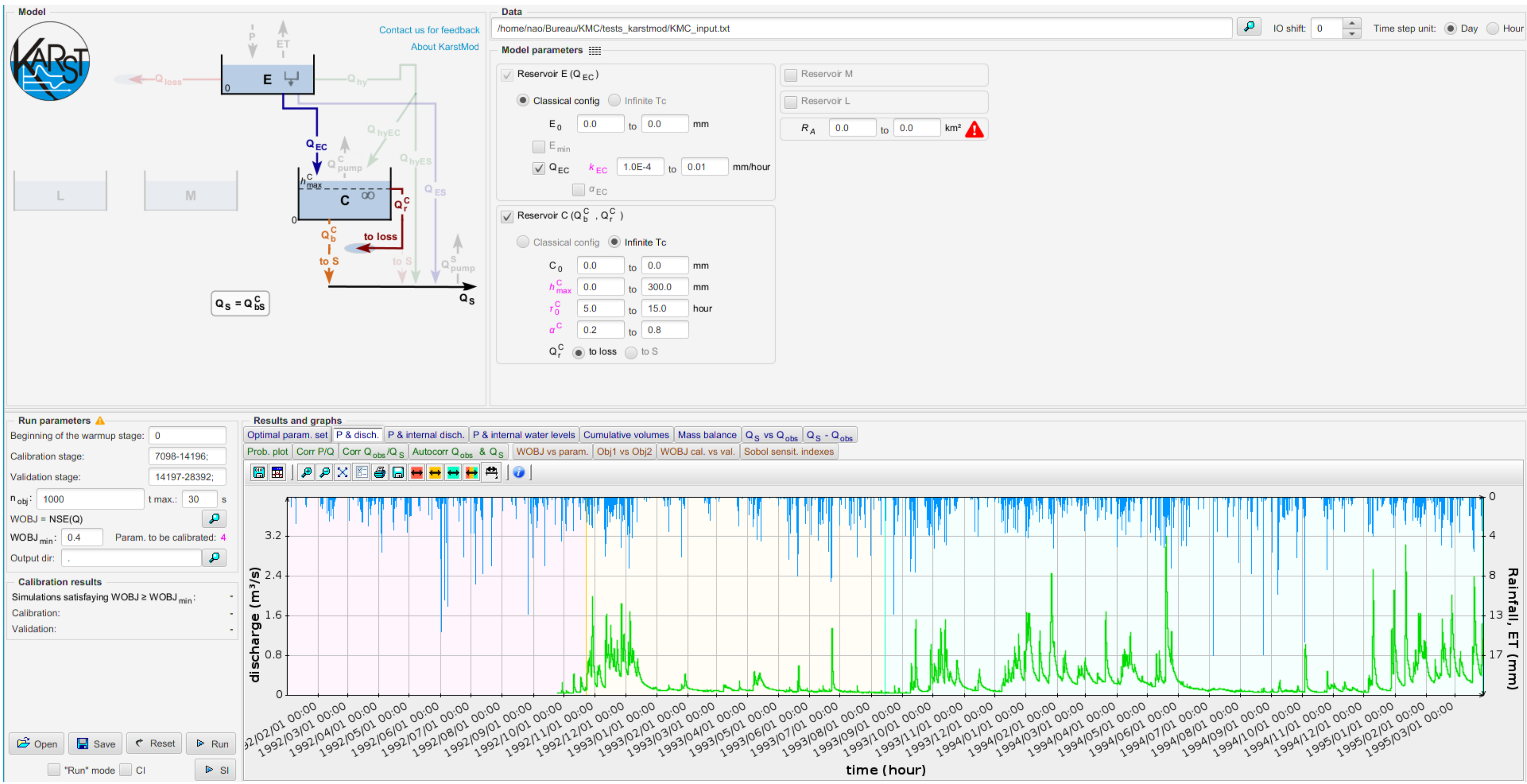
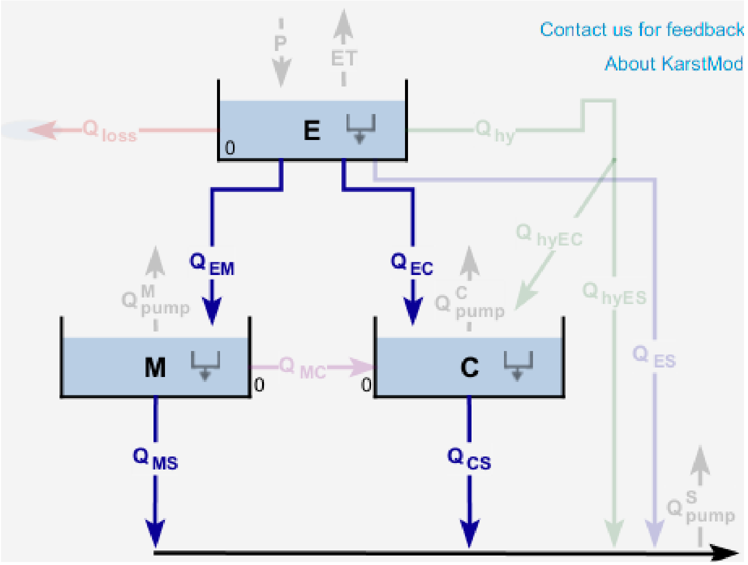
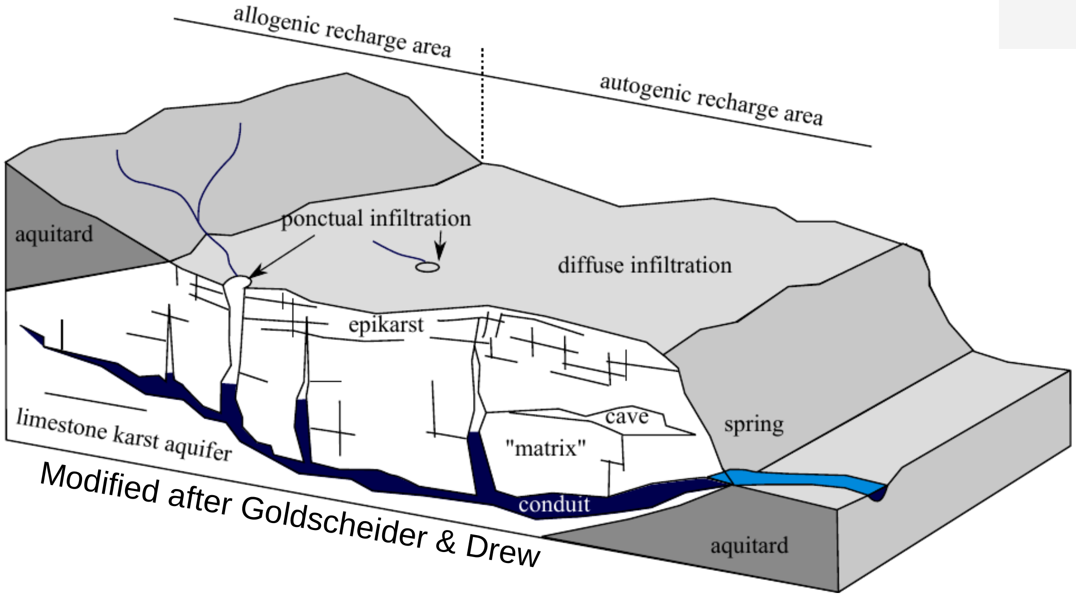
KarstMod platform : an overview



1D compartment models





Modified after Goldscheider & Drew

Operational :

→ Forecast of system response

Research

→ Understanding of the main processes at stake

→ Insights into internal behaviour

Modelling workflow

Choose performance measure

↓

Define calibration period

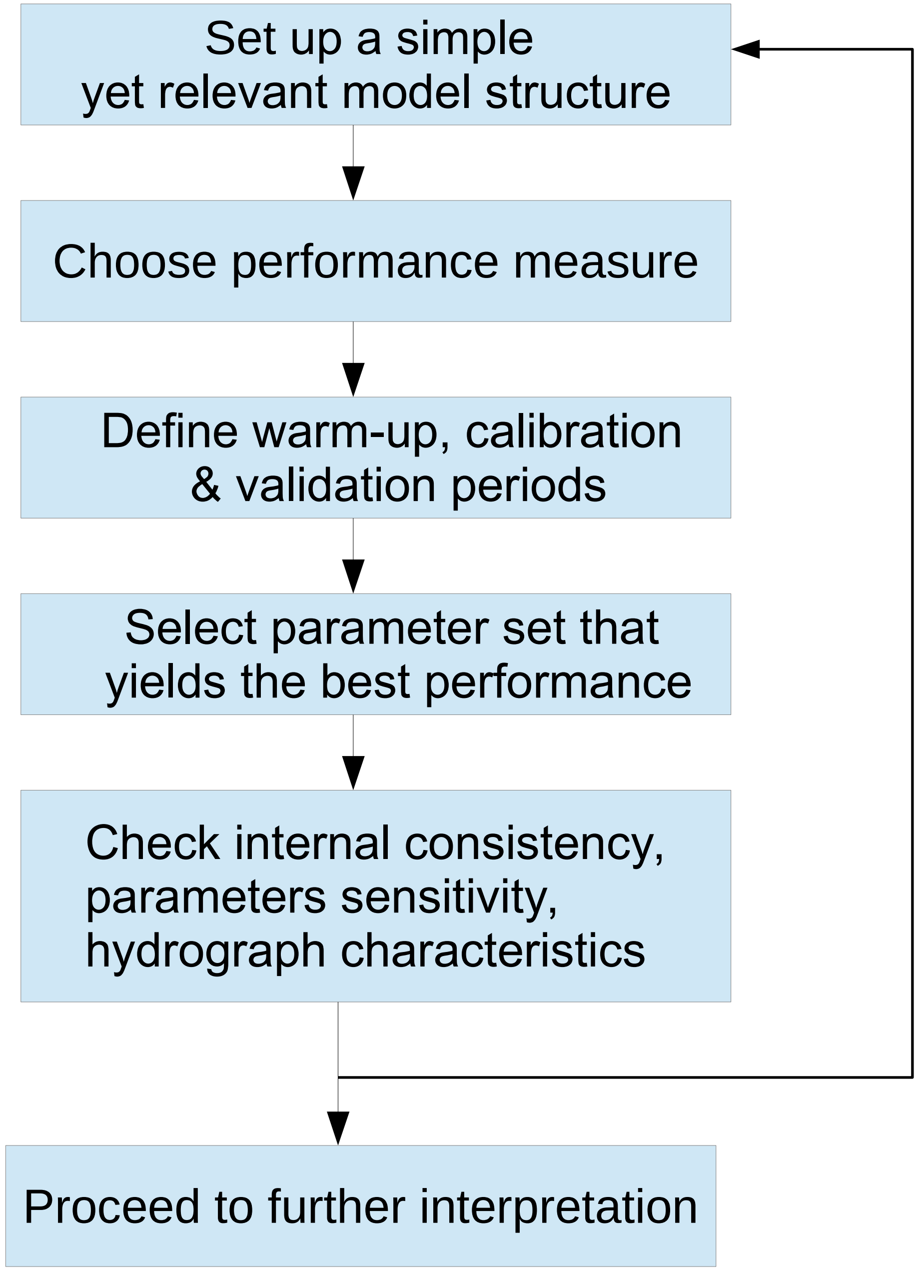
↓

Select parameter set that yields the best performance

↓

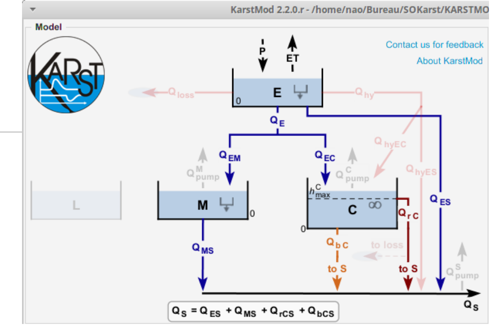
That's it !

Modelling workflow



Start simple !
Do you data really supports your model ?
Gradual complexification approach

Modelling workflow



1. Set up a simple yet relevant model structure
2. Choose performance measure
3. Define warm-up, calibration & validation periods
4. Select parameter set that yields the best performance
5. Check internal consistency, parameters sensitivity, hydrograph characteristics
   (loop back to step 1 if needed)
6. Proceed to further interpretation

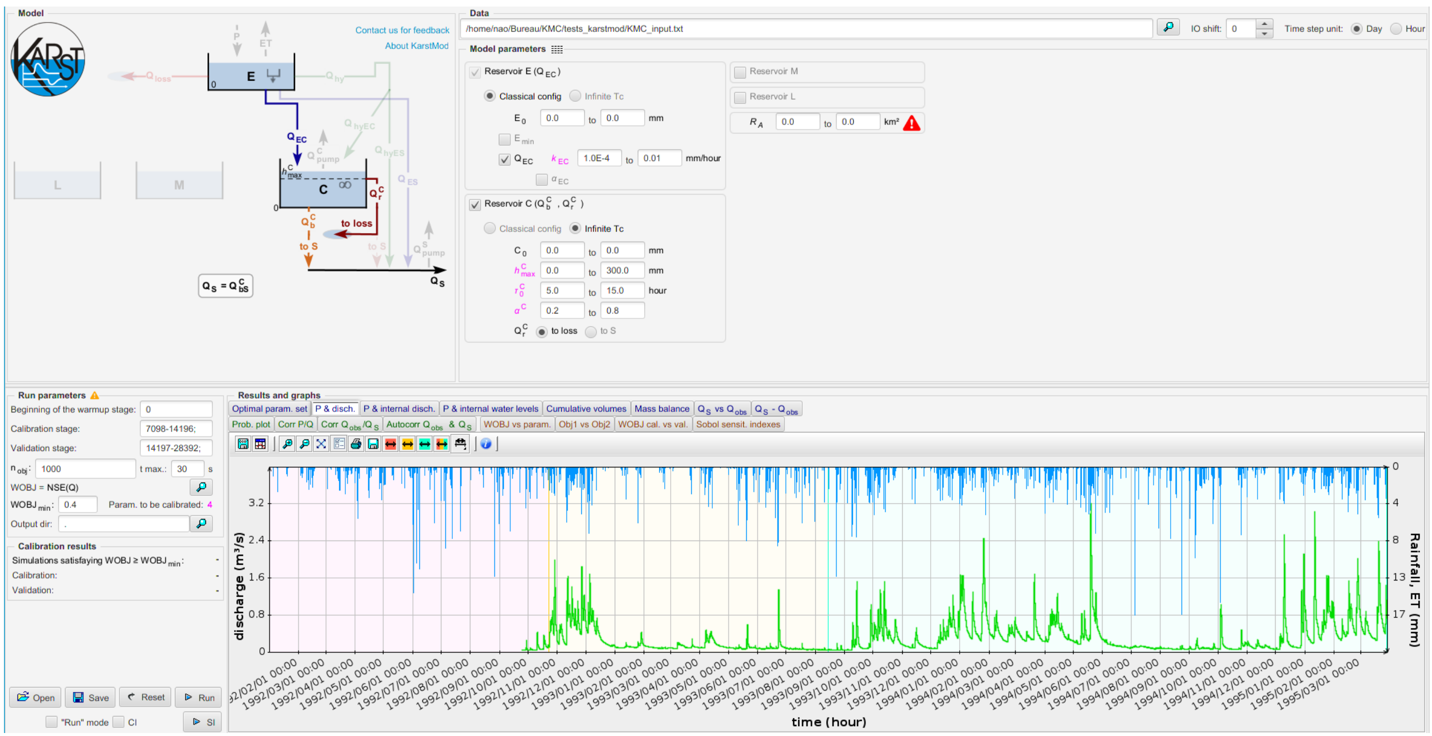
Aim of KarstMod platform

- Provide a friendly environment of 1D rainfall / water level / discharge modelling
- Provide analytical solutions, whenever possible
- Promote good modelling practices

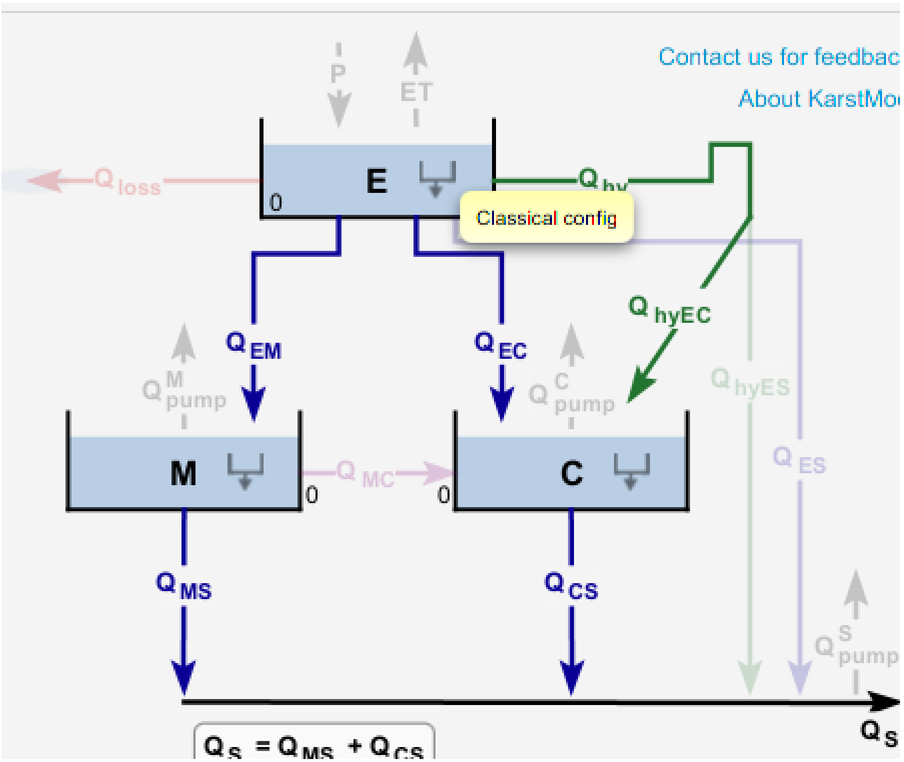
Start simple !
Do you data really supports your model ?
Gradual complexification approach

Step by Step example

- KarstMod_2.2.0.r.jar
- Java Runtime Environment 64 bits ≥ 1.8
- KarstMod user manual
- Input file : FontaineVaucluse1994_2000.txt



Step by Step example : structure selection



2 configurations allowed for each compartment

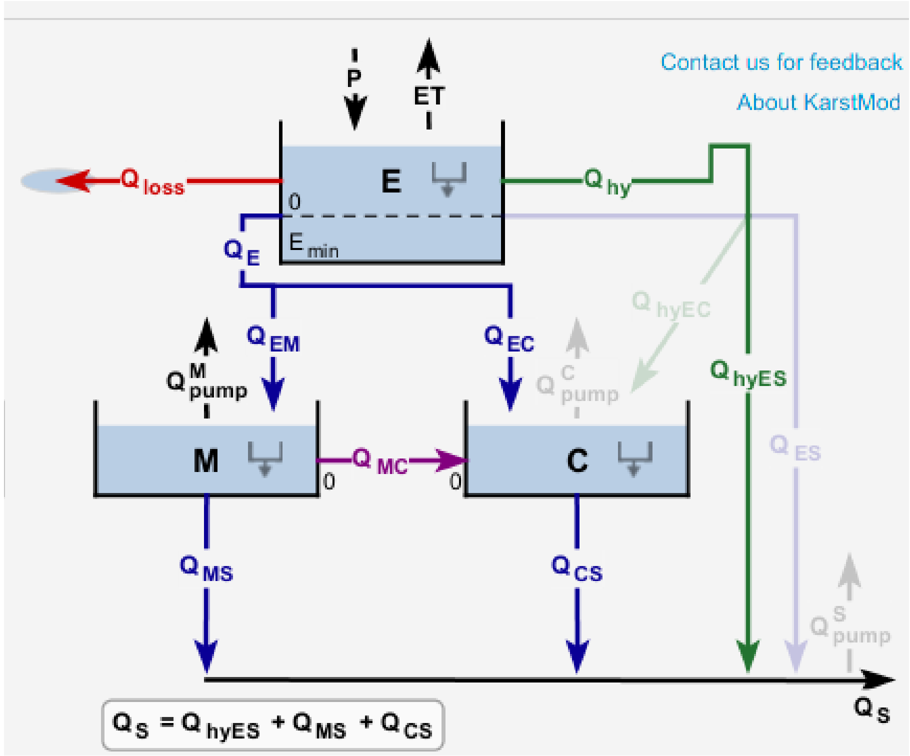
- Classical configuration (Maillet-type law)
- Infinite characteristic time transfer function

Start simple !
Do you data really supports your model ?
Gradual complexification approach

Step by Step example : transfer laws

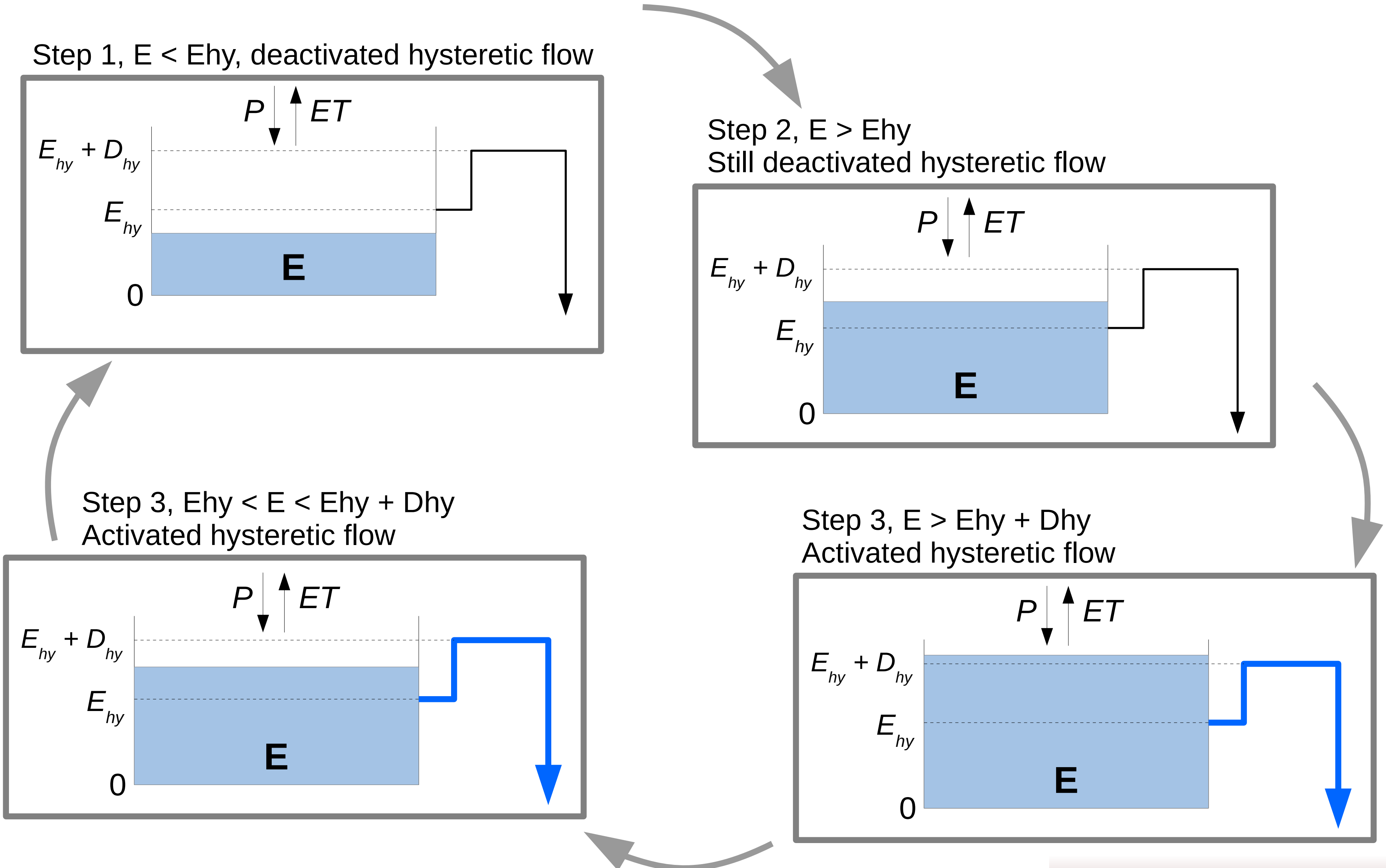
Classical configuration

- Linear discharge law $Q_{AB}(t)=k_{AB}\times A(t)$
- Non-linear discharge law $Q_{AB}(t)=k_{AB}\times A(t)^{\alpha_{AB}}$
- Activation thresholds
- Soil available water content
- Pumping / Losses
- Hysteretic discharge law
- M-C interaction



Step by Step example : transfer laws

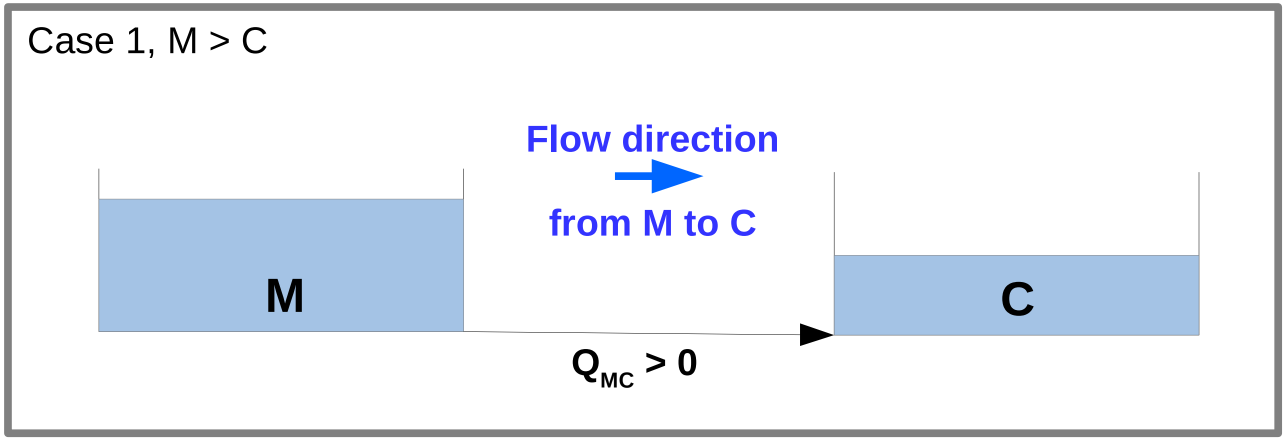
Classical configuration : Hysteretic discharge law $Q_{hy}(t)=k_{HY}(E-E_{hy})^{\alpha}$

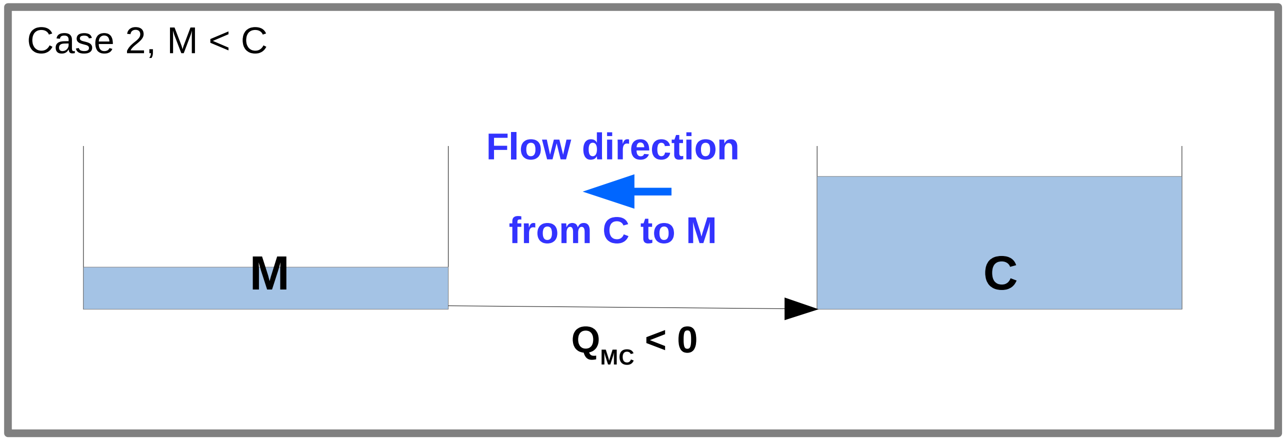


Activation of discharge law depends on prior state of saturation

Step by Step example : transfer laws

Classical configuration : Inter-compartments discharge law $Q_{MC}(t)=k_{MC}(M-C)^{\alpha}$



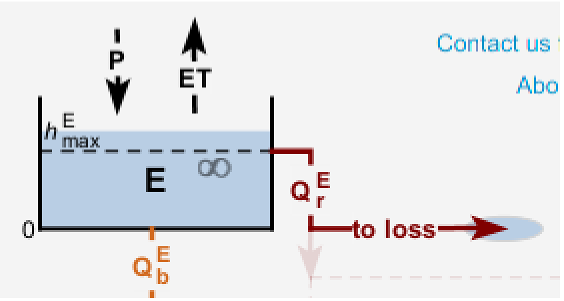


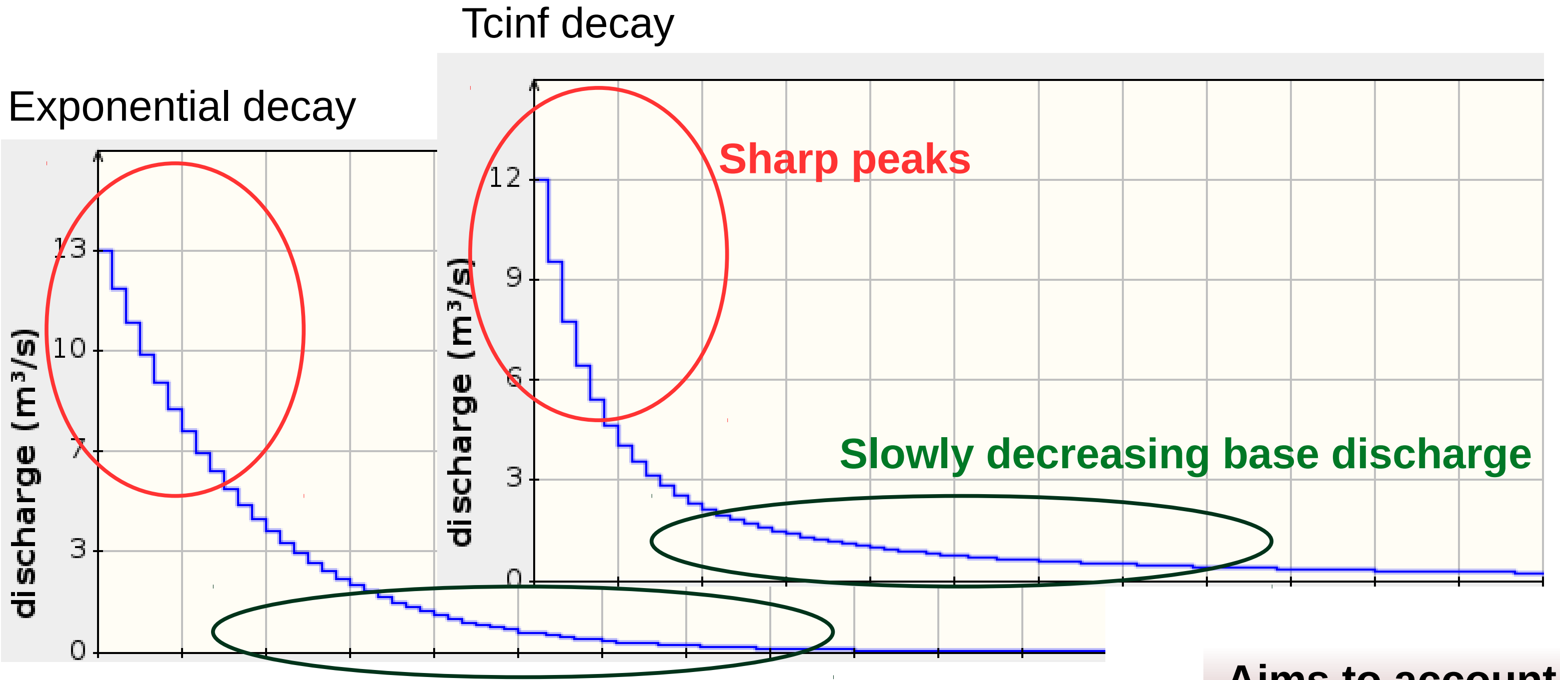
Flow direction depends on relative water levels between compartments

Step by Step example : transfer laws

Infinite characteristic time configuration

- Unit response $$\omega(t)=\frac{\alpha\,\tau_0^{\alpha}}{(\tau_0+t)^{1+\alpha}} \qquad 0<\alpha<1$$



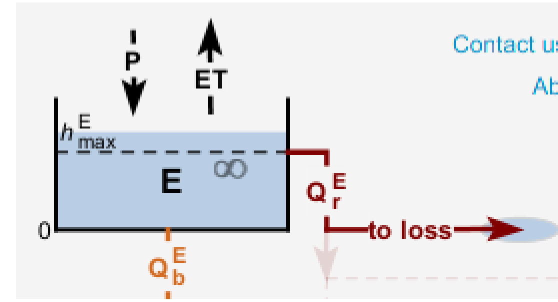


Aims to account for multiple transfer time scales in hydrosystems
→ Dual flow behaviour

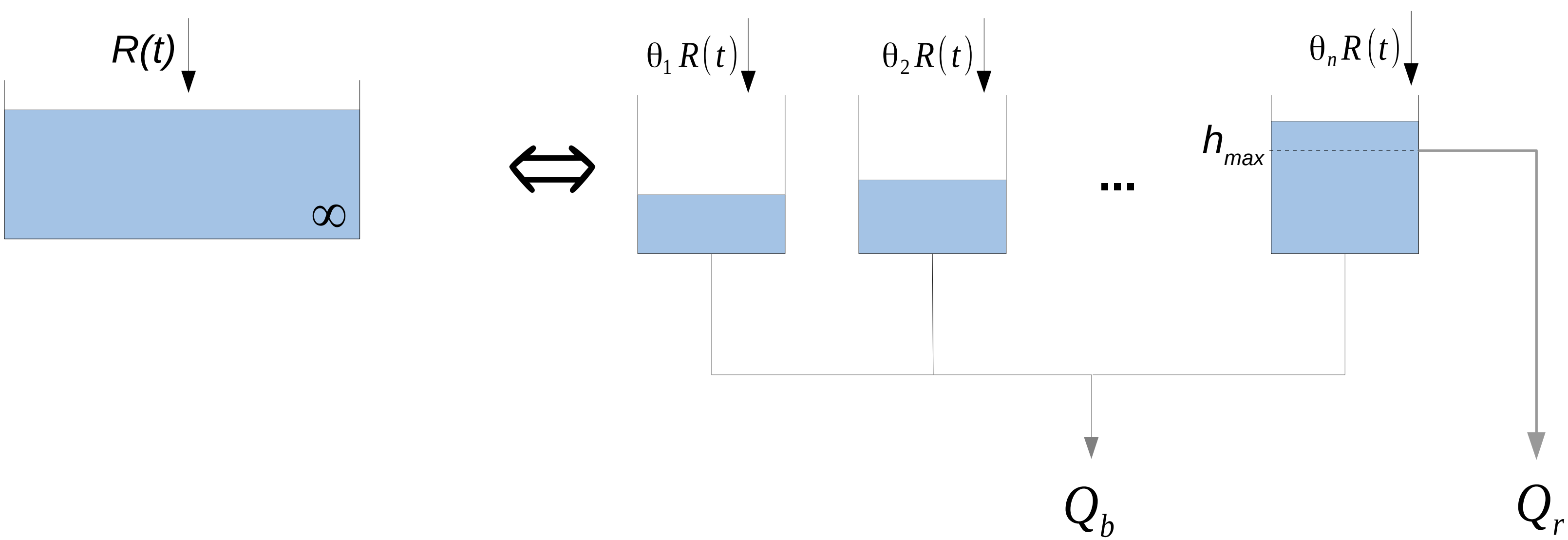
Step by Step example : transfer laws

Infinite characteristic time configuration

- Unit response $$\omega(t)=\frac{\alpha\tau_0^{\alpha}}{(\tau_0+t)^{1+\alpha}}$$ $$0<\alpha<1$$ $$Q_b=R\otimes\omega(t)$$



- Volume higher than threshold h_{max} triggers direct overflow Q_r



$$\sum_{i=1}^{n}\theta_i=1$$

Amounts to partitioning reservoir C into sub-reservoirs with linear discharge law, running in parallel.

Step by Step example : objective function

Performance measure

Volume Error (VE)
Nash-Stucliffe efficiency (NSE)
Kling-Gupta efficiency (KGE)

Balance error

Use 1 or a combination of 2 objective functions

Dataset

- Entire dataset Q(t)
- Peak flow Q(t) > Qmin
- Base discharge Q(t) < Qmax

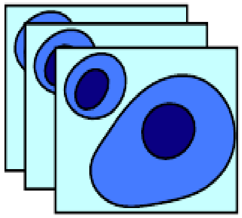
Variable

- Discharge or equivalent water level
- √, log()

Performance measures drive the calibration process
Which characteristics of the measured signal do you want to reproduce ?

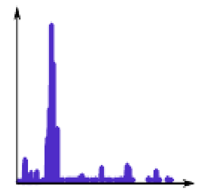
Step by Step example : your model can't perfectly fit the data

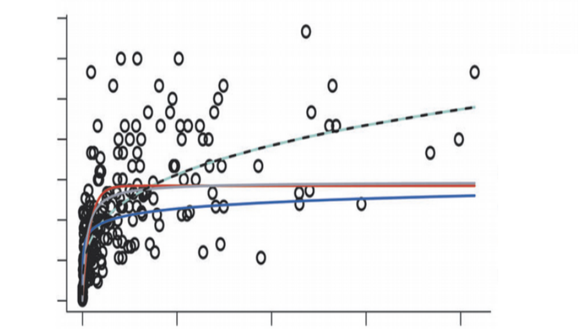
BOUNDARY CONDITIONS



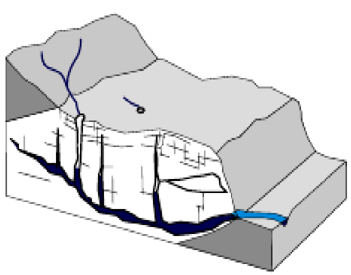
DONNEES

BOUNDARY CONDITIONS



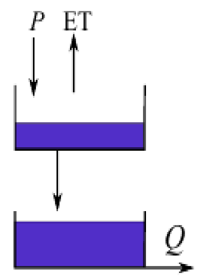


HYDROSYSTEM



CONCEPTUALISATION

MODEL



RESOLUTION NUMERIQUE

CALIBRATION

SYSTEM RESPONSE

SIMULATION RESULT

Errors occur at all stages of the modelling process

There's no unique solution to the modelling problem
=
EQUIFINALITY

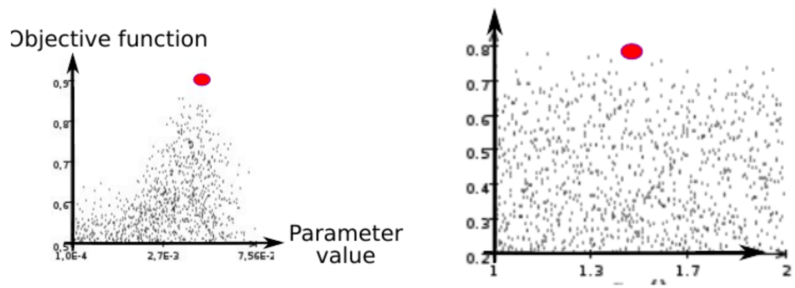
Non-optimal parameters set may still provide some interesting information

Step by Step example : relevant realizations approach

→ **In KarstMod, all simulations that comply WOBJ > $WOBJ_{min}$ are retained for analysis**

1/ At first, set a low minimal performance measure $WOBJ_{min}$

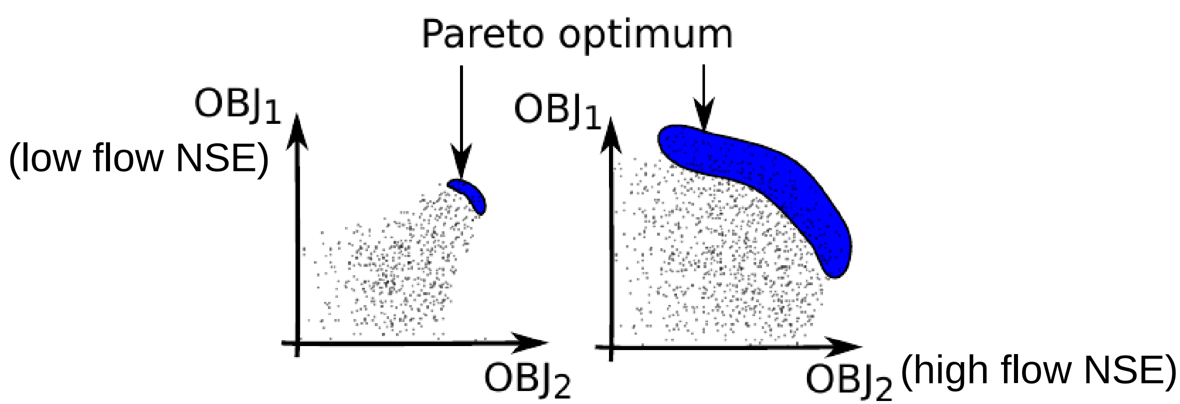
→ check parameter bounds & optimum



→ check key parameters (sensitivity indexes)

→ ...

→ check possible conflicts between signal characteristics



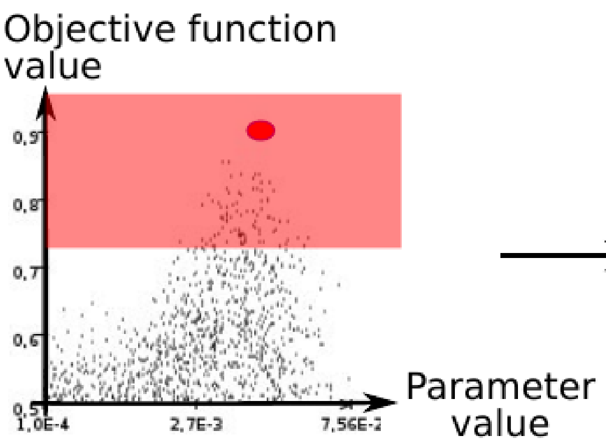
Final choice of wobj

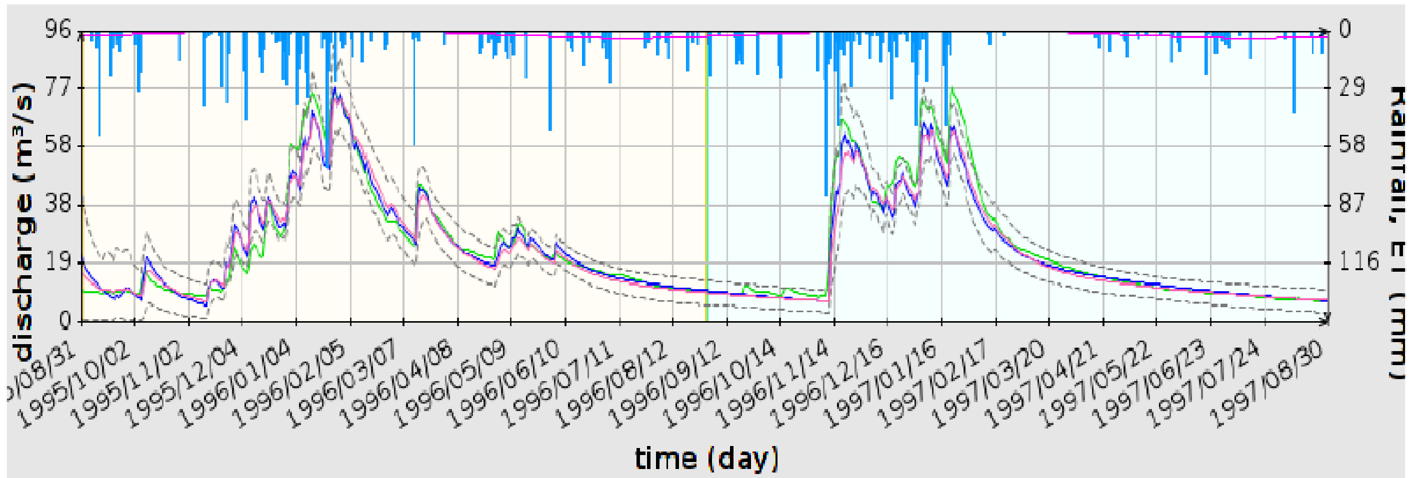
Set model structure & transfer laws

Step by Step example : relevant realizations approach

→ **In KarstMod, all simulations that comply WOBJ > WOBJ_{min} are retained for analysis**

1/ At first, set a low minimal performance measure WOBJ_{min}
2/ When model structure is deemed adequate, use higher WOBJ_{min}





→ simulation resulting from optimal parameter set (best wobj)
→ min & max Q values from set of acceptable simulations
→ most likely Q value based on set of acceptable simulations
→ 95 % confidence bounds based on acceptable simulations

GLUE methodlogy : Beven 1992

APPENDIX

PERFORMANCE MEASUREMENTS

Nash-Sutcliff efficiency

$$NSE = 1 - \frac{\sum (Q_{OBS} - Q_{¿})^2}{\sum (Q_{OBS} - \overline{Q_{OBS}})^2}$$

- $\in$]-∞ , 1]
- Qobs = Qobs ⇒NSE = 0

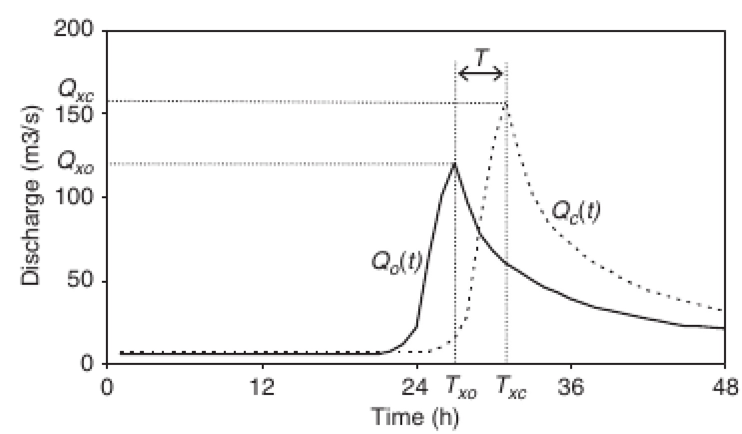
<u>NSE provide a relative quantification of model performance</u>

NSE = 0.8
⇔
erreur quadratique moyenne ÷ 5
As compared to reference simulation

NSE will be higher if the reference model is bad (high variability of Q(t))

NSE may be low even though the general shape of Q(t) is ok

more pertinent reference simulations can be used



Moussa (2010) HSJ