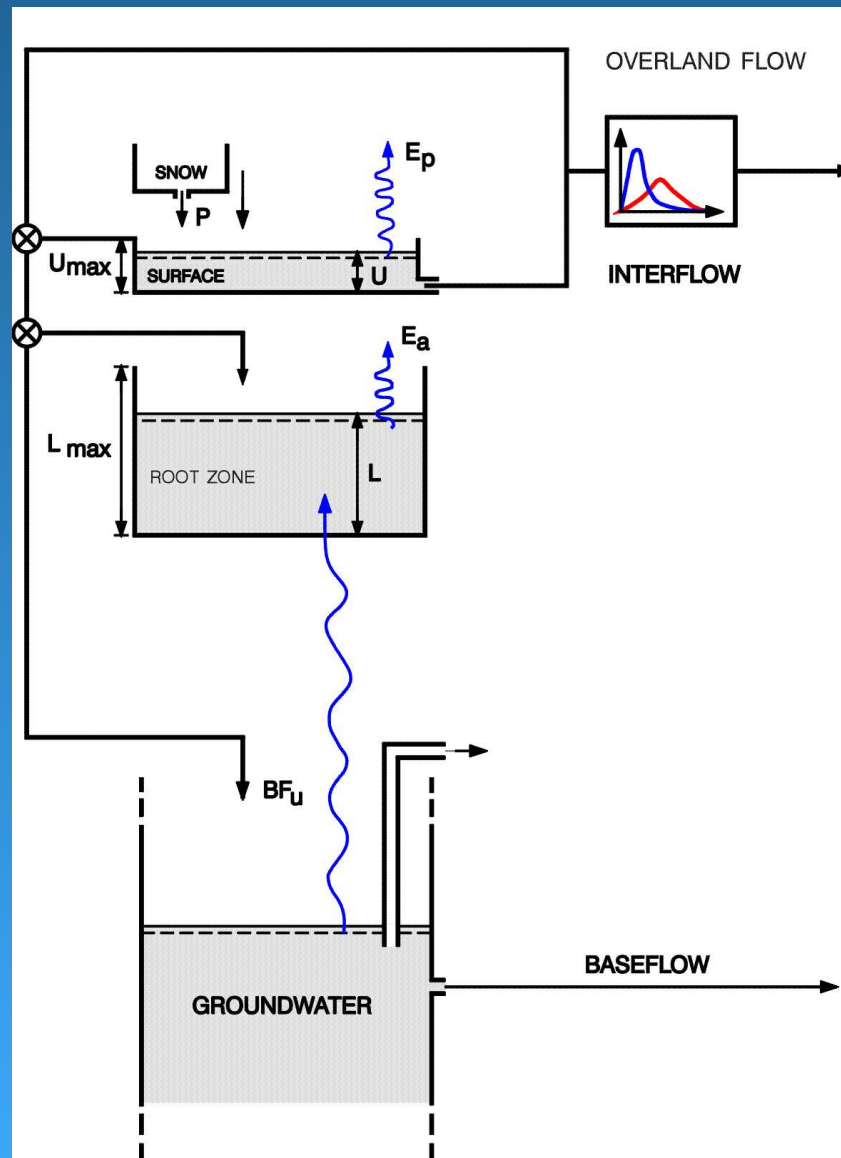


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# Automatic calibration of the NAM rainfall-runoff model using multiple objectives



## NAM rainfall-runoff model

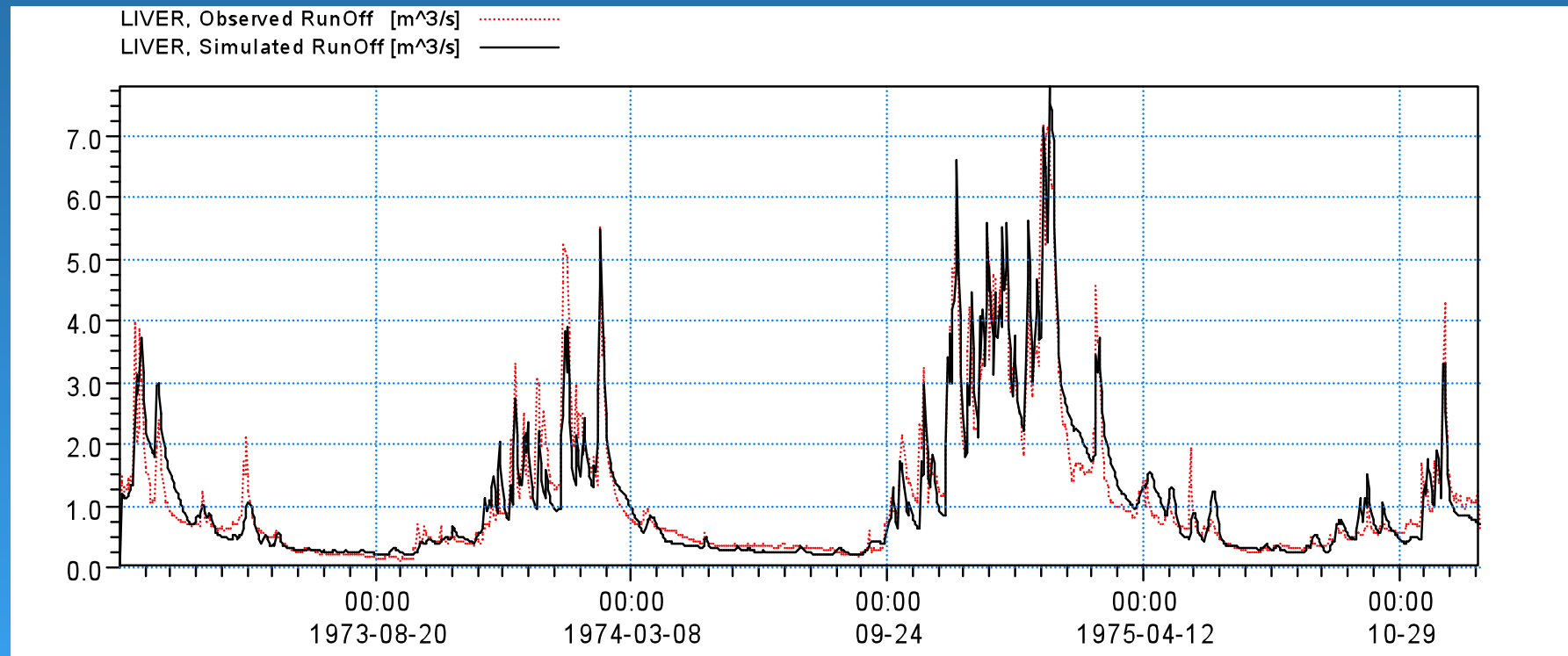
- Simulates the land phase of the hydrological cycle
- Lumped, conceptual type of model
- 9 model parameters (basic NAM)

# Calibration objective

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- Overall calibration objective:  
*Selection of model parameters so that the model as closely as possible simulates the hydrological behaviour of the catchment*
- Constrained by:
  - Data availability
  - Model structural errors
  - Data errors

# Observed vs. simulated hydrograph



# Definition of calibration objectives

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- A good agreement between average simulated and recorded catchment runoff (good water balance)
- A good overall agreement of the shape of the hydrograph
- A good agreement of peak flows
- A good agreement for low flows

⇒ Calibration problem is multi-objective

⇒ Trade-off between different objectives

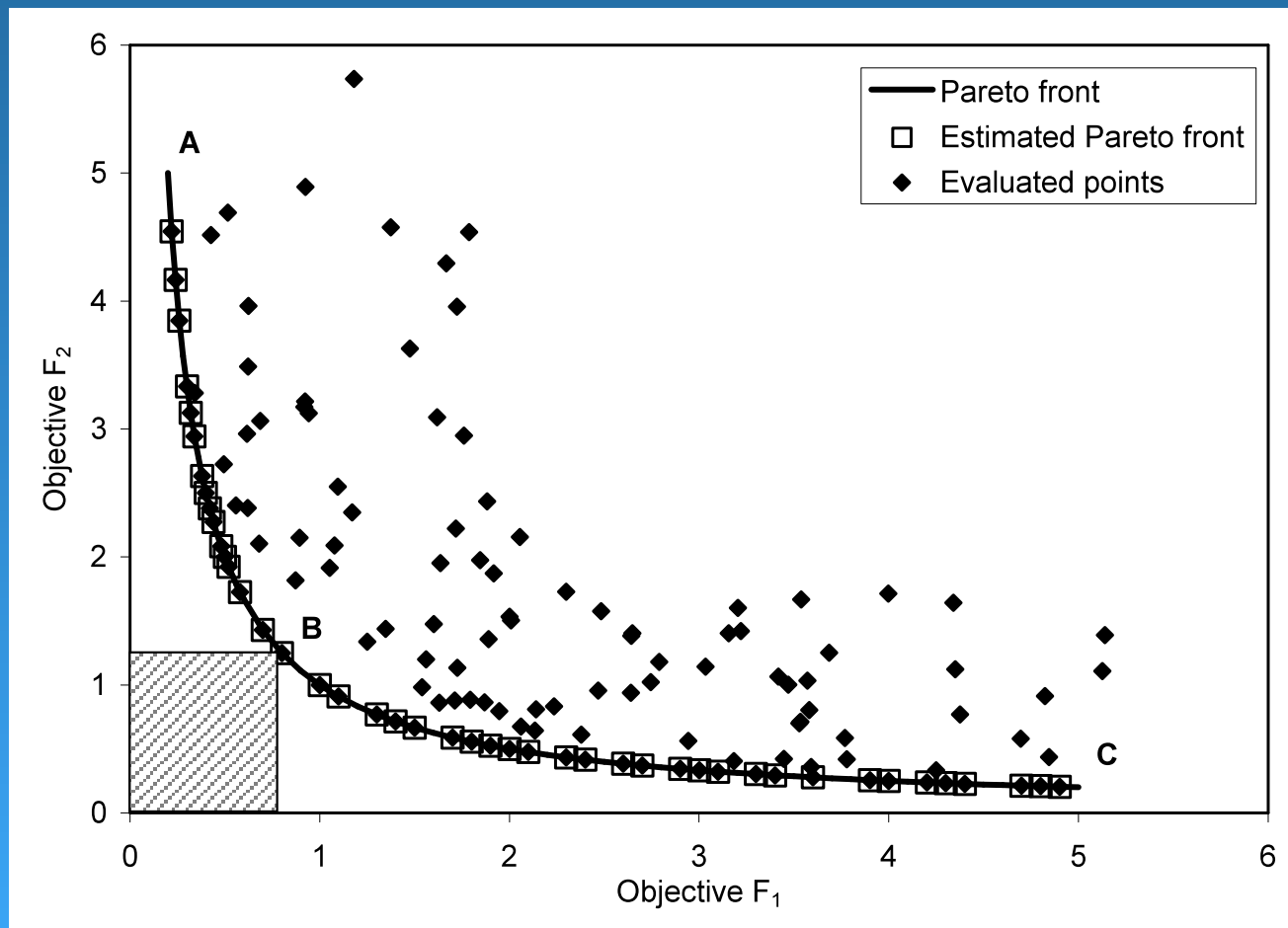
# Formulation of multi-objective calibration problem

- Optimisation problem

$$\text{Min} \{F_1(\theta), F_2(\theta), \dots, F_p(\theta)\} \quad , \quad \theta \in \Theta$$

- Pareto optimal (non-dominated) set of solutions
  - (1) Parameter space divided into “good” (Pareto optimal) and “bad” solutions
  - (2) None of the “good” solutions can be said to “better” than any of the other “good” solutions

# Pareto front



# Aggregated objective function

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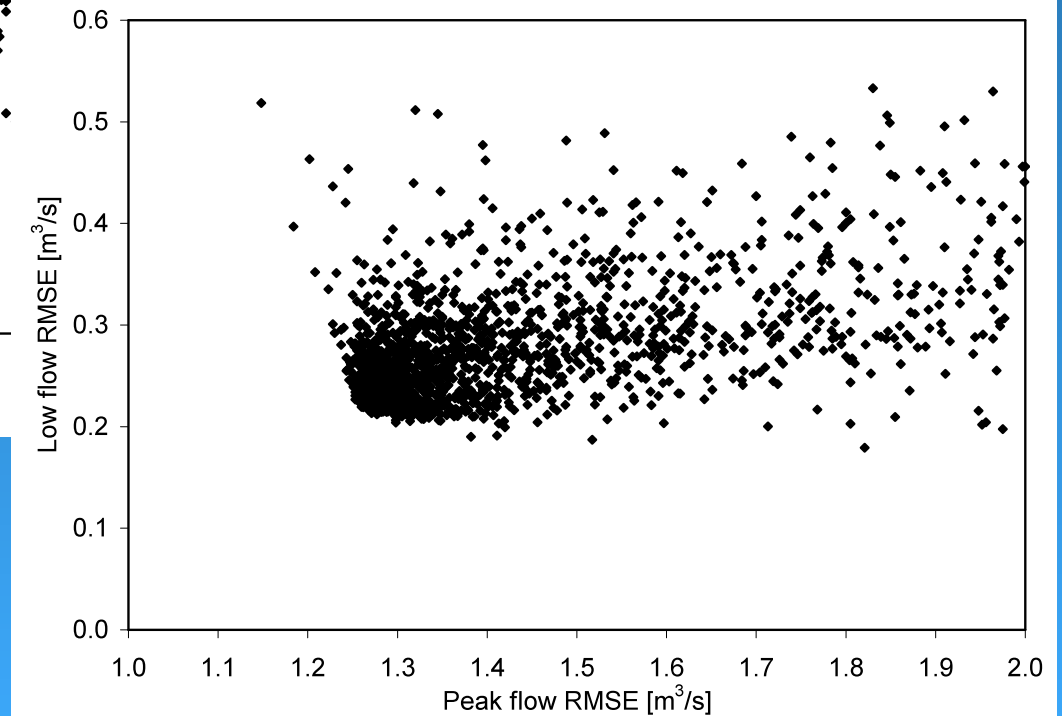
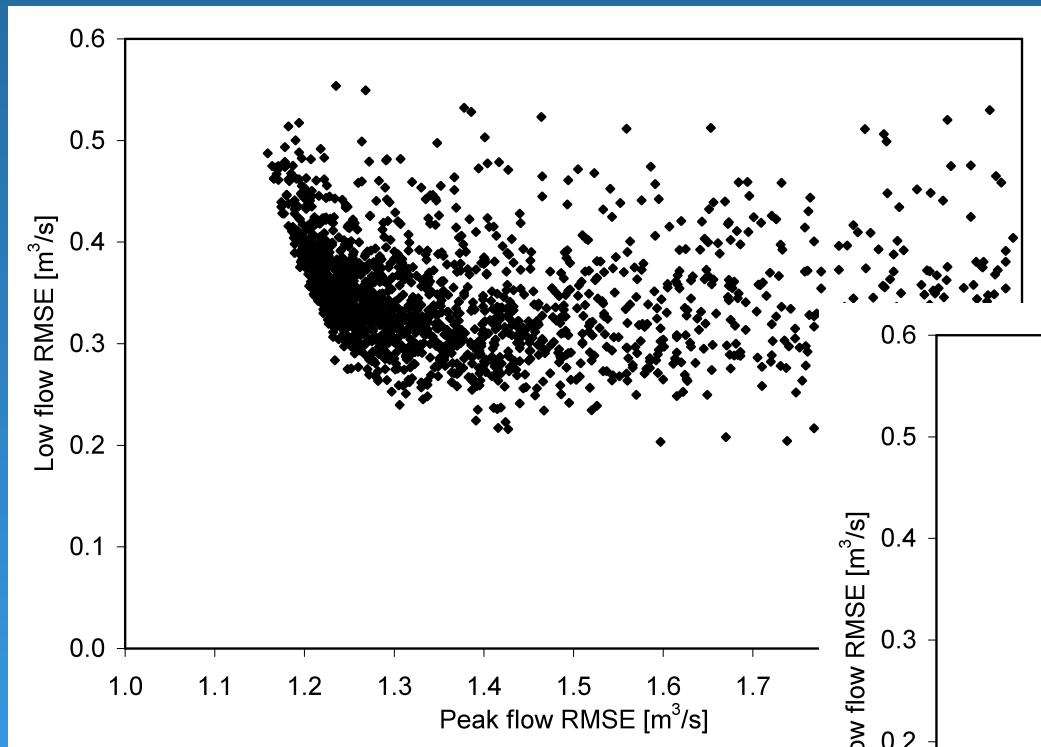
- Euclidian distance measure

$$F_{agg}(\theta) = \left[ (F_1(\theta) + A_1)^2 + (F_2(\theta) + A_2)^2 + \dots + (F_p(\theta) + A_p)^2 \right]^{1/2}$$

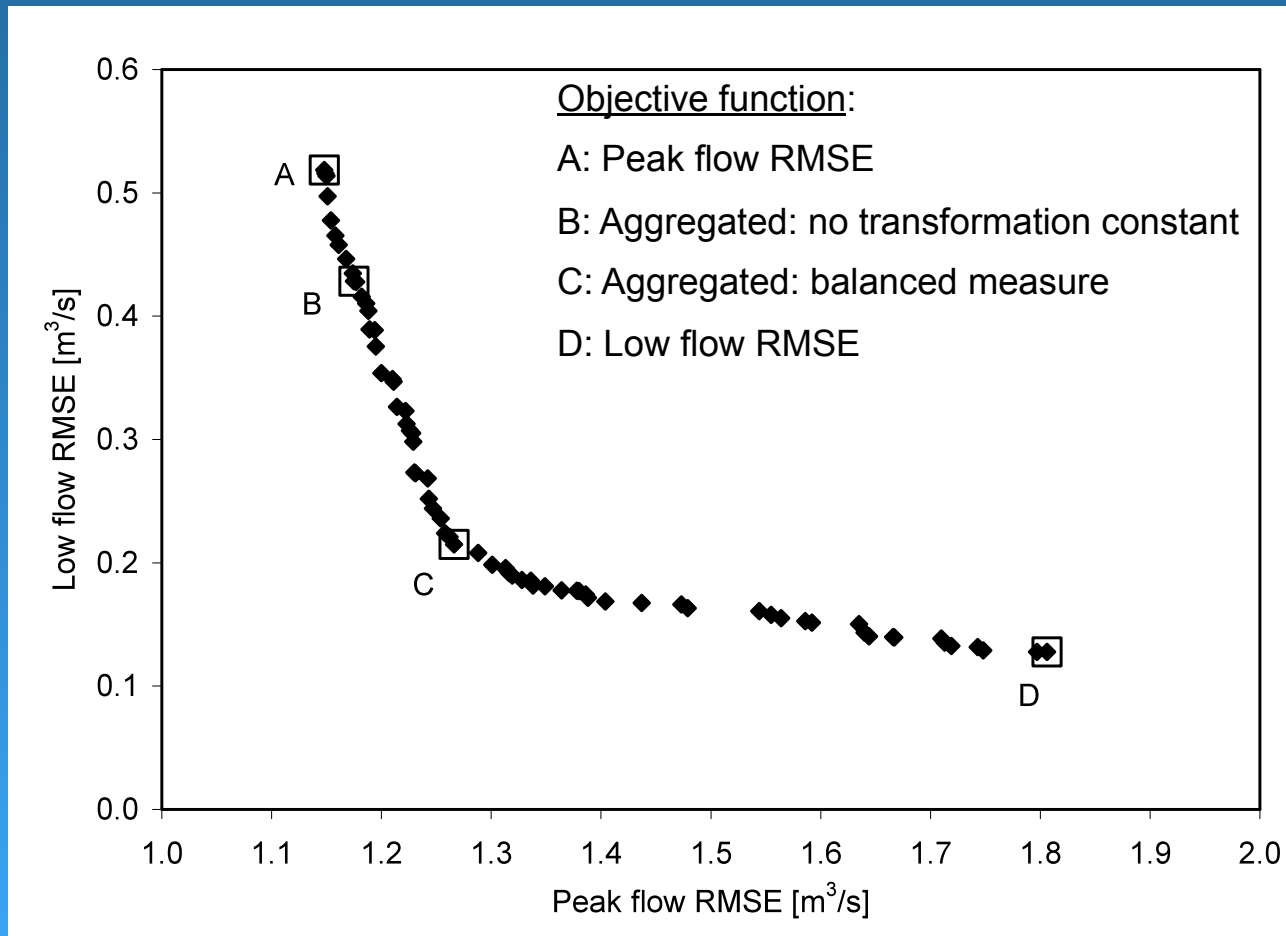
- Estimation of entire Pareto front:  
Optimisation with different transformation constants
- Estimation of single optimum:
  - User defined transformation constants
  - Balanced measure



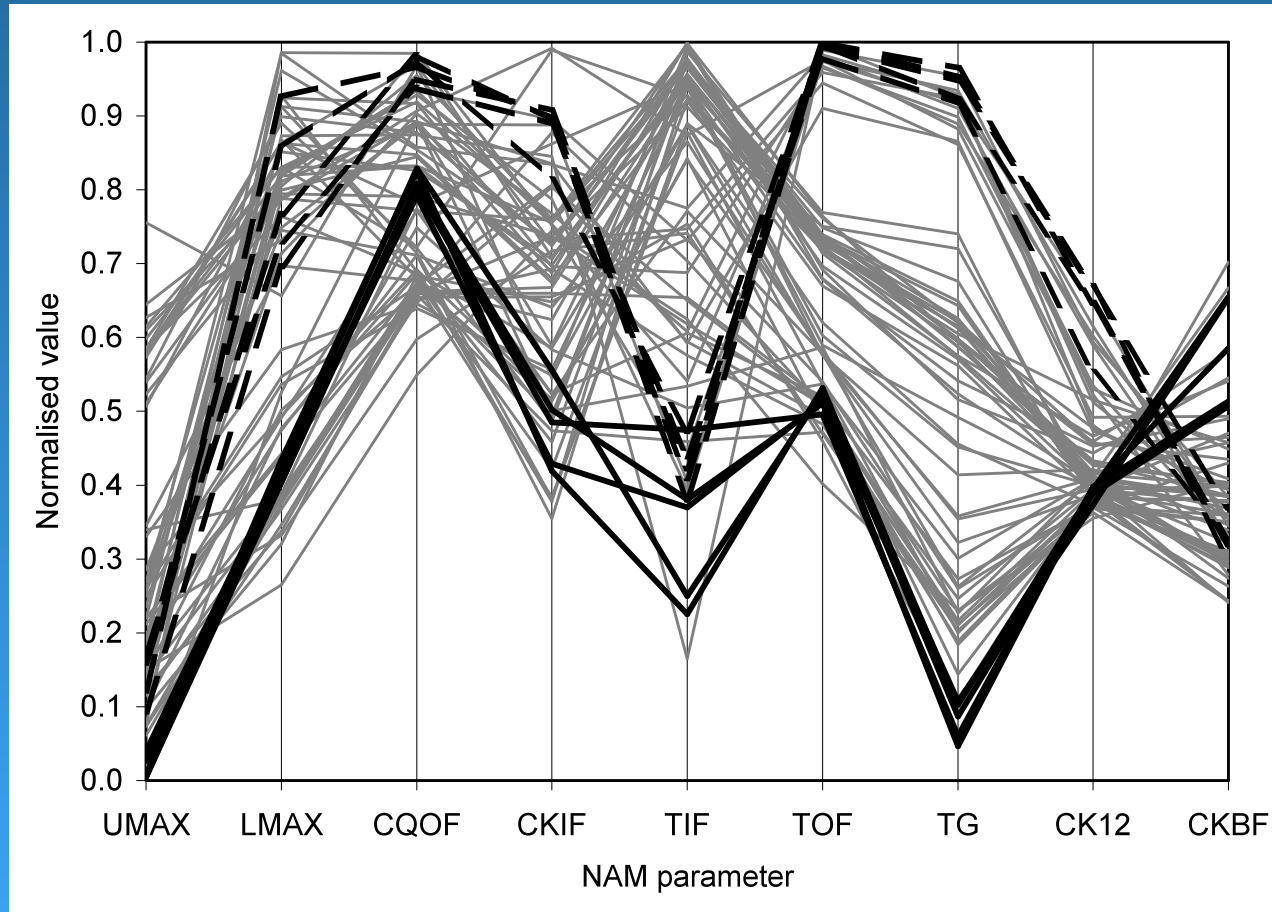
# Example of output



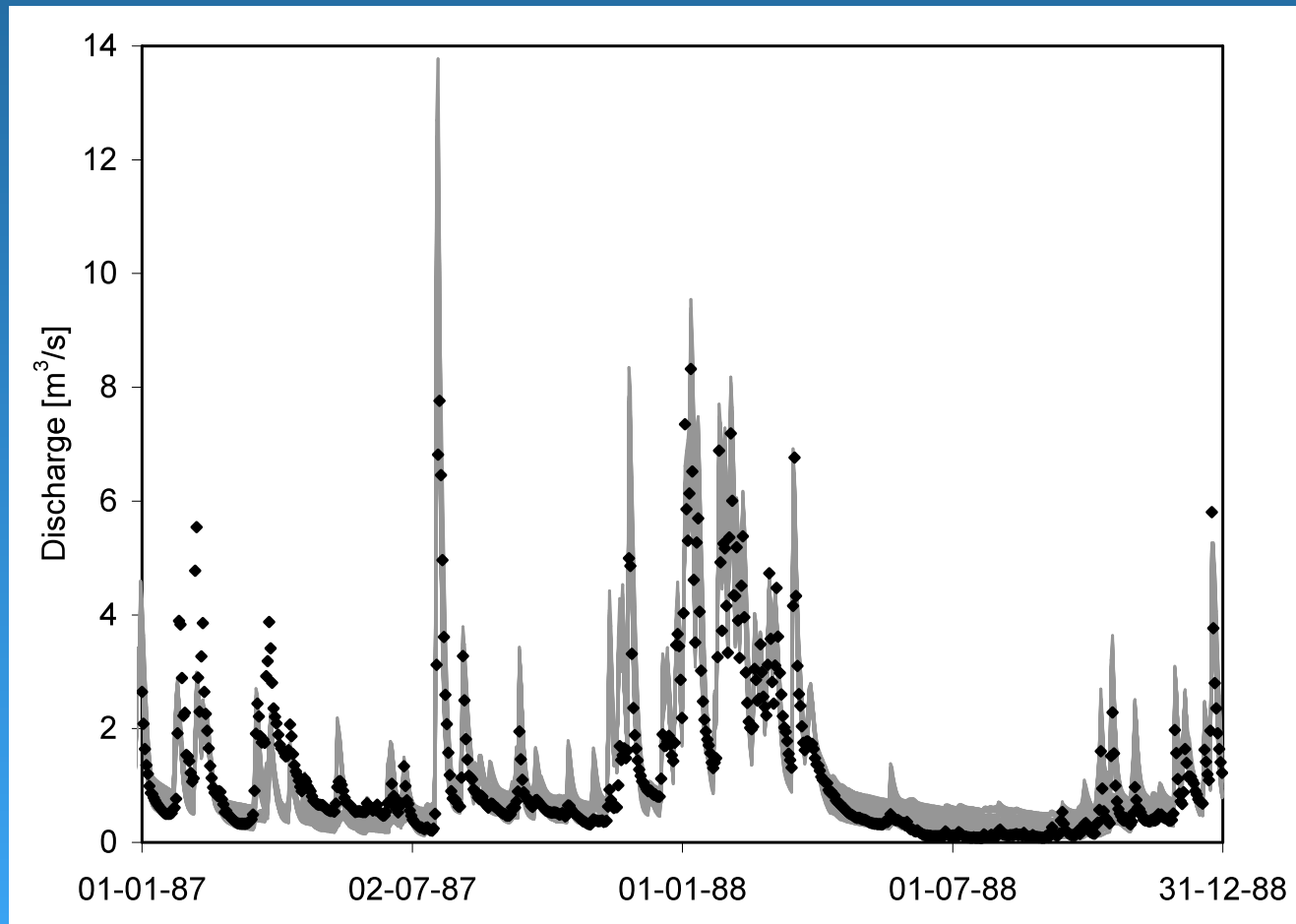
# Estimated Pareto front



# Range of parameter values along the Pareto front



# Range of simulated hydrographs along the Pareto front



## Summary and conclusions

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- Careful formulation of calibration objectives is important
- The calibration problem is in general multi-objective  
⇒ numerical performance measure should reflect various objectives
- In general, no unique optimal set of parameter values exists  
⇒ multi-objective equivalence of parameter sets (Pareto optimal solutions)  
⇒ single solution according to priorities of the different objectives
- Choice of numerical optimisation algorithm less important

**Liver.RR11 - Modified**

Catchments NAM UHM Timeseries

Surface-Rootzone Ground Water Snow Melt Irrigation Initial Conditions Autocalibration

☒ Include autocalibration LIVER

Calibration Parameters

Parameter	Fit	Initial Value	Lower Bound	Upper Bound
Umax	<input checked="" type="checkbox"/>	10.00	5.00	35.00
Lmax	<input checked="" type="checkbox"/>	100.00	50.00	350.00
CQOF	<input checked="" type="checkbox"/>	0.50	0.00	1.00
CKIF	<input checked="" type="checkbox"/>	750.00	500.00	1000.00
CK1.2	<input checked="" type="checkbox"/>	10.00	3.00	72.00
TOF	<input checked="" type="checkbox"/>	0.00	0.00	0.90
TIF	<input checked="" type="checkbox"/>	0.00	0.00	0.90
TG	<input checked="" type="checkbox"/>	0.00	0.00	0.90
CKBF	<input checked="" type="checkbox"/>	2000.00	500.00	5000.00

Objective Function

☒ Overall Water Balance

☒ Overall Root Mean Square Error

☐ Peak flow RMSE Peak flow >  m3/s

☐ Low flow RMSE Low flow <  m3/s

Maximum number of evaluations

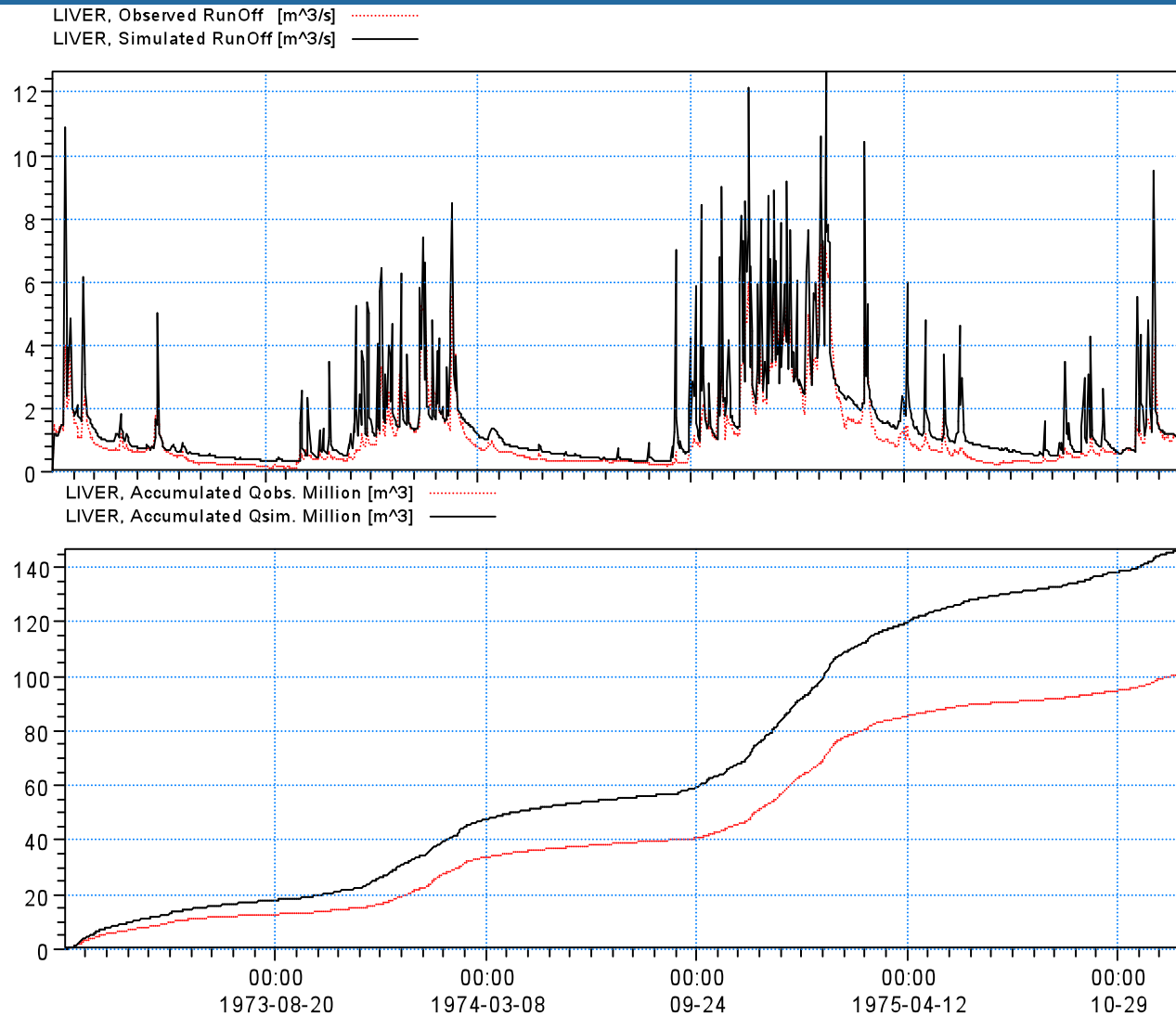
Overview

	Name
1	LIVER

## Specifications:

- Calibration parameters
- Range of parameters
- Objective functions
- Stopping criterion

# Initial parameters



# Calibrated parameters

