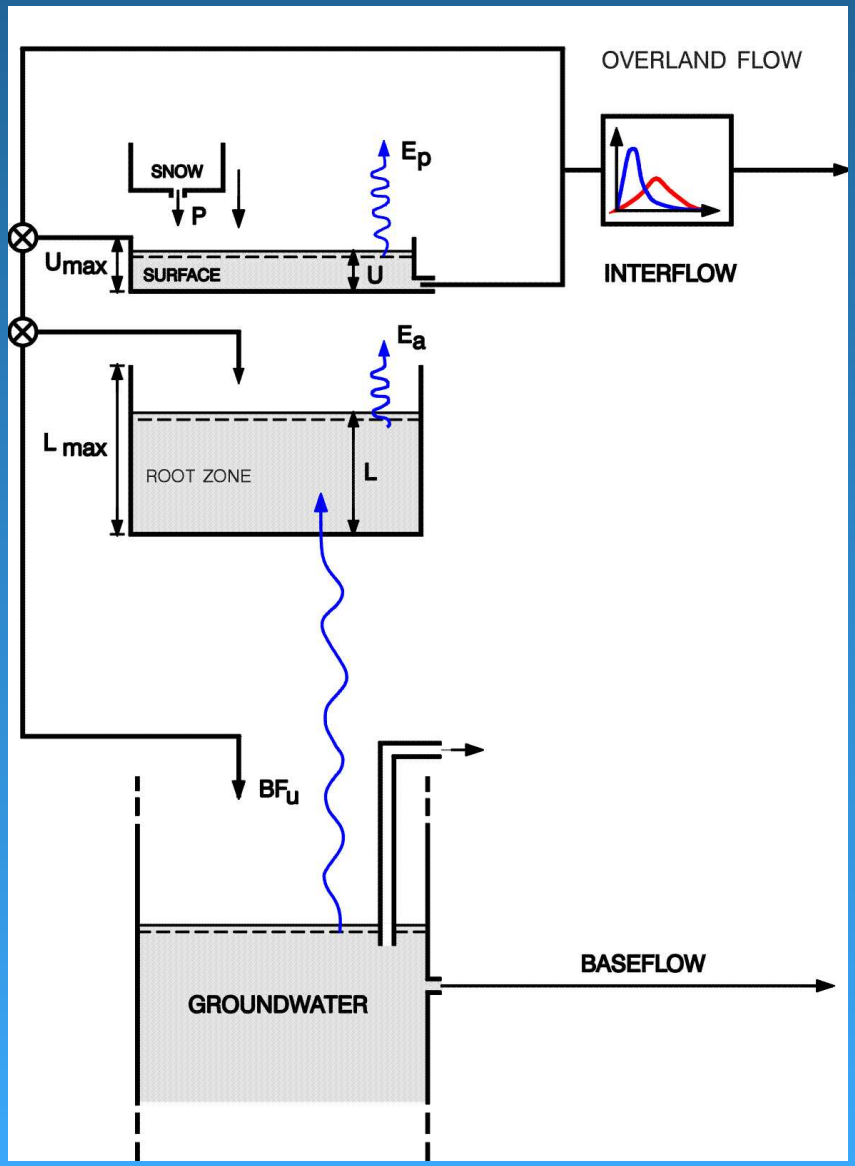
Automatic calibration of the NAM rainfall-runoff model using multiple objectives



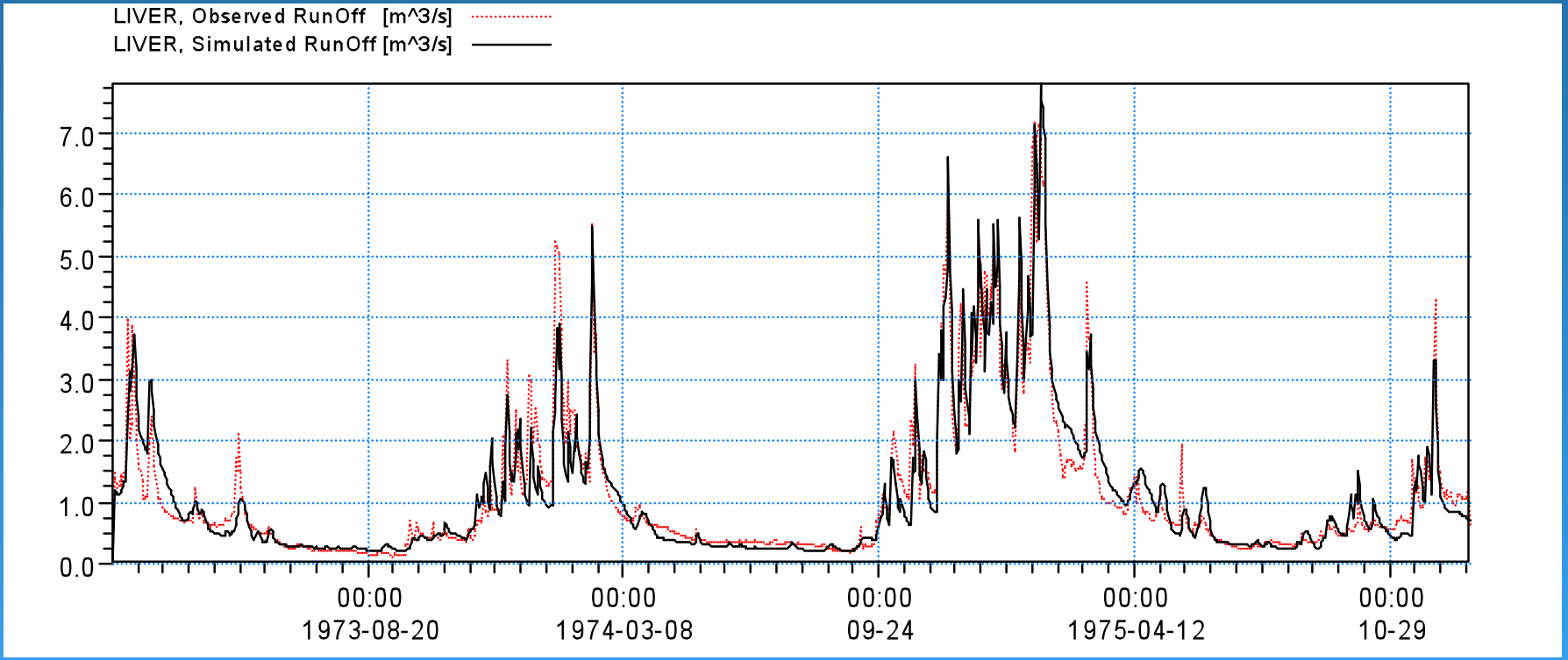
NAM rainfall-runoff model

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

Calibration objective

- 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

- 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

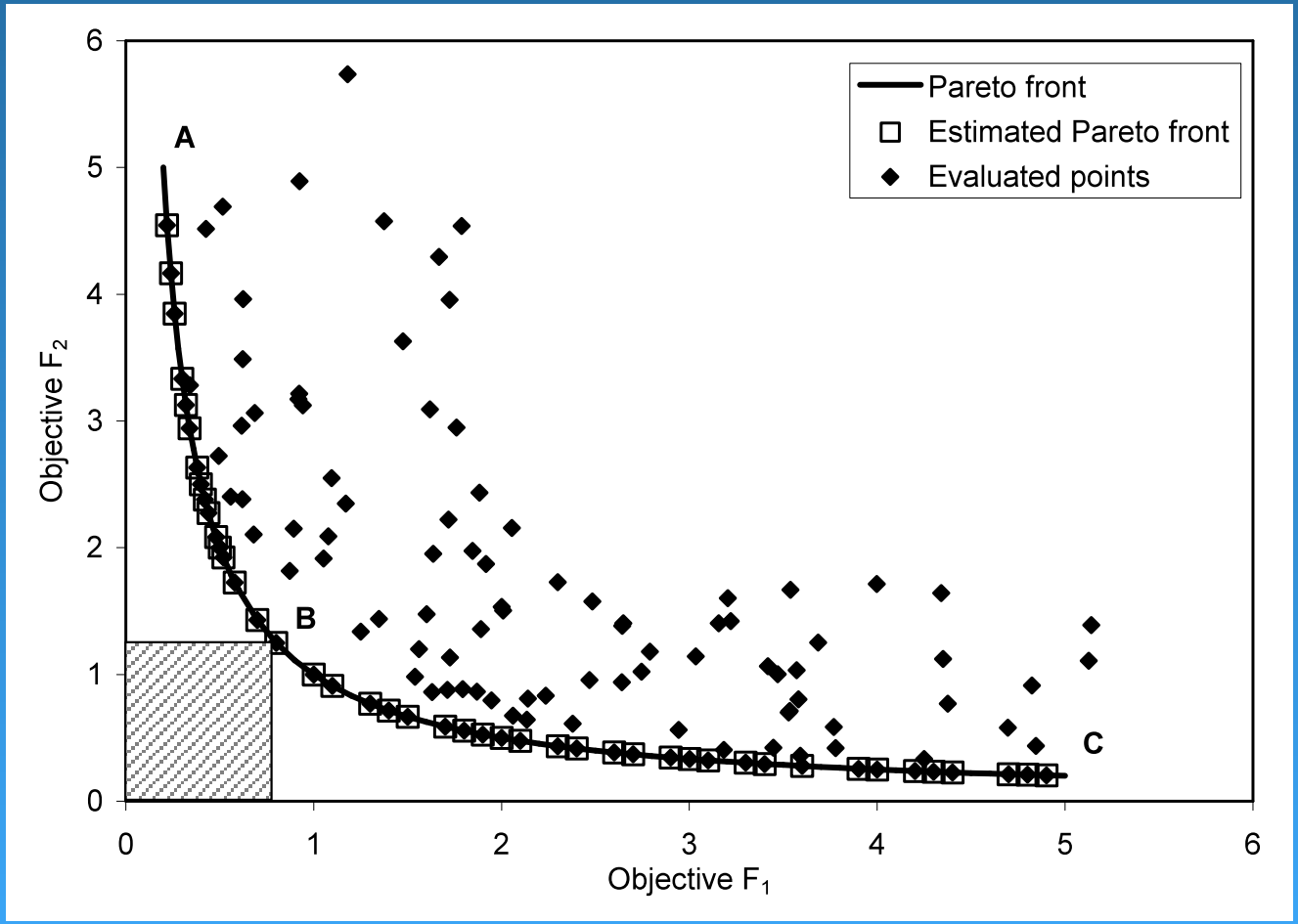
Formulation of multi-objective calibration problem

- Optimisation problem

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

- 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



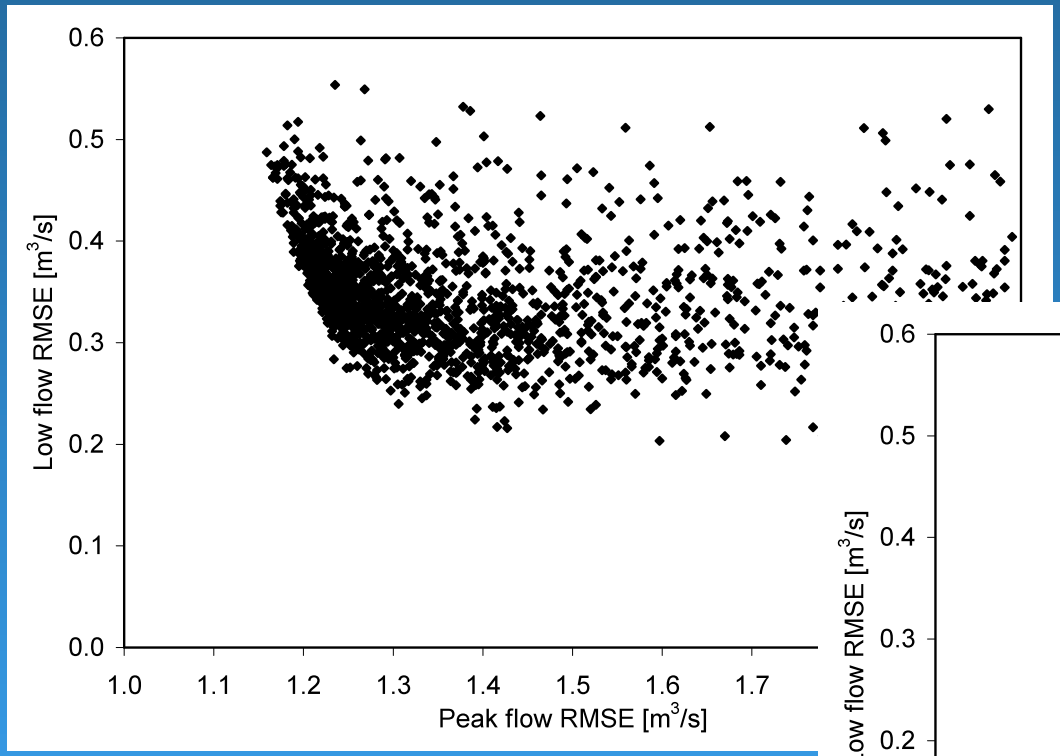
Aggregated objective function

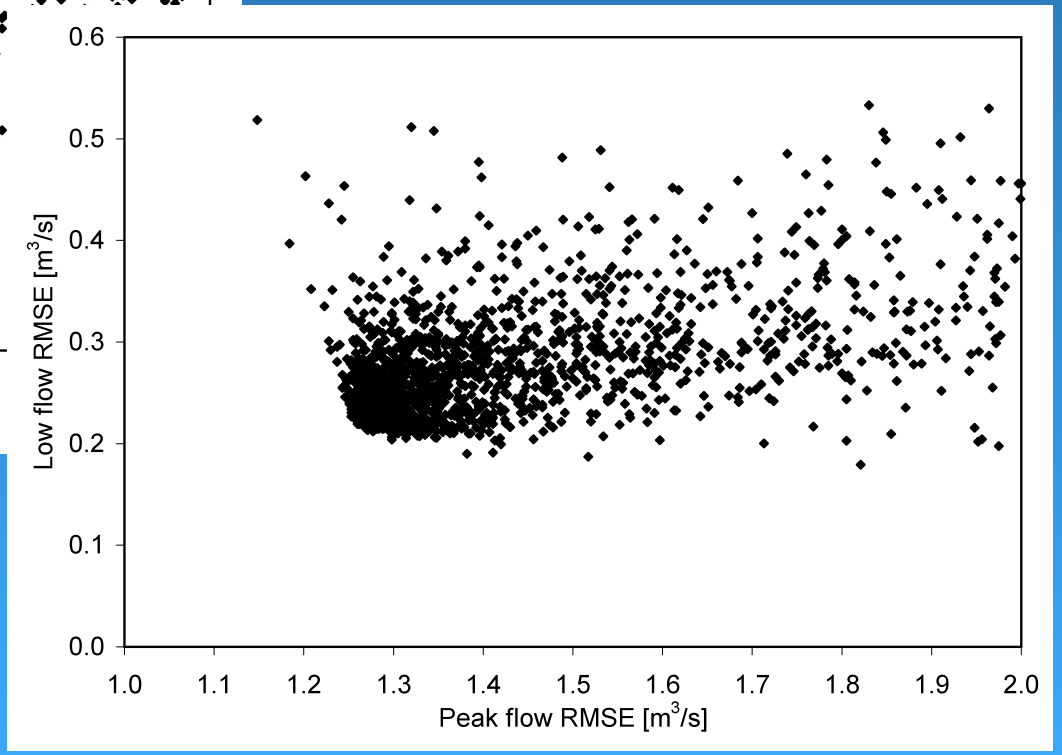
- Euclidian distance measure

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

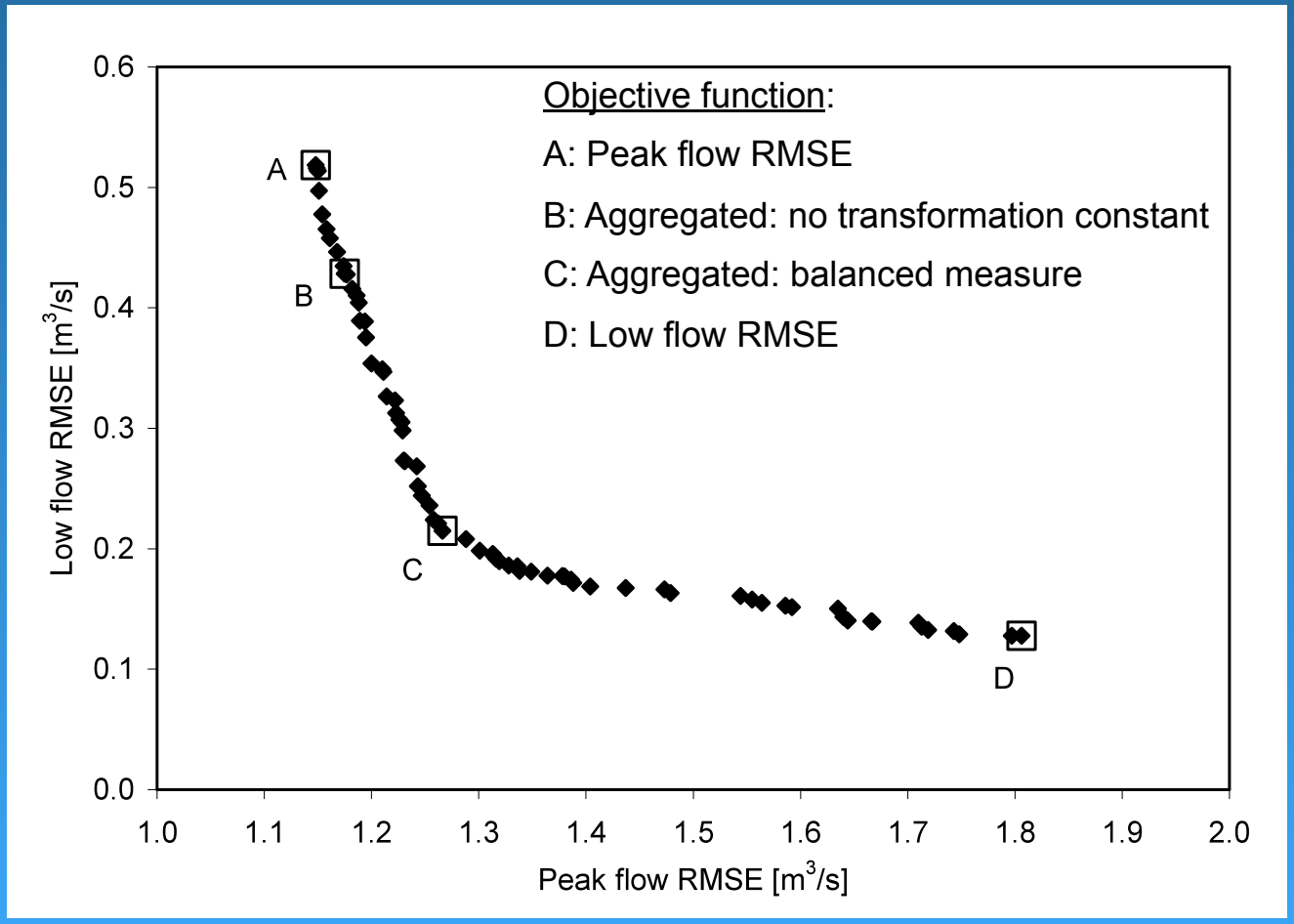
- Estimation of entire Pareto front:
  Optimisation with different transformation constants
- Estimation of single optimum:
  - User defined transformation constants
  - Balanced measure

Example of output

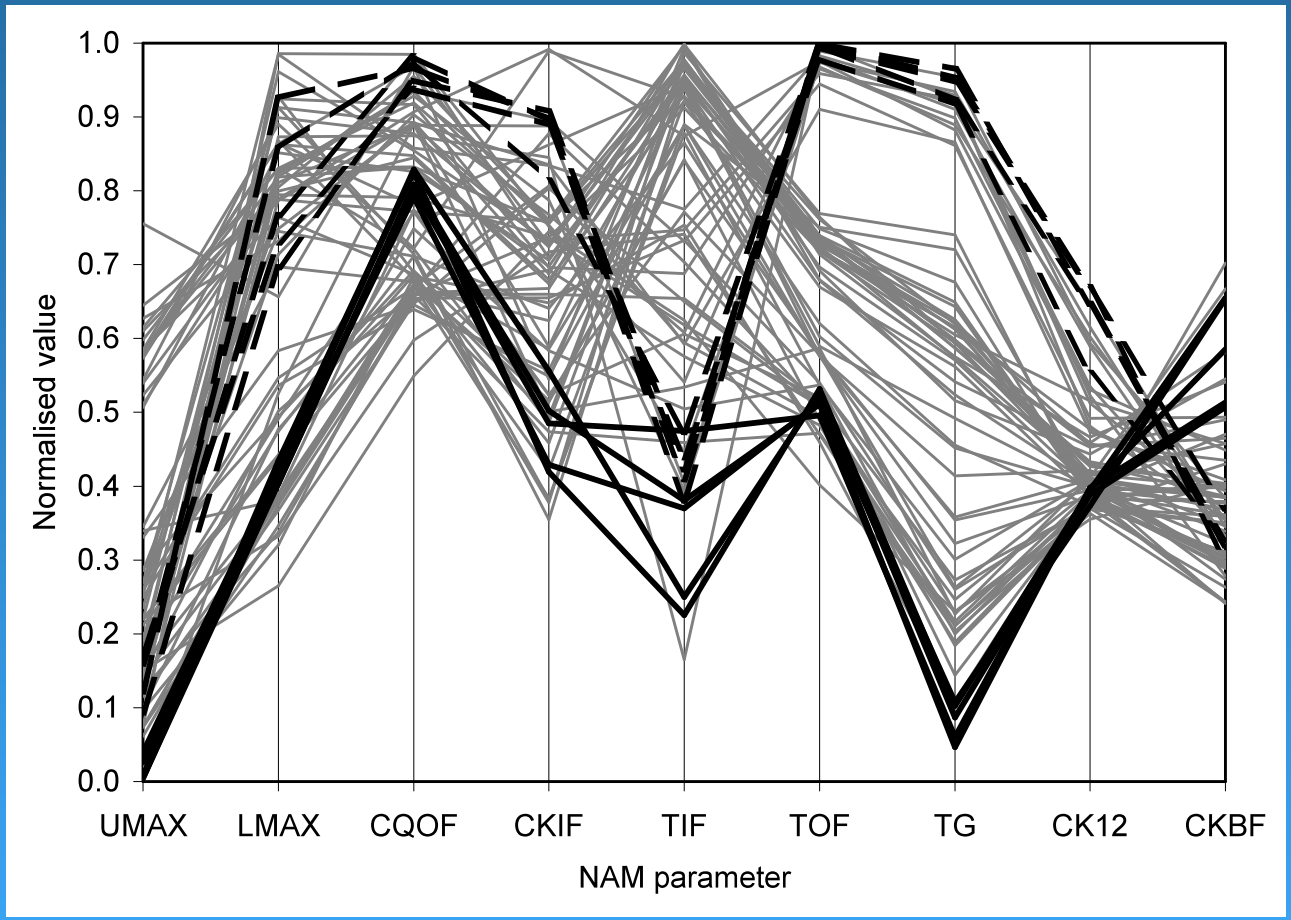




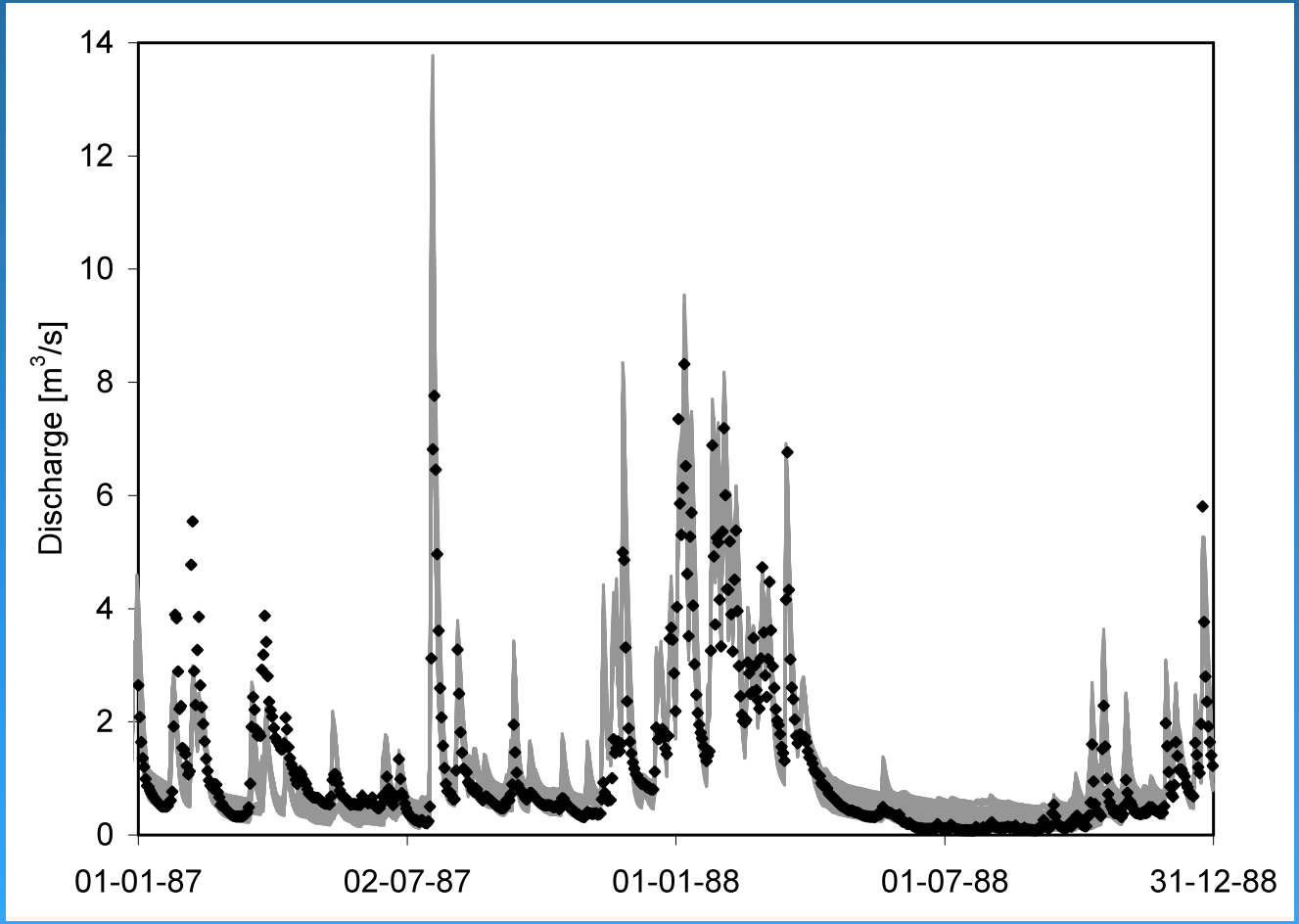
Estimated Pareto front



Range of parameter values along the Pareto front

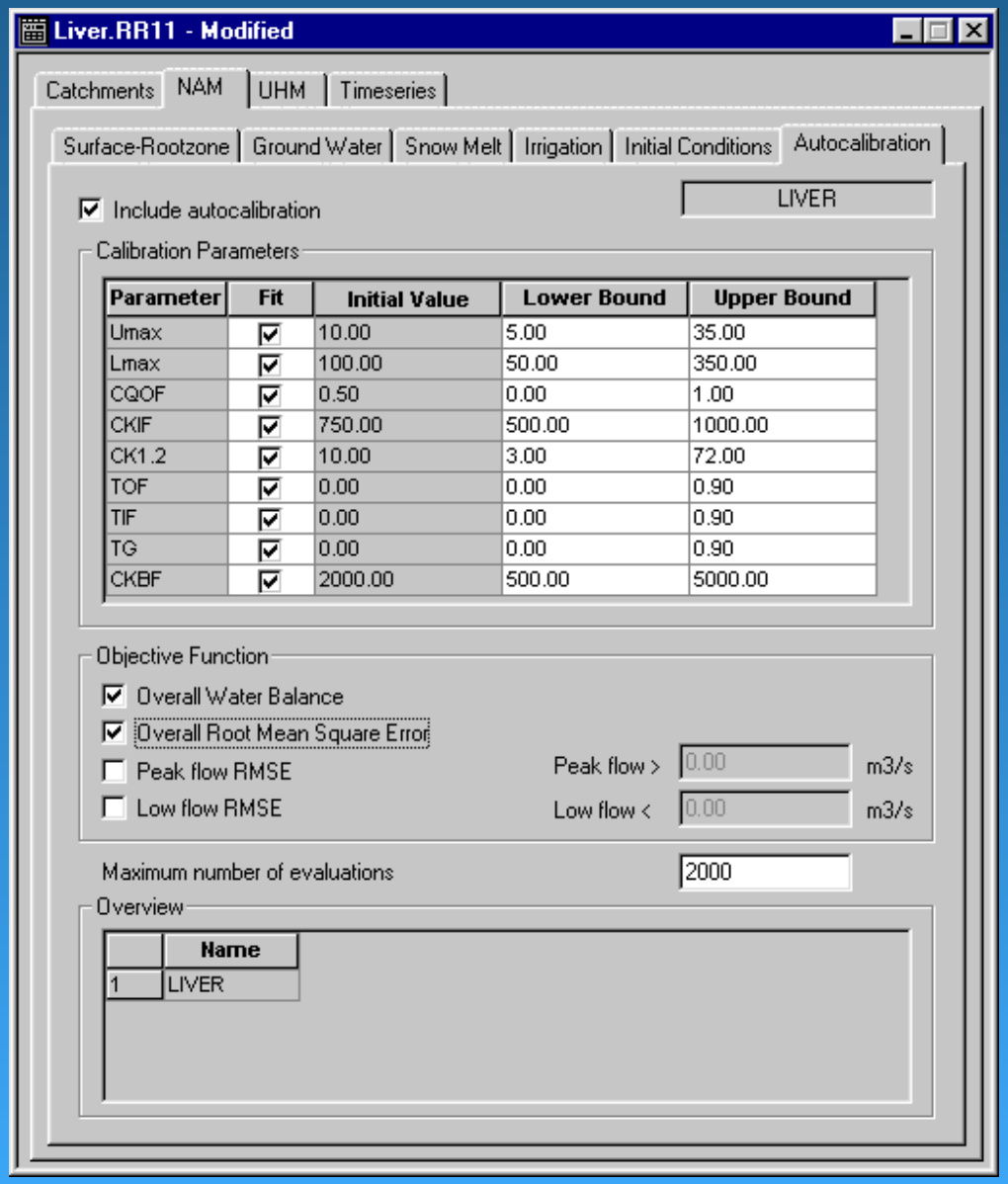


Range of simulated hydrographs along the Pareto front



Summary and conclusions

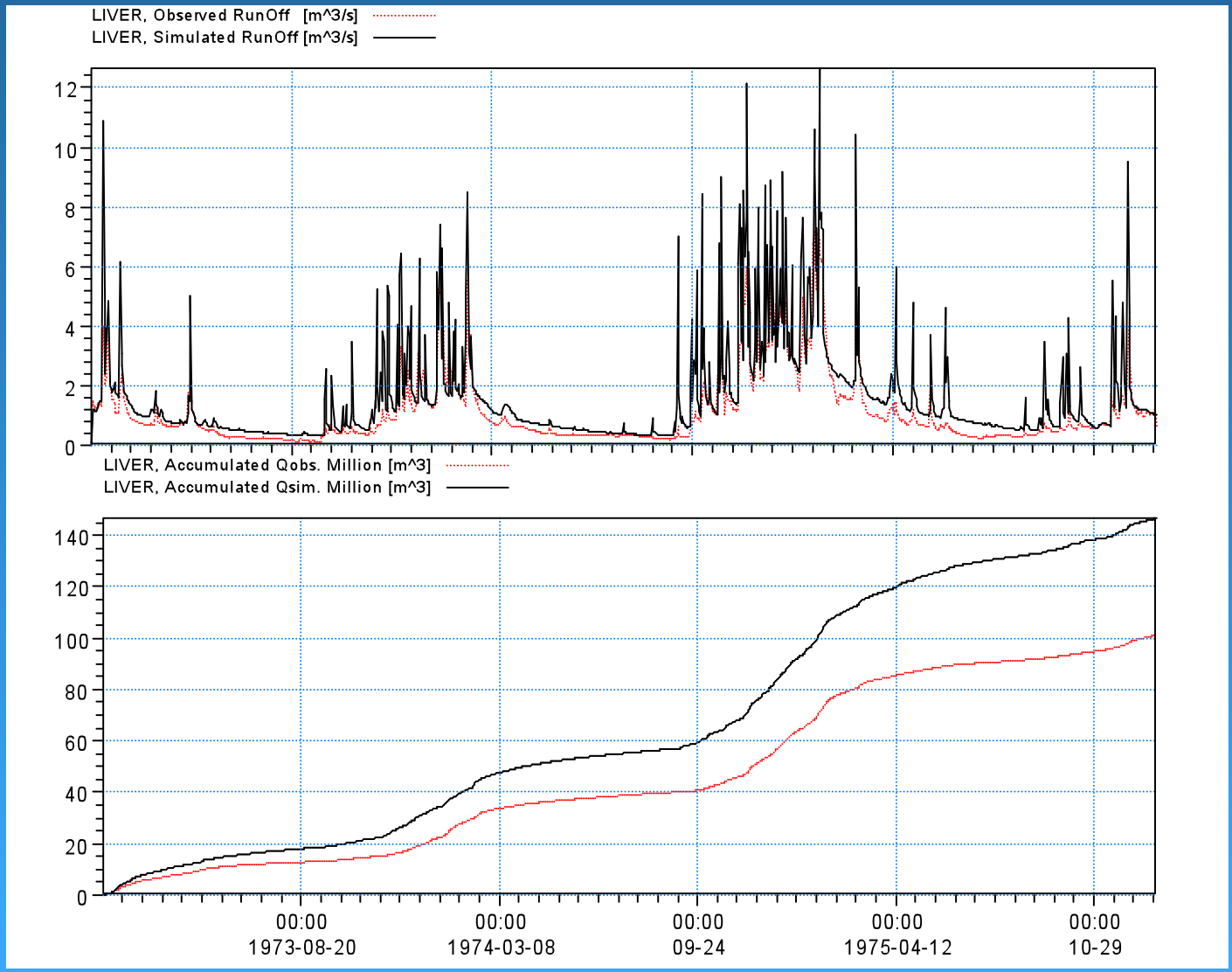
- Careful formulation of calibration objectives is important
- The calibration problem is in general multi-objective
  $\Rightarrow$ numerical performance measure should reflect various objectives
- In general, no unique optimal set of parameter values exists
  $\Rightarrow$ multi-objective equivalence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



Specifications:

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

Initial parameters



Calibrated parameters