Comparative discharge prediction from a small artificial catchment without model calibration: representation of initial hydrological catchment development

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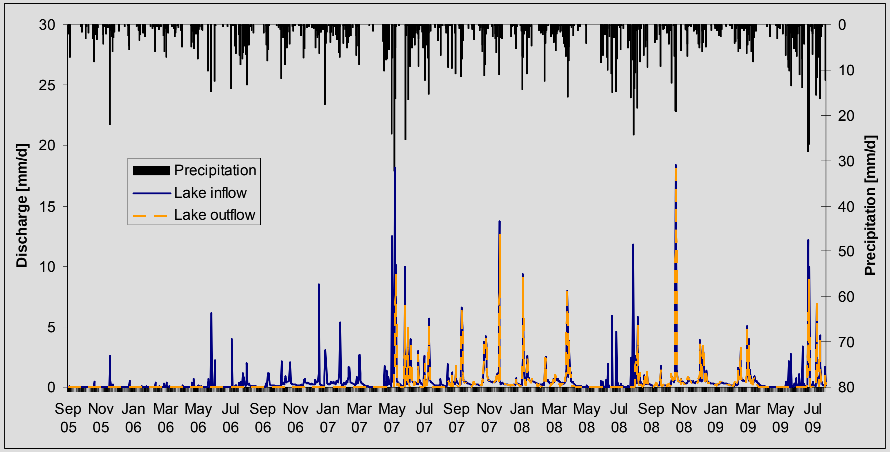
Motivation



PUB: model based prediction of water flows without any calibration

Research questions

1) Feasibility of a priori predictions applying state of the art models

2) Comparability of predictions of different hydrological models?

3) Value of additional information (soft, hard data)

Focus of this study:

- Model philosophy
- Parameterisation strategy
- Modeller('s experience, decisions)

Design of the model comparison experiment

- One artificial catchment (initial state of development)
- Observational network
- Ten modelling groups, ten different hydrological models
- Different modelling stages: starting with limited data (no calibration)

Modelling stages:

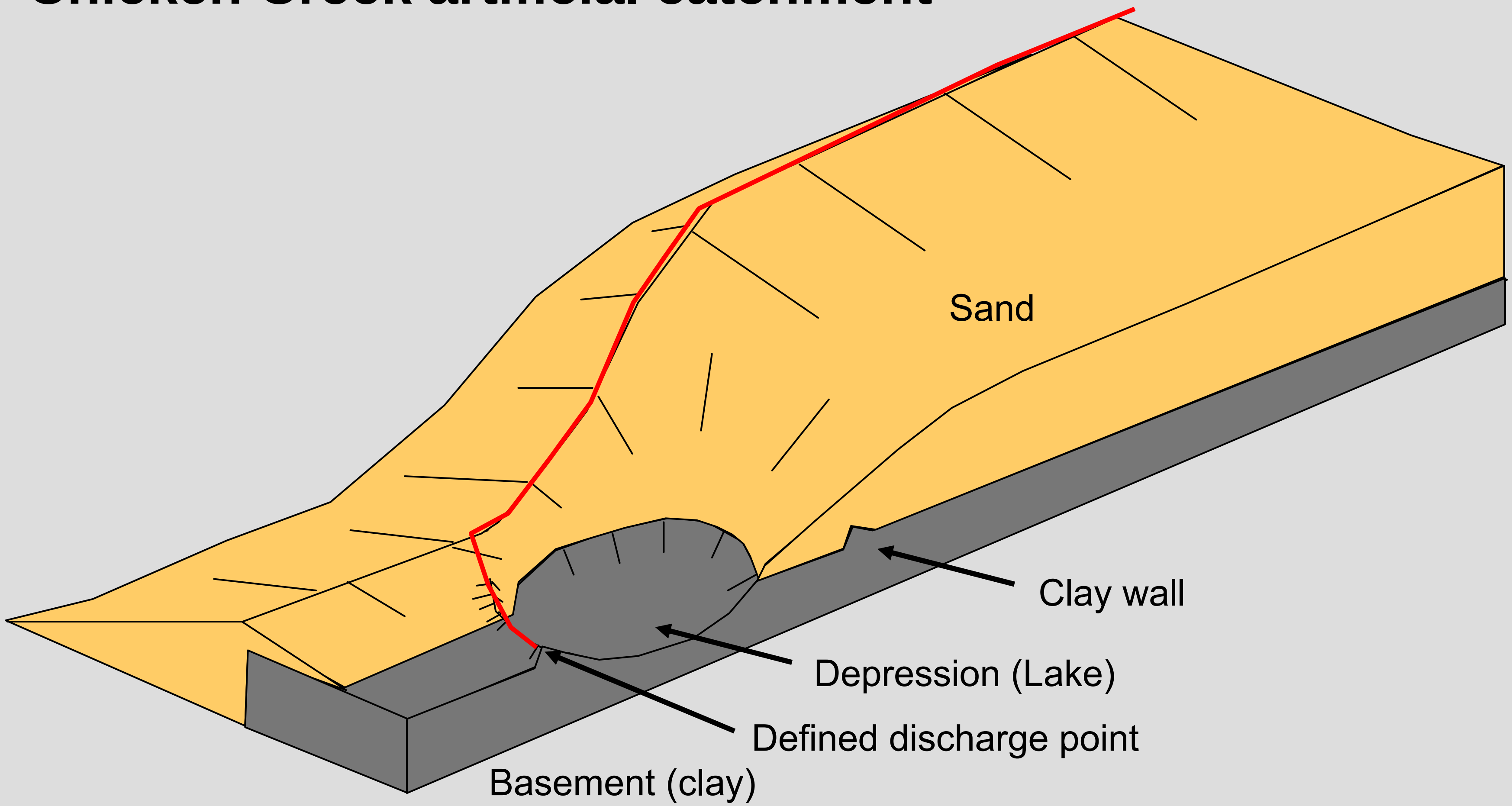
1) A priori prediction without knowing the catchment based on sparse data base
2) Prediction after having visited the catchment
3) Prediction based on additional data (Ksat, infiltration, bulk density, soil moisture)
4) Calibration based on runoff data

Boundary condition: no funding for the modeling groups

Chicken Creek artificial catchment

Lausatia, East Germany, 6 ha size, largest artificial catchment worldwide
Post mining landscape

Chicken Creek artificial catchment

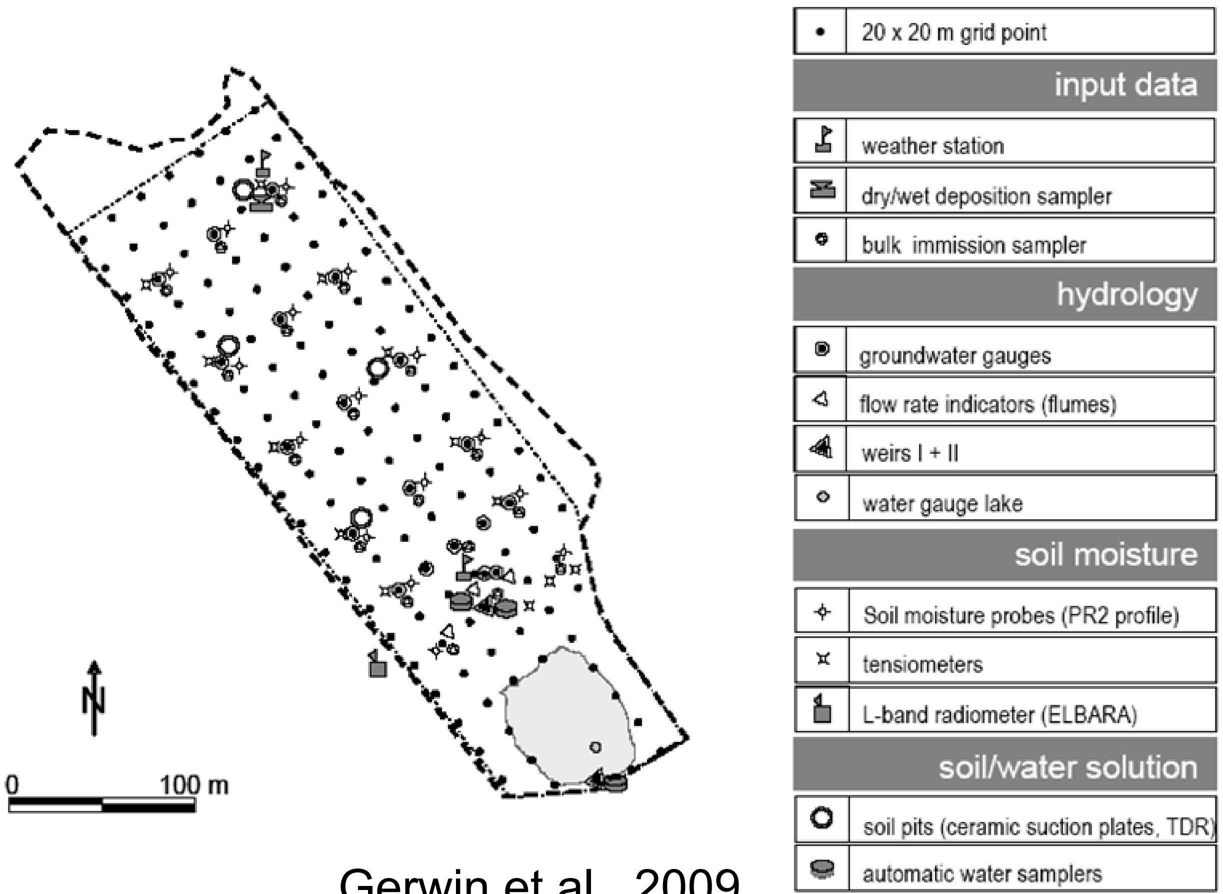


Catchment was built as an abiotic environment in an initial state: no plants, no melioration, allowing for a free ecological and hydrological development

Available data (a priori predictions):

- DEM (surface, basement, 20 m grid)
- Aerial photo
- Soil texture (20 m grid)
- Hourly weather data
- Annual information on plant coverage
- Initial groundwater levels
- Lake area

Catchment instrumentation:



Gerwin et al., 2009

Models:

Catflow,
CMF,
Coupmodel,
Hill-Vi,
GSDW,
Hydrus 2-D
NetThales,
Simulat,
SWAT,
Topmodel,
WaSiM-ETH (Richards-based),
WaSiM-ETH (Topmodel-based)

Reason for model choice?

→ Experience with the model
→ Availability of the model
→ Trust in the model

→ Predominantly process based models
→ Modellers had no experience with artificial catchments
→ Parameterisation based on data and previous model applications

Models – process representation

Model	Dimen-sion	Infiltration	Unsaturated flow	Saturated flow	Potential ET
Catflow	2D	Richards eq.	Richards eq.	Richards eq.	Penman-M.
CMF	3D	Richards eq.	Richards eq.	Darcy	Penman-M.
CoupModel	Semi3D	Darcy	Richards eq.	Hooghoudt	Penman-M.
Hill-Vi	3D	Mualem-van Genuachten	Gravity flow	Dupuit-Forchheimer	Turc
Hydrus-2D	2D	Richards eq.	Richards eq.	Richards eq.	Penman-M.
Net-Thales	3D	Rain	–	Kinematic flow	Penman-M.
SIMULAT	1D	Richards eq.	Richards eq.	Concentration time	Penman-M.
SWAT	3D	SCS	Soil function	Hooghoudt	Hargreaves
Topmodel	3D	Green-Ampt	Exp. Function	Time delay	Penman-M.
WaSiM-ETH	3D	Green-Ampt	Richards eq.	Linear storage	Penman-M.

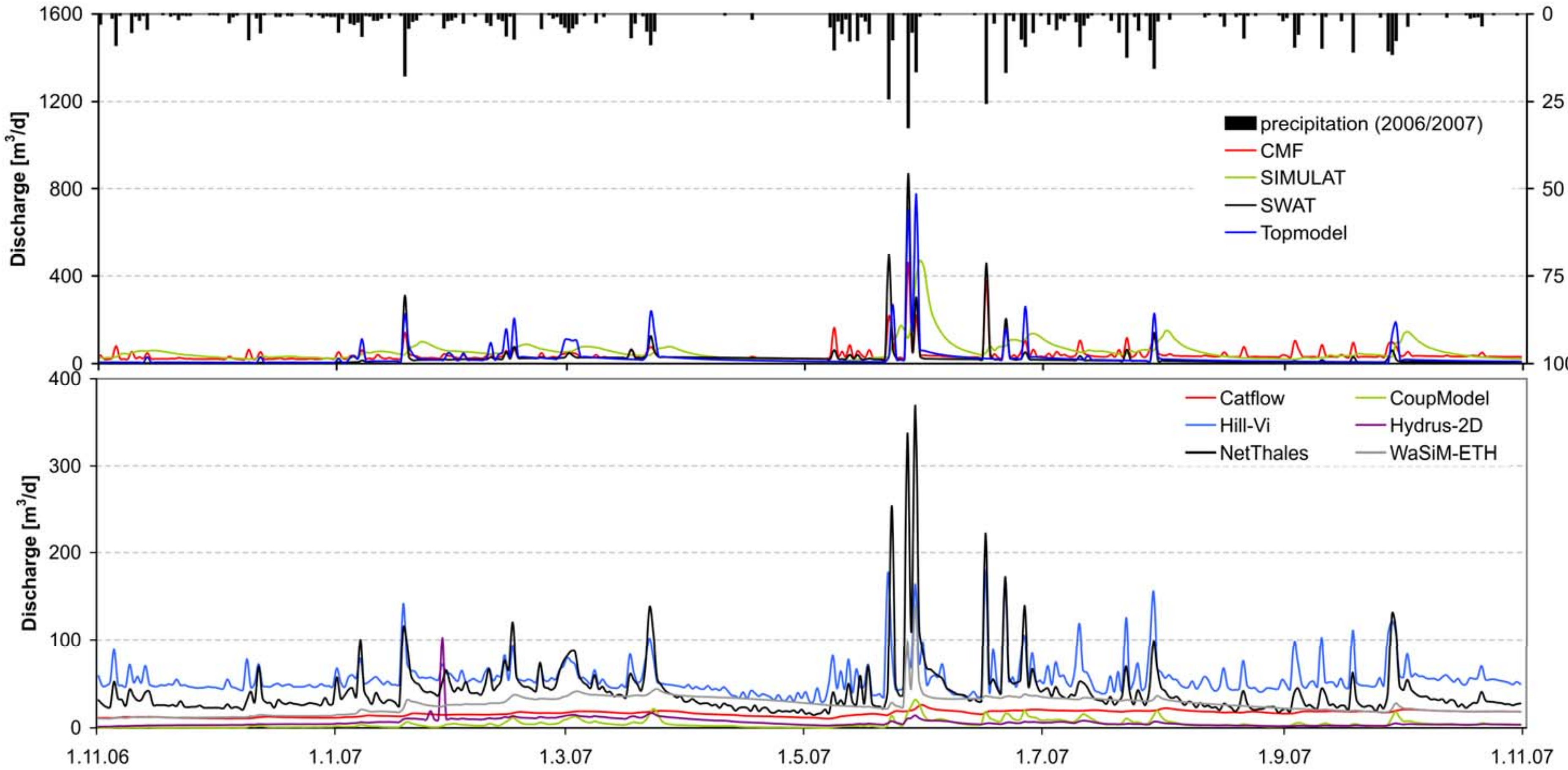
Modellers' assumptions (1st stage)

- Important processes:	infiltration, soil water flow evaporation
- Unimportant processes:	interception, transpiration (sparse vegetation), infiltration excess runoff (sandy soil), runoff routing
- Spatial representation:	topography soil depth
- Partly neglecting spatial representation:	soil properties vegetation

Model parameterisation/initialisation (1st stage)

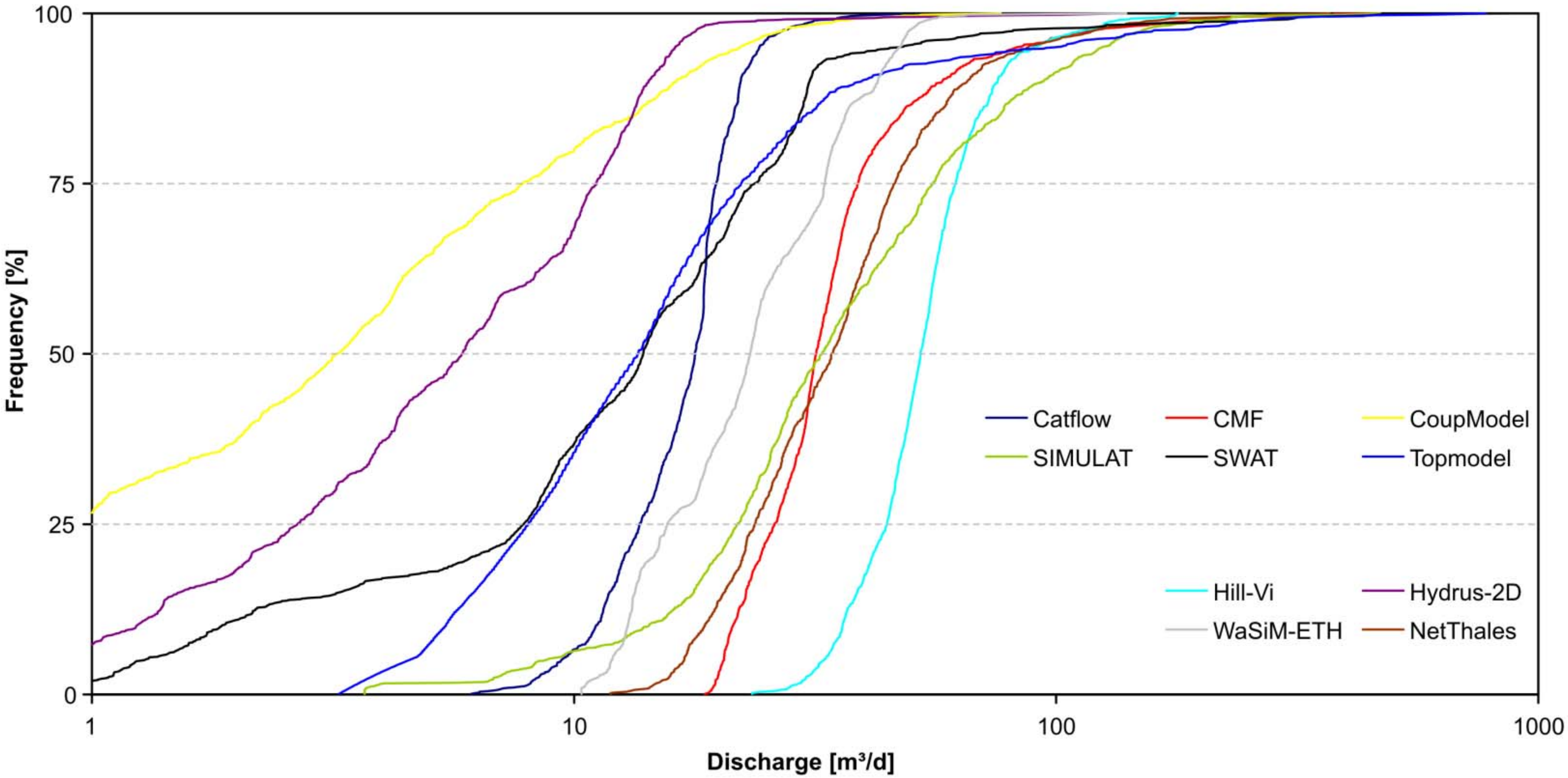
- Soil hydraulic parameters:	PTF (6 modellers) National datasets, literature (4 modellers)
- Evapotranspiration:	Previous studies Match water balance of similar environments
- Initial conditions:	Warm up period Typical values for similar environments

Model Results (1st stage)



Holländer et al., 2009, HESS

Model Results (1st stage)



Holländer et al., 2009, HESS

Evaluation of results:

- All models different (runoff generation, water balance)
- All models wrong (water balance)
- Most hydrographs baseflow dominated

Modeller's problems:

- Initial soil water content
- Soil hydraulic properties (hydraulic conductivity, porosity)

- Wrong assumptions (process understanding) based on available data

Field visit (2nd stage):



Revised process understanding:

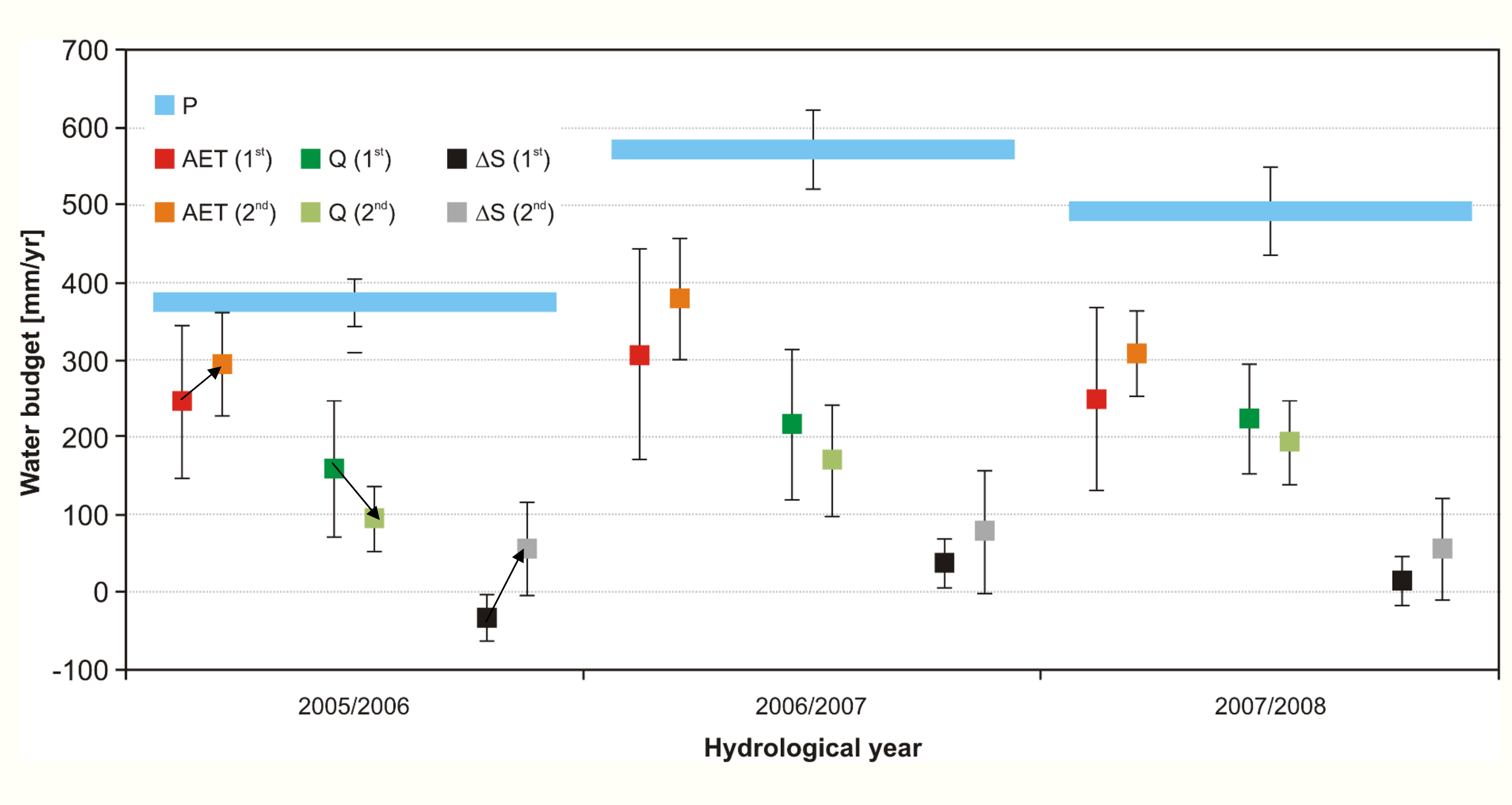
- Importance of surface runoff (gullies, soil crusting)
- Importance of the clay wall (subsurface water storage)
- Increasing importance of vegetation

Model revision for 2nd stage

- Changes in parameterisation (soils, plants, subsurface)
- Partly changes in model structure (key processes not represented)
- Reduction of initial water storage

Catchment more heterogeneous than expected…
- spatial distributed soil, plant properties

Results (2nd stage)



Chirico et al., 2010, EGU; changed

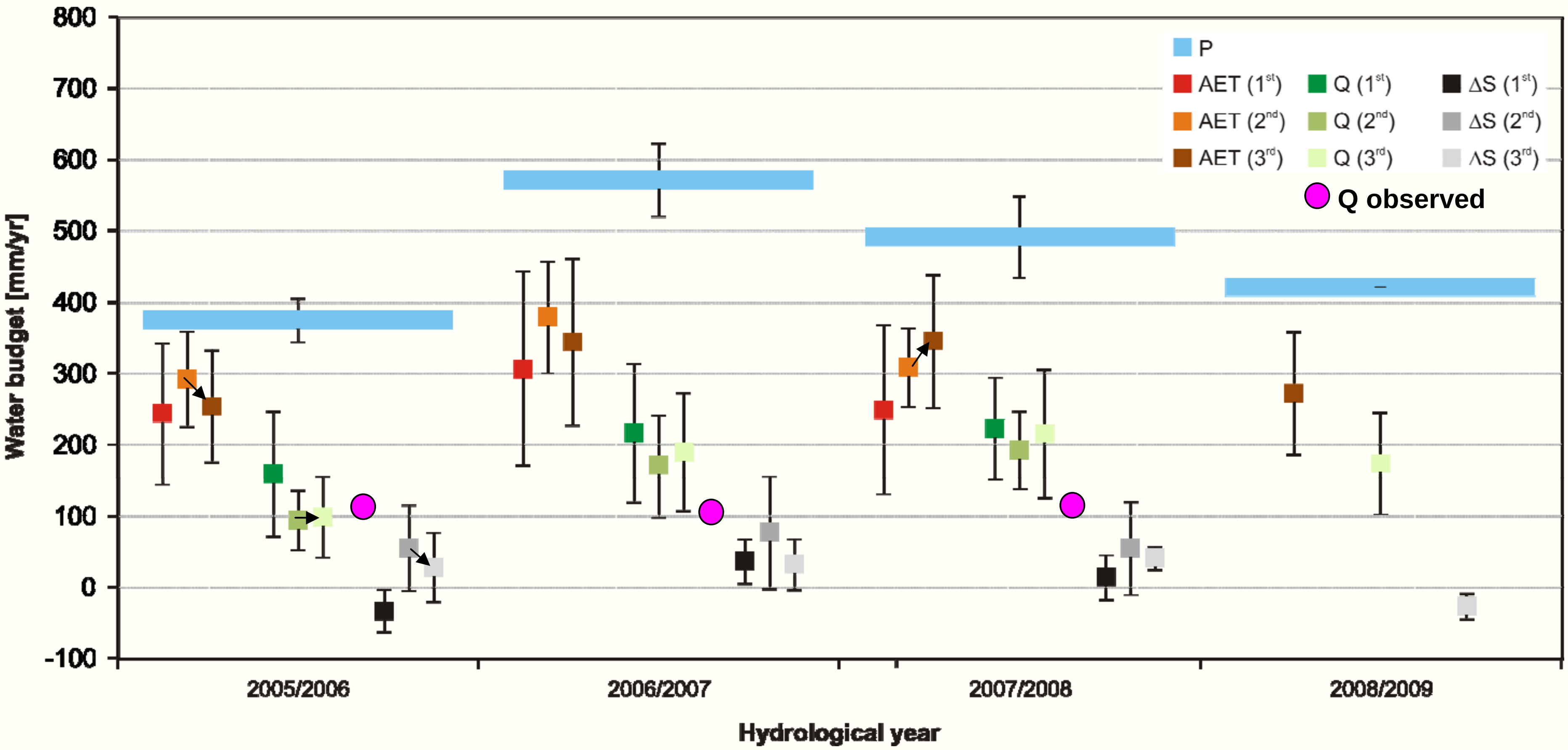
Additional data (3rd stage)

- Measurements on bulk density
- Measurements on Ksat
- Measurements on infiltration capacity
- Soil moisture measurements (4 soil pits)

→ Revision of parameterisation (soil)
→ Confirmation of revised process understanding

→ calibration/validation against point scale state variables

Results 3rd stage (preliminary: 6 models)



(Wrong) Simulated fluxes confirmed, but still large variability among models

Conclusions

→ A priori model application results in huge variability in simulations (model philosophy + parameterisation + modeller)

→ Soft information (field visit) is valuable (*necessary*) information for improving process understanding (decreasing variability among models)

→ Hard data useful for parameterisation and calibration

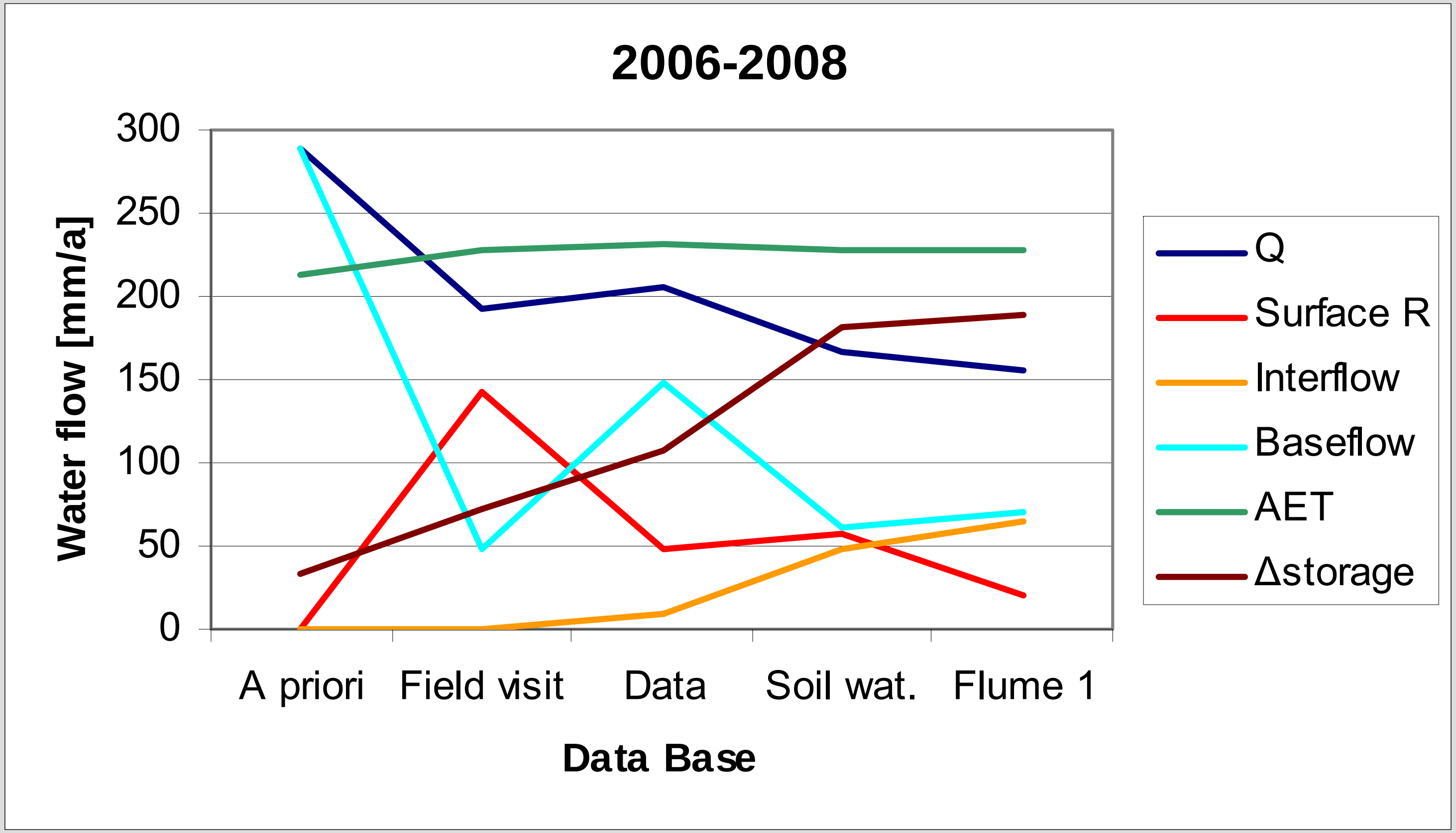
→ Difficulties under non-stationary conditions (esp. initial conditions)

→ Modeller's decisions seem to be as important as choice of the model

→ Further modelling stages in progress: benefit from further data (groundwater dynamics, runoff events)

Outlook

→ All modelling stages finished for one model
→ Intercomparison expected for end of September 2010



Thanks to all modellers / co-authors!
Thank you for your attention!