Instituto de Ingeniería del
Agua y Medio Ambiente

Importance of the spatial heterogeneity in the non-linear response of a small Mediterranean catchment

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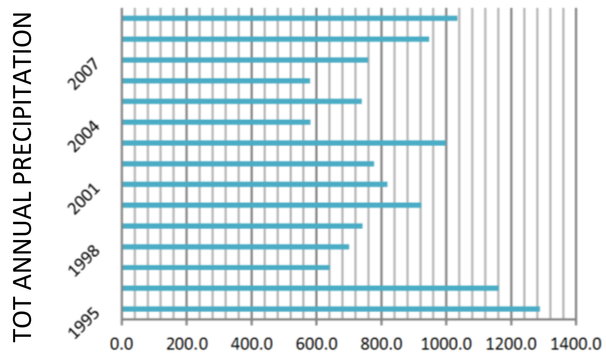
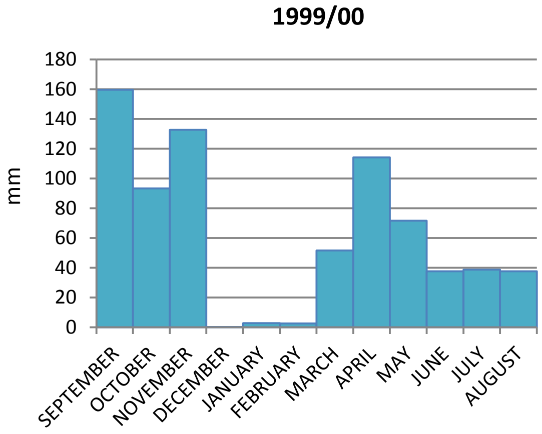
INTRODUCTION

- ❑ Mediterranean basins
- ❑ Non-linear hydrological behaviour

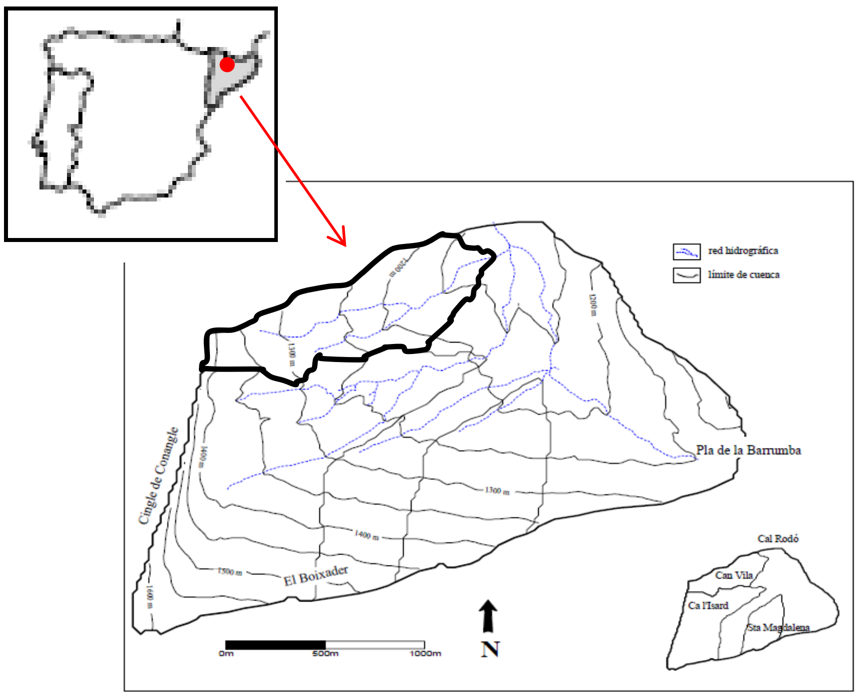
Large inter- and intra-annual precipitation variability





STUDY AREA

❑ ***Can Vila*** catchment:



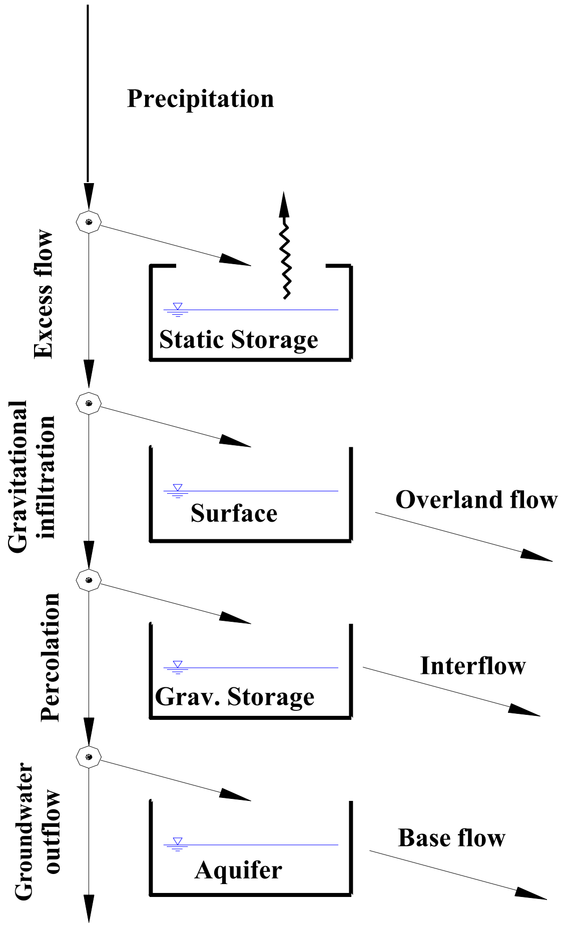
- ✓ Experimental catchment
- ✓ Area: 0.56 km^2
- ✓ Silt-loam soil
- ✓ Soil thickness: 0.15-3.0 m

INTRODUCTION

❑ ***Research questions:***

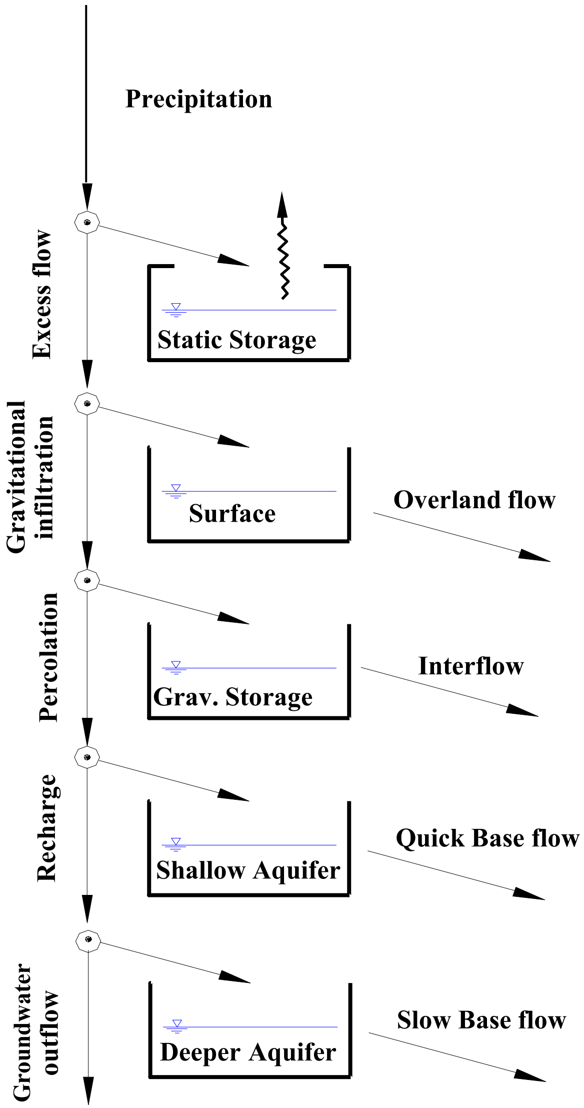
1. Can we reproduce its hydrological behaviour with a ***simple lumped model*** based on few parameters?
2. If not, it is because a ***non-linear mechanism is missing*** into the model conceptual scheme or it is because we are not taking into account the ***catchment spatial heterogeneity***?
3. Which is the most suitable approach, ***lumped or distributed***, to simulate the discharge at the outlet of the study case considered?

HYDROLOGICAL MODELS



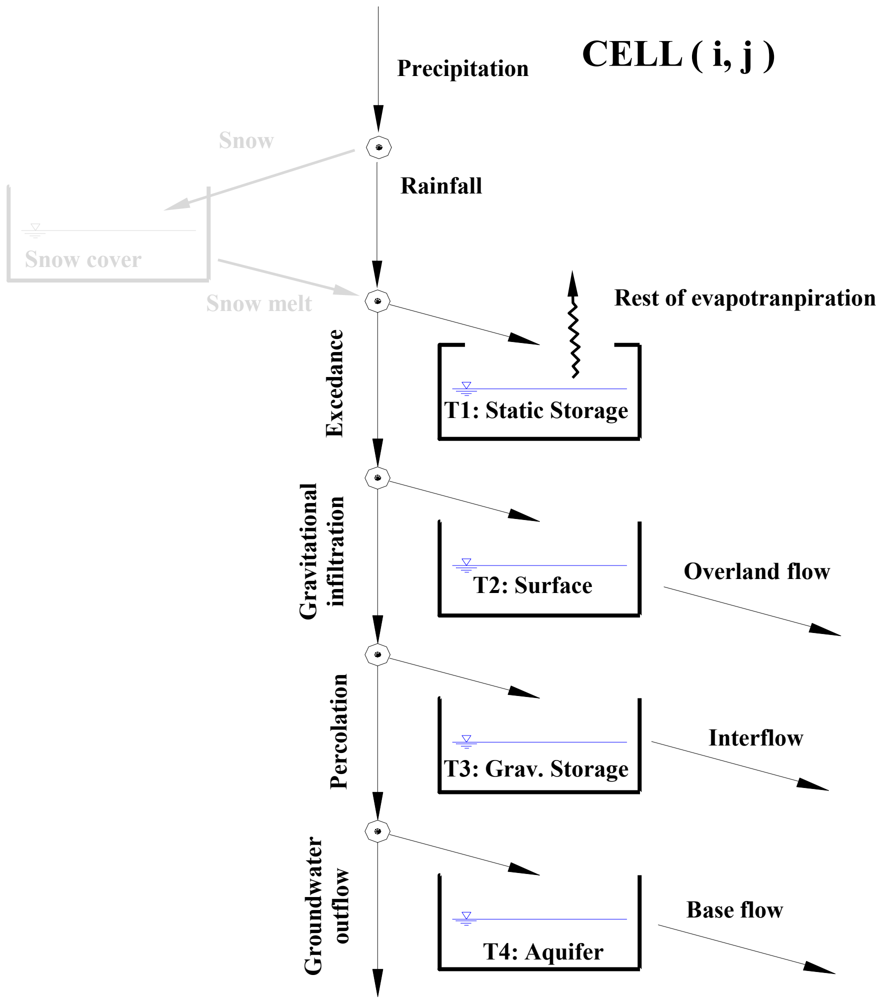
- ✓ **LU3 – LUMPED MODEL**
- ✓ **6 parameters** to be calibrated
- ✓ 3 catchment hydrological responses
- ✓ Linear tanks

HYDROLOGICAL MODELS



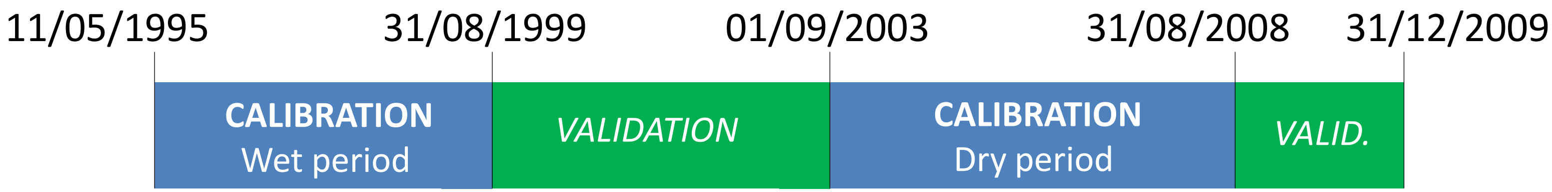
- ✓ **LU4 – LUMPED MODEL**
- ✓ **8 parameters** to be calibrated
- ✓ 4 catchment hydrological responses
- ✓ Linear tanks
- ✓ **Non-linear recharge** to the permanent saturated zone

HYDROLOGICAL MODELS



- ✓ **TETIS – DISTRIBUTED CONCEPTUAL MODEL**
- ✓ **8 correction factors** to be calibrated
- ✓ Several soil-related parameter maps to be estimated
- ✓ 3 catchment hydrological responses
- ✓ Linear tanks

CALIBRATION & VALIDATION



Nash-Sutcliffe efficiency index

$$E = 1 - \frac{\sum_1^n (X_{sim} - X_{obs})^2}{\sum_1^n (X_{obs} - \overline{X_{obs}})^2}$$

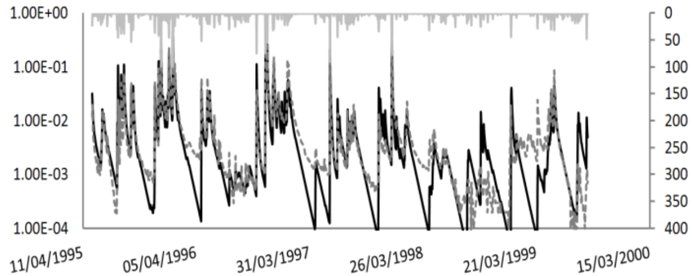
Volume error

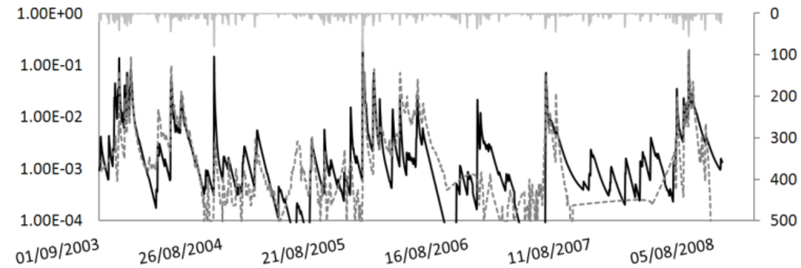
$$V = \frac{\sum_1^n (X_{sim} - X_{obs})}{\sum_1^n X_{obs}}$$

CALIBRATION RESULTS:

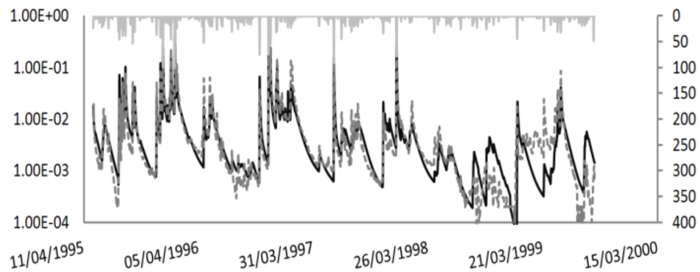
WET PERIOD | DRY PERIOD

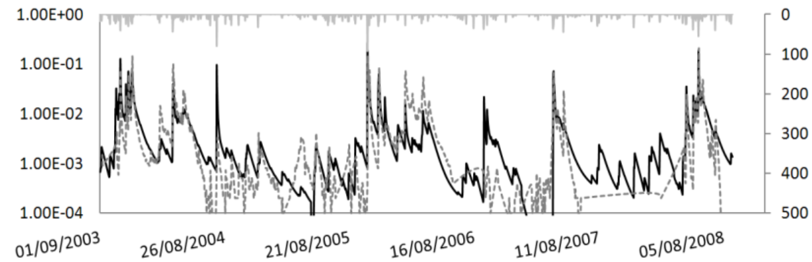
LU3



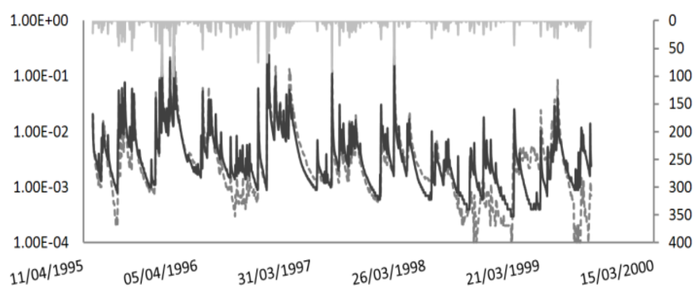


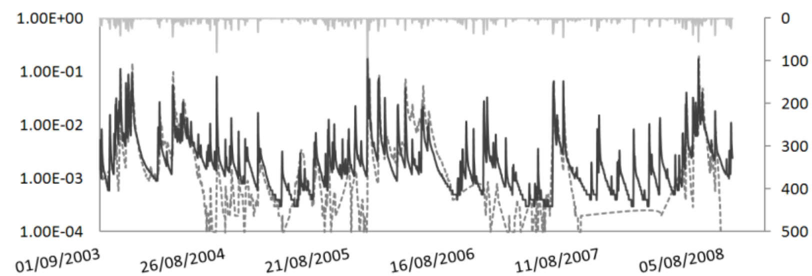
LU4



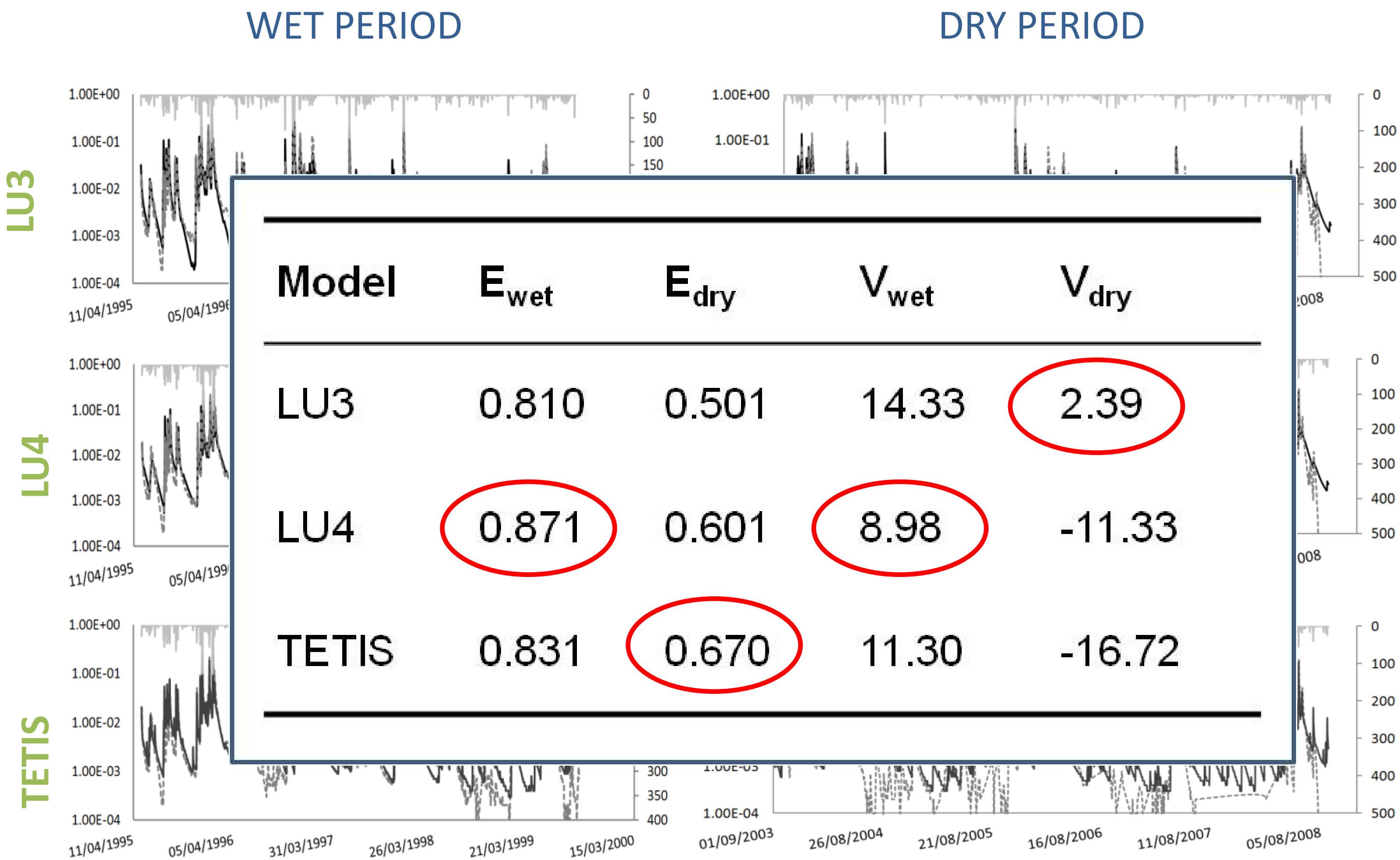


TETIS





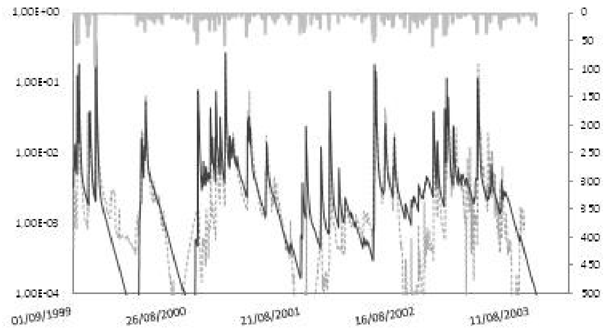
CALIBRATION RESULTS:

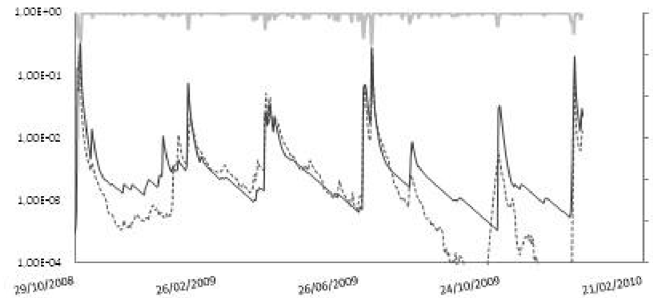


Model	E_{wet}	E_{dry}	V_{wet}	V_{dry}
LU3	0.810	0.501	14.33	2.39
LU4	0.871	0.601	8.98	-11.33
TETIS	0.831	0.670	11.30	-16.72

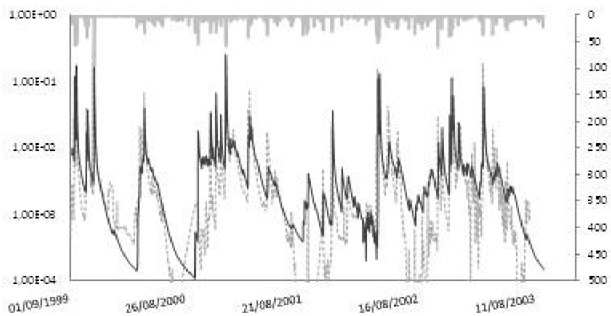
VALIDATION RESULTS

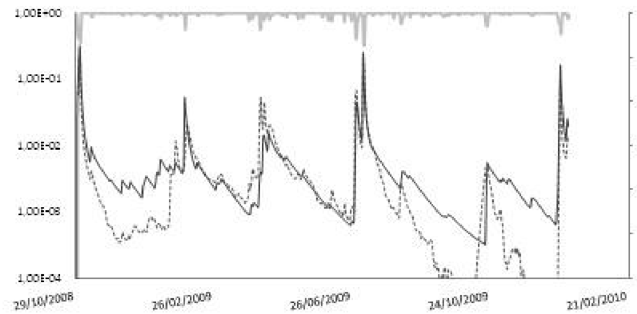
LU3



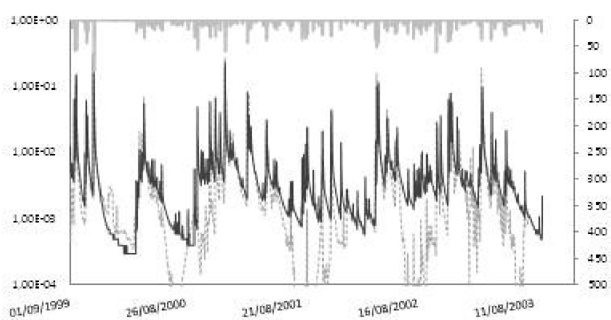


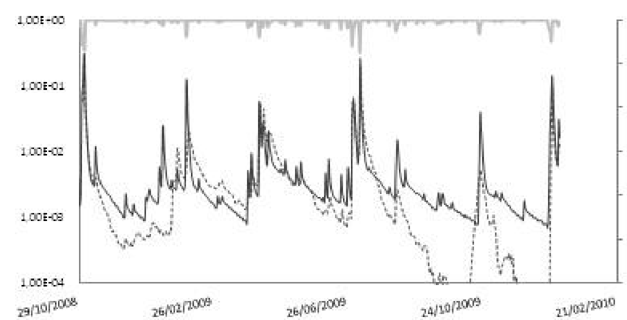
LU4





TETIS



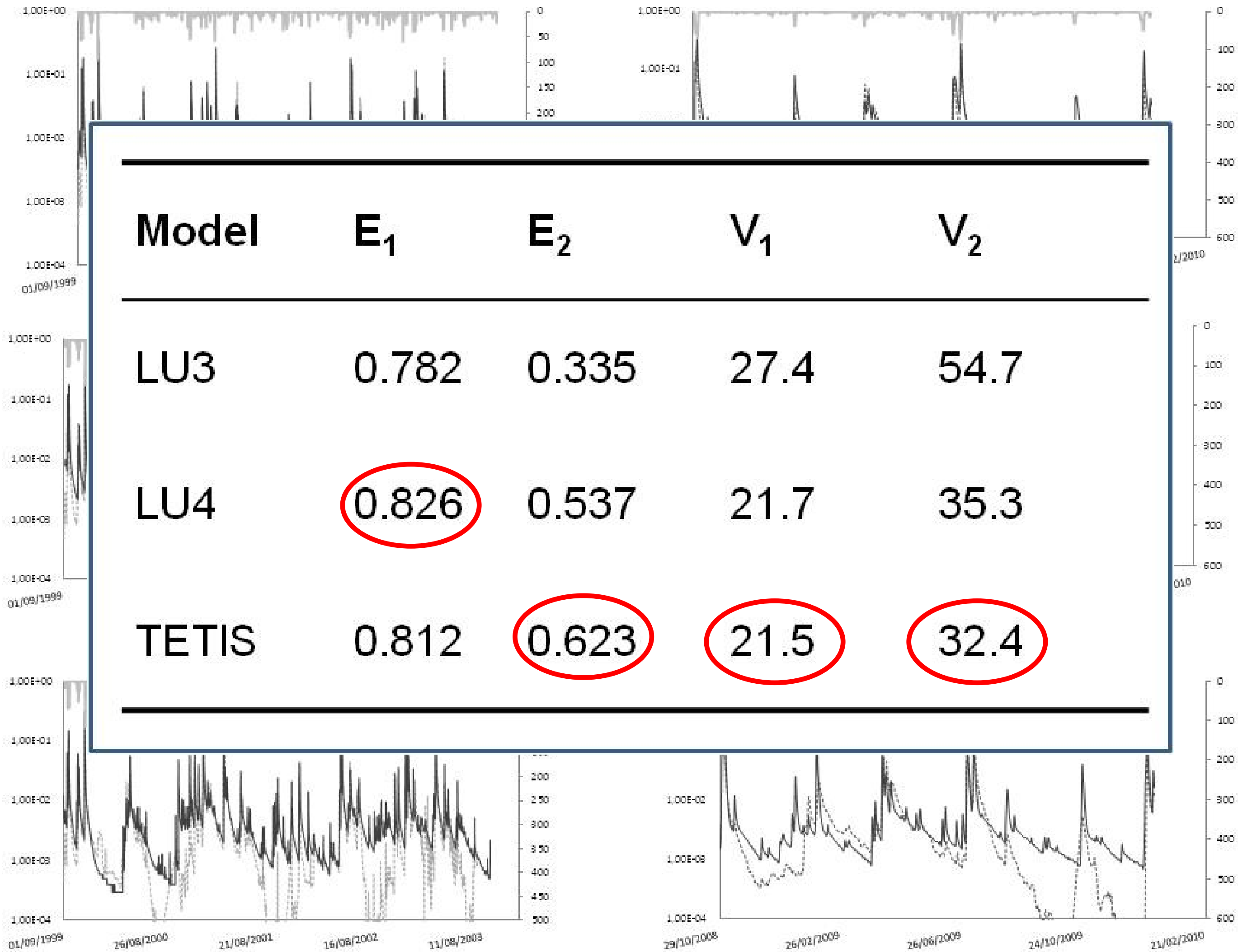


VALIDATION RESULTS

LU3

LU4

TETIS

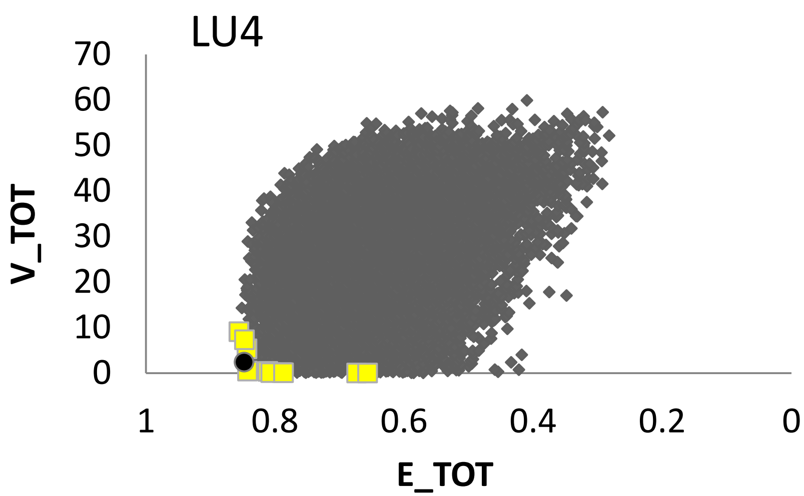


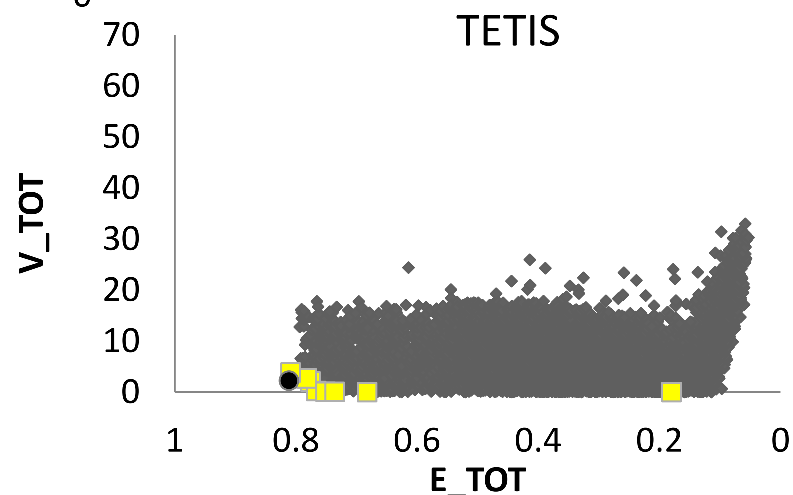
Model	E_1	E_2	V_1	V_2
LU3	0.782	0.335	27.4	54.7
LU4	0.826	0.537	21.7	35.3
TETIS	0.812	0.623	21.5	32.4

PARETO FRONTIER ANALYSIS

- ✓ 10.000 Monte Carlo (MC) simulations
- ✓ Parameters values were sampled randomly by UNIFORM distributions

PARETO FRONTIER

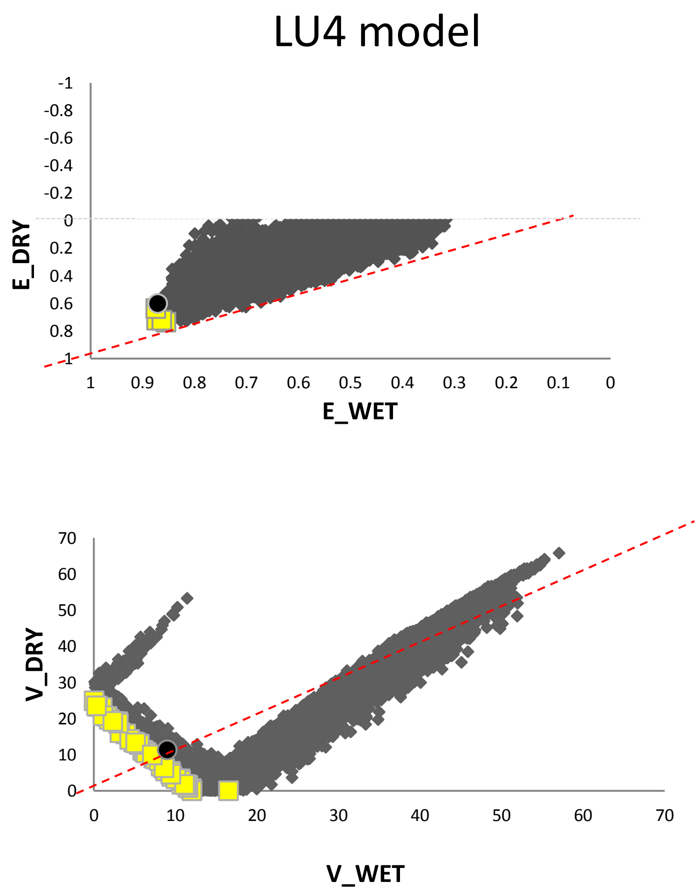


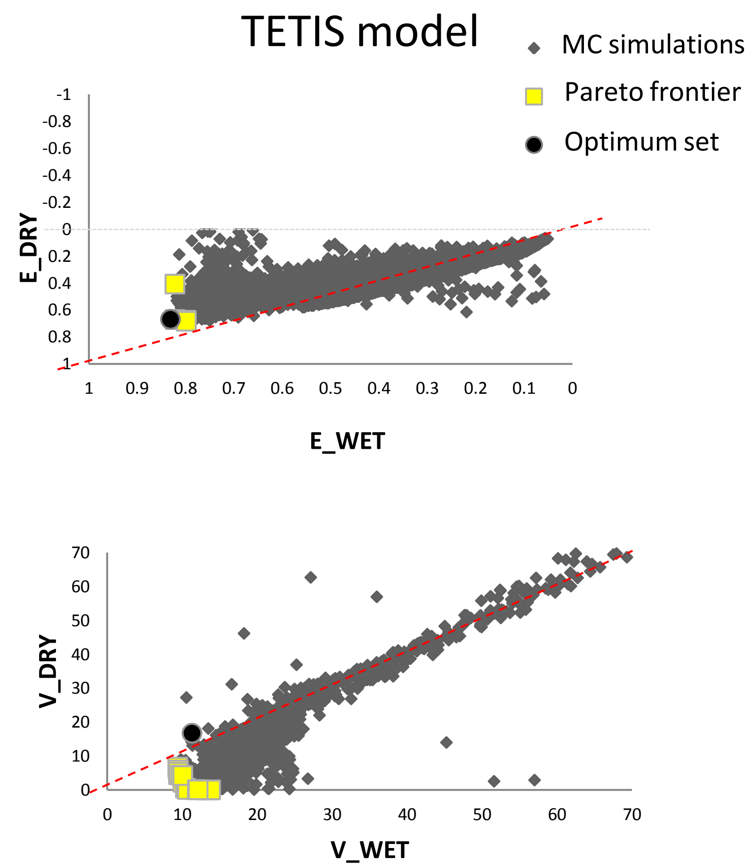


E_{TOT} : Nash index

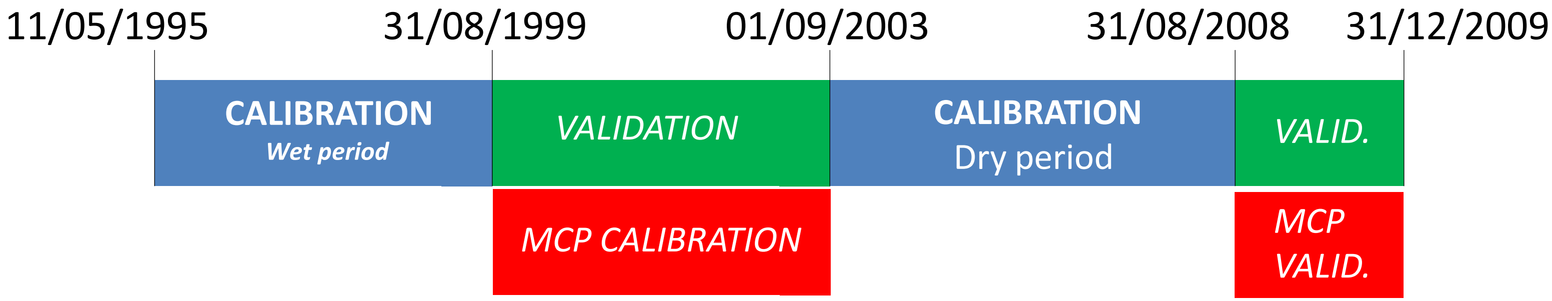
V_{TOT} : Volume Error

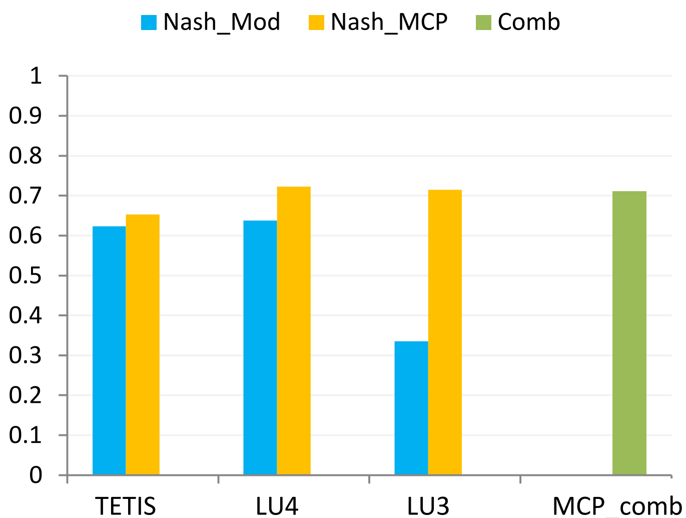
PARETO FRONTIER

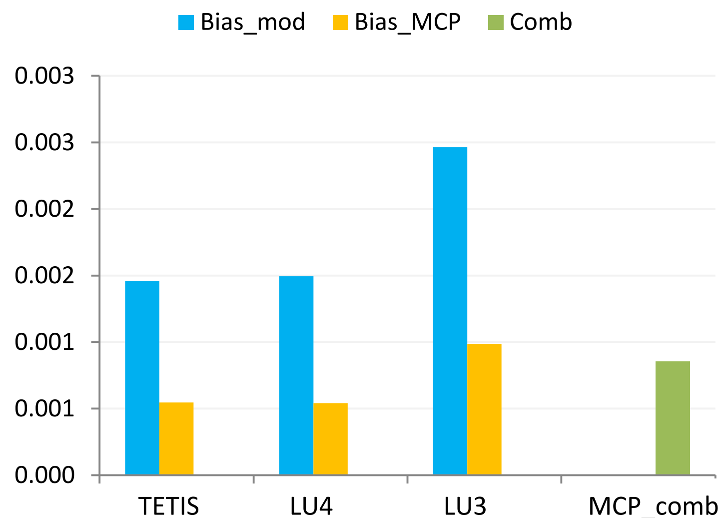




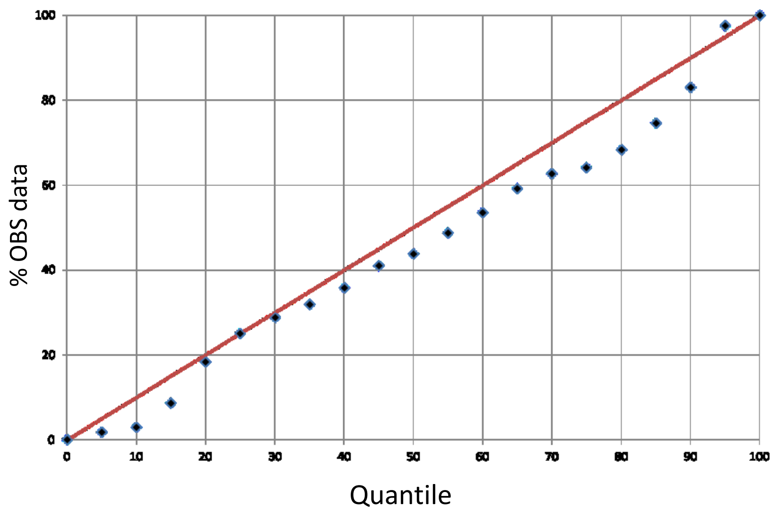
MCP ANALYSIS

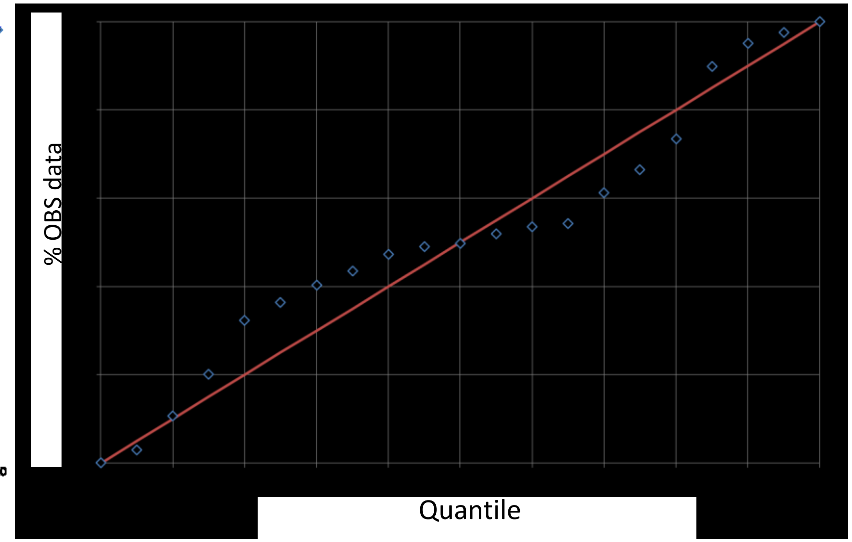


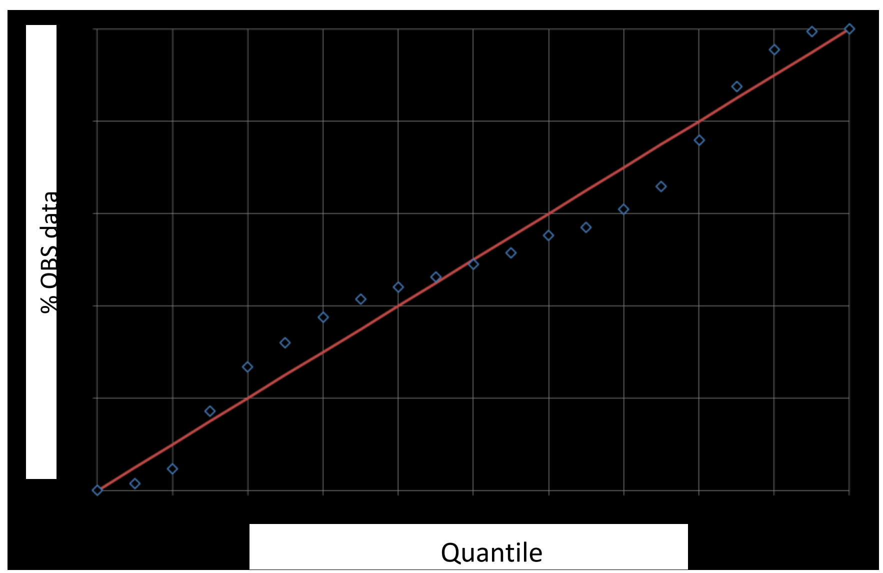




MCP ANALYSIS - RELIABILITY







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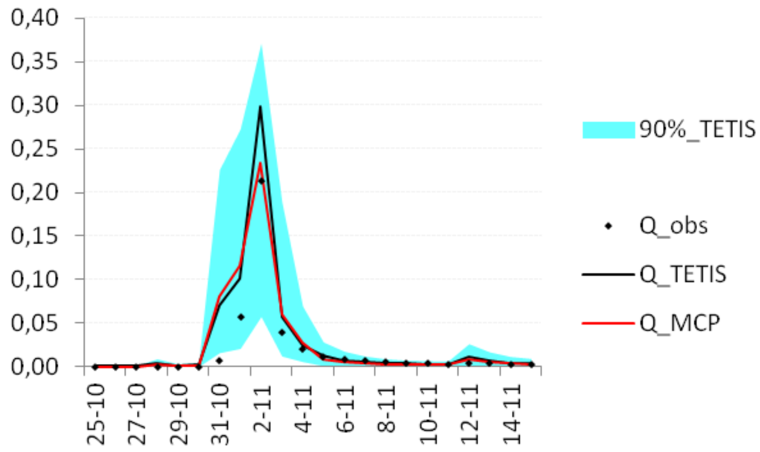
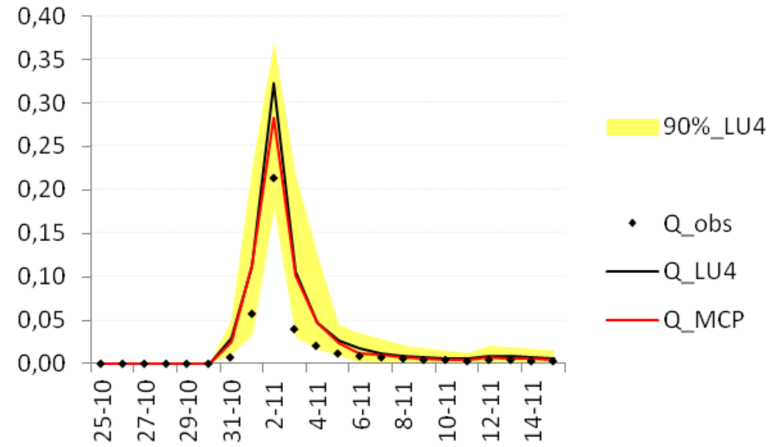
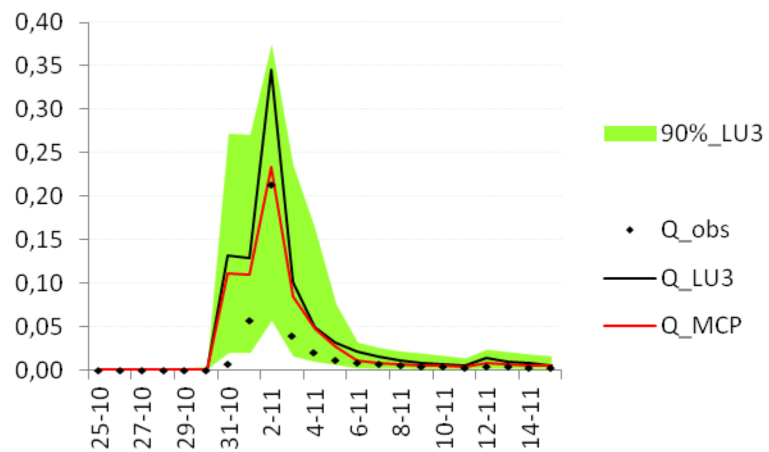
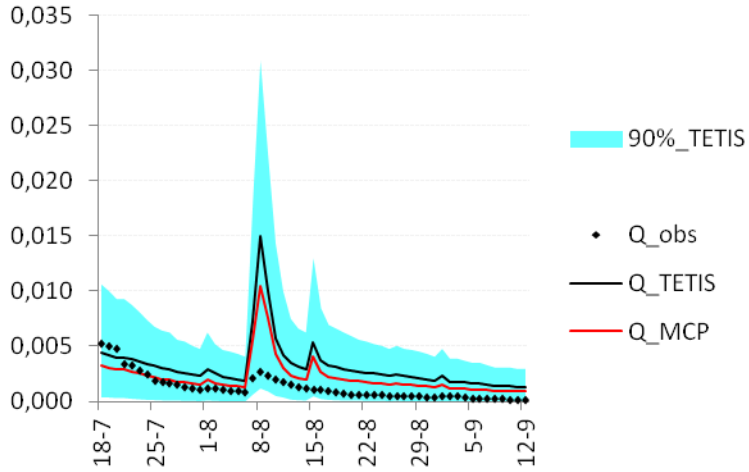
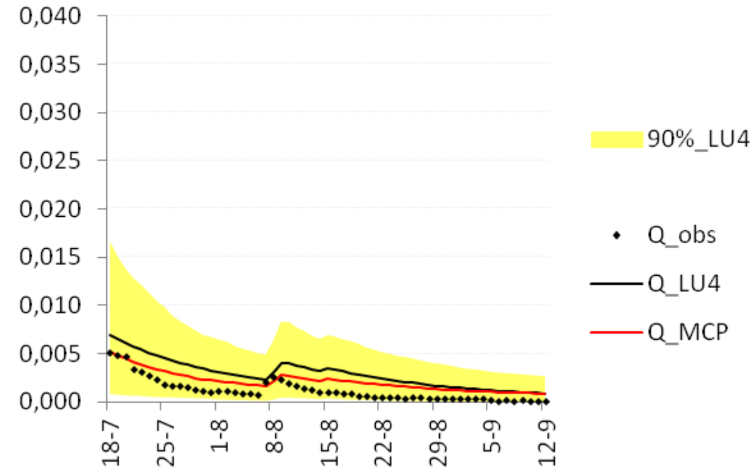


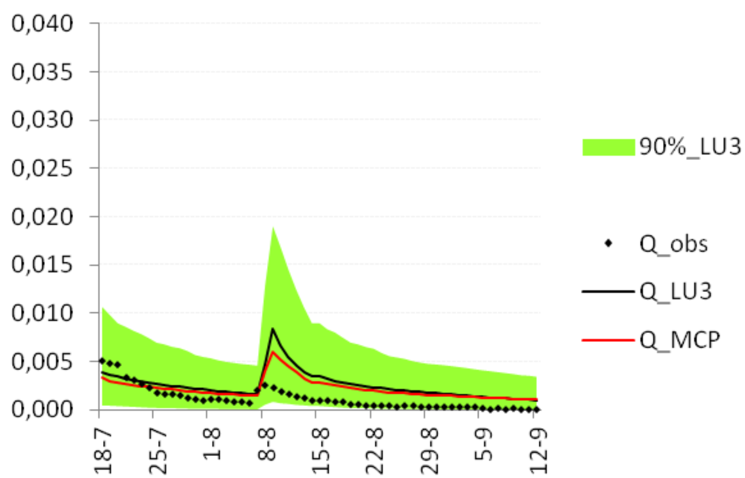




MCP ANALYSIS







MCP ANALYSIS – Band’s width

	Tot	Recessions	Events	Recession limbs band's increment	Events band's increment
TETIS	0,0086	0,0062	0,1365	**0,0%**	46,1%
LU4	0,0074	0,0070	0,0935	12,9%	**0,0%**
LU3	0,0094	0,0081	0,1561	31,1%	67,0%
MCP_TETIS_LU3	0,0130	0,0073	0,1361	3,8%	25,0%
MCP_TETIS_LU4	0,0110	0,0070	0,1134	**0,0%**	4,1%
MCP_LU3_LU4	0,0120	0,0075	0,1088	6,9%	**0,0%**

CONCLUSIONS

✓ The **deterministic approach** pointed out:

- The simplest lumped model **LU3** provided the worst results
- The non-linear lumped model **LU4** performed slightly better than the distributed **TETIS** model for the wet period, while the latter gave better results during the dry periods

✓ The **Pareto frontier** analysis pointed out:

- The calibrated optimum parameter sets were included into the Pareto frontier
- The TETIS model showed a more consistent behaviour in terms of the dispersion of the cloud of points

✓ The **MCP analysis** pointed out

- The LU4 provided the narrowest band for the discharge events
- The TETIS model provided the narrowest band for the recession limbs
- A MCP combination of the LU4 and TETIS gave the best result in terms of predictive uncertainty

CONCLUSIONS

✓ We could not simulate the non linear discharge behaviour at the outlet of this small Mediterranean catchment with the simplest lumped model LU3

✓ The non-linear mechanism seems to be relevant during the high discharge period

✓ The spatial heterogeneity may have a key role during the driest periods

✓ A combination of the two approaches may represent the solution to guarantee the most reliable results

✓ The inclusion of a non-linear percolation mechanism will be tested in the future