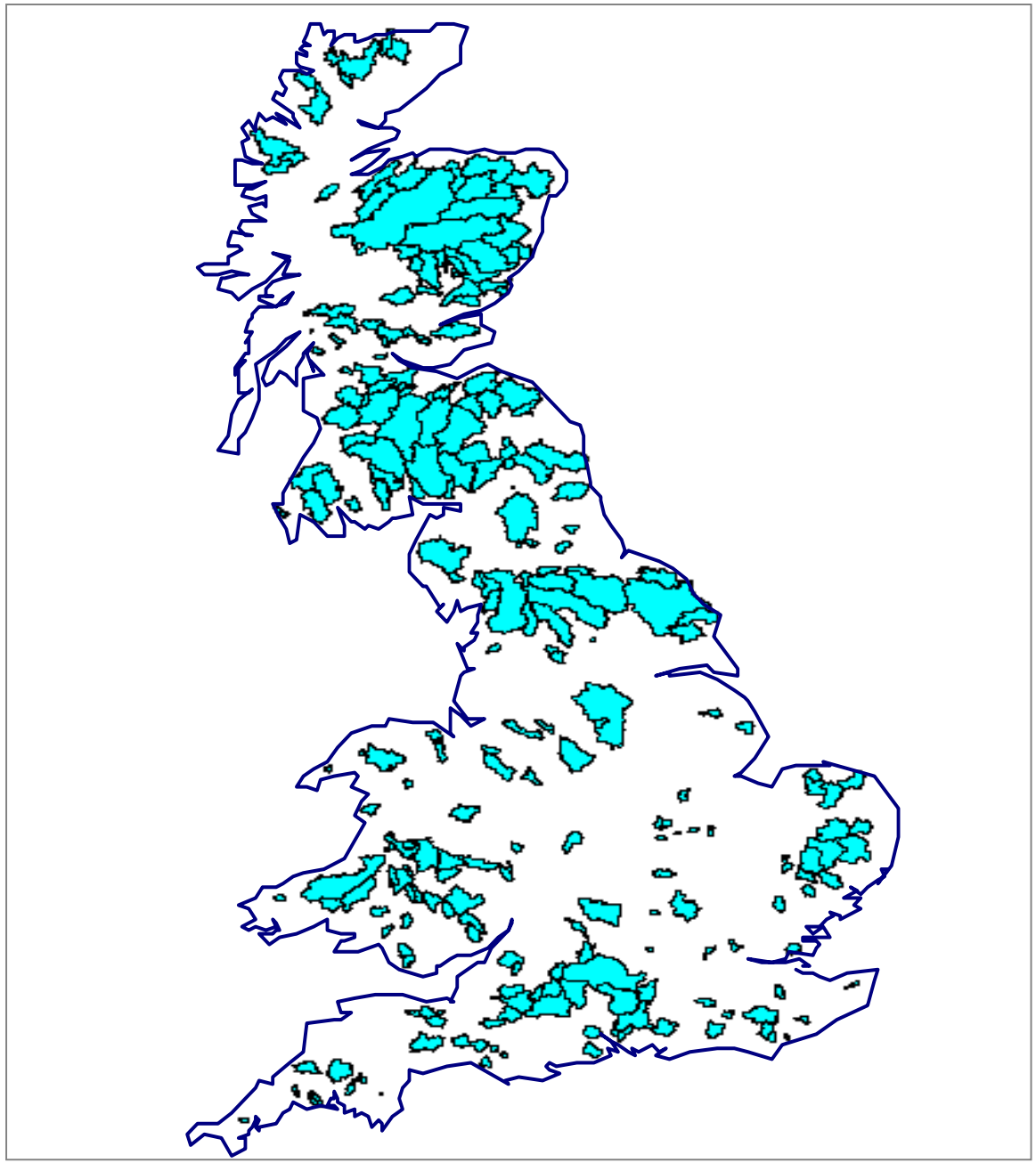
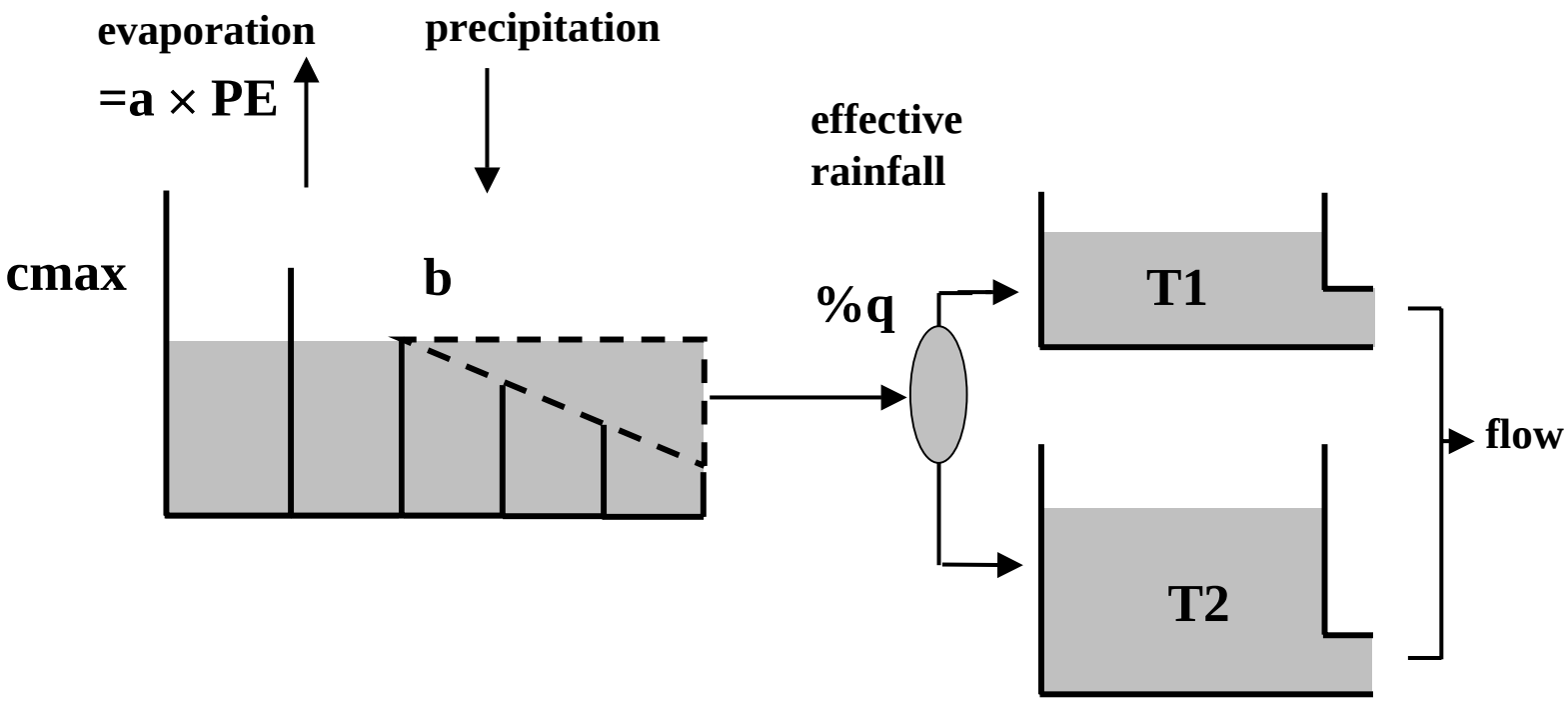
Evaluating uncertainty in predictions of streamflow in ungauged UK catchments

Neil McIntyre (Imperial College London)
Hyosang Lee (Imperial College London)
Howard Wheater (Imperial College London)
Andy Young (Center for Ecology and Hydrology, Wallingford)

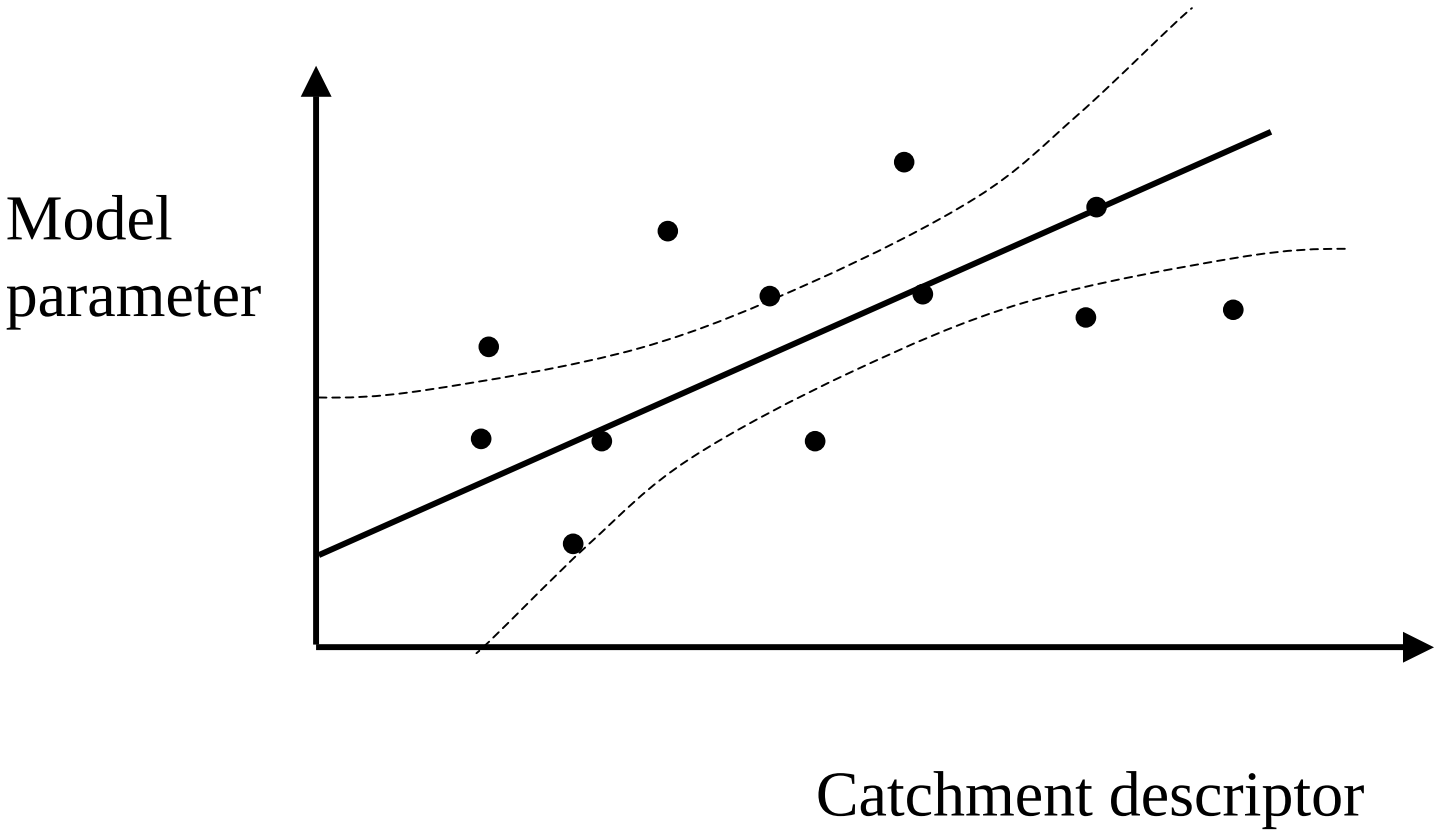
IEMSS Osnabruck June 2004



Conceptual models for continuous-time flow prediction

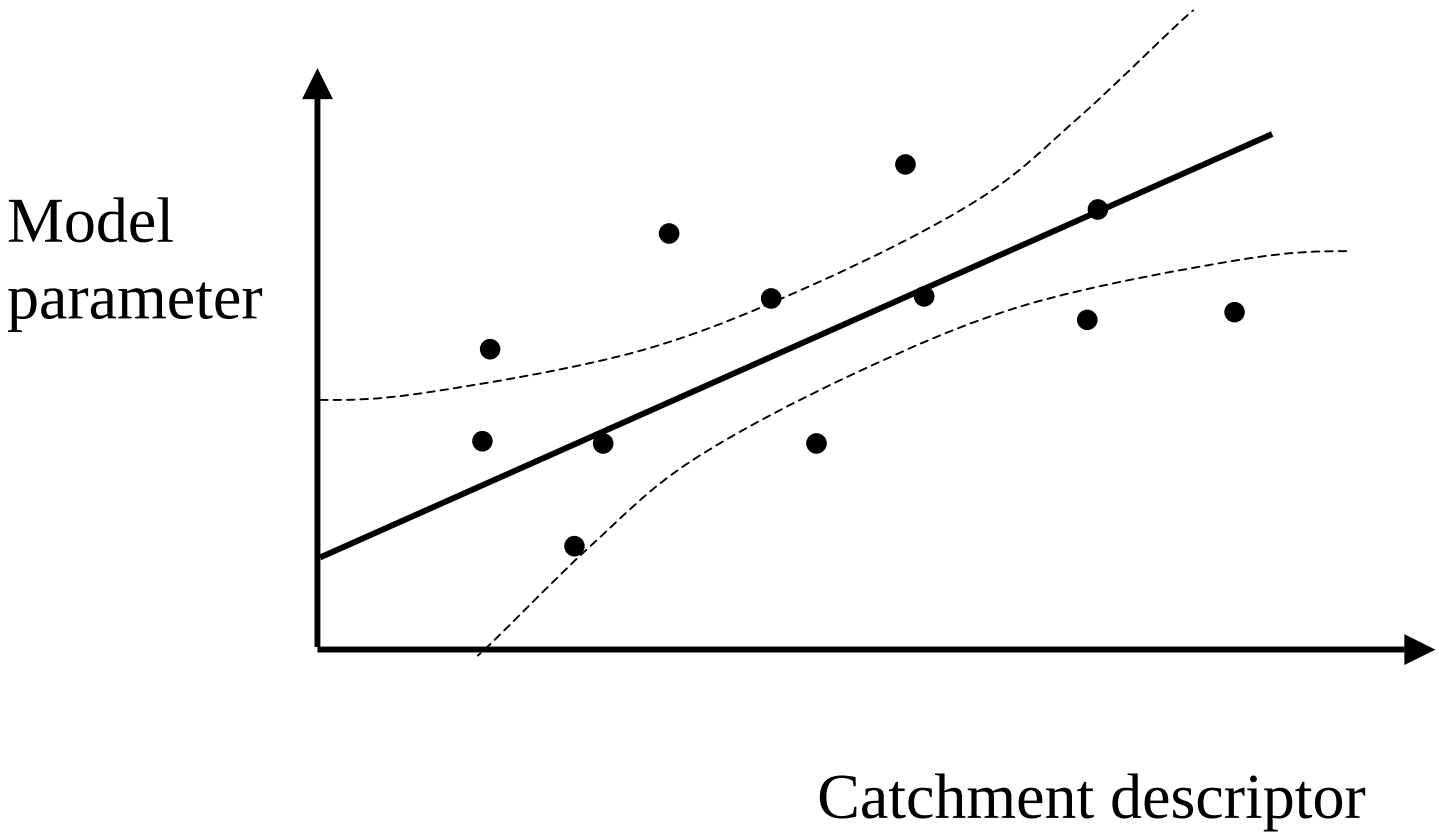


Regression

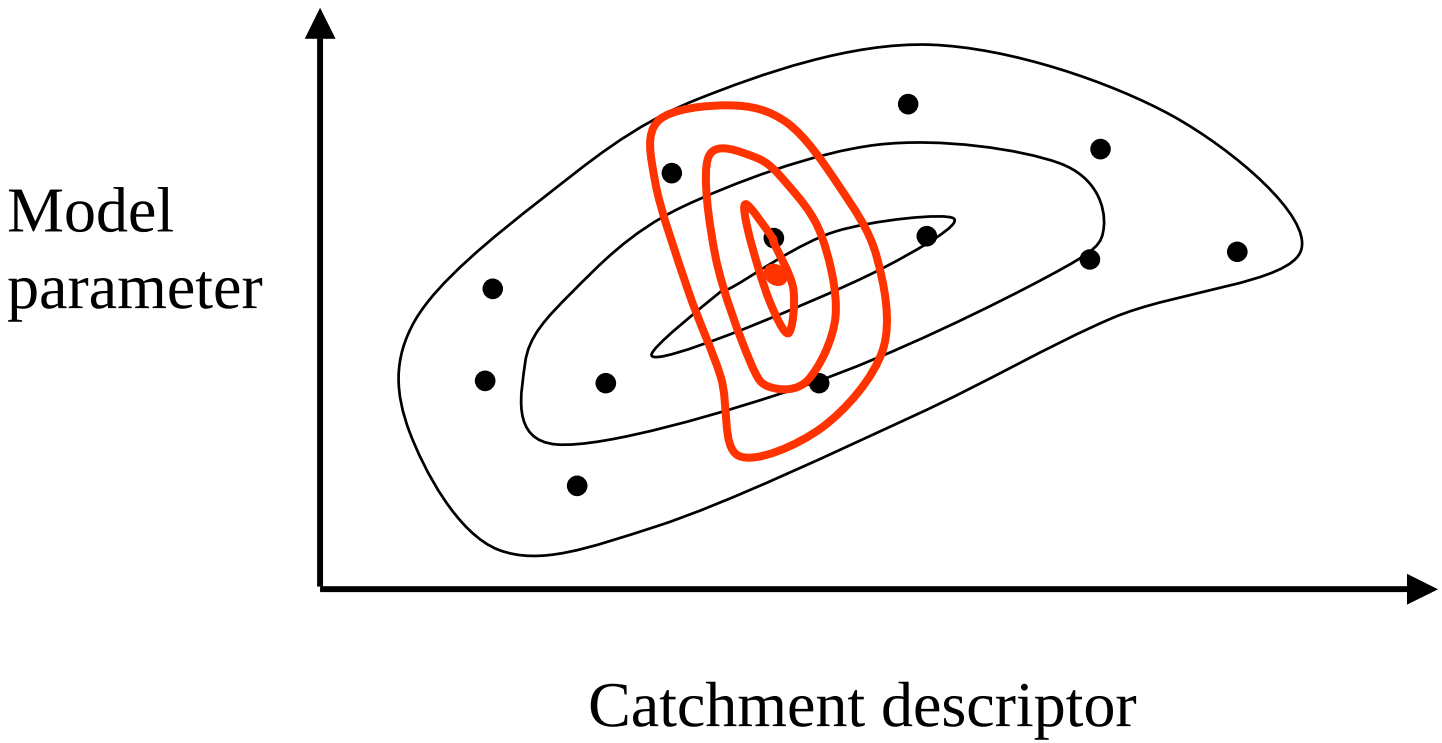


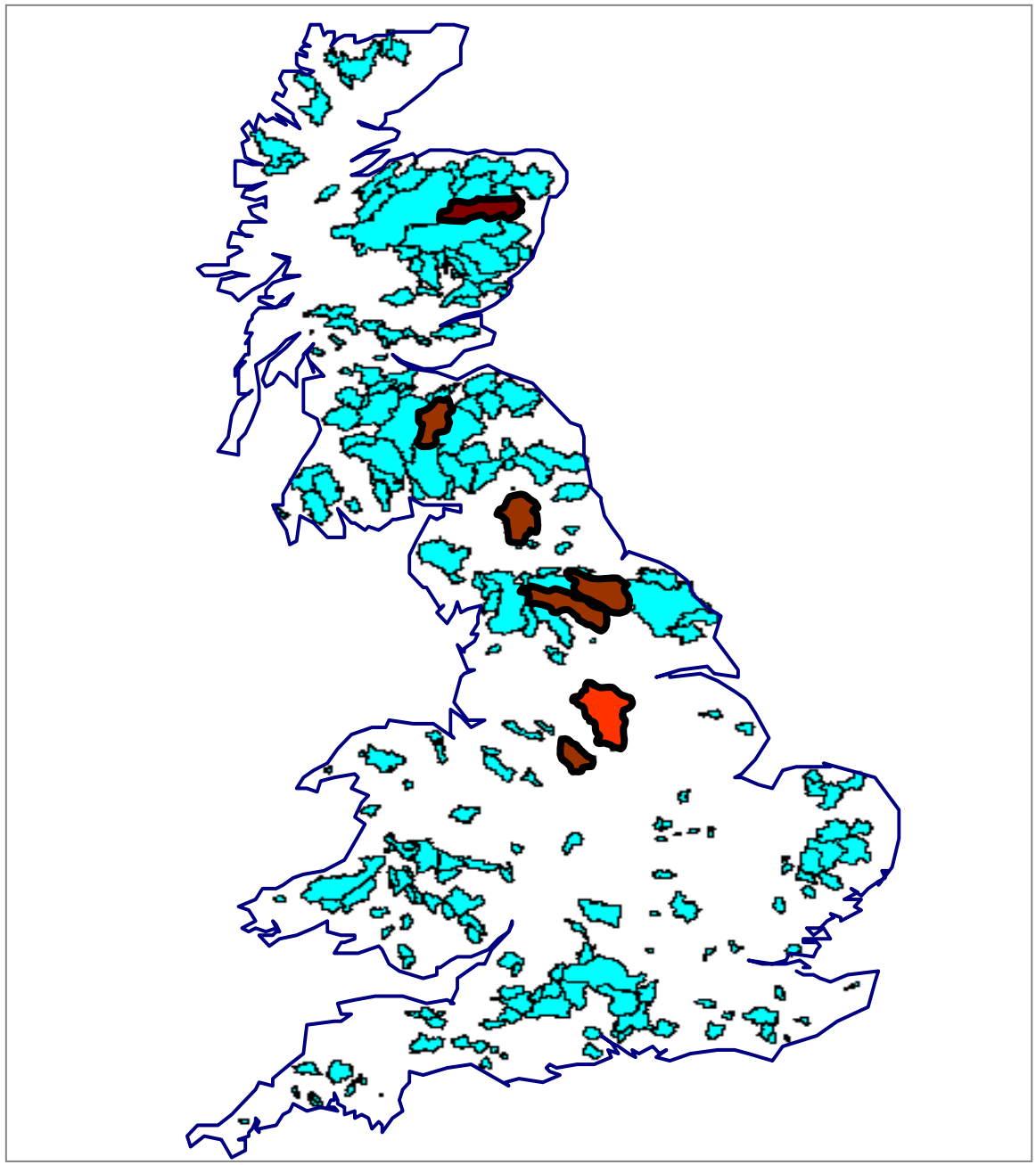
Problems with regression

- Regression model unknown a-priori
- Outliers
- Covariance of catchment descriptors
- Covariance of parameters
- Gaussian error assumptions
- Catchment descriptors assumed known

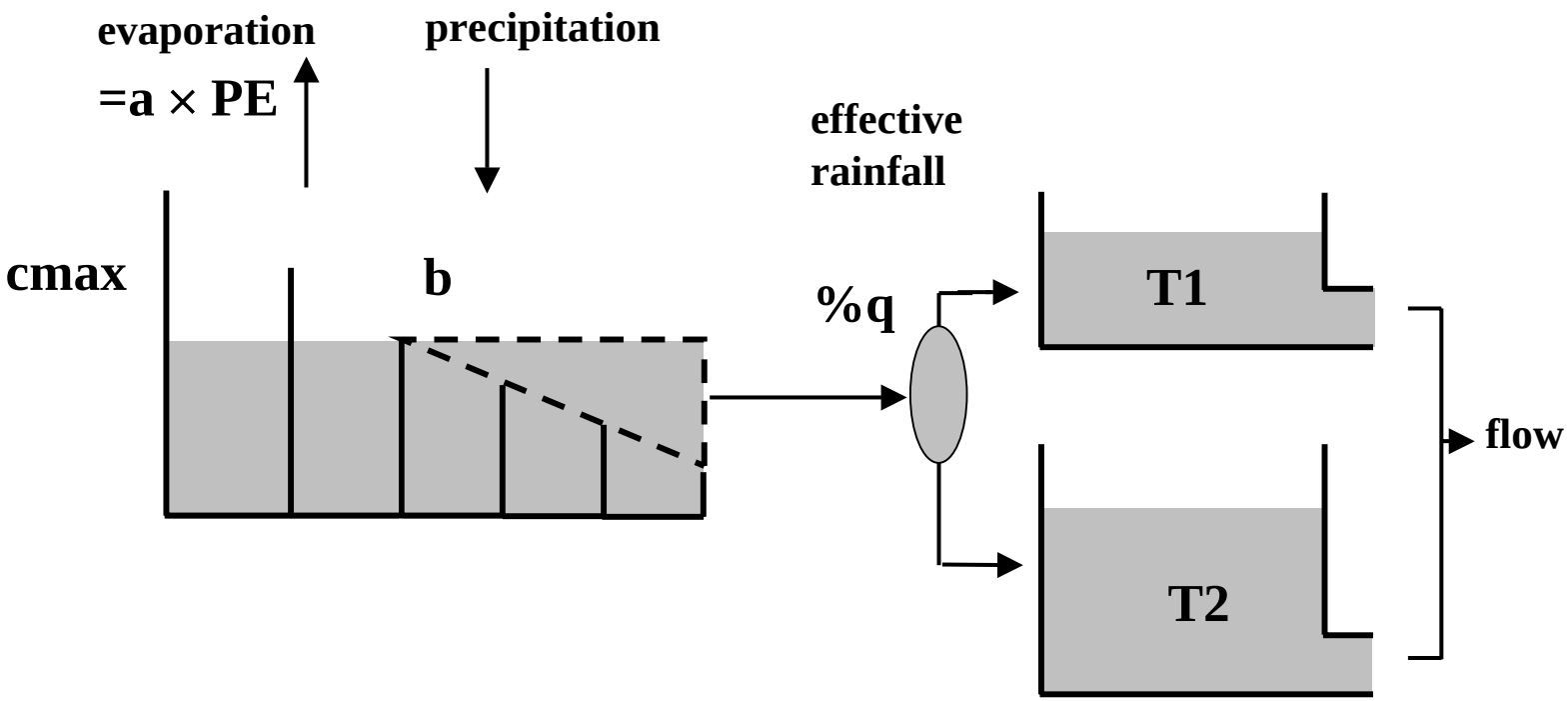

Model
parameter
Catchment descriptor

Model output averaging

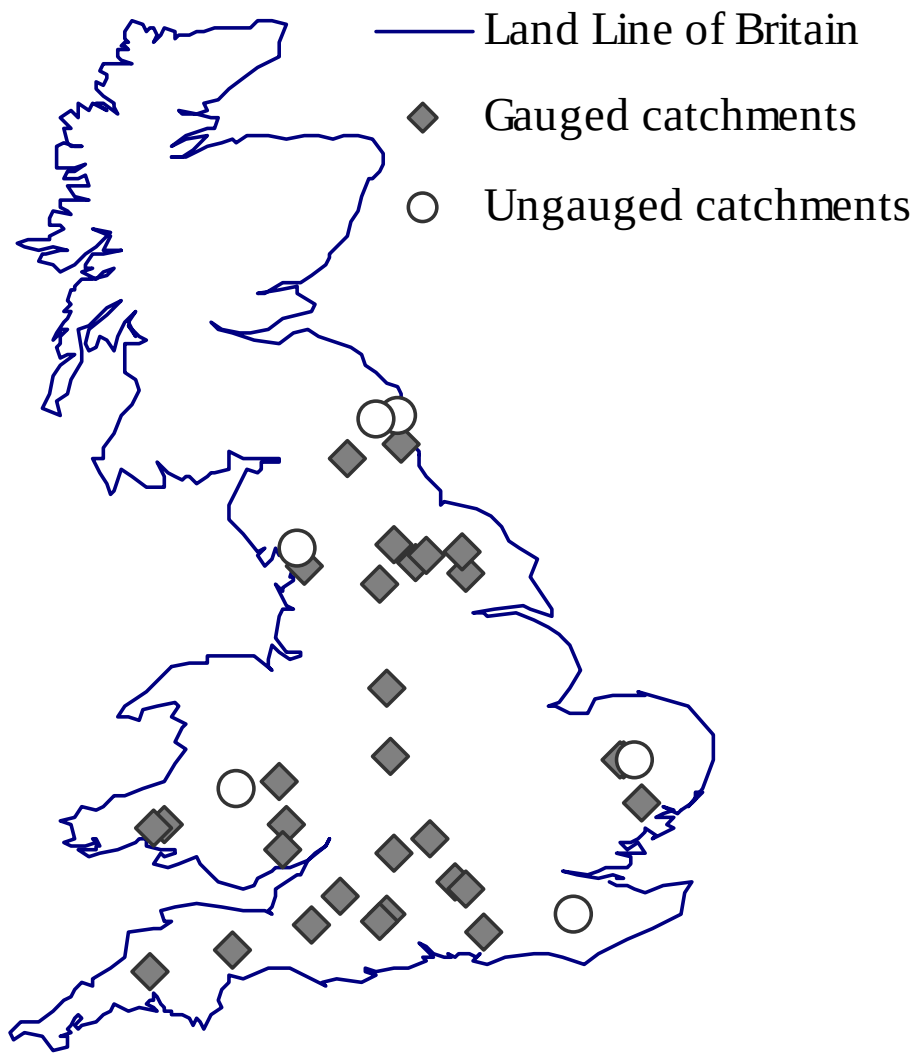




Case study


evaporation
=a × PE
precipitation
effective
rainfall
cmax
b
%q
T1
T2
flow

Case study


Land Line of Britain
Gauged catchments
Ungauged catchments

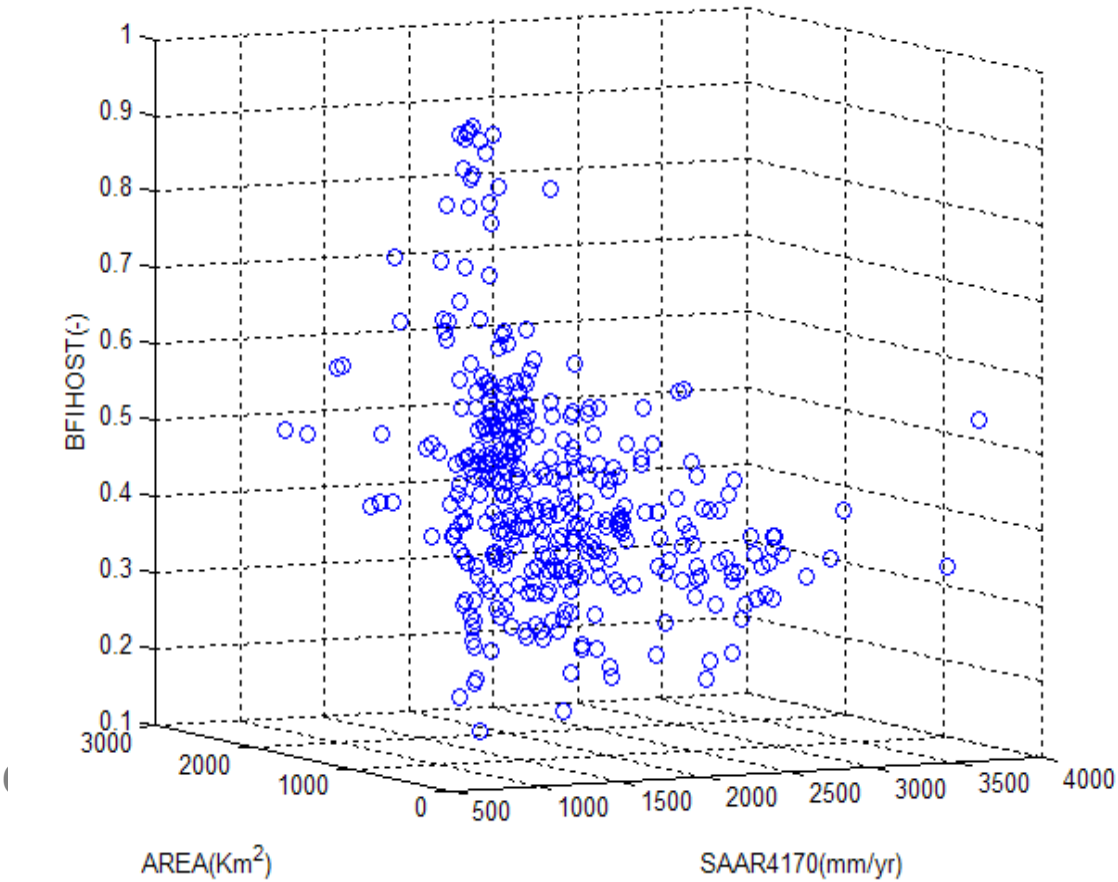
30 gauged catchments

River	AREA [km^2]	SAAR4170 [mm/yr]	BFI [ ]
Blyth	264.88	726	0.353
South Tyne	750.23	1236	0.333
Ure	913.79	1120	0.403
Ure	511.95	1343	0.326
Derwent	1594.8	784	0.685
Wharfe	432.1	1404	0.332
Rye	239.98	875	0.689
Swale	1354.23	873	0.483
Manifold	148.51	1087	0.544
Cole	119.72	732	0.443
Thet	311.82	636	0.78
Little Ouse	708.28	618	0.802
Brett	155.75	603	0.473
Kennet	1032.64	769	0.872
Loddon	176.49	757	0.764
Evenlode	427.45	730	0.714
Cole	140.01	680	0.548
Rother	157.02	935	0.618
Avon	326.46	768	0.904
Wylye	447.95	845	0.9
Culm	228.69	995	0.532
Thrushel	112.71	1228	0.415
Brue	139.52	881	0.473
Frome (Somerset)	261.85	966	0.529
Lugg	202.85	1062	0.658
Monnow	355.14	999	0.512
Olway Brook	111.27	1001	0.466
Cothi	298.54	1637	0.438
Gwili	130.98	1614	0.471
Lune	983.59	1524	0.323

6 ‘ungauged’ catchments

Catchment	***B*** **[-]**	***A*** **[km^2]**	***R*** **[mm/yr]**
Thet at Bridgham	0.68	276	640
Ithon at Disserth	0.43	359	1130
Bela at Beetham	0.54	132	1298
Coquet at Morwick	0.39	578	884
Coquet at Rothbury	0.40	346	951
Medway at Chafford	0.44	252	852

Distribution of Catchments in BFIHOST-AREA-SAAR space



$$E_i = \sqrt{\frac{1}{2}\left(\frac{\ln A_i - \ln A'}{\sigma(\ln A')}\right)^2 + \left(\frac{\ln R_i - \ln R'}{\sigma(\ln R')}\right)^2 + \left(\frac{B_i - B'}{\sigma(B')}\right)^2}$$

1. $$W_i = \frac{1}{\sum_{N}\left(1 - E_i / E_{\max}\right)}\left(1 - E_i / E_{\max}\right)$$

2. $$W_i = \frac{1}{\sum_{S}\left(1 - E_i / E_{\max}\right)}\left(1 - E_i / E_{\max}\right)$$

3. $$W_{i,j} = \frac{1}{\sum_{S,10}\left(W1 \times W2\right)} W1_i \times W2_{i,j}$$

4. $W_i = 0$ for all i where $E_i \neq E_{\boldsymbol{max}}$

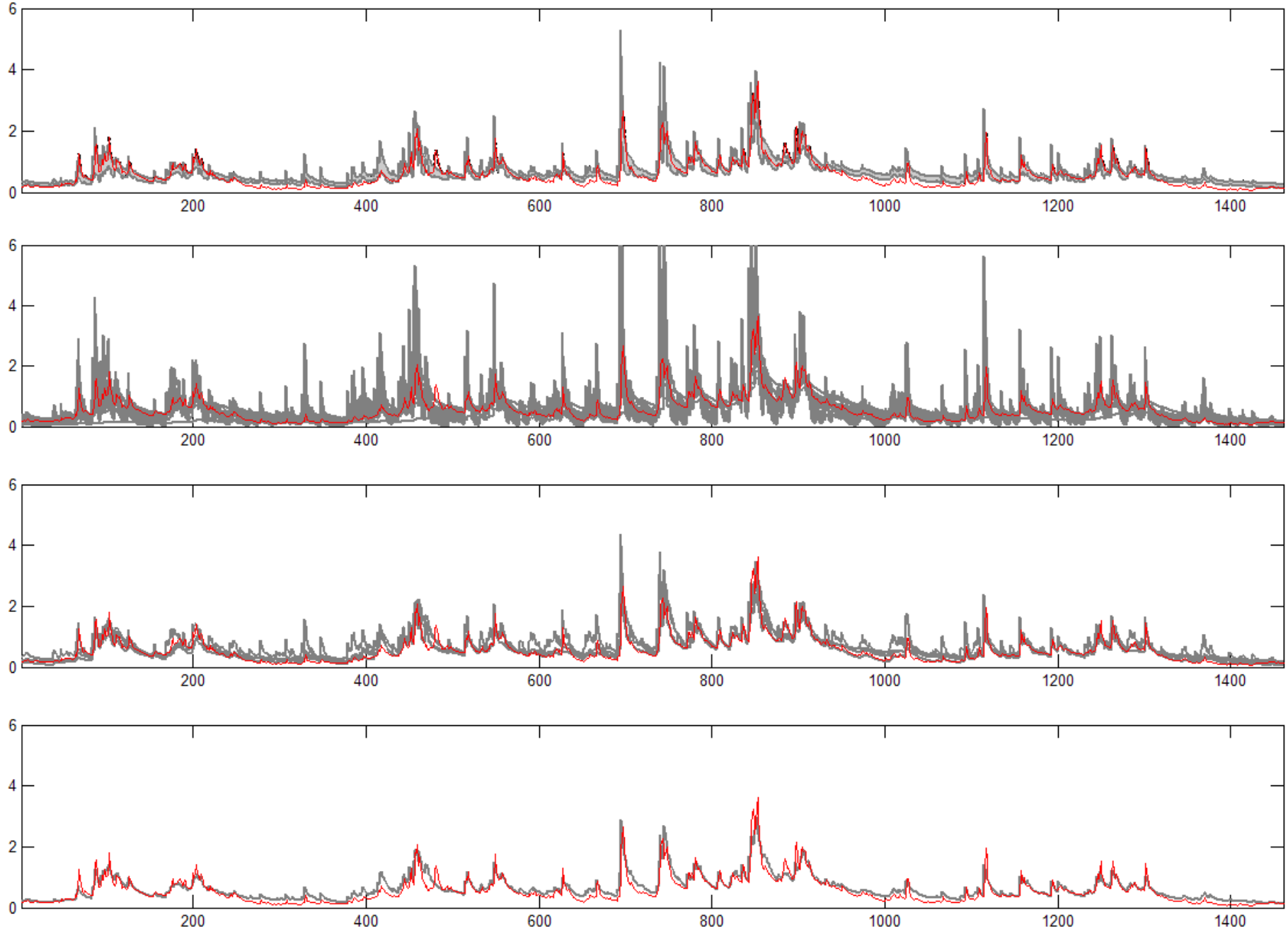
5. Univariate multiple regression

Performance for ungauged catchment predictions

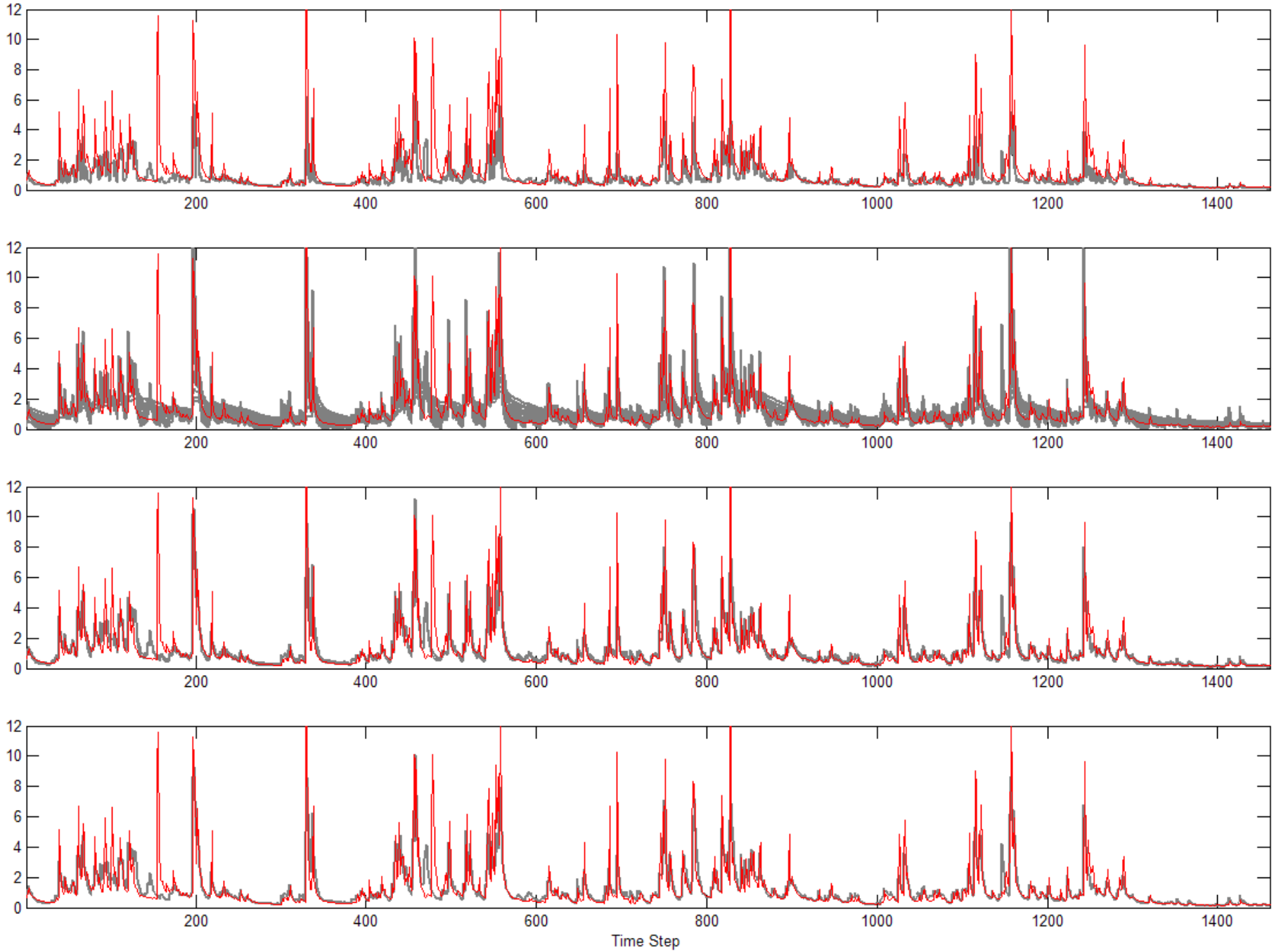
Catchment	(a)	(b)	(c)	(d)	(e)	(f)
Thet at Bridgham	0.84	0.75	0.68	**0.81** (4)	**0.77**	**0.80**
Ithon at Disserth	0.85	0.82	0.81	**0.83** (4)	**0.83**	0.81
Bela at Beetham	0.89	0.82	0.61	0.63 (4)	**0.89**	**0.87**
Coquet at Morwick	0.64	0.61	0.61	**0.63** (2)	**0.62**	0.60
Coquet at Rothbury	0.63	0.58	**0.62**	**0.62** (1)	**0.61**	**0.62**
Medway at Chafford	0.82	0.40	**0.81**	**0.80** (5)	**0.80**	**0.78**

Note: (a) Local calibration, (b) Regression, (c) Model averaging (using the optimum parameter set from all 30 gauged catchments), (d) Model averaging (using the optimum parameter set from *S* most similar catchments), with *S* given in parenthesis, (e) Model averaging (using the 10 best parameter sets from the similar catchments), (f) Using the model from only the most similar gauged catchment. Regionalisation performances better than regression are boldened.

Predictions at Thet catchment versus observations



Predictions at Coquet catchment versus observations



Conclusions

- Importance of maintaining parameter sets – regression loses this information
- Importance of avoiding Gaussian error assumption in representing uncertainty
- Some evidence to suggest Bayesian averaging valuable way forward for PUBs using CCRRs
- Needs comparison with more robust regression methods, integration of more catchments, sensitivity analysis of different similarity measures and objective functions.