UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Research Group of Hydrological and Environmental Modelling

Instituto de Ingeniería del Agua y Medio Ambiente

AN INCIPIENT UNCERTAINTY ANALYSIS IN HYDROLOGICAL MODELING …

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eawag aquatic research

5th Summer School in Environmental Systems Analysis

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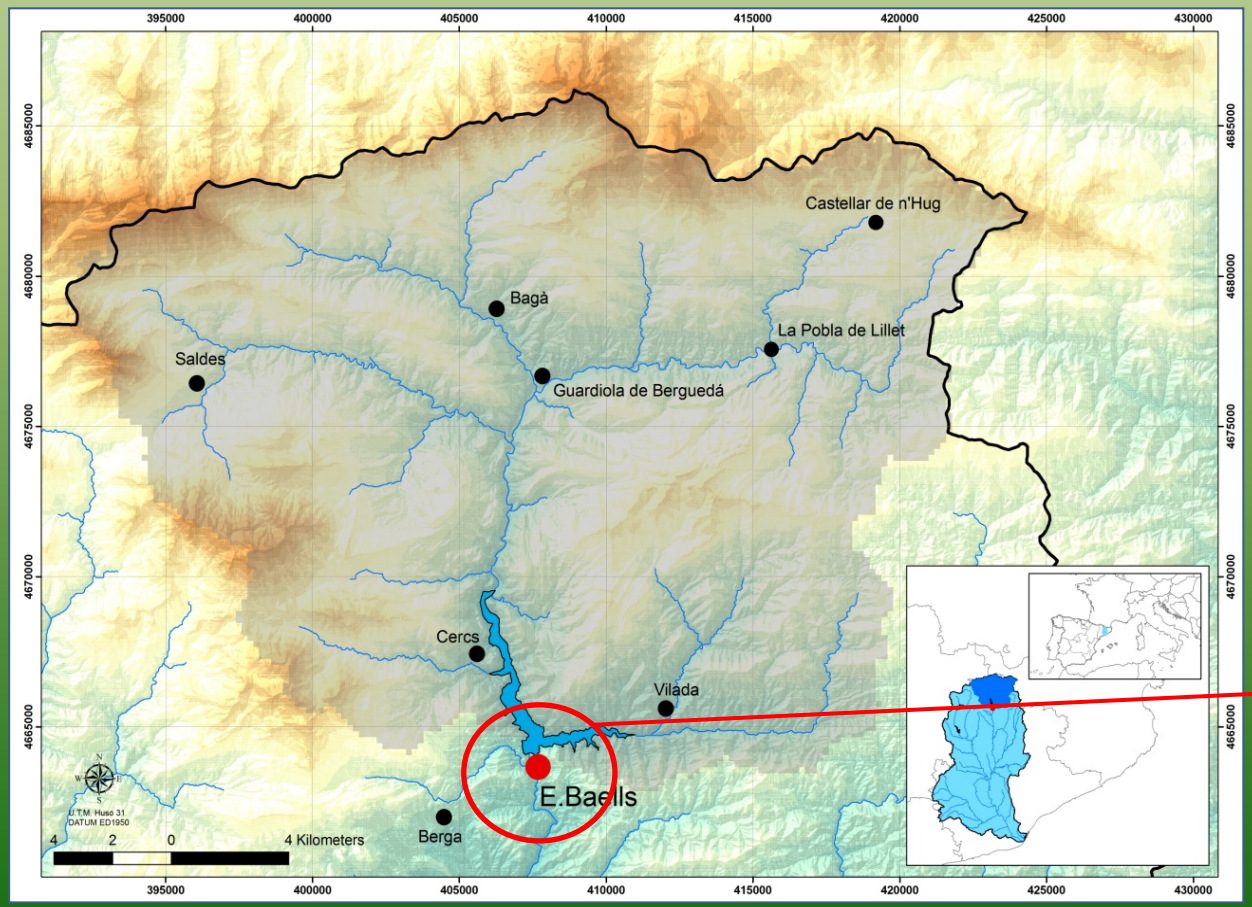
The Basin

Name: La Baells Basin (High Llobregat River, Barcelona, Spain)

Area: 504 Km²

Mediterranean - High mountain climate (with Seasonal Snow)



The Data

- Two Years of observed Stream Flow
- One previous Warm Up year
- Rain Series, Temp. (7 stations)

1 Streamflow Gauging Station

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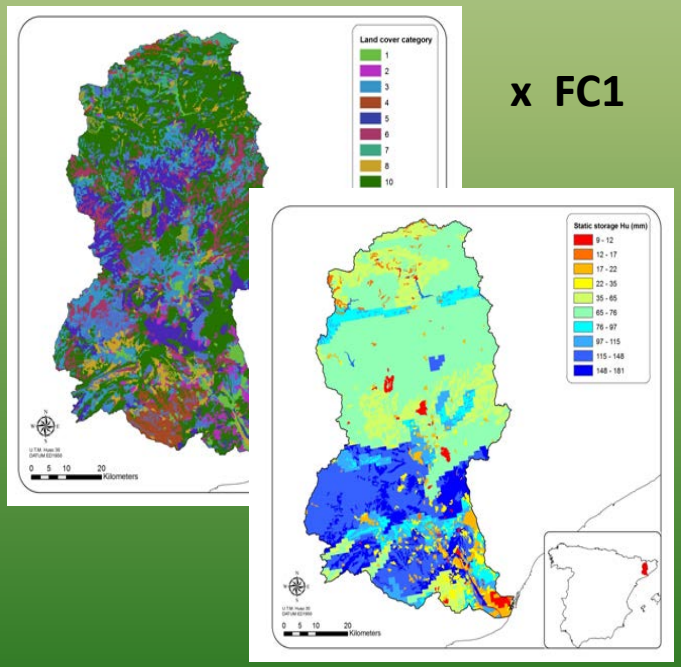
The (deterministic) Hydrologic Model

Name: TETIS (http://lluvia.dihma.upv.es/EN/software/software.html)

Model Type: Distributed Conceptual Model

Parameters: Split-parameter structure

"Split-parameter structure for the automatic calibration of distributed hydrological models." Francés, F., Vélez, I., and Vélez, J. (2007). *Journal of Hydrology, 332(1-2), 226–240.*



x FC1

x FC2

.....

x FC12

Parameters to calibrate are,

Effective Parameters:

Not physically based, but
With physical Meaning

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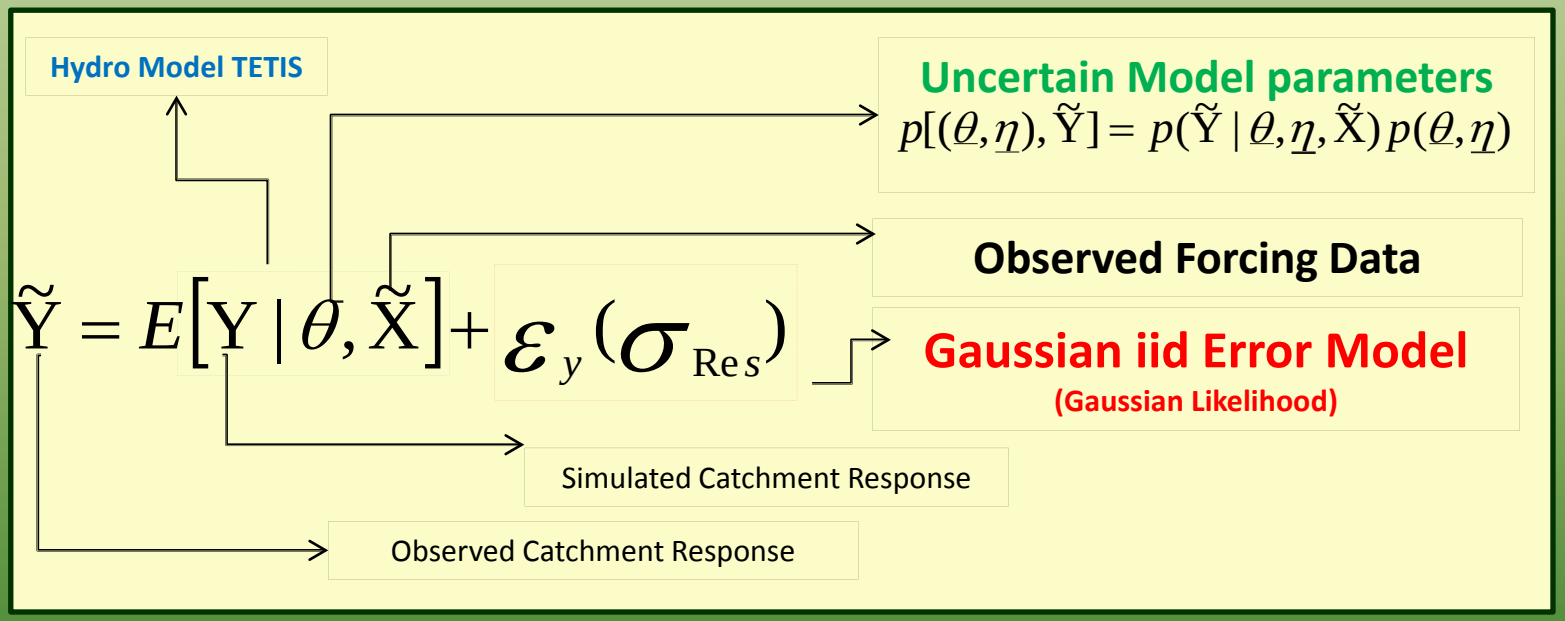
Calibration of Parameters

Traditional Estimation Criterion:

Minimizing SSR or RMSE or … another Least Squares Approach

Bayesian Formal Equivalent Approach with Lumped Total Error:



Sampling Process of Parameters:

MCMC ADAPTIVE METHOD (DREAM; Vrugt & Braak)

31.250 MCMC SIMULATIONS

(31.250 X 8 = 250.000) LIKELIHOOD EVALUATIONS (PARALLEL!!!!)

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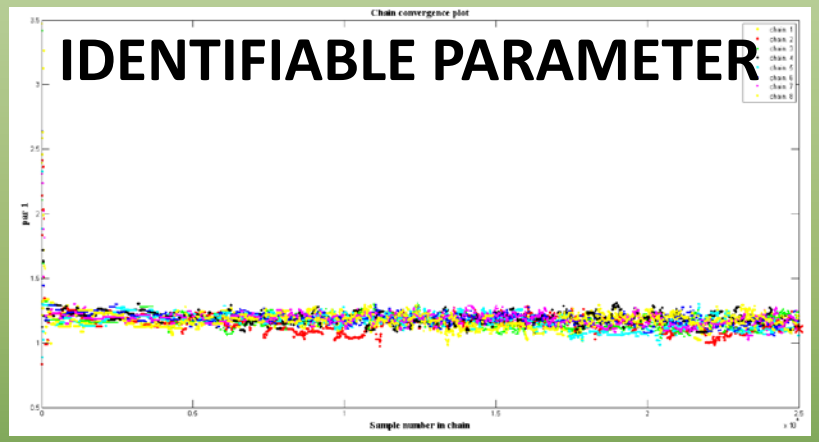
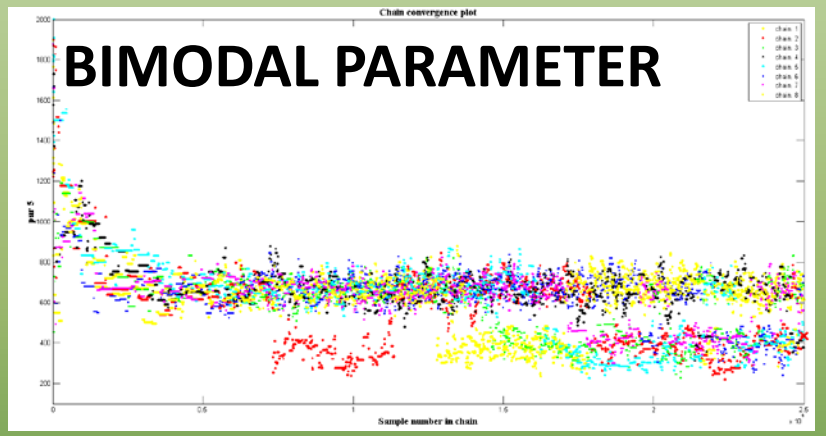
Calibration of Parameters

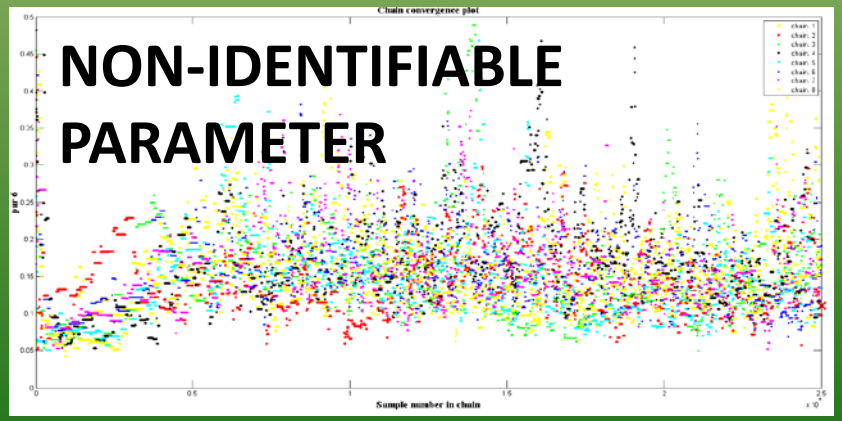
Sampling Process of Parameters:

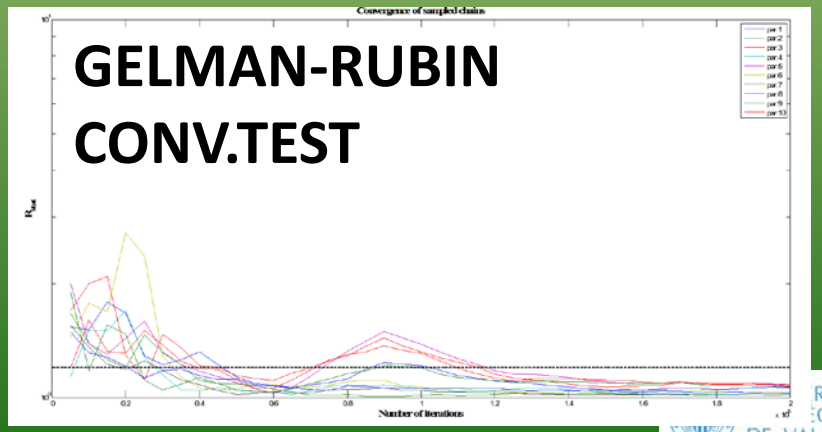
MCMC ADAPTIVE METHOD (DREAM; Vrugt & Braak)

Evolution of the 8 Chains …









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Calibration of Parameters
Traditional Criterion

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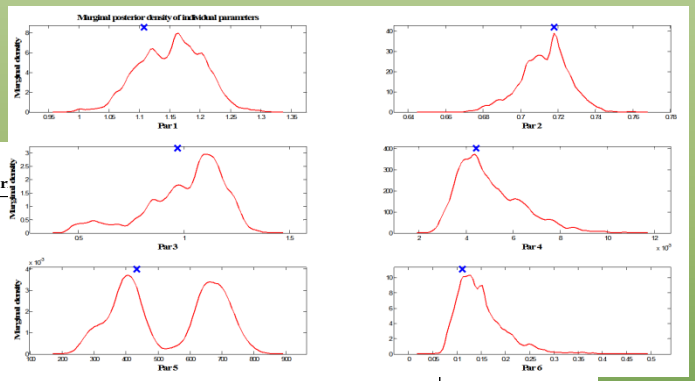
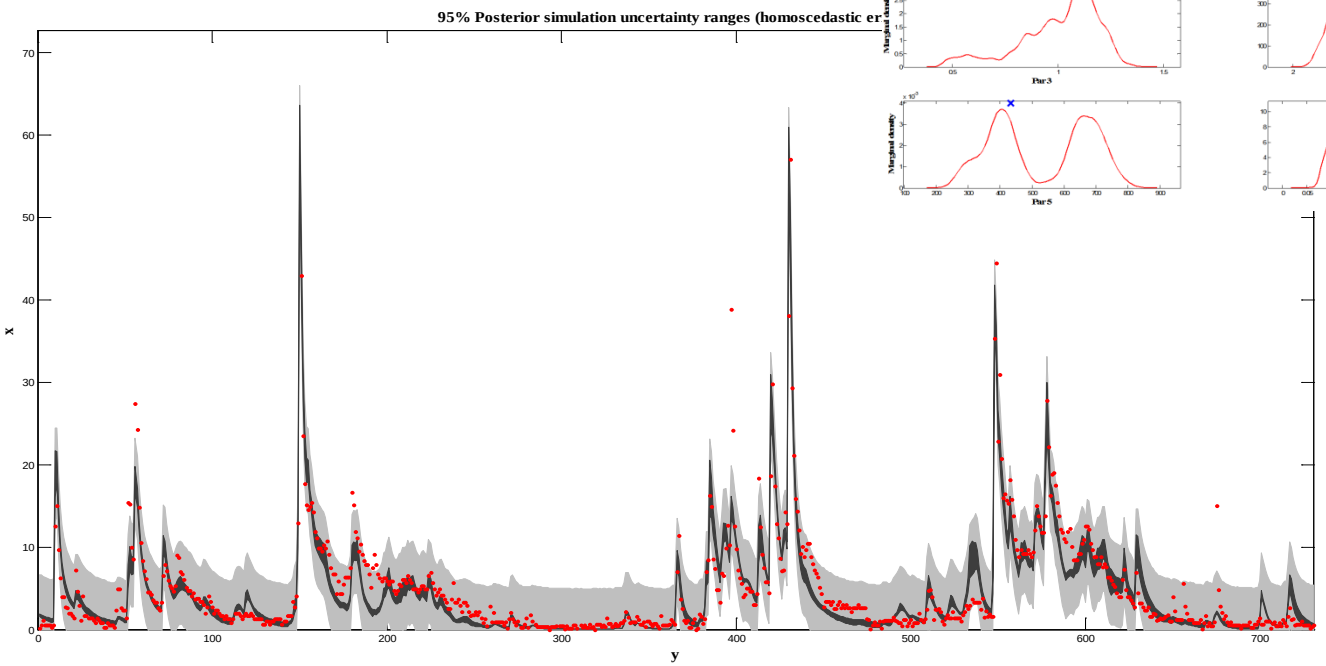
MCMC Sampling Process of 12 Hydrologic Parameters:

Considering a constant variance of Residuals like a Nuisance Parameter

Parameter Uncertainty & Predictive Uncertainty





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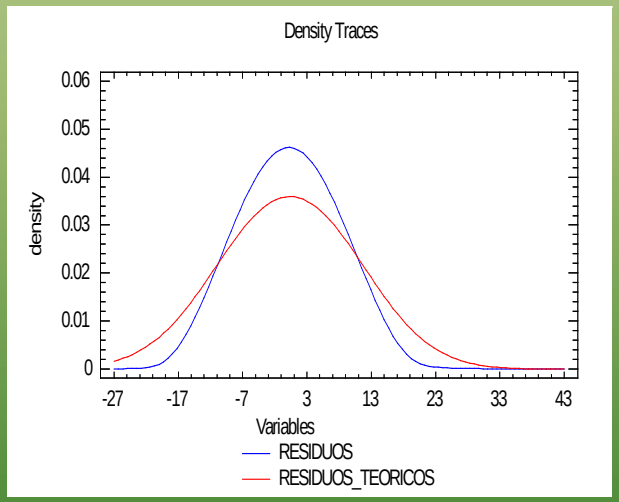
Problems Encountered

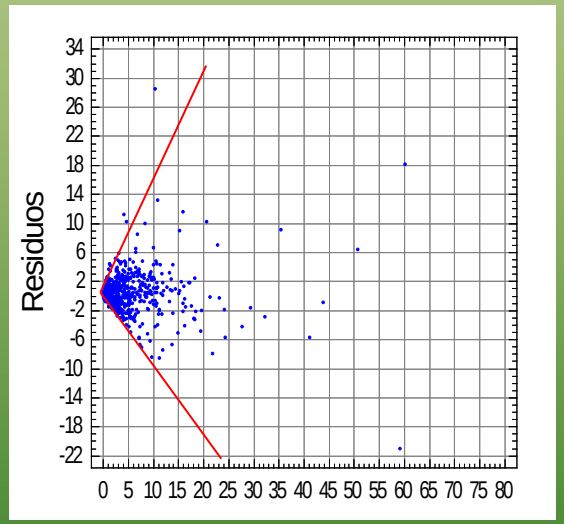
1- Testing the Residuals…

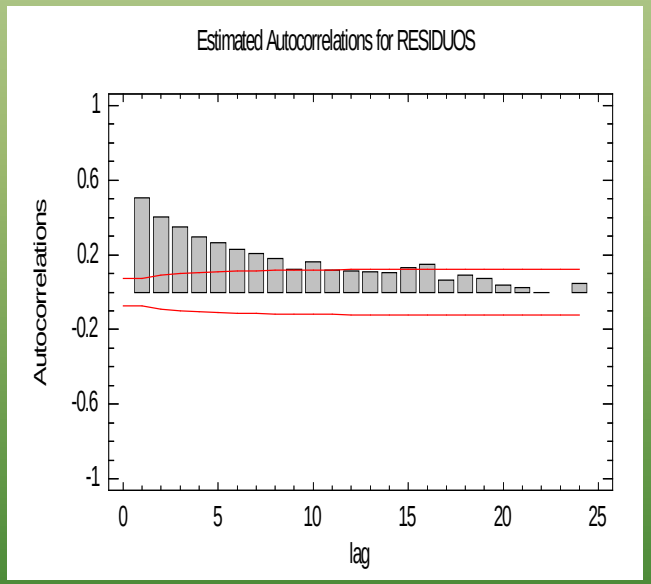
GAUSSIAN ERRORS ??

HOMOSCEDÁSTIC RESIDUALS ??

INDEPENDENCE IN RESIDUALS???







2- Symmetrical and equal-spread Uncertainty Bands with respect to Expectation leads to negative flows

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Bayesian Calibration of Parameters

Bayesian Formal Estimation : Minimizing -log (GL)

GL: Generalized Likelihood (Vrugt & Schoups)

$$L(\eta|\mathbf{Y}) = n\log\frac{2\sigma_\xi\omega_\beta}{\xi+\xi^{-1}} - \sum_{t=1}^{n}\log\sigma_t - c_\beta\sum_{t=1}^{n}\left|a_{\xi,t}\right|^{2/(1+\beta)}$$

…that can take into account Residuals Not Gaussian i.i.d:

- -Heteroscedastic Residuals
- -Autocorrelation
- - Kurtosis and Skewness of errors distribution

Hydro Model TETIS

$$\tilde{\mathrm{Y}} = E\left[\mathrm{Y}\mid\theta,\tilde{\mathrm{X}}\right] + \varepsilon_y$$

Uncertain Model parameters

$$p[(\underline{\theta},\underline{\eta}),\tilde{\mathrm{Y}}] = p(\tilde{\mathrm{Y}}\mid\underline{\theta},\underline{\eta},\tilde{\mathrm{X}})\,p(\underline{\theta},\underline{\eta})$$

$p(\tilde{\mathrm{Y}}\mid\underline{\theta},\underline{\eta},\tilde{\mathrm{X}})$ → $L(\eta|\mathbf{Y})$

Generalized Error Model
(Generalized Likelihood)

Bayesian Calibration of Parameters

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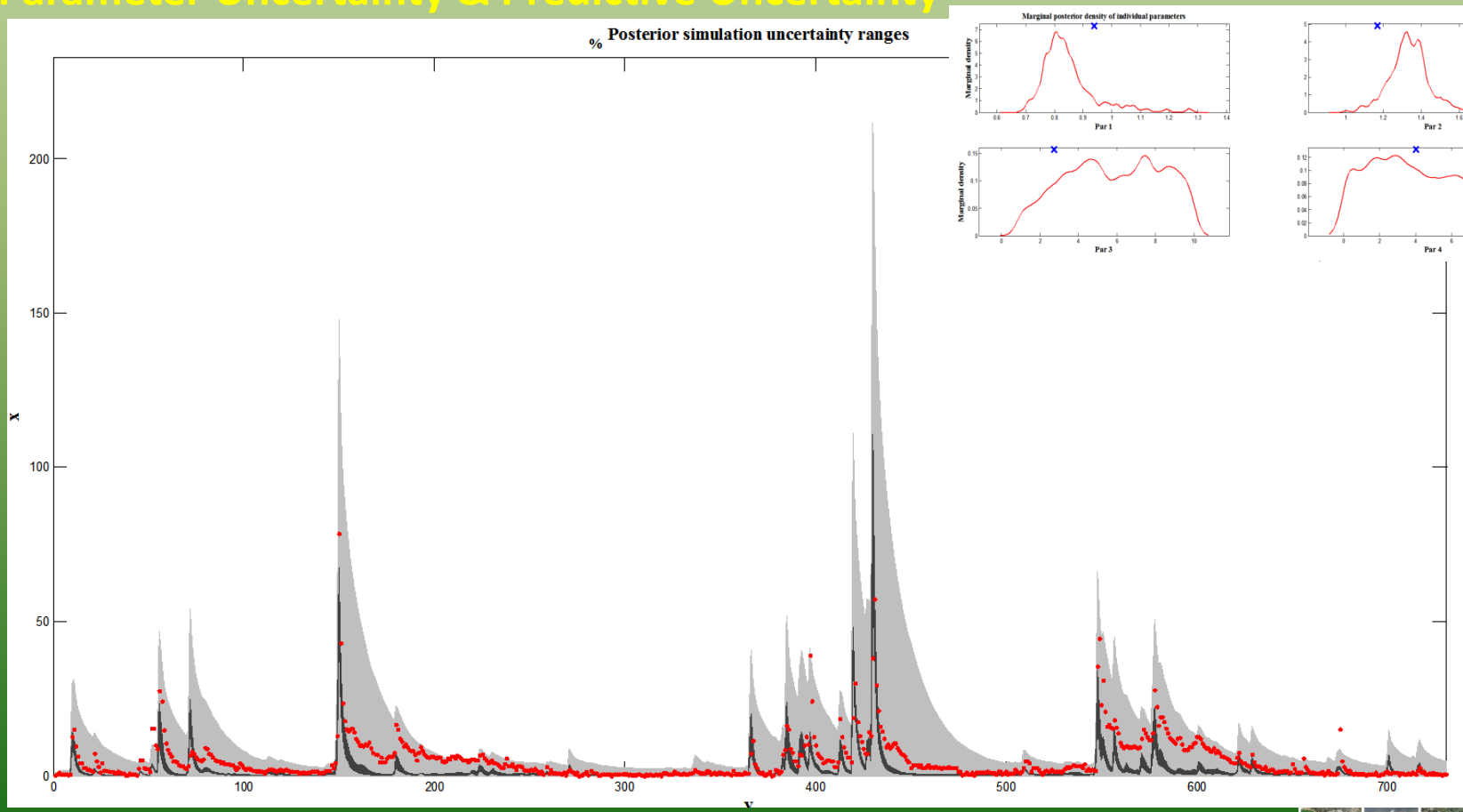
Sampling Process of 12 Hydrologic Parameters + 5 Error Model parameters: MCMC ADAPTIVE METHOD (DREAM; Vrugt & Braak)

Parameter Uncertainty & Predictive Uncertainty



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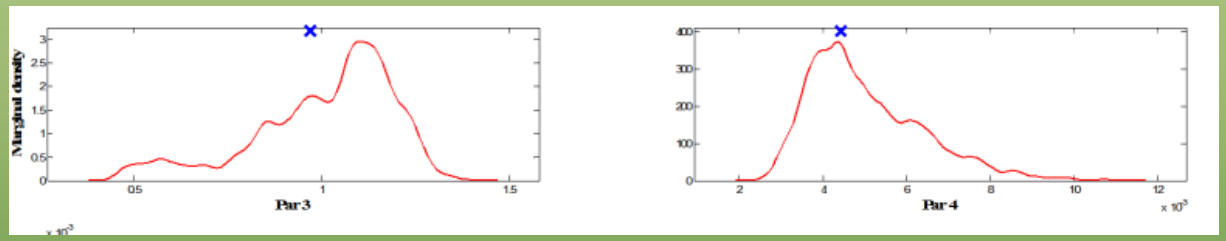
Bayesian Calibration of Parameters
Generalized Likelihood

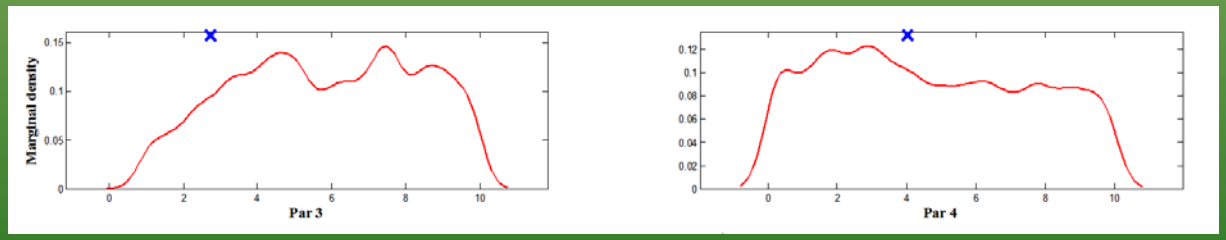
Problems Encountered

1 – Some Parameters of Hydro Model have degenerated in Not-Identifiable Parameters

Gauss. Lik.



General. Lik.



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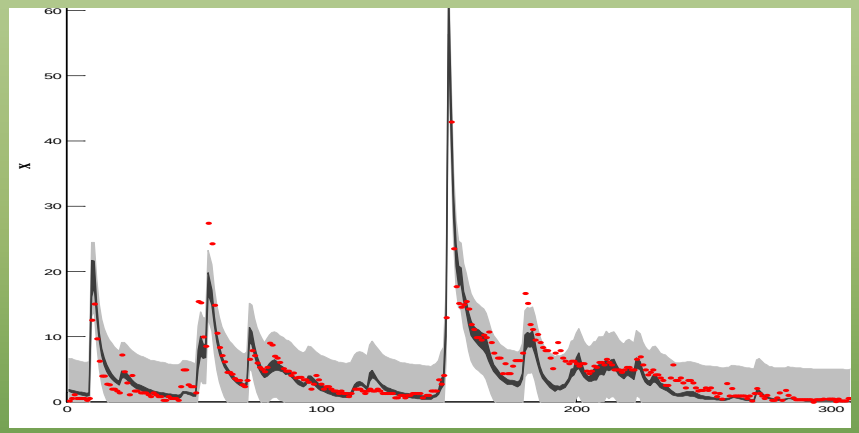
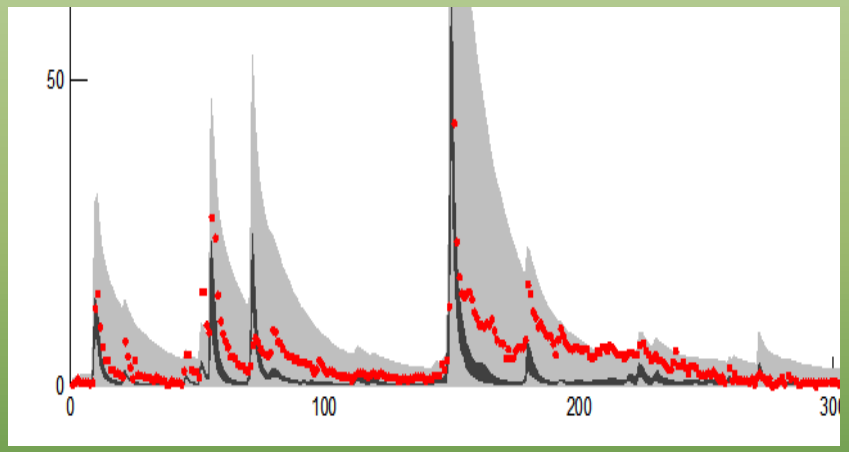
Problems Encountered

2 – The Error Model has taken more responsibility in the fitting to the data set. Consequently the hydrological model has a worse performance.



Gauss. Lik.
the Hydro. model is working to fit the data



General. Lik.
the Hydro. model is not working to fit the data, and delegates in the Error Model to obtain the maximum likelihood

NEXT STEP: Testing conclusions of "Pitfalls and improvements in the joint inference of heteroscedasticity and autocorrelation in hydrological model calibration (G. Evin , D.Kavetski et al. 2013) "

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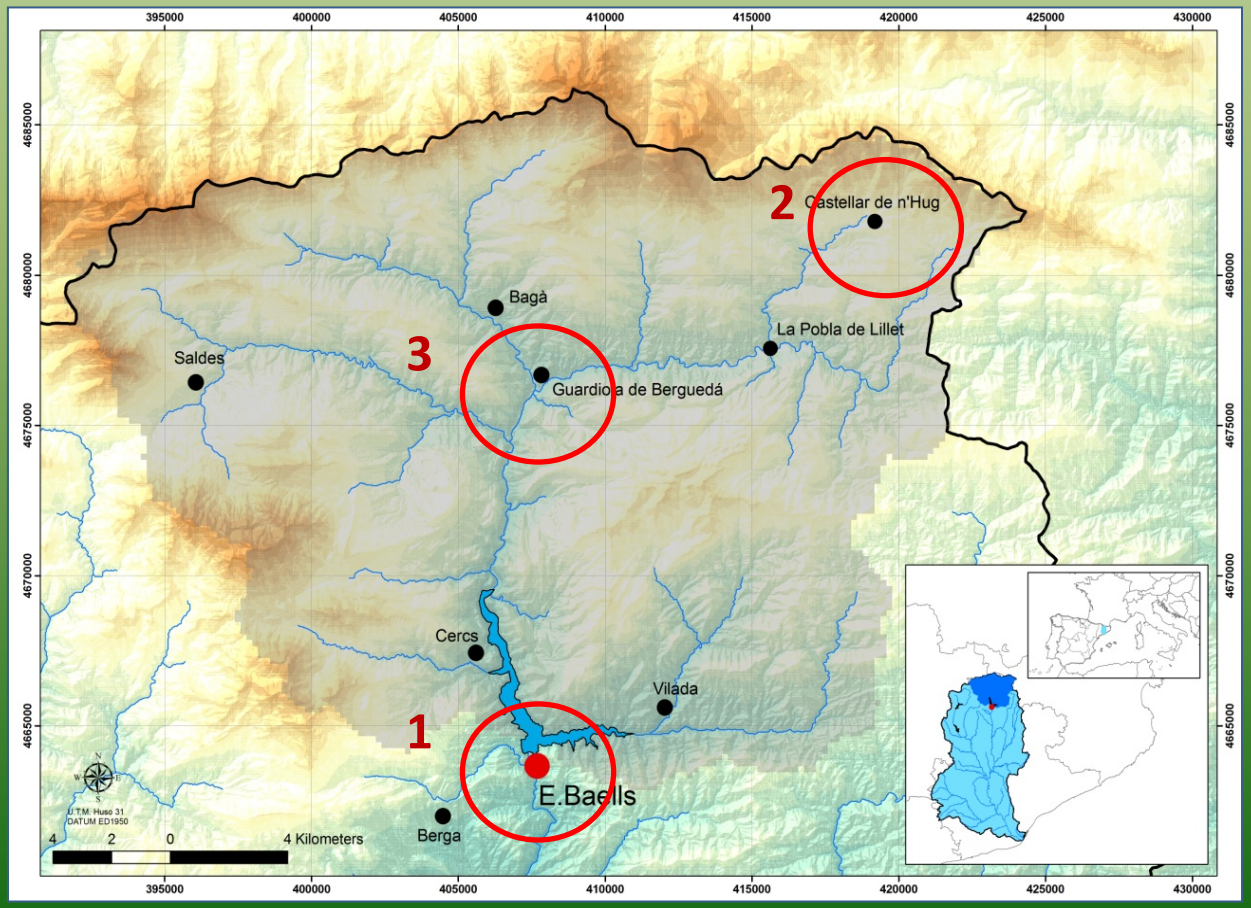
Bayesian Calibration of Parameters
Generalized Likelihood

Challenges Encountered

How Can I use the information of several Gaugin Stations ?

First Approach: Sum Log Likelihoods

Then…: Test the independence between residuals of the distinct gauge stations



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THANK YOU FOR YOUR ATTENTION

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