A Monte Carlo based Approach to Recursive Parameter Estimation

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1 MOTIVATION

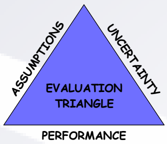
• Conceptual hydrological modeling requires identification of a suitable model structure and estimation of parameter values through calibration.

• Current problems are [1] a lack of objective approaches to evaluate model structures, [2] the inability of calibration procedures to distinguish between the suitability of different parameter values, [3] the sub-optimum use of available information.

• We introduce an innovative approach which analyses model performance in a dynamic fashion to reduce information loss.

•It also allows for the testing of assumptions underlying the model structure (e.g. parameters are constant in time). Enabling model evaluation in 3-dimensions (Fig. 1).

[1]



2 DYNAMIC IDENTIFIABILITY ANALYSIS – DYNIA

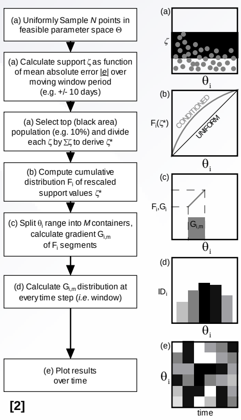
• DYNIA (Fig. 2) is a Monte Carlo based approach to adaptive parameter estimation.

• Objectives of the algorithm are:

[1] To avoid the loss of information through aggregation of model residuals during parameter identification.

[2] To evaluate structures with respect to failure of individual components (e.g. optimum parameter values change in time).

[3] To separate data periods of information and of noise.



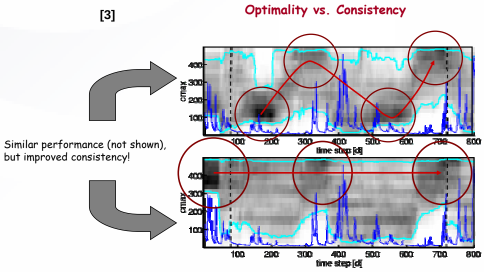
[2]

Wagener, T., Wheater, H.S. and Gupta, H.V. 2003. Rainfall-runoff modelling in gauged and ungauged catchments. Imperial College Press, London, UK, 300 pp., in Press, Fall 2004.

3 MODEL STRUCTURAL ANALLYSIS

[3]

Optimality vs. Consistency



• How can we use uncertainty estimation as model diagnostic tool to analyze model structures?

• The DYNIA results for two different HyMod structures are shown in Figure 3. Model A evaporates at the potential rate as long as soil moisture is available. Model B uses a linear relationship between actual evapotranspiration and soil moisture content, though without adding an additional parameter.

• Both structures show identical (indistinguishable) degrees of performance when measured using a standard objective function (e.g. RMSE).

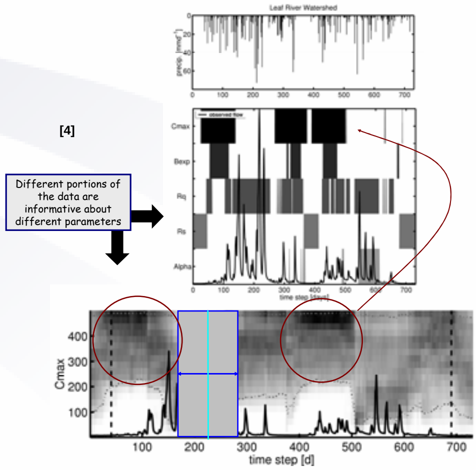
• However, the DYNIA plot for the parameter *cmax* exposes some ambiguity about the optimum value for this parameter. Model A shows different optima during different periods violating the assumption of constant parameters, indicating inadequacies within the model structure.

• Is consistency in a model more important than optimality?

Wagener, T., Wheater, H.S. Gupta, H.V. 2002. Identification and evaluation of watershed models. In Duan et al. (eds.) Advances in calibration of watershed models. AGU Monograph, Washington DC, USA.

4 PARAMETER ESTIMATION & PARAMETER/DATA RELATIONSHIPS

[4]



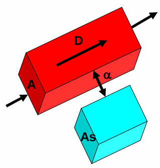
• Does the data contain information to estimate the parameters? When do individual parameters dominate the model response? Link to processes?

•The 90% confidence limits come closer together when the posterior distribution is conditioned. The distance can be used as a measure of identifiability and a threshold can be selected for visualization purposes.

• One can see the particular importance of the wetting up period, i.e. the storage elements overflow, for the parameter estimation process.

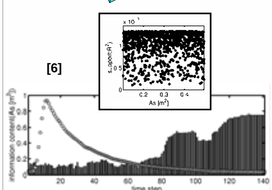
Wagener, T., McIntyre, N., Lees, M.J., Wheater, H.S. and Gupta, H.V. 2003. Towards reduced uncertainty in conceptual rainfall-runoff modelling: Dynamic identifiability analysis. *Hydrological Processes*, 17(2), 455-476.

5 EXPERIMENTAL DESIGN

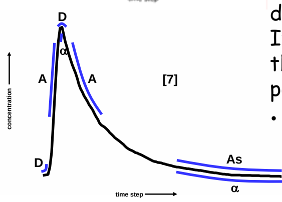


[5]

[6]



[7]



• How can we identify the most informative experiment? Example of the 4-parameter transient storage model.

• This solute transport model conceptualizes the river into a main and a storage zone (Fig. 5).

• Figure 6(a) shows a dotty plot of the cross-sectional storage area parameter using a Nash-Sutcliffe Efficiency (R^2) measure. The parameter appears non-identifiable.

• Figure 6(b) shows an 'information plot' derived using DYNIA (width of 90% cfl.). It clearly shows that information about this parameter is located in the pollutograph tale.

• Figure 7 shows where information is located for all 4 parameters.

Wagener, T., Camacho, L.A. and Wheater, H.S. 2002. Dynamic identifiability analysis of the transient storage model for solute transport in rivers. *Journal of Hydroinformatics*, 4(3), 199-211.

6 CONCLUSIONS

• DYNIA is applicable for any dynamic model.

• It is applicable off-line. Only requires Monte Carlo sampling.

• It adds the dimension of assumption testing to model evaluation.

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SAHRA