CALIBRATION OF WATERSHED MODELS WITH EVOLUTIONARY ALGORITHMS

[1]Francisco Venicius Fernandes Barros; [2]Eduardo Sávio P. R. Martins, [3]Luiz Sérgio V. Nascimento & [4]Dirceu Silveira Reis Jr

[1]FUNCEME, veniciusfb@gmail.com, [2]FUNCEME, espr.martins@gmail.com, [3]FUNCEME, luizsergiovn@gmail.com, [4]FUNCEME, dirceu.reis@gmail.com

Introduction: Experience has shown that the optimal search based on only one goal cannot determine a solution that models satisfactorily a given phenomenon. Calibration of hydrological models using multiobjective approaches can be justified by the nature of the realworld problems, which require the use of multiple objectives, often conflicting.

Objectives: Application of evolutionary algorithms uni-(HBMO, PSO and SCEM), multi-purpose (MOHBMO, MOPSO and MOSCEM) in the calibration of hydrological models.

Evolutionary Algorithms: The algorithms used in this paper are: HBMO, proposed initially by Haddad et al (2006); its multiobjective version MOHBMO, proposed here; PSO e MOPSO as in Nascimento et al. (2006 e 2007); and SCEM e MOSCEM as described by Duan et al. (1992, 1993) and Vrugt et al. (2003), respectivelly.

Hydrologic Model: HYMOD (5 para,meters).

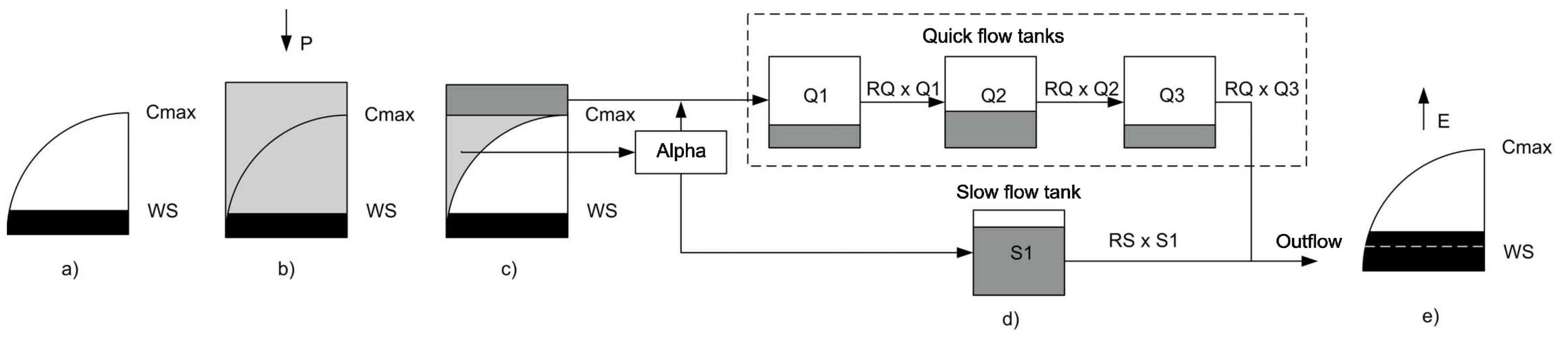

Figura 1: Schematic representation of HYMOD.

Test Functions: The performance of the algorithms were evaluated with test functions (Figure 2) which represent a challenge for any optimization algorithm. The difficulty for miminizing these functions is due to their inherent characteristics, such as: bias, discontinuity, concavity, minimum in their limits,among others.

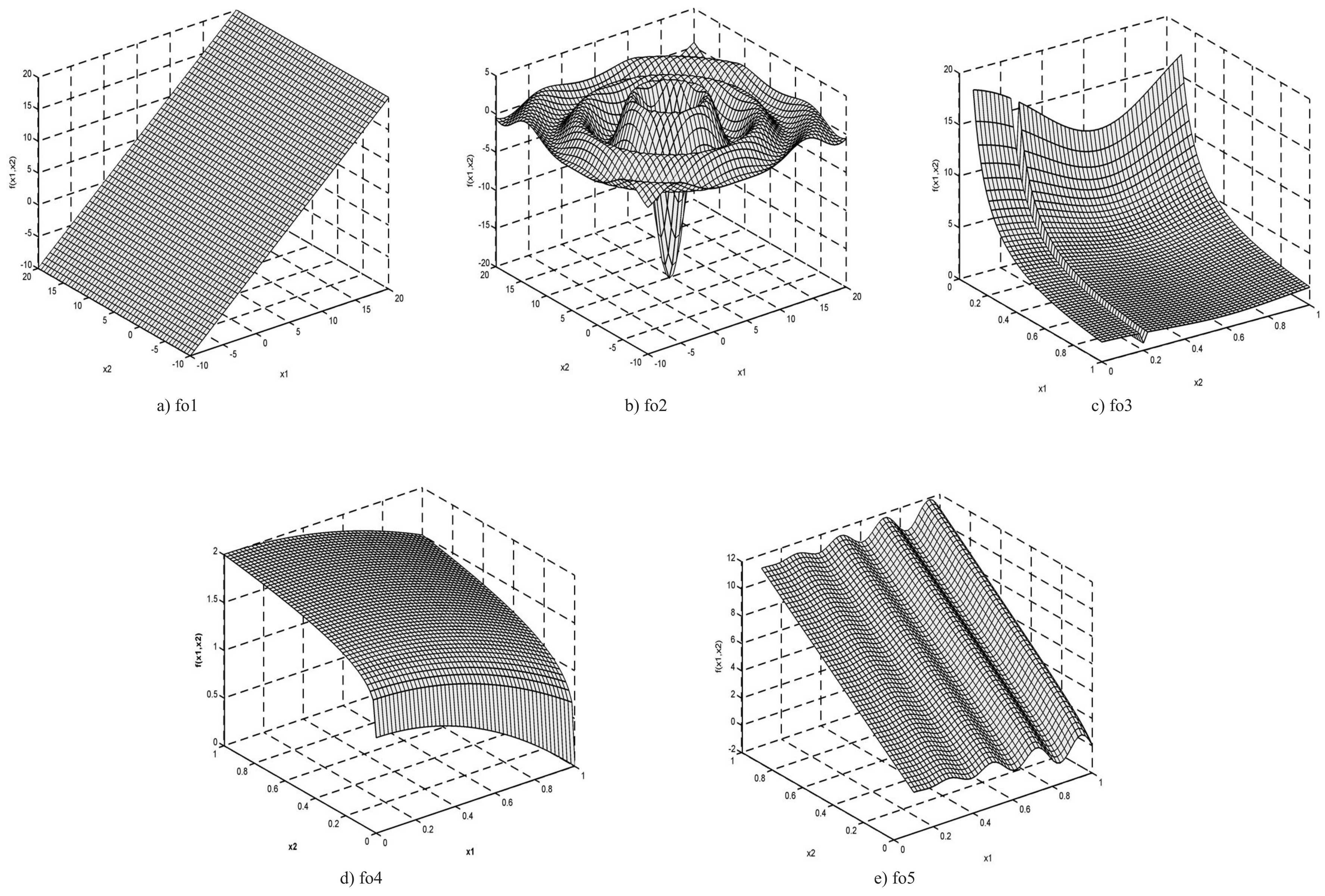

Figure 2: Test Functions.

Case of Study: Calibration of HYMOD for stream gage stations of Ceará and Piaui States, Brazil.

Objective Functions: Nash-Suttcliffe was applied to daily streamflow series (fo1), to characteristic points of the flow-duration curve (fo2), to peak flows (fo3) and to monthly volume series (fo4):

$$fo = \max_{\theta}\left\{1-\left(\sum_{i=1}^{N}(Q_i-\hat{Q}_i(\theta))^2\right)\Big/\left(\sum_{i=1}^{N}(Q_i-\overline{Q})^2\right)\right\}$$

Results/Test Functions: For the uniobjective minimization, it was analized the identified optimal value and the convergence as a function of the number of evaluations of the objective function. For the multiobjective optimization, it was analized the ability of each algorithm in filling the Pareto Front and in minimizing the objective functions. Figure 3 presents the results for the MO5 problem.

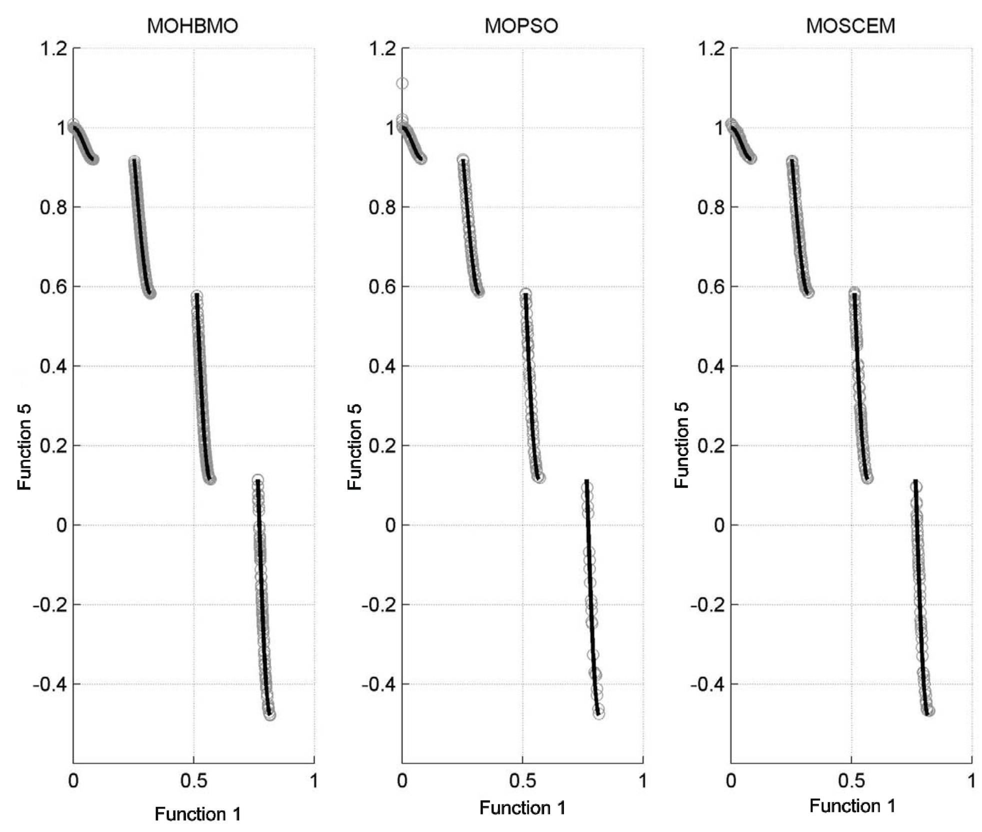

Figure 3: True and identified Pareto Fronts for the problem Mo5.

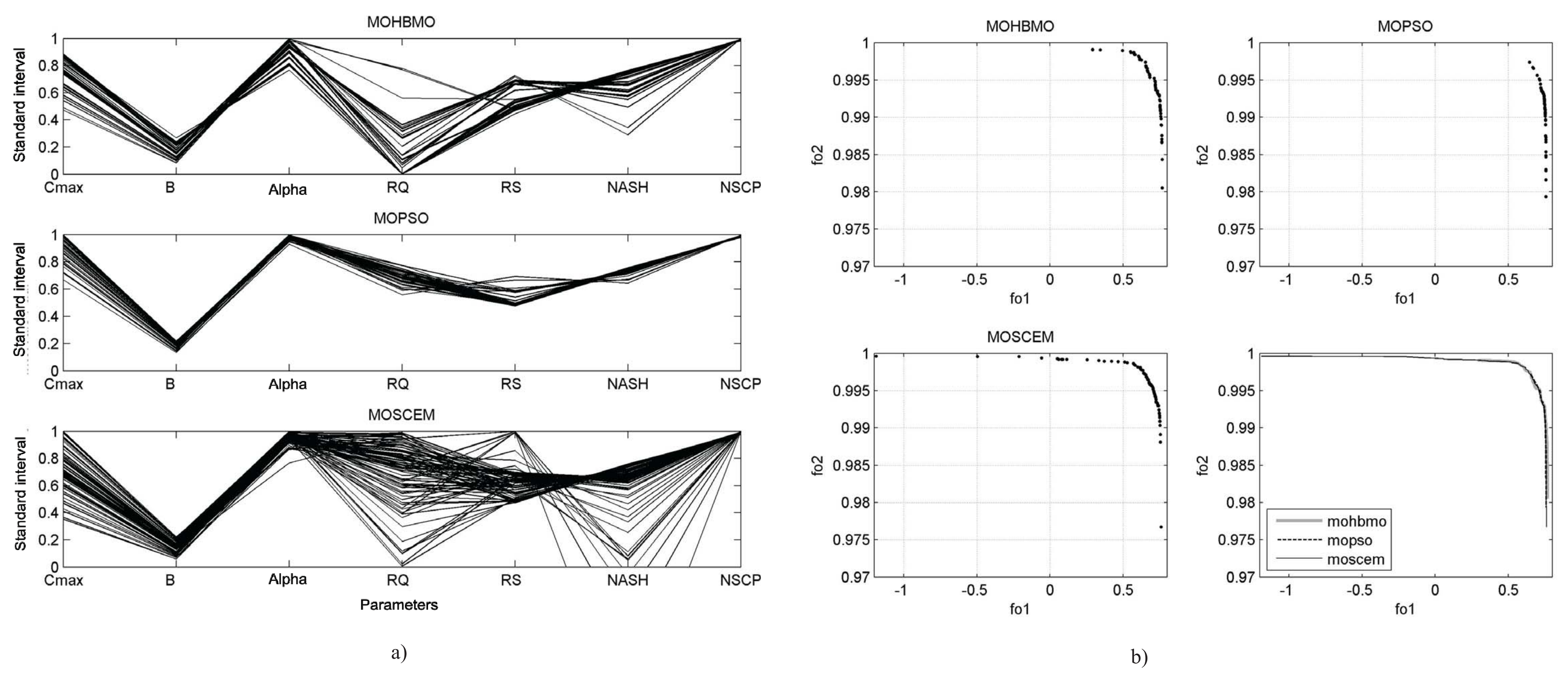

Figure 4: Optimal solutions identified by MOHBMO, MOSCEM e MOPSO algorithms using the objective function 1 and 2 in the calibration of the HYMOD model for the stream gage station 34750000: (a) set of optimal parameters; (b) Identified Pareto Fronts.

Results/Calibration: The performance of the before mentioned algorithms were evaluated for the calibration of the HYMOD model for the 21 stream gage stations employed here. The criteria of analisis are the same used in the minimization of the test functions. Figure 4 presents the result for calibration of stream gage station 34750000 using fo1 e fo2. Figure 5 presents the observed hydrograph and those associated to optimal solution set (Pareto Front) identified by the MOHBMO algorithm with objectives fo1 and fo3.

Conclusões: Generally, MOHBMO and MOSCEM had performance superior to MOPSO.

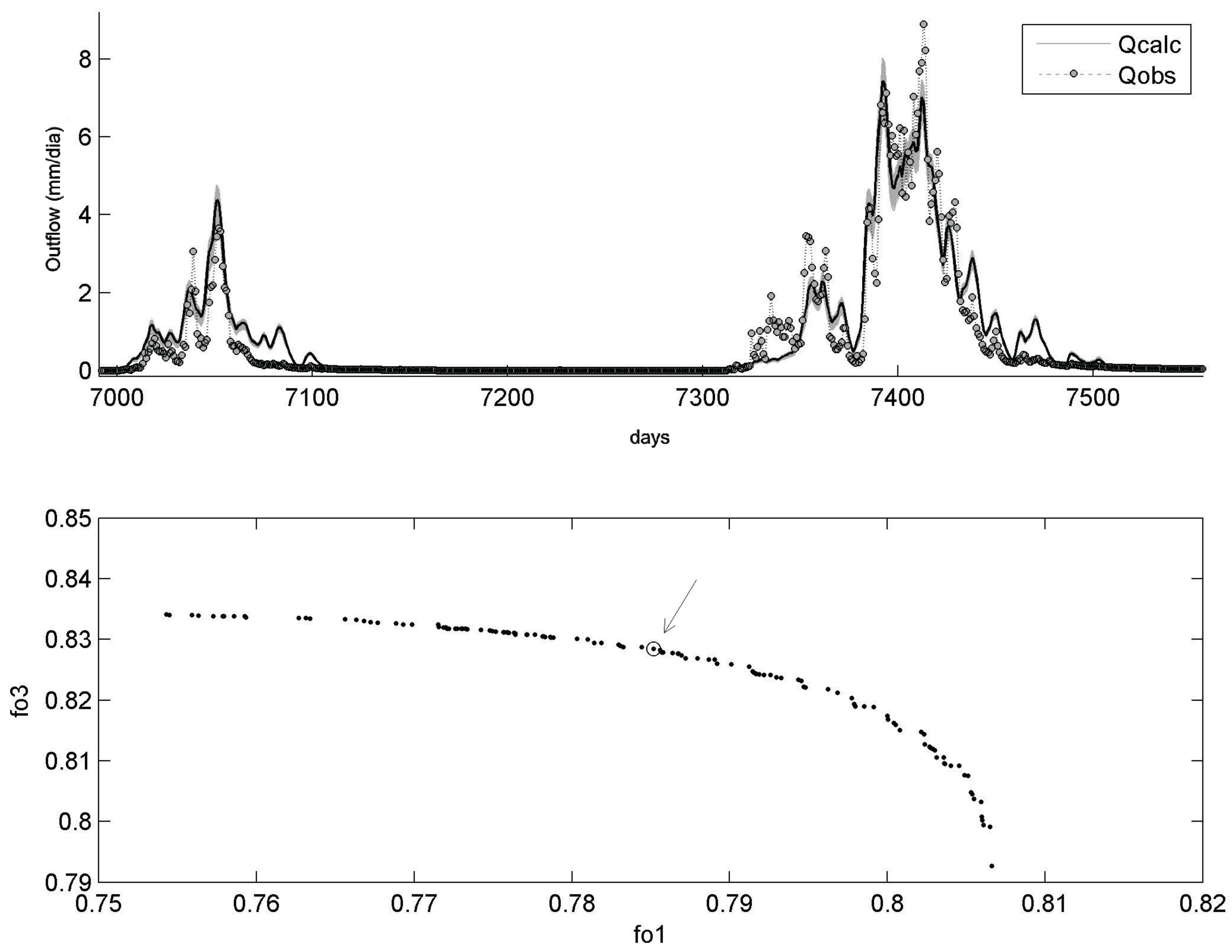

Figure 5: Observed Hydrographs and Pareto Front-based Hydrographs from fo1 e fo3. The dashed line represents the observed hydrograph, while the bold black line represents the best trade-off solution identified from the Pareto Front (see arrow). The Pareto Front is below the hydrographs.

Acknowlegments: The authors are thankfull to FUNCAP and FUNCEME for the finantial support over the course of this research.