

# A SOFTWARE FOR SENSITIVITY ANALYSIS, CALIBRATION AND INVERSION OF MACRO MODEL

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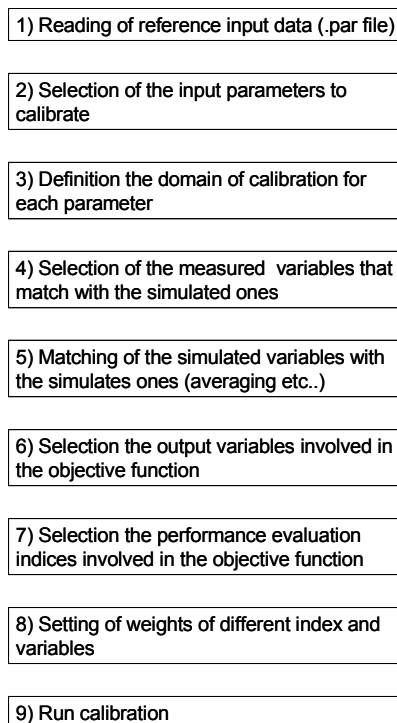
## Introduction

The correct use of mathematical models requires, after the verification phase (internal coherence and consistency), the analysis of sensitivity and the analysis of uncertainties. Besides this, the calibration of some (the minimum possible) empirical parameters is very common. More recently, models have also been used as an instrument for estimating physical parameters by a process called inversion. In a fully controlled environment (i.e. soil samples in the laboratory), with a extensive knowledge of soil parameters, inversion is considered a way to obtain values for physically based parameters. Even if inversion is typically done with laboratory data (Simunek et al., 1998) there are some examples also using field data (e.g. Ferraris and Acutis, 1994, Acutis et al, 2001). The widely used MACRO model (Jarvis, 1994) simulates water redistribution and solute (chemicals and pesticides) fate using Richards' and the convection-dispersion equations. Gravitational flow in macroporosity is simulated as a separate flow domain. The parameters involved in the definition of the separation and exchanges between the two domains are difficult to measure. Instead, the values of some of these parameters may be obtained by fitting to experimental data. Performing such a task is nearly impossible with such a highly complex model as MACRO without developing specific software tools. In this paper we describe a software tool for Win 9x and Win NT/2000 which performs batch runs, sensitivity analysis and automatic calibration (under a user defined objective function and constraints) of the MACRO model.

## Material and Methods

The flow of operation needed to use the program is shown in fig.1. Given that the software searches for matching of simulated and measured, it is possible to use data measured at irregular time step. This also implies that the date of measurement does not need to be the same for all the variables evaluated. The program will average value across soil layers, when the observed data are not measured with the same spatial resolution of the model output (fig 2). The indices used as objective function are RMSE, RRMSE, CRM, model efficiency and the predicted vs. actual regression coefficient and the probability of the Student t for paired data. A system of normalization of differences between measured and simulated data, and the use of a weight vector allows using as a objective function not only a single index computed on a single variable, but also a combination of more indices calculated on different variables (fig.3). Currently, the software performs: a) an exhaustive grid search for a maximum of 4 parameters within a user specified range. The grid step can be selected as constant, logarithmic, or defined by user), b) an adaptive

Figure 1. Main steps in program usage



random search in one, two or three steps. c) batch runs of MACRO, based on a user definition of a table of parameters and their values. Multi starting points simplex optimisation algorithm, under the constraints in the parameter domain, and a Marquardt like algorithm customised for inversion- are in advanced stage of development. A series of graphical output (predicted vs. measured, contour and surface plots of the objective function as a function of values of the calibrated variables) are available.

### Results

A software allowing for a collection of inversion and calibration methods (and other utilities) in the framework of a user friendly interface, is in advanced level of development. An automatic approach to model calibration results in a significant improvement with respect to the usual trial and error methods. The same structure is usable also for other models than MACRO, that have input and output files in ASCII or other known file format.

### Conclusions

Even if inversion is already included in some hydrological models and specific software are already proposed as a general purpose model inversion, the software that we are developing offers a wide range of possibilities to formulate the objective function, based on different indices and output variables, with a user-friendly interface and other accessories that can simplify the calibration and the performance evaluation of a complex model.

### References

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Figure 2. The matching between measured and predicted data tab.

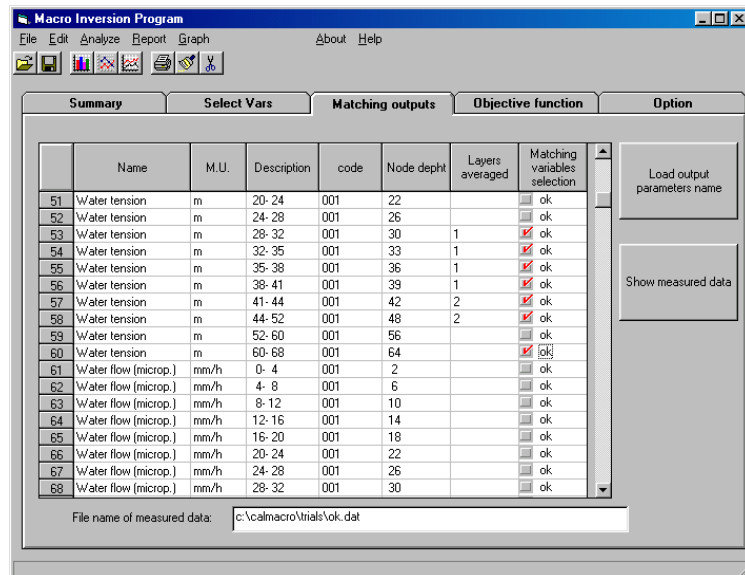


Figure 3. The Objective function definition tab.

