Overview of UCODE & Associated Codes

Modes that can be accomplished:

Forward Process Model run with Residuals

Conduct Sensitivity Analysis

Estimate Optimal Parameter values and associated linear uncertainty

Evaluate quality of the model

Estimate values of Predictions and associated linear uncertainty

Evaluate model linearity

Evaluate NonLinear uncertainty associated with
estimates of parameter values and predicted values

Auxiliary: Investigate Objective Function

See UCODE Manual
Chapter 1 for overview and description of manual contents
Chapter 2 for overview and program control
Also Chapter 4 Table 3

Evaluate MODEL LINEARITY - Beale's Measure
Use of linear confidence intervals, assumes the model is linear in the confidence regions of the parameters, this can be tested using Beale's Measure

Sets of parameter values near the optimal values but deviating based on the variances/covariances are generated and used in 2 ways:

To calculate the simulated equivalents using the application codes
achieving convergence for these values may require loosening up solver tolerance log transforming parameters may be necessary to prevent physically impossible negative values

To calculate the simulated equivalents using a linear approximation based on the sensitivities

Given these values Beale's Measure is calculated as:

Beale's Measure

$$\hat{N}_b = \frac{\sum_{j=1}^{2xNP'} \sum_{i=1}^{ND} \left(\tilde{y}_{ji} - \tilde{y}^o_{ji}\right)\omega_i\left(\tilde{y}_{ji} - \tilde{y}^o_{ji}\right)}{\sum_{j=1}^{2xNP'} \sum_{i=1}^{ND} \left(\tilde{y}^o_{ji} - \hat{y}_i\right)\omega_i\left(\tilde{y}^o_{ji} - \hat{y}_i\right)}$$

ND is the number of observations of hydraulic head and flow

$\hat{y}_i$ are hydraulic heads and flows simulated using the optimized parameter values

for the generated sets of values:

$\tilde{y}_{ji}$ represents the values calculated by the application codes

$\tilde{y}^o_{ji}$ represents the calculated linear approximation

CAUTION: if a model is optimized using only heads, Beale's measure will not reflect linearity with respect to a flow prediction, which is relevant to validity of the calculation of confidence intervals in the predicted flow

Sets of parameters for calculating Beale's Measure are determined based on their variance which depends on their sensitivity and the goodness of fit:

$$\underline{b} = \underline{\hat{b}} \pm \frac{\sqrt{NP \quad F_\alpha(NP, NDOF)}}{s_{b_i}} \underline{V_{b_i}}$$

$$\underline{\hat{b}} = \text{optimal parameter values}$$

$$\underline{V_{b_i}} = \text{the } i^{th} \text{ column of } \underline{\underline{V_{b_i}}} = \left(\underline{\underline{X}}^T \omega \underline{\underline{X}}\right)^{-1} s^2$$

$$s_{b_i} = \sqrt{V_{b_{ii}}}$$

Evaluate MODEL LINEARITY with UCODE (p35 p168)

ucode3-linearity with output files from the regression ucode1 be copied into that folder

This next step requires only a small change to UCODE input that was used for REGRESSION input not PREDICTION input

UCODE_DATA_CONTROL
(linearity=yes) for an execution that does not overwrite any previously created output files but needs to have them in the directory.

UCODE calculates the simulated equivalents for the parameter sets in _b1 and writes them in _b2

output: fn.#umodlin and fn._b2

Notice that the parameter sets in _b1 are so divers that modflow cannot run, so at this point the linearity assessment is beyond our reach.

We will resolve that in the future by incorporating transient data

After that is done we would run a UCODE auxiliary code: model_linearity.exe (make a batch file for this, p35)

It must be executed in the directory where the files from the regression, optimize=yes
And the
_b2 file from the linearity=yes
executions reside.

See fn.#modlin, particulary comments at the end of the file