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

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When prediction=yes, UCODE calculates predictions and sensitivities (if sensitivities=yes) of the model parameters to those predicted values for the purpose of calculating 95-percent linear confidence and prediction intervals on the predictions. IN PREDICTION MODE WE CHANGE THE PROCESS MODEL TO THE PREDICTIVE CONDITIONS

We will get both
CONFIDENCE INTERVALS and PREDICTION INTERVALS
ON PREDICTED VALUES

CONFIDENCE INTERVALS are based on var-cov of parameters, reflecting certainty associated with the parameters

PREDICTION INTERVALS are based on var-cov of parameters AND the measurement error reflecting our ability to measure the predicted value

3 ALTERNATIVE METHODS OF CALCULATION OF INTERVALS for both CONFIDENCE INTERVALS AND PREDICTION INTERVALS on PREDICTIONS

Appropriate method depends on # of predictions jointly considered

1) INDIVIDUAL INTERVALS
2) SIMULTANEOUS INTERVALS - more than one interval
3) SIMULTANEOUS INTERVALS - undefined number of intervals (e.g. drawdown over an area must be limited to a given magnitude, but the location of the maximum drawdown cannot be determined a priori).

Only the critical values differ and are obtained from one of:

- Student-t Distribution
- Bonferroni-t Distribution
- Scheffe (based on the F-distribution)

UCODE tests for the appropriate method, then prints intervals for Individual and Both Simultaneous Intervals. Of these 3, the user selects the interval appropriate for their question.

INDIVIDUAL CONFIDENCE INTERVALS

$$z'_\ell \pm t_s\left(n, 1.0-\frac{\alpha}{2}\right) s_{z'_\ell}$$

$z'_\ell = \ell^{th}$ simulated value

$t_s\left(n, 1.0-\frac{\alpha}{2}\right)$ = critical value, value with $\frac{\alpha}{2}$ probability that a student-t distributed random value would be larger

n = degrees of freedom (ND+NPR-NP)

α = significance level, commonly 0.05 or 0.10 (5 or 10%)

$s_{z'_\ell}$ = standard deviation of the prediction

Sensitivity of the simulated equivalent of the prediction to the parameters

$$s_{z'} = \left[\sum_{i=1}^{NP}\sum_{j=1}^{NP}\frac{\partial z'}{\partial b_j}\, V(b_{ij})\, \frac{\partial z'}{\partial b_i}\right]^{\frac{1}{2}}$$

Element ij of the variance/covariance matrix

SIMULTANEOUS CONFIDENCE INTERVALS

Two Methods: Bonferroni & Scheffe

Both conservative with respect to significance level

Both are calculated by UCODE and the smaller is used

Bonferroni: $z'_\ell \pm t_B\left(n\ , 1.0 - \frac{\alpha}{2k}\right) s_{z'_\ell}$

where k is the number of simultaneous intervals and
t_B is the Bonferroni - t probability distribution for a
given number of degrees of freedom and
simultaneous intervals
at the selected significance level

Scheffe: $z'_\ell \pm t_s\left(d, F_\alpha(d,n)\right) s_{z'_\ell}$

where d = k (# simultaneous intervals)
OR
the # of parameters (whichever is less) and
F_α is the critical value from the
F probability distribution for a given
number of degrees of freedom at the
selected significance level

PREDICTION INTERVALS are broader than confidence intervals because they include the probability that the MEASURED value will fall into the interval. Calculations are the same as for confidence intervals, however the standard deviation is increased to reflect the measurement error as follows:

$$z'_\ell \pm t_s\left(n\ , 1.0 - \frac{\alpha}{2}\right)\left(s_{z'_\ell} + s_a\right)$$

where s_a is the product of the
standard error of the regression
and the
expected measurement error of the prediction

EVALUATE PREDICTIVE UNCERTAINTY using OPTIMAL PARAMETER VALUES with UCODE

Develop a predictive MODLFOW Model
Import to ModelMate as per instructions in PDF file

Run UCODE with prediction=yes, first to be sure all is functioning correctly
Then with sensitivity=yes
UCODE calculates the sensitivity of the predictions to the parameters at the optimal values

linear_uncertainty is executed in that folder with the ucode root file name as input, e.g.

C:\WRDAPP\UCODE_2005\bin\linear_uncertainty.exe ep_Ucode

This ucode prediction execution must be done in the folder with the regression data exchange files and does not overwrite previously created UCODE output files

It produces additional files

#upred
_p _pv _dmp _spu _sppp _sppr _spsp _spsr

The linear_uncertainty execution produces

#linunc and ._linp

You can view the results in GW_Chart