GDSMI Video's

General

A series of training videos has been prepared. These discuss the theory of inversion and uncertainty analysis, and how this theory is implemented in PEST and its utility support software suite. Each of these videos is narrated by John Doherty, the author of PEST. These videos, as well as PowerPoint slideshows that are displayed in these videos, are all downloadable at no cost.

What is PEST

This video provides an overview of PEST and the three families of utility software that accompany it. It also provides a brief discussion of the demands of decision-support environmental modelling, for this is the context in which PEST must operate.

What is Calibration?

This short video discusses what it means to calibrate a groundwater (or other) environmental model. Calibration implies uniqueness. The quest for uniqueness is not a quest for truth. Uniqueness of solution of an ill-posed inverse problem requires regularization. If properly applied, regularization yields a solution to that problem which is of minimized error variance. However the potential for error in a calibrated parameter field, and in many predictions made by a calibrated model, can still be high.

Vectors and Statistics

This video provides a short reminder of some aspects of matrix and vector algebra that we all learned at school but have since forgotten. It does the same for a few basic statistical concepts. It may be useful to watch this video before watching some of the videos listed below.

Well-Posed Inverse Problems

This video shows how parameters can be estimated when model calibration constitutes a well-posed inverse problem. Unfortunately, in groundwater modelling, well-posedness does not occur unless preceded by manual regularization. This is not recommended practice, for reasons discussed in the video. Nevertheless, the discussion provides a solid foundation for other videos in this series which focus on solution of ill-posed inverse problems. Of particular interest is the discussion on how to extend linear inverse theory to calibration of nonlinear models.

Problems with Manual Regularization

This video extends the discussion of the preceding video, while laying foundations for ensuing videos. It explains how calibration based on manual regularization may fail to find a parameter field that minimizes the error variance of important model predictions. It also shows why calibration achieved through manual regularization does not provide a good foundation for post-calibration uncertainty analysis, and does not resolve the relationships between estimated and true properties of an environmental system. The "cost of uniqueness" can therefore not be assessed.

Singular Value Decomposition

Singular value decomposition (SVD) is explained. Also explained is the important role that SVD can play in solving ill-posed inverse problems, and the insights that it can provide into what calibration of an environmental model can and cannot achieve. Important concepts such as the null space are introduced. An explanation of over-fitting is provided; the reasons why this should be avoided are explained.

Tikhonov Regularization

The importance of Tikhonov regularization in solution of ill-posed inverse problems is discussed. PEST's implementation of Tikhonov regularization in groundwater model calibration is explained. It is shown how appropriate implementation of Tikhonov regularization can facilitate the use of expert knowledge, and of information forthcoming from site characterization studies, in groundwater model calibration.

Pilot Points

Pilot points are often employed as a parameterization device for groundwater models. This is because they can provide a sound basis for highly-parameterized inversion, while restricting parameters to a number which is low enough to allow filling of a Jacobian matrix using finite difference derivatives. This video discusses options for their emplacement, and how Tikhonov regularization is best applied in estimation of pilot point parameters. The video finishes with an example which demonstrates how, despite our best efforts to introduce geologically-meaningful Tikhonov regularization to the groundwater model calibration process, important hydrogeologically-significant structures may remain invisible to it.

Getting the Most out of PEST – Part 1

This is the first video of a two-part series whose intention is to provide PEST users with some information on how to use PEST, and some of its supporting software, to best effect. This video covers the PEST control file, the difference between singular value decomposition and SVD-assist, and easy ways to add Tikhonov regularization to a PEST control file.

Getting the Most out of PEST – Part 2

This second video of a two-part series covers calculation of finite-difference derivatives, defences against model output numerical granularity, some aspects of observation weighting, termination criteria, Marquardt lambda settings, and the use of some important PEST support utilities.