The Use of Spatial Statistics in Estimating the Properties for a Phase Change Process

A. F. Emery and D. Bardot

Abstract:

Because inverse problems are so ill conditioned, the estimation of thermal properties often involves regularization. The choice of the regularization and the constants associated with it are not always well defined. As a consequence, there is some uncertainty about the effect of the choice and of the stopping criterion. Since regularization can be related to Bayesian estimation, some understanding of these effects can be gained by viewing the process from this point of view.

Irrespective of the approach, estimation of parameters is in effect the determination of the extremum point of a response surface that is typically done using Gauss or Gauss-Newton iterative techniques. When the computations of the nonlinear system response are expensive, the iterative process can be very expensive and the additional costs associated with trying different regularization functions can make a global examination of the property estimation process computationally infeasible.

An alternative approach is the use of spatial statistics, especially kriging, which can be regarded as a BLUE estimation based only on a knowledge of the spatial structure of the interaction between the system response and the parameters. This method is widely and successfully used in hydology and other areas in which field data are available. For property estimation, instead of an iterative process based on updated property values, one chooses a number of sample values of the parameters, computes the responses, i.e., the field data, and then determines the extremum through a minimization of an ensemble of functions.

Change of phase problems are intrinsically difficult to solve, highly nonlinear, and their inverse is particularly ill conditioned. In this paper we compare the methods of estimation based on a) traditional regularization and b) spatial statistics. Both problems are affected by the high degree of non-linearity. Both are shown to give acceptable and comparable results under limiting assumptions.