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Sensitivity and uncertainty analysis in basin modeling to quantify the value of data

In basin modeling, uncertainties exist concerning the geologic concept of a model, its assumptions and its input parameters. Therefore, outcomes of geologic models should be expressed in a probabilistic rather than a single-valued form. Monte Carlo methods are not appropriate because they need many realisations which is not feasible for multidimensional non-linear basin models due to their oftentimes extensive computing times. Methods of experimental design and response surface modeling are more appropriate because they sample the parameter space in an optimal manner thereby reducing the number of necessary model runs significantly. Higher-order designs can be used to describe the actual behavior of the response function and their uncertainty. Well data, seismic data or laboratory data are used to constrain the model outcome. Their potential in reducing uncertainty can be determined and therefore the actual value of available data and data to be acquired can be quantified.

It is the particular geological history and the particular exploration and modeling question that determines which parameters are most important and which type of data has the greatest influence on the model response and therefore the greatest value in reducing the uncertainty of the model outcome. Applications to 1D thermal modeling show that maturity of source rocks and timing of HC generation and expulsion can be a complex function of individual parameters such as heat flow history and source rock type but also of the interaction of parameters which is frequently neglected. 2D fluid flow modeling is particularly sensitive to permeability structure and to sedimentation history while 3D migration is sensitive to spatial distributions of thermal, geochemical and structural geological parameters. Examples of all three applications will be shown