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Estimating uncertainties in complex joint inverse problems

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Sources of uncertainty affecting geophysical inversions can be classified either as reflective (i.e. the practitioner is aware of her/his ignorance) or non-reflective (i.e. the practitioner does not know that she/he does not know!). Although we should be always conscious of the latter, the former are the ones that, in principle, can be estimated either empirically (by making measurements or collecting data) or subjectively (based on the experience of the researchers). For complex parameter estimation problems in geophysics, subjective estimation of uncertainty is the most common type. In this context, probabilistic (aka Bayesian) methods are commonly claimed to offer a natural and realistic platform from which to estimate model uncertainties. This is because in the Bayesian approach, errors (whatever their nature) can be naturally included as part of the global statistical model, the solution of which represents the actual solution to the inverse problem. However, although we agree that probabilistic inversion methods are the most powerful tool for uncertainty estimation, the common claim that they produce "realistic" or "representative" uncertainties is not always justified. Typically, ALL UNCERTAINTY ESTIMATES ARE MODEL DEPENDENT, and therefore, besides a thorough characterization of experimental uncertainties, particular care must be paid to the uncertainty arising from model errors and input uncertainties. We recall here two quotes by G. Box and M. Gunzburger, respectively, of special significance for inversion practitioners and for this session: "...all models are wrong, but some are useful" and "computational results are believed by no one, except the person who wrote the code".
In this presentation I will discuss and present examples of some problems associated with the estimation and quantification of uncertainties in complex multi-observable probabilistic inversions, and how to address them. Although the emphasis will be on sources of uncertainty related to the forward and statistical models, I will also address other uncertainties associated with data and uncertainty propagation.