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Quantifying Uncertainties in Inverse Problems: Meaning and Usefulness of Error Bars in Large-Scale Inversion

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Abstract: While the U.S. Department of Energy's National Nuclear Security Administration (NNSA) has moved to a scientific paradigm driven by modeling and simulation and in which experimentation is motivated primarily by code validation, there is still much to be learned by analyzing data directly and extracting information from experimental data by solving inverse problems. In order to quantify the uncertainties associated with the solutions, however, it is necessary to use statistical approaches to formulating the inverse problems and to understand the nature of the uncertainties for which such formulations can correctly account. In this work we will present data from NNSA X-ray imaging experiments related to the stockpile stewardship program, some inverse problems whose solutions inform the evolution of our experiments and diagnostics systems, and the challenges associated with the Bayesian formalisms used to assign error bars to the information extracted. The discussion will include details of the experiments themselves, where mathematical data analysts fit into the experimental programs, the role of mathematical theory in development of analysis techniques, and results demonstrating the efficacy of solving statistical inverse problems to drive stockpile stewardship..

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