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Recent Advances in Optimizing Field Campaigns (Invited)

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In the environmental sciences, scarcity and observation errors in data impede all endeavors to uniquely calibrate, identify or even verify models. This is often countered by engaging stochastic or statistical models, combined with (geo)statistical inversion, data assimilation, or any other related forms of Bayesian updating that openly admit and quantify the remaining uncertainty.

The Quest for the Grail consists in having more and "better" data to more tightly constrain the remaining uncertainties in spite of limited budgets for additional field campaigns. Optimal field campaigns would reduce, at minimum costs, the uncertainties in model structures and parameters, boundary and initial conditions. Thus, they would allow more precise predictions, more transparent management decisions, more reliable engineering designs or more confident scientific conclusions.

There is a variety of approaches to optimize field campaigns along these lines. All of them need to touch four basic elements: (1) how to provide a suitable envelope and formulation for the (prior) uncertainties pertinent in modeling, (2) how to conceptualize the information needs arising from a given task at hand as a (set of) suitable objective(s) for optimization, (3) how to efficiently evaluate a proposed design under these objectives while no actual data values are available yet, and (4) how to formulate, implement and solve the optimization problem. They vary greatly in accuracy, efficiency, complexity and philosophy.

This talk is a progress report on recent advances in optimization methods for field campaigns, providing examples from the 'stochastic modeling of hydrosystems' workgroup and reviewing exemplary developments in each of the four basic elements. Emphasis is on Bayesian (geo)statistics and model averaging in element (1), task-driven formulations of information needs in step (2), accurate (non-linear) information processing versus computational efficiency in step (3), and simplistic versus complex multi-objective optimization philosophies in step (4).