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Optimizing an experimental design for an electromagnetic experiment

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Most of geophysical studies focus on data acquisition and analysis, but another aspect which is gaining importance is the discussion on acquisition of suitable datasets. This can be done through the design of an optimal experiment. Optimizing an experimental design implies a compromise between maximizing the information we get about the target and reducing the cost of the experiment, considering a wide range of constraints (logistical, financial, experimental . . .).

We are currently developing a method to design an optimal controlled-source electromagnetic (CSEM) experiment to detect a potential CO_2 reservoir and monitor this reservoir during and after CO_2 injection.

Our statistical algorithm combines the use of linearized inverse theory (to evaluate the quality of one given design via the objective function) and stochastic optimization methods like genetic algorithm (to examine a wide range of possible surveys). The particularity of our method is that it uses a multi-objective genetic algorithm that searches for designs that fit several objective functions simultaneously.
One main advantage of this kind of technique to design an experiment is that it does not require the acquisition of any data and can thus be easily conducted before any geophysical survey.

Our new experimental design algorithm has been tested with a realistic one-dimensional resistivity model of the Earth in the region of study (northern Spain CO_2 sequestration test site). We show that a small number of well distributed observations have the potential to resolve the target. This simple test also points out the importance of a well chosen objective function.

Finally, in the context of CO_2 sequestration that motivates this study, we might be interested in maximizing the information we get about the reservoir layer. In that case, we show how the combination of two different objective functions considerably improve its resolution.