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Interactive Comment

Interactive comment on "Designing optimal greenhouse gas observing networks that consider performance and cost" *by* D. D. Lucas et al.

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Response to Anonymous Referee #2

We greatly appreciate the feedback from Anonymous Referee #2. The referee identified a few minor issues that will be corrected in our revised manuscript (i.e., a couple of typos, fixing the colorbar in Fig. 9, and adding a reference).

In addition, the referee draws attention to the "Number of evaluations" metric used to compare the efficiency of the Incremental optimization (IO) and single objective genetic

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algorithm (SOGA) schemes. We address the efficiency comparison in more detail below. Moreover, we note that the data used to compare the optimization methods will be released to a public data repository. This data can be used by the referee and other researchers to test and compare the efficiencies of different optimization algorithms for network design problems.

Efficiency of IO versus SOGA. The referee points out that our comparison of the algorithmic efficiency of IO versus SOGA should consider other factors besides just the raw number of evaluations of the objective function, and we agree. In particular, the "evaluation time" of a single computation of the objective function f_1 depends on the number of stations in the network because the sizes of $\boldsymbol{\xi}_m$, $\boldsymbol{\xi}_o$, and $\mathbf{X}_m$, and hence the time to solve $\mathbf{S}_N$, vary with the network size. The "evaluation time" changes for IO because it adds stations one-by-one to the network, whereas it remains constant for SOGA because 6 stations are assessed during each iteration. We have estimated the "evaluation time" versus number of network stations for our Bayesian inversion implementation on a specific hardware configuration. We find that the relationship is best described by a straight line with a slope of 0.034 seconds per station added and an intercept of 0.079 seconds, which is associated with fixed data i/o. Using these estimates, the "evaluation time" accumulated across the number of objective function evaluations is about 3481 seconds for IO, 1678 seconds for SOGA Best, and 470 seconds for SOGA Efficient. By this measure, SOGA Best and SOGA Efficient are 2 and 7 times more efficient than IO, respectively, because the overall number of objective function evaluations is more important than the increase in "evaluation time" for larger networks. Even if we remove the time for fixed data i/o, SOGA still outperforms IO. There is, however, an additional efficiency factor that was not identified by the reviewer and that varies between IO and SOGA. The "decision time" is the amount time it takes for the algorithm to determine which station or stations to add to the network. For IO, the "decision time" is negligible and is based on a search for the station with the smallest inversion variance at each stage. The "decision time" for SOGA, on the other hand, is larger because it ap-

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plies the four genetic operations at each generation (fitness assessment, reproduction, crossover and mutation). The SOGA "decision time" is not constant and varies from generation-to-generation because the population changes, so we estimate an average value of 0.052 seconds per objective function evaluation from the difference between the cumulative "evaluation time" and total run time. Relative to the "evaluation time" of 0.283 seconds for a 6-station network, the SOGA "decision time" does not adversely impact the performance of the algorithm. We therefore conclude that SOGA Best and SOGA Efficient are 2 and 7 times more efficient than IO, respectively, for our problem. We will revise the manuscript to reflect our better understanding of the efficiency differences.

Interactive comment on Geosci. Instrum. Method. Data Syst. Discuss., 4, 705, 2014.