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Multiscale Data Assimilation of Spatially Distributed Information

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In data assimilation problems, various types of data are naturally linked to different spatial scales (e.g. seismic and electromagnetic data), and these scales are usually not coincident to the subsurface simulation model scale. Alternatives like down/upscaling [1] of the data and/or the simulation model can be used, but with potential loss of important information. To address this issue, a novel Multiscale (MS) data assimilation method is introduced. The overall idea of the method is to keep uncertain parameters and observed data at their original representation scale, avoiding down/upscaling of any quantity. The method relies on a recently developed mathematical framework to compute Adjoint gradient via a MS strategy [2, 3]. The fine-scale uncertain parameters are directly updated and the MS grid [4, 5] is constructed in a resolution that meets the observed data resolution. The advantages of the technique are demonstrated in the assimilation of data represented in a coarser scale than the simulation model. The misfit objective function is constructed to keep the MS nature of the problem. The regularization term is represented at the simulation model (fine) scale, whereas the data misfit term is represented at the observed data (coarse) scale. The performance of the method is demonstrated in synthetic models and compared to down/upscaling strategies. The numerical experiments show that the MS strategy provides advantages on the computational side –expensive operations are only performed at the coarse scale; on the accuracy –the matched uncertain parameter distribution is closer to the "truth"model; and in the optimization performance –faster convergence behavior and smaller OF value are obtained. As conclusion, the newly developed method is capable of providing superior results when compared to strategies that rely on the downscaling of the observed data, addressing the scale dissimilarity via a robust, consistent MS strategy.

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