Adaptive renormalization of stochastic dynamics with application to data assimilation and numerical modeling

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A fundamental problem in upscaling is that one procedure may work well to upscale form scale A to scale B, but fails to upscale from scale B to scale C. One example of this is in geological CO_2 sequestration where a broad range of relevant scales prevent any one approach from being effective on all scales. We propose an adaptive renormalization group approach to overcome this problem. The method assimilates data from different scales and uses statistical tests to determine the appropriate upscaling behavior. Then a suitable scale-dependent renormalization group operator is selected. This operator is used to upscale the process until the scaling behavior associated with this operator breaks down. Upon detecting this breakdown, more statistical tests are performed to determine the appropriate upscaling behavior on this larger scale. Such an approach makes it possible to adaptively select one renormalization operator to go from scale A to scale B and a potentially different operator to go from scale B to scale C. The adaptive renormalization group approach can be used broadly to upscale many processes provided sufficient experimental and simulation data is available.