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Rigorous Analysis and Numerical Implementation of Nudging Data Assimilation Algorithms

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In this talk, we will introduce downscaling data assimilation algorithms for weather and climate prediction based on discrete coarse spatial scale measurements of the state variables (or only part of them, depending on the underlying model). The algorithm is based on linear nudging of **the coarse spatial scales** in the algorithm's solution toward the coarse spatial scales corresponding to the observed measurements of the unknown reference solution. The algorithm's solution can be initialized arbitrary and is shown to converge at an exponential rate toward the exact unknown reference solution. This indicates that the dynamics of the algorithm is globally stable (not chaotic) unlike the dynamics of the model that governs the unknown reference solution. Capitalizing on this fact, we will also demonstrate uniform in time error estimates of the numerical discretization of these algorithms, which makes them reliable upon implementation computationally. Furthermore, we will also present a recent improvement of this algorithm by employing nonlinear nudging, which yields super exponential convergence rate toward the unknown exact reference solution. Notably, this algorithm applies to all dissipative systems, however, we will show by examples that it does not work for non-disspative systems.