Part I

Basic methods and algorithms for data assimilation

After an introduction that sets up the general theoretical framework of the book and provides several simple (but important) examples, the two approaches for the solution of DA problems are presented: classical (variational) assimilation and statistical (sequential) assimilation. We begin with the variational approach. Here we take an *optimal control* viewpoint based on classical variational calculus and show its impressive power and generality. A sequence of carefully detailed inverse problems, ranging from an ODE-based to a nonlinear PDE-based case, are explained. This prepares the ground for the two major variational DA algorithms, 3D-Var and 4D-Var, that are currently used in most large-scale forecasting systems. For statistical DA, we employ a Bayesian approach, starting with optimal statistical estimation and showing how the standard KF is derived. This lays the foundation for various extensions, notably the ensemble Kalman filter (EnKF).