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Session 8: Data assimilation and model validation

Data assimilation in geophysics. An update

Olivier Talagrand[1]

[1] *Laboratoire de Météorologie Dynamique, IPSL, École Normale Supérieure, Paris, France*

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Assimilation of observations, which originated from the need of defining initial conditions for numerical weather forecasts, and then progressively extended to many diverse applications, has become a basic component of numerical modeling of geophysical systems. Assimilation of observations is best expressed as a problem in Bayesian estimation. Namely, determine the probability distribution for the state of the system under observation, conditioned to the available information. That information essentially consists of the observations proper, and of the physical laws that govern the system, available in practice in the form of discretized numerical model. For a number of reasons, starting with the very large dimension of the corresponding state space (up to 10^8 for numerical weather prediction models), Bayesian estimation is not possible in practice, and one has to restrict to more modest goals. The main two present types of assimilation algorithms, Variational Assimilation (VA) on the one hand, and Ensemble Kalman Filter (EnKF) on the other, are empirical extensions, to weakly nonlinear situations, of Best Linear Unbiased Estimation (BLUE), which achieves Bayesian estimation in linear and Gaussian cases. Variational Assimilation globally adjusts a model solution to observations distributed over a period of time. Ensemble Kalman Filter evolves in time an ensemble of estimates of the system state, and updates those estimates as new observations become available. The update is performed according to the theory of BLUE. The performances of both types of algorithms is presented, and their respective advantages and disadvantages is discussed. Particle Filters, like EnKF, evolve an ensemble of state estimates, but use an exactly Bayesian updating scheme. However, their cost has so far been too high for use for large dimension systems. Their performance, and possible future evolution, are discussed.