Uncertainty quantification based on 4DVar data assimilation for massive simulation models

*伊藤 伸一[1]、加納 将行[2]、長尾 大道[1]
*Shin-ichi Ito[1], Masayuki Kano[2], Hiromichi Nagao[1]

1. 東京大学、2. 東北大学
1. The University of Tokyo, 2. Tohoku University

Data assimilation (DA) is a fundamental computational technique that integrates numerical simulation models and observation data on the basis of Bayesian statistics. Originally developed for meteorology, especially weather forecasting, DA is now an accepted technique in various scientific fields. One key issue that remains controversial is the implementation of DA in massive simulation models under the constraints of limited computation time and resources. This work proposes a DA technique based on a four dimensional variational (4DVar) method for massive autonomous models that produces optimum estimates and their uncertainties within reasonable computation time and resource constraints. The uncertainties are given as several elements of an inverse Hessian matrix, which is the covariance matrix of a normal distribution that approximates the target posterior probability density function in the neighborhood of the optimum. The proposed method based on a second-order adjoint method allows us to directly evaluate the elements of the inverse Hessian matrix without computing all of its elements. Some numerical tests assuming a massive simulation model confirm that the proposed method works well and enables us to evaluate the uncertainties of the parameters involved in the assumed model faster than the conventional DA approaches. Such information regarding uncertainty is valuable, as it can be used to optimize the design of experiments.

キーワード：ベイズ統計、データ同化、不確実性評価
Keywords: Bayesian statistics, Data assimilation, Uncertainty quantification

