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A Comparison between the Ensemble and Standard Sequential Data Assimilation Methods Based on the Kalman Filter for an Impact-Induced Shock-Wave Study with Laboratory Data

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This study is based upon our recent work of data assimilation using the extended Kalman filter (EKF) method in a nonlinear shock-wave code with a limited amount of laboratory data in a one-dimensional configuration (Kao et al., 2004, *J. Comp. Phys*. 196, 705; EGU General Assembly, 2004). EKF was proofed to be useful in tracking the evolution of all the state variables with a shock passage and reducing model errors by sequentially assimilating available data into the model system. The state variables obtained by the blending of the model solution with the available data, along with their associated minimized errors (or uncertainties), are then used as initial conditions for further prediction. However, the "standard" application of EKF as used in the above study is known to be extremely expensive for solving its associated error-covariance equation if multi-dimensional problems are encountered. We are thus motivated to experiment with the widely used ensemble Kalman filter (EnKF) method (Evensen, 1994), based on the same nonlinear code and data in our earlier study where the standard EKF was used.

The ensemble with a size N was constructed using N different stochastic forcing functions as described in Kao et al. (2004). This is somewhat different from typical geophysical applications where the ensembles are constructed from the initial fields. For a case of N equal 100, our results show that the EnKF assimilation of a small amount of pressure data helps track the evolution of all the state variables, while the ensemble average is not discernable from the original model simulation without the stochastic forcing. The mean error growth in time is well bounded in the case of EnKF except with a magnitude several factors larger that in the case of EKF, which explains

the closer resemblance between data and assimilated values in the case of EnKF. It appears that the current work has provided a basic justification for using EnKF in multi-dimensional shock-wave studies.