ON THE PHYSICAL CONSISTENCY OF DATA ASSIMILATION AND A COMPUTATIONALLY EFFECTIVE APPROXIMATE SMOOTHER

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Because of model errors, data assimilated state estimates by themselves have physically inconsistent temporal evolution. For example, in the atmosphere and ocean, estimates often do not satisfy continuity and their energy budgets cannot be closed. Such inconsistencies make it difficult to infer mechanisms and processes that underlie changes in these dynamic systems. Emphasis on state estimation is rooted in part in interests in forecasting. Understanding dynamic systems, however, requires establishing descriptions of a physically consistent evolution of the state. Smoothers can be recognized as inverting estimates into such consistent results. A partitioned smoother is introduced as a rigorous yet computationally effective assimilation method that can be employed with large general circulation models. An essential element in such inversion is estimation of process noise (or control) in addition to the estimation of the state. Process noise is the source of model uncertainty, such as errors associated with the model's external forcing, parameters, and numerics. The distinction between estimating the state and control is illustrated and discussed using examples in ocean and atmosphere data assimilation. The importance of identifying explicit physical models of model process noise and of constructing an effective approximation of these errors are emphasized.