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Optimal weighting of scarce measurements for accurate prediction of chaotic transition dynamics[1] DAVID BUCHTA, TAMER ZAKI, Johns Hopkins University — Transition dynamics in chaotic systems are extremely sensitive to uncertainties in control parameters such as initial conditions. This uncertainty compromises predictions of models and simulations. To enhance the fidelity of simulations, we infuse them with available observations and minimize a Bayes-based cost function. The accuracy of our estimated state depends on the observations, and naively infusing all observations, equally, may be ill-suited for gradient-based optimization. Observations with chaotic dynamics create an oscillatory cost-function landscape, which is tortuous to navigate and contains multiple high-curvature optima. To smooth the landscape, we developed a sensor weighting that optimizes invariants of the Hessian matrix of the cost function. Weights are selected to reduce the most extreme curvature which we ascribe to observations that are highly sensitive to uncertainty in the control parameters. Relative to equal sensor weights, the proposed weighting accelerates convergence to the optimal estimate of the flow and improves prediction accuracy. Thermal convection and high-speed boundary-layer transition are examined in this context.

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