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Vortex-based flow estimation with an ensemble Kalman filter[1]
DARWIN DARAKANANDA, JEFF D. ELDREDGE, University of California, Los Angeles, ANDRE FERNANDO DE CASTRO DA SILVA, TIM COLONIUS, California Institute of Technology — Inviscid vortex models have been used for decades to investigate unsteady aerodynamics, including those with leading-edge separation. While these models successfully capture the qualitative behavior of the force response at large angles, the lack of a leading-edge condition makes them poor predictors of separated flows, and the buildup of vortex particles renders them increasingly inefficient over time. In this work, we introduce a flow estimator based on the Ensemble Kalman Filter, in which the prediction of an ensemble of inviscid vortex models is improved by incorporating surface pressure measurements from an experiment. Our state consists of the position and circulation of all the vortex particles, as well as critical suction parameters that govern vortex shedding from the two edges of the airfoil. To prevent the dimension of the state from continuously increasing over time, we introduce a vortex pruning algorithm that regularly merges dynamically related clusters of vortex particles. We demonstrate the estimator on a variety of problems, including pitch-up, impulsive translation, as well as flows with pulse actuation near the leading edge.

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