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Least Squares Shadowing Sensitivity Analysis of Chaotic and Turbulent Fluid Flows[1] PATRICK BLONIGAN, QIQI WANG, STEVEN GOMEZ, Massachusetts Institute of Technology — Computational methods for sensitivity analysis are invaluable tools for fluid dynamics research and engineering design. These methods are used in many applications, including aerodynamic shape optimization and adaptive grid refinement. However, traditional sensitivity analysis methods break down when applied to long-time averaged quantities in chaotic fluid flow fields, such as those obtained using high-fidelity turbulence simulations. This break down is due to the "Butterfly Effect"; the high sensitivity of chaotic dynamical systems to the initial condition. A new sensitivity analysis method developed by the authors, Least Squares Shadowing (LSS), can compute useful and accurate gradients for quantities of interest in chaotic and turbulent fluid flows. LSS computes gradients using the "shadow trajectory," a phase space trajectory (or solution) for which perturbations to the flow field do not grow exponentially in time. This talk will outline Least Squares Shadowing and demonstrate it on several chaotic and turbulent fluid flows, including homogeneous isotropic turbulence, Rayleigh-Bénard convection and turbulent channel flow.

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