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Lyapunov Exponents and Covariant Vectors for Turbulent Flow Simulations PATRICK BLONIGAN, SCOTT MURMAN, NASA Ames Research Center, PABLO FERNANDEZ, QIQI WANG, Massachusetts Institute of Technology — As computational power increases, engineers are beginning to use scale-resolving turbulent flow simulations for applications in which jets, wakes, and separation dominate. However, the chaotic dynamics exhibited by scale-resolving simulations poses problems for the conventional sensitivity analysis and stability analysis approaches that are vital for design and control. Lyapunov analysis is used to study the chaotic behavior of dynamical systems, including flow simulations. Lyapunov exponents are the growth or a decay rate of specific flow field perturbations called the Lyapunov covariant vectors. Recently, the authors have used Lyapunov analysis to study the breakdown in conventional sensitivity analysis and the cost of new shadowing-based sensitivity analysis [1]. The current work reviews Lyapunov analysis and presents new results for a DNS of turbulent channel flow, wall-modeled channel flow, and a DNS of a low pressure turbine blade. Additionally, the implications of these Lyapunov analyses for computing sensitivities of these flow simulations will be discussed.
[1] Q. Wang, R. Hui, and P. Blonigan. Least squares shadowing sensitivity analysis of chaotic limit cycle oscillations. Journal of Computational Physics, 267:210224, June 2014.

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