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Adjoint-field errors in high fidelity compressible turbulence simulations for sound control RAMANATHAN VISHNAMPET, DANIEL BODONY, JONATHAN FREUND, University of Illinois at Urbana-Champaign — A consistent discrete adjoint for high-fidelity discretization of the three-dimensional Navier-Stokes equations is used to quantify the error in the sensitivity gradient predicted by the continuous adjoint method, and examine the aeroacoustic flow-control problem for free-shear-flow turbulence. A particular quadrature scheme for approximating the cost functional makes our discrete adjoint formulation for a fourth-order Runge-Kutta scheme with high-order finite differences practical and efficient. The continuous adjoint-based sensitivity gradient is shown to to be inconsistent due to discretization truncation errors, grid stretching and filtering near boundaries. These errors cannot be eliminated by increasing the spatial or temporal resolution since chaotic interactions lead them to become $O(1)$ at the time of control actuation. Although this is a known behavior for chaotic systems, its effect on noise control is much harder to anticipate, especially given the different resolution needs of different parts of the turbulence and acoustic spectra. A comparison of energy spectra of the adjoint pressure fields shows significant error in the continuous adjoint at all wavenumbers, even though they are well-resolved. The effect of this error on the noise control mechanism is analyzed.

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