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ASSESSMENT OF TURBULENCE CLOSURES FOR DETACHED FLOWS CONTROL

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Active flow control is an active research area for the last decade, which benefits from the progress of simulation methods, in terms of accuracy and robustness, and from the continuous increase of computational facilities. Actuator devices, such as synthetic jets or vortex generators, have proved their ability to modify the flow dynamics and represent a promising way to improve the aerodynamic performance of a system, without modifying its shape. However, the determination of efficient flow control parameters, in terms of location, frequency, amplitude, etc., is tedious and highly problem dependent.

To overcome this issue, the numerical simulation of controlled flows is often considered to determine optimal control parameters, or at least a range of efficient parameters [1, 2]. However, several studies have shown that the simulation of controlled flows is a difficult task, because the actuation generates complex turbulent structures. Large Eddy Simulation (LES) is certainly the most appropriate approach for such problems [3], but the related computational burden makes its use tedious for optimization or exploration of control parameters. Reynolds-Averaged Navier-Stokes (RANS) models are more suitable in practice, but the results obtained may be highly dependent on the turbulence closure used. Moreover, the numerical assessment should be done carefully because the solution is strongly influenced by the numerical parameters, such as the time step or the grid size.

Therefore, the objective of the current study is to provide a rigorous and systematic assessment of some classical turbulence closures (Spalart-Allmaras, Launder-Spalding $k-\epsilon$, Menter SST $k-\omega$, EASM models) for RANS-based simulations with a synthetic jet actuation. Two test cases are selected, corresponding to the flows over a backward facing step and a 25° ramp, for which a synthetic jet is introduced to minimize the time-averaged recirculation length. The impact of turbulence closures is quantified for a range of actuation

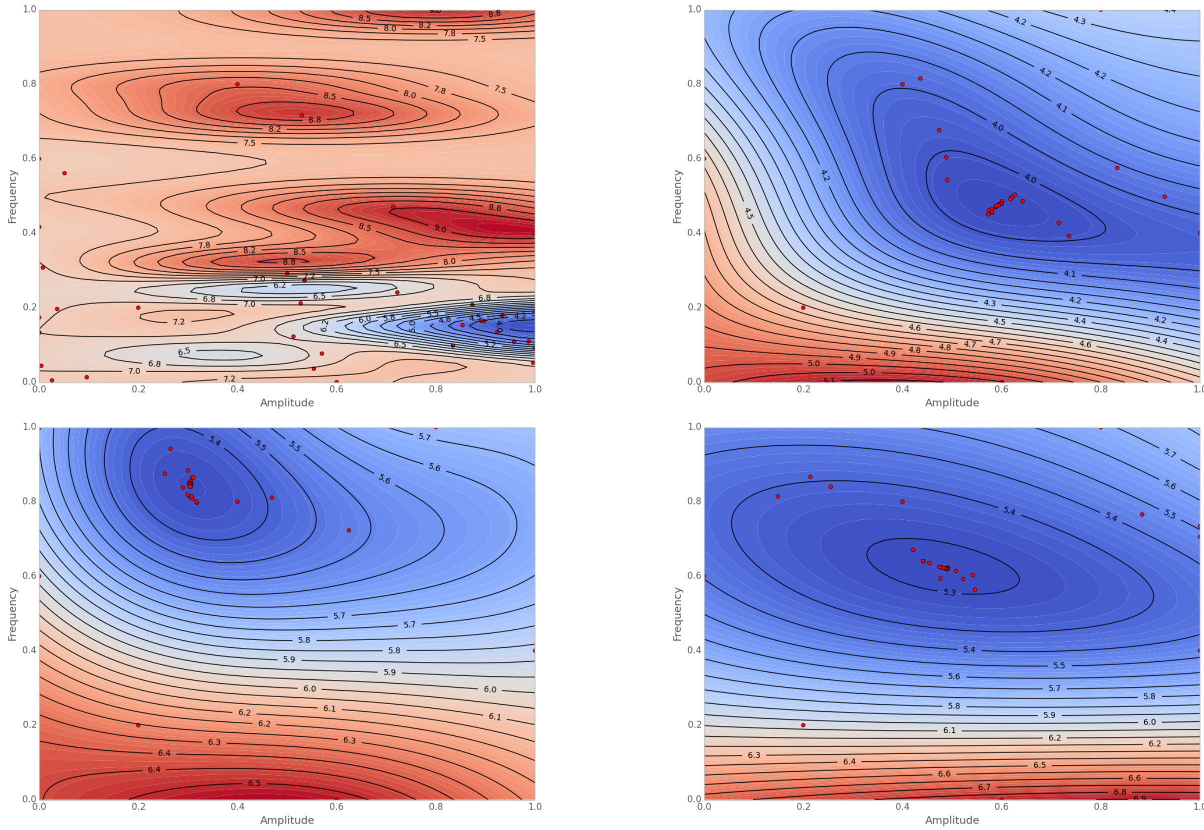

Figure 1: Recirculation length w.r.t. actuation parameters for the backward facing step case, for Spalart-Allmaras (top-left), Launder-Spalding $k-\epsilon$ (top-right), Menter SST $k-\omega$ (bottom-left), EASM (bottom-left) models, reconstructed from the optimization process.

parameters (frequency, amplitude) and for a complete optimization process. Therefore, the influence of the turbulence closures on the optimal control parameters found by the automated optimization procedure is quantified, as illustrated by Fig. (1). Finally, flow characteristics are analyzed to understand the discrepancies observed between the different flow predictions and provide practical guidelines for forthcoming studies.

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