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INFLUENCE OF PRESSURE-STRAIN CLOSURE ON THE PREDICTION OF SEPARATED FLOWS

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Computationally efficient RANS calculations are necessary in the aerospace design process [11], where a large number of simulations must be performed. Flow separation, that often dominates complex practical flows, even at nominal operating conditions [3] presents marked anisotropy [10] and strong hysteresis [4] phenomena which require advanced turbulence closures to achieve acceptable accuracy. Differential Reynolds-stress models (RSMs) which directly include several important mechanisms (anisotropy, convective history, streamline curvature, redistribution, Coriolis effects) in the exact equations that are modelled are increasingly considered as a promising practical alternative [8] to the 2-equation closures that have widely dominated RANS CFD in the past two decades [2], especially with the availability of efficient and robust low-diffusion slovers [1]. The paper discusses the performance of the final evolution of a 7-equation $r_{ij} - \varepsilon^*$ wall-normal-free RSM [5], especially with reference to selected test-cases of the NASA Turbmodels project [9], namely the 2-D NACA4412 airfoil trailing-edge separation case and the 2-D convex curvature boundary-layer validation case. The GLVY RSM slightly improves a previous successfull model [6], especially in the reattachment region, and also has a different apparent transition behaviour [7].
The success of both these models [5, 6] in predicting flows with large separation (Fig. 1) is attributed to the particular functional dependence of the rapid redistribution isotropization of production model coefficient [6, Fig. 4, p. 1837]. To further substantiate the previous results [3, 5] we study two separated flow configurations that are part of the NASA Turbmodels test cases [9], and discuss perspectives in differential Reynolds-stress modelling.

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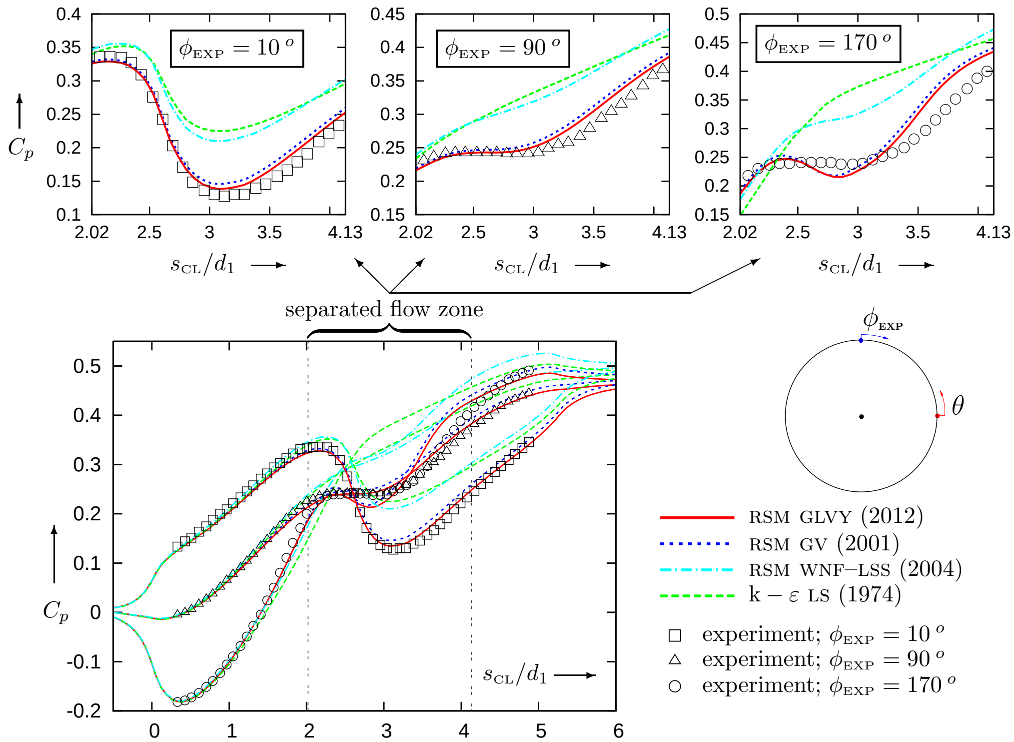

Figure 1: Comparison of computed and measured pressure coefficient C_p along the centerline s_{CL}/d_1 directions at three circumferential angles ϕ_{EXP} in the S-duct of Wellborn et al. [12], using three Reynolds-stress models and a linear $\text{k}-\varepsilon$ model ($Re_{\text{CL}} = 2.6 \times 10^6$, $2{\times}10^6$ points grid) with a zoom in the experimental separated flow region between $s_{\text{CL}}/d_1 = 2.02$ and $s_{\text{CL}}/d_1 = 4.13$.

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