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APPLICATION OF REYNOLDS STRESS MODELS TO SEPARATED AERODYNAMIC FLOWS

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Second-moment Reynolds stress models (RSM) have been around for many years, but they are rarely used for industrial aeronautical applications. Partly, this has been because they are more expensive than one- and two-equation turbulence models, but also there is a perception that they are less robust and more difficult to converge. Furthermore, in spite of supposedly better physics, RSMs have often failed to achieve significantly improved results compared to simpler models. However, several groups have continued to work to improve RSMs, including Gerolymos et al. [1] and Cecora et al. [2]. There is renewed interest in RSMs as a possible route to improve Reynolds-averaged Navier-Stokes (RANS) capabilities for predicting separated flows. Most widely used workhorse eddy-viscosity models are considered unreliable for predicting such flows. The ω-based Reynolds stress model of Wilcox (WilcoxRSM-w2006) [3] and its variant (SSG/LRR-RSM-w2012) due to Cecora et al. [2] have been implemented into the NASA code CFL3D [4]. WilcoxRSM-w2006 uses the LRR pressure-strain correlation model [5], while SSG/LRR-RSM-w2012 blends LRR near walls with SSG [6] away from walls. As a realistic test case, the ONERA M6 wing [7] is of interest because it has a shock-induced boundary layer separation. The conditions computed here are $\alpha = 4.08°$, $M = 0.84$, $Re_c = 11.72 \times 10^6$. Results are shown in the figures. The WilcoxRSM-w2006 model agreed with experiment better inboard, but predicted massive separation outboard. SSG/LRR-RSM-w2012 predicted only a small amount of outboard separation, and agreed better with experiment in that region. The current results for the latter model also agreed well with those in Cecora et al. [2]. Additional explorations using these models on relevant 3-D configurations, including those with side-of-body separation bubbles, will be conducted for the final presentation.

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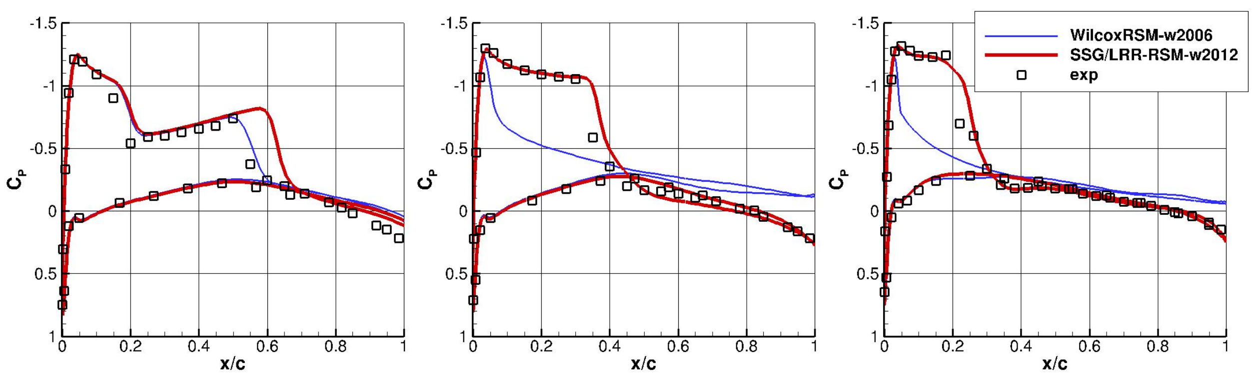
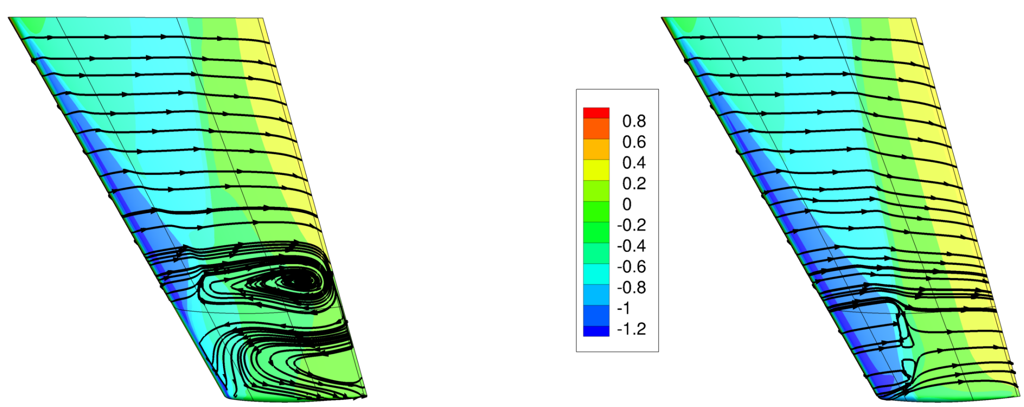


(a) $\eta = 0.44$ (b) $\eta = 0.80$ (c) $\eta = 0.96$

Figure 1: Onera M6 wing surface C_p computed with RSMs, $\alpha = 4.08°$.



(a) WilcoxRSM-w2006 model (b) SSG/LRR-RSM-w2012 model

Figure 2: Onera M6 wing surface streamlines computed with RSMs, $\alpha = 4.08°$ (contours represent surface C_p).