Subgrid-scale modelling towards large-eddy simulation of laminar-turbulent transitional flows: methodology and application

Zuoli Xiao[a] and Xiaole Wang[a,b]

A transition predictive subgrid-scale model is proposed for large-eddy simulation (LES) of wall-bounded turbulent flows characterized by laminar-to-turbulent transition. The present SGS model is designed to be composed of two parts depending on the distance to the nearest wall. In the near-wall region, both the mean SGS stress and heat flux are constrained by external Reynolds stress and heat flux to ensure the total target quantities and onsite of transtion, while the fluctuating SGS stress and heat flux are closed in a traditional fashion but using residual model parameterizations.[1,2] In the far-wall region, a helicity-featured SGS model is directly employed with necessary smoothing operation in the neighborhood of the constrained/unconstrained interface, which might be different for the stress and heat flux depending on the flow configuration.[3] Flows past an E387 airfoil and an ultra-high-lift low-pressure turbine cascade are numerically studied using the new LES technique. The results are compared with the available experimental and direct numerical simulation (DNS) data, and those from traditional LES and detached-eddy simulation (DES). It turns out that the transition-based constrained large-eddy simulation (TrCLES) method can predict the size of the separation bubble, mean flow profile, and friction force, etc. more accurately than traditional LES and DES techniques. Moreover, the TrCLES method proves to be much less sensitive to the grid resolution than traditional LES method.

[a] Dep. Mechanics and Engineering Science, Peking University, 5 Yiheyuan Rd., Beijing, China

[b] The 28th Research Institute of CETC, 1 Muxuyuan E St, Nanjing, Jiangsu, China

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[3] Wang and Xiao, J. Fluid Mech. **941**, A22 (2022).

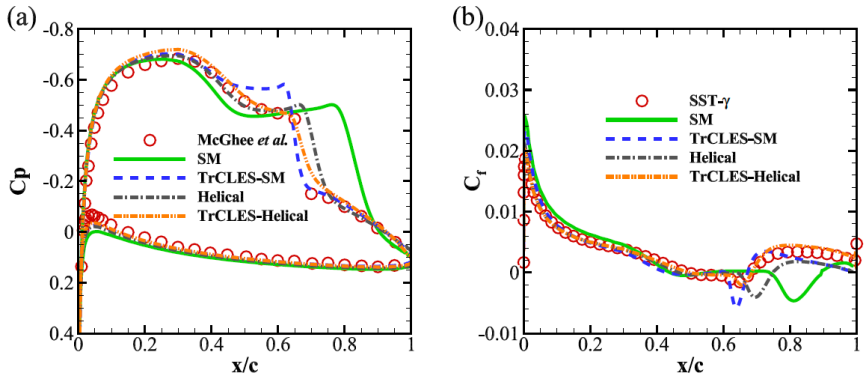

Figure 1: Distributions of (a) pressure coefficient and (b) skin friction coefficient along the surface of E387 airfoil obtained using different methods.