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A sub–grid scale model with natural near–wall damping

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Abstract

A zero–equation sub–grid scale (SGS) model with a variable eddy–viscosity coefficient C_μ is developed for large–eddy simulation. Since C_μ is evaluated based on the resolved shear and vorticity parameters accompanied by the hybrid time scale T_t (combination of dynamic and Kolmogorov time scales), it is sensitized to non-equilibrium flows, preserving the anisotropic characteristics of turbulence. The current model accounts for the SGS kinetic energy with $k_{sgs} = C_\mu^{\frac{2}{3}}(\bar{\Delta}\bar{S})^2$ and guarantees the positivity in the energy components. Unlike the original Smagorinsky model, the present SGS model does not need any *ad-hoc* damping function (C_μ acts as a natural damping function as the wall is approached) or averaging/clipping of the model coefficient for numerical stabilization as required by the dynamic Smagorinsky model (DSM). The model is validated against well–documented flow cases, yielding predictions in good agreement with the direct numerical simulation (DNS) and experimental data. Comparisons indicate some advantages of the new model over the DSM; the current model needs only a single-filtering operation that recovers the numerical stability and computational effort to a greater extent.

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