H.9 Lecture 9

$k-\omega$ SST DES (modify $\beta^* k\omega$)

$$C^k = D^k + P^k - F_{DES}\beta^* k\omega, \quad F_{DES} = \max\left\{\frac{L_t}{C_{DES}\Delta}, 1\right\} = \max\left\{\frac{k^{1/2}}{\beta^*\omega C_{DES}\Delta}, 1\right\}$$

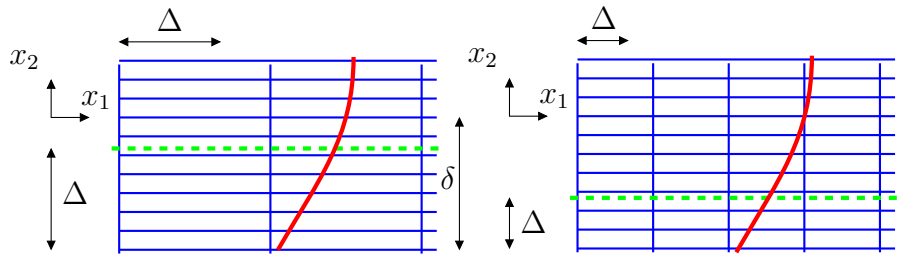
Dissip. term $\beta^* k\omega \propto \dfrac{k^{3/2}}{L_t} \Rightarrow \beta^* k\omega \propto \dfrac{k^{3/2}}{C_{DES}\Delta}$ in LES region

¶See Section 20.3, DDES

▶It may occur that the F_{DES} term switches to DES in the boundary layer because Δx_1 is too small (Δx_3 is usually smaller than Δx_1)

Hence boundary layer is treated in LES mode with too a coarse mesh ⇒ poorly resolved LES ⇒ inaccurate predictions.

▶The solution is DDES (Delayed DES)



Grid (in blue) and a velocity profile (in red). RANS-LES interface is shown by the dashed-green line.

- The left grid above is a good DES mesh because (see Eq. 20.4) $\ell_t = \min\left(C_\mu \frac{k^{3/2}}{\varepsilon}, C_{DES}\Delta\right) = C_{DES}\Delta = C_{DES}\Delta x_1 \simeq \delta$ ($C_{DES} = 0.67$) → the entire boundary layer is modeled by RANS.
- The grid on the right is a poor DES grid because the outer part of the boundary layer is in LES mode (and the LES resolution requirements are not satisfied)

▶In DDES, F_{DES} is computed as (see Eq. 20.9)

$$F_{DDES} = \max\left\{\frac{L_t}{C_{DES}\Delta}(1 - F_S), 1\right\}$$

where F_S ($F_S = 1$ in the boundary layer) is taken as F_1 or F_2 (see Eqs. 16.12 and 16.18) of the SST model.