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Mellor-Yamada Turbulence Scheme - Level 2.5

The material derivative in (ξ,η,ς,t) coordinates is given by

$$\frac{H_\theta}{mn}\frac{DA}{Dt} = \frac{\partial}{\partial t}\left(\frac{H_\theta A}{mn}\right) + \frac{\partial}{\partial \xi}\left(\frac{H_\theta u A}{n}\right) + \frac{\partial}{\partial \eta}\left(\frac{H_\theta v A}{m}\right) + \frac{\partial}{\partial \varsigma}\left(\frac{H_\theta \Omega A}{mn}\right) \tag{1}$$

where A is any fluid property (scalar or vector).

Level 2.5 closure

The governing equation for the turbulent energy square is

$$\frac{D}{Dt}\left(\frac{q^2}{2}\right) - \frac{\partial}{\partial z}\left[l q S_q \frac{\partial}{\partial z}\left(\frac{q^2}{2}\right)\right] = P_s + P_b - \varepsilon_d \tag{2}$$

where q^2 is the turbulent energy square, P_s is the shear production of turbulent energy, P_b is the buoyant production of turbulent energy, and ε_d is the dissipation of turbulent energy, and

$$P_s = -\langle wu \rangle \frac{\partial u}{\partial z} - \langle wv \rangle \frac{\partial v}{\partial z} \tag{3}$$

since

$$-\langle wu \rangle = K_M \frac{\partial u}{\partial z} \tag{4}$$

$$-\langle wv \rangle = K_M \frac{\partial v}{\partial z} \tag{5}$$

$$\boxed{P_s = K_M\left[\left(\frac{\partial u}{\partial z}\right)^2 + \left(\frac{\partial v}{\partial z}\right)^2\right]} \tag{6}$$

The buoyant production of turbulent energy is

$$P_b = \frac{g}{\rho_0}\langle w\rho \rangle \tag{7}$$

since

$$-\langle w\rho \rangle = K_H \frac{\partial \rho}{\partial z} \tag{8}$$