and the material derivative

$$\frac{DA}{Dt} = \left(\frac{\partial A}{\partial t}\right)_z + (\vec{V}\cdot\nabla_z)A + w\frac{\partial S}{\partial z} = 0 \qquad \text{advective form} \qquad (1.6)$$

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

1.1 Boundary conditions

ⓐ The surface boundary conditions at $z = \zeta(x,y,t)$ are :

$$K_M \frac{\partial u}{\partial z} = \tau_s^x(x,y,t), \quad K_M \frac{\partial v}{\partial z} = \tau_s^y(x,y,t) \qquad (1.7)$$

$$K_H \frac{\partial T}{\partial z} = \frac{Q_T}{\rho_0 C_p} \qquad (1.8)$$

$$K_H \frac{\partial S}{\partial z} = \frac{E-P}{\rho_0} \qquad (1.9)$$

where τ_s^x, τ_s^y are the components of the wind stress acting on the free surface in the x- and y- directions respectively; Q_T is surface heat flux, E is evaporation, P is precipitation, and C_p is the Capacity of sea water.

ⓑ The bottom boundary conditions at $z = -h(x,y)$ are :

$$K_M \frac{\partial u}{\partial z} = \tau_b^x(x,y,t), \quad K_M \frac{\partial v}{\partial z} = \tau_b^y(x,y,t) \qquad (1.10)$$

$$K_H \frac{\partial T}{\partial z} = 0 \qquad (1.11)$$

$$K_H \frac{\partial S}{\partial z} = 0 \qquad (1.12)$$

where

$$\tau_b^x = \left(\gamma_1 + \gamma_2\sqrt{u^2+v^2}\right)u \qquad (1.13)$$

$$\tau_b^y = \left(\gamma_1 + \gamma_2\sqrt{u^2+v^2}\right)v \qquad (1.14)$$

and γ_1 an γ_2 are coefficients of linear and quadratic bottom friction, respectively.