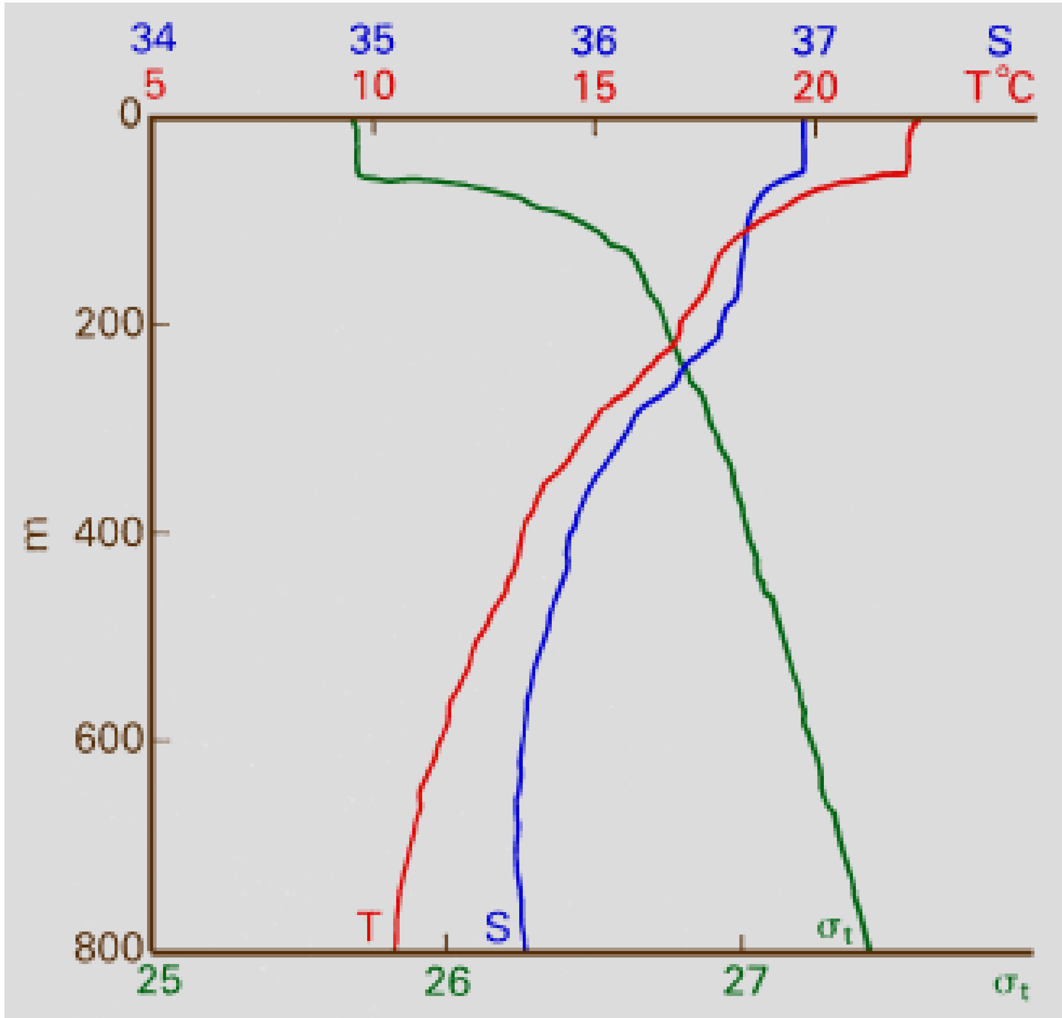
Capa Límite

Jorge Zavala-Hidalgo

Curso sobre ciclones tropicales con énfasis en el Pacífico Oriental

Marzo 2008, La Paz, B.C.S.

➢ Perfil típico en el océano tropical y capa de mezcla



➢ Evolución de la capa mezclada

- Crecimiento
  - Convección
  - ECT (TKE)

- Decrecimiento
  - Calentamiento (aumento en la flotación)
  - Menor ECT

Modelos de capa mezclada

- Diferenciales (Mellor/Yamada)
  - Integrales (Tipo Krauss/Niiler)

Diferenciales (Mellor/Yamada)

$$\frac{\partial u}{\partial t} = fv + \frac{\partial}{\partial z}\left(K_M + \nu_M \frac{\partial u}{\partial z} \right)$$

$$\frac{\partial v}{\partial t} = -fu + \frac{\partial}{\partial z}\left(K_M + \nu_M \frac{\partial v}{\partial z} \right)$$

$$\frac{\partial T}{\partial t} = \frac{\partial}{\partial z}\left(K_H + \nu_H \frac{\partial T}{\partial z} \right) + \frac{1}{\rho Cp_r} \frac{\partial F}{\partial z}$$

$$\frac{\partial S}{\partial t} = \frac{\partial}{\partial z}\left(K_H + \nu_H \frac{\partial S}{\partial z} \right)$$

Condiciones de frontera

$$(K_M + \nu_M)\frac{\partial u}{\partial z}\bigg| = \frac{\tau^x}{\rho_0}$$

$$(K_M + \nu_M)\frac{\partial v}{\partial z}\bigg| = \frac{\tau^y}{\rho_0}$$

$$(K_H + \nu_H)\frac{\partial T}{\partial z} = \frac{Q_b + Q_e + Q_s}{\rho_0 c_p}$$

$$(K_H + \nu_H)\frac{\partial S}{\partial z} = S\big|_{z=0}(E - P)$$

$$K_{H_1} = lqS_M$$

$$K_{M_1} = lqS_M$$

$$0 = K_H\left[\left[\left(\frac{\partial u}{\partial z}\right)^2 + \left(\frac{\partial u}{\partial z}\right)^2\right] + K_H \frac{g}{\rho_o}\frac{\partial \rho}{\partial z} - \frac{q^3}{cl}$$

l	es la escala turbulenta
$q^2/2$	es la energía cinética turbulenta
S_M y S_H	son funciones de estabilidad

Modelos tipo KT

$$h\frac{\partial u_m}{\partial t} + \Delta u \frac{\partial h}{\partial t} = \frac{1}{\rho_0}\tau^x - \nu_M \frac{\partial u}{\partial z}\bigg|_{-h} + hfv \qquad (7a)$$

$$h\frac{\partial v_m}{\partial t} + \Delta v \frac{\partial h}{\partial t} = \frac{1}{\rho_0}\tau^y - \nu_M \frac{\partial v}{\partial z}\bigg|_{-h} - hfu \qquad (7b)$$

$$h\frac{\partial T_m}{\partial t} + \Delta T \frac{\partial h}{\partial t} = \frac{1}{\rho_0 c_p} Q_0 - \nu_H \frac{\partial T}{\partial z}\bigg|_{-h} + \frac{1}{\rho_0 c_p} Q_R(1 - F_h) \qquad (7c)$$

$$h\frac{\partial S_m}{\partial t} + \Delta S \frac{\partial h}{\partial t} = S_m(E - P) - \nu_H \frac{\partial S}{\partial z}\bigg|_{-h} \qquad (7d)$$

$$\frac{1}{2}\frac{\partial h}{\partial t}\frac{\Delta\rho}{\rho_0}gh = m_0 u_*{}^3 + m_s A + D + m_c C \tag{8a}$$

$$A = \frac{1}{2}\left[\left(\Delta u^2 + \Delta v^2\right)\frac{\partial h}{\partial t} + \nu_M\left(\Delta u \left.\frac{\partial u}{\partial z}\right|_{-h} + \Delta v \left.\frac{\partial v}{\partial z}\right|_{-h}\right)\right] \tag{8b}$$

$$\begin{aligned} D = \frac{\alpha g}{\rho_0 c_p} Q_R \int_{-h}^{0} F\,dz - \frac{1}{2} h\Bigg[& B_0 + \frac{\alpha g}{\rho_0 c_p} Q_R F_{-h} \\ & + g\nu_H\left(\alpha \left.\frac{\partial T}{\partial z}\right|_{-h} - \beta \left.\frac{\partial S}{\partial z}\right|_{-h}\right)\Bigg] \end{aligned} \tag{8c}$$

$$C = \tfrac{1}{4} h(B_0 - |B_0|) \tag{8d}$$

$$B_0 = \frac{\alpha g}{\rho_0 c_p}(Q_0 + Q_R) - \beta g S_m(E - P) \tag{8e}$$

$$h = \frac{m_0 u_*^{\,3} + \dfrac{\alpha g}{\rho_0 c_p} Q_R \displaystyle\int_{-h}^{0} F \, dz}{\dfrac{1}{2}\left[B_0 + \dfrac{\alpha g}{\rho_0 c_p} Q_R F_{-h} \right]}$$

Integrales (Krauss/Niiler)

$$\frac{\partial T_1}{\partial t} = \frac{Q}{\rho C_p h_1} + \frac{w_e(T_2 - T_1)}{h_1} \quad ,$$

$$T_2 = cte \quad ,$$

$$\frac{\partial h_1}{\partial t} = w_e + w_d \quad ,$$

$$w_e' = D\frac{mu_*^3 - h_1 B_0}{g\alpha h_1 (T_1 - T_2)} \quad ,$$

$$w_e = w_e'\Gamma(w_e')\Gamma\left(H_{\max} - h_1\right) \quad ,$$

$$w_d = w_e'\Gamma(-w_e')\Gamma\left(h_1 - H_{\min}\right) \quad .$$

$$B_0 = \frac{\alpha g Q}{\rho C_p}$$

$$H_{MO} = \frac{mu_*^3}{B_0}$$