A MARINE THERMOCLINE NUMERICAL MODEL

G.A. DALU - R. PURINI
Istituto di Fisica dell'Atmosfera - CNR
P.le Luigi Sturzo, 31 - Rome, Italy

In an initially stable stratified sea, a thermocline can be induced adiabatically through the work done by the mechanical turbulence or/and diabatically by cooling. When the forcing terms are constant in time, analytical solutions of the depth of the mixed layer can be found:

$$h^3 = 12\ Mt/\ N^2 \qquad (1)$$

$$h^2 = 6\ R^* B_o t/N^2 \qquad (2)$$

where M is the kinetic energy turbulent flux, N^2 is the Brunt-Vaisala frequency, R* is the Manins and Turner energy ratio[1], B_o is the cooling heat flux.

When the Brunt-Vaisala frequency is not constant in the vertical or the forcing terms are not constant in time, as when they are derived from a surface energy budget, the depth h of the mixed layer has to be computed numerically.

The energetic balance model, which we are developing proceeds as follows:

$\varepsilon_m = M\Delta t$ — ε_m is the energy spent by the mechanical turbulence against gravity;

$\varepsilon_T = \frac{1}{2} g \alpha_T h^2 \quad T$ where $\delta T = B \Delta t / c \rho h$ is the potential energy variation due to diabatic heat flux B;

$A = \varepsilon_T R* + \varepsilon_m$ A is the total energy spent against gravity;

$\delta T_1 = 2A/\rho g \alpha_T h^2$
and are the temperature variations
$\delta T_2 = h/\Delta z \delta T_1$ due to the entrainment.

The temperature at the time step n + 1 are defined as follows:

$$T^{n+1}(i\Delta z - \Delta z/2) = T^n(i\Delta z - \Delta z/2) - \delta T - \delta T_1 \qquad i = 1, I$$

$$T^{n+1}(I\Delta z + \Delta z/2) = T^n(I\Delta z + \Delta z/2) + \delta T_2$$

The stability condition[2]

$$T^{n+1}(I\Delta z - \Delta z/2) > T^{n+1}(I\Delta z + \Delta z/2)$$

defines the depth of the mixed layer

$$I\Delta z = h$$

The time step t is defined by the accuracy required.

This model is now being applied to study some experimental situations, in particular in the Ligurian Sea.

(1) Manins, P.C. and J.S. Turner, 1978. The relation between the flux ratio and energy ratio in convectively mixed layers, Quart. J. Roy. Met. Soc., 104, 39-44.

(2) Dalu, G.A., 1978. A parameterization of heat convection for a numerical sea breeze model, Quart. J. Roy. Met. Soc., 104, 797-807.