Turbulent Mixing in the Strait of Sicily

by

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The Strait of Sicily forms a division between the two distinctly different water basins of the eastern and western Mediterranean, and because of the narrow, shallow channels found there through which any communicating waters must flow, oceanographic processes can play an important role in the flow of the entire Mediterranean. Although much work has been done in this important region, little is known of the influence of turbulence, turbulent mixing and turbulent friction affecting the flow. Until some idea of the effects of turbulence is obtained, a balance of forces cannot be done, an energy balance cannot be made, a time response of the flow system will not be known and the amount of vertical exchange of temperature, salt and momentum will not be available. However meager, an attempt is made to answer some of these important questions.

Vertical shear velocities are found at the western sill of the Strait of Sicily due to the " Atlantic waters " entering the eastern Mediterranean from the surface to about 80 m, while the " Levantine Intermediate waters " are flowing out of the eastern Mediterranean from about 80 m to the bottom. However, at the depth at which the interface of these two water masses occurs, the water column is staticly stable, mainly due to the positive gradient of salinity. Thus, the vertical shear will tend to cause vertical mixing of the water, while the vertical stability will tend to damp out any mixing.

A dynamic stability criterion is the RICHARDSON number, given by

$$R_i = \frac{N^2}{(du/_{dz})};\ N^2 = \frac{g}{\rho}\frac{\delta\rho}{\delta z} - g^2/_{c^2} \quad (1)$$

where u is the horizontal velocity, z the vertical axis (positive downwards), ρ the density, g the acceleration of gravity, N the Väisälä frequency and c the speed of sound. Theoretical work [TAYLOR, 1931, MILES, 1961 *and others*, but for a discussion see MONIN and YAGLON, 1971, p. 125] have shown that stability should occur for $R_i < 1/4$ and it is possible that instability can occur for $R_i < 1/4$. Further arguments have been put forth [see MONIN & YAGLON, 1971, p. 400] to indicate that the proper criterion for turbulence is the flux Richardson number,

$$Rf = \frac{\acute{\upsilon}_T}{\nu_T} R_i \quad (2)$$

where $\acute{\upsilon}_T$ is the turbulent diffusion coefficient for density. In fact, large turbulent parameters have been measured [WILLIAMS, 1974] in oceanic shear flow conditions for $R_i > 1/4$. In any case, finding a threshold for turbulence does not solve the problem of establishing values of turbulent parameters. It is necessary with today's understanding of turbulence in a stratified medium to make direct measurements at small enough scales at which turbulence exists.

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Rough estimates of the turbulent parameters such as ε, the rate of dissipation of kinetic energy, ν_T, the vertical turbulent diffusion of momentum, γ_T the turbulent coefficient for salt and F_s, the vertical salt flux are inferred from the shape of the power spectrum of the salinity profile, similarity arguments and comparison of profiles shapes. The measurements were made in and near the Strait of Sicily; spectral analysis was made at depths from 60 to 260 m where vertical stability is mainly due to the positive salinity gradient. Analysis of data near the Western sill of the Strait indicates rather large turbulent activity : $\varepsilon \backsim 0.08$ cm^2 sec^{-3}, $\nu_T \simeq 80$ cm^2 sec^{-1} and RICHARDSON length scale, $L_R \backsim 2.5$ m. Analysis of data 50 miles away from the Strait shows that the turbulence is too weak to be measured with this technique.

Implications of the effects of turbulence on the flow as to the vertical mixing of momentum and salt, turbulent friction and a time response of the flow are discussed in the complete text. It appears that although the turbulent friction is much smaller than the Coriolis force, strong vertical mixing takes place, diverting some of the salt from flowing out of the eastern Mediterranean. Time response due to friction is about 2 hours.

References

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