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Comments on "Stability of algebraic non-equilibrium second-order closure models" by H. Burchard and E. Deleersnjder [Ocean Modelling 3 (2001) 33–50]

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As stated in the Abstract, the subject paper deals with "reasons for the failure of the Mellor and Yamada (1974, 1982) level 2.5 closure model". This paper is the latest of a series of papers by one or the other of the authors showing rather ugly on–off oscillations of the vertical distribution of mixing coefficients for momentum and temperature, K_M and K_H. Readers of these papers might and, in fact, have concluded that this behavior is endemic to the Mellor–Yamada (henceforth M–Y) model and has simply been tolerated by users of the model. However, such oscillations are nowhere to be found in papers by this writer and others. The oscillation problem was indeed discovered in the early days of the model and promptly remedied.

One of the main contributions of the M–Y model was that

$$K_M = lqS_M, \qquad K_H = lqS_H, \tag{1a, b}$$

where l is the turbulence length scale and $q^2/2$ is the turbulence kinetic energy and where

$$S_M = S_M(G_M, G_H), \qquad S_H = S_H(G_M, G_H). \tag{2a, b}$$

G_M and G_H are non-dimensional functions of current shear and vertical buoyancy gradient. Negative values of G_H yield stable stratification and positive values yield unstable stratification. The problem noted by the authors is that, for a staggered grid (whereby the mean variables, velocity and temperature, are staggered relative to the turbulence variables; the oscillations did not appear for a non-staggered grid) the variable, G_M, can oscillate from $k-1$ to k to $k+1$, etc. where k is the vertical numerical grid index. The problem was eliminated by insertion of a simple $0.25G_M(k-1) + 0.50G_M(k) + 0.25G_M(k+1)$ filter before evaluating (2a, b). A users guide

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describing the M–Y model as employed in a general circulation ocean model and the code itself is available on the web at www.aos.princeton.edu/WWWPUBLIC/htdocs.pom.

Galperin et al. (1988) has found that, consistent with the ordering process (Mellor and Yamada, 1974) that produced the level 2.5 approximation, Eq. (2a, b) could be simplified so that $S_M = S_M(G_H)$ and $S_H = S_H(G_H)$. This eliminated the oscillatory problem ab initio. At present, I use Galperin's simplification for boundary layer flows—I could see no difference in the results—but there may be flow cases prompting reversion to the original formulation.

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