Reply

Dear Sir,

Mr. Harris' suggestion that part of the diurnal variation of the wind is due to the diurnal pressure variation is certainly a valid one, and the information he has furnished regarding the pressure variation permits an evaluation of this influence. Some indication of the possible magnitude of this contribution may be obtained by integrating the horizontal equations of motion with the following simplifying conditions: constant density, no friction and zero horizontal variation of velocity. If we now express the pressure in terms of the mean pressure $\bar{p}$ plus the component which varies diurnally p', namely, $p = p + p'$; the equations of motion may be written

$$\frac{\partial u}{\partial t} = -\frac{1}{\varrho}\frac{\partial \bar{p}}{\partial x} - \frac{1}{\varrho}\frac{\partial p'}{\partial x} + fv$$

$$\frac{\partial v}{\partial t} = -\frac{1}{\varrho}\frac{\partial \bar{p}}{\partial y} - \frac{1}{\varrho}\frac{\partial p'}{\partial p} - fu \qquad (1)$$

where f is the Coriolis parameter.

Next we may express the mean pressure force in terms of the equivalent geostrophic wind components,

$$f\bar{u}_g = -\frac{1}{\varrho}\frac{\partial p}{\partial y},\ f\bar{v}_g = \frac{1}{\varrho}\frac{\partial \bar{p}}{\partial x} \qquad (2)$$

Finally, utilizing Harris' expression for the periodic component of the pressure force

$$-\frac{1}{\varrho}\frac{\partial p'}{\partial x} = 1.45 \times 10^{-2} \sin (\omega t + 123^\circ);\ \frac{1}{\varrho}\frac{\partial p'}{\partial y} = 0 \qquad (3)$$

we obtain the following system of equations:

$$\frac{\partial u'}{\partial t} = 1.45 \times 10^{-2} \sin (\omega t + 123^\circ) + fv';\ \frac{\partial v'}{\partial t} = -fu' \qquad (4)$$

$$\text{where } u' = u - \bar{u}_g,\ v' = v - \bar{v}_g \qquad (5)$$

The expressions on the left in Eqs. (4) are permissible since u_g and v_g are invarient with time.

The solution of the system (4) is easily found to be

$$u' = k_1 \sin ft + k_2 \cos ft + \frac{1.45 \times 10^{-2}\omega}{f^2 - \omega^2} \cos (\omega t + 123^\circ) \qquad (6)$$

$$v' = k_1 \cos ft - k_2 \sin ft - \frac{1.45 \times 10^{-2} f}{f^2 - \omega^2} \sin (\omega t + 123^\circ)$$

where k_1 and k_2 are constants and $f \neq \omega$.

The first two terms on the left in the expression for u' and v' give the inertial oscillations, while the last term in each expression gives the contribution resulting from the diurnal pressure variation. At 45° latitude the latter terms give velocities of about three to four knots which represent deviations from the mean geostrophic wind.

If the friction force is added to Eqs. (4) the solution is not so simple; and the effect of the diurnal pressure variation is more difficult to assess. It may be noted however that the effects of the diurnal pressure variation and the inertial oscillations are similar in the solution given by (6). Hence they may act somewhat similarly when friction is included. In the solution for the diurnal wind variation which did not include the diurnal pressure variation (HALTINER 1959), inertial oscillations are damped where the friction force is large. However, aloft where the friction force is comparatively small, any unbalance between the pressure and Coriolis forces gives rise to a distinct inertial oscillation. A similar condition may occur when the diurnal pressure variation is taken into account. In order to determine these influences more completely some numerical solutions are being obtained through the use of a high-speed electronic computer. It would be desirable here to know the vertical variation of the component of the pressure gradient resulting from the diurnal pressure variation.

Yours very truly,

G. J. HALTINER
U. S. Naval Postgraduate School
Department of Meteorology
and Oceanography
Monterey, California

REFERENCE

HALTINER, G. J., 1959: The diurnal variation of the wind *Tellus*, 11, pp. 452—458.