Letters to the Editor

10th December, 1952.

Dear Sir,

In a paper published in this journal CHARNEY and ELIASSEN (1949) have discussed the influence of a mountain barrier on a westerly current flowing over it. In their one-dimensional treatment of the problem the effect of horizontal *convergence* in the flow in the lee of the mountains is shown to be a negative pressure (contour-height) tendency over a limited distance downstream from the peak. A series of actual tendency computations, in the 500 mb pressure surface, made by BOLIN and CHARNEY (1951) on the basis of the two-dimensional, barotropic non-divergent vorticity equation gave a. o. an apparent verification of the existence of such a convergence area in the lee of the Rocky Mountains. In a preliminary note (see BOLIN and H. NEWTON, 1951) the present writer purported to have verified that topopraphic effect in a case of similar large-scale flow over North America, through computation on a series of five-day mean 500 mb contour charts.

Meanwhile a check of signs involved in the interpretation of the difference between the computed and observed tendency has shown that an identical oversight has occurred in both the latter authors' and the present writer's study. Correcting for the mistake the respective area, in either case in the lee of the Rocky Mountains and downstream from a broad westerly current crossing it, would have to be regarded as the seat of horizontal divergence in the ligth of the limited interpretation of that difference in tendency. It must then be assumed that during those two-week periods treated the topographic effect, if any, was overshadowed by other processes such as a soleneoidal or frictional source or else a large-scale horizontal eddy-transfer of vorticity in the region.

In view of the general importance which is attached to the significance of semi-permanent fields of divergence and convergence, it may be indicated to give here what is contended to be the right interpretation of the numerical findings by BOLIN and CHARNEY.

The quasi geostrophic vorticity equation for the purpose of the present discussion has the (reduced) form

$$\frac{\partial \zeta}{\partial t} + \mathbf{V} \cdot \nabla \eta = -\eta \ \mathrm{div}_2 \ \mathbf{V}$$

where the usual notation is used, ζ being the geostrophic relative vorticity and η the absolute vorticity $(\eta = \zeta + f)$. Since in the notation of the authors $\partial\zeta/\partial t = g f^{-1} \nabla^2 x_2$ and consistently with it $-\mathbf{V} \cdot \nabla \eta = g f^{-1} \nabla^2 x_1$ the above equation becomes

$$\nabla^2 (x_2 - x_1) = -\frac{f\eta}{g} \ \mathrm{div}_2 \ \mathbf{V}$$

Applying the authors' regression equation $x_1 = a\, x_2 + b$ or $x_2 - x_1 = -b + x_2 (1 - a)$, it follows

$$\nabla^2 b = \frac{f\eta}{g} \ \mathrm{div} \ \mathbf{V} - \nabla^2 \Big(x_2 \ (1 - a)\Big)$$

In considering the distribution of the constant b in relation to divergence, the regression coefficient a has to be put equal to unity, whence

$$\nabla^2 b = \frac{f\eta}{g} \ \mathrm{div}_2 \ \mathbf{V}$$

The quantity $f\eta \equiv f^2 + f\zeta$ may be approximated by f^2 so that $f\eta g^{-1} \equiv A$, a positive quantity. Therefore

$$\nabla^2 b = A \ \mathrm{div}_2 \ \mathbf{V}$$

In Fig. 7 of the paper by BOLIN and CHARNEY the factor b is *negative* over the area in question and has a pronounced minimum. The Laplacian in the vicinity of that minimum is certainly *positive* as it is also over a large area surrounding the minimum. Thus the divergence is *positive* in that area.

Although the authors do not explicitly identify that area of negative b with a region av convergence ($\mathrm{div}_2\ \mathbf{V} < 0$), they draw attention to the resemblance with the negative tendency field corresponding to a topographically produced convergence area (Fig. 8). Naturally they did not imply resemblance in position and shape only, as is clear from the context.

Yours sincerely,

F. A. BERSON

REFERENCES

BOLIN, B. and CHARNEY, J., 1951: Numerical Tendency Computations from the Barotropic Vorticity Equation. *Tellus*, **3**, p. 248—257.

BOLIN, B. and NEWTON, H., 1952: Report on a conference on the application of numerical methcds in forecasting atmospheric flow patterns. *Tellus*, **4** see p. 143.

CHARNEY, J. and ELIASSEN, A., 1949: A numerical method for predicting the perturbations of the middle latitudes. *Tellus*, **1**, 2, pp. 38—54.

REPLY

Dear Sir,

We should like to thank Dr. BERSON for pointing out an inconsistancy in our article on the influence of the mountains on the flow pattern at the 500 mb surface. Checking the original computations once more we have found that the inconsistancy is explained by a drafting error in the sign of the isopleth labels of figure 7. Our conclusions therefore remain as before.

Sincerely yours

BERT BOLIN, JULE CHARNEY