CORRESPONDENCE

On the propagation of isolines

By LEON SHERMAN

Dept. of Meteorology, Florida State University, Tallahassee

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Riehl and Jenista[1] recently have focussed attention upon the direct forecasting of the wind field. I feel strongly that such an explicit introduction of the wind field into the wind forecast is a step in the right direction; however, I feel that Riehl and Jenista should have given more attention to one of their major assumptions.

In brief, what they did is essentially the following. They correctly expressed the local rate of change of the wind speed in terms of the velocity of propagation ($\boldsymbol{c}_i$) of the lines of constant wind speed,[2] and the gradient of the wind speed, as

$$\partial v/\partial t = -\boldsymbol{c}_i \cdot \nabla v. \tag{1}$$

They then used (1) to eliminate the local rate of change of the wind speed from the tangential component of the equation of motion. Neglecting certain terms of this equation, and replacing $\alpha\,\delta p$ by $g\,\delta h$ (an increment of geopotential height of a pressure surface), they obtained the approximation

$$-\boldsymbol{c}_i \cdot \nabla v \approx -c\,\delta v/\delta s - g\,\delta h/\delta s. \tag{2}$$

Following Petterssen,[3] they then noted that the vector field $\boldsymbol{c}_i$ may be specified with considerable arbitrariness, as is the case for the velocity of propagation of any set of isolines. Thus, referring to fig. 1 for example, it is possible to choose various orientations for $\boldsymbol{c}_i$; each choice, together with the subsequent motion of the isolines, will determine a corresponding field of speeds of propagation. Any choice for the orientation of $\boldsymbol{c}_i$ is tenable, so long as the displacements $\boldsymbol{c}_i\,\Delta t$ will put the points of an isoline into one-to-one correspondence with the points occupied by the same isoline at a time Δt later. This is not too great a restriction. However, it is manifestly not true that the orientations of the vectors $\boldsymbol{c}_i$ may always be taken to be the same as the wind directions. For, suppose the streamlines to be constant in time and as shown in fig. 2. Further, suppose that a speed isoline moves from the position indicated by the solid line to that indicated by the dashed line. Then, clearly, the wind speeds will not have been propagated along the streamlines.

But Riehl and Jenista, in deriving the equation basic to their investigation, tacitly assumed that the wind directions can be taken as the directions of $\boldsymbol{c}_i$, so that (2) becomes

$$\delta v/\delta s \approx v\,\delta v/\delta s + g\,\delta h/\delta s, \tag{3}$$

where all of the increments δs are the same. This led them to their basic formula (4),

$$c_i = v + g\,\Delta h/\Delta c. \tag{4}$$

Clearly this formula is in doubt, until the transition from $\boldsymbol{c}_i \cdot \nabla v$ to $c_i\,\delta v/\delta s$ is justified. Perhaps this could be done upon empirical grounds. However, Riehl and Jenista ignore the whole question, leaving to their readers the impression that their and my (4) follow rigorously, and on purely kinematic grounds, from

[1] H. Riehl and C. O. Jenista, "A quantitative method for 24-hour jet-stream prognosis," *J. Meteor.*, 9, 159–166, 1952.

[2] *Isovels* to those of us who prefer to follow V. Bjerknes' 1911 usage; *isotachs* to those purists who ride in *autokinetes*.

[3] S. Petterssen, *Weather analysis and forecasting*, New York, McGraw-Hill Book Co., 503 pp., 1940.

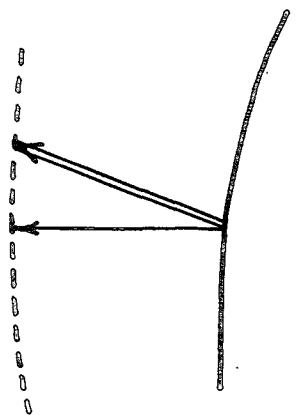

FIG. 1. Arbitrariness in choice of velocity of propagation of an isoline; either arrow represents an admissible displacement.

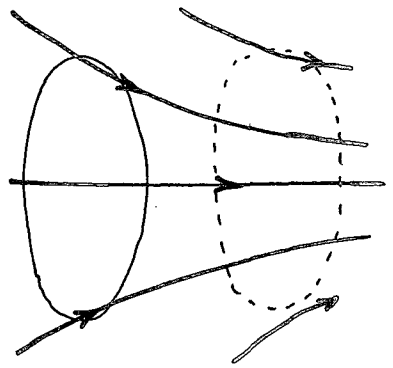

FIG. 2. Closed isoline in a field of steady-state confluent streamlines, illustrating a case in which wind direction is *not* an admissible choice for direction of velocity of propagation of isolines.

their and my (2). They go on to cite a "model showing contraction of an area enclosed by (an) isotach in (a) region of converging streamlines," with no indication of whether this is the result of their theory (it follows from the assumption here put in question) or is an empirical result.

In summary, my criticism is essentially aimed at the assumption that *any* set of directions can be chosen as directions for the velocity-of-propagation field. If this assumption were valid, it would, of course, follow that in particular the wind directions could be chosen as the directions for the velocities of propagation. It may well be true *upon empirical grounds* that the wind directions play such a role, but it is *not* a simple result from kinematics.

Because this lack of *complete* arbitrariness in the choice of the direction of propagation applies to *all* isolines, it may be of wider interest than otherwise.