CORRESPONDENCE

The forecasting significance of the Reed-Sanders article

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Since my colleagues R. J. Reed and F. Sanders[1] analyzed the synoptic situation of 28 January 1953, it has become increasingly evident that many important weather patterns develop in a like manner. For this reason, it is the purpose of this communication to emphasize the forecasting significance of their analysis.

One of the most striking developments at 500 mb is the intensification of a trough downstream from a previously intensifying ridge, as shown in figs. 1 and 2. Such a major change in the 500-mb flow leads to a new pattern of sea-level pressure systems. In most cases, the later stages of the trough development are accompanied by sea-level cyclogenesis to the east of the upper trough. Synoptic studies[2] show the important connection between surface cyclogenesis and the field of height falls within and in advance of such troughs at 500 mb:

1. An investigation of the first 12-hr changes in the centers of 122 new surface cyclones over North America showed a mean sea-level fall of 4.8 mb directly beneath a mean height fall of 103 ft at 500 mb;
2. 28 out of 29 cases of rapid cyclogenesis over North America during the period February–April 1951 were located ahead of a 500-mb trough; even though thermal gradients in the lower troposphere were an important feature for the cyclogenesis, it must be noted that a trough development such as in figs. 1 and 2 defines the region where such rapid deepening is possible.

A detailed example of the development of an upper trough and surface cyclogenesis has been presented by Palmén.[3] The prediction of trough intensification at 500 mb is an important aspect, therefore, of the prediction of surface cyclogenesis.

As in the Reed-Sanders example, the trough development in figs. 1 and 2 is accompanied by the creation of an upper-level zone of strong temperature contrast about AB (fig. 2), and high cyclonic vortic-

[1] R. J. Reed and F. Sanders, "An investigation of the development of a mid-tropospheric frontal zone and its associated vorticity field," *J. Meteor.*, 10, 338–349, 1953.

[2] Technical Reports of a Massachusetts Institute of Technology project on pressure changes, sponsored by the Office of Naval Research under Contract No. N5ori-07804.

[3] E. Palmén, "The aerology of extratropical disturbances," *Compendium meteor.*, Boston, Amer. meteor. Soc., 599–620, 1951.

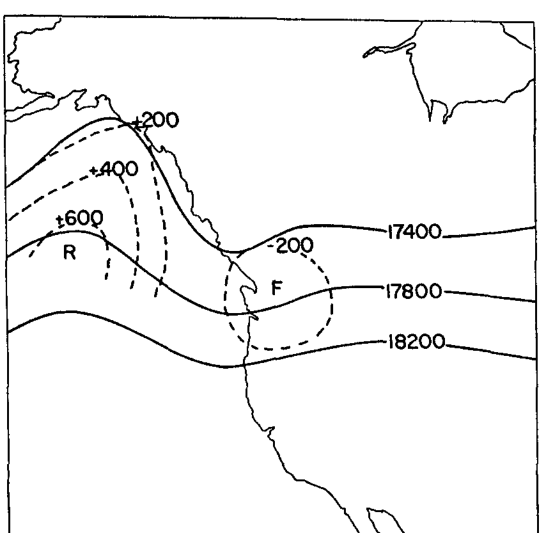

FIG. 1. 500-mb chart for 1500 GCT 17 February 1953. Solid lines are contours; dashed lines are 12-hr height changes.

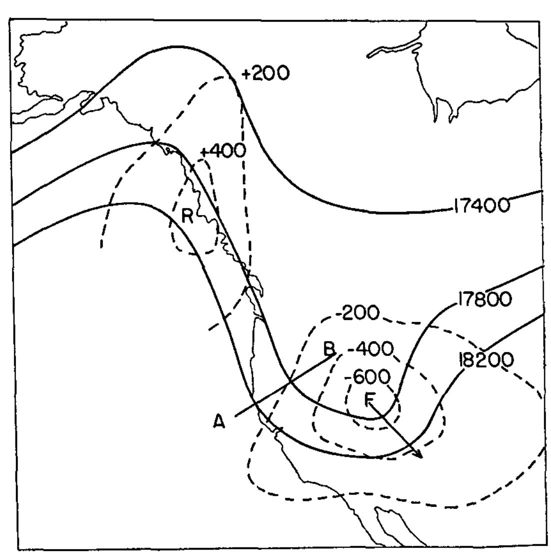

FIG. 2. Same as fig. 1, but 24 hr later. Arrow indicates direction of motion of height-fall center.

ity[4] on the cold side of the northerly winds. The strong cyclonic vorticity is being created in the upper troposphere, where the divergence contribution to the vorticity change is small. This is a region of strong vertical motion and, hence, the fronto-genesis and the development of the cyclonic vorticity arise from the subsiding motion on the warm side (A), with zero or slight rising vertical motion on the cold side (B). In figs. 1 and 2, the height changes show the 12-hr field of $\partial\zeta/\partial t$, where ζ is the vertical component of the vorticity of the geostrophic wind. The $\partial\zeta/\partial t$ maximum in the trough moves southeastward in response to the developing cyclonic vorticity upstream from the trough. Statistics on the frequency of the phenomenon of trough development downstream from ridge intensification have been presented by me.[5] Bjerknes[6] has discussed the importance of this "unstable growth of an upper wave trough." Another example of the process is to be found in a synoptic situation discussed by Riehl and Teweles,[7] where again surface cyclogenesis occurs ahead of the 500-mb trough. The empirical evidence strongly suggests that the mechanism described by Dr. Reed and Mr. Sanders plays an important role in the development of these significant high-level troughs.

Dr. Reed and Mr. Sanders have incorporated the "vertical shear" terms in a model for numerical prediction. Two features of the structure of the atmosphere in the above cases of development should also be considered in the formulation of a numerical prediction scheme:

1. The maximum horizontal temperature contrast across AB (fig. 2) occurs in the region between 600 and 400 mb; the thermal gradient decreases markedly toward the earth's surface; in this respect, the thermal structure differs from the inclined zone of temperature gradient commonly associated with surface fronts; with such frontal zones, frequently located ahead of a 500-mb trough, the temperature gradient is a maximum near the earth's surface;
2. The shear vorticity varies rapidly in the horizontal; a close network of vorticity values is required to portray the actual vorticity distribution.

In conclusion, attention is drawn to the geographical distribution of this type of development. Over the North American region, the most striking examples occur downstream from the building of a 500-mb ridge in the Gulf of Alaska.

[4] By the term "vorticity," I am referring to the vertical component of the relative vorticity.

[5] J. M. Austin, "Aspects of intensification and motion of wintertime 500-mb patterns," *Bull. Amer. meteor. Soc.*, **34**, 383–392, 1953.

[6] J. Bjerknes, "Extratropical cyclones," *Compendium meteor.*, Boston, Amer. meteor. Soc., 577–598, 1951.

[7] H. Riehl and S. Teweles, "A further study on the relation between the jet stream and cyclone formation," *Tellus*, **5**, 66–79, 1952.