CORRESPONDENCE

Comments on "Cyclogenesis and Precipitation in the Blizzard of March 21-26, 1957"

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Recently I reexamined the storm situation of March 1957 which was discussed by McQueen and Loopstra [1]. I was particularly interested in this storm at the time of its occurrence because this office did reasonably well with the forecasts involved and because the concept of the 500-mb. tendency method (Hughes [2]) contributed materially to those forecasts.

In their article McQueen and Loopstra indicated that they were unsuccessful in applying the 500-mb. tendency method. From the description in the article I was unable to discover just where, when, and how it was applied so I could not tell whether they had difficulty in applying it or whether it really gave incorrect results. For this reason I made new computations and found that the method indicated essentially what happened. I therefore feel that I failed to supply an adequate explanation in my published article. I will attempt to clarify those points which from their article I judge were misunderstood.

The formula allows computation of the local quasi-instantaneous 500-mb. height tendency from the surface pressure tendency and the mean temperature advection from 1000 mb. to 500 mb. The computation can be averaged over any time interval for which a pressure tendency can be obtained, since the portion due to the advection is instantaneous. Since pressure tendencies are customarily reported for a 3-hour period, this time interval is convenient and usually small enough so that the entire computation can be considered as instantaneous.

It is also convenient, however, to express the result in terms of a 12-hour tendency. It is important, though, to see that this does not change the character of the tendency, for it is still essentially instantaneous. However, now it is in more familiar units and can be compared with the 12-hour height changes from successive radiosonde reports. Because these reports yield a 12-hour average tendency, this comparison must be done with care.

In applying or verifying the results of a computation one must keep in mind some of the things considered in Petterssen's rules of pressure kinematics at sea level. This is done through consideration of the operator

$$\frac{\delta}{\delta t}=\frac{\partial}{\partial t}-C\frac{\partial}{\partial x}$$

applied to the 500-mb. height Z_5. Now $\frac{\delta Z_5}{\delta t}$ is the change in Z_5 in a coordinate system moving with pressure (height) system—the deepening tendency—and $\frac{\partial Z_5}{\partial t}$ is the change in Z_5 in a coordinate system fixed to earth—the local change, in this case computed by the tendency method. C is the speed of movement of the pressure system and $\frac{\partial Z_5}{\partial x}$ is the gradient of 500-mb. height in the direction of C. One can compute the local tendency at many points but its value to the forecaster is usually small, because it is difficult to interpret, unless the effect of movement of the pressure system is removed or nonexistent. When this is done the local tendency and the deepening tendency are the same. This can occur in essentially two ways: (1) where C is zero, and (2) when $\frac{\partial Z_5}{\partial x}$ is zero in the direction of C. The second occurs mainly in low centers and on trough and ridge lines (lines of maximum or minimum curvature) when C is perpendicular to the line. We can always evaluate C perpendicular to the trough line, in fact that is what we usually mean as C. Thus, if we want the computation to indicate the amount of deepening of a trough, we must compute it only on the trough line.

This, of course, means that the computed tendency is usually appropriate only for a very short time locally, i. e., at any one point on earth, since the condition $\frac{\partial Z_5}{\partial x}=0$ usually will not persist for very long at that point. Thus in order to verify a computation it is necessary to make the comparison with the real height changes computed in a coordinate system moving with the trough, the $\frac{\delta}{\delta t}$ coordinate system, such as would be done in verifying the deepening of a surface low center.

To indicate how the technique worked in the March 1957 case at hand, the 500-mb. height tendency was computed each 12 hours from 2130 CST March 20 to 0930 CST March 23. Prior to these times the surface pressure tendencies could not be quantitatively evaluated as the trough was over the Pacific Ocean. The results of these computations are given below:

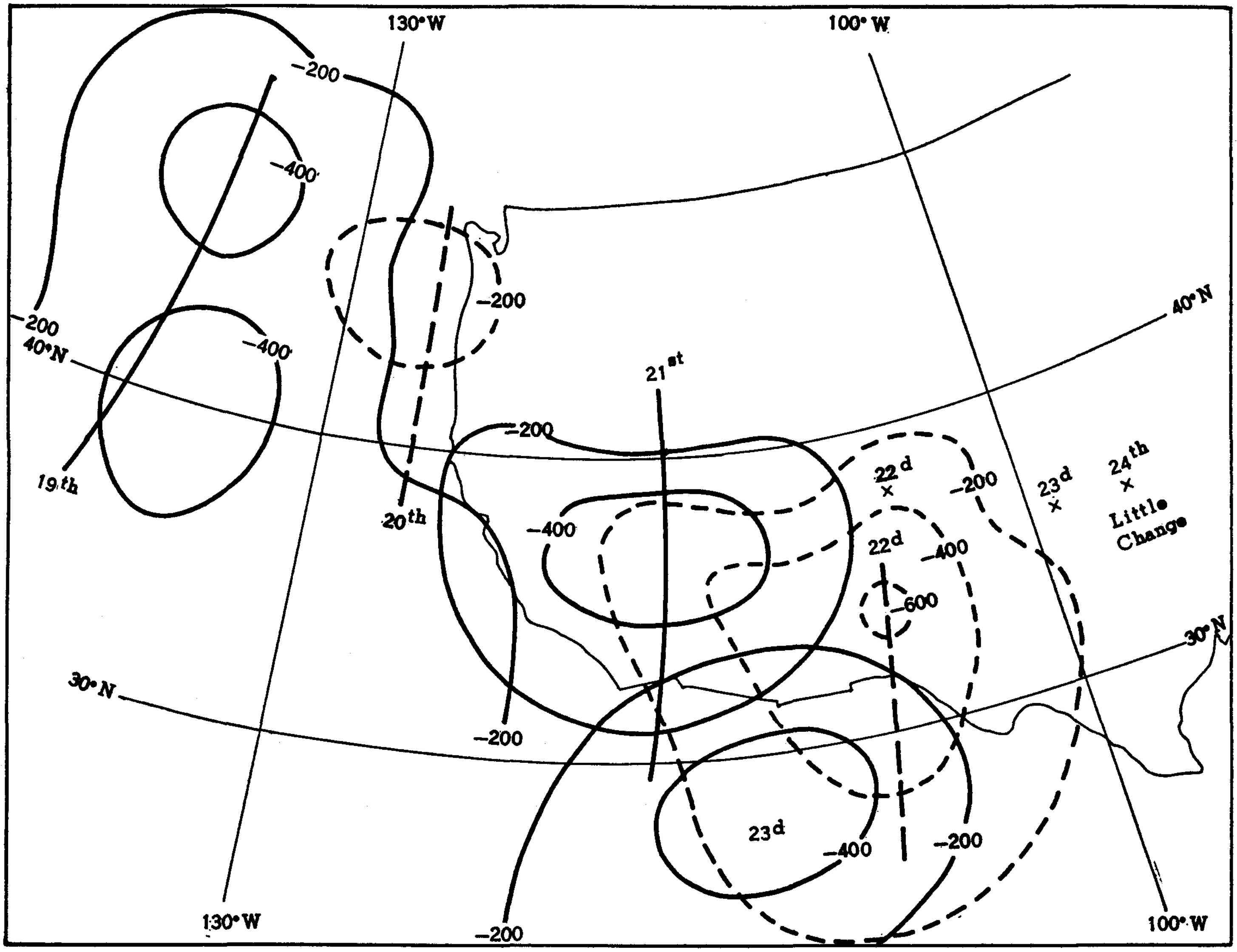

FIGURE 1.—Twenty-four-hour 500-mb. height changes in feet (2100 to 2100 CST) for March 1957 computed in a coordinate moving eastward with the speed of the trough line (the low center was used for the last two days). The position of the trough line at the end of each tendency interval is indicated by the more or less vertical lines. The position of the low center on the last three days, when the trough was becoming ill-defined, is indicated by an "X". Only the changes related to this one trough were computed.

Date—Time (CST)		Net 500-mb. height change (ft./12 hr.)	Area of computation
March 20	2130	−200	Oregon coast.
March 21	0930	−200	Northern California.
March 21	2130	−100	Southern Nevada.
March 22	0930	−400	Arizona.
March 22	2130	−300	New Mexico.
March 23	0930	−500	Mexico, south of Arizona and New Mexico (questionable data).

The above computations were made from the routine maps of the Chicago forecast center mainly because they were current with the upper-air charts and had a good amount of surface pressure tendency data. Computations from the facsimile copies would differ but little. A *preselected* "K" factor was used; 0.5 for the first three computations, 0.4 for the computations over Arizona and over New Mexico, and 0.3 over Mexico. The values other than 0.5 were used to allow mainly for orographically induced downslope motion.

Verification was done rather easily in this case since the trough was oriented essentially north-south throughout the period and it was merely necessary to superimpose two charts, rotate one about the North Pole until the trough lines under consideration became superimposed, and then perform a graphical subtraction. The results are given in Figure 1.

A low center formed on the 22d so the coordinate system was allowed to shift southward from the 22d to the 23d to follow this center, thus reducing the falls for the 23d from what they would have been otherwise. A 24-hour tendency was used for verification because the 12-hour tendencies were small for a 200-ft. contour spacing and too much overlapping would occur in the figure. For comparison just halve the verifying values.

It can be easily seen that the trough deepened slowly and rather uniformly for four straight days up to 2100 CST on the 22d. This was followed by deepening in the southwestern portion which deformed the trough, then deepening stopped. The relatively small amount of deepening shown for the 20th could easily be due to an error in analysis on either the 19th or the 20th since the trough during this 24-hour interval was west of the good data network of the United States. If the error were mainly on the map of the 20th, the amount of deepening shown for the 21st would be somewhat too high. The amount of deepening shown for the 22d is also somewhat excessive since the trough had some tilt from north at the time and the coordinate system should have been moved slightly southward but was moved due east. These changes would make the deepening appear even more uniform and closer to that indicated by the computations. Incidentally, the suggested method of making the computation gives a mean value of the tendency over an area usually the size of an average State and not the peak value. Considering that these computations were mostly made over regions where both the 1000-mb. geostrophic wind and the 1000–500-mb. thickness is fictitious, the verification indicated is as good as one should expect.

One must keep in mind when using this tendency method that it indicates essentially what is happening at the moment and thus can catch the beginning of new trends which, because of the relative frequency of surface charts with respect to upper-air charts and the time lag for transmission of the latter, may give up to about 21 hours advance warning of the new trend over that indicated by the upper-air chart alone. It cannot, however, indicate a trend that is not occurring at the time. This last, however, is characteristic of practically all, if not all, forecasting techniques.

REFERENCES

1. H. R. McQueen and J. F. Loopstra, "Cyclogenesis and Precipitation in the Blizzard of March 21–26, 1957," *Monthly Weather Review*, vol. 85, No. 3, Mar. 1957, pp. 99–111.
2. L. A. Hughes, "On the Determination of 500 mb. Height Tendencies," *Bulletin of the American Meteorological Society*, vol. 38, No. 4, Apr. 1957, pp. 221–225.