Comments on "The Effect on Rainfall of a Large Steelworks"

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Another study of the industrial effects on precipitation has recently become available for examination (Ogden, 1969), although the title does not indicate the true subject of this paper. Of particular interest is Ogden's analysis of the La Porte "total rainfall" data and his ensuing conclusions.

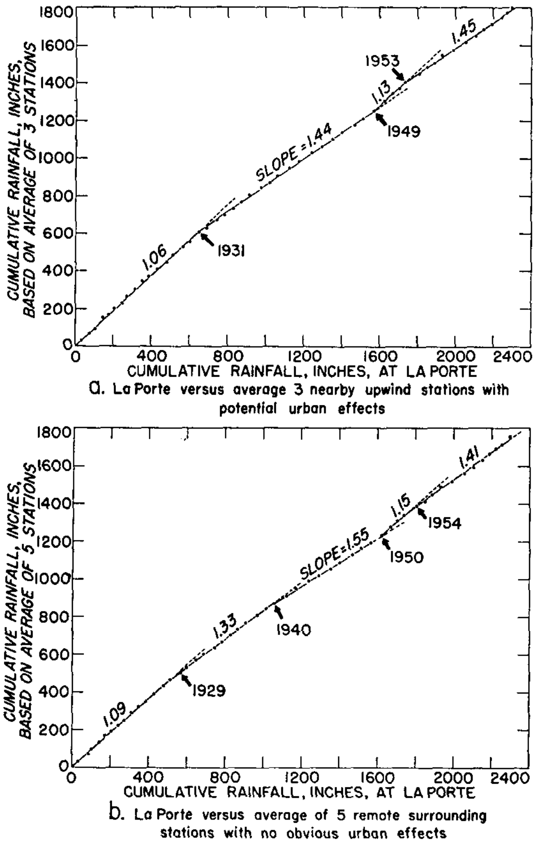

FIG. 1. Double mass curves for La Porte rainfall using two different groups of surrounding base stations.

The paper initially deals with an examination of precipitation around a large Australian steel plant, but a major purpose appears to be a further evaluation of the La Porte anomaly (Changnon, 1968). The 1968 analysis of the striking increases in several precipitation conditions at La Porte was directed toward a thorough, unbiased examination of the possible explanations for the increases. It was concluded that the increases were likely not due to observer bias nor exposure changes. Conversely, the Australian paper, which examined only the total (annual) rainfall, concludes 1) that the La Porte precipitation increase was due to an exposure change and not to an industrial (steel plant) effect, and 2) that the lack of a detectable annual precipitation increase near a major Australian steel plant is thus in agreement with the non-industrial effect, as concluded for La Porte.

To compare the results of a study of the potential effects by an Australian steel mill on environmental annual precipitation with those at La Porte requires two assumptions: 1) that the La Porte increase (if real) was largely related to the nearby steel mill complex, and 2) that all steel mills affect total rainfall. Although certain precipitation changes at La Porte were grossly compared with those in the steel mill production of the Gary-Chicago area (Changnon, 1968), these comparisons were intended to illustrate the general variations in the activity and production of the total industrial complex of the Chicago area. The substantial increases in the annual and warm season rainfall, rain days, thunderstorms and hailstorms at La Porte may very likely have resulted from a combination of the gross industrial effects (of which the steel mills are only a portion) and the urban effects. The information that Ogden (1969) presents on the extent of the industrial complex and urban agglomeration around the steel plant at Port Kembla indicates that they are considerably less extensive than those in the Chicago area which ranks as the second largest industrial-urban complex in the United States. As just one example, the Chicago-Gary steel complex produced more than 25 million tons of steel in most recent years as compared to a high of 3.6 million tons at Port Kembla. The point is that in Chicago there are probably many other possibilities for industrial and urban effects, in addition to the steel mills, than at Port Kembla, and one should not expect to find equivalent precipitation changes at Port Kembla or anywhere else.

Although the scale of miles on Ogden's Fig. 1 is incorrectly labeled and the distance is hard to check, there is a large fan-shaped area (45° wide) that extends from ~10–70 mi westward and downwind of Port Kembla and contains only one rainfall station. This area is much larger than the high rainfall area around La Porte (see Fig. 4, Changnon, 1968) which is only about 650 mi². The possibility that an undetected "industrial" high (or low) exists west of Port Kembla in this largely ungaged area must be considered unless Ogden has information that was not presented in his paper.

Ogden (1969) analyzed the La Porte annual rainfall data using the commonly-used mass curve technique and concluded that one of the major changes in the precipitation curve ("about" in 1929) was due to the La Porte observer change in 1927. The three other changes in the mass curve are not explained with equal clarity other than to say that 1) similar slope changes were noted in mass curve plottings using Australian data, and 2) there is no obvious explanation for these changes.

Kohler (1949) and Wisler and Brater (1959) both emphasize that the use of the double-mass curve technique relies 1) on a high degree of correlation between the data being compared, and 2) on the fact that all stations being compared are "influenced by the same meteorological conditions." Thus, this is a valid technique for searching for instrumental and/or exposure errors, but it may not be a valid means for evaluating urban-produced changes in precipitation since the affected area is not always influenced by the same meteorological conditions that affect the base (surrounding) stations used in the comparison. Thus, Ogden's comparison of the La Porte precipitation with the average of that of South Bend and Valparaiso may be improper, especially since the Valparaiso precipitation is likely affected by urban-industrial influences (see Fig. 4, Changnon, 1968), whereas that at South Bend is not.

Therefore, two double-mass curves were prepared for the La Porte annual precipitation. One (Fig. 1a) uses (as the base average) data from three nearby stations with potential urban effects [Hobart, Whiting and Valparaiso—see Fig. 1, Changnon (1968)], and the other (Fig. 1b) data from five other stations (South Bend, Joliet, Kankakee, Wheatfield and Plymouth) whose average values for precipitation, thunderstorms and hail are not in the same urban-effect precipitation regime of La Porte (Changnon, 1968).

Comparison of the two graphs (their lines, slopes and years) with slope changes is quite revealing. From 1915–29 both graphs show a comparable line and slope. A change in slope in the La Porte, non-urban station graph (Fig. 1b) occurs in 1929 (1.3 years after the observer change), while the first change in the La Porte urban station graph (Fig. 1a) occurs in 1931. This shift in the 1929–31 period at La Porte might be due to industrial changes during the Depression or to observer bias, but no explanation is clear. The observer change came in 1927, and there was no gage site shift after 1927 (until 1967) or observer change since 1927; thus, the major economic shifts in industrial activity appear to be the more likely explanation.

The La Porte precipitation shows a shift (increase) away from the non-urban base stations in 1940, but this shift is not shown (Fig. 1a) with regard to the urban base stations. This strongly suggests an urban-industrial increase at La Porte (and at the other urban stations) associated with the major industrial expansion prior to World War II. Both graphs show slope alterations in 1949–50 and 1953–54 with a lower slope (less relative increase at La Porte) during the notable postwar economic recession. In general, these double-mass analyses do not furnish results that support the conclusions reached by Ogden (1969) as to dates of slope shifts or their causes. Even if one wishes to disagree with grouping of three stations labeled as potential urban-effect stations, the differences between its lines, slopes, and years of change and those of the five rural stations indicate the lack of significance one can place in the results of double-mass analyses, especially for constructing a synthetic La Porte rainfall data curve (Ogden, 1969).

It appears inconsistent to conclude that the La Porte total rainfall increase is not realistic due to exposure when one considers the fact that La Porte had marked increases in hail, thunderstorms, and moderately heavy rain days that agreed with the total rain increase. Also, how can an exposure-produced change at La Porte explain the warm season rainfall maximum (Fig. 4, Changnon, 1968) which is apparent at three other nearby stations?

Some questions concerning Ogden's analysis include: 1) What was the number of ridge-top samples of smoke (and freezing nuclei concentrations) taken to conclude there were none "in the plume" 16 km downwind?, and 2) How at that distance, could one be sure he was "in the plume"? At a 16-km distance, considerable diffusion could be expected which makes plume identification questionable and the lack of freezing nuclei not unexpected. One could certainly question the analytical approach which assumes that any effect would 1) produce only a small localized increase (or decrease), and 2) be represented by a gradual increase with time. Thus, the analytical approach employed for the precipitation data to produce quinquennial maps yields percentages that are nothing more than deviations from the overall regional trend surface and hence can only represent random variation.

In summary, there are four reasons for disagreeing with Ogden's conclusion that the La Porte increase is exposure-related and with his theme that the lack of effect between Port Kembla steel mills and precipitation supports the lack of a steel mill effect at La Porte (or anywhere). First, the increases in the other precipitation conditions at La Porte cannot be exposure-related errors; second, his explanation and interpretation of his double-mass curves are vague; third, a more exhaustive double-mass curve analysis reveals shifts in the La Porte rainfall regime that are not related to observer or site changes and are reasonably related to shifts in the national economy; and finally, the Chicago urban-industrial complex is markedly larger and much more capable of affecting the atmosphere than that at Port Kembla. Urban plus industrial effects on precipitation should and do vary considerably between cities (Changnon, 1969) depending on many factors including the climate, topography, lake-marine effects, type of industries, and the areal extent of the urban-industrial complex. Thus, there is no reason to suspect that an Australian steel plant should produce an increase of any size just because a similar plant in Germany or the United States does.

Ogden's conclusion that "there remains no strong positive evidence that industrial activity anywhere has measurably influenced total rainfall" is questioned. Examination of the statistical significance values obtained for the various urban rainfall highs presented in a recent paper (Changnon, 1969), a re-examination of the results in the La Porte paper, a check of Landsberg's results (1956), and a reading of several European studies over the past 40 years (Kratzer *et al.*, 1956) are recommended. I believe that the unbiased reader of these publications will conclude that there is "strong positive" evidence that urban and/or industrial effects in some localities have measurably influenced total rainfall.

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