EFFECTS OF BAROMETRIC PRESSURE AND WINDS ON THE LEVEL OF LAKE MICHIGAN

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Although most persons know that Lake Michigan fluctuates 3 to 5 feet in level over a period of several years, due to periodic variations in annual precipitation, few are aware of the sharp fluctuations that occur from day to day or even from one hour to the next. Figures 1 and 2 show the hourly levels of Lake Michigan as recorded during February, 1933, at Calumet Harbor, Indiana, and referred to the low-water datum (579.6 ft. A. T.) Two of the larger fluctuations are particularly striking: a rise of 1.93 feet in 41 hours on February 5 to 7, and a rise of 1.22 feet in 4 hours on February 20 to 21, 0.79 feet of this rise occurring during the first hour. During this month the extreme fluctuation was 2.56 feet which occurred within 5 days. The conditions of February, 1933, are quite typical.

The several factors which collectively control the level of Lake Michigan are precipitation, withdrawal of water through the Chicago Sanitary System drainage channel, evaporation, true tides, barometric pressure, winds, and seiches. These controls differ in their relative values.

Precipitation cannot account for the sudden changes in level indicated in figures 1 and 2. No precipitation occurred during the rise of 1.22 feet on February 20 and 21, and only 0.094 feet of precipitation during the rise of 1.93 feet on February 5 to 7.

Withdrawals through the Chicago Sanitary Canal are relatively constant, but differences from day to day should lead to slight changes in lake level. The maximum day-to-day difference during January, 1933, amounted to 1,950 second feet; the depressing effect of this, if spread over the southern half of the Lake Michigan basin would amount to 0.00055 feet, or over the southern quarter of the lake basin, to 0.0011 feet per day. The withdrawals are too small and too slow to account for the fluctuations in level.

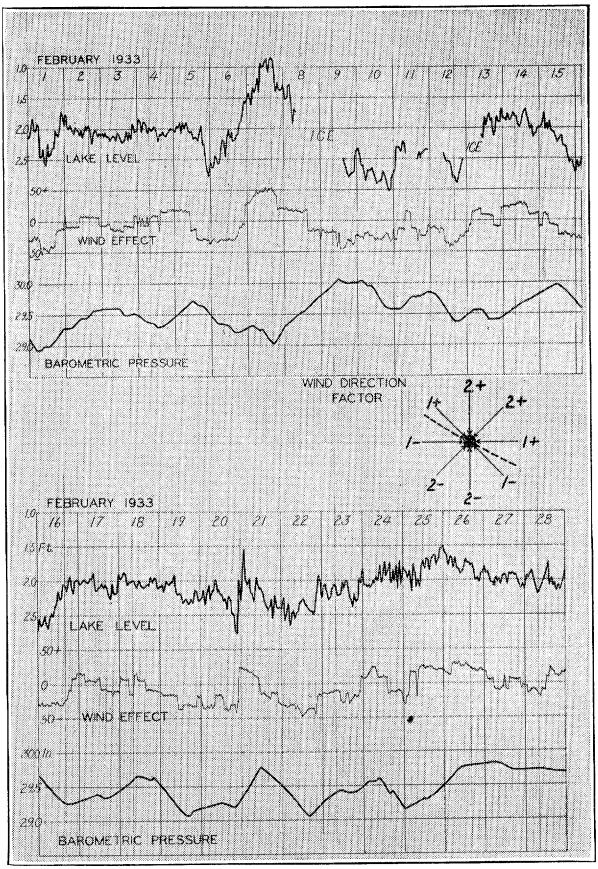
Evaporation from the surface never exceeds 0.021 feet per day, according to Hayford, and therefore evaporation can account for no considerable part of the daily and hourly fluctuations in lake level.

The true tide at Chicago gives a maximum range of oscillation of 0.14 feet. The short period fluctuations (Figs. 1 and 2) are (1) too great to be caused by tides, and (2) do not show the periodicity characteristic of tides.

Barometric pressures should affect the lake level in an inverse relationship. The curve of barometric pressure in figures 1 and 2 shows this inverse relationship on some dates, notably February 7; but it shows a direct relationship at many other times, as on February 1. The "improper" relationships generally occur when the lows and highs pass to the north of Chicago, thus inducing winds that oppose the effects of the barometric pressure.

Wind effects on the lake level during February, 1933, are very marked. Bearing in mind the west-northwesterly trend of the shore at Calumet Harbor and the probable effect of winds in piling up water or repelling it, the writer arbitrarily assigned to the 8 major wind directions the values indicated in the wind rose in figure 2. By multiplying the wind velocities by these wind direction factors the wind effects from hour to hour were computed and plotted in the wind effect curve shown in figures 1 and 2. The close correspondence between this curve and that for the lake levels is marked and indicates that the winds are a major cause of short-period fluctuations.

Seiches are free oscillations of the lake water under the influence of inertia, initiated by changes in distribution of the lake water. The seiches and seiche areas of Lake Michigan have never been carefuly worked out but their importance is unquestioned. Unexplained residuals left after computing the effects of the other factors may represent the effects of the seiches.



—*Courtesy Northwestern University.*

FIGS. 1 (above) and 2 (below). Hourly levels of Lake Michigan at Calumet Harbor, Indiana, during February, 1933, referred to low-water datum. Wind effect computed from records of U. S. Weather Bureau in Chicago. Barometric pressures recorded by microbarograph at Northwestern University.

The surprisingly large short-period fluctuations of the water surface of Lake Michigan correlate best with the wind direction and force, and more poorly with barometric pressure. Precipitation, withdrawals, evaporation and tides individually exert only a very slight control. Seiches are an important factor as yet never accurately evaluated for Lake Michigan.