RAINFALL MAPS OF WISCONSIN AND ADJOINING STATES

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The maps accompanying this paper are based on a new computation of the average rainfall. Earlier maps and discussions of the rainfall of Wisconsin are listed at the end.

The data are derived from observations made by and under the supervision of the U. S. Weather Bureau, and with standard rain gages. The observing stations are of two classes, (1) regular stations, manned by paid observers, and equipped with automatic recording gages, (2) cooperative stations, operated by public spirited citizens who perform the duty voluntarily, equipped with non-registering gages. The relative number and density of stations from which data were used are given in the following table:

<table>
<thead>
<tr>
<th>State</th>
<th>Observing stations</th>
<th>Reg.</th>
<th>Co-op.</th>
<th>Sq. mi. per station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois (Northern)</td>
<td>19</td>
<td>1</td>
<td>18</td>
<td>945</td>
</tr>
<tr>
<td>Iowa</td>
<td>51</td>
<td>7#</td>
<td>44</td>
<td>1090</td>
</tr>
<tr>
<td>Michigan (Upper Peninsula)</td>
<td>20</td>
<td>4</td>
<td>16</td>
<td>818</td>
</tr>
<tr>
<td>Minnesota (south of Lat. 47½°)</td>
<td>33</td>
<td>3</td>
<td>30</td>
<td>1745</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>81</td>
<td>5</td>
<td>76</td>
<td>708</td>
</tr>
<tr>
<td><strong>Total stations</strong></td>
<td><strong>204</strong></td>
<td><strong>20</strong></td>
<td><strong>184</strong></td>
<td><strong>984</strong></td>
</tr>
</tbody>
</table>

# Including Omaha, Neb.

The period of 31 years from 1897 to 1927 inclusive was taken as standard, and the records for only those years were used for stations with longer records. Missing observations within that period were estimated, and shorter periods of observation at 46 places in Wisconsin, and 16 in upper Michigan were extrapolated by comparison with surrounding observation points.

No corrections have been applied, beyond the extrapolation just mentioned, and the elimination of typographical errors.
It is well-known that the gaging of rain is not independent of wind, the catch diminishing the stronger the wind. The diminution is still greater in the case of snow. The regular stations of the Weather Bureau are generally located on high buildings in cities, and in plotting these charts it was found that their catch in the warmer months was less than at cooperative stations, which usually have a ground exposure. In winter the professional observer adjusts record of snow to correspond with the accretion of fresh snow on the ground, while the cooperative observer continues gage measurements. The cooperative observers are found in general to have less winter precipitation than the regular observers. As an example, the regular station at Duluth has a 31-year average precipitation for January of 1.01 inches, while the cooperative observer in the contiguous city of Superior, has only 0.58 inches adjusted average, based on 19 years of observations. On the other hand, the Duluth average for the 6 months, April-September, is 18.70 inches, against 19.76 for Superior.

Although precipitation is neither increasing nor decreasing permanently, its yearly deviations from the average are highly erratic. It is for this reason that care was taken to average the same period of years at all stations. Beyond this, the variations are local, especially in the warmer months, whence it is easily conceivable that some of the features of these maps are accidental. It is intended to study the dispersion of the data employed in these maps at some later time, but in the meantime it is of interest to remark that previous studies have shown that the average deviation of the annual rainfalls rises from 10% of the average in the Upper Peninsula of Michigan to 20% in southwestern Iowa.

That the main features of the distribution of rainfall shown by these maps are persistent can be verified by comparison with figures 2 and 8 of Kincer, (4).

Most of the precipitation in Wisconsin and adjacent states falls in connection with cyclonic storms. These move from west to east, but on account of their centripetal circulation and the western mountain barrier, their supply of moisture comes from the Gulf of Mexico and the Atlantic ocean. Decrease of rainfall with distance from source is
plainly seen on these maps, especially from Illinois and southern Iowa to northwestern Minnesota. The importance of the Great Lakes depends upon the season. In winter these lakes remain open, so that they are relatively much warmer than the land. Their vapor is then the source of heavy snowfalls on lee shores, e.g. the northern shore of the Upper Peninsula in map 3. A reach of wind across more than 30 miles of water appears to be essential, as the heavy snowfalls do not appear along the western end of Lake Superior, until the prevailing northwest winds have passed Bayfield Peninsula. In summer the heavy rains occur mostly in summer thunderstorms, which must be regarded as local convectional overturnings, although they mostly occur during the passage of large cyclonic whirls. In summer, however, the Great Lakes are relatively cool, conditions adverse to local convection. Map 2 shows that the summer rainfall is deficient around the lake shores.

The rising of air is considered by meteorologists to be the cause of rainfall. This is paradoxical to the lay mind which has become attached to the erroneous explanation that the rain is due to contact with the cold upper atmosphere. The correct explanation is that rising air expands to equalize its internal pressure with the external pressure, which diminishes with height. This expansion does work at the expense of the temperature. Consequently the cooling goes on continuously at a rate proportional to the rate of rising. We expect to find heavier rainfall where the ascent is fastest. Ascent in cyclonic whirls and thunderstorms is not localized, but highlands cause localized ascents of air, and it is this factor that explains the heavier rainfall in western and northern Wisconsin, and the smaller rainfall of the level lands extending from Green Bay up the Fox River valley, down the lower Wisconsin valley, and up and down the Mississippi valley. Additional discussion of the rainfall distribution of this region will be found in the papers listed below, of which Kincer must be mentioned as containing an extensive bibliography.
REFERENCES


2. Climatological reports, Wisconsin, 1907, monthly and annual summary. (Average monthly and annual rainfall of Wisconsin.) Milwaukee, 1907.


Map 1. Average annual precipitation, 1897-1927 inc.
Map 2. Average warm season precipitation, April-September, 1897-1927 inc.
Map 3. Average cold season precipitation, October-March, 1897-1927 inc.
Map 4. Percentage of the annual rainfall that falls in the six warmer months, April-September.