THE ADIRONDACK RAINFALL SUMMIT.

By ROBERT E. HORTON. Dated Albany, N. Y., December 21, 1906.

Rainfall maps of New York have been prepared by Turner (1894), Rafter (1898), and Kuichling (1900). The latter two are on a large scale and embody the means of a large number of records. In preparing these maps no effort was made to reduce the records to a uniform epoch, and even on the assumption that the average of each record for whatever period it covered was the true mean for the station, the data were found to be too meager to permit of any definite conclusion as to the distribution of rainfall over the Adirondack plateau.

Between 1900 and 1906 a greatly increased number of records have been kept in New York. Believing that a rainfall map of this region plotted from entirely synchronous records would at least show the relative rainfall distribution for the base[1] period covered, the writer compiled the records for twenty-five stations and computed the means for the pentad 1901–1905. The results are stated in Table 1 and are shown on the accompanying map (fig. 1). In a few cases incomplete records have been filled out from adjoining stations. In case of the record at Number Four eight months were missing and in case of North Lake the record from 1902 to 1905 was wanting. These have been filled out by Fournie's method,[2] using as base records in each case three well-authenticated stations so situated as to form the vertices of a triangle surrounding the station to which the method is applied. In each case base records have been chosen which run parallel with the record to be extended during five years. Special care has been taken in this extrapolation because the location of the 50-inch and 55-inch isohyetals depends chiefly on the Number Four and North Lake records.

TABLE 1.—*Comparative precipitation at stations on the Adirondack plateau, 1901–1905.*

Station.	Altitude.	1901.	1902.	1903.	1904.	1905.	Mean.
	Feet.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Adams Center	597	57.17	51.24	47.83	59.07	54.44	53.95
De Kalb Junction	440	43.75	31.86	37.09	34.11	36.02	36.56
Blue Mountain Lake	1,771	45.25	48.65	49.34	45.01	56.58	48.96
Deerfield	700	42.56	54.50	49.76	45.94	51.98	48.95
Glens Falls	340	35.10	42.71	43.31	36.39	37.35	38.97
Gloversville	850	36.46	46.88	49.16	42.88	49.29	44.93
Indian Lake	1,705	37.99	47.88	43.36	36.01	40.10	41.07
Keene Valley	1,000	42.60	48.62	41.23	29.86	41.45	40.75
Little Falls No. 2	1,526	45.09	47.11	46.20	50.61	55.21	48.84
Little Falls No. 1	924	36.62	43.81	44.52	36.25	46.62	41.56
Lowville	900	45.38	45.96	48.61	36.65	44.86	44.29
Lake George	350	42.35	49.38	47.83	41.15	39.82	44.11
Moira	800	49.35	35.26	36.45[a]	34.68	43.44	39.83
Number Four	1,571	55.18	60.41	64.72	53.70	58.60	58.52
North Lake	1,822	56.45	63.68	60.71[b]	51.06[b]	62.42[b]	58.86
Ogdensburg	258	34.07	24.15	37.60	27.91	29.68	30.68
Plattsburg	125	34.87	36.66	28.90	35.30[a]	36.08	34.36
Rome	445	44.45	49.34	47.77	48.82	52.24[c]	48.52
Saranac Lake	1,750	35.41	35.93	36.13	30.90	44.30	36.53
South Scroon	1,225	40.24	48.79	45.96	36.25	45.60	43.37
Saratoga	316	38.84	44.71	48.74	42.12	41.75	43.23
Ticonderoga	128	32.79	34.76	35.09	25.46	31.23	31.87
Utica Reservoir	700	47.00	52.36	50.37	44.40	59.59	50.74
Watertown	486	44.70	37.24	40.91	40.48	44.80	41.63
Wells	850	49.61	53.09	43.85	45.32	47.94	47.96

[a] Chazy. [b] Fournie's method. [c] 1900.

[1] This is the "fundamental period" of some authors.—EDITOR.

[2] V. Fournie, engineer of roads and bridges, France, is said to have been the first to formulate, in 1864, a method of interpolating isolated months so as to obtain complete years of rainfall and a method of interpolating isolated years so as to obtain homogeneous rainfall data for a given "fundamental period". (See Angot on the rainfall of the Iberian Peninsula, in the Annals of the Central Meteorological Bureau, Paris, 1893, quoted at length in the Monthly Weather Review, April, 1902, page 238.) Mr. Horton gives the following as an example of the application of Fournie's method:

"In order to complete the North Lake record 1896–1902 for the period 1901–1905, I chose as base stations Gloversville, Number Four, and Utica Reservoir (1897 to 1905). I computed the ratio of the mean rainfall at each of these stations for the period of 1897 to 1901 to that at North Lake for the same period, and then multiplied the measured rainfall at each base station for each year, 1902 to 1905, by the corresponding ratio, and used the average of the three results as the rainfall for North Lake for the corresponding year".

Every study of climatological data must be preceded by careful reduction to a fundamental period if we would avoid erroneous conclusions.—EDITOR.

Certain additional records which do not cover any portion of the period 1901 to 1905 have been included. Using the best available base records the proportional rainfall at these stations for the period here considered has been deduced as shown in Table 2.

TABLE 2.—*Earlier precipitation records and estimated precipitation for base period.*

Station.	Altitude.	Period.	Mean.	Estimated mean, 1901-1905.
	Feet.	*Years.*	*Inches.*	*Inches.*
Houseville	900	1867–69	48.22	54.60
Turin	1,240	1890–95	52.92	56.69
Constableville	1,246	1889–93	55.04	50.98
South Trenton	825	1863–76	52.51	63.41

The southwestern Adirondack rainfall summit is the most striking feature of the map (fig. 1). It has been figured on earlier maps and the main object of the present study has been to confirm and account for it. The rainfall stations at Number Four and North Lake have been inspected, the former by the writer, the latter by an assistant. The exposures are favorable and the records have apparently been intelligently and accurately kept. The record at North Lake is confirmed by two short records the results of which are given in Table 3.

TABLE 3.—*Comparative precipitation, in inches, at North Lake and neighboring stations.*

Month.	1900.			1901.		1906.		
	North Lake.	Honnedaga.	Bisby Lodge.	North Lake.	Honnedaga.	North Lake.	Honnedaga.	Hoffmeister.
January	......	......	......	......	......	5.30	......	2.90
February	......	......	......	5.08	2.50	......	2.53	4.24
March	......	......	......	3.04	3.89	2.62	......	5.57
April	......	......	......	3.40	1.65	2.17	2.09	3.70
May	......	......	......	5.57	6.80	7.21	5.22	5.55
June	2.59	3.94	4.90	8.06	5.81	......	5.24	5.58
July	4.94	5.56	4.18	6.34	7.37	4.84	2.99	4.35
August	5.28	5.54	7.41	3.86	5.23	3.15	4.24	4.76
September	2.60	3.36	3.67	3.59	1.42	3.30	4.89	3.69
October	3.25	3.39[a]	3.39	......	......	......	......	......
November	7.56	7.21	8.55	......	......	......	......	......
December	2.09	4.66	3.19	......	......	......	......	......
Total	28.31	33.66	35.29	38.94	34.67	......	......	......

[a] Bisby Lodge.

Topographic contours at 1000-foot intervals have been sketched on the map, also the principal watershed lines. The most elevated regions receive about forty inches precipitation. It should be noted, however, that there are no extensive areas in the Adirondacks lying above elevation 3000 feet; the valleys and lakes at the headwaters of the streams lie in most cases below elevation 2000. The 3000 and 4000-foot contours have been drawn to include areas in which most of the mountain masses are above these elevations and the included area has been cross-hatched. There are, however, many peaks outside this area which project above 3000 feet.

In fig. 2 is shown a profile along parallel 43° 30′ north extending eastward from Lake Ontario on a line running a few miles south of North Lake. This shows an ascent from the elevation of the lake, 247 feet, to elevation 1600 feet in the first forty miles, crossing what is known as Tuigg's Hill. Black River Valley is then crost at elevation 1000 feet, after which the Adirondacks are entered. The elevation in the region of maximum rainfall varies from 2000 to 2500 feet. F. Pockels has calculated the height in meters that a current of air must be uplifted by a mountain slope in order to produce rain by dynamic cooling. The results reduced to feet are given in Table 4, which shows the height to which a mass of air must be raised above H_1 to produce condensation. The table is based on average temperature and moisture gradients deduced

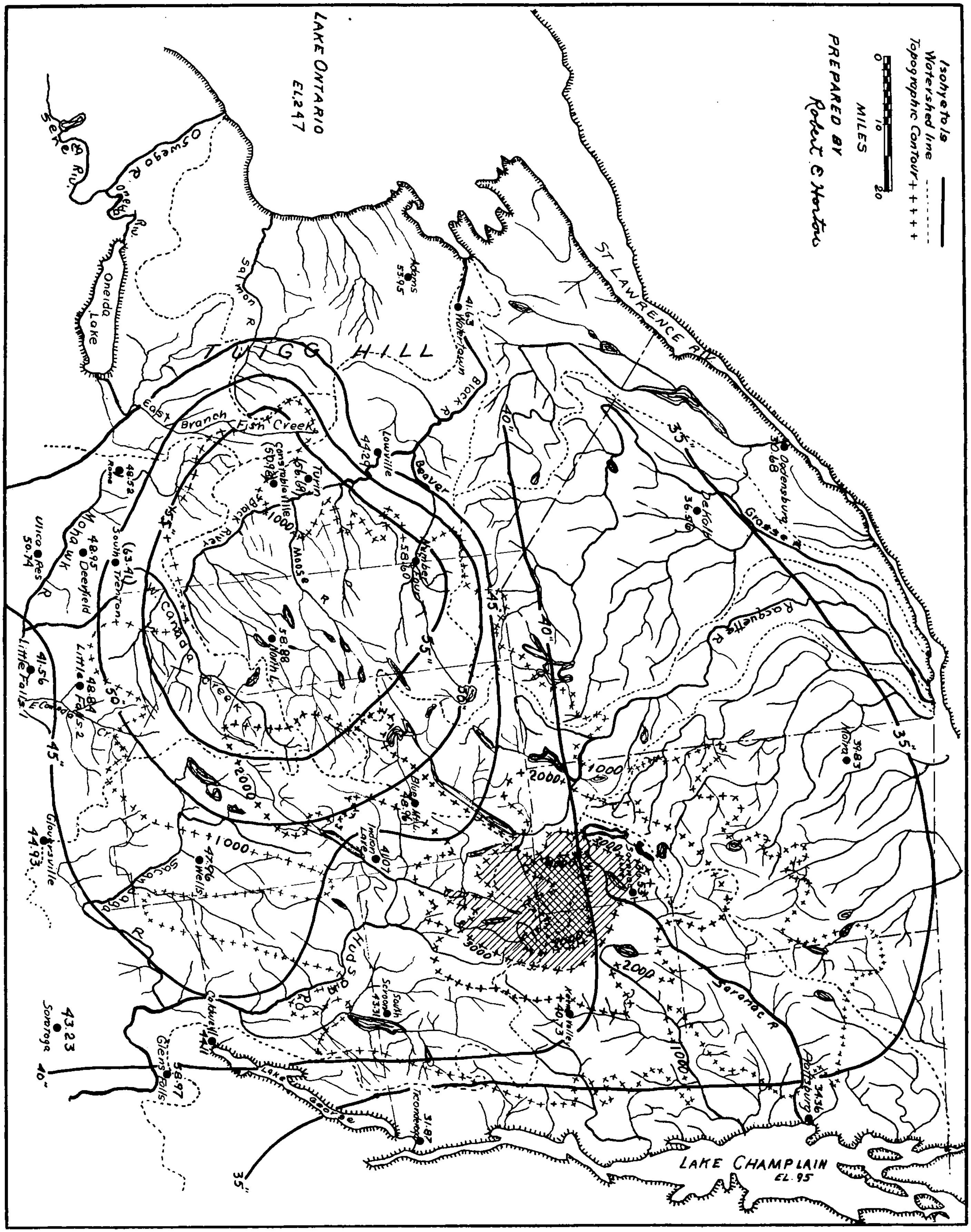

FIG. 1.—Adirondack rainfall, drainage basins and topography.

from balloon ascensions. For the moisture-laden prevailing west-southwest winds blowing off Lake Ontario and ascending the southwest slope of the Adirondacks, the tendency to condensation would presumably be greater. With moisture and temperature conditions as assumed in Table 4, the elevations at which condensation will be produced on the southwestern Adirondack slope will be about as follows :

	Feet.		Feet.
Spring......................	2,507	Summer.....	2,966
Autumn......................	1,678	Winter......................	1,736

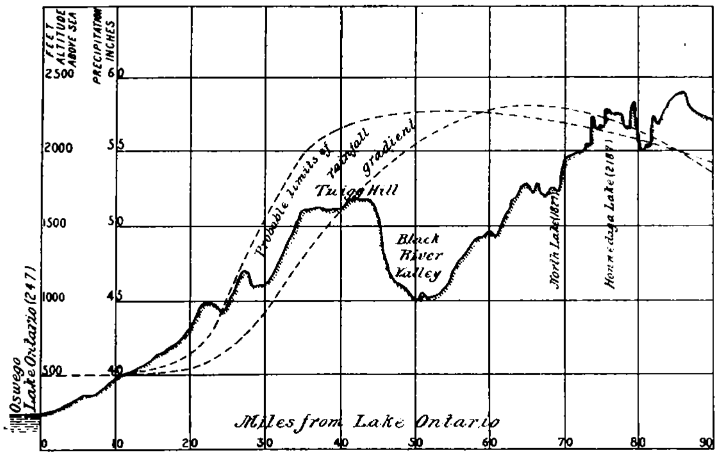

FIG. 2.—Profile along parallel 43° 30′ N. from Lake Ontario eastward.

TABLE 4.—*Pockels's table showing minimum height that a mass of air originally at elevation H_1 must rise in order to produce condensation.*[3]

	Height in feet above H_1 when condensation begins.			
H_1 (feet).	Spring.	Summer.	Autumn.	Winter.
0................................	2,378	2,788	1,328	1,312
1,640................................	1,591	2,329	2,017	2,493
3,280................................	2,804	1,870	1,968	3,510
4,920................................	2,919	2,230	2,738	3,739
6,560................................	3,018	2,394	3,870	3,608
9,840................................	2,722	3,477	3,969	3,706
13,120................................	2,296	3,690	4,067	3,608

Bearing in mind the nearness to Lake Ontario and the excessive snowfall experienced on Tuigg's Hill and in Black River Valley it appears probable that Tuigg's Hill is a sufficient barrier to produce a large increase in precipitation in winter. The fact that the precipitation decreases easterly from North Lake, altho the altitude northeast of the rainfall summit increases rapidly, indicates that in this case the southwest slope has sufficient elevation to relieve the southwest winds of most of their available moisture.

In the Adirondacks we have then, first, a rapid increase of precipitation with altitude over the southwest slope; then a rapid decrease of precipitation as the altitude increases proceeding northeast. In this decrease of rainfall, however, the orography probably plays no part whatever. This matter of relation of orography to rainfall has been much discust, and the apparent negative results in cases similar to the above have been assumed to disprove the existence of any definite law of relation. In the writer's mind the conditions forcibly illustrate the fundamental principal of oro-dynamic condensation, it being apparent that, given a moisture-laden wind blowing over a sufficient slope, increased precipitation must result. Certain orographic and meteorological conditions must, however, be present. If suitable meteorological conditions are not present, obviously there will be no increase of precipitation adjacent to mountains.

The area having over fifty inches rainfall includes a large portion of Black River drainage basin, the principal tributaries being Moose and Beaver rivers. It also includes the headwaters of Salmon River, east branch of Fish Creek, Mohawk River, and East and West Canada creeks. All of these streams have been gaged. In the absence of adequate records in the rainfall summit region a number of attempts have been made to deduce the precipitation for these drainage basins by combining the nearest adjacent precipitation records.

The discrepancy between such estimates of rainfall or of run-off based thereon, and the measured stream flow, forcibly illustrates the folly of too close adherence to numerical data in such studies, and also illustrates the necessity for rain gages at the higher altitudes. An estimate of the rainfall in the region here considered based on the records at surrounding stations would bear about the same relation to the truth as an estimate of the height of a mountain based on the average elevation of points around its base.

The comparative run-off during the summer season of streams having their headwaters in the Adirondack region is shown in Table 5. The first three streams named in the table have their headwaters in or drain a portion of the rainfall summit region.

Saranac River, Lake George outlet, and Hudson River drain much of the eastern Adirondack slope. The run-off of the Hudson River is subject to artificial control and to diversion above the point of gaging during the summer period. Its total yearly run-off during the period 1901 to 1905 has averaged about twenty-seven inches.

TABLE 5.—*Comparative annual depth of run-off, in inches, for streams having their headwaters in the Adirondack region.*

Stream.	Gaging station.	Area above gaging station.	1901.	1902.	1903.	1904.	1905.	Mean.
		Sq. miles.	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*
East Canada Creek .	Dodgeville...	256	29.16	32.58	44.07	34.02	37.57	35.48
West Canada Creek.	Twin Rock....	364	40.50	53.22	55.75	44.39	50.87	48.95
Oneida River.......	Oak Orchard..	1313	....	....	37.49	32.50	33.16	34.38
Seneca River.... .	Baldwinsville.	3103	....	....	17.92	17.42	15.19	16.84
Oswego River	Battle Island..	4990	....	....	22.05	24.31	21.81	22.72
Weighted mean of the Oneida and Seneca rivers		4416	....	....	....	....	....	22.28
Precipitation at Number Four... ..		....	55.18	60.41	64.72	53.70	58.61	......

The geology and topography do not differ materially and the influence of forest cover is apparently about the same for the eastern as for the western portion of the Adirondack region. The excess in summer run-off for the southwestern as compared with the eastern Adirondack slope is clearly shown by comparing the run-off of Saranac River (13.86 inches) and Lake George outlet (11.71 inches) with the other streams in 1905. The average run-off for the two regions bears the ratio 12.78 : 22.28. As further confirmation of the heavy run-off from the southwest Adirondack slope, we may compare the gaging records of the Oneida and Seneca rivers, which unite to form the Oswego.

As above stated, a part of the Oneida basin lies in the region of maximum precipitation, for which, however, records are mostly wanting. Seneca River drains the Finger Lake region of central New York. The average precipitation on this basin is about thirty-five inches and is well determined.

The total measured outflow from the Oneida and Seneca basins is 7266 cubic feet per second. Taking such a proportion of the Oswego flow as its drainage area bears to the combined drainage areas above the other two gaging stations, we obtain 7273 cubic feet per second. This confirms the gaging records.

The depth of the run-off from the Oneida basin is more than double that from the Seneca basin. The aggregate volume of water draining from the Oneida basin is also nearly as great

[3] Monthly Weather Review, July, 1901, Vol. XXIX, p. 306. The figures are there given in meters.

as from the Seneca basin, which has 2.36 times as large a drainage area.

TABLE 6.—*Drainage per square mile.*

River.	Drainage area above gaging station.	Mean flow, 1903-1905.	
		Cubic feet per second.	Cubic feet per second per square mile.
	Square miles.		
Oneida	1,313	3,410	2.60
Seneca	3,103	3,856	1.24
Oswego	4,990	8,187	1.64

For a number of the streams here considered the run-off data for the winter period have been omitted in order to eliminate such uncertainty as may arise in measuring snowfall and in gaging frozen streams.

The gaging record for West Canada Creek, which has been kept at Twin Rock Bridge, is less reliable for winter than for summer, and probably gives somewhat excessive results. Allowing for any probable error, the recorded run-off is still greater than can be accounted for from the measured winter precipitation. For the summer season the measured run-off and precipitation are consistent. This is shown by the following Table 7:

TABLE 7.—*Precipitation and run-off, in inches, West Canada Creek basin.*

May to November.			December to April.		
	Precipitation.	Run-off.	Year.	Precipitation.	Run-off.
			1900-1901	16.61	17.78
1901	36.63	15.03	1901-1902	25.93	31.71
1902	34.25	26.17	1902-1903	26.21	34.24
1903	34.35	24.98	1903-1904	30.17	21.92
1904	30.30	22.90	1904-1905	14.93	20.47
1905	41.06	27.07	1905-1906	16.61	28.09
Mean	35.32	23.23		21.74	25.70

Similar data may be deduced from a comparison of the winter and summer records for other streams heading in the southwestern Adirondack slope. Such studies lead to the conclusion that the measured winter precipitation in this region is considerably less than the actual precipitation.

An effort has been made to ascertain the facts by the establishment of special snowfall stations, but for the present only general evidence is available. It is frequently reported, and the writer has himself seen late in winter, a snow accumulation in the woods of this region greater than the total reported precipitation for the winter at the nearest station.

The data cited are only a portion of those available indicating excessive run-off from the southwestern slope, as compared with either the observed rainfall or with the run-off from other Adirondack streams. The excess in case of the Moose, Beaver, and Black rivers is less marked than for east branch Fish Creek, upper Mohawk River, and West Canada Creek, indicating so far as such evidence may be given weight that the rainfall summit lies farther to the southwest and is more pronounced than appears from the available precipitation records.

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