Leffler's Method of Estimating Average Temperatures of Appalachian Summits: Evaluation in New York

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ABSTRACT

R. J. Leffler recently presented regression equations to estimate average monthly temperatures of Appalachian summits based on the long-term average temperatures on Mt. Washington, New Hampshire, and temperature lapse rates as a function of latitude and elevation. The data used to derive his equations came from eight summits in northern New England and from Virginia southward. Long-term average monthly temperatures are derived here from 8–14 years of data for four summit locations in New York to evaluate Leffler's equations where they have not previously been tested. The average monthly temperatures estimated by Leffler's equations for the four New York summits are generally within 0.6°C of the long-term averages and Leffler's equations may therefore be applied with reasonable accuracy in New York.

1. Introduction

A recent paper by Leffler (1981b) noted the lack of temperature observations on Appalachian summits and the need for estimates of average summit temperatures for applications in snowmaking, wildlife and forestry management, backpacking, timberline studies and mountain weather forecasting. Leffler examined temperature records from eight summit stations (defined as a crest at least 300 m above the surrounding ground) from New Hampshire to South Carolina at elevations from 524 to 2022 m. The period 1941–70 was used for most stations. His results included calculated lapse rates of average monthly and annual summit temperatures as a function of elevation and latitude. Average temperatures of a summit without weather records can then be estimated from the long-term temperatures of one of the eight instrumented summits using the two summits' latitudes and elevations and the given lapse rates. Leffler (1981b) presented the data in Table 1 to estimate average summit temperatures with

$$T = A + B(44.27 - \mathrm{LAT}) + C(1.909 - \mathrm{ELEV}), \quad (1)$$

where T is the estimated average monthly temperature (°C) of the summit in question, A is the average monthly temperature on Mt. Washington, New Hampshire, B and C are the monthly lapse rates of temperature with latitude (°C per degree latitude) and elevation (°C km^{-1}), 44.27 and 1.909 are the latitude and elevation (km) of Mt. Washington, and LAT and ELEV are the latitude and elevation of the summit in question.

Leffler (1981b) found no Appalachian summit stations between northern Vermont and Virginia with acceptably long temperature records to use in calculating the lapse rates of average temperatures given in Table 1. There are, however, a few summit or near-summit weather stations in New York which have records shorter than 30 years. Four of these summit locations are used in this note to determine whether Leffler's method of estimating Appalachian summit temperatures is appropriate in New York.

2. Evaluation of Leffler's method in New York

The four locations used in this paper are Whiteface Mountain, Tully-Heiberg Forest, Gannett Hill and Walton 5NE (Fig. 1 and Table 2). Whiteface Mountain is a peak in the Adirondack Mountains, 1000 m above the surrounding valleys. The summit is at the climatic timberline (Leffler, 1981a). Seventy-five months of average temperatures at or near the summit are available from January 1938 through August 1946. All temperature data referred to here are from *Climatological Data, Annual Summary for New York*, for the appropriate year. To correct the average monthly temperatures of the 1938–46 period to a long-term average, the Whiteface Mountain averages were adjusted according to the monthly departures from the long-term normal reported at Lake Placid Club (568 m), 11 km southwest of the summit. For example, the average of the seven available average June temperatures for Whiteface

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TABLE 1. Coefficients for Leffler's equations (Leffler, 1981b).*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
A	−14.6	−15.0	−11.2	−5.2	1.3	7.1	9.3	8.3	5.1	−0.3	−6.3	−12.8	−2.8
B	1.42	1.45	1.32	1.29	1.06	0.83	0.76	0.82	0.89	0.92	0.98	1.31	1.08
C	4.4	5.2	6.2	6.5	6.6	6.2	6.3	6.2	5.7	5.9	5.4	4.6	5.8

* *A* is the average monthly temperature (°C) on Mt. Washington (1909 m), *B* the lapse rate of temperature with latitude (°C per degree latitude), and *C* the lapse rate of temperature with elevation (°C km^{-1}).

Mountain is 11.1°C and the departure of Lake Placid Club temperatures from the long-term normal for those seven months averaged +1.0°C. The long-term average June temperature for Whiteface Mountain is therefore taken to be 10.1°C. The elevation of the Whiteface station was 1407 m until February 1943 when it was moved to the summit at 1484 m. A time-weighted average elevation of 1449 m is used here to estimate average temperatures with Leffler's equations.

Tully-Heiberg Forest is a cooperative substation in the highlands of central New York. The station is located in a clearing 36 m below the summit of Truxton Hill and 200–250 m above nearby valleys. Air drainage is good. The temperature record began at Tully-Heiberg Forest in January 1967 and continues to the present. Average temperatures for the 1967–80 period were adjusted to long-term averages with the monthly departures from normal at Cortland (344 m), 21 km to the southwest.

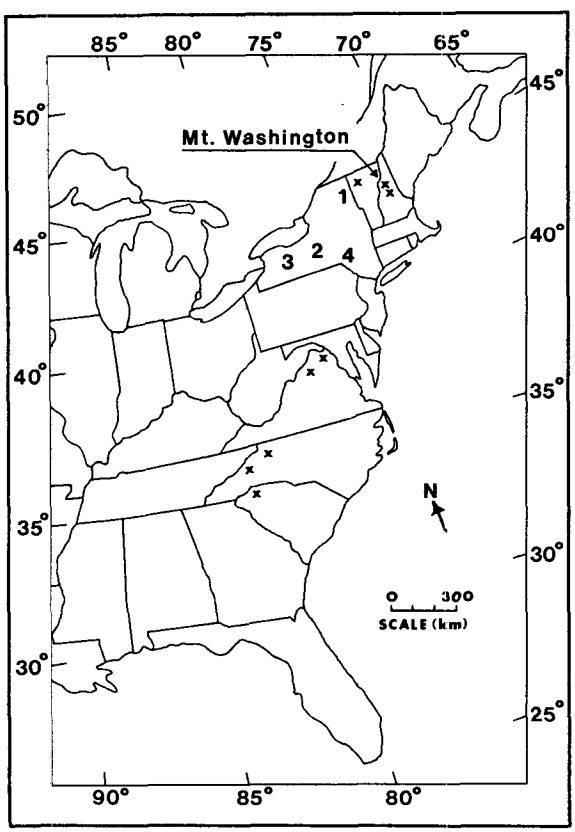

FIG. 1. Location of eight summit stations used by Leffler (1981b), each marked with an 'X', and four stations used to evaluate Leffler's equations in New York. New York stations are identified in Table 2.

Gannett Hill is a cooperative substation in western New York, outside of the area Leffler considered, but representative of western New York highlands. The station is 100 m below the peak of Gannett Hill but air drainage is good into valleys 150–250 m below the station. Observations began in July 1971 and continue, with an 11-month break in 1974–75, to the present. Average temperatures for the 1971–80 period were adjusted to long-term averages with the monthly departures from normal at Hemlock (275 m), 15 km northwest of Gannett Hill.

Walton 5NE was located on a hilltop farm in the Catskill Mountains. It stood ~150 m above the surrounding valleys. The period of record at Walton 5NE extends from January 1947 to July 1956 with no missing months. The 1947–56 average temperatures were adjusted to long-term averages with the monthly departures from normal at Delhi (445 m), 13 km to the east.

The long-term averages of monthly and annual temperatures derived from short-term records as described above and average temperatures estimated from Leffler's equations are compared in Table 3 for the four New York summit locations.

The methods used in this note to derive long-term average temperatures from 8–14 years of record for

TABLE 2. Identification of New York summit stations.

	Elevation (m)	Latitude (°N)	Longitude (°W)
1. Whiteface Mountain	1449	44.37	73.92
2. Tully-Heiberg Forest	579	42.77	76.08
3. Gannett Hill	594	42.70	77.40
4. Walton 5NE	549	42.23	75.08

TABLE 3. Comparison of average temperatures as estimated by Leffler's equations (L) to the long-term measured average (M) for four New York summits.

		Temperature (°C)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Whiteface Mountain	Leffler (L)	−12.7	−12.8	−8.5	−2.3	4.2	9.9	12.1	11.1	7.6	2.3	−3.9	−10.8	−0.2
	Mean (M)	−12.6	−13.0	−8.4	−2.1	5.0	10.1	12.6	11.2	8.0	2.2	−4.7	−9.9	−0.1
	L − M	−0.1	0.2	−0.1	−0.2	−0.8	−0.2	−0.5	−0.1	−0.4	0.1	0.8	−0.9	−0.1
Tully-Heiberg Forest	Leffler (L)	−6.6	−5.9	−1.0	5.4	11.7	16.6	18.8	17.8	14.0	8.9	2.4	−4.7	6.5
	Mean (M)	−6.9	−6.8	−2.2	5.6	11.7	16.9	19.4	18.2	14.5	8.7	1.9	−5.3	6.3
	L − M	0.3	0.9	1.2	−0.2	0.0	−0.3	−0.6	−0.4	−0.5	0.2	0.5	0.6	0.2
Gannett Hill	Leffler (L)	−6.6	−5.9	−1.0	5.4	11.7	16.6	18.8	17.7	14.0	8.9	2.3	−4.7	6.5
	Mean (M)	−6.6	−5.9	−2.1	5.3	11.7	17.4	19.4	18.7	14.7	9.1	2.5	−4.4	6.7
	L − M	0.0	0.0	1.1	0.1	0.0	−0.8	−0.6	−1.0	−0.7	−0.2	−0.2	−0.3	−0.2
Walton 5NE	Leffler (L)	−5.7	−4.9	−0.1	6.3	12.4	17.2	19.4	18.4	14.7	9.6	3.1	−3.9	7.3
	Mean (M)	−5.5	−5.5	−0.5	5.4	11.9	16.8	19.2	18.2	14.6	8.6	2.8	−4.0	6.8
	L − M	−0.2	0.6	0.4	0.9	0.5	0.4	0.2	0.2	0.1	1.0	0.3	0.1	0.5

four summits, and the different periods of record at the summits, introduce uncertainties in the results. In addition, the four New York summit locations differ in various ways from true summit locations as defined by Leffler (1981b). In spite of these weaknesses, it is helpful to potential users of Leffler's equations if a quantitative evaluation of the equations can be made in as many areas as possible. The best New York summit temperatures available, as presented here, indicate that Leffler's method of estimating average Appalachian summit temperatures can be used with reasonable accuracy in New York.

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