ELEVATION AND ALTITUDE.[1]

Engineers use the word *elevation* with reference to the height of an object, usually on the ground, relative to some sea level or some other fixed datum. In aerology and aviation, heights above ground in free air are commonly referred to as *altitudes*. In meteorology and other scientific discussions, heights either on the ground or above it are sometimes referred to indifferently as elevations or altitudes and the terms are often used interchangeably. In the table of stations in the reports of the U. S. Weather Bureau, height of ground above sea and height of instruments above ground are both referred to as elevations. Such uses of the word elevation are sometimes confusing. Cases have arisen where it was difficult to ascertain whether the height of an instrument, anemometer, barometer, or thermometer, for example, was with reference to sea level or ground level. Of course, this uncertainty could only exist at stations near sea level. It is suggested that a distinction in usage of the terms elevation and altitude, somewhat akin to that suggested by Dr. H. R. Mill for the terms mean and average,[2] may be desirable. Would it not be well to limit the use of the term altitude to heights above ground at a particular location, and the use of the term elevation to the height of the ground or a fixed object on the ground with reference to sea level, or some other definite datum, the actual point of reference being near or remote, as the case may be. On this basis the height of a meteorological station would be given as its elevation and would be the ground level elevation at the station. The heights of the instruments above ground would be expressed as altitudes.—*Robert E. Horton.*

[1] The suggestion by Mr. Horton is an excellent one, and I may express the hope that it will be uniformly adopted by writers for the REVIEW. In the beginning it would be well for each writer to announce on the occasion of the first use of either of the terms "elevation" or "altitude" the sense in which it is used. The official publications of the Weather Bureau where the expression "elevation" appears make it clear what reference point is taken as a base level.—EDITOR.

[2] Cf. MO. WEATHER REV., November, 1918, 46: 514–515.

TEMPERATURES OF THE SOIL AND AIR IN A DESERT.

By JOHN G. SINCLAIR.

[Medical School, University of North Dakota, March 15, 1922.]

The Carnegie Institution of Washington maintains a Desert Laboratory at Tucson, Ariz., where for some years the activities of plants and animals in relation to their desert environment have been studied. Much work has been done with water relations both as to evaporation and movement in soils. Extensive records of soil and air temperature are kept.

While assistant in charge of Professor Tower's "Experiments in Evolution" (see Carnegie Publication No. 263) I undertook a further analysis of the temperature conditions of air and soil. The results have a meteorological as well as a biological interest.

It is a well-recognized fact that the range of temperatures in the desert is tremendous. The surface of the soil is heated and it is a matter of interest to know to what extent this heat is transferred to deeper levels. It is well known that the surface air becomes rapidly chilled in the evening. What is the relation of temperature here to the levels above and the soil beneath? Desert animals and plants live in a comparatively narrow zone.

There were available at Tucson an exceptional aggregation of thermometers. The measurements in air were taken with German-made instruments, having large bulbs and graduated to tenths of a degree centigrade. These instruments were divided into two sets. One set was coated with a glossy white paint and the other with a dull black. I anticipated criticisms of this and so took the precaution to read the standard shelter thermometer at the same time that any other readings were taken. Since they were to be used in the open sunlight, the entire lot were standardized. To do this they were placed at a uniform level about 4 feet above ground and readings were taken every hour of the day. The thermometers were inclined, so that their axes were at right angles to the circle of the sun, insuring uniform exposure at all times. The members of each set differed only by tenths of a degree from each other. The constant necessary to reduce each to the median member of the group was adopted for each thermometer and for each hour of the day separately. All further data were then corrected by these constants.

The soil temperatures were read on standard mercury thermometers, which, like the others, had to be checked in a water bath for comparison. It was found necessary to use a boiling-point thermometer for the surface soil, as the temperature there burst the one first employed. At two of the levels Friez soil thermographs registered continuously and the records from other instruments were available for comparison but from a different locality.

Figure 1 illustrates in diagram the apparatus set up. The levels of the black and white thermometers were the same and the exposure was made uniform through the day as in the tests. The upper six soil thermometers were permanently embedded and were read in place. The depth indicated the distance to the center of the bulb. The thermometers for the deeper levels were slipped into close-fitting glass tubes, so that the bulbs rested in molds in the soil below. These were drawn up rapidly by strings sufficiently high to be read and were immediately dropped back and the tube corked.

After the preliminary tests the reading began at 5:30 a. m., June 17, 1915, and continued almost hourly to 10:30 p. m. The series was repeated nearly daily till September 19, 1915. An inspection of the data showed a repetition of the main features daily. For this reason that day was chosen for presentation which showed the highest temperature reached for the year. This was June 21, 1915.

Table 1 shows the data taken June 21. In the table the data for air and soil temperatures are separated at the ground level. At this point are placed the readings of the standard shelter thermometer and as a matter of added interest readings taken in shade among the red volcanic rocks of the Desert Laboratory grounds. All the apparatus except this one thermometer recorded the conditions in the adobe soil of the garden well away from the rocks. The maximum temperatures reached in the air series at any time of day are in bold-faced type and are arranged to compare the black and white thermometers with the standard shade temperature.

The minimum temperatures for any time of day are given in italics. The peculiar shift of the point of maximum and minimum temperatures is a significant problem. At 4:30, when this shift occurs, the sun is still high and the earth is much hotter than the air immediately above it.

The temperatures of the soil series in bold-faced type are the maxima for that level for the entire day and the minima for the day are underlined. Here the steady progress of the heat downward is graphically shown. The minima are underlined. The minima for the levels 2 cm. and 4 cm., of course, occur before 5:30 a. m.

TABLE 1.—*Temperture data (° C.) for June 21, 1915, Desert Laboratory, Ariz.*

		5:30 A		6:30 A		7:30 A		8:30 A		9:30 A		10:30 A		12:00	
		B	W	B	W	B	W	B	W	B	W	B	W	B	W
Air levels in centimeters above the ground level.	175	12.0	12.0	26.6	18.8	30.6	24.8	37.7	32.0	41.1	35.6	42.7	38.4	43.8	41.5
	114	11.4	11.2	27.5	18.9	32.7	25.5	40.2	32.3	43.9	36.5	45.6	38.9	46.9	39.9
	65	10.7	10.2	27.8	19.0	32.8	26.2	41.7	33.3	44.8	36.9	46.7	40.0	48.1	41.8
	32	10.3	10.0	27.4	18.8	34.4	26.8	42.8	35.0	46.9	39.5	48.3	41.9	50.1	43.0
	12	10.2	9.7	27.8	19.4	35.6	27.9	44.0	36.1	48.3	40.9	50.3	43.6	52.2	44.4
	4	10.0	9.6	28.6	20.0	36.0	28.1	45.8	37.1	50.3	41.7	53.1	43.6	53.9	46.4
Standard shade		....	11.6	....	19.8	....	25.4	....	30.6	....	35.7	....	38.4	....	40.7
Shade among rocks		22.0	....	25.0	....	28.2	....	30.6	....	32.5	....	35.0	....	36.0	....
Soil levels in centimeters below ground level.	0.4	.....	17.0	.....	23.3	.....	31.8	.....	43.5	.....	54.2	.....	62.1	.....	58.3
	2	.....	22.0	.....	22.7	.....	26.9	.....	32.3	.....	37.8	.....	40.4	.....	45.8
	4	.....	23.5	.....	23.5	.....	26.1	.....	29.9	.....	34.3	.....	37.1	.....	41.4
	7	.....	25.8	.....	25.2	.....	26.2	.....	28.4	.....	31.2	.....	33.8	.....	37.1
	10	.....	28.1	.....	26.5	.....	27.2	.....	27.9	.....	28.2	.....	30.7	.....	33.0
	15	.....	30.2	.....	29.6	.....	28.1	.....	28.9	.....	28.8	.....	29.1	.....	29.9
	20	.....	30.6	.....	30.1	.....	29.8	.....	29.4	.....	29.2	.....	29.0	.....	29.2
	30	.....	29.7	.....	29.5	.....	29.3	.....	29.2	.....	28.7	.....	27.9	.....	27.8
	45	.....	27.8	.....	27.8	.....	27.8	.....	27.8	.....	27.9	.....	27.9	.....	27.9
	60	.....	26.4	.....	26.4	.....	26.4	.....	26.4	.....	26.4	.....	26.4	.....	26.4
	100	.....	24.5	.....	24.5	.....	24.5	.....	24.5	.....	24.5	.....	24.5	.....	24.5
	200	.....	20+	.....	20+	.....	20+	.....	20+	.....	20+	.....	20+	.....	20+

		1:00 P		2:00 P		3:30 P		4:30 P		6:00 P		7:30 P		9:00 P		10:30	
		B	W	B	W	B	W	B	W	B	W	B	W	B	W	B	W
Air levels in centimeters above the ground level.	175	46.9	41.6	44.1	41.5	46.0	42.7	47.2	42.6	40.4	38.8	31.7	31.8	24.3	24.2	20.5	20.5
	114	48.7	42.7	46.1	41.5	48.3	42.8	48.6	42.6	38.7	38.0	30.8	30.7	23.7	23.7	19.5	19.5
	65	50.8	44.0	47.5	42.4	48.6	43.6	49.8	43.2	37.6	36.7	29.6	29.4	22.8	22.8	18.4	18.4
	32	53.3	45.8	49.1	44.3	50.7	45.0	50.5	44.3	36.0	35.8	28.5	28.7	21.9	21.9	18.3	18.3
	12	55.7	48.4	52.2	46.3	53.0	46.7	47.7	43.2	36.2	35.0	27.9	27.8	21.4	21.4	18.1	18.1
	4	57.5	49.7	52.0	47.8	55.7	48.6	47.8	43.8	35.8	35.6	27.9	27.8	21.5	21.5	18.2	18.2
Standard shade		....	42.5	....	42.2	....	42.0	....	41.5	....	38.7	....	31.8	....	24.8	....	19.8
Shade among rocks		40.1	....	42.0	....	42.5	....	44.0	....	38.5	....	34.0	....	30.5	....	23.0	.....
Soil levels in centimeters below ground level.	0.4	.....	71.5	.....	70.2	.....	67.8	.....	62.8	.....	49.3	.....	39.2	.....	31.8	.....	27.4
	2	.....	50.4	.....	62.1	.....	52.5	.....	51.0	.....	43.5	.....	38.1	.....	32.9	.....	29.5
	4	.....	45.4	.....	47.3	.....	48.1	.....	47.5	.....	43.1	.....	38.8	.....	34.2	.....	31.0
	7	.....	40.5	.....	42.7	.....	43.8	.....	44.1	.....	42.2	.....	39.6	.....	35.9	.....	33.0
	10	.....	35.5	.....	37.6	.....	39.1	.....	40.1	.....	40.1	.....	39.0	.....	35.8	.....	34.5
	15	.....	30.8	.....	32.0	.....	33.1	.....	34.4	.....	35.4	.....	35.6	.....	35.3	.....	34.4
	20	.....	29.7	.....	30.2	.....	31.0	.....	31.9	.....	32.9	.....	33.2	.....	33.4	.....	33.2
	30	.....	28.7	.....	28.7	.....	28.7	.....	28.8	.....	29.1	.....	29.3	.....	29.5	.....	29.8
	45	.....	27.9	.....	27.8	.....	27.8	.....	27.8	.....	27.8	.....	27.8	.....	27.8	.....	27.8
	60	.....	26.4	.....	26.4	.....	26.4	.....	26.4	.....	26.4	.....	26.4	.....	26.4	.....	26.4
	100	.....	24.5	.....	24.5	.....	24.5	.....	24.5	.....	24.5	.....	24.5	.....	24.5	.....	24.5
	200	.....	20+	.....	20+	.....	20+	.....	20+	.....	20+	.....	20+	.....	20+	.....	20+

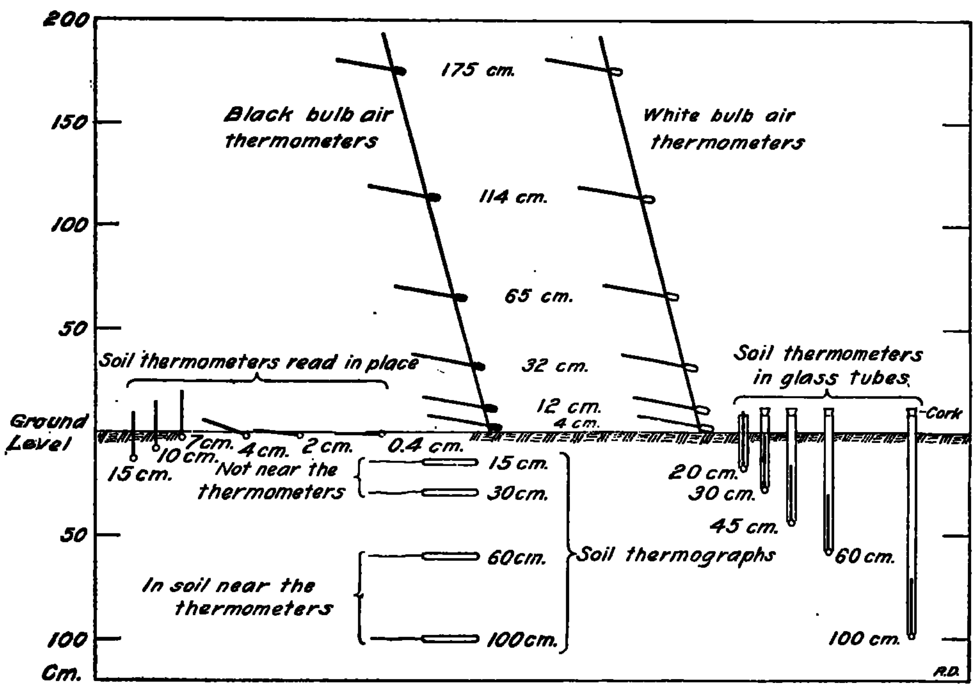

FIG. 1.—Arrangement of apparatus for measuring temperatures in the soil and lower strata of the air.

Figure 2 is a picture of the most interesting records of the day. The graphs are self-explanatory, except at two points. The short sections of the curves at 7 and 8 are taken from thermograph records made in different soil and among the rocks. The conserving of heat is well illustrated here.

Table 2 presents certain facts concerning the daily range in comparison with the annual range at different levels. It also shows the progressive movement of heat into the ground.

These data present problems which are not easily solved. The outstanding feature of the ground series is the tremendous daily and yearly range of surface temperatures. It so happens that the daily range is so nearly the yearly range that the effects are not transmitted much beneath the surface, and a relatively moderate and constant temperature is quickly reached. For this reason it is important biologically to know how deep desert animals burrow to æstivate or hibernate, as the case may be.

TABLE 2.

	June 21, 1915.				Annual temperatures.			Daily range.	Annual range.
	Max.	Time.	Min.	Time.	Maximum.		Minimum.		
	° C.		° C.		° C.			° C.	° C.
Shelter.....	42.5	1 p. m...	11.0	4–5 a. m.	42.5	1914–1915	.3°C.1914–15	31.5	42.2
Soil .4 cm..	71.5	1 p. m...	15.0	4–5 a. m.	71.5	June 21 .	....	56.5	......
Soil 2 cm...	62.1	2 p. m..	22.0	5 a. m...	62.5	June 25 .	....	40.1	......
Soil 4 cm...	48.1	3.30 p. m	23.5	5.30 a. m	50.2	July 8...	....	24.6	......
Soil 7 cm...	44.1	4.30 p. m	25.2	6 a. m...	46.1	July 9...	....	18.9	......
Soil 10 cm..	40.1	6 p. m...	26.3	6.30 a. m	42.2	July 10..	....	13.8	......
Soil 15 cm..	35.6	7.30 p. m	28.1	7.30 a. m	37.0	July 10..	3° Aug. 1904–1914.	7.5	34.0
Soil 20 cm..	33.4	9 p. m...	29.0	10.30 a.m	35.0	July 11..	....	4.4	......
Soil 30 cm..	29.8	10.30 p.m	27.8	12 a. m..	31.6	July 12..	9° Aug. 1904–1914.	2.0	22.6
Soil 45 cm..	27.9	10 a. m..	27.8	2 p. m...	29.7	July 20..	....	0.1	......
Soil 60 cm..	26.4	....	26.4	....	29.0	Aug. 10 .	15° 1915....	......	14.0
Soil 100 cm.	24.5	....	24.5	....	27.0	Aug. 16 .	18° 1915....	......	9.0
Soil 200 cm.	Nearly constant temperature throughout the year; about 20° C.								

The graphs of air temperature show an inclination at night opposite the daytime. Notice that there is practically no difference between the black and white thermometers during the night and that in that period four thermometers at each level register 2° C. difference in the height of a man, his feet being colder than his head. The ground beneath is warmer than the air at any point above. I am unable to explain this anomalous condition. The temperature gradient is reversed at 4:30 p. m. A study of the graphs 3B and 3W of Figure 2 shows a chill at the ground surface itself and in the face of a bright sunlight. The phenomena can not be explained readily by air movement because there is very little movement, and the point of maximum temperature is only 30 cm. above the surface. In all the graphs the standard shade temperature corresponds closely but with the upper levels recorded on the white thermometers. The heat-conserving action of the rocks is again shown by the shade readings taken among them at the same time.

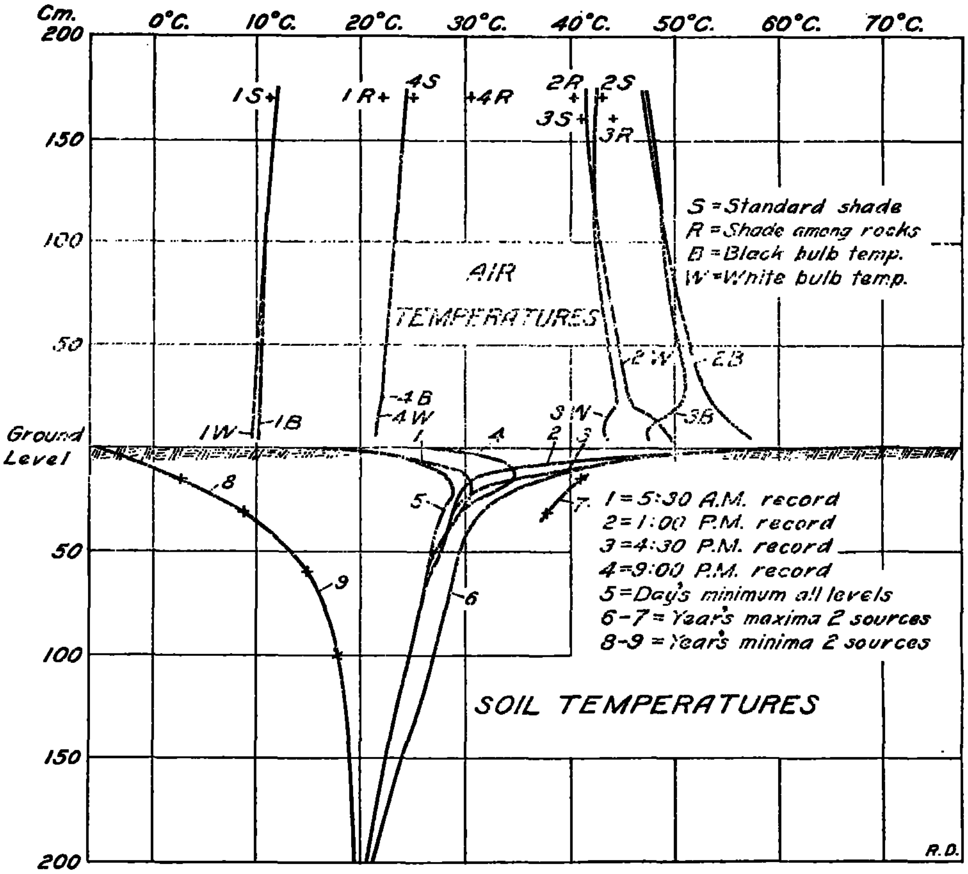

FIG. 2.—Curves of diurnal changes in soil and air temperatures.

Two applications are worth making. The terrific forces involved in the merely surface expansion and contraction of rock may be a very potent factor in their disintegration. The reversal of the temperature gradient, to whatever cause it may be due, may lay the foundation, for the later large displacement of air known as cold-air drainage on a level desert.

DAMAGE TO WIRE SERVICE BY HEAVY SNOWSTORM IN KANSAS.

A heavy fall of wet, clinging snow that fell on March 9–10, 1922, over a strip about 50 miles wide extending from the northeast corner of Kansas to the south central part, near Hutchinson, resulted in damage to telephone and telegraph lines almost without precedent in the State. Sleet and ice accumulations on wires have frequently broken down pole lines in past years, serious trouble of this nature due solely to snow was a new experience to linemen, even when it fell to a depth of a foot or more, as it did in the central counties during this storm.

The snow occurred with temperatures somewhat below freezing and a high wind, estimated at 45 miles an hour, that packed it solidly against the north side of wires, poles, and other objects. In the Hutchinson district, where the damage was most severe, a cone-shaped mass of snow projected along the north side of every pole. The wind also packed the snow against the north side of each wire until the weight of the accumulation was sufficient to turn it partly over, exposing another surface to the wind. In this way wires were turned back and forth until they were completely coated with cylinders of packed snow that in some cases measured 2½ inches in diameter.

A single copper wire, No. 12 gauge, N. B. S., 1 foot long, with its incasing cylinder of snow, was carefully removed by linemen of a telephone company after the storm and found to weigh a pound. With a 30-wire lead, which is not unusual in an important line, and poles at the standard distance of 130 feet, this would mean a weight of 3,900 pounds, or almost 2 tons, on each pole.

This immense weight at a time when a high wind was blowing broke off thousands of poles, and wires were also broken and tangled. The Southwestern Bell Telephone Co. reported a loss of 5,000 poles and an estimated damage of $200,000, while the Western Union Telegraph Co. and the United Telephone Co. were also heavy losers.

Hutchinson, the second largest city in the central portion of the State, was completely isolated, as far as wire service was concerned, for more than 24 hours and without service in its local telephone service for six days. Complete service in some of the less important leads in the district was not restored until more than two weeks after the storm.—*S. D. Flora.*