# SECTION I.—AEROLOGY.

## SOLAR AND SKY RADIATION MEASUREMENTS DURING OCTOBER, 1918.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Weather Bureau, Washington, Nov. 30, 1918.]

For a description of instrumental exposures, and an account of the methods of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1918, 46:2.

The monthly means and departures from normal values given in Table 1 show that direct solar radiation averaged slightly below its normal intensity at Washington, D. C., and Lincoln, Nebr., and above normal at Madison, Wis. No measurements were obtained at Santa Fe, N. Mex., on account of a broken suspension in the galvanometer.

Table 3 shows only slight departures from the normal radiation for the month at Washington and Madison, although both these stations and also Lincoln, show a deficiency for the third decade. At Madison this deficiency amounted to 34 per cent of the decade normal, and at Lincoln to 25 per cent. The deficiency for the month at Lincoln was about 10 per cent.

Skylight polarization measurements obtained on six days at Washington give a mean of 60 per cent, with a maximum of 64 per cent on the 22d. These values are very close to October averages for Washington. Measurements obtained on nine days at Madison give a mean of 64 per cent with a maximum of 69 per cent on the 9th.

TABLE 1.—*Solar radiation intensities during October, 1918.*

[Gram-calories per minute per square centimeter of normal surface.]

**Washington, D. C.**

| Date. | Sun's zenith distance. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.0° | 48.3° | 60.0° | 66.5° | 70.7° | 73.6° | 75.7° | 77.4° | 78.7° | 79.8° |
| | Air mass. | | | | | | | | | |
| | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 |
| A. M. | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* |
| Oct. 1 | | 1.14 | | | | | | | | |
| 4 | | 0.97 | 0.94 | 0.77 | 0.68 | 0.60 | 0.53 | | | |
| 8 | | 1.26 | 1.23 | 1.16 | 1.09 | 1.03 | 0.97 | 0.93 | 0.88 | 0.82 |
| 9 | | | | | | | 0.87 | | | |
| 10 | | 1.15 | 0.94 | | 0.75 | 0.70 | 0.65 | | | |
| 11 | | | | 0.72 | | | | | | |
| 14 | | | 1.16 | 1.09 | 1.02 | 0.93 | 0.86 | 0.79 | 0.73 | |
| 15 | | | 1.22 | 1.13 | 1.03 | 0.97 | 0.90 | 0.86 | 0.83 | 0.80 |
| 16 | | | 1.21 | 1.09 | 0.99 | 0.89 | 0.84 | 0.80 | 0.76 | 0.71 |
| 19 | | | 1.10 | 1.03 | 0.96 | 0.95 | 0.91 | 0.81 | | |
| 21 | | 1.32 | 1.16 | 1.04 | | 0.74 | 0.67 | 0.62 | 0.57 | 0.52 |
| 22 | | | 1.36 | | | 1.08 | 1.07 | 1.07 | 0.98 | |
| 31 | | | | 0.98 | | | | | | 0.84 |
| Monthly means | | 1.17 | 1.15 | 1.00 | 0.93 | 0.88 | 0.83 | 0.84 | 0.79 | 0.74 |
| Departure from 10-year normal | | −0.06 | +0.03 | −0.02 | ±0.00 | +0.01 | +0.01 | +0.06 | +0.02 | ±0.00 |
| P. M. | | | | | | | | | | |
| Oct. 1 | | 1.01 | 0.85 | | | | | | | |
| 2 | | 1.08 | 0.98 | 0.89 | 0.81 | 0.74 | 0.68 | 0.63 | 0.58 | |
| 8 | | | 1.13 | 1.04 | 0.97 | 0.82 | 0.77 | 0.73 | 0.69 | |
| 13 | | 1.26 | | | | | | | | |
| 15 | | 1.15 | 0.86 | 0.76 | 0.67 | | | | | |
| 21 | | | | 1.12 | | | | | | |
| 22 | | 1.27 | 1.24 | 1.13 | 1.09 | 1.04 | 1.01 | 0.92 | 0.84 | |
| Monthly means | | 1.15 | 1.01 | 0.99 | 0.88 | 0.87 | 0.82 | 0.76 | 0.70 | |
| Departure from 10-year normal | | −0.08 | −0.11 | −0.03 | −0.03 | +0.04 | +0.05 | +0.04 | +0.02 | |

TABLE 1.—*Solar radiation intensities during October, 1918*—Contd.

[Gram-calories per minute per square centimeter of normal surface.]

**Madison, Wis.**

| Date. | Sun's zenith distance. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.0° | 48.3° | 60.0° | 66.5° | 70.7° | 73.6° | 75.7° | 77.4° | 78.7° | 79.8° |
| | Air mass. | | | | | | | | | |
| | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 |
| A. M. | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* |
| Oct. 5 | | 1.33 | 1.19 | | | | | | | |
| 9 | [*1.45] | | 1.25 | 1.16 | 1.09 | 1.01 | | | | |
| 12 | | 1.27 | | | | | | | | |
| 21 | | | | 1.30 | 1.26 | 1.18 | 1.12 | 1.07 | | |
| 25 | | | | 1.27 | 1.17 | 1.08 | 1.04 | 0.96 | 0.93 | 0.89 |
| Monthly means | | (1.30) | (1.22) | 1.24 | 1.17 | 1.09 | (1.08) | (1.02) | (0.93) | (0.89) |
| Departure from 9-year normal | | +0.05 | +0.06 | +0.14 | +0.13 | +0.14 | +0.21 | +0.27 | +0.26 | +0.23 |
| P. M. | | | | | | | | | | |
| Oct. 3 | | 1.29 | 1.21 | 1.15 | 1.07 | 0.99 | | | | |
| 7 | | | 1.08 | | | | | | | |
| 12 | | | 1.20 | 1.08 | | | | | | |
| 25 | | | 1.29 | 1.18 | 1.11 | 0.94 | | | | |
| Monthly means | | (1.29) | 1.20 | 1.14 | (1.09) | (0.96) | | | | |
| Departure from 9-year normal | | −0.02 | +0.04 | +0.04 | +0.08 | −0.01 | | | | |

**Lincoln, Nebr.**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| A. M. | | | | | | | | | | |
| Oct. 5 | | 1.39 | 1.25 | 1.16 | 1.08 | 1.00 | | | | |
| 8 | [*1.41] | 1.28 | 1.16 | 1.06 | 0.96 | 0.89 | 0.82 | 0.75 | | |
| 13 | [*1.48] | 1.38 | 1.29 | | | | | | | |
| 14 | | 1.36 | 1.27 | 1.21 | 1.14 | 1.07 | 1.02 | 0.90 | | |
| 28 | | | 1.27 | | | | | | | |
| 29 | | | | | 1.12 | 1.07 | | | | |
| 30 | | | 1.37 | 1.30 | 1.22 | 1.15 | | | 1.01 | |
| Monthly means | | 1.35 | 1.27. | 1.18 | 1.10 | 1.04 | (0.92) | (0.82) | (1.01) | |
| Departure from 4-year normal | | −0.01 | −0.04 | −0.05 | −0.05 | −0.02 | −0.09 | −0.11 | +0.09 | |
| P. M. | | | | | | | | | | |
| Oct. 5 | | | 1.27 | | 1.10 | 1.03 | 0.98 | 0.93 | 0.86 | 0.82 |
| 13 | | | | 1.20 | 1.12 | 1.04 | 0.97 | 0.91 | 0.87 | 0.83 |
| 14 | | | 1.27 | 1.16 | 1.05 | 0.95 | 0.87 | 0.78 | | 0.69 |
| Monthly means | | | (1.27) | (1.18) | 1.09 | 1.01 | 0.94 | 0.87 | (0.86) | 0.78 |
| Departure from 4-year normal | | | +0.02 | +0.02 | +0.01 | −0.02 | −0.03 | −0.04 | ±0.00 | −0.05 |

* Extrapolated, and reduced to mean solar distance.

TABLE 2.—*Vapor pressures at pyrheliometric stations on days when solar radiation intensities were measured.*

| Washington, D. C. | | | Madison, Wis. | | | Lincoln, Nebr. | | |
|---|---|---|---|---|---|---|---|---|
| Date. | 8 a. m. | 8 p. m. | Date. | 8 a. m. | 8 p. m. | Date. | 8 a. m. | 8 p. m. |
| 1918. | *mm.* | *mm.* | 1918. | *mm.* | *mm.* | 1918. | *mm.* | *mm.* |
| Oct. 1 | 6.27 | 7.04 | Oct. 3 | 5.36 | 4.57 | Oct. 5 | 9.47 | 7.57 |
| 2 | 8.48 | 14.10 | 5 | 9.14 | 6.76 | 8 | 9.83 | 7.29 |
| 4 | 6.50 | 9.14 | 7 | 6.50 | 6.76 | 13 | 5.79 | 5.26 |
| 8 | 5.36 | 5.56 | 9 | 7.04 | 7.29 | 14 | 4.75 | 6.27 |
| 9 | 6.02 | 7.87 | 12 | 12.24 | 10.59 | 28 | 3.45 | 6.76 |
| 10 | 7.57 | 9.14 | 21 | 5.16 | 3.30 | 29 | 3.45 | 7.04 |
| 11 | 7.57 | 11.38 | 25 | 4.37 | 5.56 | 30 | 3.81 | 5.56 |
| 13 | 10.97 | 9.47 | | | | | | |
| 14 | 6.27 | 4.95 | | | | | | |
| 15 | 5.36 | 6.27 | | | | | | |
| 16 | 6.02 | 8.81 | | | | | | |
| 19 | 5.16 | 6.27 | | | | | | |
| 21 | 7.57 | 4.75 | | | | | | |
| 22 | 4.57 | 4.75 | | | | | | |
| 31 | 9.83 | 13.61 | | | | | | |

TABLE 3.—*Daily totals and departures of solar and sky radiation during October, 1918.*

[Gram—calories per square centimeter of horizontal surface.]

| Day of month. | Daily totals. | | | Departures from normal. | | | Excess or deficiency since first of month. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Washington. | Madison. | Lincoln. | Washington. | Madison. | Lincoln. | Washington. | Madison. | Lincoln. |
| | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* |
| Oct. 1 | 384 | 225 | 312 | 44 | −63 | −58 | 44 | −63 | −58 |
| 2 | 389 | 379 | 305 | 53 | 94 | −62 | 97 | 31 | −120 |
| 3 | 320 | 362 | 375 | −12 | 81 | 11 | 85 | 112 | −109 |
| 4 | 380 | 209 | 212 | 51 | −69 | −149 | 136 | 43 | −258 |
| 5 | 319 | 375 | 459 | −6 | 100 | 101 | 130 | 143 | −157 |
| 6 | 277 | 284 | 406 | −45 | 13 | 52 | 85 | 156 | −105 |
| 7 | 182 | 373 | 374 | −137 | 105 | 24 | −52 | 261 | −81 |
| 8 | 424 | 92 | 411 | 108 | −172 | 65 | 56 | 89 | −16 |
| 9 | 322 | 373 | 328 | 9 | 112 | −14 | 65 | 201 | −30 |
| 10 | 388 | 270 | 138 | 78 | 13 | −200 | 143 | 214 | −230 |
| 11 | 277 | 62 | 211 | −30 | −192 | −123 | 113 | 22 | −353 |
| 12 | 124 | 339 | 410 | −180 | 89 | 80 | −67 | 111 | −273 |
| 13 | 358 | 285 | 432 | 57 | 38 | 106 | −10 | 149 | −167 |
| 14 | 299 | 289 | 428 | 1 | 45 | 106 | −9 | 194 | −61 |
| 15 | 354 | 302 | 390 | 59 | 61 | 72 | 50 | 255 | 11 |
| 16 | 365 | 281 | 360 | 72 | 43 | 46 | 122 | 298 | 57 |
| 17 | 314 | 286 | 324 | 24 | 51 | 14 | 146 | 349 | 71 |
| 18 | 198 | 304 | 94 | −90 | 72 | −212 | 56 | 421 | −141 |
| 19 | 389 | 90 | 106 | 103 | −139 | −196 | 159 | 282 | −337 |
| 20 | 79 | 334 | 362 | −204 | 108 | 64 | −45 | 390 | −273 |
| Decade departure | | | | | | | −188 | 176 | −43 |

TABLE 3.—*Daily totals and departures of solar and sky radiation during October, 1918*—Continued.

[Gram—calories per square centimeter of horizontal surface.]

| Day of month. | Daily totals. | | | Departures from normal. | | | Excess or deficiency since first of month. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Washington. | Madison. | Lincoln. | Washington. | Madison. | Lincoln. | Washington. | Madison. | Lincoln. |
| | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* |
| Oct. 21 | 376 | 285 | 248 | 95 | 62 | −46 | 50 | 452 | −319 |
| 22 | 371 | 153 | 135 | 92 | −67 | −155 | 142 | 385 | −474 |
| 23 | 307 | 218 | 191 | 31 | 1 | −95 | 173 | 386 | −569 |
| 24 | 249 | 48 | 379 | −25 | −166 | 97 | 148 | 220 | −472 |
| 25 | 170 | 302 | 43 | −102 | 91 | −235 | 46 | 311 | −707 |
| 26 | 191 | 43 | 29 | −79 | −165 | −246 | −33 | 146 | −953 |
| 27 | 234 | 42 | 27 | −34 | −164 | −245 | −67 | −18 | −1,198 |
| 28 | 208 | 115 | 288 | −58 | −88 | 19 | −125 | −106 | −1,179 |
| 29 | 201 | 53 | 363 | −63 | −148 | 97 | −188 | −254 | −1,082 |
| 30 | 102 | 113 | 292 | −160 | −85 | 29 | −348 | −339 | −1,053 |
| 31 | 187 | 140 | 288 | −73 | −56 | 28 | −421 | −395 | −1,025 |
| Decade departure | | | | | | | −376 | −785 | −752 |
| Excess or deficiency since first of year: gr.-cal. | | | | | | | −2,774 | +509 | −135 |
| Excess or deficiency since first of year: per cent | | | | | | | −2.4 | +0.5 | −0.1 |

## HALO PHENOMENA OBSERVED DURING OCTOBER, 1918.

By WILLIS RAY GREGG, Meteorologist.

| Station. | Altitude. | Latitude. | Longitude. | Date. | Form observed. | Time of— Beginning. | Time of— Ending. | Theodolite readings. Time. | Radius inside. | Radius outside. | Length of arc. | Distance from sun or moon. | Altitude of sun or moon. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *m.* | ° ′ | ° ′ | | | | | | ° | ° | ° | ° | ° |
| *Broken Arrow, Okla. | 233 | 36 02 | 95 49 | 16 | Solar halo, 22° | 7:00 a. m. | 4:34 p. m. | 7:24 a. m. | 22.5 | 23 | 180 | | 9.5 |
| | | | | 20 | Lunar halo, 22° | 8:30 p. m. | 11:30 p. m. | | | | | | |
| | | | | 21 | Solar halo, 22° | 12:00 m. | 3:45 p. m. | 12:52 p. m. | 22 | 23 | 360 | | 42 |
| Canton, N. Y. | 137 | 44 36 | 75 10 | 4 | Solar halo, 22° | 2:45 p. m. | 3:20 p. m. | | | | | | |
| | | | | 9 | Solar halo, 22° | 7:50 a. m. | 8:40 a. m. | | | | | | |
| | | | | 15 | Solar halo, 22° | 12:05 p. m. | 12:45 p. m. | | | | | | |
| | | | | 15 | Parhelion, right, 22°. | 12:05 p. m. | 12:45 p. m. | | | | | | |
| | | | | 16 | Solar halo, 22° | 2:00 p. m. | 2:35 p. m. | | | | | | |
| | | | | 16 | Lunar halo, 22° | 7:45 p. m. | 8:45 p. m. | | | | | | |
| | | | | 22 | Lunar halo, 22° | 8:00 p. m. | 10:00 p. m. | | | | | | |
| | | | | 23 | Lunar halo, 22° | 6:00 a. m. | 6:30 a. m. | | | | | | |
| | | | | 23 | Solar halo, 22° | 10:00 a. m. | 10:20 a. m. | | | | | | |
| Cincinnati, Ohio | 191 | 39 06 | 84 30 | 10 | Solar halo, 22° | 2:30 p. m. | 2:50 p. m. | | | | | | |
| | | | | 10 | Parhelion, right, 22°. | 2:24 p. m. | 2:32 p. m. | | | | | | |
| | | | | 10 | Parhelion, left, 22°. | 2:24 p. m. | 2:32 p. m. | | | | | | |
| | | | | 17 | Solar halo, 22° | 12:15 p. m. | 1:45 p. m. | | | | | | |
| | | | | 17 | Lunar halo, 22° | 5:35 p. m. | 9:00 p. m. | | | | | | |
| | | | | 22 | Solar halo, 22° | 12:45 p. m. | 1:45 p. m. | | | | | | |
| | | | | 29 | Solar halo, 22° | 11:00 a. m. | 11:25 a. m. | | | | | | |
| Dayton, Ohio | 274 | 39 46 | 84 10 | 5 | Solar halo, 22° | 11:40 a. m. | 1:15 p. m. | | | | | | |
| | | | | 11 | Solar halo, 22° | 8:00 a. m. | 8:40 a. m. | | | | | | |
| | | | | 17 | Solar halo, 22° | 10:40 a. m. | 12:30 p. m. | | | | | | |
| | | | | 22 | Solar halo, 22° | 12:00 m. | 12:30 p. m. | | | | | | |
| | | | | 29 | Solar halo, 22° | 11:00 a. m. | 11:40 a. m. | | | | | | |
| *Drexel, Nebr. | 396 | 41 20 | 96 16 | 2 | Solar halo, 22° | 9:30 a. m. | 12:45 p. m. | 9:45 a. m. | 22 | 22.5 | 260 | | 34 |
| | | | | 7 | Solar halo, 22° | 12:12 p. m. | 1:00 p. m. | 12:37 p. m. | 22 | 22.5 | 200 | | 44 |
| | | | | 9 | Solar halo, 22° | 11:35 a. m. | 3:30 p. m. | 2:20 p. m. | 22 | 22.5 | 300 | | 35 |
| | | | | 15 | Lunar halo, 22° | 6:30 p. m. | 7:45 p. m. | 7:00 p. m. | 22 | 23 | 260 | | 35 |
| | | | | 17 | Solar halo, 22° | 11:35 a. m. | 2:30 p. m. | 11:50 a. m. | 22 | 22.5 | 320 | | 39 |
| | | | | 24 | Solar halo, 22° | 8:00 a. m. | 8:38 a. m. | 8:18 a. m. | 23 | 24.5 | 180 | | 16 |
| | | | | 28 | Solar halo, 22° | 2:40 p. m. | 3:21 p. m. | 2:47 p. m. | 22 | 22.5 | 120 | | 24 |
| | | | | 28 | Circumhorizontal arc. | 2:40 p. m. | 3:21 p. m. | 2:47 p. m. | | | 10 | 46 | 24 |
| *Ellendale, N. Dak. | 444 | 45 59 | 98 34 | 4 | Solar halo, 22° | 3:00 p. m. | 3:15 p. m. | | | | | | |
| | | | | 11 | Solar halo, 22° | 3:30 p. m. | 4:35 p. m. | 3:45 p. m. | 21.8 | 22.6 | 220 | | 21.5 |
| | | | | 17-18 | Lunar halo, 22° | 9:57 p. m. | 2:22 a. m. | | | | 360 | | |
| *Groesbeck, Tex. | 141 | 31 30 | 96 28 | 19 | Solar halo, 22° | 4:28 p. m. | 4:46 p. m. | | | | | | |
| | | | | 20 | Lunar halo, 22° | 11:00 p. m. | | | | | | | |
| *Leesburg, Ga. | 85 | 31 47 | 84 14 | 15 | Solar halo, 22° | 3:00 p. m. | 3:50 p. m. | | | | | | |
| | | | | 17 | Lunar halo, 22° | 6:40 p. m. | 9:00 p. m. | | 22 | | 360 | | |
| | | | | 18 | Lunar halo, 22° | 7:00 p. m. | 7:30 p. m. | | | | | | |
| | | | | 23 | Solar halo, 22° | 9:00 a. m. | 9:20 a. m. | | | | | | |
| | | | | 27 | Solar halo, 22° | 12:30 p. m. | 1:30 p. m. | | | | | | |
| Madison, Wis. | 297 | 43 05 | 89 23 | 1 | Solar halo, 22° | | | | | | | | |
| | | | | 4 | Solar halo, 22° | 10:30 a. m. | 12:00 m. | | | | | | |
| | | | | 10 | Solar halo, 22° | 11:30 a. m. | 1:00 p. m. | | | | | | |
| | | | | 10 | Parhelion, right, 22°. | 6:46 a. m. | 9:00 a. m. | | | | | | |
| | | | | 10 | Parhelion, left, 22°. | 6:46 a. m. | 9:00 a. m. | | | | | | |
| | | | | 10 | Solar halo, 22° | 3:44 p. m. | 3:55 p. m. | | | | | | |
| | | | | 10 | Solar halo, 46° | 3:44 p. m. | 3:50 p. m. | | | | | | |
| | | | | 15 | Parhelion, right, 22°. | 4:00 p. m. | 4:30 p. m. | | | | | | |
| | | | | 16 | Solar halo, 22° | 9:30 a. m. | 10:00 a. m. | | | | | | |
| | | | | 18 | Solar halo, 22° | 10:50 a. m. | 5:00 p. m. | | | | | | |
| | | | | 19 | Lunar halo, 22° | 4:30 a. m. | 5:00 a. m. | | | | | | |
| | | | | 22 | Lunar halo, 22° | D. N. a. | 6:05 a. m. | | | | | | |
| | | | | 22 | Solar halo, 22° | 1:00 p. m. | 2:00 p. m. | | | | | | |
| | | | | 29 | Solar halo, 22° | 7:50 a. m. | 8:00 a. m. | | | | | | |
| Nashville, Tenn. | 166 | 36 10 | 86 47 | None. | | | | | | | | | |
| *Royal Center, Ind. | 225 | 40 53 | 86 29 | 10 | Solar halo, 22° | 7:57 a. m. | 1:50 p. m. | | | | | | |

* Aerological station.