

# **SOLAR AND NET RADIATION**

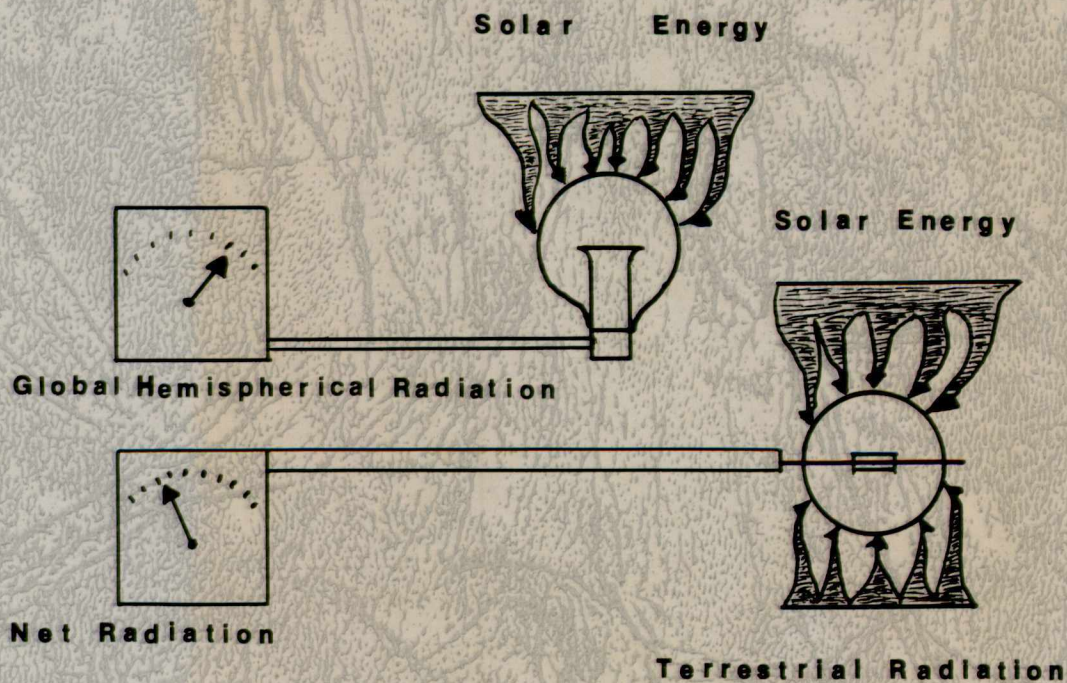
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**PALMER, ALASKA      1960--71**

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Solar and net radiation received at Palmer, Alaska ( $61^{\circ} 36' \text{ N. lat.}, 149^{\circ} 06' \text{ W. long.}$ ) have been observed for more than ten years. On a yearly basis, the daily average incoming global short wave radiation has been 219.1 langley, and net radiation has been 70.0 langley.

From May 3 thru August 1, net radiation averages 221.2 langley. This is 2.571 kilowatt hours per square meter, or 815.2 Btu per square foot (English units).

From November 1 thru January 30, net radiation is negative, showing an energy loss of 54.2 langley per day. This is equivalent to 0.630 kilowatt hours per square meter or 199.8 Btu per square foot.

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## SOLAR AND NET RADIATION AT PALMER, ALASKA

1960-71

Solar radiation which falls upon the surface of the earth exerts a powerful influence upon many physical and biological processes. It provides the energy both for photosynthesis and atmospheric circulation. Crabb (1952) states, in discussing hydrologic relationships, that the amount and intensity of radiant solar energy is known to have a marked effect on losses of soil moisture by evaporation. This radiation is also related to evapotranspiration (Mielke and Peck, 1967), and to soil temperatures (McWhorter and Brooks, 1965).

The annual peak of solar radiation generally occurs about one month before the peak of air temperatures (Peck, et al., 1968). The distribution and variation of solar energy at different times of the year are important in all areas of the world, but are particularly important in high latitudes where energy is in short supply.

Solar radiation is highly concentrated in the visible and short infra-red wave lengths. Its measurement gives an incomplete picture of the total energy flux. Net radiation, the difference between the incoming and outgoing components of radiant energy, has become recognized as an important meteorological parameter. Net radiation will be positive (incoming component greater than the outgoing component) on a sunny day and negative (outgoing component greater than the incoming component) on a clear night. For a 24-hour period it is usually positive in the warm season, and in areas of high latitudes is negative during the cold season. At Palmer, Alaska, both solar and net radiation have been measured over a period of eleven years.

### Instrumentation and Data Handling

The incident solar radiation on a horizontal surface was first measured at Palmer with a 10-junction Eppley pyranometer starting June 13, 1960. On February 19, 1962 a new but similar instrument was installed; this was

replaced on April 25, 1962 with a more sensitive Eppley unit. On November 23, 1966, a 50-Junction Eppley was obtained and since that date it has been used for winter conditions and the 10-Junction unit for warm season measurements.

The original net radiation instrument, a Beckman and Whitley radiometer, was installed June 13, 1960. Data from a Funk net radiometer installed October 19, 1964, were used for the remaining record. On December 9, 1969, a new sensor was installed on the Funk radiometer. The plastic domes on the radiometer have been replaced as necessary.

Originally the data were recorded on strip charts and the daily totals obtained by hand integration. On October 19, 1965, automatic integrators were installed. The data are still recorded on strip charts as a back-up source in case of integrator malfunction and to provide a record of the daily pattern of radiation.

### Results and Discussion

The average daily solar and net radiation in langley's per day for each week of record, and the weekly average for the eleven year period, are presented in Tables 1 and 2. Data were summarized by climatological weeks. The data for the interval February 21-28 or 29, were all included in the last week of the climatological year.

Dale (1956) reported that the June and July, 1954 records of the Matanuska Experiment Station showed solar radiation roughly comparable to stations in the northwestern and northeastern United States. This was an exceptionally high radiation period. The 11-year record summarized here shows that individual days can reach quite high radiation levels, but that on the average, solar radiation is lower here than for stations in

any of the 49 more southern states.

Data summarized by Lof et al., (1966) indicates that the 2-year record of Goose Bay, Labrador is the closest to that of Palmer of all the stations in the U.S. and Canada having available records. Seattle records for solar radiation during May and June are only slightly higher than those at Palmer but for July and August their records exceed those of Palmer three out of four years.

A similar relationship exists between Palmer, Alaska and Caribou, Maine. The cloudiness that usually occurs during July-August at Palmer results in a reduction of radiation for this period.

Net radiation reaches an average maximum of about 250 langleys per day in mid-June. Positive values are usually obtained from March 15 to October 12 and negative values for the rest of the year. The daily mean values for each week appear in Table 2.

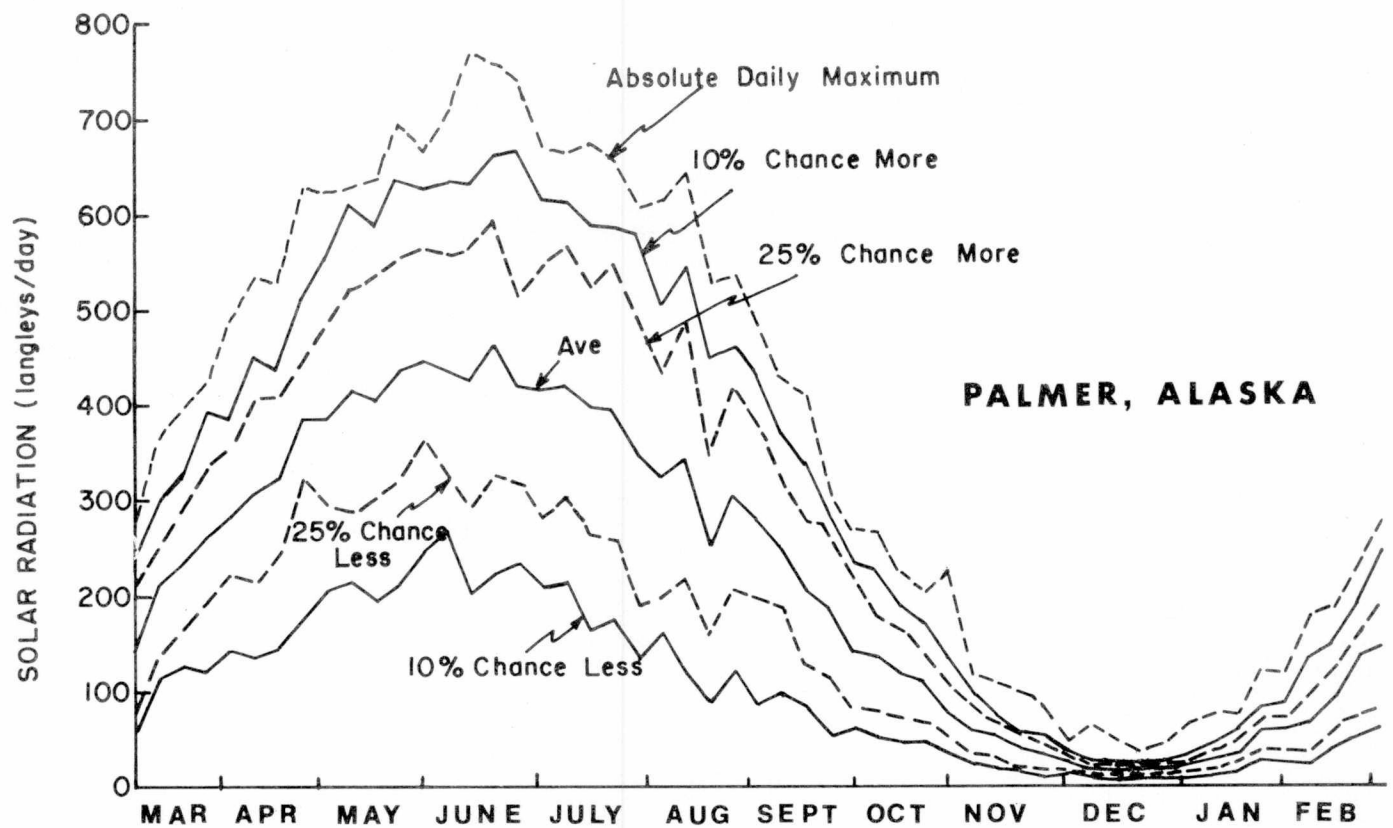
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Figure 1 shows graphically the average amount of incoming short wave energy (insolation) and the extent and direction of the net radiation. The large range of diurnal variability in incoming short wave energy is illustrated by the intervals between the probability curves at the 10 percent and 25 percent "chance" of receiving greater or lesser amounts shown on Figure 1. Solar energy received on a horizontal surface at various locations in the United States is shown on Table 3. Palmer and Fairbanks, Alaska receive the lowest amounts of insolation of any locations shown in the tables during the months of October, November, December, January, and February, due primarily to the positions of high latitude.

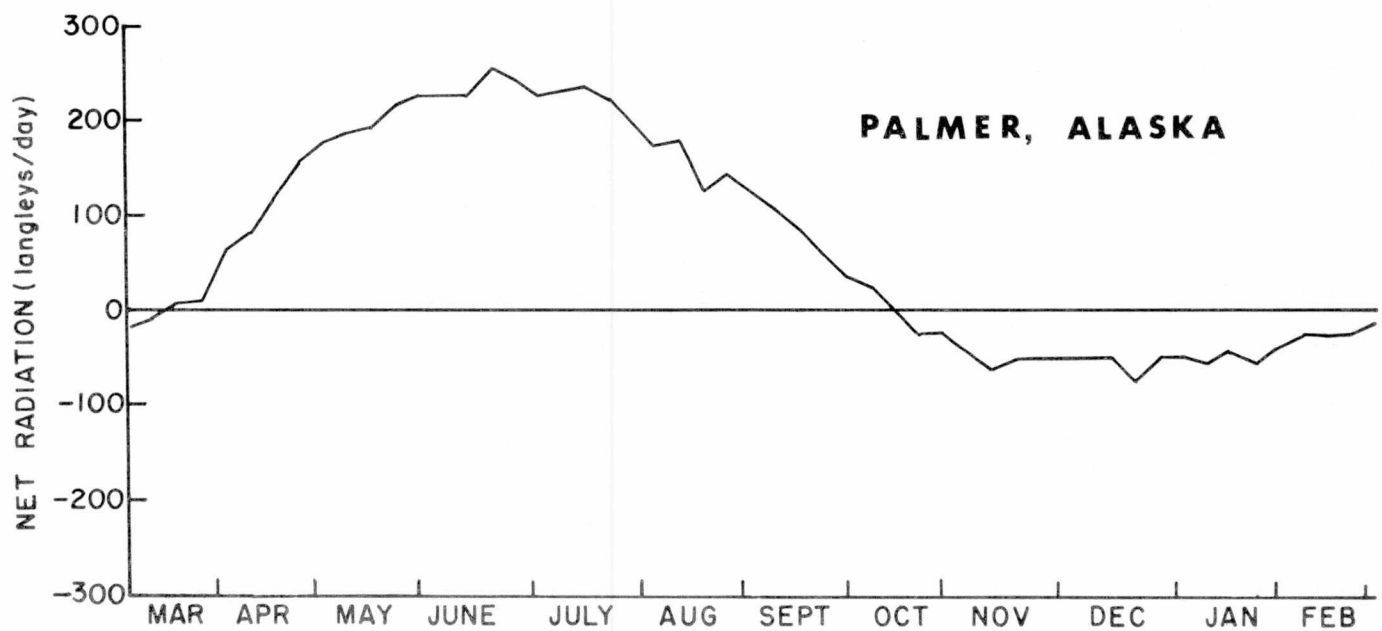
Energy from the sun is continuous in supply and free except for the cost of interception and utilization. Planning for its use requires an estimate of the variability and minimum levels of anticipated energy flux. These data provide such information for a period of eleven years at Palmer, Alaska.

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### PATTERN OF GLOBAL HEMISPHERICAL RADIATION



NET RADIATION-MEAN, June 1960 - 1971

Figure 1

Table 1. SOLAR RADIATION AT PALMER, ALASKA, LATITUDE 61° 36' N.

| Period <sup>1</sup> | 1960<br>-61 | 1961<br>-62 | 1962<br>-63 | 1963<br>-64 | 1964<br>-65 | 1965<br>-66 | 1966<br>-67 | 1967<br>-68 | 1968<br>-69 | 1969<br>-70 | 1970<br>-71 | 1971 | Av. |
|---------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------|-----|
| —langleys per day—  |             |             |             |             |             |             |             |             |             |             |             |      |     |
| Mar 1-7             | -           | 223         | 196         | 83          | 121         | 71          | 189         | 94          | 121         | 170         | 134         | 163  | 142 |
| Mar 8-14            | -           | 300         | 250         | 137         | 266         | 147         | 225         | 222         | 234         | 197         | 192         | 188  | 214 |
| Mar 15-21           | -           | 239         | 277         | 257         | 280         | 167         | 241         | 233         | 226         | 210         | 175         | 254  | 233 |
| Mar 22-28           | -           | 371         | 341         | 268         | 251         | 129         | 196         | 286         | 252         | 247         | 264         | 297  | 264 |
| Mar 29-Apr 4        | -           | 327         | 309         | 378         | 301         | 208         | 231         | 183         | 298         | 286         | 264         | 314  | 282 |
| Apr 5-11            | -           | 267         | 421         | 326         | 313         | 219         | 387         | 215         | 338         | 262         | 331         | 312  | 308 |
| Apr 12-18           | -           | 313         | 348         | 344         | 290         | 421         | 273         | 318         | 395         | 365         | 256         | 245  | 324 |
| Apr 19-25           | -           | 354         | 525         | 277         | 292         | 369         | 418         | 458         | 415         | 416         | 340         | 364  | 384 |
| Apr 26-May 2        | -           | 500         | 443         | 441         | 398         | 268         | 461         | 400         | 328         | 345         | 312         | 346  | 386 |
| May 3-9             | -           | 601         | 489         | 338         | 449         | 357         | 371         | 448         | 320         | 345         | 402         | 397  | 411 |
| May 10-16           | -           | 387         | 340         | 375         | 426         | 497         | 389         | 377         | 380         | 367         | 430         | 451  | 402 |
| May 17-23           | -           | 513         | 298         | 499         | 427         | 416         | 436         | 395         | 434         | 501         | 448         | 445  | 437 |
| May 24-30           | -           | 456         | 385         | 570         | 451         | 381         | 376         | 486         | 399         | 544         | 468         | 412  | 448 |
| May 31-Jun 6        | -           | 530         | 431         | 331         | 517         | 384         | 424         | 310         | 432         | 466         | 506         | 475  | 437 |
| Jun 7-13            | -           | 558         | 422         | 439         | 492         | 405         | 474         | 346         | 525         | 474         | 296         | 231  | 424 |
| Jun 14-20           | 576         | 466         | 617         | 403         | 414         | 456         | 456         | 396         | 403         | 541         | 334         | 381  | 454 |
| Jun 21-27           | 488         | 551         | 424         | 386         | 399         | 381         | 445         | 336         | 465         | 437         | 292         | 544  | 429 |
| Jun 28-Jul 4        | 422         | 427         | 586         | 422         | 373         | 366         | 337         | 337         | 484         | 469         | 349         | 333  | 409 |
| Jul 5-11            | 525         | 457         | 427         | 463         | 335         | 420         | 333         | 464         | 396         | 414         | 368         | 545  | 429 |
| Jul 12-18           | 414         | 458         | 443         | 313         | 535         | 320         | 480         | 335         | 311         | 400         | 355         | 306  | 389 |
| Jul 19-25           | 360         | 383         | 385         | 305         | 405         | 309         | 528         | 277         | 564         | 428         | 383         | 237  | 380 |
| Jul 26-Aug 1        | 217         | 397         | 472         | 368         | 300         | 447         | 281         | 295         | 356         | 405         | 248         | 263  | 337 |
| Aug 2-8             | 331         | 283         | 349         | 281         | 345         | 312         | 218         | 307         | 456         | 427         | 270         | 216  | 316 |
| Aug 9-15            | 413         | 443         | 417         | 432         | 308         | 201         | 328         | 169         | 353         | 410         | 301         | 282  | 338 |
| Aug 16-22           | 347         | 219         | 323         | 177         | 192         | 333         | 146         | 222         | 303         | 335         | 235         | 278  | 259 |
| Aug 23-29           | 308         | 447         | 161         | 310         | 314         | 308         | 267         | 245         | 344         | 356         | 294         | 269  | 302 |
| Aug 30-Sep 5        | 266         | 419         | 316         | 283         | 294         | 261         | 282         | 121         | 312         | 282         | 240         | 175  | 271 |
| Sep 6-12            | 177         | 197         | 258         | 291         | 314         | 214         | 221         | 248         | 276         | 255         | 235         | 222  | 242 |
| Sep 13-19           | 260         | 233         | 221         | 208         | 160         | 90          | 150         | 119         | 262         | 325         | 213         | 197  | 203 |
| Sep 20-26           | 155         | 202         | 147         | 242         | 141         | 87          | 205         | 128         | 245         | 272         | 193         | 182  | 183 |
| Sep 27-Oct 3        | 104         | 141         | 238         | 127         | 109         | 159         | 102         | 195         | 115         | 151         | 103         | 102  | 137 |

Table 1. (Continued)

| Period <sup>1</sup> | 1960<br>-61      | 1961<br>-62 | 1962<br>-63 | 1963<br>-64 | 1964<br>-65 | 1965<br>-66 | 1966<br>-67 | 1967<br>-68 | 1968<br>-69 | 1969<br>-70 | 1970<br>-71 | Av.    |
|---------------------|------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------|
|                     | langleys per day |             |             |             |             |             |             |             |             |             |             |        |
| Oct 4-10            | 151              | 200         | 196         | 112         | 72          | 92          | 99          | 168         | 134         | 124         | 122         | 134    |
| Oct 11-17           | 166              | 138         | 95          | 87          | 100         | 133         | 78          | 124         | 100         | 151         | 77          | 114    |
| Oct 18-24           | 126              | 90          | 83          | 92          | 84          | 118         | 105         | 101         | 113         | 155         | 126         | 108    |
| Oct 25-31           | 117              | 73          | 69          | 81          | 75          | 73          | 68          | 55          | 101         | 96          | 53          | 78     |
| Nov 1-7             | 71               | 47          | 68          | 49          | 61          | 94          | 31          | 33          | 66          | 84          | 41          | 59     |
| Nov 8-14            | 61               | 46          | 59          | 50          | 41          | 44          | 62          | 29          | 43          | 83          | 41          | 51     |
| Nov 15-21           | 46               | 27          | 28          | 54          | 12          | 41          | 41          | 13          | 33          | 62          | 34          | 38     |
| Nov 22-28           | 52               | 41          | 46          | 33          | 29          | 17          | 19          | 26          | 24          | 31          | 22          | 31     |
| Nov 29-Dec 5        | 32               | 17          | 26          | 18          | 19          | 23          | 26          | 23          | 22          | 22          | 27          | 23     |
| Dec 6-12            | 25               | 15          | 15          | 9           | 17          | 10          | 23          | 9           | 22          | 28          | 11          | 17     |
| Dec 13-19           | 32               | 15          | 7           | 13          | 12          | 10          | 7           | 12          | 14          | 18          | 8           | 13     |
| Dec 20-26           | 27               | 26          | 8           | 15          | 15          | 15          | 13          | 15          | 20          | 20          | 9           | 17     |
| Dec 27-Jan 2        | 25               | 16          | 18          | 14          | 19          | 21          | 11          | 7           | 26          | 22          | 18          | 18     |
| Jan 3-9             | 41               | 17          | 19          | 21          | 19          | 18          | 19          | 18          | 22          | 25          | 18          | 22     |
| Jan 10-16           | 49               | 20          | 15          | 20          | 17          | 25          | 33          | 28          | 36          | 36          | 31          | 28     |
| Jan 17-23           | 40               | 42          | 20          | 44          | 22          | 22          | 44          | 27          | 38          | 44          | 47          | 35     |
| Jan 24-30           | 83               | 50          | 61          | 43          | 54          | 48          | 55          | 42          | 54          | 49          | 64          | 55     |
| Jan 31-Feb 6        | 63               | 61          | 79          | 34          | 43          | 56          | 55          | 62          | 54          | 55          | 43          | 55     |
| Feb 7-13            | 97               | 100         | 50          | 83          | 37          | 62          | 83          | 38          | 73          | 58          | 50          | 66     |
| Feb 14-20           | 126              | 85          | 105         | 115         | 113         | 90          | 84          | 64          | 97          | 87          | 54          | 93     |
| Feb 21-28           | 169              | 200         | 142         | 91          | 111         | 133         | 123         | 71          | 144         | 73          | 98          | 123    |
| Total               |                  | 90,916      | 87,276      | 78,064      | 78,288      | 71,736      | 76,643      | 69,510      | 83,846      | 86,975      | 71,575      | 79,483 |
| Av. per mo.         |                  | 7,576       | 7,273       | 6,505       | 6,524       | 5,978       | 6,387       | 5,793       | 6,987       | 7,248       | 5,965       | 6,624  |

<sup>1</sup> Calculations made on standard climatological weeks where March 1-7 is week 1. Period December 27-January 2 includes last 5 days of one calendar year and only 2 days of next calendar year. February 21-28 includes 8 days, except in leap years when 9 days are included.

Table 2. NET RADIATION AT PALMER, ALASKA, LATITUDE 61° 36' N.

| Period           | 1960<br>-61 | 1961<br>-62 | 1962<br>-63 | 1963<br>-64 | 1964<br>-65 | 1965<br>-66 | 1966<br>-67 | 1967<br>-68 | 1968<br>-69 | 1969<br>-70 | 1970<br>-71 | 1971 | Av. |
|------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------|-----|
| langleys per day |             |             |             |             |             |             |             |             |             |             |             |      |     |
| Mar 1-7          | -           | -30         | -15         | 19          | 16          | 5           | -72         | -3          | 10          | -46         | 19          | -75  | -16 |
| Mar 8-14         | -           | -7          | 13          | 23          | -49         | 18          | -44         | -38         | 11          | -13         | 40          | -56  | -9  |
| Mar 15-21        | -           | 29          | -15         | 3           | 9           | 58          | -46         | 36          | 4           | 13          | 49          | -71  | 6   |
| Mar 22-28        | -           | 34          | 23          | 28          | 13          | 75          | 44          | 59          | -36         | 30          | 58          | -68  | 10  |
| Mar 29-Apr 4     | -           | 134         | 135         | 142         | 30          | 95          | 52          | 66          | 19          | 55          | 46          | -13  | 69  |
| Apr 5-11         | -           | 117         | 155         | 88          | 129         | 89          | 115         | 38          | -25         | 37          | 81          | 50   | 79  |
| Apr 12-18        | -           | 192         | 140         | 34          | 147         | 183         | 69          | 144         | 130         | 73          | 113         | 73   | 118 |
| Apr 19-25        | -           | 108         | 232         | 126         | 181         | 168         | 158         | 184         | 168         | 127         | 120         | 132  | 155 |
| Apr 26-May 2     | -           | 226         | 230         | 256         | 181         | 134         | 193         | 183         | 116         | 123         | 156         | 138  | 176 |
| May 3-9          | -           | 291         | 269         | 184         | 232         | 155         | 160         | 203         | 119         | 98          | 179         | 156  | 184 |
| May 10-16        | -           | 200         | 187         | 201         | 245         | 239         | 164         | 172         | 171         | 147         | 202         | 166  | 190 |
| May 17-23        | -           | 282         | 186         | 263         | 244         | 205         | 200         | 194         | 230         | 192         | 228         | 169  | 218 |
| May 24-30        | -           | 253         | 221         | 319         | 252         | 199         | 182         | 227         | 205         | 223         | 250         | 143  | 225 |
| May 31-Jun 6     | -           | 299         | 272         | 188         | 323         | 204         | 227         | 153         | 212         | 196         | 249         | 170  | 227 |
| Jun 7-13         | -           | 309         | 255         | 264         | 316         | 210         | 212         | 175         | 256         | 177         | 188         | 98   | 224 |
| Jun 14-20        | 359         | 270         | 376         | 260         | 265         | 249         | 215         | 180         | 218         | 224         | 207         | 160  | 249 |
| Jun 21-27        | 428         | 288         | 240         | 234         | 272         | 227         | 211         | 186         | 241         | 186         | 179         | 226  | 243 |
| Jun 28-Jul 4     | 178         | 253         | 358         | 267         | 241         | 189         | 158         | 186         | 246         | 204         | 194         | 134  | 217 |
| Jul 5-11         | 256         | 256         | 242         | 301         | 242         | 228         | 167         | 232         | 208         | 204         | 185         | 236  | 230 |
| Jul 12-18        | 386         | 264         | 284         | 192         | 373         | 189         | 238         | 166         | 157         | 188         | 166         | 154  | 230 |
| Jul 19-25        | 216         | 244         | 283         | 196         | 260         | 164         | 252         | 159         | 274         | 213         | 188         | 127  | 215 |
| Jul 26-Aug 1     | 122         | 242         | 312         | 217         | 224         | 230         | 135         | 166         | 170         | 161         | 119         | 135  | 186 |
| Aug 2-8          | 196         | 153         | 204         | 167         | 255         | 170         | 93          | 167         | 206         | 169         | 129         | 105  | 168 |
| Aug 9-15         | 248         | 247         | 258         | 249         | 199         | 110         | 138         | 98          | 134         | 127         | 143         | 131  | 174 |
| Aug 16-22        | 208         | 138         | 179         | 106         | 115         | 175         | 46          | 116         | 133         | 109         | 96          | 123  | 129 |
| Aug 23-29        | 183         | 241         | 116         | 149         | 197         | 131         | 101         | 123         | 150         | 95          | 103         | 103  | 141 |
| Aug 30-Sep 5     | 153         | 226         | 160         | 157         | 139         | 115         | 96          | 64          | 107         | 82          | 113         | 65   | 123 |
| Sep 6-12         | 101         | 95          | 127         | 150         | 142         | 104         | 61          | 145         | 80          | 54          | 96          | 70   | 102 |
| Sep 13-19        | 154         | 124         | 104         | 148         | 69          | 39          | 22          | 34          | 76          | 60          | 95          | 57   | 82  |
| Sep 20-26        | 96          | 101         | 51          | 112         | 45          | 33          | 20          | 30          | 41          | 42          | 61          | 47   | 57  |
| Sep 27-Oct 3     | 60          | 80          | 82          | 34          | 30          | 36          | 8           | 39          | 2           | -2          | 39          | 18   | 36  |

Table 2. (Continued)

| Period       | 1960<br>-61       | 1961<br>-62 | 1962<br>-63 | 1963<br>-64 | 1964<br>-65 | 1965<br>-66 | 1966<br>-67 | 1967<br>-68 | 1968<br>-69 | 1969<br>-70 | 1970<br>-71 | Av.    |
|--------------|-------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------|
|              | langley's per day |             |             |             |             |             |             |             |             |             |             |        |
| Oct 4-10     | 83                | 36          | 49          | 11          | -1          | 29          | -5          | 18          | 15          | -19         | 40          | 23     |
| Oct 11-17    | -2                | 47          | 7           | -1          | 12          | -27         | -12         | -5          | -32         | -50         | 9           | -6     |
| Oct 18-24    | -20               | -2          | -18         | 26          | -31         | -27         | -43         | -20         | -57         | -47         | -35         | -25    |
| Oct 25-31    | 15                | 3           | -25         | -75         | -49         | -27         | -29         | -7          | -51         | -33         | -14         | -26    |
| Nov 1-7      | -6                | -46         | -34         | -66         | -36         | -58         | -26         | -30         | -51         | -43         | -51         | -41    |
| Nov 8-14     | -39               | -40         | -75         | -78         | -51         | -36         | -76         | -30         | -47         | -80         | -121        | -61    |
| Nov 15-21    | -4                | -36         | -69         | -120        | -17         | -45         | -49         | -25         | -69         | -68         | -49         | -50    |
| Nov 22-28    | -33               | -47         | -70         | -114        | -97         | -32         | -45         | -46         | -47         | -46         | -15         | -54    |
| Nov 29-Dec 5 | -15               | -14         | -40         | -56         | -50         | -66         | -102        | -66         | -56         | -57         | -90         | -56    |
| Dec 6-12     | -4                | 6           | -62         | -71         | -60         | -43         | -98         | -17         | -64         | -101        | -52         | -51    |
| Dec 13-19    | -88               | -30         | -45         | -98         | -65         | -18         | -59         | -43         | -41         | -69         | -22         | -52    |
| Dec 20-26    | -53               | -102        | -67         | -103        | -99         | -77         | -55         | -79         | -38         | -96         | -38         | -73    |
| Dec 27-Jan 2 | 17                | -24         | -126        | -59         | -87         | -95         | -41         | -14         | -62         | -31         | -44         | -51    |
| Jan 3-9      | -75               | 0           | -32         | -48         | -82         | -65         | -31         | -22         | -68         | -106        | -58         | -53    |
| Jan 10-16    | -58               | 9           | -42         | -52         | -16         | -27         | -66         | -46         | -84         | -132        | -138        | -59    |
| Jan 17-23    | -39               | -6          | -14         | -79         | -55         | -29         | -83         | -28         | -37         | -48         | -84         | -46    |
| Jan 24-30    | -83               | -25         | -56         | -80         | -70         | -64         | -110        | -29         | -42         | -21         | -60         | -58    |
| Jan 31-Feb 6 | -12               | 2           | -107        | -20         | -15         | -55         | -64         | -57         | -37         | -10         | -41         | -38    |
| Feb 7-13     | -14               | 1           | 13          | -38         | -17         | -45         | -55         | -23         | -32         | -30         | -27         | -24    |
| Feb 14-20    | -32               | 21          | -39         | -23         | -49         | -40         | -47         | -6          | -36         | -15         | -40         | -28    |
| Feb 21-28    | -15               | -24         | -27         | -19         | -5          | -53         | -51         | -21         | -40         | 1           | -58         | -18    |
| total        |                   |             |             |             |             |             |             |             |             |             |             |        |
| positive     |                   | 40,747      | 40,341      | 35,798      | 37,702      | 31,178      | 26,159      | 27,601      | 28,763      | 25,270      | 28,980      | 32,254 |
| negative     |                   | 3,031       | 6,846       | 8,400       | 7,021       | 6,503       | 9,163       | 4,585       | 7,364       | 8,141       | 7,259       | 6,831  |
| net          |                   | 37,716      | 33,495      | 27,398      | 30,681      | 24,675      | 16,996      | 23,016      | 21,399      | 17,129      | 21,721      | 25,423 |

Table 3. SOLAR ENERGY RECEIVED ON A HORIZONTAL SURFACE AT VARIOUS LATITUDES

| City                | North<br>Latitude | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Av. |
|---------------------|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| langleys per day    |                   |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Miami, FL           | 25°49'            | 323 | 384 | 468 | 546 | 531 | 485 | 547 | 522 | 435 | 400 | 353 | 326 | 444 |
| Brownsville, TX     | 25°55'            | 258 | 329 | 401 | 486 | 545 | 611 | 633 | 561 | 479 | 411 | 315 | 245 | 440 |
| Apalachicola, FL    | 29°45'            | 270 | 346 | 435 | 536 | 595 | 593 | 525 | 485 | 455 | 408 | 326 | 262 | 436 |
| El Paso, TX         | 31°48'            | 340 | 441 | 556 | 674 | 737 | 735 | 676 | 630 | 552 | 471 | 348 | 300 | 539 |
| Charleston, SC      | 32°54'            | 238 | 310 | 418 | 518 | 556 | 527 | 523 | 480 | 424 | 367 | 297 | 236 | 408 |
| Riverside, CA       | 33°32'            | 271 | 358 | 468 | 584 | 603 | 629 | 660 | 611 | 505 | 394 | 290 | 258 | 470 |
| Albuquerque, NM     | 35°03'            | 295 | 379 | 495 | 625 | 702 | 728 | 666 | 619 | 519 | 434 | 310 | 267 | 504 |
| Oak Ridge, TN       | 35°55'            | 186 | 244 | 327 | 418 | 503 | 637 | 487 | 443 | 378 | 308 | 199 | 156 | 357 |
| Las Vegas, NV       | 36°05'            | 287 | 374 | 509 | 632 | 707 | 734 | 673 | 627 | 546 | 436 | 301 | 255 | 507 |
| Davis, CA           | 38°32'            | 183 | 272 | 418 | 537 | 686 | 712 | 724 | 640 | 502 | 351 | 216 | 153 | 450 |
| Columbia, MO        | 38°57'            | 192 | 264 | 344 | 432 | 527 | 558 | 581 | 517 | 403 | 312 | 201 | 174 | 376 |
| Salt Lake City, UT  | 40°46'            | 188 | 288 | 427 | 504 | 640 | 676 | 702 | 601 | 497 | 362 | 216 | 163 | 356 |
| New York, NY        | 40°46'            | 155 | 228 | 317 | 400 | 476 | 506 | 495 | 447 | 364 | 269 | 157 | 126 | 329 |
| Cleveland, OH       | 41°24'            | 128 | 191 | 280 | 466 | 494 | 536 | 511 | 453 | 347 | 241 | 121 | 94  | 311 |
| Medford, OR         | 42°22'            | 119 | 216 | 352 | 475 | 588 | 658 | 696 | 595 | 472 | 290 | 146 | 100 | 358 |
| Ithaca, NY          | 42°27'            | 122 | 202 | 282 | 361 | 465 | 511 | 491 | 423 | 346 | 221 | 103 | 91  | 247 |
| Madison, WI         | 43°05'            | 184 | 271 | 359 | 411 | 521 | 564 | 572 | 507 | 363 | 262 | 157 | 133 | 294 |
| St. Cloud, MN       | 45°35'            | 164 | 263 | 361 | 402 | 474 | 532 | 566 | 479 | 349 | 245 | 144 | 113 | 341 |
| Caribou, ME         | 46°52'            | 149 | 238 | 466 | 429 | 462 | 517 | 503 | 416 | 315 | 199 | 115 | 108 | 327 |
| Spokane, WA         | 47°37'            | 108 | 196 | 319 | 429 | 559 | 628 | 661 | 535 | 401 | 239 | 116 | 76  | 356 |
| Seattle, WA         | 47°39'            | 71  | 145 | 243 | 337 | 433 | 504 | 524 | 426 | 316 | 198 | 91  | 59  | 280 |
| Glasgow, MT         | 48°11'            | 154 | 239 | 380 | 434 | 519 | 580 | 635 | 539 | 389 | 260 | 152 | 117 | 367 |
| Goose Bay, Labrador | 53°19'            | 70  | 160 | 290 | 380 | 440 | 430 | 420 | 330 | 240 | 140 | 80  | 60  | 254 |
| Palmer, AK          | 61°36'            | 36  | 87  | 220 | 339 | 422 | 433 | 393 | 307 | 211 | 112 | 43  | 17  | 219 |
| Fairbanks, AK       | 64°51'            | 17  | 74  | 219 | 378 | 495 | 531 | 477 | 338 | 212 | 85  | 32  | 6   | 239 |

# Alaska

0 200 400  
Scale of miles

