# SOUTHERN HEMISPHERE METEOR SHOWER ACTIVITY IN JULY AND AUGUST

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*Summary*

Observations of the radiant positions and the activities of the δ-Aquarids and three minor showers of July and August, obtained with high resolution radio equipment at Adelaide from 1957 to 1959, are given in detail. Data for the δ-Aquarids are combined with similar observations in 1953 to obtain the radiant ephemeris

$$\alpha = 342\cdot3° + 0\cdot76\ (\odot - 126\cdot0°)$$
$$\delta = -16\cdot4° + 0\cdot13\ (\odot - 126\cdot0°).$$

The δ-Aquarid activity extends from July 20 to August 14, with a maximum near July 29. Minor shower activity, extending over and beyond the whole duration of δ-Aquarid activity, is identified as proceeding from three main centres already known visually: the Capricornids, the Pisces Australids, and the Cetids.

## I. Introduction

The period from the beginning of July to the middle of August is one of high meteor shower activity in the southern hemisphere. The principal shower is the δ-Aquarids. Numerous minor showers with radiants south of the ecliptic have been detected by visual observations (McIntosh 1935). In addition, a previously unreported day-time shower, the Phoenicids, has been discovered by the Adelaide radio surveys.

With the exception of 1955, observations over July and August have been made each year from 1953 to 1959. The observations prior to 1956 have already been published (Weiss 1955, 1957), and all available data on the Phoenicid shower have been summarized in Weiss (1960). The present paper describes the remaining observations for 1957 to 1959, and summarizes the measurements, with high resolution equipment, of the radiant coordinates and echo rates for the δ-Aquarids and three of the more prominent of the minor showers. The observations for 1954 and 1956, made with the 27 Mc/s "wind" equipment, lack the resolution necessary for the separation of the δ-Aquarid from the minor shower activity, and have been excluded from this summary.

## II. Equipment

The bulk of the observations have been made with the 67 Mc/s radiant survey equipment (Weiss 1955, 1960). This is a high resolution radar system with two narrow-beam aerials directed at low elevation along azimuths 35·5° S. of E. (termed the N aerial) and 14° N. of E. (S aerial). The line densities of electrons in the faintest trails detected by this equipment are close to $1\times10^{11}$ electrons/cm, corresponding to visual magnitude $M_v \sim +7$. The method of

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measuring radiant coordinates has been described adequately in the papers cited. The equipment operated at the same high sensitivity in 1957 and 1958, and at much lower sensitivity in 1953.

During 1959 the 67 Mc/s equipment was replaced by a new equipment operating at 61 Mc/s, the transmitter power of 50 kW remaining unchanged. The observations were made during the period of reconstruction with a temporary aerial system with only one receiving channel; the beam axis was directed due west at an elevation of 29°. Because of the temporary nature of the installation the geometry of this aerial system has not been investigated in detail. The resolving power of the system, however, is inferior to that of the 67 Mc/s array, and the detection threshold is $M_v \sim +6$.

## III. The Phoenicid Shower

For the sake of completeness the following details of this day-time shower are given. The activity extends from July 5 to July 19, with a fairly sharp maximum at July 14, $\odot = 112°$, when the echo rate is 30/hr. Radiant coordinates for 1958, which are the most reliable determinations, are

$$\alpha = 31 \cdot 1° + 1 \cdot 05 \; (\odot - 109 \cdot 6°),$$
$$\delta = -47 \cdot 9° + 0 \cdot 54 \; (\odot - 109 \cdot 6°).$$

Data for the earlier years will be found in Weiss (1960).

## IV. The δ-Aquarid Shower

### (a) *Observations for 1957, 1958, and 1959*

The daily positions of the radiant, and the echo rates, are listed in Table 1. The times of detection of echoes at 700 km slant range, from which the radiants were determined, are plotted in Figure 1.

The shower appears to persist until about August 14, but near the emergence of the Earth from the stream the range-time plots show considerable scatter, presumably associated with a diffuse radiant. This, coupled with the low echo rate, precludes accurate measurement of the radiant. In 1957 echoes were received from N and S aerial channels on alternate days, and the radiants for individual days were determined by interpolation between times of passage separated by two days. Since only one channel was available in 1959, the radiant could not be measured to the same order of accuracy as in the previous years, and no data have been given.

The times for the 700 km echoes, plotted in Figure 1, were determined by maximizing the echo count within theoretical range-time envelopes. The main source of error is random grouping amongst both shower and sporadic meteors. We see from Figure 1 that except near the fringes of the stream the error in the measurement of these times probably does not exceed ±5 min; the consequent errors in radiant coordinates are: R.A. ±1°, declination ±3°. It is also evident from Figure 2, by comparison of the 1957 and 1958 data, that the interpolations which are necessary to derive radiant coordinates for the individual days of 1957 do not introduce appreciable errors. The overall uncertainty in an individual radiant determination should not exceed ±2° in R.A. and ±5° in declination.

The " envelope " echo rates of Table 1 for 1957 and 1958 are the actual numbers of shower echoes detected inside theoretical range-time envelopes for the appropriate radiant positions on the corresponding days. No attempt has been made to reduce these envelope rates to hourly rates. Theoretical envelopes have not been calculated for the 1959 aerial system, and an empirical

Table 1

RADIANTS AND ECHO RATES FOR THE δ-AQUARID SHOWER 1957–1959

| Date | Radiant Coordinates | | | | Echo Rates | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1957 | | 1958 | | Envelope | | | Total | | |
| | α | δ | α | δ | 1957 | 1958 | 1959 | 1957 | 1958 | 1959 |
| July 20 .. | | | 332 | —23 | | 17 | | | 97 | |
| 21 .. | 337 | —18 | 336 | —20 | 18 | 23 | 82 | 93 | 104 | 88 |
| 22 .. | 337 | —18 | 337 | —18 | 27 | 45 | 118 | 99 | 144 | 96 |
| 23 .. | 337 | —17 | 337 | —18 | 39 | 58 | 133 | 117 | 140 | 160 |
| 24 .. | 338 | —17 | 338 | —18 | 50 | 52 | 184 | 107 | 126 | 216 |
| 25 .. | 339 | —16 | 339 | —18 | 67 | 65 | 230 | 132 | 152 | 289 |
| 26 .. | 340 | —16 | 339 | —18 | 95 | 110 | 242 | 158 | 218 | 280 |
| 27 .. | 340 | —16 | — | — | 92 | — | 242 | 220 | — | 264 |
| 28 .. | 341 | —15 | — | — | 111 | — | 292 | 271 | — | 322 |
| 29 .. | 342 | —15 | — | — | 140 | — | 296 | 319 | — | 342 |
| 30 .. | 343 | —15 | 343 | —17 | 120 | 99 | 289 | 176 | 247 | 338 |
| 31 .. | 343 | —15 | — | — | 119 | — | 243 | 233 | — | 276 |
| Aug. 1 .. | 344 | —15 | 344 | —17 | 68 | 65 | 235 | 156 | 144 | 246 |
| 2 .. | 345 | —16 | 345 | —17 | 68 | 56 | 209 | 171 | 148 | 228 |
| 3 .. | 345 | —16 | 345 | —17 | 43 | 47 | 216 | 118 | 145 | 211 |
| 4 .. | 346 | —16 | 346 | —17 | 65 | 35 | 217 | 144 | 111 | 252 |
| 5 .. | 346 | —17 | — | — | 38 | — | 160 | 116 | — | 175 |
| 6 .. | 347 | —17 | 347 | —17 | 42 | 32 | 135 | 130 | 67 | 135 |
| 7 .. | 347 | —17 | | | 23 | 49 | 112 | 69 | 104 | 116 |
| 8 .. | 348 | —15 | | | 25 | 12 | 122 | 94 | 66 | 146 |
| 9 .. | 350 | —13 | | | 31 | 22 | 72 | 99 | 100 | 66 |
| 10 .. | 351 | —12 | | | 17 | 22 | | 82 | 49 | |
| 11 .. | | | | | | 15 | | | 55 | |
| 12 .. | | | | | | 16 | | | 50 | |
| 13 .. | | | | | | 20 | | | 27 | |
| 14 .. | | | | | | 17 | | | 35 | |

envelope has been determined from the echo rates themselves. The " total " echo rate is the number of shower echoes detected each day over the following periods: 1957 and 1958, N aerial, 01–04 hr; S aerial, 02–05 hr; 1959, 22–02 hr. Small corrections have been applied to both sets of rates to allow for known variations in sensitivity over each run, assuming a mass-distribution parameter* $s \sim 1 \cdot 6$ for the δ-Aquarids and $s = 2 \cdot 0$ for sporadics. The value of $s \sim 1 \cdot 6$ has

* This parameter is the exponent in the differential law for the distribution of meteor masses, namely, $\nu_m dm = \text{const.}\, m^{-s} dm$.

been determined (in 1959) from a comparison of the echo rates in two receiver channels held at different sensitivities. The high echo rates in 1959, relative to 1957 and 1958, are due to the increased aperture of the aerial system used in 1959, and do not necessarily indicate a higher shower activity.

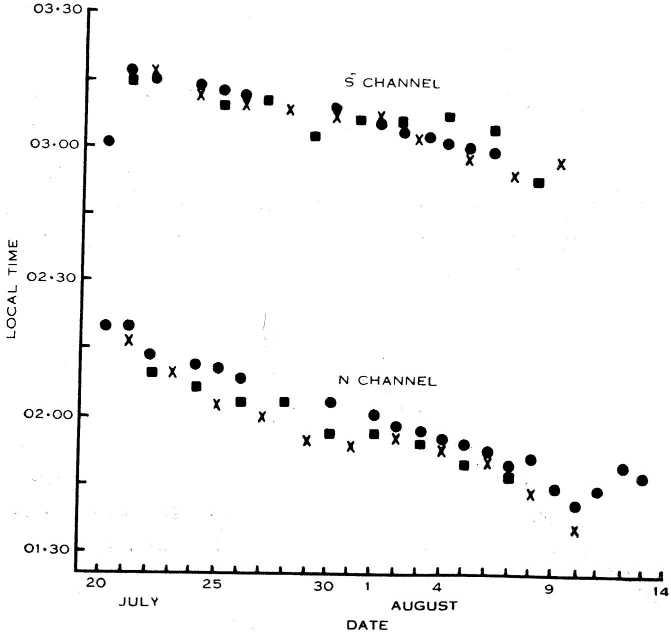


Fig. 1.—Times of detection of echoes at 700 km slant range, δ-Aquarids. 1953, ■; 1957, ×; 1958, ●.

## (b) *Radiant*

Radiant positions on individual days are plotted in Figure 2. The radiant ephemeris estimated by the method of least squares is

$$\alpha = 342 \cdot 2° + 0 \cdot 77 \ (\odot - 126 \cdot 0°),$$
$$\delta = -16 \cdot 6° + 0 \cdot 19 \ (\odot - 126 \cdot 0°).$$

These daily motions in $\alpha$ and $\delta$ are considerably smaller than those, namely, $0 \cdot 96°$ in $\alpha$, $0 \cdot 41°$ in $\delta$, determined by a different method by McIntosh (1934) from the New Zealand visual observations. It is evident from Figure 2 that McIntosh's daily motion in $\delta$ is not incompatible with the radio determination. This is, however, not the case for the daily motion in $\alpha$, nor can the discrepancy be attributed to the two different methods used in determining the ephemeris. The ephemeris was formed by McIntosh by reducing all radiant coordinates to apparent ecliptical latitude $\beta$ and the difference in longitude, $\lambda - A$, between the apparent radiant $\lambda$ and the apex of the Earth's way, $A$, taking the mean position of the whole and translating it back to the $\alpha,\delta$ coordinate system. $\beta$ and $\lambda - A$ have been termed apparent coordinates because corrections for zenith attraction and diurnal aberration have not been applied. These corrections are small, however, and barely exceed $0 \cdot 5°$. The data used by McIntosh are plotted in Figure 3, and it is seen that there is, for the visual observations, no systematic dependence of $\lambda - A$ and of $\beta$ on the longitude of the apex, $A$. Similar treatment of the radio data, on the other hand, reveals systematic changes in both $\lambda - A$ and in $\beta$ with the age of the shower. These, when translated back to the $\alpha,\delta$ system, yield the daily motions sketched in Figure 2. The corresponding ephemeris, which differs only slightly from the least squares ephemeris, is

$$\alpha = 342 \cdot 3° + 0 \cdot 76\ (\odot - 126 \cdot 0°),$$
$$\delta = -16 \cdot 4° + 0 \cdot 13\ (\odot - 126 \cdot 0°).$$

The Adelaide radiant coordinates have not been corrected to epoch 1950, to which the longitude of the Sun is referred, because the probable errors far exceed the corrections. The corrections required to reduce the radio and visual

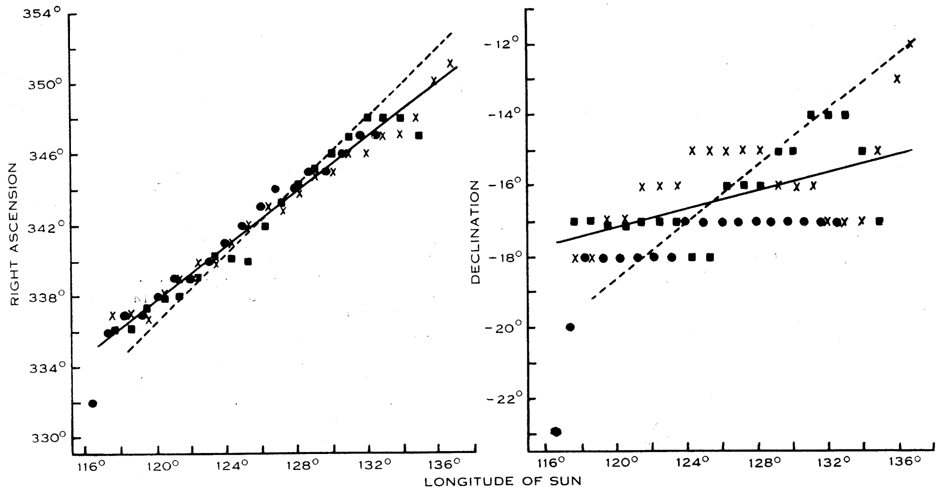


Fig. 2.—Right Ascension and declination of the $\delta$-Aquarid radiant. Determinations for individual days: 1953, ■; 1957, ×; 1958, ●. The full lines are the best fits to the radio data determined through ecliptical coordinates in the manner indicated in Section IV (*b*) of the text. The dashed lines are similar fits to visual data for 1926 to 1933 (after McIntosh).

observations, separated by over 20 years, to common epoch will be appreciable, but as the reference epoch for the visual observations is not stated, no corrections have been applied. An error not exceeding $0 \cdot 5°$ may thus have to be taken into account in comparing mean radiants; the daily motions, of course, will not be affected.

That these systematic changes in $\lambda - A$ and $\beta$ are real can be seen from the following argument. A constant value of $\lambda - A$ implies that the time of transit of the radiant changes by only a few minutes over the duration of the shower; any change in the time of passage of the shower radiant through the aerial collecting sectors is thus produced almost entirely by a shift in the declination of the radiant. Now, for radiants whose declinations lie in the range $0° > \delta > -20°$, the time of passage for the S aerial is extremely insensitive to the declination (see, e.g. Figure 1 of Weiss 1955), and if $\lambda - A$ is constant the time of passage through the S aerial collecting sector should change by a few minutes at most. In actual fact we find (Fig. 1) for the S aerial an advance of 18 min from July 22 to August 6, which is identical for each of the three years for which observations are available. Since a change of this magnitude is quite outside the experimental error in the measurement of times of passage, we may conclude that $\lambda - A$, at least, cannot be constant for the duration of the shower. Further consideration of the times of passage for the N aerial then indicates that $\beta$ also is not constant for the duration of the shower.

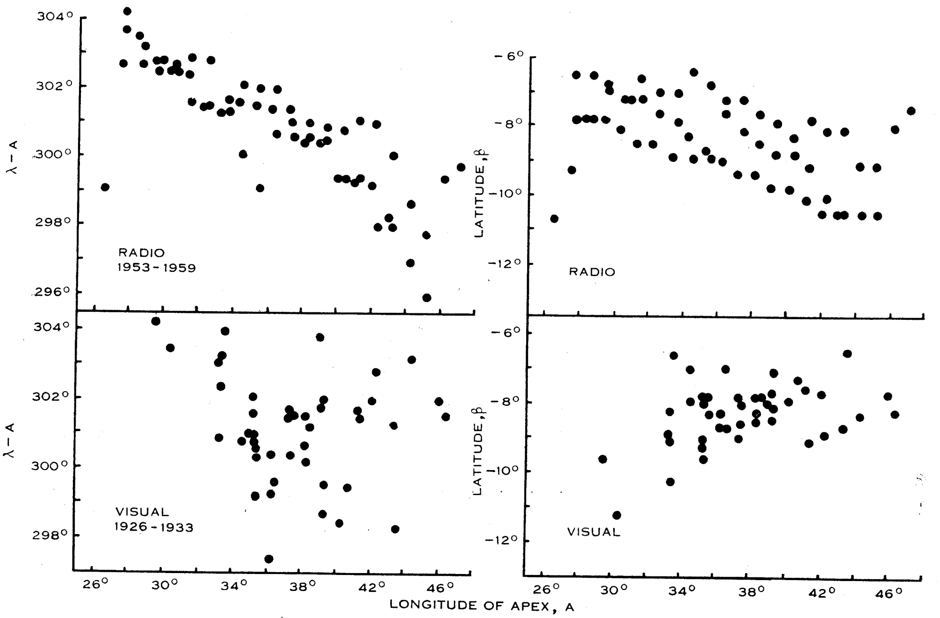


Fig. 3.—Comparison in ecliptical coordinates of the New Zealand visual radiant and the Adelaide radio radiant for the δ-Aquarids. Corrections for zenith attraction and diurnal aberration have not been applied, and coordinates are not reduced to common epoch.

Although it is possible that the discrepancy between the visual and the radio ephemerides could be due to incomplete separation of the minor showers from the δ-Aquarids in the Adelaide observations, this explanation is unlikely in view of the excellent agreement between the mean positions of the radiant as found from the two sets of data.

### (c) *Radiant Diameter*

It is not possible to measure the radiant diameter because two of the minor showers cannot be fully resolved from the δ-Aquarid radiant. The large variations in radiant diameter attributed to the δ-Aquarid stream on the basis of the 1953 observations (Weiss 1955) are now recognized as largely due to the intermittent nature of the minor shower activity.

### (*d*) *Activity*

The shower is first detectable on July 20 and persists until August 14. This duration agrees with the visual observations.

An overall picture of the dependence of shower activity on solar longitude has been determined by multiplying the envelope rates for 1953 and 1959 by factors of 3·2 and 0·30 respectively, and then combining these with the 1957 and 1958 data. Echo rates so obtained are plotted in Figure 4. The activity is slightly asymmetrical about a flat maximum between ⊙=124° and ⊙=125°.

Variations in equipment sensitivity have been so large that no conclusions can be drawn regarding variations from year to year in the activity of the δ-Aquarid stream.

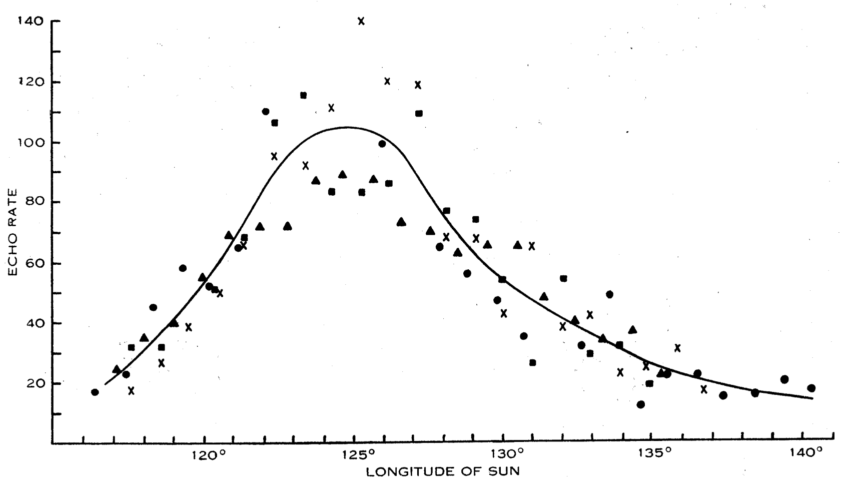


Fig. 4.—The rate of shower echoes falling inside range-time envelopes for the δ-Aquarids. Echo rates for 1953 and 1959 have been reduced to the 1957/1958 level of activity. 1953, ■; 1957, ×; 1958, ●; 1959, ▲.

## V. The Minor Showers

The period from mid July to mid August is one of remarkably high minor shower activity in the southern hemisphere. It can be seen from Table 1 that after excluding sporadic activity the total echo rates for 1957 and 1958 in 3 hr centred on the time of peak δ-Aquarid activity exceed the envelope rates by a factor usually exceeding 2. A similar excess was noted in 1953 when the equipment operated at much lower sensitivity. Some at least of the excess echoes are to be attributed to δ-Aquarid meteors which fall outside the theoretical envelopes, which are computed for a point radiant, but the majority are associated with minor stream activity.

At the higher sensitivity of 1957 and 1958, three main centres of activity could be recognized. The times of occurrence of echoes at 700 km range in each of the two aerial channels are plotted in Figure 5. The large scatter in each set of points is due to the low echo rates of these minor showers, which rarely ever exceed the sporadic rate. Radiants have been determined by drawing straight lines through these plots. In addition, day-by-day radiants were computed from the 1958 data, in which information was available on most days (see Table 2). In general, the quality of the individual radiant determinations is poor, again because of the low echo rates ; a radiant classified as A is probably accurate to 3°, but the quality of the radiant deteriorates rapidly for the B and C classifications. The radiant ephemerides, and the 1958 measurements for individual days, are plotted in Figure 6.

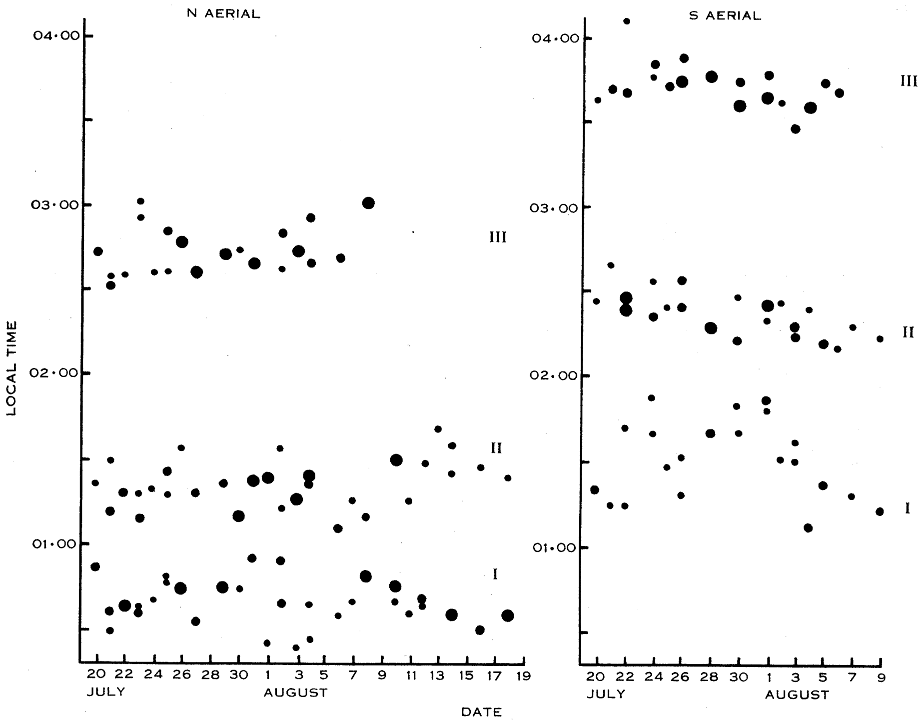


Fig. 5.—Times of detection of echoes at 700 km slant range, minor showers 1957 and 1958. Large dots represent determinations of good accuracy, and small dots, determinations of low accuracy. I, Capricornids ; II, Pisces Australids ; III, Cetids.

The identification of the Cetid radiant is beyond doubt. It corresponds closely with a visual radiant at 352°/11°, −18° active from July 19 to August 1, reported by McIntosh (see, e.g., southern hemisphere finding list compiled by Ellyett and Roth (1955)).

Although the times of passage of the other two centres through the N and S collecting areas are fixed with reasonable precision, there is some uncertainty in the way in which they are to be paired for the determination of the radiants. The criterion adopted was the relative strengths of the activities in each aerial channel on the same days, which indicated that the 00·39 passage through the N aerial is linked with the 01·31 passage through the S aerial, and 01·22 (N aerial) with 02·31 to 02·05 (S aerial). This grouping also gave the best agreement with the visual results, according to which the minor shower activity is confined to

TABLE 2

RADIANTS OF THE MINOR SHOWERS 1958

| Date | Capricornids | | | Pisces Australids | | | Cetids | | |
|---|---|---|---|---|---|---|---|---|---|
| | α | δ | Class | α | δ | Class | α | δ | Class |
| July 20 | 307 | —26 | B | 322 | —17 | C | 341 | —20 | C |
| 21 | 306 | —22 | C | 326 | —10 | C | 342 | —16 | B |
| 22 | 313 | —17 | B | 324 | —16 | A | 343 | —17 | C |
| 24 | 314 | —18 | C | 325 | —18 | C | 347 | —15 | C |
| 25 | 313 | —23 | C | 327 | —18 | C | 346 | —17 | C |
| 26 | 315 | —21 | B | 330 | —18 | C | 348 | —19 | A |
| 30 | 320 | —19 | C | 332 | —13 | B | 350 | —20 | B |
| Aug. 1 | 321 | —12 | C | 333 | —19 | B | — | — | — |
| 2 | 321 | —20 | C | 335 | —14 | C | 353 | —18 | C |
| 3 | 322 | —17 | C | 333 | —19 | A | — | — | — |
| 4 | 319 | —26 | C | 337 | —18 | C | 355 | —19 | A |

only two radiants other than the Cetids—see Table 3. Although there are some discrepancies between the visual and radio radiants, the visual nomenclature has been retained to avoid confusion.

The strengths of all three showers vary irregularly from day to day. The Pisces Australids are the most active of the three; and the Cetids, which are resolved from the δ-Aquarid shower only with difficulty, are the weakest. The

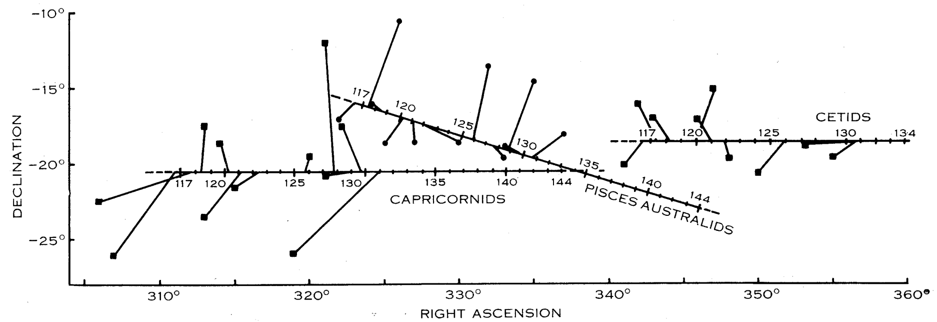


Fig. 6.—Ephemerides for the minor streams of July and August. The three straight lines, which are averages for 1957 and 1958, indicate the mean positions of the respective radiants in Right Ascension and declination as functions of the longitude of the Sun, whose value is marked along the lines. Individual radiants shown are for 1958; each is joined to the point on the mean radiant path corresponding to the longitude of the Sun at which it was determined.

onset of all three showers occurs prior to July 20, the date from which the detailed analysis was made; the Capricornids and the Pisces Australids persist beyond the middle of August, but the Cetid activity was not detected after August 8.

The comparatively small excess of the total rates (in 4 hr) over the envelope rates for 1959 is thought to be misleading and not a true measure of the minor shower activity. As already mentioned, the resolving power of the 1959 aerial system is lower than that used in previous years and the activity from only one of the three recognized minor radiants can be resolved completely from the main δ-Aquarid activity. The envelopes used in the analysis of the 1959 data were determined empirically from the observations, and it is almost certain that a considerable fraction of the Cetid and Pisces Australid activity has been included

TABLE 3

COMPARISON OF RADIO AND VISUAL RADIANTS

| Shower | Adelaide Radio | | | Visual† | | |
|---|---|---|---|---|---|---|
| | Dates of Activity | Radiant | | Dates of Activity | Radiant | |
| | | α | δ | | α | δ |
| Capricornids | July 20*–Aug. 18* | 311/337 | —20 | July 10–Aug. 5 | 300/325 | —10/—19 |
| Pisces Australids | July 20*–Aug. 18* | 323/346 | —16/—23 | July 14–Aug. 22 | 330/339 | —30 |
| | | | | July 26–Aug. 8 | 337/350 | —30/—33 |
| δ-Aquarids | July 20 –Aug. 14 | 335/353 | —14/—19 | July 22–Aug. 15 | 331/351 | 0/—17 |
| Cetids .. | July 20*–Aug. 8 | 342/0 | —18 | July 19–Aug. 1 | 352/11 | —18 |

* Shower may commence before, or terminate after, these dates.

† From Ellyett and Roth (1955).

in the envelope activity for the δ-Aquarids. There are, however, in the range-time plots some excess echoes whose range changes with time in the manner expected of shower activity and which precede the main δ-Aquarid activity by 130 min. These are identified as proceeding from the Capricornid radiant. In fact, this time difference of 130 min gives for the Capricornid radiant in 1959 a Right Ascension which agrees better with the visual radiant than the 1957 and 1958 determinations.

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