ETA AQUARIDS 1969-1977 FROM ONDŘEJOV METEOR RADAR RECORDS

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ABSTRACT. On the basis of 75 000 radar meteor echoes observed during the Eta Aquarid shower period in 1969-1977 at the Ondřejov Observatory, the activity of the shower is deduced. Mean hourly rates and the dependence of the echo rates on the shower radiant elevation are compared with other data. The results support the presence of shower features obtained from the Springhill radar meteor data. The characteristic double peak of activity in the central part of the stream is located to 45.5° of solar longitude.

ЭТА АКВАРИДЫ 1969-1977 гг. ПО ДАННЫМ РАДИОЛОКАЦИОННЫХ НАБЛЮДЕНИЙ В ОНДРЖЕЕВЕ. По данным наблюдений 75 000 метеорных радиоэхо в Астрономической обсерватории Чехословацкой Академии наук в Ондржееве в 1969-1977 гг. приведены кривые активности метеорного потока Эта Акварид вдоль и в поперечнике потока. Средние часовые числа метеоров и их зависимость от высоты радианта потока согласуются с данными наблюдений тогоже потока в Спрингхильской обсерватории. Характеристический двойный максимум центральной части потока соответствует 45.5° долготы Солнца. Данные наблюдений приведены подробнее в 7 таблицах и 8 изображениях.

ETA AKVARIDY 1969-1977 Z METEORICKÝCH RADAROVÝCH ZÁZNAMOV V ONDŘEJOVE. Na základe 75 000 radarových ozvien meteorov, získaných pomocou meteorického radaru na Astronomickom observatóriu ČSAV v Ondřejove v r. 1969-1977 bola od-

vodená aktivita meteorického roja Eta Akvaríd pozdĺž prúdu i v jeho priereze. Priemerné hodinové frekvencie a závislosť frekvencií od výšky radiantu sú v úplnom súlade s nezávislými pozorovaniami roja v Springhill Observatory. Charakteristické dvojité maximum v centrálnej časti prúdu zodpovedá 45.5° slnečnej dĺžky. Podrobné údaje sú obsiahnuté v siedmich tabuľkách a ôsmich obrázkoch.

1. OBSERVATIONS

The data used in the present analysis have been obtained at the Astronomical Observatory of the Czechoslovak Academy of Sciences at Ondřejov with a 25 kW meteor radar operating at a frequency of 37.5 MHz. For the other characteristic of the equipment see Plavcová and Šimek (1960). The meteor echoes were recorded on the range-time record, using a 35 mm film with a recording speed of 5.6 cm/min.

A total number of 75 000 radar meteor echoes were observed in 293 hours during the periods of May 3 - May 10 in 1969 and 1972-1977. The summary of the observational data containing the total and net observational times and the total number of meteor echoes observed in a particular year is shown in

Table I

YEAR	T_{obs} (h)	T_{net} (h)	N_{echoes}
1969	42	37,9	12 139
1972	28	23,5	7 334
1973	47	39,7	11 557
1974	38	34,3	11 447
1975	41	35,0	8 958
1976	51	39,1	11 057
1977	46	37,7	12 583
	293	247,2	75 075

In some cases interferences appeared on the records causing errors in film reading. In such cases the necessary corrections were applied to obtain the correct meteor rates. The method of determining the corrections was described elsewhere (Váňa, 1985).

2. HOURLY RATES OF METEORS

As the geographic longitude of the Ondřejov Observatory $\varphi = 14^{\circ}47'$, the local time coincides within 1 minute with the standard Central European Time - CET, in which all the data are tabulated. A time interval of 5 hours (between 05:00 - 10:00 h), centred at the meridian transit of the shower radiant has been used in most observations, with some exceptions, when the level of interferences was too high to read the records correctly. The hourly rates of meteor echoes for each hour observation are given in Table II for all echoes and in Table III for echoes with durations $\tau \geq 1$ sec. The data show a regular increase in the echo rates with the elevation of the shower radiant.

Table II

Hourly rates of all echoes

1969 MAY	h 3	4	5	6	7	8	9	10	11
5			287	327	280	345	295	262	224
6			302	368	341	403	223	287	212
7			238	289	305	447	338	319	245
8			301	380	423	313	347	253	353
9			288	301	414	350	313	267	241
10			425	318	416	398	338	310	245
1972 MAY									
3			382	388	372	345	393	298	294
4			303	-	-	339	273	315	264
5			222	229	292	289	-	210	256
6			381	287	407	426	315	268	358
7			443	212	256				
1973 MAY									
3			-	392	280	209	198	157	138
4		365	287	263	198	244	241	152	
5			171	292	328	312	320	245	210
6			272	292	301	337	333	279	
7		383	346	-	-	380	335	340	385
8			373	424	385	426	375	321	-
9			226	237	373	348	310		
1974 MAY									
3		84	106	140	218	329	349	271	
4		263	364	365	425	428	354	268	
5			445	494	436	365	416	296	
6		253	218	172	413	413	324	273	
7		281	369	432	490	402	349	353	
8		224	261	453	421				
1975 MAY									
2	154	131	158	186	175	200	242		
3	103	83	253	316	309	311			
4	217	149	185	332	330	298	247	306	
5			280	330	436	373	352	396	230
6								497	353
7						(630)	351	(548)	330
8		212	182	272	246	220	188	184	

1976

MAY	h 3	4	5	6	7	8	9	10	11
4	240	266	328	376	434	442	359	282	
5	174	153	175	220	290	350	322	233	
6	190	181	253	217	324	357	338	284	
7	142	188	230	318	362	405	411	360	
8	178	241	253	300	350	390	380	280	
9	164	197	270	303	289				
10	208	210	314	294	345	320	324		

1977

MAY	h 3	4	5	6	7	8	9	10	11
3		372	311	320	349	306	271	239	
4		314	432	449	176				
5		681		611	695	658	135	190	
6		372		372	376	306	140	474	
7				383	306	267	380		
8	250	326	434	384	481	452			
9		224	249	252	412	356	374		
10		229	339	435	425	155			

Table III

Hourly rates of echoes with $\tau \geq 1.0$ s

1969

MAY	h 3	4	5	6	7	8	9	10	11
5			33	32	38	35	46	33	32
6			31	50	40	36	34	45	32
7			30	36	43	47	48	54	45
8			25	46	56	51	36	44	24
9			14	19	41	42	44	42	41
10			19	25	41	55	64	56	43

1972

MAY	h 3	4	5	6	7	8	9	10	11
3			16	29	20	27	44	29	31
4			10	-	-	27	12	21	24
5			11	15	33	20	-	20	37
6			26	22	27	35	15	34	31
7			28	17	30	29	31	34	36

1973

MAY	h 3	4	5	6	7	8	9	10	11
3				32	14	16	12	10	5
4		37	10	15	21	13	15	11	
5			9	29	26	37	29	37	23
6			21	26	25	38	38	30	-
7		30	23	-	-	43	38	45	41
8			33	28	27	36	39	37	-
9			16	15	34	41			

MAY	h 3	4	5	6	7	8	9	10	11
1974									
3		8	9	4	29	36	53	51	
4		22	29	33	42	40	32	28	
5			34	27	43	22	49	26	
6		14	22	19	28	37	27	27	
7		27	29	27	32	48	37	43	
8		15	23	48	39				
1975 MAY									
2	6	6	10	12	11	19	29		
3	5	1	15	22	16	27			
4	11	9	10	23	33	25	28	23	
5			19	22	36	35	37	43	24
6								50	33
7						50	54	70	49
8		19	10	16	20	23	18	26	
1976 MAY									
4	20	25	30	27	47	35	32	26	
5	17	14	13				33	17	
6	8	11	8	18	25	27	20	20	
7	4	12	17	29	27	37	38	38	
8	7	18	21						
9	14	13	21	19	24				
10	12	16	18	23	28	39	36		
1977 MAY									
3		27	38	52	49	48	48	49	
4		32	36	33	10		41		
5		90	9	80	90	150	42	45	
6		22		41	40	46	22	65	
7				40	34	29	49		
8	14	36	39	34	46	30			
9		16	22	29	47	43	39		
10		26	32	53	51	19			

In some cases, however, the influence of minor showers, active during the A-quarid period, can be recognized. The scatter of the data is, of course, much larger for the long duration echoes, but in spite of this a clear influence of the sunrise effect on the long duration echoes has been detected, and will be discussed below.

3. THE DEPENDENCE OF THE ECHO RATES ON THE SHOWER RADIANT ELEVATION

The radiant of the Eta Aquarid shower culminates at about 07:30 h CET. The average echo rates for each year in a particular hour are summarized in Table IV (for all echoes) and Table V (echoes with durations $\tau \geq 1$ sec.).

Table IV

h	1969	1972	1973	1974	1975	1976	1977
3			(374,5)		(216,7)	181,8	
4			(374,5)	253,4	169,0	204,9	349,8
5	287,2	329,2	292,0	331,7	215,6	247,6	422,7
6	341,6	242,7	319,3	382,9	311,3	286,2	436,8
7	336,0	318,5	310,6	437,4	337,3	352,0	326,6
8	384,1	351,4	340,0	401,6	324,0	388,8	258,0
9	314,3	299,4	321,7	362,0	272,9	362,0	202,5
10	282,6	269,1	267,0	296,2	363,6	287,8	(276,6)
11	244,1	275,1	240,4		294,0		

Table V

h	1969	1972	1973	1974	1975	1976	1977
3					(11,0)	10,1	
4			(33,1)	19,5	(12,3)	15,9	32,4
5	29,6	18,6	19,9	27,5	13,1	18,0	37,6
6	41,4	18,0	24,7	30,4	20,4	24,9	44,3
7	44,2	30,1	33,5	37,0	29,6	33,0	34,9
8	41,5	27,8	33,6	36,7	29,5	33,1	42,4
9	40,8	19,3	32,0	36,5	30,9	30,8	34,3
10	44,1	27,3	31,9	30,6	37,5	24,9	(50,8)
11	34,5	32,0	31,6		33,9		

The resulting values of mean hourly rates in dependence on time corresponding to the motion of the radiant, constructed for all echoes and 1 sec echoes over all years of observation are shown in Fig. 1 and Fig. 2. All temporal interferences, seen in particular hourly rates in Tables I and II disappeared in the overall mean of 75 000 echoes. While the rates of all echoes follow the radiant motion on both sides of the culmination point, the rate of echoes with durations $\tau \geq 1$ s, corresponding to the persistent trains, show only a little decrease after reaching the maximum radiant elevation. Exactly the same effect was observed in the Springhill Eta Aquarid data from 1958-1967 (Hajduk, 1981, Fig. 5). The explanation of this independently recorded effect is in the increasing ionization of the atmosphere after sunrise at the level of the meteoric zone. As shown by McIntosh and Hajduk (1977) and Hajduk et al. (1980), the proportion of 1 s duration echoes increases slowly after local sunrise (which takes place at about 03:45 h at 90 km height in the period of observations), reaching a maximum approx. 6 hours later. This result obtained for the spora-

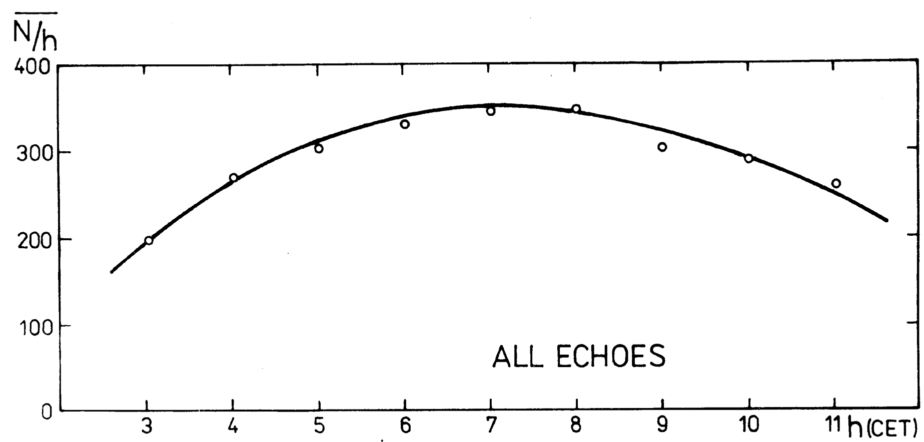

Fig. 1 The dependence of mean hourly rates of echoes on the diurnal radiant motion (with the meridian transit at 07:30 h) for 75 000 meteor echoes from the whole observational period (1969-1977).

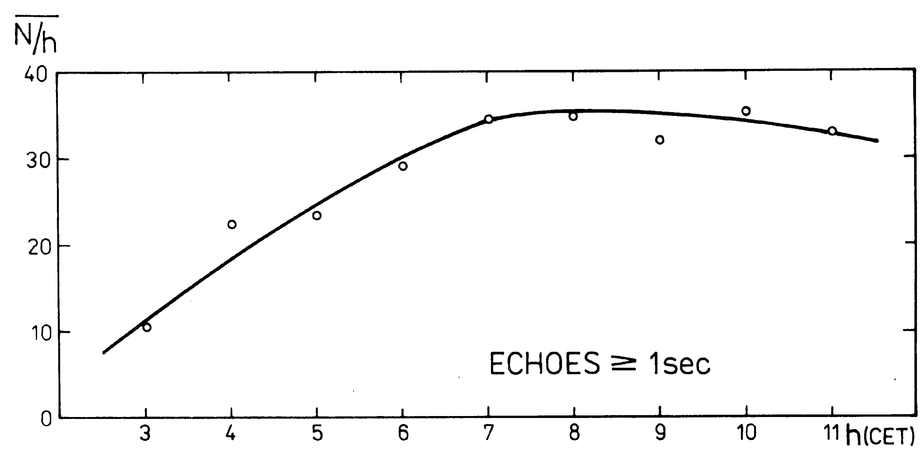

Fig. 2 The dependence of mean hourly rates of long duration echoes on the diurnal radiant motion corresponding to Fig. 1.

dic meteors is in full agreement with the present results of the observations of Aquarid shower meteors. A sunrise effect has been recorded in the observations of the Quadrantid meteor shower by Hughes and Baggaley (1972) and Nicholson and Poole (1974). Expressing the radiant motion over the observational time, we obtain the exact dependence of the echo rates on the radiant elevation ε . The results are seen in Figures 3 and 4, where the circles represent the arm of the dependence after culmination and the dots before it. Naturally, the presence of the sporadic background included in the material should be taken into account. However, the contribution of the background to the long duration echoes before the appearence of the shower and before sunrise seems to be negligible.

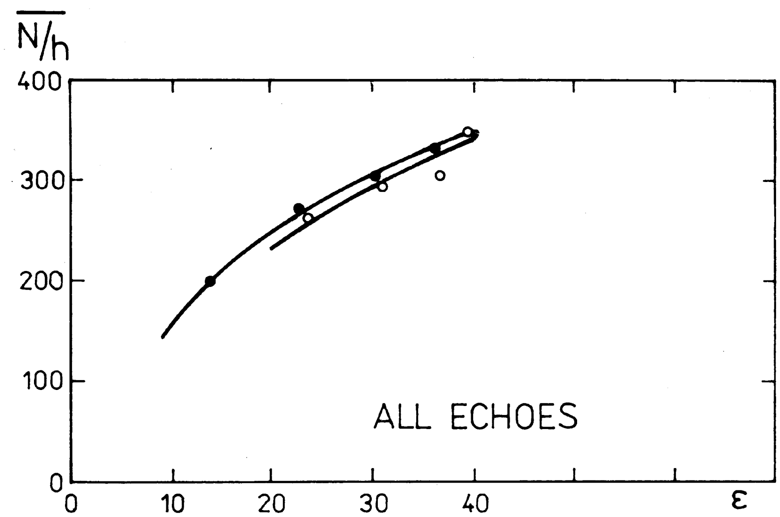

Fig. 3 The dependence of mean hourly rates of 75 000 echoes on the radiant elevation ε .

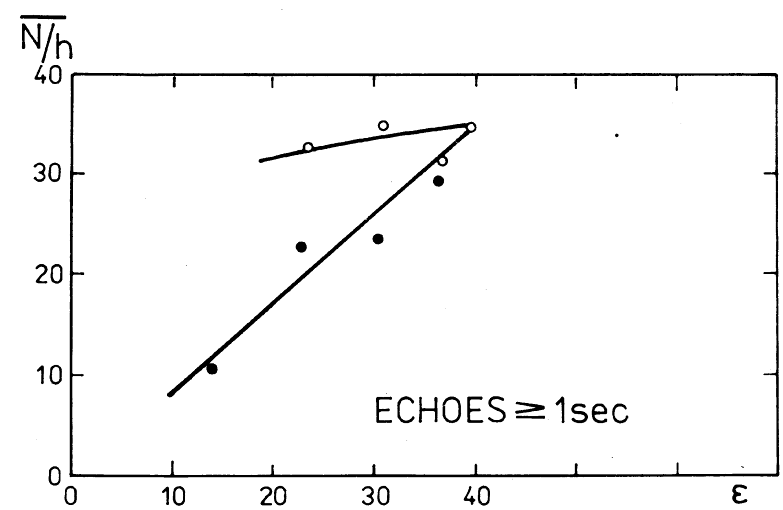

Fig. 4 The dependence of mean hourly rates of long duration echoes on the radiant elevation ε .

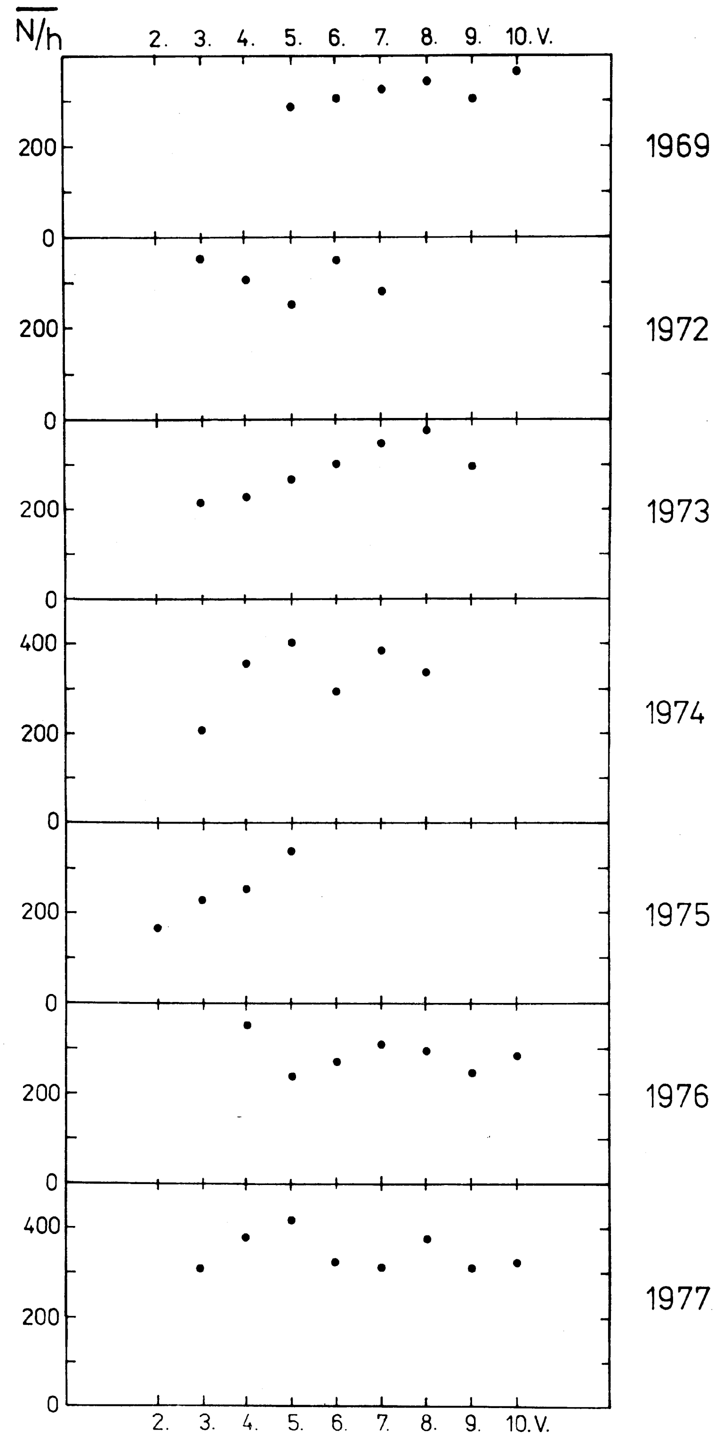

Fig. 5 The observed shower activity deduced from 5 hour intervals, centred at the meridian transit of the radiant, for each day and year, given in mean hourly rates.

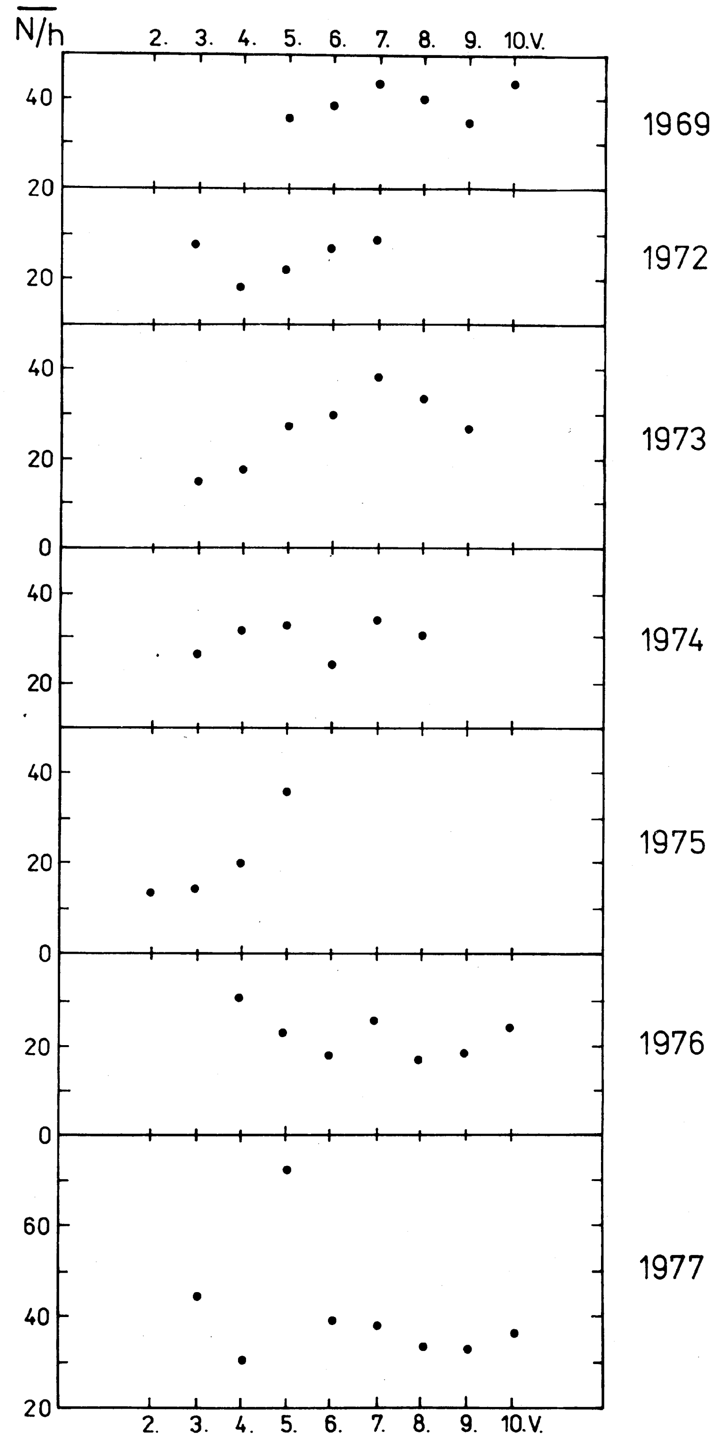

Fig. 6 The observed shower activity for long duration echoes corresponding to Fig. 5.

4. THE SHOWER ACTIVITY

The shower activity in particular years is shown in Fig.5 for all echoes and Fig.6 for overdense trains. There is a little variation in the peak rates or in the total activity in different years, with some higher values in 1974 and 1977. The final values of the mean echo hourly rates, expressed for solar longitudes, reduced to the equinox 1950.0, including supplementary values to the data published earlier (Hajduk and Buhagiar, 1982) are listed in Tables 6 and 7.

Table VI

All echoes

	40,5	41,5	42,5	43,5	44,5	45,5	46,5	47,5	48,5	49,5
1969					287,9	305,7	324,6	342,6	302,7	361,7
1972			351,0	302,3	251,8	349,1	280,6			
1973			(214)	(229)	269,9	300,6	347,4	378,6	296,8	
1974			210,0	359,6	408,2	296,2	385,9	336,1		
1975	170,9	233,6	257,4	341,9						
1976				354,2	240,0	272,3	309,2	297,0	248,5	286,5
1977			308,3	378,3	413,9	322,0	312,3	376,7	311,1	321,0
All	170,9	233,6	268,1	327,6	312,0	307,7	326,7	346,2	289,8	323,1

Table VII

Echoes with $\tau \geq 1$ s

	40,5	41,5	42,5	43,5	44,5	45,5	46,5	47,5	48,5	49,5
1969					35,5	38,2	43,3	40,2	34,7	43,3
1972			28,0	18,8	22,5	27,1	29,0			
1973			14,8	17,4	27,1	29,7	38,0	33,3	26,5	
1974			27,1	32,3	33,5	24,9	34,7	31,3		
1975	13,3	14,3	20,3	36,0						
1976				30,3	22,5	17,1	25,3	16,8	18,2	23,9
1977			44,4	30,4	72,3	39,3	38,0	33,2	32,7	36,2
All	13,3	14,3	26,9	27,5	35,6	29,4	34,7	31,0	28,0	34,5

The mean activity curve, deduced from the whole period of 1969-1977, containing 75 000 radar meteor echoes, is seen in Fig. 7 and the corresponding activity of higher particles, causing persistent trains (from meteors brighter than 5 vis. magnitude), is seen in Fig. 8. The resulting activity curve is in full agreement with that obtained by the Springhill meteor radar in 1958-1967 (Hajduk, 1981), with the New Zealand radar data (Ellyett and Keay, 1963 and Keay and Ellyett, 1969) and with the other observations of Eta Aquarids, summarized by Hajduk (1980). The main feature, observed here as well as in all the data, is a double central peak, located on both sides of solar longitude 45.5 deg., with a small dip between the peaks.

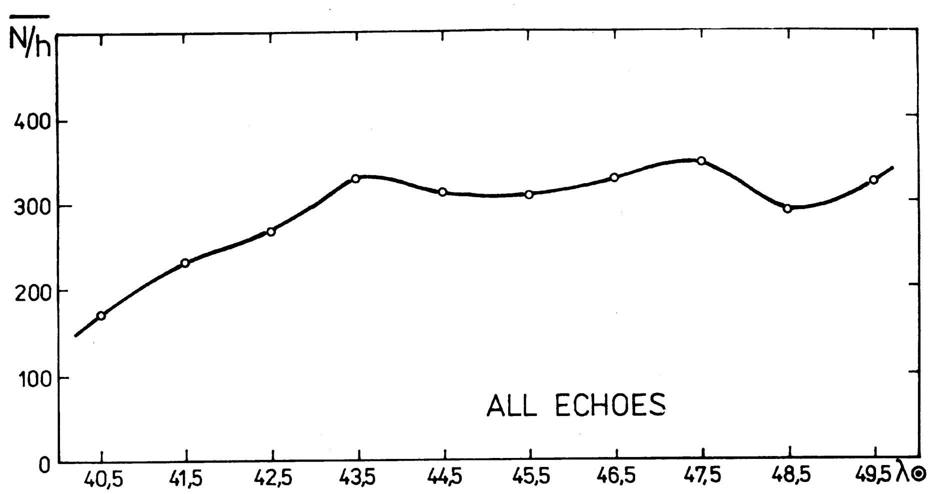

Fig. 7 The final shower activity expressed in the mean hourly rates deduced from 75 000 meteors and reduced to the equinox 1950.0, for particular values of solar longitude.

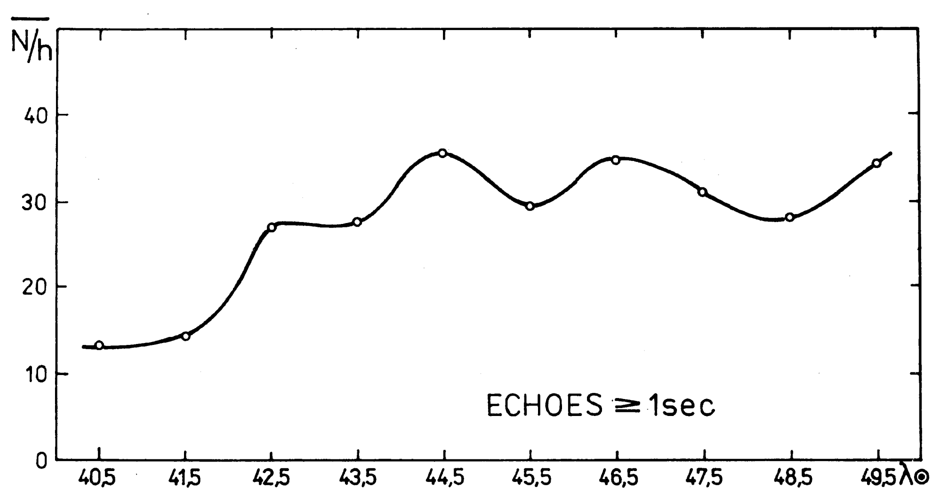

Fig. 8 The final shower activity of long duration echoes corresponding to Fig. 6.

In the interpretation of this peak as a double belt in the shell model of the meteor stream of Comet Halley, McIntosh and Hajduk (1983) suggest that such a belt must be narrower for larger particles than for the smaller ones. The observational period is not long enough to confirm the presence of the side belts of that model. However, they give independent confirmation of the main structural features of the stream.

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