CHANGES IN RADAR METEOR ECHO RATES AT SUNRISE

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Abstract: The effect of sunrise on mean hourly rates of meteor echoes recorded with the Ottawa patrol radar during selected periods of sporadic meteor activity through the year was noted in an earlier paper (McIntosh and Hajduk, 1977). Here we present in a more complete way the change in the proportion of echoes in all duration classes recorded. The magnitude of the relative increases is found to be approximately the same for all duration classes, but the rate of increase after sunrise is slower for counts down to shorter duration, and the maximum of the increase occurs later in time.

1. Observations

In a previous paper (McIntosh and Hajduk, 1977 hereafter referred to as Paper I) analysing persistent meteor echo rates recorded at the Springhill Meteor Observatory, Ottawa, Canada a rapid increase after sunrise in the proportion of echoes of duration $\tau \geqq 8$ s was demonstrated. The increase persists through a part of the daylight hours and returns to normal before sunset. This paper investigates in a similar way meteor echo rates in the cumulative duration categories $\tau \geqq 1$ s, $\tau \geqq 2$ s, $\tau \geqq 4$ s and the total count designated "ALL" echoes.

Table 1 lists for each hour of the day the total numbers of ALL meteors recorded during the years 1963—1967 in eight selected "sporadic

Table 1

E.S.T.	I	II	III	IV	V	VI	VII	VIII	Σ
1	9313	9177	8438	8581	10948	13082	12556	10144	82239
2	10439	9584	9011	9807	12582	15181	13976	11549	92129
3	11846	9952	9677	11245	13890	16175	16001	13919	102705
4	12262	8909	10153	13717	14870	16679	17727	16158	110475
5	11800	8007	11776	16285	15777	16119	18879	17447	116090
6	10496	7296	13902	19187	16399	15933	18863	17157	119233
7	8999	7280	16937	22078	17830	15750	17710	16249	122843
8	7829	7897	19302	23752	18918	16655	16605	14588	125546
9	7036	9234	19892	22735	18539	17227	13530	12288	120481
10	6917	10076	19589	21033	17721	17147	11605	10275	114363
11	6942	10378	18359	19347	15262	16108	9720	8926	105042
12	7116	9600	17141	18704	13360	14967	8170	7934	96992
13	6429	8665	15246	17890	11996	13271	7097	7198	87792
14	5413	7105	13058	15949	10928	10771	6147	6413	75784
15	4543	5354	10310	12554	9609	8917	5631	5665	62583
16	3532	4098	7639	9387	7713	7148	5134	4729	49380
17	2970	3107	5275	6700	6489	5612	4877	4353	39383
18	2661	2787	4119	5092	5472	4805	4834	3990	33760
19	2807	2676	3795	4308	4864	4549	5232	4284	32515
20	3530	2954	4142	4427	4473	5252	6159	4951	35888
21	4327	3781	4612	4560	4893	6153	7553	5958	41837
22	5684	5018	5778	5419	5813	7638	9082	7000	51432
23	6982	6735	6701	6372	7353	9563	10563	8209	62478
24	8195	7820	7832	7313	9000	11276	11561	9221	72218

periods" each of 10 days. The data are plotted in Fig. 1. The change in the form of the diurnal variation throughout the year results from combined effects of the geometry of the Earth's motion and the distribution of sporadic "sources" (Štohl, 1968). The variations are similar to those published by Millman and McIntosh (1964) for the previous 5-year period.

Periods IV and VII are not entirely shower free, IV being contaminated by the day-time Zeta Perseids and Beta Taurids, and VII by the autumn Taurid shower. Since these showers transit well before (VII) or well after sunrise (IV), they do not influence the investigated effect near sunrise but it is necessary to take into account their presence in the diurnal distribution of echo rates.

The ratio of echo-rates in duration classes $\tau \geqq 1$ s, 2 s, 4 s to ALL rates are shown in Figs 2—4. Time

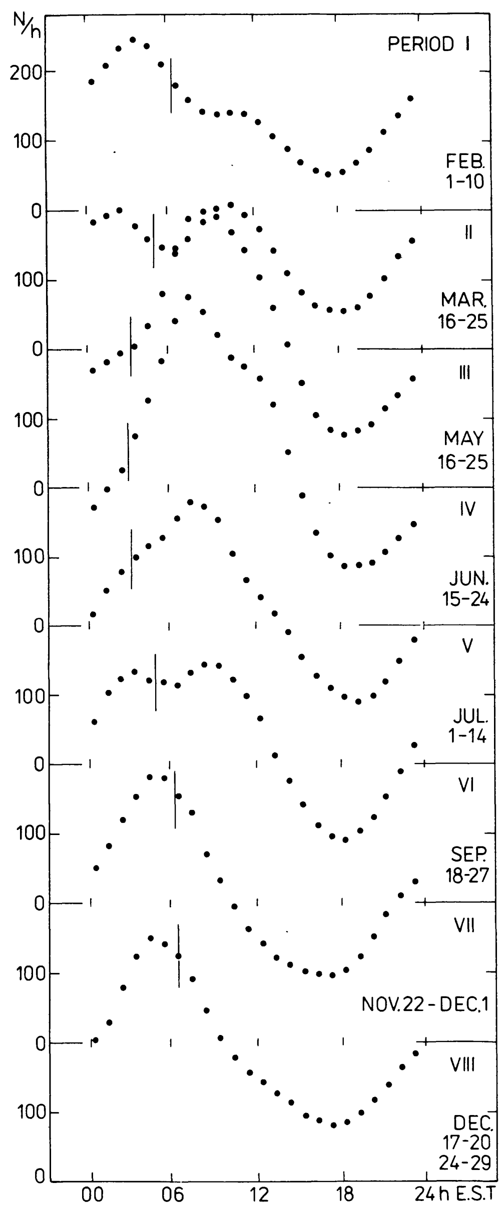

Fig. 1. Mean hourly rates for 5 years (1963—1967) for each of the 10-day periods listed in Table 1.

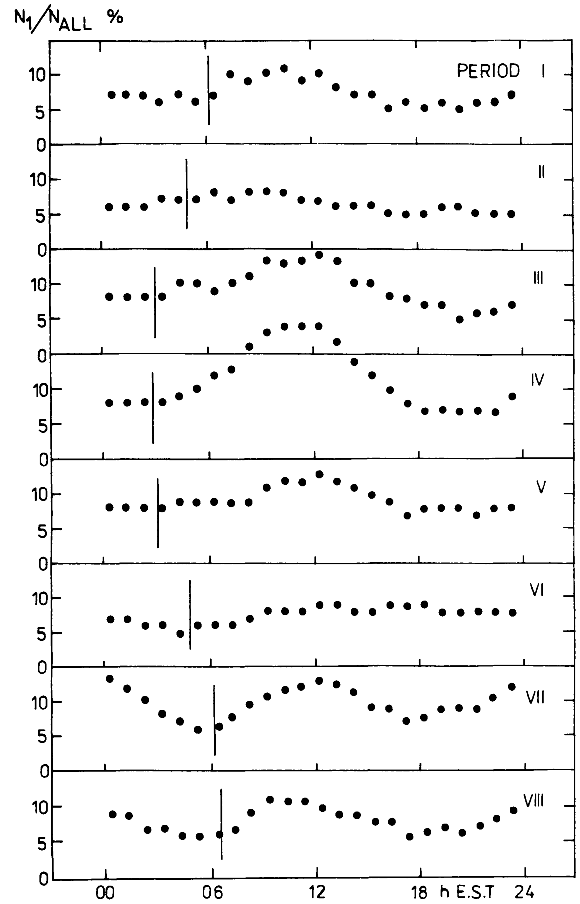

Fig. 2. Ratio $R = N_1/N_{ALL}$ for 10-day periods averaged over 5 years.

of local sunrise in each period at a height of 90 km is marked in Figs 1—4 by a vertical line. The times of corresponding ground sunrise and at other heights can be found in Table 2.

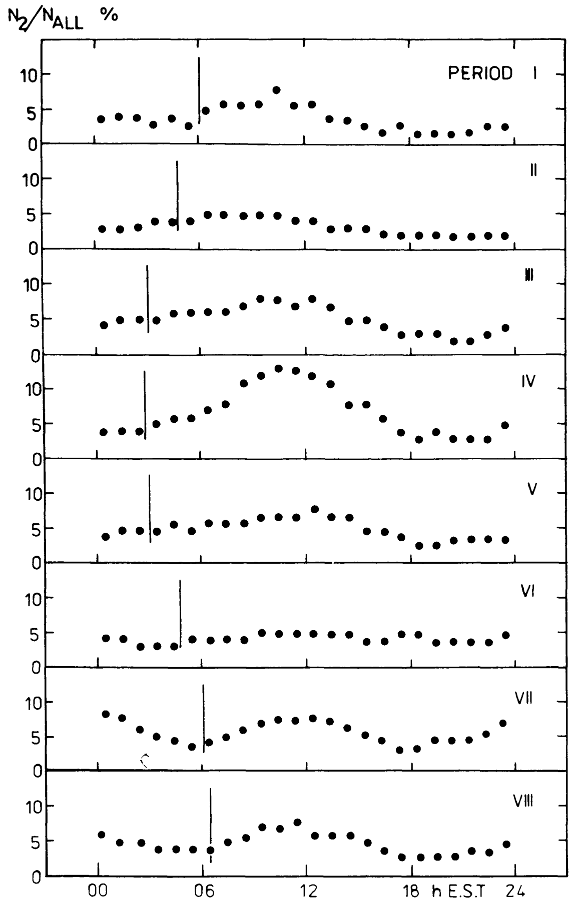

Fig. 3. Ratio $R=N_2/N_{ALL}$.

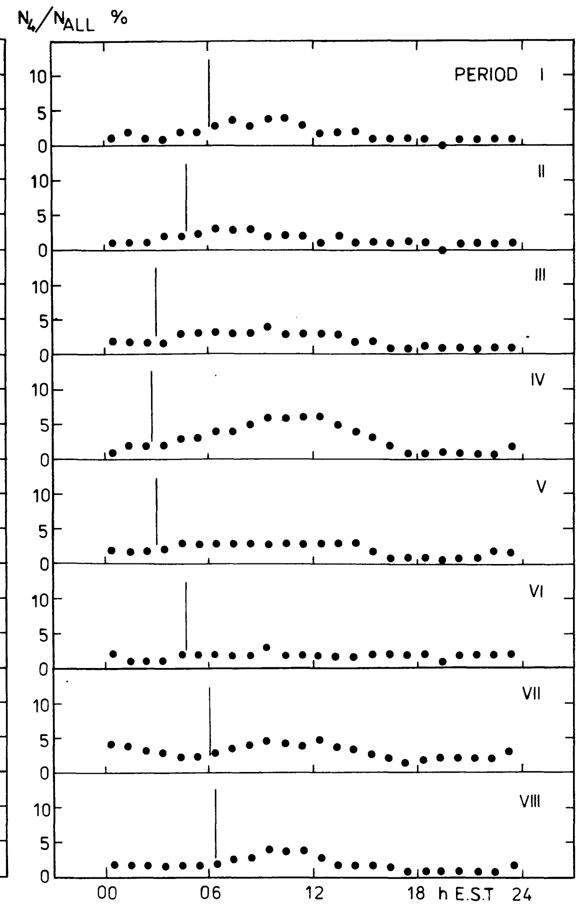

Fig. 4. Ratio $R=N_4/N_{ALL}$.

Table 2

Period	Ground	80 km	90 km	100 km
		Sunrise		
I	7.16	6.22	6.19	6.16
II	6.04	5.13	5.10	5.07
III	4.26	3.23	3.18	3.14
IV	4.13	3.04	3.00	2.55
V	4.23	3.16	3.11	3.07
VI	5.48	4.57	4.54	4.51
VII	7.14	6.18	6.14	6.11
VIII	7.38	6.40	6.36	6.33
		Sunset		
I	17.15	18.09	18.12	18.15
II	18.13	19.05	19.08	19.11
III	19.30	20.34	20.38	20.42
IV	19.52	21.01	21.05	21.10
V	19.50	20.56	21.01	21.05
VI	17.58	18.50	18.53	18.56
VII	16.23	17.20	17.23	17.26
VIII	16.23	17.21	17.24	17.27

2. Magnitude of the Increase and Time of Maximum

By aligning the values given in Figs 2—4 with respect to the time of sunrise and then averaging over all 8 periods we obtain for each duration class the proportion relative to ALL echoes as a function of time from sunrise (Fig. 5). For comparison purposes we have also replotted from Paper I the corresponding dependence for echoes $\tau \geqq 8$ s.

Figure 6 shows the absolute rates for ALL echoes treated in a similar way. The change after sunrise is very slight and is undoubtedly contributed by the persistent echoes which are included in the cumulative "ALL" count.

Comparison of the effect of sunrise on the relative rates in the different duration classes is best seen in Fig. 7, where they are plotted normalized to the value at sunrise as $N_1/N_{ALL} = N_2/N_{ALL} = N_4/$

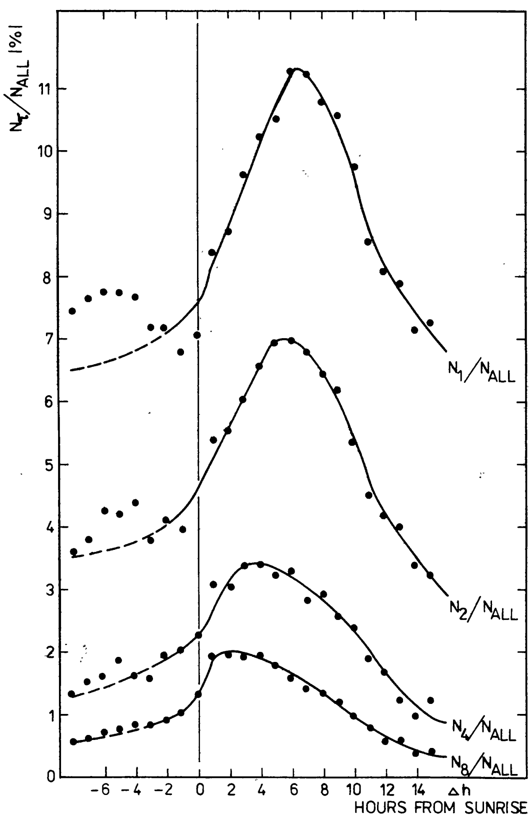

Fig. 5. R values averaged over all 8 periods aligned at the hour of 90-km sunrise. Duration class $\tau \geqq 8$ s replotted from Paper I.

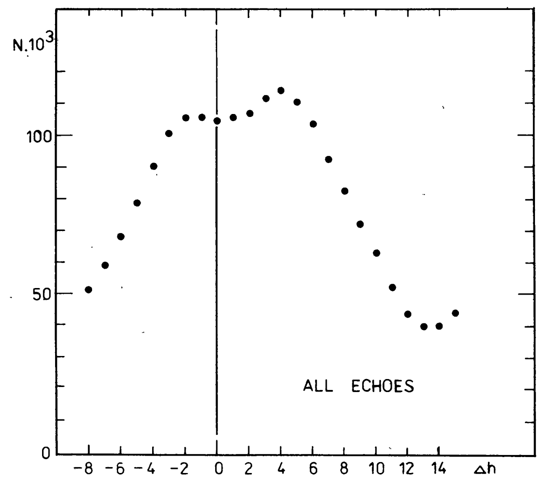

Fig. 6. Mean hourly rates of ALL echoes over 8 periods aligned at the hour of 90-km sunrise.

$N_{ALL} = N_8/N_{ALL} = R_\odot = 1$, for $\Delta h = 0$. For the 8 s duration class the effect starts very rapidly and reaches a maximum value about 2 hours after sunrise. The rate of increase is consistently less rapid towards shorter durations and the time of maximum after sunrise is correspondingly later. The delays for the other categories are $\tau \geqq 4$ s $-$ 4 h, $\tau \geqq 2$ s $-$ 5.5 h, $\tau \geqq 1$ s $-$ 6.7 h.

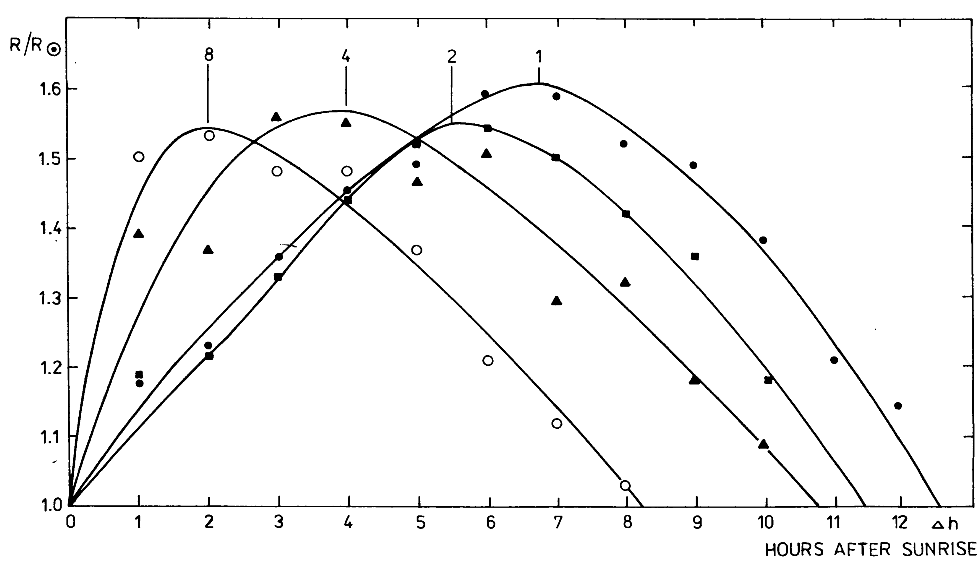

Fig. 7. Comparison of ratios normalized to the value $R_\odot$ at sunrise.

The maximum of the increased proportion of echoes caused by the daylight effect is nearly the same for all duration levels, having values $R_{\odot}$ between 1.50 and 1.55. The increase returns to the sunrise level $R_{\odot}=1$ in 8 to 12 hours.

The possible mechanisms for this effect, basically change in electron loss rates through atmospheric constituents depending on solar radiation, were discussed in Paper I. It remains now to explain the shift in activity of these processes for the different echo duration classes.

Conclusion

After sunrise there is an increase in the relative proportion of persistent meteor echoes even down to durations as short as 1 s. The rate of increase is most rapid, and reaches maximum earlier, for the longest duration echoes $\tau \geqq 8$ s. The commencement of the increase is slowest for the shorter-duration echoes and their maxima are shifted towards noon. In spite of these differences, the value of the maximum ratio, normalized to that at sunrise, is constant at 1.5 for all duration classes.

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ZMENY FREKVENCIE RADAROVÝCH OZVIEN METEOROV S VÝCHODOM SLNKA

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Súhrn

Práca nadväzuje na výsledky získané radarovou aparatúrou observatória v Ottawe o vplyve východu slnka na priemerné hodinové frekvencie ozvien sporadických meteorov (McIntosh a Hajduk, 1977). Sú v nej odvodené zmeny frekvencie ozvien pre všetky hladiny trvaní. Zvýšenie relatívneho zastúpenia ozvien po osvetlení meteorickej zóny slnkom je rovnaké pre všetky kategórie trvaní ozvien, avšak strmosť, akou počet ozvien narastá, je menšia pre kratšie trvajúce ozveny a maximum zastúpenia kratších ozvien sa oneskoruje oproti dlhším trvaniam až o niekoľko hodín.

ИЗМЕНЕНИЕ ЧИСЛЕННОСТЕЙ МЕТЕОРНЫХ РАДИОЭХО С ВОСХОДОМ СОЛНЦА

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Резюме

Влияние восхода солнца на средние часовые числа метеорных эхо, зарегистрированных радиолокационной установкой обсерватории в Оттаве, в течении избранных вдоль года периодов спорадической активности метеоров обсуждалось в предидущей статьи (Мак-Интош и Хайдук, 1977). Здесь приводятся более полным образом изменения относительных численностей эхо для всех категорий длительностей. Величина повышения относительной численности эхо оказывается одинаковой по всем длительностям, но крутизна подъема меньшая для более коротких длительностей и максимум последних появляется позже.