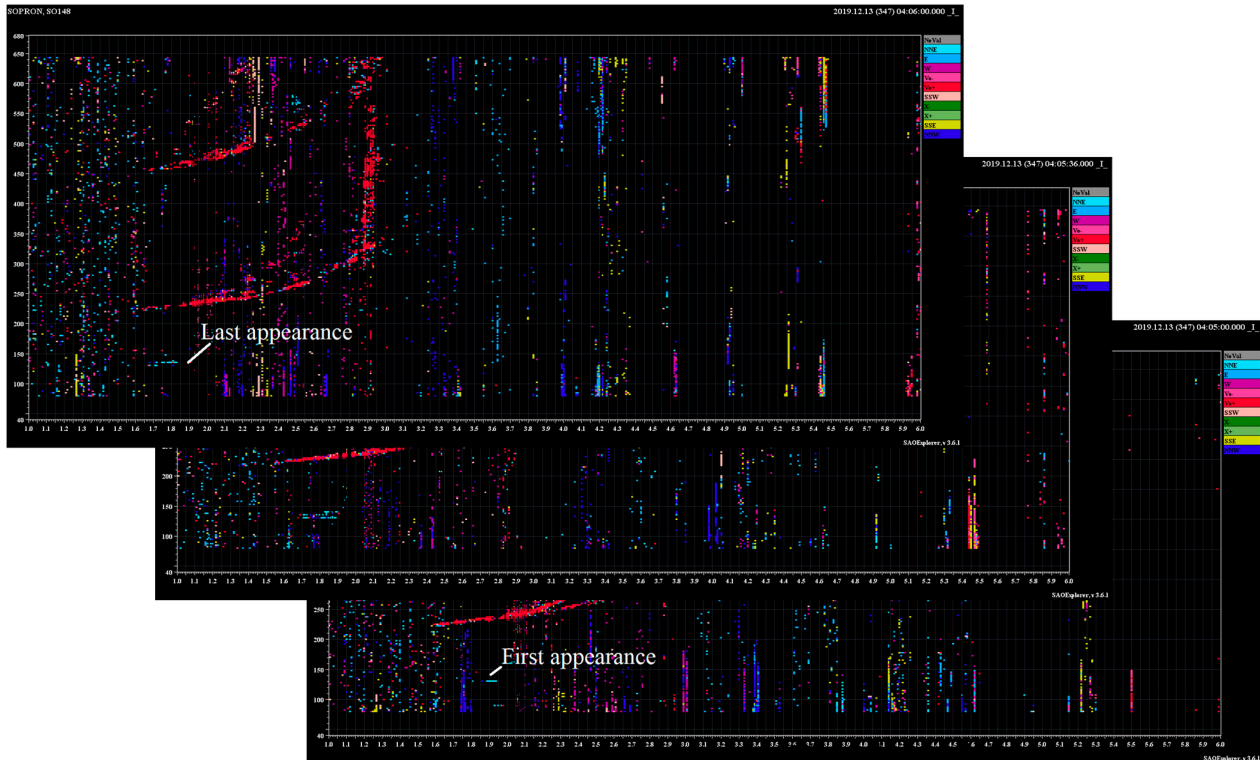
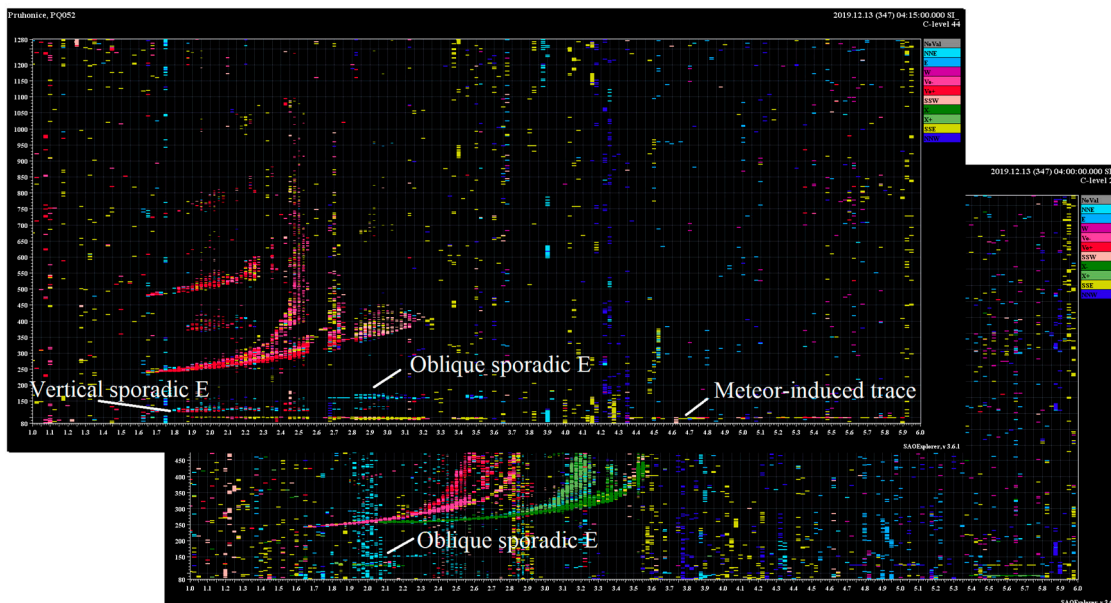


Supplementary material

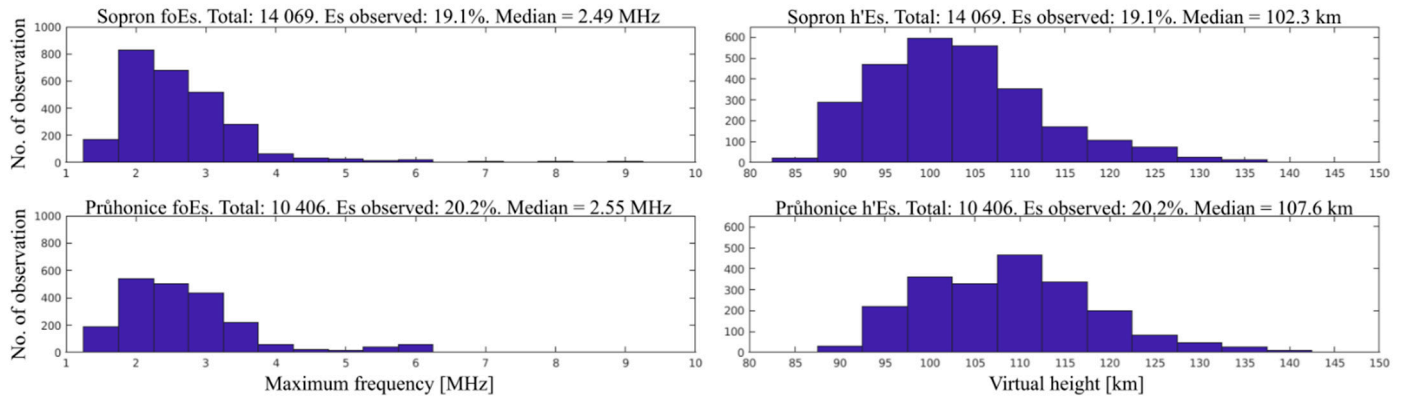


Sopron

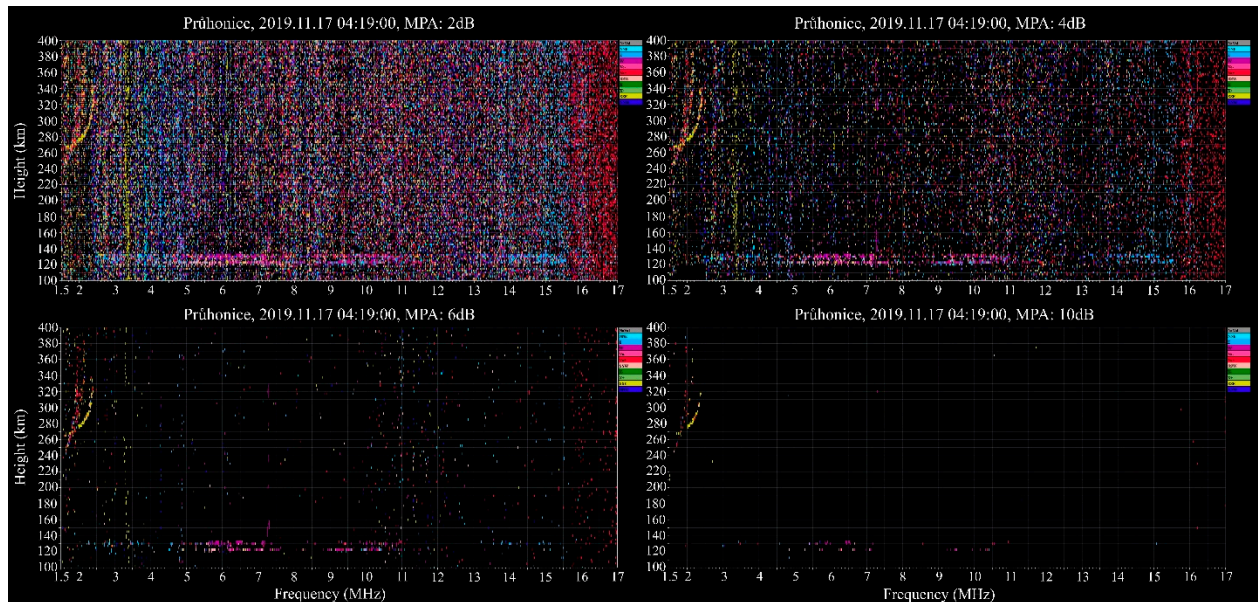


Pruhonice

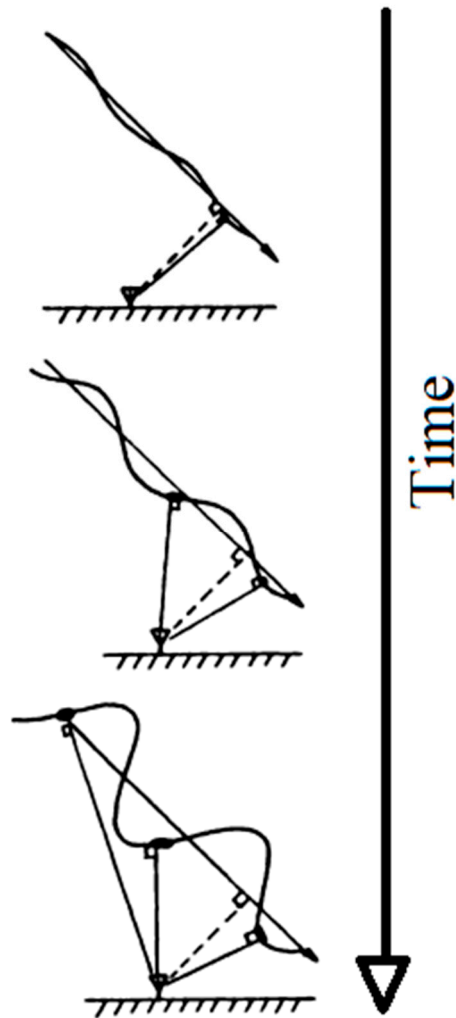
Supplementary Figure S1. An example of the problems caused by sporadic E in the detection of meteor-induced traces. On the ionograms, taken at Sopron, (upper part) appears a meteor-induced-like trace formed by NNE reflection at 2019.12.13. 04:05:00 (UT) at ~130 km. On the next ionogram, the trace widens up, then it disappears at 04:06:00 (UT). Its appearance and lifetime could indicate that it was a meteor-induced trace, but upon checking the ionograms at Pruhonice (lower part, these are regular ionograms taken at every 15 minutes) it became clear that there is a regional sporadic E with strong NNE oblique reflection. The oblique sporadic E in Sopron reappeared at 04:08:00, and the vertical sporadic E appeared at 04:11:00.



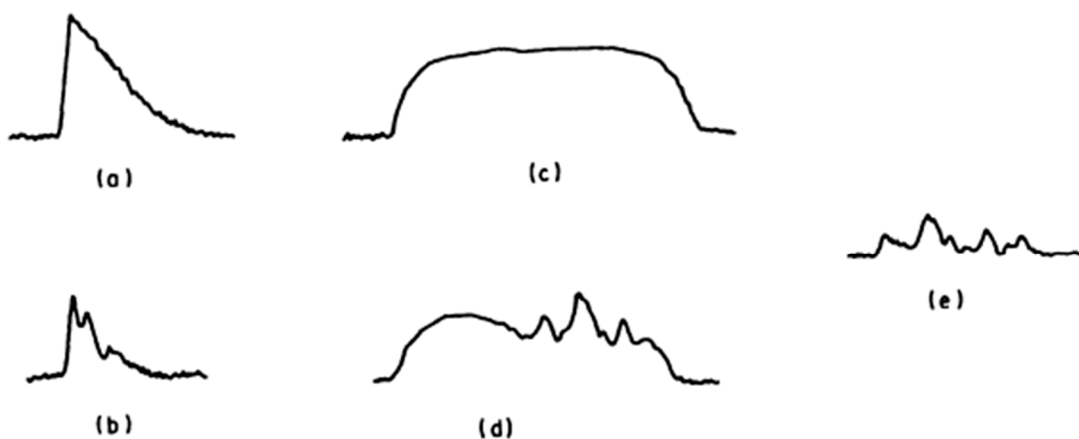
Supplementary Figure S2. Of the processed ionograms the phenomenon occurred in 20.2 % over Průhonice and 19.1 % over Sopron. Despite the proximity of the two stations, there were differences in distribution of virtual height ($h'Es$) and critical frequency ($foEs$). The median of $h'Es$ was 107.6 km over Průhonice and 102.3 km over Sopron. The median value of the critical frequencies was 2.55 MHz over Průhonice and 2.49 MHz over Sopron - in addition, the histograms for Průhonice seem to show a second peak just below 6 MHz, which is not at all the case for Sopron. The histogram broken down into two months is shown in Figure 2.



Supplementary Figure S3. The effect of the most probable amplitude threshold settings. The lower the threshold (2 dB or 4 dB, upper row) the noisier the ionogram, but also more details of the fireball's effect can be seen. The higher the threshold (6 dB—the default setting used for processing—or 10 dB, lower row), the lower the noise, but the more detail is lost from the fireball's effect. In addition, this picture also shows the problem of phase shifting due to the geometric parameters of the antennas. The fireball was physically east of the Digisonde, yet most of the reflections were in a west-southwest (W, SSW) direction with no vertical transition. This image is Figure 4. in Szárnya et al. (2023) [45].



Supplementary Figure S4. Distortion of a meteor trail, that can cause it to appear as a splitted trace on the ionograms. The image was made based on: Stuart (1970) [16], Figure 10-23., p. 831.



Supplementary Figure S5. Time plots of signal strength of radio reflections from meteor trails: (a) through a specular reflection, underdense trail; (b) underdense trail with wind distortion; (c) overdense trail; (d) overdense trail with wind distortion; (e) nonspecular reflection, overdense trail with wind distortion. The image based upon: Stuart (1970) [16], Figure 10-25, p. 833.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
			Meteor first appearance (UT) [hh:mm:ss]	Brightness [mag]	Altitude - beginning [deg]	Altitude - end [deg]	Duration - from picture [s.cs]	Pixel	Direction	Velocity (deg/sec)	Ionogram first appearance (UT) [hh:mm:ss]	Duration on ionograms [hh:mm:ss]	Maximum frequency [MHz]	Virtual Height [km]	Directio n	Label	Skymap	Difference in direction [deg]	Difference in detection time [s]
2																			
3	Pruhonice																		
4	2019.11.17	Leonids	04:15:0.2	-15.96	51.960	53.578	0.96	1	-	- 70.5 km/s	4:15:40	0:20:00	17	129.5	W/SSW/N	6B, 4B	*	0 / 180	39
5																			
6	Sopron																		
7	2019.11.18	S-Taurids	17:10:11.16	1.3	51.960	53.578	0.96	4	183	11.2	17:10:40	0:00:00	6.49	123.5	V/SSE	4D	-	0	28
8																			
9	2019.11.19	Leonids	0:48:23.85	0.7	70.962	65.138	0.96	10	180	36.9	0:48:40	0:00:20	5.5	113.8	W	6B	-	0	16
10		sporadic-L	1:26:37.05	1.4	72.553	72.660	0.89	2	213	20.5	1:27:40	0:00:00	5.89	119.2	SSW	4C	-	0	62
11		sporadic-L	1:45:47.74	0.4	63.919	60.248	0.92	13	173	40.9	1:46:00	0:01:40	5.47	137	SSW	6B	*	0	12
12		Leonids	1:50:34.18	-0.5	51.885	44.885	1.13	63	217	28.6	1:51:00	0:01:40	4.96	132.2	NNW	6D, 4B	-	0	25
13		Leonids	2:50:03.67	-0.2	51.535	46.438	0.96	22	212	31.9	2:51:00	0:00:00	3.12	131.8	W	4D	-	0	56
14		sporadic-L	3:39:03.86	1.2	40.357	40.350	0.88	3	226	16.4	3:39:40	0:00:00	8.68	99.6	NNE/SSE	4D	-	180	36
15		sporadic-L	3:47:56.36	0.2	49.525	45.085	0.96	8	104	27.8	3:48:40	0:00:00	4.06	113.4	SSW	4D	-	0	44
16																			
17	Sopron																		
18	2019.12.14	Geminids	17:26:42.40	0.1	53.951	38.571	3.08	18	136	15.0	17:27:36	0:01:00	3.54	114.8	NNW	4C	-	0	78
19		sporadic-G	18:11:48.08	-0.3	45.458	48.554	2.28	40	120	15.0	18:14:00	0:00:36	3.47	118.5	SSE	6B	-	0	132
20		Antihelion	18:16:27.71	1.1	41.127	38.886	1.16	4	156	11.7	18:17:36	0:00:24	4.76	139.5	NNW	6D, 4B	-	0	69
21		sporadic-G	18:16:41.67	0.5	69.730	46.552	1.60	12	142	28.9	18:17:00	0:03:36	5.77	97.5	V/SSW	6B	-	0	18
22		sporadic-G	18:56:08.12	0.5	46.569	36.080	1.24	11	149	23.9	18:57:00	0:03:00	4.96	102.2	SSW	6B	*	0	51
23		sporadic-G	19:22:43.59	1.2	44.596	35.279	1.24	5	152	21.4	19:23:36	0:03:00	4.4	114.6	SSW	6C, 4B	*	0	52
24		sporadic-G	19:31:09.09	1.0	76.959	67.938	1.16	7	154	25.3	19:32:00	0:03:00	4.6	92.8	SSW/V	6B	*	0	50
25		sporadic-G	19:47:37.34	1.2	75.167	67.339	1.12	4	156	26.5	19:48:36	0:00:24	3.54	92.1	SSW	6B	-	0	48
26		Geminids	20:12:59.58	0.5	82.855	88.710	1.32	11	161	15.7	20:15:00	0:00:00	2.97	84.7	V	6D, 4B	-	0	120
27		Sigma-Hydr	20:52:51.53	0.4	57.683	47.243	1.36	16	184	20.1	20:54:00	0:04:00	3.49	96.7	V/NNW	6C, 4B	-	0	68
28		Geminids	21:56:12.25	0.4	63.958	57.276	1.20	21	205	18.2	21:57:36	0:01:00	4.42	110.7	W/SSW	6C, 4B	*	0	83
29		Geminids	22:45:19.96	0.5	84.135	84.950	0.96	4	182	10.4	22:47:00	0:00:00	3.56	84.4	V/SSE	2B	-	0	40
30		Monocerot	22:46:40.60	0.7	62.507	58.381	1.12	10	243	15.1	22:48:00	0:02:00	3.18	84.3	V	6D, 4B	-	0	79
31		sporadic-G	22:50:44.91	0.0	65.304	63.57	1.12	23	142	13.5	22:51:36	0:00:00	2.55	94.5	V/SSE	4C	-	0	51
32		sporadic-G	23:32:23.04	0.1	60.808	56.202	1.96	17	147	16.6	23:32:36	0:01:00	3.55	96	V/NE	4C	-	180	12
33																			
34	Pruhonice																		
35	2019.12.14	sporadic-G	19:15:43.36	0.2	26.570	27.768	1.32	8	197	12.6	19:16:40	0:01:00	5.69	104.5	NNE	4C	-	0 or 180	57
36		sporadic-G	19:51:02.70	0.5	33.427	33.038	1.08	8	205	13.1	19:51:40	0:00:20	3.40	106.1	SSE	6C, 4B	-	0	37
37																			
38	Sopron																		
39	2015.12.15	Geminids	0:21:34.71	0.1	65.083	60.303	1.12	14	248	14.8	0:22:36	0:00:00	1.9	82.4	V/NNW/V	2C	-	0	61
40		sporadic-G	0:25:22.18	-0.7	58.852	56.542	0.96	5	233	14.7	0:25:36	0:00:24	3.4	92.3	W/NNW	4D	-	0	13
41		sporadic-G	3:02:38.19	0.4	52.811	50.702	0.88	7	316	27.7	3:05:00	0:00:36	4.37	101.8	NNE	2B	-	0	131
42		Geminids	3:12:26.30	-0.5	84.043	83.836	1.08	13	322	9.1	3:13:36	0:00:00	3.47	82.4	V	2D	-	0	79
43		sporadic-G	3:27:44.79	0.1	40.701	28.497	1.36	18	332	21.9	3:29:00	0:01:00	4.94	101	SSE	2B	-	0	75
44		Geminids	4:43:46.61	0.0	49.212	46.384	1.16	42	38	15.3	4:44:36	0:02:24	4.4	103.4	SSE/SSW	6C, 4D	-	0	49
45																			

Supplementary Table S1. The summary of the meteors that were detected by both the optical camera and the Digisondes.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		Time of detection	Where it could have been detected?		The reason why it was not detected									
2			Sopron	Pruhonice			Answer							
3	2019.11.19	1:26:37.05	+	-	1, 2		1 The meteoric trace is at the edge of the picture							
4							2 Altitude angle is low							
5	2019.12.13	22:45:15.02	+	-	1, 2		3 No ionogram taken at Pruhonice							
6		23:11:16.57	+	-	1, 2?		4 Overlap with a sporadic E							
7		23:17:48.76	+	+	1		5 Unknown, it should have been detected							
8							6 There are suspicious reflections in the ionogram							
9	2019.12.14	18:11:38.48	+	+	1, 2, 6		, but it couldn't be identified as a meteoric trace							
10		18:15:04.15	+	-	1		7 There is a meteoric reflection, but probably it is just a coincidence							
11		18:32:00.42	+	-	1									
12		18:48:29.25	+	+	1, 2, 6									
13		18:58:25.19	+	-	1									
14		19:15:25.20	+	-	5									
15		19:18:37.07	+	-	1									
16		19:28:40.10	+	-	4, 6									
17		19:33:24.89	+	+	4									
18		19:35:01.52	+	-	4									
19		19:40:54.63	+	-	1									
20		19:41:20.23	+	-	1									
21		19:41:54.67	+	-	4, 6									
22		20:07:39.95	+	-	4									
23		20:18:35.49	+	-?	1, 3									
24		20:20:06.96	+	+	1, 2, 3									
25		20:24:40.27	+	+	2?, 3									
26		20:29:29.94	+	-	1, 2									
27		20:34:01.12	+	-	1, 2									
28		21:09:08.30	+	-	1, 2									
29		21:14:05.05	+	-	1									
30		21:17:42.80	+	-	1, 2, 7									
31		21:43:17.28	+	-?	1, 2, 3									
32		21:50:28.78	+	-	1, 2									
33		21:58:32.97	+	-	1, 2									
34		22:06:03.12	+	-	5									
35		22:08:46.71	+	-	5									
36		22:34:43.82	+	-	5									
37		22:46:22.92	+	-	1, 2, 7									
38		22:48:44.84	+	-	1									
39		22:50:52.19	+	-	1, 2, 7									
40		22:59:55.58	+	-?	1, 2, 3									
41		23:10:00.76	+	+	1, 2, 3									
42		23:15:12.07	+	-	1									
43		23:17:59.26	+	-	1, 2									
44		23:18:56.58	+	-	2									
45		23:20:25.66	+	-	5									
46		23:24:46.65	+	-	1, 2?									
47		23:27:09.05	+	+	1, 2?, 3									
48		23:30:25.32	+	+	1, 2?, 3									
49		23:53:34.72	+	-	1, 6									
50														
51	2019.12.15	0:10:41.29	+	-	1, 6									
52		0:10:52.21	+	-	5, 6?									
53		0:12:02.68	+	-	1, 6									
54		0:20:17.15	+	+	5									
55		0:38:28.44	+	-	1, 2									
56		2:43:37.59	+	-	1									
57		2:51:03.93	+	-	1, 2									
58		3:03:22.51	+	-	1									
59		3:06:06.51	+	+	2, 3									
60		3:07:38.26	+	-	5									
61		3:22:24.92	+	+	1, 2?, 3									
62		4:16:25.90	+	-	4									
63														

Supplementary Table S2. The summary of the optically detected meteors that were not detected by the Digisondes.

	R (Pearlson correlation coefficient)	Textual evaluation of R	R^2	P-value	Covariance
Brightness – maximum frequency (all)	0.4832	significant, medium positive	0.2334	0.0059	0.3606
Brightness – maximum frequency (no 2 dB data)	0.4221	significant, medium positive	0.1781	0.03558	0.2548
Velocity – maximum frequency (all)	0.2235	non-significant, medium positive	0.04995	0.2268	2.4082
Velocity – maximum frequency (no 2dB data)	0.4309	significant, medium positive	0.1857	0.03554	3.4563

Supplementary Table S3. Summary of the results of the statistical calculations.