Efforts to Improve the IAU MDC List of Meteor Showers

presented by L. Neslušan

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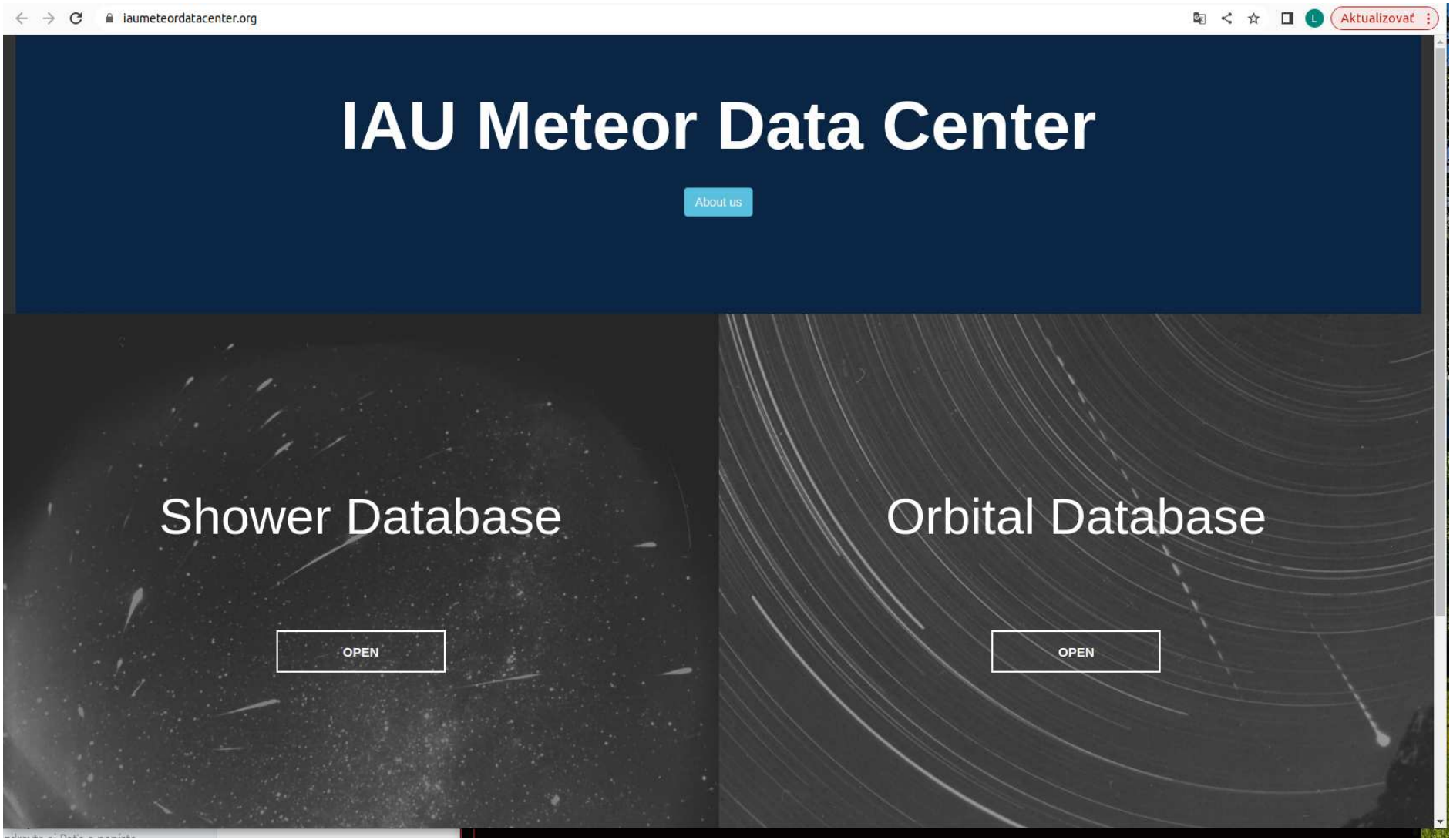
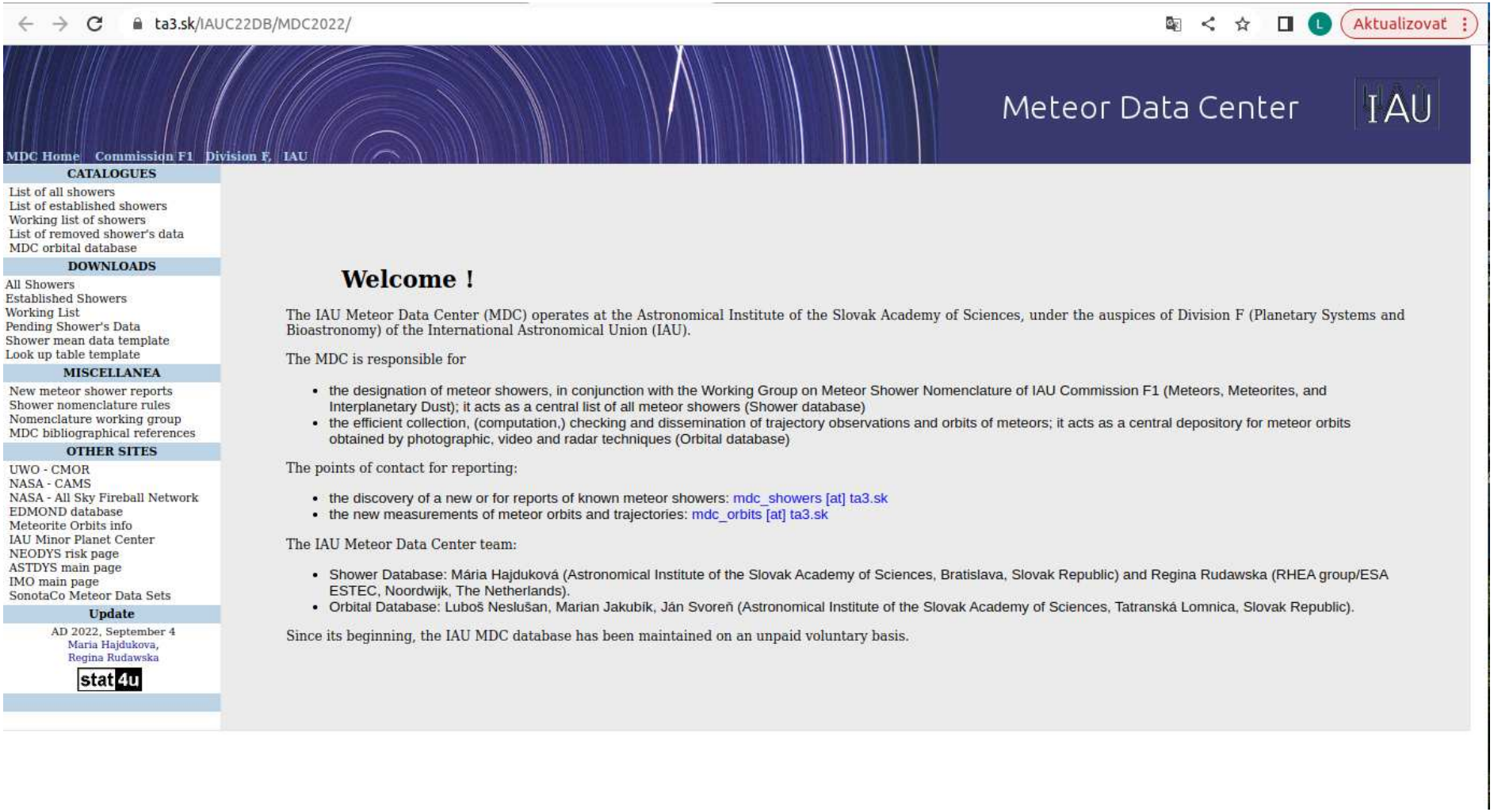
IAU MDC List of Showers

- Meteor Data Center (MDC) of the International Astronomical Union (IAU) provides the official list of known meteor showers (and the data on the individual meteors)
- Each shower in the list is characterized with a set of mean (median or various averaging) parameters
- The shower characteristics can be divided to the geocentric (geophysical) parameters and orbital elements; some showers are characterized only with the geocentric parameters
- Many showers were found in various source data and submitted to the MDC by more than one author team. Each individual set of mean characteristics is referred to as a “solution”
- The solutions of given shower are distinguished by additional identification number (AdNo) to the IAUNo of the shower

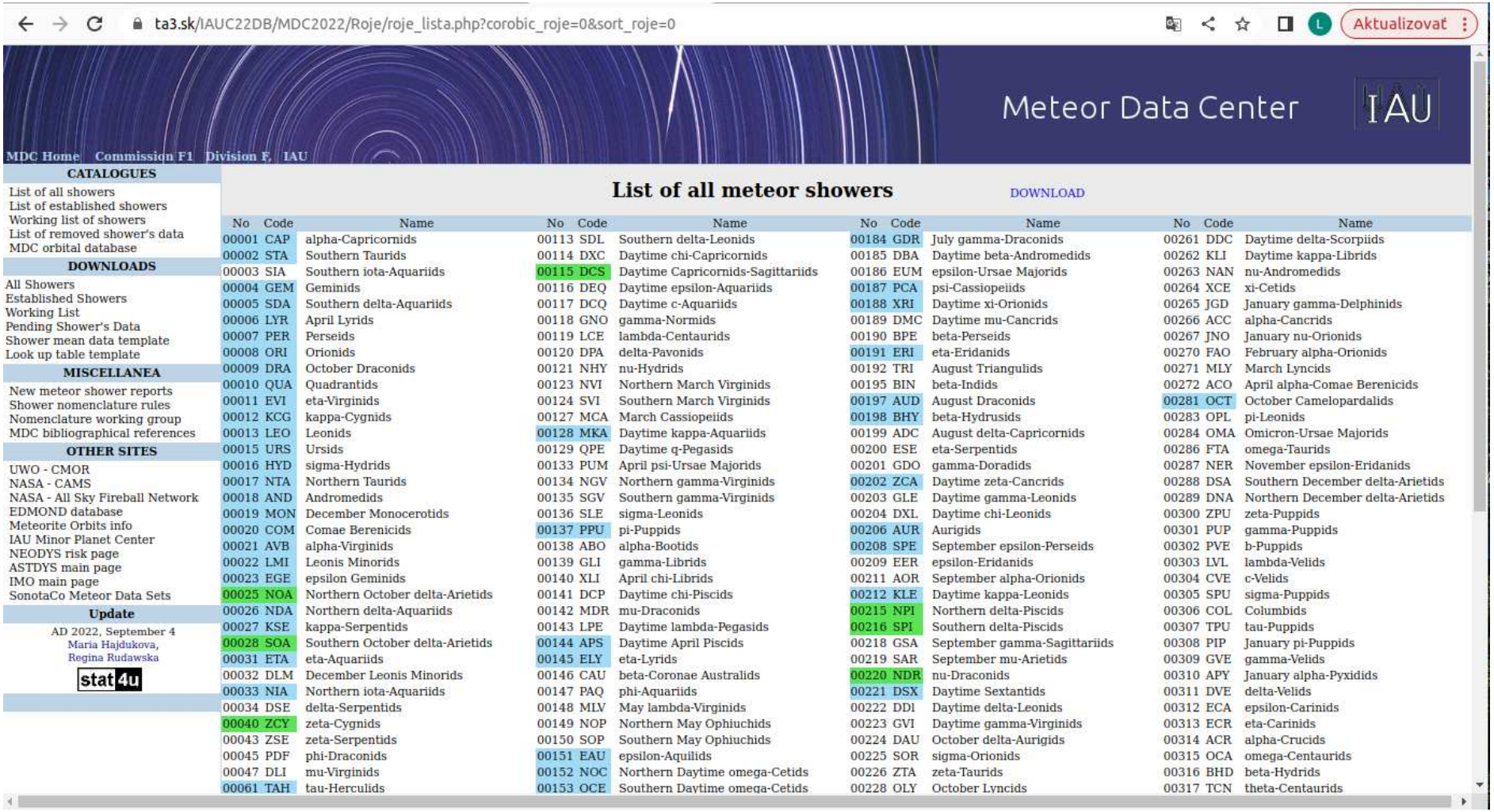
IAU MDC webpages



IAU MDC webpages - Shower-Database part



IAU MDC webpages - Shower-Database part



ta3.sk/IAUC22DB/MDC2022/Roje/roje_lista.php?corobic_roje=0&sort_roje=0

Aktualizovať

Meteor Data Center IAU

MDC Home Commission F1 Division F, IAU

CATALOGUES

List of all showers
List of established showers
Working list of showers
List of removed shower's data
MDC orbital database

DOWNLOADS

All Showers
Established Showers
Working List
Pending Shower's Data
Shower mean data template
Look up table template

MISCELLANEA

New meteor shower reports
Shower nomenclature rules
Nomenclature working group
MDC bibliographical references

OTHER SITES

UWO - CMOR
NASA - CAMS
NASA - All Sky Fireball Network
EDMOND database
Meteorite Orbits info
IAU Minor Planet Center
NEODYS risk page
ASTDYS main page
IMO main page
SonotaCo Meteor Data Sets

Update

AD 2022, September 4
Maria Hajdukova,
Regina Rudawska

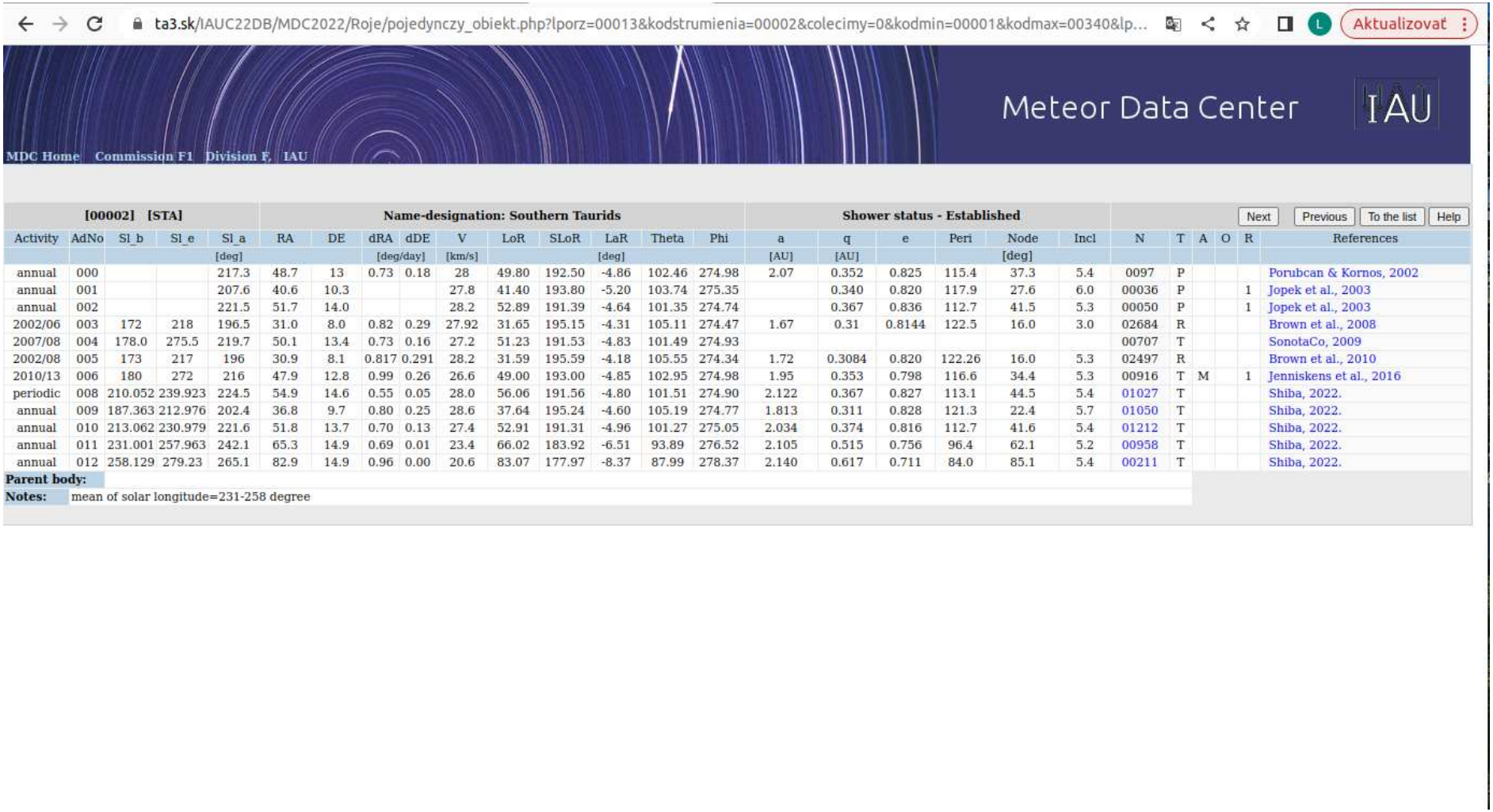
stat4u

List of all meteor showers

DOWNLOAD

No	Code	Name	No	Code	Name	No	Code	Name	No	Code	Name
00001	CAP	alpha-Capricornids	00113	SDL	Southern delta-Leonids	00184	GDR	July gamma-Draconids	00261	DDC	Daytime delta-Scorpiids
00002	STA	Southern Taurids	00114	DXC	Daytime chi-Capricornids	00185	DBA	Daytime beta-Andromedids	00262	KLI	Daytime kappa-Librids
00003	SIA	Southern iota-Aquariids	00115	DCS	Daytime Capricornids-Sagittariids	00186	EUM	epsilon-Ursae Majorids	00263	NAN	nu-Andromedids
00004	GEM	Geminids	00116	DEQ	Daytime epsilon-Aquariids	00187	PCA	psi-Cassiopeiids	00264	XCE	xi-Cetids
00005	SDA	Southern delta-Aquariids	00117	DCQ	Daytime c-Aquariids	00188	XRI	Daytime xi-Orionids	00265	JGD	January gamma-Delphinids
00006	LYR	April Lyrids	00118	GNO	gamma-Normids	00189	DMC	Daytime mu-Cancrids	00266	ACC	alpha-Cancrids
00007	PER	Perseids	00119	LCE	lambda-Centaurids	00190	BPE	beta-Perseids	00267	JNO	January nu-Orionids
00008	ORI	Orionids	00120	DPA	delta-Pavonids	00191	ERI	eta-Eridanids	00270	FAO	February alpha-Orionids
00009	DRA	October Draconids	00121	NHY	nu-Hydrids	00192	TRI	August Triangulids	00271	MLY	March Lyncids
00010	QUA	Quadrantids	00123	NVI	Northern March Virginids	00195	BIN	beta-Indids	00272	ACO	April alpha-Comae Berenicids
00011	EVI	eta-Virginids	00124	SVI	Southern March Virginids	00197	AUD	August Draconids	00281	OCT	October Camelopardalids
00012	KCG	kappa-Cygnids	00127	MCA	March Cassiopeiids	00198	BHY	beta-Hydrusids	00283	OPL	pi-Leonids
00013	LEO	Leonids	00128	MKA	Daytime kappa-Aquariids	00199	ADC	August delta-Capricornids	00284	OMA	Omicron-Ursae Majorids
00015	URS	Ursids	00129	QPE	Daytime q-Pegasids	00200	ESE	eta-Serpentids	00286	FTA	omega-Taurids
00016	HYD	sigma-Hydrids	00133	PUM	April psi-Ursae Majorids	00201	GDO	gamma-Doradids	00287	NER	November epsilon-Eridanids
00017	NTA	Northern Taurids	00134	NGV	Northern gamma-Virginids	00202	ZCA	Daytime zeta-Cancrids	00288	DSA	Southern December delta-Arietids
00018	AND	Andromedids	00135	SGV	Southern gamma-Virginids	00203	GLE	Daytime gamma-Leonids	00289	DNA	Northern December delta-Arietids
00019	MON	December Monocerotids	00136	SLE	sigma-Leonids	00204	DXL	Daytime chi-Leonids	00300	ZPU	zeta-Puppids
00020	COM	Comae Berenicids	00137	PPU	pi-Puppids	00206	AUR	Aurigids	00301	PUP	gamma-Puppids
00021	AVB	alpha-Virginids	00138	ABO	alpha-Bootids	00208	SPE	September epsilon-Perseids	00302	PVE	b-Puppids
00022	LMI	Leonis Minorids	00139	GLI	gamma-Librids	00209	EER	epsilon-Eridanids	00303	LVL	lambda-Velids
00023	EGE	epsilon Geminids	00140	XLI	April chi-Librids	00211	AOR	September alpha-Orionids	00304	CVE	c-Velids
00025	NOA	Northern October delta-Arietids	00141	DCP	Daytime chi-Piscids	00212	KLE	Daytime kappa-Leonids	00305	SPU	sigma-Puppids
00026	NDA	Northern delta-Aquariids	00142	MDR	mu-Draconids	00215	NPI	Northern delta-Piscids	00306	COL	Columbids
00027	KSE	kappa-Serpentids	00143	LPE	Daytime lambda-Pegasids	00216	SPI	Southern delta-Piscids	00307	TPU	tau-Puppids
00028	SOA	Southern October delta-Arietids	00144	APS	Daytime April Piscids	00218	GSA	September gamma-Sagittariids	00308	PIP	January pi-Puppids
00031	ETA	eta-Aquariids	00145	ELY	eta-Lyrids	00219	SAR	September mu-Arietids	00309	GVE	gamma-Velids
00032	DLM	December Leonis Minorids	00146	CAU	beta-Coronae Australids	00220	NDR	nu-Draconids	00310	APY	January alpha-Pyxidids
00033	NIA	Northern iota-Aquariids	00147	PAQ	phi-Aquariids	00221	DSX	Daytime Sextantids	00311	DVE	delta-Velids
00034	DSE	delta-Serpentids	00148	MLV	May lambda-Virginids	00222	DDl	Daytime delta-Leonids	00312	ECA	epsilon-Carinids
00040	ZCY	zeta-Cygnids	00149	NOP	Northern May Ophiuchids	00223	GVI	Daytime gamma-Virginids	00313	ECR	eta-Carinids
00043	ZSE	zeta-Serpentids	00150	SOP	Southern May Ophiuchids	00224	DAU	October delta-Aurigids	00314	ACR	alpha-Crucids
00045	PDF	phi-Draconids	00151	EAU	epsilon-Aquilids	00225	SOR	sigma-Orionids	00315	OCA	omega-Centaurids
00047	DLI	mu-Virginids	00152	NOC	Northern Daytime omega-Cetids	00226	ZTA	zeta-Taurids	00316	BHD	beta-Hydrids
00061	TAH	tau-Herculids	00153	OCE	Southern Daytime omega-Cetids	00228	OLY	October Lyncids	00317	TCN	theta-Centaurids

IAU MDC webpages - Shower-Database part



ta3.sk/IAUC22DB/MDC2022/Roje/pojedynczy_obiekt.php?lporz=00013&kodstrumienia=00002&colecimy=0&kodmin=00001&kodmax=00340&lp...

Aktualizovať

Meteor Data Center IAU

MDC Home Commission F1 Division F, IAU

[00002] [STA]					Name-designation: Southern Taurids									Shower status - Established										Next Previous To the list Help
Activity	AdNo	Sl_b	Sl_e	Sl_a	RA	DE	dRA	dDE	V	LoR	SLoR	LaR	Theta	Phi	a	q	e	Peri	Node	Incl	N	T	A	O	R	References
				[deg]			[deg/day]		[km/s]			[deg]			[AU]	[AU]			[deg]							
annual	000			217.3	48.7	13	0.73	0.18	28	49.80	192.50	-4.86	102.46	274.98	2.07	0.352	0.825	115.4	37.3	5.4	0097	P				Porubcan & Kornos, 2002
annual	001			207.6	40.6	10.3			27.8	41.40	193.80	-5.20	103.74	275.35		0.340	0.820	117.9	27.6	6.0	00036	P			1	Jopek et al., 2003
annual	002			221.5	51.7	14.0			28.2	52.89	191.39	-4.64	101.35	274.74		0.367	0.836	112.7	41.5	5.3	00050	P			1	Jopek et al., 2003
2002/06	003	172	218	196.5	31.0	8.0	0.82	0.29	27.92	31.65	195.15	-4.31	105.11	274.47	1.67	0.31	0.8144	122.5	16.0	3.0	02684	R				Brown et al., 2008
2007/08	004	178.0	275.5	219.7	50.1	13.4	0.73	0.16	27.2	51.23	191.53	-4.83	101.49	274.93							00707	T				SonotaCo, 2009
2002/08	005	173	217	196	30.9	8.1	0.817	0.291	28.2	31.59	195.59	-4.18	105.55	274.34	1.72	0.3084	0.820	122.26	16.0	5.3	02497	R				Brown et al., 2010
2010/13	006	180	272	216	47.9	12.8	0.99	0.26	26.6	49.00	193.00	-4.85	102.95	274.98	1.95	0.353	0.798	116.6	34.4	5.3	00916	T	M		1	Jenniskens et al., 2016
periodic	008	210.052	239.923	224.5	54.9	14.6	0.55	0.05	28.0	56.06	191.56	-4.80	101.51	274.90	2.122	0.367	0.827	113.1	44.5	5.4	01027	T				Shiba, 2022.
annual	009	187.363	212.976	202.4	36.8	9.7	0.80	0.25	28.6	37.64	195.24	-4.60	105.19	274.77	1.813	0.311	0.828	121.3	22.4	5.7	01050	T				Shiba, 2022.
annual	010	213.062	230.979	221.6	51.8	13.7	0.70	0.13	27.4	52.91	191.31	-4.96	101.27	275.05	2.034	0.374	0.816	112.7	41.6	5.4	01212	T				Shiba, 2022.
annual	011	231.001	257.963	242.1	65.3	14.9	0.69	0.01	23.4	66.02	183.92	-6.51	93.89	276.52	2.105	0.515	0.756	96.4	62.1	5.2	00958	T				Shiba, 2022.
annual	012	258.129	279.23	265.1	82.9	14.9	0.96	0.00	20.6	83.07	177.97	-8.37	87.99	278.37	2.140	0.617	0.711	84.0	85.1	5.4	00211	T				Shiba, 2022.
Parent body:																										
Notes:	mean of solar longitude=231-258 degree																									

Process of creation of IAU MDC list

- IAU MDC list is a collection of published discoveries of meteor showers in the modern era
- Unfortunately, the process of the creation of the list was not perfect; some mistakes occurred. The reason could be, e.g.,
  - typeing error at re-writing the data,
  - mistakes in a manual calculation of parameters,
  - reading a wrong (uncorrespodning) line when the geophysical and orbital data were merged,
  - or, a shower was already mis-classified in the original work of the authors, etc.
- The shower parameters as submitted by the authors must be identical to those in their source publication (such formal inconsistencies have been eliminated by a recent verification process; see Hajduková M., et al.: 2023, A&A 671, id. A155)

This talk...

- In this talk, I point out additional inconsistencies identified within a particular shower, and discuss a further effort of the MDC team to resolve these problems
- When the shortcomings will be removed from the list, it will be possible to reasonably propose another showers from the working list to become the established showers

1. Internal consistency of parameters

- Many errors can be revealed by checking of the internal consistency of data
- It means that an error is visible at the re-calculation of mean orbital elements, which can be calculated from the geocentric parameters and vice versa

Example of inconsistent data (#226 ζ-Taurids, ZTA):

	q	e	ω	Ω	i
#226/0	0.23100	0.85800	311.800	194.190	163.090
	0.22422	0.85304	133.249	12.285	175.780

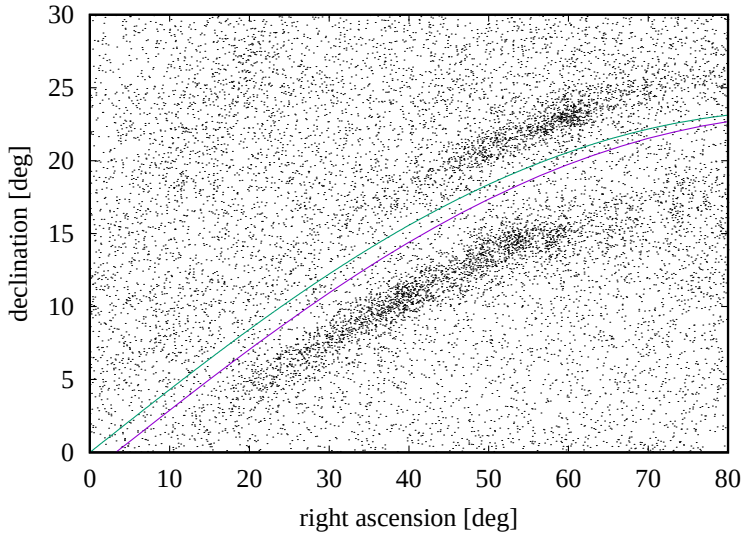
$$\beta = -1.44^\circ;\ \lambda_\odot = 194.20^\circ$$

1. Internal consistency of parameters

- There are several per cents of inconsistent solutions (depending on a tolerance limit of individual parameters)
- To avoid an inconsistency in the future, a computer program to check the internal consistency of a given set of solutions (of one solution on-line) was created by the MDC team
- A description was published in:
  Neslušan L., Jopek T.J., Rudawska R., Hajduková M., Ďurišová S.: 2024, Contributions of the Astronomical Observatory Skalnaté Pleso 54, 57-71.)
- It is accessible through the web site of the journal:
  https://www.astro.sk/caosp/index.html
  as well as through the NASA ADS service
- It is also available through the new MDC web site:
  https://www.iaumeteordatacenter.org/

2. Northern shower classified as southern and vice versa

- Another problem in the IAU MDC list is a mis-classification of southern showers as northern and vice versa
- Mean radiant of some showers is situated in the northern ecliptical hemisphere = northern showers ($\beta > 0°$)



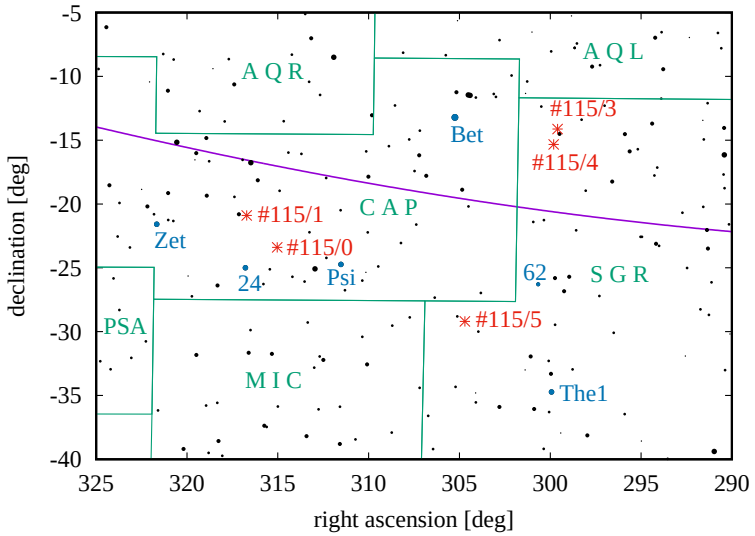
- Mean radiant of the other showers is situated in the southern ecliptical hemisphere = southern showers ($\beta < 0°$)
- Meteoroids of northern (southern) shower collide with the Earth in the descending (ascending) node of their orbit, but the definition of "longitude of ascending node" is based on the ascending node

2. Northern shower classified as southern and vice versa

- In more detail, the meteoroids of an ecliptical compact stream can have radiant as on the northern as southern ecliptical hemisphere of sky
- However, there is no unique definition of argument of perihelion, ω, and longitude of ascending node, Ω, of the meteoroids of both these groups; ω and Ω of meteoroids with radiants on the northern sky are shifted about $\sim 180^\circ$ in respect to the ω and Ω of meteoroids with radiants on the southern sky, respectively
- We must distinguish between the northern and southern branch of the stream, i.e. between the northern and southern shower
- Examples: Northern and Southern Taurids, Northern and Southern δ-Aquariids, etc.

2. Northern shower classified as southern and vice versa

- Ten solutions in the IAU MDC list were found to be mis-classified: few solutions with $\beta > 0°$ were regarded as the solutions of a southern shower and few solutions with $\beta < 0°$ were regarded as the solutions of a northern shower



Example:

[00115] [DCS]				Name-designation: Daytime Capricornids-Sagittariids										Shower status - nominated to be Established					
AdNo	Sl_b	Sl_e	Sl_a	RA	DE	dRA	dDE	V	LoR	SLoR	LaR	Theta	Phi	a	q	e	Peri	Node	Incl
			[deg]			[deg/day]		[km/s]			[deg]			[AU]	[AU]			[deg]	
000	-		325.10	315.03	-23.40			26.8	310.76	345.67	-6.11	104.25	83.70	1.684	0.355	0.789	242.50	145.07	6.79
001	-		324.70	316.71	-20.90			28.91	312.99	348.29	-4.16	101.68	85.75		0.36	0.82	246.00	144.66	4.49
003	-		309.80	299.60	-14.13			25.1	298.82	349.02	6.40	100.91	96.51	1.712	0.415	0.758	69.80	309.84	6.20
004	-		314.00	299.81	-15.33			29.4	298.77	344.78	5.18	105.16	95.37	1.991	0.314	0.842	60.00	314.03	6.80
005	294	315	301	304.7	-29.2	0.73	0.24	23.8	300.24	359.24	-9.33	90.75	80.67	2.67	0.5559	0.792	270.86	121.0	7.3
dy:	2001 ME1?,169P/NEAT																		
Twin of 1/CAP																			

2. Northern shower classified as southern and vice versa

- Specific description of these cases and suggestion to correct the mis-classification was published by the MDC team in: Neslušan L., Jopek T.J., Rudawska R., Hajduková M., Kokhirova G.: 2023, Planetary and Space Science, Vol. 235, art.id. 105737
- Working Group on Meteor Shower nomenclature was requested for the approval of these suggestions. This approval is pending

WARNING:

- The problem may concern not only the mean parameters of whole showers, but the individual meteors as well

2. Northern shower classified as southern and vice versa

- When the members of an ecliptical shower are selected from a database, the members belonging to the northern shower can erroneously be included into the southern branch or those belonging to the southern shower into the northern branch (e.g. the Northern Taurids can be regarded as Southern Taurids)
- For example, solution AdNo=4 of shower #17, Northern Taurids, has the ecliptical latitude of mean radiant $\beta = +1.78^\circ$, whereby 470 meteors observed by radar were used to determine the mean characteristics of this northern shower
- Dispersion of radiants would have to be within the 1.78° if the meteors of the Southern Taurids, #2, were not admixtured to the shower #17; so narrow radiant area of radio-meteor shower is improbable

2. Northern shower classified as southern and vice versa

- Such an admixture could happen because:
  - the shower was selected from the radio database on the basis of an enhancement in rates from a particular radiant over a set period of time or an enhancement in rates from a particular radiant, with particular velocity, over a set period of time, i.e. parameters λ_g, β_g, and V_g were considered; in the automatic, computer processing, the authors could not notice that β_g of a part of meteors is positive and that of the other part is negative
  - using the geocentric parameters, the authors did not faced the problem of the shift about $\sim 180^\circ$ of ω and Ω

2. Northern shower classified as southern and vice versa

- In an identification of ecliptical shower from a database, it is recommended to divide the data into two parts; first part with the meteors having $\beta > 0^\circ$ and second part with $\beta < 0^\circ$
- A northern shower can be searched for only in the first part and a southern shower only in the second part

3. Problem of duplicate showers

- Many showers are found in various data by more than one author team (#2 Southern Taurids were already shown)
- If a new shower is identified in the data, the author must often ask the question: is it a new, not-yet-known shower or is it another solution of already known shower?
- Each author has had their own criteria to answer this question
- ...and this circumstance caused a large heterogeneity of the classification, which should be removed
- The MDC team has been urged several times to do it; the suggestions to correct the list occurred in the literature, e.g. Koseki M.: 2020, eMeteorNews 5, 93; Koseki M.: 2023, eMeteorNews 8, 337, etc.)
- The MDC responded by trying to find a method, but as we showed in Jopek et al., 2024: an exact mathematical method does not work; the MDC continues working (a preparation of Jopek et al. II)

3. Problem of duplicate showers

- For example, there are following solutions of shower #152:

	q	e	ω	Ω	i	D_{SH}
AdNo=0	0.108	0.889	25.61	47.79	42.00	
AdNo=1	0.17	0.93	42.61	64.36	10.20	0.758

- But, on the other-hand, there are the autonomous showers α-Monocerotids and ζ-Canis Minorids:

	q	e	ω	Ω	i	D_{SH}
#246/0	0.488	0.999	90.7	59.3	134.1	
#1196/0	0.47013	0.97028	93.730	59.817	133.816	0.058

- Should not the solutions of shower #152 (Northern Daytime ω-Cetids) be regarded as two autonomous showers?
- And should not the shower #1196 (its solution AdNo=0) be regarded as another solution of shower #246?

3. Problem of duplicate showers

- A correction of the IAU MDC list of showers is necessary, but the correction in a specific case is often unclear
- Anyway, the unique rules and criteria are always much more advantageous than a lot of various criteria of individual authors
- What should be the criteria to classify a solution as another solution of already known shower?
- When a newly discovered shower is actually new?
- An exact mathematical method does not work as demonstrated by Jopek et al., 2024 (Jopek T.J., Neslušan L., Rudawska R., Hajduková M.: 2024, A&A 682, art.id. A159)
- To find out which solutions are duplicates, two methods were suggested; but they provided us with a different result

3. Problem of duplicate showers

- Some progress would likely be possible if we had the LookUp tables (LuTs) for every solution (or, at least, the sigmas of the determination of mean parameters); but LuTs are available for a less than 10% of solutions, they are obligatory since 2019
- This implies the large importance of the LookUp table, which is now compulsory and should accompany every submission of shower to the MDC
- The criteria for the classification will have to be established in an empirical way; within a convention?
- But, who should work out and approve the criteria? Should this be done by the IAU F1 Working Group? by voting? (opened questions, at the moment)
- The IAU MDC team upgrades the official list of meteor showers
- However, the IAU MDC was not established as an authority to revide the published data, or to establish various criteria

3. Problem of duplicate showers

- The members of the MDC attempt to correct all shortcomings in the MDC list of showers
  - They expect to find solutions within a further collaboration with the members of the IAU Working Group on Meteor Shower Nomenclature
  - Or, maybe, within a new working group that could be temporarily established in purpose to solve the inconsistencies in the MDC list
  - It would also be worth, if other meteor astronomers deal with the outlined problem of duplicate showers (if they publish concerning papers)

Conclusion

- In conclusion, let us believe that the IAU MDC list of meteor showers will be improved soon; within a collaboration of the meteor astronomers
- At last, but not least, I would like to thank all meteor astronomers, profesional as well as amateur, for their important contributions to meteor observations and in particular for the individual meteoroid and meteoroid stream data provided to the MDC database

Information about the Meteor-Orbits Part of the MDC

- Beside the official list of meteor showers, the MDC provides the data on the orbits of individual meteors
- The most recent, Version 2024, contains:
  - 6345 photographic meteor orbits (42 catalogs)
  - 962,773 video orbits (471,582 CAMSv3 2010-2016, 490,283 SonotaCo 2007-2023, and 908 DMS 1991-1998 orbits)
  - 11,057,023 radio-meteor orbits (8,916 Hissar 1968-1969 and 11,048,107 SAAMER 2020-2023 orbits)
- Because the large bulk of data, it is recommended to download the video and radio data part by part; one part = catalog/year

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