International Meteor Conference, Šachtička, Slovakia, September 18-21, 2008

A new Analysis of the IMO Video Meteor Database

Sirko Molau

Arbeitskreis Meteore e.V. (AKM), Germany

Agenda

- Background
- Problems
- Solutions
- Analysis Results
- Summary

Background (I)

- The first full analysis of the IMO Video Meteor Database, presented at the IMC 2006, yielded many interesting results
  - » an automatically created list of meteor shower (including so far unknown showers) based on objective criteria
  - » radiant positions and drifts
  - » activity intervals
  - » activity profiles
- However, during and after the analysis, a few weak points were recognized
- » Before a new analysis in 2008 was started - based on a dataset that had almost doubled in size - these problems should be sorted out first

Background (II)

Algorithm (as presented in 2006)

1.) Separated accumulation of probabilities P (M | R) for each solar longitude interval in a three-dimensional coordinate system (right ascension, declination, velocity)

» like an automatic run of the Radiant software for all possible velocities

2.) Determination of local maxima (radiants) at each solar longitude interval (program RadFind)

3.) Conneting radiants in consecutive solar longitude intervals to derive possible meteor showers (program StrmFind)

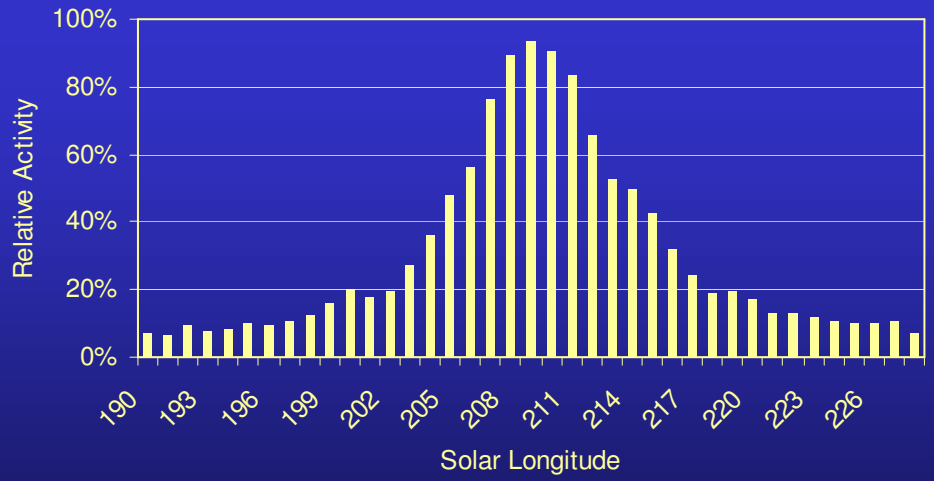
4.) Identification of meteor showers based on IMO‘s Working List and known sporadic sources

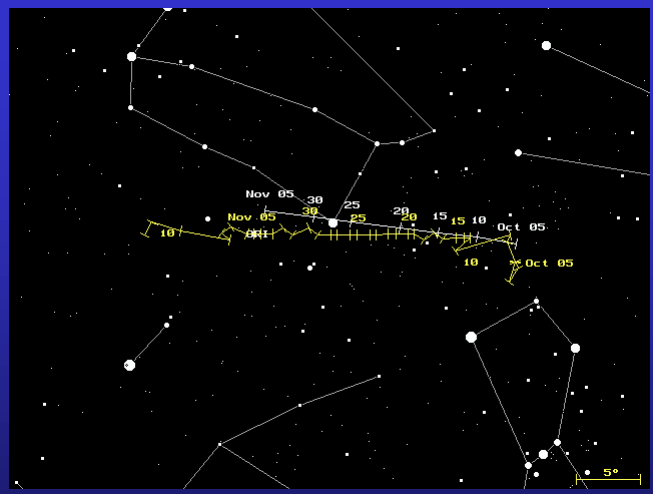
Background (III)

Example from 2006

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 57	190-228	Oct 03-Nov 11	11804	209	Oct 23	93.6%
ORI	189-224	Oct 02-Nov 07	-	207	Oct 21	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 57	209	Oct 23	96.0	16.0	0.8 / 0.1	61 km/s
ORI			95	16	0.7 / 0.1	66 km/s





Problems and Solutions (I)

Problem 1: Comparability

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 9	37-58	Apr 27-May 19	959	45	May 06	35.9%
ETA	29-67	Apr 19-May 29	-	44	May 05	-

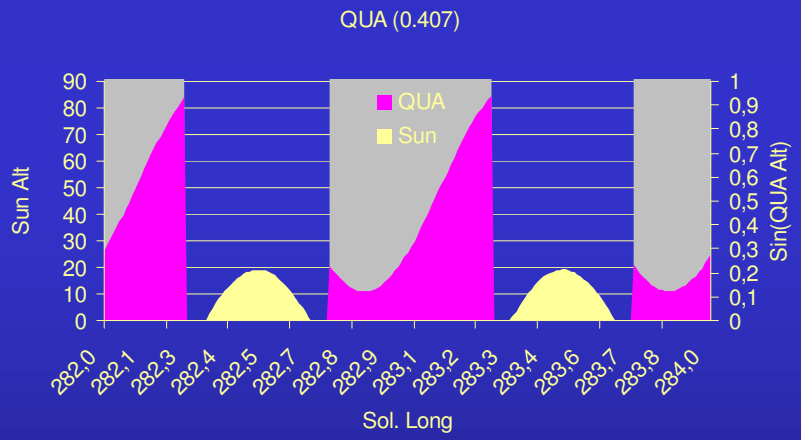
	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 25	117-158	Jul 20-Sep 01	4577	128	Jul 31	45.0%
SDA	110-146	Jul 13-Aug 19	-	125	Jul 28	-

- The effective observing time and the limiting magnitude are unknown (the analysis is based on the PosDat database)
- » The only normalization is by the number of sporadic meteors
- » Due to different observing geometry, the activity of meteor showers cannot be compared with one another

Problems and Solutions (II)

Solution

- For each meteor shower, an *Observability Function* is computed, which covers the observing geometry; each meteor is weighted with that value
- The observability depends on how long and at what altitude (sine) the radiant is above the horizon at night

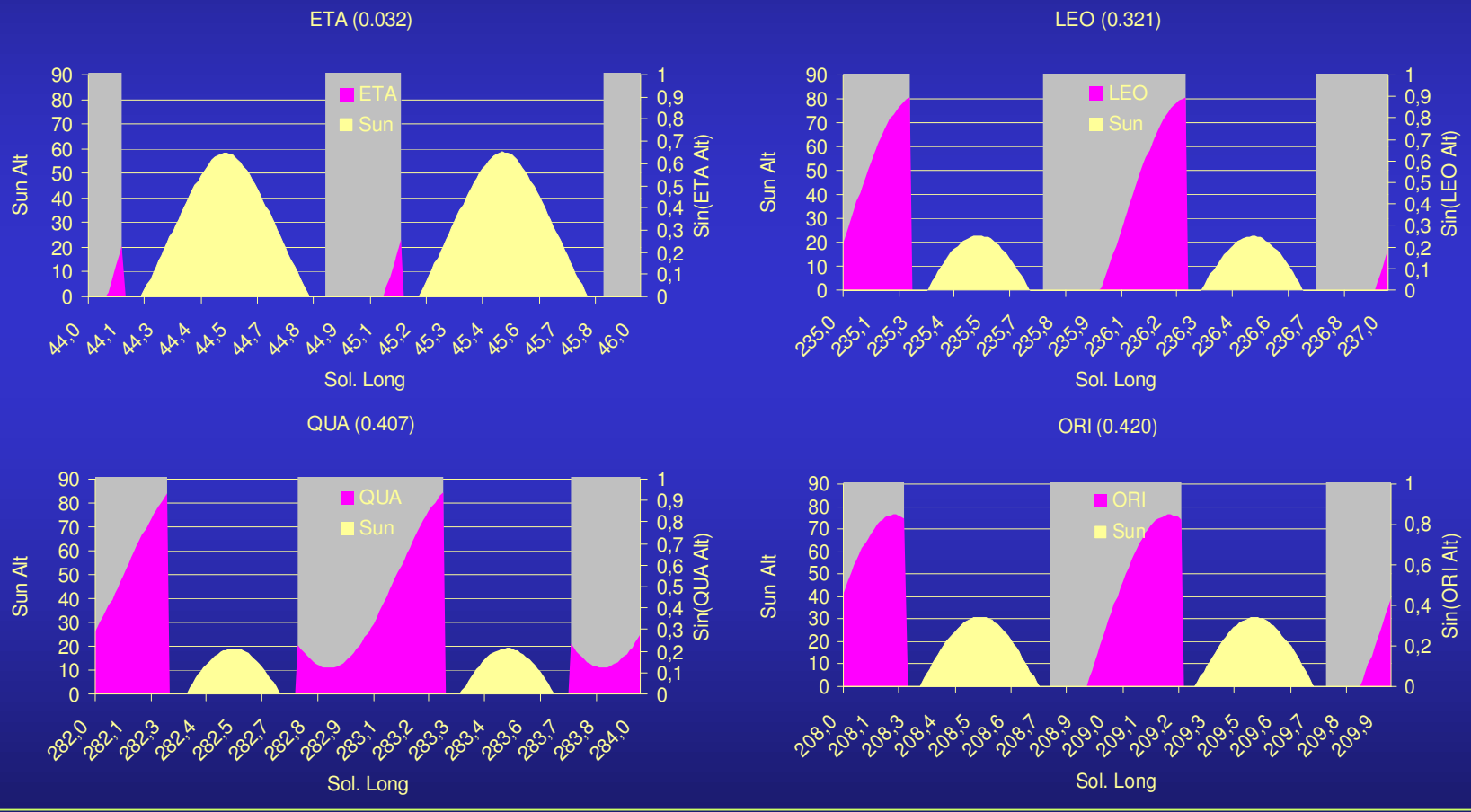


- It only depends from the radiant position and the geographic latitude of the observing site

» Example: Quadrantids = 0.407 (at 48° N)

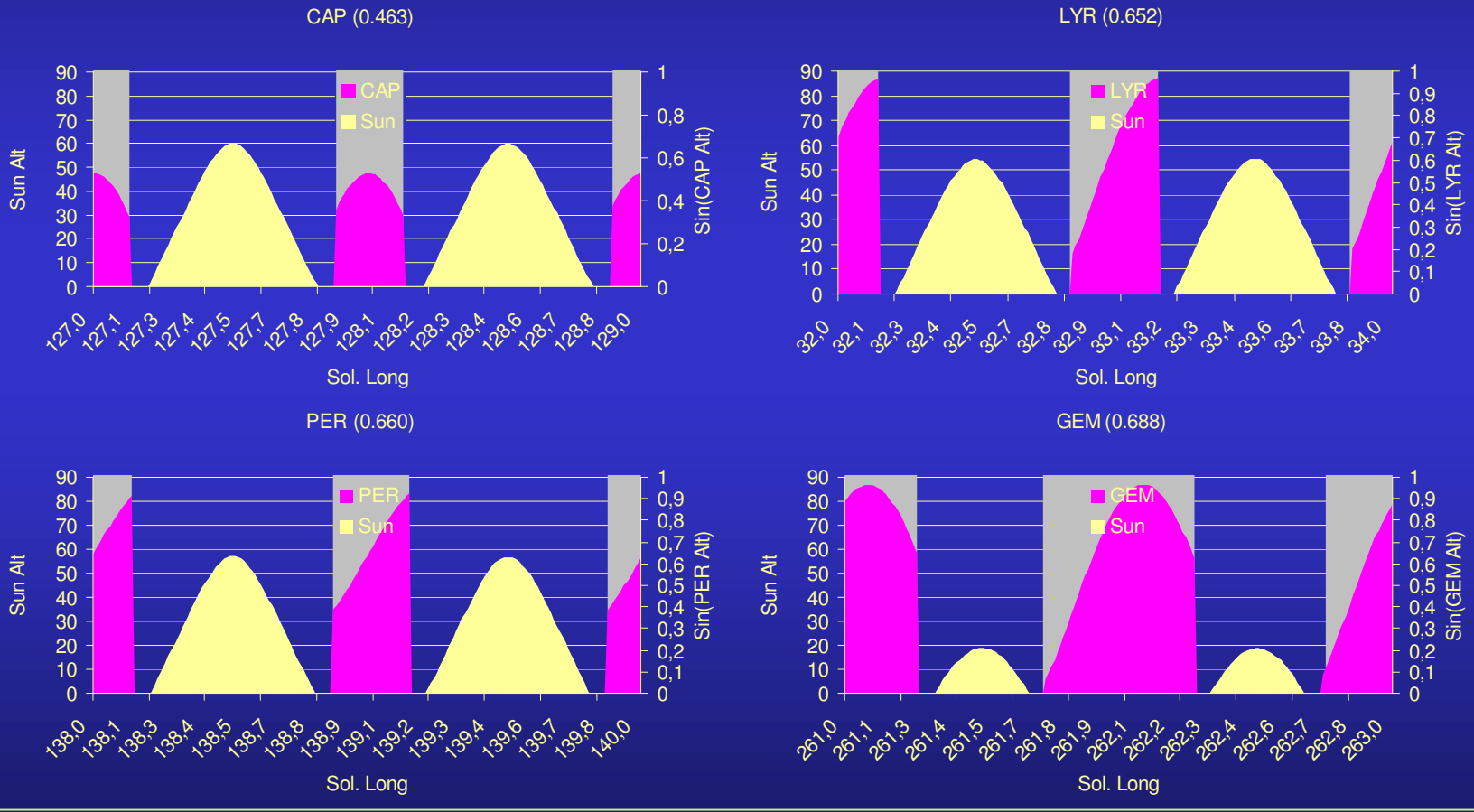
Problems and Solutions (III)

Observability function for different meteor showers at 48°N



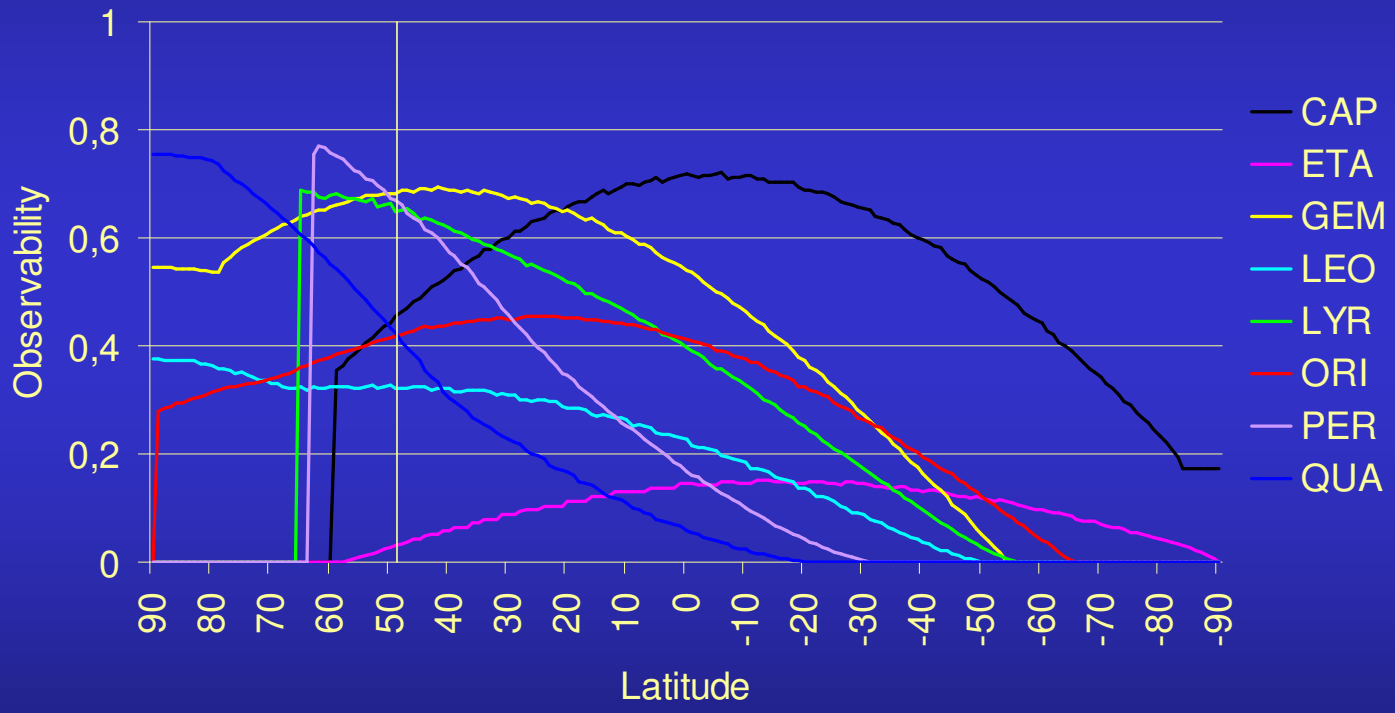
Problems and Solutions (IV)

Observability function for different meteor showers at 48°N



Problems and Solutions (V)

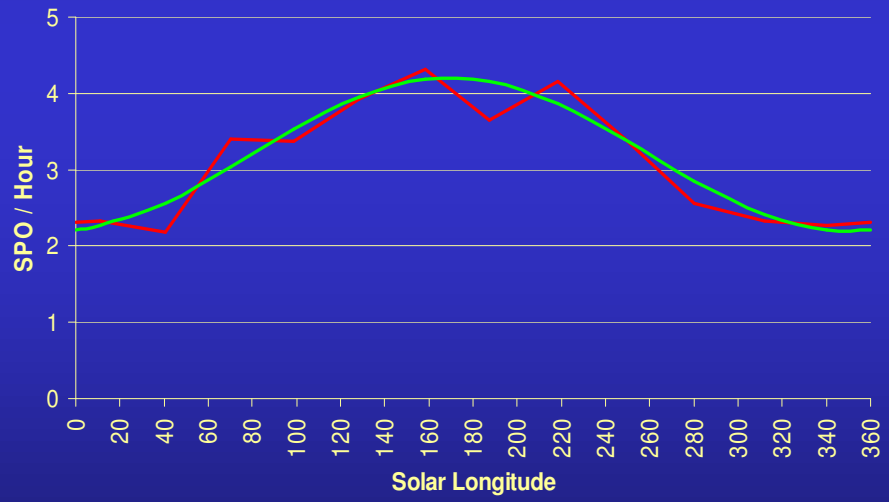
Dependency on the geographic latitude



» Central Europe is a good place for meteor observation!

Problems and Solutions (VI)

- Unfortunately, the annual sporadic activity is not constant
» In months with strong sporadic activity, the meteor shower counts will be scaled down more strongly
- From the monthly network statistics, the average hourly sporadic count was computed
» It was fitted by a function 3.2 + sin (sol. long-80)
» This correction is additionally applied



Problems and Solutions (VII)

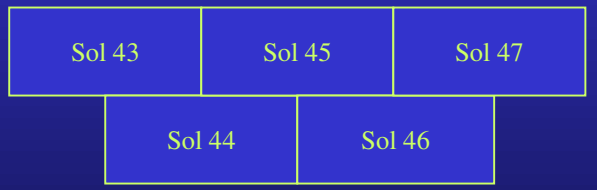
Problem 2: Absolute meteor counts

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 9	37-58	Apr 27-May 19	959	45	May 06	35.9%
ETA	29-67	Apr 19-May 29	-	44	May 05	-

- The analysis uses sliding intervals (2° length, 1° shift)
- The radiant search is independent of the meteor shower search

sol= 43 (42-44) May 04 equ= 336.2 / -2.0 ecl= 337.2 / 7.4 vel= 61 val= 55.53 met= 32 / 12.1%
sol= 44 (43-45) May 05 equ= 337.1 / -1.5 ecl= 338.3 / 7.5 vel= 58 val= 139.09 met= 122 / 30.0%
sol= 45 (44-46) May 06 equ= 337.5 / -1.0 ecl= 338.8 / 7.8 vel= 59 val= 135.83 met= 181 / 32.6%
sol= 46 (45-47) May 07 equ= 338.5 / -1.0 ecl= 339.8 / 7.5 vel= 59 val= 106.61 met= 121 / 30.2%
sol= 47 (46-48) May 08 equ= 338.5 / 0.0 ecl= 340.1 / 8.4 vel= 62 val= 110.43 met= 83 / 27.1%

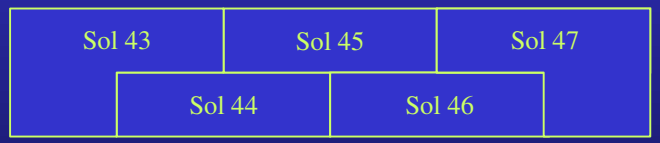
» Most (but not all) meteors are counted twice!



Problems and Solutions (VIII)

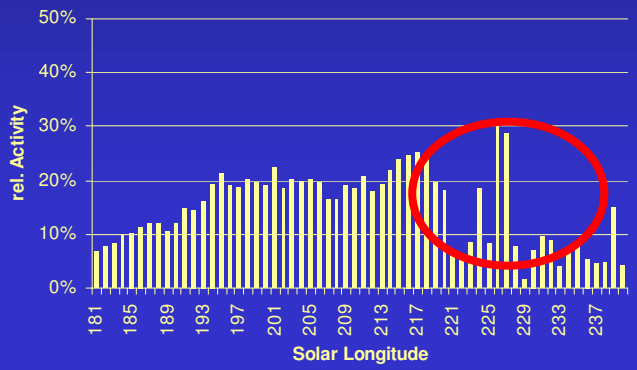
Solution 2

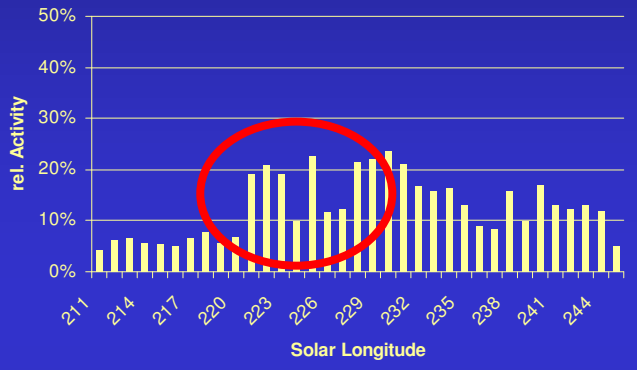
- It is not feasible to store the meteors corresponding to each radiant, and remove double counts later on (in fact, the meteor assignment to a shower may be ambiguous due to radiant drift)
- » For each radiant, the number of meteors in the first and the last half of the solar longitude interval is accumulated separately
- » When the overall meteor count of a shower is determined, the counts of all half intervals but the first and the last are divided by two



Problems and Solutions (IX)

Problem 3: Interferences





- Iterative radiant search: the strongest radiant is determined, the meteors belonging to this radiant are computed and removed from the data set, the next strongest radiant is determined, ...

» Wenn there are two equally strong sources nearby (NTA/STA), both will become the strongest shower at some time, and will „attract“ the meteors inbetween the radiants

Problems and Solutions (X)

Solution

- The algorithm is augmented by an extra step
- » After all radiants are determined, the meteor shower assignment will be repeated once more
- » Hence, meteors inbetween the radiants are not assigned to the stronger radiant, but to the one that fits better

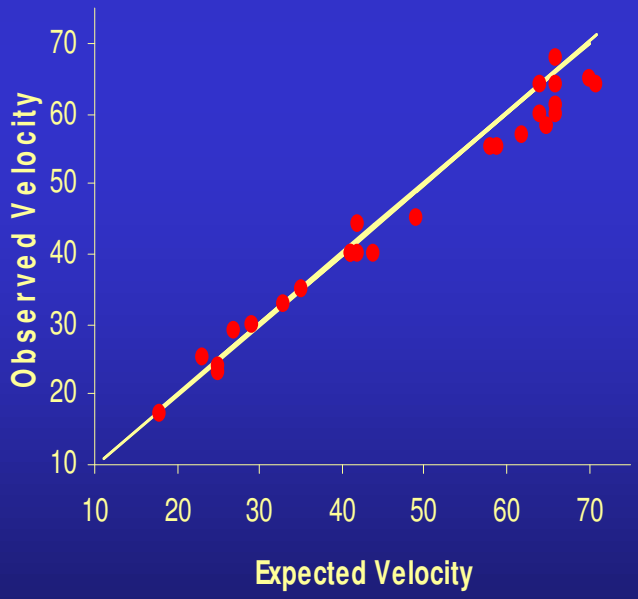
Problems and Solutions (XI)

Problem 4: Meteor shower velocities

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 70	236	Nov 19	154.2	21.5	0.6 / -0.4	64 km/s
LEO			151	22	0.7 / -0.4	71 km/s

- Contrary to double station analysis, the meteor shower velocity is not measures directly, but it is statistically determined

» The analysis of well-know meteor shower showed that the velocity of fast shower is systematically underestimated



Problems and Solutions (XII)

Solution

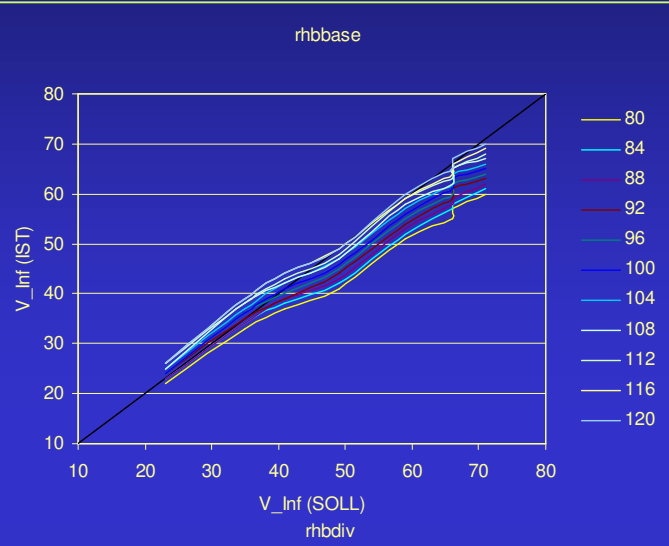
- In single station analysis, the expected angular velocity for each radiant at the observed meteor position is computed
- » Main factor in the velocity formula is the average meteor altitude, which is assumed to depend from the meteor shower velocity
- » Systematic errors of the meteor altitude cause systematic deviations of the angular velocity
- » In the 2006 analysis, a formula from P. Gural (1999) was used with the following altitudes

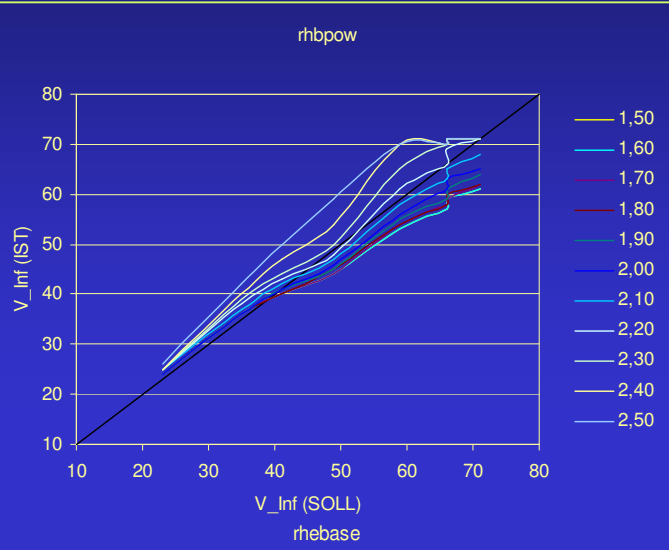
  begin height [km] $h_b=100+v^2_{inf}/200$, end height [km] $h_e = 85$

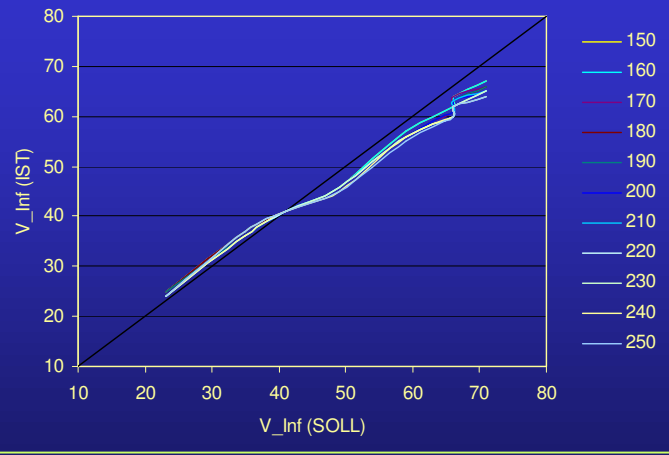
Problems and Solutions (XIII)

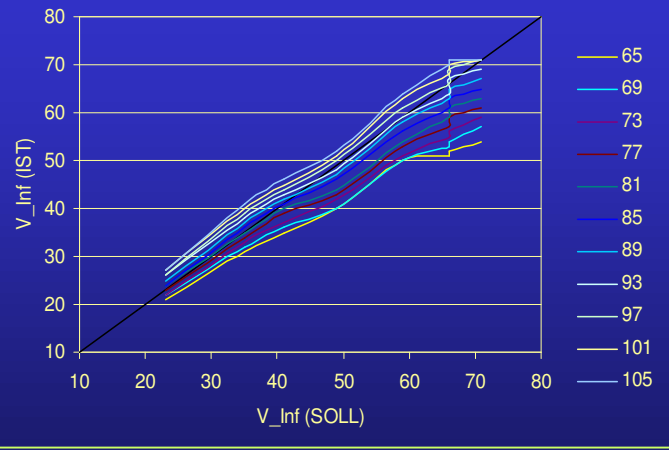
- The four parameters (100, 2, 200, 85) were systematically modified
- For each value, the velocity of eight well known meteor showers (QUA, LYR, ETA, SDA, PER, ORI, LEO, GEM) was determined
- » The dependency is well-natured, i.e. systematic modifications of one parameter yields systematic deviations of the meteor shower velocity
- » However, none of these parameters adapts only the velocity of fast showers

Problems and Solutions (XIIII)









Problems and Solutions (XV)

- The systematic deviation disappears, if the end altitude is also made dependent from the meteor shower velocity

  $h_b = 100 + v^2_{inf}/200$

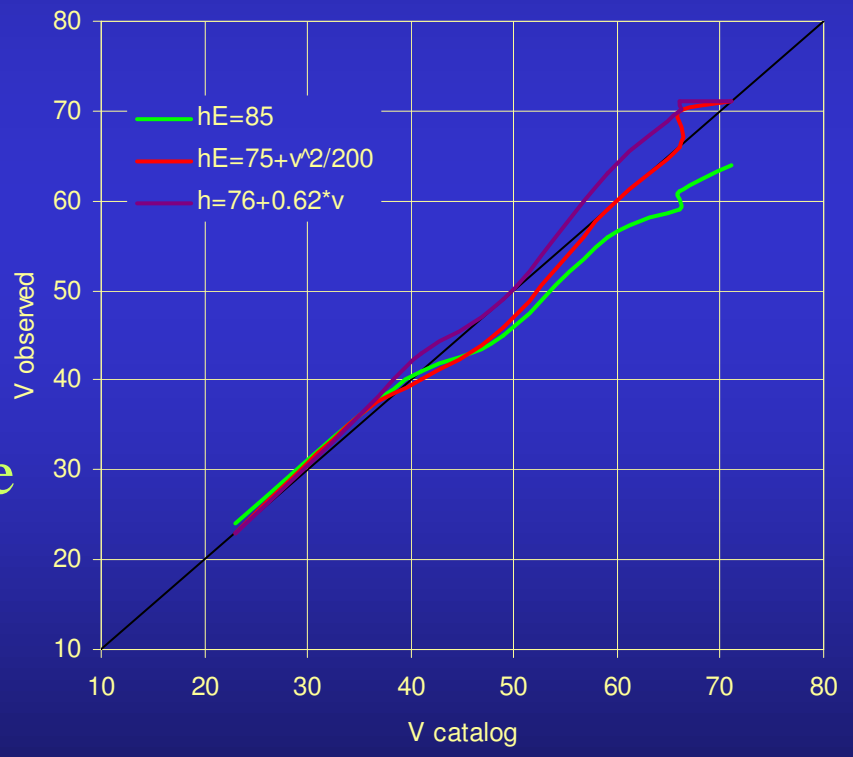
  $h_e = 75 + v^2_{inf}/200$

  or

  $h = 86 + v^2_{inf}/200$

- The formula yields also better results that the one given in the old „IMO Visual Handbook“ and applied in Radiant

  $h = 76 + 0.62 * v_{inf}$



Problems and Solutions (XVI)

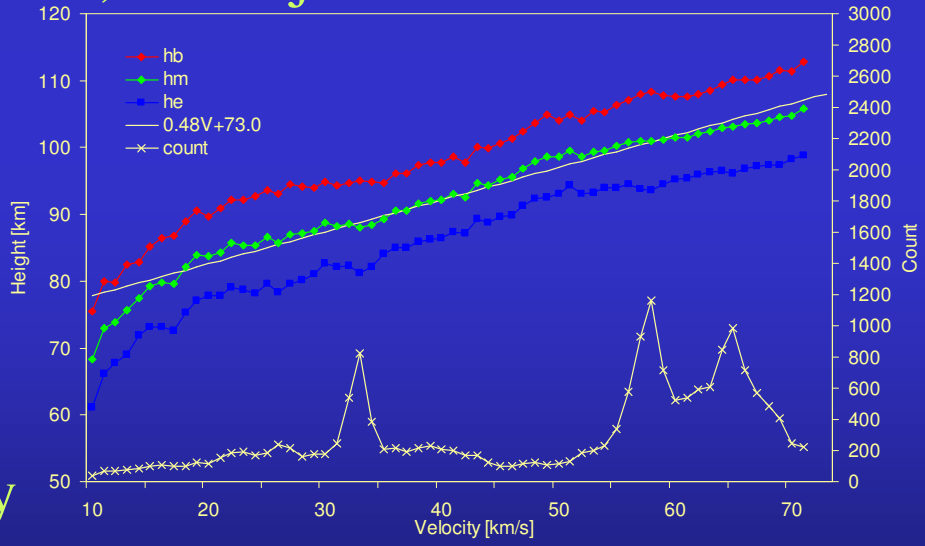
- The result was verified with double station data from the Japanese SonotaCo network: 140,000 single station meteor records in 2007 » 71,000 simultaneous recordings » 54,000 meteors with good accuracy » 18,650 trajectories and orbits

» Linear dependency between velocity and meteor altitude

$h=73+0.48*v_{inf}$

» Altitude range is 12 km independent of the velocity

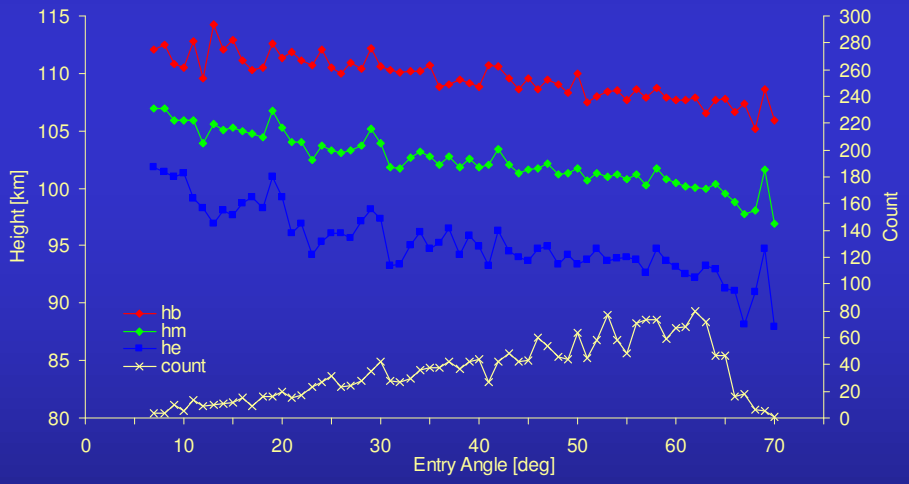
» If the same linear dependency is used for IMO single station data, the offset is 74..75 km



Problems and Solutions (XVII)

- The dependency from other parameters was further analysed
  - » The average altitude increases by 1 km per magnitude
  - » The altitude range depends from the meteor duration: h_b-h_e=38*d
  - » The altitude decreases by 1 km for every 10° entry angle (radiant altitude)
  - » Resulting formula

    $h=78+0.48*v_{inf}+m-ea/10$
  - » Analysis of single station IMO data yields exactly the same offset (details in next WGN)!



Problems and Solutions (XIX)

Problem 5: Empirical parameter estimation

- The following probability distribution was used in 2006:

  $P(M \mid R) = [\exp(-0.5\, D^2) * \exp(-1.5\, V^2)]$

  with: D ... Radiant miss distance [°]

  V ... Velocity deviation [°/s]

» Because the true distribution was unknown, a Gaussian distribution was used and the standard deviation (scaling factors 0.5, 1.5) was set empirically

Problems and Solutions (XX)

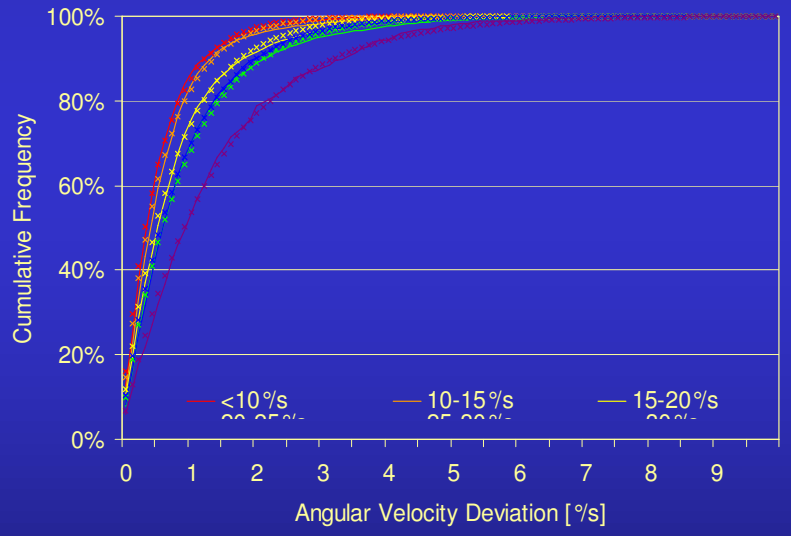
Solution

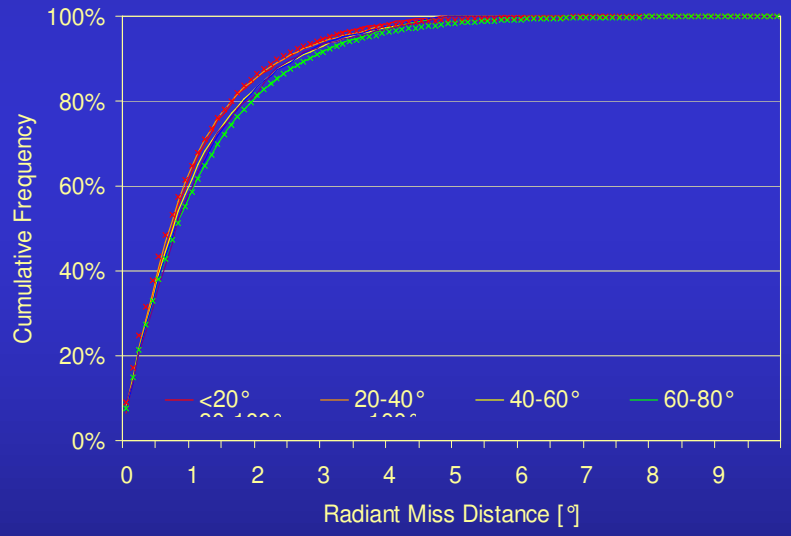
- The probability distribution is estimated from data: First the radiant position of major meteor showers (PER, ORI, GEM) at the time of their maxima was computed, then the distribution of the angular and position errors was determined
  - » The standard deviation was smaller than expected: 50% of all meteors deviated < 1/2°/s in velocity and < 3/4° in position
  - » The probability distribution is Laplacian, not Gaussian
  - » The deviation of the velocity depends on the angular velocity
  - » The miss distance is independent of the meteors radiant distance

Problems and Solutions (XXI)

» Resulting probability distribution:

$$P(M \mid R) = [\exp(-0.8\,D) * \exp(-V/(0.4+V/50)]$$

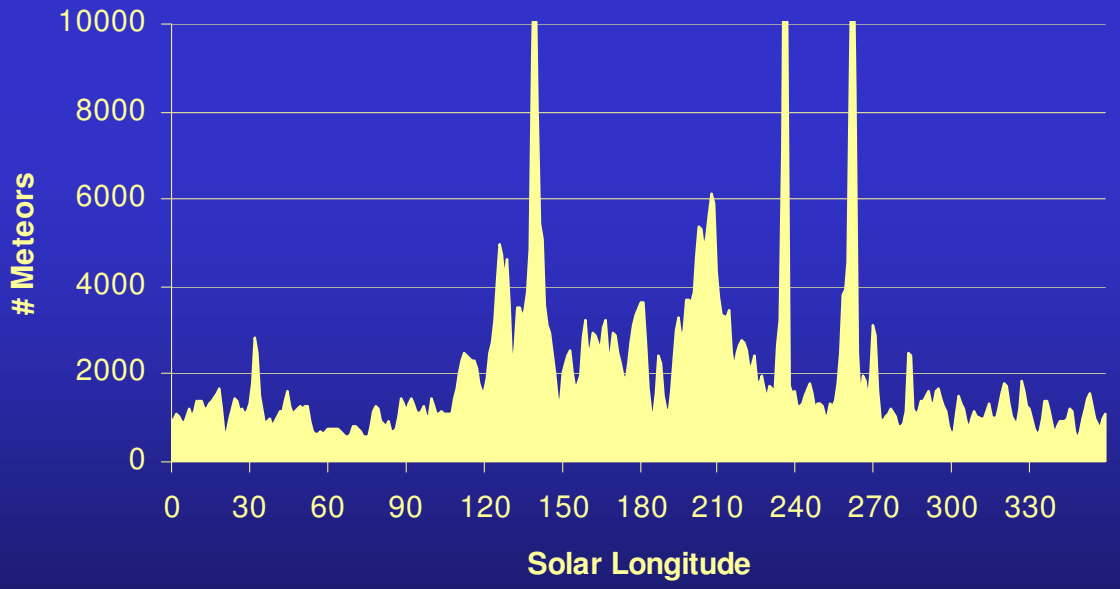




Results (I)

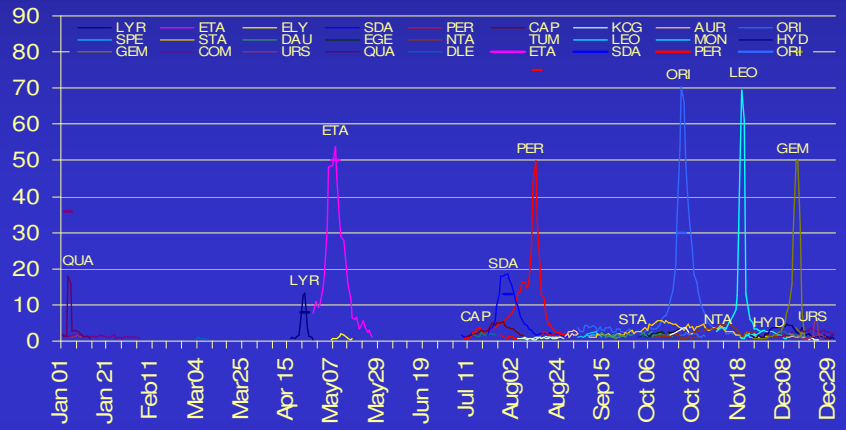
Statistics

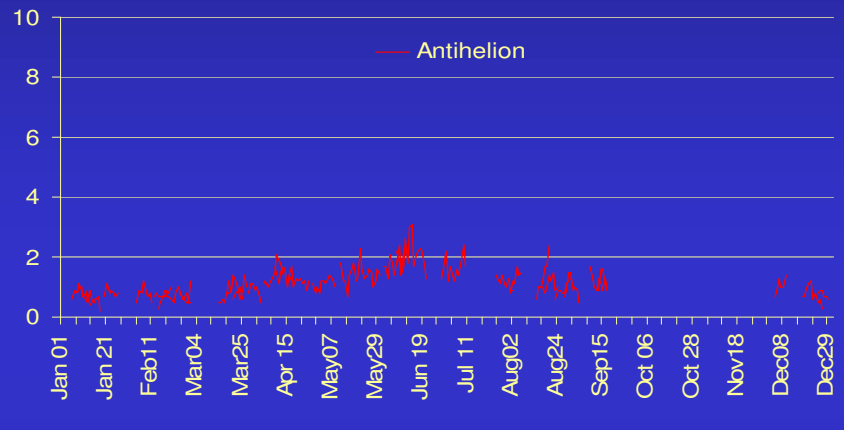
- 359,957 meteors, recorded between Jan 1993 and Jul 2008
- » Data set has almost doubled since the last analysis in 2006
- » Between 535 (March 7 / solar longitude 348°) and 14,641 meteors (November 19 / solar longitude 236°) per interval
- Setting for stream search not yet modified

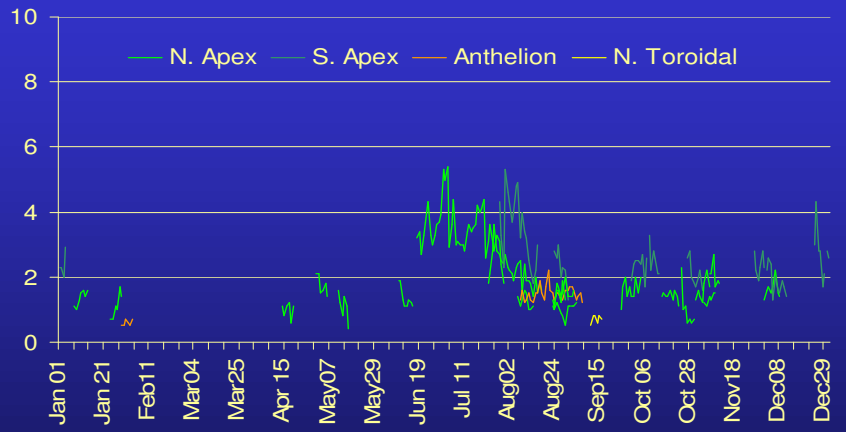


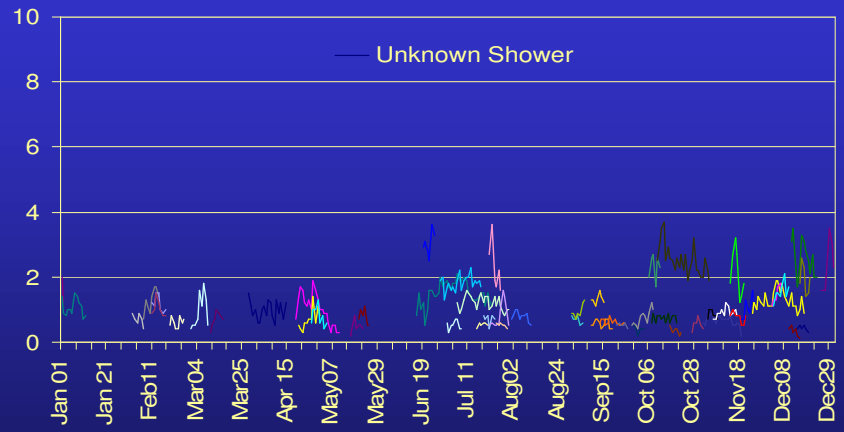
Results (II)

Meteor Shower Activity



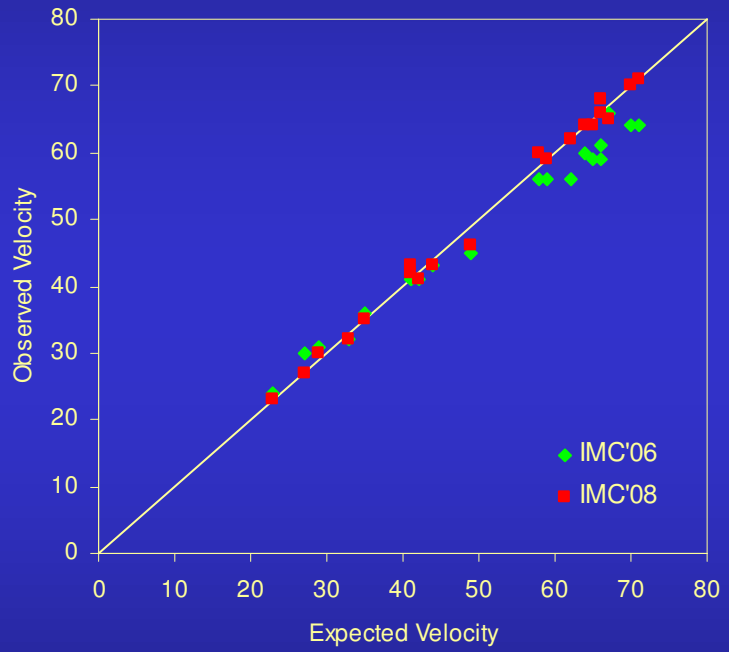






Results (III)

Meteor Shower Velocities

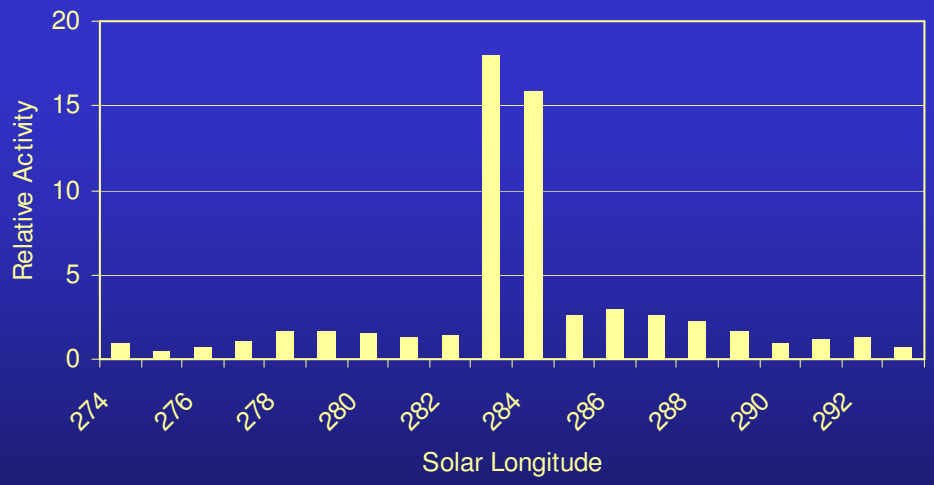


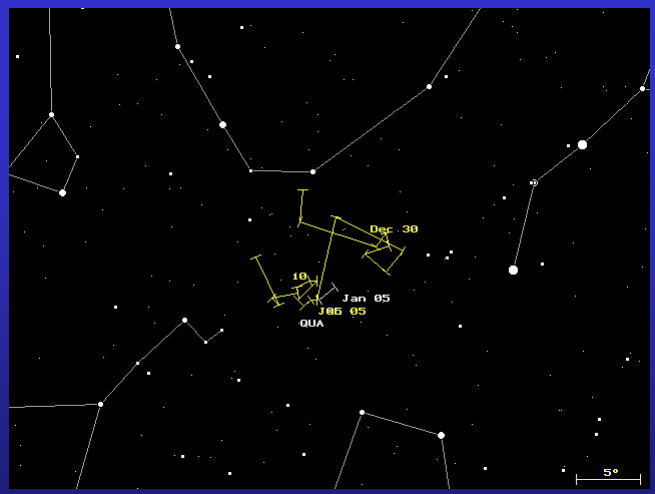
» The systematic shift in meteor shower velocities has been successfully removed

Results (IV)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 146	274-293	Dec 26-Jan 13	1336	283	Jan 04	18.0
QUA	280-284	Jan 01-Jan 05	-	282	Jan 03	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 146	283	Jan 04	230.2	49.0	0.6 / -0.3	42 km/s
QUA			230	49	0.8 / -0.2	41 km/s

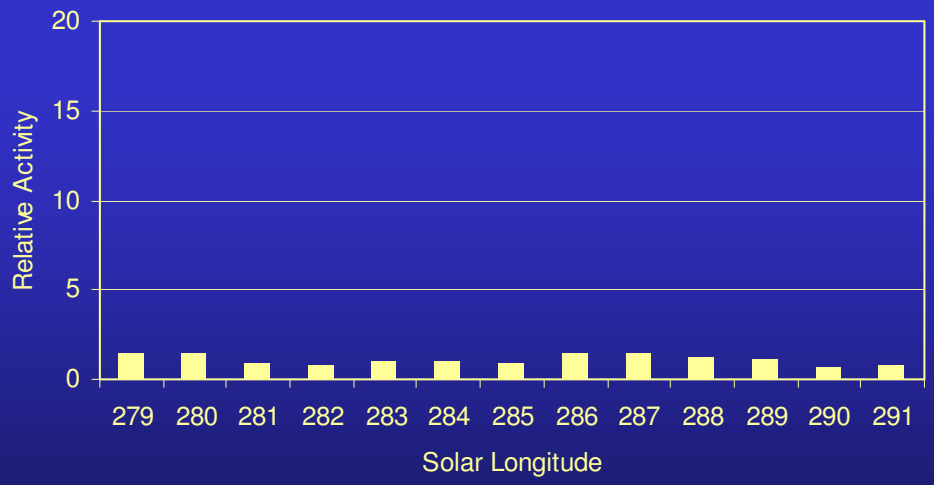


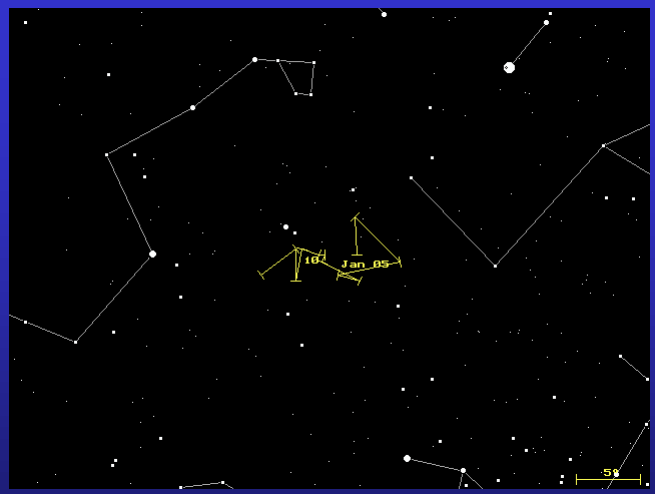


Results (V)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 148	279-291	Dec 31-Jan 11	161	286	Jan 07	1.5
-	-	-	-	-		

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 148	286	Jan 07	128.6	-9.0	0.6 / -0.1	40 km/s
-			-	-	-	-

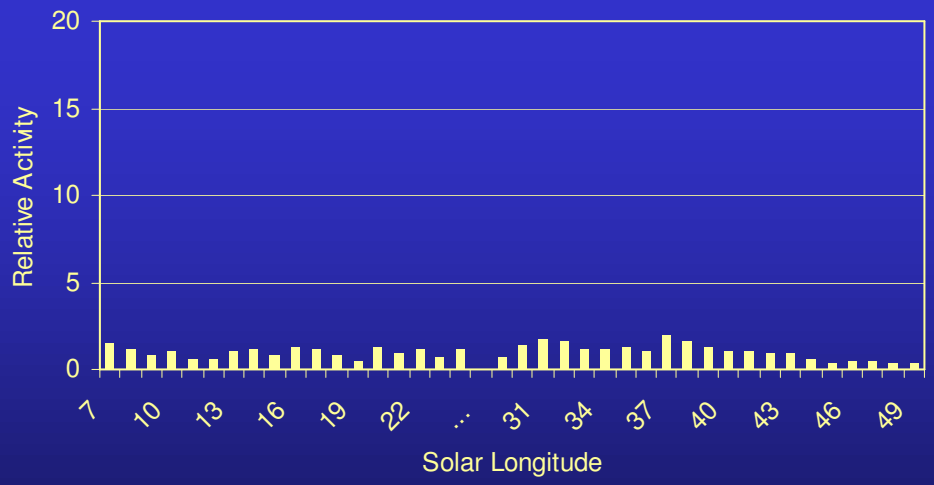


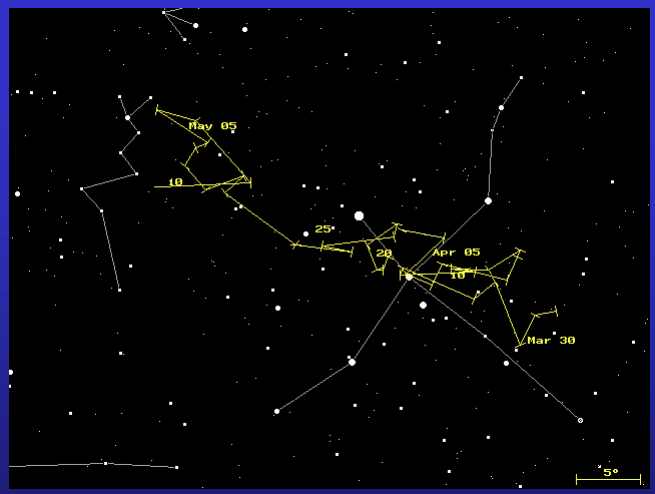


Results (VI)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 4	7-24	Mar 28-Apr 14	307	20	Apr 10	1.3
Shower 10	29-49	Apr 19-May 10	401	37	Apr 27	1.9
-	-	-	-	-		

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 4	20	Apr 10	302.1	41.0	0.4 / 0.4	41 km/s
Shower 10	37	Apr 27	317.2	43.0	1.5 / 0.4	44 km/s
-	-	-	-	-	-	-

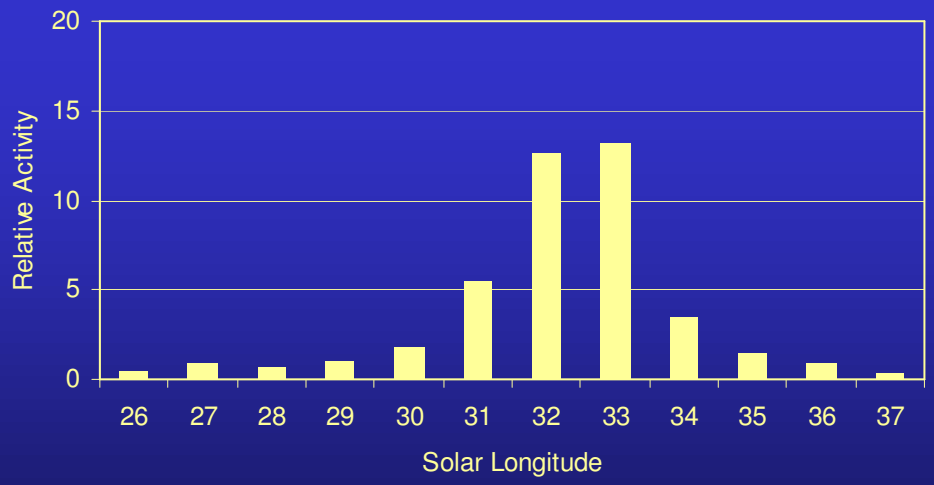


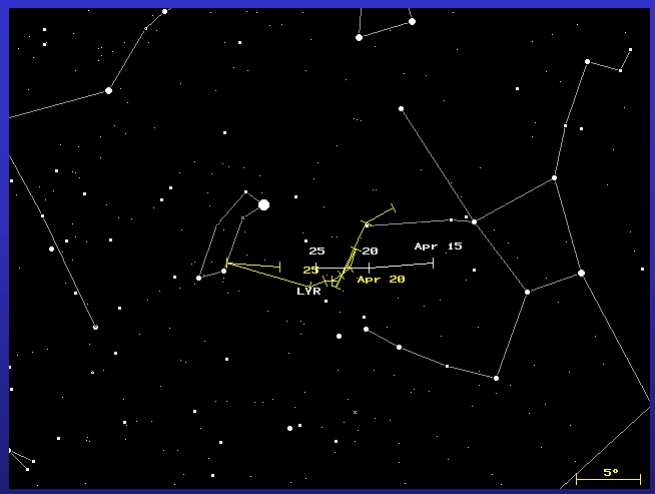


Results (VII)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 9	26-37	Apr 16-Apr 27	1516	33	Apr 23	13.2
LYR	26-35	Apr 16-Apr 25	-	32	Apr 22	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 9	33	Apr 23	272.5	33.0	0.9 / -0.4	46 km/s
LYR			271	34	1.1 / 0.0	49 km/s

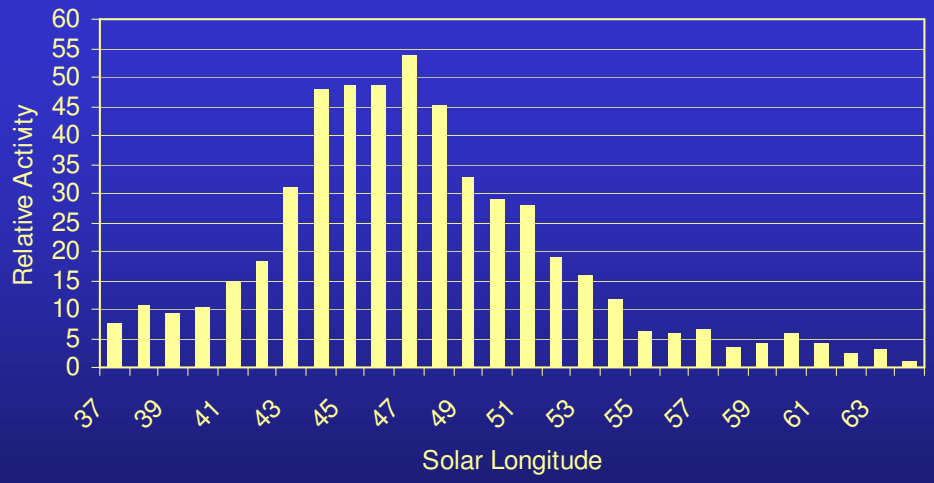


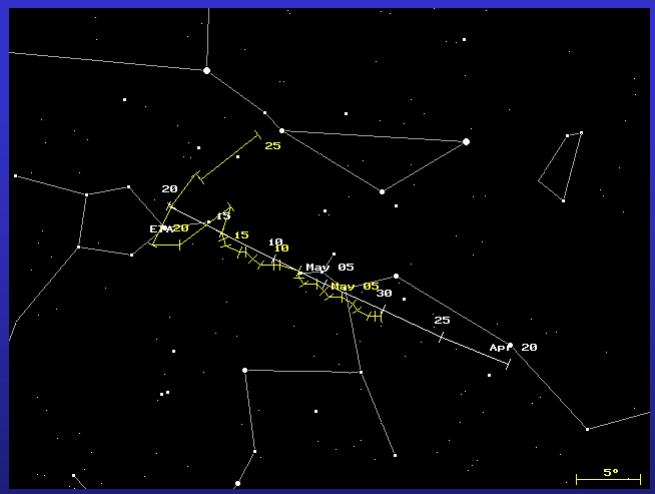


Results (VIII)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 14	37-64	Apr 27-May 25	1051	47	May 08	53.8
ETA	29-67	Apr 19-May 29	-	44	May 05	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 14	47	May 08	339.0	-0.5	0.6 / 0.4	68 km/s
ETA			338	-1	0.9 / 0.4	66 km/s

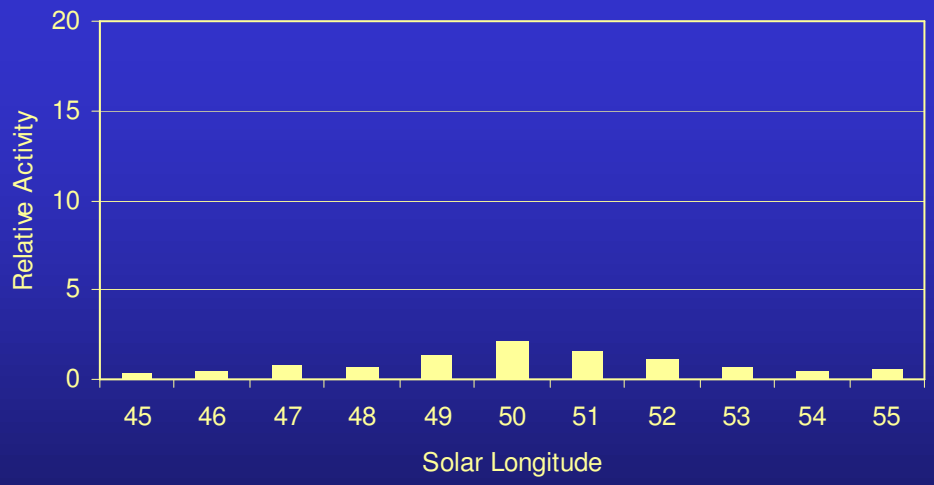


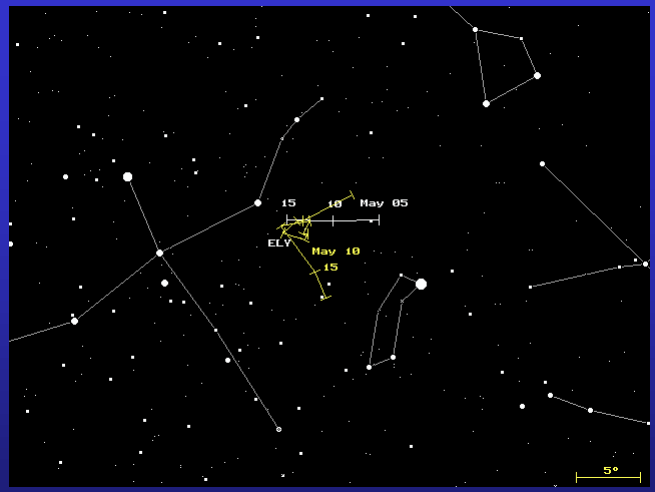


Results (IX)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 16	45-55	May 06-May 16	264	50	May 11	2.1
ELY	42-51	May 03-May 12	-	48	May 09	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 16	50	May 11	290.6	43.0	0.1 / -0.5	43 km/s
ELY			287	44	1.0 / 0.0	44 km/s

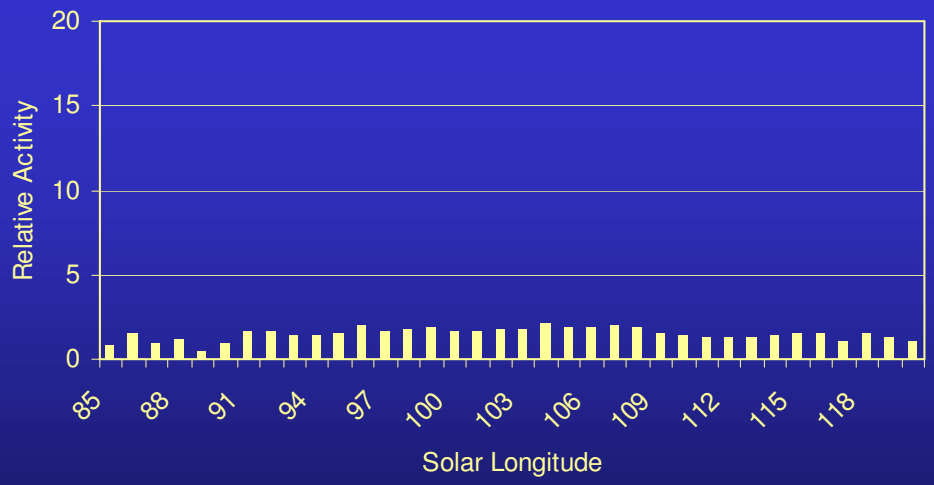


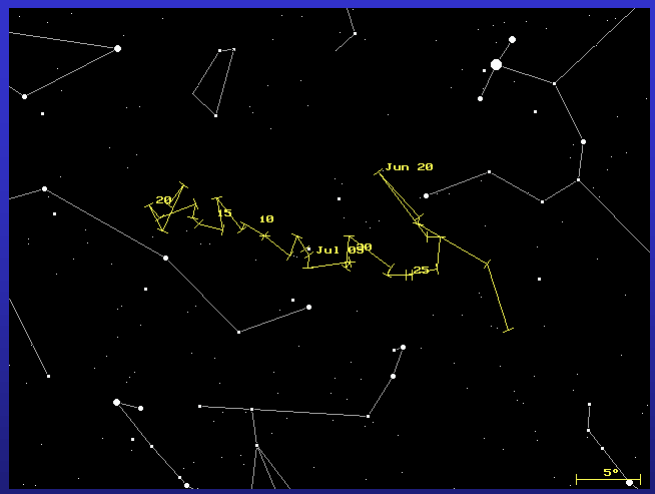


Results (X)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 25	85-120	Jun 16-Jul 23	907	104	Jul 06	2.1
-	-	-	-	-		

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 25	104	Jul 06	312.2	-5.0	0.7 / 0.1	43 km/s
-			-	-	-	-

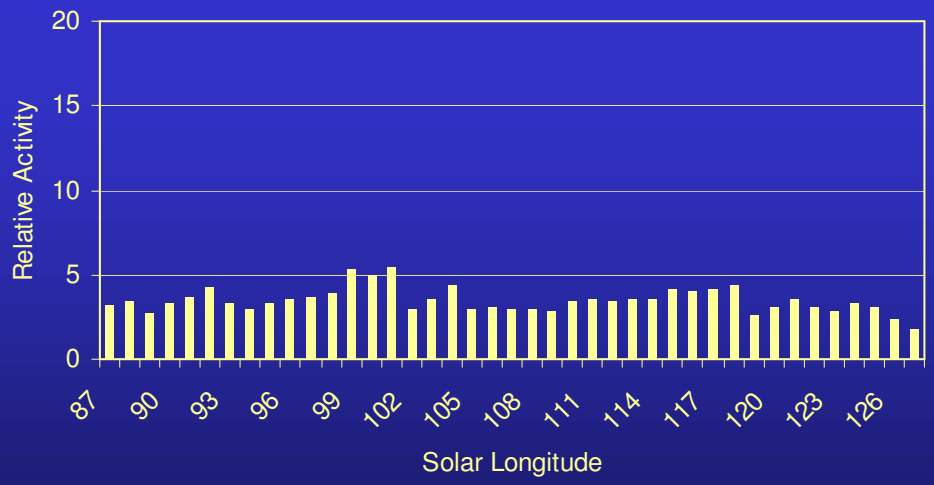


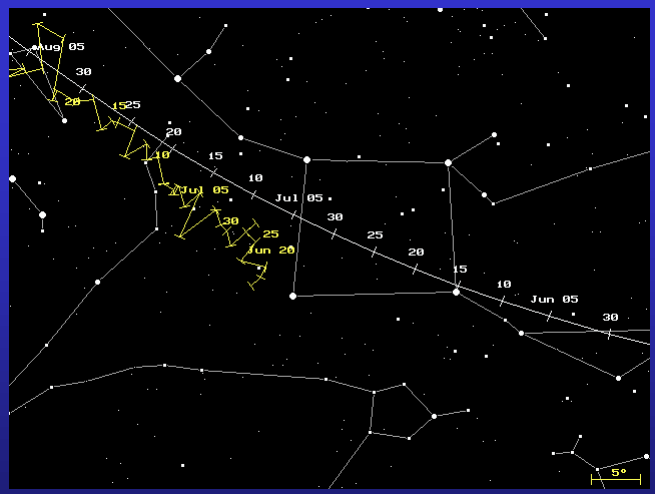


Results (XI)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 26	87-127	Jun 18-Jul 30	1658	101	Jul 03	5.4
N Apex	-	-	-	-		

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 26	101	Jul 03	15.3	23.5	0.8 / 0.4	70 km/s
N Apex			3	21	0.9 / 0.4	58 km/s

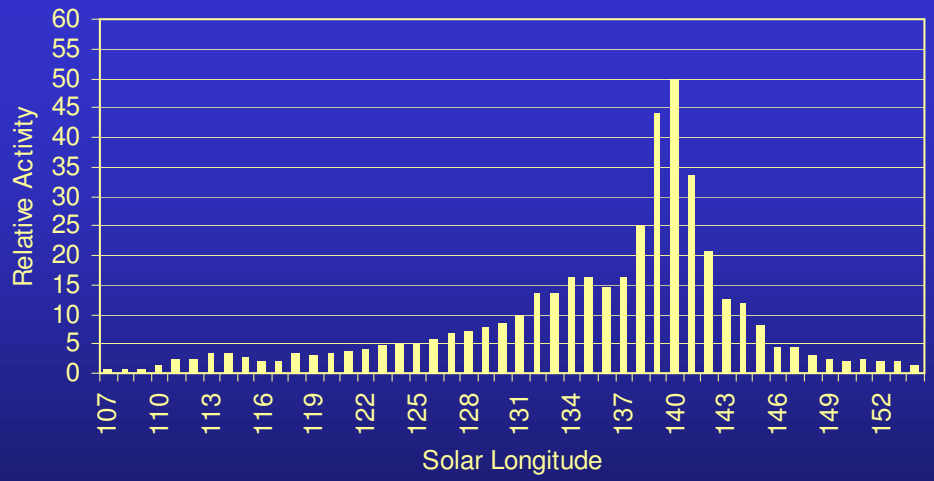


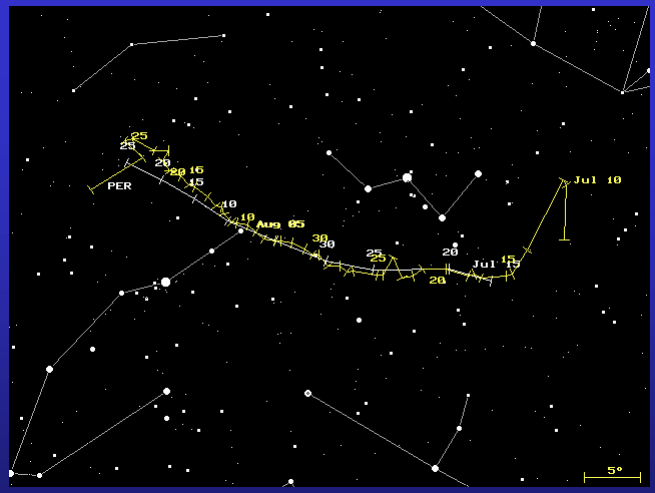


Results (XII)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 33	107-154	Jul 09-Aug 27	17872	140	Aug 13	49.8
PER	114-151	Jul 17-Aug 24	-	139	Aug 12	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 33	140	Aug 13	47.5	57.5	1.5 / 0.2	59 km/s
PER			46	58	1.3 / 0.2	59 km/s

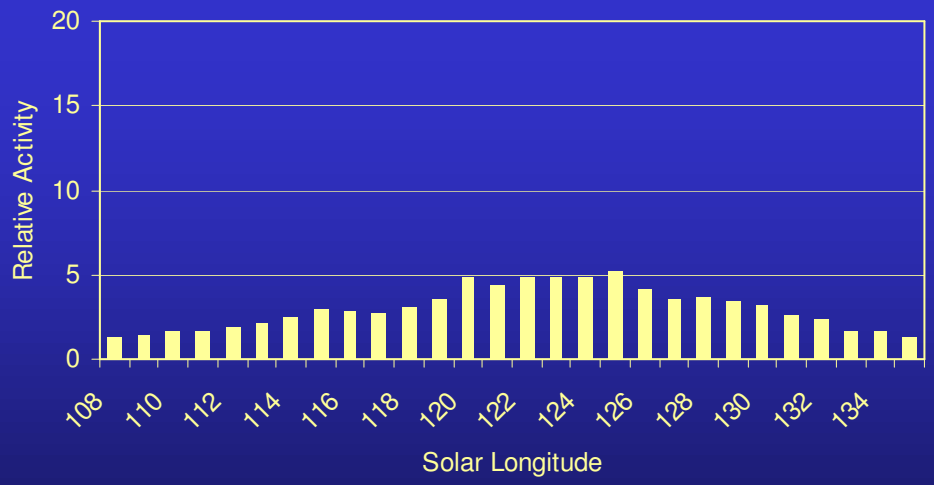


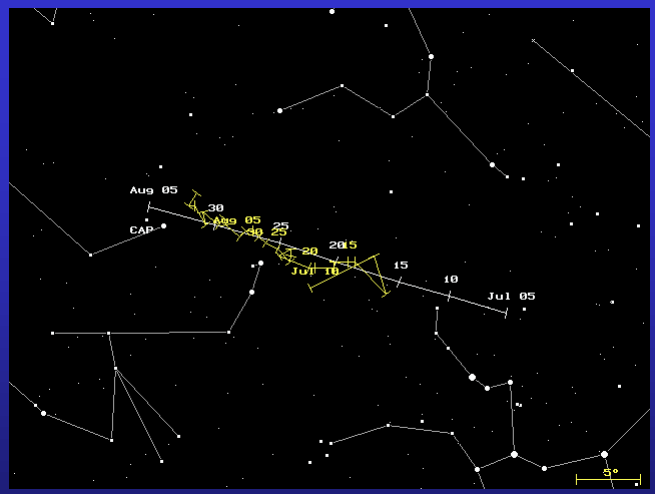


Results (XIII)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 34	108-135	Jul 10-Aug 08	1979	125	Jul 28	5.2
CAP	101-142	Jul 03-Aug 15	-	127	Jul 30	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 34	125	Jul 28	305.1	-10.0	0.5 / 0.2	24 km/s
CAP			308	-10	1.0 / 0.3	23 km/s

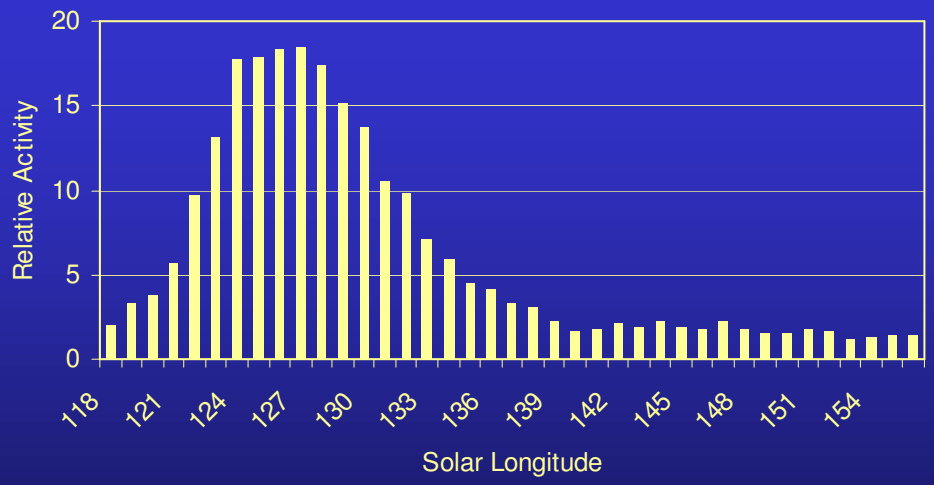


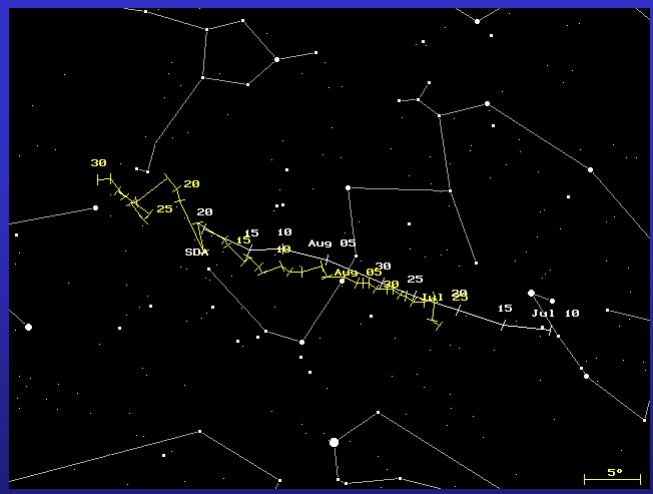


Results (XIV)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 38	118-156	Jul 21-Aug 30	4101	127	Jul 30	18.5
SDA	110-146	Jul 13-Aug 19	-	125	Jul 28	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 38	127	Jul 30	340.5	-16.5	0.9 / 0.3	43 km/s
SDA			339	-16	1.0 / 0.3	41 km/s

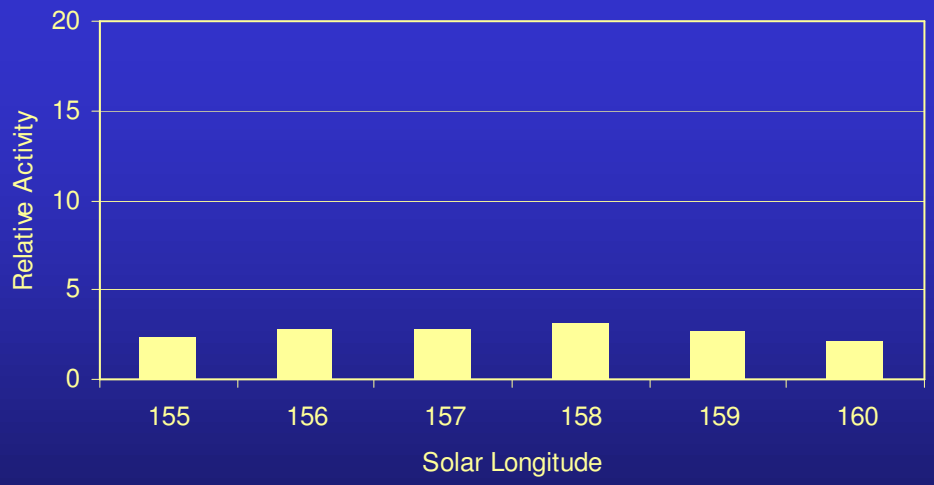


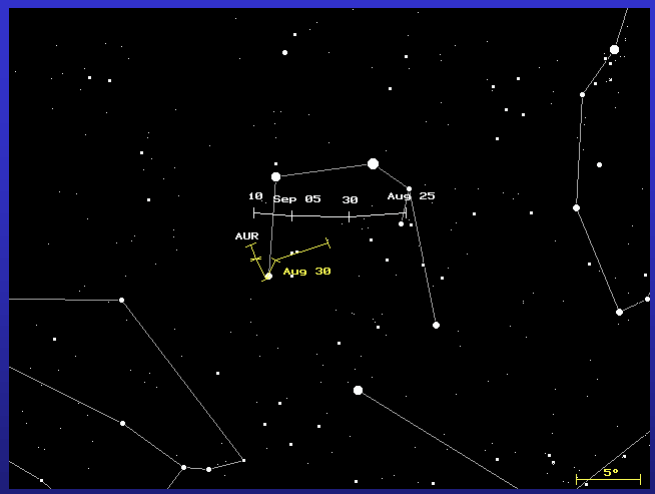


Results (XV)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 64	155-160	Aug 28-Sep 03	240	158	Sep 01	3.1
AUR	152-165	Aug 25-Sep 08	-	158	Sep 01	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 64	158	Sep 01	91.4	38.5	1.3 / 0.0	65 km/s
AUR			91	39	0.0 / 0.0	67 km/s

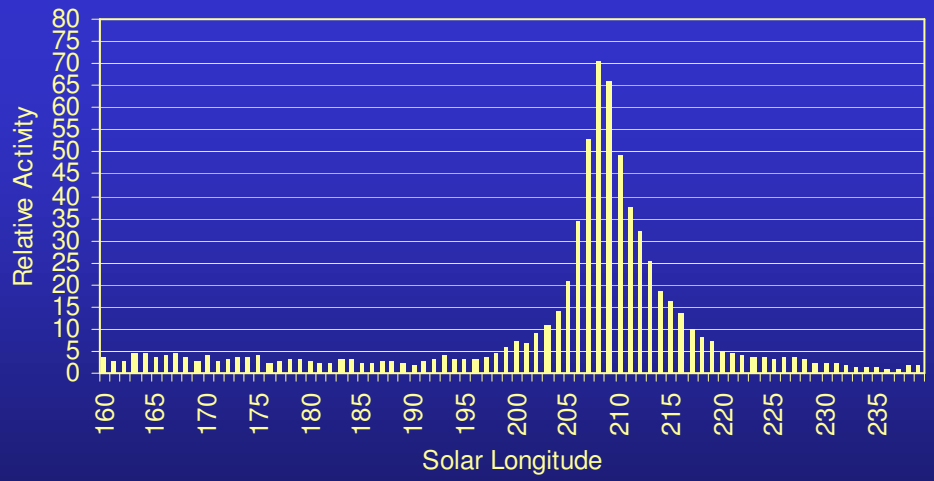


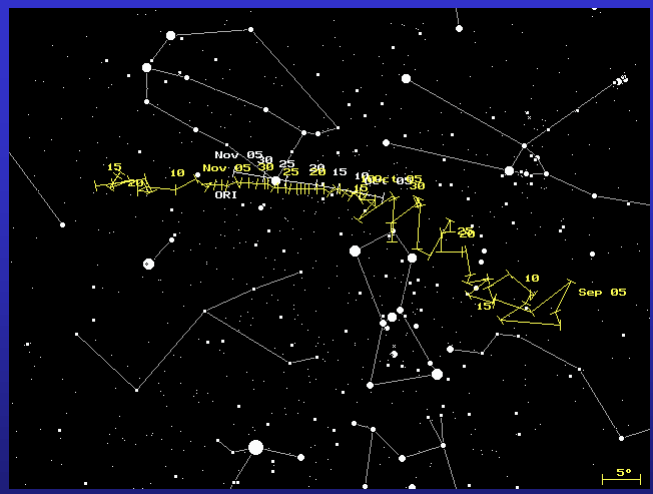


Results (XVI)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 67	160-239	Sep 03-Nov 21	14012	208	Oct 22	70.4
ORI	189-224	Oct 02-Nov 07	-	207	Oct 21	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 67	208	Oct 22	95.5	15.5	0.7 / 0.2	68 km/s
ORI			95	16	0.7 / 0.1	66 km/s

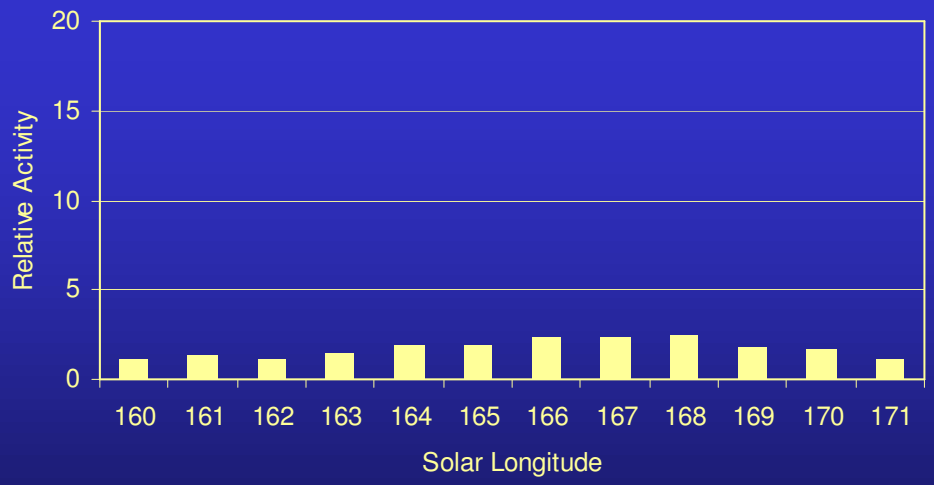


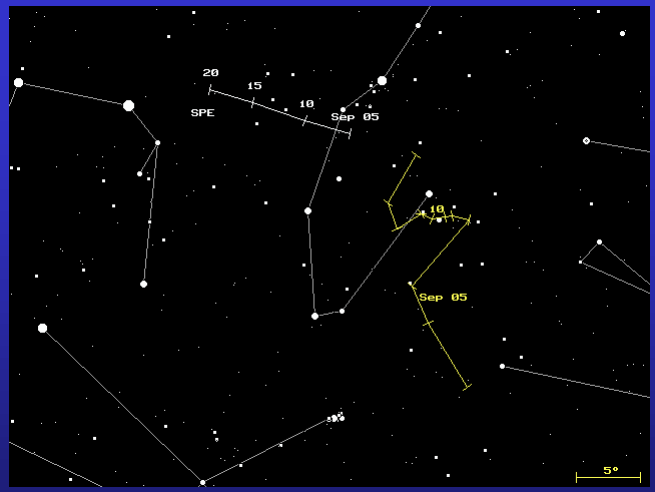


Results (XVII)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 68	160-171	Sep 03-Sep 14	760	168	Sep 11	2.5
SPE	162-174	Sep 05-Sep 17	-	166	Sep 09	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 68	168	Sep 11	48.0	39.5	0.3 / 1.1	65 km/s
SPE			59	47	1.1 / 0.1	64 km/s

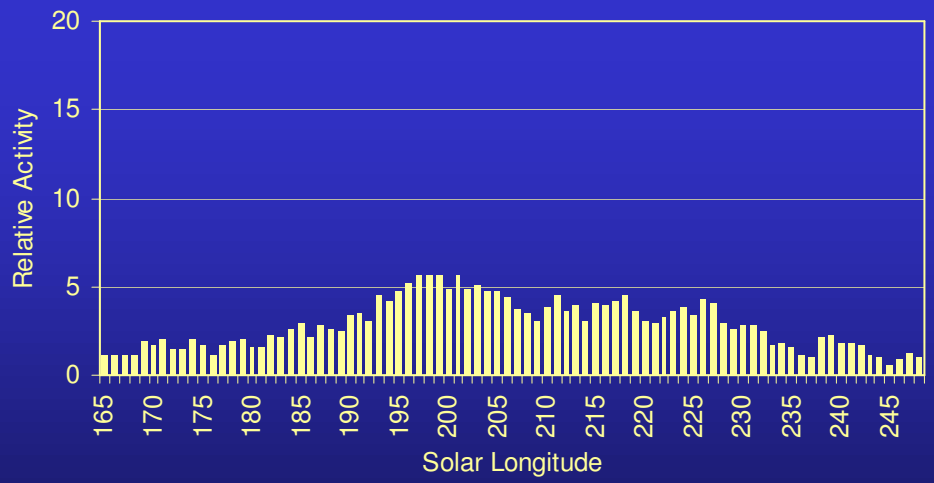


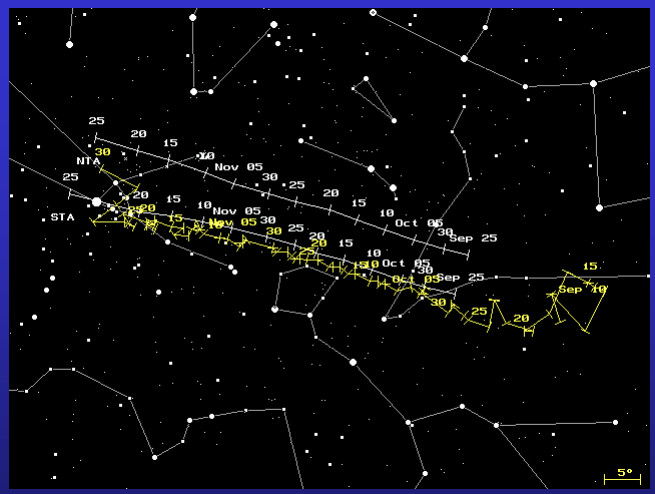


Results (XVIII)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 70	165-248	Sep 08-Nov 30	6823	198	Oct 11	5.7
STA	182-210	Sep 25-Oct 24	-	197	Oct 10	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 70	198	Oct 11	34.4	9.0	0.8 / 0.2	29 km/s
STA			32	9	0.7 / 0.3	27 km/s

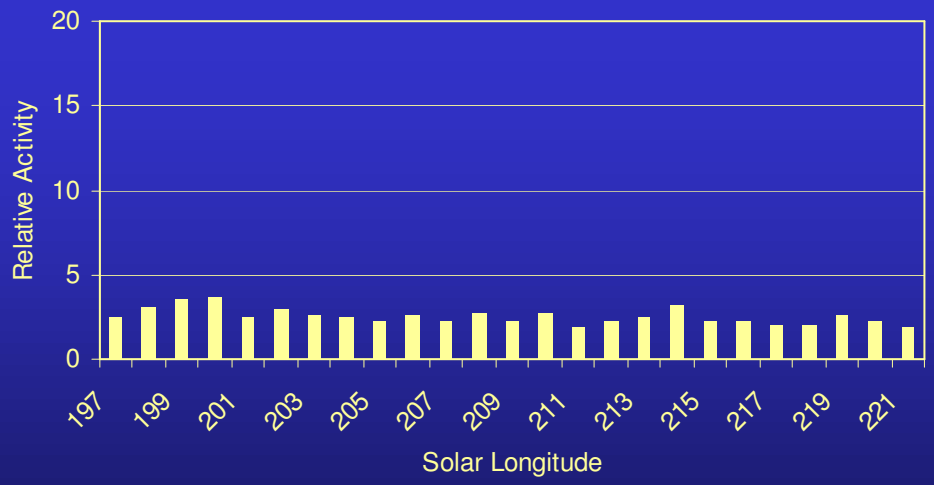


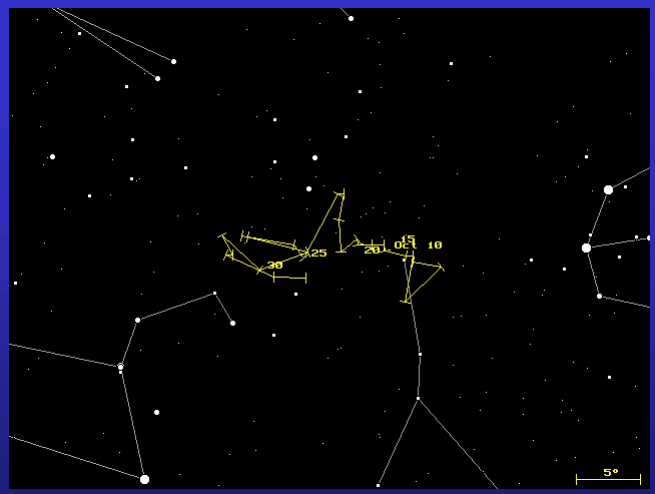


Results (XIX)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 95	197-221	Oct 10-Nov 04	1001	200	Oct 14	3.7
-	-	-	-	-		

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 95	200	Oct 14	130.9	29.0	0.7 / 0.0	67 km/s
-			-	-	-	-

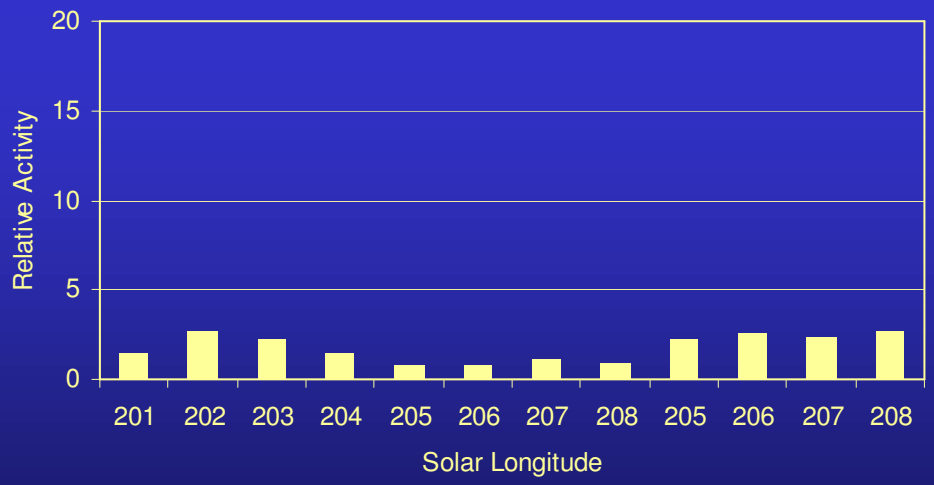


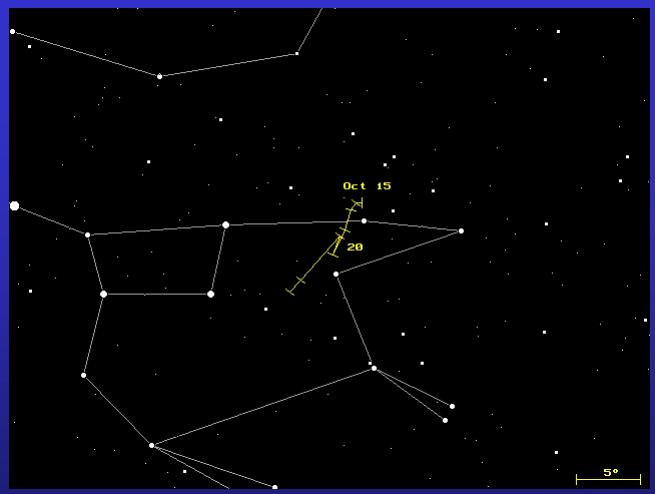


Results (XX)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 96	201-208	Oct 15-Oct 22	468	202	Oct 16	2.7
TUM	199-204	Oct 12-Oct 18	-	202	Oct 16	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 96	202	Oct 16	144.0	64.5	1.6 / -1.1	54 km/s
TUM			144	64	1.5 / -0.5	51 km/s

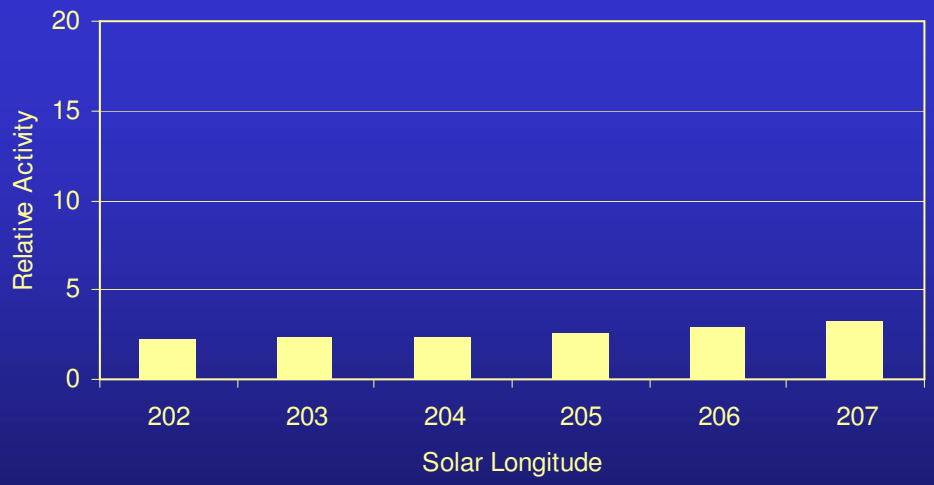


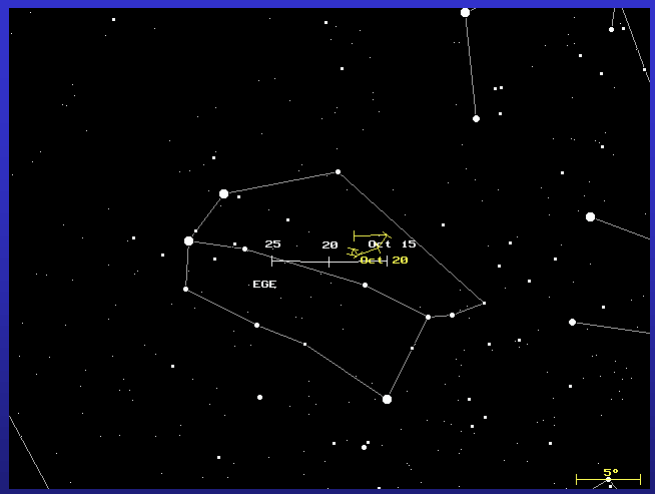


Results (XXI)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 98	202-207	Oct 16-Oct 21	551	207	Oct 21	3.2
EGE	199-213	Oct 12-Oct 27	-	204	Oct 18	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 98	207	Oct 21	102.0	27.5	0.3 / -0.3	71 km/s
EGE			102	27	1.0 / 0.0	70 km/s

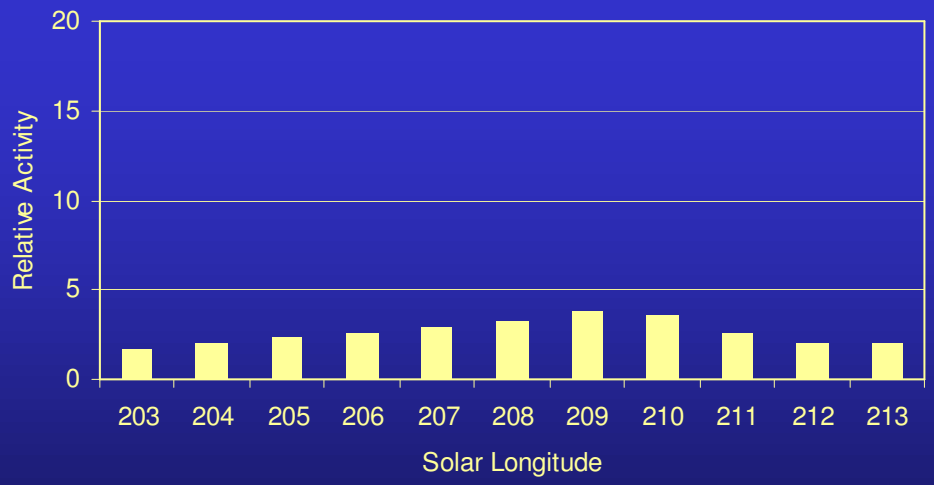


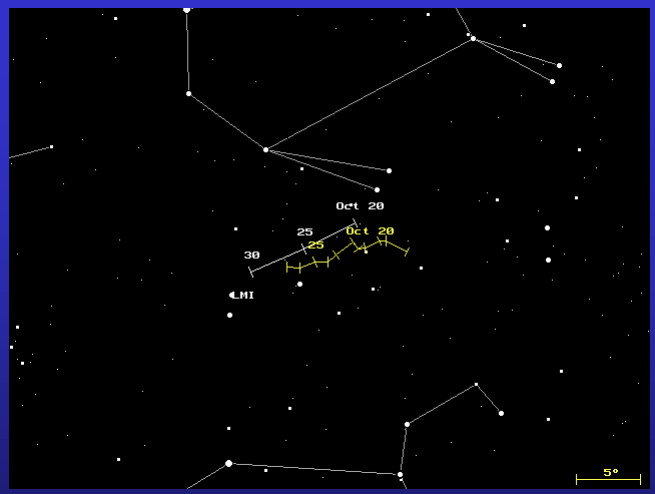


Results (XXII)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 100	203-213	Oct 17-Oct 27	421	209	Oct 23	3.8
LMI	205-213	Oct 19-Oct 27	-	210	Oct 24	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 100	209	Oct 23	159.9	36.5	1.1 / -0.2	61 km/s
LMI			162	37	1.0 / -0.4	62 km/s

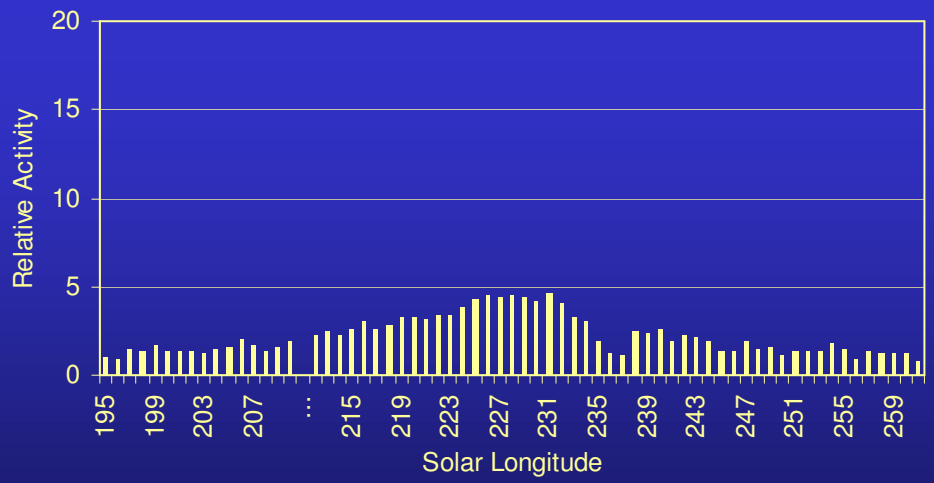


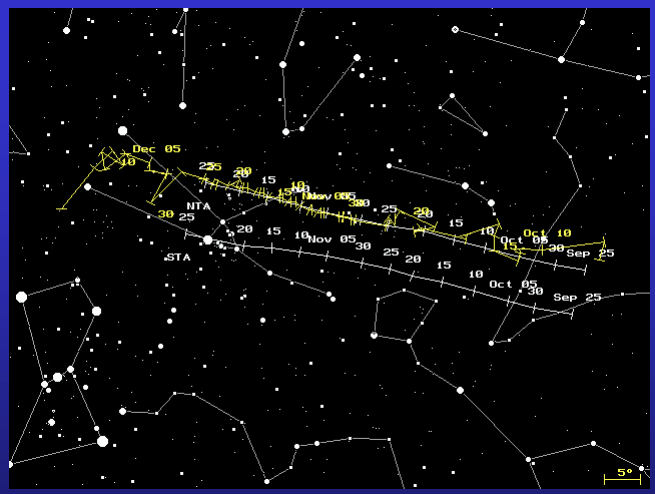


Results (XXIII)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 93	195-210	Oct 08-Oct 24	973	206	Oct 20	2.0
Shower 106	212-261	Oct 26-Dec 13	3417	231	Nov 14	4.7
NTA	211-243	Oct 25-Nov 25	-	227	Nov 10	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 93	206	Oct 20	38.5	18.5	1.6 / 0.5	30 km/s
Shower 106	231	Nov 14	59.2	23.0	0.9 / 0.1	29 km/s
NTA	231	Nov 14	56	22	0.9 / 0.2	29 km/s

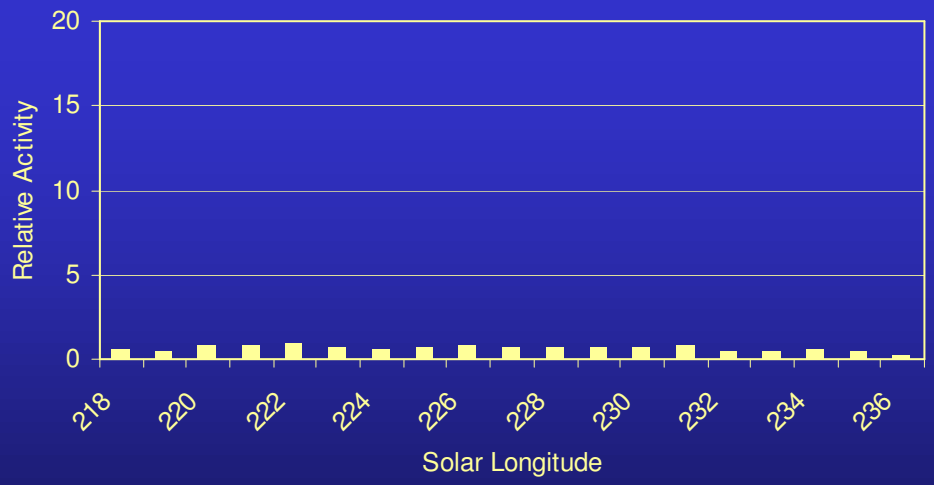


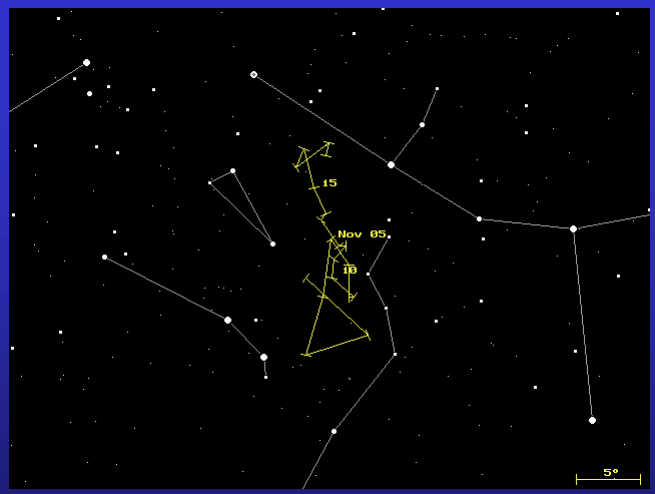


Results (XXIV)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 110	218-236	Nov 01-Nov 19	429	222	Nov 05	0.9
-	-	-	-	-		

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 110	222	Nov 05	23.1	30.0	0.1 / 0.8	19 km/s
-			-	-	-	-

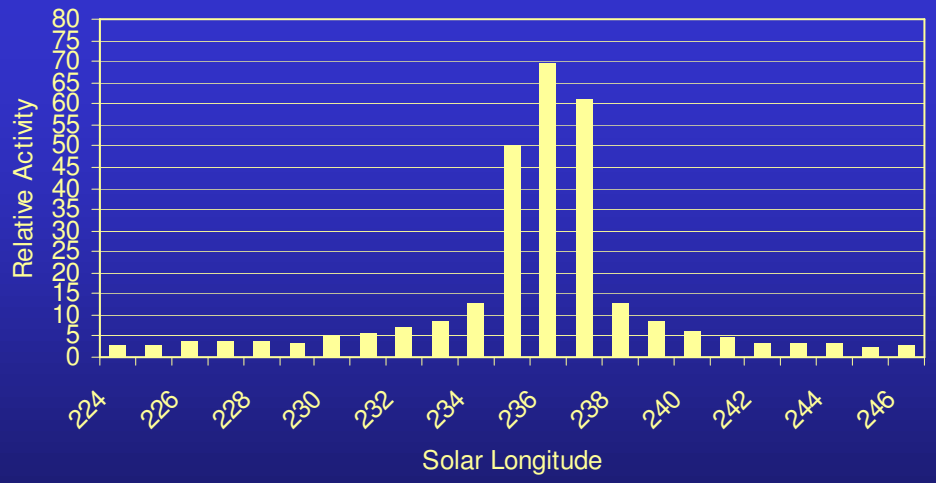


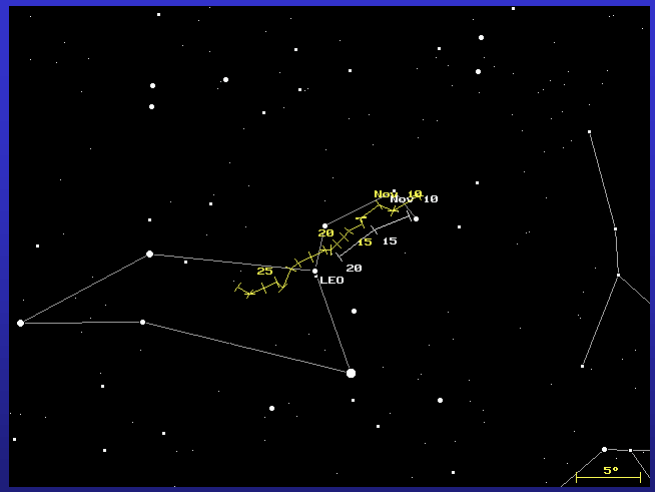


Results (XXV)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 115	224-246	Nov 07-Nov 28	8788	236	Nov 19	69.5
LEO	227-241	Nov 10-Nov 23	-	234	Nov 17	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 115	236	Nov 19	154.2	21.5	0.6 / -0.4	71 km/s
LEO			151	22	0.7 / -0.4	71 km/s

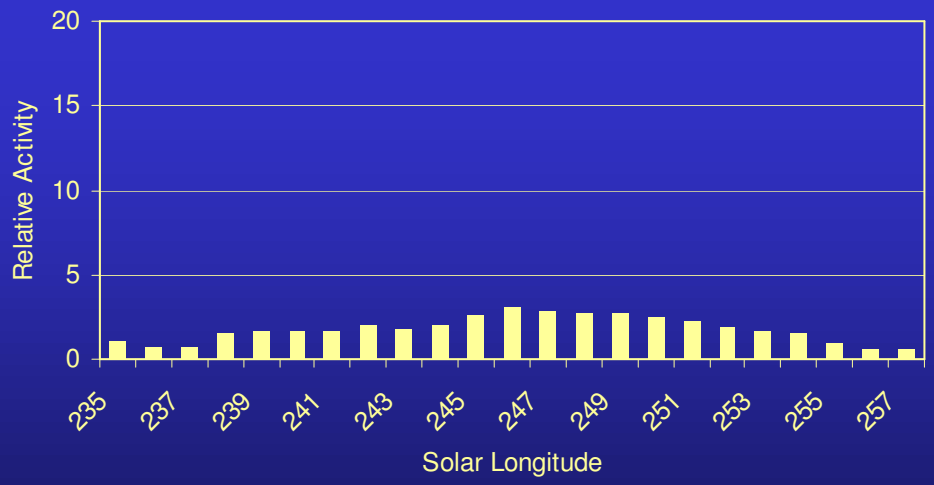


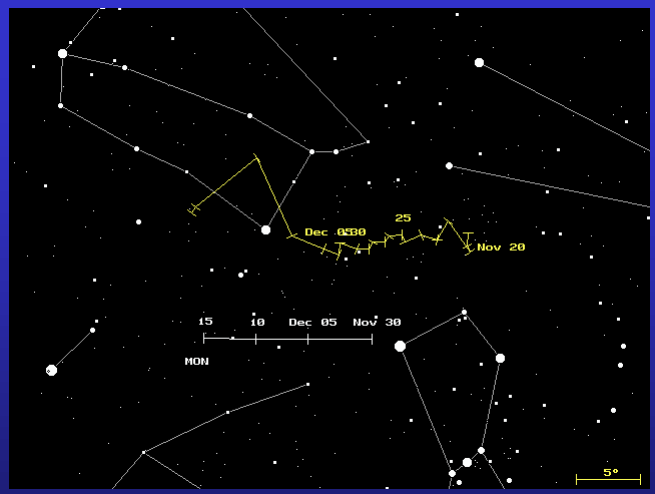


Results (XXVI)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 118	235-257	Nov 18-Dec 09	855	246	Nov 28	3.1
(MON)	245-265	Nov 27-Dec 17	-	257	Dec 09	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 118	246	Nov 28	90.8	15.5	0.9 / 0.1	45 km/s
(MON)			103	8	0.9 / 0.0	42 km/s

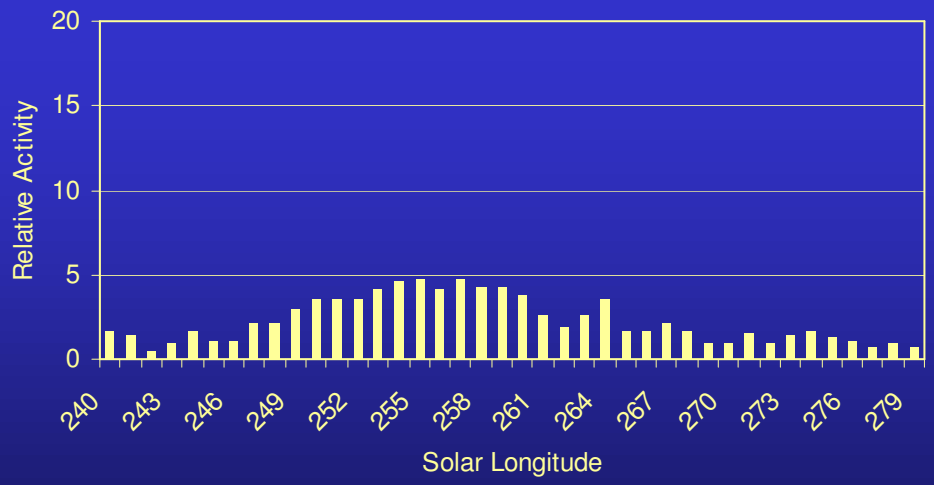


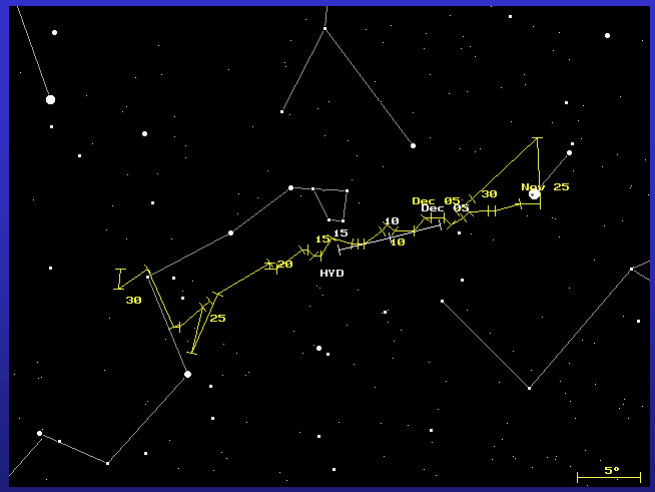


Results (XXVII)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 121	240-279	Nov 22-Dec 31	1382	257	Dec 09	4.7
HYD	251-263	Dec 03-Dec 15	-	260	Dec 12	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 121	257	Dec 09	126.2	3.0	0.8 / -0.2	60 km/s
HYD			128	2	0.8 / -0.2	58 km/s

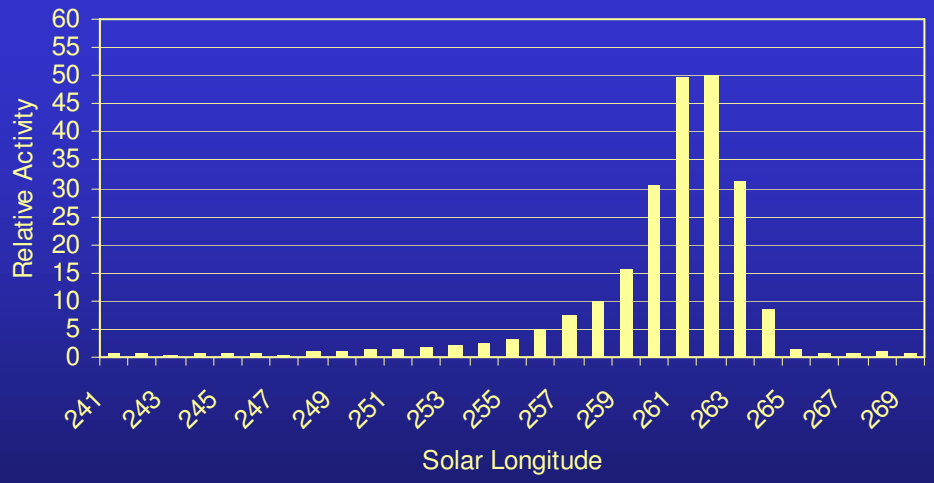


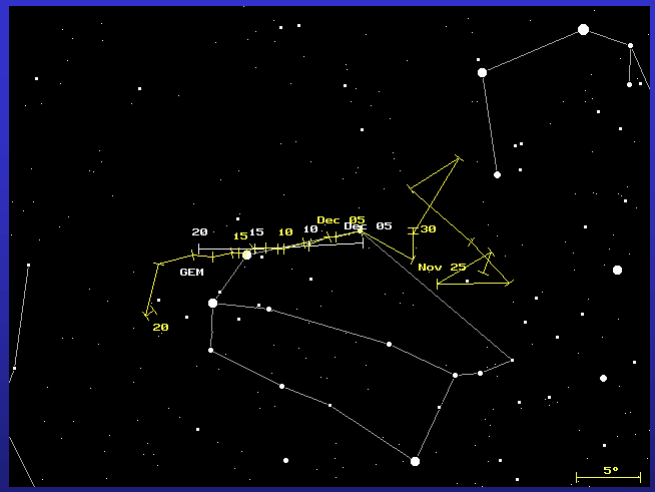


Results (XXVIII)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 123	241-269	Nov 23-Dec 21	12103	262	Dec 14	50.2
GEM	255-265	Dec 07-Dec 17	-	262	Dec 14	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 123	262	Dec 14	113.8	32.0	1.1 / -0.1	35 km/s
GEM			112	33	1.0 / -0.1	35 km/s

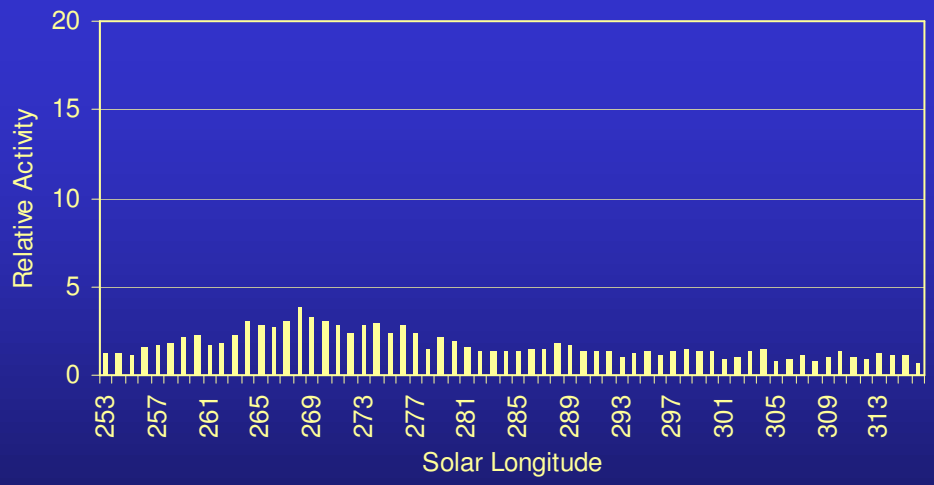


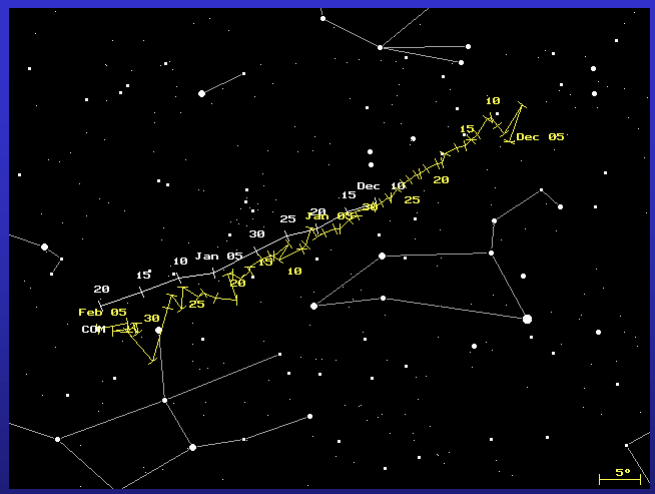


Results (XXIX)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 130	253-316	Dec 05-Feb 05	2328	268	Dec 20	3.8
COM	260-303	Dec 12-Jan 23	-	267	Dec 19	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 130	268	Dec 20	161.9	30.5	0.9 / -0.4	64 km/s
COM			176	24	0.8 / -0.3	65 km/s

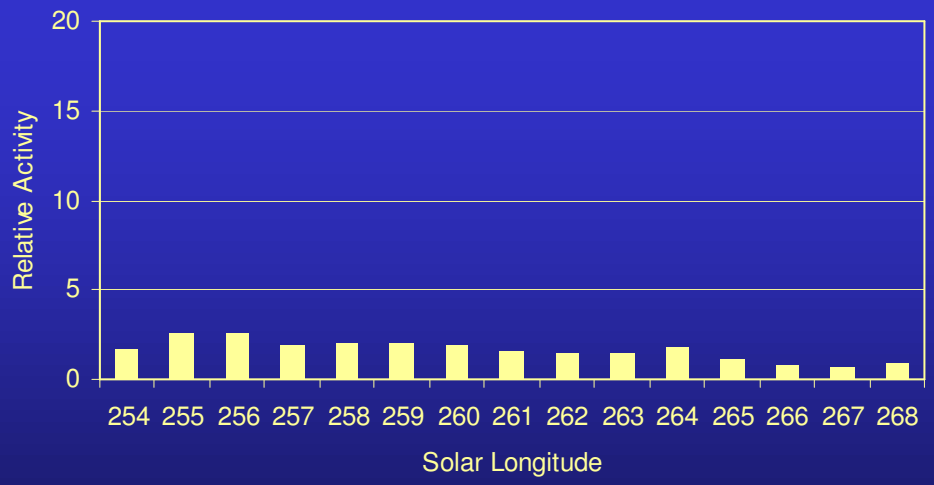


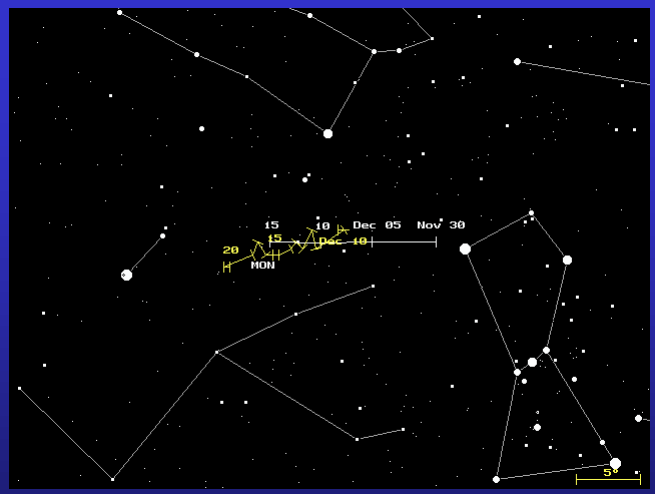


Results (XXX)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 131	254-268	Dec 06-Dec 20	630	255	Dec 07	2.6
MON	245-265	Nov 27-Dec 17	-	257	Dec 09	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 131	255	Dec 07	98.2	9.0	0.7 / -0.2	41 km/s
MON			103	8	0.9 / 0.0	42 km/s

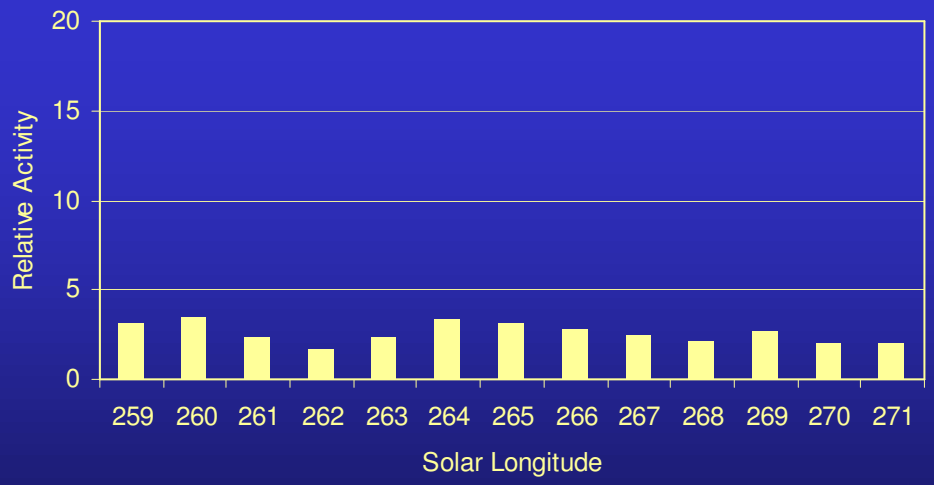


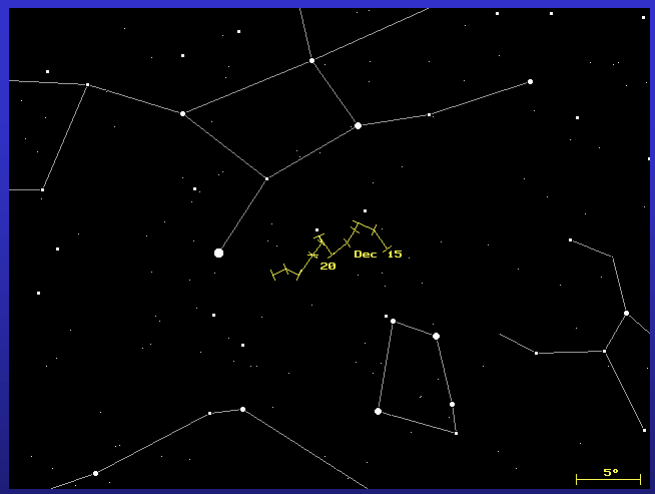


Results (XXXI)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 135	259-271	Dec 11-Dec 23	235	260	Dec 12	3.5
-	-	-	-	-		

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 135	260	Dec 12	189.1	-9.5	0.7 / -0.3	69 km/s
-			-	-	-	-

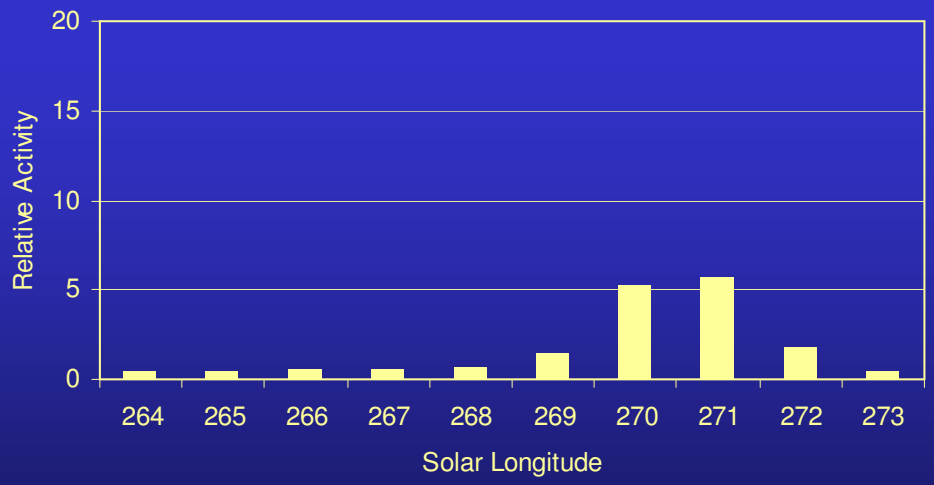


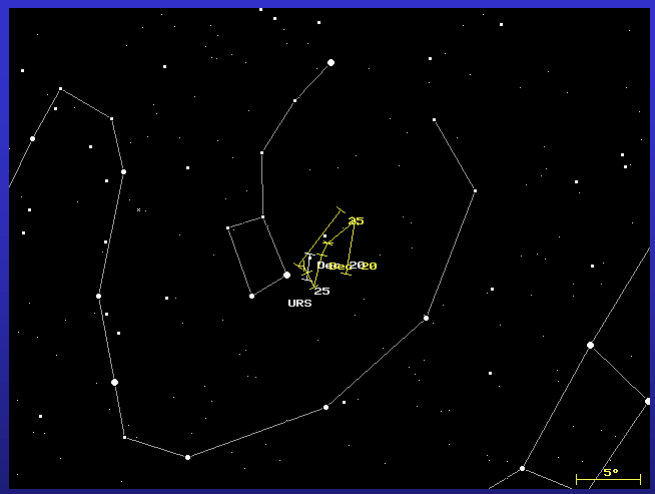


Results (XXXII)

	Period of Activity			Maximum		
	Solar Longitude	Date	Meteors	Solar Longitude	Date	Activity
Shower 139	264-273	Dec 16-Dec 25	753	271	Dec 23	5.7
URS	265-274	Dec 17-Dec 26	-	270	Dec 22	-

Mean Parameters	Solar Longitude	Date	Right Ascension	Declination	Drift	Velocity
Shower 139	271	Dec 23	218.3	75.0	1.6 / -0.2	32 km/s
URS			217	75	0.0 / -0.4	33 km/s





Summary

Summary

- Thanks to the Observability Function, the activity of meteor showers can be better compared with one another - however, there is still room for improvement
- The meteor counts are more accurate now
- There are no more interferences between nearby showers
- There is no systematic deviation anymore in the meteor shower velocities
- The data quality has further improved thanks to the larger data set

The End

Thanks for your attention!

Questions?