Activity Level and radio ZHR

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Monitoring meteor shower activity at all time

- **Radio Meteor Observation has following problems.**
  - **Geographical conditions**
    - relation between transmitting, receiving stations, etc.
  - **Observational equipments**
    - performances of transmitter,receiver,frequency,antenna and how to count etc.

it is impossible (hard work) to consider their fators.

relative value : **Activity Level Index** H.Ogawa et al. (2001)

How many times are echoes observed compared to background echoes ?

Activity Level Index

$$A(t) = \frac{H_{obs}(t) - H_{ave}(T)}{D}$$

*Not consideration of radiant elevation

Hourly Rate at site "i"	0h	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	UT
day 1	2	4	2	3	1	1	1	2	2	4	2	2	5	10	10	6	10	12	15	12	20	16	16	13	
day 2	8	9	12	6	3	6	7	4	1	2	2	4	1	4	10	5	12	8	11	16	15	12	14	13	
day 3	11	8	9	8	2	9	4	3	1	2	3	3	9	11	8	9	4	9	15	4	14	13	15	14	
day 4	5	7	6	5	3	2	4	3	2	2	3	1	6	3	7	4	6	8	14	13	8	12	5	9	
day 5	13	10	6	5	3	2	5	3	5	3	3	6	4	15	1	5	14	11	12	9	4	24	20	10	
day 6	3	3	6	5	4																	6	3	3	
day 7	7	4	2	2	4																	8	11	8	
day 8	8	10	6	7	4																	8	7	8	
day 9	8	3	1	3	4	5	4	4	4	4	3	4	13	13	8	10	10	6	6	15	5	7	8	5	
day 10	8	13	9	3	8	5	1	5	4	1	2	3	6	6	7	10	9	10	17	16	10	17	12	12	
day 11	7	12	11	3	3	3	3	3	2	2	3	3	4	3	6	9	9	7	17	10	10	11	13	13	
day 12	14														8	6	7	10	11	11	11	11	8	8	
day 13	11														8	10	20	10	11	9	12	8	18	4	
day 14	16	16	11	9	10	7	5	4	2	3	6	6	6	6	7	11	5	14	12	21	16	14			

Observed Data at site i
The period of Background is about 2weeks.

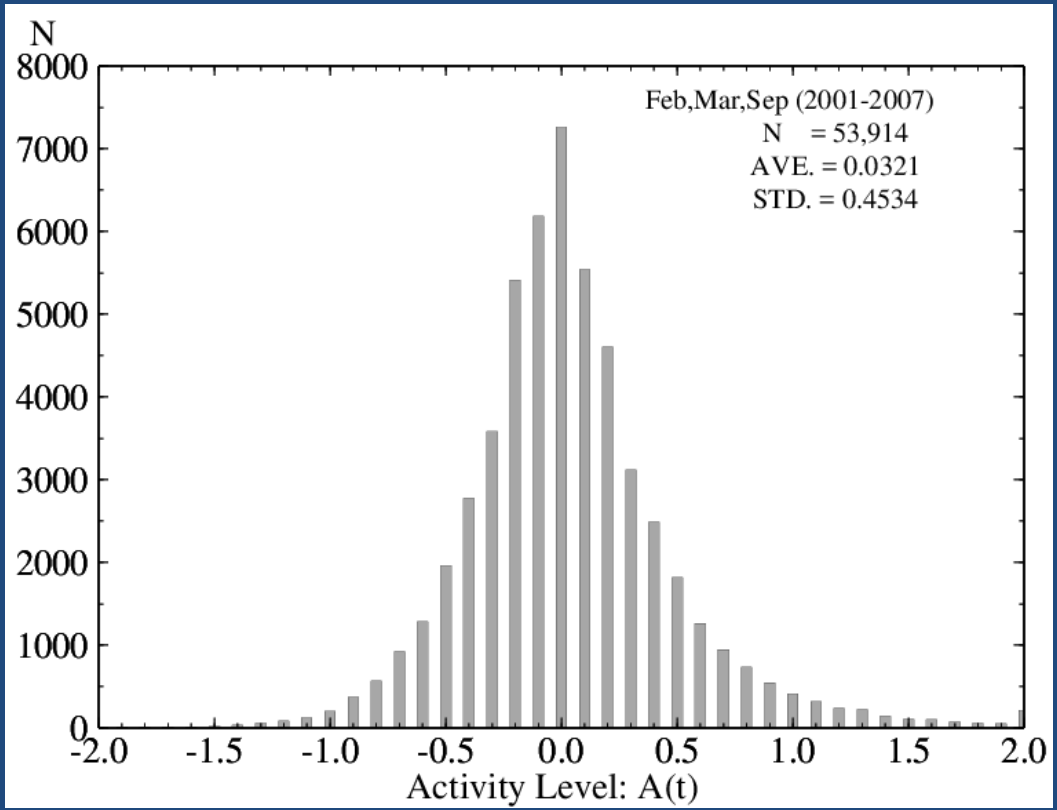
1) averaged for the period of 2weeks

2) averaged for a day

T=	0h	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	UT	D_i
H_spo_i	8.6	8.6	7.1	4.6	4.6	4.3	3.6	3.4	2.5	2.4	3.1	3.2	6.4	8.1	7.9	8.1	9.4	10.1	12.4	11.7	11.0	11.9	11.6	9.5		7.3

Activity Level Index

- Histogram of Activity Level
  for the period of without main meteor shower activities.



February, March and September in 2001 – 2007 (Japanese stations)

$0.03 \pm 0.45(1\sigma)$

Calculating processes (1)

- Calculate Activity Level $A_i(t)$ at each site i

$$A_i(t) = \frac{H_{obs,i}\,(t) - H_{ave,i}(T)}{D_i \cdot \sin h_i(t)}$$

- excluding data at low and high radiant elevation

  Only used between $20° \leq h_i \leq 70°$

In addition,
it needs to exclude error data caused by something wrong.

Calculating processes (2)

- Calculate Activity Level $A_i(t)$ at each site i

$$A_i(t) = \frac{H_{obs,i}\,(t) - H_{ave,i}(T)}{D_i \cdot \sin h_i(t)}$$

- excluding data at low and high radiant elevation

  Only used between $20° \leq h_i \leq 70$

- Calculate average value as $A_{ave1}(t)$ using all data.
- Use only data as following,

$$A_{ave1}(t) - n\sigma < A_i(t) < A_{ave1}(t) + n\sigma$$

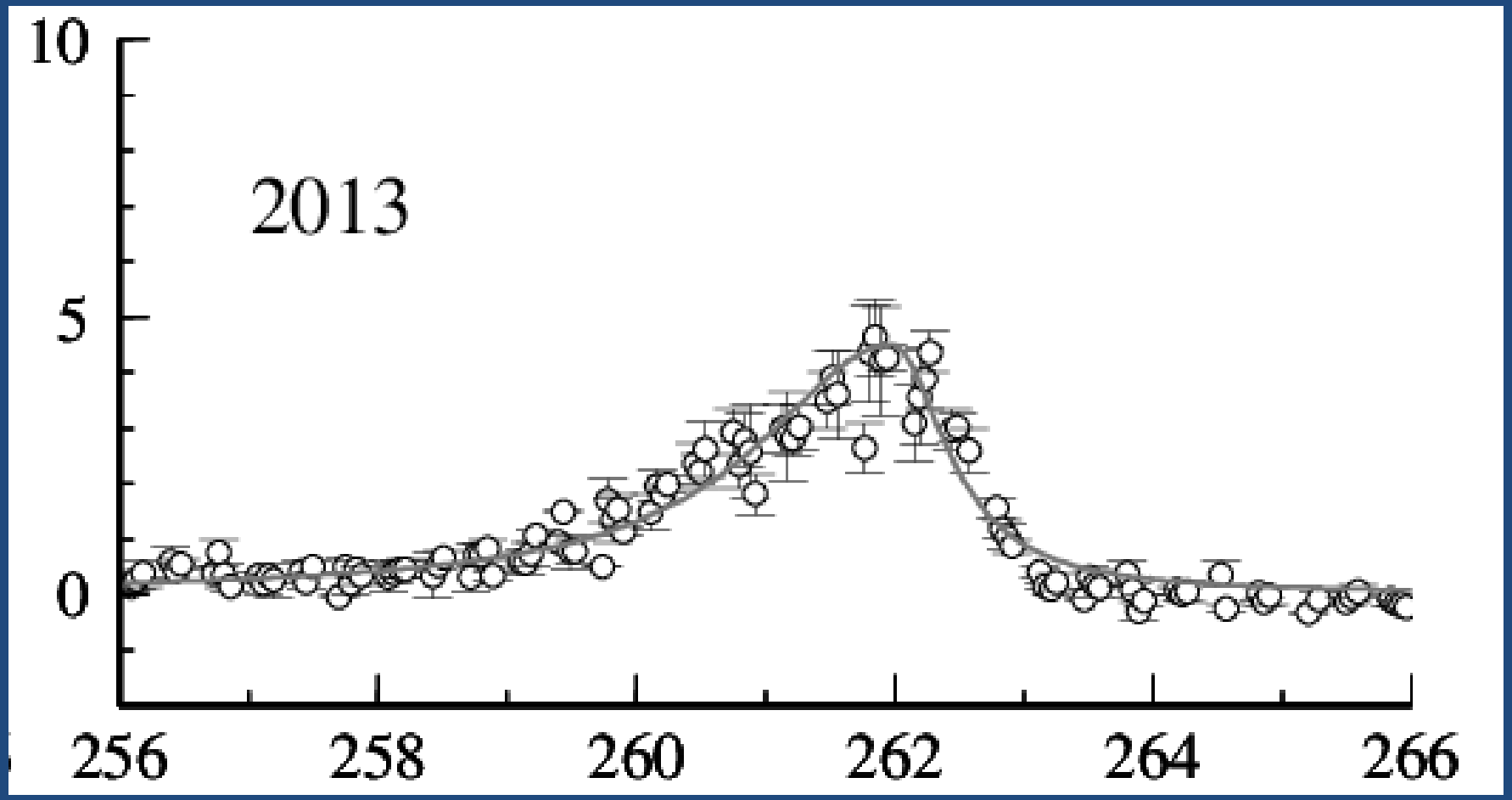
*usually n=0.75 or 1.00

- Finally, calculate average value using .

$$A(t) = \frac{1}{N}\sum_{i=1}^{N} A_i(t)$$

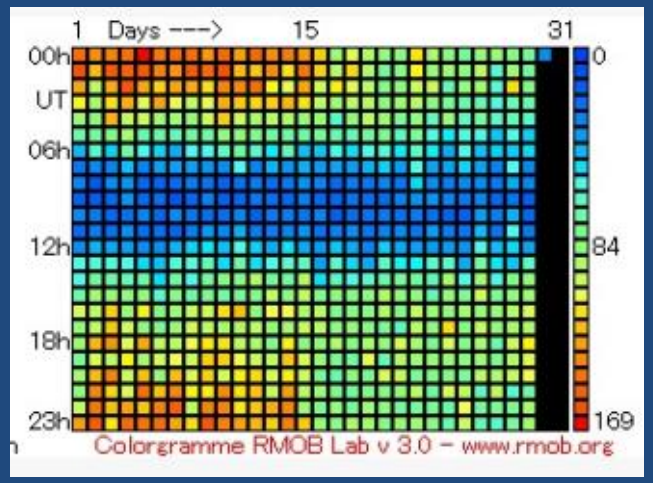
example of activity level results

- Geminis 2013



Points of calculation

- **Only use data at “stable” observing stations.**
  - Diurnal curve is clear (this is very important)
  - stable observing data (a few data loss)



diurnal variation
is clear

- **Many Observed Data are needed.**
  - The error bar becomes wide under a few observed data.

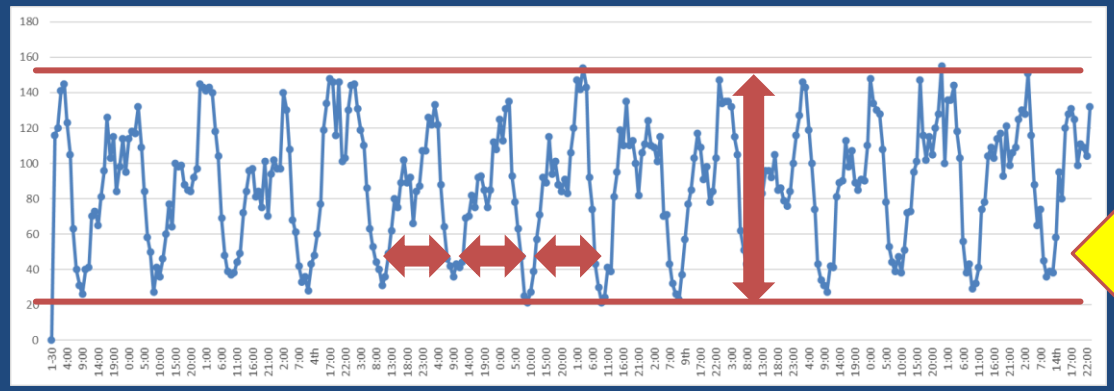
“Stable”

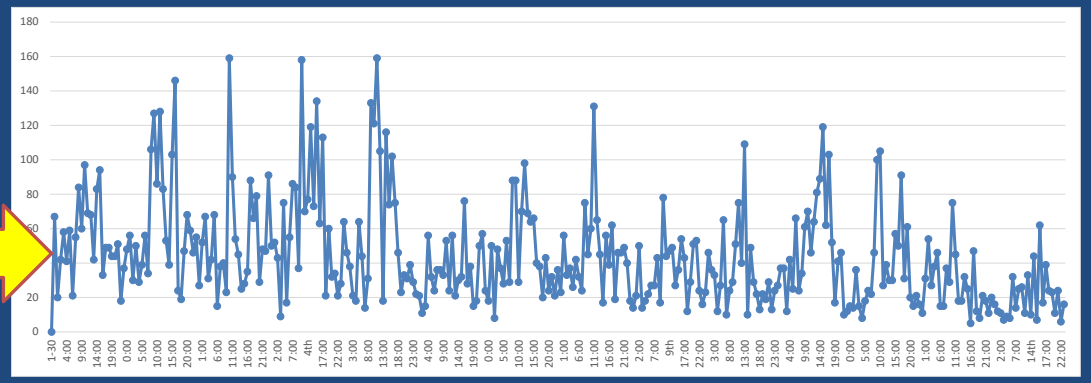
1. After average two weeks data, averaged diurnal curve shows similar to sinusoid or not.

both of graphs are located in Europe.

Left averaged diurnal curve is similar to sin-curve.
Right is not

2. For the period of 2weeks (no shower), diurnal curve is not huge change.





But I do **not decided the objectively criteria value** such as within 95% change...

- this is because there were not a lot of observed data before.
- But it might be possible to define criteria or to exclude as error data without judgement because there are many observed data recently.

Characteristics of Activity Level Index

- **Positive**
  - It is possible to use worldwide data. (= relative value)
  - We do not need to correct factors such as observing equipment and geographical conditions.
  - Calculating process is very simple.
  - Successful of calculating in many meteor showers including daytime meteor showers. (Ogawa and Steyaert, 2017)

- **Negative**
  - We do not know Activity Level is corresponding to ZHR.

trying to ZHR from Activity Level

ZHR_r is suggested

- ZHR_r is calculated by adding new factor S_{bas} to Activity Level.

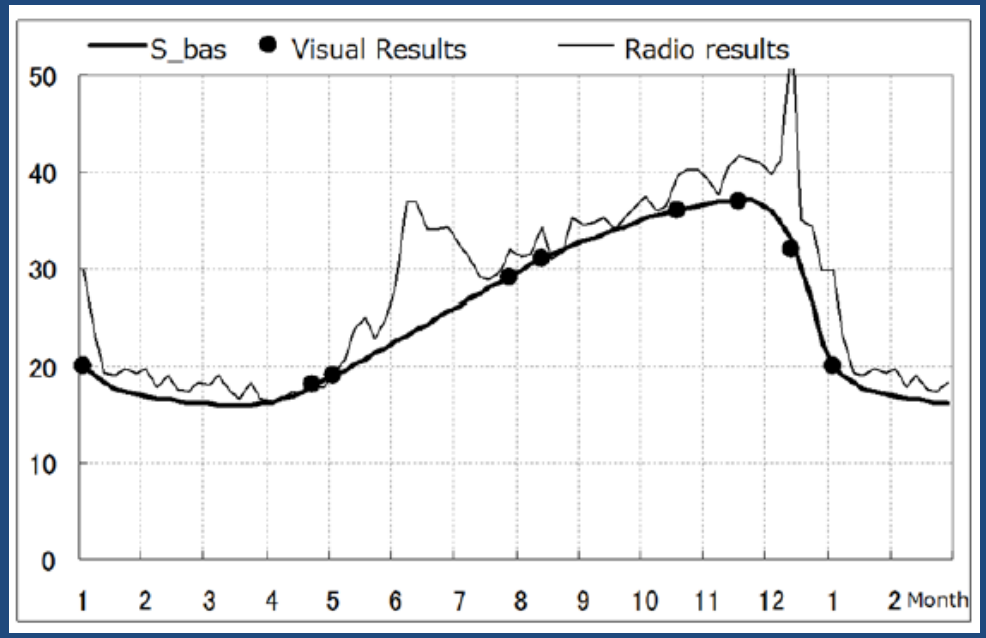
$$ZHR_r(t) = \frac{1}{N} \cdot \sum_{i=1}^{N} A_i(t) \cdot S_{bas}$$

Sugimoto (2017)

- S_{bas} is fixed function of the day.

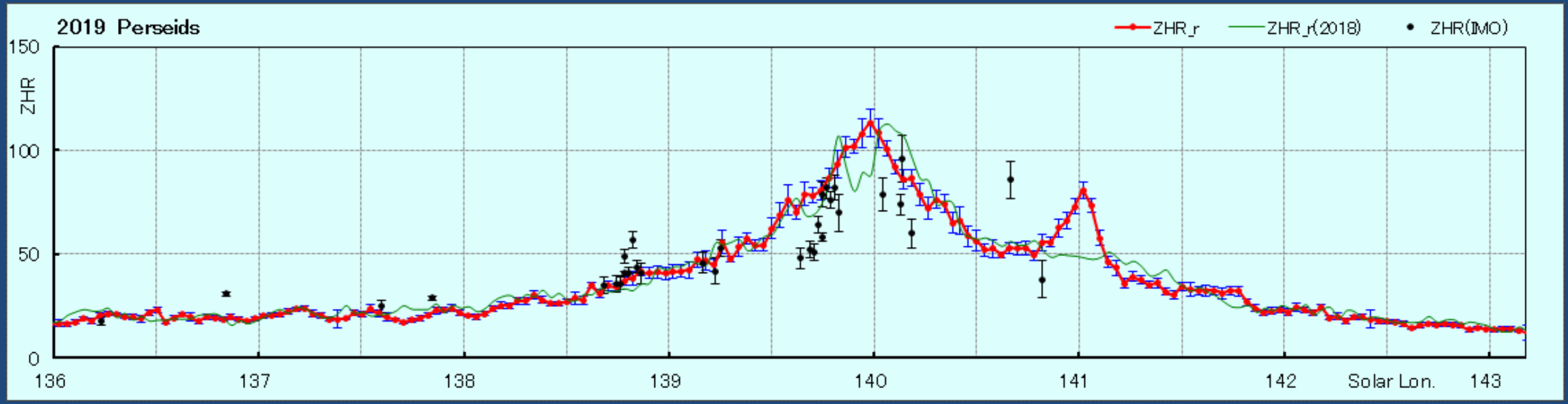
  lead by the relationship between visual and radio results.

  ---similar curve as annual curve of sporadic meteors.



Sample results of ZHR_r

- 2019 Perseids



Characteristics of ZHR_r

- Positive
  - Similar ZHR in visual is calculated by worldwide data.
  - Calculating process is simple.

- Negative
  - Detail activity profiles are different between ZHR and ZHR_r
    - We do not know weather S_{bas} is wrong or not.
      - S_{bas} , $A(t)$, or observing station environment ...

References

[1] Ogawa H., Toyomasu S., Ohnishi K., Amikura S., Maegawa K., Jenniskens P., 2002:

The 2002 Leonids as monitored by the International Project for Radio Meteor Observations. WGN 30, 225–231.

[2] Ogawa H., Steyaert C., 2017:

Major and daytime meteor showers using global radio meteor observations covering the period 2001–2016. WGN 45, 98-106.

[3] Sugimoto H., 2017:

The New Method of Estimating ZHR using Radio Meteor Observations. eMetN 2, 109-110.