

Meteor Radio Workshop

# Activity Level Index and radio ZHR

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# Agenda

- Activity Level Index :  $AL$
- Estimated ZHR :  $ZHR_r$

# What is “Activity Level Index (AL)” ?

# Motivation

## ○ Radio Meteor Observation has following problems.

### ○ Geographical conditions

- relation between transmitting and receiving stations, etc.

### ○ Observing equipment

- performances of transmitter, receiver, frequency, antenna and how to count etc.

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

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

How many times are echoes observed compared to background echoes ?

# Activity Level Index

$$AL(t) = \frac{H_{obs}(t) - H(T)}{D}$$

\*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	1																	3	3	
day 7	7	4	2	2	4																		11	8	
day 8	8	10	6	7	4	3																	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	7	
day 14	16	16	11	9	10	7	5	4	2	3	6	6	6	6	7	11	5	14	12	21	16	14			
	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
H_spo_i	8.0	8.5	6.0	5.0	4.0	5.0	4.0	3.0	2.0	2.0	3.0	3.0	6.0	8.5	8.0	9.0	9.0	10.0	12.5	11.0	10.5	11.5	12.5	9.5	D_i
																									7.1

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

①median for the period of 2weeks

②averaged for a day

# Calculating processes of Meteor Shower Activity

- calculate Activity Level  $AL_i(t)$  at each site  $i$

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

- exclude data at low and high radiant elevation

Only used between  $20^\circ \leq h_i \leq 70$

- calculate average value as  $AL_{ave1}(t)$  using all data.

- use only data as following,

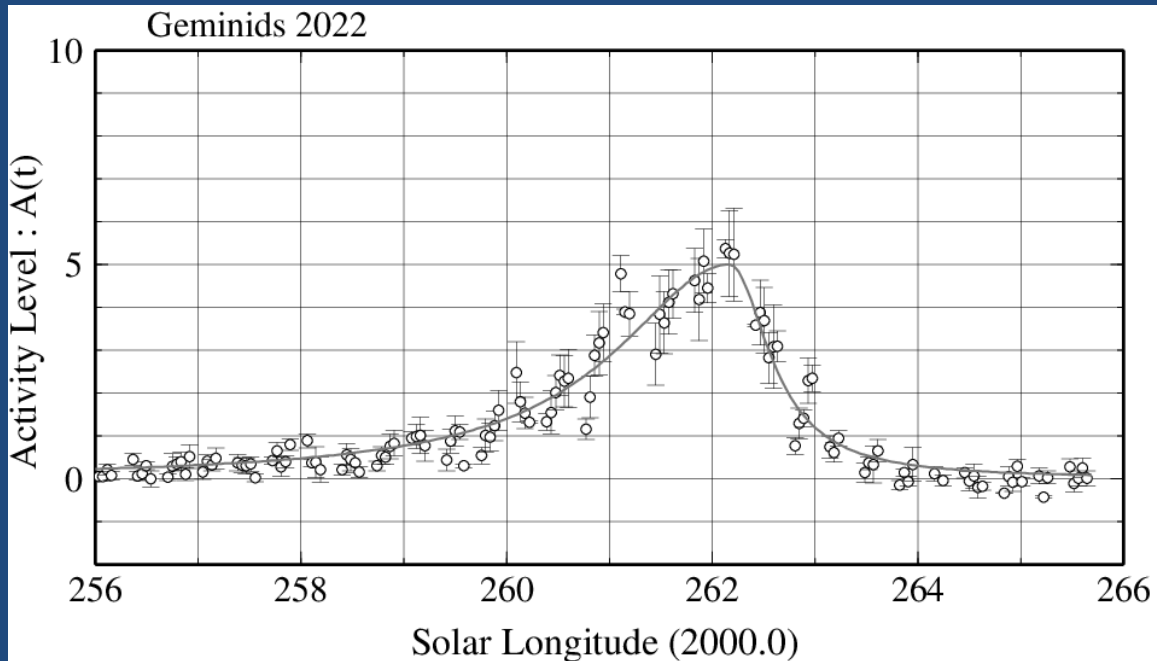
$$AL_{ave1}(t) - n\sigma < AL_i(t) < AL_{ave1}(t) + n\sigma \quad *usually n=0.50 \text{ or } 1.00$$

- Finally, calculate average value using remained data.

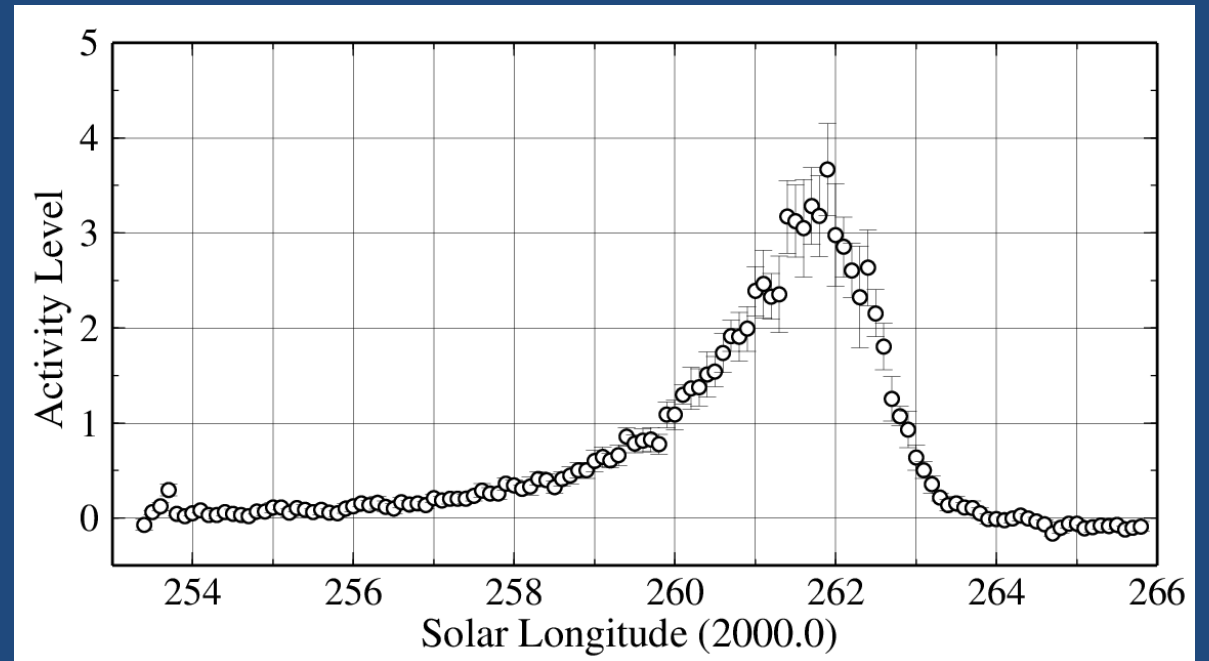
$$AL(t) = \frac{1}{N} \sum_{i=1}^N AL_i(t)$$

# Sample: a whole meteor shower activity

## ○ Geminis 2022

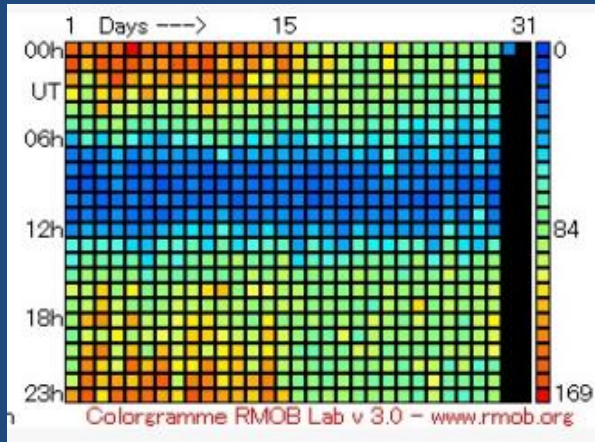


## ○ Geminis : average for the period of 2004-2021



# Points of calculation

- using data at only “stable” observing stations.
  - Diurnal curve is clear (this is very important)
  - continuous of observation (a few data loss)



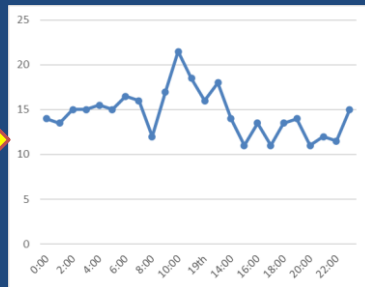
diurnal variation is clear  
with a few data loss

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



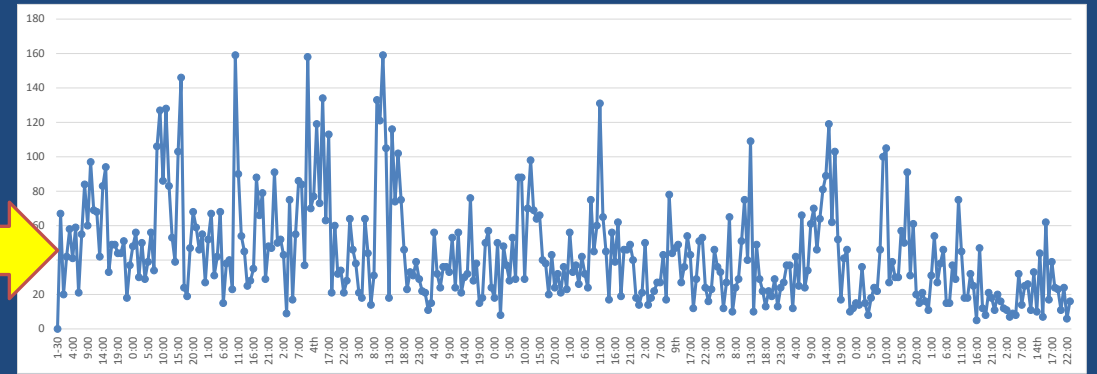
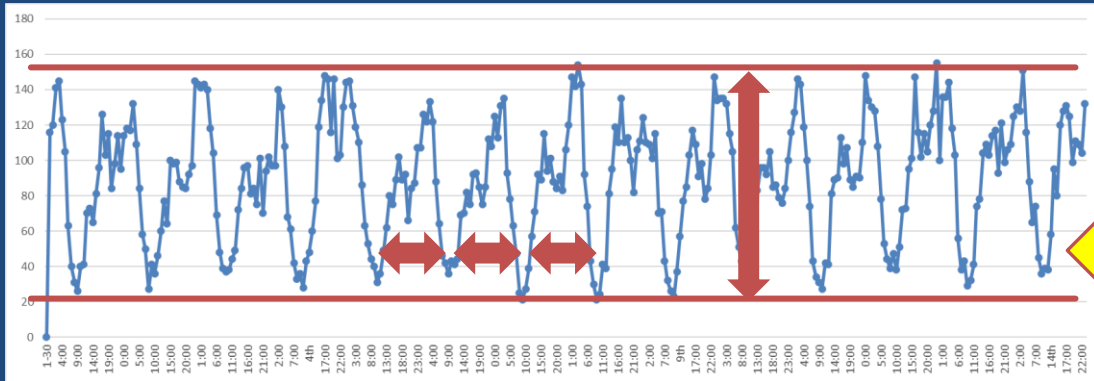
# "Stable"

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



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 a future work)

# 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 2022, Ogawa and Steyaert, 2017)

## ○ Negative

- It is **impossible to compare between meteor showers**
  - AL=1.0 of Perseids  $\neq$  AL=1.0 of Geminids
    - This is caused by a geocentric velocity and a population index.
- Activity Level is **not corresponding to visual ZHR**.

# trying to ZHR from Activity Level

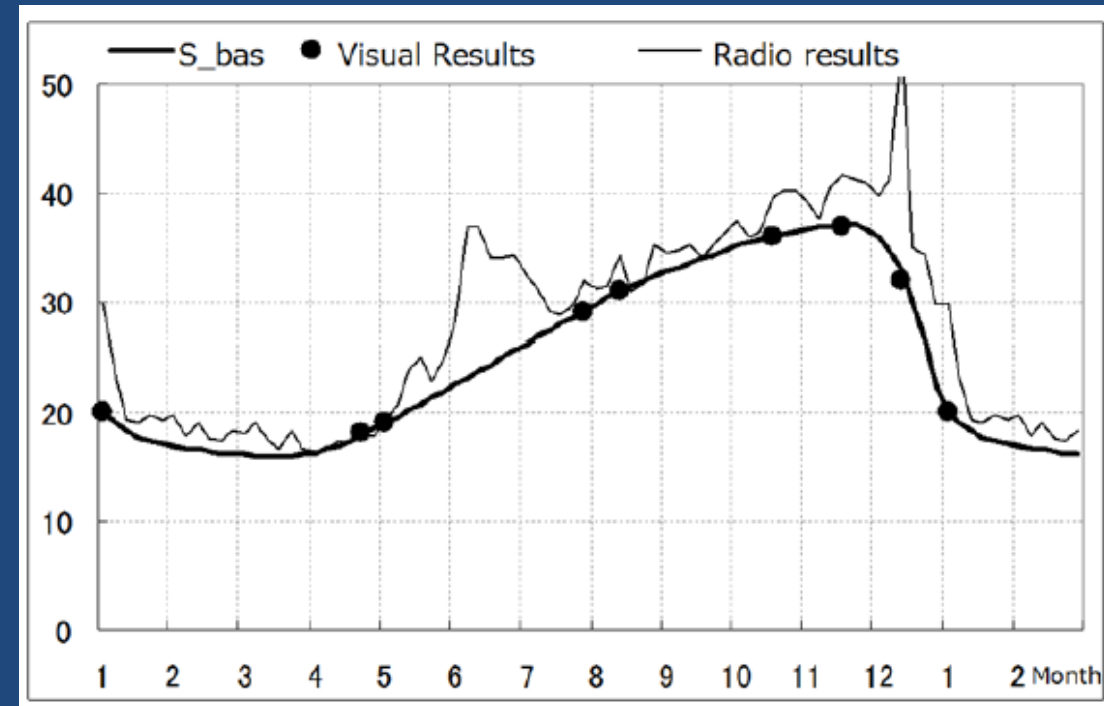
# ZHR<sub>r</sub> was suggested by Hirofumi Sugimoto

- ZHR<sub>r</sub> is calculated by adding a new factor “ $S_{bas}$ ” to Activity Level.

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

H.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.

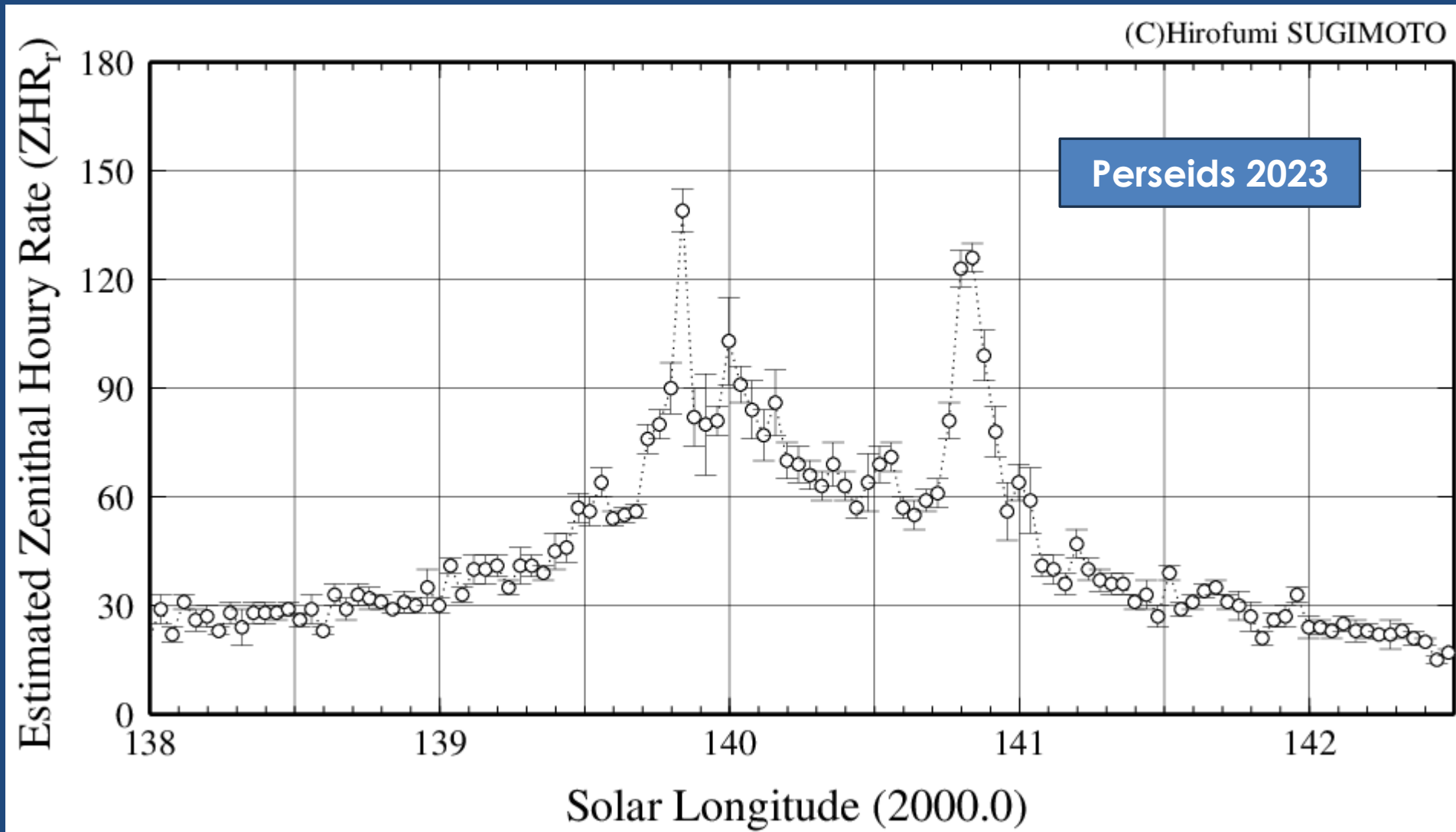


# Sample : results of ZHRr

## ○ 2020 Geminids



# Sample : Perseids 2023



# Characteristics of $ZHR_r$

## ○ Positive

- **Similar result in visual ZHR.**
- Possible to compare between meteor showers.
- Calculating process is a simple.

## ○ Negative

- Detail activity profiles are different between visual ZHR and radio  $ZHR_r$ 
  - We need to work more...

# Conclusion

- With “Activity Level Index”, it is possible to calculate average using worldwide radio data.
- $ZHR_r$  is an useful index for comparing with visual ZHR.
- IPRMO use data of
  - RMOB
  - Network in Japan (AMRO-NET) –RMOJ
- Thank you for all radio meteor observers !





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