B306

Wavelet Analysis of Thermal Activity and Cloud Initiation Based on Boundary Layer Radar and Time Lapse Camera Observation

〇Ginaldi Ari NUGROHO, Kosei YAMAGUCHI, Eiichi NAKAKITA, Masayuki K YAMAMOTO, Seiji KAWAMURA

1. Introduction

Several study are using simulation to understand the impact of thermal activity towards the cloud development [1]. In this study, wavelet analysis and also combined observation are used to observe the connection between thermal activity and cloud generation process. This combined observation are utilizing time lapse camera and high resolution Boundary Layer Radar (BLR) in the urban area of Kobe Japan during summer season.

BLR with high resolution setting are utilized to observed small air perturbation affected by thermal (surface heating). From time lapse camera pointing upward, the first generated cumulus cloud are observed. Location of the camera is in the same location of the BLR. Analysis using wavelet coherence between thermal activity and cloud image are conducted to find the relationship between these two parameters.

2. Data and Methodology

Two primary data are used in this study. First data is the BLR. Product of BLR used in this study are the vertical velocity and echo power. This data are retrieved using time interval of 8.192 s with range sampling of 30-m intervals. Second data is the image from time lapse camera. Image sequence are collected with the interval of 5 frame per second (fps). The image from camera (RGB format) are then transformed into grayscale in order to be able to quantized and compared with the BLR data. Grayscale value represent object in one color (shades of gray), so we could distinguish the present of the cloud from the amount of pixel of grayscale. Location of this study is in Kobe (34°39'56.87"N and 135°8'34.66"E) of Japan.

Wavelet coherence is used to analyze the relationship between two datasets [2]. In this study, we only showed one case study on 5 September 2018 from 11.48 JST until 11.52 JST. Before applying the wavelet, normalization is conducted into these two datasets (grayscale and vertical velocity time series). Morlet are used as mother wavelet in this wavelet analysis.

3. Result and Discussion

Figure 1 is the BLR product data of vertical velocity and echo power. Vertical velocity data in Fig 2a showed a coherent structure of updraft from 11.49 JST until 11.51 JST. This coherent structure is representing the thermal activity that occur. Thermal are reached up to 1260 m and lasted about 2 min. Thermal is also seems to pushed the stable layer for about 150 m from previous elevation (in the range of 900 m) from echo power data in Fig 2b.

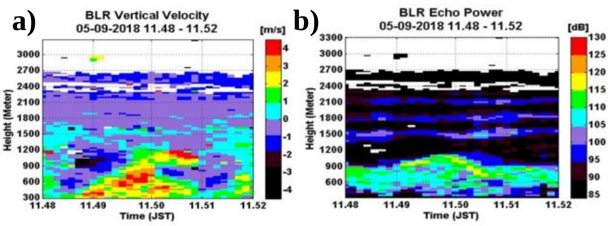

Figure 1. BLR product in case study 5 September 2018 from 11.48 until 11.52 JST, a) Vertical velocity, b) Echo power.

Figure 2 is the image from time lapse camera. The upper part is the image sequence of the first generated cloud, meanwhile the lower graph is the digitize grayscale value of the cloud cover of the image. Compared the image sequence and the BLR vertical velocity profile showed that BLR can capture the updraft inside the cloud at height 900-1200m after 11.50 JST. The maximum updraft at this period are located in the upper part of the cloud which means the cloud is still growing after generated.

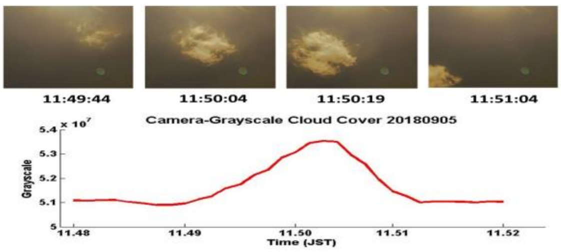

Figure 2. Image sequence and grayscale value of the cloud cover image from time lapse camera.

Wavelet coherency are applied on grayscale cloud cover from image camera with both of BLR product data (vertical velocity and echo power) on each height. Figure 3 is the example of wavelet coherency result between camera grayscale and BLR product in height 660 m. In this height, the maximum updraft (4.6 m/s) of thermal are located. Correlation value from the wavelet coherency power spectrum showed strong correlation with high significant value in period 11:49:04 JST (First target) and 11:49:59 JST (Second target). From these two-correlation value, the phase coherency has different phase (based from arrow direction). In the first target, the dominant direction is left arrow. This means that phase coherence is anti-phase between grayscale and vertical velocity. Meanwhile in second target, dominant direction is right arrow which means the phase coherency is in-phase. Anti-phase coherence is very interesting because it showed that thermal have not only good correlation but also an early timing compared with cloud existence.

Focused on the first target, the correlation is occurred from 11:49:04 JST until 11:50:54 JST. The correlation is also located in the region between 1 until 2 min period (in y-axis). This showed that the pattern of the vertical velocity in height 660 m is occur from period of 1 until 2 min with anti-phase characteristic. This method will be applied to other seven case study to gain more information on this relationship between thermal activity and early stage of cloud initiation.

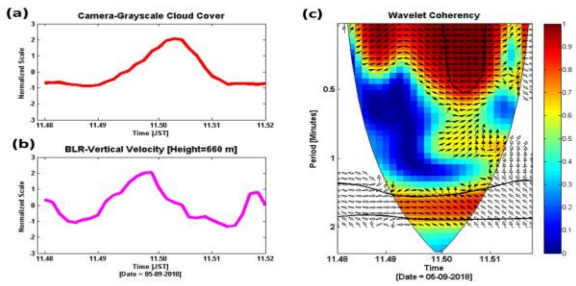

Figure 3. Wavelet coherency, (a) Camera grayscale, (b) BLR Vertical Velocity, (c) Wavelet coherency result.

4. Conclusion

Thermal activity is observed during the first generated of cumulus cloud (based from case study 5 September 2018 from 11.48 JST until 11.52 JST). During first generated cumulus cloud, BLR can capture the updraft inside the cloud. BLR can also capture thermal activity which has maximum height above 1km with maximum updraft located in the 660 m. Using wavelet analysis, showed strong coherence on 11:49:04 JST, with anti-phase pattern, and also period of 1 min until 2 min. This study showed possible relation between thermal and cloud initiation from observation result.

References

1. Yamaguchi, K.,Takami, K., Inoue, M., and Nakakita, E, “Development of Meteorological Model Based on Large-Eddy Simulation in Consideration of Urban Effects To Understand Convection Genesis”, JSCE, Vol 72(4), I_205-I_210, 2016.
2. Erick K.W.Ng and Johny C.L.Chan, “Geophysical Application of Partial Wavelet Coherence and Multiple Wavelet Coherence”, Journal of Atmospheric and Oceanic Technology, Vol 29, pp 1845-1853, 2012.