Answers to the comments of NHESS-2018-357-RC2-supplement

We thank to reviewer of RC2-supplement for his/her productive comments and keen insight. He/she not only indicated the crucial points in our research but also suggested the way how to improve them. Thanks to the comments, the manuscript has been revised as follows.

**General comments:**

• The goal of this study is very clear. However, I believe that using solely 8 clouds to draw conclusions on the difference in lead time between the old and new observational satellite data is too little. The authors need to include much more data, i.e., increase the amount of observed clouds, simply by extending the amount of observation days (now only 10 & 11 Aug 2017). Why not using for instance all the thunderclouds observed in August 2017 & 2018?

Only eight clouds are a small number to show enough conclusions. We selected clouds that occurred during the day and night in July and August 2017. We added a total of 60 cloud cases, 30 per month. Specifically, Table 1 shows information about cloud data. It's a good idea to add 2018 data. However, we didn't have enough time to get the 2018 data. Instead, we used data for two months in 2017 which are July and August, when tropical clouds were frequently observed each year.

p. 10

**Table 1. The observation time and number of observed clouds in this study.**

| Date | Observation time | Number of observed clouds |
|---|---|---|
| July, 2017 | 03:00 - 06:50 UTC (Day)<br>21:00 - 24:50 UTC (Night) | 20<br>10 |
| August, 2017 | 03:00 - 06:50 UTC (Day)<br>21:00 - 24:50 UTC (Night) | 20<br>10 |

• Fig 1 & 2 only include the data based on the new satellite observations. I believe its worthwhile to include in the figures as well the behavior of the virtual (lower resolution) data. In this way it is easy for the reader to see the difference between the two.

I totally agree with this comment. Figures have revised for the reader to compare high-resolution and low-resolution data.

p. 13

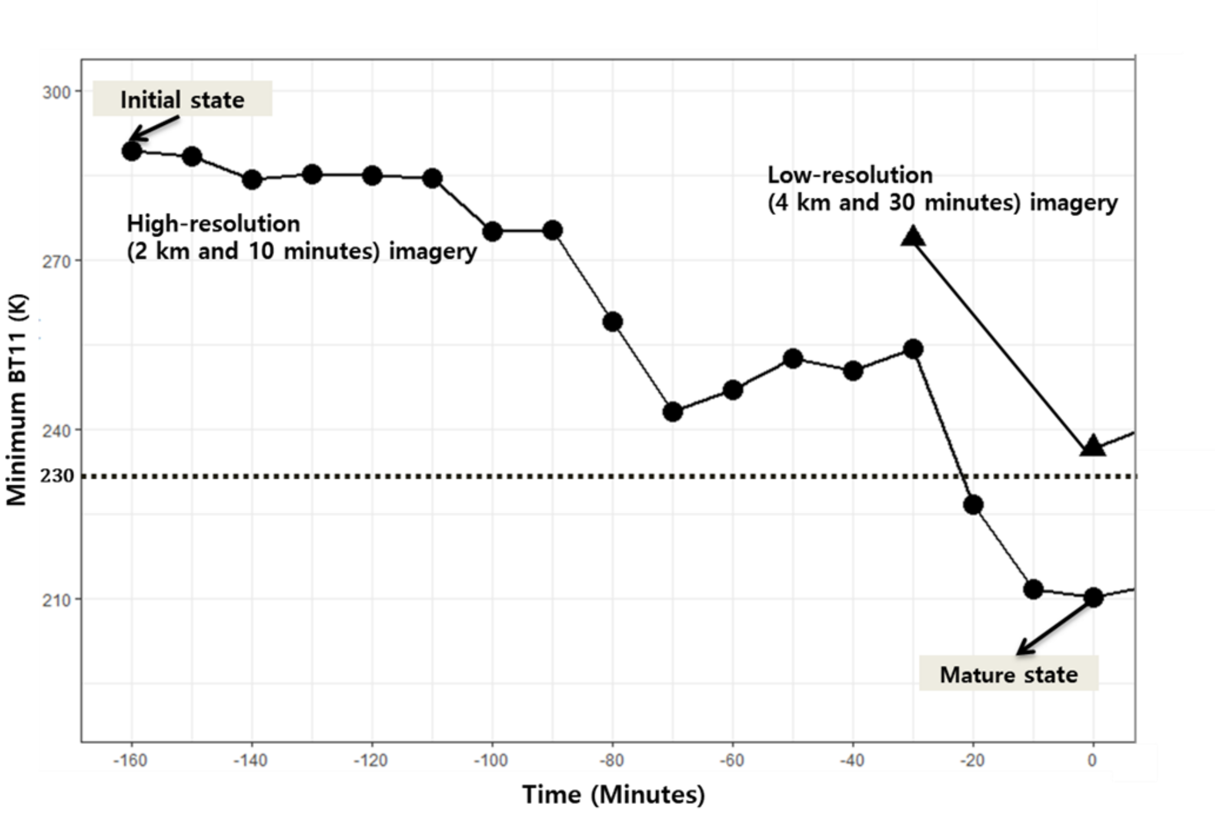



Figure 2. An example of temporal changes in minimum BT11 among thunderstorm pixels (10 August 2017, 03:10-05:50 UTC) for the high-resolution (2 km and 10 minutes) imagery (circle) and the low-resolution (4 km and 30 minutes) imagery (triangle). In this study, the lead time is defined as the time between the initial state and the mature state (time 0). The negative sign of time indicates the time ahead of the mature state of a tropical thunderstorm

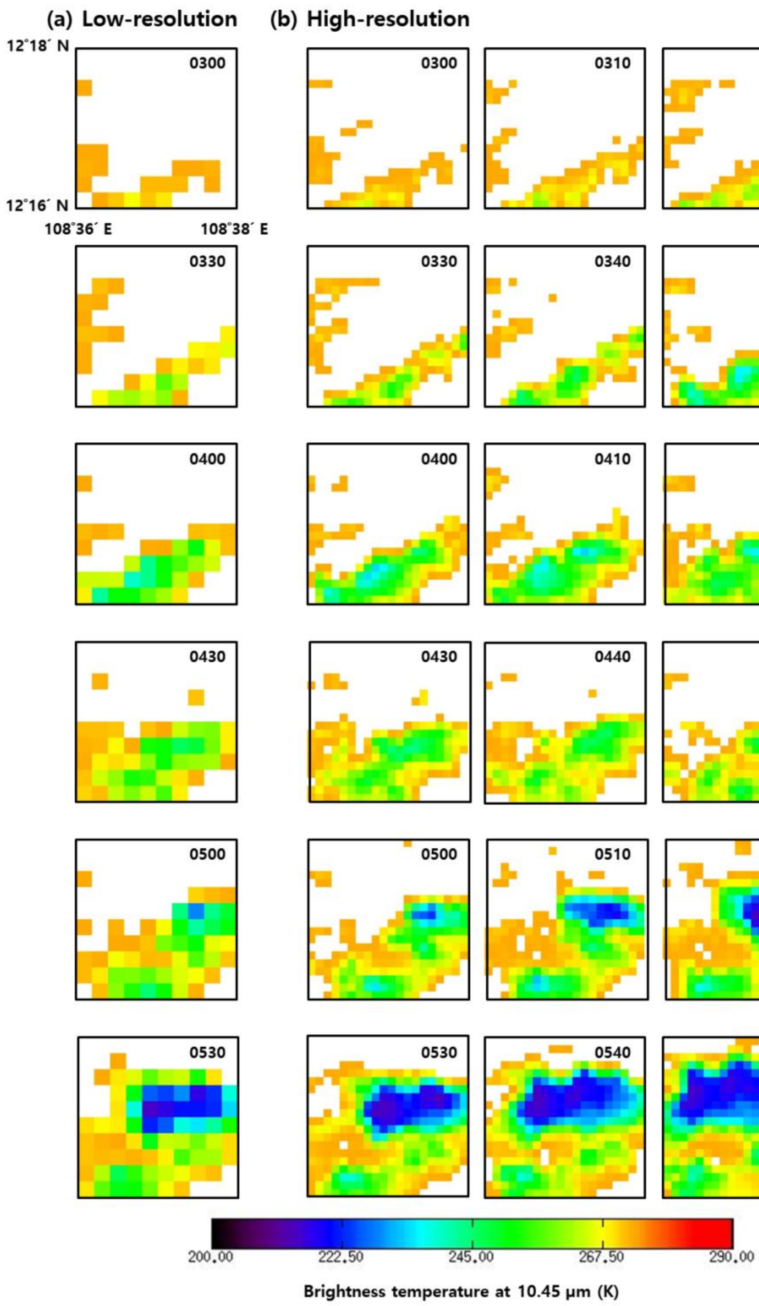



**Figure 3. An example of the thunderstorm development process through BT11 images (10 August 2017, 03:00-05:50 UTC); (a) the low-resolution (4 km and 30 minutes) imagery and (b) the high-resolution (2 km and 10 minutes) imagery**

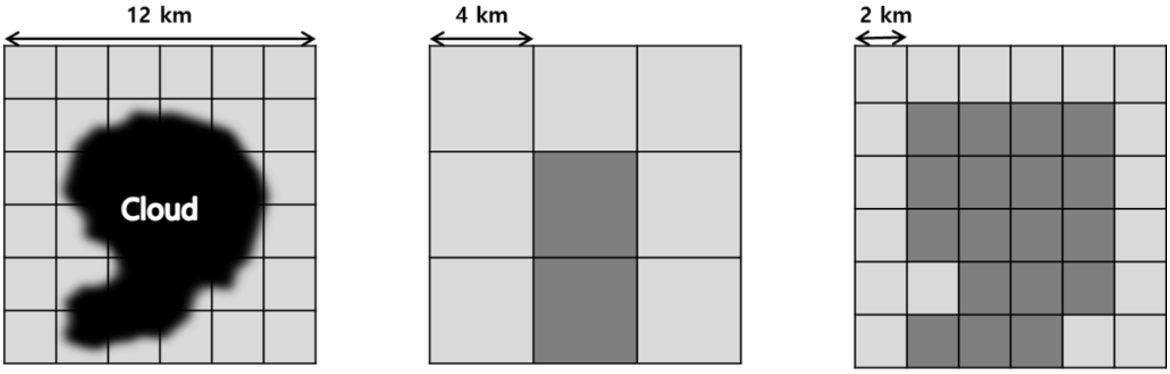



Figure 4. Illustrations of 12 × 12 km pixels with different resolutions. The dark grey indicates the cloudy pixel, and the light grey indicates the clear-sky pixel. Only 2 cloudy pixels can be detected with the 4 km resolution imagery; in contrast, 18 cloudy pixels can be detected with the 2 km resolution imagery. The number of pixels at the cloud boundary varies depending on the resolution.

**Specific comments (chronological in appearance):**

**The new manuscript has changed the number of lines and pages.**

**1. Introduction:**

• p1, L27, typo: "… lead to extensive economic losses"

Corrected as below

p. 2, line 6

These severe events lead to extensive economic losses, environmental degradation, and subsequently, damage to human life.

• p2, L10/11: please rephrase "should be grounded" in this sentence. It is not clear what you mean.

Removed

• p2, L16: "(briefly, min)": what do you mean?

Removed.

• p2, L20/21: "Moreover, … measurements": there are of course advantages using satellite in stead of ground-based observations, but also disadvantages. A network of radars, such as NEXRAD in the US or OPERA in Europe do provide high-resolution precipitation observations over a large area continuously with a higher spatial resolution compared to satellite observations.

This is very helpful comment. We added to the manuscript that some countries are using high-resolution radar system as well as satellites as follows.

p. 2, line 14 – 19

Not only is the model itself insufficient, but the observational data to support the modeling are also insufficient. To make matters worse, unlike the middle latitudes, the tropical atmosphere is conditionally unstable, making the models hard to predict tropical thunderstorms. Hence, alarms for the hazards in the tropics are generally managed by the nowcasting system by real-time observations from radar and meteorological satellites. For example, European Operational Program for Exchange of Weather Radar Information (OPERA) do provide precipitation data over a large area continuously with a higher spatial resolution compared to satellite observations (Huuskonen et al., 2014).

## 2. Data and Method

• p2, L30-p3,L2: so is this the only reason why the authors chose this particular region to investigate?

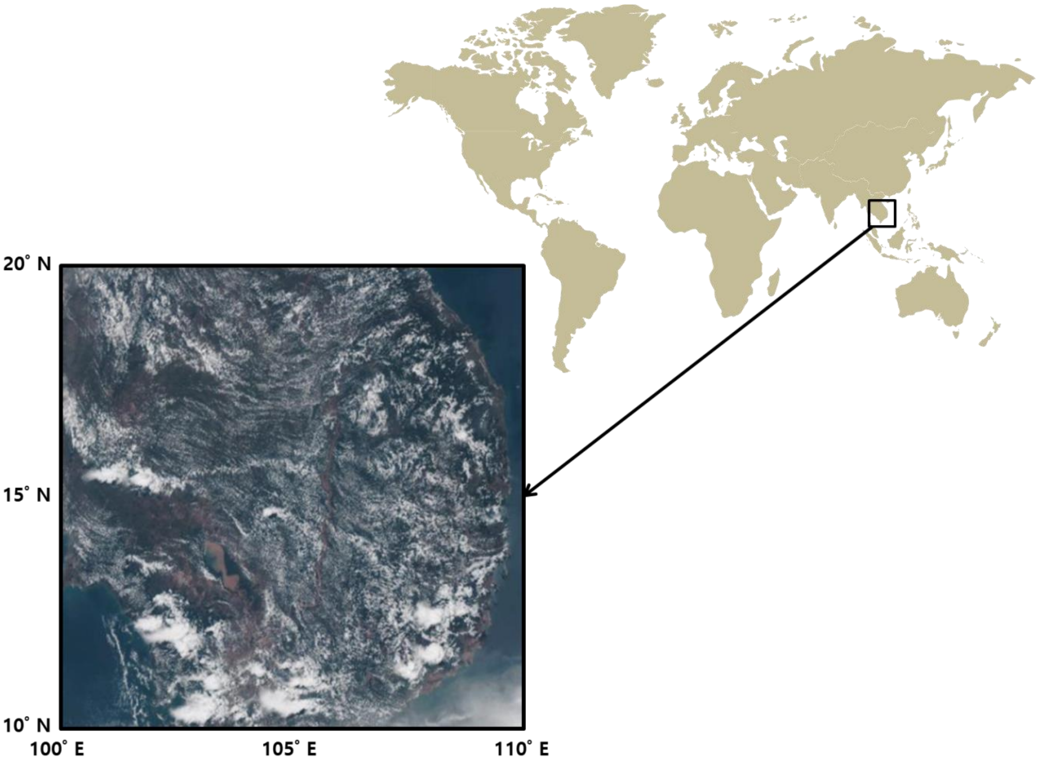



**Figure 1. Himawari-8 AHI RGB image taken for this study area on 19 August 2015, 05:50 UTC. Several convective clouds (white color) are shown in the southern part of the area**

p. 3, line 4 – 12

The region of interest of this study is from 10°N to 20°N and from 100°E to 120°E, which is closely related to the Mekong River Commission. The Mekong River Commission is the only inter-governmental organization that works directly with the governments of Cambodia, Lao PDR, Thailand, and Viet Nam to jointly manage the shared water resources and the sustainable development of the Mekong River (Jacobs, 2002). Unfortunately, this is known as a vulnerable disaster region because of a high risk of extreme weather. As changes in weather patterns are being felt across the Mekong River Commission, the impacts of climate change have become a strong issue. The warmer atmosphere can contain more moisture, which increases the potential to invigorate thunderstorms if all else being equal. It is generally assumed that the temperature increase associated with global climate change will lead to increased thunderstorm intensity and associated heavy precipitation events (Schefczyk et al. , 2015).

• p3, L6: please rephrase " ...dramatically uprising in the clean sky"

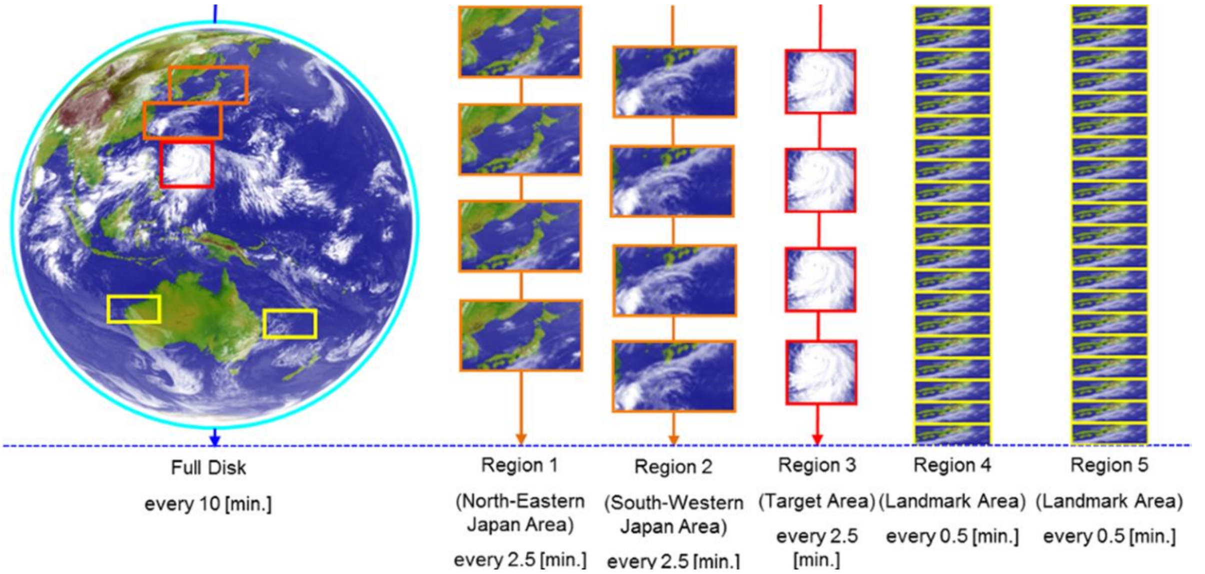
"Corrected as below"

p. 3 line 23

convective clouds which are developing within 2 hours in the clear sky

• p3, L11,12: Regions 1, 2 and 3 are mentioned in the text but its not totally clear where those are located. A new figure indicating the three regions would clarify this.

The observation range and time interval vary for each area in Himawari-8 AHI observation. In Southeast Asia, it does not belong to specific targeted regions which are from Region 1 and Region 5.like below.




Thus, this study only observed the Southeast Asia, high-resolution data provided per 10-minutes were used. Different time cycles of observation for each region are not covered in detail.

• p3, L14: Reference to JMA/MSC is now “2017”, however, in the reference list it is “2018”

Corrected as below

p. 3, line 28

(JMA/MSC: Himawari-8/9 Imager (AHI), 2018).

• p3, L29: “… whose resolution is similar to the MTSAT ...”

Corrected as below

p. 4, line 1

In order to carry out this study, we make virtual data whose resolution is similar to the MTSAT

**3. Determining thunderstorm pixels and defining the lead time**

• p3, L31: please add a reference(s) for " … BT11 of clouds, which insofar, has been shown to be highly associated with the predictability of thunderstorms [references]"

References are written and rearrange the paragraph

p. 4, line 10-15

60 thunderstorms are subjectively selected based on the RGB images over Southeast Asia. Sizes of selected thunderstorms are less than 120 km since those convective-scales typically accompany precipitation (Houze, 2004). We set the target boundaries depending on the thunderstorm size and the specific locations of thunderstorms are different. In that target boundary, BT11 values are monitored to determine thunderstorm pixels and phases (initial/mature states) for the whole life cycle of thunderstorms. It is because temporal changes in BT11 inform vertical drift velocity, the current status of clouds and diagnose the probability of imminent heavy rains/lightning soon (Vila et al., 2008).

• p4, L8: please rephrase "… time passed from when the ..." into " time in between the

cloud … and ..."

Corrected as below

p. 4, line 24

The lead time is defined as the time between the initial state and the mature state.

• p4, L15: reference (Houze, 204) → 2004

Corrected as below

p. 5, line 15

(Houze, 2004)

**4. Improved predictability by comparing lead time differences**

• p4, L25: please rephrase: “the sooner early clouds”

Rephrased as below

p. 7, line 2 - 3

To reduce the risk of natural disasters after occurring thunderstorms, the long lead time is beneficial to disaster risk reduction.

• p4, L26 add references: “Some previous studies have shown … [references]”

Corrected as below

p. 4, line 10 - 11

60 thunderstorms are subjectively selected based on the RGB images over Southeast Asia. Sizes of selected thunderstorms are less than 120 km since those convective-scales typically accompany precipitation (Houze, 2004).

• p4, L29: 8 clouds are not a lot to build your conclusions upon

We added a total of 60 cloud cases. Table 3 shows the result of lead time according to imagery.

**Table 3. The lead time according to imagery for cloud No. 1-20 occurred in the daytime of July 2017, No. 21-30 in the nighttime of July 2017, No. 31-50 in the daytime of August 2017, and No. 51-60 in the nighttime of August 2017.**

| No. | Cloud-scale (km) | Lead time (min) | | Lead time difference (min) (A minus B) |
|---|---|---|---|---|
| | | 2 km and 10 min imagery (A) | 4 km and 30 min imagery (B) | |
| 1 | 120 | 180 | 60 | 120 |
| 2 | 104 | 160 | 30 | 130 |
| 3 | 120 | 140 | 30 | 110 |
| 4 | 120 | 180 | 30 | 150 |
| 5 | 120 | 180 | 60 | 120 |
| 6 | 40 | 130 | 30 | 100 |
| 7 | 40 | 140 | 0 | 140 |
| 8 | 44 | 120 | 0 | 120 |
| 9 | 64 | 120 | 30 | 90 |
| 10 | 40 | 180 | 60 | 120 |
| 11 | 40 | 130 | 0 | 130 |
| 12 | 48 | 90 | 0 | 90 |
| 13 | 96 | 180 | 60 | 120 |
| 14 | 104 | 120 | 0 | 120 |
| 15 | 120 | 140 | 30 | 110 |
| 16 | 80 | 180 | 60 | 120 |
| 17 | 56 | 100 | 0 | 100 |
| 18 | 80 | 180 | 30 | 150 |
| 19 | 96 | 180 | 0 | 180 |

| | | | | |
|---|---|---|---|---|
| 20 | 56 | 100 | 0 | 100 |
| 21 | 40 | 160 | 0 | 160 |
| 22 | 72 | 150 | 30 | 120 |
| 23 | 120 | 140 | 30 | 110 |
| 24 | 96 | 120 | 30 | 90 |
| 25 | 84 | 130 | 0 | 130 |
| 26 | 100 | 180 | 60 | 120 |
| 27 | 60 | 100 | 0 | 100 |
| 28 | 100 | 130 | 0 | 130 |
| 29 | 104 | 120 | 0 | 120 |
| 30 | 96 | 180 | 60 | 120 |
| 31 | 100 | 120 | 30 | 90 |
| 32 | 32 | 100 | 0 | 100 |
| 33 | 48 | 120 | 30 | 90 |
| 34 | 100 | 180 | 30 | 150 |
| 35 | 112 | 180 | 60 | 120 |
| 36 | 64 | 120 | 30 | 90 |
| 37 | 100 | 180 | 60 | 120 |
| 38 | 96 | 140 | 0 | 140 |
| 39 | 68 | 120 | 0 | 120 |
| 40 | 80 | 130 | 30 | 100 |
| 41 | 44 | 90 | 0 | 90 |
| 42 | 60 | 100 | 0 | 100 |
| 43 | 100 | 120 | 0 | 120 |
| 44 | 96 | 120 | 30 | 90 |
| 45 | 68 | 100 | 0 | 100 |
| 46 | 88 | 140 | 30 | 110 |
| 47 | 108 | 180 | 30 | 150 |
| 48 | 124 | 180 | 60 | 120 |
| 49 | 104 | 140 | 0 | 140 |
| 50 | 100 | 120 | 0 | 120 |
| 51 | 120 | 130 | 30 | 100 |
| 52 | 66 | 110 | 0 | 110 |
| 53 | 80 | 130 | 0 | 130 |
| 54 | 120 | 180 | 60 | 120 |
| 55 | 120 | 100 | 0 | 100 |
| 56 | 40 | 180 | 30 | 150 |
| 57 | 56 | 180 | 0 | 180 |
| 58 | 56 | 100 | 0 | 100 |
| 59 | 88 | 160 | 0 | 160 |
| 60 | 92 | 180 | 30 | 150 |

• p5, L2: what is meant with “the floating population”?

Removed

• P5, L7/8: remove the brackets “(...)”

Removed

• p5, L19: What is meant with “it is difficult to reflect the whole cloud”

Corrected as below

p. 5, line 27-31

To monitor the rapid development of the thunderstorm within 2 hours, it is better to consider the influence of the resolution on the boundary of the clouds. The higher the resolution, the more precisely the change rate of minimum BT11 is per pixel. The low-resolution imagery cannot detect cloudy pixels whose scale is between 2 km and 4 km. For example, only one cloud pixel can be reflected on the area of 16 km2 in the case of 4 km resolution imagery per 30 minutes; whereas, four cloud pixels can be reflected on the same area in the case of 2 km imagery per 10 minutes.

• p5, L18-L31: it would be worthwhile to include in Figure 2 the behaviour of the "virtual" lower resolution MTSAT data. In that way, the reader can check visually directly the difference for this particular case.

"Yes, that's good point. Figure 2 is modified."

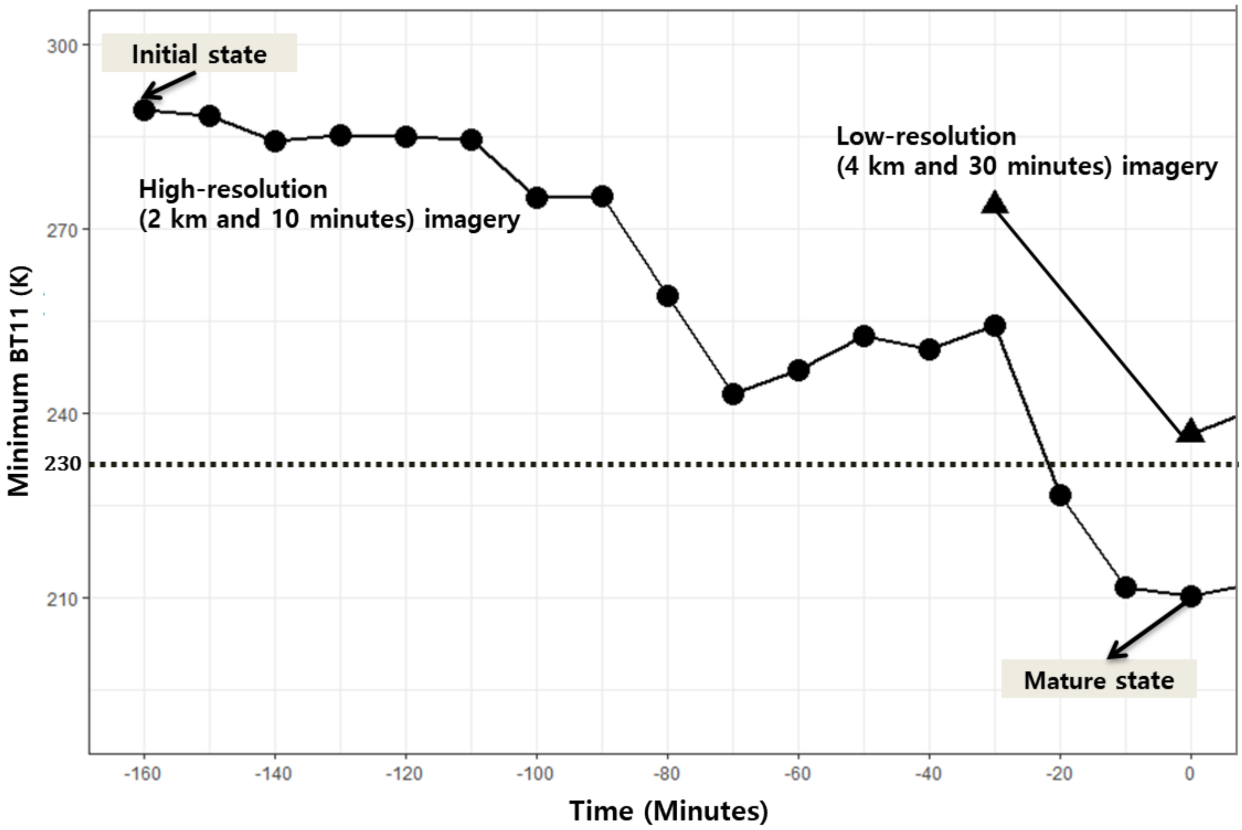



**Figure 2. An example of temporal changes in minimum BT11 among thunderstorm pixels (10 August 2017, 03:10-05:50 UTC) for the high-resolution (2 km and 10 minutes) imagery (circle) and the low-resolution (4 km and 30 minutes) imagery (triangle). In this study, the lead time is defined as the time between the initial state and the mature state (time 0). The negative sign of time indicates the time ahead of the mature state of a tropical thunderstorm**

**5. Conclusions and limitation**

• p6, 1 sentence: this is expected. Even without this study one expects that newer instruments provide higher quality data, which in turn have a positive effect for any meteorological purpose. Exactly what you wrote on p6, L13-15.

We have clearly rearranged the paragraph.

p. 6 line 9 - 15

In this paper, we compared one infrared channel at 10.45 µm of the high-resolution imagery and the low-resolution imagery. It is difficult to track rapid BT11 changes of clouds in the development process. As a result of 60 cloud samples, the lead time with the low-resolution imagery is not enough to monitor the whole development process of tropical thunderstorms because the maximum of lead time is 60 minutes. In contrast, the lead time of high-resolution imagery is from 90 minutes and 180 minutes before the cloud reach to mature state. Therefore, this shows that higher spatial and temporal resolution of satellite observations can be more effective for alarming about 2 hours earlier tropical thunderstorms over Southeast Asia with the validation using 60 thunderstorms events.

• p6, L9-10: please rephrase " … and the mature deep convective with heavy rain"

Corrected as below

p. 6 line 18-20

Second, future studies are needed to determine whether thunderstorms are rainy after lead time. In order to more accurately examine the lead time, validation with surface precipitation data based on ground observation is further required.

• p6, L23: "if applied to real technology". Do you mean " if implemented operationally?"

Corrected as below

p. 6 line 29-30

If implemented operationally to real life, the high-resolution (2 km and 10 minutes) imager is required to provide practical assistance to disaster management.

• p6, L26-27: " For example, Cambodia … satellite data are 4 km.": I am wondering if this is really the best place/appropriate (in a scientific article) referring to a specific country. I believe it is better to write in general terms that there are countries in southeast Asia who receive 4km data. For example, last line of the summary is written in more general words, which is in my opinion better.

Absolutely, you are right. Thanks for your sincere comment!

p. 6 line 30 - 32

With the high-resolution imagery, the alarm for evacuation can disseminate two hours in advance. Although there are many developing countries in Southeast Asia using the Himawari-8 satellite data, few countries carefully think about satellite resolution.

Tables:

I think Table 1 & 3 could be transformed into 1 single table. The observation times in Table 1 can be put into Table 3. However, since more data will be included in the paper, the authors should think how to restructure those tables. I can imagine that when you have not 8, but for example 80 observed clouds it would be better not to use a table but to make a figure of the distribution of the lead times & cloud scales … Is there maybe a relation between the cloud scale and the lead time? More things can be done when including more data!

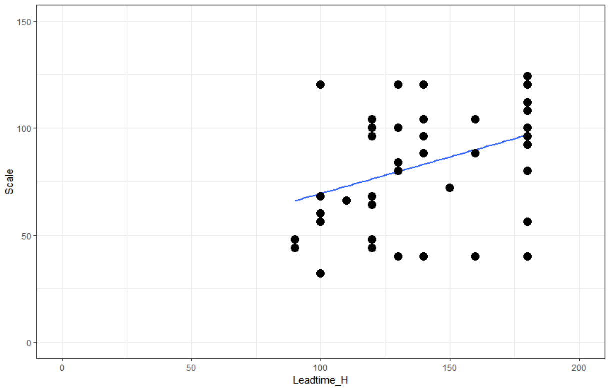
60 cloud examples are difficult to represent in a single table. The results are divided into Tables 1 and 3.

**Table 1. the sample number obtained during each observation time.**

| Month | Observation time | Sample number |
|---|---|---|
| July 2017 | 03:00-06:50 UTC (Day)<br>21:00-24:50 UTC (Night) | 20<br>10 |
| August 2017 | 03:00-06:50 UTC (Day)<br>21:00-24:50 UTC (Night) | 20<br>10 |

At the same time, thank you for suggesting new ideas related to this study. To analyze the correlation between cloud size and lead time, a preliminary test was conducted with 60 cloud samples. As a result, it was difficult to see a notable correlation between cloud scale and lead time. We consider that the number of samples will be increased to identify the relationship between cloud size and lead time. But, your idea is worth studying in the future. More detailed assumptions and definition about cloud scale will be needed to precede the research.

(a) Correlation : 0.3755376




(b) Correlation : 0.3755376

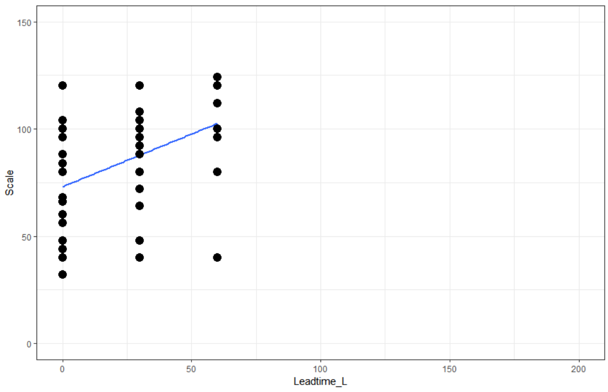
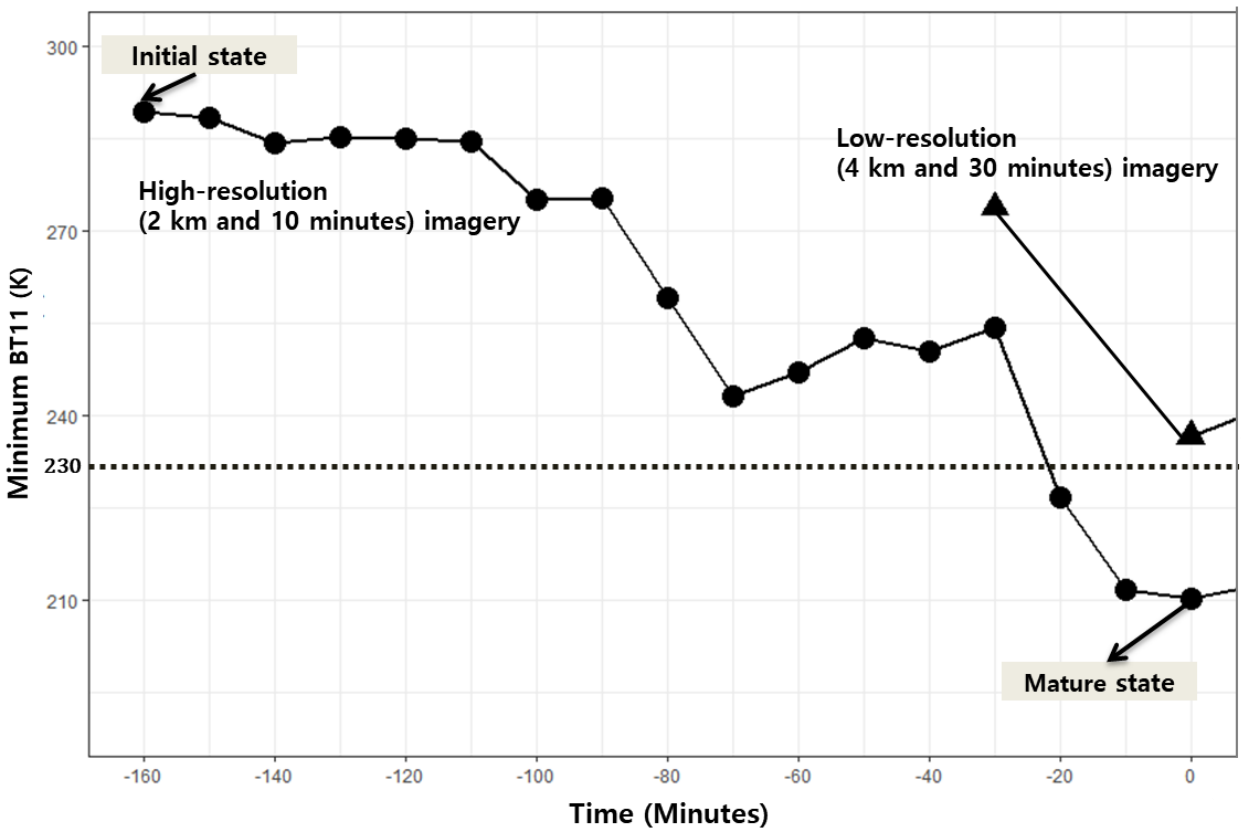



**Figure. The correlation between lead time and cloud scale; (a) the high-resolution (2 km and 10 minutes) imagery and (b) the low-resolution (4 km and 30 minutes) imagery**

Figures:

• Figure 1: Please rephrase last sentence in the caption of this figure. At the moment, it is not clear. + Include the low-resolution data in this figure as well for direct comparison.

That's good. Sentences in the caption of Figure 2 are revised.

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• Figure 2: I would like to see for Fig. 2 a & b that the authors include the virtual (lower resolution) data in order for the reader to see directly the difference between the new and old observational data.

“Yes, that’s right. Figure 3 is modified for direct comparison of imageries.”

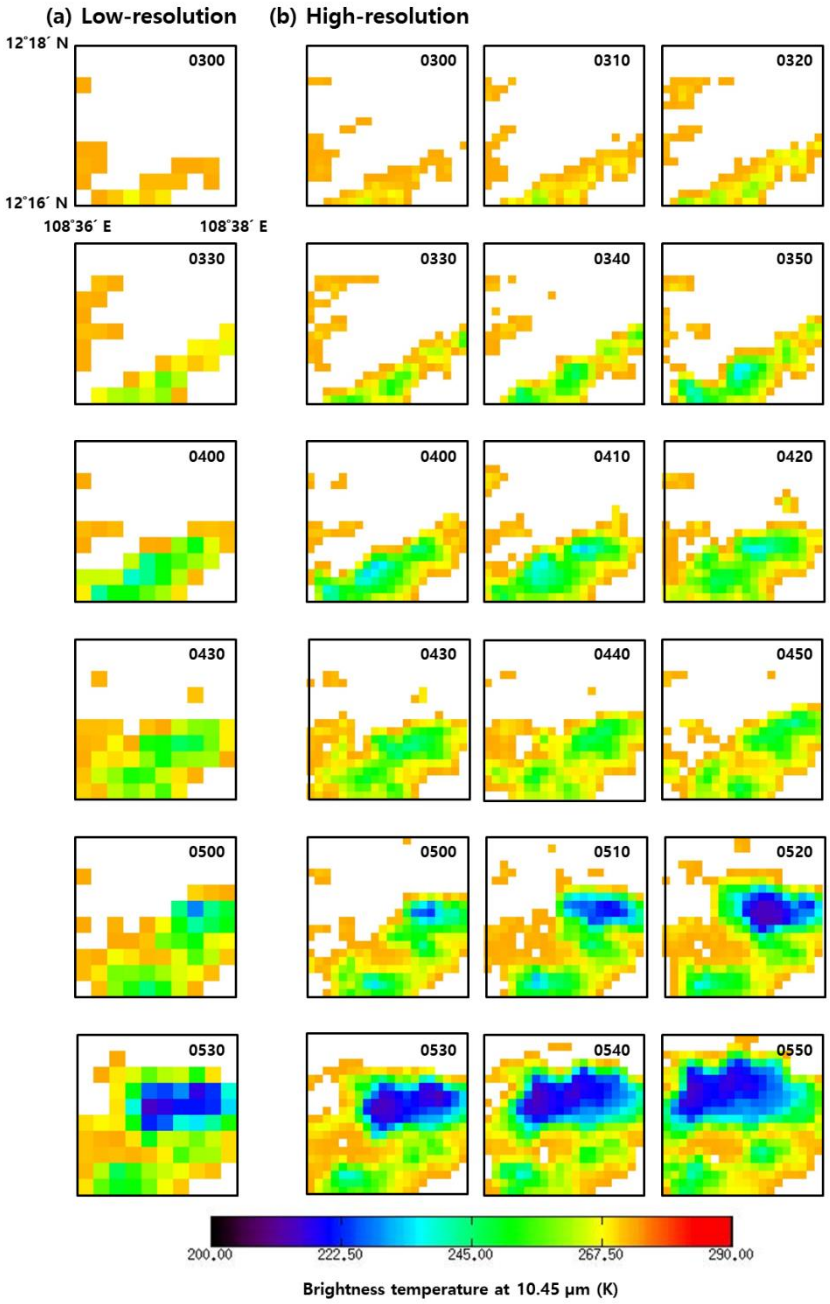


**Figure 3. An example of the thunderstorm development process through BT11 images (10 August 2017, 03:00-05:50 UTC); (a) the low-resolution (4 km and 30 minutes) imagery and (b) the high-resolution (2 km and 10 minutes) imagery**