A Study on the Analysis of the Urban Microclimate Changes by the Urban Growth

SangHun Baek[1]· DaeWuk Kim· JiWon Ryu· JaeGyu Cha· EungHo Jung

ABSTRACT

Based on preceding researches on the plan of reducing urban heat island through introduction of wind path, this study analyzed the effects that the change of land cover, which is resulted from urbanization, brought about on the cold air formation and flow. Dalseo-gu district in Daegu was selected as the subject and research was carried out about the urban micro-climate change in 1987, 1997 and 2007.

Research showed that increased artificial land cover was unfavorable to the cold air formation and flow and the quantity and height of cold air downtown remarkably lowered. This implied that cold air formation and flow is influenced by land cover. Simulation in main zones of cold air formation and flow showed that the cold air formation and flow became positive after the areas are turned into natural land cover. To secure continuous cold air formation and flow, it is judged that the spatial characteristics of the outskirts of the city should be analyzed to carry out urban development or urban restoration, and through the process, to formulate a pleasant and healthy town.

Key words : Wind flow, Heat island, Land cover

1. INTRODUCTION

The cold air formation and flow is to be influenced by the characteristics of space, and such characteristics of space as land cover and geographical condition are known to be closely related with the cold air formation and flow. However, urban development in the process of urbanization damaged the natural land cover and increased the artificial land cover that had a negative effect on the cold air formation and flow.

Accordingly, this study analyzed the impact of the land cover transformed in the process of urbanization on the cold air formation and flow in urban space.

Zones that are sensitive of the cold air formation and flow were selected, then the land cover in those zones were re-classified as favorable to the cold air formation and flow before conducting a simulation. The simulation identified the relationship between the cold air formation and flow and the spatial characteristics. The purpose of this study was to present basic data in deciding policy of city plan to reduce the urban heat island phenomenon and to create a pleasant urban environment.

2. CASE STUDY

2.1 Object Zone of Research

Daegu metropolitan city is an extreme heat city representing Korea. The object of this study was Dalseo-gu where the surface temperature has greatly changed and population has increased abruptly in Daegu. A square zone of 15㎞ by 15㎞ that contains Dalseo-gu was selected for a highly confident analysis of urban micro-climate.

1 Keimyung University, Department of Environmental Planning, Dalseo-Gu Shindang-Dong 1000, Daegu, iljiad@gmail.com

2.2 Analysis of the change of cold air formation and flow

1) Change of cold air flow

To investigate the change of cold air flow, KLAM_21 program was used to conduct simulation of each period of 600 minutes from 20:00 to 06:00 next dawn. Here the point of time about 120 minutes passed was investigated.

Zone A shows the change of cold air flow well. This is a very important zone for securing wind path where the cold air generated in the valley flows into urban region. The cold air flow in 1987 shows that the range of yellow color indicating fast cold air flow displays itself widely, suggesting the cold air flowing into downtown very fast. Compared to this, the range of yellow color in 1997 was narrowed and the simulation of cold air formation and flow in 2007 showed an aspect similar to that in 1997, suggesting cold air flowing into downtown is unfavorable.

It is identifiable that the slowed cold air flow in the zone A had an effect on the whole downtown area as well as zone A, so the cold air flow speed was slowed down over the whole downtown area. Therefore, for a pleasant city, the obstacle that hinders the cold air flow in the zone A should be removed to secure the zone A as a cold air flow area.

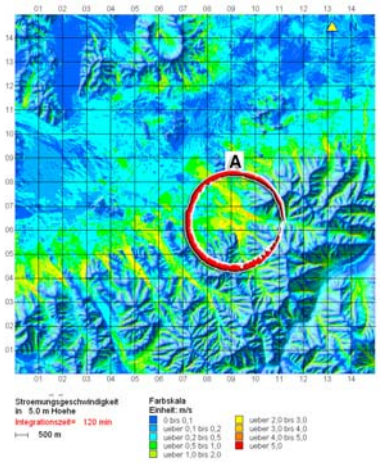


Figure 1. Air flow(1987, 120min)

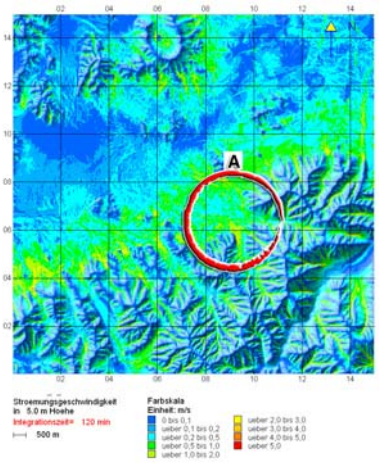


Figure 2. Air flow(1997, 120min)

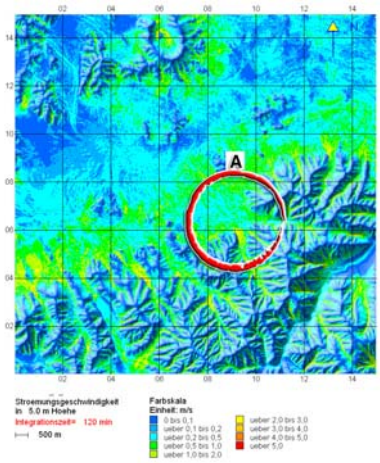


Figure 3. Air flow(2007, 120min)

2) Change of the height of cold air

The zone B, the center of object area, shows the change of the height of cold air well. The height of cold air is one of evaluation items of micro-climate environment that is represented at KLAM_21. The formulated cold air moves through flow, and when the quantity of cold air flowing into the moved region is more, the cold air will stack up. The cold air is characterized by heavier mass than warm air and that is why it stacks on the surface. In case of the artificial land cover, however, the heat storage capacity is greater than that of natural one and generates heat after sunset, warming the cold air. Consequently, it is unfavorable for the cold air to stack on the artificial land cover. Natural land cover has little capacity of heat storage and cools quickly after sunset, making it favorable to stack cold air. The height of cold air means that the higher the height of cold air is, the greater the possibility of advantage of cold air is.

The height of cold air in 1987 shows that the color indicating high height of cold air spreads widely, suggesting the height is good due to the stack of cold air caused by the cold air inflow. However, the regions with high height of cold air reduced a lot in 1997 and even more in 2007, suggesting unfavorable state of stack due to the cold air inflow.

The reason why the height of cold air is lowered seems that the speed of cold air flow is slowed down and the land cover unfavorable for cold air stack is increased. The height of cold air tends to spread, so when the height of cold air is heightened in a region, that have an effect on the vicinity and it becomes easy to spread. Therefore, it is necessary to select the zone B with lowered cold air as the height of cold air security zone.

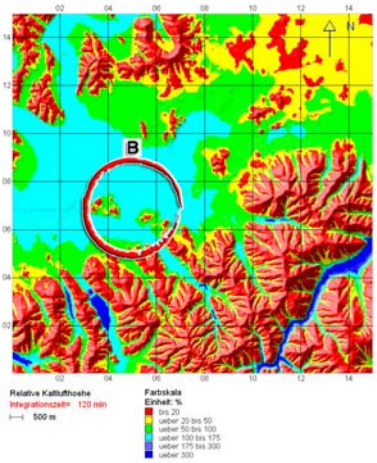


Figure 4. Height of cold air(1987, 120min)

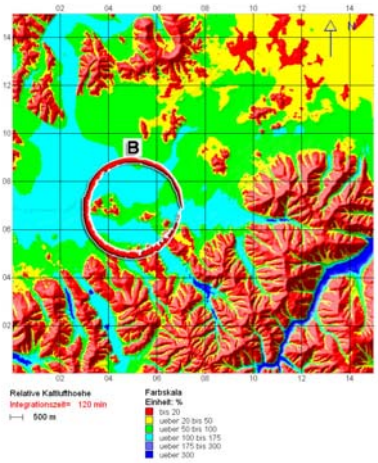


Figure 5. Height of cold air(1997, 120min)

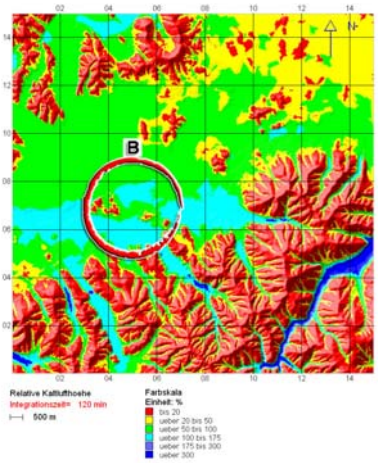


Figure 6. Height of cold air(2007, 120min)

2.3 Simulation of the Object Place

2.3.1 Scenario A

The point of time when the cold air flow simulation passes 120 minutes shows that it becomes fast compared to the cold air flow speed in 2007. This findings back up that the cold air flow is smooth as the characteristics of spatial environment is closer to natural land cover than to artificial one. In case of the existing land cover in 2007, the cold air formulated in forest could not flow in downtown area being more likely to worsen the urban heat island phenomenon, and especially the decline of cold air flow in the nighttime seems to accelerate the tropical nights phenomenon.

2.3.2 Scenario B

To compare with the cold air height in 2007, the cold air height at the point of time when 120 minutes passes in 『Scenario B』 was investigated. The zone of higher height of cold air relatively widens compared to that in 2007. When the land cover in the region where cold air flow is active was altered into natural land cover, the height of cold air was heightened, suggesting natural land cover is more favorable than artificial land cover for cold air to stack. Therefore, it appears contributing to the reduction of tropical night phenomenon and the formation of a pleasant city to alter the land cover with sensitive cold air as in zone B into natural land cover.

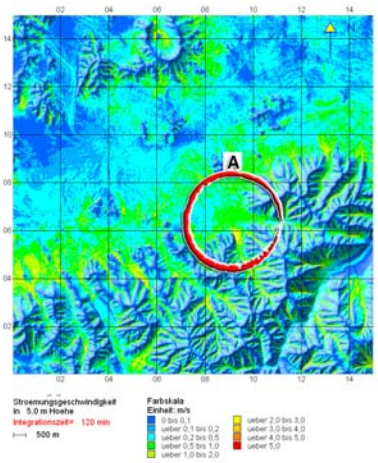


Figure 7. Air speed(Scenario A, 120min)

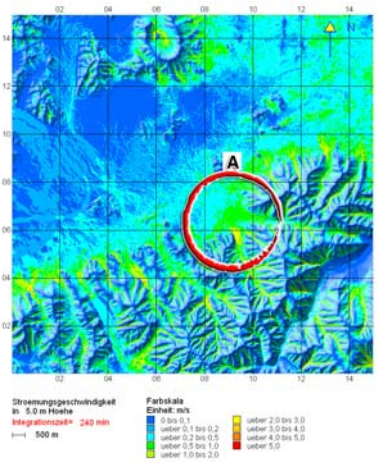


Figure 8. Air speed(Scenario A, 240min)

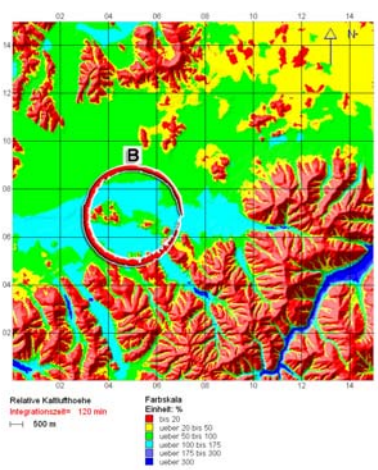


Figure 9. Height of cold air(Scenario B, 120min)

3. CONCLUSION

First, a systematic development is necessary at the important region where the fresh and cold air formulated in outskirts flows in downtown area. Out of artificial land cover, such land cover as very rough and densely residential district has an effect on the entire cold air flow in downtown area and worsens the heat island phenomenon. Therefore, it is necessary to select important region as cold air formation and flow security zone and to develop and administer systematically.

Second, it is very important to raise the green restoration rate against urban development in order to maintain the cold air in downtown area. It is necessary to develop greens systematically in advantageous area for cold air formulation and flow rather than to improve a formal green restoration rate.

Lastly, the cold air formulation area, flow area and preservation area should be connected spatially to maximize the reduction of urban heat island phenomenon through inflow of cold air into downtown area. Separate, regional administration drops the efficiency and that is why areas should be connected spatially so that cold air network may be possible.

To secure persistent cold air formulation and flow, the general characteristics of urban space should be analyzed to carry out urban development or urban restoration.

It is inevitable that the artificial land cover increases according to urbanization, but the development of multistory buildings or densely populated districts should be limited in important areas for cold air formulation and flow for urban development or restoration from now. A focus must be put on the improvement of the green rate or the green restoration rate so that natural land cover can be preserved to the maximum degree in order to develop a pleasant and healthy city through cold air.

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