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学 位 論 文 要 旨

Dissertation Summary

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論　文　名:静止気象衛星の日射量データと地上観測データを用いた局地気候に関する研究

(Dissertation Title) STUDY OF THE LOCAL CLIMATE USING GEOSTATIONARY SATELLITE SOLAR RADIATION AND GROUND-BASED MEASUREMENT

The biggest problem we are facing and we will be facing in this and following century is the fast growing population towards the cities and the urbanization. Local climate is highly influenced by the urbanization factor. Urbanization is not simply a micro to local scale e□ect but it also demonstrates a regional-scale signature. The urbanization affects various atmospheric parameters like temperature, pressure, humidity, local winds, cloud properties, radiation, water cycles etc. through the modification of natural surfaces and atmospheric conditions, and further changes the local weather and climate system. The chance in such local climate may result in human discomfort and extreme events like torrential rainfall, flash flood etc. Therefore, understanding of local climate and its effect on atmospheric parameters are very important.

Dataset collection and analysis are integral part of local climate studies. Ground based measurement of meteorological parameters is a typical way of collecting dataset. The calibration and the maintenance of such instruments is very important for precise measurement of the parameters. Ground based measurement are the base of all other way of measuring dataset. It is considered as the most accurate form of data available in present condition. However, the uneven distribution and limitation of these isolated meteorological stations may not fully represent the distribution of atmospheric parameters across the region. The satellite dataset can

be a very good alternative. Therefore in this study, we have used both satellite and ground based measurement dataset to achieve the objective of this study. In this study, we have used downward shortwave radiation dataset from geostationary satellite for the cloud studies. Landsat 8 images were used for the classification of study area into a standard land use/land cover classification. Other meteorological parameters like temperature and humidity are collected from ground-based stations available in the study area (Matsuyama plain) for the estimation of Urban Heat Island (UHI) and Urban Dry Island (UDI) intensities.

The main objective of the study was to use the downward shortwave (SW) radiation dataset from geostationary satellite in a local level. We have used the dataset to know the spatial and temporal variation of cloud properties in different sized cities in Japan and to know the variation of cloud in different geographical, seasonal and land use category. The other objective of the study was to classify the Matsuyama plane into Local Climate Zones (LCZ), calculate, and compare the UHI and UDI intensities with similar studies available.

In this study reduction of solar radiation was used as an index of cloud presence and cloud thickness. Decrease of solar radiation due to the blockage of cloud was calculated using the following concept. First the fair weather days with sunshine percentage ranging from 50% to 80% was selected on the basis of the meteorological data available from the Matsuyama meteorological observatory under the Japan Meteorological Agency (JMA). Satellite SW radiation dataset were downloaded for selected days. An ideal time series dataset was created by selecting the maximum values of each time series for every month. The ideal time series data resembles solar radiation on a virtual clear sky condition. The averaged time series SW dataset of target days is normalized by respective SW in fair weather day to get Clear Sky Rate (CSR).

$$\mathrm{CSR} = \frac{\text{target day SW}}{\text{SW in virtual clear sky condition}}$$

CSR value ranges between zero to one (0-1). Lower the CSR, higher the cloud coverage and the cloud thickness, while higher the CSR, and lower the cloud coverage and the cloud thickness. Using CSR as the thickness and cloud presence index, we have analyzed cloud properties in different sized coastal cities (Tokyo, Osaka, Hiroshima and Matsuyama). We have further analyzed and compared the spatial and temporal variation of clouds in different geographical locations and land use like “mountain –plane”, “coastal-noncoastal”, “summer and winter” analysis for “urban and rural” comparison.

We have also classified our study area (Matsuyama) into a standard land use /land cover classification called Local Climate Zones (LCZ). Landsat 8 images, Google Earth and SAGA GIS were used for the classification of study area. First, the Landsat 8 images were downloaded and cropped to the region of interest (ROI). The training areas were digitised using Google Earth and were loaded to SAGA in KML format. The layers were then merged and coordinate were transformed. Resampling followed by resampling was conducted and post classification was applied to get the LCZ map. The processed LCZ map was further tested in Google Earth platform for the verification. Corrections were made by adding the training areas if necessary and the same process is continued to create the representative LCZ map. For the investication of UHI and UDI intensity in different LCZ category in Matsuyama plane, we used ground based temperature and humidity measurment in matsuyama plane. In the later part of the chapter we have compared the UHI and UDI intensity in different LCZ catagories and further compared our studies with other similar studies available.

The analysis conducted using CSR as a cloud property index in different sized coastal cities shows that the formation and distribution of cloud is highly affected by the wind speed and its direction. Due to the active sea breeze in the coastal areas, the presence of cloud in the coastal urban area is low compared to the urban areas far from the coastal areas and the mountaintops. The influence of urbanization on clouds highly depends on its location within the coastal plane. Closer the city towards the coastal line, lower will be the thickness of cloud. With reference to other urban heat island studies in respective study areas, it shows that the cloud formation is likely to be higher in areas having higher temperature. The areas experiencing UHI with low intensity of wind or the places having wind convergence line generally leads to the formation of cloud above them.

Another analysis, the effect of geographical and land use/land cover effect on local cloud in Matsuyama plane shows that the thickness of cloud increases with the increase in altitude. The comparison between mountainous and plain areas suggest that the thickness of clouds is likely to be higher in mountainous areas than in plain areas throughout the day. The comparison between the coastal and noncoastal area suggest that noncoastal area is covered by the cloud specially afternoon due to the presence of wind convergence line. An additional comparison between urban and rural (summer case) suggest that formation of cloud in the urban area is likely to occur during the early morning and from afternoon. Similar comparison (urban and rural) but for winter shows not much difference in the urban and rural cloud formation.

The analysis conducted to see the effect of landuse/landcover change in meteorological parametres like temperature and humidity by dividing the study area into a standard landuse/landcover called Local Climate Zones (LCZ) using WUDAPT template shows that the concept of LCZ classification is an outstanding concept for the urban/ rural studies on the global scale. This study shows that the built up areas area hotter and dryer than the less built up or non-built up ones. In the study, a maximum nocturnal air temperature of about 2.5°C was detected between urban and non-urban LCZ ($T_{LCZ\ 2}$-$T_{LCZ\ D}$). LCZ with compact midrise building were on an average 2.5% dryer at daytime and 1.25% dryer at nighttime than LCZ with low plants. It also suggests that urban dry island phenomena are significant at daytime during fine days compared to nights. The results show that the magnitude of UHI and UDI highly depends on the LCZ type and they can be used to make a sensible interpretation of the temperature and absolute humidity values in urban neighborhoods where there are no observations.