Material Stock Analysis Using Satellite Nighttime Light Observation Data: A Case Study of Kitakyushu City

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I. Introduction

Human civilization's advance has involved the consumption of many natural resources. The depletion of natural resources has become a serious issue, especially for foreign resource dependent countries. The estimation of current material stock became important key to gain the knowledge of current material stock-in-use in the world. However, stock estimation is difficult in a city or country where statistical data are not sufficiently available.

In order to get the entire world material stock data, the night-time light imagery data are considered unique among remote sensing data sources because it offers a strong correlation with some form of human activity such as electricity consumption, gross domestic product (GDP), the material stock in infrastructures or settlements.[1] The nighttime light imagery data cover the entire world. Hence, a method utilizing nighttime lights could be a powerful appliance for the world material stock estimation.

The nighttime light images are processed at the National Geophysical Data Center (NGDC) of US National Ocean Atmosphere and Administration (NOAA) by using the Defense Meteorological Satellite Program/Operational Line Scan System (DMSP/OLS).[2] The DMSP-OLS is unique in its capability to perform low-light imaging of the entire earth on a nightly basis

Kitakyushu City in Fukuoka Prefecture, Japan, was selected for a case study whereas satisfactory spatial data are available for this city. The aim of this paper is to correlate the values obtained from radiance calibrated DMSP/OLS nighttime image of 2009 and material stock in Kitakyushu city.

2. Methodology and Data

2.1 Night-time light (DMSP/OLS) datasets

The files are cloud-free composites made using all the available archived DMSP/OLS smooth resolution data for calendar years. In cases where two satellites were collecting data - two composites were produced.

The resolution of the used nighttime images are 30 arc second grids, spanning -180 to 180 degrees longitude and -65 to 75 degrees latitude. The grid cell size is approximately a square kilometer.

In this study we used the stable lights data for 2009. The light radiance was calculated by formula (1) in order to gain light intensity from DMSP/OLS nighttime data. [3]

$$\text{Radiance} = DN^{1.5} \times 10^{-10} \quad W/cm^2/sr/\mu m \quad (1)$$

DN : Digital Number

Because of the need to focus on internal structure of individual city, the radiance calibrated DMSP/OLS low gain setting is preferred. [4]

Fig.1 Radiance Calibrated obtained from nightlight imagery

2.2 Building data

Mesh datasets for the building in Kitakyushu were established by using the data from Bureau of Statistics, Ministry of Internal Affairs and Communication of Japan. [5] In this study, the building data for 2005 is used for analysis.

2.3 Roadway data

Mesh datasets for roadway in Kitakyushu were established by using the data from Bureau of Land Planning, Ministry of Land, Infrastructure, Transport and Tourism of Japan. [6)]

2.3 Data Analysis

The obtained nighttime light (DMSP/OLS) dataset from NGDC is the entire world data. First, the Kitakyushu city nighttime light dataset were made then the light intensity retrieved by using formula (1). The nightlight intensity and both building and roadway mesh datasets are compared in a graph to find the correlation between them. All mesh size was made uniformly a square kilometer to avoid complicated analysis.

3. Results and Discussion

The correlation between light intensity and building area is shown in figure 2.

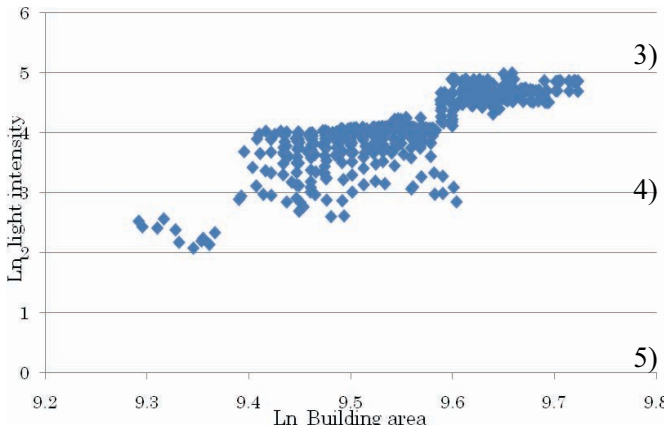

Fig.2 The correlation between light intensity and building area.

The result of this study showed that light intensity and building area has a fair linear correlation in Kitakyushu city case study. Some region showed low light intensity regardless they have large building area. On the other hand, some narrower building areas have higher light intensity than the larger one. It means that, the other correlation factors for light intensity are exists. The similar case study for Aichi prefecture in Japan implied that the roadway stock has a closer linear correlation with light intensity compared to building stock.

A further study by considering more factors is needed in order to get higher liability results.

It is also important to put the real condition of earth into consideration. The original nightlight time mesh dataset for equatorial and polar region slightly different due to the vertical light image capture by the satellite. Thus, choosing the precise coordinate axis for the mesh data is essential in order to provide a reliable nightlight time mesh datasets.

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References

1) Christopher N.H., Doll (2008) CIESIN Thematic Guide to Nighttime Light Remote Sensing and Its Application.
2) National Geophysical Data Center (NGDC) (http://www.ngdc.noaa.gov/dmsp/downloadV4composites.html)
3) Roychowdhury, K. Jones, S. Arrowsmith, C. (2009) Assessing the uitility of DMSP/OLS nighttime images for characterizing Indian urbanization. Urban Remote Sensing Event ; 1-7.
4) Elvidge CD, Baugh KE, Kihn EA, Krehl HW, Davis ER, Davis CW. (1999) Radiance calibration of DMSP/OLS low-light imaging data of human settlements. Remote Sens Environ; 68:77-88
5) The Statistics Bureau, Director-General for Policy Planning of Japan and Statistical Research and Training Institute. (http://www.stat.go.jp/data/index.htm)
6) Bureau of Land Planning, Ministry of Land, Infrastructure, Transport and Tourism of Japan (http://nlftp.mlit.go.jp/ksj/)
7) Takahashi, K.I. Terakado, R. Nakamuta, J. Adachi, Y. Elvidge, C.D. Matsuno, Y (2010) In-use stock analysis using satellite nighttime light observation data. Resource, Conservation and Recycling; 55: 196-200
8) Takahashi, K.I, Terakado, R. Nakamuta, J. Daigo, I . Matsuno, Y. Adachi, Y. (2009) In-use stock of copper analysis using satellite nighttime light observation data. Mater Trans; 50(7): 1871-1874.