Comparison of New York and Tokyo's material stock of buildings estimation model using nighttime light data

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1. Introduction

According to the UN, 68% of the world population is projected to live in urban areas by 2050. Due to this urban expansion the natural resource use is likely to keep increasing globally. To establish a sustainable society, it is crucial that we reduce the use of natural resources. In order to achieve this aim, we should understand the distribution and movement of "Material Stock" is crucial.

"Material stock" is the accumulation of natural resources in society. Material Stock and Flow Analysis is one of the best ways to analyze the distribution of "Material Stock". One way to do Material Stock and Flow Analysis is called "The Bottom Up Method". This is a method that estimates material stock of existing infrastructure and its material use per unit. In this study, we used the bottom up method because it can analyze detailed scales.

Fishman et al. (2014), Gierlinger and Krausmann (2009) calculated the material stock in Japan and the United States. But these studies did not use geographic information. Which means that they did not consider spatial information. In this study we used geographic information for the material stock of buildings data.

To compare with the material stock of buildings data we also used nighttime light data called SNPP VIIRS. In recent years, nighttime light data is being used in numerous studies because it is not tied down to statistical data.

The objective of this study is to make an estimation model of material stock of buildings with nighttime light data in New York State and Tokyo.

2. Database in this study

In this study, the Microsoft database of building footprints in the US was used. This dataset contains 152,192,184 building footprint polygon geometries in all 50 US States in GeoJSON format. Moreover, for the material stock of buildings data in Tokyo we used "Z-map TOWN Ⅱ" data from ZENRIN CO., LTD. "Z-map TOWN Ⅱ" is a building mapping database.

Furthermore, SNPP-VIIRS (2016) data provided by National Oceanic Atmospheric Administration (NOAA) in the US was used.

3. Methodology

In this study, we used the estimation equation as shown below.

$$MS = \alpha NTL + \beta$$

Where MS is the material stock of buildings, NTL is the nighttime light intensity. α and β are coefficients to be calculated. In this study MS is expressed by building floor area and the unit is m^2. NTL's unit is $nW/cm^2/sr$.

4. Results and Discussion

Figure 1 shows the material stock of buildings distribution and nighttime light data in New York State. The 2 maps have high correlation. However, from the 2 graphs we can see that the SNPP VIIRS didn't pick up some buildings in the Long Island area.

Figure 2 shows the material stock of buildings distribution and nighttime light data in Tokyo.

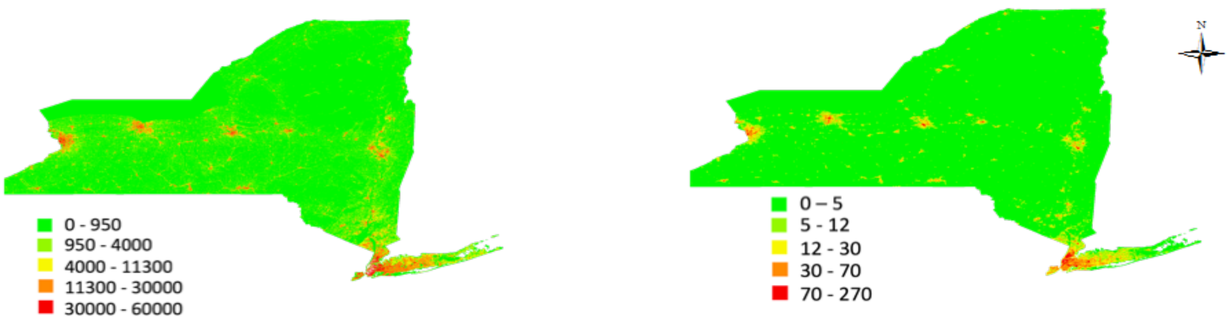

Figure 1. Comparison of Material Stock of buildings distribution (left) and SNPP-VIIRS (2016) in New York State (right)

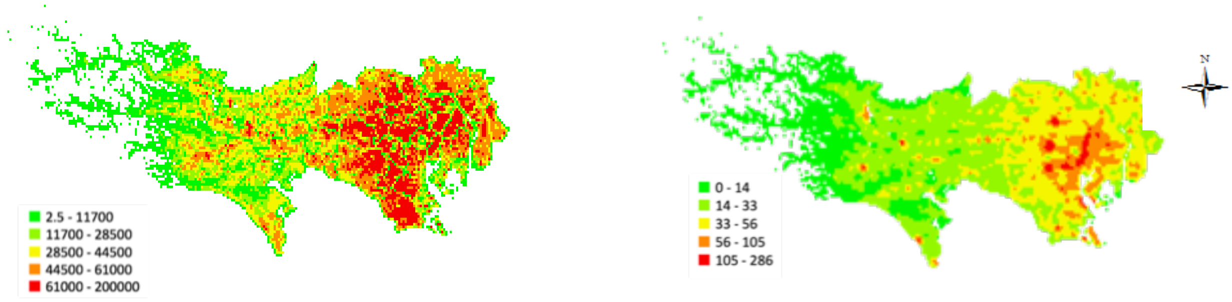

Figure 2. Comparison of Material Stock of buildings distribution (left) and SNPP-VIIRS (2015) in Tokyo (right)

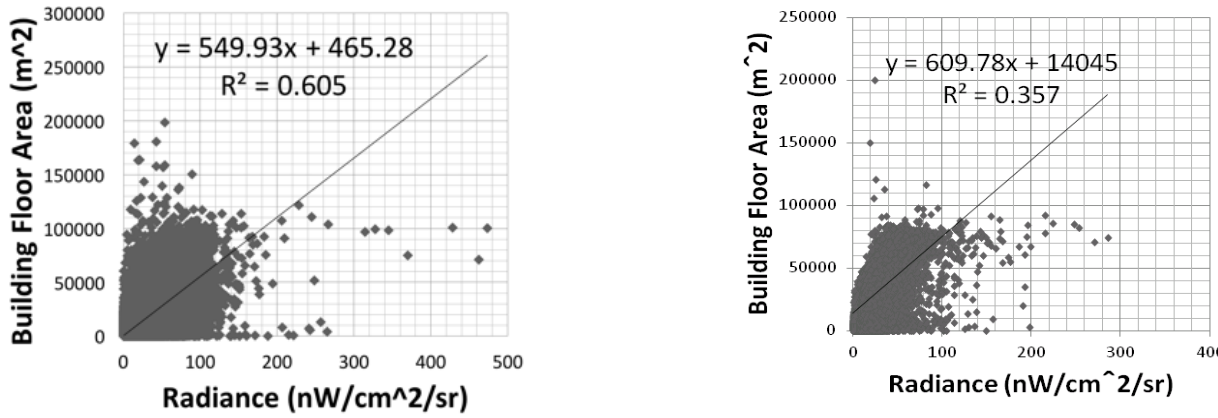

Figure 3. Scatter plot between building floor area and radiance in New York State (left) and Tokyo (right)

Table 1. Coefficients of the estimation models

	α	β	R^2
New York	549.93	465.28	0.605
Tokyo	609.78	14045	0.357

Figure 2 shows that there's a large discrepancy between the material stock of buildings distribution and SNPP-VIIRS data in Tokyo. The reason for this might be because we showed material stock of buildings with building area data. The building area data doesn't account for the number of floors the buildings have. Another reason for the difference might be because of saturation problems.

Figure 3 shows the scatter plot between nighttime light data and material stock of buildings in New York and Tokyo.

In both of the scatter plots there's illumination in places with little to no buildings. This is because in this study we only accounted for buildings. We didn't account for other infrastructure like roads, airports and street lights. The α from the estimation models are closely related, showing that there is a correlation between the two models.

However, New York's estimation model's R^2 came out to be 0.605 and Tokyo's R^2 came out to be 0.357. This may be because the two area's population density is vastly different.

5. Conclusion

In this study, New York State and Tokyo's material stock of buildings estimation model were calculated. The two estimation models were shown to have correlation.

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