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（博士課程）
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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Surface energy balance (SEB) model is commonly used to explore urban surface-atmosphere heat exchange, which quality is affected by the input thermophysical properties of urban surfaces. Coupling the multi-spectral remote sensing and SEB simulation, this thesis proposes a new estimation method on thermophysical properties (i.e., albedo, thermal conductivity, and heat capacity) of building surfaces at a block or neighborhood scale.

In Chapter 2, taking a block in university campus (Yokohama city, Japan) as a study area, the effect of thermophysical properties of building surface were estimated in terms of the surface temperature and sensible heat flux, demonstrating that a non-negligible temperature difference behaved by building surface with different thermophysical properties, suggesting a large potential of the proposed estimation method to be workable. SEB model sensitivities of the building surface temperature in terms of the thermophysical properties were also studied. The sensitivity to $\Delta \lambda_c$ of 1 $Wm^{-2}K^{-1}$ and a ΔC_a of 50 $kJm^{-2}K^{-1}$ are both close to 0.1 °C, and the difference owing to the orientation is slight. It demonstrates that SEB model sensitivity is sufficient to distinguish the different thermal properties. The combined modification of thermal properties can enlarge the accumulated cooling effects of individual modifications but can also reduce/eliminate their single effects, depending on how to modify the thermal properties. However, the combined effect would not be a compromise in opposite season, revealing the possible problem (two very different combinations of thermal properties showing similar performance on surface temperatures) and potential solution (to conduct measurement once more in opposite season) of the estimation method developed in Chapter 4.

In Chapter 3, the technique process and three narrow-to-broadband (NTB) conversion models were developed to estimate the total shortwave albedo of the building surface based on the multispectral RS. Based on the measured spectral reflectances of urban surfaces and simulated at-surface solar spectral irradiances under various conditions (season, solar zenith angle, and horizontal/vertical surface), we simulated datasets of extensive spectral albedos of urban surfaces. Based on the built datasets of various at-surface solar irradiances and spectral albedos, we developed three NTB conversion models following published methodologies for three common UAV-based multispectral cameras, and evaluated their performance as well as the camera capacity to estimate broadband albedo. In addition, the models' sensitivities to the solar conditions and the surface material class were analyzed. These models and the

proposed technique process were well-validated using independent sample surfaces covered by different construction materials with a root mean square error (RMSE) of the estimated albedo less than 0.033, which are acceptable for SEB modeling.

In Chapter 4, the thermal conductivity and heat capacity of building surfaces were estimated based on multispectral RS and SEB model-based simulation. Taking a concrete building in the university campus as a target building, the multispectral and hourly infrared thermal images from sunrise to sunset of the target building were taken. Meanwhile, the indoor air temperature and weather data were measured in site. Typical combinations of thermal properties of building surface were characterized by clustering based on a database established here. The typical cases were input as possible thermal properties of the target building in SEB simulation with other boundary conditions and the estimated albedo of the target building (Chapter 2). The results showed that the estimated thermal properties based on this developed estimation method were with a low absolute error of 0.1 $Wm^{-2}K^{-1}$ (1.1%) and 1.3 $KJm^{-2}K^{-1}$ (0.3%) respectively in thermal conductivity and heat capacity according to the well-documented wall component and ISO6946 method. It validates the effectiveness of this developed estimation method on thermal properties of building surfaces. The mistaken estimation may happen, which estimated thermal properties could be largely different from the actual ones due to the combined effect of thermal properties as a compromise (Chapter 2). However, these misestimated λ_c and C_a are applicable in same season, which error in SEB-based simulated surface temperature and sensible heat flux can be ignored even though they are not close to the actual ones. According to some findings in Chapter 2, this limitation due to the compromise effect can be effectively overcome by applying this method once more in opposite season or extending measurement period until night.

As a conclusion, coupling multispectral RS and SEB simulation, a new estimation method on thermophysical properties of building surfaces at block and neighborhood scale is developed and primarily proved to be effective and applicable on the common heavy wall composed of concrete with a surface reflectance near isotropic. This estimation method is limited to be applied for estimating the albedos of the Lambertian building surfaces and the estimated thermal properties are limited to be applied on the same season as the one to conduct this estimation method. However, considering the reflectance of most construction materials used for building walls and roofs is near isotropic as Lambertian, to attach an isotropic-reflection material to the limited building surfaces which original materials' reflectance are anisotropic can probably overcome the former limitation. To apply this estimation method on thermal properties once more in the opposite season or extending the measurement period until night may break through the latter limitation.