耶鲁大学–南京信息工程大学大气环境中心

Yale-NUIST Center on Atmospheric Environment

A Discussion on the paper “Surface Albedo in Cities: Case Study in Sapporo and Tokyo, Japan”

By Hirofumi Sugawara · Tamio Takamura

Boundary-Layer Meteorology

Zhang Xue

2014-10-10

Outline

- Introduction
- Materials and methods
- Results
- Discussion
- Conclusion

Introduction

- In order to more precise forecasts for **urban warming** and **pollution dispersion**, a physical understanding is needed of the heat budget of the building canopy, which influences surface air temperatures and flow patterns .

- There are some factors determining urban albedo: surface material, **vegetation, the geometric structure of buildings**, street widths and building heights.

- In this study, we get the albedo value by using airborne observations to avoid **the bidirectional reflectance distribution(BRD)**, and albedo variations inside the urban area were also analyzed.

Materials and methods

- Sapporo

Based on the building structure, we divided the city area into three categories:

(1) **High-rise areas**: H > 30 m

(2) **Low-rise areas**: 10m < H < 30m

(3) **Residential areas**: H < 10 m

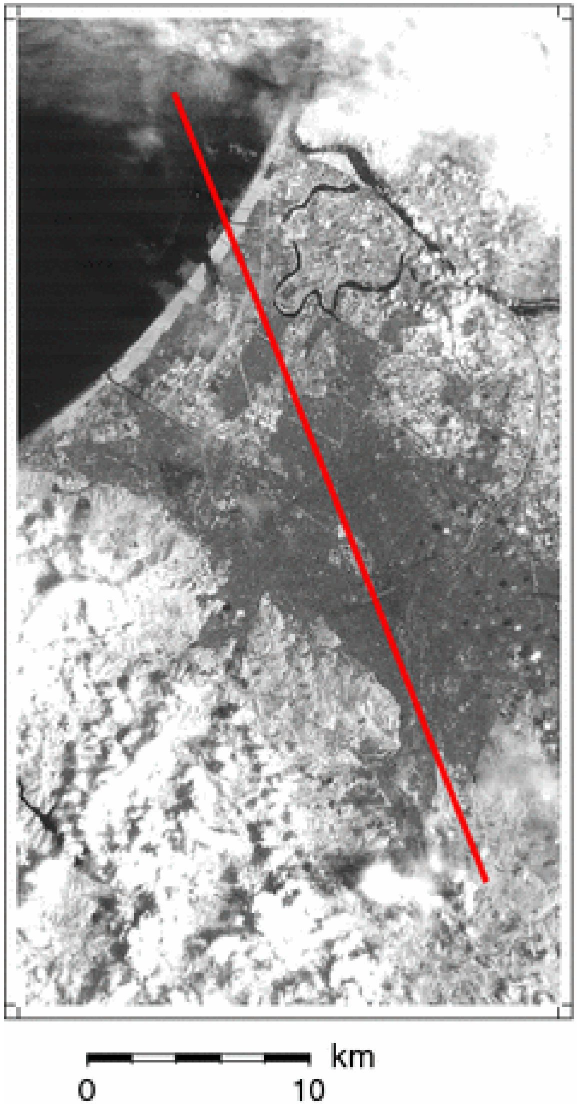

Fig. 1 Flight course over Sapporo

Materials and methods

- Sapporo

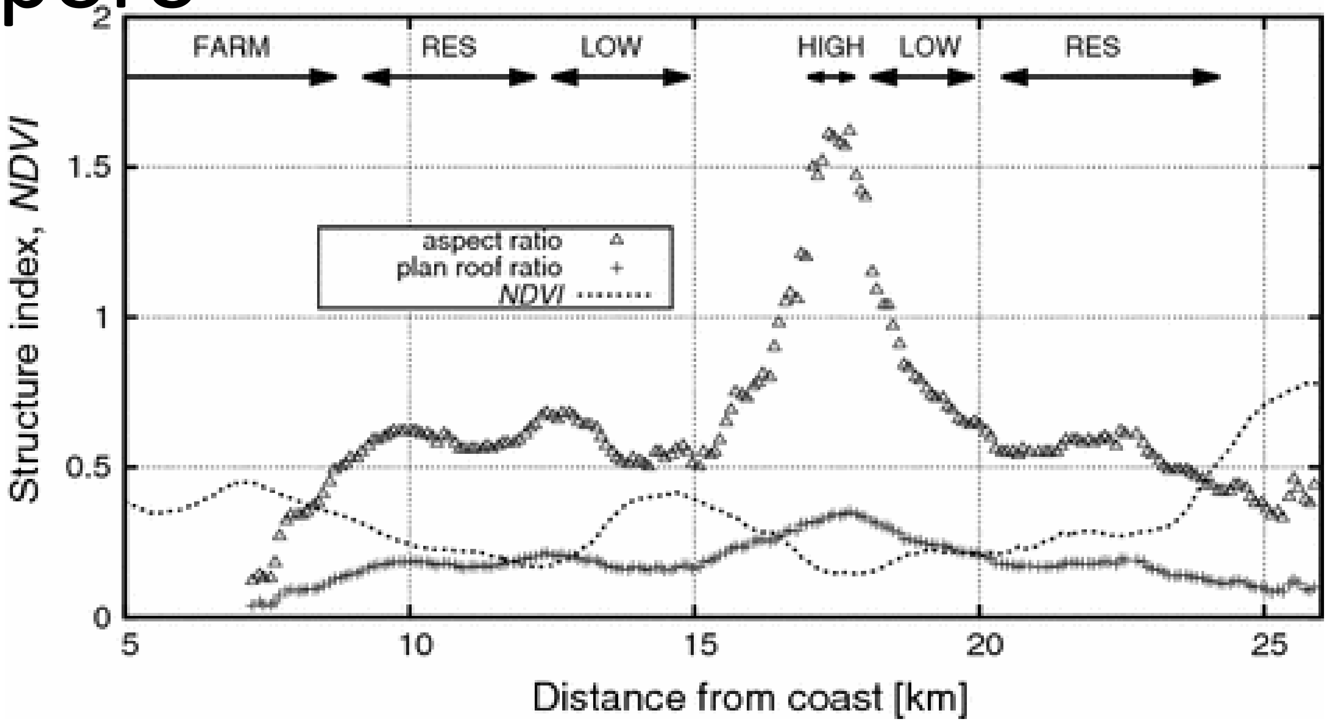

Fig.2 Structure indices of building canopies, λ_p , H/W and NDVI in Sapporo.

Indices

The plan roof ratio : $\lambda_p = S_{roof} / S_{total}$

The street-canyon aspect ratio: $H/W = H_{building} / W_{street}$

The normalized vegetation index: $NDVI = (\alpha_{nir} - \alpha_{vis}) / (\alpha_{nir} + \alpha_{vis})$

Materials and methods

- Sapporo

$$\alpha = \int \alpha_\lambda \frac{S_\lambda^{\downarrow}}{S^{\downarrow}} d\lambda \qquad (0 < \alpha < 1)$$

α : The surface albedo

$S_\lambda^{\downarrow}$: The downward shortwave spectral irradiance

$S^{\downarrow}$: The downward shortwave irradiance

Materials and methods

- Sapporo

$$\alpha_\lambda = \frac{S_\lambda^{\uparrow}}{S_\lambda^{\downarrow}} \qquad (395\text{nm} < \lambda < 850 \text{ nm})$$

α_λ : The spectral reflectance

$S_\lambda^{\uparrow}$: The upward shortwave spectral irradiance

The atmospheric correlation method

Two-stream approximation : It was used to solve the radiation transfer in the correction where the input parameters are determined from the airborne-measured size distribution of aerosols.

Materials and methods

- Sapporo

Linear combination of asphalt and vegetation spectra

$$\alpha_{\lambda} = A_{\mathrm{v}} \alpha_{\mathrm{g}\lambda} + \left(1 - A_{\mathrm{v}}\right) \alpha_{\mathrm{a}\lambda} \qquad (\lambda > 850\ \mathrm{nm})$$

A_{v} : the area ratio of vegetation

$\alpha_{\mathrm{g}\lambda}$: the reflectance spectra of vegetation

$\alpha_{\mathrm{a}\lambda}$: the reflectance spectra of asphalt

Materials and methods

- Sapporo

Table 1 comparison between author and others' research

	Author's calculation	Burt (1954)	Kondratyev (1969)	Katsaros et al. (1985)
Sea surface albedo	0.044 ± 0.009	0.055	0.024	0.05-0.1 or 0.03-0.07

factors

sea turbidity, incident solar angle, and surface roughness due to waves.

Materials and methods

- Tokyo

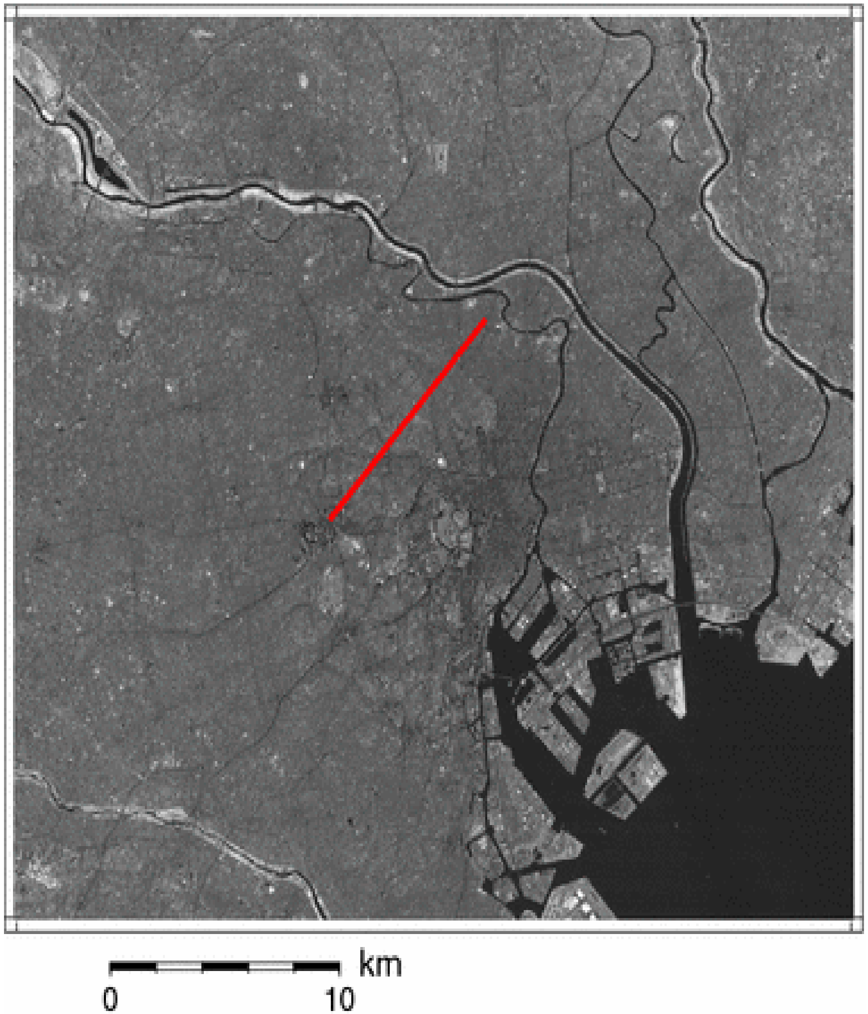

Fig.3 Flight course over Tokyo

Materials and methods

- Tokyo

The atmospheric correlation method

LOWTRAN7

IHAZE=5(urban)

VIS=25km

Comparison

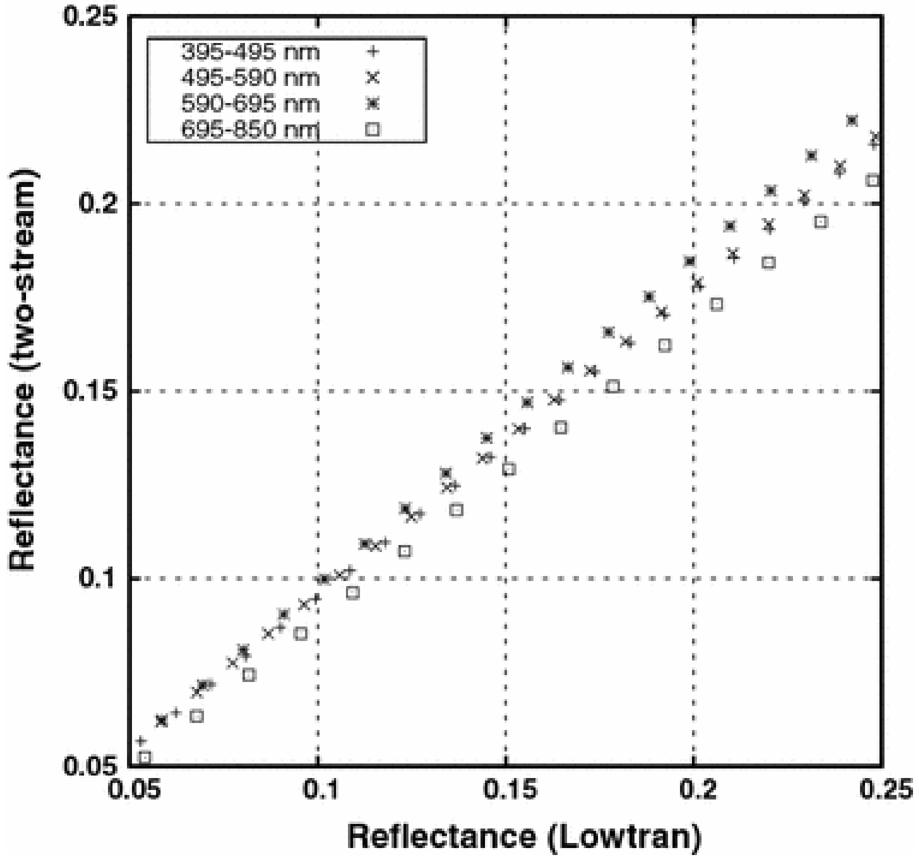

Fig. 4 Comparison of atmospheric correction methodologies(Sapporo)

Accordingly, the albedo of Tokyo could be overestimated by 10% for Tokyo.

Results

- Observed Results

Table 2 Structure index and albedo. Standard deviations of spatial variation are indicated in parentheses

	Sapporo				Tokyo
	Residential	Low rise	High rise	Forest	
Geometry					
H/W	0.59 (0.02)	0.67 (0.02)	1.55 (0.12)		1.37 (0.06)
λ_p	0.18 (0.01)	0.21 (0.004)	0.34 (0.13)		0.33 (0.01)
Albedo					
Morning	0.18	0.16	0.16	0.20	
Day	0.13	0.13	0.12	0.16	0.12

Results

- Dependency on Building Structure

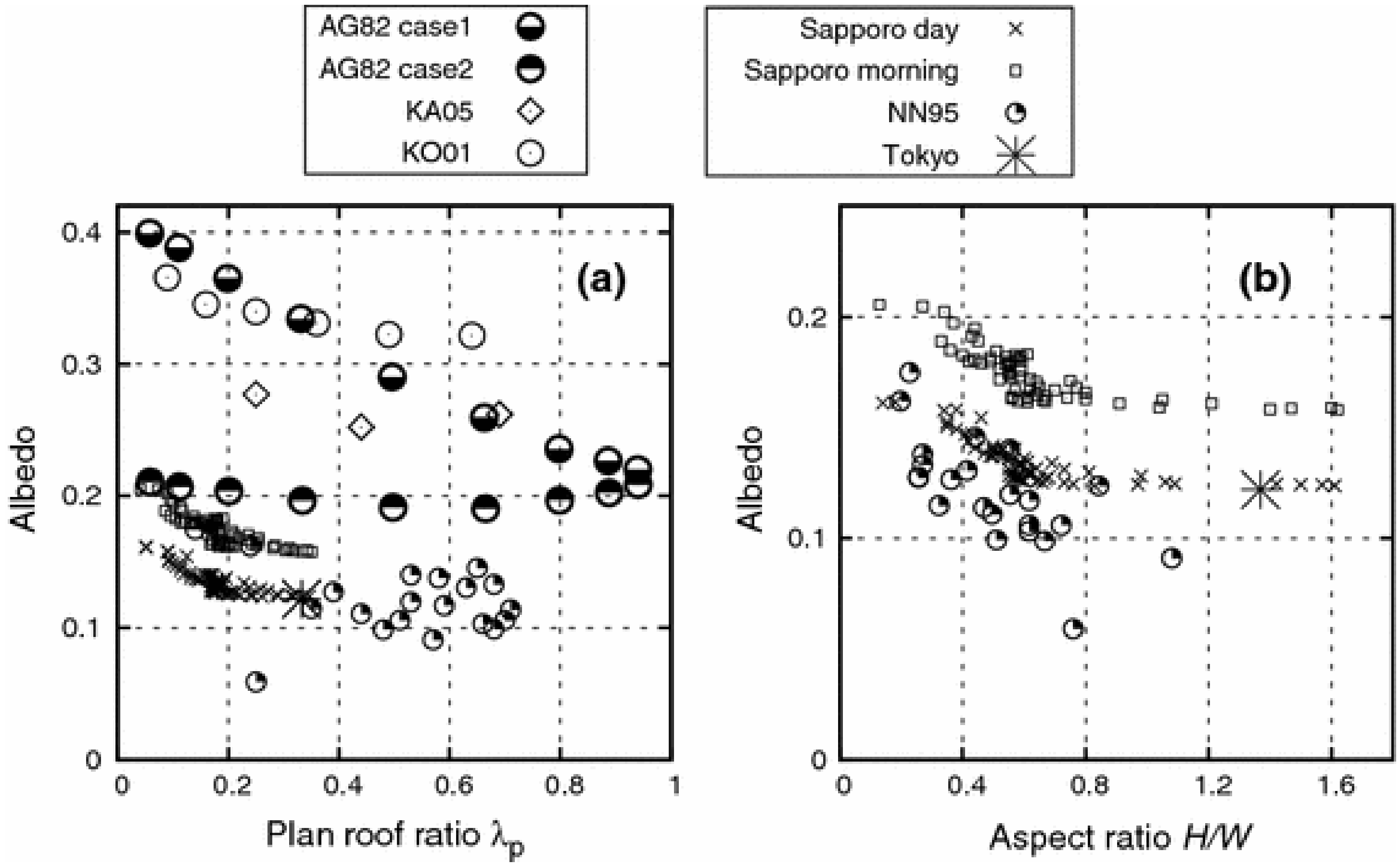

Fig. 5 Correlation of albedo with canopy structure indices.

Results

- Dependency on Vegetation

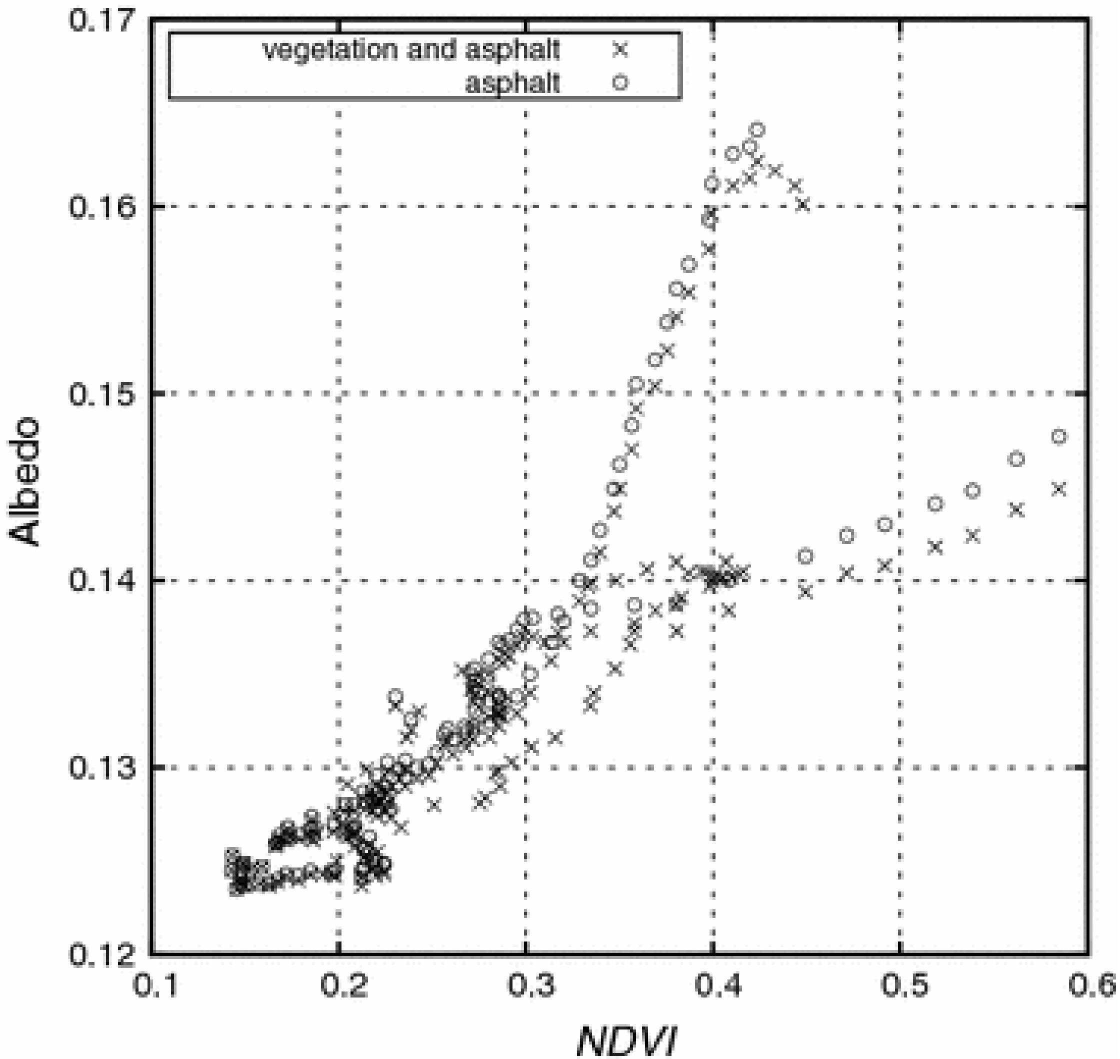

Fig. 6 Correlation between NDVI and albedo measured in daytime Sapporo

Discussion

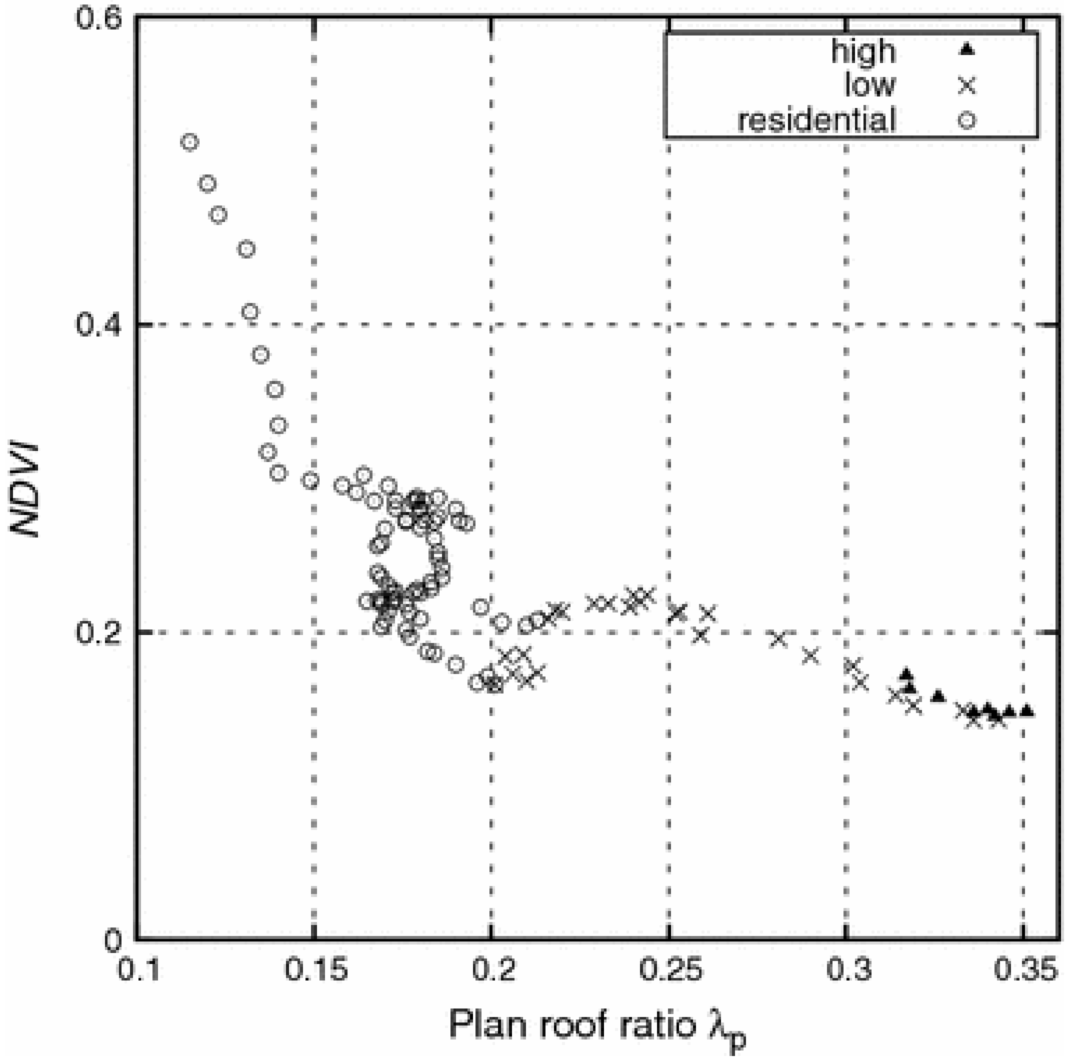

Fig. 7 Correlation of plan roof ratio and NDVI (daytime, Sapporo)

Discussion

- The canopy structure influences the urban NDVI

(1) More building shadows cover the canopy floor in the larger H/W areas.

(2) The sky-view factor on the canopy floor is reduced in response to increases in H/W and/or λ_p .

Discussion

- The correlation between λ_p and H/W

(1) The high land prices inevitably lead to taller and wider buildings in urban areas.

(2) The maximum height of buildings in many areas is specified by Japanese construction laws.

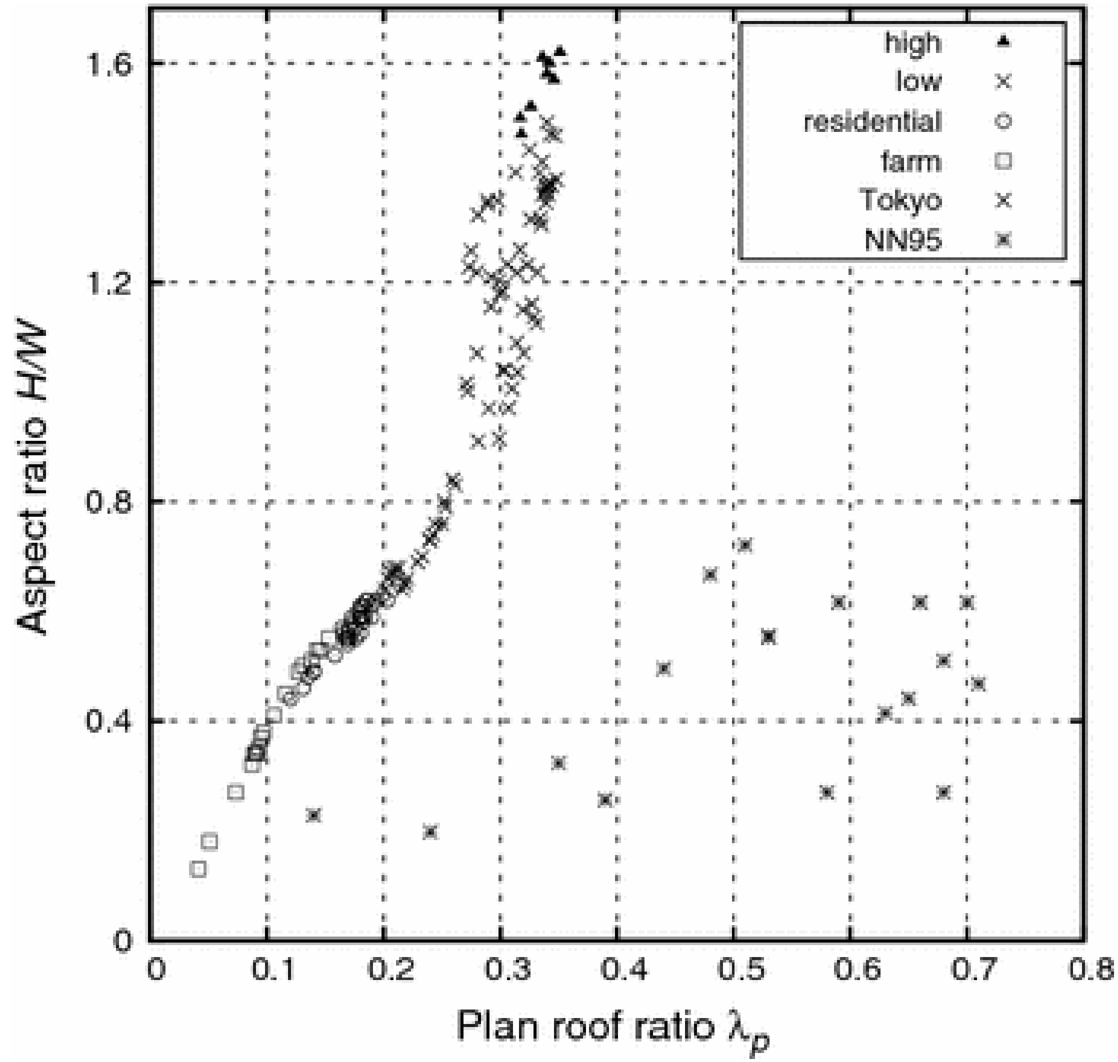

Fig. 8 Correlation of plan roof ratio and aspect a ratio of street canyon

Discussion

- The discussion of constant values

(1) The small variation of the vegetation amount in the low-rise area.

(2)The shadow on the canopy floor.

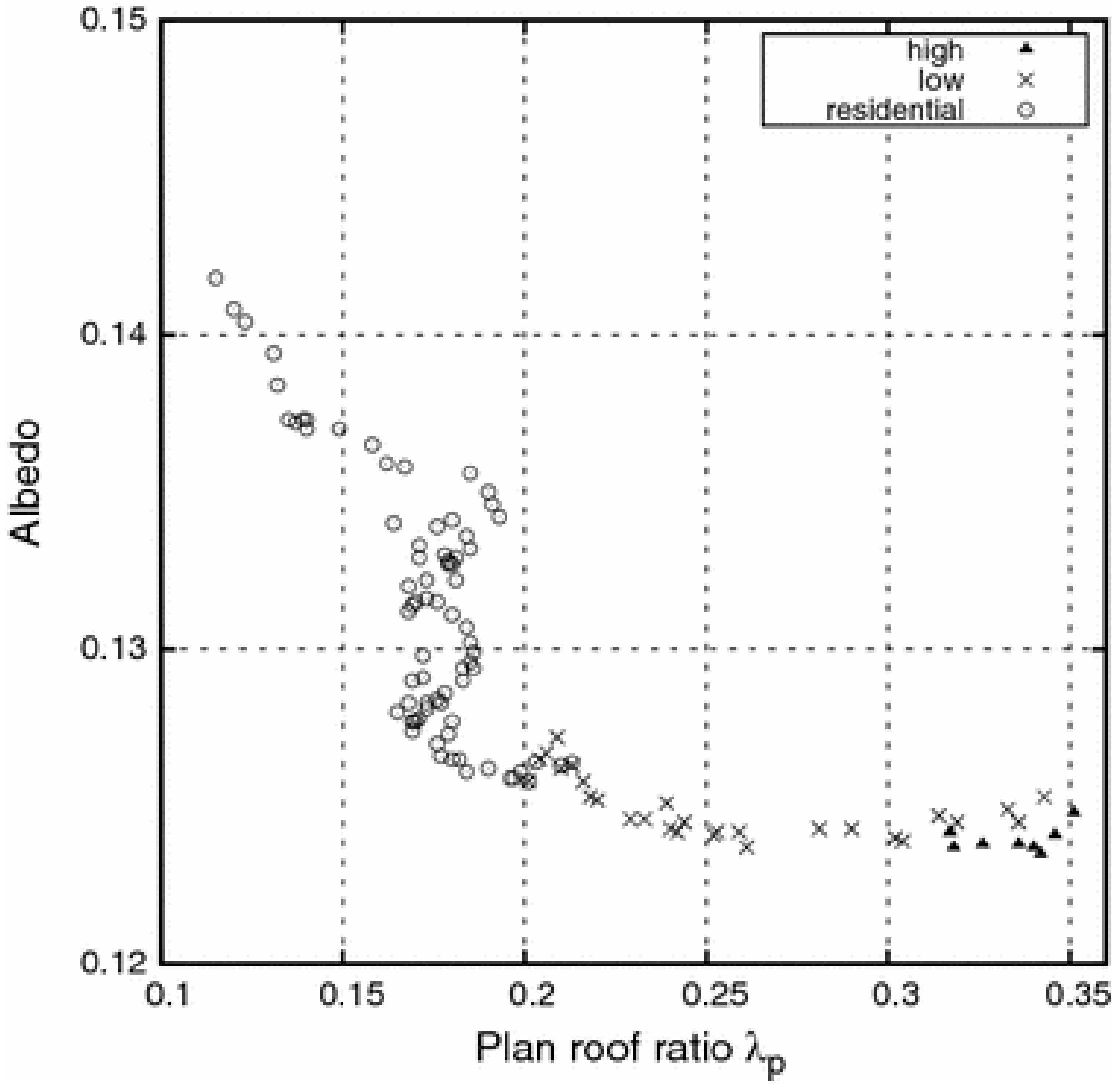

Fig. 9 Correlation of albedo (daytime, Sapporo) to the plan roof ratio

Conclusion

- The daytime albedo was 0.12 in the cities, which was less than that of a nearby forest (0.16).
- The albedo was dependent on building structure in the cities, the albedo was lower in areas with more buildings, and decreased as the aspect ratio of street canyons increased.
- Lower albedo in the high-rise area could be attributed to the larger H/W compared to that in the low-rise area.

Thank you