P6.2

SURFACE PARAMETERS IN A DENSLY BUILT-UP RESIDENTIAL AREA IN TOKYO

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1. INTRODUCTION

Observed data of urban surface parameters are very rare, compared with grass land, water and vegetated surface. In this study, surface parameters, such as roughness length for momentum and scalar transfer, wetness parameter, and albedo, are estimated based on the long-term observation.

2. FIELD OBSERVATION DESIGN

The "*Kugahara experiment* " has been performed continuously since May 2001 to the present. A tower was installed in a uniform low-storied residential area in *Kugahara*, Tokyo, JAPAN (35 ° 34'N,139 ° 41'E). Plane aspect ratio is 0.48 and the green cover is less than 20%. The average building height is 7.3 m. Turbulence data, i.e. the fluctuations of 3D wind velocities, temperature, vapor, and CO_2 concentration, are sampled with 8 Hz at the height z=29 m. Vertical fluxes are estimated using eddy correlation method. Up- and downward short-wave and long-wave radiation is measured separately at the height of 25m.

3. HEAT BALANCE AND CO_2 FLUX IN THE CITY

3.1 *Diurnal Evolution Pattern*

The diurnal changes of the energy balance and CO_2 flux are shown in Figure 1. They are ensemble averaged over all clear days of one month. In July, the peak values of *Rn*, *H*, and *lE* are about 700, 300, and 200 Wm^{-2} respectively. In December, these values are less than half. Observed *lE* (lE_{obs}) at noon is relatively large in July. Assuming that lE_{obs} is only evaporated from vegetation and soil – their area portion is less than 30 %, the local *lE* should be 700 Wm^{-2}. This value is as much as *Rn* and seems too large. An experiment for mass change of concrete blocks exposed to the nature condition was done in winter. *lE* from the block is 20-70% of lE_{obs} even when several days passed after the rainfall. This indicates that concrete evaporation should be considered as one of evaporation sources in urban environment.

Figure1(c) shows that the net CO_2 flux is always positive in the urban area. The emission from vehicles makes the flux positive. The flux in July is smaller than in December. One of the reasons is the absorption of CO_2 by photosynthesis of the vegetation.

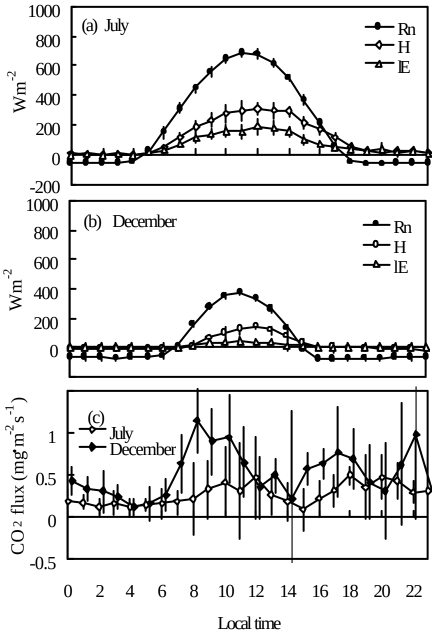

Figure 1 Diurnal changes of energy and CO_2 flux. *Rn*: net radiation, *H*: sensible heat flux, *lE*: latent heat flux.

4. LAND SURFACE PARAMETERS IN THE CITY

4.1 *Roughness Lengths for Momentum and heat- and vapor-transfer*

Roughness lengths for momentum and heat- and vapor-transfer (z_0 , z_T , z_q) are iteratively evaluated using the following equations,

$$u_*^2 = C_M U^2, H / c_P r = C_H (T_s^R - T)U, E / r = C_E (q_s - q)U \quad (1)$$

$$C_M = \frac{k^2}{y_M^2} \quad , \quad C_{H,E} = \frac{k^2}{y_M y_{H,E}} \quad (2)$$

$$y_M = \ln\frac{z - z_d}{z_0} + b_1(z, L, z_0, z_d)$$
$$y_{H,E} = \ln\frac{z - z_d}{z_{T,q}} + b_2(z, L, z_0, z_{T,q}, z_d) \quad (3)$$

where u_*: friction velocity, C_M,$C_{H,E}$: bulk transfer coefficient for momentum, heat, and vapor, T_s^R: radiometric surface temperature, *T*: air temperature, q_s: saturation specific humidity at the T_s^R, *q*: specific humidity, *U*: wind speed, Y_M, $Y_{H,E}$: universal function for momentum, heat, and vapor (Dyer and Hicks(1970)), z_d: zero-plane displacement height (5.6 m, calculated using Macdonald's (1998) method).

Seasonal change of daily-averaged z_0 is shown in Figure 2. Each plot is averaged over the daytime of each day. z_0 varies between 0.5 and 2.5 m. There is no significant seasonal change. The average value of z_0 is 1.37 m. This is larger than the value 0.86 m estimated by Macdonald's morphometric method.

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Figure 3 shows daily-averaged kB_T^{-1} (=$ln(z_0/z_T)$) against roughness Reynolds number (Re_*). kB_T^{-1} is smaller than the bluff rough curve from Brutsaert (1982) and larger than the permeable rough curve. This result is similar to a light industrial area (Voogt and Grimmond(2001)). The seasonal change of kB_T^{-1} is shown in Figure 4. kB_T^{-1} decreases in winter. Solar radiation with low zenith angle in winter mainly heats roof and wall – the upper part of the canopy where the turbulent exchange occurs most effectively. This indicates that heat is more easily transferred in winter. The relations of $ln(z_T)$ with $-\Delta T/T_*$ and $ln(z_q)$ with $-\Delta q/q_*$, are shown in Figure 5. The relation of $ln(z_T)$ with $-\Delta T/T_*$ agrees well with previous empirical results (eg. Sun and Mahrt (1995), Voogt and Grimmond). $ln(z_q)$ is much less than $ln(z_T)$ due to the dry condition in the urban surface. The $ln(z_T)$-$ln(z_q)$ are larger than the values estimated over various vegetation covers by Kondo and Watanabe(1992).

4.2 *Wetness Parameter*

Wetness parameter (b) is evaluated as follow eq.,

$$b = C_E / C_H \tag{4}$$

Many deciduous trees in this area lose leaves in the middle of November. It is expected that b in winter is smaller than summer. But seasonal change of b is not significant in Figure 6. This result also suggests that there are other sources of water in the urban area.

4.3 *Albedo*

Albedo at noon is shown in Figure 7. The albedo decreases in winter. In the urban canopy, input solar radiation is multi-reflected by wall and street. Most of the radiation is absorbed within the canopy. In winter the solar zenith angle is smaller than in summer, therefore a larger portion of radiation is now trapped within the canopy.

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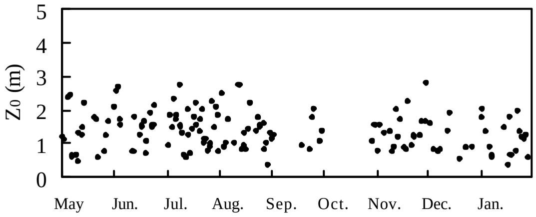

Figure 2 Seasonal change of daily averaged z_0

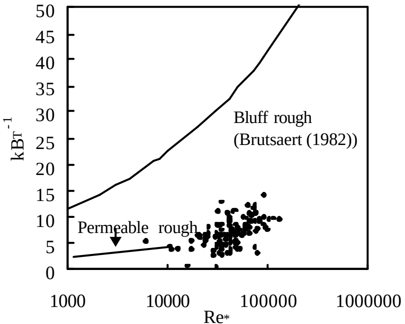

Figure 3 kB_T^{-1} against Re_* .

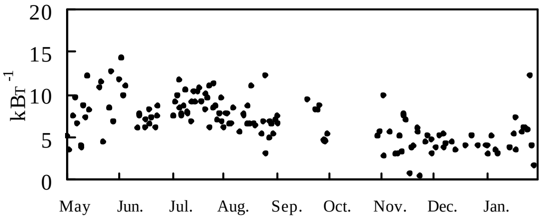

Figure 4 Seasonal change of daily averaged kB_T^{-1}

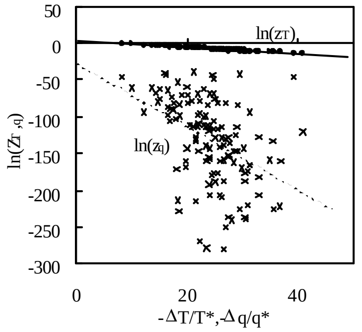

Figure 5 $ln(z_T)$ versus $-\Delta T/T_*$ and $ln(z_q)$ versus $-\Delta q/q_*$

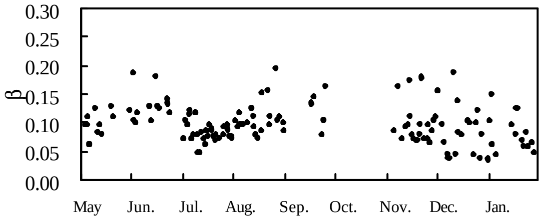

Figure 6 Seasonal change of β.

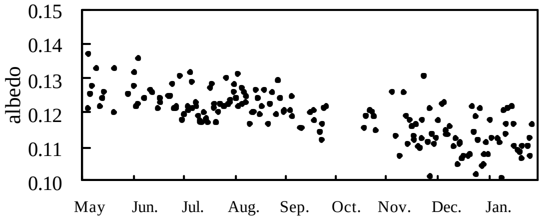

Figure 7 Seasonal change of albedo.