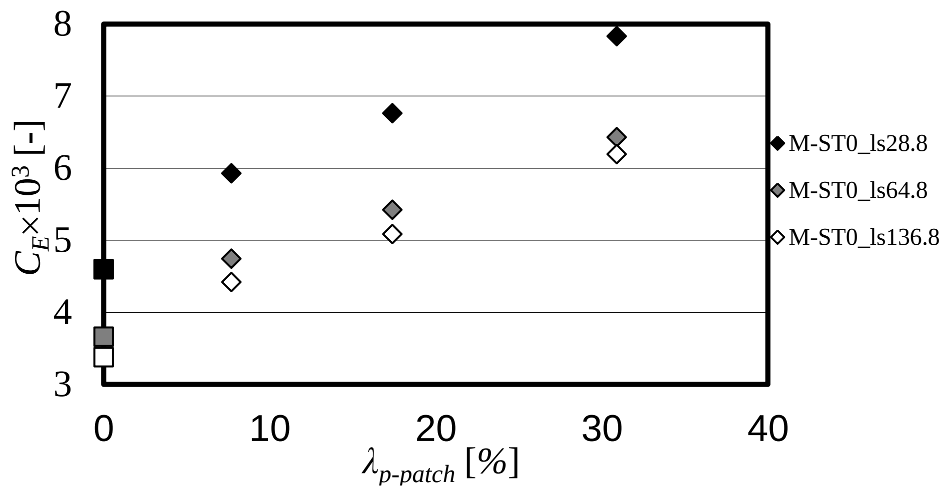

Figure 3. *Scalar transfer coefficient CEs for M-ST0 and Smooth against dry plan area ratio $\lambda_{p\text{-}patch}$.*

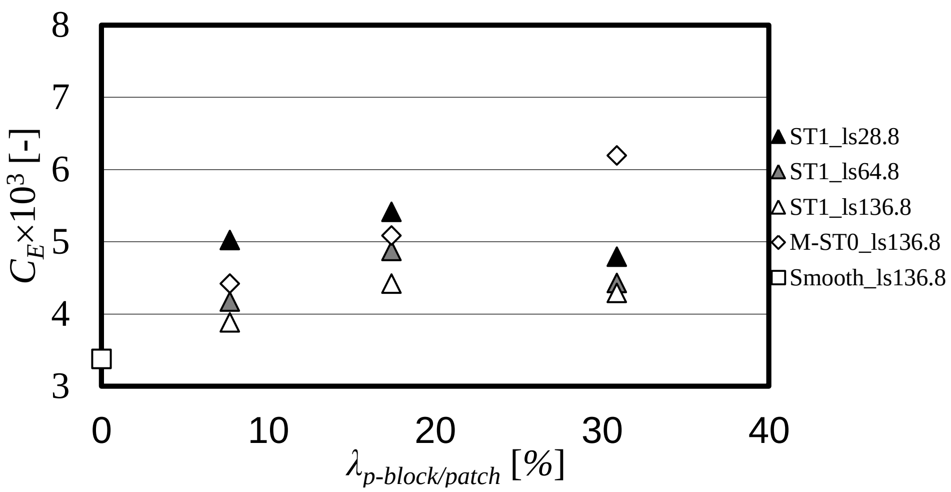

Figure 4. *Scalar transfer coefficient CEs for ST1 against block plan area ratio $\lambda_{p\text{-}block}$.*

Figure 4 shows estimated values of C_E for the block array (case ST1) for 3 different conditions of whole scalar source length l_s. The data for ST1 with the minimum scalar source area (l_s = 28.8L) obtained in Ikegaya et al. (2012), and those for M-ST0 and Smooth with the maximum scalar source area (l_s = 136.8L) are also included for a reference.

The values of C_E for whole scalar source area l_s of both 64.8L and 136.8L show a maximum value at the condition of $\lambda_{p\text{-}block}$ = 17.4% similar to the case of l_s = 28.8L. This tendency clearly indicates that the dry air above the block is efficiently accepted inside the canyon at the front of the block at $\lambda_{p\text{-}block}$ = 17.4%.

The scalar transfer efficiency depends on not only the scattered wet areas but also the aerodynamic effect of the blocks. Comparing the difference of C_E between ST1 and M-ST0 under the same condition of l_s = 136.8L, we can see the large difference for $\lambda_{p\text{-}block/patch}$ = 30.9% compared to those for $\lambda_{p\text{-}block/patch}$ = 7.7%. It implies that the aerodynamic effect of the blocks, which reduces horizontal advection, is stronger than the partitioning effect of dry patches at the high $\lambda_{p\text{-}block/patch}$ condition.

Furthermore, scrutinizing the data of ST1 between a basic scalar source size conditions of l_s = 28.8L and the extended scalar source conditions of l_s = 64.8L and 136.8L, it is apparent that a slight difference in C_E occurs between $\lambda_{p\text{-}block}$ = 7.7% and 30.9%. That is, C_E for $\lambda_{p\text{-}block}$ = 30.9% is larger than that for λ_p = 7.7% under l_s = 64.8L and 136.8L. In contrast, the data for l_s = 28.8L demonstrate the opposite trend. This implies that, at least to some extent, the relationship between C_E and the block density is affected by the condition of the whole scalar area. Thus, the applicability of experimental data under a limited scalar length condition to a real urban scale must be carefully examined.

3.2 Vertical Distribution of the Absolute Humidity

Figure 5 shows the vertical profiles of the absolute humidity over ST1, M-ST0 and Smooth under the condition of the maximum scalar source size l_s = 136.8L and $\lambda_{p\text{-}block/patch}$ = 17.4%. The error bar indicates the standard deviations of four positions in a unit and two times measurement for ST1 and M-ST0. In addition, the vertical profiles of skewness $u'^3/\sigma_u{}^3$ over surface with same conditions of surface geometry, and the streamwise length shown in Hagishima et. al (2009) are included in Fig. 5(a) for a reference. Although the velocity of Hagishima et. al (2009) was measured in a different wind tunnel, the negative peaks of the profiles of skewness shown in Fig. 5(a) are supposed to be approximate estimation of the thickness of the velocity boundary layer.

As shown in the graphs, the skewness of the velocity above the height of the negative peaks gradually regresses to the uniform state of the original inflow condition of the wind tunnel at a height of around 7.5L for ST1 and 2.5L for a smooth surface, and we can interpret these values as the height of momentum boundary layer. In short, the velocity boundary layer height for ST1 is much deeper than that of a smooth surface due to strong turbulence generated by the roughness.

Similarly, the height of scalar boundary layer for ST1 is deeper than other two surfaces of M-ST0 and Smooth as can be seen from the fact that the heights where normalized absolute humidity reaches to 1% are around 10L for ST1 and 5L for M-ST0 and Smooth, respectively. It would be caused by the fact that the similarity of the turbulent transport between momentum and scalar over the surfaces exists, and the moist air is transported as a passive scalar.

In addition, as can be seen in Fig. 5(b), the scalar profiles show logarithmic trends in middle region of the boundary layer (approximately z = 1L to 10L for ST1, and 0.2L to 2L for M-ST0 and Smooth). Furthermore, comparing the data of two flat surfaces M-ST0 and Smooth, the normalized values of absolute humidity for M-ST1 are higher than those for the fully wet smooth surface near the surface region below a height of around 3L, because of the partitioning effect of dry patches; however, the dry patches have little influence on the development of the scalar boundary layer.

To discuss more precisely the effect of the streamwise scalar source size on the similarity of the profiles of scalar concentration, the further improvement of the accuracy, spatial resolution and the spatial representativeness would be necessary.

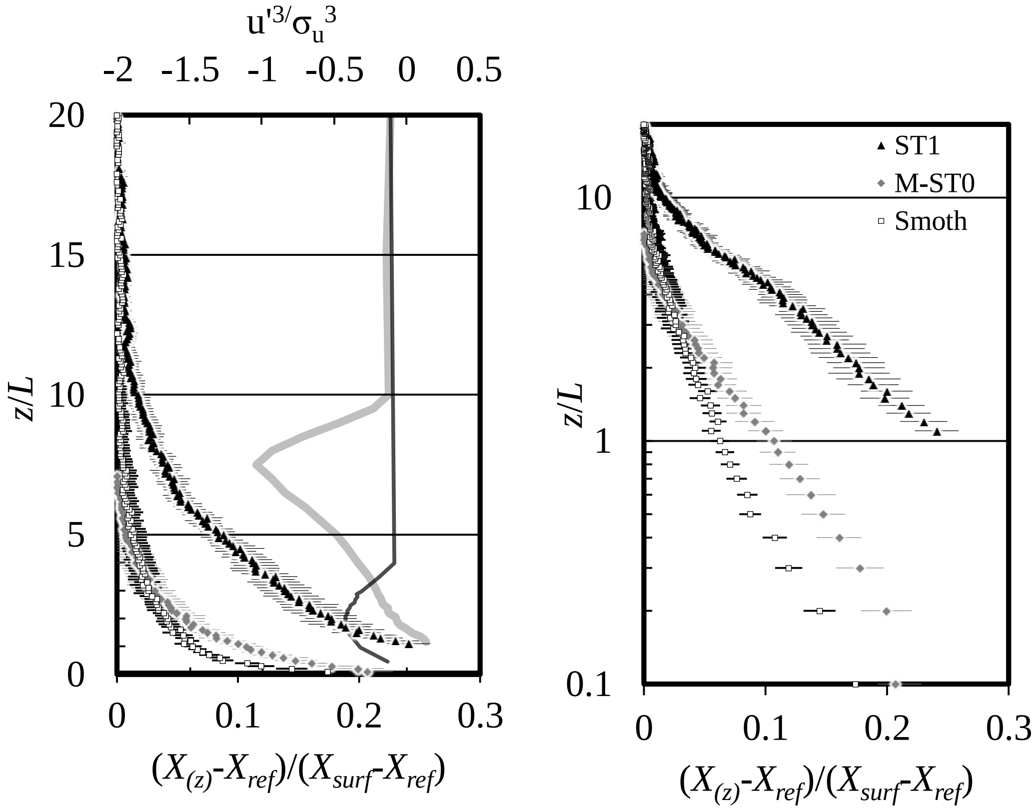

Figure 5. *(a) Spatial profiles of the absolute humidity under the condition of maximum length of the whole scalar source (ls = 136.8 L) and the condition of* $\lambda_{p\text{-}block/patch}$ *= 17.4%. Black triangle, grey diamond, and white square plots refer to ST1, M-ST0 and Smooth, respectively. Black and grey lines indicate the velocity profile of skewness for ST1 and smooth surface, respectively. (b) Power low index of Fig. 5(a).*

CONCLUSION

The scalar transfer coefficient (C_E) of street surfaces of cube arrays (ST1), wet smooth surfaces with dry patches (M-ST0), and a fully wet smooth surface (Smooth) were measured in a wind tunnel based on the salinity method and water evaporation method under different scalar source sizes and different fractions of blocks and dry patches. In addition, the vertical profiles over these three surfaces were measured. The results show that the evaporation from wet surface partitioned by small dry patches are enhanced, and C_E of this surface is larger than that of street surface of cube arrays under the same condition of plan area ratio of dry parches and blocks. It implies that the partitioning effect of evaporation areas from small wet surfaces in an urban area (such as the oasis effect) is possible to dominant over the turbulent mixing of the urban roughness.

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