

## Relation between the distribution of summertime intense rainfall frequency and the high-rise buildings in Tokyo Metropolitan Area

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### I. Introduction

Recently, the frequent occurrence of 'urban floods' due to summertime, short-duration intense rainfall has been reported in the Tokyo Metropolitan Area. Detailed climatological spatial structure of intense rainfall in urban areas, such as the Tokyo Metropolitan Area has not been analyzed completely using high-density rainfall data.

Here we present the spatial structure of the occurrence frequency of intense rainfall in the Tokyo Metropolitan Area based on detailed hourly rainfall data. In order to discuss the causal factors for the localized high-frequency area of intense rainfall, the distribution of surface aerodynamic parameters is calculated using surface elevation data, which can resolve individual buildings for simple evaluation of ascending wind velocity.

### II. Data

This study utilized hourly rainfall data recorded by the Japan Meteorological Agency, East Japan Railway Company, and the Bureau of Construction of the Tokyo Metropolitan Government. The target period covers the months of June to September in the years 1991 to 2002. In total, 226 cases were extracted where at least one station recorded an hourly rainfall of 20 mm or more in the central part of the Tokyo Metropolitan Area without being influenced by synoptic- or meso-scale disturbances.

The heights of artificial constructions were determined as the elevation difference between the 2.5 m interval elevation of a digital surface model (Pasco Corporation Ltd.) and the 2.5 m interval ground elevation interpolated from the 5 m interval DEM of the Geographical Survey Institute. Next, the aerodynamic parameters (roughness length,  $z_0$ , and zero-plain displacement,  $z_d$ ), representing 1 km<sup>2</sup> areas were calculated in the Tokyo Wards Area by Raupach's method.

### III. Discussion

The figure indicates the relative frequency distribution of intense rainfall among the 226 cases. High-frequency zones of intense rainfall are located along the boundary of the Tokyo Saitama Prefecture, and the northwest region of the Tokyo Wards Area. Although the wind direction at Tokyo (Otemachi) varies between northeast and south-southwest during periods of intense rainfall, it is concentrated in the easterly and southerly directions 2-3 hours before the occurrence of intense rainfall. In the case of easterly winds, the occurrence increases toward the west from the center of Tokyo or Shinjuku; the highest frequency occurs in Nakano Ward (west of Shinjuku). For southerly winds, a relatively high-frequency zone appears along the boundary of the Tokyo and Saitama Prefecture; the maximum frequency occurs in the Itabashi Ward, located north of Ikebukuro. In addition, a high-frequency zone of intense rainfall also appears south of the Shibuya-Kasumigaseki area in the case of northerly winds.

To evaluate the effect of surface roughness on the occurrence of intense rainfall, the distribution of ascending wind velocity in the lower layer is estimated from the convergence of horizontal wind. The distribution of horizontal wind velocity at an arbitrary height for the four wind directions is evaluated by applying the logarithmic rule using calculated  $z_0$  and  $z_d$  values assuming a wind velocity of 10 m/s at 250 m. In the case of the easterly winds, a large ascending wind velocity of about 0.2 m/s appears near Shinjuku, although that around Ikebukuro is smaller. A large ascending wind velocity is also present near both Shinjuku and Ikebukuro in the case of the southerly wind direction. Moreover, the ascending wind velocity near Kasumigaseki is larger in the case of northerly winds as compared with southerly winds. The distribution of estimated ascending wind velocity varies according to the wind direction, which corresponds to that of intense rainfall frequency for the respective wind directions. Thus, large surface roughness created by high-rise buildings is a possible factor for localized high-frequency areas of intense rainfall in urban areas.

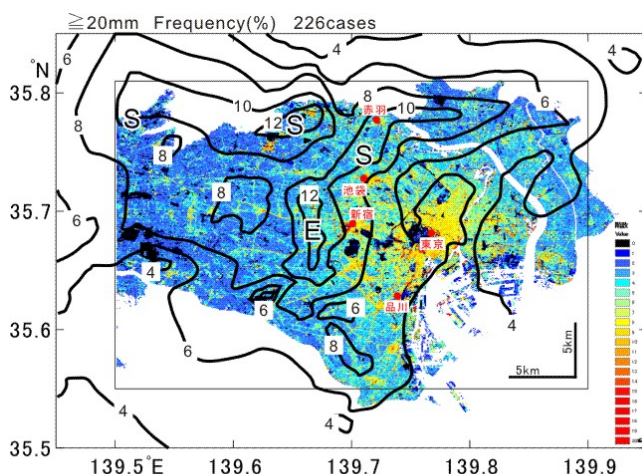


Figure: Distribution of relative frequency of intense rainfall (20mm/h or more) among the 226 cases in the central part of Tokyo Metropolitan Area (within the inside frame) and representative number of building floors. E and S show the high frequency areas of intense rainfall in the case of easterly and southerly winds, respectively.