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Analysis of the Environmental Conditions for Local-Scale Heavy Rainfall with Operational Meteorological Analysis Data

Tetsuya Takemi[1*], Syohei Nomura[1]

[1]Kyoto University

Local-scale extreme weather such as heavy rainfall, tornadoes, and gusty winds occur within a short period of time, and thus the prediction of their occurrence is extremely difficult. Nevertheless, the diagnosis and prediction of these local-scale extreme events are critically important, because those events sometimes spawn significant disasters and are expected to occur more frequently and more intensely under global warming and urban heat island. One of the approaches to diagnosing and predicting extreme weather is to deploy an observational network with high spatial and temporal resolutions and to enhance surveillance systems. One of the examples is a now-casting technique by high-frequency radar observational network for local-scale heavy rainfall. Such an approach has an advantage of real-time observations; however, it is not easy to identify pre-event conditions. In addition, local-scale extreme weather develops not deterministically but randomly. Therefore, there will be another approach that evaluates the degree of the development potential for extreme weather. If we should predict high/low probability for the development of extreme weather, such forecast information would be quite useful. How to evaluate the potential of the occurrences will matter at this point. Considering that local-scale extreme weather is mostly due to the existence of cumulonimbus clouds, it is important to evaluate the potential for the occurrence of a cumulonimbus cloud and/or organized convective systems. The environmental conditions for the development of cumulonimbus clouds are related to the stability of atmospheric stratification and the shear and convergence/divergence due to the spatial variation of winds. To examine the stability and wind conditions three-dimensional atmospheric data are required; these data should have a high temporal resolution owing to the short timescales of cumulonimbus clouds. Furthermore, it is important to examine the environmental conditions in mesoscales (i.e., O(100 km) scales) in investigating the occurrence of local-scale extreme weather. For this purpose objective meteorological analysis data are useful, and previous studies used such data to show the environmental conditions for past extreme events. The aim of this study is to investigate, with the use of the operational mesoscale objective analyses by Japan Meteorological Agency (JMA), the environmental conditions for local-scale heavy rainfall over the Kanto plain in summer under synoptically undisturbed conditions. The synoptically undisturbed conditions were determined as having no significant influences of fronts and typhoons, and the days with no rainfall in the morning and high temperature around noon were chosen. Atmospheric stability, vertical wind shear, and convergence/divergence of surface winds are examined to indicate the characteristic features of the environments for local-scale rainfall over the region. From the investigations, we will show how the operational meteorological analysis data can be used for diagnosing the occurrence of local-scale extreme weather. The present results are based on those included in Nomura and Takemi (2011, SOLA).

Keywords: Objective analysis data, Local heavy rainfall, Atmospheric stability, Stability index, Kanto plain, Urban