POTEKA Observation/Prediction Technology on the Ground Surface

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Abstract – Many localized, high-density, ground surface meteorological observation networks continue to observe with a resolution of approximately 1 to 10 km by approximately 1000 POTEKA compact weather station points in Japan. The POTEKA network succeeded in observing 15 gust events of the localized extreme weather changes, such as a downburst and a tornado, in the plains of Gunma and Saitama prefectures. The POTEKA gust prediction technology, developed by analyzing the meteorological features of the three severe downbursts among the 15 gust events, could predict the gust-damaged area and the gust-damaged time precisely approximately 20 minutes before the gust damage occurrence. This gust prediction technology, which is called as the temperature drop type, uses temperature observation data. Temperature and multiple other variables, such as sea level pressure and precipitation, are extremely changed just before the gust occurrence. For example, if we use sea level pressure observation data, we can predict the downburst gust, the same as using temperature. It might be called the POTEKA gust prediction technology of the pressure jump type.

1. Introduction

Localized extreme weather changes, such as a downburst and a tornado, are social issues that should be solved for humans, like synoptic weather, such as a typhoon and a linear rainband.

Goff [1], Wakimoto [2], Wilson et al. [3], Klingle et al. [4], Hjelmfelt [5], Martner [6], Inoue et al. [7], and Kim and Maki [8] have tried to observe localized extreme weather changes by remote sensing technology, such as Doppler and multiparameter radar. However, it was difficult to observe in detail because these weather changes are said to be meso-ɤ-scale, and these sizes are defined as 2 to 20 km. Currently, the ground surface structure of these weather changes is not well-known. The high-density ground surface meteorological observation network is required to be at a resolution of less than 10 km to understand the details of these weather changes. Bedard et al. [9] installed a high-density ground surface pressure observation network around Dallas airport and succeeded in observing the gust front transition. Iwashita et al. [10] reported that the POTEKA high-density ground surface observation network observed the multiple gust events of a downburst and a tornado in the plains of Gunma and Saitama prefectures in Japan. Iwashita and Kobayashi [11] analyzed the details of the downburst of an F1 category (Fujita scale), which occurred in Maebashi and Isesaki cities in Gunma prefecture on June 15, 2015. By analyzing the meteorological features of the multiple severe gust events, Iwashita et al. [12] developed the POTEKA gust prediction technology, which had a lead time of approximately 20 minutes from the prior notice to the gust occurrence. The details of the localized extreme weather changes are gradually clarified through the high-density ground surface meteorological observation network.

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2. POTEKA Weather Station and High-Density Observation Network

POTEKA weather observation equipment (hereinafter, POTEKA) in Figure 1, which includes the compact weather station, can observe eight meteorological variables, such as temperature, sea level pressure, relative humidity, sunshine, rain, wind direction, wind speed, and precipitation. The Japan Meteorological Agency certificates the latest version of POTEKA. POTEKA can be installed anywhere because of its compact size. Japan has many localized, high-density ground surface meteorological observation networks composed of approximately 1000 POTEKA points with a resolution of approximately 1 to 10 km, as shown in Figure 1.

3. Gust Observation Results

The very-high-density POTEKA network has been constructed from approximately 150 POTEKA points in the plains of Gunma and Saitama prefectures over approximately 9 years from 2013 to 2021. These plains are in Japan's hottest area in the summer and are characterized by localized extreme weather changes, such as a downburst and a tornado. We observed 15 gust events, including three severe downbursts and one severe tornado of the F1/JEF1 category (Fujita scale), as shown in Figure 2.

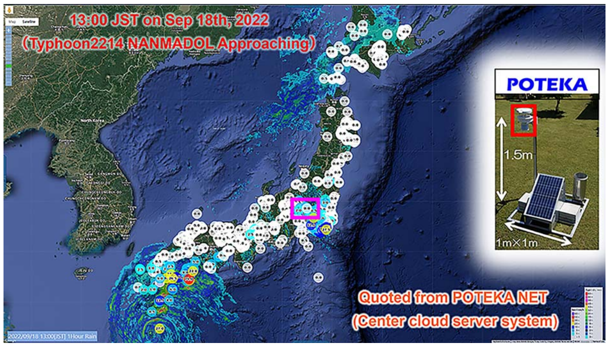

Figure 1. The latest version of POTEKA weather observation equipment, which includes the compact weather station/the localized high-density ground surface meteorological observation networks in Japan.

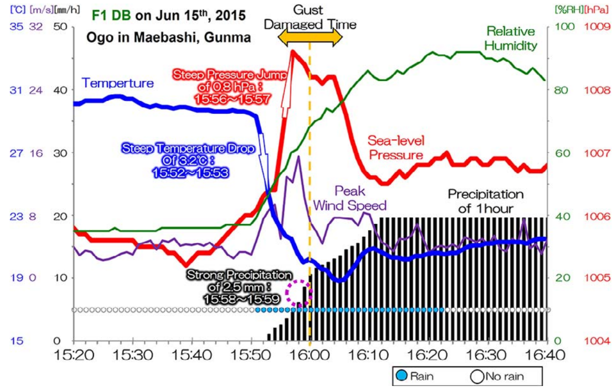

Figure 3. The observation data of the nearest POTEKA from the most damaged area of the F1 downburst on June 15, 2015.

4. POTEKA Gust Prediction Technology of the Temperature Drop Type

We analyzed the details of the three severe downbursts that occurred on August 11, 2013, June 15, 2015, and July 14, 2016. We introduced the meteorological features of the downburst of the F1 category on June 15, 2015. Figure 3 shows the observation data of the nearest POTEKA from the most damaged area. The multiple variables of temperature, sea level pressure, precipitation, and so forth were extremely changed just before the gust occurrence. Figure 4 shows the contour data of the downburst. If we trace the extreme meteorological variable change realm, such as low temperature or high sea level pressure, we can estimate the cumulonimbus advancing line, which is thought to cause the downburst with its direction and speed. Figure 5 shows the temperature and sea level pressure data of POTEKA points around the estimated cumulonimbus advancing line in Figure 4. The five points from A1 to A5 exist within 5 km from the advancing line. The five points from B1 to B5 exist outside 5 km from the advancing line. The five points from A1 to A5 have a steep temperature drop/a steep pressure jump. The five points from B1 to B5 have a moderate temperature drop/a moderate pressure jump.

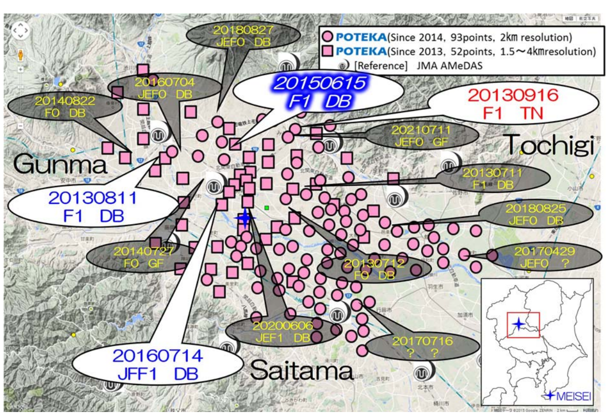

Figure 2. The very high-density POTEKA network in Gunma and Saitama prefectures/the observation results of 15 gust events.

Considering the meteorological features of the severe downburst, we thought we could predict the gust occurrence area and time using the following:

1. The first change observation point is defined as the starting point, and the change points observed afterward are automatically traced.
2. By defining the threshold (for example, 2°C drop over 1 min) and identifying the drop degree at each point, we distinguish which is the high- or low-probability area of the gust occurrence.

We developed the POTEKA gust prediction technology, which had a lead time of approximately 20 minutes from the prior notice to the gust occurrence. This technology could predict the gust-damaged area and time precisely for the three severe downbursts in the simulation. Figure 6 shows the gust prediction result for the downburst of the F1 category on June 15, 2015. We call it the POTEKA gust prediction technology of the temperature drop type.

5. POTEKA Gust Prediction Technology of the Pressure Jump Type

A steep temperature drop and a steep pressure jump were noted just before the three severe downburst

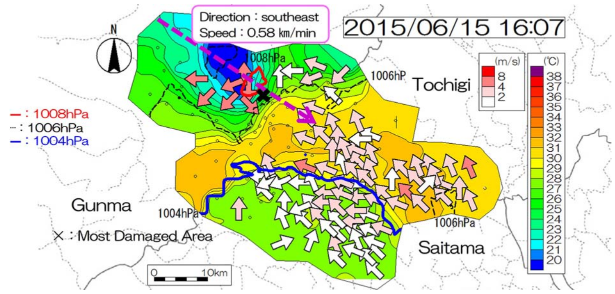

Figure 4. The contour data of the F1 downburst on June 15, 2015.

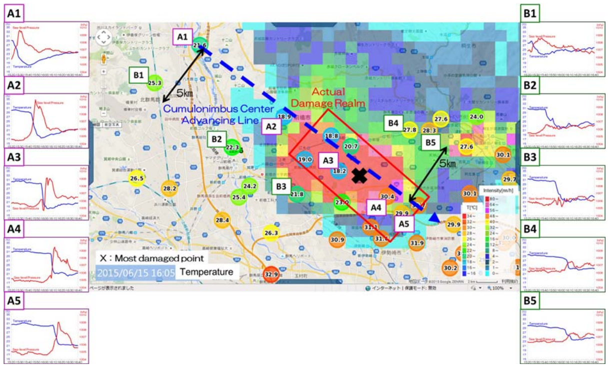

Figure 5. The temperature and sea level pressure data of the POTEKA points around the cumulonimbus advancing line of the F1 downburst on June 15, 2015.

occurrences. The threshold was a 2°C drop over 1 min in the temperature drop type. We substitute the threshold of a pressure jump for a temperature drop. When it was determined that the threshold was a 0.8-hPa jump over 1 min, we obtained the prediction result almost the same as the temperature drop type. Figure 7 shows the prediction result using pressure observation data for the downburst of the F1 category on June 15, 2015. It might be known as the POTEKA gust prediction technology of the pressure jump type.

6. Discussion

We introduced the POTEKA gust prediction technology for temperature drop and pressure jump types. Localized weather changes, such as downbursts and tornadoes, are thought to cause steep changes in other meteorological variables. For example, a downburst may cause a steep precipitation increase other than a steep temperature drop and a steep pressure jump. A tornado may cause a steep pressure drop and a steep precipitation increase. In other words, if we change from the threshold of temperature to the

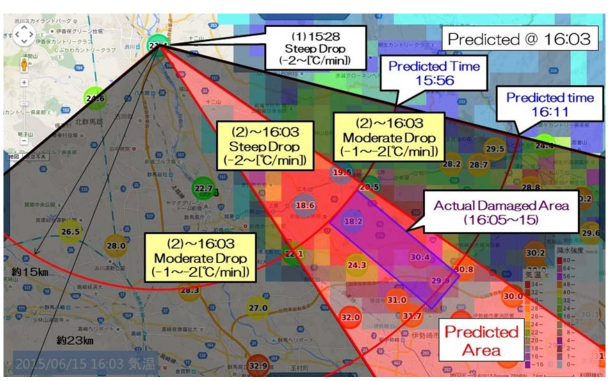

Figure 6. The prediction results of the POTEKA gust prediction technology of the temperature drop type for the F1 downburst on June 15, 2015.

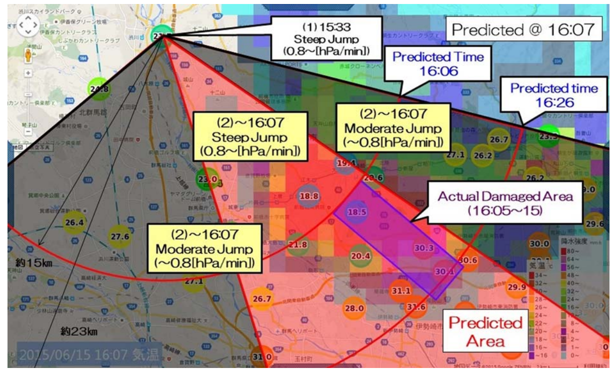

Figure 7. The prediction results of the POTEKA gust prediction technology of the pressure jump type for the F1 downburst on June 15, 2015.

threshold of other variables properly, we might be able to predict the localized weather changes depending on the gust types, such as a downburst and a tornado.

The thresholds of a 2°C drop over 1 min in the temperature drop type and a 0.8-hPa jump over 1 min in the pressure jump type may be proper for only the plains of Gunma and Saitama prefectures. We have to review the proper threshold value depending on each area's meteorological feature.

7. References

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