Observational study on precipitation patterns in the Fukui plain by using weather radar and wind profiler radars

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***Abstract* – We statistically compared wind data at lower troposphere based on wind profiler radars with precipitation distribution data based on C-band weather radar in order to investigate the effects of interaction between terrain and lower wind on precipitation patterns in the Fukui plain. The results show detailed precipitation patterns in the Fukui plain are classified by wind at altitude lower than 1 km. In particular, localized strong rainfall often occurs in the northern area of Fukui plain in the condition that wind at altitude lower than 1 km is westerly. These results indicate the measurement of lower wind at altitude lower than 1 km is important on local weather forecasting.**

***Index Terms* — wind profiler radar, weather radar, orographic precipitation.**

1. Introduction

It has been well known that orographic effects on precipitation are very important in strong precipitation event. Ref. [1] and [2] reported that horizontal distribution of precipitation had a relationship with lower wind at ground or 1000 hPa altitude through the interaction with terrain. Even in events categorized to non-orographic precipitation, it has been pointed out by many authors that interaction between terrain and lower wind has very important role in the precipitation patterns (Ref. [3], [4], and [5]).

In Hokuriku area of Japan, Ref. [6], [7] and [8] show that heavy snow events tend to occur at mountain area of Niigata when the wind is westerly at ground, especially, blows vertically to mountain range. They also show that heavy snow events tend to occur in plain area when wind at ground brows parallel to mountain range.

On the other hand, Fukui plain located in Hokuriku area as well as Niigata has more complex terrain compared to Niigata area, and the effects of interaction between terrain and lower wind on precipitation patterns have not been investigated in detail. Therefore, we have researched the relationship between precipitation patterns and wind at lower troposphere in this study.

2. Data and instruments

We use the C-band weather radar (WR) data as precipitation patterns in the Fukui plain, and AMeDAS (Automated Meteorological Data Acquisition System) and wind profiler (WPR) data as winds at ground and lower troposphere, respectively. Temporal resolutions of these data are 10 minutes.

Fig. 1 shows the map of Fukui plain and the locations of observation points for wind data. In the central area of Fukui plain (labeled as "FUKUI"), AMeDAS and wind profiler radar are operated at Fukui local meteorological observatory. On the other hand, in the coastal area, AMeDAS is operated at the location labeled as "MIKUNI" and same type wind profiler radar as FUKUI works at the location labeled as "AWARA". We use the wind data at three locations in order to investigate the localized characteristics of lower wind in the Fukui plain.

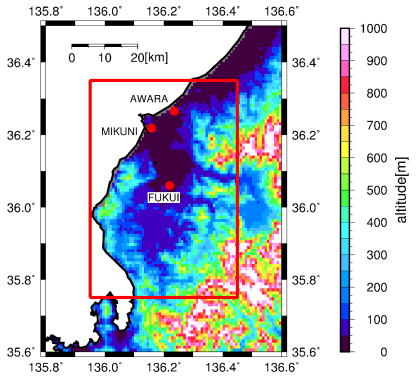

Fig. 1 Map of Fukui plain and locations of wind measurement instruments. The red square indicates the definition of area of Fukui plain in this study.

3. Data analyses

(1) Methodology

The data analyses period is from April to October in 2013. We made a dataset including time series of WR, AMeDAS and WPR described above. In order to investigate the statistical characteristics of precipitation patterns, we first extracted the data of precipitation patterns at a certain time from the dataset if the lower wind at the same time satisfies some conditions given on wind direction and wind speed.

Second, we composited the extracted data of precipitation patterns to produce a precipitation pattern which indicates the statistical characteristics of precipitation pattern under the conditions given on lower wind data.

(2) Classification of lower wind at the Fukui plain in the case of precipitation

In order to classify the wind direction patterns in the case of precipitation, we produced Fig. 2 by using wind direction data at both ground and altitude of 1~2 km. Former includes the effect of terrain and latter shows the characteristics of general wind. In this study, we used the result of coastal area (left panel) for lower wind classification because wind direction patterns clearly appear compared to those of central area (right panel). As the results of comparison of the wind direction patterns with resulted precipitation distributions, we finally classified wind direction patterns corresponding to typical precipitation distribution in the Fukui plain as follows;

(A) Southerly (135–225 deg.) wind at both ground and altitude of 1~2 km (17 %),

(B) Northerly (315-60 deg.) wind at ground (33 %),

(C) Westerly (225-315 deg.) wind at altitude of 1~2 km (50 %).

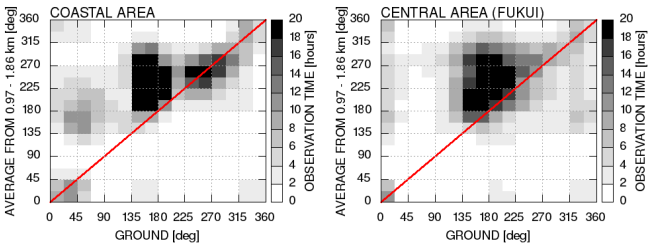

Fig. 2 Wind direction patterns of lower wind in the Fukui plain at coastal area (left) and central area (right).

The above three wind direction patterns can be recognized also in the result of central area. However, occurrence frequency of westerly wind (225-315 deg.) at ground is less at central area than at coastal area. The westerly wind at ground is one of significant features in the coastal area.

4. Results

The occurrence probability of wind direction pattern C reaches 50 %. Fig. 3 shows the statistical precipitation paterns in the case of wind direction pattern C. The left panel labeled as “C1” shows the result in the case of westerly wind at ground. On the other hand, the right panel labeled as “C2” shows the result in the case of southerly wind at ground. In each case, precipitation increases in mountain area at east side of Fukui plain. However, in the case C1, precipitation distribution is more localized around the boundary region between plain and mountain area in the northern area of Fukui plain compared to the case C2.

The characteristics seen in C1 is emphasized under the condition that wind speed of general wind is greater than about 10 m/s. At this time, wind speed at the altitude of a few hundred meters in the northern area of Fukui plain tends to be greater than that at the same altitude in the central area. (Figures are omitted).

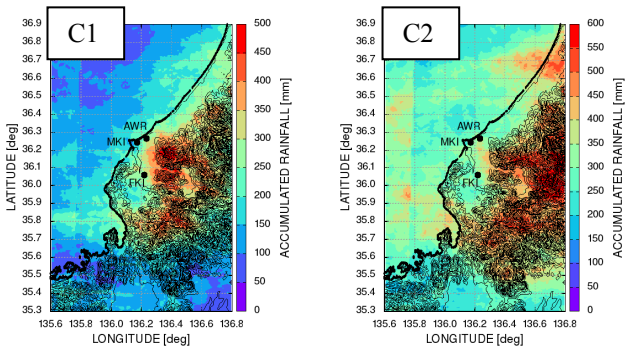

Fig.3 Statistical precipitation distributions in the case of wind direction pattern C. The results in the cases of westerly and southerly wind at ground are shown in the left and right panels, respectively.

5. Conclusions

We have investigated the relationship between precipitation patterns and wind patterns at lower troposphere in the Fukui plain. The results obtained show that wind at altitude lower than 1 km affects the detailed precipitation paterns in the Fukui plain. Especially, localized wind characteristics at altitude of a few hundred meters might be related to the localized precipitation patterns.

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