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Observation of local circulation in north area of Fukui prefecture by using two adjoining 1.3-GHz wind profiler radars

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Global impact of our lifestyle to our own has been pointed out previously. In the field of atmospheric environment, it has been considered that heavy rainfall, of which occurrence and damages are increasing in recent years, to be related with global warming. In addition to influence of yellow dust and PM 2.5 on our health, it has been known that photochemical oxidant tends to increase again since 1980's. Furthermore, the severe accident of Fukushima Daiichi Nuclear Power Station has caused us the interest about diffusion of radioactivity.

Above atmospheric problems are not only global but also local because they are strongly affected by local circulation. Local circulation occurs in atmospheric boundary layer (ABL) which has different characteristics in each local area, therefore, it is essential to reveal the detailed characteristics of ABL for resolution of the atmospheric problems.

Under such a situation, Fukui University of Technology started a project named as "Formation of research base for measurement and conservation of environment in Hokuriku area" (H23 - H27) supported by MEXT. In the project, a 1.3-GHz wind profiler radar (FUT-WPR), which is same type atmospheric radar as that of JMA WINDAS network, was installed in the coastal area of northern part of Fukui prefecture in 2012. In Fukui prefecture, a WPR of WINDAS has worked at Fukui local meteorological observatory (WINDAS-FUKUI), and the distance between FUT-WPR and WINDAS-FUKUI is only 24 km. There is no area in Japan where two WPRs are located within such a short distance, which enables more detailed study of the local circulation in Fukui plain than previous studies.

The observation results of FUT-WPR have revealed the detailed characteristics of see and land breeze (SLB) which is well known local circulation in coastal areas; its temporal variation, structure in altitude, relation with ABL, occurrence probability, and effect on generating area of clouds. Especially, the comparison with WINDAS-FUKUI not only confirms the observation results by FUT-WPR but also shows the SLB reaches from the seashore to a few 10 km inland. Although the observation results are fundamental in meteorology, this is the first time that the real picture of SLB in Fukui plain was revealed in detail so far. The comparison with WINDAS-FUKUI also shows the horizontal winds under about 1 km in altitude often differs between FUT-WPR and WINDAS-FUKUI, which indicates the importance of measurement of ABL.

We also carried out the data analyses in the case of heavy rain. On September 3 in 2013, passage of the stationary front accompanying the typhoon No. 17 brought about the heavy rain reaching to 10 mm/10min in Fukui prefecture from 14:00 to 16:00 (JST). FUT-WPR observed not only a typical structure and temporal variation of horizontal wind followed by the passage of stationary front but also intermittent upward flow, of which velocity reaches 1 m/s in the altitude from 200 m to about 4 km, from 7 hours before the passage of front. Especially, a strong upward flow with the velocity of 4 m/s was observed around 12:00 in the altitude from 3.5 to 5 km although the duration was relatively short. The observations of MTSAT from 10:00 to 14:00 have shown that optically thick clouds, of which top altitude was estimated to reach about 10 km, had arrived over Fukui prefecture. Therefore, the upward flows observed by FUT-WPR should be a part of cumulonimbi system which brought about the heavy rain. On the other hand, upward flows observed by WINDAS-FUKUI was weaker than that of FUT-WPR, which indicates the horizontal scale of upward flow accompanying the cumulonimbi system was under 24 km at least.

The results of observations and data analyses obtained so far indicates the observation of ABL by adjoining WPRs will be useful in early detection of arriving cumulonimbi system or local weather prediction.

Keywords: atmospheric boundary layer, local circulation, see and land breeze, heavy rain, wind profiler radar