Comparison of VIL Nowcast Social Experiment Results Using XRAIN and MP-PAWR Data Conducted in the Tokyo Metropolitan Area in 2015 and 2018

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Localized heavy rain has been garnering attention as a cause of urban flood disasters typified by street inundation and flooding of small and medium-sized rivers. The term “localized heavy rain” refers to a phenomenon that causes short-term severe rainfall amounting to tens of millimeters in a period from tens of minutes to approximately an hour, in spatial scales typically ranging from several kilometers to between ten and twenty kilometers. In order to reduce and prevent damage from localized heavy rain, it is important to improve the technology used to monitor and predict the sudden development of these cumulonimbus clouds.

In recent years, high-precision rainfall measurement technology –offered via a dual-polarization radar network called the XRAIN (for eXtended RAdar Information Network) primarily established in urban regions by the Ministry of Land, Infrastructure, Transport and Tourism of Japan –has rapidly improved the technology used to monitor the sudden development of cumulonimbus clouds. Moreover, recent years have witnessed the development of the dual-polarization phased-array weather radar (MP-PAWR), a fast scanning radar capable of producing three-dimensional (3D) observations under a minute and accurately detecting temporal evolution in suddenly developing cumulonimbus clouds.

The development of technology to predict the sudden development of cumulonimbus clouds, which produce localized heavy rain, is also advancing in conjunction with the improvements in radar technology.

We carried out social experiments of a nowcasting method where a 3D rainfall distribution was input, the vertically integrated liquid water content (VIL) was calculated as an analysis variable, and a 2D rainfall distribution was estimated (henceforth called the VIL Nowcast (VILN) method) developed by Hirano and Maki (2018). The development of the basic concept of VILN was inspired by the RadVil model proposed by Boudevillain et al. (2006). VILN is a system for predicting rainfall up to 1 h in advance using radar rainfall intensity and VIL calculated from X-band multi parameter (MP) radar volume scan data. Consideration of precipitation aloft is expected to enable rainfall, particularly severe rainfall, to be predicted immediately before they pour down, more quickly than rainfall is observed on the ground surface.

The radar data used as input values for VILN consist of X-band multi parameter (MP) radar volume scan data every 5 min from the two stations in Saitama and Shin-Yokohama that compose a part of XRAIN in 2015 summer season. On the other hand, 3D data collected every 30 sec by the MP-PAWR in Saitama were used as input values for VILN in 2018.

As for the accuracy of VILN, Iwanami et al. (2019) statistically examined for the experiment in 2015 not only whether VILN improves the accuracy of rainfall intensity predictions, but also whether the start of severe rainfall at both the initial stage and at a suddenly intensifying stage can be predicted accurately, and Hirano et al. (2019) report the results in 2018 in this conference.

The prediction accuracy must be increased and the limitation of the prediction must be communicated appropriately to the end users in order to boost confidence in prediction information. Furthermore, from the perspective of users, it is also important to consider evaluation methods according to the users' needs and demands in order to link the validation results of this social experiment with societal implementation. We conducted a social experiment with approximately 2,000 testers in each season, in which we sent warnings by VILN to the testers via e-mails and received their feedback by questionnaire survey.

In this presentation, we show the testers' feedback in both 2015 and 2018 experiments and discuss differences between them relating to the physical prediction accuracy. For example, the critical success index (CSI) of 10-min ahead prediction for 10-min rainfall amount of more than 5 mm was 0.41 and 0.35 in 2015 and 2018, respectively. It was supposed as the main reason that the number of radars for input of 3D rainfall data decreased from two with overlapped coverage area to one and the resulting in the wider radio extinction area at X-band.

Grid spacing, update time interval and prediction time of VILN were 500 m, 5 min and 20 min in 2015, whereas 250 m, 1 min and 30 min in 2018, respectively. Although the number of points for prediction per one tester was two in both seasons, it was possible for testers to change them in 2018. The 10-min rainfall amount for e-mail warnings to be sent were only 5 mm in 2015, but testers could select and change one among 0.2, 1, 5, 10, 15 mm in 2018 experiment. It took up to 7 and 1 min to send e-mail warnings after the end time of radar volume scan.

As a use of the VILN information, a relatively large number of questionnaire answers were related to daily life such as commuting and disaster prevention like attention around the home and tester. The comment shows the advantage as very short-term prediction of VILN that VILN information was very effective in deciding whether to act or wait, because the duration of heavy rainfall became clear.
As a result of the questionnaire on the usefulness, 51 and 63 % answered that it was helpful, and 38 and 29 % answered that it was somewhat helpful in 2015 and 2018, respectively. Although the sum of both categories was almost the same, the ratio of the answers of helpful increased by more than 10 % in 2018. The reason why the ratio of the answers of helpful increased in spite of decreased accuracy (CSI) is mainly considered improving immediacy and more choice of 10-min rain amount threshold for warning. Analysis of the relationships between the physical prediction accuracy and users' feedback from the social experiment might lead to a more practical and useful system.

Keywords: localized heavy rain, social experiment, vertically integrated liquid water content (VIL), VIL Nowcast, MP-PAWR